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Mode Water in the Sea of Japan: A Study on the Reproducibility of Mode Water in the Data-Assimilating Regional Navy Coastal Ocean Model

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Mode water, a vertically homogenous layer situated within or near the top of the permanent pycnocline, is found in every major ocean basin of the world. Two familiar types of mode water are those associated with the Gulf Stream and Kuroshio Extension regions, which are known as the North Atlantic 18°C and North Pacific Sub-Tropical Mode Water (NPSTMW). Mode water is also found in the Sea of Japan (SoJ) and is associated with anticyclonic eddies that form in the quasi-stationary meanders of the offshore branch of the Tsushima Warm Current (O-TWC). During the spring and summer months, these meander eddies evolve into intrathermocline eddies displaying a domed top and bowled bottom. During this time period, the eddies act as mode water repositories.

There have been several modeling efforts to determine mode water dynamics and formation mechanisms in the past decade. While trying to determine the "why" of mode water formation in the SoJ, Hogan and Hurlburt (2006) showed a free-running, high-resolution ocean model (HYCOM) was able to reproduce the correct mode layer structure of the meander eddies. While this lends confidence to the ability of advanced ocean circulation models to capture the physical processes that generate mode water, data assimilation seems to have a negative effect on model results, and its impact, therefore, must be quantified. For this study, a 3.5km resolution Regional Navy Coastal Ocean Model (RNCOM) is used to assess the ability of a data-assimilating model to reproduce the mode water structure in the SoJ. The model's response to the assimilation of in-situ mode water profiles and synthetic profiles (derived from sea surface satellite observations) demonstrates that the model is unable to fully recreate mode water layers or, if they are created, is often unable to maintain them beyond a single forecast run. Because the meander eddies are relatively small, 50-100km in diameter, and contain a mode water signature only in the spring and summer time months, we suggest the model's inability to create and maintain mode water occurs because the climatological data used to derived the synthetic profiles are too coarse to depict the seasonal mode water evolution of the meander eddies. The solution proposed to address the issue of mode water formation and retention in a data-assimilating model is to design a set of synthetic profiles specifically for the SoJ.