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Turbulence sources in mountain terrain: results from MATERHORN program

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Improving high-resolution numerical weather prediction in complex terrain is essential for the many applications involving mountain weather. It is commonly recognized that high intensity weather phenomena near mountains are a safety hazard to aircrafts and unmanned aerial vehicles, but the prediction of highly variable weather is often unsatisfactory due to inadequacy of resolution or lack of the correct dynamics in the model. Improving mountain weather forecasts has been the goal of the interdisciplinary Mountain Terrain Atmospheric Modeling and Observations (MATERHORN) program (2011-2016). In this paper, we will report some of the findings focusing on several mechanisms of generating turbulence in near surface flows in the vicinity of an isolated mountain. Specifically, we will discuss nocturnal flows under low synoptic forcing. It has been demonstrated that such calm conditions are hard to predict in typical weather predictions models where forcing is dominated by local features that are poorly included in numerical models. It is found that downslope flows in calm and clear nights develop rapidly after sunset and usually persists for few hours. Owing to multiscale flow interactions, slope flows appear to be intermittent and disturbed, with a tendency to decay through the night yet periodically and unexpectedly generated. One of the interesting feature herein is the presence of oscillations that can be associated to different types of waves (e.g. internal and trapping waves) which may break to produce extra mixing. Pulsations of katabatic flow at critical internal-wave frequency, flow intrusions arriving from different topographies and shear layers of flow fanning out from the gaps all contribute to the weakly or intermittently turbulent state. Understanding of low frequency contributions to the total kinetic energy represent a step forward into modelling sub-grid effects in numerical models used for aviation applications.