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Influence of Terrain Smoothness on the Development of Banded Orographic Convection

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Precipitation often organizes into mesoscale banded precipitation downstream of high terrain. In such a case downstream of the Rocky Mountains on 16–17 February 2007, a single band of precipitation associated with frontogenesis is followed by multiple smaller bands. The presence of large-scale regions of conditional, inertial, and dry symmetric instabilities complicate our understanding of how these bands form. To test the hypothesis that the small-scale features in the terrain affect the precise location of bands, we ran mesoscale model simulations using WRF-ARW with 9-km horizontal grid spacing.

The control simulation used the default topographic fields on the 9-km grid. For the sensitivity experiments, the topography was smoothed by using a Fourier transform to calculate and remove topographic features with wavelengths less than a specified value. Six experiments were conducted, with wavelengths less than 12, 25, 50, and 100Δx (i.e., 108 km through 900 km) removed from the model topography. The large-scale evolution was similar in each of the simulations, allowing us to focus on the changes to the banded precipitation among the different simulations.

Remarkably, although the exact location of the bands differed from run to run, the bands in all simulations were in the same general region where they were observed on 16–17 February 2007. We therefore hypothesize that the primary mechanism for initiating and maintaining banded convection in this case was the movement of cold air toward higher terrain, where it was lifted in the presence of conditional, symmetric, or inertial instabilities. In other words, it is the general west-to-east gradient in terrain, rather than specific small-scale topographic features, that is responsible for the lift that initiates the bands.