EVALUATING THE PERFORMANCE OF WRF-CMAQ MODELS IN BULGARIA BY MEANS OF THE DELTA TOOL

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Our motivation

1. AQ status – persistent problems in Bulgaria, related to PM10 and PM2.5

2. Lack of model evaluation on yearly basis for simulations over the whole country

3. Harmonization of model performance evaluation with EU initiatives related to the EU AQD

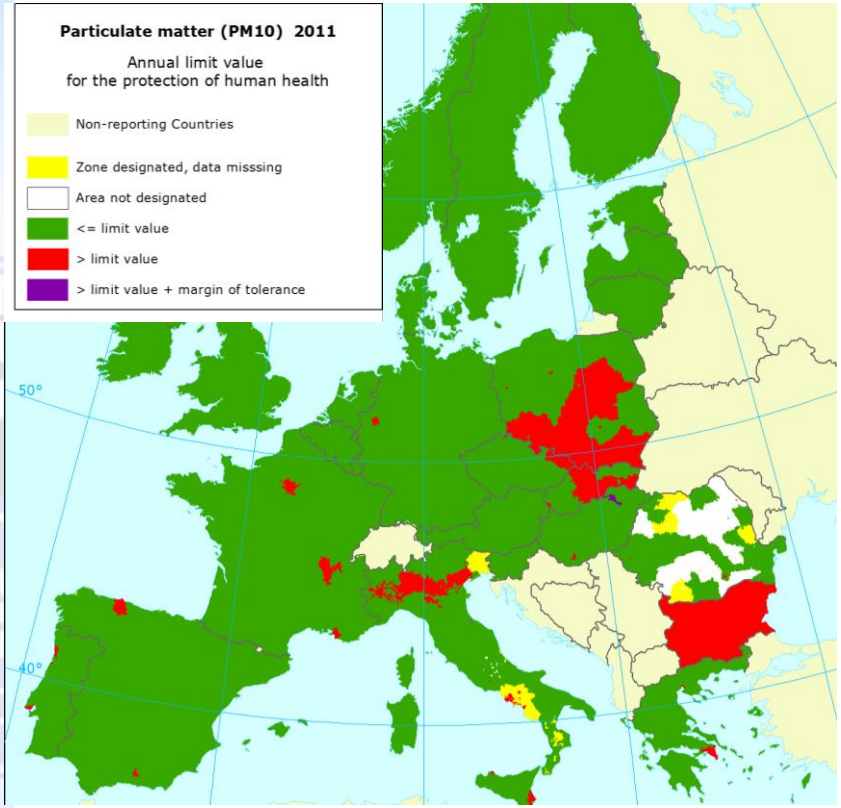
   FAIRMODE → use of DELTA Tool

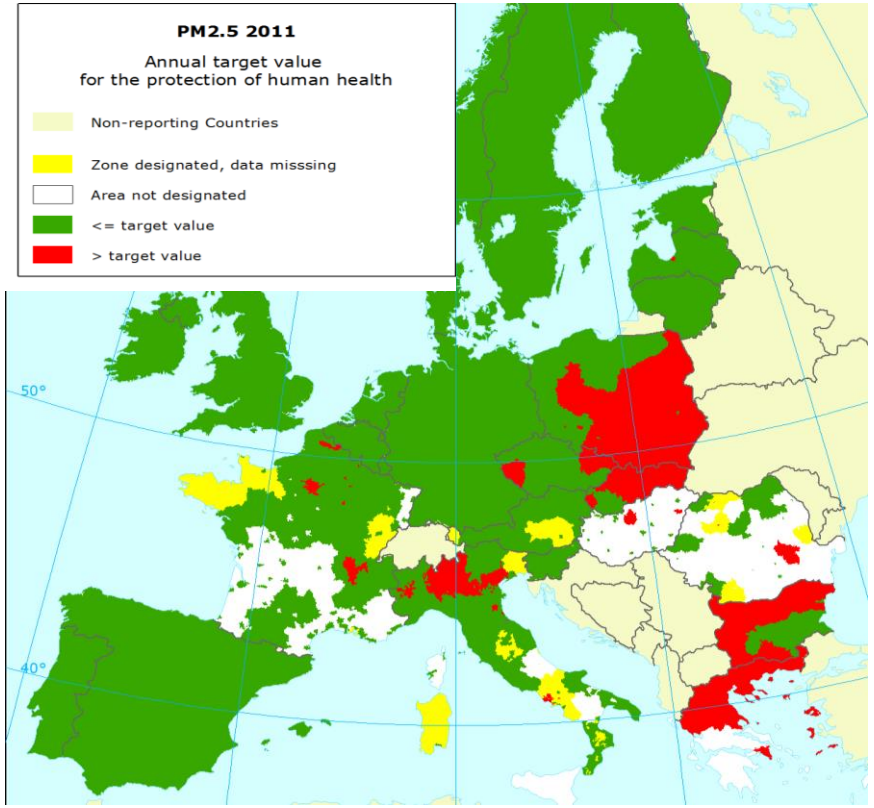
   fairmode.jrc.ec.europa.eu

AQ status – 2011
PM10 & PM2.5 annual limit values in 2011

PM10 > 40 µg/m^3

PM2.5 > 25 µg/m^3





Source: www.eea.europa.eu/data-and-maps/figures/

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Main purpose of this study

- A first check of WRF-CMAQ performance

  For one year - 2013

  Focus on daily PM10, daily max 8h-mean O3 and hourly NO2

- Highlight model weakness and strengths, outline more detailed evaluation milestones

- Define next steps for model application and improvement

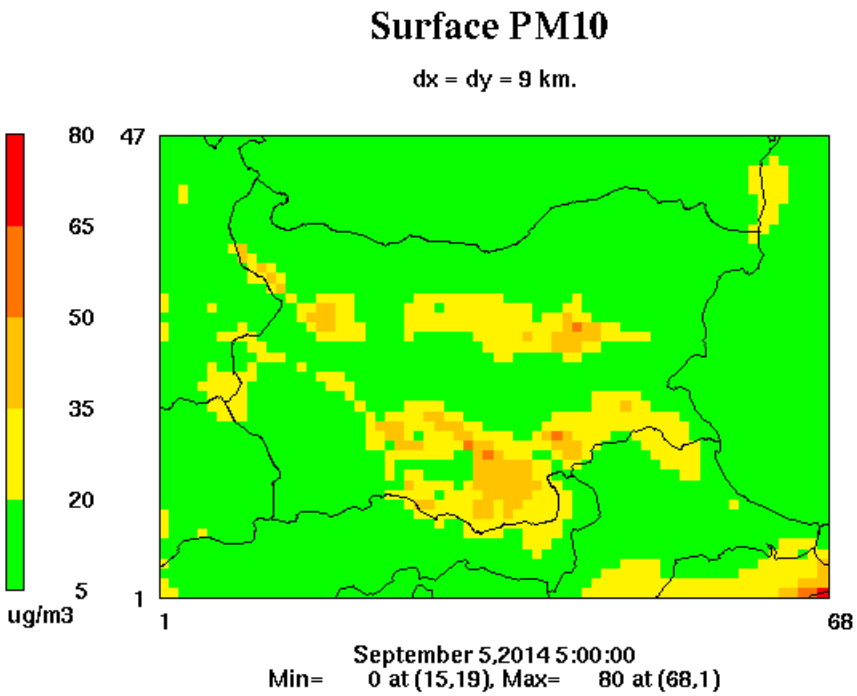
WRF – CMAQ model system at NIMH

- BG Chem. Weather Forecast system

5 domains - 81km 27km, 9km, [3km, 1km over Sofia]

