The performance of CAMS regional products following FAIRMODE model quality indicators

Michael Gauss[1], Valentin Petiot[2], Blandine Raux[3], Frédérik Meleux[3], and the CAMS2_83 team

1) Norwegian Meteorological Institute, Norway

2) Meteo-France, France

3) INERIS, France

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Evaluation using FAIRMODE metrics

- Evaluation of the 11 CAMS Regional models and the ENSEMBLE
  - The CHIMERE, EMEP and LOTOS-EUROS models (participating in CAMS Policy Support) are among the 11 models of the CAMS Regional ENSEMBLE

- CAMS2_83 uses the FAIRMODE *assessment* MQI to evaluate the CAMS regional *analyses*
  - Seasonal and annual evaluations
- CAMS2_83 uses the FAIRMODE *forecast* MQI to evaluate the CAMS regional *forecasts*
  - Seasonal evaluations

MQI = Model Quality Indicator

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Evaluation using FAIRMODE metrics

- The following types of graphs proposed by FAIRMODE are shown in our quarterly and annual evaluation reports:
  - Target plots (*forecast* and *assessment*)
  - Summary reports
  - Performance diagrams
- All evaluation reports are publicly available at the following website: https://atmosphere.copernicus.eu/regional-services

- In the FAIRMODE-type of evaluations we use surface measurements provided by EEA
- To be consistent with the spatial resolution of the CAMS regional ENSEMBLE (0.1°×0.1°) we use only measurement sites that fall into Joly&Peuch* classes 1 to 7, i.e.
  - mainly rural, sub-urban and urban sites
  - most of the traffic sites are not used

*) Joly, M. and Peuch, V.H., 2012: Objective classification of air quality monitoring sites over Europe, Atm.Env., https://doi.org/10.1016/j.atmosenv.2011.11.025

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https://environment.ec.europa.eu/topics/air/air-quality/eu-air-quality-standards_en

Pollutant	Concentration	Averaging period	Permitted exceedences each year
Fine particles ($PM_{2.5}$)	25 µg/m^3	1 year	n/a
Fine particles ($PM_{2.5}$)	20 µg/m^3	1 year	n/a
Sulphur dioxide (SO_2)	350 µg/m^3	1 hour	24
Sulphur dioxide (SO_2)	125 µg/m^3	24 hours	3
Nitrogen dioxide (NO_2)	200 µg/m^3	1 hour	18
Nitrogen dioxide (NO_2)	40 µg/m^3	1 year	n/a
Particulate matter (PM_{10})	50 µg/m^3	24 hours	35
Particulate matter (PM_{10})	40 µg/m^3	1 year	n/a
Carbon monoxide (CO)	10 mg/m^3	Maximum daily 8 hour mean	n/a
Ozone	120 µg/m^3	Maximum daily 8 hour mean	25 days averaged over 3 years

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In the following slides we show examples from the ENSEMBLE evaluation of :

- the summer season of 2023 (‘JJA2023’)
- the whole year of 2022 (‘interim reanalysis’)

