Helmholtz Climate Initiative

Regional Climate Change

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Topic 9

The impact of aerosol effects on meteorological fields and regional pollutant distributions - A case study with WRF/Chem

R. Forkel[1] (renate.forkel@kit.edu), J. Werhahn[1], G. Grell[2], S. McKeen[2], S. Peckham[2], P. Suppan[1]
[1] Karlsruhe Institute of Technology, IMK-IFU, Kreuzeckbahnstr.19,Garmisch-Partenkirchen, Germany
[2] National Oceanic and Atmospheric Administration, Earth System Research Lab., Boulder, USA

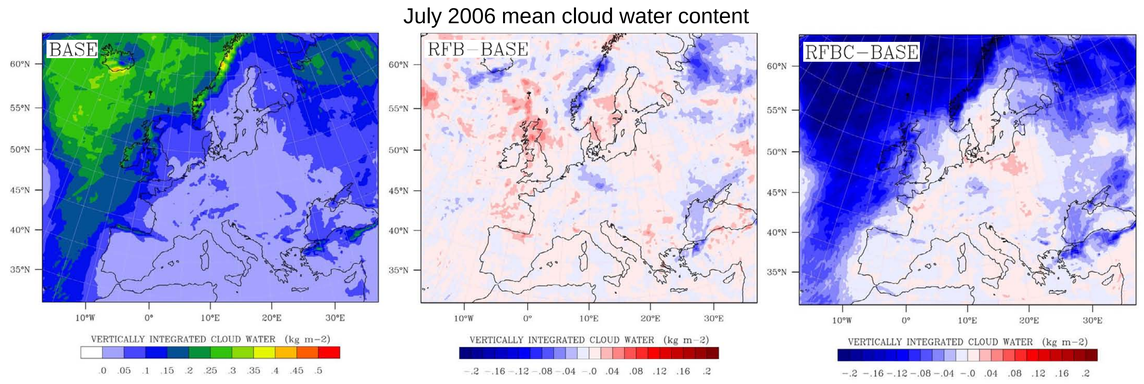
Introduction

Atmospheric aerosol particles are known to affect weather and climate via several pathways. Fully coupled “online” meteorology-chemistry models provide the possibility to account for feedback mechanisms between simulated aerosol concentrations and meteorological variables. Simulations with the online coupled model WRF/Chem were carried out to investigate the impact of the direct effect of aerosol particles on radiation and the indirect aerosol effect on meteorological variables and subsequent distributions of near surface ozone and PM_{10} over Europe.

Case study results

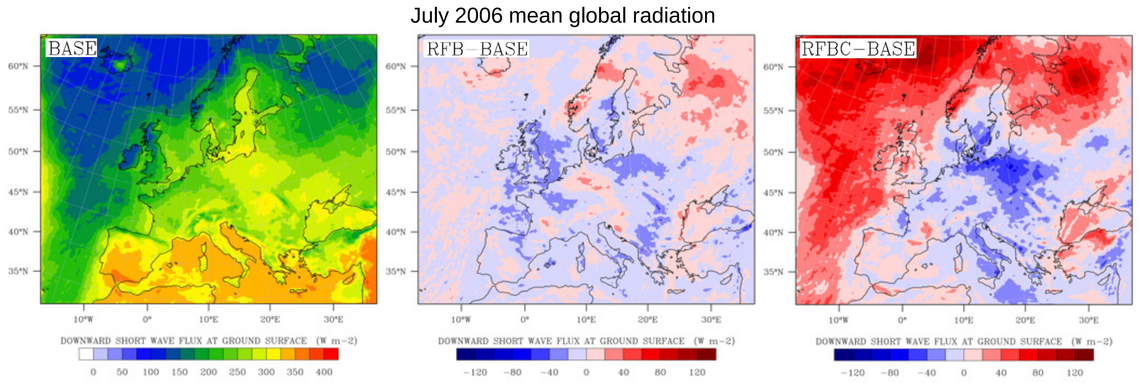
Case	Description
BASE	Baseline case; without any aerosol feedback effect
RFB	Direct aerosol-radiative effect and semi direct effect
RFBC	Direct aerosol-radiative effect + indirect aerosol effect (semi-direct effects and second indirect effect included)