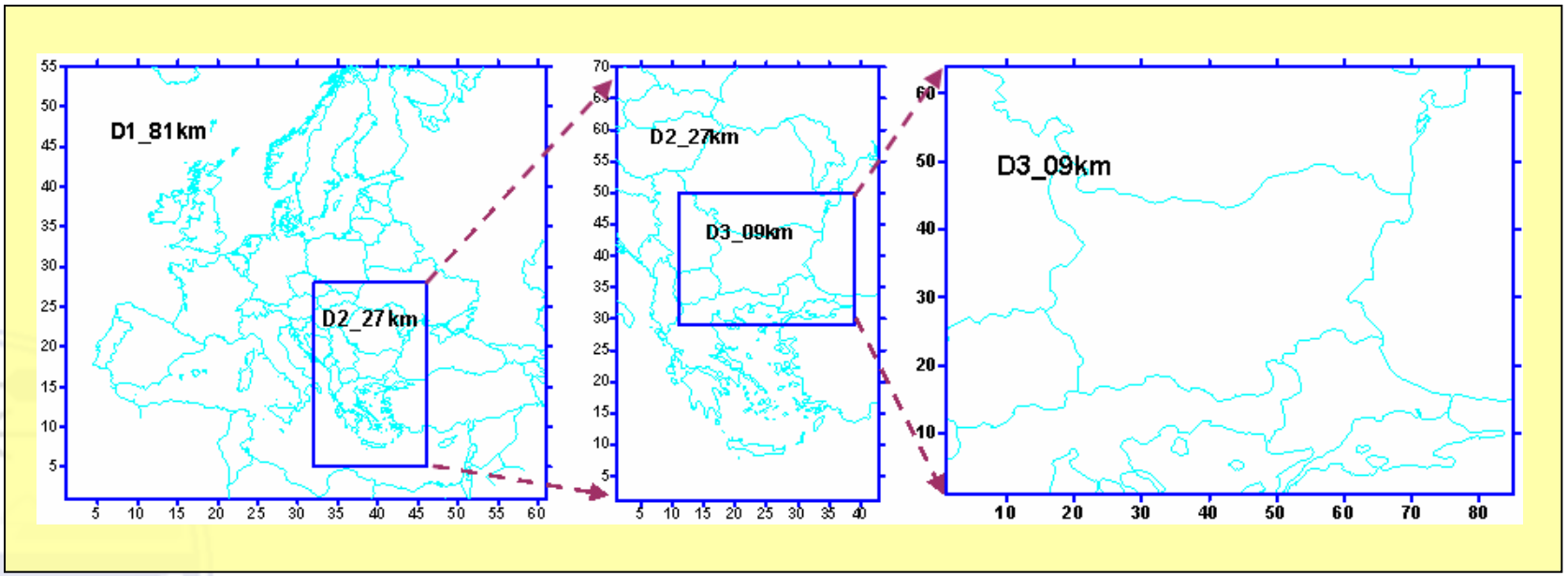
Operational runs for +72h forecast

Surface maps: SO2, NO2, O3, PM10



http://info.meteo.bg/cw2.2

WRF – CMAQ domains



Nesting: D1: 81 km to D3 (BG): 9km

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WRF v.3.2.1

- Driven by NCEP/GFS free data
- Analysis nudging only on D1
- 27 vertical levels

Microphysics :	WSM6 scheme (Hong and Lim, 2006)
Cumulus Parameterization:	Kain-Fritsch scheme (Kain, 2004)
Planetary Boundary Layer:	YSU scheme (Hong et al., 2006)
Longwave Radiation:	RRTM scheme (Mlawer et al., 1997)
Shortwave Radiation :	Dudhia scheme (Dudhia, 1989)
Land Surface Model:	NOAH LSM scheme (Chen and Dudhia, 2001)

CMAQ v.4.6

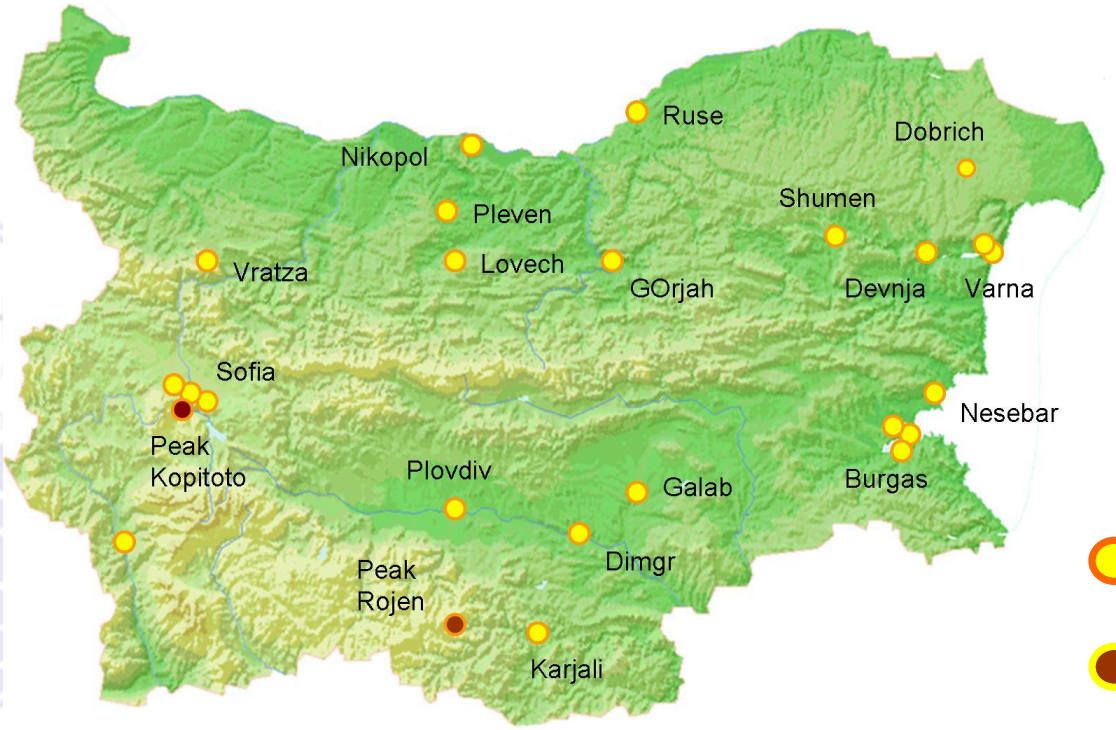
- Boundary conditions – climatic for D1
- CB-4 chemical mechanism
- 14 vertical levels

Emissions

- SMOKE module - partially used: for biogenic emissions and their merging with Area (AS) and LargePoint Source (LPS) emissions in a single input file for CMAQ
- TNO emission inventory 2005 for D1 and D2
- National inventory for D3
- Temporal allocation – based on TNO profiles
- Speciation profiles – based on US-EPA approach adapted for EU

The obs. data set 2013

No. of stations	NO2	O3	PM10
Background (BG)	21	17	23
BG with data >75%	18	16	18



Provided by the BG Executive Environment Agency

Urban, suburb

Rural – mountain 1750 m and 1325m

DELTA TOOL (JRC)

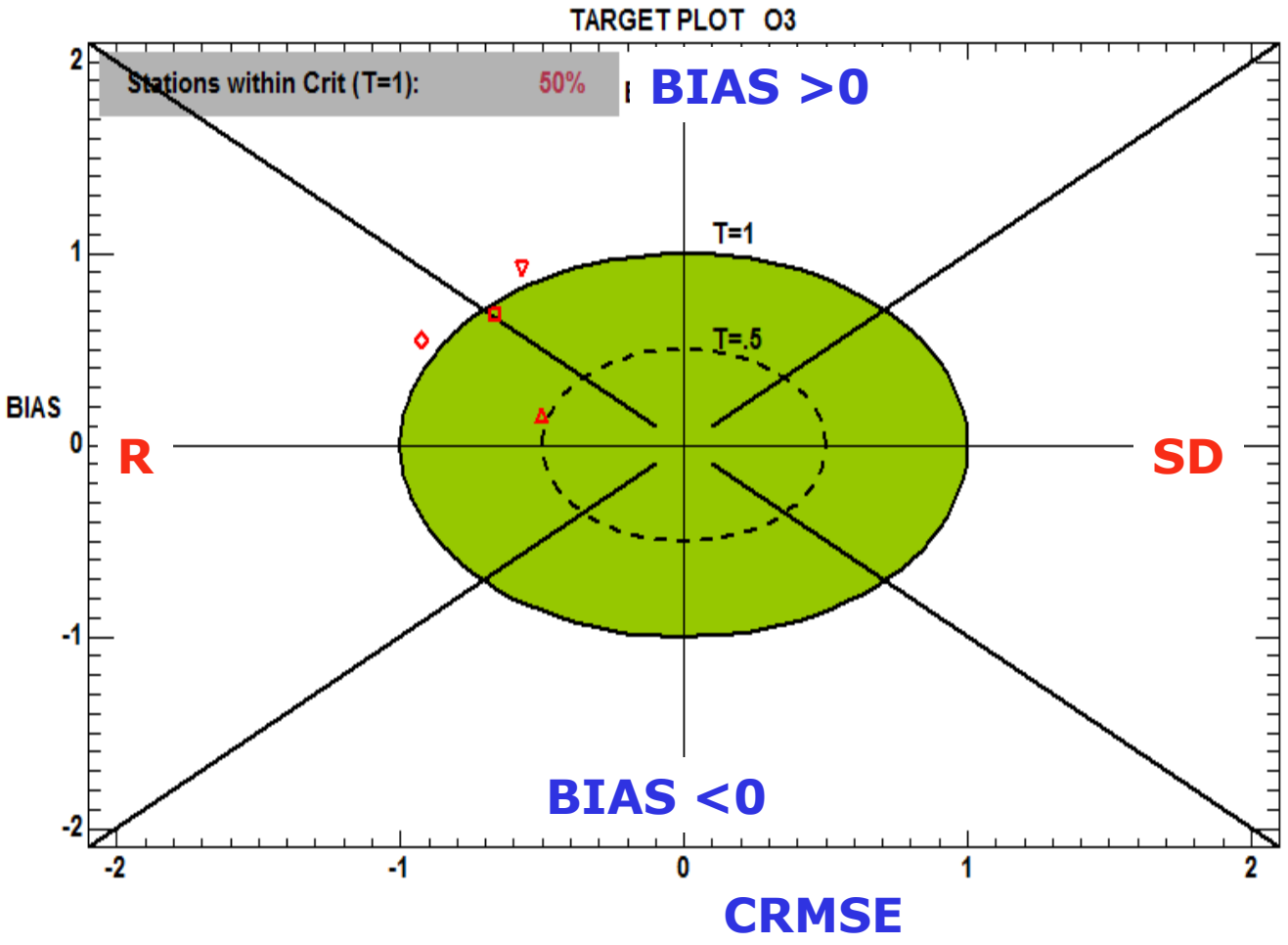
- modelled – observed data pairs at surface level (meteo and pollutants)
- "Exploration" and "Benchmarking" (EU_AQD) mode (O3, PM10, NO2) – 1 calendar year
- Performance criteria (MPC) : level of accuracy considered to be acceptable for regulatory applications
- MPC take into account observation uncertainty

