# The European Commission's science and knowledge service

Joint Research Centre

# Status of the Intercomparison Exercise

## Spatial Representativeness of Air Quality Monitoring Stations

Oliver Kracht

with contributions from

AwAC (Belgium), CIEMAT (ES), ENEA (IT), EPA (IE), Finnish Consortium (FMI / HSY / Kuopio / Turku), INERIS (FR), ISSeP (Belgium), RIVM (NL), SLB (SE), UBA (AT), VITO (BE) & VMM (BE)

FAIRMODE Technical Meeting, 19/21 June 2017, Athens (GR)

European Commission

# Outline

Timeline & Agenda:

- Short overview

Assessment from the methodological point of view:

- Short overview of candidates methods in terms of:
  - Input Data & Procedures

Assessment from the results point of view:

- Comparison of candidate methods in terms of:
  - Overview, location and lumped size of SR areas
  - Mutual degree of a agreement regarding the geometry (position, size, continuity) of SR areas

Assessment tools:

- Limited by the absence of a ‘true value’ for the reference
- We need to measure ‘consistency’ rather than ‘correctness’.
  - Quantitative indicators for mutual similarities
  - Mapping & cross tabulation of similarity indicators



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# Intercomparison Exercise of Spatial Representativeness Methods

Currently concluded activities:

- Screening of incoming results & bilateral consultations with participants (verifying methodological details and corrections)
- Harmonization of results structure across participants
- Dissemination of draft individual outcomes amongst participants
- Intercomparison with regard to the quantitative results obtained

Next steps:

- Some further comparisons regarding methodological details (input data & procedures)
- Final consolidation of results meta data and participants documentation
- Summary and reporting

Target dates:

- JRC Technical Report with internal target date 15/09/2017
- Presentations at HARMO18 (9-12 October in Bologna)



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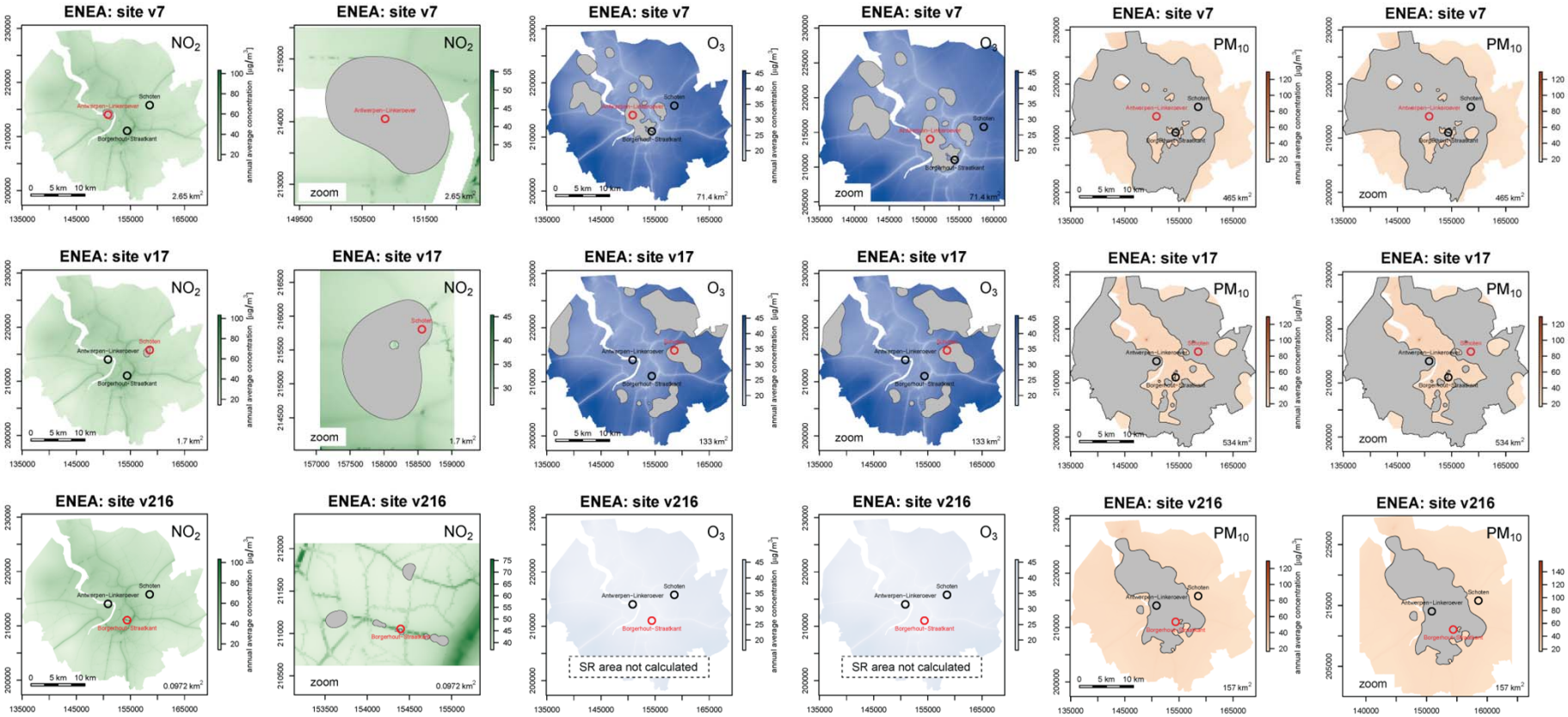
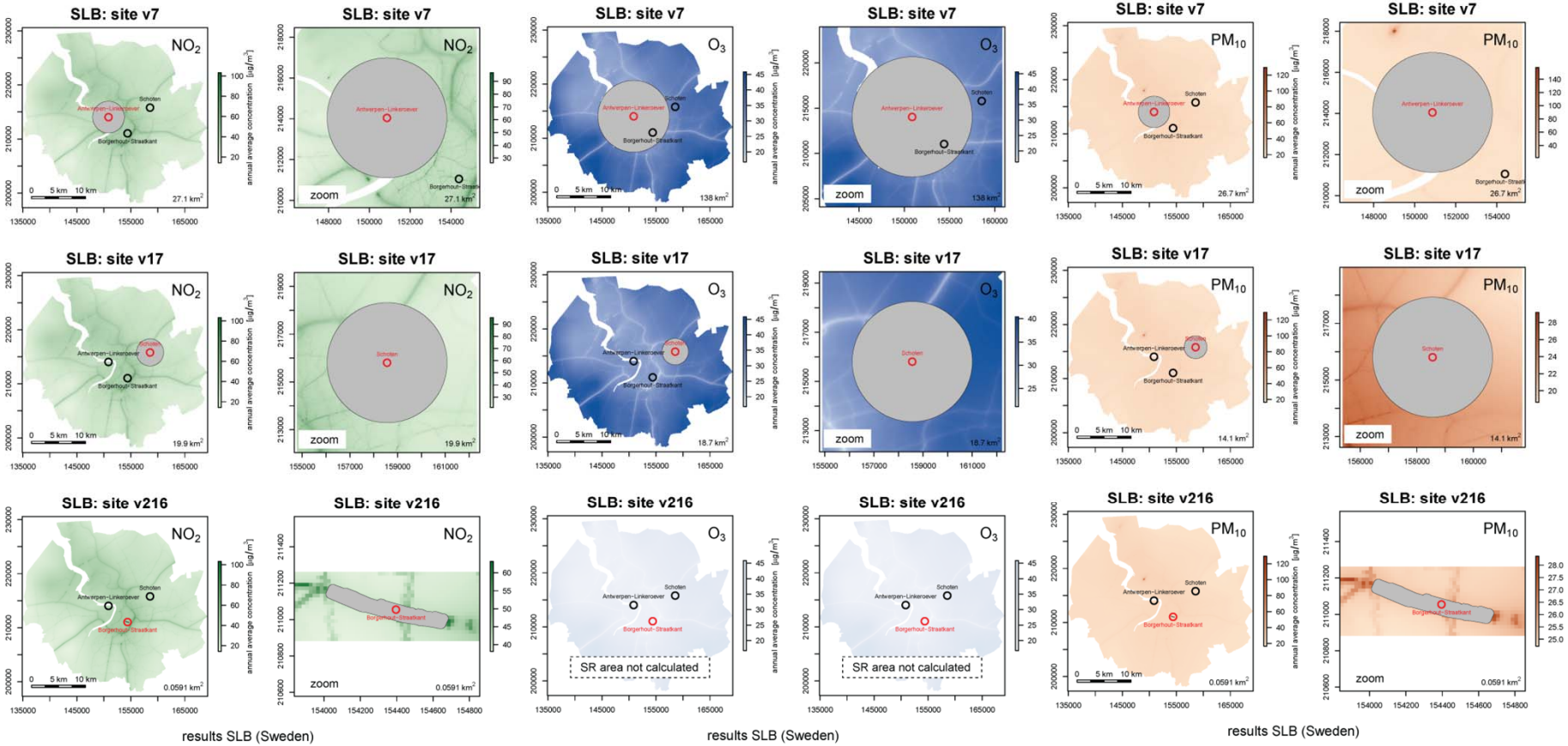
# Intercomparison Exercise of Spatial Representativeness Methods

