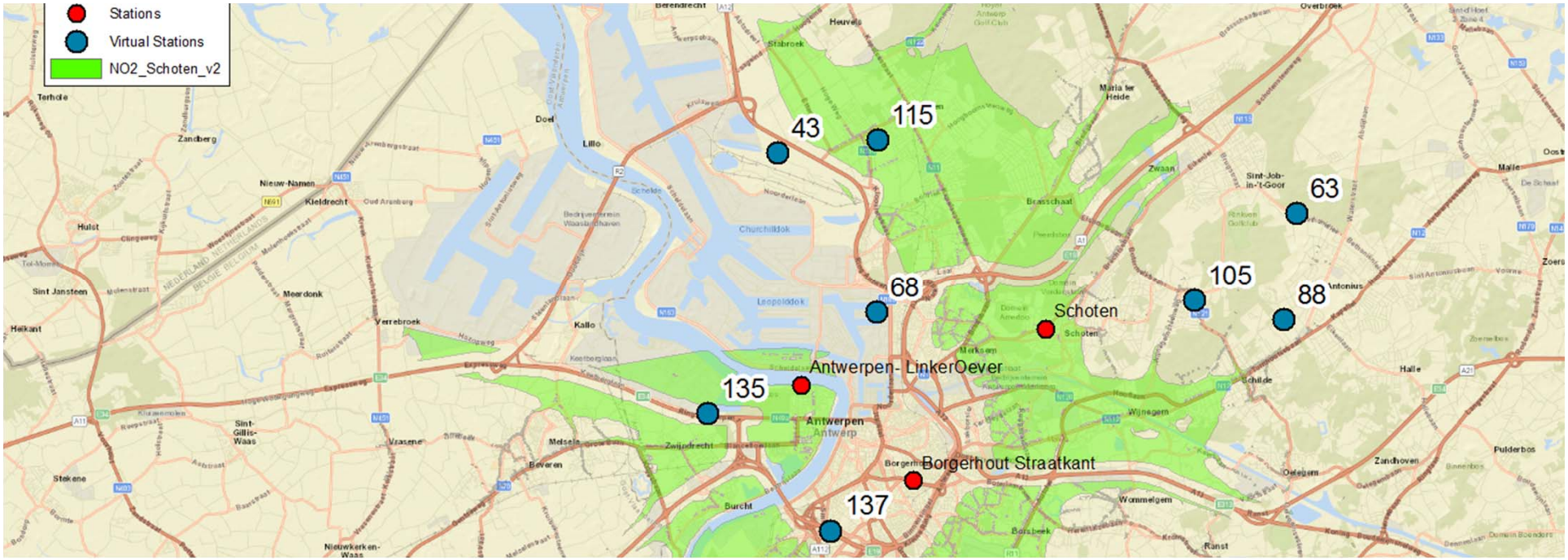


SPATIAL REPRESENTATIVENESS

CONCEPT, METHODS & INTERCOMPARISON EXCERICE ANTWERP

ENVIRONMENT AGENCY AUSTRIA umweltbundesamt

SCOPE, OBJECTIVES AND TYPICAL USE OF THE SELECTED SPATIAL REPRESENTATIVENESS (SR) METHOD (1)

1) What is the **scope** and the detailed **objectives** of your SR method used in the exercise?

- Pollutants: applied for PM_{10}, NO_2, O_3 (but in principle applicable for all pollutants)
- Time scale: Year (or several years)
- Spatial scale: any (spatial resolution restricted by available input data)
- Applied for:
  - Exposure Assessment
  - Monitoring network design
  - Estimate of exceedance areas

2) In which **context** do you typically use this method?

Support to AQ assessment

SCOPE, OBJECTIVES AND TYPICAL USE OF THE SELECTED SPATIAL REPRESENTATIVENESS (SR) METHOD (2)

3) Are there **other SR methods** that you would typically use in your work on SR assessments?

No.

4) How does the use of your method(s) relate to local / regional / national / EU-wide **regulatory and /or legal obligations**?

No relation to legal obligations.

MATURITY AND FITNESS TO PURPOSE OF THE SR METHOD USED IN THE EXERCISE

1) How many **years of experience** do you have with the specific SR method used in the exercise?

   Since 2007, starting with the study „Representativeness and classification of air quality monitoring stations“ (**http://www.umweltbundesamt.at/fileadmin/site/publikationen/REP0121.pdf**, 2007) done under a contract of the European Commission.

2) How many **years of experience** do you have with evaluating SR in general (including experience with other methods?

   The study „Representativeness and classification of air quality monitoring stations“ comprises some validation with data from NL and UK.

   The intercomparison exercise for Antwerp was the first evaluation using a comprehensive dataset.

3) How would you rate the **maturity of the SR method** you have used in the exercise?

   Several applications in Austria; Antwerp is the first comprehensive evaluation.

4) Is it possible to **apply your method by other institutes** using the tools you have developed?

   Yes, depending on available input data.

SIMILARITY CRITERIA & DEFINITION OF SPATIAL REPRESENTATIVENESS (1 -1)

1) Please summarize the underlying **definition of SR** you have used in the exercise.

- Pollutant specific
- Based on spatial distribution of pollutant concentrations
- Annual time scale
- Similarity criteria:

1. **Concentrations**: annual metrics related to limit or target values of EC legislation (average, percentiles)
2. Predominant contribution of specific **emissions**: road traffic; domestic heating; „industry“ (including power plants, waste incineration, ships, etc.)
3. Considers **dispersion conditions** on local (buildings), regional (topography) and large scale (climate)

SIMILARITY CRITERIA & DEFINITION OF SPATIAL REPRESENTATIVENESS (1 - 2)

2) Please summarize the underlying **similarity criteria & threshold parameters** you have used (1)

Concentrations: Metrics for concentration similarity criteria related to limit or target values of EC legislation:

NO_2: Annual mean

PM_{10}: Annual mean, and 90.4 percentile of daily mean values of the calendar year (equivalent to 35 days per year >50 µg/m³)

O_3: 93.2 percentile of daily max. 8-hour mean values of the calendar year (equivalent to 25 days per year >120 µg/m³)

- Concentration range for „representativeness“: ±5% of the total concentration range observed in Europe
- The selection of the concentration range for „representativeness“ is deliberate. It triggers the size of the representative area of a monitoring site, as well as the total number of „representative areas“ that is necessary to cover a territory.
- This selection produces a reasonable size of representative areas in Central Europe.

