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Motivation

- Acidifying substances (SO_4^{2-} , NO_3^- , NH_4^+) – cause damage to human health, ecosystems, buildings and materials.
- Emissions of SO_2 have fallen in EU, thus NO_x and NH_3 relative contribution is higher.
- **SE Europe is still a hot spot for SO_2 emissions.**
- Lack of observations in this region of Europe

Aims and Hypothesis

- To check model performance for sulphur, reduced and oxidized nitrogen wet depositions at two close but different sites analysing daily values.
- **Main hypothesis** - the transboundary transport of atmospheric pollutants has significant contribution to the deposition of acidifying substances on the territory of Bulgaria.

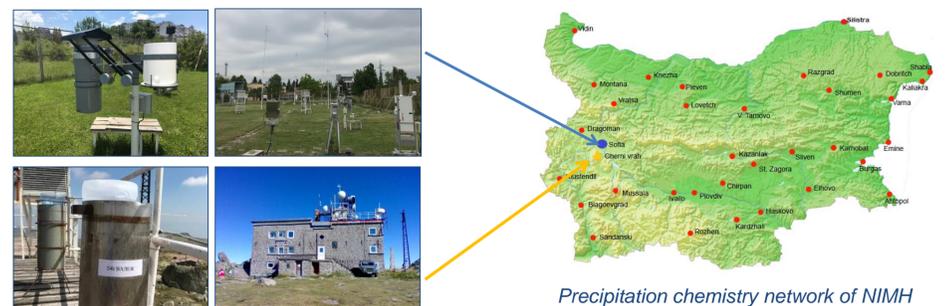
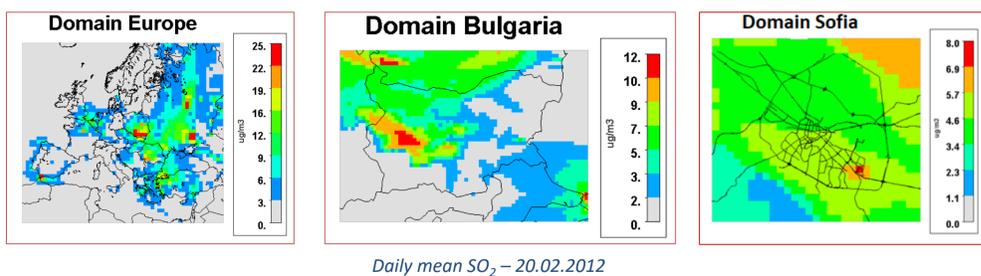
Methodology

Model: WRF - CMAQ

- WRF v.3.3 - Driven by NCEP-GFS global model ($1^\circ \times 1^\circ$, 6h); Analysis nudging; 27 vertical levels.
 - CMAQ v. 4.6 - CB4, wet deposition – RADM, 14 vertical levels.
 - Emissions -TNO-MACC inventory 2009 (7-8 km resolution) + BG national inventory for 2010
 - Precipitation Bias Adjustment (PBA) for Wet Depositions
- $$WD_{mod}^{adj} = WD_{mod} \cdot (PR_{obs}/PR_{mod})$$
- Deposition: $N_{ox} = \text{NO}_3^-$, NO , NO_2 ; $N_{red} = \text{NH}_3$, NH_4^+ , $S = \text{SO}_4^{2-}$ and SO_2 .
 - 3 nested domains from EU ($\Delta=81\text{km}$) to Bulgaria ($\Delta=9\text{ km}$)

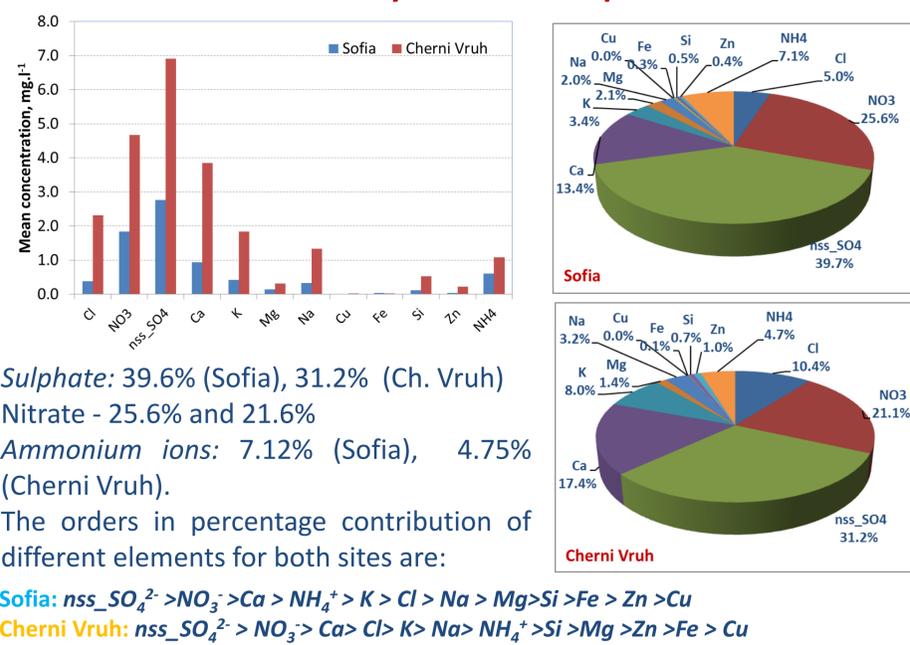
Observational data

- Sampling sites:
Central Meteorological Observatory **Sofia** (42.655N, 23.384E, 586m a.s.l.) and High Mountain Observatory - **Cherni vrach** (42.616 N 23.266 E at 2230 m a.s.l.)
- Precipitation sampling periods – 24h (at 9:00 LST), period June – Dec 2017
- 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.

