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SR5: Assessing the spatial representativeness of air quality sampling points

ENV.C.3/FRA/2017/0012

FAIRMODE meeting – Madrid, 7-9 October 2019

Beth Conlan

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Aims and Objectives

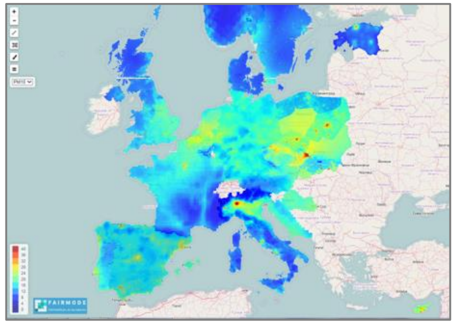
The overarching objective of this specific agreement is to underpin recommendations on the spatial representativeness of sampling points – focussed on those monitoring particulate matter, nitrogen dioxide and ozone – and related modelling and reporting.

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
- *Fitness for purpose* of models in model-based methodologies
- **Engage** with the FAIRMODE 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

The Project Team

ENV.C.3/FRA/2017/0012
Service Request 5

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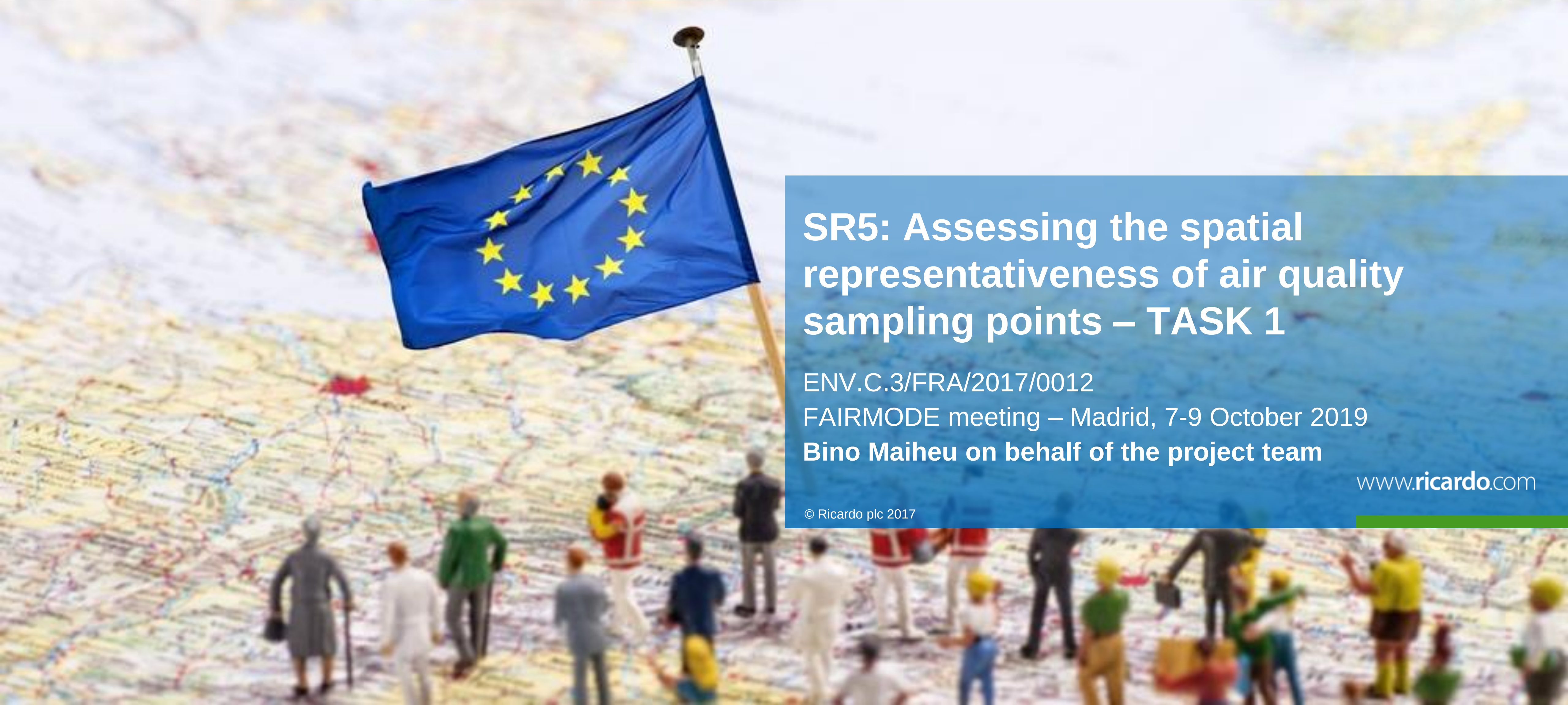

SR5: Assessing the spatial representativeness of air quality sampling points – TASK 1

ENV.C.3/FRA/2017/0012

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Bino Maiheu on behalf of the project team

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Outline

- Literature overview
  - Context of the AQ directive
  - Overview and conclusions from recent literature
    - Overview table
    - Discussion
  - Methodological requirements for different applications
  - Tiered approach as a framework for guidance recommendations
- Discussion points
- Outlook & sensitivity studies

Literature overview

- Lack of guidance in the IPR (https://www.eionet.europa.eu/aqportal/doc/IPR%20guidance_2.0.1_final.pdf on p 36 under (iv))

  “There is no definition of the spatial representativeness of monitoring stations in the AQ legislation yet. FAIRMODE is in the process of developing tools for its quantitative assessment.”

