A sensitivity study with WRF/chem on the impact of aerosol-radiation feedback on regional pollutant distributions and meteorological fields

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Motivation

- Air Quality Model Evaluation International Initiative (AQMEII)
- Online coupled meteorological-chemistry model
- Aerosol feedback mechanism
- Direct/indirect effects
Model Setup

- Model: WRF/chem 3.3 (April 2011)
- RADM2 gas phase chemistry
- MADE/SORGAM modal aerosol module
  - Nucleation mode < 0.1 µm; accumulation mode 0.1-2 µm; coarse mode >2 µm
- Summer episode: 2 months - June / July 2006
- Free development of feedback effects → no FDDA
- Hourly AQMEII ‘standard’ emissions → TNO
- Biogenic emissions online → Guenther et al., 1994
- Sea salt emissions → Ginoux et al., 2001
Model runs

- Baseline case; without any aerosol feedback effects
  → BASE

- Direct aerosol-radiative effect and semi direct effect
  → RFB

- Direct aerosol-radiative effect plus indirect aerosol effect (semi-direct effects and second indirect effect included)
  → RFBC
Definitions

- **Direct effect**
  - solar radiation

- **Semi direct effect**
  - change of cloud properties, e.g. “burning off”, liquid water path, temperature, boundary layer and subsequent effect on radiation

- **Indirect effect**
  - radiation properties of clouds (e.g. cloud albedo, lifetime, cloud droplet number)
Solar Radiation

June

BASE

July

Direct & semi direct

RFB-BASE

+ Indirect

RFBC-BASE
Water Content

BASE

+ Indirect RFBC-BASE

July
Solar Radiation

July 2006: BASE vs. observed

July 2006: RFB vs. observed

July 2006: RFBC vs. observed

Simulated versus Observed
Temperature

Direct & semi direct
RFB-BASE

July

+ Indirect
RFBC-BASE
Ozone

Direct & semi direct

RFB-BASE

July

+ Indirect

RFBC-BASE
PM10

June

Direct & semi direct
RFB-BASE

Development

+ Indirect
RFBC-BASE

July
Simulated versus Observed
Conclusions

- snapshot of investigation → episode of a specific meteorological situation
- further investigations are necessary (e.g. higher horizontal resolution, cloud resolving resolution)
- semi-direct effects (temperature, boundary layer, clouds) dominated the direct effect
- Development of semi-direct effects become more dominant in July
- Indirect effects result in a decrease of up to 70% cloud water content and higher precipitation over parts in the Northern Atlantic
- better agreement for cloudy conditions by considering indirect effects
Thank you very much for your attention

Publication