14th International Conference on Harmonisation
Kos Island, Greece, 2-6 October 2011

THE USE AND EVALUATION OF MULTI-POLLUTANT SOURCE APPORTIONMENT METHODOLOGIES BY EU AUTHORITIES AND RESEARCH GROUPS

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FAIRMODE
Forum for air quality modelling in Europe

Scope and objective of FAIRMODE

In view of the requirement for increased modelling use in air quality assessment, as put forward within the frame of the current Air Quality Directive (AQD) 2008/50/EC, the

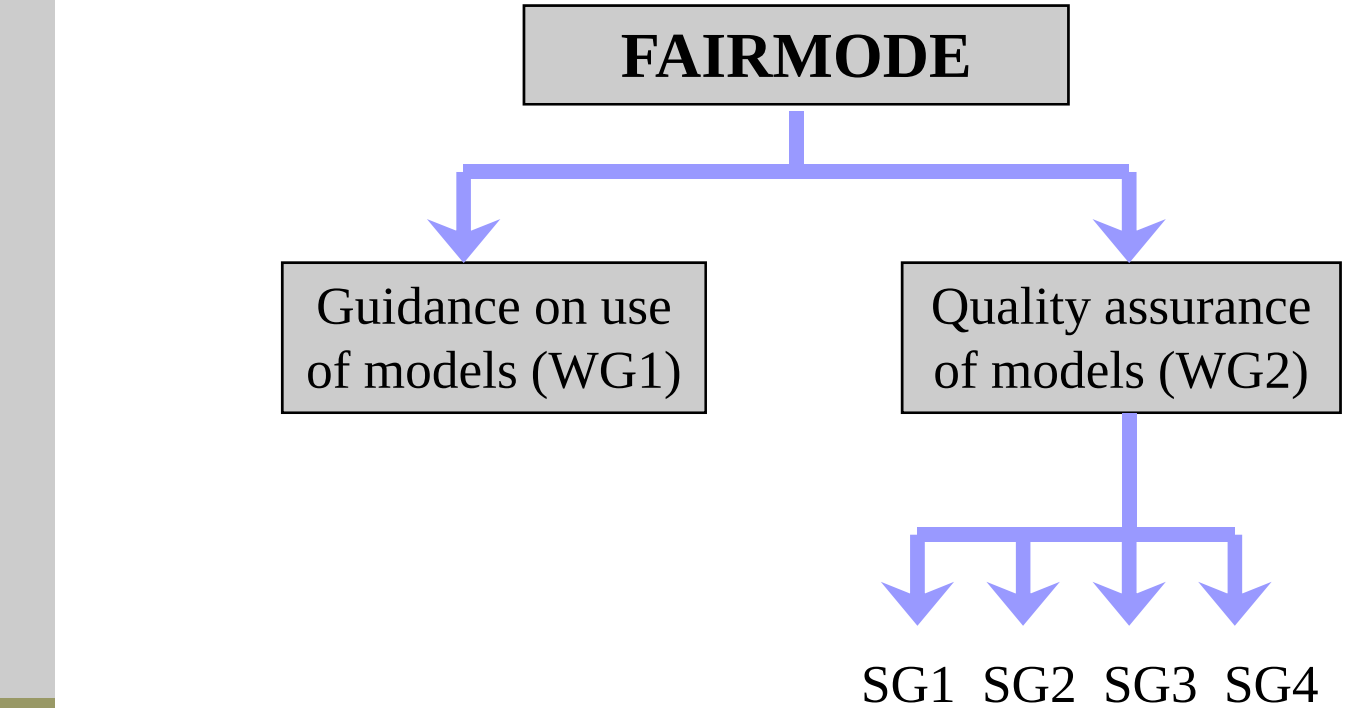
- European Environment Agency (EEA) and the
- European Commission Joint Research Centre (JRC)

set up a Forum for Air Quality Modelling.

The Forum aims generally in:

- promoting the use of these modelling tools for policy purposes in a harmonised manner between member states,
- the promotion of good modelling practices and
- the interaction between authorities and the modelling community at national and European levels.

