

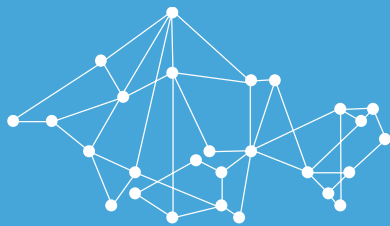


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CT3 FORECAST: WRAP UP AND NEXT STEPS

ANTONIO PIERSANTI, STIJN JANSSEN



FAIRMODE TECHNICAL MEETING (ONLINE), 6-8 OCTOBER 2021

FAST RECAP: MQI AND SUPPORTING PLOTS FOR FORECAST EVALUATION



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FORECAST EVALUATION

General concept for the evaluation metrics

- » Forecast Modelling Quality Objective comes on top of FAIRMODE's assessment MQO
- » The forecast MQO should test two different features of a forecast model:
 1. Detection of “episodes” (changes in the concentration)
 2. Threshold exceedances (as trigger for short term action plans)
- » For 1. we use the “persistence model” as a benchmark
- » For 2. we use standard threshold indicators

1. Detection of “episodes” (changes in the concentration)

» For 1. we use the “persistence model” as a benchmark

MQI FOR FORECAST

Target for the forecast model M is to do better than the “persistence” model P

» Definition: MQI

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

$$P_i = O_{i-1} - \text{forecast horizon}$$

$MQO_{forecast}$ is fulfilled if $MQI_{forecast} \leq 1$,



MQI FOR FORECAST: NEW PROPOSAL (FEBRUARY 2021)

Target for the forecast model M is to do better than the “persistence” model P, taking into account the uncertainty of observations (OU)

» Definition: MQI

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

$$P_i = O_{i-1-forecast\ horizon} \pm OU(O_{i-1-forecast\ horizon})$$

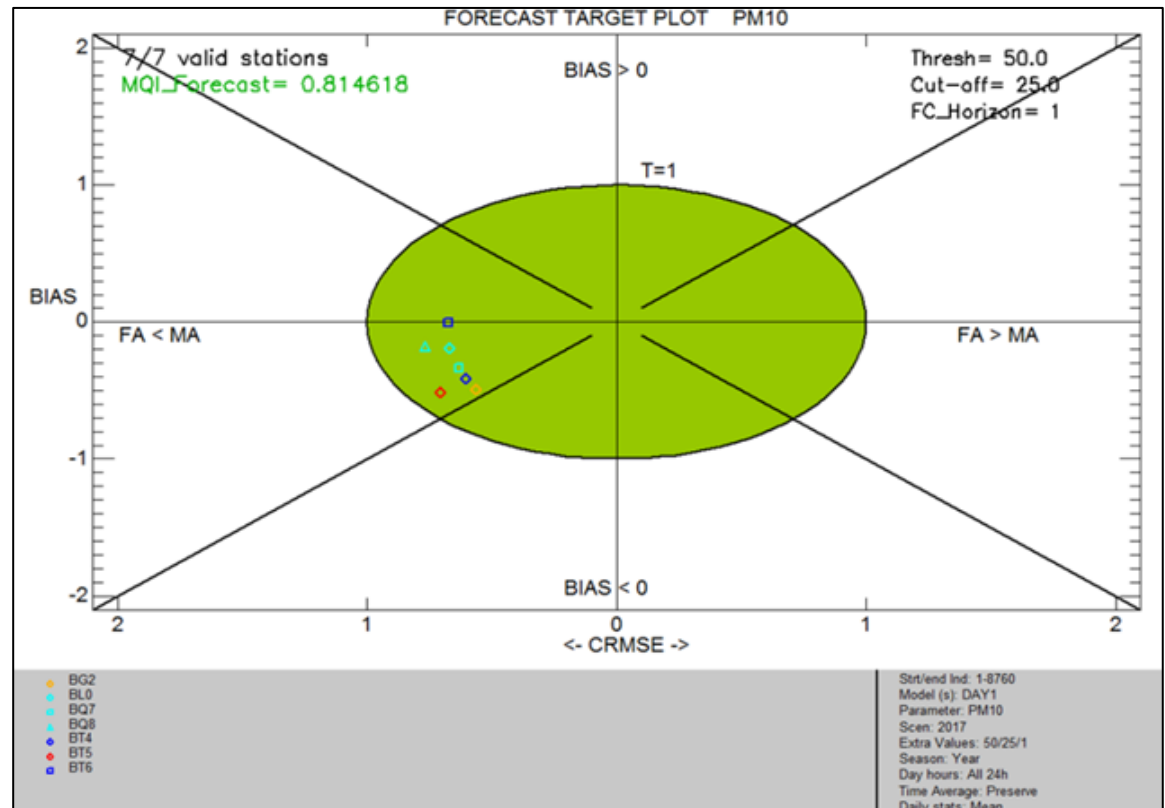
$MQO_{forecast}$ is fulfilled if $MQI_{forecast} \leq 1$,



FORECAST TARGET DIAGRAM

Normalization by the intra-day variations

- » Target forecast: RMSE
- » Y-axis: Bias
- » X-axis: CRMSE
- » Left/right asymmetry:

