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Mountain wave-induced turbulence: Elevated turbulence zones over a double mountain ridge

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In their seminal 1974 paper on "Lower Turbulent Zones Associated with Mountain Lee Waves", P. F. Lester and W. A. Fingerhut attempted to characterize regions of low-level turbulence in the lee of mountain ranges, using in situ measurements by research aircraft. Their "Lower Turbulent Zones" (LTZs), associated with large-amplitude mountain waves and ensuing atmospheric rotors, encompass the turbulent flow on the lee side of an obstacle that reaches all the way to the ground.

This work is based on aircraft measurements collected during the Terrain-Induced Rotor Experiment (T-REX, Sierra Nevada, California, 2006) that was focused on the investigation of the coupled mountain-wave, rotor, and boundary-layer system. The analysis of airflow during several T-REX Intensive Observation Periods (IOPs) reveals a variety of mountain-flow scenarios, underlining the influence of the secondary orographic obstacle (the White and Inyo Mountains east of the Sierra Nevada) on the formation of wave-induced turbulence zones.

In the present contribution, we focus on a scenario characterized by an inversion-capped valley atmosphere documented during T-REX IOPs 1 and 2. The valley inversion imposes an additional positive buoyancy force on the downslope flow in the lee of the primary ridge and prevents it from penetrating deep into the valley. Consequently, the flow separates higher up along the lee slope, forming an elevated turbulence zone that resides above the "virtual valley floor", represented by the inversion.

The elevated turbulence zone shares some characteristics of the well-known low-level turbulence zone such as turbulence intensity being highest below the ascending part of the lee wave. However, clear indication of flow reversal at the bottom of the turbulent region, suggestive of a rotor circulation, is missing. For sufficiently short wavelength of the lee wave, multiple wave crests can fit between the primary and secondary mountain ridge and can give rise to several elevated patches of turbulence above the virtual valley floor.