

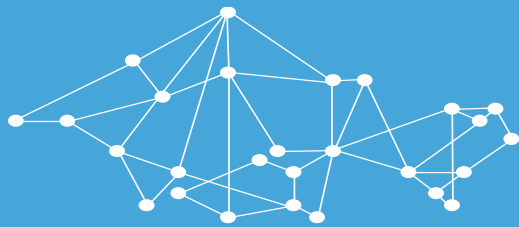


FAIRMODE

Forum for air quality modelling in Europe

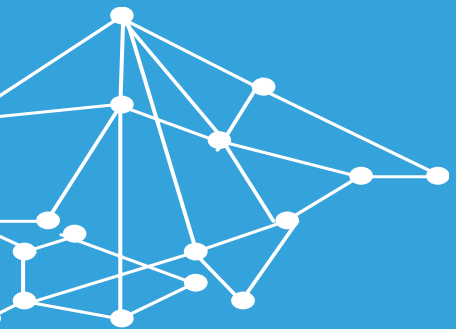
**WG8:
SPATIAL REPRESENTATIVENESS,
EXCEEDANCE SITUATION INDICATORS &
MONITORING DESIGN**

**STIJN JANSSEN, LEONOR TARRASON & MATT ROSS-JONES
MARCH 2, 2023**



- » Status update
 - » WG8 subtopics:
 - » Spatial Representativeness
 - » Exceedance Situation Indicators
 - » Network Design
- » Cooperation with CAMS on natural source deduction to exceedances
- » Future activities and links to AAQD
- » Road Map Discussion



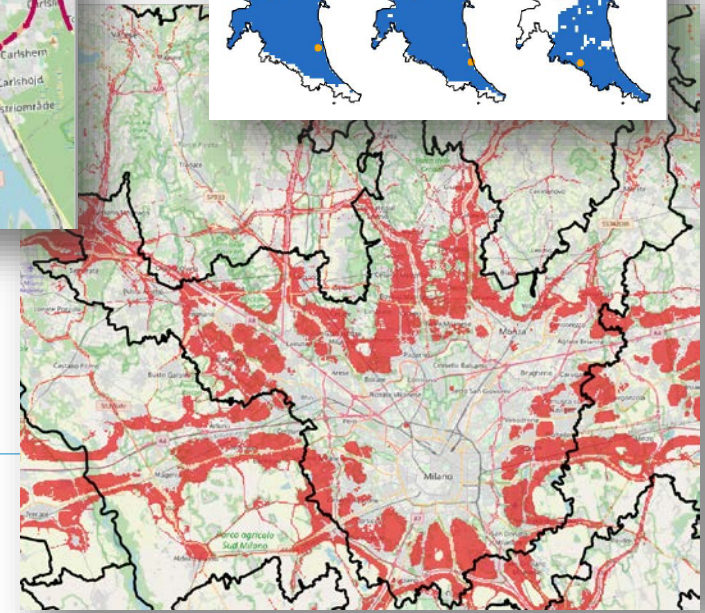
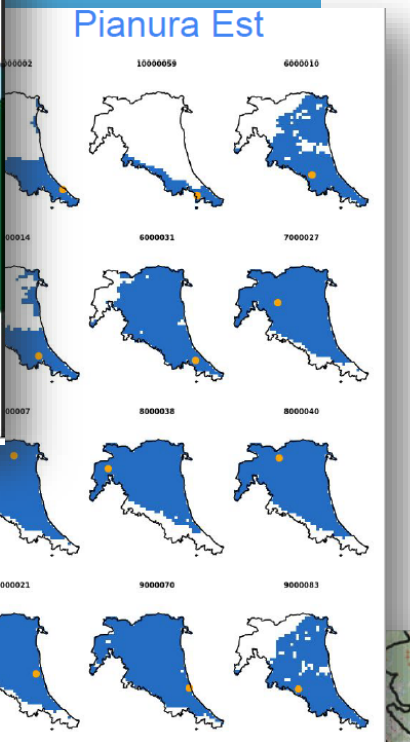
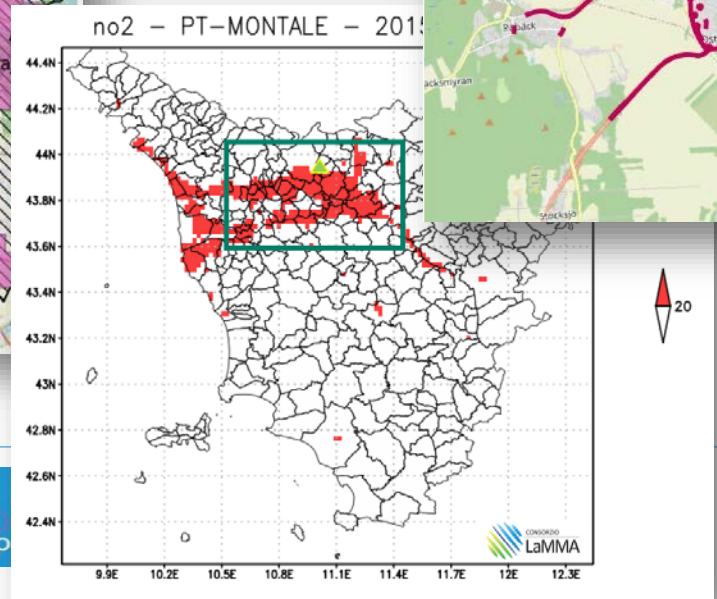
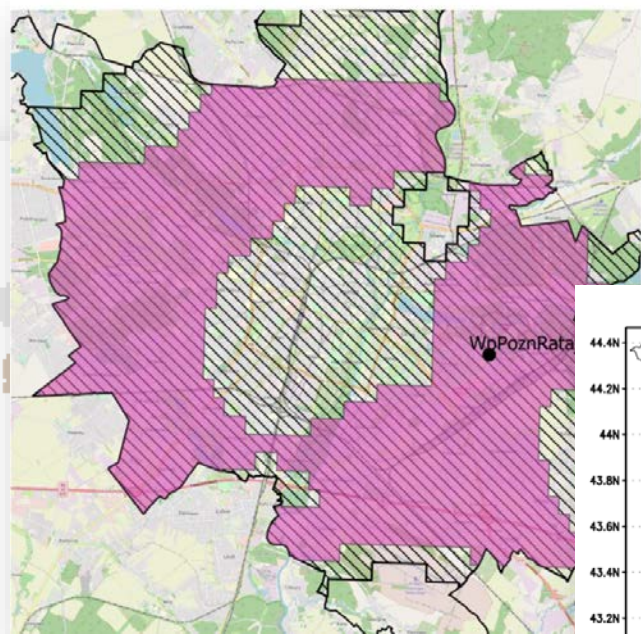
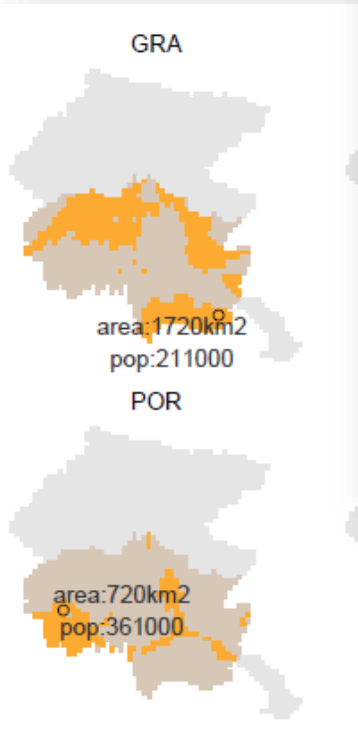