July 2006 mean cloud water content

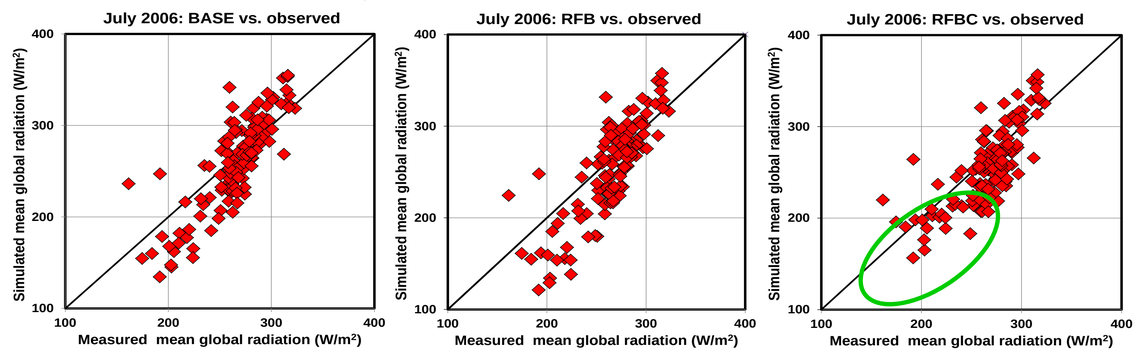


- Semi-direct effects (temperature, boundary layer, clouds) dominate the direct effect.
- Semi-direct effects develop at a timescale of several weeks.
- Indirect effect results in a lower cloud water content and a higher rain water content.
- Better agreement between observed and simulated solar radiation over Europe for cloudy conditions by including the indirect effect.
- Choice of boundary conditions has large effect on indirect effect over the North Atlantic and only minor effect over Europe

July 2006 mean global radiation



Comparison of observed and simulated solar radiation



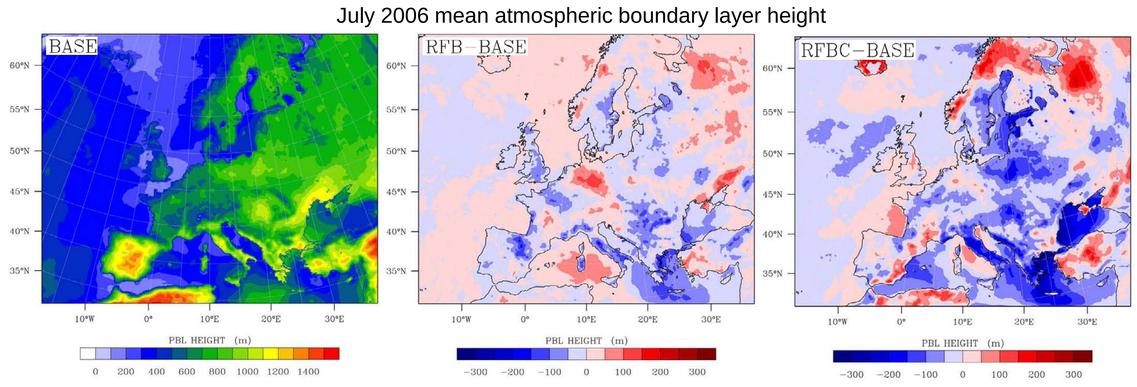
Model description and setup

Community model WRF/Chem (Grell et al., 2005, 2011).

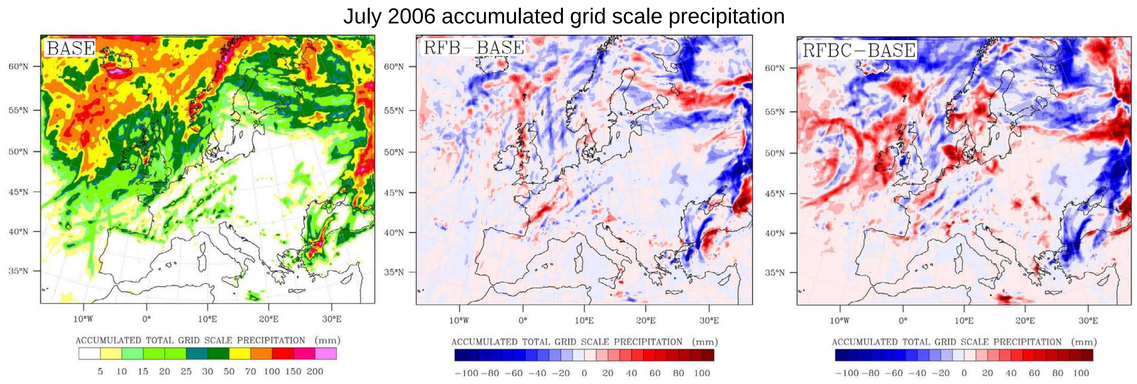
- Morrison two moment cloud physics scheme
- RADM2 gas phase chemistry
- MADE/SORGAM modal aerosol module
  - Nucleation mode < 0.1µm; accumulation mode 0.1-2 µm; coarse mode >2 µm, sea salt and dust module
- No FDDA, free development of semi-direct effects possible
- June-July 2006; Europe, Δx=22.5 km