Structure of FAIRMODE



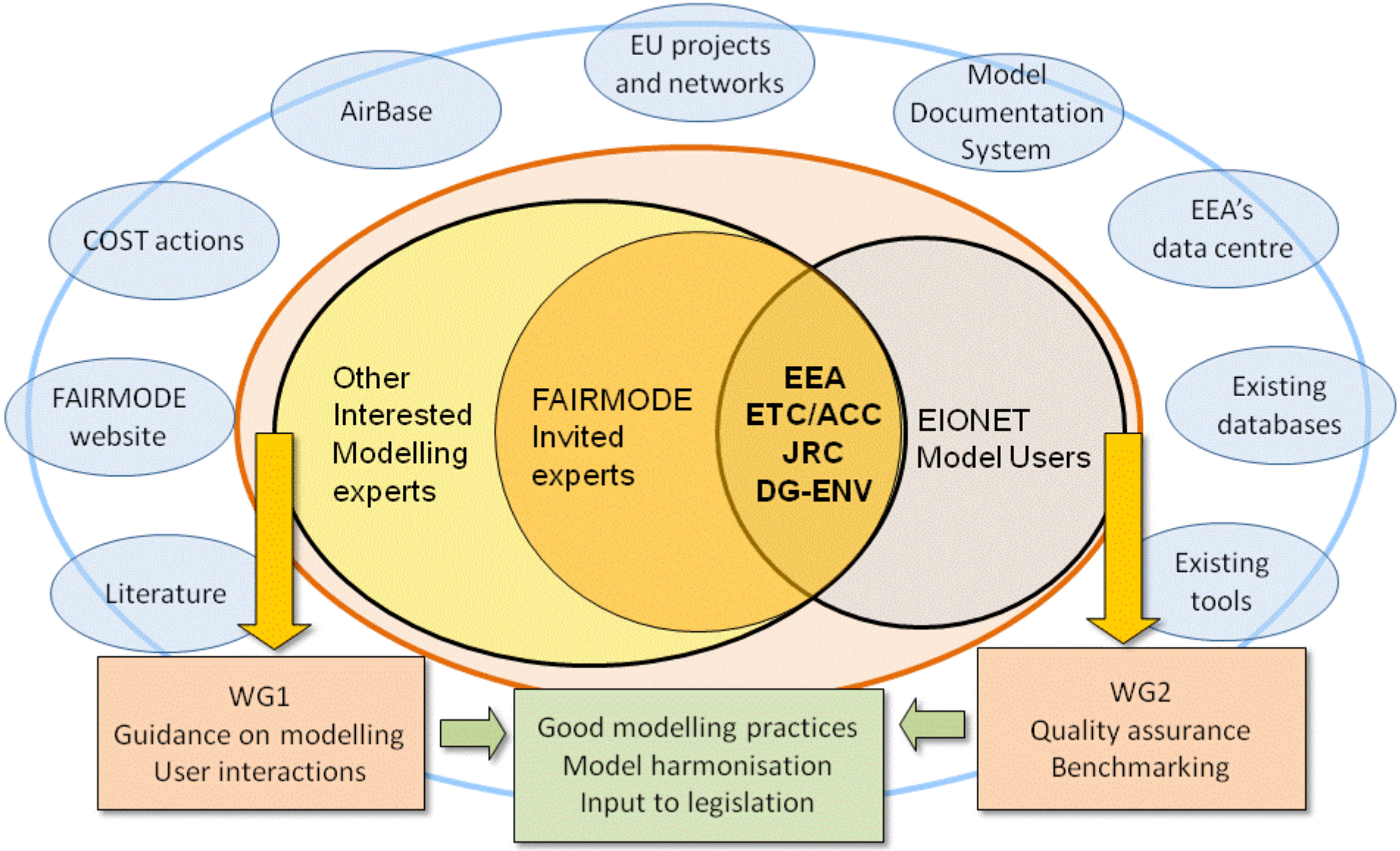
Forum for Air Quality Modelling in Europe

Work-Groups

Sub-Groups

SG1: Combined Use of Monitoring & Modelling
SG2: Contribution of Natural Sources and Source Apportionment
SG3: Emissions & Projections
SG4: Models Benchmarking

FAIRMODE


EU projects and networks
AirBase
Model Documentation System
COST actions
EEA's data centre
FAIRMODE website
Other Interested Modelling experts
FAIRMODE Invited experts
EEA
ETC/ACC
JRC
DG-ENV
EIONET Model Users
Existing databases
Literature
Existing tools
WG1
Guidance on modelling
User interactions
Good modelling practices
Model harmonisation
Input to legislation
WG2
Quality assurance
Benchmarking

Source apportionment in the AQD

- Source apportionment studies include assessing the contribution from **local sources** as well as from **natural sources**, **neighbouring countries** and the contribution from **resuspended road sand** and **salt**.
- **AQD**: possibility to discount natural sources and long-range transport of pollution and resuspension attributable to winter sanding-salting of roads when assessing compliance against limit values.
- Although not explicitly mentioned in the AQD, modelling is necessary for this purpose as monitoring of these contributions everywhere in a zone or agglomeration would be unrealistic.

