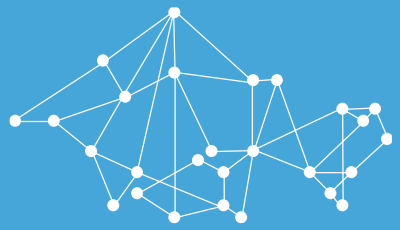
FAIRMODE
Forum for air quality modelling in Europe

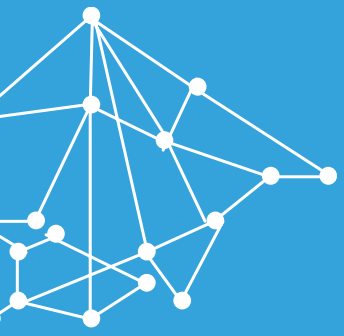


WG1: STATUS UPDATE & WORK PLAN

STIJN JANSSEN & CRISTINA GUERREIRO

CONTENT

- Status Update
  - Updated Modelling Quality Objective & Guidance Document
  - MQO for forecasting
  - Composite Mapping
  - Exceedance Modelling & Fit for purpose
- Work plan 2017 - 2019
- Spatial Representativeness
- Discussion



Updated MQO & Guidance Document

CLARIFICATIONS OF DEFINITIONS

» **Modelling Quality Indicator (MQI)**: Statistical indicator calculated on the basis of measurements and modelling results.

» **Modelling Quality Objective (MQO)**: Criteria for the value of the MQI. The MQO is said to be fulfilled if MQI is less than or equal to unity.

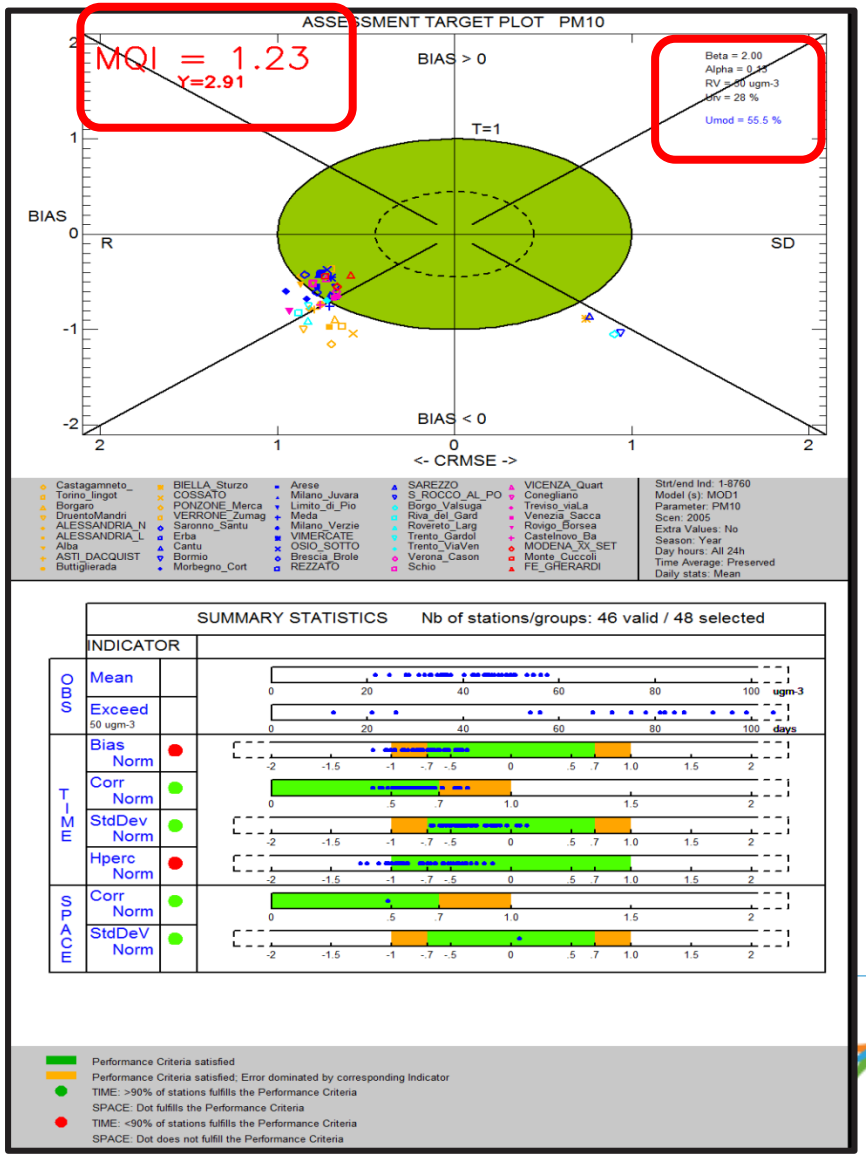
» **Modelling Performance Indicator (MPI)**: Statistical indicators calculated on the basis of measurements and modelling results. Each of the MPI describes a certain aspect of the discrepancy between measurement and modelling results.

» **Modelling Performance Criteria (MPC)** Criteria that MPI are expected to fulfil. They are necessary, but not sufficient criteria to determine whether the MQO are fulfilled.

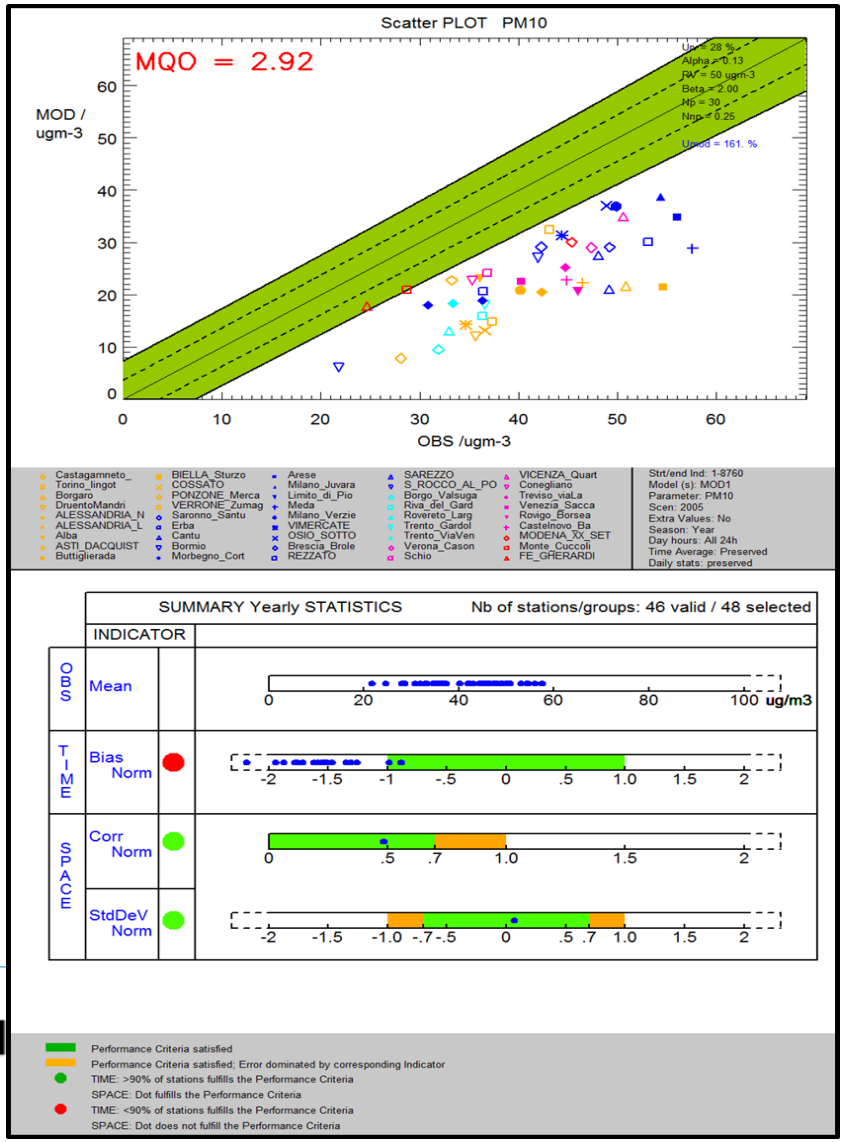
$$MQI = \frac{\mathrm{RMSE}}{\beta RMS_U} \quad \text{and MQO: MQI} \leq 1$$

UPDATED REPORTING TEMPLATE

Hourly/daily frequency



Yearly frequency



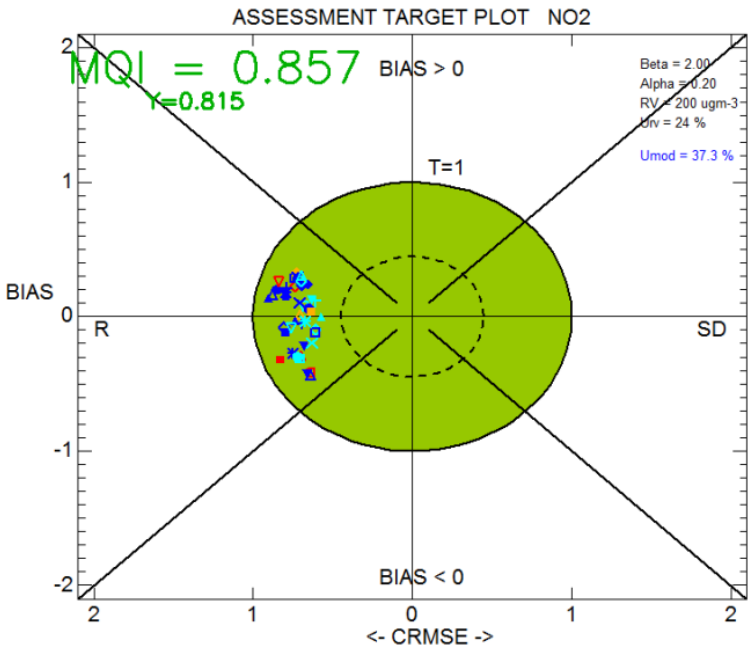
MODELLING QUALITY OBJECTIVE

Proposal for a new Target Diagram got positive evaluation

- Integration of the 90% fulfilment criteria in the MQI
- Model uncertainty & annual mean MQI explicitly mentioned
- New DELTA vs5.5 will be released in March 2017!