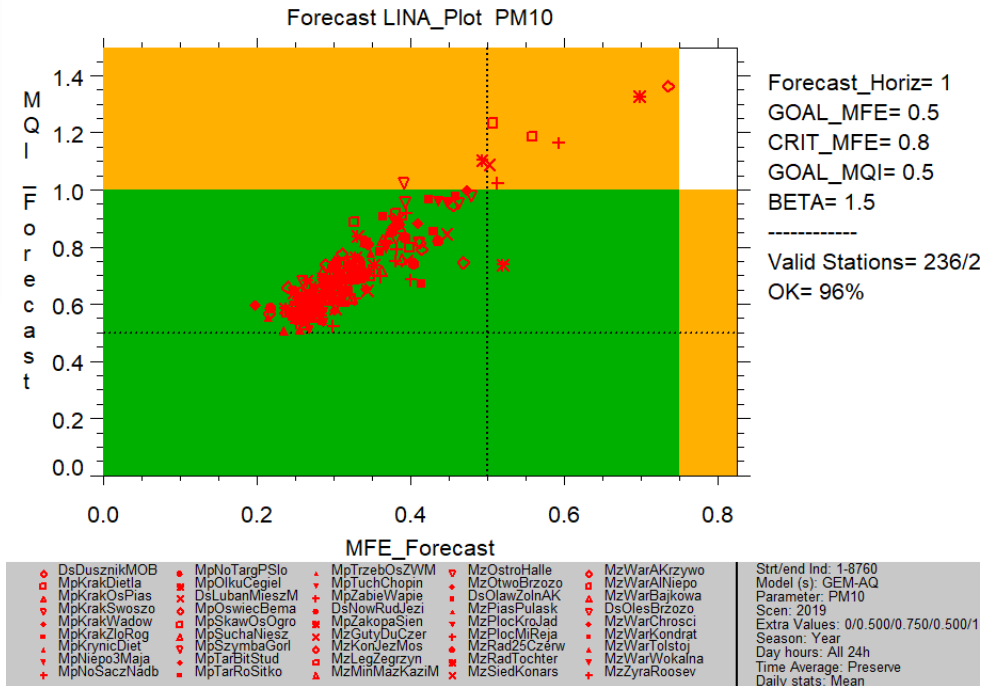


FORECAST MQI&MFE PLOT (FEBRUARY 2021)

$$MQI_{forecast} = \frac{MFE_{forecast}}{\beta MFE_{persistence}}$$

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

$$P_i = O_{i-1-forecast\ horizon}$$



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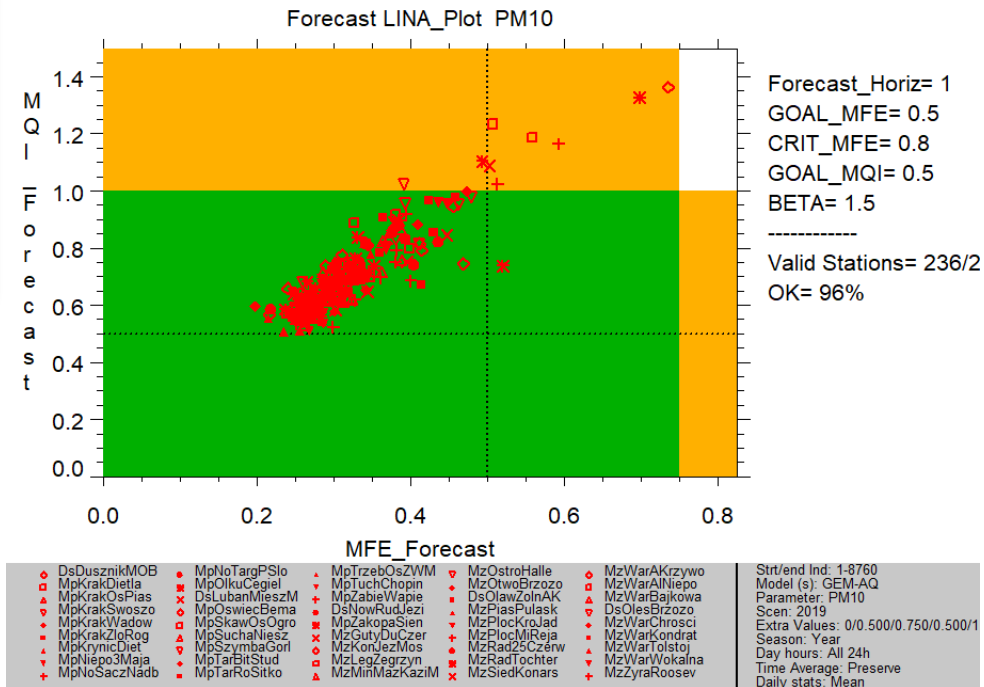
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FORECAST MQI&MFE PLOT (OU) (MAY 2021)

