Air Quality Modelling with WRF-CMAQ over Europe – Focus on Ozone and Particulate Matter

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Motivation and Outline

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

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

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/

- AQ Model Evaluation Intern. Initiative – simulations **over EU and NA**
- **1 year – 2010,** 13 groups in EU and 4 in NA,
- Focus on '**on-line'** coupled MET- CHEM (8 models)
- NIMH's WRF-CMAQ system is uncoupled
- Huge amount of **observational data sets**
- Web based model **evaluation platform ENSEMBLE** (EC-JRC)

First results in *Special Issue Atm Env*, v. 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)

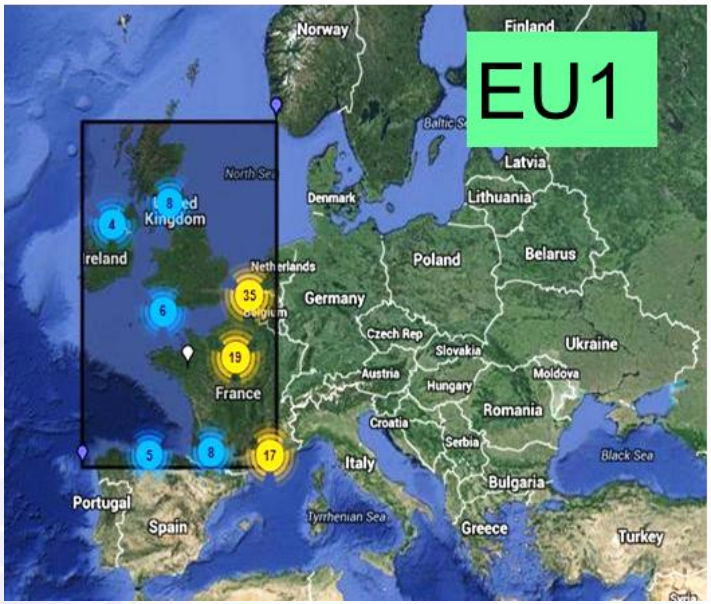
Chemical Boundary Conditions: MACC reanalysis

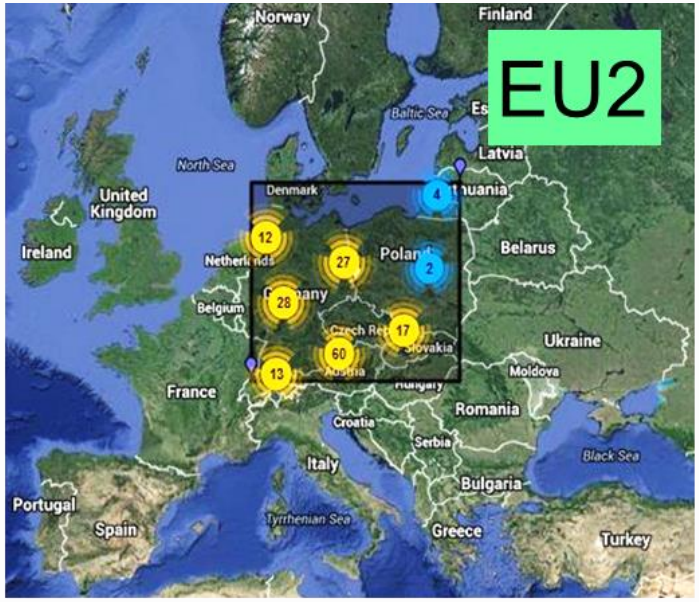
Emissions:

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

Operational model evaluation

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





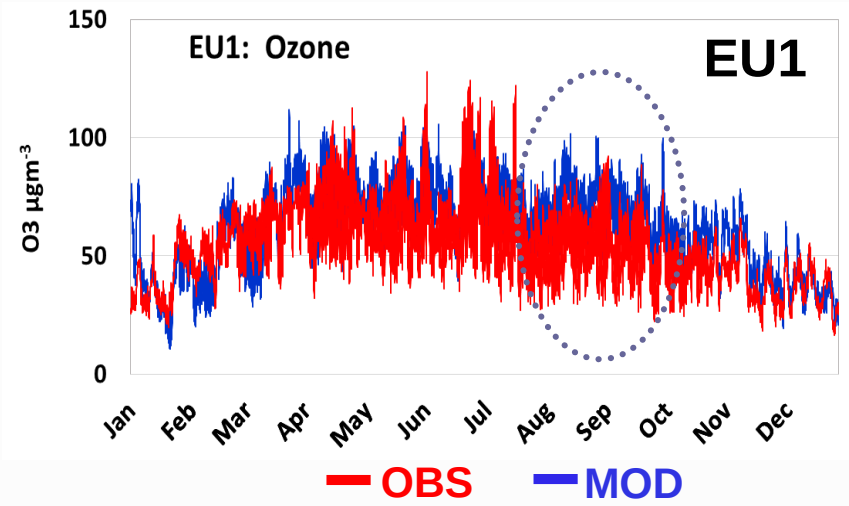
Number of stations (AIRBASE, EMEP):

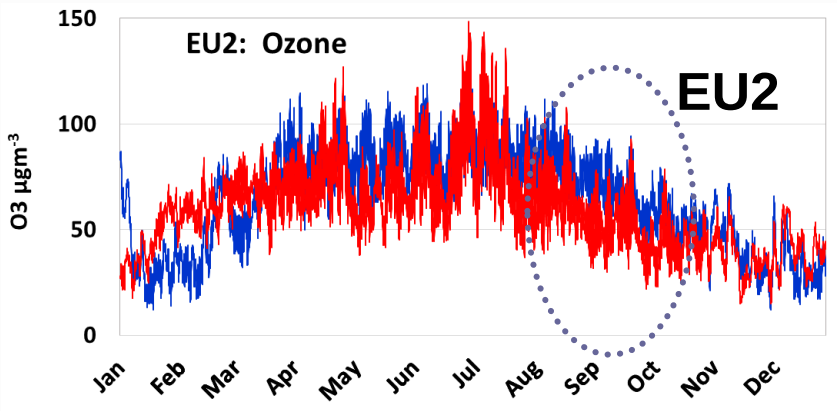
O3 hourly :	100	148
PM10daily:	46	129

O3 (μgm^{-3}) time series

EU1 & EU2 : ozone is overestimated

NMB:	EU1	EU2
Annual:	11%	4%
August:	25 %	21%
December	-3%	-19%
PCC:	0.79	0.58





Coupled models: EU wide NMB: - 8% , PCC = 0.86

Im et al, 2015: Atm, Env, 115, 404-420

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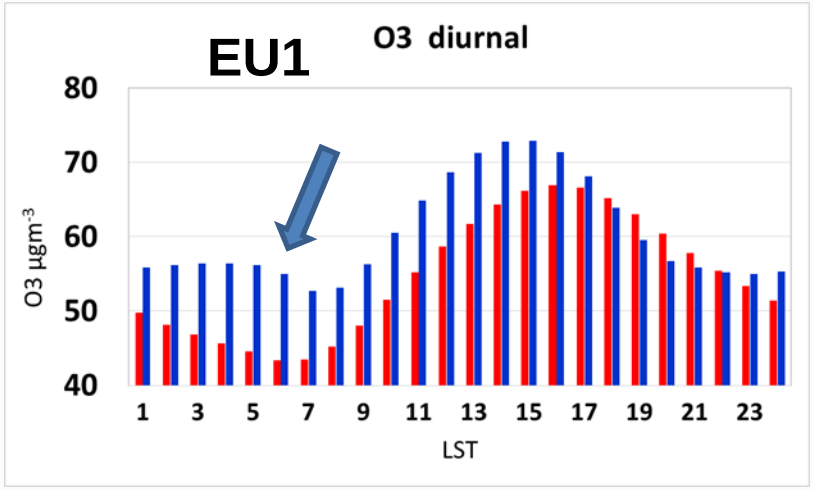
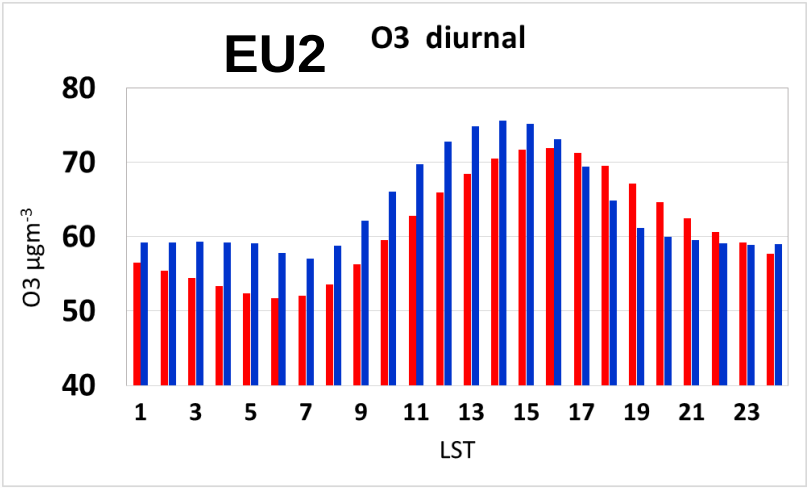
O3 (µgm^{-3}) mean diurnal cycle:

