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COST Action TD1105

3rd International Workshop *EuNetAir* on

New Trends and Challenges for Air Quality Control

University of Latvia - Faculty of Geography and Earth Sciences

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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 → DELTA Tool

fairmode.jrc.ec.europa.eu

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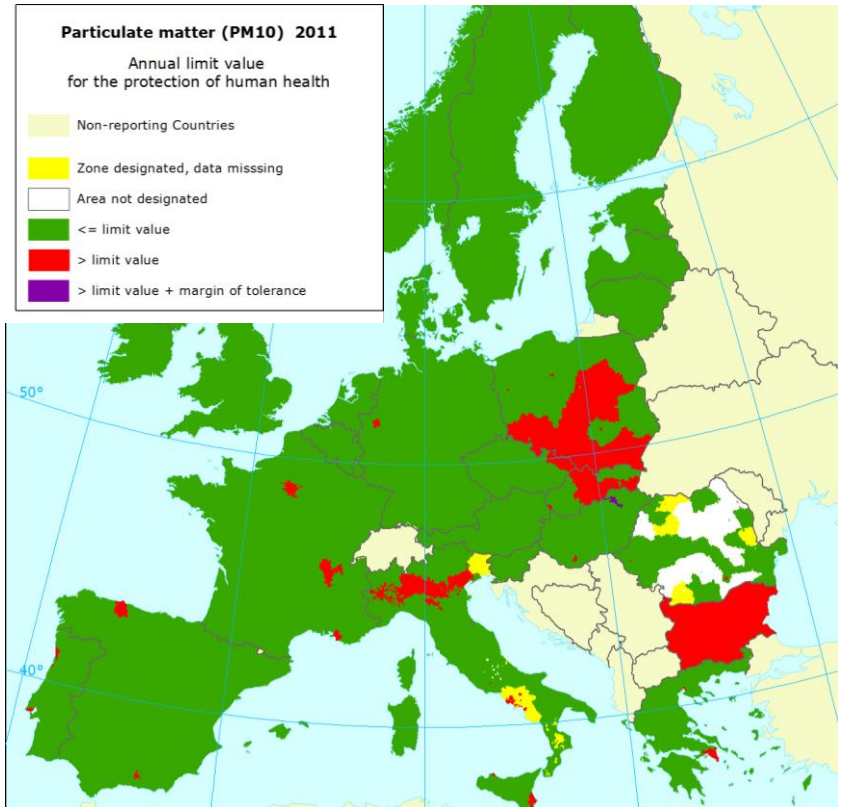
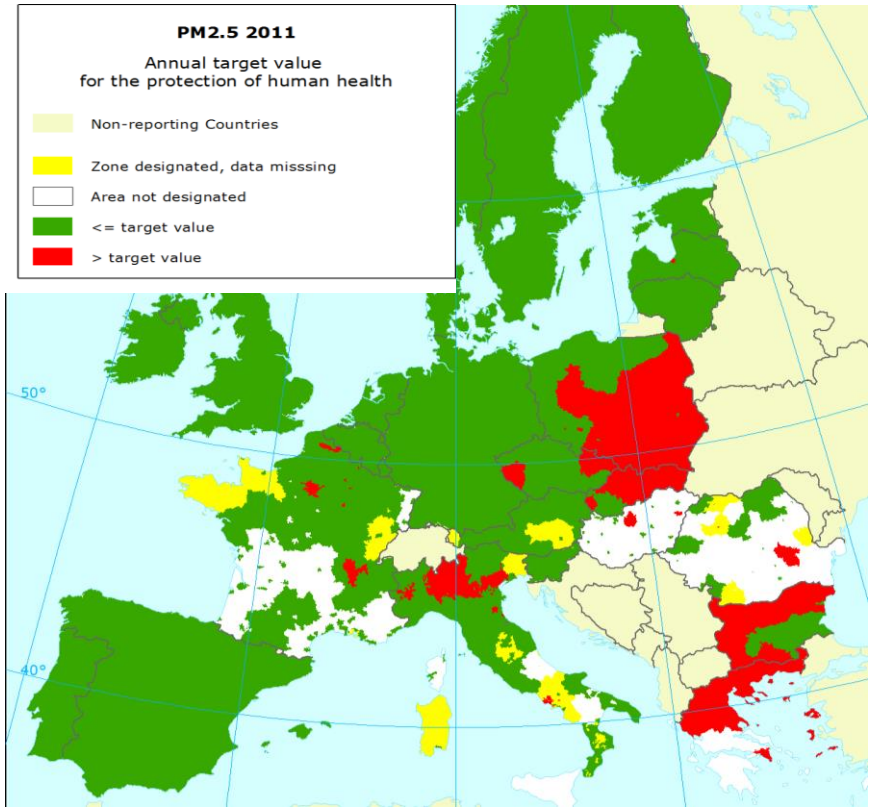
AQ status – 2011
PM10 & PM2.5 annual limit values in 2011

PM10 > 40 µg/m^3



PM2.5 > 25 µg/m^3



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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 - EU AQD key pollutants
- Highlight model weakness and strengths, outline more detailed evaluation milestones
- Define next steps for model application and improvement

