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Analysis of turbulence statistics above a Scots pine forest in a sub-arctic northern region

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Analysis of turbulence data measured in a typical area for the subarctic Northern Finland with sparse Scots pine forests is presented. Tower-based turbulence measurements were collected above a forest ($h_c \approx 15m$) at the Sodankylä Meteorological Observatory, located at Tähtelä in Finnish Lapland, 100 km north of the polar circle. High-frequency wind velocity components and sonic temperature are measured using three-dimensional sonic anemometers at three level (22, 25 and 47 m). In addition, measurements of wind velocity and air temperature are performed at different heights by cup anemometers and temperature sensor respectively. Vertical profiles of mean wind velocity and turbulent statistics until the fourth order were calculated. The vertical profiles are wind direction dependent, showing different characteristics determined by the combined effect of the density and fetch of the canopy. For several directions, the wind flow show a discrete deceleration just above the canopy top, departing from a classical logaritmic profile. Turbulent statistics profiles were analyzed in the context of Monin-Obukhov similarity theory, as determined by stability at the top level ($3.13h_c$), to assess the extent to which surface scaling is valid as the canopy top is approached. The profiles of velocity standard deviations σ_i, normalized by u_* measured at $z = 3.13h_c$, are influenced by the inhomogeneity of canopy density and for several wind directions don't follow a similarity scaling, showing an increase of turbulent energy at $z = 1.46h_c$ and $z = 1.66h_c$.