Feasibility of an Intercomparison Exercise of Methods for the Assessment of the Spatial Representativeness of Monitoring Sites

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Outline

- Introduction (motivation, scope, benefits)
- State of the art
- Questionnaire
- Feasibility analysis
- Proposal of exercise

Motivation

- Systematic monitoring and collection of ambient air quality data is a mandatory.
- Directives 2008/50/EC and 2004/107/EC endeavour to ensure that the information collected on air pollution is sufficiently representative and comparable.
- Air quality monitoring stations have been deployed trying to cover most of the territory. How representative are these?
- The assessment of spatial representativeness is required for different tasks (Station classification, network design, AQ assessment, etc).
- **Reporting information on spatial representativeness is not yet mandatory and not harmonized (no reference method specified).**
- **FAIRMODE is highly concerned in advancing the assessment procedure of spatial representativeness (Cross Cutting Activity on Spatial Representativeness).**

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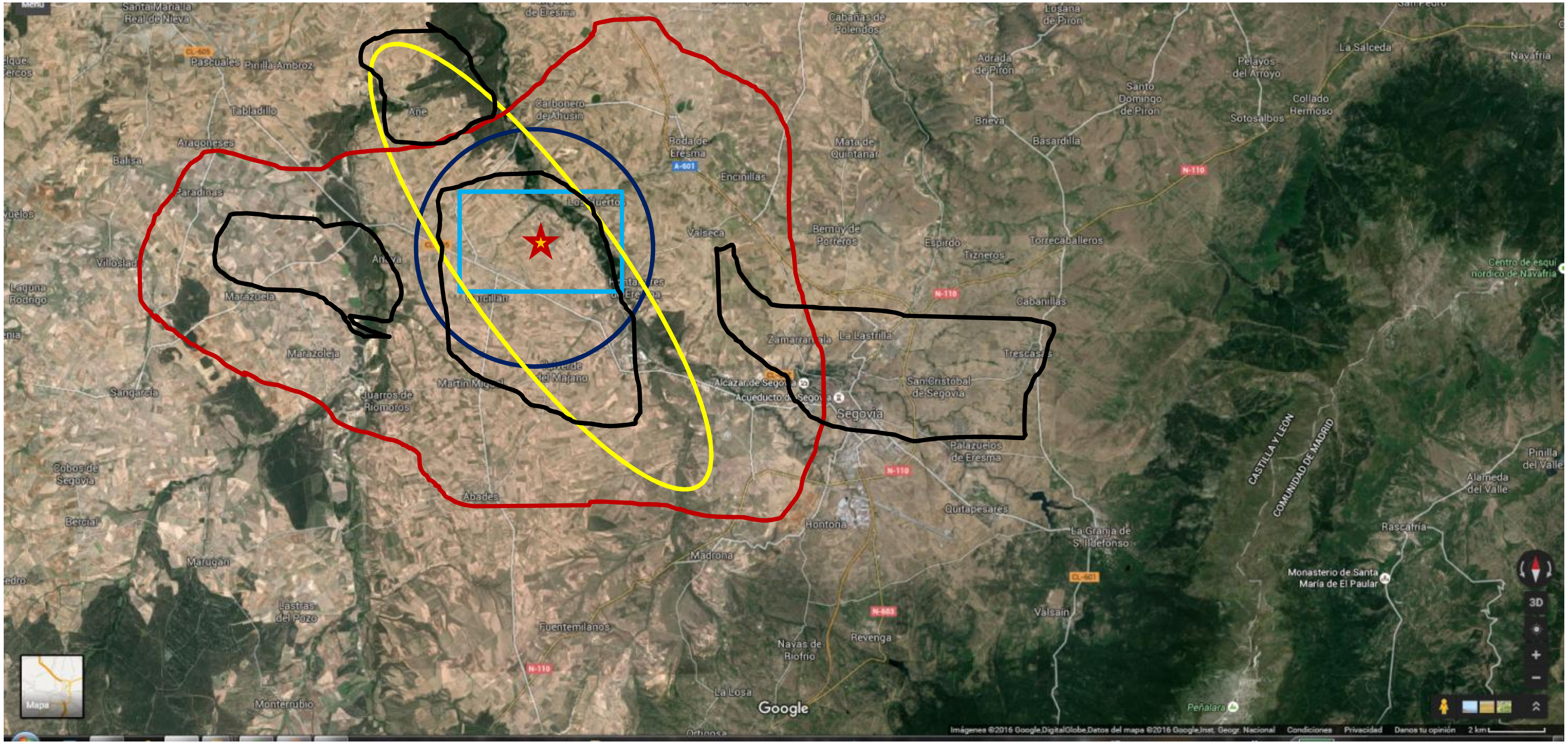
Motivation

- The **basic concept of spatial representativeness (SR) area**: determining the zone to where the information observed at the a monitoring site can be extended.
- **What is the spatial representativeness (SR) area of an air quality station?**
- **How can we estimate it?**



Scope of the feasibility study

- To prepare and evaluate the feasibility of the actual methodological intercomparison study.
- Identification of :
  - candidate methodologies,
  - requirements on datasets,
- Evaluation of the comparability of the different types of spatial representativeness results.
- To investigate about the best way to compare the outcomes of the different spatial representativeness (SR) methods
- To identify the limitations to be expected.

Expected benefits

- To gather a comprehensive information about the state of art of spatial representativeness (SR) of AQ stations.
- To identify the requirements for carrying out an intercomparison exercise including as many methodologies as possible.
- To help to the design of the intercomparison exercise

State of the art

- Tens of papers and reports were collected. The oldest ones are from the 70s.
- In the framework of FAIRMODE, Castell-Balaguer and Denby (2012) compiled specific comments of experts that revealed the main following points:
  - A scientific objective methodology to determine the **spatial representativeness of a monitoring station is necessary**.
  - There are **more parameters** that should be considered in addition to **pollutant and station classification** of the air quality monitoring station.
  - The concept of **circular area of representativeness is not applicable**.