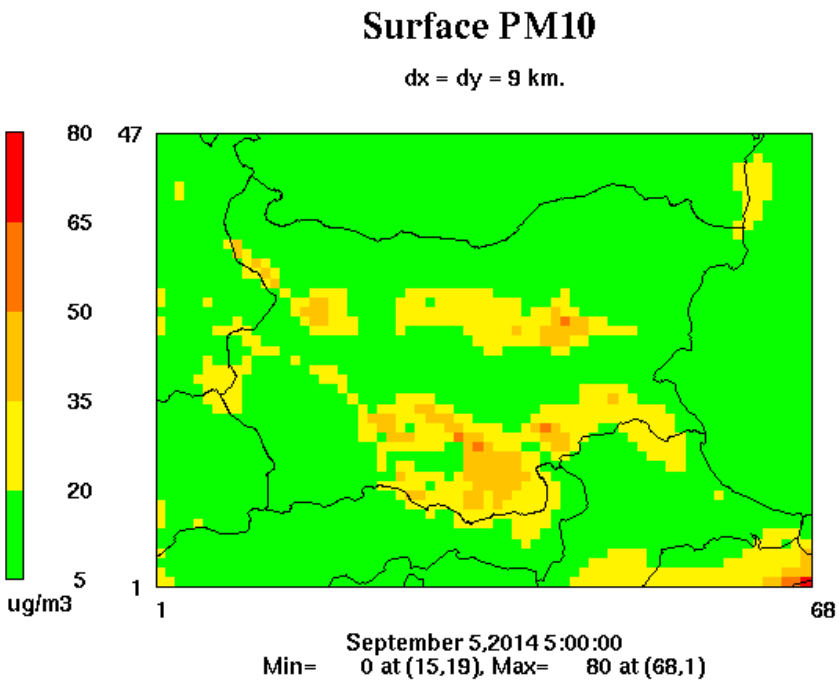
WRF – CMAQ model system at NIMH

BG Chemical Weather Forecast system

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

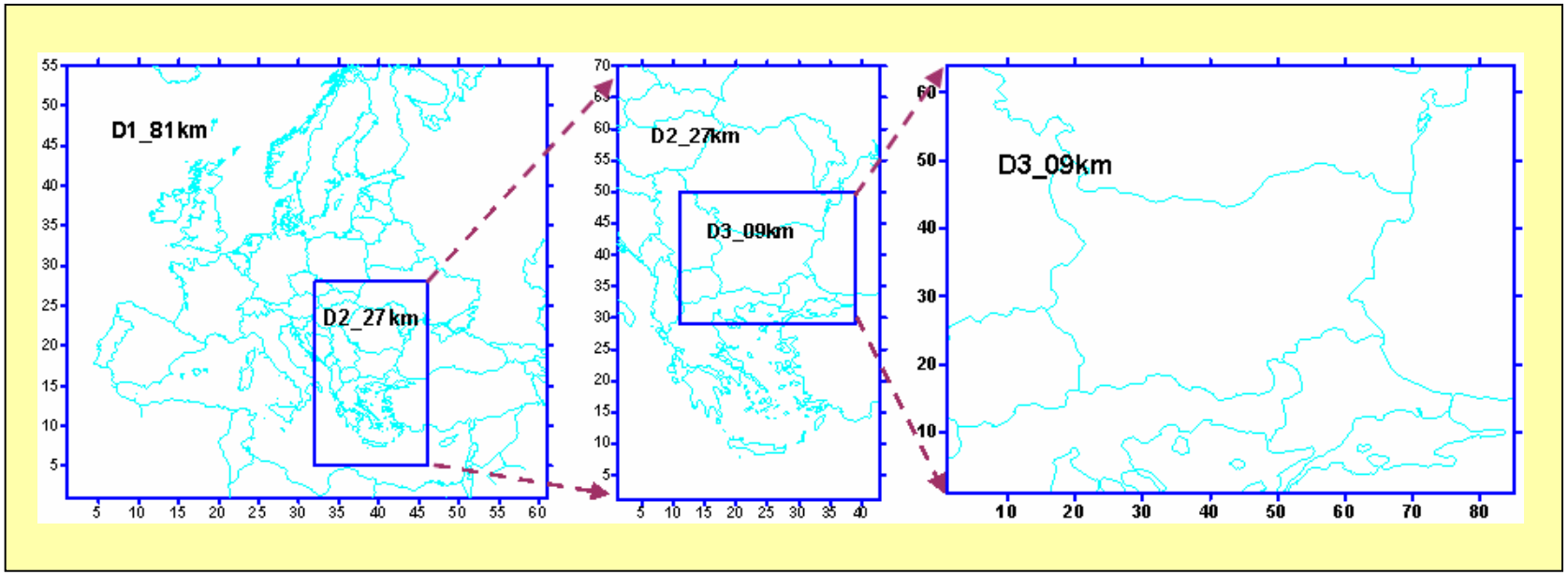
Operational runs for +72h forecast

Surface maps: SO_2, NO_2, O_3, PM_{10}



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

CMAQ v.4.6

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

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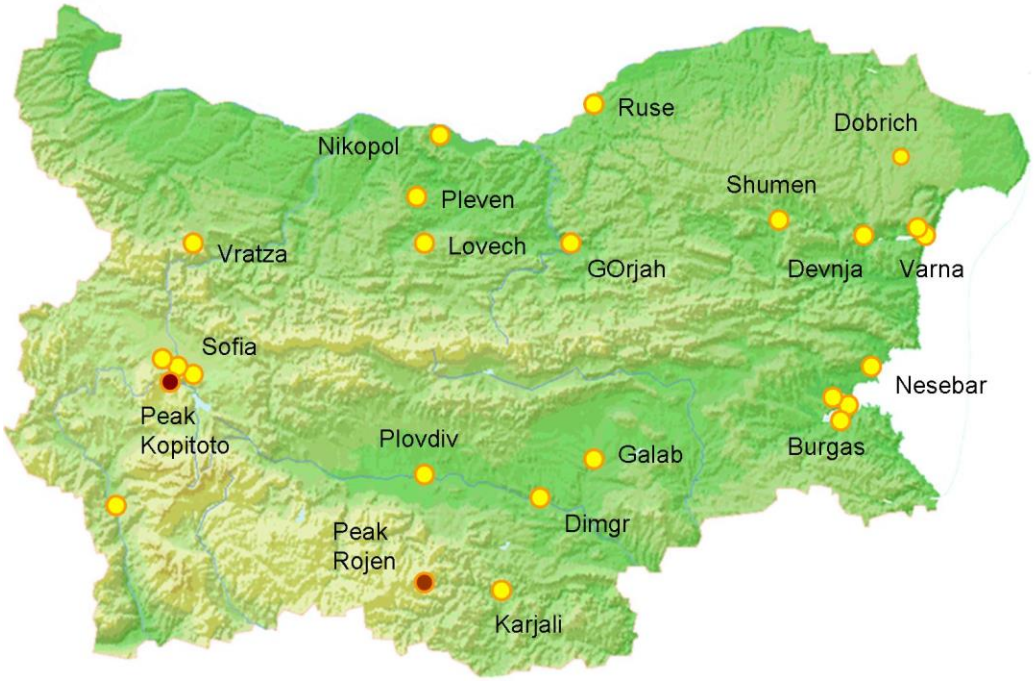
Emissions

- Emission processors – *AEmis, PEmis*
- 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

- SMOKE model - partially used: for biogenic emissions and their merging with Area (AS) and Large Point Source (LPS) emissions in a single input file for CMAQ

Observational data set 2013

No. of stations	NO_2	O_3	PM_{10}
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

