EMS Annual Meeting Abstracts
Vol. 14, EMS2017-260-1, 2017

Near-surface temperature inversion growth rate during the onset of the stable boundary layer

Ivo van Hooijdonk (1), Carsten Abraham (2), Amber Holdsworth (2), Adam Monahan (2), Etienne Vignon (3), Arnold Moene (4), Peter Baas (5), Herman Clercx (1), and Bas van de Wiel (5)

(1) Eindhoven University of Technology, Fluid Dynamics Laboratory, Eindhoven, Netherlands (i.g.s.v.hooijdonk@tue.nl), (2) School of Earth and Ocean Sciences, University of Victoria, Victoria, British Columbia, Canada, (3) Univ. Grenoble Alpes/CNRS/IRD, IGE, F-38000, Grenoble, France, (4) Meteorology and Air Quality Group, Wageningen University and Research, Wageningen, The Netherlands, (5) Faculty of Civil Engineering and Geosciences, and Remote Sensing, Delft University of Technology, Delft, The Netherlands

This study aims to find the typical growth rate of the temperature inversion during the onset of the stable boundary layer around sunset. The sunset transition is a very challenging period for numerical weather prediction, since neither accepted theories for the convective boundary layer, nor those for the stable boundary layer appear to be applicable. To gain more insight in this period a systematic investigation of the temperature inversion growth rate is conducted. A statistical procedure is used to analyse almost 16 years of observations from the Cabauw observational tower, supported by observations from two additional sites (Dome C and Karlsruhe). The results show that, on average, the growth rate of the temperature inversion (normalized by the maximum inversion during the night) weakly declines with increasing wind speed. The observed growth rate is quantitatively consistent among the sites, with slightly lower values at Dome C. Moreover, the normalized growth rate appears insensitive to various other parameters. The results were also insensitive to the afternoon decay rate of the net radiation except when this decay rate was very weak. This point explains why slightly lower values were found for Dome C, where the magnitude of the diurnal cycle is weaker. These observations are compared to numerical solutions of three models with increasing complexity: a bulk-model, an idealized single-column model (SCM) and an operational-level SCM. It appears only the latter could reproduce qualitative features of the observations using a first-order closure. Moreover, replacing this closure with a prognostic TKE-scheme substantially improved the quantitative performance. This suggests that idealized models assuming instantaneous equilibrium flux-profile relations may not aid in understanding this period, since history effects may qualitatively affect the dynamics.