- Open issues:
  - MPC for high percentiles / exceedances
  - Consistency between hourly/daily and annual MQI
  - Model evaluation with limited monitoring stations (small to medium cities)
  - Data assimilation (especially on-line DA)

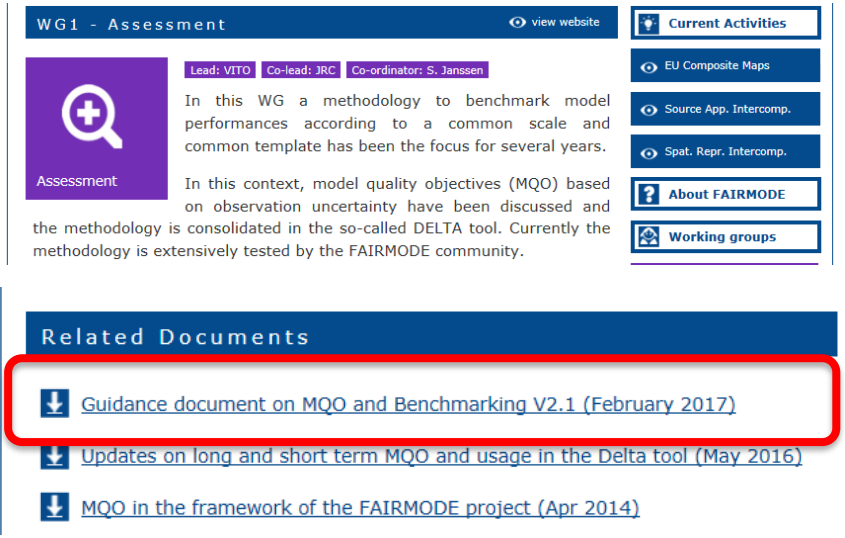
  → CEN working group

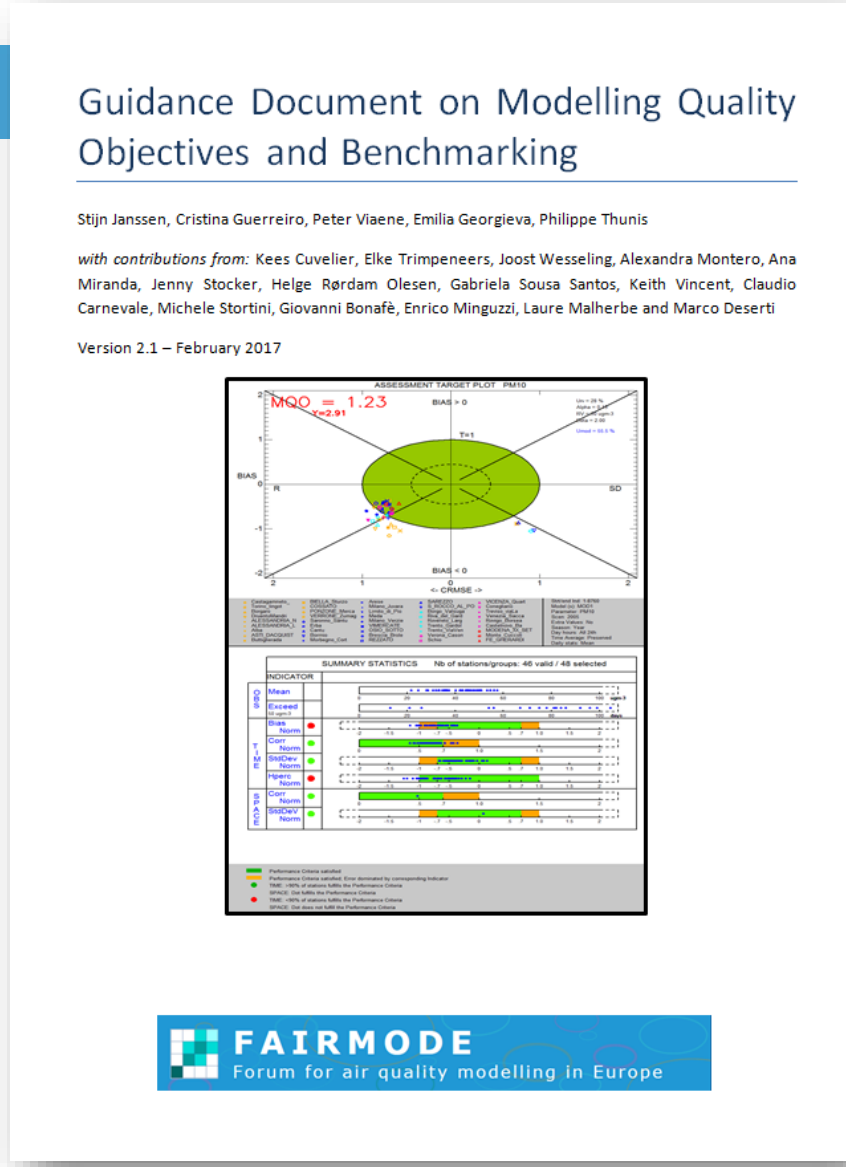


GUIDANCE DOCUMENT VS2.1

New version available via the FAIRMODE website

- Improved readability (Executive Summary, Definitions, Main assumptions…)
- Section on Forecast evaluation included
- Best practices are removed → publication

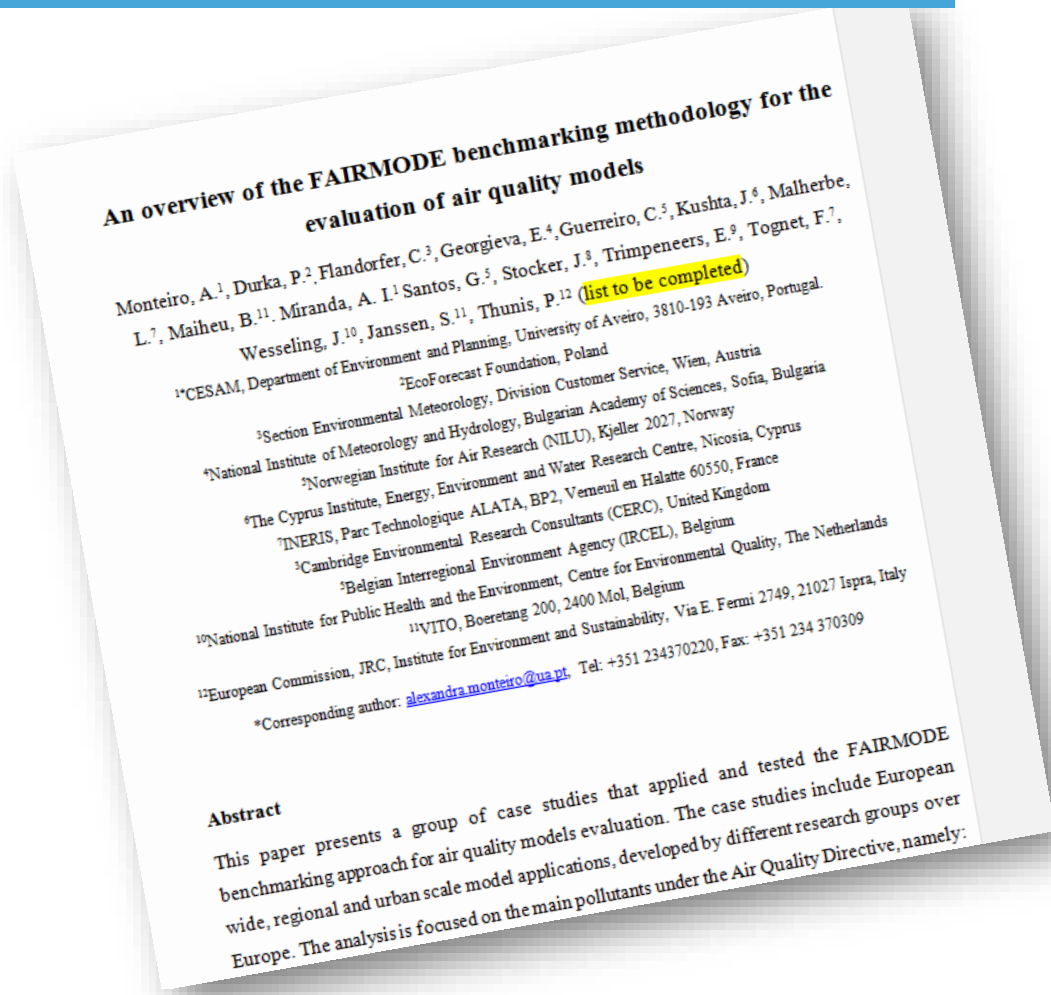




JOINT WG1 PUBLICATION

Lead author Alexandra Monteiro

- Description of 11 applications (regional to urban scales)
- Harmonized model evaluation based on FAIRMODE methodology
- Comparison with “old” evaluation schemes
- SWOT analysis of the FAIRMODE methodology



An overview of the FAIRMODE benchmarking methodology for the evaluation of air quality models

Monteiro, A.[1], Durka, P.[2], Flandorfer, C.[3], Georgieva, E.[4], Guerreiro, C.[5], Kushta, J.[6], Malherbe, L.[7], Maiheu, B.[11], Miranda, A. I.[1] Santos, G.[5], Stocker, J.[8], Trimpeneers, E.[9], Tognet, F.[7], Wesseling, J.[10], Janssen, S.[11], Thunis, P.[12] (list to be completed)

[1]*CESAM, Department of Environment and Planning, University of Aveiro, 3810-193 Aveiro, Portugal.

[2]EcoForecast Foundation, Poland

[3]Section Environmental Meteorology, Division Customer Service, Wien, Austria

[4]National Institute of Meteorology and Hydrology, Bulgarian Academy of Sciences, Sofia, Bulgaria

[5]Norwegian Institute for Air Research (NILU), Kjeller 2027, Norway

[6]The Cyprus Institute, Energy, Environment and Water Research Centre, Nicosia, Cyprus

[7]INERIS, Parc Technologique ALATA, BP2, Verneuil en Halatte 60550, France

[8]Cambridge Environmental Research Consultants (CERC), United Kingdom

[9]Belgian Interregional Environment Agency (IRCEL), Belgium

[10]National Institute for Public Health and the Environment, Centre for Environmental Quality, The Netherlands

[11]VITO, Boeretang 200, 2400 Mol, Belgium

[12]European Commission, JRC, Institute for Environment and Sustainability, Via E. Fermi 2749, 21027 Ispra, Italy

*Corresponding author: alexandra.monteiro@ua.pt, Tel: +351 234370220, Fax: +351 234 370309

Abstract

This paper presents a group of case studies that applied and tested the FAIRMODE benchmarking approach for air quality models evaluation. The case studies include European wide, regional and urban scale model applications, developed by different research groups over Europe. The analysis is focused on the main pollutants under the Air Quality Directive, namely:

JOINT WG1 PUBLICATION

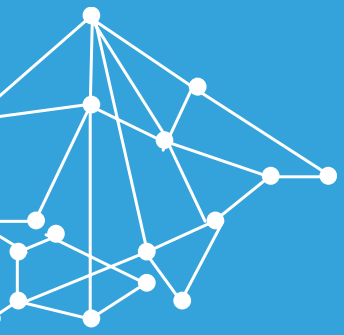
Nº	Participants	Country	Institution	Questionaire	Revision
1	Jenny Stocker	UK	CERC		
2	Laure Malherbe	FR	INERIS		
3	Jonilda Kushta	Cyprus	The Cyprus Institute,		
4	Flandorfer Claudia	Austria	ZAMG - Zentralanstalt für Meteorologie und Geodynamik		
5	Elke Trimpeneers	Belgium	IRCEL		
6	Emilia Georgieva	Bulgaria	National Institute of Meteorology and Hydrology		
7	Cristina Guerreiro	Norway	NILU		
8	Pawet Durka	Poland	EcoForecast Foundation		
9	Joost Wesseling	Netherlands	National Institute for Public Health and the Environment		
10	Maiheu Bino	Belgium	VITO		
11	Alex. Monteiro	Portugal	UA		

Next steps:

» 25th Feb → revised version will be sent to co-authors

» 15th March → receiving revision (from the other 50% co-authors)

» April → paper submission → which journal?

