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Boundary-Layer Impacts and Modulation of Liquid Water in Wintertime Arctic Clouds

Ola Persson (1), Amy Solomon (1), Gijs de Boer (1), Matthew Shupe (1), and Cassie Wheeler (2)
(1) CIRES/NOAA/ESRL, Univ. of Colorado, Boulder, CO USA (Ola.Persson@colorado.edu), (2) Broomfield, CO USA

Cloud liquid water (CLW) in wintertime Arctic mixed-phase clouds produces dramatic transitions in downwelling longwave radiation, and regulates the responses in other surface energy budget (SEB) terms such as the turbulent sensible heat flux and the conductive heat flux through snow and ice. The modulation of the CLW by synoptic and mesoscale forcing is ilustrated using SHEBA observations, while the magnitudes of the SEB responses are also available from these observations. Furthermore, through cloud-top longwave cooling of the primarily stratocumulus clouds, upside-down convective mixing is produced and a mixed layer descends towards the surface at the same time as the surface warming through longwave radiative fluxes produce a surface-based mixed layer. This all occurs during the polar night with no solar radiation, a time which is generally considered to have a very stable boundary layer. The frequency of these events and the magnitudes of the various transitions for the SHEBA winter will be presented. In addition, these same processes and process relationships will be examined in simulations with the Weather Research and Forecasting Model (WRF) and in reanalysis data, which are primarily dependent on model output in the Arctic. It will be shown that the physical processes and process relationships in these models differ from observations because of their inability to reproduce the observed amount of CLW.