- Room for interpretation in absence of guidance w.r.t. spatial representativeness,
- Identification of areas where guidance is required (see also study by EP (Nagl et al, 2019)) :
  - **macroscale siting** criteria (AAQD, Annex III B)
    - *sample the “areas within zones and agglomerations where the highest concentrations occur to which the population is likely to be directly or indirectly exposed for a period which is significant in relation to the averaging period of the limit value(s)” as well as the request to provide data on the “levels in other areas within the zones and agglomerations which are representative of the exposure of the general population”.*
      - 1. what is “significant” ?
      - 2. what is “representative” ?
      - 3. how to account for discontinuous concentration patterns ?
    - *sampling points shall be “be sited in such a way that the air sampled is representative of air quality for a street segment no less than 100m length at traffic-orientated sites and at least 250m × 250m at industrial sites”*
      - 4. how much variability is ‘tolerated’ with these length scales

Literature overview

- *In paragraph C under Annex III – B.1, when siting for urban background locations, it is required that sampling points at such locations should be representative for several square kilometres, with their levels not dominated by a single source*
  - 5. what means “dominated” and what is “several”, more general : how to define urban background ?
- **microscale siting** criteria (AAQD, Annex III C)
  - *“the inlet probe shall not be positioned in the immediate vicinity of sources in order to avoid the direct intake of emissions unmixed with ambient air”, it should be “some metres away from buildings, balconies, trees and other obstacles and at least 0.5 m from the nearest building in the case of sampling points representing air quality at the building line” and “for all pollutants, traffic-orientated sampling probes shall be at least 25 m from the edge of major junctions and no more than 10 m from the kerbside.”*
    - 6. immediate vicinity, some meters away
    - 7. compatibility 10m mentioned here with 100m in macroscale criteria
- minimum **number of sampling points** (AAQD, Annex V)
  - 8. how to determine maximum concentration within the zone
  - 9. how to fulfill requirements on model validation
- **quantification of guidelines,** e.g.
  - recommendations assessing the local dispersion situation : when to account for street canyons ?
  - station classification criteria for traffic, industrial and background stations are formulated as a function of “*proximity to a source*”, however not quantification what distances apply or are relevant

Literature overview

- Translate the main aim of this literature review into **establishing the framework**
- Assessment needs :
  - *a) Estimate of the surface area where the level was above the environmental objective,*
  - *b) Estimate of the length of road where the level was above the environmental objective,*
  - *c) Estimate of the total resident population in the exceedance area,*
  - *d) Facilitate the configuration of a representative monitoring network,*
  - *e) Identify sampling points that are suitable for model calibration and validation,*
  - *f) Determine the spatial variability within the "area of representativeness.*

- FAIRMODE IE & previous efforts
  - concept of **SR area** applies for each of the needs above
  - **similarity** criterion
  - **tolerance** level

- Paradigm shift
- Concept of a "primary similarity criterion"

Literature overview

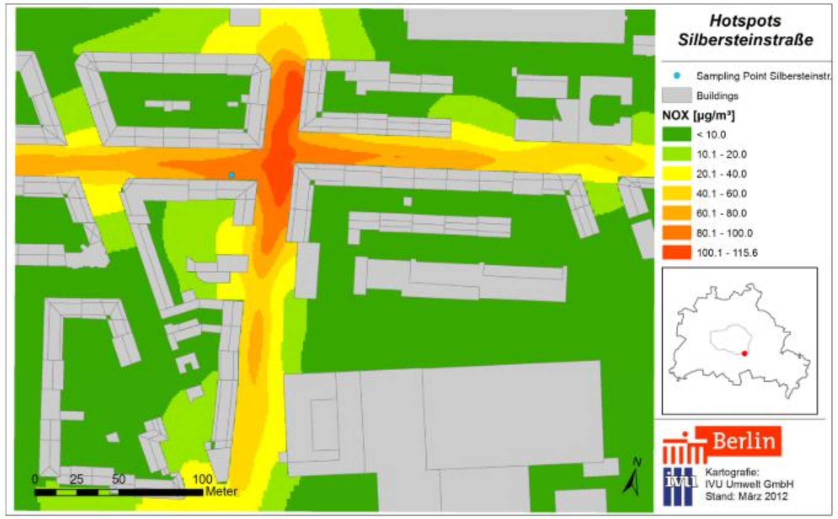
- Report contains comprehensive overview of past & recent literature & methodologies
- 29 papers analyzed & attributes discussed