- Collection of results
- Harmonization of results structure
- Dissemination of draft outcomes amongst participants



# Intercomparison Exercise of Spatial Representativeness Methods

- Collection of results
- Harmonization of results structure
- Dissemination of draft outcomes amongst participants

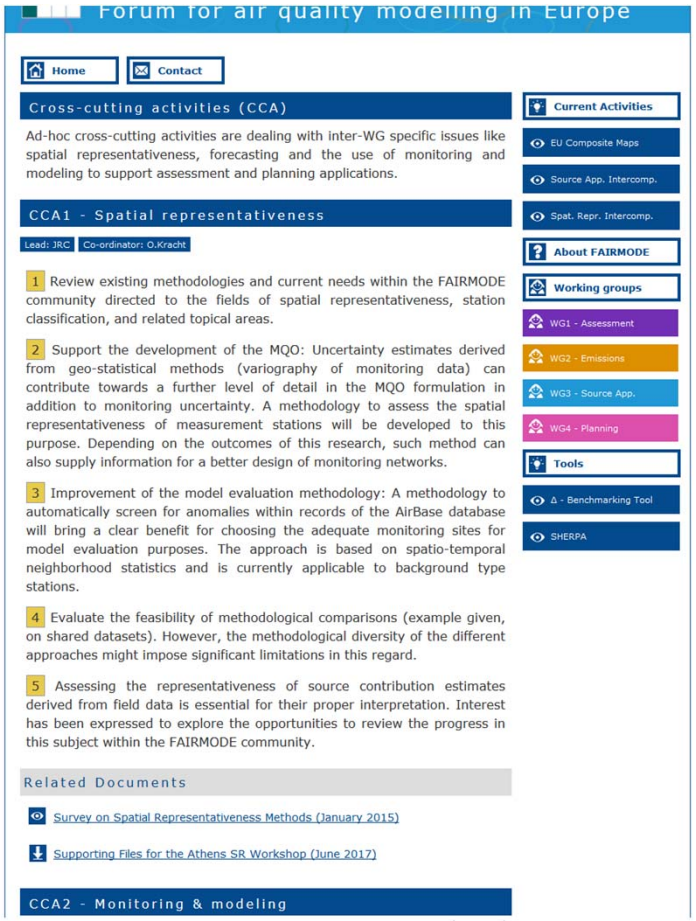


# Supporting Files

## http://fairmode.jrc.ec.europa.eu/


1

2



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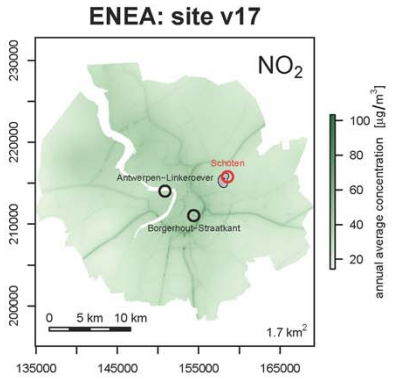
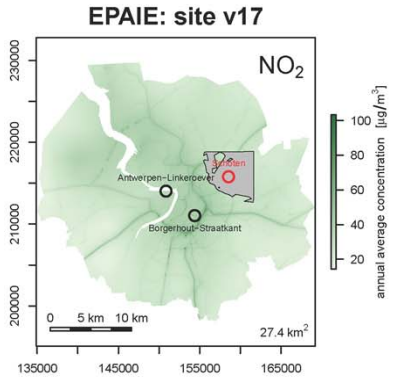
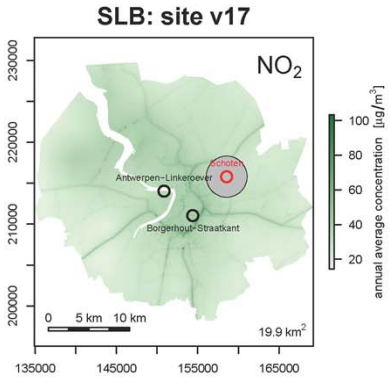
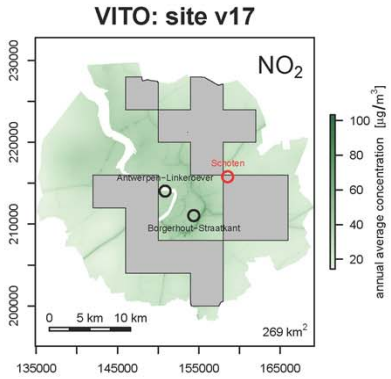
| | FAIRMODE CCA-1 Spatial Representativeness Intercomparison Exercise ---- Overview Table | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **CIEMAT** | **ENEA** | **FEA-AT** | **FI** (consortium) | **EPA** | **INERIS** | **ISSeP&AwAC** | **RIVM** | **SLB** | **VITO** | **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? | | X (only in 1st version) | | | | | | 3 |
| | | | | | | | | | | | | |
| Virtual Monitoring Stations (n=341) | | X | | | X | X | | X | | | | 4 |
| raw timeseries (hourly) | | X | | | X | | | | | | | 2 |
| virtual samplers | | | | | | X | | X | | | | 2 |
| noisy virtual samplers | | | | | | | | | | | | 0 |
| | | | | | | | | | | | | |
| Concentration Maps (annual avg) | | | X | X | | X (?) | | | X | X (?) | X | 4 (6) |
| Raw Model Outputs (annual avg) | | | | | | X | | | | | | 1 |
| **Emissions** | | | | | | | | | | | | |
| Road Traffic | X | | | | | X | X | | X | | X | 5 |
| 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 | | | concentration maps | | | | | | | | | 1 |
| **Dispersion Conditions** | | | | | | | | | | | | |
| Building Geometry | X | | | X (?) | | | X | | X (?) | | | 1 (3) |
| Street Width | X | | | | | | | | | | | 1 |
| Corine Landcover Classes | | | (X) | | | | | | | X | X | 3 |
| **Meteorological Data** | | | | | | | | | | | | |
| Wind Velocity | X | | | X | | | | | | | | 2 |
| **External Information** | | | | | | | | | | | | |
| Google Satellite Images | | | | X | | | number of lanes | | | | | 2 |
| Google Street View Data | | | | X | | | | | | | | 1 |
| Traffic Network | | | | | X | | | | | | | 1 |
| **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 | 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 | (X) | no | no | X | no | X | X | no | 4 (5) |
| 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 |

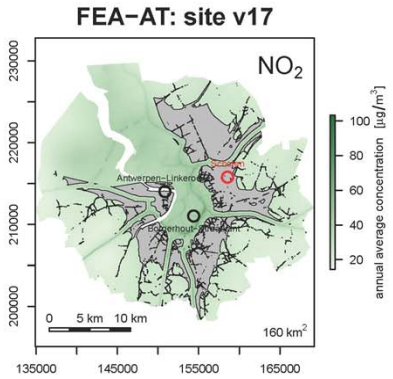
# Size and Location of estimated SR areas ($NO_2$ at site v17)

