European Network on New Sensing Technologies for Air Pollution Control and Environmental Sustainability - *EuNetAir*

COST Action TD1105

WGs Meeting, Belgrade, 13 - 14 October 2015

organized by VINCA Institute and co-organized by Public Health Institute of Belgrade

hosted by Faculty of Mechanical Engineering, University of Belgrade

Action Start date: 16/05/2012 - Action End date: 30/04/2016

Year 4: 1 July 2015 - 30 April 2016 (*Ongoing Action*)

AIR QUALITY MODELING WITH BULGARIAN WRF-CMAQ SYSTEM OVER EUROPE - O3, PM AND METEOROLOGY

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COST is supported by the EU Framework Programme

ESF provides the COST Office through a European Commission contract

Motivation and Outline

WRF-CMAQ: backbone of the BG national "Chemistry weather forecast system"

http://www.meteo.bg/en/cw

1. **Model intercomparison -AQMEII phase 2**
2. **WRF - CMAQ set up**
3. **O3, PM10 - operational model evaluation**
4. **Wind10, TEMP2, PBL**
5. **Summary and next steps**

AQMEII – 2

http://aqmeii.jrc.ec.europa.eu/

- Air Quality Model Evaluation International Initiative (AQMEII) – simulations **over EU and NA**
- 13 groups in EU and 4 in NA, 1 year – **2010**
- Focus on **on-line** coupled MET- CHEM models
- NIMH's WRF-CMAQ system is **uncoupled**
- Huge amount of **observational data** (surface, profiles, flights)
- on-line model **evaluation platform ENSEMBLE** (EC-JRC)

First results in Special Issue Atm Env 115 (2015)

Set up: WRF – CMAQ (BG2) - 1/2

- **WRF model version 3.3**

Driven by NCEP/GFS (1°), - Analysis nudging

27 vertical levels , dx = 25 km

Physics Options	Parameterization
Microphysics	WSM6 scheme
Cumulus param	Kain-Fritsch scheme
PBL	YSU scheme
Longwave Radiation	RRTM scheme
Shortwave Radiation	Dudhia scheme
Land Surface Model	NOAH LSM scheme

Set up: WRF – CMAQ (BG2) - 2/2

CMAQ v. 4.6

CB4 mechanism

14 vertical levels (7 below 1000 m)

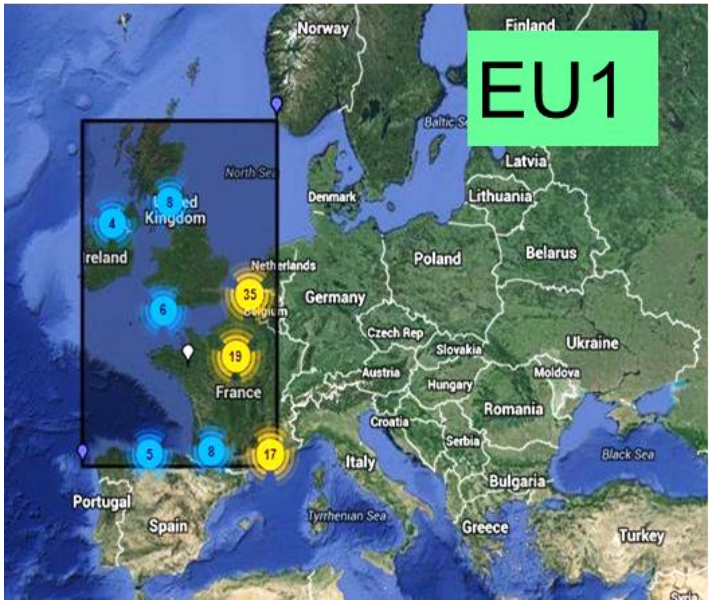
Chemical Boundary Conditions: **MACC reanalysis**

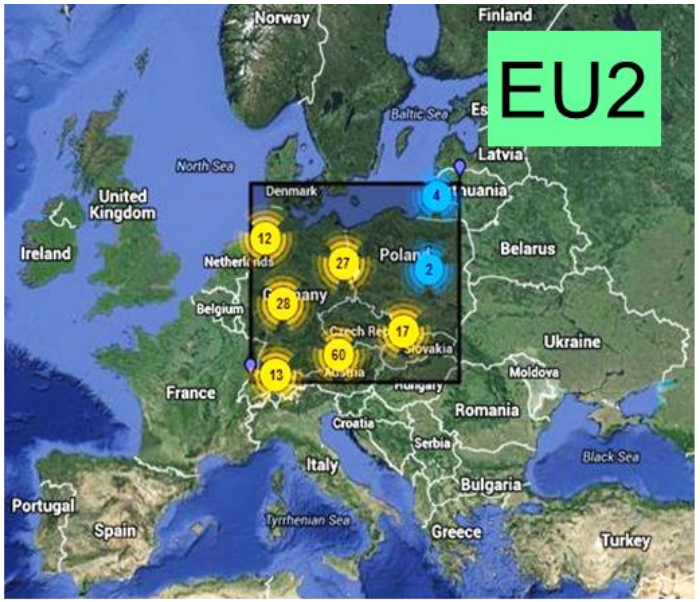
Emissions:

- **Inventories – TNO-MACC inventory for 2009 dx~7×8 км) – common for all groups**
- **Emission processing (e.g. disaggegation) –by individual groups (NIMH)**

Operational model evaluation

- rural surface stations bellow 1000 m
- Data availability > 75%
- 2 sub-regions





Number of stations (AIRBASE, EMEP):