State of the art

- SR definition based on the **similarity of concentration** of a specific pollutant.
- **Concentration does not differ** from the concentration measured at the station by more than **a specified threshold**.
- **Additional criteria** (depending on the context):
  - similarity caused by common external factors
  - air quality in the station and in the representativeness area should have the same status regarding the air quality standards
  - limit the extension of SR areas
  - SR areas has to be stable over time periods, etc.

State of the art

- **No consensus on a procedure for assessing spatial representativeness has been reached yet.**
  - There are several methods for estimating SR area.
  - Classification of methodologies:
    1) *SR computed by using* ***concentrations maps*** *around monitoring sites. (From models or measurements)*
    2) *SR area computed from the distribution of related* ***proxies or surrogate data*** *(land cover/use, emissions, population density, etc.)*
    3) *Methodologies linked with* ***station classification****.*
    4) *Qualitative information of SR according to a* ***qualitative analysis*** *(e.g. expert knowledge).*
  - There are several types of outputs (maps, areas, indexes, etc).
  - Covering from remote stations to urban-traffic stations
  - Different pollutants, etc.

Design of the survey and questionnaire

- Context (station siting, data assimilation, model evaluation, AQ reporting, etc) and regulatory purpose**. Questions 1 and 2.**
- Definition of SR. **Question 3.**
- Methodologies:
  - Description including time and spatial scale, pollutant, etc. **Question 4.**
  - Input data. **Question 5.**
  - Output data. **Question 6.**
  - Transferability to other regions. **Question 7**
- Prospective intercomparison exercise:
  - Participation. **Question 8.**
  - Requirements related to the SR methodology. **Question 9.**
  - Recommendations about the type of comparison. **Question 10.**
  - Requirements on Confidentiality. **Question 11.**

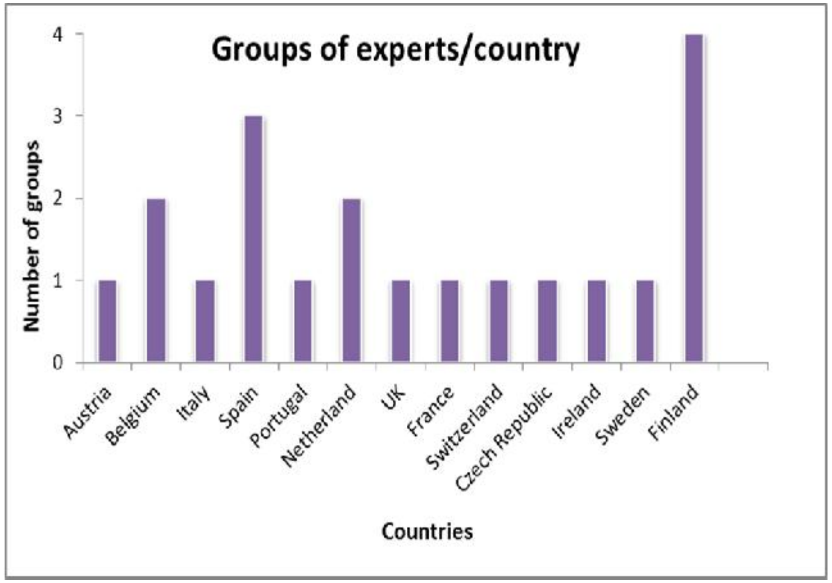
To whom the questionnaire was sent?

- **Survey** (launched January 2015):
  - Final version of the questionnaire was sent to more than 600 email contacts:
    - The **complete FAIRMODE distribution list** (ca 600 contacts).
    - **FAIRMODE national contact points** (33 contacts).
    - **AQUILA members**. (37 national air quality reference laboratories)
    - A selected group of **international experts**, who have been identified by the literature study (23 contacts)
    - The group of **reviewers of the questionnaire** (7 contacts)

Participants in the survey

Expert	Institution	Country
Jutta Geiger	LANUV, FB 42	Germany
Wolfgang Spangl	Umweltbundesamt Austria	Austria
Jan Duyzer	TNO	Netherland
David Roet	Flemish Environment Agency (VMM)	Belgium
Antonio Piersanti	ENEA	Italy
Maria Teresa Pay	Barcelona Supercomputing Center	Spain
Ana Miranda	University of Aveiro	Portugal
Florian Pfäfflin	IVU Umwelt GmbH	Germany
Ronald Hoogerbrugge	National Institute for Public Health and the Environment	Netherland
Fernando Martin	CIEMAT	Spain
Daniel Brookes	Ricardo-AEA	UK
Laure Malherbe	INERIS	France
Stephan Henne	Empa	Switzerland
Stijn Janssen	VITO	Belgium
Roberto San Jose	Technical University of Madrid (UPM)	Spain
Jan Horálek	Czech Hydrometeorlogical Institute	Czech Republic
Kevin Delaney	Irish EPA	Ireland
Lars Gidhagen	Swedish Meteorological and Hydrological Institute	Sweden
Hannele Hakola	Finnish Meteorological Institute	Finland
Tarja Koskentalo	Helsinki Region Environmental Services Authority	Finland
Erkki Pärjälä	City of Kuopio, Regional Environmental Protection Services	Finland
Miika Meretoja	City of Turku / Environmental division	Finland

