



Assessing the spatial representativeness of air quality sampling points

ENV.C.3/FRA/2017/0012

FAIRMODE, 13 February 2019

Bino Maiheu on behalf of the project team

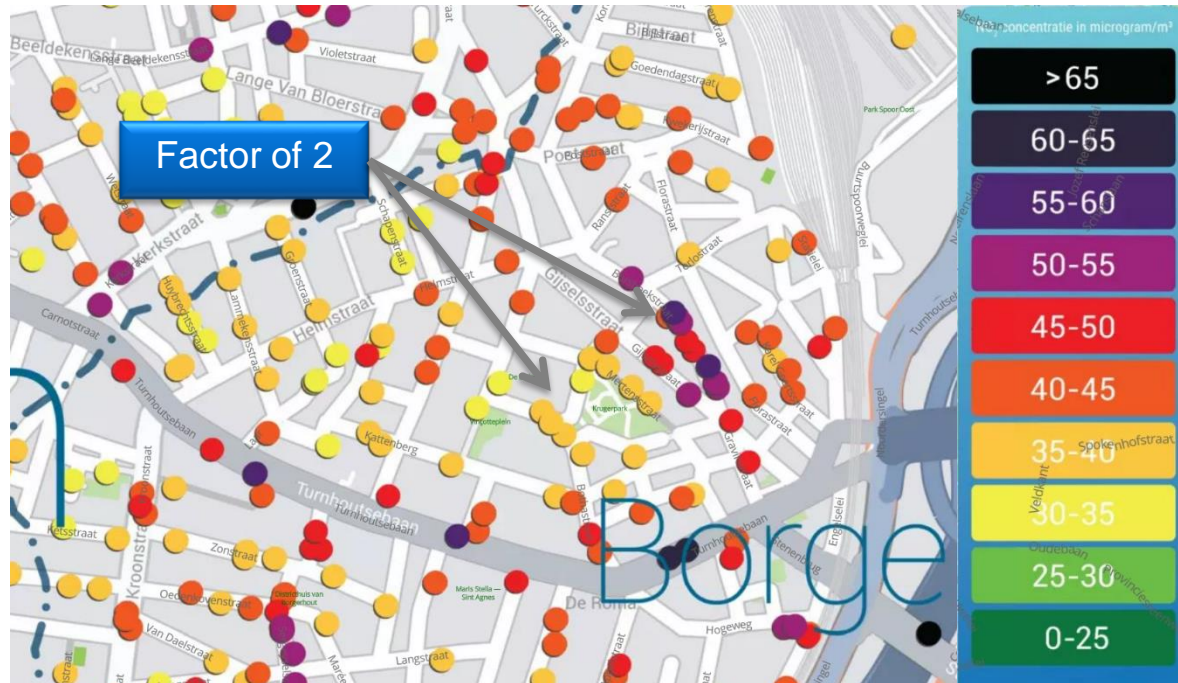
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- Relevance of spatial representativeness
- A brief history, initiatives, challenges
- Service contract to improve recommendations
- Brief project outline
- Involvement of FAIRMODE, AQUILA, CAMS

What is spatial representativeness ?

- Spatial variability ?
- <https://curieuzeneuzen.be/>



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- KU LEUVEN
- HVA
- STAD ANTWERPEN