SG2 of FAIRMODE

- SG2 of FAIRMODE focuses on source apportionment and the contribution of natural sources on pollutant concentrations and aims to:
  - provide useful guidance and suggest best modelling practices and quality assurance procedures for member countries.
  - promote harmonised model use for source apportionment in the EU
- **Phase 1:** Extensive review of the current status of modelling practices used for source attribution and quantification of contributions by member states to identify gaps and problems.
- **Phase 2:** Follow-up review of the current status of modelling practices used by member states for source apportionment and focusing on evaluation methods applied to validate SA results

Conclusions from Phase 1

- The review from Phase 1 confirmed the **increased use of modelling** tools for source apportionment in member states
- The analysis of the time extension reports revealed the **lack of a a uniform methodology** for source apportionment
- A lack of uncertainty estimation, evaluation of SA results solely based on traditional model validation
- Limitations regarding:
  - certain compounds not adequately quantified (e.g. biogenic secondary organic material and the nitrate component)
  - the apportionment of specific anthropogenic emission sources not sufficiently discriminated in many source apportionment studies (e.g. shipping emissions)
  - the identification of biomass combustion sources

Phase 2 – Methodology followed

- Questionnaires were prepared by FAIRMODE SG2
- The questionnaires were a "*Request for information concerning source apportionment methodologies using models in Europe*" and included questions on:
  - the type of models used for SA
  - the pollutants for which SA is performed by each member state
  - what SA methodology is used (short description and references)
  - if any evaluation of the SA methodology is performed (short description and references)
  - any issues, concerns related to SA using models, especially in regard to the EU Air Quality Directive (2008/50/EC)
  - affiliation and contact/personal details

Request for information concerning source apportionment methodologies using models in Europe: A task of SG2 (source apportionment) WG2 FAIRMODE

Question 1. What **type** of models do you use for source apportionment (tick one or more)?

Type of model	*Tick*	*Model Name/Method*
Receptor model		
Eulerian model		
Lagrangian model		
Trajectory model		
Gaussian model		
CFD model		
Combination of models		
Other		

Question 2. For which ***pollutants*** are you performing source apportionment with the use of models?

Pollutant	*Model Name/Method*
Particulate Matter	
NO_2	
O_3	
Other (please specify)	

Question 3. Are you using any method to ***evaluate*** your model results for source apportionment (e.g. intercomparison with other modelling results, comparison with measurements from sampling campaigns, other)? ***If yes***, please provide a short description below.

Question 4. Please provide a short (1 paragraph) description of your methodology for ***source apportionment*** (including references).

Question 5. Please provide a short (1 paragraph) description of your methodology for ***evaluating*** the source apportionment results from the model, if any (including references).

Question 6. What are your main ***issues***, ***concerns*** related to source apportionment using models, especially in regard to the EU Air Quality Directive (2008/50/EC)?

Question 7. Would you like to suggest ***other colleagues or contacts*** who you think would be interested and could be approached by FAIRMODE SG2?		
Name	*Organisation*	*Contact details*

Question 8. Any other comments

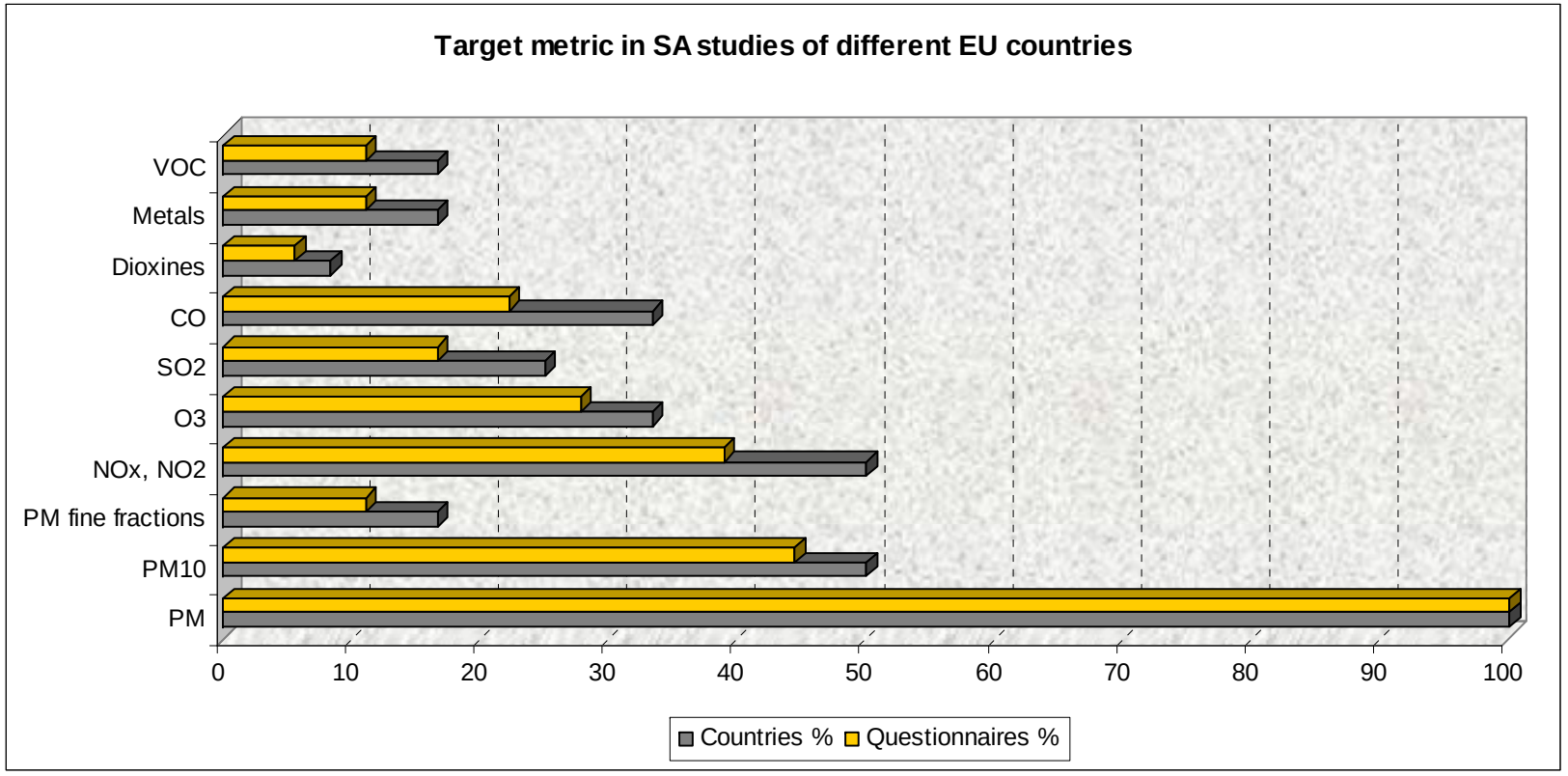
Personal details
Name and Title
Affiliation
Address
Country
Telephone
Email
Function

