Italian National Agency for New Technologies,
Energy and Sustainable Economic Development

European Commission

FAIRMODE
Forum for air quality modelling in Europe

QUALITY CONTROL INDICATORS FOR THE VALIDATION OF AIR QUALITY FORECAST APPLICATIONS IN THE FRAMEWORK OF FAIRMODE ACTIVITIES

Aveiro, Portugal, September 27-30, 2022

Antonio Piersanti (ENEA), Cornelis Cuvelier (JRC), Stijn Janssen (VITO), Alexandra Monteiro (University of Aveiro), Paweł Durka (IEP), Philippe Thunis (JRC) and Lina Vitali (ENEA)

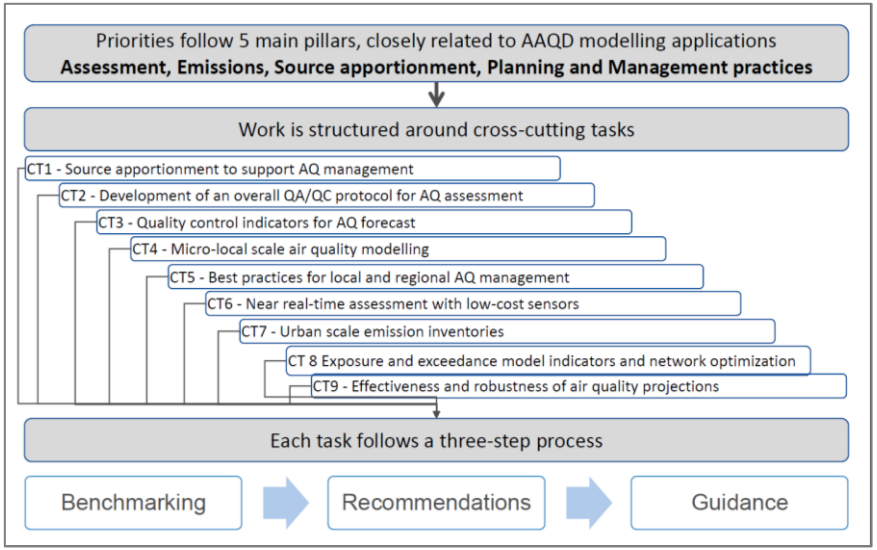
Outline

1. FAIRMODE crosscutting task **CT3 - Quality indicators for model forecast**
   - ✓ CONTEXT
   - ✓ ROADMAP
   - ✓ ACTIVITIES
2. Developed methodology
   - ✓ MAIN FEATURES
   - ✓ APPLICATION FOR A CASE STUDY

FAIRMODE crosscutting task CT3 - Quality indicators for model forecast

CONTEXT

2022 FAIRMODE's working structure & Expected outcome of each crosscutting tasks



Benchmarking
- CT4 - Microscale air quality modelling
- CT6 - Near real-time assessment with low-cost sensors
- CT9 - Effectiveness and robustness of air quality projections

Recommendations
- CT2 - Development of an overall QA/QC protocol for AQ assessment
- CT5 - Best practices for local and regional AQ management
- CT7 - High resolution emission inventories

Guidance
- CT1 - Source apportionment to support AQ management
- CT3 - Quality control indicators for AQ forecasts
- CT8 - Exposure and exceedance model indicators and network optimization

Within FAIRMODE 2020-2022 workplan, CT3 was expected to reach the final Guidance stage

FAIRMODE crosscutting task CT3 - Quality indicators for model forecast

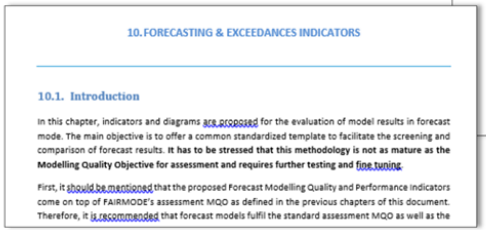
ROADMAP

CT3 Roadmap presented at FAIRMODE SG Berlin, February 2020

CT3 - Quality control indicators for AQ forecasts

Guidance

- Test the proposed indicators (national and CAMS data).
- Elaborate a guidance document on the use of forecast indicators



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FAIRMODE crosscutting task CT3 - Quality indicators for model forecast

ACTIVITIES

2020-2022

- the proposed indicators were **tested by CT3 community**
  among the others Pawel Durka (IEP), Lina Vitali (ENEA), Alexandra Monteiro, Carla Gama, Miguel Rosa (UniAveiro), Giulia Giovannini, Michele Stortini, Roberta Amorati, Giorgio Verratti (ARPAE), Annalisa Tanzarella (Arpa Puglia), Eivind Grøtting Wærsted (MetNorway), Agniezska Bartocha (ATMOTERM), and ***for CAMS Regional****: Augustin Colette, Frédérik Meleux (INERIS), Adrien Royer (MétéoFrance) and Micheal Gauss (Met Norway)*