Antwerpen

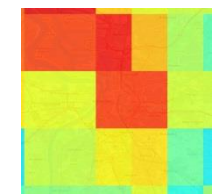
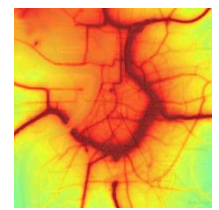
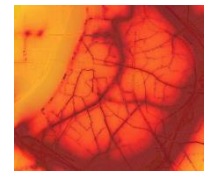
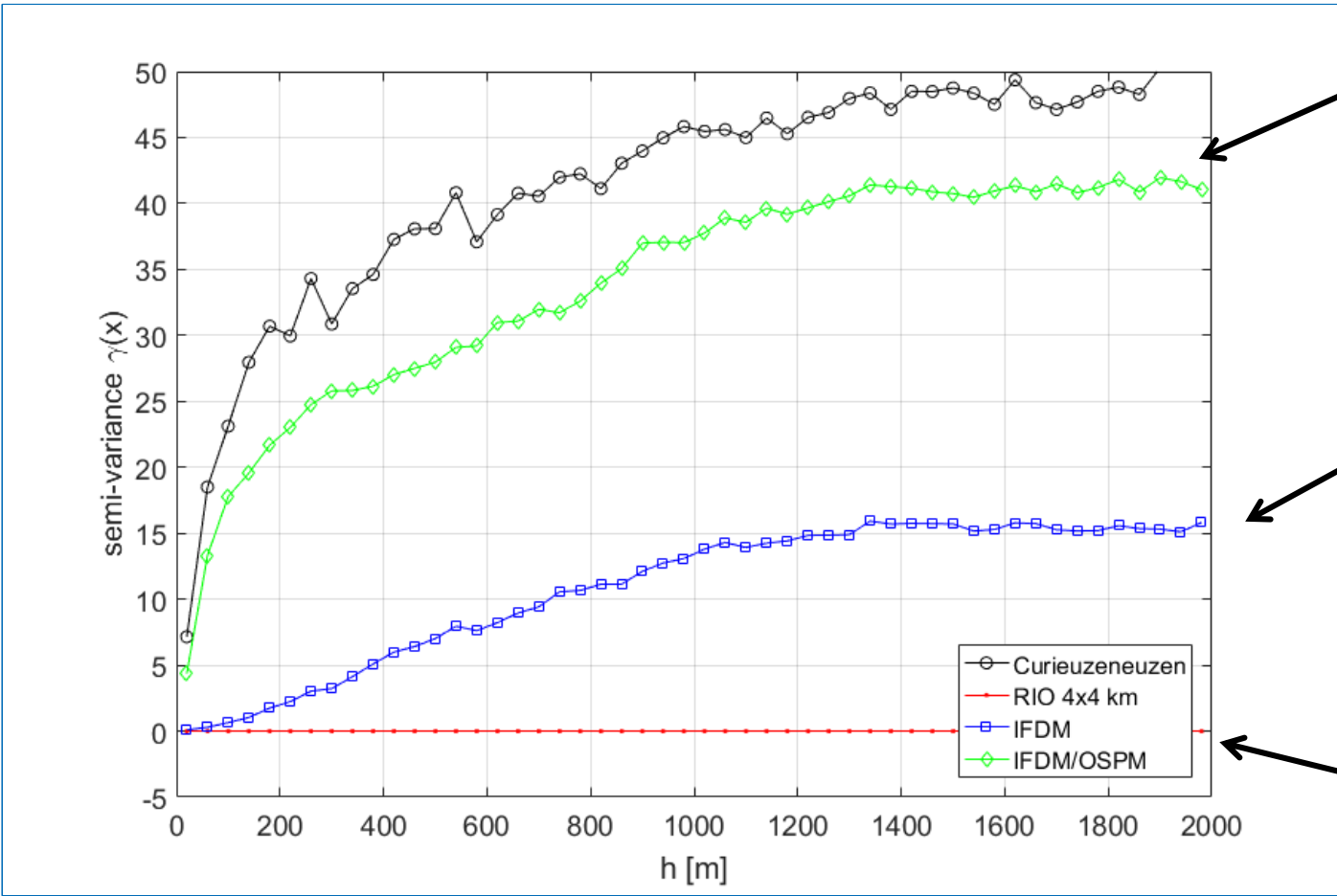
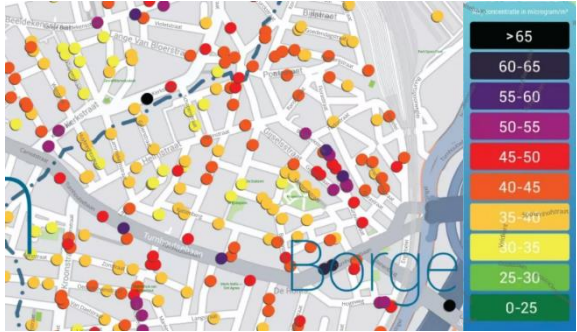
NO₂-concentratie µg/m³

+65
60-65
55-60
50-55
45-50
40-45
35-40
30-35
25-30
-25

What is spatial representativeness ?