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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 (>75%)

Model Performance Criteria (MPC)

Model Quality Objective: RMSE/2U = T < 1

$$\left|NMB\right| < \frac{2U}{\overline{O}} \qquad (MPC_{NMB})$$

$$\left|NMSD\right| < \frac{2U}{\sigma_O} \qquad (MPC_{NMSD})$$

$$R > 1 - 2\left(\frac{U}{\sigma_O}\right)^2 \qquad (MPC_R)$$

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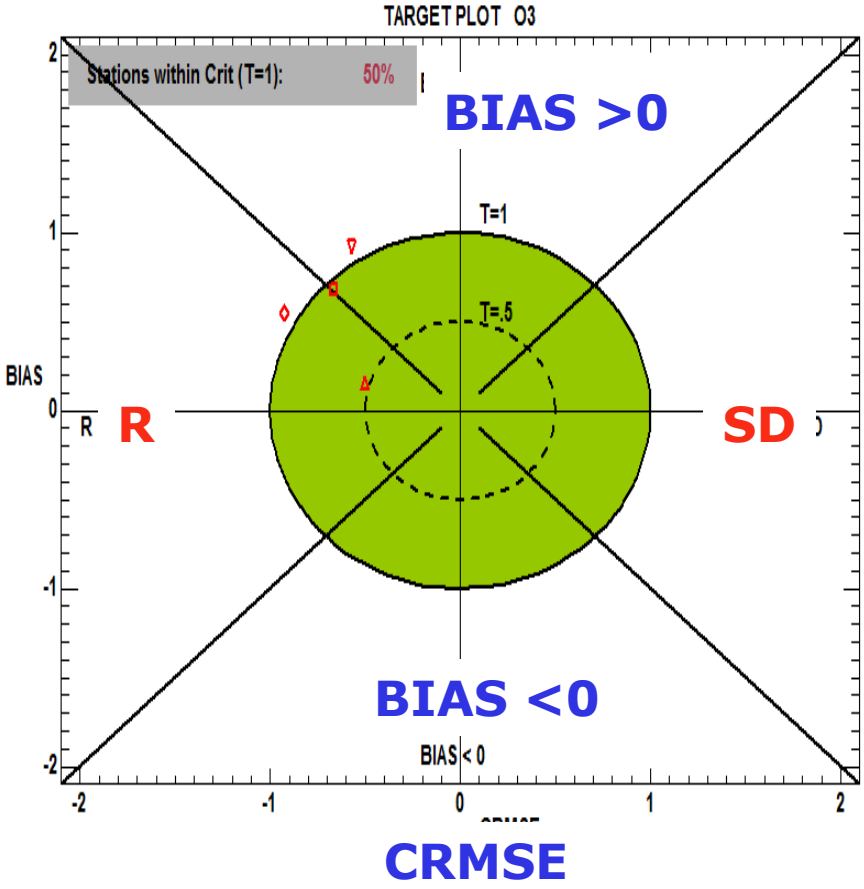
TARGET diagram

Model Quality Objective: RMSE/2U = T = 1



- RMSE/2U ≤ 0.5 : model results are on average within the range of the observation uncertainty for that station any attempt to improve the model performance further is unhelpful.

- 0.5<RMSE/2U≤1 : RMSE on average > the range of U but the model might still be closer to the “true value” (i.e. the perfect measurement) than observations.

- RMSE/2U>1 observations are closer to the “true value” than the model results.

