



Evaluation re-analysis air pollutants CAMS models

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Air quality modelling

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Goal of the study

The goal of this work is twofold:

- (1) To assess the relevance and usefulness of the assessment indicators using in the context of FAIRMODE.
- (2) To assess the quality of the CAMS Re-analysis using QA/QC FAIRMODE Tools.

To reach the goal we evaluate CAMS Re-analysis air pollution data using the Delta Tool.



Methodology

Re-analysis data, Year 2021, both calculated and observed concentrations. Evaluation of assimilated and non-assimilated stations. In this work results are shown for non-assimilated stations.

The nine CAMS models are:

1. Chimere (FR),
2. DEHM (DK),
3. EMEP (NO),
4. GEMAQ (PL),
5. SILAM (FI),
6. LOTUS-EUROS (NL),
7. MATCH (SE),
8. EURAD-IM (DE) and
9. Ensemble.

The evaluation of the calculated air pollutants (NO₂, O₃, PM_{2.5} and PM₁₀) Delta Tool (developed by Kees Cuvelier).

Indicators for the comparison (1)

- **Assessment Target Model Quality Indicator (MQI)**, which is defined as the ratio between model-measured bias and a quantity proportional to the measurement uncertainty U as:

Yearly MQI:

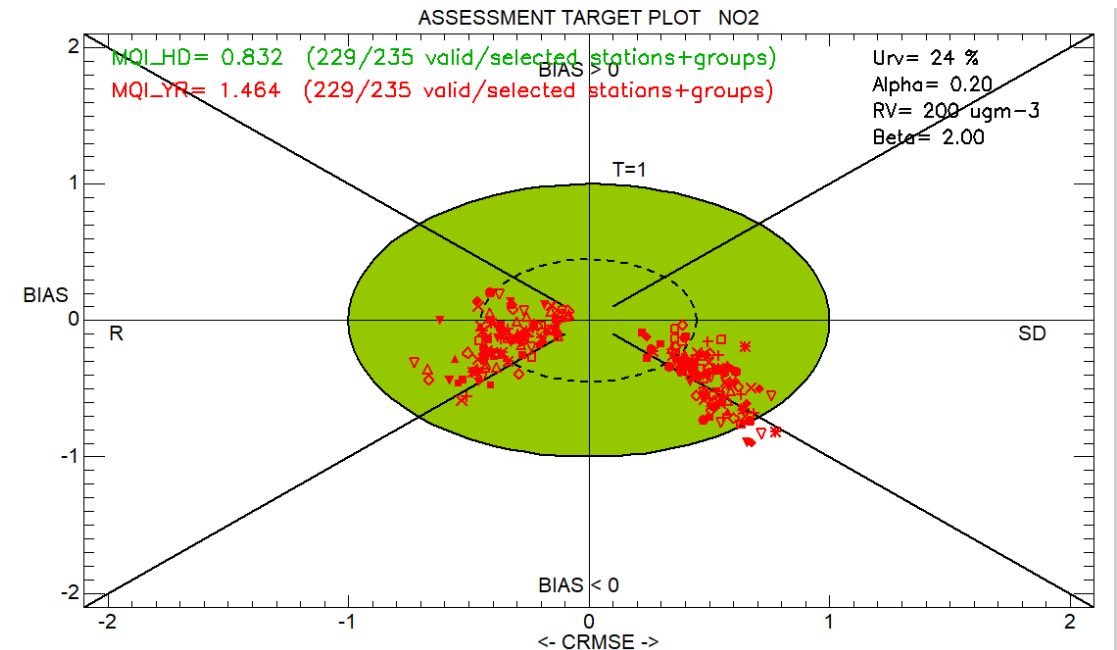
$$MQI = \frac{|\bar{O} - \bar{M}|}{\beta U(\bar{O})}$$

(has two uncertainties in the denominator, U [obs uncertainty] and β [2])

Daily MQI:

$$MQI = \frac{RMSE}{\beta RMS_U}$$

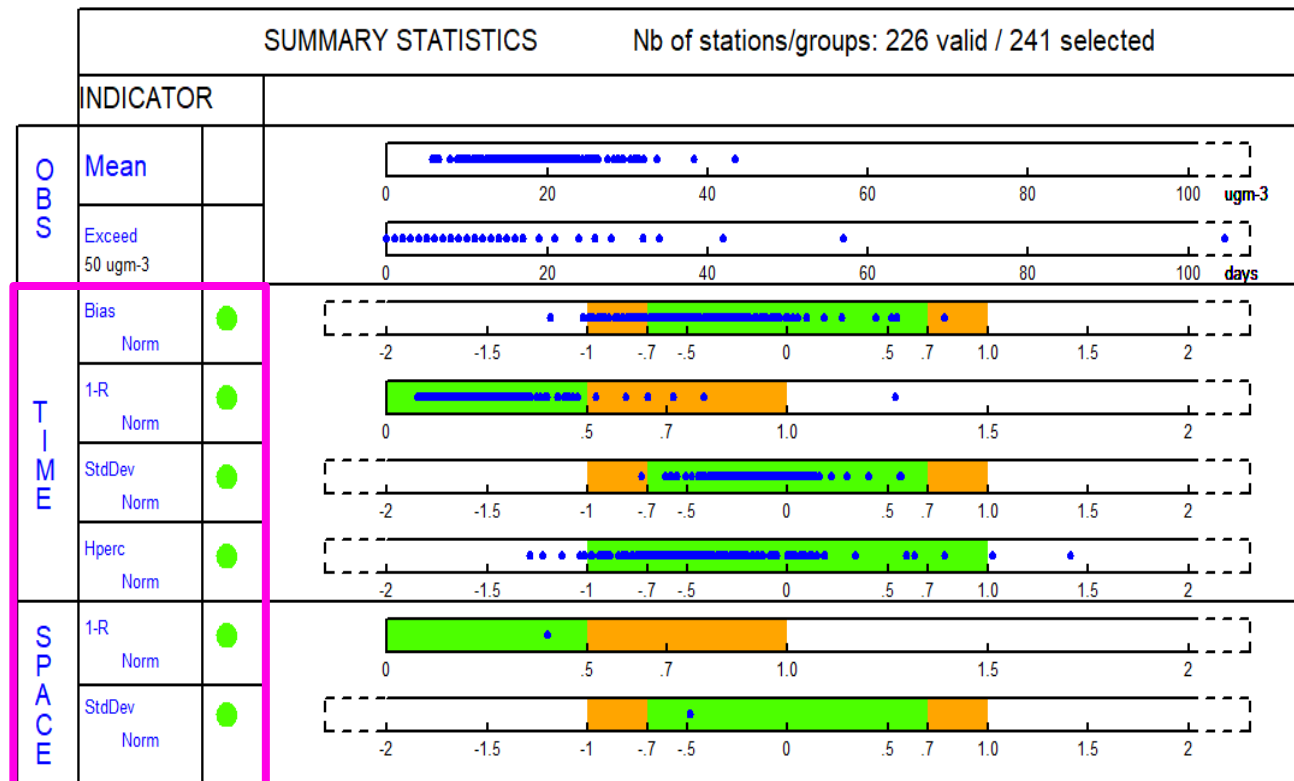
The Model Quality Objective (MQO)
is fulfilled when $MQI < 1.0$!



Indicators for the comparison (2)

- **Summary report**

The summary statistics table provides information on model performances. It is meant as a complementary source of information to the MQI (Assessment Target) to identify model strengths and weaknesses.



TIME: provides an overview of the temporal statistics for bias, R and STDEV as well as information on the ability of the model to capture the highest range of concentration values "Hperc".

SPACE: provides an overview of spatial statistics for R and STDEV.

The green area represents criteria fulfilment.

The orange area represents fulfilment, but the error associated to the particular statistical indicator is dominant.

More on this in the Delta User's Guide.

Summary report

Model Performance Indicator	Model Performance Criteria
MPI	MPC
BIAS ($R = 1, \sigma_O = \sigma_M$)	$ BIAS \leq \beta RMS_U$
R ($BIAS = 0, \sigma_O = \sigma_M$)	$1 - R < 0.5\beta^2 \frac{RMS_U^2}{\sigma_O \sigma_M}$
Std. dev. ($BIAS = 0, R = 1$)	$ \sigma_M - \sigma_O \leq \beta RMS_U$

Temporal Statistics

MPI	MPC
Correlation	$1 - R < 0.5\beta^2 \frac{RMS_U^2}{\sigma_O \sigma_M}$
Std. dev.	$ \sigma_M - \sigma_O \leq \beta RMS_U$

Spatial Statistics

Normalized by the hourly/daily uncertainty.

