



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

# European MINNI Simulation in the framework of CAMS Regional production

Validation using DELTA Tool Forecast Indicators

18-20/10/2022 – Oslo - FAIRMODE Technical Meeting

*Lina Vitali, Mario Adani, Antonio Piersanti*

**ENEA, Laboratory of Atmospheric Pollution**



1101 0110 1100  
0101 0010 1101  
0001 0110 1110  
1101 0010 1101  
1111 1010 0000



# BACKGROUND

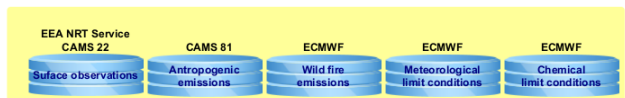
One of the questions for CT3 discussion on future activities

***Can/should we plan an application of the methodology on European scale (e.g. on CAMS data)?***

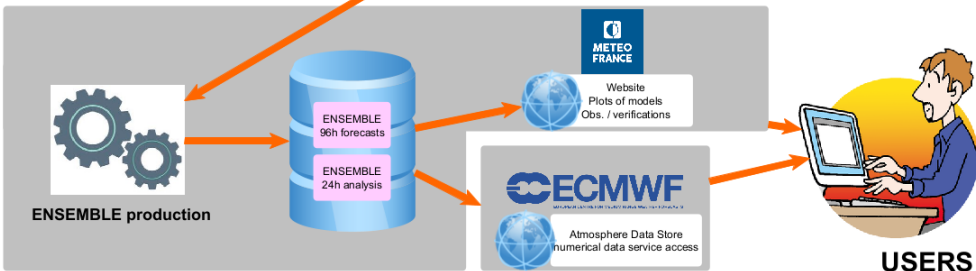
# MINNI WITHIN CAMS2\_40

<https://regional.atmosphere.copernicus.eu/>

## Daily production of forecasts and analysis



### Individual models



MF/IGM/CSE/EN/EB 210200925

## ENEA team in CAMS2\_40:

Mario Adani, Gino Briganti, Ilaria D'Elia, Massimo D'Isidoro, Guido Guarnieri, Mihaela Mircea, Antonio Piersanti

# THE MINNI SIMULATION “v51” SETUP

<b>MODELLING SYSTEM:</b>	MINNI
<b>GEOGRAPHICAL DOMAIN:</b>	0.1 deg resolution, 25°W-45°E, 30°N-72°N
<b>TIME PERIOD:</b>	2018
<b>METEOROLOGY:</b>	IFS
<b>BOUNDARY CONDITIONS:</b>	C-IFS
<b>EMISSION:</b>	CAMS 5.1 Inventory
<b>FIRE EMISSION:</b>	hourly GFAS

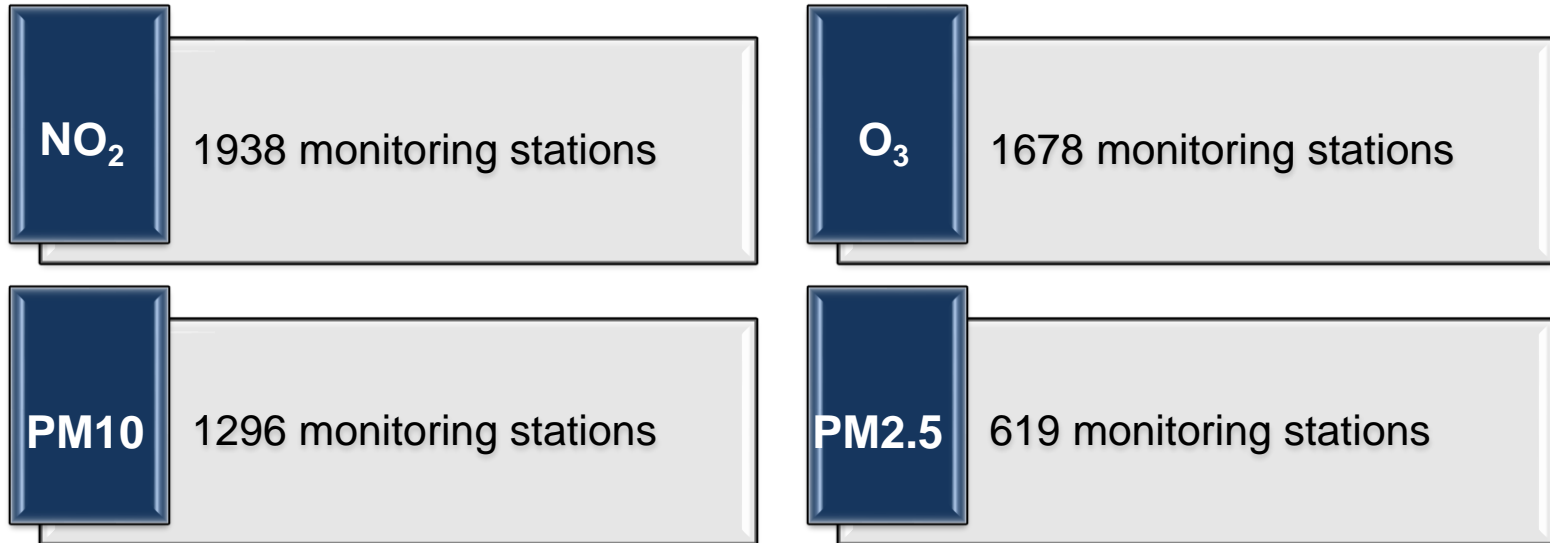


*The MINNI simulation “v51” was carried out within CAMS\_50.II (2018-2021) when MINNI (operated by ENEA, Italy) and MONARCH (operated by BSC, Spain) was participating as “candidate” models*

*The MINNI simulation “v51” was carried out using CAMS input and setup but it is not an official CAMS product*

