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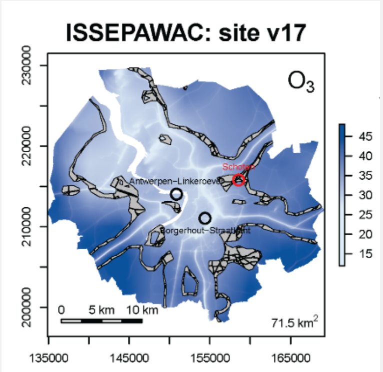
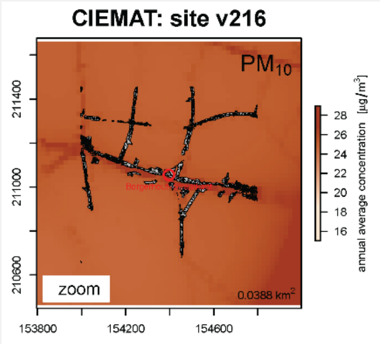
Spatial representativeness of air quality monitoring sites

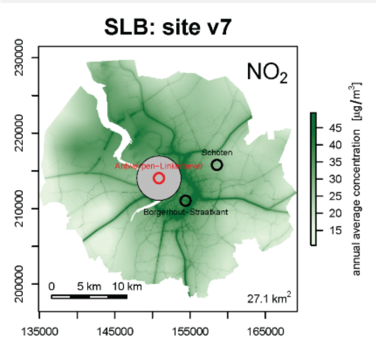
Outcomes of the FAIRMODE/AQUILA intercomparison exercise

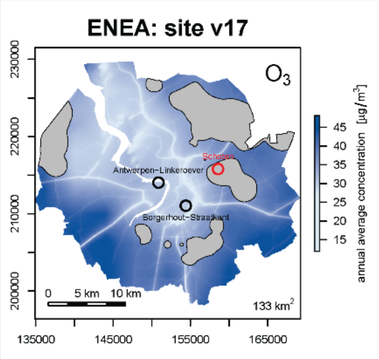
Kracht O., Santiago J.-L., Martin F., Piersanti A., Cremona G., Righini G., Vitali L., Delaney K., Basu B., Ghosh B., Spangl W., Brendle C., Latikka J., Kousa A., Pärjälä E., Meretoja M., Malherbe L., Letinois L., Beauchamp M., Lenartz F., Hutsemekers V., Nguyen L., Hoogerbrugge R., Eneroth K., Silvergren S., Hooyberghs H., Viaene P., Maiheu B., Janssen S., Roet D. and Gerboles M.

2017









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EUR 28987 EN

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JRC Science Hub
https://ec.europa.eu/jrc

JRC108791

EUR 28987 EN

PDF	ISBN 978-92-79-77218-4	ISSN 1831-9424	doi:10.2760/60611

Luxembourg: Publications Office of the European Union, 2017

How to cite this report: Kracht O., Santiago J.-L., Martin F., Piersanti A., Cremona G., Righini G., Vitali L., Delaney K., Basu B., Ghosh B., Spangl W., Brendle C., Latikka J., Kousa A., Pärjälä E., Meretoja M., Malherbe L., Letinois L., Beauchamp M., Lenartz F., Hutsemekers V., Nguyen L., Hoogerbrugge R., Eneroth K., Silvergren S., Hooyberghs H., Viaene P., Maiheu B., Janssen S., Roet D. and Gerboles M., *Spatial representativeness of air quality monitoring sites - Outcomes of the FAIRMODE/AQUILA intercomparison exercise*, EUR 28987 EN, Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-77218-4, doi:10.2760/60611, JRC108791.

Contents

Acknowledgements

The results presented in this report have been achieved in the course of a fruitful collaboration between **FAIRMODE** (Forum for Air Quality Modelling in Europe) and **AQUILA** (the European Network of Air Quality Reference Laboratories). The initiative of this work has been taken by the participants of the **FAIRMODE Cross-Cutting Activity group on Spatial Representativeness**.

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Summary

We are presenting an evaluation of the outcomes of the FAIRMODE & AQUILA intercomparison exercise (IE) on spatial representativeness (SR). To the best of our knowledge, this study is the first attempt to investigate systematically the differences in SR estimates that are achieved by applying a large set of SR approaches to the same common dataset.

The **assessment of the spatial representativeness (SR)** of air quality monitoring stations is an important subject that is linked to several highly topical areas, including risk assessment and population exposure, the design of monitoring networks, model development, model evaluation and data assimilation. Nevertheless, **European regulations lack a clear definition and provisions** to determine the SR of the stations. Also in the scientific literature, there is no unified agreement to address this complex problem.

In order to further explore this topic and to make progress in the harmonisation of the related assessment procedures, the **FAIRMODE** (Forum for Air Quality Modelling in Europe) Cross-Cutting Activity group on SR organised a comprehensive intercomparison exercise (IE). The main objective of this IE was to **evaluate the possible variability of spatial representativeness results** obtained by applying the range of different contemporary approaches to a jointly used example case study. In order to ensure a broad participation in this exercise, a collaborative effort has been established between FAIRMODE and **AQUILA** (the European Network of Air Quality Reference Laboratories). As a working basis, a shared dataset has been collected among a set of monitoring, emission and modelling data from the city of Antwerp.

Within this IE, **11 different teams from 9 different countries** provided their SR estimates for PM_{10} and NO_2 at one traffic site, and for PM_{10}, NO_2 and O_3 at two urban background sites. In order to narrow down the range of conceivable SR approaches and definitions, it was beforehand suggested to use the area of SR of the monitoring sites as a general concept to work with. During the course of the exercise, this concept of the SR area in fact turned out to be a useful indicator, and **10 of 11 teams were able to define shapes** surrounding the stations under investigation, whereas **one team rather worked towards a classification** of the stations, as this was more common practice for SR evaluation in their member state.

The resulting SR areas nevertheless revealed a **considerable range of dissimilarity** between the different teams - not only **in terms of the extent and position of the SR perimeters**, but also in the **technical procedures** and the **extent of input data** effectively used. These differences required detailed evaluations in order to identify the major factors triggering and controlling this spread, which can be found amongst (1) the basic principles of the methods, (2) the parameterisation of the similarity criteria and thresholds, (3) the effective use of input data, and (4) the detailed conceptualisation and definitions of SR. These outcomes do **underline the need** for (i) a more **harmonised definition** of the concept of "the area of representativeness" and (ii) **consistent and transparent criteria** used for its quantification.

A **comprehensive concluding section** (chapter 10) is highlighting the challenges that the expert community working on spatial representativeness is currently facing. Recommendations are given for the **directions to be focused on SR in the near to mid-term future**. In this regards, we are outlining a **roadmap towards a modular approach for better SR characterisation**. It is stressed that that for the aim of harmonisation the concept of spatial representativeness will **probably require a paradigm shift** in its definition (chapter 10.8). In specific, it is suggested that **a clear distinction needs to be made** between the four different aspects:

1. The **purpose** of evaluating SR in a specific case of application
2. The set of **SR metrics** / SR characteristics required for this purpose

3. Context related **definitions of SR metrics**
4. The **technical methods** for estimating a particular SR metric

Beyond the questions of harmonisation, it should not be disregarded that **alternative interpretations** for the strong variability of the SR results might exist. The observed divergences in SR results could for example point us to some **more fundamental discrepancies** related to the evaluation of the air quality data. It is advised to take care, that in the endeavour for methodological harmonisation such **alternative explanations are not overlooked**. An example could be a potential inconsistency within the input data coming from emission, monitoring and modelled data.

Furthermore, the findings of this study are not only relevant with regard to the SR of a single monitoring station. It also gives evidence that questions need to be raised about what is the real **representativeness of network monitoring data in general** since it seems that there is no current consensus on its evaluation. Example given: Is there a need for the European Commission to re-evaluate the criteria for **the number and the siting of Air Quality Monitoring Stations** set in the Air Quality Directive when a consensus on SR is reached?

1 Introduction

The elementary concept of **spatial representativeness (SR)** is based on determining the area to where the information observed at a monitoring site can be extended. For the case of an **air quality monitoring station (AQMS)**, the key question about SR is thus as to what extent a point measurement at this station is representative of the ambient air pollutant concentrations around it.

Commonly used definitions for the spatial representativeness of an AQMS are established on an evaluation of the similarity of pollutant concentrations around this point. Hence, in its most basic definition the **spatial representativeness area (SR area)** is described by the set of all locations where the concentration of a pollutant does not differ from the measurements at the central point (monitoring station) by more than a certain threshold. In practical applications, SR has sometimes been described by rather (over-) simplified geometrical concepts. However, subject to the site-specific conditions and to the different SR conceptualisation deployed, SR areas can in reality have quite complex, irregular and even discontinuous shapes.

The assessment of the spatial representativeness of air quality monitoring stations is in fact an important subject that is linked to several highly topical areas, including risk assessment and population exposure, the design of monitoring networks, model development, model evaluation and data assimilation.

The European Commission has worked intensively on the implementation of a harmonised programme for the monitoring of air pollutants. The harmonisation program relies on the adopted Air Quality European Directives, AQD, 2008/50/EC[1] (amended with Directive 2015/1480[2]) and 2004/107/EC[3], which endeavour to improve the quality of measurements and data collection, and to ensure that the information collected on air pollution is sufficiently representative and comparable across the Community. However, though these directives include several considerations about the order of magnitude of the SR of a monitoring site, no detailed provisions on the methods for assessing the SR are provided. Also in the scientific literature, there is no unified agreement to address this complex problem, and no well-established procedure for assessing SR has been identified so far.

In order to further explore this topic and to make progress in the harmonisation of the related assessment procedures, the **FAIRMODE Cross-Cutting Activity group on SR** organised a comprehensive **intercomparison exercise (IE)**. In order to ensure a broad participation in this exercise, a collaborative effort has been established between **FAIRMODE** (Forum for Air Quality Modelling in Europe) and **AQUILA** (the European Network of Air Quality Reference Laboratories).

The main objective of this IE was to **examine the possible variability of SR results** obtained by applying the range of different contemporary approaches to a jointly used example case study. As a working basis a shared dataset has been selected among a set of modelling data from the city of Antwerp.

It should be pointed out that the aim of the IE was less to evaluate investigate how the different methods perform. This would in fact not have been possible, as by principle a known SR reference value ("true value") was missing. We rather intended to investigate how the outcomes of different approaches would compare to each other, in this way

[1] DIRECTIVE 2008/50/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 21 May 2008 on ambient air quality and cleaner air for Europe, Official Journal of the European Union L 152/1

[2] COMMISSION DIRECTIVE (EU) 2015/1480 of 28 August 2015 amending several annexes to Directives 2004/107/EC and 2008/50/EC of the European Parliament and of the Council laying down the rules concerning reference methods, data validation and location of sampling points for the assessment of ambient air quality, Official Journal of the European Union L 226/4

[3] DIRECTIVE 2004/107/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 15 December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air, Official Journal of the European Union L 23/3

measuring consistency rather than correctness. Thereby two fundamental questions needed to be addressed: Are the different SR methods actually targeting the **same metric**? Or, conversely, do the professionals and experts probably speak about several **different concepts and quantities** when they name it SR?

Within the IE, **11 different teams from 9 different countries** provided their SR estimates for particulate matter (PM_{10}) and nitrogen dioxide (NO_2) at one traffic site, and for PM_{10}, NO_2 and ozone (O_3) at two urban background sites. As it was the main objective of this IE to evaluate the possible variability of SR results obtained by applying the range of different contemporary approaches, all participating teams worked by applying their own selected methods and by using those parts of the dataset that they would normally require. In order to focus and reasonably narrow down the range of conceivable SR approaches and definitions, it was however suggested to use the **area of SR** of the monitoring sites as a general concept to work with. During the course of the IE, this concept of the SR area in fact turned out to be a useful indicator, and 10 of 11 teams were able to define shapes surrounding the stations under investigation, whereas one team rather worked towards a classification of the stations, as this was more common practice for SR evaluations in their member state. Participants were furthermore asked to provide estimates for the **number of inhabitants** within their calculated areas of representativeness. This later task was relevant for inspecting as to what extent prospective incongruences in the SR areas would translate to a comparable incongruence in the population estimates.

2 Content of the Shared Dataset

This chapter provides an overview of the datasets prepared for the intercomparison exercise. The dataset was prepared by VITO (BE). It includes:

2.1 Measurements of the automatic stations for the city of Antwerp and its regional area for the year 2012.

- All available measurements of the AQMS are included in the dataset. The measurements consist of hourly values for: $PM_{2.5}$, PM_{10}, O_3, NO/NO_2, CO, SO_2 and BTX and black carbon.
- The file General_info.csv gives information about the stations: names, coordinates, classification, units, measurement methods and instruments. The percentage uncertainties of measurements are given.
- Ancillary measurements including temperature, precipitation, wind velocity, wind direction and sun radiance are included at one station.

2.2 Measurements of the ATMOSYS-campaign with passive samplers and mobile stations

This part of the dataset includes:

- NO_2 measurements (2-week averages in µg/m³) at 6 sampling sites between 29-06-2011 and 11-07-2012
- PM_{10} with chemical speciation sampled every 4th day at 3 sites (measured parameters: PM_{10}, elemental carbon / organic carbon, levogluconsan, ions:, NO_3, Cl, SO_4, Na, NH_4, K, Mg, Ca and heavy metals: Al, As, Ba, Ca, Cd, Cr, Cu, Fe, K, Mn, Mo, Ni, Pb, Sb, Ti, V and Zn). All units are µg/m³.
- The files general_info_atmosysNO2.csv and general_info_atmosysPM.csv gives information about the sampling sites with names, address, classification, coordinates plus the temperature for the NO2 measurements.
- Projection system: Lambert Belgium 72 (EPSG: 31370).

2.3 Gridded model data

The dataset includes annual mean gridded concentrations for 2012 on a 5x5 m² grid over a regional domain for $PM_{2.5}$, PM_{10}, black carbon, benzene, O_3 and NO_2.

- The measurements are µg/m³.
- Projection system: Lambert Belgium 72 (EPSG: 31370).
- The data is provided in a GIS compatible format (.asc-files).

Figure 1 exemplifies some examples of the gridded model data.

2.4 Virtual monitoring sites

- 341 virtual monitoring sites were simulated out of model data with hourly values for NO_2, black carbon, $PM_{2.5}$, PM_{10}, benzene and O_3.
- These virtual monitoring sites could be used as input data by participants who needed additional stations not included in the automatic network for their data treatment with hourly values. The virtual monitoring sites may simulate virtual diffusive samplers with to 2-week averages for NO_2 and O_3, and virtual monitoring stations with daily averages for PM_{10}. However, if virtual diffusive samplers or virtual monitoring stations were needed, participants were requested to use the time series given in point 2.9, in which the typical noise of indicative measurement methods had been added.

- Please note that no bias correction with the measurements of the automatic network had been applied to these data.
- A total number of 341 virtual monitoring sites were created out of the irregularly gridded model data. Among the virtual monitoring points, 100 sites are located in street canyons and the rest are located at urban background locations. VITO specified a first set of street canyon and non-street canyon locations at arbitrary positions of the underlying irregular model grid (source type "random"). In addition, 111 virtual monitoring points have been allocated in a field around the Borgerhout traffic station (47 at traffic sites in street canyons and 64 at arbitrary positions aligned along circles around this traffic station).
- Projection system: Lambert Belgium 72 (EPSG: 31370).
- The data is provided in digital format (.csv-files). The file virtual_stations.csv gives the numbered labels of the virtual monitoring sites, their coordinates, information about the type of site, the distance to stations (for the station type circlesBorgerhout and SC Borgerhout) or the distance to roads (for the station type "perpendicular").

2.5 Emission inventories

- The dataset includes 1x1km² gridded emission files for CO, NH_3, NMVOCs, NOx, PM_{10}, $PM_{2.5}$ and SO_2 containing all the emissions in the domain (including point sources and road traffic emissions re-gridded to the 1x1km² resolution). In addition, some extra files are added to further downscale the emissions to a higher resolution with hourly traffic, annual average of road emissions and point sources. Please refer to the detailed information given in appendix to use the emission data.

2.6 Gridded population density for the great Antwerp area

- The dataset includes a grid of population density with a high resolution of 100x100 m.
- Projection system: Lambert Belgium 72 (EPSG: 31370).
- The data is provided in a GIS compatible raster format (pop_antw_100m.asc).

2.7 Cadastre of building heights for the city of Antwerp

- The dataset includes building information for all buildings in the domain. Every building is represented as a polygon with altitude being its altitude in cm provided in shapefile format.

2.8 CORINE land use/cover classification within the domain

- The dataset includes the Corine land cover classification 2012 version (CLC2012) in the domain gridded on a 100x100 m² grid with an overview of the different classes. Geographic projection is Belgium Lambert 72 (EPSG: 31370).

2.9 Virtual station dataset

For those participants that potentially needed additional indicative measurements (e. g. diffusive samplers), 2-week averages for NO_2 and O_3, and daily averages of PM_{10} time series were computed.

It is generally expected that indicative measurements have more scattering than reference values. However, we observed that the virtual monitoring sites presented lower relative standard deviations than the reference values of the Air Quality Monitoring Stations of the automatic network. Therefore, random noise was added to the NO_2 and 2-

week O_3 averages and to the PM_{10} daily values. We used previous studies[4],[5],[6] to estimate the variance function versus the reference values. We did not take into consideration the bias between the modelled virtual monitoring stations and stations and the existing stations of the Antwerp monitoring network

For the choice of the participants, 2-weeks and daily averages without noise were also given.

2.10 PM_{10} data (speciation)

A pdf file presents a short summary of a study of PM_{10} speciation including the city of Antwerp between mid 2011 and mid 2012.

2.11 Daily traffic

The file timefactors.xlsx includes 3 worksheets:

- "Daily" gives the daily traffic profiles for the three types of roads contained in the dataset (highway, rural, urban)
- "Monthly" gives the monthly traffic profiles for the three types of roads contained in the dataset (highway, rural, urban)
- "Weekly" gives the weekly traffic profiles

These profiles are based on traffic counts and composed by the Flemish Traffic Agency (VVC).

[4] Gerboles M., Detimmerman F., Amantini L., De Saeger E., Validation of Radiello diffusive sampler for monitoring NO2 in ambient air, Commission of the European Communities, EUR 19593 EN, 2000

[5] Detimmerman, F., Gerboles, M., Amantini, L, de Saeger, E,, Validation of Radiello diffusive sampler for monitoring ozone in ambient air, Commission of the European Communities, EUR 19594 EN, 2000

[6] F. Lagler, C. Belis and A. Borowiak, A Quality Assurance and Control Program for $PM_{2.5}$ and PM_{10} measurements in European Air Quality Monitoring Networks, EUR 24851 EN, ISBN 978-92-79-20481-4, ISSN 1831-9424, DOI 10.2788/31647, 2011

3 General Description and Characterisation of the Datasets

For the purpose of this intercomparison exercise a set of modelled data had been prepared by VITO (Belgium) by applying the RIO-IFDM-OSPM model chain to the modelling domain of the city of Antwerp for the year 2012 ([7]). In this model chain, the RIO land-use regression model, based on the data of the official monitoring network in Belgium, provides the regional background concentration. The local increment due to traffic and industrial emissions is calculated using IFDM, a bi-Gaussian plume model designed to simulate non-reactive pollutant dispersion at a local scale. For the computation of concentrations in street canyons, the RIO-IFDM chain is furthermore coupled to the OSPM box model ([8]).

Within the framework of the FAIRMODE intercomparison exercise, the following three monitoring sites have been selected for closer evaluation:

As an example for the traffic sites:

— Borgerhout II (Straatkant) (Belgium Lambert 72 coordinates: 154396 / 211055)

As examples for the urban background sites:

— Antwerpen-Linkeroever (Belgium Lambert 72 coordinates: 150865 / 214046)

— Schoten (Belgium Lambert 72 coordinates: 158560 / 215807)

A set of 341 virtual monitoring points time series with hourly data have been extracted from the RIO-IFDM-OSPM model chain outputs. The initial aim of these time series was to simulate virtual monitoring stations with daily averages for PM_{10}, and virtual diffusive samplers with to 2-week averages for NO_2 and O_3.

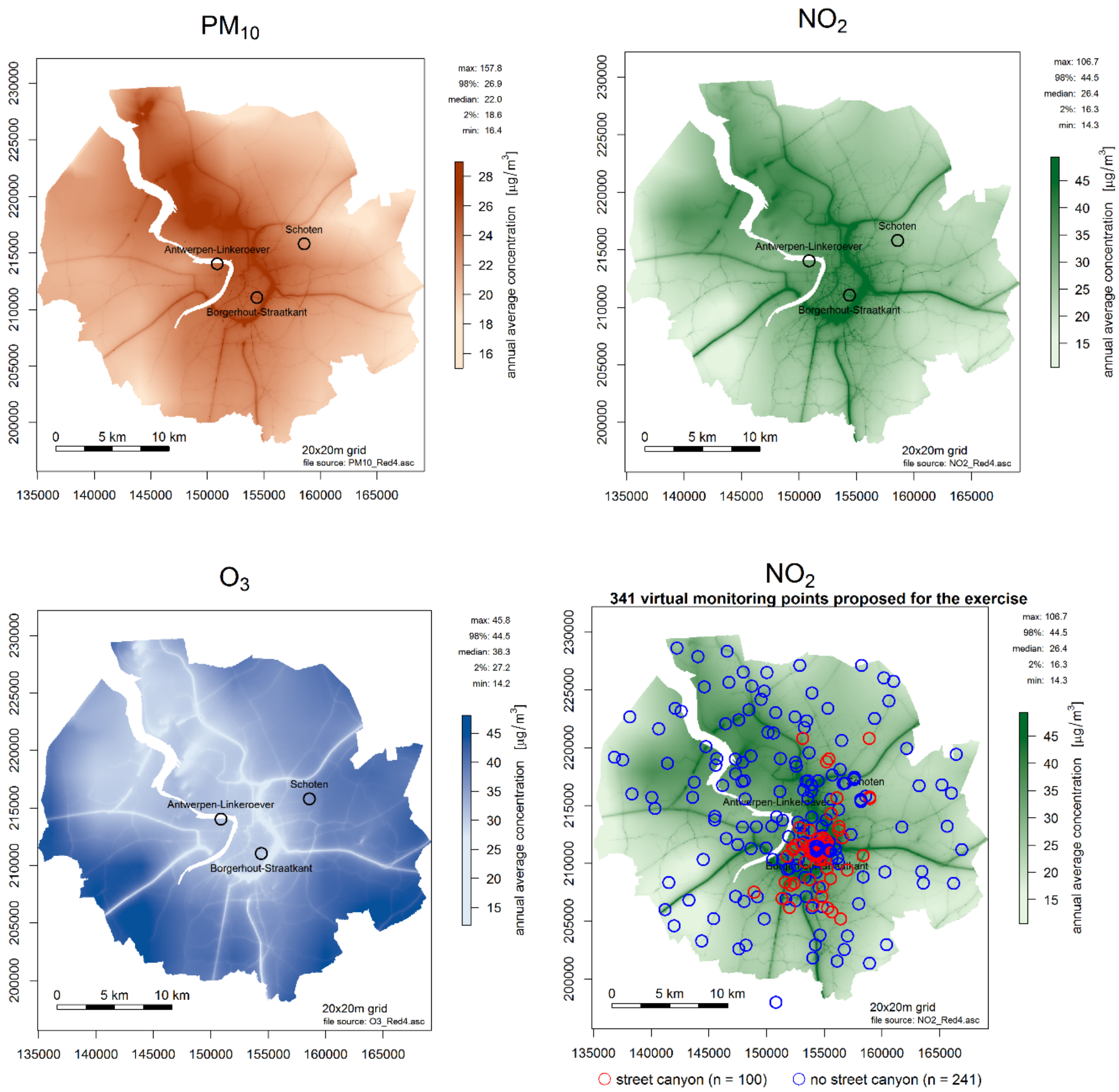
Figure 1 provides an Overview of the annual average concentration fields obtained for PM_{10}, NO_2 and O_3 for the modelling year 2012. In addition, the locations or the three selected monitoring sites, and the positioning of 341 virtual monitoring points are shown. The aim of the virtual monitoring points was to extract time series with hourly data from the RIO-IFDM-OSPM model chain outputs.

Table 1 summarises some general statistical characterisation of the underlying dataset. In total, time series of 341 virtual monitoring points have been extracted from the model data. These 341 virtual receptors can be distinguished into points located within street-canyons (SC) and points located outside of street-canyons (noSC). Furthermore, the immediate modelling outputs, consisting of simulated hourly data, are aggregated into time series of 1-day averages and 14-days averages. It should be noted that the summary statistics calculated for this set of virtual monitoring points should tend to approximate, but are not necessarily exactly identical to, the means and standard deviations of the full set of gridded data.

([7]) Kracht, O., Hooyberghs, H., Lefebvre, W., Janssen, S., Maiheu, B., Martin, F., Santiago, J.L., Garcia, L. and Gerboles, M. (2016): FAIRMODE Intercomparison Exercise - Dataset to Assess the Area of Representativeness of Air Quality Monitoring Stations. 267 p. JRC Technical Reports 102775. EUR 28135 EN. EUR – Scientific and Technical Research Series. ISSN 1831-9424 (online), ISBN 978-92-79-62295-3 (PDF), DOI 10.2790/479282.

([8]) Berkowicz, R., Hertel, O., Larsen, S.E., Sørensen, N.N., Nielsen, M. (1997): Modelling traffic pollution in streets (report in PDF format, 850 kB, http://www.dmu.dk/en/air/models/ospm/ospm_description/)

Figure 1. Overview of the annual average concentration fields obtained for PM_{10}, NO_2 and O_3 for the modelling year 2012.



Coordinates are referring to a projection in the Belgium Lambert 72 system (EPSG: 31370). The locations of the three selected monitoring stations (Antwerpen-Linkeroever and Schoten for urban background sites, and Borgerhout-Straatkant for the traffic site) are also shown in the plots.

The bottom right panel illustrates the positioning of 341 virtual monitoring points (the NO_2 concentration field is repeated in the background of this panel for a better spatial orientation).

Table 1. Summary statistics of the time series of 341 virtual monitoring points

Simulated Hourly Data (Antwerp 2012)													
Virtual Station Type	Number of Points	Grand Mean [μg/m³]			Grand Standard Deviation [μg/m³]			Pooled Standard Deviations of the Individual Time Series [μg/m³]			Standard Deviation of the Annual Means of the Time Series [μg/m³]		
		PM_{10}	NO_2	O_3	PM_{10}	NO_2	O_3	PM_{10}	NO_2	O_3	PM_{10}	NO_2	O_3
all	341	24.7	40.0	31.2	16.0	22.3	25.3	15.8	18.2	25.0	2.3	11.8	4.1
SC	100	26.0	49.4	30.1	16.2	21.8	24.9	16.1	18.9	24.8	1.9	10.8	2.4
noSC	241	24.1	36.1	31.7	15.8	21.2	25.4	15.6	18.0	25.0	2.3	10.0	4.5
1-day Averages of Simulated Data (Antwerp 2012)													
Virtual Station Type	Number of Points	Grand Mean [μg/m³]			Grand Standard Deviation [μg/m³]			Pooled Standard Deviations of the Individual Time Series [μg/m³]			Standard Deviation of the Annual Means of the Time Series [μg/m3]		
		PM_{10}	NO_2	O_3	PM_{10}	NO_2	O_3	PM_{10}	NO_2	O_3	PM_{10}	NO_2	O_3
all	341	24.7	40.0	31.2	14.2	17.7	18.6	14.0	12.9	18.2	2.3	11.8	4.1
SC	100	26.0	49.4	30.1	14.4	16.7	18.3	14.3	12.8	18.2	1.9	10.8	2.4
noSC	241	24.1	36.1	31.7	14.1	16.6	18.7	13.9	13.0	18.2	2.3	10.0	4.5
14-days Averages of Simulated Data (Antwerp 2012)													
Virtual Station Type	Number of Points	Grand Mean [μg/m³]			Grand Standard Deviation [μg/m³]			Pooled Standard Deviations of the Individual Time Series [μg/m³]			Standard Deviation of the Annual Means of the Time Series [μg/m3]		
		PM_{10}	NO_2	O_3	PM_{10}	NO_2	O_3	PM_{10}	NO_2	O_3	PM_{10}	NO_2	O_3
all	341	24.7	40.1	31.1	9.8	13.8	13.5	9.7	7.1	13.1	2.3	11.9	4.1
SC	100	26.0	49.5	30.0	9.8	12.7	13.1	9.8	6.9	13.1	1.9	10.8	2.4
noSC	241	24.2	36.2	31.6	9.7	12.2	13.6	9.6	7.2	13.1	2.3	10.0	4.5

Summary statistics of the time series of 341 virtual monitoring points extracted from the modelled dataset for the city of Antwerp for 2012. The total set of 341 receptor points is additionally disaggregated into points located within street-canyons (SC) and points located outside of street-canyons (noSC). The immediate modelling outputs (simulated hourly data) are compared to the aggregated time series (1-day averages and 14-days averages of simulated data).

The annual average concentrations of PM_{10}, NO_2 and O_3 for these three groups of selected virtual monitoring points are derived by calculating the arithmetic means of the complete set of all time series of all selected receptor points ("grand mean"). The grand means of hourly data and 1-day averages are naturally exactly the same.[9]

In analogy to the grand mean, the overall variability of the pollutant concentrations is described by the grand standard deviation, which is likewise calculated from all time series values of all selected receptor points. This overall standard deviation includes all contributions originating from the temporal and from the spatial variability. By comparison, the "pooled standard deviation of the individual time series" reflects the inter-annual temporal variations within the individual receptor points' time series only. To complement this, the field "standard deviation of the annual means of the time series" provides the standard deviation of the annual averages of the selected receptor points (a measure of the spatial variability within the annual average concentration field).

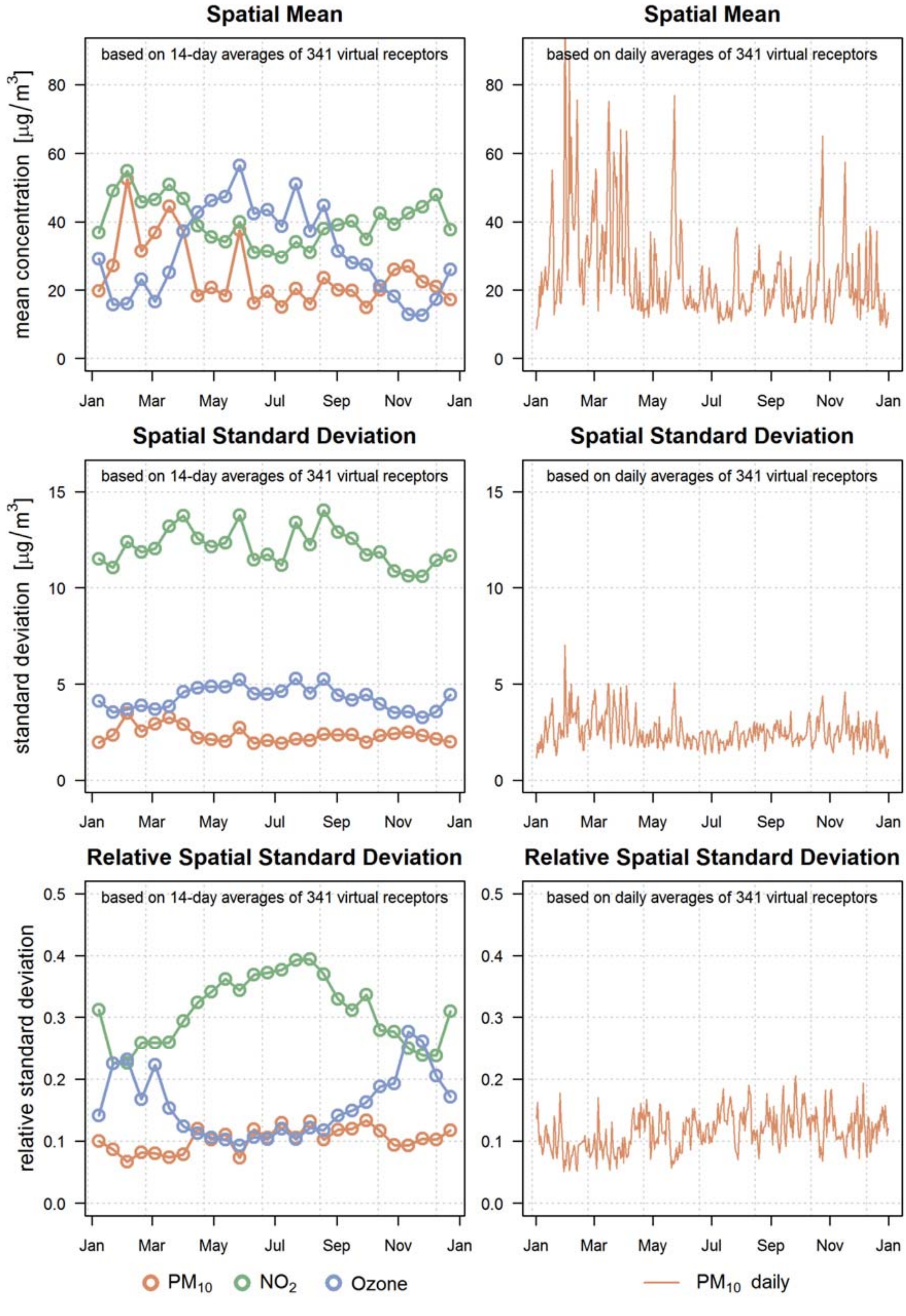
As a general observation from these simple characterisations, the spatial variability tends to be highest for NO_2, whereas the temporal variability tends to be highest for O_3. For all three aggregations (hourly, daily and 14-days) the spatial variability is lowest for PM_{10}. The temporal variability is lowest for PM_{10} in the case of the hourly time series. However, for the daily and for the 14-day time series the temporal variability is lowest for NO_2. This change in the ranking positions with longer averaging times is probably attributable to the relatively short life-time of NO_2 (stronger fluctuations observable in the hourly values which are then suppressed by the daily and 14-days averaging).

In order to get a better insight into the inter-annual evolutions of the spatial concentration fields, figure 2 presents time series of the spatial mean, the spatial standard deviation, and the relative spatial standard deviation calculated for the full set of 341 virtual monitoring points. These calculations have been based on the 14-day averages time series of NO_2, PM_{10} and O_3, and on the daily averages time series for PM_{10}. For the brevity of the illustration, a split-up into street-canyon and non-street-canyons locations has been omitted.

From the time series presented in figure 2, the mean O_3 concentration shows a typical continental annual cycle with a broad summer maximum. In contrast to O_3, the annual variation of NO_2 concentration reveals an anti-cyclic behaviour with higher levels in the winter time and a broad depression of concentrations in the summer time. The seasonal variation of PM_{10} is less pronounced, with elevated concentrations occurring in late winter and in spring. An important characteristic with regards to considerations on the spatial representativeness of monitoring sites is the annual evolution of the spatial variability within the concentration fields. It can be seen that the spatial variability of NO_2 concentrations increases in summer time, whereas O_3 shows the opposite behaviour. This is especially expressed very clearly in the relative standard deviation time series. A seasonal variation of the spatial variability of PM_{10} is less clearly pronounced.

[9] Note that, however, the grand means of 14-day averages do not exactly match these former values, because the 26 full 14-day periods considered do not include the last 2 days of the year: the series of 14-day averages contain only 364 of the 366 days in total for the leap year 2012.

Figure 2. Time series of spatial mean, spatial standard deviation, and relative spatial standard deviation of virtual monitoring points.



Time series of spatial mean, spatial standard deviation, and relative spatial standard deviation of the 14-day average values (left side) and 1-day average values (right side) of 341 virtual monitoring points for the modelling year 2012. These metrics reflect the overall means, the total standard deviations and total relative standard deviations of concentrations of virtual monitoring points within the full spatial extent of the model domain as can be obtained for each timestep.

4 Participating Teams

Eleven teams from nine different countries participated in this intercomparison exercise on the spatial representativeness of air quality monitoring sites. **Table 2** summarises team names, participants, and details their affiliations.

Table 2. List of participating teams and institutions

Team Name (Acronyms)	**Country**	**Participants**	**Affiliations**
CIEMAT	ESP	José Luis Santiago	Research Centre for Energy, Environment and Technology (CIEMAT), Madrid, Spain
		Fernando Martin	
ENEA	ITA	Antonio Piersanti	Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA), Bologna, Italy
		Giuseppe Cremona	
		Gaia Righini	
		Lina Vitali	
EPAIE	IRL	Kevin Delaney	Environmental Protection Agency (EPA), Dublin, Ireland
		Bidroha Basu	Trinity College Dublin (TCD), Dublin, Ireland
		Bidisha Ghosh	
FEA-AT	AUT	Wolfgang Spangl	Federal Environment Agency - Austria (FEA-AT), Vienna, Austria
		Christine Brendle	
FI	FIN	Jenni Latikka	Finnish Meteorological Institute (FMI), Helsinki, Finland
		Anu Kousa	Helsinki Region Environmental Services Authority (HSY), Helsinki, Finland
		Erkki Pärjälä	City of Kuopio, Kuopio, Finland
		Miika Meretoja	City of Turku, Turku, Finland
INERIS	FRA	Laure Malherbe	National Institute for Industrial Environment and Risks (INERIS), Verneuil-en-Halatte, France
		Laurent Letinois	
		Maxime Beauchamp	
ISSEPAWAC	BEL	Fabian Lenartz	Public Service Scientific Institute (ISSeP), Liege, Belgium
		Virginie Hutsemekers	Walloon Air and Climate Agency (AwAC), Jambes, Belgium
RIVM	NLD	Lan Nguyen	Netherlands National Institute for Public Health and the Environment (RIVM), Bilthoven, Netherlands
		Ronald Hoogerbrugge	
SLB	SWE	Kristina Eneroth	Environment and Health Administration City of Stockholm, Stockholm, Sweden
		Sanna Silvergren	
VITO	BEL	Peter Viaene	Flemish Institute for Technological Research (VITO), Mol, Belgium
		Bino Maiheu	
		Stijn Janssen	
VMM	BEL	David Roet	Flanders Environment Agency (VMM), Aalst, Belgium

5 Spatial Representativeness Methods used by the Participants

In the following, we will provide a short overview of the SR methods that have been used by the different participating teams. A more detailed compilation of full methods descriptions provided by each team can be found in **ANNEX I** (Documentation of Methods and Criteria).

Furthermore, **Table 3** (at the end of this chapter) provides a consolidated overview of the input data used by the different participating teams, whereas **Table 4** and **Table 5** show a breakdown of this information into input data used for traffic stations and for background station, respectively. These tables do also indicate if data additional to the shared Antwerp dataset has been used (e.g., satellite maps or street view data from different online providers).

More detailed information about the particular input data files used by each team have been collected amongst the participants and are compiled in **ANNEX II**.

5.1 Brief methods descriptions

5.1.1 CIEMAT

The methodology applied by **CIEMAT** (Spain) is based on annual average concentration maps obtained by means of weighted averages of Computational Fluid Dynamics simulation results (WA CFD-RANS methodology[1,2]) taking into account hourly averages of local meteorological observations. High-resolution average concentration maps of NO_2 and PM_{10} are computed in a domain of 0.8 km x 0.8 km around the AQMS Borgerhout-Straatkant (traffic site). From these maps, the SR area is delimited as the area where the similarity condition for concentration is fulfilled. In this exercise, the threshold used to calculate the SR area was ± 20% of the concentration at the AQMS.

References:

[1]Santiago, J.L., Borge, R., Martín, F., de la Paz, D., Martilli, A., Lumbreras, J., Sanchez, B., 'Evaluation of a CFD-based approach to estimate pollutant distribution within a real urban canopy by means of passive samplers', *Science of the Total Environment*, 576, 2017, pp. 46-58, doi: 10.1016/j.scitotenv.2016.09.234.

[2]Santiago, J.L., Martín, F., Martilli, A., 'A computational fluid dynamic modelling approach to assess the representativeness of urban monitoring stations', *Science of the Total Environment* 454-455, 2013, pp. 61–72, doi: 10.1016/j.scitotenv.2013.02.068.

5.1.2 ENEA

Calculations by **ENEA** (Italy) are based on the application of the Concentration Similarity Frequency (CSF) function[1], which recursively relates time series of modelled concentration fields to the concentration at the AQMS. For every time step, relative concentration differences between the AQMS and all 341 receptor points are compared with a threshold, in order to assess the condition of similarity. Finally, the SR area is delimited as the area where the similarity condition is fulfilled >90% of the time on a yearly basis. In order to obtain SR areas from the sparse CSF point values available within this IE, inverse distance weighting interpolation has been applied in an intermediate step.

References:

[1]Piersanti, A., Ciancarella, L., Cremona, G., Righini, G., Vitali, L., 'Spatial representativeness of air quality monitoring stations: a grid model based approach', *Atmospheric Pollution Research,* No 6, 2015, pp. 953-960, doi: 10.1016/j.apr.2015.04.005

5.1.3 EPAIE

The method applied by **EPAIE** (Ireland) compared 1 year hourly concentration time series of the 341-virtual receptor points to the corresponding time series of the associated AQMS. Within the SR area the median of the 8784 concentration differences (366 days x 24 hours) should not exceed 20%. For the traffic site, the area of assessment was limited to virtual receptors within 500 m of the AQMS, while a limit of 3 km was chosen for the background AQMS. Finally, the SR area was delimitated using kriging interpolation.

5.1.4 FEA-AT

Calculations of **FEA-AT** (Austria) are based on similarity criteria comparing the modelled annual mean concentration fields to the AQMS. The similarity thresholds (± 5 µg/m³ for NO_2, ± 3 µg/m³ for PM_{10}, and ± 4.1 µg/m³ for O_3) originate from considerations about the concentration ranges observed in Europe, and have been updated for the Antwerp case.

In addition, criteria for emissions are applied: For PM_{10} domestic heating emissions are considered (traffic emissions were found to not contribute information in addition to the concentration itself). For traffic stations, road type (motorway or not) is considered. The industrial area is separated by expert judgement based on the modelled concentration fields.

References:

UMWELTBUNDESAMT (2007): Spangl, W., Schneider, J., Moosmann, L. & Nagl, C.: *Representativeness and classification of air quality monitoring stations – final report*. *Service contract to the European Commission - DG Environment Contract No. 07.0402/2005/419392/MAR/C1.* Umweltbundesamt, Wien, 2007, Reports, Bd. REP-0121.

5.1.5 FI

Estimations of SR areas by the **FI** team (Finland) are based on annual mean concentrations modelled by VITO, measurements of the AQMS's, and data presenting their surrounding (building height & density, roughness, land-use). In addition, traffic intensity was the main input when estimating SR areas for the traffic station. For the background stations, locations of emission sources and wind direction distributions have been also considered.

SR assessment is established on similarity. At the traffic station, streets with similar traffic intensity are chosen from the area with equal city structure. At the background stations, areas with similar city structure, modelled concentration and under same emission sources are chosen.

5.1.6 INERIS

INERIS assessed SR areas for NO_2 and PM_{10} on annual averages. The SR areas were estimated in two main stages. First, a spatial estimate of concentrations and concentration uncertainties (from kriging error standard deviations) was prepared. Second, NO_2 and PM_{10} concentrations were interpolated from modelling output data applying a recently developed kriging-based approach (Beauchamp et al., 2016). This methodology is an adaptation of external drift kriging where emission data and distance to the roads are used as secondary variables to account for concentration gradients in urban areas and include traffic-related data in the map. Finally, the SR area was delimitated based on a combined criterion for maximum permissible concentration deviations (30% for NO_2 and for PM_{10}) and maximum permissible statistical risk (15% risk of wrongly including a point in the SR area).

References:

BEAUCHAMP M., MALHERBE L., 2016. ANNEXE TECHNIQUE AU RAPPORT INTITULÉ ESTIMATION DE L'EXPOSITION DES POPULATIONS AUX DÉPASSEMENTS DE SEUILS RÉGLEMENTAIRES. INTERPOLATION DES SORTIES DE MODÈLES URBAINS PAR KRIGEAGE AVEC DÉRIVE POLYNOMIALE. NOTE LCSQA, HTTP://WWW.LCSQA.ORG.

Beauchamp M., Malherbe L., Létinois L., 2011. Application de méthodes géostatistiques pour la détermination de zones de représentativité en concentration et la cartographie des dépassements de seuils. Rapport LCSQA, http://www.lcsqa.org.

Beauchamp M., 2012. Cartographie du NO2 à l'échelle locale, Représentativité des stations, Dépassements de seuils. Note LCSQA (complémentaire du rapport précité), http://www.lcsqa.org.

Bobbia M., Cori A., de Fouquet Ch., 2008. Représentativité spatiale d'une station de mesure de la pollution atmosphérique. Pollution Atmosphérique, n°197, 63-75.

5.1.7 ISSEeP & AwAC

The methods used by **ISSEeP & AwAC** (Belgium) are based on emission data and depend on the type of station:

For traffic sites, all streets are classified into three pollution levels depending on road emissions and on how the traffic lanes are enclosed by surrounding buildings. The SR area is evaluated within a 500 m radius around the AQMS and extends to all road segments with the same emission level.

For background sites, total emissions of each pollutant are first disaggregated into 100x100 m² cells, then re-aggregated through a spatially moving sum with a circular window of radius 1 km. The SR area extends to all points with total emission values similar to those at the AQMS ± a tolerance. The tolerance value in this similarity criterion is set subjectively but based on indications found in the literature[1].

References:

[1]Spangl, W., Schneider, J., Moosmann, L. and Nagl C., Representativeness and classification of air quality monitoring stations, REP-0121, Umweltbundesamt GmbH, Austria, 2007.

5.1.8 RIVM

RIVM (Netherlands) worked towards a station classification based on Principal Component analysis (PCA) together with a study of the micro/macro status of the station. In the PCA analysis the first principal component (PC1) is defined as the linear combination of the original variables that describes the maximum amount of variation present in the data set, and so on. Based on previous experience obtained with the Dutch Monitoring network[1] the PCA was performed with diurnal concentration variations. The results are shown as projections of the measurement locations (score plot) and as projection of the initial variables (loadings plot) on the principle components. Similar stations appear as clusters in the score plots.

References:

[1]Nguyen,P.L., Stefess,G., de Jonge,D., Snijder,A., Hermans,P.M.J.A., van Loon,P., Hoogerbrugge,R., Evaluation of the representativeness of the Dutch air quality monitoring stations. The National, Amsterdam, Noord-Holland, Rijnmond-area, Limburg and Noord-Brabant networks. RIVM Report 680704021/2012,2012

5.1.9 SLB

In the contribution of **SLB** (Sweden), SR area for the two urban background AQMS was defined as the circular buffer zone around the stations where the standard deviation of the modeled average concentration within the buffer zone was equal to a specific threshold[1]. The standard deviation was calculated on the set of all modeled average concentrations within the buffer zone. SR area for the traffic AQMS was defined as the part of the street where there are buildings on both sides and the traffic emissions differ less than 10 % from those at the AQMS. The SR area for the traffic AQMS consists of the street canyon width plus a buffer zone of 25 m.

References:

[1]Lövenheim, B. Exposure to air pollution within the region of Eastern Sweden's Air Quality Management Association. Calculations of population exposure of particulate matter (PM10) and nitrogen dioxide in 2015 (in Swedish). Eastern Sweden's Air Quality Management Association, Report LVF 2017:12. In press, will be available at: http://slb.nu/slbanalys/rapporter/pdf8/lvf2017_012.pdf.

5.1.10 VMM

VMM (Belgium) applied a classification methodology[1] which considers emissions from road traffic, domestic heating and industrial emissions, and dispersion conditions for all AQMS in the network. Population density is used as a proxy for domestic heating, and CORINE land cover data for dispersion conditions. The surrounding of the AQMS is divided into smaller sub-areas, each of which is classified (in this IE a 1100x1100 m^2 grid with mesh size 100 m was chosen for subdivision). The similarity in classifications of the sub- areas and the AQMS is then quantified. Finally the SR area is calculated as the set of sub areas for which the weighted sum of a similarity indicator is above a given threshold[2].

References:

[1]Spangl, W., Schneider, J., Moosmann, L. and Nagl, C., *Representativeness and classification of air quality monitoring stations*, Umweltbundesamt, Wien, 2007

[2]Roet, D. and Celis, D., *Life + ATMOSYS deliverable: A method for selecting monitoring stations for model validation*, VMM, Belgium, 2014
http://www.atmosys.eu/faces/doc/ATMOSYS%20Deliverable%20Action%204_updateV1.1.pdf

Table 3. Overview of input data used by the different teams. Grey background indicates data additional to the shared Antwerp dataset.

	FAIRMODE CCA-1 Spatial Representativeness Intercomparison Exercise ---- Overview Table											
	CIEMAT	ENEA	FEA-AT	FI	EPA	INERIS	ISSeP&AwAC	RIVM	SLB	VITO	VMM	Totals
	Spain	Italy	Austria	Finland	Ireland	France	Belgium	Netherlands	Sweden	Belgium	Belgium	
	(CFD-RANS)							(PCA)				
Concentrations												
Monitoring Stations (hourly)	x		x	x				x				4
Monitoring Stat. (only annual avg)			x	x		for ref (only 1st trial)				x		4
Virtual Monitoring Stations (n=341)		x	x	x	x	x		x				6
raw timeseries (hourly)		x	x	x	x			x				5
virtual samplers (14-day avg)												0
noisy virtual samplers (14-day avg)						for reference						1
Concentration Maps (annual avg)			x	x					x		x	4
Raw Model Outputs (annual avg)						x						1
Emissions												
Road Traffic	x		x	x		x	x		x		x	7
Domestic Heating			x (for PM_{10})	x		x	x					4
Industry				x		x	x					3
Emission Proxies												
Traffic Emission Proxies			road type "motorway"	x								2
Domestic Heating Proxies											from population	1
Industry Emission Proxies			from conc. maps									1
Population Density										x	x	2
Dispersion Conditions												
Building Geometry	x			x			x		x			4
Street Width							x					1
Distance to Roads			not applied for Antwerp			x						1 (2)
Corine Landcover Classes			x	x						x	x	4
Meteorological Data												
Wind Velocity	x			x								2
External Information												
Google or Bing Satellite Images				x			number of lanes					2
Google Street View Data				x				x				2
Traffic Network					x							1
Miscellaneous												
used a buffer							for traffic site		for traffic site			2
a priori restricted domain					x						x	2
Final Results												
Polygons	x	x	x	x	x	x	x		x	x	x	10
allways contiguous				x	x				x	x		4
also non-contiguous	x	x	x			x	x				x	6
other types	gridded values							PCA classification				2

Table 4. Overview of input data used by the different teams for **traffic sites**. Grey background indicates data additional to the shared Antwerp dataset.

	FAIRMODE CCA-1 Spatial Representativeness Intercomparison Exercise ---- Overview Table (Traffic Sites)											
	CIEMAT	**ENEA**	**FEA-AT**	**FI**	**EPA**	**INERIS**	**ISSeP&AwAC**	**RIVM**	**SLB**	**VITO**	**VMM**	**Totals**
	Spain	Italy	Austria	Finland	Ireland	France	Belgium	Netherlands	Sweden	Belgium	Belgium	
	(CFD-RANS)							(PCA)				
Concentrations												
Monitoring Stations (hourly)	X		X	X				X				4
Monitoring Stat. (only annual avg)			X	X		for ref (only 1st trial)				X		4
Virtual Monitoring Stations (n=341)		X	X	X	X	X		X				6
raw timeseries (hourly)		X	X	X	X			X				5
virtual samplers (14-day avg)												0
noisy virtual samplers (14-day avg)						for reference						1
Concentration Maps (annual avg)			X	X					X		X	4
Raw Model Outputs (annual avg)						X						1
Emissions												
Road Traffic	X		X	X		X	X		X		X	7
Domestic Heating			X (for PM_{10})	X		X						3
Industry				X		X						2
Emission Proxies												
Traffic Emission Proxies			road type "motorway"	X								2
Domestic Heating Proxies											from population	1
Industry Emission Proxies			from conc. maps									1
Population Density										X	X	2
Dispersion Conditions												
Building Geometry	X			X			X		X			4
Street Width							X					1
Distance to Roads			not applied for Antwerp			X						1 (2)
Corine Landcover Classes				X						X	X	3
Meteorological Data												
Wind Velocity	X											1
External Information												
Google or Bing Satellite Images				X			number of lanes					2
Google Street View Data				X				X				2
Traffic Network					X							1
Miscellaneous												
used a buffer							X		X			2
a priori restricted domain					X						X	2
Final Results												
Polygons	X	X	X	X	X	X	X		X	X	X	10
allways contiguous				X	X				X	X		4
also non-contiguous	X	X	X			X	X				X	6
other types	gridded values							PCA classification				2

Table 5. Overview of input data used by the different teams for **background sites**. Grey background indicates data additional to the shared Antwerp dataset.

	FAIRMODE CCA-1 Spatial Representativeness Intercomparison Exercise ---- Overview Table (Background Sites)											
	CIEMAT	**ENEA**	**FEA-AT**	**FI**	**EPA**	**INERIS**	**ISSeP&AwAC**	**RIVM**	**SLB**	**VITO**	**VMM**	**Totals**
	Spain	Italy	Austria	Finland	Ireland	France	Belgium	Netherlands	Sweden	Belgium	Belgium	
	(CFD-RANS)							(PCA)				
Concentrations												
Monitoring Stations (hourly)			X	X				X				**3**
Monitoring Stat. (only annual avg)			X	X		**for ref (only 1st trial)**				X		**4**
Virtual Monitoring Stations (n=341)		X	X	X	X	X		X				**6**
raw timeseries (hourly)		X	X	X	X			X				**5**
virtual samplers (14-day avg)												**0**
noisy virtual samplers (14-day avg)						**for reference**						**1**
Concentration Maps (annual avg)			X	X					X		X	**4**
Raw Model Outputs (annual avg)						X						**1**
Emissions												
Road Traffic				X		X	X				X	**4**
Domestic Heating			X (for PM_{10})	X		X	X					**4**
Industry				X		X	X					**3**
Emission Proxies												
Traffic Emission Proxies			**road type "motorway"**									**1**
Domestic Heating Proxies											**from population**	**1**
Industry Emission Proxies			**from conc. maps**									**1**
Population Density										X	X	**2**
Dispersion Conditions												
Building Geometry				X								**1**
Street Width												**0**
Distance to Roads			**not applied for Antwerp**			X						**1 (2)**
Corine Landcover Classes			X	X						X	X	**4**
Meteorological Data												
Wind Velocity				X								**1**
External Information												
Google or Bing Satellite Images				X								**1**
Google Street View Data				X				X				**2**
Traffic Network					X							**1**
Miscellaneous												
used a buffer												**0**
a priori restricted domain					X						X	**2**
Final Results												
Polygons		X	X	X	X	X	X		X	X	X	**9**
allways contiguous				X	X				X	X		**4**
also non-contiguous		X	X			X	X				X	**5**
other types								**PCA classification**				**1**

6 Reporting of Data and Results

Within the IE, the **11 participating teams** delivered SR estimates for the pollutants PM_{10} and NO_2 at **one traffic** site (**Borgerhout-Straatkant**, corresponding to virtual station location v216), and for PM_{10}, NO_2 and O_3 at **two urban background** sites (**Antwerpen-Linkeroever** and **Schoten**, corresponding to virtual station location v7 and v17, respectively). **Table 6** provides a detailed overview of the sets of results received from the different teams. From this table it can be seen that 10 teams delivered polygons f SR areas surrounding the stations under investigation, whereas one team (RIVM) rather worked towards a classification of the stations by principal component analyses (PCA).

On top of these mandatory tasks, some teams provided **additional results** that had been suggested as **optional tasks** following discussions at the previous FAIRMODE technical meeting in Zagreb (27-29 June 2016). In specific, four teams provided additional SR estimates for the 8 virtual stations v43, v63, v68, v88, v105, v115, v135 and v137. Furthermore, two teams provided also a classification of the 3 + 8 virtual stations. However, as the response to these optional tasks was only from a smaller part of the participants group, the evaluation of these additional data will not be part of this present report. These additional data can nevertheless be useful for further investigations in the future.

Table 6. Overview of results received from the different teams

	FAIRMODE CCA-1 Spatial Representativeness Intercomparison Exercise ---- Overview Table											
	CIEMAT Spain	**ENEA** Italy	**FEA-AT** Austria	**FI** Finland	**EPA** Ireland	**INERIS** France	**ISSeP&AwAC** Belgium	**RIVM** Netherlands	**SLB** Sweden	**VITO** Belgium	**VMM** Belgium	**Totals**
Final Results												
Polygons	**x**	**x**	**x**	**x**	**x**	**x**	**x**		**x**	**x**	**x**	**10**
allways contiguous				**x**	**x**				**x**	**x**		**4**
also non-contiguous	**x**	**x**	**x**			**x**	**x**				**x**	**6**
other types	gridded values							PCA classification				**2**
3 Primary Stations												
VS 216 (Borgerhout - traffic)												
NO_2	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**11**
PM_{10}	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**11**
O_3	**no**	**no**	**no**	**no**	**no**	**no**	**no**	**no**	**no**	**no**	**no**	**0**
VS 7 (Linkeroever - background)												
NO_2	**no**	**x**	**no**	**x**	**x**	**x**	**x**	**no**	**x**	**x**	**x**	**8**
PM_{10}	**no**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**10**
O_3	**no**	**x**	**no**	**no**	**no**	**no**	**x**	**no**	**x**	**x**	**no**	**4**
VS 17 (Schoten - background)												
NO_2	**no**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**10**
PM_{10}	**no**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**10**
O_3	**no**	**x**	**x**	**x**	**x**	**no**	**x**	**x**	**x**	**x**	**no**	**8**
8 Additional Stations												
SR area	**no**	**x**	**x**	**no**	**no**	**x**	**no**	**no**	**no**	**x**	**no**	**4**
classifications	**no**	**no**	**x**	**no**	**no**	**no**	**no**	**x**	**no**	**no**	**no**	**2**

7 Quantitative Outcomes of the Intercomparison

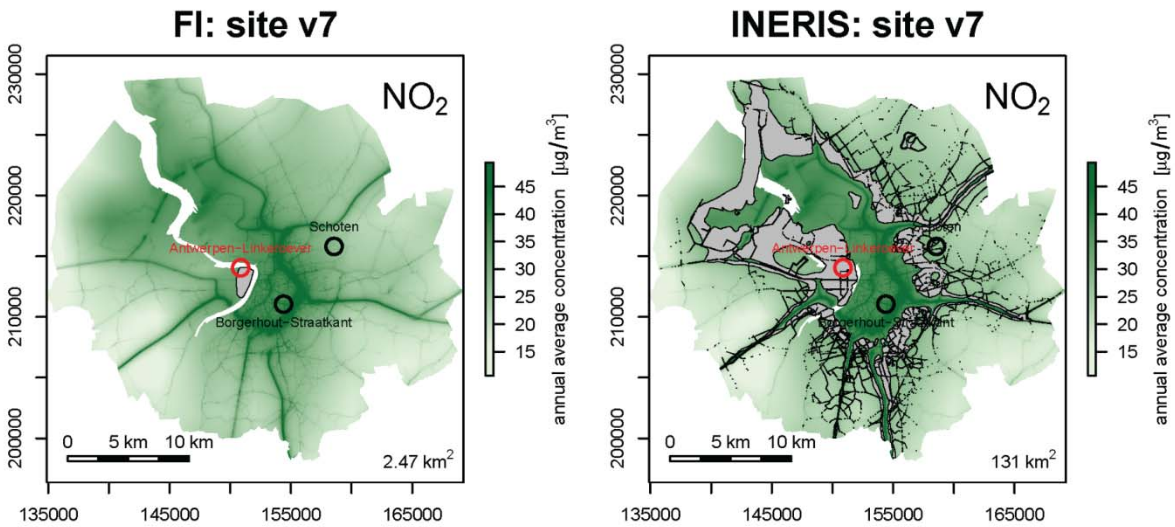
7.1 Methods and procedures followed by the participants

The SR methodologies applied within this exercise can roughly be distinguished as methods relying on air quality measurements, methods relying on proxy data, and methods relying on air quality model outputs. However, certain overlap between these categories exists. From a rough categorisation based on the selection of input data, 4 out of the 11 teams deployed the high resolution annual average concentration fields, which was made available from the RIO-IFDM-OSPM model chain outputs on a 5x5 m^2 regular grid, as an immediate starting point (FEA-AT, FI, SLB and VMM). In contrary, 2 teams (ENEA and EPA-IE) performed an interpolation similarity criteria applied to time series of the 341 modelled virtual stations, and one team (INERIS) performed a geostatistical interpolation of the annual average raw model outputs (which were available on an irregular grid). Furthermore, 2 teams primarily focused on the use of concentration proxies (ISSEPAWAC and VMM), one team deployed their own computational fluid dynamics (CFD) model (CIEMAT), and one team worked on principal component analyses (PCA) of concentration measurements (RIVM).

7.2 SR area estimates

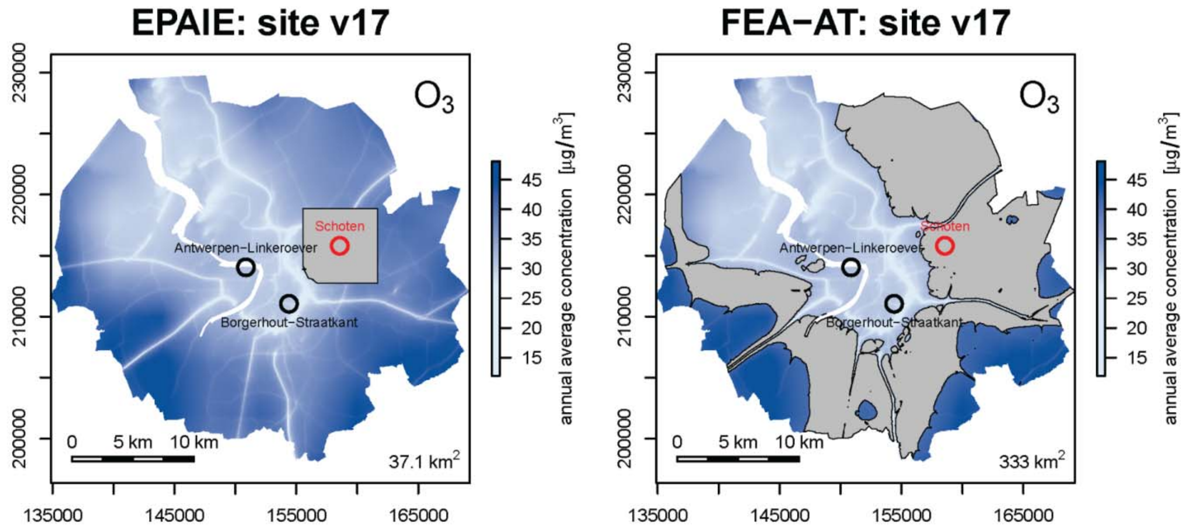
Some selected examples of different SR estimates obtained within this intercomparison exercise are exemplified in **Figure 3** (NO_2 at site v7), **Figure 4** (O_3 at site v7) and **Figure 5** (PM_{10} at site v7). For the brevity of this chapter and in aiming to save space, only a small excerpt of the comprehensive results can be shown here. A complete compilation of maps for all SR area estimates can be found in **Annex III** (spatial representativeness maps organised by team) and in **Annex IV** (spatial representativeness maps organised by pollutant & station).

Figure 3. Examples of SR area estimates obtained for NO_2 at the urban-background site Antwerpen-Linkeroever (site v7).



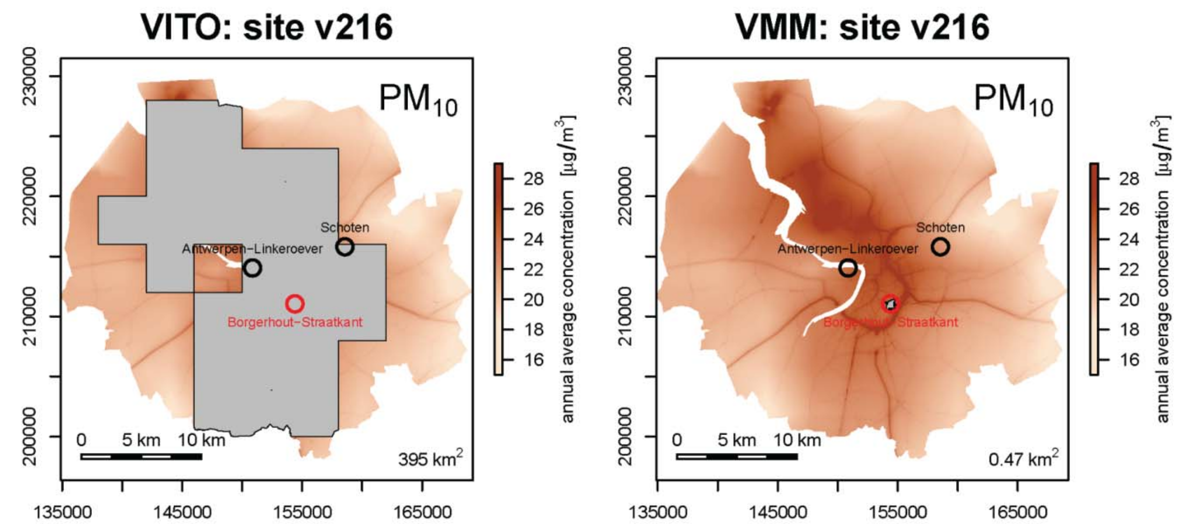
Left: estimate obtained by the team FI (2.47 km^2), Right: estimate obtained by INERIS (131 km^2); green background colours depict the annual average concentration field of NO_2. The position of the AQMS Antwerpen-Linkeroever is highlighted in red. The actual SR areas are described by the grey coloured fields in the foreground.

Figure 4. Examples of SR area estimates obtained for O_3 at the urban-background site Schoten (site v17).



Left: estimate obtained by EPAIE (37.1 km^2), Right: estimate obtained by FEA-AT (333 km^2); green background colours depict the annual average concentration field of O_3. The position of the AQMS Schoten is highlighted in red. The actual SR areas are described by the grey coloured fields in the foreground.

Figure 5. Examples of SR area estimates obtained for PM_{10} at the traffic site Borgerhout-Straatkant (site v216).



Left: estimate obtained by VITO (395 km^2), Right: estimate obtained by VMM (0.47 km^2); orange background colours depict the annual average concentration field of PM_{10}. The position of the AQMS Borgerhout-Straatkant is highlighted in red. The actual SR areas are described by the grey coloured fields in the foreground.

7.3 Size of the SR areas

For ENEA, EPAIE, FEA-AT, FI, INERIS, ISSEPAWAC, SLB, VITO and VMM surface areas could be immediately calculated from the shapefiles (containing single and/or multipart polygons) delivered by these teams.

Yet, two exceptions for SR area size calculations exist for the teams CIEMAT and RIVM:

In the case of CIEMAT the original mesh of the computational fluid dynamics (CFD) simulations is an irregular grid, having a resolution of 1m x 1m close to the investigated station. The CFD model is 3-dimensional and data have been extracted at the height of the plane z = 3m (which was assumed to be more or less the height of the measurements of the air quality monitoring station). From this CFD grid extractions, SR areas for the site v216 can be directly directly computed to be 0.03178 km^2 (NO_2) and 0.04595 km^2 (PM_{10}). In a later step, for the purpose of reporting the results to the intercomparison exercise in the format of raster- and shape-files, results from the original CFD mesh were converted onto a regular grid with a horizontal resolution of 2m x 2m. SR areas calculated from this secondary raster files finally yield slightly smaller values, which amount to 0.02595 km^2 (NO_2) and 0.03716 km^2 (PM_{10}). These secondary results are however assumed to be less accurate than those areas obtained from the primary CFD grid. Results in the table therefore are those values from the primary CFD grid.

The RIVM team worked towards a station classification based on PCA, which naturally does not immediately provide an SR area. RIVM pointed out that in the Dutch system concentration levels are mainly determined by modelling and direct application of a measured value is usually only recommended in the small area that is comparable with the modelling resolution. In order to (i) obtain provisional SR area sizes that could be compared within this exercise, and to (ii) estimate the number of inhabitants within the SR areas later on, it was assumed that the geometry of the traffic station is such that it is representative of (at least) 100 meters of street (as required by ANNEX III of the European Directive 2008/50/EC). The area of representativeness was then assumed to be (at least) 100*5*2 m^2 (5 meters at both sides of the street), equalling 0.001 km^2. For the background stations, a representative area of (at least) 1 km^2 was assumed (the AQD formulates "several square kilometres" in ANNEX III with regards to NO_2 and PM_{10}, and "a few km^2" in ANNEX VIII for O_3).

Finally, **Table 7** provides a complete overview of all spatial representativeness estimates (SR area in km^2) which have been obtained by the different teams for the pollutants NO_2, O_3 and PM_{10} at the urban-background sites Antwerpen-Linkeroever (v7) and Schoten (v17), and at the traffic site Borgerhout-Straatkant (v216).

The quantitative SR area data are also displayed in a summary strip chart (**Figure 6**). From this chart, it can immediately be seen that the results obtained by the different teams revealed a considerable range of variation of the SR estimates.

More detailed graphical information can be obtained from a series of bar charts (**Figure 7**, **Figure 8** and **Figure 9**), which compare the total surface areas of the SR estimates by pollutant and site. These bar charts are sorted in descending order by the size of the SR area. Names of the reporting teams can be distinguished from the x-axis. In cases where no results have been reported for that combination of site and pollutant, the team names are parenthesised and follow in alphabetical order.

Table 7. Overview of spatial representativeness estimates (SR area in km²) obtained for the pollutants NO_2, O_3 and PM_{10} at the urban-background sites Antwerpen-Linkeroever (v7) and Schoten (v17), and at the traffic site Borgerhout-Straatkant (v216).

Pollutant:	**NO_2**			**O_3**			**PM_{10}**		
Receptor point:	**v7**	**v17**	**v216**	**v7**	**v17**	**v216**	**v7**	**v17**	**v216**
Participants	**estimated SR areas [km²]**								
CIEMAT	NA	NA	0.03	NA	NA	NA	NA	NA	0.05
ENEA	2.65	1.70	0.10	71.36	133.0	NA	464.9	534.3	157.1
EPAIE	NA	27.44	3.44	NA	37.06	NA	37.68	37.68	3.39
FEA-AT	NA	159.9	2.06	NA	332.8	NA	257.5	118.5	0.52
FI	2.47	58.60	0.57	NA	117.2	NA	32.01	58.60	16.69
INERIS	130.8	69.90	4.37	NA	NA	NA	628.4	700.0	417.5
ISSEPAWAC	7.95	71.54	0.19	7.95	71.54	NA	12.84	99.61	0.19
RIVM	NA	> 1	> 0.001	NA	> 1	NA	> 1	> 1	> 0.001
SLB	27.13	19.89	0.06	138.1	18.75	NA	26.71	14.12	0.06
VITO	176.0	269.4	160.0	160.0	397.0	NA	442.8	465.2	395.2
VMM	1.21	1.21	0.63	NA	NA	NA	1.21	1.21	0.47

Figure 6. Summary chart of spatial representativeness areas (SR area in km²) obtained for the pollutants NO_2, O_3 and PM_{10} at the urban-background sites Antwerpen-Linkeroever (v7) and Schoten (v17), and at the traffic site Borgerhout-Straatkant (v216).

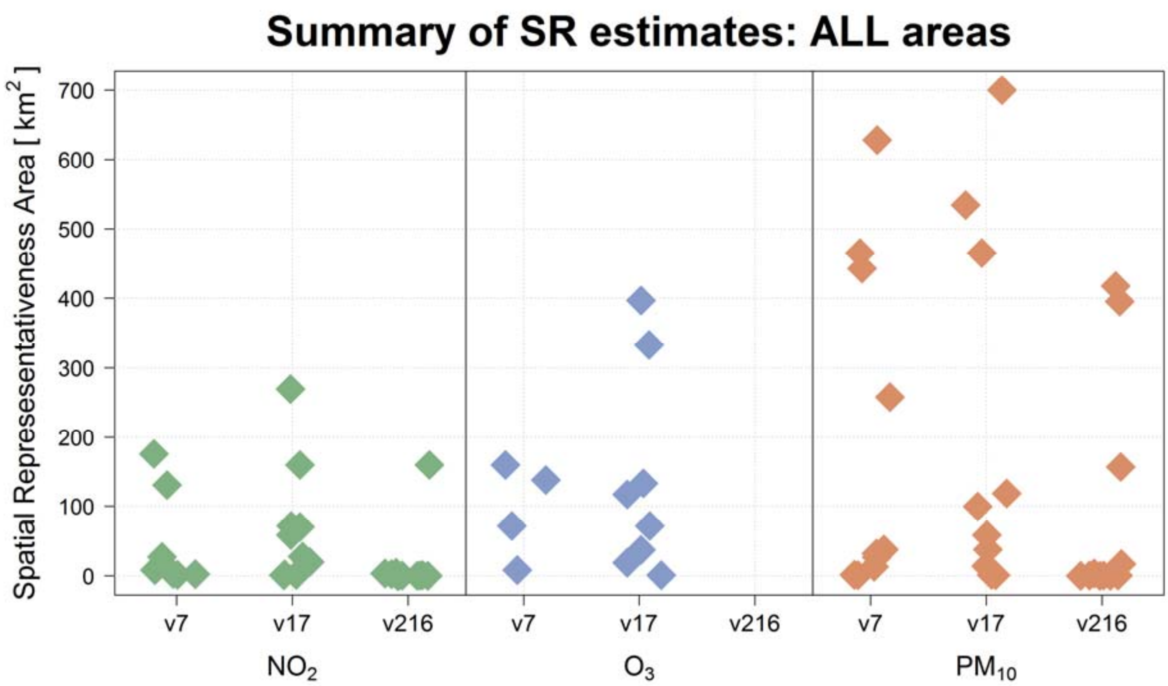


Figure 7. Spatial representativeness area estimates (SR area in km^2) obtained for the pollutant NO_2 at the urban-background sites Antwerpen-Linkeroever (v7) and Schoten (v17), and at the traffic site Borgerhout-Straatkant (v216).

The bars are sorted in decreasing size of SR-areas. Parenthesised team names indicate that no results have been reported for that combination of site and pollutant.

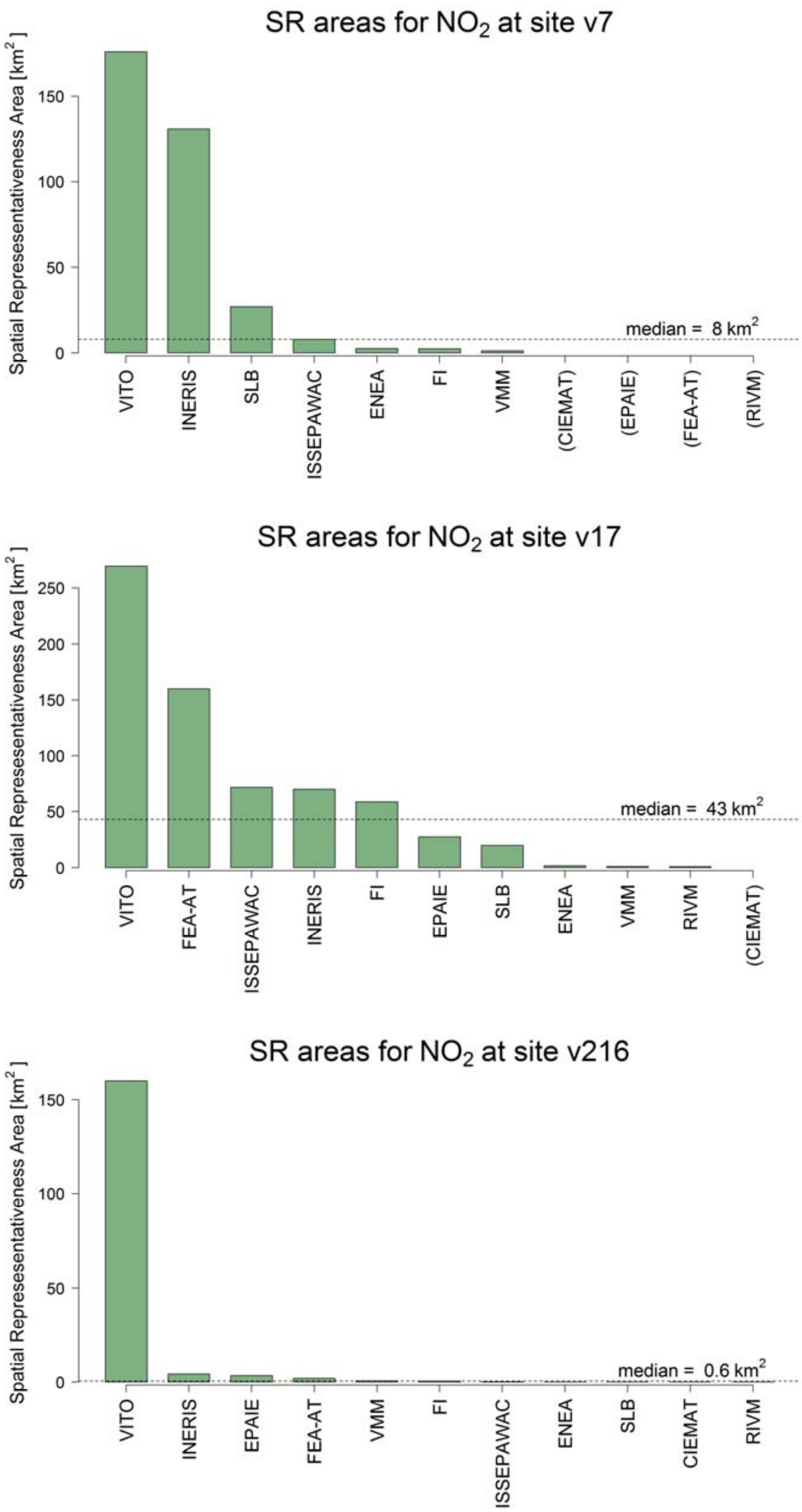


Figure 8. Spatial representativeness area estimates (SR area in km^2) obtained for the pollutant O_3 at the urban-background sites Antwerpen-Linkeroever (v7) and Schoten (v17).

The bars are sorted in decreasing size of SR-areas. Parenthesised team names indicate that no results have been reported for that combination of site and pollutant. SR areas for O_3 have not been estimated at the traffic site Borgerhout-Straatkant (v216).

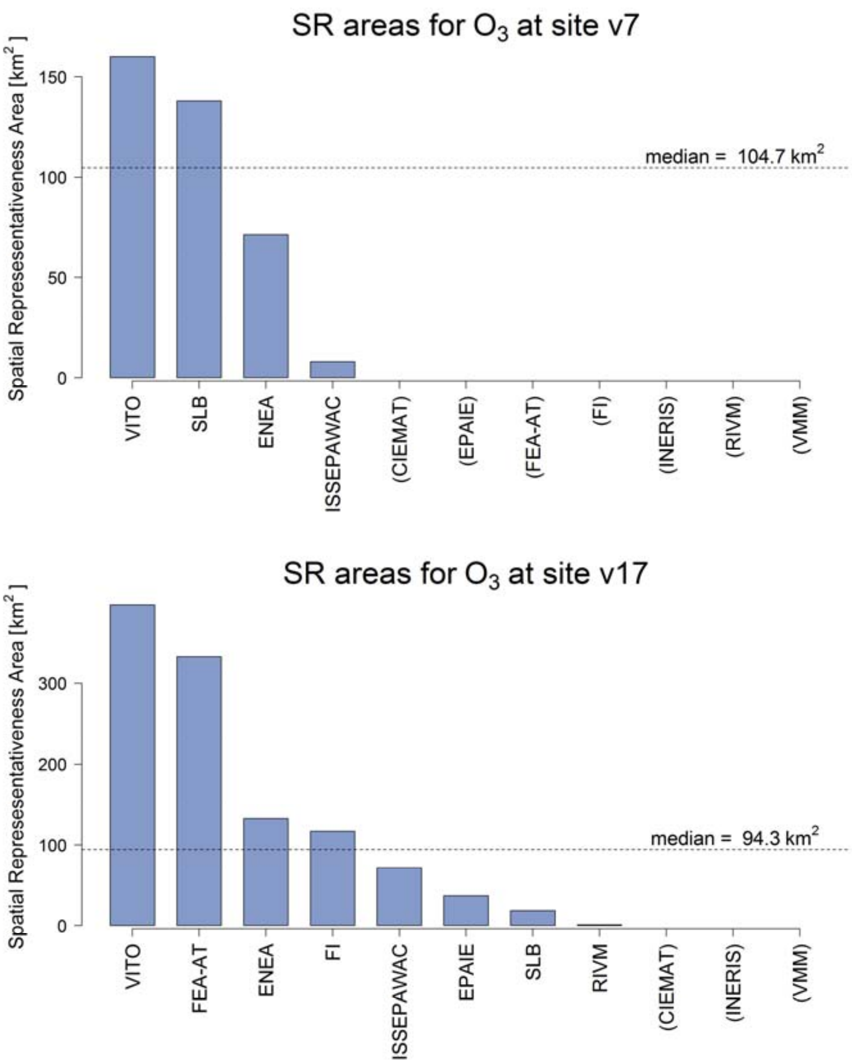
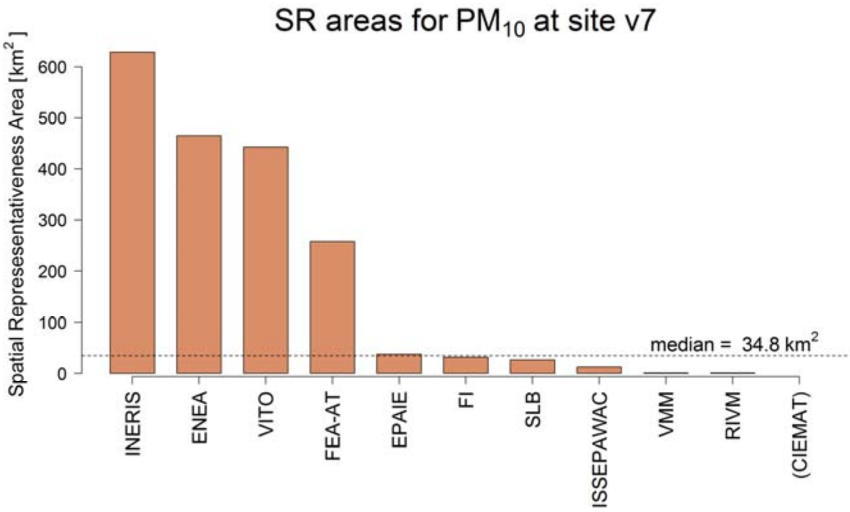
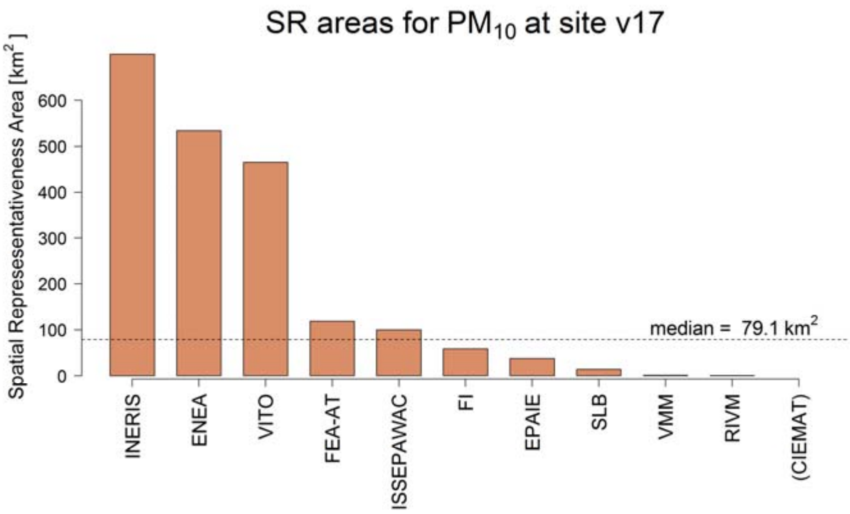
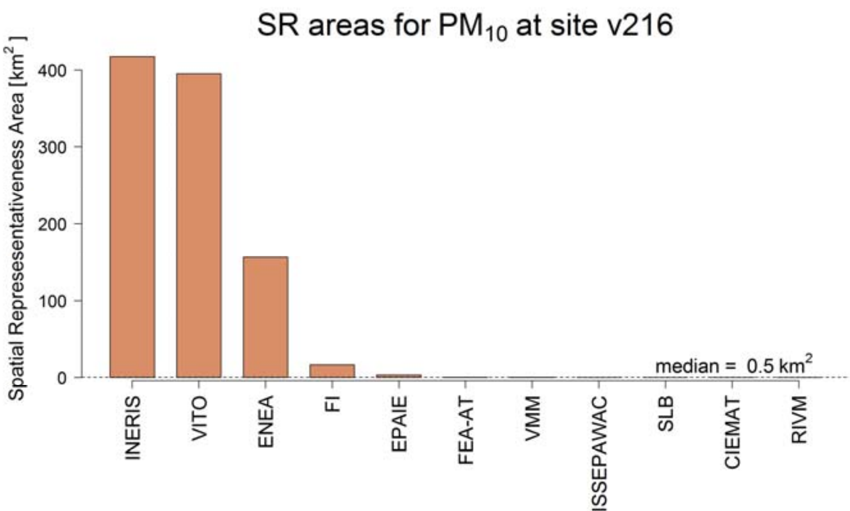


Figure 9. Spatial representativeness area estimates (SR area in km²) obtained for the pollutant PM_{10} at the urban-background sites Antwerpen-Linkeroever (v7) and Schoten (v17), and at the traffic site Borgerhout-Straatkant (v216).

The bars are sorted in decreasing size of SR-areas. Parenthesised team names indicate that no results have been reported for that combination of site and pollutant.







7.4 Population within the SR areas

Participants were furthermore asked to provide estimates for the number of inhabitants within their calculated areas of representativeness. In this second step, most of the teams decided to compute zonal statistics for the population within the SR areas by overlaying the SR-area polygons with a population density raster file which was provide on a 100 m x 100 m grid.

However, two teams (CIEMAT and RIVM) followed slightly different approaches adapted to the specific structure of their SR outcomes:

As a consequence of the CFD approach used by the CIEMAT team, areas covered by buildings have by principle not been part of their estimated SR area. For calculating the amount of population within the SR area, the gridded population density data therefore needed to be adjusted beforehand to correct for the proportion of built-up areas within in each grid cell. In this way, the CIEMAT team re-allocated the part of the population density that was intersecting with the built-up area to the open area of each grid cell. Afterwards these adjusted population density data could be intersected with the SR-area polygons as described before.

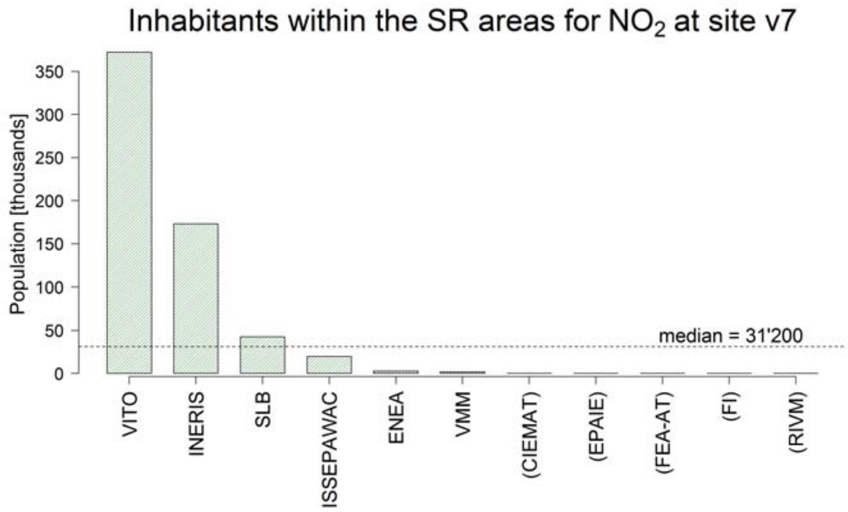
The RIVM team worked towards a station classification based on PCA. As already explained in section 7.3, it was then assumed that the geometry of the traffic station is such that it is representative of (at least) 100 meters of street, as required by the AQD. For background stations a representative area of 1000x1000 meters was assumed, and then intersected with the population density information. The numbers of inhabitants within the SR areas stated by RIVM are therefore providing a lower limit (>=), as opposed to the finite numbers derived by the other teams.

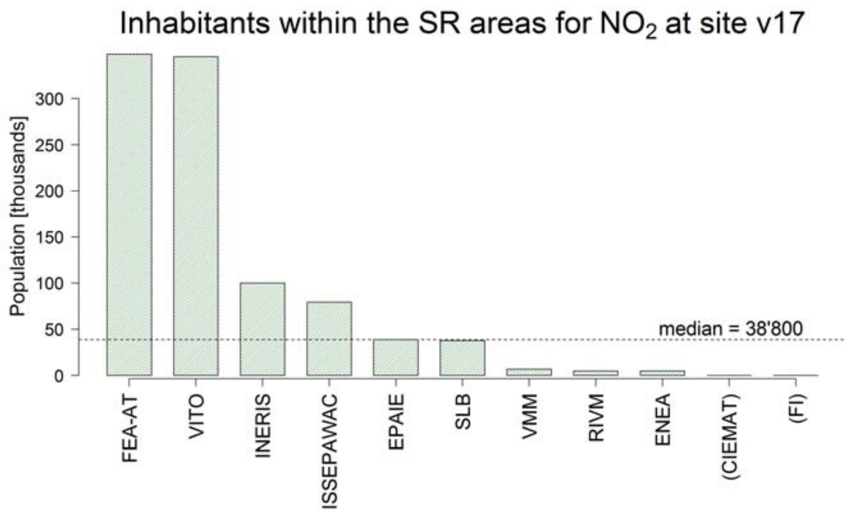
Bar charts presented in **Figure 10**, **Figure 11** and **Figure 12** recapitulate the numbers of inhabitants within the areas of representativeness. Names of the reporting teams can be distinguished from the x-axis. The bar charts are sorted in descending by the magnitude of the population within the SR areas. In cases where no results have been reported for that combination of site and pollutant, the team names are parenthesised and follow in alphabetical order.

It has to be pointed out that the estimates concerning the size of the SR area and the results obtained for the number of inhabitants within these SR areas cannot be linked immediately to each other in a simple linear way. The relationship between these two different strata of the final results is in fact rather complex, as it emanates from the intersection of (i) SR areas that do not only differ in the extent of their perimeter, but also in their exact shape and position, with (ii) a spatially distributed and heterogeneous population density field.

Figure 10. Number of inhabitants within the estimated areas of representativeness (population in thousands) obtained for the pollutant NO_2 at the urban-background sites Antwerpen-Linkeroever (v7) and Schoten (v17), and at the traffic site Borgerhout-Straatkant (v216).

The bars are sorted in decreasing size of population in within the SR-areas. Parenthesised team names indicate that no results have been reported for that combination of site and pollutant.





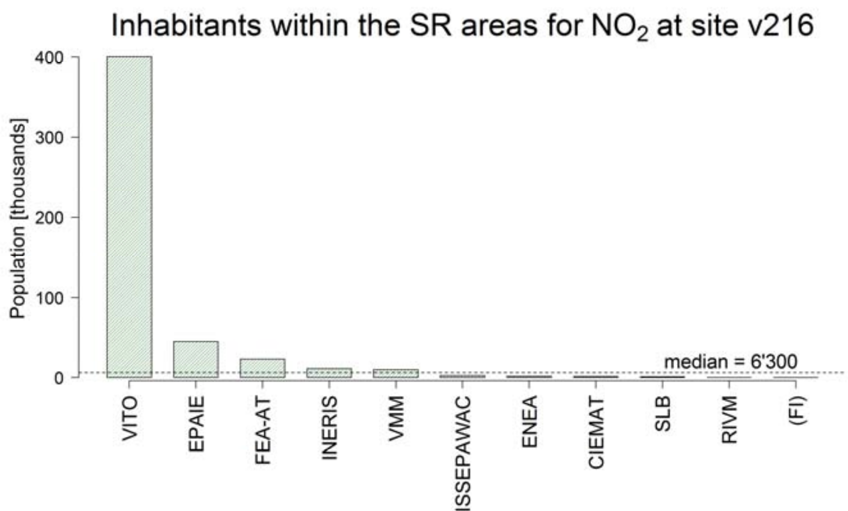
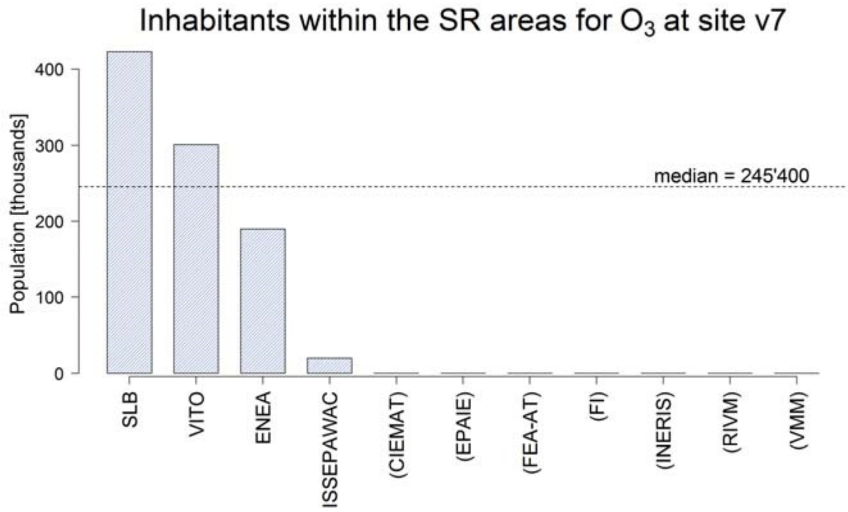


Figure 11. Number of inhabitants within the estimated areas of representativeness (population in thousands) obtained for the pollutant O_3 at the urban-background sites Antwerpen-Linkeroever (v7) and Schoten (v17).

The bars are sorted in decreasing size of population in within the SR-areas. Parenthesised team names indicate that no results have been reported for that combination of site and pollutant.

SR areas for O_3 have not been estimated at the traffic site Borgerhout-Straatkant (v216).



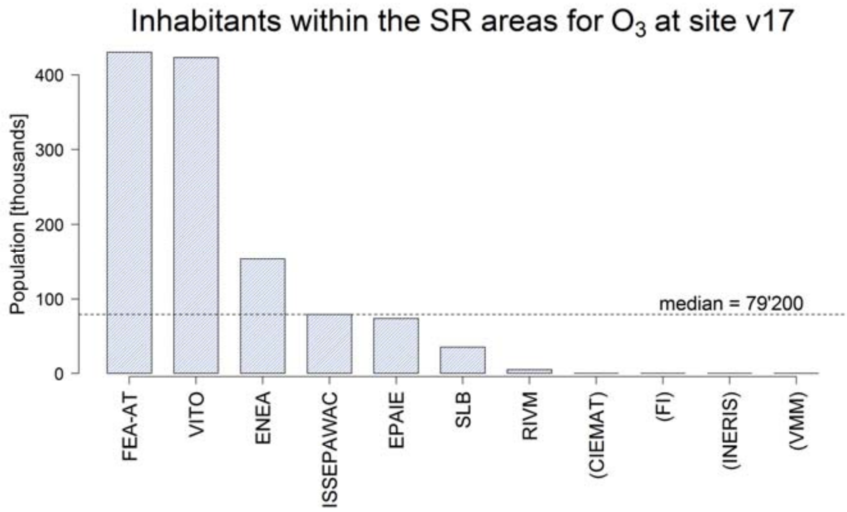
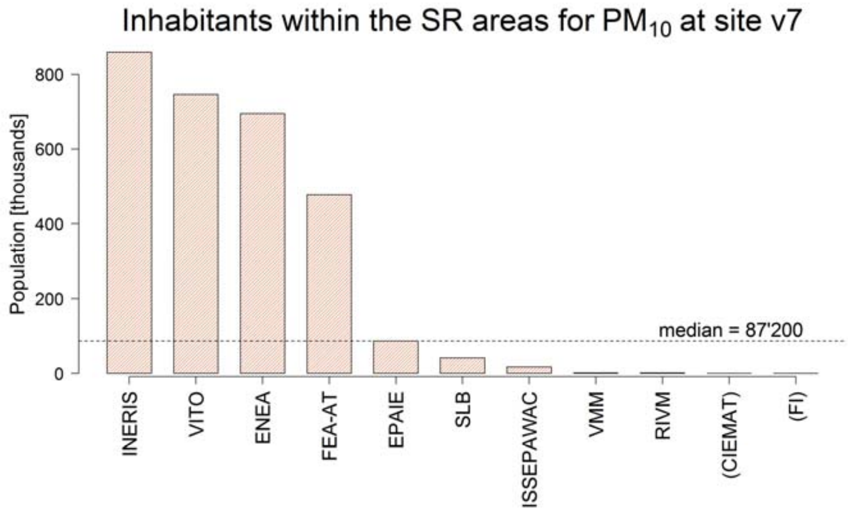
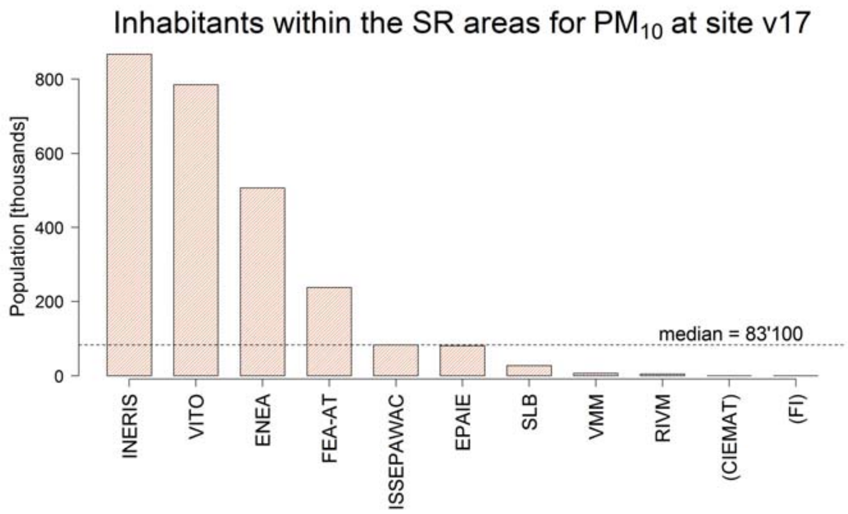
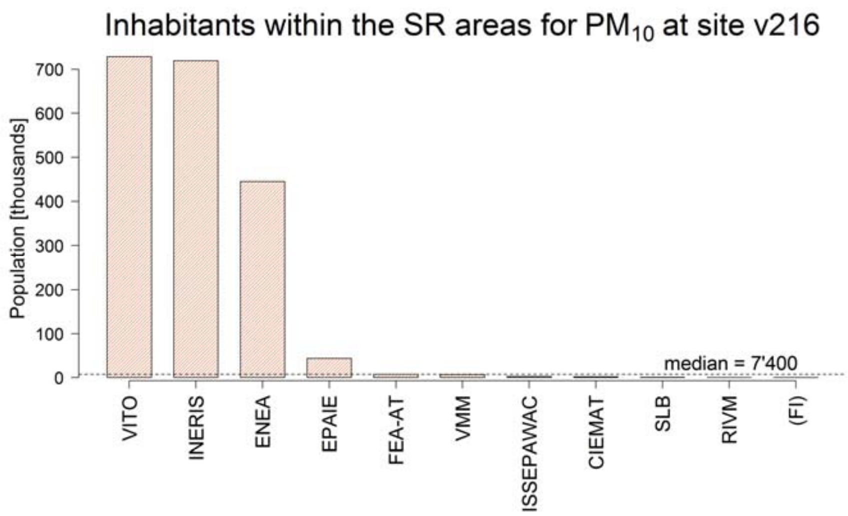


Figure 12. Number of inhabitants within the estimated areas of representativeness (population in thousands) obtained for the pollutant PM_{10} at the urban-background sites Antwerpen-Linkeroever (v7) and Schoten (v17), and at the traffic site Borgerhout-Straatkant (v216).

The bars are sorted in decreasing size of population in within the SR-areas. Parenthesised team names indicate that no results have been reported for that combination of site and pollutant.







7.5 Further instruments of the intercomparison

7.5.1 Incremental intersections

Total unions and stepwise sequential intersections of the SR area estimates **(incremental intersections)** have been computed and evaluated by pursuing the following principals:

For each particular site and pollutant:

1) Form the **union** of all SR area estimates obtained by **all participants**.
2) Take the **largest individual** SR estimate and **intersect** it with the **union**.
3) Take this **intersection** as the **new (reduced) union**.
4) Take the **second largest** individual SR estimate and **intersect** it with the **reduced union**.
5) Take this **intersection** as the new (shrunken) **union**.
6) … continue likewise
7) Finally reaching the **intersection of all** estimates.

The complete set of incremental intersections maps can be found in **Annex V** (incremental intersection maps by pollutant & station). A summary of this analysis is given in **Table 8**, where the total union is compared to the final intersection of all estimated SR areas for each combination of site and pollutant. For the theoretically ideal case of full agreement in-between a set of SR area estimates, total union and complete intersection should be identical. For the results of this intercomparison exercise, total union and complete intersection are yet typically separated by several orders of magnitude.

Table 8. Results of the intersection analysis: areas of the total union and the final intersection of all SR area estimates.

	NO_2			**O_3**			**PM_{10}**		
[km^2]	**v7**	**v17**	**v216**	**v7**	**v17**	**v216**	**v7**	**v17**	**v216**
$\cup_{\mathbf{all}}$	240	354	161	233	482	-	636	718	458
$\cap_{\mathbf{all}}$	0.05	0.19	0.00	0.77	2.54	-	0.16	0.49	0.01

All areas are in km^2.

7.5.2 Mutual comparisons of the level of agreement

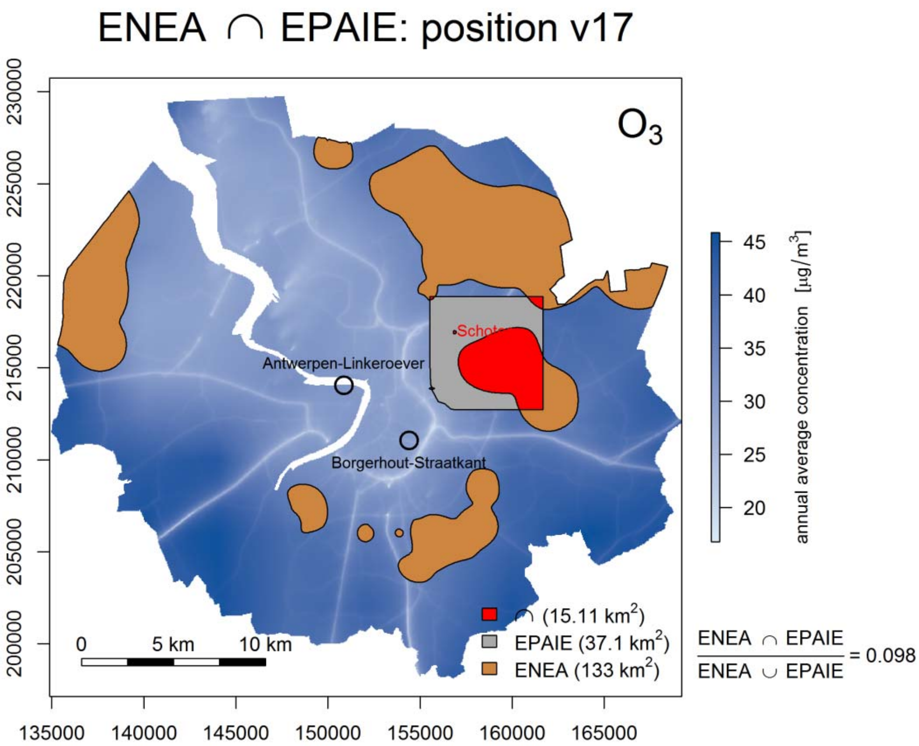
Mutual comparisons of the SR area estimates by calculations of the **mutual level of agreement indicator (MLA)** function have been established based on the following definition:

$$MLA = \frac{|SR\ area\ 1| \cap |SR\ area\ 1|}{|SR\ area\ 1| \cup |SR\ area\ 1|}$$

As by its general principal, the MLA indicator converges to 1 for full agreement between area 1 and area 2. In contrary, it converges to 0 for no agreement between area 1 and area 2.

Figure 13 demonstrates an example for the pairwise MLA indicator function calculated for the SR area estimates of ENEA and EPAIE for O_3 at position v17. The SR area estimated by ENEA is shown in brown colour, whereas the SR area estimated by EPAI is shown in grey. The intersection of both estimates is depicted in red. In this example, the MLA amounts ca 10%,

Figure 13. Example of the MLA indicator calculated between ENEA and EPAIE for O_3 at the urban-background site Schoten (site v17).



The complete set of mutual comparison maps and MLA indicator calculations can be found in **Annex VI** (mutual comparison maps by pollutant & station).

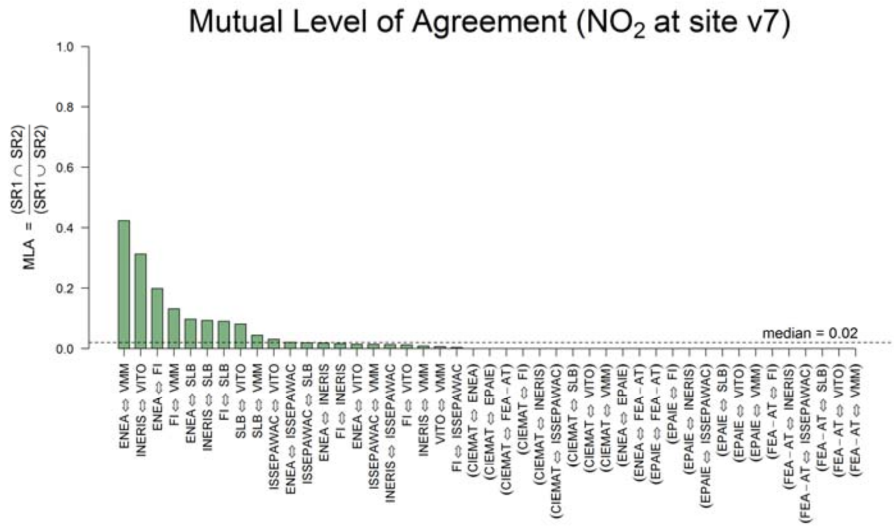
Detailed numerical summaries of the MLA evaluation can be obtained from a series of bar charts (**Figure 14**, **Figure 15**, **Figure 16** and **Figure 17**), which summarise the calculated MLA values by pollutant and site. The bar charts are sorted in descending order by the level of agreement within between the paired SR area estimates. Names of the paired teams are shown on the x-axis. In cases where no results have been reported for that combination of site and pollutant by at least one of the teams in a pair, the MLA could not be calculated. These paired team names are parenthesised and follow in alphabetical order.

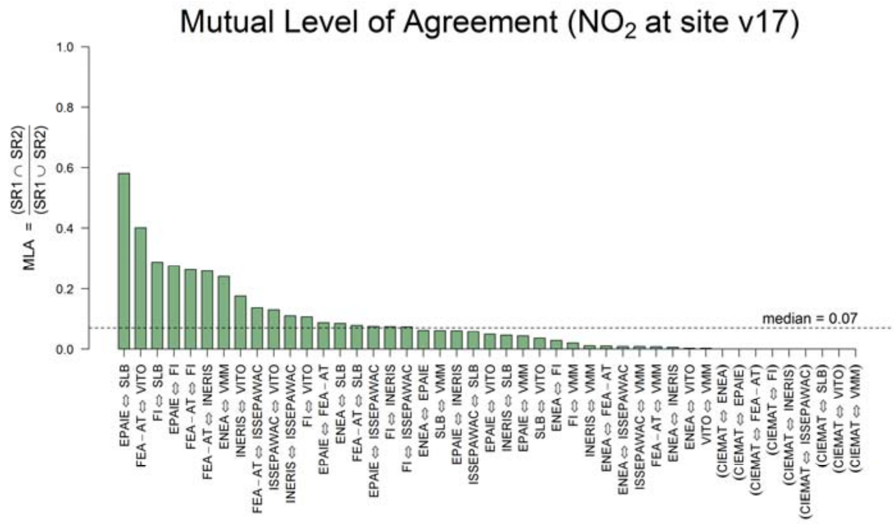
The **results** from the mutual comparisons of the **level of agreement** can be summarised as follows:

- Values for all **MLA indicators are rather low** in general.
- Median MLAs are always clearly < 10% for the whole set of comparisons.
- A deduced ranking in terms of the order of paired similarities should be taken with care and is probably not reasonably conclusive.

Figure 14. MLA indicators (pairwise level of agreement) of the SR estimates obtained for NO_2 at the urban-background sites Antwerpen-Linkeroever (v7) and Schoten (v17), and at the traffic site Borgerhout-Straatkant (v216).

The bars are sorted in decreasing size of MLA levels. Parenthesised paired team names indicate that no SR results have been reported for this combination by at least one of the teams in a pair.





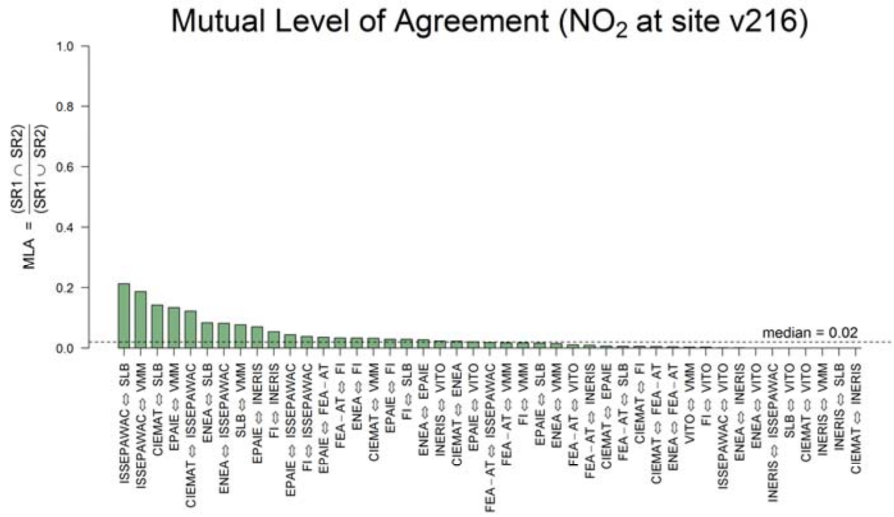
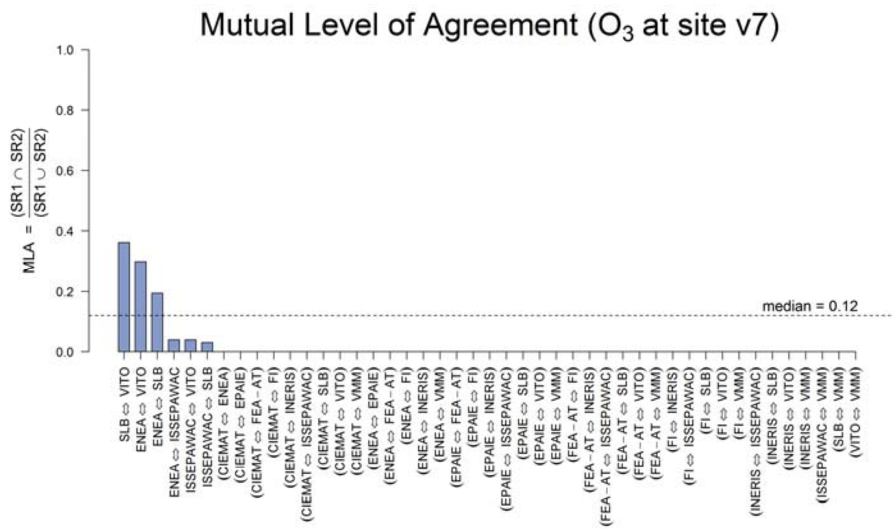


Figure 15. MLA indicators (pairwise level of agreement) of the SR estimates obtained for O_3 at the urban-background sites Antwerpen-Linkeroever (v7) and Schoten (v17).

The bars are sorted in decreasing size of MLA levels. Parenthesised paired team names indicate that no SR results have been reported for this combination by at least one of the teams in a pair.



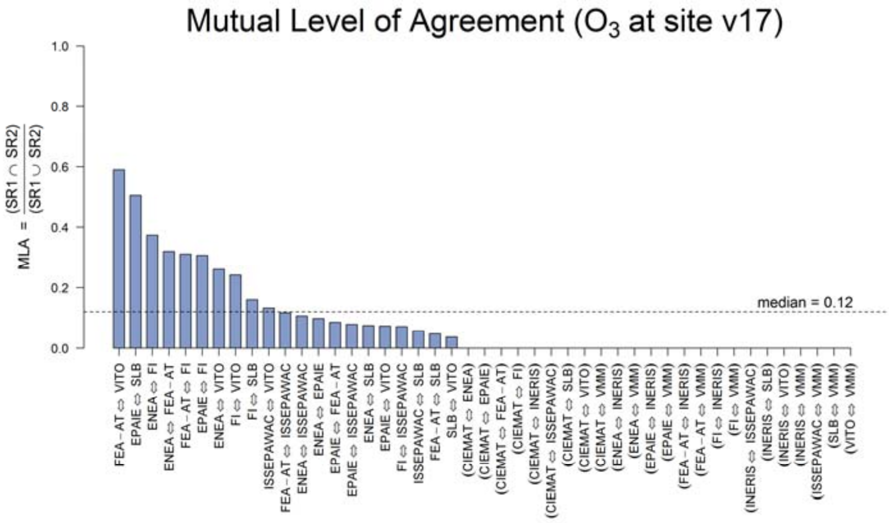
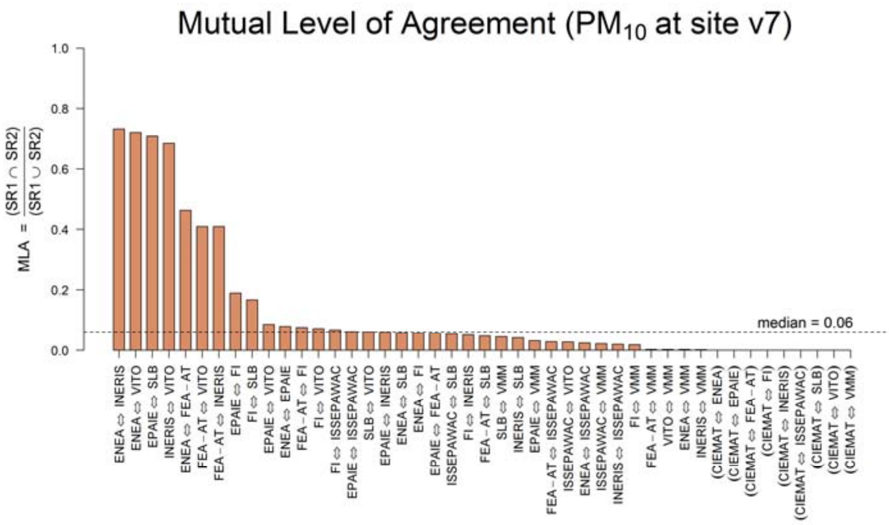
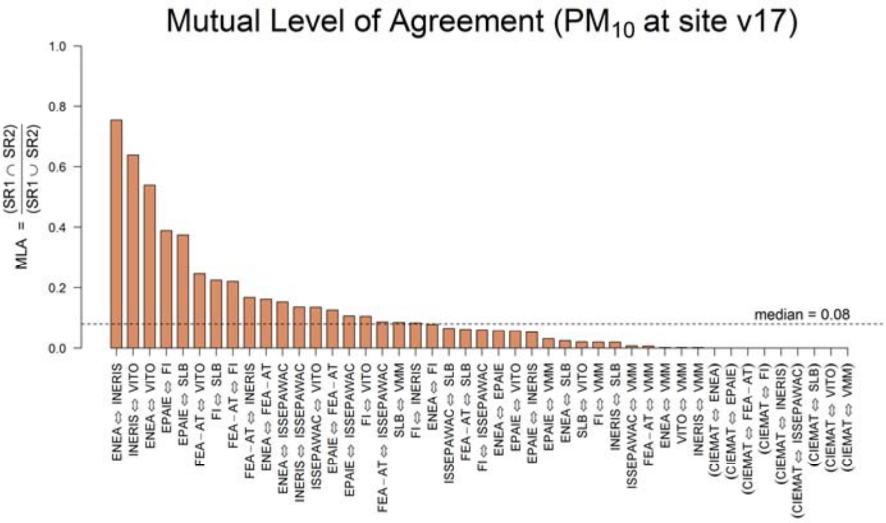


Figure 16. MLA indicators (pairwise level of agreement) of the SR estimates obtained for PM_{10} at the urban-background sites Antwerpen-Linkeroever (v7) and Schoten (v17), and at the traffic site Borgerhout-Straatkant (v216).

The bars are sorted in decreasing size of MLA levels. Parenthesised paired team names indicate that no SR results have been reported for this combination by at least one of the teams in a pair.




Mutual Level of Agreement (PM10 at site v17)
MLA = (SR1 ∩ SR2) / (SR1 ∪ SR2)
1.0
0.8
0.6
0.4
0.2
0.0
median = 0.08
ENEA ⇔ INERIS
INERIS ⇔ VITO
ENEA ⇔ VITO
EPAIE ⇔ FI
EPAIE ⇔ SLB
FEA − AT ⇔ VITO
FI ⇔ SLB
FEA − AT ⇔ FI
FEA − AT ⇔ INERIS
ENEA ⇔ FEA − AT
ENEA ⇔ ISSEPAWAC
INERIS ⇔ ISSEPAWAC
ISSEPAWAC ⇔ VITO
EPAIE ⇔ FEA − AT
EPAIE ⇔ ISSEPAWAC
FI ⇔ VITO
FEA − AT ⇔ ISSEPAWAC
SLB ⇔ VMM
FI ⇔ INERIS
ENEA ⇔ FI
ISSEPAWAC ⇔ SLB
FEA − AT ⇔ SLB
FI ⇔ ISSEPAWAC
ENEA ⇔ EPAIE
EPAIE ⇔ VITO
EPAIE ⇔ INERIS
EPAIE ⇔ VMM
ENEA ⇔ SLB
SLB ⇔ VITO
FI ⇔ VMM
INERIS ⇔ SLB
ISSEPAWAC ⇔ VMM
FEA − AT ⇔ VMM
ENEA ⇔ VMM
VITO ⇔ VMM
INERIS ⇔ VMM
(CIEMAT ⇔ ENEA)
(CIEMAT ⇔ EPAIE)
(CIEMAT ⇔ FEA − AT)
(CIEMAT ⇔ FI)
(CIEMAT ⇔ INERIS)
(CIEMAT ⇔ ISSEPAWAC)
(CIEMAT ⇔ SLB)
(CIEMAT ⇔ VITO)
(CIEMAT ⇔ VMM)

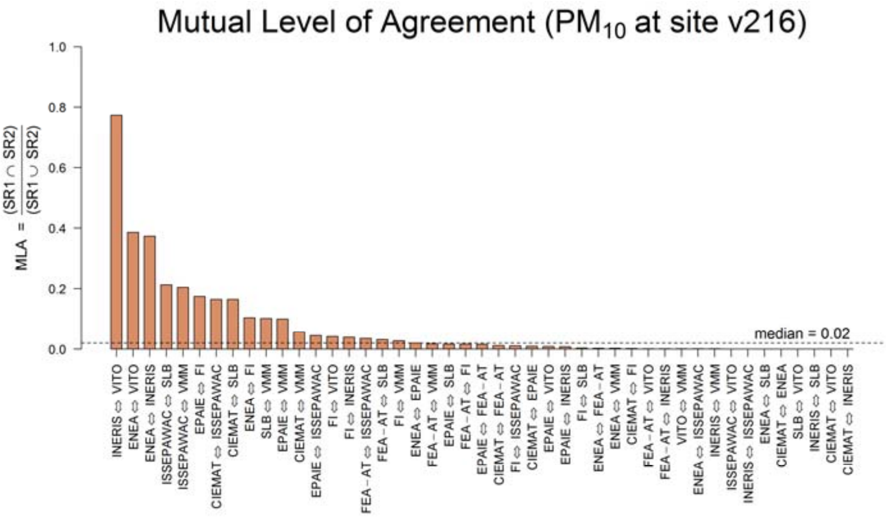
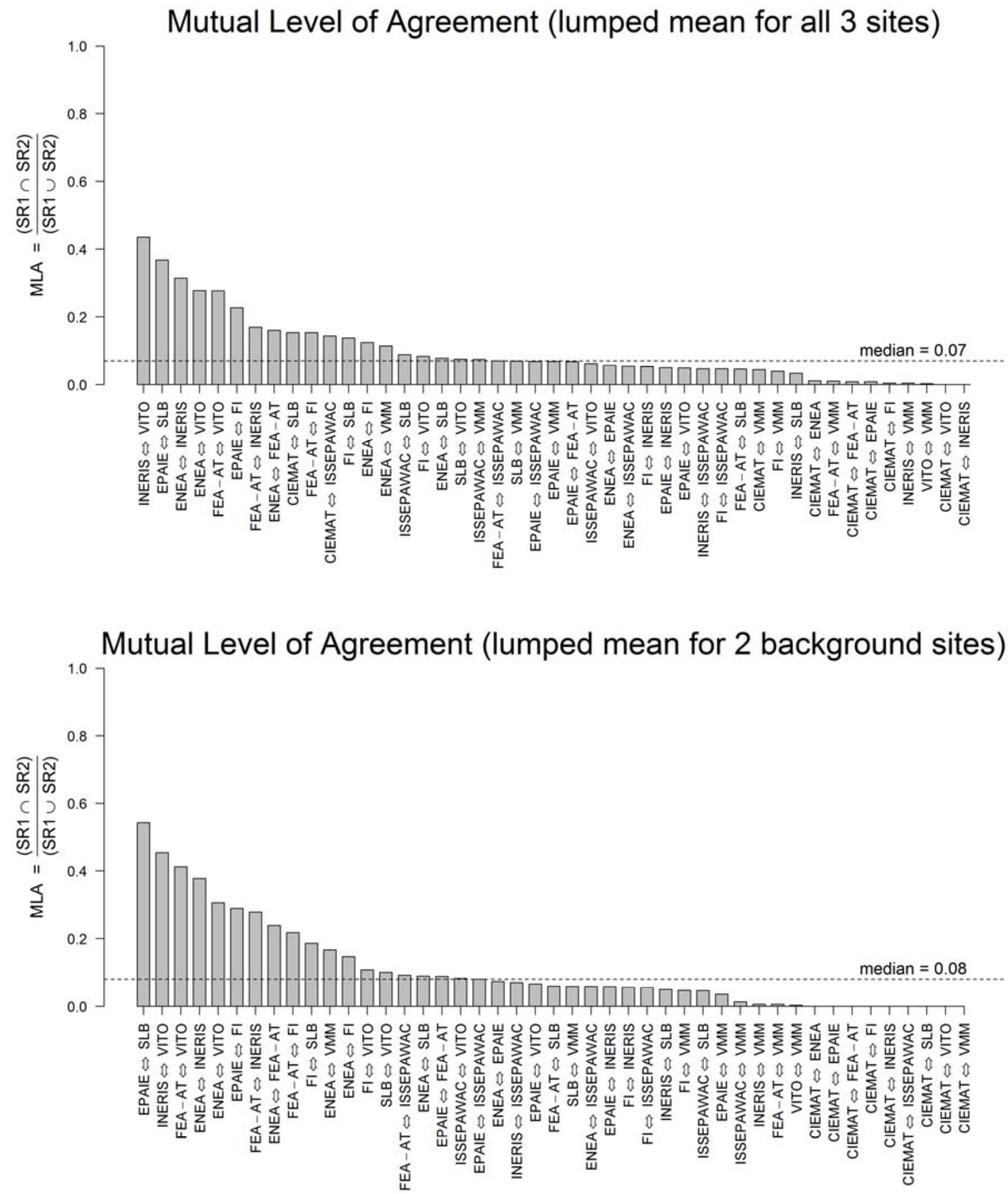

Mutual Level of Agreement (PM10 at site v216)
MLA = (SR1 ∩ SR2) / (SR1 ∪ SR2)
1.0
0.8
0.6
0.4
0.2
0.0
median = 0.02
INERIS ⇔ VITO
ENEA ⇔ VITO
ENEA ⇔ INERIS
ISSEPAWAC ⇔ SLB
ISSEPAWAC ⇔ VMM
EPAIE ⇔ FI
CIEMAT ⇔ ISSEPAWAC
CIEMAT ⇔ SLB
ENEA ⇔ FI
SLB ⇔ VMM
EPAIE ⇔ VMM
CIEMAT ⇔ VMM
EPAIE ⇔ ISSEPAWAC
FI ⇔ VITO
FI ⇔ INERIS
FEA − AT ⇔ ISSEPAWAC
FEA − AT ⇔ SLB
FI ⇔ VMM
ENEA ⇔ EPAIE
FEA − AT ⇔ VMM
EPAIE ⇔ SLB
FEA − AT ⇔ FI
EPAIE ⇔ FEA − AT
CIEMAT ⇔ FEA − AT
FI ⇔ ISSEPAWAC
CIEMAT ⇔ EPAIE
EPAIE ⇔ VITO
EPAIE ⇔ INERIS
FI ⇔ SLB
ENEA ⇔ FEA − AT
ENEA ⇔ VMM
CIEMAT ⇔ FI
FEA − AT ⇔ VITO
FEA − AT ⇔ INERIS
VITO ⇔ VMM
ENEA ⇔ ISSEPAWAC
INERIS ⇔ VMM
ISSEPAWAC ⇔ VITO
INERIS ⇔ ISSEPAWAC
ENEA ⇔ SLB
CIEMAT ⇔ ENEA
SLB ⇔ VITO
INERIS ⇔ SLB
CIEMAT ⇔ VITO
CIEMAT ⇔ INERIS

Figure 17. Lumped MLA indicators obtained by combining MLAs for all three pollutants (NO_2, O_3 and PM_{10}) at all three sites v7, v17 and v216 (top panel), and at the two background sites v7 and v17 (bottom panel), respectively.

The bars are sorted in decreasing size of MLA levels..



8 First Evaluation and Interim Analysis of the Results

The outcomes of the IE are providing quantitative evidence for a **large variation in between the results** obtained by the range of different contemporary methods. The considerable spread of the results obtained by the different teams nevertheless **concerns the extent and position of the estimated SR area perimeters**, but also the **technical procedures** and the **extent of input data effectively used**. In fact, though the general concept of the area of SR proved to be a useful indicator to work with, some important differences revealed regarding the details of the underlying concepts and definitions employed. These differences require detailed evaluations in order to identify the major factors triggering and controlling this variability, which could be found amongst:

- the **basic principles** of the methods
- the effective use of **different types of input data** (different choices made for subsets used from the entire data available)
- the parameterisation of the **similarity criteria** and **thresholds**
- the **underlying** conceptualisations and detailed **definitions of SR**

We consider that the diversity observed in this exercise requires the experts community to take **further efforts towards a**

- more **harmonised definition** of the concept of **"the area of representativeness"**, and
- **consistent and transparent criteria** used for its **quantification**,

in this way eliminating unnecessary differences in the SR methodologies.

Furthermore, from a methodological point of view, it was an important observation that even on a shared dataset, individual teams made a clearly diverse choice on those subsets of the data (average concentrations, concentration time series, emissions, population densities, traffic, land cover, building geometries, etc.) that had been substantial or supportive to their particular SR method. It should deserve a closer look, as how far this indicates that harmonised recommendations should be established for the input requirements of SR assessments, too.

9 Follow-Up Activities (Concluded)

With a view of harmonisation in the field of SR, the IE also provided an excellent opportunity for the **exchange of knowledge** on this subject, which was organised in the form of a **1½-day workshop** in conjunction with the FAIRMODE technical meeting in Athens (June 2017). The revelation of the diversity in the SR results opened a very insightful and constructive discussion. In fact, from having worked on the same shared dataset, participants of the IE were able to efficiently exchange background information in a much more detailed way as compared to what would have been feasible without this common ground.

Participants of the IE agreed that the diversity of the results requires us to take further efforts towards the quantitative definition of the concept of "the area of representativeness" and in eliminating unnecessary differences in the SR methodologies. Questions that have been elaborated in more detail during the follow-up of the IE therefore included:

1. What are the future needs for **harmonisation** and for establishing a **common frame of reference?**
2. Is there a future need for **standardisation**, too?
3. Beyond standardisation, should the regulators / political bodies make the use of standards **mandatory?**
4. Would it conversely be preferable to have at disposal a **set** of **transparent definitions** and **practical guidelines**, but maintaining the freedom of choosing the most appropriate procedures for the **different** particular **purposes** and **applications**?

A general consensus was found amongst participants of the IE:

- Currently it **would not (yet) be reasonable to start discussing about (2) or (3)**.
- For the **mid term** objectives, the **efforts** of the experts community should rather be directed **towards (4)** first.

In the view of the organisers of this IE, it has to be pointed out that this objective will first **require establishing a common framework for SR definitions and SR similarity criteria**, and for **harmonising the related terminologies**. Even if different purposes of estimating SR might cause some conflict of goals, there is a substantial room for improvements towards a **higher transparency** and the need for a **better comparability** of SR estimates.

Further to the workshop in Athens, participants were asked to prepare a **brief sum-up file** on their individual summaries & conclusions from the workshop and from the SR intercomparison exercise. The complete set of these contributed **Individual Summaries & Conclusions** can be found in **Annex VII**. These summary files provide a valuable overview of opinions about the current state of the art and about future directions within this FAIRMODE group.

Following his particular role as being the main organiser of the SR intercomparison exercise and of the SR workshop, Oliver Kracht also worked out an **extended conclusions file**, which provides a **comprehensive overview** on the **current state** of these activities, and the **general summary and conclusions**, presented in the following chapter (chapter 10).

10 Conclusions About the IE and Current State of Work on SR Within the Expert Community

This chapter has been worked out as the summary and conclusion of Oliver Kracht, as being the main organiser of intercomparison exercise and of the FAIRMODE activities on SR. The following sections thus give the JRC's views on the outcome of the IE.

10.1 Introduction and general remarks

The assessIment of the spatial representativeness of air quality monitoring stations is an important subject that is linked to several highly topical areas, including risk assessment and population exposure, the design of monitoring networks, model development, model evaluation and data assimilation. Nevertheless, European regulations lack a clear provision to evaluate the spatial representativeness of the stations. Also in the scientific literature, there is no unified agreement to address this complex problem.

Indeed, spatial representativeness (SR) of air quality monitoring stations has been investigated and discussed intensively in the past within FAIRMODE and AQUILA. However, no well-established procedure for assessing SR has been identified so far. Also in the scientific literature, there is no unified agreement to address this complex problem. With a view of harmonisation in this field, the recently concluded intercomparison exercise (IE) on the SR of air quality monitoring sites thus also provided an excellent opportunity for the exchange of knowledge on this subject, which was organised in the form of a 1½-day workshop.

The main objective of the IE was to evaluate the possible variety of SR results obtained by applying the range of different contemporary approaches to a jointly used example case study. As the working basis, a shared dataset has been selected among a set of modelling data from the city of Antwerp.

All participating teams worked by using their own selected methods and by using those parts of the dataset that they would normally require. Therefore, the aim of the IE was less to see how the different methods perform. This would in fact not have been possible, as by principle a known SR reference value ("true value") was missing. We thus rather intended to investigate how the outcomes of different approaches would compare to each other, in this way measuring consistency rather than correctness. Thereby two fundamental questions needed to be addressed: Are the different SR methods actually targeting the same metric? Or, conversely, do the professionals probably speak about several different concepts and quantities when they name it SR?

In fact, the results of the IE revealed a considerable range of variation between the SR estimates - not only in terms of the size and position of the SR perimeters, but also in the technical procedures and the extent of input data effectively used. For the workshop, the revelation of this diversity opened a very insightful and constructive discussion. In fact, from having worked on the same shared dataset, participants were able to efficiently exchange background information in a much more detailed way as compared to what would have been feasible without this common ground. This was supported by well-prepared individual presentations of all participating teams. In the course of the workshop, the major factors triggering and controlling the observed spread of the SR results have been identified amongst:

1. the **basic principles** of the methods
2. the **effective use of different types of input data** (different choices made for subsets used from the entire data available)
3. the parameterisation of the **similarity criteria** and **thresholds**
4. the **underlying** conceptualisations and **definitions of SR**

The conclusions that can be drawn from the IE and from the discussions at the workshop underline the need for (i) a more harmonised definition of the concept of "the area of representativeness" and (ii) for consistent and transparent criteria used for its quantification.

In the following sections, we will provide our detailed summary and conclusions on the particular task and key points that have been addressed during the workshop. We will also outline the opportunities for making progress towards a more harmonised quantification of SR.

10.2 Integration time scales

Unsurprisingly, large agreement exists across the expert community that when assessing the SR of an AQMS, specific areas of SR need to be defined for the different pollutants. Also with regard to the different integration time scales (e.g., annual averages as opposed to daily mean values) it is commonly accepted that these do imply a different extent of the related SR areas, and that consequently customised definitions should be needed for the test statistics and for the similarity criteria. However, contrasting to the specific adoptions considered for the pollutants, it is not always clear if and how the existing SR approaches do actually include provisions for the aforementioned differences in the time scales. In particular with regards to the use of information related to the dispersion conditions (e.g., the street canyon topography and the built-up situation, but also land use in general), it gets not immediately clear how these can be quantitatively linked to a specific integration time scale (though this link might seem obvious from a qualitative point of view). To our opinion, integrating these data and establishing this relationship would ultimately best be done by the use of a suitable air quality simulation model. Similar considerations regarding the integration time scales naturally apply to the use of emission proxies, but to a certain extent also to the use of emission data in general. From a conceptual point of view, it is clear that integrating these types of information should improve the delimitation of the SR areas. However, it is difficult to quantify the level of improvement, and to conclude about the effective time scale to which this finally applies.

Explicit versus effective (implicit) integration time scales: In conclusion, it seems sometimes challenging to conclude on the **effective integration time scale** of a methodology, which might differ from the integration time scale explicitly declared.

Furthermore, comparing the approaches of different teams, in some cases it is not finally clear as how far the effects of different integration time scales get compensated (at least in part) by the selection of more strict or less strict similarity criteria. Example given, ENEA evaluated concentration differences between the AQMS and the virtual monitoring points on a time bases specifically adapted to the regulatory requirements for each particular pollutant (hourly for NO_2, daily maximum of 8 hours running average for O_3, daily average for PM_{10}). EPA-IE, on the other hand, chose a unique time bases (hourly) for all three pollutants. For verifying similarity, both teams used a 20% threshold criterion with regard to the concentration differences of the single time steps. However, whereas ENEA deployed a second (frequency-based) criterion targeting the 90% percentiles of the one-year time series, EPA-IE chose this second criterion to assess the medians (i.e. the 50% percentiles). Following these considerations, it is obvious that for NO_2 both teams worked on the same integration time basis (hourly), but with very different frequency criteria (90% percentiles as opposed to the less strict 50% percentiles). For O_3 and for PM_{10} the comparison is yet more complex: The larger integration times chosen by ENEA lead to an effectively less strict thresholding operation as compared to the hourly bases chosen by EPA-IE. However, the 90% percentiles frequency criterion chosen by ENEA is more stringent than the 50% percentiles deployed by EPA-IE. It remains an open question as how far these two counter-directed choices do compensate each other and how (if at all) this could be quantified.

In conclusion, integration time scales, similarity criteria, and possible other criteria always need to be considered together when evaluating the outcome of the SR area determination by any method in a comparative way.

10.3 Integrating different types of input data and auxiliary information:

With regard to the **integration of input data**, the methodologies applied by the different teams can roughly be distinguished into

1) methods that apply the relevant similarity criteria to concentration maps derived from an **air quality model** (which can be both from an existing model, or from a dedicated model simulation established for this specific purpose)
2) methods applying similarity criteria to concentration maps derived from the **interpolation of measurements**
3) methods relying on a simplified integration of **proxy data** and **auxiliary information**

The integration of complex information from multiple sources, possibly even at different space and time scales and at varying quality levels is a challenging task. However, as already discussed in the previous section (section 10.2: Integration time scales) integration of multiple data can nowadays best be done by the use of a suitable air quality simulation model. Model outputs could further be improved by using data assimilation techniques to derive a combination of modelling and measurement data.

Pros and Cons of using of air quality models to estimate SR:

Different arguments concerning this aspect have been exchanged in the FAIRMODE group:

Pros for deploying a (high-resolution) model:

- A high-resolution urban air quality model seems the most adequate way to integrate all relevant influencing variables.
- If accurate enough, such model takes into account the high spatial variability of concentrations in an urban area.

Cons of using model data:

- Potential uncertainty and inadequate quality of the model outputs
- Suitable type of modelling data is not available everywhere.
- Various user groups can thus be in need of more simple estimation methods.
- Accurate calibration and validation of (high-resolution) models might require a precise SR area estimate. This could be a vicious cycle, viewing that the SR area estimate itself requires a calibrate model beforehand.

However, we are nowadays observing a rapid increase of the availability of high-resolution air quality models for many places in Europe. Growingly more modelling teams have the expertise and technical capacities to apply this kind of simulation techniques. Against this background, it can be expected that the aforementioned need for rather simplified alternatives will steadily decrease. On the other hand, notwithstanding the actual availability of the modelling tools, the availability of suitable input data (e.g., traffic volumes at line segments) might still be a different limiting factor.

10.4 Similarity criteria

In this exercise, both absolute and relative similarity criteria have been applied.

Absolute similarity criteria can more easily be linked to certain regulatory requirements. Example given, ANNEX I of the 2008/50/EC directive might serve as a model. Table A of this ANNEX I in fact provides data quality objectives for ambient air quality assessment. These data quality objectives are expressed as percentages, but according to the directive they shall be interpreted as being applicable in the region of the appropriate limit value. Such percentage of an absolute value (the limit values), would thus result into an absolute criterion.

Relative similarity criteria are, on the other hand, more suitable for assessing the full concentration range within a fluctuating time series. However, relative similarity criteria can be problematic in the low concentration ranges.

Following these considerations, we propose that a combined absolute / relative similarity criterion would be the better choice. Example given, a mathematical rule for such similarity criterion δ could be defined as the max of [± xx µg/m3] and [± yy% of the observed concentration].

10.5 What are the controlling factors for the SR estimates

From our intercomparison exercise we obtained very interesting insights about how SR estimates obtained by different experts can differ. Wide difference could be observed not only in size and extent, but also in the location and shape of the SR areas. Thereby the teams have worked on a common shared dataset, but using their own individual methods and their own particular similarity criteria and threshold values. The IE thus concerned the full user manipulable parameter space, including (i) the choice of a subset from the data available, (ii) the SR method as such, (iii) the similarity criteria definitions, and (iv) the parameter values chosen for these similarity criteria.

However, current outputs do not enable us to distinguish between the individual influences of these different groups of parameters: In fact we did not explicitly investigate and consequently have less clear information about how SR results would vary when manipulating only one of the aforementioned factors (i) to (iv) while keeping the others fixed. Example given, from our available results it is thus difficult to conclude about the sensitivity of a particular method to the different possible choices for the similarity criteria parameters. It becomes evident that certain further evaluations would be helpful to provide more quantitative evidences for the discussions and to support the process harmonisation.

In order to better support the future discussion on prospectively harmonised similarity criteria and methodological recommendation, we suggest that further quantitative investigations would be of immediate interest:

- How does the parameterisation of the similarity criteria/threshold values quantitatively influence the estimation of SR areas?
- How does the choice of additional criteria (i.e. should SR area be contiguous or not) quantitatively influence the estimation of SR areas?

Such investigations could be based on simple variations of parameter values and / or more systematically by Monte Carlo simulations. The outcomes of this assessment could then be turned into a **sensitivity analysis** and aid to distinguish regions within the parameter space which are more influential on the SR results from those where a variation of the similarity criteria does only cause lesser or negligible effects. Practically this type of analysis would best be done based on a fully automated formalisation of one or more selected methods into a suitable computer code.

It should be pointed out that the analyses proposed here would be **important to be conducted before** getting into serious discussion about the selection of parameter values for the similarity criteria. In this way we would a-priori be able to avoid being trapped into conceptual discussions on the selection of similarity criteria, without knowing if there were important practical constraints potentially overruling the theoretical considerations.

Beyond these immediate needs, such integrated code would also be useful for further works in the mid-term future, example given to investigate questions like:

- Can we demonstrate how SR evolves over the evaluation period (examples given time series of daily SR areas over a year, time series of SR for the hours of the day – i.e. 24 averages of 365 hours)?
- Can the SR codes be inverted to identify optimal station positions?

10.6 Population within the SR area

To estimate the amount of population for which a monitoring station is representative one needs to intersect SR areas with the population density. In this exercise, population density in turn constituted a spatially distributed and heterogeneous raster field. Estimates for the size of the SR area and the number of inhabitants within the SR areas can therefore not be linked in a simple linear way.

Participants of the IE have thus been asked also to report the number of inhabitants coupled to their estimates of SR areas. This was relevant for inspecting as to what extent prospective incongruence in the SR areas would translate to a comparable incongruence in the population estimates. Example given, if the spatially incongruent portions of the SR area estimates (i.e. those parts of the SR areas that do not intersect within between participants) would have mainly concerned very low populated or even non-populated areas, this disagreement in SR areas would probably have been less relevant.

During the workshop, participants suggested to take a closer look at this matter. We therefore further followed up on this analysis after the workshop. The analysis however confirmed that also with a view on population the overall picture of the intercomparison results is not fundamentally different from the conclusions already obtained for the areas. In fact, the estimates for the size of population within the SR areas do reveal a similar level of diversity as the SR area estimates themselves.

As a general remark, it should be noted that the evaluation of population data by intersecting SR areas and population density is of course already a certain simplification in itself. It assumes a static relationship, whereas in reality people in a city do actually move around in more or less complicated ways, thereby entering or leaving the SR area of a monitoring station in a complex temporal pattern.

10.7 Miscellaneous subjects and open questions

During the SR workshop, a set of topics has been identified with open questions, which have been subject to more detailed discussions:

10.7.1 Shall SR areas be strictly contiguous?

As one of the basic features of any SR definition it has to be decided whether the SR area is (A) forced to be a contiguous field and spatially connected to the station, or if (B) non-contiguous sub-areas should be allowed as well. In the latter case (B), one also needs to make a definition about the spatial extents of the domain within which the SR is assessed in order to avoid spurious correlations, which are not based on physical grounds.

This question of contiguous / non-contiguous SR areas has been discussed controversially during the workshop.

Amongst the arguments for a strictly contiguous area of SR are:

- The advantage of this definition is its simplicity.
- It has a clear physical meaning as it can be more immediately connected to the concept of advective-diffusive transport.
- Particularly in situation where similarity of concentrations is not primarily caused by pollution transport but by similarities in the emission and dispersion conditions (probably the more frequent case in practice), one needs to have strong evidence that the types of emission sources within this SR area are

really the same. This seems to be more safely granted by a strictly contiguous SR area.

Amongst the arguments for using a non-contiguous area of SR are:

- The non-contiguous approach can deliver a more fine-grained description of the SR area.
- It can more completely describe the spatial coverage and interrelations within a monitoring network.
- In contrary, a strictly contiguous area of SR could be largely impractical with regards to the design of air quality monitoring networks, for which one needs to provide optimal cover of a region while at the same time respecting cost-efficiency.

In our opinion, the appearance of non-contiguous SR areas is often an immediate technical consequence of moving from a coarser SR assessment tool towards a more detailed and fine grade SR approach. By increasing the level of detail, a method might for example reach the capacity to resolve the discontinuities imposed to the SR area from the influence of the road network. In such example it would be quite counterintuitive for me, if the estimated SR area was subject to substantial drops in its quantitative values because of eventually cropping away larger subsections which have become non-contiguous as compared to an alternative coarse grained approach. Or to put it this way: in this thought experiment non-contiguous SR areas are an implication of improved assessment skills (without having changed anything about the spatial structure of the concentration field).

It should also be noted in this context that the Air Quality directive 2008/50/EC states that "Sampling points should, where possible, also be representative of similar locations not in their immediate vicinity." (ANNEX III: "… location of sampling points for … nitrogen dioxide … particulate matter …"; and ANNEX VIII: "… locating sampling points for assessments of O_3 concentrations").

Preference for a contiguous or a non- contiguous approach certainly depends on the purpose of the SR assessment. Probably one cannot replace the other, but both approaches contribute information to answer different questions. It is reasonable to assume that both a contiguous and a non- contiguous variant of the SR estimation should be done in parallel in order to provide a holistic and complete SR assessment.

10.7.2 Shall SR assessments be a-priori limited to a certain spatial extent of the domain?

Some of the participants did a priori restrict the extent of the domain where SR is evaluated.

Pros:

- For conceptual reasons this can help to avoid the false positive inclusion of spurious correlations into the SR area.
- For practical reasons it can help limiting the computational costs.

Cons:

- One might significantly overlook the true extent of the SR area, especially if rather small pre-defined domain extents are chosen.

The question of a-priori limiting the spatial extent of the assessment is also linked to point 7.1. (contiguous vs. non – contiguous SR areas).

10.7.3 Shall SR areas be exclusive or non-exclusive?

This addresses the question of whether the SR estimates of different monitoring stations shall be allowed to overlap or not. In the non-exclusive approach, a single receptor point can be part of the SR area of two or more monitoring stations. In the exclusive approach, a single receptor point can only be part of the SR area of exactly one station. To establish this, in the case of initial overlap between two or more SR areas a criterion needs to be applied to separate all intersecting parts (e.g., by considering the minimum concentration deviation from the station). The exclusive approach is thus useful to determine by which station each point of the domain is best represented. However, such separation is naturally depended on the current meteorological conditions (wind speed and directions), in consequence potentially making it a time dependent variable.

Within our IE only INERIS has deployed an exclusive variant (in parallel and together with a non-exclusive approach). For the IE only the non-exclusive approach results have been considered.

10.7.4 Shall SR similarity criteria follow strict prescriptive rules or would some case-by-case flexibility be preferable?

Shall we aim to define unified parameter values for the different SR similarity criteria? Or would it be preferable to adapt these threshold parameters on a case by case basis?

Adapting the thresholds on a case-by-case basis can provide the advantage of better delimitating exclusive SR areas. This discussion is thus strongly linked to the previous section ("10.7.3: ... exclusive or non-exclusive?").

In our opinion, such a case-by-case adaption is a special solution, suiting for a specific purpose, but less suitable for generalisation.

10.7.5 General Remarks on the "miscellaneous subjects and open questions"

To the end, all questions that have been reconsidered in this section can be reasonably discussed without having to take a final decision if preference shall be given to the one or to the other variant now. In most practical cases, there can be important pros and cons for both alternatives. However, transparency is needed in the SE methodologies, to make the eventual implementation of these alternative features comprehensible and traceable.

10.8 How to make progress towards a more harmonised quantification of SR ?

10.8.1 General considerations

To the best of our knowledge, this study provides the first attempt to quantitatively compare the range of methods used for estimating the SR of air quality monitoring stations in Europe. The outcomes of the IE are providing **quantitative evidence for a large variation** in between the results obtained by the range of different contemporary approaches.

During the workshop participants of the IE agreed that the diversity of the results requires us to take further efforts towards the quantitative definition of the concept of "the area of representativeness" and in eliminating unnecessary differences in the SR methodologies. Discussion then focused on the potential need for a paradigm shift in the SR definition. It crystallised that even if different purposes of estimating SR might cause some conflict of goals, there is substantial room for improvements towards a **higher transparency** and the need for a **better comparability** of SR estimates.

Topics discussed in more detail during the second part of the workshop therefore included:

1. What are the future needs for **harmonisation** and for establishing a **common frame of reference?**
2. Is there a future need for **standardisation**, too?
3. Beyond standardisation, should the regulators / political bodies make the use of standards **mandatory?**
4. Would it conversely be preferable to have at disposal a **set** of **transparent definitions** and **practical guidelines**, but maintaining the freedom of choosing the most appropriate procedures for the **different** particular **purposes** and **applications**?

It was found general consensus amongst participants that currently it **would not (yet) be reasonable to start discussing about (2) or (3)**, but that for the **mid term** objectives the **efforts** of the experts community should be directed **towards (4)** first.

In our view, it has to be pointed out that this objective will first **require establishing a common framework for SR definitions and SR similarity criteria**, and for **harmonising the related terminologies**.

10.8.2 Do we need a paradigm shift in the concepts of SR?

We need to face that the concept of spatial representativeness has been investigated and discussed intensively within FAIRMODE and AQUILA for many years (>10 years). However, no well-established consensus on either its definition, nor on the procedure for assessing SR has been identified so far. Against this background it is hardly conceivable to make progress towards a more harmonised quantification of SR, without untangling its underlying concept.

We propose that for the aim of **harmonisation** the concept of spatial representativeness requires a **paradigm shift in** its definition. In this we need to abandon the idea of SR being one single property of a monitoring site (there is no such thing like a "swiss army knife" for SR), but need to more **clearly distinguish** between **SR definitions, SR methods,** and the **objectives** and **purposes** for performing a **SR assessment**.

In specific, **a clear distinction needs to be made** between the following 4 different aspects:

5. The **purpose** of evaluating SR in a specific case of application
6. The set of **SR metrics** / SR characteristics required for this purpose
7. Context related **definitions of SR metrics**
8. The **technical methods** for estimating a particular SR metric

These different concepts will be explained in more detail in the following sections:

10.8.2.1 Context related definitions of SR characteristics

Any manageable definition of SR needs to be clearly context related: It needs to be related to the particular pollutant parameter and to a specific integration time scale. Probably also the observation time scale (i.e. the temporal extent of a data series) needs to be specified.

In order to reasonably describe SR within a certain setting, **one or more** context related **SR metrics** (maybe also to be called SR measures, or SR characteristics) could be required.

Examples for such separable **SR metrics** could be aligned along the relevant integration time scales:

- the SR area for PM_{10} annual averages
- the SR area for PM_{10} daily averages

- the SR area for 8 hours running averages of O_3

However, it could be the case that definitions for even more specific metrics are required. Examples in the context of regulatory purposes might be:

- the SR area for the daily maximum of 8 hours running average for O_3
- the SR area for the number of PM_{10} daily averages exceeding 50 µg/m^3

It certainly requires further investigations to evaluate if the level of detail of these second types of examples would finally be required. In another example, however, specific metrics might be useful in the framework of model calibration and model validation:

- the SR area for the temporal correlation of concentration values (i.e. evaluating the correlation between time series at the AQMS and time series at the receptor points within its SR area)
- the SR area for the amplitude of the temporal variations (i.e. comparing the amplitude of time series at the AQMS to the amplitude of time series at the receptor points within the SR area)

In all these regards, we do need a common agreement and understanding of SR characteristics, nomenclature and taxonomy. Based on this, transparent definitions of a suitable set of **SR metrics** should be elaborated, including the specification of their **primary similarity criteria.**

We anticipate that finding agreement on a set of clearly defined context related definitions of SR would significantly improve the communication and comparability of SR results. Such a set of transparent SR definitions would serve as a valuable toolbox to select from for the different purposes.

10.8.2.2 Technical methods for estimating a particular SR metric

The definitions of **SR metrics** need to be clearly distinguished from the **technical methods** used for estimating a particular SR metric.

If applicable, these techniques or methods might include the specification of one or more secondary similarity criteria. Example given, a method for the "SR area for NO_2 annual averages" might comprise a secondary similarity criterion related to NO_2 emissions or to traffic conditions. The primary similarity criterion however needs to remain the tolerance criterion related to NO_2 annual average concentrations. It needs to be shown that compliance with these secondary criteria can guarantee compliance with the primary criterion. Otherwise the results should not be named "SR area for NO_2 annual averages", but a more correct name would then probably be "SR area for NO_2 annual average emissions".

As a side note, this brings up some important issues:

- How should we validate SR methods that are not immediately based on concentration fields?
- Would it be necessary and reasonable to define an order of preferences for the selection of methods in an application? Example: Methods based on concentration fields would be preferred if such data are available. If concentration fields are not available, then an alternative proxy could be used…?
- How can we establish coherence between methods that are targeting the same SR metric?

In our view, this objective requires first establishing a common framework for SR definitions and SR similarity criteria, and for harmonising the related terminologies (see previous section). The technical methods also need to be compatible with and fit for the respective purpose of evaluating SR (see next section).

10.8.2.3 Purpose of evaluating SR in a specific case of application

Examples for the purposes of evaluating SR could include regulatory purposes and legislation, the local design of monitoring networks, the calibration of air quality simulation models, etc.

In our opinion, harmonisation should not necessarily mean trying to force all SR approaches into the same box. In fact, different purposes of estimating SR might require differently adopted SR methods. However, transparency is needed to be able to make this distinction, and compatibility in-between methods should nevertheless be improved as far as possible.

It needs to be reminded that conflicts of goals between different purposes do potentially exist.

10.8.2.4 The (sub-) set of SR metrics / SR characteristics required for this purpose

A **specific purpose** and **case of application** does typically require a set of more than one suitable SR metrics to be estimated. The overall aim of such a comprehensive set of information might then be called **"spatial representativeness characterisation"**.

The user / local expert / regulator / legislator could specify **the set of SR metrics required for** such a **spatial representativeness characterisation** that is carried out for a particular purpose.

10.9 A modular approach towards better SR characterisation

In summary, the considerations and suggestions presented here should preferably lead to a **modular approach** that can be condensed in to the following hierarchy:

{purpose of a SR characterisation**}**

→ **{**determines the set of **SR metrics** needed**}**

→ **{**resorts to established **definitions** of these SR metrics**}**

→ **{**determines the selection of valid **methods** for estimating these SR metrics**}**

In practice, a well-structured, transparent and harmonised documentation on the definitions of the chosen SR metric and on the primary and the secondary similarity criteria applied should be an attribute feature attached to every SR estimate. Such type of **SR vignette or SR label** could very much support the **comprehensibility and transparency of the SR characterisation**.

It should be pointed out here, that we see the advantage of this modular approach described above in that it would **not require a specific definition of a SR metric for different purposes**, but rather a small **pool of SR metrics definitions** that can serve for several different applications. The purpose of a **particular SR characterisation** on the other hand would then (only) determine **which of these SR metrics** should specifically be **selected** and evaluated.

10.10 Coverage of methods and approaches

As far as we know, this study is the first attempt to investigate systematically the differences in SR estimates that are obtained from a large set of different contemporary SR approaches applied to the same common dataset. The IE had a remarkably strong attendance by 11 teams from 9 different countries. However, as this exercise was based on voluntary participation, it cannot finally be guaranteed that the set of methods applied does ultimately cover the full range of SR approaches and possible varieties thereof employed in Europe. It could likely be the case that in other member states methods are in use that have not been considered within this exercise. The results of such could even more divert from the set that we have obtained so far.

10.11 Alternative interpretations for the diverging SR results

Finally, it should be taken into account that alternative interpretations for the strong variability of the SR results might exist. Very generally speaking, the observed divergence **could** for example **point** us to some **more fundamental discrepancies** related to the evaluation of the air quality data, beyond the question of spatial representativeness. Care should be taken, that in the endeavour for methodological harmonisation such **alternative explanations are not overlooked**. An example could for example be a potential bias between monitoring data, emission data and modelled concentrations.

An ultimate validation of SR methodologies can never be done on purely synthetic data or on modelling, but will require a strong consideration **of air quality measurement with a high spatial resolution**. A strong link can for example be seen between the assessment of spatial representativeness and the emerging research field of (low-cost) mobile air quality sensors.

11 Concluding Proposals for Directing Future Research Work on SR

We conclude this report with a summary of suggestions on where to direct future research work on spatial representativeness:

The assessment of the spatial representativeness of air quality monitoring stations remains an outstanding issue that has substantial links to several highly topical areas, including risk assessment and population exposure (ref: Directive 2008/50/EC and Implementing Decision 2011/850/EU), the design of monitoring networks, model development, model evaluation and data assimilation. . Even if different purposes of estimating SR might cause some conflict of goals, there is a substantial room for improvements towards a **higher transparency** and the need for a **better comparability** of SR estimates.

11.1 Proposed work with regards to harmonisation

The conclusions that can be drawn from the IE and from this report underline the need for a more **harmonised definition** of the concept of "the area of representativeness" and for **consistent and transparent criteria** used for its quantification. We have pointed out that this objective will first **require establishing a common framework for**

1. SR definitions and
2. SR similarity criteria
3. harmonising the related terminologies

For the aim of **harmonisation,** however, the **concept of SR** probably requires a more fundamental **paradigm shift in** its definition, which has been detailed in the previous chapter 10. In that chapter, we proposed a **modular approach towards better SR characterisation**, in which a more clear distinction needs to be made between the four different aspects of spatial representativeness, repeated here:

1. The **purpose** of evaluating SR in a specific case of application
2. The **set of SR metrics** / SR characteristics required for this purpose
3. Context related **definitions of SR metrics**
4. The **technical methods** for estimating a particular SR metric

11.2 Proposed work regarding methodological evaluations

As explained in the previous chapters, the IE concerned the full user manipulable parameter space, including (i) the choice of a subset from the data available, (ii) the SR method as such, (iii) the similarity criteria definitions, and (iv) the parameter values chosen for these similarity criteria. Unfortunately, current outputs do in turn not enable us to distinguish between the individual influences of these different groups of parameters.

We thus consider that a range of statistical analyses would be **important to be conducted before** getting into serious discussion about harmonisation of the selection of parameter values for the similarity criteria and SR methods. Amongst these suggestions are:

- Quantitative sensitivity analysis (permutations, Monte Carlo simulations) to investigate how the parameterisation of the similarity criteria / threshold values influences the estimation of SR areas. These tasks have been laid out in more detail in chapter 10.5.
- How can SR codes be inverted to find optimal station positions?

- Investigate how the SR area evolves over different evaluation periods (i.e. time series of daily SR area estimates over a year, time series of SR for the hours of the day – i.e. 24 averages of 365 hours, etc.)

More detailed information about these suggestions have been outlined and can be found in chapter 10.

11.3 Proposed work regarding measurements

It has been pointed out (chapter 10) that an ultimate validation of SR methodologies can never be done on purely synthetic data or on modelling, but will require a strong consideration **of air quality measurement with a high spatial resolution**. On the one hand, a future link can thus be seen between the assessment of spatial representativeness and the emerging research field of (low-cost) mobile air quality sensors. On the other hand SR could be compared with pollution distribution estimated using – if available – measurements obtained by high spatial resolution sampling campaigns with diffusive samplers

List of Abbreviations and Definitions

AQD	air quality Directive
AQMS	air quality monitoring station or air quality monitoring site
AQUILA	Network of Air Quality Reference Laboratories
CFD	computational fluid dynamics
FAIRMODE	Forum for Air Quality Modelling in Europe
PCA	principal component analyses
SR	spatial representativeness
IE	intercomparison exercise
SR area	spatial representativeness area

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Annexes

Annex I. Documentation of Methods and Criteria

Methods descriptions provided by each participating team:

- CIEMAT (Spain)
- ENEA (Italy)
- EPAIE (Ireland)
- FEA-AT (Austria)
- FI (Finland)
- INERIS (France)
- ISSeP & AwAC (Belgium)
- RIVM (Netherlands)
- SLB (Sweden)
- VITO (Belgium)
- VMM (Belgium)

FAIRMODE Intercomparison Exercise on the Spatial Representativeness of Air Quality Monitoring Stations

Documentation of Methods and Criteria

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Type of SR methodology: method based on modelled pollutant concentrations

Type of output: spatial representativeness areas (shape files)

2 Methodology

The methodology is based on the computation of concentration maps using CFD-RANS simulations. 16 scenarios corresponding to 16 wind directions are simulated for each pollutant. The average concentration maps are obtained by means of weighted-average of RANS simulation results (WA-RANS methodology, see Santiago et al. (2013), Santiago and Martin (2015) and Santiago et al. (2017)) following the experimental meteorology. The meteorological data were taken from the M802 station (file = 'meteo.csv'). The frequency and mean velocity for each wind sector are computed and used to calculate the average concentration maps.

