Geophysical Research Abstracts
Vol. 18, EGU2016-10052, 2016
EGU General Assembly 2016


# On improving the accuracy of the M2 barotropic tides embedded in a high-resolution global ocean circulation model

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The ocean tidal velocity and elevation can be estimated concurrently with the ocean circulation by adding the astronomical tidal forcing, parameterized topographic internal wave drag, and self-attraction and loading to the general circulation physics. However, the accuracy of these tidal estimates does not yet match accuracies in the best data-assimilative barotropic tidal models. This paper investigates the application of an Augmented State Ensemble Kalman Filter (ASEnKF) to improve the accuracy of M2 barotropic tides embedded in a 1/12.5° three-dimensional ocean general circulation model. The ASEnKF is an alternative to the techniques typically used with linearized tide-only models; such techniques cannot be applied to the embedded tides in a nonlinear eddying circulation. An extra term, meant to correct for errors in the tide model due to imperfectly known topography and damping terms, is introduced into the tidal forcing. Ensembles of the model are created with stochastically generated forcing correction terms. The discrepancies for each ensemble member with TPXO, an existing data-assimilative tide model, are computed. The ASEnKF method yields an optimal estimate of the model forcing correction terms, that minimizes resultant root mean square (RMS) tidal sea surface elevation error with respect to TPXO, as well as an estimate of the tidal elevation. The deep-water, global area-averaged RMS sea surface elevation error of the principal lunar semidiurnal tide M2 is reduced from 4.4 cm in a best-case non-assimilative solution to 2.6 cm. The largest elevation errors in both the non-assimilative and ASEnKF solutions are in the North Atlantic, a highly resonant basin. Possible pathways for achieving further reductions in the RMS error are discussed.