Evaluation of the ECMWF Ensemble of Ocean Reanalyses using Assimilation Diagnostics

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A new operational global ocean reanalysis system (ORAS4) has been implemented at ECMWF, spanning 1958 to present ([1], [4]). ORAS4 consists of five ensemble members: one unperturbed member and four additional members obtained by randomly perturbing the surface wind-stress forcing, the initial conditions at the start of the reanalysis period, and the observation rejection criterion. The ensembles have been used to provide information about the uncertainty in the reanalysis but have not been used interactively to specify the background-error (bge) covariance matrix. ORAS4 has been evaluated using various metrics, including comparisons with non-assimilated observations, impact on seasonal forecast skill, and robustness of prominent climate signals ([1], [2]). Observation-space assimilation diagnostics provide an additional metric. This presentation describes results from a statistical analysis of the innovations and analysis residuals in ORAS4. The objectives of this work are to assess: 1) the quality of the model fit to the assimilated observations; 2) the statistical consistency of the bge and observation-error (obe) covariance specifications ([3]); and 3) the adequacy of the ensemble spread.

Results show that the fit to temperature and salinity data in the forecast cycle of the reanalysis is systematically improved with ORAS4 compared to a control experiment defined as an ensemble of forced simulations with no data assimilation. The specified bge variances are reasonably consistent with the diagnosed bge variances, especially for temperature, and notably are able to capture seasonal variations by using a flow-dependent parameterization in terms of the background state. The parameterized bge variances are independent of the observing network, however, and this limitation manifests itself as an increasing discrepancy between specified and diagnosed bge variances with time. The specified obe variances are generally much larger than the diagnosed obe variances for all data types (temperature and salinity profiles, as well as altimeter data), which can be mainly attributed to the deliberate inflation of the specified obe variances near continental boundaries to account for representativeness error. As expected, comparisons with ORAS4 and the control illustrate that data assimilation has a significant damping effect on the ensemble spread, particularly in the last half of the reanalysis period. Compared to the diagnosed bge standard deviations, the ensemble spread in ORAS4 is too small suggesting that variance inflation and/or improvements in the ensemble generation strategy will be necessary in order to use the ensemble perturbations effectively for defining flow-dependent bge covariances in the variational assimilation system.

References

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