FAIRMODE Spatial representativeness feasibility study:

State of the art

Questionnaire design and replies

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Outline

- Introduction
- **State of the art**
- **Questionnaire design and replies**
- Feasibility analysis
- Comments and discussion

Scope of the feasibility study

- To prepare and evaluate the feasibility of the actual methodological intercomparison study.
- Identification of :
  - candidate methodologies,
  - requirements on shared datasets,
- Assessment 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

- Compiled more than 50 papers, reports and conference/ workshop presentations and posters.
- Oldest references are from 70s (Ott and Eliassen, 1973)
- SR studies are related to air quality assessment, model evaluation, station classification, combination of models and measurements, etc.

State of the art

- The basic concept of SR: determining the zone to where the information observed at the a monitoring site can be extended.
- Sometimes SR areas are defined as a **qualitative concept** based on simple geometric parameters (surface area around the station or length of a street segment or circular area) depending on the type of station.
- 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**:
  - 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 agreement on a procedure for assessing spatial representativeness has been identified 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 surrogated 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 sitting, 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**
- Intercomparison exercise:
  - Participation. **Question 8.**
  - Requirements related to the SR methodology. **Question 9.**
  - Recommendations about the type of comparison. **Question 10.**
  - Confidentiality. **Question 11.**

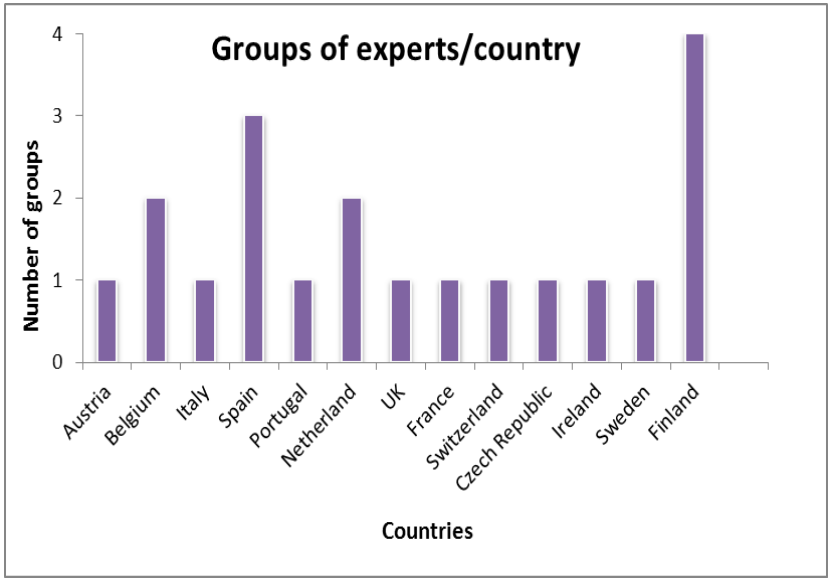
To whom questionnaire was sent?

- **Review process**:
  - Questionnaire draft sent for review and feed-back to (sent to 20 people with 7 replies):
    - FAIRMODE Steering Group members
    - Few representatives of the AQUILA-SCREAM group.
- **Survey** (launched January 2015):
  - Final version of questionnaire was sent to:
    - The complete FAIRMODE distribution list (ca 600 email contacts).
    - FAIRMODE national contact points (33 email contacts).
    - AQUILA members. (37 national air quality reference laboratories)
    - A selected group of international experts, who have been identified by the literature study (23 email contacts)
    - The group of reviewers of the questionnaire (7 email 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

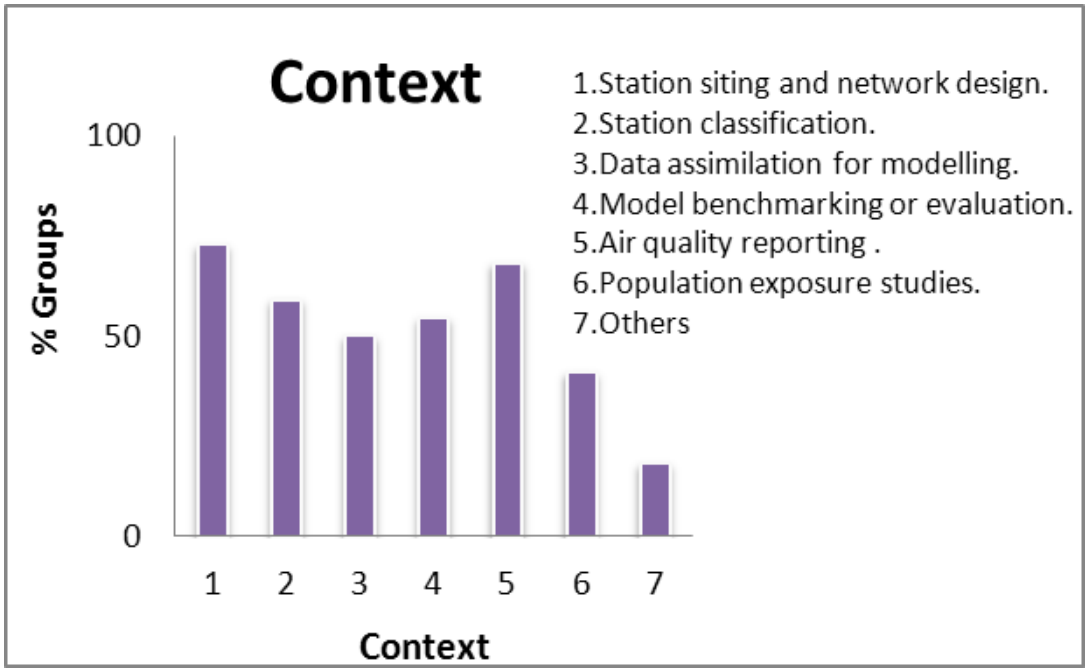
Table 1: Experts, groups and countries that replied the questionnaire.



- A total of 22 groups from 15 different countries

Results of the questionnaire

- **Question 1. Context.**



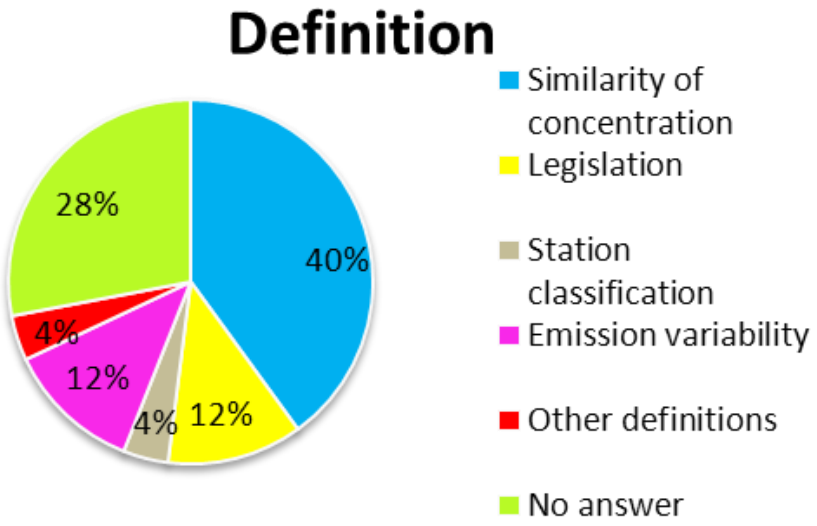
Context	Number of groups
Station siting and network design	16
Station classification	13
Data assimilation for modelling	11
Model benchmarking or evaluation	12
Air quality reporting	15
Population exposure studies	9
Others	4

  - Mostly for station sitting, network design and air quality reporting (around 70% of the groups).