Thank you very much for your help!

Distribution of questionnaires and received responses

- Distribution via e-mail to:
  - **EIONET NFPs representatives** (representing **40** European countries)
  - **49 experts and regulators** who have registered their interest on SG2 activities (**17** countries).
- Universities and research institutions, regulatory bodies and environmental consulting companies were addressed.
- **18** questionnaires were returned from **12** EU countries, mostly from the Mediterranean and the Balkan regions.
- **Cyprus** (1 response), **Denmark** (1 response), **Finland** (1 response), **Germany** (1 response), **Greece** (2 responses), **Italy** (4 responses), **Lithuania** (1 response), **The Netherlands** (1 response), **Slovakia** (1 response), **Slovenia** (1 response), **Spain** (3 responses), **United Kingdom** (1 response).

Phase 2: Target metrics for SA

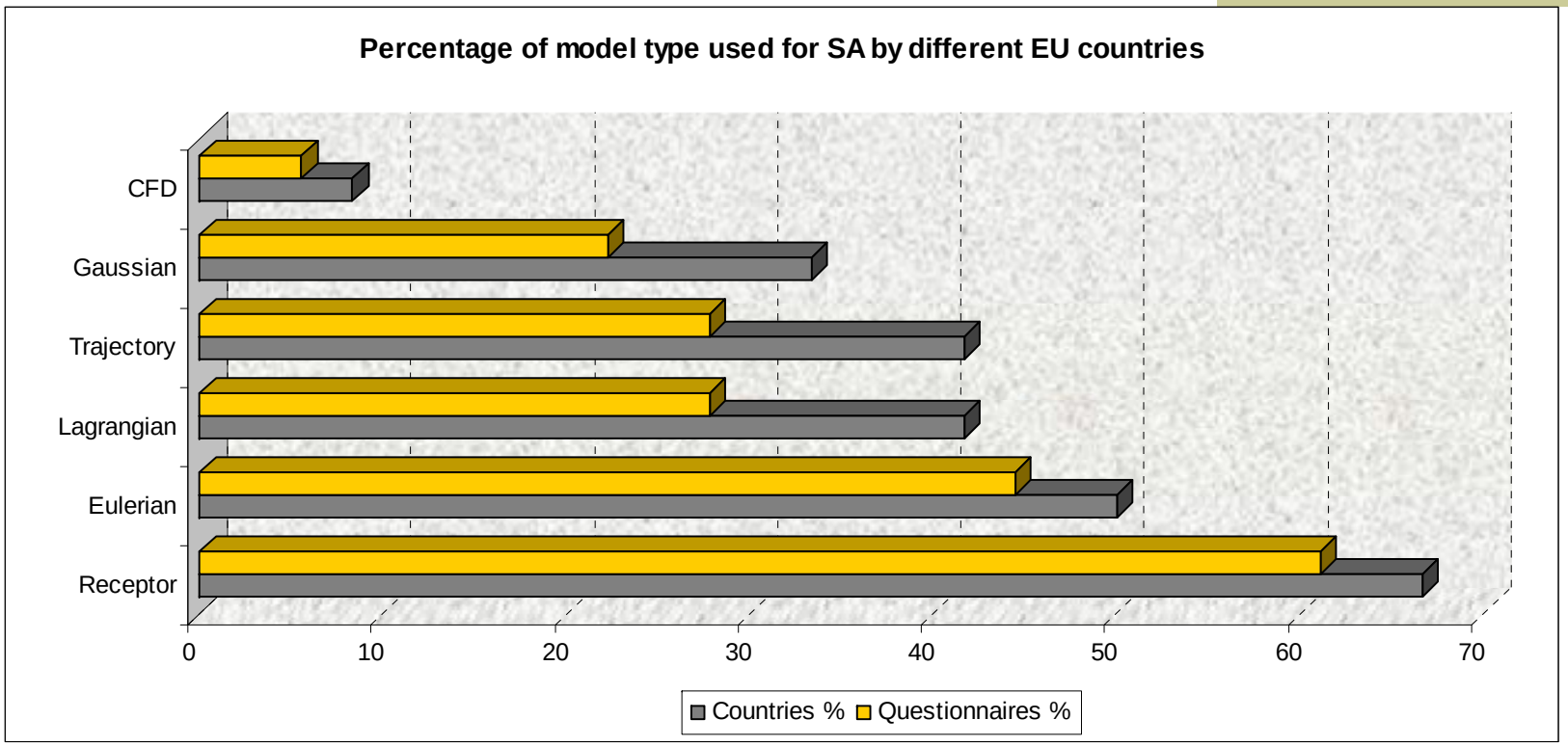


