An equatorial jet in shallow-water turbulence on a rotating sphere and its acceleration mechanisms

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Cho and Polvani (1996) reported that an equatorial jet emerges in shallow-water turbulence on a rotating sphere. Although they concluded that the emerged equatorial jet is always retrograde, it is still not confirmed whether or not its direction is independently of an initial field. We perform ensemble experiments with various initial states to investigate robustness of emergence of the retrograde jet and examine how emergence of an equatorial jet and its magnitude depend on an initial state.

Our results indicate that the frequency distribution with magnitude of an equatorial jet depends on Rossby number. While the distribution is narrow and there is no prograde jet for small Rossby number, a prograde jet can be formed and maintained for large Rossby number.

Further, a zonal mean flow induced by wave-wave interactions is examined with a linearized model to investigate acceleration mechanisms of the equatorial jet. The second-order acceleration is almost induced by the Rossby and Rossby-gravity waves and its mechanisms can be categorized into two types. First, the local meridional wavenumber of a Rossby wave packet propagating toward the equator increases due to meridional variation of the Rossby deformation radius and/or the retrograde mean flow and the wave packet dissipates in the equatorial region. This mechanism always contributes to retrograde acceleration of the equatorial jet. Another mechanism is derived from equatorial waves tilting due to meridional shear of the mean flow. In this case, a zonal mean flow induced by Rossby waves intensifies a given basic flow. The latter mechanism suggests that both prograde and retrograde jets can be intensified and maintained, if initial PV mixing make a equatorial zonal flow.