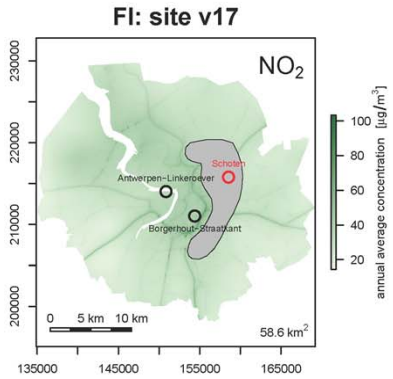


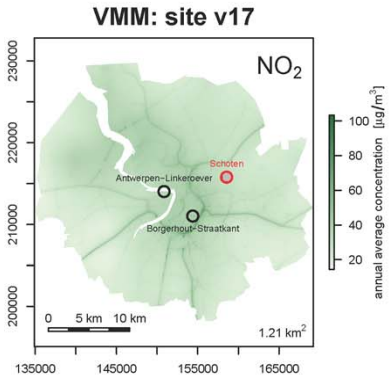



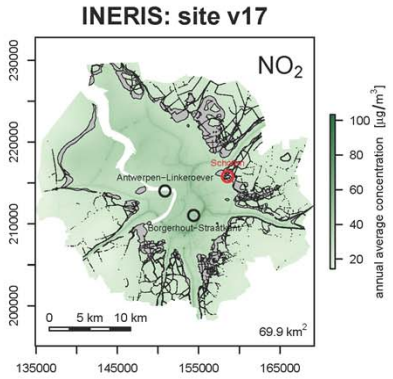



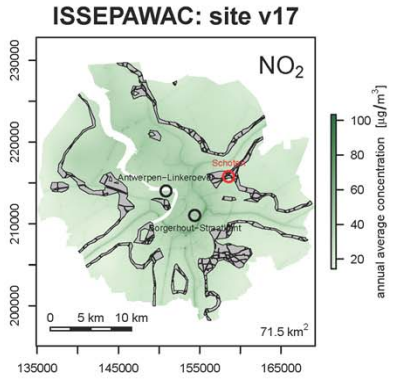



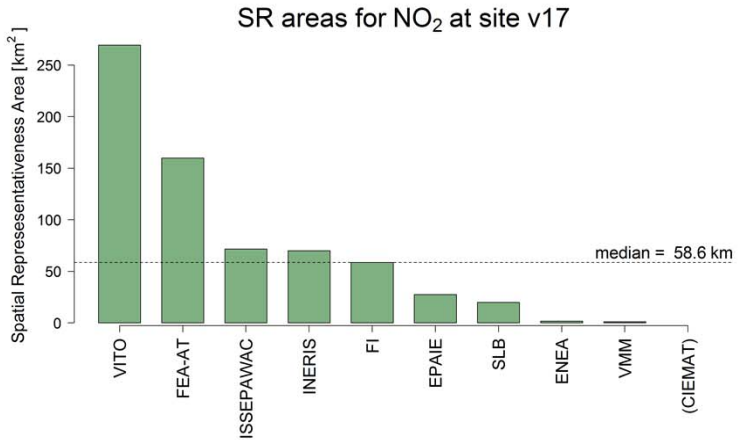



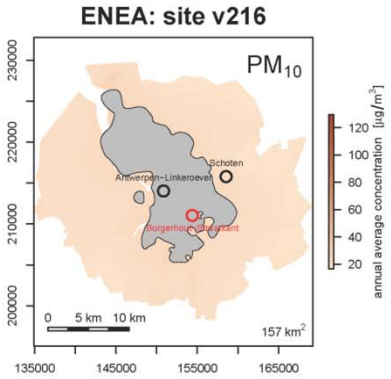



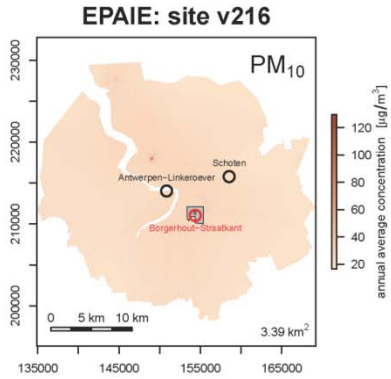



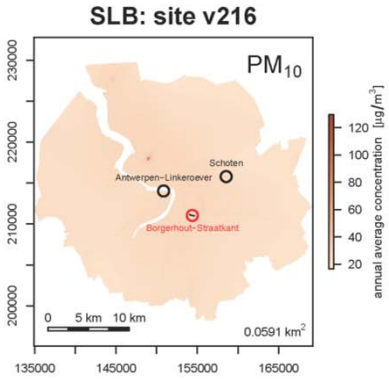



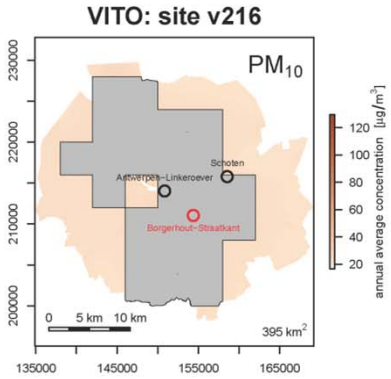



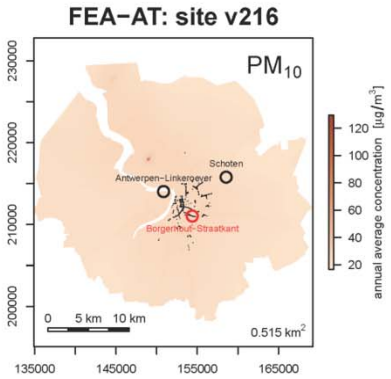
# Size and Location of estimated SR areas ($PM_{10}$ at site v216)

