Impact of the valley-wind system on the dispersion of passive tracers in the stably stratified atmosphere of an Alpine valley

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Abstract

In wintertime, mountain valleys frequently experience very stable atmospheric conditions, leading to air pollution episodes, especially when strong ground-based temperature inversions persist for days. Under such conditions, the valley-wind system (consisting of thermally-driven down-slope and down-valley flows) is key to providing some degree of ventilation. In this study, we analyze results from detailed numerical simulations to quantify the impact of the valley-wind system on the dispersion of passive tracers over an idealized Alpine valley decoupled from the atmosphere above. The numerical simulations were performed using the Weather Research and Forecasting model coupled with Chemistry (WRF-Chem). The down-valley flow extends from the ground surface and the top of the inversion layer and is characterized by a jet-like structure. Tracers emitted at the ground level are trapped below the height of the jet maximum and mixed by shear turbulence within this layer. By contrast, turbulence is generally weak above the jet maximum, and so tracers released there are not mixed in the vertical and are transported down the valley by the down-valley flow. Results show that temporal oscillations of the wind speed within the down-slope and down-valley flows provide a signature of the interactions between the two flows, which affect the tracer concentrations in the along-valley direction.

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