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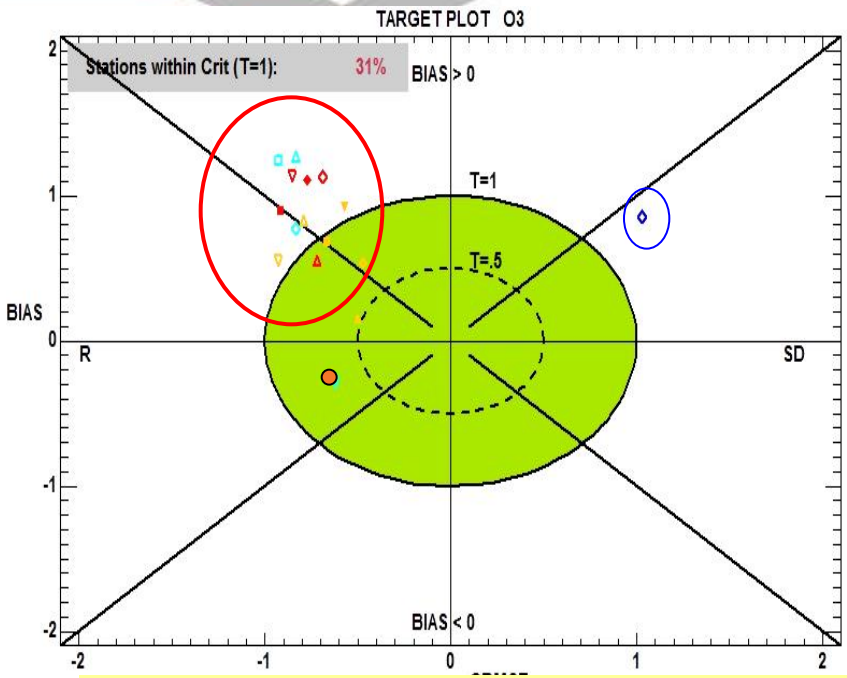
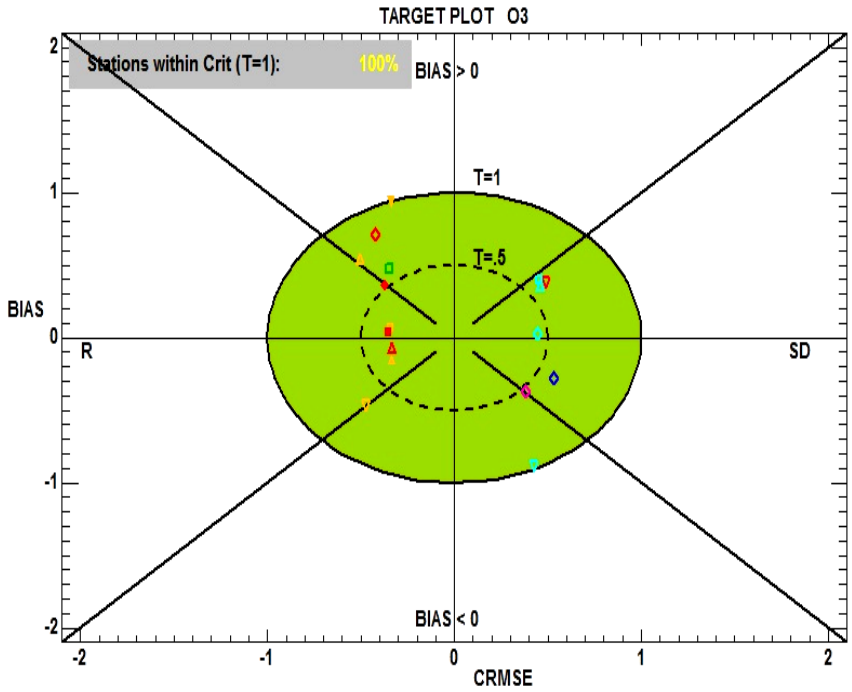
O3 daily max 8h mean

year



- BIAS>0 : overestimation except for 1 mountain station
- error is dominated by lack of R
- 31% fulfill the target criteria

