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

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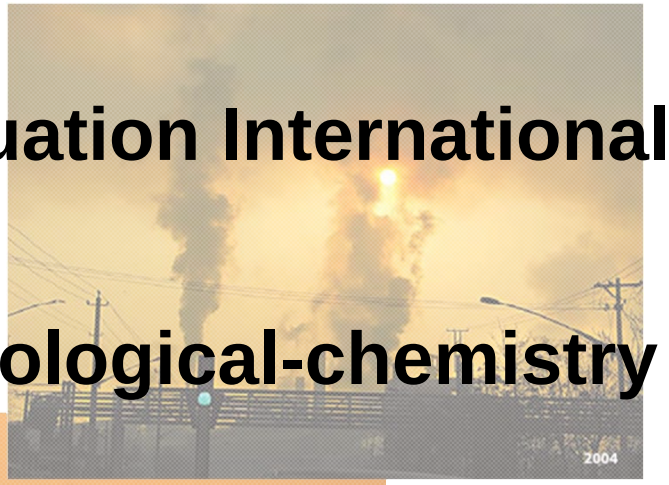
Motivation



- 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 < 0.1µm; 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**

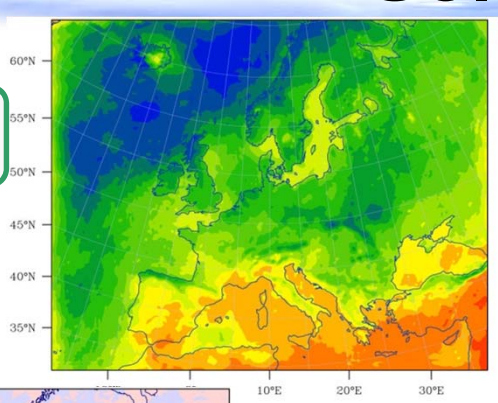
- **Indirect effect**
  - → **radiation properties of clouds (e.g. cloud albedo, lifetime, cloud droplet number)**