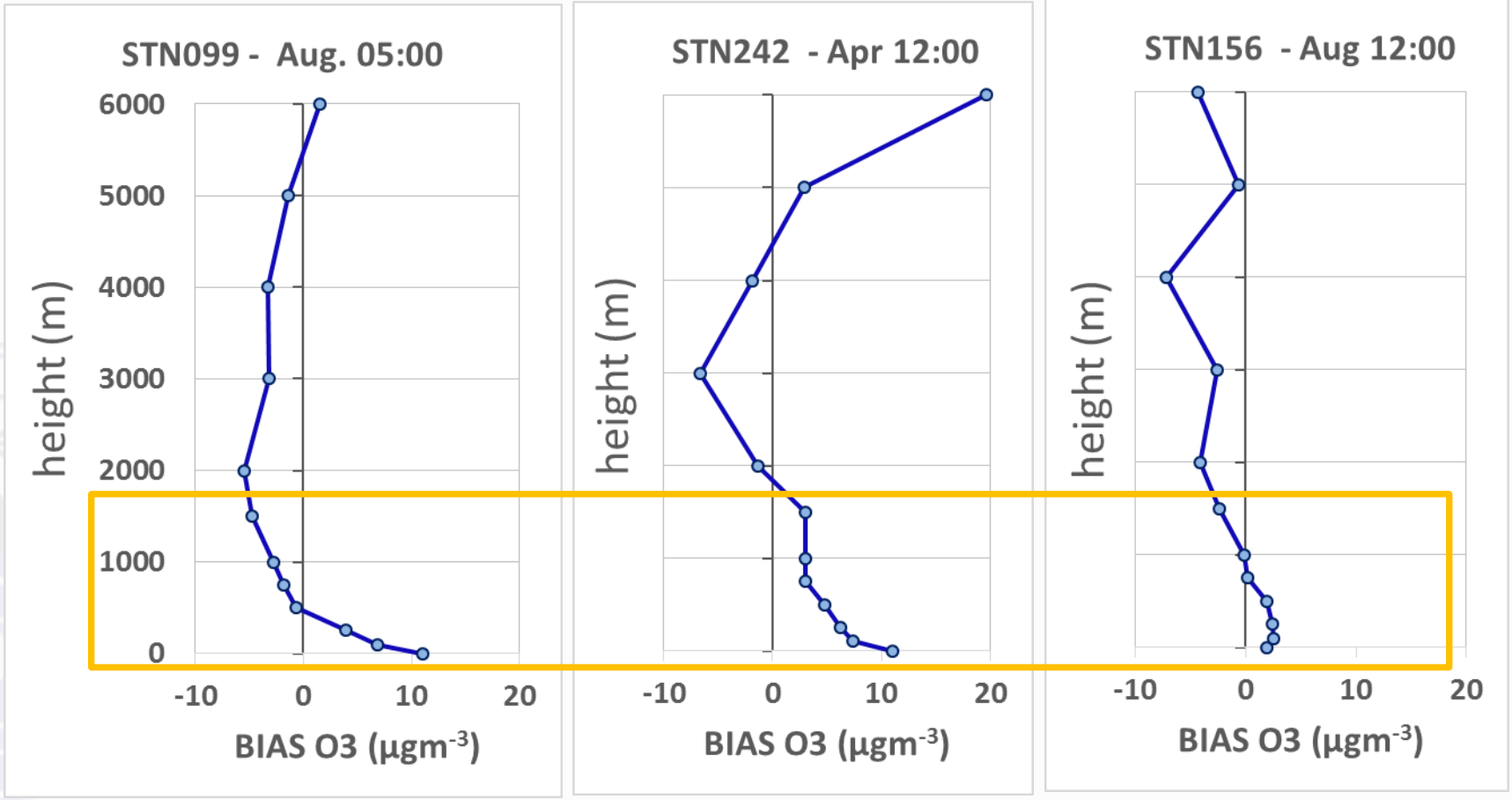
- Night-time overestimation
- Timing of DMAX





