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Investigating the dynamics of thermally driven up-slope flows: analysis of data from measurements in the Inn Valley (Austria) and comparison with a simple model

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Diurnal wind systems typically develop in mountainous areas following the daytime heating and nighttime cooling of sloping surfaces. While down-slope winds have been extensively treated in the literature, up-slope winds have received much less attention. In particular, the physical mechanisms associated with the development of these winds, as well as the search for appropriate parameterization of turbulent fluxes of mass, momentum, and heat over slopes in numerical weather prediction models are still open research topics.

Here we present some preliminary results from the analysis of turbulence data (sonic wind speed, temperature, humidity, and turbulent fluxes) collected at two slope stations which are part of the i-Box initiative. The i-Box project (Rotach et al. 2017) aims at studying turbulent exchange processes in complex terrain areas. The experimental setup is composed of six stations disseminated in the surroundings of the alpine city of Innsbruck, in the Inn Valley. The two stations adopted for the present study are located at different points on the valley sidewalls, one with a slope angle of 27° (labelled NF27) and one with a slope angle of 10° (NF10). Both stations are located over slopes covered by alpine meadow and at an altitude of about 1000 m MSL (400 m above the valley floor). The station NF27 has two measurement points, 1.5 and 6.8 m AGL, while the station NF10 has one measurement point, at 6.2 m AGL.

The analysis shows that criteria proposed in the literature for the selection of valley-wind days may not apply for the identification of slope-wind days. Furthermore, from the analysis of second order moments, scaling relationships are derived for up-slope flow conditions. In addition, measurements representing the evolution of the up-slope flow structure from the early morning to the mid-afternoon are compared with an existing, simplified, analytical model, which provides the evolution of the vertical profiles of temperature and along-slope wind velocity as generated by a sinusoidal forcing representing the daily cycle of surface temperature. An improvement of the existing model, where the surface energy budget is considered as the boundary condition for the surface temperature, is also tested.