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Mountain Wave-Induced Turbulence – "Lower Turbulent Zones" Revisited

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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 that are commonly associated with large-amplitude mountain waves aloft. For their study, they made extensive use of airborne measurements with small research aircraft that penetrated into the "lower turbulent zone" (LTZ).
The Lester and Fingerhut study complemented previous work on wave-induced LTZs by J. P. Kuettner and others in the 1950s who were among the first to employ sailplanes as scientific measurement platforms. Given the limitations of scientific instrumentation on research aircraft in the 1970s (e.g., no GPS) and, in particular, on sailplanes in the 1950s, credit has to be given to these authors for their remarkably detailed account and classification of LTZs. Ever since then, scientists have been trying to refine the conceptual model of the LTZ and shed more light on the origin of turbulence therein.

The Terrain-Induced Rotor Experiment (T-REX, Sierra Nevada, California, 2006) is the most recent, major effort organized to investigate the characteristics of LTZs by studying the coupled mountain-wave, rotor, and boundary-layer system. During T-REX, comprehensive ground-based and airborne, in situ and remote sensing measurements were collected during 15 Intensive Observation Periods (IOPs).
In this study, we make use of the extensive T-REX datasets to revisit the LTZ concept. During T-REX IOPs, the University of Wyoming King Air (UWKA) research aircraft flew straight-and-level legs aligned with the mean wind direction to document the variation of flow and turbulence over and downwind of the Sierra Nevada. In order to characterize the structure and intensity of turbulence within the LTZ, turbulent kinetic energy (TKE) and eddy-dissipation rate (EDR) were computed from UWKA research flights. In contrast to the rough average values of TKE and EDR obtained by Lester and Fingerhut, high-rate measurements by the UWKA allow documentation of the turbulent flow field at unprecedented spatial resolution and accuracy.
Using TKE and EDR obtained from UWKA measurements from the T-REX IOPs with strong low-level turbulence, an attempt is made to summarize the T-REX findings on low-level turbulence and place them in the context of the extant conceptual models of the LTZ. Given the rich variety and complexity of mountain-wave cases observed during the campaign, simple conceptual models, while helpful, provide merely rough guidelines for a possible LTZ classification.