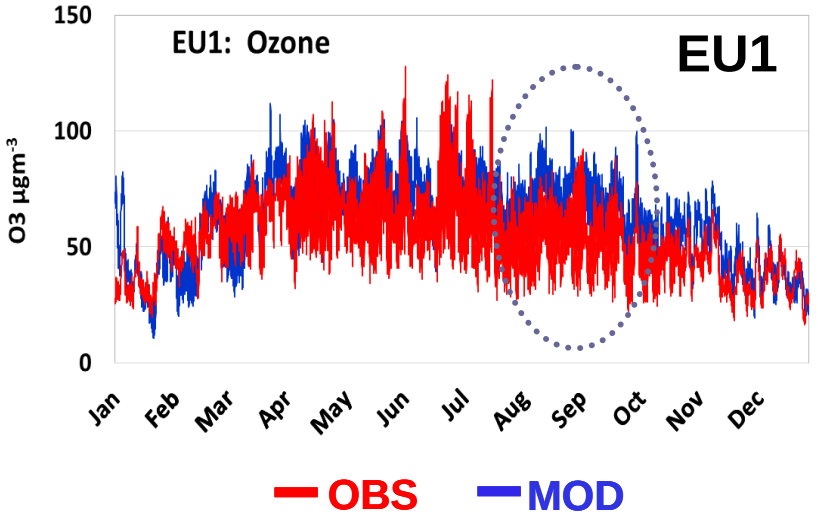
O3 hourly :	100	148
PM10daily:	46	129

O3 (µg/m3) time series

EU1: MEAN OBS/MOD 54.7 / 60.4

NMB	11%
FA2	83%
PCC	0.79

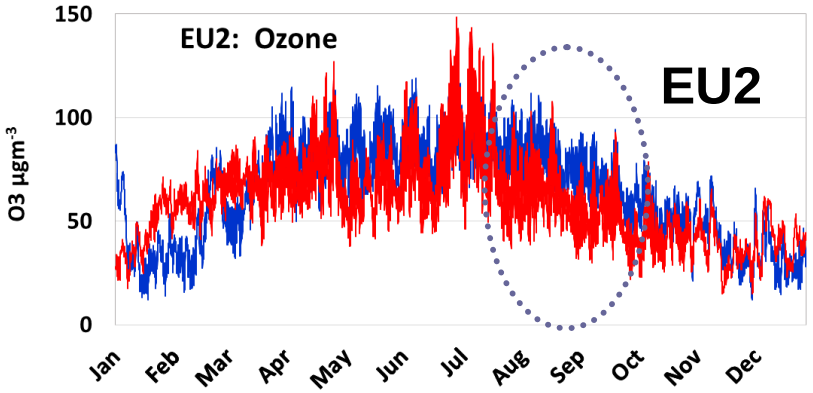
AUG – overprediction by 25%
DEC – underprediction by 3%



EU2: MEAN OBS/MOD 61.5 / 64.1

NMB	4%
FA2	81%
PCC	0.57

AUG – overprediction by 21%
DEC – underprediction by 19%



COUPLED MODELS (*Im et al, 2015*) EU wide : NMB: - 8% , PCC: 0.86

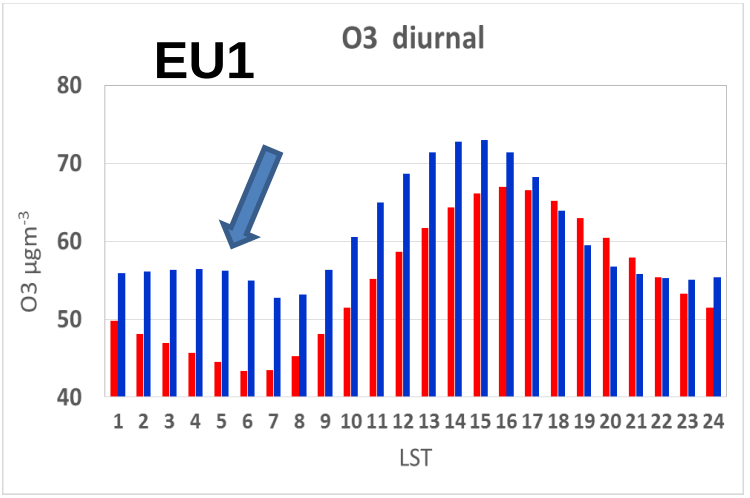
O3 (ug/m3) diurnal cycle

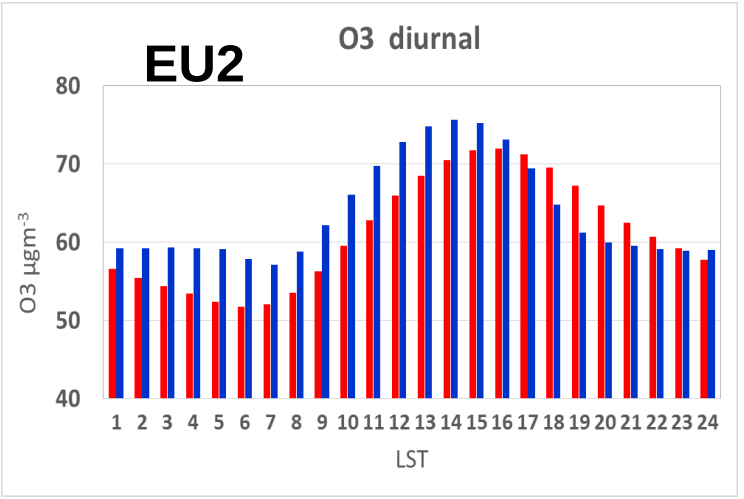
- Timing of DMAX
- Night-time overestimation

Possible reasons for O3 overestimation:

- Emissions
- Dry deposition velocity underestimation
- NO titration by ozone overestimation
- PBL physics