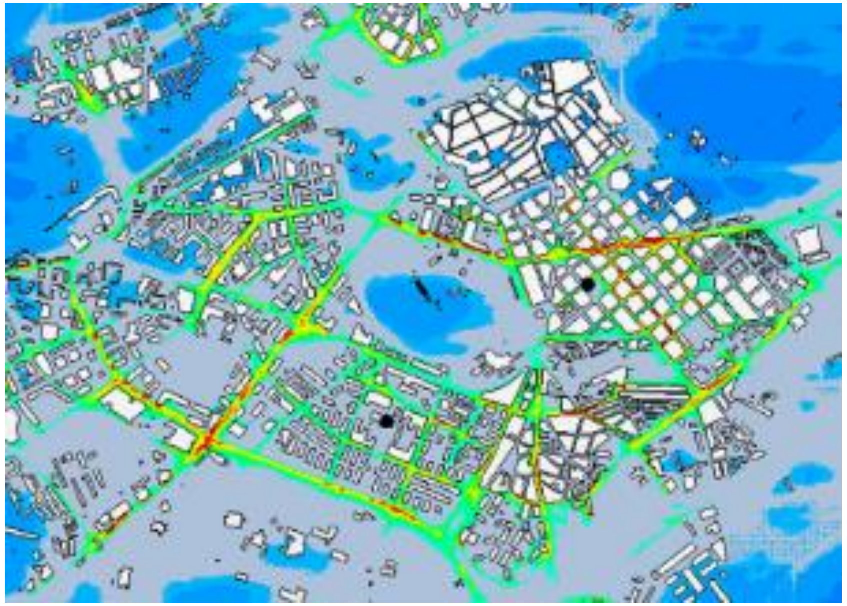
Reference	Outcome	Spatio-temporal variability method	Spatial scale	Temporal variability	Similarity	Pollutants	Goal of SR assessment
(Martin et al., 2014)	SR area	WRF-CHIMERE CTM, corrected via residual Kriging with spherical variogram	Gridded results at 9x9 km^2	Time aggregations as required by the AAQD, no temporal variability	Depending on the pollutant, factor of 1.2 (20%) or factor of 2 for lowest concentration values	NO_2, SO_2, O_3 and PM_{10}	Quantifying SR areas of rural background stations; evaluate station redundancy and network coverage
(Piersanti et al., 2015)	SR area	AMS-MINNI CTM	Gridded results at 4x4 km^2	Hourly model timeseries	Concentration Similarity Function (CSF) using 20% deviation threshold	$PM_{2.5}$, O_3	Quantifying SR areas of rural background stations in Italy
(Duyzer et al., 2015)	Descriptive assessment of SR	Urban dispersion model URBIS with separate calculation for canyons (CAR)	Gridded results at 10x10 m	Annual averaged	n/a	NO_2	Derive exposure curves, assess compliance
(Diegmann et al., 2015)	Descriptive assessment of SR	MISKAM CFD model	Gridded results at 1-5m resolution	Annual mean	Percentage deviation	NO_2, NO_x	Assess spatial representativeness of traffic oriented sites
(Barrero et al., 2015)	classification	n/a	n/a	Houly PM_{10} measurements	k-means clustering in 4 groups based on time series properties	PM_{10}	
(Vitali et al., 2016)	SR area	Lagrangian dispersion model	100 m	Hourly	Concentration Similarity Function (CSF) using % threshold.	PM_{10}	Assess representativeness area of industrial station

…

Literature discussion : applicability of methods

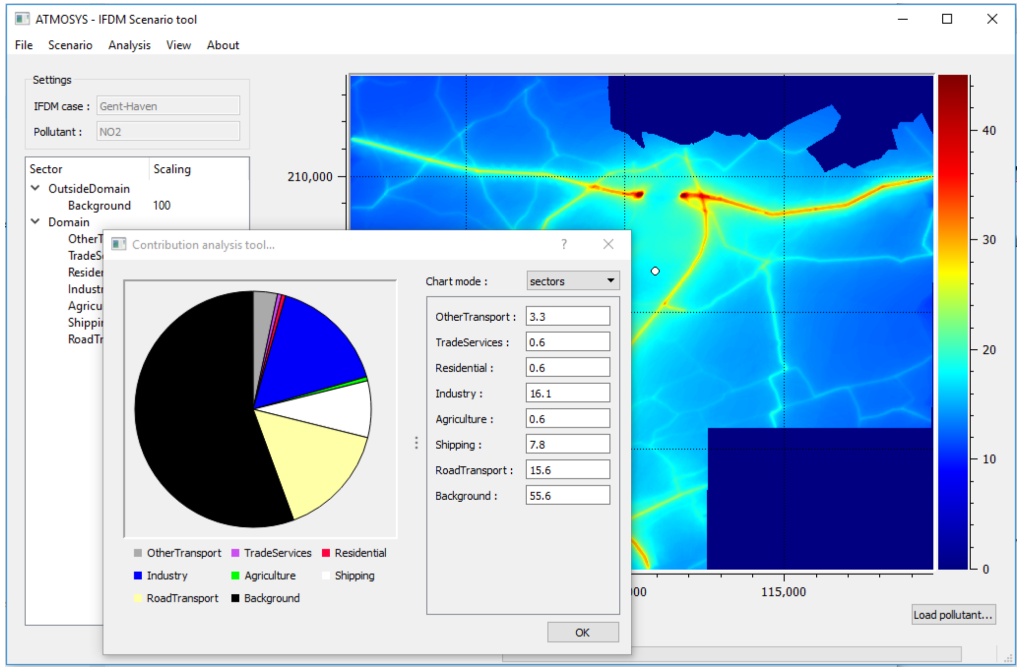
- Establishing spatio-temporal variability
- **CFD / microscale 3D obstacle resolved modelling**;
  - Can be used to delineate SR areas in urban (traffic-related) setting or near industrial sources for pollutants with strong local variability, mainly NO_2 / NO_x, but also PM, depending on completeness of emission inventory (assessment needs a) to c)).
  - very demanding computational nature of CFD calculations -> the modelling domain remains limited and the method therefore is mainly targeted at assessing intra-urban variability, still: (Rivas et al., 2019)
  - less suited to derive SR areas for the percentile values (90.4 for PM_{10} daily main, 99.8 pct of hourly for NO_2), unless relationships with annual averages can be found.
  - not applicable for classification
  - Suited to account for microscale environment & dispersion conditions where a complex environment geometry is relevant and thus facilitate configuration of representative monitoring network.





