

A case study on the aerosol-meteorology feedback for Europe with WRF/Chem

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Motivation

Another simulation of direct and indirect aerosol effect? Why?

- **Feedback to meteorology for a longer episode, temporal development**
- **Investigation for Europe**
- **No particularly high aerosol loads**

Air Quality Model Evaluation International Initiative (AQMEII): WRF/Chem simulations with and without aerosol direct/indirect effects

Model Setup

- **Model: WRF/Chem 3.3 (April 2011)**
- **RADM2 gas phase chemistry**
- **MADE/SORGAM modal aerosol module**
 - Nucleation mode $< 0.1 \mu\text{m}$;
accumulation mode $0.1\text{-}2 \mu\text{m}$; coarse mode $>2 \mu\text{m}$
- **Hourly AQMEII 'standard' emissions from TNO**
Biogenic emissions Guenther et al., 1994
GOCART sea salt emissions (Ginoux et al., 2001)
- **June - July 2006, Europe $\Delta x=22.5 \text{ km}$**
- **Continuous run, no FDDA →**
Free development of semi-direct effects possible

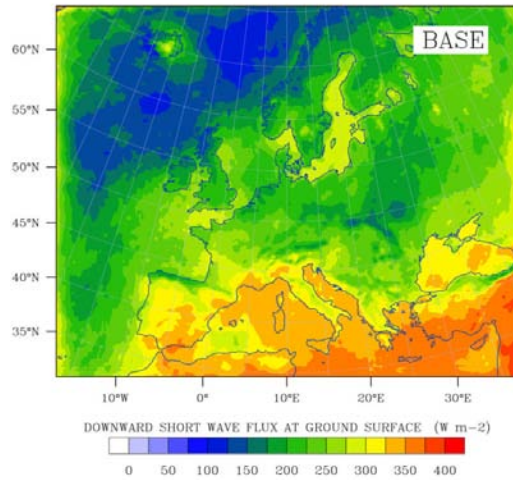
Model runs

- BASE** Baseline case; no aerosol feedback
- RFB** Direct aerosol-radiative effect and semi direct effect
- RFBC** Direct aerosol-radiative effect plus indirect aerosol effect (+ semi-direct effects and second indirect effect)
- RFBC2** Direct aerosol-radiative effect plus indirect aerosol effect (+ semi-direct and second indirect effect)
Much higher boundary values for aerosol than for RFBC

