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Simulating Arctic Clouds using the Numerical Weather Prediction Model ICON

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The Arctic is a fascinating part of the Earth, remote and inaccessible but so important for the climate. Its now evident role in climate change, such as the loss of sea ice concentration, makes it an even more attractive place to study. The Arctic climate is a highly coupled state between the open ocean, the ice sheet and the atmosphere where they feed back to each other. While the loss of sea ice s a current hot topic where we now understand more and more, the atmosphere, and especially clouds are still challenging topics. Clouds impact the climate in drastic ways, the incoming solar radiation is reduced by the scattering of cloud water and ice while the longwave radiation to the surface is increased by downwelling heat from the clouds, the sum of these interactions makes the clouds cool the Earth on average. In the Arctic however, this is an even more complicated interplay where the reflectivity of the ice renders the effect of clouds positive, meaning the presence of clouds warm the surface. Arctic cloud effects are thus vital when considering surface energy budgets as well as for the overall climate. With the projection of an increased cloud cover in the Arctic with higher temperatures this interaction between clouds and the sea ice becomes more important.

Looking at clouds on a microphysical level, how they are formed and how they develop, we can, for example, deduce where the cloud was formed by looking at what aerosols the cloud contain. Aerosols are suspended particles such as pollen, seasalt, dust and air pollutants. In the presence of water these particles grow into cloud droplets which form clouds but the relative amount of these aerosols in the cloud can tell us if the cloud was formed for example over seas or by planes passing by, as in the case of contrails. These aerosols impact the cloud in many ways such as their lifetime –how long the cloud survives, if it precipitates, if it freezes into an ice cloud or how much sunlight it can scatter. These effects are termed aerosol effects and their interactions with clouds is then the aerosol-cloud interactions. In the Arctic, there are not many industries present, nor is it close to any dust sources or civilisations, thus this area is supposedly very clean. However, from ship based campaigns in the Arctic we have seen that clouds are very abundant, even more so than at lower latitudes, and survive for days indicating we don't yet know the full story.

To explore these clouds and the aerosol effects, we are using a Numerical Weather Prediction model called ICON (ICOsahedral Nonhydrostatic Model), developed by KIT together with the German weather service, DWD, and Max Planck Institute, MPI for Meteorology. This model can be used for climate projections,weather forecasts as well as atmospheric research. The dynamics of the atmosphere is evolving in time as well as processes on smaller scales than what we resolve in the model which are parameterised. On top of this we couple an aerosol module developed at KIT called ART, where aerosol dynamics as well as chemistry are included, which provides a prognostic aerosol concentration. Using a model has many advantages as we can tweak inputs such as aerosols, and watch how the model behaves, how the situation has changed and from this deduce aerosol impacts and microphysical processes in the clouds. This will give an improved understanding on how these clouds behave which will lead to a better representation of these clouds in weather forecasts, shedding more light on the causes and effects of Arctic Amplification and Climate Change. Here, I will give an intro to Arctic clouds and especially focus on multilayered cloud systems, showcasing aerosol impacts on clouds when perturbing the aerosols in the Arctic.

Category

Meteorology / Atmospheric Physics

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