Control of the ocean circulation by bottom topography and generation of mesoscale disturbances

*Yuri Kase[1], Tomonori Matsuura[1]

1. National university corporation University of Toyama

One of the representative ocean current in the North Pacific is the Kuroshio. The Kuroshio which is the western boundary current of the North Pacific subtropical gyre leaves off the coast of Choshi, Chiba Prefecture, and it will be the eastward Kuroshio extension. At about 160°E, the Kuroshio-extension current encounters the Shatsky rise extending north and south, and fluctuation of flow path and generation of mesoscale disturbances due to flow-topography interaction is seen around this topography. We study the mechanism of phenomena as geophysical fluid dynamics in the North Pacific, mainly generation of mesoscale disturbances due to flow-topography interaction in rotating stratified fluid, by modeling which is target of the North Pacific.

We simulated four cases with different ocean bottom topography using the eddy resolving 3-layer QG model (Hogg et al., 2010) based on the quasi-geostrophic vorticity equation for the generation of the mesoscale disturbances accompanied the main flow path variation.

In Figure 1, the strong flow in each case is seen near the west-coast and mid-latitudes, and in case 1 where no topography is given, the most noticeable double gyre and the zonal strong flow as the gyre's front are seen. It can be inferred that this double gyre corresponds to the North Pacific subtropical gyre / subpolar gyre, and the flow on the front corresponds to the Kuroshio extension because we give the wind stress corresponding to the North Pacific about this time. On the other hand, in case 2, 3, and 4, which topography is given in each case, the strong flow near the mid-latitude is obstructed or meandered depending on the topography, and there is the long-lived eddy as an anticyclonic eddy over the topography. Especially, paying attention to the meandering flow behind the topography, and comparing case 3 and case 4, we can see that the addition of "corn" to "kamaboko" strengthens the flow of two wavelengths behind "kamaboko" (in case 4 of Figure 1).

Figure 2 shows the spatial patterns of the 10 years mean values of the squared disturbances of the potential vorticity in layer 1. The higher value area has the stronger and finer mesoscale disturbances. The development of the mesoscale disturbances in each case is seen at the west-coast, the mid-latitude area and the area surrounding the topography, corresponding to the strong flow as seen in Figure 1. In addition, when comparing case 3 and case 4, the addition of "corn" to "kamaboko" strengthens the meandering flow which has two wavelengths behind "kamaboko" (in case 4 of Figure 1), and the mesoscale disturbances are developed along the flow (in case 4 of Figure 2). From these results, it is suggested that the baroclinic instability is strengthened around the topography. We think the mechanism as described later; flow is disturbed by the influence of the topography, and the interface (of two layers) height anomaly increases, so the potential energy becomes large (strengthened baroclinic instability), and then the enlarged potential energy is released as kinetic energy (resolution of the baroclinic instability), and the mesoscale disturbances develop. It was suggested that how to change the flow and the degree of strengthened its baroclinic instability depend on the shape, arrangement and combination of the topography. And it was found that the bottom topography plays an important role in the generation of mesoscale disturbances.

Hereafter, by modeling which is given “kamaboko”, “corn” as a bottom topography imitating the Izu Ridge and the Shatsky rise (Tam massif) in the North Pacific, respectively, and simulating in some cases which have defferent positions (latitude / longitude) and heights of the topography, we presume that it is possible to realize the application of the mechanism of phenomena from the simulation results to the real phenomena.

Keywords: mesoscale disturbance, bottom topography, western boundary current, Kuroshio, Kuroshio extension

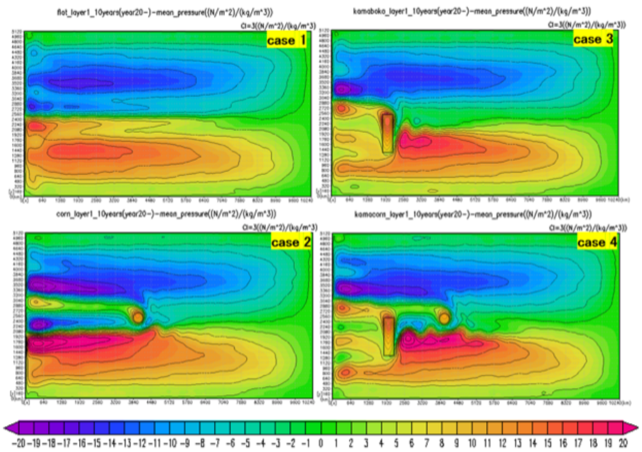

Figure 1: the four cases’ spatial patterns of the 10 years mean values of the pressure in layer 1 ($\overline{p_1}(10)$) (superimposed the horizontal section of the bottom topography in each case)

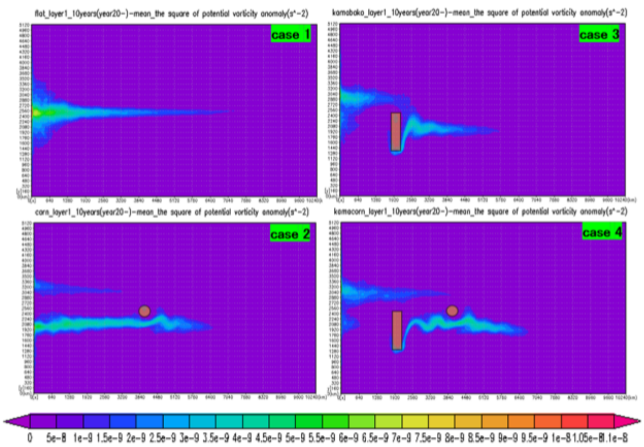

Figure 2: the four cases’ spatial patterns of the 10 years mean values of the squared disturbances of the potential vorticity in layer 1 ($\overline{(q_1')^2}(10)$) (superimposed the horizontal section of the bottom topography in each case)

