

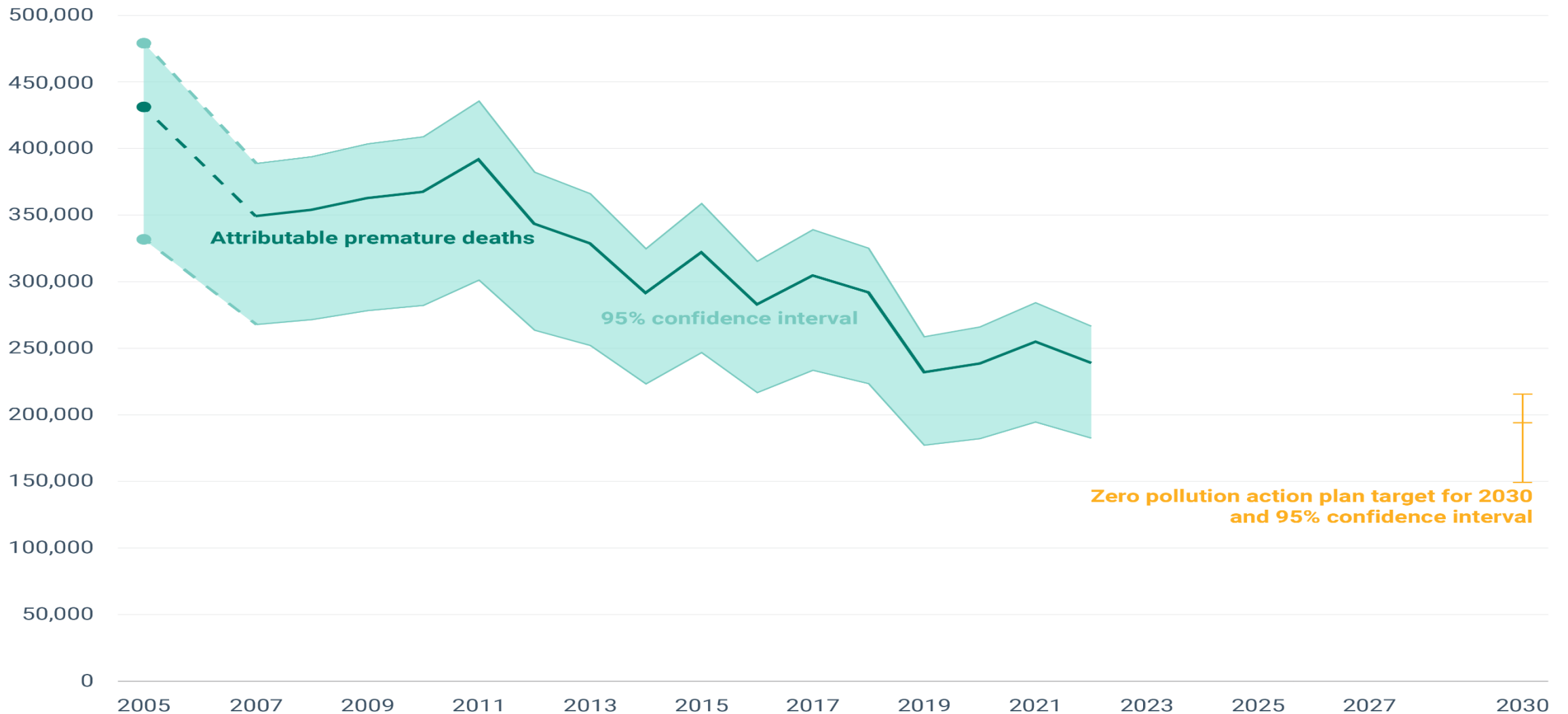
Harmonisation of air quality modelling approaches in support to legislation

The European experience

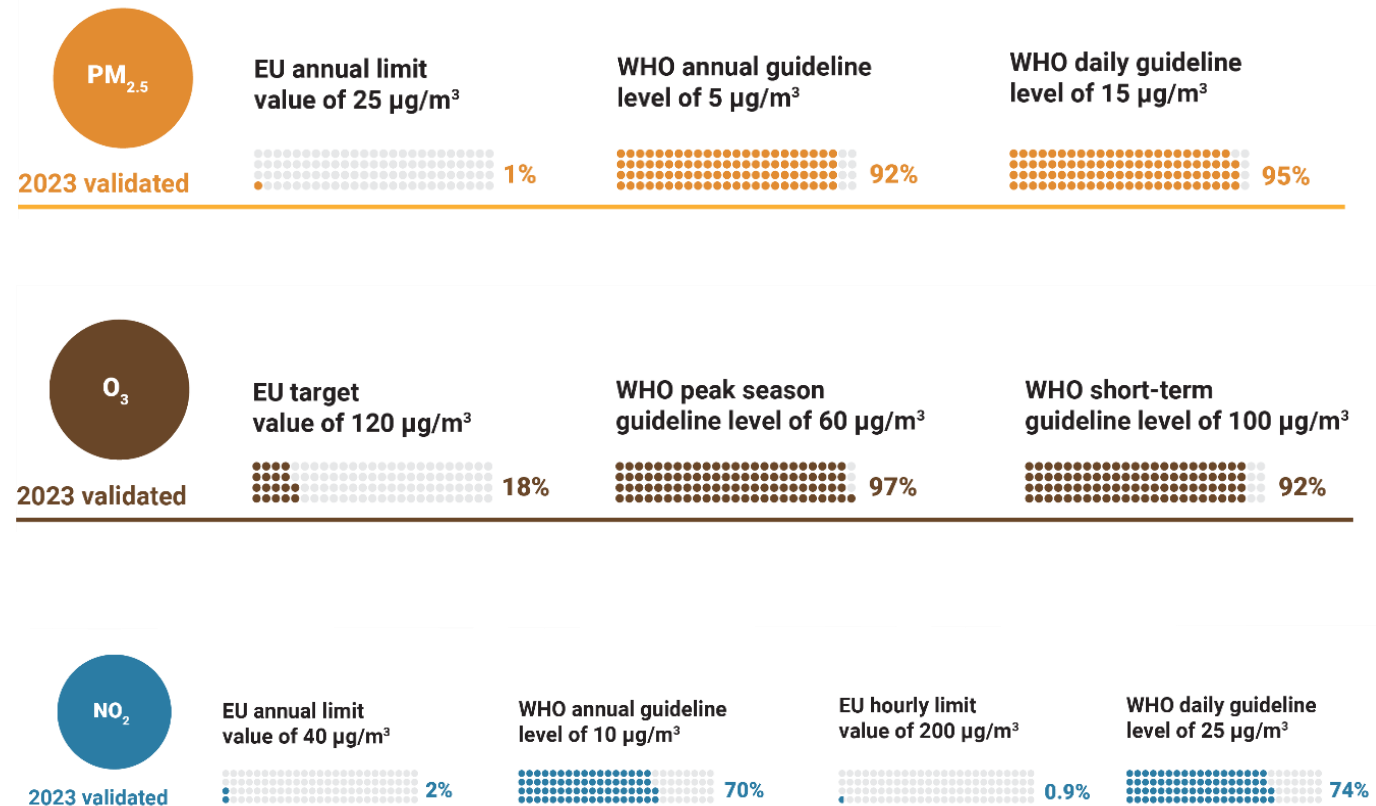
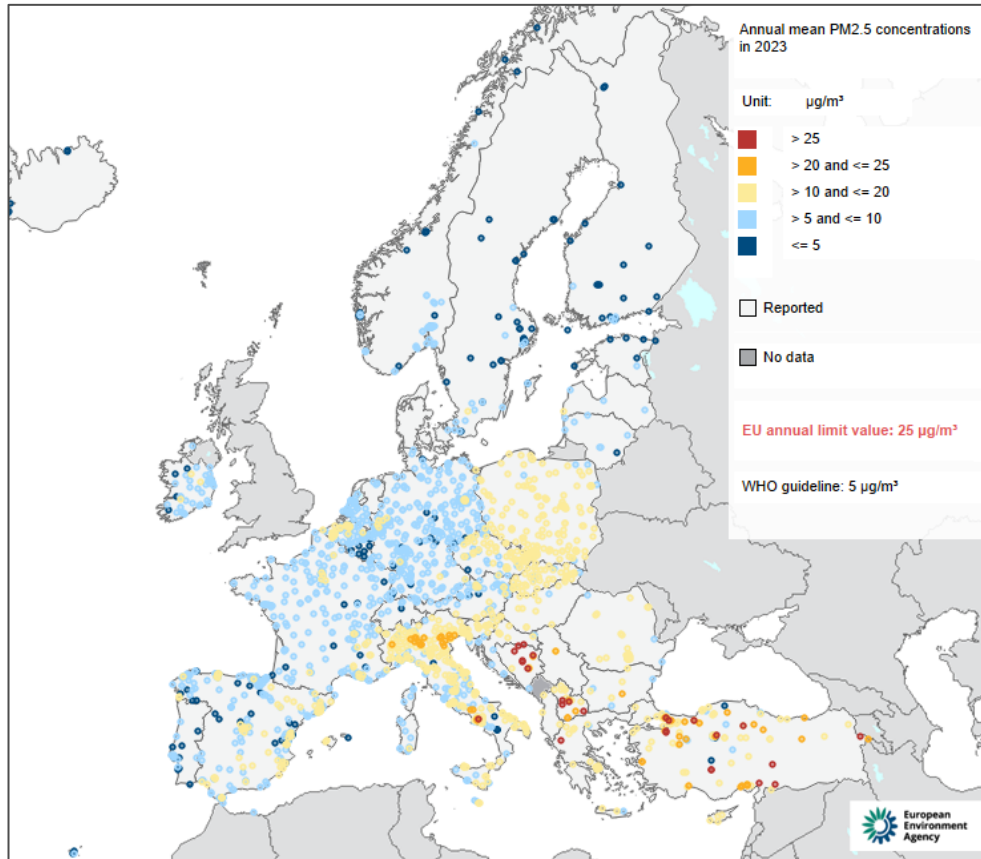
P. Thunis
CASAP 2025

Clean air policy works ... but

Number of premature deaths attributed to exposure to PM_{2.5}



Clean air policy works ... but



The Ambient Air Quality Directive

Directive 2008/50/EC

on ambient air quality and cleaner
air for Europe

As amended by **Commission
Directive (EU) 2015/1480**

Directive 2004/107/EC

relating to arsenic, cadmium,
mercury, nickel and polycyclic
aromatic hydrocarbons in ambient air

