

TITLE

Spontaneous gravity wave radiation from unsteady rotational flows in the shallow water system on an f -plane and a rotating sphere

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ABSTRACT

Observational studies suggest that gravity waves are spontaneously radiated from strong rotational flows, such as polar night jet, sub-tropical jet, and typhoon. Using the shallow water system on an f -plane and a rotating sphere, we investigate this spontaneous gravity wave radiation numerically. We set barotropically unstable zonal jet flow initially, and maintain this zonal jet flow with a forcing. Unlike the classical Rossby adjustment problems which suppose to initial unbalanced states, spontaneous gravity waves are continuously radiated from nearly balanced unsteady rotational flow in both system.

An f -plane shallow water system is equivalent to a compressible fluid system with a ratio of specific heats $\gamma = 2$, if the effect of the earth rotation is negligible. Thus, gravity waves are analogous to sound waves. In the aero-acoustic sound wave radiation theory, the Lighthill theory, it is well known that the flux of sound waves radiated from rotational flows depends on the power law of Mach number. In the present study, we investigate the parameter dependence of gravity wave flux for a wide range of Rossby number, Ro , and Froude number, Fr , in the f -plane shallow water system. In the results of fixed Ro experiments, while gravity wave flux is proportional to Fr for large fixed Ro , which is consistent with the Lighthill theory, this linear dependence of Fr does not hold for small fixed Ro , where the effect of the earth rotation is not negligible. In addition, in the results of fixed Fr experiments, there is a local maximum of gravity wave flux for middle Ro . We introduce gravity wave sources and analyze those spectral frequency. Since interaction of each vortex motion is weakened in the case of small deformation radius for large Fr , unsteady rotational flows are more stabilized. This is the reason for the breakdown of

the power law of Fr in small fixed Ro . It is also shown that the increase of the sources related to the earth rotation causes the local maximum of gravity wave flux in the middle Ro . This results suggest that the earth rotation can intensify gravity wave radiation.

Recently, one of the authors has developed the spectral-like three point combined compact difference (sp-CCD) scheme for the shallow water system on a rotating sphere, which has high accuracy and resolution as well as the spherical harmonics model. We are now investigating spontaneous gravity wave radiation from unsteady zonal jet flows, using this scheme. We will discuss these results, too.