DELTA – check data integrity module

- Look at the data before any analysis , simple statistics
- Some “outliers” identified , mainly in PM2.5
- Aware of obs. data availability

TARGET diagram

- Main quality objective: RMSE/ RMSu = T = 1



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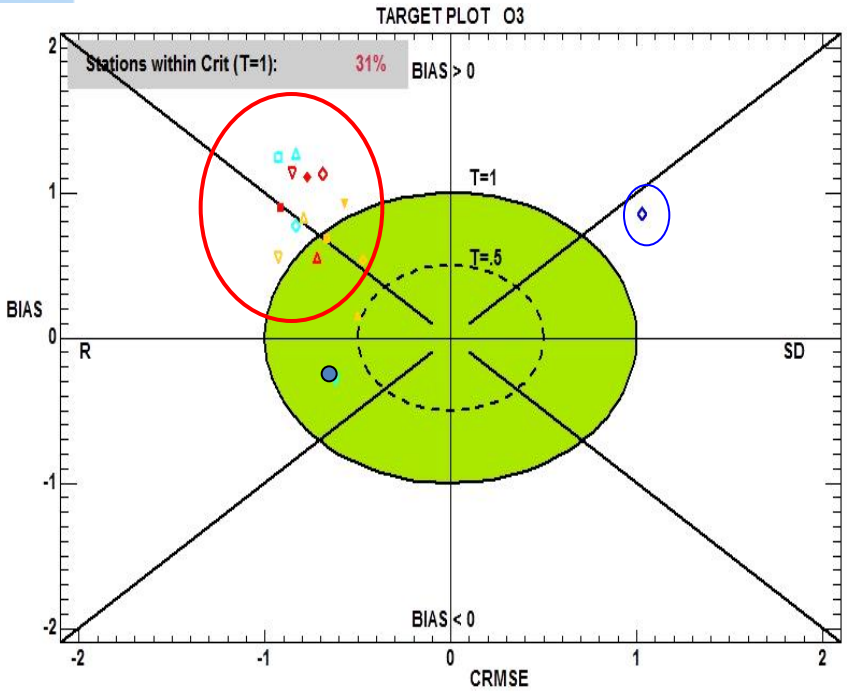
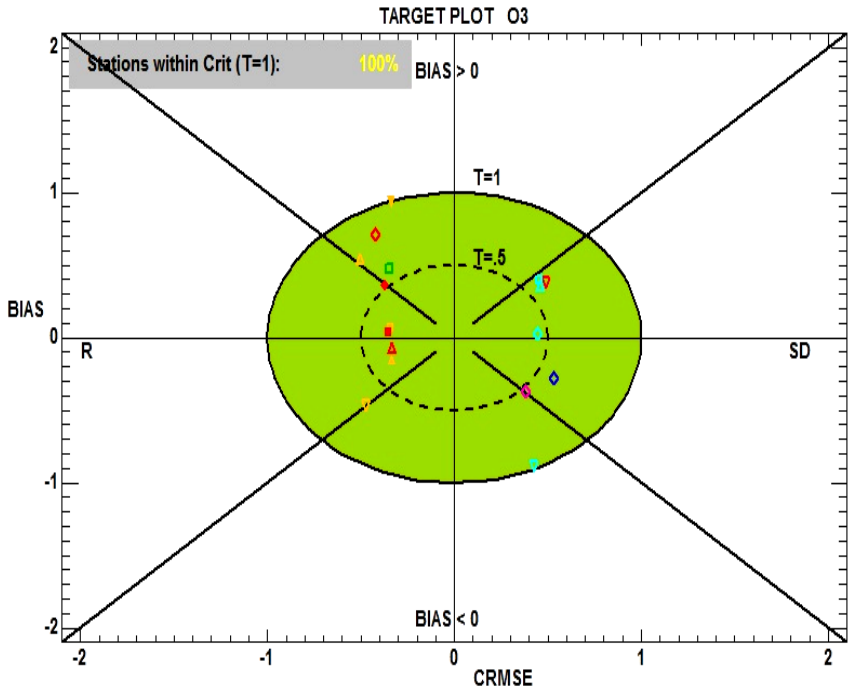
O3 daily max 8h mean -1/3

year



- BIAS>0 : overestimation except for 1 mountain station (Kopitoto)
- error is dominated by lack of R
- 1 station with systematic errors in amplitude (Plovdiv)
- 31% fulfill the target criteria

summer



- both over-/ under-estimation
- 100% fulfill the target criteria

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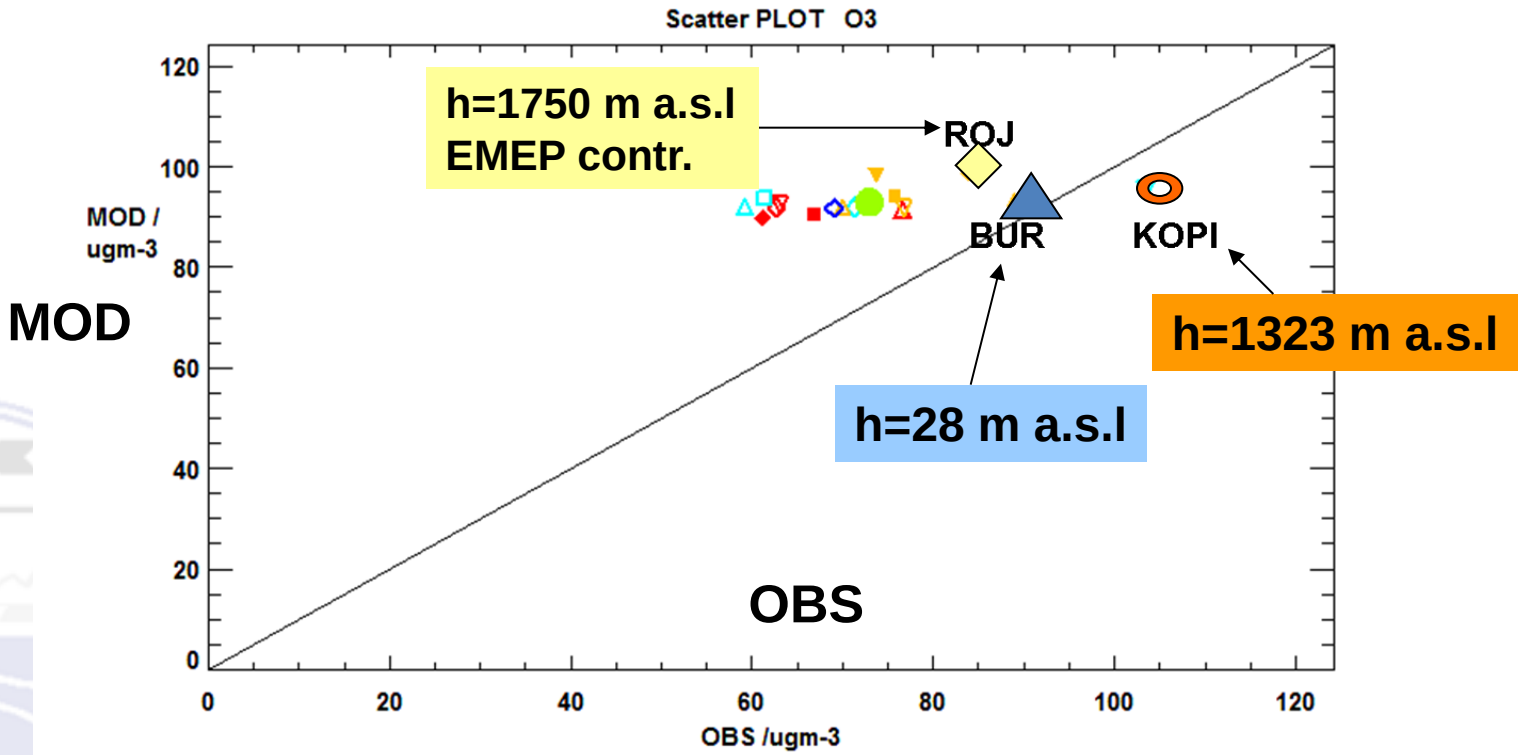
O3 daily max 8h mean -2/3