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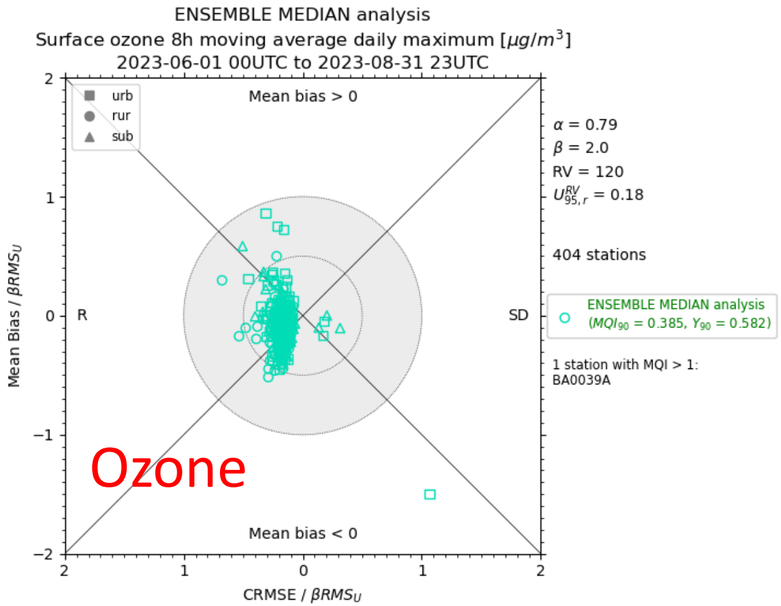
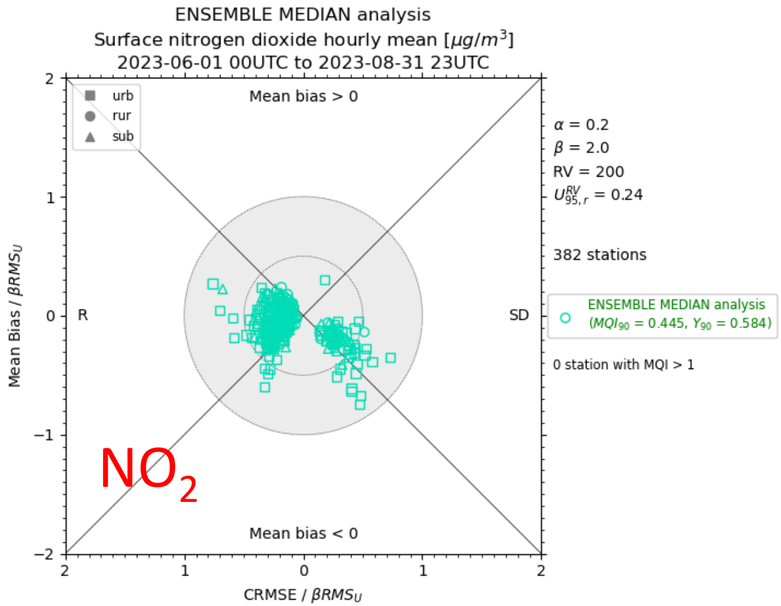
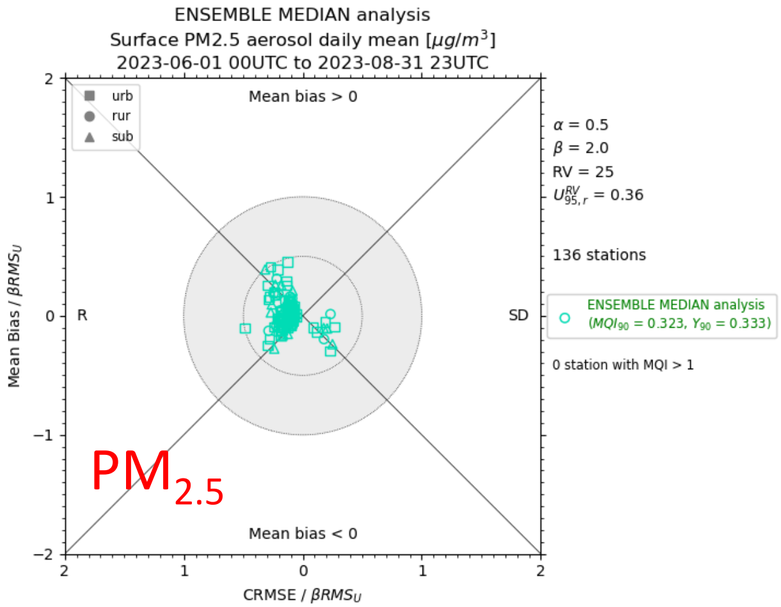
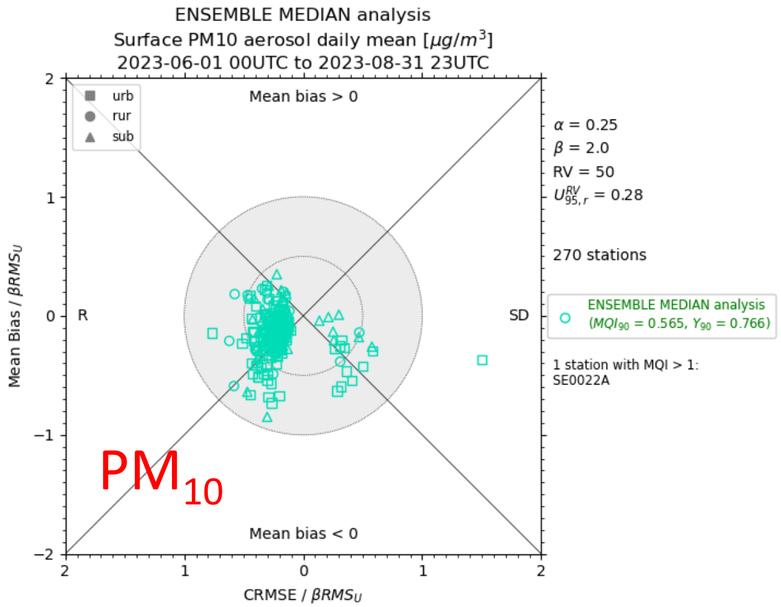
Evaluating the CAMS regional *analyses*









Here we are using the *assessment* MQI

The analysis should be within twice the measurement uncertainty for at least 90% of the sites.

