Towards improving Arctic mixed-phase cloud representation in the ECMWF model through MOSAiC observations and model sensitivity tests

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The presence of Arctic clouds is crucial for the evolution of surface temperature of Arctic sea-ice. However, large biases in cloud representation remain in state-of-the-art weather and climate models such as the ECMWF Integrated Forecasting System (IFS). We use observational data from the one-year MOSAiC campaign to evaluate the ECMWF model cloud liquid water path and confirm systematic seasonal biases: liquid-containing cloud occurrence is underestimated in winter and overestimated in summer. In the IFS single column model setup we investigate the sensitivity of liquid-containing clouds to different uncertainties in the model. In winter, we find the strongest sensitivity is to uncertainties in cloud microphysics and show that reducing the assumed ice particle number concentration (within the bounds of uncertainty) reduces the ice deposition rate and significantly improves the underestimation of liquid-containing clouds. Furthermore, we find a strong sensitivity of the clouds to small fractions of open ocean in the sea-ice, which are often present in the model when satellite observations show full sea-ice cover. By combining conditional verification with targeted sensitivity tests, we identify pathways for improving Arctic cloud representation in the IFS.

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