# THE DATA SET FOR THE VALIDATION

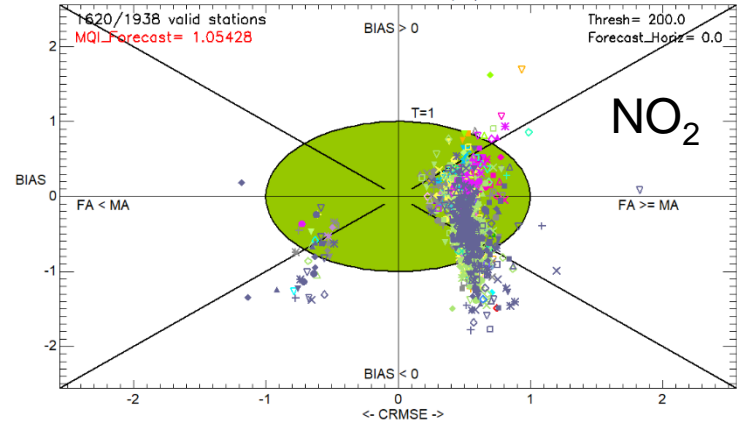
ALL AVAILABLE DATA MEASURED AT BACKGROUND MONITORING STATIONS WERE DOWNLOADED FROM EEA AND CONSIDERED FOR THE VALIDATION  
(E1a at <https://discomap.eea.europa.eu/map/fme/AirQualityExport.htm>)



# DELTA TOOL APPROACH FOR FORECAST VALIDATION

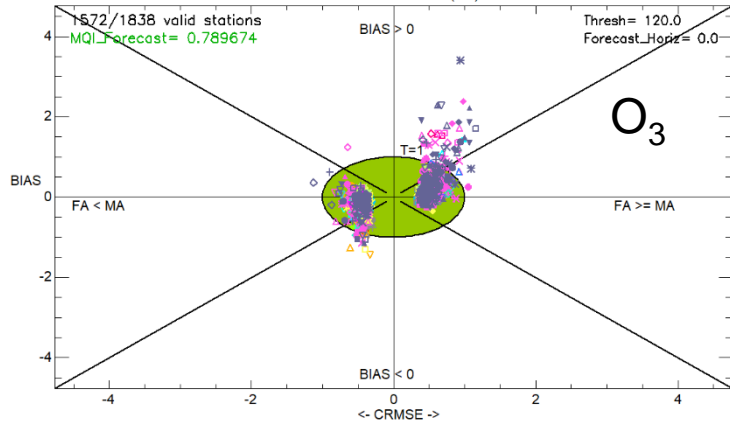
1. Comparison with the Persistence Model to assess if the forecast application is “good enough”
2. Assessment of the model Capability in predicting Exceedances
3. Assessment of the model Capability in predicting Air Quality Indices

FORECAST TARGET PLOT (OU) NO2



0601941	AT0P1L1	AT2SP10	AT30401	AT31701	Stn/and Ind: 1-8760
0602041	AT0SON1	AT2SP18	AT30403	AT31703	Model (s): v51
4101241	AT2W035	AT30407	AT31901	AT31705	Parameter: NO2
AD0944A	AT0ZOE2	AT30085	AT31904	AT31904	Scen: 2018
AL0206A	AT10001	AT30601	AT32001	AT32001	Extra Values: 200/0
AL0206A	AT10002	AT30201	AT31204	AT32004	Season: Year
AT0E0K1	AT10003	AT30202	AT31401	AT32501	Day hours: All 24h
AT0L1L1	AT10035	AT30301	AT31413	AT32504	Time Average: Preserve
AT0K0H1	AT2KAT1	AT30302	AT31502	AT32701	

FORECAST TARGET PLOT (OU) O3

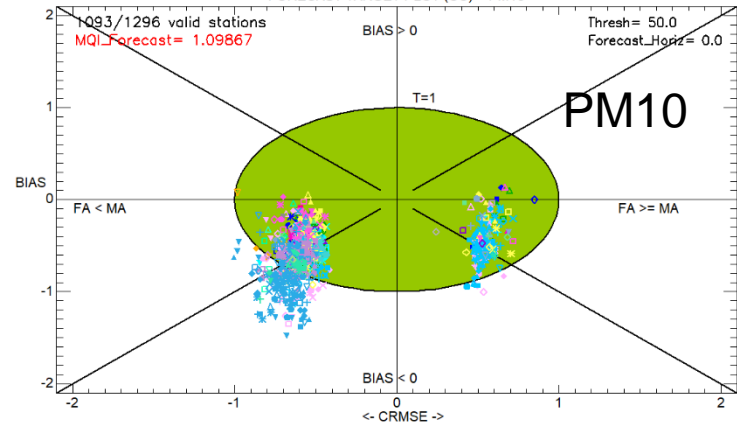


0602041	AT0L1L1	AT11007	AT30103	AT30603	Stn/and Ind: 1-8760
4101241	AT0P1L1	AT2K441	AT30201	AT30701	Model (s): v51
AD0944A	AD0944A	AT2K471	AT30202	AT30801	Parameter: O3
AL0206A	AT0ZOR1	AT2SP10	AT30301	AT31102	Scen: 2018
AL0206A	AT0ZOE2	AT2SP18	AT30302	AT31204	Extra Values: 120/0
AL0203A	AT10001	AT2V152	AT30401	AT31301	Season: Year
AL0206A	AT10002	AT2W035	AT30403	AT31401	Day hours: All 24h
AL0206A	AT10003	AT30605	AT30502	AT31502	Time Average: 8h
AT0E0K1	AT10035	AT30101	AT30601	AT31701	

# 1. Comparison with the Persistence Model

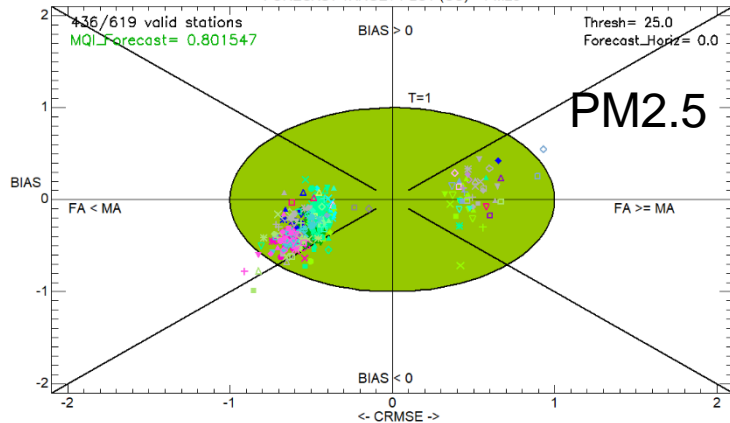
- ✓ MQO is fulfilled in simulating O<sub>3</sub> and PM2.5
- ✓ some room for improvement concerning NO<sub>2</sub> and PM10