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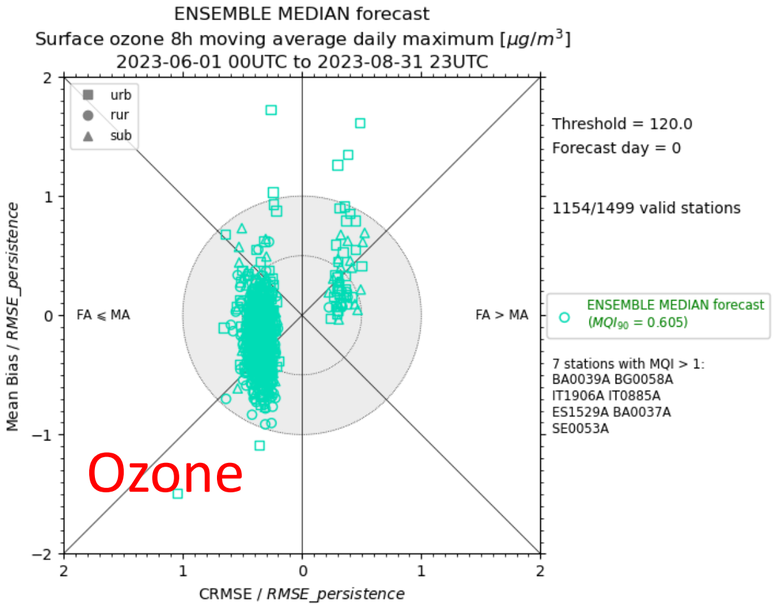
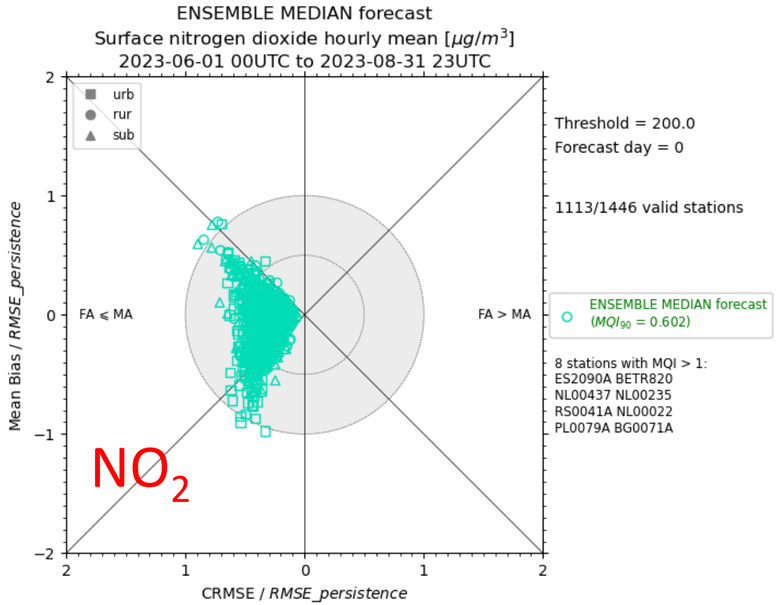
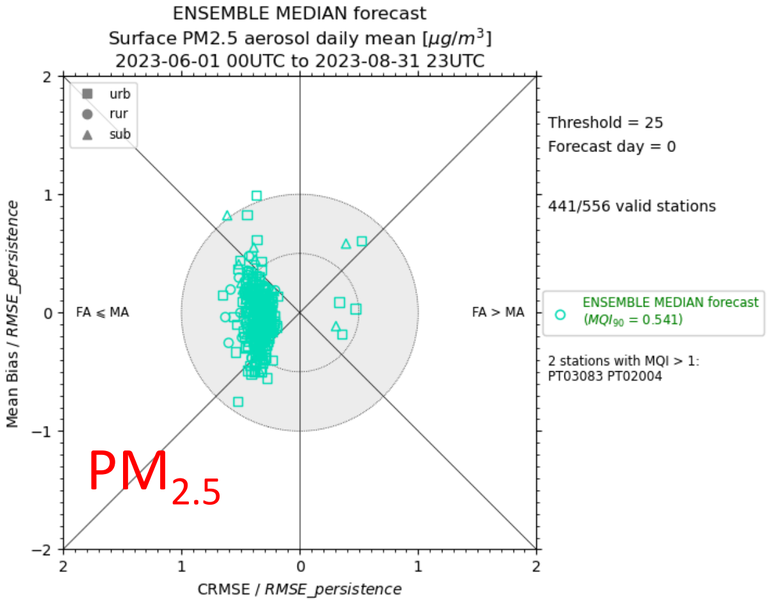
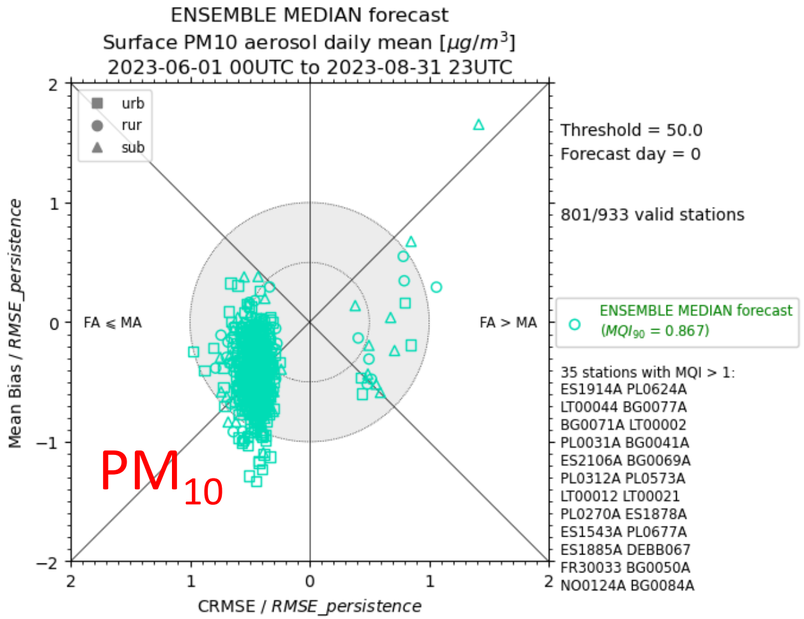
Evaluating the CAMS regional *forecasts*