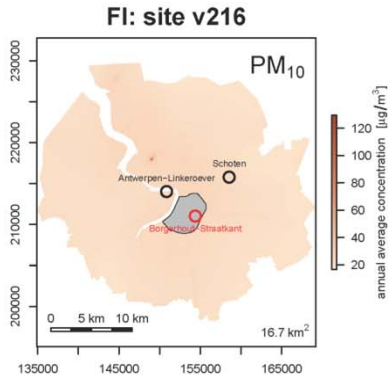


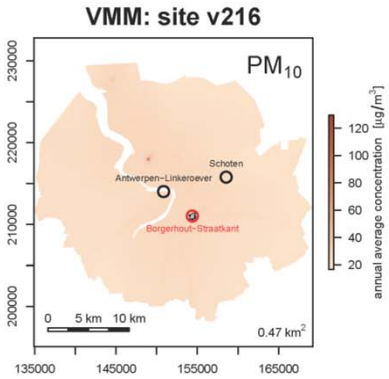



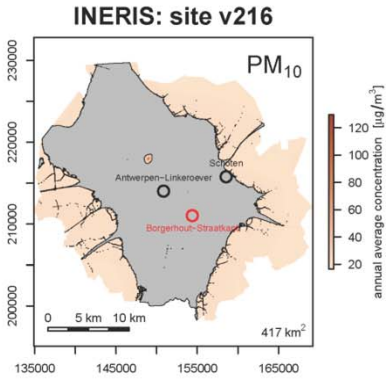



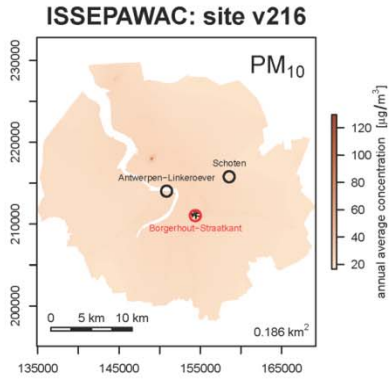



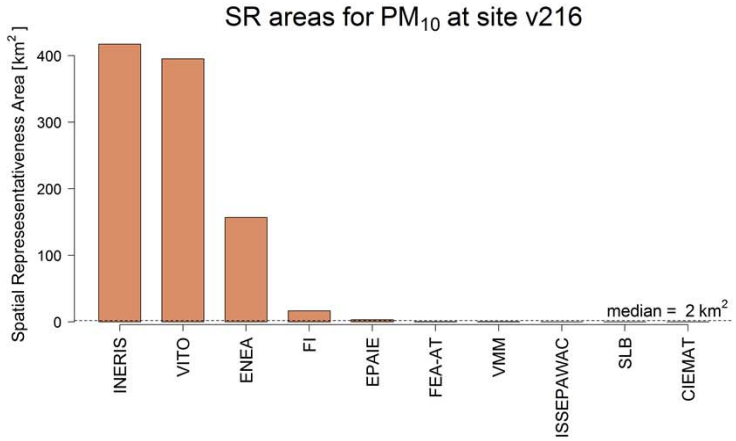



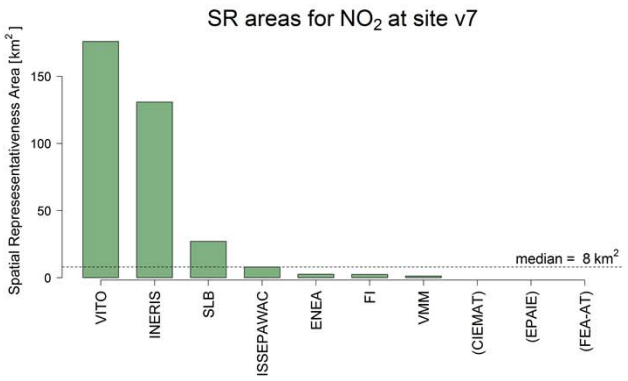



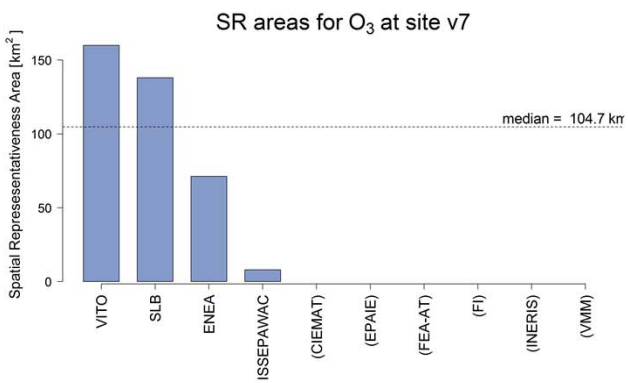



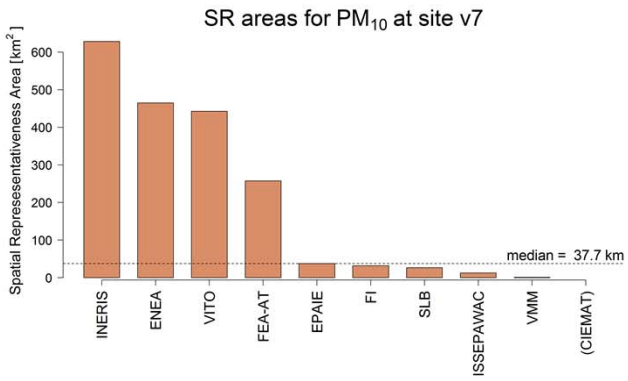



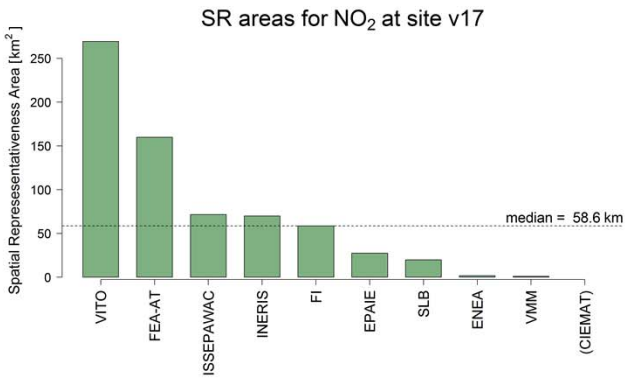



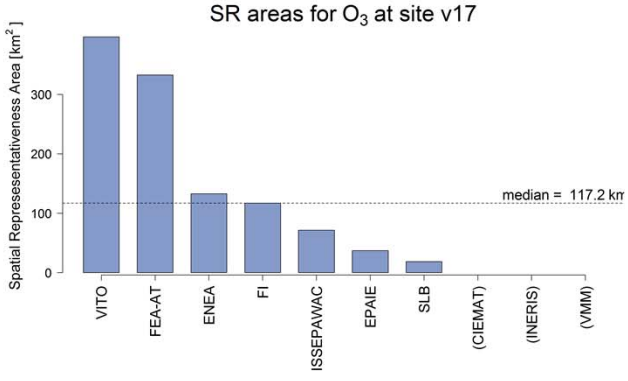



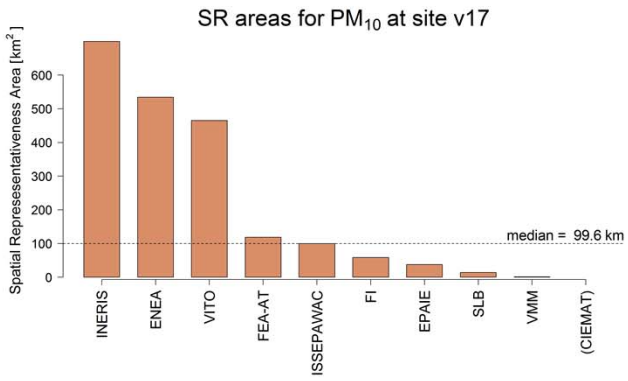

SR areas for NO2 at site v7
Spatial Represesentativeness Area [km2]
median = 8 km2
VITO
INERIS
SLB
ISSEPAWAC
ENEA
FI
VMM
(CIEMAT)
(EPAIE)
(FEA-AT)

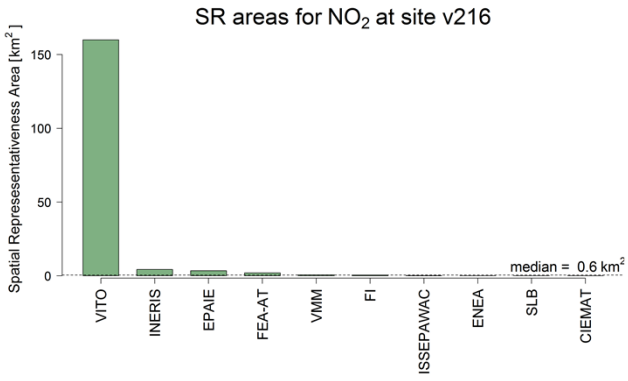

SR areas for O3 at site v7
Spatial Represesentativeness Area [km2]
median = 104.7 km
VITO
SLB
ENEA
ISSEPAWAC
(CIEMAT)
(EPAIE)
(FEA-AT)
(FI)
(INERIS)
(VMM)

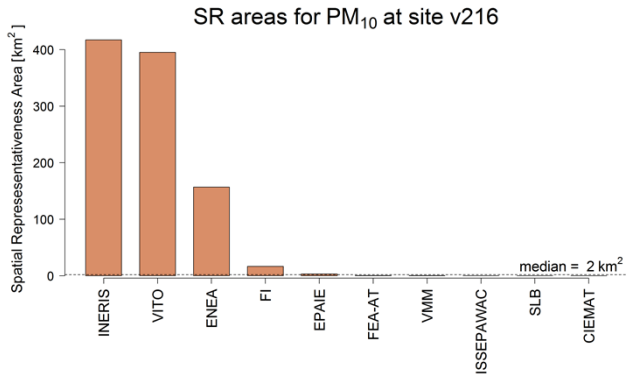

SR areas for PM10 at site v7
Spatial Represesentativeness Area [km2]
median = 37.7 km
INERIS
ENEA
VITO
FEA-AT
EPAIE
FI
SLB
ISSEPAWAC
VMM
(CIEMAT)


SR areas for NO2 at site v17
Spatial Represesentativeness Area [km2]
median = 58.6 km
VITO
FEA-AT
ISSEPAWAC
INERIS
FI
EPAIE
SLB
ENEA
VMM
(CIEMAT)

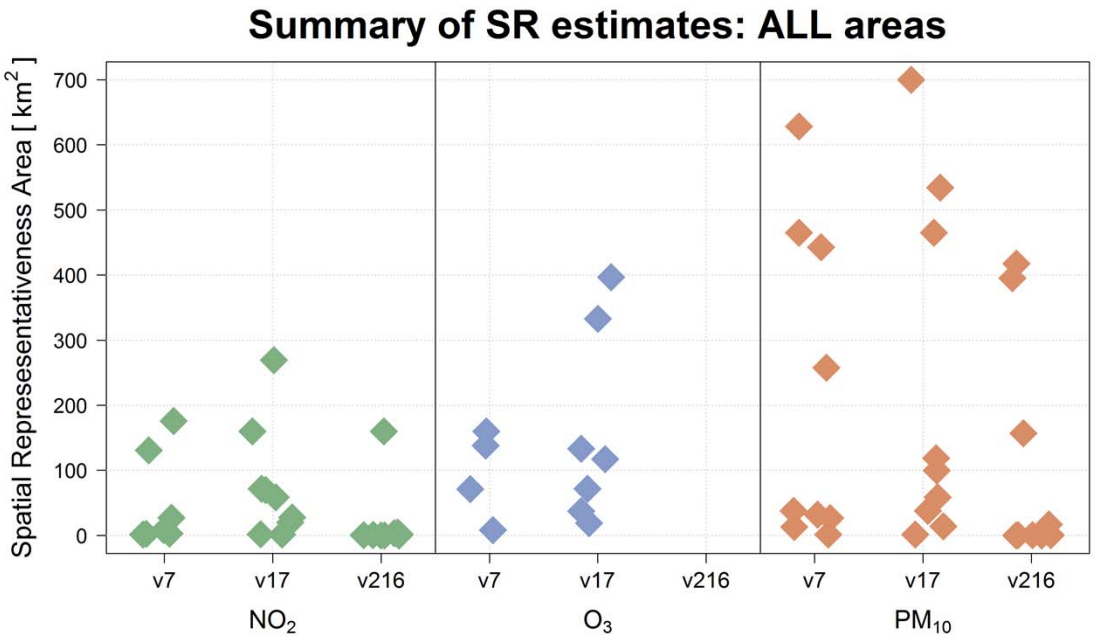

SR areas for O3 at site v17
Spatial Represesentativeness Area [km2]
median = 117.2 km
VITO
FEA-AT
ENEA
FI
ISSEPAWAC
EPAIE
SLB
(CIEMAT)
(INERIS)
(VMM)