3 Computational domain

Due to computational requirements of CFD models, the buildings within a rectangle of 1 km x 1 km with the station located in the center was considered in the simulations. The building geometry information was taken from building.shp. These were simplified and grouped in blocks using ArcGIS software. The height of each block is computed taken into account the mean of building heights. The domain is meshed (irregular) with a resolution of 1 m close to the station.

4 Emissions

The emissions were distributed along each street following the information given by Road_emissions.csv. A raster with these values was introduced in the CFD model.

5 Average Concentration map

The average concentration maps were computed in a rectangle of 0.8 km x 0.8 km around the station.

5.1 NO_2

In order to minimize the effects of chemistry in the NO_2 map, firstly the average concentration map of NO_x is computed and finally it is transformed into NO_2 by taking into account the average of experimental ratio between NO_2 and NO_x measured at the station.

To quantify the NO_x background concentration, the values measured by 42R811 station were considered. Taking into account this background, simulation results are normalized in order to provide the same value of time average NO_x concentration measured at traffic station.

5.2 PM10

The same procedure is followed to compute PM10 average concentration map, but, in this case, PM10 background concentration is taken from the 40SA04 station.

6 Representativeness threshold

To compute the representativeness area, the threshold used is ± 20% of the station concentration. NO_2 and PM10 average concentrations at the traffic station are 50 and 30 $\mu g\ m^{-3}$, respectively. Then, the used threshold for representativeness in terms of concentration is ± 10 and ± 6 $\mu g\ m^{-3}$ for NO_2 and PM10, respectively.

7 Representativeness area: Results and Conclusions

Using the methodology described above, NO_2 and PM10 average concentration maps are established and the representativeness areas for the traffic station are computed. These are shown in Figs 1 and 2.

Figure 1. NO_2 average concentration map. Red dot indicates the location of the traffic station and the representativeness area is represented in grey.

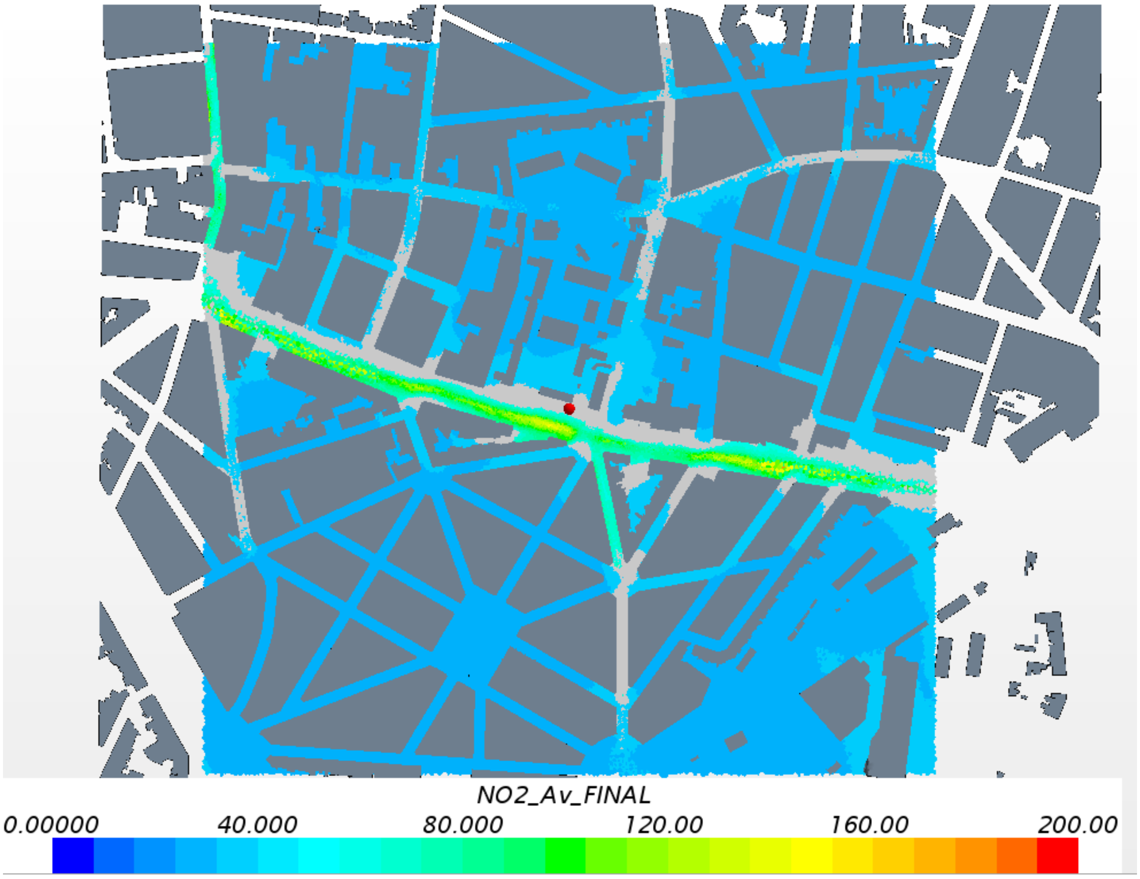
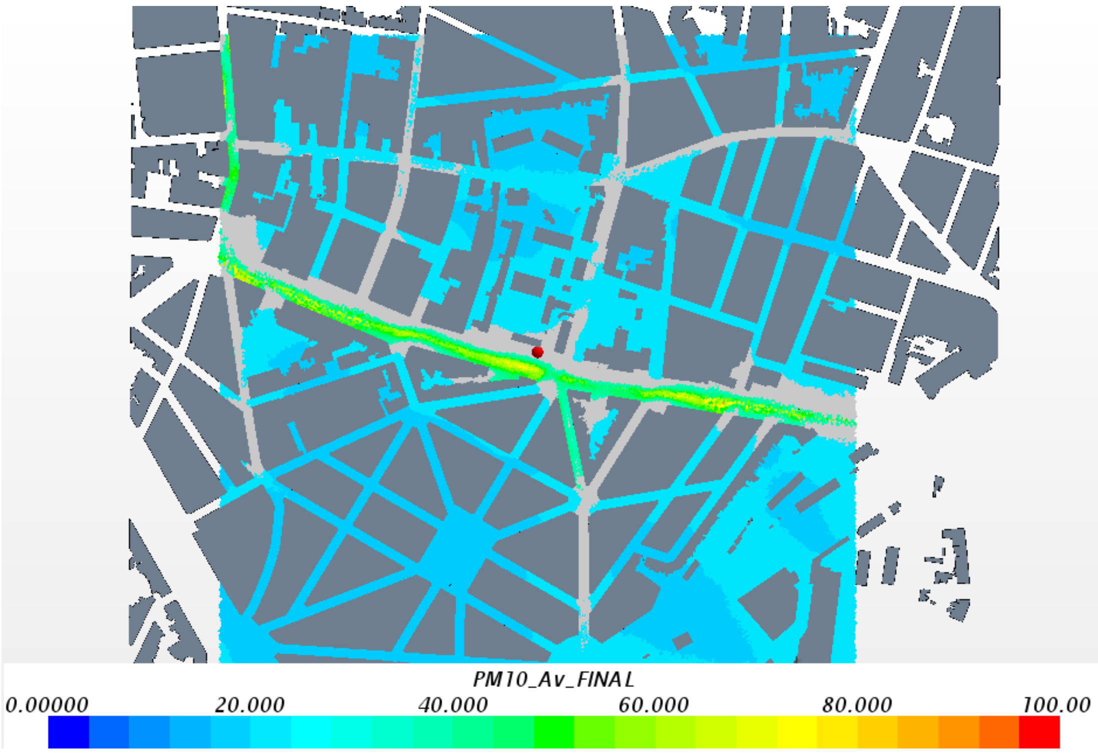


Figure 2. PM10 average concentration map. Red dot indicates the location of the traffic station and the representativeness area is represented in grey.



The size of the representativeness areas is immediately calculated from the original irregular mesh of the CFD simulations, and can be compared to the available area within the computation domain. Within the rectangle of 0.8 km x 0.8 km the available area (the area of this rectangle minus the building plan area) is 0.2813588 km^2. The representativeness areas (RA) within the 0.8 km x 0.8 km rectangle are 0.03177680 km^2 (11.3% of the available area) and 0.04594605 km^2 (16.3% of the available area) for NO_2 and PM10 respectively. Within this area, the NO_2 average concentration is 46.7 μg m^{-3} with a standard deviation of 5.4 μg m^{-3}. Concerning PM10, the average concentration and standard deviation within the representativeness area is 27.9 μg m^{-3} and 3.3 μg m^{-3}, respectively. Within the whole rectangle of 0.8 km x 0.8 km the average concentration of NO_2 and PM10 are 36.6 and 23.6 μg m^{-3} respectively, and their standard deviations are 16.2 μg m^{-3} for NO_2 and 7.7 μg m^{-3} for PM10.

These data are delivered in an Excel file (CIEMAT_FAIRMODE SR Intercomparison_Results Form.xlsx). Furthermore, CIEMAT_Representativeness.txt is a text file with the data immediately extracted of the irregular mesh of the CFD model at the height of 3m:the mesh of CFD model is 3D and 3 m in this case is the height of the plane z = 3m (more or less the height of the measurements of the air quality monitoring station). From this file, we also created two raster files ("Raster_RepNO2.txt" and "Raster_RepPM10_cor.txt") transforming the irregular mesh to a regular mesh with a horizontal resolution of 2m x 2m. The variables Rep_NO2 and Rep_PM10 indicate the representativeness area (RA) for NO_2 and PM10 respectively. If its value is 1 then this point is within RA and if it is 0 then the point is outside of RA. The raster file is a XY-table with these data.

8 Population

In order to compute the number of inhabitants within the RA, we use the data provided in the file pop_antw_100m.asc. We understand that these data are the population density in cells of 100 m x 100 m (C100x100). For each C100x100 cell, we compute the ratio between the available area (C100x100 cell area minus building plan area) and RA and assume that this ratio is the same ratio of population within the RA. Finally, we sum up the population within the RA corresponding to each C100x100 cell. For example, in a C100x100 cell where the population is 176 inhabitants, if the ratio between the available area and the RA in this cell is 0.06, we then consider that 11 inhabitants are within the RA in this C100x100 cell.

The number of inhabitants within the RA is 1284 for NO_2 and 1899 for PM10 from a total population of 13812 inhabitants in this area. To compute the density of inhabitants within the RA, we divide the number of inhabitants within the RA by the surface area of representativeness. The values obtained (40407 and 41331 inhab./km^2 for NO_2 and PM10, respectively) are very high due to the plan area of the buildings are not taken into account in the computation and the considered area is only located around the traffic station.

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FAIRMODE Intercomparison Exercise on the Spatial Representativeness of Air Quality Monitoring Stations

Documentation of Methods and Criteria

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Type of SR methodology: method based on measured or modelled pollutant concentrations

Type of output: spatial representativeness areas (shape files)

2 Methodology

The calculation methodology is based on the application of the CSF function, described in Piersanti et al. (2015) and hereafter briefly summarized.

The CSF (Concentration Similarity Frequency) function is a procedure for recursively comparing concentration time series, based entirely on gridded model results. The CSF function recursively compares, at surface level, model concentration time series at the monitoring site of interest, $C(X_{site},Y_{site},t)$, to those at each grid point, $C(x,y,t)$, in the model computation domain. At each time step, t, the relative difference between these concentration values is computed and compared with a threshold, in order to assess the condition of "concentration similarity".

The threshold on the difference of the single time step concentration was set to a value of 20% according to literature and to data quality objectives for most monitoring data included in the EU Air Quality Directive.

A frequency function $f_{site}(x,y)$, specific of each monitoring site of interest, counting positive occurrences ("flag") of concentration similarity on a yearly basis, for each grid point of the model domain, was so defined in Equation 1.

$$f_{site}(x,y) = \frac{\sum_{t=1}^{N_t} flag}{N_t}, \quad where\ flag = \begin{cases} 1, & \dfrac{|C(X_{site}, Y_{site}, t_t) - C(x,y,t_t)|}{C(X_{site}, Y_{site}, t_t)} < 0.2 \\ 0, & \dfrac{|C(X_{site}, Y_{site}, t_t) - C(x,y,t_t)|}{C(X_{site}, Y_{site}, t_t)} > 0.2 \end{cases}$$

Equation 1. Frequency function according to the condition $\Delta C/C_{site}<0.2$. C(x,y,t) represents the surface concentration field, while N_t is the number of time steps.

According to Nappo (1982), the representativeness area of the site of interest was finally assessed as the area where the condition $f_{site}(x,y)>0.9$ is fulfilled on a yearly basis.

In our usual applications the inputs of the CSF function are time series of modelled concentration fields. Since such data was not available in this exercise, we choose a slightly different approach by using concentration time series from the 341 virtual stations instead (hourly for NO_2, daily maximum of 8 hours running average for O_3, daily average for PM10). For each of the 11 studied monitoring stations the CSF function value (i.e. the indicator of concentration similarity) was therefore calculated on all 341 virtual stations. The threshold applied to the differences of the single time step concentrations was 20%.

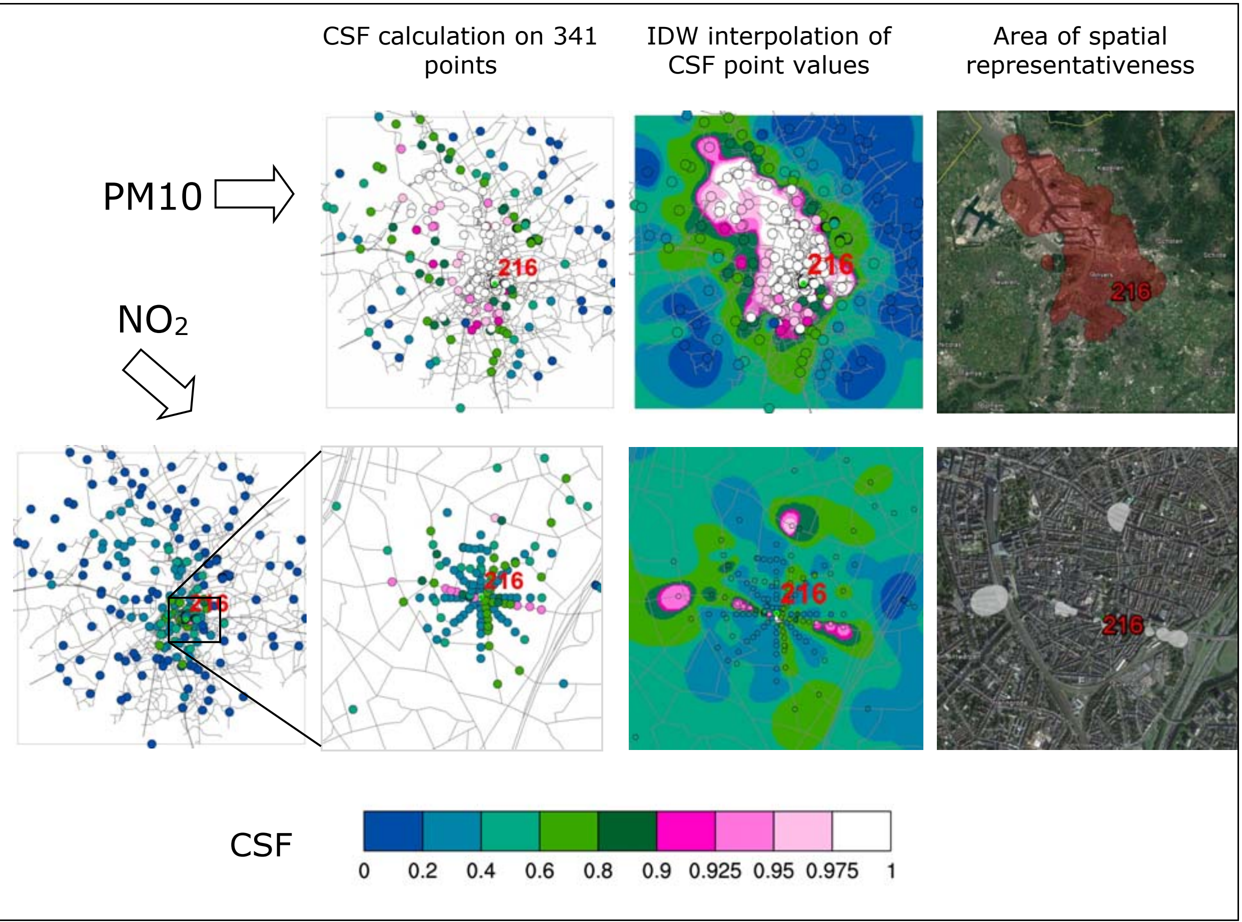
In order to obtain areas of spatial representativeness from the sparse CSF point values, an intermediate step was needed before applying the Nappo condition ($f_{site}(x,y)>0.9$). Inverse Distance Weighting (IDW) interpolation has been applied to the CSF point estimates in order to obtain numerical values on a regular grid. Other geostatistical interpolation methods interpolation methods, i.e. kriging, were tried but resulted not satisfactory.

The maximum extension of the domain for IDW interpolation was set according to virtual stations coverage in order to avoid interpolation artefacts (spatial representativeness areas covering zones without availability of concentrations values). The SR areas were also clipped with the concentration domain boundaries, provided in .shp format by JRC.

Finally, the feature polygons of spatial representativeness were intersected with the thematic layers of population and pollutant concentration in order to obtain the population density and pollutant standard deviation for each multipart polygon.

Figure 1 shows a step by step example of the procedure, applied to PM10 and NO_2 for station 216.

Figure 1. Example of the procedure, applied to PM10 (above) and NO_2 (below) for virtual station 216. White and pink points belong to the area of representativeness, while green and blue points are outside.



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FAIRMODE Intercomparison Exercise on the Spatial Representativeness of Air Quality Monitoring Stations

Documentation of Methods and Criteria

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Type of SR methodology: method based on measured or modelled pollutant concentrations

Type of output: spatial representativeness areas (shape files)

2 Introduction

Spatial representativeness (SR) of a monitoring station is one of the most relevant parameters to interpret the measured concentration of a specified atmospheric pollutant for the station. The SR identifies the geographic area surrounding the monitoring station that is expected to exhibit similar pollution level as that of the monitoring station and can be used to assess effects on population to long-term exposure to air pollution in the area. Identification of efficient SR is essential in designing an air quality monitoring network, avoiding redundant measuring nodes and maximizing spatial coverage. SR is useful in human health and ecosystems risk assessment as well as in quantifying population and vegetation exposure to the atmospheric pollution. SR of a monitoring station can be quantified based on the variability of concentrations of a chosen pollutant around the site (Blanchard et al., 1999, Larssen et al., 1999 and Spangl et al., 2007).

Assessment of SR can be based on information from various sources, such as additional measurements of air pollution concentration (Flemming et al., 2005; Vardoulakis et al., 2005; Parra et al., 2009; Venegas and Mazzeo, 2010; Joly and Peuch, 2012), modelled air pollutant concentration obtained from different models (Martin et al., 2013; Santiago et al., 2013), and spatial surrogate data such as emission sources and land-cover characteristics (Henne et al., 2010; Janssen et al., 2012; Righini et al., 2014). It should be noted that obtaining additional measurements of air pollution concentration can be cost-expensive and the performance depends on the allocation and density of the available samplers. Use of surrogate data can be affected on the hypotheses used to generate the surrogates. For this purpose, researchers sometimes tend to use simulated data generated for several virtual receptors for analysing the spatial representativeness (Santiago et al., 2013; Martin et al., 2014). In the present study, the variability in concentration of a pollutant has been obtained by using the virtual station data obtained based on 5km x 5km gridded population data.

The remainder of the document is structured as follows. A short description of the data used, the methodology and results are provided in section 2. Finally, conclusions and future scope is provided in section 3.

3 Data description, methodology and results

In the present study, air pollution concentration of three pollutants, namely nitrogen dioxide (NO_2), particulate matter 10 (PM10) and ozone (O_3), for the city of Antwerp, Belgium were used to identify the spatial representativeness for three monitoring stations at the city. One of the monitoring stations (Traffic: Borgerhout-Straatkant, station ID: 42R802) is an urban traffic station and the remaining two stations are urban background stations (Urban Background (1): Antwerpen-Linkeroever, station ID: 40AL01 and Urban Background (2): Schoten, 42R8011). The locations are shown in Figure 1. The air pollutant data were available from Environmental Protection Agency (EPA) for the year 2012 at an hourly scale. PM10 was available for all the three monitoring stations, while NO_2 was available for Traffic and Urban Background (2) monitoring station, whereas O_3 was available for Urban Background (2) station only for the year. A population density profile is shown in Figure 1. It can be noted that the population is highest near the traffic station. To model the variability in air pollution concentration, 341 virtual station hourly time series data for the three aforementioned air pollutants were considered in the study. The virtual station data were simulated based on the 5km x 5km gridded air pollution data obtained using the RIO-IFDM-OSPM model. A road network for the city of Antwerp was obtained from http://www.mapcruzin.com/free-belgium-arcgis-maps-shapefiles.htm.

The analysis is performed in three steps. The first step involves identification of virtual stations that are similar to the monitoring station in terms of the chosen air pollution concentration, the second step involves identification of the spatial representativeness area and the third step involves estimation of different statistical properties (such as total population, length and area of road network, average air pollutant concentration) for the identified SR area. A brief description of the methodology and results are given below.

3.1 Identification of virtual stations

Out of 341 virtual stations, firstly those stations were selected which can be considered to be similar to the monitoring station (traffic as well as urban background stations). The identification criteria considered are the following:

i) The distance between the monitoring station and the virtual station should not exceed a pre-specified (threshold) distance. A square block of length equal to twice the threshold distance was considered to surround the monitoring station. In the present study, the distance considered for the traffic station was 500m and that for each of the urban background stations was 3000m. A higher value was considered for the urban background stations to ensure that sufficient numbers of virtual stations are present for the analysis.

ii) The deviation in concentration values between the monitoring station and the virtual stations should not exceed a pre-specified (threshold) percentage. In the present study, hourly concentration data for the year 2012 were considered. It is impractical to ensure that deviation corresponding to all the 8784 data points (366 days x 24 hours) will be within the pre-specified value for a virtual station to be considered similar. For this purpose, the median of the deviations of concentration between the monitoring and the virtual stations was considered. If the median is less than or equal to 20%, the virtual station were considered to be similar.

3.2 Identification of spatial representativeness (SR) areas

Once the set of similar virtual stations were identified, the annual mean concentration for each of the selected virtual station were estimated. Subsequently, the annual mean concentration for those selected virtual stations were used to obtain spatial concentration profile using krigging based interpolation. To perform krigging, Gaussian interpolation had been used for the study.

To identify the spatial representativeness area for the monitoring station, the aforementioned two criteria (threshold distance and concentration differences) were ensured and the spatial representativeness (SR) areas were identified. The SR areas for NO_2, PM10 and O_3 for the monitoring stations were shown in Figure 2.

3.3 Estimation of statistical properties for SR area

Based on the variation in concentration within the identified SR area, the mean and standard deviation of concentration were estimated (see Table 1). Following this, the number of inhabitants and the population density for SR area were estimated based on the population density information (see Table 1). Further, the road network was superimposed for each of the SR area to estimate the total length and area of road network for each of the SR area corresponding to traffic or urban background stations and for different pollutants (NO_2, O_3 or PM10). Those values are provided in Table 1. Though the current study does not consider the road network and the traffic volume data to identify the SR area, those information might be used in future research.

It can be noted from the table that the average NO_2 concentration is considerably higher (~1.5 times high) than that of the urban background station (Urban Background (2)). However, the average concentration of PM10 is similar for SR area corresponding to all the three monitoring stations. The population density in the SR area of the traffic station is very high (~5-10 times more) when compared to that of the urban background stations. This indicates that more people are exposed to higher NO_2 concentration near the traffic station.

4 Conclusion

Spatial representativeness (SR) areas for monitoring stations at Antwerp, Belgium were identified using krigging based Gaussian interpolation technique. The methodology utilizes air pollution concentration from monitoring station and from modelled stations to identify the spatial representativeness area. The methodology can be extended to obtain a better SR area by using additional information such as transportation network, land cover, wind speed and direction, traffic volume, point source emission, road emission and monitoring network. One option can be to use model such as Simulation for Environmental health analysis (SIENA), which can perform simulations in an environmental epidemiological context (Fecht et. al, 2014). The SIENA model can be combined with Atmospheric Dispersion Modelling System (ADMS, Carruthers et. al., 1994) to account for the dispersion of the concentration of air pollution. However, it is to be noted that currently Dublin, Ireland has only data from few monitoring stations available for analysis. Lack of any detailed data as well as the modelled station data makes it a challenge to estimate SR areas for Dublin using even a simple method.

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Table 1. Details for each of the spatial representativeness area for NO_2, O_3 and PM10.

Station name	Borgerhout-Straatkant		
Additional info	Traffic Station ID: 42R802		
	NO_2	PM10	O_3
Surface area of representativeness in km²	3.43	3.39	NA
Number of inhabitants within the area of representativeness	45042	44004	NA
Density of inhabitants within the area of representativeness	13131.8	12980.5	NA
Mean pollutant value within the area of representativeness	43.54	25.71	NA
Standard deviation of pollutant values within the SR area	7.617	1.183	NA
Area of road network (km2)	3.44	3.39	NA
Length of road network (km)	75.9	75.68	NA

Station name	Antwerpen-Linkeroever			Schoten		
Additional info	Urban Background (1) Station ID: 40AL01			Urban Background (2) Station ID: 42R8011		
	NO_2	PM10	O_3	NO_2	PM10	O_3
Surface area of representativeness in km²	NA	37.7	NA	27.43	37.7	37.7
Number of inhabitants within the area of representativeness	NA	87233	NA	38773	81045	73982
Density of inhabitants within the area of representativeness	NA	2313.9	NA	1413.5	2149.7	1962.4
Mean pollutant value within the area of representativeness	NA	24.91	NA	28.22	22.47	35.36
Standard deviation of pollutant values within the SR area	NA	1.192	NA	4.129	1.718	3.013
Area of road network (km2)	NA	37.68	NA	27.44	37.68	37.06
Length of road network (km)	NA	349.65	NA	175.85	279.4	267.57

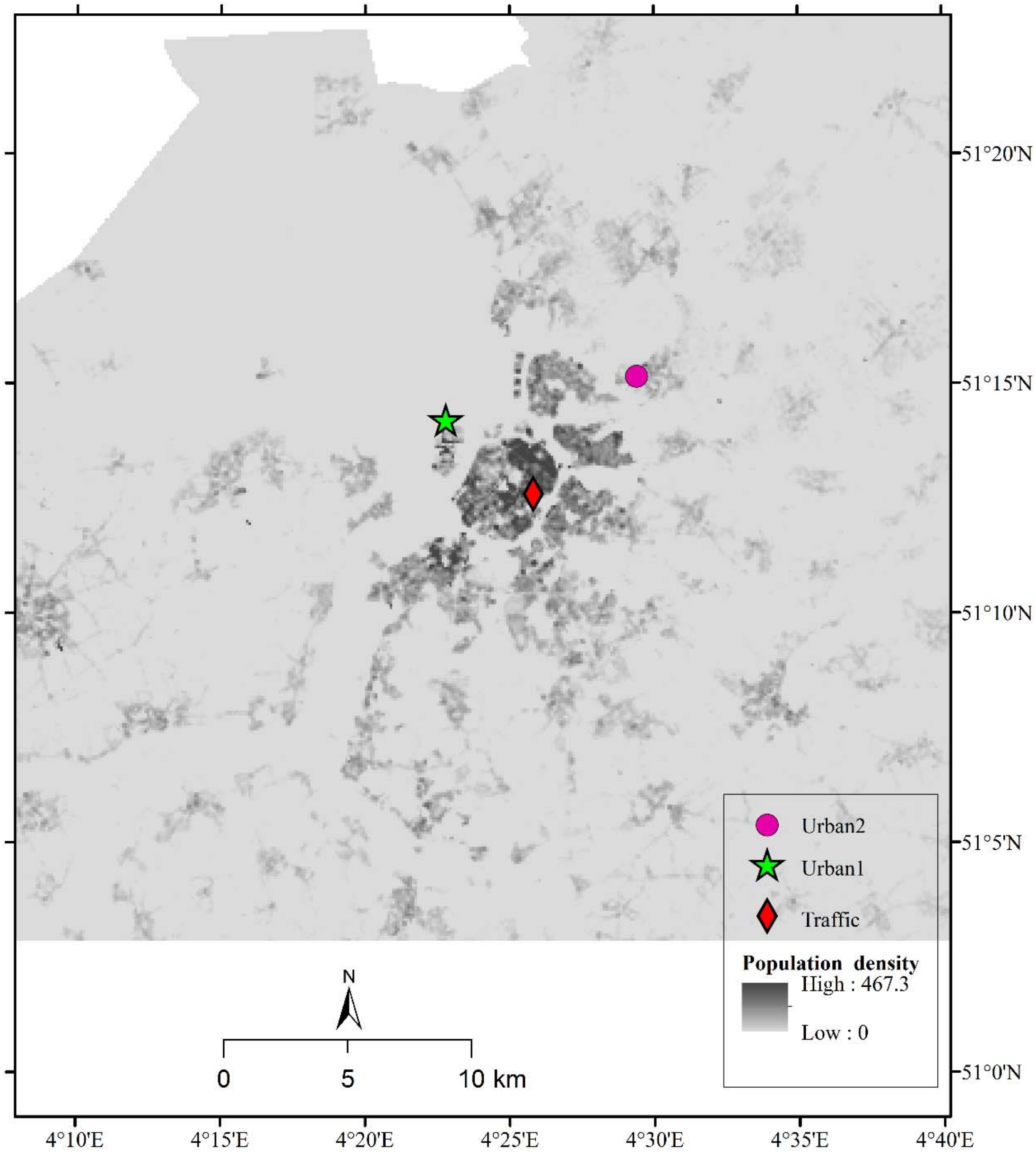

Figure 1. Locations of the traffic (Borgerhout-Straatkant) monitoring station and two urban background monitoring stations Urban Background (1) (Antwerpen-Linkeroever) and Urban Background (2) (Schoten) along with the population density.

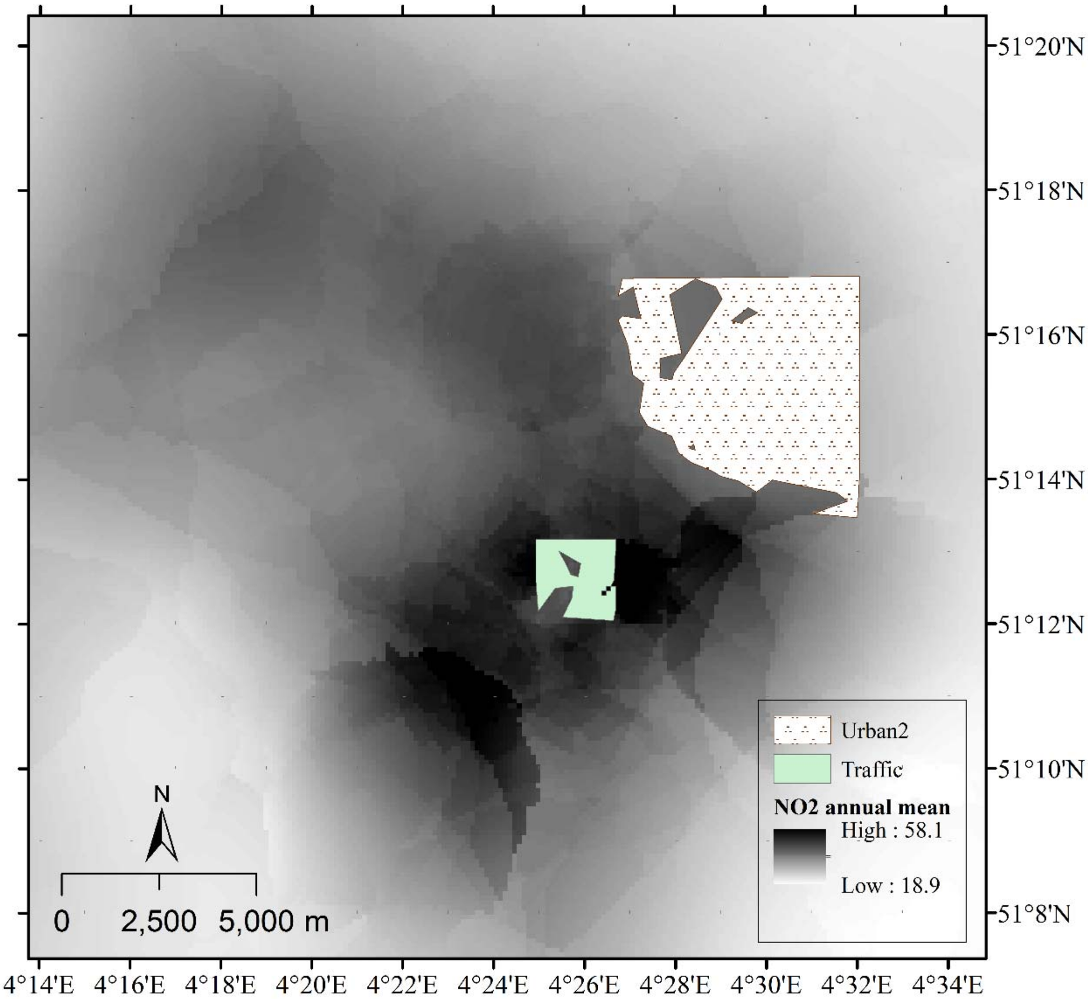

Figure 2a. SR area for NO_2 concentration for the traffic station Borgerhout-Straatkant and Urban Background (2) station Schoten.

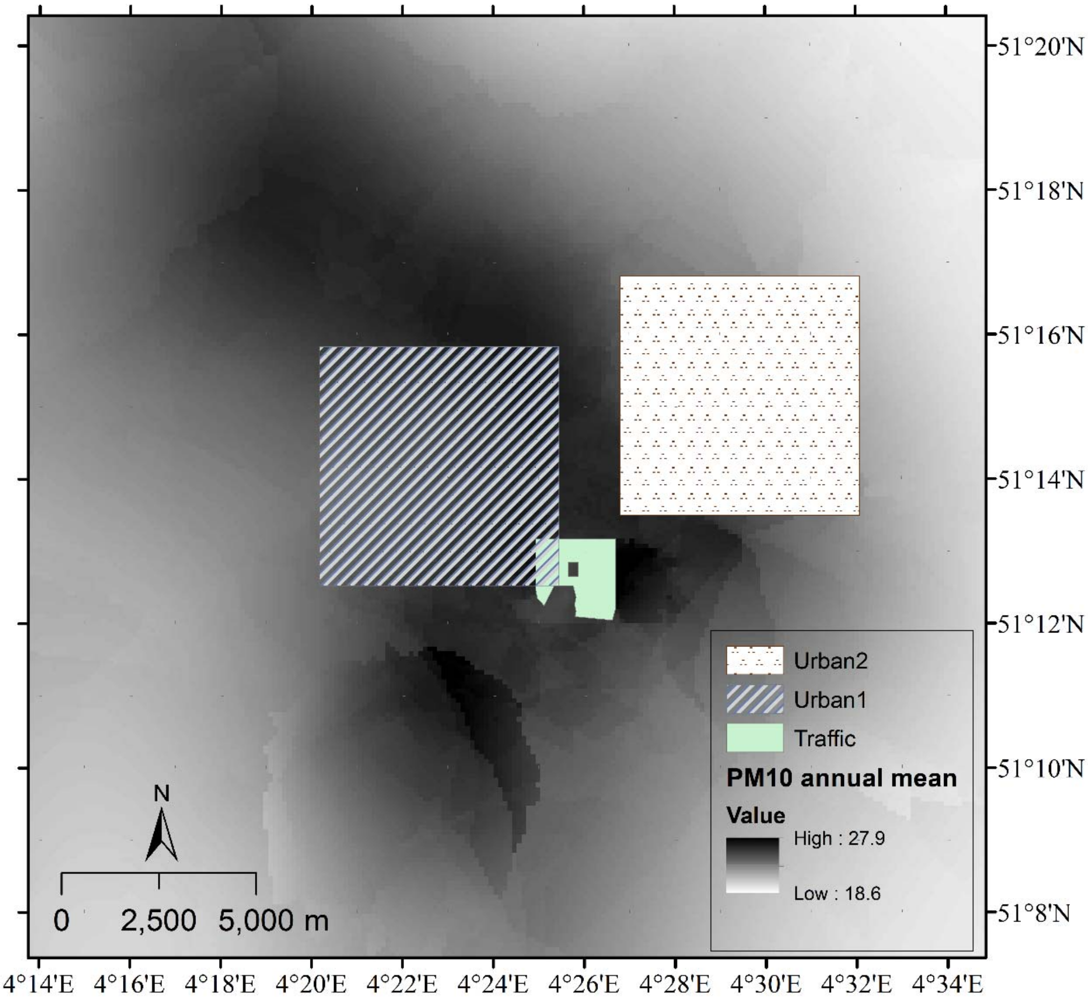

Figure 2b. SR area for PM10 concentration for the traffic station Borgerhout-Straatkant, Urban Background (1) station Antwerpen-Linkeroever and Urban Background (2) station Schoten.

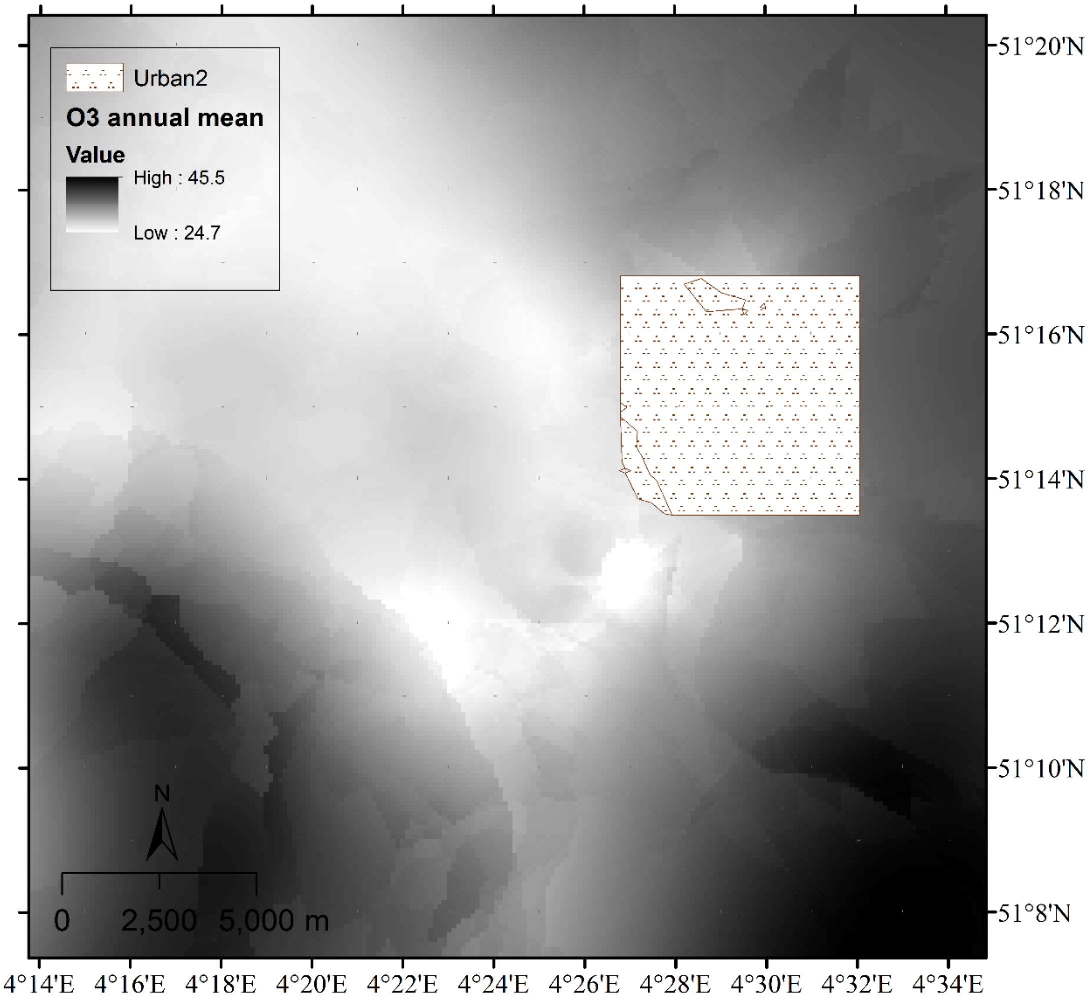

Figure 2c. SR area for O_3 concentration for Urban Background (2) station Schoten.

FAIRMODE Intercomparison Exercise on the Spatial Representativeness of Air Quality Monitoring Stations

Documentation of Methods and Criteria

Umweltbundesamt / Federal Environment Agency Austria (UBA)

1 General Information

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Institute Abbreviation: UBA

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Type of SR methodology: Method based on both measured or modelled pollutant concentrations (if not available: concentration proxies).

In addition to concentration based similarity criteria, information on emissions, road-type and dispersion conditions (land-use) are used; delimitation of industrial influences by modelling and expert judgement.

Type of output: spatial representativeness areas (shape files)

2 Definition of representativeness

The representative area of a monitoring station for a specific pollutant is defined by a concentration range based tolerance criterion (calculated as specified metrics) around the measured value.

In addition, the area of representativeness is limited by criteria concerning emissions and dispersion conditions. The original documentation of the definition was given in the study "Representativeness and classification of air quality monitoring stations" (Umweltbundesamt, 2007)[1].

2.1 Concentration similarity threshold

Within the representative area, the concentration of a specific pollutant, assessed as a specific metric, is within a certain concentration range.

Concentration similarity thresholds have been laid down for the pollutants NO_2, PM_{10} and Ozone based on the metrics related to legal limit or target values according to Dir. 2008/50/EC: Annual mean values for NO_2 and PM_{10}, 90.4 percentile of the daily mean

[1] http://www.umweltbundesamt.at/fileadmin/site/publikationen/REP0121.pdf

values of a calendar year for PM_{10}, 93.2 percentile of the daily maximum eight hour mean values of a calendar year for Ozone.

The concentration similarity thresholds for the representative area have been set as ±5 % of the total concentration range observed in Europe. These values, based on AirBase data for 2002 to 2004, are given below:

- NO_2: Annual mean value at the monitoring station ± 5 µg/m³
- PM_{10}: Annual mean value at the monitoring station ± 5 µg/m³
- PM_{10}: Annual 90.4 percentile of daily mean values at the monitoring station ± 8 µg/m³
- Ozone: annual 93.2 percentile of daily maximum 8-hour mean values at the monitoring station ± 9 µg/m³

It should be noted that the selection of the concentration similarity threshold is a deliberate decision. The applied values can be justified as the give representative areas for urban background and traffic stations which do not overlap.

2.2 Emissions

According to Umweltbundesamt (2007), the predominant influence of the three source categories

- road traffic
- domestic heating
- industry (including waste incineration, power generation and shipping emissions)

is considered.

Modelling could be an instrument to separate the contributions from different source categories; however, the model data available for Antwerp do not allow such separation.

Umwelbundesamt (2007) proposes to quantify the impact of local road traffic emissions by the proxy: "emissions divided by the square root of the distance from kerb".

Different types of roads – urban road, extra-urban roads and motorways – could be discriminated.

The impact of domestic heating emissions is considered by the annual emissions within 1 km Radius around the monitoring station.

Umweltbundesamt (2007) proposes no criteria for the identification of the impact of industrial emissions; this should be done based on plume dispersion modelling or expert judgement (which could be the interpretation of modelled concentrations).

2.3 Dispersion conditions

Umweltbundesamt (2007) considers dispersion conditions on three different spatial scales:

1. Local dispersion conditions are related to the buildings near the monitoring station and distinguish street canyons, streets with detached buildings and open terrain.
2. Regional dispersion conditions distinguish between plane terrain, hilly terrain, basins, valleys and mountainous terrain
3. Large-scale dispersion conditions distinguish areas with different topographic and climatic conditions, e.g. Alps (separated north and south of the central rim), pre-alpine lowlands, the Hungarian Plane, the Bohemian massif, etc.

In addition, our method restricts the extent of the representative area to a radius of 100 km (roughly corresponding to the life-time of NO_2 and the formation of secondary particles), in order to avoid very large representative areas in regions with a homogeneous distribution of climatic conditions, concentrations, and emissions.

3 Methods for identifying representative areas in Antwerp

3.1 Concentrations

The concentration criteria laid down in section 2.1 have been modified for the representativeness assessment for Antwerp:

- The 90.4 percentile for the PM_{10} daily mean values is not applied, because the model data are available (only) as annual mean values[2].
- The concentration similarity threshold for the PM_{10} annual mean value has been reduced to ± 3 µg/m³ with respect to the overall decrease of PM_{10} levels in the last decade.
- Since ozone model data are available (only) as annual mean values, the concentration criterion for ozone has been transferred to annual mean values using the data available for the virtual stations in Antwerp. The average ratio between the annual mean value and the 93.2 percentile of daily maximum 8-hour mean values for the virtual stations is 0.45. This gives a similarity threshold of ± 4.1 µg/m³ for the ozone annual mean.

The delimitation of representative areas within the concentration similarity threshold is based on the high-resolution model data for the annual concentration fields.

Since model data are available for Antwerp, the use of proxy data as discussed in Umweltbundesamt (2007) is not necessary.

3.2 Emissions

The identification of areas predominantly influenced by industrial emissions could be derived from sector specific modelling. However, since such data are not available in Antwerp, the delimitation of areas predominantly influenced by industrial emissions in Antwerp is based on the total concentration from the model and done by expert judgement. The concentration pattern shows areas with high NO_2 und PM_{10} concentrations north-west of the city centre of Antwerp, which are obviously not caused by domestic heating or road transport. The area of predominant industrial influence (identical for NO_2 und PM_{10}) is delimitated manually in the GIS[3].

The assessment of the impact of traffic emissions according to Umweltbundesamt (2007) ("emissions divided by the square root of the distance from kerb") has not been applied in Antwerp because

(a) it causes high effort in GIS calculations and

(b) the results more or less follow the modelled concentration pattern itself and provide no additional information.

The different emission pattern on motorways compared to urban roads has been considered by the identification of motorways (as "road type 1"). The area influenced by motorway emissions has been delimitated as ±300 m alongside the motorways. The distance of 300 m has been derived from the Antwerp model data; it should make sure

[2] 90.4 percentiles of daily mean values have been calculated from the time series provided at selected „virtual monitoring stations"; these revealed the same spatial distribution as the annual mean values, therefore the 90.4 percentile was finally not considered for the representativeness assessment.

[3] Note: The virtual station 68 is located at the boundary of the "industrial area", but also influenced by major roads. The representative area covering medium polluted background areas near the city centre is therefore questionable. The station may alternatively be classified as "industrial", and its representative area may cover parts of the "industrial" area north-west of the city centre.

that areas with medium concentrations up to 300 m meters from motorways are not included in the representative area of urban traffic stations.

Domestic heating emissions for NO_x are not considered, because:

(a) the impact of domestic heating emissions on the observed/modelled NO_2 concentrations is low compared to road traffic and

(b) the emission data allow no unique identification of domestic heating emissions, which are included in SNAP sector 2 "non-industrial combustion plants". Besides the city centre, there are areas in the south with (very) high emissions from SNAP sector 2 which do not correspond to the high NO_2 levels from the model outputs.

Domestic heating emissions for PM_{10} are included in the assessment of representativeness; their relative contribution, compared to road traffic, to PM_{10} levels is higher than for NO_x.

However, the criteria for domestic heating emissions developed in Umweltbundesamt (2007) provide no useful results for Antwerp. Most (virtual) stations are located in areas with low domestic heating emissions, where the emissions do not seem to influence PM_{10} levels significantly.

Instead, a larger concentration range of ± 10 t/km² per year, compared to the 1 km-surroundings of each (virtual) station, has been selected as a threshold (which more or less separates the city centre from all suburban areas).

3.3 Dispersion conditions

In order to assess the local dispersion conditions, CORINE Landcover (CLC) data are used as a proxy for the building structure, applying CLC class 1.1.1 for street canyons, 1.1.2 for areas with detached buildings, and other classes for open terrain.

The only station in Antwerp within the CLC 1.1.1 area is Borgerhout Straatkant. The location of this site, however, does not look like a street canyon in "google maps", since there are detached buildings and green areas north of the street Plantin en Moretuslei.

The suburban stations are partly located in the CLC 1.1.2 area, partly outside. The concentration pattern is likely not influenced by the CLC 1.1.2 boundary.

Since there are no street canyon stations within the set of monitoring stations and virtual stations, local dispersion conditions are not considered as a parameter to delimitate representative areas.

Regional dispersion conditions, which consider the topographic situation, do not apply in the Antwerp area, because it is uniformly flat.

4 Classification

4.1 Station type: Traffic – industrial – background

The classification described in Umweltbundesamt (2007) is based on the quantification of the impact of road traffic and industrial emissions.

As stated above, the parameter "emissions divided by the square root of the distance from kerb" to describe the impact of local road traffic emissions has not been analysed.

The classification of "traffic" stations is based on the spatial distribution of the modelled concentration. Borgerhout and the virtual stations 115 und 135 are clearly classified as "traffic".

Since no information about the contribution of industrial emissions is available (e.g. from modelling), the area influenced by industrial emissions is estimated manually from the model results.

The virtual station 43 is therefore classified as "industrial".

The classification of the virtual station 68 is not clear. It is located at the boundary of the "industrial area", but also located near large roads and highways. With an NO_2 annual mean of 37 µg/m³, the concentration level is above the suburban background level, which is a hint on a significant industrial impact.

All other virtual stations as well as Schoten and Linkeroever are "background".

4.2 Type of area: Rural – suburban - urban

The "type of area" classification is based on the population distribution.

Based on Umweltbundesamt (2007), areas with < 1000 inh. in within a 1 km radius are classified as "rural", with 1000 – 8000 inh. as "suburban", and with more than 8000 inh as "urban".

Note 1: It may be appropriate to select a higher threshold between "rural" and "suburban" with respect to the high rural population density in Belgium.

Note 2: The virtual station 43 is located in uninhabited area. However, with respect to the position in relation to the town and the industrial surroundings, it should be classified as "suburban" rather than "rural".

Note 3: Virtual station 88 is near the classification boundary between "rural" and "suburban".

Note 4: The virtual station 68 is located at the classification boundary of the "industrial area", but also influenced by large roads. The station may alternatively be classified as "industrial".

5 Possible future modifications of the SR method

The experience obtained by applying the SR method laid out in Umweltbundesamt (2007) on the Antwerp data as well as on data sets in Austria suggests some future modifications.

The criteria for the impact of predominant emissions turned out to be not very useful, because

a) the predominant contributions to NO_2 concentrations originate from road transport even in background areas,

b) the spatial distribution of NO_2 concentrations is distinctly triggered by the spatial distribution of road traffic emissions (except for those areas influenced by industrial emissions),

c) the predominant contribution to PM_{10} concentrations in most (urban as well as rural) background areas is from a large-scale background which cannot be attributed to specific sources,

d) domestic heating is rarely the predominant source of NO_2 concentrations and even in case of PM_{10} only in specific areas with a high share of solid fuels used.

Therefore it could be considered only to take into account the impact of industrial emissions.

The impact of road traffic emissions is included in the spatial concentration pattern itself, and needs no separate assessment of traffic emissions.

References

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FAIRMODE Intercomparison Exercise on the Spatial Representativeness of Air Quality Monitoring Stations

Documentation of Methods and Criteria

Finnish consortium (FI)

1 General Information

Institute: Finnish consortium: Finnish Meteorological Institute (FMI), Helsinki Region Environmental Services Authority (HSY), Environmental Services Authority of City of Turku (Turku), Environmental Services Authority of City of Kuopio (Kuopio)

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Type of SR methodology: method based on both measured or modelled pollutant concentrations and concentration proxies

Type of output: spatial representativeness areas (shape files) + Result form (excel file) and description of used method (.docx)

2 Description of used method and result of the IE

Estimation of SR areas was based on modelled yearly mean concentrations modelled by VITO, measurements of the AQMSs and data presenting their surrounding (building height & density, roughness /land-use). In addition to these, traffic intensity was a main input when estimation SR areas for the traffic station. For background stations, locations of emission sources and wind direction distributions have been also considered. As a background information also other data has been studied to have more in-depth understanding on weather, emissions and pollution in Antwerp. This included seasonal temperature variation, location of emissions sources, results of passive sampling campaigns and concentration at the most closest virtual monitoring stations.

SR areas have been estimated based on similarity. At the traffic station, streets with similar traffic intensity have been chosen from the area with equal city structure. At the background stations, areas with similar city structure, modelled concentration and under same emission sources have been chosen.

Number of inhabitants wasn't calculated because of problems with the provided data. In addition to the provided data, Google satellite images and Google street view data have been used. Google data gives a good overview of the area under review and the surroundings of the measurement stations. Google data has been used instead of e.g. CORINE land use data.

As opposed to Belgium, PM_{10} representative areas cannot be estimated based on NO_2 in Northern Europe because of specific winter conditions (sanding, winter tires -> pollution). This is important to notice when planning equal methods to estimate representativeness.

Below is a short summary of main background information used by station wise.

2.1 Borgerhout-Straatkant

2.1.1 NO_2

Used background information:

- information on traffic (average traffic volume, speed, diurnal & weekly variation)
- distribution of yearly mean concentration
- measurements of monitoring stations
- city structure (building information, density and classification of streets, google satellite images and street view)

Representative **roads** have been chosen based on above mentioned data. Main data were average daily traffic volume, speed limit, city structure and model results. Mean pollutant concentration and SD values were estimated based on measurements and model results.

2.1.2 PM_{10}

Used background information:

- information on traffic (average traffic volume, speed, diurnal & weekly variation)
- distribution of yearly mean concentration
- measurements of monitoring stations
- city structure (building information, density and classification of streets, google satellite images and street view)

The representative area has been estimated based on above mentioned data. Main data were measurements (PM_{10} + $PM_{2,5}$, also monthly variation), model results, city structure. Mean pollutant concentration and SD values were estimated based on measurements and model results.

2.2 Antwerpen-Linkeroever

2.2.1 NO_2

Used background information:

- information on traffic (average traffic volume, speed)
- distribution of yearly mean concentration
- measurements of monitoring stations
- city structure (building information, density and classification of streets, google satellite images and street view)
- meteorology

The representative area has been estimated based on above mentioned data. Main data were model results and city structure. Mean pollutant concentration and SD values were estimated based on measurements and model results.

2.2.2 PM_{10}

Representative area is the same as for NO_2 based on same data. Note: this method could not be used in norther countries because of the specific winter conditions.

2.2.3 O_3

Used background information:

- meteorology (wind direction)
- distribution of yearly mean concentration
- measurements of monitoring stations
- city structure (industry – point sources, building density, google satellite images and street view)

The representative area has been estimated based on above mentioned data. Main data were model results, city structure (especially location of industry) and meteorology. Mean pollutant concentration and SD values were estimated based on measurements and model results.

2.3 Schoten

2.3.1 NO_2

Used background information:

- meteorology (wind rose)
- information on traffic (average traffic volume, speed)
- distribution of yearly mean concentration
- measurements of monitoring stations
- city structure (building density and classification of streets, google satellite images and street view)

Representative area has been estimated based on above mentioned data. Main data were wind rose, model results and city structure (location of highway). Mean pollutant concentration and SD values were estimated based on measurements and model results.

2.3.2 PM_{10}

Representative area is the same as for NO_2 based on same data. Note: this method could not be used in norther countries because of the specific winter conditions.

2.3.3 O_3

Used background information:

- meteorology (wind rose)
- distribution of yearly mean concentration
- measurements of monitoring stations
- city structure (industry – point sources, building density, google satellite images and street view)

Representative area has been estimated based on above mentioned data. Main data were model results, city structure (especially location of industry) and meteorology. Mean pollutant concentration and SD values were estimated based on measurements and model results.

FAIRMODE Intercomparison Exercise on the Spatial Representativeness of Air Quality Monitoring Stations

Documentation of Methods and Criteria

LCSQA/INERIS

1 General Information

Institute: National Institute for Industrial Environment and Risks

Institute Abbreviation: INERIS

Participation of INERIS as part of the **Central Laboratory for Air Quality Monitoring (LCSQA)** – the French National Reference Laboratory -.

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Type of SR methodology: method based on modelled pollutant concentrations

Type of output: spatial representativeness areas (shape files)

2 Introduction

As member of the French National Reference Laboratory (LCSQA), INERIS was mandated by the Ministry in charge of the environment to participate to the FAIRMODE Representativeness Intercomparison Exercise.

Station representativeness was assessed for **NO_2 and PM_{10} on annual averages**. The applied methodology is described hereafter. No results were produced for ozone as the methodology has not been adapted for this pollutant yet.

3 Methodology: summary

The station representativeness (SR) areas were estimated in two main stages.

A spatial estimate of concentrations and concentration uncertainties (from kriging error standard deviations) was first prepared. NO_2 and PM_{10} concentrations were interpolated from modelling output data applying a recently developed kriging-based approach (Beauchamp et al., 2016). This methodology is an adaptation of external drift kriging where emission data and distance to the roads are used as secondary variables to account for concentration gradients in urban areas and include traffic-related data in the map.

Finally, the SR areas were delimitated based on a combined criterion for maximum permissible concentration deviations (30% for NO_2 and PM_{10}) and maximum permissible statistical risk (15% risk of wrongly including a point in the SR area). Details on this combined criterion are provided in the next section.

4 Methodology: detailed description

4.1 Assessing representativeness of a single monitoring point

The methodology used to delimit SR areas is described in Beauchamp et al. (2011) and Bobbia et al. (2008). Spatial representativeness is defined per pollutant and type of variable (here the annual mean) according to concentration similarity. The evaluation is based on a kriging estimation of concentrations, using the kriging error standard deviation as a measurement of interpolation uncertainty.

The representativeness area of a station S_0 located in x_0 is defined as:

$$A_0 = \{x \mid |Z(x) - Z(x_0)| < \delta\} \quad (1)$$

Where:

- $Z(x)$ is the unknown concentration at a location x
- $Z(x_0)$ is the observed concentration at station S_0 (the measurement error is not taken into account
- **δ is the similarity criterion,** expressed as the maximum tolerated deviation of concentration with respect to the station (in $\mu g.m^{-3}$ or in percentage of the station measurement)

Considering the annual mean concentration as the realization of a random function, definition (1) can be expressed in terms of expectation. $Z(x)$ is then replaced by its kriging estimate, noted $Z^K(x)$, and the estimation error is pragmatically assumed to be normally distributed.

Given the **statistical risk, noted η_r**, that a point be wrongly included in A_0, definition (1) finally becomes:

$$A_0 = \left\{x \ : |Z^{\mathrm{K}}(x) - Z(x_0)| < \delta - \sigma_{\mathrm{K}}(x) \times q_{1-\frac{\eta_r}{2}}\right\} \ (2)$$

$\sigma_K(x)$ is the kriging standard deviation at location x and $q_{1-\frac{\eta_r}{2}}$, the quantile of order $1-\frac{\eta_r}{2}$ of the normal distribution.

4.2 Assessing representativeness of a monitoring point in relation to other stations

Only the results from the previous step (§4.1) were considered in the intercomparison. However, in case of overlap between two or several SR areas, a further step may consist in attributing each point in the intersection zone to only one SR area.

The objectives of such imputation are:

- to check whether the representativeness areas of the different stations together cover the whole domain;
- to determine by which station each point of the domain is best represented.

Different ways of doing this imputation were previously tested (Beauchamp et al., 2011). The retained criterion is the minimum concentration deviation from the station measurement.

5 Discussion

In this exercise, a similarity criterion in % gave more realistic representativeness areas than a criterion in $\mu g.m^{-3}$ which tended to produce too large areas for stations measuring low values. The quality objective in terms of modelling uncertainty for NO_2 annual mean (Directive 2008/50/EC), namely 30%, was used for NO_2. Though stricter than the quality objective for PM_{10} (50%), it was also applied to PM_{10} stations which displayed large representativeness areas.

The methodology described in section 4.1 amounts to modulating the similarity criterion according to the map uncertainty (see formula 2): the criterion is less strict where the kriging standard deviation is low and more stringent where the kriging standard deviation is high. Despite moderate kriging standard deviation values, it occurred that for NO_2 and for some of the stations, this modulation led to exclude the station grid cell itself and neighbouring cells from the station representativeness area. The initial statistical risk of 10% (risk of wrongly including a point in a representativeness area) was increased to compensate for this effect without however fully solving this issue. A risk of 15% was selected as an acceptable compromise.

Excessive sensitivity to the kriging standard deviation may thus be a limitation of the methodology. More research would be necessary to investigate this problem and make adjustments where appropriate.

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FAIRMODE Intercomparison Exercise on the Spatial Representativeness of Air Quality Monitoring Stations

Documentation of Methods and Criteria

ISSeP & AwAC

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Type of SR methodology: method based on pollutant concentration proxies

Type of output: spatial representativeness areas (shape files)

2 Description of the method

The methodology that we used aims at defining a monitoring site's spatial representativeness (SR) area without a priori knowledge of the concentration levels. We only used emission data and, in the case of sites locally influenced by traffic, the topography of its surroundings. This choice was made so that the method can be used either to install new permanent or temporary stations, or to define the spatial representativeness area of already existing ones.

2.1 Verification of the site classification

The first step of our methodology is to determine whether the site is locally influenced by traffic or not. Although the type of the three investigated stations (40AL01, 42R802 and 42R811) was pre-determined, we measured the distance of their location to the closest major road and used this parameter to confirm the 42R802's characterization as a traffic site. We used 30 m as a threshold to distinct traffic (distance < 30 m) and non-traffic (distance >= 30 m) sites. As a confirmation, when measurements are available, this character can be confirmed by historical series, on the basis of temporal profile. We used the most recent results of the Joly and Peuch methodology (2012) over the European monitoring network to confirm the traffic character of the 42R802 site for both NO_2 and PM_{10}.

2.2 Traffic stations

As traffic sites are highly influenced by very local sources, their spatial representativeness areas are much more restricted and the way to evaluate them is performed with a different method than for the background sites. We assumed here that road emissions are the main, and in practice only, sources that influence the concentrations at the stations.

Our similarity criteria for the traffic stations are based on road emissions in the nearest vicinity and on street configuration. As the pollutant concentrations are highly influenced by local sources, we restricted the analysis area to a 500 m radius buffer.

Road segments within this area were divided into three categories of pollution level (Table 1). Thresholds of pollution levels were defined in order to represent three classes of equivalent size. We note here that we restricted the study to the segments where emissions were available, and which are supposed to be the main roads.

Table 1. Categories of pollution level.

Category	Level	NO_2 (kg/km/yr)	PM_{10} (kg/km/yr)
Low	1	<100	<20
Medium	2	100-500	20-100
High	3	>500	>100

However, in traffic sites pollutants may not disperse properly due to street canyons. We therefore evaluated if the road segments were located within a street canyon, and increased the pollution level by one when a segment was considered as such.

For this purpose, the street canyon index was calculated as follows:

- Steepness index = Average building height/Segment width (ADEME 2002).

  In order to obtain a proxy of the segment width, we defined the number of lanes manually (through satellite aerial information) and applied an average width of 8 meters per lane. However, as a further improvement, the segment width could be calculated directly from the buildings layer.
- Building density = Number of buildings/Segment length.
- The segment is considered as a street canyon if the steepness index > 0.5 (ADEME 2002; Austrian report 2007) and the building density > 0.25.

Finally, the spatial representativeness area was defined as the set of road segments in a 500 m radius buffer around the station which present the same pollution level like the station. We furthermore added a 30 m buffer around the segments to reach the first buildings.

From our results we observe that there is almost no difference between the NO_2 and PM_{10} spatial representativeness maps, given that the NO_2 and PM_{10} road emissions are highly correlated.

2.3 Background stations

For the background stations, the determination of the SR areas is based on the similarity of emissions. We used the total emissions of all sectors by km². First, emission grand totals over all snap sectors from the "NOx_OPS_2012_0.csv" and the "PM10_OPS_2012_0.csv" files were resampled on 100*100 m² cells. Then we computed for each of these pixels, the sum of emissions within a 1 km radius circular buffer. By proceeding like this, we smoothed out large variations in the field but kept a fairly high spatial resolution. This is similar to the running mean methodology applied to time series.

The spatial representativeness area is finally estimated by the extraction of all grid cells where the value belongs to the range: emission_value_station ± emission_tolerance. This tolerance was set to 10 $tyr^{-1}(pi*km^2)^{-1}$, i.e. 0.317 $gs^{-1}(pi*km^2)^{-1}$ or 0.101 $gs^{-1}km^{-2}$.

Obviously, emission_tolerance is the key parameter governing the SR area extension. Its choice was made by the following indication found in *Representativeness and classification of air quality monitoring stations* (Austrian report 2007):

Thresholds of 10 $tyr^{-1}(pi*km^2)^{-1}$ and 20 $tyr^{-1}(pi*km^2)^{-1}$ are used to make the distinction between low, medium and high emissions of NO_2. Here, we decided to use the width of the medium class, i.e. 10 $tyr^{-1}(pi*km^2)^{-1}$ as the typical spread as well as our tolerance parameter.

We used the same principle for PM_{10} with a value of 2 $tyr^{-1}(pi*km^2)^{-1}$, i.e. 0.063 $gs^{-1}(pi*km^2)^{-1}$ or 0.020 $gs^{-1}km^{-2}$. A posteriori, we noticed that this value was used for only one emission sector (domestic heating), a value of 10 $tyr^{-1}(pi*km^2)^{-1}$ should have been used to take into account all emission sectors.

For O3, we used the same SR areas as for NO_2, except for Borgerhout.

For further improvements, as discussed in FAIRMODE, the total emissions could be disaggregated by sectors, given their different impact (industrial emissions are emitted at a higher point than road emissions for example). Furthermore, the tolerance criterion could be adjusted to our specific case thanks to the measurement data provided in the Antwerp dataset.

Table 2. Tolerance on NO_2 emissions (expressed in $gs^{-1}(pi*km^2)^{-1}$) for the determination of the site's SR area

Site code	Site emission	Lower bound	Upper bound
40AL01	7.388	7.071	7.705
42R811	1.371	1.054	1.688

Table 3. Tolerance on PM_{10} emissions (expressed in $gs^{-1}(pi*km^2)^{-1}$) for the determination of the site's SR area

Site code	Site emission	Lower bound	Upper bound
40AL01	0.826	0.763	0.889
42R811	0.327	0.264	0.390

References

Joly M., Peuch V.H., 'Objective classification of air quality monitoring sites over Europe', *Atmospheric Environment*, Vol. 47, 2012, pp 111-123.

Agence de l'Environnement et de la Maitrise de l'Energie (ADEME) – Direction de l'Air et des Transports – Département Air, *Classification et critères d'implantation des stations de surveillance de la qualité de l'air*, 2002.

Spangl, W., Schneider, J., Moosmann, L. and Nagl C., Representativeness and classification of air quality monitoring stations, REP-0121, Umweltbundesamt GmbH, Austria, 2007.

FAIRMODE Intercomparison Exercise on the Spatial Representativeness of Air Quality Monitoring Stations

Documentation of Methods and Criteria

National Institute for Public Health and the Environment (RIVM)

1 General Information

Institute: National Institute for Public Health and the Environment

Institute Abbreviation: RIVM

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Type of SR methodology: method based on measured or modelled pollutant concentrations: principal component analysis (PCA)

Type of output: plots with clusters of stations

2 Method

For this exercise we applied the approach which was used to assess the representativeness of the Dutch national Air Quality Monitoring Network (LML) and the other Dutch monitoring networks (Nguyen et al., 2012). This approach consist of two techniques:

— A visualisation/interpretation of the measurement results by means of PCA (principal components analysis).

— A study of the micro/macro status of the stations.

It has to be noted that in the assessment of the area of representativeness of measurement stations the Dutch approach clearly deviates from the information requested in this exercise. In the Dutch system, levels are mainly determined by modelling; therefore the representativeness is evaluated as the applicability to calibrate and validate AQ models. Direct application of a measured value is only recommended in the small area that is comparable with the modelling resolution.

Principal component analysis (PCA):

PCA is a well-known data visualization/data reduction tool that is often applied in analyses of large data sets. For example, the data set of hourly data of 40 stations consists of a matrix of 40 stations × 8760 hourly values. The information can therefore be described in a mathematical space with at least 40 dimensions. Such a space in itself cannot be visualized; to this end, multivariate data visualization tools have been developed. PCA can deliver the "best" two-dimensional projection of the multivariate space. With "best" in this defined as the projection with the conservation of the maximum amount of information present in the data set. The results of the PCA are the principle components. The first principal component (PC1) is defined as the linear combination of the original variables that describes the maximum amount of variation present in the data set. The second principal component (PC2) is similarly defined as the linear combination of the original variables that describes the maximum amount of the remainder of the information found in the data set, and so on.

The samples in this study, i.e. the measurement locations, can be projected on the principal components (PCs). These projections, usually called scores, can be shown as two-dimensional plots; for example, the plot of the scores of PC2 vs. PC1, which is the linear two-dimensional projection of the data set with a maximum amount of variation.

In addition, the relation between the original variables and the PCs, usually called loadings, facilitates the interpretation of the phenomena observed. The results of the first three principle components were studied. If the third component was not very informative, then only the first two are presented in this report.

The analysis tool used in this study is the PLS Toolbox of Eigenvector Research Incorporated for use with MATLAB®.

Study of the micro/macro status of the station

For this stage, Google earth was used to determine whether a monitoring station fulfils the criteria of the EU Directive 2008/50/EC for that type. In the Dutch context the comparison of the measurement results with models is of key importance. Therefore each of measurement locations is also classified according to the official Dutch modelling scheme.

Estimating the number of inhabitants within the representativeness area

In order to estimate the number of inhabitants within the area of representativeness it is assumed that the geometry of the street locations is such that it is representative of (at least) 100 m of street, as required by the AQD. The area of representativeness is then 100*5*2 m^2 (5 meters at both sides of the street). In the assessment of the area of representativeness of measurement stations the Dutch approach clearly deviates from the information requested. In the Dutch system levels are mainly determined by modelling; therefore the representativeness is evaluated as the applicability to calibrate and validate AQ models. Direct application of a measured value is only recommended in the small area that is comparable with the modelling resolution.

For background stations a representative area of 1000x1000 m^2 is assumed. The density of inhabitants as given by dataset Pop_Antw_100m (dataset 6) was used.

3 Dataset used in the analyses

The set of measurement data itself is too small to fully explore the potential of this technique. Because of the small size of the measurements dataset (the dataset covers only measurements in Antwerp) we had to combined measurements data with part of the modelled data (dataset 4). Only modelled data with a clear classification were used:

— Virtual stations which were modelled as streetcanyon (“SC”).

— Virtual stations which were modelled as “no SC” and have a distance of 0 or 10 m to a road were used as “Traffic (T)” data.

— Virtual stations with a distance =200m to a main road or 100m to a minor road (station 314 &334) were used as UB data.

The minimum data capture was set at 75%. A few stations have only a few months data and were therefore left out.

Furthermore, OpenStreetMap road network was used for sighting the data. These data is not required for the PCA analysis.

Based on previous experiences obtained with the Dutch Monitoring network, the PCA analysis was performed with diurnal variation. For each hour of the day, an average concentration over the whole year was calculated. For each component the data set of N stations is an N-by-24 matrix. To ensure that all relevant information is obtained, both score plots of the PC1 vs PC2 and PC1 vs PC3 are studied. However, the plot of PC1 vs PC3 is only shown if relevant additional information from this plot can be reported.

In order to explore the influence of local sources, a similar second study was performed using average concentration roses. Both analyses were performed without autoscaling of data.

The results are shown as projections of the measurement locations (usually called score plot) and as projections of the initial variables (usually called loadings plot) on the principle components.

The legends in the plots are as follows:

I_M: industrial (measured)

SC: virtual Street canyon

T: virtual traffic location, “no SC”-stations, with a distance of 0 or 10m to road

UB: virtual stations with a distance > 200m to a road and > 100m to a minor road (station 314 &334)

SC_M: measured SC station Borgerhout-Straatkant 42R802 (to be investigated, only NO_2 and PM_{10})

T_M: measured traffic station 42R801

UB_M: measured UB stations to be investigated: Schoten 42R811 (NO_2, PM_{10}, O_3) and Antwerpen-Linkeroever 40AL01 (only PM_{10})

Remark: virtual SC stations 237, 326, 327 are left out because these stations differ too much from the rest and dominate the plot. These stations are very close (distance 0-10m) to a highway/major road.

4 Assessment based on NO_2 concentrations

4.1 Analysis using diurnal variation

Figure 1 shows the projection of the NO_2 measurement results on their first 2 PC-s. The first PC on the x-axis covers 99.5 % of the variance/information in the data set. A hypothetical measurement station with always zero concentrations would be projected at the origin of the plot (on the far left hand side). The picture is very similar to the projection on the first two PC's of the Dutch monitoring stations. Stations with high average concentrations are projected on the right hand side. From the picture we clearly see that both modelled and measured street canyon locations are on the right hand site (high concentrations). The urban background locations are found on the left hand site. The second PC covers 0.45 % of the variance in the data set. A shift is observed between urban background and traffic stations which is shown with the blue arrow. For more detailed interpretations we also have to study the loading plot (figure 3).

Figure 2 shows the projection of the NO_2 measurement results on their first and third PC-s. Note that the third PC only covers 0.03 % of the variance. The scores show on the third PC mainly a separation of the industrial stations. Apparently the diurnal pattern of industrial stations differs from urban background and traffic stations.

Figure 1. Score plot of PC1 and PC2 for diurnal variation

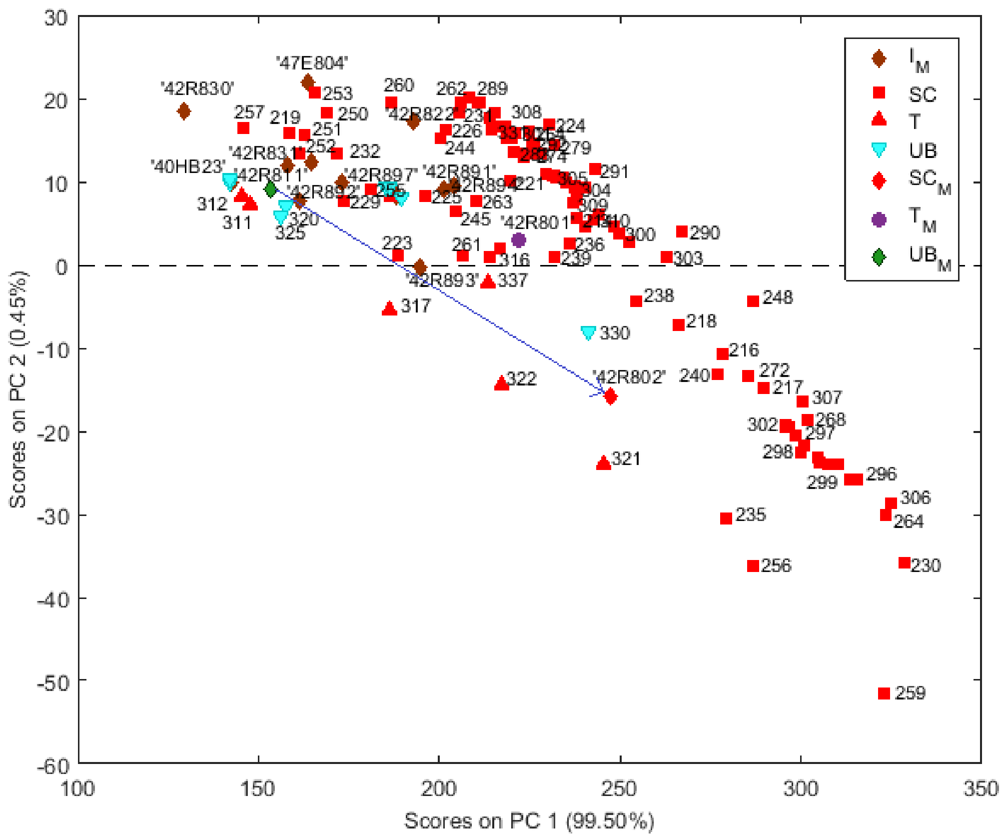


Figure 2. Score plot of PC1 and PC3 for diurnal variation

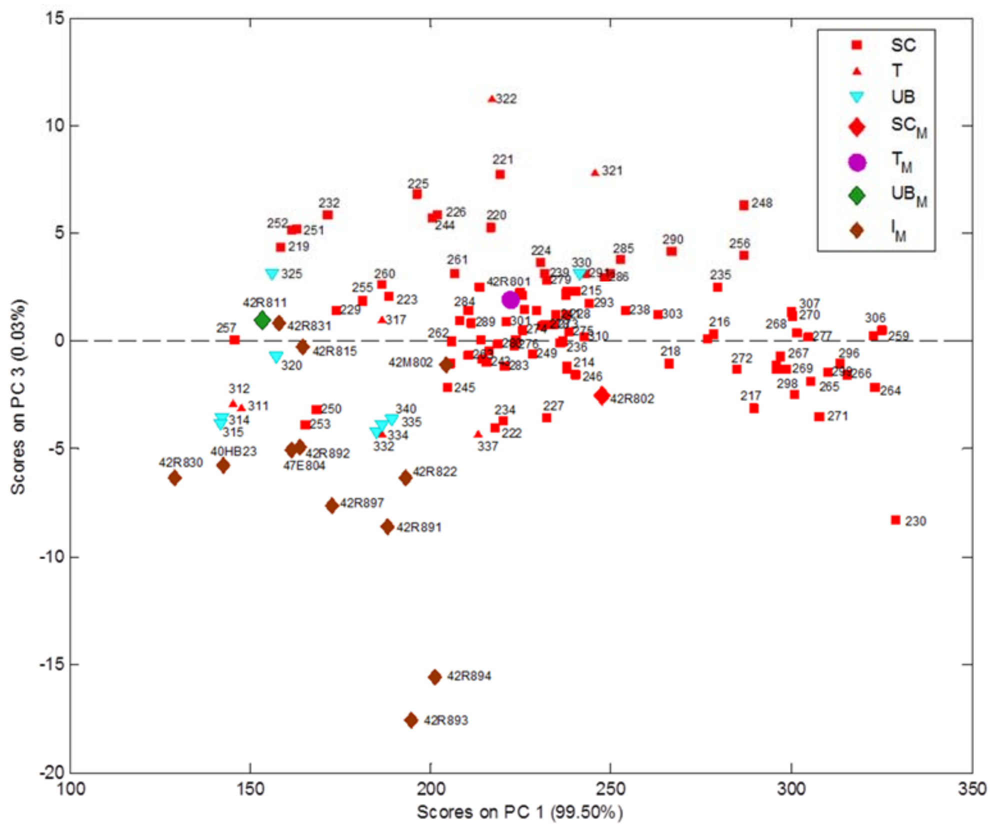


Figure 3. Loadings plots for diurnal variation

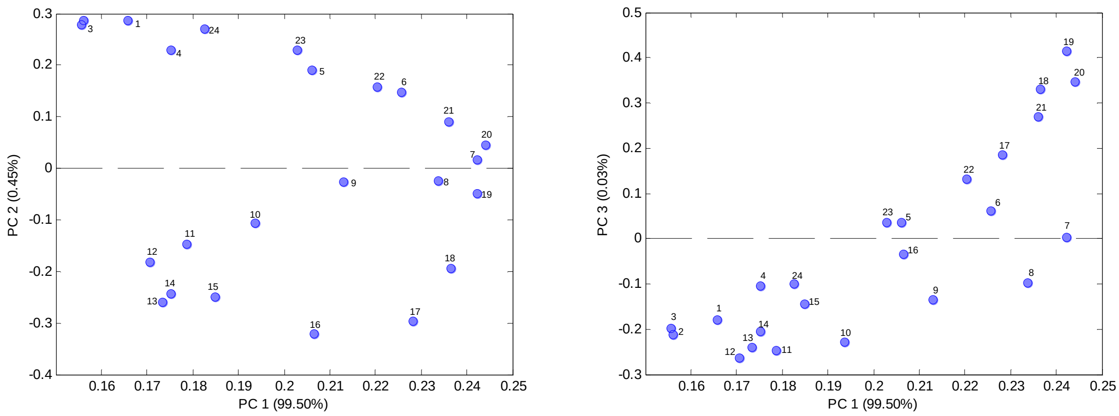


Figure 3 shows the projections of the average concentrations of the hours of the day. The highest concentrations are found (right hand site) on the rush hours (7 and 8 in the morning and 18-20 in the late afternoon and early evening). The lowest concentrations are found in the middle of the night. These hours are separated on PC2 (upper site of the plot) indicating that the shift found in figure 1 corresponds with the difference between the night and the rush hours. Such a shift is consistent with the expected traffic contribution.

Results of the analysis using diurnal variation:

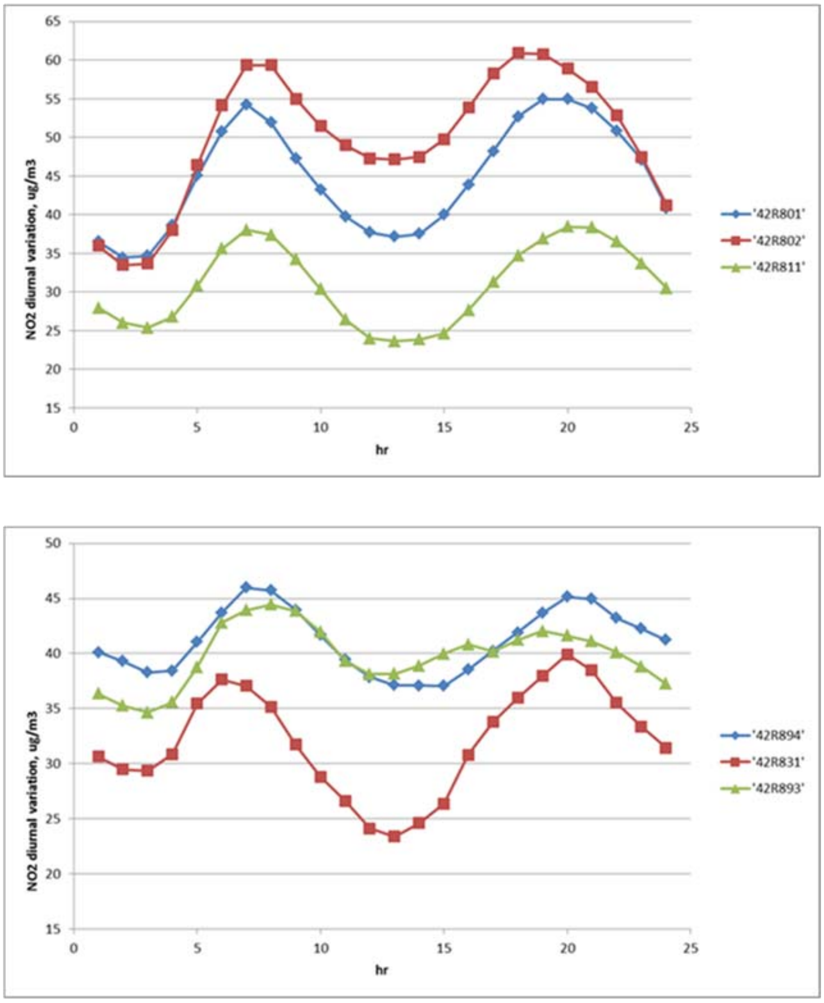
— The score plot of PC2 (fig 1) shows a shift from the urban background station 42R811 to traffic/ street canyon stations in the direction of higher PC1 score and lower PC2 score. This shift is also found with part of the virtual stations. Higher PC1 score means higher average concentration. In combination with the loading plot of PC2 (fig 3,left), a shift to lower PC2 score means higher concentrations during the rush hours as can be confirmed by figure 4 (upper). The same shift is also observed in the Dutch monitoring network and consistent to the expected pattern of a traffic station.

— With this analysis we can conclude that station 42R811 seems to be a representative urban background station. Stations 42R802 and 42R801 are both consistent with traffic stations. The influence of traffic at 42R802 is roughly twice as large as the influence at 42R801. This might be due to the geometry of the street (canyon vs open) and/or the intensity. The measurement data cannot discriminate between both types. This will be done on the bases of maps and photo's.

Extra remark (as it is not requested to analyse industrial stations):

The PC1/PC3 analysis is shown because some industrial stations are clearly separated on PC3: 42R893 and 42R894.These stations have low PC3 score. In combination with the loading plot of the PC3 (fig 3,right) we can conclude that these stations are less dominated by the evening rush hours and show relative high concentrations in the middle of the day and during the night hours (fig 4,lower). Such shift might be consistent by a larger influence of a continuous source.

Figure 4. Diurnal variation of some typical stations



Remark on the modelled data

The modelled data at location 42R802 (virtual station 216) shows, compared to the measurement at this location, only a shift to a higher PC1 score. This means that the modelled concentration is a little higher than the measured concentration but both stations have comparable pattern (comparable PC2 score). If we assume that the modelled data are representative, the result of this analysis confirms that station 42R802 could be a representative street canyon.

However, in the study of the modelled concentrations some strange features were observed:

— 270 and 307 are identical. Both are modelled as SC however with a distance of circa 100m between the stations.

— 167 (modelled as no SC) and 299 (SC) are also identical.

— 216 (modelled data of 42R802) is identical to 151 (no SC station).

This list is not necessarily complete.

4.2 Additional analysis including 8 extra virtual stations

As the scope of the Intercomparison Exercise (IE) was extended by 8 virtual stations (43, 63, 68, 88, 105, 115, 135 & 137), an additional analysis was done with a dataset including the NO_2 diurnal variation of these 8 extra stations.

Fig 5 shows the score plot of two first PC's; the legend "extra" shows these 8 extra stations.

From the score plot we can conclude that:

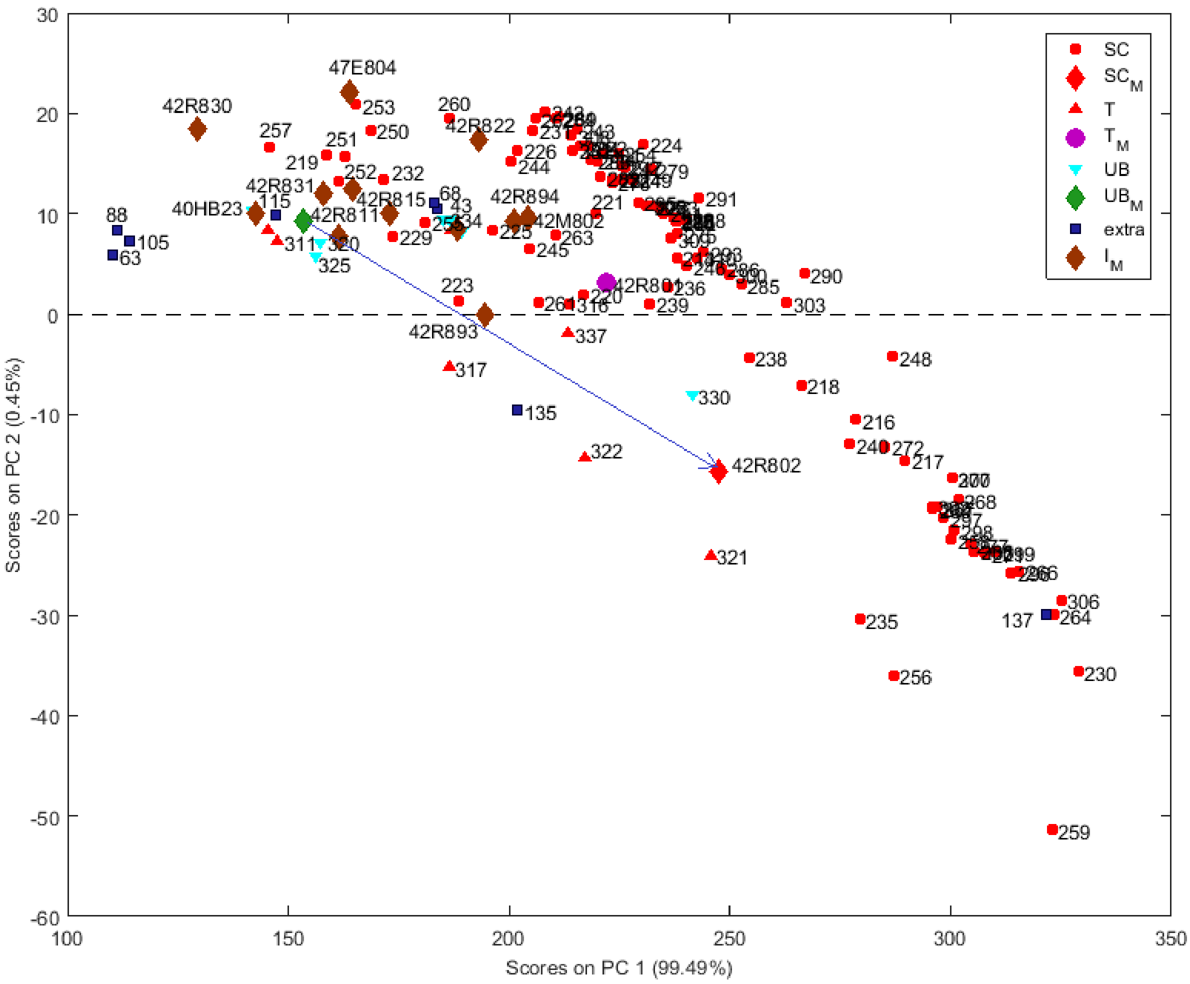
— Virtual stations 63, 88, 105 and 115 are background stations. For stations 63, 88, 105 concentrations are even lower than other Urban Background stations. Perhaps these station are more sub urban.

— Virtual stations 43 and 68, have relative high concentrations compared to background stations; however the diurnal profile does not match with traffic. These stations may be more in the "emission" centre of the city or may have some influence from other, more continues, sources.

— Virtual station 137 is clearly influenced by traffic. To our standards it would be classified as a traffic station.

— Virtual station 135 seems to be influenced by traffic. Presumably it would be classified as a traffic station; however the classification of this station is less clear.

Figure 5. Score plot of PC1 and PC2 for diurnal variation analysis including 8 virtual stations



4.3 Analysis of NO_2 using concentration roses

The NO_2 hourly concentrations were also summarized as concentration roses for the various 30 degrees wind directions. The explanation of the plots is very similar with the diurnal data set.

The analysis with concentrations roses does not show extra information of requested stations. The loading plot and the score plot of PC2 (fig 6 & fig 7) suggest that the concentration of the industrial station 42R830 is high when the wind is south easterly as can be expected by the location of this station (fig 8). This type of result is quite similar to the Dutch evaluation.

Figure 6. Score plot of PC1 and PC2 for concentration roses

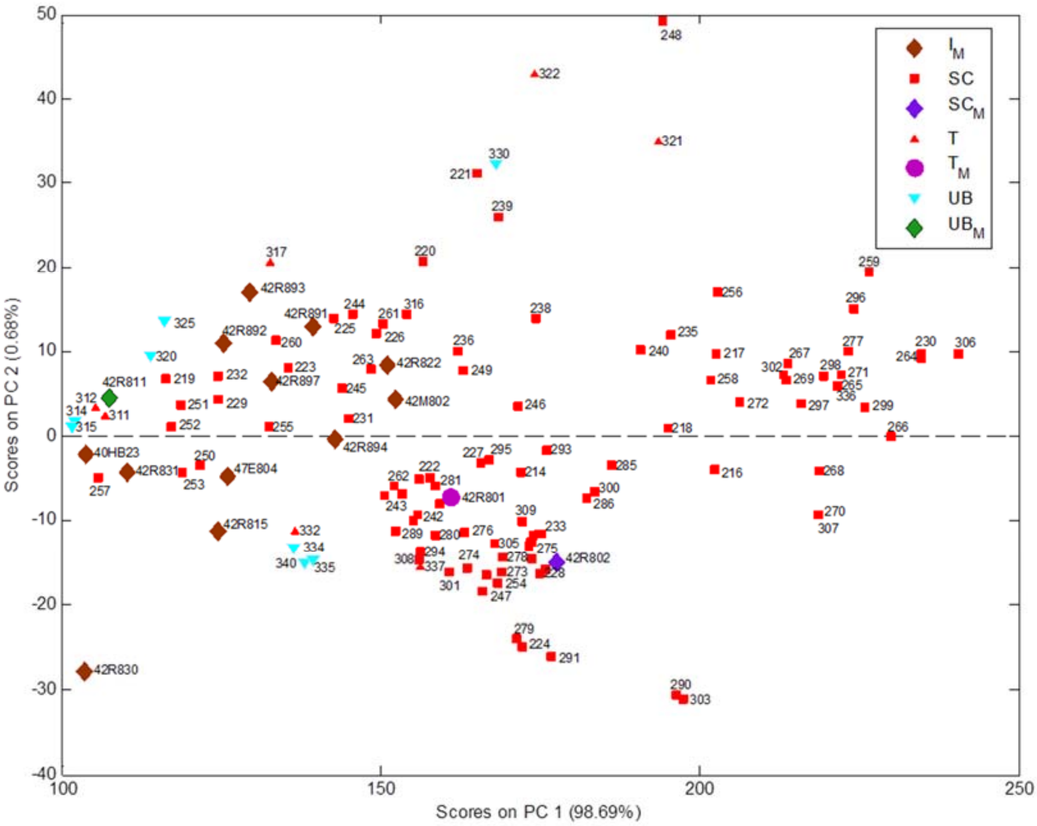


Figure 7. Loadings plot for concentration roses

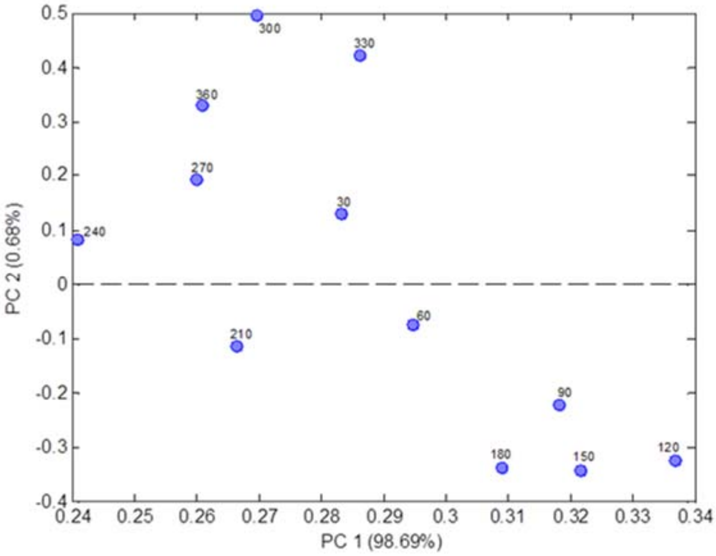
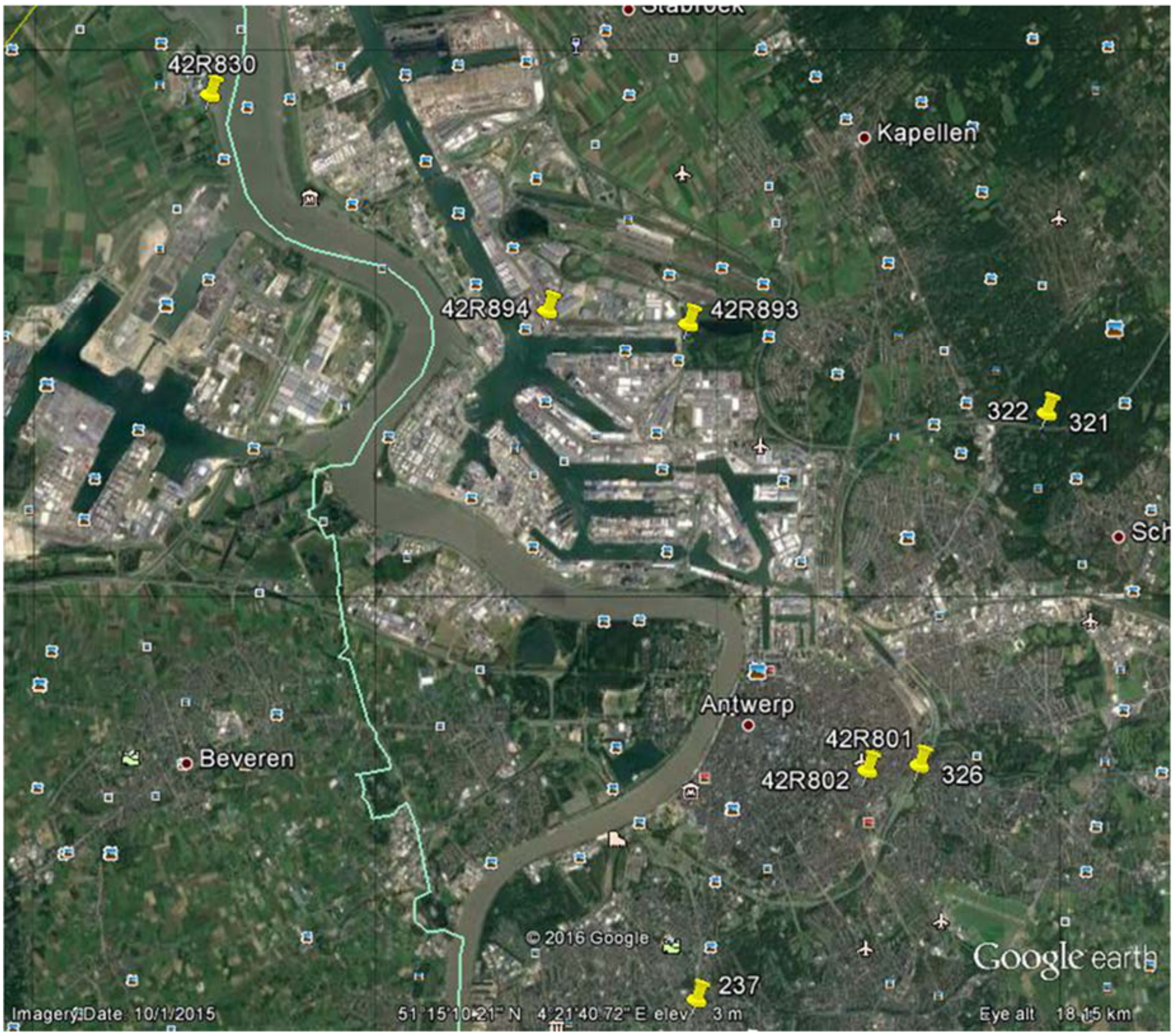


Figure 8. Locations of some typical stations



4.4 Is station 42R802 representative for a street canyon?

Based on the PCA analysis it is not possible to determine the character of station 42R802 as a street canyon. Therefore we use google earth to evaluate the macro/micro situation of this station.

In the Dutch system, the standard calculation model for Air quality in urban streets is used to determine air quality of streets in cities. This model categorized a street in 4 groups:

- Relatively wide street with buildings on both sides.
- Narrow street with relatively high buildings on both sides.
- Street with buildings at one side.
- Other types of street.

In above categories the first and second type of street represent the street canyon. It is necessary that the buildings are roughly joined together. However, the situation around station 42R802 is as follows:

- At only one side of the street, buildings are five storeys high. The opposite side has only a few blocks of high buildings; the remaining buildings are only approx. 4 meters high.
- The buildings are not joined together.

Based on these observations the location at 42R802 is not classified as a street canyon.

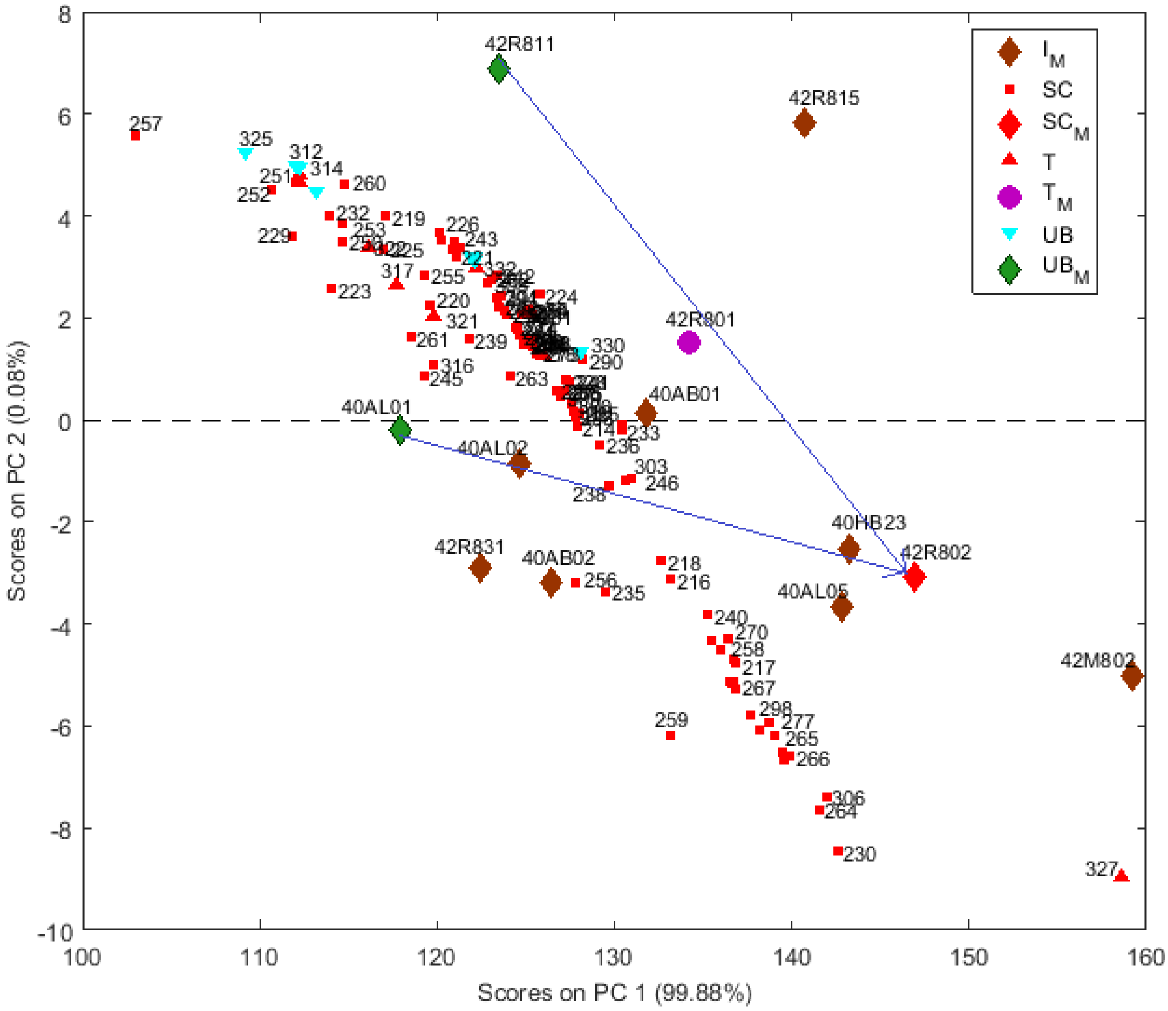
The simple classification scheme above is designed for a nation covering monitoring of air quality exceedances primarily using a model. Using this system the air quality is modelled for more than 300.000 locations including many traffic locations (van Zanten et al., 2015). To enable comparisons with measurement locations the classification system is also applied for the approximately 100 standard measurement locations using reference instruments. Also the hundreds of measurement locations using passive samplers are classified according to this scheme (Wesseling et al., 2013).

5 Assessment based on PM_{10} concentrations

5.1 Analysis using diurnal variation

Figure 9 shows the projection of the PM_{10} measurement results on their first 2 PC-s. The first PC on the x-axis covers 99.88 % of the variance/information in the data set. A hypothetical measurement station with always zero concentrations would be projected at the origin of the plot (on the far left hand side). The picture is very similar to the projection on the first two PC's of the Dutch monitoring stations. Stations with high average concentrations are projected on the right hand side. From the picture we clearly see that both the modelled and the measured street canyon locations are on the right hand site (high concentrations). The urban background locations are found on the left hand site. The second PC covers 0.08 % of the variance in the data set. Shifts observed between urban background and traffic stations which is shown with the blue arrows. For more detailed interpretations we also have to study the loading plot (figure 10).

Figure 9. Score plot of PC1 and PC2 for diurnal variation



In combination with the loading plot of PC2 (fig 10), a shift to lower PC2 score means higher concentrations during the rush hour. Such a clear shift is consistent with the NO_2 results. This shift seems to be stronger than results from the Dutch monitoring where no consistent distinction between UB stations and traffic stations was found.

The background station 40AL01 seems to differ from the background station 42R811. Analysis with concentration roses (see below) shows influence of local source on this station.

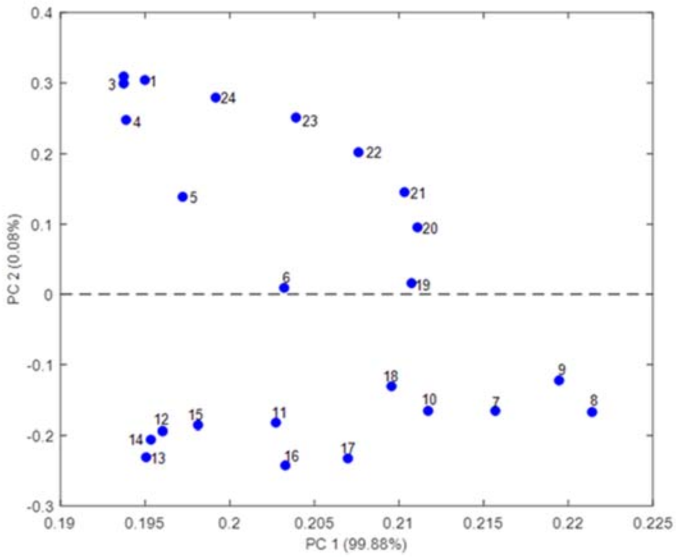


Figure 10. Loadings plot for diurnal variation

5.2 Analysis of PM_{10} using concentration roses

The score plot (fig. 11) and the loading plot (fig.12) of the analysis with concentration roses show that the concentration at station 40AL01 is high when the wind is north-westerly and the concentration at station 42R815 is high when the wind is south-easterly. Although the average PM_{10} concentration at station 40AL01 is comparable to that of station 42R811 (comparable PC1 score), the analysis shows influence of local sources on station 40AL01.

Figure 11. Score plot of PC1 and PC2 for concentration roses

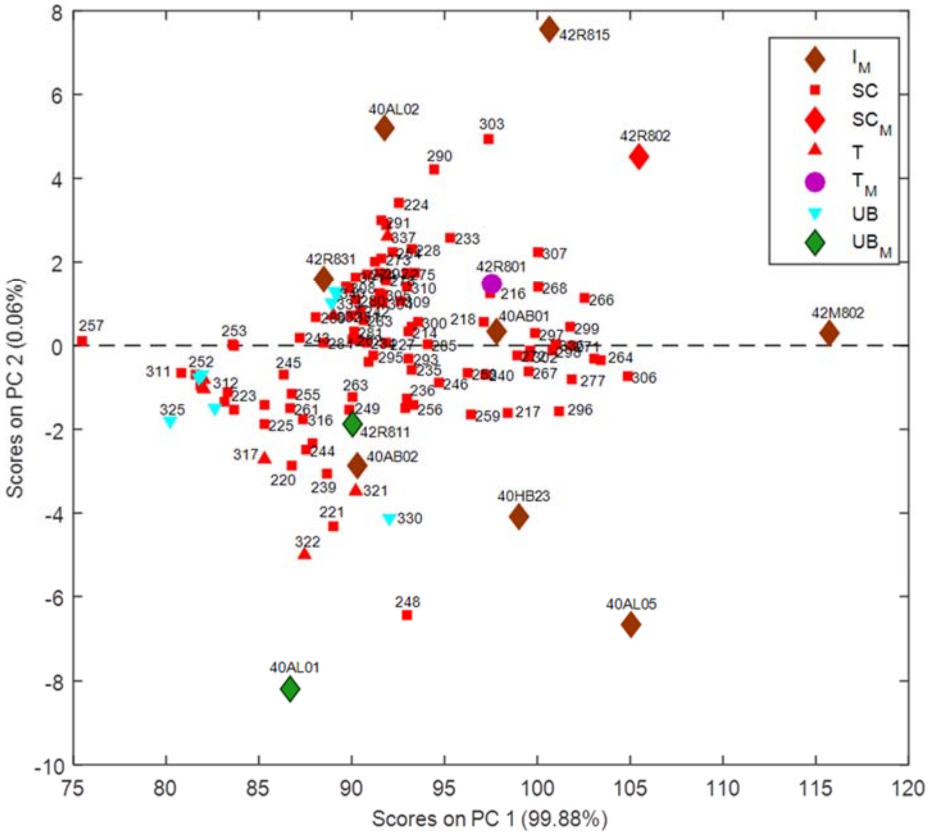
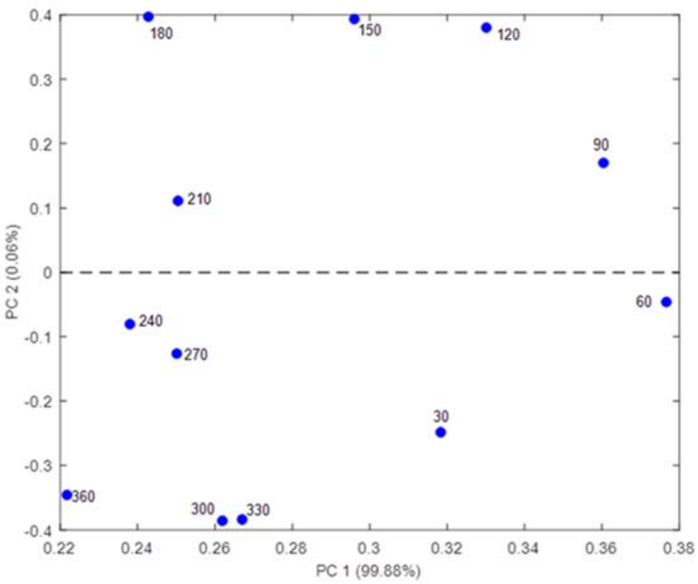


Figure 12. Loadings plot for concentration roses



6 Assessment based on O_3 concentrations using diurnal variation

The score plot of PC1 and PC2 (fig. 13) shows a distinct difference between station 42R811 (UB station to be investigated) and the traffic station 42R801. Compared to the traffic station 42R801, station 42R811 has a shift toward higher PC1 score and lower PC2 score. This means that station 42R811 has higher yearly concentration and relatively higher concentration during rush hours (6-8 hrs and 16-18 hrs) as can be confirmed by Fig. 15. This difference in pattern is indeed expected between a background station and a traffic station.

Note that the analysis also shows a cluster of virtual SC stations with an unexpected higher O_3 concentrations than other traffic stations.

Figure 13. Score plot of PC2 for diurnal variation

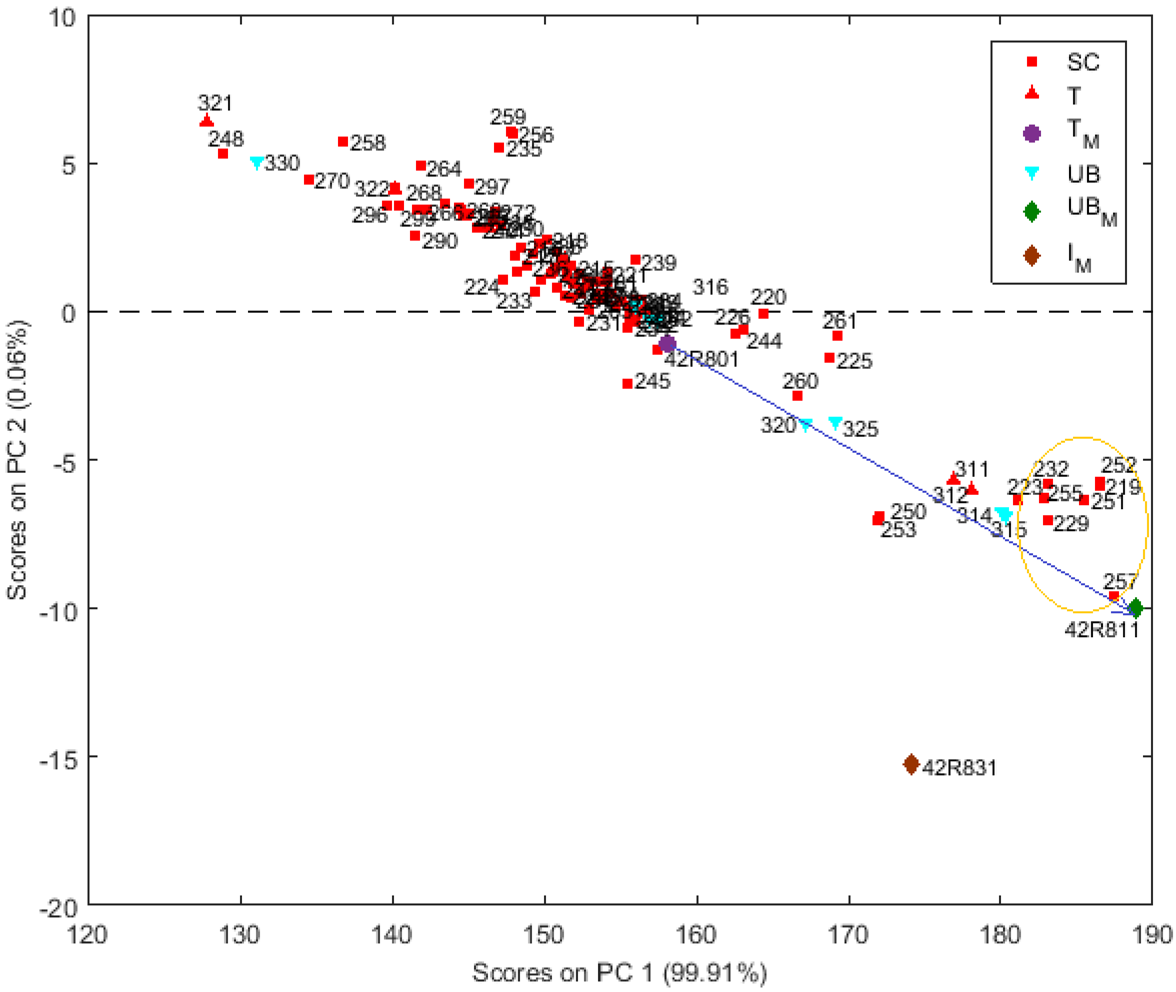


Figure 14. Loadings plot of PC2 for diurnal variation

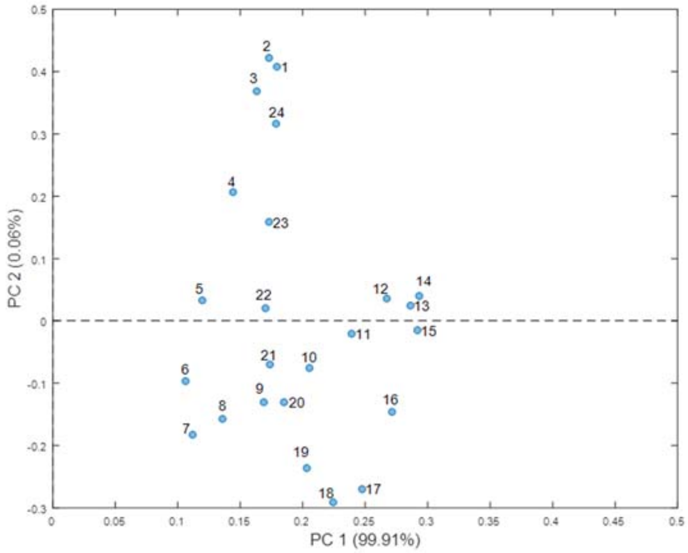
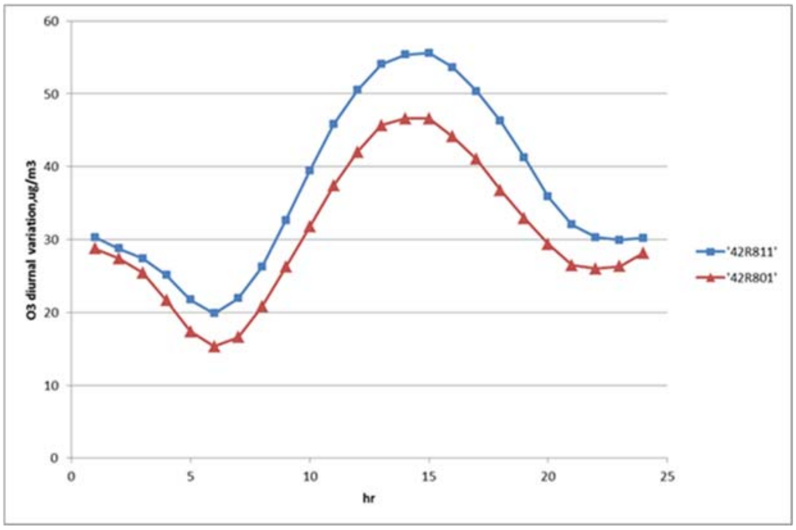


Figure 15. Diurnal variation of O_3 at UB station 42R811 and traffic station 42R801



7 Conclusions

The data set of measured concentrations is much too small to fully explore the Dutch system to determine the representativeness. Addition of modelled values gives results which are quite comparable with the evaluation of all Dutch monitoring stations. Within these limitations the results can be summarized as follows:

42R811 (Schoten): The data for NO_2 and ozone are consistent with an urban background location. For PM_{10} the data do not contradict with an urban background location

40AL01 (Antwerpen-Linkeroever): Only data for PM_{10}. Apparently the location is influenced by a source in NW direction. Apart from this source the data seem to be consistent with an urban background location.

42R802 (Borgerhout-Straatkant): The NO_2 and PM_{10} measurement data indicate a large influence from traffic. Based on the measurement data the distinction between a street canyon and another traffic location is not possible. Based on maps this location would, according to the Dutch system, not be classified as a street canyon.

Industrial stations 42R815 and 42R830 are clearly influenced by local sources in SE direction.

Table 1. Results of the analysis.

Station		NO_2	PM_{10}	O_3
42R811 40AL01 42R802	UB station to be investigated UB station to be investigated SC station to be investigated	Yes No data Traffic (2)	possibly NW (1) Traffic	Yes No data No data
42R815 42R830	Industrial station Industrial station	 SE	SE	
63,88,105	Virtual station to be investigated	UB/Sub urban		
115	Virtual station to be investigated	UB		
43,68	Virtual station to be investigated	UB with influence of more continues sources		
135	Virtual station to be investigated	Possibly traffic		
137	Virtual station to be investigated	Traffic		

(1) This station can be a background station; however it is influenced by source from NW direction.

(2) Traffic: the analysis investigates that this is a traffic station. However based on the micro situation at this location, station 42R802 would, according to the Dutch system, not be classified as a street canyon.

References

Nguyen,P.L., Stefess,G., de Jonge,D., Snijder,A., Hermans,P.M.J.A., van Loon,P., Hoogerbrugge,R., *Evaluation of the representativeness of the Dutch air quality monitoring stations. The National, Amsterdam, Noord-Holland, Rijnmond-area, Limburg and Noord-Brabant networks*. RIVM Report 680704021/2012, 2012

van Zanten, M.C., Berkhout,J.P.J., Wesseling,J., Mooibroek,D., Nguyen,P.L., Groot Wassink,H., Sanders,A., *Monitoringsrapportage NSL 2015, stand van zaken Nationaal Samenwerkingsprogramma Luchtkwaliteit*, RIVM Report 2015-0166,2015

Wesseling,J., van Velze,K., Hoogerbrugge,R., Nguyen,L., Beijk,R., Ferreira,J., *Gemeten en berekende (NO2) concentraties in 2010 en 2011. Een test van de standaardrekenmethoden 1 en 2*, RIVM Report 680705027/2013, 2013

FAIRMODE Intercomparison Exercise on the Spatial Representativeness of Air Quality Monitoring Stations

Documentation of Methods and Criteria

SLB-analysis, Environment and Health Administration, City of Stockholm

1 General Information

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Type of SR methodology: method based on measured or modelled pollutant concentrations

Type of output: spatial representativeness areas (shape files)

2 Introduction

SLB-analysis is a department at the Environment and Health Administration, City of Stockholm. In addition to the air quality monitoring of the Stockholm City, SLB-analysis operates an air monitoring system covering four counties in eastern Sweden, a region equivalent to approximately 10 % of Sweden's surface and about 1/3 of Sweden's population. The air quality monitoring system includes emission databases, dispersion models as well as measuring stations.

The measurement stations consist of traffic stations and background stations (urban and rural). The purpose of traffic stations is to measure in places where we expect to find the highest concentrations of air pollutants and where there is a risk that the air quality standards will be exceeded. Traffic stations are considered very local measurements. The background stations, on the other hand, are located to represent a large area and to be representative of the average population exposure of air pollutants. In addition to monitoring air quality and follow time-trends, the purpose of the urban background stations in Stockholm is to get a measure of population exposure to air pollutants in the region. We also use the urban background stations to validate our model calculations.

As a consequence of our different purposes for traffic stations and background stations we use, depending on the type of measurement station, different methods and criteria for the determination of the area of representativeness.

Traffic site monitoring stations

In Stockholm, our traffic site monitoring stations are located in street canyons where we expect to find the highest concentrations of air pollutants, i.e. hot-spots. This to check that we meet the air quality standards everywhere within the city. Our experience says that every street canyon is unique, and it is difficult to apply measurements from one traffic monitoring site to an adjacent street canyon. We believe that a street canyon measurement is representative of that particular street, and just the part of the street with similar buildings (e.g. buildings on both sides or just one side of the street canyon, building heights), where the distance between the houses are about the same, and with similar traffic emissions (composition of the vehicle fleet, percent heavy-duty vehicles, signed speed limit, traffic flow et cetera).

2.1 Traffic site: Borgerhout-Straatkant

In the example of Borgenhaut-Straatkant this means that the surface area of representativeness is the part of the street where there are buildings on both sides of the street, and the traffic emissions differ less than 10 % from those at the measuring station, i.e. PM10: 746 ± 10 % kg/km/yr, NO_2: 2630 ± 10 % kg/km/yr. The surface area of representativeness consists of the street canyon width plus a buffer zone of 25 m. This to include people who live in houses with frontage to the street, as they are exposed to concentrations of air pollutants in the street canyon when getting from/to their residences.

3 Urban background monitoring stations

In Stockholm, we strive to put our background stations so that they represent as large an area as possible. To demonstrate that the stations represent the concentrations over a wide area, we compare measured concentrations with modeled mean concentrations within buffer zones around the measuring stations. The buffer zones can either be in the form of circles or rectangles. Based on the graph over the difference in concentration between the measuring station and modeled concentration in the buffer zone as a function of distance from the measuring station, we define a suitable threshold. We usually use modeled concentrations at a resolution of 100 m x 100 m. We are also considering the variance in modeled concentration across the whole region when we define the threshold.

Figure 1 shows an example of different buffer zones around the urban background station Torkel Knutssonsgatan in Stockholm - circular and rectangular buffer zones as well as buffer zones based on administrative boundaries or type of land (i.e. urban area). Figures 2 and 3 show the model calculated exposure of PM10 and NO_2 for the different buffer zones in figure 1 compared to the measured concentrations at Torkel Knutssonssgatan (Lövenheim, 2017).

Figure 1. Buffer zones around the urban background monitoring station at Torkel Knutssonsgatan in Stockholm.

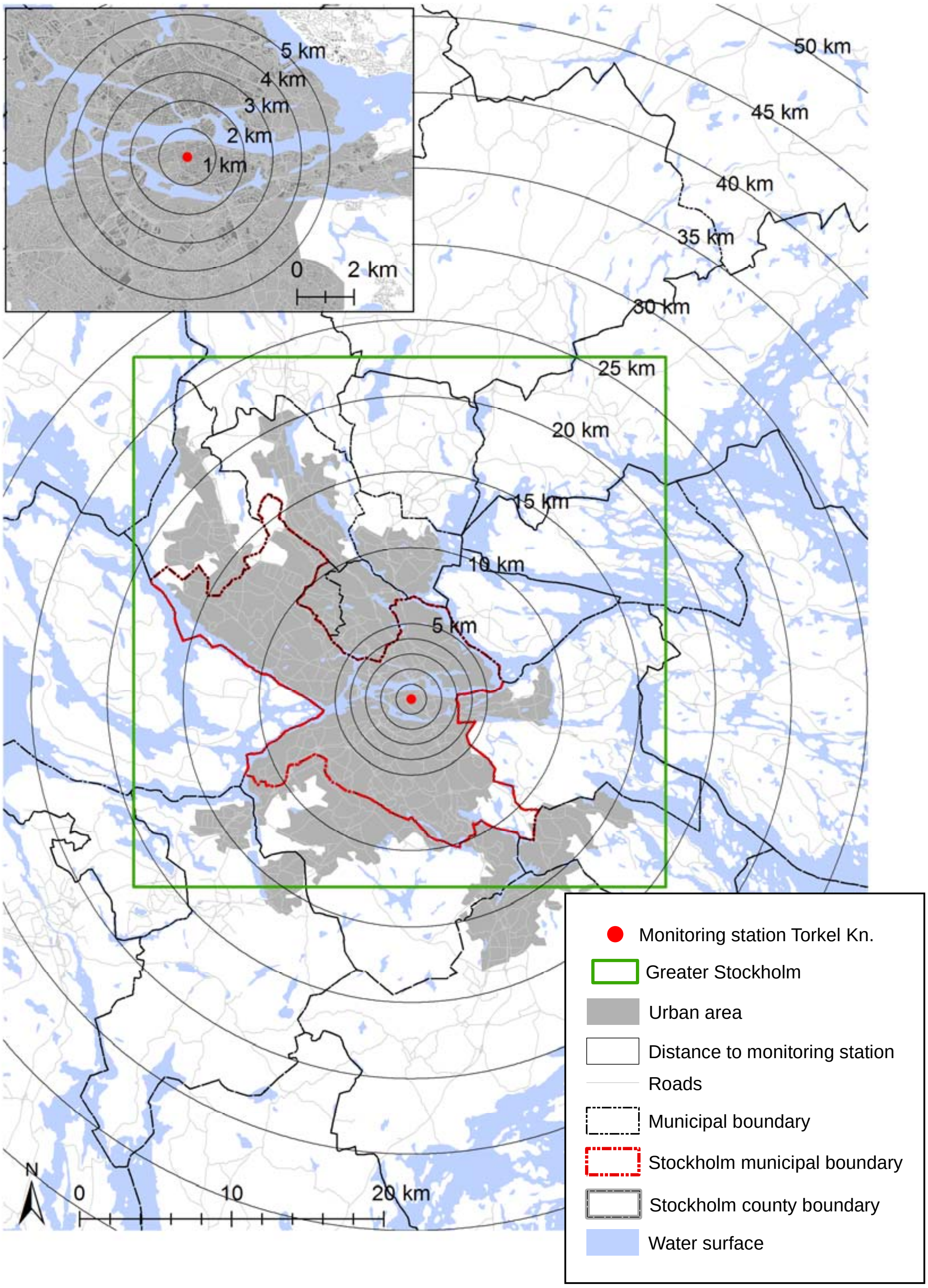


Figure 2. Calculated exposure of PM10 in the different buffers zones (see fig. 1) compared to measured concentrations at the urban background station Torkel Knutssonsgatan in Stockholm.

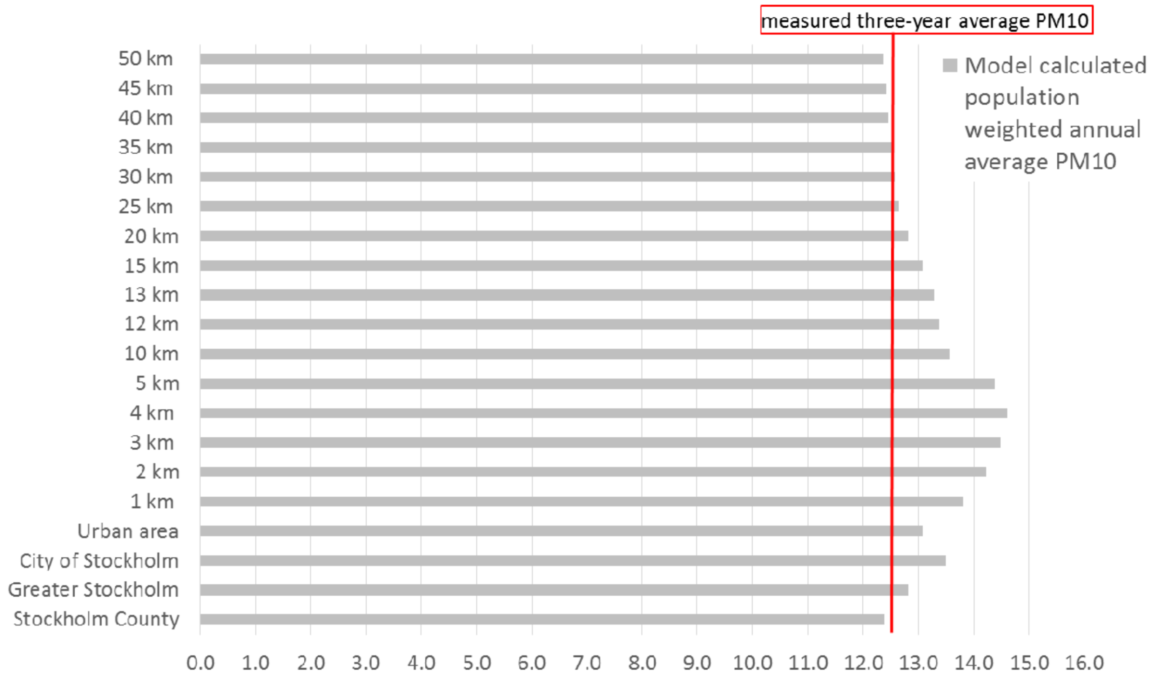
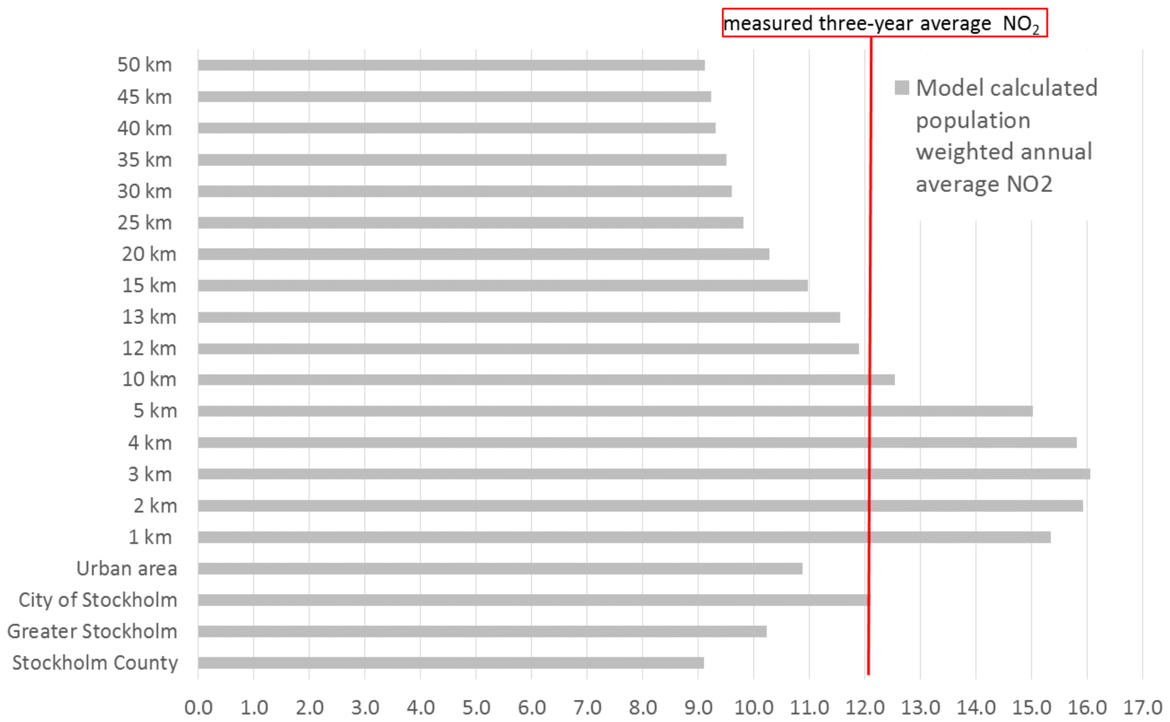


Figure 3. Calculated exposure of NO_2 in the different buffers zones (see fig. 1) compared to measured concentrations at the urban background station Torkel Knutssonsgatan in Stockholm.



3.1 Urban background sites: Antwerpen-Linkeroever and Schoten

In the example in Antwerp, we used modeled concentration of PM10, NO_2 and O_3 with a resolution of 100 m x 100 m. We did circular buffer zones around each measuring station. Surface area of representativeness was defined as the buffer zone around the station where the standard deviation of the modeled average concentration within the buffer zone was equal to the following thresholds: NO_2: 3.6 µg/m^3 PM10: 1.2 µg/m^3, O_3: 2.4 µg/m^3. The standard deviation was calculated on the set of all modeled average concentration within the buffer zone. The buffer zones were established on a purely geometric rule (with the station in the centre of the buffer). The concentration at the actual location of the station did not play a privileged role in the calculation (the central station concentration contributed with the same weight to the standard deviation as all other concentrations within the buffer).

References

Lövenheim, B. *Exposure to air pollution within the region of Eastern Sweden's Air Quality Management Association. Calculations of population exposure of particulate matter (PM10) and nitrogen dioxide in 2015* (in Swedish). Eastern Sweden's Air Quality Management Association, Report LVF 2017:12. In press, will be available at: http://slb.nu/slbanalys/rapporter/pdf8/lvf2017_012.pdf.

FAIRMODE Intercomparison Exercise on the Spatial Representativeness of Air Quality Monitoring Stations

Documentation of Methods and Criteria

Flemish Institute for Technological Research (VITO)

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Type of SR methodology: method based on both measured concentrations and a pollutant concentration proxy

Type of output: spatial representativeness areas (shape files)

2 Methodology

2.1 General outline

The methodology is described in Janssen et al. 2012 and can be summarized in the following 5 steps:

1) A relationship is derived between a land cover indicator and pollutant concentration

   The land cover indicator, β, is derived for a buffer with a radius of 2 km as:

$$\beta = \log\left[1 + \frac{\sum_i a_i A_{LCi}}{A_{total}}\right]$$

   Where A_{LCi} is the area covered by the land cover class i inside the buffer and a_i is the pollution related coefficient for the land cover class and A_{Total} is the total area of the buffer.

2) A 2nd order polynomial ('trend function') is fitted to the concentrations at measurement stations versus the β at those stations.

3) Create a map of β for a 4km x 4km grid.

4) Derive the β value interval corresponding to a variation of 15% in concentration at measurement stations.

5) Select the grid cells that have a β within this β interval AND that form a contiguous area neighbouring the measurement station.

2.2 Application to Antwerp

The trend function was determined based on long term average NO_2 and O_3 concentrations for the period 2008 – 2012 from respectively 72 and 41 measurement stations that were provided by IRCEL, the Belgian Interregional Environment Agency. For PM_{10}, the trend function was based on the 2009-2010 average from 61 stations provided by IRCEL.

The coefficients, p_i found for the trend function $C = p_1\beta^2 + p_2\beta + p_3$ based on the measurements are presented in **Table 1.**

Table 1. Coefficients of the trend functions for the different pollutants used for Flanders.

pollutant	p_1	p_2	p_3
NO_2	-10.653947	41.267721	7.7741282
PM_{10}	-11.240506	34.201268	5.9761098
O_3	6.9076646	-29.768359	54.667401

These trend functions were used to derive the β interval that was used to select the grid cells that have to be included for the representative area for each of the stations in Antwerp.

References

Janssen, S., Dumont, G., Fierens, F., Deutsch, F., Maiheu, B., Celis, D., Trimpeneers, E. and Mensink, C., 'Land use to characterize spatial representativeness of air quality monitoring stations and its relevance for model validation', *Atmospheric Environment,* Vol. 59, 2012, pp 492-500.

FAIRMODE Intercomparison Exercise on the Spatial Representativeness of Air Quality Monitoring Stations

Documentation of Methods and Criteria

Flanders Environment Agency (VMM)

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Type of SR methodology: method based on both measured or modelled pollutant concentrations and concentration proxies

Type of output: spatial representativeness areas (shape files)

2 Short outline of the used method

VMM's methodology to determine the spatial representativeness is based on the method of Spangl et al. (Spangl, 2007) and is described in detail in a deliverable of the Life+ ATMOSYS project (Roet, 2014).

In brief, we first start by constructing histograms for the categories road traffic (RT), domestic heating (DH), industrial emission (IE) and land cover (CLC). This is done by deriving parameters based on specific model and/or measurement data for each (virtual) monitoring station and/or its immediate surrounding.

Table 1 shows the data VMM used from the available datasets and which parameters were derived from it.

Table 1. Data used by VMM from the available datasets and their use in the method.

Dataset nr. and data	**Used as/for deriving parameter …**
5 – Road_emissions	Calculating the influence from (local) road traffic by considering the summed road traffic emissions for both NO_2 and PM_{10} from all roads within a radius of 1 km.

6 – Pop_Antw_100m	Calculating the population density in a radius of 1 km as a proxy for domestic heating. Note: no difference is made for DH coming from NO_2 and PM_{10}.
3 – NO2 and PM10 annual mean maps	Normally we would use a bi-Gaussian dispersion model IFDM to calculate the NO_2 and primary PM_{10} concentrations coming only from industrial points sources. To save time we used the annual mean maps as a proxy in this exercise.
8 – Corine Land Cover	Assessing the similarity in land use and dispersion conditions of the (virtual) monitoring station and its surroundings. We reclassified this map to three main categories: open, halfopen and closed.

From the histograms for road traffic, domestic heating and industrial emissions we defined the class boundaries low, medium and high. Instead of looking at visual breaks in the histogram – as we did in the Life+ ATMOSYS deliverable – we now used the median and 90th percentile (P90) as a more objective approach, i.e.:

— values [0; median[→ low class
— values [median; P90[→ medium class
— values [P90; max] → high class

The specific class breaks we found for the different parameters are shown in Table 2.

Table 2. Overview of the different class breaks derived by VMM.

Class	**LRT NO_2 (g/day.$m^{3/2}$)**	**LRT PM_{10} (g/day.$m^{3/2}$)**	**DH/Population (# residents)**	**"IE" NO_2 (µg/m^3 NO_2)**	**"IE" PM_{10} (µg/m^3 PM_{10})**
low	0.0 – 18.2	0.0 – 4.9	0 - 21333	0.0 – 39.3	0.0 – 25.0
medium	18.2 – 33.1	4.9 – 8.5	21333 – 43996	39.3 – 52.0	25.0 – 26.8
high	≥ 33.1	≥ 8.5	≥ 43996	≥	≥ 26.8

With these classification results we now repeat the procedure for each grid cell within a larger grid around the (virtual) monitoring station. We used a square grid of 1100x1100 m^2 consisting of 100x100 m^2 grid cells surrounding the (virtual) monitoring station.

To arrive at the final spatial representativeness map the grid (cell) results for each class RT, DH, IE and CLC are combined into a final score by taking the weighted sum for each grid cell. The assigned weight to each grid cell for each class is positive when the classification of that grid cell is exactly the same as that of the VMS, or negative in the opposite case. A weighted sum of 100% for a grid cell indicates that it has identical classifications as that of the VMS itself, a weighted sum of -100% indicates it has completely the opposite classifications as that of the VMS itself.

The amount (%) of grid cells with a certain weight above a threshold determines to what degree the (virtual) monitoring station and its surrounding of 1100 m^2 have similar characteristics. The weight thresholds used were 32.6 for NO_2 and 28.8 for PM_{10}, i.e. all grid cells in the NO_2 representativeness map having a weighted sum greater or equal to 32.6 are considered to be sufficiently similar to that of the VMS itself (which is the grid cell at the center of the map and always having 100%).

2.1 Results

It was asked to apply our method to virtual monitoring stations (VMS) 7, 17 and 216 for both NO_2, PM_{10} and O_3. Our method is currently only suitable for NO_2 and PM_{10}, so O_3 was not considered.

First, the classification results for these VMS's (for a full list for all VMS's see the Appendix) are shown in Table 3.

Table 3. VMM's classification results for some VMS.

Station	**LRT class NO_2**	**LRT class PM_{10}**	**DH class NO_2 & PM_{10}**	**"IE" (an. mean) class NO_2**	**"IE" (an. mean) class PM_{10}**	**CLC class**
7	low	low	low	low	low	halfopen
17	low	low	low	low	low	halfopen
216	medium	medium	medium	high	high	closed

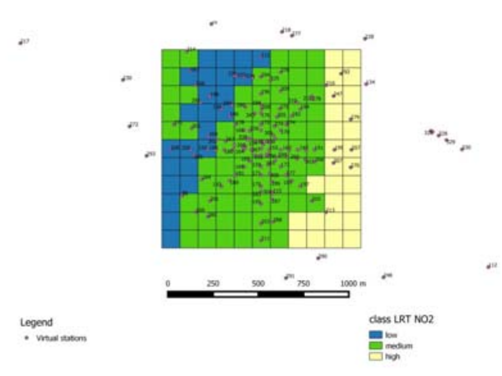
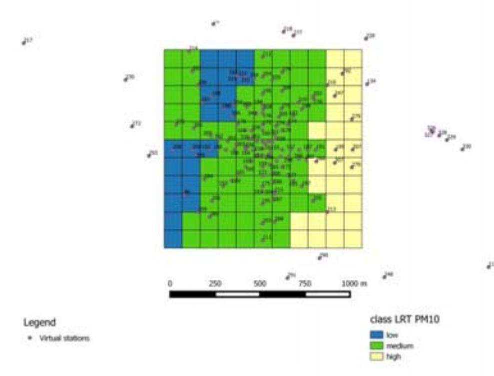
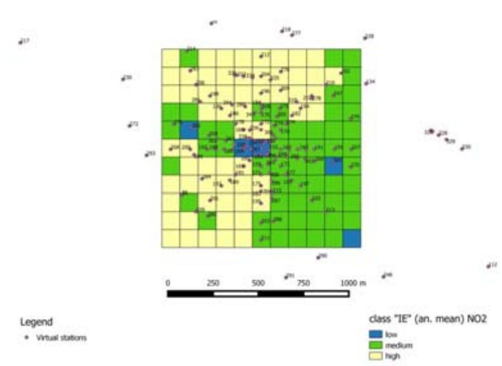
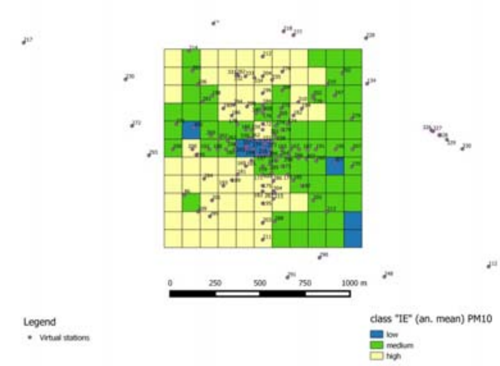
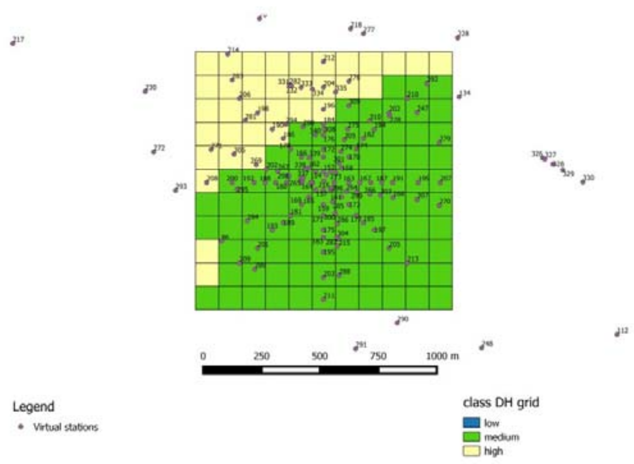
We find the same classification results at for VMS's 7 and 17. This does not necessarily mean that they will have the same spatial representativeness though. These results are shown in Table 4.

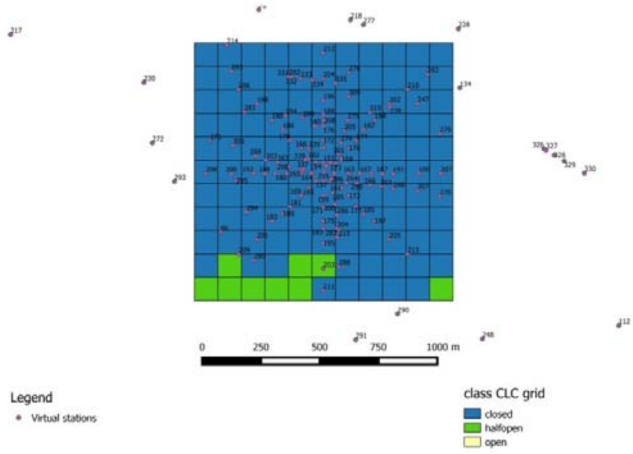
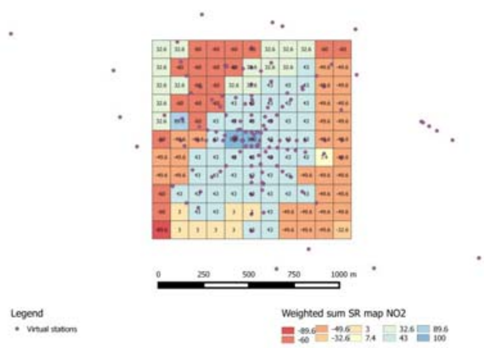
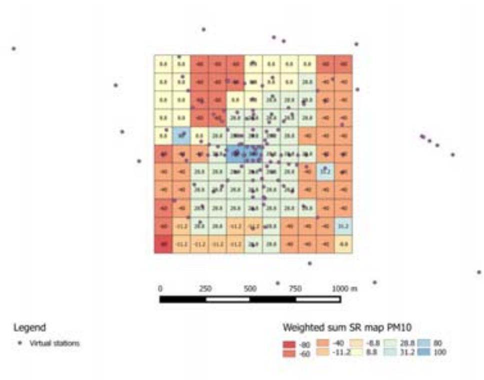
Table 4. VMM's spatial representativeness results for some VMS.

Station	**% gridcells above NO_2 similarity threshold**	**% gridcells above PM_{10} similarity threshold**	**representativeness for NO_2**	**representativeness for PM_{10}**
7	100.0	100.0	Very good	Very good
17	100.0	100.0	Very good	Very good
216	52.1	38.8	Fair	Poor

The detailed results for VMS 216 showing the different grid results for each class and pollutant are shown in Table 5 completion.

Table 5. Detailed step-wise grid results from VMM's method for VMS 216.