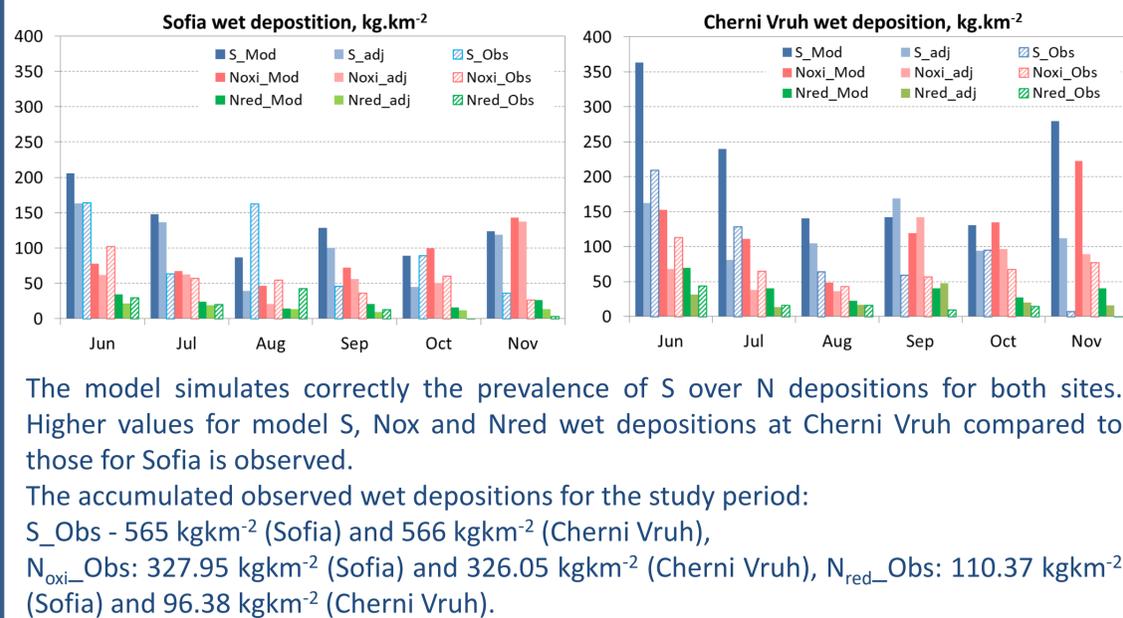


Results

Chemical analysis of the samples

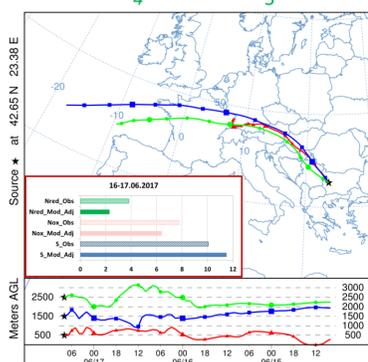


Comparison between model and observed wet depositions

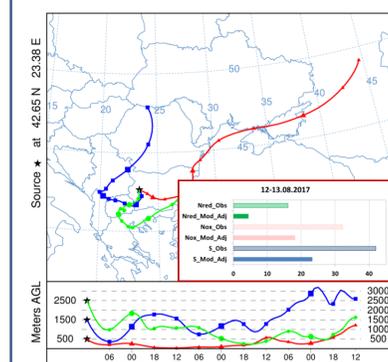


Long range effects for some selected periods – HYSPLIT BTs and comparison of daily WD

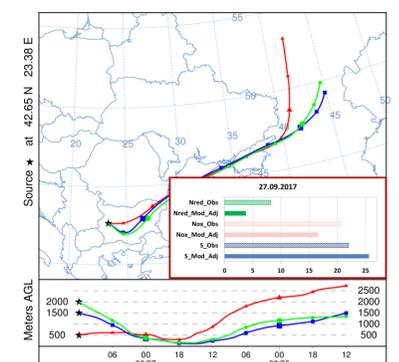
16-17.06.17 – high concentrations of SO_4^{2-} and NO_3^-



12-13.08.17 - unusually high concentration of K



16-17.06.17 - elevated levels of Cu



Number of fires in the period 09-13.08.2017 over SE Europe. Data from VIIRS 375 m, cloud cover by MODIS Terra on 13.08.2017 (<https://firms.modaps.eosdis.nasa.gov/>)

CONCLUSIONS

- The BgCwFS has been set up for calculations of deposition fluxes in Bulgaria.
- The simulated wet depositions have been compared to observed depositions from two stations – Sofia (urban) and Cherni vruch (mountain).
- $nss_SO_4^{2-}$ is found to be the dominant anion in precipitation samples for both sites
- The correction PBA has been applied as post processing to simulated monthly wet depositions and showed positive effect, especially for sulphur depositions.
- Results for wet deposition of S, N_{oxi} and N_{red} for 3 selected synoptic situations have been discussed. The simulated daily S wet deposition slightly overestimates the observed ones for both sites.

Acknowledgments

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