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Mechanisms of along-valley winds and heat exchange over mountainous terrain

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The physical mechanisms leading to the formation of diurnal along-valley winds are investigated over idealized three-dimensional topography. The topography used in this study consists of a valley with a horizontal floor enclosed by two isolated mountain ridges on a horizontal plain. A diagnostic equation for the along-valley pressure gradient is developed and used in combination with numerical model simulations to clarify the relative role of various forcing mechanisms such as the valley volume effect, subsidence heating, and surface sensible-heat-flux effects. The full diurnal cycle is simulated using comprehensive model physics including radiation transfer, land-surface processes, and dynamic surface-atmosphere interactions. It is found that the basic assumption of the valley volume argument of no heat exchange with the free atmosphere seldom holds. Typically, advective and turbulent heat transport reduce the heating of the valley during the day and the cooling of the valley during the night. In addition to presenting a reference case, we will investigate the effect of varying the dimensions of the idealized valley on the heat exchange between the valley and the free atmosphere. The theoretical developments confirm the importance of the valley volume effect for the formation of the diurnal along-valley winds, but also clarify the role of subsidence heating and the limitations of the valley volume effect argument. In summary, the analysis brings together different ideas of the valley wind into a unified picture.