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Diurnal behaviour of turbulence in the summer PBL at Dome C: Sodar and In-situ Observations

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A long-term experiment to study turbulence in the atmospheric boundary layer (ABL) over the Antarctic plateau was carried out in 2011-2015 at Concordia station (Dome C). The main observational instrument was a high-resolution sodar (vertical resolution better than 2 m, time resolution of 2 s, first range gate of $\approx$ 3 m). Observations were made using both sodar and in-situ instruments (ultrasonic thermometer-anemometers, wind and temperature sensors near the surface and on a 45-m tower, radiometers and radiosoundings).
The results presented here are restricted to the summer period from December 2014 to January 2015, when accurate turbulence measurements by a high-quality ultrasonic thermometer-anemometer HS-50 (Gill Instruments Ltd) were performed in synergy with the other instruments. This device is capable to provide accurate measurements of weak-turbulence parameters even under neutral and very stable stratification conditions. It was installed close to a more conventional sonic anemometer USA-1 by Metek GmbH (the instrument routinely used during the entire long-term experiment) to compare their measurements for methodological purposes. The deployment of the HS-50 allowed us to determine the diurnal behaviour of the principal turbulent parameters (heat and momentum fluxes as well as temperature and wind structure parameters) with the accuracy required to improve a number of previous results. An accurate calibration of the sodar CT2 measurements was performed to refine the sodar results obtained previously. The diurnal behaviour of the height dependence of CT2 together with the mixing layer height was determined for the entire diurnal cycle. Some conventional and advanced models of the diurnal evolution of the ABL were applied and compared based on accurately measured input turbulence parameters (heat and momentum turbulent fluxes). Several parametrizations of the depth of both the mixing layer and the stable boundary layer were verified for different turbulence regimes. The characteristics of the wave structures occurred within the elevated inversion layer were determined and analyzed.
The behaviour of turbulence spectra at high-frequency range (especially, their slopes) under stable stratification was determined correctly and compared with previous results. Relationships between thermal and mechanical turbulence intensities under different stability conditions were analyzed.