Here we are using the *forecast* MQI

The RMSE of the forecast should be ≤ the RMSE of the persistence model plus the measurement uncertainty for at least 90% of the stations

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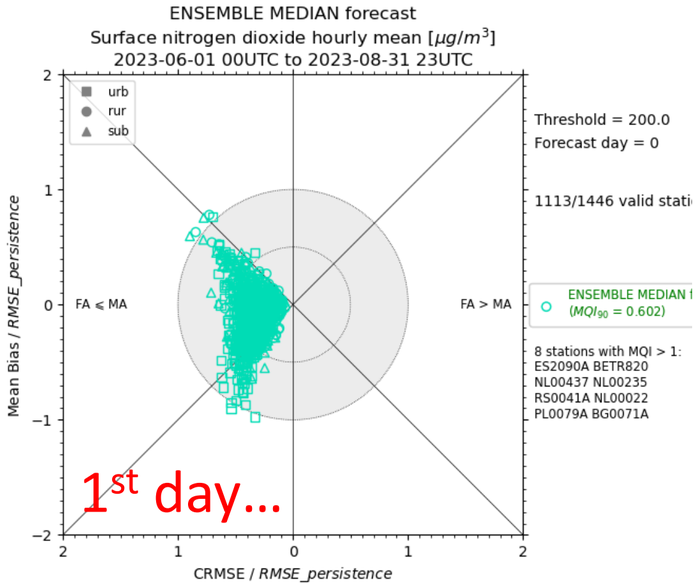
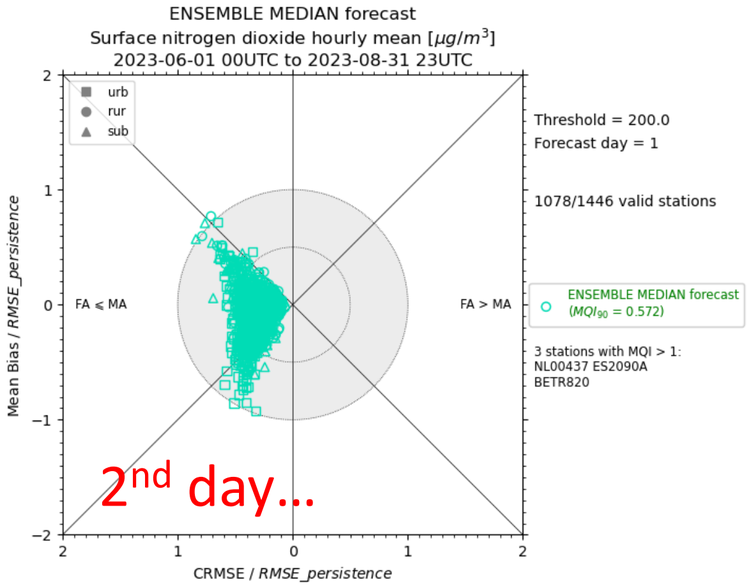
Performance as a function of forecast horizon

