PRELIMINARY EVALUATION OF CMAQ MODELLED WET DEPOSITION OF SULPHUR AND NITROGEN OVER BULGARIA

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ABSTRACT

Wet depositions of sulphur and nitrogen by the WRF-CMAQ modelling system are compared to observations for the region of Sofia.

36 precipitation samples were collected and chemically analysed for the period March-June 2016.

Sulphate is prevailing for the whole period (share of 34%), following by nitrate (share of 25%).

The precipitation amount on a monthly basis is overestimated by the model (average NMB 70%), thus a precipitation adjustment using observed values is applied as post-processing of CMAQ output data.

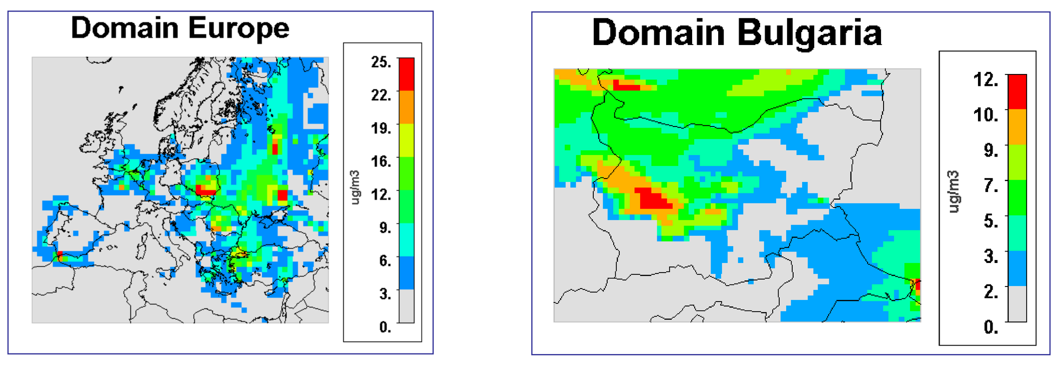
This correction leads to improvement of simulated monthly depositions, especially for sulphur (NMB 9%). The effect on nitrogen deposition is not so clear, as the correction leads, in general, to underestimation of nitrogen depositions.

Back trajectories for two selected periods with high sulphate concentrations suggest importance of emissions at local and regional scale.

METHODOLOGY

Model: WRF - CMAQ

- WRF v.3.3 - Driven by NCEP-GFS global model (1° x 1°, 6h); Analysis nudging; 27 vertical levels.
- CMAQ v. 4.6 - CB4, wet deposition – RADM (Chang et al., 1987), 14 vertical levels.
- Emissions -TNO-MACC inventory 2009 (7-8 km resolution) + BG national inventory for 2010
- Precipitation adjustment of mod. deposition (Appel etal.,2007)
- Deposition: Ndep = NO_3^-, NH_3, NH_4^+, NO, NO_2
  Sdep = SO_4^{2-} and SO_2.
- 3 nested domains from EU (Δ=81km) to Bulgaria (Δ= 9 km)

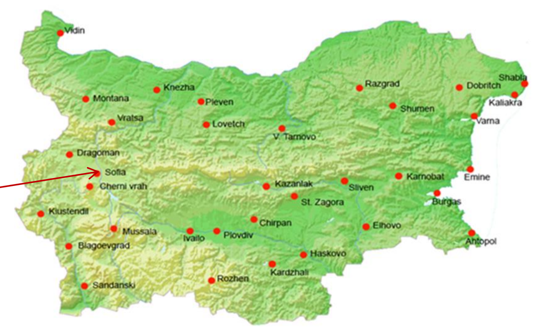


Daily mean SO_2 – 20.02.2012

Observational data

- Sampling site - Central Meteorological Observatory Sofia (42.655N, 23.384E,586m a.s.l.)
- Precipitation sampling periods – 24h (at 8:00 LST), March-June 2016
- Wet only precipitation collector WADOS (Kroneis GmBH)
- pH meter 7110 WTW and Cond 7110 WTW
- Chemical analysis for Cl^-, SO_4^{2-}, NO_3^-, Ca, Mg, K, Na, Fe, NH_4^+ by Ion Chromatograph (ICS 1100, DIONEX), ICP OES (Vista MPX CCD Simultaneous, VARIAN) and Spectrophotometer S-20.

