Influence of eddy-trapped water mass reaching 137E survey line using OGCM and a particle-tracking method

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Mesoscale eddies are known to play a major role in water mass formation and transport. In recent years, several studies have estimated eddy-trapped transport (e.g., Zhang et al 2014), arguing that this can be comparable to the mean-flow transport. However, these estimates are based on satellite observation and ideal vortex vertical structure of eddies, not based on direct ones. In this study, we directly diagnose the eddy-trapped transport by using eddy-resolving Ocean General Circulation Model (OGCM) and off-line particle tracking method. We focus on the eddy-trapped watermass reaching the 137E survey line, which is maintained for more than 50 years by the Japan Meteorological Agency and the importance of eddy activity is pointed out. Along 137E meridional section, a total of about 1 million particles are released every August during 1993 to 2017. Using daily output and offline-particle tracking method, reverse tracking is performed until each particle reaches the mixed-layer, where each particle is ventilated and its properties significantly change due to air-sea interaction. Each particle is divided into typical water mass categories, judging from its temperature, salinity, potential vorticity and location during the ventilation. Whether or not each particle is trapped in the mesoscale eddies is judged by Okubo-Weiss parameter. Distribution of ventilated areas of typical water masses such as Tropical Water (TW), Subtropical Mode Water (STMW), Eastern Subtropical Mode Water (ESTMW), Lighter variety of Central Mode Water (L-CMW) is realistically reproduced. About 20% of TW are present in mesoscale eddies during ventilation, and 60% of the them are present in anticyclonic ones. About half of them (~10% of the total TW) reach137E in a state trapped in the eddies. Their trajectories are almost westward, whereas the trajectories not trapped in eddies are the west-southwest direction reflecting the subtropical circulation. Arrival times from the ventilated area nearly the same for the both, except for the subtropical countercurrent where the average flow is eastward and the arrival time is shorter for those trapped in the eddies. About 30% of STMW are present in eddies during ventilation, and about 80% of them are present in anticyclonic ones. About 1/3 of them (~10% of total STMW) reach 137E in a state trapped in eddies. For the STMW, the arrival time is longer for those trapped in the eddies, and their trajectories are not simple westward. Less than 20% of ESTMW and L-CMW are present in eddies during ventilation, and the ratio between the anticyclonic and cyclonic eddies is almost the same. Only 1/4 of them (5% of the total water masses) reach 137E in a state trapped in eddies. Even though the trajectory of the water mass trapped in the eddies show a clear east-west direction like TW, the arrival time is longer for the water mass trapped in the eddies. This estimate that 5-10% of these water masses reaching 137E trapped in a state eddies may be smaller than the recent estimate in past studies. These differences are also discussed.

Keywords: mesoscale eddy, watermass, particle tracking