summer



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

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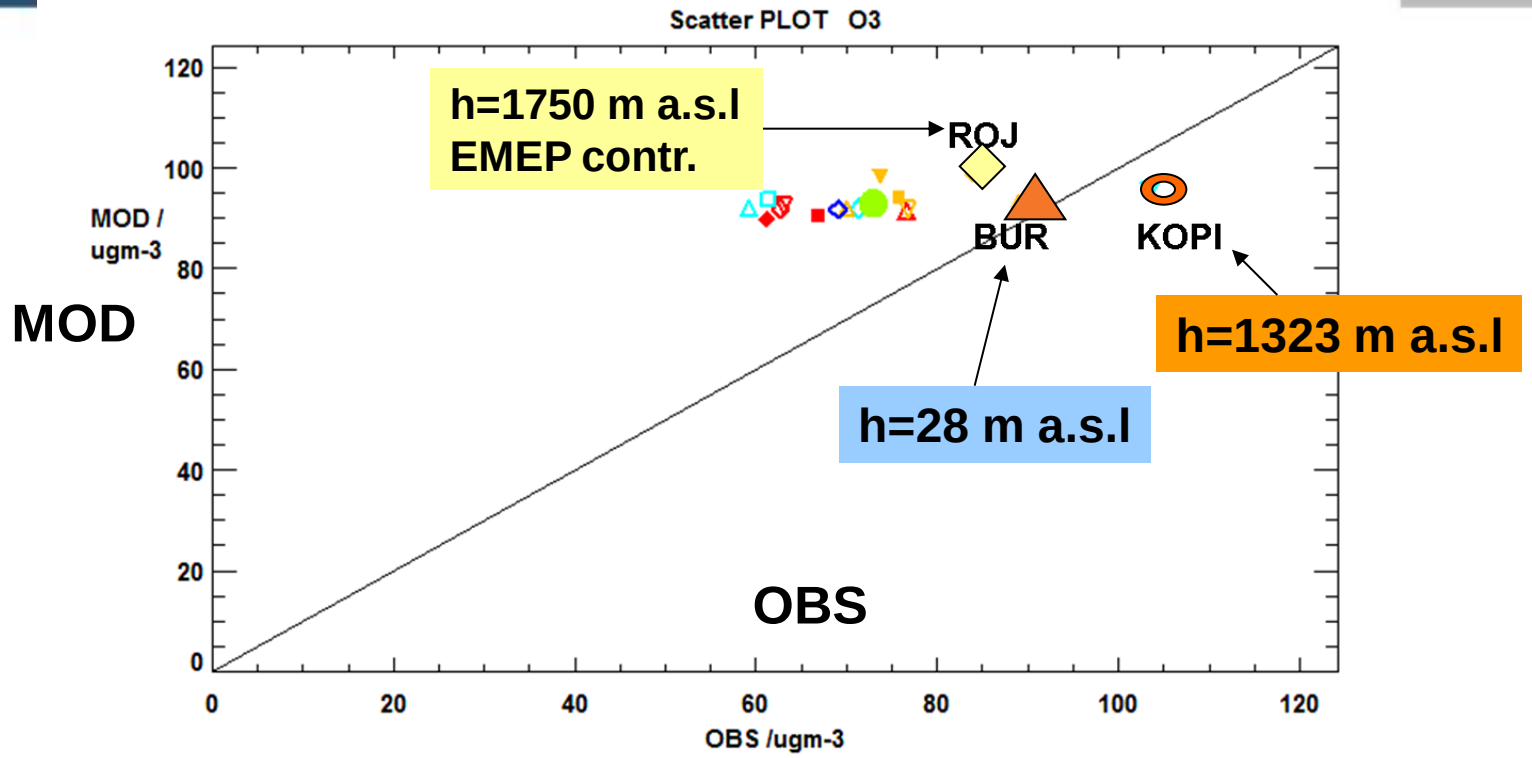
O3 daily max 8h mean (Cont.)

Scatter plot - year



MEAN OBS : 73 µgm-3