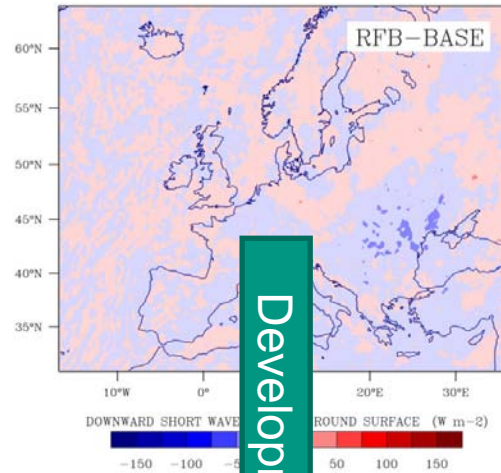
Solar Radiation

June

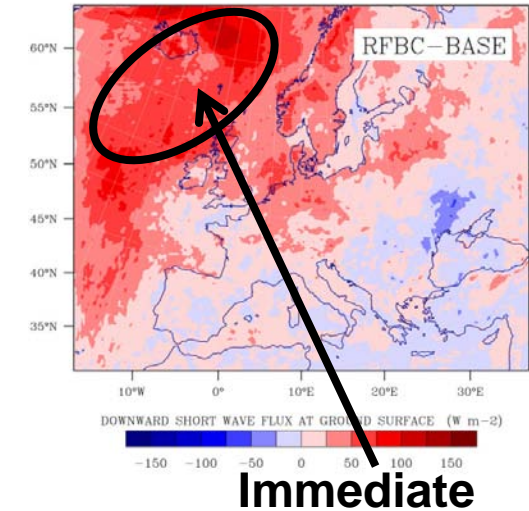
No aerosol effect



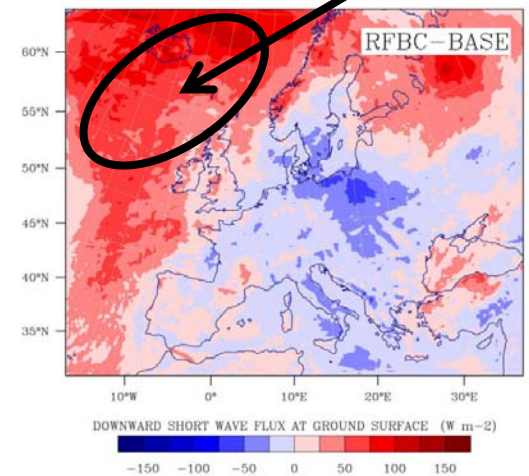
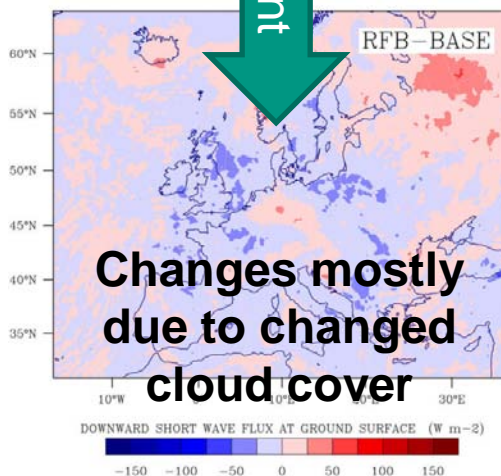
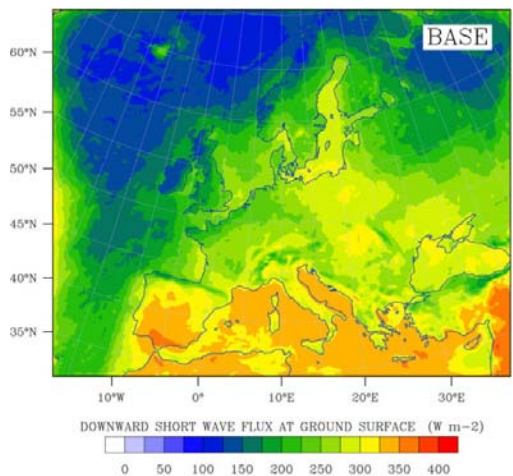
Direct & semi direct



+ indirect effect



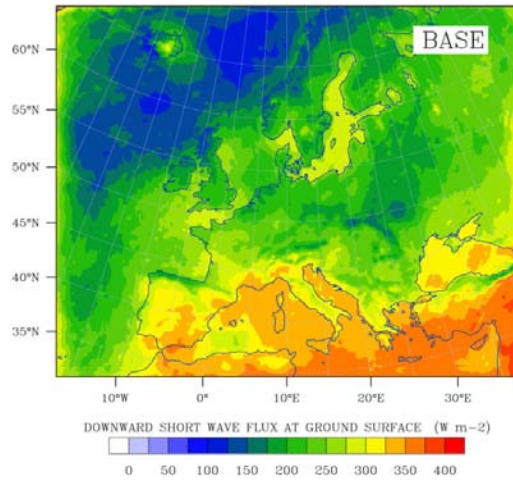
July



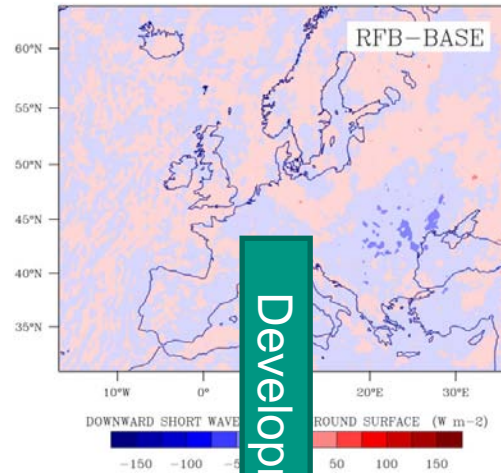
Solar Radiation

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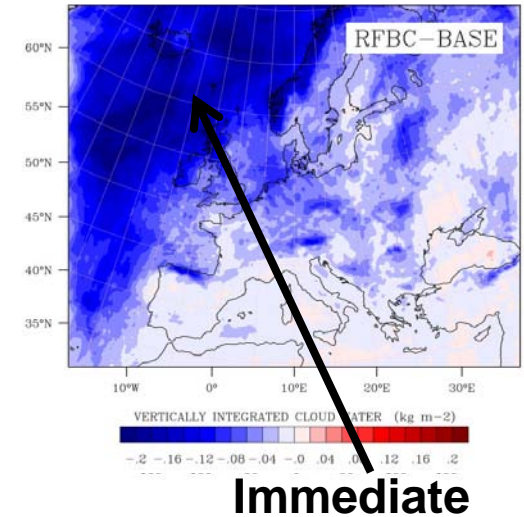
No aerosol effect