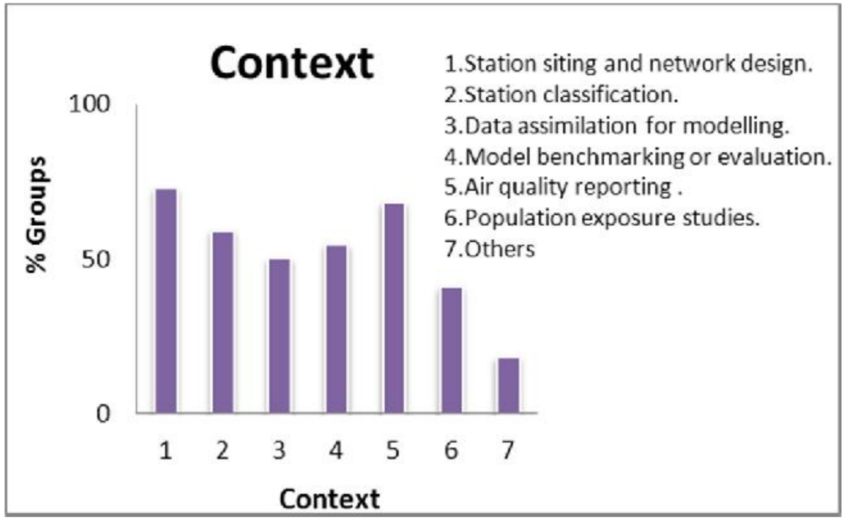
Table 1: Experts, groups and countries that replied the questionnaire.



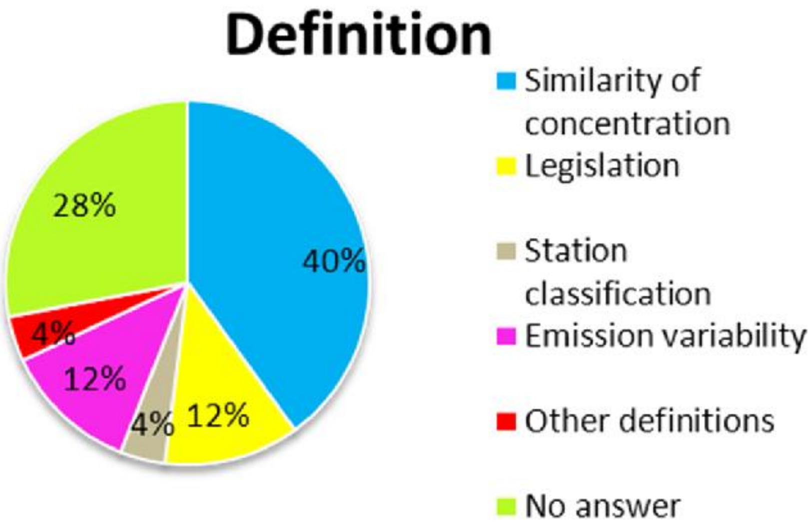
- A total of 22 groups from 15 different countries

Results of the questionnaire

- **Context.**
  - Mostly for **station siting, network design and air quality reporting** (around 70% of the groups).
  - The majority of groups (68%) link their SR **studies to legislative or regulatory purposes** .



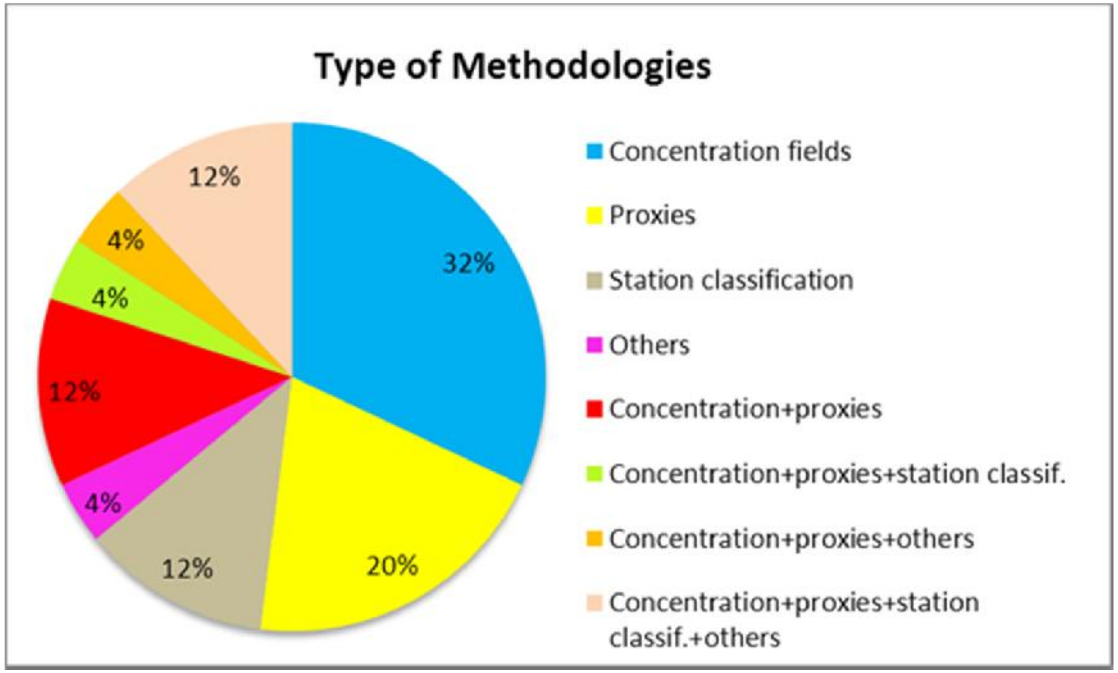
- **Definition.**
  - **Similarity of concentration** is the most frequently used definition (40%)



Results of the questionnaire

- **Type of Methodologies.**
    i. Methods which are based on estimates of the **spatial distribution of pollutants**
    ii. Methods which are based on pollutant **proxies and / or surrogate data**
    iii. Methods which are linked to the **classification of stations** or sites
    iv. **Other types** of methods.

- **Most of the groups (16) use methodologies based totally or partially on the spatial distribution of pollutant concentrations**, 8 of them are also based on other types. **13 groups use methodologies based totally or partially on proxies or surrogate data**.