Profiles of O3 Mean Bias (Mod-Obs)

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



O3 – overestimated between 500-2000 m

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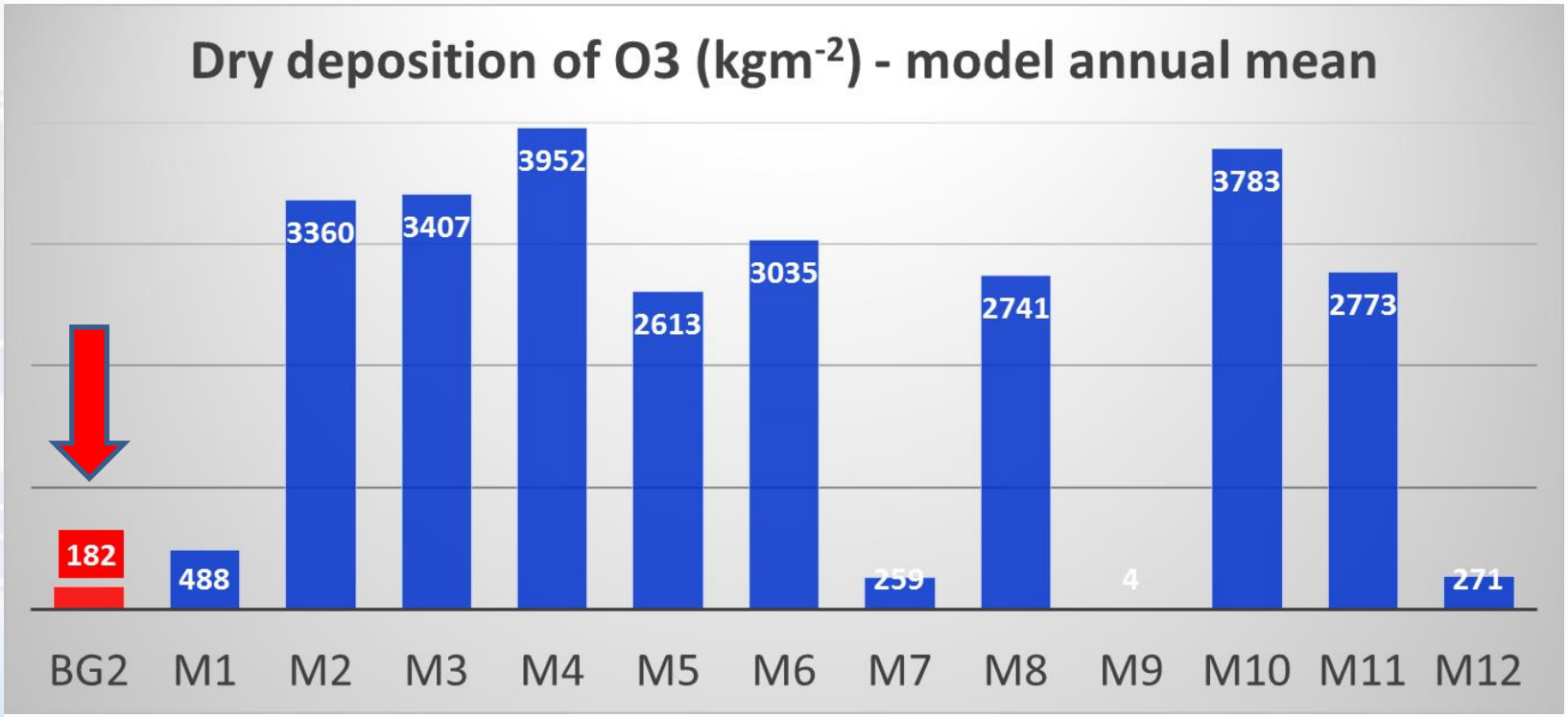
Why O3 overestimation ?

