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Atmospheric boundary layer characteristics based on the observations at the Climate Change Tower in Ny Alesund(Svalbard).

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At high latitudes, the Atmospheric Boundary Layer (ABL) is often characterized by extremely stable vertical stratification since the surface radiative cooling determines inversions in temperature profiles especially during the polar night over land, ice and snow surfaces. Improvements are required in the theoretical understanding of the turbulent behavior of the high-latitude ABL. The parameterizations of surface-atmosphere exchanges employed in numerical weather prediction and climate models have also to be tested in the Arctic area. Moreover, the boundary layer structure and dynamics influence the vertical distribution of aerosol. The main issue is related to the height of PBL: the question is whether some decoupling occurs between the surface layer and the atmosphere aloft when the PBL is shallow or the mechanical mixing due to the synoptic circulation provides an overall vertical homogeneity of the concentration of the aerosol irrespective of the stability conditions. In this aim, the work investigates the features of the high-latitude ABL with particular attention to its vertical structure, the relationships among the main turbulent statistics (in a similarity approach) and their variation with the ABL state.

The used data refer to measurements collected since 2012 to 2016 by slow and fast response sensors deployed at the 34 m high Amundsen-Nobile Climate Change Tower (CCT) installed at Ny-Ålesund, Svalbard. Data from four conventional Young anemometers and Väisäla thermo-hygrometers at 2, 4.8, 10.3 and 33.4 m a.g.l., alternated by three lined up sonic anemometers at 3.7, 7.5 and 21 m a.g.l., are used in the analysis.

The presented results highlight that the performance of the commonly adopted ABL similarity schemes (e.g. flux-gradient relationships and parameterizations for the stable ABL height) depends upon the ABL state, determined mainly by the wind speed and the shape of the profiles of second order moments (the two being related) . For neutral or stable stratification, strong wind and second order moments monotonically decreasing with height (traditional stable ABL), classical similarity schemes perform well also in the Arctic ABL. Instead, critical conditions, for which the classical similarity approach is not satisfactory, occur for low wind and profiles of second order moments deviating from the traditional case: e.g. upside-down ABL.

Numerical experiments with the atmospheric model Bolam have been performed, for the whole period April-August 2013 in hindcast mode, on a domain covering the area of the observations, in order to assess the capability of an atmospheric numerical model to reproduce the observed vertical profiles in the PBL under different synoptic situations.