Literature discussion : applicability of methods

- **Local/street scale dispersion modelling (Gaussian, Lagrangian, …)**
  - Well suited for assessment needs a) to c), depending on the completeness of emission inventory and accounting for street canyons.
  - Especially suited for assessment need b since line sources are explicitly taken into account.
  - Due to the hourly time resolution, also suited to derive SR areas for the percentile based metrics for all pollutants (depending on method)
  - Can aid in the configuration of network via local scale source apportionment and SR area (see 1.4.1)
  - Not well suited for microscale environment dispersion conditions as dispersion at microscale is parametrized
  - Allow for **source apportionment** for primary emissions and therefore study representativeness as a function of emission sectors



Literature discussion : applicability of methods

- **Chemical Transport Modelling**
  - Not able to resolve urban scale concentration gradients and thus not suited to assess SR in these areas.
  - Mainly used to quantify SR areas for rural background areas.
  - Not suited for assessment need b) (length of road) only a) and c), also to a lesser extent d) and e).
  - Some authors use CTMs for optimisation of monitoring networks (assessment need d)) (Soares et al., 2018).
  - Allow for source apportionment and therefore study representativeness as a function of emission sectors, these considerations are valuable for facilitating the configuration of a representative network.
- **GIS based methods**
  - Approximate the spatial variability via proxy information; mimic dispersion relations
  - Depending on the scale resolved by the proxy information, method is suited to derive SR areas and therefore deliver assessment needs a and c, though, estimation of the length of road in exceedance (assessment need b) is less obvious.
  - Given the statistical nature, typically all pollutants and metrics can be covered
  - Does **not allow for source apportionment** and are therefore only to a lesser degree suited to facilitate configuration of a representative network (assessment need d)).

Literature discussion : applicability of methods

- **Passive sampling / mobile monitoring**
  - Generally not suited to estimate the SR area as in-situ data does not provide a full areal picture unless complemented by modelling.
  - Well suited to facilitate the configuration of a representative network when campaigns have been set up specifically for this purpose e.g. (Vardoulakis et al., 2005).
  - Can be used to determine residual spatial variability within the area of representativeness.
  - Availability of monitoring technique and aggregation time depends on pollutant.
- **Low cost sensor networks**

Literature discussion : some key aspects learned…

- Establishing similarity
  - wide variety
  - attempts to combine concept of SR area with classification add value (e.g. Soares et al, 2018)
  - several authors use data fusion techniques to remove model bias to assess SR, most notably (Beauchamp et al, 2018).
  - inclusion of additional information
  - similarity tolerance : 20 % used a lot
  - differences in opinion on what maximum range should be allowed to establish spatial representativeness. (Spangl et al., 2007) argue to take 100 km as maximum range, whereas (Martin et al., 2014) suggest 200 km to prevent underestimation of SR area in case of remote stations.

Methodological requirements

- Paradigm shift in IE → modular approach towards better SR characterization
- Clearly state for each assessment need :
  - The **purpose** of evaluating SR, including the **legislative requirements** from the perspective of the AAQD.
  - The **set of metrics / characteristics** required for the purpose/application.
  - **Context** related definitions of SR metrics.
  - Fitness of **technical methods** for estimating a particular SR metric

Methodological requirements : area in exceedance

- **Estimate of spatial area where the level was above the environmental objective**
  - *Legislative requirements e.g.*
    - the area in which the **annual averaged PM_{10}** concentration exceeds **40 µg/m^3**.
    - the area in which the **90.4th percentile value** of the **PM_{10} daily means** exceeds **50 µg/m^3**
    - the area in which the **annual averaged $PM_{2.5}$** concentrations exceed **25 µg/m^3 (exceed 20 µg/m^3 by 2020)**
    - the area in which the **93.2th percentile** value of the **daily maximum of the 8-hour moving average O_3** concentrations exceeds **120 µg/m^3**
    - the area in which the **annual averaged NO_2** concentrations exceed **40 µg/m^3**
  - *Set of metrics and characteristics required*
    - requires geographically explicit **area**
    - **capacity to estimate percentiles,**
  - *Context related definitions of the metrics*
    - Primarily concerned with spatial variability : **time aggregation** clearly defined by legislative requirement → primary similarity criterion should suffice
    - Important to realize : area of similarity is not area of exceedance (Beauchamp et al, 2018), yet hard threshold

Methodological requirements : area in exceedance

- *Fitness of technical methods*
  - spatial explicit modelling required (explicit area)
  - NO_2 : resolve strong roadside gradients and account for urban structure
  - PM_{10}, $PM_{2.5}$: road side gradients smaller, but resuspension
  - O_3 : sizeable roadside gradients may exist, however exceedances more likely to occur outside of urban environment