- **Emissions**

  2nd run with NO increased by 30 %
  decrease surface ozone by 7%

- **dry deposition :** lower than other models



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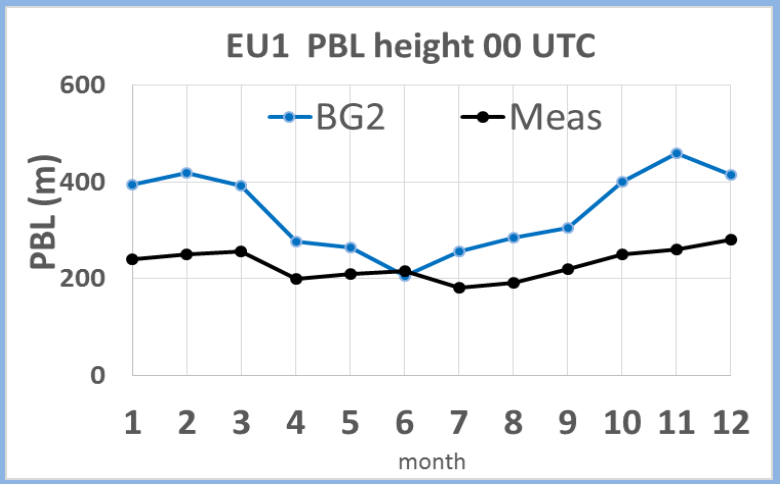
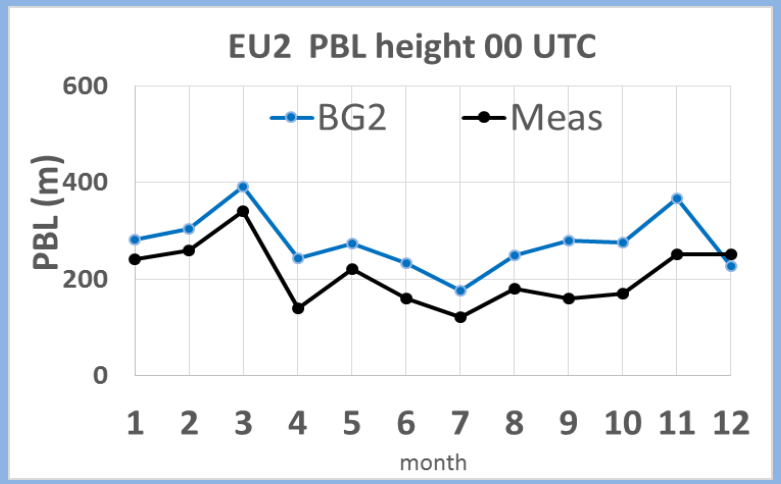
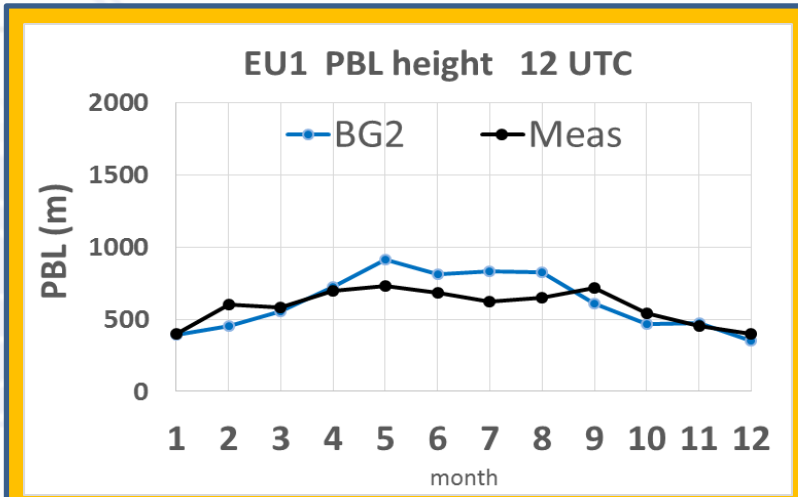
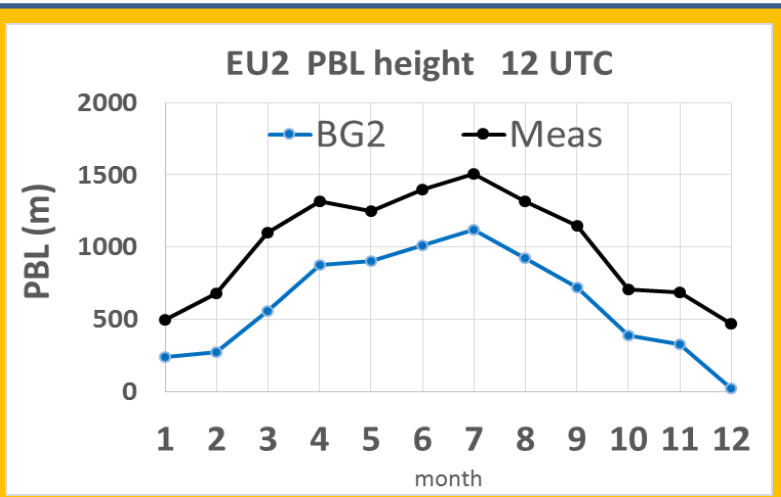
PBL height MOD by WRF-CMAQ and MEAS at sounding sites from Brunner et al, 2015



