Barotropic Energy Spectrum by the Rossby Wave Saturation in the Zonal Wavenumber Domain

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In this study, characteristics of the energy slope for the barotropic component of the atmosphere are examined in the framework of the 3D normal mode decomposition.

The energy slope of $E=ac^2$ was derived by Tanaka et al. (2004) based on the criterion of the Rossby wave breaking, where E is total energy, c is a phase speed of Rossby wave, and a is a constant. The wave breaking occurs when the local meridional gradient of potential vorticity is negative, i.e., dq / dy smaller than 0, somewhere in the domain. If the spectrum obeys the c^2 law, it should obey the -4 power of the zonal wavenumber n, because the phase speed c is related to the total wavenumber by $c = -\beta/k^2$, and if we assume the isotropy for zonal wind u and the meridional wind v over the range of synoptic to short waves, the energy spectrum can be expressed as a function of n instead of k.

The theoretical inference of the energy slope is examined using JRA-25 data. According to the result of the analysis, the spectral slope agrees quite well with the -4 power law for the barotropic component of the atmosphere.

It is, however, confirmed that the spectrum obeys the -3 power law as in previous studies for the baroclinic atmosphere. It is also found that the barotropic energy spectrum obeys the saturation theory where energy cascades up, but it does not obey where energy cascades down.