Indicators for the comparison (3)

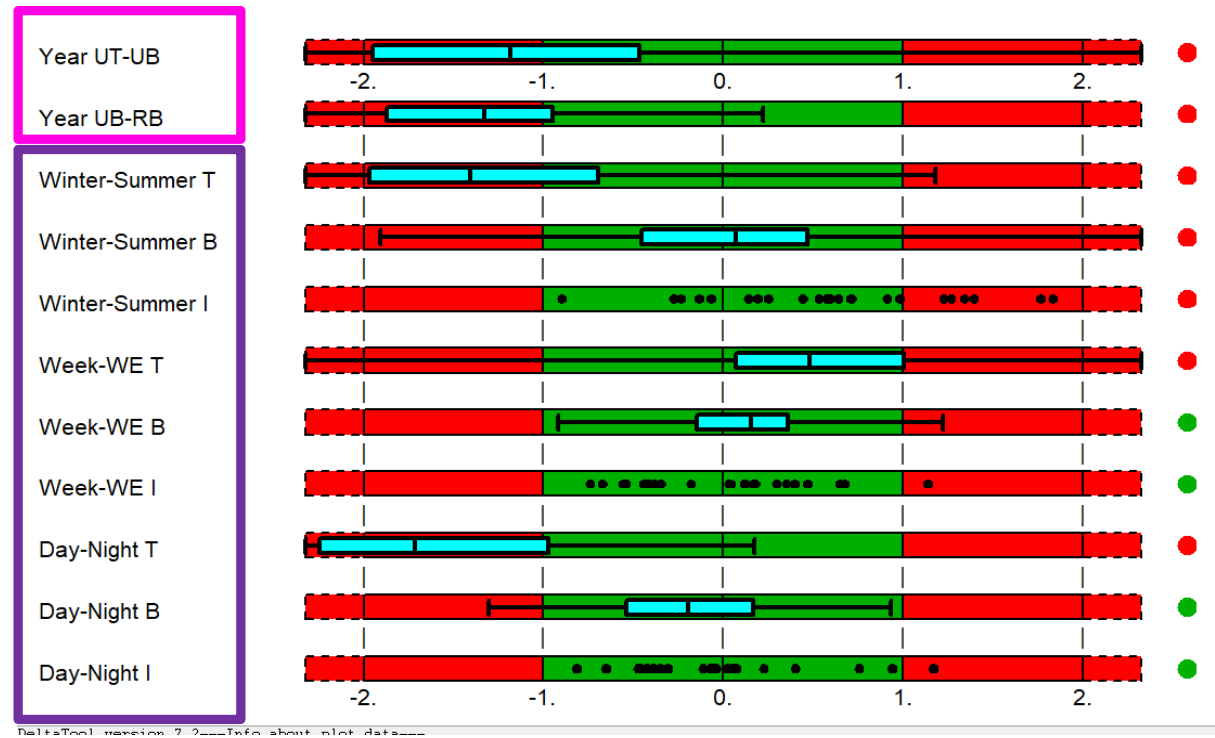
- **Dynamic evaluation**

Each row corresponds to a specific indicator and each dot to a specific station. A dot will be in the green zone (sufficient quality) when the absolute value of the indicator is less than one (indicator normalised by the measurement uncertainty). The circle on the right-hand side indicates if sufficient quality is reached for that indicator, i.e. when at least 90% of the available dots are within the green area.

Year **UT-UB** is the spatial gradient around a **T**raffic station, considering the **U**rban **B**ackground stations.

Temporal/seasonal gradient:

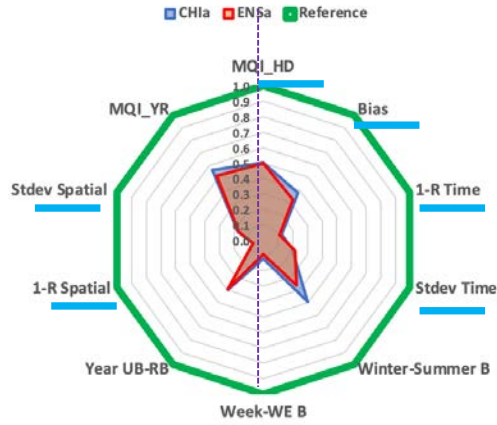
- Winter - Summer
- Week - WE
- Day - Night



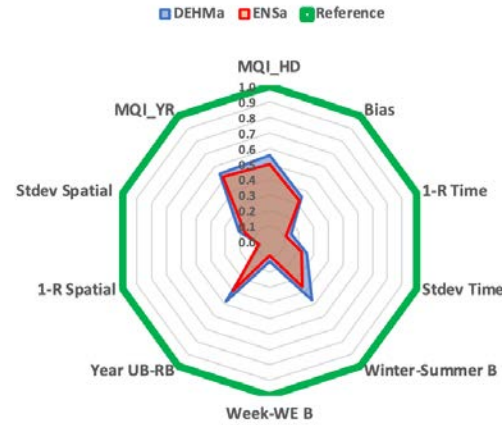
For more details on the statistics we refer to the Delta User Guide, which can be found here:
<https://aqm.jrc.ec.europa.eu/section/assessment/Document#DELTA-UserGuide>.