SIMILARITY CRITERIA & DEFINITION OF SPATIAL REPRESENTATIVENESS (1 - 3)

2) Please summarize the underlying **similarity criteria & threshold parameters** you have used (2)

Emissions:

- Contributions from road traffic, domestic heating, and industry are classified in two or three classes, each
- Emissions from urban roads, rural roads and motorways can be discriminated as appropriate

Ozone:

- Local road traffic emissions considered (as an ozone sink)
- Areas with increased ozone formation potential (scale ≥100 km) are considered

Note: In many cases, the road traffic emissions give no additional compared to the spatial concentration distribution itself.

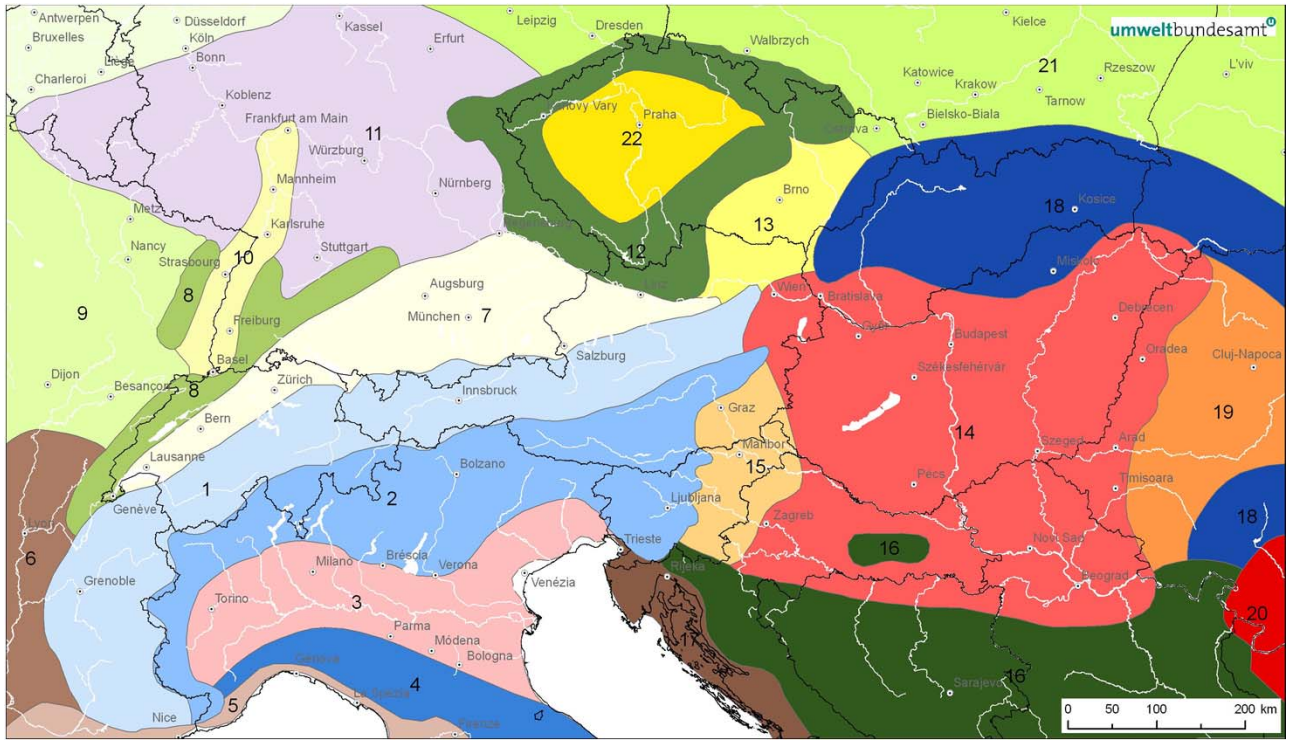
SIMILARITY CRITERIA & DEFINITION OF SPATIAL REPRESENTATIVENESS (1 - 4)

2) Please summarize the underlying **similarity criteria & threshold parameters** you have used (3)

Dispersion conditions:

- Local:
  street canyon; detached buildings; flat terrain; exposed
- Regional:
  Flat terrain; hilly terrain; valley; basin; mountain
- Large Scale:
  Regions with different climate and topography.
  In any case, the representative area is limited to about 100 km around the monitoring site.

DISPERSION CONDITIONS ON THE LARGE SCALE – REGIONS WITH DIFFERENT CLIMATE AND TOPOGRAPHY



SIMILARITY CRITERIA & DEFINITION OF SPATIAL REPRESENTATIVENESS (1 - 5)

3) Are there **other SR definitions** and / or **similarity criteria** you would typically use in your work on SR?

No.

SIMILARITY CRITERIA & DEFINITION OF SPATIAL REPRESENTATIVENESS (2 – SOME DETAILS)

1) Are the boundaries of your spatial SR areas constrained **exactly**, or did you add some additional **buffers or safety factors**?

No buffers or safety factors added.

With respect to (a) the "deliberate" choice of thresholds for similarity criteria of concentrations and emissions and (b) the (limited) quality of input data, SR should not be considered as "exact".

2) Can SR areas of different stations **overlap** or are they considered to be **exclusive** by principal?

SR areas of different stations can overlap.

3) Are your similarity criteria applied **one sided** or **two sided**?

Both upper and lower boundaries are considered.

4) Within your estimated SR areas: is spatial representativeness guaranteed for locations of **all station types**, or only for locations of **station types identical** to the type of the central station?

The representative area of a monitoring station should comprise (only) locations of the same station type (background/traffic/industrial).

INPUT DATA (1)

1) Please summarize which part of the **input dataset** you have used in the exercise.