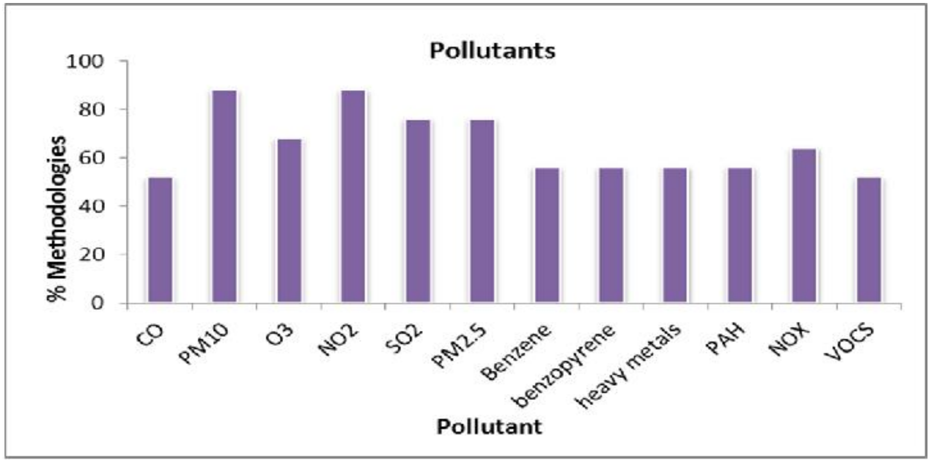


Type of Methodology	Number of Methodologies
Concentration fields	8
Proxies	5
Station classification	3
Others	1
Concentration+proxies	3
Concentration+proxies+station classif.	1
Concentration+proxies+others	1
Concentration+proxies+station classif.+others	3
Total	**25**

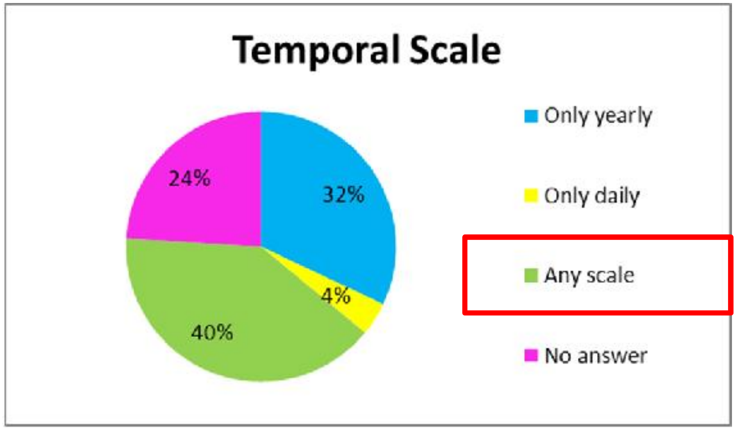
Results of the questionnaire

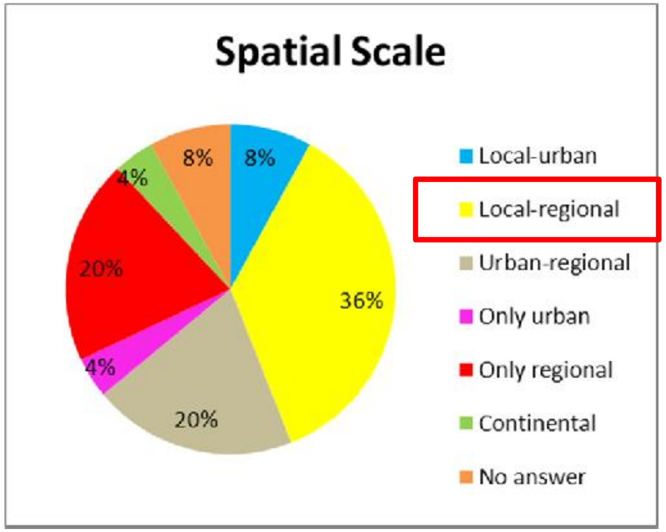
- **Type of Stations.**
- **Main Pollutants**

Type of station	Number of Methodologies
Traffic	1
Background	3
Industrial	0
Urban	2
Suburban	1
Rural	4
All	18
Remote	1
No answer	2