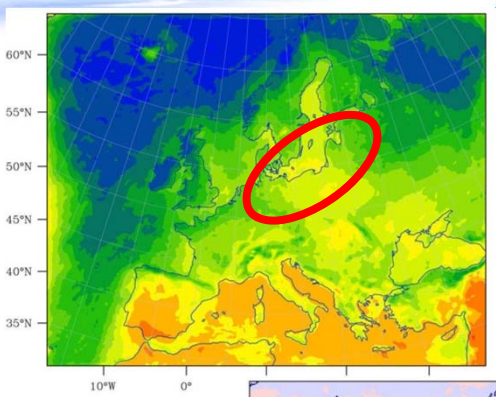
Solar Radiation

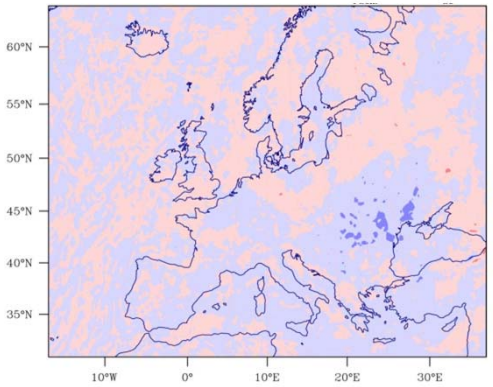
June

July

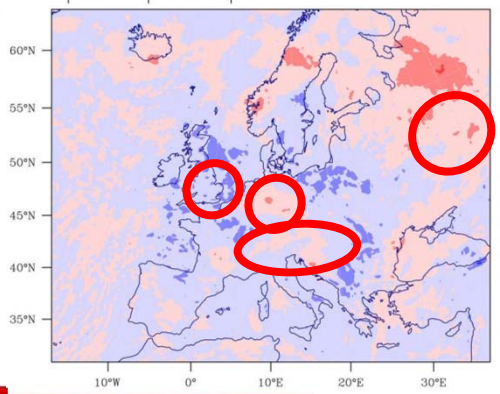
BASE

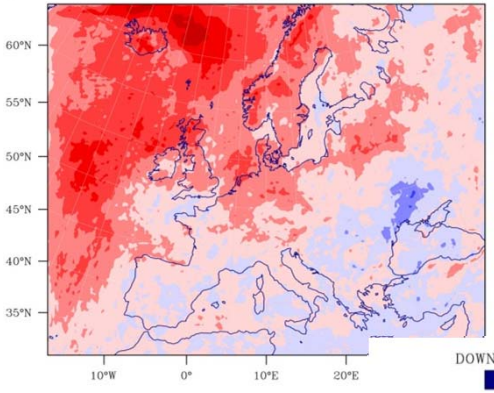




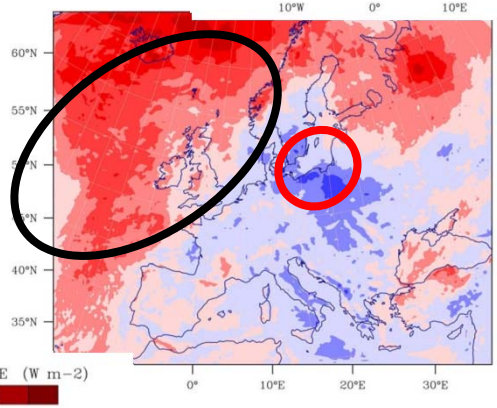


Direct & semi direct RFB-BASE





+ Indirect RFBC-BASE

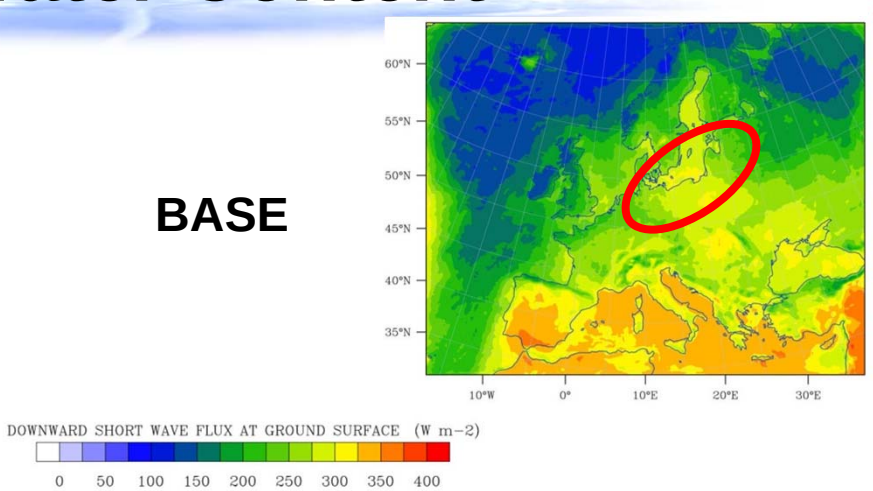


Water Content

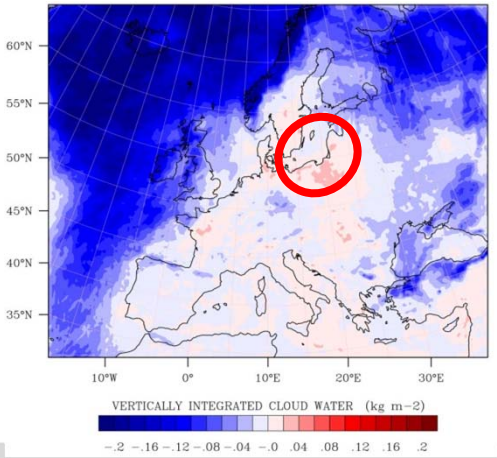