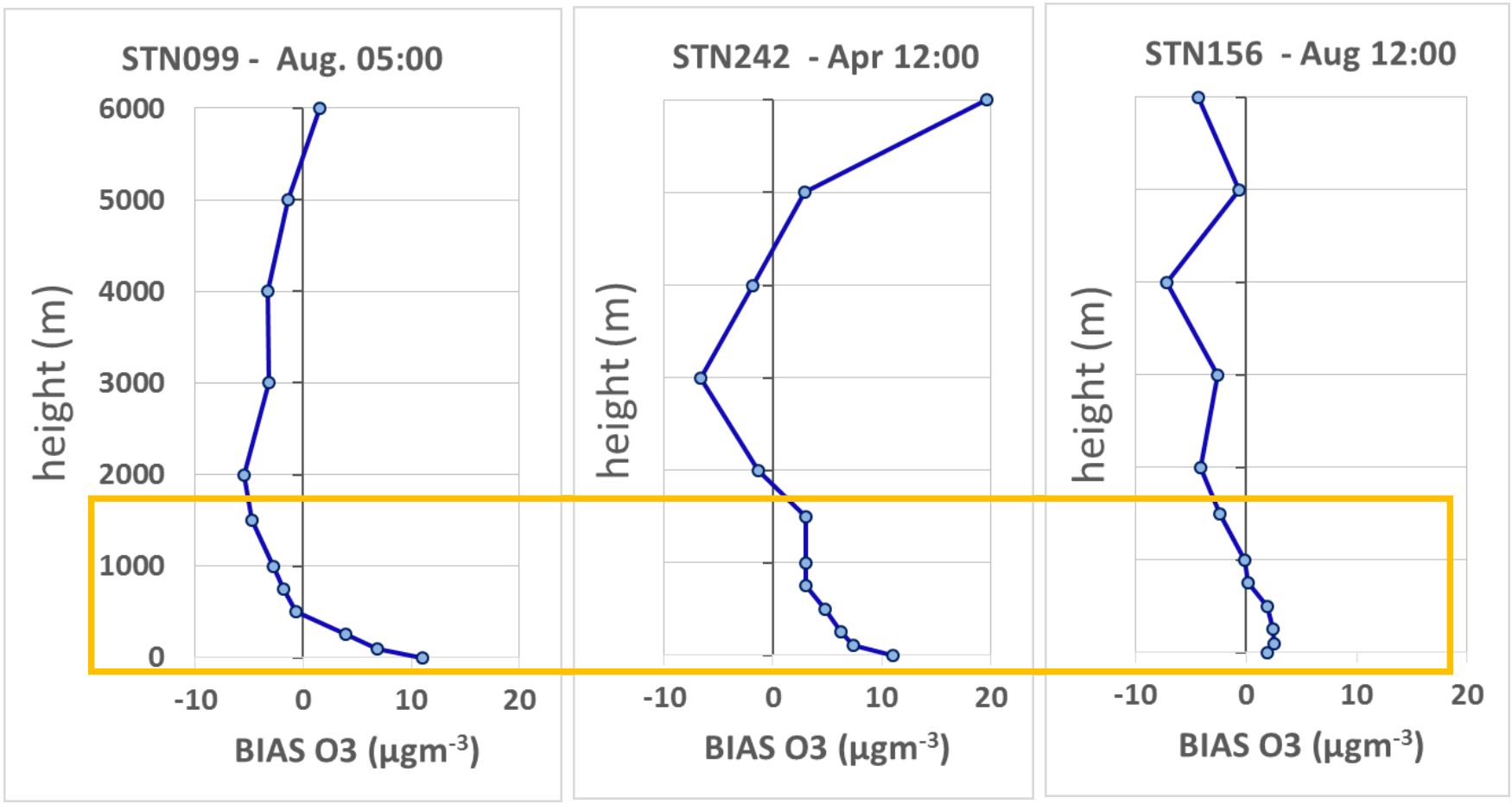
Sensitivity to NOx emissions (Syrakov et al, Harmo16) – increase of NOx by 30% has led to only 7-8% decrease in surface ozone





Profiles of O3 Mean Bias (Mod-Obs)

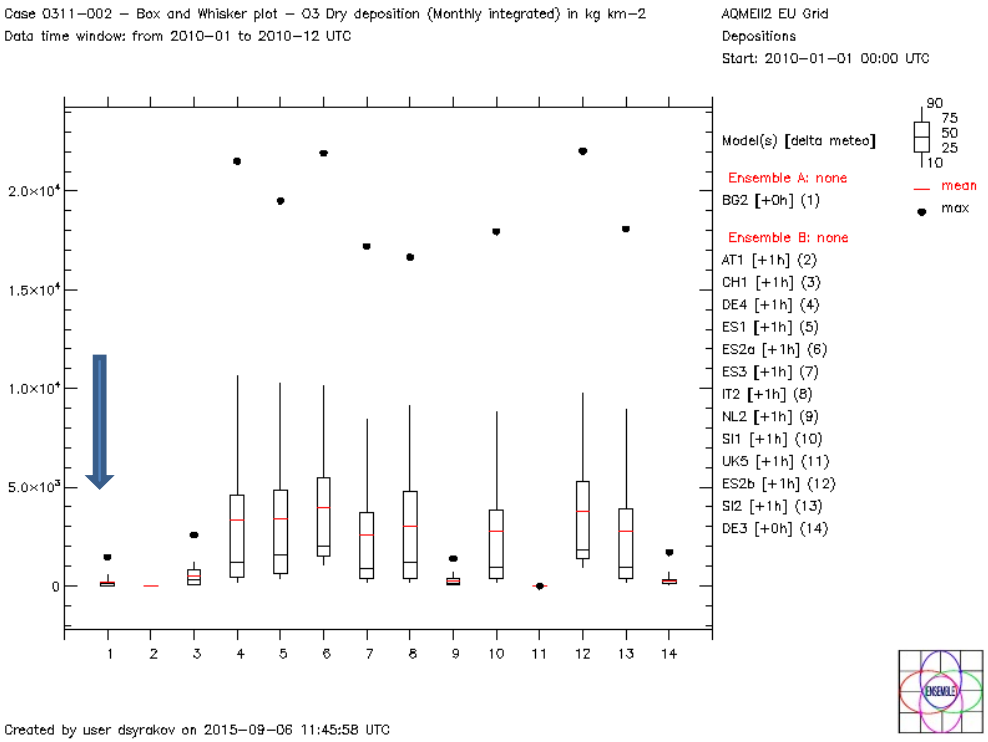
Ozonesondes 3 sites: STN099 (DE), STN242 (CZ), STN156 (CH)

