Simulazione di Circolazioni Locali in una Valle Idealizzata: Sensitività alle Parametrizzazioni della Turbolenza e delle Interazioni Superficie-Atmosfera

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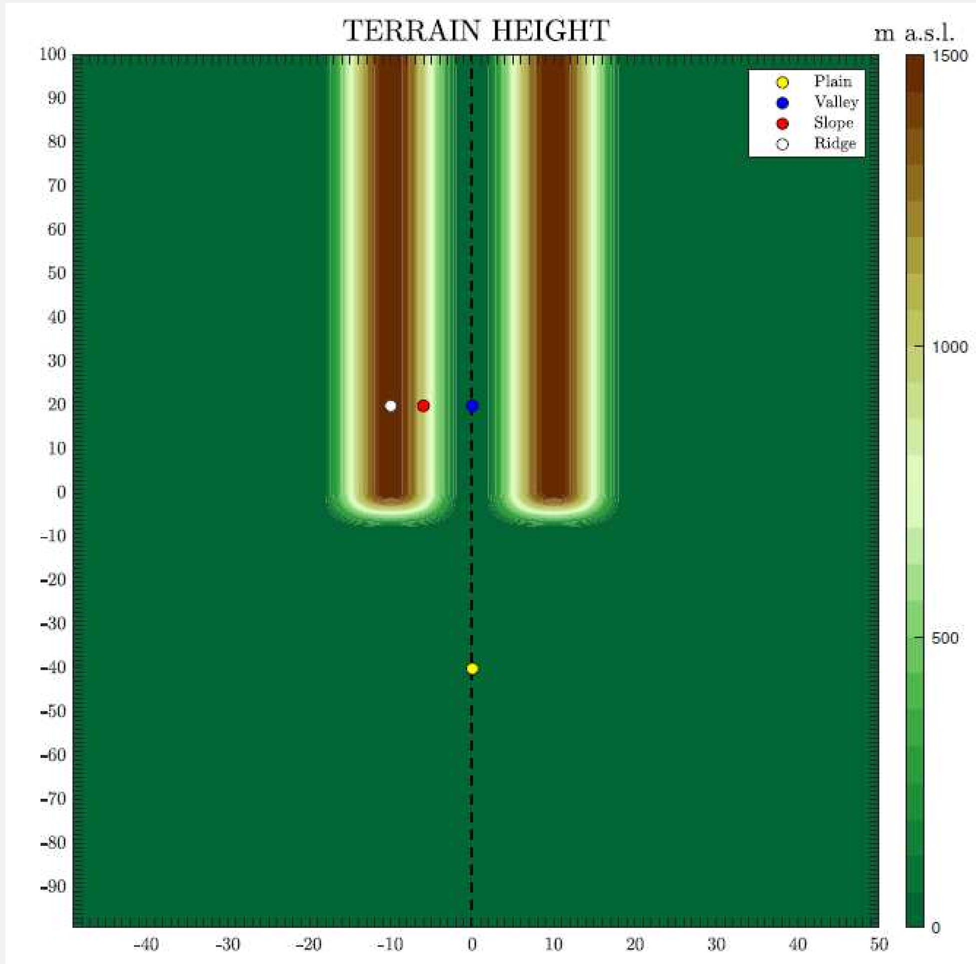
Introduction

This contribution aims at presenting results from the project "Atmospheric boundary-layer modeling over complex terrain", a collaboration between the University of Trento, Bolzano and Innsbruck with the objective to evaluate turbulence and land surface parameterizations in mountainous terrain and to identify potential issues that have a large impact on model results and consequently on the quality of weather forecasts. A set of Reynolds-Averaged Navier-Stokes (RANS) simulations at 1 km horizontal resolution has been performed in an idealized three-dimensional valley-plain topography, using typical geometrical features of a north-south Alpine valley, with ridges up to 1500 m above the valley floor and a distance of 20 km from crest to crest. The aim of the modeling experiment is to evaluate the sensitivity of model results to planetary boundary layer (PBL) parameterizations and land surface models (LSMs), exploring all the possible combinations of PBL and LSMs available in the Weather Research and Forecasting (WRF) model. Simulations are run for 48 hours and a full diurnal cycle has been considered for the evaluation of numerical results, focusing on the development of along- and cross-valley thermally-driven circulations and on the associated thermal field both in the nighttime and in the daytime phases.