As amended by **Commission
Directive (EU) 2015/1480**

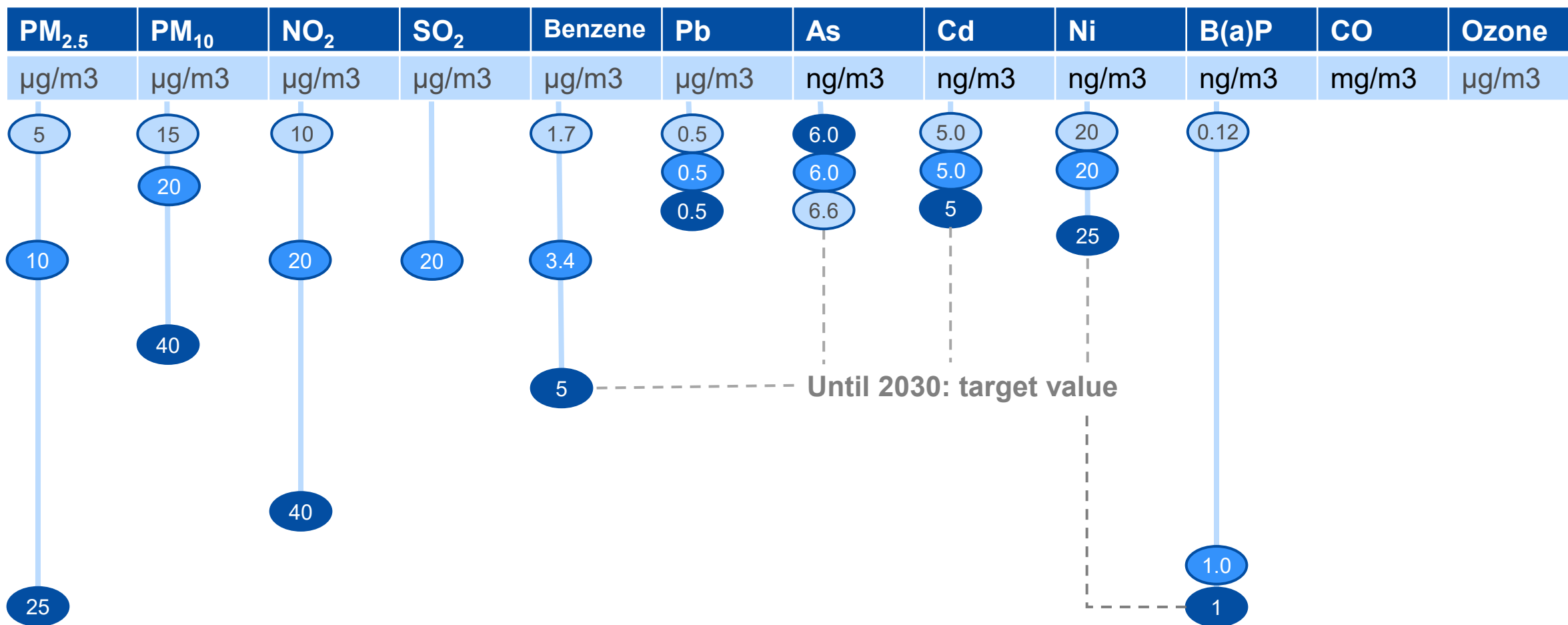
Published in Official Journal on
20 November 2024

Directive (EU) 2024/2881

on ambient air quality and cleaner
air for Europe (recast)

Member States need to
transpose this by **11 Dec 2026**

Air quality standards (annual)



x WHO guidance levels

x EU limit value as of 2030

x EU limit/target value until 2030

Role of modelling in the revised AAQD

Role for Modelling: AQ Assessment

Modelling applications provide data on distribution and levels of air quality

Role for Modelling: Spatial Represent- ativeness

Modelling applications inform spatial representativeness and network design

Role for Modelling: Forecasting

Modelling applications offer short-term projections of air quality / pollution peaks

Role for Modelling: Source Apportionment

Modelling applications assess links between emission sources and air quality

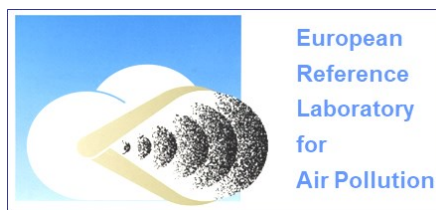
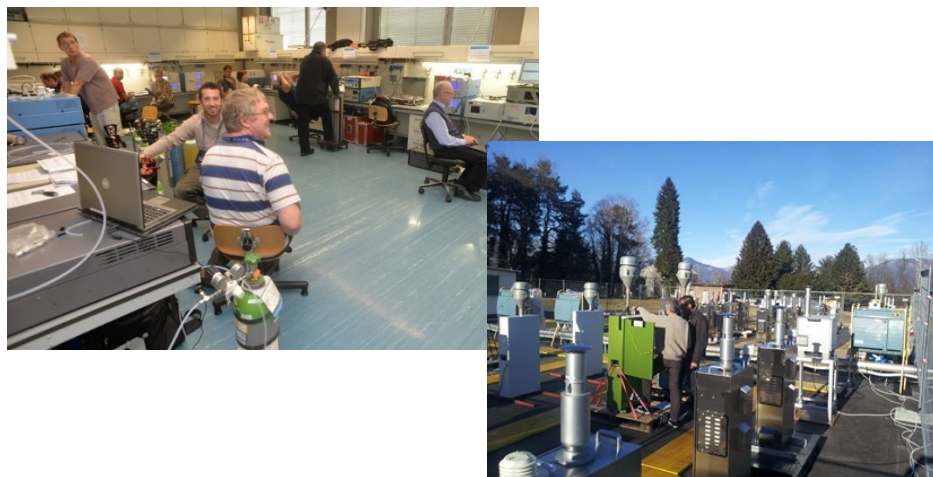
Role for Modelling AQ Planning

Modelling applications quantify the expected impact of measures

The revised AAQD includes several articles to promote and support the **harmonised use of scientifically sound air quality modelling**

Two main technical networks in support to AAQDs

Monitoring: AQUILA



Network Members: National Reference Laboratories from EU Member States

Modelling: FAIRMODE (2007)



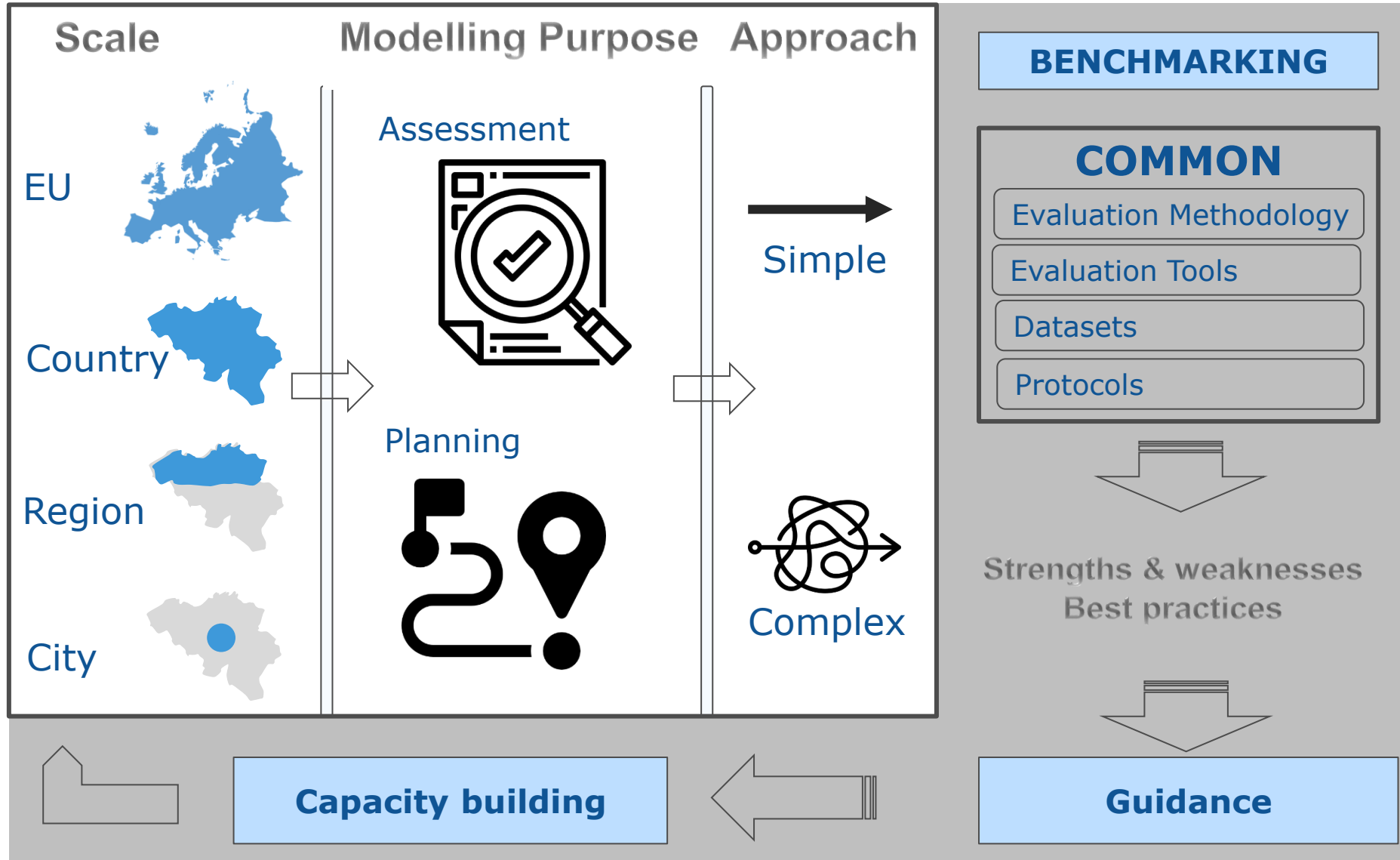
Network Members: National Contact Points from EU Member States + Modelling community

What is FAIRMODE?