Spatial Representativeness

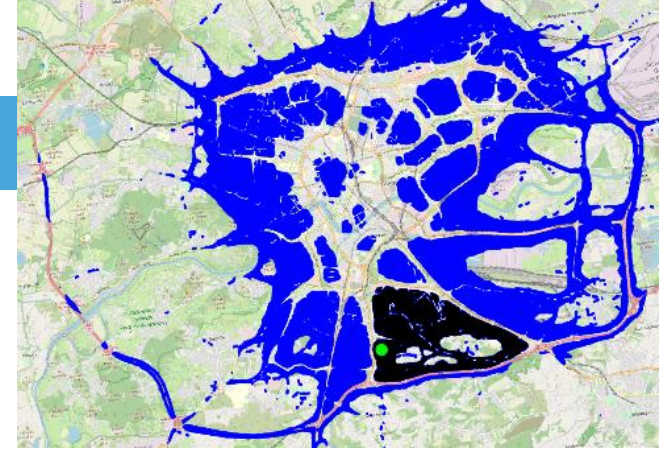
- » **Spatial representativeness (SR)** is an essential indicator of any monitoring site
- » SR is relevant for various applications under the AAQD:
 - » Assessment of **population exposure** based on monitoring data
 - » Assessment of **exceedance situations** based on monitoring data
 - » **Monitoring network design**
 - » Use of monitoring data for **model validation and data fusion**

WG8 EXERCISE ON SR

» Models become fit-for-purpose to assess SR at all spatial scales and all station types



- » (Dis)contiguity
 - » Similarity criterion
 - » Tolerance (or threshold) level
-
- » Important note: no objective criteria to define the concept → need for consensus based on expert judgement



- » Discontiguous SR area, limited by the IPR AQ zone
 - » If needed the area can be reduced (e.g. based on expert opinion)
- » Similarity criterion: **annual mean concentrations**
- » **Tolerance level** (tested for NO_2 , PM_{10} , $\text{PM}_{2.5}$, O_3):
 - » $\pm 10\%$ for rural & urban background stations
 - » $\pm 20\%$ for traffic stations
 - » Absolute lower cut-off of $2 \mu\text{g}/\text{m}^3$
- » Use **modelled** concentrations at station location (assuming bias is small \rightarrow fit-for-purpose model)

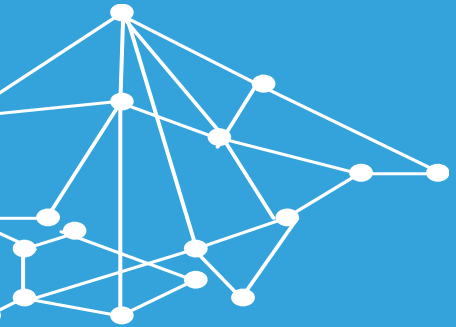
When defining the spatial representativeness area the following associated characteristics shall be considered:

- (a) the geographical area may include non-contiguous domains but shall be limited in its extension by the borders of the air quality zone under consideration;
- (b) if assessed via modelling, a fit-for-purpose modelling system shall be used and modelled concentrations shall be used at station location to prevent systematic model-measurement biases from distorting the assessment;
- (c) other metrics than absolute concentrations can be considered (e.g. percentiles);
- (d) the tolerance levels and possible cut-offs for the different pollutants may change depending on the station characteristics;
- (e) the annual average of the observed pollutant concentration shall be used as the air quality metric for a specific year.