Results PM25, Spain

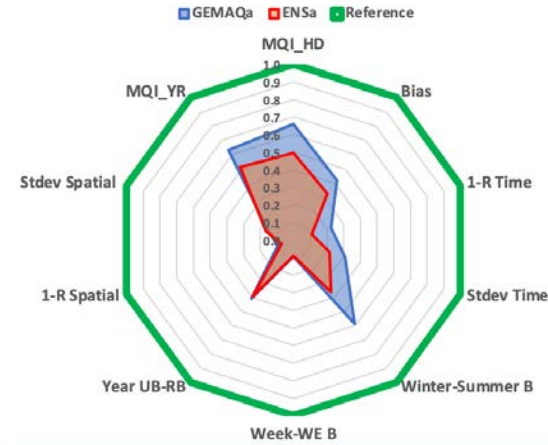
PM25 SPAIN CHIA VS ENSEMBLE



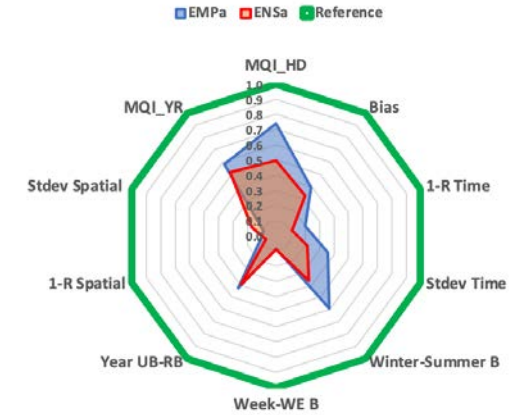
PM25 SPAIN DEHMA VS ENSEMBLE



PM25 SPAIN GEMAQA VS ENSEMBLE

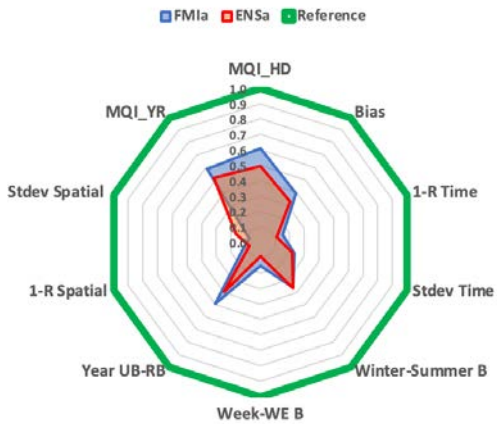


PM25 SPAIN EMPA VS ENSEMBLE

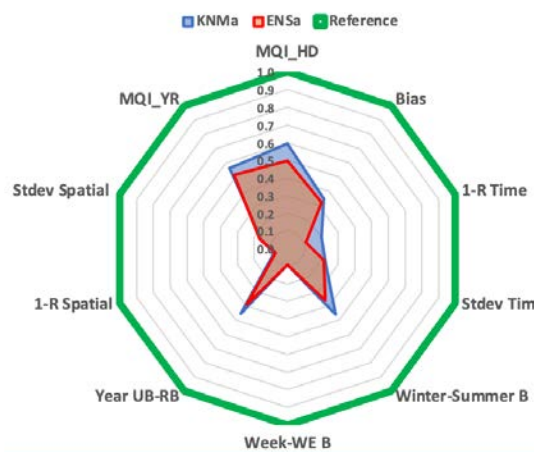


Spatial | Time

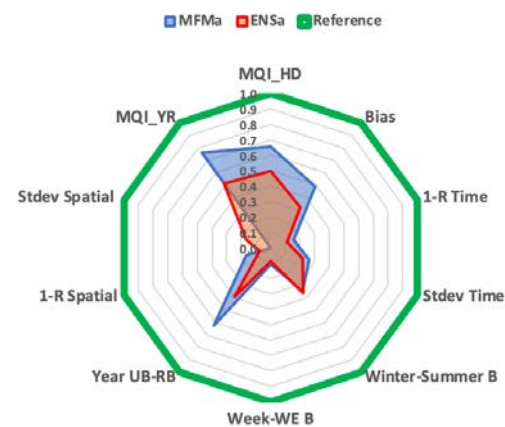
PM25 SPAIN FMIA VS ENSEMBLE



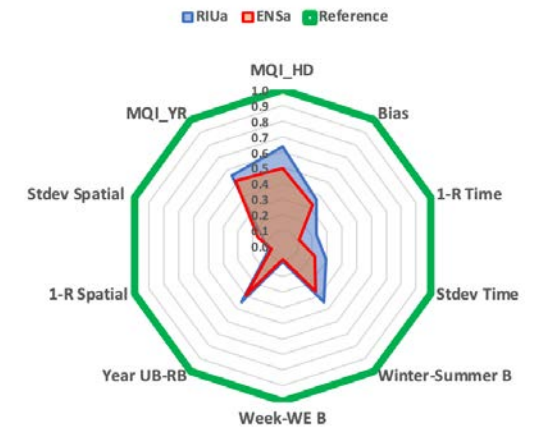
PM25 SPAIN KNMA VS ENSEMBLE



PM25 SPAIN MFMA VS ENSEMBLE



PM25 SPAIN RIUA VS ENSEMBLE



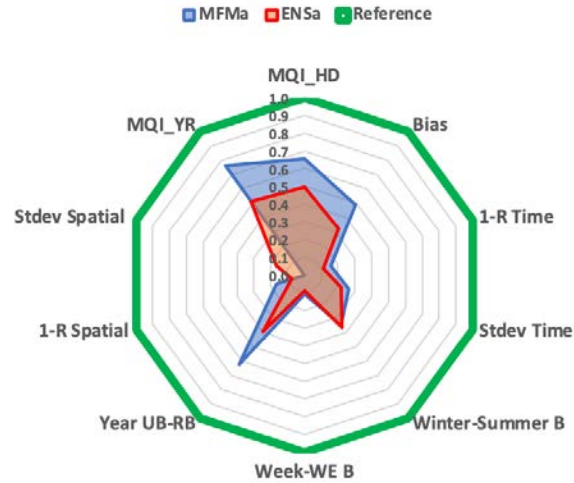
! The numbers of valid stations might differ between the statistical indicators (bias, 1-r, stdev, winter-summer, etc)

Model Quality Objectives are fulfilled.