MEAN MOD : 93 µgm-3

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

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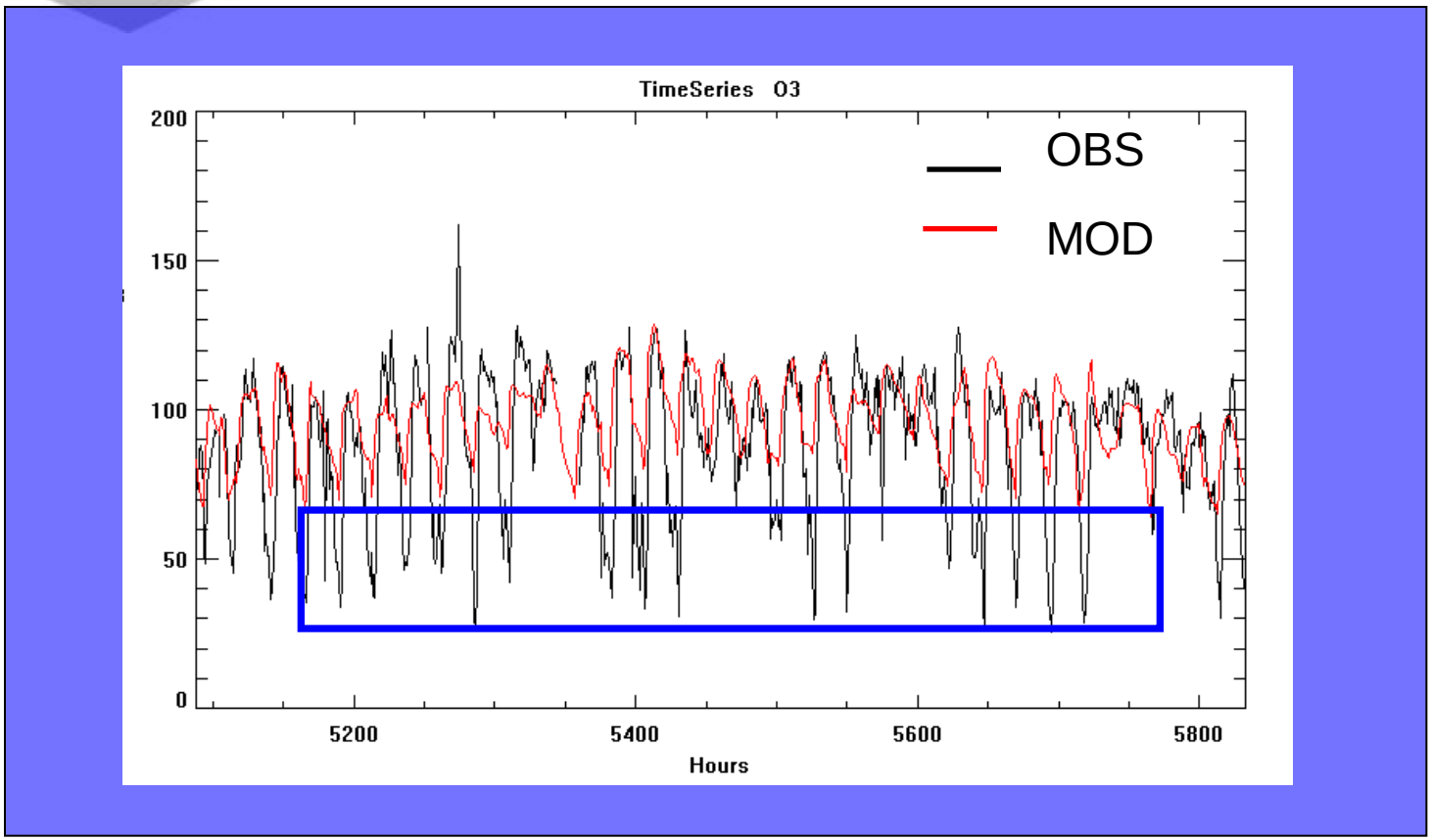
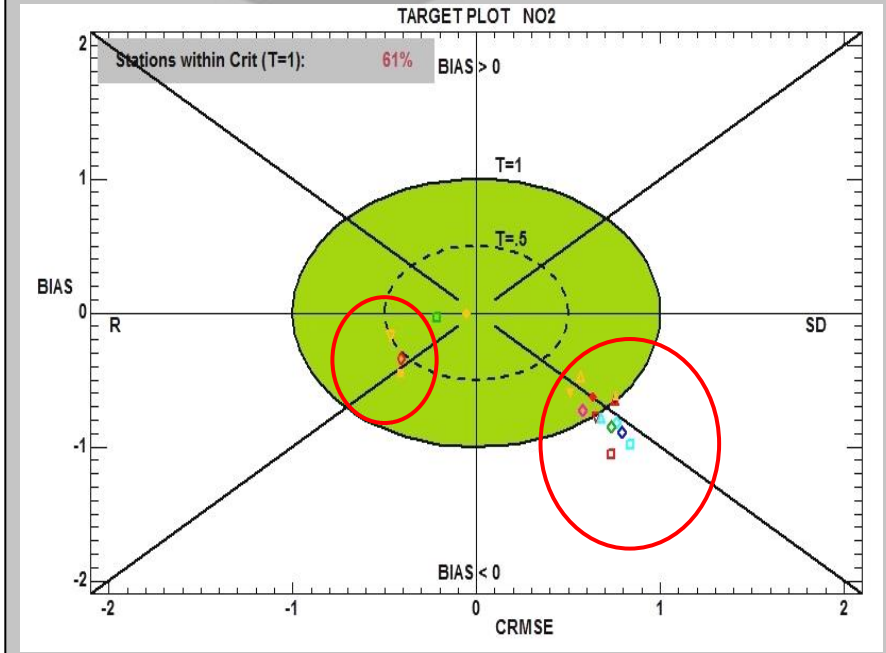
O3 hourly – time series

