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Validation of the sea ice albedo scheme of the HIRHAM-NAOSIM model using aircraft observations

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Arctic climate simulations require reliable estimates of the surface albedo, one of the key parameters related to the ice–albedo feedback. Since this feedback significantly contributes to the Arctic amplification, uncertainties of the surface albedo parameterization in climate models have a direct effect on the model-based quantification of the Arctic amplification.

In this study, the sea ice albedo parametrization of the coupled regional climate model HIRHAM-NAOSIM was validated against measurements performed during the ACLOUD (Arctic CLoud Observations Using airborne measurements during polar Day) and PASCAL (Physical feedbacks of Arctic boundary layer, Sea ice, Cloud and AerosoL) campaigns which were performed 2017 north of Svalbard. HIRHAM-NAOSIM uses the prognostic variables surface temperature and snow depth to estimate the fractions of ice subtypes (snow covered ice, bare ice, and melt ponds) and the corresponding subtype surface albedo. In this study, these prognostic variables were replaced by measured quantities of surface temperature (KT19), snow depth (Magna Probe), and ice subtype fractions (derived from Canon images taken onboard of the Polar 5/6 aircraft).

Overall, two main issues were found comparing modeled and measured albedo frequency distributions along the flight tracks of 12 flights from May 29 to June 26. First, the parameterized surface albedo shows a smaller distribution than the measurements caused by a biased functional dependence of the surface albedo parameterization on temperature. Second, a temporal trend was observed with higher measured than modeled albedo (0.88 vs. 0.84 for 29 May 2017) in the beginning of the campaign, and an opposite relationship towards the end of the campaign (0.67 vs 0.83 for 25 June 2017). Furthermore, the surface type fraction parameterization was tested against the Canon image product, showing an agreement within 1%.

Finally, a dependence of the measured surface albedo on the cloud conditions was observed, which was considered in an adjusted surface albedo scheme. Accounting for the cloud cover could reduce the root mean squared error from 0.14 to 0.04 for cloud free/broken cloud situations and from 0.06 to 0.05 for overcast conditions.