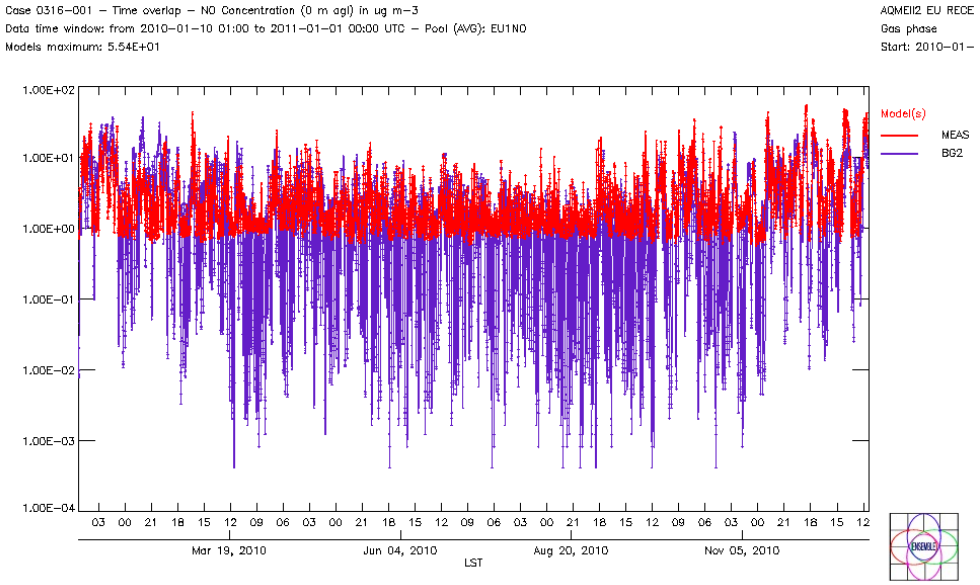


O3 – overestimated between 500-2000 m

O3 dry deposition

-O3 dry deposition of BG2 is smaller than other AQMEII models





PM10 monthly variation

EU1: MEAN OBS/MOD 20.9 / 11.9

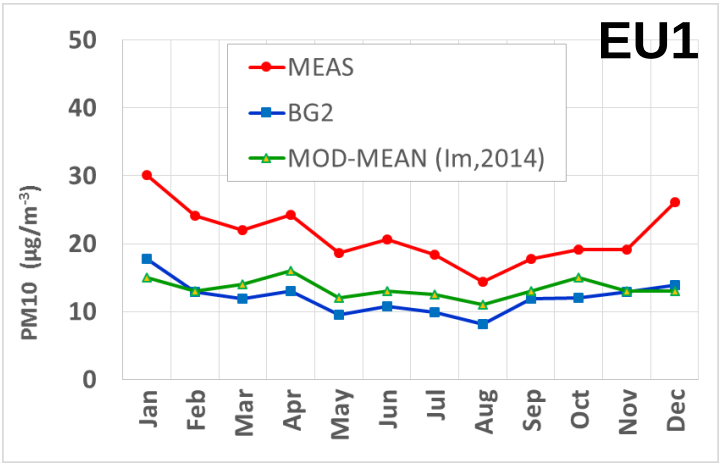
NMB	- 43.3%
FA2	63%
PCC	0.68

EU1 & EU2 : underestimation especially in winter

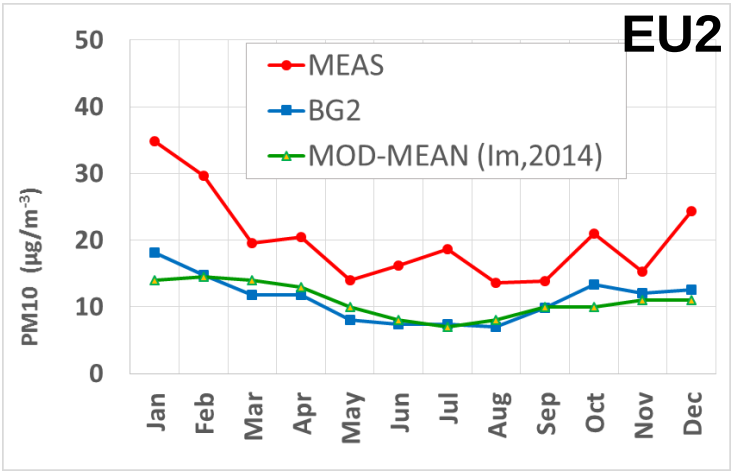
EU2: MEAN OBS/MOD 20.7 / 10.9

NMB	- 47.3%
FA2	56%
PCC	0.52

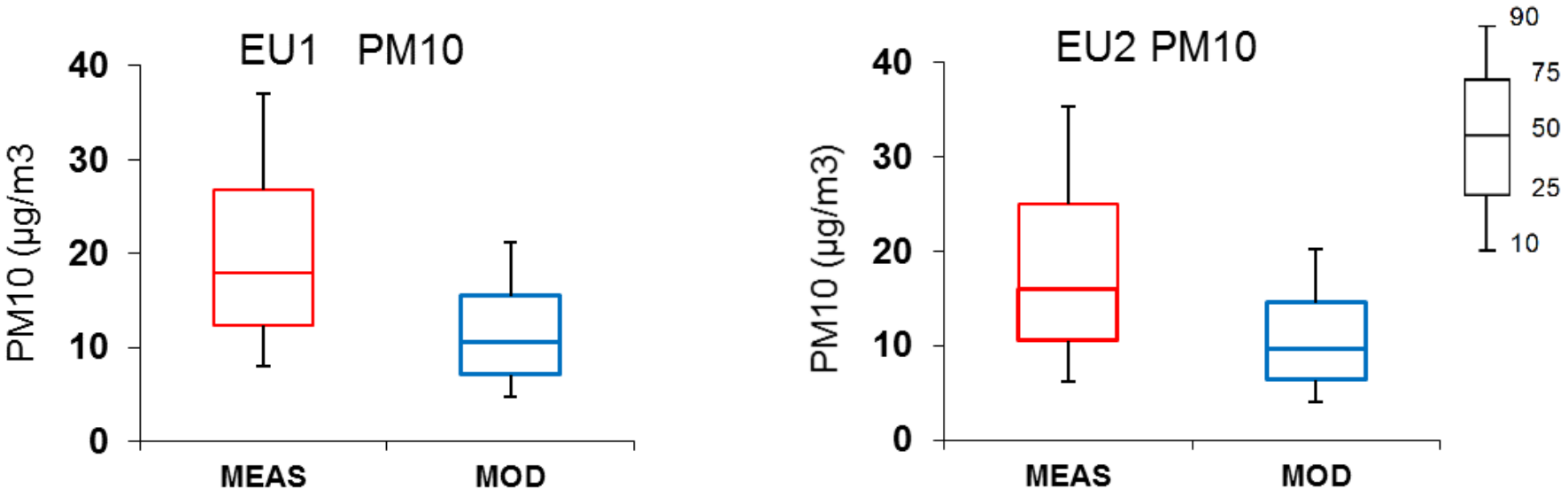
PCC is within values by coupled models: EU1 (0.4-0.9) EU2 (0.2-0.9)
(Im et al, 2015)



