# Reanalyzing Temperatures and Salinities on Long Time Scales Using a 3D Ocean Circulation Model of the Baltic Sea

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The Baltic Sea is a strongly stratified semi-enclosed basin. There is large freshwater supply from rivers and net precipitation and water exchange with high-saline water from the North Sea through the Kattegat. In the Danish straits, water exchange is hampered both by bathymetric restrictions such as narrow and shallow sills, and by hydrodynamic restrictions like fronts and mixing. Furthermore, because the mean water depth is only 54 m, the dynamics of the Baltic Sea is controlled by the atmospheric forcing causing a large temporal variability in motions and physical properties. These features of the Baltic Sea make model simulations including predictions more uncertain than in the open sea. Furthermore, there are about 85 million inhabitants surrounding the Baltic Sea. Large-scale changes of the Baltic Sea hydrography and environment have impacts on human activities in the Baltic Sea region. The accurate understanding of the Baltic Sea response to changing forcing, e.g. eutrophication and changing climate, is important for industries and society in general. In addition, the coastal shelf observation systems have been largely improved in the Baltic Sea area. For example, the Baltic Operational Oceanographic System (BOOS) is now providing real-time ocean observations and forecasts for the marine industry, the public and other end-users. And the corrected system InfoBOOS provides online data delivery of both satellite and in-situ measurements over the Baltic Sea since 1999. Hence, the use of observations utilizing advanced analysis methods to reduce the model bias and to improve the initial conditions of numerical model is important.

Based on the above consideration, a description of the data assimilation system based on the cost-effective ensemble optimal interpolation (EnOI) approach is presented, which is used to reanalyze simulated fields in the Baltic Sea. The method uses anomalies from an ensemble of model simulations to estimate the background error covariances (BECs). In this paper, the details of the implementation of the reanalysis system are presented. Sample from a static ensemble for EnOI are chosen from the same season as the analysis time to deal with the strong seasonal variability in coastal regions. Furthermore, it is also discussed that the handle of observations in different time. A single observation experiment shows that the ensemble based BECs is multivariate, inhomogeneous and anisotropic. To evaluating the performance of the analysis system in the Baltic Sea, a set of experiments spanning the period January 1970 to December 1973 has been carried out by assimilating temperature and salinity profiles into the Rossby Centre Ocean model (RCO) developed at the Swedish Meteorological and Hydrological Institute (SMHI). Experiments with and without data assimilation have been performed. The root mean square deviations (RMSDs) between reanalysis results and observations at all levels show that temperature and salinity have been improved significantly by 31.1% and 38.8% respectively compared to the simulation without data assimilation. The vertical structure of the reanalysed fields is also adjusted. Comparing the reanalysis fields and forecasting fields with independent CTD data, we found significantly improved temperatures in middle and upper layers and for salinity in deeper layers, respectively. Especially, the temporal variations of the deep water salinity caused by salt water inflow are improved.

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