OPEN ISSUES TO BE CLARIFIED

- » Further testing required for:
 - » A pollutant specific lower cut-off value:
 - » $2\mu\text{g}/\text{m}^2$ might be too high for some pollutants
 - » Station type specific tolerance level
 - » Two tolerance levels (10% & 20%) → additional layer of complexity?
 - » What if station type is not clear?
 - » SR takes up an important role in the new AAQD → requires a simple & robust definition!
 - Arguments for a one-fits-all tolerance level of 15%
- » Open methodological issues:
 - » Similarity criteria for percentiles → important for e.g. AAQD daily limit values
 - » SR for industrial sites → poorly tested up to now
 - » Reporting of SR under e-Reporting → what is feasible?





Exceedance Situation Indicators

Context

- Exceedance Situation Indicators:
 - Additional information about **extent and severity** of the observed exceedances
 - Purpose is dual: **compliance checking & input for AQ planning**
- Exceedance Situation Indicators (year X) reported via e-Reporting Data Flow G in September X+1
 - **Too early** for a comprehensive analysis in many MS



New proposal

- Proposal for a 2 staged approach:
 - Exceedance Flagging Indicator (EFI): qualitative indicator to flag the severity of the exceedance (compliance purpose) → year X+1
 - Exceedance Situation Indicator (ESI): quantitative indicator that identifies all the “hot spot areas” in the air quality zone (planning purpose) → year X+2



EXCEEDANCE FLAGGING INDICATORS

- Qualitative additional information about severity of the observed exceedance
- **Class based** indicator that can be easily assessed
- Assessment based on **available data sources** (e.g. existing modelling results) and **expert judgement**
- Can be reported in **year X+1** via Data Flow G
- (*Assessment method should be documented via Data Flow D?*)

Class	Residents in exceedance in the AQ Zone	Description of the exceedances
1	< 100	Limited
2	100 - 100	Some
3	1000 - 100.000	Many
4	> 100.000	Widespread

Ranges
require
reality
check!



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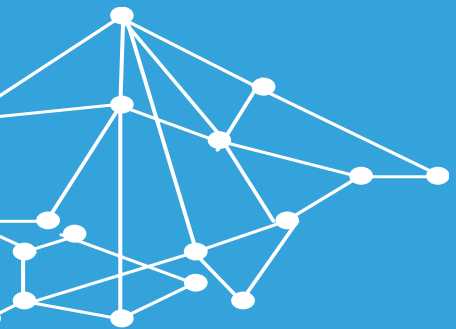
EXCEEDANCE SITUATION INDICATORS

- Comprehensive and quantitative indicator
- Provides **full understanding** of the exceedances in the air quality zone
- Input for the design of an **air quality plan**
- ESI for **area** (km²) and **population** (#residents) in exceedance
 - Relevance of **road length** (km) is questioned by some experts
- Assessment based on fit-for-purpose **modelling**
- Reporting under IPR (via e-Reporting):
 - ESI via Data Flow H-K or I?
 - Assessment method via Data Flow D?
- Timing: **year X+2** → Too late?



- Fine tuning of the Exceedance **Flagging** Indicator
 - Focus on absolute population only !?
 - Reality check of the ranges of the classes
- Guidance for the estimation of the Exceedance **Situation** Indicator:
 - Spatial resolution: what about **street canyons** in population exposure?
 - What about the **road length** in exceedance?
 - What about the **ecosystem** indicator?
- Open issues to be clarified before the revision of the IPR





Monitoring network design

MONITORING NETWORK EVALUATION EXERCISE - FAIRMODE & AQUILA COOPERATION

- FAIRMODE & AQUILA cooperation
- 45 participants
 - Both research and air quality managers
- 17 presentations sharing experience in two sessions
 - 10 countries: Austria (1), Germany (1), Ireland (1), Italy (4), the Netherlands (1), Norway (1), Portugal (1), Slovakia (1), Spain (2), Sweden (2)
 - Most focused on two domains: country, region/AQ zone
 - Most focused on PM10 and/or NO2 (some in PM2.5 and O3 in addition)
 - Mostly hourly data, few daily (PM10)
- 33 new users of MoNet (individual/Institution)

*Thank you for interest!!
Thank you for your contribution!!*



FAIRMODE

Forum for air quality modelling in Europe

The MoNET tool was used for :

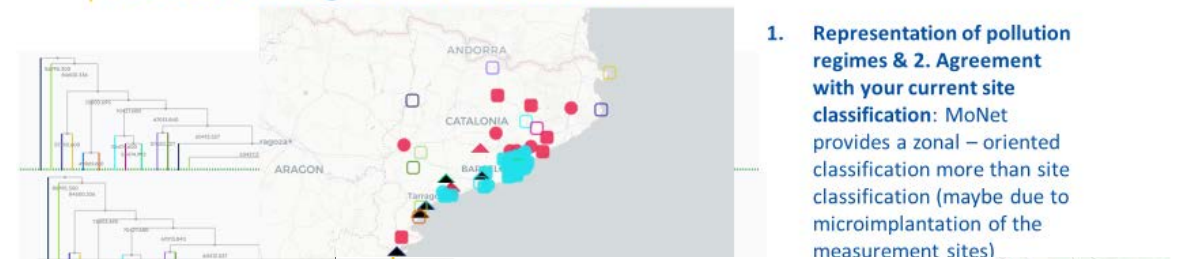
- Comparing different spatial areas: regional (country) vs. local (e.g., AQ zone)
- Comparing different components (PM10 vs NO2)
- Comparing different temporal aggregations (hourly vs. daily)
- Comparing model and measurement data
- Assessing how different technologies may influence the assessment
- Assess how meteorology may impact the outcome - normalised data



