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The breakdown of balance and generation of inertia- gravity waves in a two-layer model on the sphere

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The spontaneous generation of inertia–gravity waves in an idealized simulation of jet instability is investigated using the isentropic two-layer model on the sphere. The CASL algorithm is applied to solve the primitive equations in (potential vorticity, velocity divergence, acceleration divergence) representation. The fourth-order compact differencing and spectral transform are used, respectively, in latitudinal and longitudinal directions and time stepping is carried out using a three-time-level semi-implicit scheme. The initial state used is a zonal balanced jet with a very small perturbation added to trigger instability. In order to determine the inertia–gravity waves more accurately, the Bolin–Charney balance relations are used to decompose the flow into a balanced part and an unbalanced part representing free inertia–gravity waves.

The analysis of the velocity divergence and acceleration divergence points to generation of two wave packets of IGWs. With regard to balanced initial conditions used, these gravity waves are spontaneously generated from the breakdown of balance. The first wave packet is found on the downstream side of the trough similar to the mesoscale waves described by Zhang. The second wave packet is identified on the upstream side of the trough similar to the wave packet described by Plougonven and Snyder in idealized simulations of baroclinic life cycle dominated by cyclonic behavior. By determining the characteristics of the waves, the magnitude of the intrinsic frequency of both wave packets are found to be larger than those of the previous studies. To process frequency characteristics of the packets more accurately, a short-time Fourier transform is used to find dominant absolute frequency. The results for the intrinsic frequency are in agreement with the estimates based on the local dispersion relation.