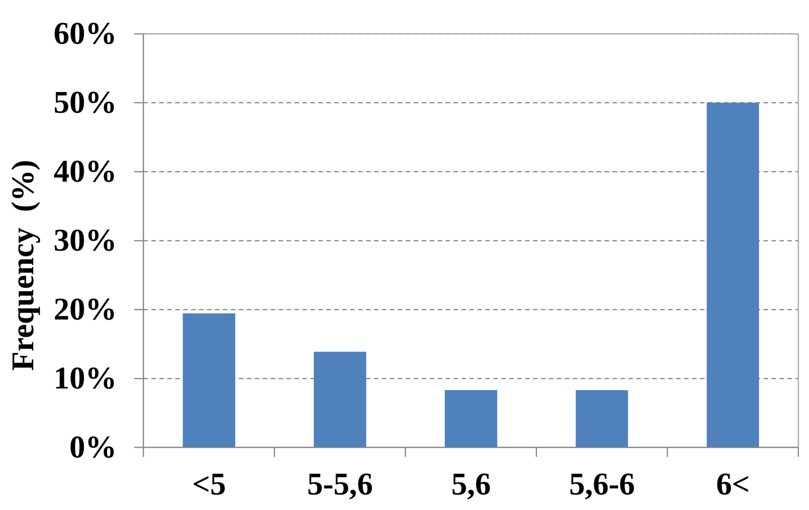
Automatic samplers for wet and dry deposition (WADOS - Kroneis GmBH)



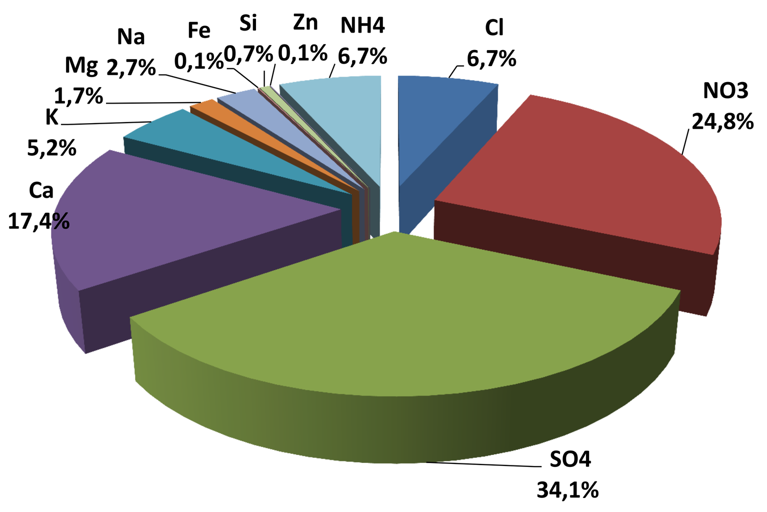
Precipitation chemistry network of NIMH

RESULTS

Observation data



Frequency analysis of pH in wet deposition



Percent contribution of individual ions to total ionic composition

•pH values for the period from March to June 2016 are in the range 4.7 - 7.6.

•33% are in acidic range (below 5.6) and 58% are in alkaline range.

•Only 8% of precipitation events are in neutral range.

•The contribution of sulphate and nitrate (the acidifying components) is 34.1% and 24.8%, respectively. 33.8% of the total ionic mass is on alkaline cations (NH_4^+, Ca, Mg, K, Na, Fe).

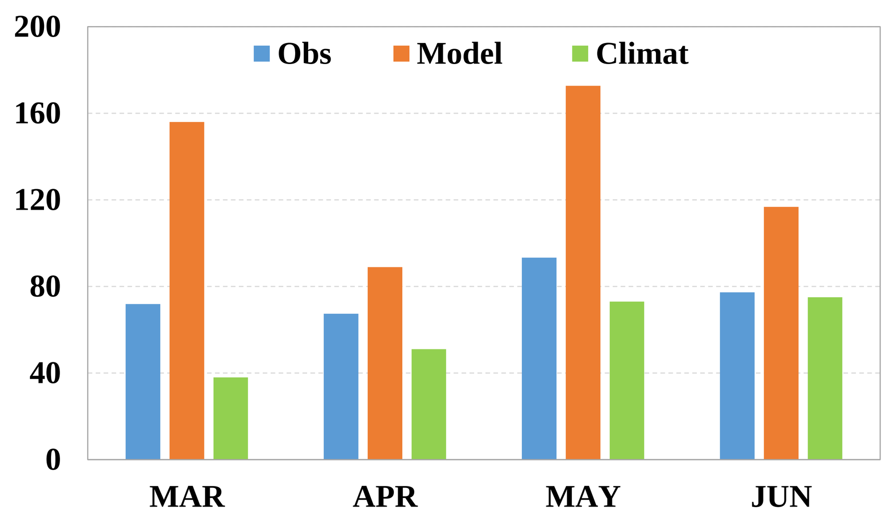
•The concentration of main anions and cations in precipitation samples follows the order:

SO_4^{2-} > NO_3^- > Ca > NH_4^+, Cl^- > K > Na > Mg > Si > Fe, Zn

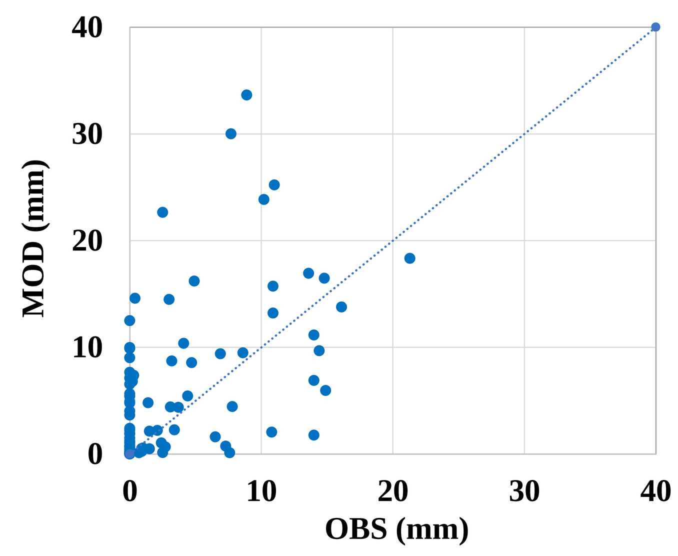
Precipitation

Precipitation (Q) adjustment for model WDEP as post- processing:

*WDadj = WDmod*Qobs/Qmod*



Monthly precipitation (mm) for Sofia



Scatter plot of daily precipitation

•Whole period marked by precipitations above the climate values.

•Model overestimation, more significant in April and May, model variability higher than the observed.

•Average NMB - 70.1%, maximum value for March – 117%.

•Average correlation coefficient for daily values - 0.59, lowest value for June (0.1).

Monthly accumulated wet depositions (mgm^{-2}) of N and S

•CMAQ modelled wet depositions – two data sets: MOD (without Qadj) and MODa (with Qadj)

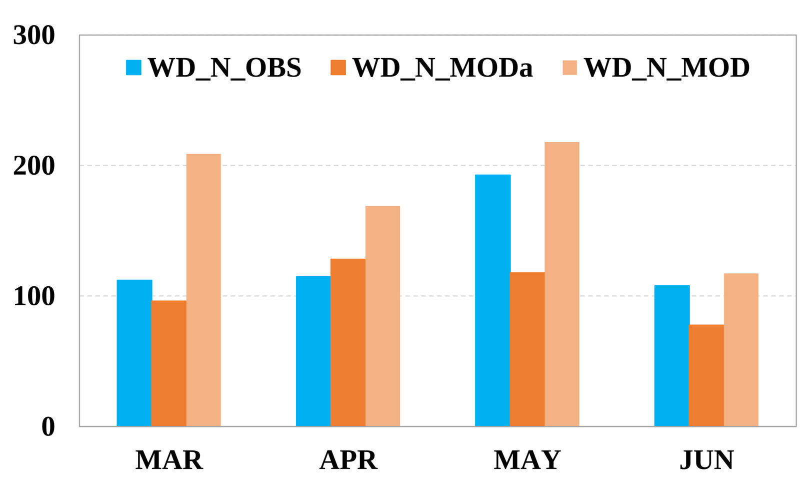
•MOD - overestimates observed wet deposition - average NMB of 87% for sulphur and 39% for nitrogen

•MODa –wet deposition is closer to observed ones on monthly basis.

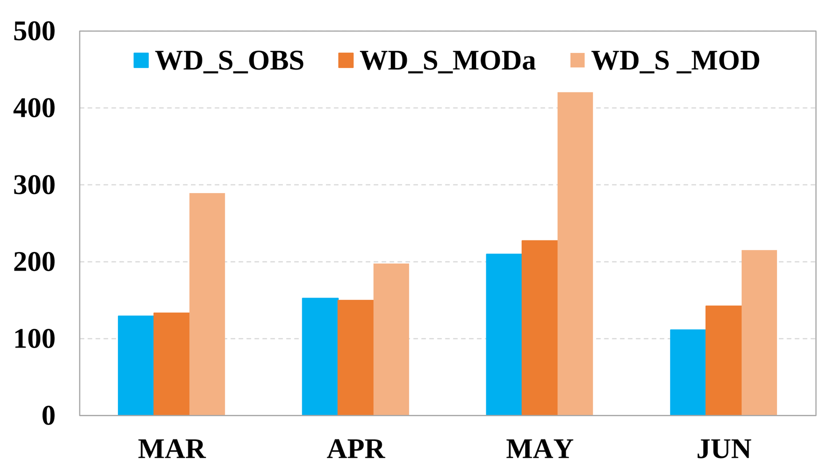
S-deposition - mean NMB is reduced significantly (9%),

