3.5 The impact of the atmospheric stability on the unresolved topography for surface winds in WRF model

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The small scale orography (SSO) generates an additional drag that has been recognized as a relevant factor in the atmospheric circulations at different scales. The Numerical Weather Prediction models consider this drag through subgrid-scale parameterizations. In particular, in the Weather Research and Forecasting (WRF) model, Jiménez and Dudhia (2012) resolved the SSO by including a factor in the momentum equation which is function of the terrain features. Nevertheless, how this drag affect to the flow in the boundary layer not only depends on the terrain features, but also the boundary layer (PBL) structure. Bearing this in mind, this work assesses the role of the atmospheric stability on the SSO drag focusing on the surface winds.

In agreement with recent studies, in this work we found that the SSO parameterization reduces the systematic overestimations of the wind speed represented by WRF. However, it also underestimates the wind speed during the windiest months as a consequence of an overbraking during unstable conditions. To overcome these limilations, a more realistic SSO drag is parametrized by including the atmospheric stability conditions. Building on the WRF scheme of the SSO, some corrections are proposed in order to modulate the SSO drag with PBL parameters such as the convective velocity (VCONV), the boundary layer height (PBLH) and turbulent kinetic energy (TKE).

Results show that the inclusion of the atmopheric stability in the SSO scheme plays a key role in controlling the intensity of this drag. When VCONV and the hybrid PBL height are included in SSO drag, the modelled wind speed is improved. The modulation of the drag through the VCONV allows decrease its intensity when the convective processes dominate. Meanwhile the inclusion of the PBL height is relevant during the late afternoon when the convection is vanished, but the flow is still turbulent and less affected by the drag. This correction accelerates the wind speed during the daytime which improves the representation of the diurnal cycle. Consequently, the wind speed underestimation for the windiest months is reduced. However, the improvement of this correction could be constrained by representativeness errors due to physical processes appearing in the observations but not in the model, such as flow blocking, specially in the Mediterranean region.

These results hightlight the neccessity of including the atmospheric stability to correct the SSO drag to modulate its intensity, and its relevance to improve the representation of the surface winds.

Jiménez, P. A. and J. Dudhia, 2012: Improving the representation of resolved and unresolved topographic effects on surface wind in the WRF model. J. Appl. Meteor. Climatol., 51 (2), 300–316.