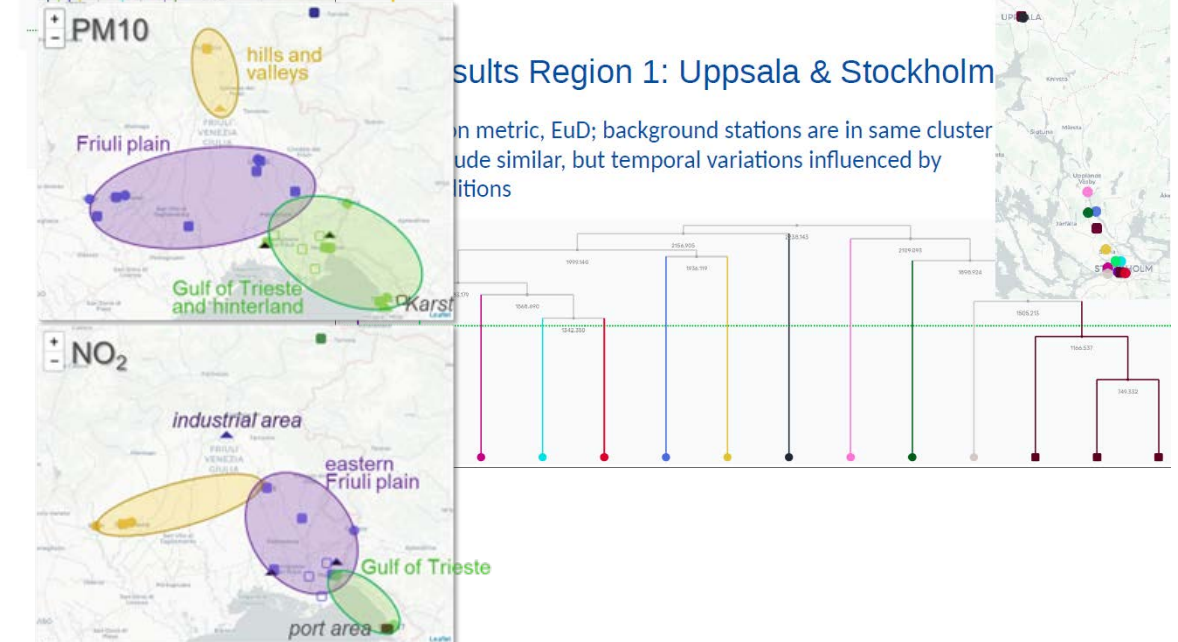
AQUILA-FAIRMODE monitoring network evaluation exercise – lessons learnt (I)

- **Identification of outliers**
 - expected: e.g. industrial source
 - not expected: reflection on the reason behind it
- **Identification of potential gaps and clusters**
 - sources not being identified
 - Cluster of stations measuring similar circumstances
- **Identification of regional (di)similarities**
 - Which stations are isolated and why
 - Which characteristics are relevant for (di)similarities

Results Region 2: Catalonia

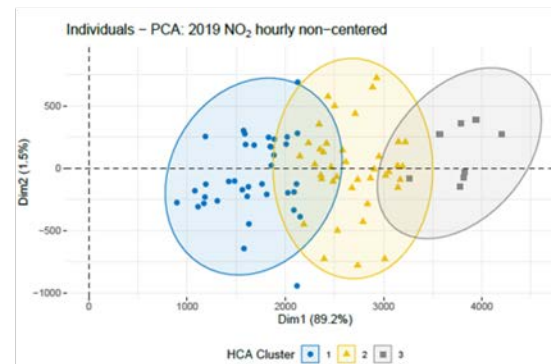
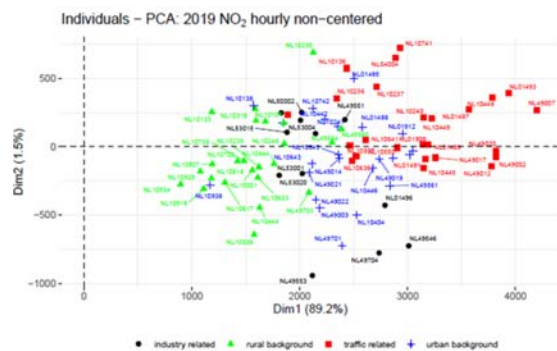


Results Region 1: Uppsala & Stockholm



AQUILA-FAIRMODE monitoring network evaluation exercise – lessons learnt (II)

- Identification of inconsistencies in the monitoring sites classification
- Identification of different monitoring techniques/instrumentation effects
- Comparison with other statistical methods
- Improvements of the MoNET tool



Results PM₁₀

Large clusters:

- Northern/north-eastern extra-alpine
- Southern extra-alpine
- Klagenfurt Basin
- Several small clusters in inner-alpine stations for 1-h mean values, which belong to larger clusters for daily mean values

Isolated stations:

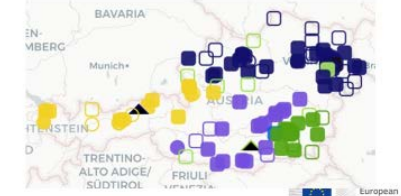
- Traffic (urban and motorway)
- Industrial sites
- Elevated alpine sites
- Alpine valleys

