Effects of Koshu Seamount on the Development of Baroclinic Instability Leading to the Kuroshio Large Meander

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It is well known that the Kuroshio south of Japan shows bimodal path fluctuations between the large meander (LM) path and the nonlarge meander (NLM) path. The transition from the NLM path to the LM path is triggered by a small meander which is generated off the southeastern coast of Kyushu and then propagates eastward to Cape Shiono-misaki while being amplified slowly through baroclinic interaction with a lower layer cyclone-anticyclone pair. This small meander thereafter amplifies rapidly over Koshu Seamount located about 200 km to the south of Cape Shiono-misaki, leading to the formation of the LM path. Although it is shown that the existence of Koshu Seamount is essential for the rapid amplification of the small meander, the underlying physical mechanism has not been fully understood yet.

In this study, the effects of Koshu Seamount on the development of baroclinic instability leading to the formation of the LM path of the Kuroshio are investigated using a two-layer quasi-geostrophic model taking into account the effect of bottom topography. Numerical experiments show that the transition processes from the NLM path to the LM path can be successfully reproduced only when the bottom topography mimicking Koshu Seamount is taken into account. In this case, the upper layer meander trough is amplified rapidly together with the lower layer cyclone-anticyclone pair during their passage over the seamount. This suggests that the transition from the NLM path to the LM path is caused by baroclinic instability enhanced over the seamount. A linear stability analysis with the bottom topography mimicking Koshu Seamount shows that baroclinic instability over the seamount is caused by a coupling between the upper layer Rossby wave propagating eastward in the background geostrophic flow and the lower layer topographically trapped wave propagating clockwise around the seamount. These two waves in the upper and lower layers propagate in the same direction with nearly the same speed so that they can resonantly interact with each other over the northern slope of the seamount. The spatial structure of the most unstable mode is shown to be close to that of the rapidly amplifying meander trough over the seamount reproduced in the numerical experiment.

Keywords: Large Meander of Kuroshio, Koshu Seamount, Baroclinic Instability, Topographically Trapped Wave, Two-Layer Quasi-Geostrophic Model, Linear Stability Analysis