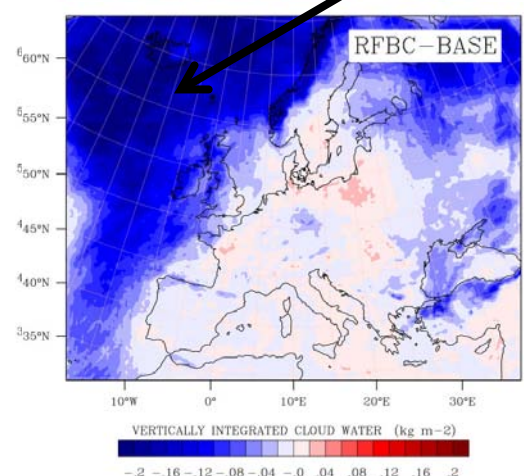
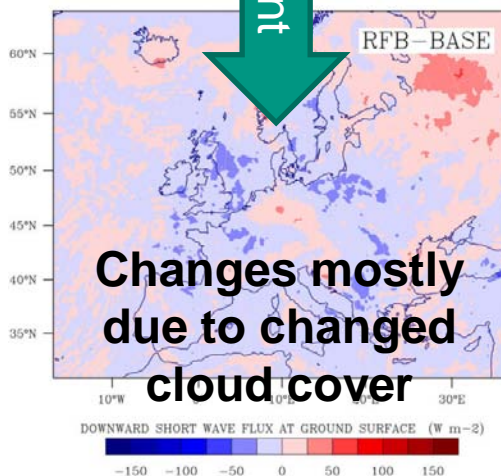
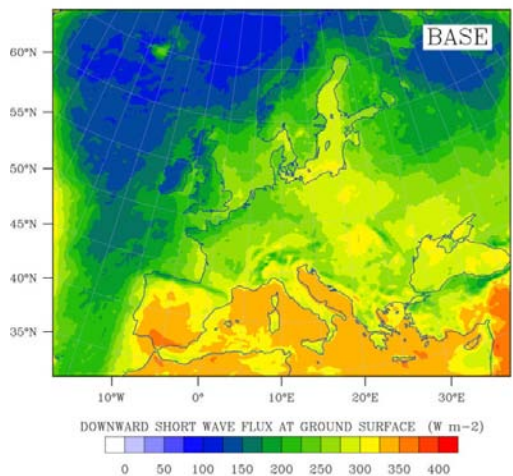
Direct & semi direct



Effect on cloud water



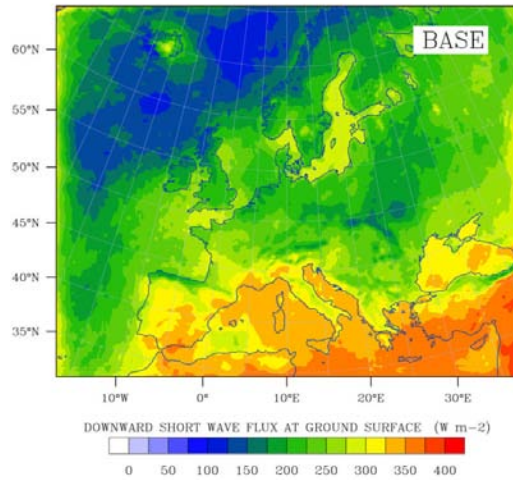
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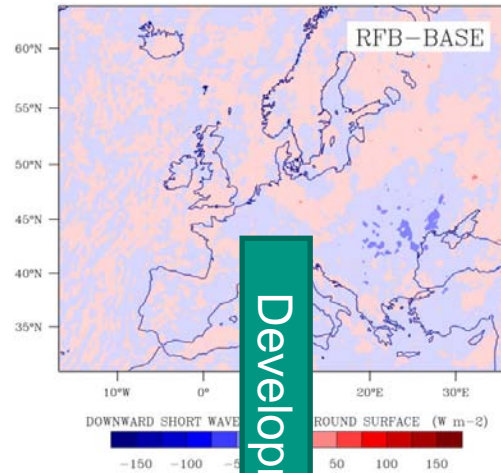
Solar Radiation

June

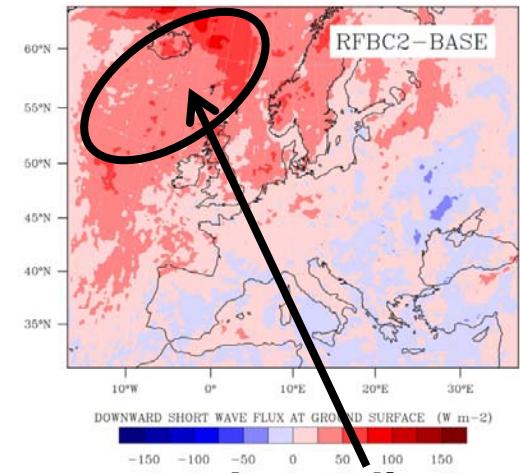
No aerosol effect



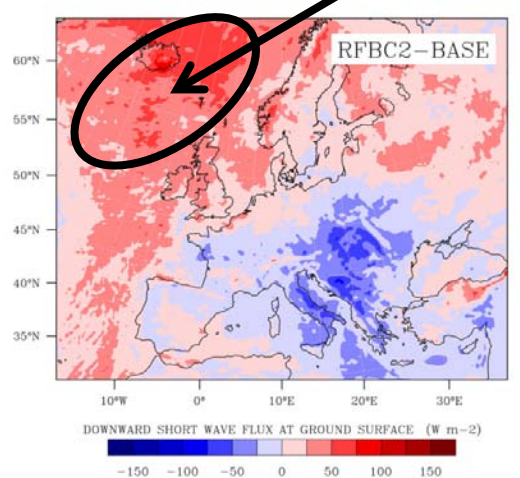
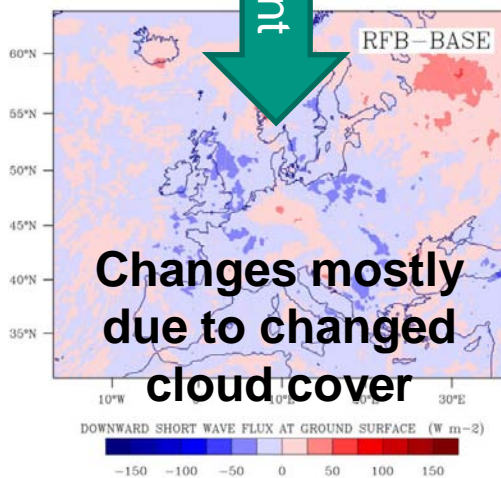
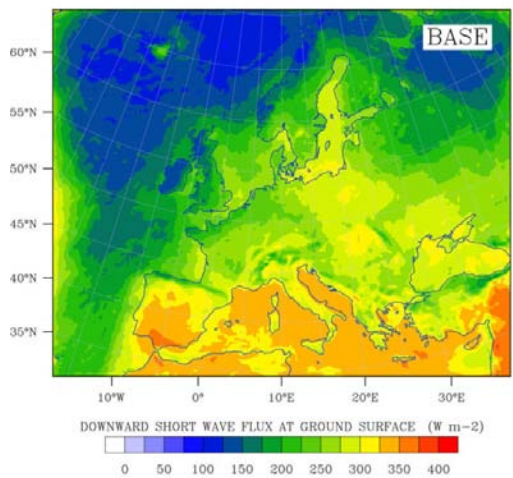
Direct & semi direct