$$MQI_{forecast} = \frac{MFE_{forecast}}{\beta MFE_{persistence}}$$

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

$$P_i = O_{i-1-forecast\ horizon} \pm OU(O_{i-1-forecast\ horizon})$$



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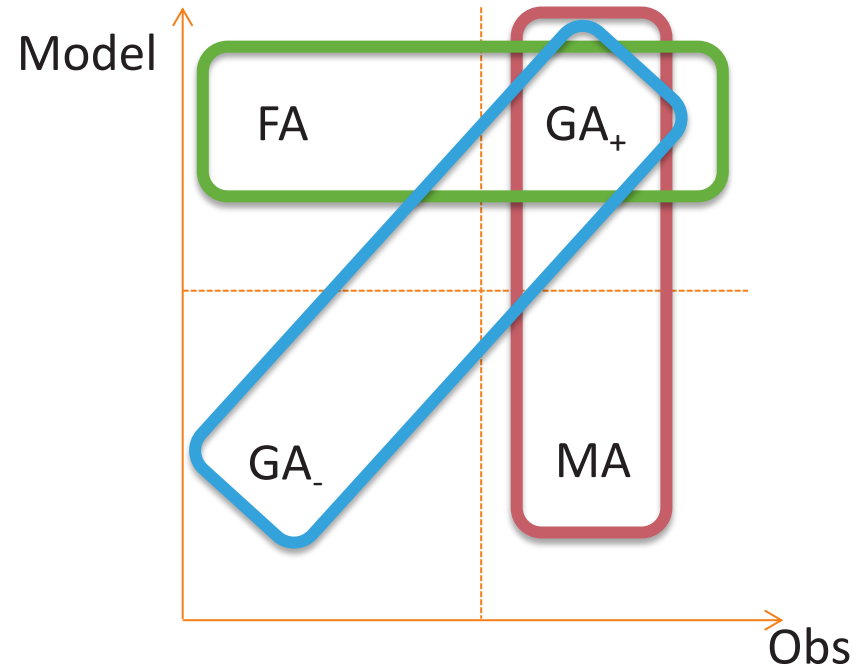
2. Threshold exceedances (as trigger for short term action plans)

» For 2. we use standard threshold indicators

THRESHOLD EXCEEDANCES

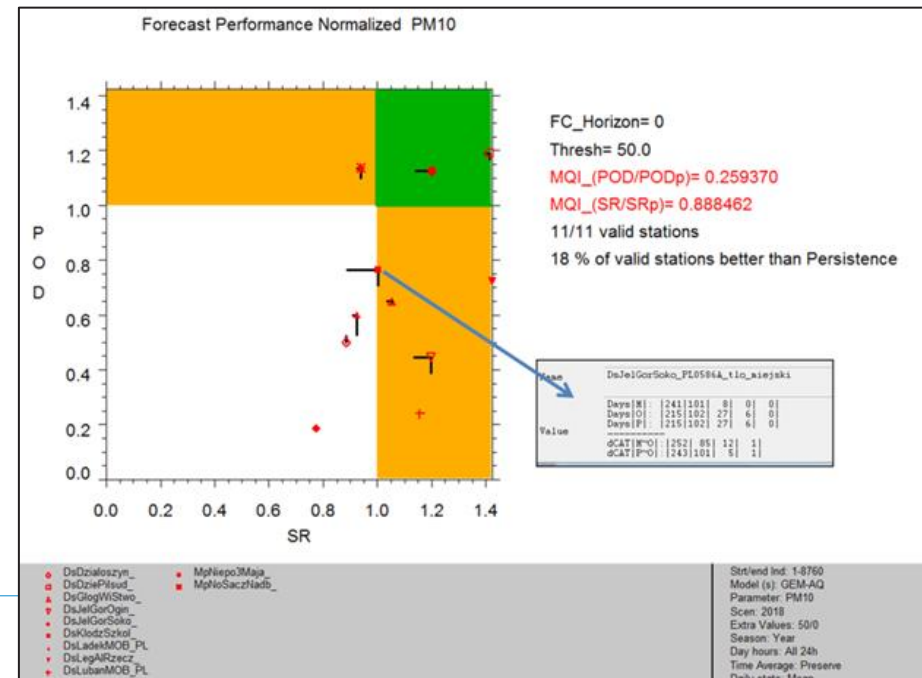
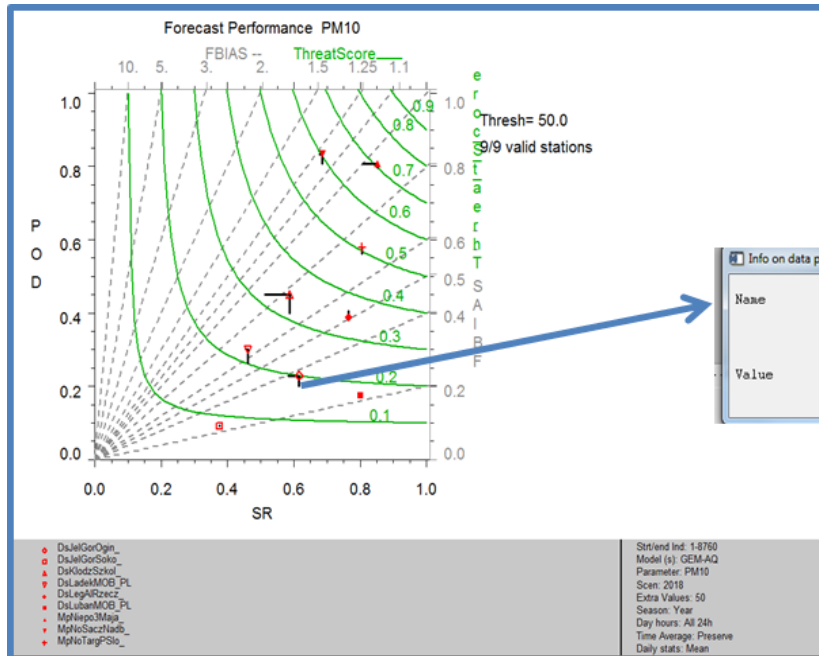
Definition of threshold exceedance indicators