Scatter plot - year

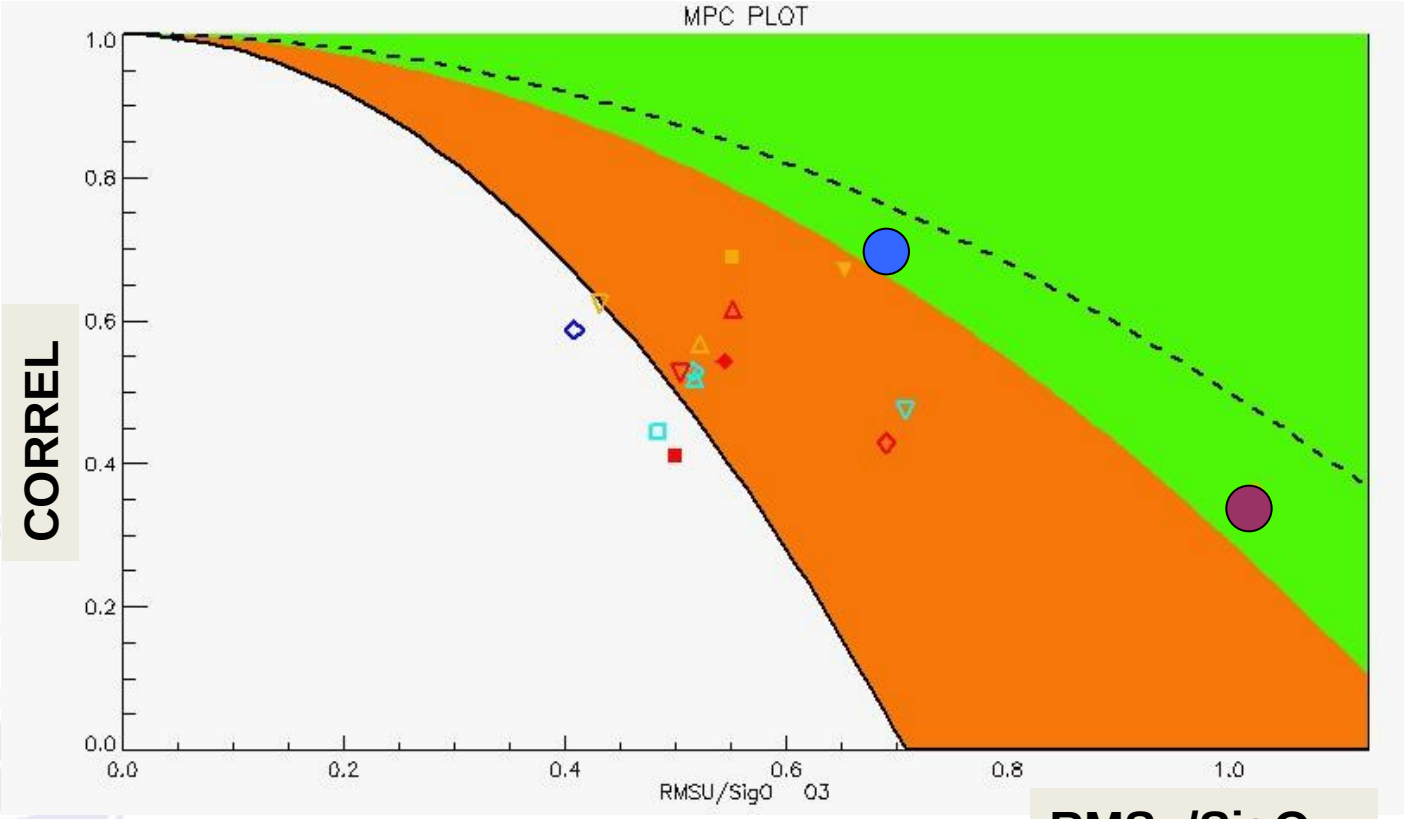


MEAN OBS : 73 µgm-3

MEAN MOD : 93 µgm-3

Highest values: rural/mountains sites + Coastal site (Burgas)