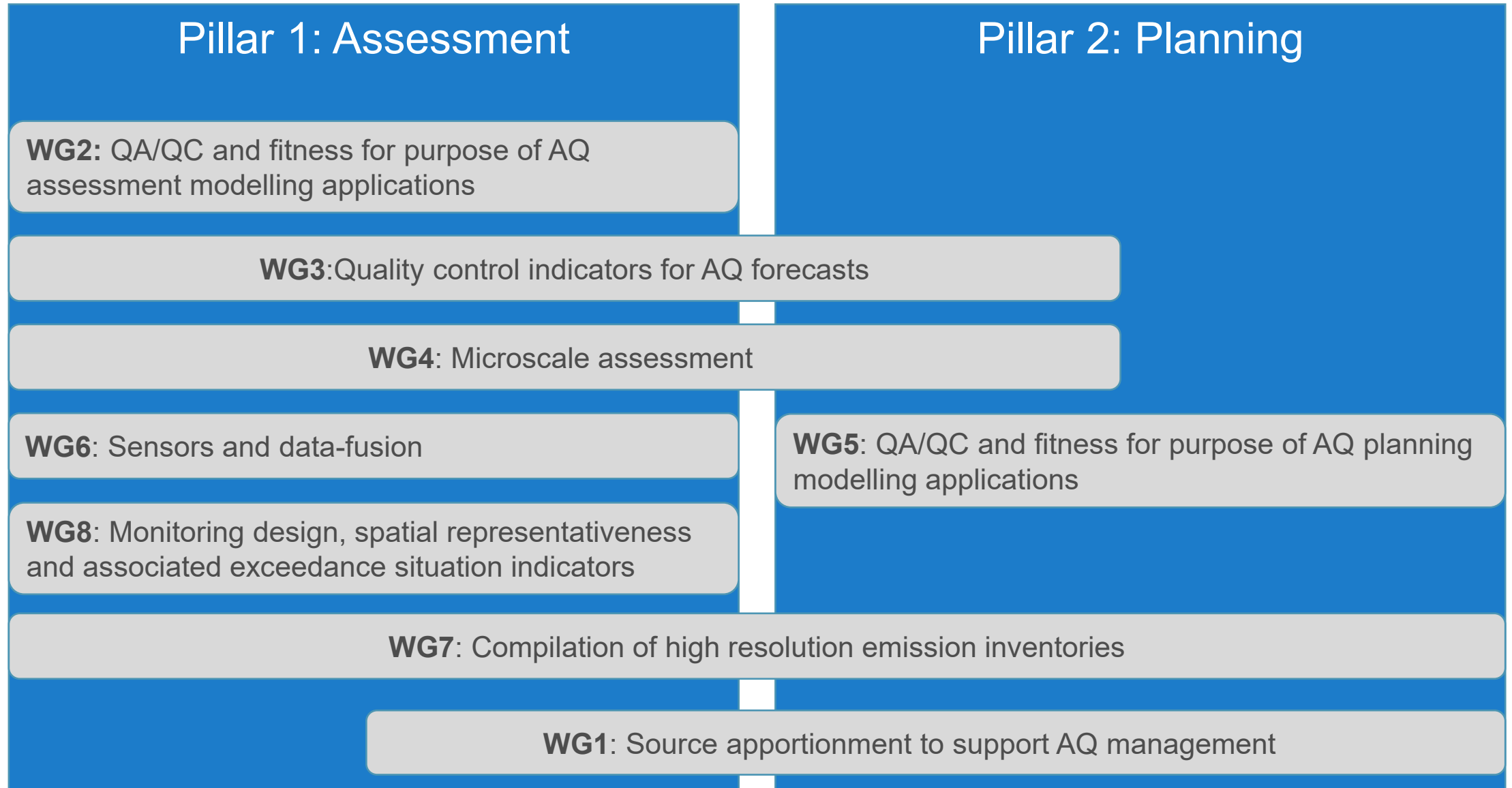
FAIRMODE is a Forum for **Air Quality Modeling** chaired by the JRC created for **exchanging experience** and results from air quality modeling in the context of the **Air Quality Directive** and for promoting the use of modeling for regulatory purposes in a **harmonized** manner between Member States.

- ❑ To provide a permanent European Forum for air quality modelers, to address modelling issues
- ❑ To set-up a system (protocols and tools) on the quality assurance at different spatial scales from national to urban and local.
- ❑ To provide guidance, support the standardization and evaluate the fitness-for-purpose of air quality models within the framework of implementing the EU's Air Quality Directives.

FAIRMODE working strategy



FAIRMODE Structure



Air Quality Assessment

Pillar 1: Assessment

WG2: QA/QC and fitness for purpose of AQ assessment modelling applications

WG3: Quality control indicators for AQ forecasts

WG4: Microscale assessment

WG6: Sensors and data-fusion

WG8: Monitoring design, spatial representativeness and associated exceedance situation indicators

WG7: Compilation of high resolution emission inventories

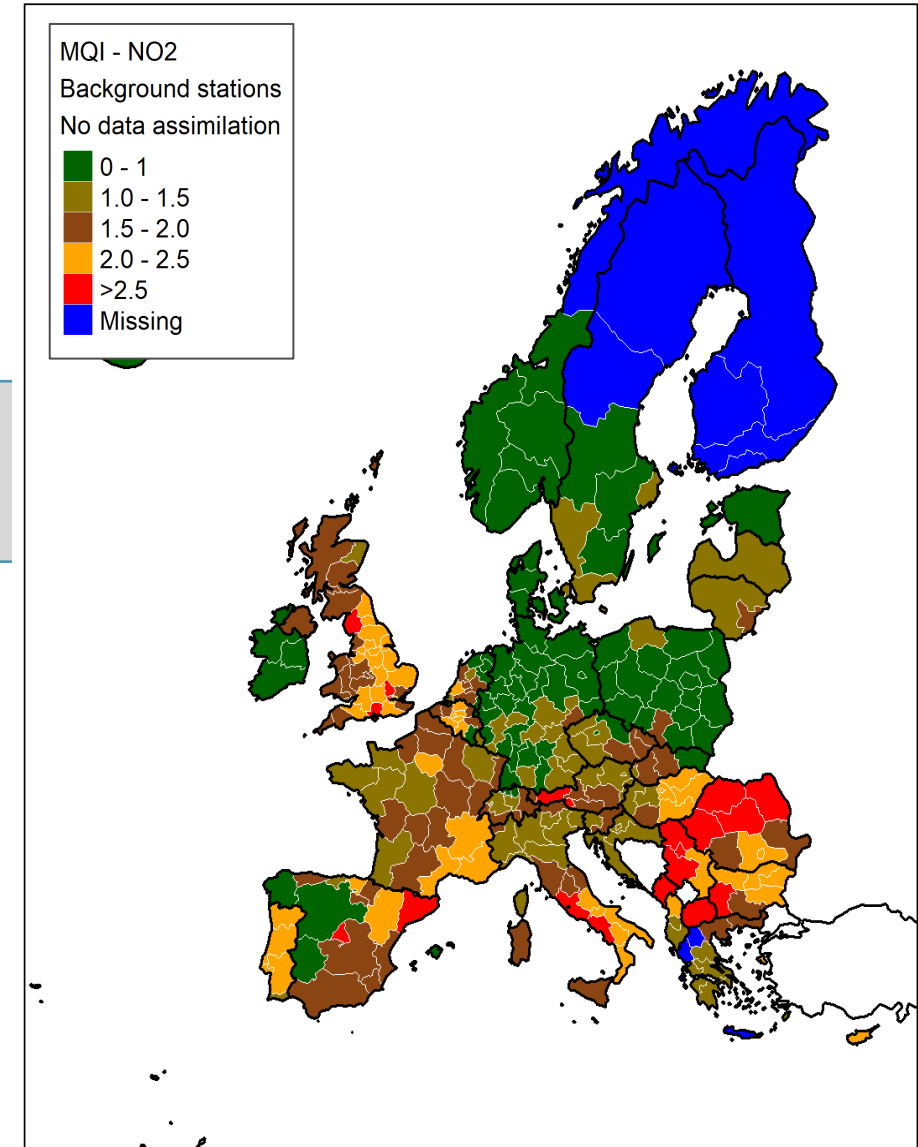
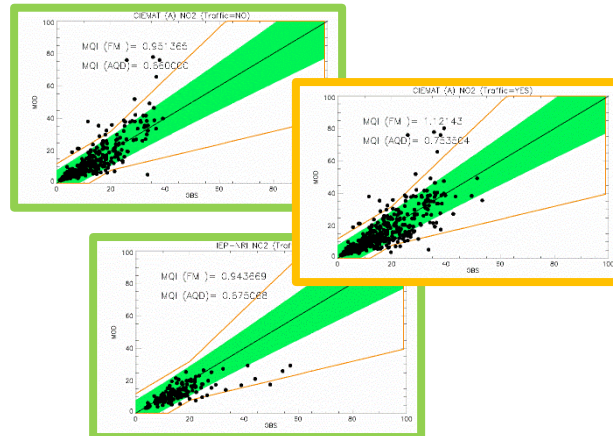
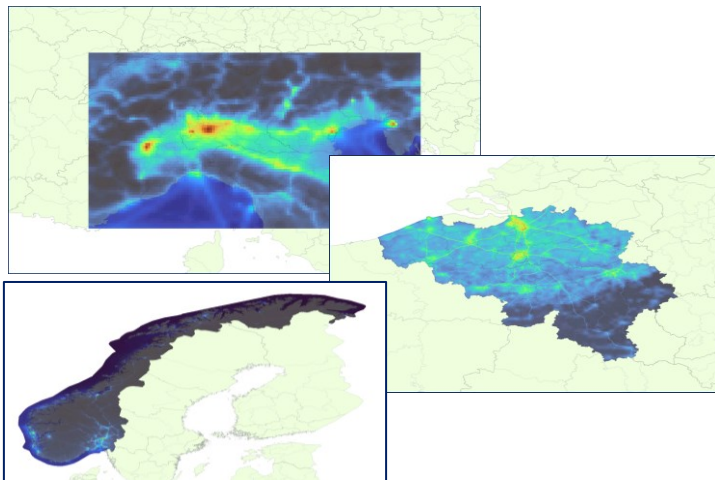
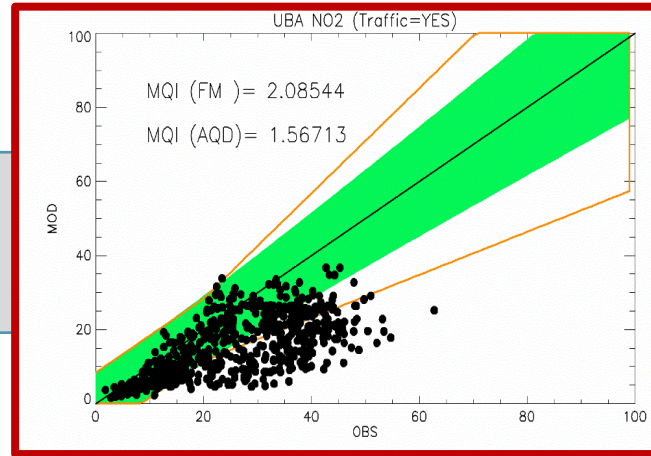
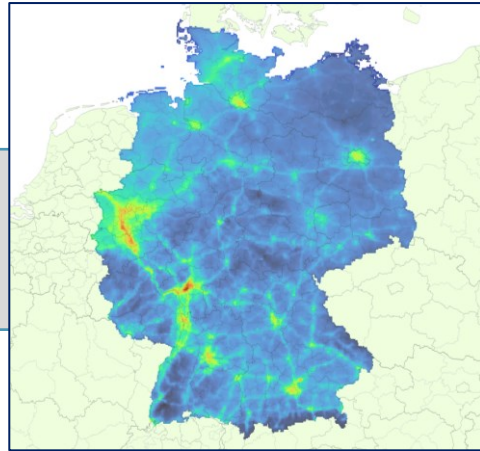
WG1: Source apportionment to support AQ management

