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

COST Action TD1105

INTERNATIONAL WG1-WG4 MEETING on

New Sensing Technologies and Methods for Air-Pollution Monitoring

European Environment Agency - EEA

Copenhagen, Denmark, 3 - 4 October 2013

Action Start date: 01/07/2012 - Action End date: 30/06/2016 - Year 2: 2013-2014

Bulgarian participation in the AQ model inter-comparison exercise AQMEII-p2

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COST is supported by the EU Framework Programme

ESF provides the COST Office through a European Commission contract

Scientific context and objectives

- **Background / Problem statement:**

  New sensing technologies such as cost-effective micro-sensors based on gas-sensitive nanomaterials is critical for improving the monitoring of ambient air in urban, rural or remote sites, in traffic on road network. This improvement is important for validation of dispersion models of air-pollutants and evaluation of exposure of population. The model verification and data assimilation techniques applications are expected to improve AQ modeling and Chemical Weather forecast.

- **Brief reminder of MoU objectives:**

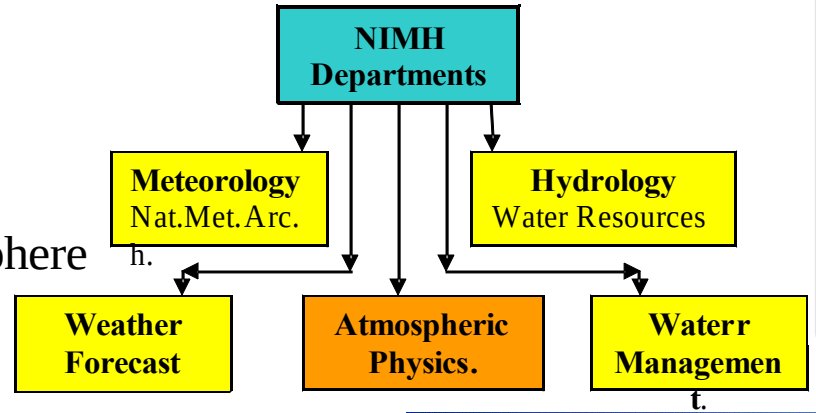
  To monitor real-world environmental conditions with experimental campaigns to assess composition of indoor air (buildings: house and office) and outdoor air (urban areas and industrial sites) and to investigate how such data can be utilized in air pollution modeling;

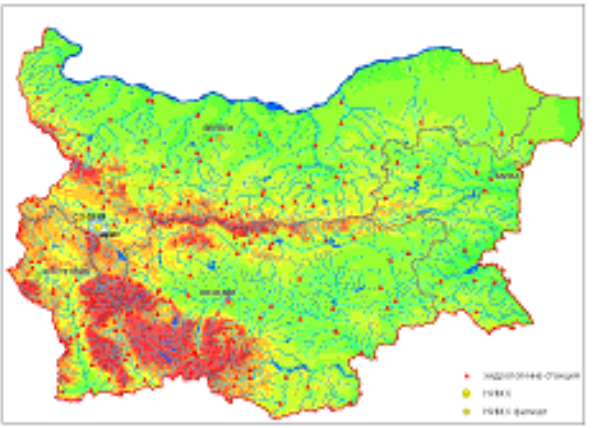
- **Involvement:**

  WG3.2: Air-quality modeling and chemical weather forecasting
  SIG4: Expert comments for the Revision of the Air Quality EU Directive