<table>
<tr><th></th><th>NO₂</th><th>PM₁₀</th></tr>
<tr><td>LRT</td><td>
</td><td>
</td></tr>
<tr><td>"IE"</td><td>
</td><td>
</td></tr>
<tr><td>DH</td><td colspan="2">
</td></tr>
</table>

<table>
<tr><td>CLC</td><td colspan="2">
</td></tr>
<tr><td>Final SR map</td><td>
</td><td>
</td></tr>
</table>

References

Spangl, W., Schneider, J., Moosmann, L. and Nagl, C., *Representativeness and classification of air quality monitoring stations*, Umweltbundesamt, Wien, 2007

Roet, D. and Celis, D., *Life + ATMOSYS deliverable: A method for selecting monitoring stations for model validation*, VMM, Belgium, 2014, http://www.atmosys.eu/faces/doc/ATMOSYS%20Deliverable%20Action%204_updateV1.1.pdf

Table 6 (appendix)**.** Classification results for all VMS's

Station	LRT class NO_2	LRT class PM_{10}	DH class	"IE" class NO_2	"IE" class PM_{10}	CLC class
0	medium	medium	medium	medium	medium	halfopen
1	medium	medium	medium	medium	low	halfopen
2	medium	low	low	medium	medium	halfopen
3	medium	high	medium	medium	medium	closed
4	low	low	low	low	low	halfopen
5	low	low	low	medium	medium	open
6	low	low	low	low	low	open
7	low	low	low	low	low	halfopen
8	low	low	low	low	low	open
9	low	low	low	low	low	halfopen
10	low	low	low	medium	medium	halfopen
11	low	low	low	low	low	halfopen
12	low	low	low	low	low	halfopen
13	low	low	low	low	low	halfopen
14	low	low	low	low	medium	halfopen
15	medium	medium	low	medium	medium	halfopen
16	medium	medium	medium	medium	medium	closed
17	low	low	low	low	low	halfopen
18	low	low	low	low	low	halfopen
19	low	low	low	low	low	halfopen
20	low	low	low	low	medium	halfopen
21	low	low	low	low	low	open
22	low	low	low	low	low	halfopen
23	low	low	low	low	low	unknown
24	low	low	low	low	medium	halfopen
25	low	low	low	low	low	halfopen
26	low	low	low	low	medium	halfopen
27	low	low	low	low	high	halfopen
28	low	low	low	low	low	halfopen
29	medium	medium	low	high	high	halfopen
30	low	low	low	low	low	halfopen
31	low	low	low	low	low	halfopen
32	low	low	low	medium	medium	halfopen
33	low	low	low	medium	medium	halfopen
34	low	low	low	low	low	halfopen
35	low	low	low	low	low	halfopen
36	low	low	low	low	low	closed
37	low	low	low	low	low	halfopen
38	low	low	low	low	low	halfopen
39	low	low	low	medium	high	halfopen

40	low	low	low	high	medium	halfopen
41	low	low	low	low	low	halfopen
42	low	low	low	low	low	open
43	low	low	low	low	medium	halfopen
44	medium	low	low	low	low	halfopen
45	low	low	low	low	low	halfopen
46	low	low	low	low	low	open
47	low	low	low	low	low	halfopen
48	medium	medium	low	medium	high	halfopen
49	low	low	low	low	medium	closed
50	low	low	low	low	low	halfopen
51	medium	medium	medium	medium	medium	halfopen
52	low	low	low	low	low	open
53	low	low	low	low	low	halfopen
54	high	high	medium	medium	medium	closed
55	low	low	low	low	low	open
56	medium	medium	low	medium	medium	halfopen
57	low	low	low	low	low	halfopen
58	low	low	low	low	medium	halfopen
59	low	low	low	low	low	open
60	low	low	low	low	low	closed
61	low	low	low	low	low	halfopen
62	low	low	medium	low	low	halfopen
63	low	low	low	low	low	closed
64	low	low	low	low	low	halfopen
65	low	low	low	low	low	halfopen
66	low	low	low	low	low	halfopen
67	low	low	low	low	low	closed
68	low	low	low	low	medium	halfopen
69	low	low	low	low	medium	halfopen
70	medium	medium	high	low	low	closed
71	low	low	low	low	low	halfopen
72	high	medium	low	medium	medium	halfopen
73	low	low	low	low	low	halfopen
74	low	low	low	low	low	halfopen
75	medium	medium	low	medium	medium	halfopen
76	low	low	low	low	low	halfopen
77	medium	medium	high	medium	medium	closed
78	low	low	low	low	low	halfopen
79	low	low	low	low	low	halfopen
80	low	low	low	low	low	halfopen
81	low	low	low	low	low	open
82	low	low	low	low	medium	open

83	low	low	low	low	low	closed
84	low	low	low	low	low	open
85	low	low	low	low	low	open
86	low	low	high	medium	medium	closed
87	low	low	low	low	low	open
88	low	low	low	low	low	open
89	medium	medium	medium	medium	medium	closed
90	medium	medium	low	medium	low	open
91	low	low	low	low	low	open
92	low	low	low	low	low	halfopen
93	low	low	low	low	low	halfopen
94	low	low	low	low	low	halfopen
95	low	low	low	low	low	halfopen
96	low	low	low	low	low	halfopen
97	low	low	medium	low	low	halfopen
98	low	low	low	low	low	halfopen
99	low	low	low	low	low	halfopen
100	low	low	low	low	low	closed
101	low	low	low	low	medium	open
102	low	low	low	low	low	halfopen
103	low	low	low	low	low	halfopen
104	low	low	low	low	low	halfopen
105	low	low	low	low	low	halfopen
106	low	low	low	low	low	open
107	low	low	low	low	low	halfopen
108	low	low	low	low	low	halfopen
109	low	low	low	low	low	open
110	low	low	low	low	low	open
111	low	low	low	low	low	halfopen
112	medium	medium	medium	low	low	halfopen
113	medium	low	low	low	low	halfopen
114	high	high	medium	medium	medium	halfopen
115	low	low	low	low	low	open
116	low	low	low	low	low	open
117	low	low	low	low	low	open
118	high	high	medium	high	high	halfopen
119	low	low	low	low	low	halfopen
120	low	low	medium	low	low	halfopen
121	medium	medium	low	medium	high	halfopen
122	low	low	low	low	low	open
123	low	low	low	low	low	open
124	high	high	low	medium	medium	halfopen
125	medium	medium	low	medium	high	halfopen

126	low	low	low	low	low	closed
127	low	low	low	low	low	halfopen
128	low	low	low	low	low	open
129	low	low	low	low	low	open
130	low	low	low	low	medium	open
131	low	low	low	low	low	halfopen
132	low	low	low	low	low	halfopen
133	low	low	low	medium	low	halfopen
134	high	high	medium	medium	medium	closed
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136	low	low	low	low	low	halfopen
137	medium	medium	low	high	high	halfopen
138	low	low	low	low	medium	open
139	high	high	medium	medium	medium	halfopen
140	high	high	medium	medium	medium	halfopen
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144	low	low	low	low	high	open
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147	low	low	low	medium	low	halfopen
148	medium	medium	low	medium	low	halfopen
149	high	high	low	high	high	halfopen
150	medium	medium	medium	medium	medium	closed
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155	medium	medium	medium	medium	medium	closed
156	medium	medium	medium	medium	medium	closed
157	medium	medium	medium	medium	medium	closed
158	medium	medium	medium	medium	medium	closed
159	medium	medium	medium	medium	medium	closed
160	medium	medium	medium	low	low	closed
161	medium	medium	medium	medium	medium	closed
162	medium	medium	medium	medium	medium	closed
163	medium	medium	medium	medium	medium	closed
164	medium	medium	medium	high	high	closed
165	medium	medium	medium	medium	low	closed
166	medium	medium	medium	low	medium	closed
167	medium	medium	medium	medium	medium	closed
168	medium	medium	medium	medium	medium	closed

169	medium	medium	medium	low	low	closed
170	medium	medium	medium	medium	medium	closed
171	medium	medium	medium	medium	low	closed
172	medium	medium	medium	low	low	closed
173	medium	medium	medium	medium	medium	closed
174	medium	medium	medium	low	medium	closed
175	medium	medium	medium	low	low	closed
176	medium	medium	medium	medium	medium	closed
177	medium	medium	medium	medium	medium	closed
178	medium	medium	medium	low	medium	closed
179	medium	medium	medium	medium	medium	closed
180	medium	medium	medium	medium	medium	closed
181	medium	medium	medium	low	low	closed
182	medium	medium	medium	low	low	closed
183	medium	medium	medium	low	low	closed
184	medium	medium	high	medium	medium	closed
185	medium	medium	medium	medium	low	closed
186	low	medium	high	low	medium	closed
187	medium	medium	medium	medium	medium	closed
188	medium	medium	medium	medium	medium	closed
189	medium	medium	medium	low	low	closed
190	low	low	high	low	low	closed
191	medium	medium	medium	medium	medium	closed
192	medium	medium	medium	low	low	closed
193	medium	medium	medium	low	low	closed
194	medium	medium	medium	low	low	closed
195	medium	medium	medium	low	low	closed
196	medium	medium	high	low	low	closed
197	medium	medium	medium	medium	medium	closed
198	low	low	high	low	low	closed
199	high	high	medium	medium	medium	closed
200	low	low	medium	low	low	closed
201	medium	medium	medium	low	low	closed
202	medium	medium	medium	low	medium	closed
203	medium	medium	medium	low	low	halfopen
204	medium	medium	high	low	low	closed
205	medium	medium	medium	medium	medium	closed
206	low	medium	high	low	medium	closed
207	high	high	medium	medium	medium	closed
208	low	low	medium	low	medium	closed
209	medium	medium	medium	medium	low	closed
210	high	high	medium	low	medium	closed
211	medium	medium	medium	medium	low	closed

212	low	medium	high	low	low	closed
213	high	high	medium	medium	medium	closed
214	medium	medium	high	medium	medium	closed
215	medium	medium	medium	medium	medium	closed
216	medium	medium	medium	high	high	closed
217	high	high	medium	high	high	closed
218	medium	medium	high	high	high	closed
219	low	low	low	low	low	halfopen
220	low	low	low	medium	low	halfopen
221	high	high	low	medium	low	halfopen
222	medium	medium	medium	medium	medium	closed
223	low	low	low	low	low	halfopen
224	high	high	medium	medium	medium	closed
225	low	low	low	medium	low	halfopen
226	medium	medium	low	medium	low	halfopen
227	medium	medium	medium	medium	medium	closed
228	high	high	high	medium	medium	closed
229	low	low	low	low	low	halfopen
230	medium	medium	high	high	high	closed
231	low	low	low	medium	medium	halfopen
232	low	low	low	low	low	halfopen
233	medium	medium	low	medium	medium	closed
234	medium	medium	medium	medium	medium	closed
235	low	low	low	medium	medium	halfopen
236	low	low	medium	medium	medium	halfopen
237	medium	low	low	high	high	halfopen
238	medium	medium	medium	medium	medium	halfopen
239	medium	medium	low	medium	low	halfopen
240	medium	medium	medium	medium	medium	closed
241	high	high	medium	medium	medium	closed
242	high	high	high	medium	medium	closed
243	low	low	medium	medium	low	halfopen
244	low	low	low	medium	low	halfopen
245	low	low	low	medium	low	halfopen
246	medium	medium	medium	medium	medium	closed
247	high	high	medium	medium	medium	closed
248	high	high	medium	high	medium	halfopen
249	low	low	medium	medium	medium	closed
250	low	low	low	low	low	halfopen
251	low	low	low	low	low	halfopen
252	low	low	low	low	low	halfopen
253	low	low	low	low	low	open
254	high	high	medium	medium	medium	closed

255	low	low	low	low	low	halfopen
256	medium	medium	low	high	medium	halfopen
257	low	low	low	low	low	halfopen
258	medium	medium	medium	high	high	halfopen
259	medium	medium	low	high	medium	halfopen
260	low	low	low	low	low	halfopen
261	low	low	low	medium	low	halfopen
262	low	low	high	low	medium	closed
263	low	low	low	medium	medium	halfopen
264	medium	medium	medium	high	high	closed
265	medium	medium	medium	high	high	closed
266	medium	medium	medium	high	high	closed
267	medium	medium	medium	high	high	closed
268	medium	medium	medium	high	high	closed
269	low	medium	high	medium	medium	closed
270	high	high	medium	medium	medium	closed
271	medium	medium	high	high	high	closed
272	medium	medium	high	high	high	closed
273	medium	medium	medium	medium	medium	closed
274	medium	medium	medium	medium	medium	closed
275	medium	medium	medium	medium	medium	closed
276	medium	medium	high	low	medium	closed
277	medium	medium	high	medium	medium	closed
278	medium	medium	medium	medium	medium	closed
279	high	high	medium	medium	medium	closed
280	medium	medium	high	medium	medium	closed
281	low	low	high	medium	medium	closed
282	low	low	high	medium	medium	closed
283	medium	medium	high	medium	medium	closed
284	medium	medium	medium	medium	low	closed
285	medium	medium	medium	high	medium	closed
286	medium	medium	medium	medium	medium	closed
287	medium	medium	medium	medium	medium	closed
288	medium	medium	medium	medium	medium	closed
289	medium	medium	medium	medium	low	closed
290	high	high	medium	high	medium	closed
291	high	high	medium	medium	medium	closed
292	high	high	medium	medium	medium	closed
293	medium	medium	medium	medium	medium	closed
294	low	low	high	medium	medium	closed
295	low	low	high	medium	medium	closed
296	medium	medium	medium	medium	medium	closed
297	medium	medium	medium	medium	medium	closed

298	medium	medium	medium	medium	medium	closed
299	medium	high	medium	medium	medium	closed
300	medium	medium	medium	medium	medium	closed
301	medium	medium	medium	medium	medium	closed
302	medium	medium	medium	high	high	closed
303	medium	medium	medium	medium	medium	closed
304	medium	medium	medium	medium	medium	closed
305	medium	medium	medium	medium	medium	closed
306	medium	medium	high	high	high	closed
307	high	high	medium	high	high	closed
308	medium	medium	medium	medium	medium	closed
309	medium	medium	medium	medium	medium	closed
310	medium	medium	medium	medium	medium	closed
311	low	low	low	low	low	halfopen
312	low	low	low	low	low	halfopen
313	low	low	low	low	low	halfopen
314	low	low	low	low	low	halfopen
315	low	low	low	low	low	halfopen
316	low	low	low	medium	low	halfopen
317	low	low	low	medium	low	halfopen
318	low	low	low	low	low	halfopen
319	low	low	low	low	low	halfopen
320	low	low	low	low	low	halfopen
321	low	low	low	medium	low	halfopen
322	low	low	low	medium	low	halfopen
323	low	low	low	low	low	halfopen
324	low	low	low	low	low	halfopen
325	low	low	low	low	low	halfopen
326	high	high	medium	high	high	halfopen
327	high	high	medium	high	high	halfopen
328	high	high	medium	high	high	halfopen
329	high	high	medium	high	high	halfopen
330	high	high	medium	medium	medium	halfopen
331	low	low	high	medium	medium	closed
332	low	low	high	low	low	closed
333	low	low	high	low	low	closed
334	medium	medium	high	low	low	closed
335	medium	medium	high	low	low	closed
336	medium	medium	medium	high	high	closed
337	medium	medium	medium	high	high	closed
338	medium	medium	medium	medium	medium	closed
339	medium	medium	medium	low	medium	closed
340	medium	medium	medium	low	low	closed

Annex II. Data and Files used by Participants

Detailed listing of files used within the IE by each participating team:

- CIEMAT (Spain)
- ENEA (Italy)
- EPAIE (Ireland)
- FEA-AT (Austria)
- FI (Finland)
- INERIS (France)
- ISSeP & AwAC (Belgium)
- RIVM (Netherlands)
- SLB (Sweden)
- VITO (Belgium)
- VMM (Belgium)

FAIRMODE Intercomparison Exercise on the Spatial Representativeness of Air Quality Monitoring Stations

Data and Files used by CIEMAT

	background stations	traffic stations	Comments
Team: CIEMAT	(insert **X** for files you have used)	(insert **X** for files you have used)	
Folder 1			
Measurements of the Antwerp monitoring stations for the year 2012			
bc.csv			
btx.csv			
co.csv			
General_info.csv		X	
meteo.csv		X	
no.csv		X	
no2.csv		X	
ozon.csv			
pm10.csv		X	
pm25.csv			
so2.csv			
Folder 2			
Measurements of the ATMOSYS sampling campaigns with passive samplers and mobile stations			
dataPart1_atmosysPM.csv			
dataPart2_atmosysPM.csv			
general_info_atmosysNO2.csv			
general_info_atmosysPM.csv			
measurements_atmosysNO2.csv			
Folder 3			
Gridded yearly mean concentration data from the RIO-IFDM-OSPM model			
BC.asc			
C6H6.asc			
NO2.asc			
O3.asc			
PM10.asc			
PM25.asc			
Folder 4			
Time series from virtual monitoring points			
BC_timeseries.csv			
C6H6_timeseries.csv			
NO2_timeseries.csv			
O3_timeseries.csv			
PM10_timeseries.csv			
PM25_timeseries.csv			
Information on coordinates and SC / no SC classification:			
virtual_stations.csv			

Folder 5			
Emission datasets in the region			
CO_OPS_2012_0.csv			
NH3_OPS_2012_0.csv			
NMVOS_OPS_2012_0.csv			
NOx_OPS_2012_0.csv			
PM10_OPS_2012_0.csv			
PM25_OPS_2012_0.csv			
Point_sources.csv			
Road_emissions.csv		**X**	
SOx_OPS_2012_0.csv			
traffic_meanhour.csv			
Folder 6			
Population density in the domain			
pop_antw_100m.asc		**X**	only used for calculating the population within the SR area
pop_antw_100m.asc.aux.xml		**X**	
Folder 7			
Building information			
Buildings.shp		**X**	
Folder 8			
CORINE land use data			
corine2012_100m_antwerp.asc			
Folder 9			
Modified time series from virtual monitoring points			
Time averaged data:			
NO2_timeseries_modJRC_14d-avg.csv			
O3_timeseries_modJRC_14d-avg.csv			
PM10_timeseries_modJRC_1d-avg.csv			
Time averaged data with superimposed noise:			
NO2_timeseries_modJRC_14d-avg+noise.csv			
O3_timeseries_modJRC_14d-avg+noise.csv			
PM10_timeseries_modJRC_1d-avg+noise.csv			
Folder 10			
Results of the fourth Chemkar PM10-study.			
EnglishSummaryCK4.pdf			
Folder 11			
timefactors.xlsx			
External Data:			
Google Maps		**X**	
Google Aerial Photography / Satelite Images		**X**	
Google Street View Pictures		**X**	
OpenStreetMap road network			

FAIRMODE Intercomparison Exercise on the Spatial Representativeness of Air Quality Monitoring Stations

Data and Files used by ENEA

	background stations	traffic stations	Comments
Team: ENEA	(insert **X** for files you have used)	(insert **X** for files you have used)	
Folder 1			
Measurements of the Antwerp monitoring stations for the year 2012			
bc.csv			
btx.csv			
co.csv			
General_info.csv			
meteo.csv			
no.csv			
no2.csv			
ozon.csv			
pm10.csv			
pm25.csv			
so2.csv			
Folder 2			
Measurements of the ATMOSYS sampling campaigns with passive samplers and mobile stations			
dataPart1_atmosysPM.csv			
dataPart2_atmosysPM.csv			
general_info_atmosysNO2.csv			
general_info_atmosysPM.csv			
measurements_atmosysNO2.csv			
Folder 3			
Gridded yearly mean concentration data from the RIO-IFDM-OSPM model			
BC.asc			
C6H6.asc			
NO2.asc			
O3.asc			
PM10.asc			
PM25.asc			
Folder 4			
Time series from virtual monitoring points			
BC_timeseries.csv			
C6H6_timeseries.csv			
NO2_timeseries.csv	**X**	**X**	
O3_timeseries.csv	**X**		
PM10_timeseries.csv	**X**	**X**	
PM25_timeseries.csv			
Information on coordinates and SC / no SC classification:			
virtual_stations.csv	**X**	**X**	

Folder 5			
Emission datasets in the region			
CO_OPS_2012_0.csv			
NH3_OPS_2012_0.csv			
NMVOS_OPS_2012_0.csv			
NOx_OPS_2012_0.csv			
PM10_OPS_2012_0.csv			
PM25_OPS_2012_0.csv			
Point_sources.csv			
Road_emissions.csv			
SOx_OPS_2012_0.csv			
traffic_meanhour.csv			
Folder 6			
Population density in the domain			
pop_antw_100m.asc	**X**	**X**	only used for calculating the population within the SR area
pop_antw_100m.asc.aux.xml	**X**	**X**	
Folder 7			
Building information			
Buildings.shp			
Folder 8			
CORINE land use data			
corine2012_100m_antwerp.asc			
Folder 9			
Modified time series from virtual monitoring points			
Time averaged data:			
NO2_timeseries_modJRC_14d-avg.csv			
O3_timeseries_modJRC_14d-avg.csv			
PM10_timeseries_modJRC_1d-avg.csv			
Time averaged data with superimposed noise:			
NO2_timeseries_modJRC_14d-avg+noise.csv			
O3_timeseries_modJRC_14d-avg+noise.csv			
PM10_timeseries_modJRC_1d-avg+noise.csv			
Folder 10			
Results of the fourth Chemkar PM10-study.			
EnglishSummaryCK4.pdf			
Folder 11			
timefactors.xlsx			
External Data:			
Google Maps			
Google Aerial Photography / Satelite Images			
Google Street View Pictures			

FAIRMODE Intercomparison Exercise on the Spatial Representativeness of Air Quality Monitoring Stations

Data and Files used by EPAIE / TCD

	background stations	traffic stations	Comments
Team: EPAIE / TCD	(insert **X** for files you have used)	(insert **X** for files you have used)	
Folder 1			
Measurements of the Antwerp monitoring stations for the year 2012			
bc.csv			
btx.csv			
co.csv			
General_info.csv	X	X	
meteo.csv			
no.csv			
no2.csv	X	X	
ozon.csv	X		
pm10.csv	X	X	
pm25.csv			
so2.csv			
Folder 2			
Measurements of the ATMOSYS sampling campaigns with passive samplers and mobile stations			
dataPart1_atmosysPM.csv			
dataPart2_atmosysPM.csv			
general_info_atmosysNO2.csv			
general_info_atmosysPM.csv			
measurements_atmosysNO2.csv			
Folder 3			
Gridded yearly mean concentration data from the RIO-IFDM-OSPM model			
BC.asc			
C6H6.asc			
NO2.asc	X	X	
O3.asc	X		
PM10.asc	X	X	
PM25.asc			
Folder 4			
Time series from virtual monitoring points			
BC_timeseries.csv			
C6H6_timeseries.csv			
NO2_timeseries.csv	X	X	
O3_timeseries.csv	X	X	
PM10_timeseries.csv	X	X	
PM25_timeseries.csv			
Information on coordinates and SC / no SC classification:			
virtual_stations.csv	X	X	

Folder 5			
Emission datasets in the region			
CO_OPS_2012_0.csv			
NH3_OPS_2012_0.csv			
NMVOS_OPS_2012_0.csv			
NOx_OPS_2012_0.csv			
PM10_OPS_2012_0.csv			
PM25_OPS_2012_0.csv			
Point_sources.csv			
Road_emissions.csv			
SOx_OPS_2012_0.csv			
traffic_meanhour.csv			
Folder 6			
Population density in the domain			
pop_antw_100m.asc			
pop_antw_100m.asc.aux.xml			
Folder 7			
Building information			
Buildings.shp			
Folder 8			
CORINE land use data			
corine2012_100m_antwerp.asc			
Folder 9			
Modified time series from virtual monitoring points			
Time averaged data:			
NO2_timeseries_modJRC_14d-avg.csv			
O3_timeseries_modJRC_14d-avg.csv			
PM10_timeseries_modJRC_1d-avg.csv			
Time averaged data with superimposed noise:			
NO2_timeseries_modJRC_14d-avg+noise.csv			
O3_timeseries_modJRC_14d-avg+noise.csv			
PM10_timeseries_modJRC_1d-avg+noise.csv			
Folder 10			
Results of the fourth Chemkar PM10-study			
EnglishSummaryCK4.pdf			
Folder 11			
timefactors.xlsx			
External Data:			
Google Maps			
Google Aerial Photography / Satelite Images			
Google Street View Pictures			
OpenStreetMap road network			
road network for the city of Antwerp obtained from:			Not used in the method for determining the SR area. Only used in a later step for estimating the total length and area of road network within the SR area.
http://www.mapcruzin.com/free-belgium-arcgis-maps-shapefiles.htm	**x**	**x**	

FAIRMODE Intercomparison Exercise on the Spatial Representativeness of Air Quality Monitoring Stations

Data and Files used by FEA-AT

	background stations	traffic stations	Comments
Team: FEA-AT	(insert **X** for files you have used)	(insert **X** for files you have used)	
Folder 1			
Measurements of the Antwerp monitoring stations for the year 2012			
bc.csv			
btx.csv			
co.csv			
General_info.csv	X	X	
meteo.csv			
no.csv			
no2.csv	X	X	
ozon.csv	X	X	
pm10.csv	X	X	
pm25.csv			
so2.csv			
Folder 2			
Measurements of the ATMOSYS sampling campaigns with passive samplers and mobile stations			
dataPart1_atmosysPM.csv			
dataPart2_atmosysPM.csv			
general_info_atmosysNO2.csv			
general_info_atmosysPM.csv			
measurements_atmosysNO2.csv			
Folder 3			
Gridded yearly mean concentration data from the RIO-IFDM-OSPM model			
BC.asc			
C6H6.asc			
NO2.asc	X	X	
O3.asc	X	X	
PM10.asc	X	X	
PM25.asc			
Folder 4			
Time series from virtual monitoring points			
BC_timeseries.csv			
C6H6_timeseries.csv			
NO2_timeseries.csv			
O3_timeseries.csv	X	X	used to establish an average ratio between the 93.2 percentile of daily maximum 8-hour mean values and the annual mean value
PM10_timeseries.csv	X	X	used to calculate 90.4 percentiles of daily mean values per year as metric for representativeness assessment for PM_{10}. However, since the results did not differ significantly from the analysis of the PM_{10} annual mean values, only annual mean PM_{10} values were finally used for the representativeness assessment.
PM25_timeseries.csv			
Information on coordinates and SC / no SC classification:			
virtual_stations.csv	X	X	

Folder 5			
Emission datasets in the region			
CO_OPS_2012_0.csv			
NH3_OPS_2012_0.csv			
NMVOS_OPS_2012_0.csv			
NOx_OPS_2012_0.csv	X	X	
PM10_OPS_2012_0.csv	X	X	
PM25_OPS_2012_0.csv			
Point_sources.csv	X	X	
Road_emissions.csv		X	
SOx_OPS_2012_0.csv			
traffic_meanhour.csv			
Folder 6			
Population density in the domain			
pop_antw_100m.asc			
pop_antw_100m.asc.aux.xml			
Folder 7			
Building information			
Buildings.shp			
Folder 8			
CORINE land use data			
corine2012_100m_antwerp.asc	X		
Folder 9			
Modified time series from virtual monitoring points			
Time averaged data:			
NO2_timeseries_modJRC_14d-avg.csv			
O3_timeseries_modJRC_14d-avg.csv			
PM10_timeseries_modJRC_1d-avg.csv			
Time averaged data with superimposed noise:			
NO2_timeseries_modJRC_14d-avg+noise.csv			
O3_timeseries_modJRC_14d-avg+noise.csv			
PM10_timeseries_modJRC_1d-avg+noise.csv			
Folder 10			
Results of the fourth Chemkar PM10-study.			
EnglishSummaryCK4.pdf			
Folder 11			
timefactors.xlsx			
External Data:			
Google Maps		X	
Google Aerial Photography / Satelite Images		X	
Google Street View Pictures			
OpenStreetMap road network			

FAIRMODE Intercomparison Exercise on the Spatial Representativeness of Air Quality Monitoring Stations

Data and Files used by FI

	background stations	traffic stations	Comments
Team: Finland	(insert **X** for files you have used)	(insert **X** for files you have used)	
Folder 1			
Measurements of the Antwerp monitoring stations for the year 2012			
bc.csv			
btx.csv			
co.csv			
General_info.csv	X	X	
meteo.csv	X	X	
no.csv	X	X	
no2.csv	X	X	
ozon.csv	X	X	
pm10.csv	X	X	
pm25.csv	X	X	
so2.csv			
Folder 2			
Measurements of the ATMOSYS sampling campaigns with passive samplers and mobile stations			
dataPart1_atmosysPM.csv	X	X	
dataPart2_atmosysPM.csv	X	X	
general_info_atmosysNO2.csv	X	X	
general_info_atmosysPM.csv	X	X	
measurements_atmosysNO2.csv	X	X	
Folder 3			
Gridded yearly mean concentration data from the RIO-IFDM-OSPM model			
BC.asc			
C6H6.asc			
NO2.asc	X	X	
O3.asc	X	X	
PM10.asc	X	X	
PM25.asc	X	X	
Folder 4			
Time series from virtual monitoring points			
BC_timeseries.csv			
C6H6_timeseries.csv			
NO2_timeseries.csv	X	X	
O3_timeseries.csv	X	X	
PM10_timeseries.csv	X	X	
PM25_timeseries.csv	X	X	
Information on coordinates and SC / no SC classification:			
virtual_stations.csv	X	X	

Folder 5			
Emission datasets in the region			
CO_OPS_2012_0.csv			
NH3_OPS_2012_0.csv			
NMVOS_OPS_2012_0.csv			
NOx_OPS_2012_0.csv			
PM10_OPS_2012_0.csv			
PM25_OPS_2012_0.csv			
Point_sources.csv	X	X	
Road_emissions.csv	X	X	
SOx_OPS_2012_0.csv			
traffic_meanhour.csv	X	X	
Folder 6			
Population density in the domain			
pop_antw_100m.asc			
pop_antw_100m.asc.aux.xml			
Folder 7			
Building information			
Buildings.shp	X	X	
Folder 8			
CORINE land use data			
corine2012_100m_antwerp.asc	X	X	
Folder 9			
Modified time series from virtual monitoring points			
Time averaged data:			
NO2_timeseries_modJRC_14d-avg.csv			
O3_timeseries_modJRC_14d-avg.csv			
PM10_timeseries_modJRC_1d-avg.csv			
Time averaged data with superimposed noise:			
NO2_timeseries_modJRC_14d-avg+noise.csv			
O3_timeseries_modJRC_14d-avg+noise.csv			
PM10_timeseries_modJRC_1d-avg+noise.csv			
Folder 10			
Results of the fourth Chemkar PM10-study			
EnglishSummaryCK4.pdf	X	X	
Folder 11			
timefactors.xlsx	X	X	
External Data:			
Google Maps	X	X	
Google Aerial Photography / Satelite Images	X	X	
Google Street View Pictures	X	X	
OpenStreetMap road network			

FAIRMODE Intercomparison Exercise on the Spatial Representativeness of Air Quality Monitoring Stations

Data and Files used by INERIS

	background stations	traffic stations	Comments
Team: INERIS	(insert **X** for files you have used)	(insert **X** for files you have used)	
Folder 1			
Measurements of the Antwerp monitoring stations for the year 2012			
bc.csv			
btx.csv			
co.csv			
General_info.csv			
meteo.csv			
no.csv			
no2.csv	(X)	(X)	Only used in the 1st version. After discussion with JRC we used the data of the collocated virtual monitoring points instead .
ozon.csv			
pm10.csv	(X)	(X)	
pm25.csv			
so2.csv			
Folder 2			
Measurements of the ATMOSYS sampling campaigns with passive samplers and mobile stations			
dataPart1_atmosysPM.csv			
dataPart2_atmosysPM.csv			
general_info_atmosysNO2.csv			
general_info_atmosysPM.csv			
measurements_atmosysNO2.csv			
Folder 3			
Gridded yearly mean concentration data from the RIO-IFDM-OSPM model			
BC.asc			
C6H6.asc			
NO2.asc			
O3.asc			
PM10.asc			
PM25.asc			
Folder 4			
Time series from virtual monitoring points			
BC_timeseries.csv			
C6H6_timeseries.csv			
NO2_timeseries.csv			
O3_timeseries.csv			
PM10_timeseries.csv			
PM25_timeseries.csv			
Information on coordinates and SC / no SC classification:			
virtual_stations.csv			

Folder 5			
Emission datasets in the region			
CO_OPS_2012_0.csv			
NH3_OPS_2012_0.csv			
NMVOS_OPS_2012_0.csv			
NOx_OPS_2012_0.csv	X	X	used as secondary variable in the external drift kriging (NO_x emissions for NO_2 and PM_{10} emissions for PM_{10})
PM10_OPS_2012_0.csv	X	X	
PM25_OPS_2012_0.csv			
Point_sources.csv			Used as secondary variable in the external drift kriging (NO_x emissions for NO_2 and PM_{10} emissions for PM_{10}). Also used to calculate the variable "distance to the road" which is combined with traffic emissions in the external drift.
Road_emissions.csv	X	X	
SOx_OPS_2012_0.csv			
traffic_meanhour.csv			
Folder 6			
Population density in the domain			
pop_antw_100m.asc	X	X	Only used to calculate population inside the representativeness areas (not as input for delimiting these areas).
pop_antw_100m.asc.aux.xml			
Folder 7			
Building information			
Buildings.shp			
Folder 8			
CORINE land use data			
corine2012_100m_antwerp.asc			
Folder 9			
Modified time series from virtual monitoring points			
Time averaged data:			
NO2_timeseries_modJRC_14d-avg.csv			
O3_timeseries_modJRC_14d-avg.csv			
PM10_timeseries_modJRC_1d-avg.csv			
Time averaged data with superimposed noise:			
NO2_timeseries_modJRC_14d-avg+noise.csv	X	X	used to calculate annual mean reference data for the evaluated stations
O3_timeseries_modJRC_14d-avg+noise.csv			
PM10_timeseries_modJRC_1d-avg+noise.csv	X	X	
Folder 10			
Results of the fourth Chemkar PM10-study			
EnglishSummaryCK4.pdf			
Folder 11			
timefactors.xlsx			
External Data:			
Google Maps			
Google Aerial Photography / Satelite Images			
Google Street View Pictures			
OpenStreetMap road network			
Supplementary folder (provided by VITO):			
Yearly mean concentration data from the RIO-IFDM-OSPM model: Raw model outputs (not interpolated on a grid)			
resultsIFDM_csv	X	X	Used for NO_2 and PM_{10} as main variable in the external drift kriging.
resultsOSPM_csv	X	X	

FAIRMODE Intercomparison Exercise on the Spatial Representativeness of Air Quality Monitoring Stations

Data and Files used by ISSEPAWAC

	background stations	traffic stations	Comments
Team: ISSEPAWAC	(insert **X** for files you have used)	(insert **X** for files you have used)	
Folder 1			
Measurements of the Antwerp monitoring stations for the year 2012			
bc.csv			
btx.csv			
co.csv			
General_info.csv			
meteo.csv			
no.csv			
no2.csv			
ozon.csv			
pm10.csv			
pm25.csv			
so2.csv			
Folder 2			
Measurements of the ATMOSYS sampling campaigns with passive samplers and mobile stations			
dataPart1_atmosysPM.csv			
dataPart2_atmosysPM.csv			
general_info_atmosysNO2.csv			
general_info_atmosysPM.csv			
measurements_atmosysNO2.csv			
Folder 3			
Gridded yearly mean concentration data from the RIO-IFDM-OSPM model			
BC.asc			
C6H6.asc			
NO2.asc			
O3.asc			
PM10.asc			
PM25.asc			
Folder 4			
Time series from virtual monitoring points			
BC_timeseries.csv			
C6H6_timeseries.csv			
NO2_timeseries.csv			
O3_timeseries.csv			
PM10_timeseries.csv			
PM25_timeseries.csv			
Information on coordinates and SC / no SC classification:			
virtual_stations.csv			

Folder 5			
Emission datasets in the region			
CO_OPS_2012_0.csv			
NH3_OPS_2012_0.csv			
NMVOS_OPS_2012_0.csv			
NOx_OPS_2012_0.csv	X		used the "Grand Total" of all snap sectors
PM10_OPS_2012_0.csv	X		used the "Grand Total" of all snap sectors
PM25_OPS_2012_0.csv			
Point_sources.csv			
Road_emissions.csv		X	used the emissions and the length of the segments
SOx_OPS_2012_0.csv			
traffic_meanhour.csv			
Folder 6			
Population density in the domain			
pop_antw_100m.asc			
pop_antw_100m.asc.aux.xml			
Folder 7			
Building information			
Buildings.shp		X	used to average the height of buildings
Folder 8			
CORINE land use data			
corine2012_100m_antwerp.asc			
Folder 9			
Modified time series from virtual monitoring points			
Time averaged data:			
NO2_timeseries_modJRC_14d-avg.csv			
O3_timeseries_modJRC_14d-avg.csv			
PM10_timeseries_modJRC_1d-avg.csv			
Time averaged data with superimposed noise:			
NO2_timeseries_modJRC_14d-avg+noise.csv			
O3_timeseries_modJRC_14d-avg+noise.csv			
PM10_timeseries_modJRC_1d-avg+noise.csv			
Folder 10			
Results of the fourth Chemkar PM10-study.			
EnglishSummaryCK4.pdf			
Folder 11			
timefactors.xlsx			
External Data:			
Google Maps			
Google Aerial Photography / Satelite Images			
Google Street View Pictures			
OpenStreetMap road network			
Please complement here any other data you have used:			
Bing area information		X	used to count the number of lanes

FAIRMODE Intercomparison Exercise on the Spatial Representativeness of Air Quality Monitoring Stations

Data and Files used by RIVM

	background stations	traffic stations	Comments
Team: RIVM	(insert **X** for files you have used)	(insert **X** for files you have used)	
Folder 1			
Measurements of the Antwerp monitoring stations for the year 2012			
bc.csv			
btx.csv			
co.csv			
General_info.csv			
meteo.csv			
no.csv			
no2.csv	X	X	
ozon.csv	X	X	
pm10.csv	X	X	
pm25.csv			
so2.csv			
Folder 2			
Measurements of the ATMOSYS sampling campaigns with passive samplers and mobile stations			
dataPart1_atmosysPM.csv			
dataPart2_atmosysPM.csv			
general_info_atmosysNO2.csv			
general_info_atmosysPM.csv			
measurements_atmosysNO2.csv			
Folder 3			
Gridded yearly mean concentration data from the RIO-IFDM-OSPM model			
BC.asc			
C6H6.asc			
NO2.asc			
O3.asc			
PM10.asc			
PM25.asc			
Folder 4			
Time series from virtual monitoring points			
BC_timeseries.csv			
C6H6_timeseries.csv			
NO2_timeseries.csv	X	X	in case of collocated virtual monitoring points and real Antwerp monitoring stations, both are independently shown in the PCA plots
O3_timeseries.csv	X	X	
PM10_timeseries.csv	X	X	
PM25_timeseries.csv			
Information on coordinates and SC / no SC classification:			
virtual_stations.csv	X	X	

Folder 5			
Emission datasets in the region			
CO_OPS_2012_0.csv			
NH3_OPS_2012_0.csv			
NMVOS_OPS_2012_0.csv			
NOx_OPS_2012_0.csv			
PM10_OPS_2012_0.csv			
PM25_OPS_2012_0.csv			
Point_sources.csv			
Road_emissions.csv			
SOx_OPS_2012_0.csv			
traffic_meanhour.csv			
Folder 6			
Population density in the domain			
pop_antw_100m.asc	**X**	**X**	only used for calculating the population within the SR area; not used as an emission, dispersion or concentration proxy
pop_antw_100m.asc.aux.xml			
Folder 7			
Building information			
Buildings.shp			
Folder 8			
CORINE land use data			
corine2012_100m_antwerp.asc			
Folder 9			
Modified time series from virtual monitoring points			
Time averaged data:			
NO2_timeseries_modJRC_14d-avg.csv			
O3_timeseries_modJRC_14d-avg.csv			
PM10_timeseries_modJRC_1d-avg.csv			
Time averaged data with superimposed noise:			
NO2_timeseries_modJRC_14d-avg+noise.csv			
O3_timeseries_modJRC_14d-avg+noise.csv			
PM10_timeseries_modJRC_1d-avg+noise.csv			
Folder 10			
Results of the fourth Chemkar PM10-study			
EnglishSummaryCK4.pdf			
Folder 11			
timefactors.xlsx			
External Data:			
Google Maps			
Google Aerial Photography / Satelite Images			
Google Street View Pictures			
OpenStreetMap road network	**X**	**X**	used for sighting the data; not required for the PCA analysis
Google Earth	**X**	**X**	

FAIRMODE Intercomparison Exercise on the Spatial Representativeness of Air Quality Monitoring Stations

Data and Files used by SLB

	background stations	traffic stations	Comments
Team: SLB, Stockholm	(insert **X** for files you have used)	(insert **X** for files you have used)	
Folder 1			
Measurements of the Antwerp monitoring stations for the year 2012			
bc.csv			
btx.csv			
co.csv			
General_info.csv			
meteo.csv			
no.csv			
no2.csv	**X**		Only used to verify agreement between measured and modelled concentrations at the stations. Not used in the method for determining the SR area.
ozon.csv	**X**		
pm10.csv	**X**		
pm25.csv			
so2.csv			
Folder 2			
Measurements of the ATMOSYS sampling campaigns with passive samplers and mobile stations			
dataPart1_atmosysPM.csv			
dataPart2_atmosysPM.csv			
general_info_atmosysNO2.csv			
general_info_atmosysPM.csv			
measurements_atmosysNO2.csv			
Folder 3			
Gridded yearly mean concentration data from the RIO-IFDM-OSPM model			
BC.asc			
C6H6.asc			
NO2.asc	**X**	**X**	For the traffic station modelled concentrations were only used to visually check that the levels within the SR area were about the same. Not used in the method of determining the SR area.
O3.asc	**X**		
PM10.asc	**X**	**X**	
PM25.asc			
Folder 4			
Time series from virtual monitoring points			
BC_timeseries.csv			
C6H6_timeseries.csv			
NO2_timeseries.csv			
O3_timeseries.csv			
PM10_timeseries.csv			
PM25_timeseries.csv			
Information on coordinates and SC / no SC classification:			
virtual_stations.csv			

Folder 5			
Emission datasets in the region			
CO_OPS_2012_0.csv			
NH3_OPS_2012_0.csv			
NMVOS_OPS_2012_0.csv			
NOx_OPS_2012_0.csv			
PM10_OPS_2012_0.csv			
PM25_OPS_2012_0.csv			
Point_sources.csv			
Road_emissions.csv		X	
SOx_OPS_2012_0.csv			
traffic_meanhour.csv			
Folder 6			
Population density in the domain			
pop_antw_100m.asc	X	X	only used for calculating the population within the SR area
pop_antw_100m.asc.aux.xml	X	X	
Folder 7			
Building information			
Buildings.shp		X	
Folder 8			
CORINE land use data			
corine2012_100m_antwerp.asc			
Folder 9			
Modified time series from virtual monitoring points			
Time averaged data:			
NO2_timeseries_modJRC_14d-avg.csv			
O3_timeseries_modJRC_14d-avg.csv			
PM10_timeseries_modJRC_1d-avg.csv			
Time averaged data with superimposed noise:			
NO2_timeseries_modJRC_14d-avg+noise.csv			
O3_timeseries_modJRC_14d-avg+noise.csv			
PM10_timeseries_modJRC_1d-avg+noise.csv			
Folder 10			
Results of the fourth Chemkar PM10-study.			
EnglishSummaryCK4.pdf			
Folder 11			
timefactors.xlsx			
External Data:			
Google Maps			
Google Aerial Photography / Satelite Images			
Google Street View Pictures			
OpenStreetMap road network			

FAIRMODE Intercomparison Exercise on the Spatial Representativeness of Air Quality Monitoring Stations

Data and Files used by VITO

	background stations	traffic stations	Comments
Team: VITO	(insert **X** for files you have used)	(insert **X** for files you have used)	
Folder 1			
Measurements of the Antwerp monitoring stations for the year 2012			
bc.csv			
btx.csv			
co.csv			
General_info.csv			
meteo.csv			
no.csv			
no2.csv			
ozon.csv			
pm10.csv			
pm25.csv			
so2.csv			
Folder 2			
Measurements of the ATMOSYS sampling campaigns with passive samplers and mobile stations			
dataPart1_atmosysPM.csv			
dataPart2_atmosysPM.csv			
general_info_atmosysNO2.csv			
general_info_atmosysPM.csv			
measurements_atmosysNO2.csv			
Folder 3			
Gridded yearly mean concentration data from the RIO-IFDM-OSPM model			
BC.asc			
C6H6.asc			
NO2.asc			
O3.asc			
PM10.asc			
PM25.asc			
Folder 4			
Time series from virtual monitoring points			
BC_timeseries.csv			
C6H6_timeseries.csv			
NO2_timeseries.csv			
O3_timeseries.csv			
PM10_timeseries.csv			
PM25_timeseries.csv			
Information on coordinates and SC / no SC classification:			
virtual_stations.csv			

Folder 5			
Emission datasets in the region			
CO_OPS_2012_0.csv			
NH3_OPS_2012_0.csv			
NMVOS_OPS_2012_0.csv			
NOx_OPS_2012_0.csv			
PM10_OPS_2012_0.csv			
PM25_OPS_2012_0.csv			
Point_sources.csv			
Road_emissions.csv			
SOx_OPS_2012_0.csv			
traffic_meanhour.csv			
Folder 6			
Population density in the domain			
pop_antw_100m.asc	X	X	
pop_antw_100m.asc.aux.xml			
Folder 7			
Building information			
Buildings.shp			
Folder 8			
CORINE land use data			
corine2012_100m_antwerp.asc	X	X	
Folder 9			
Modified time series from virtual monitoring points			
Time averaged data:			
NO2_timeseries_modJRC_14d-avg.csv			
O3_timeseries_modJRC_14d-avg.csv			
PM10_timeseries_modJRC_1d-avg.csv			
Time averaged data with superimposed noise:			
NO2_timeseries_modJRC_14d-avg+noise.csv			
O3_timeseries_modJRC_14d-avg+noise.csv			
PM10_timeseries_modJRC_1d-avg+noise.csv			
Folder 10			
Results of the fourth Chemkar PM10-study			
EnglishSummaryCK4.pdf			
Folder 11			
timefactors.xlsx			
External Data:			
Google Maps			
Google Aerial Photography / Satelite Images			
Google Street View Pictures			
OpenStreetMap road network			
long term average NO_2 concentrations for the period 2008 – 2012 for 79 Belgian stations provided by IRCEL	X	X	
long term average O_3 concentrations for the period 2008 – 2012 for 41 Belgian stations provided by IRCEL	X	X	
long term average PM_{10} concentrations for the period 2009-2010 for 61 Belgian stations provided by IRCEL	X	X	
CORINE land cover 2006 data set reclassified to 13 RIO land cover classes	X	X	

FAIRMODE Intercomparison Exercise on the Spatial Representativeness of Air Quality Monitoring Stations

Data and Files used by VMM

	background stations	traffic stations	Comments
Team: VMM	(insert **X** for files you have used)	(insert **X** for files you have used)	
Folder 1			
Measurements of the Antwerp monitoring stations for the year 2012			
bc.csv			
btx.csv			
co.csv			
General_info.csv			
meteo.csv			
no.csv			
no2.csv			
ozon.csv			
pm10.csv			
pm25.csv			
so2.csv			
Folder 2			
Measurements of the ATMOSYS sampling campaigns with passive samplers and mobile stations			
dataPart1_atmosysPM.csv			
dataPart2_atmosysPM.csv			
general_info_atmosysNO2.csv			
general_info_atmosysPM.csv			
measurements_atmosysNO2.csv			
Folder 3			
Gridded yearly mean concentration data from the RIO-IFDM-OSPM model			
BC.asc			
C6H6.asc			
NO2.asc	X	X	
O3.asc			
PM10.asc	X	X	
PM25.asc			
Folder 4			
Time series from virtual monitoring points			
BC_timeseries.csv			
C6H6_timeseries.csv			
NO2_timeseries.csv			
O3_timeseries.csv			
PM10_timeseries.csv			
PM25_timeseries.csv			
Information on coordinates and SC / no SC classification:			
virtual_stations.csv			

Folder 5			
Emission datasets in the region			
CO_OPS_2012_0.csv			
NH3_OPS_2012_0.csv			
NMVOS_OPS_2012_0.csv			
NOx_OPS_2012_0.csv			
PM10_OPS_2012_0.csv			
PM25_OPS_2012_0.csv			
Point_sources.csv			
Road_emissions.csv	**X**	**X**	
SOx_OPS_2012_0.csv			
traffic_meanhour.csv			
Folder 6			
Population density in the domain			
pop_antw_100m.asc	**X**	**X**	
pop_antw_100m.asc.aux.xml			
Folder 7			
Building information			
Buildings.shp			
Folder 8			
CORINE land use data			
corine2012_100m_antwerp.asc	**X**	**X**	
Folder 9			
Modified time series from virtual monitoring points			
Time averaged data:			
NO2_timeseries_modJRC_14d-avg.csv			
O3_timeseries_modJRC_14d-avg.csv			
PM10_timeseries_modJRC_1d-avg.csv			
Time averaged data with superimposed noise:			
NO2_timeseries_modJRC_14d-avg+noise.csv			
O3_timeseries_modJRC_14d-avg+noise.csv			
PM10_timeseries_modJRC_1d-avg+noise.csv			
Folder 10			
Results of the fourth Chemkar PM10-study.			
EnglishSummaryCK4.pdf			
Folder 11			
timefactors.xlsx			
External Data:			
Google Maps			
Google Aerial Photography / Satelite Images			
Google Street View Pictures			
OpenStreetMap road network			

Annex III. Spatial Representativeness Maps by Team

SR maps provided by each participating team:

- CIEMAT (Spain)
- ENEA (Italy)
- EPAIE (Ireland)
- FEA-AT (Austria)
- FI (Finland)
- INERIS (France)
- ISSeP & AwAC (Belgium)
- RIVM (Netherlands)
- SLB (Sweden)
- VITO (Belgium)
- VMM (Belgium)

RIVM (Netherlands) worked by PCA classification. Thus, no SR maps have been supplied.

Legend:

In all maps, the position of the respective **AQMS is highlighted in red**.

Background colours depict the **annual average concentration field** of the respective pollutant:

NO_2: green colour scale

O_3: blue colour scale

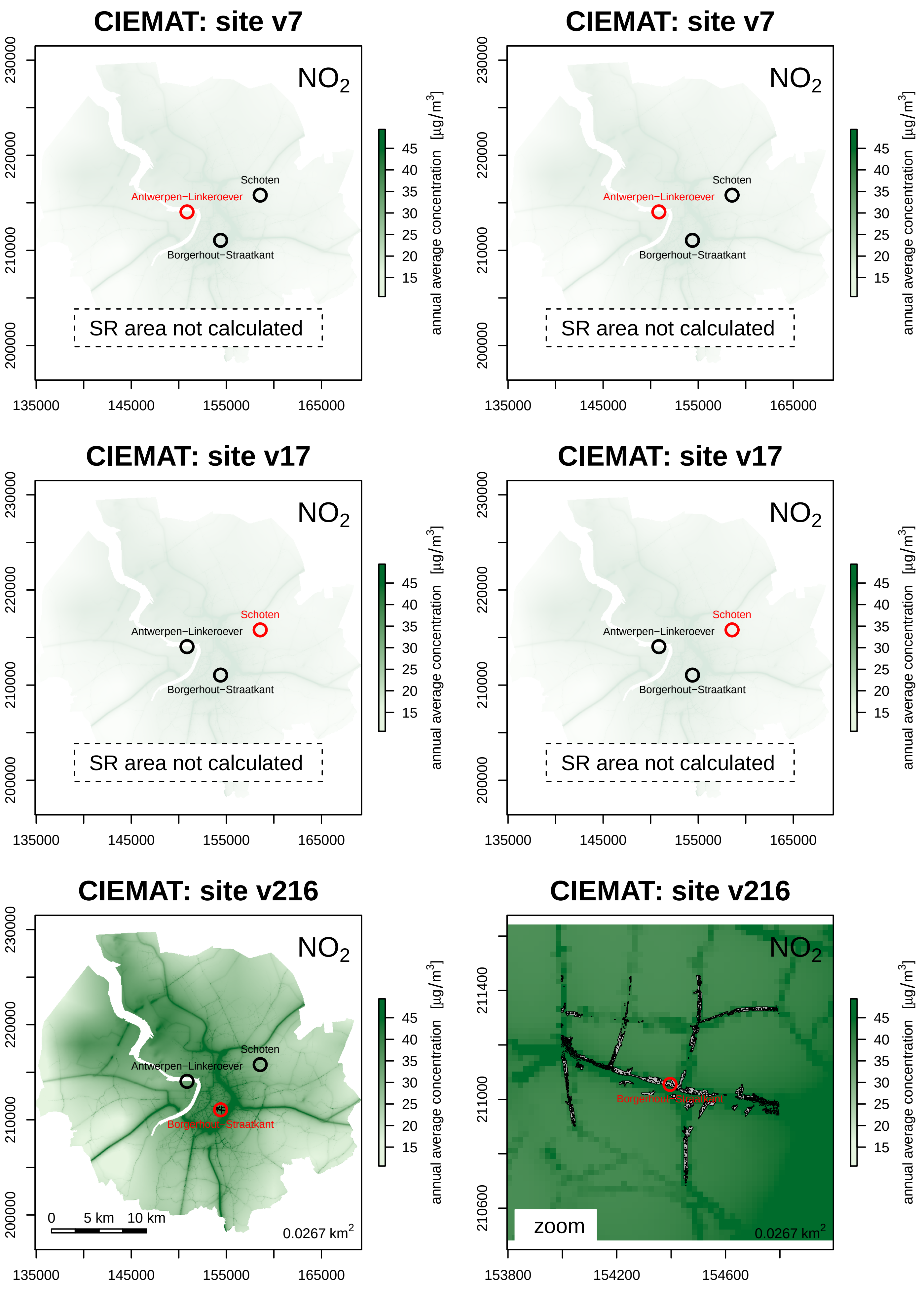
PM_{10}: orange colour scale

The actual **SR areas** are described by the **grey coloured fields** in the foreground.

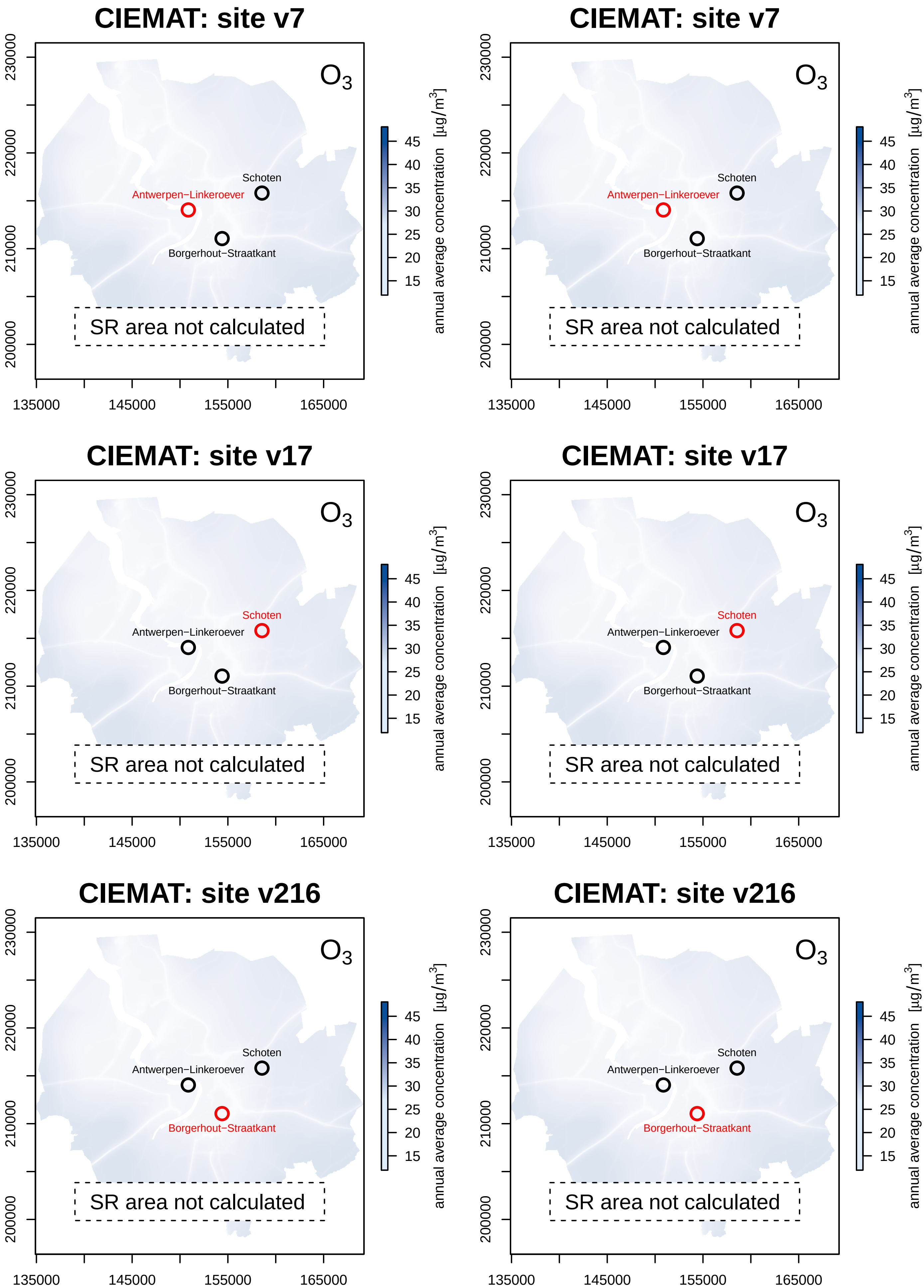
Spatial Representativeness Maps

by Team:

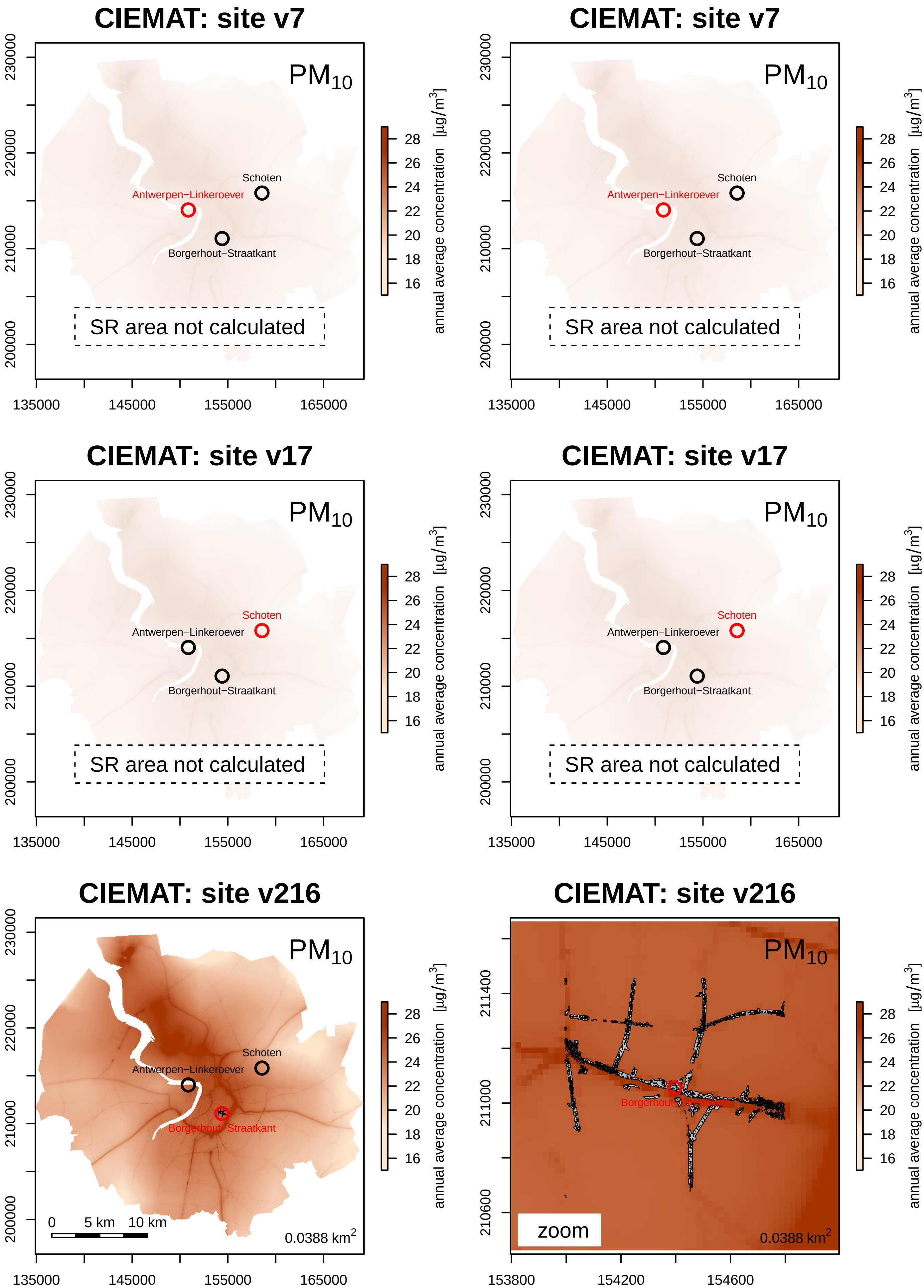
CIEMAT (Spain)



results CIEMAT (Spain)



results CIEMAT (Spain)

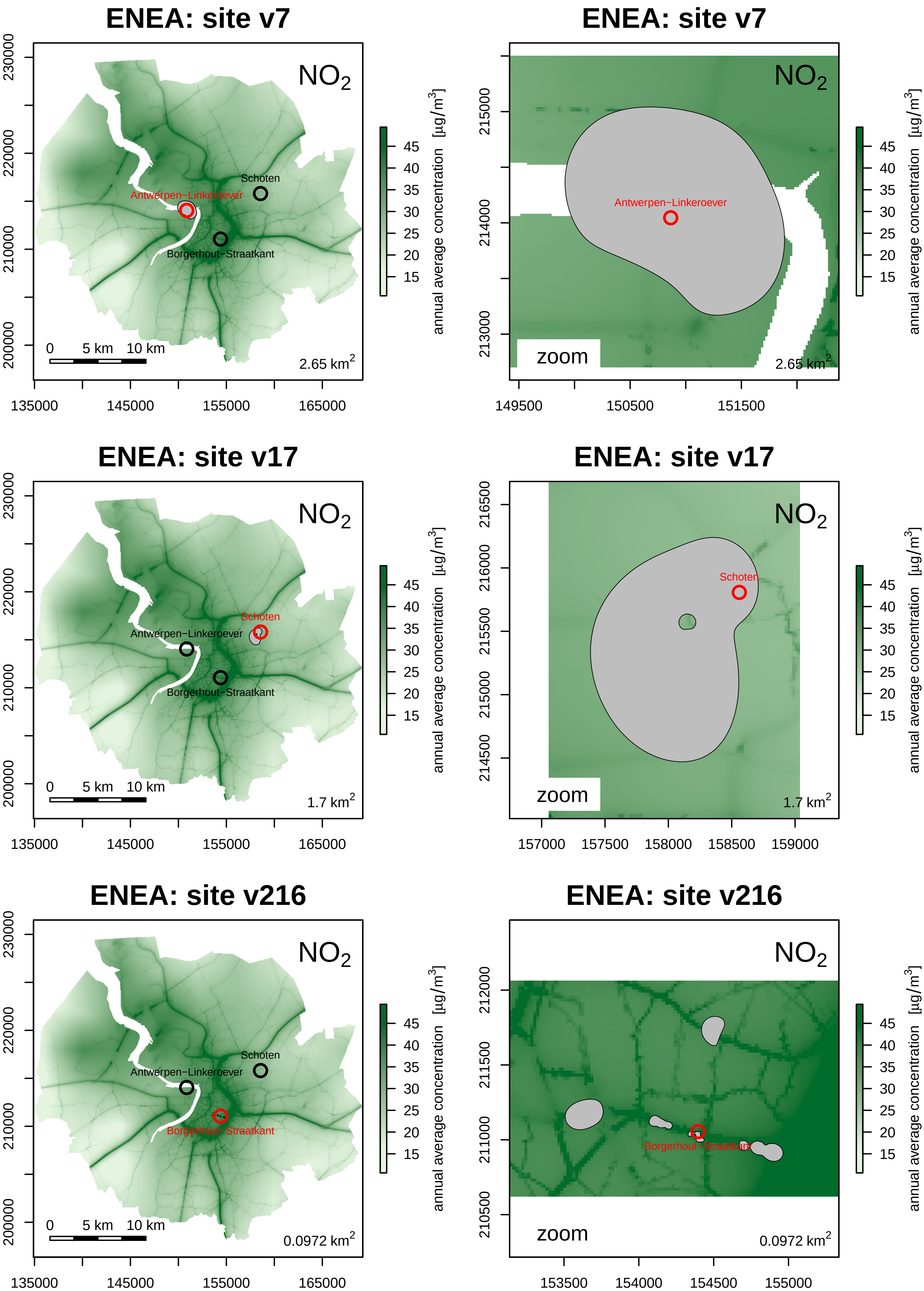


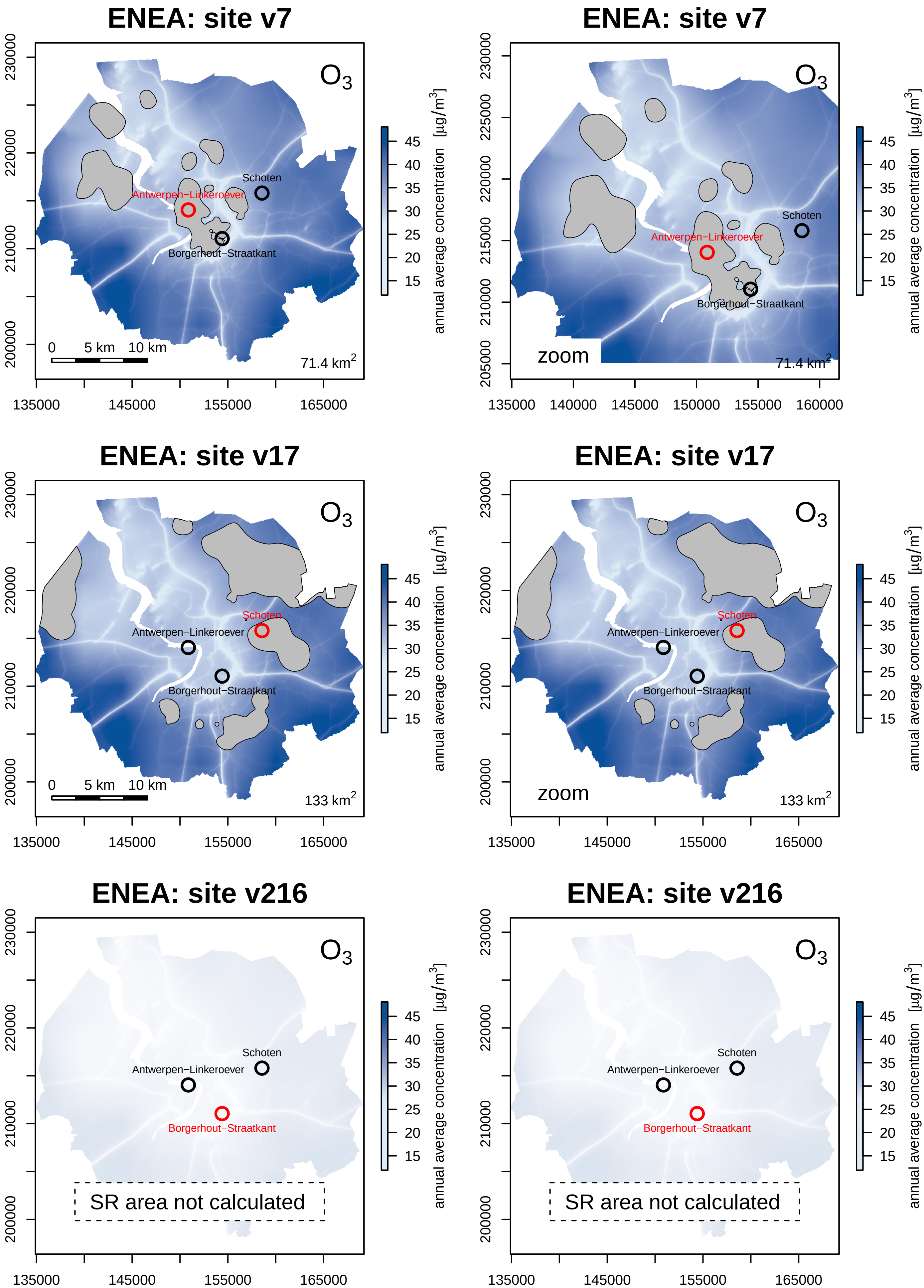
results CIEMAT (Spain)

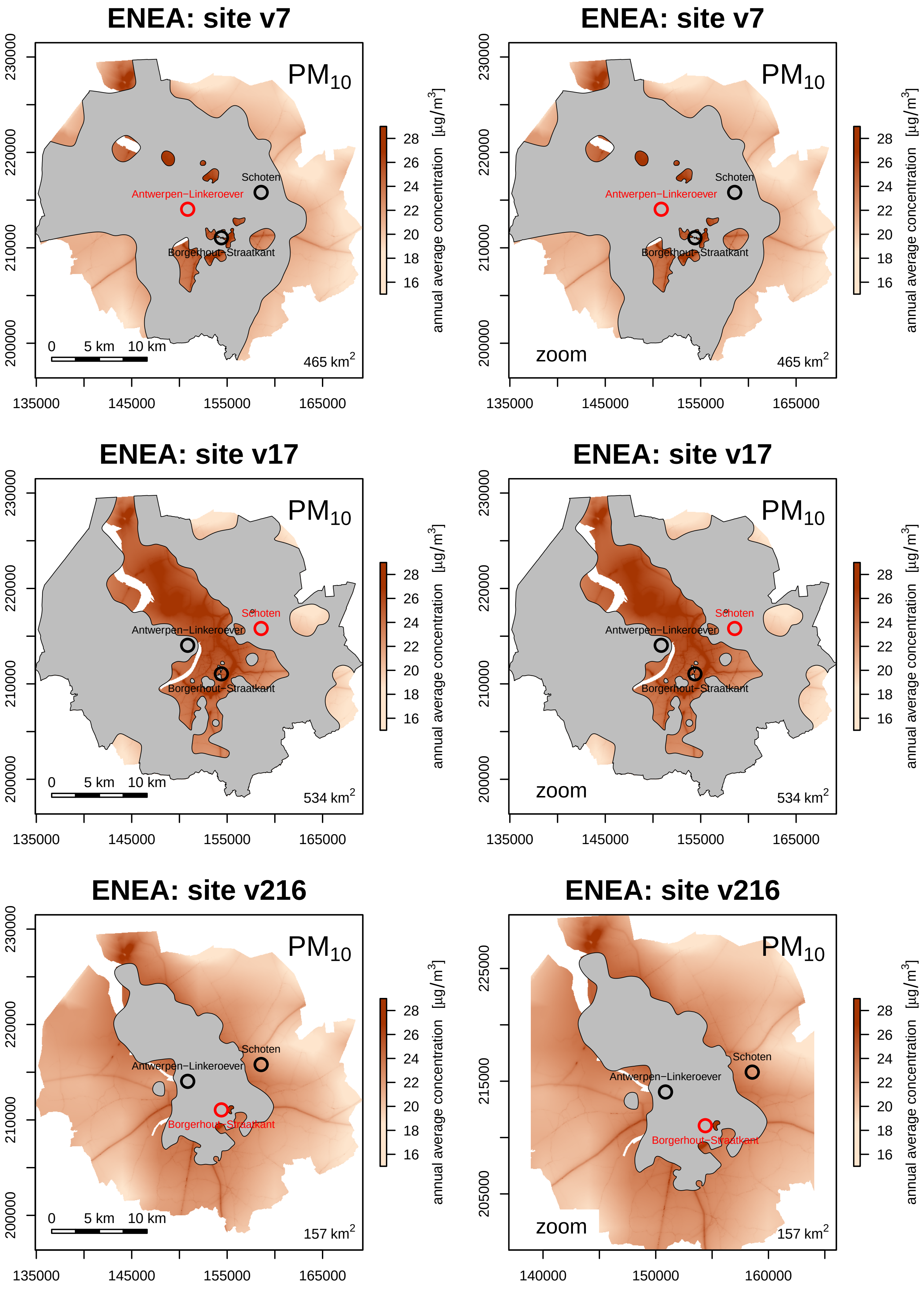
Spatial Representativeness Maps

by Team:

ENEA (Italy)


ENEA: site v7
NO2
Antwerpen−Linkeroever
Schoten
Borgerhout−Straatkant
0 5 km 10 km
2.65 km2
annual average concentration [µg/m3]
45
40
35
30
25
20
15
135000
145000
155000
165000
200000
210000
220000
230000
ENEA: site v7
NO2
Antwerpen−Linkeroever
zoom
2.65 km2
149500
150500
151500
213000
214000
215000
ENEA: site v17
NO2
Antwerpen−Linkeroever
Schoten
Borgerhout−Straatkant
0 5 km 10 km
1.7 km2
ENEA: site v17
NO2
Schoten
zoom
1.7 km2
157000
157500
158000
158500
159000
214500
215000
215500
216000
216500
ENEA: site v216
NO2
Antwerpen−Linkeroever
Schoten
Borgerhout−Straatkant
0 5 km 10 km
0.0972 km2
ENEA: site v216
NO2
Borgerhout−Straatkant
zoom
0.0972 km2
153500
154000
154500
155000
210500
211000
211500
212000


ENEA: site v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
71.4 km2
annual average concentration [µg/m3]
45 40 35 30 25 20 15
135000 145000 155000 165000
200000 210000 220000 230000
ENEA: site v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
zoom
71.4 km2
135000 140000 145000 150000 155000 160000
205000 210000 215000 220000 225000 230000
ENEA: site v17
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
133 km2
ENEA: site v17
O3
zoom
133 km2
ENEA: site v216
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
SR area not calculated
ENEA: site v216
O3
SR area not calculated

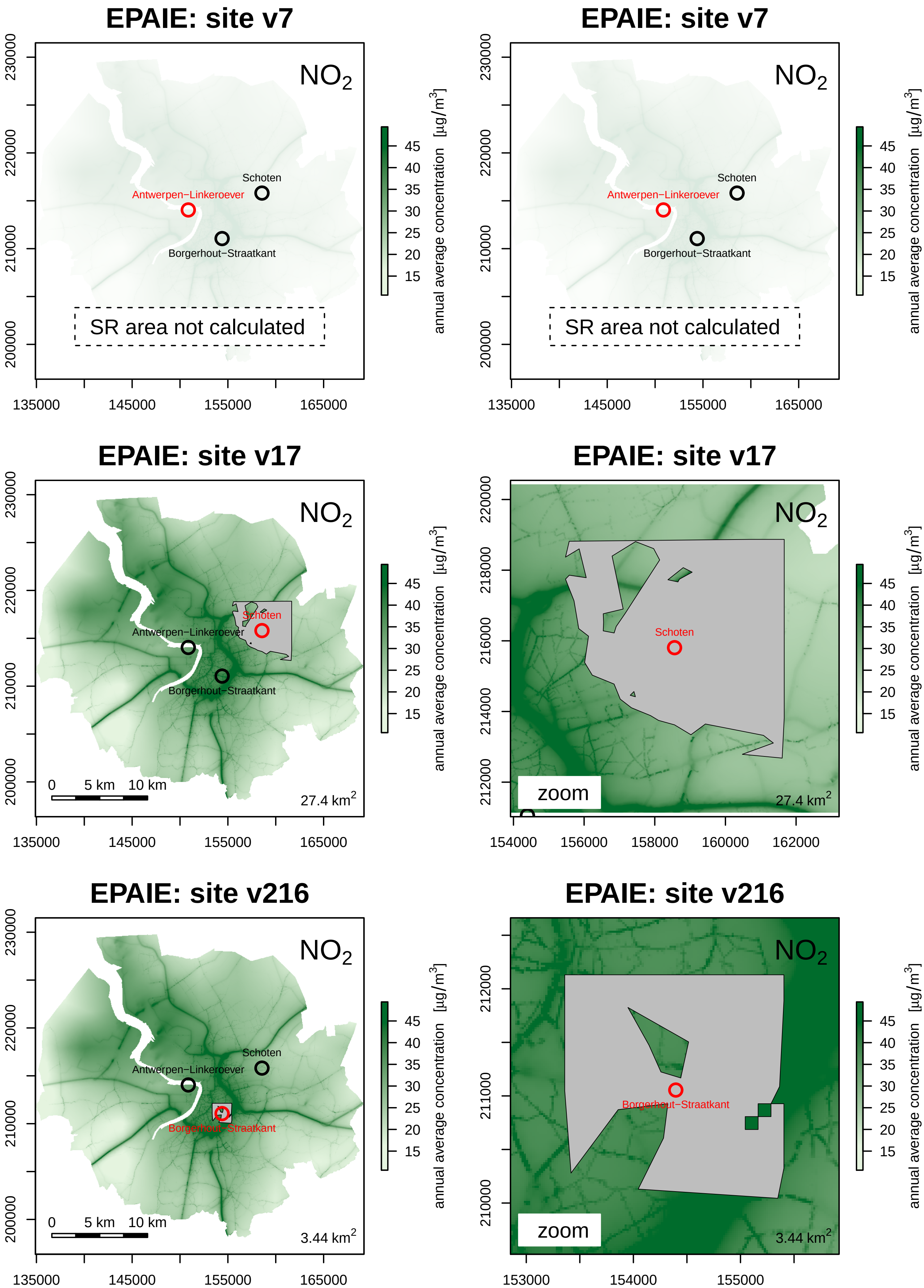


results ENEA (Italy)

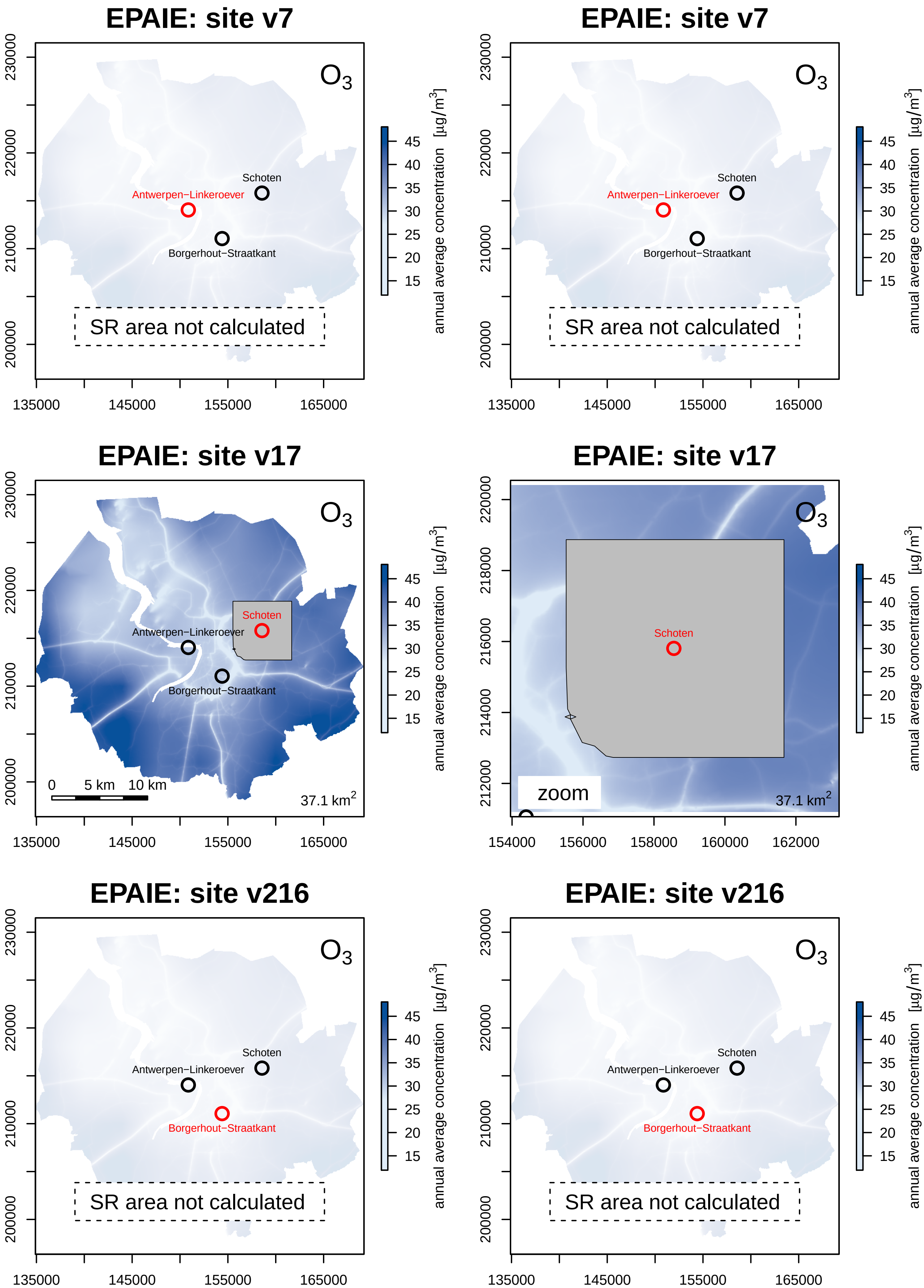
Spatial Representativeness Maps

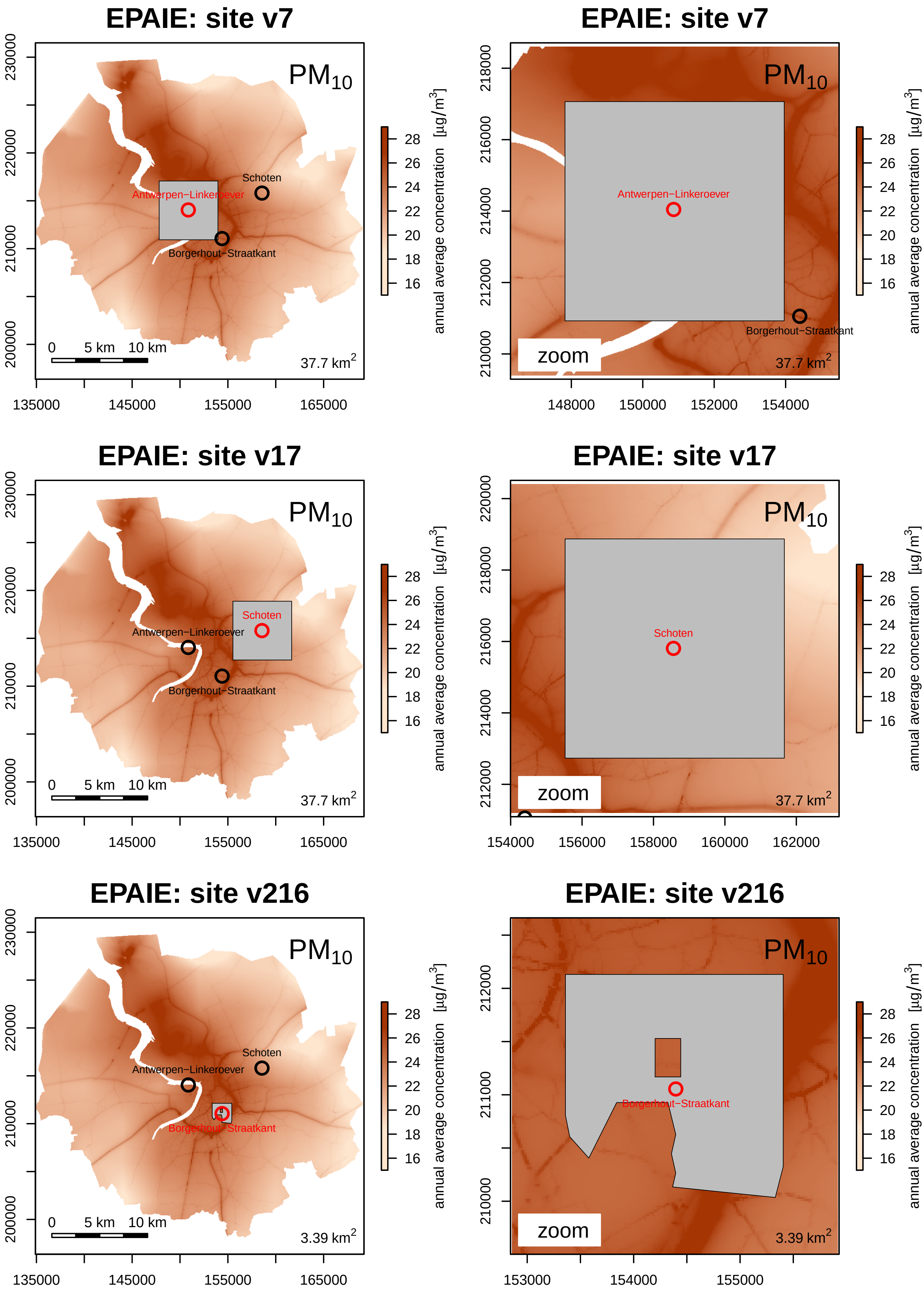
by Team:

EPA−IE (Ireland)



results EPA−IE (Ireland)


EPAIE: site v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
SR area not calculated
annual average concentration [µg/m3]
45
40
35
30
25
20
15
135000
145000
155000
165000
200000
210000
220000
230000
EPAIE: site v17
0
5 km
10 km
37.1 km2
zoom
154000
156000
158000
160000
162000
212000
214000
216000
218000
220000
EPAIE: site v216

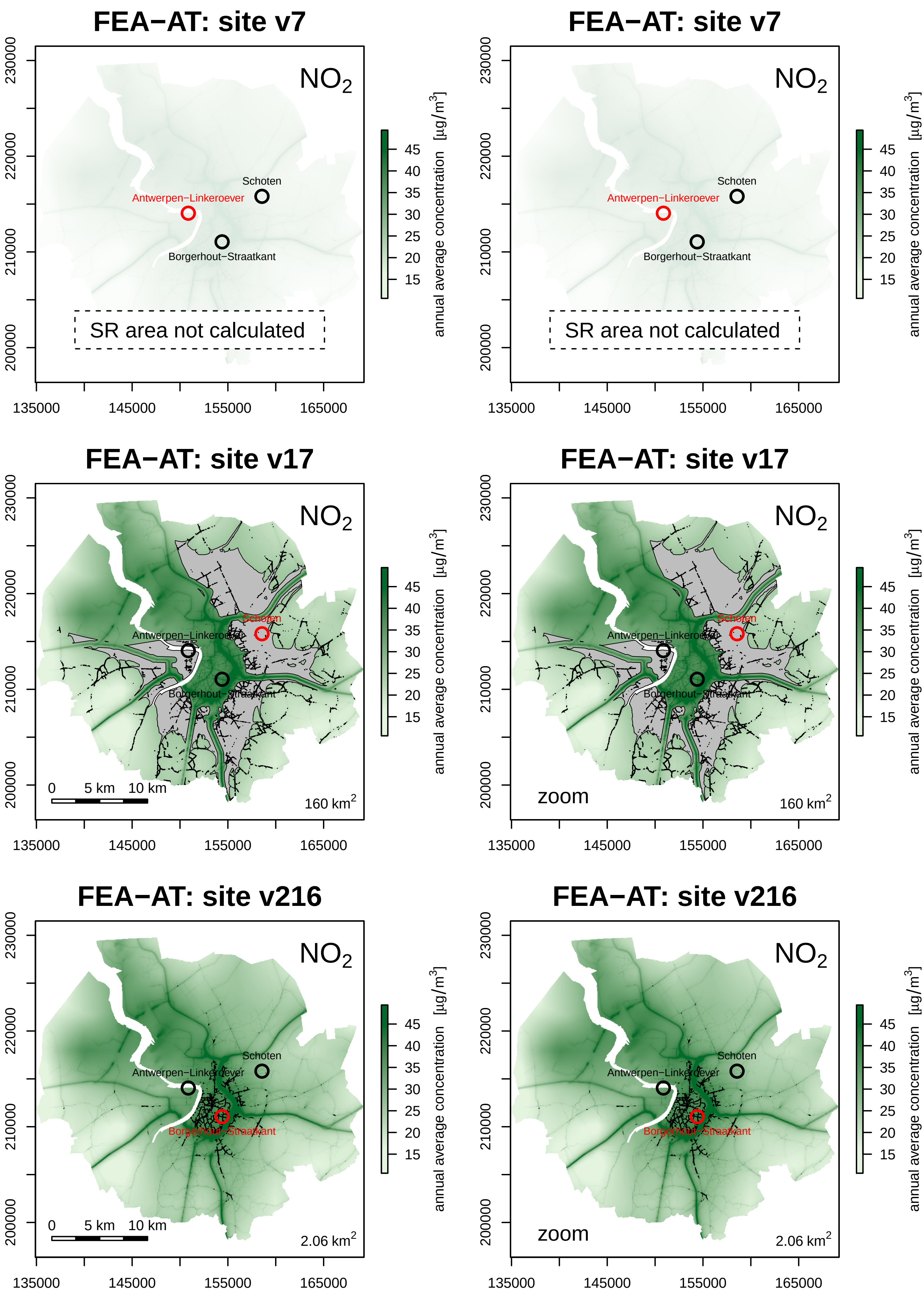


results EPA−IE (Ireland)

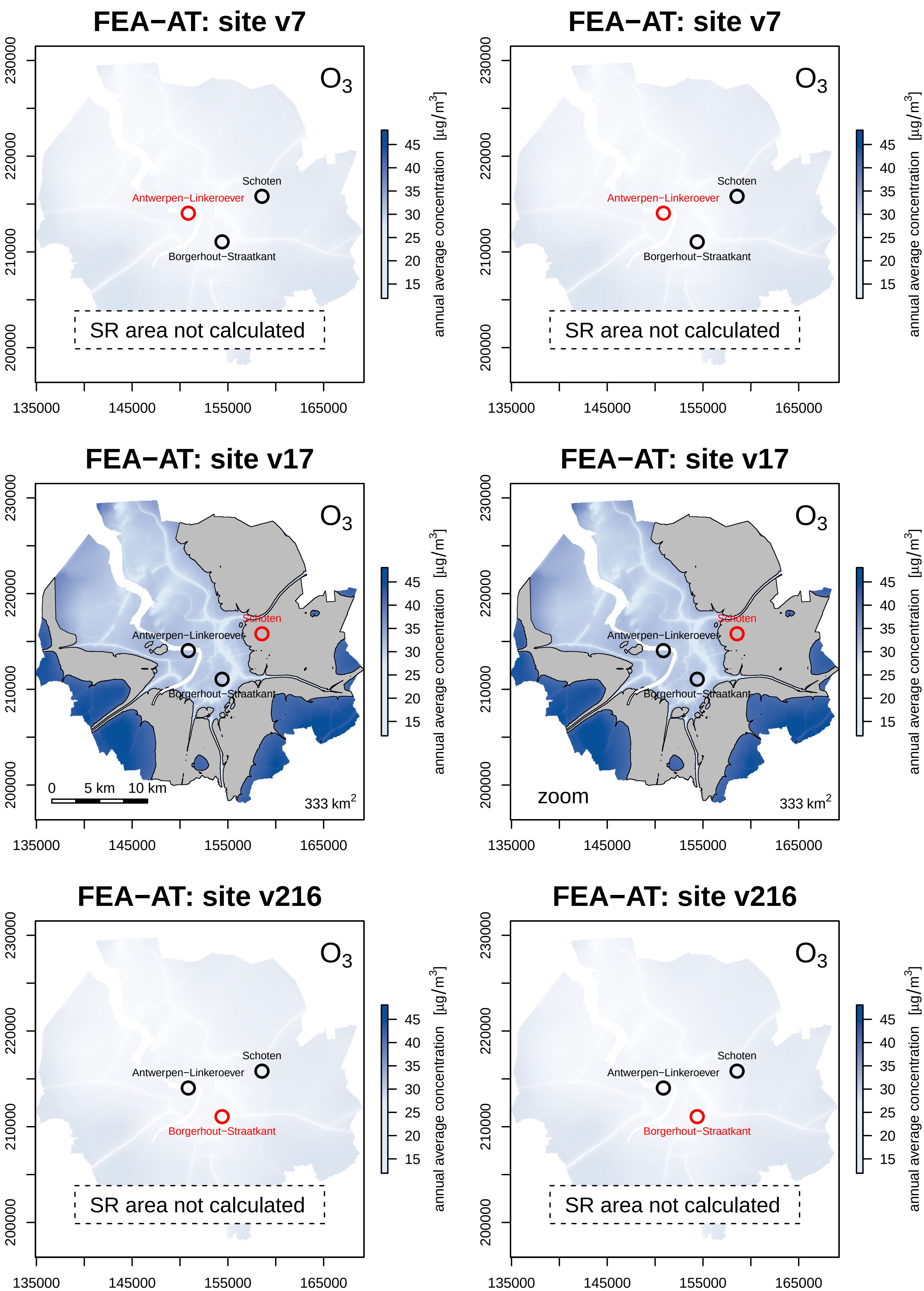
Spatial Representativeness Maps

by Team:

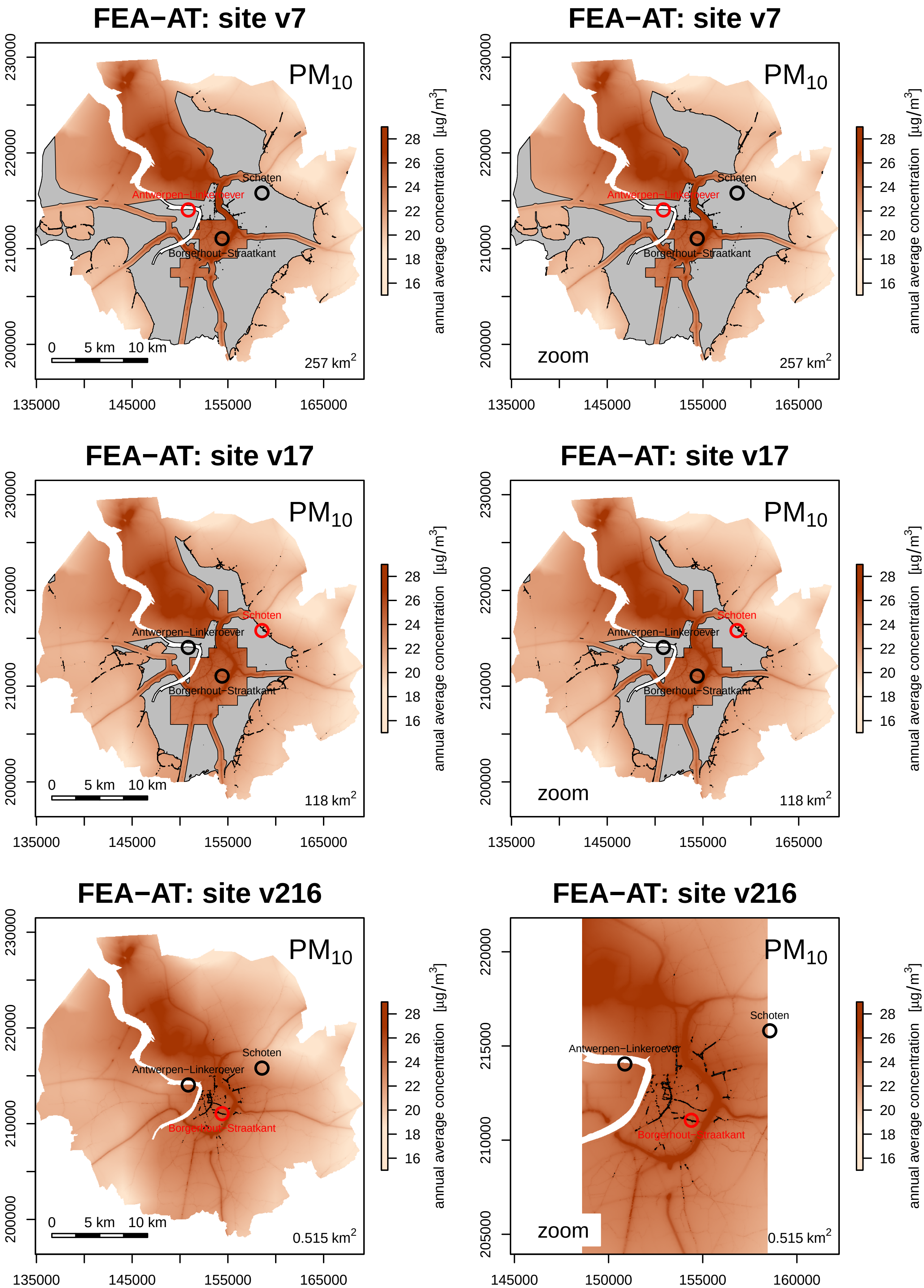
FEA−AT (Austria)



results FEA−AT (Austria)



results FEA−AT (Austria)

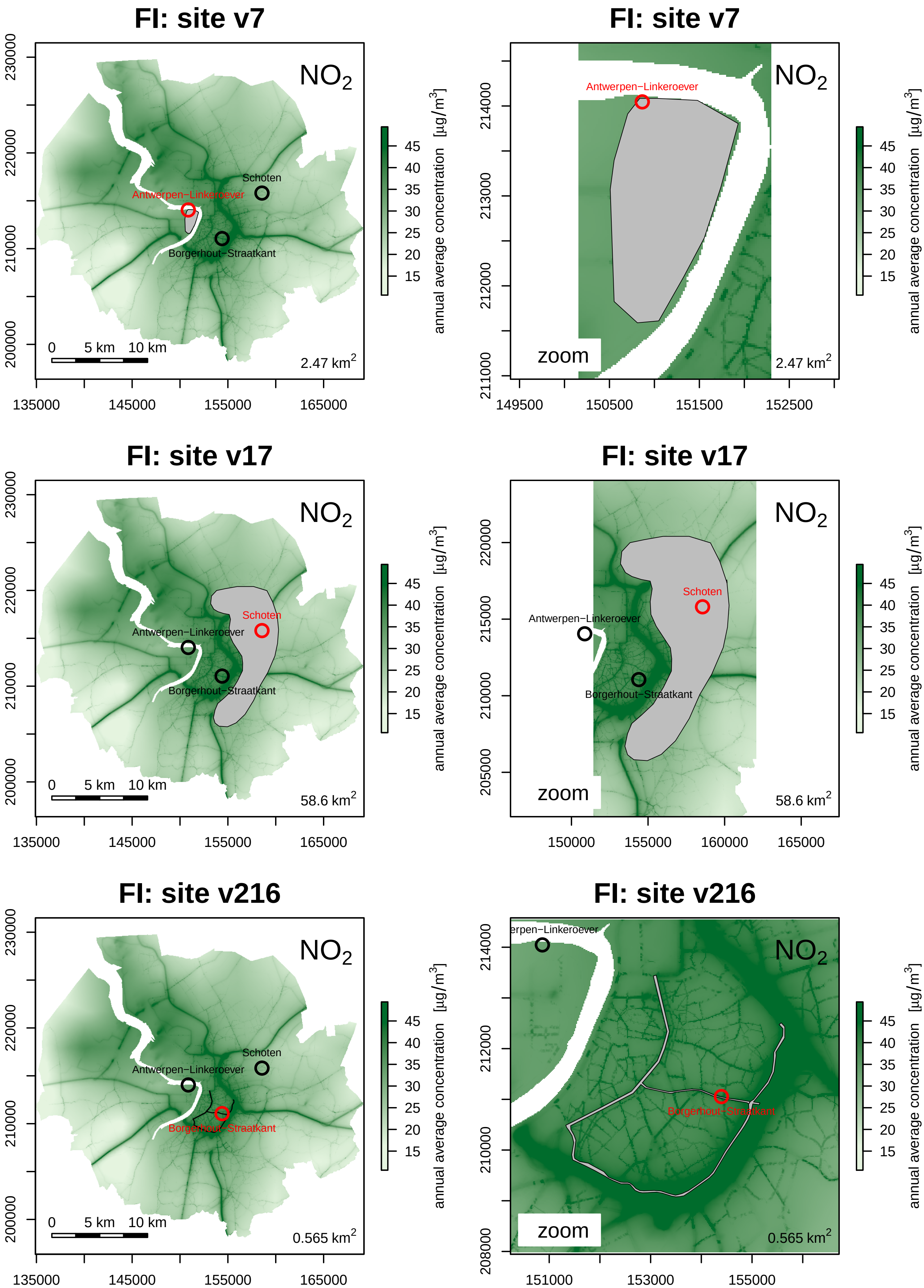


results FEA−AT (Austria)

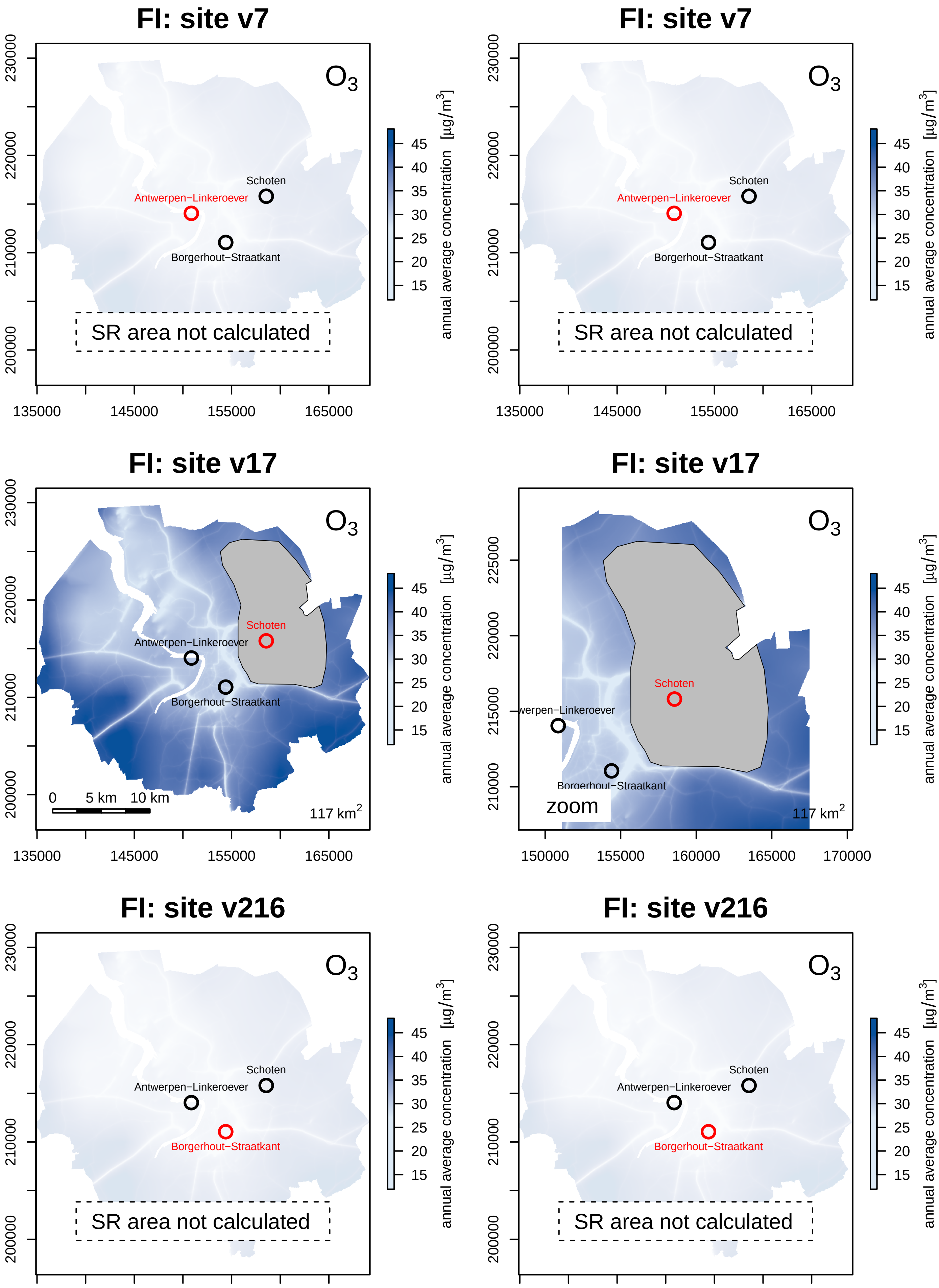
Spatial Representativeness Maps

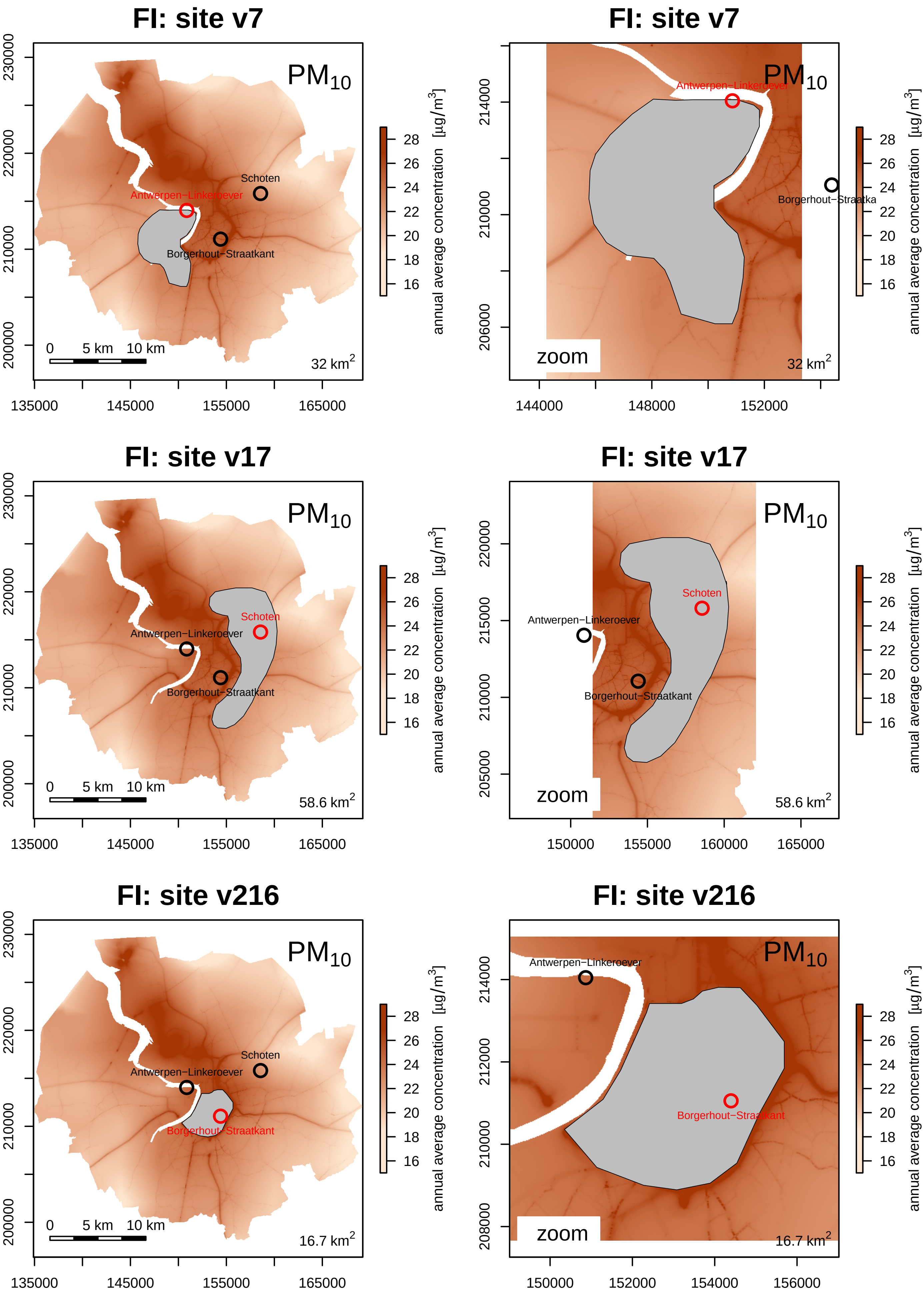
by Team:

FI (Finland)



results FI (Finland)


FI: site v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
SR area not calculated
annual average concentration [µg/m3]
45
40
35
30
25
20
15
230000
220000
210000
200000
135000
145000
155000
165000
FI: site v17
0
5 km
10 km
117 km2
zoom
225000
215000
150000
160000
170000
FI: site v216

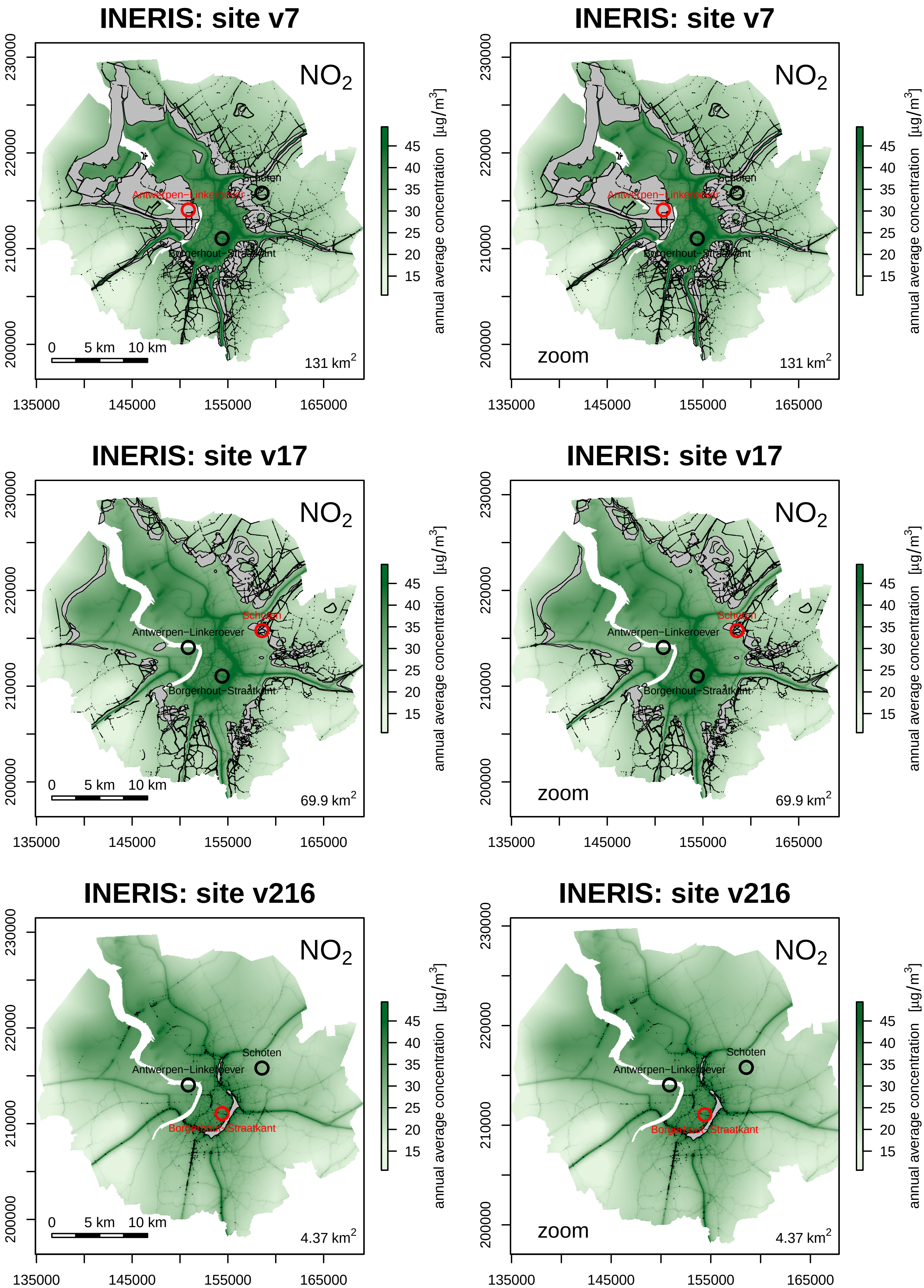


results FI (Finland)

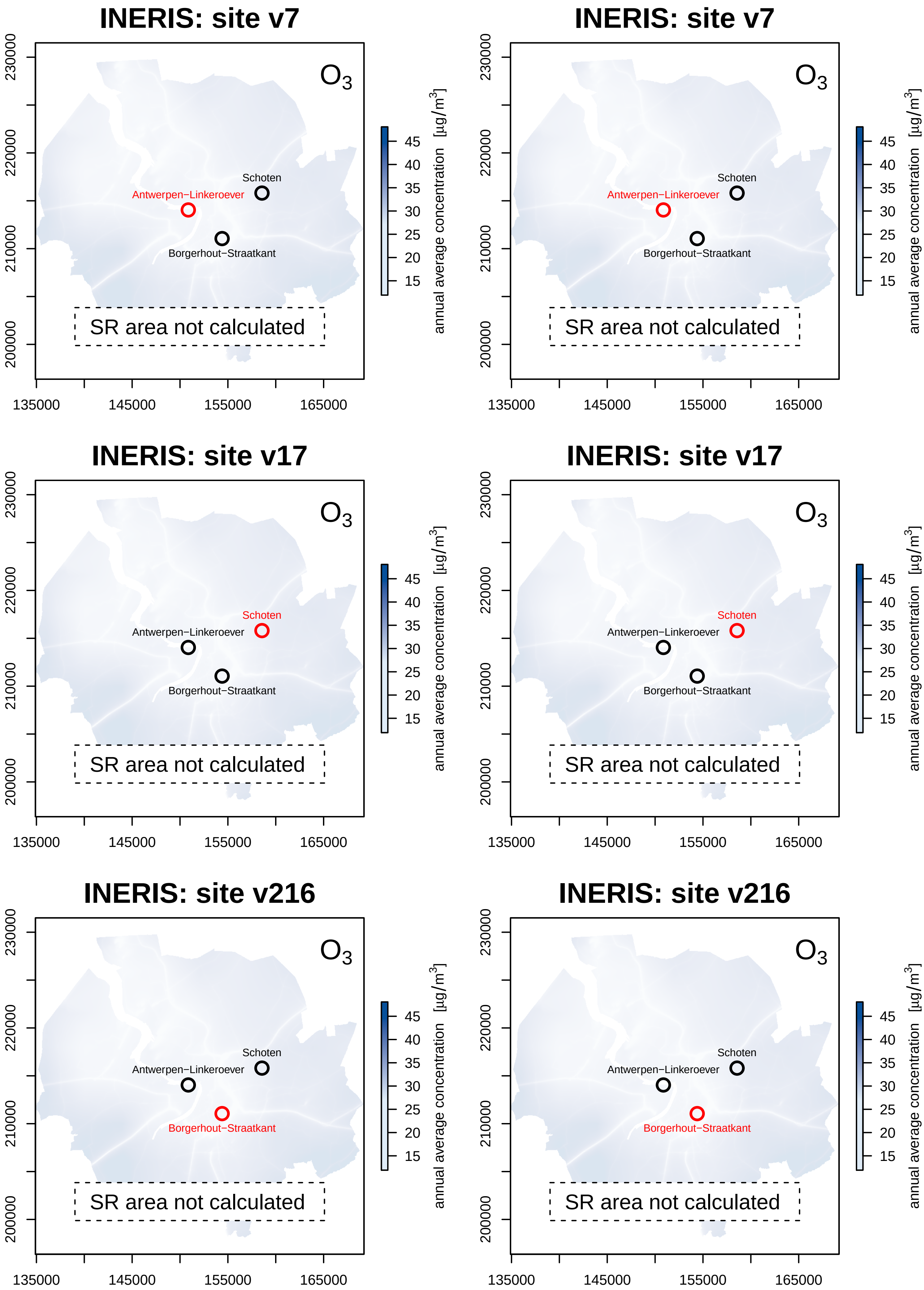
Spatial Representativeness Maps

by Team:

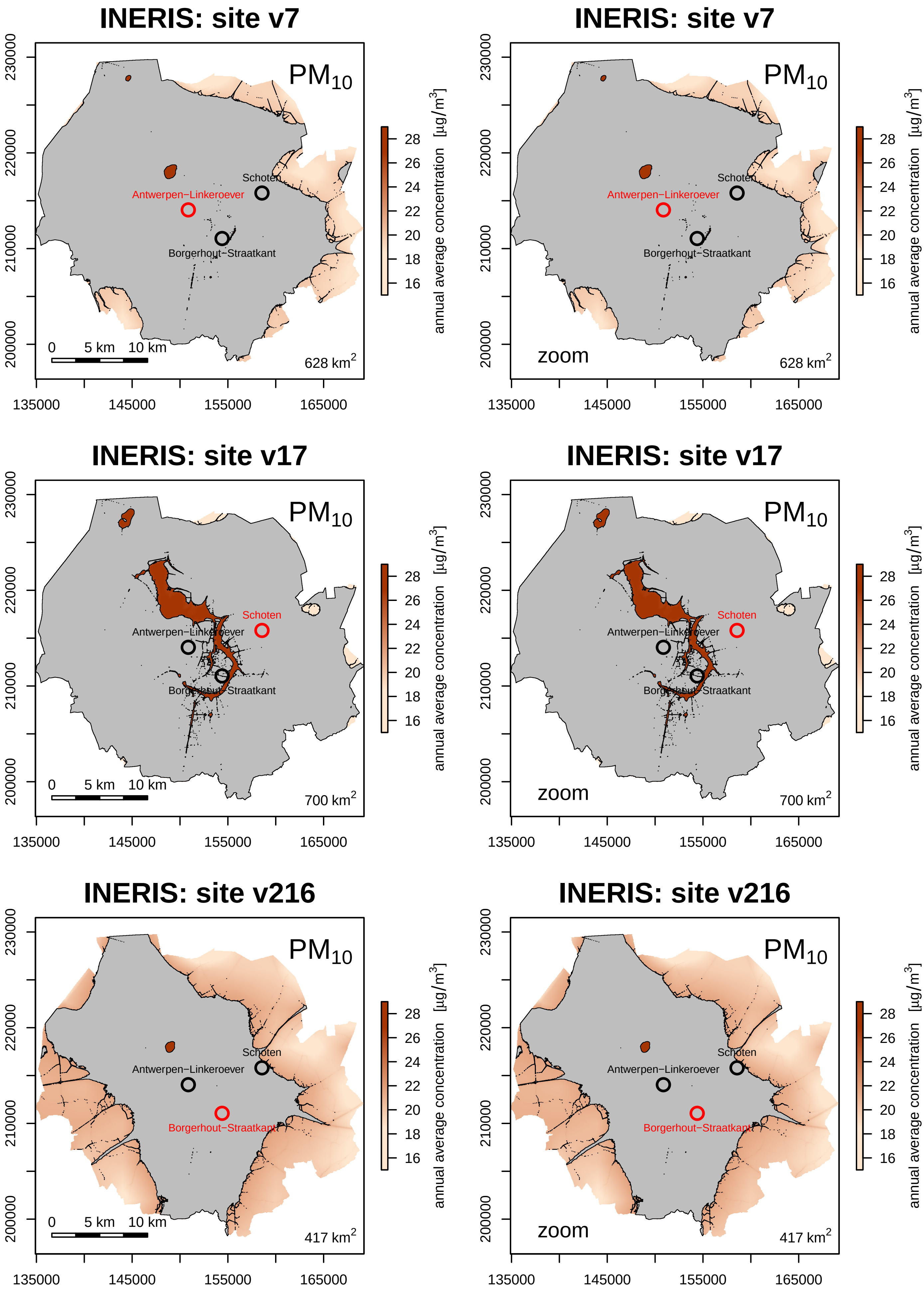
INERIS (France)



results INERIS (France)



results INERIS (France)

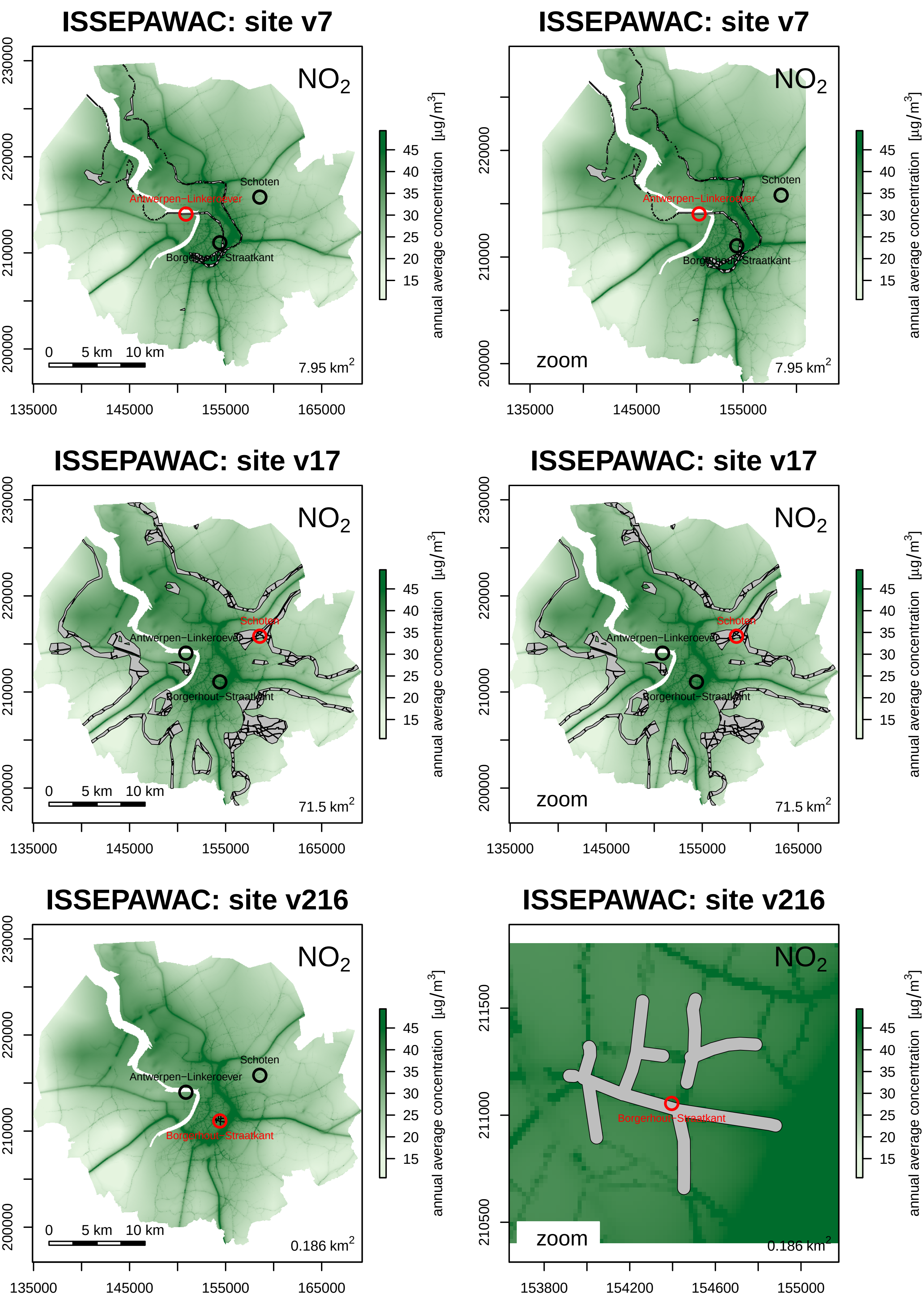


results INERIS (France)

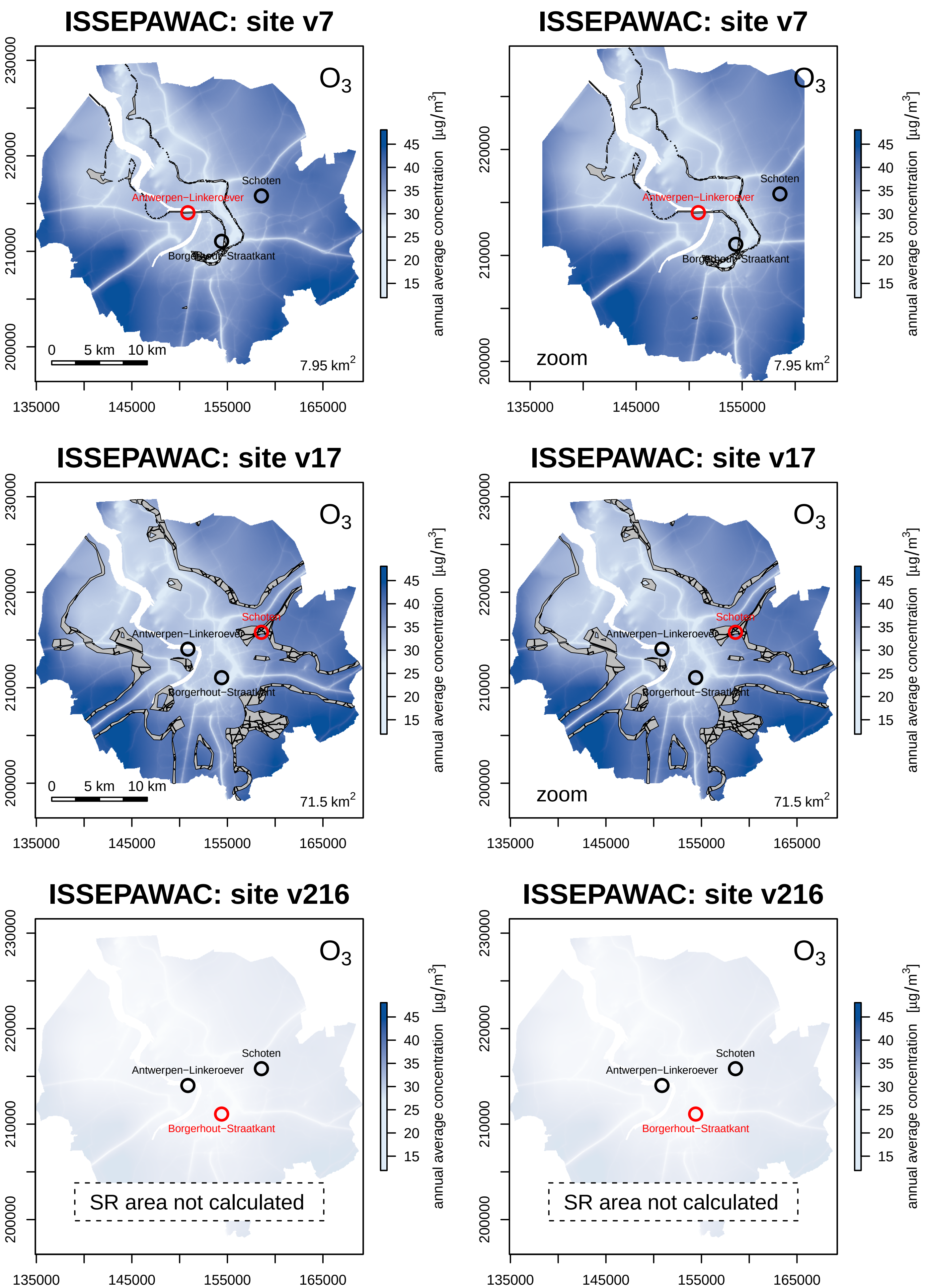
Spatial Representativeness Maps

by Team:

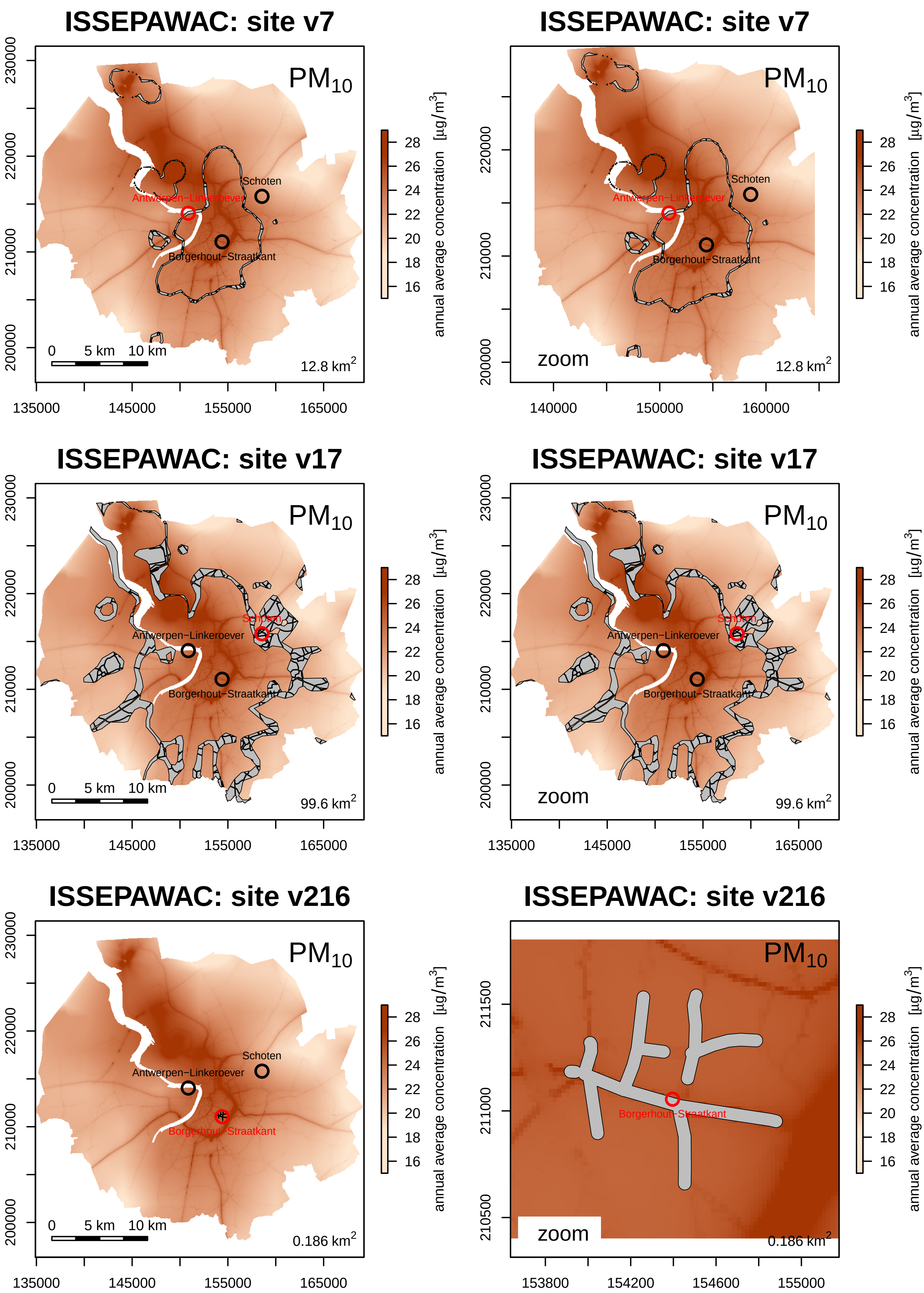
ISSEP&AWAC (Belgium)



results ISSEP&AWAC (Belgium)



results ISSEP&AWAC (Belgium)

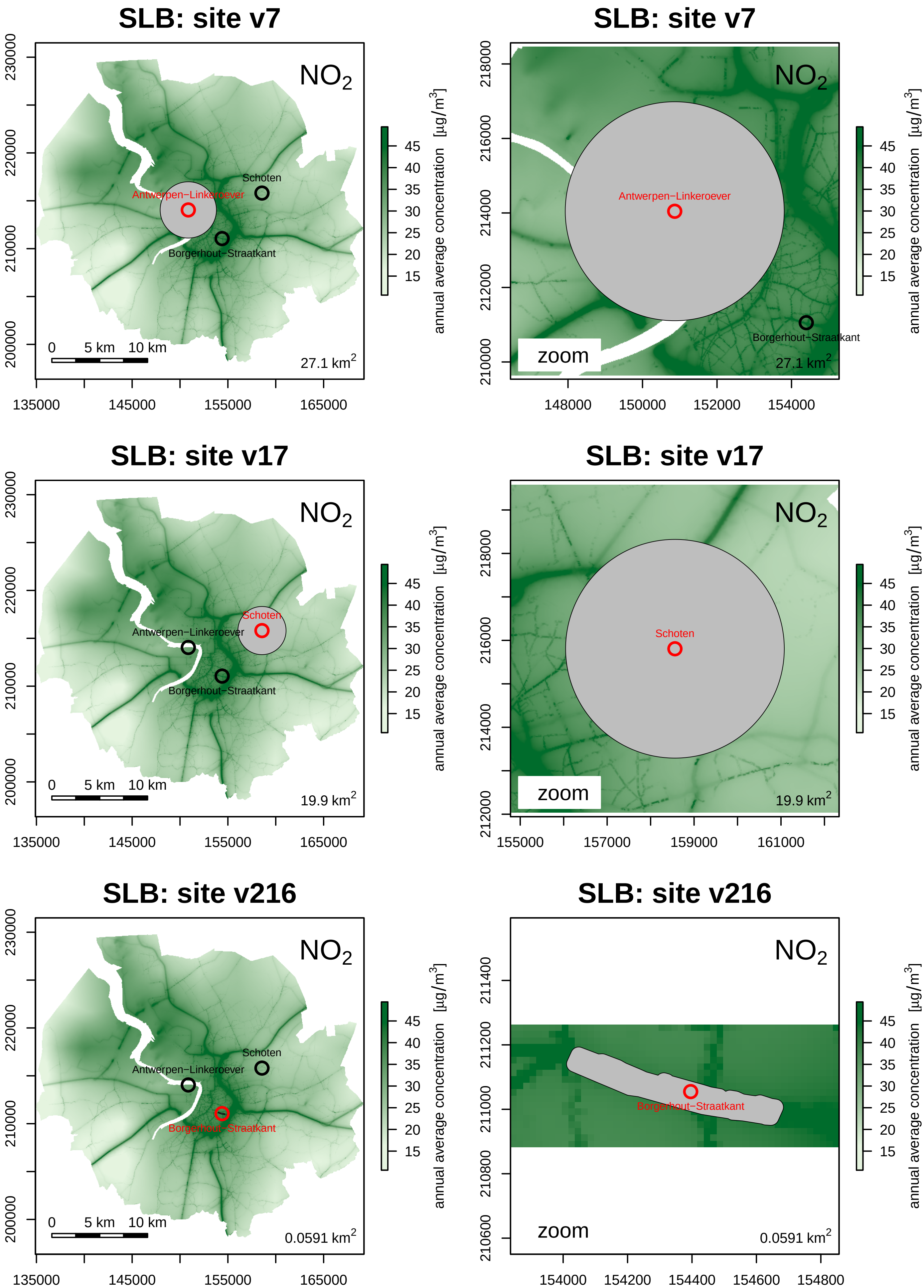


results ISSEP&AWAC (Belgium)

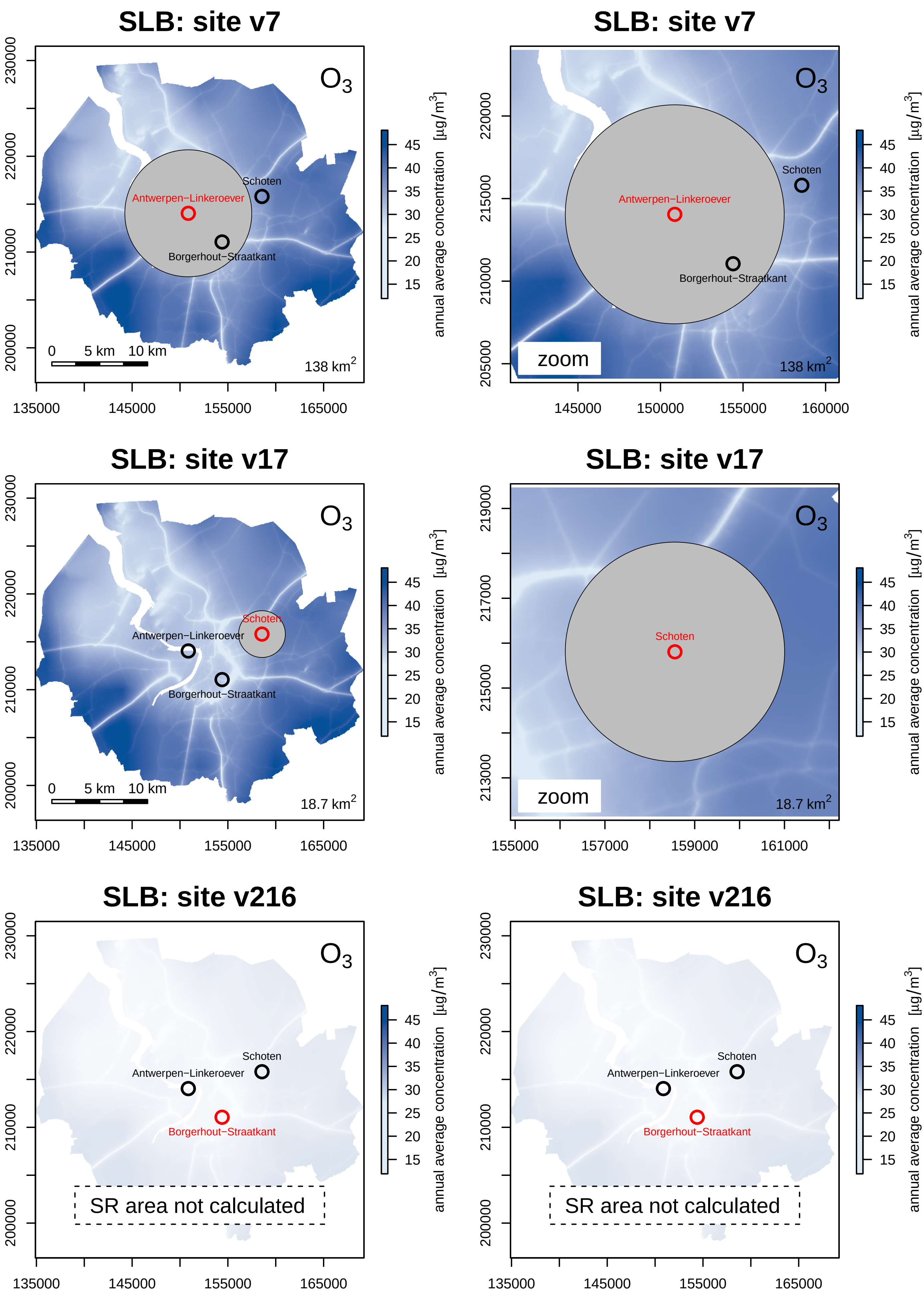
Spatial Representativeness Maps

by Team:

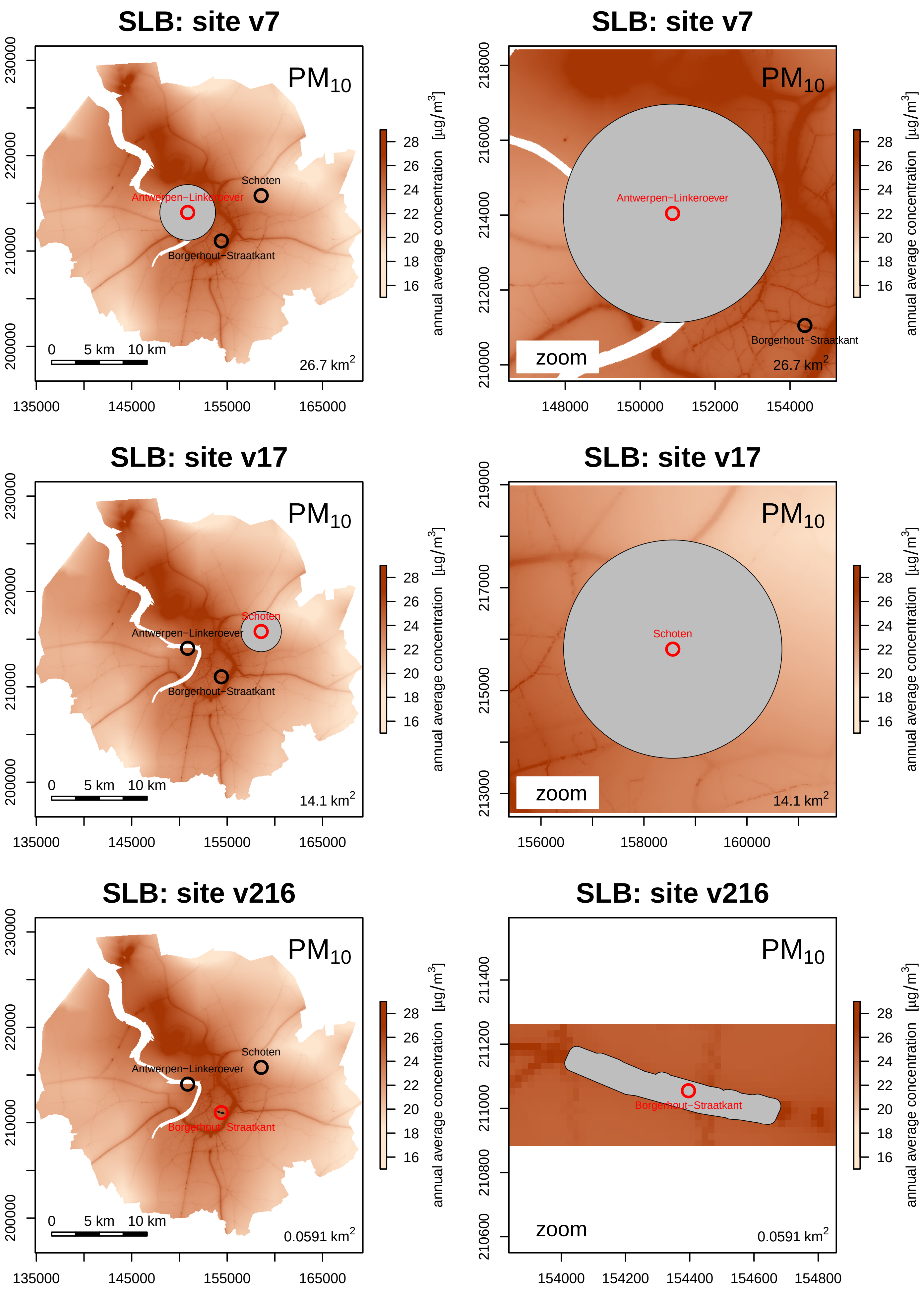
SLB (Sweden)



results SLB (Sweden)



results SLB (Sweden)

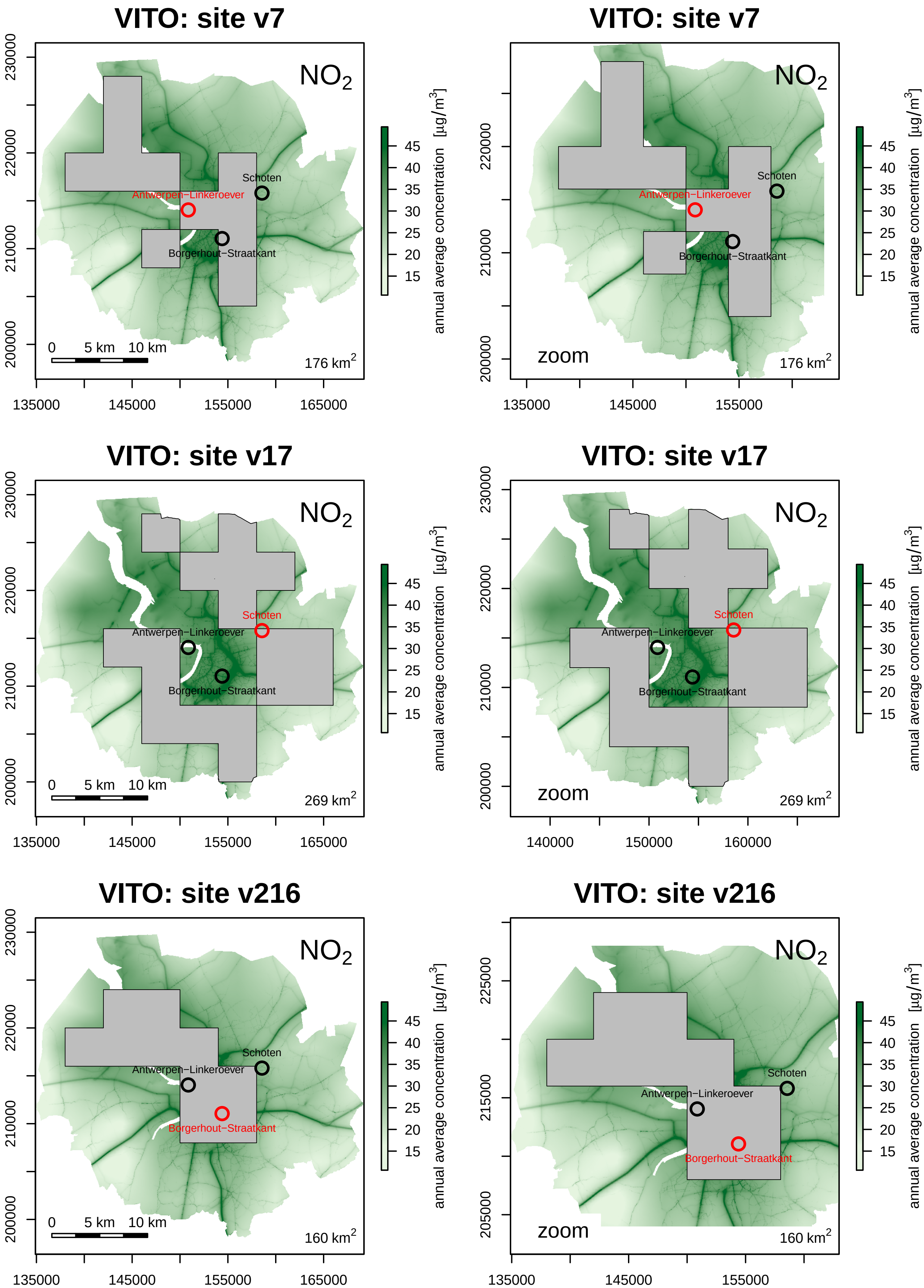


results SLB (Sweden)

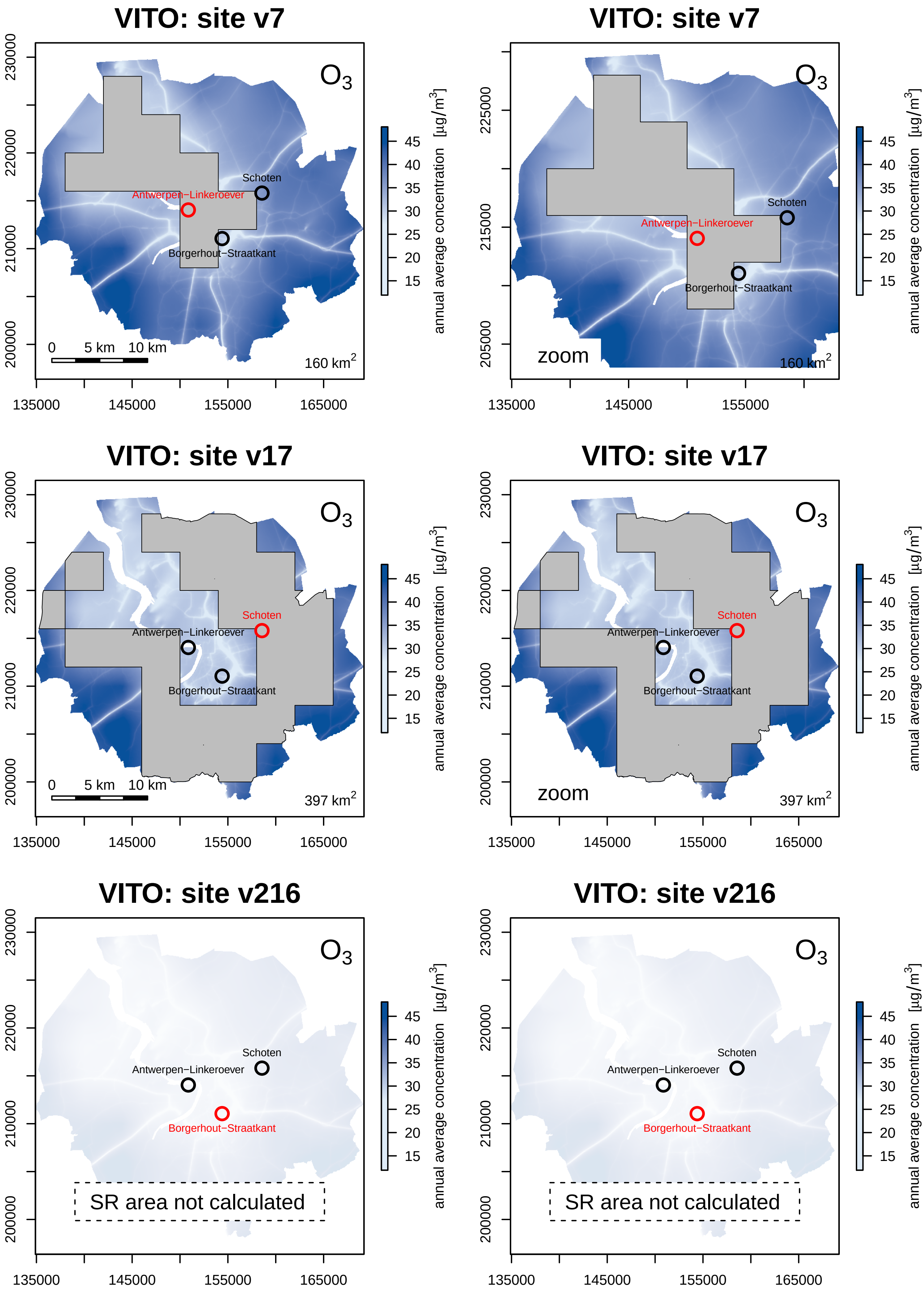
Spatial Representativeness Maps

by Team:

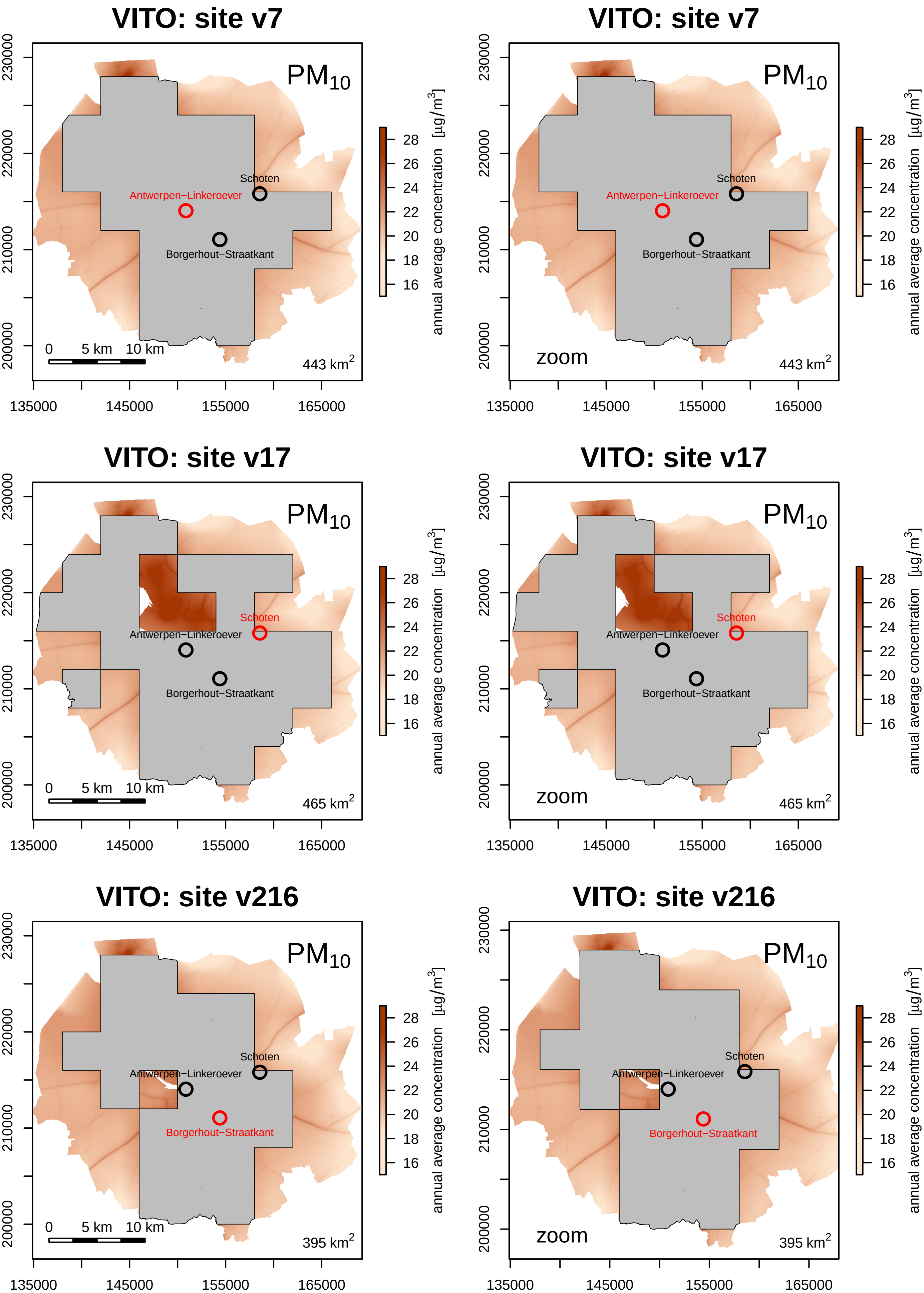
VITO (Belgium)



results VITO (Belgium)



results VITO (Belgium)

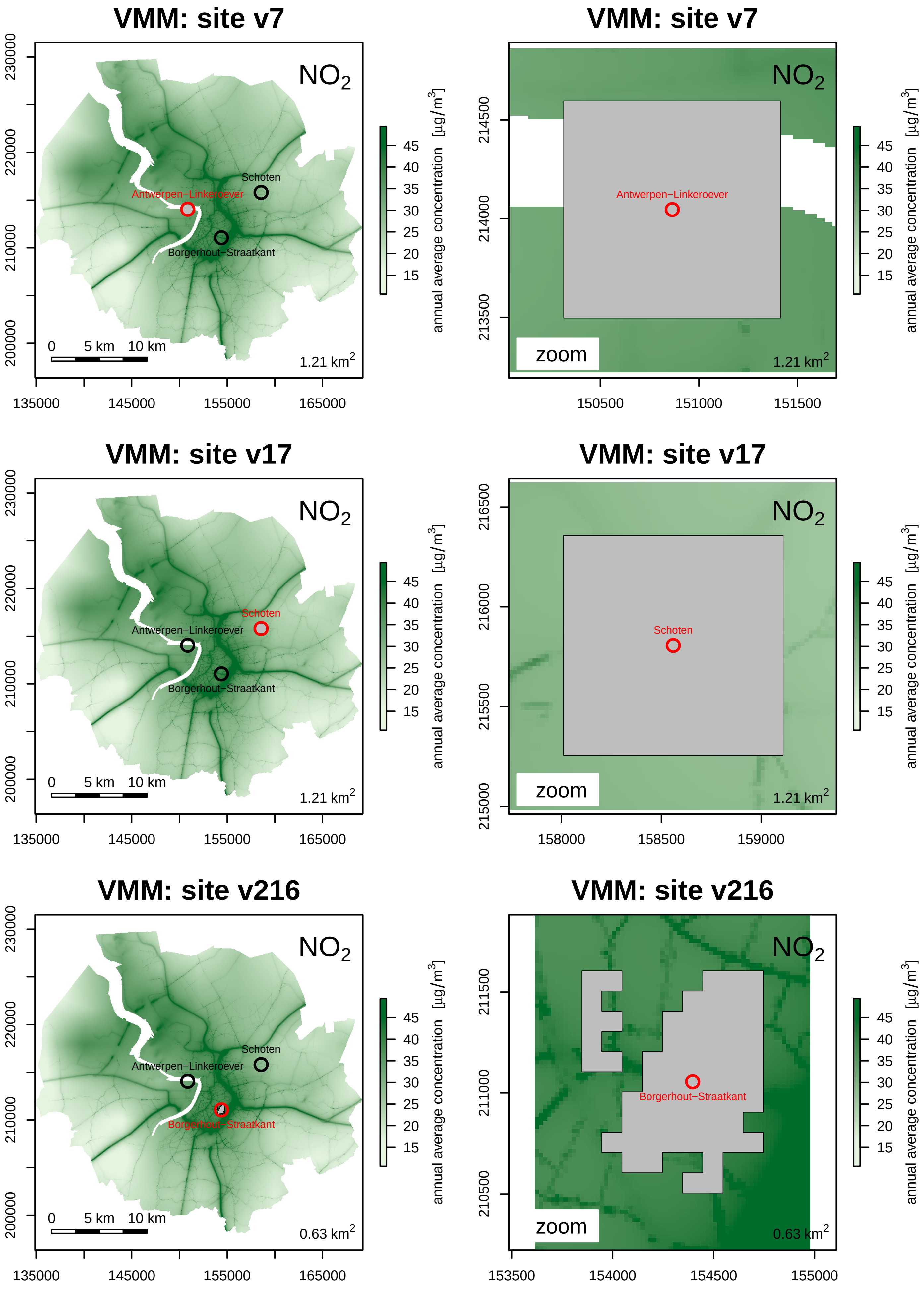


results VITO (Belgium)

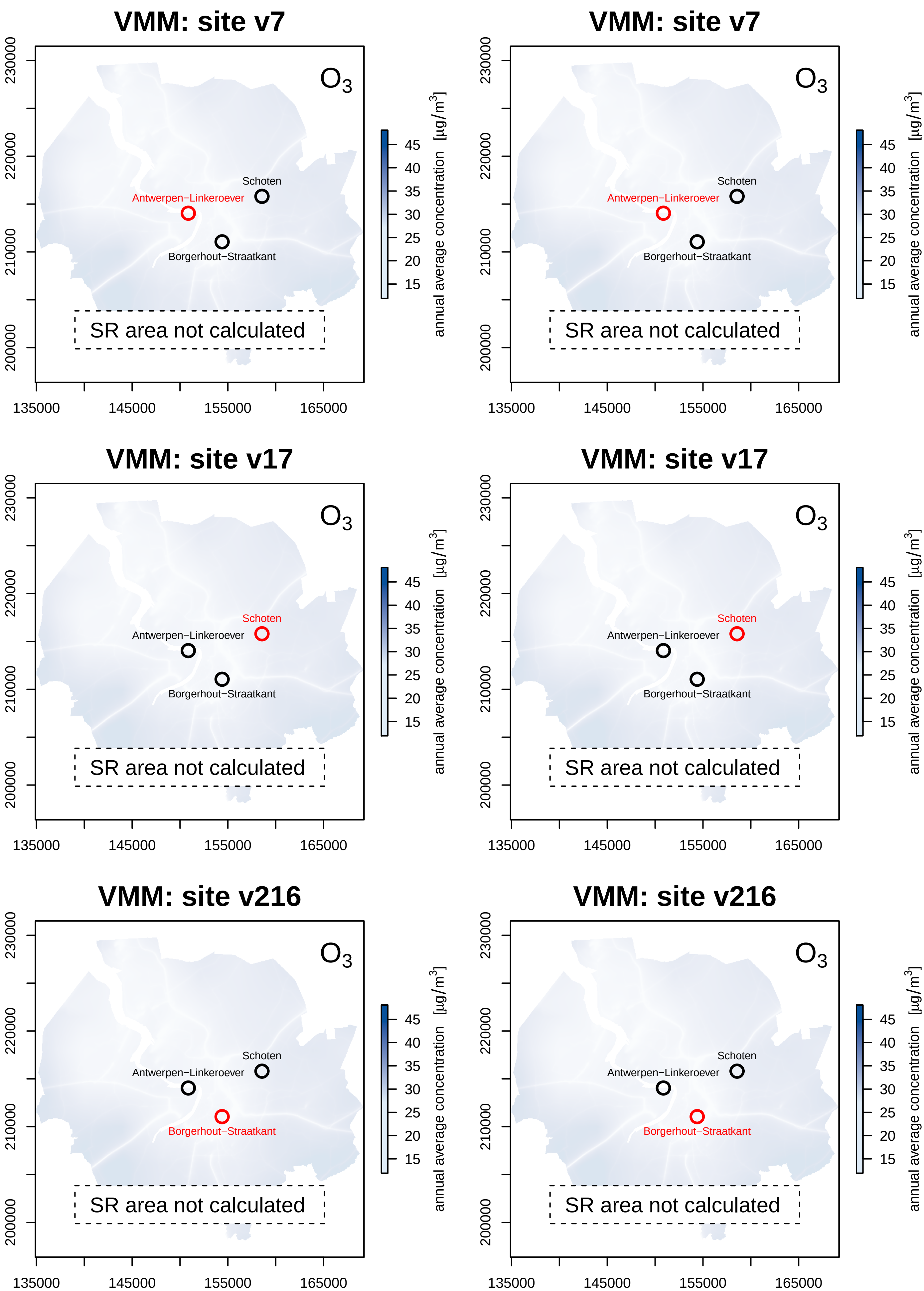
Spatial Representativeness Maps

by Team:

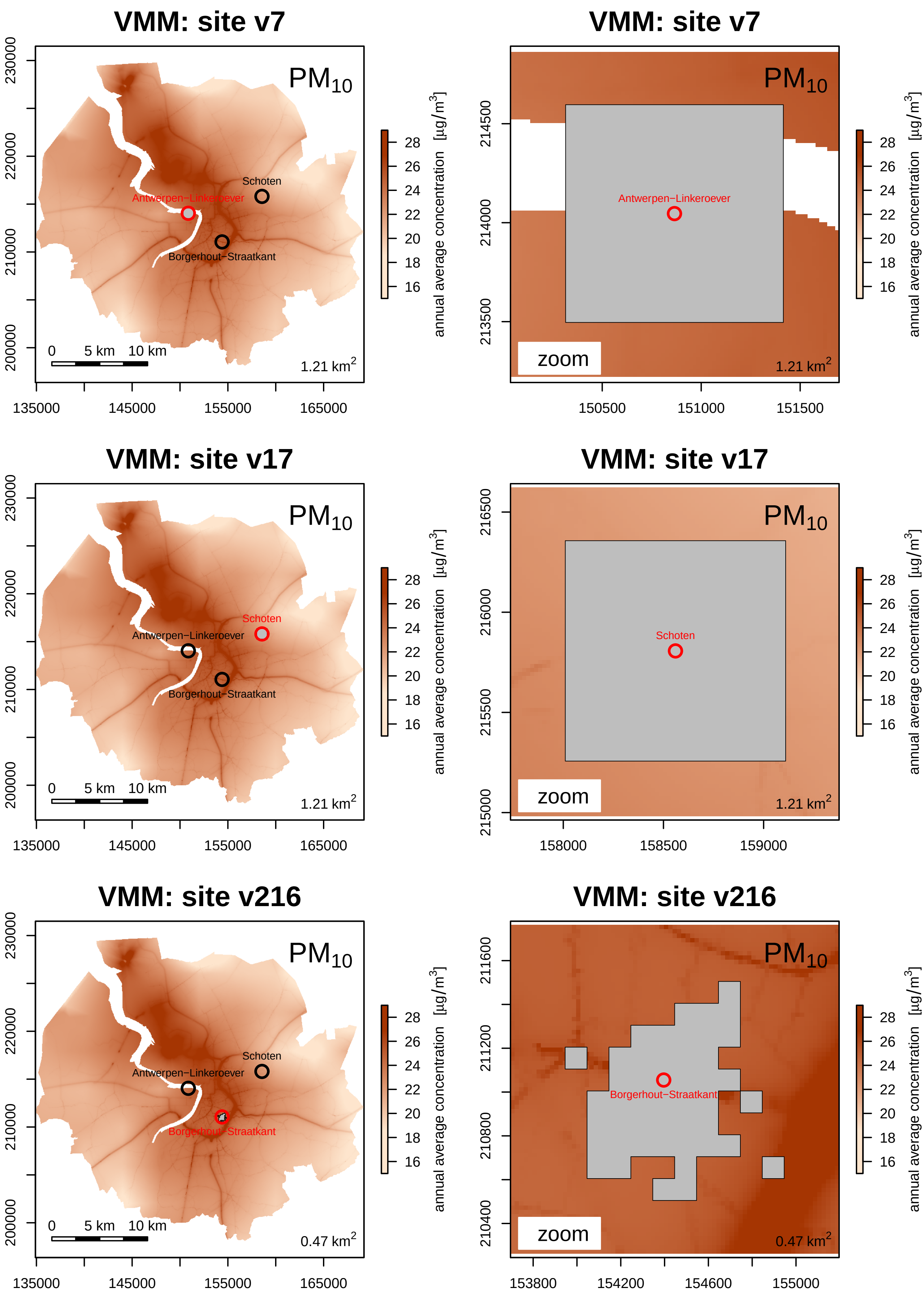
VMM (Belgium)



results VMM (Belgium)



results VMM (Belgium)



results VMM (Belgium)

Annex IV. Spatial Representativeness Maps by Pollutant & Station

<u>SR maps sorted by pollutant & station</u>:

- NO_2 at virtual station v7 (Antwerpen-Linkeroever)
- NO_2 at virtual station v17 (Schoten)
- NO_2 at virtual station v216 (Borgerhout-Straatkant)

- O_3 at virtual station v7 (Antwerpen-Linkeroever)
- O_3 at virtual station v17 (Schoten)

- PM_{10} at virtual station v7 (Antwerpen-Linkeroever)
- PM_{10} at virtual station v17 (Schoten)
- PM_{10} at virtual station v216 (Borgerhout-Straatkant)

The combination O_3 at virtual station v216 (Borgerhout-Straatkant) was not a task for the IE. It is thus omitted from plotting in this annex.

<u>**Legend**</u>:

In all maps, the position of the respective **AQMS is highlighted in red**.

Background colours depict the **annual average concentration field** of the respective pollutant:

NO_2: green colour scale

O_3: blue colour scale

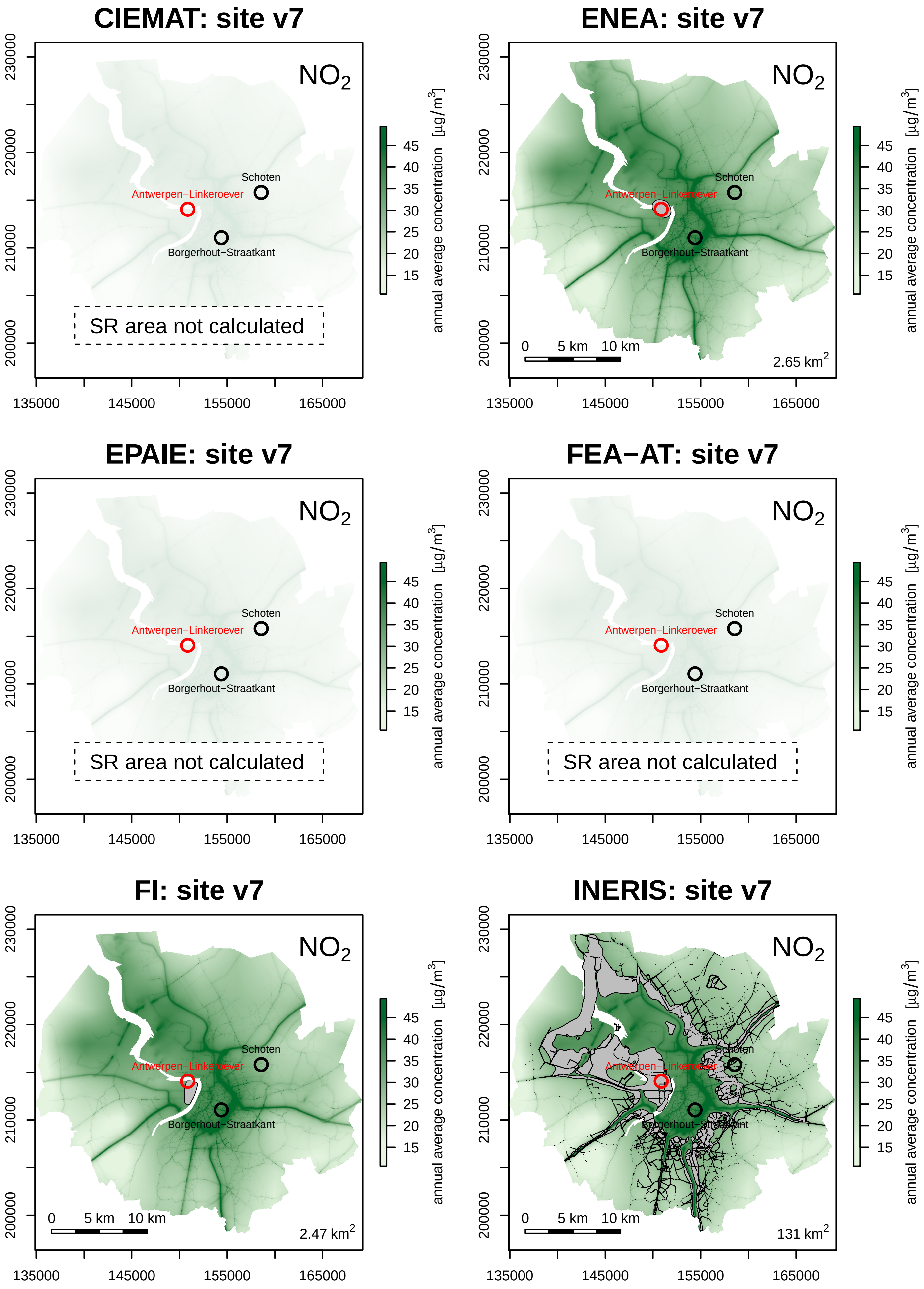
PM_{10}: orange colour scale

The actual **SR areas** are described by the **grey coloured fields** in the foreground.