Pillar 2: Planning

WG5: QA/QC and fitness for purpose of AQ planning modelling applications

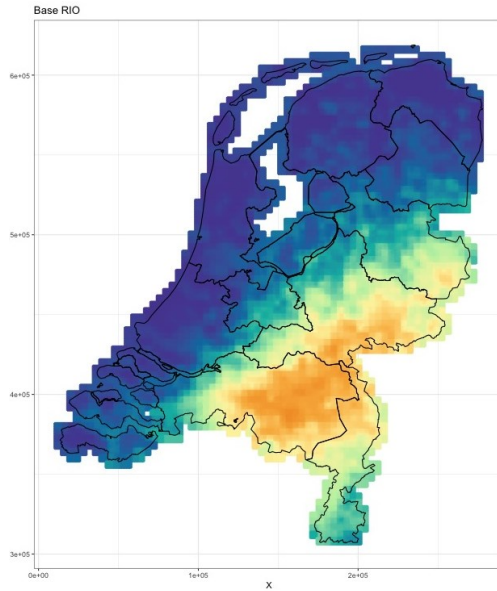
QA/QC of assessment applications

Composite mapping exercise



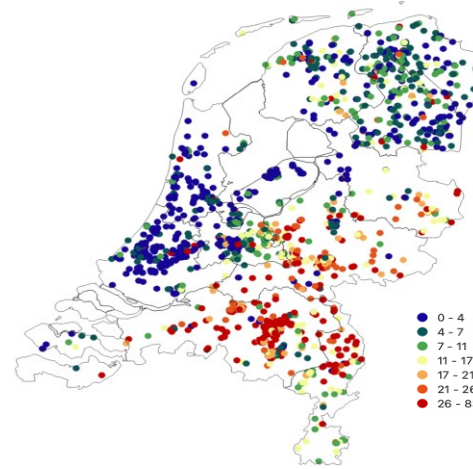
Low-cost sensors

PM2.5

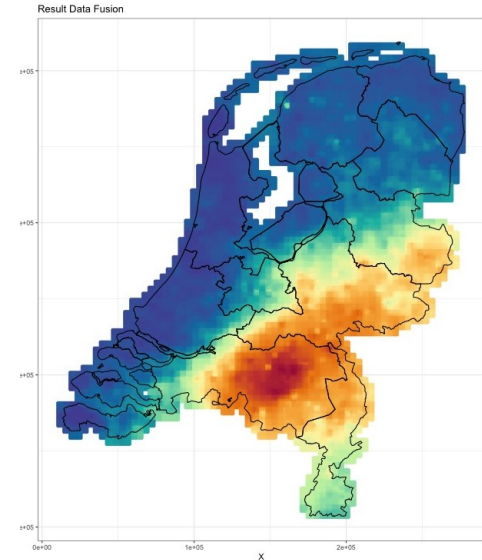


Model + Official measurements.

+



Calibrated low-cost sensors



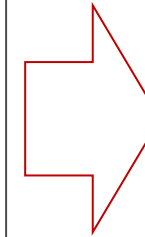
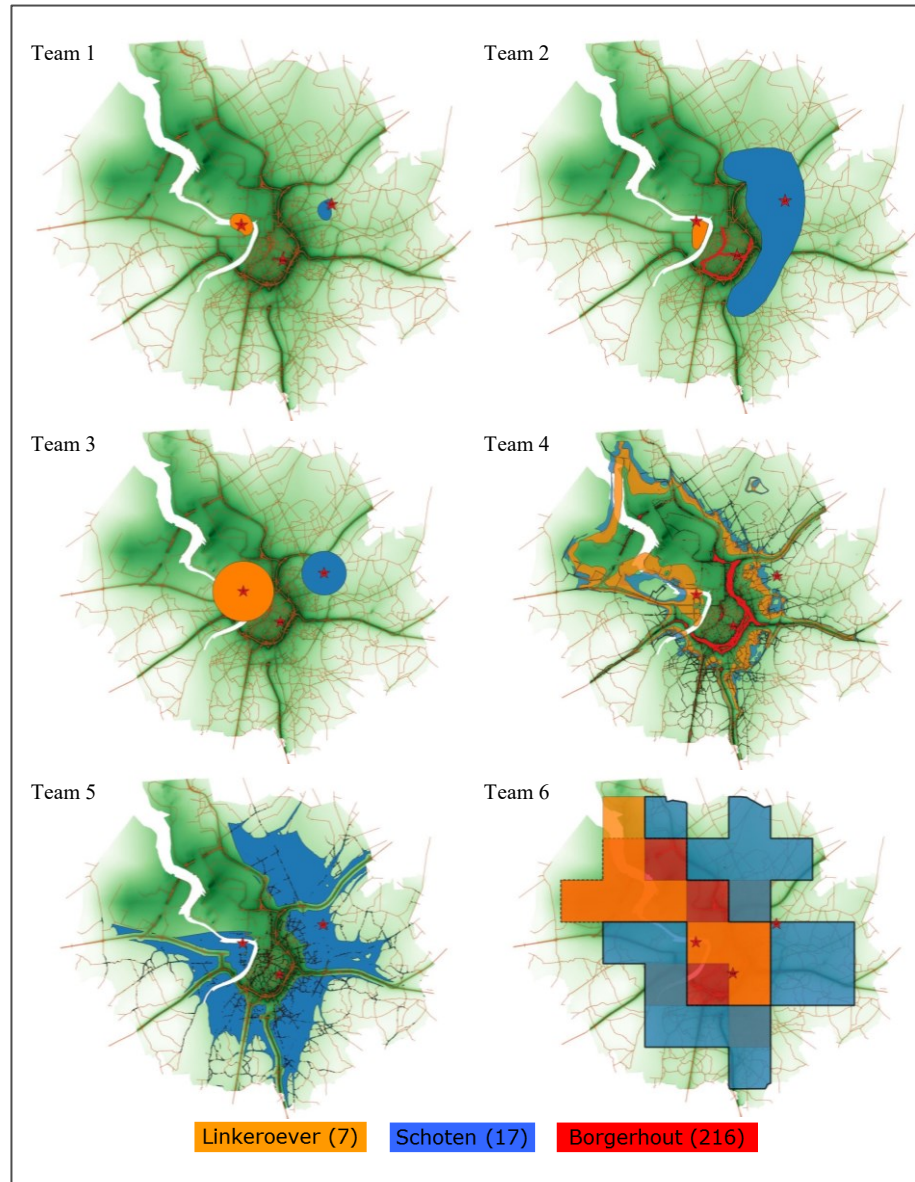
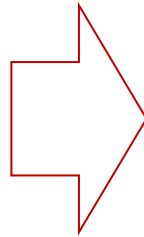
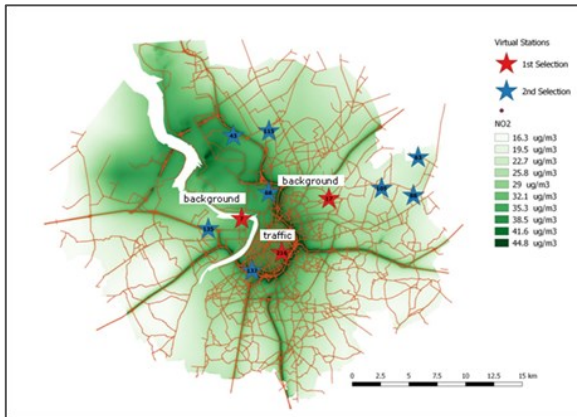
Model + official measurements + low-cost sensors

Objective of the exercise: Compare data fusion approaches using large numbers of low-cost PM2.5 measurements

- How do results depend on number and quality of sensors
- Can data fusion compensate for less official measurements or incomplete modelling?
- Identify (data) requirements for a successful use of data fusion, identify best practices and provide guidance

Spatial representativeness of monitoring stations

The Antwerp dataset



At start:

- ☐ No common definition of spatial representativeness
- ☐ A large variety of methods (from CFD to simple LUR approaches)

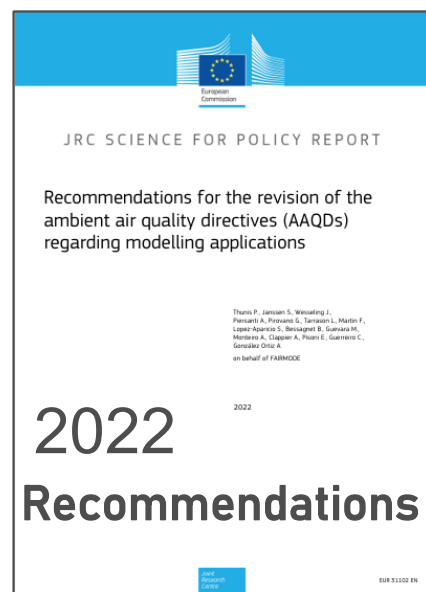


EU policy

Article 4
Definitions

For the purposes of this Directive, the following definitions apply:

- (26) ‘spatial representativeness’ means an assessment approach whereby the air quality metrics observed at a sampling point are representative for an explicitly delineated geographical area to the extent that air quality metrics within that area do not differ from the metrics observed at the sampling point by more than a pre-defined tolerance level;



FAIRMODE benchmarking

Air Quality Planning

Pillar 1: Assessment

WG2: QA/QC and fitness for purpose of AQ assessment modelling applications

WG3: Quality control indicators for AQ forecasts

WG4: Microscale assessment

WG6: Sensors and data-fusion

WG8: Monitoring design, spatial representativeness and associated exceedance situation indicators

WG7: Compilation of high resolution emission inventories

WG1: Source apportionment to support AQ management

Pillar 2: Planning

WG5: QA/QC and fitness for purpose of AQ planning modelling applications

Emissions

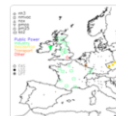
- Emissions are the most critical source of uncertainties in air quality modelling
- Benchmarking emissions is a challenging task:
 - Many dimensions to address: sectors, pollutants, reporting years...
 - Many sources of information involving many actors
 - Many inventories are available for a given area (e.g. bottom-up vs top-down)
- Purpose of the FAIRMODE screening exercise: identify main inconsistencies among inventories