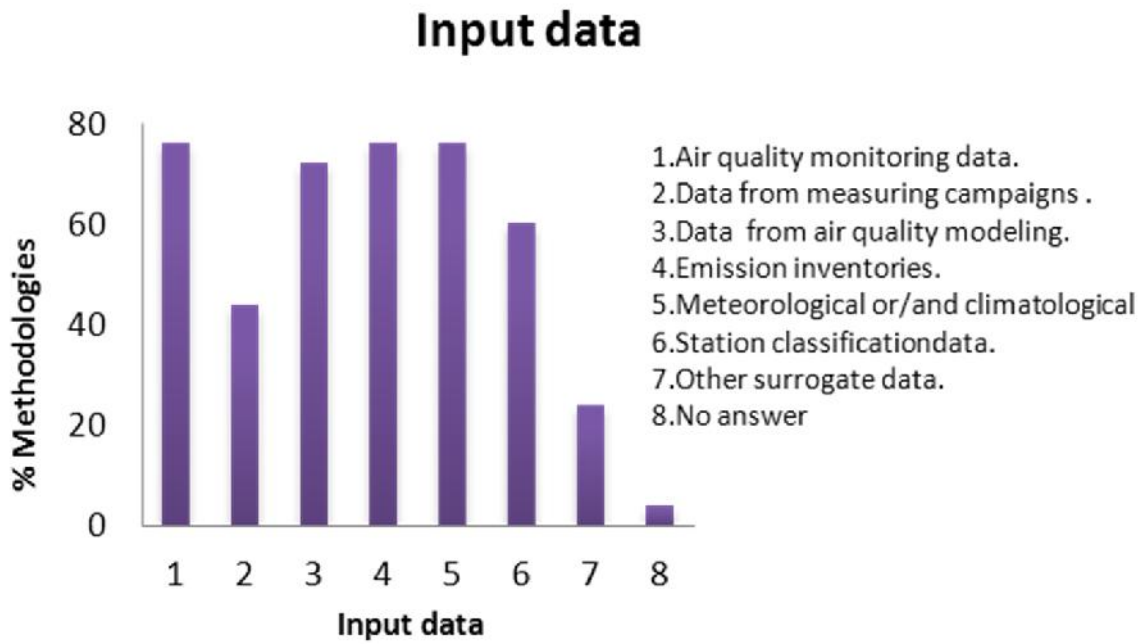
- **Spatial and Temporal Scale**





Results of the questionnaire

- **Input Data**

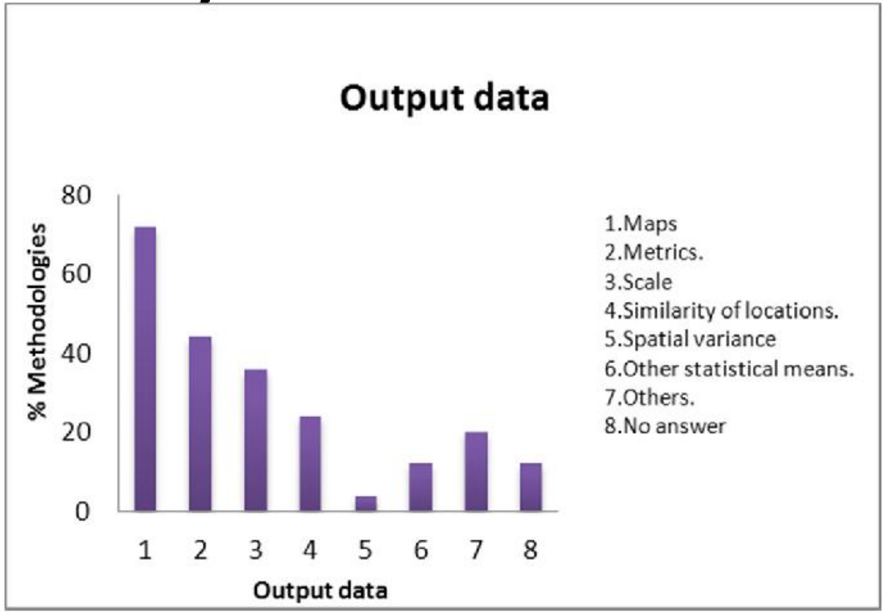


Input data	Number of Methodologies
Air quality monitoring data	19
Data from measuring campaigns	11
Data from air quality modeling	18
Emission inventories	19
Meteorological or/and climatological data	19
Other surrogate data	15
Station classification	6
No answer	1

- Most methodologies require several types of input data.
- Some input data are used in different ways by different methodologies (e.g., emission inventories used as proxy data in some methodologies or as as input data for modelling).
- **Most methods need emission inventories and meteorological or/and climatological data and air quality monitoring data (19 cases). A high percentage of methods use data from air quality modelling data (18) and other surrogate (15).**
- All of these types of data are required in order to conduct the intercomparison exercise. The lack of one of these input data would cause the exclusion of several methodologies.

Results of the questionnaire

- **Output Data**



Output data	Number of Methodologies
Maps	18
Metrics	11
Scale	9
Similarity of locations	6
Spatial variance	1
Other statistics means	3
Others	5
No answer	3

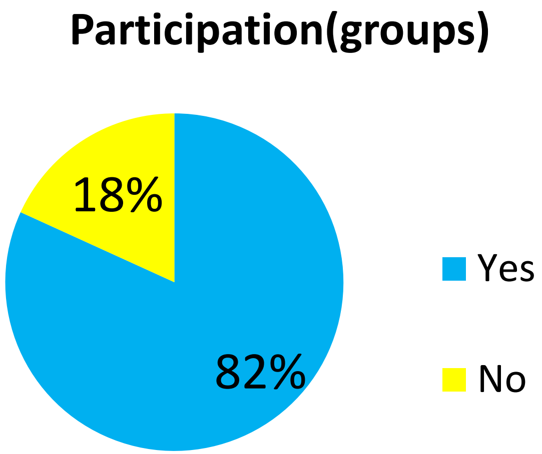
- **The outputs of most of the methodologies are reported with maps contouring the representativeness area (18 cases).**
- From the 18 cases reporting maps, simplified geometric concepts like area or scale can be derived as many survey participants explained.
- However, **simplified metrics of SR area or scale were explicitly mentioned for 11 and 9 of declared methodologies.**

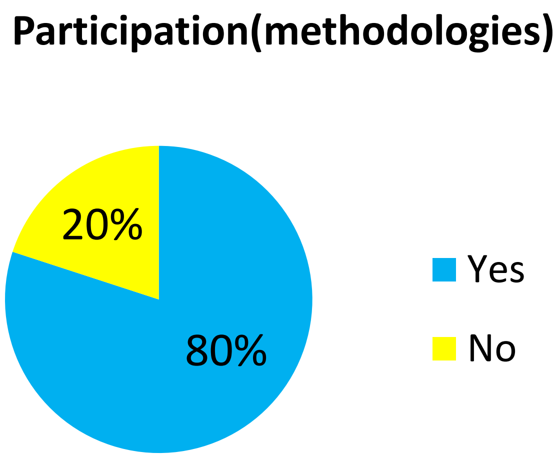
Feasibility analysis

Main objective of the intercomparison exercise:

- *to evaluate the different contemporary methodologies to compute SR of air quality monitoring stations by applying them to a jointly used example case study*.
- Open the exercise to as many participants and methodologies as possible

Feasibility analysis





Participation	Number of groups	Number of Methodologies
Yes	18	20
No	4	5
Total	22	25

Feasibility analysis

Problems:

1. Large variety of methodologies, criteria and definition of SR ➔ Difficult to harmonize the criteria to define the SR area.
2. Limitations of each methodology ➔ spatial and temporal scale, pollutants, inputs, etc.
3. Type of the outputs (features of SR) is different depending on methodology (maps, quantitative and qualitative features) ➔ How to compare??