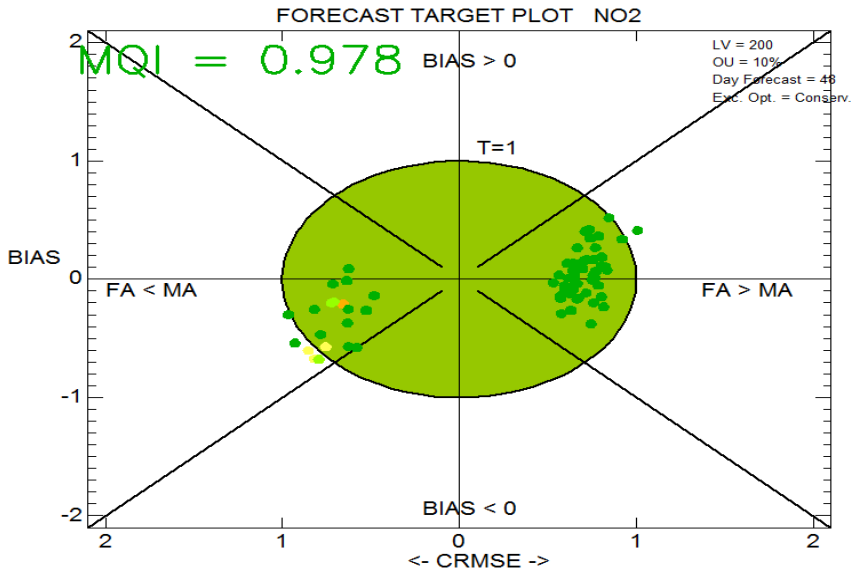


Modelling Quality Objective for Forecast

FORECAST MODELLING QUALITY OBJECTIVE

Do we need a benchmarking procedure for forecast models?

- DELTA-*in-forecast* mode
  - Additional info for forecast models
  - Is not replacing standard benchmarking process
- Comparison with the persistence model:
  - A forecast model should do better than using the monitoring data of yesterday to predict tomorrow's AQ levels

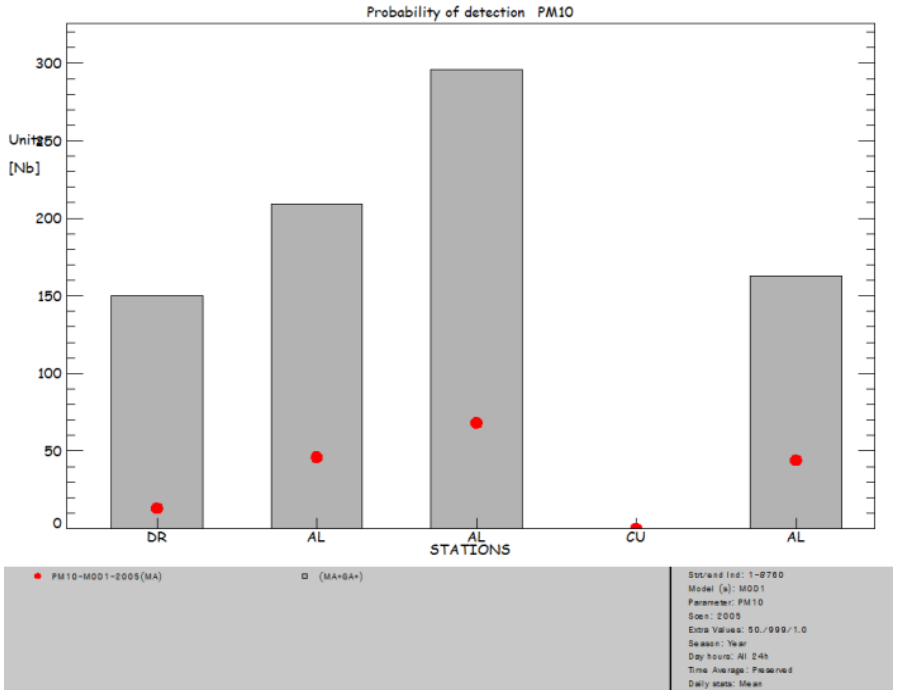


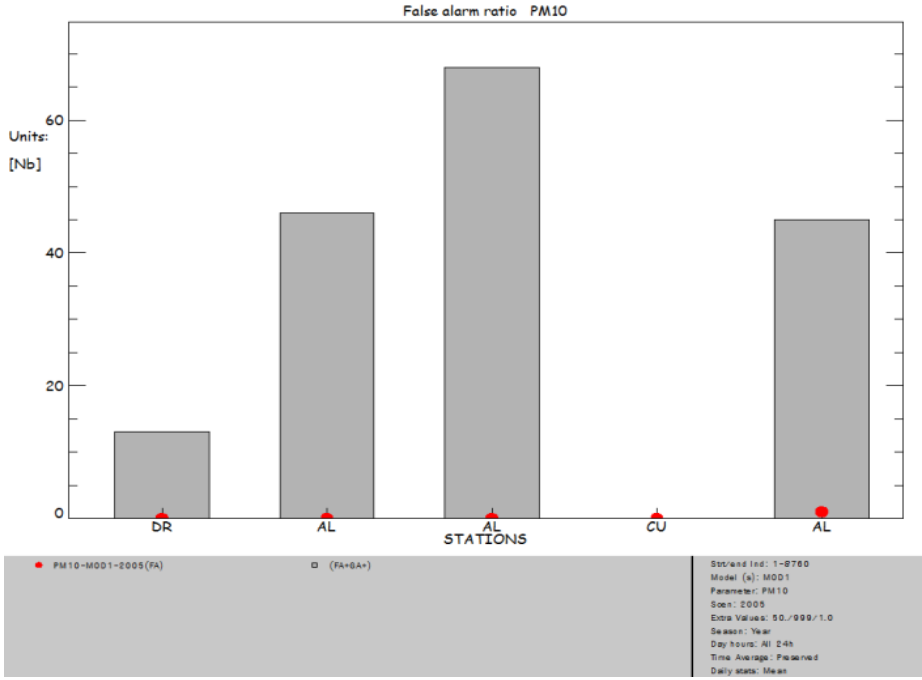
$$\text{Target}_{\text{forecast}} = \frac{\sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(M_i^* - O_i\right)^2}}{\sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(O_{i-j} - O_i\right)^2}}$$

FORECAST MODELLING QUALITY OBJECTIVE

Forecast models have a strong focus on threshold exceedances

» Threshold exceedance indicators (False Alarms, Missed Alarms)
  » Probability of Detection, False Alarm Ratio





FEEDBACK @ TECHNICAL MEETING

- Detailed feedback provided by INERIS, CERC, FMI & EcoForecast Foundation

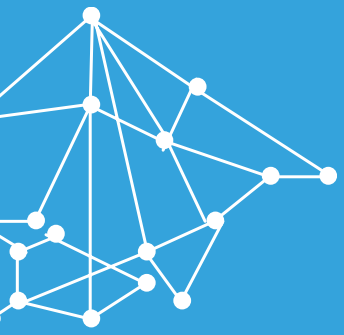
- Consensus on many aspects:
  - Overall methodology is well received
  - Some of the exceedance indicators can be removed (e.g. CEI_1)
  - Small bugs and inconsistencies identified in DELTA tool

- Jenny Stocker (CERC) summarized the findings:
  - Updated Technical Note is incorporated in the new Guidance Document (vs2.1)
  - Topics with consensus are currently implemented in new DELTA vs5.5
  - Topics under discussion are collected in the Open Issue list

FORECAST MODELLING QUALITY OBJECTIVE – OPEN ISSUES

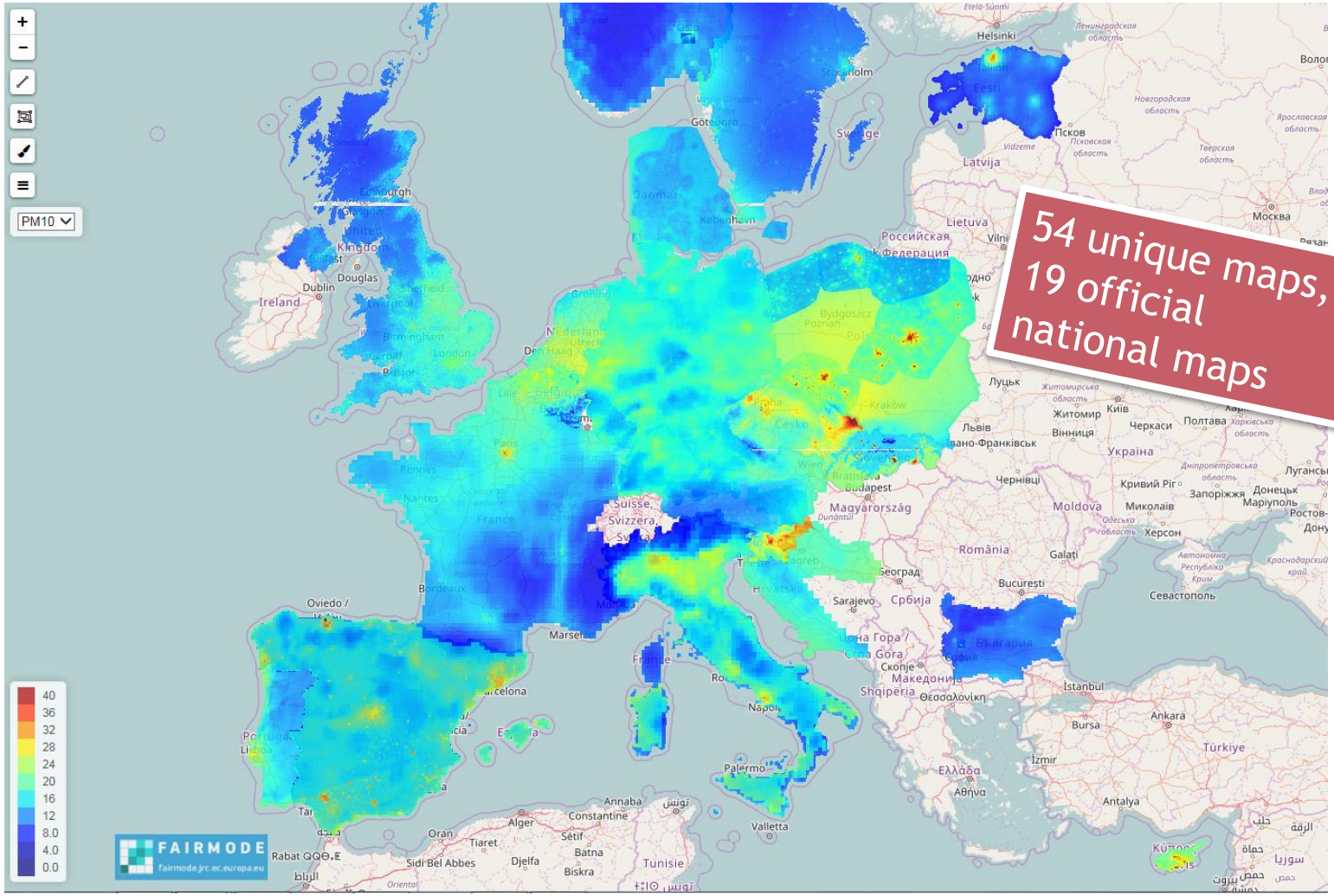
Topics to be solved after further testing and fine tuning

