Eddy transport of North Pacific Tropical Water and its impact on the salinity distribution

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North Pacific Tropical Water (NPTW), characterized as a subsurface salinity maximum in the subtropical gyre, is a major high-salinity water mass in the North Pacific. NPTW is formed in the surface layer in the central North Pacific, where evaporation is much larger than precipitation, and subsequently subducted due to Ekman pumping, and finally advected westward along the North Equatorial Current. Nakano et al. (2015) suggested that not only the variations of large-scale atmospheric forcing like Ekman pumping velocity and Evaporation-Precipitation but also mesoscale activity in the subtropical countercurrent (STCC) region may influence distribution of NPTW. In addition, Zhang et al.(2014) showed that eddy-induced zonal mass transport is comparable in magnitude to that of the large-scale wind-driven circulation mainly in subtropical regions, assuming that the fluid inside a closed potential vorticity contour on isopycnal surfaces will move with the eddy. It is thus important to investigate whether NPTW is trapped by mesoscale eddies and transported by their movement or not for clarifying the mechanism that mesoscale eddies affect the NPTW distribution. Furthermore, it is expected that if NPTW is transported by mesoscale eddies, this effect can appear not only in the interior region but also the western boundary region (southeast of Ryukyu Islands). The aim of our research is to show that mesoscale eddies transport NPTW by trapping it based on characteristics of spatio-temporal distribution of salinity in the STCC region, and show impacts of the mesoscale eddies’ transport of NPTW on salinity variation in the western boundary region.

First we focus on spatially inhomogeneous distribution of salinity on an isopycnal surface in the STCC region because high salinity water would exist in a patchy fashion if mesoscale eddies transport NPTW with trapping it. Based on JMA hydrographic section data along 24°N, Argo data, and OFES output, it is indicated that some higher salinity water masses compared with surroundings are distributed inside mesoscale eddies. By considering the advection process of NPTW demonstrated in the OFES output, we conclude that this feature is formed by the eddy transport of higher salinity water.

Next, we examine impacts of the eddy transport of NPTW on salinity variation in the western boundary region. We show that the time lag of salinity interannual variation at the western boundary region southeast of Okinawa Island behind that at 137ºE is shorter than the advection time due to mean flow. In addition, we observe that some mesoscale eddies transport high-salinity water quickly to the area southeast of Ryukyu Islands across the streamline of mean flow in the OFES output. Moreover, by means of investigating the salinity along Ryukyu current annually using observation data and OFES data, we find that, when the salinity along Ryukyu current is entirely high, locally (200-500km) and temporarily (a couple of months) high-salinity spots, which might be related to mesoscale eddies, are frequently observed and the shorter-period variation of salinity along Ryukyu current is enhanced.

Based on the results described above, it is suggested that the transport of NPTW by mesoscale eddies deliver the signal of salinity variations in the interior region to the area southeast of Ryukyu Islands more rapidly than the mean flow, and influences the characteristics of the salinity interannual variation in the western boundary region. The present study contributes to the understanding of a type of interscale interactions by clarifying impacts of mesoscale eddies on large-scale distribution of water masses. We

hope that it will lead to better understanding of not only spatio-temporal variations of water masses but also air-sea interactions and marine biogeochemical cycles.

Keywords: mesoscale eddy, eddy transport, salinity, Tropical Water, interscale interaction

中規模渦によるNPTW輸送の模式図
色影:海面塩分　コンター:24.0σ_θ面加速度ポテンシャル(単位m^2/s^2)