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Two-dimensional barotropic flow on a rotating sphere is one of the simplest mathematical models describing the dynamics of planetary atmospheres. This model is very simple and does not take into account three-dimensional fluid motion, planetary topography, or, in many cases, heat distribution for example. Nevertheless, it exhibits rich fluid dynamics, including the formation of large-scale zonal flows[1,2,3,4]. This model also has the interesting aspect that it has the same mathematical structure as the special case of Hasegawa-Mima equation when a plane approximation is applied to it.

In this talk, we consider unforced two-dimensional turbulence on a rotating sphere and discuss how the nonlinear interactions of Rossby waves, which are wave solutions unique to rotating systems, are involved in the formation of the large-scale zonal flows (westward circumpolar flows in this case. Fig. 1(A)). It is known that when the rotation rate of the sphere is very high, the three-wave resonance non-linear interaction of Rossby wave strongly dominates the dynamics of the flow field[5,6]. However, it is not possible to transfer energy to Rossby waves corresponding to zonal flows (zonal Rossby waves) directly by three-wave resonance interactions[7,8]. This means that the formation of zonal flows takes place by weakly existing non-resonant interactions, but the details have been little understood. In particular, we still do not know why the zonal flows that develop due to non-resonant interactions consist of waves that are capable of resonant interactions, rather than waves that are incapable of non-resonant interactions (Fig. 1(B))[8].

Based on our recent detailed numerical calculations of energy transfer by Rossby wave three-wave non-resonant interactions, we report that the formation of the westward circumpolar flow is due to non-local energy transfer by three-wave near-resonant interactions (special cases of non-resonant interactions) (Fig. 2).

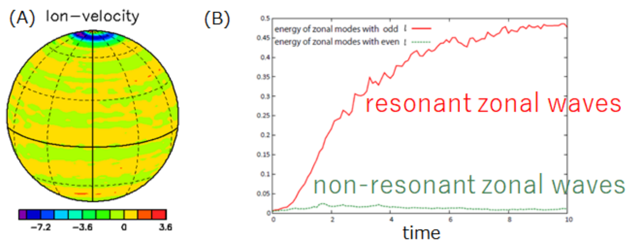

Figure 1: (A)At sufficiently large times, we observe westward circumpolar flows around both poles in unforced system. (B) We see strong energy accumulation only to waves that are capable of resonant interactions though the wave interactions giving energy to zonal Rossby waves is non-resonant interactions.

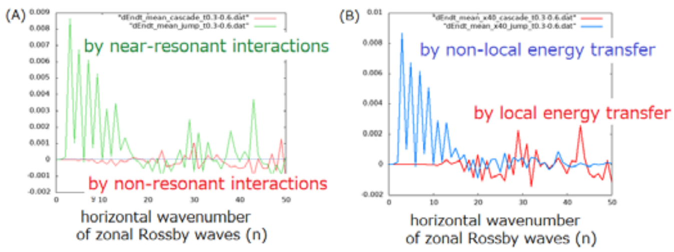

Figure 2: Temporal mean of energy transfer to zonal Rossby waves. (A) Near-resonant nonlinear interactions transfer energy to zonal Rossby waves with low wavenumber. (B) Non-local nonlinear interactions transfer energy to zonal Rossby waves with low wavenumber.

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