- Measurement uncertainty → user defined uncertainty should be fixed to commonly used values
- Explore the option to use probabilities rather than a classification scheme to deal with uncertainties in the exceedances
- Benchmarking with the *Persistence model* has as side effect that forecasts for roadside locations might perform better than rural sides.
  - Concentrations at rural sides are much more stable than road site locations and the *Persistence model* is harder to beat
- Define indicators for a Summary Report



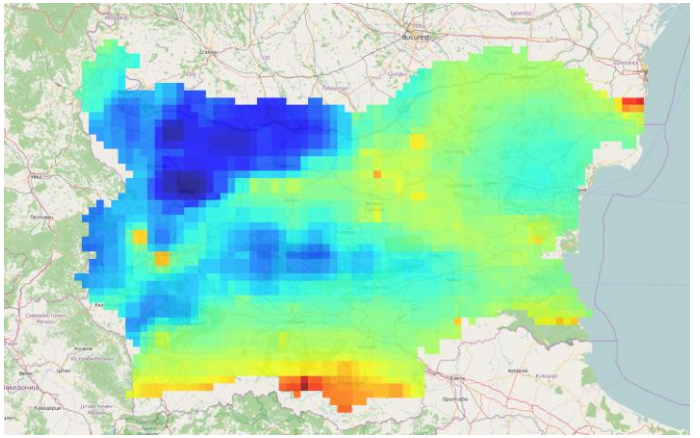
Composite Mapping

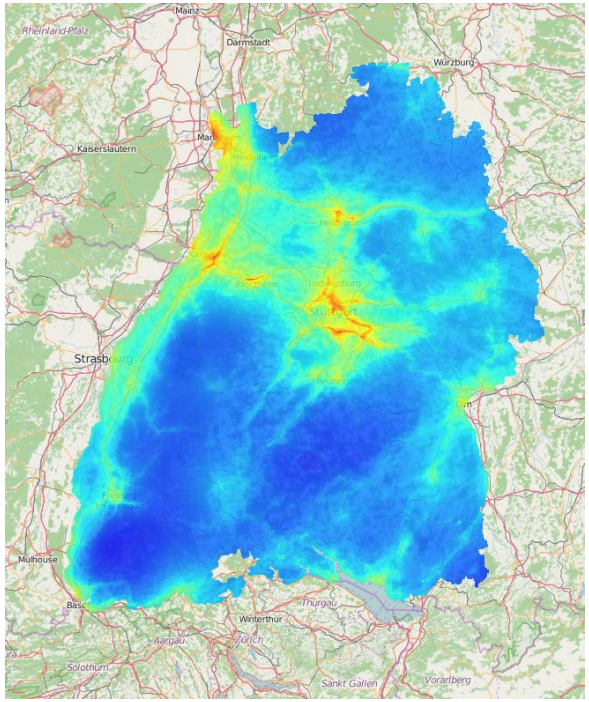
EU COMPOSITE MAP

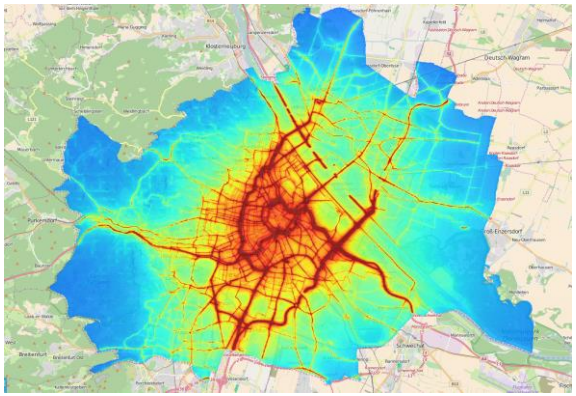


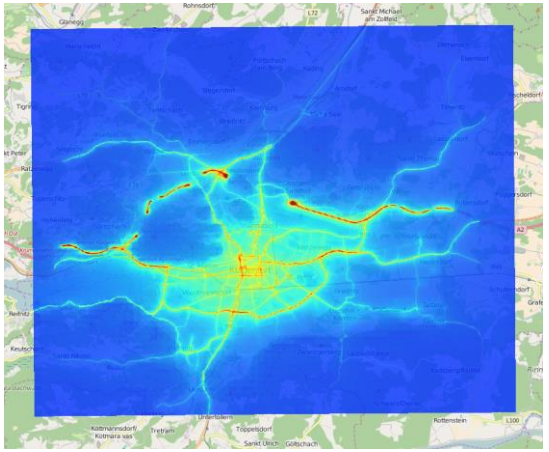
NUMBER OF NEW CONTRIBUTIONS SINCE LAST YEAR

- Bulgaria & Sophia
- Luxembourg
- Region of Baden-Württemberg
- Austrian cities (Vienna, Klagenfurt, Leibnitz, Salzburg)
- …

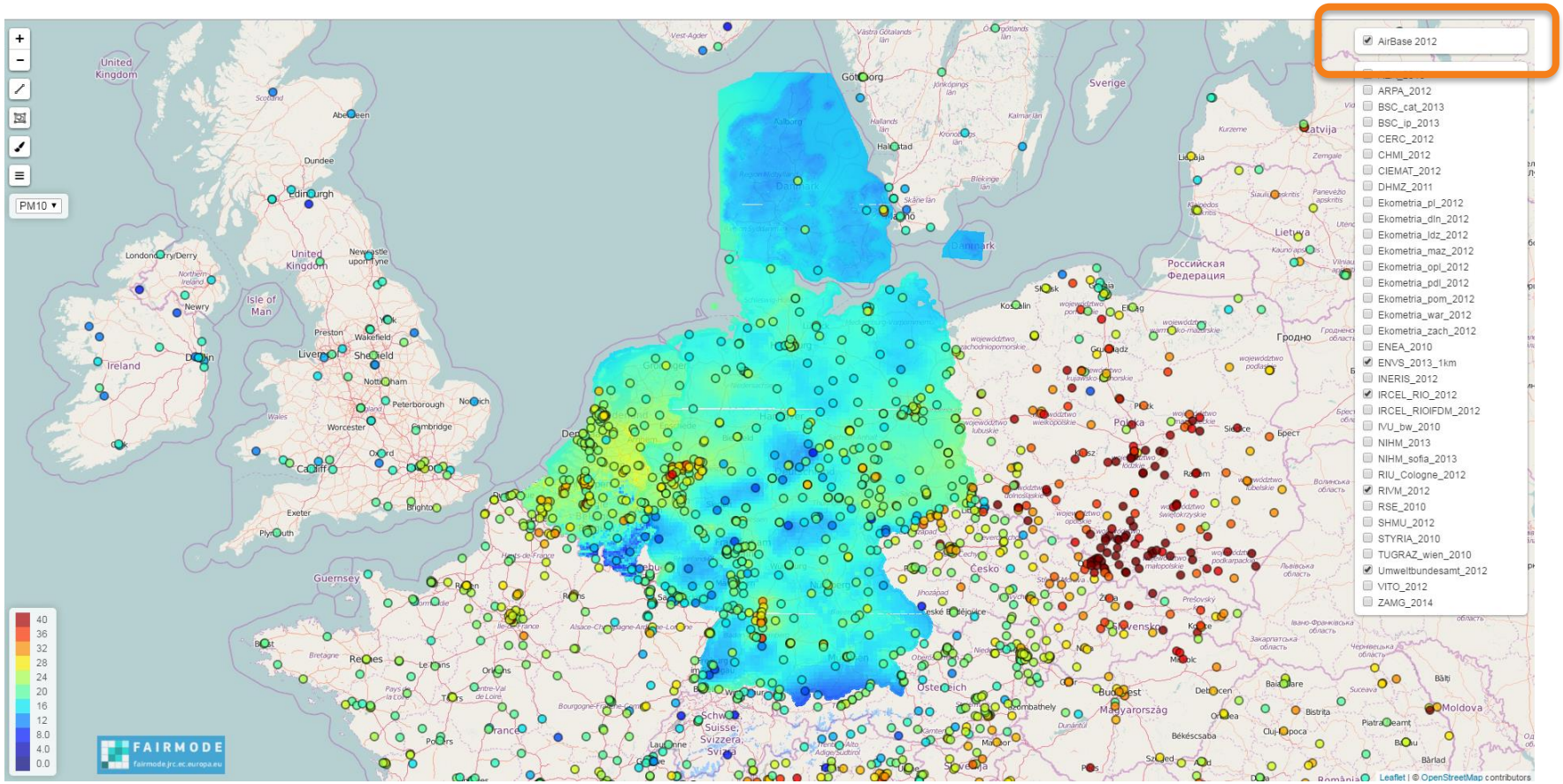








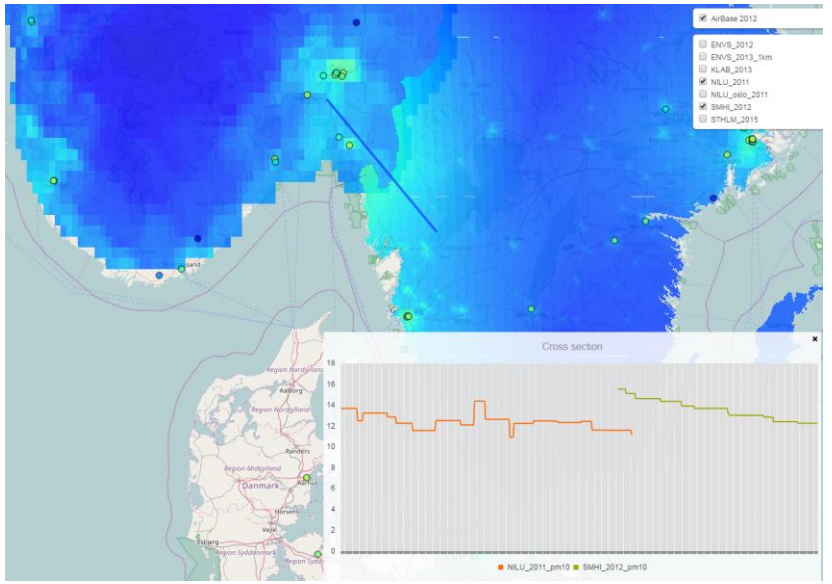
AIRBASE MEASUREMENTS (2012)