higher aerosol BC

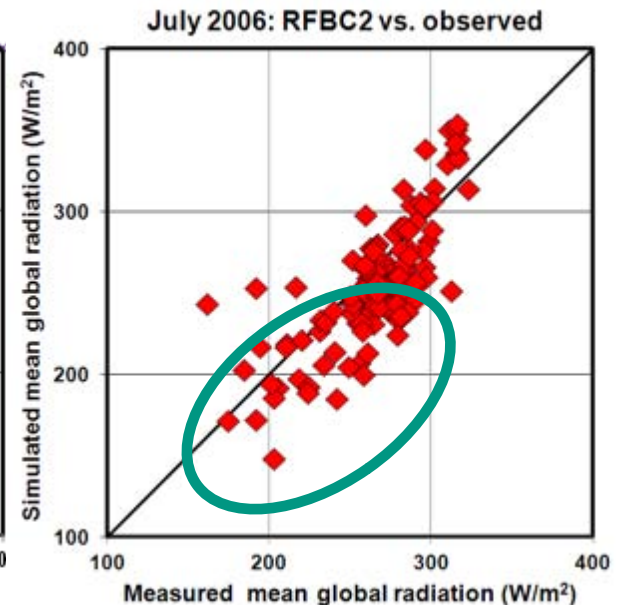
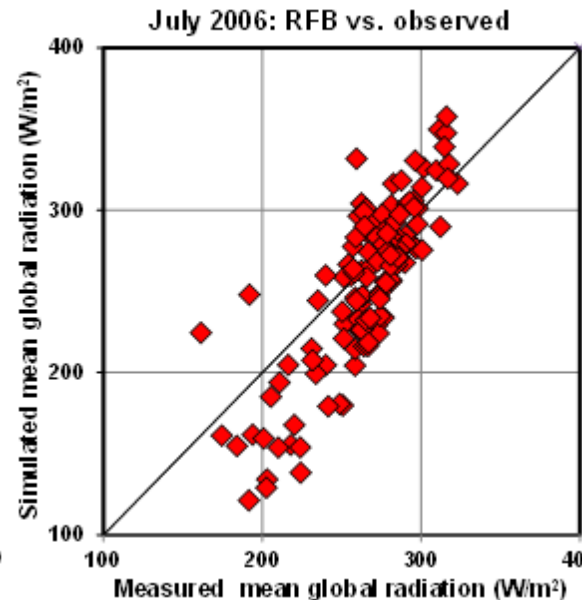
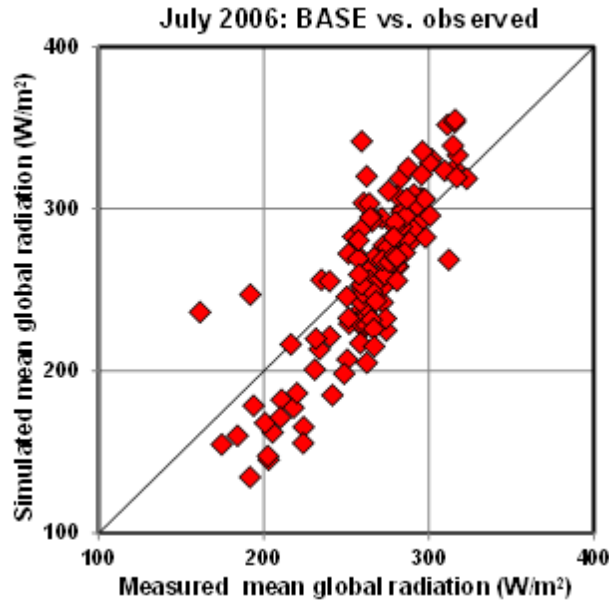


