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Wave Forcing, Parameterization, and the Breakdown of Newton's Third Law

Current parameterizations of gravity-wave drag (GWD) in general circulation models (GCMs) of the Earth's atmosphere explicitly conserve wave pseudomomentum flux and, therefore, satisfy Newton's Third Law. This approach assumes a basic-state flow that is horizontally uniform and it allows a direct connection between wave dissipation and wave-induced forcing of the flow. When the horizontal structure of the basic-state flow is no longer uniform this approach fails. In this instance the more fundamental principle of wave action conservation must be invoked. In this more general framework one can no longer associate all wave-induced forcing with wave dissipation. Newton's Third Law may be violated and when it is, the basic-state flow will be subjected to wave induced forces arising from wave dynamics that are conservative rather than dissipative in nature (Buhler and McIntyre 2005). In this study we reformulate a current parameterization of orographic GWD (Scinocca and McFarlane 2000) to allow horizontally non-uniform flow and to employ wave action flux, rather than pseudomomentum flux, as its primary conserved variable. The impact of this new formulation is investigated by offline calculations and fully interactive GCM simulations.