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Numerical investigations of mixing efficiency in mountainous terrain

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Mechanisms governing the daytime evolution of the boundary layer in mountainous terrain include excess valley heating and turbulent transfer of mass. In others terms along-valley transport and vertical exchanges coupling the boundary layer with the air aloft drive the mixing ability of the air mass. These processes may significantly enhance the dispersion of pollutants when compared with the boundary layer over flat terrain. The objectives of this study aim at providing a quantification of the mixing depending on topography and large-scale flow characteristics.

Large-eddy simulation approach was used to investigate the local atmospheric dynamics using different topographies: a flat terrain, an idealized valley with the same topographic features as the Chamonix valley (France) and the real topography of the Chamonix valley. Numerical simulations were performed with the ARPS (Advanced Regional Prediction System) model. All the numerical investigations are made over a domain of about 25 km $\times$ 25 km with horizontal grid spacings down to 125 m and a 25-m vertical resolution. Lagrangian particle dispersion has been implemented to track a large number of particle positions, based on the mean velocity components produced by ARPS, and a subgrid-scale turbulent velocity component that is based on the modelled turbulence kinetic energy.

The model has been set up to simulate atmospheric dynamics for the three topographies during episodes of different stability of the air mass including the commonly used Wangara experiment. The ARPS model was initialized using a 0900 LT (local time) sounding. Particles were continuously emitted from the lower model layer at a rate of 2000 particles per hour starting at 1000 LT. Sensible heat flux generates the development of a convective boundary layer which grows up to an afternoon depth

of about 1500 m above ground level in the Chamonix valley. The mixing depth over the flat terrain is typically found a few hundred meters lower. Within the valley the mixing efficiency depends not only on the local Richardson flux number but also on the topographic characteristics which amplify temperature changes.