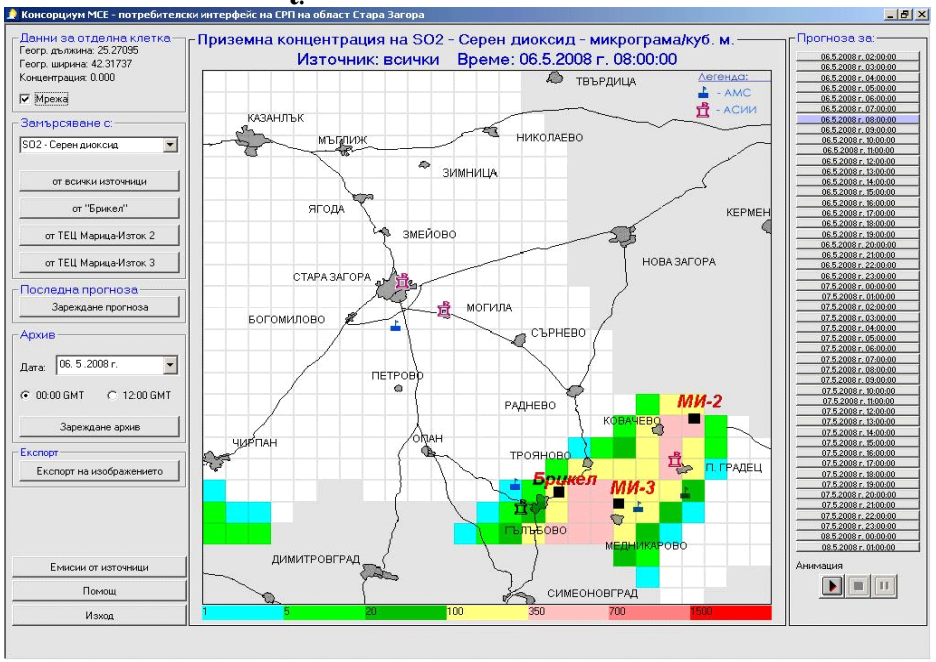
Current activities of the Partner (1/2)

- **Current research topics at NIMH-BAS:**
  - Weather forecast
  - Remote sensing
  - Emergency response
  - Climate, ecology
  - Physics of the atmosphere
  - Hydrological cycle
  - Water management





NIMH's Measurement Network



· Current activities of the Partner (1/2)

- **EuNetAir related ongoing research topics:**

(Performed in the AQ Modeling group of AF Department)

- Creation and management of Early Warning System in Case of Nuclear Accident
- Climate Change Impact Assessment on Air Quality
- Chemical Weather Forecast – creation, managing, improvement and validation of CWFSystems
- Participation in AQMEII Phase 2 Exercise
- Studding and modeling of the Atmospheric Boundary Layer

Facilities available for the Partner (1/1)

- **Research Facilities:**

  The Nuclear Emergency Response and Chemical Weather Forecast group works mainly with computational facilities– computers, printers, plotters, scanners. All necessary data is provided by other parties – meteorological centers (including Bulgarian one), European structures like EEA, EMEP, TNO; American NCEP, US EPA; Bulgarian Ministry of Environment and Waters.

- **List the main facilities**
  - A 48-core cluster (Infiniband link)
  - Two 8-core workstations
  - Three 2-core workstations
  - Two powerful PCs
  - Printers, scanner, notebooks

Participation of NIMH in AQMEII-p2

1. AQMEII exercises

Air Quality Modelling Evaluation International Initiative

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

Regional air quality modelling has undergone considerable development during the last three decades worldwide, due to the increased concern regarding the impact of air pollution on human health and ecosystems. Regional air quality models are now widely used to support the emission control policy, real-time forecasts, and integrated monitoring strategies. Furthermore they are also used in synergy with routine or field campaign observations for research on atmospheric chemistry.

AQMEII aims at promoting research on regional air quality model evaluation across the European and North American atmospheric modelling communities.

AQMEII is coordinated by two chairs, one for North America and the other for Europe. It is supported by the Joint Research Centre/IES, Environment Canada and US-EPA that act as regional focal points.

Participation of NIMH in AQMEII-p2

Objectives of AQMEII:

- **exchanging expert knowledge in regional air quality modelling**
- **identifying knowledge gaps in air quality science,**
- **developing methodologies to evaluate uncertainties,**
- **building a common strategy on model development and future research priorities,**
- **establishing methodologies for model evaluation to increase knowledge on processes and to support the use of models for policy development,**
- **preparing coordinated research projects and inter-comparison exercises.**

Specifics of AQMEII exercises:

- **Common areas for EU/NA (roughly defined)**
- **Common period of simulation (1 year)**
- **Common boundary conditions (GEMS, MACC)**
- **Common anthropogenic emissions (TNO/EPA)**
- **Common set of modeled and observed parameters**
- **Use of ENSEMBLE platform for model estimation**
- **Meteorology and biogenic emissions – free choice**

Participation of NIMH in AQMEII-p2

AQMEII phases

Phase 1 : simulation period 2006; exercise duration July 2009 – October 2010
Phase 2 : simulation period 2010; exercise duration October 2012 – July 2013
For Phase 2 mainly coupled meteorology-chemistry models are desirable.