FORECAST TARGET PLOT (OU) PM10



0601941	AT0ZOE2	AT2SP18	AT30603	AT32401	Stn/and Ind: 1-8760
0602041	AT10001	AT2W035	AT30701	AT32501	Model (s): v51
4101241	AT10002	AT2W035	AT31301	AT32604	Parameter: PM10
AD0944A	AT10003	AT30101	AT31401	AT32701	Scen: 2018
AL0206A	AT10035	AT30201	AT31413	AT32708	Extra Values: 50/0
AT0L1L1	AT10007	AT30301	AT31703	AT34325	Season: Year
AT0K0H1	AT2KAT1	AT30302	AT31901	AT43158	Day hours: All 24h
AT0P1L1	AT2KAT26	AT30401	AT31904	AT43184	Time Average: Preserve
AT0VOR1	AT2SP10	AT30502	AT32301	AT43404	Daily stats: Mean

FORECAST TARGET PLOT (OU) PM25



0602041	AT32301	AT43409	BA0048A	BETN035	Stn/and Ind: 1-8760
AL0206A	AT32701	AT43416	BELRL01	BETN052	Model (s): v51
AT0E0K1	AT43108	AT43107	BET1B011	BETN054	Parameter: PM25
AT0L1L1	AT43125	AT43178	BET1C011	BETN060	Scen: 2018
AT0E0K1	AT43156	AT43042	BET1M04	BETN062	Extra Values: 25/0
AT10001	AT43184	AT4304C	BET1M05	BETN067	Season: Year
AT2KAT1	AT43404	AT4304B	BETN070	BETN070	Day hours: All 24h
AT30407	AT43406	AT4304D	BETN073	BETN073	Time Average: Preserve
AT31413	AT43407	AT4304E	BETN075	BETN085	Daily stats: Mean

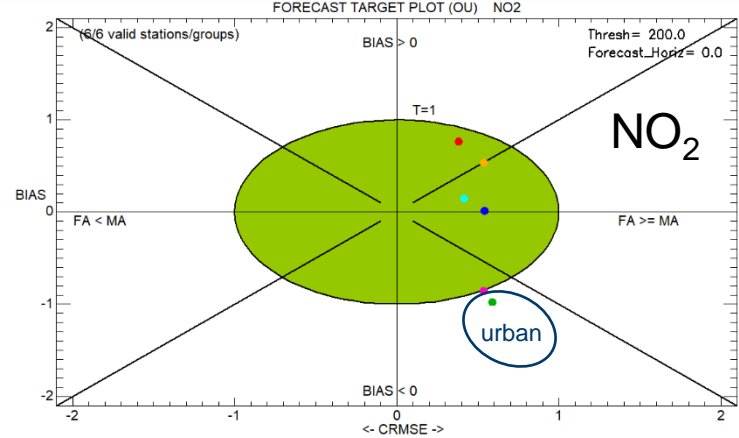
THOUSANDS OF POINTS CAN MAKE TARGET PLOTS DIFFICULT TO INTERPRET IN PARTICULAR WHEN LOOKING FOR SOME EXPLANATION AND INSIGHT (E.G. REASON FOR MQI>1)

# 1. Comparison with the Persistence Model

TARGET PLOT CAN BE PRODUCED CHOOSING **GROUP MODE** OPTION THAT IS GROUPING STATION BY AN ATTRIBUTE

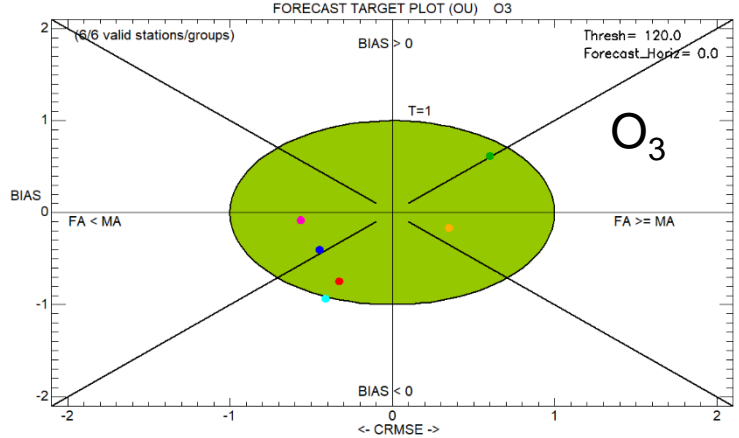
HERE STATIONS ARE GROUPED **BY EMISSION ENVIRONMENT** AND THE OPTION **«WORST INDIC IN 90% STAT»** IS SELECTED (I.E. THE POSITION OF THE POINT CORRESPONDS TO THE MQI OF THE GROUP)

✓ For both NO<sub>2</sub> and PM10 the main issues arise in urban environment (MQI is higher than 1 only for urban Group)



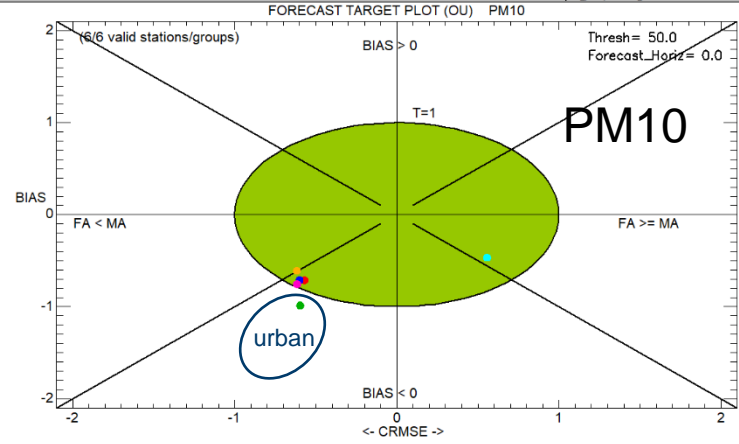
● rural  
● rural-remote  
● rural-regiona  
● rural-remote  
● suburban  
● urban

