

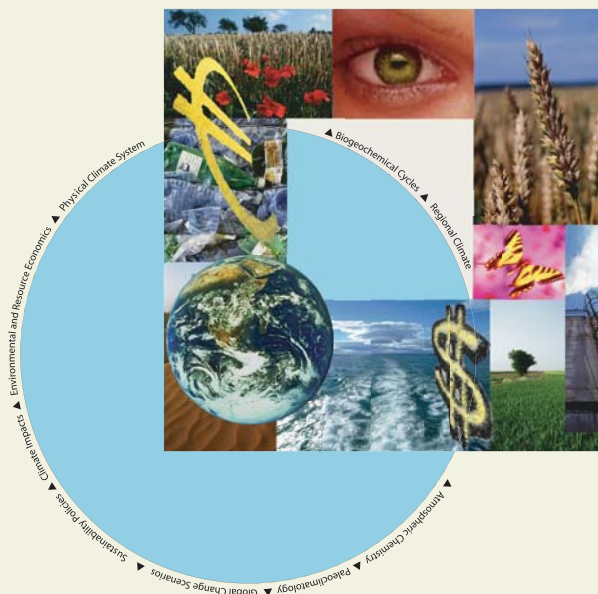


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Ship emission influence on clouds in
satellite and model data

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ABSTRACT

The impact of large-scale cloud modification through anthropogenic emissions of aerosols and aerosol precursor gases (“aerosol indirect effects”, AIEs) on Earth’s climate is weakly constrained when it comes to assessing human-induced climate change. In this thesis, the impact of shipping emissions on cloud fields at large scales is used as a test case to contribute towards the reduction of the uncertainty associated with AIEs. For this, both observational data obtained from space-borne remote sensing and results from global climate modelling are employed.

The observational approach presented here utilises aerosol and liquid-cloud properties as obtained from the two MODIS satellite instruments and combines them with meteorological data from the ERA-Interim project. Three shipping corridors over tropical oceans are investigated by using the information on the large-scale meteorological environment to separate “clean” from “polluted” sectors upwind and downwind of a shipping lane, respectively, of each corridor. Aerosol and cloud properties are then analysed statistically. The analysis reveals no statistically significant impacts of shipping emissions on clouds at a large scale in any of the selected regions. It is concluded that the net AIEs from shipping emissions are not large enough to be distinguishable from the natural dynamics controlling cloud presence and formation in the investigated regions.

A global assessment of AIEs from shipping emissions is performed by employing the aerosol climate model ECHAM5-HAM. An up-to-date shipping emissions inventory is incorporated into the model. The model’s sensitivity towards uncertainties associated with the shipping emissions themselves is investigated. Three sets of sensitivity experiments are performed to assess (1) the uncertainty associated with the size of emitted particles, (2) the uncertainty associated with the total amount of emissions and (3) the impact of reducing carbonaceous emissions from ships. From these experiments, the globally averaged AIEs are found to range from $-0.07 \pm 0.01 \text{ Wm}^{-2}$ to $-0.32 \pm 0.01 \text{ Wm}^{-2}$, the magnitude of which depends much more on the assumed emission size distribution than on the magnitude of the emissions themselves. Although the upper estimate from this thesis is relatively large, with the current best estimate of the first AIE, or “Twomey-effect”,

being -0.7 Wm^{-2} , it is about half of the previous upper estimate of AIEs from shipping emissions. The reduction of carbonaceous emissions from ships is not found to have important implications for the simulated AIEs in ECHAM5-HAM.

The gap between satellite observations and model simulations is bridged by sampling the model output in a similar way as the satellite data. The results confirm those obtained from the satellite data analysis, *i.e.* clouds are not subject to substantial changes at the location of the shipping lane in the three tropical regions considered. However, this analysis reveals marked changes in atmospheric composition at the exact position of the shipping lane.

In conclusion, the results presented in this thesis show a smaller effect of shipping emissions on large-scale clouds fields than previously estimated. Thus shipping emissions have important implications for determining the sensitivity of Earth's climate system to external forcings.