Most similar stations: Vienna background sites

Hourly values 2021. Dissimilarity cutoff 30,000



Daily values 2021. Dissimilarity cutoff 4000



Planned next steps

- Soares et al. «Applications of an advanced clustering tool for EU AQ monitoring network data analysis”
 - EGU 2023 oral presentation
 - **Peer review article**
- Initiation of the elaboration of a Monitoring Network Design Evaluation Guidebook
- Additional exercises in May/June 2023 to be reported at the next FAIRMODE technical meeting

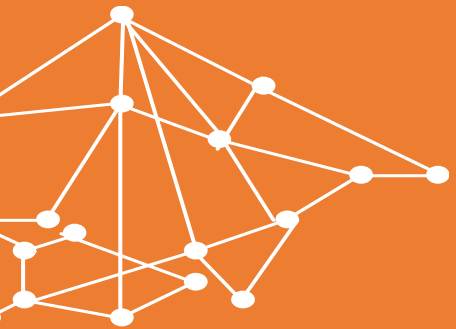


» Guidebook

- Compilation of experiences in a guidebook form
 - How to evaluate your air quality monitoring network
 - How to use the tool
 - How to interpret the results
 - Protocol for evaluation, Interactive cookbook
 - » Streamline a procedure on what to do with the outliers
 - Examples of good practices



Cooperation with CAMS on deduction of natural dust contributions to exceedances



Atmosphere
Monitoring



Copernicus
Europe's eyes on Earth



Atmosphere
Monitoring Service

EVALUATION OF EXCEEDANCES – DEDUCTION OF NATURAL CONTRIBUTIONS

Under the AAQD, Article 20, Member States are encouraged to identify zones where exceedances of limit values are attributable to natural sources. Now in Article 16 of the revised version of the AAQD proposed by the European Commission.

Member States are to follow the current guidelines in COM(208)/2011 if there are to deduce the contribution of natural dust to measured exceedances to limit values.

The current official guidance is from 2011. New modelling and measuring methods have been developed since then such as the Saharan dust information regularly provided by CAMS

Identification of best practices for exceedance evaluation at the core of FAIRMODE WG8 activities



EN

EN



Natural Dust contribution to exceedances of limit value

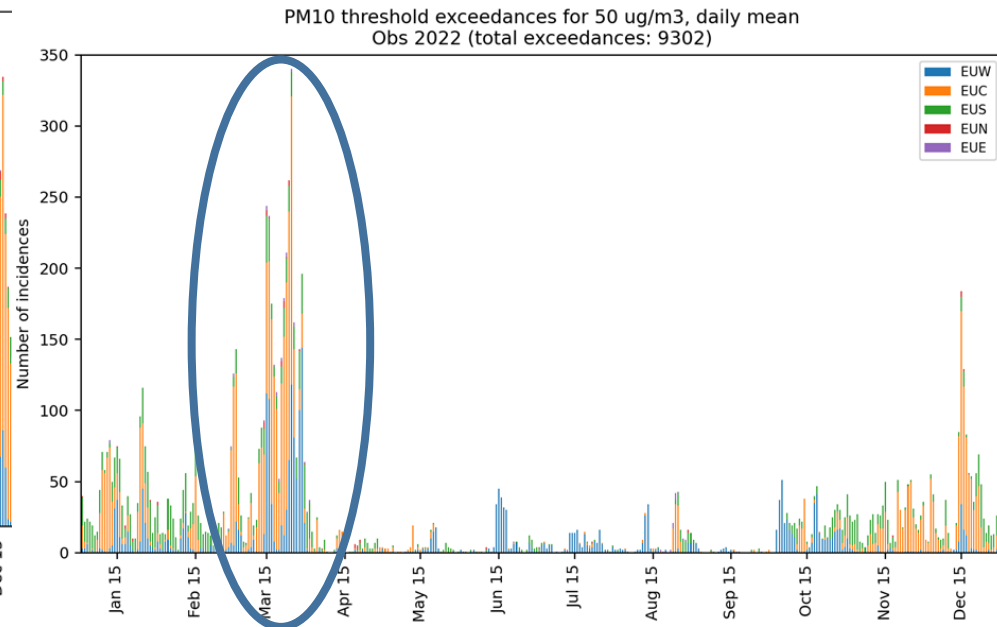
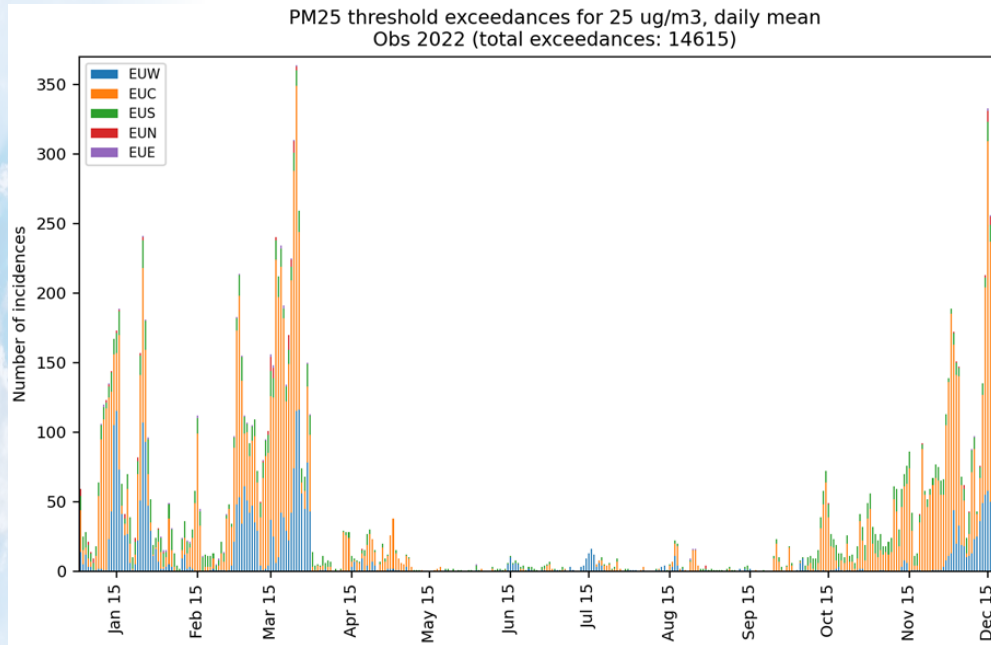
Proposal to launch a common CAMS FAIRMODE activity under FAIRMODE WG8