- **Question 2. Regulatory purpose.**
  - The majority of groups (68%) link their SR studies to legislative or regulatory purposes .

Results of the questionnaire

- **Question 3. Definition.**



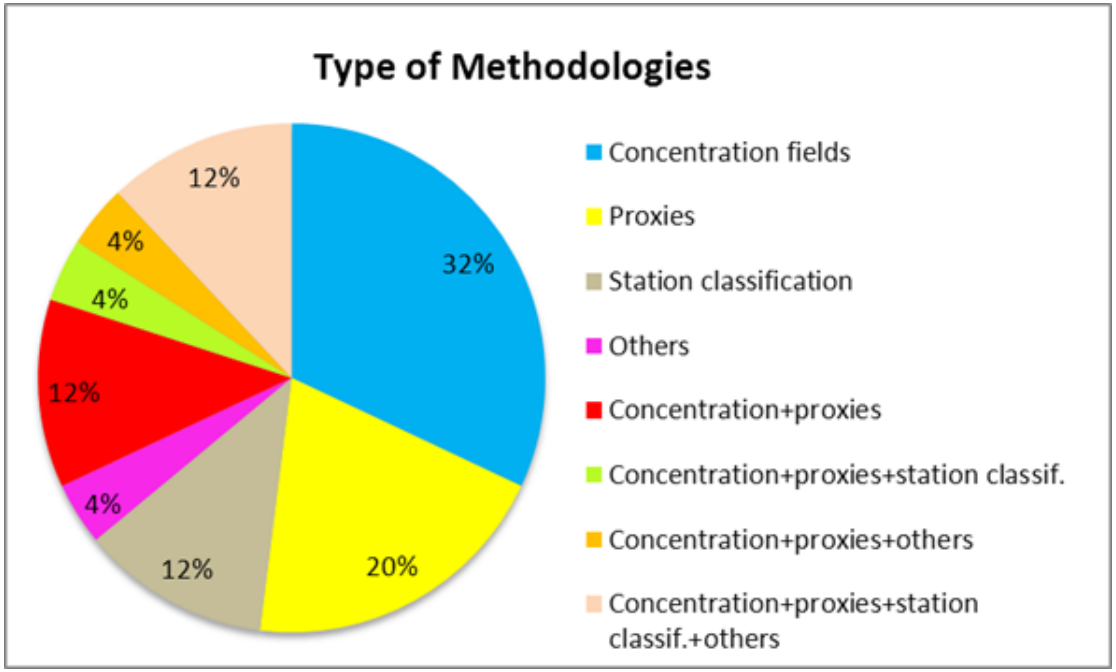
Definition	Number of Methodologies
Similarity of concentration	10
Legislation	3
Station classification	1
Emission variability	3
Other definitions	1
No answer	7
Total	**25**

  - In order to analyse the answer, we classify the definitions in 5 groups.
  - Similarity of concentration is the most used definition (40%)
  - For 28 % of methodologies, no definition was provided.

Results of the questionnaire

- **Question 4a. Type of Methodologies.**
  - i. Methods which are based on estimate 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.

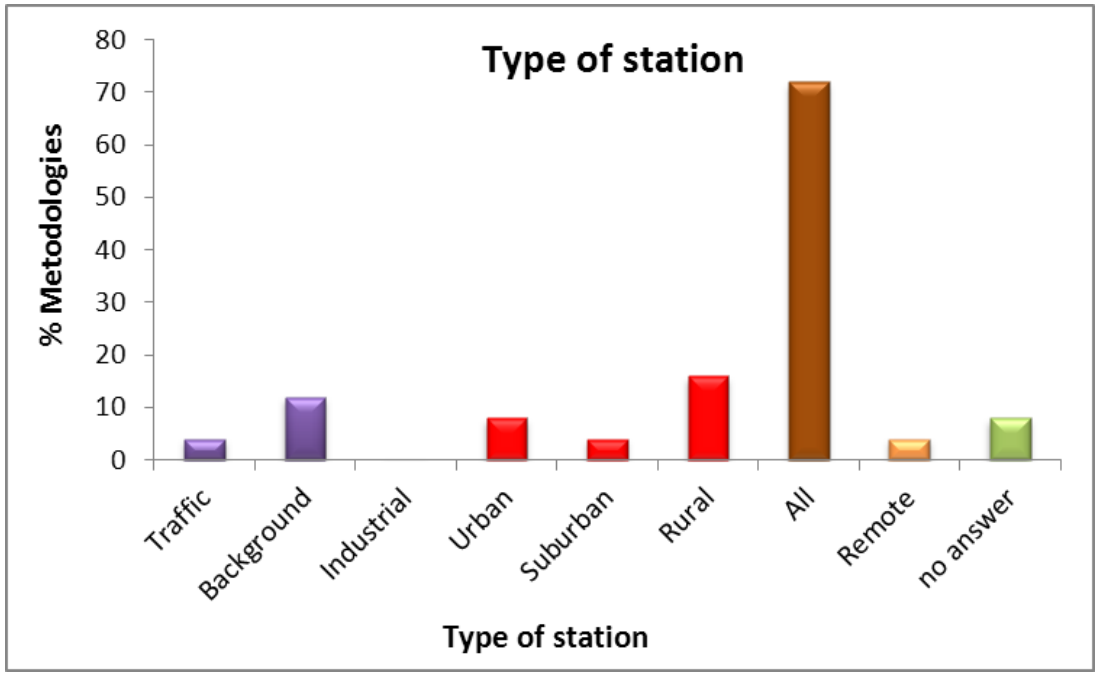
- Several groups declared their methodologies in more than one type.
- Most of the groups (16) use methodologies based totally or partially on the spatial distribution of pollutant concentrations, 8 of them are also based on other types. 13 groups use methodologies based totally or partially on proxies 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