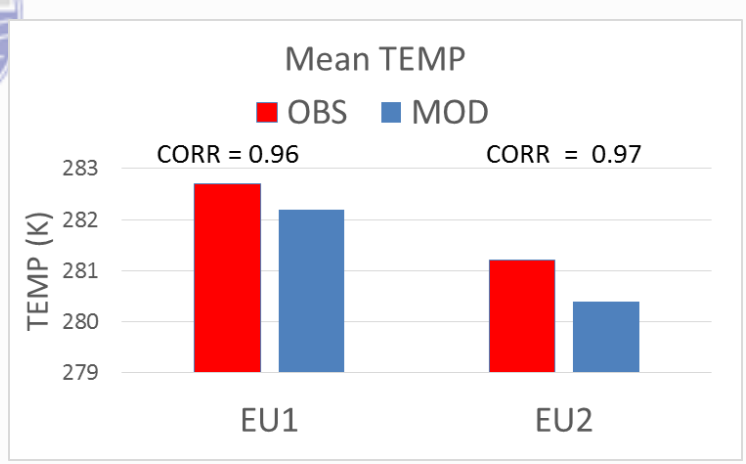


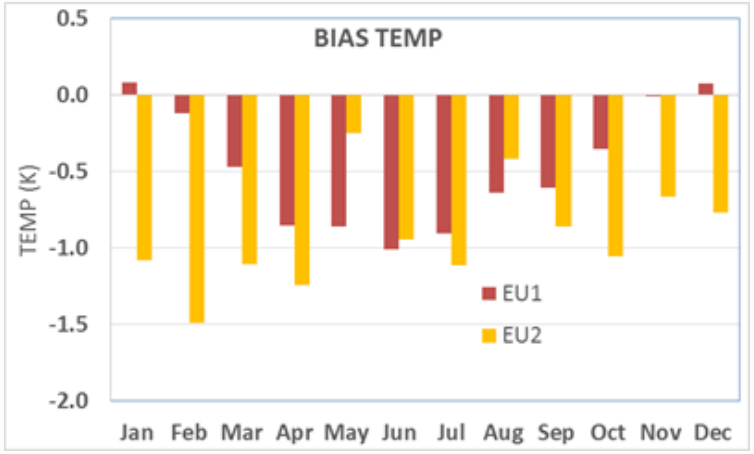


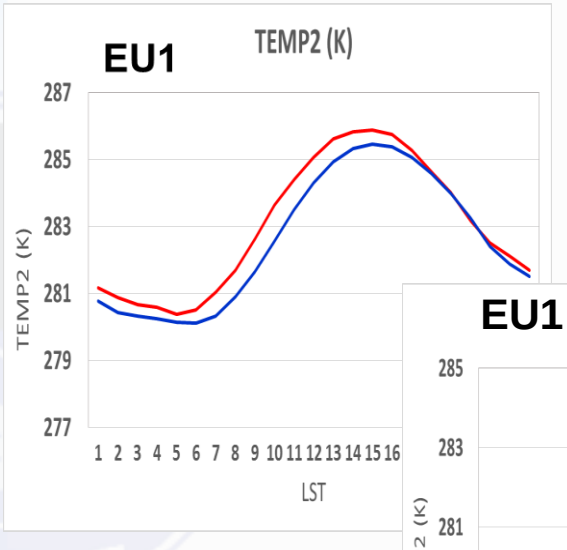


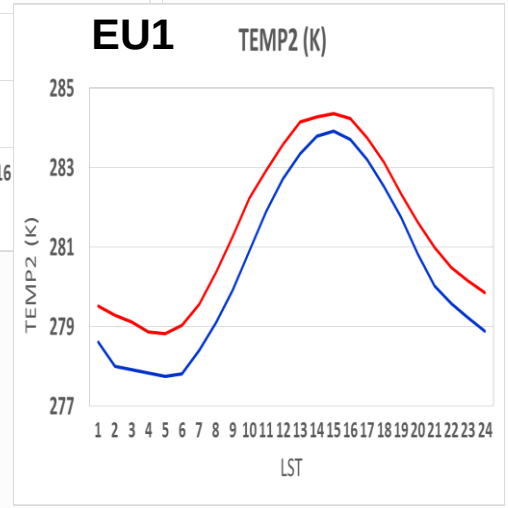
MEAS: *from Brunner et al, 2015: Atm, Env, 115, 470-498*

2m temperature - TEMP