- Identify **best practices** for use of CAMS modelling dust products when deducing natural contribution from exceedances in the context of the AAQD
- Prepare recommendations for the inclusion of reference to CAMS dust products in a possible revision of the guidelines for the deduction of natural contributions to exceedances
- Increase the awareness on the existing CAMS dust products
- Promote the use of CAMS dust products for the exceedance analysis
- Compile experiences of use of CAMS dust products for exceedance analysis
- Provide recommendations for the evolution and documentation of the CAMS dust products valuable for exceedance evaluation and analysis



Suggested procedure

- Interested participants will be asked to carry out their analysis of deduction of Saharan dust as usual, and they will be required to do an additional evaluation using some specific CAMS products for a given exceedance episode in 2022.



Comparison with current methodologies

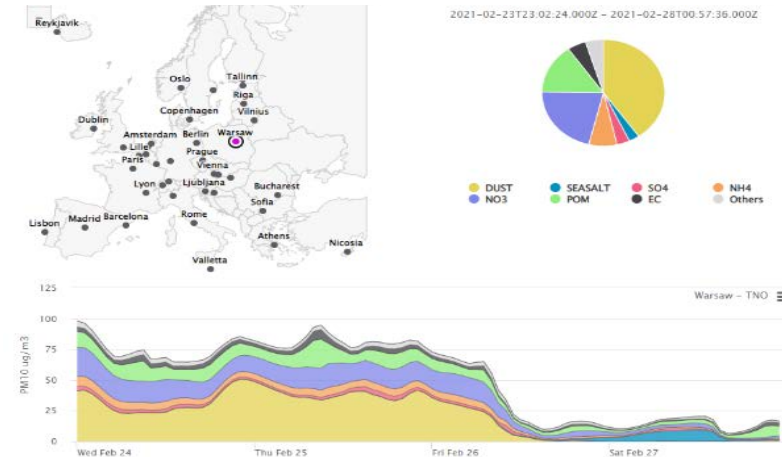
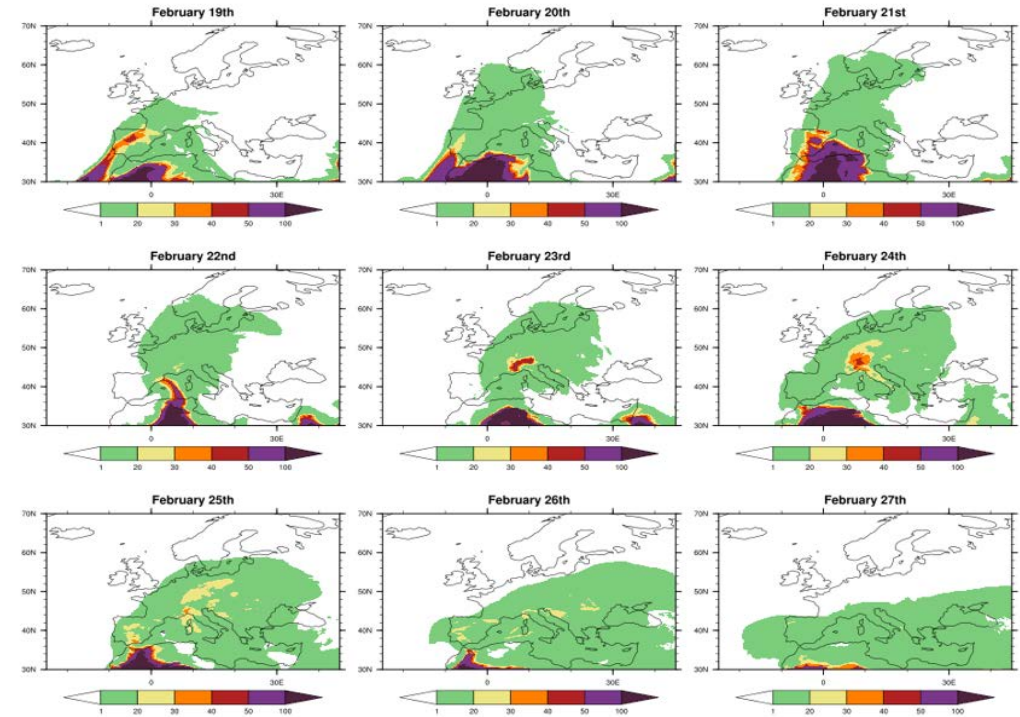
Not for compliance reporting in this first round



CAMS dust products

- The CAMS team will secure that data from 4 different CAMS products
- Possible data products to be shared are
 - CAMS regional Interim **reanalysis data** for PM10 and PM2.5 (hourly data)
 - CAMS **regional dust forecast** (hourly data)
 - CAMS **SR data for natural dust** for the selected episode in European cities (hourly data)
 - CAMS **chemical speciation** data for the selected episode in European cities (hourly data)
- No constraints on how to use the CAMS data in the evaluation

February 19th to February 27th PM Pollution Episode, Daily Average Dust PM Plots





Proposed timeline

March 2023 – Initial webinar to agree on the exercise set-up

May/June 2023 – First interpretation webinar to gather experiences from users

Sept/Oct 2023 – Second interpretation workshop to share experiences and identify lessons learnt.