- Model data (annual mean)
- Concentration time series at monitoring and virtual stations
- Road type
- Gridded domestic heating (SNAP sector 2) emissions (for PM_{10} only)
- Road traffic emissions on street graph (tested, but not applied)

2) Did you use **additional data**, not contained in our dataset?

Corine Landcover data: considered to classify local **dispersion conditions** → but not used because

- no unambiguous street canyon station in the test data set
- no obvious influence of CLC boundaries on the spatial concentration pattern.

"Google maps" pictures: used to check the location of monitoring stations in relation to streets and buildings.

INPUT DATA (2)

3) How suitable did you find the **Antwerp dataset** for your method? / How suitable would you rate your method to be for this type of dataset?

The dataset was quite suitable, especially thanks to the high-resolution model data.

However, it did not allow to apply/test the criteria for regional and large-scale dispersion conditions, because the area is completely flat.

4) Did you **miss** any type of data / information in this dataset?

- Model data providing the contribution of different source types would have been beneficial to identify areas predominantly influenced by road traffic, domestic heating, and industrial sources, resp.
- Since model data were available only as annual mean values, the concentration criteria for percentiles had to be adapted.

5) How does the dataset of the exercise compare to the **data you would more typically use** for you work on SR?

The dataset is close to the optimum input required for the SR method.

REPRESENTATIVENESS ASSESSMENT – NOTE ON SIMILARITY THRESHOLDS

For SR assessment, „similarity criteria“ are applied on concentrations and contributions of emissions from different source types.

It should be noted that these thresholds are a deliberate choice.

Higher threshold values will give a larger representative area for a specific monitoring station, and in total result in overlapping representative areas; and vice versa.

The threshold values applied in Austria provide a „reasonable“ number of representative areas.

However, the selection at ± 5 % of the European concentration range seems not the optimum because

- NO_2 levels cover almost this whole range in large cities → „many“ non-overlapping representative areas;
- PM_{10} levels are rather uniform on an urban to regional scale → „few“ non-overlapping representative areas.

REPRESENTATIVENESS ASSESSMENT - OPTIONS FOR INPUT DATA

The **methods** for SR assessment, as well as the “accuracy” and the spatial resolution and the “accuracy” of the results, depend on the available input data.

The **spatial concentration distribution** can be obtained from different sources – with different “accuracy”:

1. Model data (high spatial resolution in optimum case)
2. Monitoring data
3. Proxy data: GIS-based emission data, land-use data, population distribution

Estimate of the **contribution of predominant emissions** in the *absence of source-specific modelling results*:

- **Road traffic**: derived from simple modelling, the impact of road traffic emissions is estimated by the formula „*emissions per km / square root of distance from kerb*“
- **Domestic heating**: use of gridded emission data
- **Industry**: estimate, based on emissions or concentrations.

REPRESENTATIVENESS ASSESSMENT - EFFORTS

The effort to apply the methods for SR assessment depends on the available input data.

The major efforts in the Antwerp intercomparison exercise were

- The import of all GIS related data
- The calculation of the P93.2 for Ozone hourly values, and the identification of its average relation to the annual mean for the virtual stations
- The GIS handling of the road traffic emissions (not applied – because high effort and no additional information related to the modelled concentration field)

APPLICATION FOR ANTWERP – CONCENTRATION CRITERIA

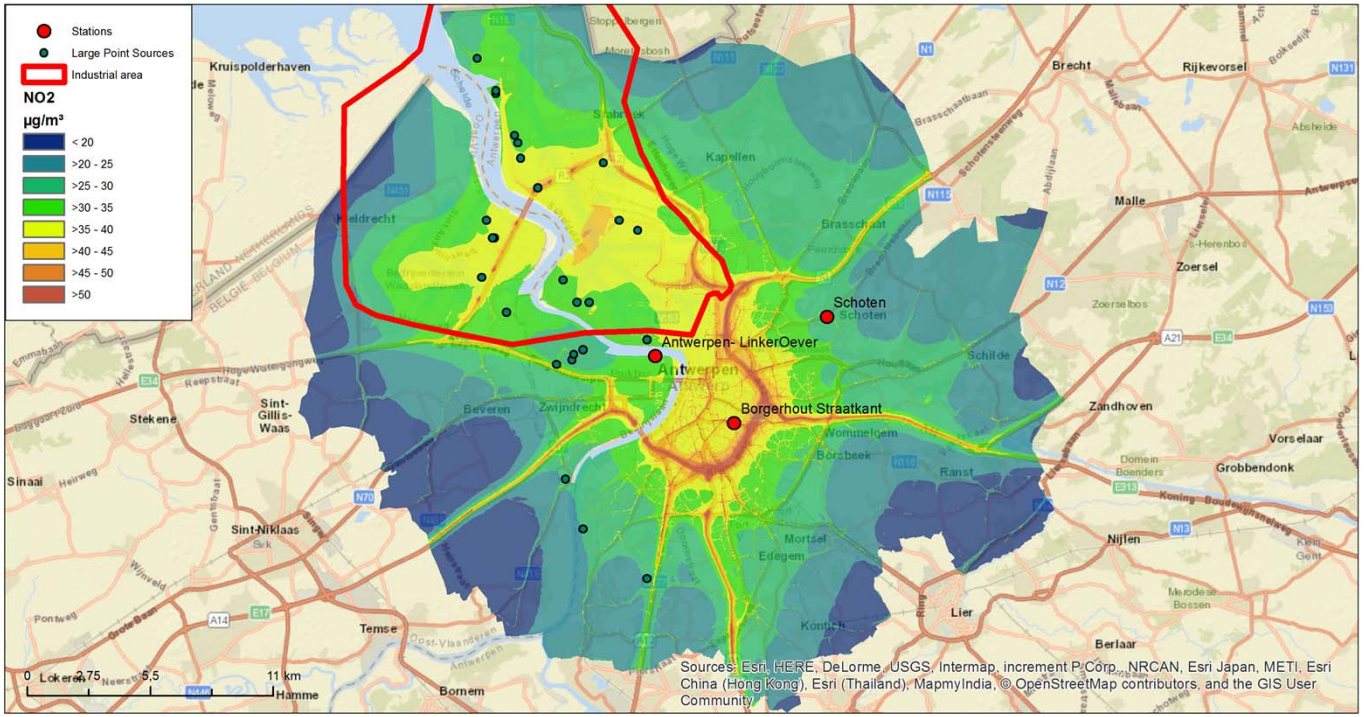
The delimitation of representative areas is based on the high-resolution model data.