ENSEMBLE platform

As to make all model results available to all groups, it is decided to use the ENSEMBLE system for data archival and consultation. The system is a web-based platform for model intercomparison and multi-model ensemble analysis with many built-in on-line statistics and graphical tools.
The ENSEMBLE system accepts data in a customized format. Participating groups convert their data in the required format and deliver it to JRC via FTP. Technical Specification Documents (TSDs) are distributed among the participants with detailed instructions.

AQMEII Phase 1 publications

"ENVIRONMENTAL MANAGER" AQMEII Phase 1 Special Iissue – July 2012
"ATMOSPHERIC ENVIRONMENT" AQMEII Special Iissue – v.53, June 2012
Individual publications in AE, BAMS, Air Waste Manag., ACPD, Geosci. MD.

Participation of NIMH in AQMEII-p2

AQMEII – phase 2 **(mainly for on-line Met-Chem coupled models, NIMH participates with off-line models)**

AQMEII-p2 requirements:

Integration period: **1.01.2010 – 31.12.2010**

Simulation regions: **Europe or/and North America (roughly defined)**

Spatial and temporal resolutions: **Participant choice (fit with ENSEMBLE requir.)**

Meteorology: **Participant choice (no special requirement)**

Chemical Boundary Conditions: **MACC data, ftp.cnrm-game-meteo.fr**

Emissions:

A) *Anthropogenic emissions* – TNO inventory for 2009, ~7×8 км resolution
B) *Biogenic emissions* – calculated by participating models
C) *Wild Fire Emissions* – data base of FMI, 0.1°×0.1° resolution
D) *Sea-salt Emissions* – use of the mechanism built in the participating CTM

Temporal, Vertical and Speciation emission profiles: **provided by TNO**

Participation of NIMH in AQMEII-p2

2. NIMH task setting

A. Models and domain used

***Models*: The US EPA Models-3 modeling system is used, consisting of**

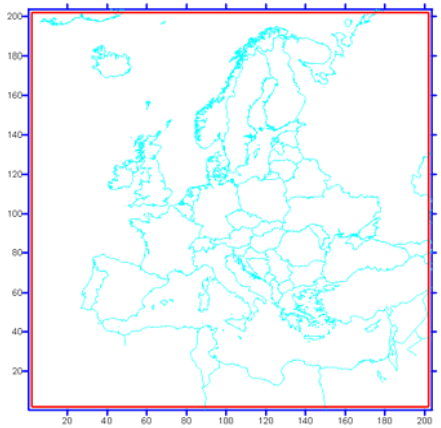
- **CMAQ - (Community Multi-scale Air Quality model), the chemical-transport model (CTM) – the most important part of the System;**
- **WRF - Weather Research and Forecasting Model, the meteorological pre-processor to CMAQ;**
- **SMOKE (Sparse Matrix Operator Kernel Emissions Modelling System) – emission pre-processor to CMAQ.**

In addition FORTRAN programs and Linux Scripts created and used

Simulation domain: **Europe**

NIMH grid

Projection: Lambert
True latitudes: 30° и 60°
Main meridian: 13°
Central point: (13°,51°)
Dimensions: 201×201
Grid step: 25 км



Participation of NIMH in AQMEII-p2

B. Meteorology

Meteorology: **NCEP-GFS (global data, 1°×1° resolution, 6 h frequency, free)**

All data files for 2010 downloaded from the GFS-server.

The data directly drives **WRF** model.

C. Boundary conditions

Meteorological Boundary Conditions

As meteorology is global there is no need of meteorological boundary conditions

Chemical Boundary Conditions (BC): **MACC (Europe, 1.125°×1.125°, 3 h)**

All MACC data files for EU downloaded (packed as decades).

