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Non-Dissipative and Dissipative Momentum Deposition by Mountain Wave Events in Sheared Environments

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Mountain waves (MWs) are generated during episodic cross-barrier flow over broad-spectrum terrain. However, most MW drag parameterizations neglect transient, broad-spectrum dynamics. Here, the influences of these dynamics on both non-dissipative and dissipative momentum deposition by MW events are quantified in a 2-D, horizontally periodic idealized framework. Influences of MW spectrum, vertical wind shear, and forcing duration are investigated. MW events are studied using three numerical models: the nonlinear, transient WRF model, a linear, quasi-transient Fourier Ray model, and an optimally tuned Lindzen-type saturation parameterization, allowing quantification of total, non-dissipative, and dissipative MW-induced decelerations, respectively.

For broad-spectrum MWs, vertical dispersion controls spectrum evolution aloft. Shorter waves propagate upward quickly and are the first to break at the highest altitudes. At a later time, additional longer waves allow breaking at lower altitudes due to their greater u-power and non-dissipative decelerations. As a result, lowest breaking levels descend with time and forcing duration. In zero and positive shear environments, this descent is not smooth, but proceeds downward in steps due to vertically recurring steepening levels. This descent is not a descending negative shear (or critical) level. Overall, non-dissipative decelerations are persistent and substantial, though dissipative decelerations dominate. Comparison of the three model solutions suggest that the conventional instant propagation and monochromatic parameterization assumptions lead to too early, too low, and too much MW drag.