Helmholtz Climate Initiative

Regional Climate Change

Analysis of the WRF-Chem simulations for the AQMEII phase2 exercise with respect to the aerosol impact on precipitation

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Introduction

Online coupled meteorology air quality models have become increasingly popular during the last decade. In order to evaluate the performance of these models the COST action ES1004 EuMetChem and the second phase of the AQMEII (Air Quality Model Evaluation International Initiative; http://aqmeii.jrc.ec.europa.eu/) model inter-comparison exercise focused on online coupled meteorology-chemistry models.

In total about 20 groups participated in the second phase of AQMEII. Among others, seven of the participating groups contributed simulations with WRF-Chem (Grell et al., 2005) for Europe. Results of this small ensemble are analyzed here.

Setup of the WRF-Chem simulations

Simulation	SI2	SI1	DE4	AT1	ES1	IT2	IT1	ES3
Version	3.4.1	3.4.1	3.4.1	3.4.1	3.4.1	3.4 with 3.5 VBS	3.4.1	3.4.1
Microphys.	Morrison	Morrison	Morrison	Morrison	Lin	Morrison	Morrison	Morrison
Gas chem.	RADM2	RADM2	RADM2 Integ1mod	RADM2	RADM2	RACM	CBMZ	CBMZ
Inorg. aerosol	MADE	MADE	MADE	MADE	MADE	MADE	MOSAIC 4bins	MOSAIC 4 bins
Org. aero	SORGAM	SORGAM	SORGAM	SORGAM	SORGAM	VBS	-	-
GS wet.dep	Simple	Simple	Easter04	Easter04	Easter04	Easter04	Simple	Easter04
Conv. w.dep	yes	yes	yes	yes	yes	yes	yes	yes
GS aq. chem	-	-	WT86	FP01	FP01	WT86	-	FP01
Conv. aq.ch	WT86	WT86	WT86	WT86	WT86	WT86	-	-
Aero dir eff	No	Yes	Yes	Yes	Yes	Yes	No	Yes
GS aero indir effect	No	No	Yes	Yes	Yes	Yes	No	Yes
Other								No dust

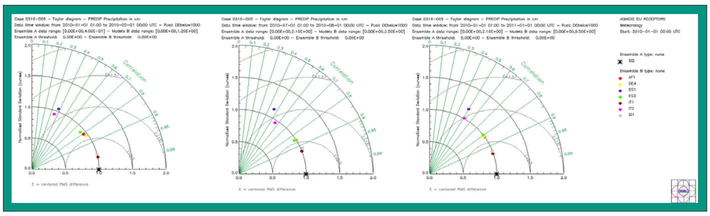
WRF-Chem simulations

According to the common simulation strategy for AQMEII phase2, the entire year 2010 was simulated as a sequence of 2-day time slices. Each of these time slices was preceded by a 1 day spin-up.

For better comparability, the seven groups using WRF-Chem applied the same grid spacing of 23 km and 270x225 grid cells, 33 levels, and shared common pre-processing and emissions.

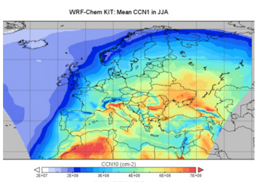
The simulations differ among each other by the chosen chemistry option, aerosol module, cloud microphysics, and by the degree of aerosol-meteorology feedback (i.e. no aerosol feedback, direct aerosol effect only, and direct plus indirect aerosol effect) that was considered.

Results and analysis



Taylor diagrams of precipitation over Germany for January 2010, July 2010, and the entire year 2010. The case SI2, which does include neither the direct nor the indirect effect is considered as baseline case.

As compared to the baseline case SI2 without any aerosol radiative feedback, the inclusion of the direct aerosol effect (case SI1) results only in a very small effect on the precipitation over Germany. The additional inclusion of the indirect aerosol effect (AT1,DE4, and ES3 vs. IT1) was found to slightly reduce the total precipitation. These deviations from the baseline case are smaller than differences due to the application of a different cloud microphysics scheme (ES1) or a different aerosol physics scheme (IT2).



Simulated precipitation for the baseline case compares moderately to well with the GPCP 2.5° gridded observational data set and the 25 km resolution E-OBS (http://www.ecad.eu) data set. Inclusion of the aerosol effect on cloud microphysics resulted in increased precipitation for regions with low CCN concentrations.

The increase of the precipitation over the Atlantic was the most persistent effect and occurred during all seasons when aerosol cloud interactions were included. Inclusion of the direct aerosol effect only had almost no effect on the simulated precipitation except for the Russian forest fire episode in 2010.

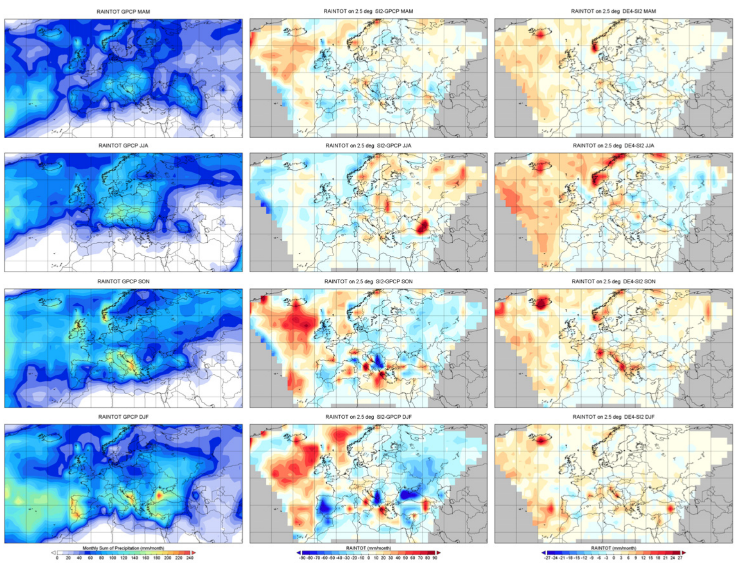
Over the entire modeling domain spatial correlations between observations and simulations for case including aerosol cloud interactions were similar to the baseline case. Inspection of the large scale patterns shows a slightly better agreement with observations over land when aerosol effects are included during summer.

Correlation coeff. vs. GPCP

Season	SI2	DE4
D-J-F	0.764	0.762
M-A-M	0.851	0.843
J-J-A	0.893	0.901
S-O-N	0.801	0.800

Correlation coeff. vs. E-OBS

Season	SI2	DE4
D-J-F	0.655	0.667
M-A-M	0.778	0.781
J-J-A	0.842	0.844
S-O-N	0.748	0.747



Left column: Seasonal precipitation merged from satellite and gauge data of the Global Precipitation Climatology Project (GPCP, http://lwf.ncdc.noaa.gov/oa/wmo/wdcamet-ncdc.html). Center: Difference between simulated precipitation for case SI2 re-gridded to 2.5° and GPCP data. Right: Difference of seasonal precipitation between a case including and without aerosol cloud interactions.

Summary

Strong impact of aerosol cloud interactions on cloud water content and precipitation pronounced indirect aerosol effect on radiation for high and also for very low aerosol concentrations.

There is no 'best' setup, feedback does not improve the results at all times. Differences depend on the parameters of the 'base case', the considered region, and season.

A complete analysis of the indirect effect will require simulations with higher resolution or aerosol awareness in convective precipitation scheme.

For the applied horizontal resolution, the impact of aerosol feedbacks on pollutant distributions was frequently smaller than the effect of the choice of the chemistry mechanism and aerosol module, and microphysics scheme.

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ES1004 EuMetChem

AQMEII