Group	Methodology					Scale		Output
	Models	Measure.	Proxies	Station classification	Others	Local/ Urban	Regional	Maps
LANUV (Germany)	x	x	x	x	x	x	x	
Umweltbundesamt (Austria)	x	x	x			x	x	x
TNO (Netherlands)	x					x		x
VMM (Belgium)	x		x	x		x		x
ENEA (Italy)	x					x	x	x
			x			x	x	x
BSC (Spain)	x						x	x
			x				x	x
UA (Portugal)	x	x				x	x	x
IVU Umwelt GmbH (Germany)	x					x		x
RIVM (Netherlands)				x		x	x	x
CIEMAT (Spain)	x	x				x	x	x
Ricardo-AEA (UK)				x		x	x	
INERIS (France)	x	x				x	x	x
VITO (Belgium)			x			x	x	x
UPM (Spain)	x		x			x	x	x
FMI (Finland)				x			x	x
Helsinki RESA (Finland)	x	x	x	x	x			
Kuopio, REPS (Finland)	x	x	x			x	x	
Turku /ED (Finland)	x	x	x		x		x	
TOTAL	14	8	10	6	3	15	16	15

Feasibility analysis

Transferability to other region

Transferability of the method to other region	Number of methodologies	Number of methodologies interested to participate	Number of groups interested to participate
Yes	21	17	15
No	2	1	1
No answer	2	2	2
Total	25	20	18

Applicability to synthetic datasets

Transferability of the method to synthetic datasets	Number of methodologies	Number of methodologies interested to participate	Number of groups interested to participate
Yes	16	14	12
No	6	3	3
No answer	3	3	3
Total	25	20	18

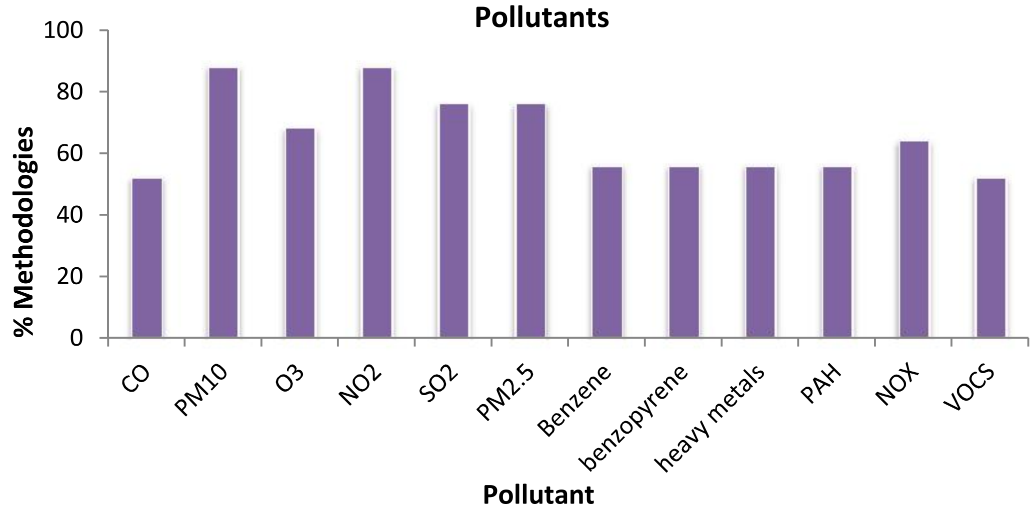
Feasibility analysis

Limitations :

Pollutants requirements.

- Most methods announced no limitations
- However others are limited to the main pollutants of the legislation such as PM_{10}, $PM_{2.5}$, SO_2, O_3 and NO_x/NO_2.

Pollutants requirements	Number of methodologies	Number of methodologies interested to participate	Number of groups interested to participate
No limitation	15	13	12
Limited	4	4	3
No answer	6	3	3
Total	25	20	18

