Radiative effect of clouds at Ny-Ålesund, Svalbard, as inferred from ground-based remote sensing observations

K. Ebell[1], T. Nomokonova[1], M. Maturilli[2], C. Ritter[2]

[1]Institute for Geophysics and Meteorology, University of Cologne, Germany
[2]Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Potsdam, Germany

e-mail: kebell@meteo.uni-koeln.de

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, the dryness of the 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, exhibit a strong impact on the radiative fluxes.

For the first time, the impact of clouds on the shortwave (SW) and longwave (LW) fluxes and heating rates is estimated for Ny-Ålesund exploiting more than 2 years (06/2016 -10/2018) of continuous vertical cloud measurements at the French-German research station AWIPEV. The observations are performed within the Transregional Collaborative Research Centre TR172 “ArctiC Amplification: Climate Relevant Atmospheric and SurfaCe Processes, and Feedback Mechanisms (AC)^3” (www.ac3-tr.de). Cloud macro- and microphysical properties have been retrieved from ground-based remote sensing observations (cloud radar, ceilometer) and used as input for the Rapid Radiative Transfer Model RRTMG. 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. In general, the agreement between simulated and observed SW and LW downward surface fluxes is very good with only a small bias in both clear-sky and cloudy conditions. Regarding the surface CRE, low-level liquid clouds lead to a warming (~50 Wm^{-2}) throughout the year. During polar day, clouds strongly cool the surface in the SW with a large daily variability. The net CRE at the surface is generally positive between September and May and negative from June to August which is due to the low surface albedo. The net CRF is dominated by the LW CRF with warming taking place in principal below the height of the maximum frequency of occurrence of liquid around 1 km, and cooling above. The strength of this cooling and warming is closely related to the amount of liquid.