Str/End Ind: 1-8760  
 Station: -1  
 Model (s): v51  
 Parameter: NO2  
 Scen: 2018  
 Extra Values: 200/0  
 Season: Year  
 Day hours: All 24h



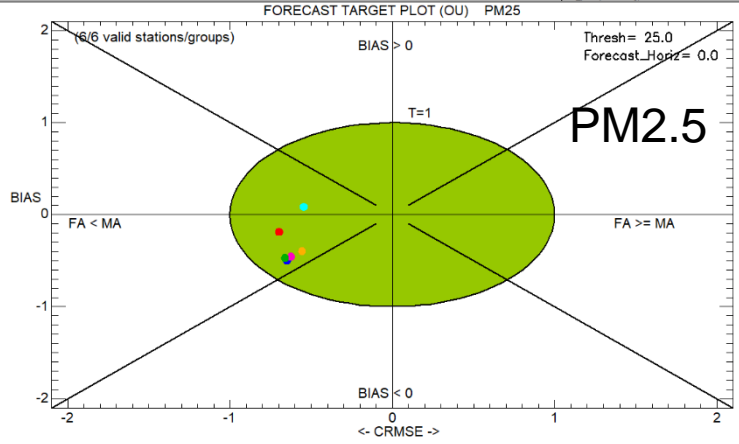
● rural  
● rural-remote  
● rural-regiona  
● rural-remote  
● suburban  
● urban

Str/End Ind: 1-8760  
 Station: -1  
 Model (s): v51  
 Parameter: O3  
 Scen: 2018  
 Extra Values: 120/0  
 Season: Year  
 Day hours: All 24h



● rural  
● rural-remote  
● rural-regiona  
● rural-remote  
● suburban  
● urban

Str/End Ind: 1-8760  
 Station: -1  
 Model (s): v51  
 Parameter: PM10  
 Scen: 2018  
 Extra Values: 50/0  
 Season: Year  
 Day hours: All 24h  
 Time Average: Preserve



● rural  
● rural-remote  
● rural-regiona  
● rural-remote  
● suburban  
● urban

Str/End Ind: 1-8760  
 Station: -1  
 Model (s): v51  
 Parameter: PM25  
 Scen: 2018  
 Extra Values: 25/0  
 Season: Year  
 Day hours: All 24h  
 Time Average: Preserve

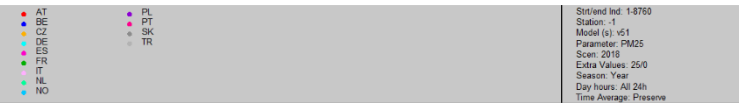
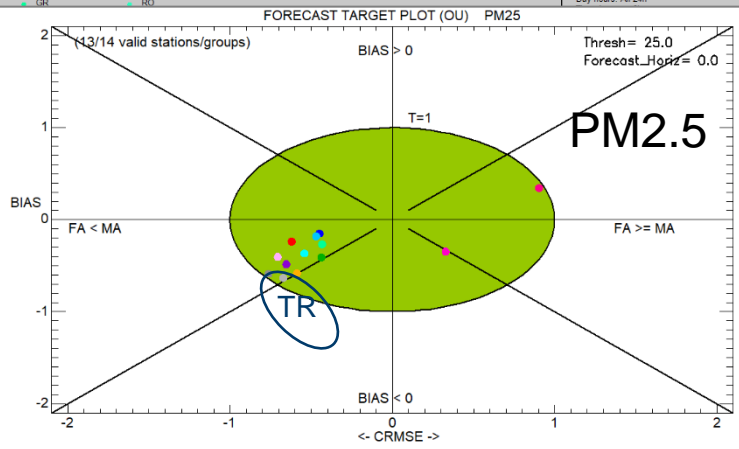
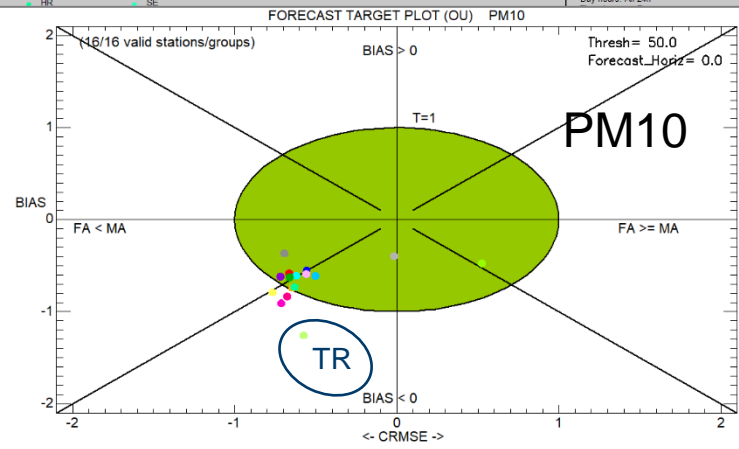
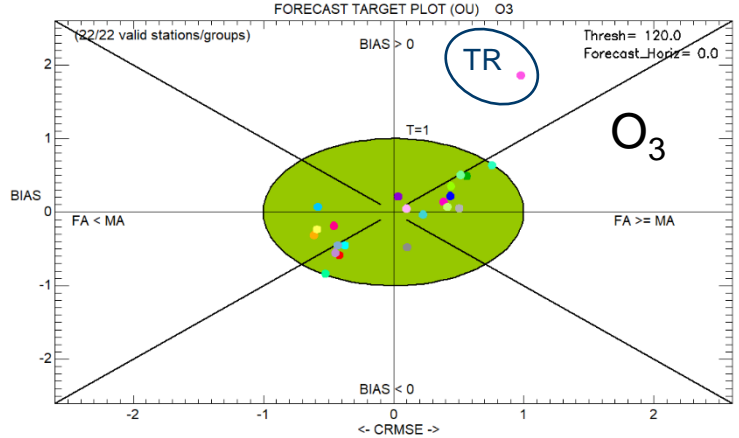
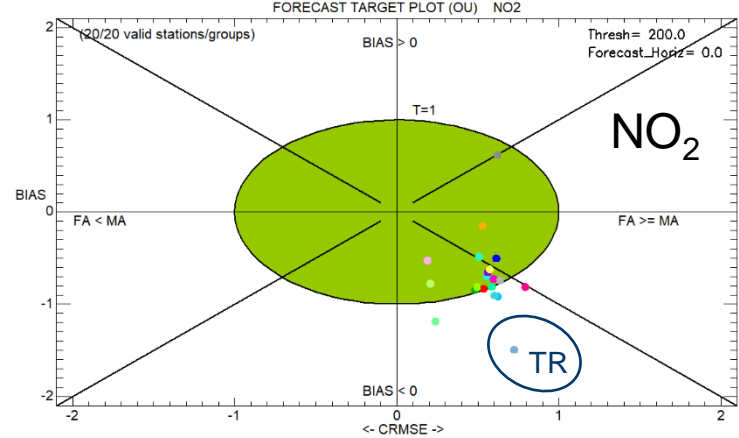