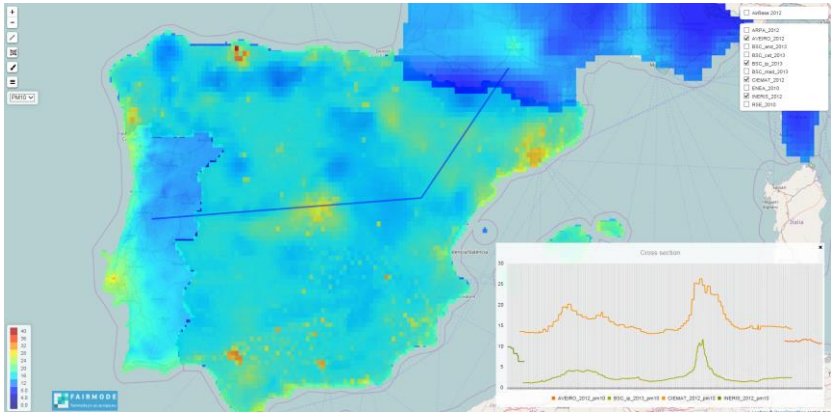


LESSONS LEARNT SO FAR

Regional workshops during the Zagreb Technical Meeting

- Regional workshop (North EU, Central West EU, South EU, Central East EU) discussed the Composite Map
- Interesting discussions about causes of inconsistencies:
  - Emissions
  - Data fusion/data assimilation
- Peer review of the air quality maps
- Clear link with IPR & e-Reporting → harmonize as much as possible
- Suggestions to improve the platform:
  - Target diagram attached to a map
  - Labeling of the maps
  - Quality control of data formats during upload process

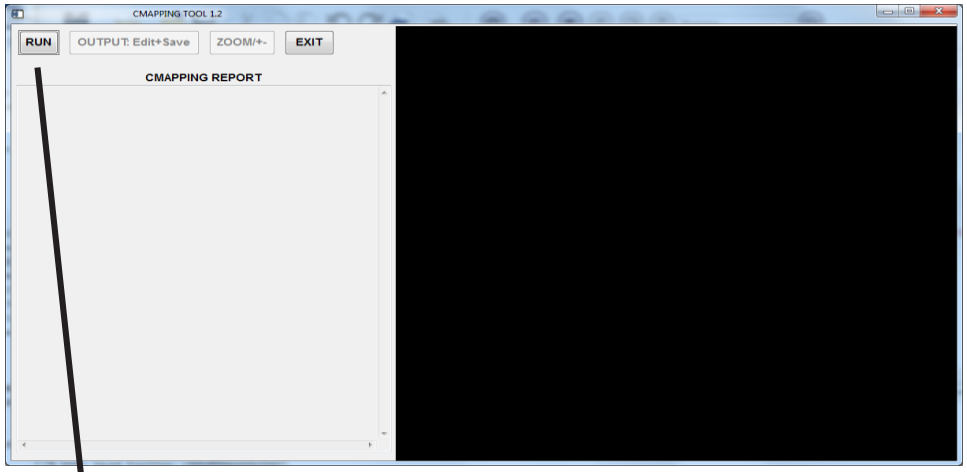




A NEW APPROACH FOR QUALITY CHECKS

Compliance/Validation Tool - Kees Cuvelier

- Tool to locally check the quality of the AQ map
- Setup file 35 Mb, including various examples. (15+20 Mb)
- 1-click, 1-sec installation, produces an icon on the desktop
- No licenses needed, IDL virtual machine is included in the setup file
- User manual available



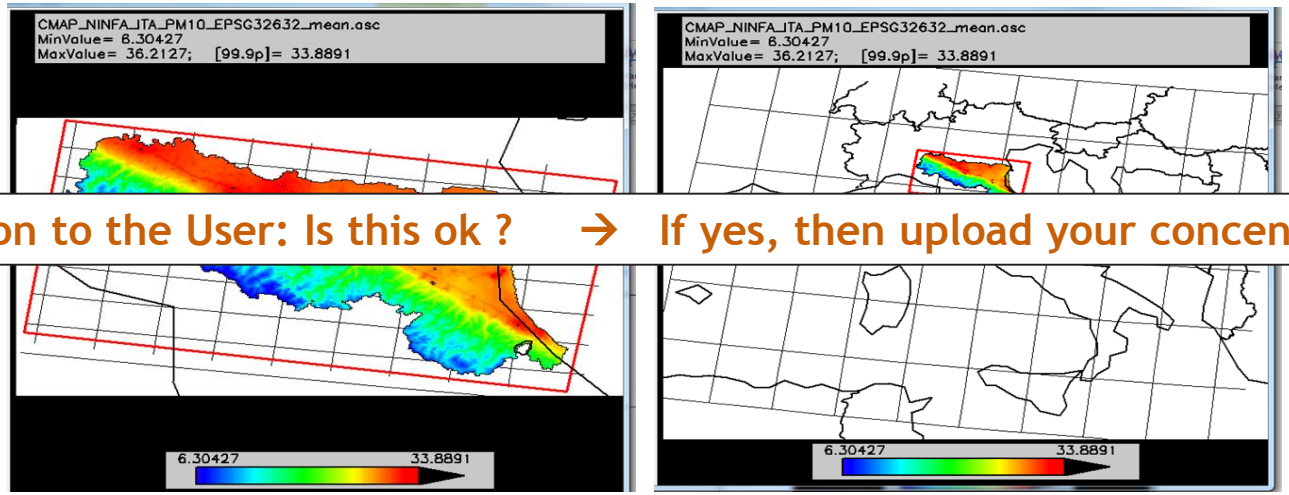
Select a file of the following type:

CMAP_Model_CountryCode_Pollutant_EPSG_userinfo.extension

- CMAP
- ModelName
- NLD, FRA, …
  (list provided)
- PM10, NO2, …
- Coord Ref System
- User info
  (version, year, …)
- ASC, TIF

A NEW APPROACH FOR QUALITY CHECKS

- A large number of tests is performed (see manual):
  - Filename format, Extension, Country code, pollutant, EPSG code,
  - nx, ny, LL corners/cell centres, nodata cells, is domain in Europe, in country, min/max values as expected
  - Coordinate transformation from EPSGuser to EPSG4326 (WGS84 world; lon, lat) using GDAL cs2cs application
- Report of all checks is produced in the left panel of the window
- If an error is detected, then an indicative message is produced
- At successful completion: A map of the following type is shown:



Question to the User: Is this ok ? → If yes, then upload your concentration field

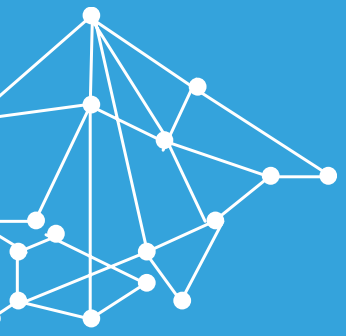
Remark: With some slight modifications this Tool can be adapted to an Emission Mapping exercise.
(Extension to the main pollutants, and the 10 SNAP sectors)

COMPOSITE MAPPING: 2E VERSION

- 2e version of the Composite Map:
  - Possibility to provide a new version of your AQ maps
  - Standardized Quality Checks before upload procedure

- Timing:
  - New data base structure & QC tool available in March/April
  - Upload maps May 2017
  - Launch at Technical Meeting June 2017

- Specifications:
  - Pollutants: PM10 & NO2 annual averages
  - Base year: 2012 or 2015 (?)