SR areas for PM10 at site v17
Spatial Represesentativeness Area [km2]
median = 99.6 km
INERIS
ENEA
VITO
FEA-AT
ISSEPAWAC
FI
EPAIE
SLB
VMM
(CIEMAT)


SR areas for NO2 at site v216
Spatial Represesentativeness Area [km2]
median = 0.6 km2
VITO
INERIS
EPAIE
FEA-AT
VMM
FI
ISSEPAWAC
ENEA
SLB
CIEMAT


SR areas for PM10 at site v216
Spatial Represesentativeness Area [km2]
median = 2 km2
INERIS
VITO
ENEA
FI
EPAIE
FEA-AT
VMM
ISSEPAWAC
SLB
CIEMAT

# Size of estimated SR areas: Summary



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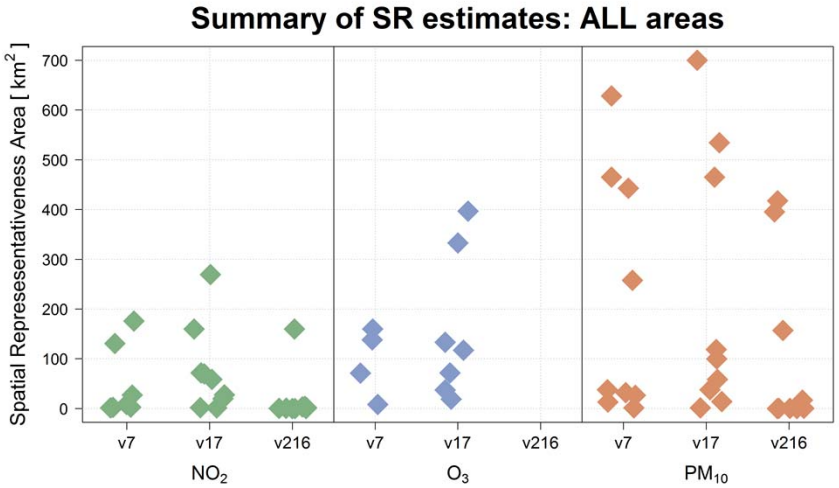
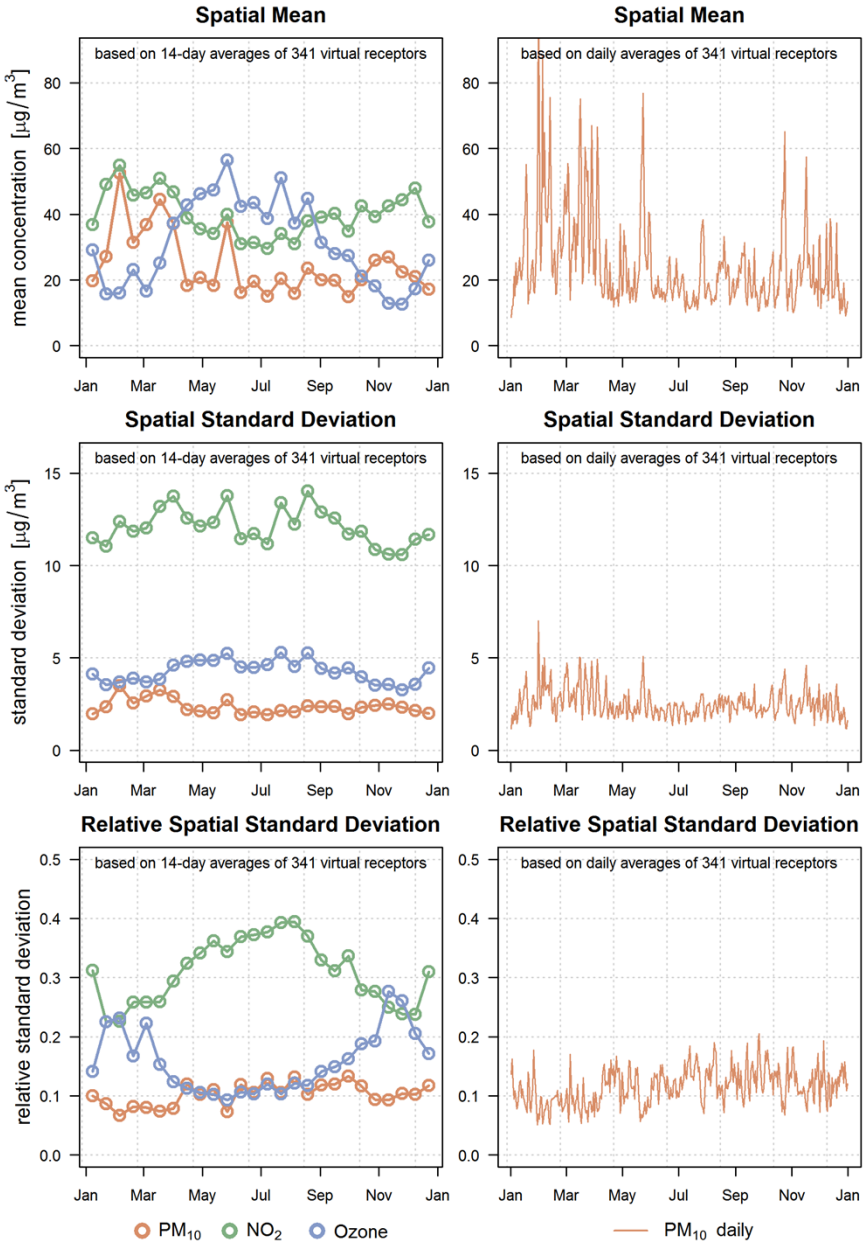
# Size of estimated SR areas: Summary




## Some broader relations with regards to the Antwerp dataset:

### Spatial variability lowest for $PM_{10}$

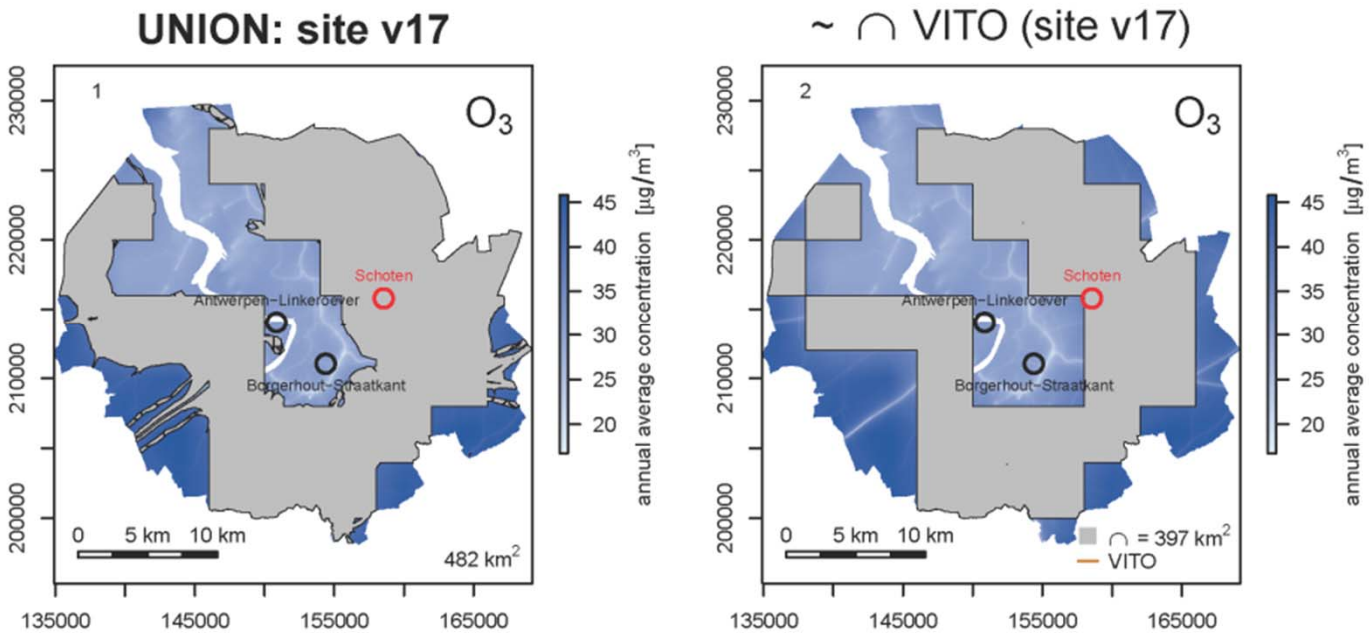
- Comparatively flat concentration field
- Resulting SR areas are comparatively large
- Pronounced scatter of the SR areas (a flat concentration field is more sensitive to deviations in the similarity mechanisms applied)