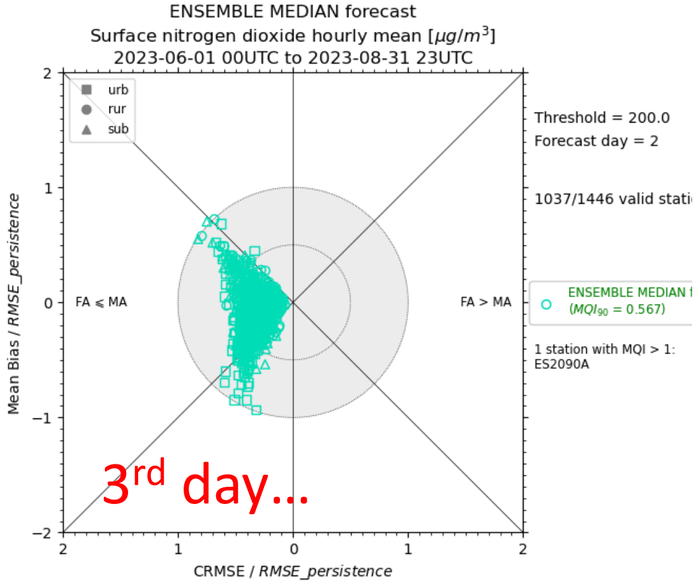
The forecast model has the advantage of using forecast meteorology, but the disadvantage of using emissions valid for a year of the past.

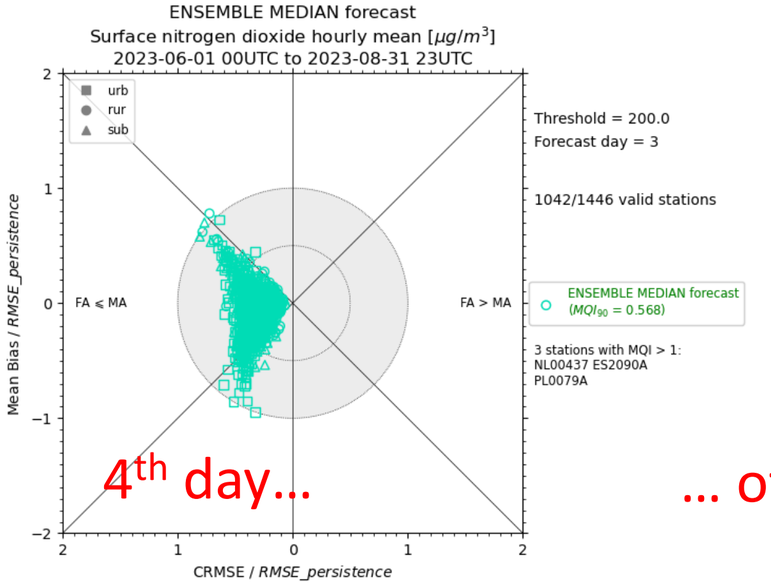
The persistence model is based on observations (thus corresponding to real emissions) but it does not take into account changes in meteorology.

In general, the performance of the persistence model degrades faster with forecast horizon than that of the regional air quality models.









... of the forecast.

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- This evaluation is done for all individual models, 4 species (O3, NO_2, $PM_{2.5}$ and PM_{10}, and all 4 days of the forecast and the day of the analysis
- The models involved in CAMS Policy Support (C71) met more than 95% of the forecast MQOs* and more than 90% of the assessment MQOs* in the summer season of 2023

*) MQO = Model quality objective (in simple terms: “at least 90% of the stations should be within the circle”)

