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Improvements to the WRF-Chem model for quasi-hemispheric simulations of aerosols and ozone in the Arctic

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Motivations

• Improve WRF-Chem’s performance compared to recent intercomparisons (AMAP, 2015) in order to study aerosols and ozone in the the Arctic (long-range transport, local sources).

• We identify missing processes in WRF-Chem 3.5.1, update the model, and evaluate the corrected model in the Arctic.

WRF-Chem model setup

WRF-Chem 3.5.1 simulations, 1 March 2008 to 1 August 2008

• MOSAIC aerosols (cloud chemistry and SOA), SAPRC-99 gas-phase chemistry

• Morrison 2-moment microphysics

• KF-Cup cumulus parameterization

• Noah Land Surface Model

• MOZART boundary and initial conditions

• Nudging to NCEP FNL

Results - aerosols in the Arctic

Effect of the updates on zonal mean PM10 in the Arctic (60°N – 90°N, April-July average)

- KF_UP_CHEM changes are mostly due to increased wet removal by cumuli

- NOAH_SEAICE reduces sea ice skin temperatures, increasing stability over sea ice, reducing vertical mixing.

Evaluation against mean rBC profiles from the ARCTAS campaigns (2008)

- BC RMSE reduced by 28 % (spring) and 50 % (summer), due to KFCUP_CHEM.

Evaluation against surface measurements in the Arctic

- BC RMSE reduced by 38 %, sulfate RMSE by 21 %.

- KFCUP_CHEM and NOAH_SEAICE have the largest impact on BC.

- DMS improves RMSE at all stations except Zeppelin

Results - ozone in the Arctic

Effect of the updates on surface O3 (April-July average)

- KFCUP_CHEM: increased vertical mixing of O3 and precursors, higher surface O3

- NOAH_SEAICE: reduced vertical mixing, lower surface O3

- SNOWDEP & SNOWPHOT: reduced dry deposition and increased photolysis rates, higher O3.

Evaluation for surface O3 in the Arctic (17 stations, lat > 60°N)

- RMSE reduced by 15 % (mostly due to SNOWDEP, SNOWPHOT and KFCUP_CHEM).

Main conclusions

• Model updates reduce RMSE significantly (-10 % to -50 %) for all datasets. Large improvements for BC, especially during summer.

- NOAH_SEAICE (improving skin temperatures over ice and stability) and KFCUP_CHEM (including cumulus cloud interactions with aerosols and gases) have the largest effect on aerosols.

- Improved deposition and photolysis over snow (SNOWDEP & SNOWPHOT) have a large effect on ozone.

• Halogen chemistry and detailed DMS gas-phase chemistry, as wells as higher resolutions are needed to improve results further.

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