PM25

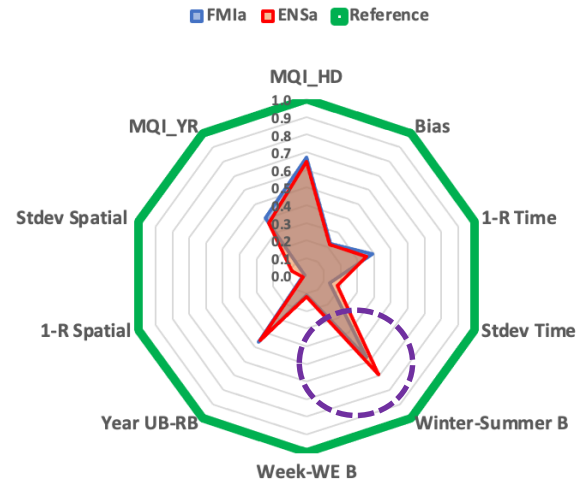
SPAIN

PM25 SPAIN MFMA VS ENSEMBLE



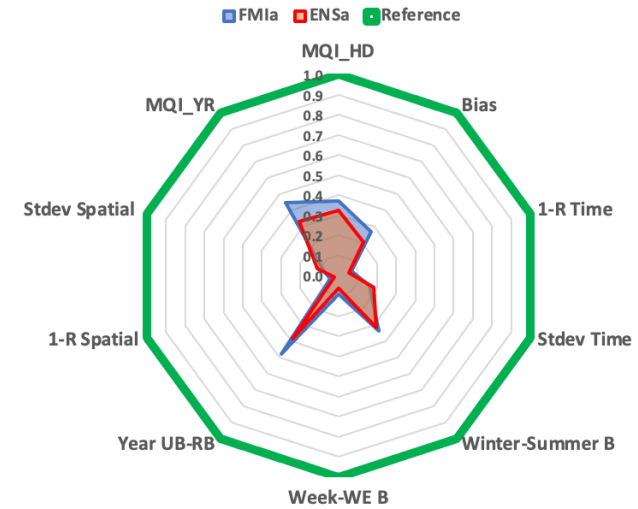
FRANCE

PM25 FRANCE FMIA VS ENSEMBLE



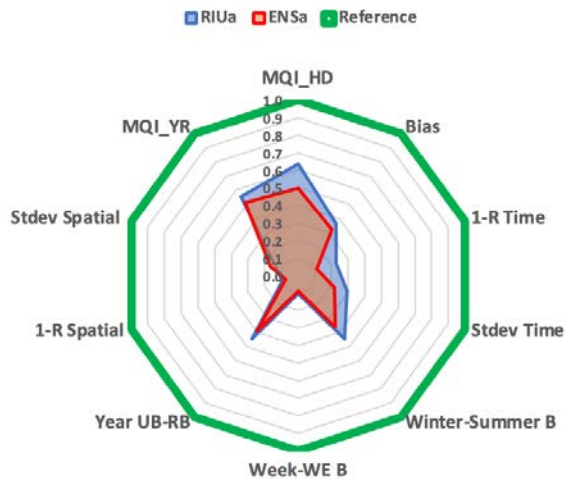
GERMANY

PM25 GERMANY FMIA VS ENSEMBLE

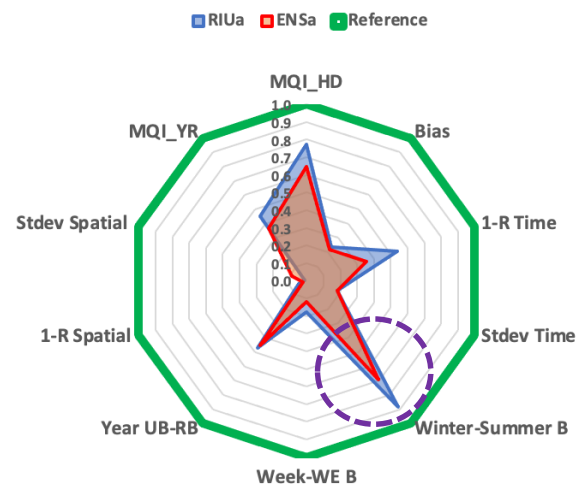


FMIA

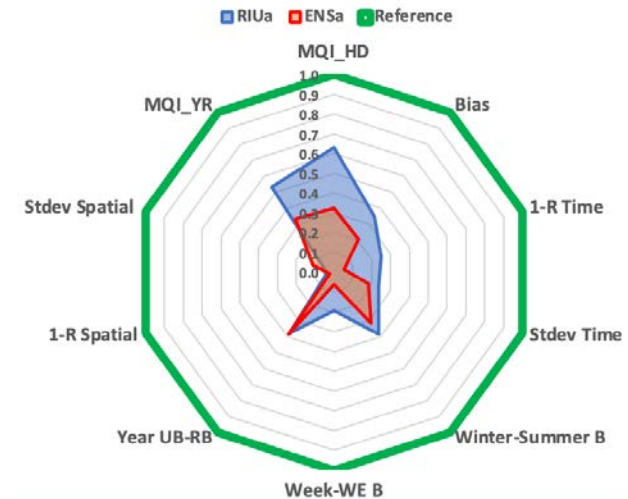
PM25 SPAIN RIUA VS ENSEMBLE



PM25 FRANCE RIUA VS ENSEMBLE



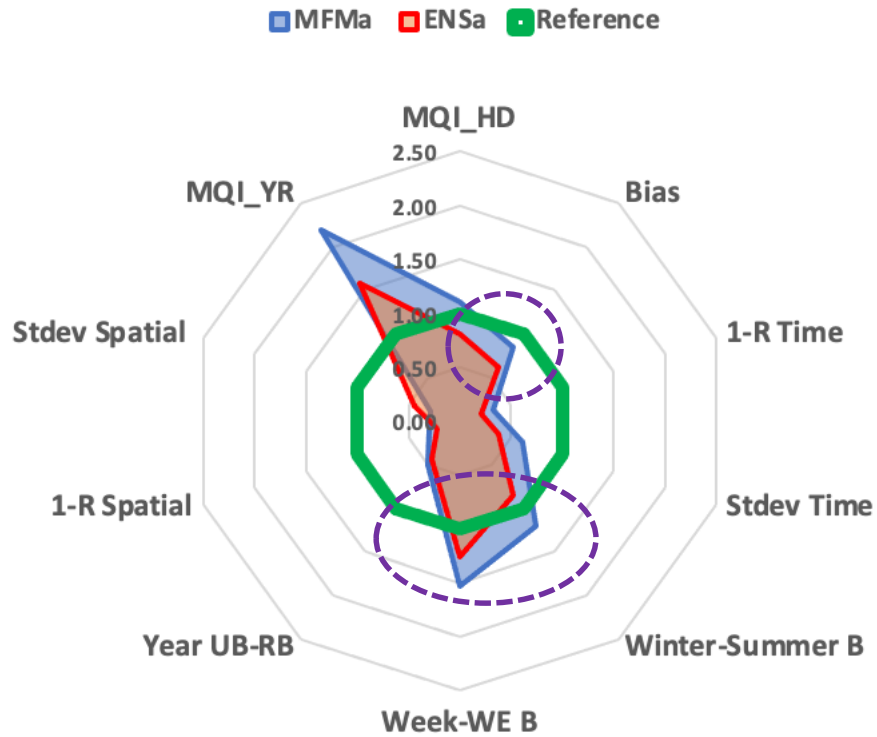
PM25 GERMANY RIUA VS ENSEMBLE



RIUA

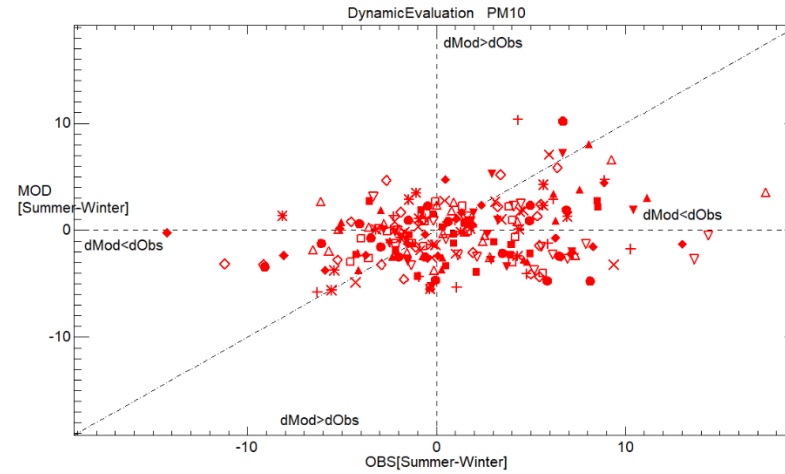
PM10 Spain

PM10 SPAIN MFMA VS ENSEMBLE



For Spain, all models show similar behaviour as MFMA, i.e. $MQI_{YeaR} > 1.0$ (lower error than for $MQI_{HourlyDaily}$). We have seen that PM10 is underestimated in the winter time, but okay for the summer period. Also, the models have difficulties in capturing the weekday-weekend profile. This is reflected in the radar plot, because MQI_{YR} is > 1.0 .

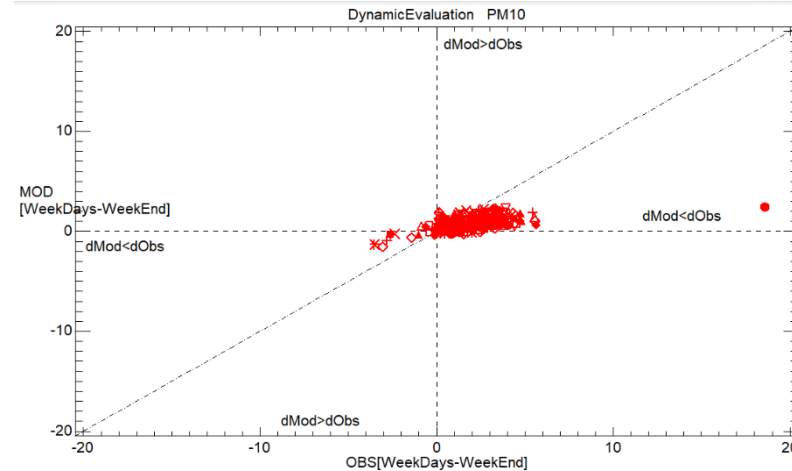
MFMA Summer – Winter Spain



Poor

Scatter plots of modeled vs. Observed Summer - Winter mean differences. Well behaving results should lie along the 1 to 1 line. Lower right and upper left part of the graphs indicate poor results.

MFMA weekdays - weekend Spain

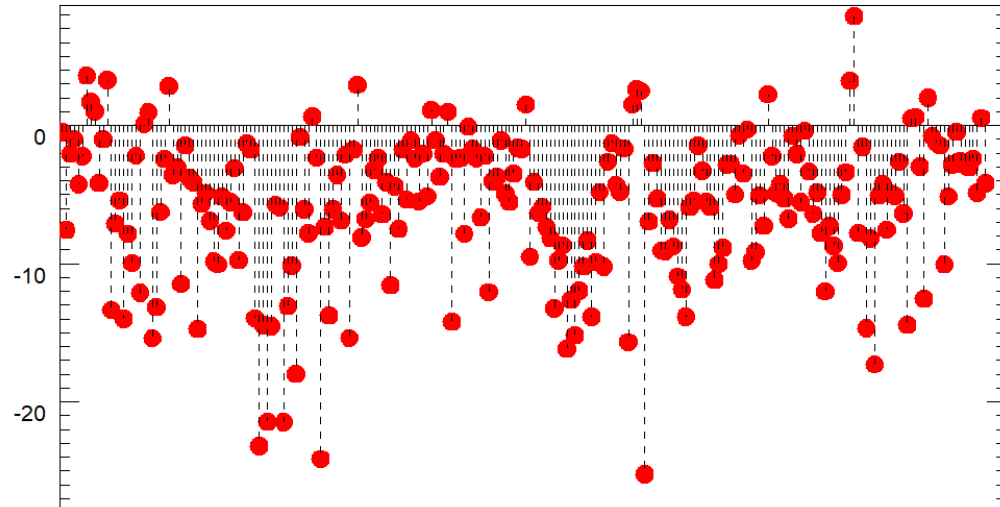


Poor

Bias MFMA PM10 Spain

MBias PM10

Units:
[ugm-3]

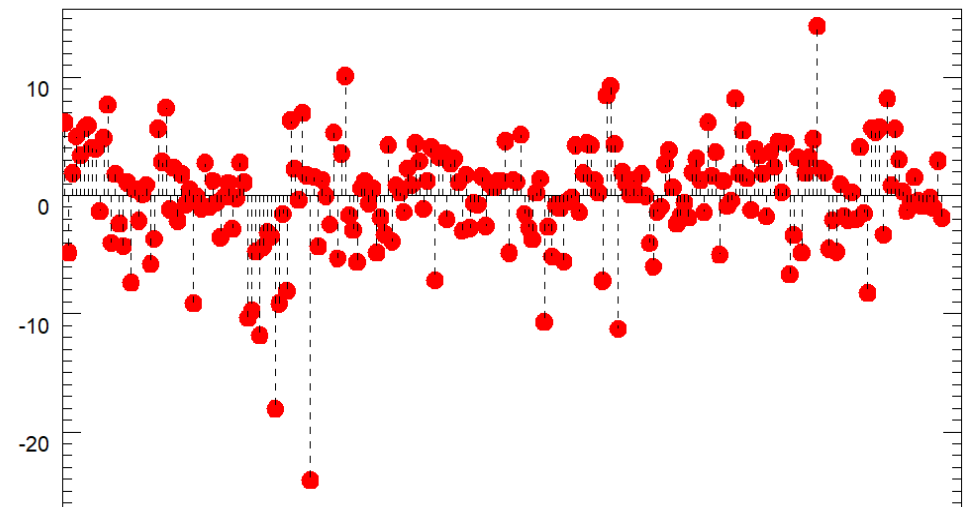


STATIONS

Bias CHMI PM10 Spain

MBias PM10

Units:
[ugm-3]

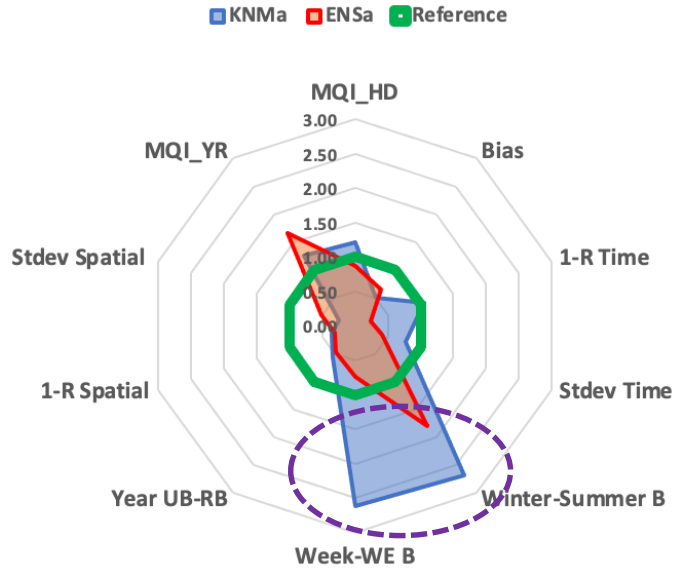


STATIONS

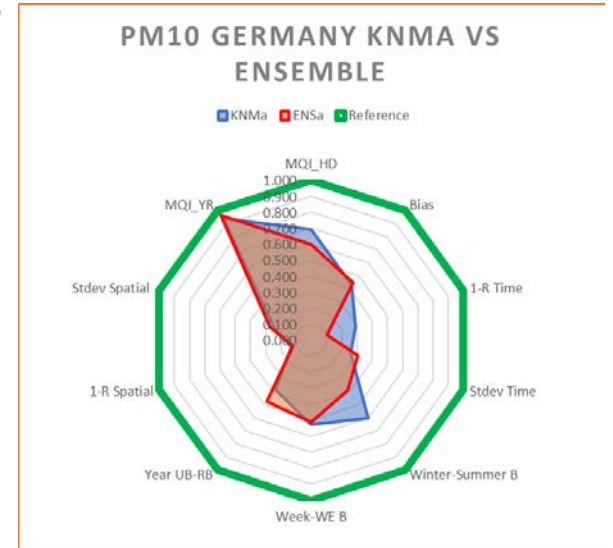
Larger Bias for MFMA than CHMI.