- NO_2: Annual mean value at the monitoring station ± 5 µg/m³
- PM_{10}: Annual mean value at the monitoring station ± 3 µg/m³
- 90.4 percentile for the PM_{10} daily mean values (± 8 µg/m³) is not applied, because the model data are available (only) as annual mean values.
- Ozone: annual 93.2 percentile of daily maximum 8-hour mean values at the monitoring station ± 9 µg/m³.
  Ozone model data available as annual mean values → concentration criterion for P93.2 is transferred to annual mean value using the hourly time series available for the virtual stations. Average ratio the annual mean/P93.2 = 0.45 → concentration range ± 4.1 µg/m³ for annual mean.

APPLICATION FOR ANTWERP – MODELLED NO_2 CONCENTRATION

Modelled annual mean NO_2 concentration.

Area predominantly influenced by industrial emissions delimited manually based on modelled NO_2 and PM_{10} concentrations.



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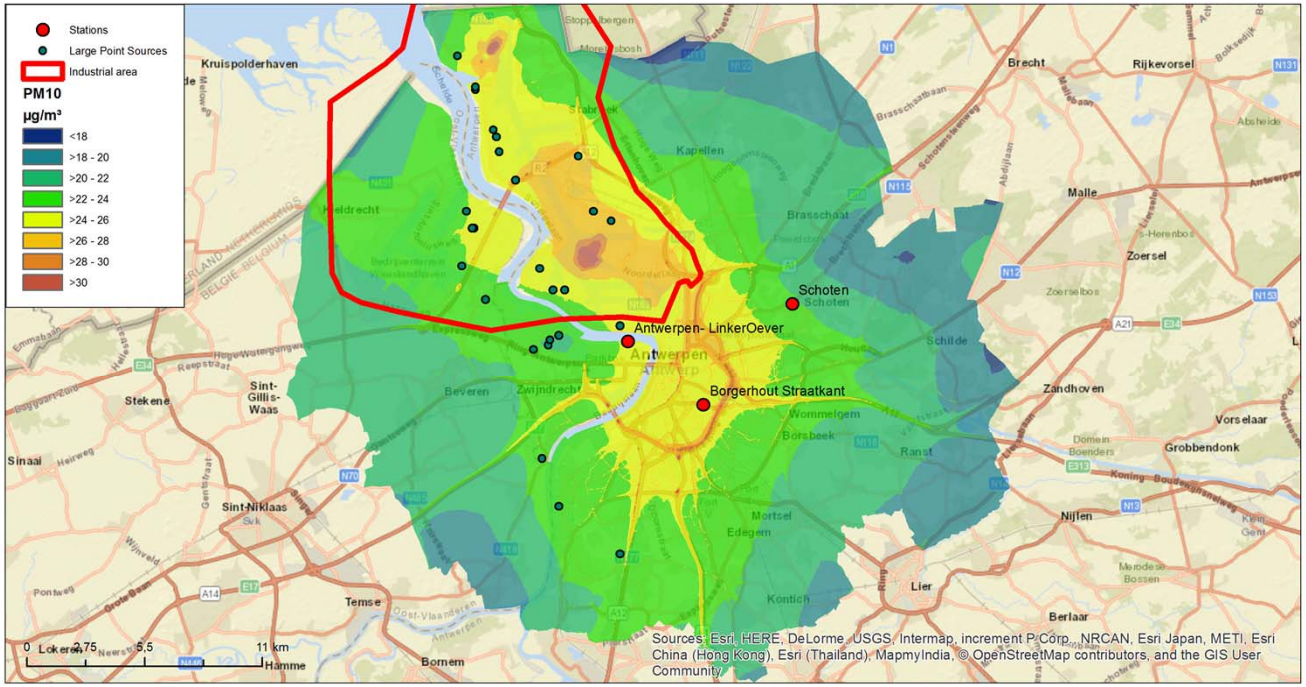
APPLICATION FOR ANTWERP – MODELLED PM_{10} CONCENTRATION

Modelled annual mean PM_{10} concentration.

Area predominantly influenced by industrial emissions delimited manually based on modelled NO_2 and PM_{10} concentrations.



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APPLICATION FOR ANTWERP – CONTRIBUTIONS FROM DIFFERENT EMISSION SOURCES - INDUSTRY

- 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.
- The identification of areas predominantly influenced by **industrial** emissions in Antwerp is based on the modelled concentration distribution itself. It 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.

APPLICATION FOR ANTWERP – CONTRIBUTIONS FROM DIFFERENT EMISSION SOURCES – ROAD TRAFFIC

The parameter "*emissions / √ distance from kerb*" has not been applied in Antwerp to classify the contribution from **road traffic** because

