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Gravity waves, dynamical resistance, and forcing efficiency

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Understanding the relationship between high frequency waves and their sources remains an ongoing challenge in mesoscale dynamics. This is particularly the case for internally-forced waves e.g., waves excited by diabatic processes inside a cloud which, unlike topographically-forced waves, originate from sources that are themselves dynamic. For such waves, source and spectrum may be mutually dependent, particularly if space and time scales characterizing waves and convection are similar. This paper considers the effect that high frequency waves may have upon the forcing from which they originate. In a simple, 2-d, linear model, we consider an idealised midtropospheric heat source that generates gravity waves. If the heating is sustained over several wave periods, then the waves may do work on the forcing itself, thereby acting as a kind of resistance or conductance. The dynamical resistance/conductance depends on the properties of the forcing. Two types of heating distributions are considered — spatially isolated heating, and an ensemble of heating elements that may generate a dynamical response that propagates horizontally and interacts with neighboring elements. The efficiency of an isolated forcing is shown to depend strongly on the characteristics of the background flow. A maximum efficiency occurs for forcing moving at a flow relative speed for which the propagating dynamical response is in phase with the moving forcing. The efficiency of an ensemble of forcing elements is shown to differ significantly from that corresponding to an isolated forcing. If the forcing elements are all of the same sign e.g., are all warmings, then the efficiency increases with decreasing separation between elements. If the elements are of alternating sign e.g., warming separated by cooling then the efficiency may decrease with decreasing separation between elements.