- **Question 4b. Type of Stations.**

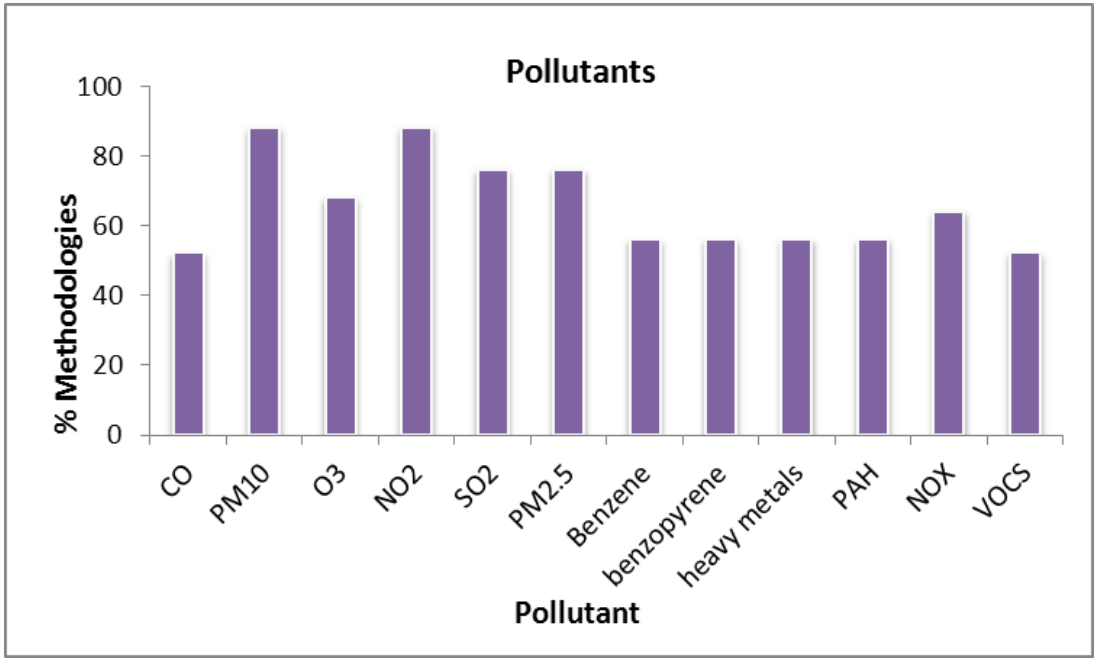


Type of station	Number of Methodologies
Traffic	1
Background	3
Industrial	0
Urban	2
Suburban	1
Rural	4
All	18
Remote	1
No answer	2

- More than 70% of the methodologies have been or could be applied to all types of stations.
- Some groups declared to apply their methodologies for two or more types of stations .

Results of the questionnaire

- **Question 4c. Main Pollutants.**

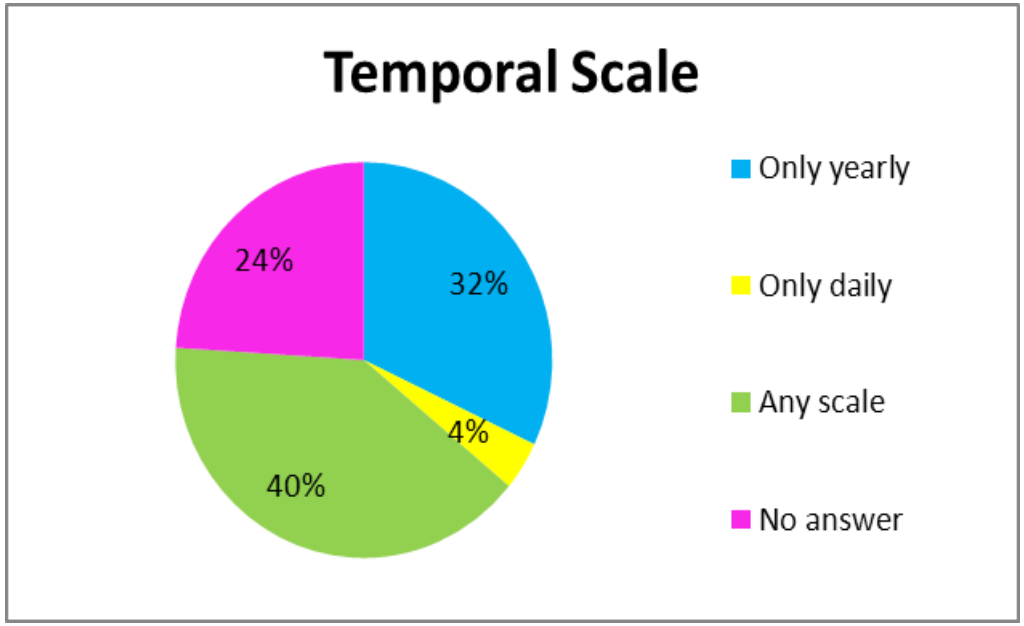


Pollutants	Number of Methodologies
CO	13
PM10	22
O3	17
NO2	22
SO2	19
PM2.5	19
Benzene	14
Benzopyrene	14
Heavy metals	14
PAH	14
NOX	16
VOCs	13

- Most of the methods can be applied to the main pollutants of the legislation.
- The more mentioned pollutants to which the methodologies have been or could be applied, are NO2 (22 out of 25), PM10 (22 methods out of 25), PM2.5 (19 out of 25), SO2 (19 out of 25) and O3 (17 out of 25).
- Some methodologies are restricted to the primary pollutants and others have no restriction about the pollutant.

Results of the questionnaire

- **Question 4d. Spatial and Temporal scale**

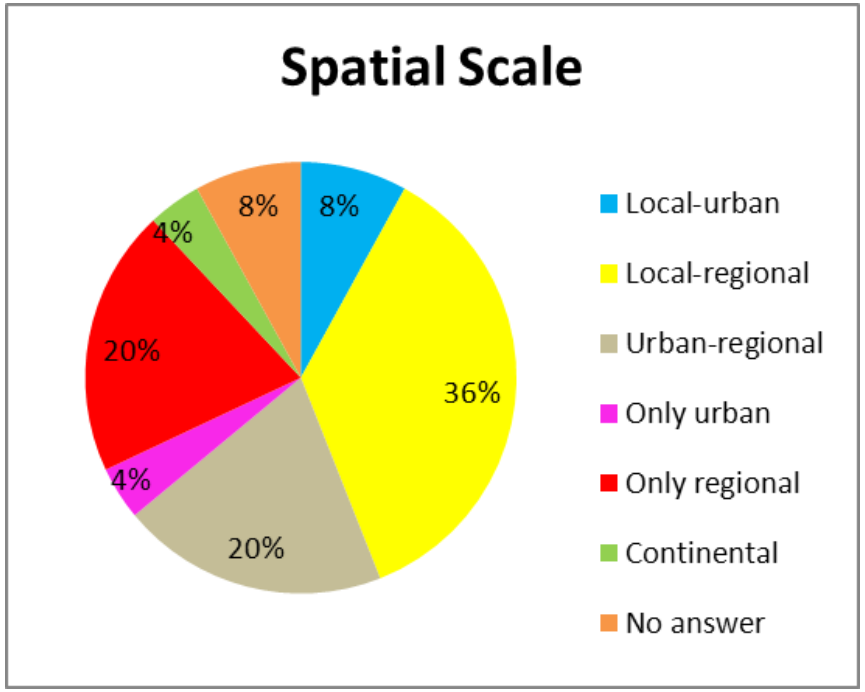


Temporal Scale	Number of Methodologies
Only yearly	8
Only daily	1
Any scale	10
No answer	6
Total	**25**

- 40% of methodologies can be applied to any scale. Others are restricted to annual (32 %) or daily (4 %) scales. Six groups (24 % of methodologies) did not answer to this question.
- Time resolution is generally limited by the resolution of the input data (measurement of pollutant concentration, emission data, etc) or the model resolution.