O3 daily max 8h mean -3/3



MEAN Correlation (year) : R = 0.55

Burgas – coast (BG0063): R = 0.72

Rojen EMEP BG0053: R = 0.36

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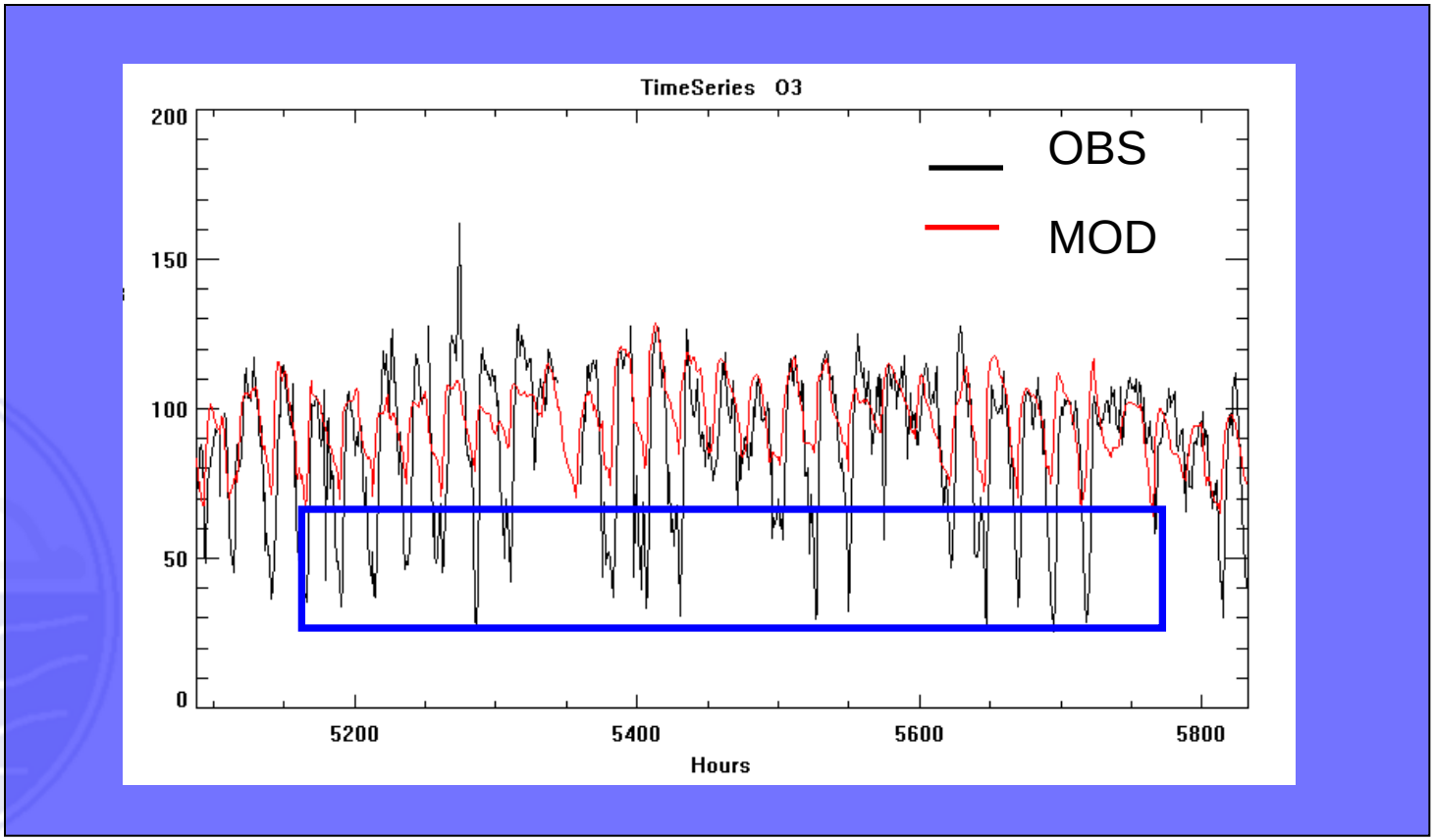
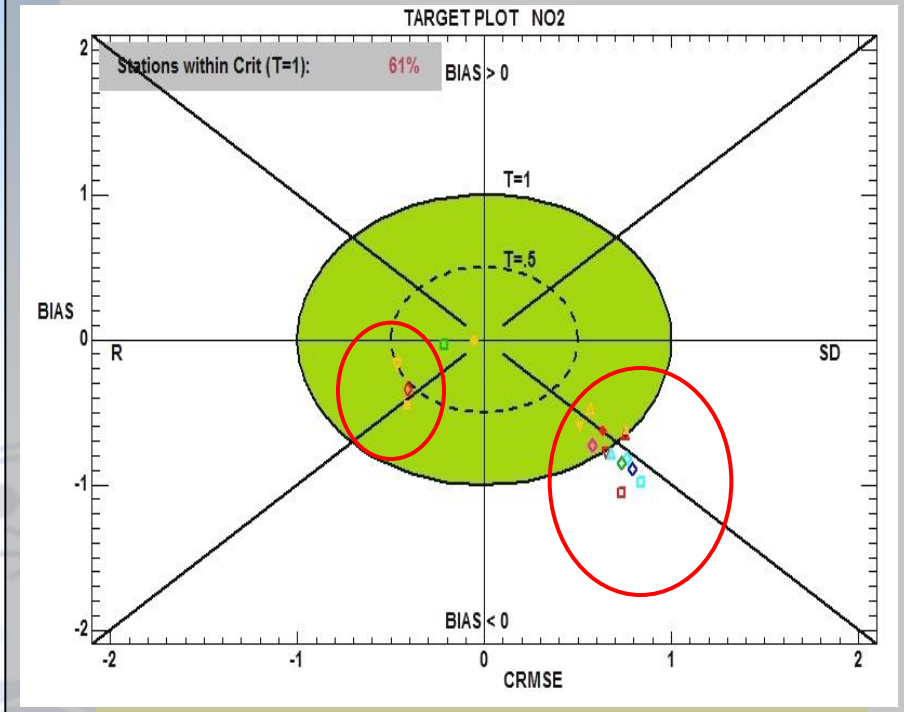
O3 hourly – time series

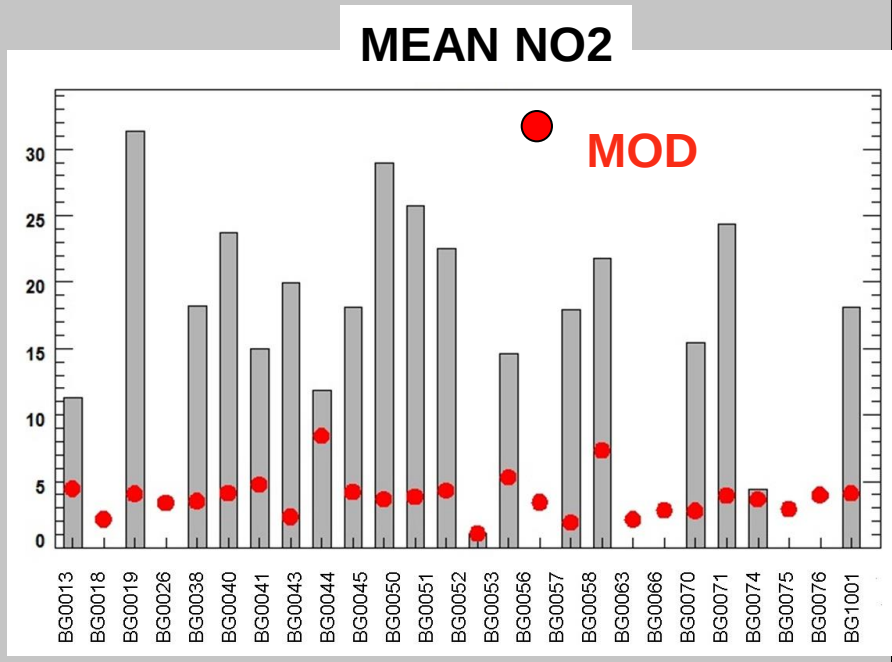
BG0063 (Burgas) August



The model overestimates night-time values

NO2 hourly





- **BIAS<0 : underestimation**
- **error is dominated by lack of amplitude**
- **Best – East and SE st.**
- **Worst – Sofia, PLOV, PLE**