PM10 Italy

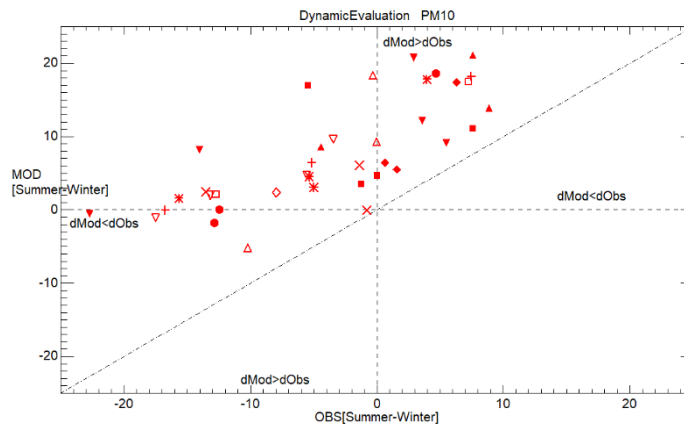
PM10 ITALY KNMA VS ENSEMBLE



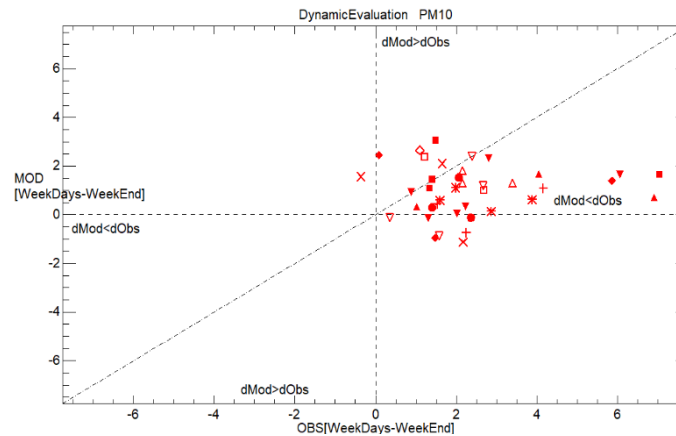
Similar to Spain and France the models have difficulties in capturing the Summer – Winter and Weekdays – Weekend profiles for PM10. Except for Germany.