Results of the questionnaire

- **Question 4d. Spatial and Temporal scale**

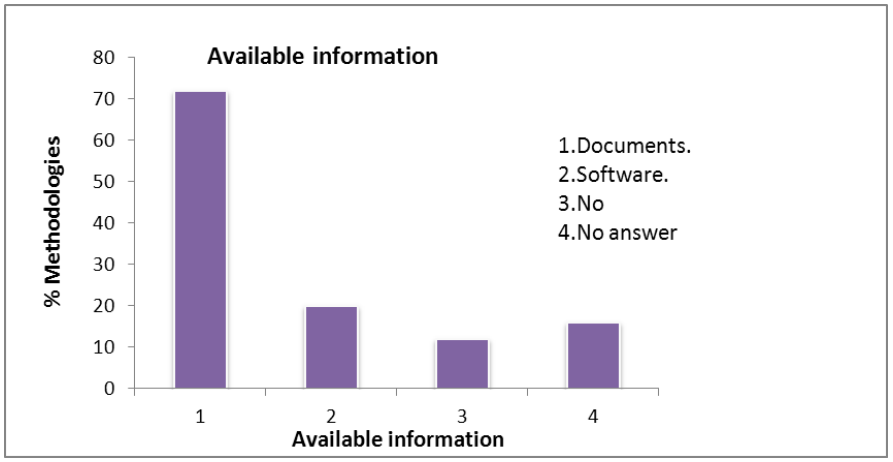


Spatial Scale	Number of Methodologies
Local-urban	2
Local-regional	9
Urban-regional	5
Only urban	1
Only regional	5
Continental	1
No answer	2
Total	**25**

- Some groups did not explicitly declare the spatial scale but it can be deduced from the information provided about the spatial resolution.
- Many groups answered that their methodologies are multi-scale. Nine methodologies can be applied to scales ranging from local to regional, 5 from urban to regional, and 2 from local to urban.
- Other methodologies can be applied only to one scale. For example, 5 of them are only for regional scale, 1 only for urban scale and 1 for continental scale. Two groups did not answer to this question.

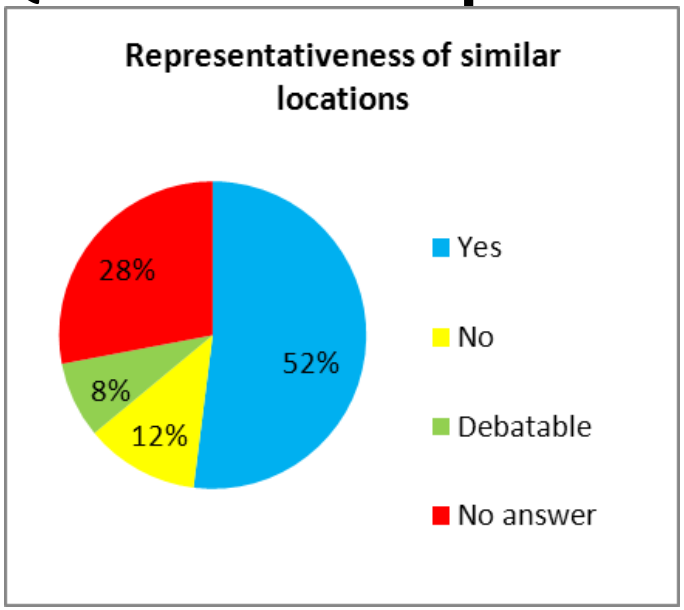
Results of the questionnaire

- **Question 4e. Available information**



Available Information	Number of Methodologies
Documents	18
Software	5
No	3
No answer	4

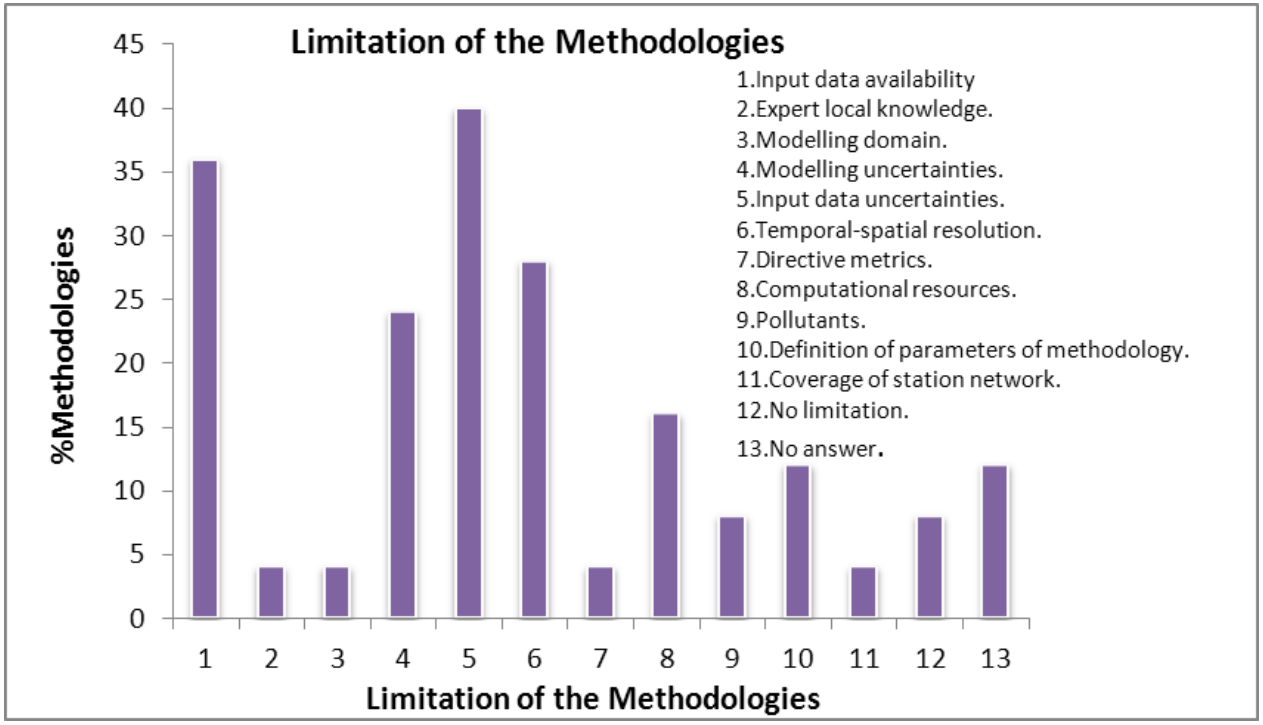
- **Question 4f. Representativeness of similar locations**