July



Immediate

Solar Radiation



Simulated versus observations
published by the WRDC

Better agreement particularly for
cloudy conditions in Northern Europe

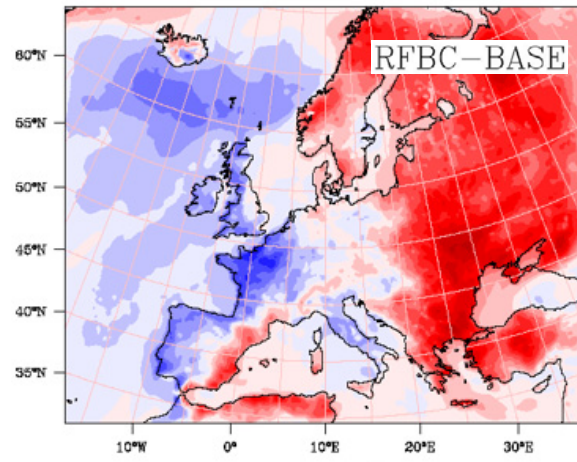
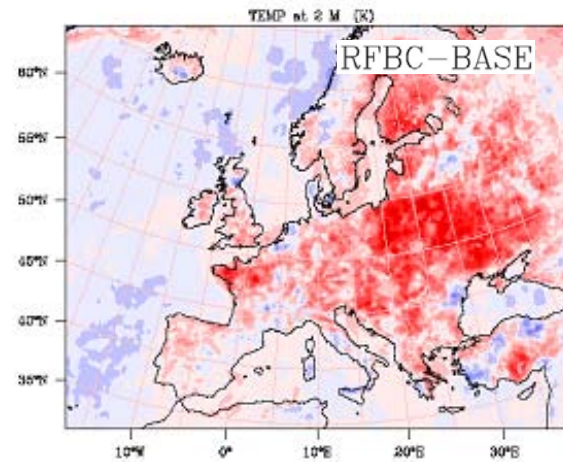
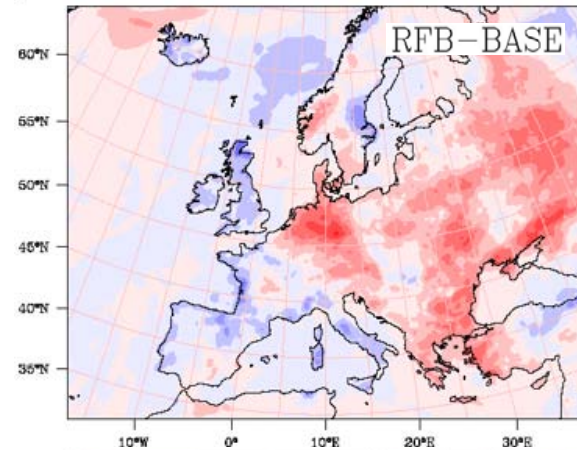
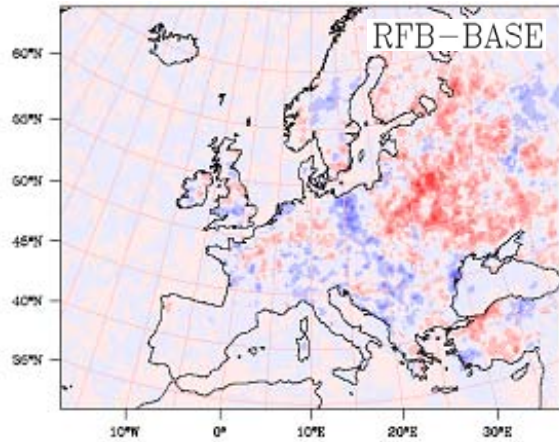
Temperature