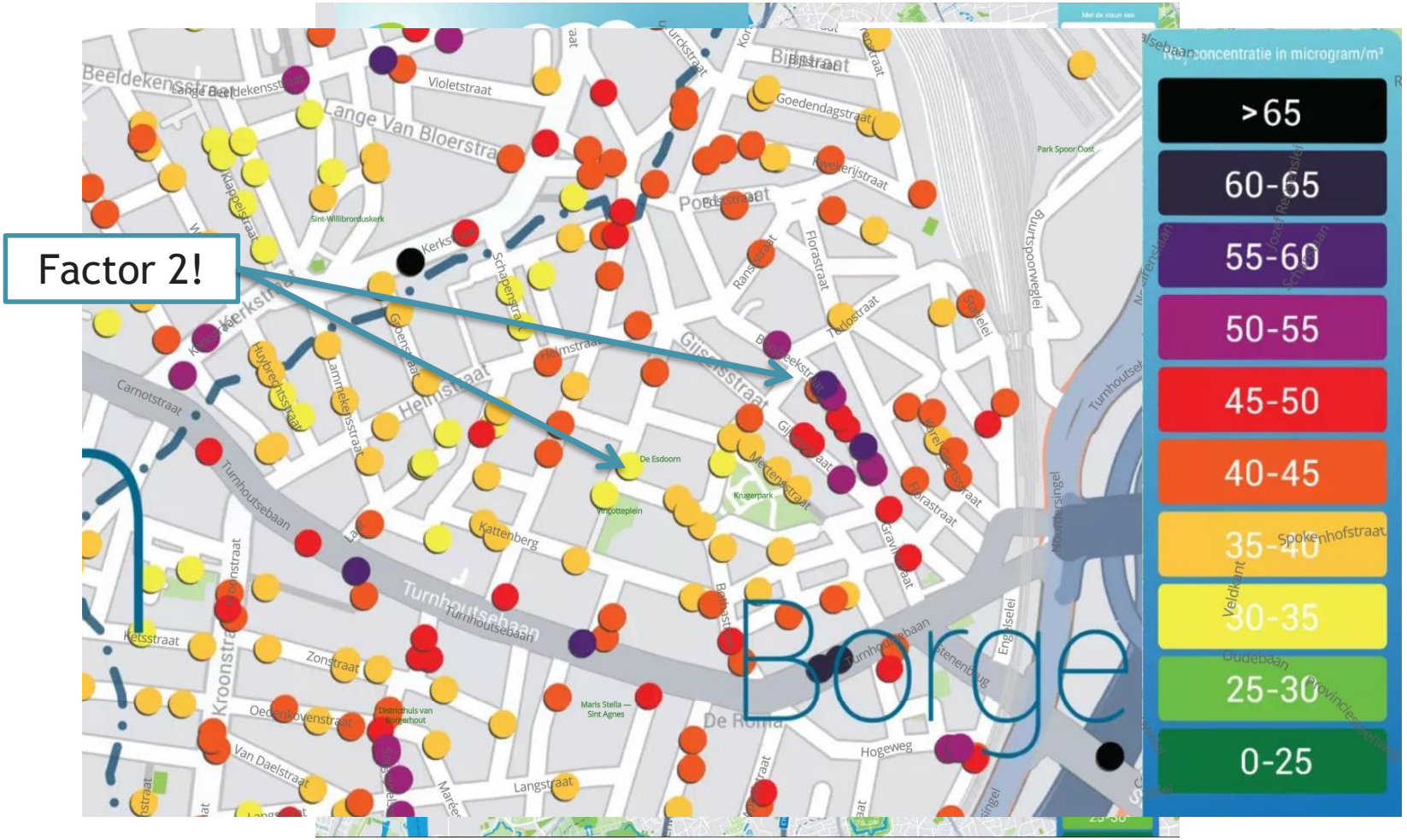


Exceedance Modelling & Model's fitness for purpose

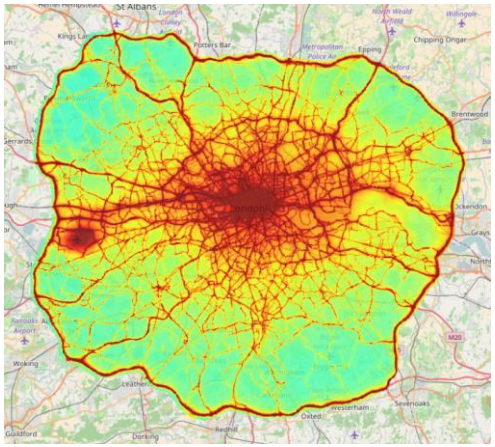
EXCEEDANCE ESTIMATES

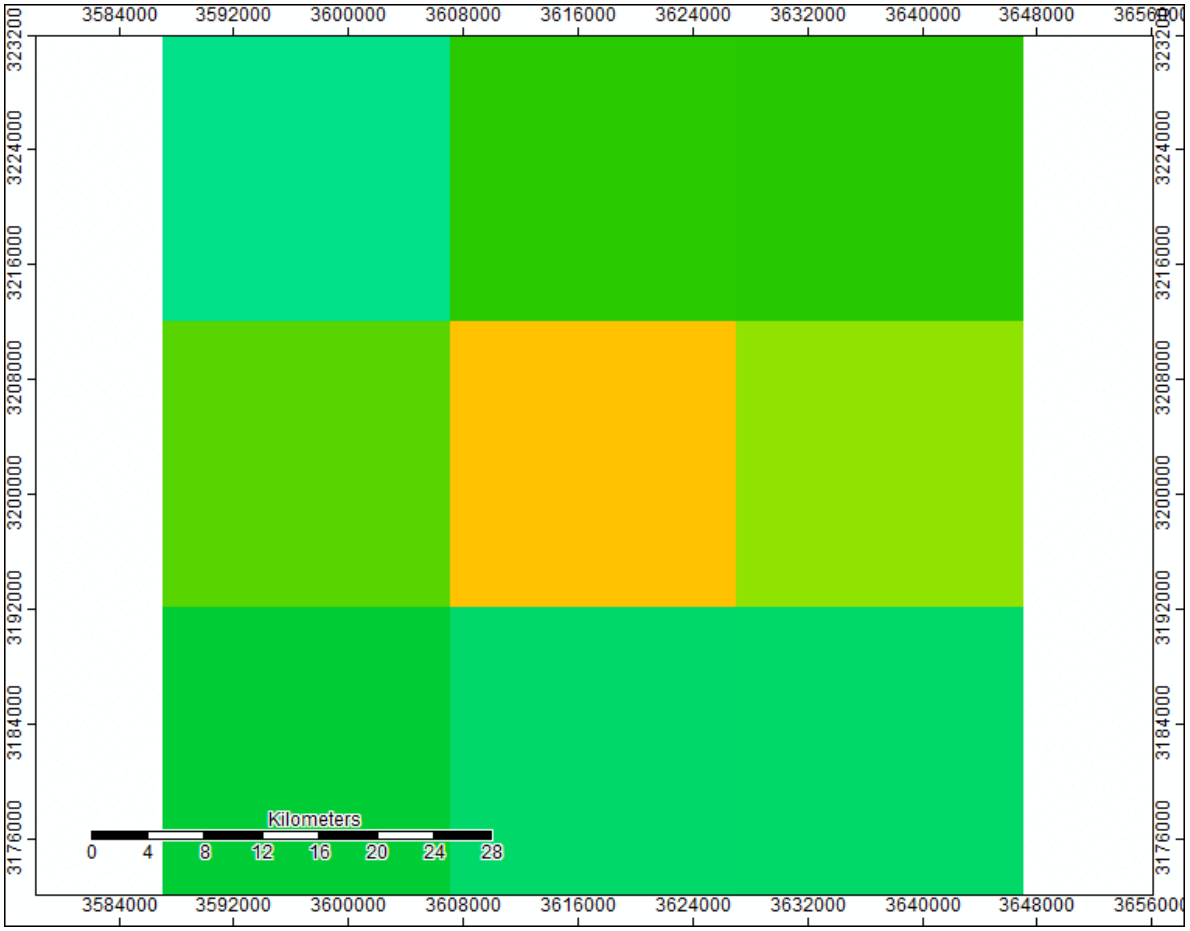
- Reporting of an exceedance situation according to implementing decision 2011/850/EC
  - *6. Estimate of the surface area where the level was above the environmental objective*
  - *7. Estimate of the length of road where the level was above the environmental objective*
  - *10. Estimate of the total resident population in the exceedence area*
  - *11. Estimate of the ecosystem/vegetation area exposed above the environmental objective*
- Analysis of population exposed to LV exceedances in Germany:
  - Stuttgart: **1.800** (2012), Hamburg **221.780** (2012)
  - Differences in exposed population are due to different approaches (modelling and station-based)
- Need for harmonization!
- → **What is an appropriate spatial scale for assessment?**

PASSIVE SAMPLING EXPERIMENT IN ANTWERP (2000 LOCATIONS, MONTHLY MEAN NO2)