Representativeness of similar locations	Number of Methodologies
Yes	13
No	3
Debatable	2
No answer	7
Total	**25**

Results of the questionnaire

- **Question 4g. Limitations of Methodologies**

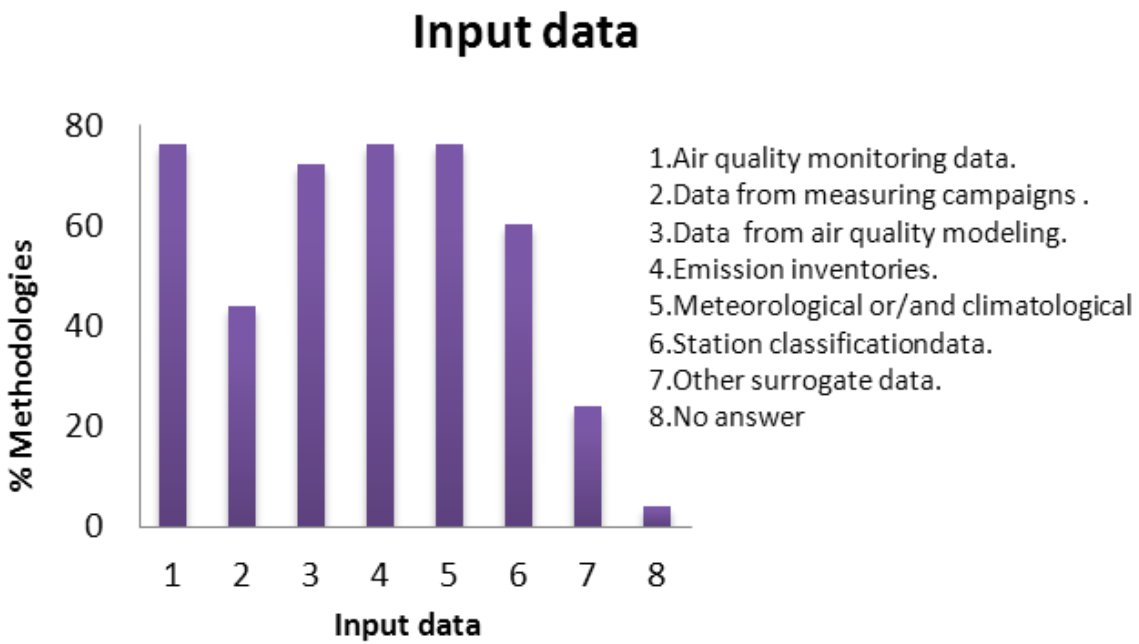


Limitation of the Methodologies	Number of Methodologies
Input data availability	9
Expert local knowledge	1
Modelling domain	1
Modelling uncertainties	6
Input data uncertainties	10
Temporal-spatial resolution	7
Directive metrics	1
Computational resources	4
Pollutants	2
Definition of parameters of methodology	3
Coverage of station network	1
No limitation	2
No answer	3

- Mostly they are limited to the availability (9) and uncertainties (10) of input data (emissions, meteorology, concentrations, land cover, traffic intensities, etc).
- Other frequent limitations were related to the modelling uncertainties (6) and the temporal and spatial resolution (7).
- Only in two cases, the groups declared not to have limitations.
- There was no feedback in three cases.

Results of the questionnaire

- **Question 5. Input Data**

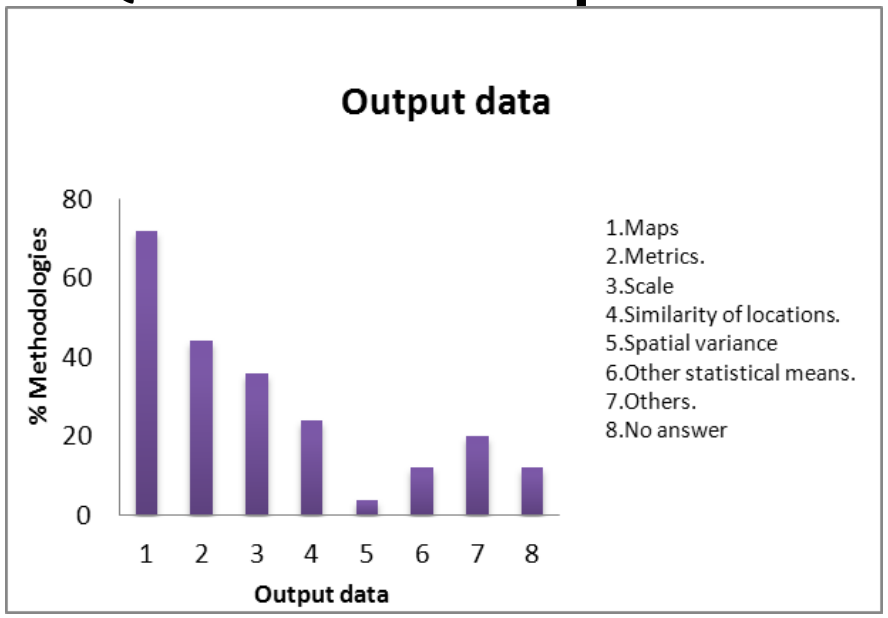


Input data	Number of Methodologies
Air quality monitoring data	19
Data from measuring campaigns	11
Data from air quality modeling	18
Emission inventories	19
Meteorological or/and climatological data	19
Other surrogate data	15
Station classification	6
No answer	1

- Most of methodologies require several types of input data.
- Some input data are used in a different way by different methodologies. For example, emission inventories are used as proxy data in some methodologies and other methodologies use them as input data for modelling.
- Mostly 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 data (15).
- This means that all of these types of data are required in order to do the intercomparison exercise. The lack of one of these input data would cause the exclusion of several methodologies.