PM: 100% of the q/nairs, **PM_{10}:** 50% of the countries and 44% of the q/nairs, **PM fine fractions:** 17% of the countries, 11% of the q/nairs, **NO_x:** 50% of the countries, 39% of the q/nairs, **O_3, CO:** 33% of the countries

Phase 2 results:
Type of models used for SA

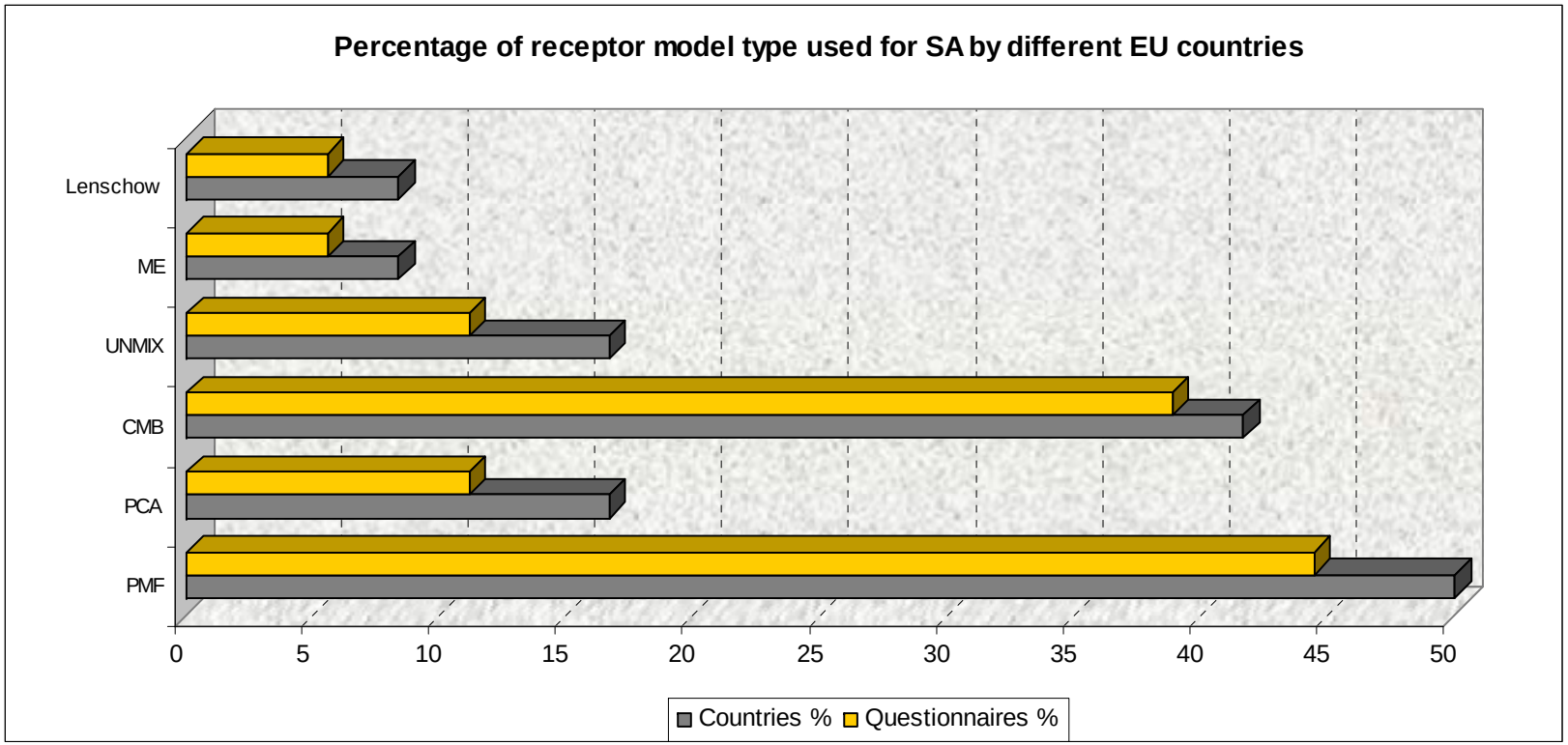
Country	Modelling Methods
Cyprus	Receptor model (PCA), Dispersion (Eulerian), Trajectory
Denmark	Receptor model (COPREM), Dispersion (Eulerian, Gaussian)
Finland	Dispersion (Eulerian-Lagrangian)
Germany	Receptor model (Lenschow, PMF), Dispersion (Lagrangian), Trajectory, CFD
Greece	Receptor model (PMF, PCA), Disperion (Eulerian), Trajectory
Greece	Receptor model (PMF, PCA), Dispersion (Eulerian)
Italy	Dispersion (Eulerian)
Italy	Receptor model (CMB)
Italy	Receptor model (PMF)
Italy	Dispersion (Eulerian)
Lithuania	Dispersion (Gaussian)
The Netherlands	Receptor model (PMF, UNMIX), Trajectory
Slovakia	Dispersion (Lagrangian)
Slovenia	Receptor model (PCA)
Spain	Dispersion (Eulerian, Lagrangian, Gaussian)
Spain	Receptor model (PCA, PMF, ME, CMB), Trajectory
Spain	Receptor model (PCA-APCS, PMF, UNMIX)
UK	Dispersion (Gaussian-Lagrangian)

