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Classification of cloud conditions during polar night based on observations at drifting stations in the Arctic

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Clouds affect the radiation balance of the sea ice cover, reduce effective surface radiation, and increase atmospheric downward longwave radiation during polar night in the Arctic, in comparison with measurements under clear sky. Visual observations of clouds at the North Pole drifting stations (NP) in 1950-1990 showed the presence of maxima in the frequency distribution of cloudiness in the clear sky (0-2 points) and overcast sky (8-10 points). Since 2007, the use at the drifting stations of a ceilometer with a pulsed diode laser has improved the resolution of cloud measurements at the zenith above the ceilometer with a time step of 15 seconds. Based on the SHEBA data, the authors (Stramler et al, 2011) revealed the presence of two modes in the longwave radiation balance frequency distribution in winter. They put these modes in accordance with the clear sky state (<=-30 W/m2) and overcast state (>=-10 W/m2), and showed that, the atmospheric boundary layer (ABL) presents in two states: under clear sky the ABL is stable, colder, and with overcast cloud cover, ABL is unstable, warmer, with a strong wind. The objective of this study is to determine the most statistically reliable way to distinguish between clear sky and cloudy cases during the polar night. An analysis of the atmospheric surface layer conditions in winter (November-February) in the Arctic in the presence and absence of clouds is presented based on the results of observations at NP-37, 39, 40 (2009 to 2013). The subdividing into categories (overcast or clear sky) was carried out in three ways: based on visual observations, by the value of the longwave radiation balance, and by a ceilometer. For each category of cloud conditions meteorological data were selected (air and surface temperatures and their difference, wind speed, atmospheric pressure, longwave radiative fluxes and balance, turbulent sensible heat flux, Monin-Obukhov stability parameter). The most appropriate method for cloud conditions classification has the largest difference between the mean values of meteorological observation series under clear skies and overcast skies, and the smallest standard deviation within the datasets. Discriminant analysis methods were also used in our study. At the NP-37 and NP-39 stations, depending on cloud conditions, more pronounced differences were obtained using ceilometer data for all parameters of the atmospheric surface layer, with the exception of the sensible heat flux, as well as the longwave radiation balance. At NP-40, the best results were obtained by separating cloud conditions by longwave radiation balance method. Information about cloudiness at NP-40, obtained using a ceilometer, show a lower flux of downward radiation, greater radiative cooling of the surface and lower air temperature compared to other stations and compared to grouping data by longwave radiation balance, which may be associated with the features of the phase composition of clouds. Visual observations of cloudiness did not show an advantage at the drifting stations.