# 1. Comparison with the Persistence Model

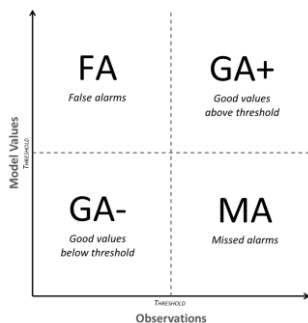
HERE STATIONS ARE GROUPED BY GEOGRAPHICAL AREA

- ✓ For both NO<sub>2</sub> and PM10 issues are spread in several geographical area (i.e. Nations)
- ✓ Turkey (TR) turns out to be the most critical context
- ✓ Performances in Turkey deteriorate not only for NO<sub>2</sub> and PM10 but for the other pollutants as well → **Are measured values reliable in Turkey?**

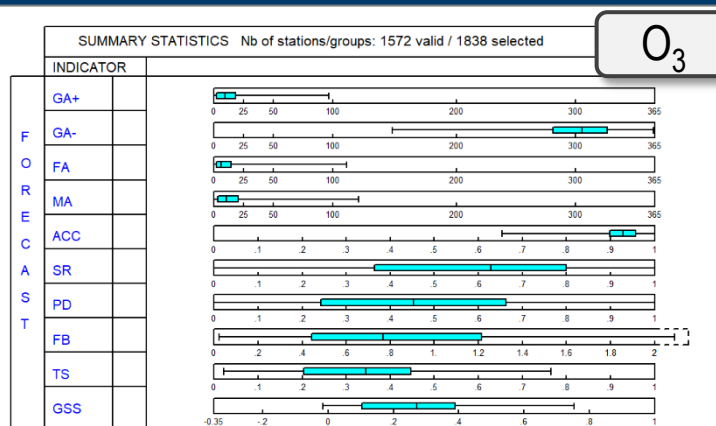
↓  
Evidence of several critical issues emerged from a preliminary investigation of the observed time series in Turkey in particular for PM10



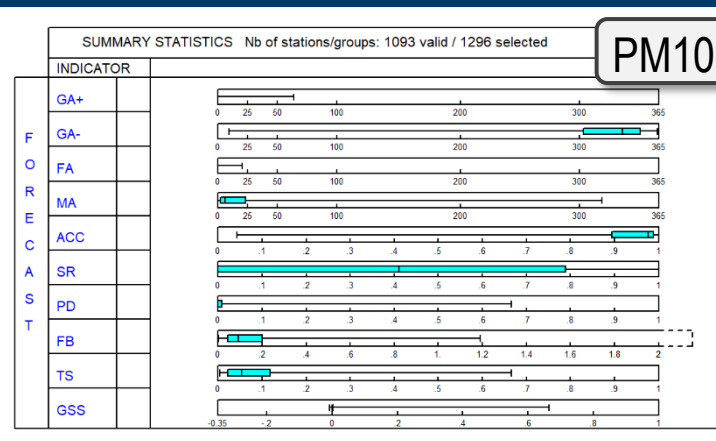
## 2. Capability in predicting Exceedances



INDICATOR	ACRONYM
Accuracy = $(GA_+ + GA_-) / \text{Total}$	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 $H = (GA_+ + MA)(GA_+ + FA) / \text{Total}$	GSS