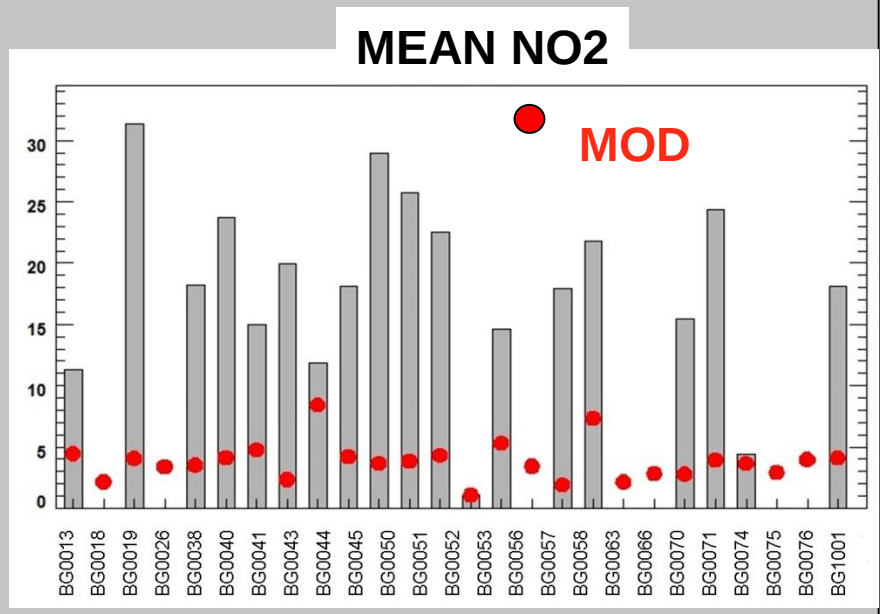
BG0063 (Burgas) August



The model overestimates night-time values

NO2 hourly





- **BIAS<0 : underestimation**
- **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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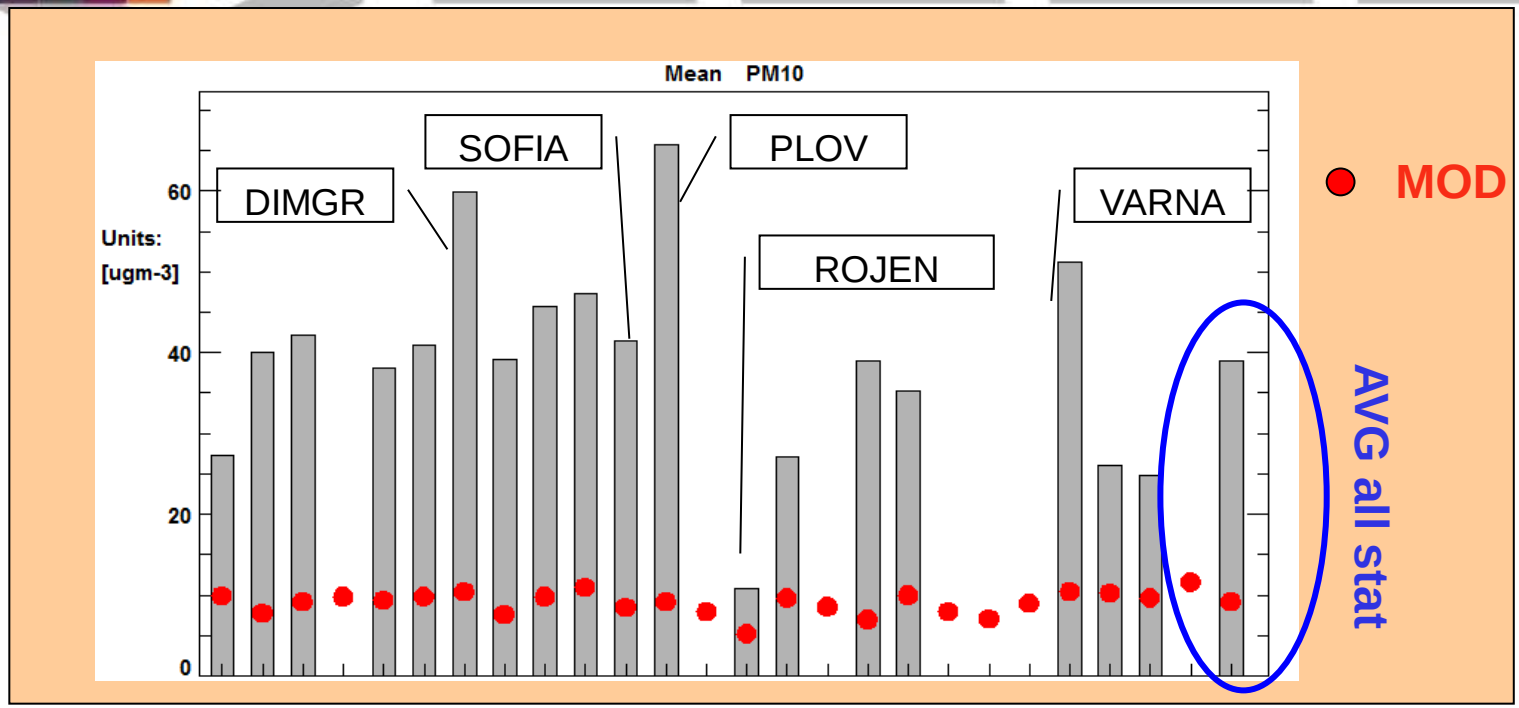
PM10 mean obs. & mod.



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

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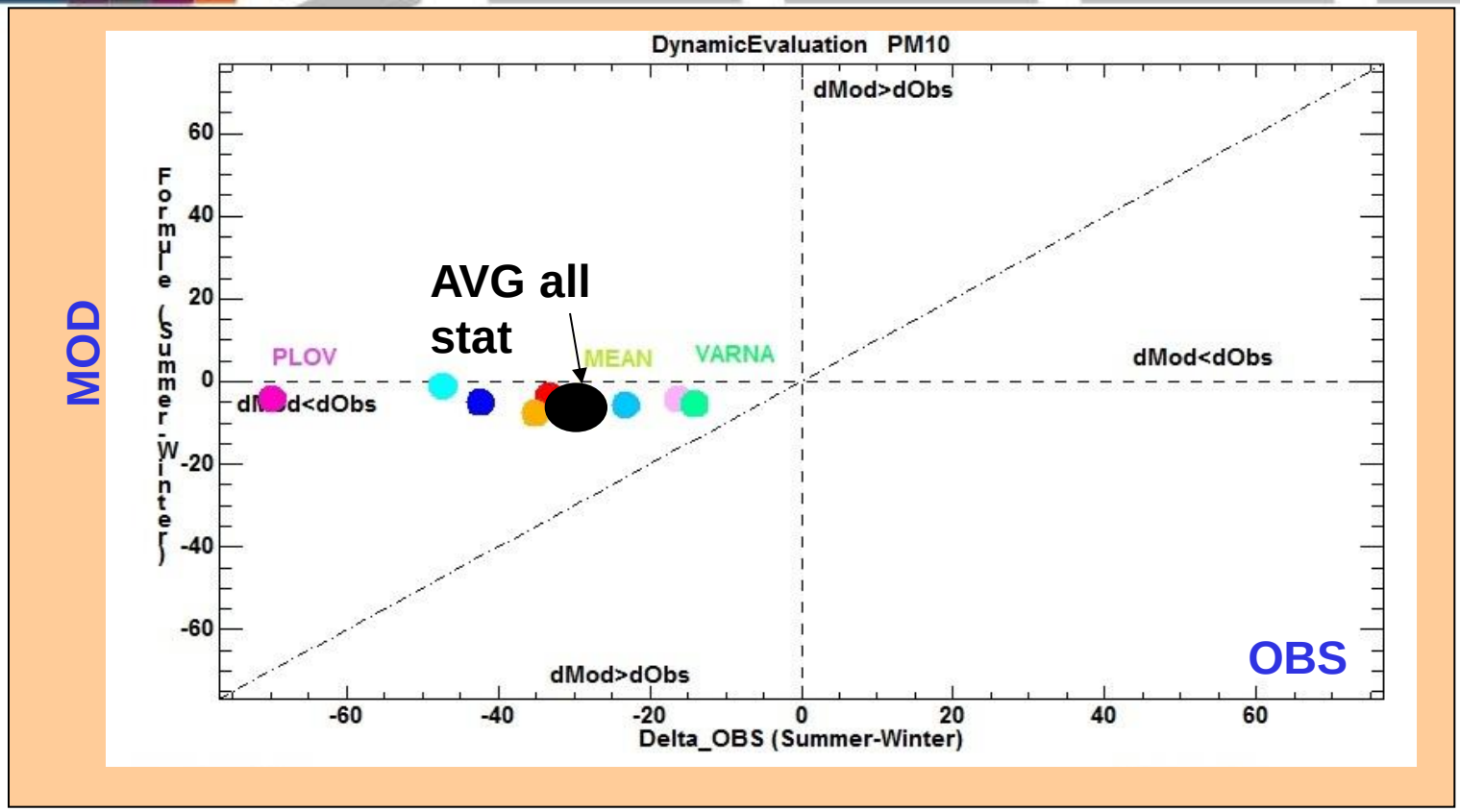
PM10 dynamic D(summer–winter)