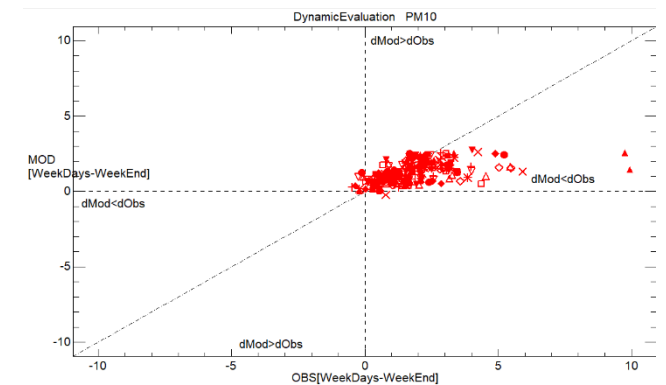
Summer - Winter



Weekdays-weekend

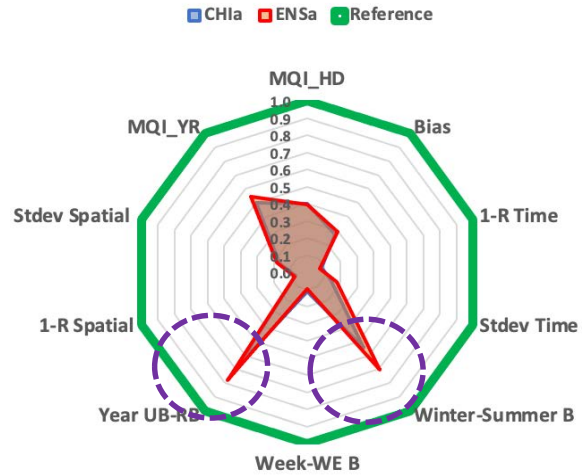


Weekdays-weekend

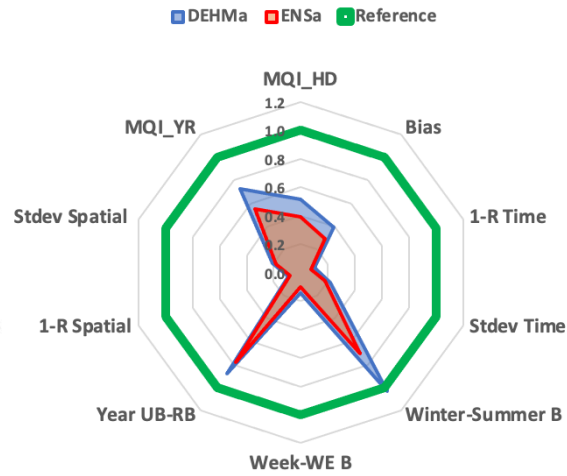


O3 Spain

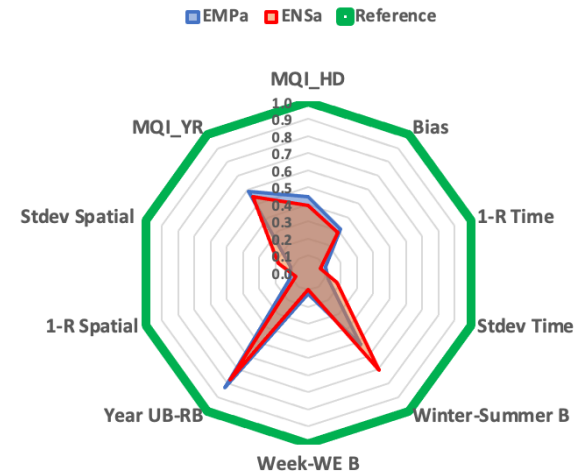
O3 SPAIN CHIA VS ENSEMBLE



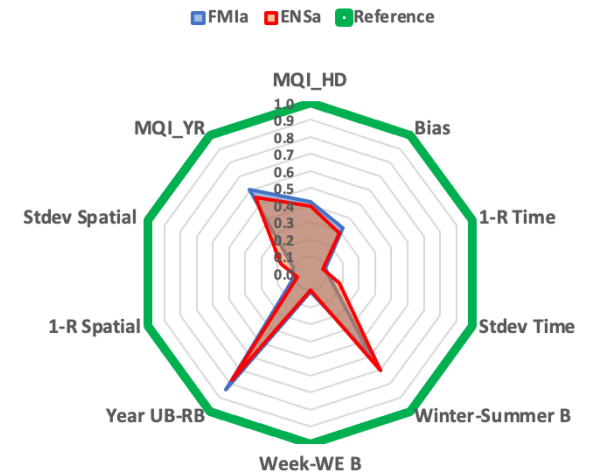
O3 SPAIN DEHMA VS ENSEMBLE



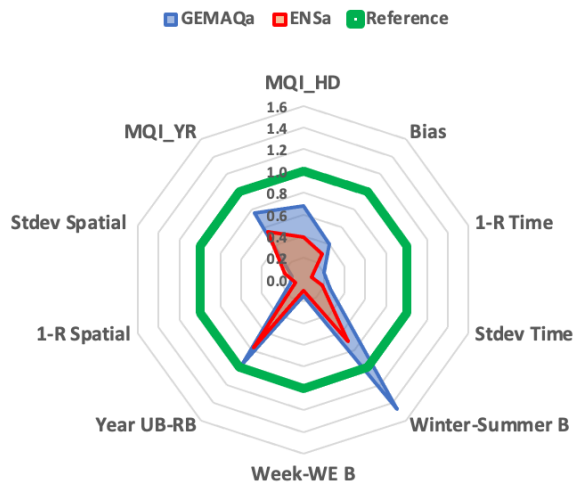
O3 SPAIN EMPA VS ENSEMBLE



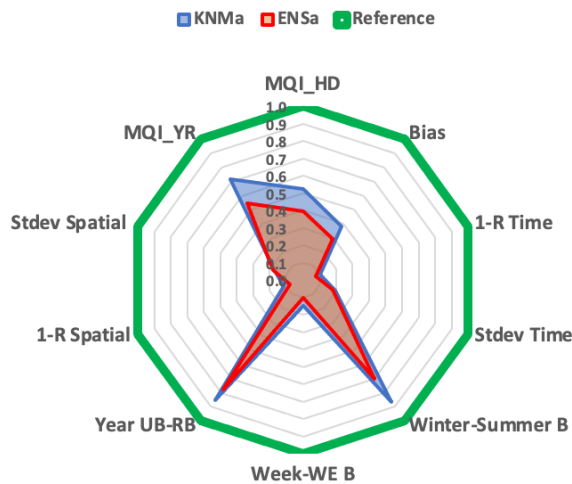
O3 SPAIN FMIA VS ENSEMBLE



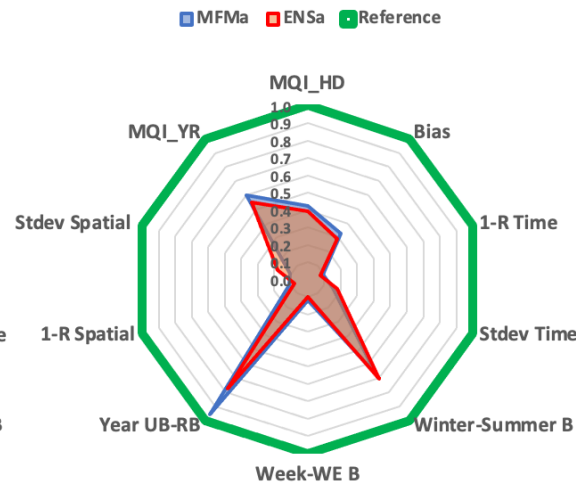
O3 SPAIN GEMAQA VS ENSEMBLE



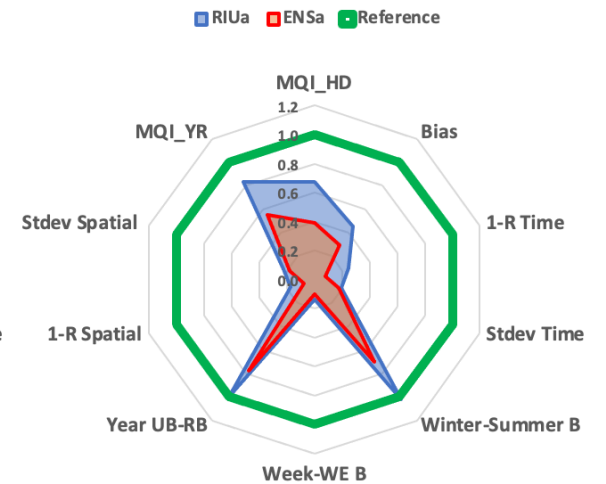
O3 SPAIN KNMA VS ENSEMBLE



O3 SPAIN MFMA VS ENSEMBLE



O3 SPAIN RIUA VS ENSEMBLE

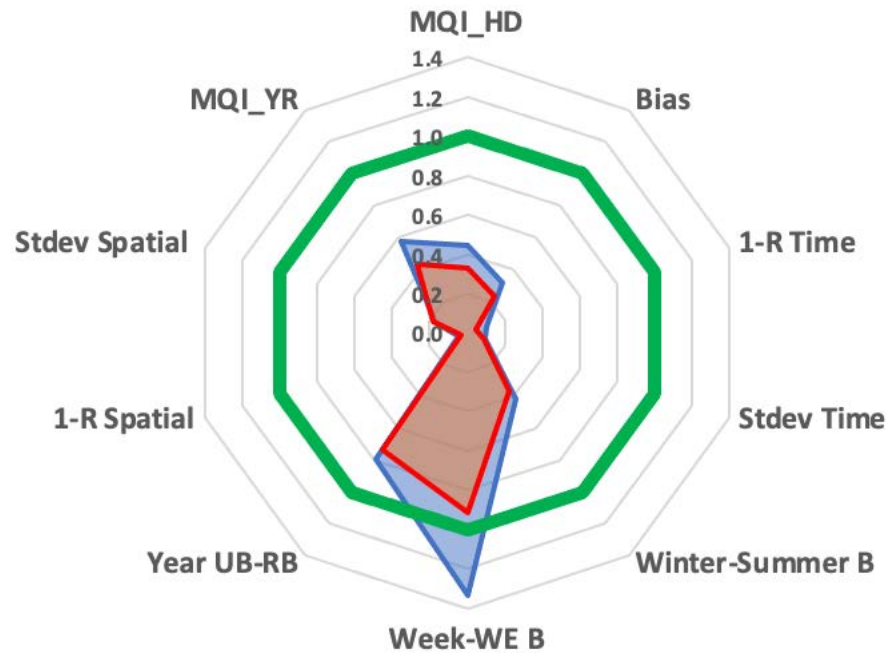


MQO are fulfilled.

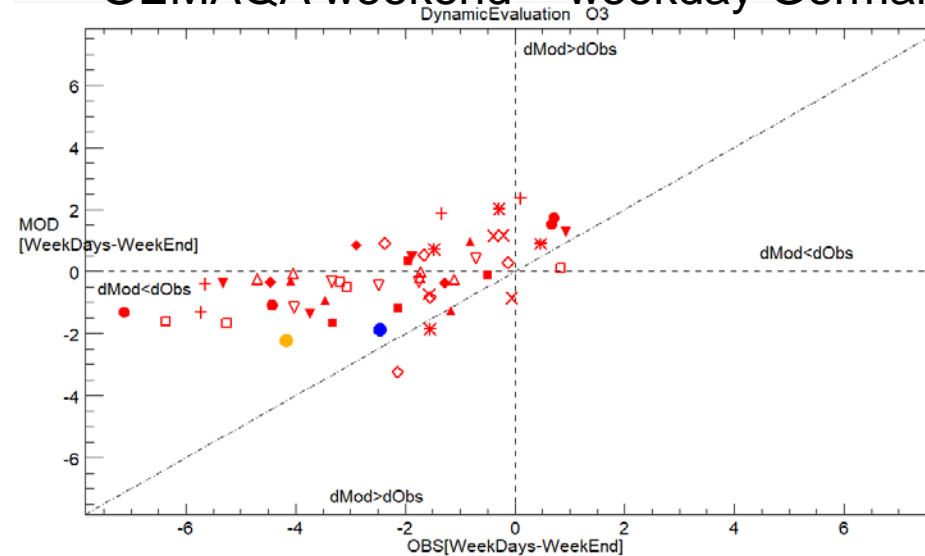
O3 Germany

O3 GERMANY GEMAQA VS ENSEMBLE

■ GEMAQa ■ ENSa ■ Reference



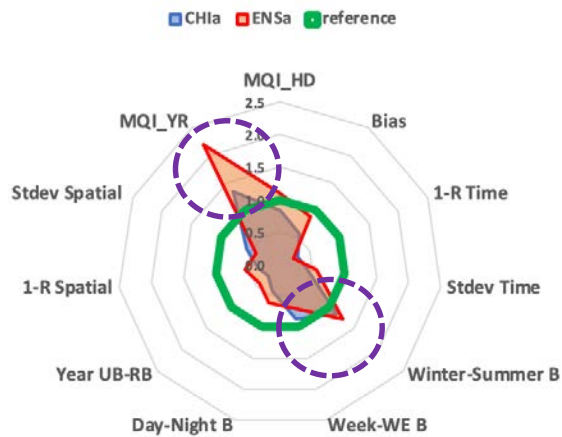
GEMAQA weekend – weekday Germany



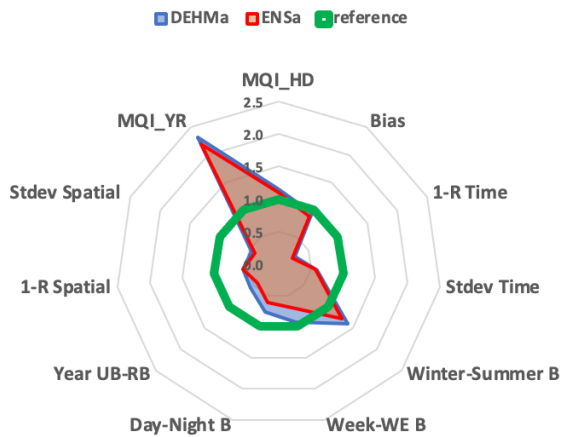
MQI_YR is the main indicator. So, your model can fulfill the MQO, while one of the indicators (Week– Weekend B) is not. ?

