

A 1/10th Degree Global Ocean Simulation Using the Parallel Ocean Program

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LONG-TERM GOALS

Our long-term goal is to perform an eddy-resolving global ocean simulation using the Parallel Ocean Program (POP) that will provide a high fidelity ocean model state for use as an initial condition in a global ocean/atmosphere/ice prediction system. In addition, the global model state may be used to specify boundary conditions for regional circulation models.

OBJECTIVES

Our primary objective is to spin up a 1/10th degree, 40 level, fully global (including the Arctic Ocean) POP model for several decades using realistic surface forcing. Once the spin-up is complete and validated against observations and other models, the resulting state can be used to address the long-term goals.

APPROACH

The Parallel Ocean Program (POP) is a primitive equation, z-level ocean general circulation model that has been used successfully for both high resolution global (Maltrud *et al.*, 1998) and North Atlantic (Smith *et al.*, 2000) ocean simulations. The model has a range of appropriate physical parameterizations that can be used to improve solution fidelity and has been designed to take advantage of current supercomputer technology, making it a viable choice for such a huge task. Previous studies focused on processes and features of importance to the Navy using a 1/10th degree North Atlantic version of POP (*e.g.*, McClean *et al.*, 2002) clearly show the importance of very high resolution in producing realistic results.

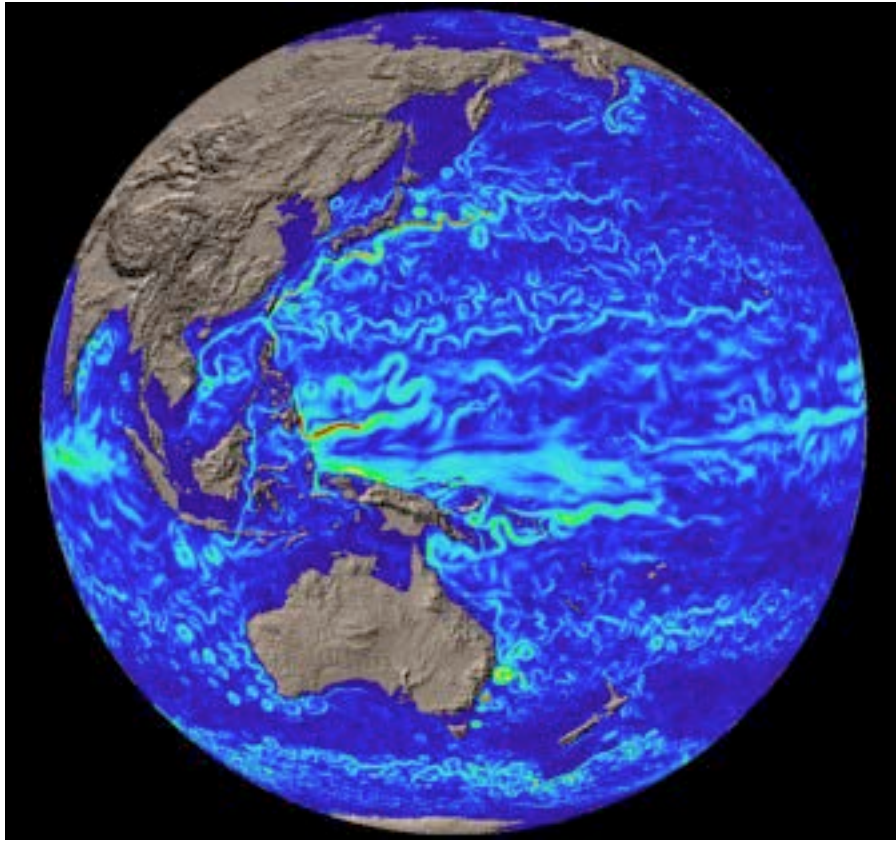
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WORK COMPLETED