OBS **MOD** **MOD MEAN**
Im et al 2015



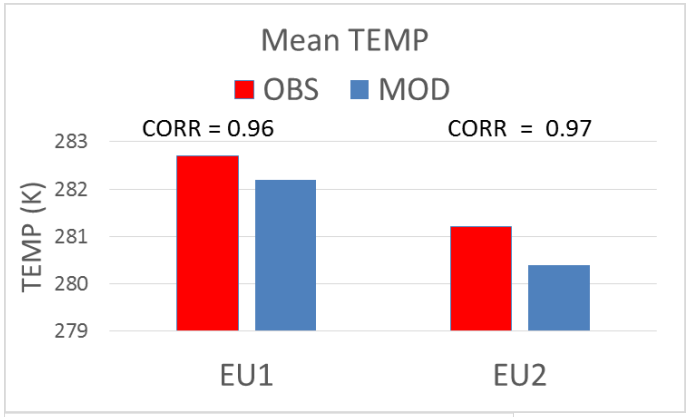
PM10 (µg/m^{-3}) 2010

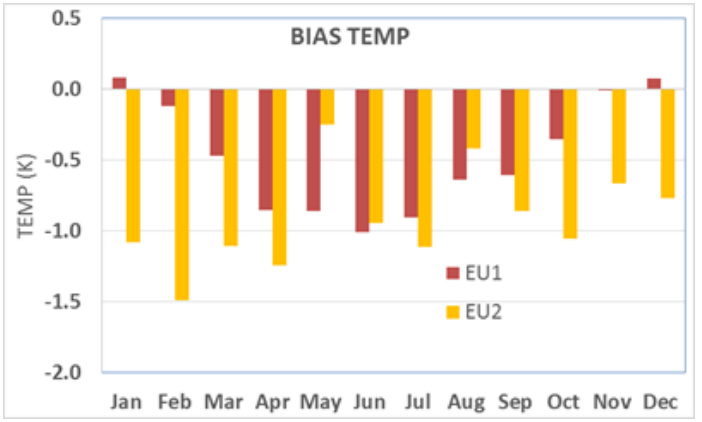


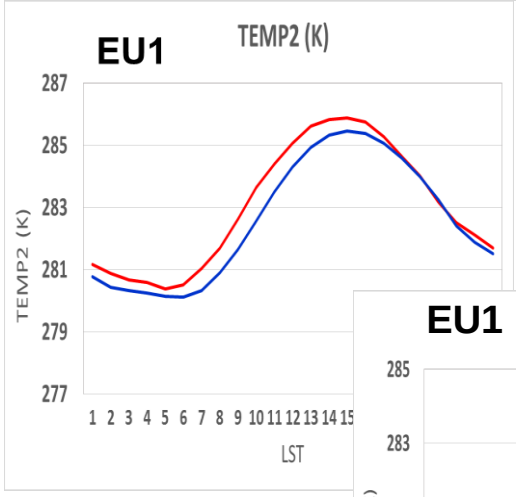
OBS MOD

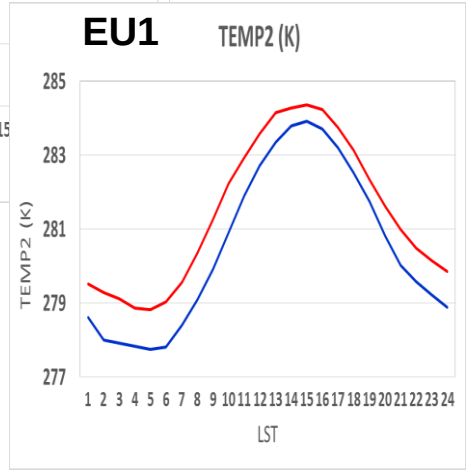
Box and Whisker Plots show smaller variability in modeled PM10