Mapping of pollutants MACC –> CMAQ done.

Horizontal and vertical interpolation coefficients calculated.

Transformation code prepared and all 365 BC files created and archived.

Participation of NIMH in AQMEII-p2

3. Emission sources and modeling

A) ***Anthropogenic:***

TNO emission inventory file downloaded.
Special GIS web-based system created for interpolation to the **CMAQ** grid
Gridded data is input to **AEmis** and **PEmis** FORTRAN codes
Time allocation and speciation (**SOx, NOx, VOC, PM2.5**) is performed.
In **PEmis** vertical allocation takes place as well.

B) Sea-salt and Biogenic:

Ocean-land-surf_zone file produced.
Sea-salt emission option of **CMAQ** switched on.
Biogenic emissions calculated by **SMOKE** based on the current meteorology and **USGS** land use.

C) Wild Fire:

FMI data for all 365 days downloaded. Total PM [kg/s] is the only pollutant

PM splitting

Fire PM [kg/s]	PMC	PM2.5	PEC	PMFINE	PNO3	POA	PSO4
SF [g/s]	260	-	118.4	35.52	1.48	569.8	14.8

Gas splitting

Fire PM [kg/s]	CO	NH3	NO	SO2	ALD2	ETH	FORM	NR	OLE	PAR
SF [moles/s]	242.857	4.706	5.667	0.891	0.025	1.673	4.117	3.693	0.358	9.313

After temporal and vertical allocation fire emissions added to the LPS emissions

D) ***Emissionin input to CMAQ:*** AS-, LPS- and BgS-files merged by **SMOKE.**

Participation of NIMH in AQMEII-p2

4. Calculations, archiving

Preminaly activities:

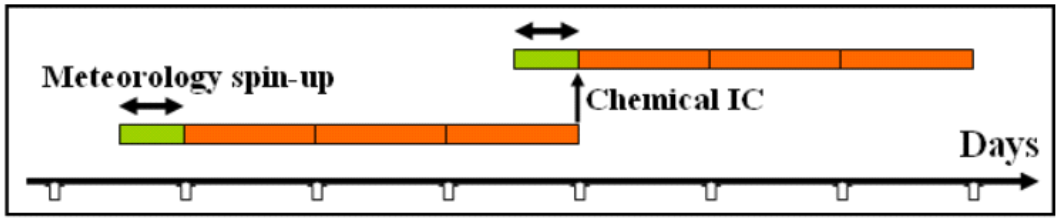
- CMAQ source code changed as to output 3D extinction coefficients (for AOD)
- Archiving scripts prepared for extracting required parameters – meteorology from MCIP output; chemistry from CMAQ output, emissions from emiss.files
- Needed parameters described in a number of TSDs, distributed by JRC.
- Meteorological parameters archived in 3-day files
- Chemistry and emissions – in 1-day files
- All data saved in 1-hour basis.

IMPORTANT:

Not all required chemical variables supported by CB-IV of CMAQ 4.6.
Not all required meteorological parameters supported by MCIP.

Computations: 64-core server used; 1-day simulation lasts 0.5 hours.
Together with calculations archiving takes place.
All simulation archive bigger than 1 TB (files in NetCDF format)

Computational scheme:



Participation of NIMH in AQMEII-p2

5. Post processing

The post processing is made after a number of TSD distributed by JRC.

Three steps:

1. **From the archived data Model-Output-File (MOF) produced (1 per pollutant)**
2. **MOF treated by ENFORM program (distributed by JRC)**
3. **"Enformed" data-file zipped and uploaded to JRC's FTP-server**

The AQMEII team in JRC treated these data and uploads it to ENSEMBLE storage

Types of TSD:

# of task (TSD)	Description	Number of pollutants
0311-001	AQMEII2 EU Grid - Concentrations and meteo	33
0311-002	AQMEII2 EU Grid - Depositions	20
0311-003	AQMEII2 EU Grid - Emissions	14
0312-001	AQMEII2 MOZAIC FRANKFURT - Vertical profiles	14
0316-001	AQMEII2 EU RECEPTORS - Gas phase	15
0316-002	AQMEII2 EU RECEPTORS - Aerosol	19
0316-004	AQMEII2 EU RECEPTORS - Ozonesondes	6
0316-006	AQMEII2 EU RECEPTORS - AERONET	4
		125