As described in previous reports, most of the model configuration and testing were performed in FY00, while in FY01 a significant amount of time was spent generating and validating the daily atmospheric state fields necessary for computing wind stress and surface heat flux, and in testing a variety of possible initial conditions, followed by the start of the production run. Most of the time spent in FY02 was used in integrating the model forward in time at an average rate of about one model year per wall clock month given availability of resources, temporary suspension of the run for sensitivity runs, and backing up to rerun from an earlier date. Global averaged quantities were routinely monitored for obviously anomalous behavior. Specific physical processes and current systems were checked less frequently, but led to two fairly major changes in the model configuration. First, analysis of the Pacific equatorial current system led to an adjustment of parameters in the vertical diffusion calculation. Because of this, it was necessary to restart from an earlier point in the simulation when the currents were not yet affected. Second, analysis of the flow in the Canadian Archipelago showed much too strong flow into Baffin Bay that was likely affecting the entire North Atlantic Current system. This problem is likely due to the lack of an active sea ice model (which would reduce the flow in the narrow passages) and possibly to some biases in the NCEP winds, but was solved by making small changes in the topography in the Archipelago. The result was much lower flow into Baffin Bay, which increased the flow southward through Fram Strait to a more realistic level. In addition, we added a simple bottom boundary layer (BBL) parameterization to the model in an attempt to improve the overflows from the Mediterranean, Red, and Greenland Seas. A number of sensitivity studies showed no noticeable improvement using the BBL scheme, so the production run continued without it.

RESULTS

Our FY01 report compared sea surface height (SSH) variability from the fifth year of the 0.1 degree simulation with previous simulations and satellite altimetry data. After an additional ten simulated years, the early conclusions about the general circulation have not changed. Both the mean and variability of the strong currents look very good over most of the world ocean (see figure). The major exception is the Gulf Stream (which typically separates too far north) and North Atlantic Current (which is too zonal). However, very recent studies using the model described in Smith *et al.*, (2000) have shown that these characteristics are much more sensitive to horizontal diffusivity than previously thought, so may be improved in the future.



Snapshot of the model speed at 50 meters depth in the East Indian and West Pacific Ocean. Dark blue color corresponds to slow speed, and red to speeds above 150 centimeters per second. The fast, narrow currents (such as the Kuroshio, Antarctic Circumpolar Current, and Indonesian Archipelago) and eddy-active regions (such as the Leeuwin Current) are clearly seen, as well as the more broad equatorial currents.

Results from the model spin-up including movie loops can be seen at <http://www.oc.nps.navy.mil/navypop>

IMPACT/APPLICATIONS

This simulation represents the state of the art in primitive equation global ocean circulation modeling and should provide a very realistic ocean state for use by Fleet Numerical Meteorology and Oceanography Center (FNMOC) for use in global forecasting. In addition, detailed analysis of the model should provide new insights into the dynamics of ocean circulation and how this affects processes of importance to the Navy.

TRANSITIONS

Once the spin-up is complete, numerous model states will be given to FNMOC to be used operationally in global forecasts. Subsets of the model data will be made available to the oceanographic

community in general for analysis.

RELATED PROJECTS

The project most closely related to this work is “Towards the use of POP in a global coupled Navy prediction system” (McClean et al., ONR award number #N0001402WR20127) which involves analysis and sensitivity studies evaluating POP’s performance using Navy atmospheric products.

Other related projects include efforts to couple POP to the NOGAPS atmospheric model, and the development of a global multivariate Optimal Interpolation (MVOI) system compatible with POP. Both of these efforts are occurring at NRL-Monterey and will take advantage of the results from the 1/10th degree simulation. Currently, a 0.5-deg POP is successfully coupled to NOGAPS as well as using the MVOI.

REFERENCES

Maltrud, M. E., R. D. Smith, R. C. Malone, and A. J. Semtner, Global eddy-resolving simulations driven by 1985-94 atmospheric fields. *J. Geophys. Res.*, 103, 30,825-30,853, 1998.

Smith, R. D., M. E. Maltrud, F. O. Bryan, and M. W. Hecht, Numerical simulation of the North Atlantic at 1/10-degree. *J. Phys. Oceanogr.*, 30, 1532-1561, 2000.

PUBLICATIONS

McClean , J., and M. Maltrud, 2002: Towards a high-resolution global coupled Navy prediction system: the ocean component, *Navigator*, Spring 2002, 14-17.

McClean, J. L., P.-M. Poulain, J. W. Pelton, and M. Maltrud, 2002: Eulerian and Lagrangian statistics from surface drifters and a high-resolution POP simulation in the North Atlantic. *J. Phys. Ocean.*, 32, 2472-2491.