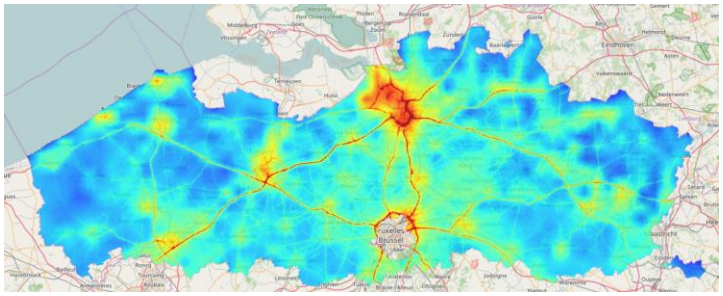


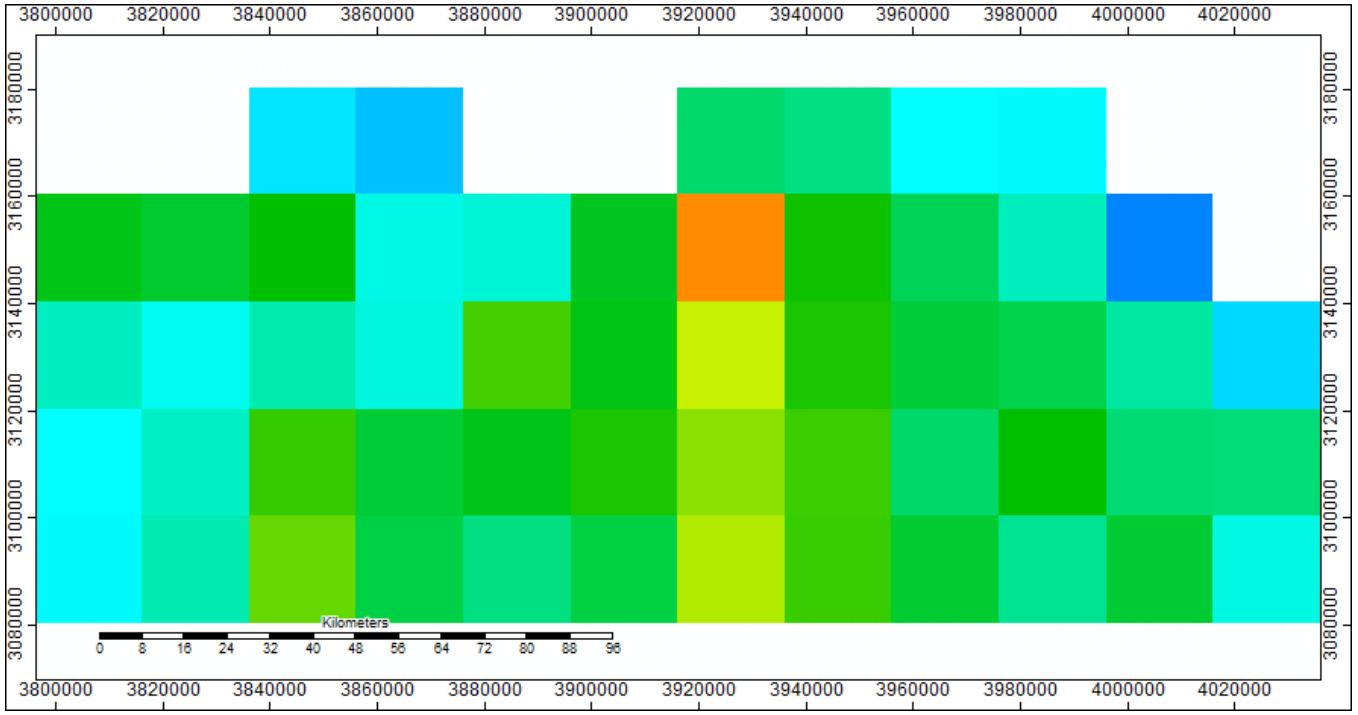
NO2 MAP OF LONDON AT VARIOUS RESOLUTION



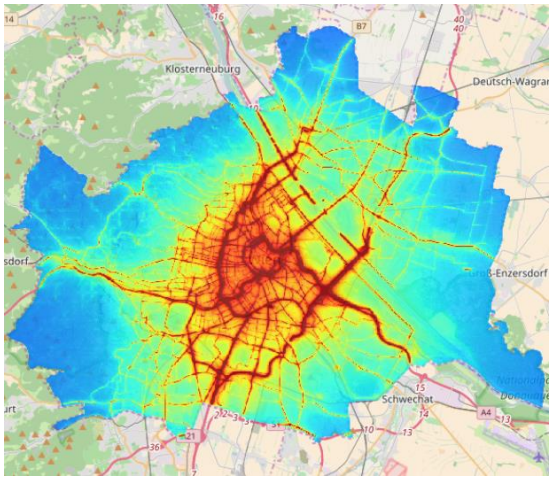


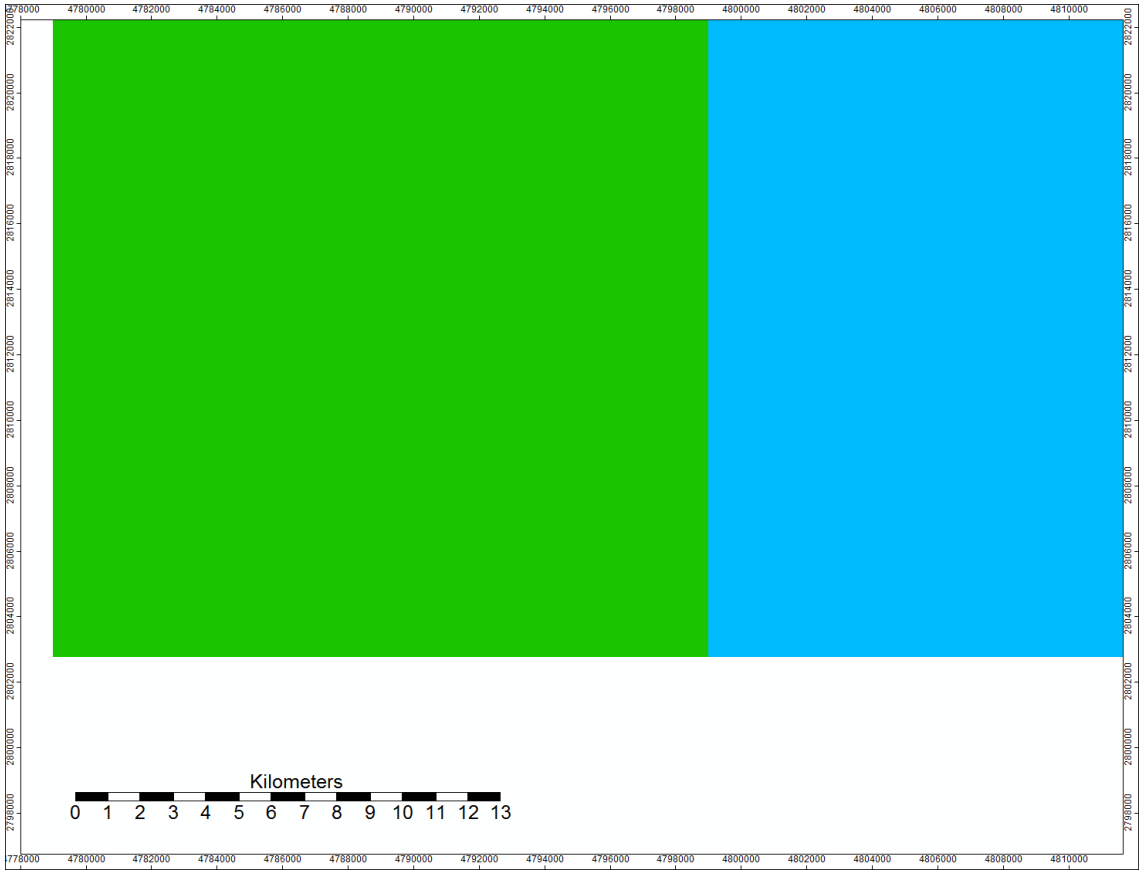
NO2 MAP OF FLANDERS REGION AT VARIOUS RESOLUTION





NO2 MAP OF VIENNA AT VARIOUS RESOLUTION

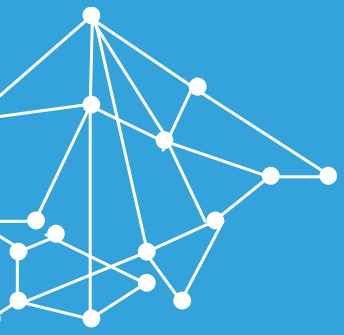




MODELLING EXCEEDANCES

What is an appropriate methodology for exceedance modelling?

- Can we come to a set of guidelines for fitness-for-purpose?
- Spatial resolution, e.g.:
  - NO_2 → 10m to 100m?
  - PM_{10} → 1km to 5km?
    - What about resuspension in street canyons? → 10m to 100m?
- What about temporal resolution?
- Link with Spatial Representativeness exercise
  - Station (location) representativeness should provide guidance here!



Work plan 2017 - 2019

WORKPLAN 2017 - 2019

What wil WG1 do in the coming years

- Modelling Quality Objective:
  - Support ongoing CEN work → propose modifications in the MQO & participate in testing (e.g. high percentiles, limited number of stations available for evaluation…)
  - MQO for forecasting
- Composite Mapping: Use the exercise as a trigger for discussions about:
  - Quality of AQ assessment
  - Fit-for-purpose criteria
- Spatial Representativeness
  - Consolidation of the 2016-2017 model intercomparison exercise
- e-Reporting of modelling results
  - Guidance towards a harmonized e-Reporting approach

The European Commission's science and knowledge service

Joint Research Centre

Status of the Intercomparison Exercise

Spatial Representativeness of Air Quality Monitoring Stations

(FAIRMODE CCA-1)

Oliver Kracht and Michel Gerboles

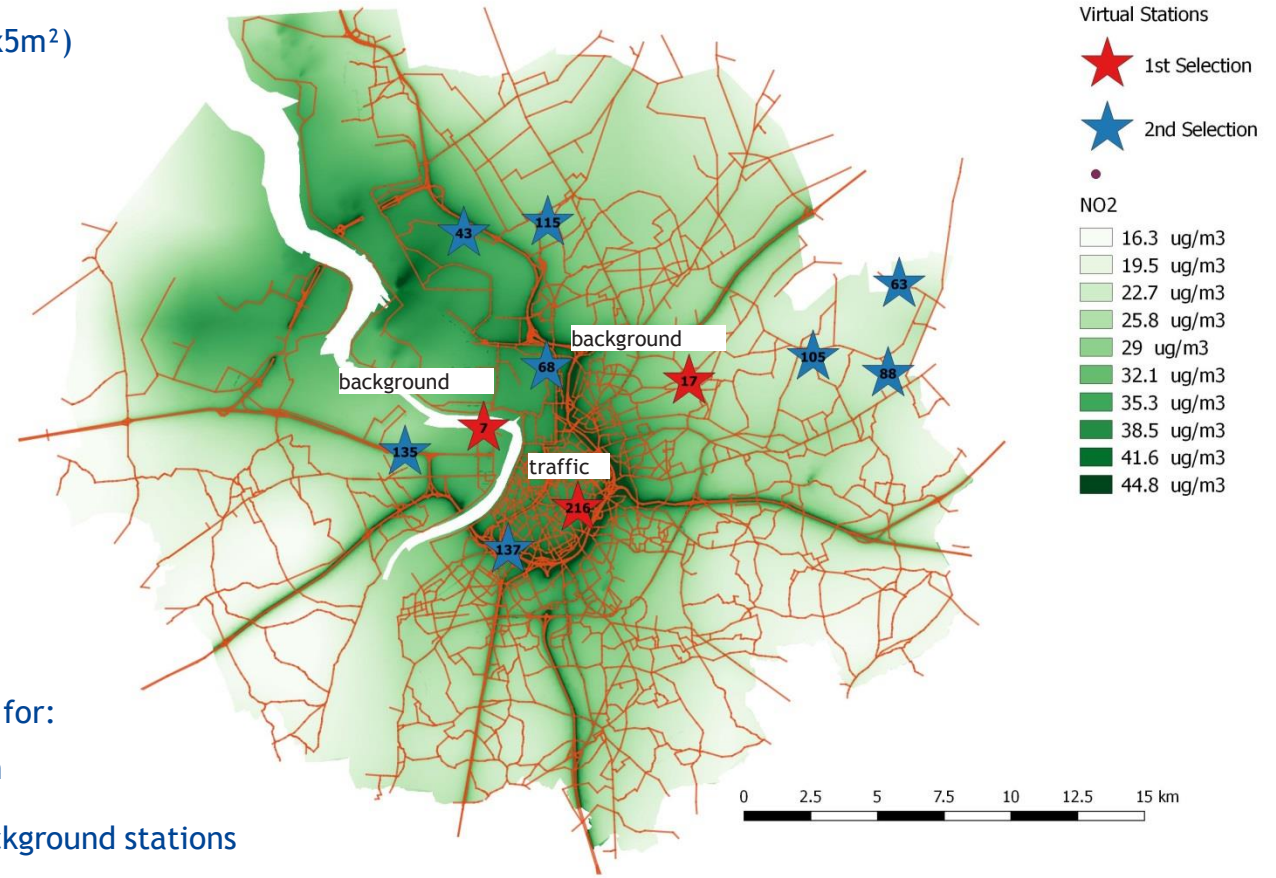
with contributions from

CIEMAT (ES), ENEA (IT), EPA (IE), Finnish Consortium (FMI / HSY / Kuopio / Turku), INERIS (FR), RIVM (NL), SLB (SE), UBA (AT), VITO (BE) & VMM (BE)

European Commission

Intercomparison Exercise of Spatial Representativeness Methods

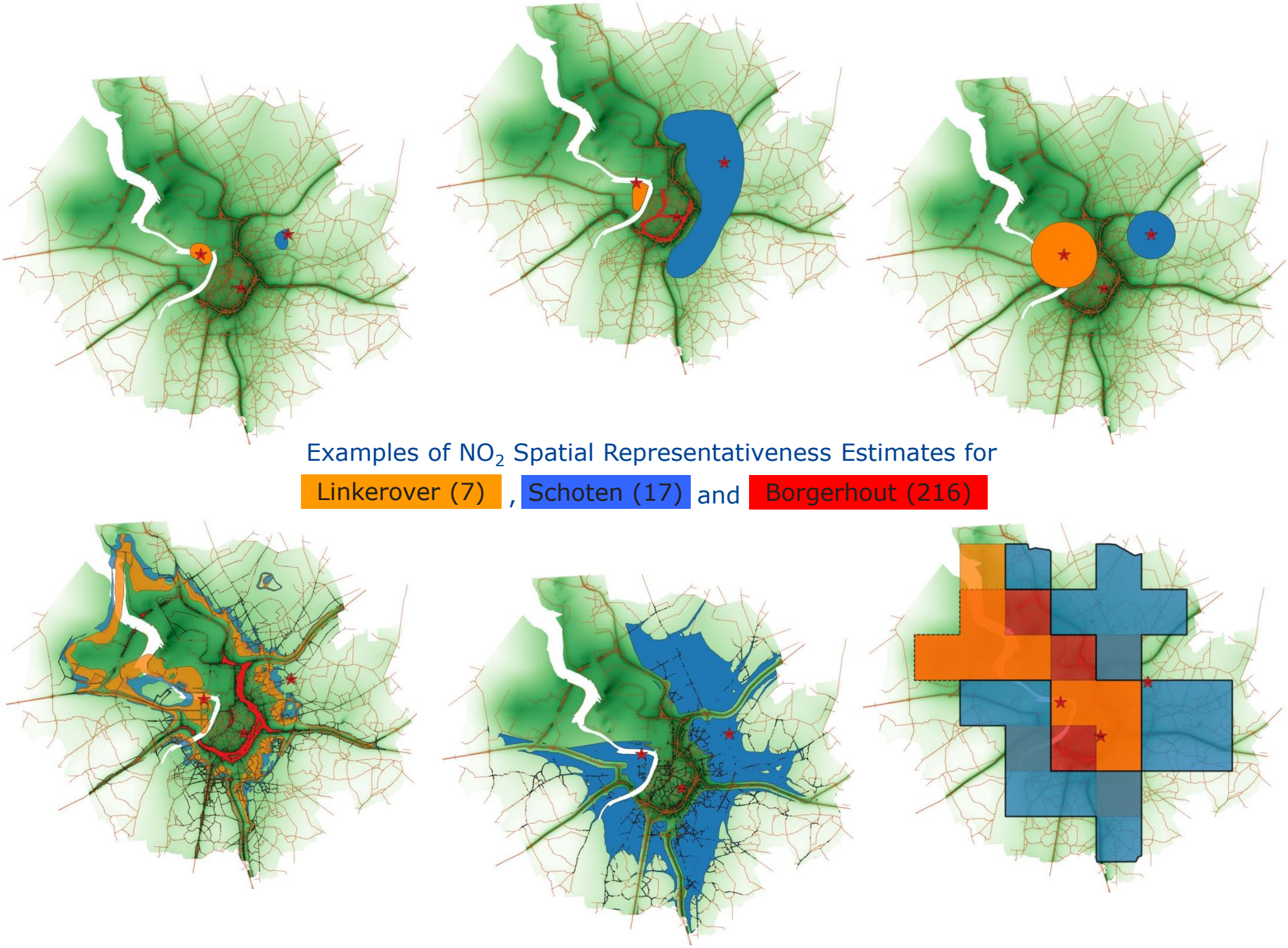
- **Performed by 10 different groups**, but on the same **shared dataset** (prepared by VITO).
- Existing stations for PM_{10} (n=15), NO_2 (n=18) and O_3 (n=3)
- Dataset based on outputs from the **RIO-IFDM-OSPM model chain** for the region of **Antwerp** (year 2012).
- Virtual stations (n=341) from hourly model data
- Gridded model data (annual means, 5x5m²)
- Emissions
- Population density
- Building heights
- CORINE land cover