NO2 Italy

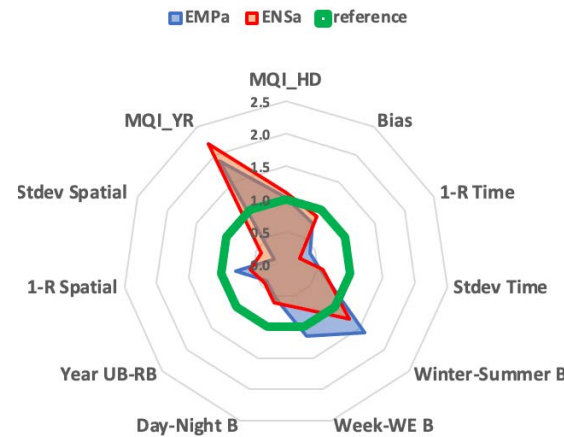
NO2 ITALY CHIA VS ENSEMBLE



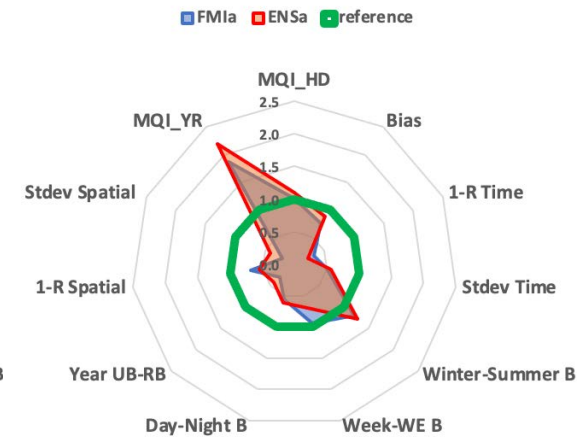
NO2 ITALY DEHMA VS ENSEMBLE



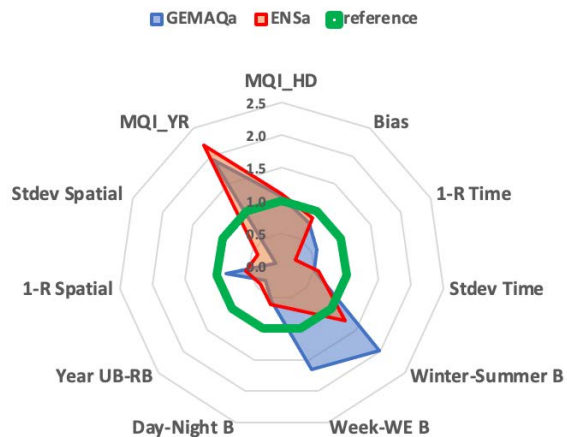
NO2 ITALY EMPA VS ENSEMBLE



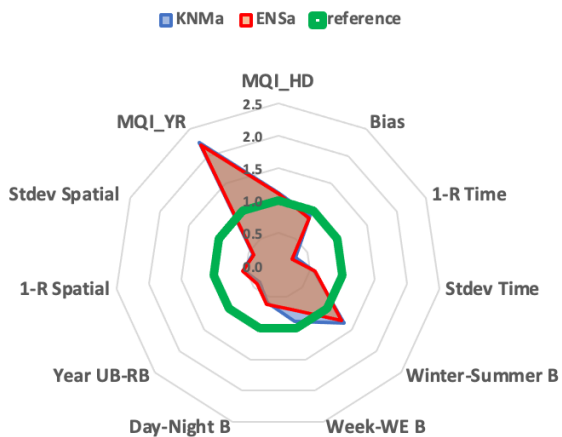
NO2 ITALY FMIA VS ENSEMBLE



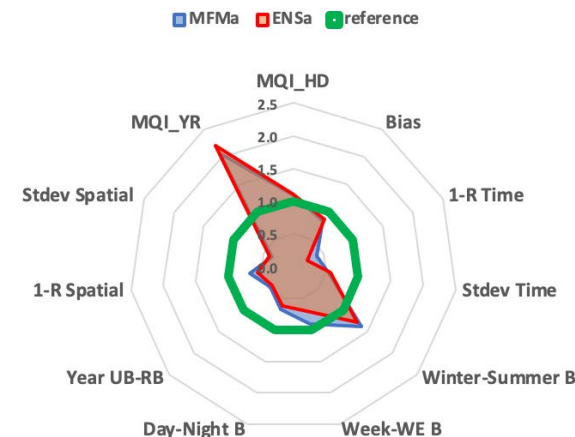
NO2 ITALY GEMAQA VS ENSEMBLE



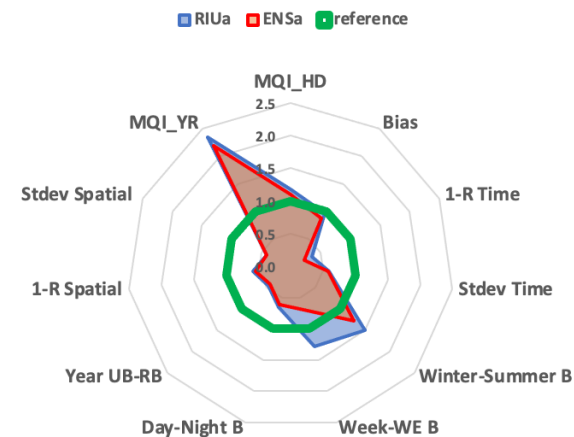
NO2 ITALY KNMA VS ENSEMBLE



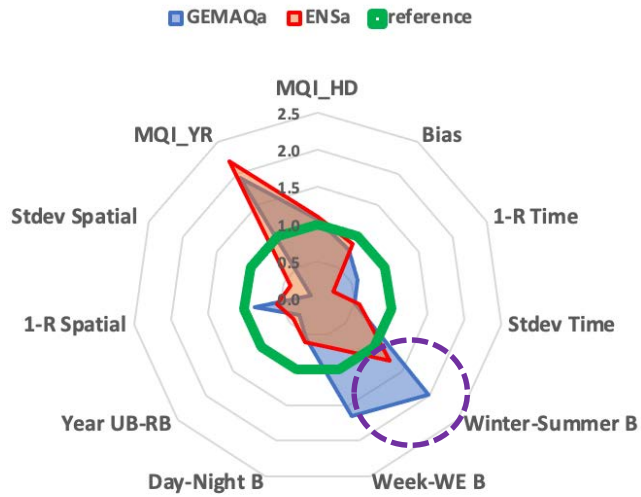
NO2 ITALY MFMA VS ENSEMBLE



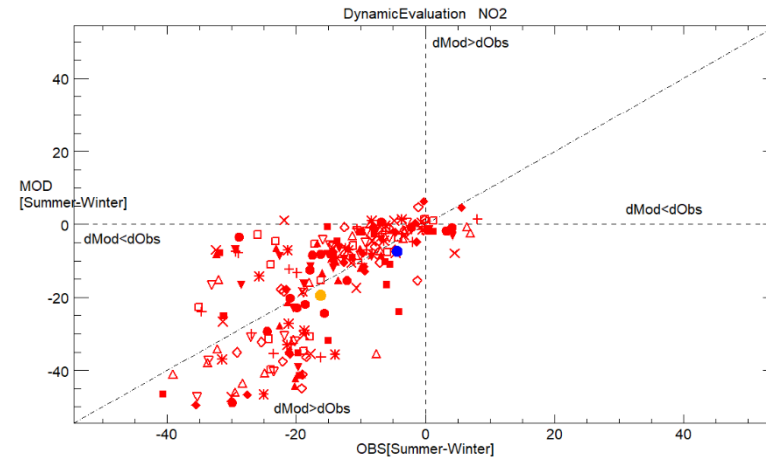
NO2 ITALY RIUA VS ENSEMBLE



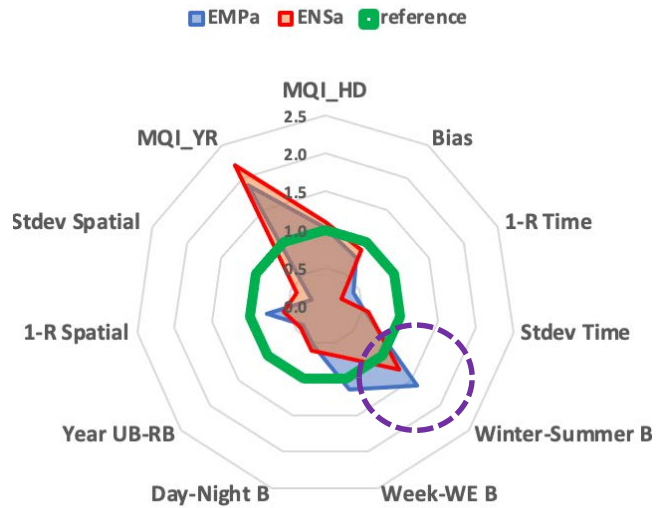
NO2 ITALY GEMAQA VS ENSEMBLE



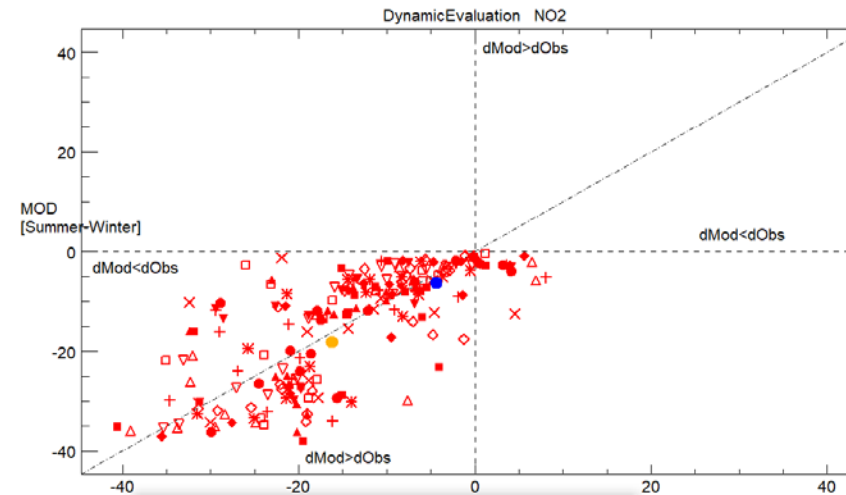
GEMAQA Summer - Winter



NO2 ITALY EMPA VS ENSEMBLE

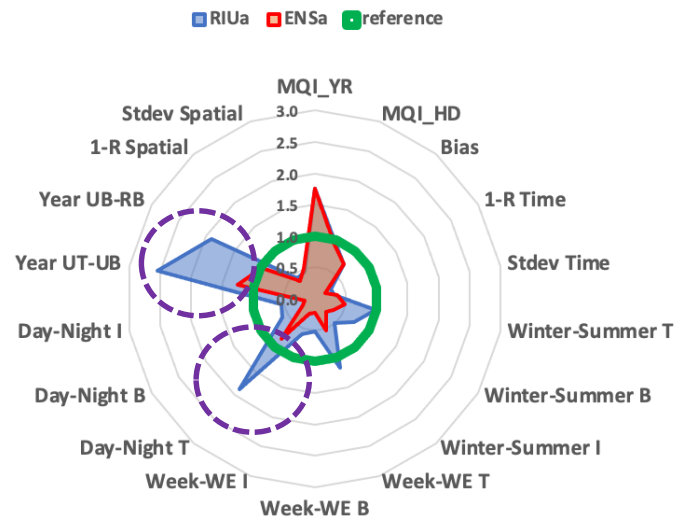


EMPA Summer - Winter

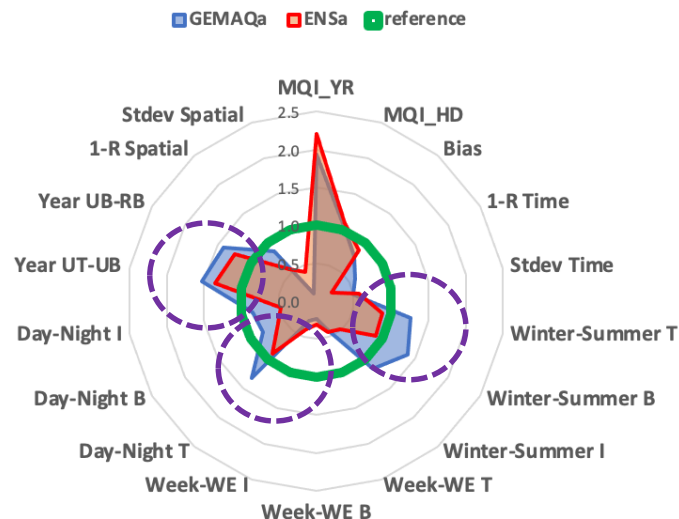


With traffic and Industry stations

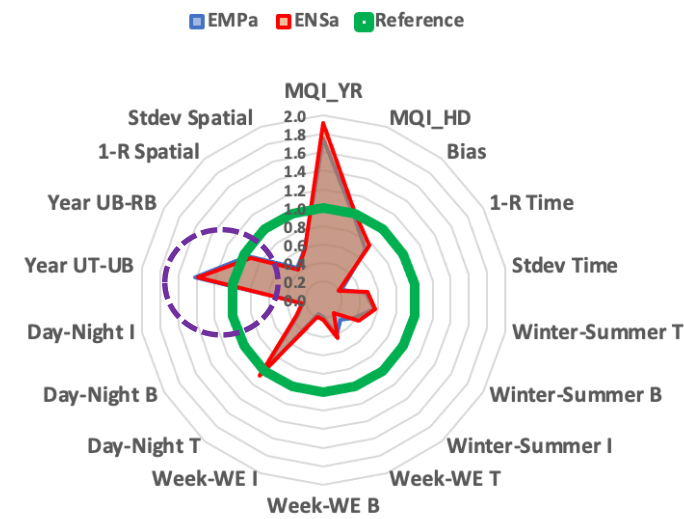
NO2 GERMANY RIUA VS ENSEMBLE



NO2 ITALY GEMAQA VS ENSEMBLE



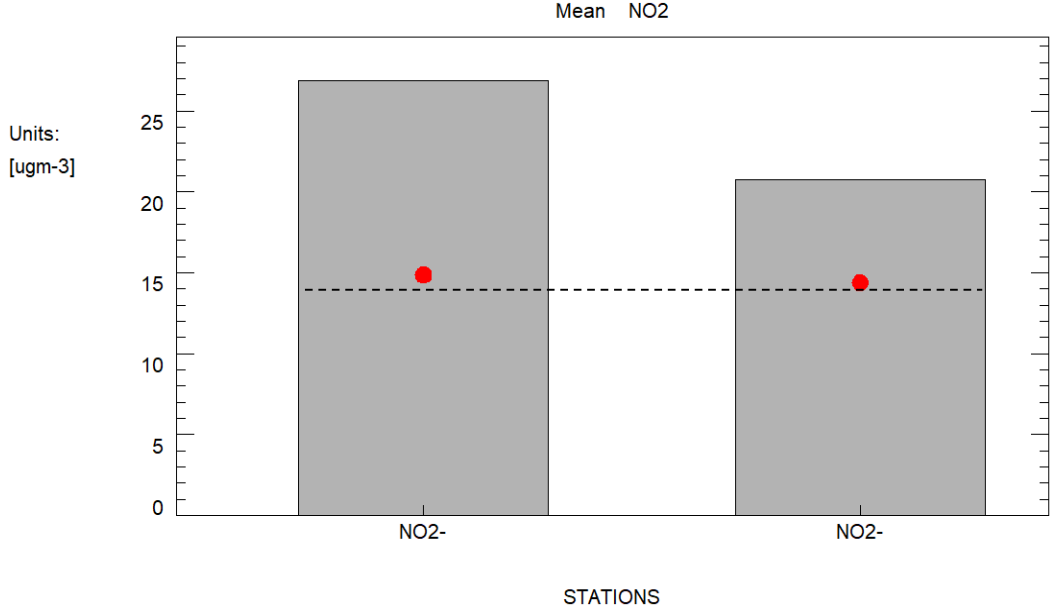
NO2 FRANCE EMPA VS ENSEMBLE



The models have difficulties to capture day – night profiles for Traffic stations, due to model resolution (0.1 x 0.1) .