61% fulfill the target criteria

- **Mean OBS. 18 µgm^{-3} (EU LV (year) 40µgm^{-3})**
- **Mean MOD. 4 µgm-3**

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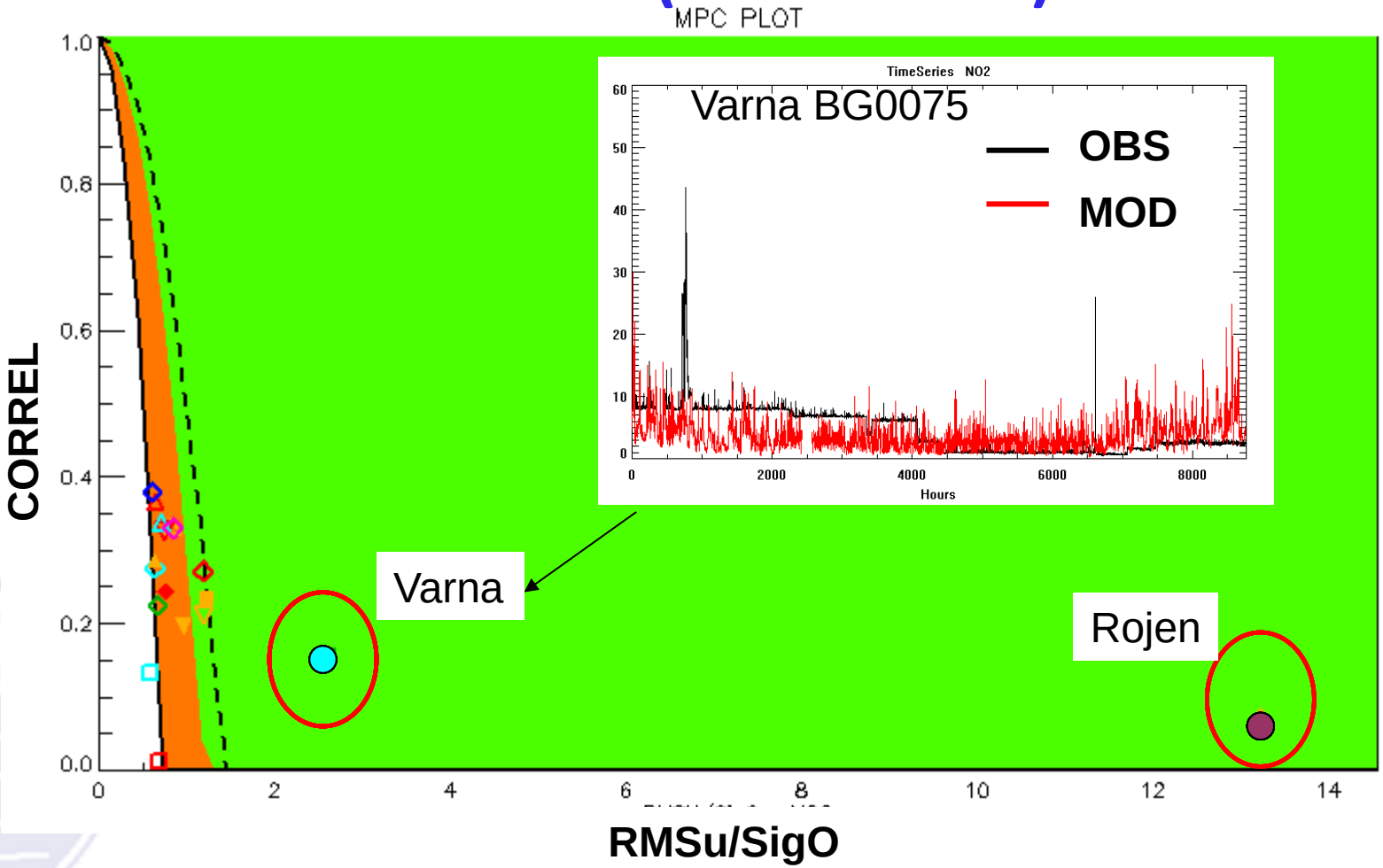
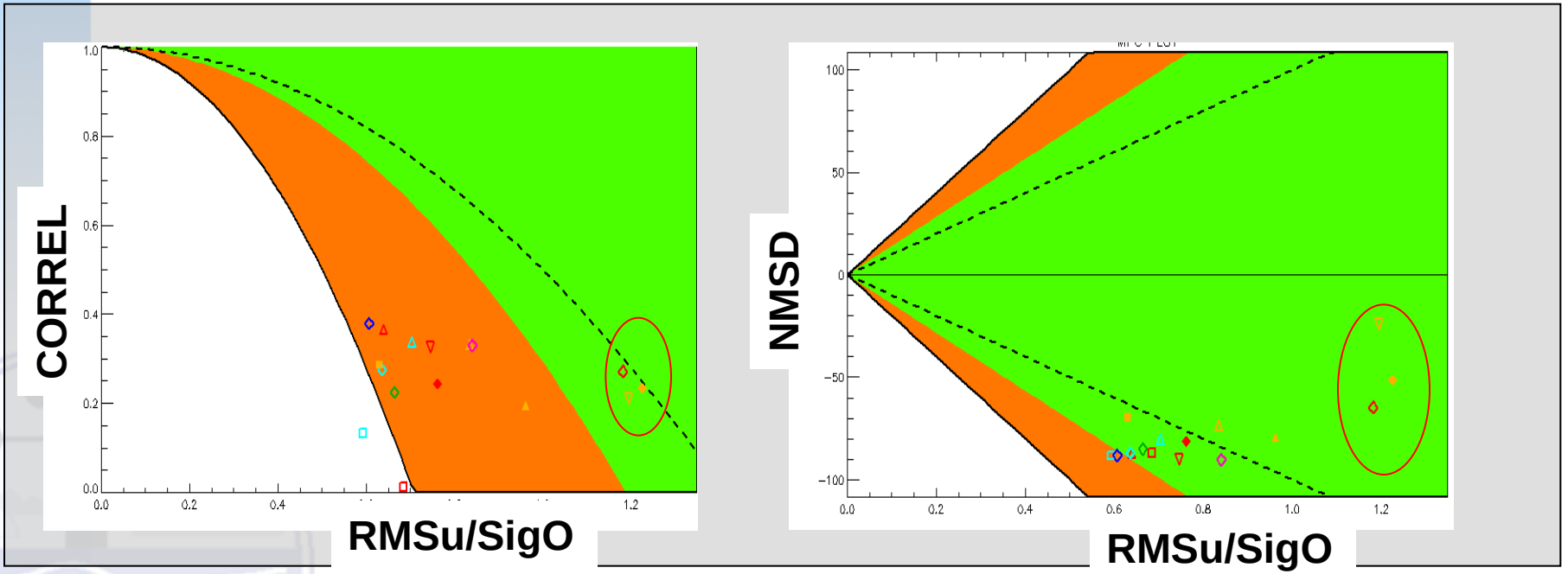
NO2 - MPC (Correlation)



- 2 outliers – “Rojen” (low values)
  - Varna (obs. - to be checked)
- R between 0.02 and 0.38

NO2 MPC (R) & MPC (NMSD)

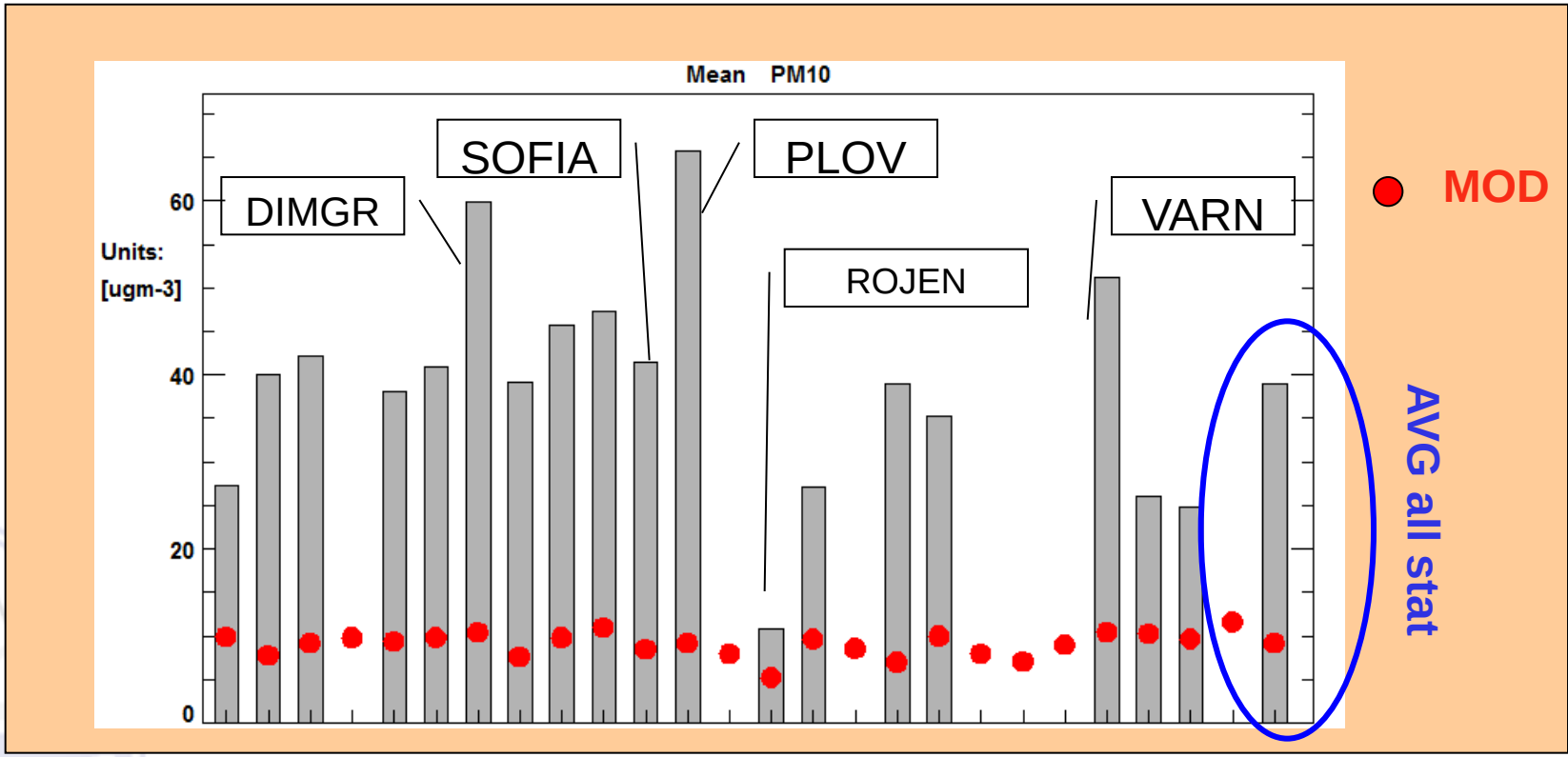


R max 0.38
min Sofia, Pleven

NMSD - 80%

3 stations in the green area: Burgas_DE , Burgas_MR and Devnja: all near large industrial plants

PM10 mean obs. & mod.