2021

- feedback of the users was collected and discussed during hackathons and FAIRMODE Technical Meetings
- consensus was reached on the final current formulation

2022

- a new version of the DELTA Tool (7.0) was developed including the new indicators (available for the download at https://aqm.jrc.ec.europa.eu/index.aspx)
- **FAIRMODE Guidance Document on Modelling Quality Objectives and Benchmarking** was produced including the new formulation (https://publications.jrc.ec.europa.eu/repository/handle/JRC129254)

Developed Methodology
MAIN FEATURES

Within the proposed formulation, Forecast Evaluation addresses three main topics

1. An overall assessment in order to evaluate if the forecast application is “good enough” based on the Comparison with the Persistence Model

2. An assessment of the model Capability in predicting Exceedances

3. An assessment of the model Capability in predicting Air Quality Indices

Developed Methodology

APPLICATION FOR A CASE STUDY

MODELLING SYSTEM FORAIR-IT

- Resolution: Europe at 20 km, Italy at 4 km
- Meteo: NCEP + WRF
- BC: CAMS
- Emissions: TNO on Europe, NEI on Italy + MEGAN BVOCs
- CTM: FARM (SAPRC-99 + aero3 + ISORROPIA + SORGAM)
- No assimilation of observations

VALIDATED MODELLING APPLICATION

- Domain: Italy at 4 km
- Year: 2017
- Pollutants: NO_2, O_3, PM10, PM2.5

MODELLING SYSTEM DEVELOPMENT
SIMULATIONS OPERATIONAL MAINTENANCE

Mario Adani, Massimo D'Isidoro

https://airqualitymodels.enea.it/
http://www.afs.enea.it/project/ha_forecast/

Comparison with the Persistence Model

MAIN OUTCOME:

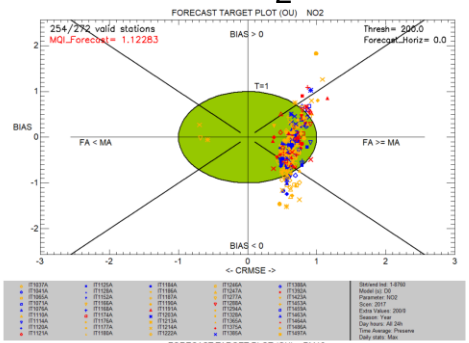
FORECAST TARGET PLOT

Formulation

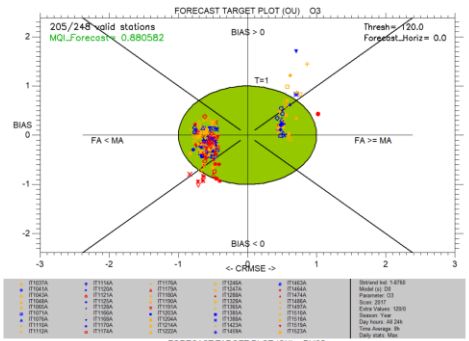
$$MQI_f = \sqrt{\frac{\frac{1}{N}\sum_{i=1}^{N}(M_i - O_i)^2}{\frac{1}{N}\sum_{i=1}^{N}(P_i - O_i)^2}}$$

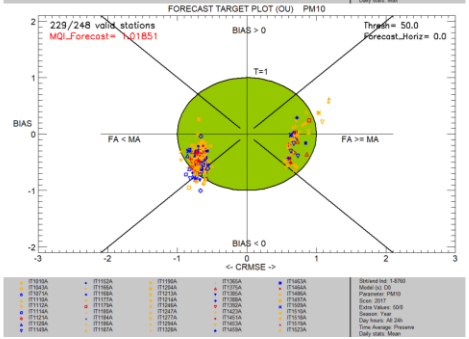
$$P_i = O_{i-1-FH} \pm U(O_{i-1-FH})$$

NO_2

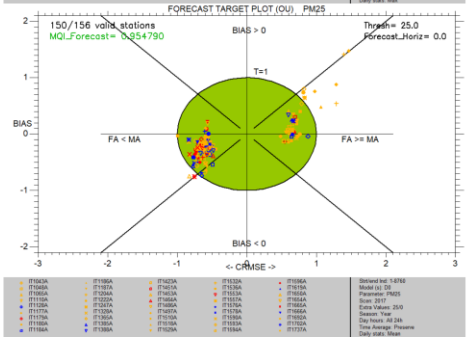


O_3





PM10



PM2.5

- ✓ good level of quality of FORAIR-IT in simulating O_3 and PM2.5
- ✓ some room for improvement concerning NO_2 and PM10