June

July

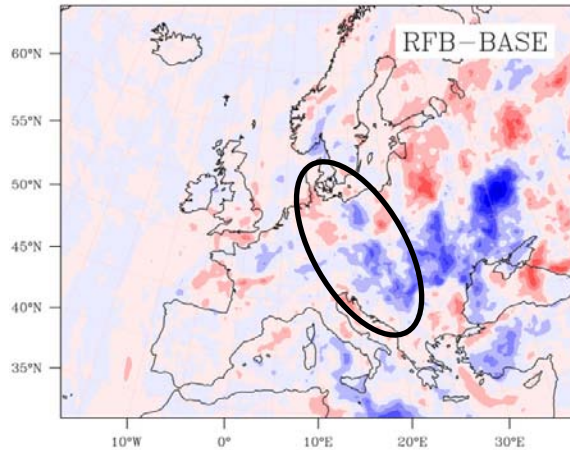
Direct &
semi direct

+ Indirect

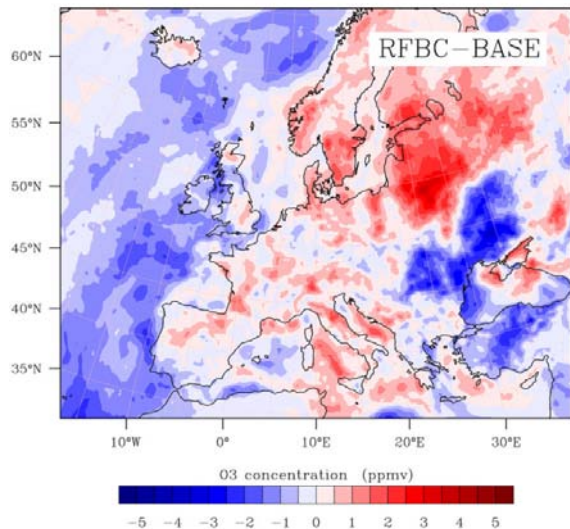


Ozone

June

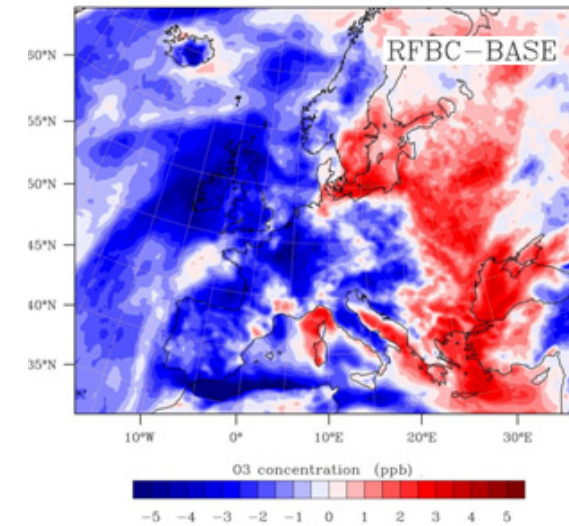
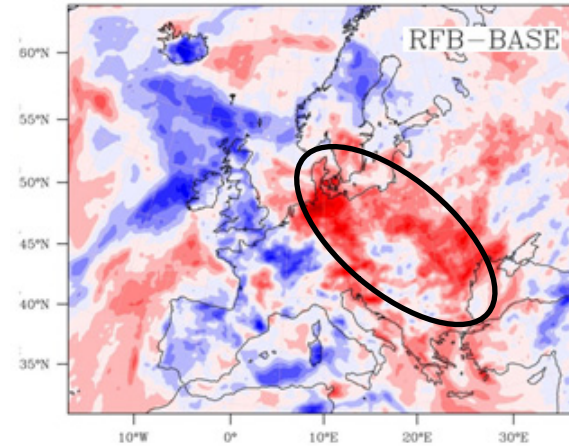


Direct &
semi direct



+ Indirect

July



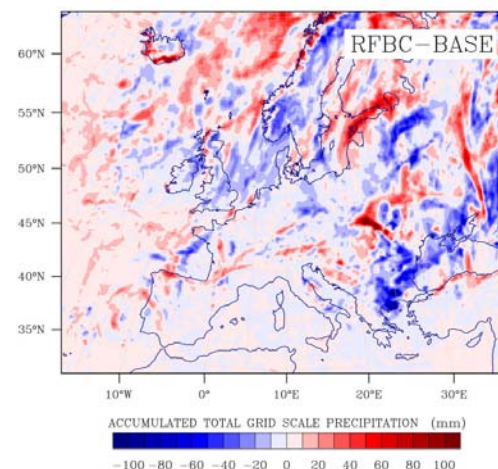
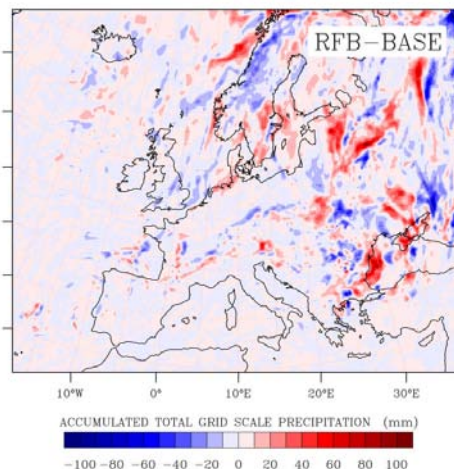
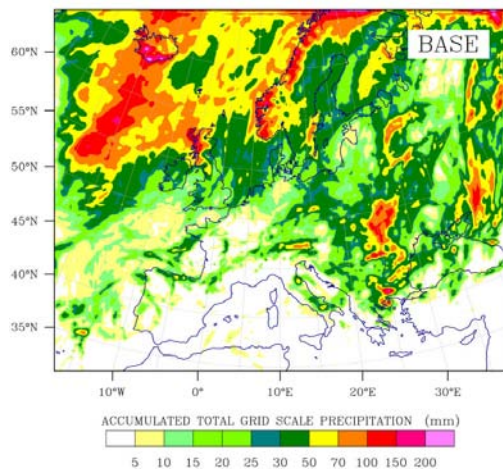
Grid Scale Precipitation