### Spatial variability highest for $NO_2$

- More uneven concentration field
- Resulting SR areas are smaller than for PM10
- SR estimated have less scatter

### Ozone is between $PM_{10}$ and $NO_2$

# Incremental Intersections




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 (shrunken) Union**.
4) Take the **second largest** individual SR estimate and **intersect** it with the **shrunken Union**.
5) Take this **Intersection** as the new (shrunken) **Union**.
6) … continue likewise
7) Finally reaching the **Intersection of all** estimates.



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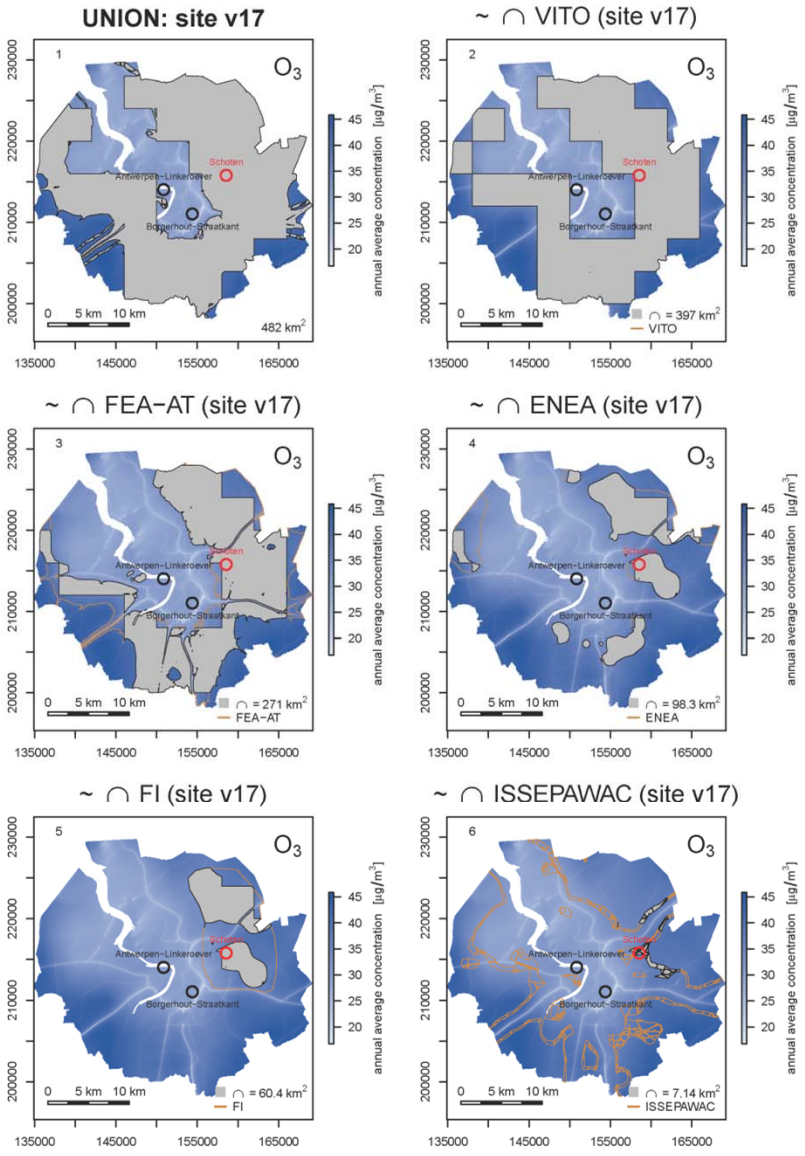
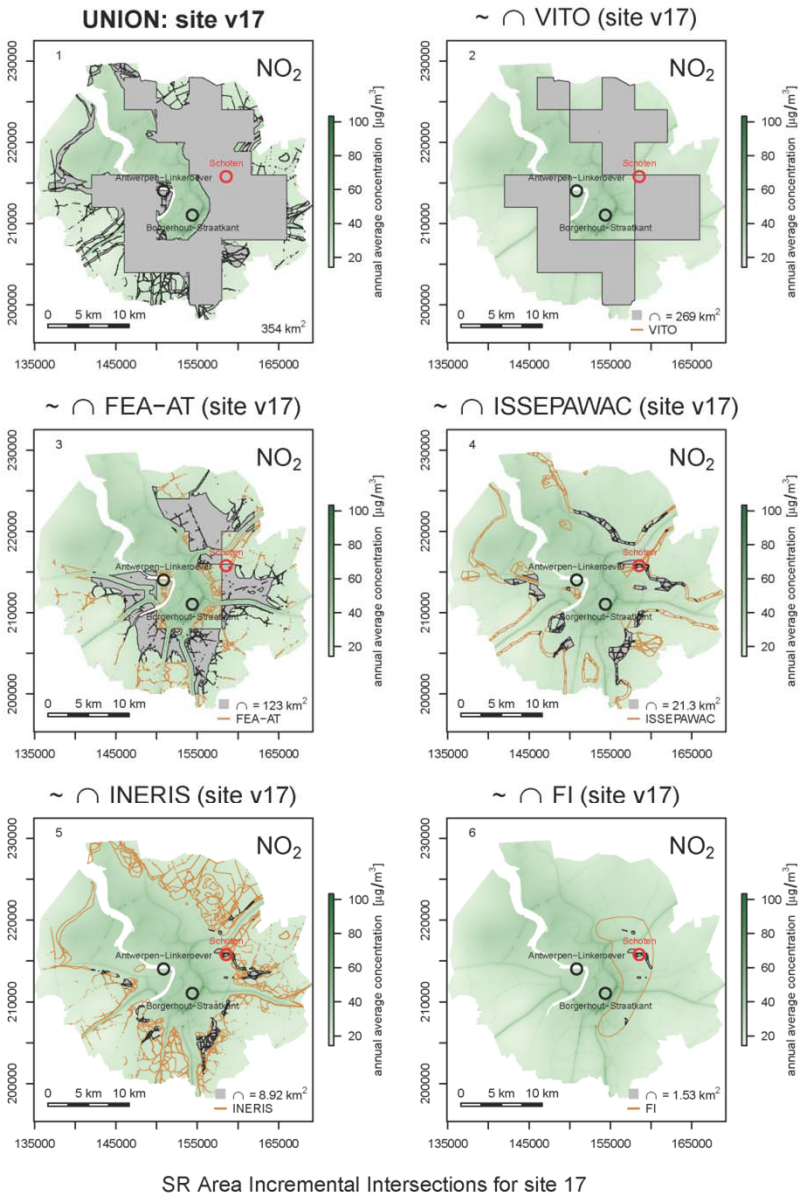
# Incremental Intersections




SR Area Incremental Intersections for site 17

For $O_3$ at site v17:

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 (shrunken) Union**.
4) Take the **second largest** individual SR estimate and **intersect** it with the **shrunken Union**.
5) Take this **Intersection** as the new (shrunken) **Union**.
6) … continue likewise
7) Finally reaching the **Intersection of all** estimates.