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

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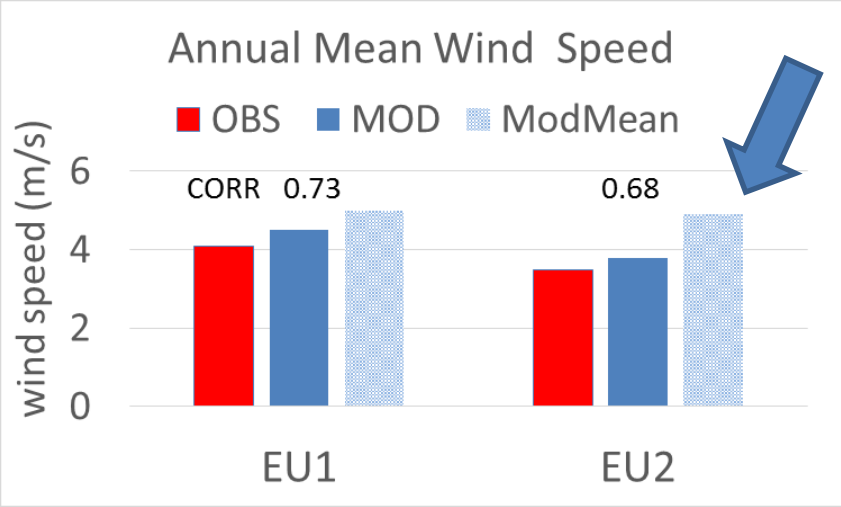
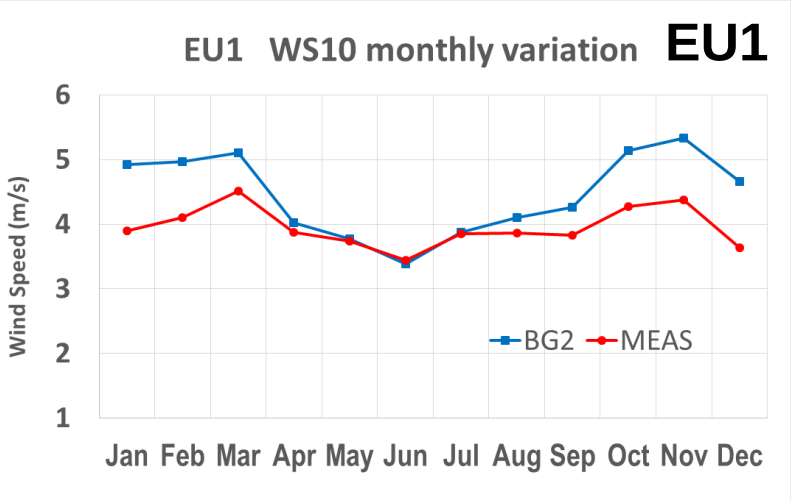
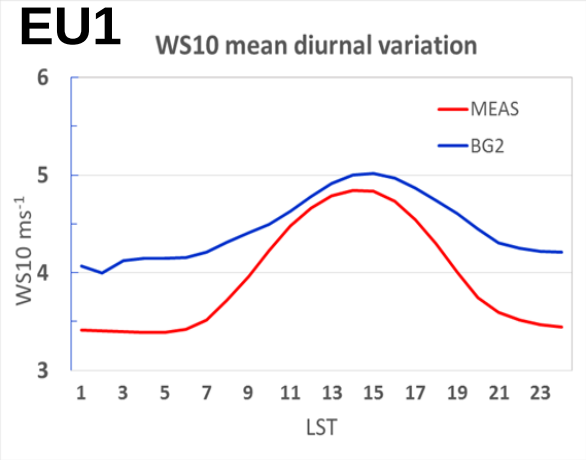
10m - Wind speed (WS10)