- Capturing this variability in air quality models

$$\gamma(h) = \frac{1}{2N(h)} \sum_{i,j \in N(h)} [Z(x_i) - Z(x_j)]^2$$



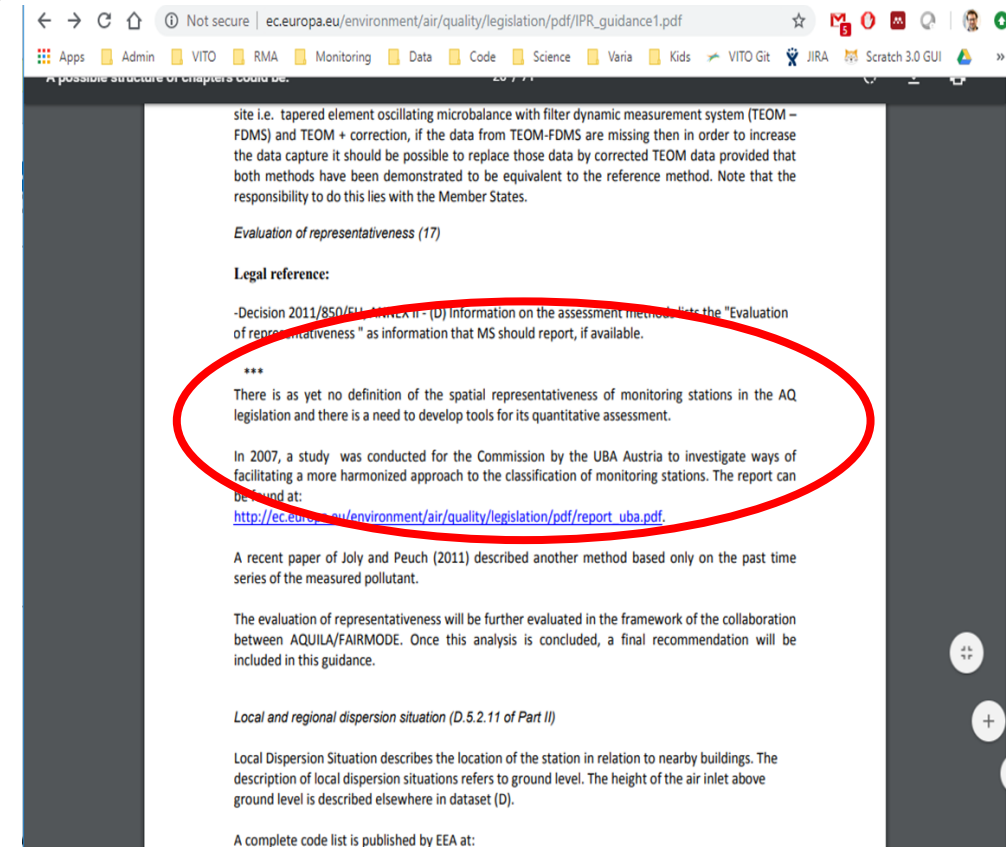
Why is it relevant?



- **In-situ** monitoring used in reporting (mostly)
 - Does not provide a comprehensive view → area
 - How does “urban”, “rural”, “suburban” translate into an explicit geographical area w.r.t. population distribution
- **Population exposure**
 - How many people exposed to concentrations in excess of certain threshold
 - Additional complication in HIA :
 - Spatial scale of the CRF's ?
- **Eco-system** damages
- Requirements in **IPR : e-Reporting !**

Why is it relevant?: requirements in IPR (e-Reporting)

