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The horizontal transport of pollutants from a slope wind layer into the valley core as a function of atmospheric stability

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Slope winds provide a mechanism for the vertical exchange of air between the valley and the free atmosphere aloft. By this means, heat, moisture and pollutants are exported or imported. However, it the static stability of the valley atmosphere is strong, one part of the up-slope flow is redirected towards the valley center and pollutants are recirculated within the valley. This may limit the venting potential of slope winds severely. The main objective of this study is to quantify the horizontal transport of pollutants from the slope wind layer into the stable valley core and to determine the dependency of this flux as a function of the initial stability of the atmosphere.

For this purpose, we conducted large eddy simulations with the Weather Research and Forecasting (WRF) model for a quasi-two-dimensional valley. The valley geometry consists of two slopes with constant slope angle rising to a crest height of 1500 m and a 4 km wide flat valley floor in between. The valley is 20 km long and homogeneous in along-valley direction. Hence, only slope winds but no valley winds can evolve. The surface sensible heat flux is prescribed by a sine function with an amplitude of 125 W m^{-2}. The initial sounding characterized by an atmosphere at rest and by a constant Brunt-Väisälä frequency which is varied between 0.006 s^{-1} and 0.02 s^{-1}. A passive tracer is released with an arbitrary but constant rate at the valley floor.

As expected, the atmospheric stability has a strong impact on the vertical and horizontal transport of tracer mass. A horizontal intrusion forms at the top of the mixed layer due to outflow from the slope wind layer. Tracer mass is transported from the slope towards the center of the valley. The efficiency of this mechanism increases with increasing stability N. For the lowest value of N, about 70% of the tracer mass released at the valley bottom is exported out of the valley. This value drops to about 12% in the case of the strongest stability. Hence, most of the tracer mass, which enters the slope wind layer at the valley bottom, is leaving it again through horizontal fluxes at the height of the intrusion and therefore remains inside the valley.