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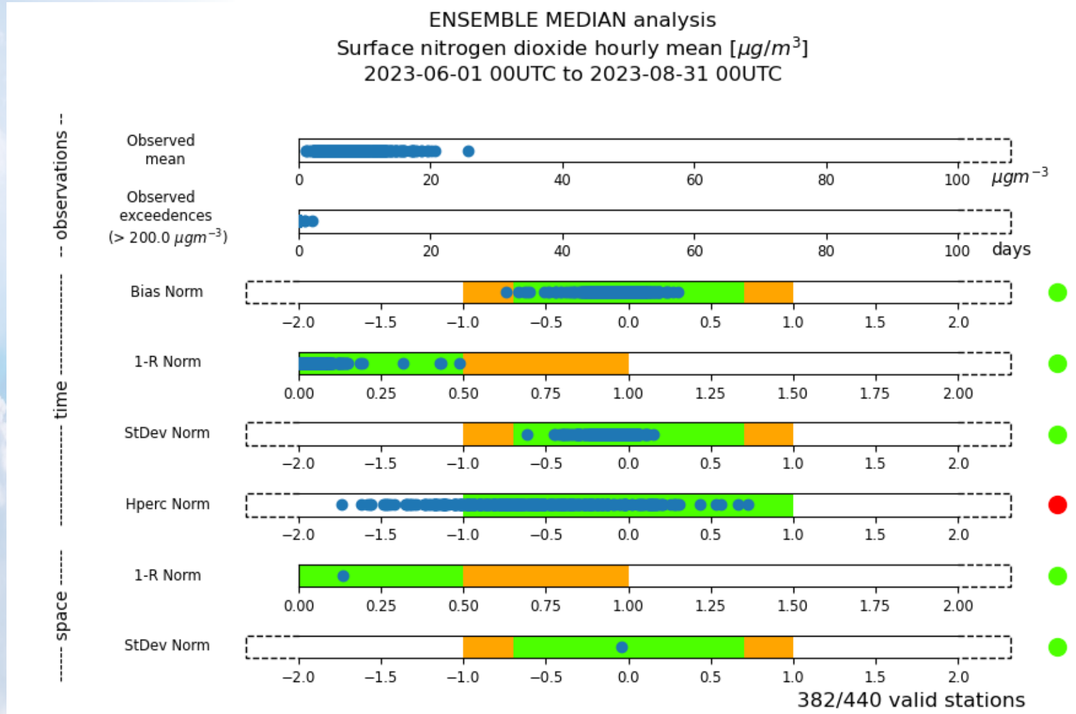
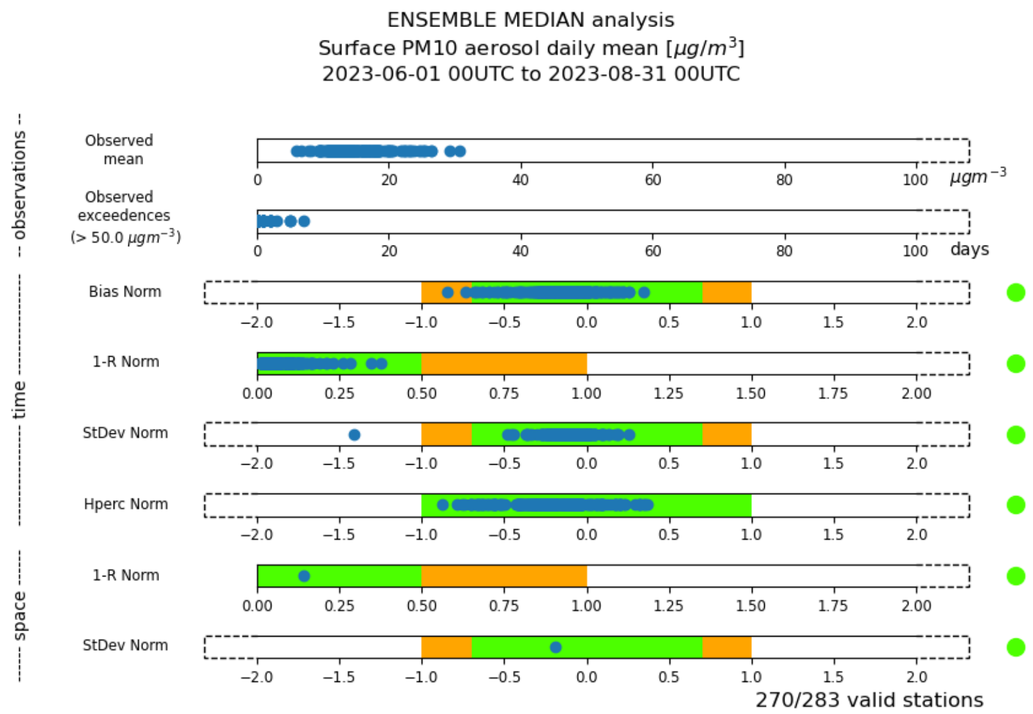
Summary reports for NO_2 and PM_{10}





Model performance can be mathematically divided into different parts (performance indicators):
bias, standard deviation in space and time, correlation in space and time, ability to reproduce high percentiles (exceedances)

Green dots mean that the indicator is met.

Red dots mean that it is not met.