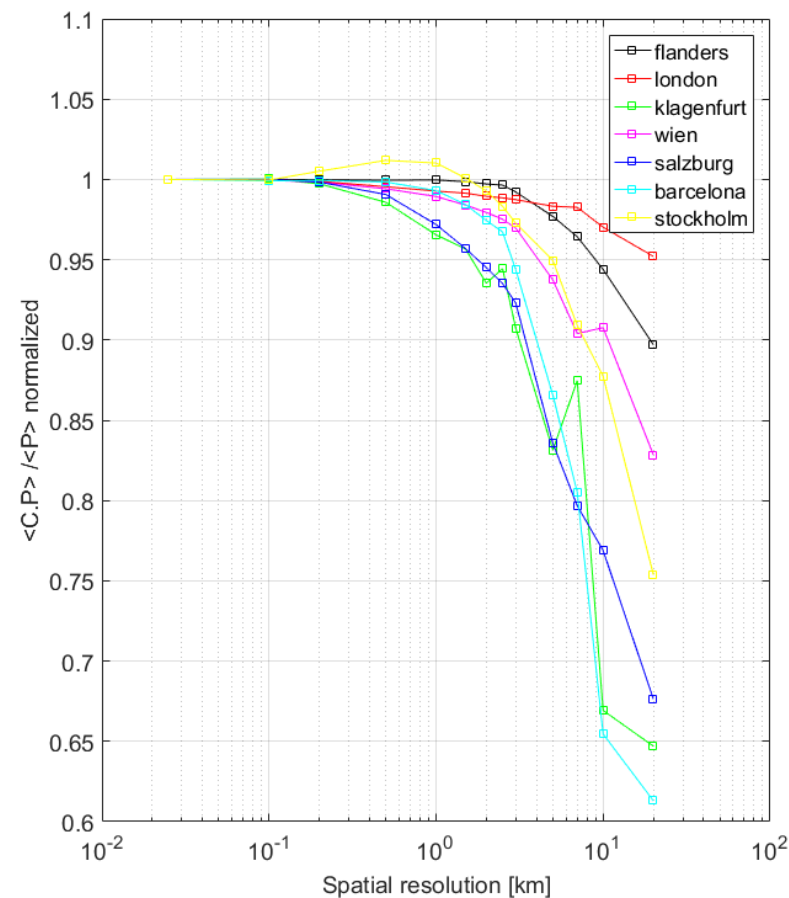
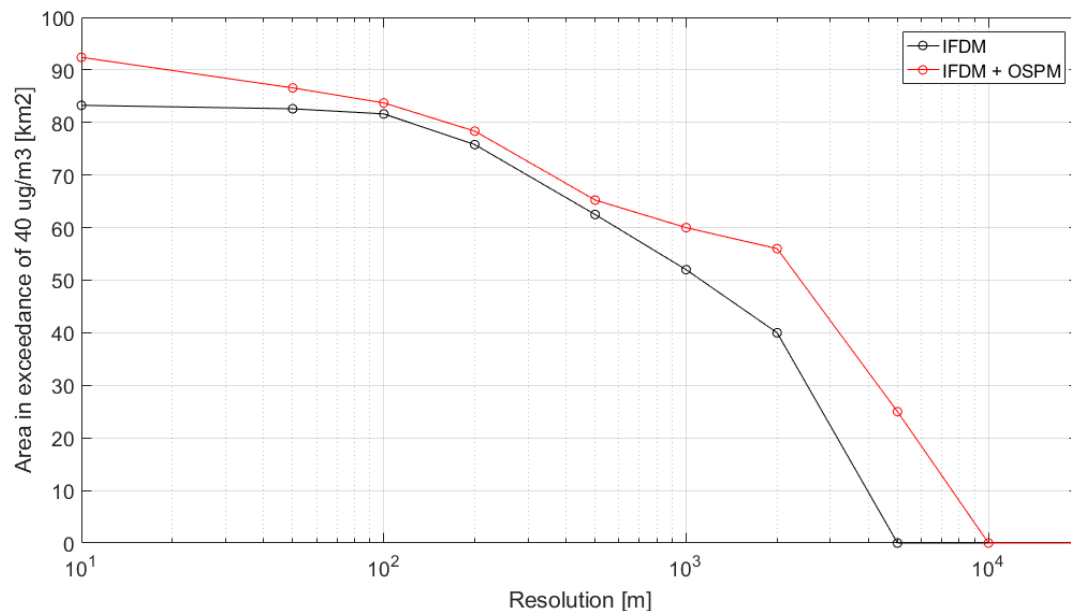
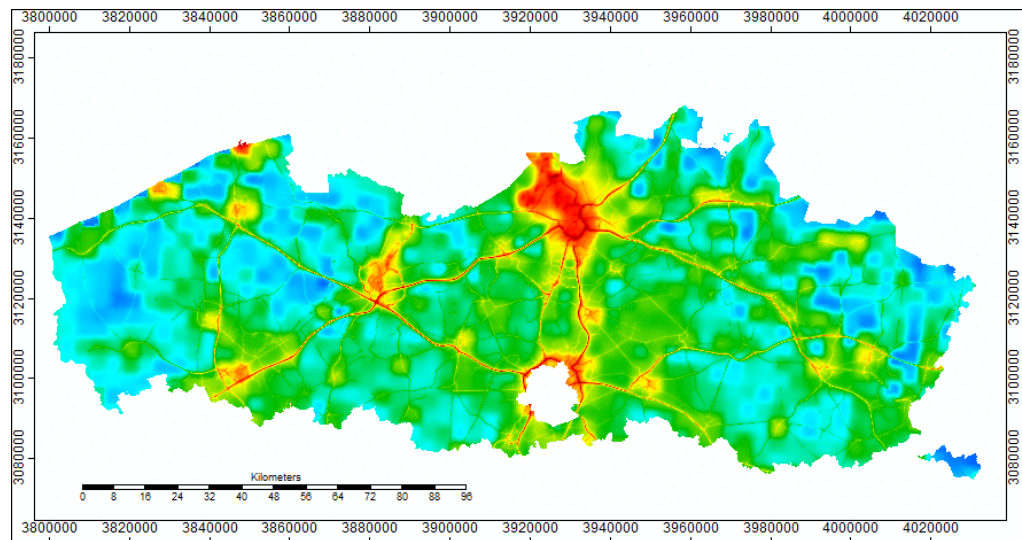
- Member states are required to report on spatial representativeness at various locations (dataflows) in e-Reporting (<https://rod.eionet.europa.eu/instruments/650>)
- **Dataflow B** : Information on zones and agglomerations (Article 6)
- **Dataflow D** : Information on the assessment methods (Articles 8 and 9) – fixed and indicative measurements
 - Evaluation of representativeness (Decision 2011/850/EU, ANNEX II - (D))
 - Classification of stations/area's/network design
 - <http://dd.eionet.europa.eu/vocabulary/aq/dispersionlocal> (Street canyon, detached/semi-detected, open terrain, elevated terrain)
 - <http://dd.eionet.europa.eu/vocabulary/aq/dispersionregional/view> (plane, hilly, alpine, coaste, ...)
 - <http://dd.eionet.europa.eu/vocabulary/aq/networktype/view> (local, urban ,regional, national, ...)
 - <http://dd.eionet.europa.eu/vocabulary/aq/stationclassification>
 - <http://dd.eionet.europa.eu/vocabulary/aq/areaclassification/view>
- **Dataflow G** : Information on the attainment of environmental objectives (Article 12)
 - Area of exceedance
 - Number of people exposed
 - Attribution to natural sources & resuspension
 - Attainment of the PM_{2,5} exposure concentration obligation
 - The information made available shall be coherent with the zone delimitation made available pursuant to Article 6 for the same calendar year and the aggregated validated assessment data made available pursuant to Article 11.