  - Guidance needed to assess ability of models to resolve spatial variation

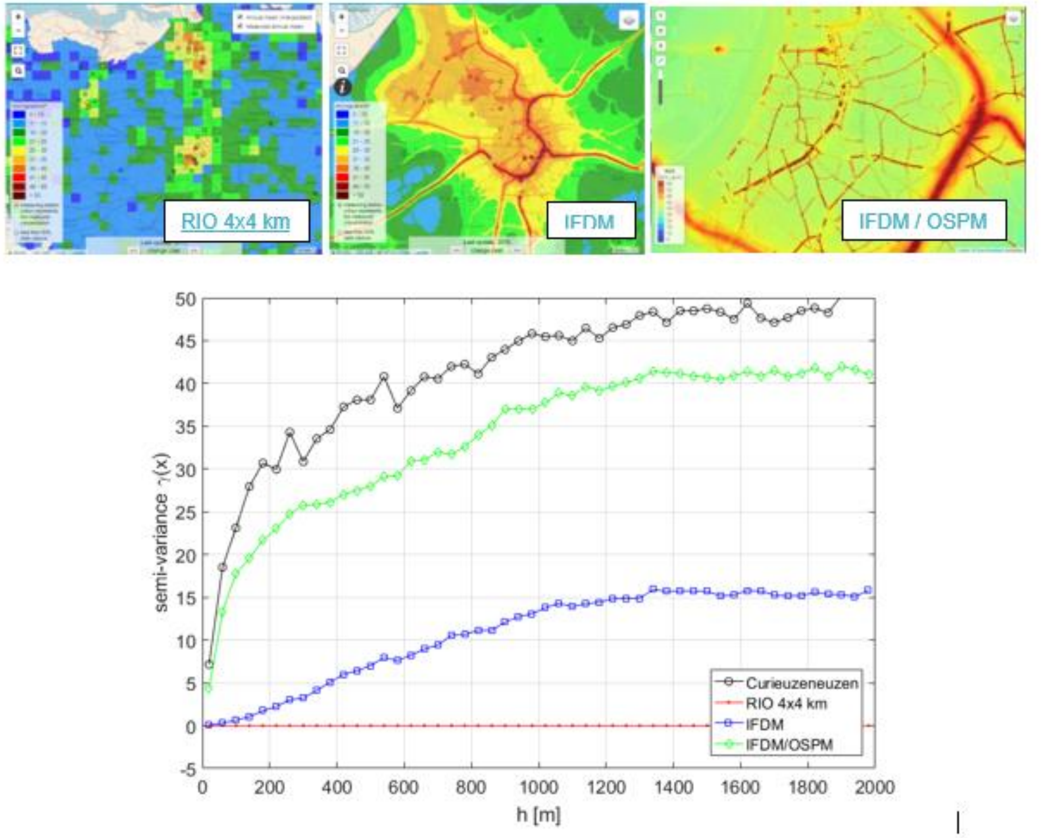


Figure 2 : Illustration of different model based approached attempting to capture the spatial variability of the Curieuzeneuzen dataset for Antwerp (https://curieuzeneuzen.be/). The top figure shows the maps for Antwerp for 3 different model assessments, a regional scale model at 4x4 km resolution, a Gaussian

Methodological requirements : road in exceedance

- **Estimate of the length of road where the level was above the environmental objective**
  - *Legislative requirements*
    - **kerbside** concentrations, no monitoring on the road required, except where pedestrians have access to the central reservation (2008/50/EC Annex III, under A.2.c.)
    - metrics same as above
  - *Set of metrics and characteristics required*
  - *Context related definitions of the metrics*

similar as above

  - *Fitness of technical methods*
    - accounting for street canyons in urban environment essential
    - assessing “central provisions” requires very high resolution modelling (e.g. CFD) unless dedicated monitoring campaigns conducted in such locations
    - need to explicitly account for line segment emissions
    - considerable uncertainty of traffic emissions data: fleet composition, traffic intensities

Methodological requirements : population in exceedance

- **Estimate of the total resident population in the exceedance area**
  - *Legislative requirements*
  - *Set of metrics and characteristics required*
  - *Context related definitions of the metrics*
  - *Fitness of technical methods*
    - additional overlay
    - assignment of population adjacent to street canyons

similar as above

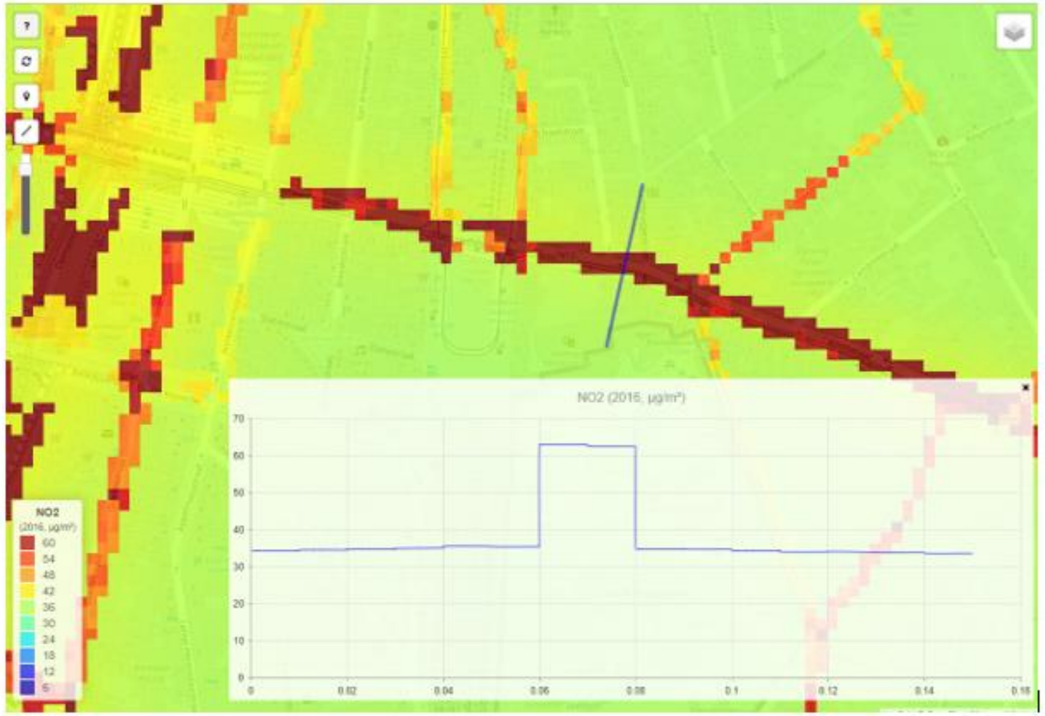


Figure 7: Example of the issue of where to assign population. In the detailed model, an exceedance of the 40 µg/m³ LV for NO_2 is modelled in the street canyon, whereas at the backside of the houses adjacent to the canyon, no exceedance is found.