This is planned as an on-site common session in conjunction with the FAIRMODE Technical meeting and the CAMS Policy User workshop in 2023

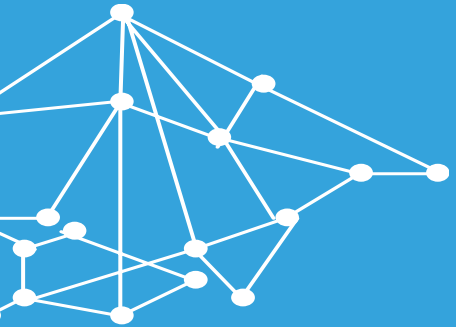
Feb/March 2024 – Summary of conclusions and lessons learnt. Follow-up actions

This is planned as a presentation under WG8 in the FAIRMODE Plenary which is to back to CAMS Policy User Workshop in 2024

Interested?

Send an email lta@nilu.no





Future Activities and links to AAQD

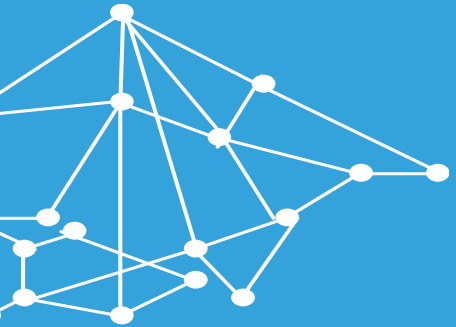
LINKS TO AAQD

- » Significantly increased role of spatial representativeness in proposal for a revised AAQD
 - » Definition of spatial representativeness & requirement to define for all sampling points in zones where concentrations are >Assessment Thresholds.
 - » Modelling applications shall provide information on spatial representativeness of fixed measurements.
 - » Where relocation of sampling points with recent exceedances is necessary - must be within the area of spatial representativeness.
 - » The whole zone shall be covered by the different areas of representativeness defined for each sampling point.
 - » Requirement for additional measurements for modelled exceedance in an area of the zone not covered by fixed measurements. Use for spatial representativeness to define coverage?
 - » Includes a number of criteria for defining spatial representativeness, based on work within CT8, e.g:
 - » Can include non-contiguous domains
 - » Tolerance levels and possible cut-offs may change depending on station characteristics



LINKS TO AAQD & OTHER ACTIVITIES

- » Some important changes regarding network design in the AAQD proposal, e.g.
 - » The design & regular review (at least every 5 years) of monitoring networks shall be supported by modelling and/or indicative measurements
- » Changes regarding exceedance indicators in AAQD proposal of more minor significance
 - » These indicators link more to IPR decision / reporting
- » Important links to other ongoing / future activities
 - » **AQUILA**: proposed future WGs on network design & station representativeness
 - » Joint activities with FAIRMODE?
 - » **IPR**: coming review of IPR decision and guidance documents
 - » Development of **technical guidance documents** (lead by DG env)
 - » Based on recommendations from AQ assessment workshops 2020 - 2021 and a [support study on strengthening monitoring, modelling and AQ plans](#).



Next Steps – Road map discussion

A.1.1 Identification of best practice to estimate SR through additional testing

- » A pollutant specific lower cut-off value - $2\mu\text{g}/\text{m}^2$ might be too high for some pollutants
- » A station type specific tolerance level - additional layer of complexity?
- » Similarity criteria for percentiles → important for AAQD limit values
- » SR for industrial sites → poorly tested up to now

A.1.2 Feasibility exercise to report on station representativeness

- ❖ Reporting of SR under e-Reporting → what is feasible to report?
- ❖ How often do we have to calculate the area of representativeness of a sampling point?
- ❖ Do we need polygons or gridded data?
- ❖ LINK TO WG4 – Microscale modelling
- ❖ LINK TO CLUSTERING APPROACHES – Monitoring design

A2.1 Fine tuning of the Exceedance **Flagging** Indicator

- Focus on absolute population only !?
- Reality check of the ranges of the classes

A2.2 Guidance for the Exceedance **Situation** Indicator:

- Spatial resolution: what about **street canyons** in population exposure?
- What about the **road length** in exceedance?
- What about the **ecosystem** indicator?
- How to report exceedance situations based on modelling data?

A2.3 Use of CAMS modelling data to support deduction of natural dust source contribution to exceedances

A3.1 AQUILA-FAIRMODE monitoring network evaluation exercise

Continue with the evaluation exercise

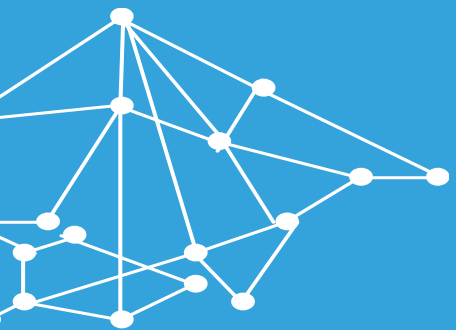
Which additional exercises are necessary ?