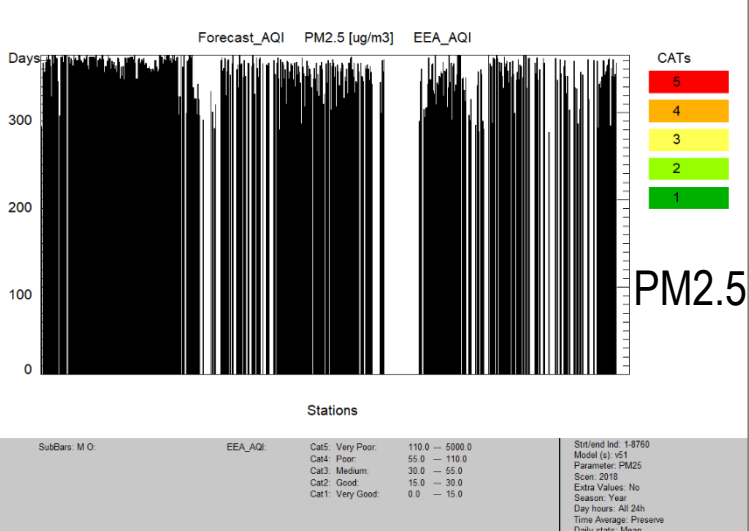
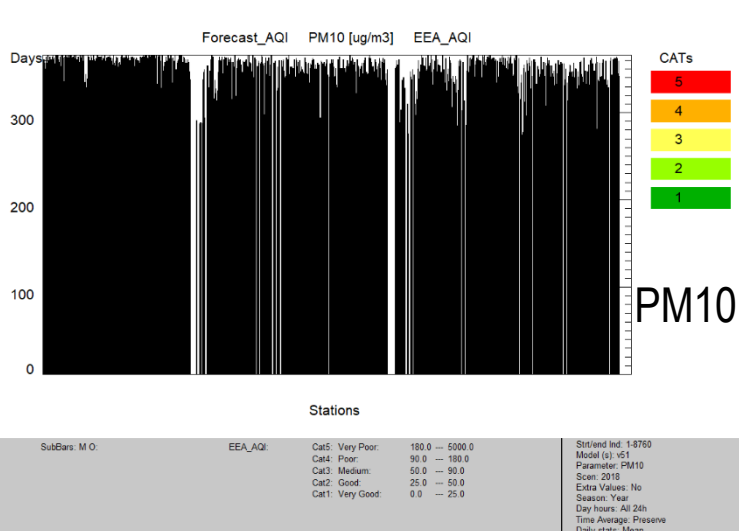
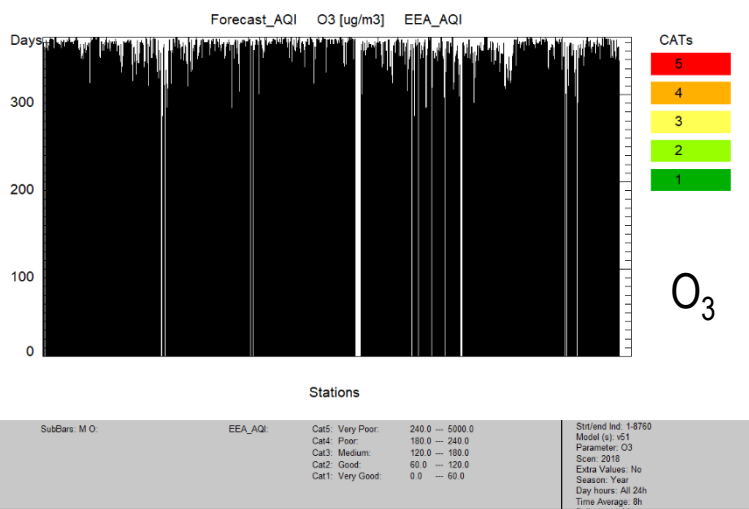
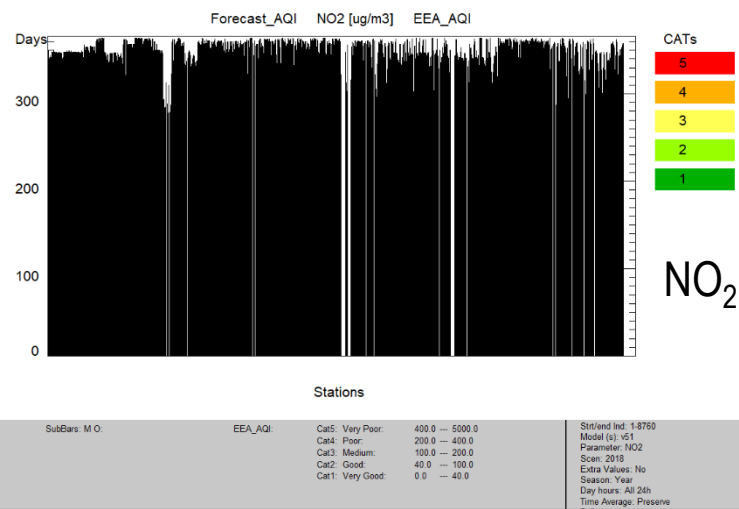


- ✓ A good performance level is reached for the Accuracy
- ✓ Performances in predicting O<sub>3</sub> exceedances are better than PM10 ones
- ✓ SR scores are generally better than POD ones, especially for PM10 (i.e. more Missed than False Alarms are predicted)



# 3. Capability in predicting Air Quality Indices

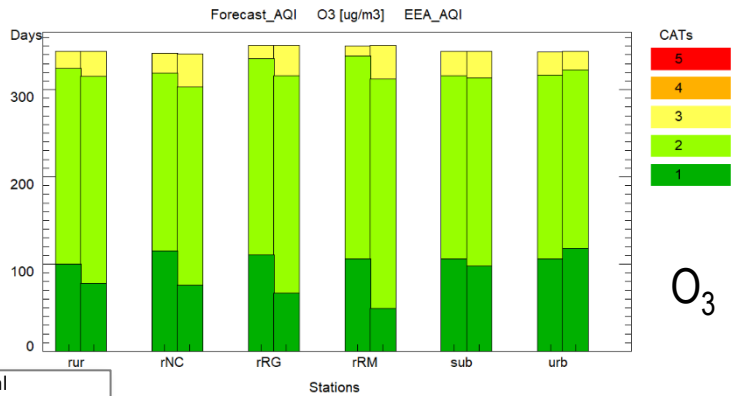
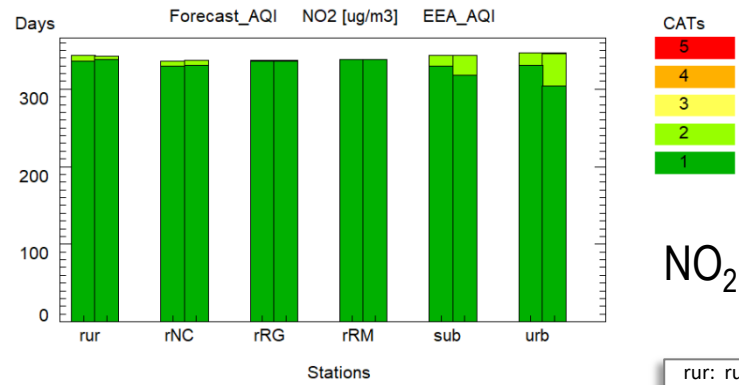
LARGE AMOUNT OF DATA  
MAKES THIS TYPE OF  
CHART IMPOSSIBLE TO  
READ