N-deposition – mean NMB of -17%.

•The precipitation adjustment - clear positive effect on S-deposition, while not so for N-deposition.



Nitrogen deposition (mgm^{-2})



Sulphur deposition (mgm^{-2})

Long-range effects for two selected periods

•The first case period - from 02.03 to 13.03.2016.

•The weather - passage of Mediterranean cyclones south of the country towards east .

•Sulphate obs wet dep 76 mgm^{-2}

•pH range 4,6 – 5,6

•HYSPLIT back-trajectories – flow from S-SE

•HYSPLYT trajectory frequency - influence of emissions at national and regional scale.

•The second case period – from 09 to11.04.2016

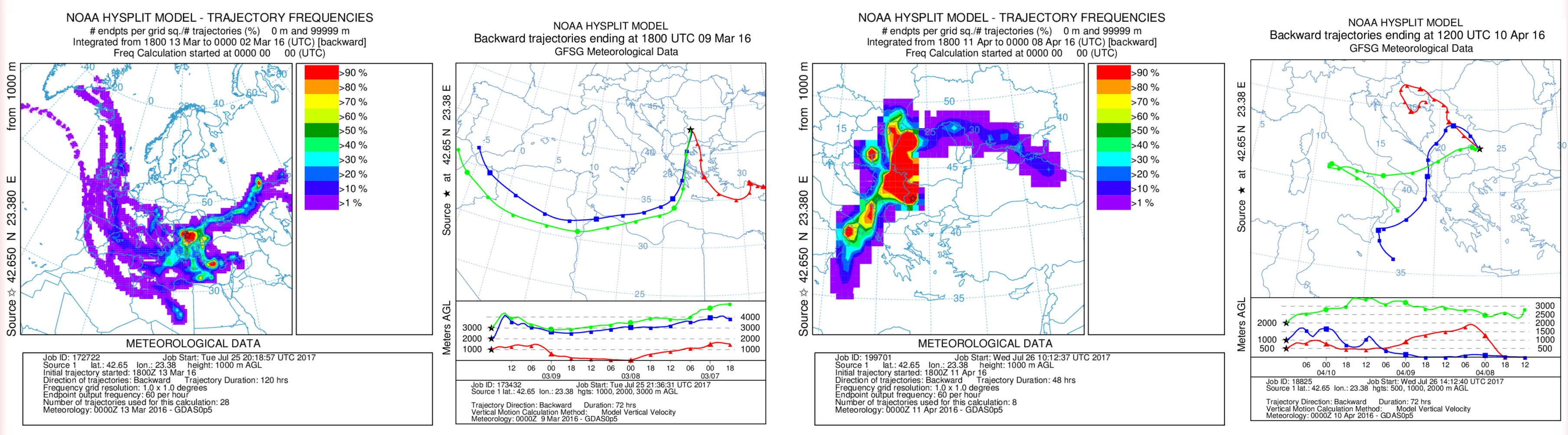
•The weather – cyclone over the Balkans

•Sulphur obs wet dep - 60 mgm^{-2}

•pH below 5.0

•HYSPLIT back-trajectories - flow from NW and W

•HYSPLYT trajectory frequency - influence of emissions from western Balkan countries.



CONCLUSIONS

- CMAQ estimated monthly wet depositions of S and N overestimate observed ones for the region of Sofia.
- CMAQ with precipitation adjustment improves model performance, especially for sulphur depositions.
- Sulphate is prevailing in precipitation samples for the studied period (March – June 2016).
- Preliminary analysis of two selected periods indicates influences of both local and regional emission sources.
- CMAQ resolution has to be improved for Sofia region.
- Precipitation amount is only one of the factors determining wet deposition. Further studies on combining observations and CMAQ model results are necessary to study the relations between emissions, transport and depositions.

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HARMO18

18th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, 9-12 October 2017, Bologna, Italy