Modelling aerosol indirect effects from shipping emissions with ECHAM-HAM

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Motivation

Aerosol indirect effects (AIEs) are the largest source of uncertainty in estimates of anthropogenic climate forcing (Forster et al., 2007)

⇒ further basic research is needed

Why ships ?
- Emissions from ships modify the composition of the often pristine marine boundary layer (MBL)
- Future implications through an increase in ship traffic (IMO 2008)

Local vs. large-scale effects of shipping emissions
- large-scale AIEs from shipping emissions unconstrained from observations
- global modeling suggests AIEs from shipping of up to -0.6 Wm⁻² (Lauer et al., 2007)

Combining observations and modeling yields opportunities for reducing uncertainties !

Methodology

Global model
- ECHAM-HAM (Roeckner et al., 2003; Zhang et al., 2012)

Emissions (aerosols and precursor gases)
- EU-IP QUANTIFY for ships (Behrens, 2006)
- AeroCom otherwise (Dentener et al., 2006)

Setup
- T63 (1.8°x1.8°), 31 levels
- analysis period 2000 – 2004 (after spinup)
- prescribed SST
- nudged dynamics (ERA-Interim)

Experiments
- AeroCom emission parameterisation, unscaled shipping emissions
- more particles assigned to soluble modes at point of emission
- Asc as A, but emissions scaled by 1.63
- Bsc as B, but emissions scaled by 1.63
- as well as a control simulation without shipping emissions

Consistency check with observations
- systematic sampling for “clean” and “polluted” oceanic regions
  ➢ Eulerian-type sampling as in Peters et al. (2011), who did not find statistically significant AIEs on large-scale cloud fields over tropical oceans (using satellite data)

Eulerian sampling – conceptual illustration

What to expect OR “How clean is the clean environment”?

Across-corridor emission gradients in experiment Bsc.
- Left: annual mean ship-emission fluxes from ships in the total emissions
- Right: Share of sulphur (S) emissions from ships in the total emissions

Results

Conclusions

- AIEs from shipping emissions are lower than previously estimated, and

- substantially depend on the assumed particle size distribution at the point of emission

- Consistent with observations (Peters et al. (2011)), large-scale AIEs are not clearly discernible over tropical oceans
- An even higher forcing can thus not be ruled out !