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Model for predicting mountain wave field uncertainties

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Studying the propagation of acoustic waves throughout troposphere requires knowledge of wind speed and temperature gradients from the ground up to about 10-20 km. Typical planetary boundary layers flows are known to present vertical low level shears that can interact with mountain waves, thereby triggering small-scale disturbances. Resolving these fluctuations for long-range propagation problems is, however, not feasible because of computer memory/time restrictions and thus, they need to be parameterized. When the disturbances are small enough, these fluctuations can be described by linear equations. Previous works by co-authors have shown that the critical layer dynamics that occur near the ground produces large horizontal flows and buoyancy disturbances that result in intense downslope winds and gravity wave breaking. While these phenomena manifest almost systematically for high Richardson numbers and when the boundary layer depth is relatively small compare to the mountain height, the process by which static stability affects downslope winds remains unclear. In the present work, new linear mountain gravity wave solutions are tested against numerical predictions obtained with the Weather Research and Forecasting (WRF) model. For Richardson numbers typically larger than unity, the mesoscale model is used to quantify the effect of neglected nonlinear terms on downslope winds and mountain wave patterns. At these regimes, the large downslope winds transport warm air, a so called “Foehn” effect than can impact sound propagation properties. The sensitivity of small-scale disturbances to Richardson number is quantified using two-dimensional spectral analysis. It is shown through a pilot study of subgrid scale fluctuations of boundary layer flows over realistic mountains that the cross-spectrum of mountain wave field is made up of the same components found in WRF simulations. The impact of each individual component on acoustic wave propagation is discussed in terms of absorption and dispersion and a stochastic model is constructed for ground-based acoustic signals in mountain environments.