Characterization of the cloud radiative effect and forcing at Ny-Ålesund based on ground-based remote sensing observations

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Clouds strongly impact the available energy at the surface and at the top of the atmosphere as well as its vertical distribution within the atmosphere by modifying the shortwave (SW) and longwave (LW) fluxes and heating rates. The so-called cloud radiative effect (CRE) and the cloud radiative forcing (CRF), i.e. the difference between the all-sky and clear-sky fluxes and heating rates, respectively, strongly depend on the cloud macrophysical (e.g. frequency of occurrence, cloud vertical distribution) and microphysical (e.g. phase, water content, hydrometeor size distribution) properties.

In the Arctic, the cloud–radiative interactions are even more complex due to low temperatures, frequently occurring temperature inversions, a dry atmosphere, large solar zenith angles and a high surface albedo. In particular (supercooled) liquid containing clouds, which frequently occur in the Arctic and often have very low amounts of liquid water [1], exhibit a strong impact on the radiative fluxes. During polar night, these clouds have a distinct warming effect at the surface. In order to characterize the CRE and CRF, which eventually has an impact on the Arctic climate, long-term, vertically resolved cloud observations are needed. In combination with a radiative transfer model, the CRE and CRF can then be calculated.

For the first time, the impact of clouds on the radiative fluxes and heating rates is estimated for the Arctic site Ny-Ålesund. To this end, the Rapid Radiative Transfer Model RRTMG is used. Cloud macro- and microphysical properties needed as input for the model, have been retrieved from ground-based remote sensing observations (cloud radar, ceilometer) taken at the French-German research station AWIPEV. Further input data, e.g. thermodynamic profiles, as well as aerosol and surface albedo information, have been generated from numerical weather prediction model data and from observations of further AWIPEV instrumentation. First, clear-sky situations have been evaluated in order to gain confidence in the setup of the radiative transfer calculations. Here, the simulated SW (LW) surface fluxes agree very well with the observed fluxes with a bias of -3 (-4) Wm^{-2} and a standard deviation of 17 (4) Wm^{-2}. The higher standard deviation in the SW is due to cases when the remote sensing observations falsely classify the situation as clear-sky. In this work, we will also present first results of the radiative transfer calculations in cloudy conditions and will discuss uncertainties due to uncertainties in the retrieved cloud microphysical properties.

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References

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