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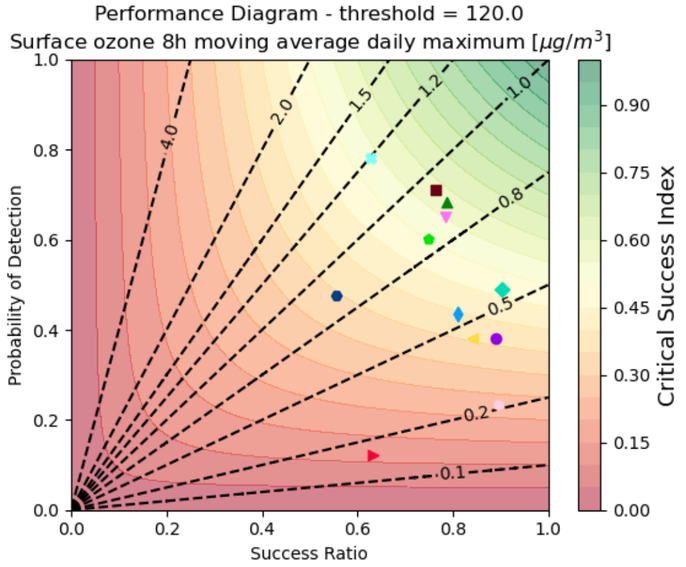
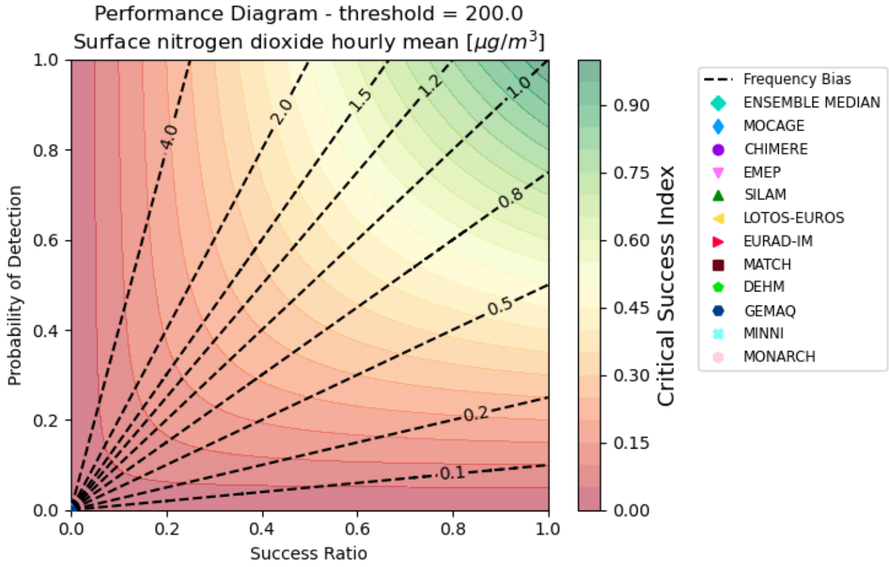
Performance diagrams for JJA2023

