High-resolution 3D numerical simulations of conditionally unstable flows over a ridge

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Numerical simulations of conditionally unstable flows impinging on a mesoscale mountain ridge have been performed with an explicitly resolving cloud model (Bryan and Fritsch, 2002) in order to investigate orographic precipitation in this regime.. The environmental conditions are the same used in a previous study but with increased horizontal resolution (grid interval = 250 m) and extended to a 3D domain in order to resolve properly the cellular-scale features. Even with the simplified atmospheric profile we considered, several external parameters come into play, so that only a limited portion of the state space has been explored.

First, the solutions have been analyzed for different uniform-wind profiles impinging on a bell-shaped ridge 2000 m high. In the experiments with weaker environmental wind speeds ($U = 2.5\ m/s$), the cold-air outflow, caused by the evaporative cooling of rain from storm cells, is the main mechanism for cell redevelopment and movement: The outflow produces 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 mountain at later times. For a larger wind speed ($U = 10\ m/s$), the evaporation is effective in generating a cold pool only on the downstream side of the mountain , in a region where the air is unsaturated; for even larger wind speeds ($U = 20\ m/s$), the air beneath the thunderstorm over the mountain remains saturated, so that rain cannot evaporate and cool the sub-cloud layer. No cold pools form in this case. Another set of experiments considers the effects of different mountain heights h. From the limited tests we have done, the height of the mountain with respect to the LCL (or LFC) turns out to be a more relevant parameter (as compared with the Froude number).