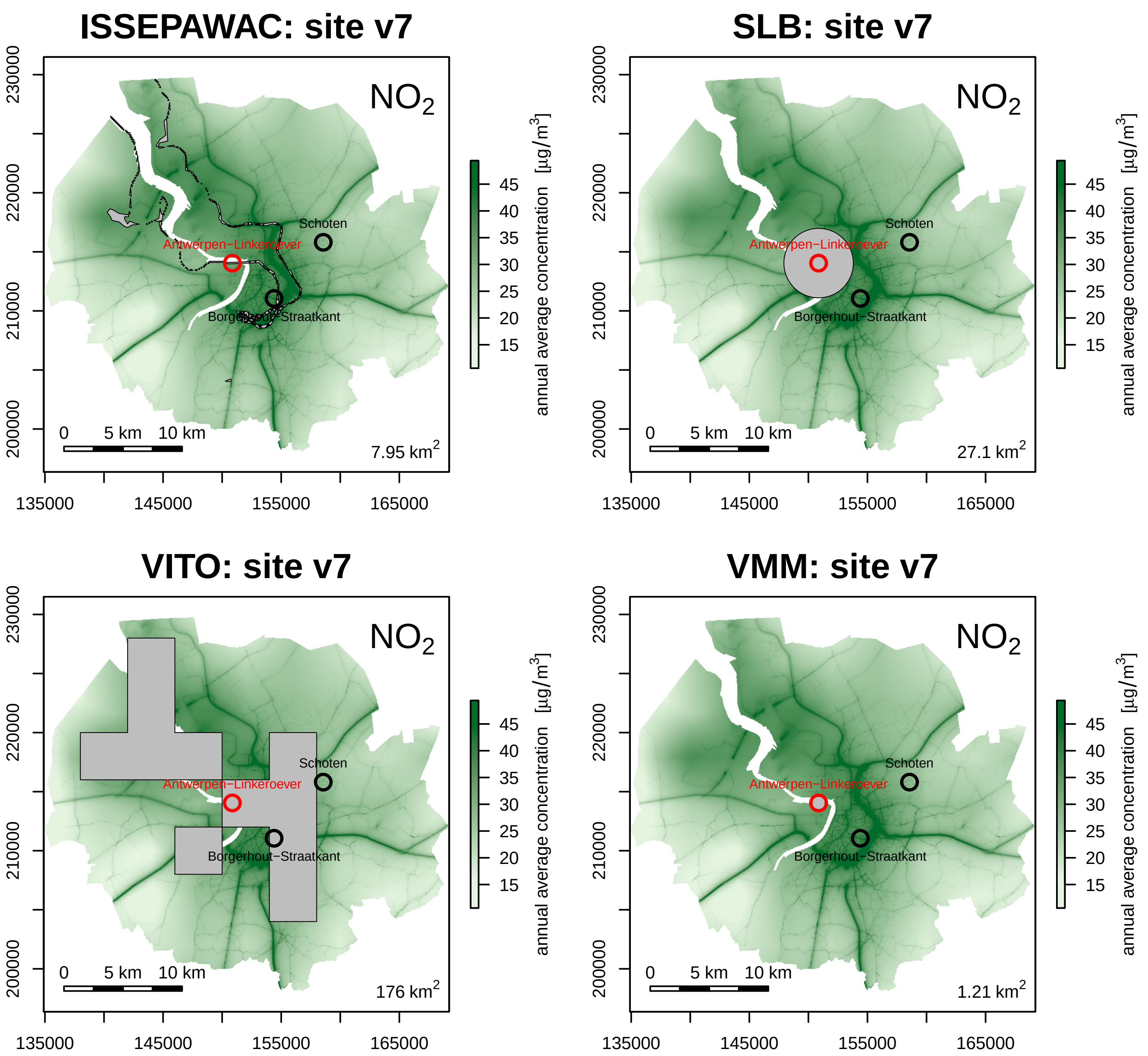
Spatial Representativeness Maps

by Pollutant & Station:

NO_2 at virtual station v7



NO_2 at virtual station v7

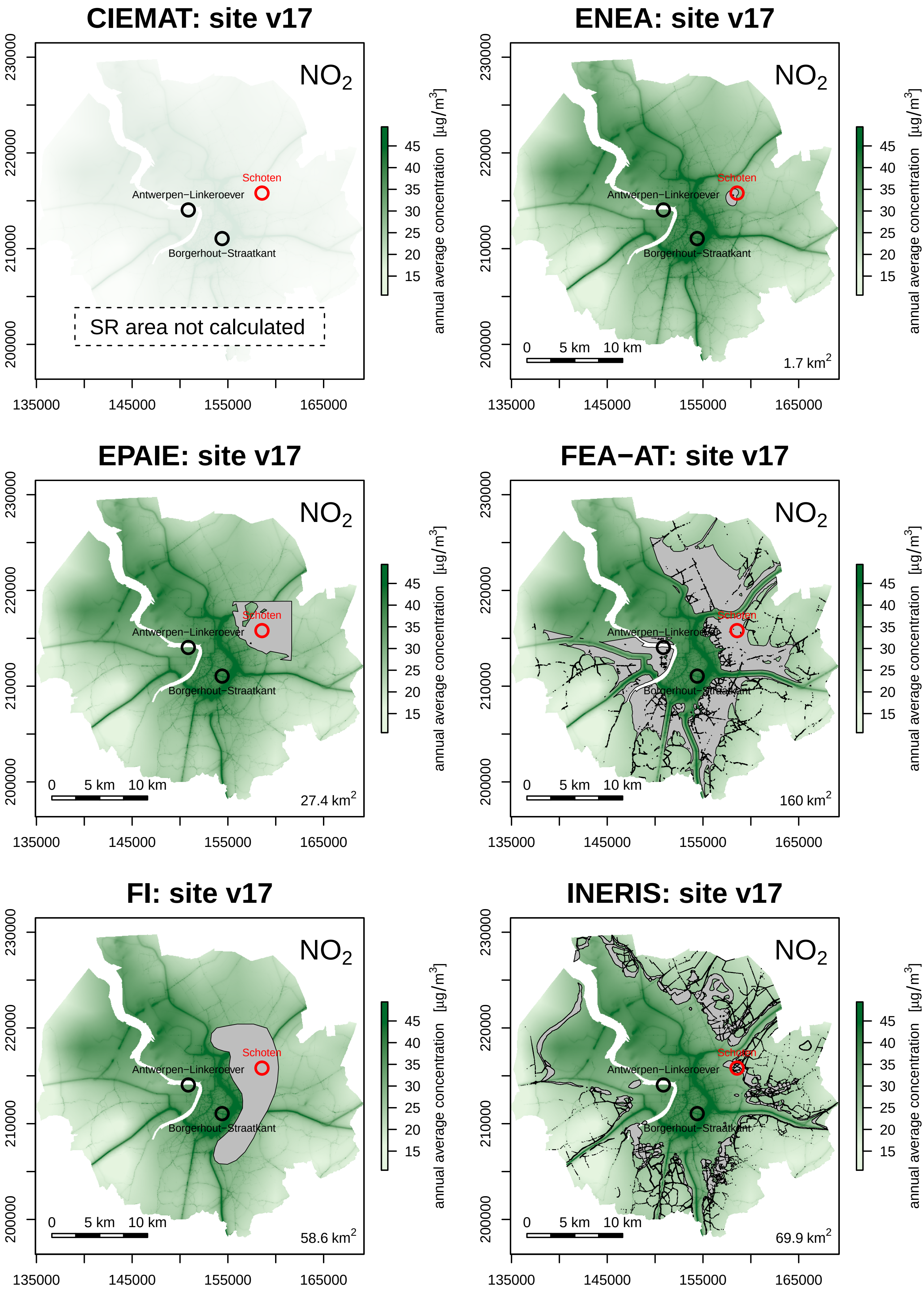


NO_2 at virtual station v7

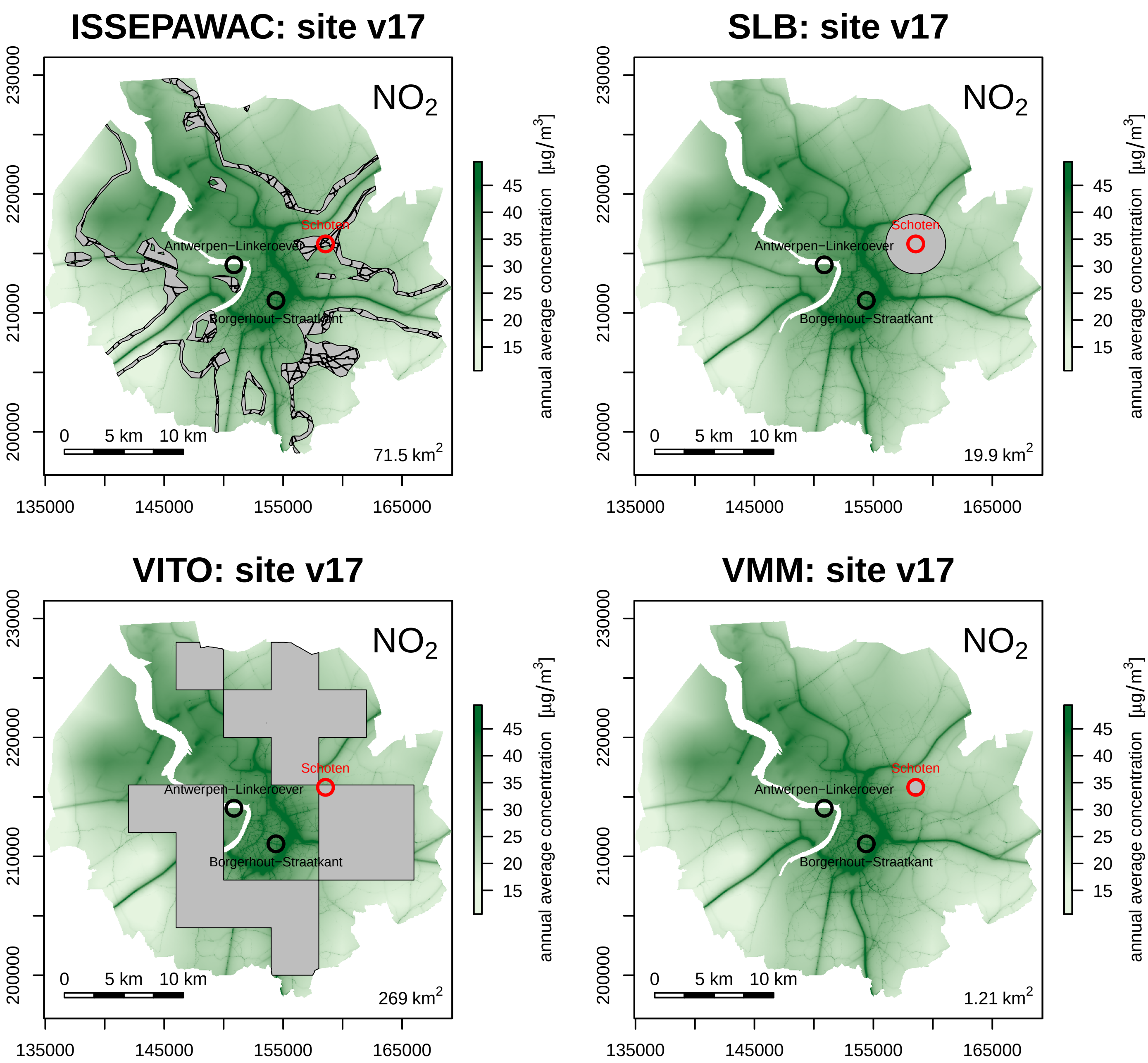
Spatial Representativeness Maps

by Pollutant & Station:

NO_2 at virtual station v17



NO_2 at virtual station v17

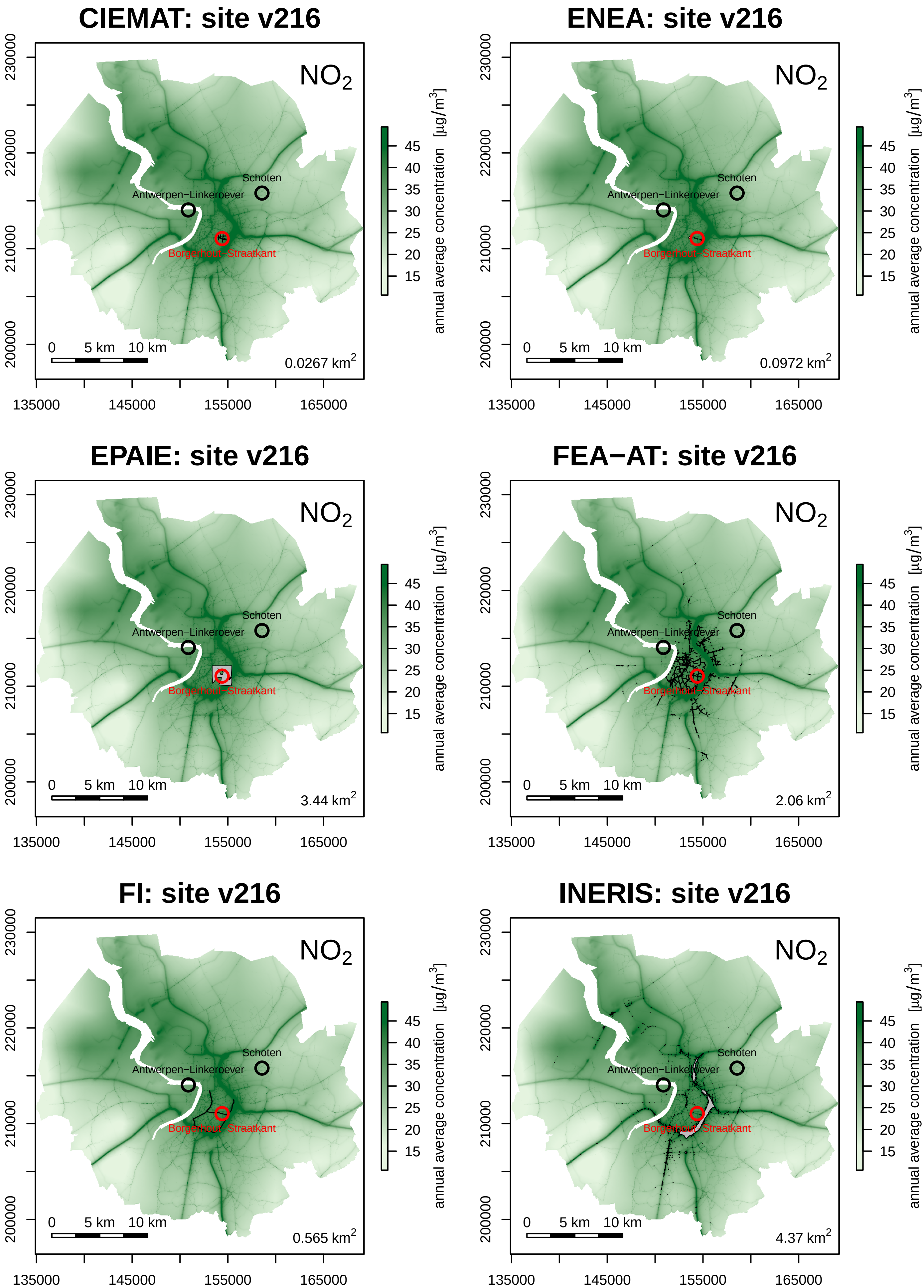


NO$_2$ at virtual station v17

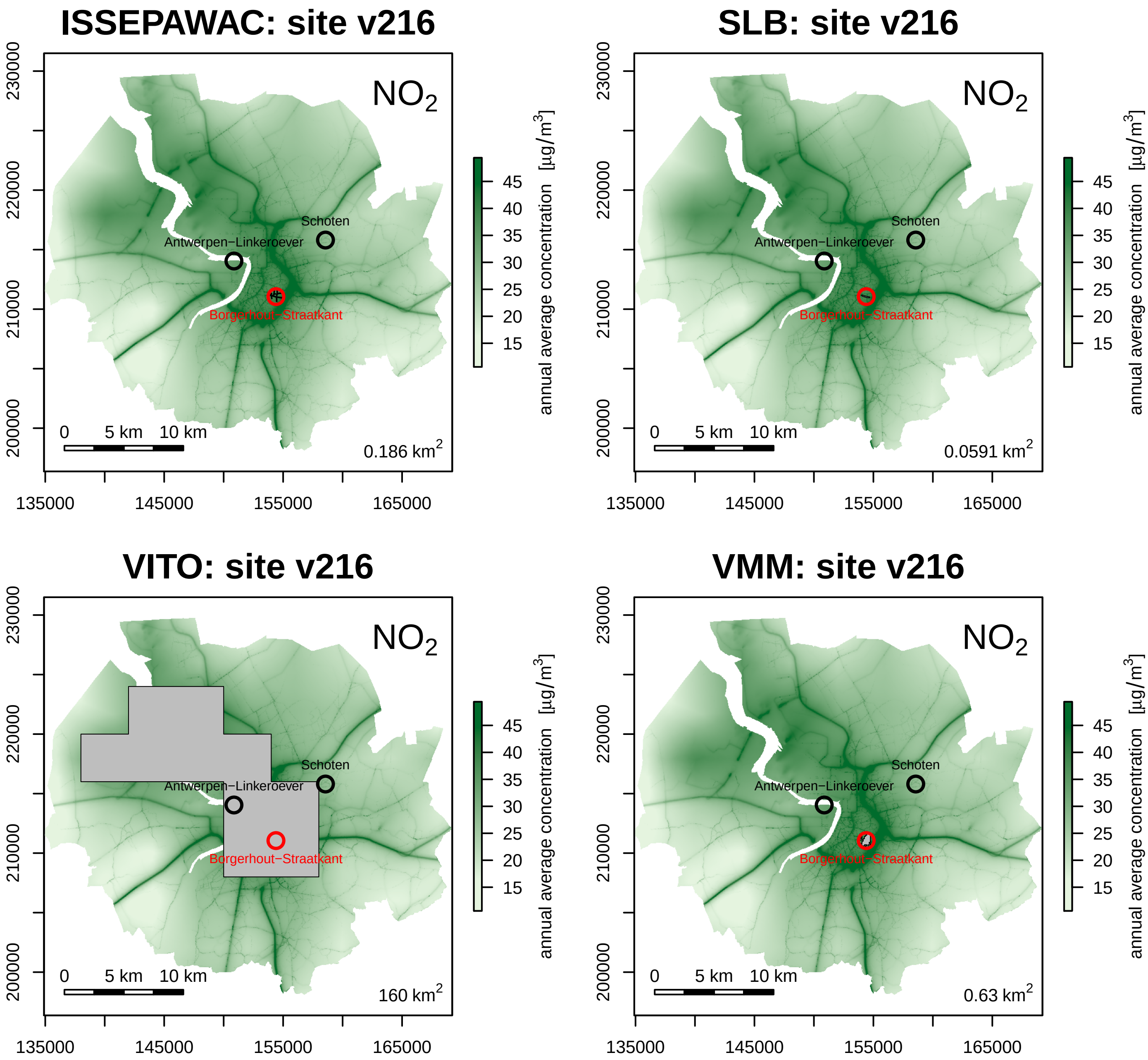
Spatial Representativeness Maps

by Pollutant & Station:

NO_2 at virtual station v216



NO_2 at virtual station v216

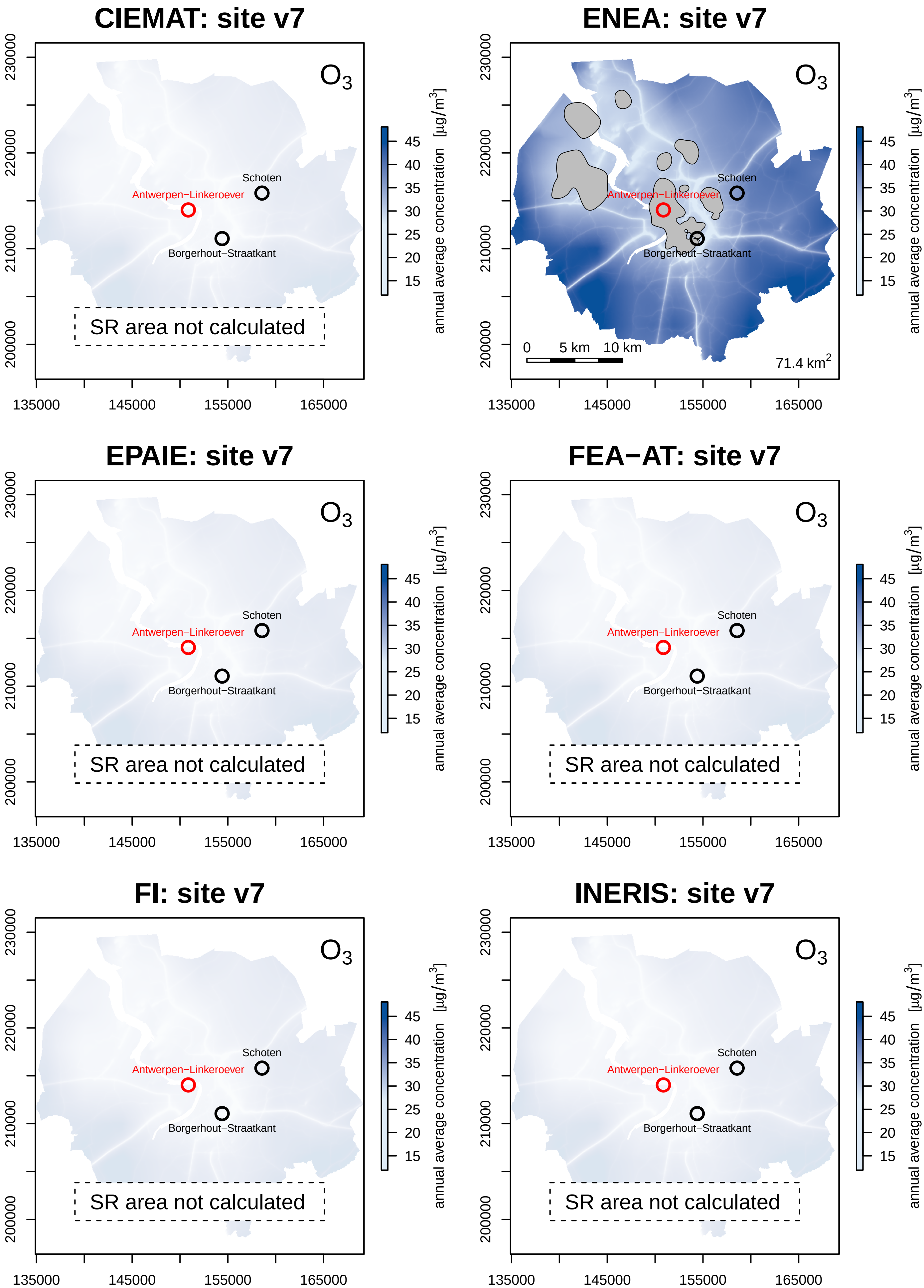


NO$_2$ at virtual station v216

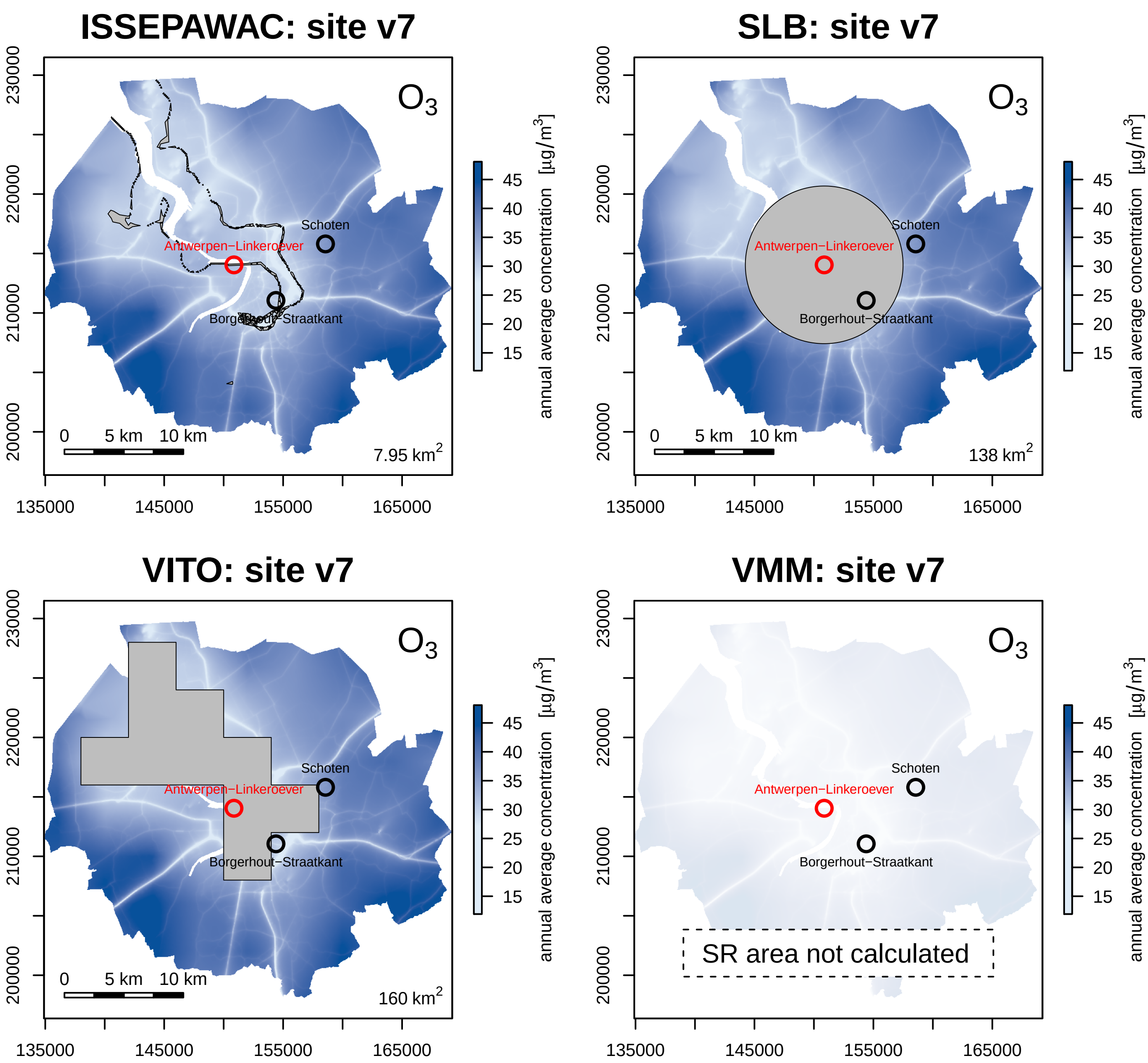
Spatial Representativeness Maps

by Pollutant & Station:

O_3 at virtual station v7



O_3 at virtual station v7

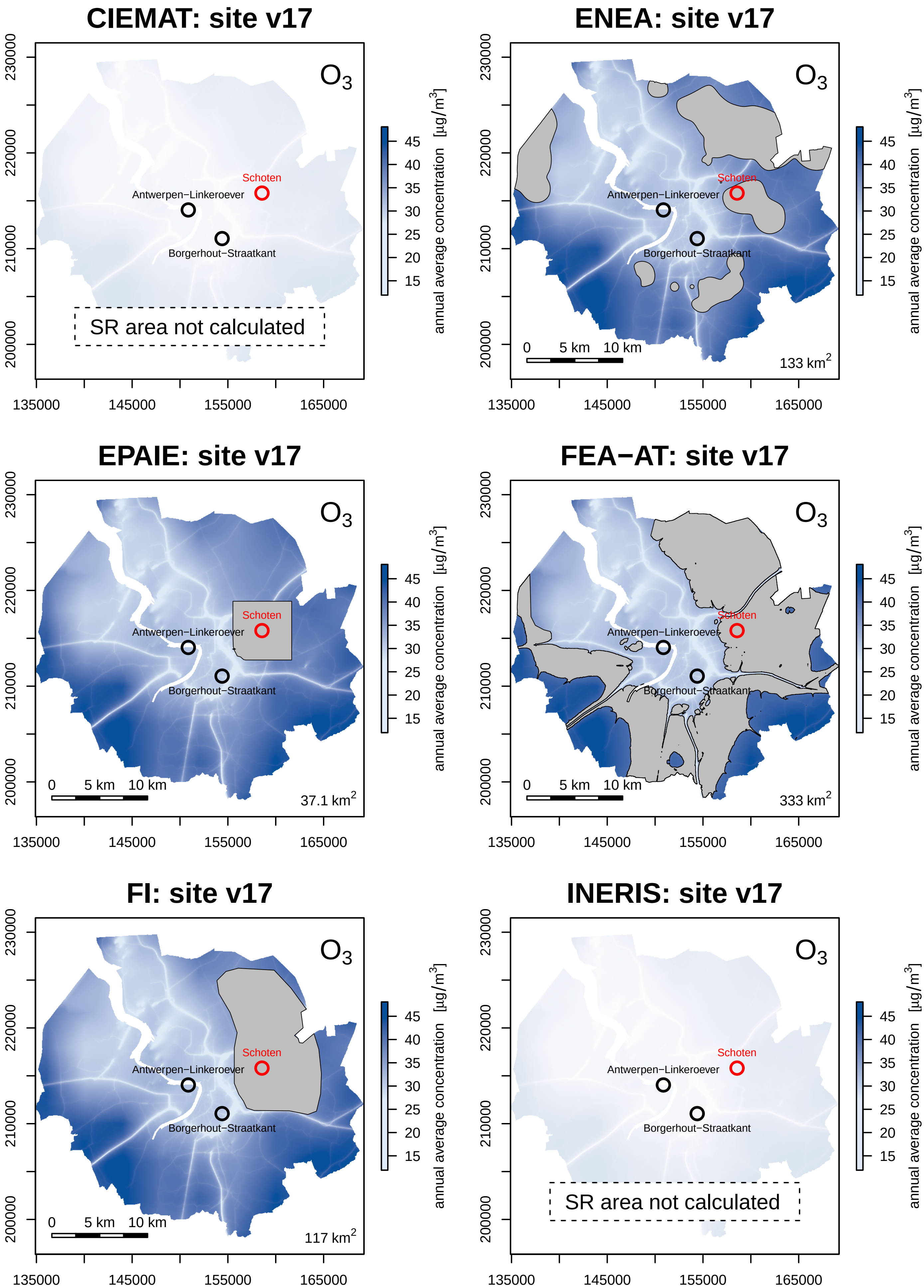


O_3 at virtual station v7

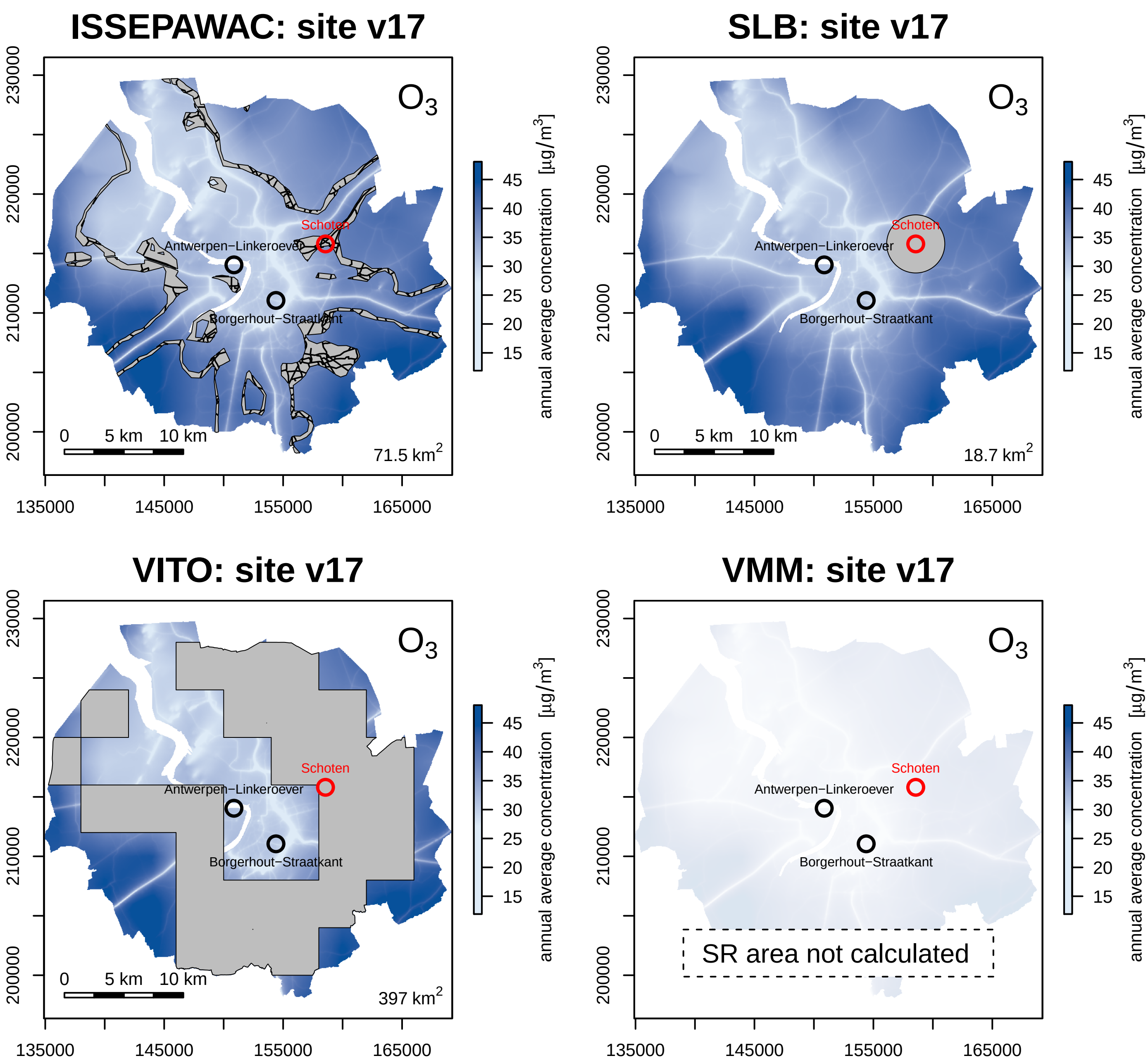
Spatial Representativeness Maps

by Pollutant & Station:

O_3 at virtual station v17



O_3 at virtual station v17



O_3 at virtual station v17

Spatial Representativeness Maps

by Pollutant & Station:

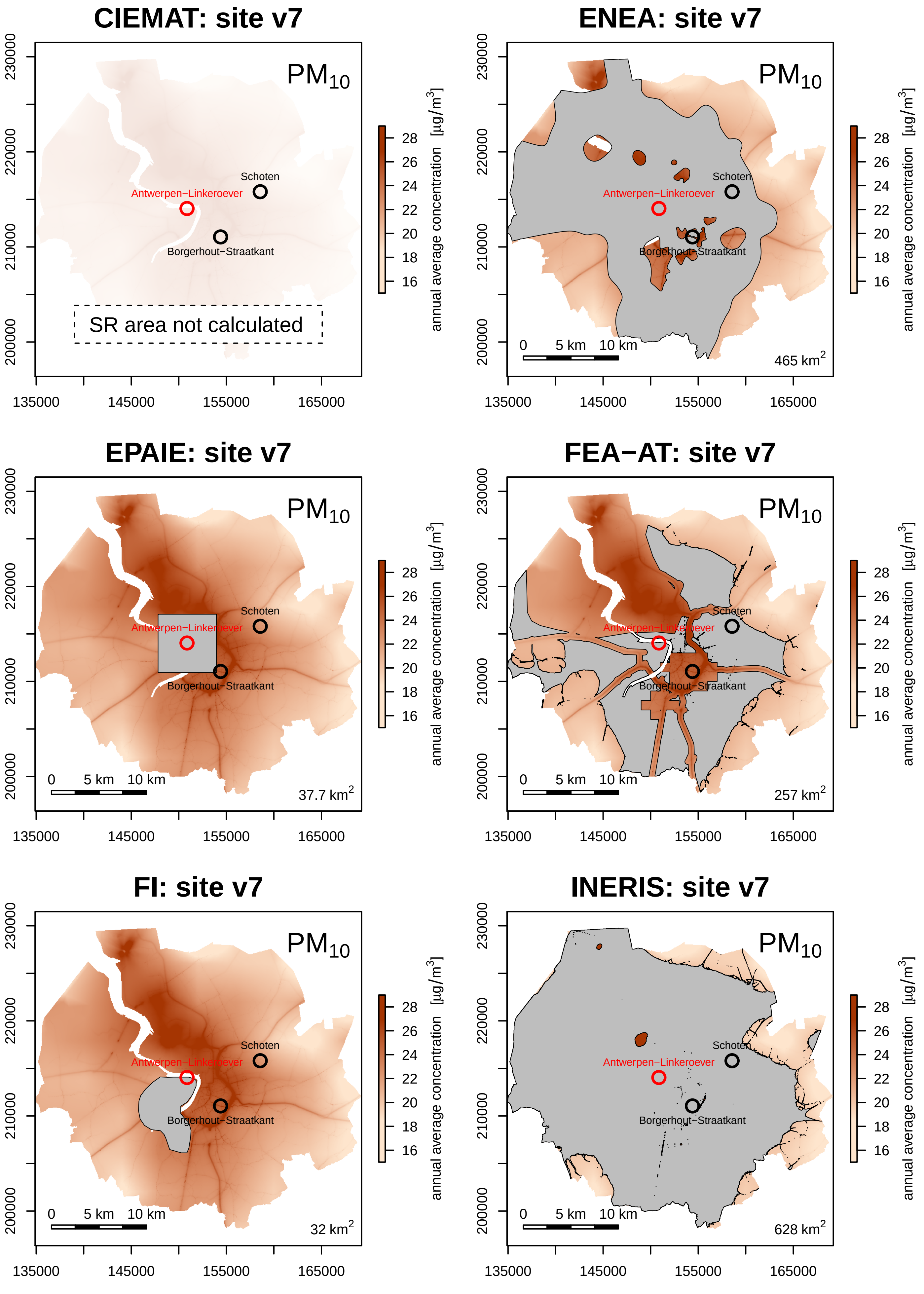
O_3 at virtual station v216

The combination O_3 at virtual station v216 was not a task for the IE. It is thus omitted from plotting here.

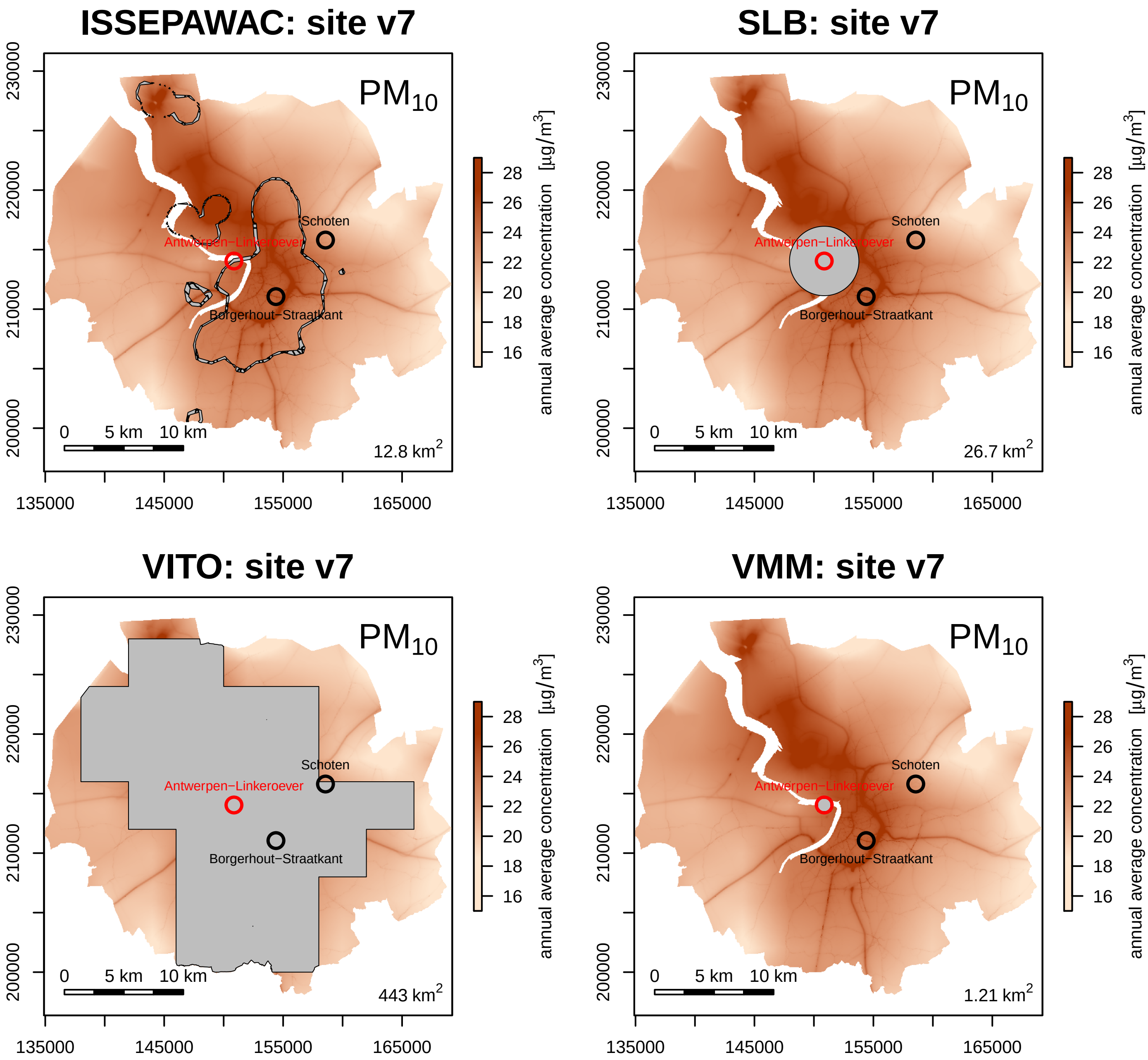
Spatial Representativeness Maps

by Pollutant & Station:

PM_{10} at virtual station v7



PM_{10} at virtual station v7

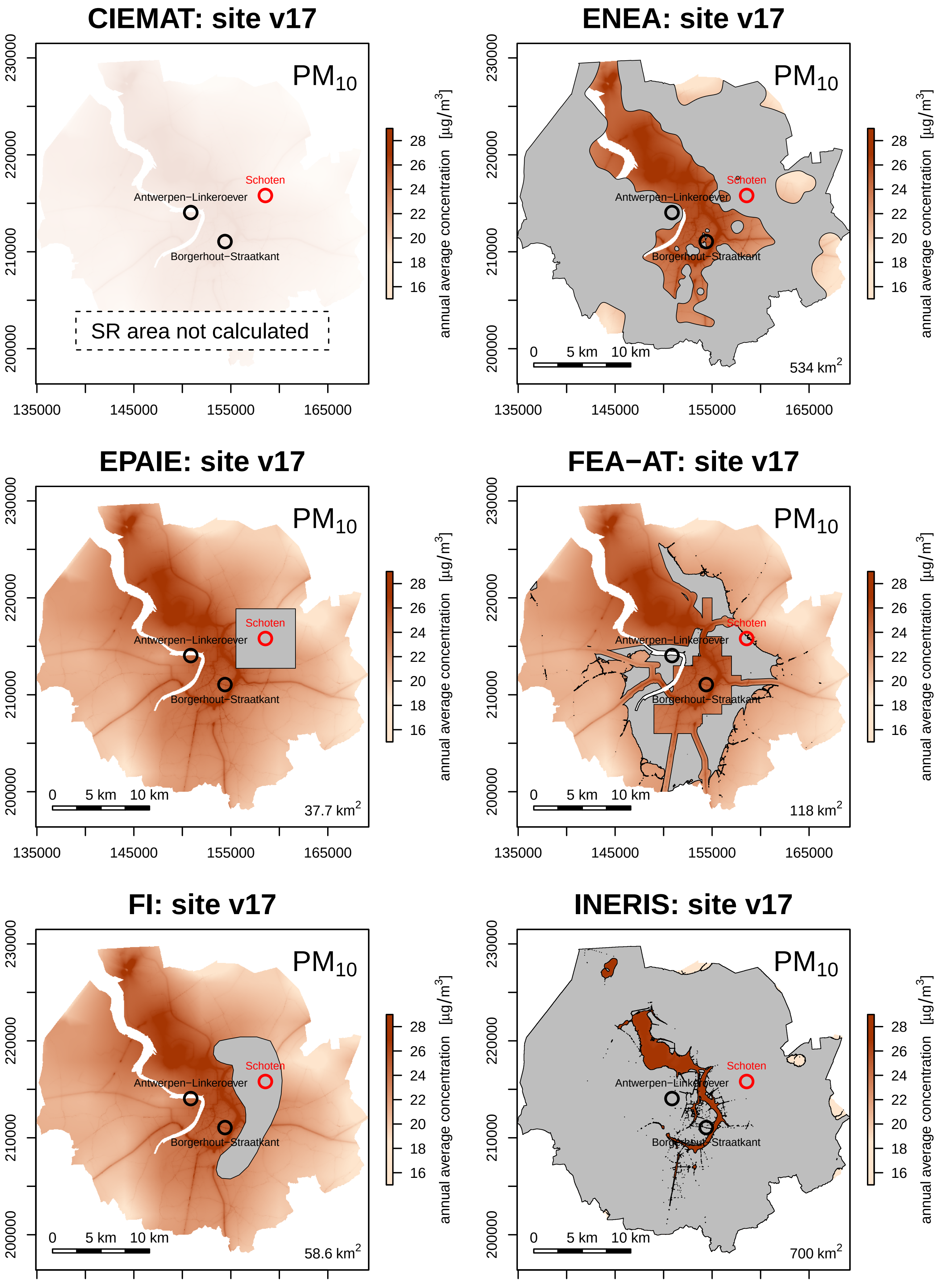


PM_{10} at virtual station v7

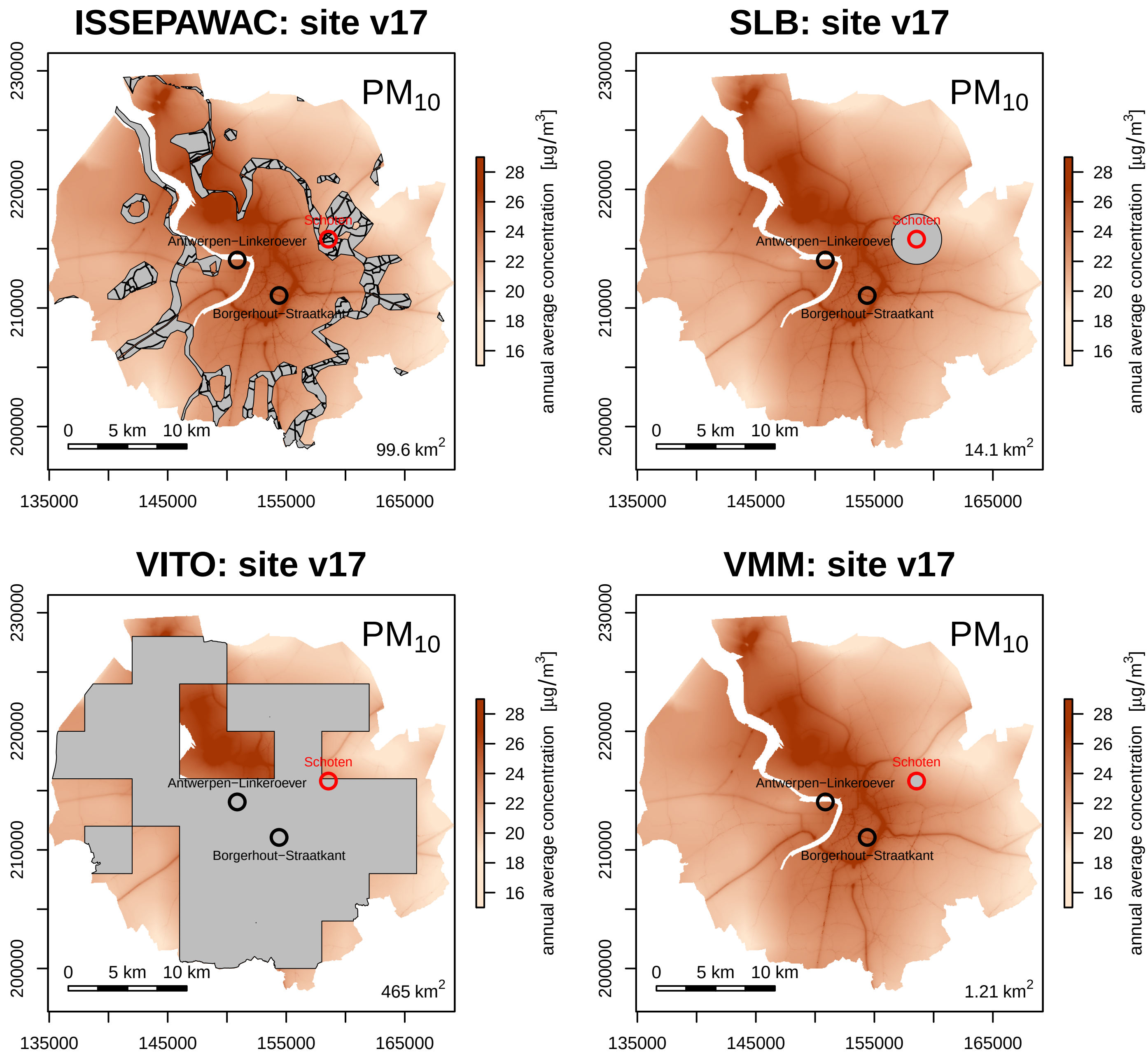
Spatial Representativeness Maps

by Pollutant & Station:

PM_{10} at virtual station v17



PM_{10} at virtual station v17

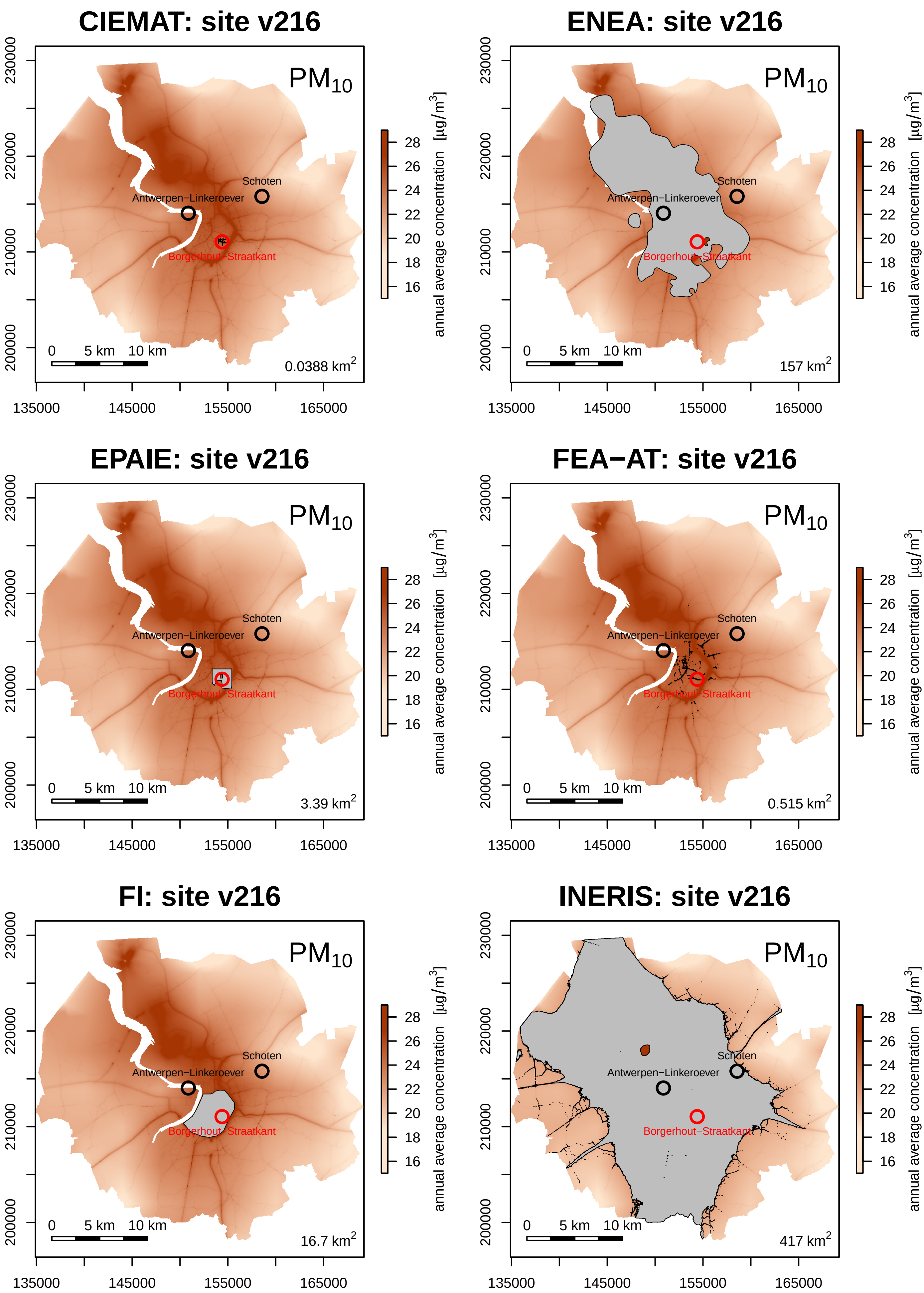


PM$_{10}$ at virtual station v17

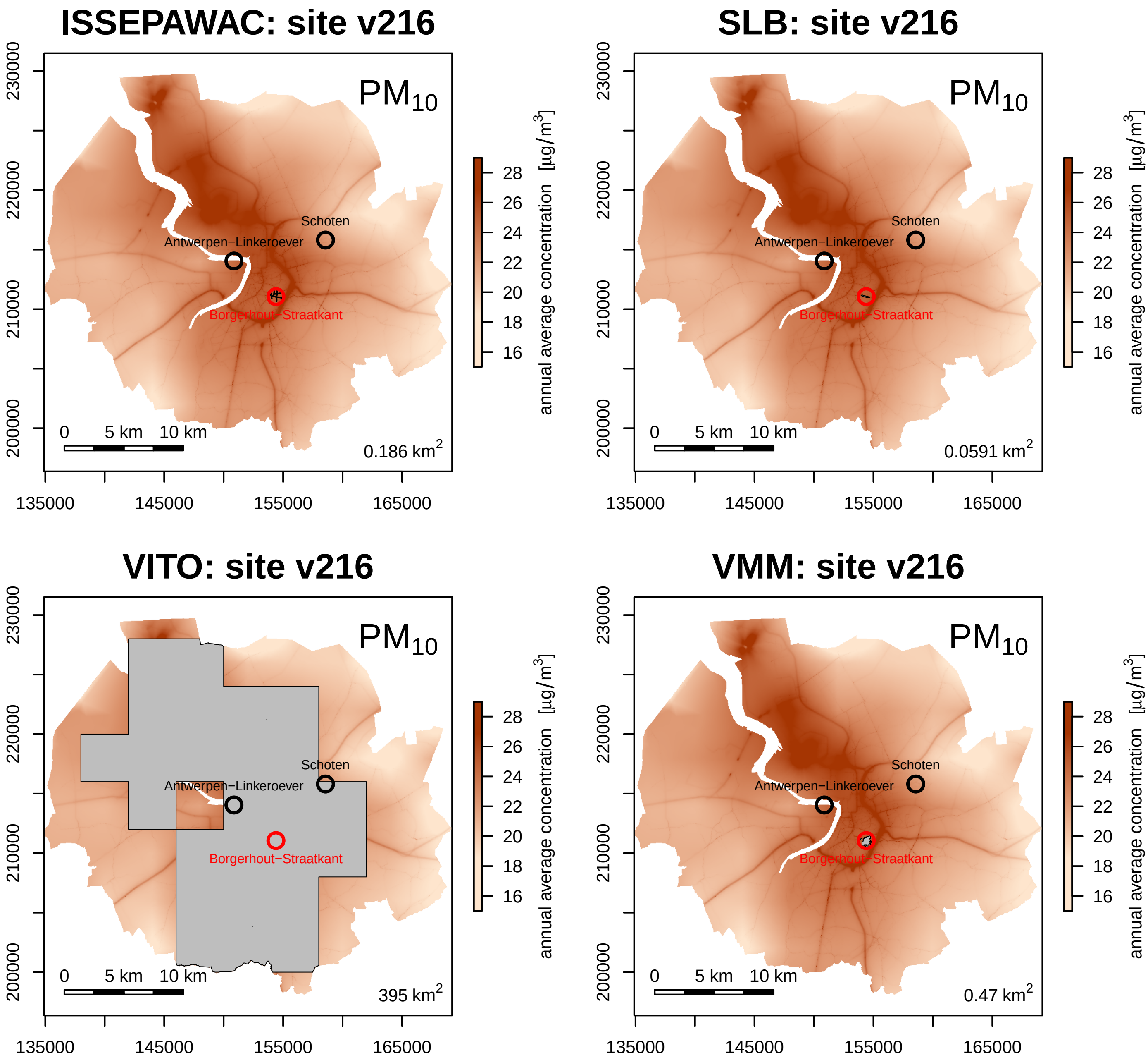
Spatial Representativeness Maps

by Pollutant & Station:

PM_{10} at virtual station v216



PM_{10} at virtual station v216



PM_{10} at virtual station v216

Annex V. Incremental Intersection Maps by Pollutant & Station

Incremental intersection maps sorted by pollutant & station:

- NO_2 at virtual station v7 (Antwerpen-Linkeroever)
- NO_2 at virtual station v17 (Schoten)
- NO_2 at virtual station v216 (Borgerhout-Straatkant)

- O_3 at virtual station v7 (Antwerpen-Linkeroever)
- O_3 at virtual station v17 (Schoten)

- PM_{10} at virtual station v7 (Antwerpen-Linkeroever)
- PM_{10} at virtual station v17 (Schoten)
- PM_{10} at virtual station v216 (Borgerhout-Straatkant)

The combination O_3 at virtual station v216 (Borgerhout-Straatkant) was not a task for the IE. It is thus omitted from plotting in this annex.

Legend:

In all maps, the position of the respective **AQMS is highlighted in red**.

Background colours depict the **annual average concentration field** of the respective pollutant:

NO_2: green colour scale

O_3: blue colour scale

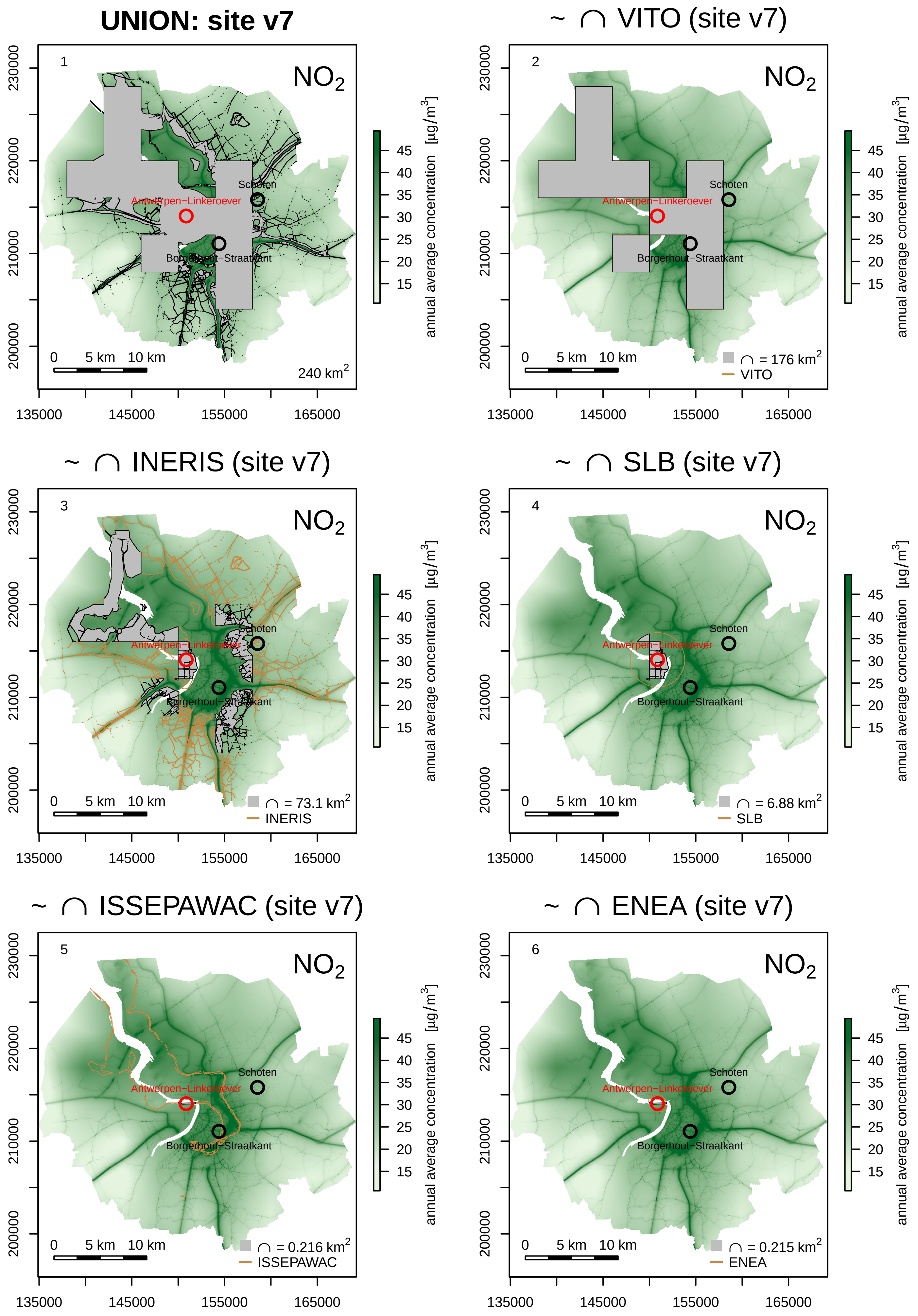
PM_{10}: orange colour scale

The **SR areas** of the total union and of the following incremental intersections are described by the **grey coloured fields** in the foreground. In each step, the SR area of the respective **intersection partner is depicted in brown colours**.

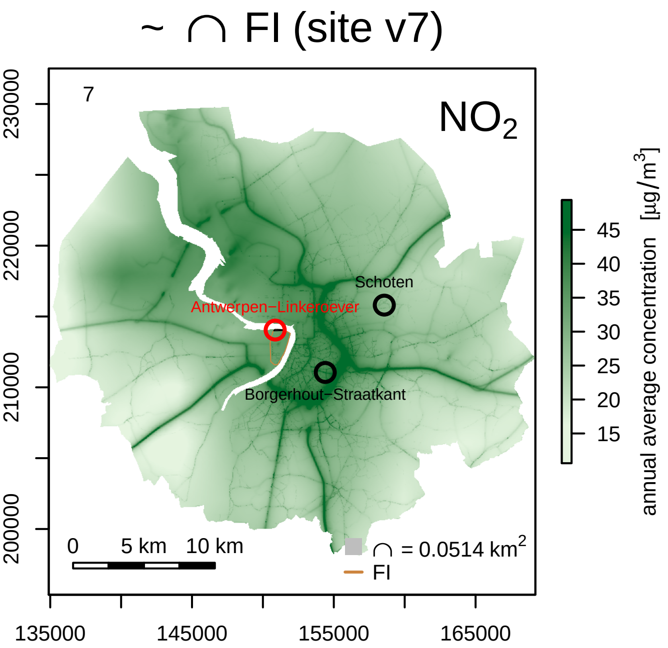
Incremental Intersections

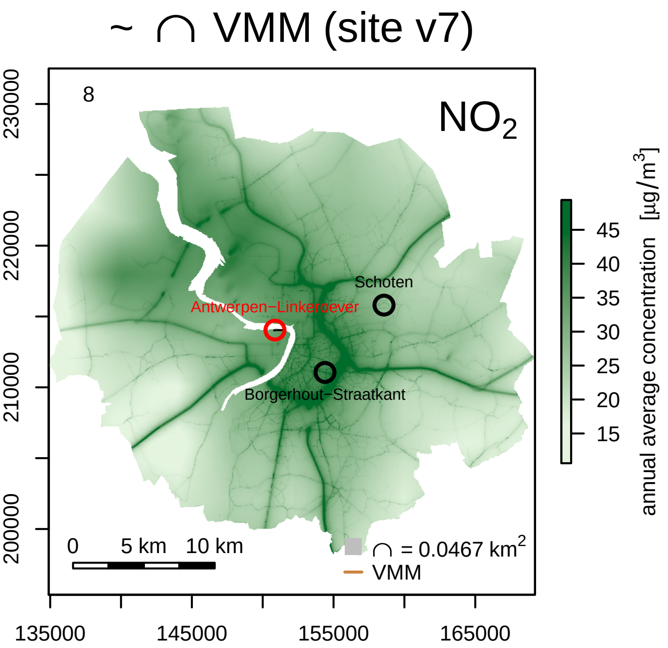
by Pollutant & Station:

NO_2 at virtual station v7



SR Area Incremental Intersections for site 7

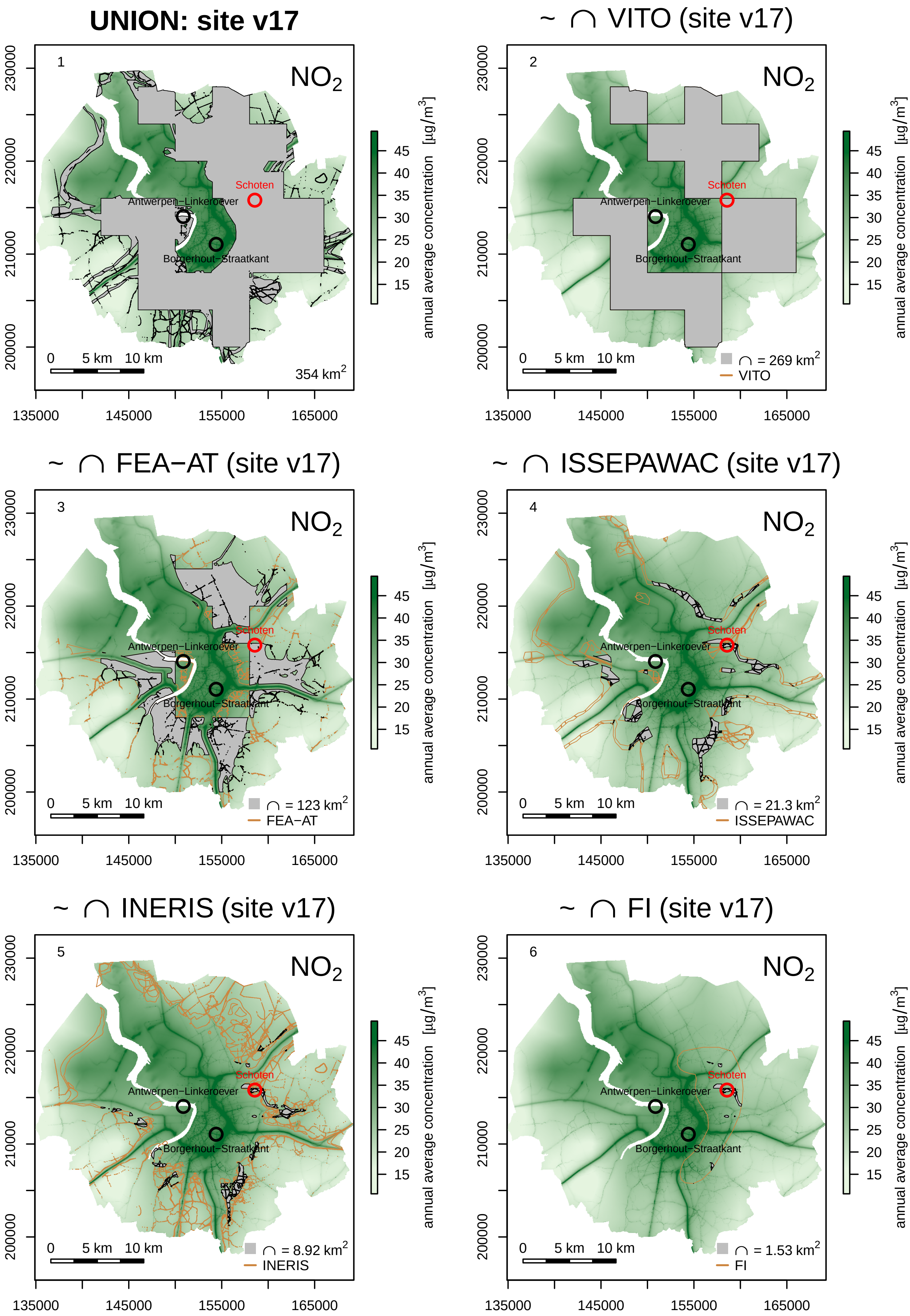

~ ∩ FI (site v7)
7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ = 0.0514 km2
FI
annual average concentration [µg/m3]
45
40
35
30
25
20
15
230000
220000
210000
200000
135000
145000
155000
165000


~ ∩ VMM (site v7)
8
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ = 0.0467 km2
VMM
annual average concentration [µg/m3]
45
40
35
30
25
20
15
230000
220000
210000
200000
135000
145000
155000
165000

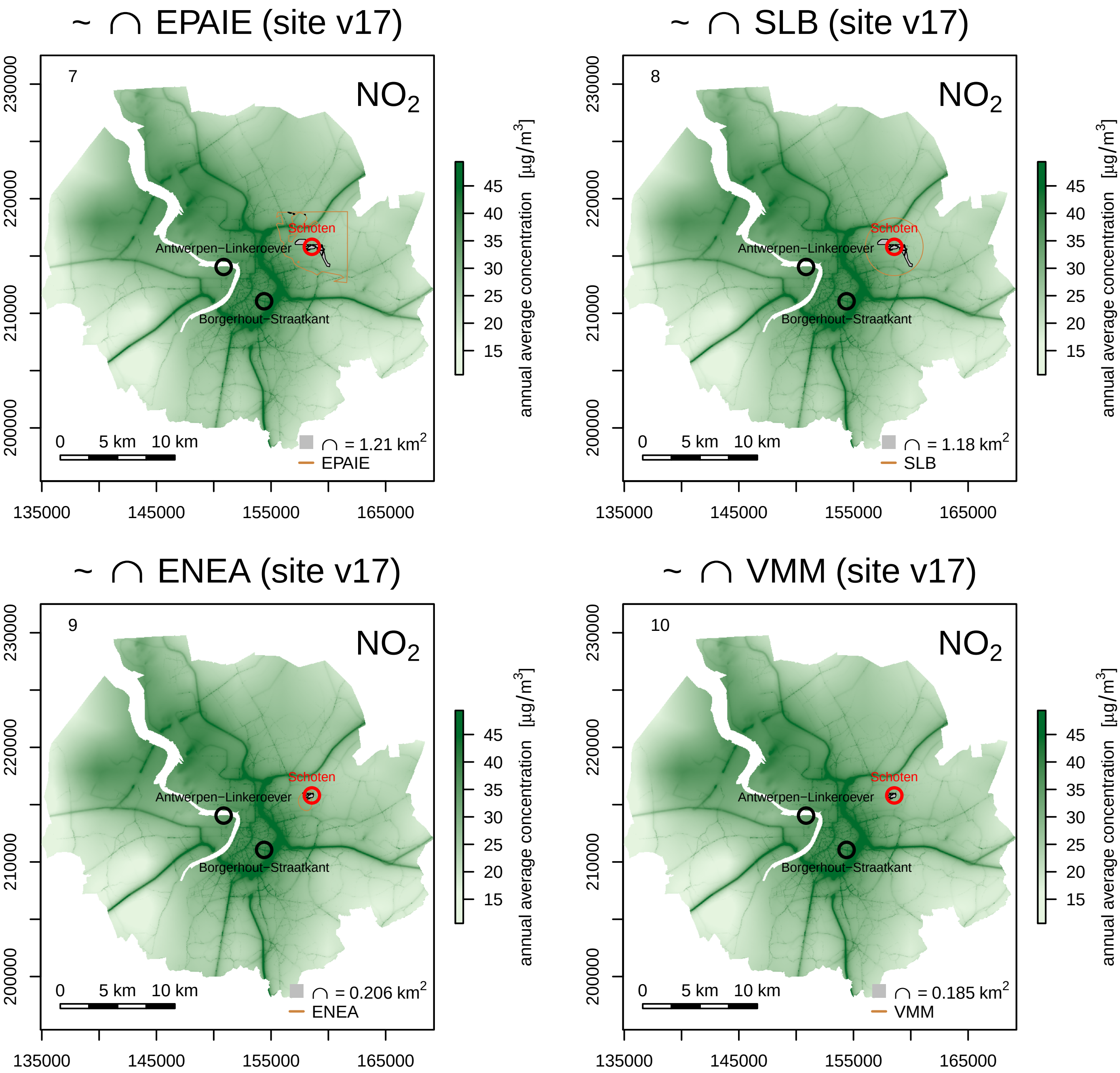
Incremental Intersections

by Pollutant & Station:

NO_2 at virtual station v17



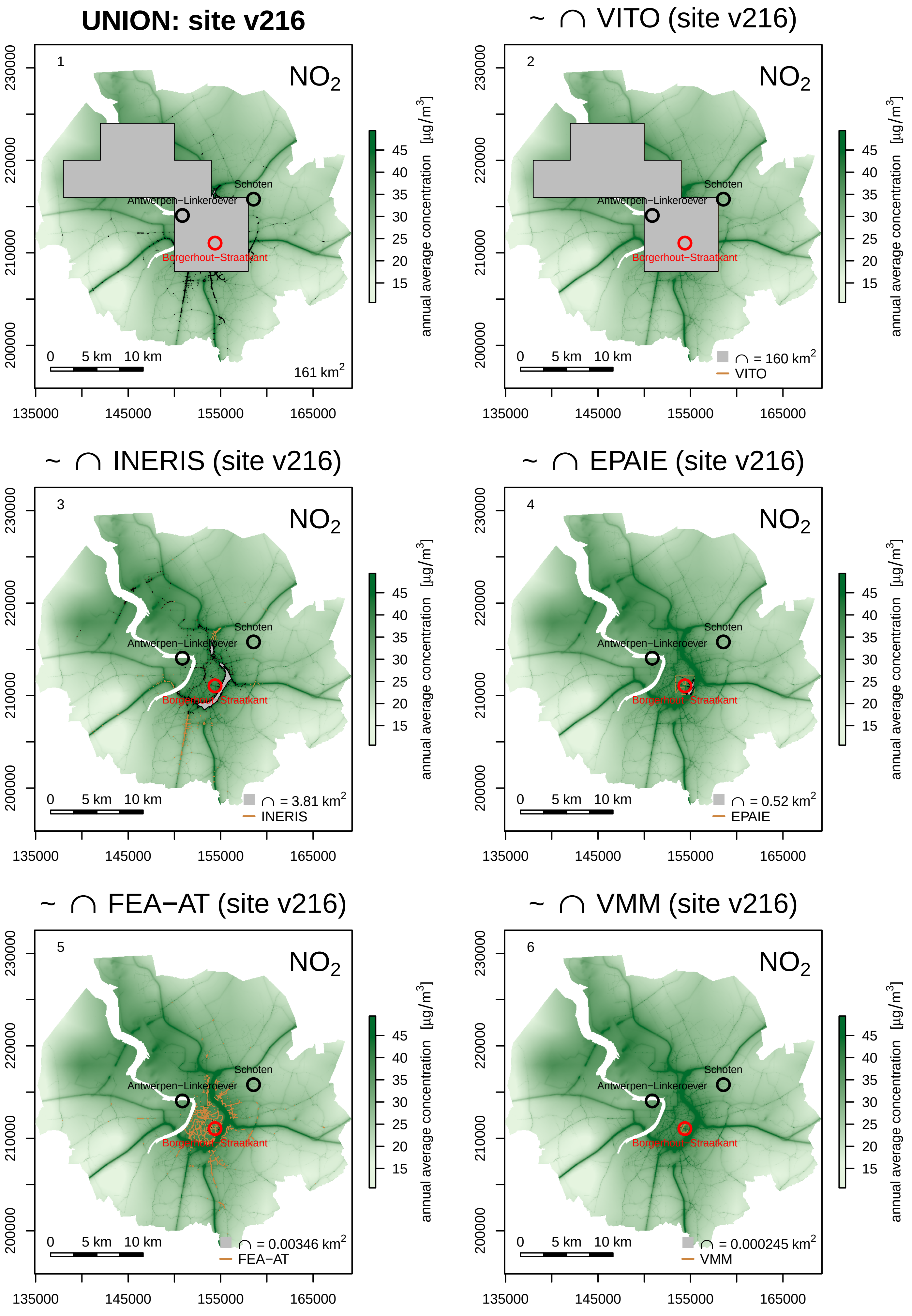
SR Area Incremental Intersections for site 17


~ ∩ EPAIE (site v17)
7
NO_2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ = 1.21 km^2
EPAIE
~ ∩ SLB (site v17)
8
NO_2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ = 1.18 km^2
SLB
~ ∩ ENEA (site v17)
9
NO_2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ = 0.206 km^2
ENEA
~ ∩ VMM (site v17)
10
NO_2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ = 0.185 km^2
VMM
annual average concentration [µg/m^3]
15 20 25 30 35 40 45
135000 145000 155000 165000
200000 210000 220000 230000

Incremental Intersections

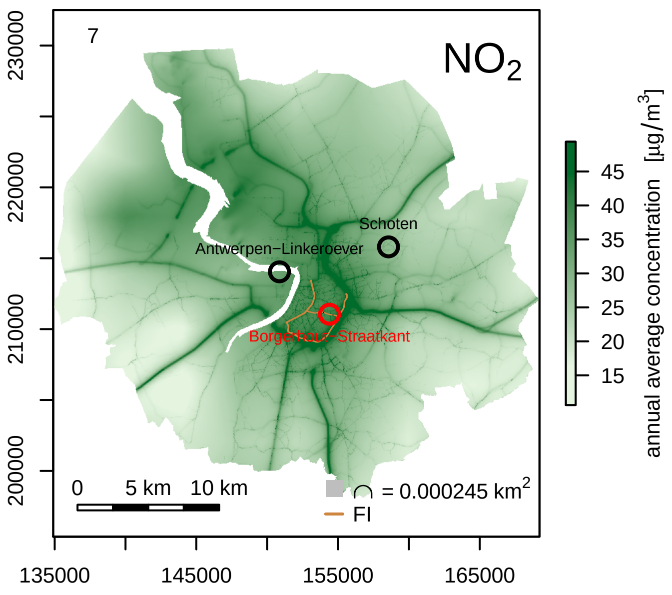
by Pollutant & Station:

NO_2 at virtual station v216

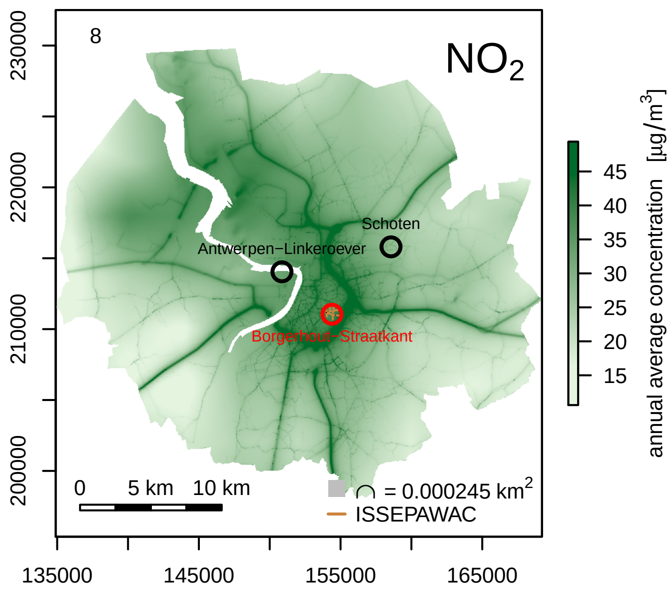


SR Area Incremental Intersections for site 216

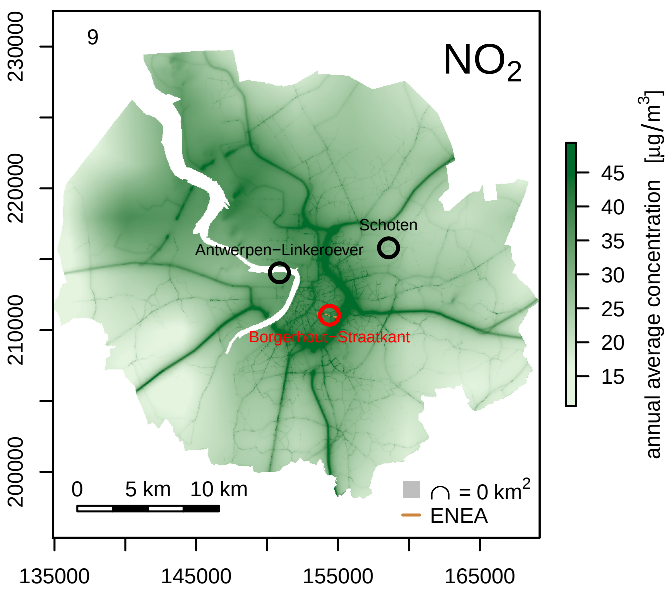
~ ∩ FI (site v216)



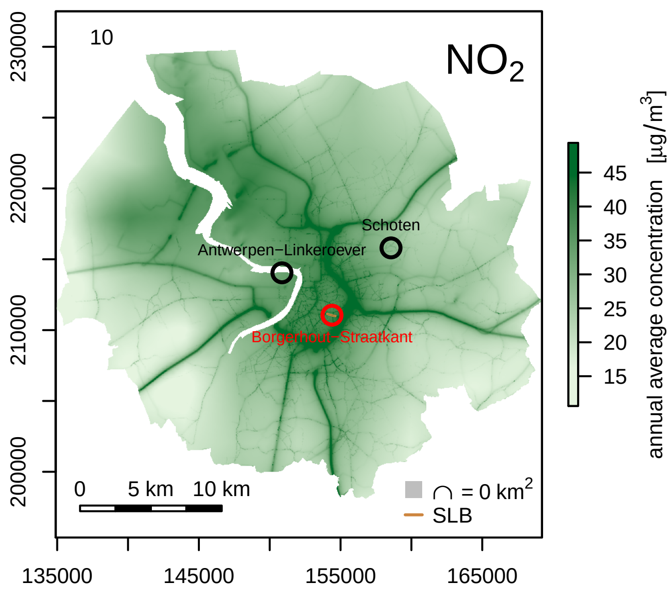
~ ∩ ISSEPAWAC (site v216)



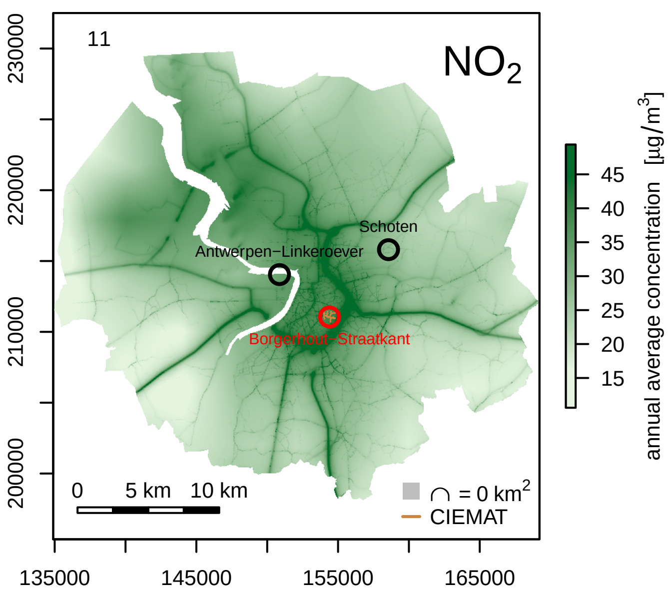
~ ∩ ENEA (site v216)



~ ∩ SLB (site v216)



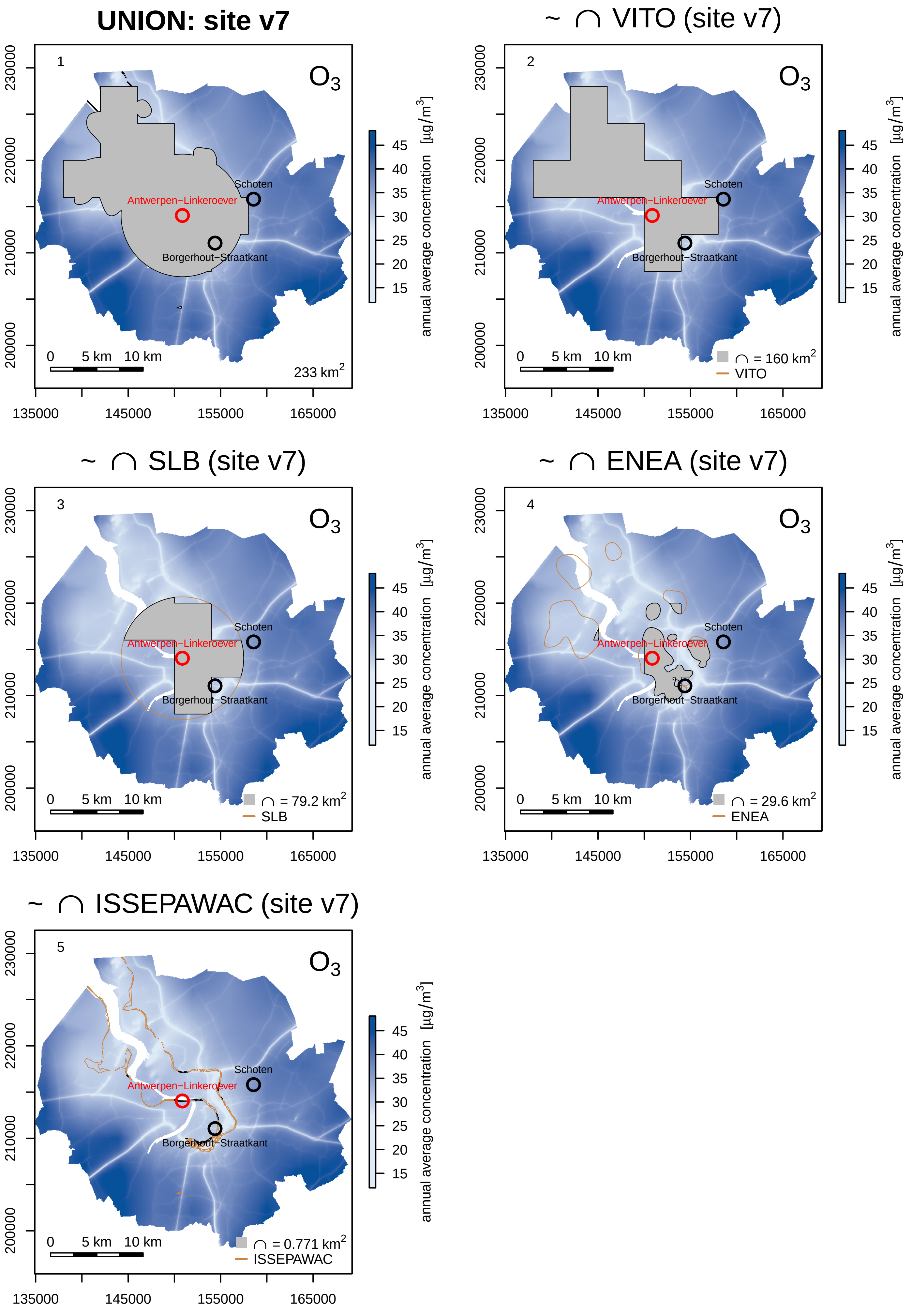
~ ∩ CIEMAT (site v216)



Incremental Intersections

by Pollutant & Station:

O_3 at virtual station v7

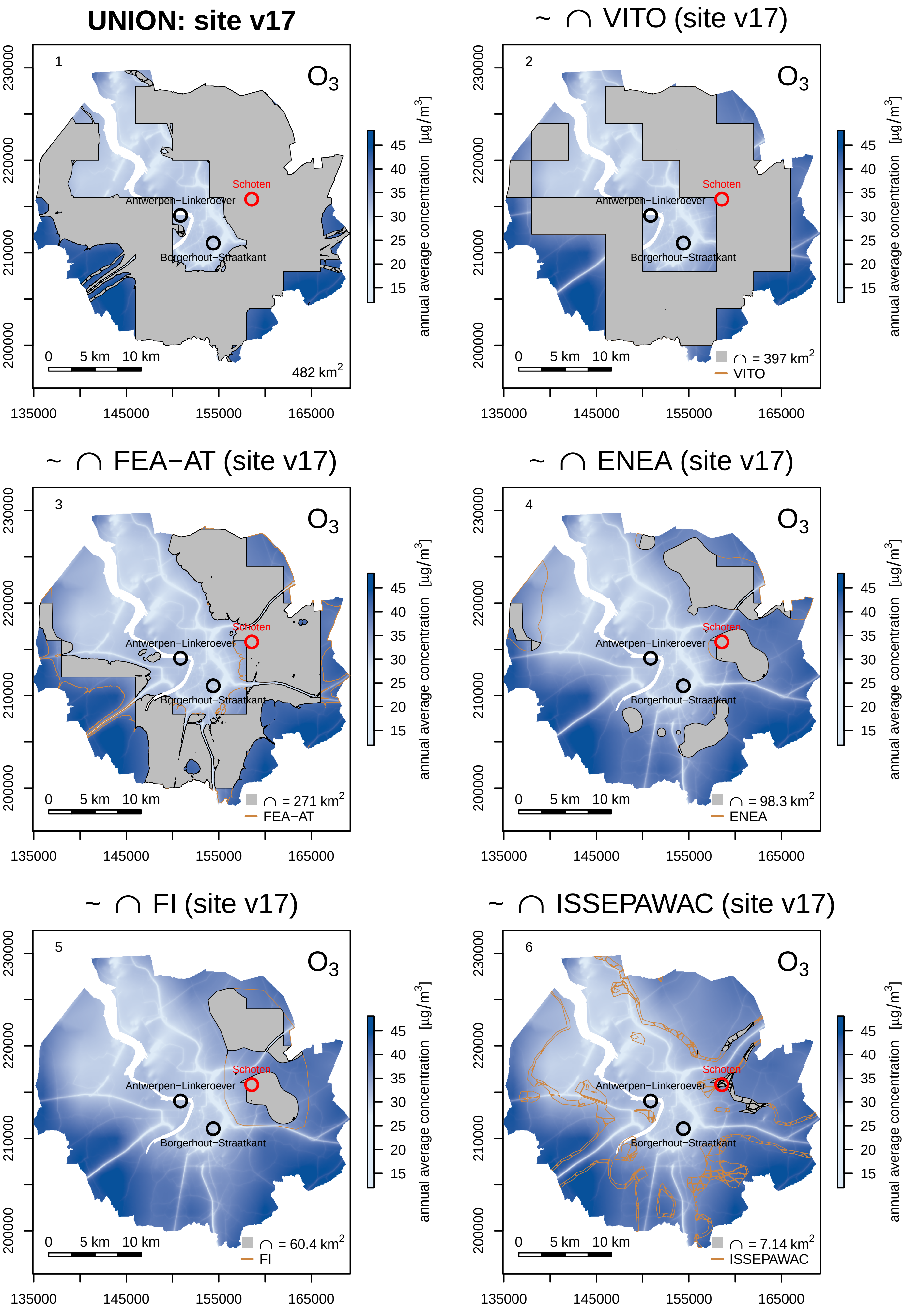


SR Area Incremental Intersections for site 7

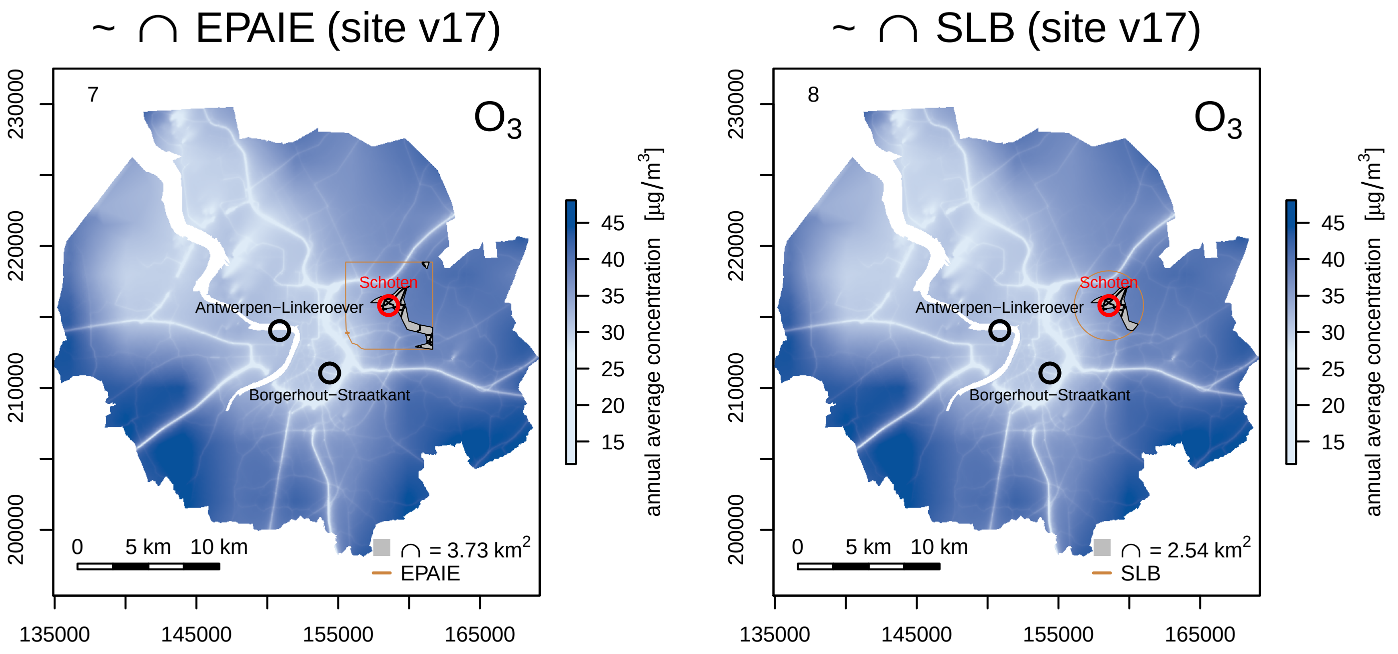
Incremental Intersections

by Pollutant & Station:

O_3 at virtual station v17



SR Area Incremental Intersections for site 17


~ ∩ EPAIE (site v17)
7
O_3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ = 3.73 km²
EPAIE
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m³]
~ ∩ SLB (site v17)
8
O_3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ = 2.54 km²
SLB

Incremental Intersections

by Pollutant & Station:

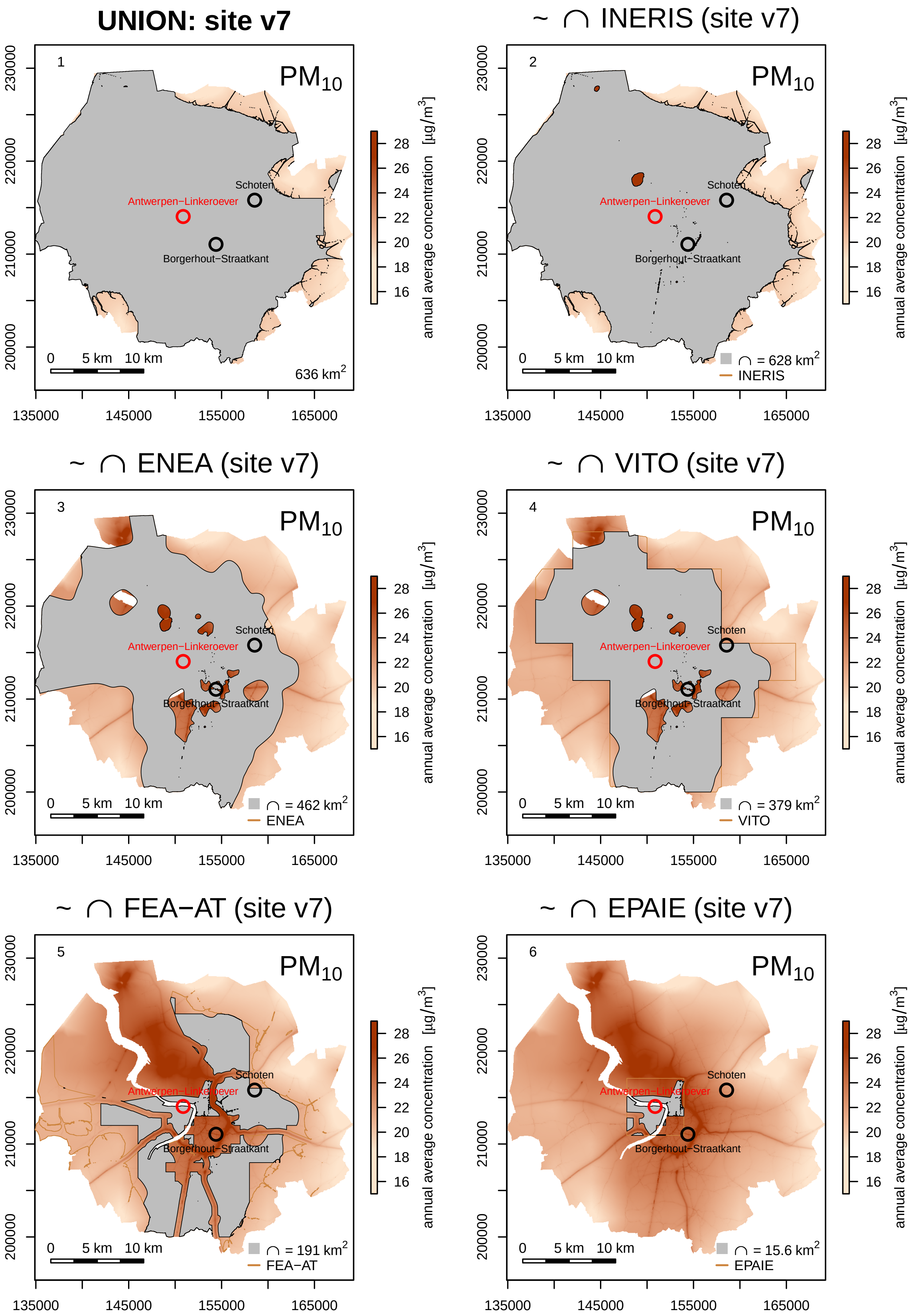
O_3 at virtual station v216

The combination O_3 at virtual station v216 was not a task for the IE. It is thus omitted from plotting here.

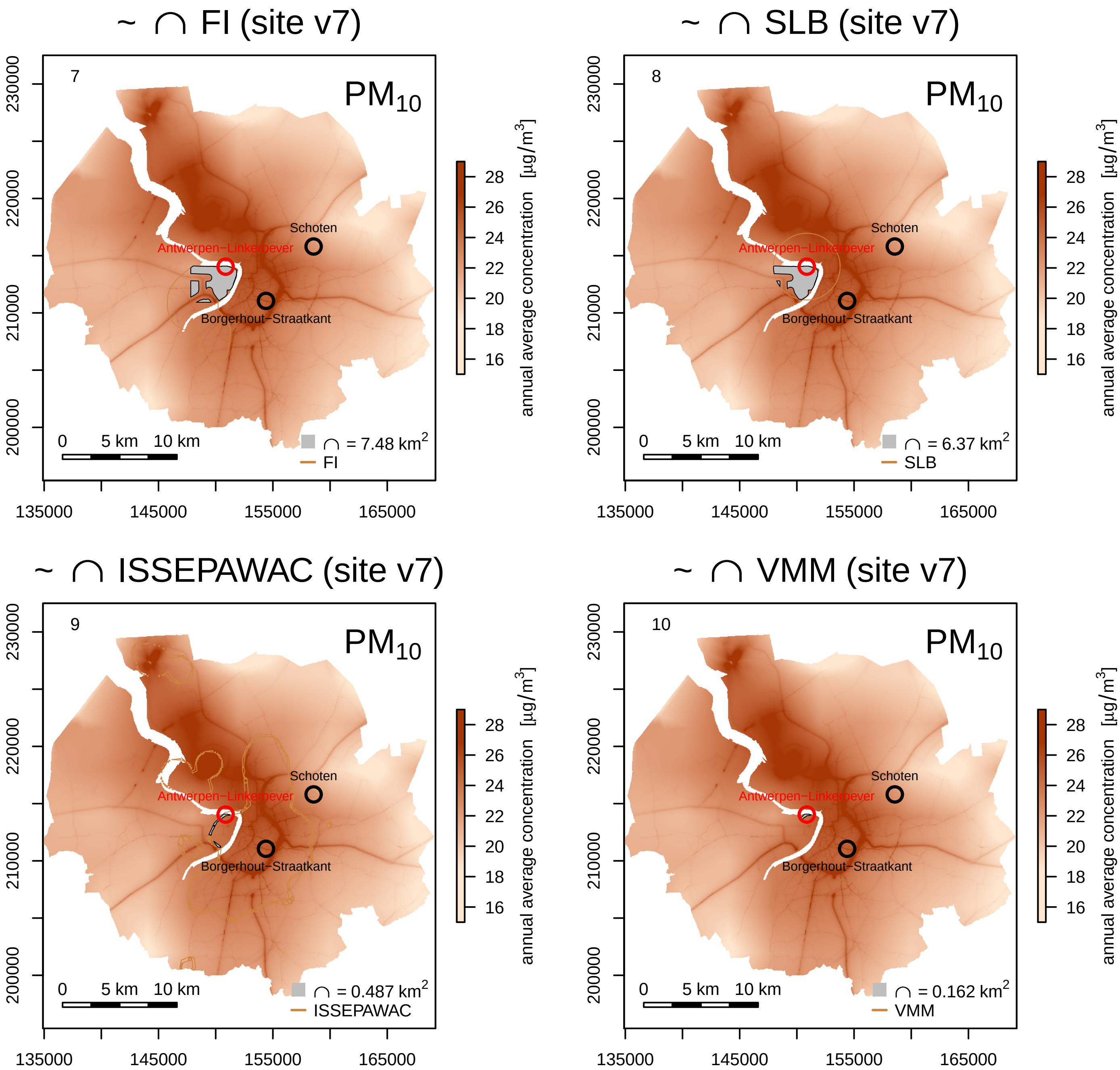
Incremental Intersections

by Pollutant & Station:

PM_{10} at virtual station v7



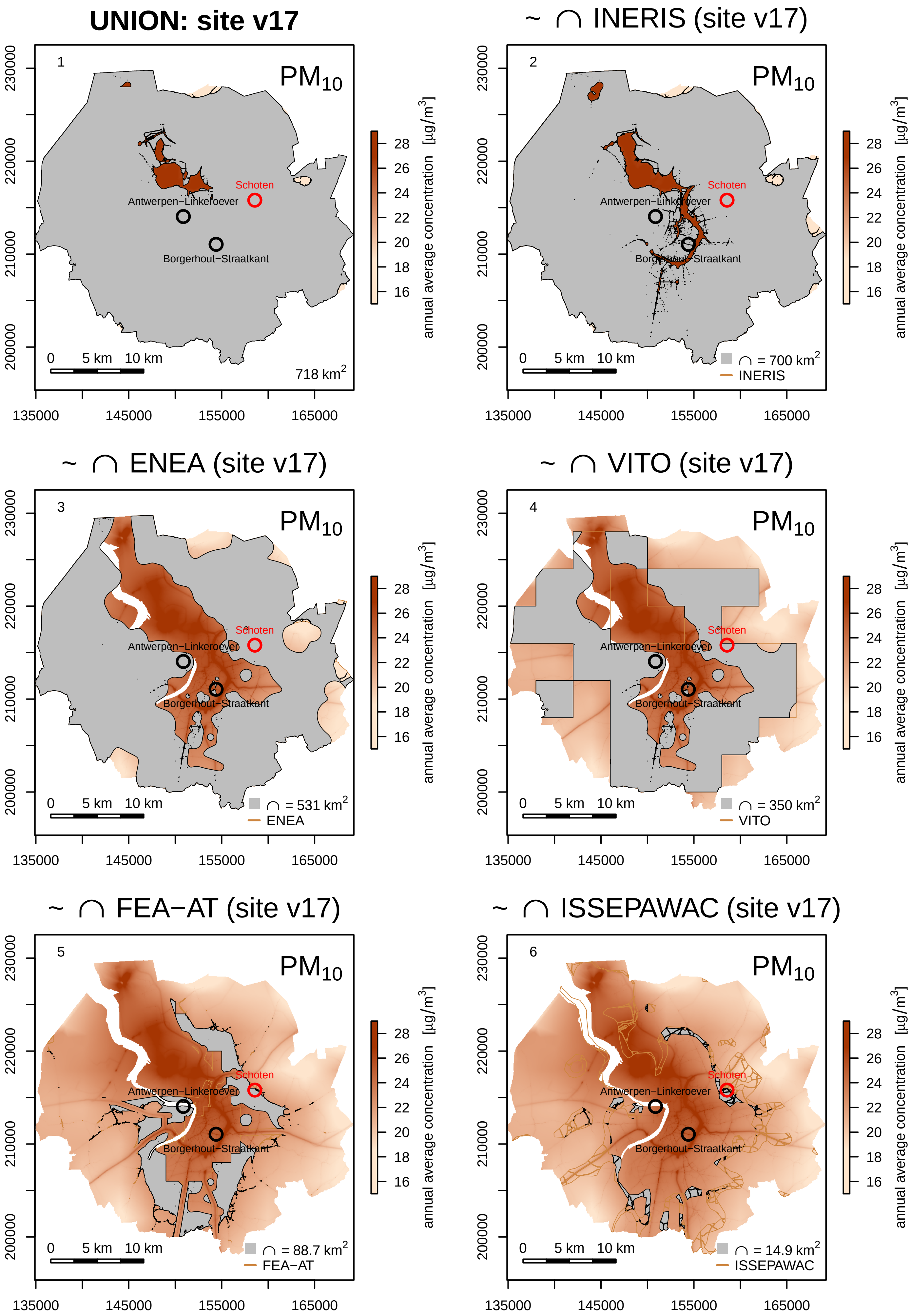
SR Area Incremental Intersections for site 7


~ ∩ FI (site v7)
7
PM_{10}
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ = 7.48 km^2
FI
~ ∩ SLB (site v7)
8
PM_{10}
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ = 6.37 km^2
SLB
~ ∩ ISSEPAWAC (site v7)
9
PM_{10}
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ = 0.487 km^2
ISSEPAWAC
~ ∩ VMM (site v7)
10
PM_{10}
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ = 0.162 km^2
VMM
annual average concentration [µg/m^3]
16 18 20 22 24 26 28
135000 145000 155000 165000
200000 210000 220000 230000

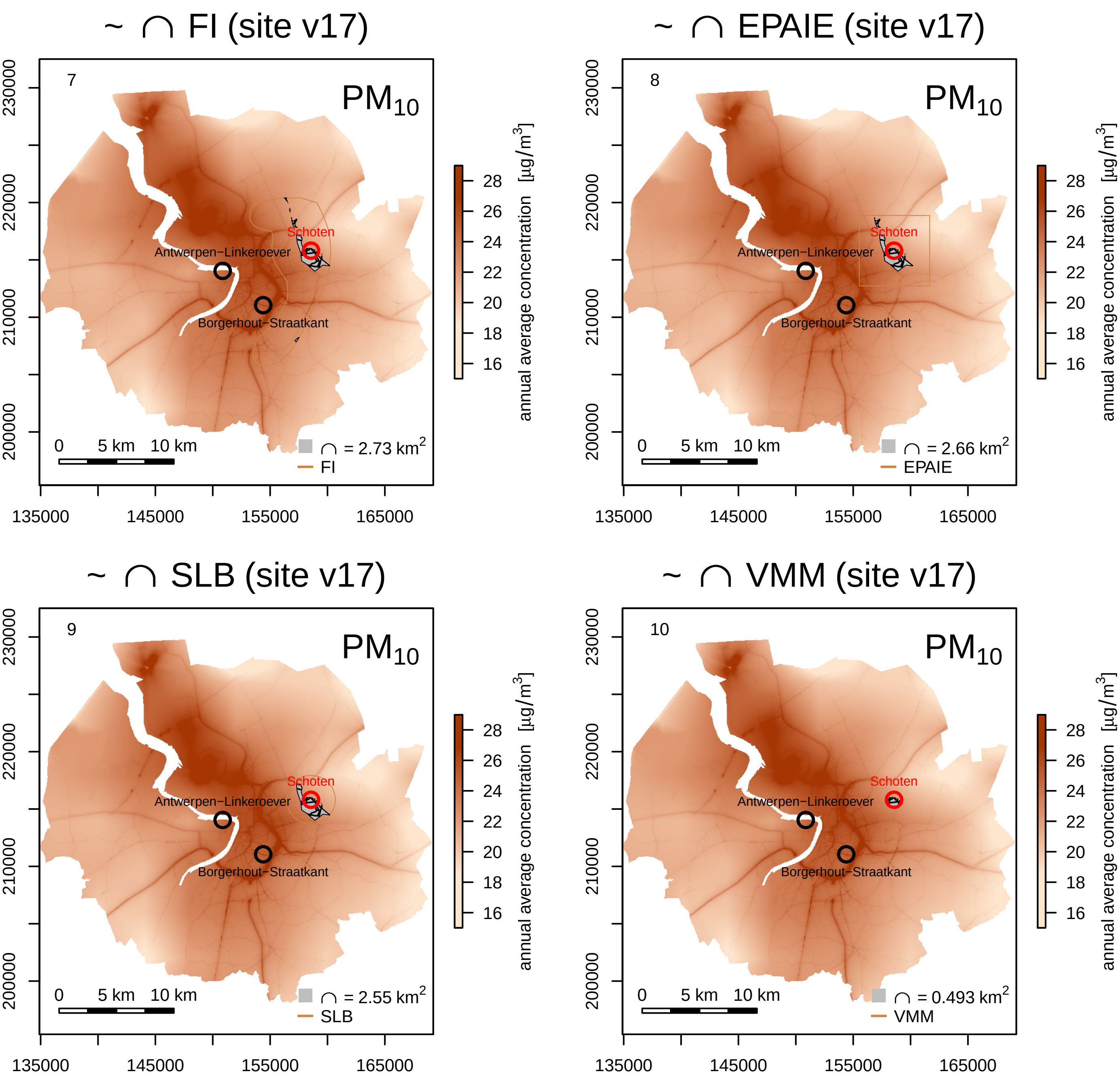
Incremental Intersections

by Pollutant & Station:

PM_{10} at virtual station v17



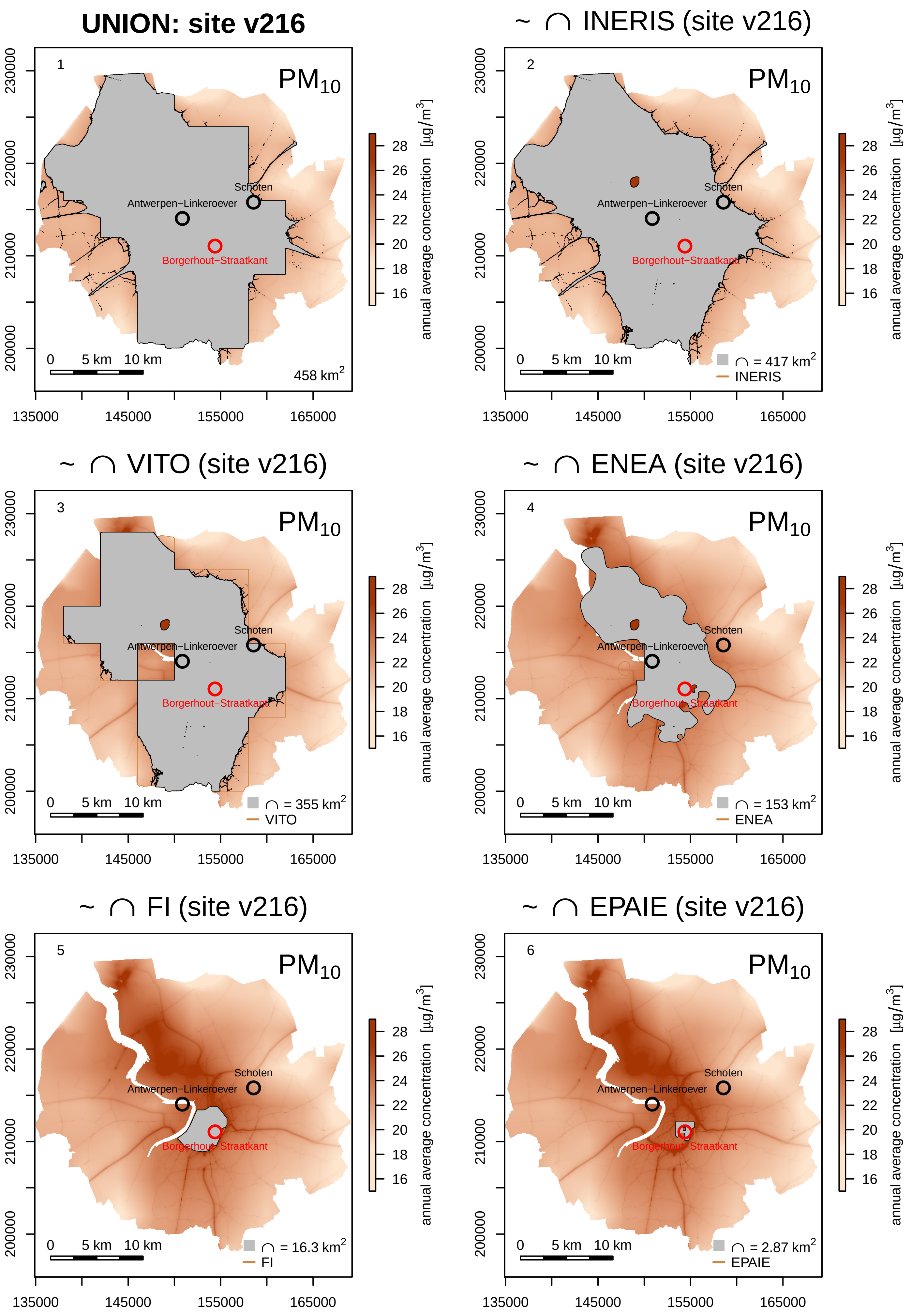
SR Area Incremental Intersections for site 17


~ ∩ FI (site v17)
7
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ = 2.73 km2
FI
~ ∩ EPAIE (site v17)
8
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ = 2.66 km2
EPAIE
~ ∩ SLB (site v17)
9
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ = 2.55 km2
SLB
~ ∩ VMM (site v17)
10
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ = 0.493 km2
VMM
annual average concentration [µg/m3]
16 18 20 22 24 26 28
135000 145000 155000 165000
200000 210000 220000 230000

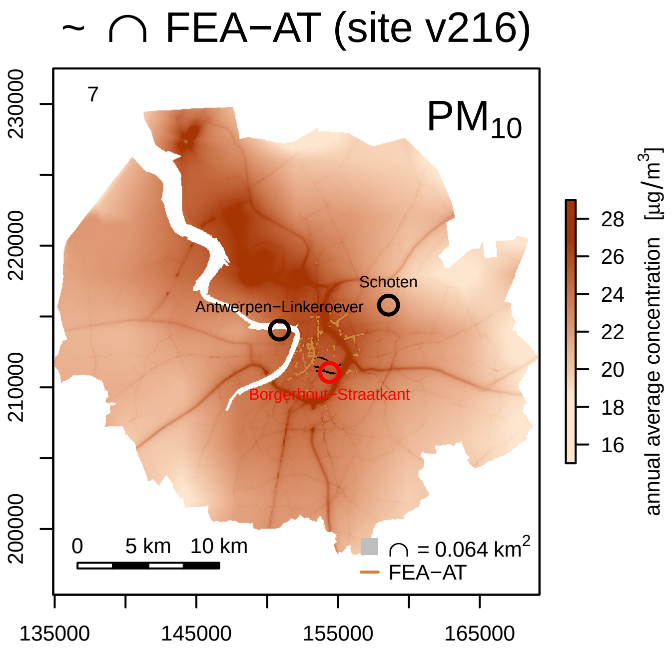
Incremental Intersections

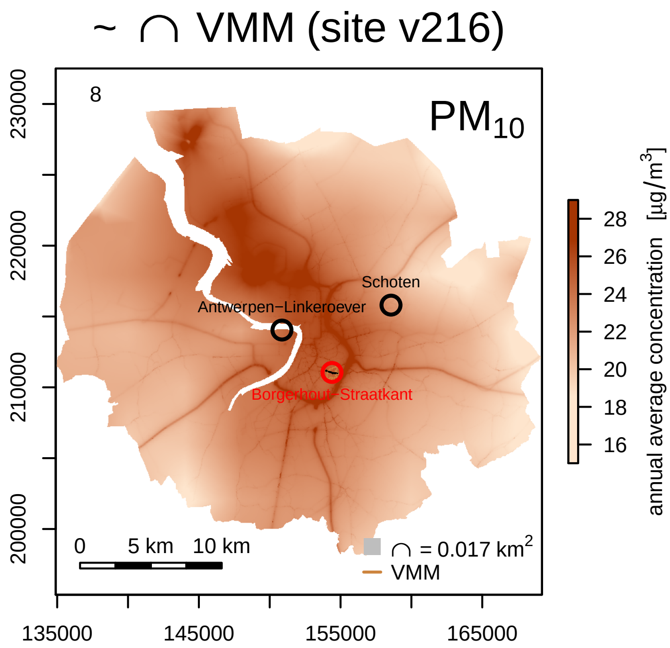
by Pollutant & Station:

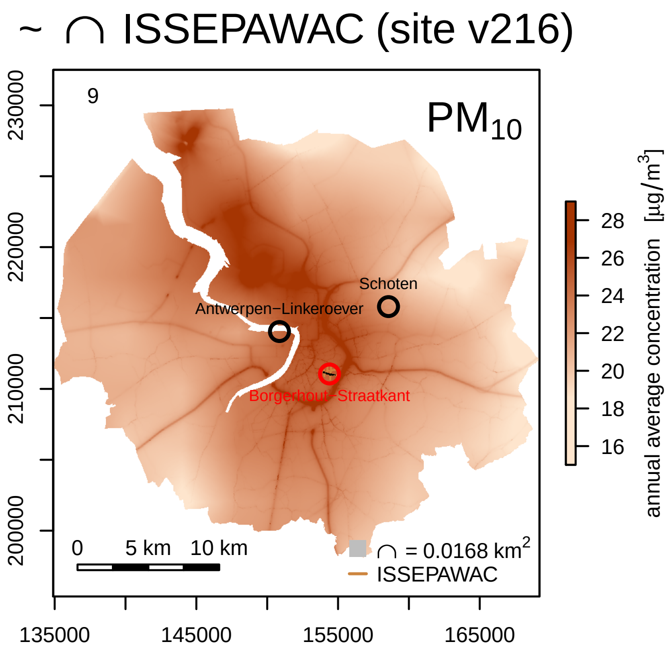
PM_{10} at virtual station v216

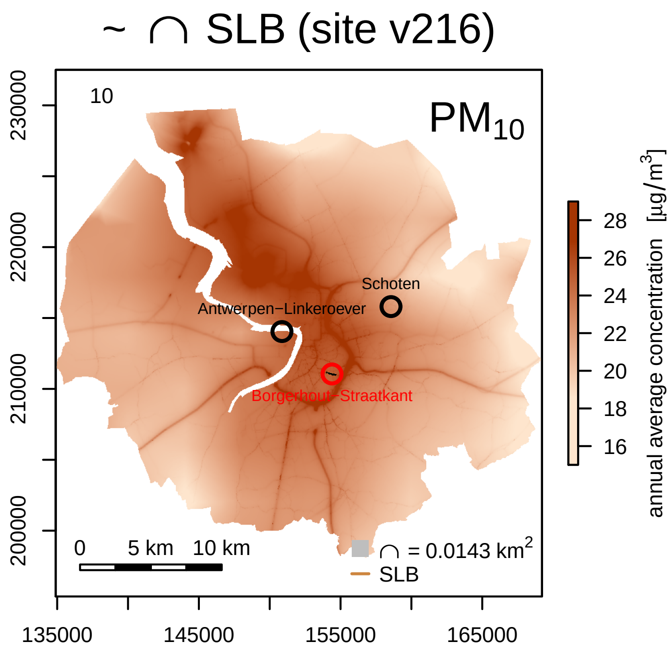


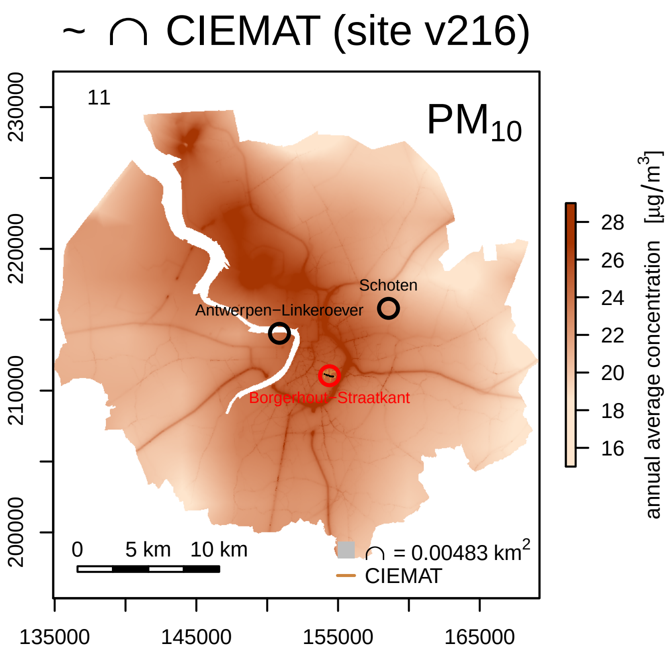
SR Area Incremental Intersections for site 216


~ ∩ FEA−AT (site v216)
7
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ = 0.064 km2
FEA−AT
annual average concentration [µg/m3]
28
26
24
22
20
18
16
230000
220000
210000
200000
135000
145000
155000
165000


~ ∩ VMM (site v216)
8
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ = 0.017 km2
VMM
annual average concentration [µg/m3]


~ ∩ ISSEPAWAC (site v216)
9
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ = 0.0168 km2
ISSEPAWAC
annual average concentration [µg/m3]


~ ∩ SLB (site v216)
10
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ = 0.0143 km2
SLB
annual average concentration [µg/m3]


~ ∩ CIEMAT (site v216)
11
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ = 0.00483 km2
CIEMAT
annual average concentration [µg/m3]

Annex VI. Mutual Comparison Maps by Pollutant & Station

Mutual comparison maps sorted by pollutant & station:

- NO_2 at virtual station v7 (Antwerpen-Linkeroever)
- NO_2 at virtual station v17 (Schoten)
- NO_2 at virtual station v216 (Borgerhout-Straatkant)

- O_3 at virtual station v7 (Antwerpen-Linkeroever)
- O_3 at virtual station v17 (Schoten)

- PM_{10} at virtual station v7 (Antwerpen-Linkeroever)
- PM_{10} at virtual station v17 (Schoten)
- PM_{10} at virtual station v216 (Borgerhout-Straatkant)

The combination O_3 at virtual station v216 (Borgerhout-Straatkant) was not a task for the IE. It is thus omitted from plotting in this annex.

Legend:

In all maps, the position of the respective **AQMS is highlighted in red**.

Background colours depict the **annual average concentration field** of the respective pollutant:

NO_2: green colour scale

O_3: blue colour scale

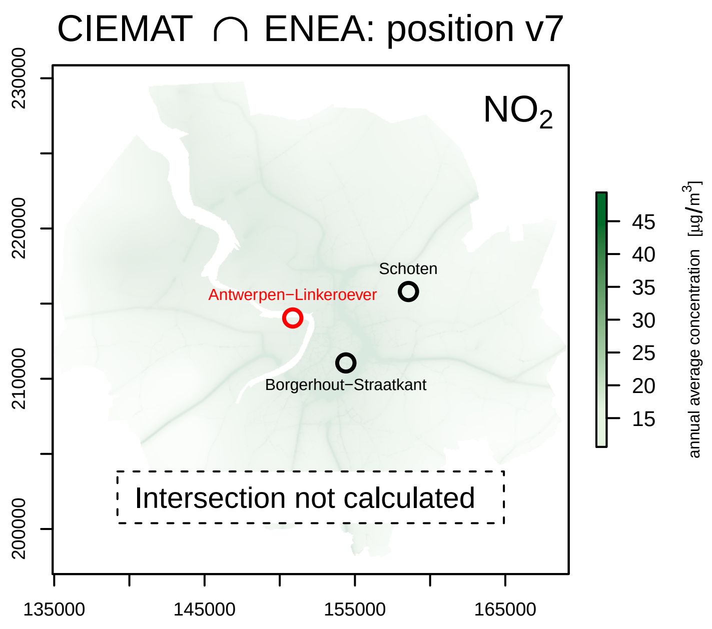
PM_{10}: orange colour scale

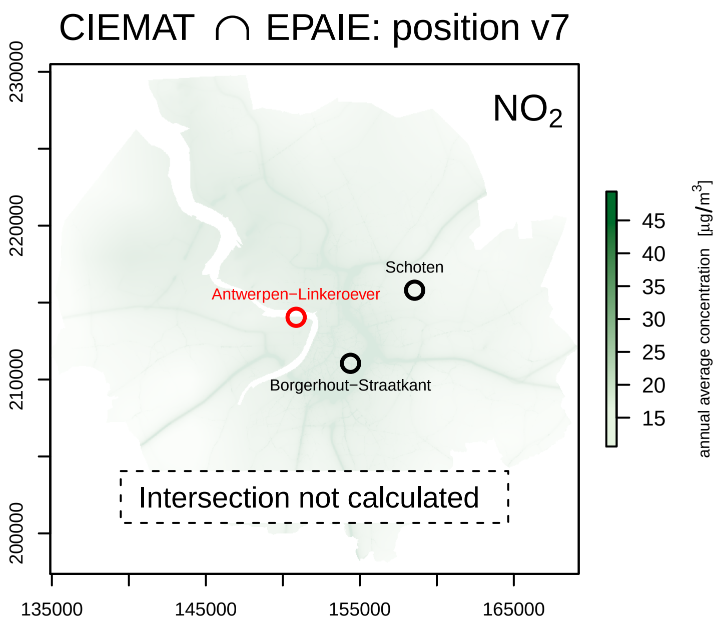
The **SR area** of the **first partner** in a mutual comparison is described by the **brown** coloured fields, whereas the **second partner** is shown in **grey**. The **intersection** of both estimates is finally depicted in **red**.

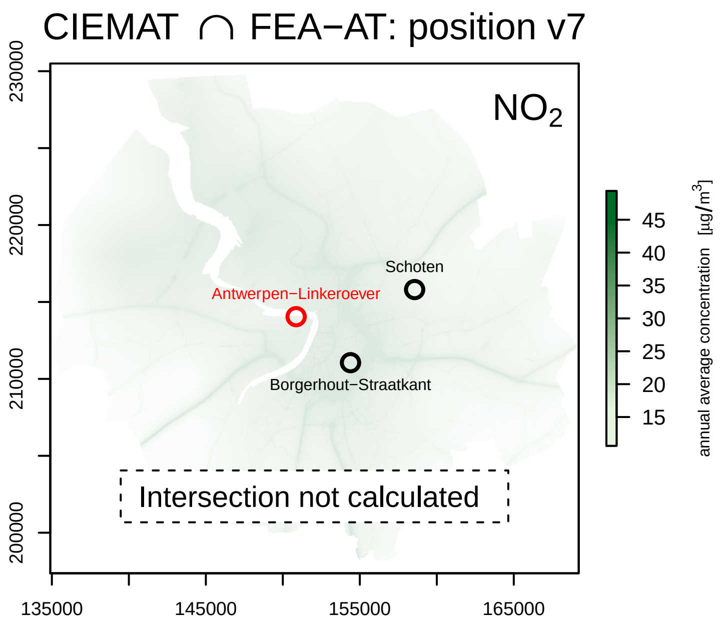
Mutual Comparisons between Teams

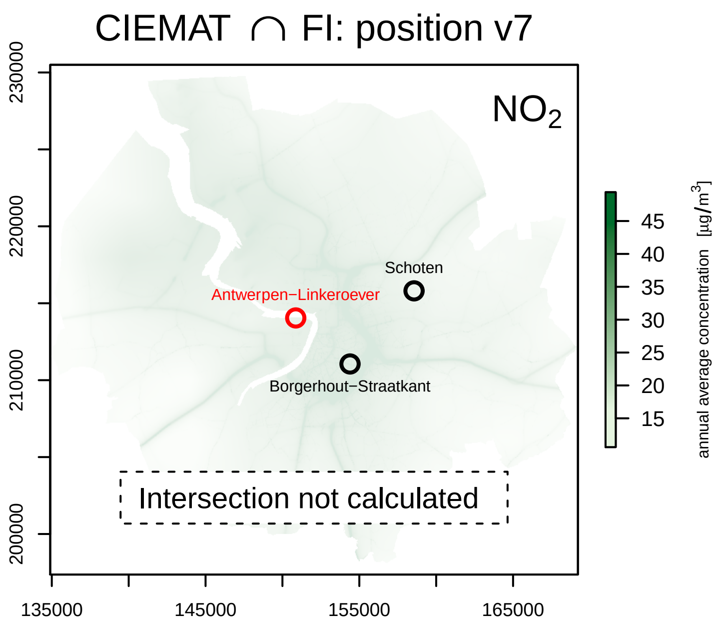
by Pollutant & Station:

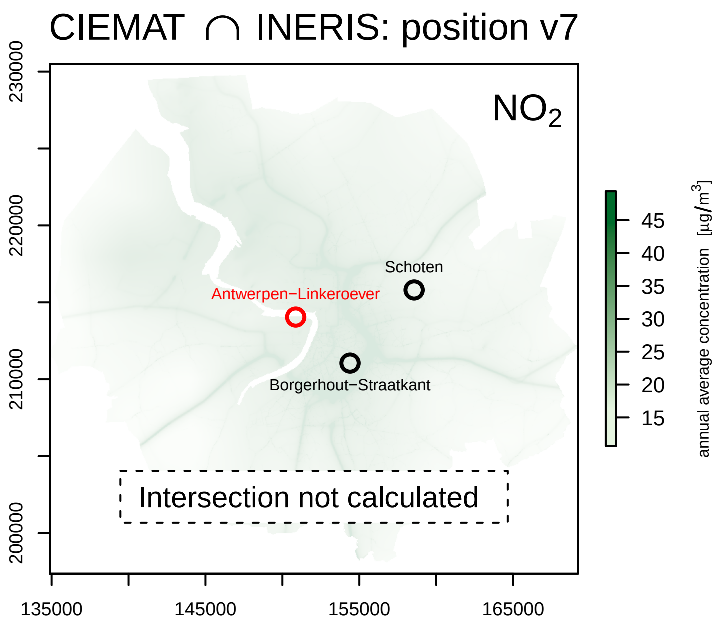
NO_2 at virtual station v7

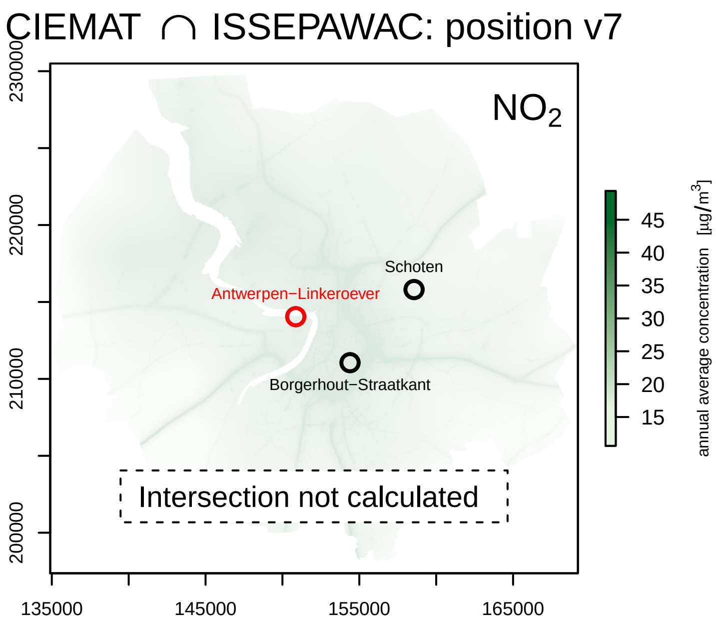

CIEMAT ∩ ENEA: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

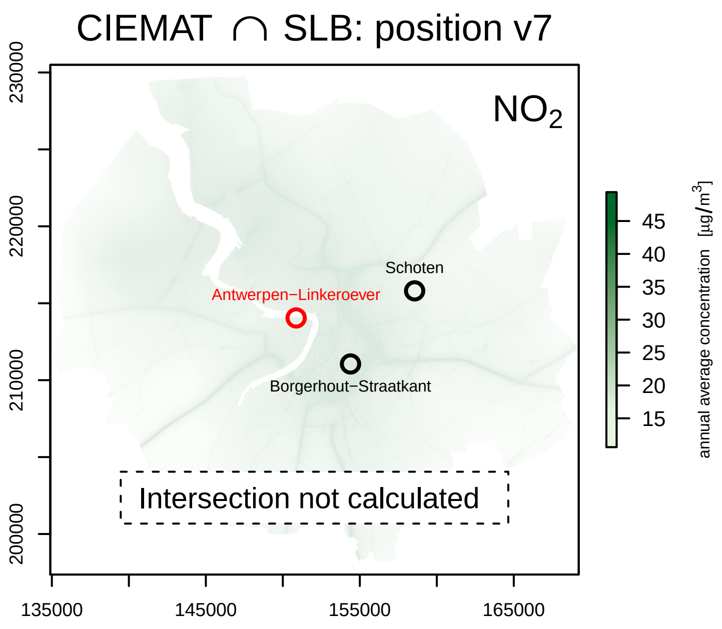

CIEMAT ∩ EPAIE: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

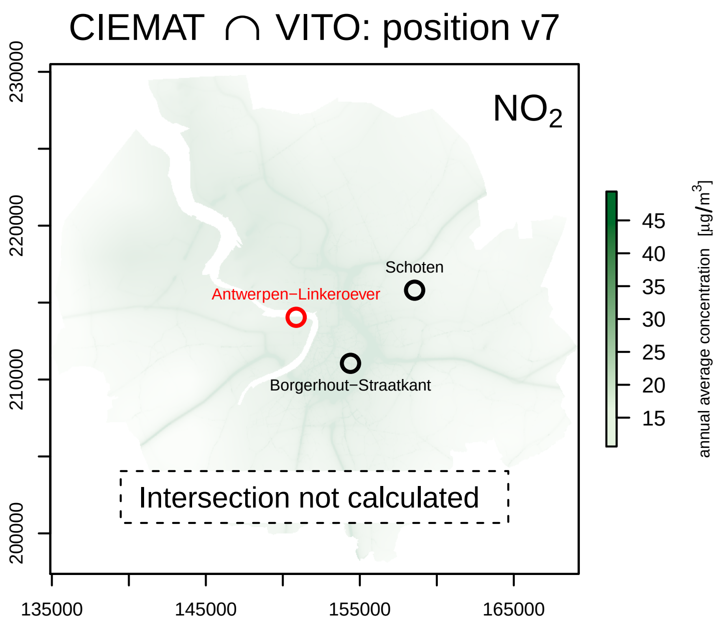

CIEMAT ∩ FEA−AT: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

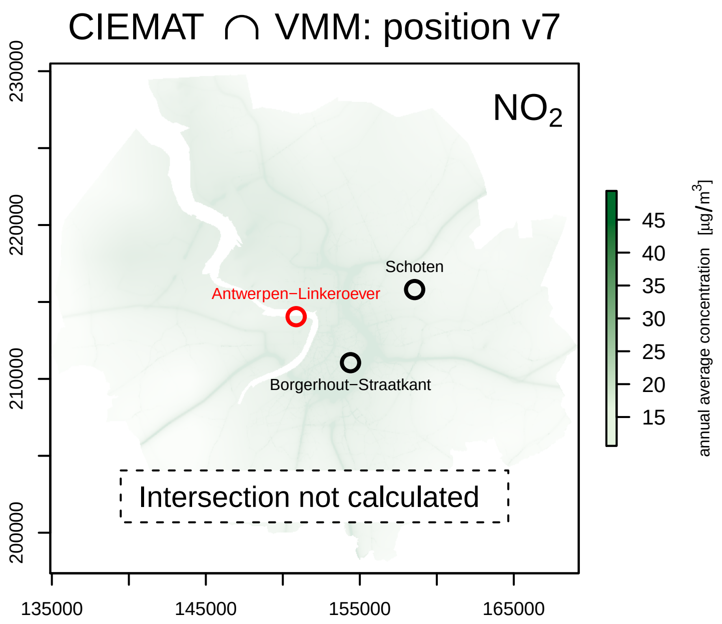

CIEMAT ∩ FI: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

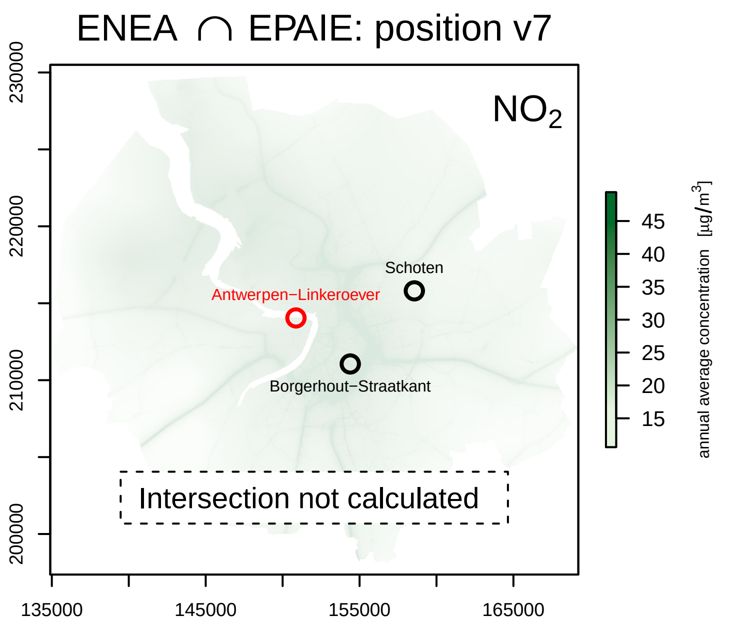

CIEMAT ∩ INERIS: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

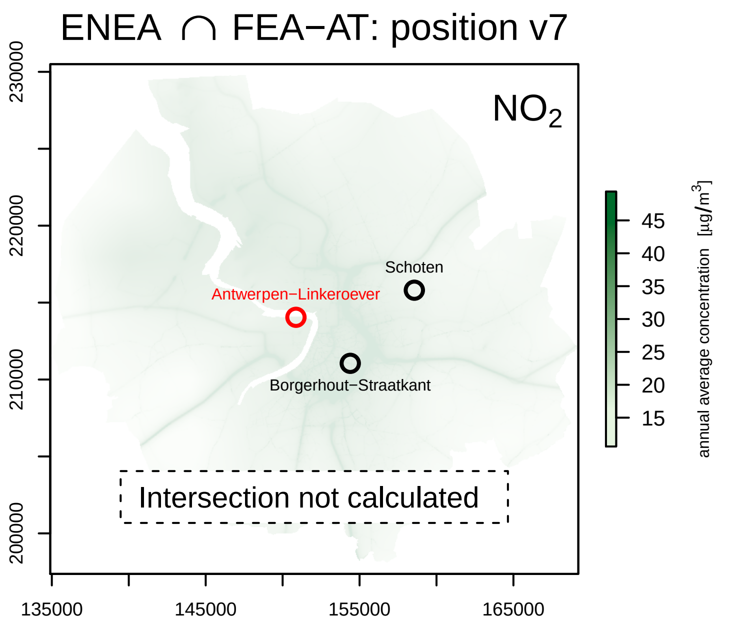

CIEMAT ∩ ISSEPAWAC: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

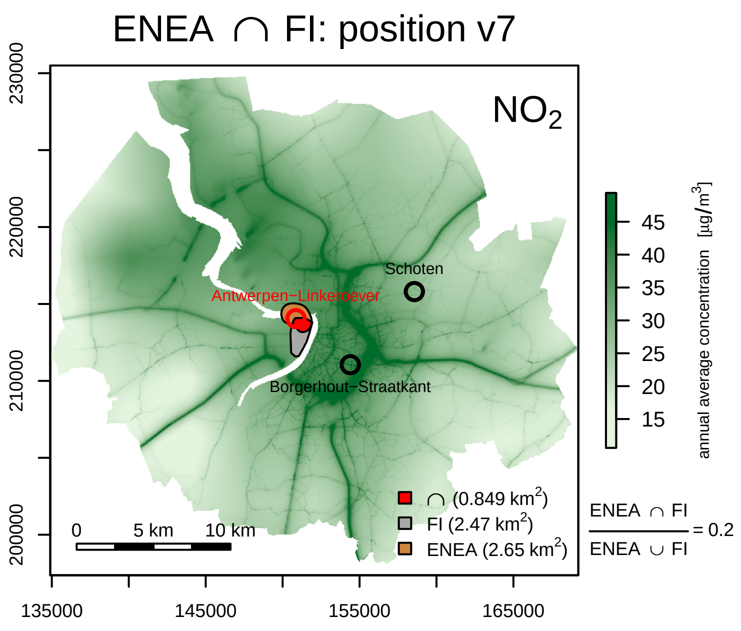

CIEMAT ∩ SLB: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

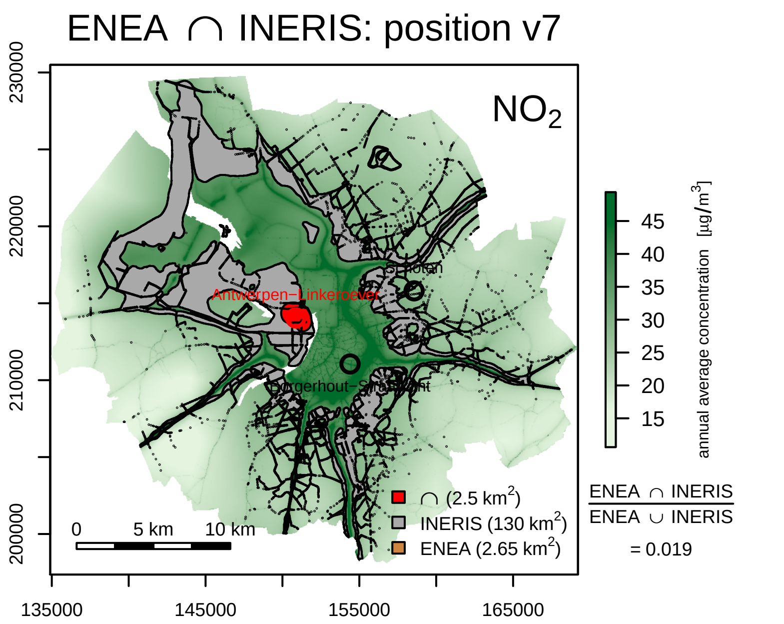

CIEMAT ∩ VITO: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

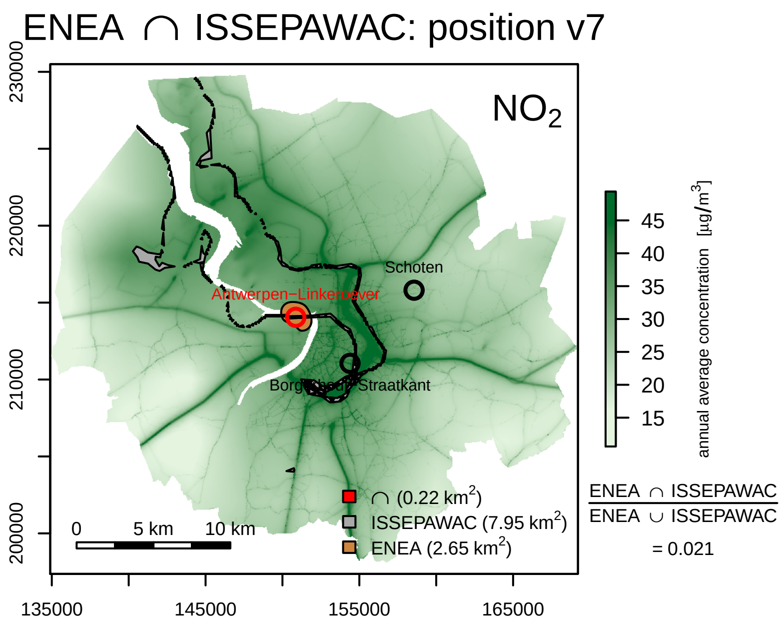

CIEMAT ∩ VMM: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

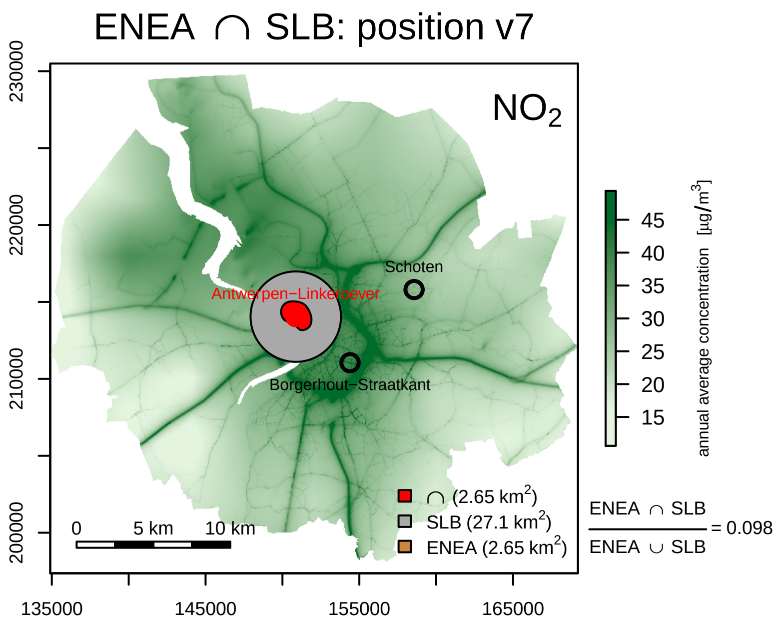

ENEA ∩ EPAIE: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
annual average concentration [µg/m3]
45
40
35
30
25
20
15
230000
220000
210000
200000
135000
145000
155000
165000

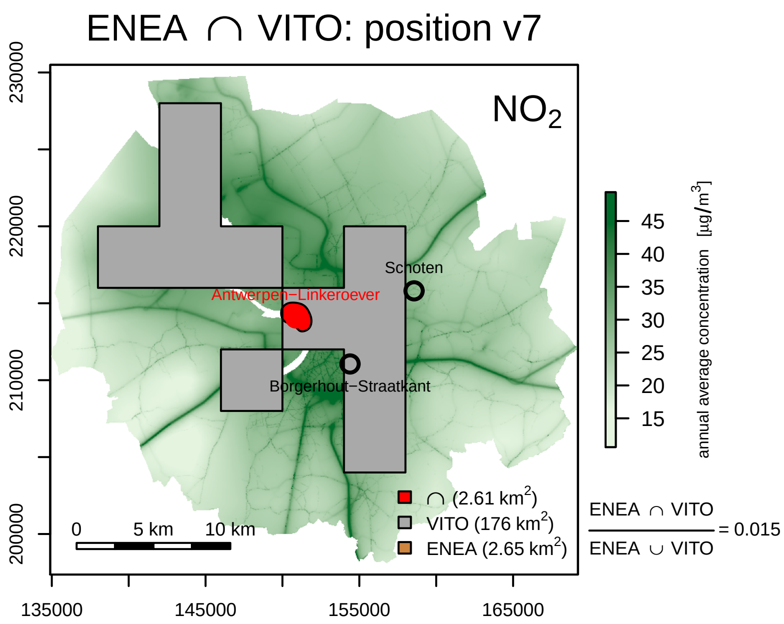

ENEA ∩ FEA−AT: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
annual average concentration [µg/m3]
45
40
35
30
25
20
15
230000
220000
210000
200000
135000
145000
155000
165000

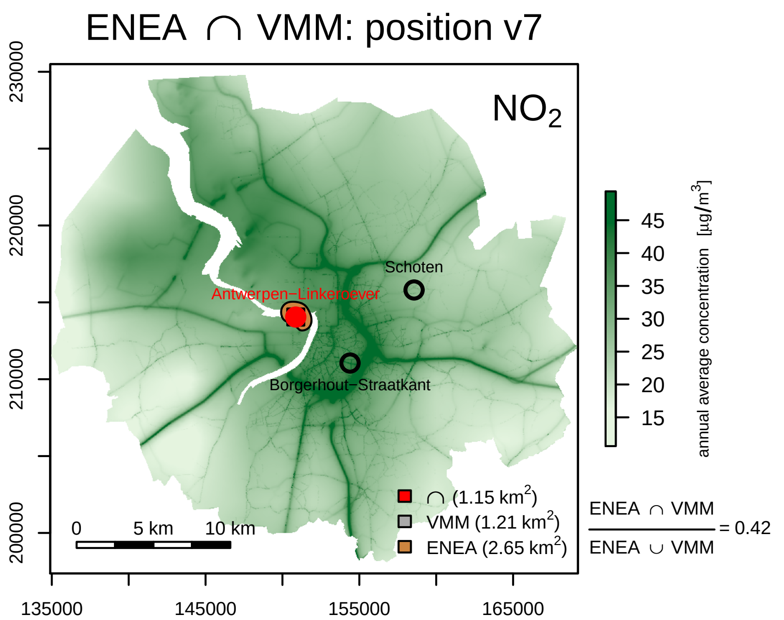

ENEA ∩ FI: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (0.849 km2)
FI (2.47 km2)
ENEA (2.65 km2)
ENEA ∩ FI / ENEA ∪ FI = 0.2
annual average concentration [µg/m3]
45
40
35
30
25
20
15
230000
220000
210000
200000
135000
145000
155000
165000

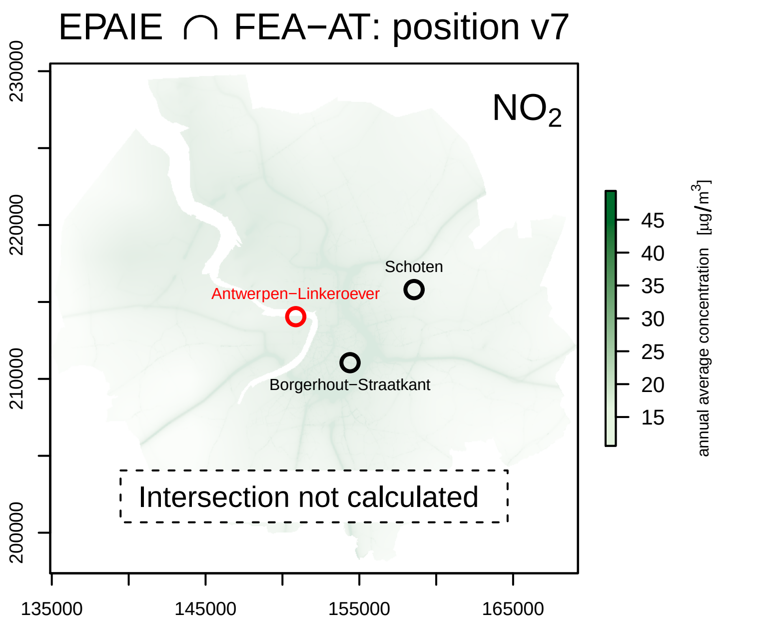

ENEA ∩ INERIS: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (2.5 km²)
INERIS (130 km²)
ENEA (2.65 km²)
45
40
35
30
25
20
15
annual average concentration [µg/m³]
ENEA ∩ INERIS
ENEA ∪ INERIS
= 0.019
230000
220000
210000
200000
135000
145000
155000
165000

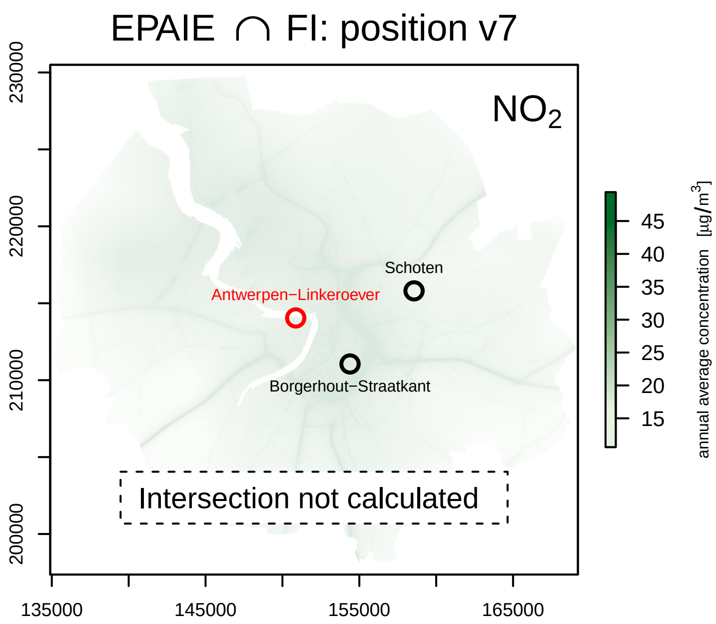

ENEA ∩ ISSEPAWAC: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (0.22 km²)
ISSEPAWAC (7.95 km²)
ENEA (2.65 km²)
45
40
35
30
25
20
15
annual average concentration [µg/m³]
ENEA ∩ ISSEPAWAC
ENEA ∪ ISSEPAWAC
= 0.021
230000
220000
210000
200000
135000
145000
155000
165000


ENEA ∩ SLB: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (2.65 km²)
SLB (27.1 km²)
ENEA (2.65 km²)
45
40
35
30
25
20
15
annual average concentration [µg/m³]
ENEA ∩ SLB
ENEA ∪ SLB
= 0.098
230000
220000
210000
200000
135000
145000
155000
165000

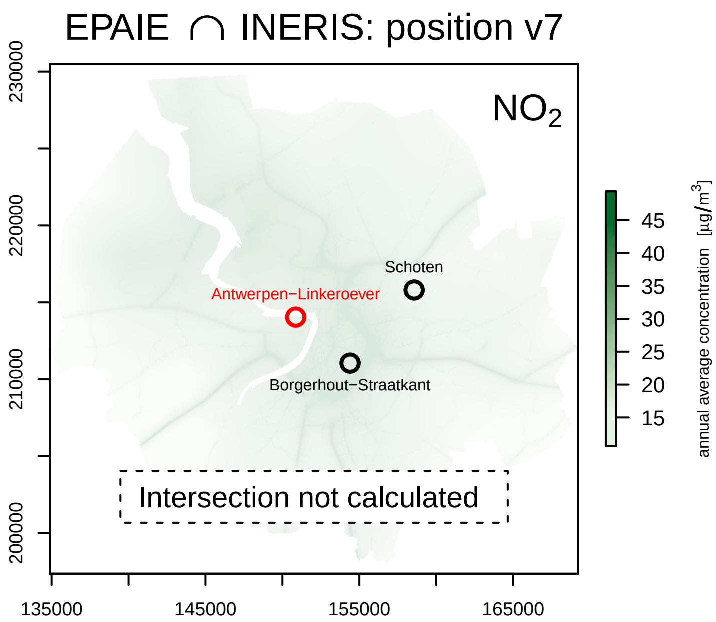

ENEA ∩ VITO: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (2.61 km2)
VITO (176 km2)
ENEA (2.65 km2)
ENEA ∩ VITO / ENEA ∪ VITO = 0.015
45
40
35
30
25
20
15
annual average concentration [µg/m3]
230000
220000
210000
200000
135000
145000
155000
165000


ENEA ∩ VMM: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (1.15 km2)
VMM (1.21 km2)
ENEA (2.65 km2)
ENEA ∩ VMM / ENEA ∪ VMM = 0.42
45
40
35
30
25
20
15
annual average concentration [µg/m3]
230000
220000
210000
200000
135000
145000
155000
165000

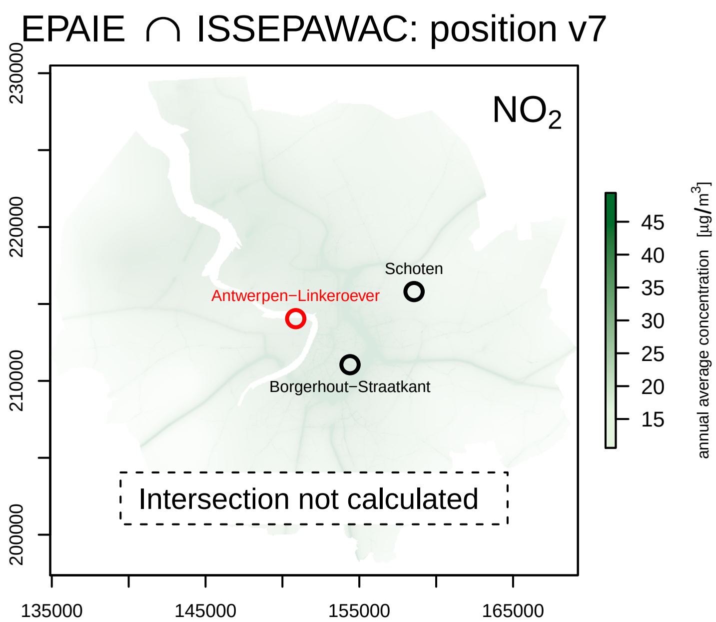

EPAIE ∩ FEA−AT: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
45
40
35
30
25
20
15
annual average concentration [µg/m3]
230000
220000
210000
200000
135000
145000
155000
165000



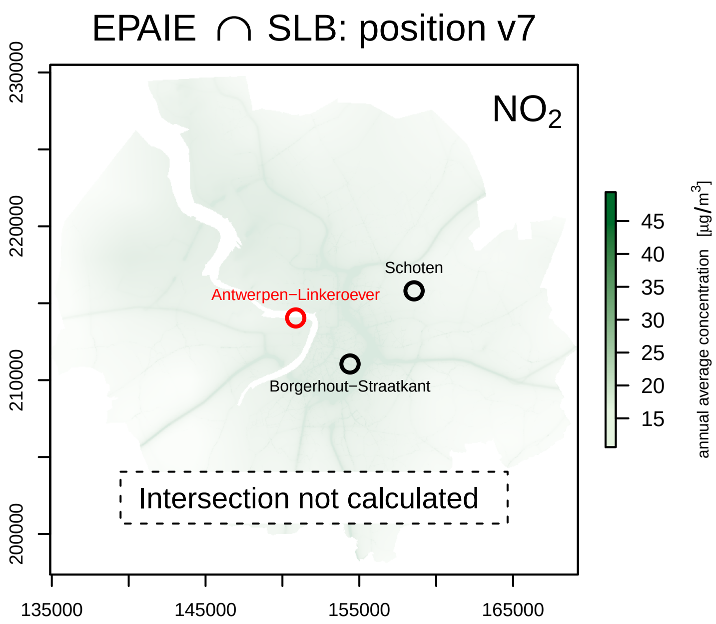
EPAIE ∩ FI: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
annual average concentration [µg/m3]
45
40
35
30
25
20
15
230000
220000
210000
200000
135000
145000
155000
165000