(a) it causes high effort in GIS calculations and

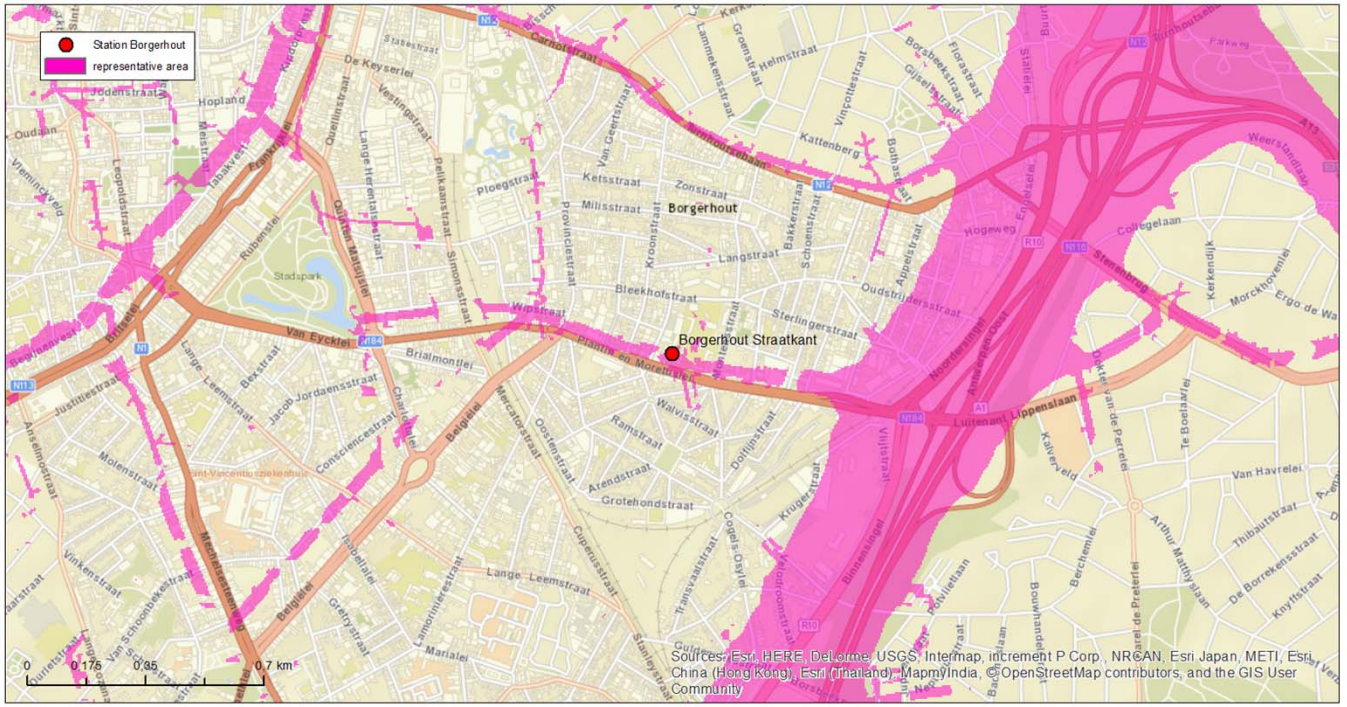
(b) the results more or less follow the modelled concentration pattern itself and provides no additional information.

The different emission pattern on **motorways** compared to urban roads has been considered by the identification of motorways ("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 model data; it should make sure that areas with medium concentrations up to 300 m meters from motorways are not included in the representative area of urban traffic stations.

APPLICATION FOR ANTWERP – DIFFERENT ROAD TYPES

Representative area for Borgerhout (NO_2) based only on the concentration criterion

(Note: There is a small mismatch between the Belgian Lambert Projection for the data from Antwerp and the Open Street Map in WGS84).



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APPLICATION FOR ANTWERP – CONTRIBUTIONS FROM DIFFERENT EMISSION SOURCES (2)

- Domestic heating emissions for NO_x are not considered, because

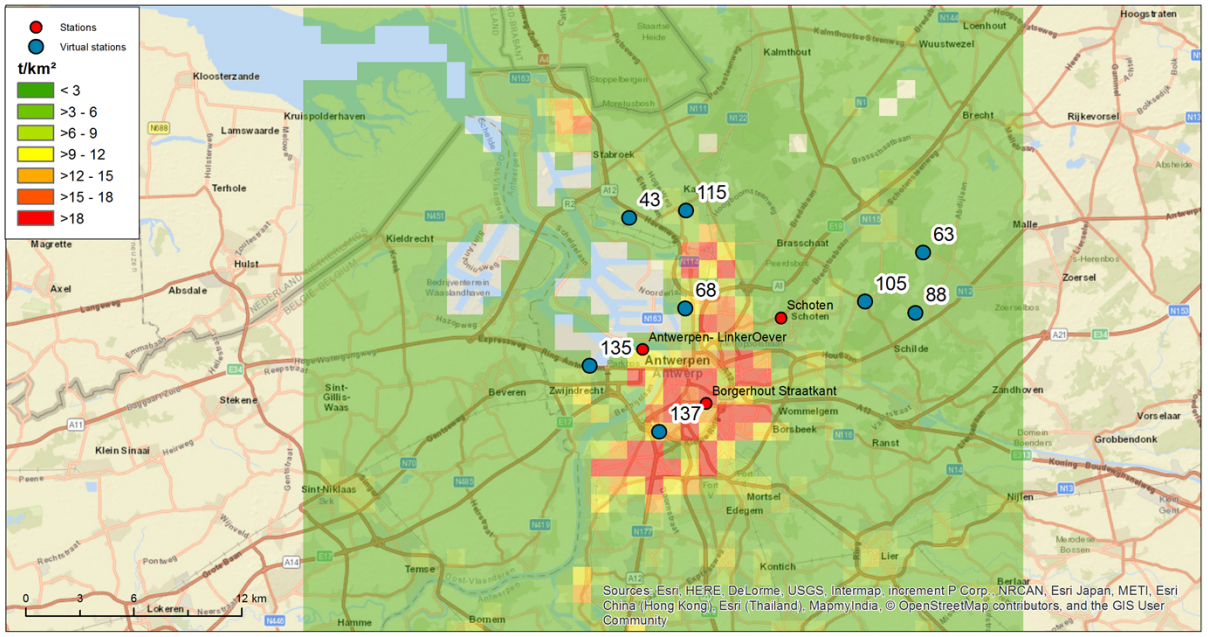
(a) impact of domestic heating emissions on the observed/modelled NO_2 concentrations is low compared to road traffic and

(b) no unique identification of domestic heating emissions, which are included in SNAP sector 2 “non-industrial combustion plants“. In some areas very high emissions from SNAP sector 2 do not correspond to high modelled NO_2 levels.

- 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.
- The classes for PM_{10} domestic heating emissions applied for Austria (class boundaries at 1 t/y and 3t/y in 1 km-surroundings) give not reasonable results for Antwerp, where domestic heating emissions are low in most parts of the town. Instead, a larger concentration range of ± 10 t/km².year has been selected (which more or less separates the city centre from all suburban areas).

