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Gravity waves, dynamical resistance, and forcing efficiency

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The interaction between gravity waves and the mean flow through which they propagate has been studied extensively and continues to be an active area of research, particularly with regard to the dynamics of the middle atmosphere. A problem that is complimentary to the wave – mean flow interaction is that concerning the interaction between gravity waves and the forcing from which they originate. The wave – forcing interaction problem is of particular relevance to mesoscale dynamics of the troposphere where, for example, convective systems evolve on time and space scales similar to the gravity waves they spawn. This paper introduces the concept of dynamical resistance in order to facilitate the analysis of gravity wave – forcing interaction. The dynamical resistance is defined as the work performed by gravity waves upon a forcing. A few simple examples are provided in order to demonstrate the dependence of the dynamical resistance and forcing efficiency on the properties of the forcing as well as the environment against which the forcing is applied. It is shown that optimal configurations of the basic state and forcing exist which minimize the resistance imposed by gravity waves upon their source and thus maximize the total energy generated by the forcing. Calculations are performed both in a simple linear model and along hypothetical ray paths for an isolated forcing propagating relative to the background flow and for fields of multiple forcing elements.