- **Spatial representativeness** estimates for:
  - PM_{10} and NO_2 at one traffic station
  - PM_{10}, NO_2 and O_3 at two urban background stations
  - 8 additional stations (optional task)
  - classification(optional task)

FAIRMODE CCA-1 Spatial Representativeness Intercomparison Exercise ---- Overview Table

	CIEMAT	ENEA	FEA-AT	FI (consortium)	EPA	INERIS	RIVM	SLB	VITO	VMM	Totals
	Spain	Italy	Austria	Finland	Ireland	France	Netherlands	Sweden	Belgium	Belgium	
	(CFD-RANS)						(PCA)				
Concentrations											
Monitoring Stations (hourly)	X			X			X				3
Virtual Monitoring Stations (n=341)		X			X	X	X				4
raw timeseries (hourly)		X			X						2
virtual samplers						X	X				2
noisy virtual samplers											0
Concentration Maps (annual avg)			X	X				X	X (?)	X	4 (5)
Raw Model Outputs (annual avg)						X					1
Emissions											
Road Traffic	X					X		X		X	4
Domestic Heating			X (for PM_{10})			X					2
Industry						X					1
Emission Proxies											
Traffic Emission Proxies			road type "motorway"	X							2
Domestic Heating Proxies										from population	1
Industry Emission Proxies			concentration maps								1
Dispersion Conditions											
Building Geometry	X			X (?)				X (?)			1 (3)
Corine Landcover Classes			(X)						X	X	3
Meteorological Data											
Wind Velocity	X			X							2
External Information											
Google Satellite Images				X							1
Google Street View Data				X							1
Traffic Network					X						1
Final Results											
Polygons		X	X	X	X	X		X	X	X	8
allways contiguous				X	X			X	X	other	4
also non-contiguous		X	X			X				other	3
other types	gridded values						PCA classification				2
3 Primary Stations											
VS 216 (Borgerhout - traffic)											
NO_2	X	X	X	X	X	X	X	X	X	X	10
PM_{10}	X	X	X	X	X	X	X	X	X	X	10
VS 7 (Linkeroever - background)											
NO_2	no	X	no	X	X	X	no	X	X	X	7
PM_{10}	no	X	X	X	X	X	X	X	X	X	9
O_3	no	X	no	(X)	no	no	no	X	X	no	3 (4)
VS 17 (Schoten - background)											
NO_2	no	X	X	X	X	X	X	X	X	X	9
PM_{10}	no	X	X	X	X	X	X	X	X	X	9
O_3	no	X	X	X	X	no	X	X	X	no	7
8 Additional Stations											
SR area	no	X	X	no	no	X	no	no	X	no	4
classifications	no	no	X	no	no	no	X	no	no	no	2



Examples of NO_2 Spatial Representativeness Estimates for

Linkerover (7), Schoten (17) and Borgerhout (216)

Intercomparison Exercise of Spatial Representativeness Methods

Current activities:

- Screening of incoming results & bilateral consultations with participants (verifying methodological details)
- Harmonization of results structure across participants
- Consolidation of results meta data and participants documentation

Next steps:

- Intercomparison regarding the methodology (input data & procedures)
- Intercomparison with regard to the quantitative results obtained
- Summary and reporting

Target dates:

- FAIRMODE Technical Meeting 19. – 21. June in Athens
- JRC Technical Report with internal target date 15/09/2017

Dimensions of the Intercomparison & Treatment of Results

Assessment from the methodological point of view:

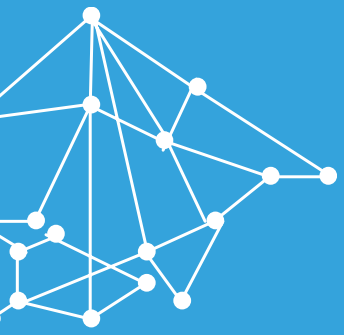
- Comparison and classification of candidate methods in terms of:
  - Input data
  - Procedures / techniques & intermediate outcomes
  - Time scale of data treated (hourly data, annual means, …)

Assessment from the results point of view:

- Comparison and classification of candidate methods in terms of:
  - Mutual degree of a agreement regarding the geometry (position, size, continuity) of SR areas
  - Comparing the lumped size of SR areas
  - Agreement regarding the magnitude and identification of population affected
  - Further geometrical relationships (shape, intersections, similarities, Hausdorff distance, size of the hull curve …)

Assessment tools:

- Limited by the absence of a 'true value' for the reference
- We need to measure 'consistency' rather than 'correctness'.
  - Quantitative indicators for mutual similarities (kappa statistics, inter-rater reliability, mutual information indices, …)
  - Mapping & cross tabulation of similarity indicators
  - Cluster analysis



Discussion

Discussion and Outlook

Outlook beyond this current project (ending October 2017):

- What are the positions about the continuation of these activities?
- Should we aim for setting up guidelines for spatial representativeness procedures as a mid term objective?
- Is there a future need for harmonization?
  - Standardization?
  - Make the use of standards mandatory?
- Specific suggestions for future research activities:
- In more detail investigate the influence of the parameterization of the similarity criteria and their thresholds on the spatial representativeness
  - Current outputs do not enable us to distinguish between the influences of (1) parameterizations, (2) basic principals of a method, and (3) input data
  - Monte Carlo Simulations & Sensitivity Analysis
  - Requires a formalization of the procedures in terms of fully automatic code.

Interest in a dedicated CCA-1 workshop for knowledge exchange?

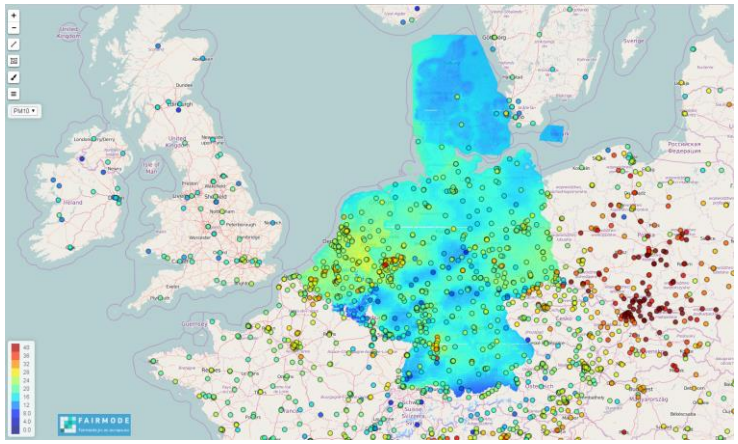
- Based on the common experiences from working on the shared datasets.
  - In conjunction with the upcoming Technical Meeting (limited time frame)?
  - As a stand-alone CCA-1 workshop (separate date)?

COMPOSITE MAPPING

A powerful instrument …how to make it effective?

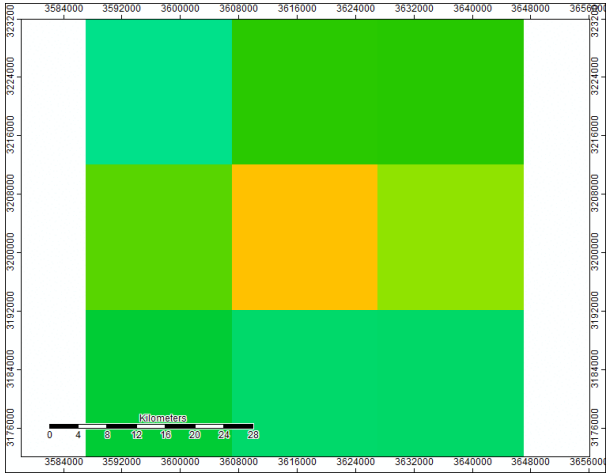
- What kind of anomalies did you observed & what did you learn from the exercise?
- Did the Comp Map help to solve issues between neighbors? How to organize this process?
- Do we need additional info (e.g. emissions, monitoring) to support the discussion?
- From an assessment point of view, is there an added value of extending the exercise to emissions?
- How to establish the link with e-Reporting?
- What about the password protected system?

- 2e version of the Comp Map:
  - Base year 2012/2015?
  - Upload before May 2017 → feasible?



FROM MQO TO FIT-FOR-PURPOSE GUIDANCE?

How do we arrive at a fit-for-purpose Guidance?



- Does fit-for-purpose relates to:
  - Type of model?
  - Spatial scale?
  - Temporal scale?
- Does fit-for-purpose depends on:
  - Pollutant?
  - Type of indicator (annual average, exceedance…)?
- Do we have to discriminate between type of applications:
  - assessment, planning, forecast, source apportionment?
- Where do we want to put the focus? Where do we start?

- Volunteers to prepare a proposal by the next Technical Meeting (June 2017)?

FORECASTING

Forecasting: towards consensus on a MQO?

- Did you test the FAIRMODE MQO on your forecast system?
- Do you see any added value in an harmonized benchmarking approach for forecast?
- Should a forecast model fulfill both the standard assessment MQO and the forecast MQO?

- Volunteers to further test and fine tune the methodology by the next Technical Meeting (June 2017)?