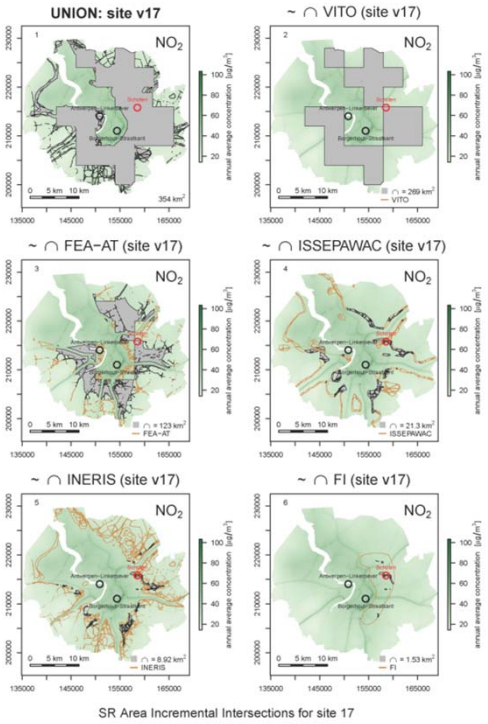



SR Area Incremental Intersections for site 17

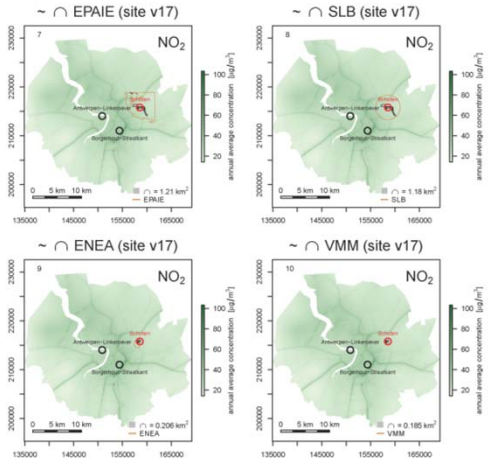
For $NO_2$ at site v17:

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 (shrunken) Union**.
4) ….

# Incremental Intersections




SR Area Incremental Intersections for site 17




## Summary:

| | $NO_2$ | | | $O_3$ | | | $PM_{10}$ | | |
|---|---|---|---|---|---|---|---|---|---|
| [km²] | v7 | v17 | v216 | v7 | v17 | v216 | v7 | v17 | v216 |
| $\cup_{all}$ | 240 | 354 | 161 | 233 | 482 | - | 636 | 718 | 458 |
| $\cap_{all}$ | 0.05 | 0.19 | 0.00 | 0.77 | 2.54 | - | 0.16 | 0.49 | 0.01 |



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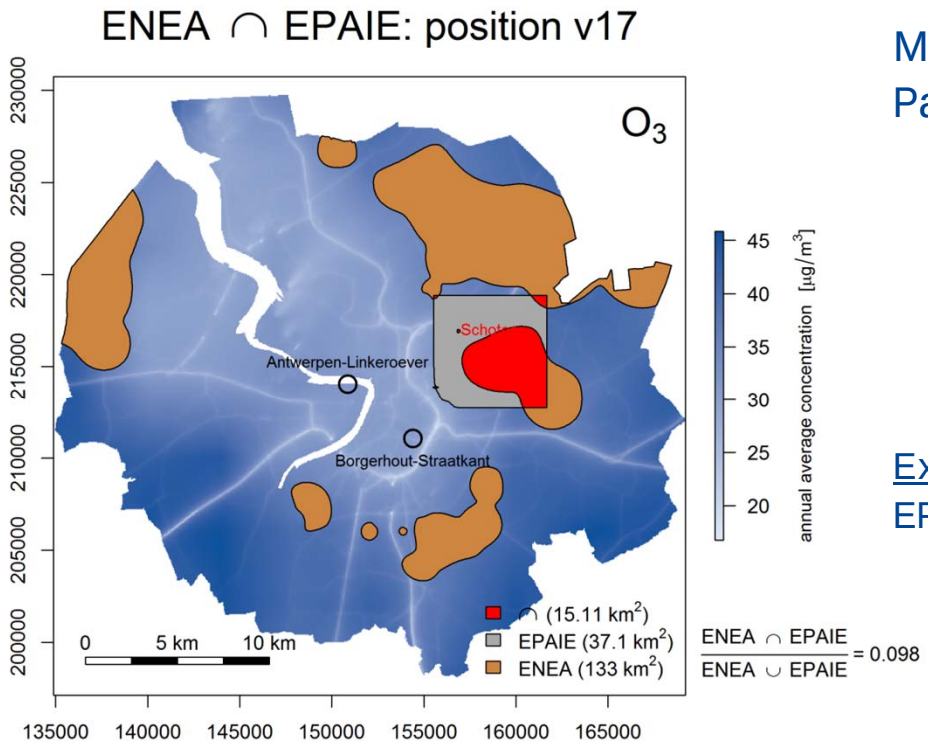
# Mutual Comparisons




Mutual Level of Agreement between Paired Teams

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

Example: MLA ca 10% between ENEA and EPAIE for the $O_3$ SR-area at position v17.

Mutual Level of Agreement Indicator (MLA)

- Converges to **1 for full agreement** between Area 1 and Area 2.
- Converges to **0 for no agreement** between Area 1 and Area 2.



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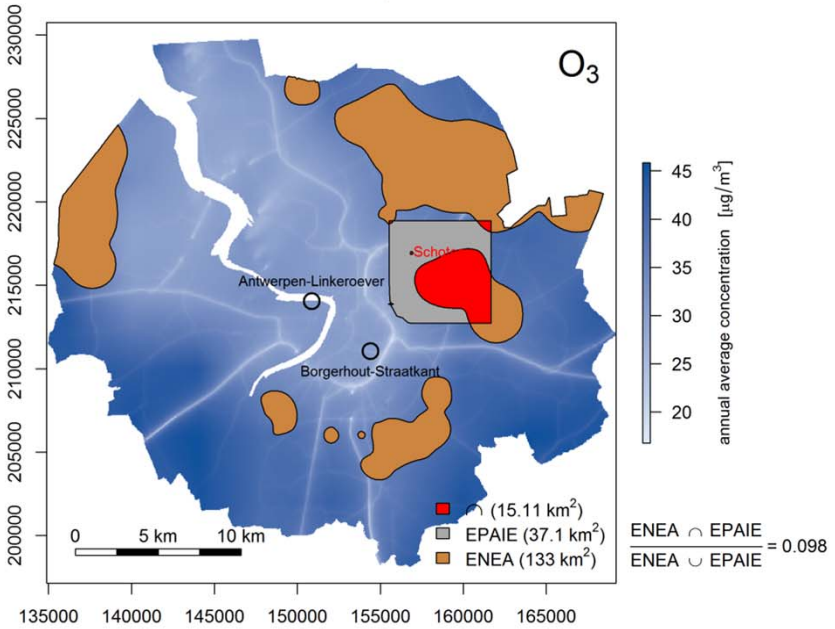
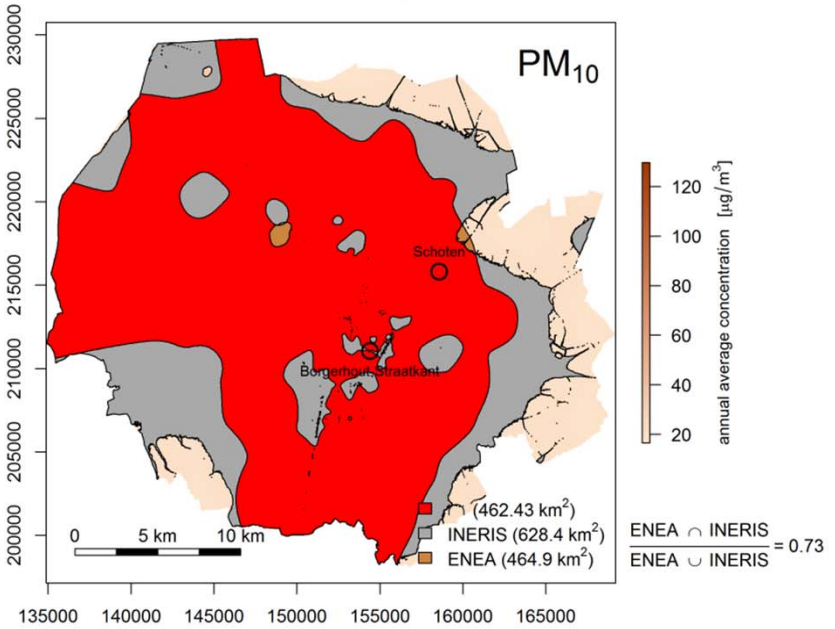
## ENEA ∩ EPAIE: position v17