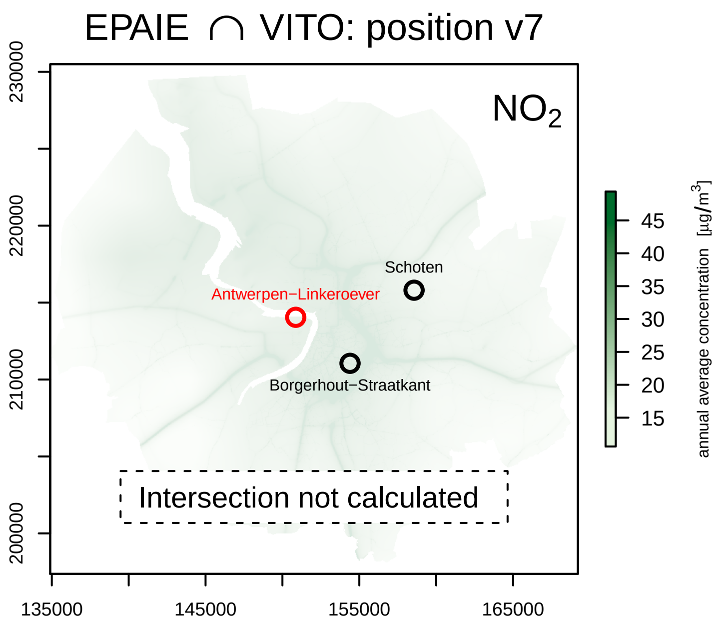


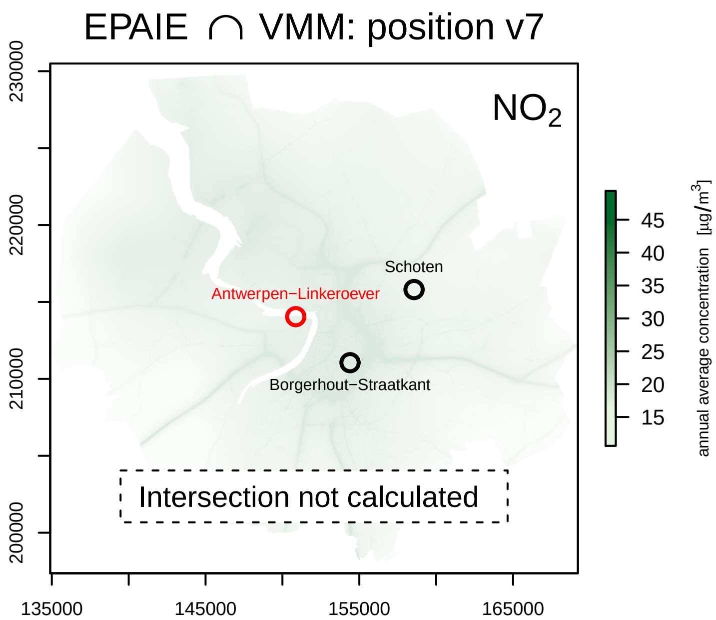
EPAIE ∩ INERIS: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
annual average concentration [µg/m3]
45
40
35
30
25
20
15
230000
220000
210000
200000
135000
145000
155000
165000

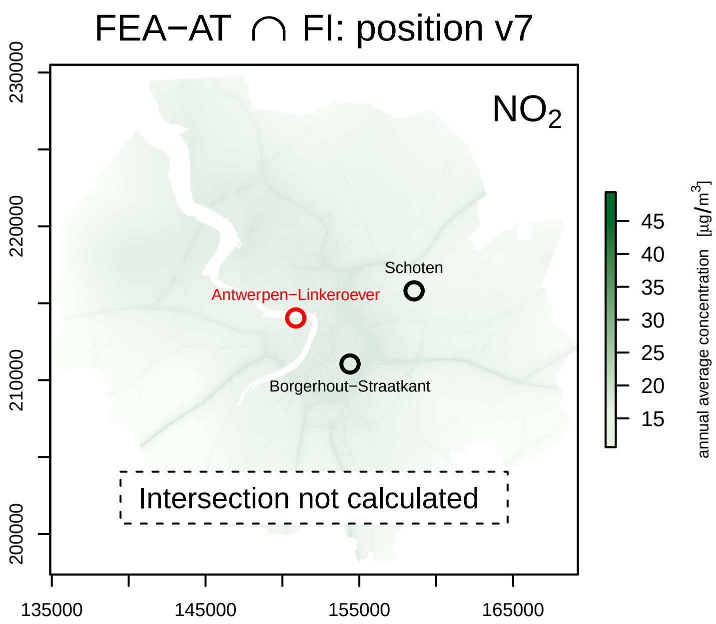


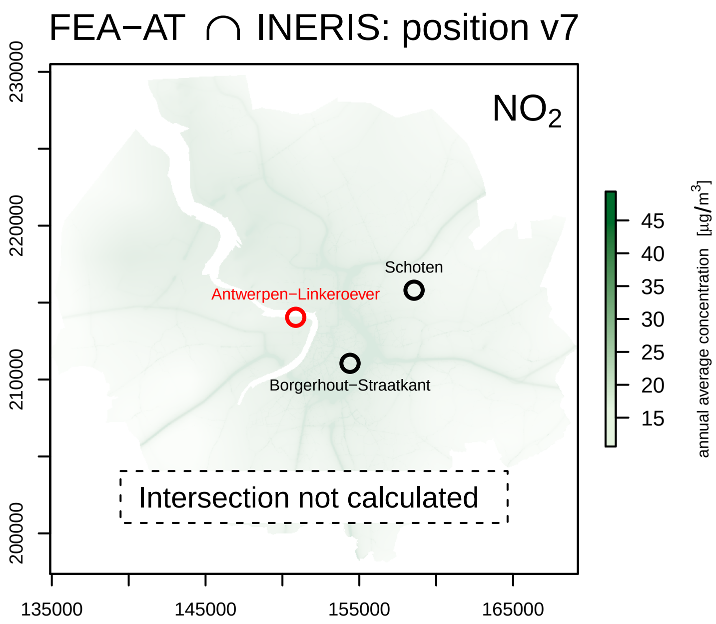
EPAIE ∩ ISSEPAWAC: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
annual average concentration [µg/m3]
45
40
35
30
25
20
15
230000
220000
210000
200000
135000
145000
155000
165000

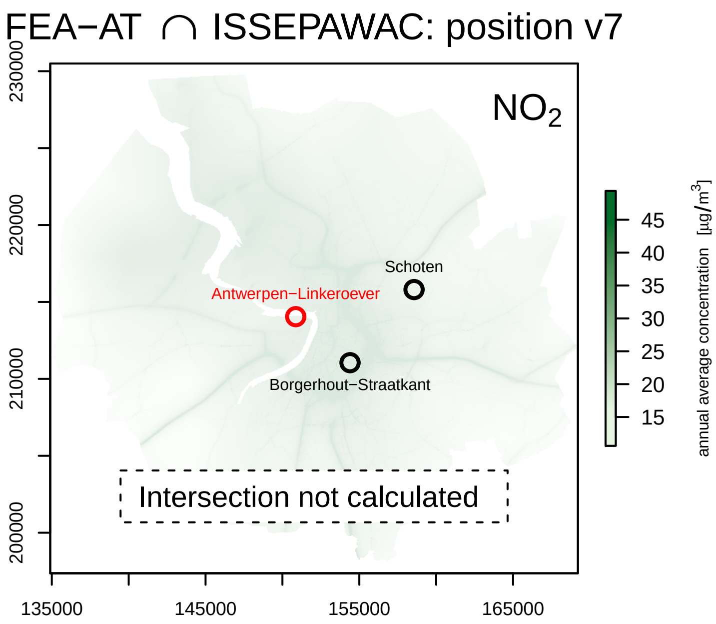

EPAIE ∩ SLB: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

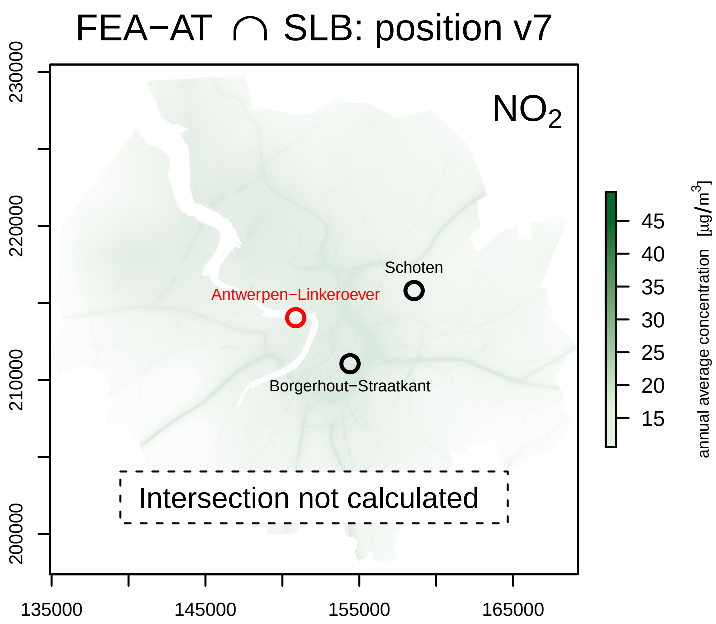

EPAIE ∩ VITO: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

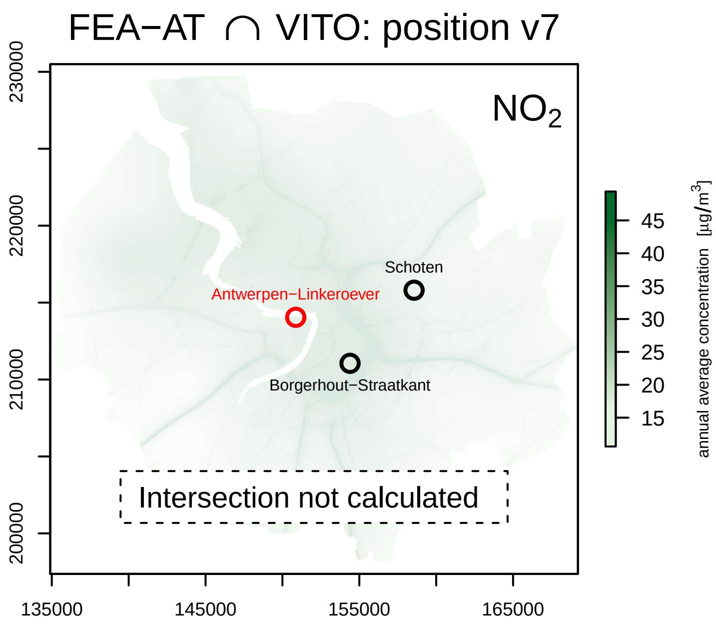

EPAIE ∩ VMM: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

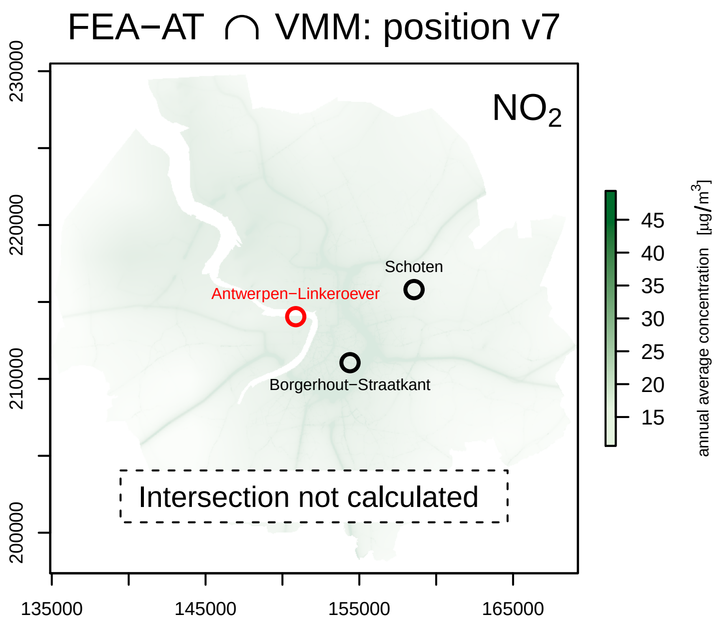

FEA−AT ∩ FI: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

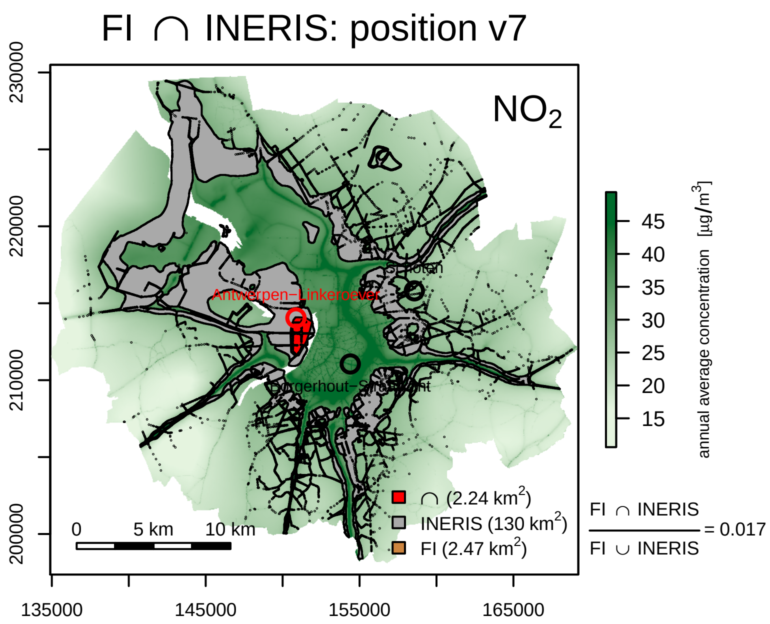

FEA−AT ∩ INERIS: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

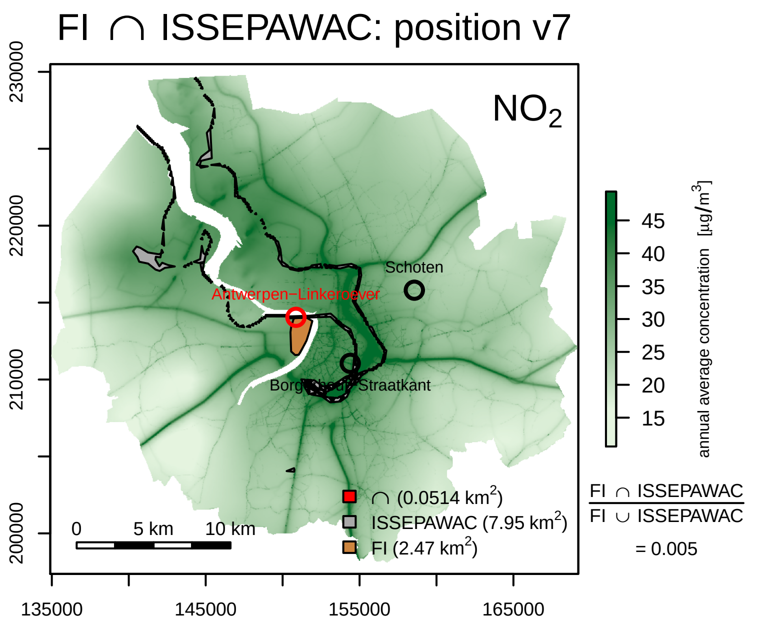

FEA−AT ∩ ISSEPAWAC: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

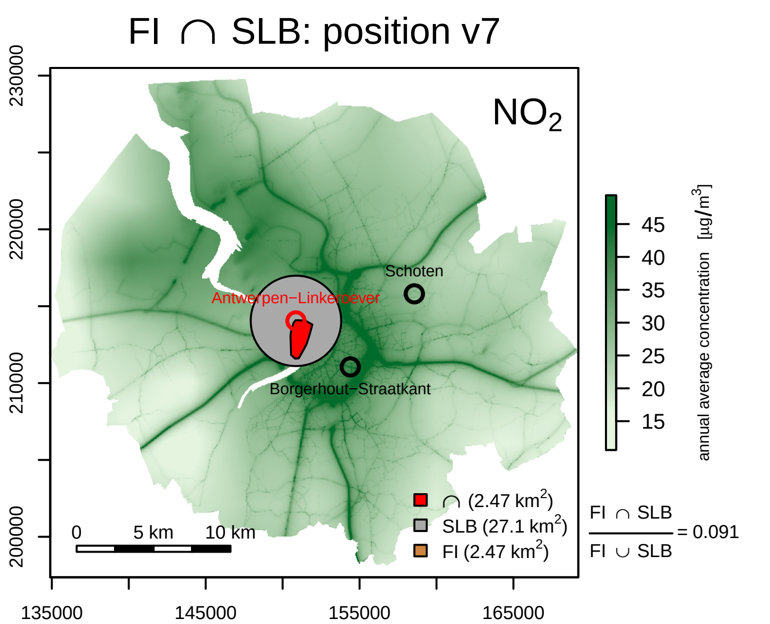

FEA−AT ∩ SLB: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

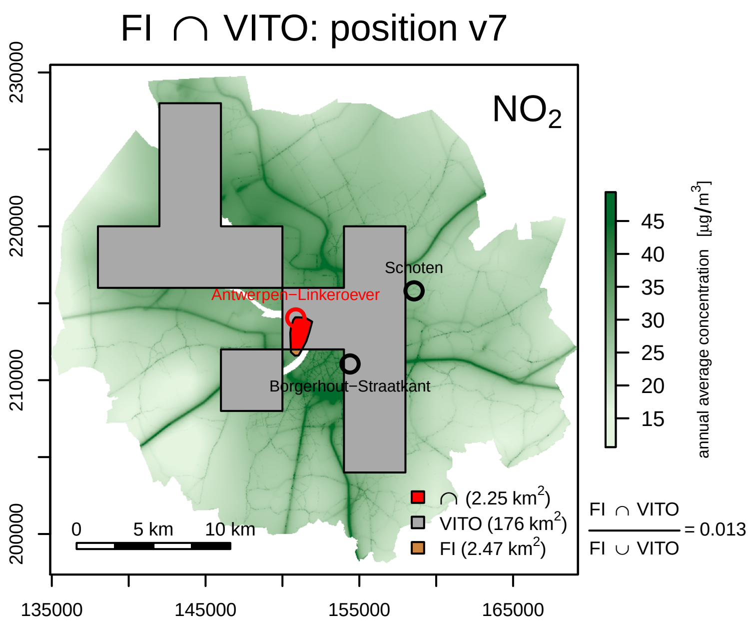

FEA−AT ∩ VITO: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

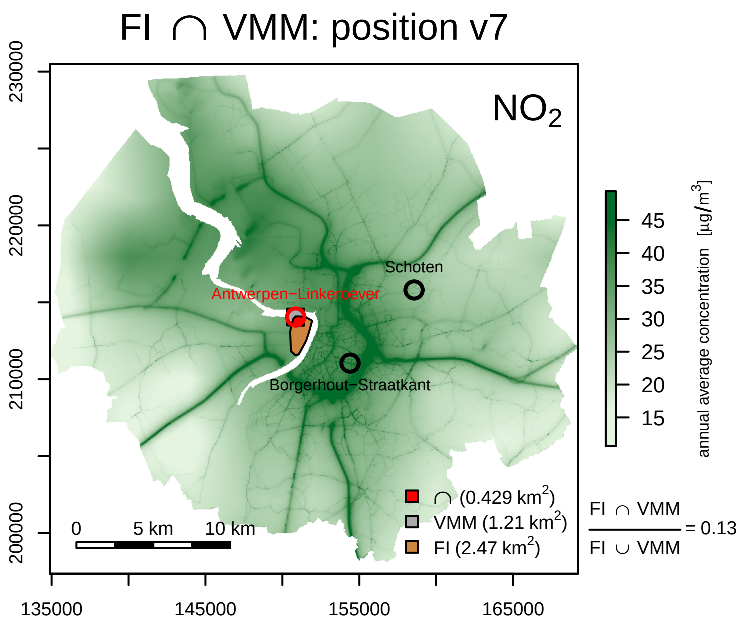

FEA−AT ∩ VMM: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

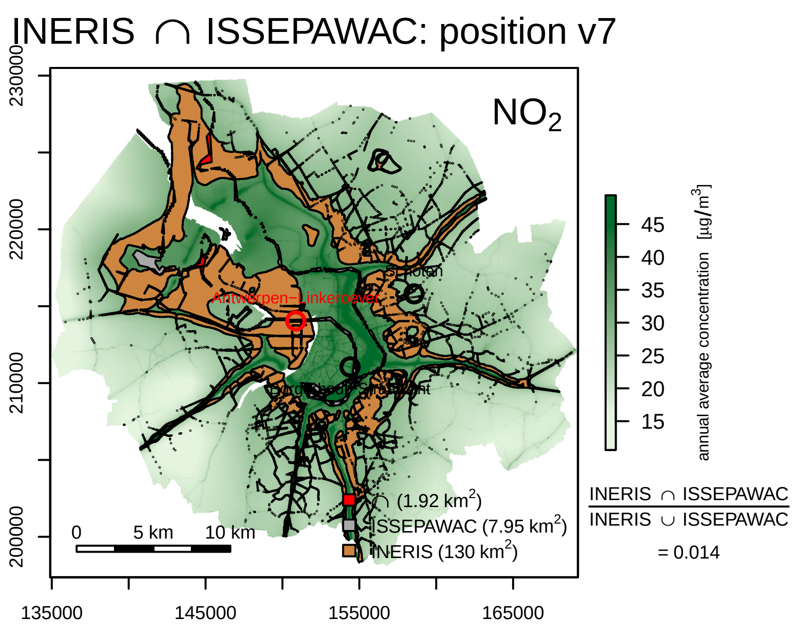

FI ∩ INERIS: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (2.24 km²)
INERIS (130 km²)
FI (2.47 km²)
0 5 km 10 km
annual average concentration [µg/m³]
45 40 35 30 25 20 15
FI ∩ INERIS / FI ∪ INERIS = 0.017
230000 220000 210000 200000
135000 145000 155000 165000

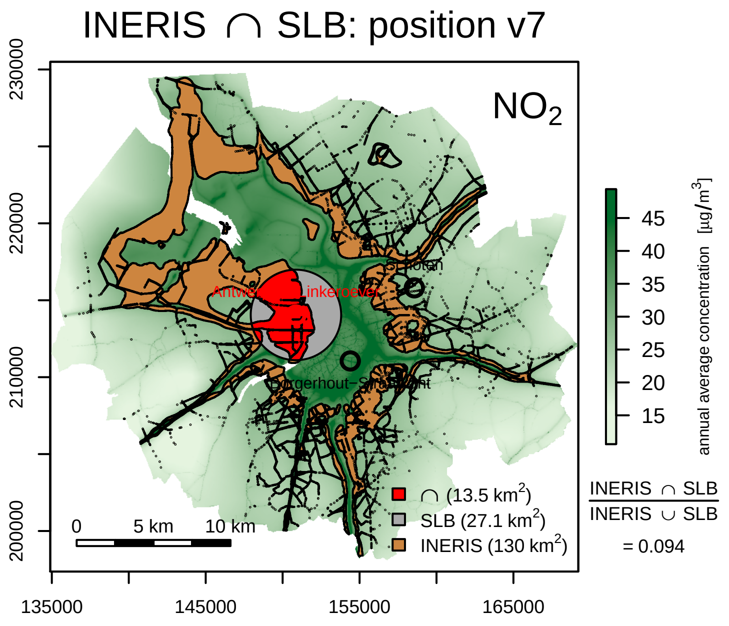

FI ∩ ISSEPAWAC: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.0514 km²)
ISSEPAWAC (7.95 km²)
FI (2.47 km²)
0 5 km 10 km
annual average concentration [µg/m³]
45 40 35 30 25 20 15
FI ∩ ISSEPAWAC / FI ∪ ISSEPAWAC = 0.005
230000 220000 210000 200000
135000 145000 155000 165000

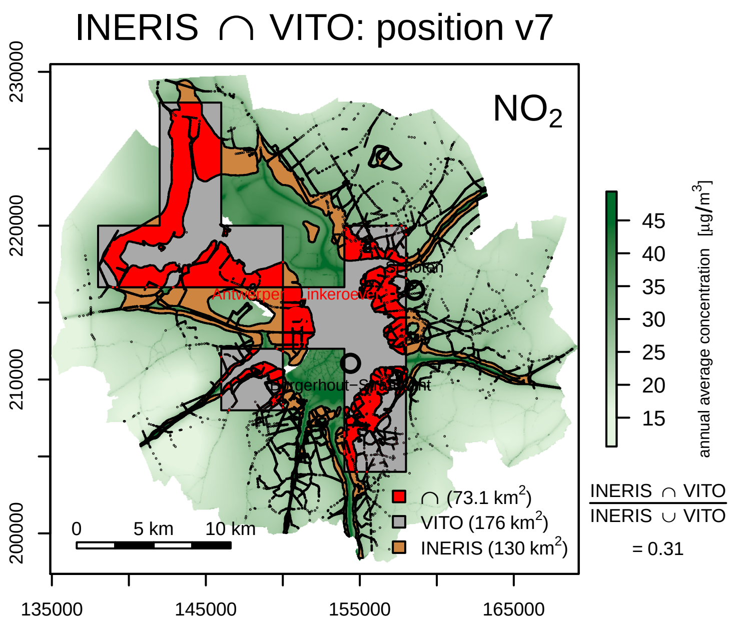

FI ∩ SLB: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (2.47 km²)
SLB (27.1 km²)
FI (2.47 km²)
0 5 km 10 km
annual average concentration [µg/m³]
45 40 35 30 25 20 15
FI ∩ SLB / FI ∪ SLB = 0.091
230000 220000 210000 200000
135000 145000 155000 165000

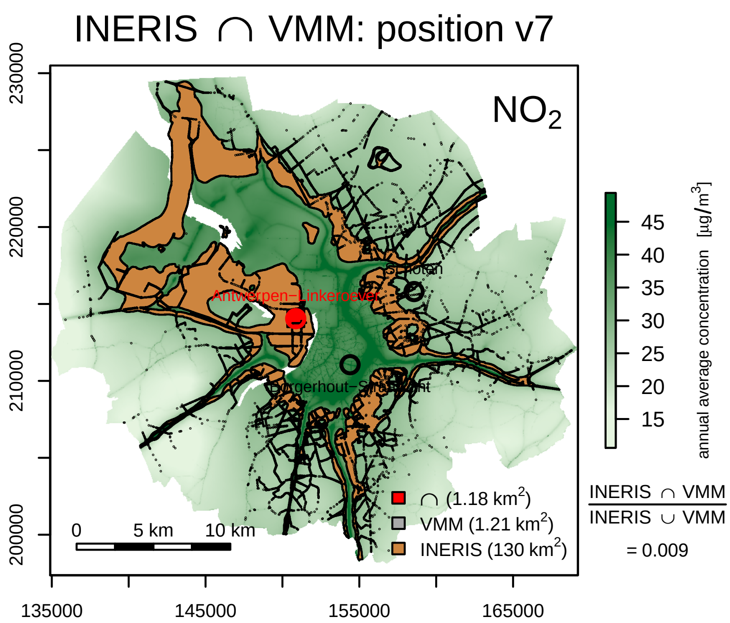

FI ∩ VITO: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (2.25 km2)
VITO (176 km2)
FI (2.47 km2)
0
5 km
10 km
annual average concentration [µg/m3]
45
40
35
30
25
20
15
FI ∩ VITO / FI ∪ VITO = 0.013
230000
220000
210000
200000
135000
145000
155000
165000


FI ∩ VMM: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.429 km2)
VMM (1.21 km2)
FI (2.47 km2)
0
5 km
10 km
annual average concentration [µg/m3]
45
40
35
30
25
20
15
FI ∩ VMM / FI ∪ VMM = 0.13
230000
220000
210000
200000
135000
145000
155000
165000

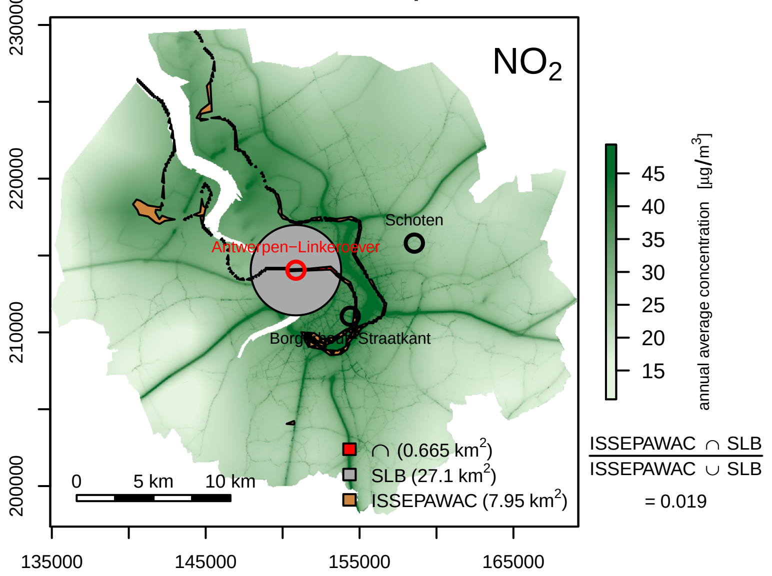

INERIS ∩ ISSEPAWAC: position v7
NO2
Antwerpen−Linkeroever
∩ (1.92 km2)
ISSEPAWAC (7.95 km2)
INERIS (130 km2)
0
5 km
10 km
annual average concentration [µg/m3]
45
40
35
30
25
20
15
INERIS ∩ ISSEPAWAC / INERIS ∪ ISSEPAWAC = 0.014
230000
220000
210000
200000
135000
145000
155000
165000


INERIS ∩ SLB: position v7
NO$_2$
230000
220000
210000
200000
135000
145000
155000
165000
0
5 km
10 km
∩ (13.5 km^2)
SLB (27.1 km^2)
INERIS (130 km^2)
45
40
35
30
25
20
15
annual average concentration [µg/m^3]
INERIS ∩ SLB / INERIS ∪ SLB
= 0.094

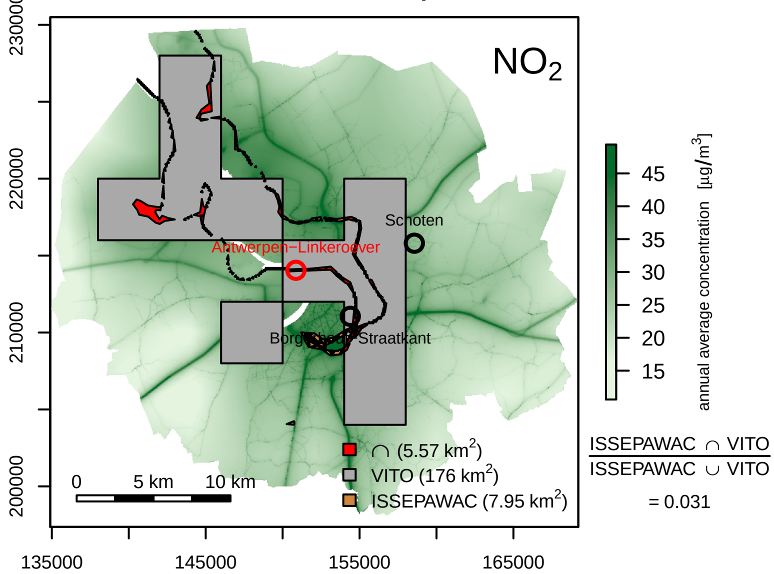

INERIS ∩ VITO: position v7
NO$_2$
230000
220000
210000
200000
135000
145000
155000
165000
0
5 km
10 km
∩ (73.1 km^2)
VITO (176 km^2)
INERIS (130 km^2)
45
40
35
30
25
20
15
annual average concentration [µg/m^3]
INERIS ∩ VITO / INERIS ∪ VITO
= 0.31


INERIS ∩ VMM: position v7
NO$_2$
Antwerpen–Linkeroever
230000
220000
210000
200000
135000
145000
155000
165000
0
5 km
10 km
∩ (1.18 km^2)
VMM (1.21 km^2)
INERIS (130 km^2)
45
40
35
30
25
20
15
annual average concentration [µg/m^3]
INERIS ∩ VMM / INERIS ∪ VMM
= 0.009

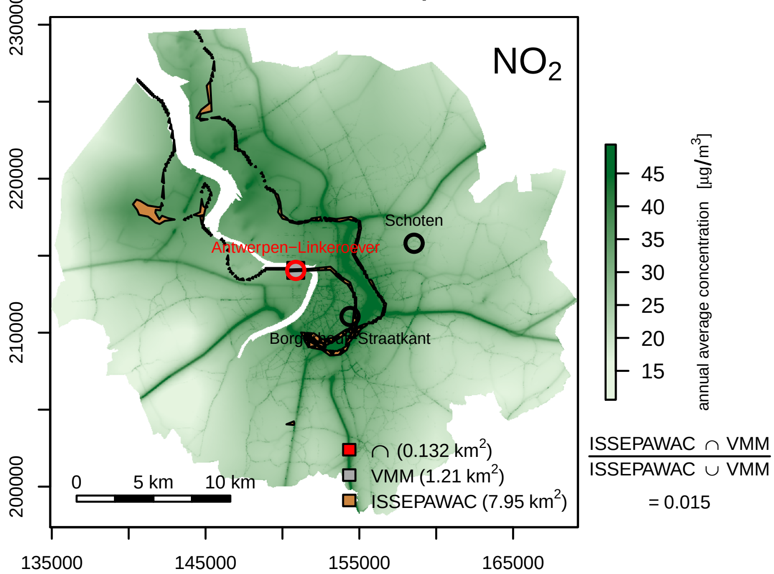
ISSEPAWAC ∩ SLB: position v7

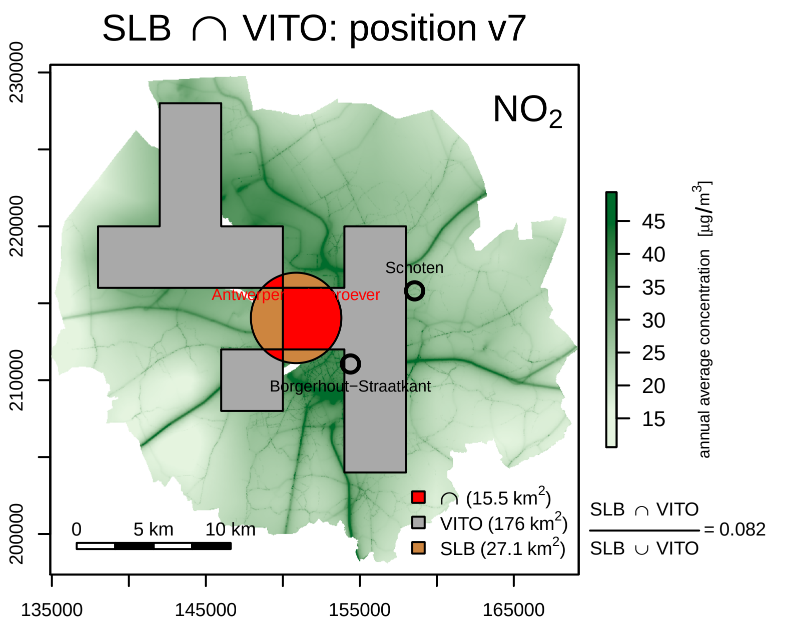


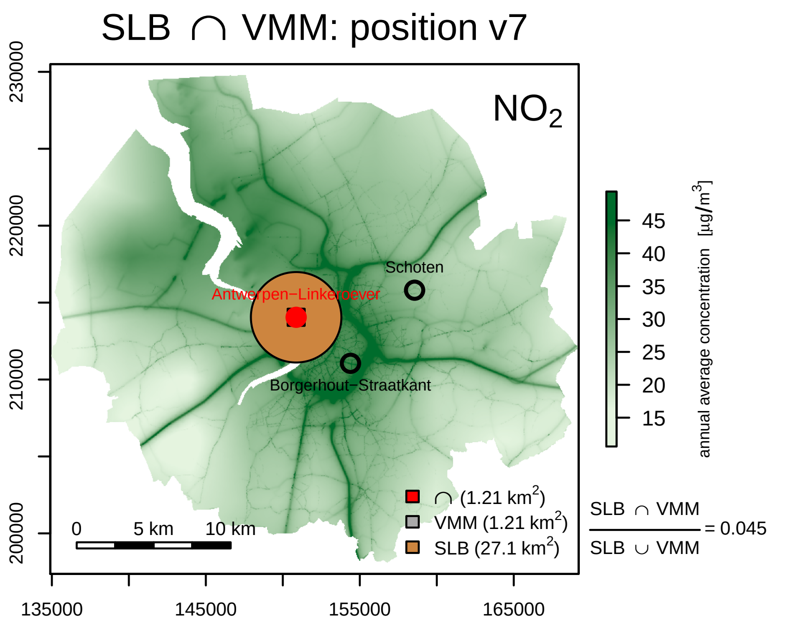
ISSEPAWAC ∩ VITO: position v7

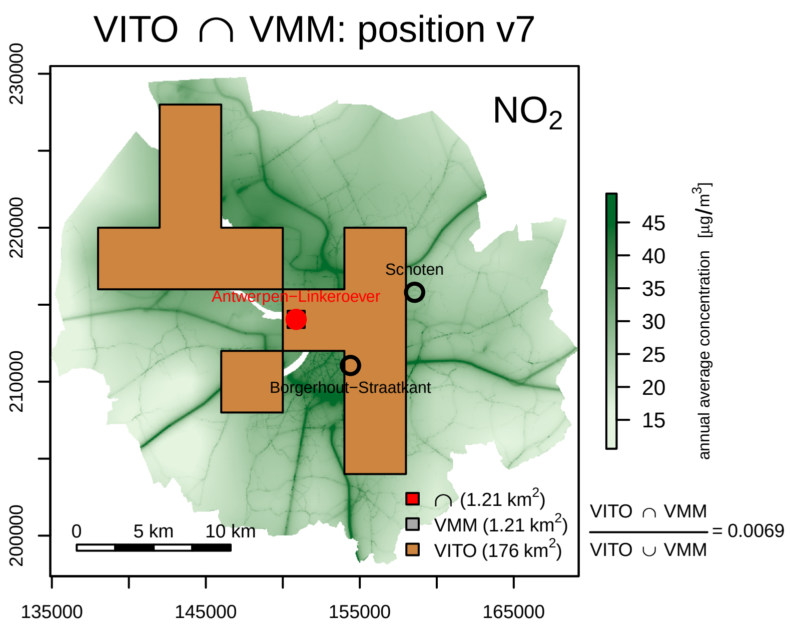


ISSEPAWAC ∩ VMM: position v7




SLB ∩ VITO: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (15.5 km2)
VITO (176 km2)
SLB (27.1 km2)
45
40
35
30
25
20
15
annual average concentration [µg/m3]
SLB ∩ VITO / SLB ∪ VITO = 0.082
230000
220000
210000
200000
135000
145000
155000
165000

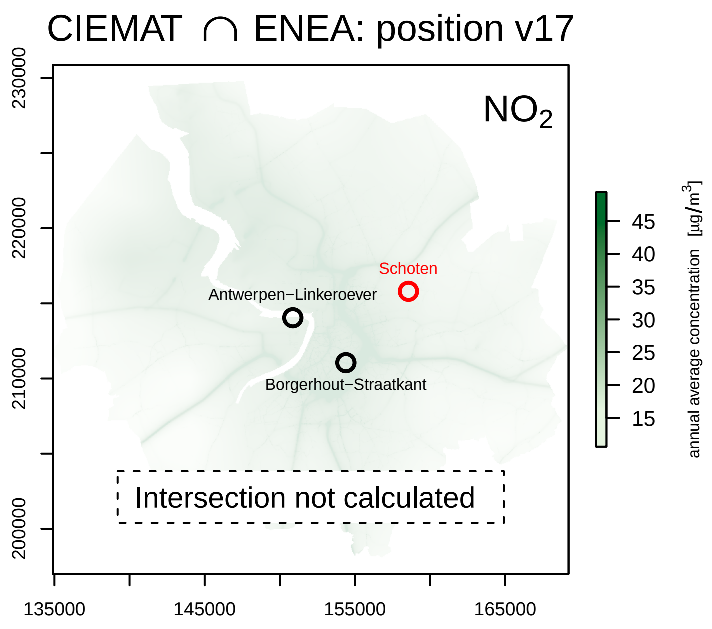

SLB ∩ VMM: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (1.21 km2)
VMM (1.21 km2)
SLB (27.1 km2)
45
40
35
30
25
20
15
annual average concentration [µg/m3]
SLB ∩ VMM / SLB ∪ VMM = 0.045
230000
220000
210000
200000
135000
145000
155000
165000

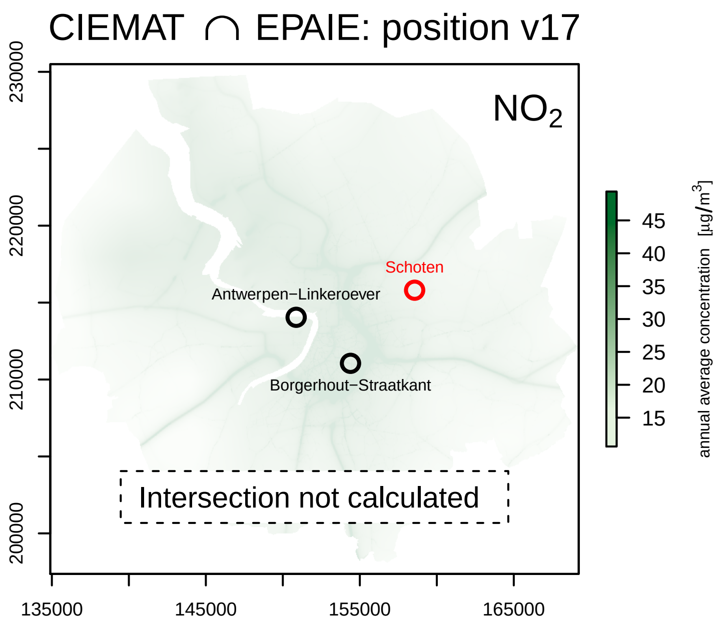

VITO ∩ VMM: position v7
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (1.21 km2)
VMM (1.21 km2)
VITO (176 km2)
45
40
35
30
25
20
15
annual average concentration [µg/m3]
VITO ∩ VMM / VITO ∪ VMM = 0.0069
230000
220000
210000
200000
135000
145000
155000
165000

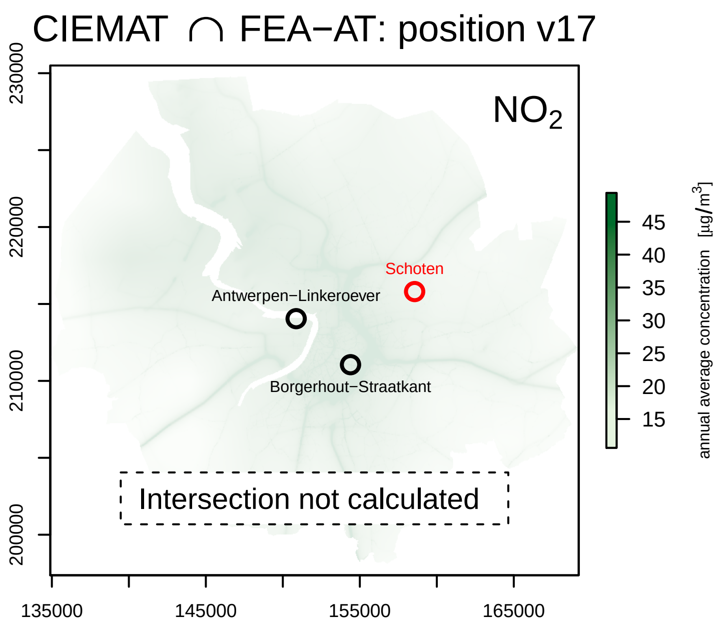
Mutual Comparisons between Teams

by Pollutant & Station:

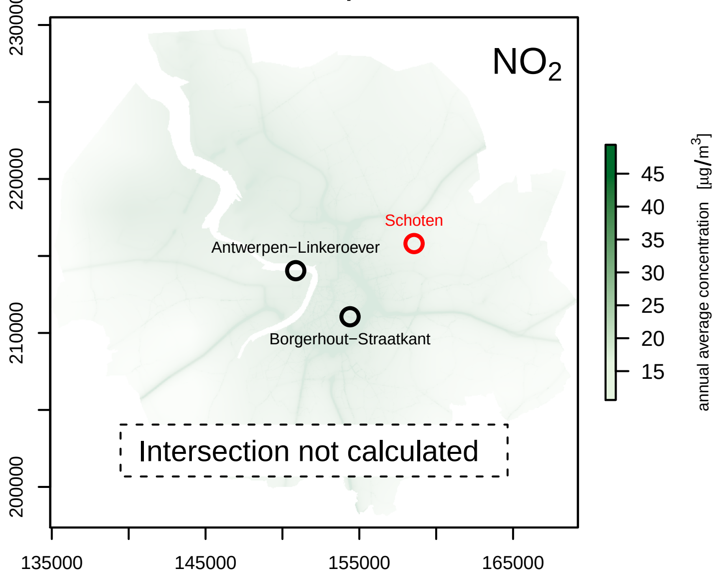
NO_2 at virtual station v17


CIEMAT ∩ ENEA: position v17
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

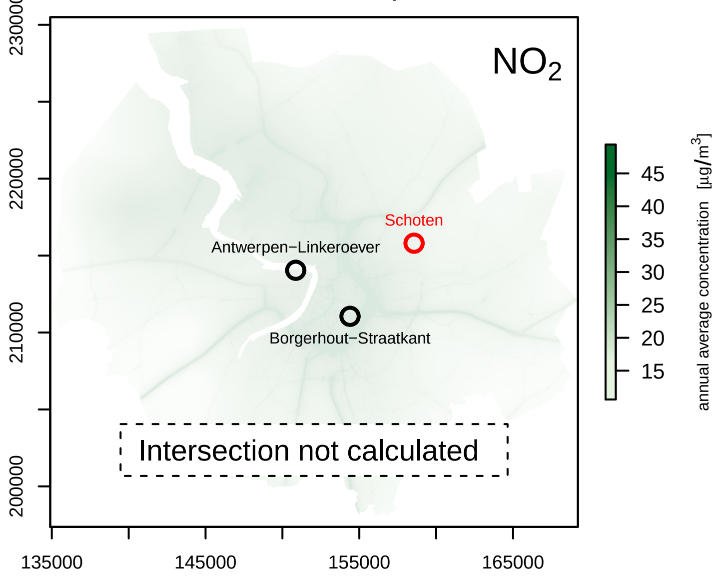

CIEMAT ∩ EPAIE: position v17
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]


CIEMAT ∩ FEA−AT: position v17
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

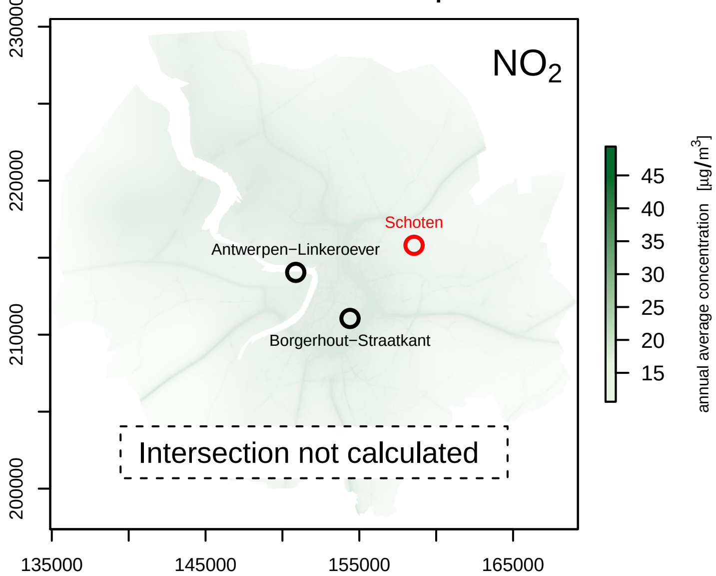
CIEMAT ∩ FI: position v17

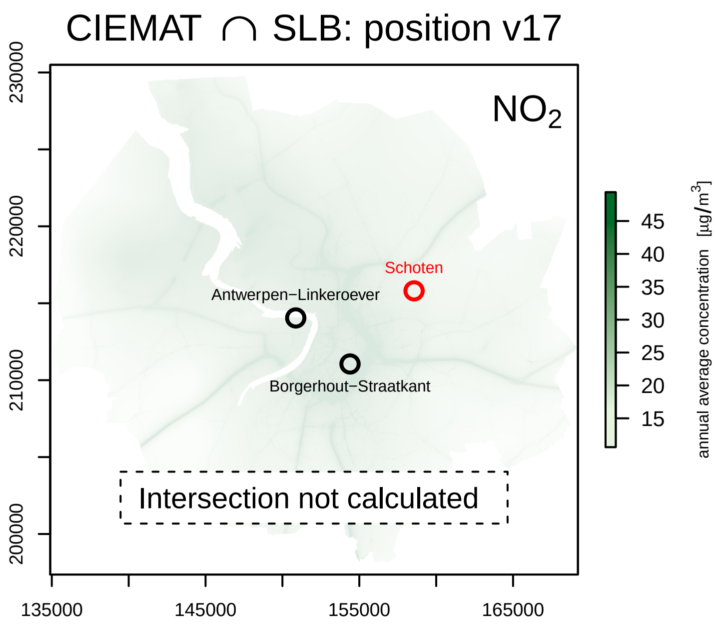


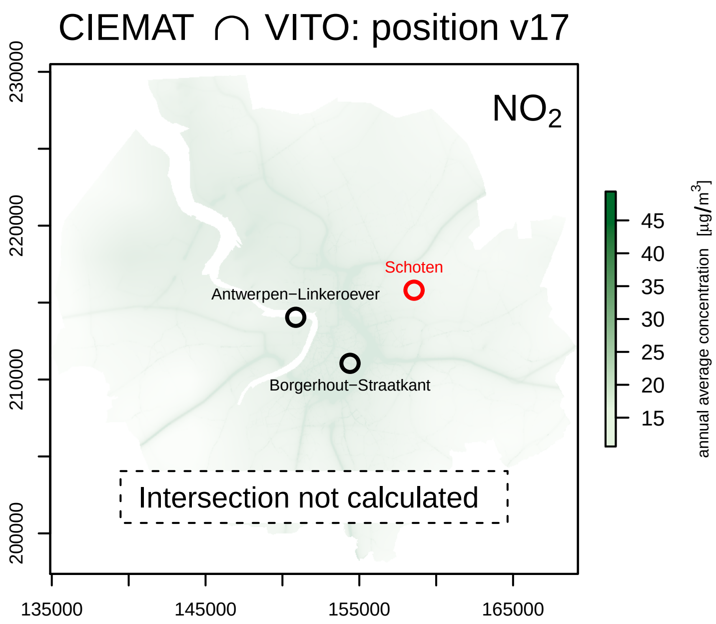
CIEMAT ∩ INERIS: position v17

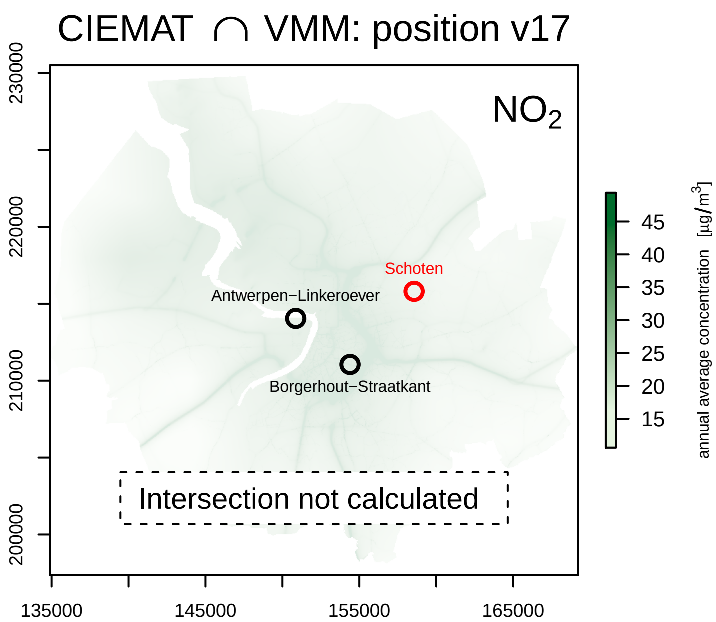


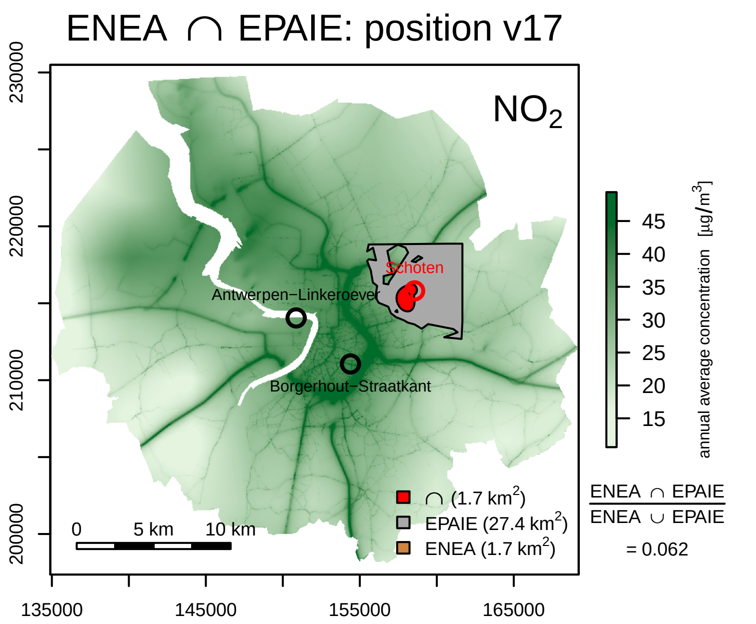
CIEMAT ∩ ISSEPAWAC: position v17

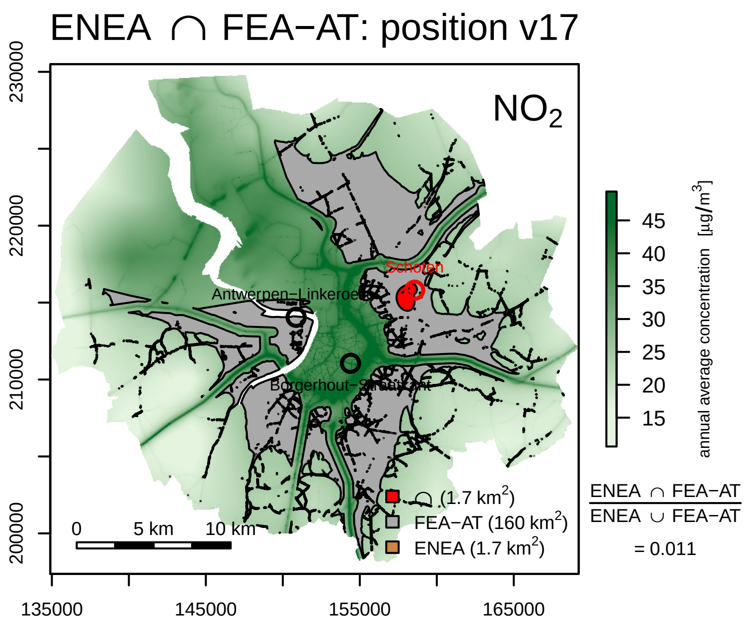


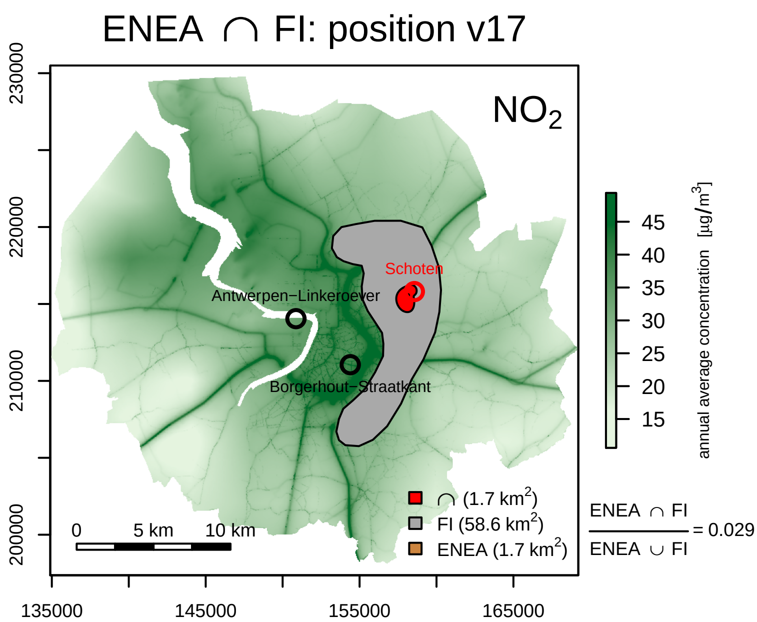

CIEMAT ∩ SLB: position v17
NO$_2$
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m^3]

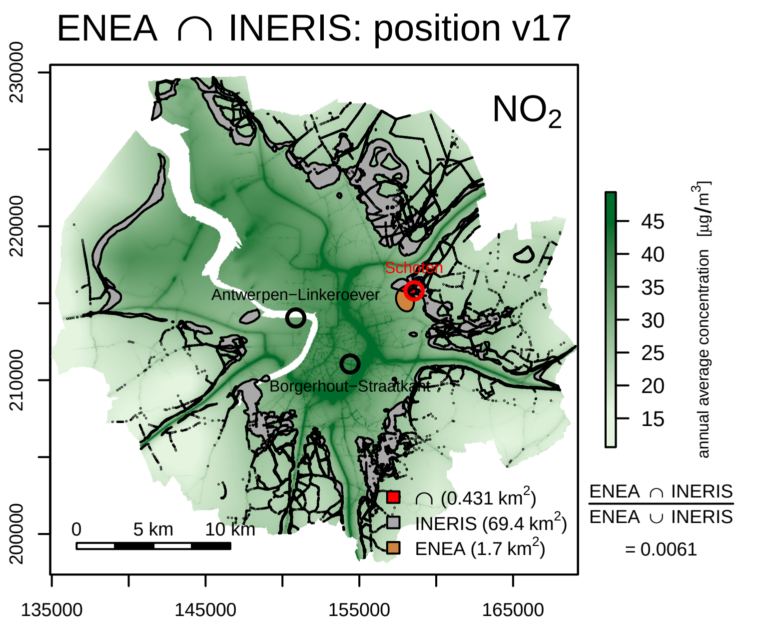

CIEMAT ∩ VITO: position v17
NO$_2$
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m^3]

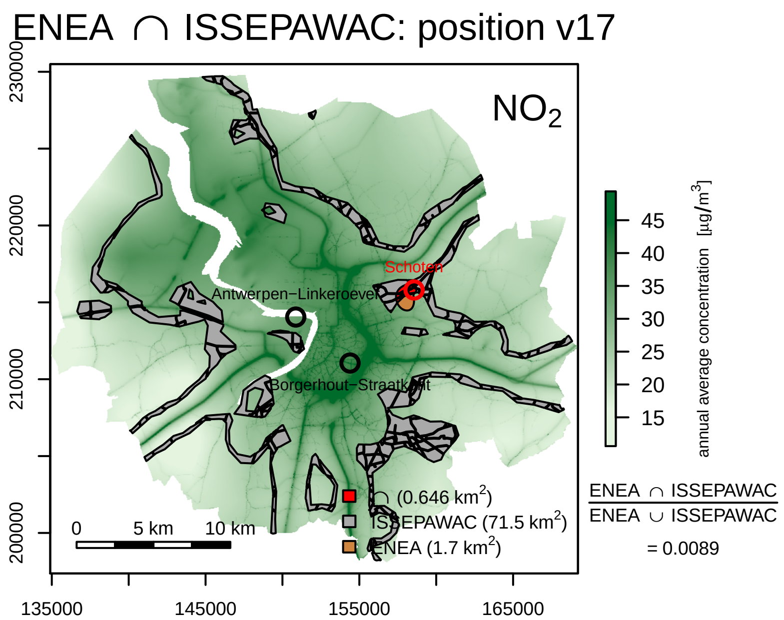

CIEMAT ∩ VMM: position v17
NO$_2$
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m^3]

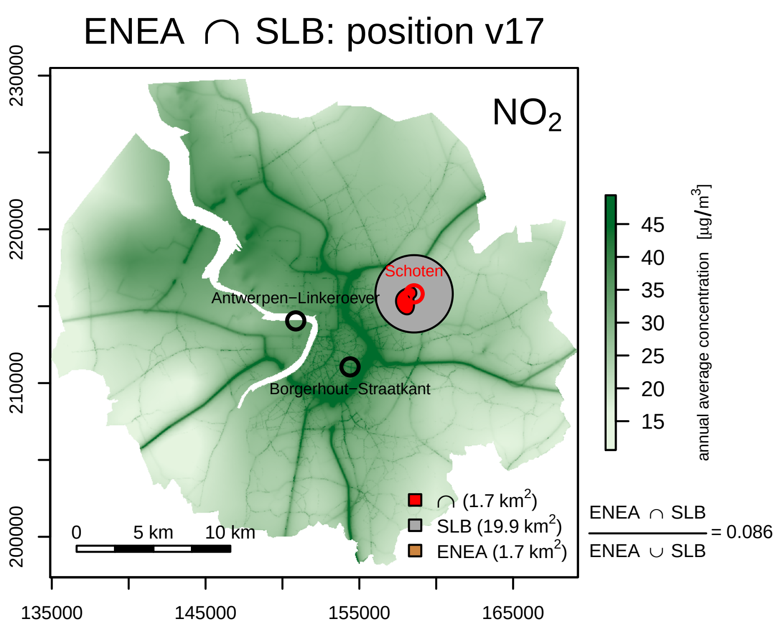

ENEA ∩ EPAIE: position v17
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (1.7 km2)
EPAIE (27.4 km2)
ENEA (1.7 km2)
45
40
35
30
25
20
15
annual average concentration [µg/m3]
ENEA ∩ EPAIE
ENEA ∪ EPAIE
= 0.062
135000
145000
155000
165000
200000
210000
220000
230000

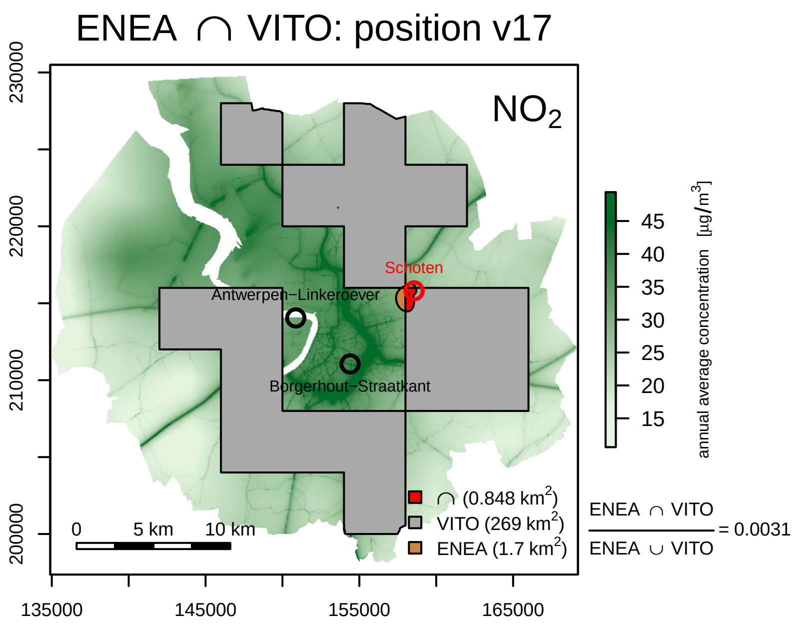

ENEA ∩ FEA−AT: position v17
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (1.7 km2)
FEA−AT (160 km2)
ENEA (1.7 km2)
45
40
35
30
25
20
15
annual average concentration [µg/m3]
ENEA ∩ FEA−AT
ENEA ∪ FEA−AT
= 0.011
135000
145000
155000
165000
200000
210000
220000
230000

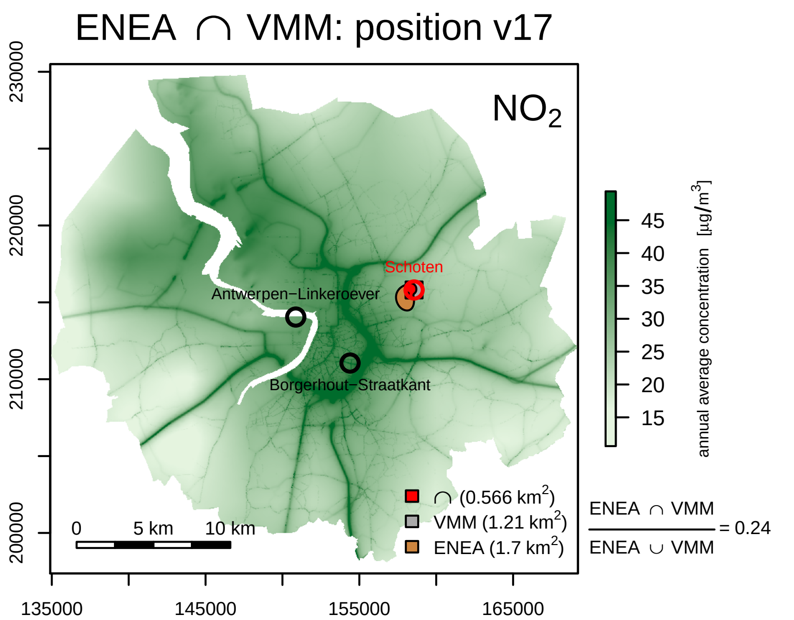

ENEA ∩ FI: position v17
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (1.7 km2)
FI (58.6 km2)
ENEA (1.7 km2)
45
40
35
30
25
20
15
annual average concentration [µg/m3]
ENEA ∩ FI
ENEA ∪ FI
= 0.029
135000
145000
155000
165000
200000
210000
220000
230000

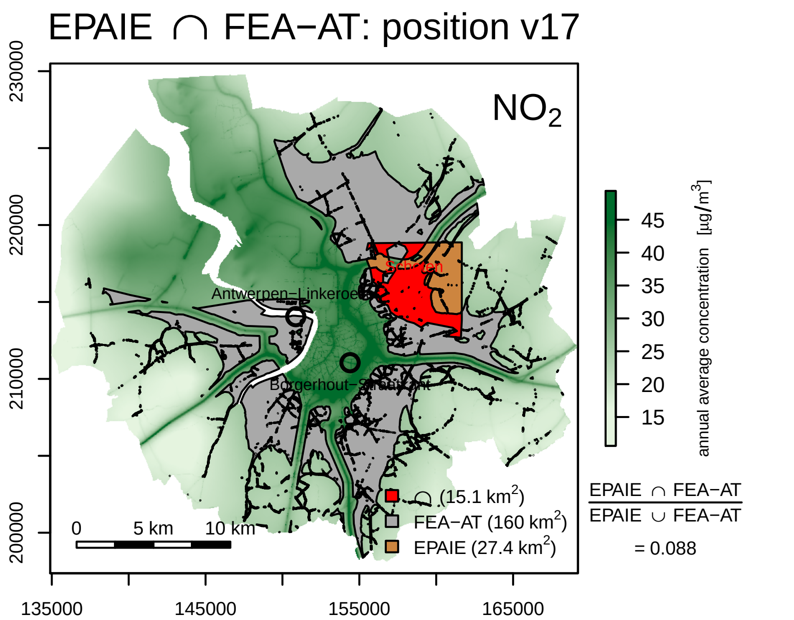

ENEA ∩ INERIS: position v17
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.431 km2)
INERIS (69.4 km2)
ENEA (1.7 km2)
0 5 km 10 km
ENEA ∩ INERIS
ENEA ∪ INERIS
= 0.0061
annual average concentration [µg/m3]
45 40 35 30 25 20 15
230000 220000 210000 200000
135000 145000 155000 165000

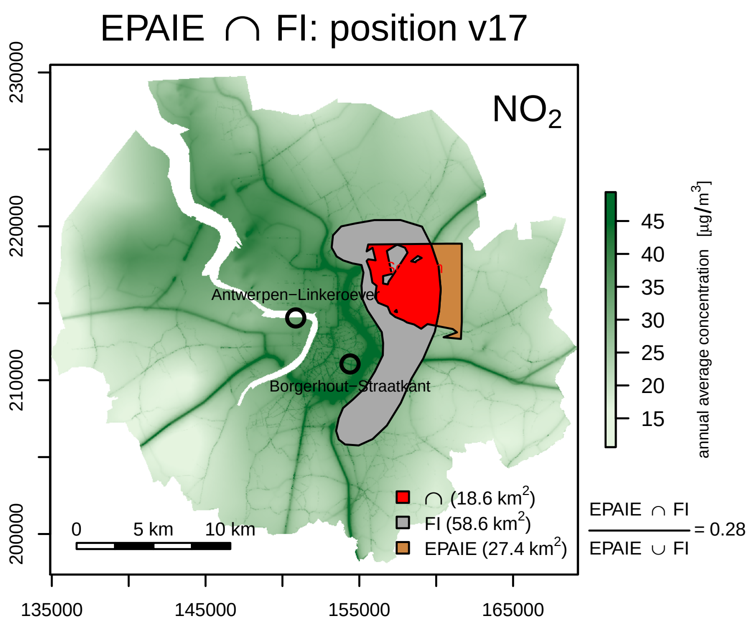

ENEA ∩ ISSEPAWAC: position v17
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.646 km2)
ISSEPAWAC (71.5 km2)
ENEA (1.7 km2)
0 5 km 10 km
ENEA ∩ ISSEPAWAC
ENEA ∪ ISSEPAWAC
= 0.0089
annual average concentration [µg/m3]
45 40 35 30 25 20 15
230000 220000 210000 200000
135000 145000 155000 165000


ENEA ∩ SLB: position v17
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (1.7 km2)
SLB (19.9 km2)
ENEA (1.7 km2)
0 5 km 10 km
ENEA ∩ SLB
ENEA ∪ SLB
= 0.086
annual average concentration [µg/m3]
45 40 35 30 25 20 15
230000 220000 210000 200000
135000 145000 155000 165000

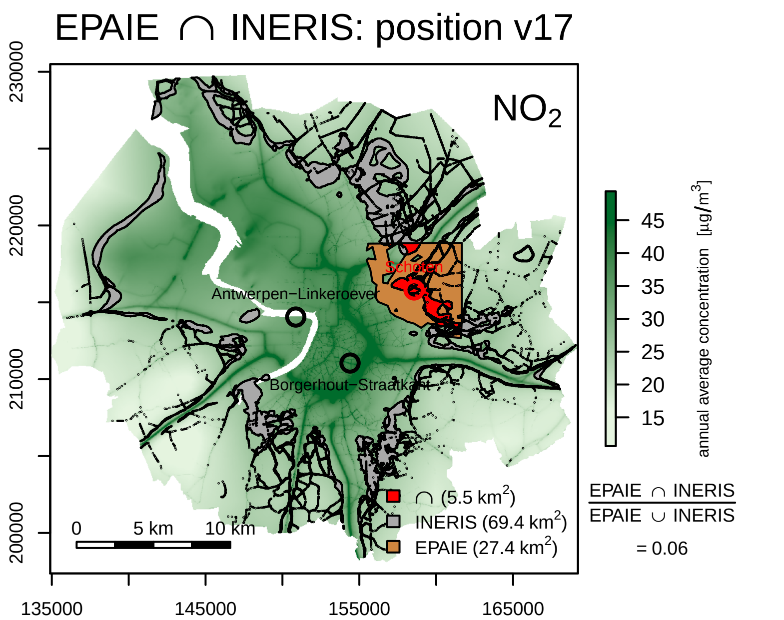

ENEA ∩ VITO: position v17
NO$_2$
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.848 km^2)
VITO (269 km^2)
ENEA (1.7 km^2)
0
5 km
10 km
ENEA ∩ VITO / ENEA ∪ VITO = 0.0031
annual average concentration [µg/m^3]
45
40
35
30
25
20
15
230000
220000
210000
200000
135000
145000
155000
165000


ENEA ∩ VMM: position v17
NO$_2$
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.566 km^2)
VMM (1.21 km^2)
ENEA (1.7 km^2)
0
5 km
10 km
ENEA ∩ VMM / ENEA ∪ VMM = 0.24
annual average concentration [µg/m^3]
45
40
35
30
25
20
15
230000
220000
210000
200000
135000
145000
155000
165000

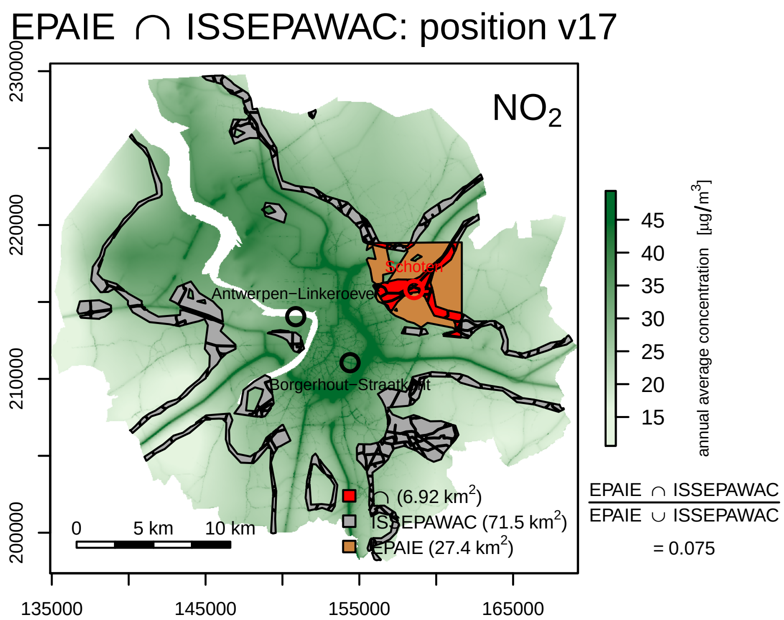

EPAIE ∩ FEA−AT: position v17
NO$_2$
∩ (15.1 km^2)
FEA−AT (160 km^2)
EPAIE (27.4 km^2)
0
5 km
10 km
EPAIE ∩ FEA−AT / EPAIE ∪ FEA−AT = 0.088
annual average concentration [µg/m^3]
45
40
35
30
25
20
15
230000
220000
210000
200000
135000
145000
155000
165000



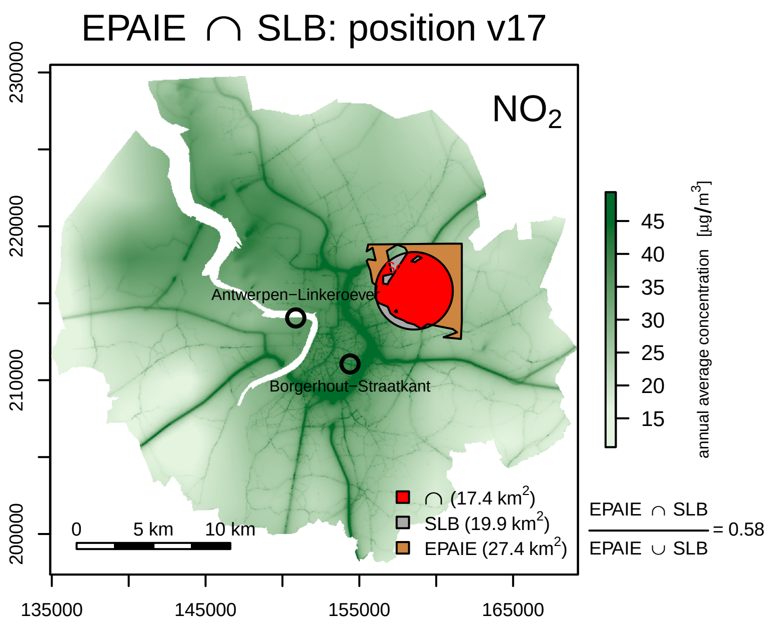
EPAIE ∩ FI: position v17
NO2
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (18.6 km2)
FI (58.6 km2)
EPAIE (27.4 km2)
annual average concentration [µg/m3]
EPAIE ∩ FI / EPAIE ∪ FI = 0.28

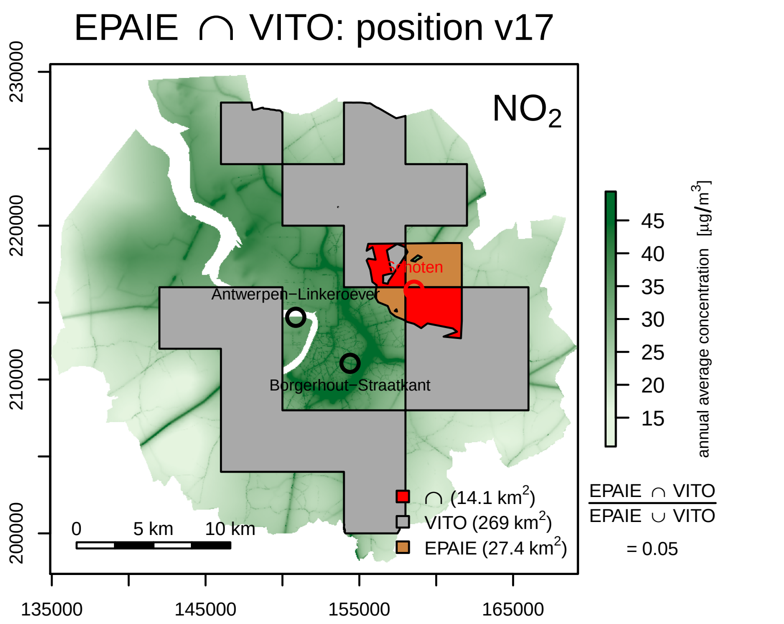


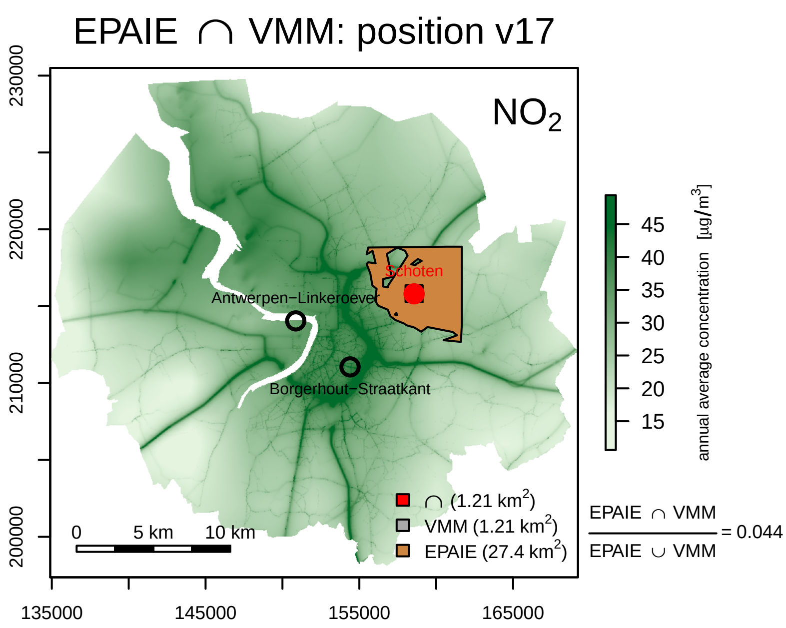
EPAIE ∩ INERIS: position v17
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (5.5 km2)
INERIS (69.4 km2)
EPAIE (27.4 km2)
annual average concentration [µg/m3]
EPAIE ∩ INERIS / EPAIE ∪ INERIS = 0.06

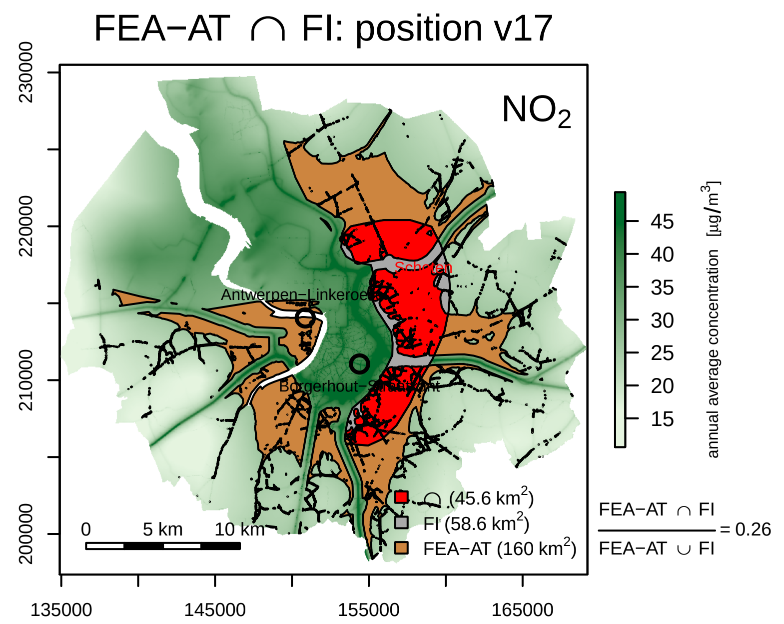


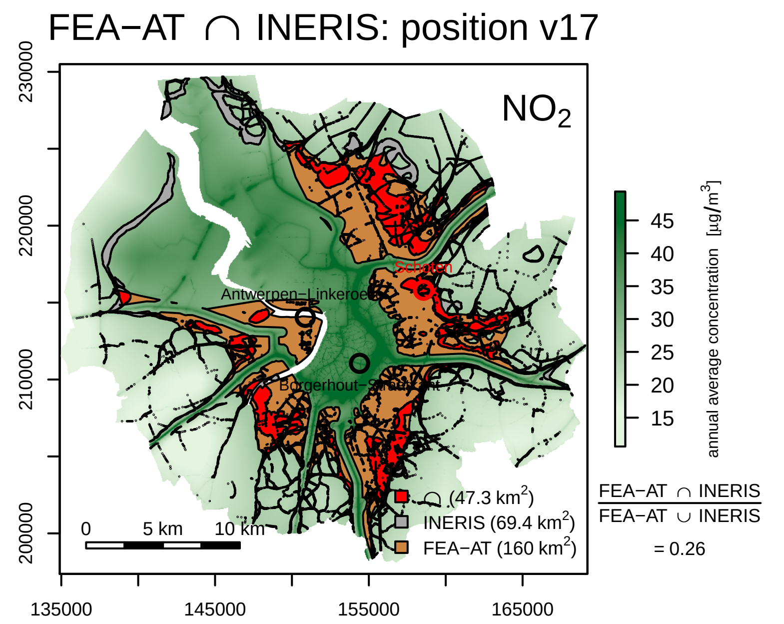
EPAIE ∩ ISSEPAWAC: position v17
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (6.92 km2)
ISSEPAWAC (71.5 km2)
EPAIE (27.4 km2)
annual average concentration [µg/m3]
EPAIE ∩ ISSEPAWAC / EPAIE ∪ ISSEPAWAC = 0.075

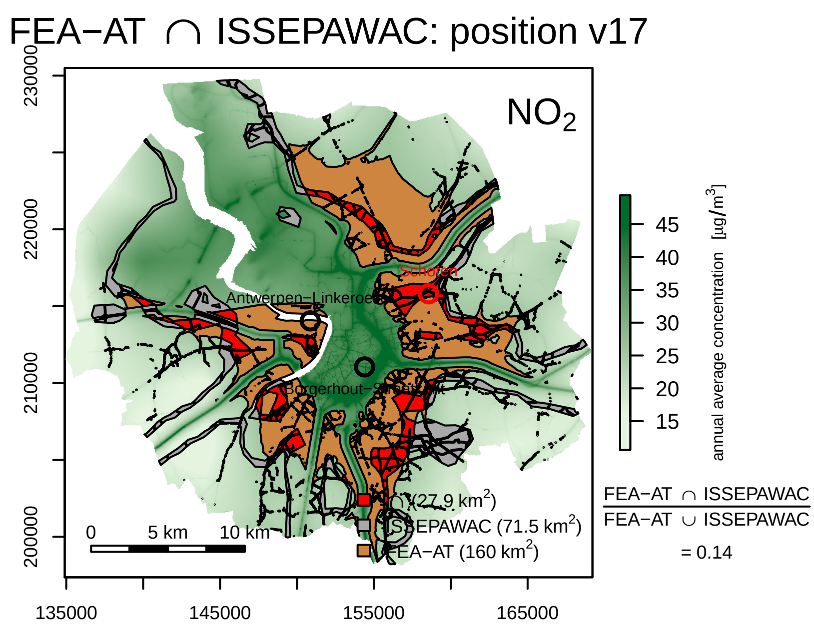

EPAIE ∩ SLB: position v17
NO2
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (17.4 km2)
SLB (19.9 km2)
EPAIE (27.4 km2)
45
40
35
30
25
20
15
annual average concentration [µg/m3]
EPAIE ∩ SLB / EPAIE ∪ SLB = 0.58
230000
220000
210000
200000
135000
145000
155000
165000

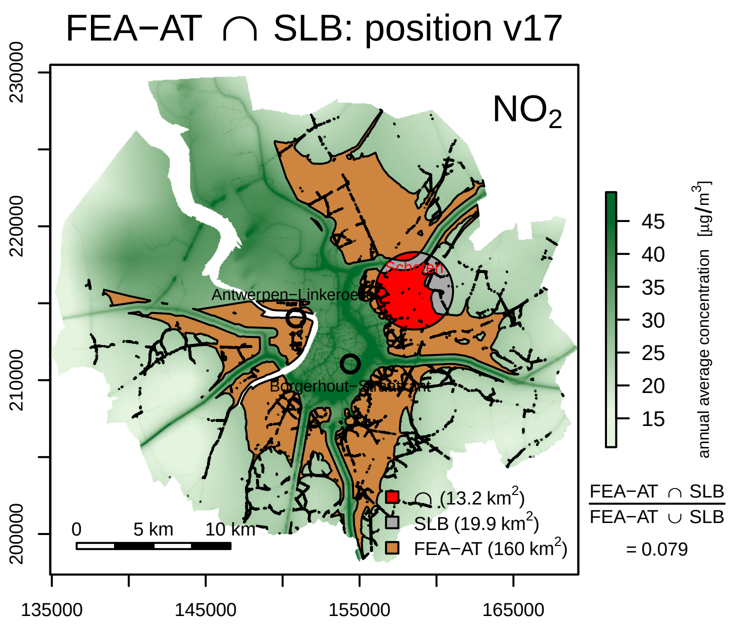

EPAIE ∩ VITO: position v17
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (14.1 km2)
VITO (269 km2)
EPAIE (27.4 km2)
45
40
35
30
25
20
15
annual average concentration [µg/m3]
EPAIE ∩ VITO / EPAIE ∪ VITO = 0.05
230000
220000
210000
200000
135000
145000
155000
165000

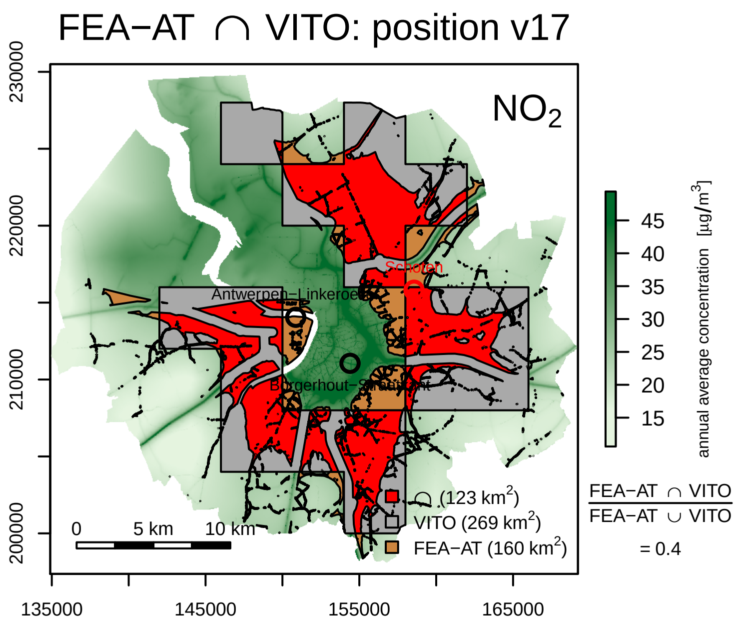

EPAIE ∩ VMM: position v17
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (1.21 km2)
VMM (1.21 km2)
EPAIE (27.4 km2)
45
40
35
30
25
20
15
annual average concentration [µg/m3]
EPAIE ∩ VMM / EPAIE ∪ VMM = 0.044
230000
220000
210000
200000
135000
145000
155000
165000

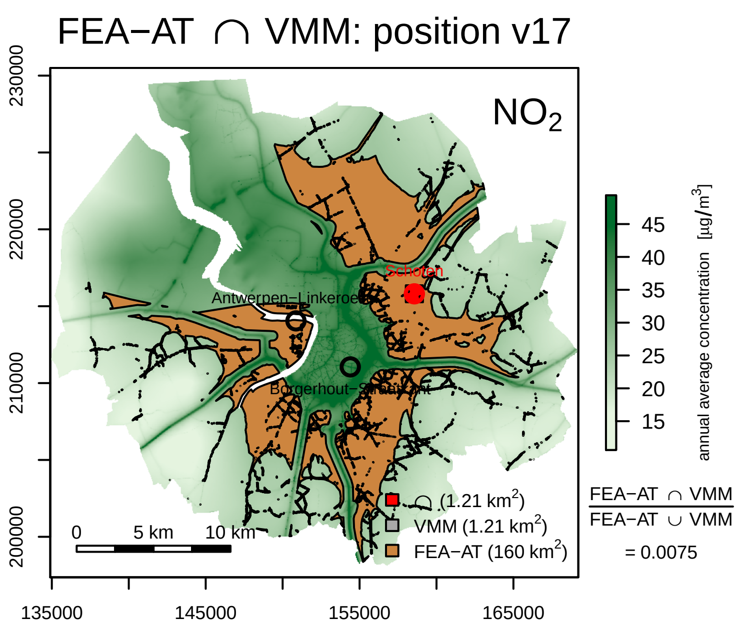

FEA−AT ∩ FI: position v17
NO2
Antwerpen−Linkeroever
0 5 km 10 km
∩ (45.6 km2)
FI (58.6 km2)
FEA−AT (160 km2)
45
40
35
30
25
20
15
annual average concentration [µg/m3]
FEA−AT ∩ FI
FEA−AT ∪ FI
= 0.26
230000
220000
210000
200000
135000
145000
155000
165000

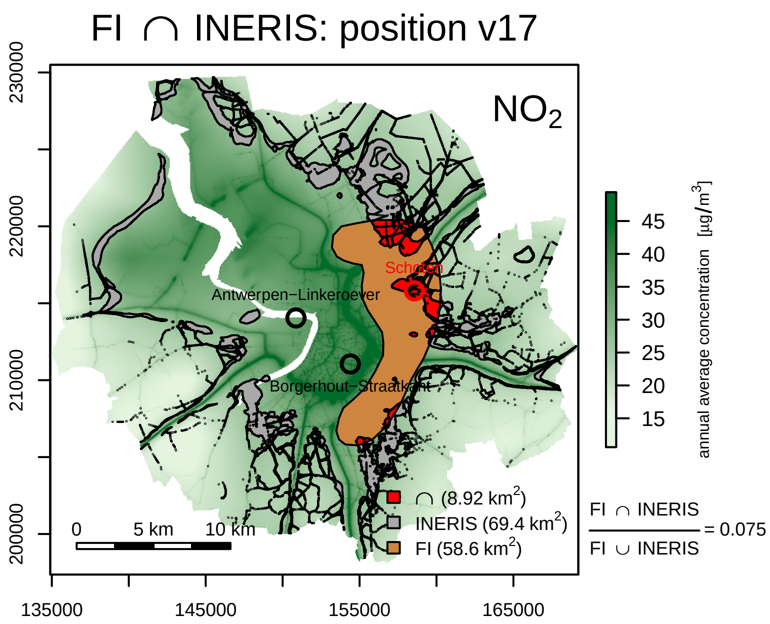

FEA−AT ∩ INERIS: position v17
NO2
Antwerpen−Linkeroever
0 5 km 10 km
∩ (47.3 km2)
INERIS (69.4 km2)
FEA−AT (160 km2)
45
40
35
30
25
20
15
annual average concentration [µg/m3]
FEA−AT ∩ INERIS
FEA−AT ∪ INERIS
= 0.26
230000
220000
210000
200000
135000
145000
155000
165000

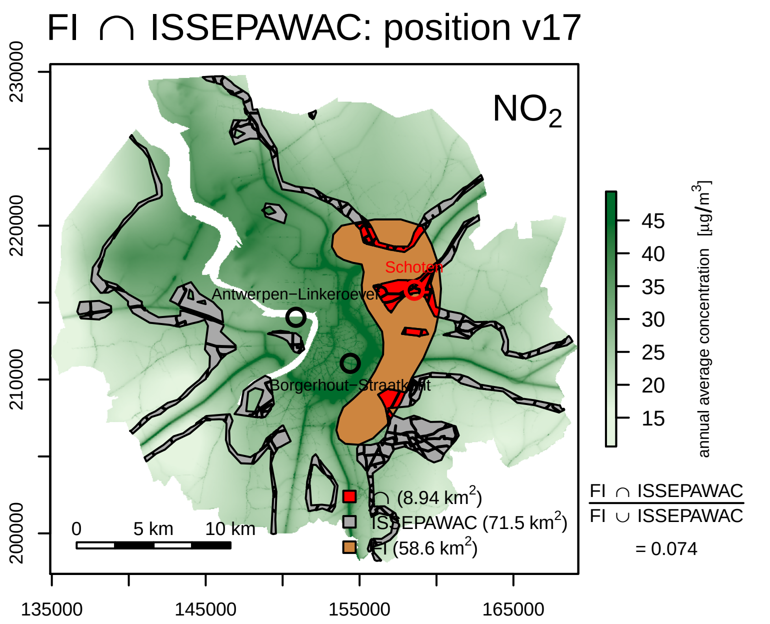

FEA−AT ∩ ISSEPAWAC: position v17
NO2
Antwerpen−Linkeroever
0 5 km 10 km
45
40
35
30
25
20
15
annual average concentration [µg/m3]
FEA−AT ∩ ISSEPAWAC
FEA−AT ∪ ISSEPAWAC
= 0.14
230000
220000
210000
200000
135000
145000
155000
165000

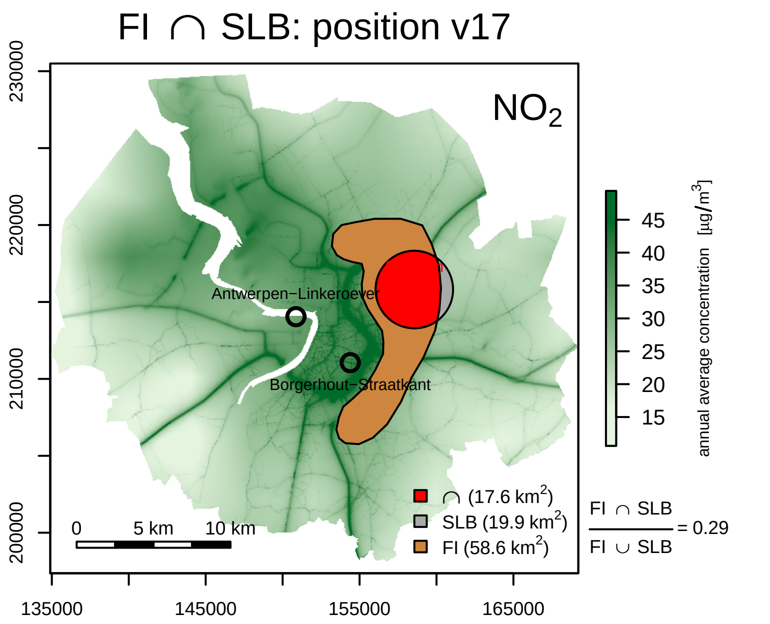

FEA−AT ∩ SLB: position v17
NO2
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (13.2 km2)
SLB (19.9 km2)
FEA−AT (160 km2)
45
40
35
30
25
20
15
annual average concentration [µg/m3]
FEA−AT ∩ SLB
FEA−AT ∪ SLB
= 0.079
230000
220000
210000
200000
135000
145000
155000
165000

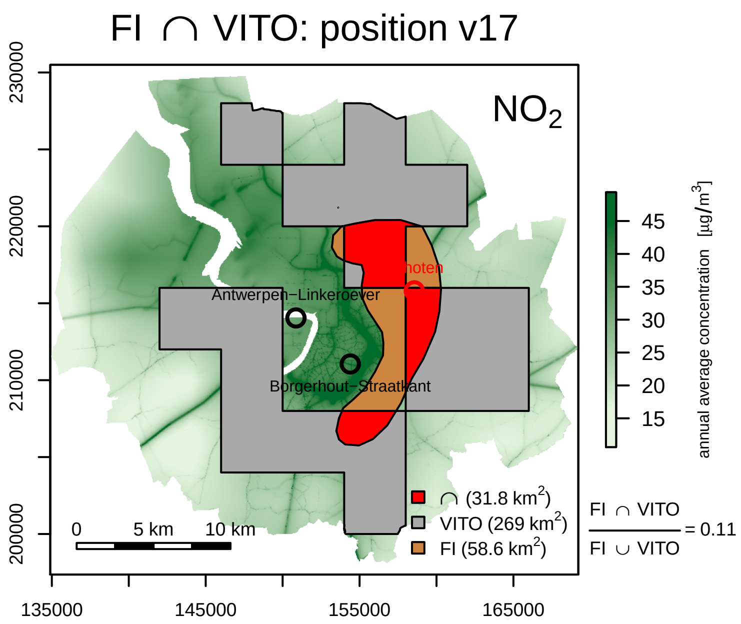

FEA−AT ∩ VITO: position v17
NO2
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (123 km2)
VITO (269 km2)
FEA−AT (160 km2)
45
40
35
30
25
20
15
annual average concentration [µg/m3]
FEA−AT ∩ VITO
FEA−AT ∪ VITO
= 0.4
230000
220000
210000
200000
135000
145000
155000
165000

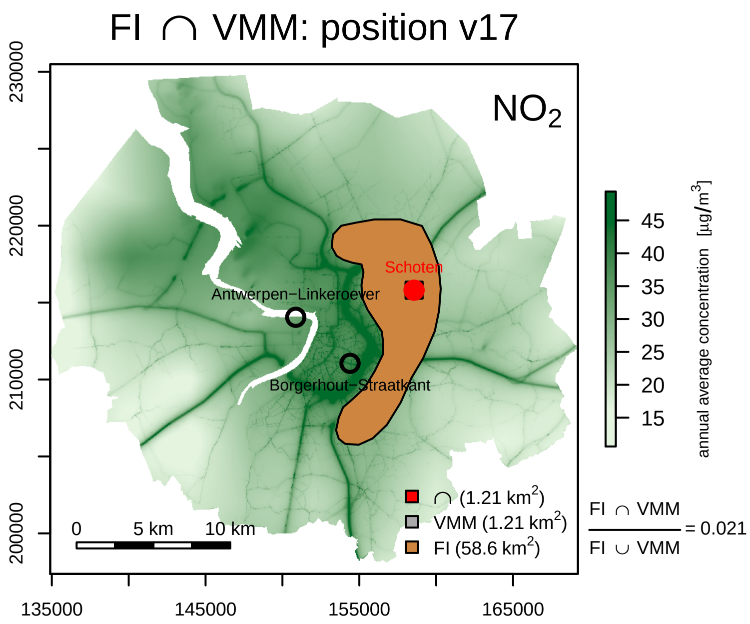

FEA−AT ∩ VMM: position v17
NO2
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (1.21 km2)
VMM (1.21 km2)
FEA−AT (160 km2)
45
40
35
30
25
20
15
annual average concentration [µg/m3]
FEA−AT ∩ VMM
FEA−AT ∪ VMM
= 0.0075
230000
220000
210000
200000
135000
145000
155000
165000

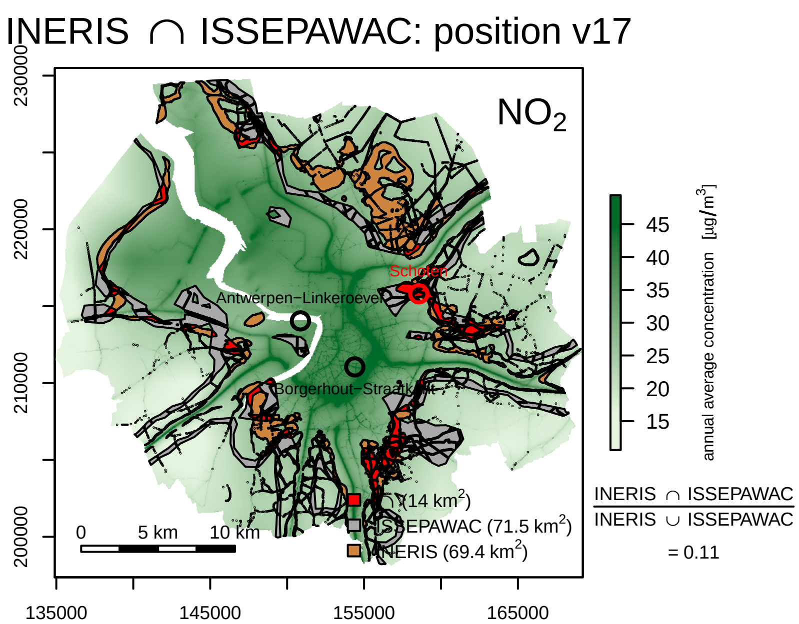

FI ∩ INERIS: position v17
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (8.92 km2)
INERIS (69.4 km2)
FI (58.6 km2)
0
5 km
10 km
45
40
35
30
25
20
15
annual average concentration [µg/m3]
FI ∩ INERIS
FI ∪ INERIS
= 0.075
230000
220000
210000
200000
135000
145000
155000
165000

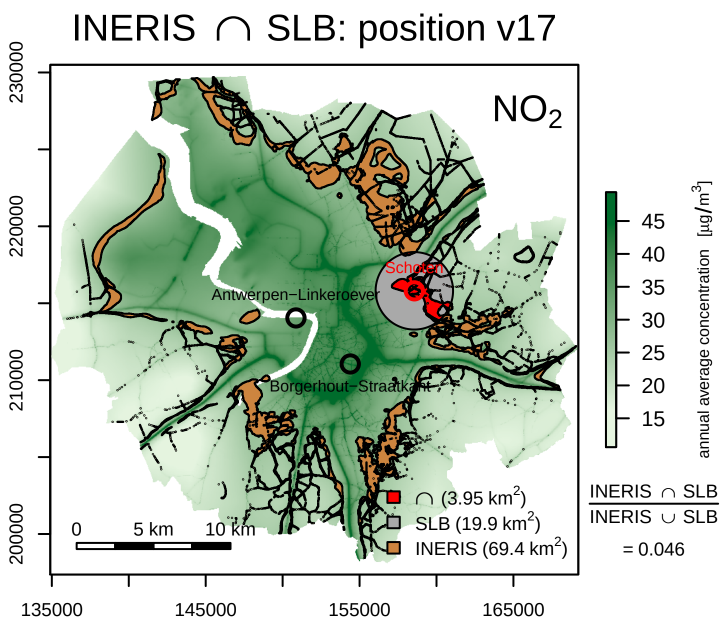

FI ∩ ISSEPAWAC: position v17
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (8.94 km2)
ISSEPAWAC (71.5 km2)
FI (58.6 km2)
0
5 km
10 km
45
40
35
30
25
20
15
annual average concentration [µg/m3]
FI ∩ ISSEPAWAC
FI ∪ ISSEPAWAC
= 0.074
230000
220000
210000
200000
135000
145000
155000
165000

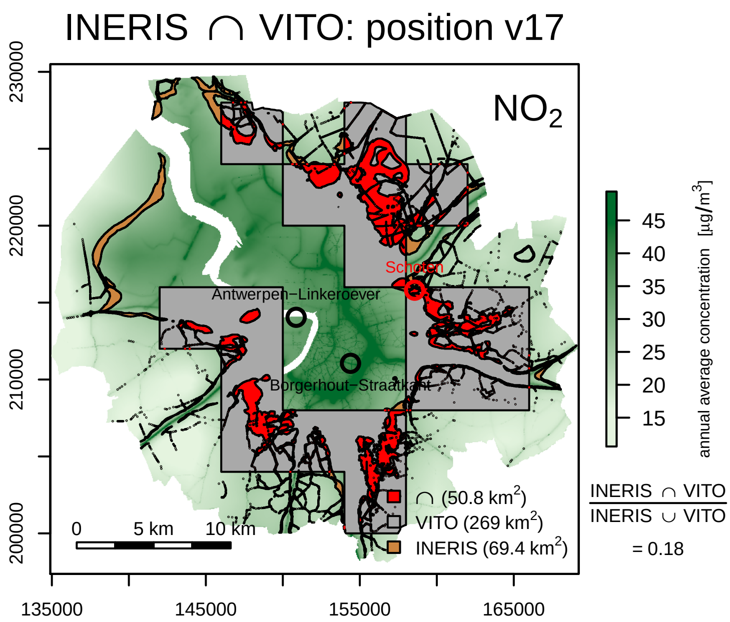

FI ∩ SLB: position v17
NO2
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (17.6 km2)
SLB (19.9 km2)
FI (58.6 km2)
0
5 km
10 km
45
40
35
30
25
20
15
annual average concentration [µg/m3]
FI ∩ SLB
FI ∪ SLB
= 0.29
230000
220000
210000
200000
135000
145000
155000
165000

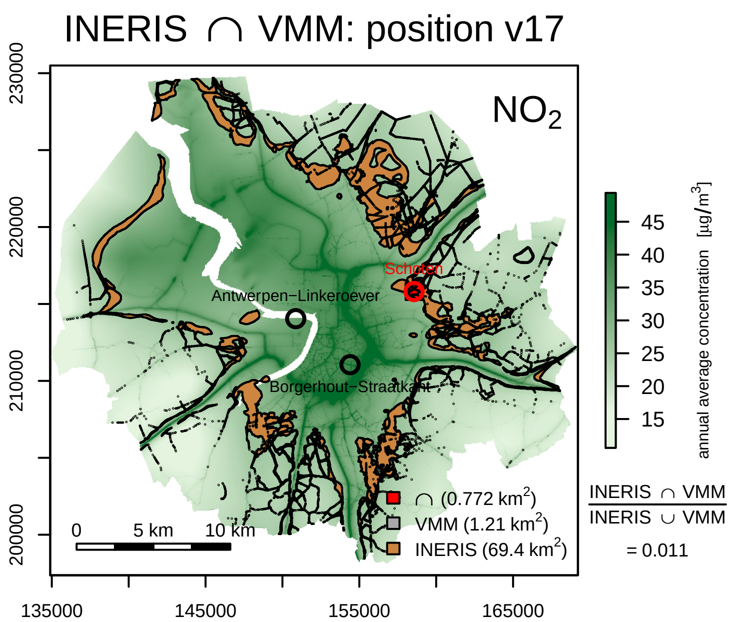

FI ∩ VITO: position v17
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (31.8 km2)
VITO (269 km2)
FI (58.6 km2)
FI ∩ VITO
FI ∪ VITO
= 0.11
45
40
35
30
25
20
15
annual average concentration [µg/m3]
230000
220000
210000
200000
135000
145000
155000
165000

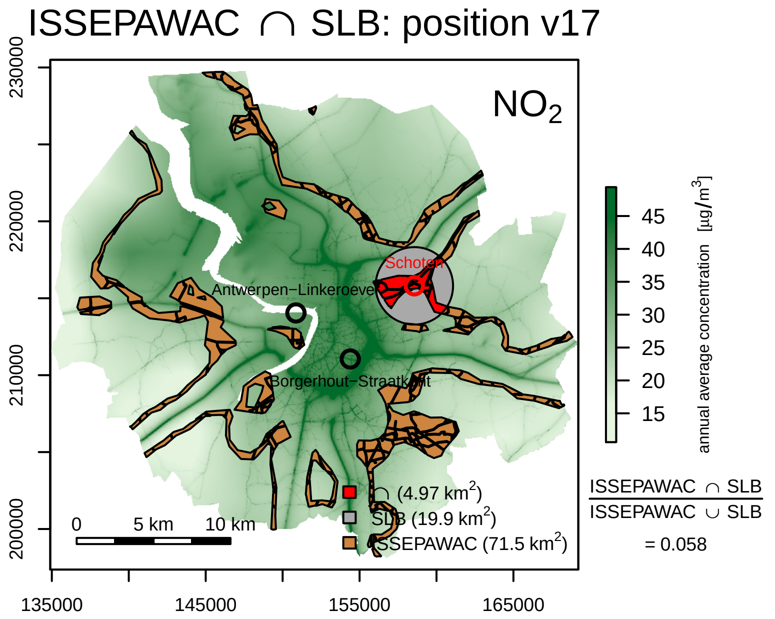

FI ∩ VMM: position v17
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (1.21 km2)
VMM (1.21 km2)
FI (58.6 km2)
FI ∩ VMM
FI ∪ VMM
= 0.021
45
40
35
30
25
20
15
annual average concentration [µg/m3]
230000
220000
210000
200000
135000
145000
155000
165000


INERIS ∩ ISSEPAWAC: position v17
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (14 km2)
ISSEPAWAC (71.5 km2)
INERIS (69.4 km2)
INERIS ∩ ISSEPAWAC
INERIS ∪ ISSEPAWAC
= 0.11
45
40
35
30
25
20
15
annual average concentration [µg/m3]
230000
220000
210000
200000
135000
145000
155000
165000

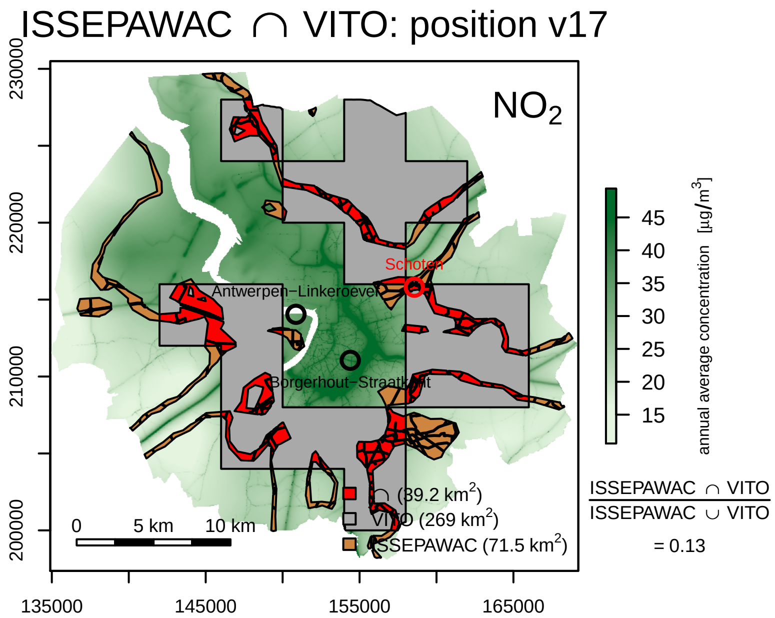

INERIS ∩ SLB: position v17
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (3.95 km2)
SLB (19.9 km2)
INERIS (69.4 km2)
45 40 35 30 25 20 15
annual average concentration [µg/m3]
INERIS ∩ SLB
INERIS ∪ SLB
= 0.046
230000 220000 210000 200000
135000 145000 155000 165000


INERIS ∩ VITO: position v17
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (50.8 km2)
VITO (269 km2)
INERIS (69.4 km2)
45 40 35 30 25 20 15
annual average concentration [µg/m3]
INERIS ∩ VITO
INERIS ∪ VITO
= 0.18
230000 220000 210000 200000
135000 145000 155000 165000

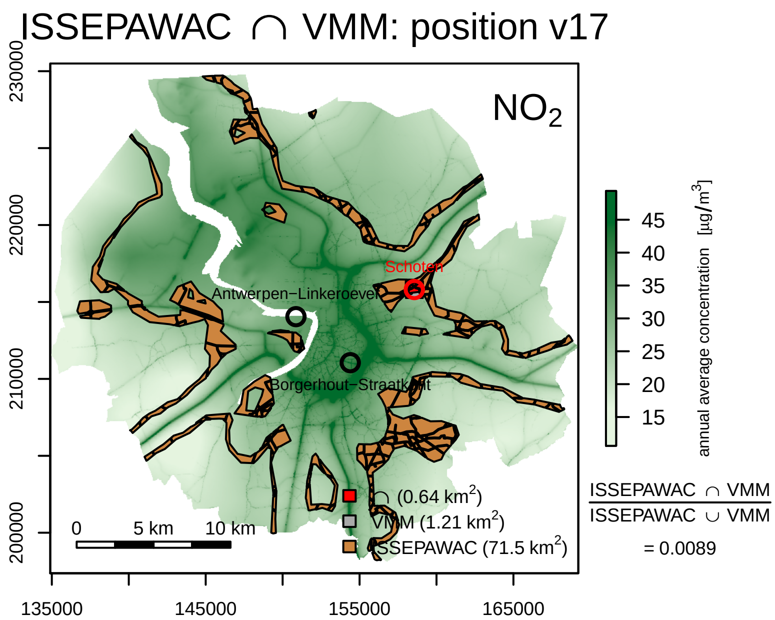

INERIS ∩ VMM: position v17
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (0.772 km2)
VMM (1.21 km2)
INERIS (69.4 km2)
45 40 35 30 25 20 15
annual average concentration [µg/m3]
INERIS ∩ VMM
INERIS ∪ VMM
= 0.011
230000 220000 210000 200000
135000 145000 155000 165000



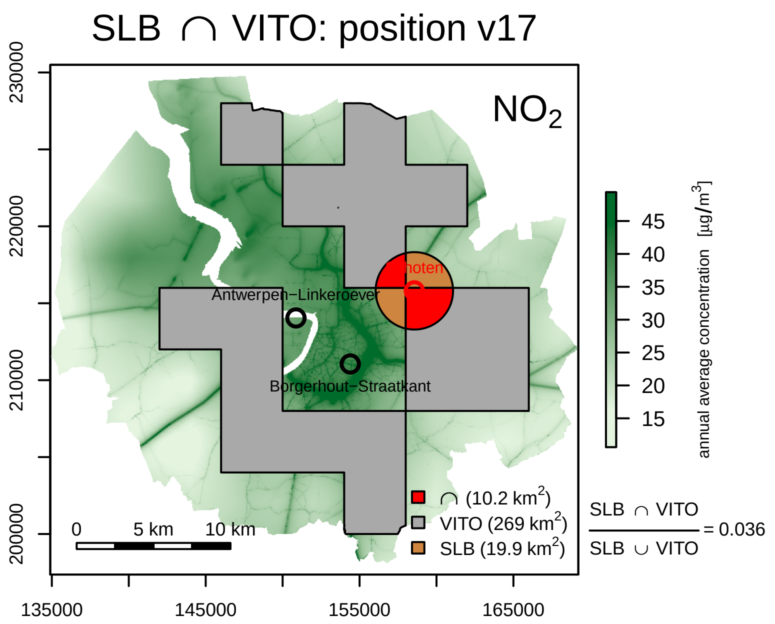
ISSEPAWAC ∩ SLB: position v17
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (4.97 km²)
SLB (19.9 km²)
ISSEPAWAC (71.5 km²)
annual average concentration [µg/m³]
45
40
35
30
25
20
15
ISSEPAWAC ∩ SLB
ISSEPAWAC ∪ SLB
= 0.058
230000
220000
210000
200000
135000
145000
155000
165000

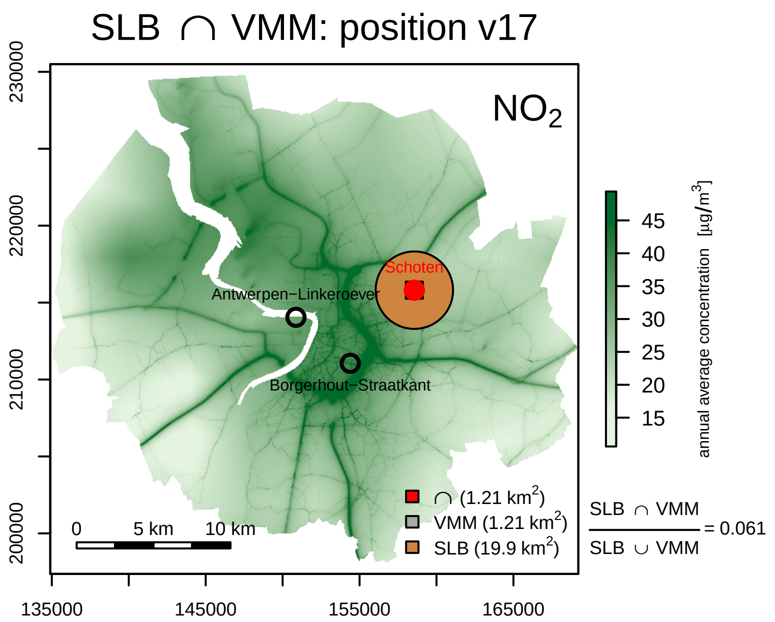


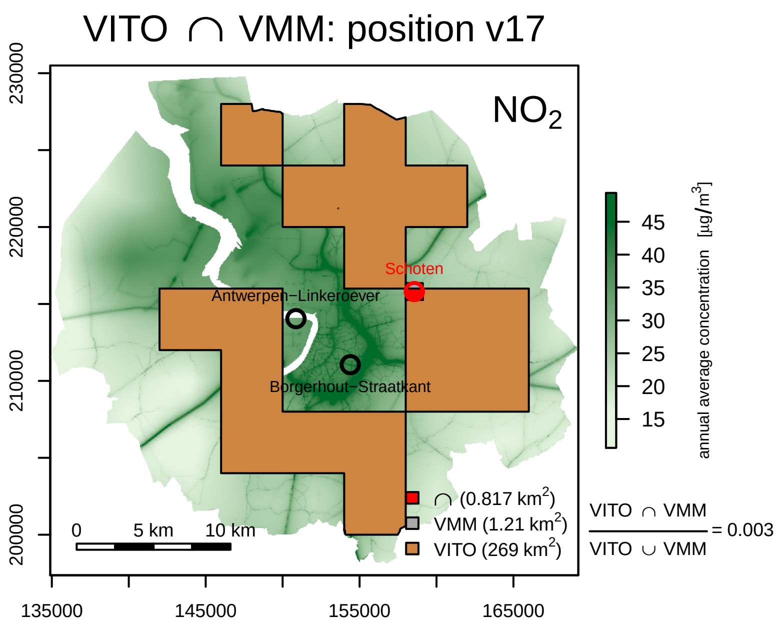
ISSEPAWAC ∩ VITO: position v17
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (39.2 km²)
VITO (269 km²)
ISSEPAWAC (71.5 km²)
annual average concentration [µg/m³]
45
40
35
30
25
20
15
ISSEPAWAC ∩ VITO
ISSEPAWAC ∪ VITO
= 0.13
230000
220000
210000
200000
135000
145000
155000
165000



ISSEPAWAC ∩ VMM: position v17
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (0.64 km²)
VMM (1.21 km²)
ISSEPAWAC (71.5 km²)
annual average concentration [µg/m³]
45
40
35
30
25
20
15
ISSEPAWAC ∩ VMM
ISSEPAWAC ∪ VMM
= 0.0089
230000
220000
210000
200000
135000
145000
155000
165000


SLB ∩ VITO: position v17
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (10.2 km2)
VITO (269 km2)
SLB (19.9 km2)
SLB ∩ VITO / SLB ∪ VITO = 0.036
annual average concentration [µg/m3]
45 40 35 30 25 20 15
230000 220000 210000 200000
135000 145000 155000 165000

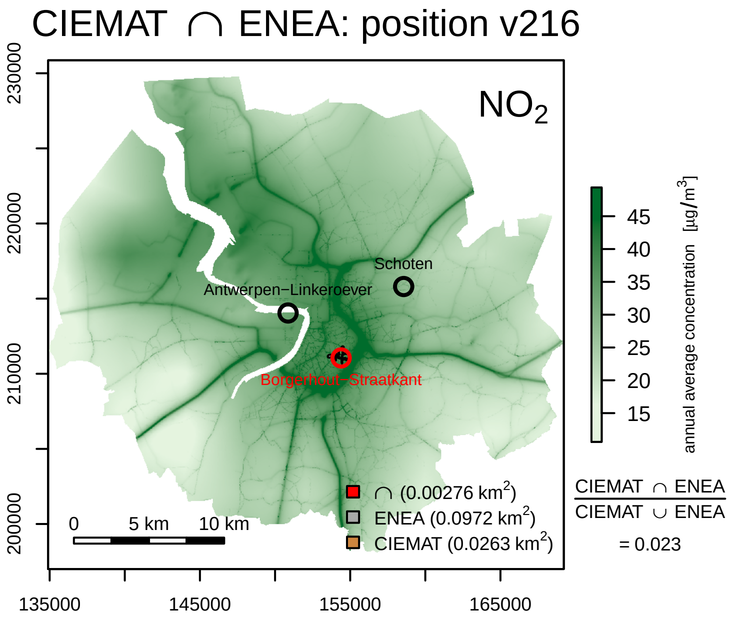

SLB ∩ VMM: position v17
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (1.21 km2)
VMM (1.21 km2)
SLB (19.9 km2)
SLB ∩ VMM / SLB ∪ VMM = 0.061
annual average concentration [µg/m3]
45 40 35 30 25 20 15
230000 220000 210000 200000
135000 145000 155000 165000

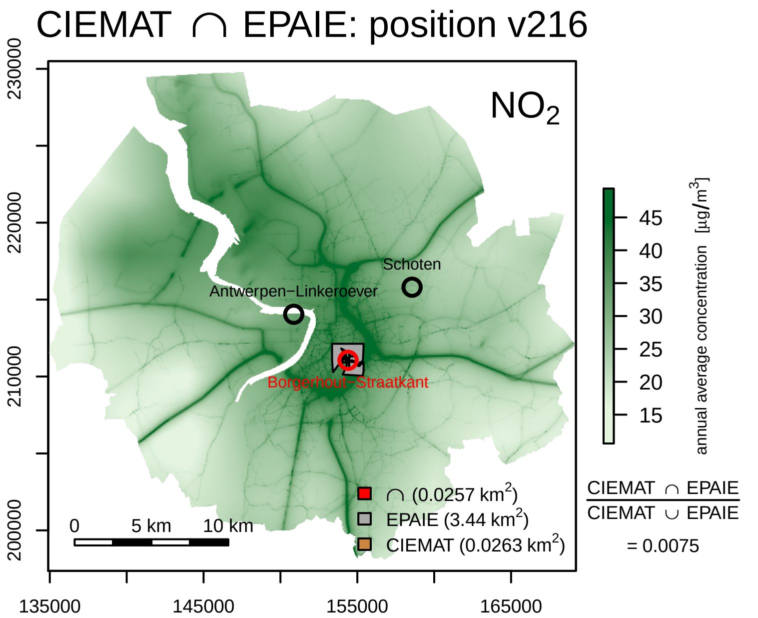

VITO ∩ VMM: position v17
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (0.817 km2)
VMM (1.21 km2)
VITO (269 km2)
VITO ∩ VMM / VITO ∪ VMM = 0.003
annual average concentration [µg/m3]
45 40 35 30 25 20 15
230000 220000 210000 200000
135000 145000 155000 165000

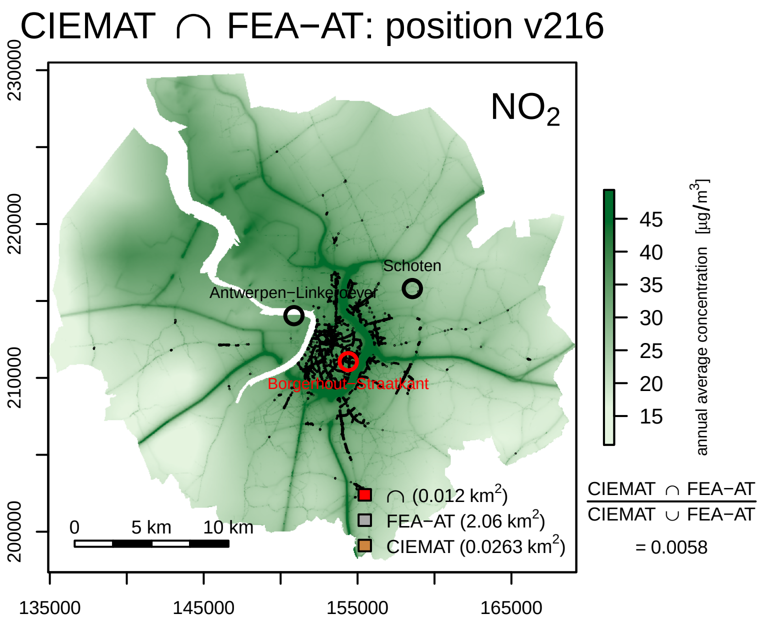
Mutual Comparisons between Teams

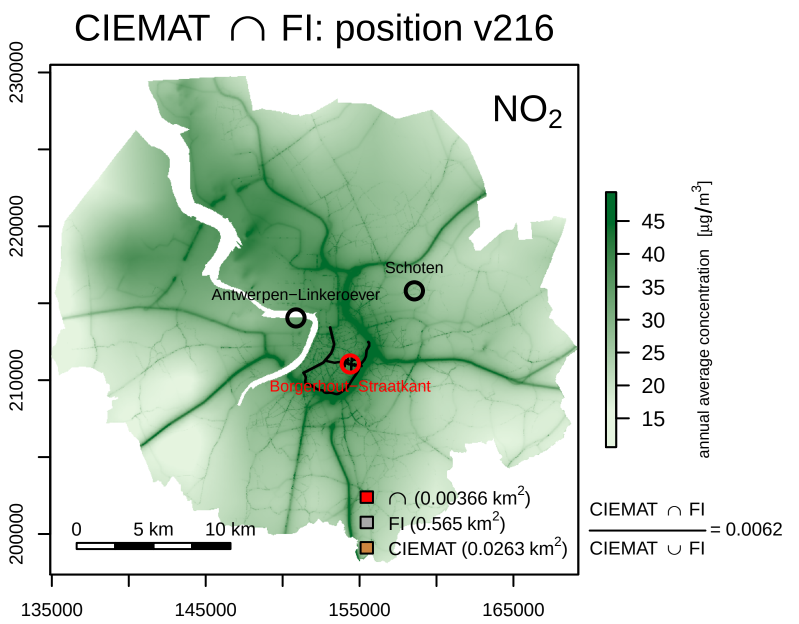
by Pollutant & Station:

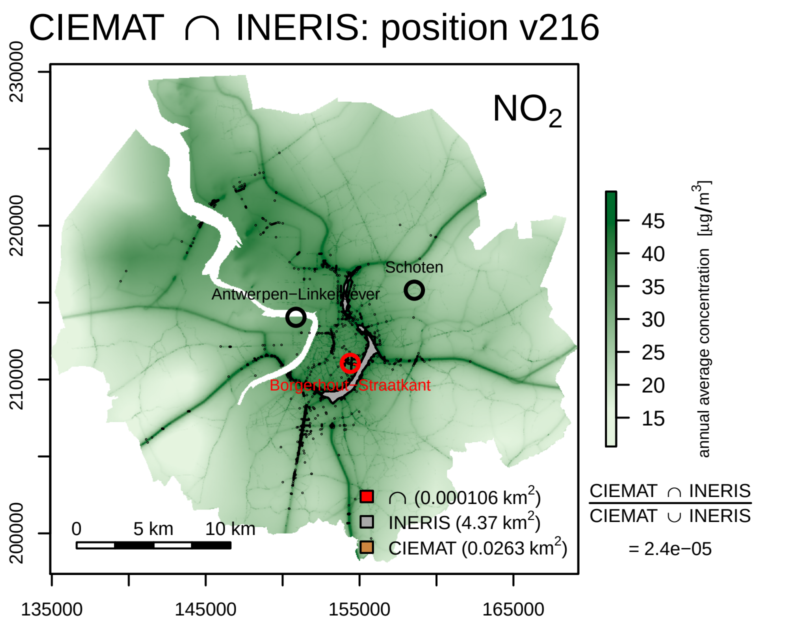
NO_2 at virtual station v216

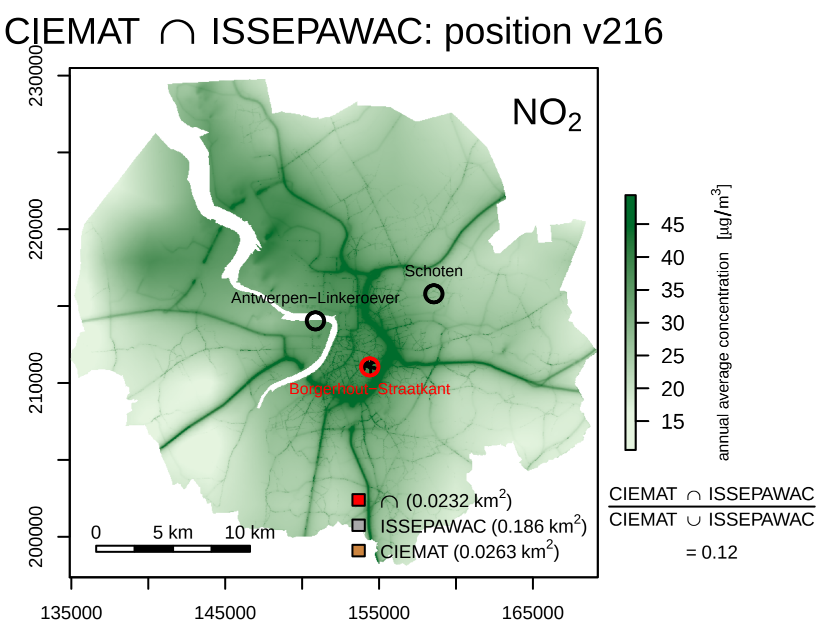

CIEMAT ∩ ENEA: position v216
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (0.00276 km2)
ENEA (0.0972 km2)
CIEMAT (0.0263 km2)
annual average concentration [µg/m3]
CIEMAT ∩ ENEA / CIEMAT ∪ ENEA = 0.023

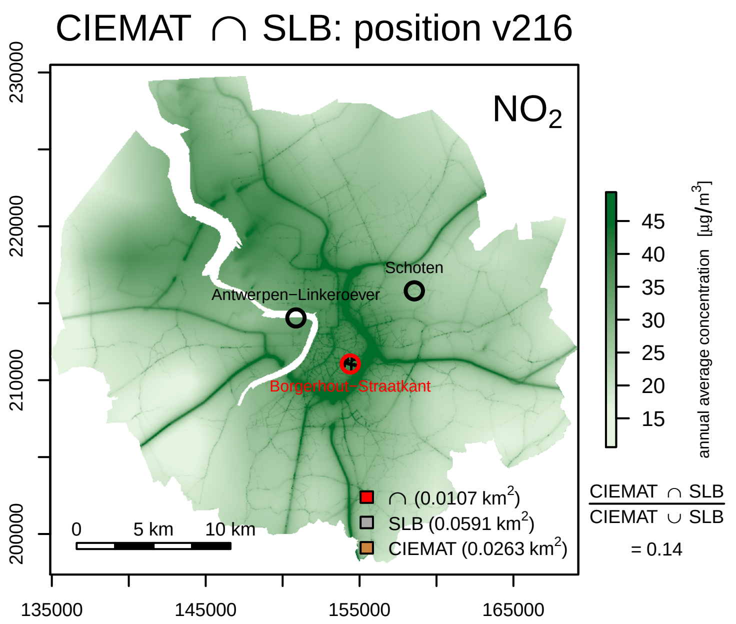

CIEMAT ∩ EPAIE: position v216
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (0.0257 km2)
EPAIE (3.44 km2)
CIEMAT (0.0263 km2)
annual average concentration [µg/m3]
CIEMAT ∩ EPAIE / CIEMAT ∪ EPAIE = 0.0075

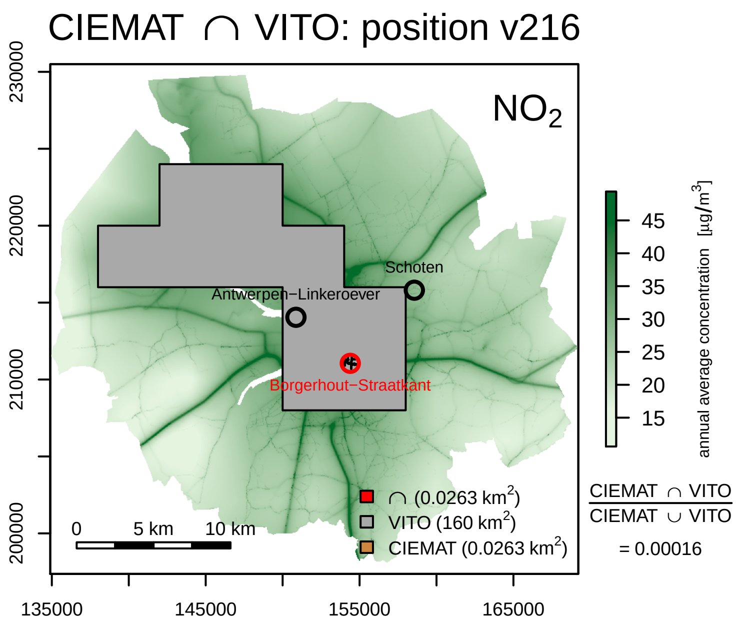

CIEMAT ∩ FEA−AT: position v216
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (0.012 km2)
FEA−AT (2.06 km2)
CIEMAT (0.0263 km2)
annual average concentration [µg/m3]
CIEMAT ∩ FEA−AT / CIEMAT ∪ FEA−AT = 0.0058

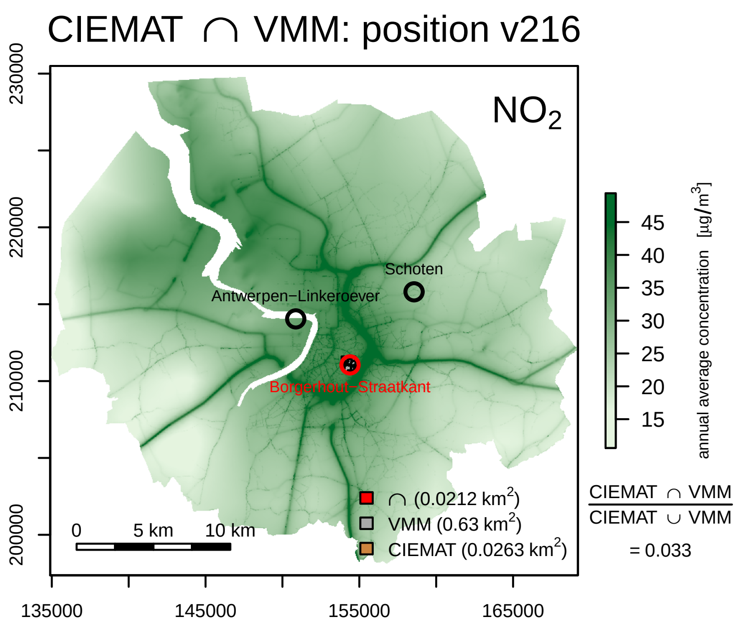

CIEMAT ∩ FI: position v216
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.00366 km2)
FI (0.565 km2)
CIEMAT (0.0263 km2)
0 5 km 10 km
annual average concentration [µg/m3]
45
40
35
30
25
20
15
CIEMAT ∩ FI / CIEMAT ∪ FI = 0.0062
230000
220000
210000
200000
135000
145000
155000
165000

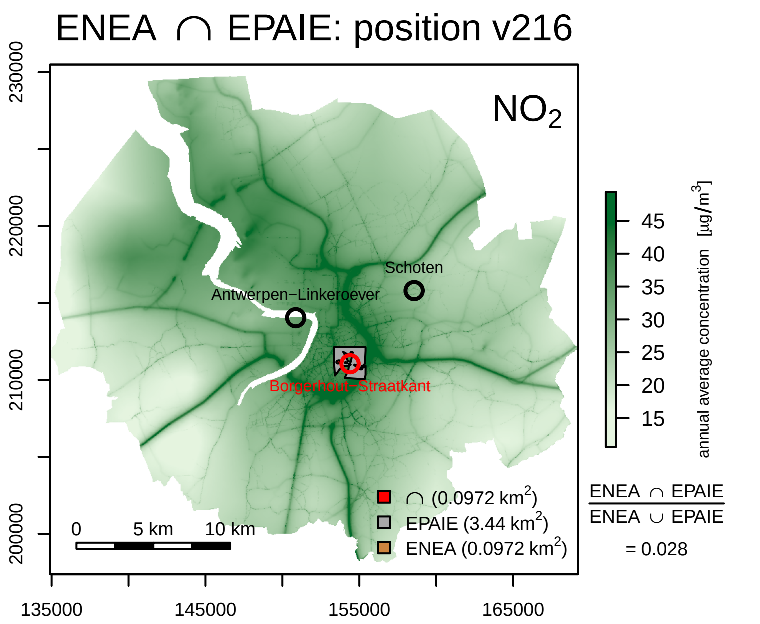

CIEMAT ∩ INERIS: position v216
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.000106 km2)
INERIS (4.37 km2)
CIEMAT (0.0263 km2)
0 5 km 10 km
annual average concentration [µg/m3]
45
40
35
30
25
20
15
CIEMAT ∩ INERIS / CIEMAT ∪ INERIS = 2.4e−05
230000
220000
210000
200000
135000
145000
155000
165000

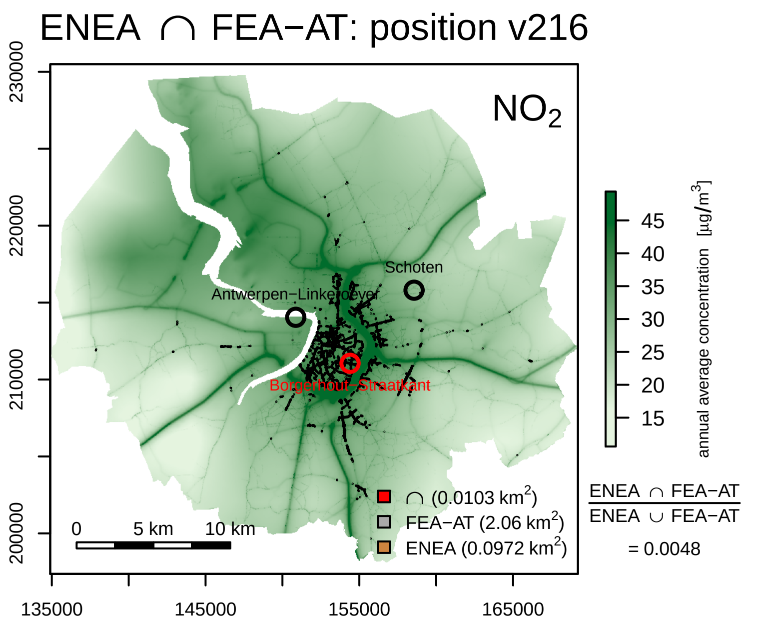

CIEMAT ∩ ISSEPAWAC: position v216
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.0232 km2)
ISSEPAWAC (0.186 km2)
CIEMAT (0.0263 km2)
0 5 km 10 km
annual average concentration [µg/m3]
45
40
35
30
25
20
15
CIEMAT ∩ ISSEPAWAC / CIEMAT ∪ ISSEPAWAC = 0.12
230000
220000
210000
200000
135000
145000
155000
165000

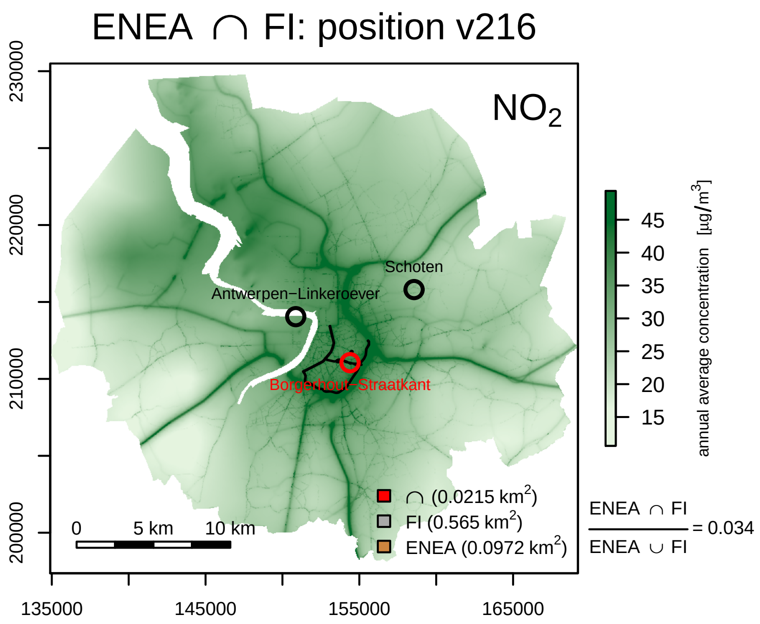

CIEMAT ∩ SLB: position v216
NO_2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (0.0107 km^2)
SLB (0.0591 km^2)
CIEMAT (0.0263 km^2)
45 40 35 30 25 20 15
annual average concentration [µg/m^3]
CIEMAT ∩ SLB / CIEMAT ∪ SLB = 0.14
135000 145000 155000 165000
200000 210000 220000 230000

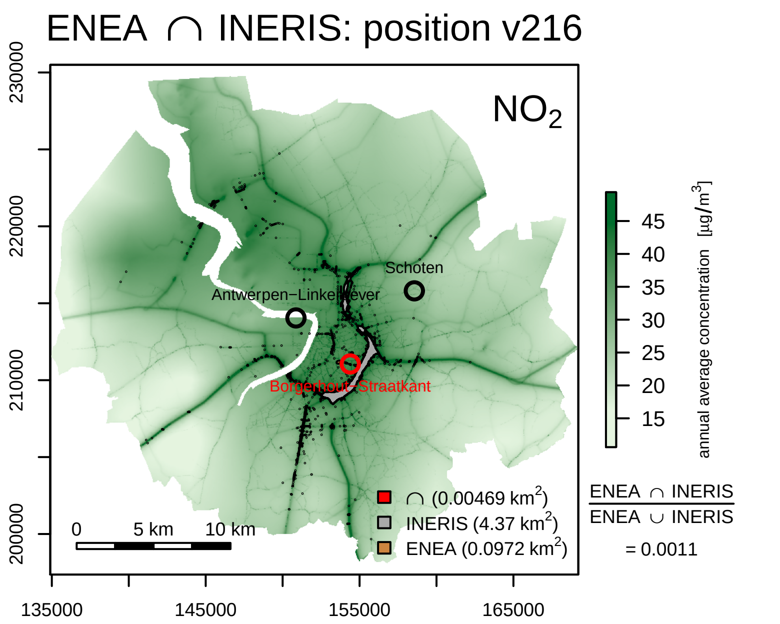

CIEMAT ∩ VITO: position v216
NO_2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (0.0263 km^2)
VITO (160 km^2)
CIEMAT (0.0263 km^2)
45 40 35 30 25 20 15
annual average concentration [µg/m^3]
CIEMAT ∩ VITO / CIEMAT ∪ VITO = 0.00016
135000 145000 155000 165000
200000 210000 220000 230000

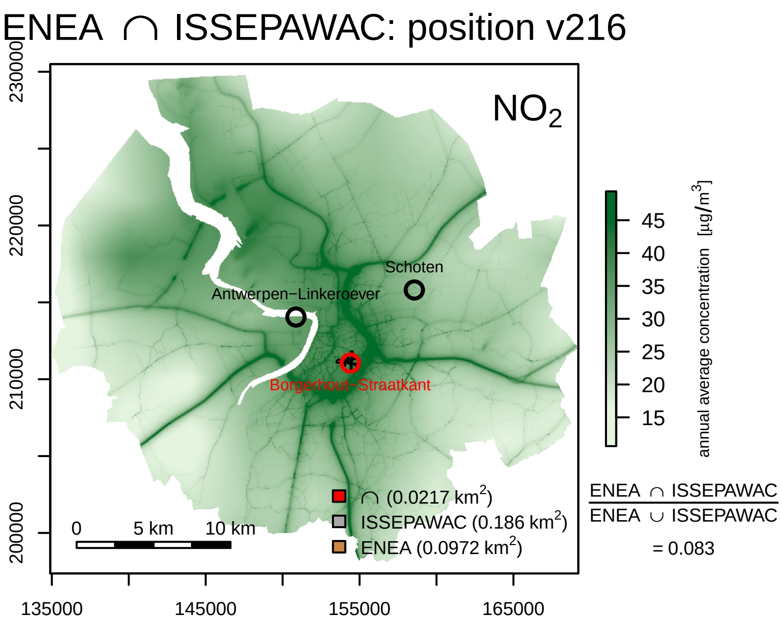

CIEMAT ∩ VMM: position v216
NO_2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (0.0212 km^2)
VMM (0.63 km^2)
CIEMAT (0.0263 km^2)
45 40 35 30 25 20 15
annual average concentration [µg/m^3]
CIEMAT ∩ VMM / CIEMAT ∪ VMM = 0.033
135000 145000 155000 165000
200000 210000 220000 230000

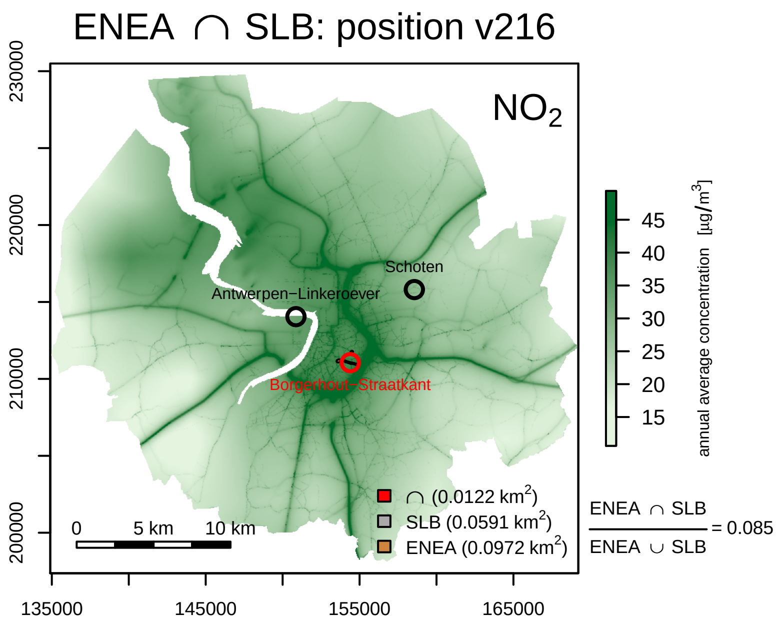

ENEA ∩ EPAIE: position v216
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.0972 km2)
EPAIE (3.44 km2)
ENEA (0.0972 km2)
0
5 km
10 km
45
40
35
30
25
20
15
annual average concentration [µg/m3]
ENEA ∩ EPAIE
ENEA ∪ EPAIE
= 0.028
230000
220000
210000
200000
135000
145000
155000
165000

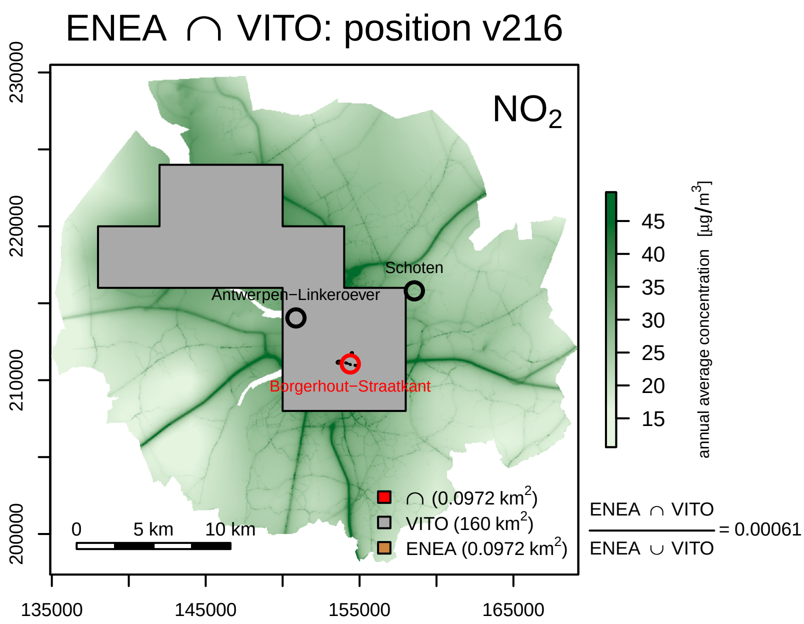

ENEA ∩ FEA−AT: position v216
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.0103 km2)
FEA−AT (2.06 km2)
ENEA (0.0972 km2)
0
5 km
10 km
45
40
35
30
25
20
15
annual average concentration [µg/m3]
ENEA ∩ FEA−AT
ENEA ∪ FEA−AT
= 0.0048
230000
220000
210000
200000
135000
145000
155000
165000

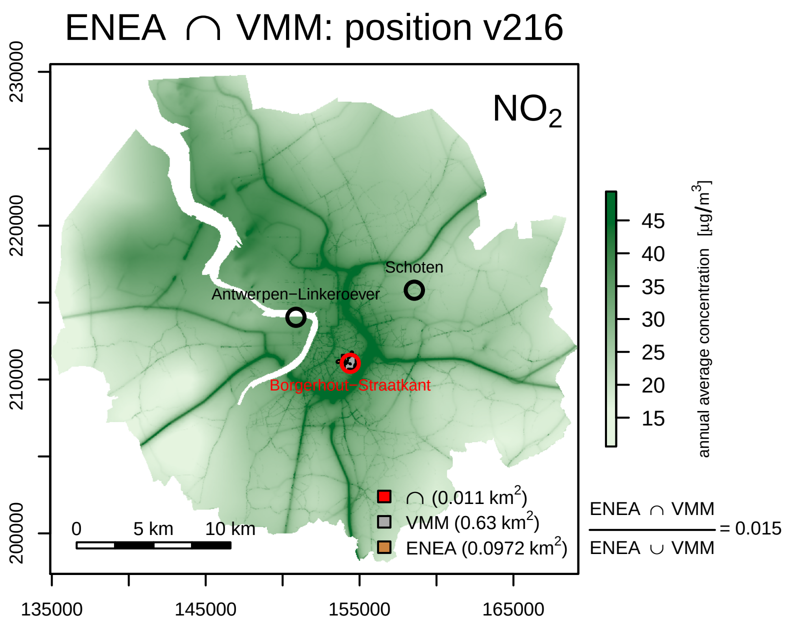

ENEA ∩ FI: position v216
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.0215 km2)
FI (0.565 km2)
ENEA (0.0972 km2)
0
5 km
10 km
45
40
35
30
25
20
15
annual average concentration [µg/m3]
ENEA ∩ FI
ENEA ∪ FI
= 0.034
230000
220000
210000
200000
135000
145000
155000
165000

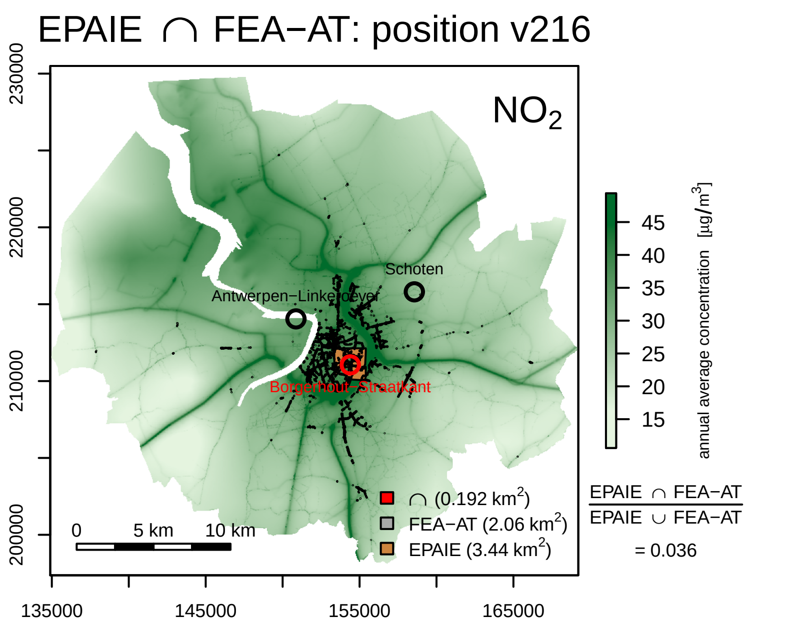

ENEA ∩ INERIS: position v216
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
45
40
35
30
25
20
15
annual average concentration [µg/m3]
∩ (0.00469 km2)
INERIS (4.37 km2)
ENEA (0.0972 km2)
ENEA ∩ INERIS
ENEA ∪ INERIS
= 0.0011
0
5 km
10 km
230000
220000
210000
200000
135000
145000
155000
165000

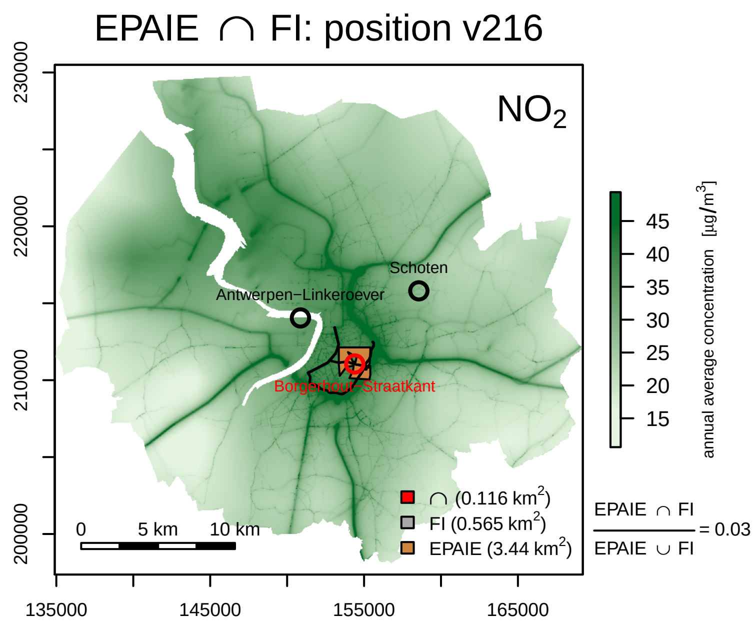

ENEA ∩ ISSEPAWAC: position v216
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
45
40
35
30
25
20
15
annual average concentration [µg/m3]
∩ (0.0217 km2)
ISSEPAWAC (0.186 km2)
ENEA (0.0972 km2)
ENEA ∩ ISSEPAWAC
ENEA ∪ ISSEPAWAC
= 0.083
0
5 km
10 km
230000
220000
210000
200000
135000
145000
155000
165000

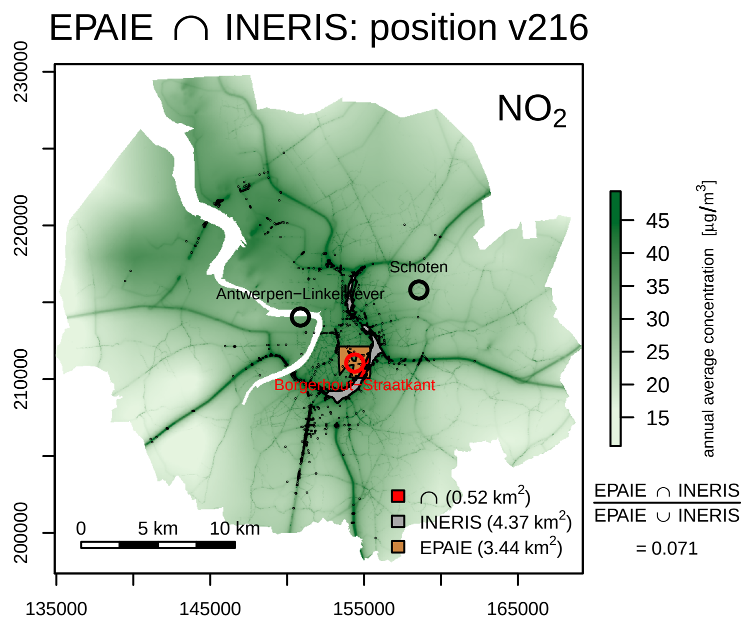

ENEA ∩ SLB: position v216
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
45
40
35
30
25
20
15
annual average concentration [µg/m3]
∩ (0.0122 km2)
SLB (0.0591 km2)
ENEA (0.0972 km2)
ENEA ∩ SLB
ENEA ∪ SLB
= 0.085
0
5 km
10 km
230000
220000
210000
200000
135000
145000
155000
165000

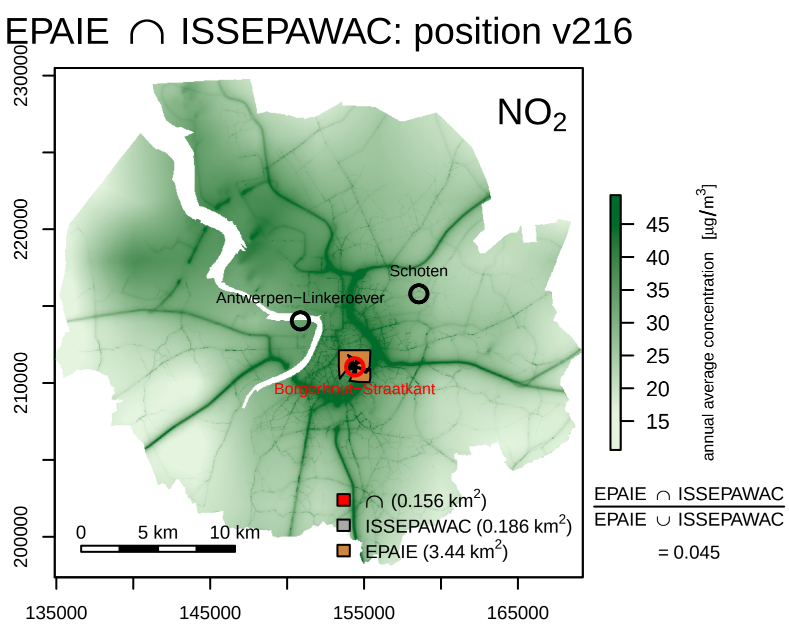

ENEA ∩ VITO: position v216
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.0972 km2)
VITO (160 km2)
ENEA (0.0972 km2)
0 5 km 10 km
annual average concentration [µg/m3]
45 40 35 30 25 20 15
ENEA ∩ VITO / ENEA ∪ VITO = 0.00061
230000 220000 210000 200000
135000 145000 155000 165000