Participation of NIMH in AQMEII-p2

Preliminary results using ENSEMBLE platform (noted as BG1)

Aim: Comparison of model results to observations

- only rural stations chosen below 1000m
- O3 values for the summer period August - September
- PM10 values for the whole year
- Three sub-domains chosen:

1st Region (Reg1) - Balkan peninsula: only 7 rural stations)

2nd Region (Reg2) – Central Europe: 168 stations for O3 and 162 for PM10
3rd Region (Reg3) – EMEP stations (without Scandinavia):
75 stations for O3 and 40 for PM10

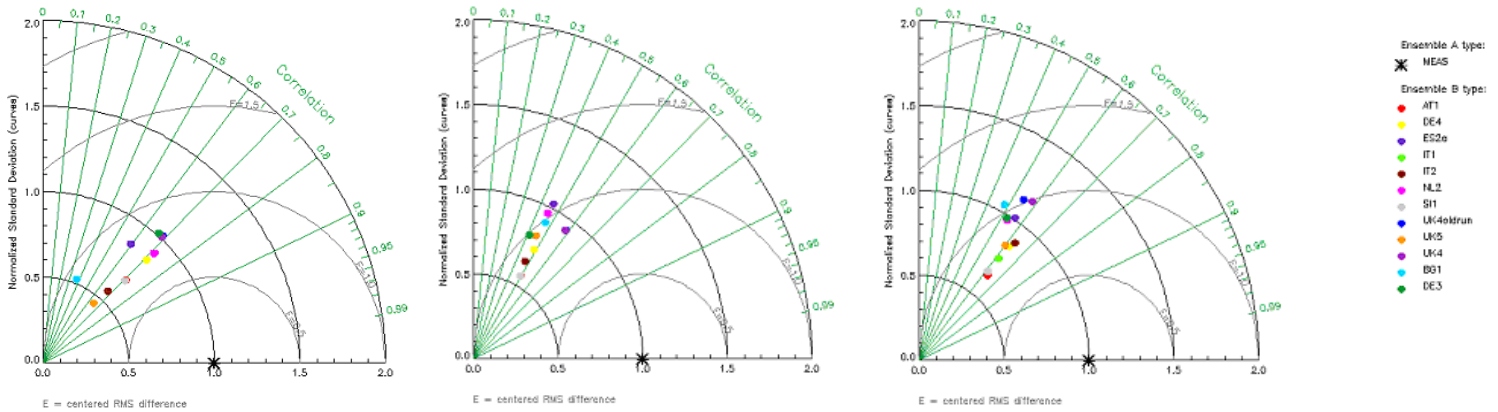
Reg1 is of special interest for Bulgaria

Participation of NIMH in AQMEII-p2

***Task* 0316-001 "AQMEII2 EU RECEPTORS - Gas phase"**

OZONE Daily Maxima (O3DMAX)