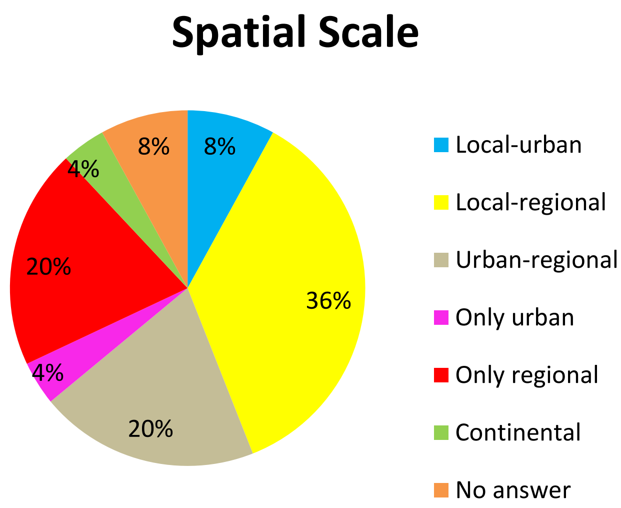


Feasibility analysis

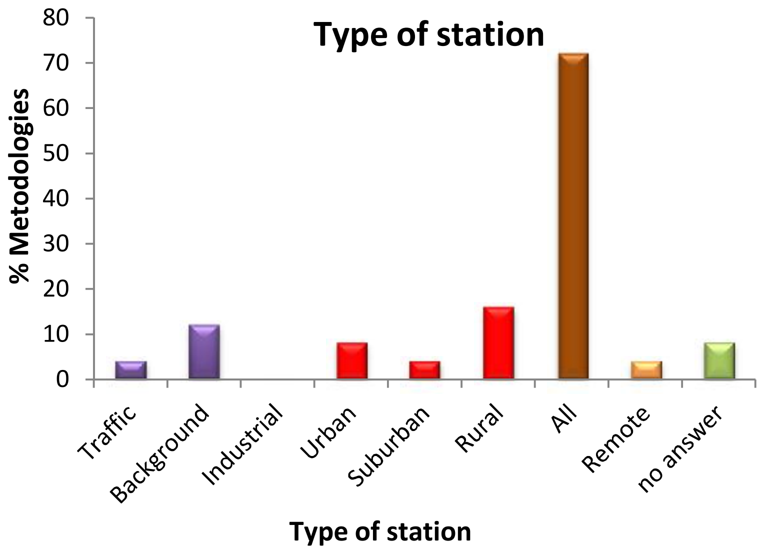
Limitations :

Site requirements.

- Two main scales: local-urban and regional
- Type of stations: Most all types, several groups note limitations.

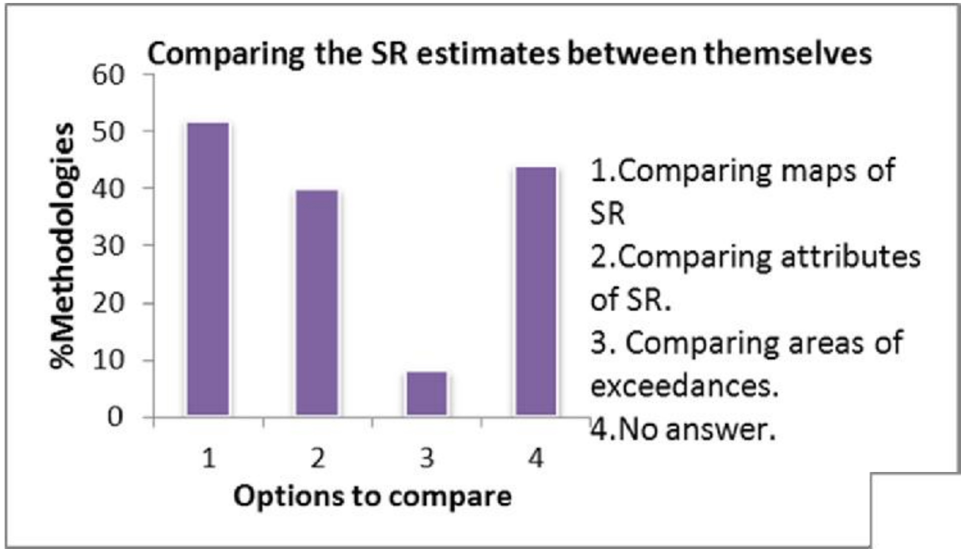


Site requirements	Number of Methodologies	Number of methodologies interested to participate	Number of groups interested to participate
Type of station	6	5	5
Type of area	4	3	2
Extent of the domain	5	5	5
Others	1	0	0
No limitation	5	5	5
No answer	9	6	6



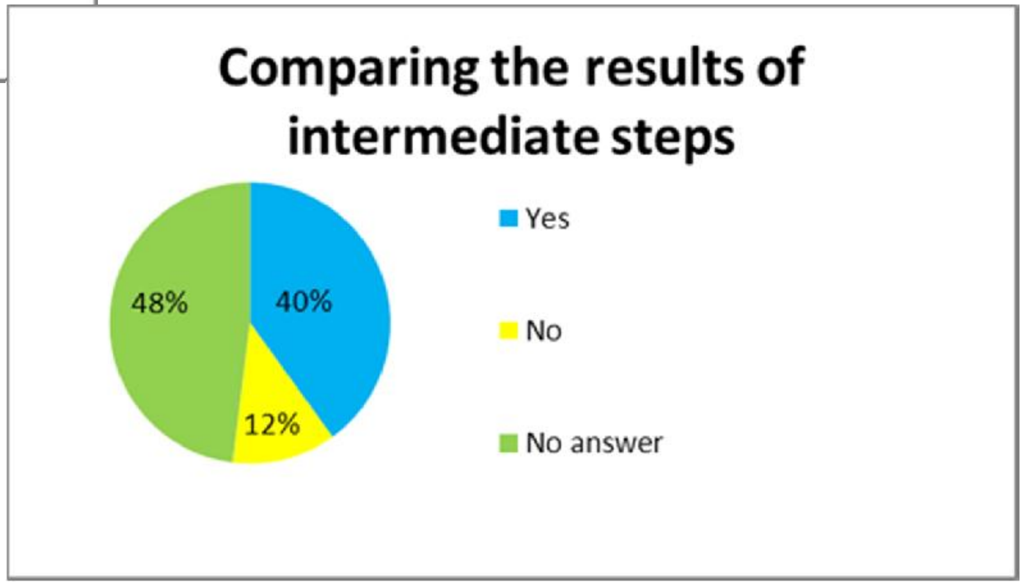
Feasibility analysis

- **How to compare outputs?**



- Several participants suggested the comparison with a unified reference of SR.
- But many highlighted that **there is no unified reference.**
- **To compare the extent of variation of SR estimates without the necessity of a reference.**

A few participants proposed a **sensitivity analysis** for the threshold parameter defining the extent of the area of SR.