Results of the questionnaire

- **Question 6. Output Data**

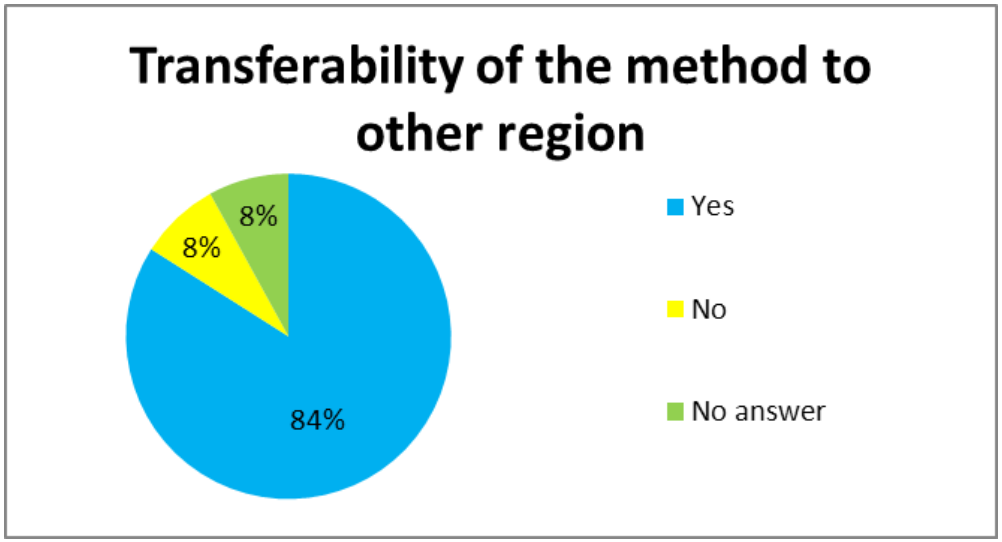


Output data	Number of Methodologies
Maps	18
Metrics	11
Scale	9
Similarity of locations	6
Spatial variance	1
Other statistics means	3
Others	5
No answer	3

- 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 only 11 and 9 of declared methodologies, respectively.
- There was no feedback for three methodologies.

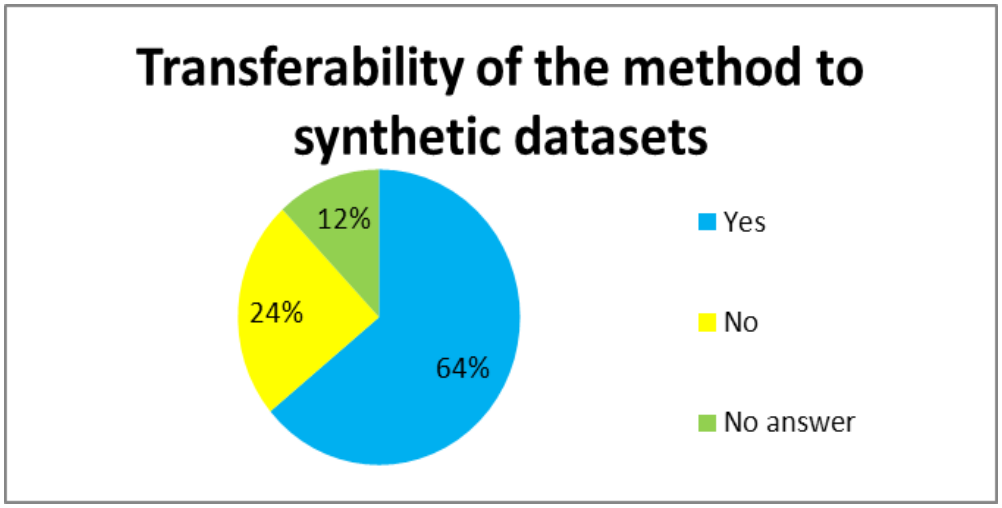
Results of the questionnaire

- **Question 7. Transferability**



Transferability of the method to other region	Number of Methodologies
Yes	21
No	2
No answer	2
Total	25

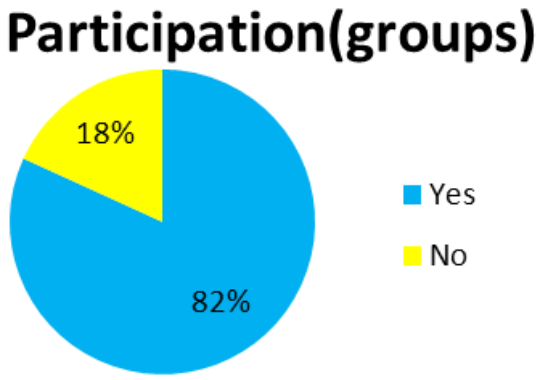
– Two participants have concerns about the limitation of their methodology to flat or homogeneous terrains. One of the groups explain that to use its methodology to other region would require a recalibration.

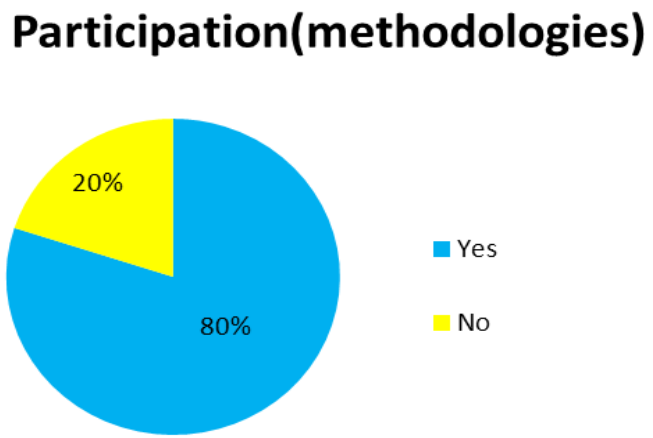


Transferability of the method to synthetic datasets	Number of Methodologies
Yes	16
No	6
No answer	3
Total	**25**

Results of the questionnaire

- **Question 8. Participation**





Participation	Number of groups
Yes	18
No	4
Total	**22**

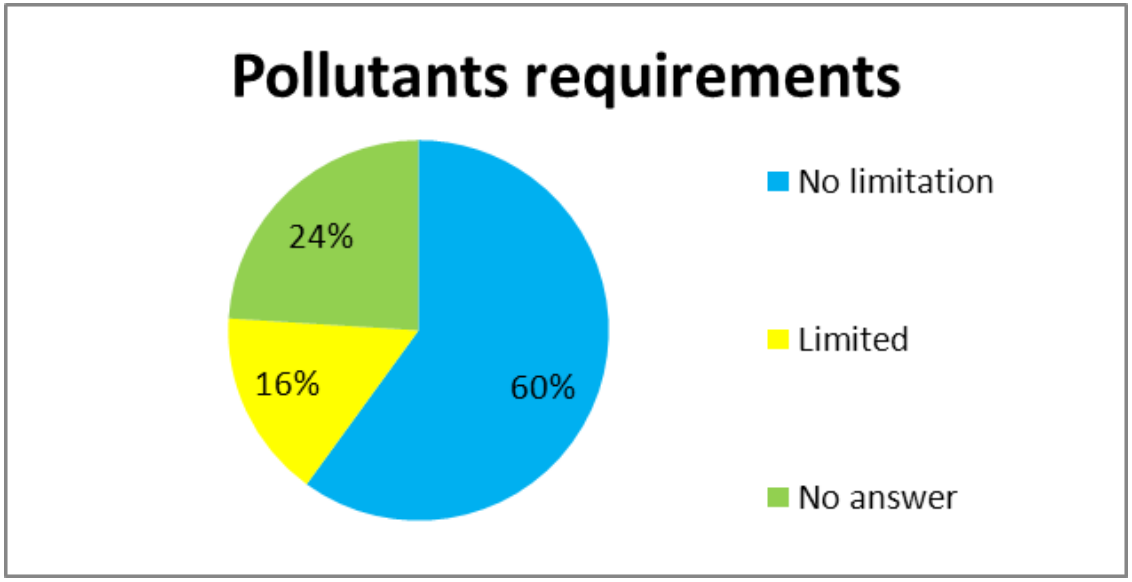
1. LANUV (Germany)
2. Umweltbundesamt (Austria)
3. TNO (Netherlands)
4. VMM (Belgium)
5. ENEA (Italy)
6. BSC (Spain)
7. University of Aveiro (Portugal)
8. IVU Umwelt GmbH (Germany)
9. RIVM (Netherlands)
10. CIEMAT (Spain)
11. Ricardo-AEA (UK)
12. INERIS (France)
13. VITO (Belgium)
14. UPM (Spain)
15. FMI (Finland)
16. Helsinki RESA (Finland)
17. Kuopio, REPS (Finland)
18. Turku /ED (Finland)

