論文の内容の要旨

Interannual variability of the western boundary currents in the southern Indian Ocean

(南インド洋における西岸境界流の経年変動)

氏名　山上　遥航

The Agulhas Current is a strong western boundary current transporting heat and water poleward along the southern Africa, and influences not only the local climate and biodiversity but also the global thermohaline circulation. Since the solitary meander of the Agulhas Current, called the Natal Pulse, explains the large part of the variance of the Agulhas Current, and triggers the early retroflection of the Agulhas Current and thus the pinch-off of the Agulhas Ring in the Agulhas Retroflection region, the Natal Pulse is a key phenomenon in this region. To understand interannual variability of the Agulhas Current, this thesis is devoted to clarify the mechanism of interannual variations in the Natal Pulse and that in the source regions of the Natal Pulse, i.e. the Northeast/Southeast Madagascar Currents (NEMC/SEMC).

From an analysis of an observational data (AVISO) and high-resolution model (OFES) outputs, it is found that most of the Natal Pulse is triggered by anticyclonic eddies propagating from the upstream regions. An eddy kinetic energy (EKE) budget analysis shows that the barotropic conversion due to the mean horizontal shear of the Agulhas Current and the advection of EKE dominate the tendency of EKE during the growth of the Natal Pulse. Hence, the interaction between the mean horizontal shear and anticyclonic eddies plays a crucial role in the generation of the Natal Pulse. An automated eddy-tracking method also reveals that sources of these anticyclonic eddies originate from mainly the SEMC.

Since the Natal Pulse shows interannual variations in the AVISO and OFES, the mechanism of interannual variations is also examined for the first time. Using a simple statistical model, it is found that anticyclonic eddies from the SEMC region is relatively important. An energy conversion analysis off the southern coast of Madagascar shows that the barotropic conversion is the main energy source and corresponds to the interannual variations of anticyclonic eddies in this region. Therefore, interannual variations of the SEMC plays a critical role in the interannual variations of the Natal Pulse. Also, no bottom trapped eddy is found during the generation of the Natal Pulse, and the amplitude of the anticyclonic eddy is one of the necessary conditions for the generation.

Since the importance of the interannual variations in the SEMC is shown, the dynamics of interannual variability of the NEMC and SEMC has been examined. From the analysis of observational and reanalysis data, it is found that interannual variations of the NEMC/SEMC transports are due to those of the South Equatorial Current (SEC) rather than SEC bifurcation latitude (SBL). The Time-dependent Island Rule (TDIR) reproduces the interannual variations and reveals the major role of the meridional transport anomaly in the interior region in the interannual variations of the SBL, NEMC, and SEMC. The variance of the meridional transport is mainly explained by geostrophic transport anomalies in 60°-90°E and thus wind stress curl anomalies.

Since wind stress curl anomalies in the interior are affected by climate modes, the relationship between the SBL, NEMC, SEMC, and climate modes are examined. Interannual variations of the SBL, and the NEMC/SEMC are correlated with the Niño 3.4 with a lag of 5-15 months. Reanalysis data shows that wind stress curl anomalies in the central Indian Ocean is a response to the diabatic heating anomalies in the western Pacific Ocean associated with the ENSO, and partly modified by the local SST forcing in the southeastern Indian Ocean. AGCM sensitivity experiments support the results from the reanalysis data and further shows that the Pacific SST is the major forcing mechanism of the wind stress anomalies while the southeastern Indian SST can generate up to 50% of the wind stress curl anomalies.