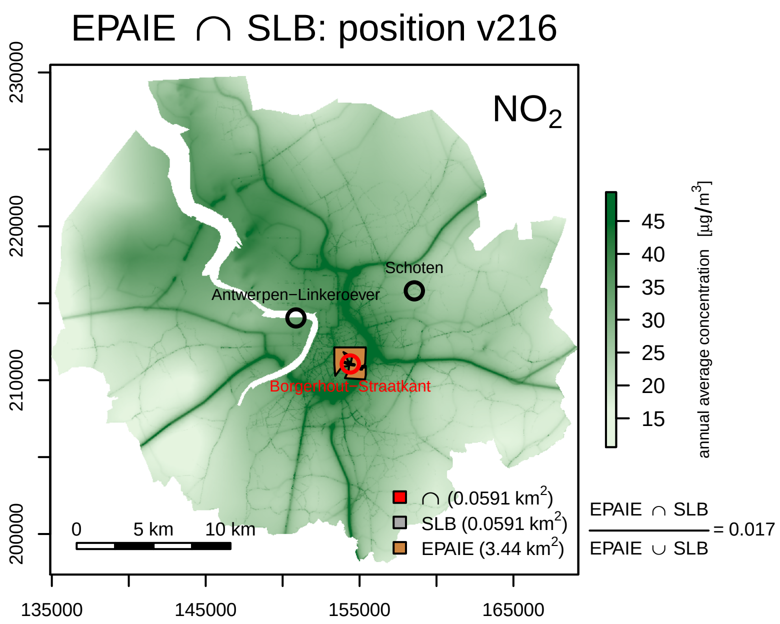

ENEA ∩ VMM: position v216
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.011 km2)
VMM (0.63 km2)
ENEA (0.0972 km2)
0 5 km 10 km
annual average concentration [µg/m3]
45 40 35 30 25 20 15
ENEA ∩ VMM / ENEA ∪ VMM = 0.015
230000 220000 210000 200000
135000 145000 155000 165000

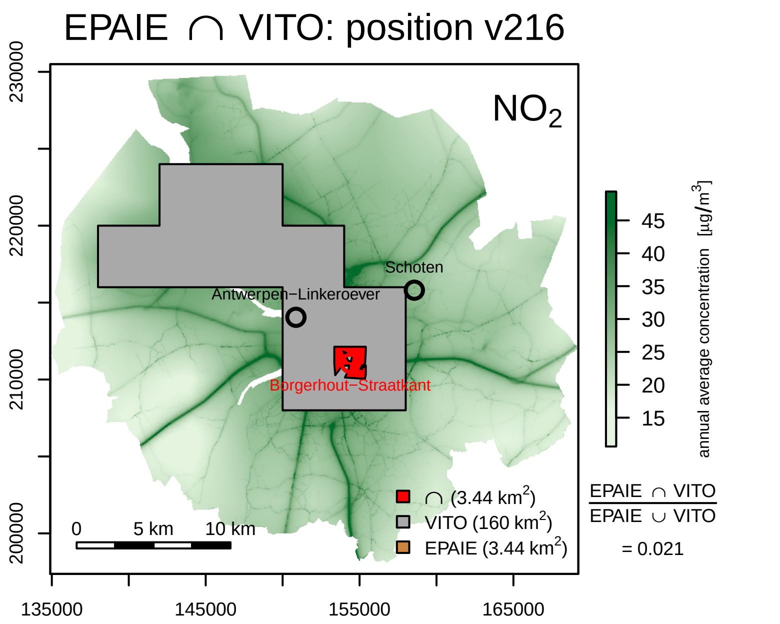

EPAIE ∩ FEA−AT: position v216
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.192 km2)
FEA−AT (2.06 km2)
EPAIE (3.44 km2)
0 5 km 10 km
annual average concentration [µg/m3]
45 40 35 30 25 20 15
EPAIE ∩ FEA−AT / EPAIE ∪ FEA−AT = 0.036
230000 220000 210000 200000
135000 145000 155000 165000

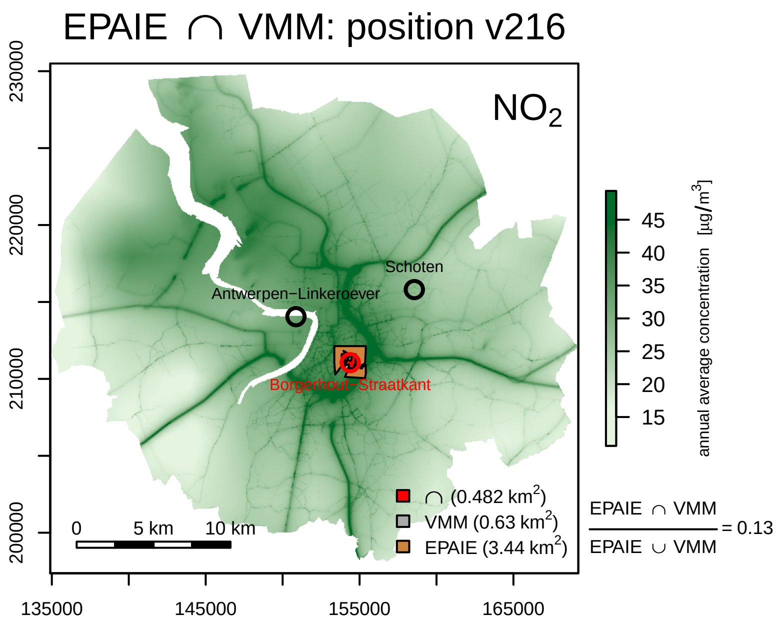

EPAIE ∩ FI: position v216
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout-Straatkant
∩ (0.116 km2)
FI (0.565 km2)
EPAIE (3.44 km2)
0 5 km 10 km
annual average concentration [µg/m3]
EPAIE ∩ FI / EPAIE ∪ FI = 0.03

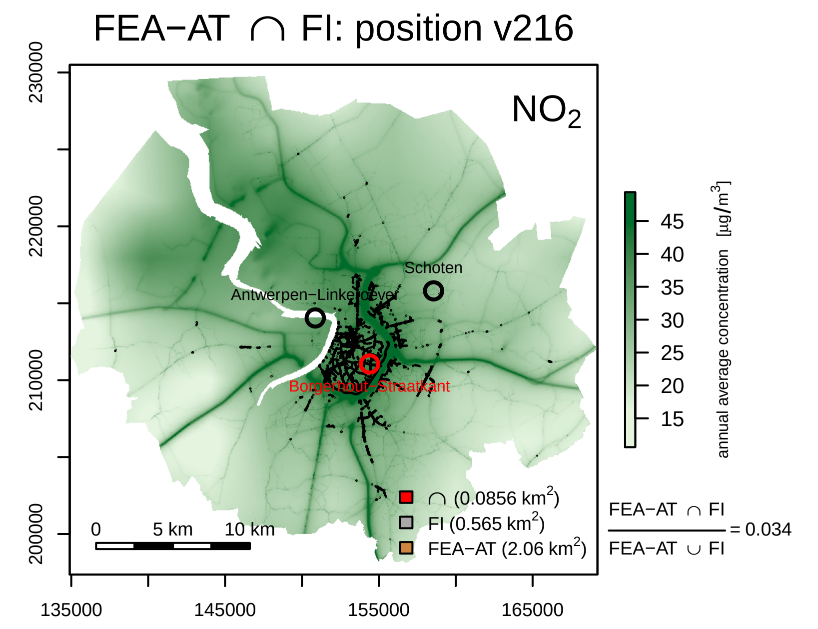

EPAIE ∩ INERIS: position v216
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout-Straatkant
∩ (0.52 km2)
INERIS (4.37 km2)
EPAIE (3.44 km2)
0 5 km 10 km
annual average concentration [µg/m3]
EPAIE ∩ INERIS / EPAIE ∪ INERIS = 0.071

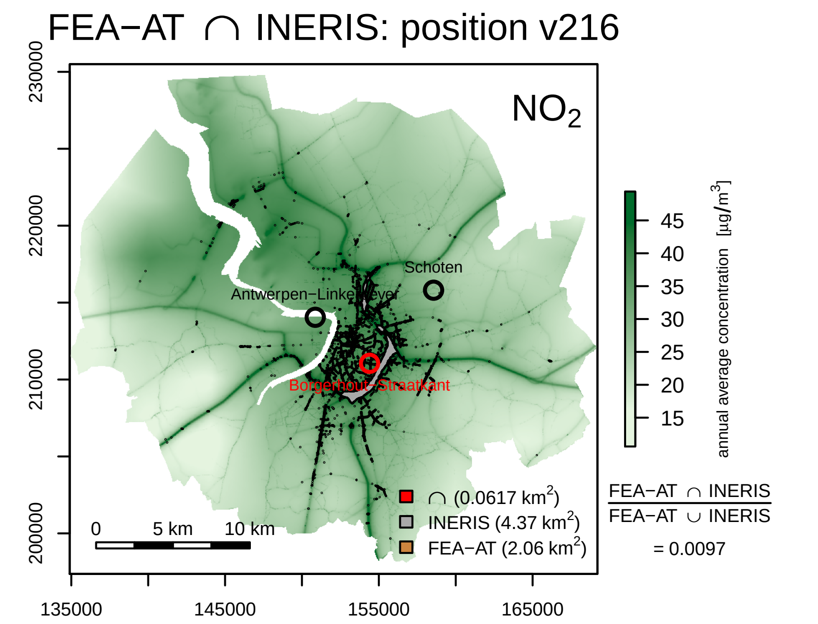

EPAIE ∩ ISSEPAWAC: position v216
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout-Straatkant
∩ (0.156 km2)
ISSEPAWAC (0.186 km2)
EPAIE (3.44 km2)
0 5 km 10 km
annual average concentration [µg/m3]
EPAIE ∩ ISSEPAWAC / EPAIE ∪ ISSEPAWAC = 0.045

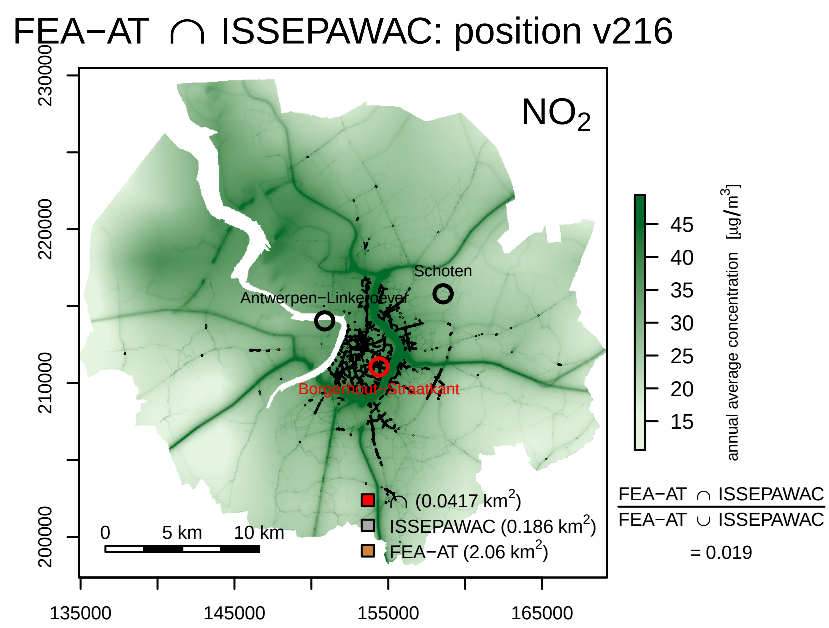

EPAIE ∩ SLB: position v216
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.0591 km2)
SLB (0.0591 km2)
EPAIE (3.44 km2)
EPAIE ∩ SLB / EPAIE ∪ SLB = 0.017
annual average concentration [µg/m3]
0 5 km 10 km


EPAIE ∩ VITO: position v216
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (3.44 km2)
VITO (160 km2)
EPAIE (3.44 km2)
EPAIE ∩ VITO / EPAIE ∪ VITO = 0.021
annual average concentration [µg/m3]
0 5 km 10 km

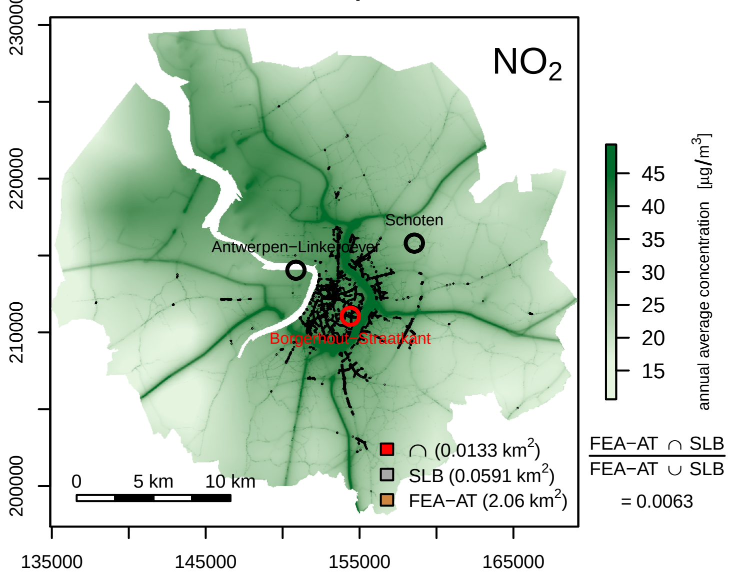

EPAIE ∩ VMM: position v216
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.482 km2)
VMM (0.63 km2)
EPAIE (3.44 km2)
EPAIE ∩ VMM / EPAIE ∪ VMM = 0.13
annual average concentration [µg/m3]
0 5 km 10 km


FEA−AT ∩ FI: position v216
NO$_2$
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.0856 km^2)
FI (0.565 km^2)
FEA−AT (2.06 km^2)
0
5 km
10 km
45
40
35
30
25
20
15
annual average concentration [µg/m^3]
$\frac{\text{FEA−AT} \cap \text{FI}}{\text{FEA−AT} \cup \text{FI}} = 0.034$
135000
145000
155000
165000
200000
210000
220000
230000

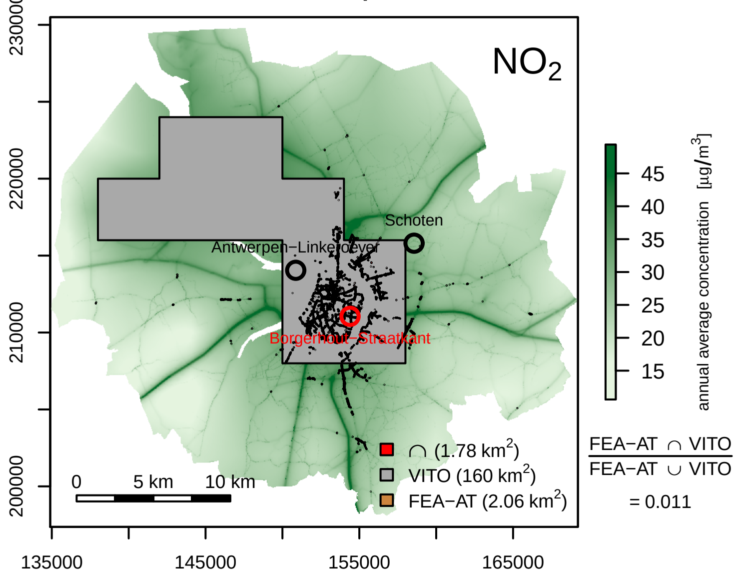

FEA−AT ∩ INERIS: position v216
NO$_2$
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.0617 km^2)
INERIS (4.37 km^2)
FEA−AT (2.06 km^2)
0
5 km
10 km
45
40
35
30
25
20
15
annual average concentration [µg/m^3]
$\frac{\text{FEA−AT} \cap \text{INERIS}}{\text{FEA−AT} \cup \text{INERIS}}$
= 0.0097
135000
145000
155000
165000
200000
210000
220000
230000


FEA−AT ∩ ISSEPAWAC: position v216
NO$_2$
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.0417 km^2)
ISSEPAWAC (0.186 km^2)
FEA−AT (2.06 km^2)
0
5 km
10 km
45
40
35
30
25
20
15
annual average concentration [µg/m^3]
$\frac{\text{FEA−AT} \cap \text{ISSEPAWAC}}{\text{FEA−AT} \cup \text{ISSEPAWAC}}$
= 0.019
135000
145000
155000
165000
200000
210000
220000
230000

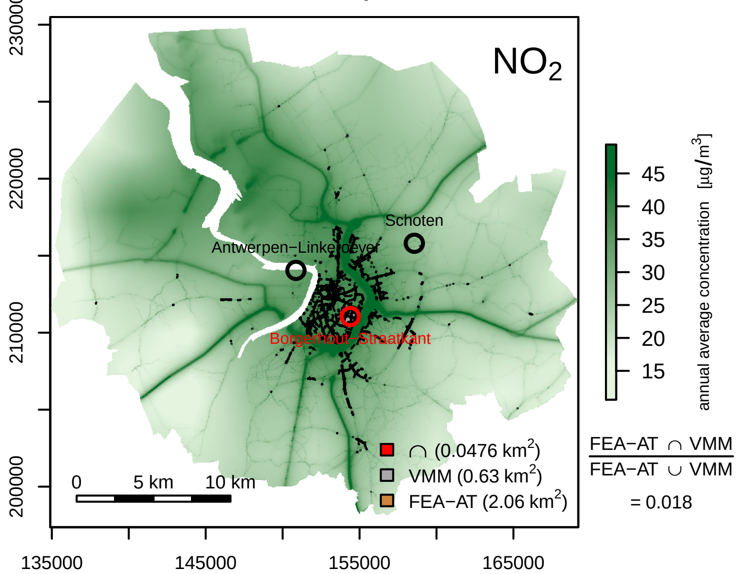
FEA−AT ∩ SLB: position v216

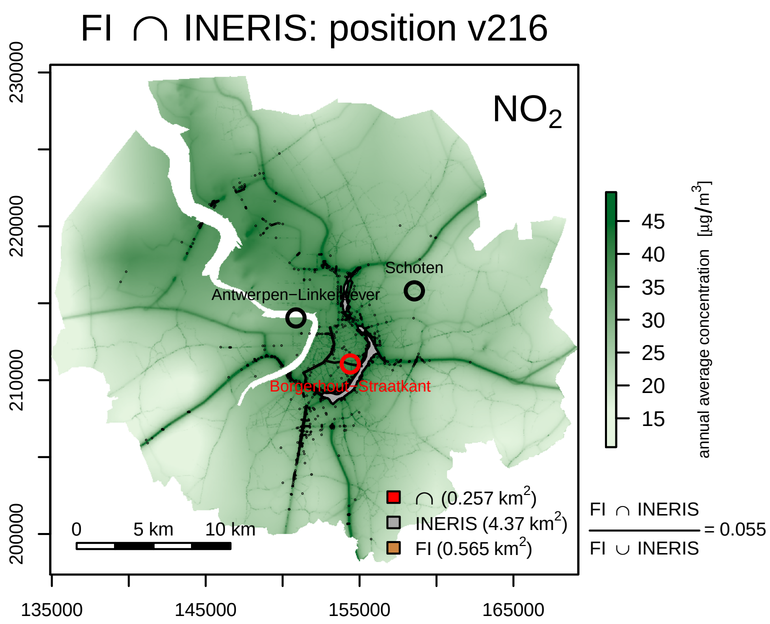


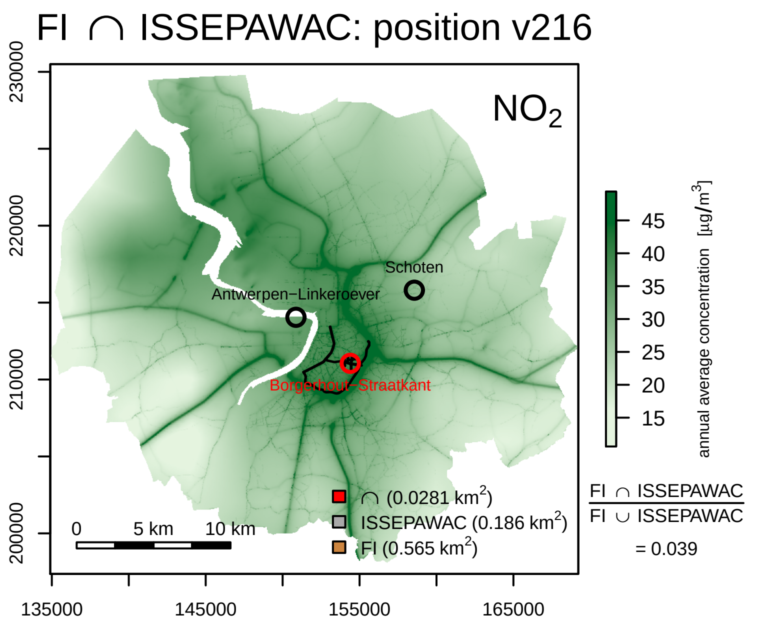
FEA−AT ∩ VITO: position v216

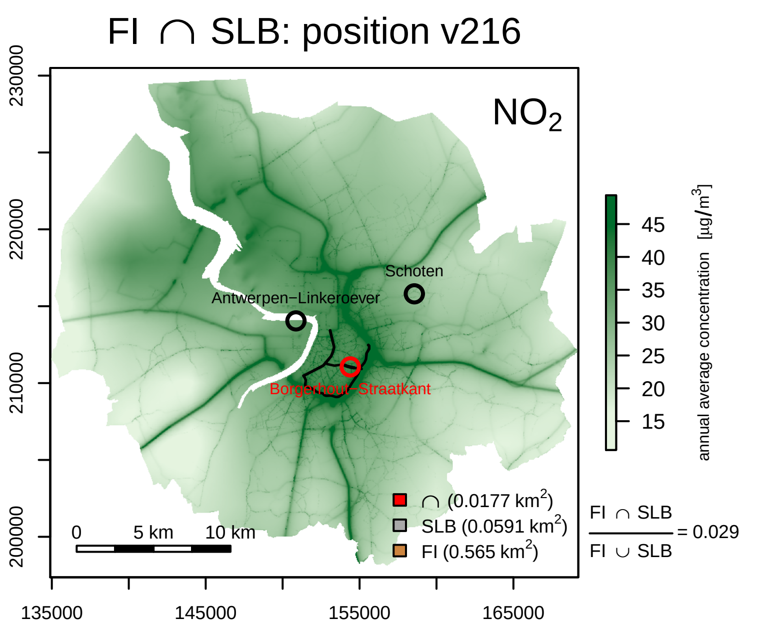


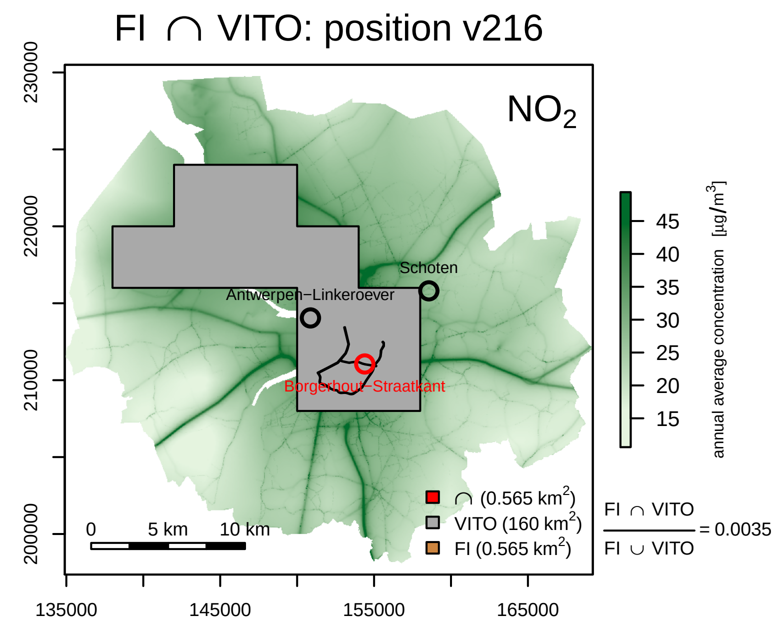
FEA−AT ∩ VMM: position v216

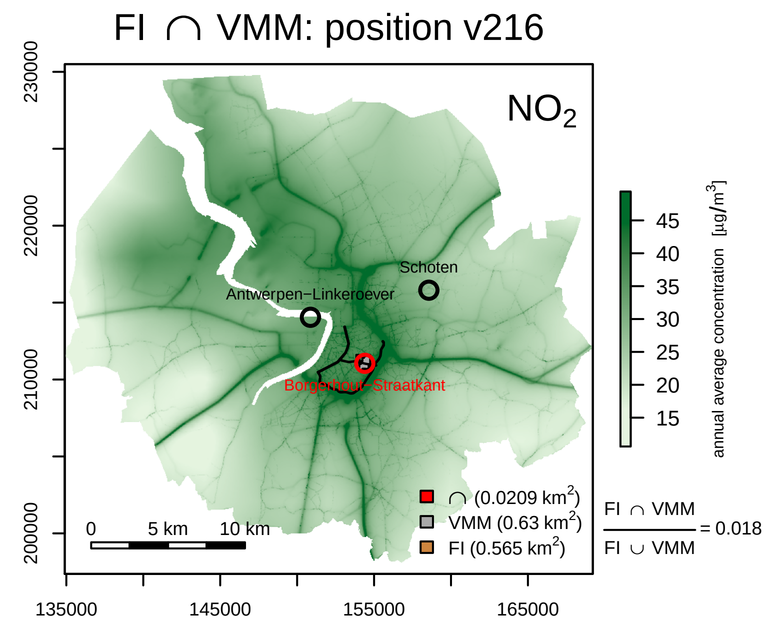


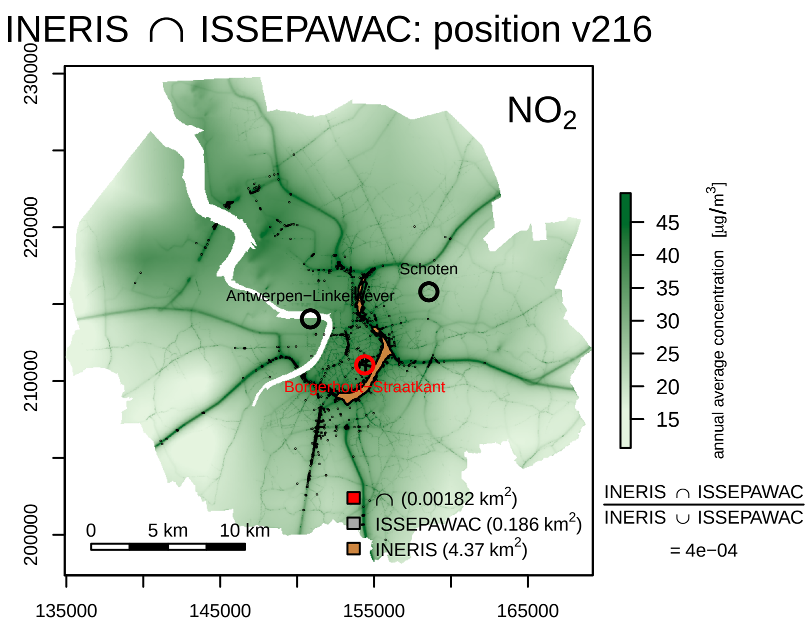

FI ∩ INERIS: position v216
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (0.257 km2)
INERIS (4.37 km2)
FI (0.565 km2)
45
40
35
30
25
20
15
annual average concentration [µg/m3]
FI ∩ INERIS / FI ∪ INERIS = 0.055
230000
220000
210000
200000
135000
145000
155000
165000

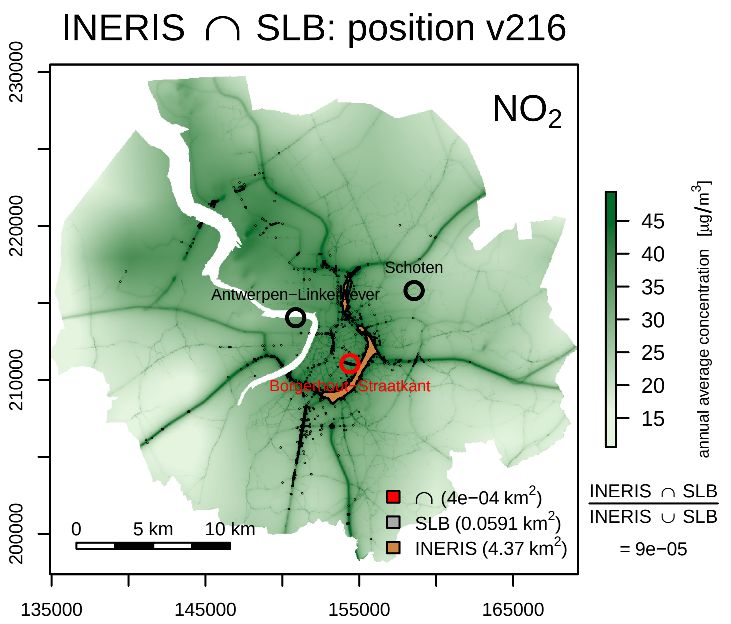

FI ∩ ISSEPAWAC: position v216
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (0.0281 km2)
ISSEPAWAC (0.186 km2)
FI (0.565 km2)
45
40
35
30
25
20
15
annual average concentration [µg/m3]
FI ∩ ISSEPAWAC / FI ∪ ISSEPAWAC = 0.039
230000
220000
210000
200000
135000
145000
155000
165000

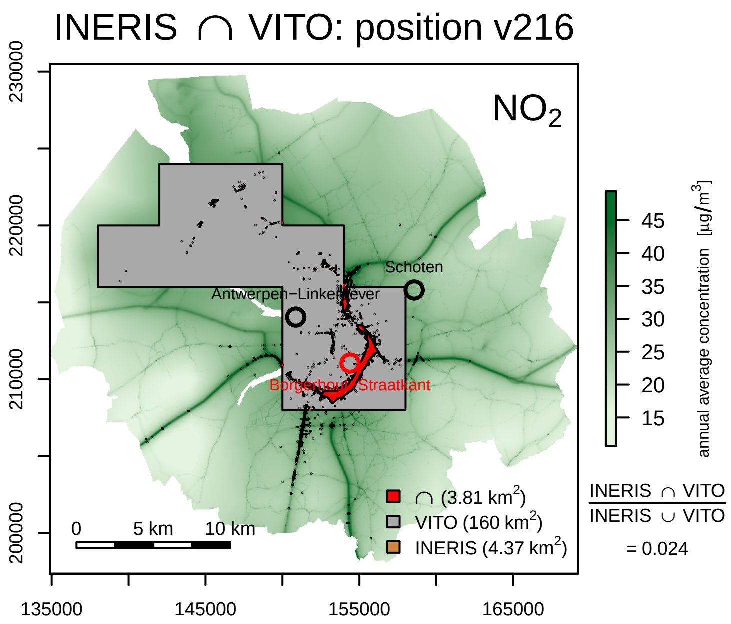

FI ∩ SLB: position v216
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (0.0177 km2)
SLB (0.0591 km2)
FI (0.565 km2)
45
40
35
30
25
20
15
annual average concentration [µg/m3]
FI ∩ SLB / FI ∪ SLB = 0.029
230000
220000
210000
200000
135000
145000
155000
165000

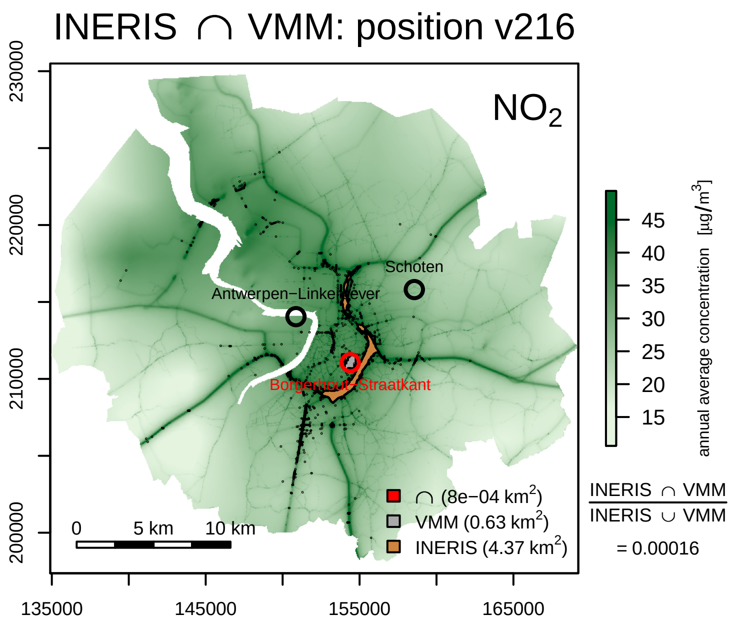

FI ∩ VITO: position v216
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.565 km2)
VITO (160 km2)
FI (0.565 km2)
0
5 km
10 km
annual average concentration [µg/m3]
45
40
35
30
25
20
15
FI ∩ VITO / FI ∪ VITO = 0.0035
230000
220000
210000
200000
135000
145000
155000
165000

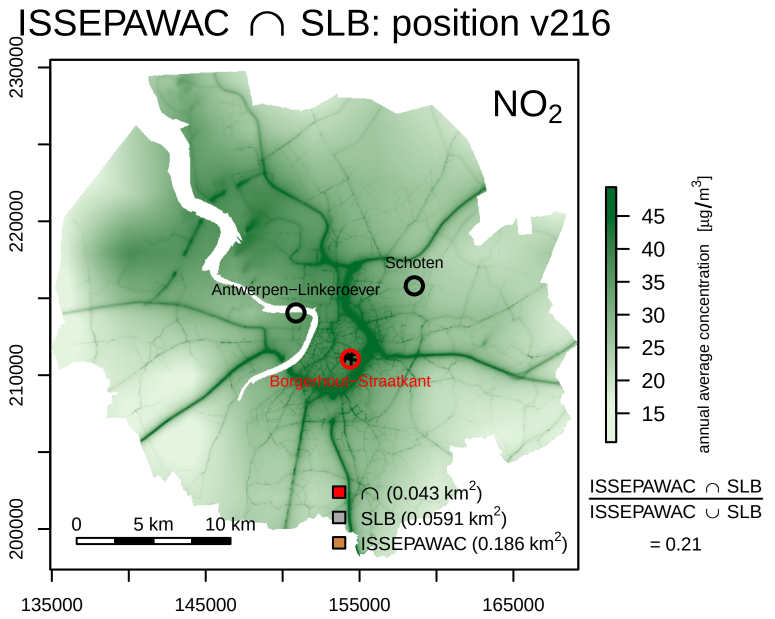

FI ∩ VMM: position v216
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.0209 km2)
VMM (0.63 km2)
FI (0.565 km2)
0
5 km
10 km
annual average concentration [µg/m3]
45
40
35
30
25
20
15
FI ∩ VMM / FI ∪ VMM = 0.018
230000
220000
210000
200000
135000
145000
155000
165000

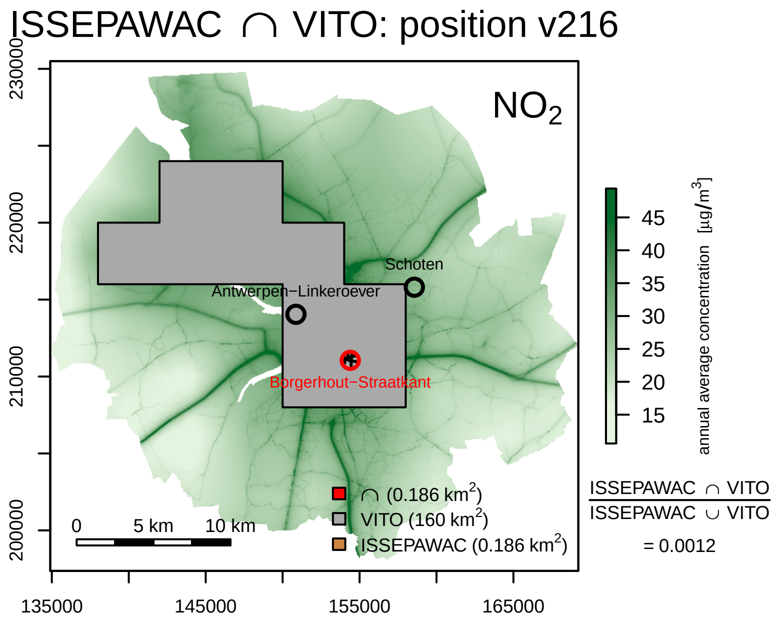

INERIS ∩ ISSEPAWAC: position v216
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.00182 km2)
ISSEPAWAC (0.186 km2)
INERIS (4.37 km2)
0
5 km
10 km
annual average concentration [µg/m3]
45
40
35
30
25
20
15
INERIS ∩ ISSEPAWAC / INERIS ∪ ISSEPAWAC = 4e−04
230000
220000
210000
200000
135000
145000
155000
165000

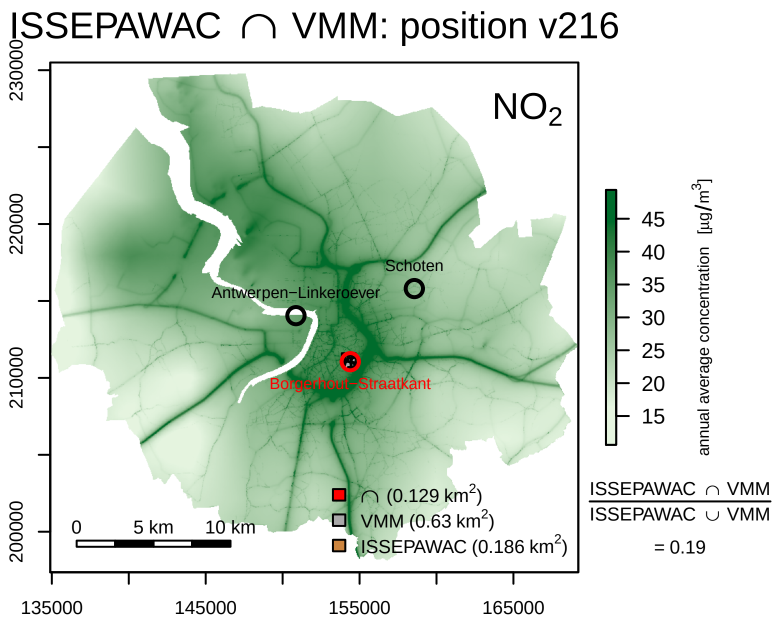

INERIS ∩ SLB: position v216
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (4e−04 km²)
SLB (0.0591 km²)
INERIS (4.37 km²)
0
5 km
10 km
annual average concentration [µg/m³]
INERIS ∩ SLB / INERIS ∪ SLB = 9e−05

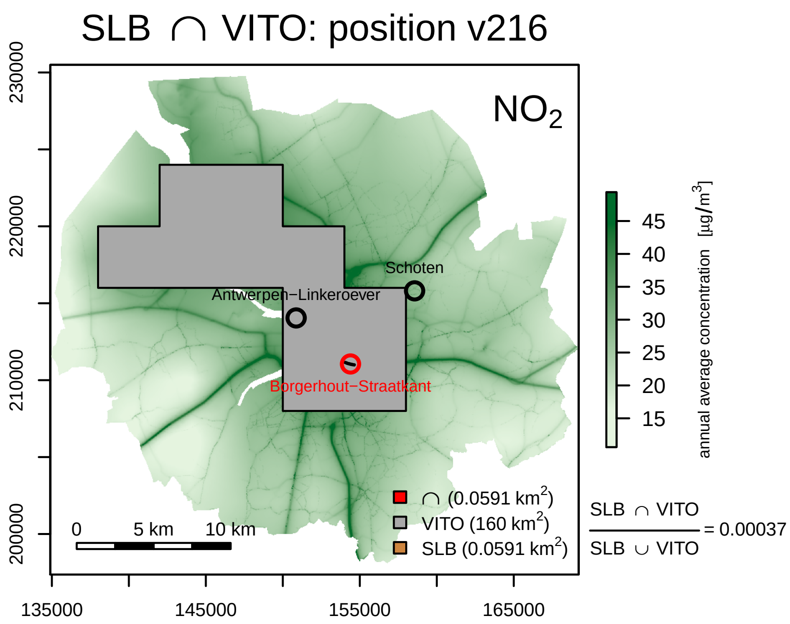

INERIS ∩ VITO: position v216
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (3.81 km²)
VITO (160 km²)
INERIS (4.37 km²)
0
5 km
10 km
annual average concentration [µg/m³]
INERIS ∩ VITO / INERIS ∪ VITO = 0.024

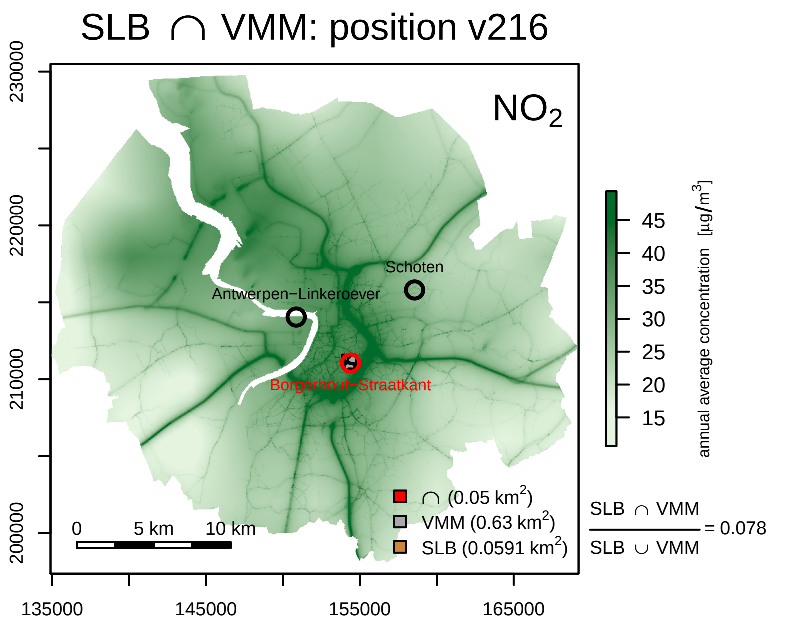

INERIS ∩ VMM: position v216
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (8e−04 km²)
VMM (0.63 km²)
INERIS (4.37 km²)
0
5 km
10 km
annual average concentration [µg/m³]
INERIS ∩ VMM / INERIS ∪ VMM = 0.00016

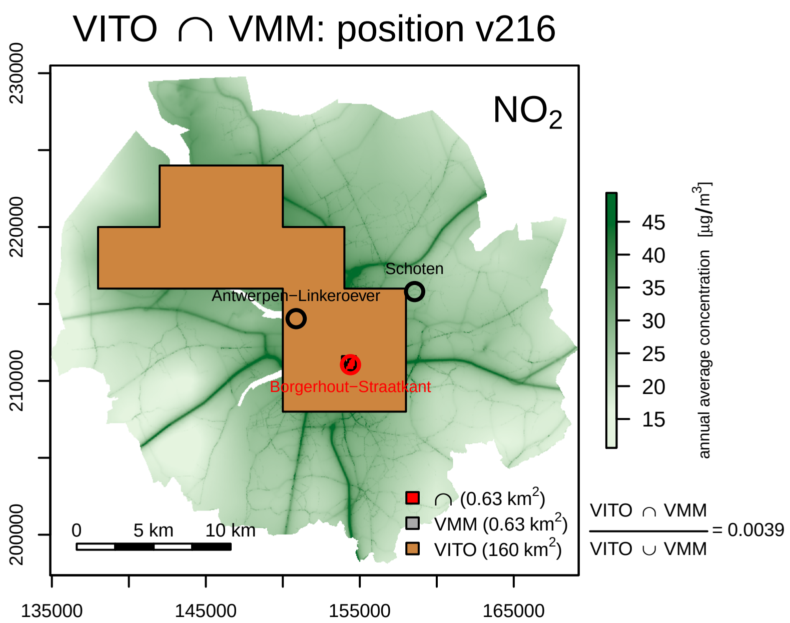

ISSEPAWAC ∩ SLB: position v216
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (0.043 km2)
SLB (0.0591 km2)
ISSEPAWAC (0.186 km2)
45
40
35
30
25
20
15
annual average concentration [µg/m3]
ISSEPAWAC ∩ SLB
ISSEPAWAC ∪ SLB
= 0.21
230000
220000
210000
200000
135000
145000
155000
165000


ISSEPAWAC ∩ VITO: position v216
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (0.186 km2)
VITO (160 km2)
ISSEPAWAC (0.186 km2)
45
40
35
30
25
20
15
annual average concentration [µg/m3]
ISSEPAWAC ∩ VITO
ISSEPAWAC ∪ VITO
= 0.0012
230000
220000
210000
200000
135000
145000
155000
165000


ISSEPAWAC ∩ VMM: position v216
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (0.129 km2)
VMM (0.63 km2)
ISSEPAWAC (0.186 km2)
45
40
35
30
25
20
15
annual average concentration [µg/m3]
ISSEPAWAC ∩ VMM
ISSEPAWAC ∪ VMM
= 0.19
230000
220000
210000
200000
135000
145000
155000
165000


SLB ∩ VITO: position v216
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.0591 km2)
VITO (160 km2)
SLB (0.0591 km2)
0 5 km 10 km
45 40 35 30 25 20 15
annual average concentration [µg/m3]
SLB ∩ VITO / SLB ∪ VITO = 0.00037
230000 220000 210000 200000
135000 145000 155000 165000

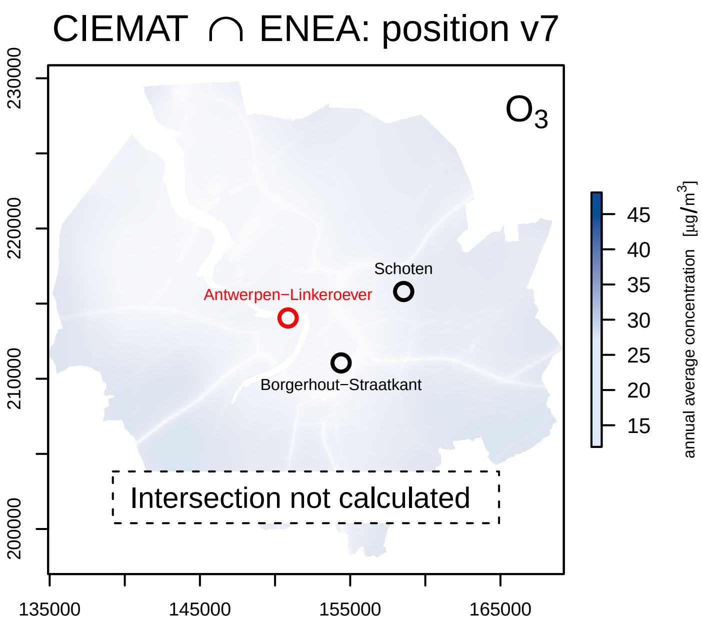

SLB ∩ VMM: position v216
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.05 km2)
VMM (0.63 km2)
SLB (0.0591 km2)
0 5 km 10 km
45 40 35 30 25 20 15
annual average concentration [µg/m3]
SLB ∩ VMM / SLB ∪ VMM = 0.078
230000 220000 210000 200000
135000 145000 155000 165000

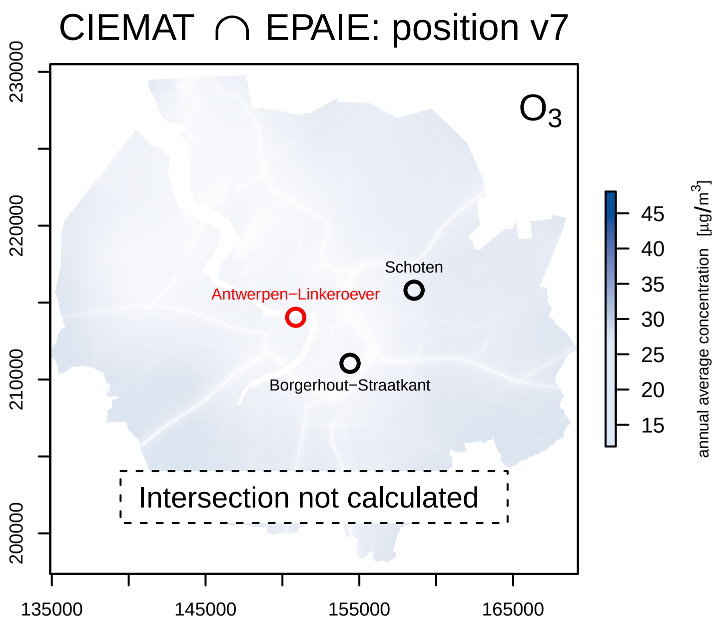

VITO ∩ VMM: position v216
NO2
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.63 km2)
VMM (0.63 km2)
VITO (160 km2)
0 5 km 10 km
45 40 35 30 25 20 15
annual average concentration [µg/m3]
VITO ∩ VMM / VITO ∪ VMM = 0.0039
230000 220000 210000 200000
135000 145000 155000 165000

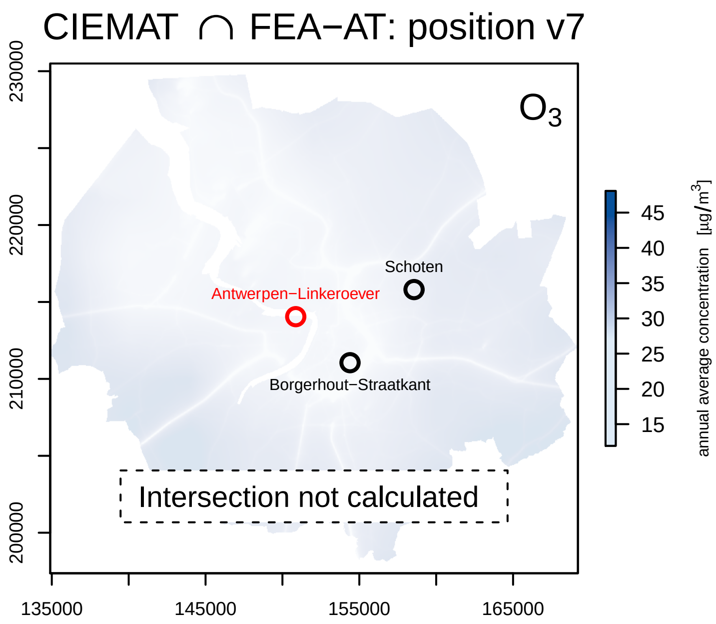
Mutual Comparisons between Teams

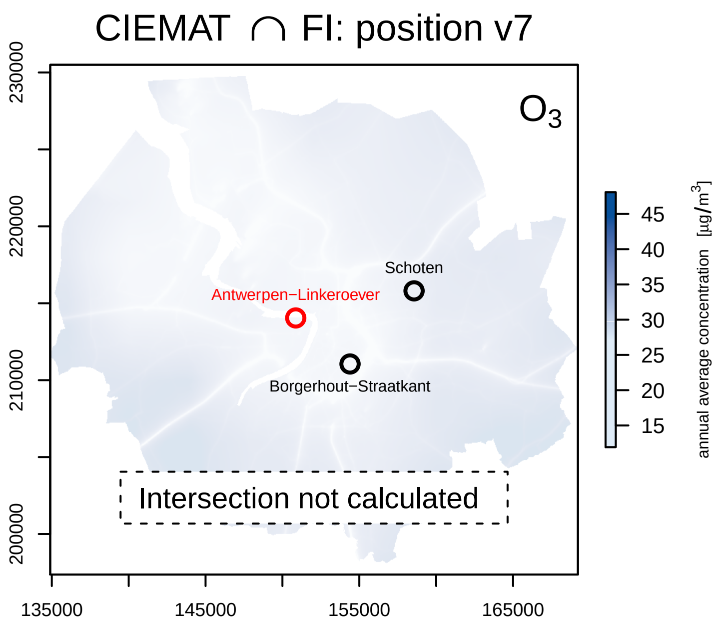
by Pollutant & Station:

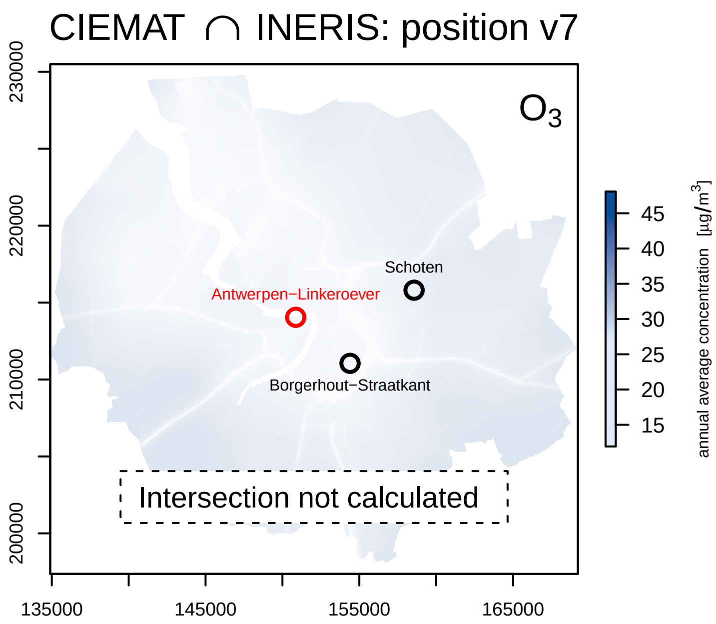
O_3 at virtual station v7

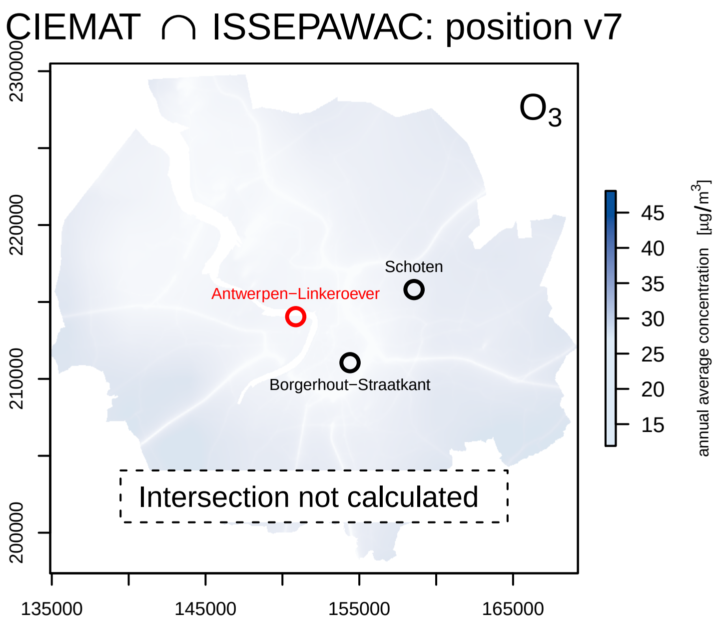

CIEMAT ∩ ENEA: position v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
annual average concentration [µg/m3]
45
40
35
30
25
20
15
230000
220000
210000
200000
135000
145000
155000
165000

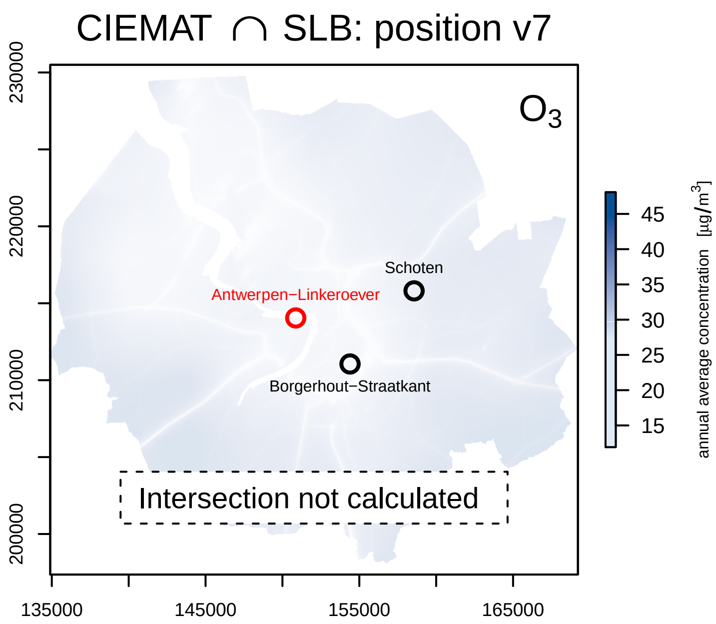

CIEMAT ∩ EPAIE: position v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
annual average concentration [µg/m3]
45
40
35
30
25
20
15
230000
220000
210000
200000
135000
145000
155000
165000

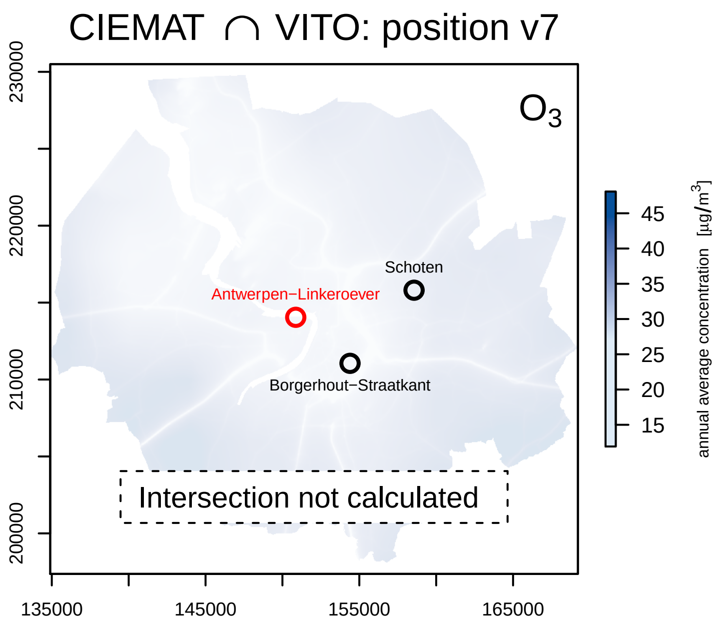

CIEMAT ∩ FEA−AT: position v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
annual average concentration [µg/m3]
45
40
35
30
25
20
15
230000
220000
210000
200000
135000
145000
155000
165000

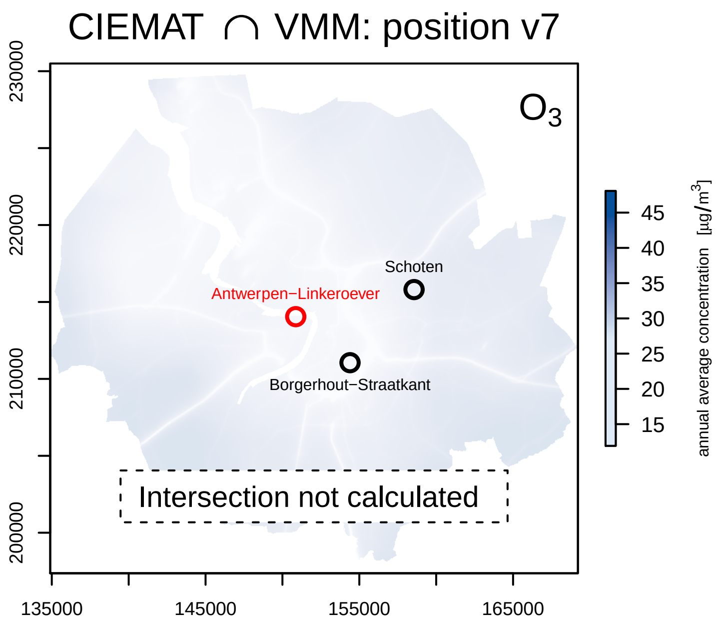

CIEMAT ∩ FI: position v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

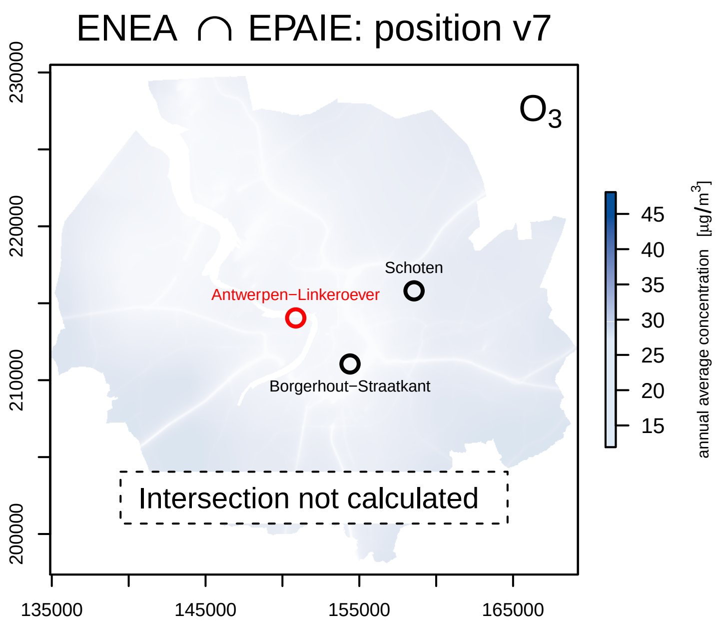

CIEMAT ∩ INERIS: position v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

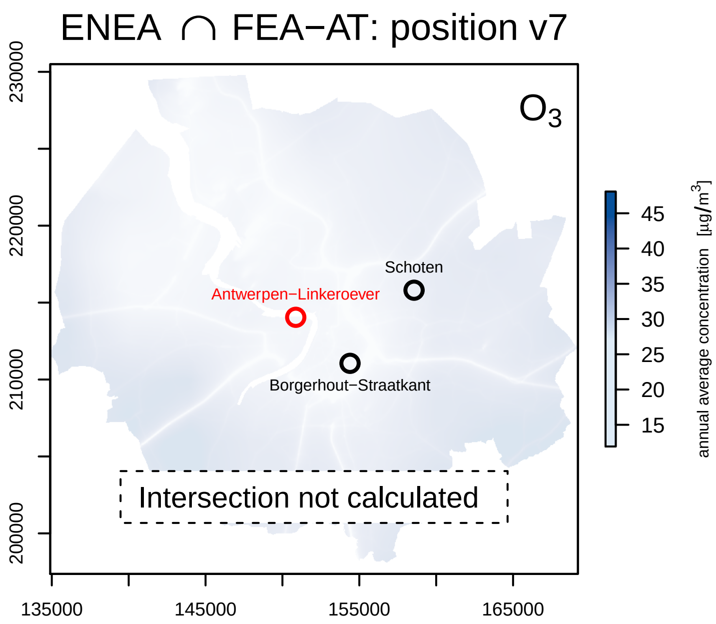

CIEMAT ∩ ISSEPAWAC: position v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

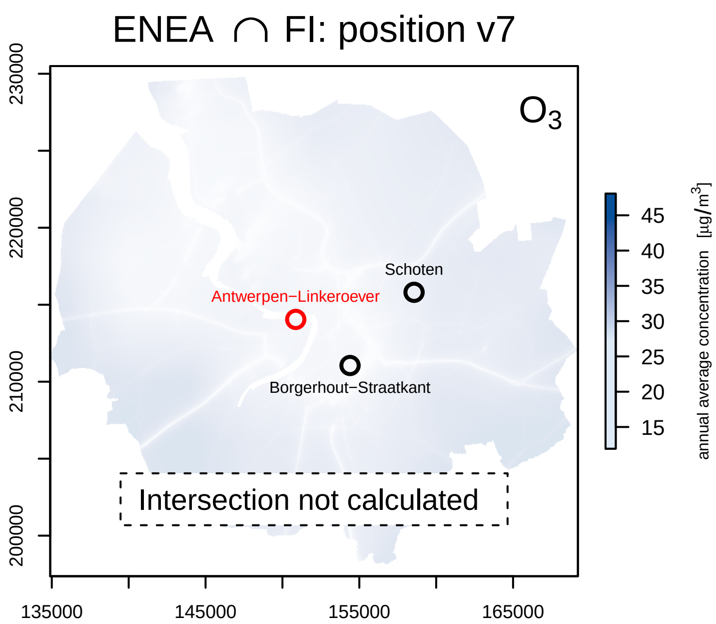

CIEMAT ∩ SLB: position v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

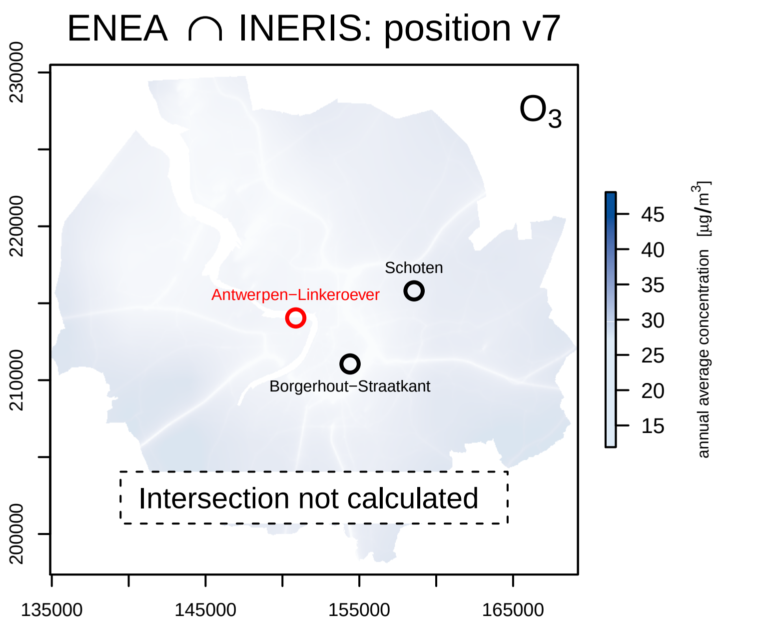

CIEMAT ∩ VITO: position v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

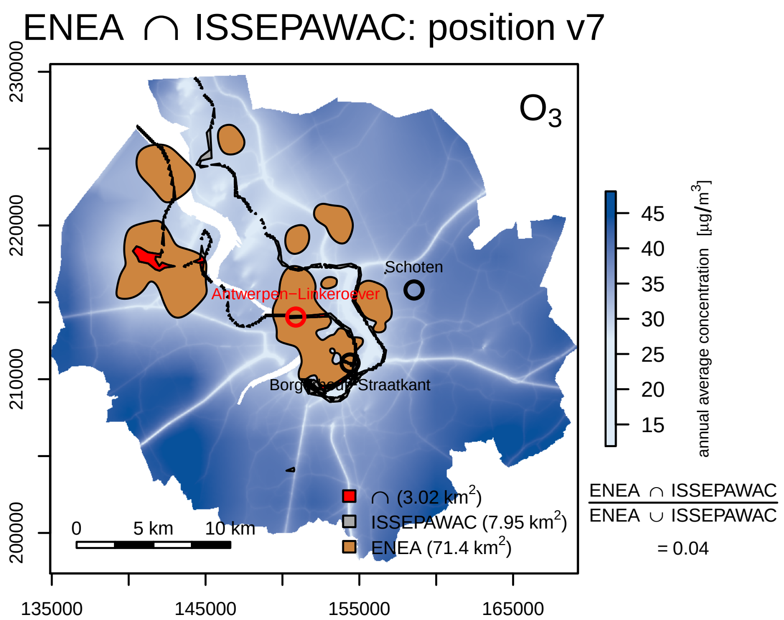

CIEMAT ∩ VMM: position v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

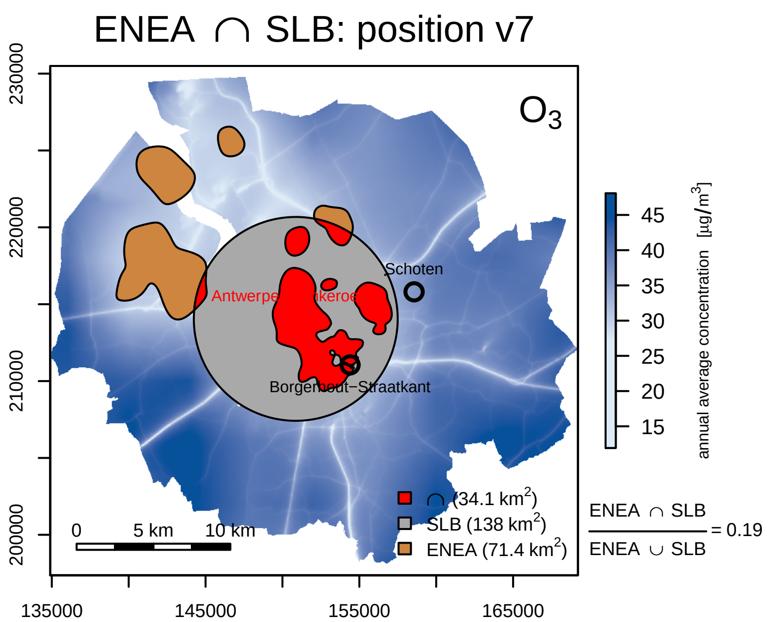

ENEA ∩ EPAIE: position v7
O_3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m^3]

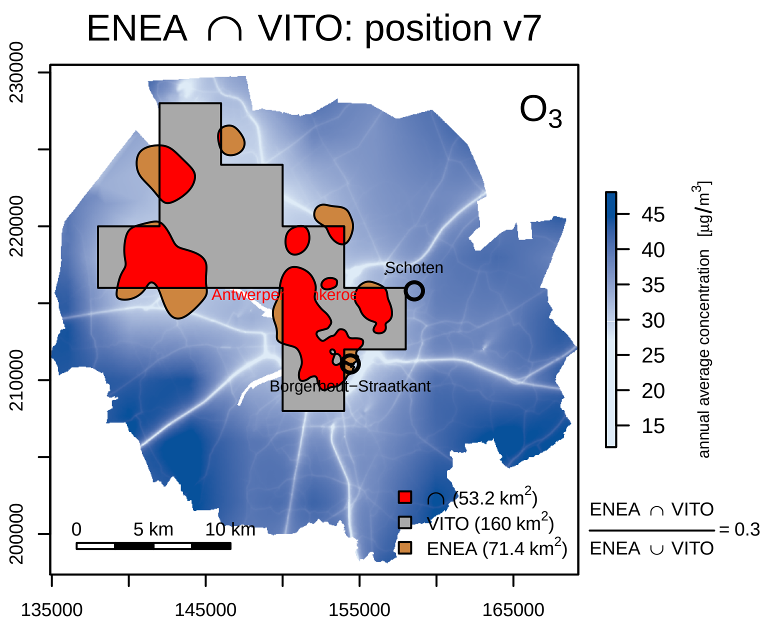

ENEA ∩ FEA−AT: position v7
O_3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m^3]

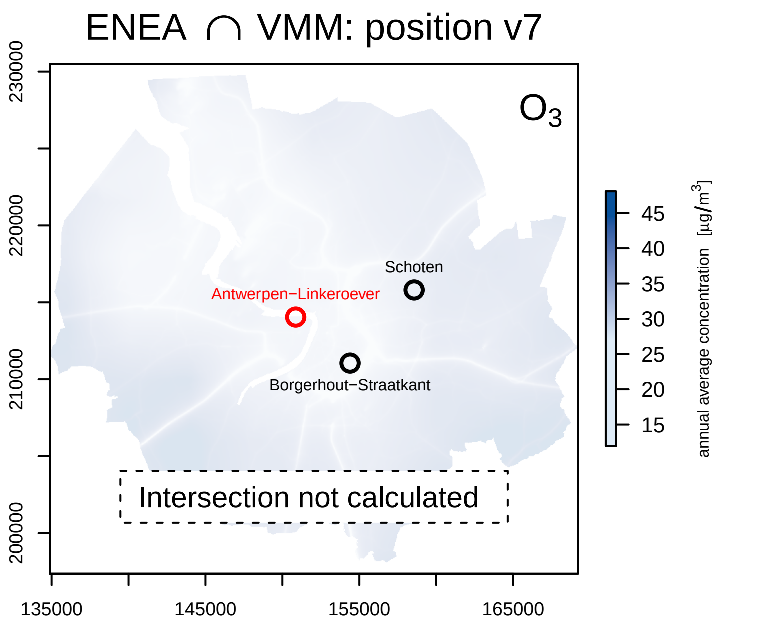

ENEA ∩ FI: position v7
O_3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m^3]

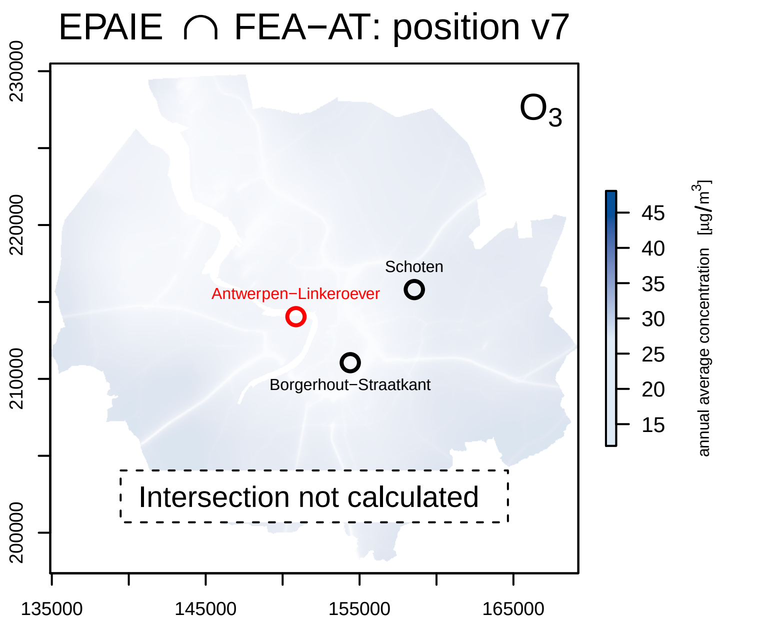

ENEA ∩ INERIS: position v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
annual average concentration [µg/m3]
45
40
35
30
25
20
15
230000
220000
210000
200000
135000
145000
155000
165000

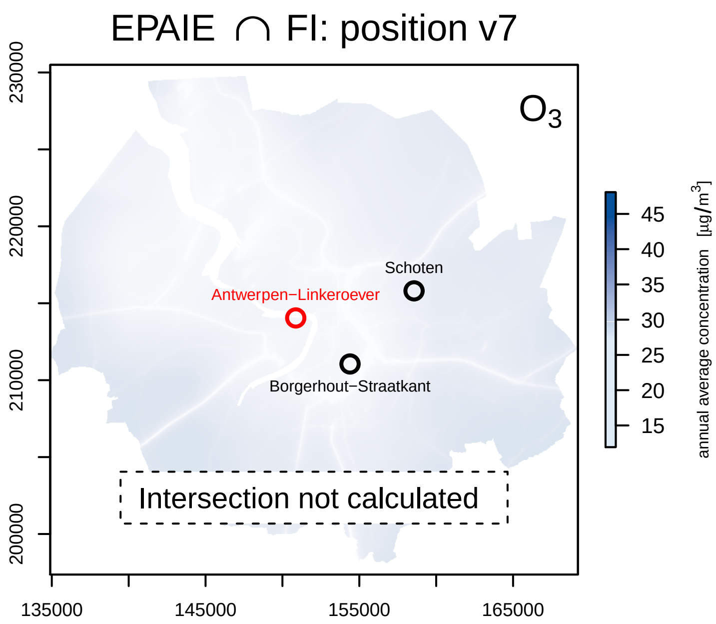

ENEA ∩ ISSEPAWAC: position v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (3.02 km2)
ISSEPAWAC (7.95 km2)
ENEA (71.4 km2)
ENEA ∩ ISSEPAWAC / ENEA ∪ ISSEPAWAC = 0.04
annual average concentration [µg/m3]
45
40
35
30
25
20
15
230000
220000
210000
200000
135000
145000
155000
165000

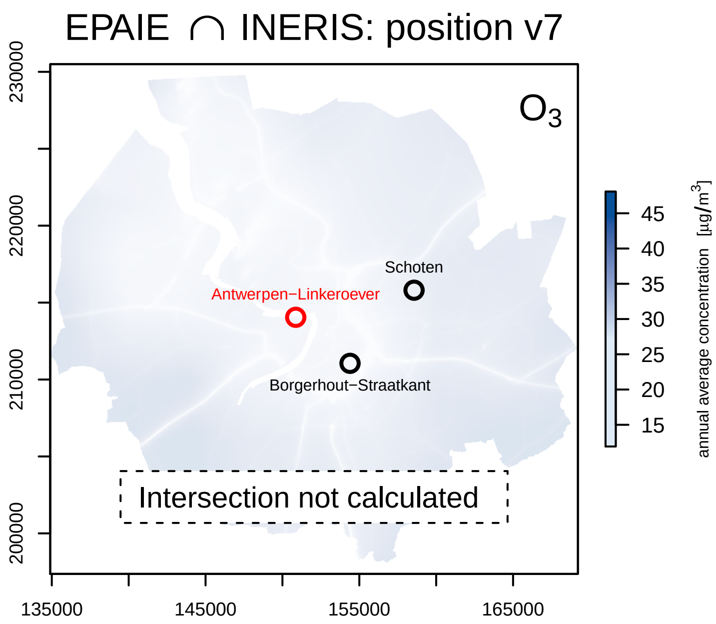

ENEA ∩ SLB: position v7
O3
Schoten
Borgerhout−Straatkant
0 5 km 10 km
∩ (34.1 km2)
SLB (138 km2)
ENEA (71.4 km2)
ENEA ∩ SLB / ENEA ∪ SLB = 0.19
annual average concentration [µg/m3]
45
40
35
30
25
20
15
230000
220000
210000
200000
135000
145000
155000
165000

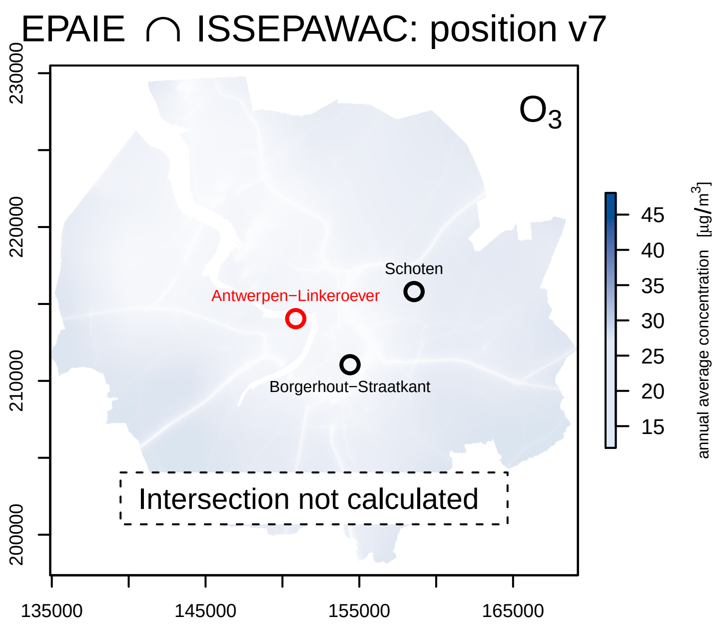

ENEA ∩ VITO: position v7
O3
Schoten
Borgerhout−Straatkant
0
5 km
10 km
∩ (53.2 km2)
VITO (160 km2)
ENEA (71.4 km2)
45
40
35
30
25
20
15
annual average concentration [µg/m3]
ENEA ∩ VITO
ENEA ∪ VITO
= 0.3
230000
220000
210000
200000
135000
145000
155000
165000

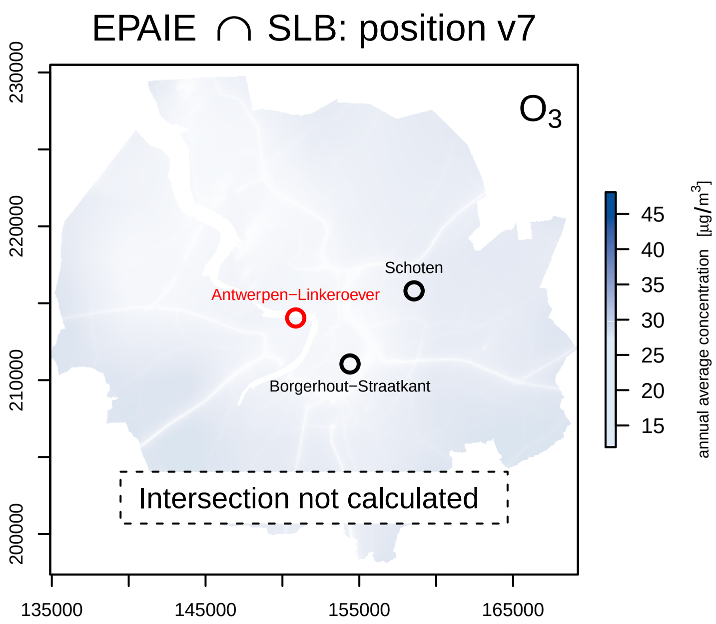

ENEA ∩ VMM: position v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
45
40
35
30
25
20
15
annual average concentration [µg/m3]
230000
220000
210000
200000
135000
145000
155000
165000

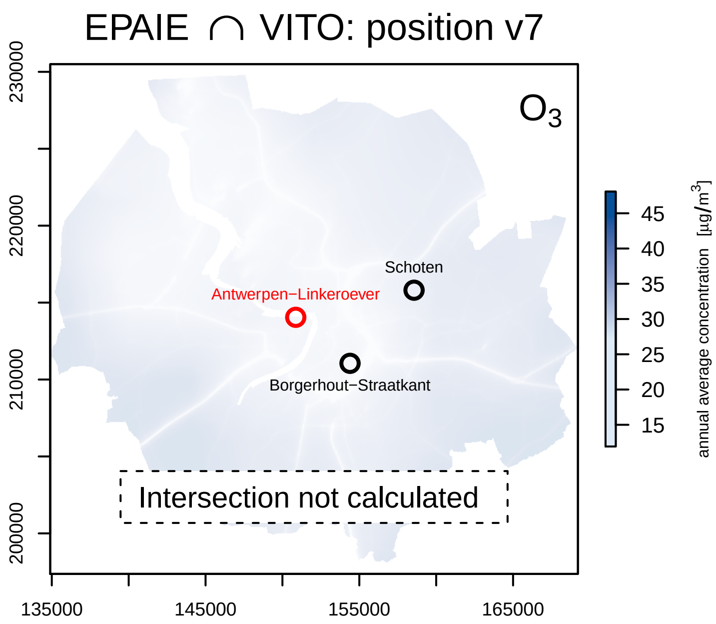

EPAIE ∩ FEA−AT: position v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
45
40
35
30
25
20
15
annual average concentration [µg/m3]
230000
220000
210000
200000
135000
145000
155000
165000

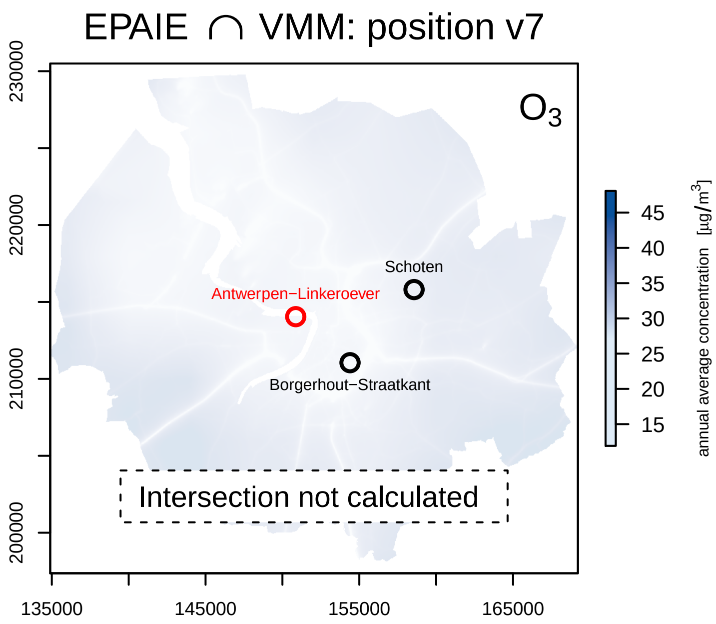

EPAIE ∩ FI: position v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

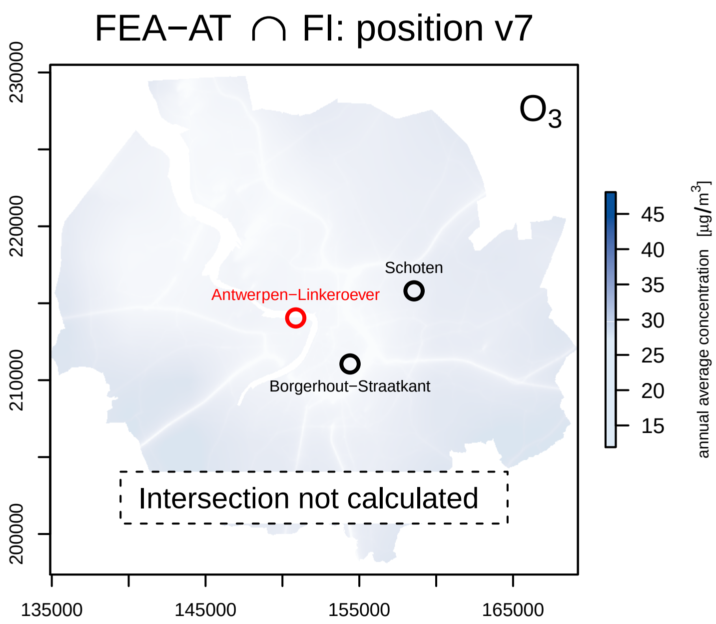

EPAIE ∩ INERIS: position v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

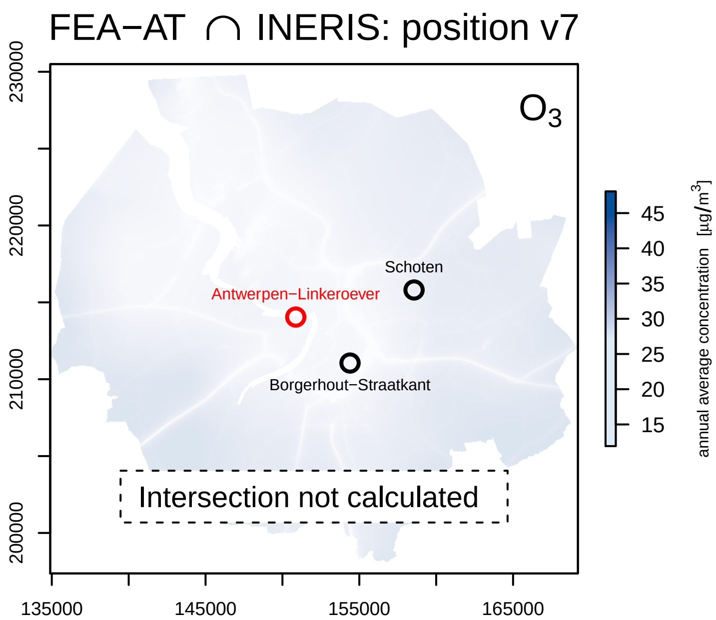

EPAIE ∩ ISSEPAWAC: position v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

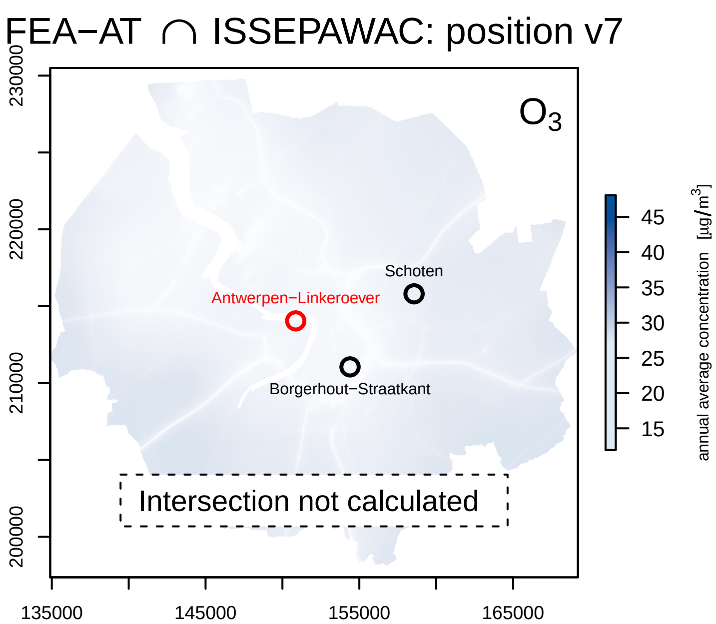

EPAIE ∩ SLB: position v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

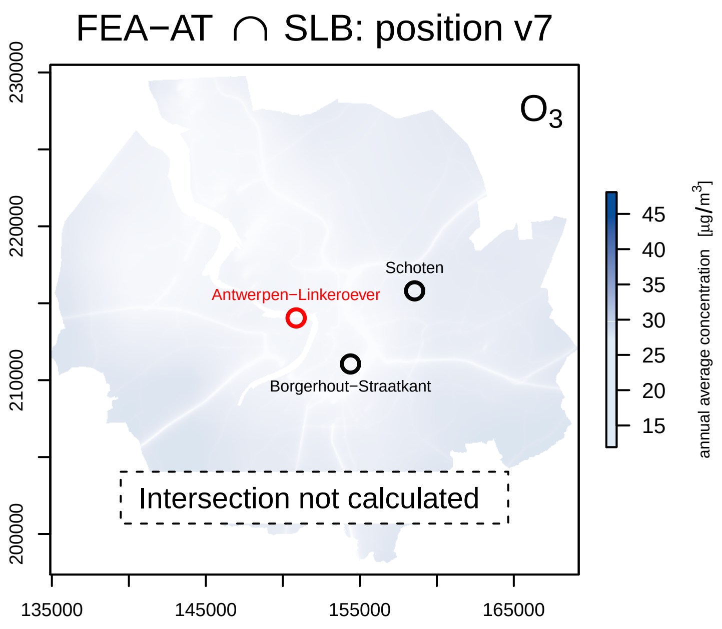

EPAIE ∩ VITO: position v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

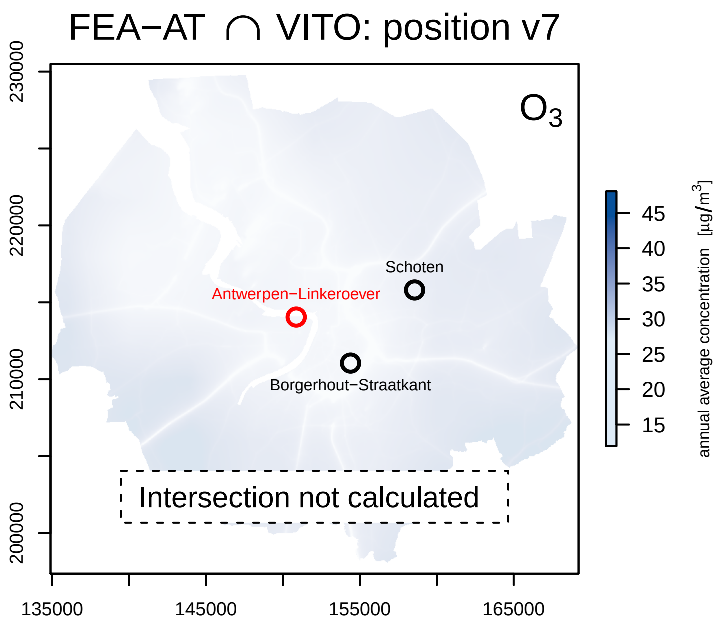

EPAIE ∩ VMM: position v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

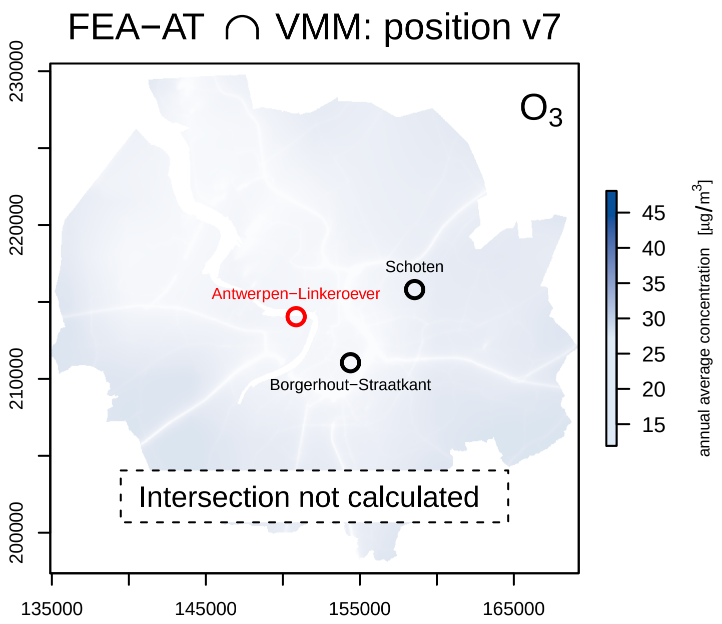

FEA−AT ∩ FI: position v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

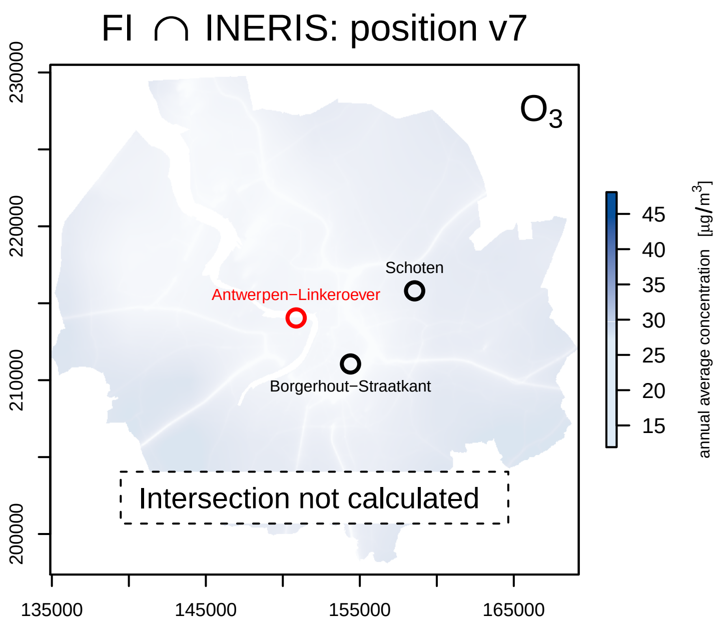

FEA−AT ∩ INERIS: position v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]


FEA−AT ∩ ISSEPAWAC: position v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

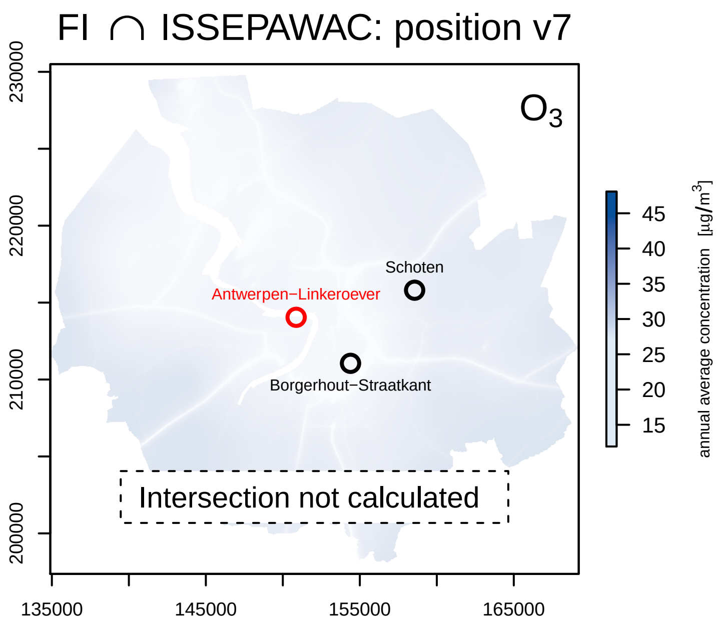

FEA−AT ∩ SLB: position v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
annual average concentration [µg/m3]
45
40
35
30
25
20
15
230000
220000
210000
200000
135000
145000
155000
165000


FEA−AT ∩ VITO: position v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
annual average concentration [µg/m3]
45
40
35
30
25
20
15
230000
220000
210000
200000
135000
145000
155000
165000

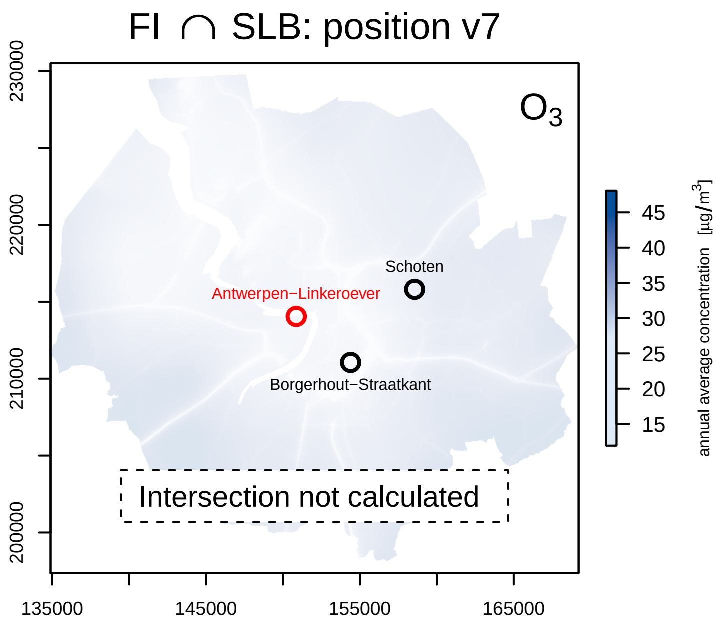

FEA−AT ∩ VMM: position v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
annual average concentration [µg/m3]
45
40
35
30
25
20
15
230000
220000
210000
200000
135000
145000
155000
165000



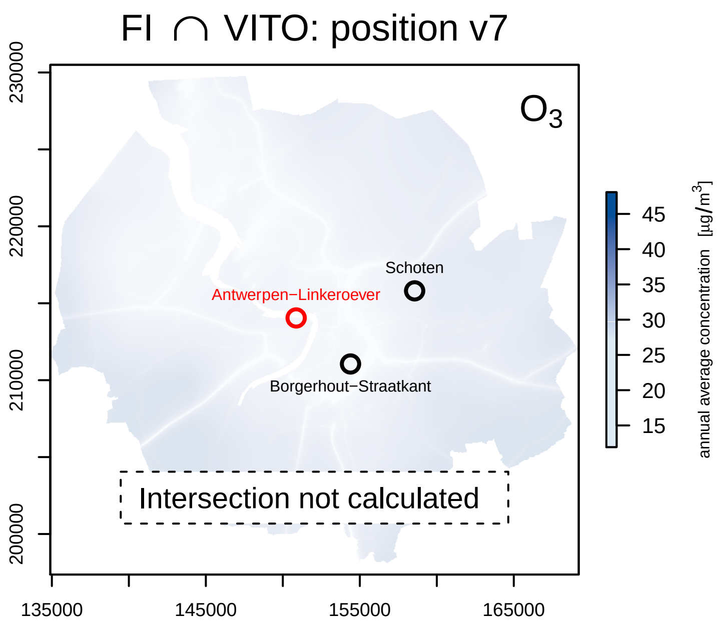
FI ∩ INERIS: position v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

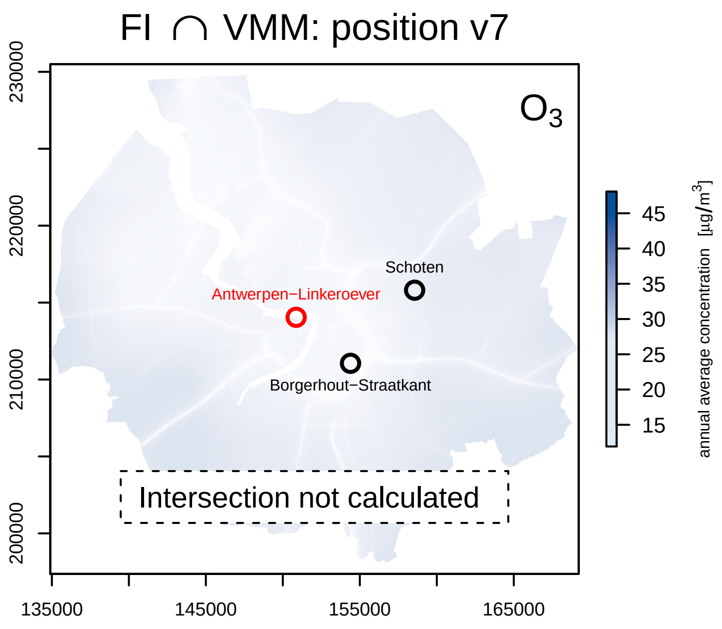


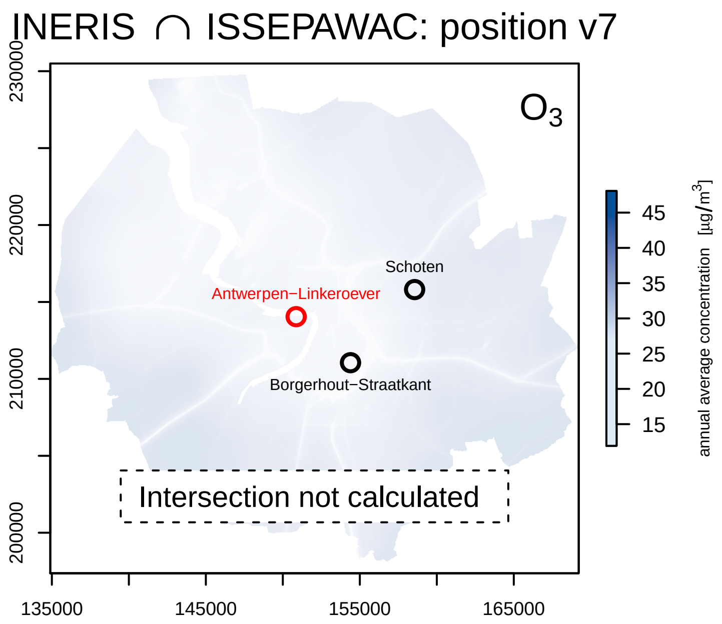
FI ∩ ISSEPAWAC: position v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

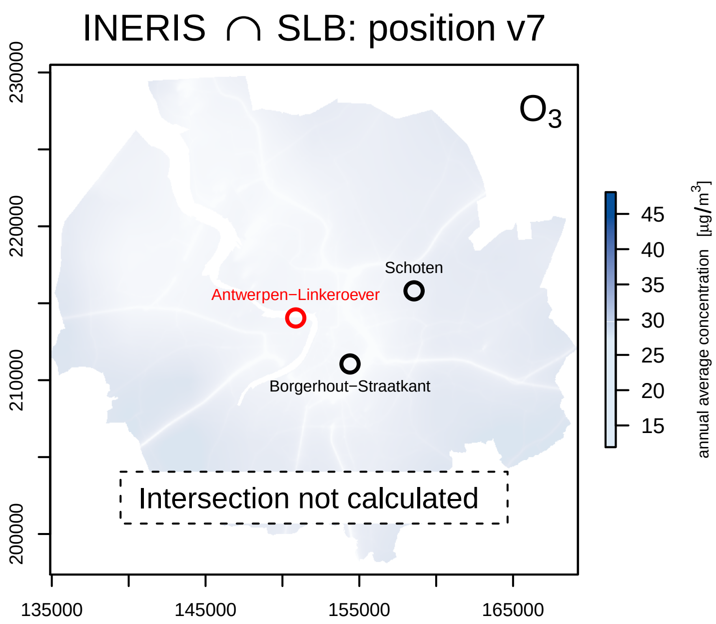


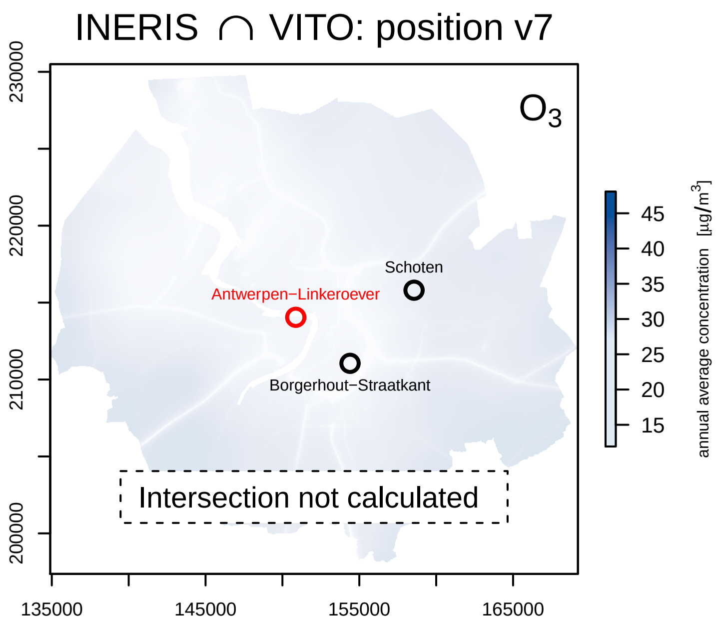
FI ∩ SLB: position v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

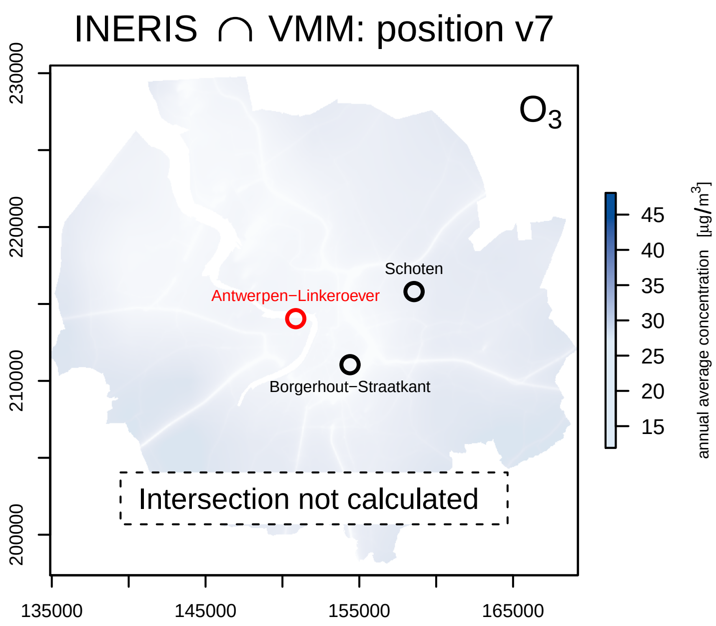

FI ∩ VITO: position v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]


FI ∩ VMM: position v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

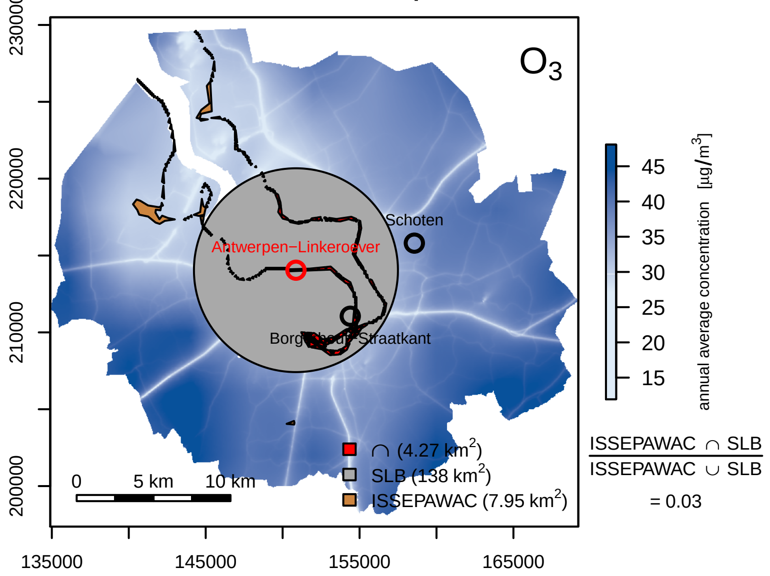

INERIS ∩ ISSEPAWAC: position v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]


INERIS ∩ SLB: position v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

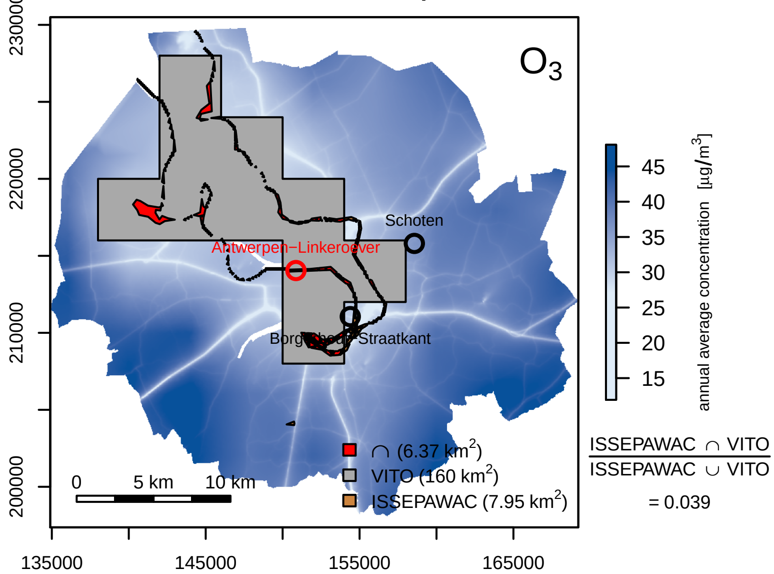

INERIS ∩ VITO: position v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]


INERIS ∩ VMM: position v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

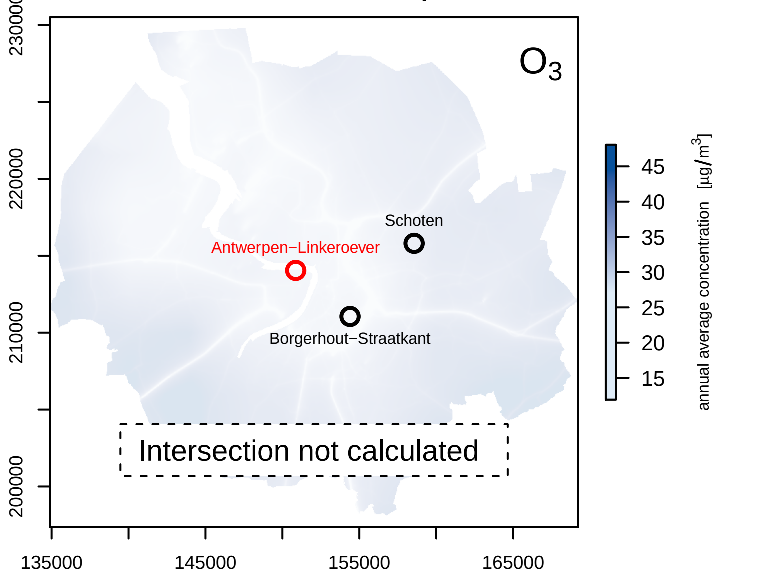
ISSEPAWAC ∩ SLB: position v7

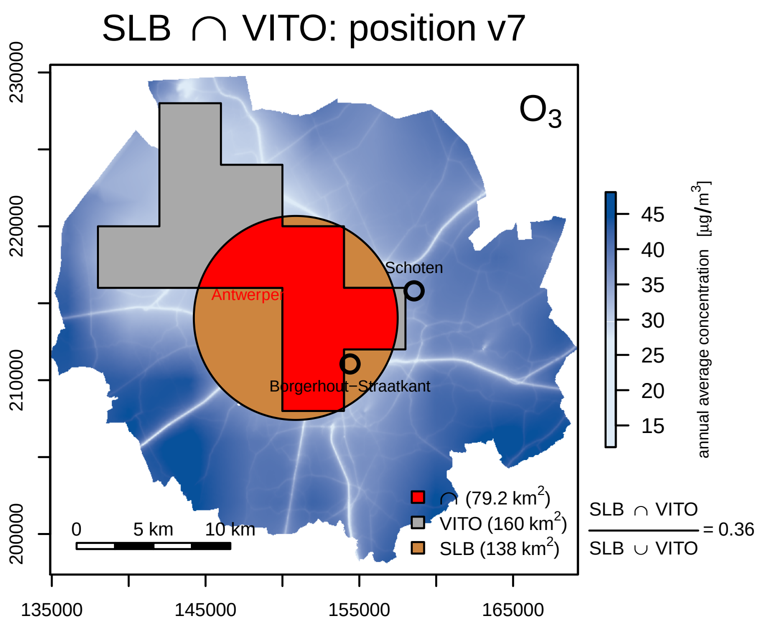


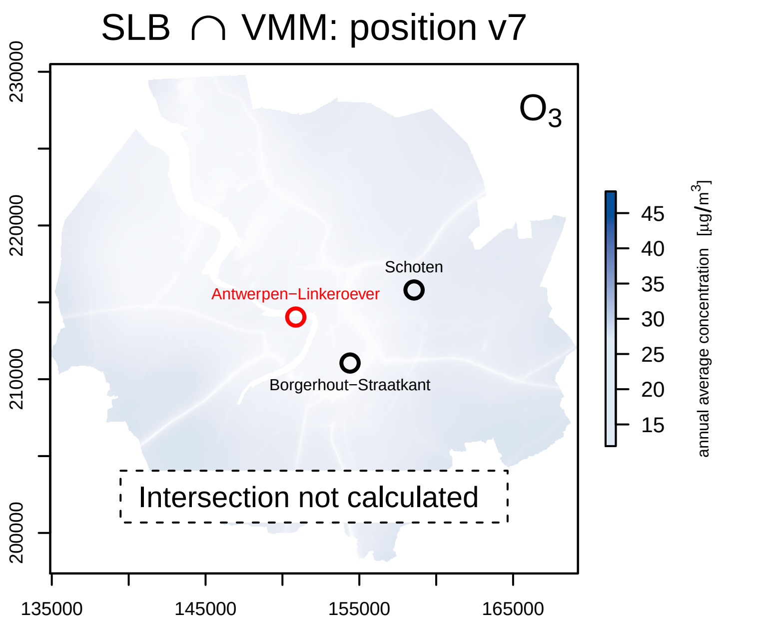
ISSEPAWAC ∩ VITO: position v7

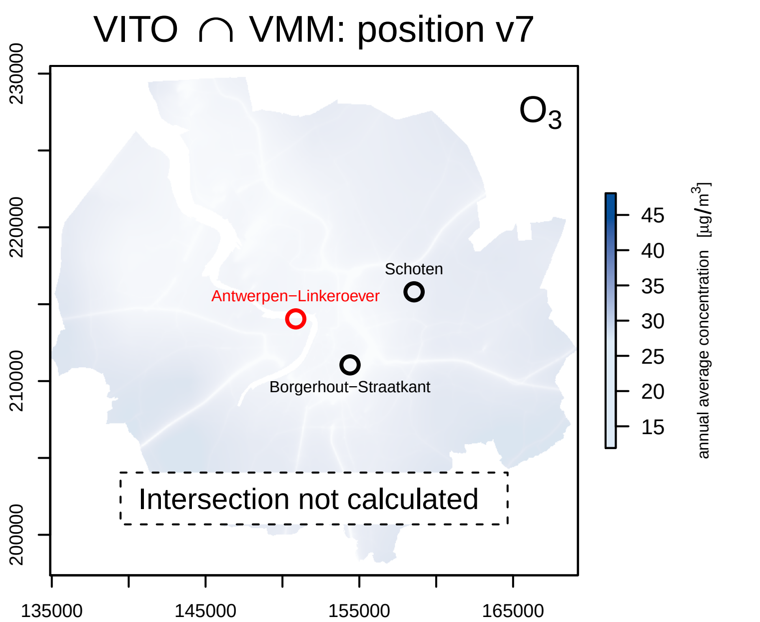


ISSEPAWAC ∩ VMM: position v7




SLB ∩ VITO: position v7
O3
Schoten
Antwerpen
Borgerhout−Straatkant
0
5 km
10 km
∩ (79.2 km2)
VITO (160 km2)
SLB (138 km2)
SLB ∩ VITO
SLB ∪ VITO
= 0.36
45
40
35
30
25
20
15
annual average concentration [µg/m3]
230000
220000
210000
200000
135000
145000
155000
165000

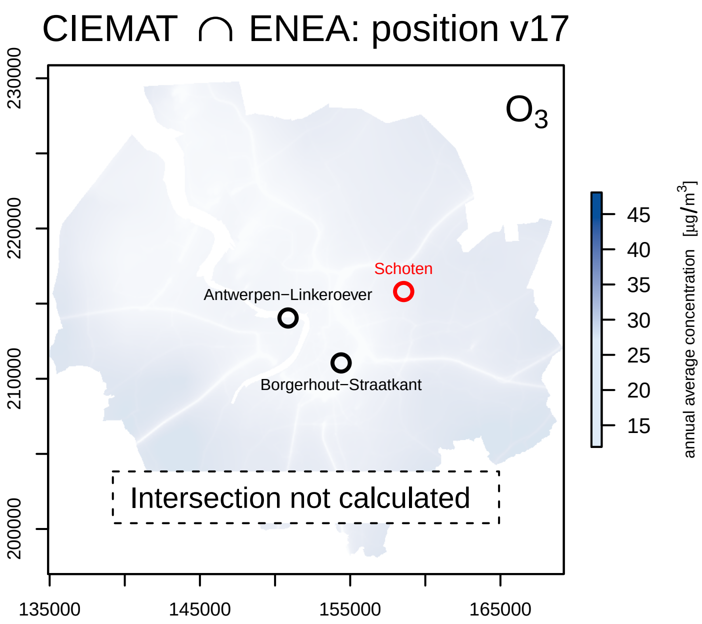

SLB ∩ VMM: position v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
45
40
35
30
25
20
15
annual average concentration [µg/m3]
230000
220000
210000
200000
135000
145000
155000
165000

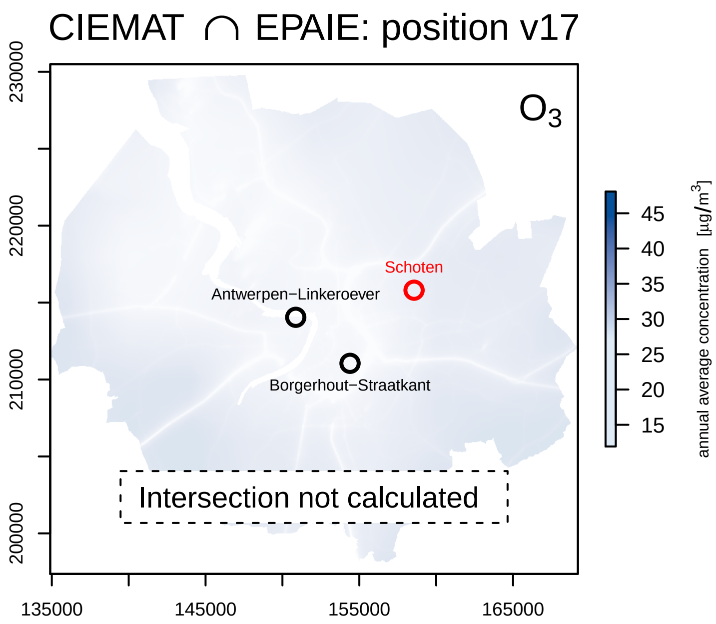

VITO ∩ VMM: position v7
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
45
40
35
30
25
20
15
annual average concentration [µg/m3]
230000
220000
210000
200000
135000
145000
155000
165000

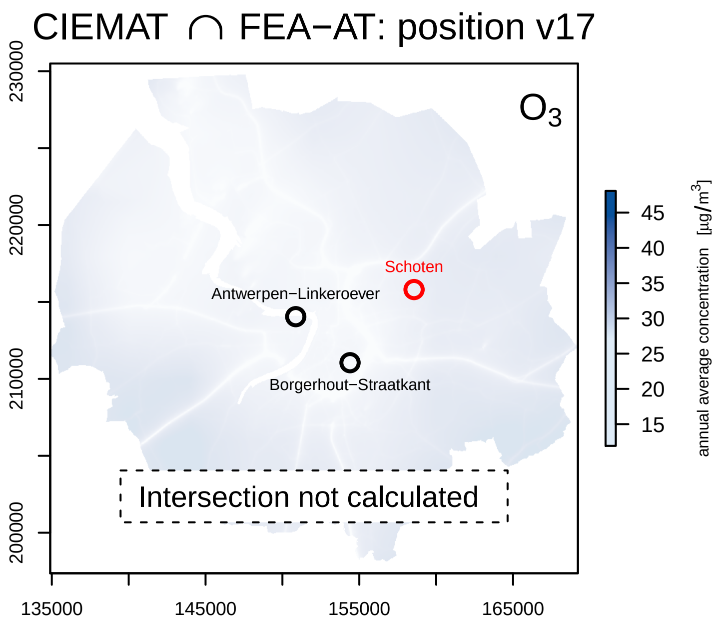
Mutual Comparisons between Teams

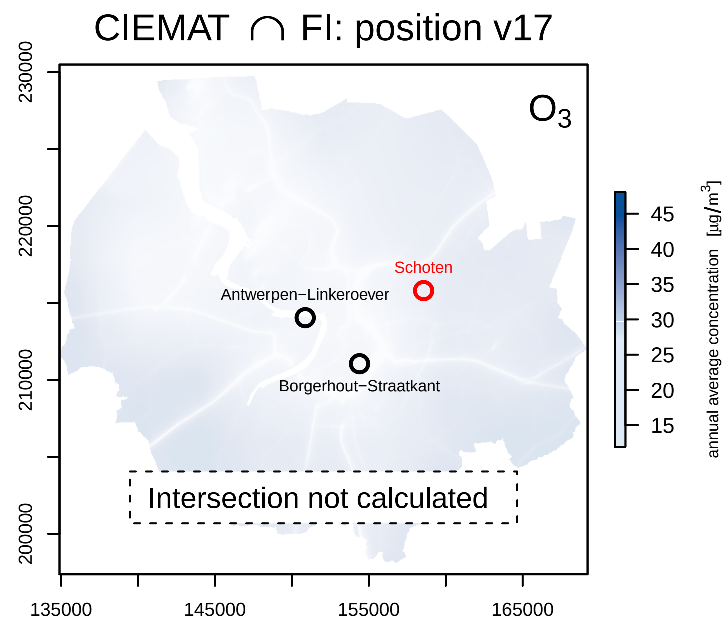
by Pollutant & Station:

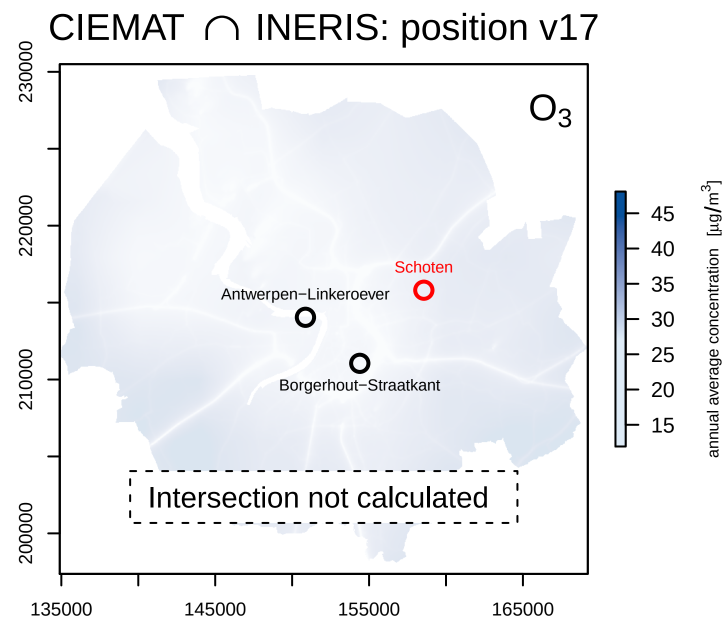
O_3 at virtual station v17

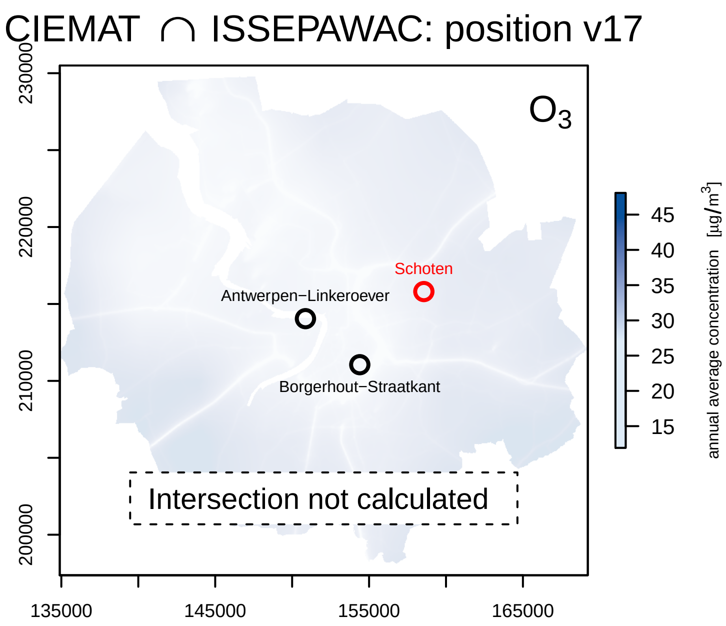

CIEMAT ∩ ENEA: position v17
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
annual average concentration [µg/m3]
45
40
35
30
25
20
15
135000
145000
155000
165000
200000
210000
220000
230000

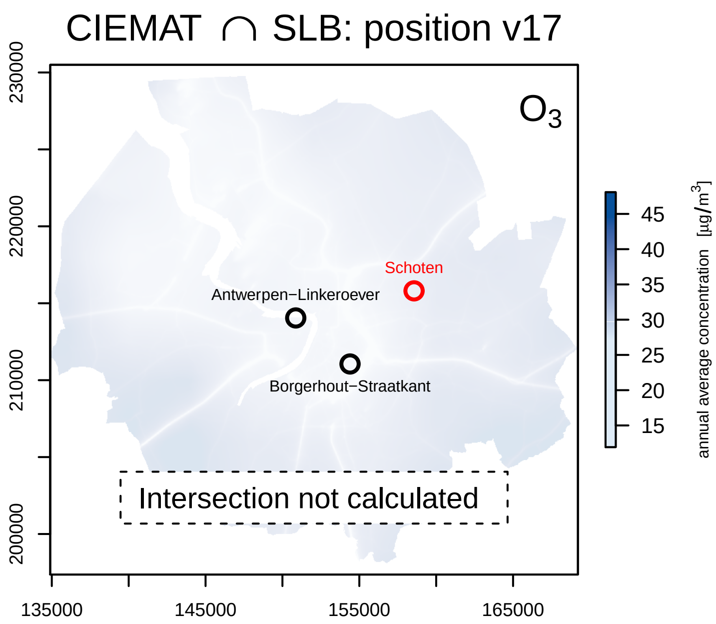

CIEMAT ∩ EPAIE: position v17
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
annual average concentration [µg/m3]
45
40
35
30
25
20
15
135000
145000
155000
165000
200000
210000
220000
230000

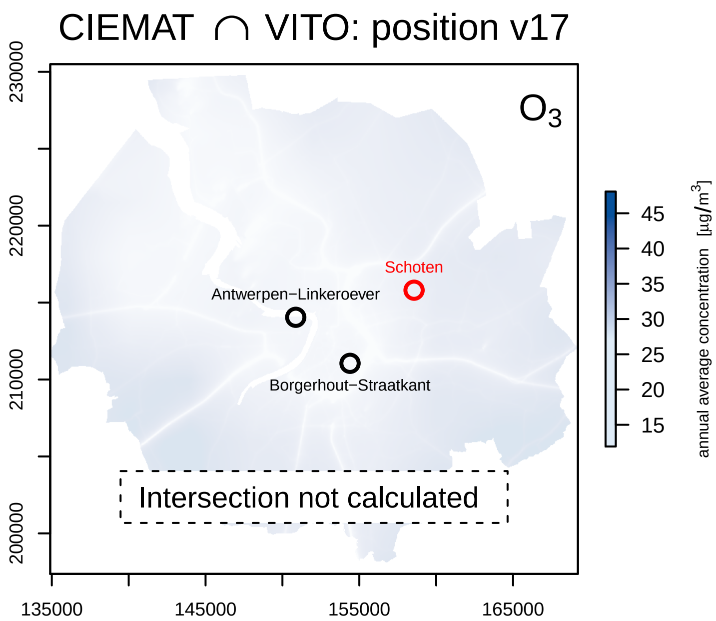

CIEMAT ∩ FEA−AT: position v17
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
annual average concentration [µg/m3]
45
40
35
30
25
20
15
135000
145000
155000
165000
200000
210000
220000
230000

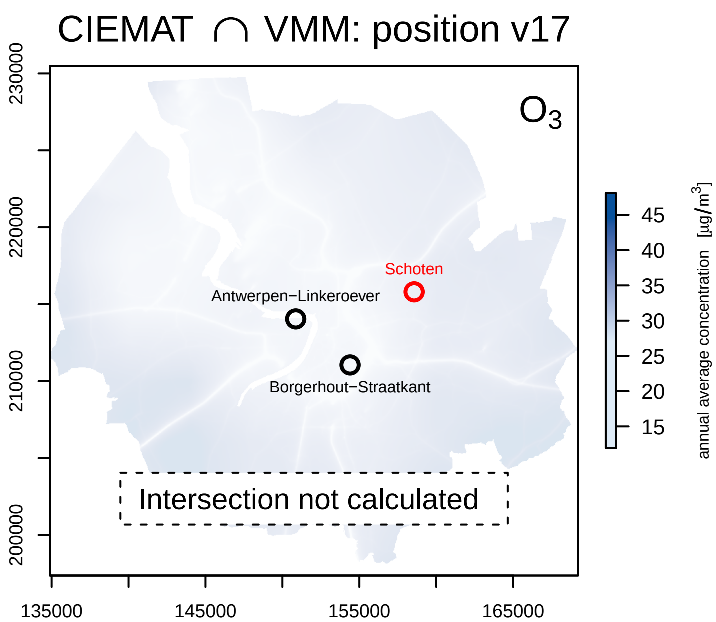

CIEMAT ∩ FI: position v17
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
annual average concentration [µg/m3]
45
40
35
30
25
20
15
230000
220000
210000
200000
135000
145000
155000
165000

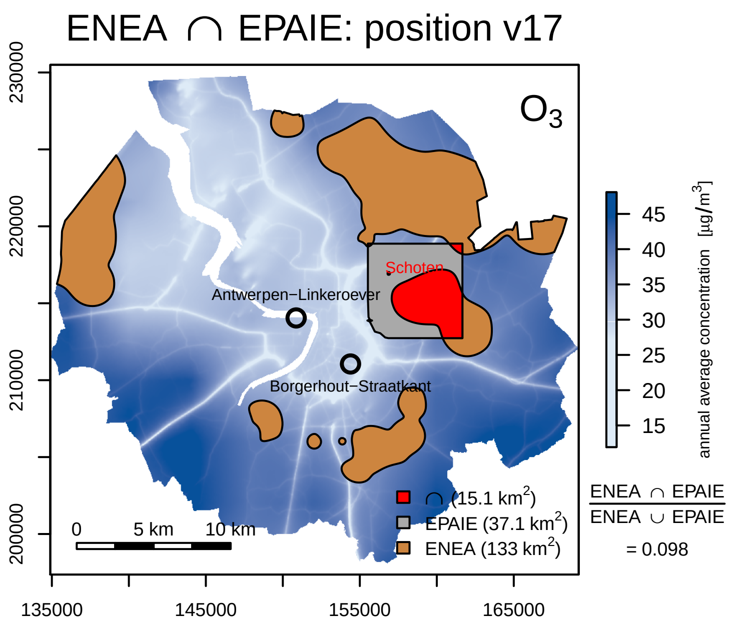

CIEMAT ∩ INERIS: position v17
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
annual average concentration [µg/m3]
45
40
35
30
25
20
15
230000
220000
210000
200000
135000
145000
155000
165000

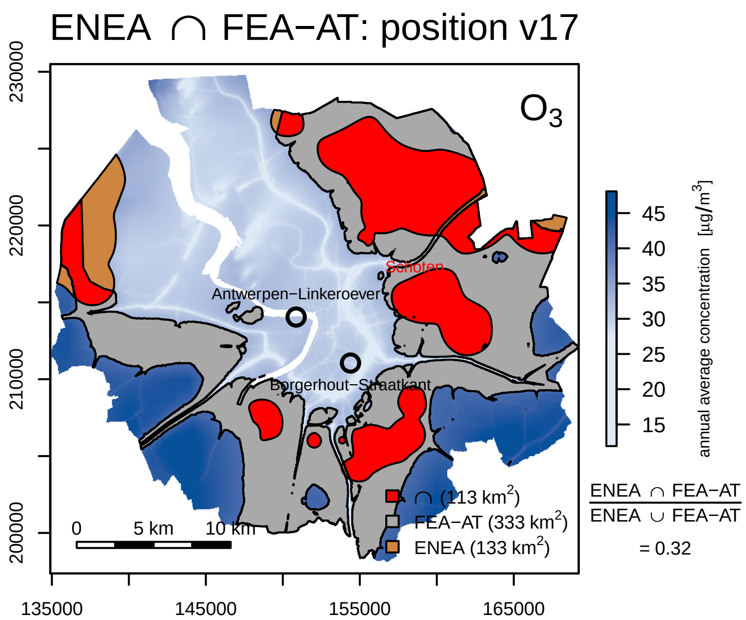

CIEMAT ∩ ISSEPAWAC: position v17
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
annual average concentration [µg/m3]
45
40
35
30
25
20
15
230000
220000
210000
200000
135000
145000
155000
165000

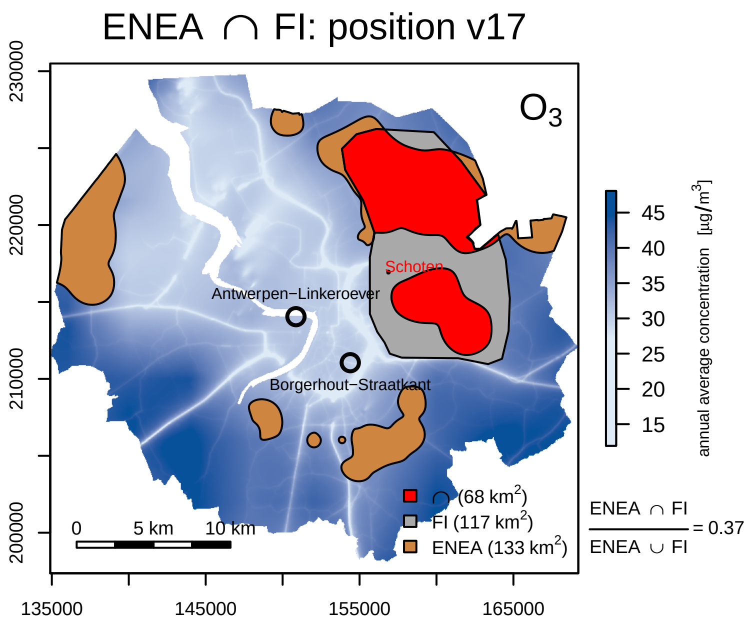

CIEMAT ∩ SLB: position v17
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

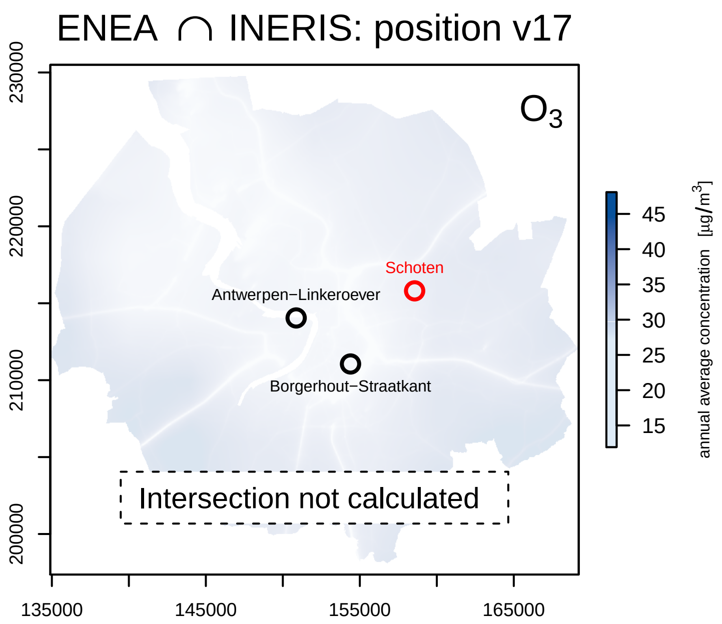

CIEMAT ∩ VITO: position v17
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

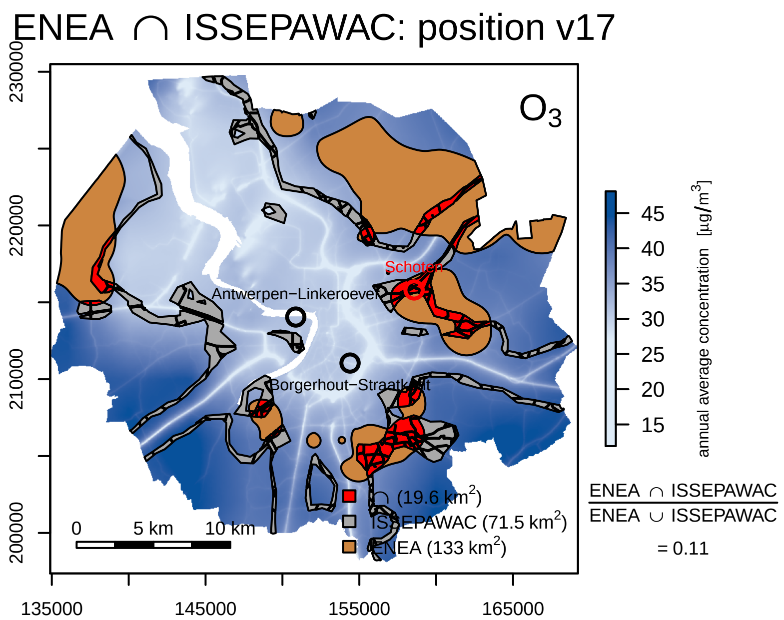

CIEMAT ∩ VMM: position v17
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

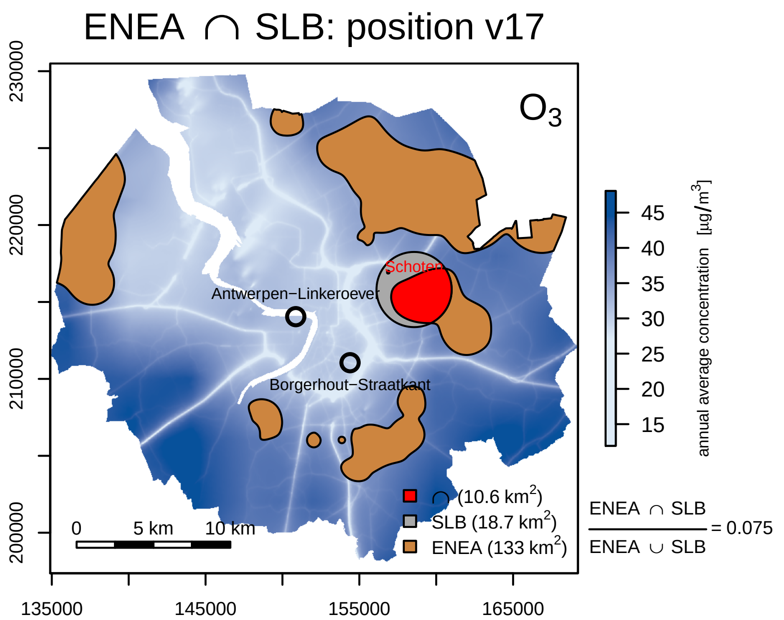

ENEA ∩ EPAIE: position v17
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (15.1 km2)
EPAIE (37.1 km2)
ENEA (133 km2)
annual average concentration [µg/m3]
ENEA ∩ EPAIE / ENEA ∪ EPAIE = 0.098

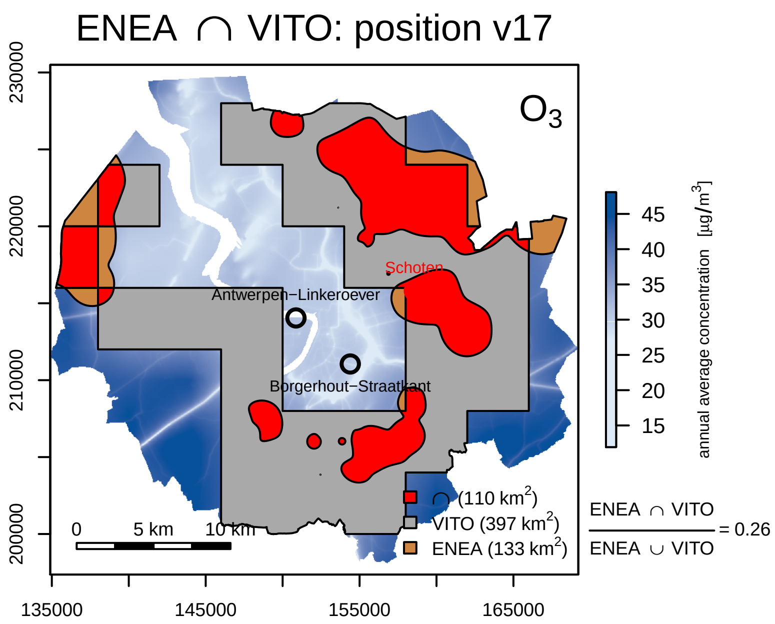

ENEA ∩ FEA−AT: position v17
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (113 km2)
FEA−AT (333 km2)
ENEA (133 km2)
annual average concentration [µg/m3]
ENEA ∩ FEA−AT / ENEA ∪ FEA−AT = 0.32


ENEA ∩ FI: position v17
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (68 km2)
FI (117 km2)
ENEA (133 km2)
annual average concentration [µg/m3]
ENEA ∩ FI / ENEA ∪ FI = 0.37

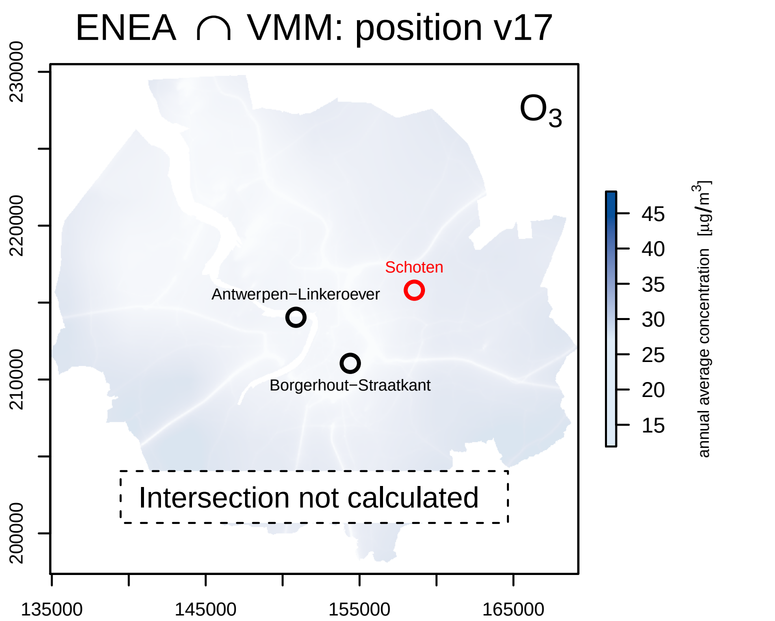

ENEA ∩ INERIS: position v17
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
annual average concentration [µg/m3]
45
40
35
30
25
20
15
230000
220000
210000
200000
135000
145000
155000
165000


ENEA ∩ ISSEPAWAC: position v17
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (19.6 km2)
ISSEPAWAC (71.5 km2)
ENEA (133 km2)
0 5 km 10 km
annual average concentration [µg/m3]
45
40
35
30
25
20
15
ENEA ∩ ISSEPAWAC / ENEA ∪ ISSEPAWAC = 0.11
230000
220000
210000
200000
135000
145000
155000
165000

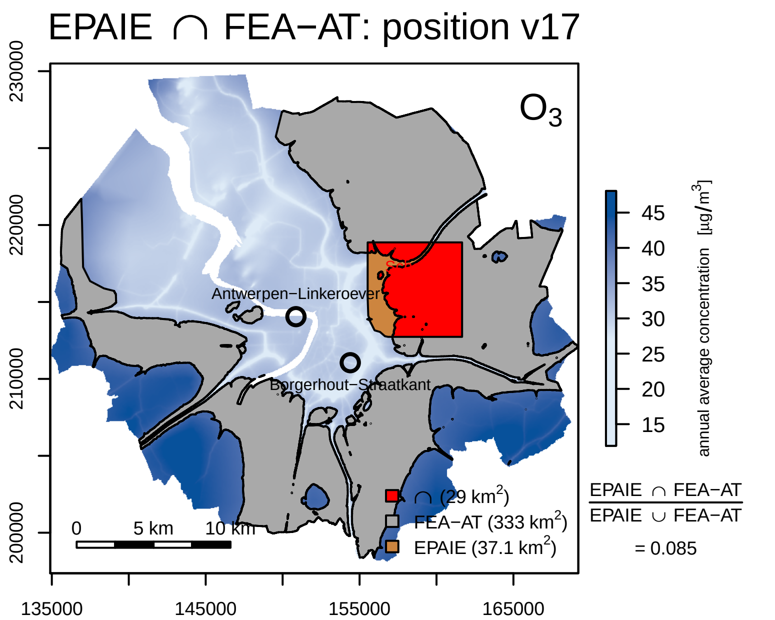

ENEA ∩ SLB: position v17
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (10.6 km2)
SLB (18.7 km2)
ENEA (133 km2)
0 5 km 10 km
annual average concentration [µg/m3]
45
40
35
30
25
20
15
ENEA ∩ SLB / ENEA ∪ SLB = 0.075
230000
220000
210000
200000
135000
145000
155000
165000



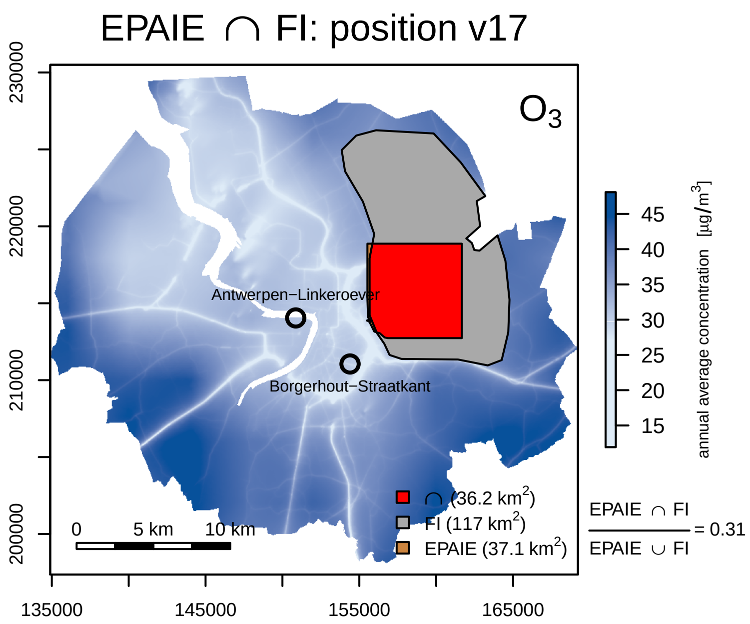
ENEA ∩ VITO: position v17
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (110 km2)
VITO (397 km2)
ENEA (133 km2)
45 40 35 30 25 20 15
annual average concentration [µg/m3]
ENEA ∩ VITO / ENEA ∪ VITO = 0.26
135000 145000 155000 165000
200000 210000 220000 230000

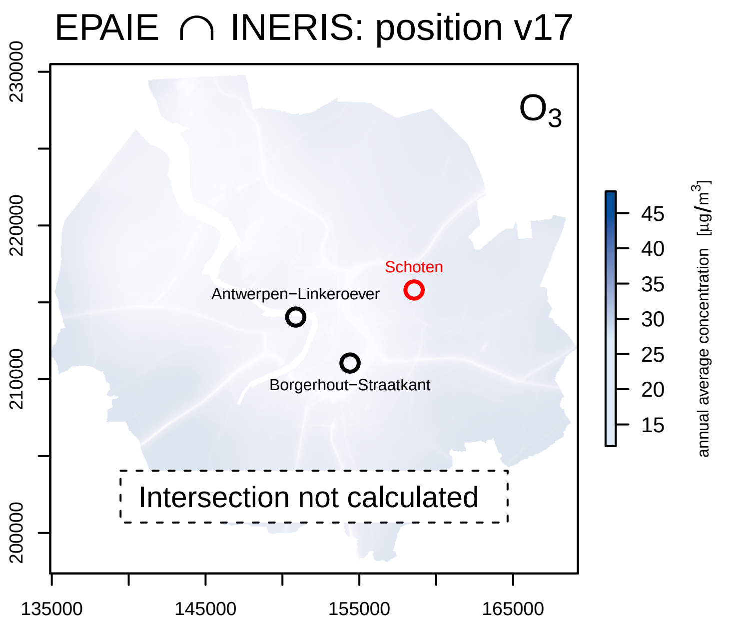


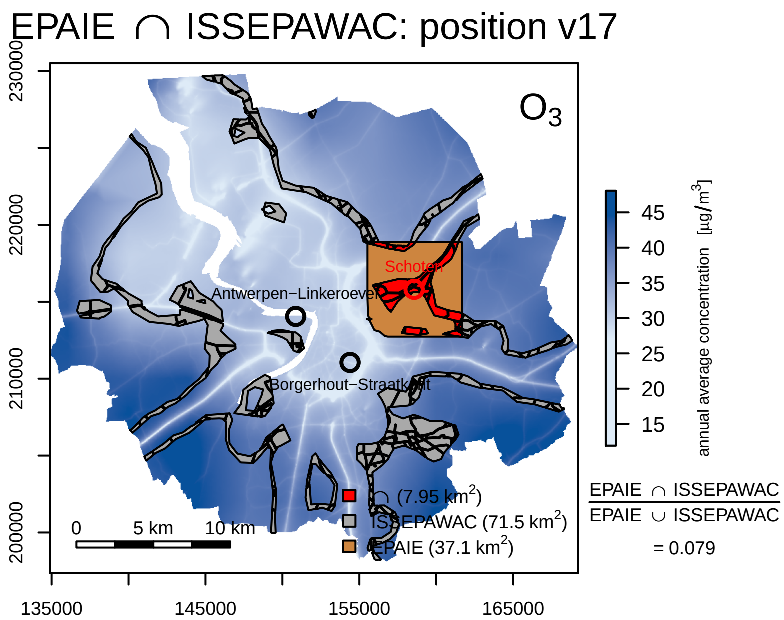
ENEA ∩ VMM: position v17
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
45 40 35 30 25 20 15
annual average concentration [µg/m3]
135000 145000 155000 165000
200000 210000 220000 230000

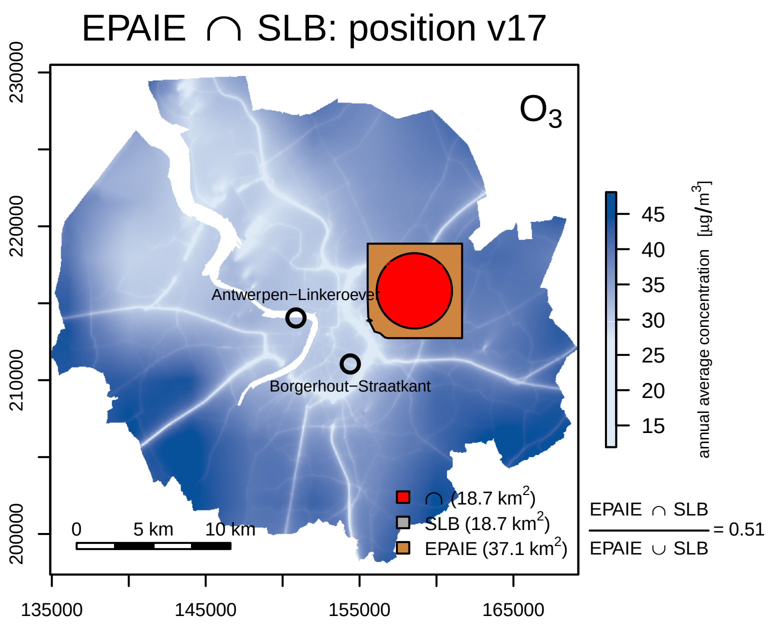


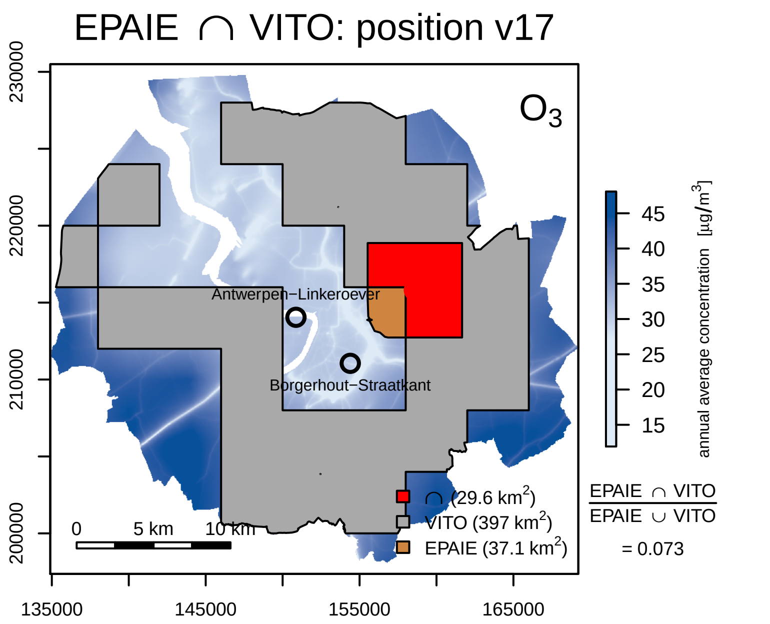
EPAIE ∩ FEA−AT: position v17
O3
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (29 km2)
FEA−AT (333 km2)
EPAIE (37.1 km2)
45 40 35 30 25 20 15
annual average concentration [µg/m3]
EPAIE ∩ FEA−AT / EPAIE ∪ FEA−AT = 0.085
135000 145000 155000 165000
200000 210000 220000 230000

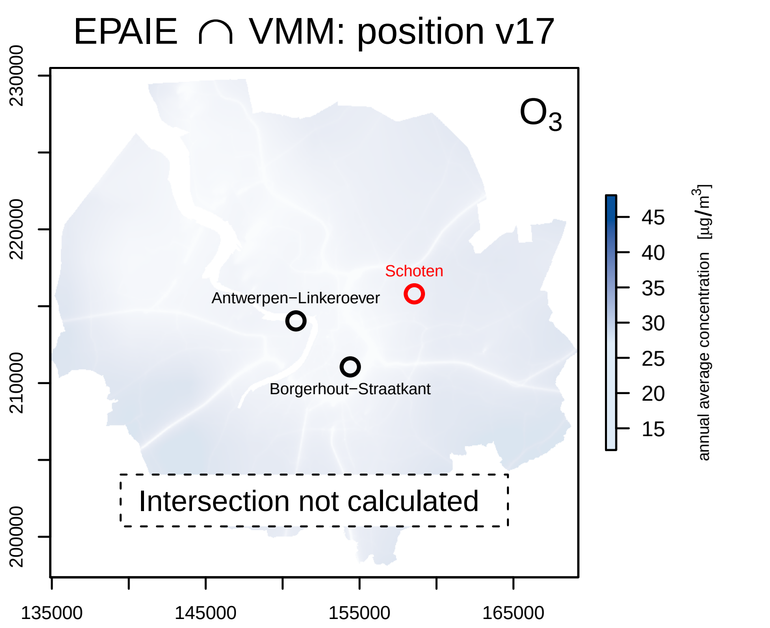

EPAIE ∩ FI: position v17
O3
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (36.2 km2)
FI (117 km2)
EPAIE (37.1 km2)
0 5 km 10 km
45 40 35 30 25 20 15
annual average concentration [µg/m3]
EPAIE ∩ FI / EPAIE ∪ FI = 0.31
135000 145000 155000 165000
200000 210000 220000 230000

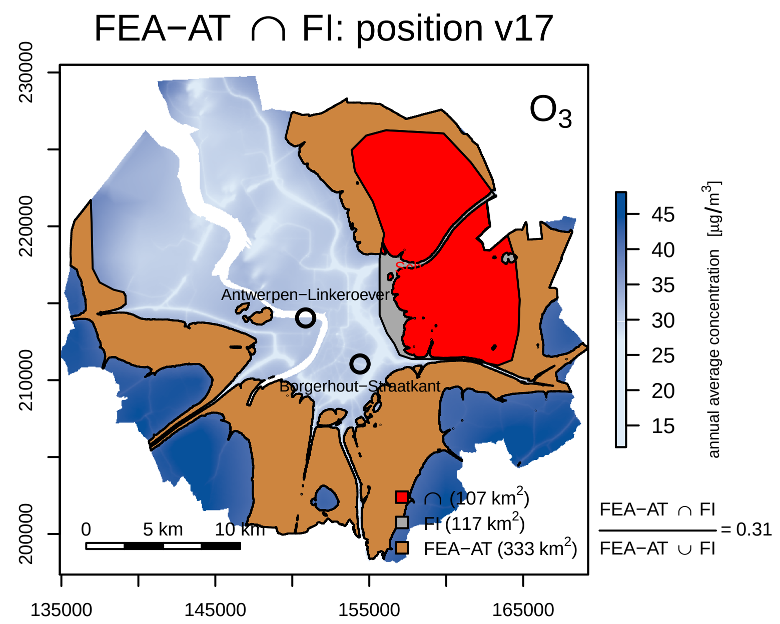

EPAIE ∩ INERIS: position v17
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
45 40 35 30 25 20 15
annual average concentration [µg/m3]
135000 145000 155000 165000
200000 210000 220000 230000


EPAIE ∩ ISSEPAWAC: position v17
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (7.95 km2)
ISSEPAWAC (71.5 km2)
EPAIE (37.1 km2)
0 5 km 10 km
45 40 35 30 25 20 15
annual average concentration [µg/m3]
EPAIE ∩ ISSEPAWAC / EPAIE ∪ ISSEPAWAC = 0.079
135000 145000 155000 165000
200000 210000 220000 230000

