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Numerical investigations on gravity wave radiation from unsteady rotational flows in an f-plane shallow water system

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Using a forced dissipative system, gravity wave radiation from unsteady rotational flows is investigated numerically in an f-plane shallow water system for a wide range of Rossby number (Ro) and Froude number (Fr). Unlike the classical Rossby adjustment problems which suppose to initial unbalanced states, gravity waves are continuously radiated from nearly balanced rotational flows. In the cases of fixed Ro experiments, while gravity wave flux is proportional to Fr for large fixed Ro, which is consistent with the aero-acoustic sound wave radiation theory (the Lighthill theory), this linear dependence of Fr does not hold for small Ro. In addition, in the cases of fixed Fr experiments, there is a local maximum of the gravity wave flux for middle Ro, where the effect of earth rotation is not negligible. Investigating the gravity wave sources and analyzing those spectral frequency, we show that the breakdown of the power law of Fr results from the both effect of deformation radius and inertial cutoff frequency of the gravity wave radiation. Since interaction of each vortex motion is weakened in the case of small deformation radius for large Fr, unsteady rotational flows are more stabilized. It was also shown that the local maximum of gravity wave flux in the middle Ro results from the both effect of large sources related to the earth rotation and small inertial cutoff frequency. This results suggest that the earth rotation can intensify gravity wave radiation.