Regional modelling and assessment of atmospheric particulate matter concentrations at rural background locations in Europe

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Challenges in meteorology 6
15 – 16 November, Zagreb, Croatia
Related conducted research..

• The increased concentrations of particulate matter (PM) - associated with significant impact on human health (Anderson, 2009; Heal et al., 2012; Jeričević et al, 2016; Samet et al., 2000; Samoli et al., 2005; Peters et al., 2001; Pope et al., 2002).

• The elevated PM concentrations in the atmosphere - effect on the ecosystem (acidification, eutrophication) and visibility (Putaud et al., 2010).

Consequently – affect on cloud formation, radiation -> strong climate forcer

• Influence on Earth’s balance - radiative effects and cloud processes (Prank et al, 2016)

• Air quality models - significant role in the assessment and management (Ritter et al, 2012)

• Variety of AQ models: EMEP, LOTOS, SILAM, CMAQ, CAMx, WRF-Chem, ... etc

• General underestimation of PM mass with large scale models (Vautard et al, 2007).

• WRF-Chem good comparison with measurements (Tucella et al, 2012), overestimation of wind speed -> underestimation (AQMEII)

• EMEP – general underestimation, improvementst in ic/bc (Techincal report 1/2016)
Monitoring data

Number of exceedance days
year 2011; LV = 50 [μg/m³]

320 rural background stations
Monitoring data

Daily concentration

Stations

Days

Concentration [ug/m^3]

MI6
15 – 16 November 2018, Zagreb, Croatia
Monitoring data

EPISODE 1: 5 – 9 Nov

920 meteo stations
Monitoring data

EPISODE 2: 12 – 16 Nov

Identification of three episodes

• Episode 1: 5 – 9 November
• Episode 2: 12 – 16 November
• Episode 3: 26 – 30 November
AQ modeling

- **WRF-Chem model** *Weather Research and Forecasting with Chemistry module*
- Domain properties
  - SETUP: 18x18km 01.10. – 30.11.2011.
  - IC/BC - FNL (GFS) reanalysis 1°x1°; dt=6h
- EMISSIONS
  - Anthropogenic - EDGARv4
  - Initial/boundary conditions: from previous runs
  - Setup: Morrison double-moment cloud microphysics

- **EMEP model**
- **ECMWF** meteorology data (Integrated Forecast System);
  - SETUP: dt = 3h; vertical levels = 20 levels; dx,dy=50km
- EMISSIONS
  - Anthropogenic (aircraft, shipping, VOC, SO2, NOx, CO, PM)
  - Biogenic (calculated from landuse) – NMVOC, DMS,
    Lightning, Volcanoes
AQ modeling

Wind speed, average; Cabauw

Wind speed, average; Karlsruhe

WRF

EMEP

R

BIAS

VALIDATION
AQ modeling

Station categories
- < 200 m Sea – level (Flat)
- 200 < 500 m Elevated (Moderate)
- 500 < m Mountain (Complex)

- wind speed
- temperature
- surface pressure

WRFChem  EMEP
AQ modeling

Station categories

- < 200 m Sea – level (Flat)
- 200 < 500 m Elevated (Moderate)
- 500 < m Mountain (Complex)
AQ modeling
AQ modeling

EMEP, 05.11.2011

Conc

Pressure

WS

Temp

PBLH

06.11.2011

BIAS

IOA

r

RMSE

NMSEsys

NMSEunsys

Sea-level  Elevated  Mountain
AQ modeling

Measurements vs Model
AQ modeling

WRF-Chem, Episode 2

12.11.2011
13.11.2011
14.11.2011
15.11.2011
16.11.2011

Conc
Conc - Nov
Pressure
WS
Temp
PBLH
AQ modeling

12.11.2011

13.11.2011

EMEP,

Conc

Pressure

WS

Temp

PBLH

BIAS

IOA

r

RMSE

NMSEsys

NMSEunsys

Sea-level

Elevated

Mountain
Summary

**AQ models**
- Significant underestimation of background PM mass concentrations
- Station differentiation according to station height was found (Tørseth et al, 2012)
- Decrease of model performance with the height (AQ, meteo)
- Overall, better performance in terms of all analysed statistical parameters obtained with the EMEP model
- Notable differences in wind speed and temperature (IC/BC)
- Differences in PBL dynamics between model (PBLH)
- Wind speed higher in WRFChem model
- Horizontal resolution – impact on spread of surface concentrations -> statistical performance

**Future work**
- longer periods of simulations for both models in order to make a comparison in various meteorological conditions.
- simulations with WRF-Chem will include more accurate emission inventory on higher resolution.
- model intercomparison focus on other species (NOx, SOx, PM compounds, O₃, etc)