Phase 2 results:
Type of models used for SA



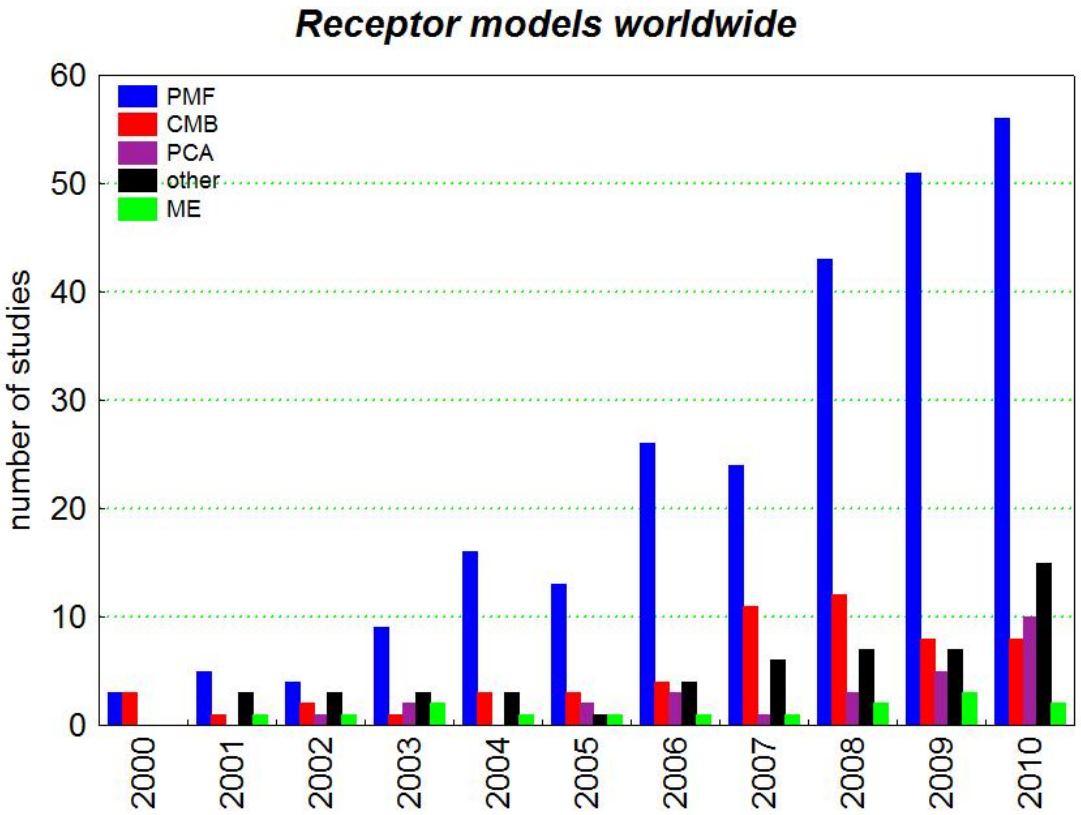
- **Dispersion models** (61% of the reported studies) and **receptor models** (61% of the reported studies) are **equally used**
- Trajectory models are less frequently used (28% of the returned forms) and always **complementary to receptor or dispersion models**.

