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Local Characteristics of the Nocturnal Boundary Layer in Response to External Pressure Forcing

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Geostrophic wind speed data, derived from pressure observations, are used in combination with tower measurements to investigate the nocturnal stable boundary layer at Cabauw, The Netherlands. Since the geostrophic wind speed is not directly influenced by local nocturnal stability, it may be regarded as an external forcing parameter of the nocturnal stable boundary layer. This is in contrast to local parameters such as in situ wind speed, the Monin-Obukhov stability parameter (z/L) or the local Richardson number. To characterize the stable boundary layer, ensemble averages of clear-sky nights with similar geostrophic wind speed are formed. In this manner, the mean dynamical behavior of near-surface turbulent characteristics, and composite profiles of wind and temperature is systematically investigated.

We find that the classification results in a gradual ordering of the diagnosed variables in terms of the geostrophic wind speed. In an ensemble sense the transition from the weakly stable to very stable boundary layer is more gradual than expected. Interestingly, for very weak geostrophic winds turbulent activity is found to be negligibly small while the resulting boundary cooling stays finite. Realistic numerical simulations for those cases should therefore have a solid description of other thermodynamic processes such as soil heat conduction and radiative transfer. This prerequisite poses a challenge for Large-Eddy Simulations of weak wind nocturnal boundary layers.