Screening of emission inventories

Comparing 2 emission inventories

Methods for assessment of models

08 Jul 2022



A multi-pollutant and multi-sectorial approach to screening the consistency of emission inventories

Philippe Thunis¹, Alain Clappier², Enrico Pisoni¹, Bertrand Bessagnet¹, Jeroen Kuenen³, Marc Guevara⁴, and Susana Lopez-Aparicio⁵

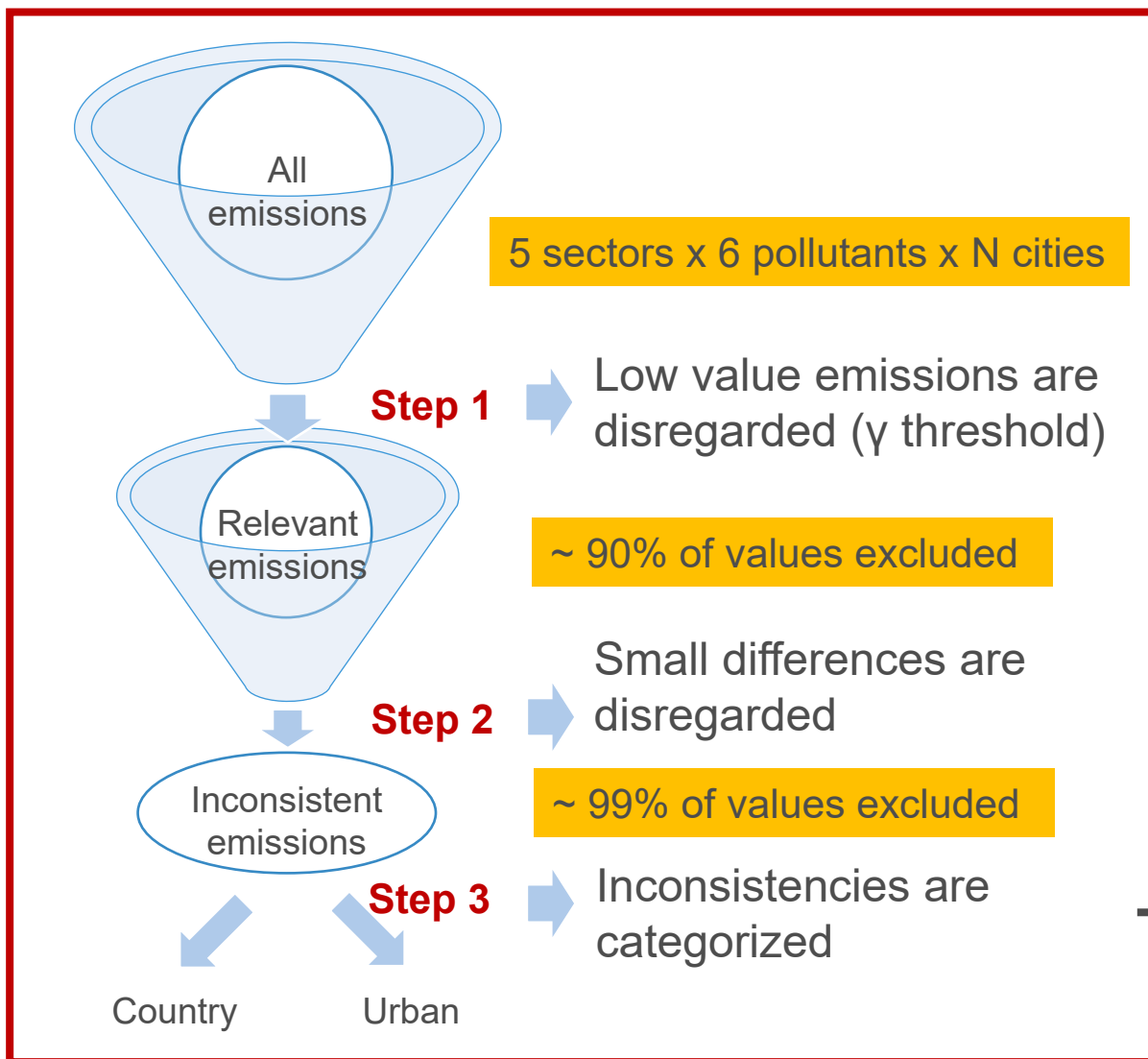
¹European Commission, Joint Research Centre, Ispra, Italy

²Université de Strasbourg, Laboratoire Image Ville Environnement, Strasbourg, France

³TNO, Department of Air, Climate and Sustainability, Utrecht, the Netherlands

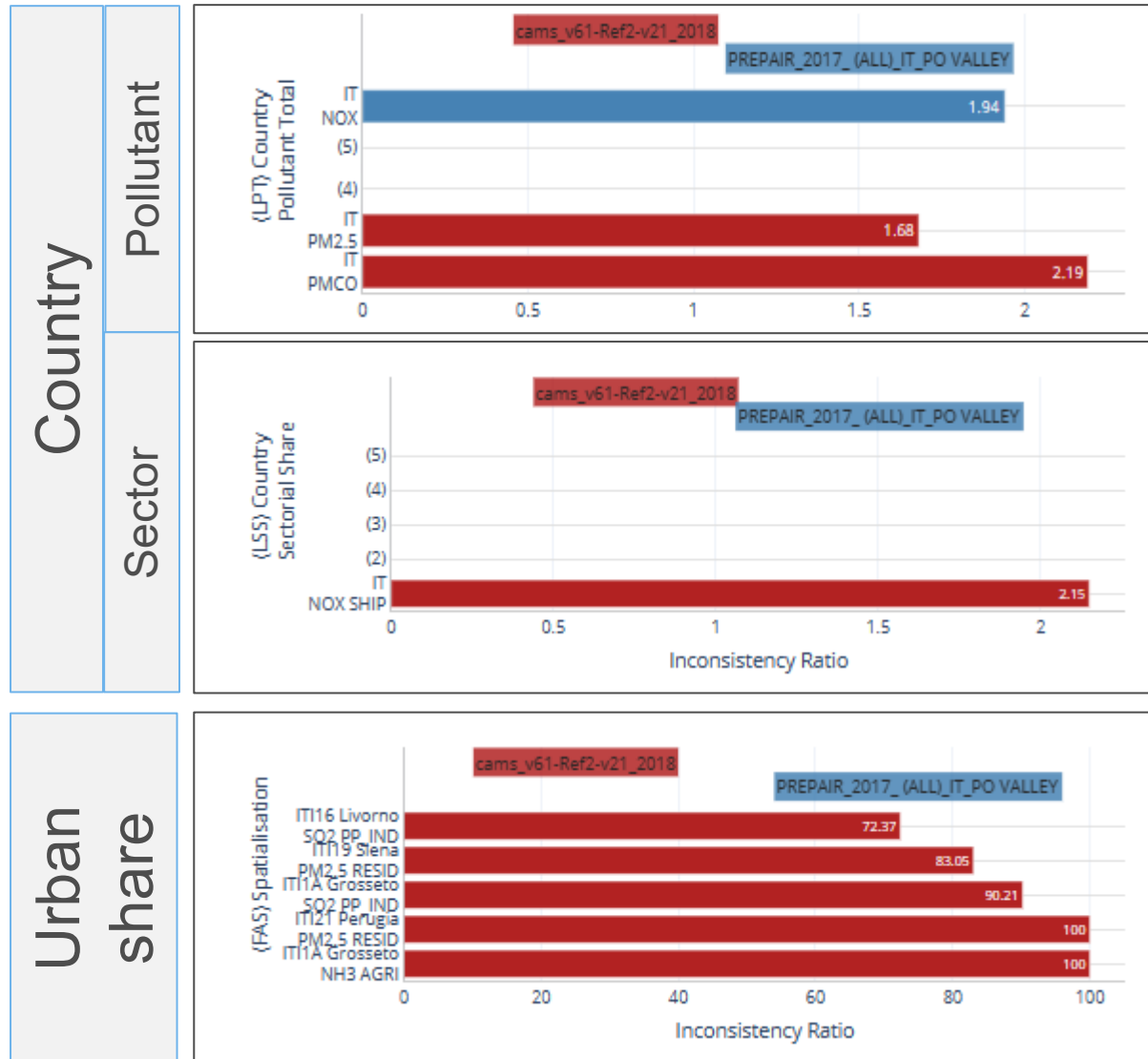
⁴Barcelona Supercomputing Center, Barcelona, Spain

⁵NILU – Norwegian Institute for Air Research, 2027 Kjeller, Norway



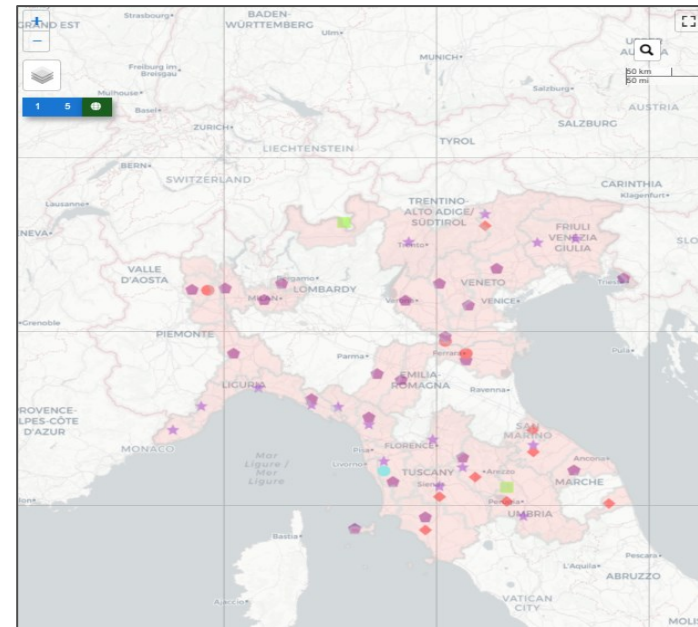
1. Country Pollutant Totals
 2. Country Sectorial share
 3. Urban share
- Only aggregated emissions data necessary!

Emissions benchmarking web interface



Objectives

- Which are the main inconsistencies?
- Can we explain them? Can we solve them?
- What are the lessons learned?