diurnal variation WS10



- **WS10 is overestimated by 11% (annual)**
- **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 of coupled models** *(Brunner et al, 2015)*

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PM10 monthly variation

EU1 & EU2 :

underestimation

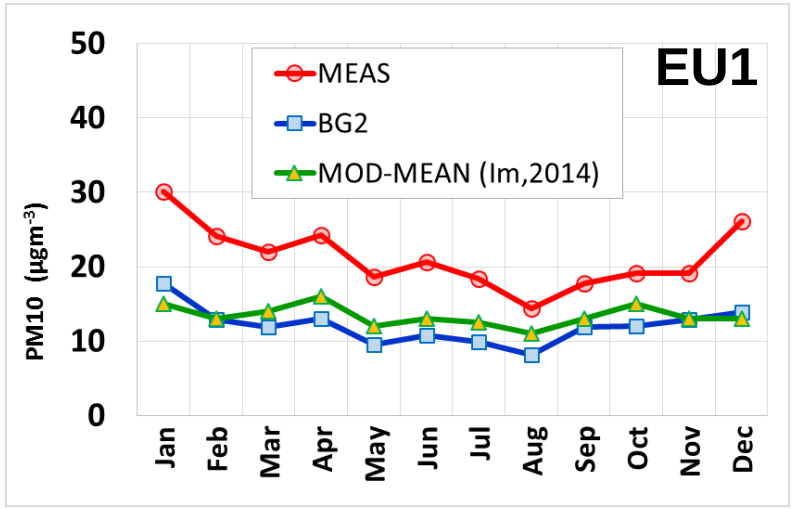
especially in winter

NMB - 43.3% , - 47.3%

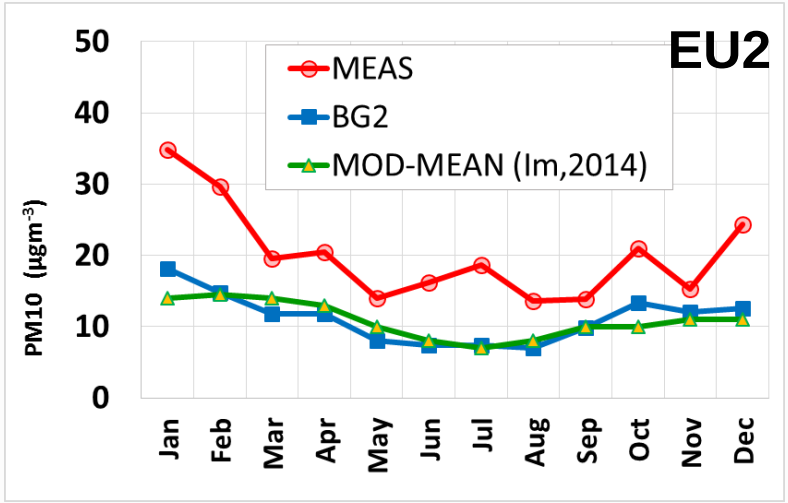
Correlation 0.68, 0.52

Within values by coupled models

- Corr = 0.6, *Im et al, 2015*



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



Im et al, 2015: Atm, Env, 115, 421-441

Summary – main messages

Preliminary *operational model evaluation*:

- **Ozone is overestimated , PM underestimated**
- **Ozone overestimation – likely due weaknesses in deposition and PBL processes**
- **WRF-CMAQ (uncoupled) – similar results to coupled models**
- **Model-intercomparison: very useful**

Acknowledgments: ENSEMBLE team at EC- JRC , AQMEII Community

THANK YOU FOR YOUR

KIND ATTENTION !