**Ship emission influence on clouds: Perspectives from model calculations and satellite data**

Karsten Peters\(^1\), Johannes Quaas\(^1\), Hartmut Grassi\(^1\)

\(^1\) Max-Planck-Institut für Meteorologie, Hamburg, \(^2\) International Max Planck Research School on Earth System Modelling, Hamburg

#### Motivation

Aerosol indirect effects (aerosol influence on clouds, AIEs) are the largest source of uncertainty when estimating climate sensitivity (Forster et al., 2007).

- Further basic research is needed.

#### Why ships?

- Emissions from ships significantly modify the composition of marine boundary layer (MBL) aerosol.
- Attribution of AIEs to the emissions.
- Future ship traffic is bound to increase.
- Future fuel-composition regulations (IMO, 2008) may change the emission-processing in the atmosphere.

#### Ship emissions in a GCM

- todays’ ship emissions do not lead to discernible AIEs in a fine-ran GCM with interactive aerosol treatment.
- scaling of ship emissions by a factor of 10(100) shows systematic changes in cloud properties.

- If future ship traffic increases distinctly (and ship pollution controls remain ineffective) in the future, significant observable AIEs from ship emissions can be expected.

#### Satellite data analysis

- reduced cloud droplet sizes of water clouds are observed over the English Channel.
- artifact of the satellite data?
- if not, why do we see it in the GCM? Is it an issue of resolution or of the parameterizations?
- we present a new method to sample for regions by which ship pollution influence on clouds could be observed.

#### The model perspective (GCM)

**The tool**

- ECHAM5-HAM aerosol climate model (Roeckner et al., 2003, Stier et al., 2005).
- TESLi31 resolution (2.8°x2.8° and 31 vertical levels).
- “AMIP-style” simulation (climatological SSTs).
- Ship emissions (BC, SO2) from the EU-UP QUANTIFY (Endresen et al., 2005, 2007) all other aerosol emissions as prescribed in AEROCOM (Dentener et al., 2006) or computed interactively.
- 7 year simulations, 5 year analysis period.

**Results**

Cloud top droplet number concentration change [d (N/m^3)]

increased BC emissions do not lead to large changes in cloud microphysical properties; SO2 is the main driver. Also, the mixing of the two species is crucial for aerosol-cloud interaction. BC-emission increase shows possible semi-direct effects (reduced cloud cover to net warming). Hansen et al., (1997)

**Outlook**

- Effects of increased model resolution
- Change of emission parameterization to assess the effect of locally large emissions
- Emission height to be made identical for both BC and SO2
- Internal mixing of BC and SO2 takes place seconds or minutes after emission.
- match mixing assumption in the model.

#### Conclusions

- The model does not predict a noticeable impact of ship emissions on cloud microphysical properties unless the emissions are scaled by one or two orders of magnitude.

#### The experiments

- So far, general sensitivity runs have been performed:
  - Control run (no ship emissions).
  - Original and scaled (x10, x100) ship emissions.
  - one emission component scaled (BC or SO2)

- This provides a first overview of the models’ response and the importance of interactive aerosol treatment.

#### The data

- GRAPE (Global Retrieval of ATSR Cloud Parameters and Evaluation, Thomas et al., 2009); processed from ATSR-2 measurements.
- time frame: 1995 – 2002

#### Low-cloud properties over Europe

- scenes with 100% water cloud fraction and high retrieval quality
- the cloud albedo at 3.7 μm should be anticorrelated with the effective radius
- fulfilled only for water surfaces
- Further investigation of surface reflectance influence on measurements needed.

- more stringent scene selection

#### The satellite perspective

**The experiments**

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**Outlook**

- Effects of local meteorology on clouds have to be ruled out.

#### References