Proposal of SR intercomparison exercise

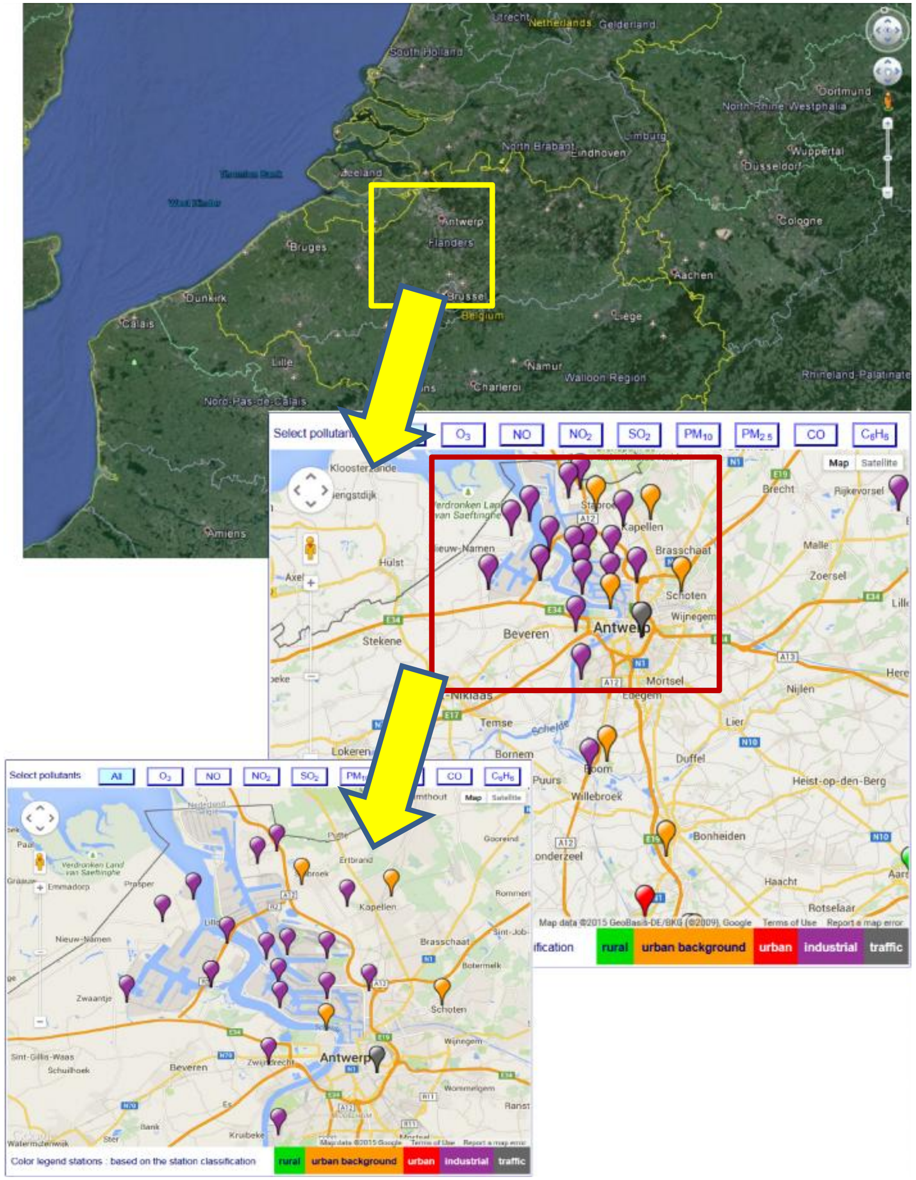
- Two spatial scales: the **local scale** and the **urban/regional scale**.
- SR for **NO_2 and PM_{10} at local scale** and for **NO_2, O_3 and PM_{10} at urban/regional** scale.
- Based on **annual metrics of concentrations** (averages or percentiles from daily or hourly values).
- Regarding inputs requirements:
  - Air quality monitoring data,
  - Data from sampling campaigns,
  - Data from air quality modelling,
  - Emission inventories,
  - Meteorological and/or climatological data
  - Other surrogate data (land use/cover, traffic intensities, population density, building geometries , etc) .
- Outputs to compare should be:
  - SR maps (contour maps),
  - dimensions of the SR (areas, radii) and
  - concentration fields (when possible).
- The exercise can be done at least for **one traffic and two background stations** covering both scales (local and urban/regional).

Proposal of SR intercomparison exercise

- Two types of comparison of the results:
  - **To compare outputs from all methodologies** in order to have more information about the variability in the SR estimates from the range of applied methodologies.
  - **To compare outputs from methodologies with the same definitions** within subgroups
- One possible **limitation** will be **how to compare the qualitative outputs from those participants to the quantitative information provided by the majority.** For these cases, we could analyse whether qualitative descriptions are compatible with quantitative results of more complex methodologies.
- **A sensitivity analysis of criteria for SR computations** (e.g. influence of concentration threshold on SR maps). Voluntary.
- Some few participants would be interested in **comparing estimates of the classification of stations** for the methodologies able to produce a station classification.

Antwerp Datasets

- Data from monitoring networks (urban background, industrial, traffic stations).
- 341 virtual stations mimic the measurements by diffusive samplers with 14-day time average..
- Modelling data for urban and regional scales.
- High spatial (street-level) and temporal (hourly) resolution
- Main pollutants (PM_{10}, Ozone and NO_2).
- Local/urban scale.
- Other data can be provided:
  - Point, line and surface emission sources from industry, traffic and domestic heating,
  - building geometry
  - meteorological data (temperature, wind speed and direction)
  - population density



For more information about the FAIRMODE Spatial representativeness feasibility study:

Martin F., J.L. Santiago, O. Kracht, L. García, M. Gerboles (2015): FAIRMODE Spatial representativeness feasibility study. Report number: Report EUR 27385 EN, Affiliation: European Commission Joint Research Centre Institute for Environment and Sustainability

For more information about the exercise,
visit http://fairmode.jrc.ec.europa.eu/cca.html
or contact Michel Gerboles (michel.gerboles@jrc.ec.europa.eu)

Thank you