Karlsruhe Institute of Technology

July

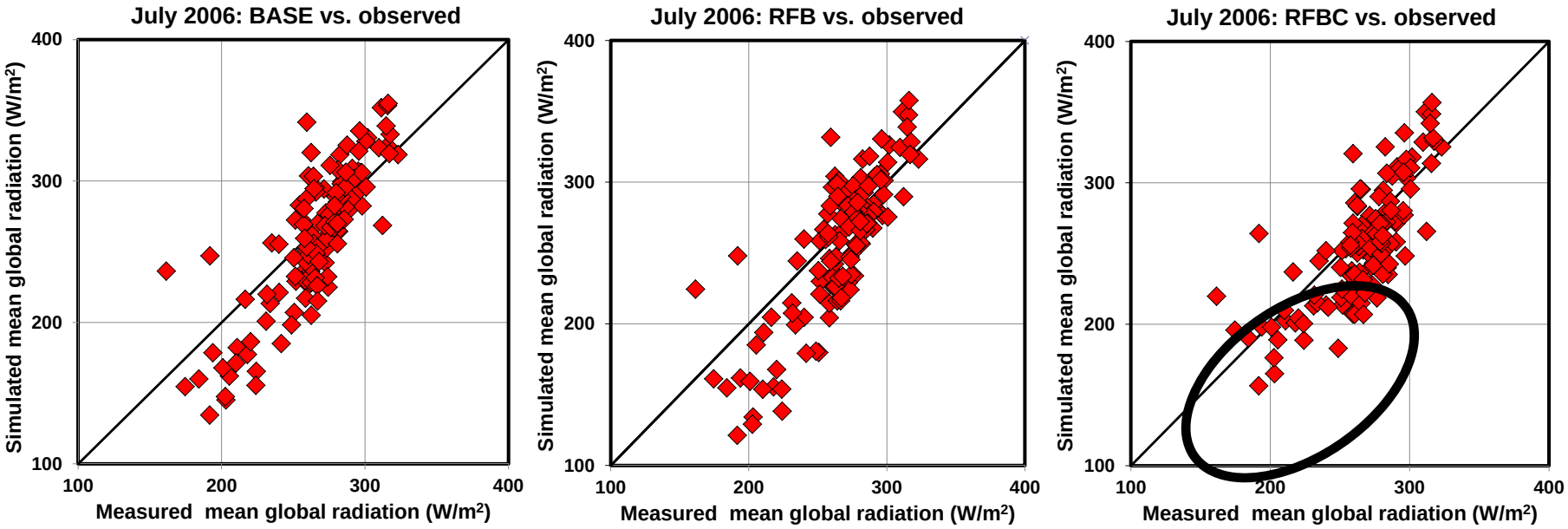
BASE



+ Indirect
RFBC-BASE

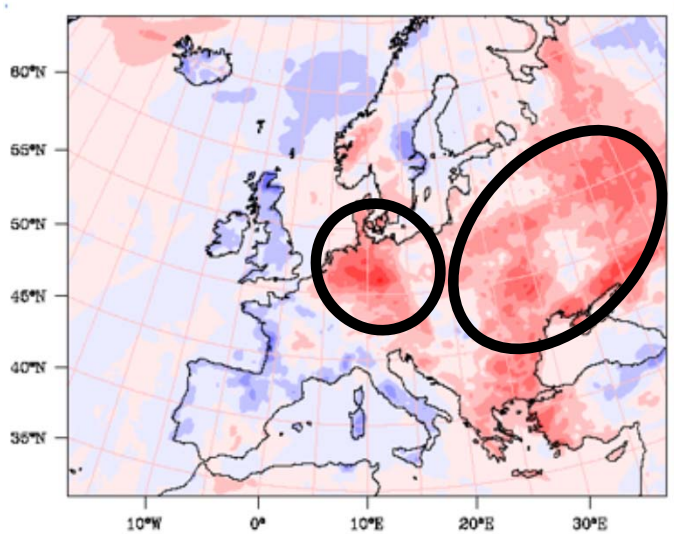


Solar Radiation



Simulated versus Observed

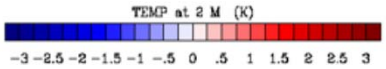
Temperature



Direct & semi direct

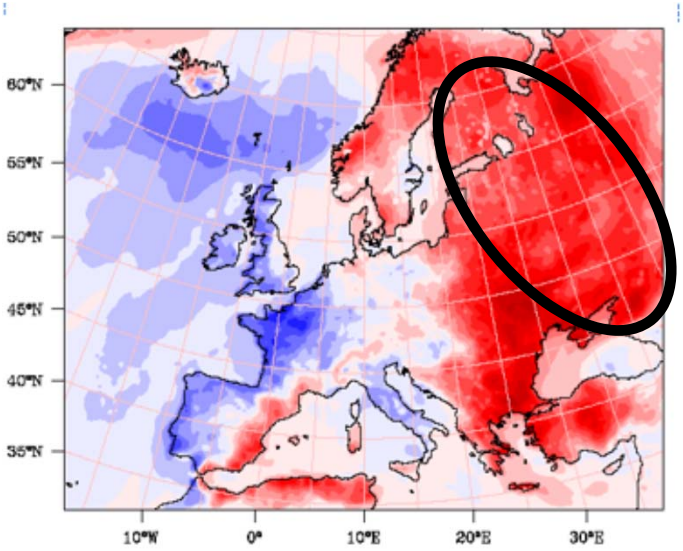
RFB-BASE

July

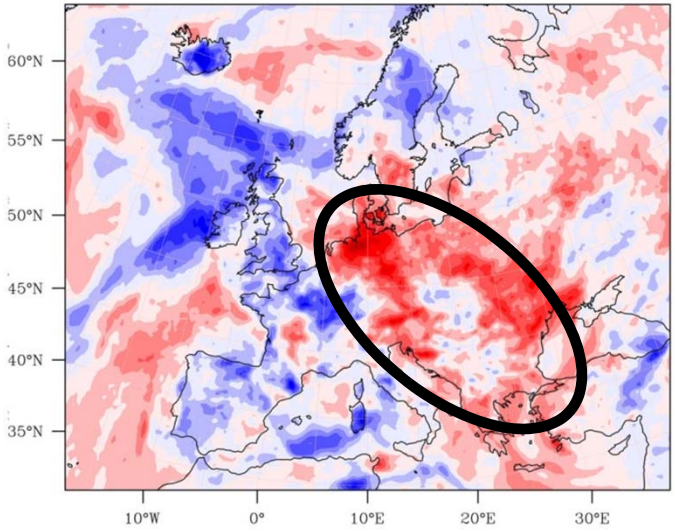


+ Indirect

RFBC-BASE



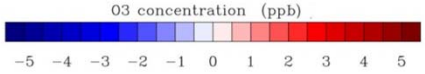