Comparison with the Persistence Model

SIDE OUTCOME:
FORECAST MPI PLOT

Formulation

$$MFE_f = \frac{2}{N}\sum_{i=1}^{N}\frac{|M_i - O_i|}{(M_i + O_i)}$$

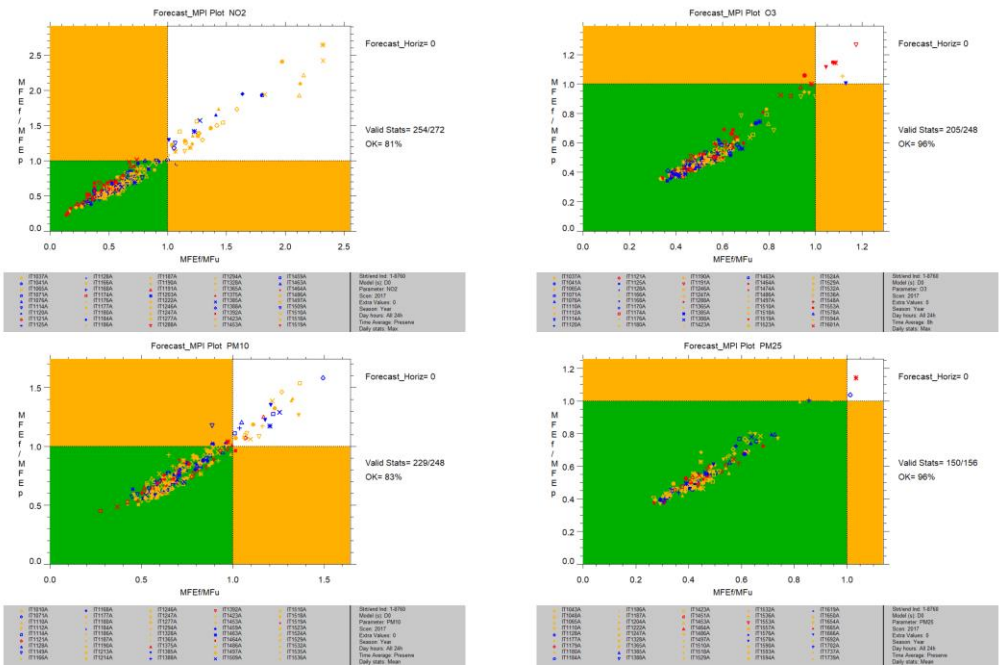
$$MFE_p = \frac{2}{N}\sum_{i=1}^{N}\frac{|P_i - O_i|}{(P_i + O_i)}$$

$$MF_U = \frac{1}{N}\sum_{i=1}^{N}\frac{2U(O_i)}{O_i}$$

$$MPI_1 = MFE_f / MFE_p \,(Yaxis)$$

$$MPI_2 = MFE_f / MF_U \,(X\ axis)$$

NO_2 O_3



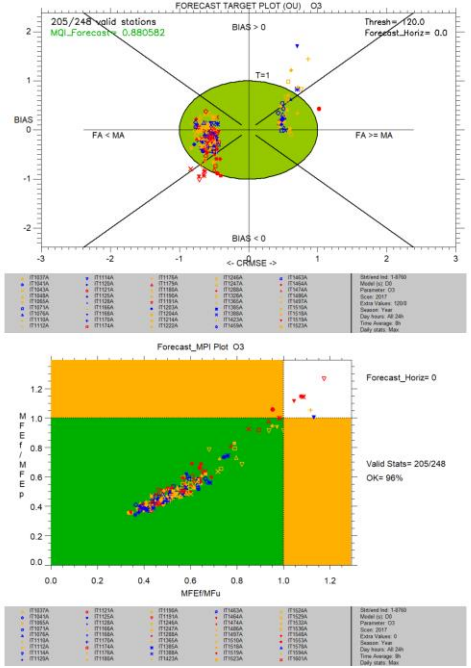
PM10 PM2.5

- ✓ very good skills in simulating O_3 and PM2.5: more than 90% of the stations fulfill both the MPIs
- ✓ quite good skills in simulating NO_2 and PM10: more than 80% of the stations fulfill both the MPIs