Current guidelines :

http://ec.europa.eu/environment/air/quality/legislation/pdf/IPR_guidance1.pdf

Impact of spatial scale



Source : VITO, under EC DG-ENV Service Contract 070201/2015/SER/717473/C.3

The spatial resolution of the exercise is an essential factor, as “coarser” resolutions may actually lead to underestimations in the area of exceedance (and therefore, in exposed population).

Why is it relevant? : requirements in IPR (e-Reporting)



- **Key issue** : How to characterize spatial variability with a station network and the available assessment methods?
- **Ultimate goal** : capture the full spatio-temporal variability of the concentration field (or IPR metric) => comprehensive assessment of spatial representativeness

Key issues	Methodological challenges (non exhaustive...)
Different interpretations of concept of representativeness : assessment needs	<ul style="list-style-type: none"> • Broad spectrum of methods, views (cfr. IE)
Station and sampling point classification	<ul style="list-style-type: none"> • What is “urban”, “rural”, “suburban”, how to generalize ? • Definition of street canyons (100 m) ?
Assessing “Area of representativeness”	<ul style="list-style-type: none"> • Limited spatio-temporal resolution of assessment techniques <ul style="list-style-type: none"> • Computational power • But more importantly : input data : traffic flows, activity patterns, ... • Resource intensive • Similarity criterion ?
Variability within area of representativeness ? Testing with “reality” ?	<ul style="list-style-type: none"> • Methods limited to high density monitoring campaigns <ul style="list-style-type: none"> • Sensors → uncertainty ! • Citizen science
...	...