# 3. Capability in predicting Air Quality Indices

HERE **GROUP MODE** OPTION IS USED (GROUPING STATIONS BY EMISSION ENVIRONMENT)

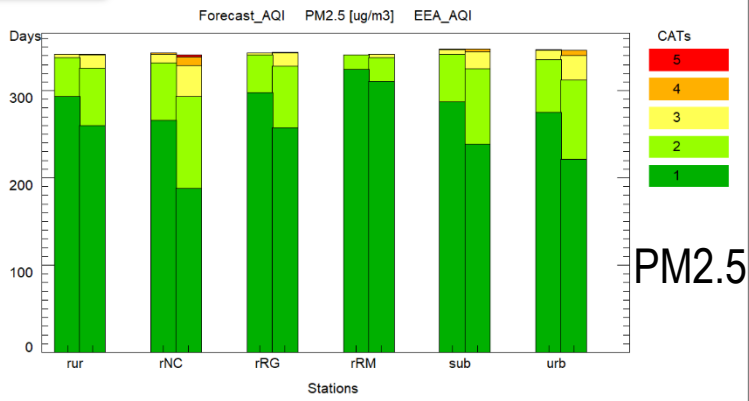
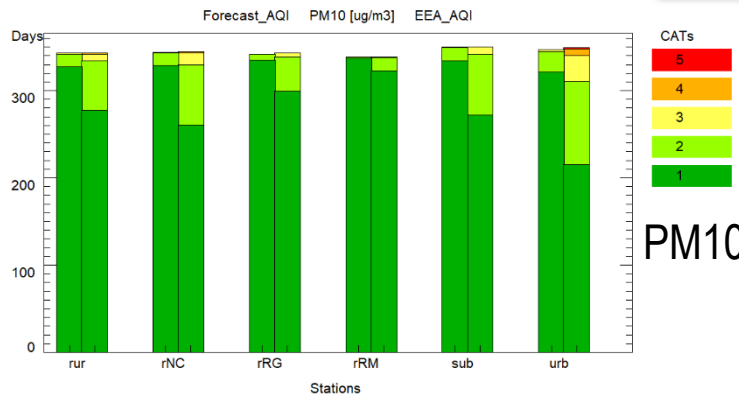
- ✓ Model values populate lower level categories to a greater extent than the measured ones (in particular for PM)
- ✓ NO<sub>2</sub>: both measurements and model predict concentrations values in Cat1 (Very Good AQ) or Cat2 (Good) for almost all the day of the year
- ✓ O<sub>3</sub>: also concentration values in Cat3 (Medium) are predicted by both measurements and model
- ✓ PM: concentration values in Cat4 (Poor) and Cat5 (Very Poor) are predicted by measurements but not by the model



rur: rural  
rNC: rural-nearcity  
rRG: rural-regional  
rRM: rural-remote  
sub: suburban  
urb: urban

SubBars: M.O:	EEA_AQI:	Cat5: Very Poor: 400.0 — 5000.0	StrI/end Ind: 1-87
		Cat4: Poor: 200.0 — 400.0	Station: -1
		Cat3: Medium: 100.0 — 200.0	Model (s): v51
		Cat2: Good: 40.0 — 100.0	Parameter: NO2
		Cat1: Very Good: 0.0 — 40.0	Scen: 2018
			Extra Values: No
			Season: Year
			Day hours: All 24

EEA_AQI:	Cat5: Very Poor: 240.0 — 5000.0	StrI/end Ind: 1-8760
	Cat4: Poor: 180.0 — 240.0	Station: -1
	Cat3: Medium: 120.0 — 180.0	Model (s): v51
	Cat2: Good: 60.0 — 120.0	Parameter: O3
	Cat1: Very Good: 0.0 — 60.0	Scen: 2018
		Extra Values: No
		Season: Year
		Day hours: All 24



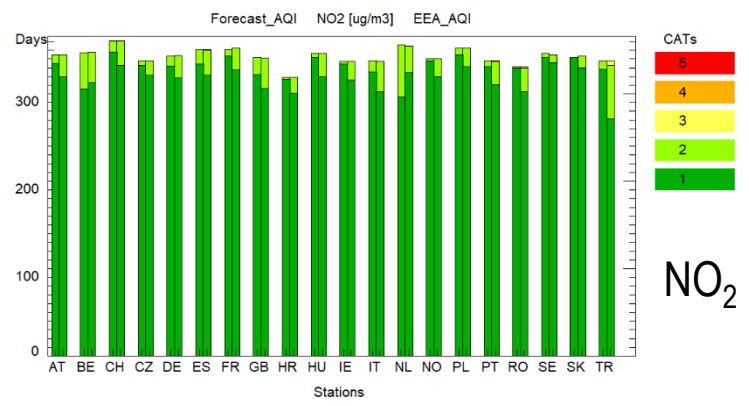
SubBars: M.O:	EEA_AQI:	Cat5: Very Poor: 180.0 — 5000.0	StrI/end Ind: 1-8760
		Cat4: Poor: 90.0 — 180.0	Station: -1
		Cat3: Medium: 50.0 — 90.0	Model (s): v51
		Cat2: Good: 25.0 — 50.0	Parameter: PM10
		Cat1: Very Good: 0.0 — 25.0	Scen: 2018
			Extra Values: No
			Season: Year
			Day hours: All 24
			Time Average: Presence

SubBars: M.O:	EEA_AQI:	Cat5: Very Poor: 110.0 — 5000.0	StrI/end Ind: 1-8760
		Cat4: Poor: 55.0 — 110.0	Station: -1
		Cat3: Medium: 30.0 — 55.0	Model (s): v51
		Cat2: Good: 15.0 — 30.0	Parameter: PM25
		Cat1: Very Good: 0.0 — 15.0	Scen: 2018
			Extra Values: No
			Season: Year
			Day hours: All 24
			Time Average: Presence

