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Numerical Simulations of Conditionally Unstable Flows over a Mountain Ridge

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This presentation describes numerical simulations of conditionally unstable flows impinging on an idealized mesoscale mountain ridge. These idealized simulations, which were performed with an explicitly resolving cloud model, allow the investigation of the solution precipitation characteristics as a function of the prescribed environment. The numerical solutions were first carried out for different uniform-wind profiles impinging on a bell-shaped ridge 2000 m high. In the experiments with weaker environmental wind speeds (2.5 m/s), the cold-air outflow, caused by the evaporative cooling of rain from precipitating convective cells, is the main mechanism for cell redevelopment and movement; this outflow produces new convective cells near the head of the up- and down-stream density currents, which rapidly propagate far from the ridge, so that no rainfall is produced close to the ridge at later times. For larger wind speeds (10, 20 m/s), there is less time for upwind, evaporation-induced, cold-pool formation before air parcels reach the ridge top and descend downwind and so the (statistically) steady rainfall tends to be concentrated near the ridge top. Further experiments with different ridge heights and half-widths were carried out in order to analyze their effect on the distribution and intensity of precipitation. Dimensional analysis reveals that the maximum (nondimensional) rainfall rate mainly depends on the ratio of mountain height to the level of free convection, the ridge aspect ratio and on a parameter that measures the ratio of advective to convective time scale.