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Radiation processes of the Rossby waves from a recirculation gyre and their effects on mean flows

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Western boundary currents such as the Kuroshio and Gulf Stream are considered to interact with eddies and the Rossby waves. Although several mechanisms such as the instability of a jet (Talley, 1983) or interaction of eddies (Rhines, 1975) have been investigated, the radiation mechanism of the Rossby waves in the western boundary region has not been fully understood. The western boundary region is also know as the place where strong potential vorticity anomaly advected by western boundary currents is dissipated and, hence, the narrow boundary current is matched with the broad interior flow (see Pedlosky, 1996 for more detailed reviews). In this study we examine (1) the radiation mechanism of the Rossby waves from an eastward jet and (2) effects of the Rossby waves on the large scale circulation, especially the matching of the western boundary current and interior flow, by conducting numerical experiments.

The Regional Ocean Model System (ROMS; Haidvogel et al., 2000), which is based on primitive equations, was employed. A narrow inflow and broad outflow were imposed on the western and eastern boundaries of the model domain on the beta plane, respectively. In the statistically steady state, westward recirculations are formed on both sides of the eastward jet driven by the inflow, causing two recirculation gyres in the western part of the model domain. The jet broadens and part of it continues to flow eastward at the eastern end of the recirculation gyres, where the barotropic Rossby waves are radiated intensely. The zonal phase speed of the radiated Rossby waves is close to the maximum speed of the recirculation as pointed out by Mizuta (2009). This speed coincides with that of eddies moving in the recirculation after being detached from the jet.

The intensity of the Rossby waves and the transport of the recirculation tend to change systematically with the width of the outflow imposed on the eastern boundary. As the outflow is broadened, the transport of the recirculation is increased. Then eddies entrained into the recirculation from the jet are increased, and the radiation of the Rossby waves is intensified. These changes support the argument that the Rossby waves are radiated from the eddies in the recirculations. An analytic model of the Rossby wave radiation is proposed based on this argument.

The convergence of the potential vorticity flux by the Rossby waves tends to compensate the change of the mean potential vorticity in a transient region between the narrow jet and the broad interior flow imposed on the western and eastern boundaries, respectively. As the outflow is broadened, the gap of the mean potential vorticity between both sides of this transient region is increased. Since, as noted above, the Rossby waves are intensified with the broadening of the outflow, the increase of the gap of the mean potential vorticity is compensated by the potential vorticity flux by the Rossby wave. These changes of the large scale circulation and Rossby waves strongly suggest that the Rossby waves are important in matching the western boundary jet such as the Kuroshio Extension with the broad interior flow.