(第3号様式) (Form No. 3)

# 学 位 論 文 要 旨
# Dissertation Summary

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論 文 名 :
(Dissertation Title)　Variations of Kuroshio transport in the East China Sea: Its relation to the Pacific Decadal Oscillation, mesoscale eddies and its influences on the throughflow in the straits of East Asian Marginal Seas

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**Background**

The Kuroshio is a western boundary current in the North Western Pacific driven by the negative wind stress curls over the North Pacific basin. The Kuroshio enters the East China Sea (ECS) through the eastern Taiwan Channel, flows along its shelf break, and exits the ECS through the Tokara Strait. The volume transport of Kuroshio varies in different temporal scales, e.g., intra-seasonal, seasonal, and interannual. Using the sea level difference between Ishigaki and Keelung as a proxy of the Kuroshio transport northeast Taiwan, Chang and Oey (2011) reported apparent interannual and seasonal variations in the Kuroshio transport. In addition to the direct effects of winds on the Kuroshio transport northeast of Taiwan, they also confirmed the influences of eddies from the Subtropical Countercurrents (STCC) region on the Kuroshio transport northeast of Taiwan.

The sea surface height (SSH) and Kuroshio transport in the ECS is known to respond well to a basin-scale interannual oscillation, i.e., the Pacific Decadal Oscillation (PDO; Mantua, et al., 1997) index that may be used as a proxy for large-scale wind stresses curl forcing (Andres et al., 2009). For example, Han and Huang (2008) reported a negative correlation between the interannual variations of SSH inside the ECS and PDO index by analyzing 11 years (October 1992-July 2002) of altimetry data and sea level data at tidal gauges, and suggested a positive correlation between Kuroshio transport in the ECS and PDO index. Andres et al. (2009) confirmed this positive correlation using the satellite altimetry derived Kuroshio transport midway along the shelf break in the ECS.

On the other hand, mesoscale eddies also affect the Kuroshio transport in the ECS. Yang et al. (1999) reported the arrival of cyclonic and anti-cyclonic mesoscale eddies southeast of Taiwan with an interval of ~100 days and their significant impacts on the Kuroshio transport east of Taiwan. Zhang et al. (2001) estimated the Kuroshio transport east of Taiwan from 20 months of

mooring data and found a period of 100 days in the variations of Kuroshio transport due to arrival of mesoscale eddies from the interior ocean. Hwang et al. (2004) found that most mesoscale eddies arriving from southeast of Taiwan had their origin in the Subtropical Countercurrent (STCC) region and propagated westward along a zonal band near 22°N-24°N. In addition, mesoscale eddies also affect the Kuroshio transport through the Tokara Strait. Ichikawa (2001) reported that an eddy-related signal existing south of Okinawa 60 days prior may move to the Kuroshio region in the ECS by passing through the Kerama Gap and finally arrive at the Tokara Strait.

Some studies also paid attentions to find the causal factors on the inflow of water from Pacific Ocean to the East Asian Marginal Seas, such as the ECS and Japan Sea. Sea level difference between areas over two straits (Tsushima-Tsugaru Straits and Tsushima-Soya Straits) in the Japan Sea controls the throughflow in Tsushima Strait that is the main entrance of the Japan Sea (Minato and Kimura, 1980; Ohshima, 1994). Tsujino et al. (2008) concluded that over the Japan Sea, both of mean state and seasonal variations are caused by the wind-stress forcing in sub polar region and its seasonal perturbation.

The previous studies on the interannual variability in the Kuroshio transport were limited by the availability of field observation data, by the only surface information of altimetry data, and by the simple barotropic model. The studies on the interannual variations of the throughflow in the marginal seas did not pay enough attention on the influence of the Kuroshio on the throughflow. Furthermore, more studies are needed to understand the mechanism on the influences of PDO and eddy-related signals on the Kuroshio and the mechanisms on the linkage of the throughflow in the marginal seas and the open ocean in both the seasonal and interannual timescales.

**Method and data**

We examine the interannual variations of Kuroshio transport in the ECS by using a reanalysis product from 1993 to 2012 produced by a data-assimilative ocean model developed by Japan Coastal Ocean Predictability Experiments 2 (JCOPE2) that uses all the available observation data and provides an optimum estimation for the Kuroshio region (Miyazawa et al., 2009). Using the model results, we revisit the correlation between the interannual variability of SSH and Kuroshio transport in the ECS and PDO Index and examine the influence of mesoscale eddies on the interannual variability of Kuroshio transport in the ECS by using composite analysis.

After the validation of the model result to an observation data in the Tsushima Strait, we also examine the seasonal and interannual variations of throughflow in the straits in the East Asian Marginal Seas and the relation between the Kuroshio transport and the transport through the straits in the marginal seas.

**Main results and conclusions**

Using 1993-2012 of JCOPE2 reanalysis data, we demonstrated both the PDO index and mesoscale eddies are closely related to the interannual variation of the Kuroshio transport in the ECS.

Positive correlation between the PDO index and the interannual variation of Kuroshio transport was confirmed in a period from 1993 to 2002. This correlation becomes weak when extending the analysis to a period from 1993 to 2012.

The eddies arriving at southeast of Taiwan have stronger impact to the Kuroshio transport in the ECS in its upstream region than in downstream region; the eddies arriving at northeast of Okinawa Island have stronger impact to the Kuroshio transport in the ECS in its downstream region than in upstream region.

The intensification of the eddies southeast of Taiwan and the reduction of PDO index variability are reasons for the weakening of correlation between the Kuroshio transport and the PDO index in the entire from 1993 to 2012.

Combination of the PDO-related signals and eddy-related signals determines the interannual variations of the Kuroshio transport in the ECS.

The JCOPE2 reanalysis results can reproduce the seasonal variation of volume transport in the straits of East Asian Marginal Seas, especially in the Tsushima Strait.

Seasonal transport variation in the Japan Sea is mainly controlled by the sea level difference between the area around the Tsushima Strait and those around Tsugaru and Soya Straits.

Interannual variations in the Kuroshio transport in the ECS have significant negative correlation to the interannual variations in the transport through the Tsushima Strait.

The interannual variation in the sea level difference between the Tsushima Strait to those of Tsugaru and Soya Straits still plays a role in controlling the transport through the Tsushima Strait. The stronger Kuroshio in the ECS induces a lower sea level inside the ECS that in turn induces a weaker throughflow in the Tsushima Strait, and vice versa.