A performance baseline for the representation of clouds and humidity for cloud-resolving ICON-LEM simulations

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In the context of the Transregional Collaborative Research Center on "Arctic Amplification: Climate Relevant Atmospheric and Surface Processes, and Feedback Mechanisms”, we challenge the ICOsahedral Non-hydrostatic modelling framework ICON by performing simulations in a complex Arctic environment. Our study aims at adding a significant reference for how well ICON can perform in the Arctic and give ideas on how to improve the performance related to the microphysical parameterizations.

With the ambition to resolve the clouds directly, we used ICON in the large-eddy mode (ICON-LEM), which enables the use of a 3D Smagorinsky turbulence scheme. We further applied a two-moment microphysics scheme. The setup consists of a circular domain with 600 m resolution centred around Ny-Ålesund (Svalbard) with approx. 100 km diameter. As forcing, hourly data from a 2.4 km ICON-NWP simulation covering a limited area around the archipelago of Svalbard was used. These NWP simulations were forced with the operational global ICON forecasts. Ny-Ålesund was chosen because of its intricate topography, heterogenic surfaces and availability of observational data for comparisons.

The setup was run semi-operationally for 24 h on a daily basis for several months and therefore we were able to create statistics based on an outstandingly large data set. Using the columnar output of Ny-Ålesund we compared it to a large variety of observations (e.g. liquid water path, wind and relative humidity). This evaluation showed an astonishingly high agreement between the measurements and the simulations. For instance, the orographically influenced flow, as well as seasonal and short-range changes in humidity, are captured. Certain aspects, such as the formation of liquid vs ice in clouds, need improvement. On the whole, we could show that ICON-LEM is a useful tool to study the Arctic atmosphere and its changing climate. Further, we can continue to get a better picture of possibilities to understand the microphysical processes and improve their representation in the model.

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