Taylor diagrams



Reg1 **Reg2** **Reg3**

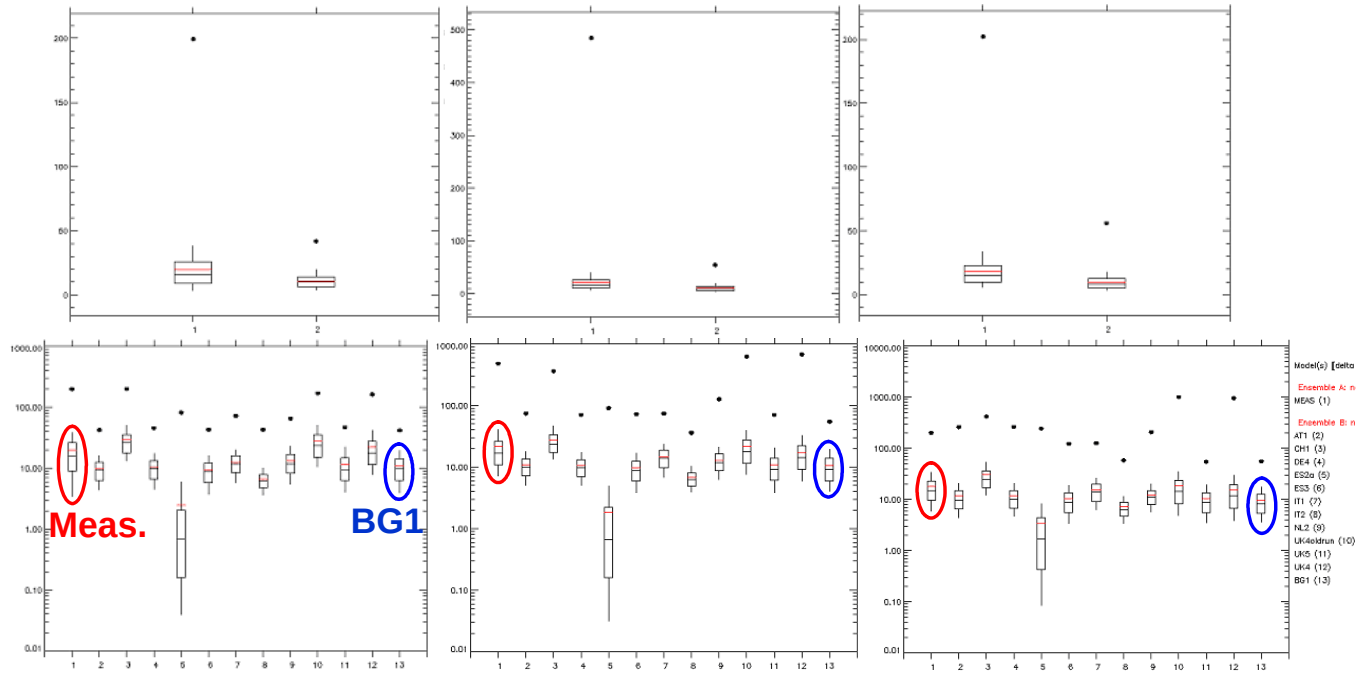
- **BG1 (cyan dot) improves the performance from Reg1 to Reg3, however is very low, especially for the Balkan region (PCC ~ 0.3).**
- **To note the relatively low correlation coefficient at EMEP stations (Region3) for all models (PCC around 0.5 - 0.6).**
- **BG1 overestimates mean O3DMAX (50% for Reg1, 16% for Reg3)**
- **The standard deviation is twice smaller as the observed ones for Reg1.**

Participation of NIMH in AQMEII-p2

Task 0316-002 "AQMEII2 EU RECEPTORS - Aerosol"