- **UNDERESTIMATION - 4 x**
- **MEAN OBS - 39 ugm-3**
- **MEAN MOD - 9 ugm-3**

- **Uniform model values**

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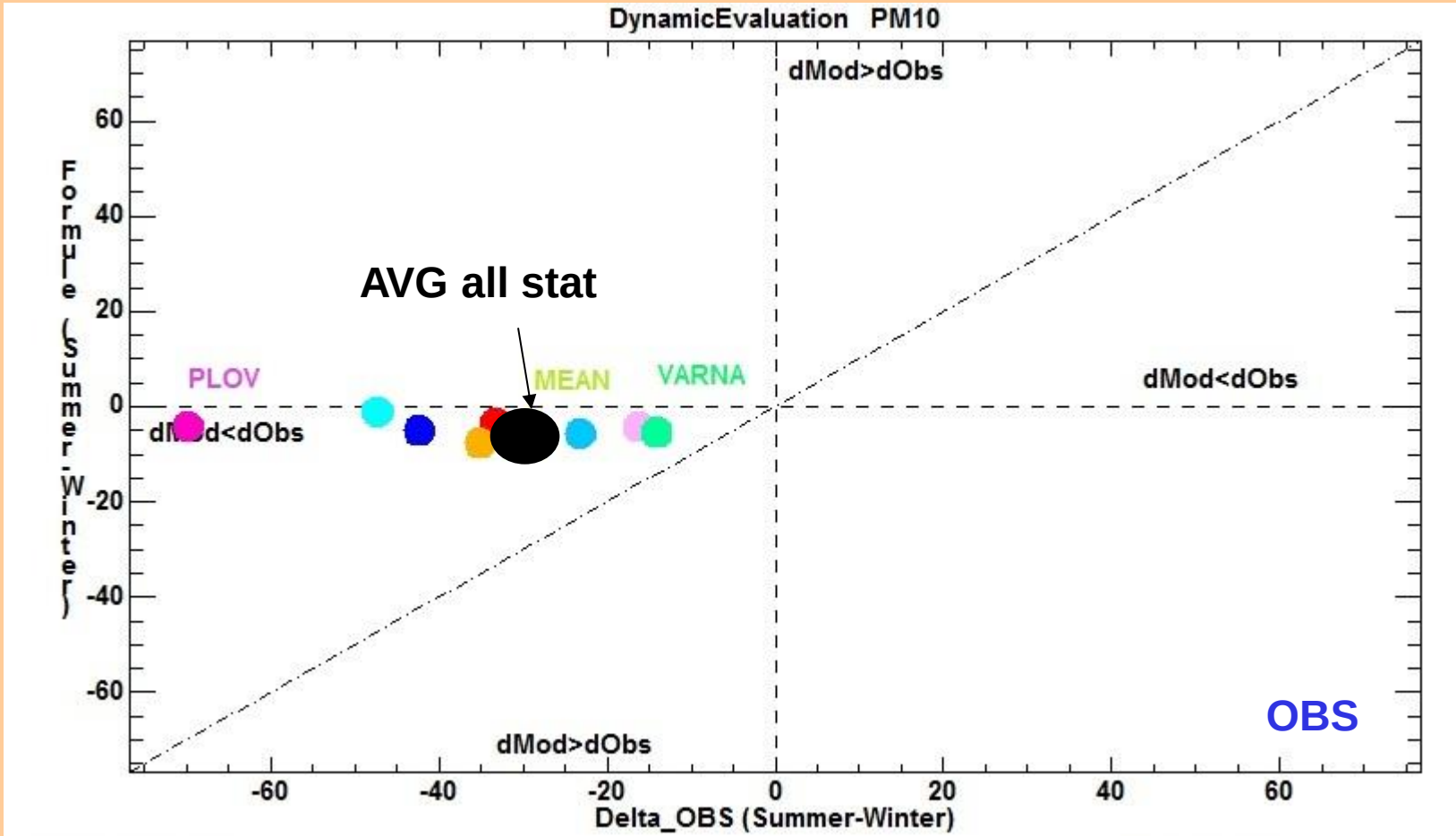
PM10 dynamic D(summer–winter)

MOD



- OBS : d(SUM-WIN): -15 to -70 ugm-3
- MOD: -5 ugm-3

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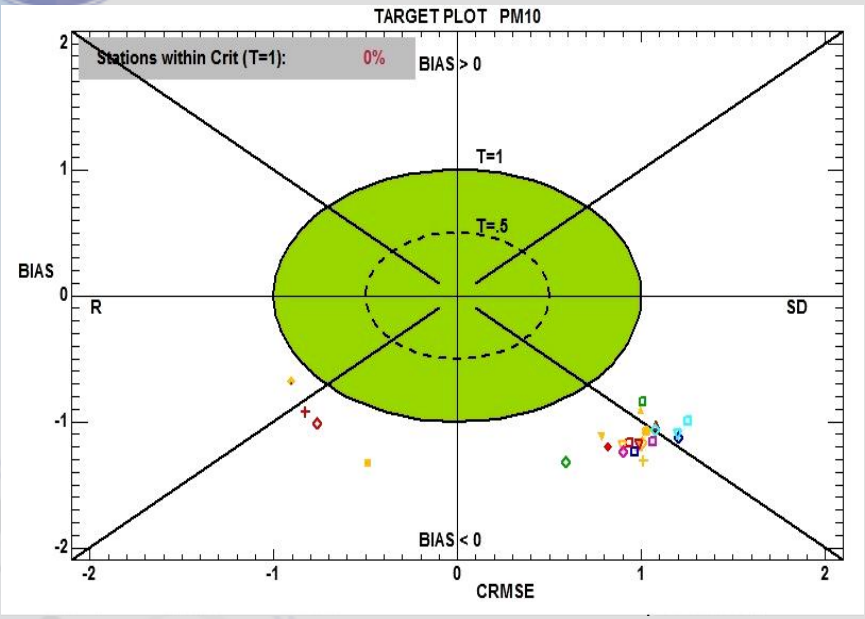
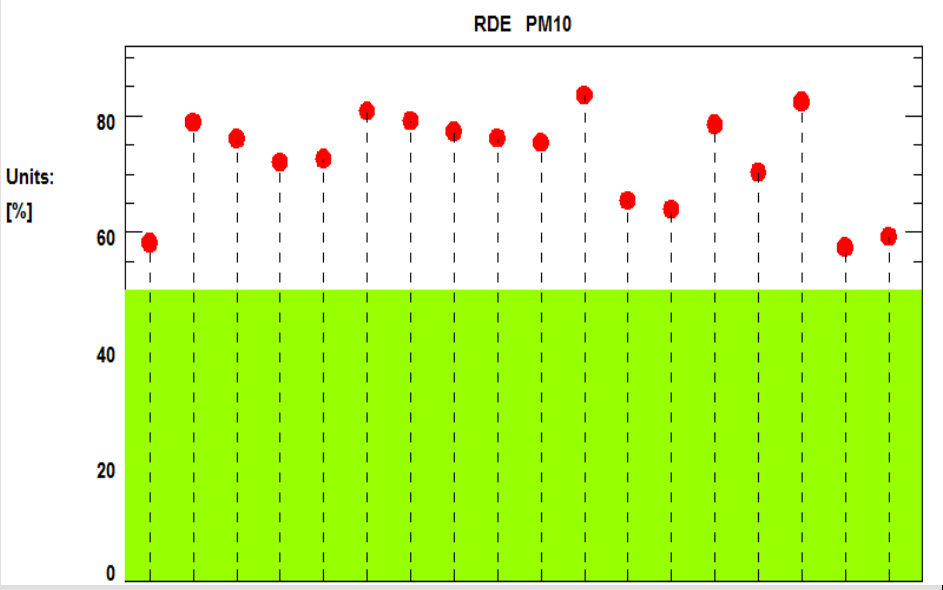
PM10: Target and RDE