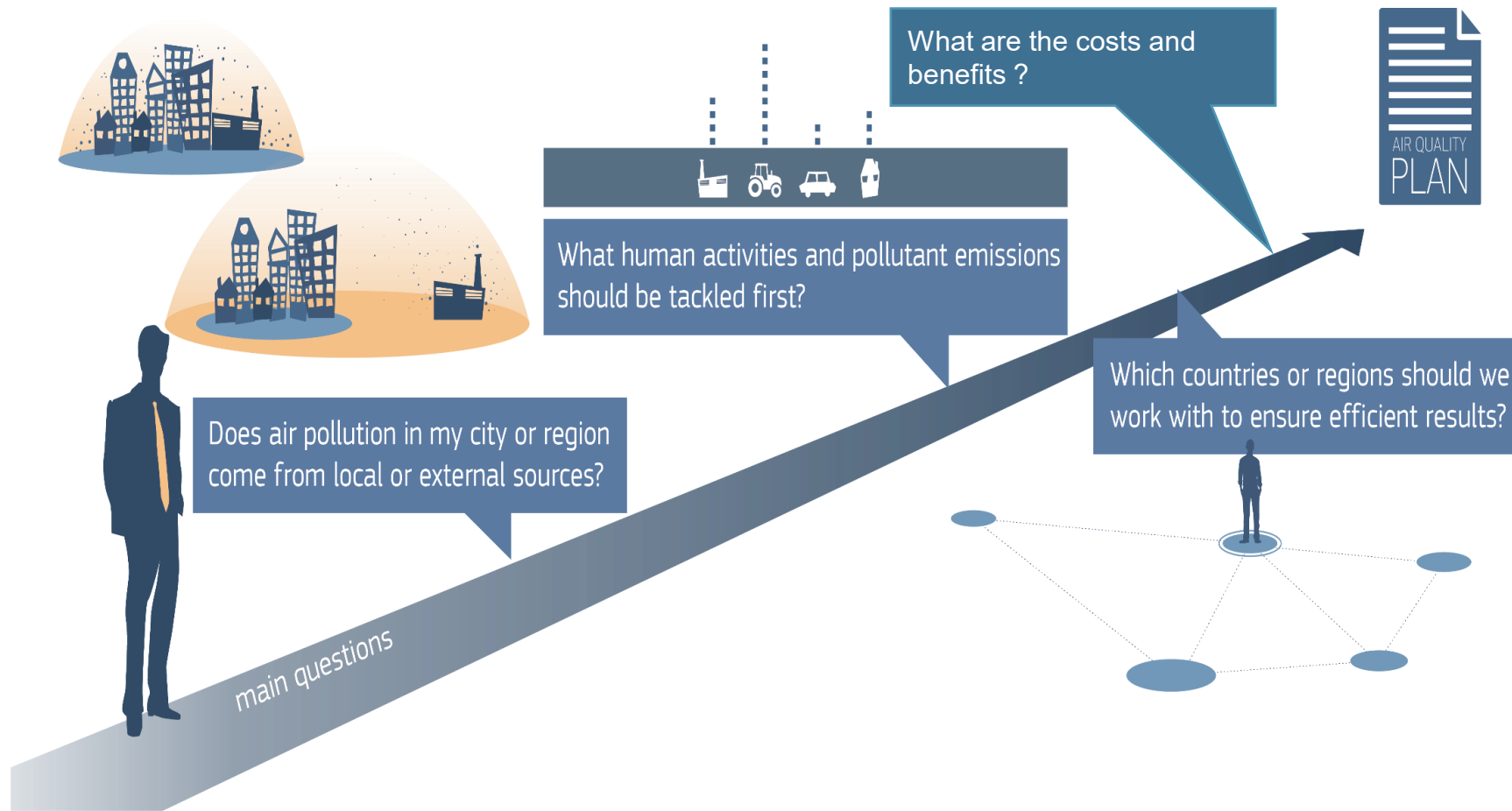


SHERPA

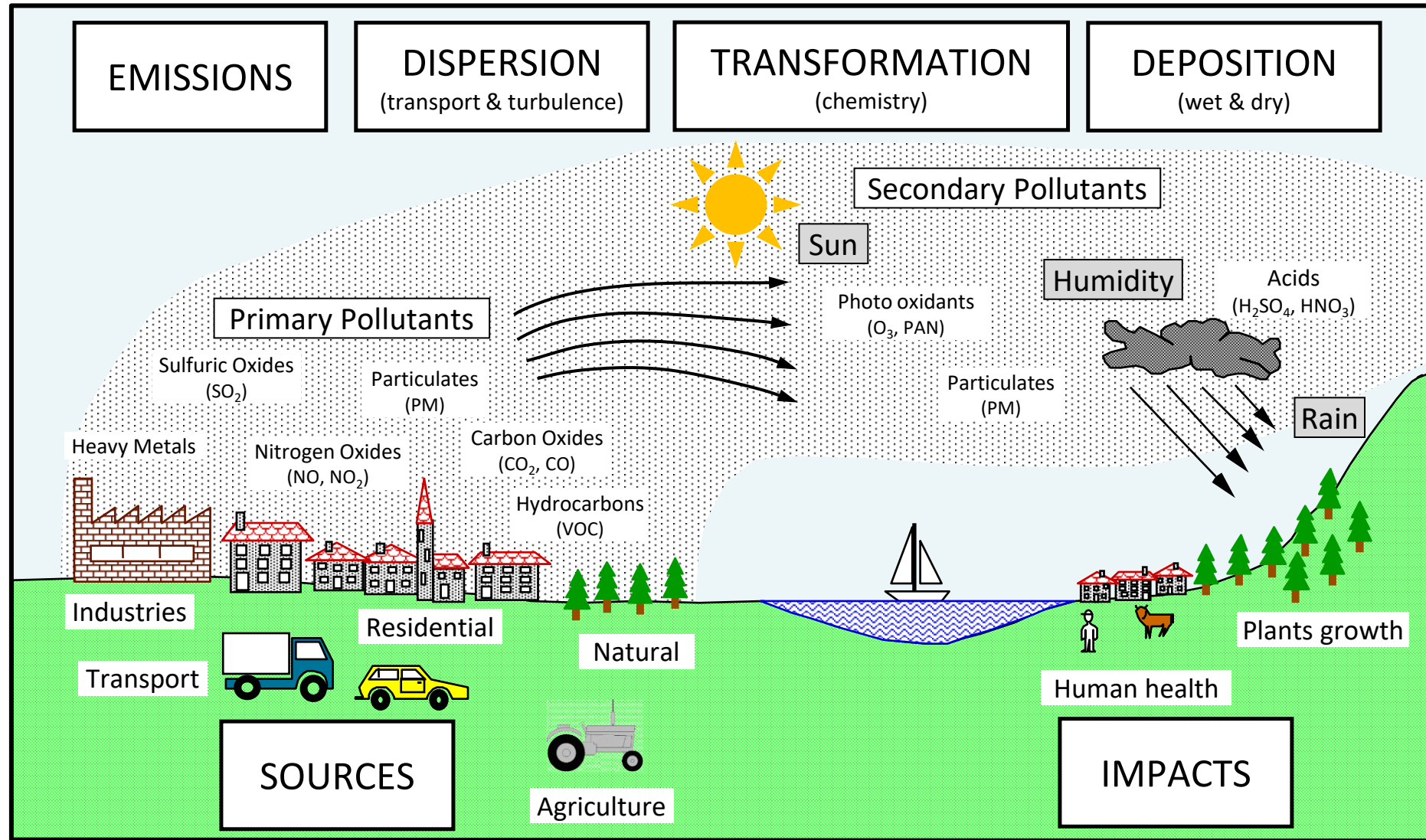
A tool for cost / benefit analysis of AQ policies



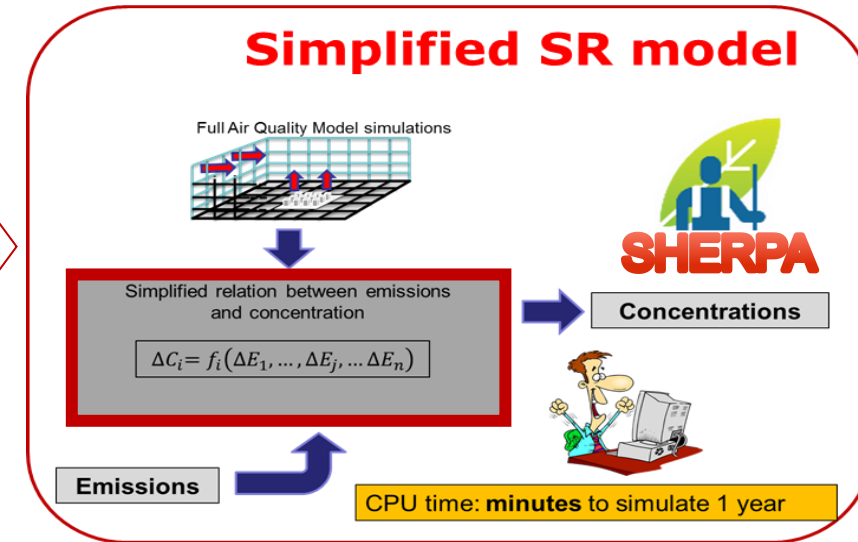
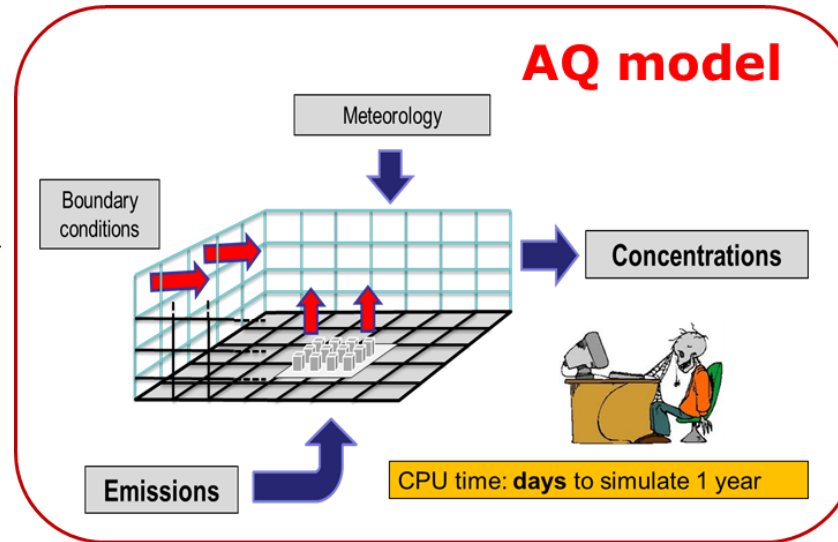
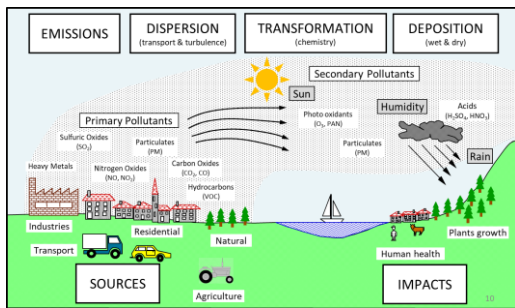
SHERPA: A tool to support the design of air quality plans