No aerosol effect

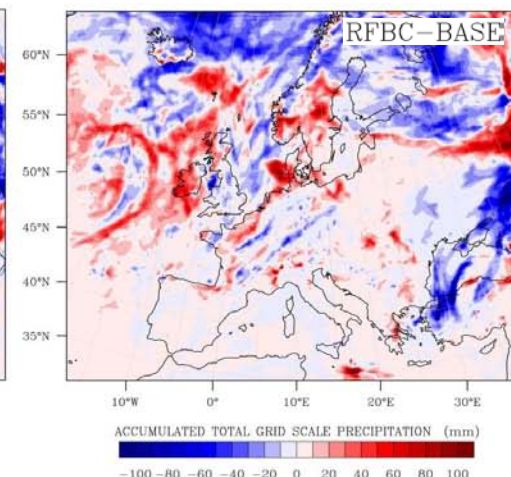
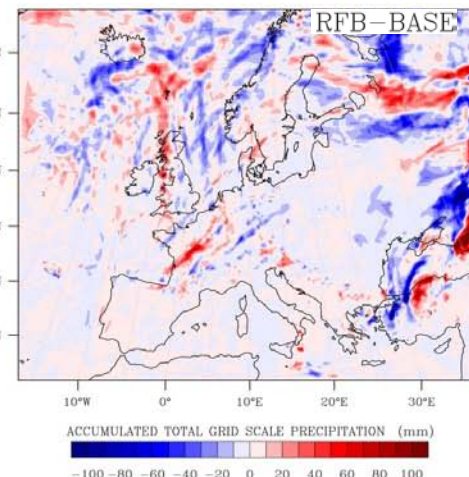
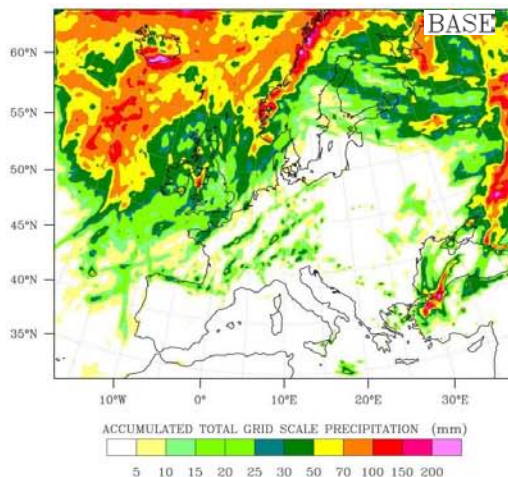
Direct & semi direct

+ indirect effect

June



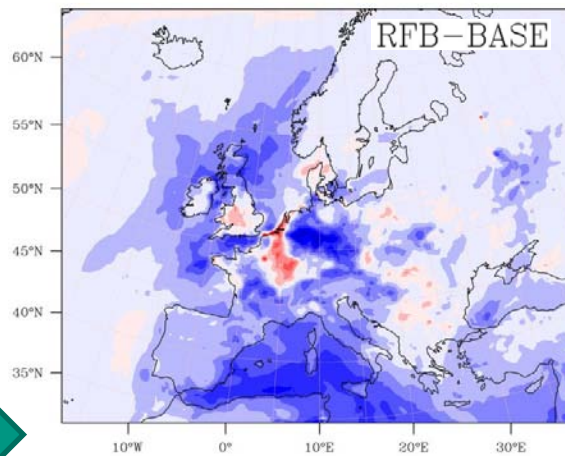
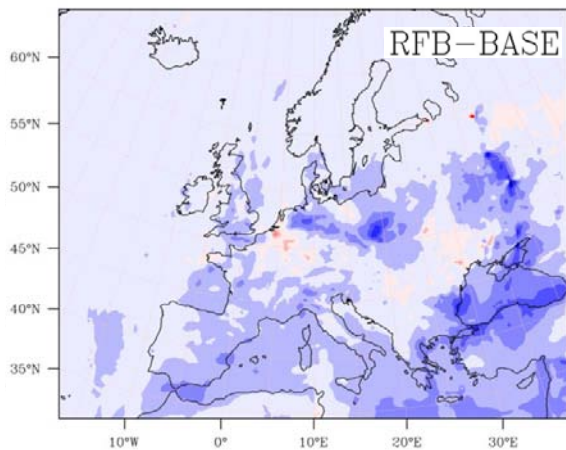
July



PM10

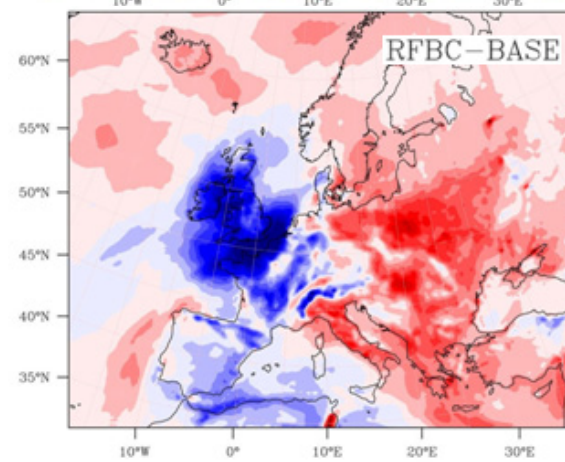
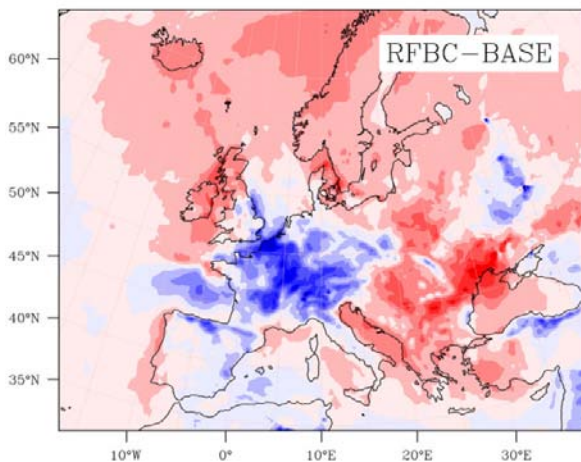
June

