MOUNTAIN WAVE MOMENTUM FLUX IN AN EVOLVING SYNOPTIC-SCALE FLOW

Dale R. Durran, C.C. Chen, G.J. Hakim

Abstract: The evolution of mountain-wave induced momentum flux is examined through idealized numerical simulations during the passage of a time-evolving synoptic-scale flow over an isolated 3D mountain of height h. The dynamically consistent synoptic-scale flow (U) accelerates and decelerates with a period of 50 hours; the maximum wind arrives over the mountain at 25 hours. The synoptic-scale static stability (N) is constant, so the time dependence of the nonlinearity parameter, $e(t) = Nh/U(t)$, is symmetric about a minimum value at 25 hours. The evolution of the vertical profile of momentum flux shows substantial asymmetry about the mid point of the cycle even though the nonlinearity parameter is symmetric. Larger downward momentum fluxes are found during the accelerating phase, and the largest momentum fluxes occur in the mid and upper troposphere before the maximum background flow arrives at the mountain. This vertical distribution of momentum fluxes produces a surprising acceleration of tropospheric zonal winds due to positive low-level momentum flux divergence. Conservation of wave action and WKB ray tracing are used to reconstruct the time-altitude dependence of the mountain-wave momentum flux in a semi-analytic procedure that is completely independent of the full numerical simulations. For quasi-linear cases, the reconstructions show good agreement with the numerical simulations, implying that the asymmetry obtained in the full numerical simulations may be interpreted using the WKB theory. These results demonstrate that even slow variations in the mean flow, with a time scale of two days, play a dominant role in regulating the vertical profile of mountain-wave induced momentum flux.