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

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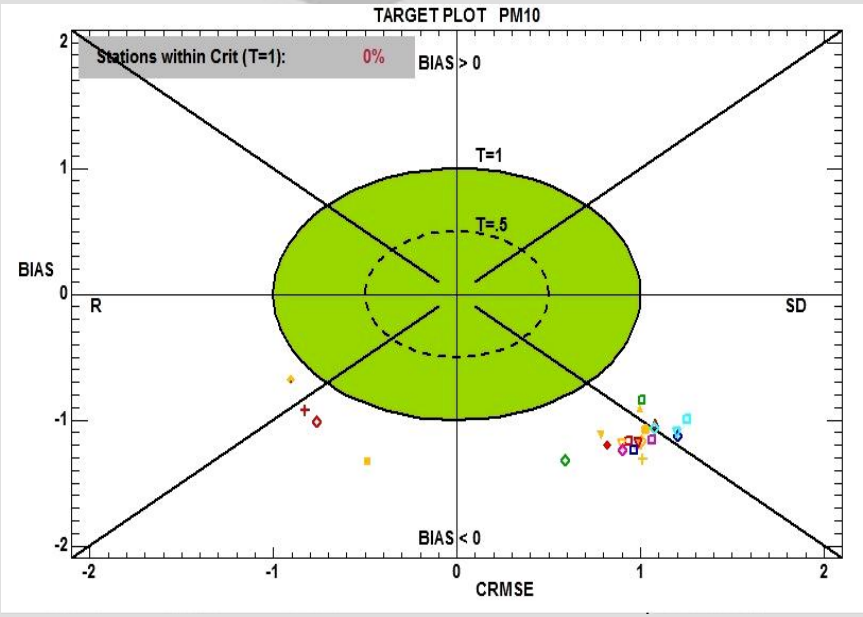
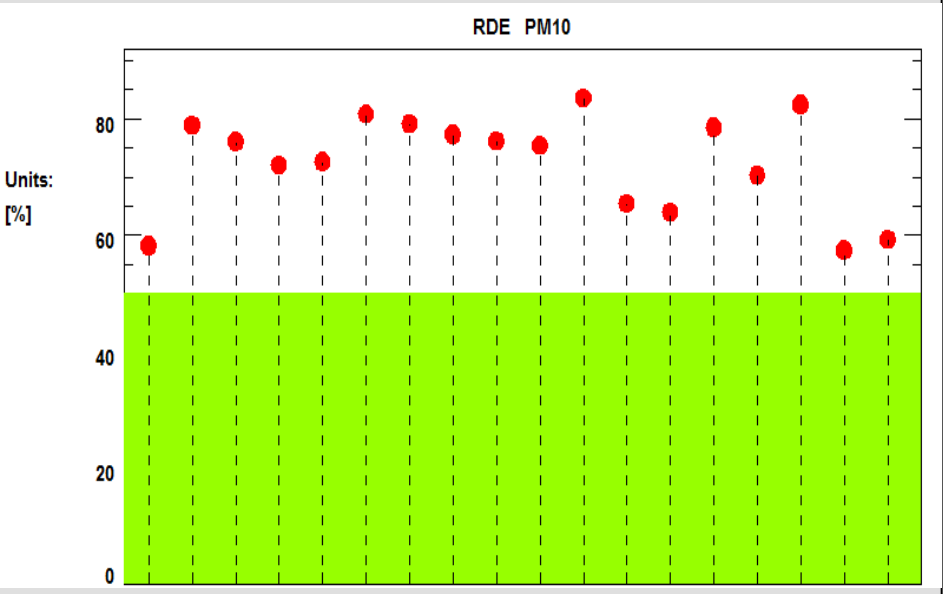
PM10: Target and Relative Directive Error





Target criteria - not satisfied

RDE of PM10 > 50%: MQO not satisfied

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

	FA2	R	NMB	RMSE	NMSD	Target %
O_3	85%	0.55 0.51 urb	30% 41% urb	30 µg/m3	-48% ±100% urb	31% EO AQD requr.>90%
NO_2	21%	0.24 0.29 urb	-68% 79% urb	20 µg/m3	-69% ±117% urb	61%
PM_{10}	14%	0.36 0.33 urb	-74% 65% urb	40 µg/m3	-78% ± 116% urb	0%

O_3 - comparable statistics to MPC
NO_2 and especially PM_{10} - more work is needed for improvement of model performance

Conclusions

O_3 : better than NO_2 and PM_{10}

overestimation (night-time)

errors related to lack of R

NO_2 : underestimated, lack in emissions at local level

PM_{10} : underestimated, correlation comparable to other studies

Problems:

- data availability and solutions representativeness
- No urban “effects” in the model
- emissions at local level and emission input as whole

DELTA - useful and fast tool for diagnostic of model performance

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