APPLICATION FOR ANTWERP – PM10 EMISSIONS SNAP SECTOR 2

Domestic heating, PM_{10} emissions



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APPLICATION FOR ANTWERP – DISPERSION CONDITIONS

- Local dispersion conditions related to the buildings near the monitoring station separate: “street canyon”, “streets with detached buildings” and “open terrain”.
- Corine Landcover (CLC): proxy for the building structure, applying CLC class 1.1.1 for “street canyon”, 1.1.2 for “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 does not look like a street canyon, 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 is no street canyon stations within the set of monitoring stations and virtual stations, CLC classes are not considered as a parameter to delimitate representative areas.

  → Local dispersion conditions are not included in the SR.

ANTWERP: CORINE LANDCOVER

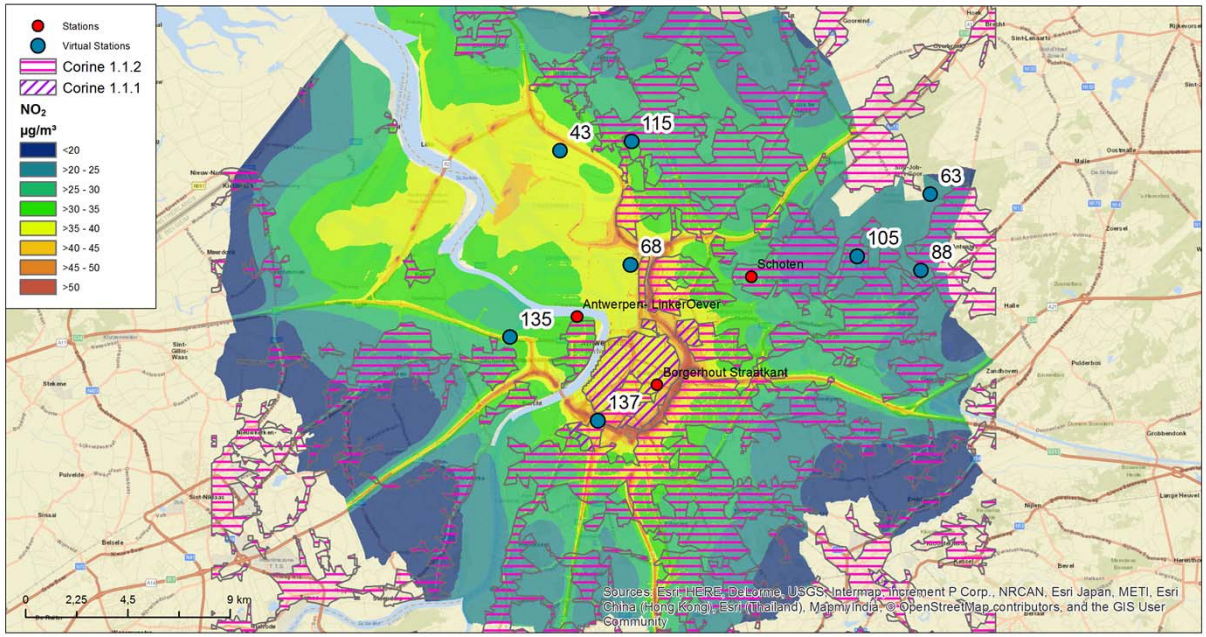
Corine Landcover classes

1.1.1 Continuous urban fabric

1.1.2 Discontinuous urban fabric

Compared to the modelled NO_2 concentration → shows no relation

Corine Land Cover Antwerpen, NO_2 annual mean



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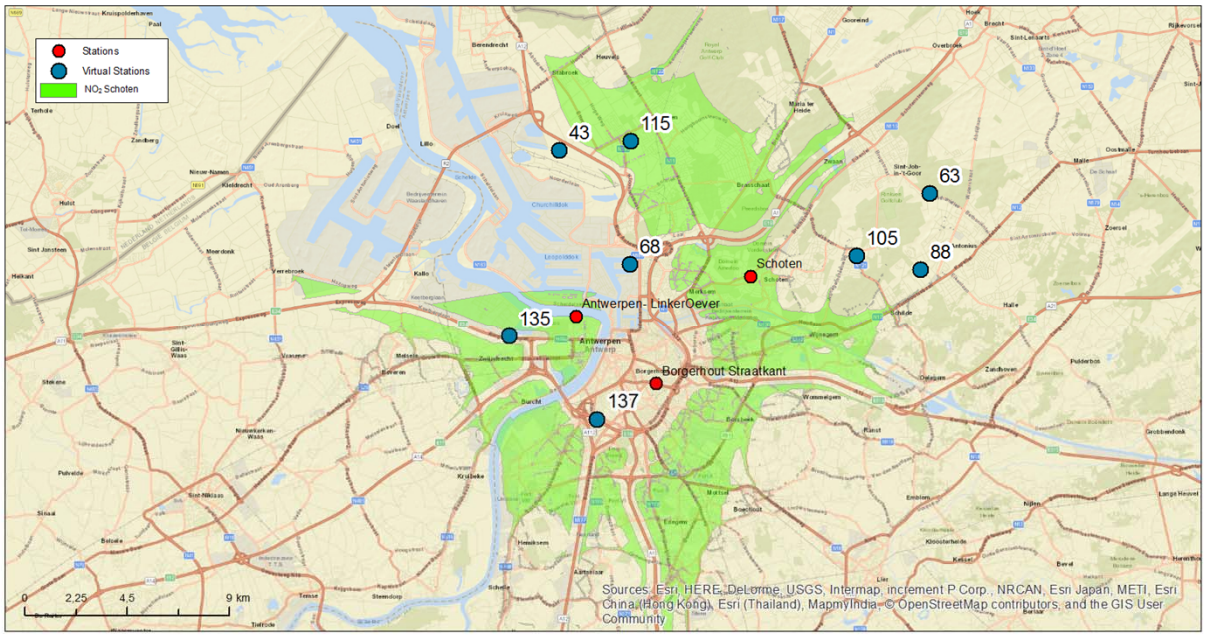
ANTWERP – EXAMPLES – NO_2 SCHOTEN