- » False Alarms (FA)
- » Missed Alarms (MA)
- » Good values below thr (GA_-)
- » Good values above thr (GA_+)



- » **Probability of detection:** $PoD = GA_+ / (MA + GA_+)$
- » **Success ratio:** $SR = 1 - FAR = 1 - FA / (FA + GA_+) = GA_+ / (FA + GA_+)$
- » **Accuracy:** $ACC = (GA_+ + GA_-) / (GA_+ + GA_- + MA + FA)$

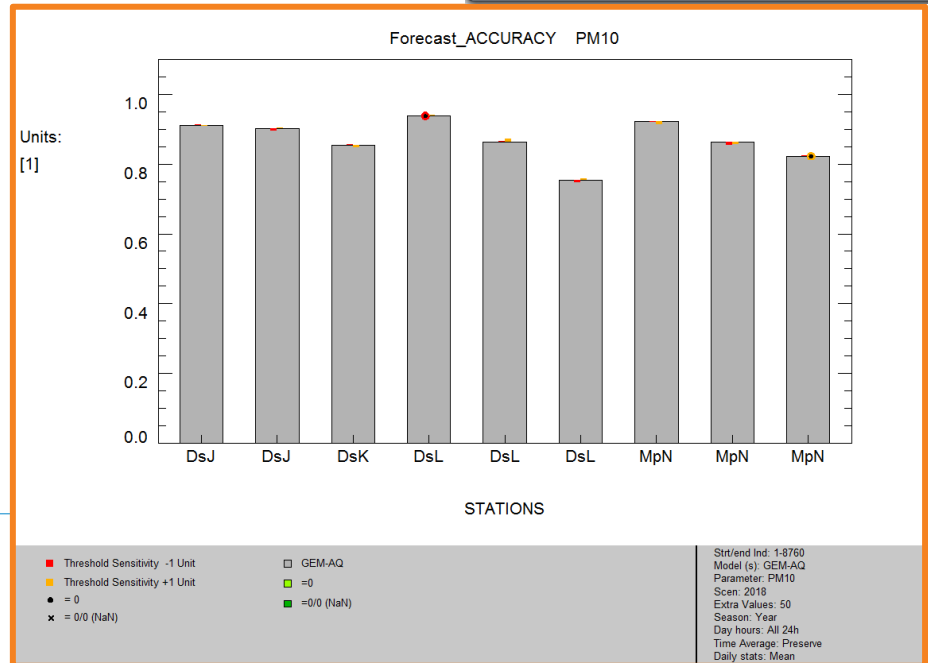
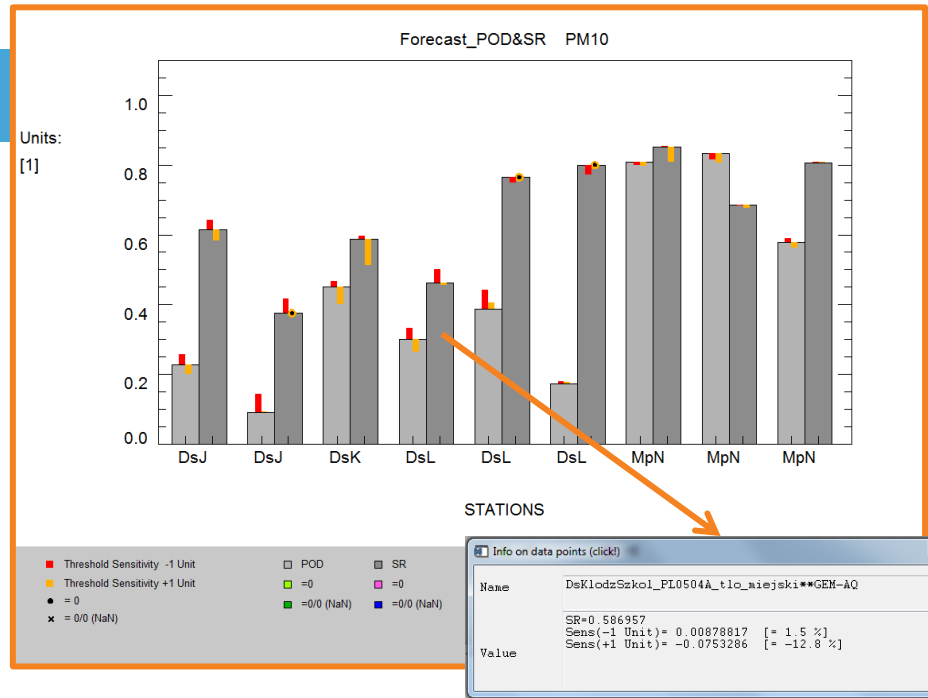
FORECAST PERFORMANCE DIAGRAM & CUVELIER PLOT