Participation	Number of Methodologies
Yes	20
No	5
Total	25

– Concerning the **time schedule**, the **first half** of year **2016** is convenient for all of the groups interested to participate.

Results of the questionnaire

- **Question 9a. Pollutant requirements**

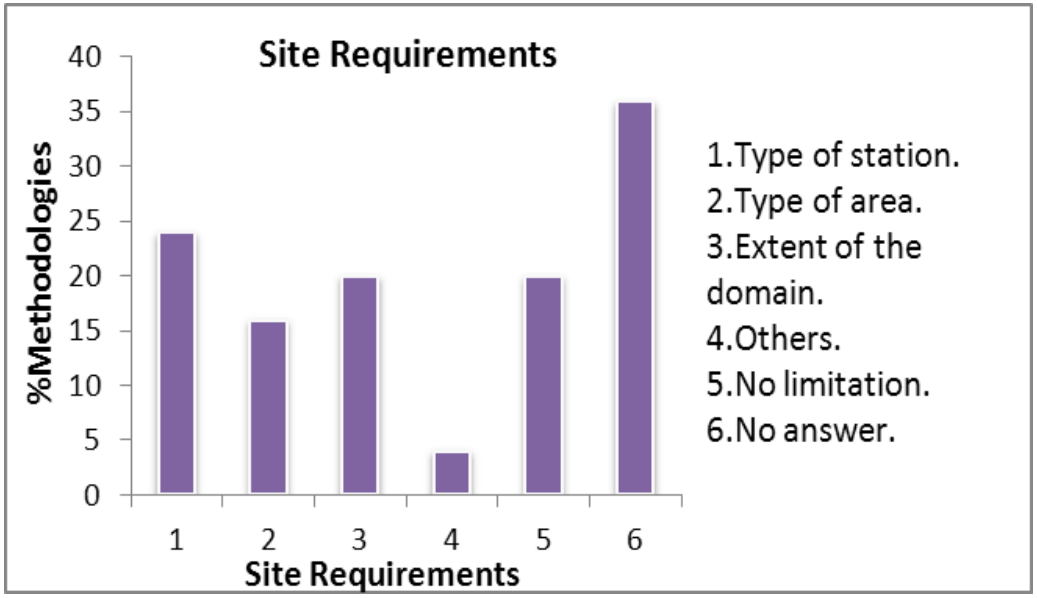


Pollutants requirements	Number of Methodologies
No limitation	15
Limited	4
No answer	6
Total	25

- No limitations about pollutants have been declared for most the methodologies (15).
- Four methodologies have limited to some specific pollutants (primary pollutants or NO2, PM10, O3 or PM2.5).

Results of the questionnaire

- **Question 9b. Site requirements**

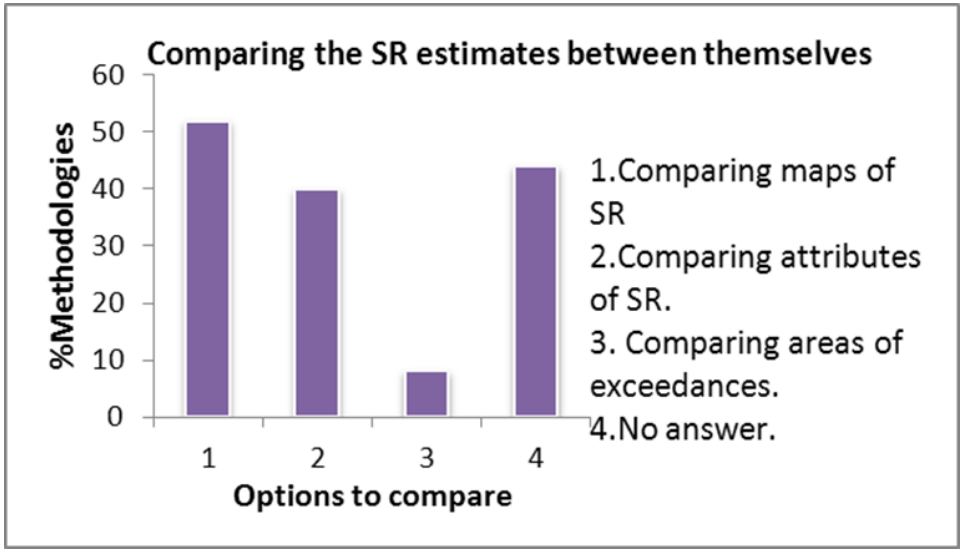


Site requirements	Number of Methodologies
Type of station	6
Type of area	4
Extent of the domain	5
Others	1
No limitation	5
No answer	9

- No limitations for 5 methodologies.
- 6 methodologies limited to the type of the stations.
- 5 are limited to the extent of domain.
- 4 are limited to the type of area.
- Some comments are related to limitations to spatial scale, model resolution and type of terrain.