Phase 2 results:
Type of receptor models used for SA



- **PMF** is the preferred receptor model (50% of countries, 44% of q/naires).
- The second preferred is **CMB** (42% of countries, 39% of q/nairs), followed by **PCA** and **UNMIX** (both in 17% of countries and 11% of q/naires).

The use of Receptor Models in SA (1)



Figures Claudio Belis & Federico Karagulian, 2011

- Dramatic increase in the number of publications dealing with SA and RM in scientific literature during the last decade. PMF is by far the most used tool worldwide.
- USA and South East Asia are leaders in the application of these techniques and have dedicated monitoring networks for speciated PM.
- In Europe there is an increasing interest but the lack of long term databases is limiting this development.

JRC
EUROPEAN COMMISSION

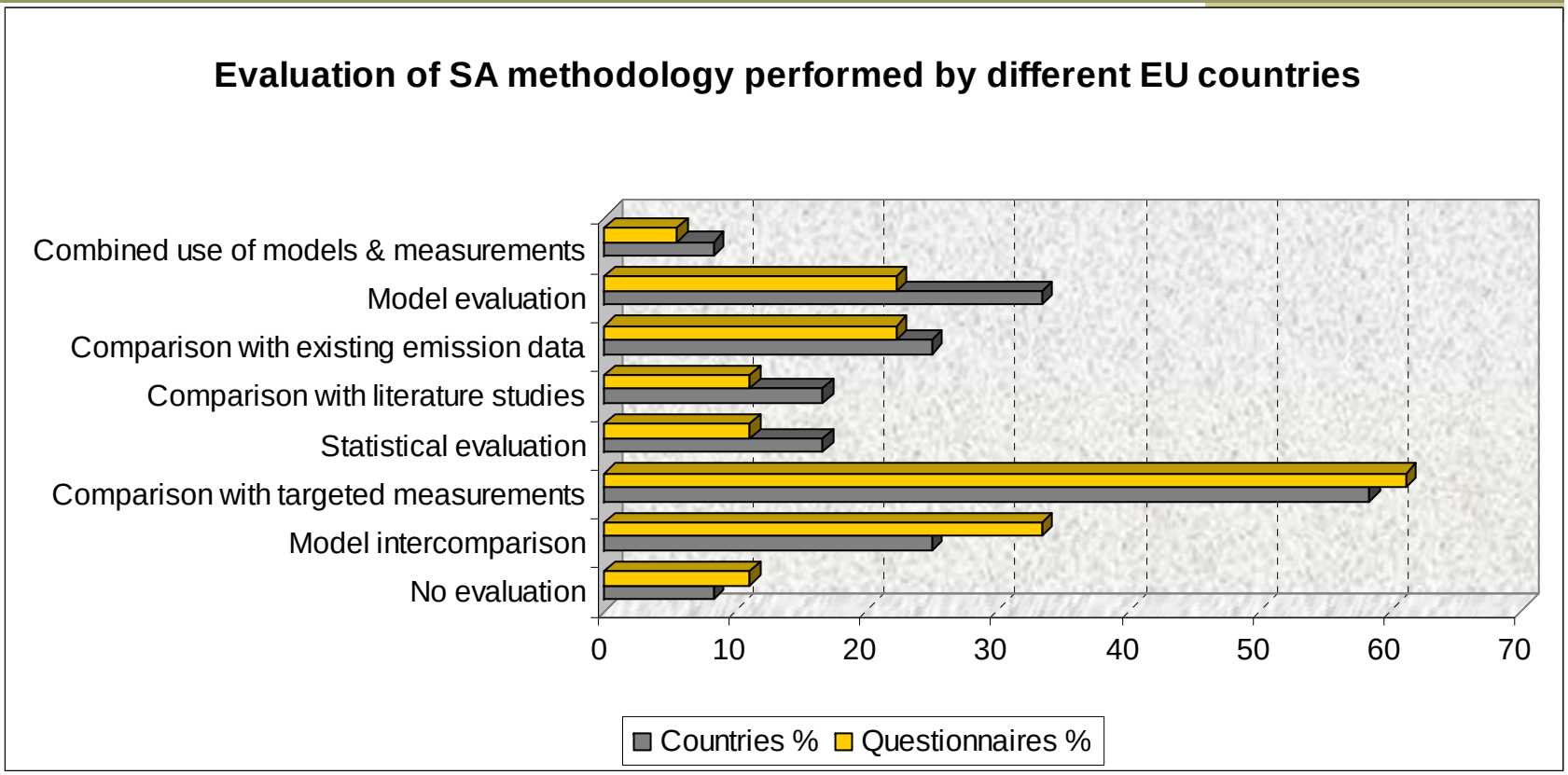
Presentation of the RM Intercomparison outline and timeline