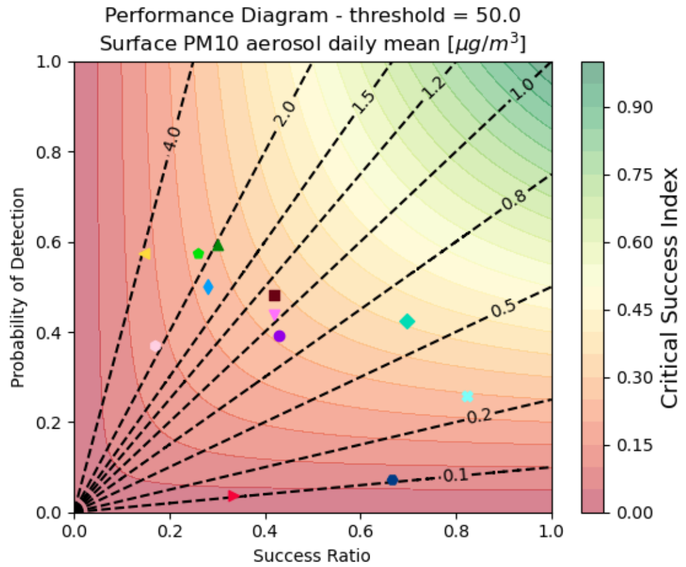
49277 exceedances in observations



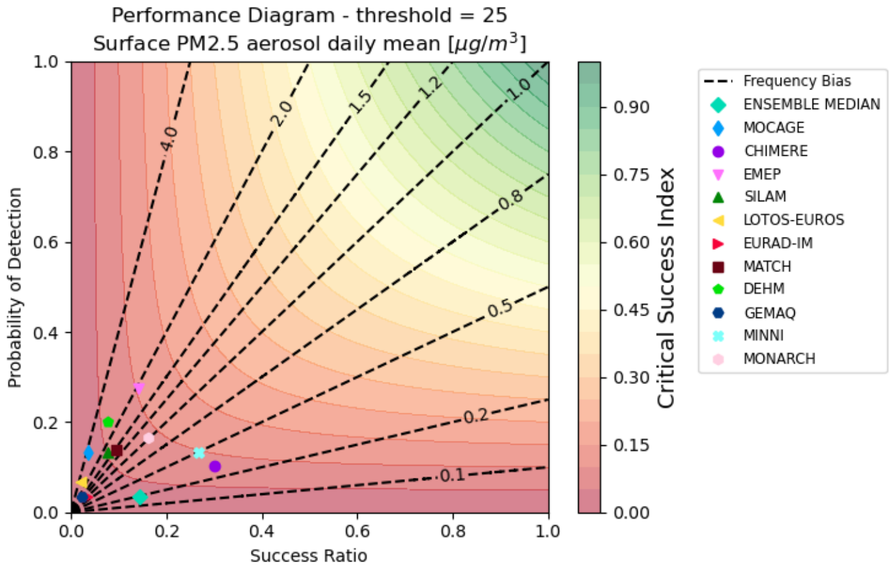
5 exceedances in observations



4695 exceedances in observations

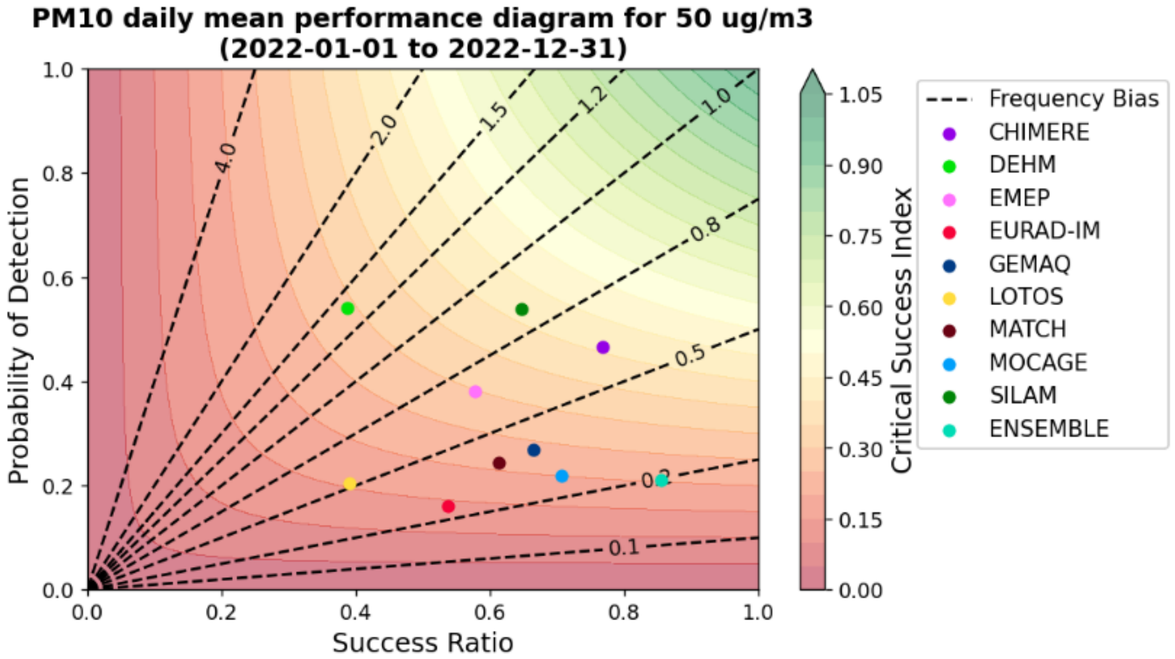


3228 exceedances in observations



Performance diagram / Contingency table

Interim Reanalysis for 2022 (IRA2022)
(EQC report was published in August)



PM_{10} threshold of 50 µg/m^3
(performance diagram)

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Conclusions

- The CAMS regional models meet the FAIRMODE Model Quality Objectives, with only very few exceptions
  - e.g. reproducing local exceedances of NO_2 and PM_{10}
- CAMS Evaluation and Quality Control (EQC) is in continuous contact with FAIRMODE
  - discussing plans to make the MQI stricter
  - exchange of experience
  - process of introducing more FAIRMODE-type of plots in CAMS EQC

https://atmosphere.copernicus.eu/regional-services