Methodological requirements : network design

- **Facilitate the configuration of a representative monitoring network**
  - *Legislative requirements*
    - Assessment requirements for air quality zones : exceedance of UAT, LAT (Annex II of 2008/50/EC - A)
    - Requirements on minimum number of sampling points
    - Requirements from model validation point of view : CEN WG 43 on MQO
  - *Set of metrics and characteristics required*
    - The network design process considers 3 topics (section 4.3.4.2 of guidance document) https://ec.europa.eu/environment/air/pdf/guidanceunderairquality.pdf
      - station classification
      - number of stations
      - location of stations : hotspot concentration in zone & background (general population exposure)
    - Concept of SR area applies here as well : looking for total coverage of the network
  - *Context related definitions of the metrics*
    - Both qualitative as well as quantitative definition for spatial representativeness
    - Design of network is not restricted to previous assessment needs : e.g. include temporal information into similarity criterion

Methodological requirements : validation and calibration

- *Fitness of technical methods*
  - both classification methods as well as methods able to resolve spatio-temporal variability needed
  - crucial to be able to separate traffic/industrial and background locations

- **Identify sampling points that are suitable for model calibration and validation**
  - *Legislative requirements*
    - purpose to select monitoring sites for model calibration and validation (data assimilation)
    - on-going standardization efforts (CEN)
    - no validation/calibration in mind in legal requirements
  - *Set of metrics and characteristics required*
    - scale of observations is to match model scale
    - different aspects of a model may be under scrutiny → similarity criterion
  - *Context related definitions of the metrics*
    - primarily qualitative estimation of SR needed, but can be complemented with explicit SR area
    - the way in which similarity is established depends on purpose and nature of validation exercise

Methodological requirements : validation and calibration

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- *Fitness of technical methods*
  - Emphasis on establishing similarity between locations
  - Clearly : classification methods
  - but : SR area is added value
  - broad range of methods →

Similarity Methodology	Description	Spatial model
Euclidean distance	The two sites should not be separated by more than a certain distance, hence the SR area will be a circular buffer around the monitoring location	n/a
Fixed absolute threshold; (Spangl et al., 2007)	The value of the air quality metric is only allowed to differ by some absolute number (e.g. +/- 5 µg/m³) in the SR area	• Can be applied to different model resolutions, doesn't require time resolved modelling.
Fixed relative threshold; (Blanchard et al., 1999), (Rivas et al., 2019), (Martin et al., 2014)	The value of the air quality metric under consideration is only allowed to differ by a fixed percentage (e.g. +/- 20 %) in the SR area	• Can be applied to different model resolutions, doesn't require time resolved modelling.
Linear Discriminant Analysis (LDA) (Joly and Peuch, 2012)	Timeseries of concentration data at monitoring locations are analysed for certain time series characteristics yielding a set of 8 characteristic indicators.	• n/a, the method described is purely an objective classification method.
Principle Component Analysis (PCA) (Nguyen et al., 2009)	A dimensionality reduction is performed on timeseries of hourly data for the selected station, resulting in loadings per station on 2 principle components axes. These 2D loadings are used for classifying the stations in rural, urban background and traffic.	• n/a, fixed distance taken
Concentration Similarity Function (CSF) (Nappo et al., 1982; Piersanti et al., 2015; Righini et al., 2014)	Imposes the requirement on the two locations that their so-called *frequency function* is above 90%, indicating that for 90% of the samples in the timeseries, the relative difference between the concentration values is less than 20%	• Required timeseries of gridded model output • Or (as in the IE) inverse distance weighted interpolation (IDW) applied.
(Temporal) Pearson correlation coefficient and Euclidean distance; (Soares et al., 2018)[1]	• Apply timeseries filter to isolate specific frequency components in the timeseries • Can be used for network design → assessing potential station redundancy	Have used GEM-MACH CTM to provide gridded timeseries concentrations.
(Temporal) Pearson correlation coefficient and NRMSE[2]; (Rodriguez et al., 2019)	Based on timeseries of simulated concentrations	PMSS (Parallel Micro-Swift-Spray) high resolution air quality model at 3 m horizontal resolution.
Kriging based approach; (Bobbia et al., 2008), (Beauchamp et al., 2018)	Expands the criterion of an absolute threshold to a probabilistic approach by requiring that the **expectation value** of the difference between the metric at the observed value be smaller than a given delta. This is demonstrated to be rewritten into the requirement that the difference between the (co)-Kriging estimate and the observed value be smaller than the given delta corrected for the Kriging error variance.	Emission based co-variates (both local and regional scale).

Methodological requirements : variability within area of representativeness

- **Determine the spatial variability within the “area of representativeness”**
  - *Legislative requirements*
    - Microscale siting criteria under 2008/50/EC Annex III, section C
      - unrestricted flow around inlet sampling probe
      - avoid direct intake of emissions
      - …
    - Somewhat peculiar : once SR area is determined it should by definition be known what the spatial variability is : given by similarity criterion
  - *Set of metrics and characteristics required*
    - contiguity of SR area
    - quantitatively : no predefined way to present variability : statistical distributions & properties thereof
  - *Context relative definitions*
    - *n/a*

Methodological requirements : variability within area of representativeness

– *Fitness of technical methods*
  - methods should allow to resolve the full spatio-temporal variability, including effects of vegetation, screens, microscale flow obstacles : CFD
  - but models remain approximations : dynamic traffic effects, lacks in input data, ….
  - dedicated monitoring campaigns

Table 4: Table summarising the applicability of monitoring based approaches for establishing SR around monitoring stations.