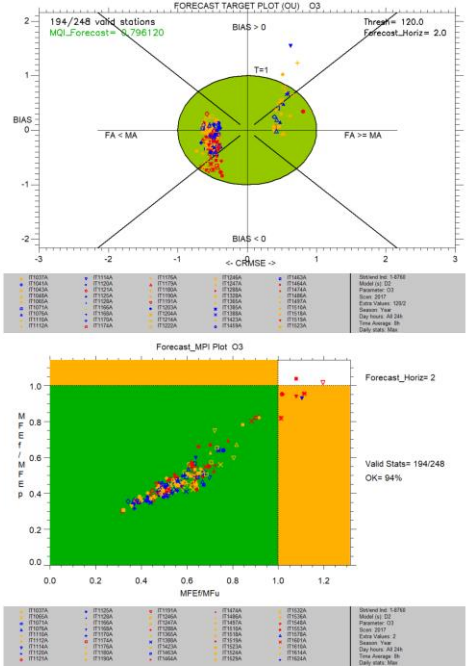
Comparison with the Persistence Model

The Forecast MPI Plot can be used to support the interpretation of results

D0



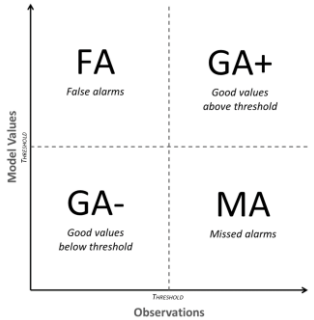
D2



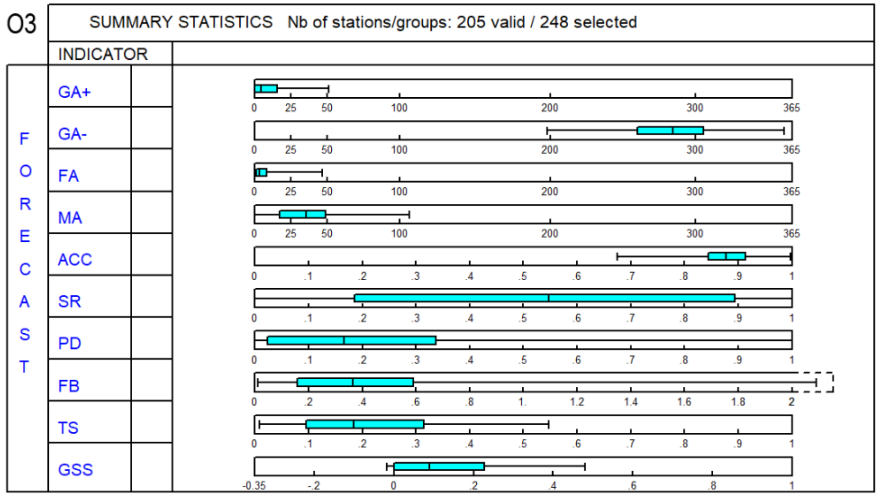
- ✓ according to Forecast Target Plot outcomes, modelling performances get better from D0 (today forecast) to D2 (the day after tomorrow)
- ✓ according to Forecast MPI plot outcomes, modelling performances get better from D0 to D2 along Y axis (i.e. when normalized to persistence model skills), but they slightly deteriorate along X axis (i.e. when considered regardless of persistence aspects)

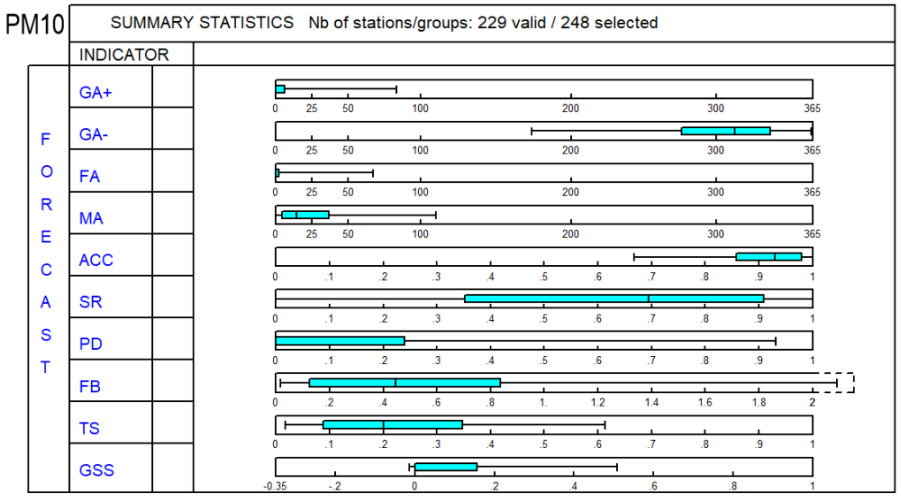
both forecast and persistence model peformances degradate along the forecast horizon but persistence model does it worse