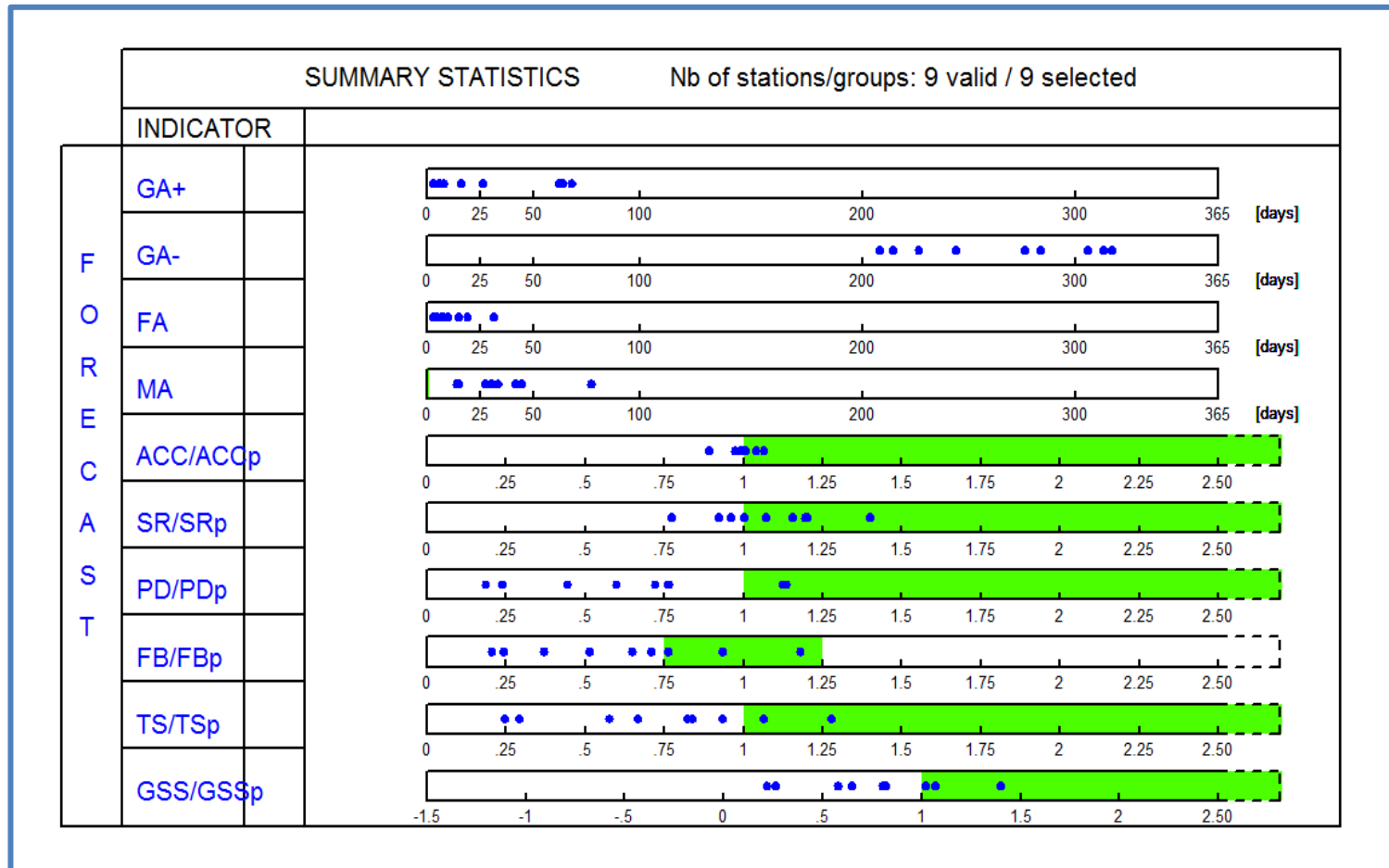
EXCEEDANCE INDICATORS

» POD, SR & ACC = 1
 → perfect model

» Sensitivity:
 » Red: threshold - 1unit
 » Yellow: threshold + 1unit



SUMMARY REPORT



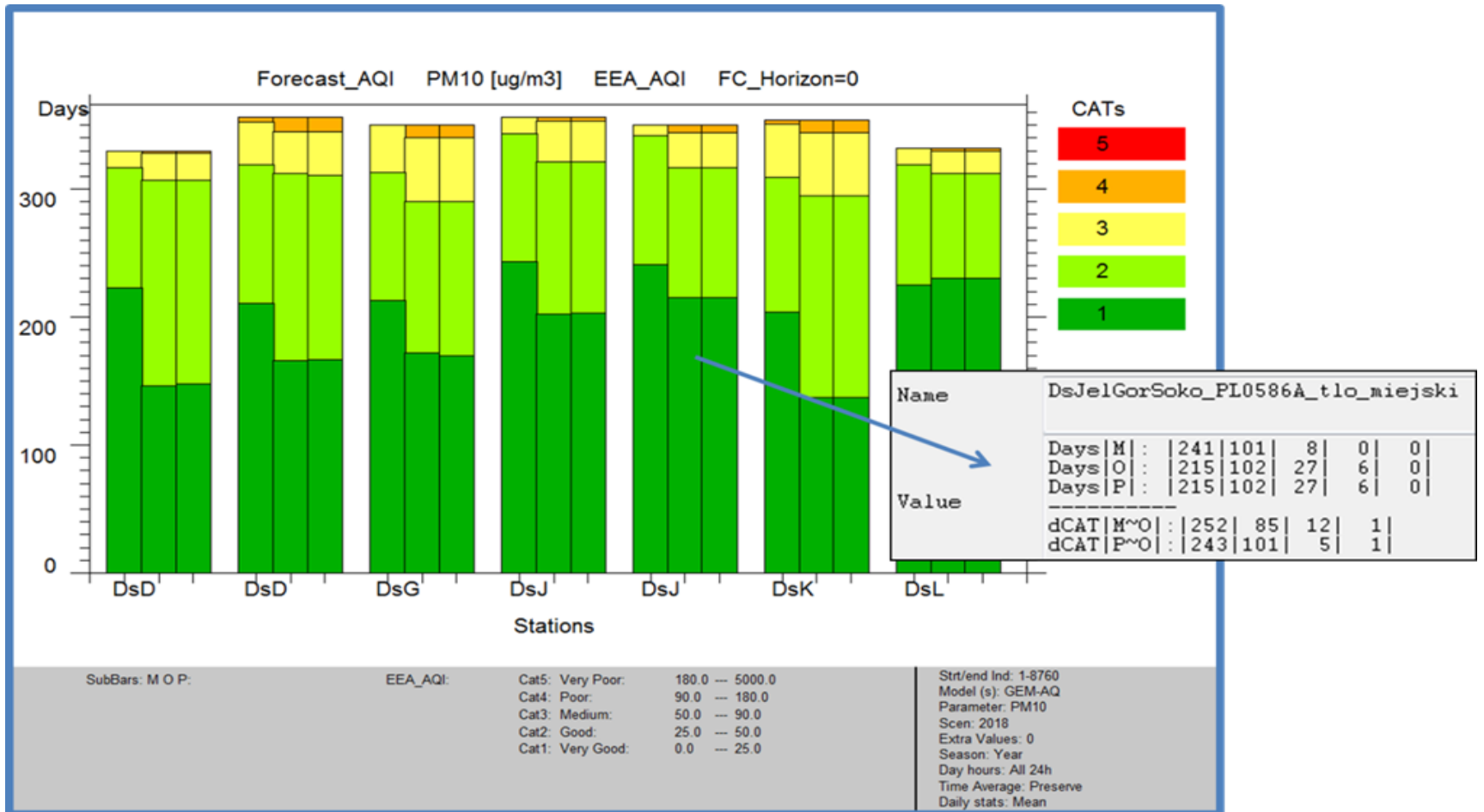
- » FBias score: $FBIAS = (GA+ + FA) / (MA + GA+)$
- » Threat score: $TS = GA+ / (MA + FA + GA+) = GA+ / (FA + GA+)$
- » Gilbert Skill score: $(GA+ - H_{random}) / (MA + FA + GA+ - H_{random})$
 - » with $H_{random} = (GA+ + MA)(GA+ + FA) / Total$



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AIR QUALITY INDICES



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PROGRESS IN 2021



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Hackathon on Feb 9:

- » After tests and evidence of some shortcomings of $MQI_{forecast}$ formulation, new formulation proposal for the persistence model in the MQI and the Forecast Target Plot, taking into account not only the persistence model performances but also the observation uncertainty (OU):

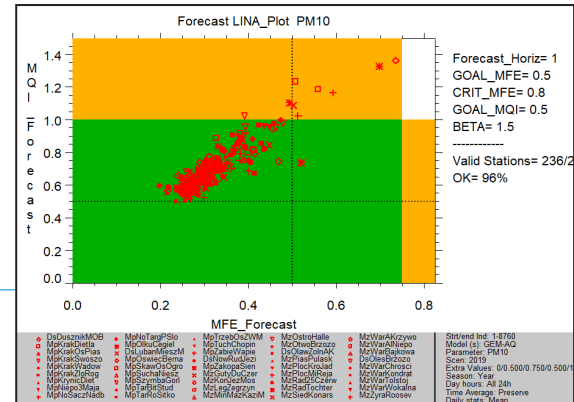
$$MQI_{forecast} = \sqrt{\frac{\frac{1}{N} \sum_{i=1}^N (M_i - O_i)^2}{\frac{1}{N} \sum_{i=1}^N (P_i - O_i)^2}}$$

$$P_i = O_{i-1-forecast\ horizon} \pm OU(O_{i-1-forecast\ horizon})$$

- » New evaluation diagram proposal, MQI&MFE

$$MQI_{forecast} = \frac{MFE_{forecast}}{\beta MFE_{persistence}}$$

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



Hackathon on May 26:

- » feedback provided on the new MQI - Forecast Target Plot (OU) formulation: most of the artifacts and shortcomings of the original formulation seem to be overcome (bias and correlation improved, MQI cannot tend to infinity) but still performances get better along with forecast horizon
- » Feedback on the MQI&MFE Plot: useful to support the interpretation of results
- » new formulation proposal for the MQI&MFE Plot, with OU and without β , to make it more consistent with the Forecast Target Plot (OU)

$$MQI_{forecast} = \frac{MFE_{forecast}}{\beta MFE_{persistence}}$$

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

$$P_i = O_{i-1-forecast\ horizon} \pm OU(O_{i-1-forecast\ horizon})$$

THANKS TO

Kees Cuvelier

Philippe Thunis - JRC

Pawel Durka - Inst. Environ. Protection Poland

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 - Met Norway

Frederik Meleux (INERIS) and Adrien Royer (Meteo France) - CAMS Regional

Agnieszka Bartocha - ATMOTERM

CT3 - Forecast (2h10') Wednesday 06/10

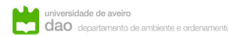
- 11:50 - 12:00 Welcome and introduction (A. Piersanti and S. Janssen)
- 12:00 - 12:15 Results with the Delta Tool Forecast on Portugal (A. Monteiro)
- 12:15 - 12:30 Results from CAMS Regional Production (A. Royer and F. Meleux)
- 12:30 - 12:45 Results with the Delta Tool Forecast on Kosovo (A. Bartocha)
- 12:45 - 13:00 Work from other groups and discussion

ENEA and ARPAE have prepared presentations which were not shown for time constraints, but are available to be shared with CT3ers and anyone interested

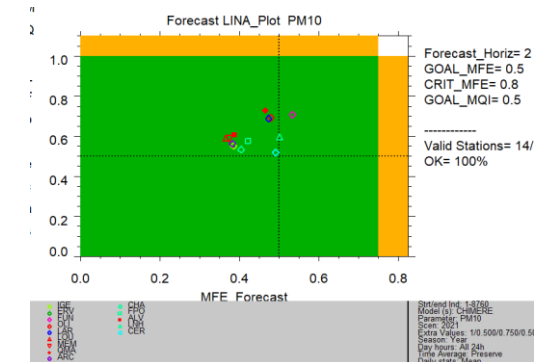
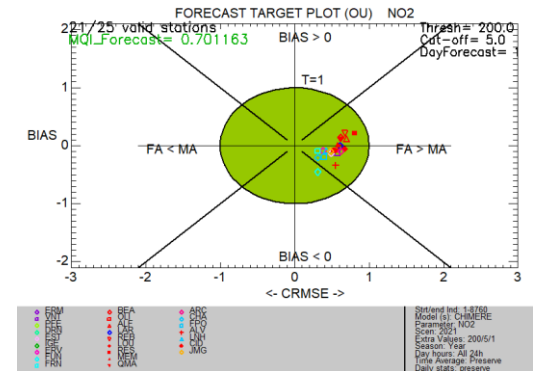
CT3 | Forecast DELTA Tool

Alexandra Monteiro | Carla Gama | Miguel Rosa
University of Aveiro

6 October 2021



- » The new method (OU) for the forecast target and the MQI&MFE plot gives better results for O₃, NO₂ and PM10 (the latter still above the MQO)
 - OU makes results more on line with expectations on the robustness of the forecast
- » The National Env Agency requires the yearly evaluation with the target plot and a validation table for the global AQI, could accept the MQI&MFE evaluation
 - a plot with pollutant-independent AQI would be useful



Aglomeracao Sul

| | prev | obs | prev | prev | prev |
|-----|------|-----|------|------|------|
| obs | 76 | 59 | 19 | 1 | 1 |
| obs | 24 | 16 | 63 | 8 | 0 |
| obs | 2 | 4 | 32 | 2 | 3 |
| obs | 0 | 0 | 1 | 0 | 0 |
| obs | 0 | 0 | 0 | 0 | 0 |



Atmosphere Monitoring

INERIS



CAMS Regional Production

QC for AQ forecasts

Fairmode technical meeting, October, 6th, 2021

Adrien Royer MétéoFrance (adrien.royer@meteo.fr)

Frédéric Meleux Ineris (frederik.meleux@ineris.fr)

- Development of an API (python) to compute the Fairmode metrics (assessment so far) with figures similar to the delta-tool representation.
- Ongoing works
 - Based on delta-tool version April, 2021 of the definition of MQO for AQ FC
 - Tested with ENSEMBLE datasets in 2020
 - O₃, NO₂, PM₁₀
 - Large number of stations dedicated to evaluation (700 stations to 1200 stations)

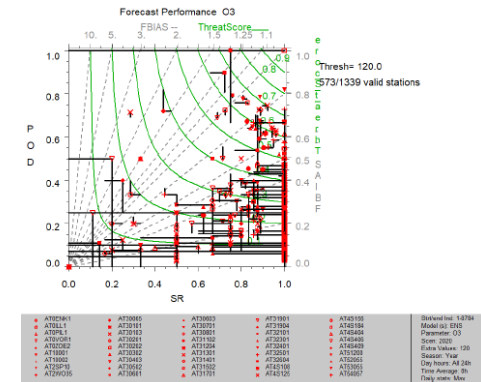
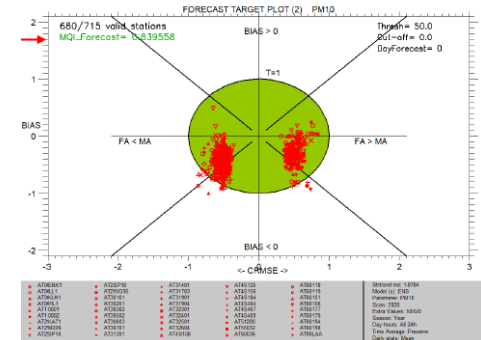