Methodology considered	Papers/references (not exhaustive)	Applicability for assessment needs
Passive sampler campaigns	(Hagenbjörk et al., 2017; Vardoulakis et al., 2011b); Curieuzeneuzen Flanders	• NO_2 Palmes tubes have successfully been applied in multiple studies. • Usually shorter campaigns compared to. averaging time of the annual environmental objectives however corrections can be applied. • Not applicable for percentile values. • Can be deployed on large scale via citizen science experiments (e.g. CurieuzeNeuzen), however, significant effort regarding organization required.
Mobile monitoring campaigns	(Gillespie et al., 2017; Li et al., 2019; Peters et al., 2013; Van den Bossche et al., 2015; Van Poppel et al., 2013)	• Difficulties interpreting results from mobile campaigns, response time corrections needed when using continuous monitoring, or some way of aggregating repeated results. • Only a snapshot relative to AAQD environmental objectives on annual timescales.
Low cost sensor networks	(Badura et al., 2018; Castell et al., 2017a; Sadighi et al., 2018; Spinelle et al., 2015)	• Significant challenges associated with sensor robustness and measurement repeatability (Castell et al., 2017b; Spinelle et al., 2015). • Issues related to sensitivity and low signal/noise ratios under ambient concentrations, chemical interference (in particular for NO_2 and O_3 using electrochemical sensors), transient effects in response to changes in relative humidity and dependence of the calibration on environmental conditions in general. These issues makes low cost sensor use currently less obvious for detailed monitoring of spatial variations within an area of representativeness. For $PM_{2.5}$ the impact of high humidity is particularly problematic and high relative errors are seen at concentrations below 20-30 µg/m^3 (Badura et al., 2018). • Considering the current uncertainties, a concern would be the ability to distinguish sensor issues from true spatial variability. • Potential for very explicit measurement of temporal variability via high monitoring frequency (sometimes minute or second-basis).

Tiered approach

- Tiered approach as a framework for guidance recommendations
- Aspects to consider :
  - account for **MS capacity** for performing complex air quality model simulations or implementing advanced statistical techniques
  - tiers should reflect **progressively more elaborate data requirements**
  - tiers should **progressively add detail and accuracy** in the assessment of SR area
  - ultimate aim **: full characterization of spatio-temporal variability**, once known, application for the different assessment needs becomes trivial
  - it should be recognised that **monitoring in itself**, though not capable of fully capturing the full, geographically explicit spatio-temporal variability, is **an effective means of informing an expert opinion in a Tier 1 approach**
  - decision to **omit a definition** in each of the different tiers as **to how similarity is established** : only pragmatic way to move forward is to define the tiers & therefore recommendations, impact of different similarity criteria to be established in later phase of project

Tier definitions : framework for recommendations

- **Tier 1** can be phrased as expert opinion or current practice
  - qualitative assessment of spatial representativeness is made based on rules of thumb
  - local knowledge of the monitoring site
  - relatively simple “distance to source” considerations.
  - can be complemented with in-situ or mobile monitoring to better understand the spatial representativeness, but recognising that a full geographically explicit, spatio-temporal assessment is not possible in this tier.
- **Tier 2**
  - add source, dispersion and long-range transport related information into the assessment of spatial representativeness via proxy data,
  - can be geographical via GIS data or temporal via time series analysis.
- **Tier 3** will complement or even replace this source related information with
  - comprehensive fit-for-purpose and geographically explicit air quality modelling
  - best possible picture of the spatio-temporal variation of the concentration field
  - explicit spatial representativeness area.
- **Tier 4** will complement the modelling with detailed observations,
  - reducing the uncertainty inherent to any modelling application.

Methodology classification

Table 6. : SR assessment methods in different tiers per assessment need.

<table>
<tr><th></th><th>Estimation of surface area in exceedance</th><th>Estimation of total resident population in area of exceedance</th><th>Estimation of length of road in exceedance</th><th>Facilitation of configuration of representative network</th><th>Identify sampling points suitable for calibration and validation</th></tr>
<tr><td>TIER 1
Expert Opinion</td><td colspan="2">Fixed radius e.g. (Castell-Balaguer and Denby, 2012)</td><td>Fixed length</td><td>Classification based on expert opinion and station siting</td><td>Expert assignment of station type</td></tr>
<tr><td>TIER 2
Proxy Information</td><td colspan="3">Methods relying on proxy data and distance relations to estimate source emissions and dispersion conditions. E.g. (Henne et al., 2010; Janssen et al., 2012; Righini et al., 2014; Spangl et al., 2007)</td><td colspan="2">Objective station classification based on timeseries or GIS proxy data (Joly and Peuch, 2012; Nguyen et al., 2009)</td></tr>
<tr><td rowspan="2">TIER 3
Geographically explicit, comprehensive fit-for-purpose modelling</td><td colspan="3">Comprehensive and fit-for-purpose local scale modelling: line source modelling, parametric street box models (OSPM, CAR, …), obstacle resolved modelling (CFD), (Rivas et al., 2019; Santiago et al., 2013)</td><td rowspan="2">Determine gaps in the network coverage taking into account the SR areas of the stations, e.g. (Soares et al., 2018)</td><td rowspan="2">Geographically explicit models applied for objective classification. (typical SR length scale based on independent modelling)</td></tr>
<tr><td colspan="2">Comprehensive and fit-for-purpose regional scale modelling: regional scale Eulerian models e.g. (Martin et al., 2014)</td><td></td></tr>
<tr><td>TIER 4
Modelling complemented with dedicated measurements</td><td colspan="5">Modelling complemented with passive sampler campaigns, mobile monitoring, e.g. (Hagenbjörk et al., 2017; Li et al., 2019; Vardoulakis et al., 2011b, 2005). In the future sensor observations (Sadighi et al., 2018) might be used as well if sensor uncertainty is properly defined.</td></tr>
</table>

Improved guidance

- How does this tiered approach provide a framework for guidance w.r.t. spatial representativeness and allows to address those issues where the AAQD and IPR allows room for interpretation ?
- e.g. :

