

# Analysis error estimation in a 4-dimensional variational ocean data assimilation system using a quasi-Newton method

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JMA/MRI has developed MOVE-WNP-4DVAR, an ocean data assimilation system of the western North Pacific using a four-dimensional variational (4DVAR) method, for monitoring and forecasting of the coastal and open ocean state around Japan. This system has generated the 4DVAR Ocean Reanalysis for the western North Pacific over 30 years (FORA-WNP30), which is now freely provided from JAMSTEC basically for research activities. It is valuable to estimate the analysis errors for assessing the reliability of assimilation fields, or reanalysis data, generated by data assimilation systems. In this study, we tried to estimate analysis errors using the information of the Hessian matrix which are used in a quasi-Newton method for minimizing the cost function in the 4DVAR analysis. We also use an ensemble approach in order to improve the estimation. The results indicate that the data assimilation reduces errors of the ocean fields in the Kuroshio Extension region, the Kuroshio-Oyashio mixed water region, south of Japan where Kuroshio meanders are often developed, and the south-west Japan Sea around the exit of the Tsushima Strait. The errors seem to be reduced effectively in the area where unstable physical modes exist. In addition, we confirm that increasing ensemble members is essential for improving the accuracy of the error estimation.

Keywords: 4DVAR, analysis error, quasi-newton method, ocean data assimilation system, ocean reanalysis