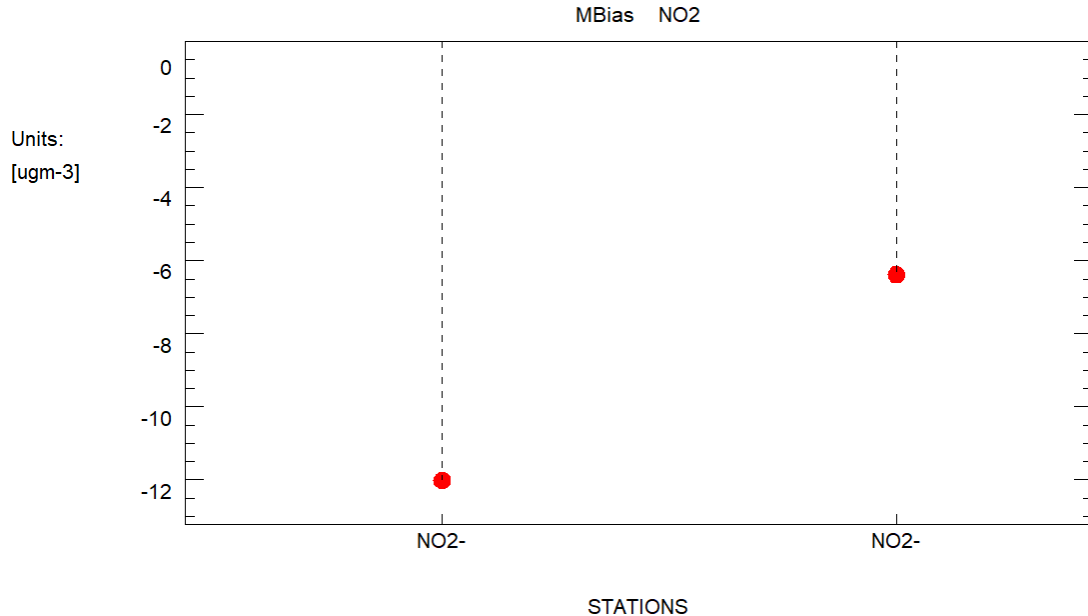
NO2 Yearly mean Germany

Traffic stations All stations



NO2 Bias Germany

Traffic stations All stations



● Model

■ Observations

Model results remain "flat"!

Preliminary conclusions

Based on the four countries we can say that:

PM25: in general, models capture well the indicators and MQO's are often fulfilled.

PM10: MQI Year is > 1.0 , which is caused by not capturing well the weekdays - weekend and Summer – Winter profiles, and the smaller uncertainty than for MQI_HD.

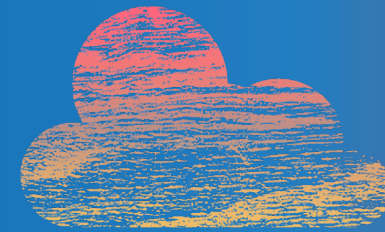
O3: For Spain, France and Germany the MQO are fulfilled in general, but not for Italy. Mainly caused by difficulties by the models to capture the Summer – Winter profiles, and UrbanBackground – RuralBackground gradient.

NO2: In general, MQI Year is > 1.0 .

For traffic stations, the models have difficulties to capture day – night profiles.

Further analysis is required to assess the consistency in terms of stringency among the indicators.

Thank you



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