Modelled NO_2 annual mean between 26.0 and 36.0 µg/m³

Additional criteria:

- Industrial area excluded
- ±300 m along motorways excluded

Representative areas NO_2 Schoten



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ANTWERP – EXAMPLES – NO_2 BORGERHOUT

Modelled NO_2 annual mean between 44.9 and 54.9 µg/m³

Additional criteria:

- Industrial area excluded
- ±300 m along motorways excluded

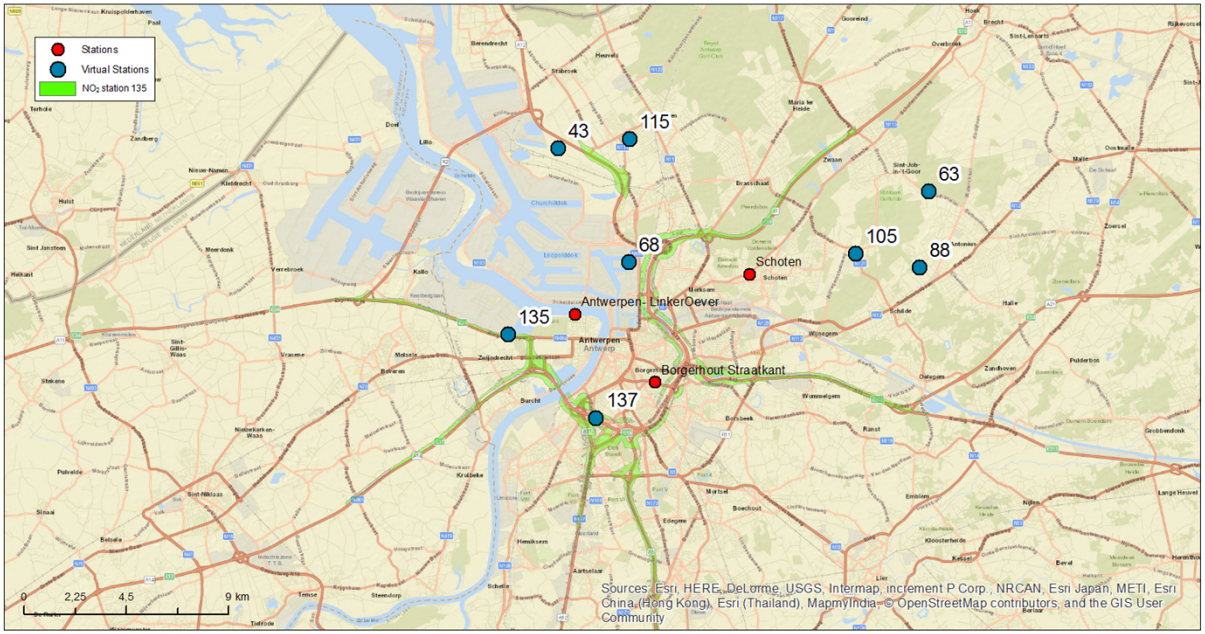
ANTWERP – EXAMPLES – NO_2 VIRTUAL STATION 135

Modelled NO_2 annual mean between 35.9 and 45.9 µg/m³

Additional criteria:

- Industrial area excluded
- within ±300 m along motorways

Representative areas



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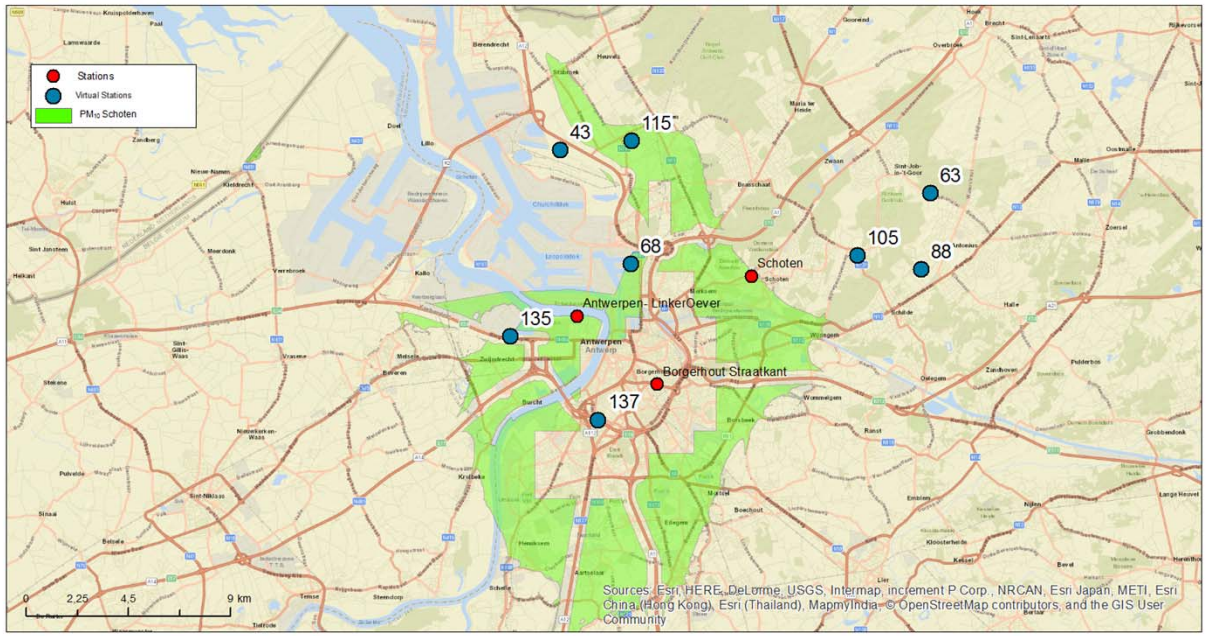
ANTWERP – EXAMPLES – PM_{10} SCHOTEN

Modelled PM_{10} annual mean between 22.2 and 28.2 µg/m³

Additional criteria:

- Industrial area excluded
- ±300 m along motorways excluded
- Domestic heating PM_{10} emissions between 1.6 and 11.6 t/km².year.