- Try with additional **pollutants** (PM2.5) ? Or for a combination of pollutants (AQI) ?
- Try different dissimilarity **metrics**? And work to understand how do we use the different metrics available for complementing the analysis?
- Should we normalise the data ? Try additional exercises on yearly dependence ? how to account for **meteorological variability**?
- Should we include also **modelling data** – model comparisons/ additional model validation approach?
- Additional exercises on **time aggregation** dependence – instrumentation relations ?
- Other?

- ✓ A3.2 Compilation of experiences in a guidebook form
 - How to evaluate your air quality monitoring network
 - How to use the tool
 - How to interpret the results
 - Protocol for evaluation, Interactive cookbook
 - Streamline a procedure on what to do with the outliers
 - Examples of good practices

[Link to spatial representativeness - new set of exercises with AQUILA](#)





Thank you

» Definition of spatial representativeness (Article 4)

(22) '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;

» Modelling applications shall provide information on spatial representativeness of fixed measurements (Article 8)

2. In all zones where the level of pollutants exceeds the assessment threshold established for those pollutants, fixed measurements shall be used to assess the ambient air quality. Those fixed measurements may be supplemented by modelling applications and indicative measurements to assess air quality and to provide adequate information on the spatial distribution of air pollutants and on the spatial representativeness of fixed measurements.

3. In all zones where the level of pollutants exceeds a limit value established for those pollutants in Table 1 of Section 1 of Annex I or an ozone target value established in Section 2 of Annex I, modelling applications shall be used in addition to fixed measurements to assess the ambient air quality.

Those modelling applications shall also provide information on the spatial distribution of pollutants and on the spatial representativeness of fixed measurements.

» Additional measurements for modelled exceedance in area not covered by fixed measurements (Article 8)

5. If modelling shows an exceedance of any limit value or ozone target value in an area of the zone not covered by fixed measurements, additional fixed or indicative measurements shall be used during at least 1 calendar year after the exceedance was recorded, to assess the concentration level of the relevant pollutant.

» If relocation of station in exceedance is necessary (Article 9)

7. Sampling points at which exceedances of any limit value specified in Section 1 of Annex I were recorded within the previous 3 years shall not be relocated, unless a relocation is necessary due to special circumstances, including spatial development. Relocation of sampling points shall be done within their area of spatial representativeness and be based on modelling results.

» Require to define spatial representativeness of sampling points and for areas to cover the whole zone (Annex IV, B)

2 (g) sampling points shall, where possible, also be representative of similar locations not in the immediate vicinity of the sampling points. In the zones where the level of air pollutants is above the assessment threshold, the area which each sampling point is representative of shall be clearly defined. The whole zone shall be covered by the different areas of representativeness defined for each sampling points;

» Criteria for defining spatial representativeness (Annex IV, B.2)

When defining the spatial representativeness area the following associated characteristics shall be considered:

- (a) the geographical area may include non-contiguous domains but shall be limited in its extension by the borders of the air quality zone under consideration;*
- (b) if assessed via modelling, a fit-for-purpose modelling system shall be used and modelled concentrations shall be used at station location to prevent systematic model-measurement biases from distorting the assessment;*
- (c) other metrics than absolute concentrations can be considered (e.g. percentiles);*
- (d) the tolerance levels and possible cut-offs for the different pollutants may change depending on the station characteristics;*
- (e) the annual average of the observed pollutant concentration shall be used as the air quality metric for a specific year.*

» Site selection, its review and documentation (Annex IV, D)

1. *The competent authorities responsible for air quality assessment shall for all zones fully document the site-selection procedures and record information to support the network design and choice of location for all monitoring sites. The design of the monitoring network shall be supported at least by either modelling or indicative measurements.*
2. *The documentation shall include the location of the sampling points through spatial coordinates, detailed maps and shall include information on the spatial representativeness of all sampling points.*
4. *Where indicative measurements, modelling or objective estimation, or a combination thereof are used within a zone, the documentation shall include details of these methods and information on how the criteria listed in Article 9(3) are met.*
9. *At least every 5 years the selection criteria, network design and monitoring site locations, defined by the competent authorities in view of the requirements of this Annex, shall be reviewed to ensure they remain valid and optimal overtime. The review shall be supported at least by either modelling or indicative measurements.*
10. *The documentation shall be updated following every review and other relevant changes to the monitoring network, and shall be made public through appropriate communication channels.*

» Range of other relevant (mostly unchanged) provisions, incl. Annex III (minimum number of stations) and Annex IV (siting criteria)

AAQD PROPOSAL - EXCEEDANCE INDICATORS

» Information to be included in Air Quality Plans (Annex VIII, A) - no change compared to 2008/50/EC

1. Localisation of excess pollution

- (a) region;
- (b) city (map);
- (c) sampling point(s) (map, geographical coordinates).

2. General information

- (a) type of zone (urban, industrial or rural area) or characteristics of NUTS 1 territorial unit (including urban, industrial or rural areas);
- (b) estimate of the polluted area (in km²) and of the population exposed to the pollution;
- (c) concentrations or average exposure indicator of the relevant pollutant observed at least 5 years prior to the exceedance;

» Public information (Annex IX)

1. Member States shall provide at least the following information:

- (c) information on observed exceedance(s) of any limit value, ozone target value, and average exposure reduction obligation, including at least:
 - (i) the location or area of the exceedance,