Ozone



Direct & semi direct

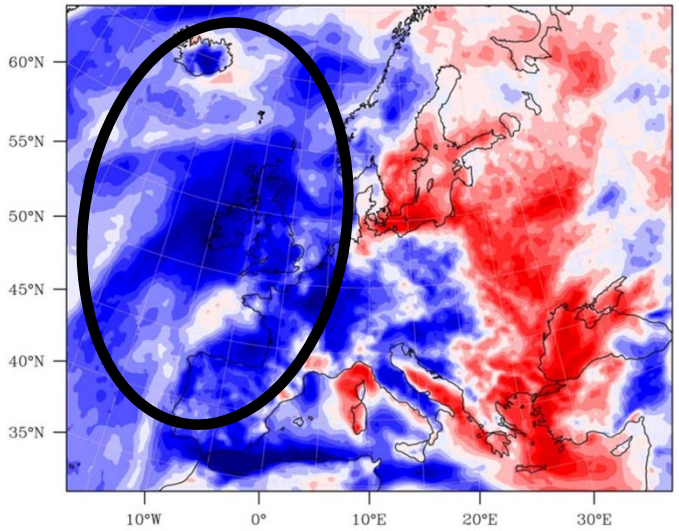
RFB-BASE

July



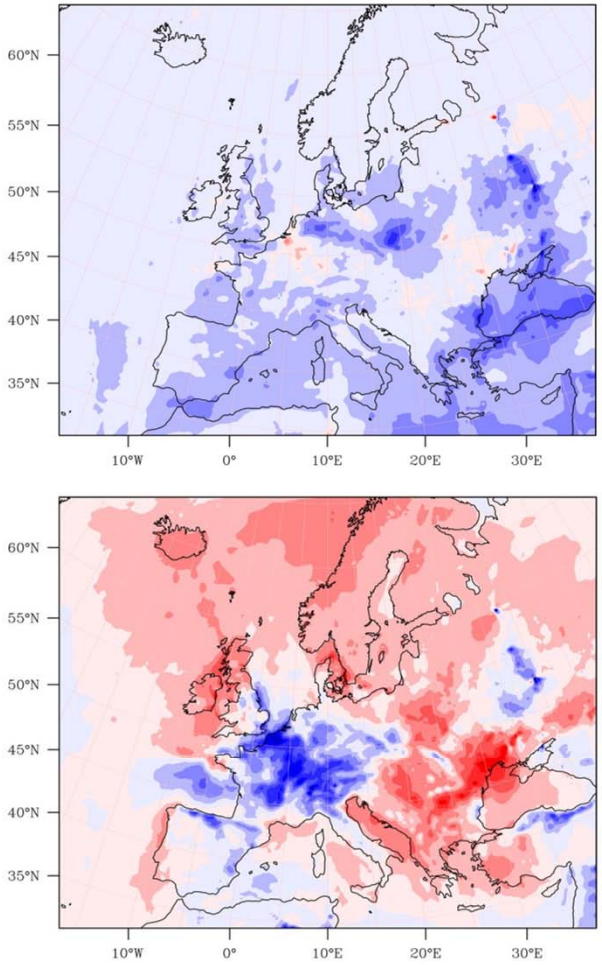
+ Indirect

RFBC-BASE



PM10

June



Direct & semi direct

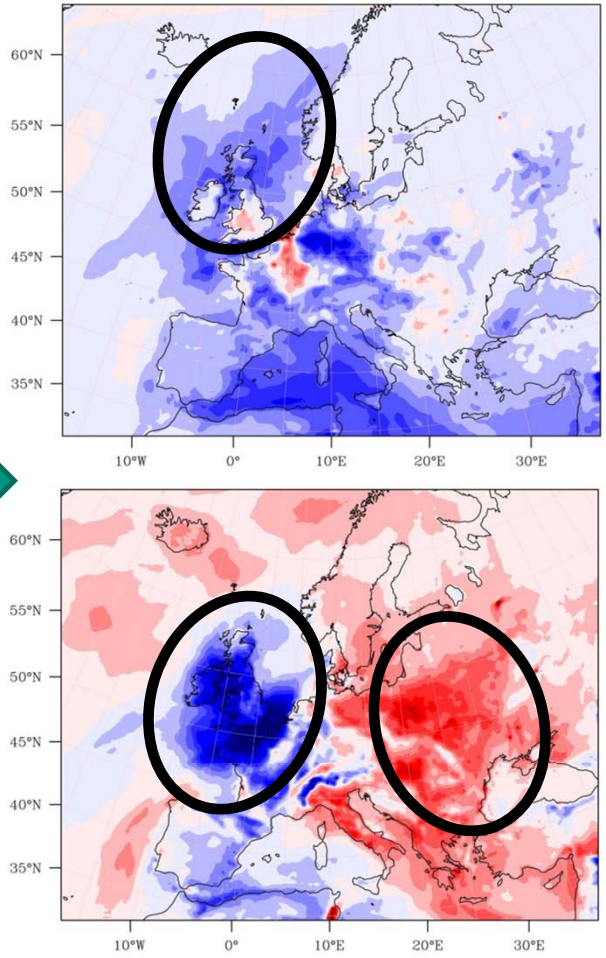
RFB-BASE

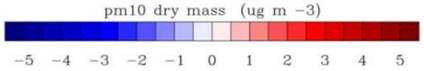
Development

+ Indirect

RFBC-BASE

July





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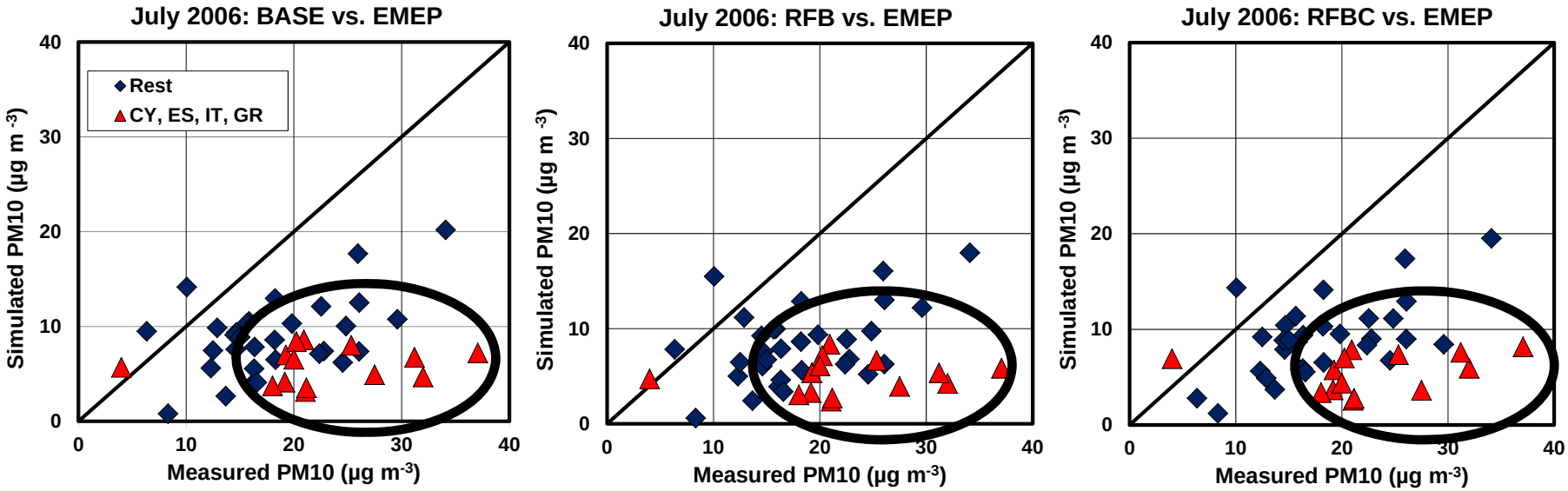

Simulated versus Observed

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

Renate Forkel, Johannes Werhahn, Ayoe Buus Hansen, Stuart McKeen, Steven Peckham, Georg Grell, Peter Suppan (2012): **Effect of aerosol-radiation feedback on regional air quality - A case study with WRF/Chem.** Atmospheric Environment, 45, doi:10.1016/j.atmosenv.2011.10.009 (special issue about the AQMEII initiative)