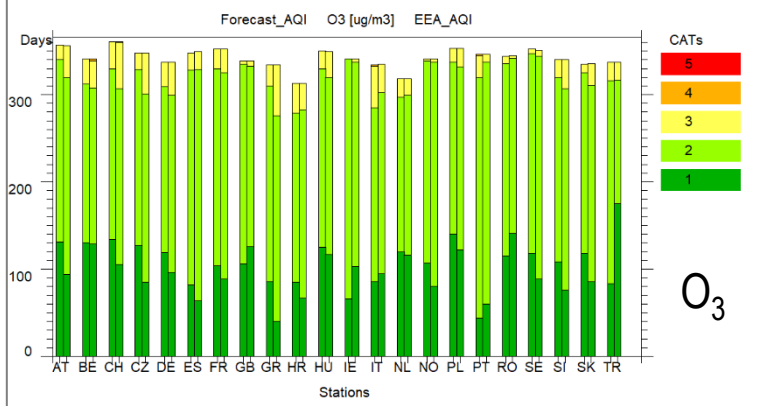
# 3. Capability in predicting Air Quality Indices

HERE **GROUP MODE** OPTION IS USED (GROUPING STATIONS BY GEOGRAPHICAL AREA.)

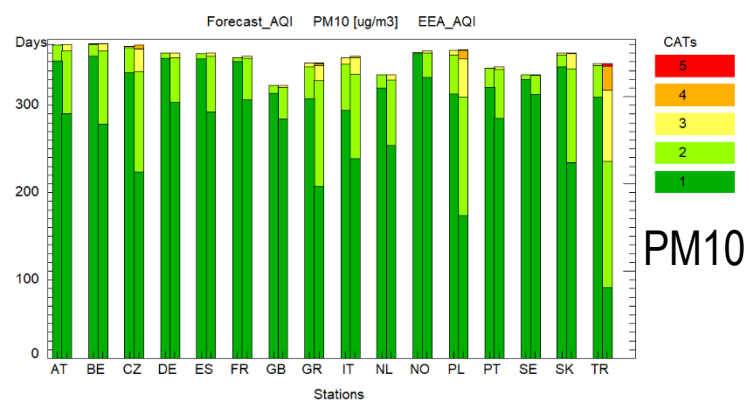
- ✓ In the context of a general underestimation, some cases of overestimation are present: e.g. in Belgium (BE) and Netherlands (NL) for NO<sub>2</sub> and in Italy (IT), Turkey (TR) and Portugal (PT) for O<sub>3</sub>
- ✓ The worst underestimation is observed for PM10 in Turkey (TR)



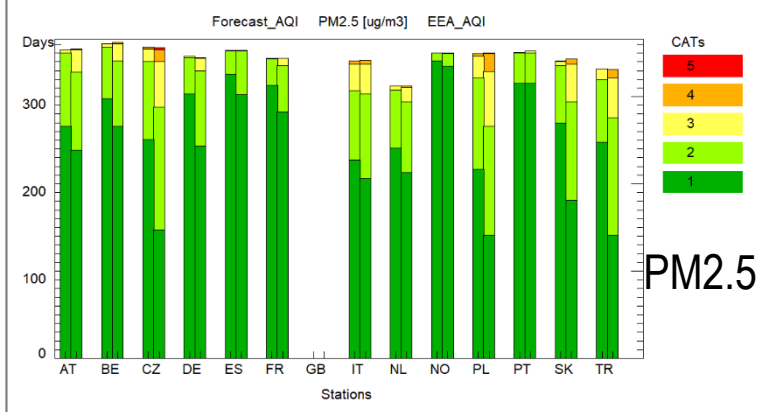
SubBars: M.O.	EEA_AQI:	Cat5: Very Poor: 400.0 — 5000.0 Cat4: Poor: 200.0 — 400.0 Cat3: Medium: 100.0 — 200.0 Cat2: Good: 40.0 — 100.0 Cat1: Very Good: 0.0 — 40.0	Str/Ind: Ind: 1-8760 Station: -1 Model (s): v51 Parameter: NO2 Scn: 2018 Extra Values: No Season: Year Day hours: All 24h
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SubBars: M.O.	EEA_AQI:	Cat5: Very Poor: 240.0 — 5000.0 Cat4: Poor: 180.0 — 240.0 Cat3: Medium: 120.0 — 180.0 Cat2: Good: 60.0 — 120.0 Cat1: Very Good: 0.0 — 60.0	Str/Ind: Ind: 1-8760 Station: -1 Model (s): v51 Parameter: O3 Scn: 2018 Extra Values: No Season: Year Day hours: All 24h
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SubBars: M.O.	EEA_AQI:	Cat5: Very Poor: 180.0 — 5000.0 Cat4: Poor: 90.0 — 180.0 Cat3: Medium: 60.0 — 90.0 Cat2: Good: 25.0 — 50.0 Cat1: Very Good: 0.0 — 25.0	Str/Ind: Ind: 1-8760 Station: -1 Model (s): v51 Parameter: PM10 Scn: 2018 Extra Values: No Season: Year Day hours: All 24h Time Average: Presence
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SubBars: M.O.	EEA_AQI:	Cat5: Very Poor: 110.0 — 5000.0 Cat4: Poor: 55.0 — 110.0 Cat3: Medium: 30.0 — 55.0 Cat2: Good: 15.0 — 30.0 Cat1: Very Good: 0.0 — 15.0	Str/Ind: Ind: 1-8760 Station: -1 Model (s): v51 Parameter: PM25 Scn: 2018 Extra Values: No Season: Year Day hours: All 24h Time Average: Presence
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# CONCLUSIONS

- A MINNI simulation on European scale was evaluated according to the new Forecast Indicators proposed by FAIRMODE
- The outcomes of the validation highlight
  - a good level of quality of this model application concerning O<sub>3</sub> and PM2.5
  - some room for improvement concerning NO<sub>2</sub> and PM10 in particular in urban areas
  - the need for further investigation concerning the quality of measurement data in Turkey
- This exercise points out the usefulness of the validation approach in highlighting shortcomings and strengths of a forecasting application
- Group Mode option turns out to be very useful in supporting the interpretation of the outcomes in particular when high numbers of validation points are taken into account

# Thank you

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1101 0110 1100  
0101 0010 1101  
0001 0110 1110  
1101 0010 1101  
1111 1010 0000