Capability in predicting Exceedances



Indicator	Acronym
Accuracy = $(GA_+ + GA_-) / Total$	ACC
Success Ratio = $GA_+ / (FA + GA_+)$	SR
Probability of Detection = $GA_+ /(MA + GA_+)$	PD
FBias score = $(GA_+ + FA) / (MA + GA_+)$	FB
Threat Score = $GA_+ / (MA + FA + GA_+)$	TS
Gilbert Skill Score= $(GA_+ - H) / (MA + FA + GA_+ - H)$ with $H = (GA_+ + MA)(GA_+ + FA) / Total$	GSS



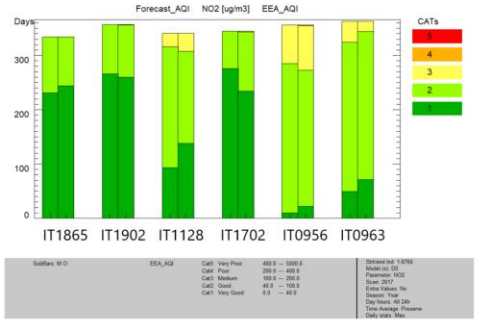


Capability in predicting Air Quality Indices

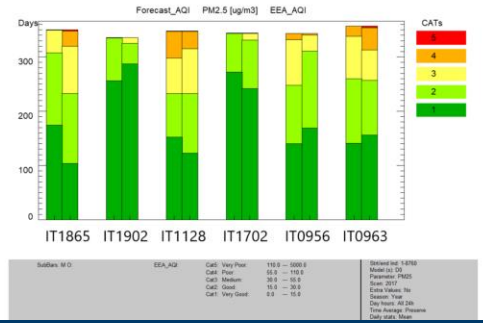
A simple multiple thresholds assessment is included in the developed approach, based on Air Quality Indices, i.e a classification of concentrations levels into air quality categories commonly used for air quality forecasting purposes.

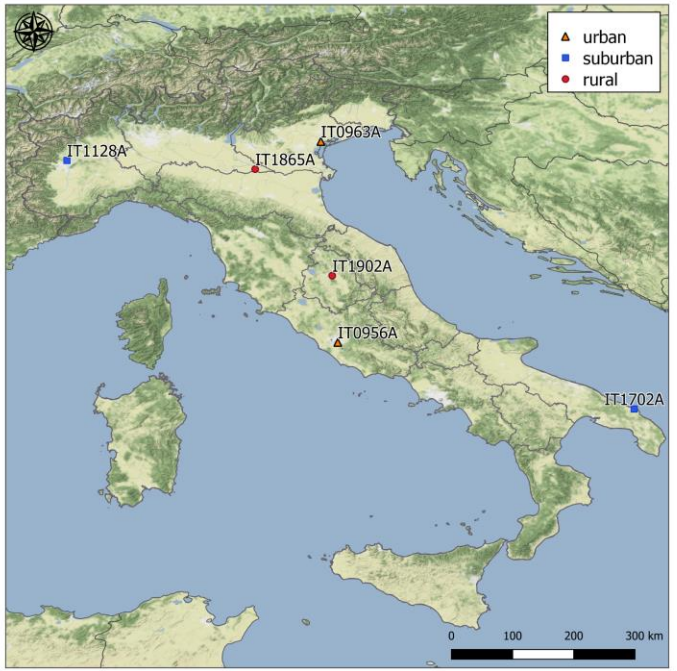
The AQI is used for public information, also an obligation under the Ambient Air Quality Directive

NO_2



PM2.5





CONCLUSIONS

- Within FAIRMODE crosscutting task CT3 a **new methodology for evaluating air quality forecast** applications was proposed and **implemented in the DELTA Tool software**

- Three main capabilities are addressed to test if a forecast modelling system is reliable for a given application
  1. capability to detect sudden changes of concentrations from day to day

     Is the model description adequate to follow sharp changes of atmospheric variables?
  2. capability to detect concentration threshold exceedances

     Can the model be used as a trigger of emergency measures applied by air quality managers for limiting emissions?
  3. capability to reproduce multi-pollutant air quality indices

- Both the methodology and the software are publicly available for testing and application especially targeting European Member States and air quality forecasting services

- Other case studies are being tested across Europe and the submission of a full paper is foreseen

Thank you

antonio.piersanti@enea.it

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