- JRC prepared and distributed a real world database to participants (20 groups from 13 countries).
- The characteristics of the real world database, the supplementary information and the result reporting templates distributed to participants were explained.
- There will be two step procedure:
  - A progress report with the evaluation of a real world database expected by the end of 2011.
  - There will be a meeting to discuss first step and distribute an artificial database.
  - Final meeting will likely take place in June 2012.

The need for model validation

- Uncertainties in emissions and models (e.g. secondary organics, nitrate partitioning, meteorological variability)
- Models have to be assessed to ensure that they meet certain quality objectives recommended for regulatory use
- Common methodologies for model validation and evaluation:
  1. Comparison with data from dedicated monitoring campaigns to test model accuracy and representativity (monitoring data accuracy and coverage is essential)
  2. Model intercomparison studies:
     - provide useful information on model accuracy and reliability
     - reveal model limitations for specific pollutants, spatial scales and applications
     - through similar exercises, hybrid models or combined model application may emerge as innovative solutions to reduce uncertainty

Phase 2 results: SA evaluation methods used



A high percentage (89%) of reported SA studies by EU member states have evaluated their results

Phase 2 results: SA evaluation methods used

- **Comparison between model results and data** from measurement campaigns (58% of countries, 61% of studies)
- **Model intercomparison** (25% of countries, 33% of studies)
  - Greece and Spain: different receptor models were applied for SA and their results were compared.
  - Spain: results from different dispersion model types were compared to evaluate NO_2 and O_3 SA results.
  - Germany and the Netherlands: HYSPLIT back-trajectories were performed to evaluate receptor model SA results.
- **Model validation** (33% of countries, 22% of questionnaires)
  - Finland, Slovakia, Lithuania and UK: comparison and statistical evaluation of calculated pollutant concentrations against measured values
  - Spain, Italy: model sensitivity runs to evaluate dispersion model SA results for NO_x

Phase 2 results: SA evaluation methods used

- **Existing emission data and emission inventories** were used for SA evaluation in questionnaires returned by Italy, Finland and Spain (25% of studies, 22% of countries).
- **Statistical evaluation** (17% of countries and 11% of studies), **comparison with literature studies** for the area of interest (17% of countries and 11% of studies) and the **combined use of model results and meteorological observations** (8% of countries, 6% of studies)
- No particular approach for calculating **uncertainties** was reported

Phase 2 results: Points raised in responses (1)

- **Relevant to the Air Quality Directive and its requirements related to SA issues**
  - The Directive requires chemical analyses of possible indicator compounds (sodium, calcium) **only for $PM_{2.5}$**
  - The Directive puts emphasis on measurements of particulate matter mass for PM_{10} and $PM_{2.5}$, but measurements of many additional PM composition parameters are needed for realistic receptor modelling
- **Relevant to specific modelling problems**
  - PM mass underestimation by CTM models due to:
    - Lack of knowledge regarding aerosol processes
    - Underestimation of aerosol organic matter
    - Inability to realistically simulate the influence of local scale processes, particularly in urban areas
  - Models that do not account for changing source release heights across different land surfaces

Phase 2 results: Points raised in responses (2)

- **<u>Relevant to SA validation and QA/QC issues</u>**
  - Well documenteed QA/QC procedures for input data and model use are generally lacking
  - Uncertainties largely related to emission inventories (e.g. smaller industry emissions may not be well represented)
  - Variability in SA accuracy depending on the pollutant (e.g. pollutants that are more susceptible to resuspension)
  - Need for validated models that can be used by non-experts and guidance for result interpretation
  - Need for comparability among receptor modelling results (what are the causes, criteria to decide on which are more accurate)

Phase 2 results: Points raised in responses (3)

- **<u>Relevant to guidance needs and harmonisation</u>**
  - Which markers should be used for each specific source
  - What is the appropriate data size that can be used and at low cost
  - List of appropriate receptor models in relation to the AQD
  - Need for standardisation to facilitate intercomparison and to recommend best practices according to pollutants

Phase 2 results: Conclusions

- The results confirm the simultaneous use of different modelling tools and methods for SA.
- The majority of the reported studies have applied some SA evaluation methodology.
- Limited information was reported on the estimation of uncertainty and several answers have commented on the need for a guidance for SA evaluation.
- Uncertainty is in a large degree linked to the uncertainty related to input data used for the SA calculations but needs to be quantified and reported.

Thanks for your attention!

http://fairmode.ew.eea.europa.eu/