TEMP2



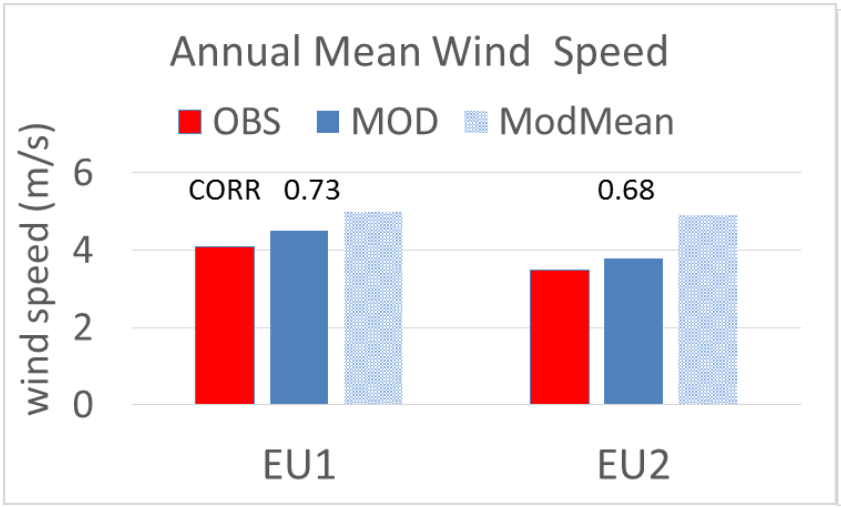


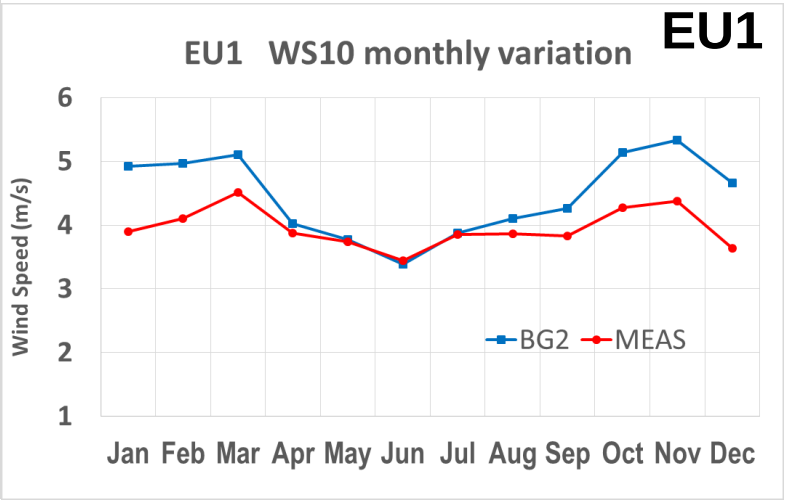




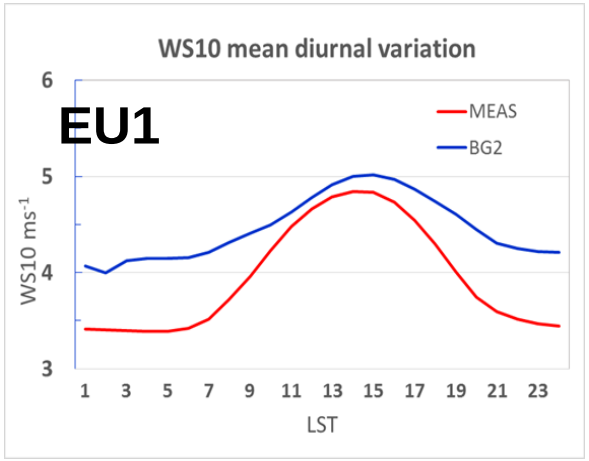
- **COLD BIAS - 0.5K (EU1), 1K(EU2), similar to range of coupled models (Brunner et al. 2015)**
- **WRF underestimates especially night-time TEMP2 (in EU2 also afternoon)**
- **time shift of about 1 hour in morning rising temperature**

10m - Wind speed (WS10)





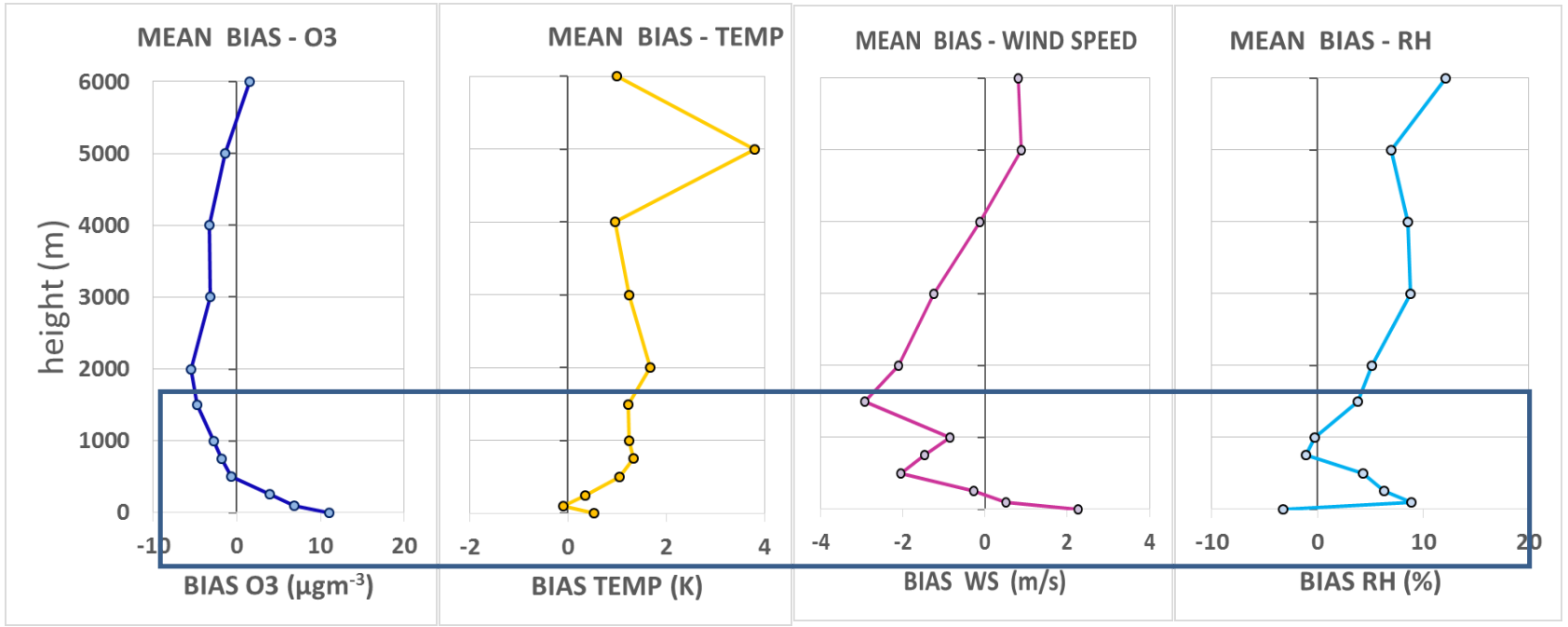
diurnal variation WS10



- **Seasonally : WS10 is overestimated by 11% (annual) summer - well**
- **Diurnal - WS10 overestimated at all times of day, especially at night time,**
- *Might be due to YSU –scheme, (version earlier than 3.4.1.*
- **Results comparable to ModMean coupled models** *(Brunner et al, 2015)*