Flexibility in Directive / IPR	
Determination of maximum concentration in air quality zone	Expert opinion provides information on where maximum concentration are expected GIS based modelling can provide additional estimations, but does not properly account for source information. Comprehensive modelling starting from emissions better reveals expected maxima in the zone, which can be further supported by validation campaigns
Compatibility of microscale and macroscale requirements for traffic stations	Siting of traffic stations : driven by expert & logistical considerations. Modelling via proxy data gives indications, but does not always correctly capture the road-side gradients. Explicit resolution of roadside gradients provides best picture and guidance for siting traffic stations.
Microscale siting criteria : “immediate vicinity”, “some meters away” from building	Rules of thumb → explicit quantification of flow around inlets using CFD
Guidance for assessment requirements w.r.t. LAT/UAT	Classification in Tier 2 to be complemented with explicit assessment of SR area by means of modelling allows to better distinguish between similar sites e.g. both classified as “industrial”
Definition of urban background	- quantify individual source contributions explicitly via scenario assessment in dispersion modelling as opposed to having an expert opinion or using proxy GIS data to represent the distance relations. - distinction between urban background, traffic and industrial stations is not always straightforward and cannot always be uniquely defined by an objective classification method.
…	

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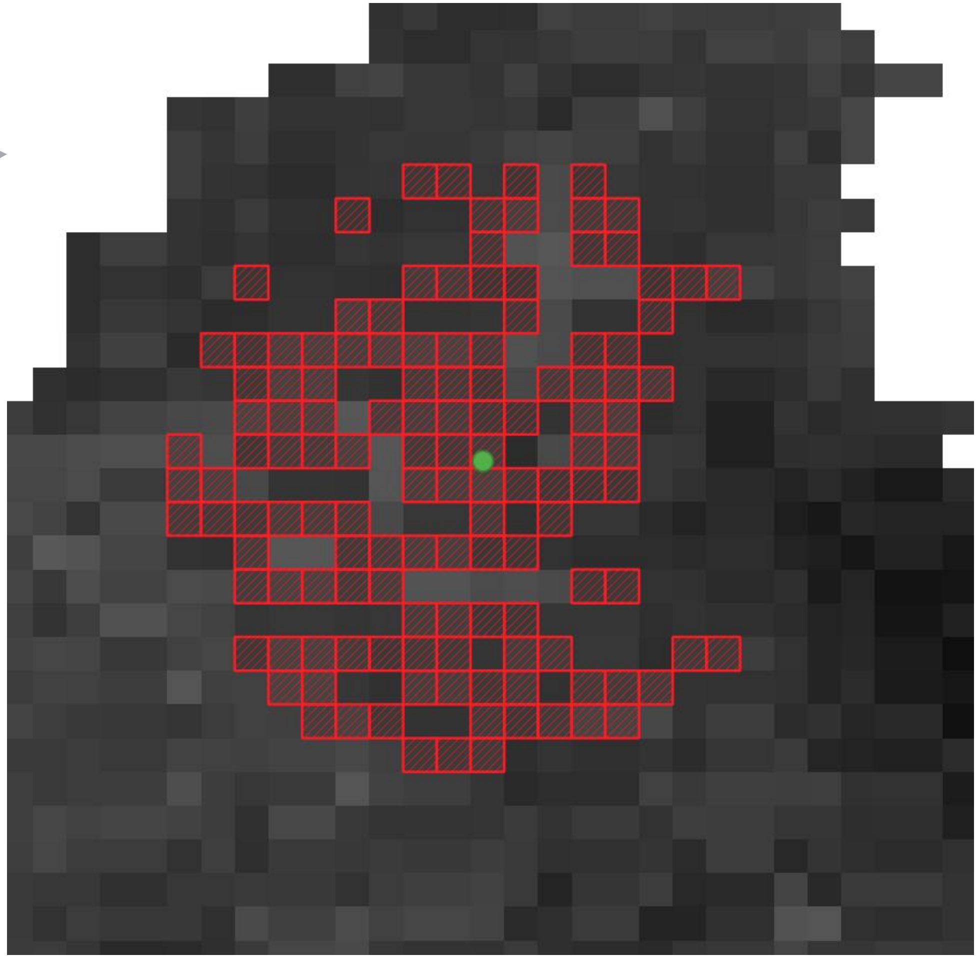
Discussion

Discussion points & sensitivity studies

- Identification of further instances where further clarification can benefit SR assessment in AAQD and current guidance
- Discussion on concept of tiered approach
  - overall approach as a way to formulate guidance ?
  - classification of methods ?
  - suggestions on how to address points where AAQD and guidance can be improved ?
- Establishing consensus w.r.t methodological requirements for assessment needs
  - Is the analysis framework put forward by the IE adequate for the requirements in the assessment needs
  - **primary similarity** criterion sufficient for compliance checking ?
  - …
- When adopting air quality modelling, as Tier 3 approach, there should be framework for assessing a model’s fitness for purpose and guidance will have to be developed for that
  - one method put forward here are semi-variograms,
  - additional thoughts ?
- Prioritization of sensitivity studies

Proposed sensitivity studies

- Further studies on how to establish model's fitness for purpose : guidance
  - comparison of semi-variograms using CN
  - functionality in composite mapping
- Study sensitivity in assigning population w.r.t. high resolution modelling → first investigations
- How does the parameterisation of the similarity criteria and threshold value influence the estimation of SR areas?
- In such studies, it will be discussed :
  - How urban structure influences the SR area (by comparing different cities) and to what extent recommendations can be generalised.
  - In what way SR areas are influenced by requiring spatial contiguity and/or exclusivity. (i.e. whether or not SR areas around neighbouring stations are allowed to overlap or not)
- Comparison of tiers



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Thank you

We are happy to take any questions