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Improvement of snow optical properties with respect to grain size in ICON

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The fraction of sunlight reflected by the surface of the earth (surface albedo) plays a pivotal role in the radiation and energy budget. Snow and ice surfaces are characterized by exceptionally high albedo and therefore reduce the absorption and heating of the earth. In the visible spectrum, the albedo of pure snow is roughly 96-99%. Light absorbing particles such as dust or soot can deposit on the surface and lower the albedo especially in the visible range. The additional absorption of shortwave radiation at the snow surface leads to enhanced warming. Thin layers of snow can disappear and hereby further reduce the albedo by revealing the darker surface below. Due to the changed radiation fluxes at the surface, the energy fluxes of the atmospheric layer above is altered and further feedbacks in the atmosphere can be triggered.
The nonhydrostatic model system ICON (ICOsahedral Nonhydrostatic model) was developed in a joint project between the German Weather Service (DWD) and the Max Planck Institute for Meteorology (MPI-M) as a unified next-generation global numerical weather prediction (NWP) and climate modeling system. ICON-ART is an extension of ICON to enable the simulation of gases, aerosol particles and related feedback processes in the atmosphere. The aim of this study is the implementation of the impact of aerosol deposition on snow and ice surfaces and the investigation of associated consequences in complex terrain with high resolution. The current snow model in ICON provides only simplified optical properties of the snow layer. The snow albedo on forest free surfaces varies between 50% and 85%, depending on an aging coefficient, which is governed by temperature, precipitation and wind. However, there is no distinction between albedo in the visible spectrum and the near infrared. Those optical attributes are insufficient for the computation of the impact of aerosols in snow.
We extended the current snow model by a new prognostic variable, which provides the basis for improved calculations of the snow albedo. The optical snow grain size is a key feature, which defines the albedo of pure snow and differs significantly between fresh and aged snow. Our calculations include the natural snow metamorphism that describes the growth of snow grains depending on temperature, snowfall and rain. New snowfall counters growth while higher temperature and rain accelerate the growth of snow grains. On the assumption of spherical ice crystals, we performed Mie calculations for different grain sizes and implemented Mie coefficients and computation of the snow albedo into the model. The new optical properties distinguish between visible and near infrared band and represent the foundation for interactions with aerosol optical properties.
First applications of the new scheme quantifying the effect of the modified snow albedo on surface temperature will be presented.