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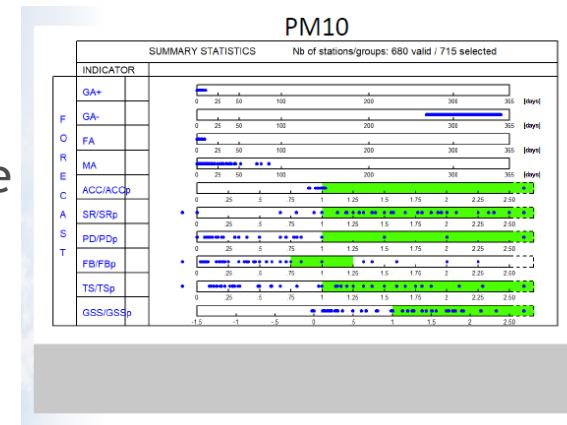
MORNING SESSION

- » The new method (OU) for the forecast target plot gives better results for PM10 and much better for NO₂
- » The outcomes are very sensitive with the cut-off value
- » Too many stations make it difficult to read and interpret the graphics → For CAMS, it would be useful to aggregate the stations to keep only one overall point to illustrate the behavior of each model
- » An output file with the individual values of each station would be welcome
- » Training sessions needed!



MORNING SESSION

- » Such CAMS evaluations will move into the new CAMS service CAMS2_83 (that will have to design how to use the Fairmode metrics over a large number of stations and forecasts to represent a synthetic overview of the performances)
- » The scores of the individual forecasts and of the ENSEMBLE appear to be perfectible regarding threshold exceedances
- » CAMS regional production will strengthen its capabilities to detect threshold exceedances, with a new ENSEMBLE method computation



FORECAST IN KOSOVO

Fairmode meeting CT3

6-8.10.2021

Authors of the presentation:
Agnieszka Bartocha
Tomasz Przybyła

Forecast system in Kosovo

3 days forecast using:

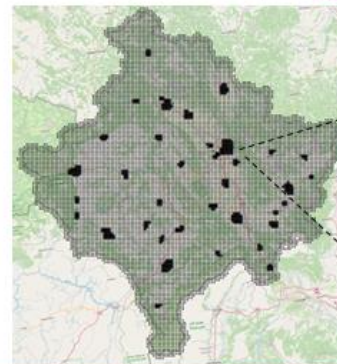
- Calpuff
 - WRF
 - CAMS Ensemble
- Update - every day

Emissions:

- Small combustion
- Transport
- Energy and Industry
- Agriculture
- Waste
- Mines and quarries

PM10
PM2.5
NO2
O3

Kosovo
1 km x 1 km , 0,5 km x 0,5 km in cities



Pristina
200 m x 200 m , 50 m x 50 m along streets



Economy and Environment
www.atmoterm.com



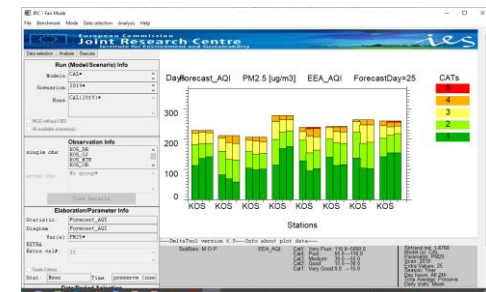
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MORNING SESSION

- » Forecast verification using traditional (CORR, RMSE, RDE, RE) and additional (compatibility of AQI [%], [%] of cases with 2 level difference of AQI, correct identification of the main pollutant [%], overestimation of AQI [%], underestimation of AQI [%], GSS: Gilbert Skill Score) indicators
- » Forecast performance and forecast performance normalized diagrams give some information considering threshold exceedances. However, they are complicated and hard to explained to politicians. There is no information about AQI level related to health advice.
- » AQI forecast bar chart gives information about total number of AQI levels but there is no information about timing of the forecasted AQI levels
- » Additional indicators turned out too detailed, GSS using AQ is simple and may be used for evaluation (but no thresholds established)

| Indicator | IHMK Pristina | Pristina - Rilindja |
|---|---------------|---------------------|
| compatibility of AQI | 72% | 77% |
| % of cases with 2 level difference of AQI | 1% | 1% |
| correct indentaicao of the main pollutant for AQI | 65% | 74% |
| overestimation of AQI | 21% | 6% |
| udnerestimation of AQI | 19% | 22% |
| GSS >= moderate | 0,43 | 0,46 |
| number of cases | 60 | 131 |
| GSS >= poor | 0,00 | 0,06 |
| number of cases | 13 | 31 |
| GSS total | 0,42 | |
| number of cases | 789 | |



POINTS FOR DISCUSSION (BESIDE THE PREVIOUS)

- » Is the new definition of Persistence model with OU better than the previous?
Is it still difficult to beat?
- » Do we accept a MQI that gets better along the forecast days?
- » Are the MQI&MFE, Performance & Cuvelier plots useful?
- » What about the lower cutoff?
- » Do we fix the threshold values for the exceedances?

→ proposal: answer by e-mail (antonio.piersanti@enea.it)

NEXT STEPS

- » ? final formulation
- » Update of the MQO guidance document (end 2021)
→ ??
- » Joint publication (end 2021)
→ ??