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How Will Aerosol-Cloud Interactions Change in an Ice-Free Arctic Summer?

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Future temperatures in the Arctic are expected to increase more than the global mean temperature, which will lead to a pronounced retreat in Arctic sea ice. Before mid-century, most sea ice will likely have vanished in late Arctic summers. This will allow ships to cruise in the Arctic Ocean, e.g. to shorten their transport passage or to extract oil. Since both ships and open water emit aerosol particles and precursors, Arctic clouds and radiation may be affected via aerosol-cloud and cloud-radiation interactions. The change in radiation feeds back on temperature and sea ice retreat. In addition to aerosol particles, also the temperature and the open ocean as a humidity source should have a strong effect on clouds.

The main goal of this study is to assess the impact of sea ice retreat on the Arctic climate with focus on aerosol emissions and cloud properties. To this purpose, we conducted ensemble runs with the global climate model ECHAM6-HAM2 under present-day and future (2050) conditions. ECHAM6-HAM2 was coupled with a mixed layer ocean model, which includes a sea ice model. To estimate Arctic aerosol emissions from ships, we used an elaborated ship emission inventory (Peters et al. 2011); changes in aerosol emissions from the ocean are calculated online.

Preliminary results show that the sea salt aerosol and the dimethyl sulfide burdens over the Arctic Ocean significantly increase. While the ice water path decreases, the total water path increases. Due to the decrease in surface albedo, the cooling effect of the Arctic clouds becomes more important in 2050. Enhanced Arctic shipping has only a very small impact. The increase in the aersol burden due to shipping is less pronounced than the increase due to natural emissions even if the ship emissions are increased by a factor of ten. Hence, there is hardly an effect on clouds and radiation caused by shipping.

References

Peters et al. (2011), *Atmos. Chem. Phys.*, **11**, 5305-5320