7B.3 LARGE-SCALE WAVES INTERACTING WITH DEEP CONVECTION IN IDEALIZED MESOSCALE MODEL SIMULATIONS

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Abstract

The authors study the interaction of large-scale waves with deep convection in nonrotating mesoscale model simulations without mean vertical shear under idealized boundary conditions (doubly periodic, fixed uniform sea surface temperature). Radiative cooling is fixed, so radiative-convective feedbacks are not considered. The model is initialized with random thermal perturbations near the surface and then run for 16 days to a state of approximate radiative-convective equilibrium. At this point, a wave-like heating is imposed for one day in order to create a wave. The heating is uniform in the meridional direction, sinusoidal with a wavelength equal to the domain size (4500 km) in the zonal direction, and has a roughly “first baroclinic mode” structure in the vertical. After this single day of forcing, the heating is turned off and the wave is allowed to evolve freely for seven more days. A range of initial forcing phase speeds and amplitudes are used, but two simulations are presented in detail. One has a flow-relative forcing phase speed of 55 ms^{-1} and the other of zero, and both have maximum forcing amplitude of 10 Kd^{-1}. Both of these forcings produce waves which are initially rapidly damped, but then settle in to quasi-steadily propagating, coherent configurations which are weakly decaying or neutral. The authors focus on this latter period.

The faster forcing produces a convectively coupled gravity wave qualitatively similar to those predicted by strict quasi-equilibrium (SQE) theory (e.g., Emanuel, Neelin, and Bretherton 1994), but whose interaction with convection is weaker than that theory predicts. The adiabatic cooling is considerably larger than the diabatic heating, and consequently the phase speed is roughly $30ms^{-1}$ rather than the $10-15ms^{-1}$ typically predicted by SQE for waves of this vertical structure. Sensitivity studies show that this wave, when propagating eastward against a mean westward flow, is destabilized by evaporation-wind feedback. The slower forcing produces a wave which is stationary in the mean flow frame and does not have the structure of a gravity wave. This wave has a much larger signal in the moisture field than does the faster wave, and much closer cancellation between adiabatic cooling and diabatic heating. This wave appears similar to ones appearing in some recent theoretical studies (Sobel, Nilsson and Polvani 2001; Fuchs and Raymond 2002) and cloud-resolving simulations (Tompkins 2001).

The complete manuscript (Sobel and Bretherton 2002) is available on the web, see below.

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