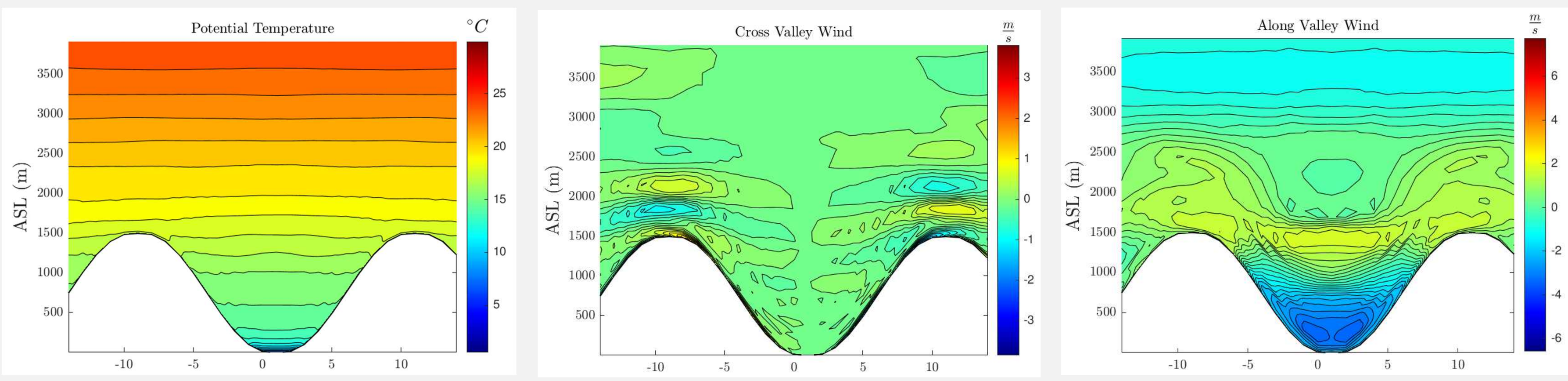
Modeling Set Up



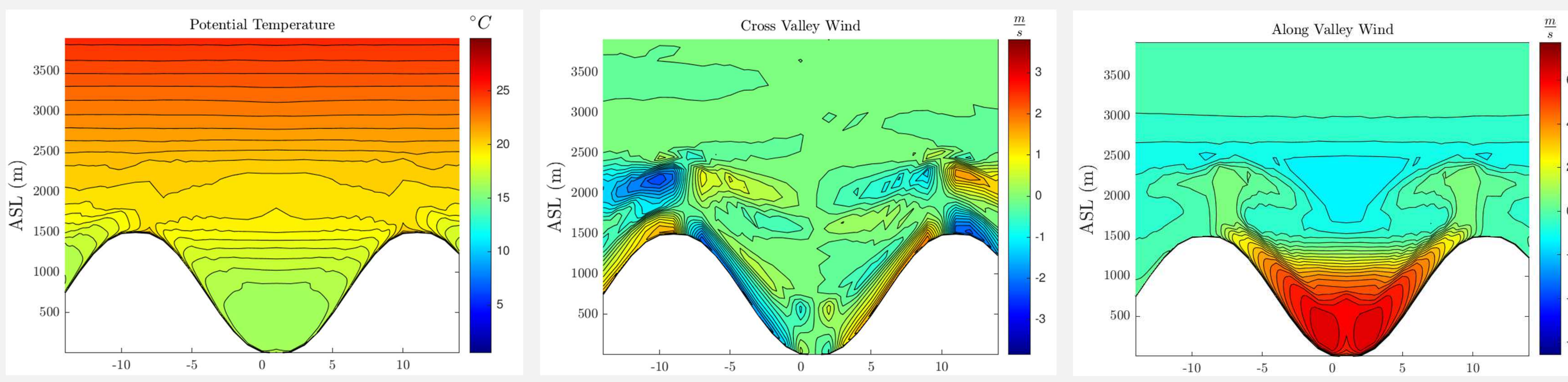
Terrain height adopted in the simulations.

- $\Delta x=\Delta y=1000$ m for RANS
- $\Delta x=\Delta y=100$ m for LES
- Δz from 15 m close to the surface to 400 m at 12000 m AGL
- #x=100, #y=200, #z=65 for RANS
- #x=1000, #y=2000, #z=65 for LES
- Symmetric domain S-N and W-E
- Symmetric boundary conditions
- $U_0=0$ m s^{-1}, $V_0=0$ m s^{-1}
- $\theta_0 = \theta_s + \Gamma z + \Delta\theta[\exp(-\beta z)]$, $\theta_s = 280$ K, $\Gamma = 3.2$ K km^{-1}, $\Delta\theta = 5$ K, $\beta = 0.002$ m^{-1}
- P_0=1000 hPa
- No Coriolis force
- Lat=46°N , Lon= 11°E
- 21st March

