OLYMPIC HARMONIE 2014 –
Influence of the details of topography in a NWP model
Laura Rontu and Sami Niemelä, Clemens Wastl, Alexander Mary and Yann Seity
Finnish Meteorological Institute, Zentralanstalt für Meteorologie und Geodynamik, Meteo France

WMO FROST, Sochi 2014
World Meteorological Organization (WMO) organized both Research Development Projects (RDP) and Forecast Demonstration Projects (PDP) during the Olympic games. The FROST-2014 (Forecast and Research: the Olympic Sochi Testbed) project focused in particular on the development/demonstration of modern short-term Numerical Weather Prediction (NWP) and nowcasting systems over mountainous region in winter-time conditions and on the assessment of practical use of this information. In order to do so, the project deployed several additional observation sites in the area. This new observation dataset was used in our study.

Orography and ororad variables

In this study, these variables were derived from SRTM (Shuttle Radar Topography Mission, Jarvis et al. (2008)) 3° data within the SURFEX Physiography definition (PGD) subroutines. For radiation variables, preprocess using GDAL (www.gdal.org) software and modification of PGD were needed. In PGD, even more variables are routinely calculated for the orographic momentum flux parameters but were not applied here.

Implementing new ororad parametrizations to HARMONIE

A parametrization scheme for orographic effects on radiation was introduced to HARMONIE-AROME-SURFEX following Senkova et al. (2007). Slope (sinθ) and shadow (sinδθ) factors are applied to modify downwelling direct shortwave radiation flux at the surface level. These factors allow to account for the different slope angles and directions with respect to the current solar position and estimate the relief shadows due to the neighbouring obstacles. Restricted visibility of sky is described by the sky-view factor (sinθsv), which is applied to modify the diffuse shortwave and downwelling longwave radiation fluxes. A simplified version of the HIRLAM smallest-scale orographic turbulence parametrization (Renou, 2006) was tried in HARMONIE instead of the default adaptation of the concept of orographic roughness. The suggested scheme is another realization of the Wood et al. (2001) idea of handling the non-separated sheltering effect. The surface value of the subgrid-scale orographic stress σs (horizontal momentum flux in the layer sliced in units of Pa) is related to the subgrid-scale orographic variance σsv, multiplied by the turbulent stress τsv, where σsv = Cσsv,svσsv,sv

\[ \tau_{sv} = C_{\sigma sv} \sigma_{sv} \]  

where Cs is the subgrid-scale orography drag coefficient and σsv denotes the turbulent surface stress (mean of elevation). Cs stands for the air density at the surface, overline denotes average over a gridscale and and \( \overline{\cdot} \) are deviations of the vertical and horizontal wind components from the average, respectively.

References


This example, picked from the full 3D HARMONIE experiments in February 2014, shows that the daytime maximum screen-level temperatures were underestimated especially in the valley as compared to the observations while the minimum temperatures tend to be somewhat overestimated. The new ororad parametrizations (magenta line, which represents within the suggested version) corrected SWD and LWD as expected, thus influencing the surface temperature, but did not significantly improve the screen-level temperatures. Standard station verification for February 2014 (not shown) over the Olympic venue and a larger Caucasian domain confirms the result. The reason of Tmin bias remains to be understood.

Wind example by MUSC, the single-column HARMONIE

The new ororad parametrizations for orographic momentum fluxes could not really be tested against the Olympic observations because of the weak wind conditions over the area in February 2014 and the unknown properties of the available near-surface wind observations. Single-column experiments were run instead to test the sensitivity of the lowest level wind, turbulent kinetic energy and friction velocity to the choice of tunable parameters of the ororad scheme. We used the atmospheric profile at Krasnya Polyana, picked from the 3D experiments, but increased the wind speed by 10 m/s at levels in two lowest kilometres. The figure below shows an example of the wind evolution after tuning of Cσsv, Equation 1. We can conclude that physically reasonable tuning the low level turbulence and wind in the boundary layer over the rough terrain as a function of the orographic standard deviation is possible but more testing against representative low level wind observations is needed.