EMS Annual Meeting Abstracts
Vol. 15, EMS2018-649, 2018

Surface layer simulations with WRF single-column model in stable nocturnal conditions

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The numerical weather modelling of the planetary boundary layer is extremely challenging, especially in stable or near neutral stratification conditions. At night, when the turbulent motions are absent, the boundary layer processes are mostly determined by the surface fluxes. The surface fluxes and the boundary layer schemes are coupled by surface layer schemes. This coupling affects daily minimum temperature predictions throughout the year over continental, landlocked areas. We have a limited knowledge on surface layer and numerical weather prediction models cannot afford large-eddy-scale computations, therefore the estimations of exchange processes require simplifications. Similarity functions based on Monin–Obukhov similarity theory are usually used.
A series of multicopter, tethered balloon and flux measurements were made in southern Hungary over a 5-day-long period in the scope of the Pannonian Atmospheric Boundary Layer Experiment in 2015 (PABLS'15). The measurements were taking place over a flat, homogeneous area in the middle of the Pannonian Plain. The aim of the measurements was to analyse the night-time stable environment of the boundary and surface layer. These datasets were used as validation for our study and for determining the surface information, the soil and vegetation parameters. The WRF single column model is used to test different parameterization schemes. Simulated fluxes were tested against the continuous flux measurements. The model setup used 61 atmospheric vertical layers, where 22 layers are found in the lowest 200 meters. Altogether 26 combinations of available parameterizations were chosen and analysed. Results show that the different physical parametrizations' performance in the near-surface layer depends on the simulated meteorological variable. The vertical gradient of the temperature is captured, but the moisture flux is not. A cluster analysis on the errors also show that in case of 1st and 1.5 order closure schemes the choice of surface layer scheme results is small variances, but in case of 2nd order closure, the choice of surface layer parameterization is an important factor. Results also show that even with using the same soil and vegetation parameters the estimated Noah and Noah-MP surface schemes perform significantly different during daytime conditions.