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Influence of the incoming solar radiation on the boundary layer of an idealized valley.

Daniel Leukauf, Johannes Wagner, Christian Posch, Alexander Gohm, and Mathias Rotach
University of Innsbruck, Institute for Meteorology and Geophysics, Innsbruck, Austria (daniel.leukauf@uibk.ac.at)

Abstract
In recent years, the mechanisms of thermally-driven wind systems and the boundary layer over complex terrain have been investigated through real-case and idealized numerical simulations. However, these studies usually consider only one given latitude or one predefined surface forcing. The question remains how the evolution and structure of the valley boundary layer and the valley wind system depends on solar forcing. This question is fundamental if one aims at developing a parametrization of exchange processes based on bulk fluxes of heat, moisture and other properties from the valley to the free atmosphere evaluated from idealized simulations.

One key goal is to determine the dependency of the vertical heat flux in a valley on the incoming solar radiation. For this purpose, we conducted large eddy simulations with the Weather Research and Forecasting (WRF) model in an idealized valley. An idealized radiation formulation has been used and simulations for different magnitude of incoming short-wave radiation were carried out.

The chosen valley geometry consists of two sine-shaped mountain ridges which form a 20 km wide and 40 km long valley with a flat valley floor. As the terrain is homogeneous in the along-valley direction and periodic boundary conditions are used, only slope winds but no valley winds evolve. The incoming short-wave radiation is defined using a simple sine function with amplitude A during the day and a value of zero during the night, while long-wave outgoing radiation is calculated using the Angstrom formula. This gives the advantage to have a single parameter, the amplitude A to vary the incoming solar radiation instead of tree pa
rameters (albedo, latitude and date) using a radiation scheme. However, control experiments using the Rapid Radiation Transfer Model (RRTM) were performed as well. Parametrizations for surface-atmosphere exchange processes were used and the initial vertical profiles are characterized by a constant buoyancy frequency, a constant relative humidity and zero winds.

As expected, the amplitude of the incoming solar radiation has a strong impact on the slope wind system. With increasing solar forcing, the width of the slope wind layer grows, the nocturnal inversion is dissolved earlier and the circulation patterns become less complex, i.e. only one huge double circulation cell is present in the valley. For a weak forcing, additional cross circulation patterns appear and persist for longer period of time. Apart from the uppermost cell, all the other circulation patterns lie within the valley and the export of air into the free atmosphere is greatly reduced. Therefore, the export of heat, moisture and momentum are reduced. Pollutants released at the valley bottom would be trapped under such conditions.