Modeling Results: Cross-Sections

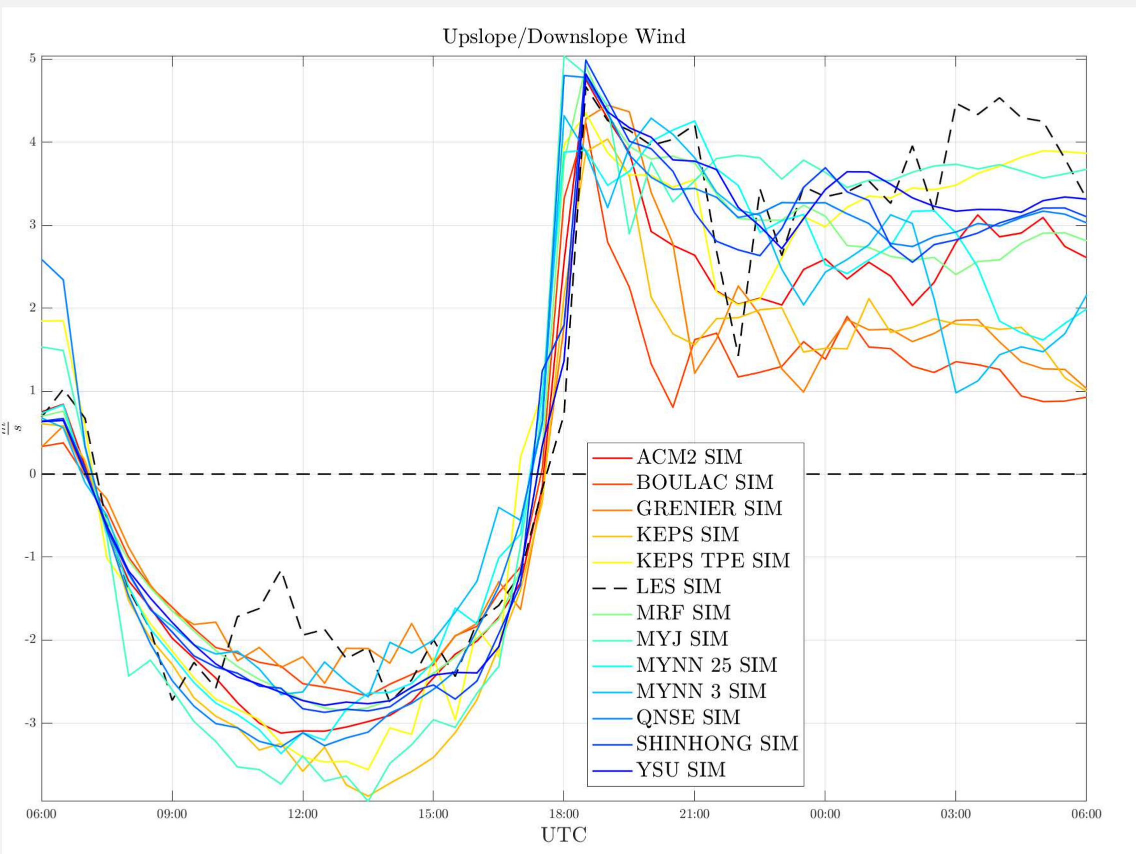


Cross section of potential temperature (left), cross-valley wind (center) and along-valley wind (right) at 03 UTC from the RANS simulation with the BouLac turbulence parameterization and the Noah LSM.



Cross section of potential temperature (left), cross-valley wind (center) and along-valley wind (right) at 15 UTC from the RANS simulation with the BouLac turbulence parameterization and the Noah LSM.

