Global Ocean Reanalyses at Eddy-Permitting Resolution: Insights from the European Project MyOcean

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Ocean mesoscale eddies are often described as being the weather systems of the ocean by dynamical analogy with the synoptic features of the atmosphere. However, the characteristic length-scale of the ocean eddies (~50 km) is 20 times smaller than that of their atmospheric counterparts (~1000 km). The dynamical impact of these structures on the global circulation is likely to be different in the two fluids. Atmospheric eddies (i.e. storms), because of their much greater size, are very efficient in transporting heat from subtropical to subpolar latitudes (and they account for the whole poleward heat transport from 30° to 60° latitude). The smaller size of ocean eddies indicated a reduced effectiveness in transporting heat poleward that is compensated by the meridional heat transport done by the persistent and continuous large scale currents flowing along the western boundaries of continents (the southern ocean being the obvious exception). Overall, the contribution of the ocean to the total meridional heat transport is comparable to that of the atmosphere. Since the dynamical length-scale that characterizes major ocean currents is similar to that of ocean eddies, providing an estimate of the synoptic state of the ocean is a considerable challenge. The present paper discusses successively the modeling, the observational and the data assimilation challenges, and describes how these challenges were taken up in the European MyOcean project to provide global ocean/sea-ice reanalyses of the last 20 years at eddy permitting resolution.

MyOcean is a project granted by the European Commission whose general objectives are to define and to set up a concerted and integrated pan-European capacity for ocean monitoring and forecasting. MyOcean provides a series of eddy permitting (1/4°) global ocean simulations, spanning the recent period for which altimeter data are available (namely 1st January 1993 until 31 December 2009) constrained by assimilation of observations. The reanalyses describe the space-time evolution of the 3D thermodynamic variables (Temperature and Salinity), of the 3D dynamical variables (velocity field), of the sea surface height, and of sea-ice features (concentration, thickness and horizontal velocity). The numerical products available for users are monthly mean averages, but it is possible in some cases to obtain daily averages if a request is addressed directly to the reanalysis production center.

The ubiquity of eddies in the ocean will be illustrated and their representation in global models will be addressed. We will describe the common high resolution ORCA025 model configuration used by all MyOcean reanalysis systems. This configuration, inherited from the DRAKKAR modeling consortium, is based on NEMO OGCM, and is forced by surface atmospheric fields derived from ERAinterim and satellite products.

The capability of the observational network to provide a synoptic view of the ocean circulation will be discussed, contrasting the satellite observations, which have the capability of a fine resolution quasi-synoptic coverage of the world ocean but are limited to its very near surface, and the in-situ observations which despite the continuous growth of the number of ARGO profiling floats, still greatly alias the mesoscales. Ocean data used in MyOcean reanalysis systems will be described.

The data assimilation strategies must account for the specific model dynamics, model errors (including surface atmospheric parameter errors and internal errors in water mass transports by both mean currents and eddies) and data coverage. The methods used by the MyOcean partners will be described, e.g. a sequential Kalman Filter adapted from operational forecasting system, or an OI with isothermal salinity analysis, or a 3DVAR approach adapted from coarse resolution models.

Finally, the paper will present assessments and measures of the quality of the reanalysis products, obtained from a validation protocol based on recommended GODAE and CLIVAR-GSOP reanalysis diagnostics, and from comparisons between the various reanalyses and a reference simulation carried out with no data assimilation. Results from end users will also be presented, highlighting the benefits of such eddy permitting global ocean reanalyses for climate, biogeochemical, energy, research, regional modeling, fisheries and off shore applications.

Last, we will review the challenges of eddy permitting and eddy resolving ocean reanalyses in the upcoming years.

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