A brief history of initiatives to characterize spatial representativeness

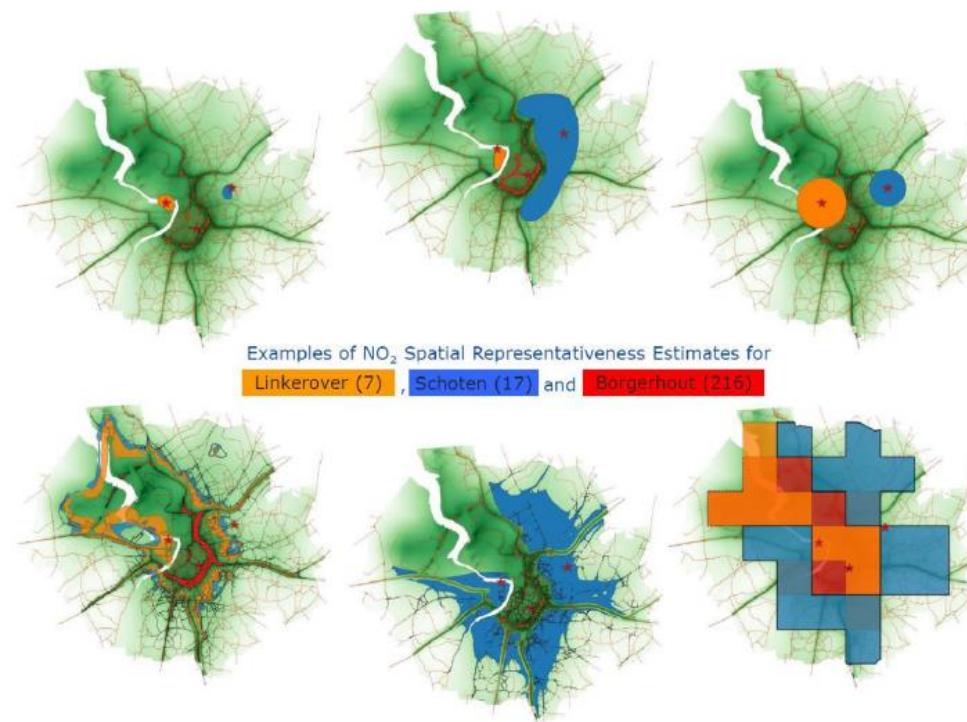


- Different expert networks are working towards defining the concept of spatial representativeness & drafting guidelines : CAMS, AQUILA, FAIRMODE
- CAMS : Method of Joly-Peuch for station classification generally accepted
 - Classification of stations Joly, M., Peuch, V., 2012. *Atm. Env.* 47, 111–123.
 - Aimed mainly at model validation
- AQUILA :
 - Position paper (SCREAM WG) *Assessment on siting criteria, classification and representativeness of air quality monitoring stations*, : <http://ec.europa.eu/environment/air/pdf/SCREAM%20final.pdf>
- FAIRMODE
 - **2011 – 2012** : FAIRMODE Meeting in Norrköping : consensus table, expert opinions differed a lot, no firm conclusions
 - **2015-2016**: Joint FAIRMODE/AQUILA inter-comparison exercise for Antwerp. 11 teams participated
 - **2017**: A dedicated workshop was held in Athens back-to-back with the FAIRMODE technical meeting. Again, there were no firm conclusions, but a ‘to-do’ list was defined

FAIRMODE SR exercise main outcomes

- Exercise aimed at evaluating consistency between methods
 - Similar resulting metrics ?
 - Do AQ experts mean the same thing when they speak about SR ?
- Extensive dataset to “play” with...
- Large spread in results
 - **Basic principles** of methods
 - Effective use of **different input data**
 - Parametrisation of **similarity criterion** and **thresholds**
 - **Underlying** conceptualization and **definition of SR**
- **Need for** : more harmonized definition of the concept of “the area of representativeness” it’s quantification

Figure 1: Results of six different modelling groups when asked to calculate the spatial representativeness of three stations (Linkeroever, Schoten, Borgerhout) in Antwerp (Source: Martin et al., 2017)



—————> **Constrained by requirements in IPR**

FAIRMODE SR exercise main outcomes & RECOMMENDATIONS



- Key points :

- **Integration timescales**

- different SR area in function of aggregation (annual vs. daily, hourly)
- Effective integration timescale of SR assessment technique ?

- **Classification of techniques**

- High resolution AQ modelling
- Geostatical interpolation
- Integration of proxy / auxiliary information

} Capturing the true spatio-temporal variability
Limited resources in member states → **TIERED** approach

- **Similarity criterion** & threshold parameters

- Absolute / relative
- Relation to observation uncertainty ? DELTA-Tool ?

- **Conceptual** differences in opinion

- Size & extent impacted by similarity criterion
- Shape : contiguous or not ?
- Exclusive or not ?

How will this contract facilitate reporting ?

