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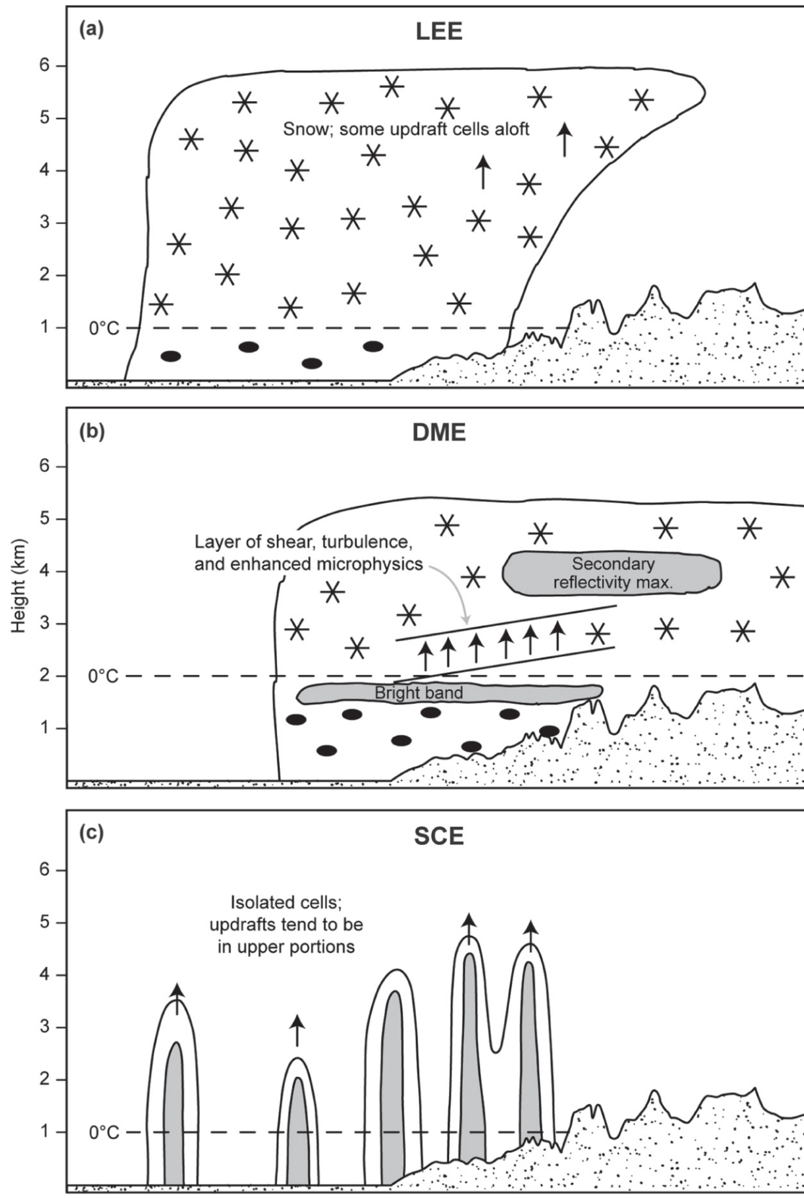
Vertical Precipitation Structures of Cyclones Crossing the Cascades

On 23 March 1806, as the Lewis and Clark expedition was breaking camp after spending the winter on the Oregon coast, Lewis complained about "rain which has fallen almost constantly since . . . November last." This thought was perhaps the first ever recorded about the seemingly continual barrage of winter rainstorms passing over the Pacific Northwest. With the region's primary annual precipitation falling from Pacific storms, their evolution into the mountainous western United States has been the focus of a long history of mesoscale studies and field projects. Our research provides a recent look at the precipitation structure in these storms from an observational perspective.

We describe radar-observed structures characterizing sectors of extratropical cyclones as they move over the Oregon Cascade Mountains from the Pacific. "Early," "middle," and "late" cyclone sectors are associated with warm advection, warm-to-cold advection transition, and cold, unstable air behind cold and/or occluded fronts, respectively. Previous studies have documented the horizontal precipitation patterns of midlatitude cyclones.



Schematic illustration of the typical reflectivity structures observed in the (a) LEE, (b) DME, and (c) SCE periods of midlatitude Pacific cyclones as they progress toward the terrain of the Oregon Cascade Range. The solid contours enclose areas of moderate reflectivity, while the shading indicates areas of increased reflectivity. The stars indicate snow and the ellipses rain. The speckled area shows the orography. Arrows represent updrafts.

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However, when these systems move over a mountain range, the horizontal patterns characterizing the different storm sectors are obscured and hard to distinguish. We determined that storm sectors can be distinguished during passage over the Cascades in terms of their vertical structures, as observed by a vertically pointing radar, rather than by horizontal patterns. Moreover, we summarized these distinguishing vertical features, repeatable from storm to storm, in a conceptual model.

During the early storm sector, a deep layer of precipitation, the leading edge echo (LEE), appears aloft and descends toward the surface. Updrafts are weak or absent. In the middle sector the radar echo consists of a thick, vertically continuous layer extending up to ~5–6 km. When the middle sector passes over the windward slope, the vertical reflectivity structure exhibits a double maximum echo (DME). One maximum is associated with the radar bright band. The second maximum, located ~1–2.5 km above the first, results from or is enhanced by the interaction of the system with the terrain. Between the two maxima there is a shear layer with turbulent updrafts, which is thought to be crucial for enhancing precipitation growth over the windward slopes. In the late sector, the precipitation consists of shallow convection echoes (SCE), with low echo tops and, occasionally, updrafts near the tops. The SCEs become broader upon interacting with the windward slopes, and the precipitation decreases sharply on the lee slopes.

The recurrent structures of each sector are associated with the basic dynamics of the parent cyclone, which are modified as the system passes over the Cascades. These structures provide a goal for numerical models and should be tested observationally in other West Coast regions of complex terrain. —Socorro Medina (University of Washington), E. Sukovich, and R. A. Houze, Jr. *"Vertical Structures of Precipitation in Cyclones Crossing the Oregon Cascades," in the October* Monthly Weather Review.