Results of the questionnaire

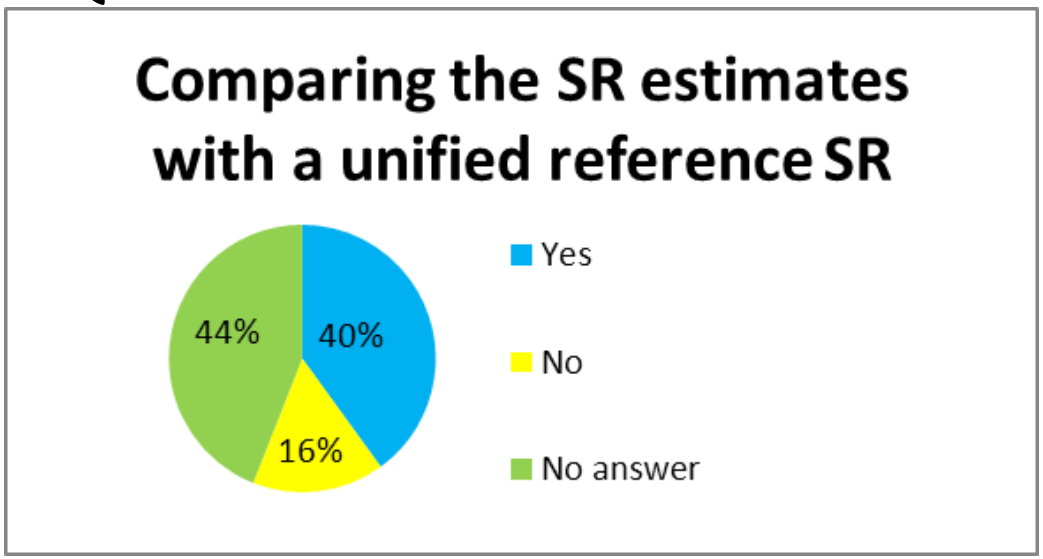
- **Question 10. Recommendations**



Comparing the SR estimates between themselves	Number of Methodologies
Comparing maps of SR	13
Comparing attributes of SR	10
Comparing areas of exceedances	2
No answer	11

Results of the questionnaire

- **Question 10. Recommendations**

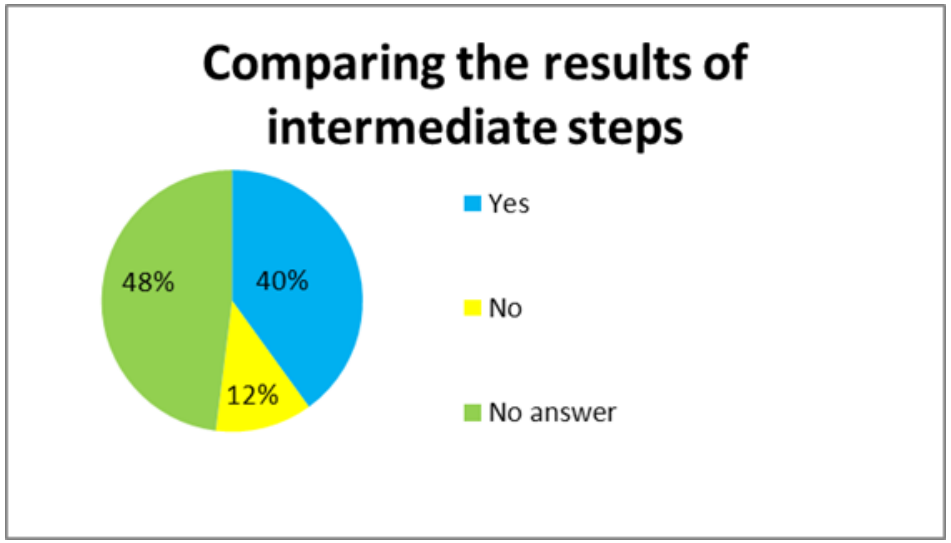


Comparing the SR estimates with a unified reference SR	Number of Methodologies
Yes	10
No	4
No answer	11
Total	**25**

  - Comments:
    - Several participants highlighted that there is no unified reference SR to compare but it should be useful to intercompare among the results from different types of methodologies.
    - One participant: The need of an agreement on the “unified standard SR” prior to the exercise and that “such comparison is then only possible – and easily performed – if the candidate SR follows the same definitions concerning time scale, metrics and parameters considered for SR as the reference SR”.
    - One participant: “discuss the criteria used to obtain SR from the concentration map (or from surrogated variables) related with the purpose of the study of SR”.

Results of the questionnaire

- **Question 10. Recommendations**

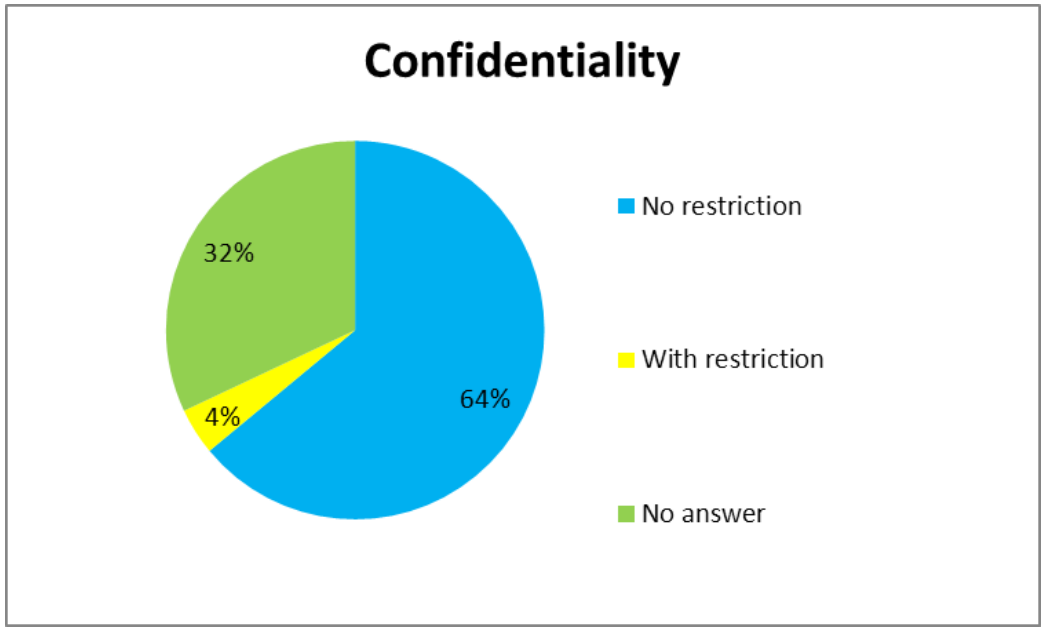


Comparing the results of intermediate steps	Number of Methodologies
Yes	10
No	3
No answer	12
Total	**25**

  - Many participants considered it useful to compare results (as modeling concentration maps or emission maps) of intermediate steps (10 cases).
  - Comment about the main focus of the exercise should be put on the SR assessment methodologies, the sensitivity of the results depending on the input data and their quality.

Results of the questionnaire

- **Question 11. Confidetiality**



Confidentiality	Number of Methodologies
No restriction	16
With restriction	1
No answer	8
Total	25

– Most participants prefer full transparency.

Feedbacks from Review Process

- Feedback from 7 reviewers.
- Two of them also sent the filled questionnaire.
- Main comments and suggestions about the questionnaire:
  - To focus strictly on spatial representativeness leaving out other aspects as station classification.
  - No changes in the main structure.
  - Some small changes to clarify questions and preselected answers.
- Some suggestions about how to carry out the intercomparison exercise:
  - Need of a previous agreement on SR definition taking into account time scales.
  - Only compare methodologies based on same SR definition.