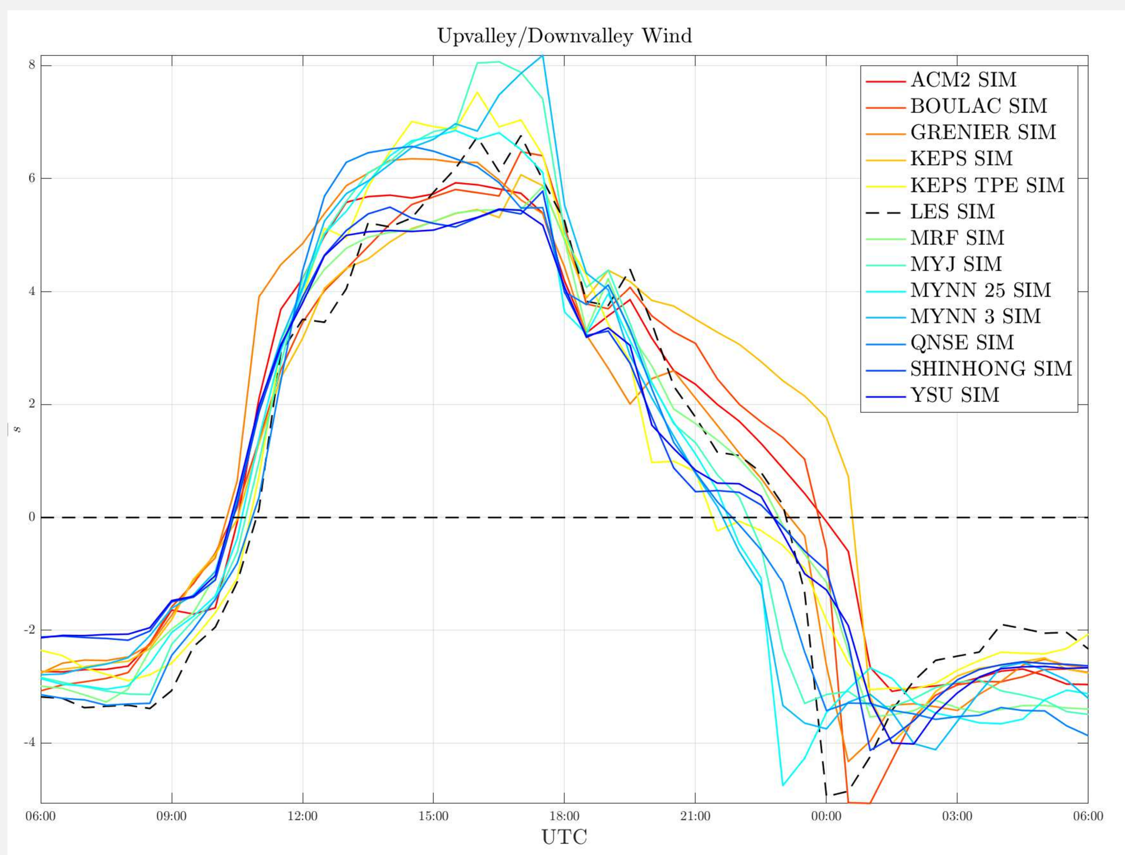
Cross-Valley Wind



Temporal evolution of the cross-valley wind in the slope point.

The transition between down- and up-slope wind and viceversa is similarly captured by all RANS simulations adopting different turbulence parameterizations, and well agree with the LES. Significant differences are present in the simulation of the strength of the slope circulation, in particular for the downslope wind during nighttime, with values ranging between 1 and 4 m s^{-1}.