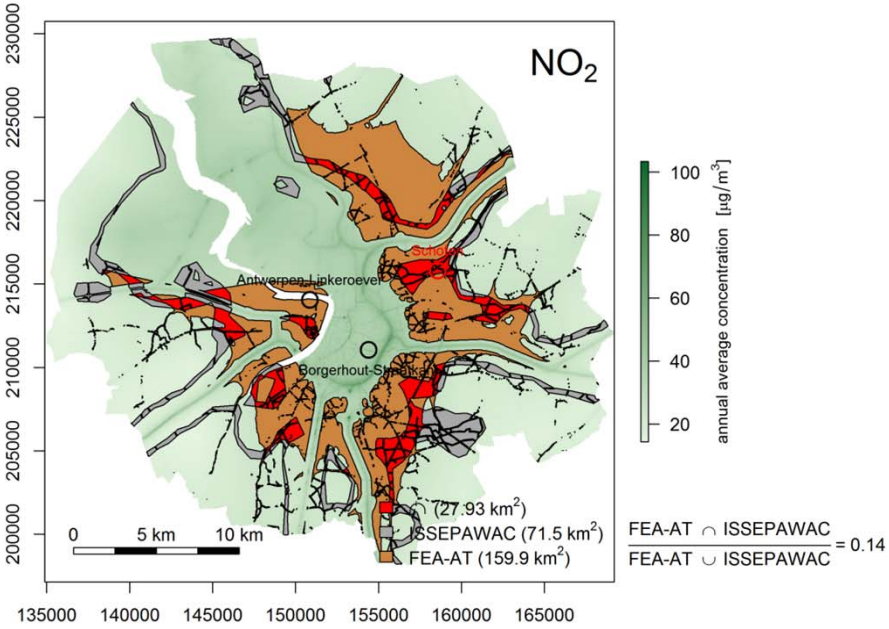

$$\frac{\text{ENEA} \cap \text{EPAIE}}{\text{ENEA} \cup \text{EPAIE}} = 0.098$$

## ENEA ∩ INERIS: position v7



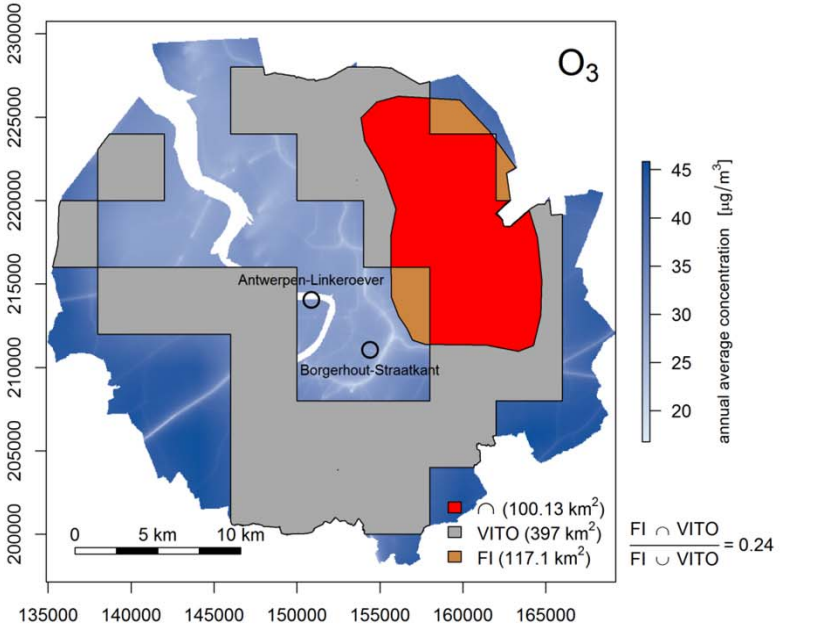

$$\frac{\text{ENEA} \cap \text{INERIS}}{\text{ENEA} \cup \text{INERIS}} = 0.73$$

## FEA-AT ∩ ISSEPAWAC: position v17



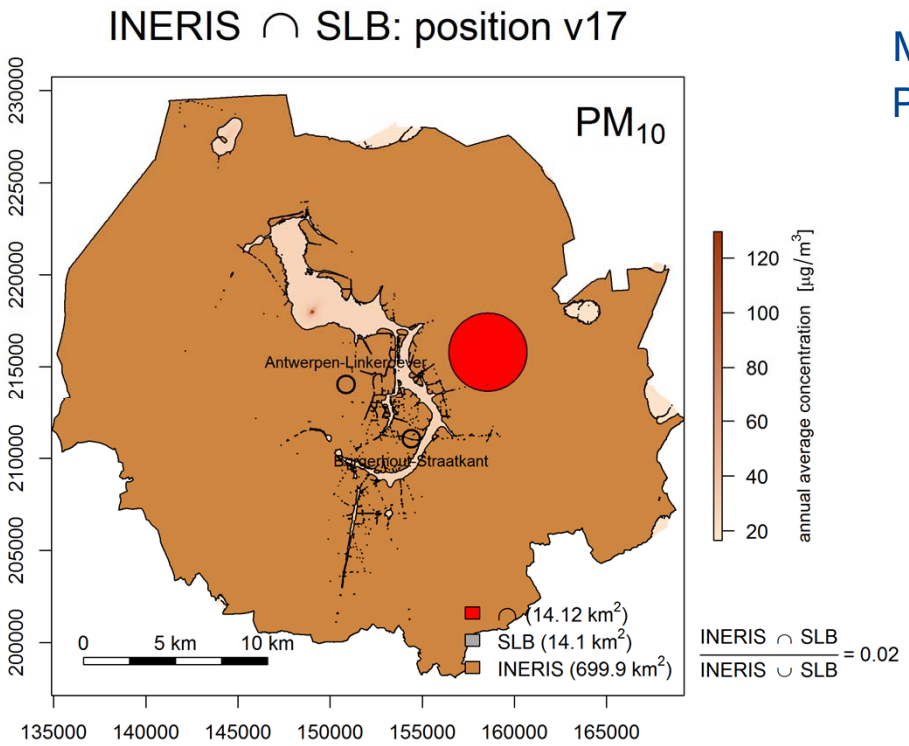

$$\frac{\text{FEA-AT} \cap \text{ISSEPAWAC}}{\text{FEA-AT} \cup \text{ISSEPAWAC}} = 0.14$$

## FI ∩ VITO: position v17




$$\frac{\text{FI} \cap \text{VITO}}{\text{FI} \cup \text{VITO}} = 0.24$$

# Mutual Comparisons




Mutual Level of Agreement between Paired Teams

More details in my summary presentation tomorrow 22. June at 12:00 o'clock.



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# Summary

Interim Conclusion:

- The Spatial Representativeness Areas estimated by the different participants are quite diverse.
- The results in particular reveal an enormous scattering of the extent and position of the estimated polygons.
- This diversity of results should deserve a closer look behind the scenes.

Pros of the Situation:

- The recently concluded SR IE provides an excellent opportunity for the exchange of knowledge.
- From having worked on the same shared dataset, we are (today and tomorrow) able to efficiently exchange background information in a much more detailed way as compared to what would be feasible without this common ground.

# Discussion and Outlook

Outlook beyond this current project (ending October 2017):

- What are the positions about the continuation of these activities?
- Should we aim for setting up guidelines for spatial representativeness procedures as a mid term objective?
- Is there a future need for harmonization?
  - Common frame of reference for SR definitions?
  - Common frame of reference regarding methods for evaluating SR?
  - Standardization?
  - Make the use of standards mandatory?
- **Spatial Representativeness Workshop tomorrow Thursday 22/06/2017**

Specific suggestions for future research activities:

- In more detail investigate the influence of the parameterization of the similarity criteria and their thresholds on the spatial representativeness
  - Current outputs do not enable us to distinguish between the influences of (1) parameterizations, (2) basic principles of a method, and (3) input data
  - Monte Carlo Simulations & Sensitivity Analysis
  - Requires a formalization of the procedures in terms of fully automatic code.

| | |
|---|---|
| 14:00-16:00 | **Spatial Representativeness I**<br>14:00 - 14:15: Introduction & Scope of the inter-comparison exercise (IE). — O. Kracht<br>14:15 - 14:30: Status of the IE — O. Kracht<br>14:30 - 15:00: Team - Presentation 1 — INERIS<br>15:00 - 15:30: Team - Presentation 2 — CIEMAT<br>15:30 - 16:00: Team - Presentation 3 — VITO<br>*all Team-Presentations are 30 minutes:*<br>*15 min + 5 min obligatory slides + 10 min discussion* |
| 16:00-16:30 | **Co** |
| | |
| 17:00-18:00 | **Spatial Representativeness II**<br>17:00 - 17:15: Team- Present. 4 (summary on behalf of RIVM) — O. Kracht<br>17:15 - 17:30: Short Summary — O. Kracht |



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