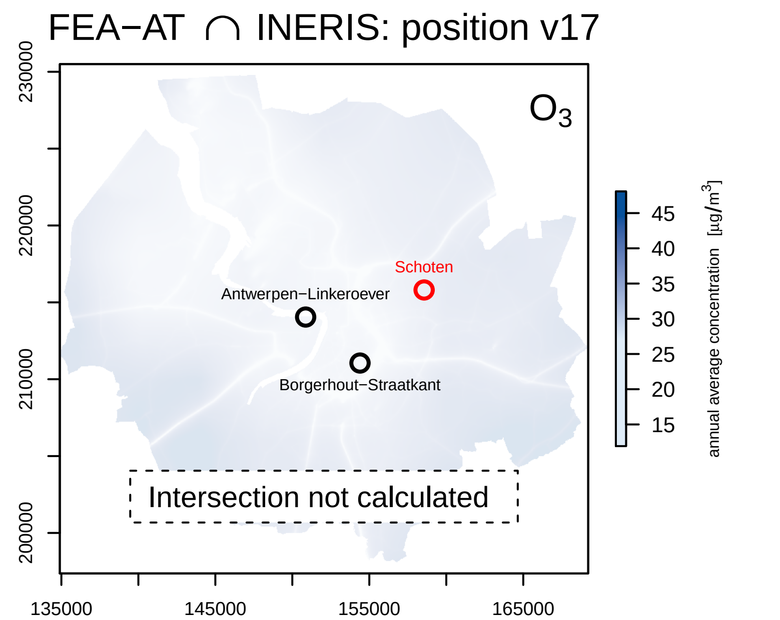

EPAIE ∩ SLB: position v17
O3
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (18.7 km2)
SLB (18.7 km2)
EPAIE (37.1 km2)
45
40
35
30
25
20
15
annual average concentration [µg/m3]
EPAIE ∩ SLB
EPAIE ∪ SLB
= 0.51
135000
145000
155000
165000
200000
210000
220000
230000


EPAIE ∩ VITO: position v17
O3
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (29.6 km2)
VITO (397 km2)
EPAIE (37.1 km2)
45
40
35
30
25
20
15
annual average concentration [µg/m3]
EPAIE ∩ VITO
EPAIE ∪ VITO
= 0.073
135000
145000
155000
165000
200000
210000
220000
230000

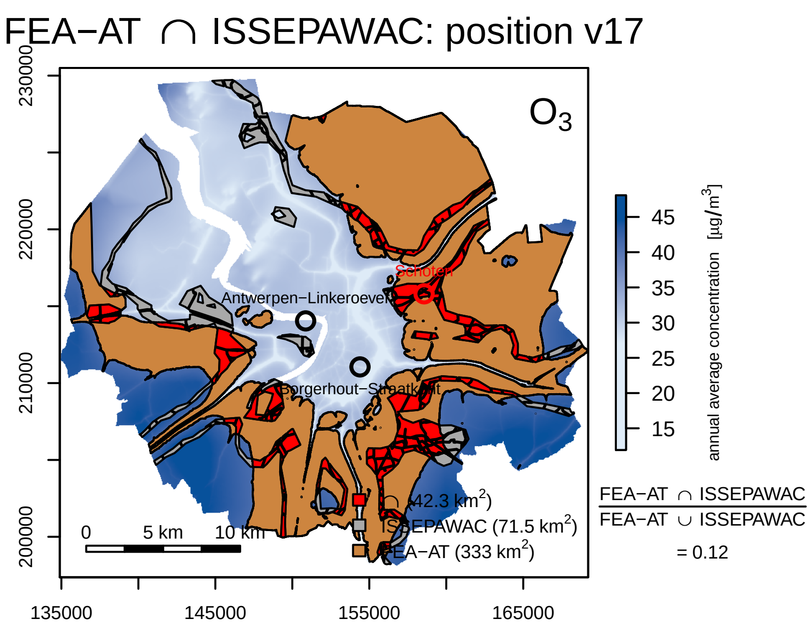

EPAIE ∩ VMM: position v17
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
45
40
35
30
25
20
15
annual average concentration [µg/m3]
135000
145000
155000
165000
200000
210000
220000
230000



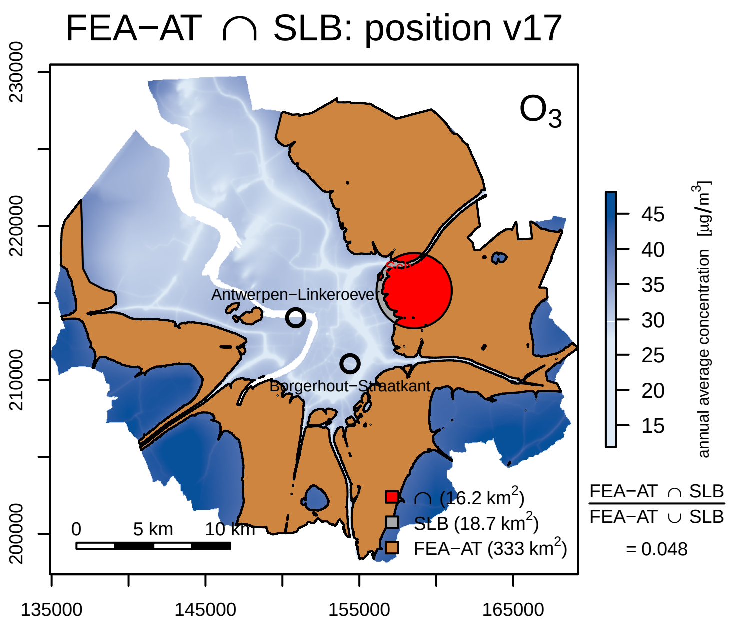
FEA−AT ∩ FI: position v17
O3
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (107 km2)
FI (117 km2)
FEA−AT (333 km2)
0 5 km 10 km
45
40
35
30
25
20
15
annual average concentration [µg/m3]
FEA−AT ∩ FI
FEA−AT ∪ FI
= 0.31
230000
220000
210000
200000
135000
145000
155000
165000

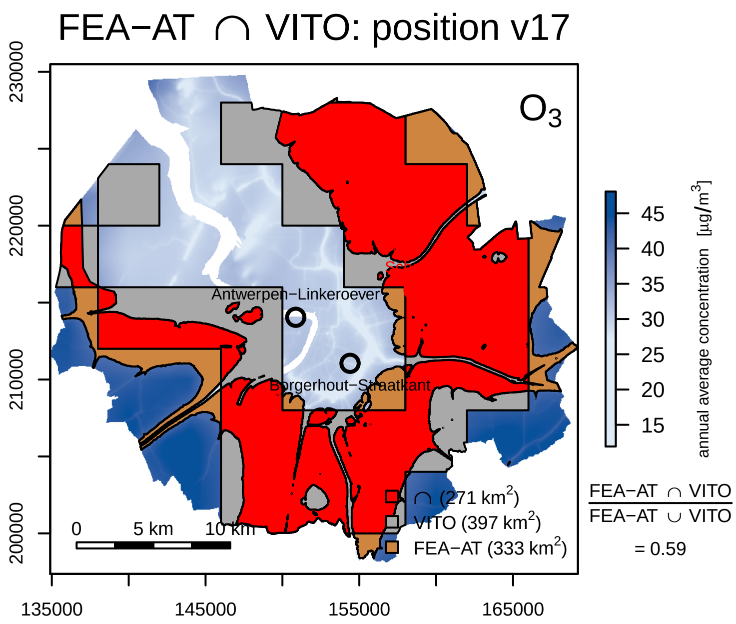


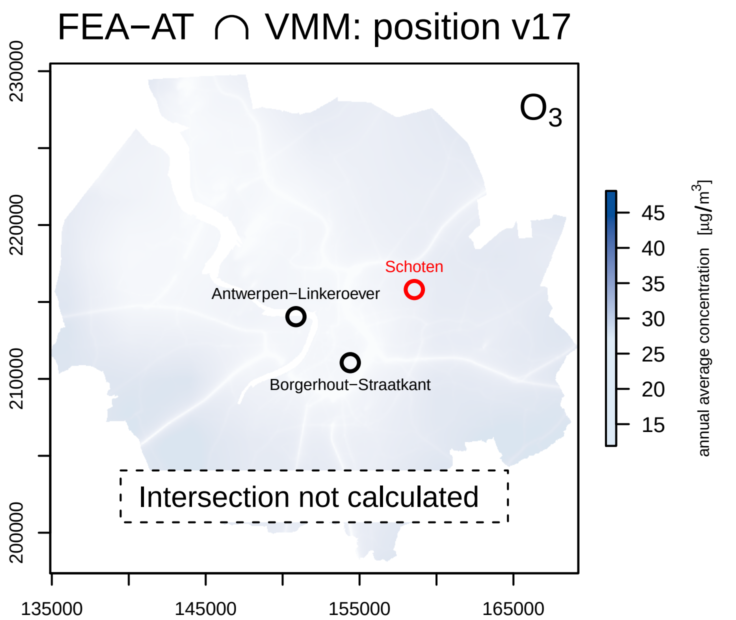
FEA−AT ∩ INERIS: position v17
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
45
40
35
30
25
20
15
annual average concentration [µg/m3]
230000
220000
210000
200000
135000
145000
155000
165000

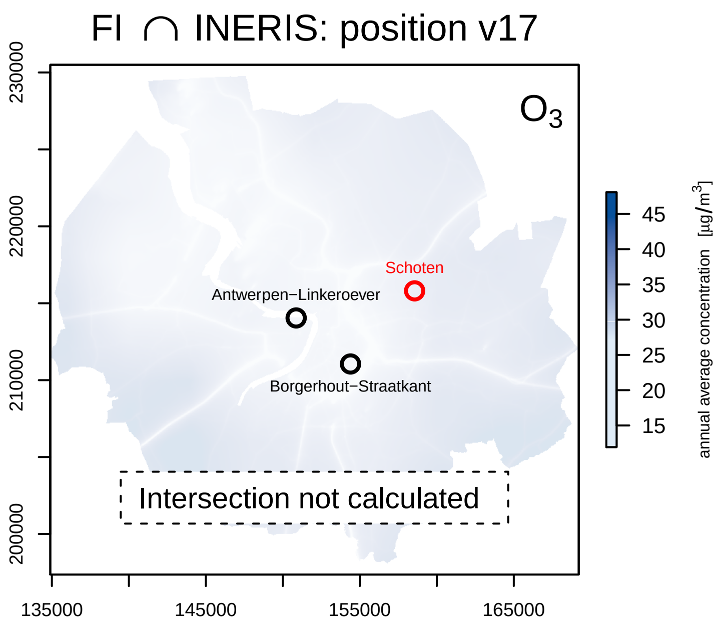


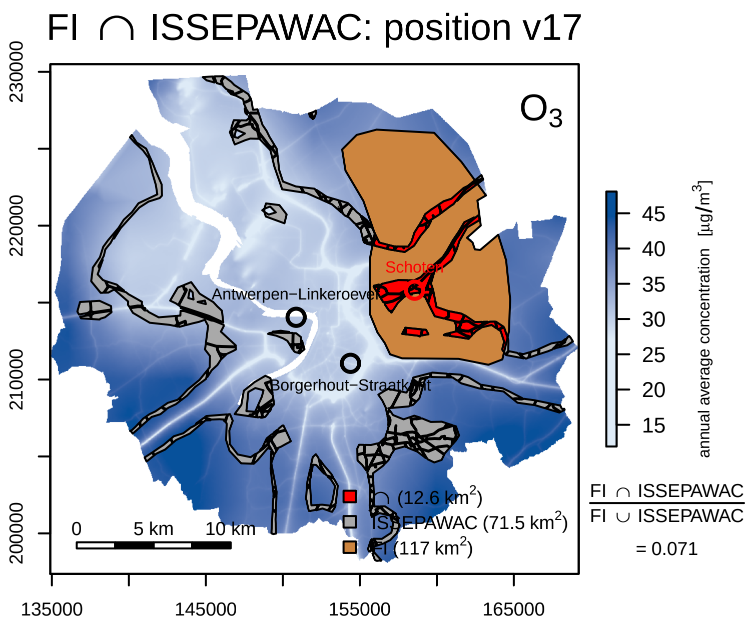
FEA−AT ∩ ISSEPAWAC: position v17
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (42.3 km2)
ISSEPAWAC (71.5 km2)
FEA−AT (333 km2)
0 5 km 10 km
45
40
35
30
25
20
15
annual average concentration [µg/m3]
FEA−AT ∩ ISSEPAWAC
FEA−AT ∪ ISSEPAWAC
= 0.12
230000
220000
210000
200000
135000
145000
155000
165000

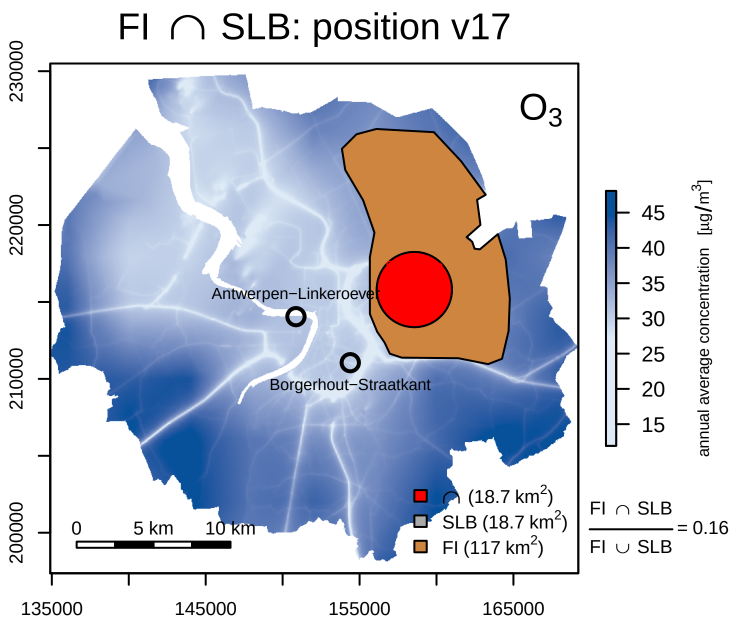

FEA−AT ∩ SLB: position v17
O3
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (16.2 km2)
SLB (18.7 km2)
FEA−AT (333 km2)
0
5 km
10 km
45
40
35
30
25
20
15
annual average concentration [µg/m3]
FEA−AT ∩ SLB
FEA−AT ∪ SLB
= 0.048
135000
145000
155000
165000
200000
210000
220000
230000

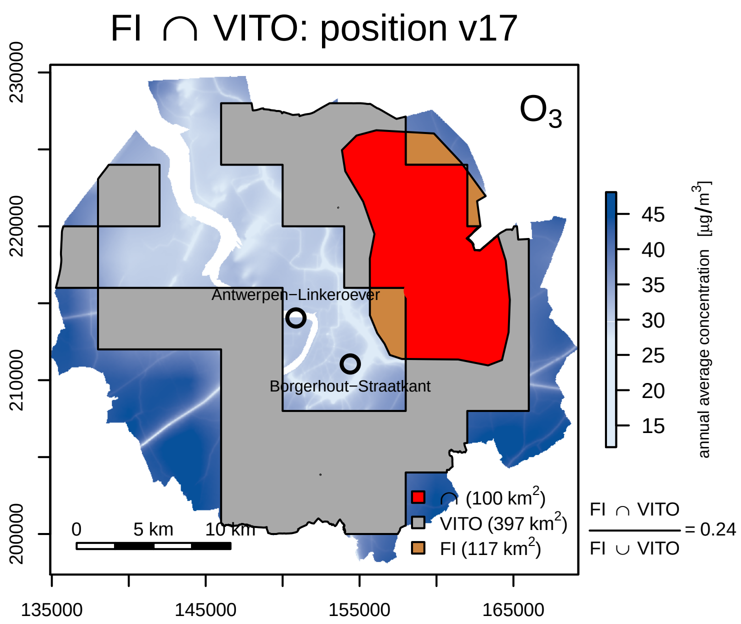

FEA−AT ∩ VITO: position v17
O3
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (271 km2)
VITO (397 km2)
FEA−AT (333 km2)
0
5 km
10 km
45
40
35
30
25
20
15
annual average concentration [µg/m3]
FEA−AT ∩ VITO
FEA−AT ∪ VITO
= 0.59
135000
145000
155000
165000
200000
210000
220000
230000


FEA−AT ∩ VMM: position v17
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
45
40
35
30
25
20
15
annual average concentration [µg/m3]
135000
145000
155000
165000
200000
210000
220000
230000

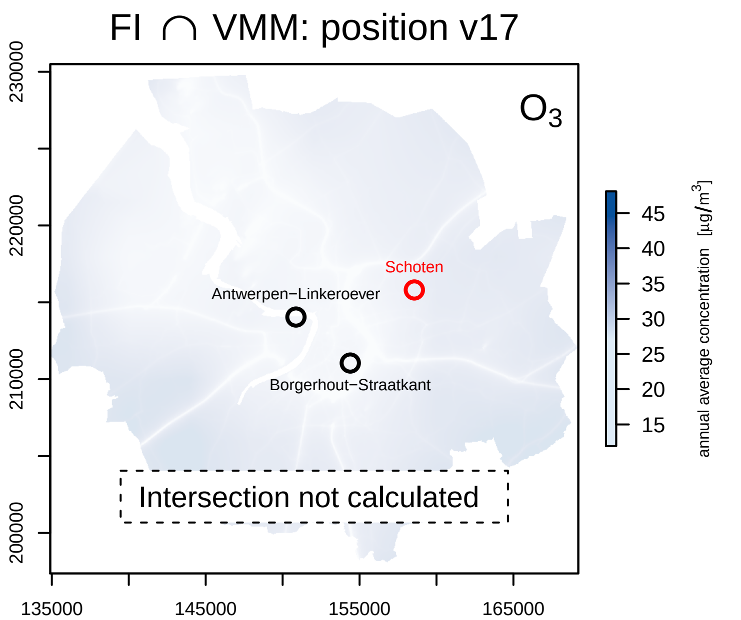

FI ∩ INERIS: position v17
O_3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
45
40
35
30
25
20
15
annual average concentration [µg/m^3]
230000
220000
210000
200000
135000
145000
155000
165000


FI ∩ ISSEPAWAC: position v17
O_3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (12.6 km^2)
ISSEPAWAC (71.5 km^2)
FI (117 km^2)
45
40
35
30
25
20
15
annual average concentration [µg/m^3]
FI ∩ ISSEPAWAC
FI ∪ ISSEPAWAC
= 0.071
230000
220000
210000
200000
135000
145000
155000
165000

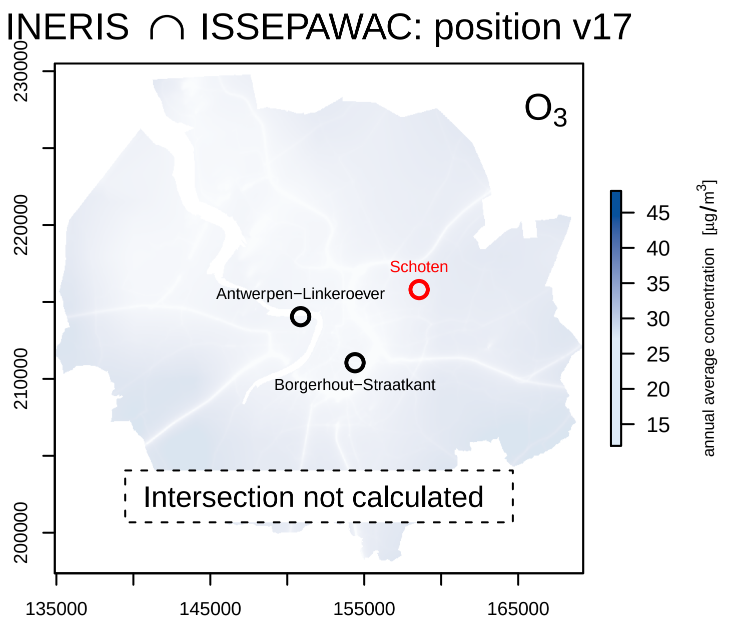

FI ∩ SLB: position v17
O_3
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (18.7 km^2)
SLB (18.7 km^2)
FI (117 km^2)
45
40
35
30
25
20
15
annual average concentration [µg/m^3]
FI ∩ SLB
FI ∪ SLB
= 0.16
230000
220000
210000
200000
135000
145000
155000
165000



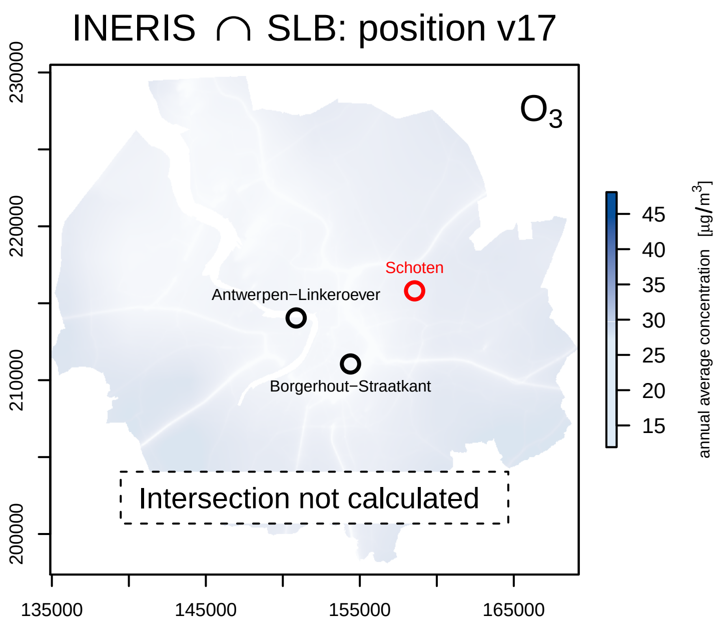
FI ∩ VITO: position v17
O3
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (100 km2)
VITO (397 km2)
FI (117 km2)
FI ∩ VITO
FI ∪ VITO
= 0.24
annual average concentration [µg/m3]
45
40
35
30
25
20
15
230000
220000
210000
200000
135000
145000
155000
165000

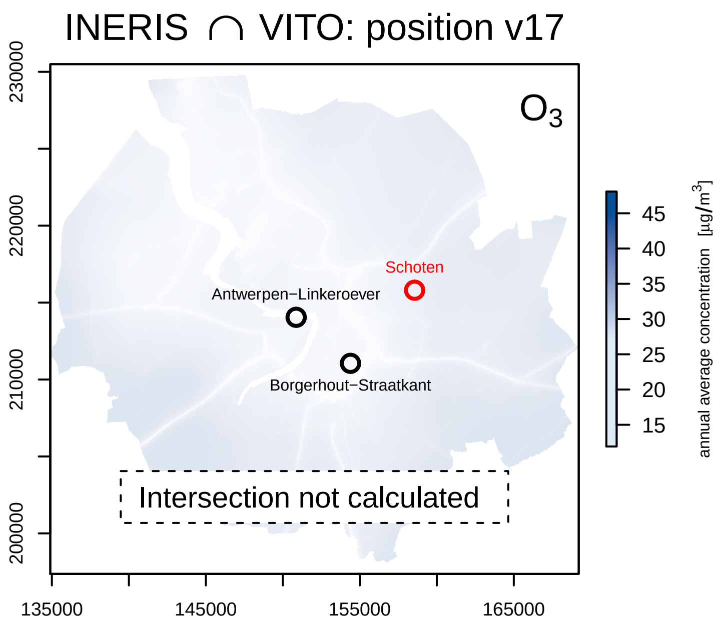


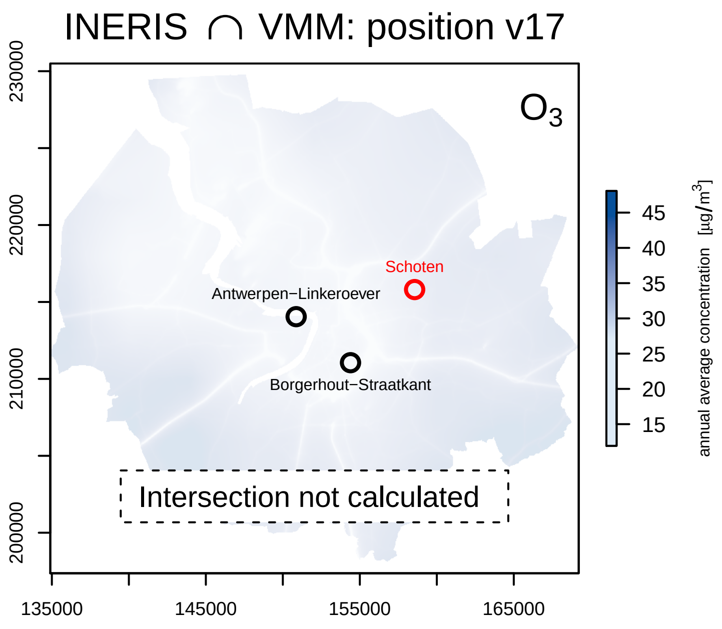
FI ∩ VMM: position v17
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
annual average concentration [µg/m3]
45
40
35
30
25
20
15
230000
220000
210000
200000
135000
145000
155000
165000

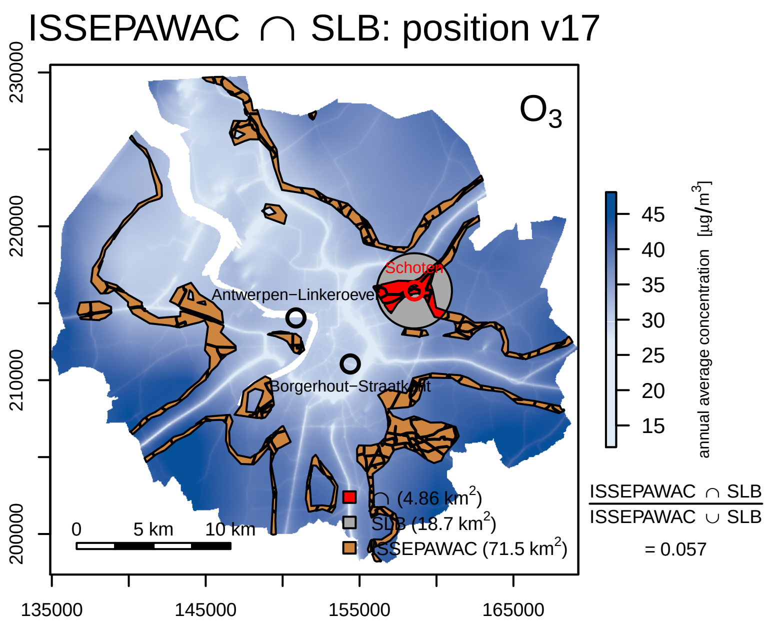


INERIS ∩ ISSEPAWAC: position v17
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
annual average concentration [µg/m3]
45
40
35
30
25
20
15
230000
220000
210000
200000
135000
145000
155000
165000

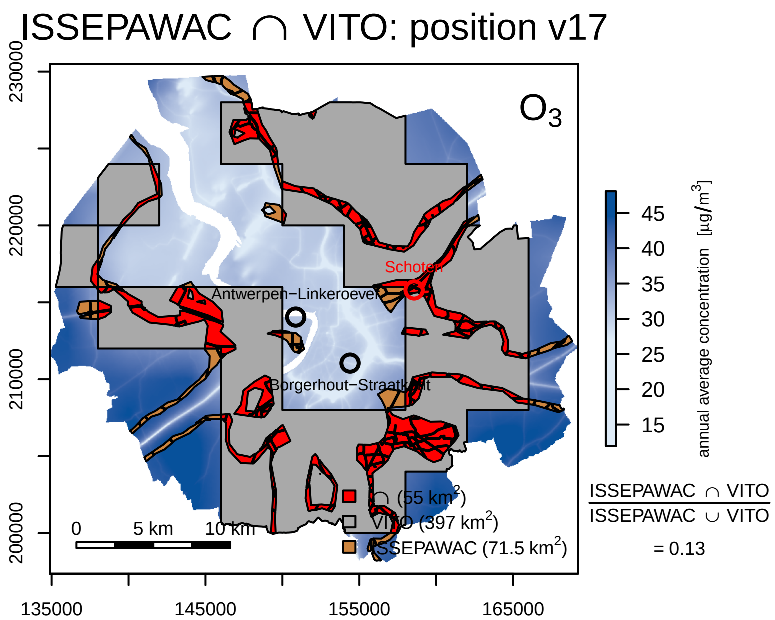

INERIS ∩ SLB: position v17
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]


INERIS ∩ VITO: position v17
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]

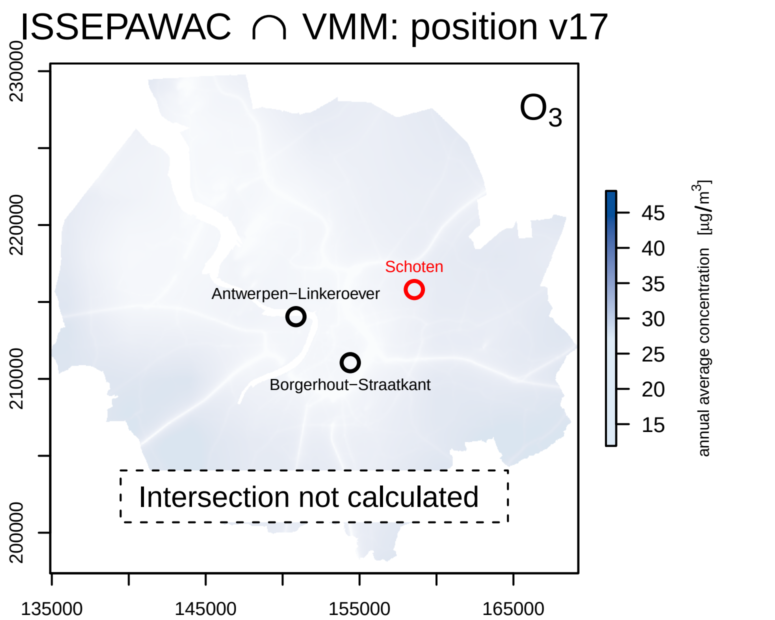

INERIS ∩ VMM: position v17
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
45
40
35
30
25
20
15
annual average concentration [µg/m3]



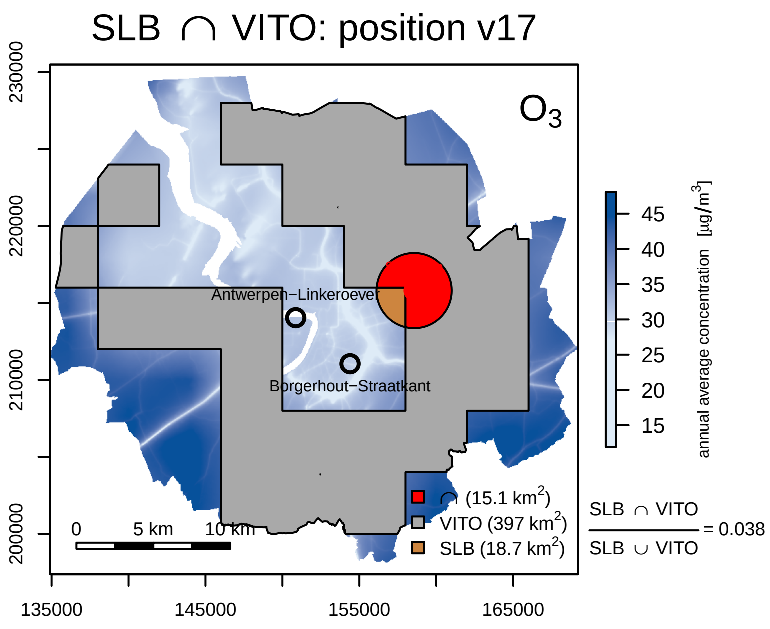
ISSEPAWAC ∩ SLB: position v17
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (4.86 km2)
SLB (18.7 km2)
ISSEPAWAC (71.5 km2)
0 5 km 10 km
45 40 35 30 25 20 15
annual average concentration [µg/m3]
ISSEPAWAC ∩ SLB / ISSEPAWAC ∪ SLB = 0.057
135000 145000 155000 165000
200000 210000 220000 230000

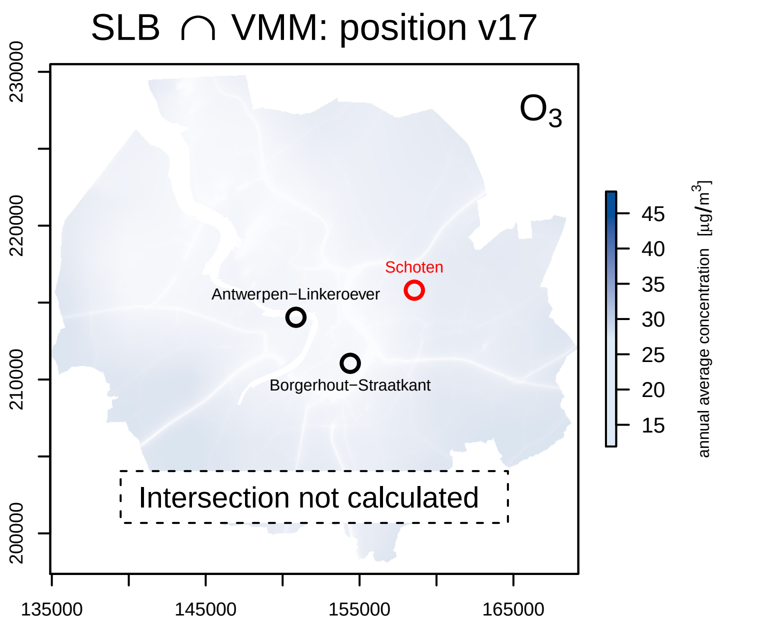


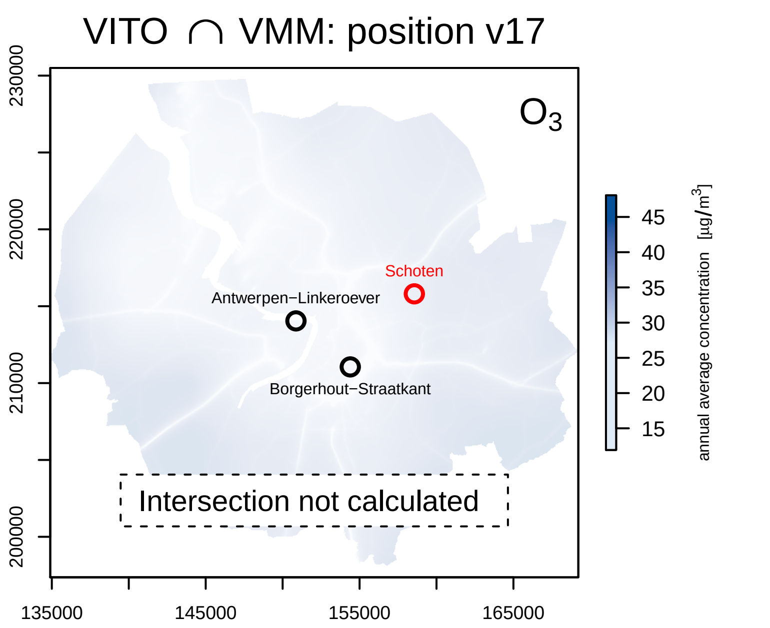
ISSEPAWAC ∩ VITO: position v17
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (55 km2)
VITO (397 km2)
ISSEPAWAC (71.5 km2)
0 5 km 10 km
45 40 35 30 25 20 15
annual average concentration [µg/m3]
ISSEPAWAC ∩ VITO / ISSEPAWAC ∪ VITO = 0.13
135000 145000 155000 165000
200000 210000 220000 230000



ISSEPAWAC ∩ VMM: position v17
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
45 40 35 30 25 20 15
annual average concentration [µg/m3]
135000 145000 155000 165000
200000 210000 220000 230000


SLB ∩ VITO: position v17
O3
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (15.1 km2)
VITO (397 km2)
SLB (18.7 km2)
SLB ∩ VITO / SLB ∪ VITO = 0.038
annual average concentration [µg/m3]
45
40
35
30
25
20
15
230000
220000
210000
200000
135000
145000
155000
165000


SLB ∩ VMM: position v17
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
annual average concentration [µg/m3]
45
40
35
30
25
20
15
230000
220000
210000
200000
135000
145000
155000
165000


VITO ∩ VMM: position v17
O3
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
annual average concentration [µg/m3]
45
40
35
30
25
20
15
230000
220000
210000
200000
135000
145000
155000
165000

Mutual Comparisons between Teams

by Pollutant & Station:

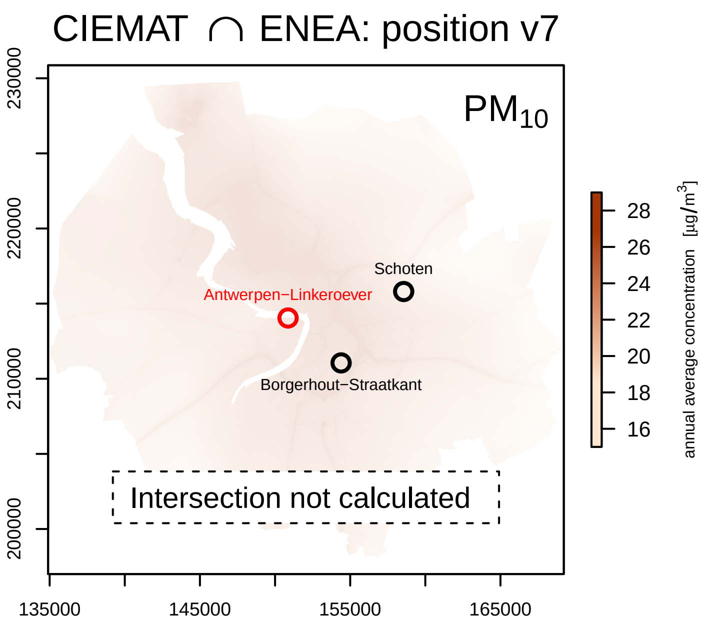
O_3 at virtual station v216

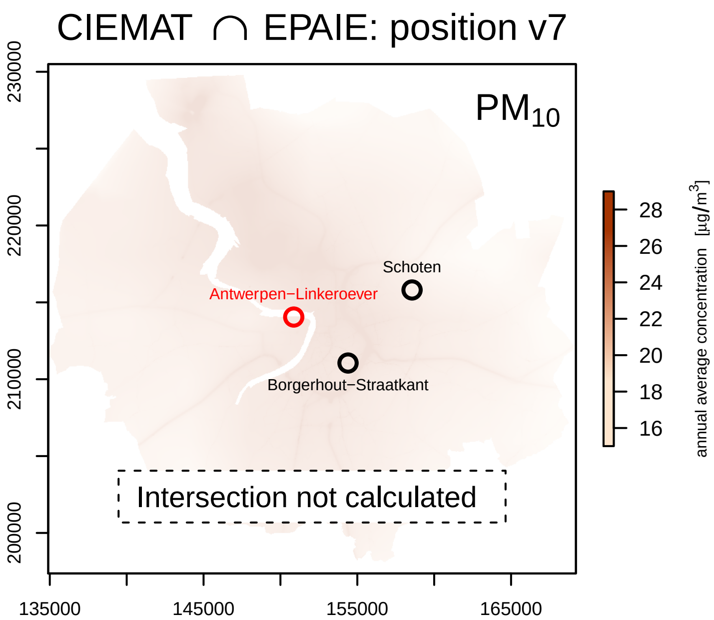
The combination O_3 at virtual station v216 was not a task for the IE. It is thus omitted from plotting here.

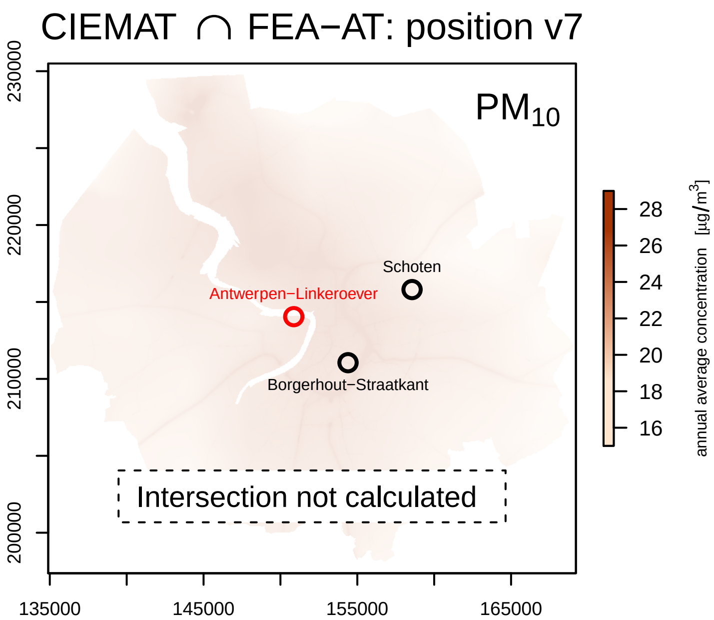
Mutual Comparisons between Teams

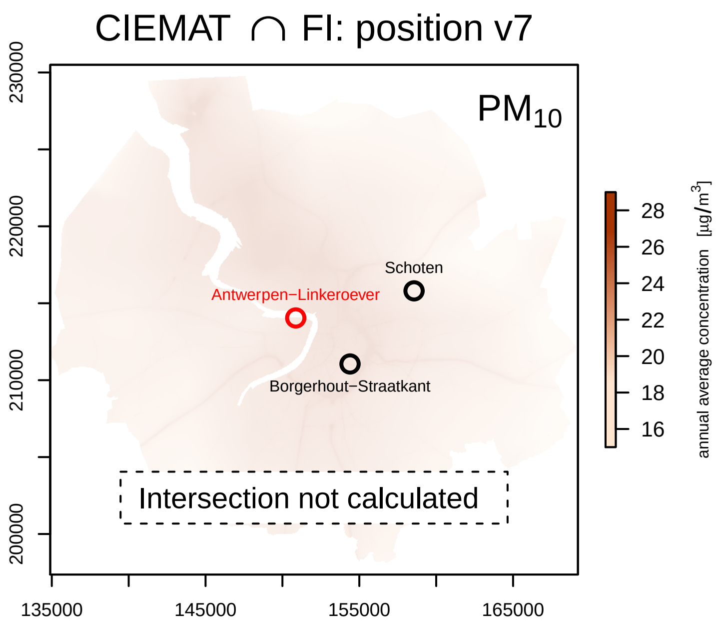
by Pollutant & Station:

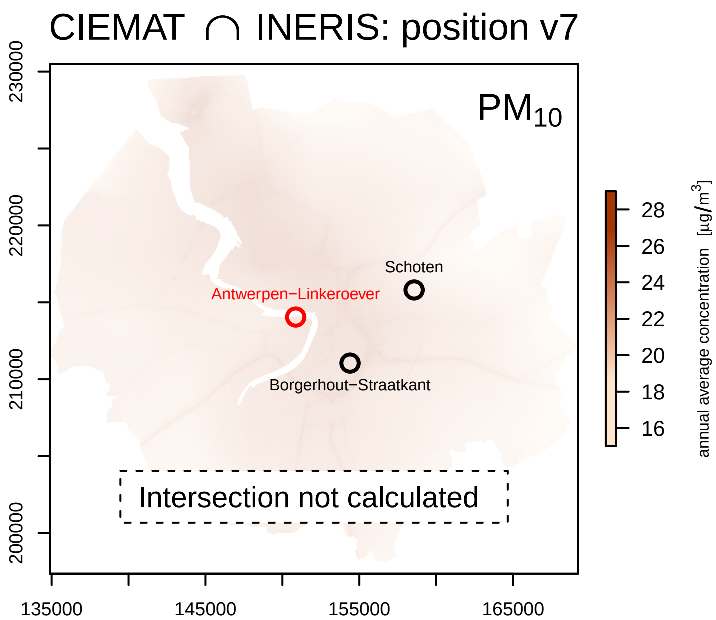
PM_{10} at virtual station v7

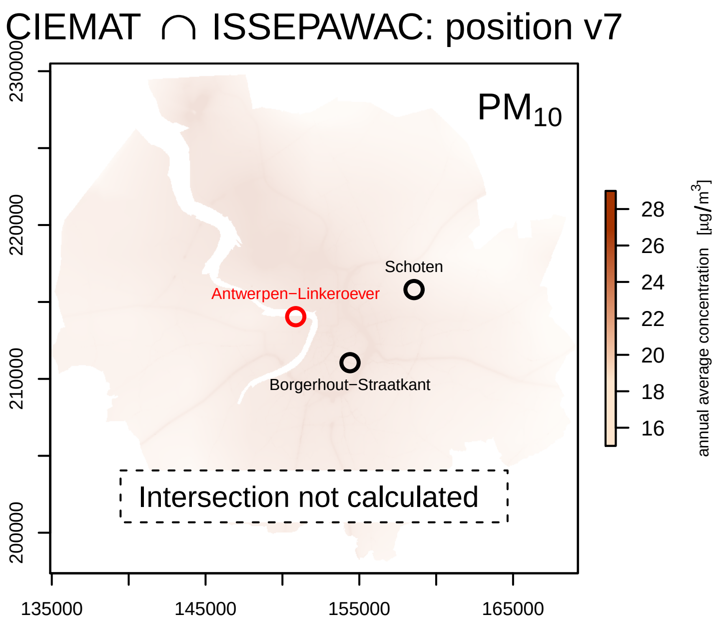

CIEMAT ∩ ENEA: position v7
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
28
26
24
22
20
18
16
annual average concentration [µg/m3]

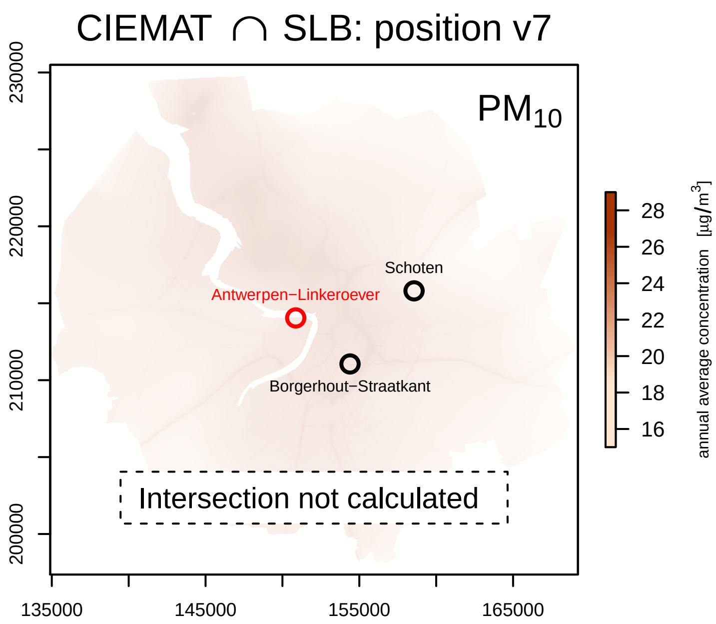

CIEMAT ∩ EPAIE: position v7
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
28
26
24
22
20
18
16
annual average concentration [µg/m3]

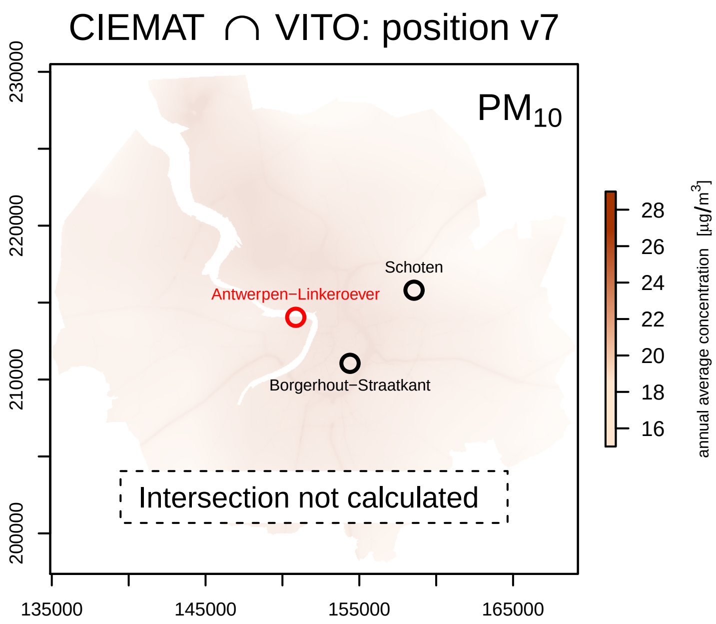

CIEMAT ∩ FEA−AT: position v7
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
28
26
24
22
20
18
16
annual average concentration [µg/m3]

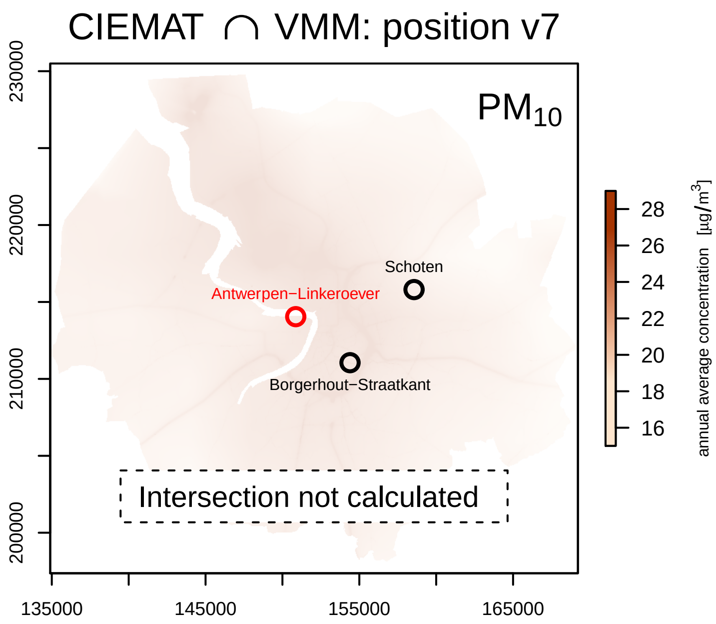

CIEMAT ∩ FI: position v7
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
annual average concentration [µg/m3]
28
26
24
22
20
18
16
230000
220000
210000
200000
135000
145000
155000
165000

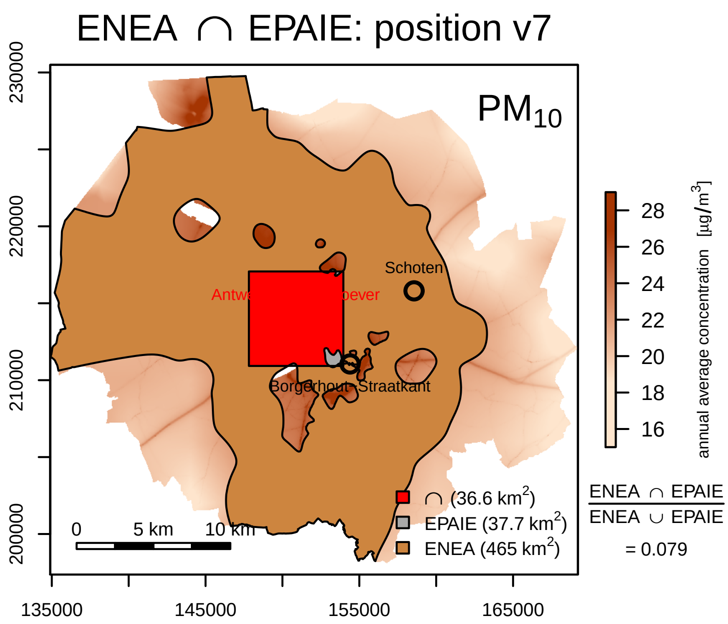

CIEMAT ∩ INERIS: position v7
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
annual average concentration [µg/m3]
28
26
24
22
20
18
16
230000
220000
210000
200000
135000
145000
155000
165000

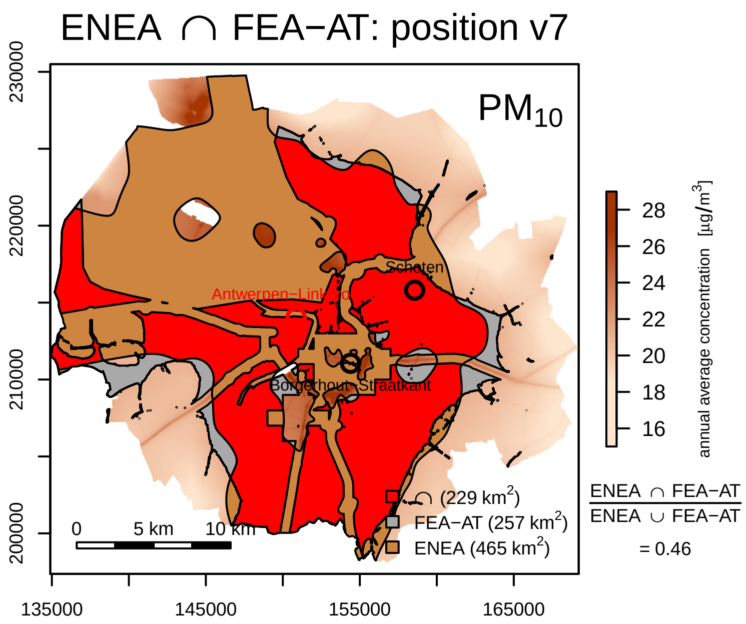

CIEMAT ∩ ISSEPAWAC: position v7
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
annual average concentration [µg/m3]
28
26
24
22
20
18
16
230000
220000
210000
200000
135000
145000
155000
165000

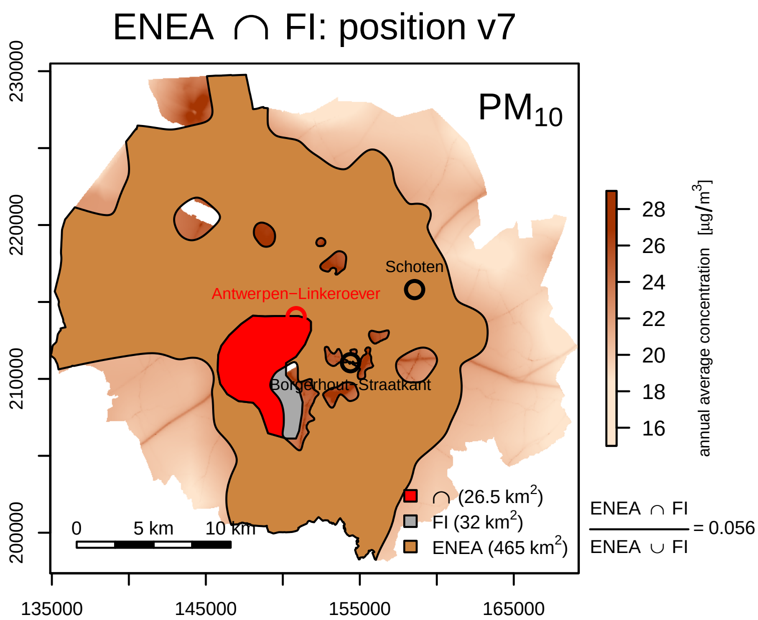

CIEMAT ∩ SLB: position v7
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
28
26
24
22
20
18
16
annual average concentration [µg/m3]

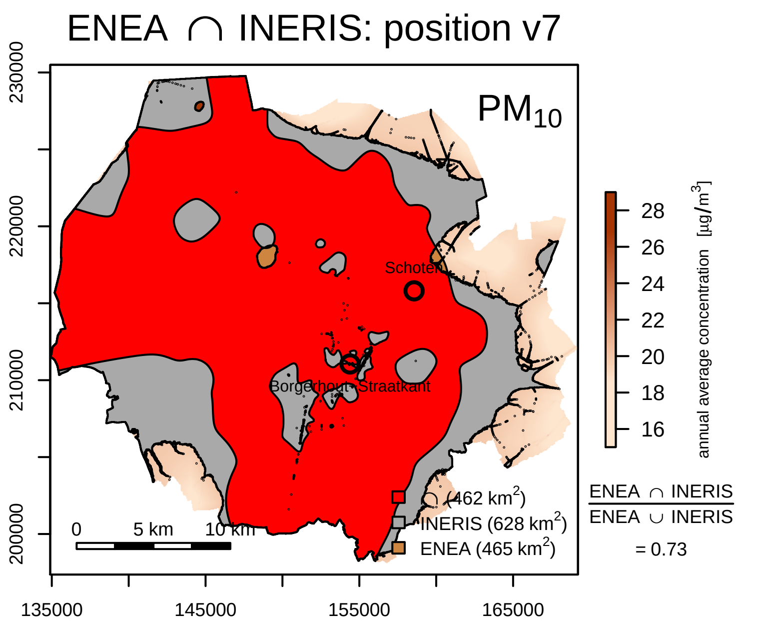

CIEMAT ∩ VITO: position v7
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
28
26
24
22
20
18
16
annual average concentration [µg/m3]

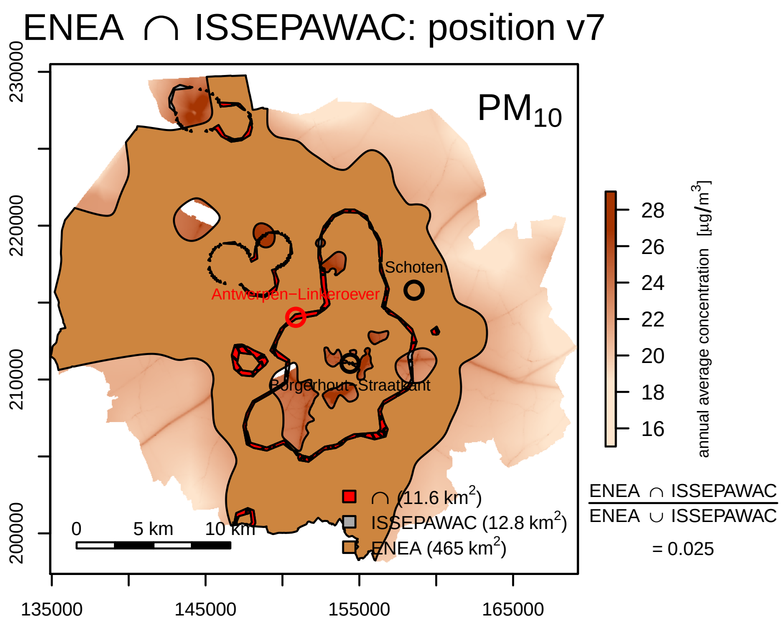

CIEMAT ∩ VMM: position v7
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
28
26
24
22
20
18
16
annual average concentration [µg/m3]

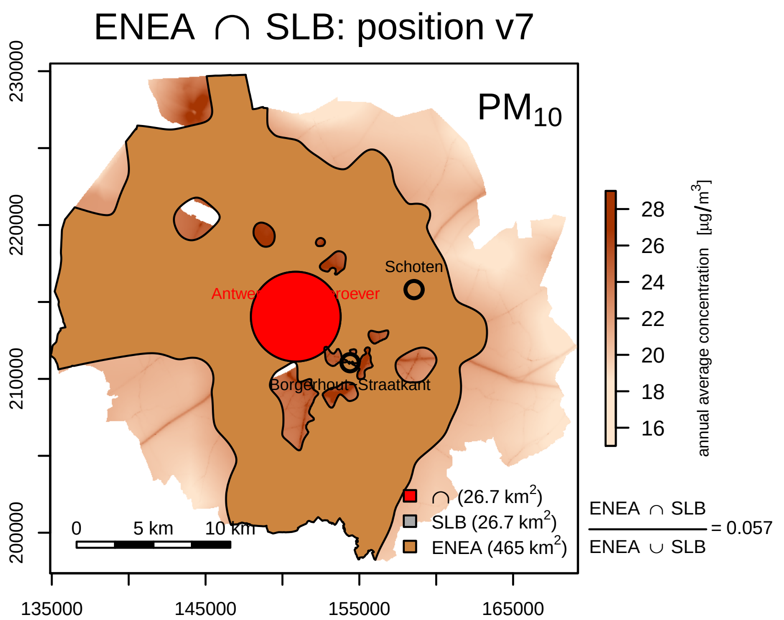

ENEA ∩ EPAIE: position v7
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (36.6 km²)
EPAIE (37.7 km²)
ENEA (465 km²)
0 5 km 10 km
230000
220000
210000
200000
135000
145000
155000
165000
28
26
24
22
20
18
16
annual average concentration [µg/m³]
ENEA ∩ EPAIE / ENEA ∪ EPAIE = 0.079

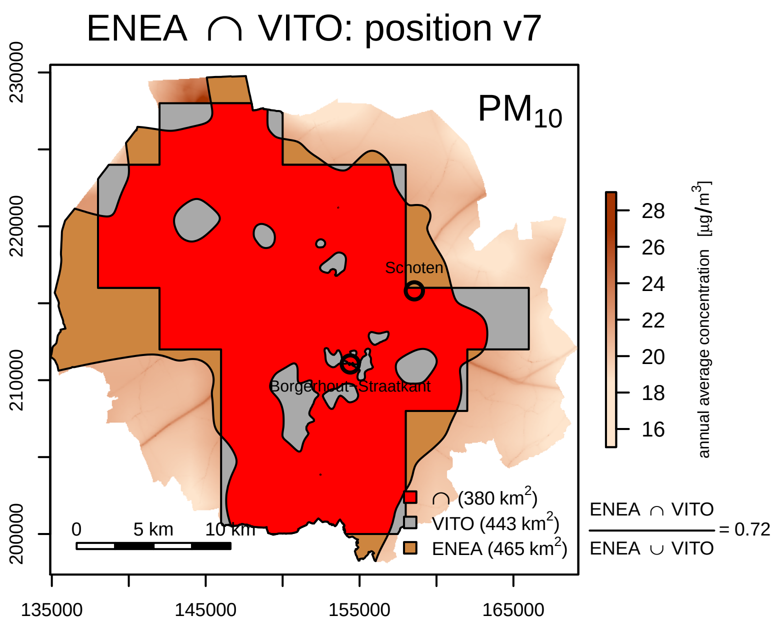

ENEA ∩ FEA−AT: position v7
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (229 km²)
FEA−AT (257 km²)
ENEA (465 km²)
0 5 km 10 km
230000
220000
210000
200000
135000
145000
155000
165000
28
26
24
22
20
18
16
annual average concentration [µg/m³]
ENEA ∩ FEA−AT / ENEA ∪ FEA−AT = 0.46

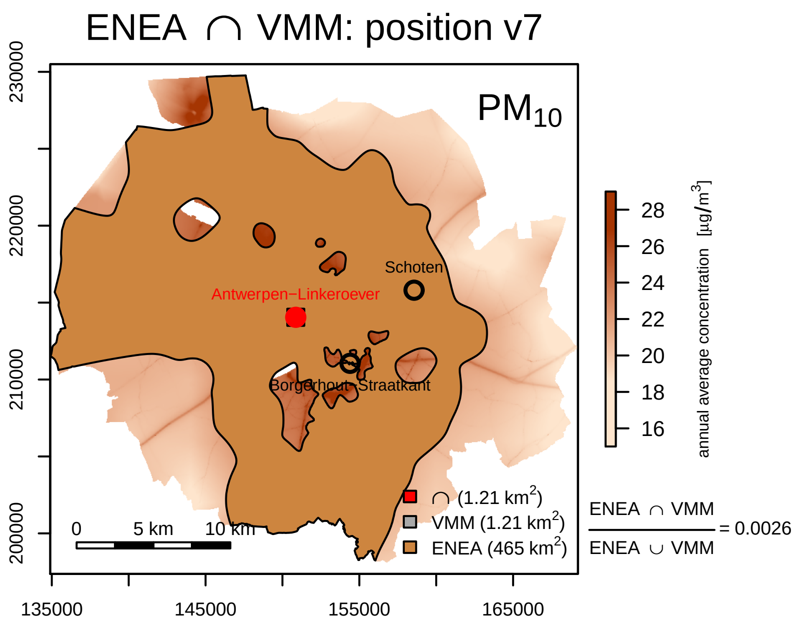

ENEA ∩ FI: position v7
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (26.5 km²)
FI (32 km²)
ENEA (465 km²)
0 5 km 10 km
230000
220000
210000
200000
135000
145000
155000
165000
28
26
24
22
20
18
16
annual average concentration [µg/m³]
ENEA ∩ FI / ENEA ∪ FI = 0.056

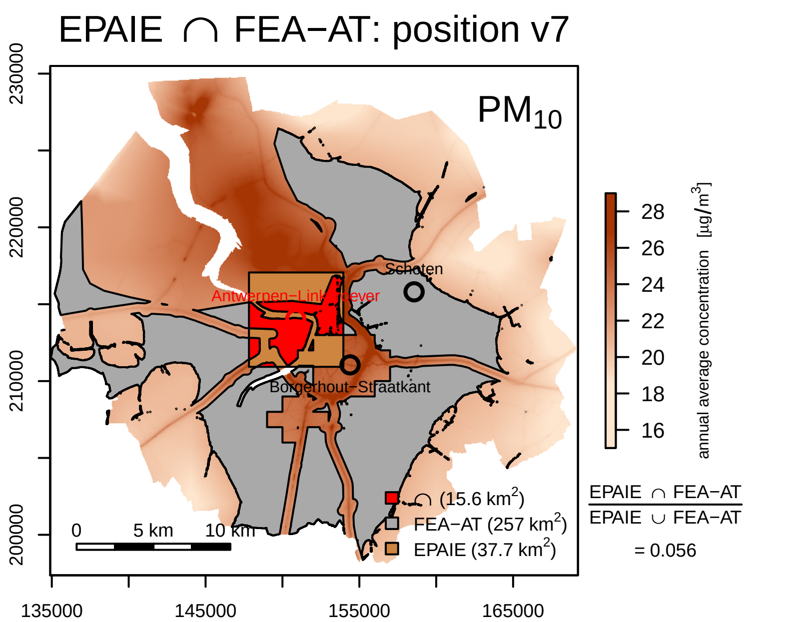

ENEA ∩ INERIS: position v7
PM10
Schoten
Borgerhout−Straatkant
0 5 km 10 km
∩ (462 km²)
INERIS (628 km²)
ENEA (465 km²)
230000
220000
210000
200000
135000 145000 155000 165000
28 26 24 22 20 18 16
annual average concentration [µg/m³]
ENEA ∩ INERIS
ENEA ∪ INERIS
= 0.73

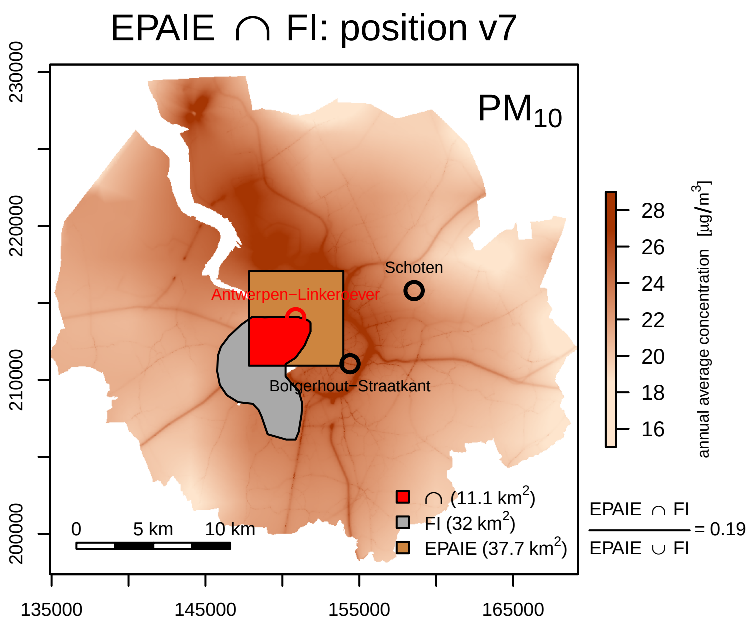

ENEA ∩ ISSEPAWAC: position v7
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (11.6 km²)
ISSEPAWAC (12.8 km²)
ENEA (465 km²)
230000
220000
210000
200000
135000 145000 155000 165000
28 26 24 22 20 18 16
annual average concentration [µg/m³]
ENEA ∩ ISSEPAWAC
ENEA ∪ ISSEPAWAC
= 0.025

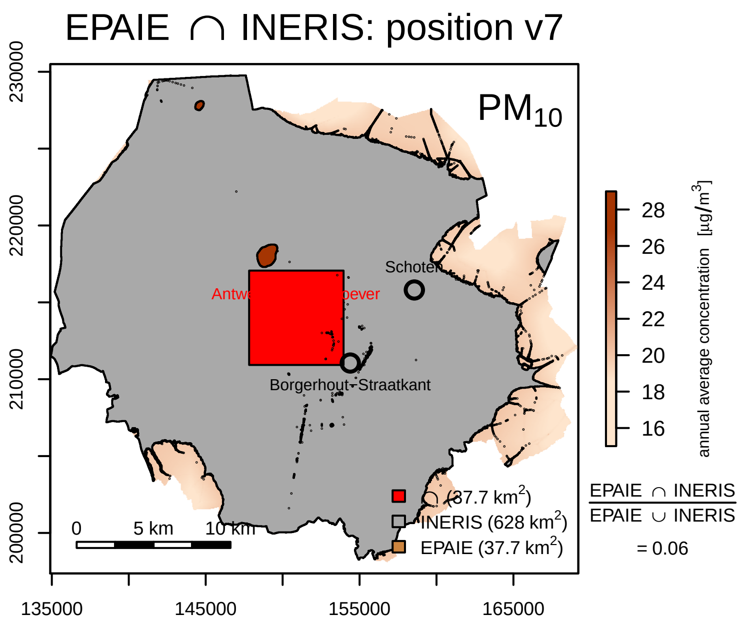

ENEA ∩ SLB: position v7
PM10
Schoten
Borgerhout−Straatkant
0 5 km 10 km
∩ (26.7 km²)
SLB (26.7 km²)
ENEA (465 km²)
230000
220000
210000
200000
135000 145000 155000 165000
28 26 24 22 20 18 16
annual average concentration [µg/m³]
ENEA ∩ SLB
ENEA ∪ SLB
= 0.057

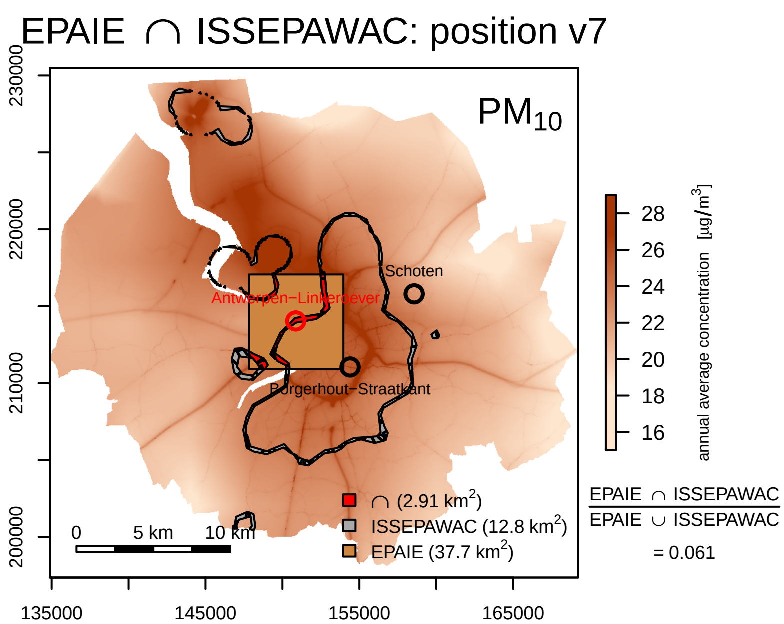

ENEA ∩ VITO: position v7
PM_{10}
Schoten
Borgerhout−Straatkant
0 5 km 10 km
∩ (380 km^2)
VITO (443 km^2)
ENEA (465 km^2)
28
26
24
22
20
18
16
annual average concentration [$\mu g/m^3$]
$\frac{\text{ENEA} \cap \text{VITO}}{\text{ENEA} \cup \text{VITO}} = 0.72$
200000
210000
220000
230000
135000
145000
155000
165000

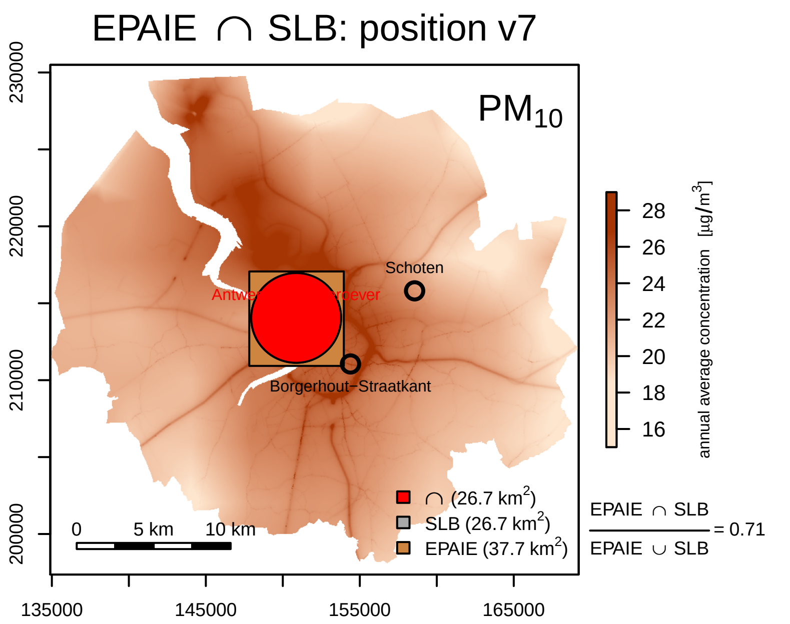

ENEA ∩ VMM: position v7
PM_{10}
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (1.21 km^2)
VMM (1.21 km^2)
ENEA (465 km^2)
28
26
24
22
20
18
16
annual average concentration [$\mu g/m^3$]
$\frac{\text{ENEA} \cap \text{VMM}}{\text{ENEA} \cup \text{VMM}} = 0.0026$
200000
210000
220000
230000
135000
145000
155000
165000

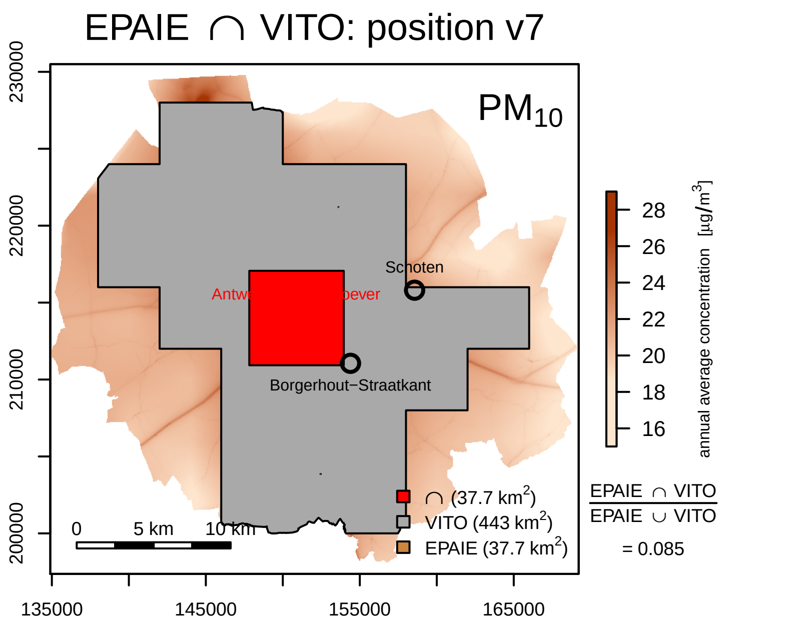

EPAIE ∩ FEA−AT: position v7
PM_{10}
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (15.6 km^2)
FEA−AT (257 km^2)
EPAIE (37.7 km^2)
28
26
24
22
20
18
16
annual average concentration [$\mu g/m^3$]
$\frac{\text{EPAIE} \cap \text{FEA−AT}}{\text{EPAIE} \cup \text{FEA−AT}}$
= 0.056
200000
210000
220000
230000
135000
145000
155000
165000

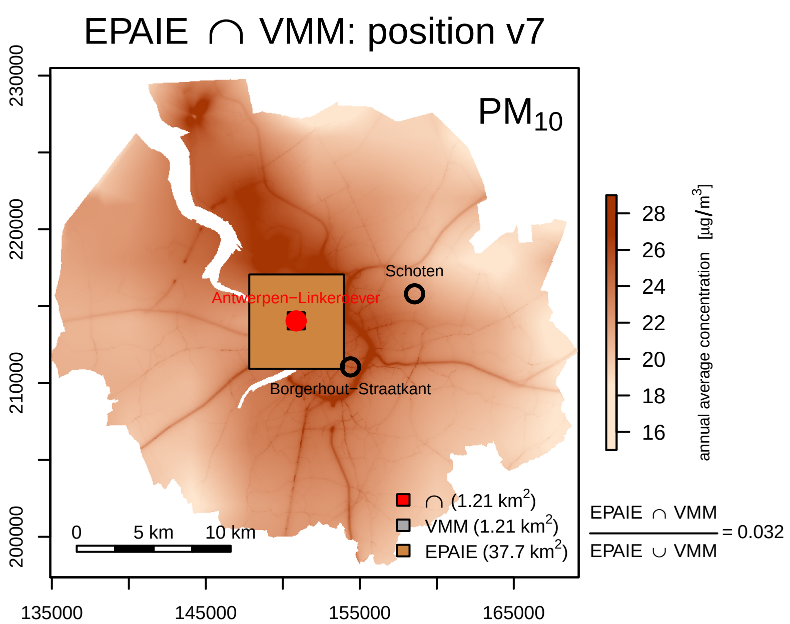

EPAIE ∩ FI: position v7
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (11.1 km²)
FI (32 km²)
EPAIE (37.7 km²)
annual average concentration [µg/m³]
28
26
24
22
20
18
16
EPAIE ∩ FI
EPAIE ∪ FI
= 0.19
230000
220000
210000
200000
135000
145000
155000
165000

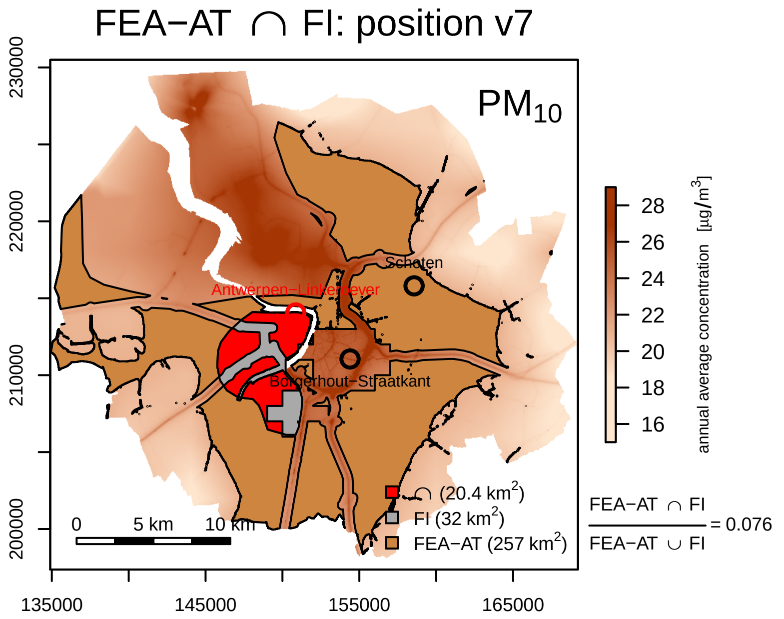

EPAIE ∩ INERIS: position v7
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (37.7 km²)
INERIS (628 km²)
EPAIE (37.7 km²)
annual average concentration [µg/m³]
28
26
24
22
20
18
16
EPAIE ∩ INERIS
EPAIE ∪ INERIS
= 0.06
230000
220000
210000
200000
135000
145000
155000
165000

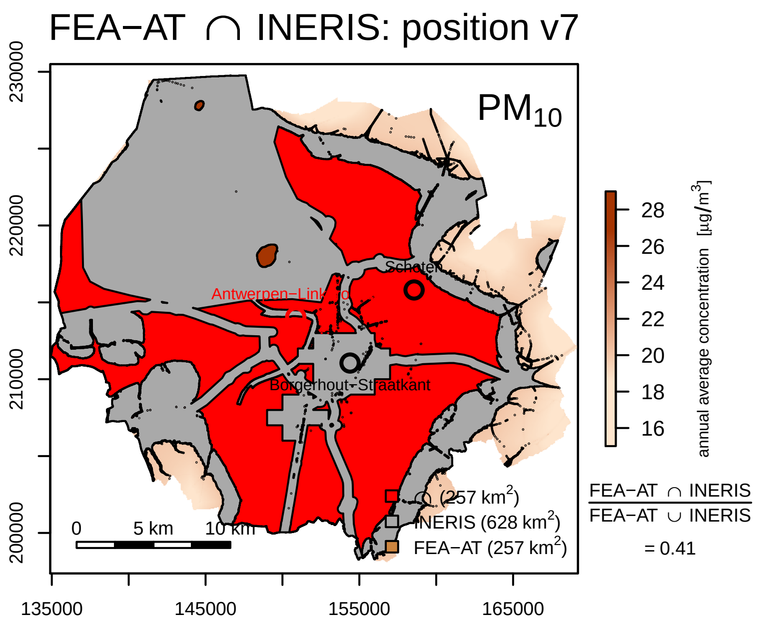

EPAIE ∩ ISSEPAWAC: position v7
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (2.91 km²)
ISSEPAWAC (12.8 km²)
EPAIE (37.7 km²)
annual average concentration [µg/m³]
28
26
24
22
20
18
16
EPAIE ∩ ISSEPAWAC
EPAIE ∪ ISSEPAWAC
= 0.061
230000
220000
210000
200000
135000
145000
155000
165000

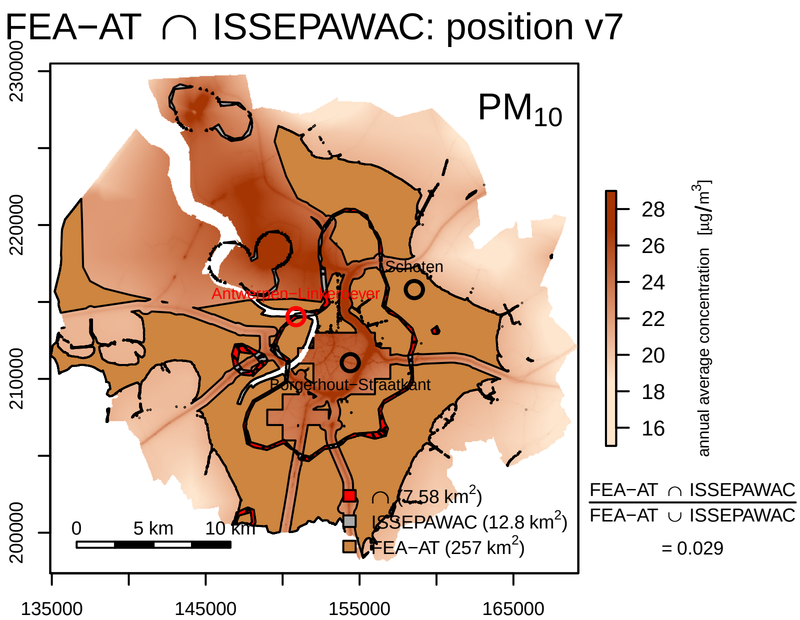

EPAIE ∩ SLB: position v7
PM10
Schoten
Borgerhout−Straatkant
0 5 km 10 km
∩ (26.7 km²)
SLB (26.7 km²)
EPAIE (37.7 km²)
28 26 24 22 20 18 16
annual average concentration [µg/m³]
EPAIE ∩ SLB / EPAIE ∪ SLB = 0.71
230000 220000 210000 200000
135000 145000 155000 165000

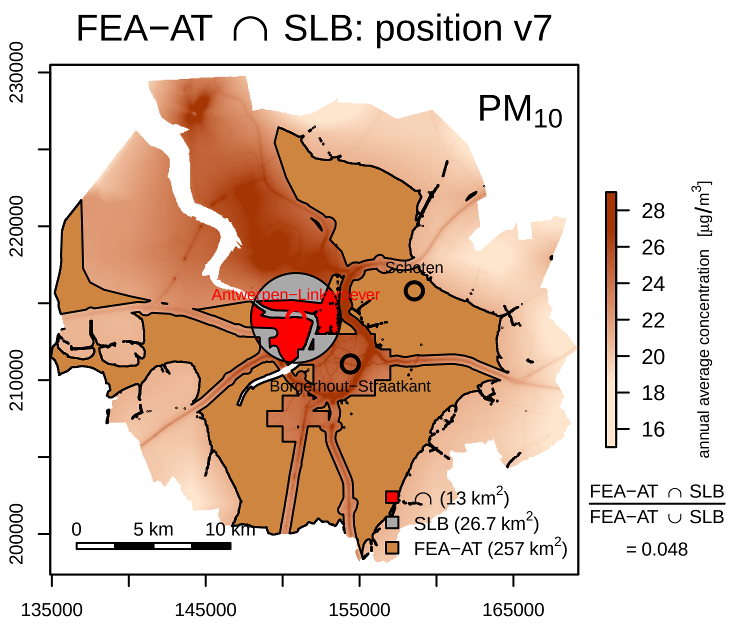

EPAIE ∩ VITO: position v7
PM10
Schoten
Borgerhout−Straatkant
0 5 km 10 km
∩ (37.7 km²)
VITO (443 km²)
EPAIE (37.7 km²)
28 26 24 22 20 18 16
annual average concentration [µg/m³]
EPAIE ∩ VITO / EPAIE ∪ VITO = 0.085
230000 220000 210000 200000
135000 145000 155000 165000


EPAIE ∩ VMM: position v7
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (1.21 km²)
VMM (1.21 km²)
EPAIE (37.7 km²)
28 26 24 22 20 18 16
annual average concentration [µg/m³]
EPAIE ∩ VMM / EPAIE ∪ VMM = 0.032
230000 220000 210000 200000
135000 145000 155000 165000

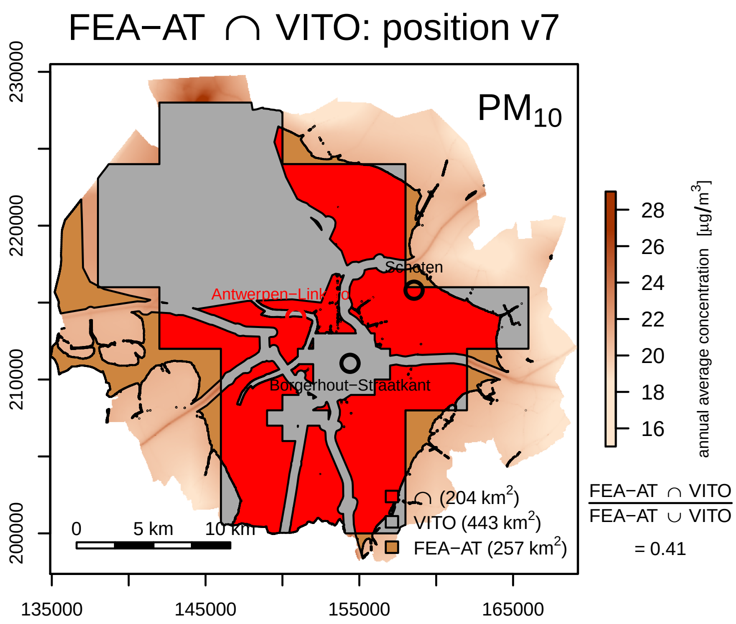

FEA−AT ∩ FI: position v7
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (20.4 km²)
FI (32 km²)
FEA−AT (257 km²)
0 5 km 10 km
230000
220000
210000
200000
135000
145000
155000
165000
28
26
24
22
20
18
16
annual average concentration [µg/m³]
FEA−AT ∩ FI
FEA−AT ∪ FI
= 0.076


FEA−AT ∩ INERIS: position v7
PM10
Schoten
Antwerpen−Linkero
Borgerhout−Straatkant
∩ (257 km²)
INERIS (628 km²)
FEA−AT (257 km²)
0 5 km 10 km
230000
220000
210000
200000
135000
145000
155000
165000
28
26
24
22
20
18
16
annual average concentration [µg/m³]
FEA−AT ∩ INERIS
FEA−AT ∪ INERIS
= 0.41

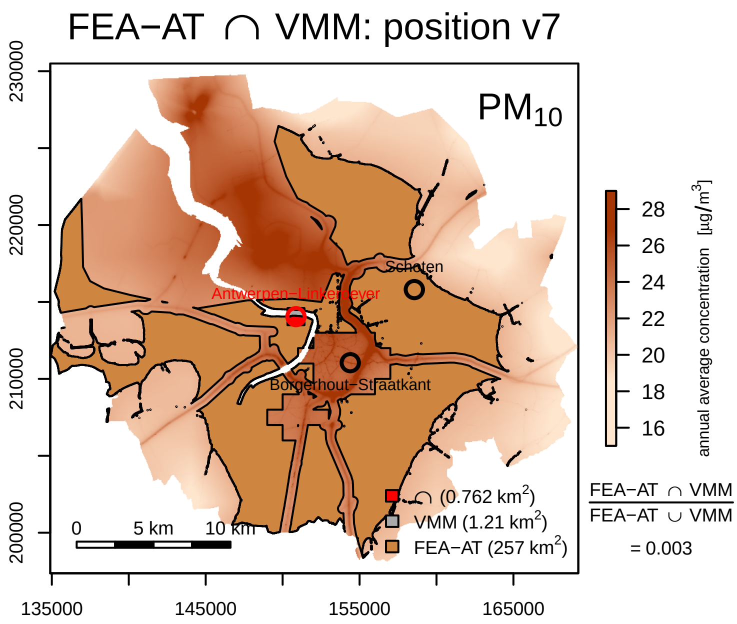

FEA−AT ∩ ISSEPAWAC: position v7
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (7.58 km²)
ISSEPAWAC (12.8 km²)
FEA−AT (257 km²)
0 5 km 10 km
230000
220000
210000
200000
135000
145000
155000
165000
28
26
24
22
20
18
16
annual average concentration [µg/m³]
FEA−AT ∩ ISSEPAWAC
FEA−AT ∪ ISSEPAWAC
= 0.029



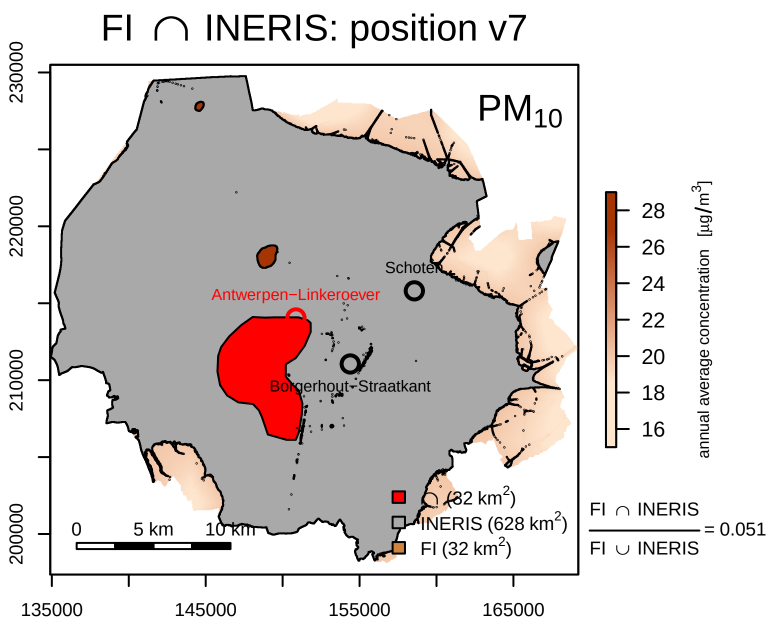
FEA−AT ∩ SLB: position v7
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (13 km2)
SLB (26.7 km2)
FEA−AT (257 km2)
FEA−AT ∩ SLB
FEA−AT ∪ SLB
= 0.048
annual average concentration [µg/m3]
0 5 km 10 km



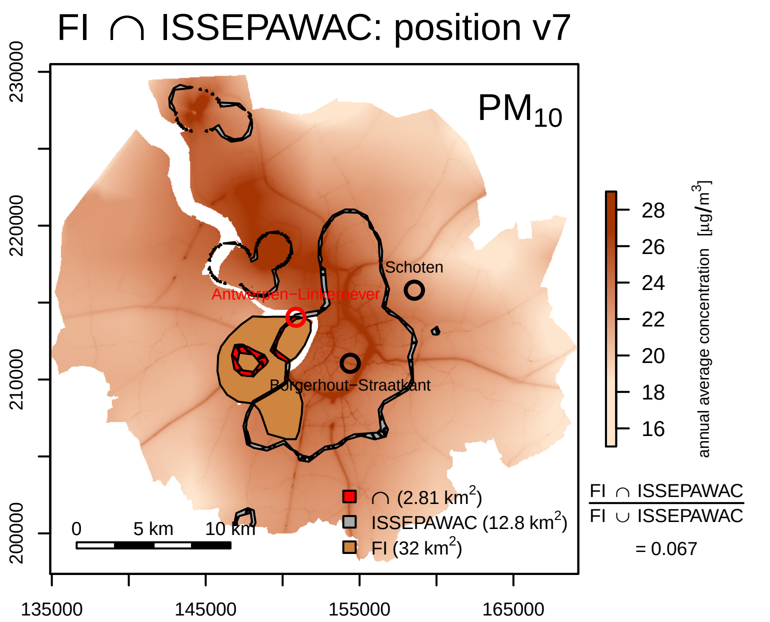
FEA−AT ∩ VITO: position v7
PM10
Schoten
Borgerhout−Straatkant
∩ (204 km2)
VITO (443 km2)
FEA−AT (257 km2)
FEA−AT ∩ VITO
FEA−AT ∪ VITO
= 0.41
annual average concentration [µg/m3]
0 5 km 10 km



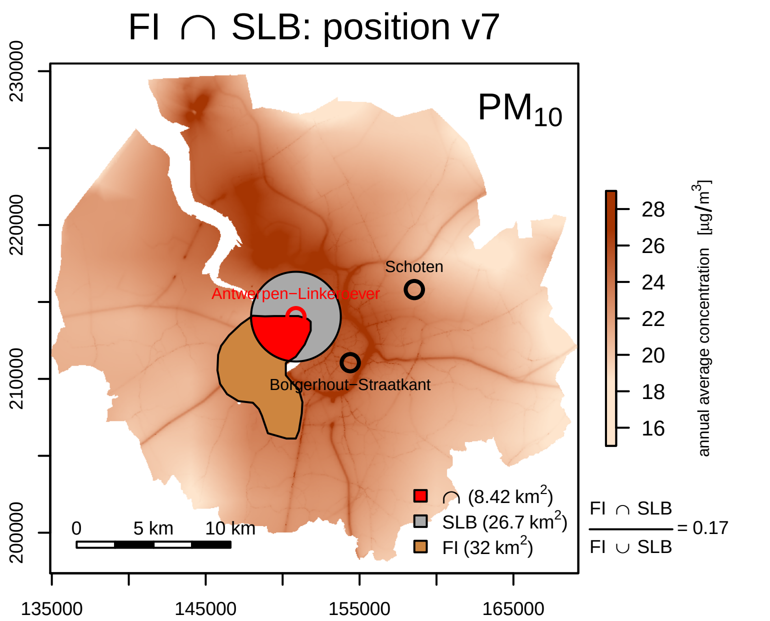
FEA−AT ∩ VMM: position v7
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.762 km2)
VMM (1.21 km2)
FEA−AT (257 km2)
FEA−AT ∩ VMM
FEA−AT ∪ VMM
= 0.003
annual average concentration [µg/m3]
0 5 km 10 km



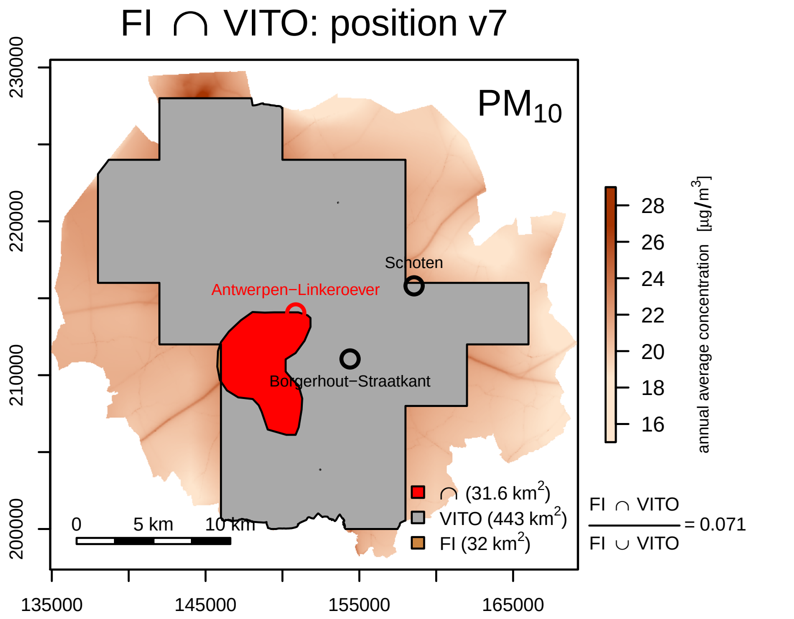
FI ∩ INERIS: position v7
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (32 km2)
INERIS (628 km2)
FI (32 km2)
FI ∩ INERIS / FI ∪ INERIS = 0.051
annual average concentration [µg/m3]
28 26 24 22 20 18 16
230000 220000 210000 200000
135000 145000 155000 165000

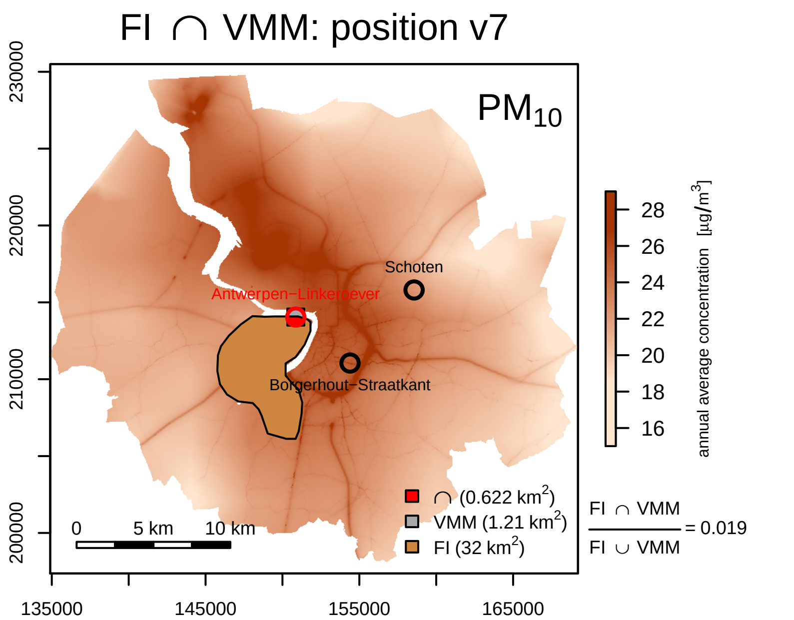


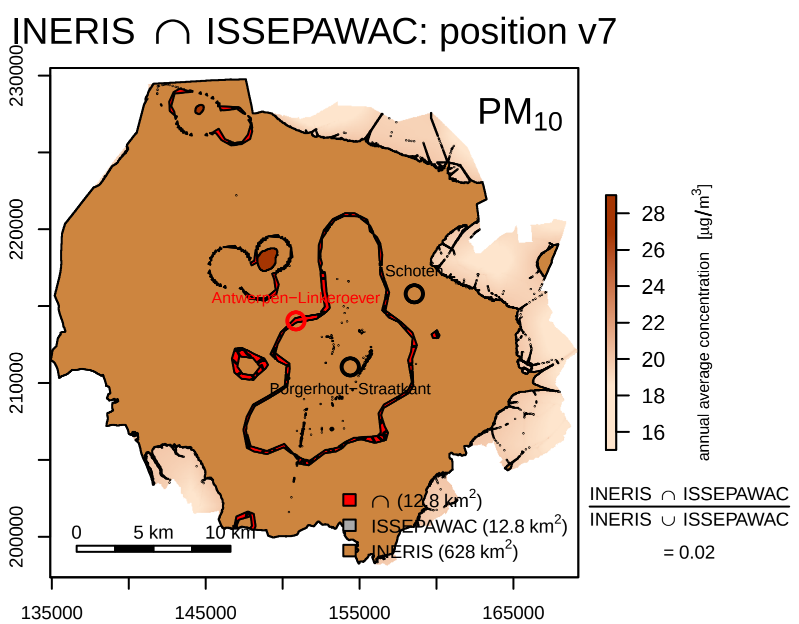
FI ∩ ISSEPAWAC: position v7
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (2.81 km2)
ISSEPAWAC (12.8 km2)
FI (32 km2)
FI ∩ ISSEPAWAC / FI ∪ ISSEPAWAC = 0.067
annual average concentration [µg/m3]
28 26 24 22 20 18 16
230000 220000 210000 200000
135000 145000 155000 165000

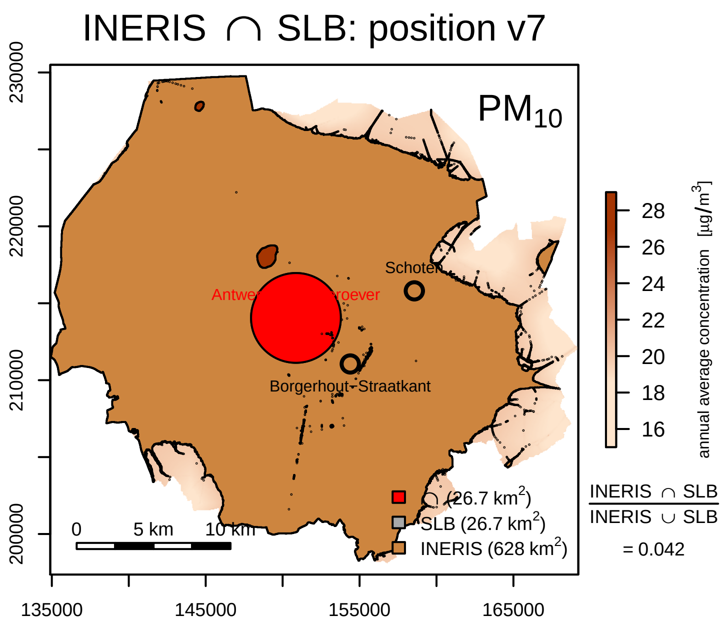


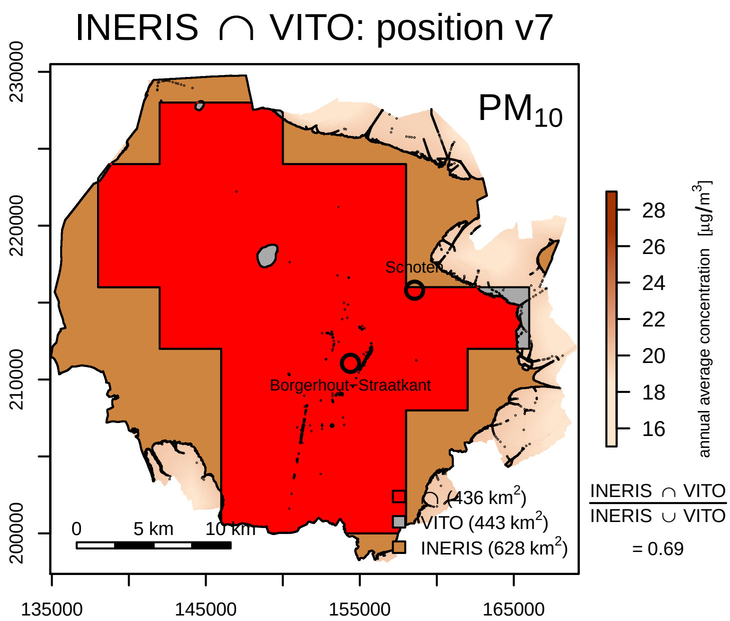
FI ∩ SLB: position v7
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (8.42 km2)
SLB (26.7 km2)
FI (32 km2)
FI ∩ SLB / FI ∪ SLB = 0.17
annual average concentration [µg/m3]
28 26 24 22 20 18 16
230000 220000 210000 200000
135000 145000 155000 165000

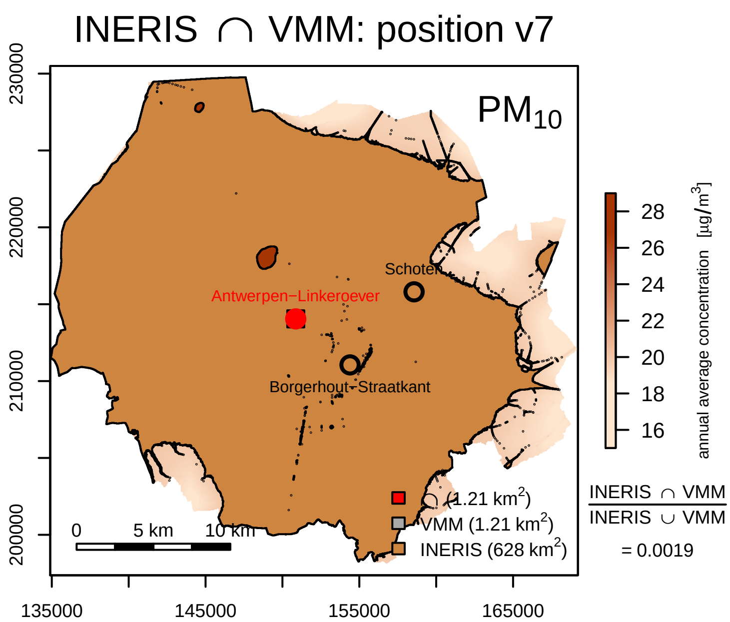

FI ∩ VITO: position v7
PM_{10}
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (31.6 km^2)
VITO (443 km^2)
FI (32 km^2)
28
26
24
22
20
18
16
annual average concentration [$\mu g/m^3$]
FI ∩ VITO / FI ∪ VITO = 0.071
230000
220000
210000
200000
135000
145000
155000
165000

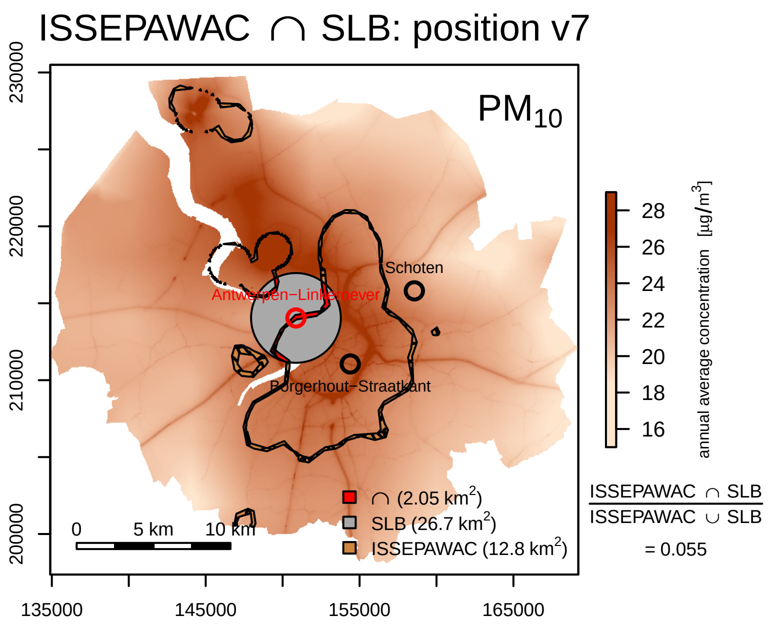

FI ∩ VMM: position v7
PM_{10}
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (0.622 km^2)
VMM (1.21 km^2)
FI (32 km^2)
28
26
24
22
20
18
16
annual average concentration [$\mu g/m^3$]
FI ∩ VMM / FI ∪ VMM = 0.019
230000
220000
210000
200000
135000
145000
155000
165000

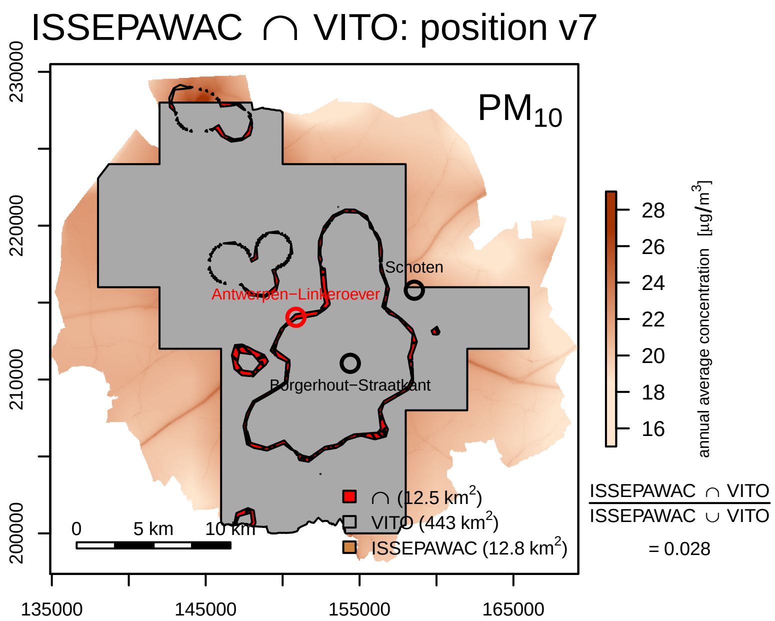

INERIS ∩ ISSEPAWAC: position v7
PM_{10}
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (12.8 km^2)
ISSEPAWAC (12.8 km^2)
INERIS (628 km^2)
28
26
24
22
20
18
16
annual average concentration [$\mu g/m^3$]
INERIS ∩ ISSEPAWAC / INERIS ∪ ISSEPAWAC = 0.02
230000
220000
210000
200000
135000
145000
155000
165000

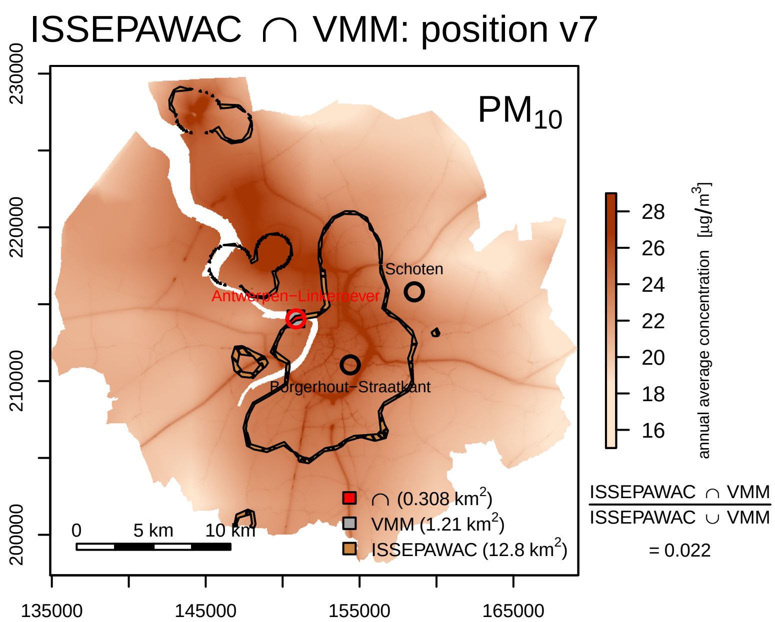

INERIS ∩ SLB: position v7
PM10
Schoten
Antwerpen-Linkeroever
Borgerhout-Straatkant
0
5 km
10 km
∩ (26.7 km²)
SLB (26.7 km²)
INERIS (628 km²)
28
26
24
22
20
18
16
annual average concentration [µg/m³]
INERIS ∩ SLB
INERIS ∪ SLB
= 0.042
230000
220000
210000
200000
135000
145000
155000
165000

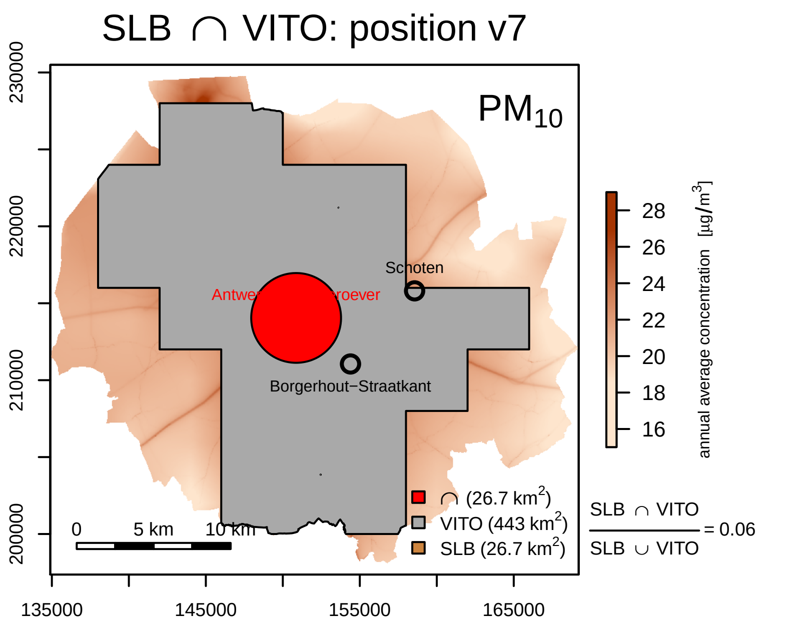

INERIS ∩ VITO: position v7
PM10
Schoten
Borgerhout-Straatkant
0
5 km
10 km
∩ (436 km²)
VITO (443 km²)
INERIS (628 km²)
28
26
24
22
20
18
16
annual average concentration [µg/m³]
INERIS ∩ VITO
INERIS ∪ VITO
= 0.69
230000
220000
210000
200000
135000
145000
155000
165000

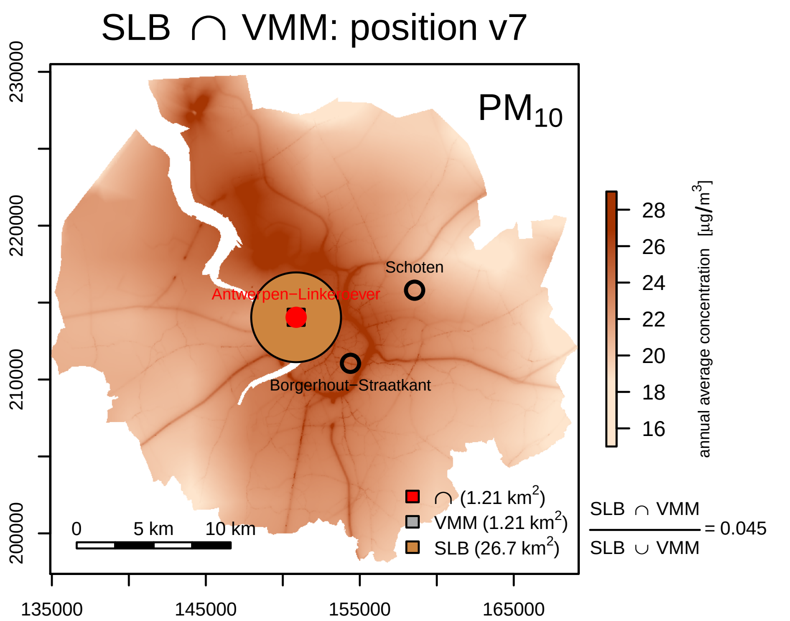

INERIS ∩ VMM: position v7
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout-Straatkant
0
5 km
10 km
∩ (1.21 km²)
VMM (1.21 km²)
INERIS (628 km²)
28
26
24
22
20
18
16
annual average concentration [µg/m³]
INERIS ∩ VMM
INERIS ∪ VMM
= 0.0019
230000
220000
210000
200000
135000
145000
155000
165000

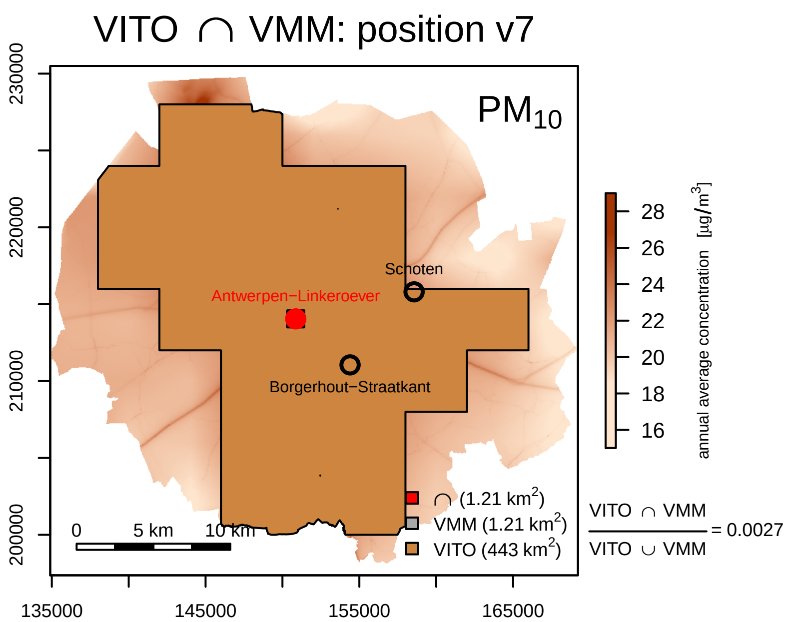

ISSEPAWAC ∩ SLB: position v7
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (2.05 km²)
SLB (26.7 km²)
ISSEPAWAC (12.8 km²)
28
26
24
22
20
18
16
annual average concentration [µg/m³]
ISSEPAWAC ∩ SLB
ISSEPAWAC ∪ SLB
= 0.055
230000
220000
210000
200000
135000
145000
155000
165000


ISSEPAWAC ∩ VITO: position v7
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (12.5 km²)
VITO (443 km²)
ISSEPAWAC (12.8 km²)
28
26
24
22
20
18
16
annual average concentration [µg/m³]
ISSEPAWAC ∩ VITO
ISSEPAWAC ∪ VITO
= 0.028
230000
220000
210000
200000
135000
145000
155000
165000


ISSEPAWAC ∩ VMM: position v7
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (0.308 km²)
VMM (1.21 km²)
ISSEPAWAC (12.8 km²)
28
26
24
22
20
18
16
annual average concentration [µg/m³]
ISSEPAWAC ∩ VMM
ISSEPAWAC ∪ VMM
= 0.022
230000
220000
210000
200000
135000
145000
155000
165000


SLB ∩ VITO: position v7
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (26.7 km²)
VITO (443 km²)
SLB (26.7 km²)
SLB ∩ VITO / SLB ∪ VITO = 0.06
annual average concentration [µg/m³]
28 26 24 22 20 18 16
135000 145000 155000 165000
200000 210000 220000 230000

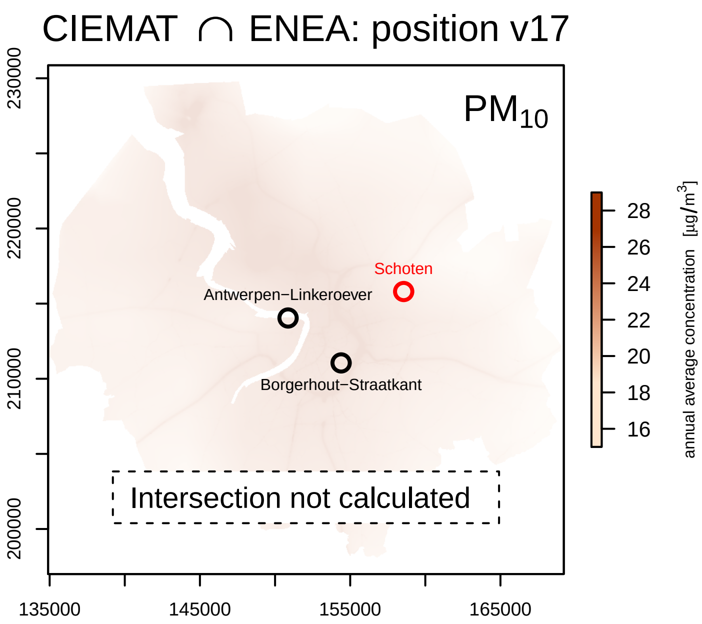

SLB ∩ VMM: position v7
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (1.21 km²)
VMM (1.21 km²)
SLB (26.7 km²)
SLB ∩ VMM / SLB ∪ VMM = 0.045
annual average concentration [µg/m³]
28 26 24 22 20 18 16
135000 145000 155000 165000
200000 210000 220000 230000

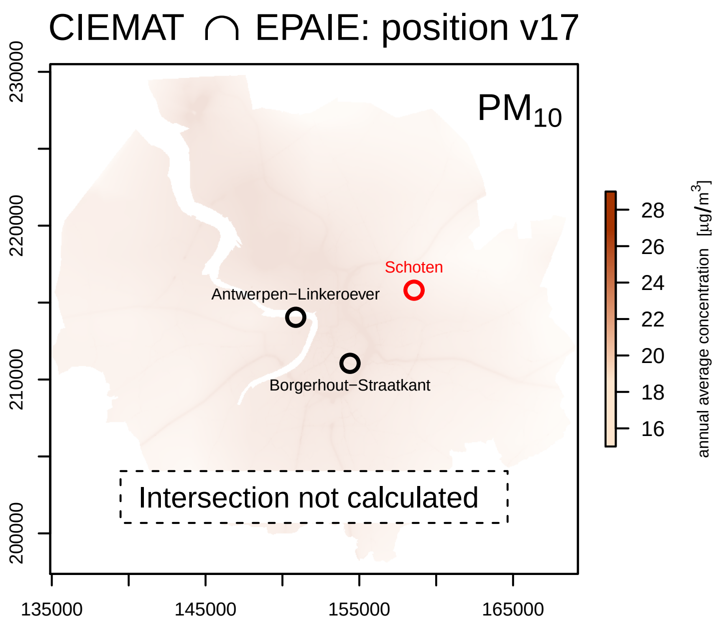

VITO ∩ VMM: position v7
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (1.21 km²)
VMM (1.21 km²)
VITO (443 km²)
VITO ∩ VMM / VITO ∪ VMM = 0.0027
annual average concentration [µg/m³]
28 26 24 22 20 18 16
135000 145000 155000 165000
200000 210000 220000 230000

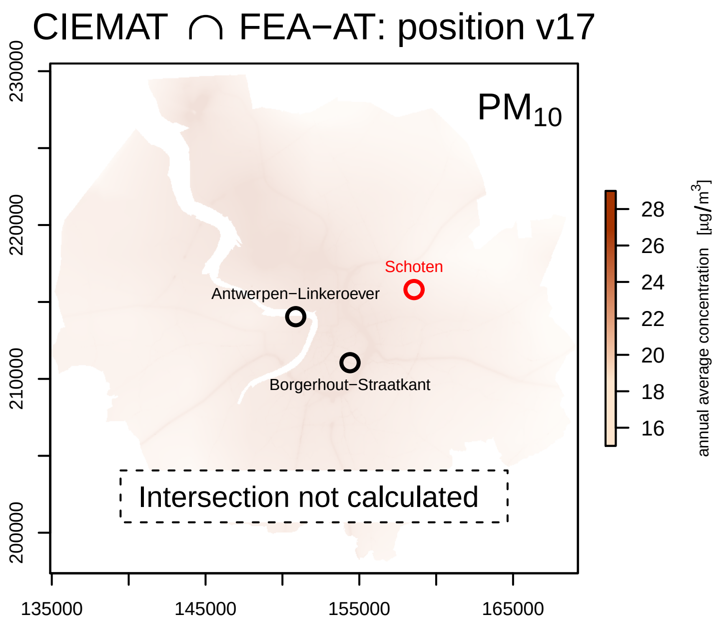
Mutual Comparisons between Teams

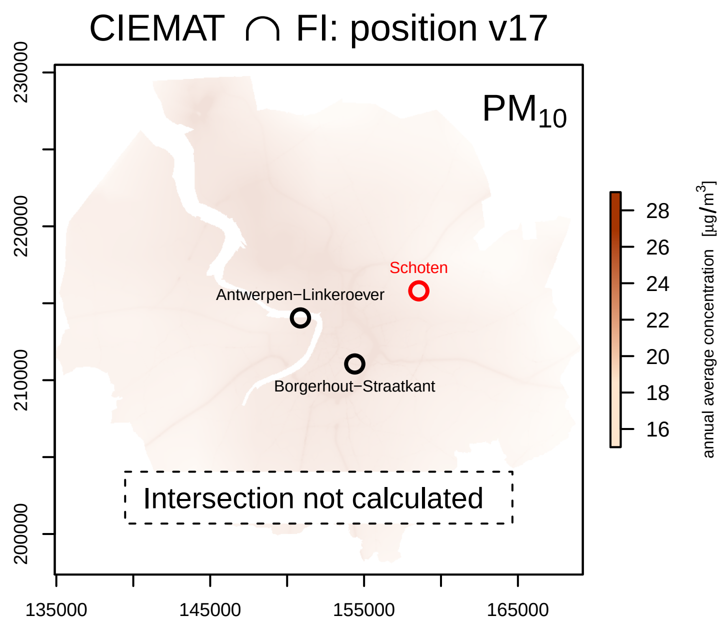
by Pollutant & Station:

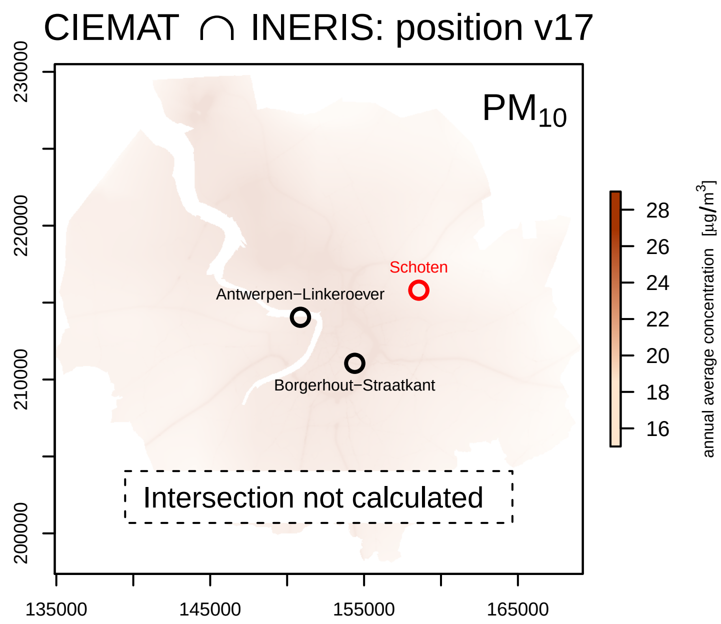
PM_{10} at virtual station v17

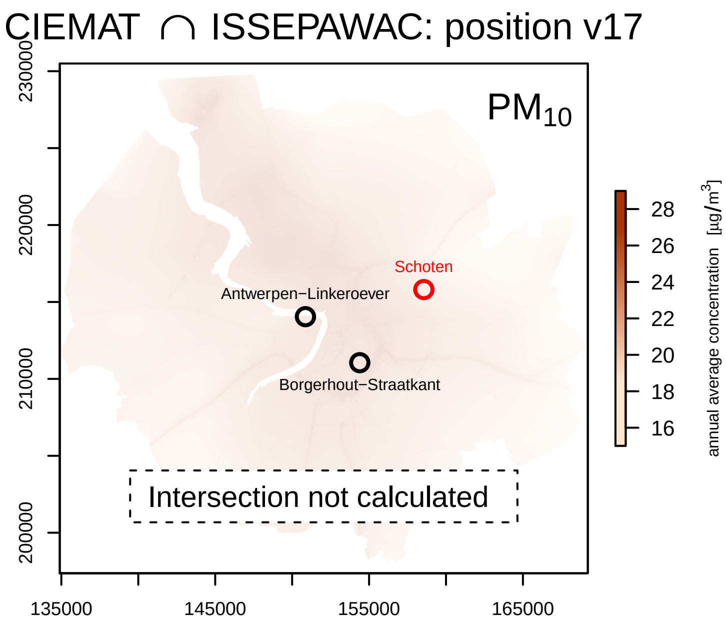

CIEMAT ∩ ENEA: position v17
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
28
26
24
22
20
18
16
annual average concentration [µg/m3]

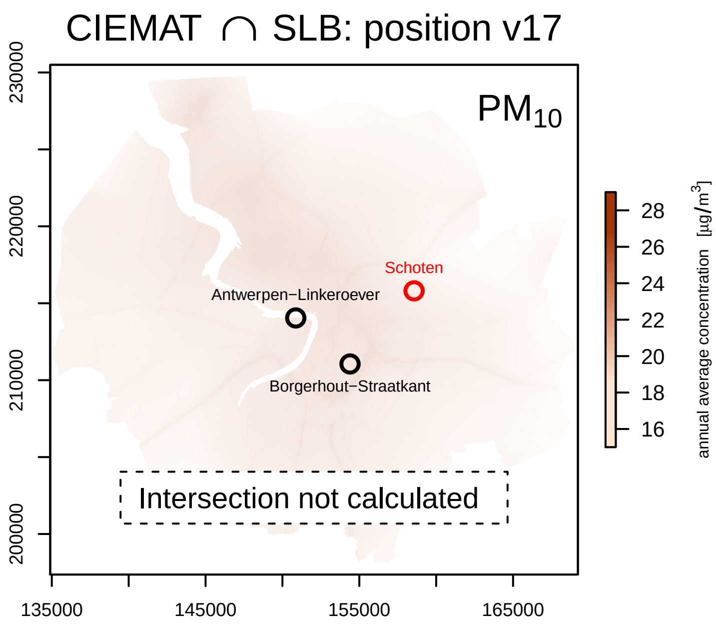

CIEMAT ∩ EPAIE: position v17
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
28
26
24
22
20
18
16
annual average concentration [µg/m3]

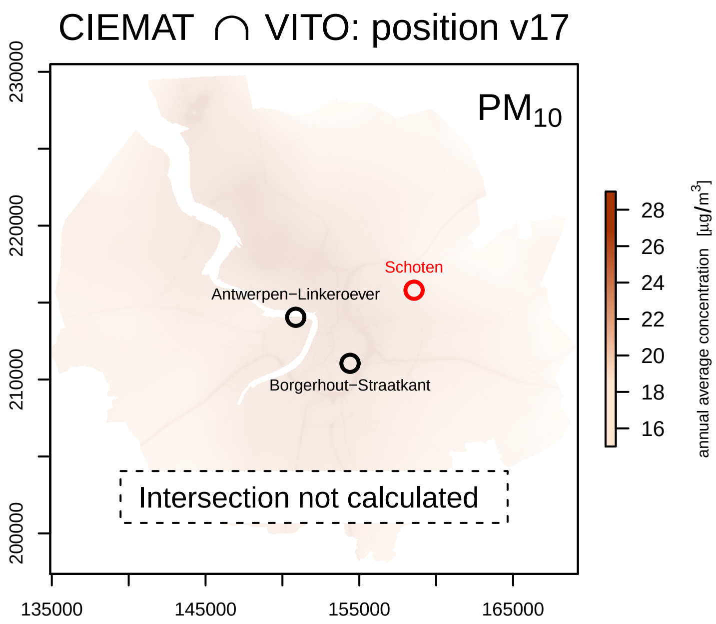

CIEMAT ∩ FEA−AT: position v17
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
28
26
24
22
20
18
16
annual average concentration [µg/m3]

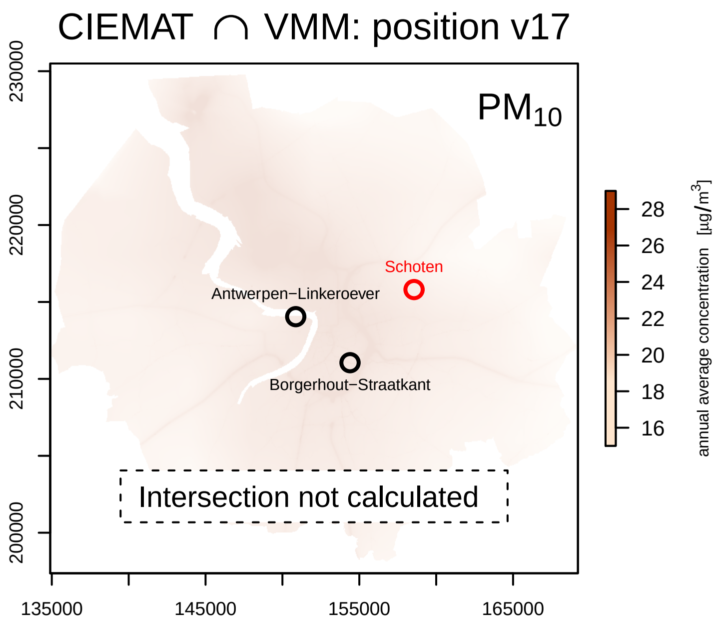

CIEMAT ∩ FI: position v17
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
annual average concentration [µg/m3]
28
26
24
22
20
18
16
230000
220000
210000
200000
135000
145000
155000
165000

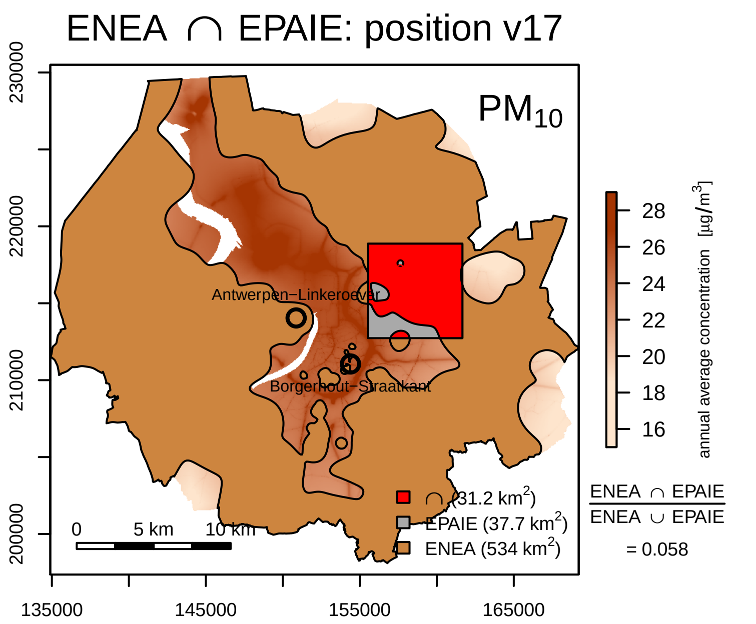

CIEMAT ∩ INERIS: position v17
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
annual average concentration [µg/m3]
28
26
24
22
20
18
16
230000
220000
210000
200000
135000
145000
155000
165000

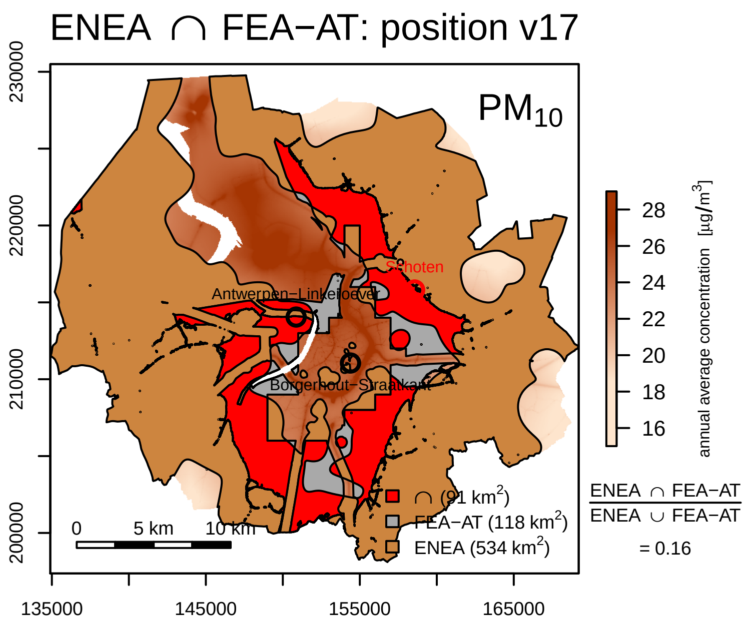

CIEMAT ∩ ISSEPAWAC: position v17
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
annual average concentration [µg/m3]
28
26
24
22
20
18
16
230000
220000
210000
200000
135000
145000
155000
165000

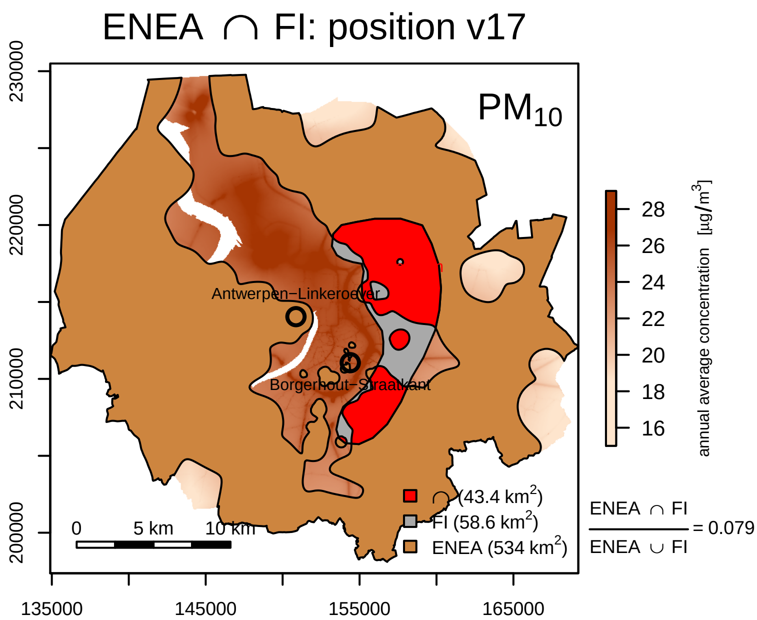

CIEMAT ∩ SLB: position v17
PM$_{10}$
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
28
26
24
22
20
18
16
annual average concentration [µg/m^3]

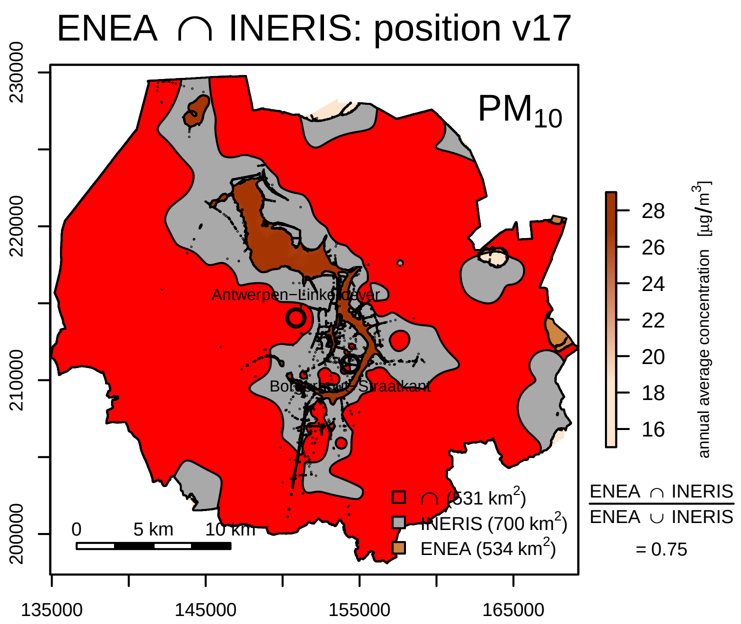

CIEMAT ∩ VITO: position v17
PM$_{10}$
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
28
26
24
22
20
18
16
annual average concentration [µg/m^3]


CIEMAT ∩ VMM: position v17
PM$_{10}$
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
Intersection not calculated
230000
220000
210000
200000
135000
145000
155000
165000
28
26
24
22
20
18
16
annual average concentration [µg/m^3]

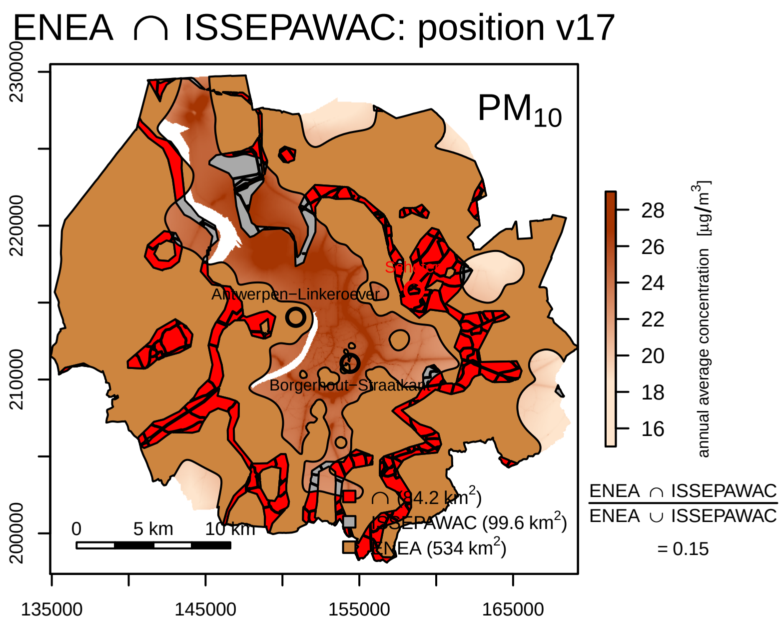

ENEA ∩ EPAIE: position v17
PM10
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (31.2 km²)
EPAIE (37.7 km²)
ENEA (534 km²)
28
26
24
22
20
18
16
annual average concentration [µg/m³]
ENEA ∩ EPAIE
ENEA ∪ EPAIE
= 0.058
230000
220000
210000
200000
135000
145000
155000
165000


ENEA ∩ FEA−AT: position v17
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (91 km²)
FEA−AT (118 km²)
ENEA (534 km²)
28
26
24
22
20
18
16
annual average concentration [µg/m³]
ENEA ∩ FEA−AT
ENEA ∪ FEA−AT
= 0.16
230000
220000
210000
200000
135000
145000
155000
165000

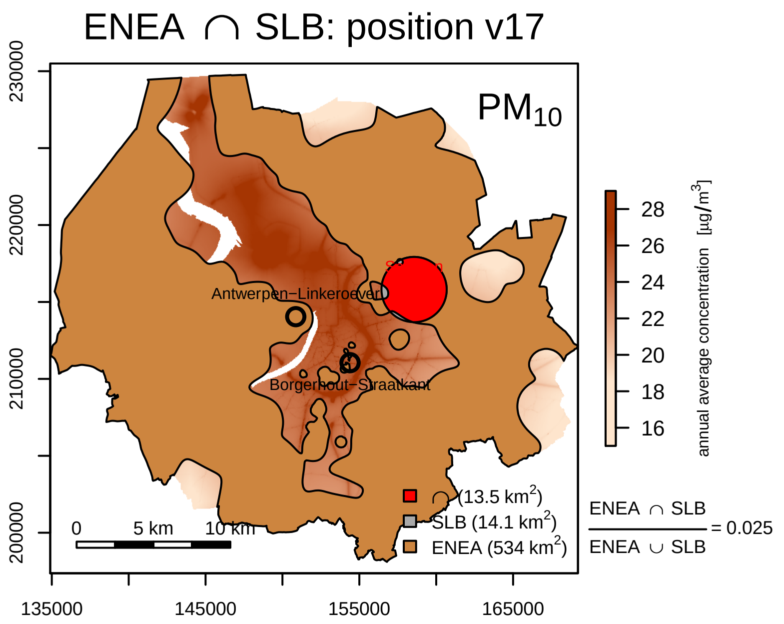

ENEA ∩ FI: position v17
PM10
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (43.4 km²)
FI (58.6 km²)
ENEA (534 km²)
28
26
24
22
20
18
16
annual average concentration [µg/m³]
ENEA ∩ FI
ENEA ∪ FI
= 0.079
230000
220000
210000
200000
135000
145000
155000
165000



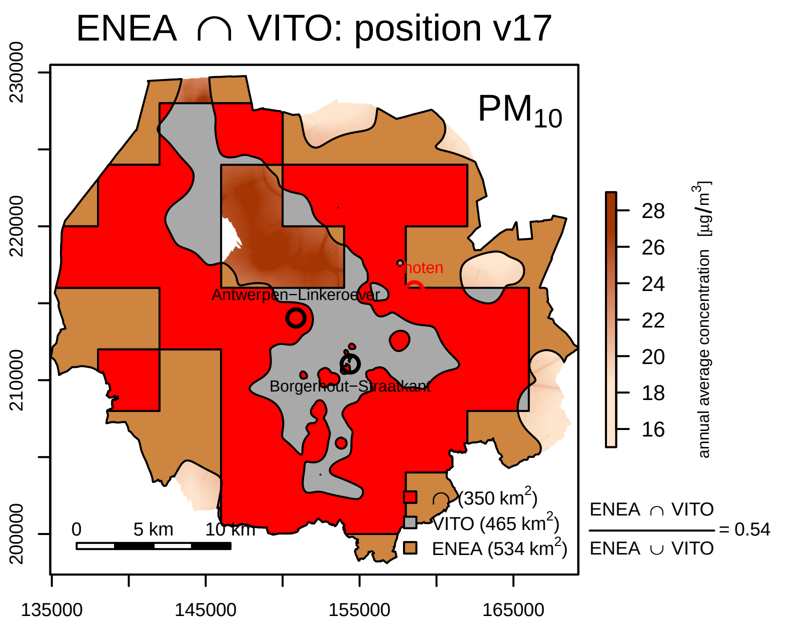
ENEA ∩ INERIS: position v17
PM10
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (531 km2)
INERIS (700 km2)
ENEA (534 km2)
0 5 km 10 km
ENEA ∩ INERIS
ENEA ∪ INERIS
= 0.75
annual average concentration [µg/m3]

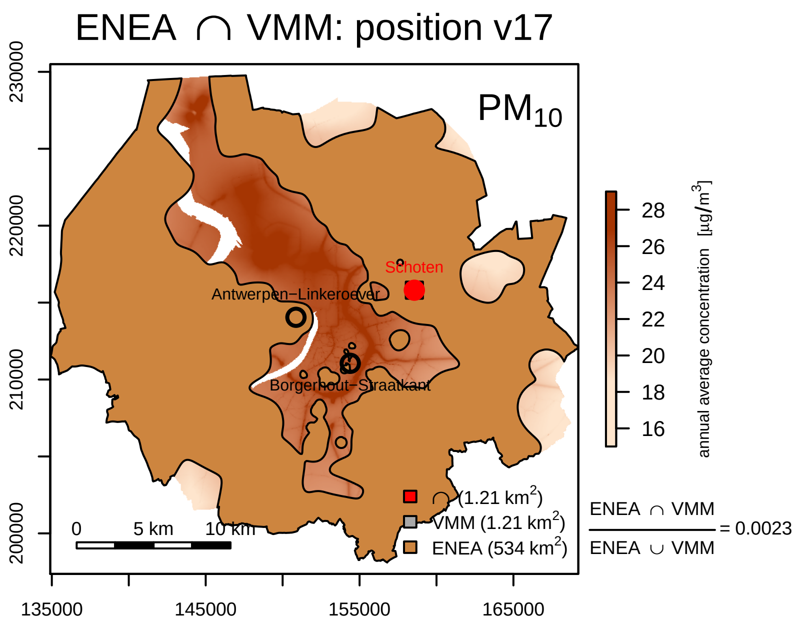


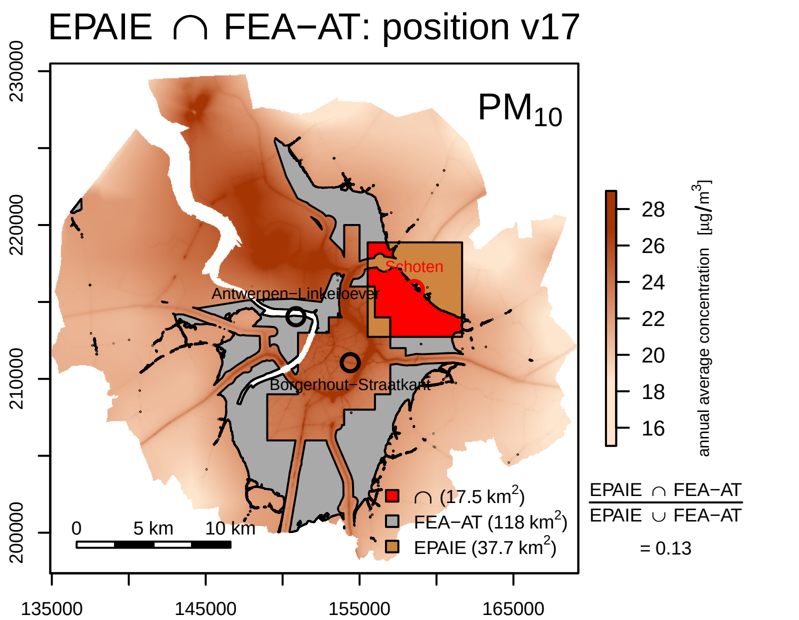
ENEA ∩ ISSEPAWAC: position v17
PM10
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (84.2 km2)
ISSEPAWAC (99.6 km2)
ENEA (534 km2)
0 5 km 10 km
ENEA ∩ ISSEPAWAC
ENEA ∪ ISSEPAWAC
= 0.15
annual average concentration [µg/m3]



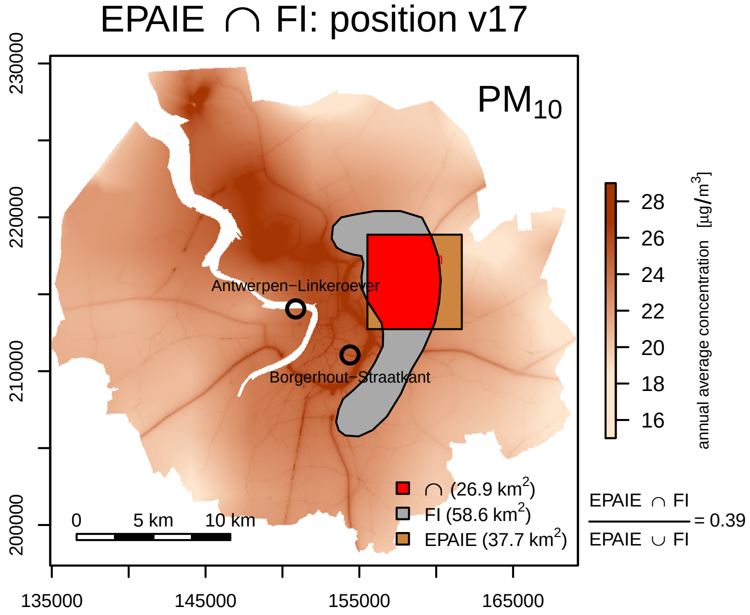
ENEA ∩ SLB: position v17
PM10
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (13.5 km2)
SLB (14.1 km2)
ENEA (534 km2)
0 5 km 10 km
ENEA ∩ SLB
ENEA ∪ SLB
= 0.025
annual average concentration [µg/m3]


ENEA ∩ VITO: position v17
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (350 km2)
VITO (465 km2)
ENEA (534 km2)
28
26
24
22
20
18
16
annual average concentration [µg/m3]
ENEA ∩ VITO / ENEA ∪ VITO = 0.54
230000
220000
210000
200000
135000
145000
155000
165000

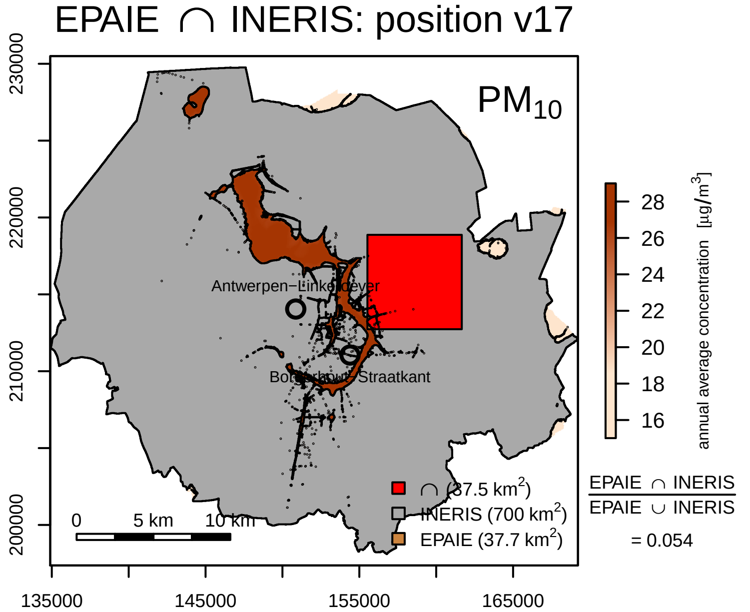

ENEA ∩ VMM: position v17
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (1.21 km2)
VMM (1.21 km2)
ENEA (534 km2)
28
26
24
22
20
18
16
annual average concentration [µg/m3]
ENEA ∩ VMM / ENEA ∪ VMM = 0.0023
230000
220000
210000
200000
135000
145000
155000
165000


EPAIE ∩ FEA−AT: position v17
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (17.5 km2)
FEA−AT (118 km2)
EPAIE (37.7 km2)
28
26
24
22
20
18
16
annual average concentration [µg/m3]
EPAIE ∩ FEA−AT / EPAIE ∪ FEA−AT = 0.13
230000
220000
210000
200000
135000
145000
155000
165000

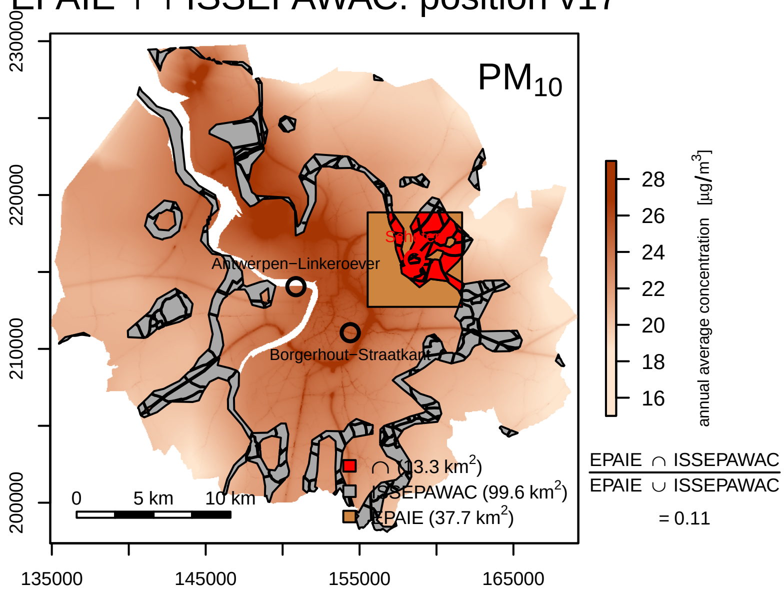
EPAIE ∩ FI: position v17

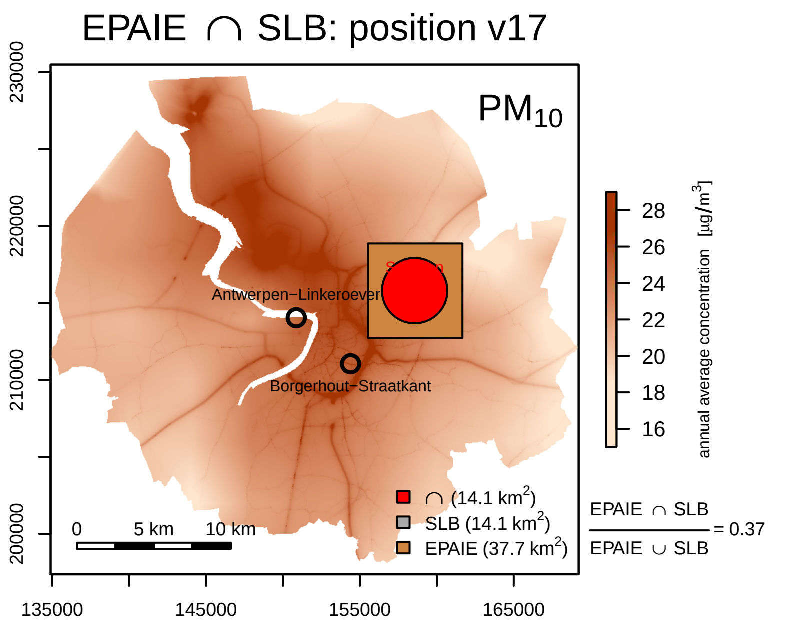


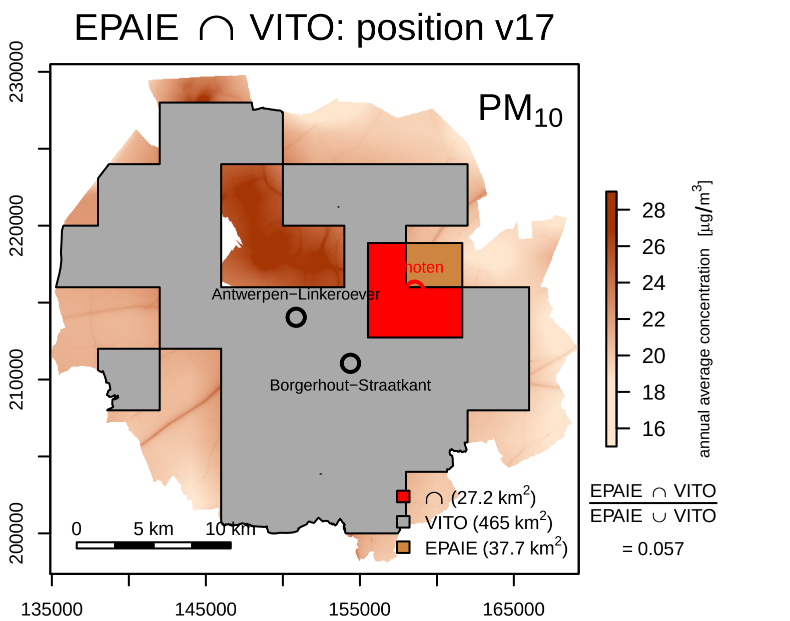
EPAIE ∩ INERIS: position v17

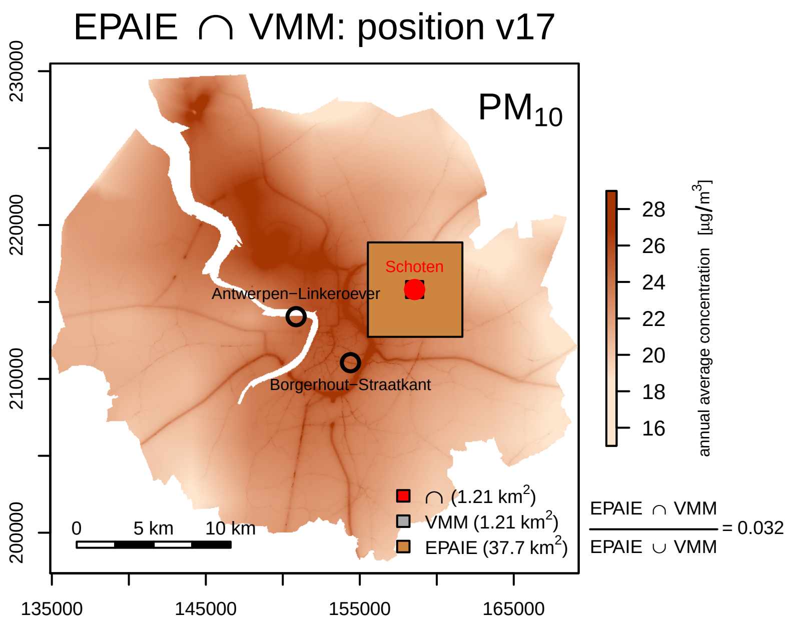


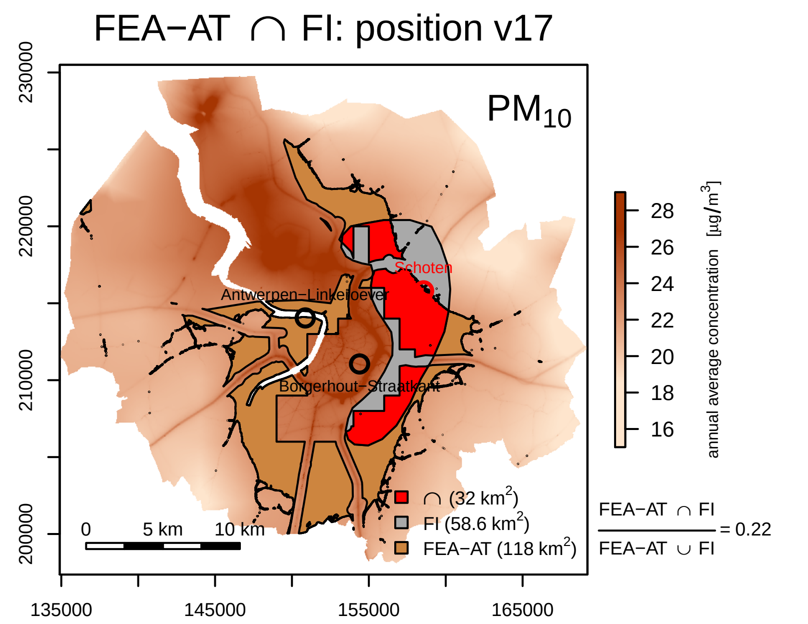
EPAIE ∩ ISSEPAWAC: position v17



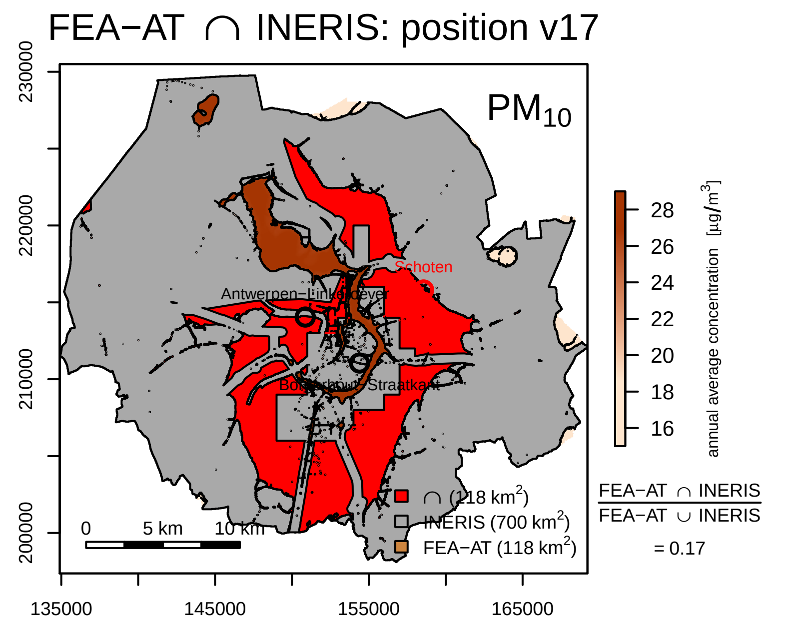

EPAIE ∩ SLB: position v17
PM10
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (14.1 km2)
SLB (14.1 km2)
EPAIE (37.7 km2)
0 5 km 10 km
28
26
24
22
20
18
16
annual average concentration [µg/m3]
EPAIE ∩ SLB
EPAIE ∪ SLB
= 0.37
230000
220000
210000
200000
135000
145000
155000
165000