Vertical profiles of MBIAS @STN099

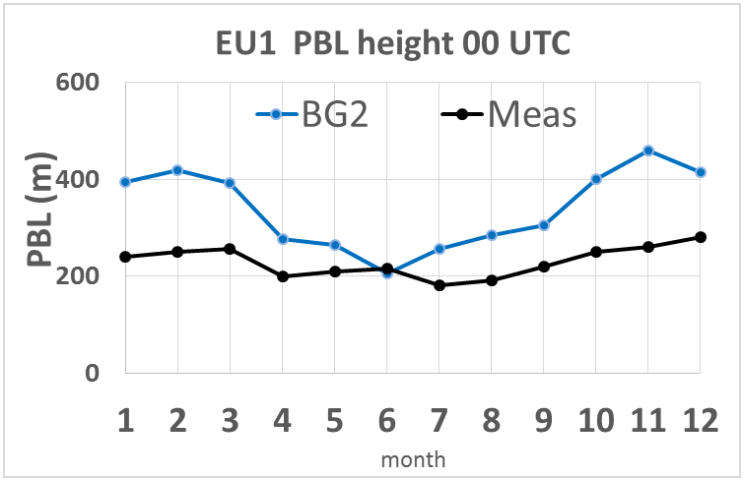
Hohenspeissenberg, (DE) **August – mean of 9 profiles - 05:00 UTC**

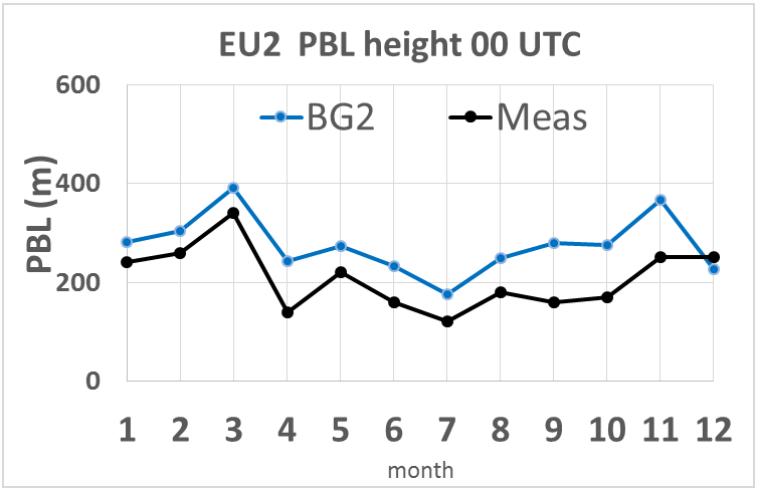


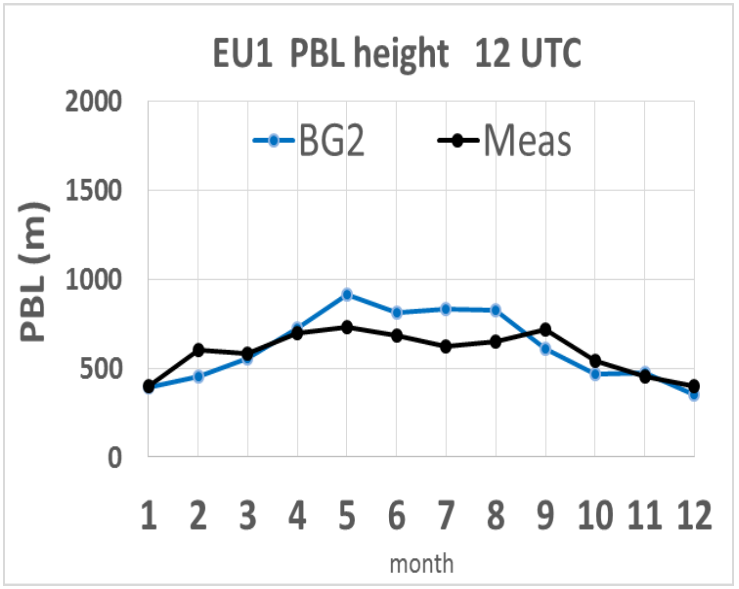
LOWER LAYERS:
O3 – overestimated
TEMP – overestimated
WIND – overestimated
RH – overestimated

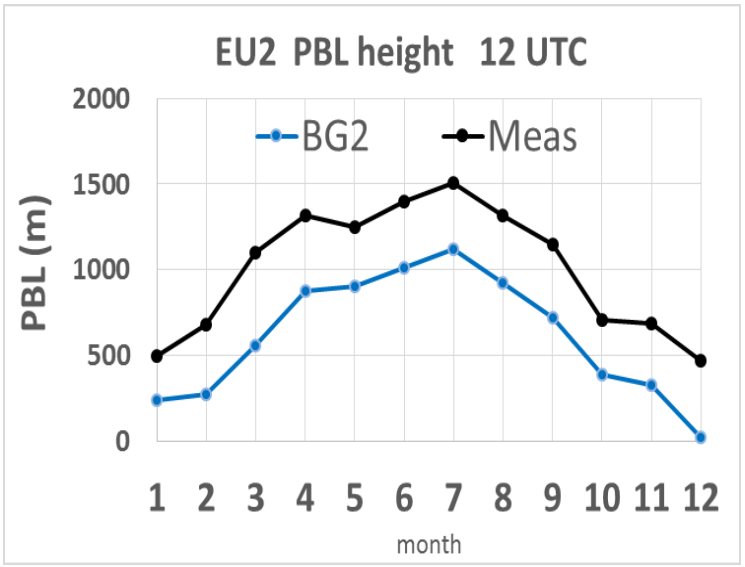
PBL height vs. Meas. from sounding sites