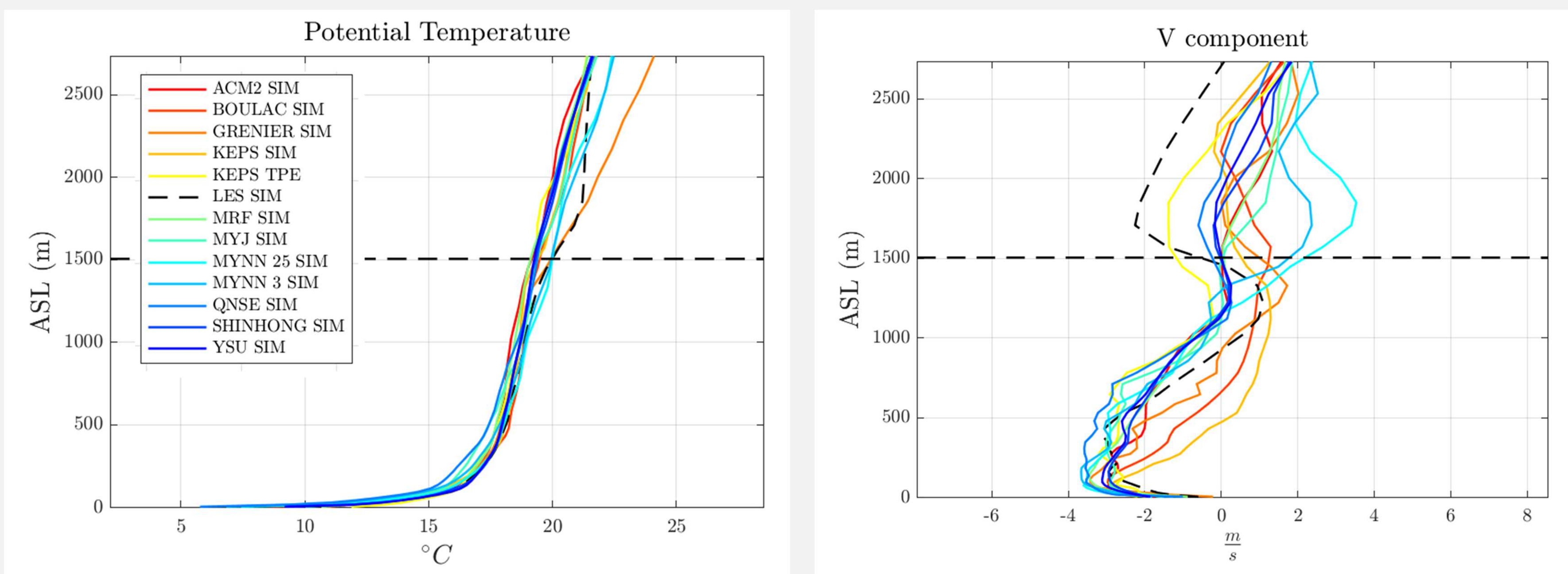
Along-Valley Wind



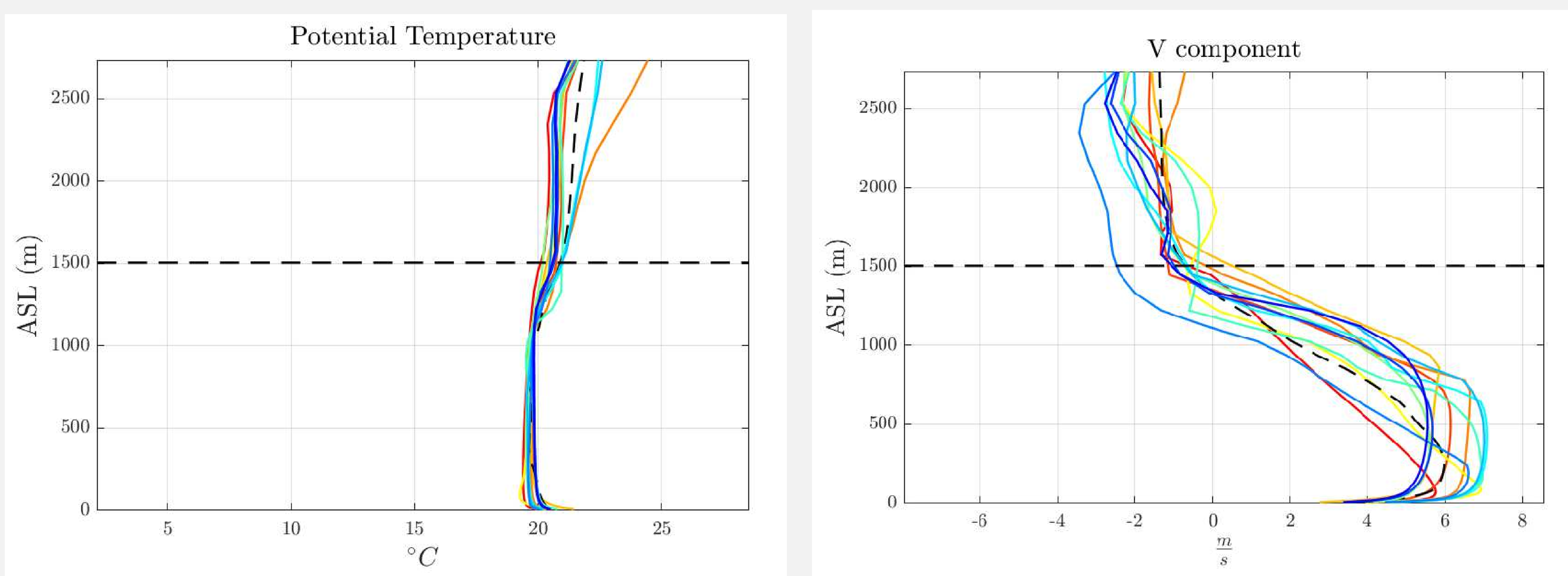
Temporal evolution of along-valley wind in the valley point.

The timing of the transition between down- and up-valley wind is similarly captured by all RANS simulations, and agree with the LES. On the other hand, significant differences between the RANS simulations are present in the evening transition between up- and down-valley wind. The strength of both down- and up-valley wind is similar in all RANS simulations, considering especially the down valley wind.

Modeling Results: Vertical Profiles



Vertical profiles of potential temperature (left) and along-valley wind (right) at 03 UTC from the RANS simulations and the LES.



Vertical profiles of potential temperature (left) and along-valley wind (right) at 15 UTC from the RANS simulations and the LES.

Project funded by the European Region Tyrol-South Tyrol-Trentino. Project IPN101 "Atmospheric boundary-layer modeling over complex terrain"