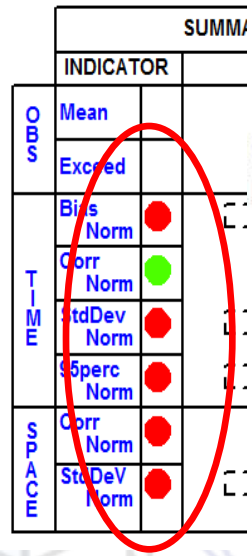


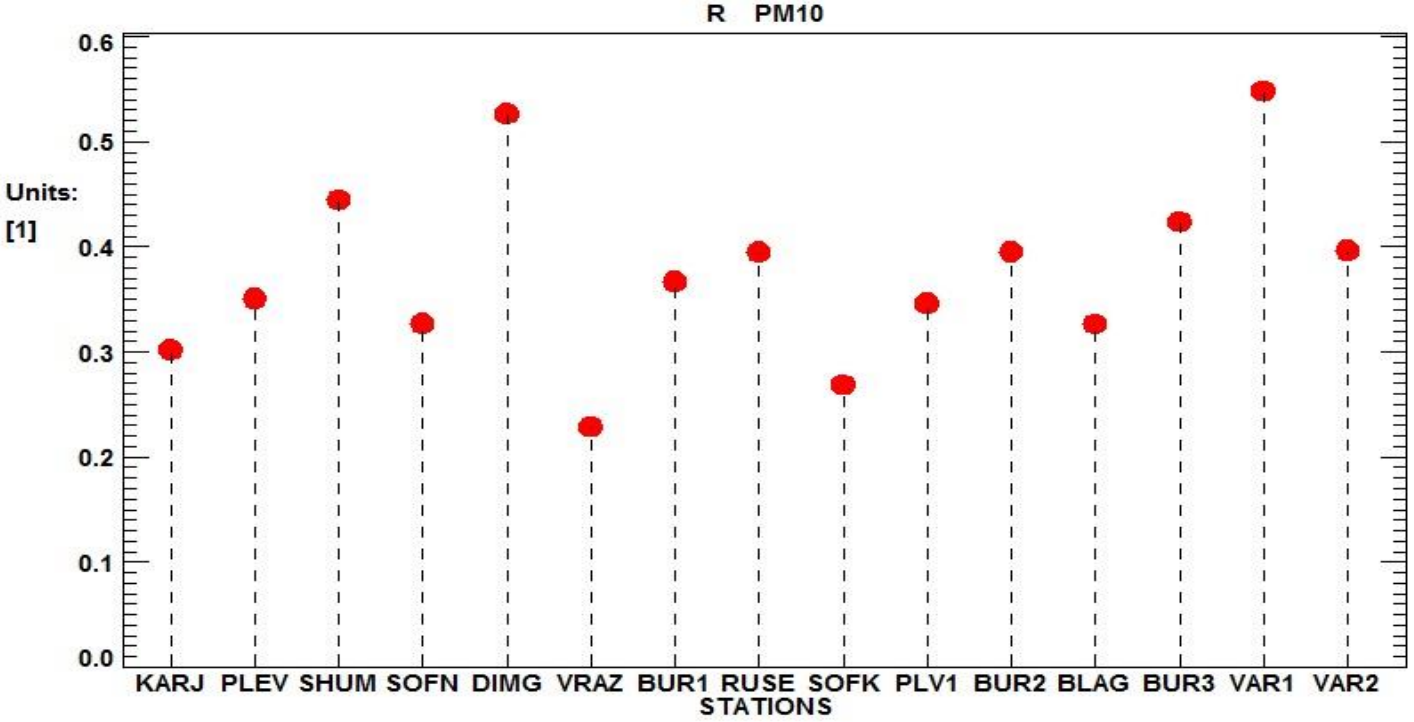


Target criteria – not satisfied

RDE - not satisfied

PM10: Summary statistics, Correlation





Correlation : mean 0.36
(values 0.2 – 0.56)

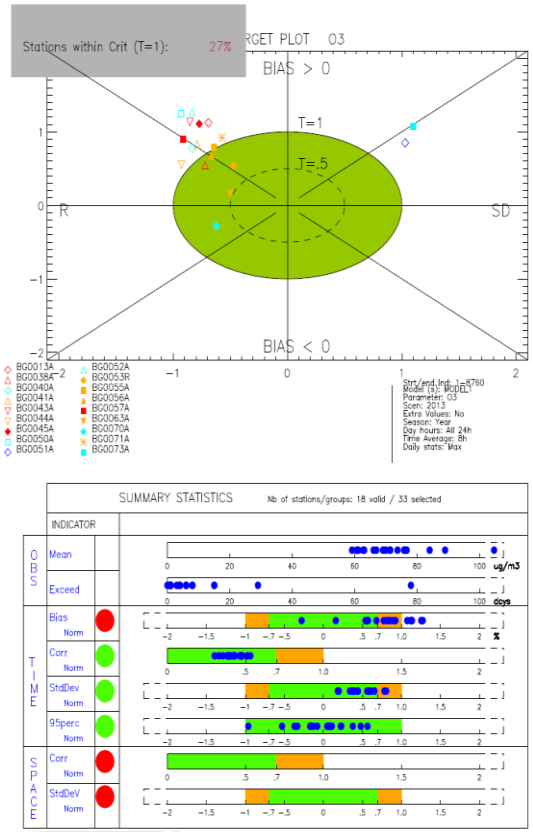
Some statistics vs. MPC ,Thunis et al 2012 (text in blue)

	FA2	R	NMB	RMSE	NMSD	Target %
O3	85%	0.55 0.51 urb	30% 41% urb	30 ugm-3	-48% 100%	31%
NO2	21%	0.24 0.29 urb	-68% 79% urb	20 ugm-3	-69% 117% urb	61%
PM10	14%	0.36 0.33 urb	-74% 65% urb	40 ugm-3	-78% 116%	0%

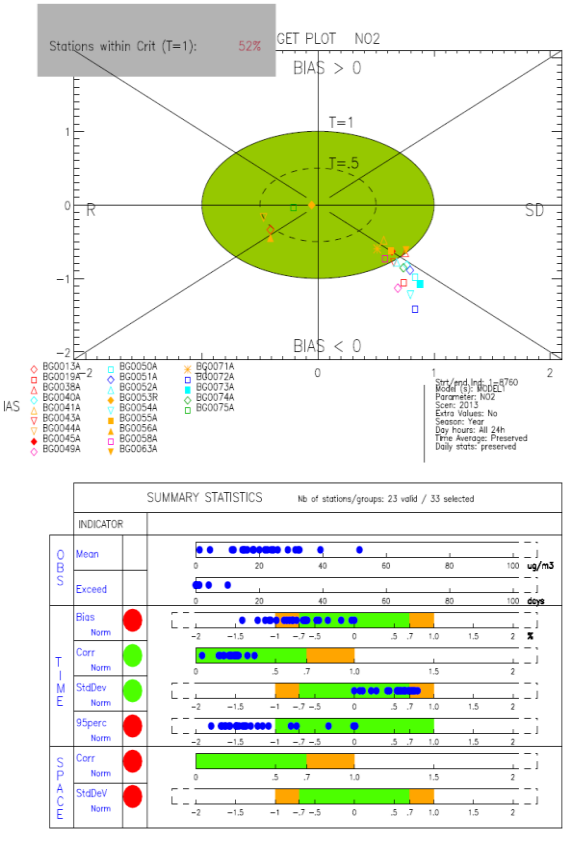
O3 – comparable statistics to MPC
NO2 and especially PM10 – more work is needed for improvement of model performance

Benchmark option

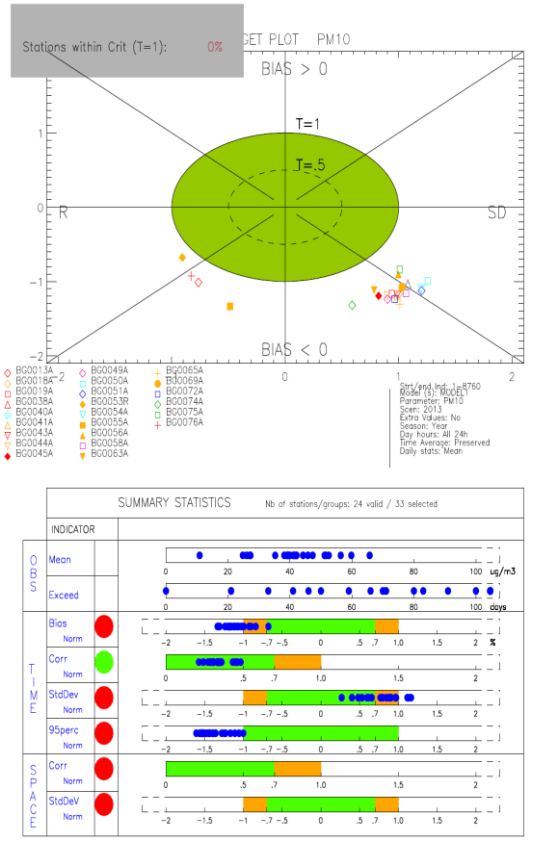
8h Dmax O3



NO2 hourly



PM10 daily



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Conclusions

O3 : better than NO2 and PM10

overestimation (night-time)
errors related to lack of R

NO2 : underestimated, lack in emissions at local level

PM10 : underestimated, correlation comparable to other studies

Problems:

- data availability and stat. representativeness
- NO urban “effects” in the model
- emissions at local level and emission input

DELTA – useful and fast tool for diagnostic of model performance

THANK YOU FOR YOUR KIND ATTENTION !

БЛАГОДАРЯ ЗА ВНИМАНИЕТО !