Simulations are part of the AQMEII model inter-comparison study.

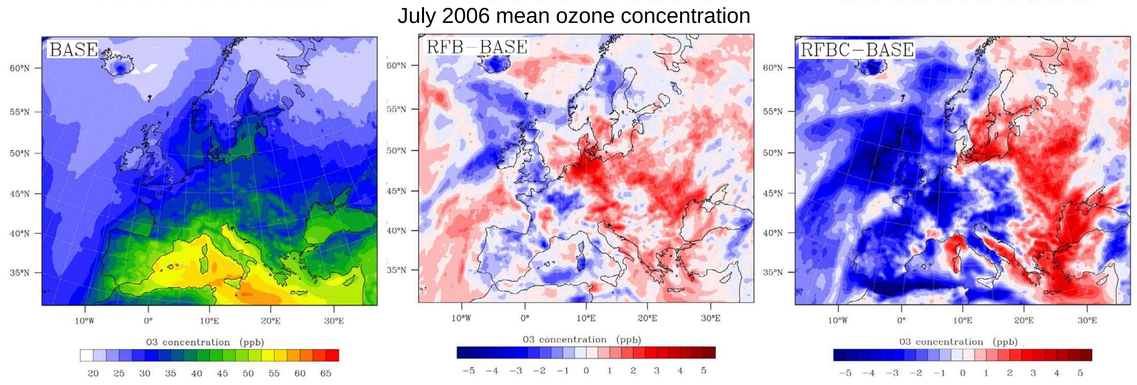
July 2006 mean atmospheric boundary layer height



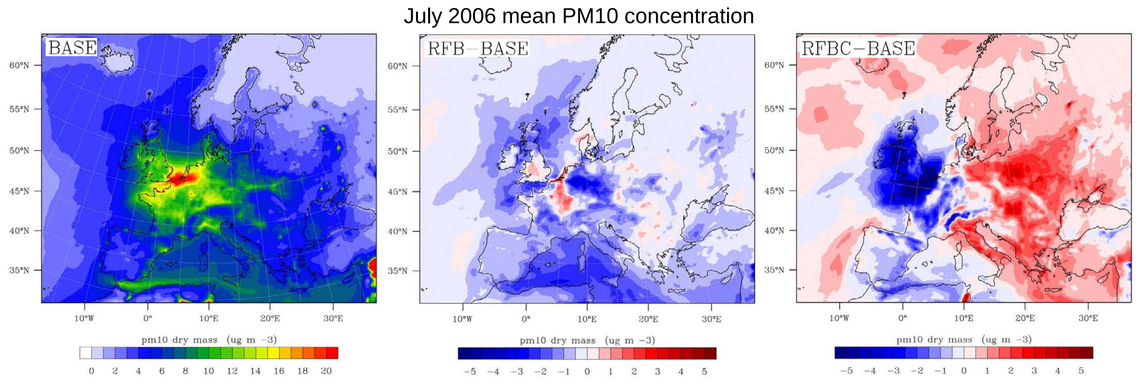
July 2006 accumulated grid scale precipitation



July 2006 mean ozone concentration



July 2006 mean PM10 concentration



- Changes in ozone up to 10%, mostly related to changes in cloud cover
- Up to 50% change in PM_{10}, mostly due changes in atmospheric boundary layer height, sea salt emission (wind speed) and precipitation (RFBC case only)
- Snapshot of investigation: Further investigations are necessary (e.g. cloud resolving simulation, different episodes)

Publication

Forkel *et al.*, 2012, *Atmospheric Environment*, doi:10.1016/j.atmosenv.2011.10.00