from Brunner et al, 2015





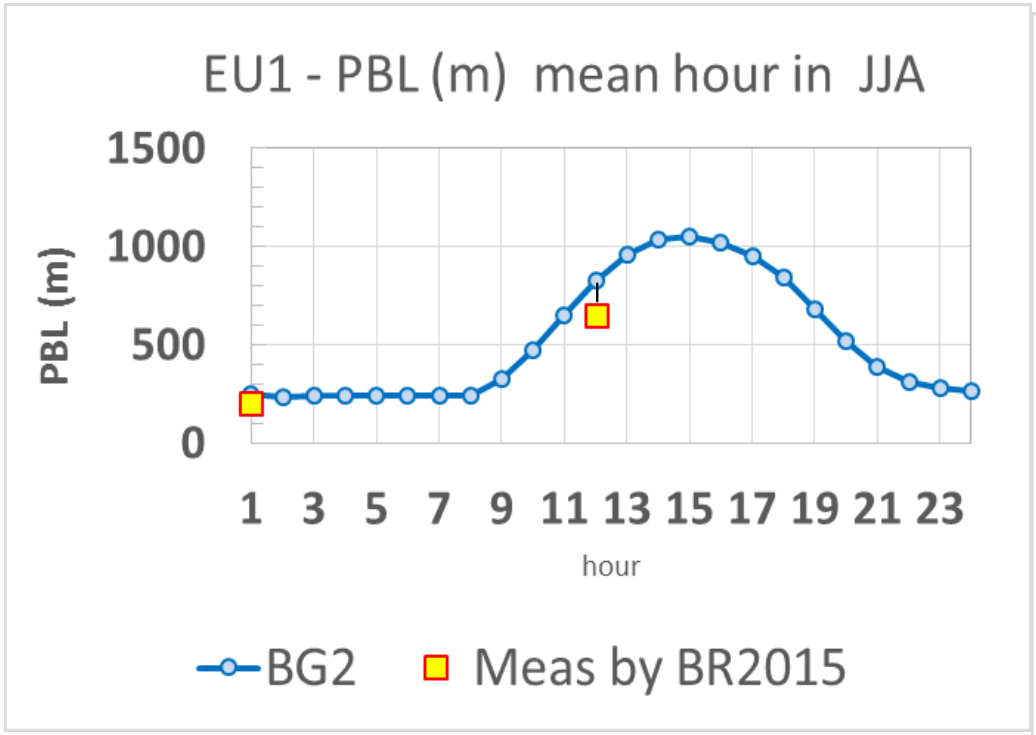


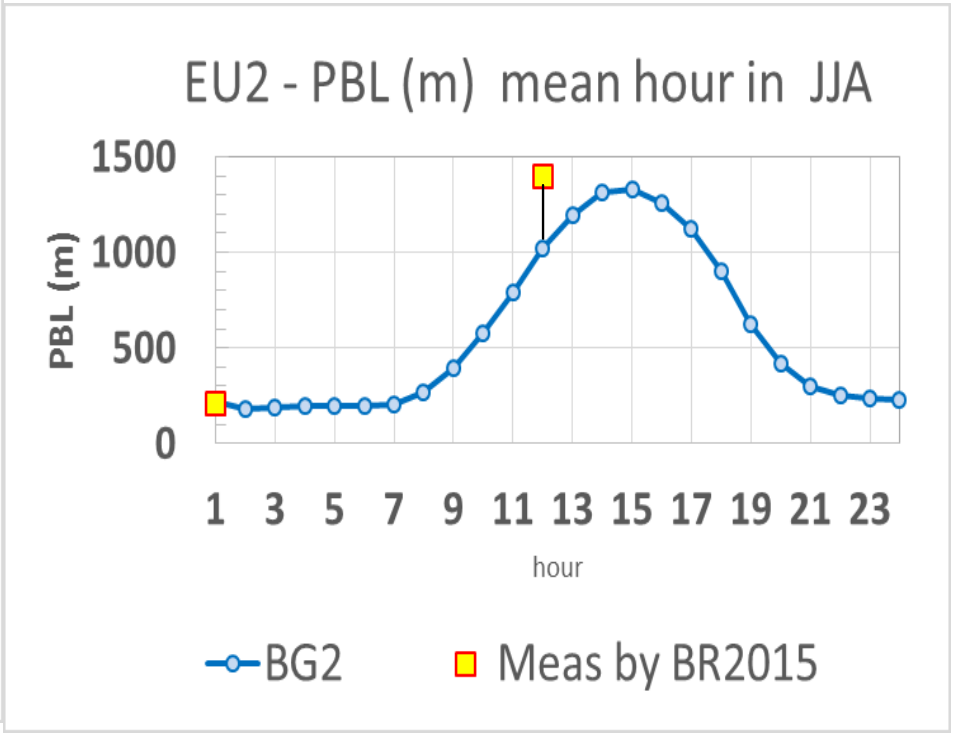


PBL height vs. Meas. from sounding sites
from Brunner et al, 2015

PBL diurnal variation in EU1 and EU2 for June-July-August

"MEAS" = estimated by sounding data , Brunner et al., 2015





Conclusions

Preliminary operational evaluation:

O3 : better in EU1 than in EU2
night-time overestimation both near ground and in the PBL

PM10 : better in EU1 than in EU2
underestimated in all seasons
relatively good PCC values
results similar to coupled models

MET: T2 - underestimated
WS overestimated (not only at surface)
RH – overestimated
PBL – overestimation at night time

Further efforts needed for understanding weaknesses of WRF-CMAQ @ NIMH

ACKNOWLEDGEMENTS

Grant from National Science Fund (Договор №Д002-161/16.12.2008).

Grant from National Science Fund (Договор № ДЦВП-02/1/29.12.2009).

COST Actions ES0602, ES1004 and TD1505.

5thFP project BULAIR (Contract Nr. EVK2-CT-2002-80024).

6thFP Network of Excellence ACCENT (Contr. Nr. GOCE-CT-2002-500337).

6thFP Integrated Project QUANTIFY (Contract Nr. GOGE-003893).

7thFP project SEE-GRID-SCI (Contract Nr. FP7 –RI-211338).

7th FP project EGI-InSPIRE (Contract Nr. 261323).

7th FP project PASODOBLE (Contract Nr. 241557).

US EPA, NSEP, EMEP, TNO for providing free-of-charge models and data

Special thanks to ENSEMBLE team at EC-JRC and all AQMEII Community

cost
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