- **Main goal**: Recommendations on the spatial representativeness (SR) of sampling points, focusing on PM₁₀, NO₂ and Ozone.
- **Project period**: February 2019 - December 2020.
- Based upon expertise compiled in AQUILA, FAIRMODE and CAMS.
- The project team will engage with FAIRMODE and AQUILA experts feedback and recommendations.



Aims and Objectives



The overarching objective of this specific agreement is to **underpin recommendations** on the spatial representativeness of sampling points – focussed on those monitoring particulate matter, nitrogen dioxide and ozone – and related modelling and reporting.

This translates to the following specific objectives:

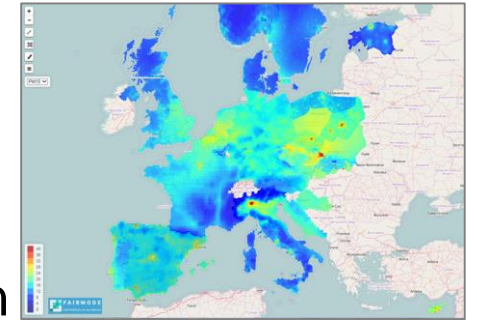
1. To **support the development of recommendations** on methodologies to assess spatial representativeness of sampling points and air quality modelling.
2. To **collate authoritative air quality and air emission maps**, and compile these to bottom-up composition maps of air pollution in Europe.
3. To **provide support to the assessment of the application of the criteria for selecting sampling points** in Member States, by carrying out an overview of the existing network.



Overview of Tasks

Task 1 : Draft **recommendations** for assessing SR for specified assessment needs in the context of **monitoring, modelling** and **reporting**. A **tiered approach** is proposed.

- Recognize limitations in member states resource
- Sensitivity studies & robustness checks
- *Fitness for purpose* of models in model-based methodologies
- **Engage** with the FAIRMODE, AQUILA, CAMS community is in the workplan



Task 2: Collate air quality and air emission information necessary to support determination of SR in the **composite mapping platform** developed under FAIRMODE

Task 3: Carry out an initial assessment of application in Member States of the criteria for selecting **traffic and industrial sites** – as basis for further dialogue and recommendations to facilitate a harmonised application of SR methods throughout the European Union

Tiered approach to formulate recommendations



... will be tested in Oslo, Antwerp and an additional city

Level	Methods yielding “area” of representativeness	Methods yielding a station classification
Tier 1	Expert judgement of SR area	Expert judgement & classification by network managers
Tier 2	Adding some form of geospatial complexity via GIS data	Supervised / unsupervised learning - based methods based on AQ monitoring data, e.g. Joly-Peuch and GIS data
Tier 3	Using detailed air quality modelling capable of resolving the spatio-temporal pattern	Methods including information on predominant emission sources (e.g. recommendation by SCREAM) and modelling data
Tier 4	Tier 3 complemented with dedicated dense measurement campaigns to fully capture spatio-temporal variability	n/a

- Benefits for the community :
 - Improving **recommendations** on methodologies to determine station representativeness (SR)
 - Improving **access to repositories and tools** (composite map) to calculate SR
 - **Assisting** member states in e-Reporting station classification and SR
- Interaction with these communities is essential !
 - Progress reports & dedicated sessions at meetings
 - Dedicated workshop planned at FAIRMODE Technical meeting (sept/oct 2019)
 - Progress reporting at AQUILA and FAIRMODE plenary meetings
 - Dedicated session at FAIRMODE Technical meeting (sept/oct 2020)
 - Presentation at the 4th CAMS Policy User Workshop (2020)
 - Liaise also with WHO expert working group on NO₂ exposure & HIA
 - Identify additional ways that the communities can provide feedback and comments – Any suggestions?

- Need for third city to test the 4-TIER approach. Ideally, the city should have:
 - A continental climate
 - A large relative contribution of household emissions
- Data requirements → sensitivity studies
 - Comprehensive monitoring data, high resolution (street canyon-scale) modelling information for PM_{10} , $PM_{2.5}$, NO_2 , O_3 willing to share for this project
 - Comprehensive emission information
 - Traffic
 - Residential heating
 - Industry
 - Comprehensive GIS information : road network, buildings, ...
 - Ideally high density monitoring campaigns (e.g. Curieuzeneuzen)

Any candidates to provide data for the third testing city?

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Thank you

We are happy to take any questions