Representative areas PM_{10} Schoten



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ANTWERP – EXAMPLES – PM_{10} BORGERHOUT

Modelled PM_{10} annual mean between 26.9 and 32.9 µg/m³

Additional criteria:

- Industrial area excluded
- ±300 m along motorways excluded
- Domestic heating PM_{10} emissions 8.9 to 28.9 t/km².year.

Representative areas PM_{10} Borgerhout

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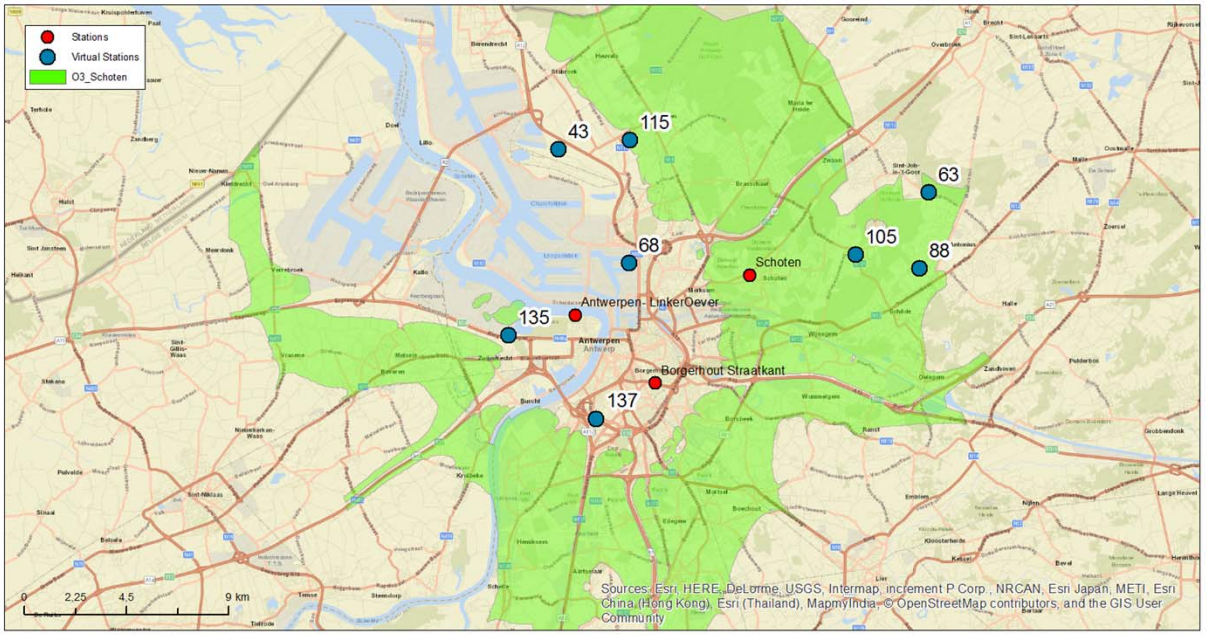
ANTWERP – EXAMPLES – O_3 SCHOTEN

Modelled Ozone annual mean between 32.7 and 40.9 µg/m³

Additional criteria:

- Industrial area excluded



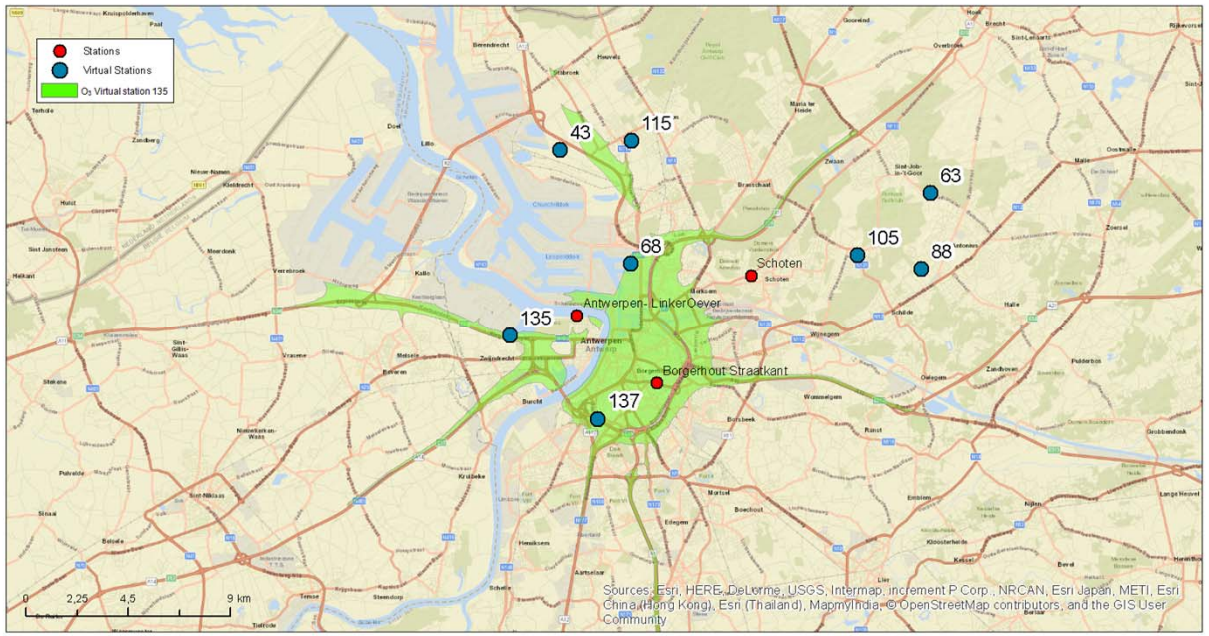
ANTWERP – EXAMPLES – O_3 VIRTUAL STATION 135

Modelled Ozone annual mean between 25.5 and 33.7 µg/m³

Additional criteria:

- Industrial area excluded

Representative areas



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