Air Quality is a complex issue



Main challenges and response tools



Journal of Environmental Management 183 (2016) 952–958



Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Research article

On the design and assessment of regional air quality plans: The SHERPA approach

P. Thunis ^{a,*}, B. Degraeuwe ^a, E. Pisoni ^a, F. Ferrari ^b, A. Clappier ^c

^a European Commission, Directorate for Energy, Transport and Climate, Ispra, Italy

^b TerrAria srl, Via M. Giola 132 20125 Milan, Italy

^c Université de Strasbourg, Laboratoire Image Ville Environnement, Strasbourg, France

Scenario Analysis



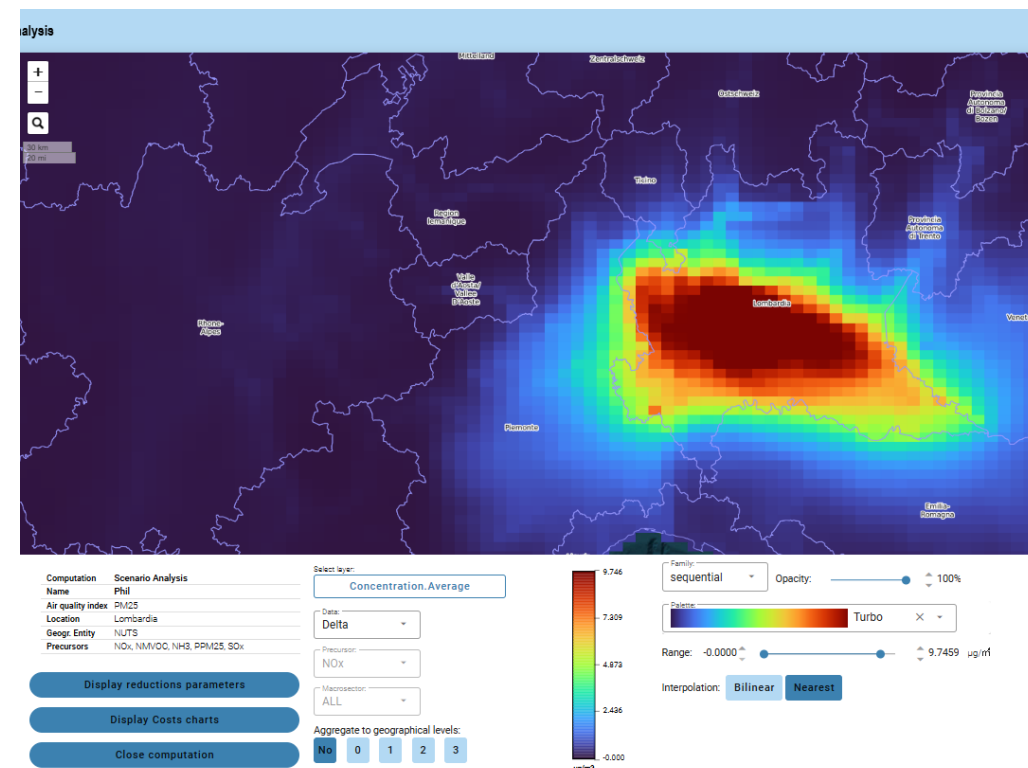
What is the impact of a given set of emission reduction on concentration / exposure?



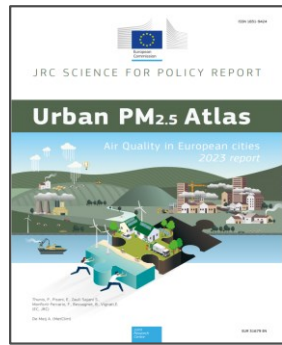
- ❖ Source area (NUTS, FUA, CNC)
- ❖ Emission reduction strategy (precursors, sectors)
- ❖ Pollutant (NO₂, PM_{2.5}, PM₁₀)



- ❖ Gridded concentrations (and deltas)
- ❖ Gridded population exposure (and deltas)
- ❖ Gridded health benefits (and delta)
- ❖ Gridded technical costs (based on BAT)

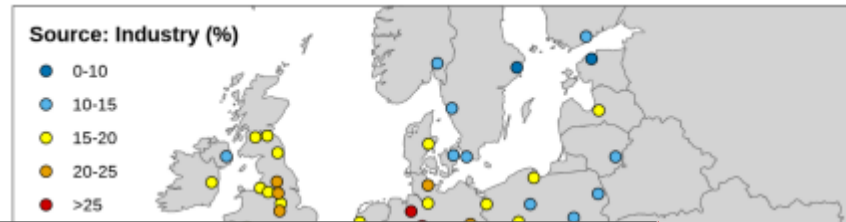


PM2.5 atlas to provide urban source apportionment overviews

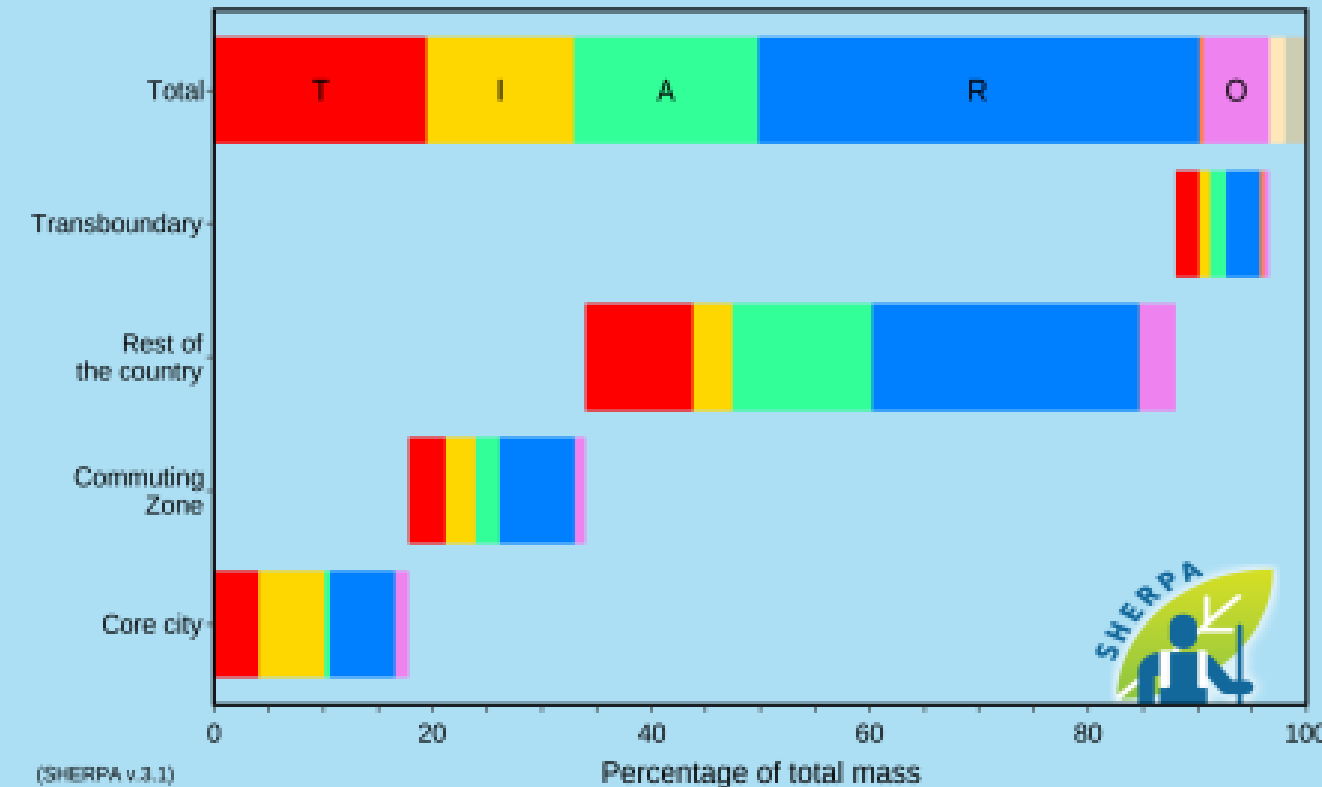


<https://publications.jrc.ec.europa.eu/repository/handle/JRC134950>

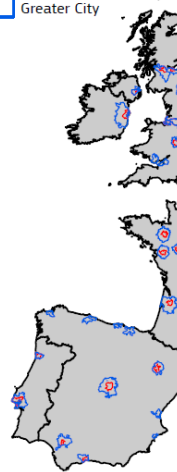
Overview maps



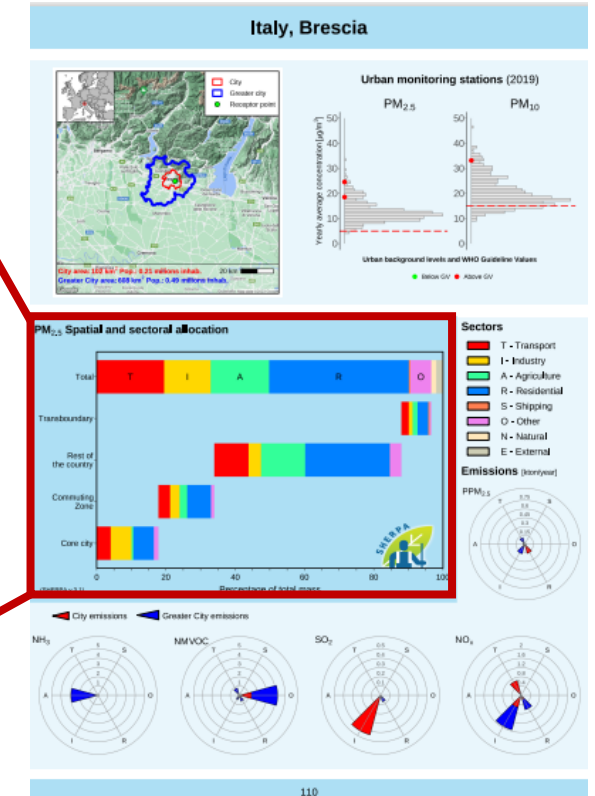
PM_{2.5} Spatial and sectoral allocation