PM10 Daily Mean values

Box-Whisker plots

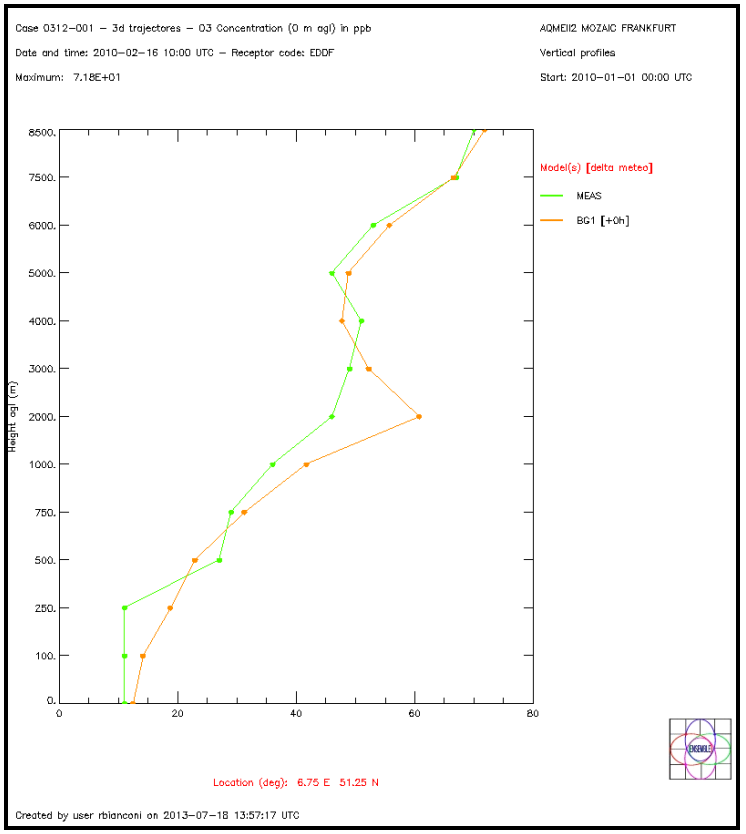


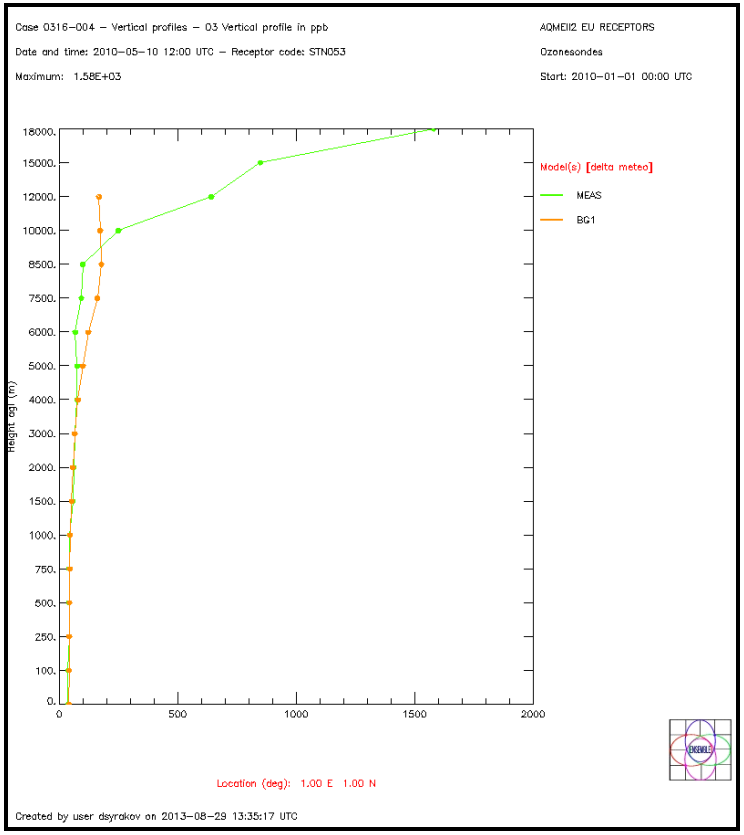
- BG1 simulates well the mean annual PM10.
- the maxima of daily PM10 are heavily underestimated (4 times).
- The BG1 mean daily values are lower than the observed ones.
- BG1 does not differ much in the mean values from other models.

Participation of NIMH in AQMEII-p2

***Task* 0312-001 "AQMEII2 MOZAIC FRANKFURT - Vertical profiles"**
***Task* 0316-004 "AQMEII2 EU RECEPTORS - Ozonesondes"**

Ozone vertical profiles





CONCLUSIONS and Future activities

CONCLUSIONS

- **BG1 model results - in line with other models (not an "outlier").**
- **O3 – model performance is disappointing (PCC= 0.6 at EMEP stations & overestimation), worse results with respect to other simulations in Reg1.**
- **PM10 – although significantly underestimated (50%) BG1 is one of the best among all models (correlation 0.45).**
- **BG1 captured the temporal variability better than other models both for gases and aerosols.**
- **O3 Profiles – good performance but not enough studied.**
- **The Balkan Region (Reg1) – has severe PM pollution problems, but observations are still limited (as number of stations and type of observations).**
- **Exercises like AQMEII using ENSEMBLE platform capabilities are quite useful for better understanding of the situation.**

FUTURE ACTIVITIES

- **Detailed analysis of NIMH simulations using ENSEMBLE platform**
- **Analysis of many different pollutants (gaseous and aerosols), profiles, integral quantities like AOD.**

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