Geophysical Research Abstracts
Vol. 16, EGU2014-654, 2014
EGU General Assembly 2014

High-resolution numerical simulations of wintertime atmospheric boundary layer processes in the Adige Valley during an ALPNAP project field campaign.

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High-resolution simulations are performed with the Weather Research and Forecasting (WRF: http://www.wrf-model.org/) model, coupled with two different land surface models (LSM), Noah and Noah_MP, to reproduce meteorological conditions leading to a severe pollution event during the winter season in the Alpine Adige Valley. Model results are compared against data collected during an intensive measurement campaign performed close to the town of Aldeno, within the project ALPNAP (www.alpnap.org). Particular attention is focused on assessing the model ability to reproduce the time evolution of 2-m temperature. Accordingly the evaluation of the terms composing the surface energy budget is examined. Validation of model results highlights that WRF poorly reproduces near-surface temperature over snow-covered terrain, with an evident underestimation, both during daytime and nighttime. Furthermore it fails to capture specific atmospheric processes, such as the development of ground-based thermal inversions and the different thermal range between the sidewall and the valley floor. The main cause of these errors is the overestimation of the average grid cell albedo and the consequent too high fraction of reflected solar radiation calculated by both Noah and Noah_MP LSMs. Modifications to the LSMs are then performed to improve model results, by intervening in the calculation of the albedo, of the snow cover, when the terrain is partially covered by snow, and of the surface temperature. Thanks to these changes in the parameterization of snow-related influences on the surface energy budget, a significant improvement in the comparisons between model results and observations is observed. In fact, the proposed changes in the LSMs lead to a better reproduction of both the main features of the terms composing the surface energy budget and of the near-surface temperature. In particular, for the latter variable, errors found are comparable to those reported in previous investigations of atmospheric processes in complex terrain with high-resolution atmospheric models. Moreover, results highlight that, with the proposed modifications, the model is able to reproduce correctly important atmospheric processes strictly connected with air pollution dispersion, such as the development of ground-based thermal inversions and the evolution of wind speed and direction.