July

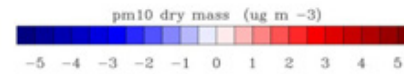
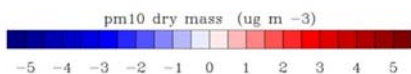


Direct &
semi direct

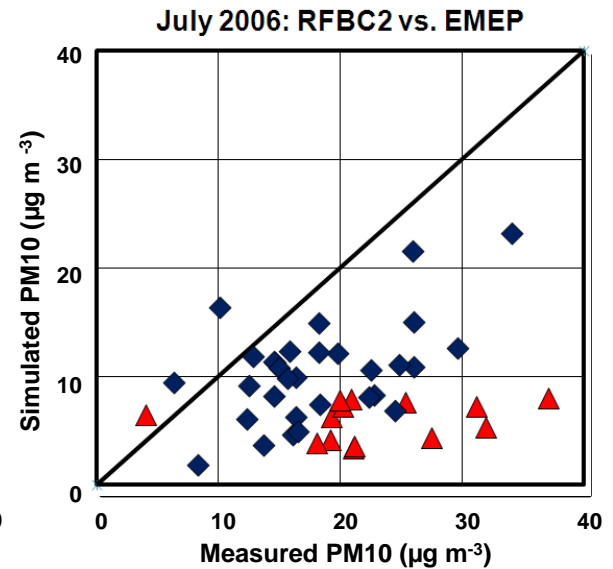
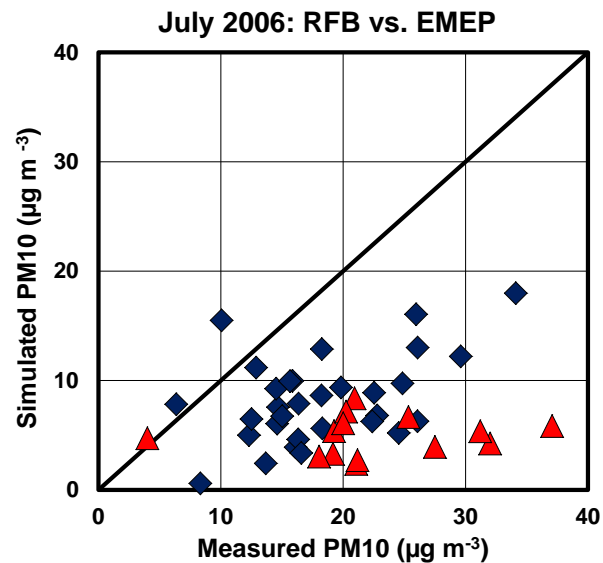
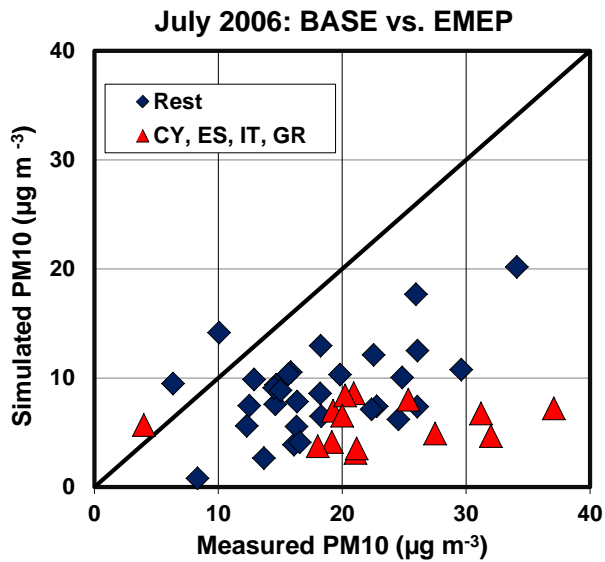
Development



+ Indirect



PM10



Simulated versus observed
(EMEP data)

Simulated versus observed for
higher boundary values for PM

Summary of results

- **Semi - direct** effects (temperature, boundary layer, clouds) develop after some days
- **Semi - direct** effects dominate the **direct** effect
- Development of **semi direct** effects become more dominant with time
- **Indirect** effects result in a decrease of up to 70 % cloud water content over the North Atlantic; higher precipitation only over parts in the Northern Atlantic
- Better agreement with observed radiation for cloudy conditions in clean areas with **indirect** effect
- Up to 10% changes in O_3 and up to 50% change in PM after 2 months

Conclusions

- **Episode of a specific meteorological situation**
→ Snapshot of investigation
- **Further investigations are necessary with higher horizontal resolution (cloud resolving resolution)**
- **Indirect effect for convective clouds necessary**
- **Mid- and long term development of semi-direct effect still need further investigation**
→ AQMEII2 (more models with feedback)

Thank you very much for your attention



Publication

Renate Forkel, Johannes Werhahn, Aoye 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)