EPAIE ∩ VITO: position v17
PM10
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (27.2 km2)
VITO (465 km2)
EPAIE (37.7 km2)
0 5 km 10 km
28
26
24
22
20
18
16
annual average concentration [µg/m3]
EPAIE ∩ VITO
EPAIE ∪ VITO
= 0.057
230000
220000
210000
200000
135000
145000
155000
165000

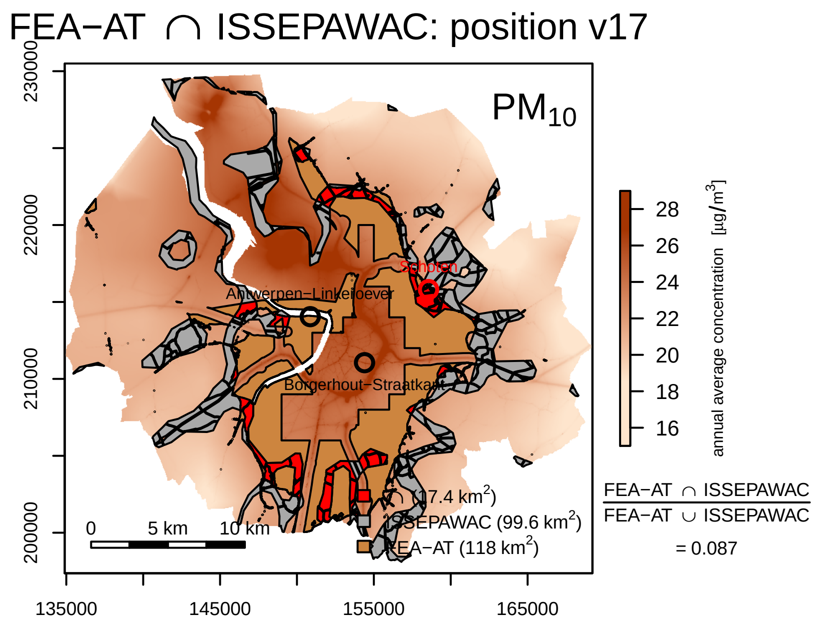

EPAIE ∩ VMM: position v17
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (1.21 km2)
VMM (1.21 km2)
EPAIE (37.7 km2)
0 5 km 10 km
28
26
24
22
20
18
16
annual average concentration [µg/m3]
EPAIE ∩ VMM
EPAIE ∪ VMM
= 0.032
230000
220000
210000
200000
135000
145000
155000
165000



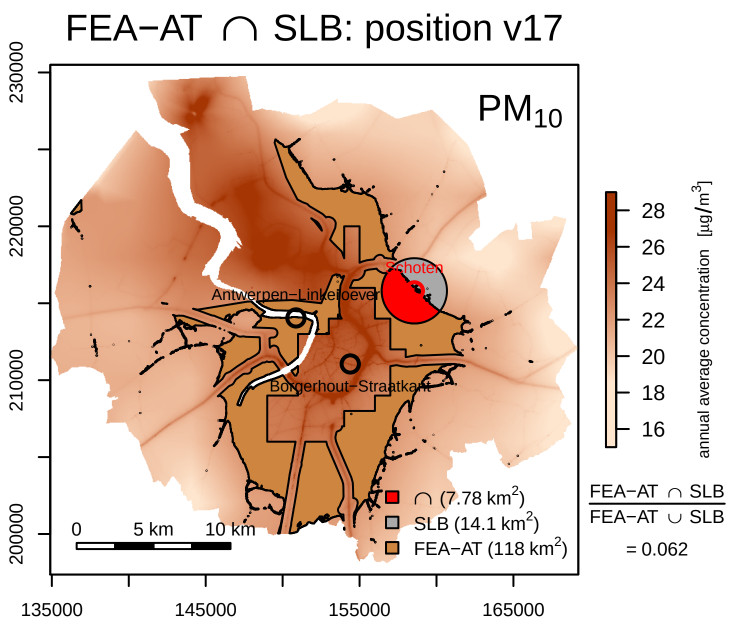
FEA−AT ∩ FI: position v17
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (32 km²)
FI (58.6 km²)
FEA−AT (118 km²)
0
5 km
10 km
annual average concentration [µg/m³]
FEA−AT ∩ FI
FEA−AT ∪ FI
= 0.22

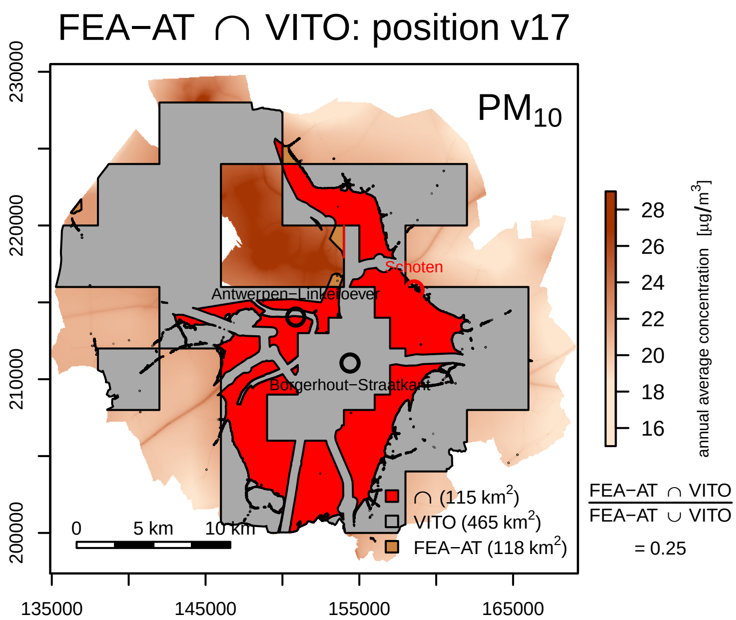


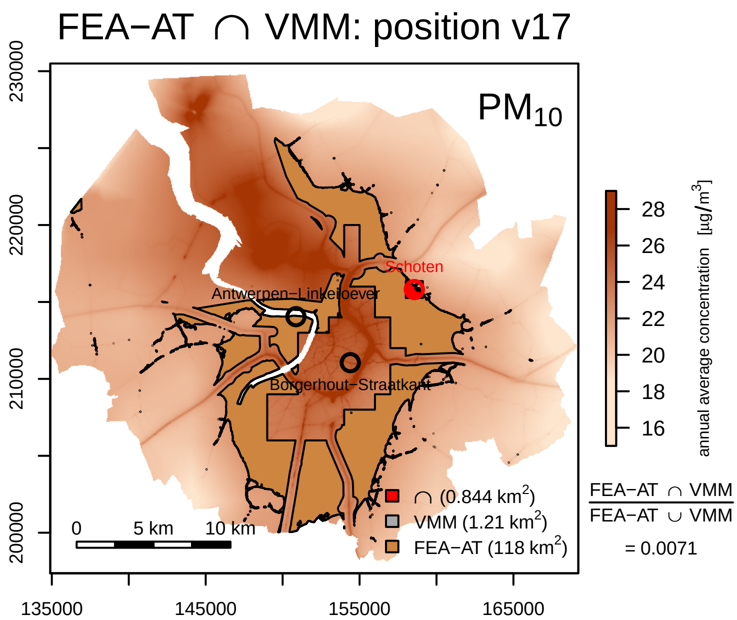
FEA−AT ∩ INERIS: position v17
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (118 km²)
INERIS (700 km²)
FEA−AT (118 km²)
0
5 km
10 km
annual average concentration [µg/m³]
FEA−AT ∩ INERIS
FEA−AT ∪ INERIS
= 0.17

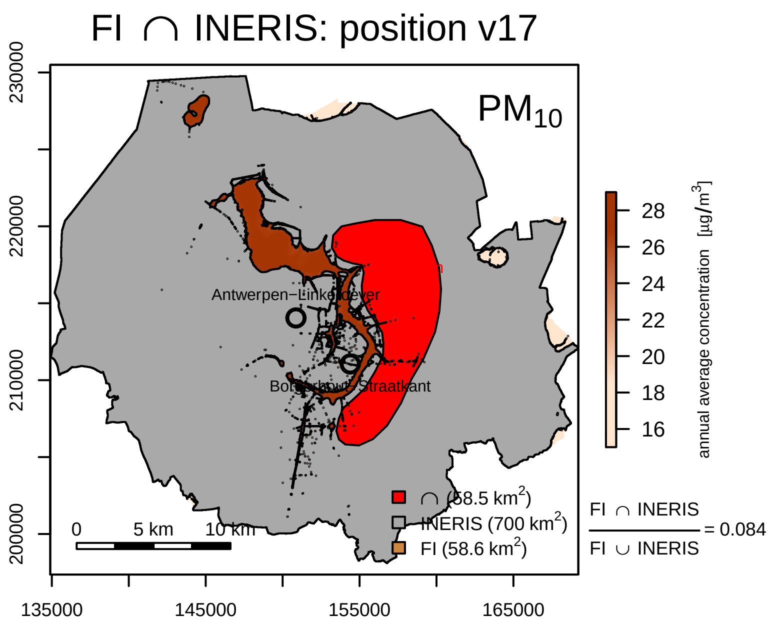


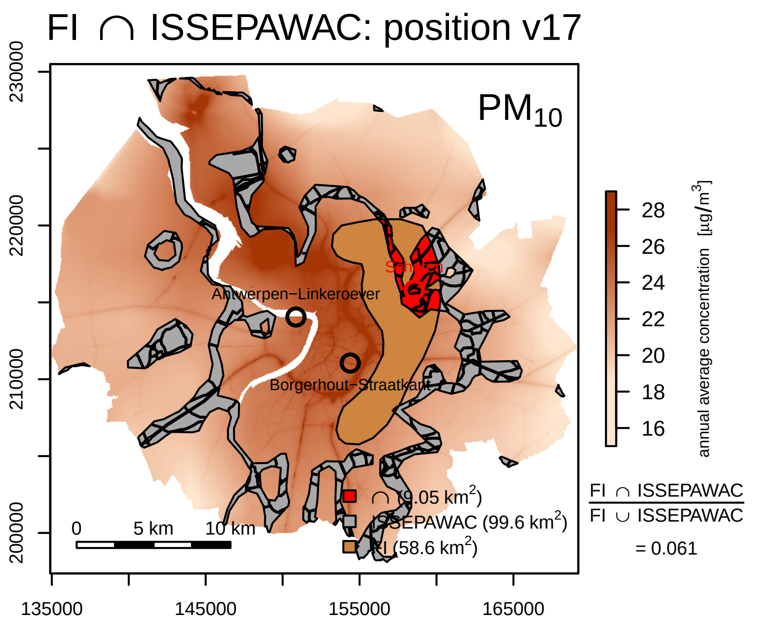
FEA−AT ∩ ISSEPAWAC: position v17
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (17.4 km²)
ISSEPAWAC (99.6 km²)
FEA−AT (118 km²)
0
5 km
10 km
annual average concentration [µg/m³]
FEA−AT ∩ ISSEPAWAC
FEA−AT ∪ ISSEPAWAC
= 0.087

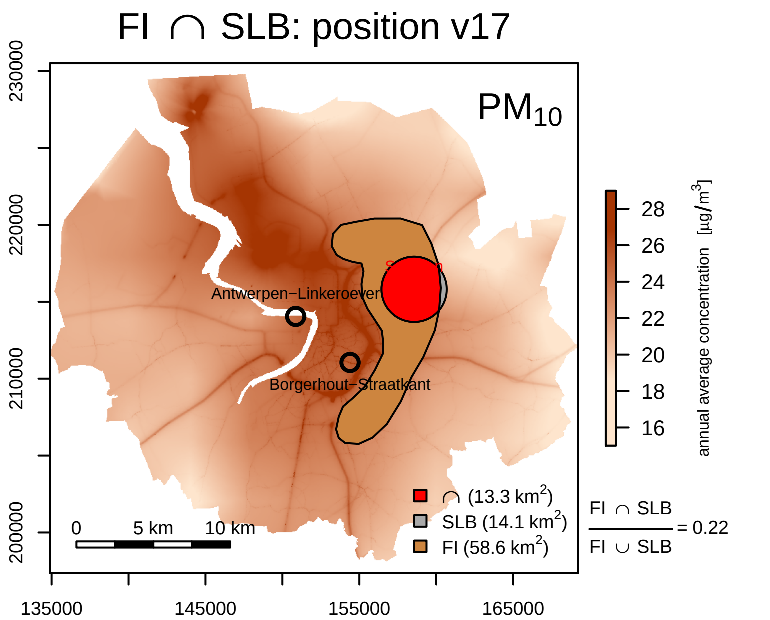

FEA−AT ∩ SLB: position v17
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (7.78 km²)
SLB (14.1 km²)
FEA−AT (118 km²)
annual average concentration [µg/m³]
28
26
24
22
20
18
16
FEA−AT ∩ SLB / FEA−AT ∪ SLB = 0.062
230000
220000
210000
200000
135000
145000
155000
165000

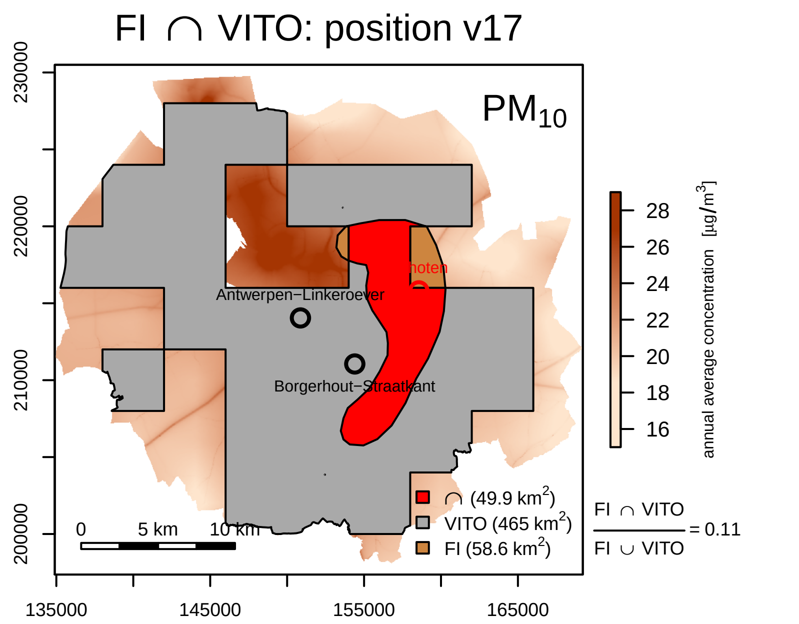

FEA−AT ∩ VITO: position v17
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (115 km²)
VITO (465 km²)
FEA−AT (118 km²)
annual average concentration [µg/m³]
28
26
24
22
20
18
16
FEA−AT ∩ VITO / FEA−AT ∪ VITO = 0.25
230000
220000
210000
200000
135000
145000
155000
165000

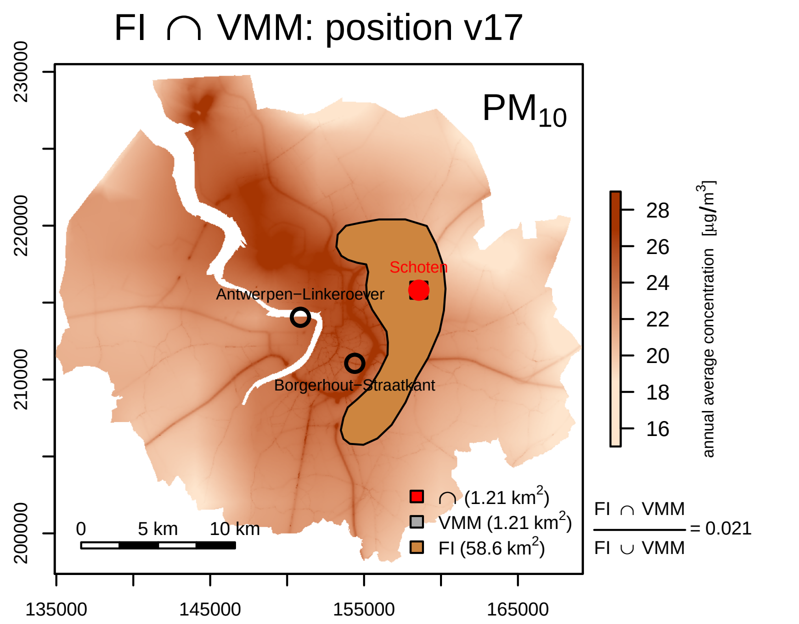

FEA−AT ∩ VMM: position v17
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (0.844 km²)
VMM (1.21 km²)
FEA−AT (118 km²)
annual average concentration [µg/m³]
28
26
24
22
20
18
16
FEA−AT ∩ VMM / FEA−AT ∪ VMM = 0.0071
230000
220000
210000
200000
135000
145000
155000
165000

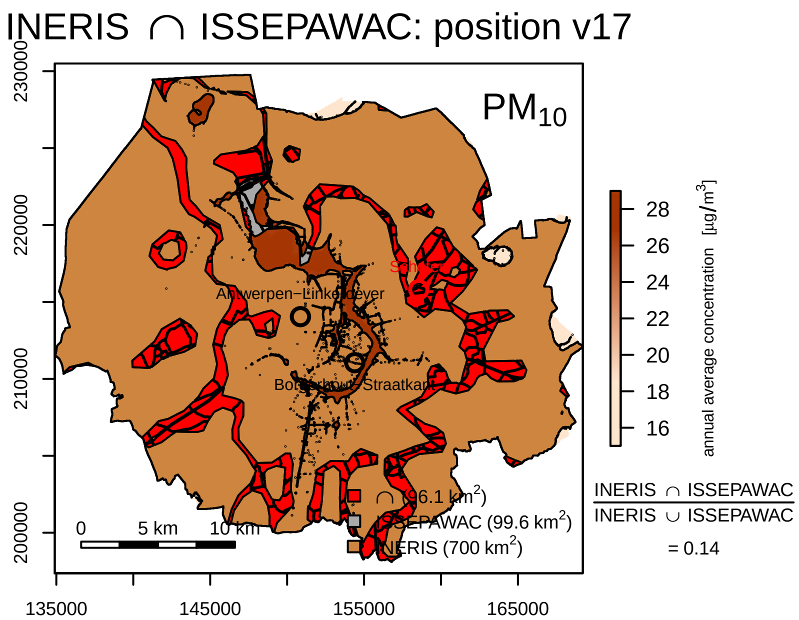

FI ∩ INERIS: position v17
PM10
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (58.5 km2)
INERIS (700 km2)
FI (58.6 km2)
28
26
24
22
20
18
16
annual average concentration [µg/m3]
FI ∩ INERIS / FI ∪ INERIS = 0.084
230000
220000
210000
200000
135000
145000
155000
165000

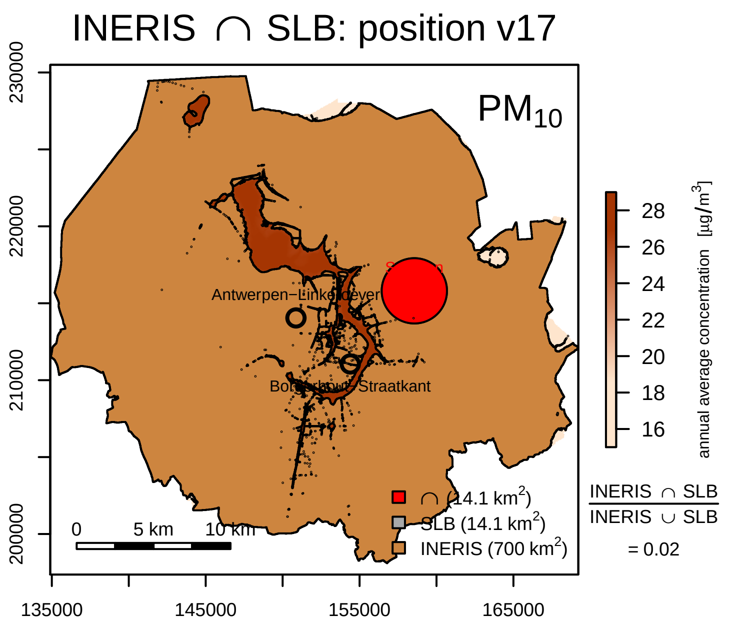

FI ∩ ISSEPAWAC: position v17
PM10
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (9.05 km2)
ISSEPAWAC (99.6 km2)
FI (58.6 km2)
28
26
24
22
20
18
16
annual average concentration [µg/m3]
FI ∩ ISSEPAWAC / FI ∪ ISSEPAWAC = 0.061
230000
220000
210000
200000
135000
145000
155000
165000

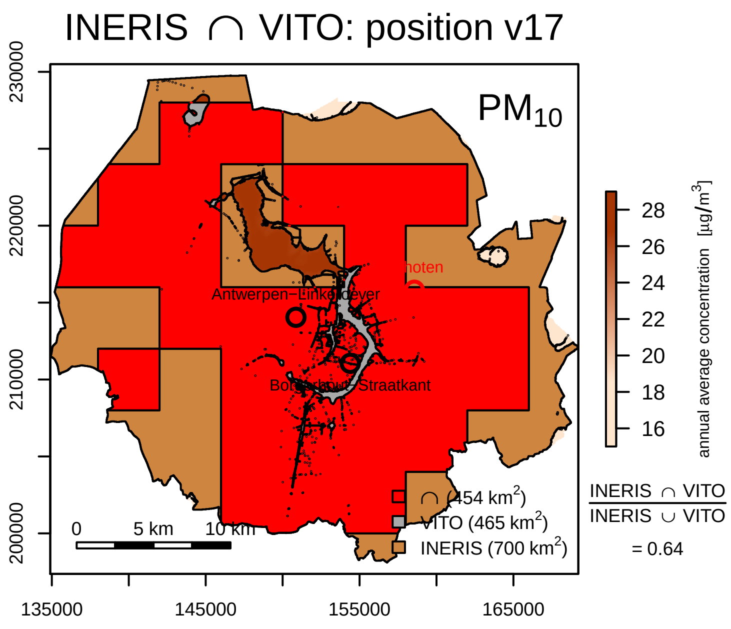

FI ∩ SLB: position v17
PM10
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (13.3 km2)
SLB (14.1 km2)
FI (58.6 km2)
28
26
24
22
20
18
16
annual average concentration [µg/m3]
FI ∩ SLB / FI ∪ SLB = 0.22
230000
220000
210000
200000
135000
145000
155000
165000

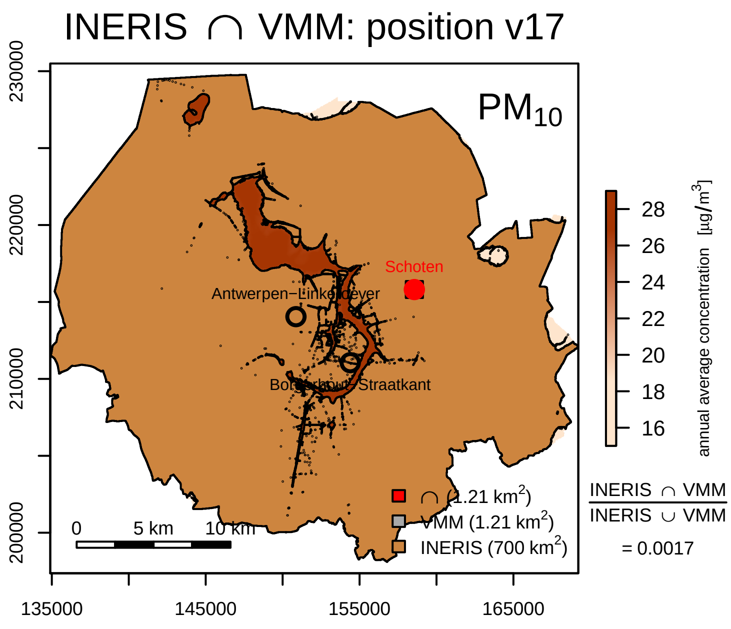

FI ∩ VITO: position v17
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (49.9 km²)
VITO (465 km²)
FI (58.6 km²)
FI ∩ VITO / FI ∪ VITO = 0.11
28 26 24 22 20 18 16
annual average concentration [µg/m³]
135000 145000 155000 165000
200000 210000 220000 230000

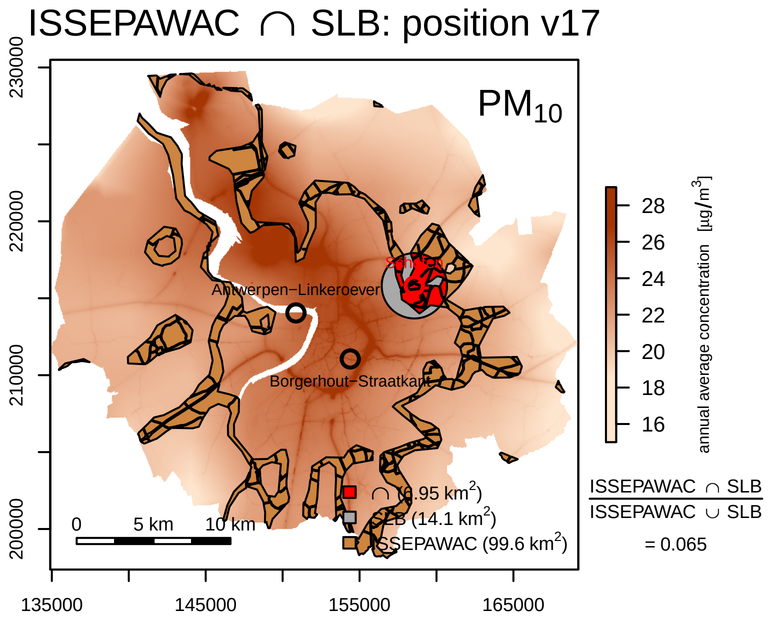

FI ∩ VMM: position v17
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (1.21 km²)
VMM (1.21 km²)
FI (58.6 km²)
FI ∩ VMM / FI ∪ VMM = 0.021
28 26 24 22 20 18 16
annual average concentration [µg/m³]
135000 145000 155000 165000
200000 210000 220000 230000

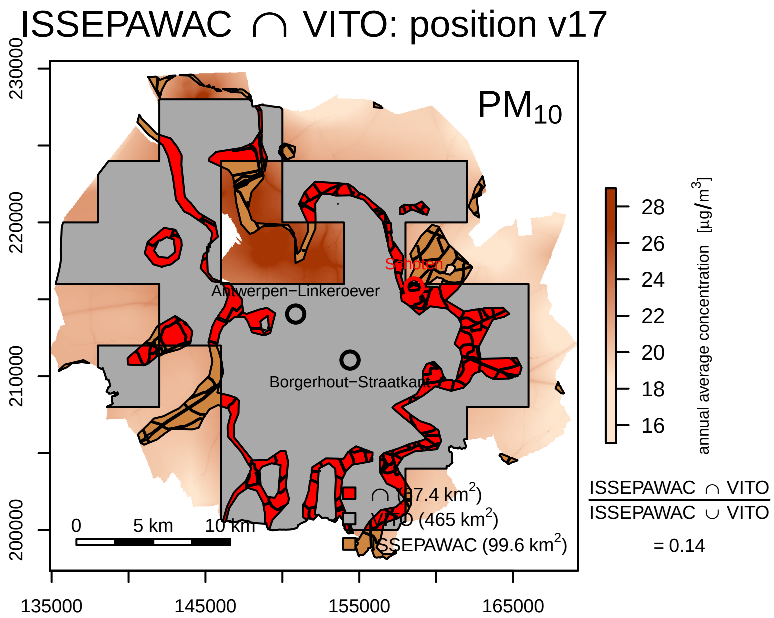

INERIS ∩ ISSEPAWAC: position v17
PM10
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (96.1 km²)
ISSEPAWAC (99.6 km²)
INERIS (700 km²)
INERIS ∩ ISSEPAWAC / INERIS ∪ ISSEPAWAC = 0.14
28 26 24 22 20 18 16
annual average concentration [µg/m³]
135000 145000 155000 165000
200000 210000 220000 230000

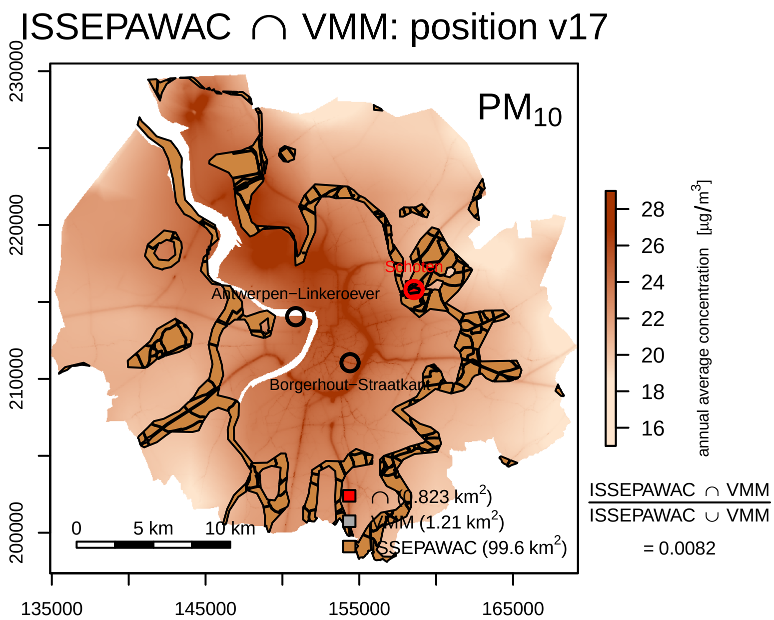

INERIS ∩ SLB: position v17
PM10
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (14.1 km2)
SLB (14.1 km2)
INERIS (700 km2)
0
5 km
10 km
28
26
24
22
20
18
16
annual average concentration [µg/m3]
INERIS ∩ SLB
INERIS ∪ SLB
= 0.02
230000
220000
210000
200000
135000
145000
155000
165000

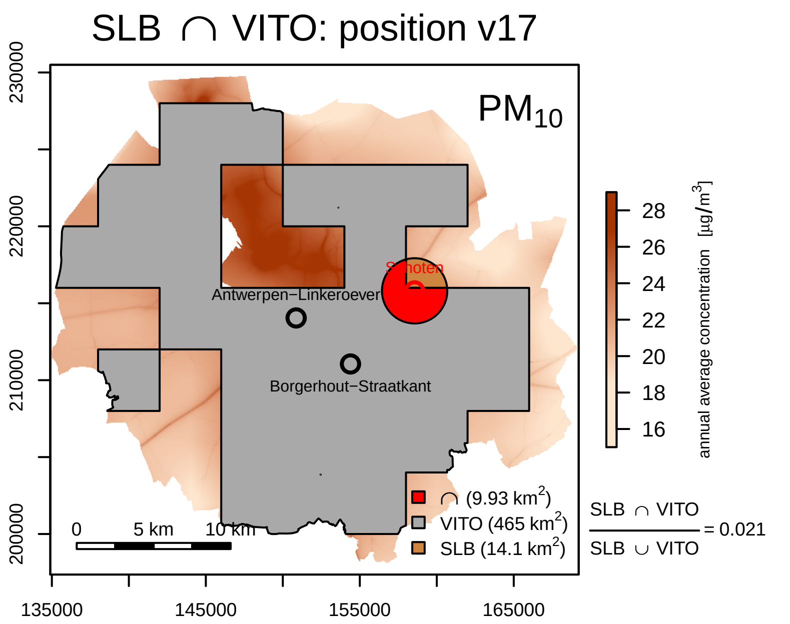

INERIS ∩ VITO: position v17
PM10
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (454 km2)
VITO (465 km2)
INERIS (700 km2)
0
5 km
10 km
28
26
24
22
20
18
16
annual average concentration [µg/m3]
INERIS ∩ VITO
INERIS ∪ VITO
= 0.64
230000
220000
210000
200000
135000
145000
155000
165000

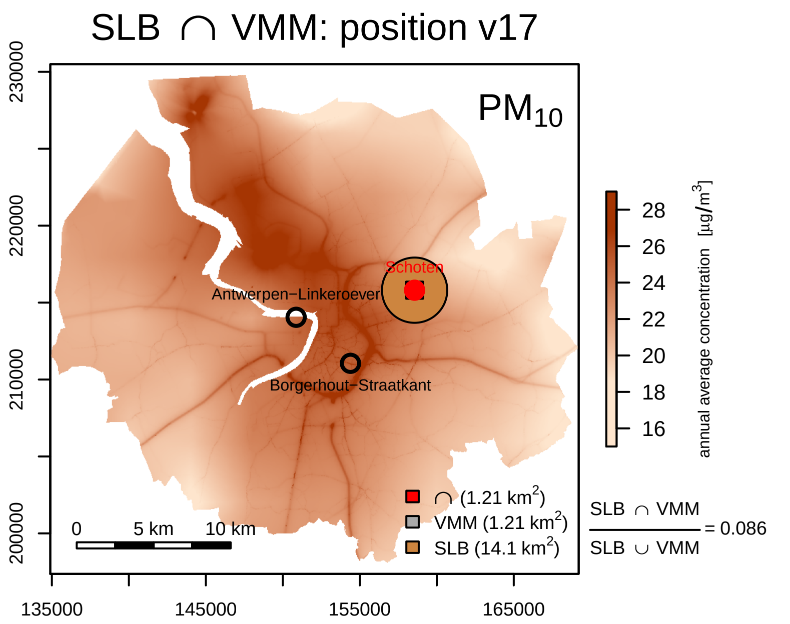

INERIS ∩ VMM: position v17
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (1.21 km2)
VMM (1.21 km2)
INERIS (700 km2)
0
5 km
10 km
28
26
24
22
20
18
16
annual average concentration [µg/m3]
INERIS ∩ VMM
INERIS ∪ VMM
= 0.0017
230000
220000
210000
200000
135000
145000
155000
165000

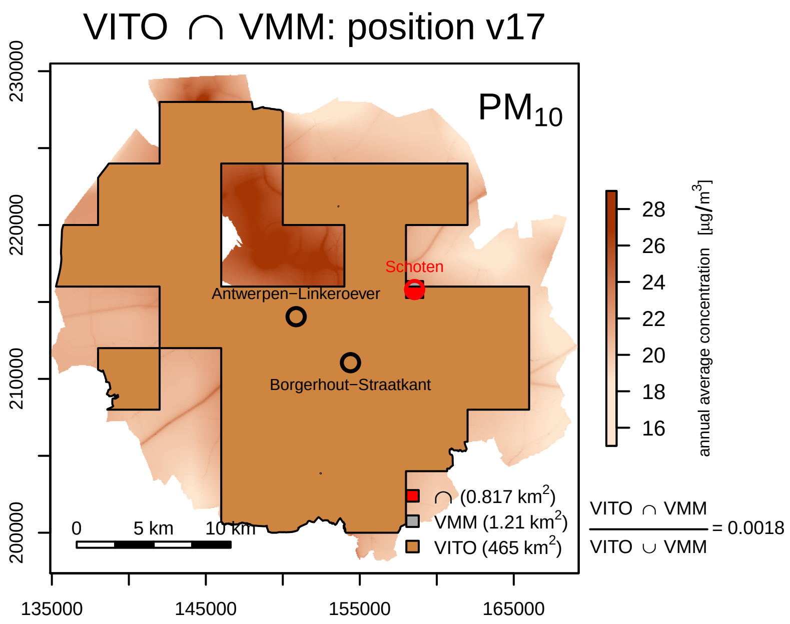

ISSEPAWAC ∩ SLB: position v17
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (0.95 km²)
SLB (14.1 km²)
ISSEPAWAC (99.6 km²)
28
26
24
22
20
18
16
annual average concentration [µg/m³]
ISSEPAWAC ∩ SLB / ISSEPAWAC ∪ SLB = 0.065
230000
220000
210000
200000
135000
145000
155000
165000


ISSEPAWAC ∩ VITO: position v17
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (67.4 km²)
VITO (465 km²)
ISSEPAWAC (99.6 km²)
28
26
24
22
20
18
16
annual average concentration [µg/m³]
ISSEPAWAC ∩ VITO / ISSEPAWAC ∪ VITO = 0.14
230000
220000
210000
200000
135000
145000
155000
165000


ISSEPAWAC ∩ VMM: position v17
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (0.823 km²)
VMM (1.21 km²)
ISSEPAWAC (99.6 km²)
28
26
24
22
20
18
16
annual average concentration [µg/m³]
ISSEPAWAC ∩ VMM / ISSEPAWAC ∪ VMM = 0.0082
230000
220000
210000
200000
135000
145000
155000
165000


SLB ∩ VITO: position v17
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (9.93 km2)
VITO (465 km2)
SLB (14.1 km2)
SLB ∩ VITO / SLB ∪ VITO = 0.021
annual average concentration [µg/m3]
0 5 km 10 km

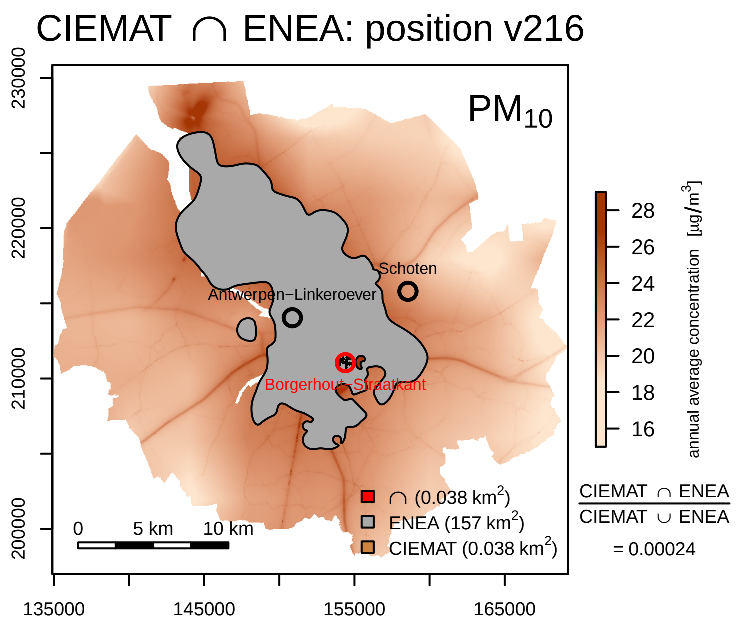

SLB ∩ VMM: position v17
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (1.21 km2)
VMM (1.21 km2)
SLB (14.1 km2)
SLB ∩ VMM / SLB ∪ VMM = 0.086
annual average concentration [µg/m3]
0 5 km 10 km

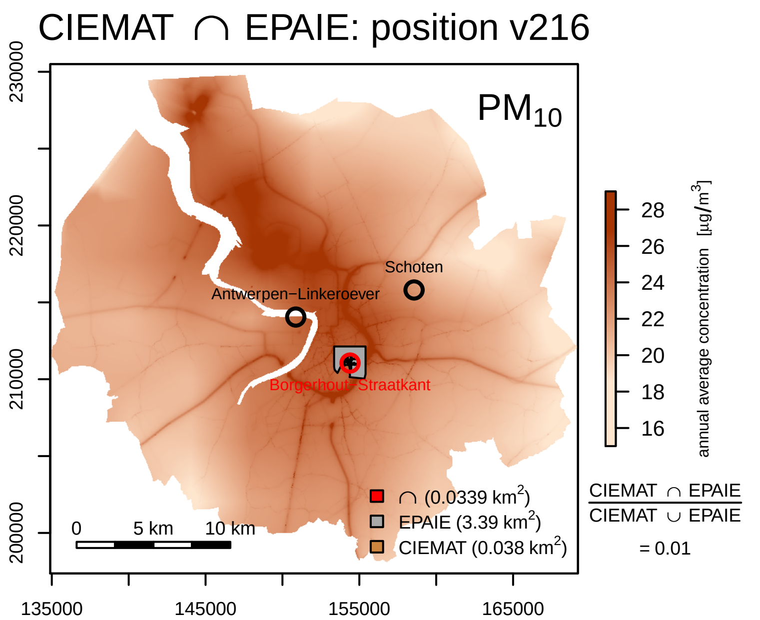

VITO ∩ VMM: position v17
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.817 km2)
VMM (1.21 km2)
VITO (465 km2)
VITO ∩ VMM / VITO ∪ VMM = 0.0018
annual average concentration [µg/m3]
0 5 km 10 km

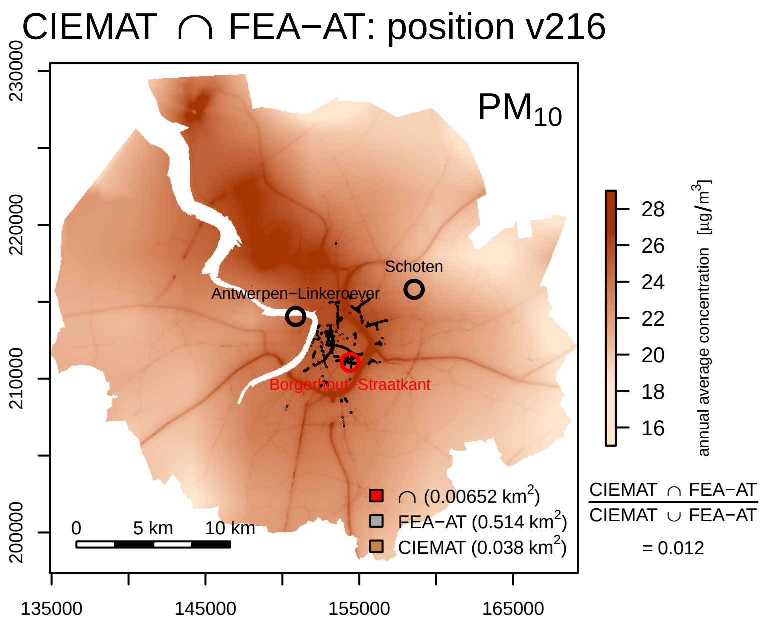
Mutual Comparisons between Teams

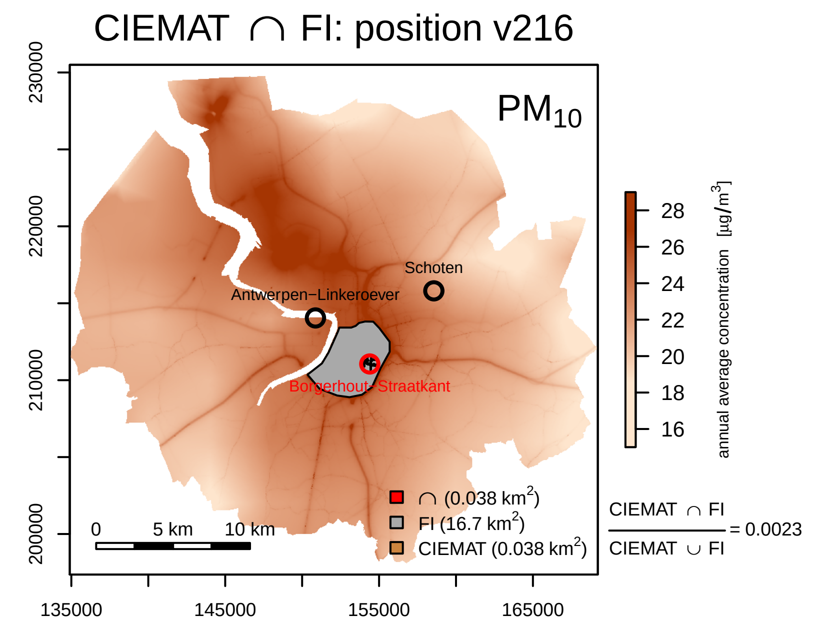
by Pollutant & Station:

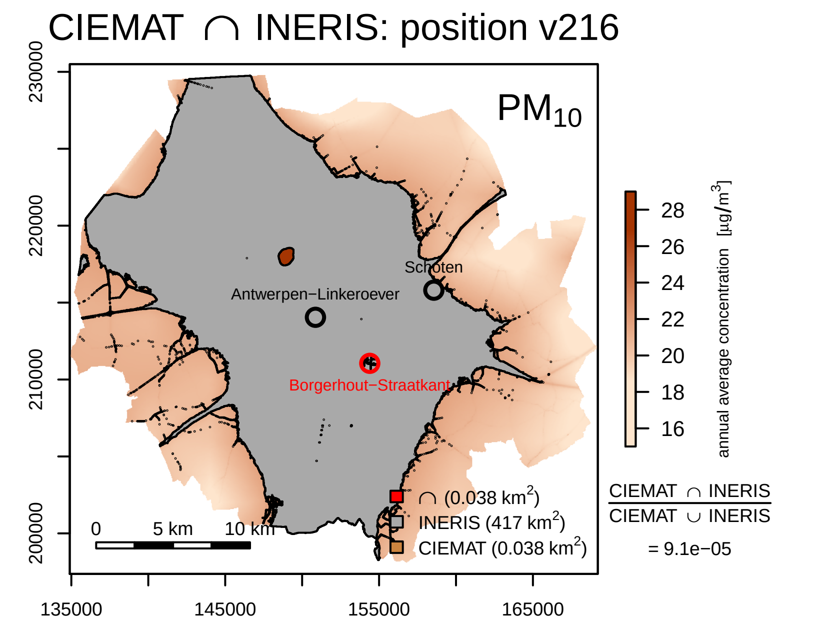
PM_{10} at virtual station v216

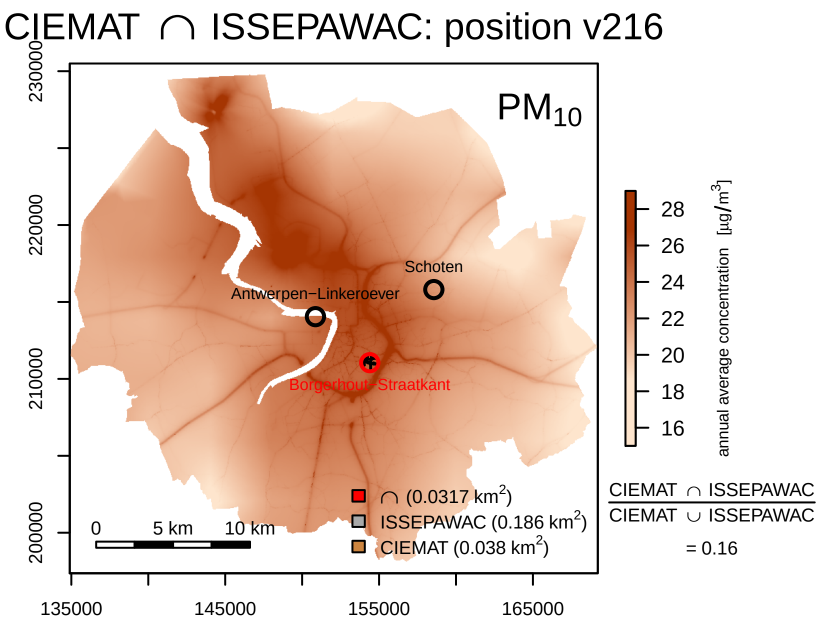

CIEMAT ∩ ENEA: position v216
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.038 km2)
ENEA (157 km2)
CIEMAT (0.038 km2)
0
5 km
10 km
annual average concentration [µg/m3]
CIEMAT ∩ ENEA / CIEMAT ∪ ENEA = 0.00024

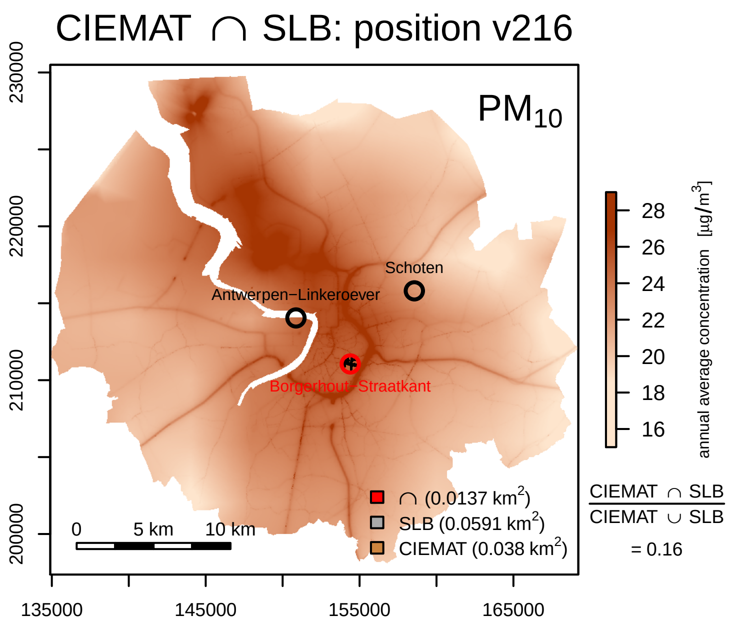

CIEMAT ∩ EPAIE: position v216
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.0339 km2)
EPAIE (3.39 km2)
CIEMAT (0.038 km2)
0
5 km
10 km
annual average concentration [µg/m3]
CIEMAT ∩ EPAIE / CIEMAT ∪ EPAIE = 0.01

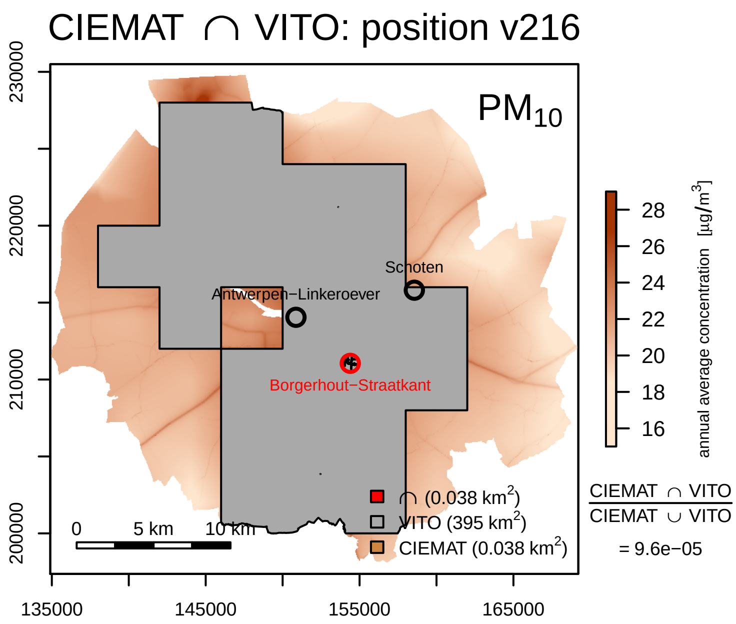

CIEMAT ∩ FEA−AT: position v216
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.00652 km2)
FEA−AT (0.514 km2)
CIEMAT (0.038 km2)
0
5 km
10 km
annual average concentration [µg/m3]
CIEMAT ∩ FEA−AT / CIEMAT ∪ FEA−AT = 0.012

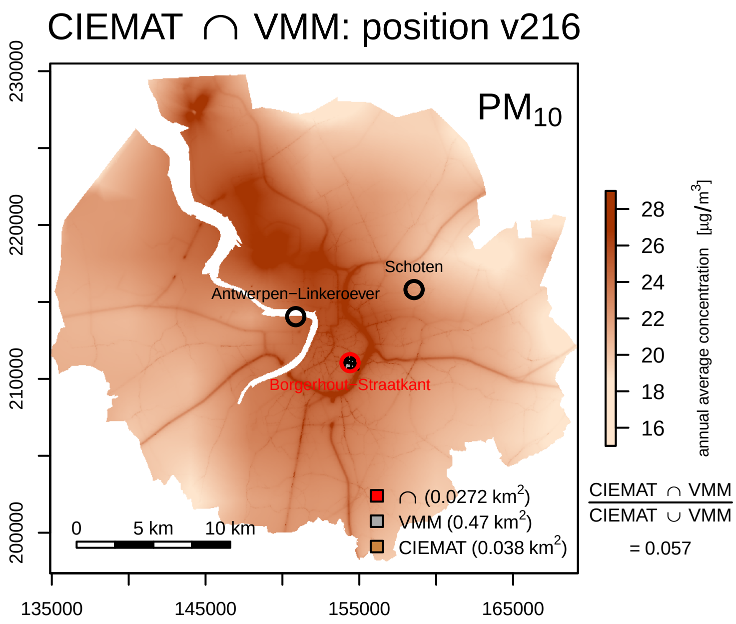

CIEMAT ∩ FI: position v216
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.038 km²)
FI (16.7 km²)
CIEMAT (0.038 km²)
0 5 km 10 km
135000 145000 155000 165000
200000 210000 220000 230000
28 26 24 22 20 18 16
annual average concentration [µg/m³]
CIEMAT ∩ FI / CIEMAT ∪ FI = 0.0023

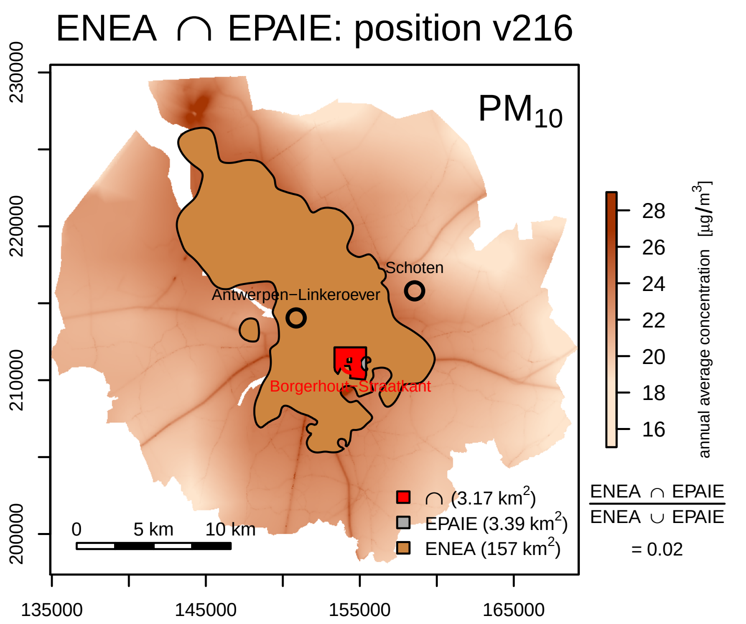

CIEMAT ∩ INERIS: position v216
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.038 km²)
INERIS (417 km²)
CIEMAT (0.038 km²)
0 5 km 10 km
135000 145000 155000 165000
200000 210000 220000 230000
28 26 24 22 20 18 16
annual average concentration [µg/m³]
CIEMAT ∩ INERIS / CIEMAT ∪ INERIS = 9.1e−05

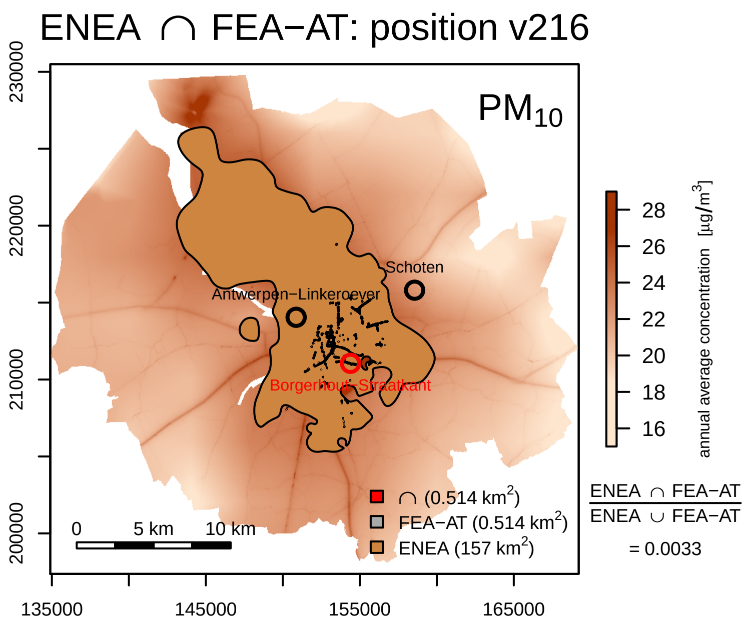

CIEMAT ∩ ISSEPAWAC: position v216
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.0317 km²)
ISSEPAWAC (0.186 km²)
CIEMAT (0.038 km²)
0 5 km 10 km
135000 145000 155000 165000
200000 210000 220000 230000
28 26 24 22 20 18 16
annual average concentration [µg/m³]
CIEMAT ∩ ISSEPAWAC / CIEMAT ∪ ISSEPAWAC = 0.16

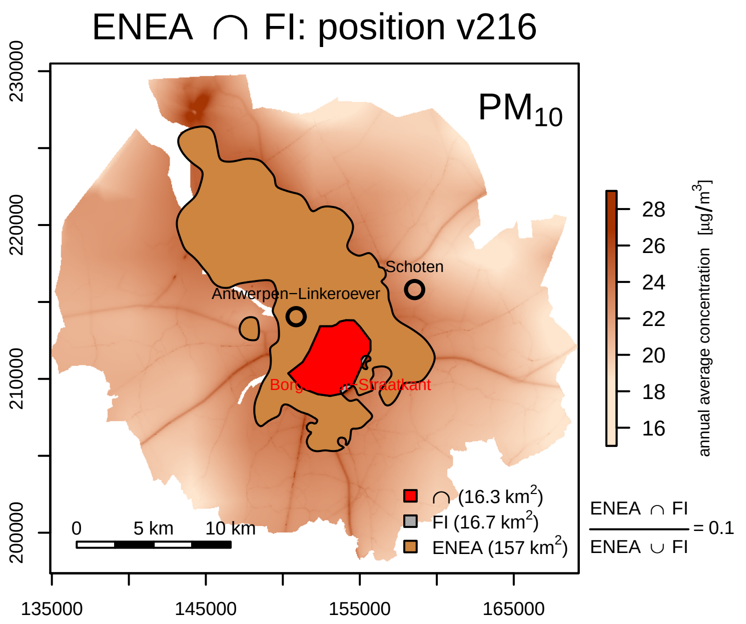

CIEMAT ∩ SLB: position v216
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.0137 km²)
SLB (0.0591 km²)
CIEMAT (0.038 km²)
0
5 km
10 km
annual average concentration [µg/m³]
CIEMAT ∩ SLB
CIEMAT ∪ SLB
= 0.16

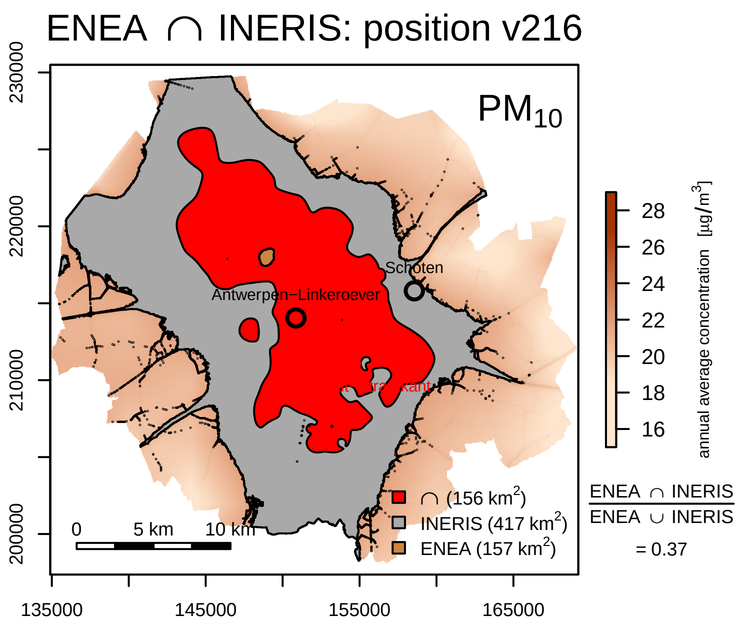

CIEMAT ∩ VITO: position v216
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.038 km²)
VITO (395 km²)
CIEMAT (0.038 km²)
0
5 km
10 km
annual average concentration [µg/m³]
CIEMAT ∩ VITO
CIEMAT ∪ VITO
= 9.6e−05

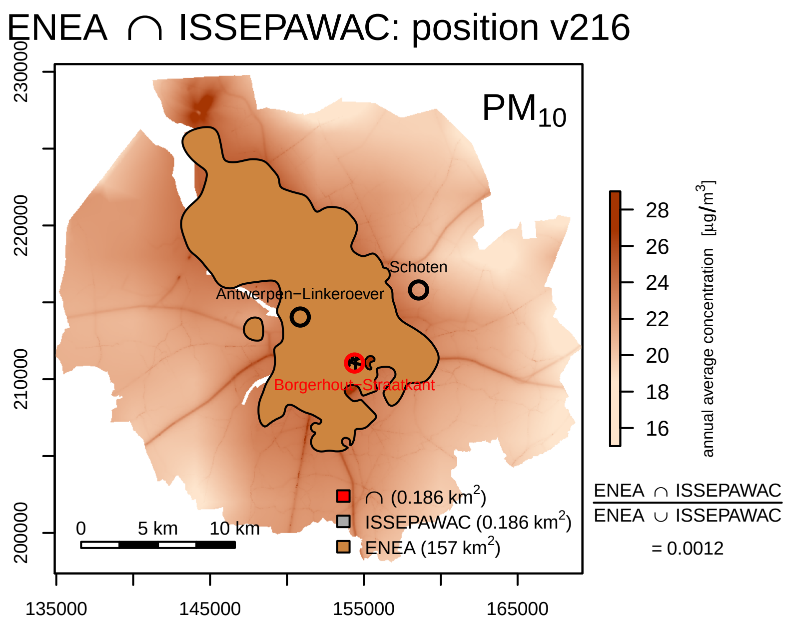

CIEMAT ∩ VMM: position v216
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.0272 km²)
VMM (0.47 km²)
CIEMAT (0.038 km²)
0
5 km
10 km
annual average concentration [µg/m³]
CIEMAT ∩ VMM
CIEMAT ∪ VMM
= 0.057

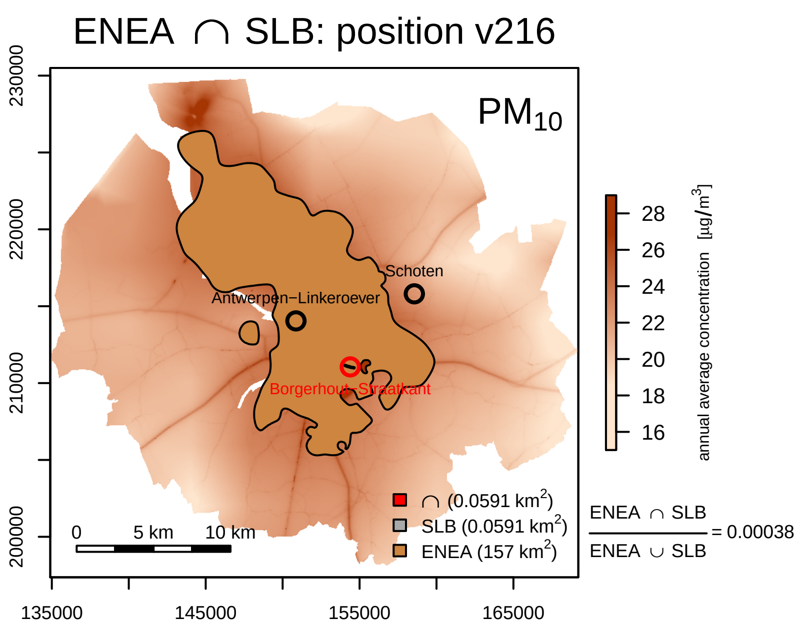

ENEA ∩ EPAIE: position v216
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (3.17 km2)
EPAIE (3.39 km2)
ENEA (157 km2)
0
5 km
10 km
28
26
24
22
20
18
16
annual average concentration [µg/m3]
ENEA ∩ EPAIE
ENEA ∪ EPAIE
= 0.02
230000
220000
210000
200000
135000
145000
155000
165000

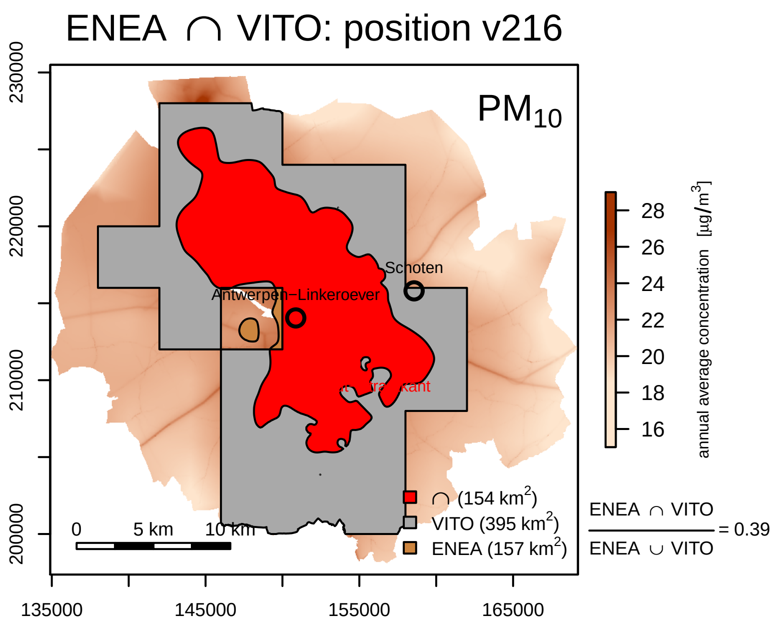

ENEA ∩ FEA−AT: position v216
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.514 km2)
FEA−AT (0.514 km2)
ENEA (157 km2)
0
5 km
10 km
28
26
24
22
20
18
16
annual average concentration [µg/m3]
ENEA ∩ FEA−AT
ENEA ∪ FEA−AT
= 0.0033
230000
220000
210000
200000
135000
145000
155000
165000

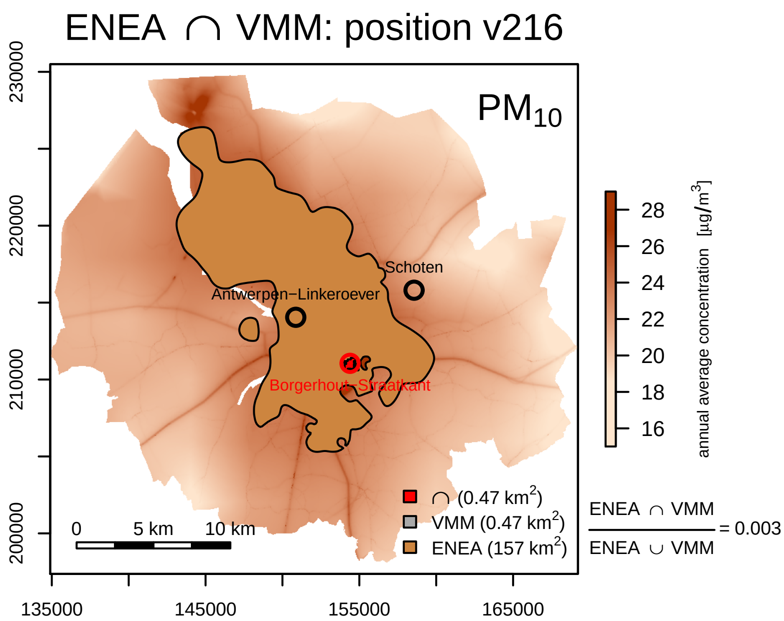

ENEA ∩ FI: position v216
PM10
Schoten
Antwerpen−Linkeroever
∩ (16.3 km2)
FI (16.7 km2)
ENEA (157 km2)
0
5 km
10 km
28
26
24
22
20
18
16
annual average concentration [µg/m3]
ENEA ∩ FI
ENEA ∪ FI
= 0.1
230000
220000
210000
200000
135000
145000
155000
165000

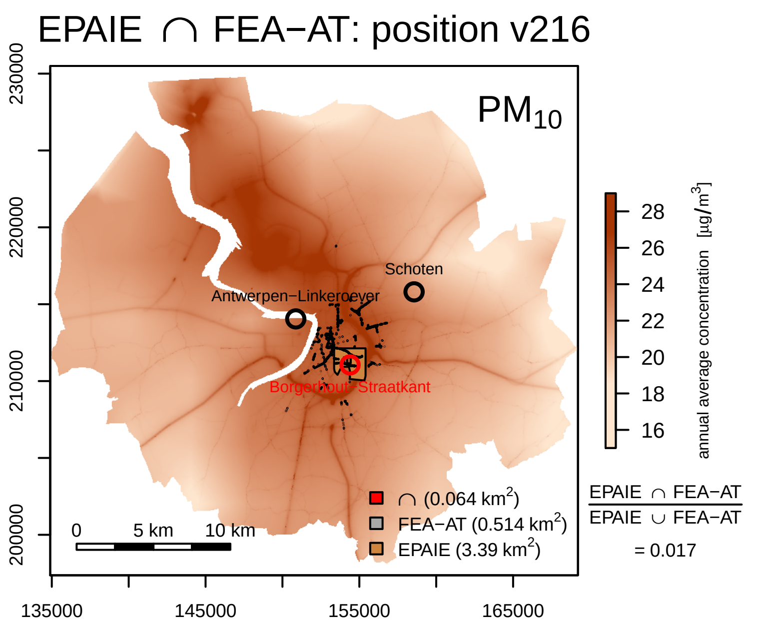

ENEA ∩ INERIS: position v216
PM10
Schoten
Antwerpen−Linkeroever
∩ (156 km2)
INERIS (417 km2)
ENEA (157 km2)
0
5 km
10 km
230000
220000
210000
200000
135000
145000
155000
165000
28
26
24
22
20
18
16
annual average concentration [µg/m3]
ENEA ∩ INERIS
ENEA ∪ INERIS
= 0.37

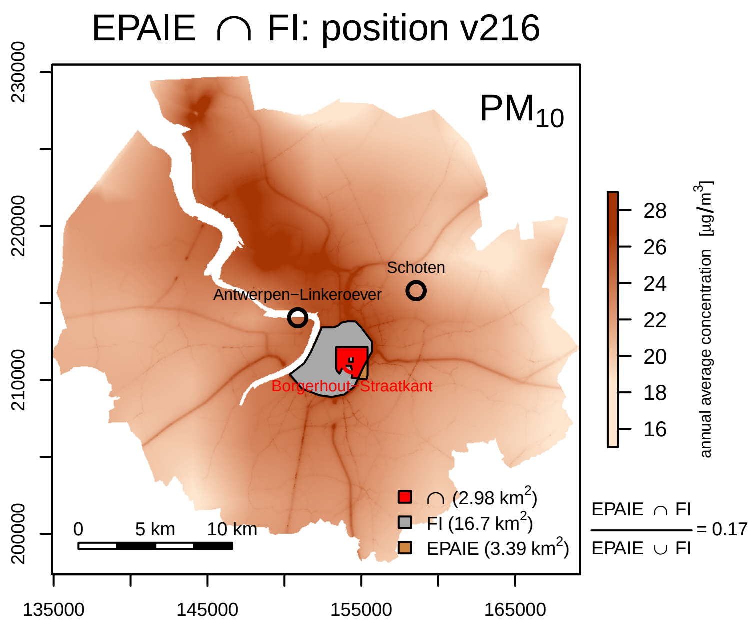

ENEA ∩ ISSEPAWAC: position v216
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.186 km2)
ISSEPAWAC (0.186 km2)
ENEA (157 km2)
0
5 km
10 km
230000
220000
210000
200000
135000
145000
155000
165000
28
26
24
22
20
18
16
annual average concentration [µg/m3]
ENEA ∩ ISSEPAWAC
ENEA ∪ ISSEPAWAC
= 0.0012

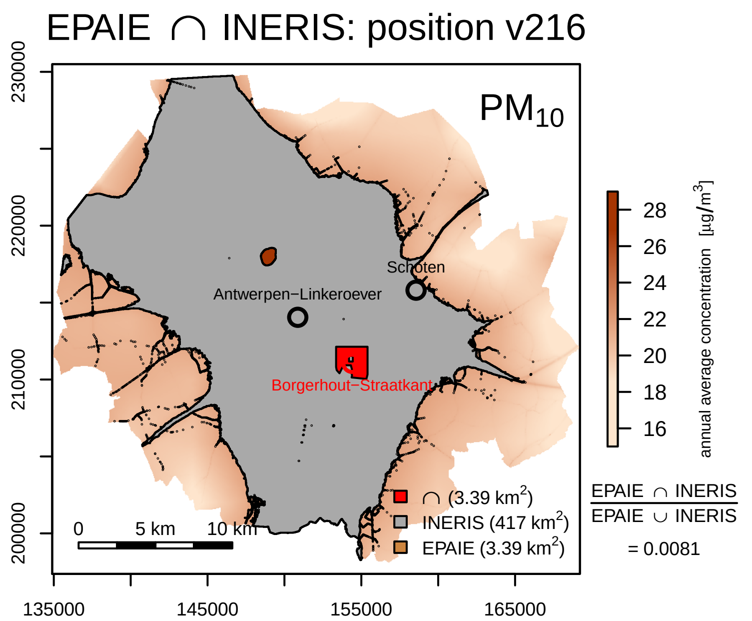

ENEA ∩ SLB: position v216
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.0591 km2)
SLB (0.0591 km2)
ENEA (157 km2)
0
5 km
10 km
230000
220000
210000
200000
135000
145000
155000
165000
28
26
24
22
20
18
16
annual average concentration [µg/m3]
ENEA ∩ SLB
= 0.00038
ENEA ∪ SLB

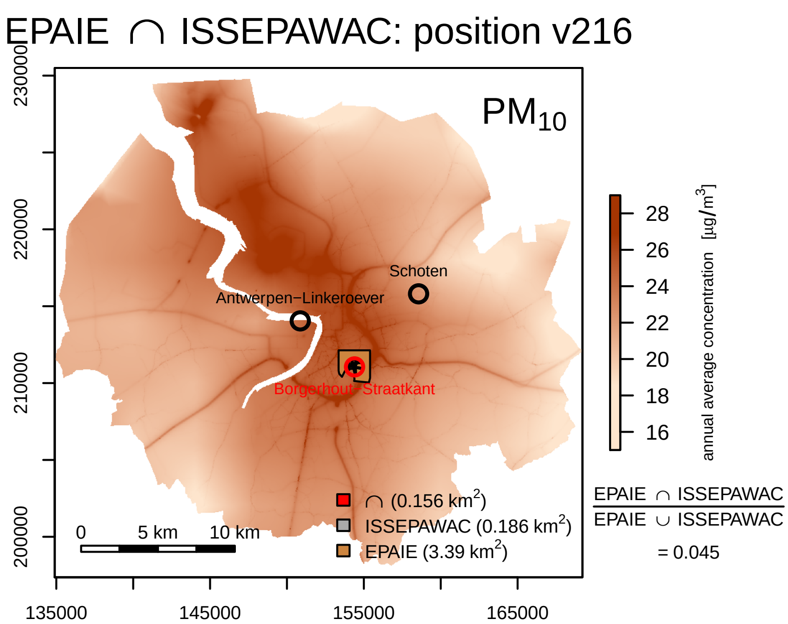

ENEA ∩ VITO: position v216
PM10
Schoten
Antwerpen−Linkeroever
∩ (154 km²)
VITO (395 km²)
ENEA (157 km²)
0 5 km 10 km
annual average concentration [µg/m³]
28 26 24 22 20 18 16
ENEA ∩ VITO / ENEA ∪ VITO = 0.39
135000 145000 155000 165000
200000 210000 220000 230000

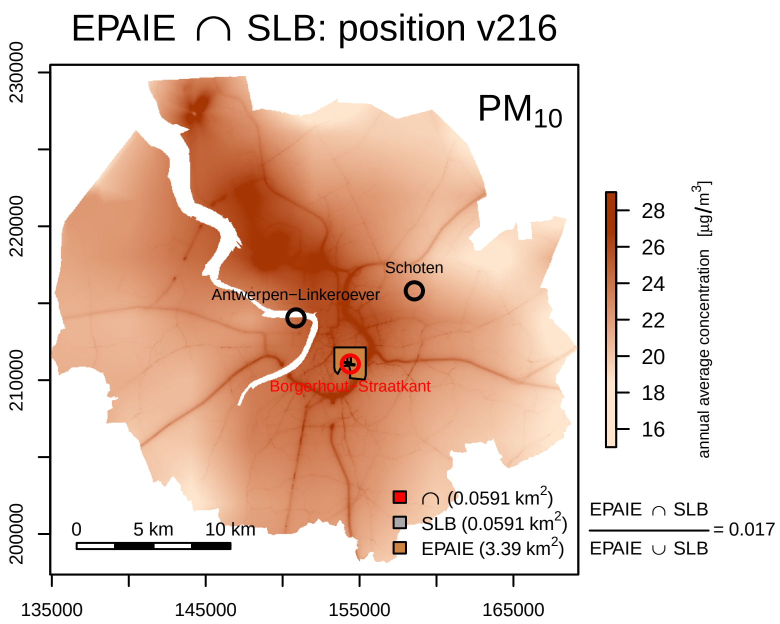

ENEA ∩ VMM: position v216
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.47 km²)
VMM (0.47 km²)
ENEA (157 km²)
0 5 km 10 km
annual average concentration [µg/m³]
28 26 24 22 20 18 16
ENEA ∩ VMM / ENEA ∪ VMM = 0.003
135000 145000 155000 165000
200000 210000 220000 230000

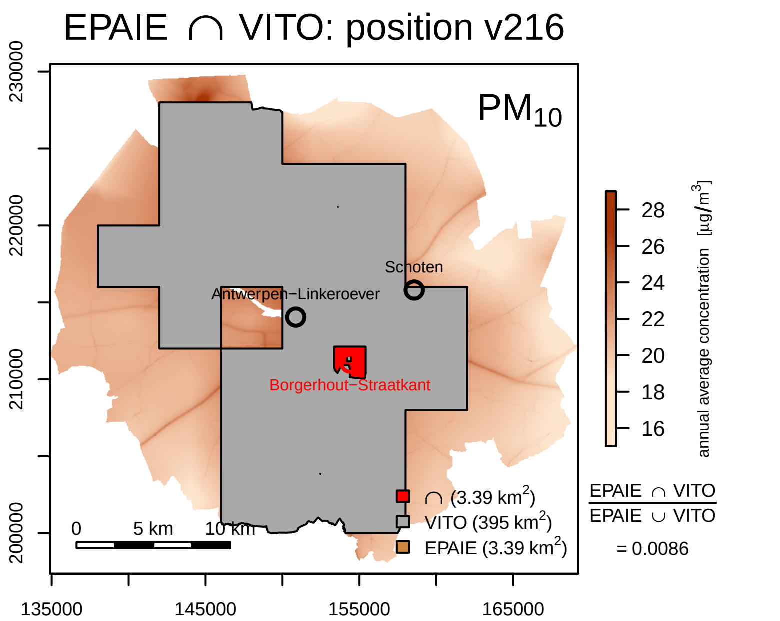

EPAIE ∩ FEA−AT: position v216
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.064 km²)
FEA−AT (0.514 km²)
EPAIE (3.39 km²)
0 5 km 10 km
annual average concentration [µg/m³]
28 26 24 22 20 18 16
EPAIE ∩ FEA−AT / EPAIE ∪ FEA−AT = 0.017
135000 145000 155000 165000
200000 210000 220000 230000

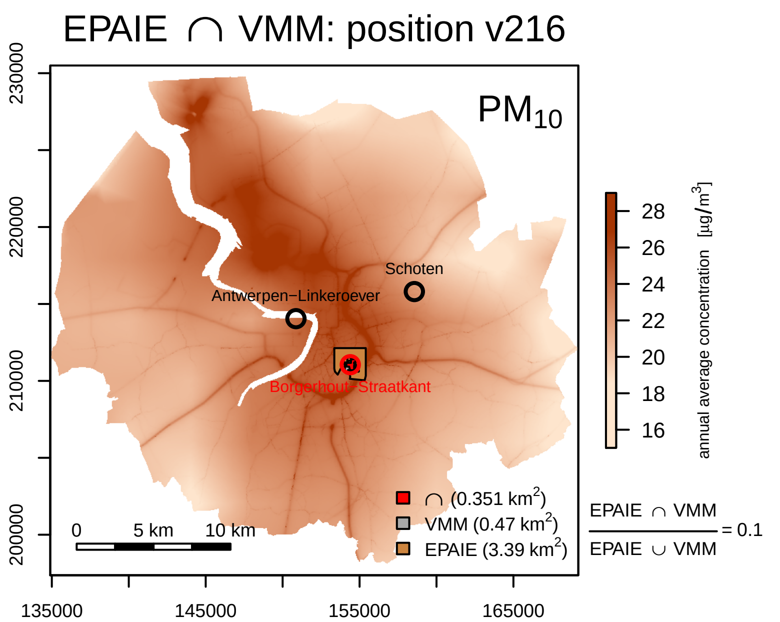

EPAIE ∩ FI: position v216
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (2.98 km²)
FI (16.7 km²)
EPAIE (3.39 km²)
0 5 km 10 km
EPAIE ∩ FI / EPAIE ∪ FI = 0.17
annual average concentration [µg/m³]
28 26 24 22 20 18 16
230000 220000 210000 200000
135000 145000 155000 165000

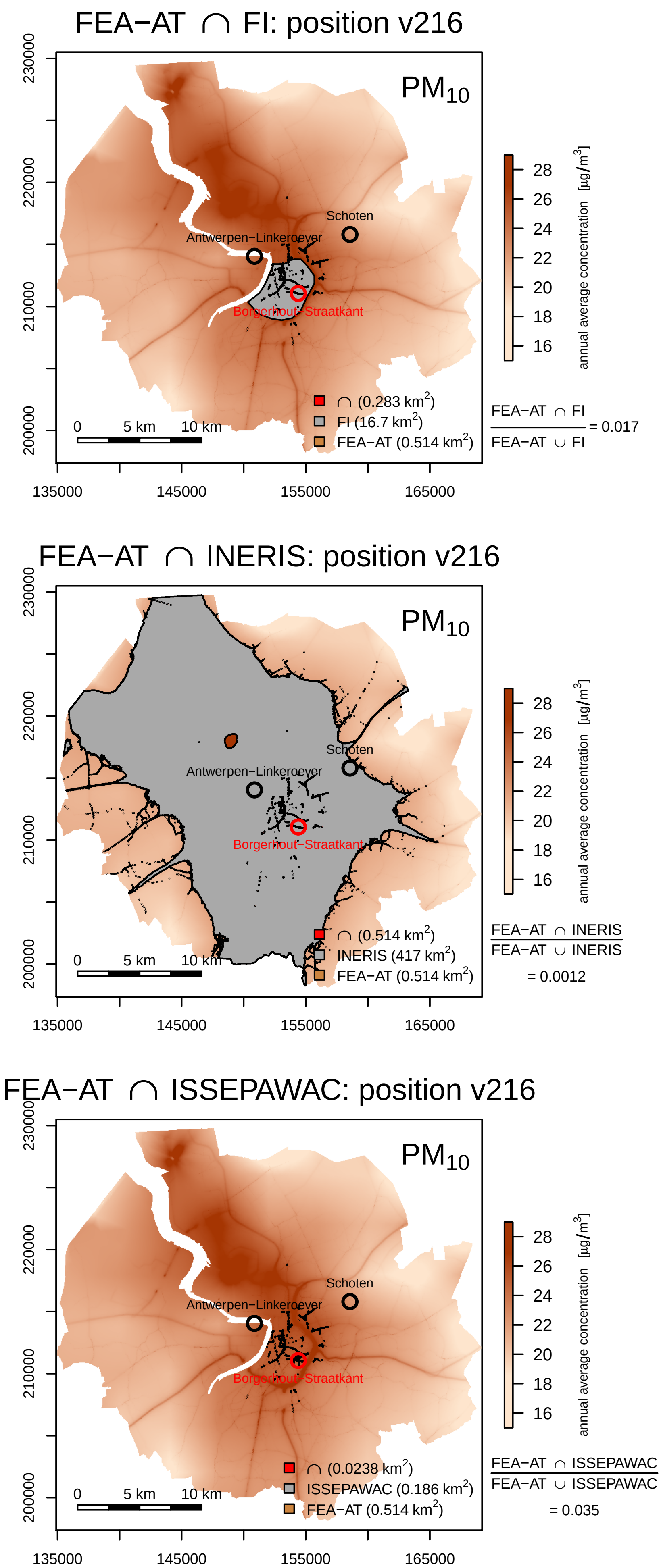

EPAIE ∩ INERIS: position v216
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (3.39 km²)
INERIS (417 km²)
EPAIE (3.39 km²)
0 5 km 10 km
EPAIE ∩ INERIS / EPAIE ∪ INERIS = 0.0081
annual average concentration [µg/m³]
28 26 24 22 20 18 16
230000 220000 210000 200000
135000 145000 155000 165000

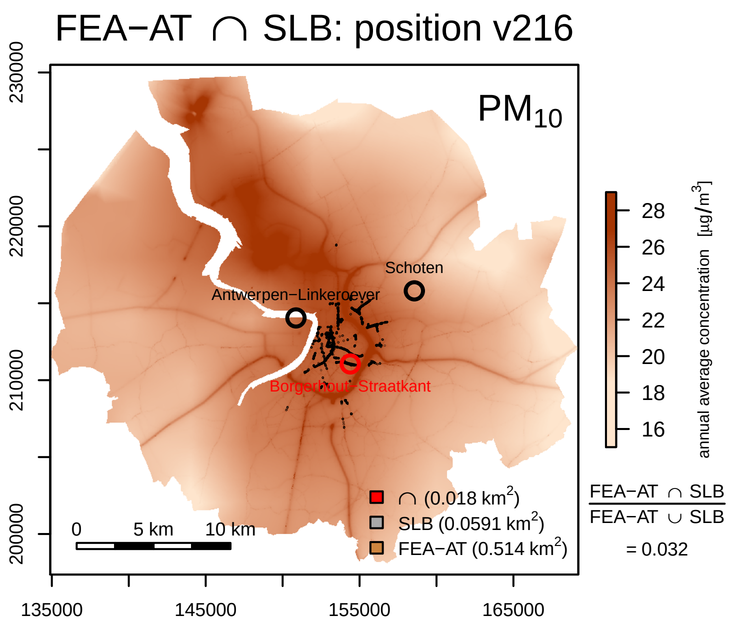

EPAIE ∩ ISSEPAWAC: position v216
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.156 km²)
ISSEPAWAC (0.186 km²)
EPAIE (3.39 km²)
0 5 km 10 km
EPAIE ∩ ISSEPAWAC / EPAIE ∪ ISSEPAWAC = 0.045
annual average concentration [µg/m³]
28 26 24 22 20 18 16
230000 220000 210000 200000
135000 145000 155000 165000

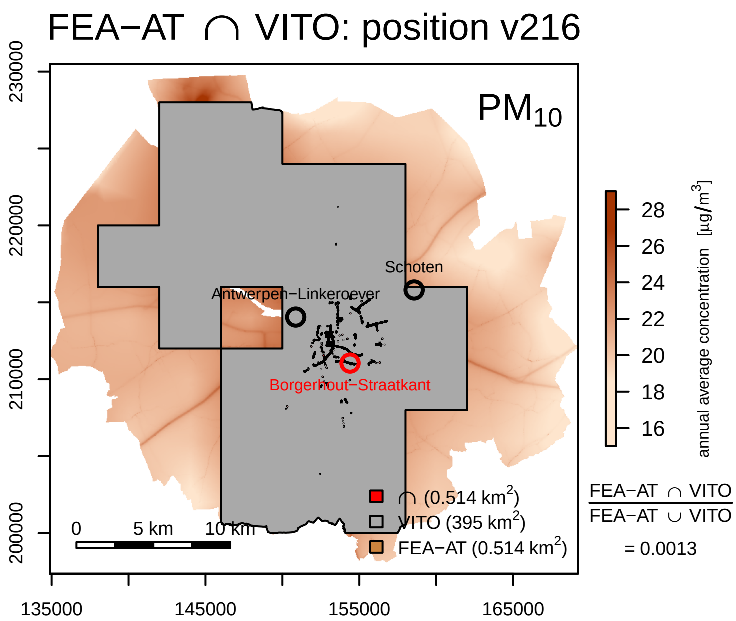

EPAIE ∩ SLB: position v216
PM_{10}
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (0.0591 km^2)
SLB (0.0591 km^2)
EPAIE (3.39 km^2)
$\frac{\text{EPAIE} \cap \text{SLB}}{\text{EPAIE} \cup \text{SLB}} = 0.017$
annual average concentration [µg/m^3]
28
26
24
22
20
18
16
230000
220000
210000
200000
135000
145000
155000
165000

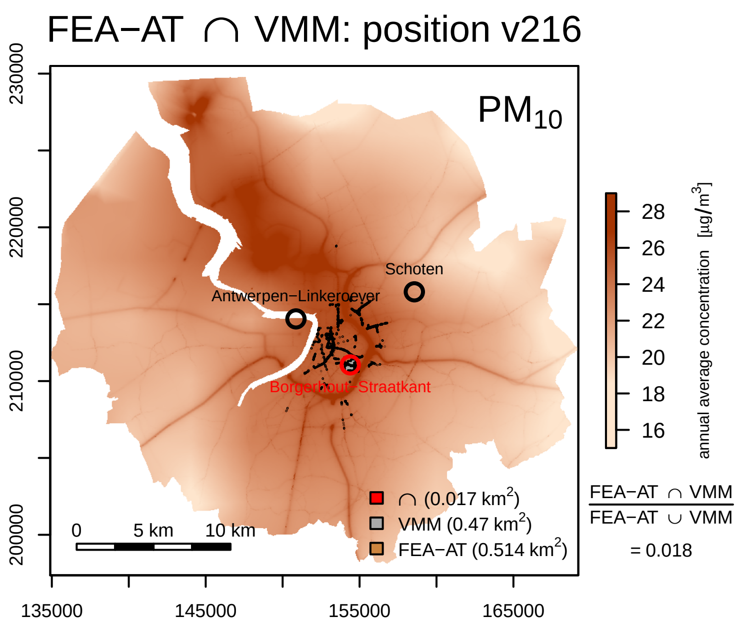

EPAIE ∩ VITO: position v216
PM_{10}
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (3.39 km^2)
VITO (395 km^2)
EPAIE (3.39 km^2)
$\frac{\text{EPAIE} \cap \text{VITO}}{\text{EPAIE} \cup \text{VITO}} = 0.0086$
annual average concentration [µg/m^3]
28
26
24
22
20
18
16
230000
220000
210000
200000
135000
145000
155000
165000

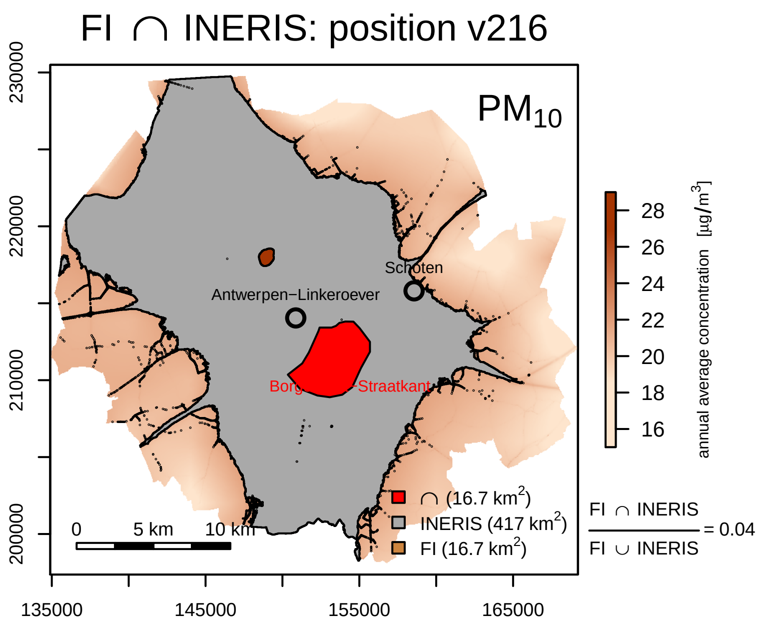

EPAIE ∩ VMM: position v216
PM_{10}
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (0.351 km^2)
VMM (0.47 km^2)
EPAIE (3.39 km^2)
$\frac{\text{EPAIE} \cap \text{VMM}}{\text{EPAIE} \cup \text{VMM}} = 0.1$
annual average concentration [µg/m^3]
28
26
24
22
20
18
16
230000
220000
210000
200000
135000
145000
155000
165000

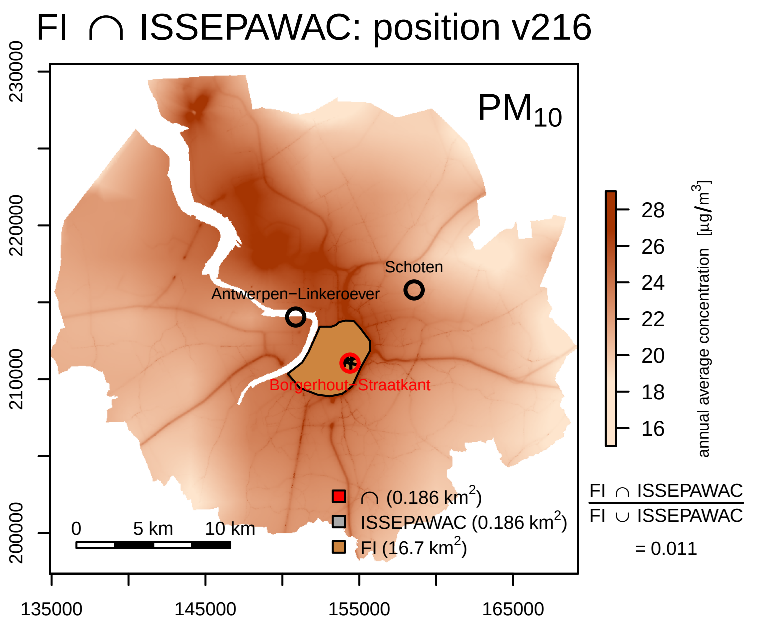

FEA−AT ∩ FI: position v216
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.283 km2)
FI (16.7 km2)
FEA−AT (0.514 km2)
0
5 km
10 km
annual average concentration [µg/m3]
FEA−AT ∩ FI
FEA−AT ∪ FI
= 0.017
FEA−AT ∩ INERIS: position v216
∩ (0.514 km2)
INERIS (417 km2)
FEA−AT (0.514 km2)
FEA−AT ∩ INERIS
FEA−AT ∪ INERIS
= 0.0012
FEA−AT ∩ ISSEPAWAC: position v216
∩ (0.0238 km2)
ISSEPAWAC (0.186 km2)
FEA−AT (0.514 km2)
FEA−AT ∩ ISSEPAWAC
FEA−AT ∪ ISSEPAWAC
= 0.035

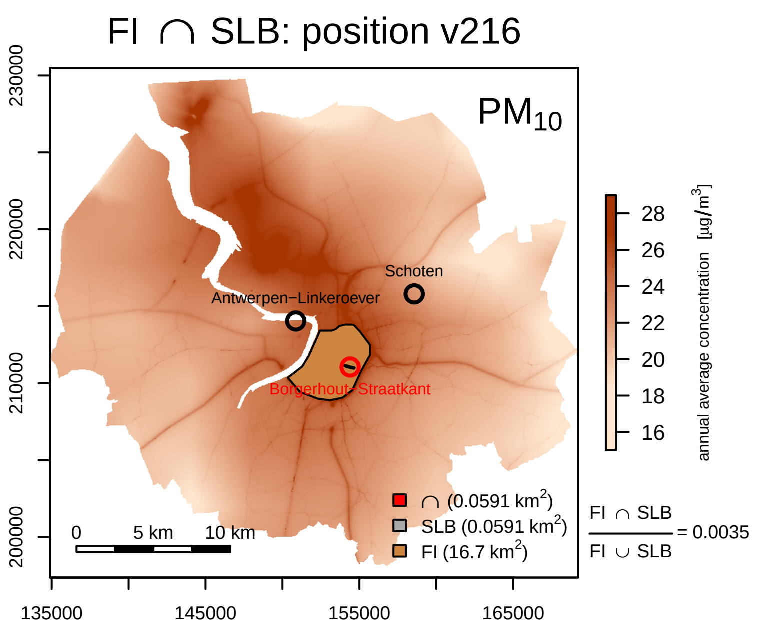

FEA−AT ∩ SLB: position v216
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (0.018 km²)
SLB (0.0591 km²)
FEA−AT (0.514 km²)
28
26
24
22
20
18
16
annual average concentration [µg/m³]
FEA−AT ∩ SLB / FEA−AT ∪ SLB
= 0.032
230000
220000
210000
200000
135000
145000
155000
165000

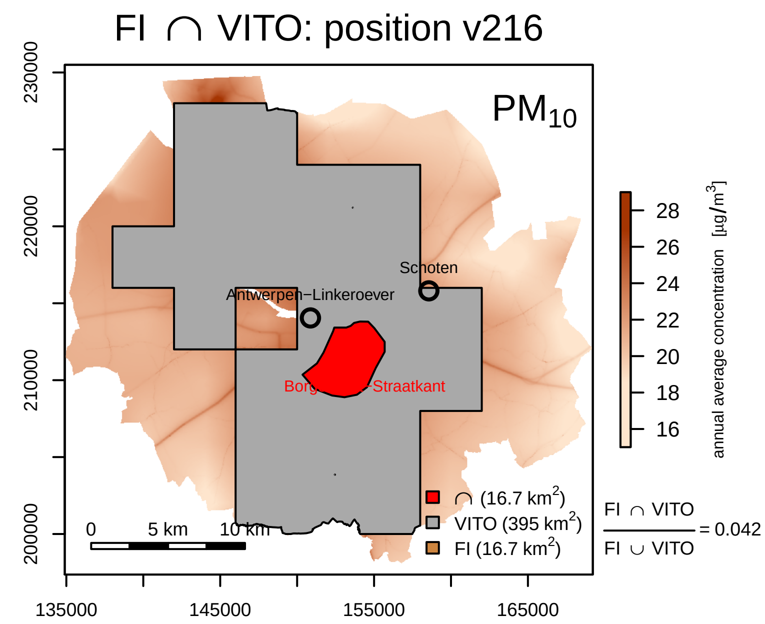

FEA−AT ∩ VITO: position v216
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (0.514 km²)
VITO (395 km²)
FEA−AT (0.514 km²)
28
26
24
22
20
18
16
annual average concentration [µg/m³]
FEA−AT ∩ VITO / FEA−AT ∪ VITO
= 0.0013
230000
220000
210000
200000
135000
145000
155000
165000

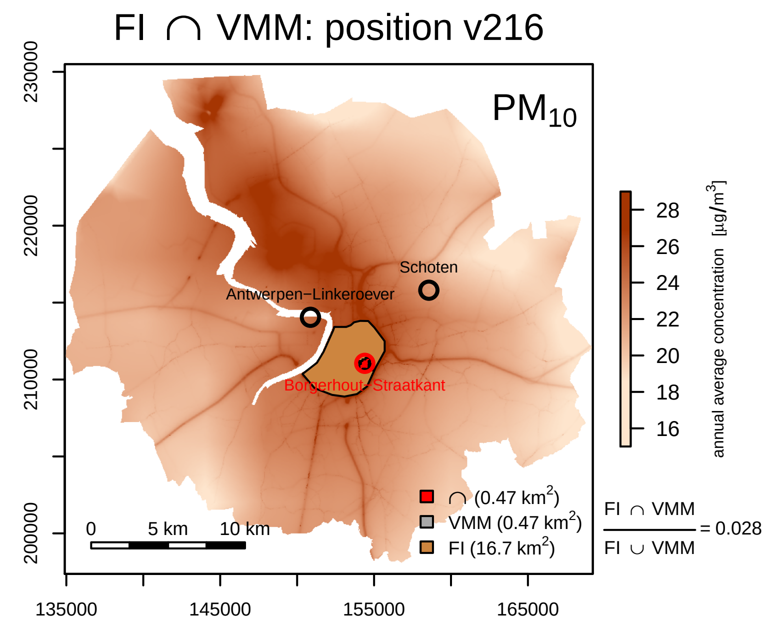

FEA−AT ∩ VMM: position v216
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0
5 km
10 km
∩ (0.017 km²)
VMM (0.47 km²)
FEA−AT (0.514 km²)
28
26
24
22
20
18
16
annual average concentration [µg/m³]
FEA−AT ∩ VMM / FEA−AT ∪ VMM
= 0.018
230000
220000
210000
200000
135000
145000
155000
165000

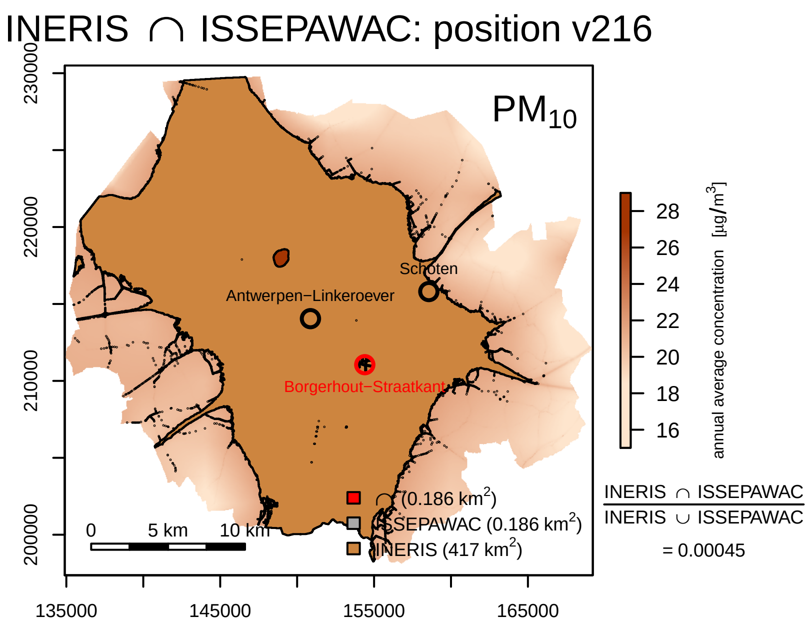

FI ∩ INERIS: position v216
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (16.7 km2)
INERIS (417 km2)
FI (16.7 km2)
0 5 km 10 km
FI ∩ INERIS / FI ∪ INERIS = 0.04
annual average concentration [µg/m3]
28 26 24 22 20 18 16
230000 220000 210000 200000
135000 145000 155000 165000

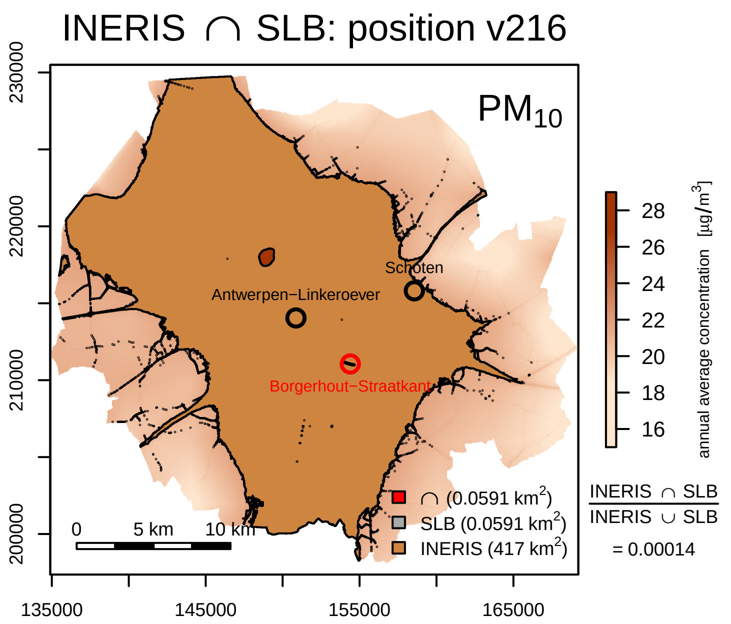

FI ∩ ISSEPAWAC: position v216
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.186 km2)
ISSEPAWAC (0.186 km2)
FI (16.7 km2)
0 5 km 10 km
FI ∩ ISSEPAWAC / FI ∪ ISSEPAWAC = 0.011
annual average concentration [µg/m3]
28 26 24 22 20 18 16
230000 220000 210000 200000
135000 145000 155000 165000

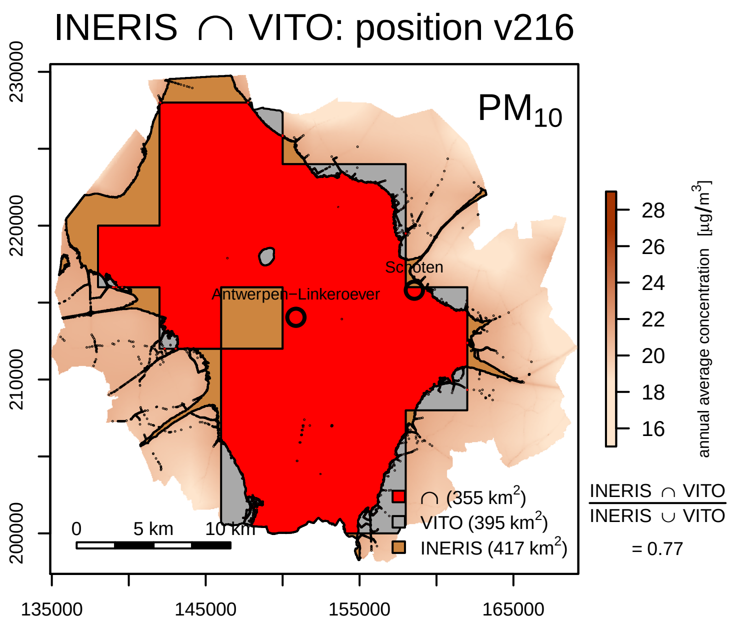

FI ∩ SLB: position v216
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.0591 km2)
SLB (0.0591 km2)
FI (16.7 km2)
0 5 km 10 km
FI ∩ SLB / FI ∪ SLB = 0.0035
annual average concentration [µg/m3]
28 26 24 22 20 18 16
230000 220000 210000 200000
135000 145000 155000 165000

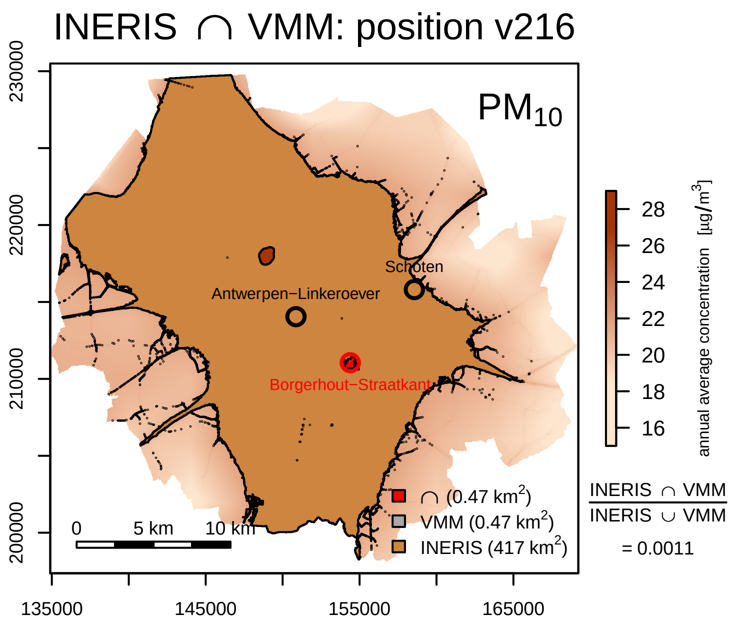

FI ∩ VITO: position v216
PM10
Schoten
Antwerpen−Linkeroever
Borg
Straatkant
∩ (16.7 km2)
VITO (395 km2)
FI (16.7 km2)
0
5 km
10 km
230000
220000
210000
200000
135000
145000
155000
165000
28
26
24
22
20
18
16
annual average concentration [µg/m3]
FI ∩ VITO
FI ∪ VITO
= 0.042

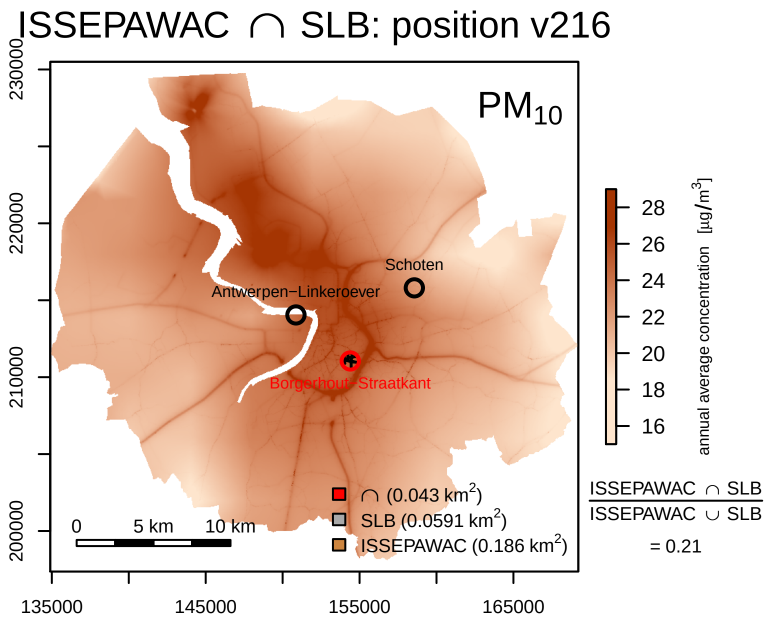

FI ∩ VMM: position v216
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.47 km2)
VMM (0.47 km2)
FI (16.7 km2)
0
5 km
10 km
230000
220000
210000
200000
135000
145000
155000
165000
28
26
24
22
20
18
16
annual average concentration [µg/m3]
FI ∩ VMM
FI ∪ VMM
= 0.028

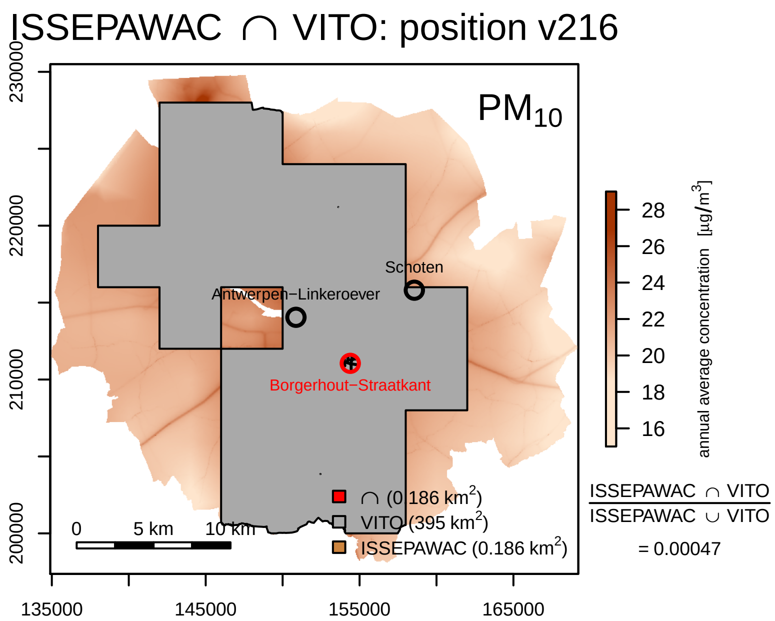

INERIS ∩ ISSEPAWAC: position v216
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.186 km2)
ISSEPAWAC (0.186 km2)
INERIS (417 km2)
0
5 km
10 km
230000
220000
210000
200000
135000
145000
155000
165000
28
26
24
22
20
18
16
annual average concentration [µg/m3]
INERIS ∩ ISSEPAWAC
INERIS ∪ ISSEPAWAC
= 0.00045

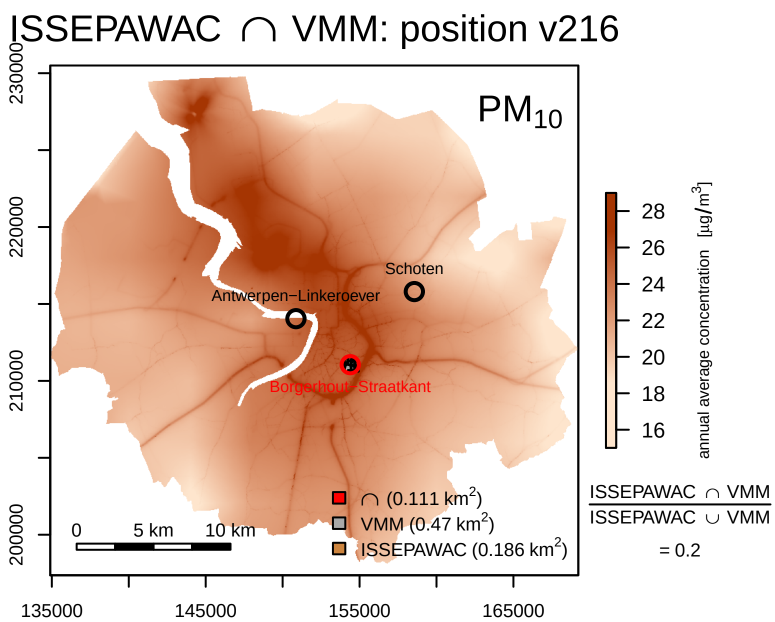

INERIS ∩ SLB: position v216
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (0.0591 km2)
SLB (0.0591 km2)
INERIS (417 km2)
INERIS ∩ SLB
INERIS ∪ SLB
= 0.00014
annual average concentration [µg/m3]
28
26
24
22
20
18
16
230000
220000
210000
200000
135000
145000
155000
165000

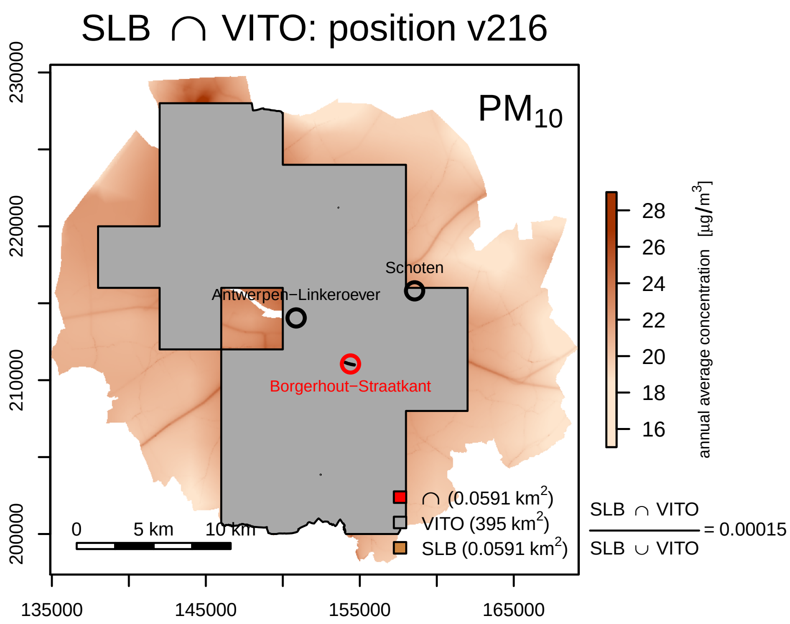

INERIS ∩ VITO: position v216
PM10
Schoten
Antwerpen−Linkeroever
0 5 km 10 km
∩ (355 km2)
VITO (395 km2)
INERIS (417 km2)
INERIS ∩ VITO
INERIS ∪ VITO
= 0.77
annual average concentration [µg/m3]
28
26
24
22
20
18
16
230000
220000
210000
200000
135000
145000
155000
165000

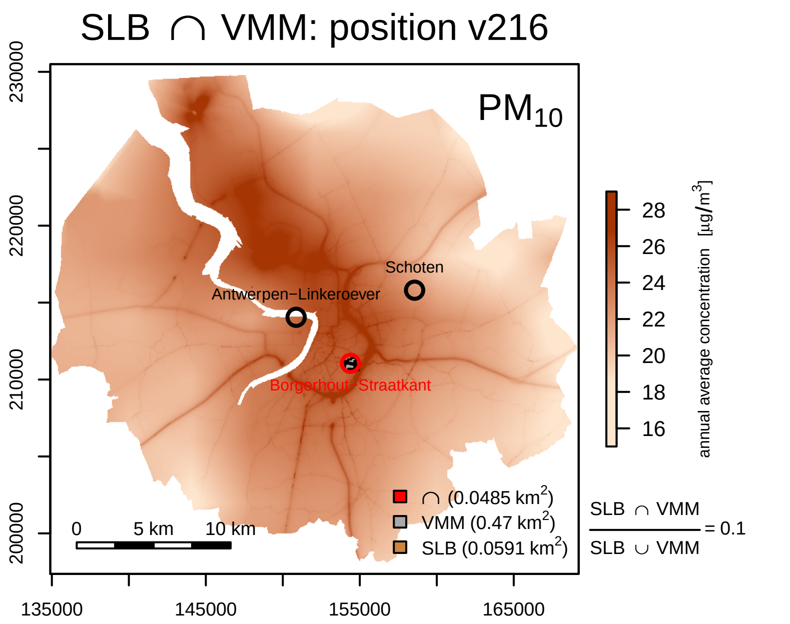

INERIS ∩ VMM: position v216
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
0 5 km 10 km
∩ (0.47 km2)
VMM (0.47 km2)
INERIS (417 km2)
INERIS ∩ VMM
INERIS ∪ VMM
= 0.0011
annual average concentration [µg/m3]
28
26
24
22
20
18
16
230000
220000
210000
200000
135000
145000
155000
165000

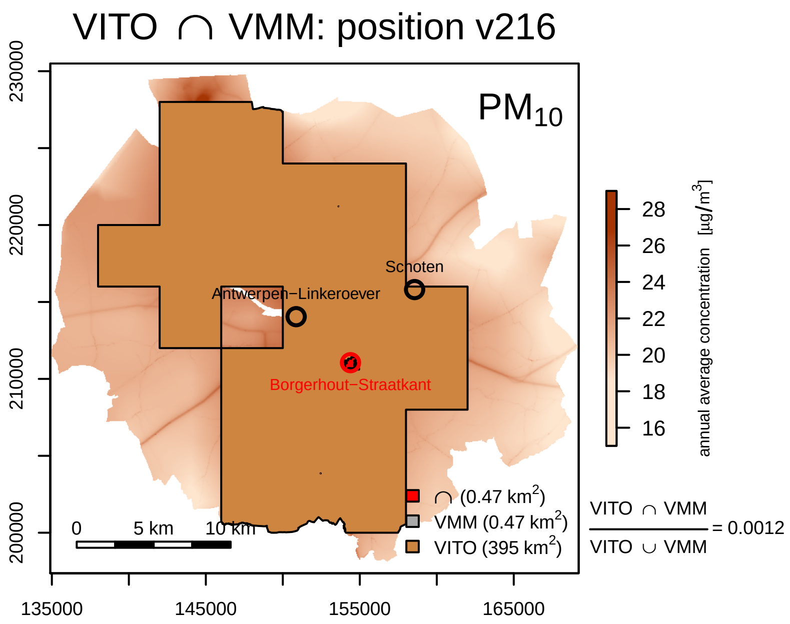

ISSEPAWAC ∩ SLB: position v216
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.043 km²)
SLB (0.0591 km²)
ISSEPAWAC (0.186 km²)
0 5 km 10 km
annual average concentration [µg/m³]
28 26 24 22 20 18 16
ISSEPAWAC ∩ SLB / ISSEPAWAC ∪ SLB = 0.21
230000 220000 210000 200000
135000 145000 155000 165000


ISSEPAWAC ∩ VITO: position v216
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.186 km²)
VITO (395 km²)
ISSEPAWAC (0.186 km²)
0 5 km 10 km
annual average concentration [µg/m³]
28 26 24 22 20 18 16
ISSEPAWAC ∩ VITO / ISSEPAWAC ∪ VITO = 0.00047
230000 220000 210000 200000
135000 145000 155000 165000


ISSEPAWAC ∩ VMM: position v216
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.111 km²)
VMM (0.47 km²)
ISSEPAWAC (0.186 km²)
0 5 km 10 km
annual average concentration [µg/m³]
28 26 24 22 20 18 16
ISSEPAWAC ∩ VMM / ISSEPAWAC ∪ VMM = 0.2
230000 220000 210000 200000
135000 145000 155000 165000


SLB ∩ VITO: position v216
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.0591 km2)
VITO (395 km2)
SLB (0.0591 km2)
0 5 km 10 km
SLB ∩ VITO
SLB ∪ VITO
= 0.00015
28 26 24 22 20 18 16
annual average concentration [µg/m3]


SLB ∩ VMM: position v216
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.0485 km2)
VMM (0.47 km2)
SLB (0.0591 km2)
0 5 km 10 km
SLB ∩ VMM
SLB ∪ VMM
= 0.1
28 26 24 22 20 18 16
annual average concentration [µg/m3]


VITO ∩ VMM: position v216
PM10
Schoten
Antwerpen−Linkeroever
Borgerhout−Straatkant
∩ (0.47 km2)
VMM (0.47 km2)
VITO (395 km2)
0 5 km 10 km
VITO ∩ VMM
VITO ∪ VMM
= 0.0012
28 26 24 22 20 18 16
annual average concentration [µg/m3]

Annex VII. Individual Summaries & Conclusions by Participants

Individual summaries & conclusions contributed by:

CIEMAT (Spain)

Fernando Martin & Jose Luis Santiago

ENEA (Italy)

Antonio Piersanti, Giuseppe Cremona, Gaia Righini & Lina Vitali

FEA-AT (Austria)

Wolfgang Spangl

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Virginie Hutsemékers & Fabian Lenartz

SLB (Sweden)

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FAIRMODE Spatial Representativeness Workshop

21/22 June 2017, Athens (GR)

Individual Summaries & Conclusions from the Workshop

Fernando Martin and Jose Luis Santiago (CIEMAT, Spain)

October, 2017

1 General Conclusions

We think the IC exercise has been very interesting and pointed out several interesting aspects as:

1. Several methodologies have been compared including measurements, proxies and modelling.
2. There is large variability in the SR areas estimates depending on used methodologies and criteria.
3. There is an agreement in:
    a. using criteria based on the similarity of pollutant concentrations applied to long time periods but in some cases taking account time series of concentrations and others based on the annual means.
    b. the SR area depends on factors as the purpose (air quality assessment, population exposure, model validation, network design, etc), the pollutant, the environment around the station, type of stations, etc.
    c. the similarity threshold is related to the measurement uncertainties.
4. It is almost impossible to set up a reference SR area and reference methodology. Then, right now it is not possible to establish some of kind of standardisation but may we can star to define some practical guidance (best practice guidelines).

2 Some ideas for future work

2.1 Similarity criteria

The similarity threshold is generally based on the measurement uncertainty but modelling uncertainty is not taken into account. Generally the model uncertainty is higher than the measurement uncertainty. Then, the SR areas could be larger. But are the SR areas really larger?

Additionally, the definition of threshold should depend on the purpose for the SR area is being estimated. For example, if the monitors measuring the pollutant concentration is more accurate (lower uncertainty) the SR area should be shorter, is that true? In our opinion, it makes no sense if you are using station data for air quality assessment because you have to be worried if the station is exceeding some air quality standard (i.e., limit value) or not. In the case of low concentrations (far to exceed any limit value), the similarity threshold can be increased. We used this idea in a study for computing SR areas for background stations in Spain.

We think SR areas can include discontinuous areas within some spatial limit provided it meets that environment; urban topography or pollutant emission characteristics are similar, that is, the pollution is due to the same causes. For example, in above mentioned study about computing SR areas for background stations in Spain, we have assumed that SR areas cannot exceed a circle of 200 km radius around the station.

We think the definition of similarity criteria depending of the purpose it is a very important issue to tackle.

2.2 Methodologies

In general, the methodologies try to estimate the spatial distribution of pollutants around the station. It can be done using:

1. measurements plus interpolation,
2. proxies (emission inventories, land cover, etc)
3. modelling

The use of measurements requires a good coverage of measuring locations and the use of a suitable interpolation method (generally kriging). The spatial distribution of pollutant concentration strongly depends on the interpolation method. The use of different interpolation methods comes out very different spatial distribution of pollutants, which provide different SR areas.

The methods based on proxies try to emulate models making some estimates on how the pollutant concentration distribution is around the station.

Validated air quality models simulate the pollutant dispersion with enough confidence and provide a good estimate of concentration maps to compute SR areas. However, they could be improved by using some data assimilation in order to correct mainly model bias. In conclusion, we think that a combination of model corrected by measurement can provide better SR areas estimates.

In addition, it is very important to use models with much higher spatial resolution that the size of expected SR area. The question is how the high resolution has to be. Hence, it is important to do some type of sensitivity studies to define what the appropriate spatial resolution is.

Working and investigating in these questions, we can progress to define what methodologies are more reliable for each case in order to get good estimates of SR areas, that is, to define some type of guidelines. However, we are far away of setting some kind of standardisation.

3 Follow up & future work: replies to the pre-defined questions

3.1 Which priorities should be set in the field of spatial representativeness (e.g. to be followed up during the next two years)?

5. Discuss about similarity criteria.
6. Discuss about what methodologies can be more reliable. To establish some kind of ranking?

3.2 What are the questions that you suggest to be tackled first?

Similarity criteria

3.3 How much time would you / your group be willing and able to spend on this subject? Do you think it would be feasible to repeat a spatial representatives intercomparison exercise (based on an adjusted definition of tasks), e.g. in the course of the next two years?

It depends of the financial support and the availability of time while working in other projects. To find a financial support for these activities should be very nice.

FAIRMODE Spatial Representativeness Workshop

21/22 June 2017, Athens (GR)

Individual Summaries & Conclusions from the Workshop

Antonio Piersanti, Giuseppe Cremona, Gaia Righini, Lina Vitali (ENEA, Italy)

05.10.2017

4 Introduction and General remarks

The intercomparison exercise was an important occasion for starting a solid scientific interaction between the involved teams from all Europe. The coordination of Oliver Kracht, supported by Michel Gerboles, was very effective, precise and inclusive. The teams' contributions were of valuable quality. The input dataset on Antwerp from VITO was very rich, but unfortunately not completely fit for the purpose of ENEA's method, requiring us to make some assumptions which influenced the quality of results. Apart from this issue, we were required a very reasonable effort for the intercomparison. We found that the duration of the exercise was a bit excessive, but we fully recognise that a project with just one JRC person dedicated (not full time) and many voluntary people from different institutions could not have been conducted much faster.

The main remark from us is on the lack of agreement on the quantitative definition of SR, directly related to the different targets of the participating teams in the calculation of SR.

In our vision, the EU obligation of reporting SR for each AQ monitoring station is one fundamental target of the calculation of SR, but there is a lack of clarity on the real use of this information by the European Commission, who should somehow clarify. Is it for assessing the quality of the station, with respect to the (not completely quantitative) requirements of the Annex III of the Air Quality Directive? or is it for human exposure assessment (which however is not methodologically regulated in the AQD, therefore it is not clear how the SR information would be used)? and how the reported field of "SR area" is related to the other reported field of the "area of exceedance"?

The other fundamental target of the calculation of SR is the human exposure assessment, beyond the requirements of EU reporting.

In our opinion, other targets for SR are either subordinate to the main two (e.g. optimisation of monitoring networks: for controlling human exposure? at what spatial and time resolution?) or of more limited or local interest (e.g. input for data assimilation in models, fitness for model validation, check of the EoI station classification).

Therefore, in a potential Phase 2 of the intercomparison on SR, the starting point should be the choice of a quantitative definition of SR, pollutant-specific and related to the time averages of the AQD limit values, with absolute or relative thresholds for concentration similarity. Contiguity of areas, similarity of emission sources and dispersion conditions, maximum distances should be matters of second-level discussion/agreement.

Focusing on the robustness of results, the methods of ENEA, EPAIE and UBA/FEA seem to us the most promising for background and industrial stations, and the methods from CIEMAT, ENEA, EPAIE, INERIS and UBA/FEA seem the most promising for traffic stations. Probably a combination of these methods would be even more robust. Of course, a cross-validation of SR areas with measurements would be the right way to assess the real robustness of the methods.

These methods should be at the basis of a Phase 2 of the intercomparison on SR. It is remarkable that many teams used the dispersion model data on the whole grid, from VITO or self-calculated (CIEMAT). This is not surprising, as models can include all the information on emissions, meteorology, chemistry, orography-3D city structure, land cover, long-range contribution. Compared to methods based on experimental measurement, methods based on model data can rely on a continuous spatial coverage of the area of interest. This is, in our opinion, a hint on the maturity and fitness for purpose of models in the SR calculation, which therefore should be somehow recommended for official use.

Focusing on the availability of input data for the calculation of SR, the gridded model data, at the detail of the Antwerp dataset, are very difficult to be produced for all European cities with monitoring stations. Therefore the method(s) using gridded model data should be included in a potential Tier-High class (complex method, reliable results) of available methods. On another side, we were impressed by the request (from the Finnish cities) of simple tools for local technicians, evaluating their local stations with very basic information like Google images and road maps, therefore a Tier-Low class (simple method, uncertain results) is absolutely needed.

5 Follow up & future work: replies to the pre-defined questions

5.1 Which priorities should be set in the field of spatial representativeness (e.g. to be followed up during the next two years)?

- Official statement of the European Commission about the meaning and the use of SR areas of monitoring stations in the official reporting of air quality data to EU (which field: SR area? Exceedance area?), and relation with human exposure assessment (at what time-spatial scale?)
- A quantitative definition of SR, pollutant-specific and related to the time averages of the AQD limit values, with absolute or relative thresholds for concentration similarity

5.2 What are the questions that you suggest to be tackled first?

FAIRMODE/AQUILA national contact points should declare what the reporting institutions mean when they provide the SR information in the reporting. The European Commission should officially clarify what the SR information from Member States is required for (see previous answer), maybe in dedicated session of a FAIRMODE/AQUILA meeting. On this basis, a quantitative definition of SR (see details in the answer before) should be agreed among EC, Member States and FAIRMODE/AQUILA national contact points, maybe in a dedicated workshop. Then, a new intercomparison on an Antwerp-style dataset (traffic and background stations, PM-NO2-O3, model and measured data, other supporting information if needed) should be done, with different teams using different methods on the same input data to calculate SR areas following the adopted definition. A cross-validation of SR areas with measurements would be of fundamental relevance, to quantify the robustness of the methods, but dedicated measurement campaigns are clearly an expensive task.

5.3 How much time would you / your group be willing and able to spend on this subject? Do you think it would be feasible to repeat a spatial representatives intercomparison exercise (based on an adjusted definition of tasks), e.g. in the course of the next two years?

My group has a strong scientific interest on this subject and will try to find adequate time to spend on it (we are required to focus on funded activities, so we cannot take long-term commitments in non-funded activities). We are interested in a new SR intercomparison in the next two years and we think it is feasible and much needed (the topic is trending and conclusions are not drawn), aiming at a guideline for air quality managers in the EU.

FAIRMODE Spatial Representativeness Workshop

21/22 June 2017, Athens (GR)

Individual Summaries & Conclusions from the Workshop

Wolfgang Spangl (Umweltbundesamt, Austria)

Wolfgang Spangl, 10.07.2017

1 Overview of SR definitions and methods

1.1 Methods based on the classification of emissions

ISSEP/AWAC (BE): Urban background: Emission classification. Traffic: Emission classification + buildings, max. distance 500 m.

VMM (BE): Emissions and CLC classification (gridded 1100m).

1.2 Methods based on concentrations (annual values)

CIEMAT (ES): Concentration criteria (annual mean, %) + maximum distance.

1.3 Methods based on concentrations (annual values), including additional criteria

FMI (FI): Concentration criteria (annual mean, abs.), traffic DTV, city structure (derived from google maps) and street geometry, estimate of industrial area (model, wind distribution).

UBA/FEA (AT): Concentration criteria (annual values related to EC LV/TV, abs.) + additional criteria: emissions (traffic, industry, domestic heating), road type, dispersion conditions (local, regional, large scale), max. distance.

INERIS (FR): Concentration criteria (annual mean, %) + evaluation by kriging including traffic emissions and road network.

SLB (SE): Urban background: Circular representative area, within its radius the standard deviation is below a concentration threshold (abs.). Traffic: Limited to the street where the monitoring station is located; criteria: traffic emissions and buildings.

1.4 Methods using concentration time series

ENEA (IT): Concentration criterion + Distribution of values: 1-hour mean concentration difference < threshold (%) during X % of the year: Processing with IDW.

EPA (IE): Concentration criteria (1-hour mean values statistics, %) + maximum distance (rectangular).

1.5 Other methods

VITO (BE): Concentrations „modelled“ by using CLC classes, only background (res. 4 km).

RIVM (NL): Classification of the diurnal variation using principal component analysis; gives no representative „areas“.

1.6 Summary

— Seven participants base their SR definition on the spatial concentration distribution; two of these use time series (1-hour mean values), the other annual mean values or percentiles

— Four of these use additional criteria – emissions, land-use data, information on buildings – besides the concentration distribution

— Two participants base their definition solely on emissions, land-use data or information on buildings.

Common to all participants: Time reference is the calendar year, or longer.

1.7 Conclusions

It has been agreed in Athens that it is too early to try to achieve agreement on a "harmonised" definition and method for SR assessment or even some „standardisation".

The "definition" of SR may depend on the objective of SR, which could be exposure assessment, identification of exceedance areas, input for monitoring network design, or model evaluation.

For different objectives, specific definitions of SR could be laid down.

The methods for determining SR depend on the definition, but also on the available input data.

Regarding the question if representative areas should be contiguous of not, I consider it a very big nonsense to assume representative areas be to be contiguous. For example: For which reason should the representative area of a background site end at the next major road?

2 Follow up & future work: replies to the pre-defined questions

2.1 Which priorities should be set in the field of spatial representativeness (e.g. to be followed up during the next two years)?

2.2 What are the questions that you suggest to be tackled first?

Suggestions for the mid-term future:

- A Europe-wide discussion – and possible harmonisation or agreement – on the definition of representativeness. As discussed in Athens, there could be different definitions of representativeness, targeted at specific objectives and applications.
- Based on the results of the Antwerp intercomparison exercise, a further investigation of definitions/methods with similar criteria would be beneficial:
    - compare the methods and results applied by UBA/FEA and INERIS
    - compare the results by UBA/FEA and INERIS with those from ENEA
    - compare the results by UBA/FEA, INERIS and ENEA with those from EPAIE without the rectangular distance limit
    - consider applying the method by SLB not to circular areas, but to grid cells

2.3 How much time would you / your group be willing and able to spend on this subject? Do you think it would be feasible to repeat a spatial representatives intercomparison exercise (based on an adjusted definition of tasks), e.g. in the course of the next two years?

It should be noted that financing the Antwerp intercomparison exercise was difficult. Getting budget for further work on representativeness on a national level will not be easy unless there is (1) an official invitation from the Commission e.g. to prepare a Guidance for identifying representative areas to be reported according to Dec. 2011/850/EC, Annex II (D), and/or (2) a financial contribution to national efforts e.g. from the Commission, JRC or EEA.

FAIRMODE Spatial Representativeness Workshop

21/22 June 2017, Athens (GR)

Individual Summaries & Conclusions from the Workshop

Jenni Latikka (Finnish Meteorological Institute)

Jenni Latikka, 28.09.2017

1 General conclusions

In generally the workshop was very useful giving good understanding on used methods by different organisations. Variation of methodologies was large but surprisingly many countries have standardised method for estimating representativeness.

2 Perspectives on guidelines and definitions

Clarification on the scope of the work was important: the main goal is to have similar results despite of used methodology.

Some methodologies seem to give rather equal air quality concentration zones (forgetting emission sources) than spatial representativeness of a single station. Thus, FAIRMODE should give guidelines what aspects are recommended to take in account at different stations, e.g. industry station (wind direction), traffic station (traffic intensity). Could Delta-tool support this?

The key question after the workshop was: what is a reasonable threshold value (in % or in $\mu g/m^3$). Could work by other FAIRMODE technical groups' support setting of threshold values, e.g. uncertainty of measurements or modelling?

One question was what is spatial representativeness and should it calculated by area or number of population. According to IPR e.g. background measurements should represent several km^2 and thus, also representativeness is recommended to base on area. Also continuation of representative area was question. Again, goal of the IPR is to have comparative AQ measurements and e.g. traffic station could represent another road with similar traffic intensity. Thus, representative area could be discontinuous.

When drafting guidelines for spatial representativeness it's good to note that the guidelines should be usable for various users, from national reference laboratory to local measurement network owner. Not all these user groups have versatile data available. Should there be guidelines for simple estimations and advanced ones?

3 Follow up & future work: replies to the pre-defined questions

3.1 Which priorities should be set in the field of spatial representativeness (e.g. to be followed up during the next two years)?

3.2 What are the questions that you suggest to be tackled first?

The work with SR is at the beginning and on coming years it should give concrete guidelines. At least the basic questions should be clarified, e.g.:

- what is spatial representativeness?

- should SR calculated by area or number of population?

- what is a reasonable threshold value (in % or in µg/m^3)?

3.3 How much time would you / your group be willing and able to spend on this subject? Do you think it would be feasible to repeat a spatial representatives intercomparison exercise (based on an adjusted definition of tasks), e.g. in the course of the next two years?

Repetition of IE would be reasonable only after the working group has clarified meaning of SR. FMI is interested to join this work but participation depends on available resources. Resource needs should be identified beforehand (e.g. on previous years).

FAIRMODE Spatial Representativeness Workshop

21/22 June 2017, Athens (GR)

Individual Summaries & Conclusions from the Workshop

Laure Malherbe & Laurent Létinois (INERIS, France)

30.10.2017

4 General remarks

Since we only participated to the beginning of the workshop, the following comments are more thoughts and suggestions than a summary and conclusions.

The issue of station representativeness (SR) has been discussed for many years within FAIRMODE and AQUILA without coming to any common definition of this concept nor any draft methodology for estimating SR areas. The intercomparison exercise organised by JRC was quite useful to make a step forward and see how FAIRMODE could deal with this issue. We would like to acknowledge the efforts and concerted manner with which the JRC coordinated it, managed to involve the different teams, and analysed and enhanced the results.

A feasibility study was first carried out and a significant number of teams got involved, giving the opportunity to make a broad inventory of existing approaches and providing solid basis for this exercise. Results demonstrated that the consequence of the large diversity of approaches was an extremely high variability of the SR areas in terms of shape, extent and geographical distribution.

5 Follow up & future work: replies to the pre-defined questions

5.1 Which priorities should be set in the field of spatial representativeness (e.g. to be followed up during the next two years)?

5.2 What are the questions that you suggest to be tackled first?

Given the high variability between the methodologies and the results, reaching a consensus might be difficult. To go forward, our advice would be that from the lessons learnt from this exercise, the JRC be now more prescriptive, setting a common definition for SR and common guidelines and criteria to delimit SR areas. Those criteria should be easily applicable considering available data and current practices in Europe.

5.3 How much time would you / your group be willing and able to spend on this subject? Do you think it would be feasible to repeat a spatial representatives intercomparison exercise (based on an adjusted definition of tasks), e.g. in the course of the next two years?

The possibility for our group to spend time on this subject will depend on available resources (no resources left for 2017). However, having a harmonised methodology to assess representativeness with regard to the Directive requirements is of importance in the analysis of the monitoring strategy, especially in assessment zones concerned by exceedances and action plans.

We do not recommend the repetition of a similar exercise as it is a demanding and time-consuming task, which probably will not lead to any diverse or additional significant conclusions. As previously mentioned, it could be more efficient that the JRC first proposes a definition of SR as well as guidelines and criteria for assessing SR areas.

Then a second exercise could be organised in a lighter mode, only to test the applicability and adequacy of the proposed criteria and check that the results between the different participants are consistent.

FAIRMODE Spatial Representativeness Workshop

21/22 June 2017, Athens (GR)

Individual Summaries & Conclusions from the Workshop

Virginie Hutsemékers, Fabian Lenartz (ISSEPAWAC)

02.10.2017

1 Introduction

Many different approaches were presented in this meeting. Some of them pointed to similar methodological aspects but as a general overview, the methods, the level of experience of each methodology and the objectives were very different from one participant to the other.

2 Similarity criteria

A shared trend in the similarity criteria of SR definition is to define the area based on the concentration values at the monitoring station within a concentration range.

Two ways were proposed to define the concentrations:

- Calculated concentrations – kriging or deterministic model
- Emissions as a proxy for concentrations

The variability threshold defined around the concentrations of the monitoring station was either relative or absolute. It appears that most of the time these thresholds were set as a percentage of the concentration at the monitoring station. In case of fixed thresholds, as discussed in the meeting, they should be adapted to the different situations/types of areas.

2.1. Modelled concentrations

Most of the participants used calculated concentrations, either provided by the VITO dataset (RIO-IFDM-OSPM); or by a kriging method (INERIS), or by their own deterministic model (CIEMAT, ENEA).

The advantage of using model results is the entire spatial coverage of the domain of interest.

From our point of view, kriging could be used only if the number of sampling points is high enough to handle the high variation of concentrations in an urban area – which is rather difficult.

A high-resolution urban model seems the most adequate method. This type of model is increasingly used and performant. Such a model presents several advantages:

– It integrates all influencing variables: emissions from all sectors, 3-D topography and meteorological conditions. Ideally, it should be corrected by the measurements.
– It's pollutant-dependent
– If accurate enough, it takes into account the high spatial variability of concentrations in an urban area.
– It can be used without any a priori knowledge of the concentration measurements. Therefore it is easy to use this methodology to determine the SR areas for a future or a mobile monitoring station.

Cons:

- Uncertainty and inadequate quality of the model. The model should be able, in the case of the road traffic stations, to take into account complex local situations such as street canyons effects. However, this subject of the model quality objectives could easily be handled within the FAIRMODE community, it could be an extension of the MQO of WG1. The issue of correction of the model by measurements would also be handled within the community.
- It is important to note that this type of model is not available everywhere – only in bigger cities, since it requires an adequate emission data set.

2.2. Proxies of concentrations – Emissions.

Only two participants presented a method based on emissions as proxies.

The advantage of this method was its simplicity. In absence of a model or any a priori knowledge of concentrations, this method gives SR areas results based on the most important criteria in an urban area – emissions, and street configuration in the case of traffic stations.

However, the use of emissions as a proxy for concentrations, in case either of road traffic stations or urban background stations, relies on a principle of linearity and isn't the most accurate way to define a SR area.

3 Main issues of discussion

Many interesting and different approaches were discussed during this meeting.

One of the first step should be to define more accurately the SR concept by answering the following questions:

3.1. Purpose?

Sweden was the only one to propose an alternative definition linked with population exposure.

The other participants' objective was first the compliance with the directive, and as a second goal, population exposure and implementation of new stations.

3.2. Similarity criteria?

Similarity criteria based on modelled concentrations or simple proxies.

When models are available and satisfying the quality objectives, it seems to be one of the most adequate method.

However, as discussed above, high-resolution models are not available everywhere and cannot be applied to each case. A simplified method using proxies might be a good solution to determine a SR area in that case.

3.3. How do we define the range of tolerance or ΔC?

A relative ΔC (= percentage of the concentration value at the monitoring site) seems more appropriate to avoid the need to adapt an absolute ΔC to each situation/ type of environment.

3.4. Time resolution?

Is the SR concentration area changing each hour depending on the meteo and, in that case, do we set a frequency count for the yearly SR (cf Italian method)? Or do we calculate the SR area based on annual mean concentrations? To our opinion, the annual mean basis seems the most representative scale.

3.5. Contiguity of SR areas and restriction of the SR domain.

The question has been raised during the meeting whether the SR areas could be discontinuous or not. Most of the participants seem to agree that the SR areas may not be contiguous. However, in that case, a restricted domain of influence is probably necessary. Defining to which extent is a difficult question too.

4 Perspectives

To our point of view, one of the most promising method is a method based on modelled results (deterministic model) on an annual mean basis.

ISSEPAWAC is willing and able to participate to another spatial representativeness exercise if an adjusted definition of SR is proposed. In our case, it would probably mean severe changes to our approach. However, we are deeply interested in an agreed European method to define the SR areas of the stations.

FAIRMODE Spatial Representativeness Workshop

21/22 June 2017, Athens (GR)

Kristina Eneroth and Sanna Silvergren (SLB, Sweden)

Kristina Eneroth, September 2017

1 General remarks

We found both the exercise and the workshop very interesting and rewarding. What was most striking was how different the results were from the different groups. Perhaps the results would have been more similar to each other if there had been more restrictions in, for example, what would be used for similarity criteria. However, in that case the different groups might not have been able to apply their own methods, and the thought of the exercise had been lost.

2 Choice of method

Some groups had very advanced methods that set high standards on input data as well as work efforts e.g. CFD models, large number of monitoring stations. We believe that when it comes to guidelines for SR areas, it may be ok to recommend one of these more advanced and resource-intensive methods, but we must also provide alternative methods that are at a more basic level.

3 Similarity criteria

We think it would be good if we could make a recommendation on what similarity criteria should be used to determine the SR area. For example, the concentrations should not deviate more than x % from the measured concentrations at the monitoring station (you may also set an absolute limit (x $\mu g/m^3$) to soften the requirements for low concentration areas). Possibly, the recommendations must contain several alternative similarity criteria, not only based on concentrations but also for example on emissions.

If you choose a method and similarity criteria using modelled concentrations as a starting point, it is important to stress out that high-resolution models must be used. Depending on the resolution of the modelled concentrations, the variability in the domain will vary.

4 Contiguous vs discontiguous areas

We think that one should strive for the SR area to be contiguous. There should also be a reasonable limit for the size of the SR area. Because even if similar concentrations can be found in areas far from the monitoring station, the sources of air pollutants may be quite different. There must be support to say that there are the same types of sources in the SR area as at the monitoring station. The same applies to meteorology, topography, etc.

Possibly, one could find a method to exclude smaller “hot-spot areas”, e.g. along highways or proximity of industries, from the SR area. In this case, discontiguous SR areas could be allowed.

5 Follow up & future work: replies to the pre-defined questions

5.1 Which priorities should be set in the field of spatial representativeness (e.g. to be followed up during the next two years)?

Make clear what is the purpose defining a SR area. For the validation of models? For design of monitoring networks, e.g. where to place stations, how many stations are needed?

5.2 What are the questions that you suggest to be tackled first?

Come up with recommendations of which method(s) and criteria to use.

5.3 How much time would you / your group be willing and able to spend on this subject?

We do not have the means to spend a lot of time on this subject. Possibly if we can get funding from the Swedish EPA. Before we know about the funding, we cannot really answer this question.

5.4 Do you think it would be feasible to repeat a spatial representatives intercomparison exercise (based on an adjusted definition of tasks), e.g. in the course of the next two years?

Yes maybe. It depends on whether we can get funding to do it. It also depends on the extent of the exercise.

FAIRMODE Spatial Representativeness Workshop

21/22 June 2017, Athens (GR)

Individual Summaries & Conclusions from the Workshop

Stijn Janssen (VITO, Belgium)

Stijn Janssen, July – August, 2017

1 SR area as a general concept

At the start of the IE it was agreed by all teams to use the area of SR for each of the stations as a general concept to work with. During the course of the exercise, this SR area turned out to be a useful indicator and all teams were able to define shapes surrounding the stations under investigation. As a matter of fact, this can be seen as a first step forward in the common understanding of the concept of SR. Defining SR as an area forced the teams in putting focus in their assessment tasks. Further, there is confidence that many of the purposes of SR (exposure assessment base on monitoring stations, model validation, network design …) can be served based on this spatially explicit SR area indicator. For example exposure can be easily assessed once the SR area of a monitoring station is known and an overlay with a population density map is made. In the context of model validation, the SR of a monitoring station defines whether or not the station can be used in the validation exercise. Here the SR area will make clear if there is an overall match between the model resolution and the size of the station's SR area. Even for network design the concept of SR area might be a useful starting point. A monitoring network in combination with its SR area will clearly point out the spatial coverage of the network as a whole and indicate where blind spots are present.

2 AQ model vs proxy data

The methodologies applied by the different teams can roughly be classified as methods relying on **proxy data** and methods relying on **air quality model** output. To assess the SR area the first category starts from a selection of the auxiliary data that was made available. Most of the techniques try to mimic some of the dispersion patterns or characteristics and rely on an indicator such as distance to road or a correlation with emission density data or land cover to estimate expected changes in concentration level. It has to be recognised that most of these techniques arrived at very different SR areas without much mutual agreement. The second category takes the high resolution model output as a starting point and uses this information to assess the SR area. Most of the teams arrived at comparable conclusions although significant variations occurred due to the different tolerance criteria used and the way uncertainty was dealt with.

As a general conclusion, it can be stated that the methodologies relying on modelled output arrive at much more "realistic" SR areas than the ones starting from auxiliary proxy data. The latter ones try to mimic to some extend the typical dispersion characteristics but never arrive at similar concentration patterns as the ones produced by a full blow dispersion model. As a results, it is recommended to start from (high resolution) model results rather than proxy data sets to assess reliable SR areas.

3 Similarity criteria or tolerance interval

Most of the methodologies rely on a so called similarity criteria or tolerance interval to mark out a SR area, starting from a concentration level observed in monitoring stations. Typically, the SR area is defined as the shape in which concentrations do not vary more than the given tolerance interval. During the FAIRMODE IE the tolerance interval was not explicitly defined but there was general agreement to define this tolerance interval in accordance with the observation uncertainty.

4 Contiguous vs discontiguous areas

When deriving an SR area, it has to be decided whether the area should be contiguous and connected to the station or discontiguous zones are allowed as well. There are pro's and contra's for both approaches. Working with a contiguous area has the advantage of simplicity. A rather limited area is defined in which it is assumed, by definition, that concentrations do not differ more than the tolerance interval. The discontiguous approach has the advantage that it delivers a much more complete picture of the spatial coverage of the station in relation with the rest of the monitoring network. Depending on the purpose, it might be useful to consider a contiguous area only or opt for the discontiguous variant. In the latter case, a wider region (e.g. within 20, 50 or 100 km, perhaps depending on the pollutant) has to be defined in which the discontiguous zone is defined. It doesn't make sense to have a SR area for a station in Vienna being connected to locations in the Netherlands. As a pragmatic solution, a multi-stage approach could be proposed in which at first level the contiguous zone is defined and at a second level, the discontiguous variant within certain boundaries has been marked out.

5 Follow up & future work: replies to the pre-defined questions

5.1 Which priorities should be set in the field of spatial representativeness (e.g. to be followed up during the next two years)?

Based on the lessons learnt during the IE, we should agree on a more confined definition of SR. In addition, we should work out a tiered approach to assess SR. Personally I'm more and more convinced that (high resolution) models can solve most of the issues and it is observed these days that more and more modelling teams in Europe have the capacity to apply this kind of simulation techniques.

5.2 What are the questions that you suggest to be tackled first?

Which tolerance level to use for SR, contiguity problem, sense and non-sense of a specific SR definition based on purpose. I'm not convinced that we need a specific SR definition for different purposes. If we know the SR area of a station, many of the needs can be served (see also above).

5.3 How much time would you / your group be willing and able to spend on this subject? Do you think it would be feasible to repeat a spatial representatives intercomparison exercise (based on an adjusted definition of tasks), e.g. in the course of the next two years?

VITO is definitely interested in the topic and we will try to find funding at national or international level to participate in a next exercise. It would be interesting to repeat the Antwerp IE with more confined boundary conditions. In a next round, VITO will withdraw the coarse RIO approach that was applied in the first phase and we will put forward a SR method base on our high resolution modelling system RIO-IFDM-OSPM, which was also used to derive the virtual stations.

FAIRMODE Spatial Representativeness Workshop

21/22 June 2017, Athens (GR)

Individual Summaries & Conclusions from the Workshop

David Roet (VMM, Belgium)

David Roet, 10.10. 2017

1 General remarks

As a general remark: the meeting was very interesting and helpful to better understand each participant's method for calculating the SR of the Antwerp dataset.

2 Concentration based similarity criteria

It seems that most of the methods rely on a similarity criterion based on the concentrations of the measuring station within a given threshold, i.e. C ± ΔC. Which immediately raises new questions like:

— should *C* be an absolute or a relative concentration?

— what is an appropriate value for *ΔC* (frequently the value of 20% was used)?

— and what pollutant dependency is there for *ΔC*?

3 Interpolation techniques and modeling

Other questions are: should *C* be derived from, or based on, measurements through interpolation techniques such as Kriging? Or, can we use modelled concentrations as values for *C*? If they are modelled concentrations, then:

— is our model able to provide *C* for every situation e.g. up to streetcanyon levels (high resolution modelling) or rather only urban background levels (lower resolution modelling)?

— what is the time-resolution of *C*? (half-)hourly values? annual means?

4 Emission based similarity criteria

Few methods (also) relied on a similarity criteria for the emissions, i.e. E ± ΔE. This was mainly the case for road traffic emissions. Here similar questions can be raised as for the similarity criterion for concentrations. It seemed that nobody besides, Fernando and CIEMAT's CFD-modelling, used E to do or repeat model calculations.

5 Further observations

Other interesting details were:

— Sweden's approach in directly linking concentrations with population exposure

— Austria and Finland's approach in first analysing the surroundings (land use) around each measuring station to include/exclude certain parts of the domain

— Italy's approach with a clear and mathematical formulation of a concentration threshold combined with a frequency count

6 General Conclusion

One thing is clear: there is a lot of variation in the available methods and their outcomes! And the absence of a true reference value for the SR make deciding "the best method" to determine the SR complex.

Still, it is clear that more descriptive definitions and terminologies like "*the SR calculated from modelled annual mean concentrations*" can be helpful to further map and categorise the available methods.

VMM is certainly interested in further participating in any future actions regarding SR within the FAIRMODE community.

7 Follow up & future work: replies to the pre-defined questions

7.1 Which priorities should be set in the field of spatial representativeness (e.g. to be followed up during the next two years)?

To have clear SR definitions together with an overview of good practices to calculate them.

7.2 What are the questions that you suggest to be tackled first?

I suggest that we start by defining the SR. The results from this IE clearly show that the interpretation of what an SR is and what purpose it serves has a big influence on the methodology used.

For example the methodology of Sweden is strongly linked to population exposure. On the other hand Italy's definition relies on a concentration similarity criterion. Both these examples show how the definition of an SR has a big impact on the final result.

Furthermore the available modelling and measurement data and their resolution influence, or limit, the possible methodologies that can applied to determine the SR.

One thing is clear, there will not be one single methodology nor definition.

7.3 How much time would you / your group be willing and able to spend on this subject? Do you think it would be feasible to repeat a spatial representatives intercomparison exercise (based on an adjusted definition of tasks), e.g. in the course of the next two years?

It is difficult to say now how much time we will be able to spend. This depends on other future projects here at VMM and their workload.

But VMM is definitely committed to staying active in the FAIRMODE SR topic and we would very much like to participate in another IE.

KJ-NA-28987-EN-N

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Publications Office

doi:10.2760/60611

ISBN 978-92-79-77218-4