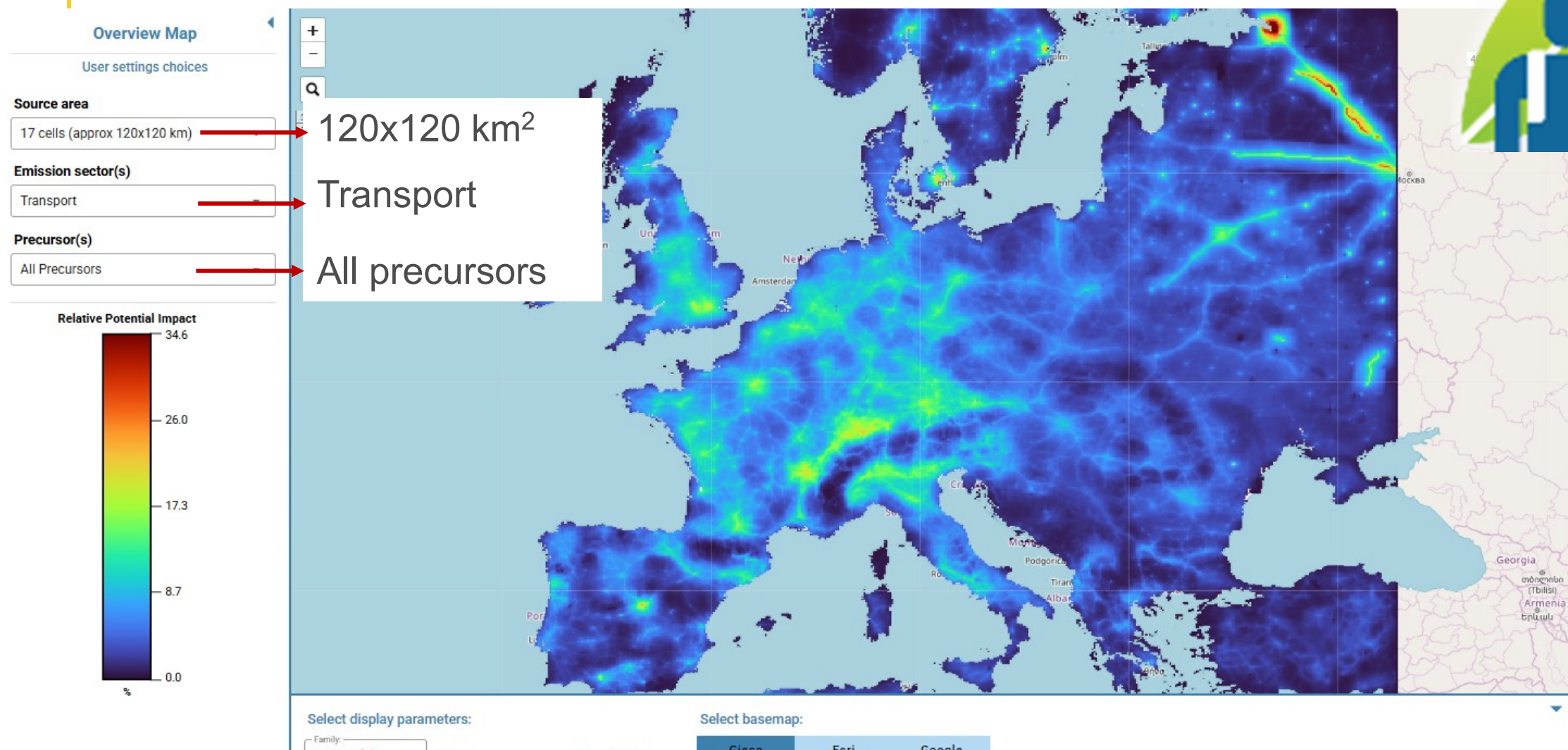
150 Greater Cities



Analysis for
Europe

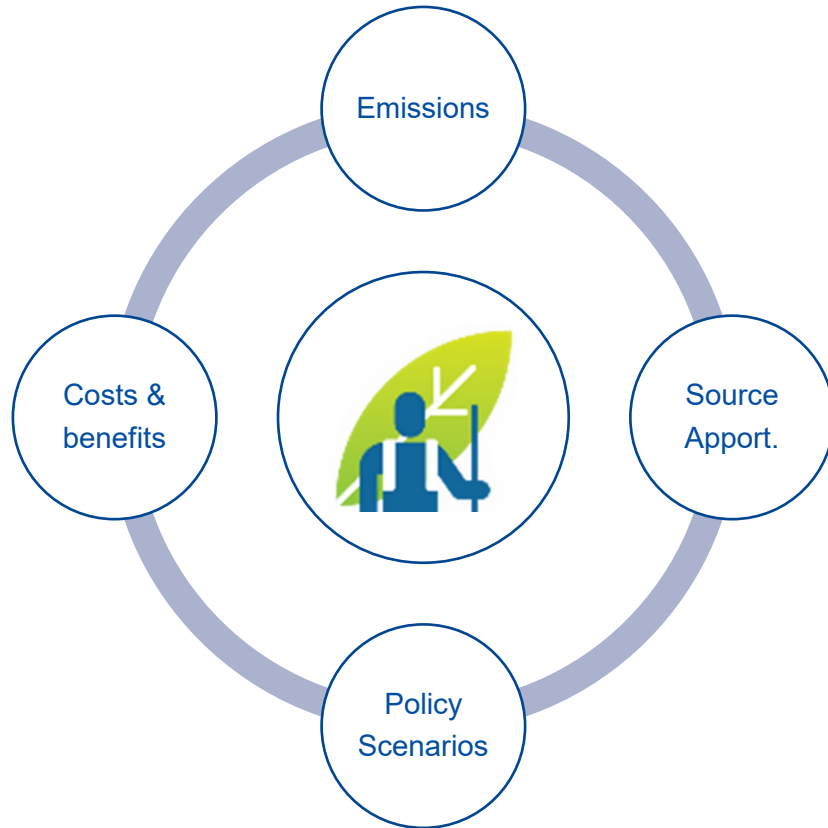


Interactive source apportionment maps



Note: Each EU map requires about 400 000 SHERPA simulations
The interface provides access to 270 maps

Towards an urban IAM tool in Colombia /S. America to support AQ policies



Co-designing a Latin-America initiative for integrated air quality management: Building regional tools for policy and action

Location room 4

Time: Thursday 17:00-18:30

Some concluding reflections (EU policies)

EU Clean Air Policy works! We have seen major improvements in air quality since the 1990s.

Air quality monitoring (4.000 monitoring stations) and air quality modelling provide us with a **robust, comparable and harmonized information basis** across the EU.

Air quality modelling is afforded a much bigger role in the revised Ambient Air Quality Directive: for assessment, spatial representativeness, source apportionment, forecasting, and planning

Modelling applications will need to be **fit-for-purpose** – what this means will depend on the purpose. The choice of model(s) to use lies with MS, but there are requirements.

Need to further advance air quality modelling to **support implementation** of the AAQD – relevant ongoing activities and technical support documents will serve as reference ... and communicate clearly **what modelling applications can / cannot do!**

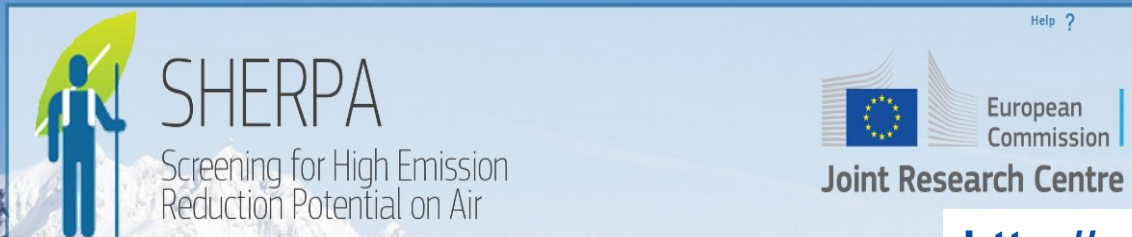
Some concluding reflections (FAIRMODE)

- **Intercomparison exercises are essential** to build confidence, to identify best practices, to feed recommendations and to support policy implementation with regards to air quality modelling.
- Many FAIRMODE exercises are organized as **permanent exercises**. Some exercises will become **mandatory** for Member States in the context of the revised AAQD

Some concluding reflections (SHERPA)

- SHERPA has proved to be a useful tool to evaluate the effect of local policies on background air quality. It mostly serves as **a screening tool**.
- SHERPA covers the entire EU at 7km resolution with default data but it **can be fed by other AQ model /emissions**. Current applications include China, Nepal & South Asia. Local versions are developed various EU countries (the Netherlands, Poland, Italy...)
- SHERPA currently **works for yearly averaged PM10, PM2.5 and NO2** concentrations.
- SHERPA is **freely available** at <http://aqm.jrc.ec.europa.eu/sherpa.aspx>

Thank-you



<http://aqm.jrc.ec.europa.eu/sherpa.aspx>

Area specific analysis

EU-wide overviews



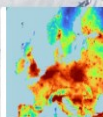
Assess the impact of simple/complex emission reduction strategies over your selected domain



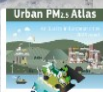
Compute the sectorial apportionment of concentrations over your selected domain



Compute the precursor apportionment of concentrations over your selected domain



Compare the impact of a given



Access source apportionment results for

FAIRMODE

Home

Activities >

Meetings >

About >

Guidance >

Tools >

Join FAIRMODE >

Meetings

08-10
OCTOBER
2025

The next FAIRMODE
"TECHNICAL MEETING" will take
place in Malta (MT)

Agenda

Logistics

Register >



View all the past meetings from 2008 with agendas,
presentations and minutes

Past meetings >

About FAIRMODE

Terms of Reference >

Steering committee >

National Experts >

Roadmap >

Strategy >

Forum >

Guidance

Assessment >

Planning >

Tools

Δ - Delta Benchmarking >

SHERPA >

EC Map (2024) >

EC MAP (2017) >

ECMap - Database >

The initiative

<https://fairmode.jrc.ec.europa.eu/>

FAIRMODE was launched in 2007 as a joint response initiative of the European Environment Agency (EEA) and the European Commission Joint Research Centre (JRC). The forum is currently chaired by the Joint Research Centre.

Its aim is to bring together air quality modelers and users in order to promote and support the harmonized use of models by EU Member States, with emphasis on model application under the European Air Quality Directives [More...]

Activities

WG1

Source apportionment to support AQ management

A.Clappier
G.Pirovano

WG2

QA/QC of AQ assessment applications

P.Thunis
L.Tarrason

WG3

Quality control indicators for AQ forecasts

A.Piersanti
A. Monteiro