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LONG-TERM GOALS

Development of a global high resolution coupled atmosphere/ocean/ice model that assimilates data providing initial conditions from which forecasts are performed. Additionally, very high-resolution regional air/ocean coupled models will be nested into the global system at key strategic locations.

OBJECTIVES

To start the spin up of the global high-resolution ocean component of this system and evaluate its realism using observations as it progressed.

APPROACH

The Parallel Ocean Program (POP) model was configured on a global displaced North Pole grid whereby the North Pole is rotated into Hudson Bay, avoiding the issue of the polar singularity. The grid has an average spacing of about 11 km at the equator decreasing to about 3 km in the Arctic Ocean. At mid-latitudes this spacing is 5-7 km corresponding to about 1/15°. It has 40 vertical levels. The POP code is designed to run on multi-processor machines; here we are using 500 processors on the IBM SP3 at the Navy Oceanographic Office to spin-up the ocean model for two decades.

We created a blended bathymetry from Sandwell and Smith (1997) and International Bathymetric Chart of the Arctic Ocean (IBCAO) products. ETOP05, with major modifications from a variety of data sources was used in the Southern Ocean. All important channels and sills were checked and modified to encourage correct flow. To produce an energetically realistic ocean state, synoptic forcing was used whenever possible during the global spin-up. We used a product provided by Yeager

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14. ABSTRACT
Development of a global high resolution coupled atmosphere/ocean/ice model that assimilates data providing initial conditions from which forecasts are performed. Additionally, very high-resolution regional air/ocean coupled models will be nested into the global system at key strategic locations.

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(NCAR) that was largely constructed from the 1958-1997 National Center for Environmental Prediction (NCEP) fluxes. Some of the quantities required for the heat and freshwater flux calculations were obtained from climatologies or observations for shorter periods, hence their availability has dictated the starting time of the model run which was January 1, 1979. Background restoring of sea surface temperature and sea surface salinity to `under ice' values with a restoring time scale of 1 month and a timescale of half a year elsewhere is active. The Large et al. (1994), K-Profile-Parameterization, mixed layer formulation was turned on after the first year of the spin-up.

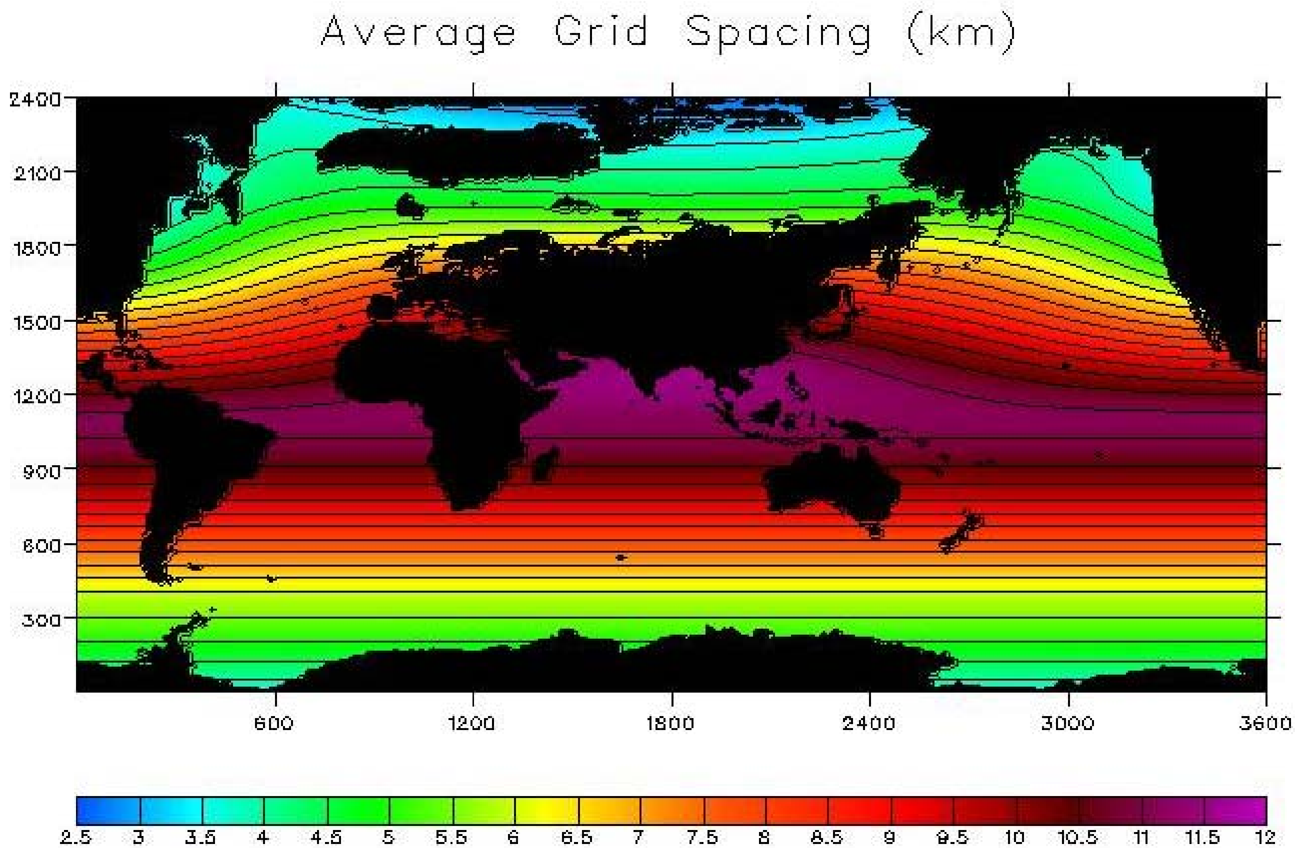

Figure 1: Average grid spacing of the global POP simulation. Values range from about 11 km at the equator to 3 km in the Arctic.

During the spin up a number of judicious choices were made with regard to the archived output. Daily two-dimensional (2-D) snapshots of sea surface height, salinity, temperature, and velocities from the upper two levels, mixed layer depth, boundary layer depth, salinity at 1000 m (depth of Mediterranean outflow), and surface heat and freshwater fluxes are saved. Ten-day snapshots of the full solution of velocity, temperature and salinity and sea surface height are also archived. After five to ten years of the spin up, averages will be saved on a more frequent basis to examine the ability of the model to produce high-frequency (days to months) processes and shorter scale (10 –1000 km) features important to Navy prediction.

This solution is examined in terms of its ability to reproduce the observed ocean circulation, in particular, the surface circulation. A number of quantities to monitor model behavior are part of the POP code: transports through key passages, globally averaged salinity, temperature, and kinetic energy. The daily 2-D fields are examined in terms of the evolving mean flow and energy levels of the surface circulation, along with eddy characteristics, frontal development, and mixed layer structure. The composition of the Mediterranean outflow is monitored from the salinity at 1000 m.

WORK COMPLETED

The first five years of the spin-up are complete. This is one of the largest ocean simulations to be attempted to date and it requires an extremely large allocation of computer resources. We have a Department of Defense High Performance Computing Modernization Office (HPCMO) Grand Challenge Grant and these resources were almost entirely used performing the five years of the spin-up. Several separate basin-only parameter studies were conducted to better understand the behavior of the global ocean model in areas where the global simulation was identified as unrealistic. Appropriate changes to the run parameters can then be made for the global run.

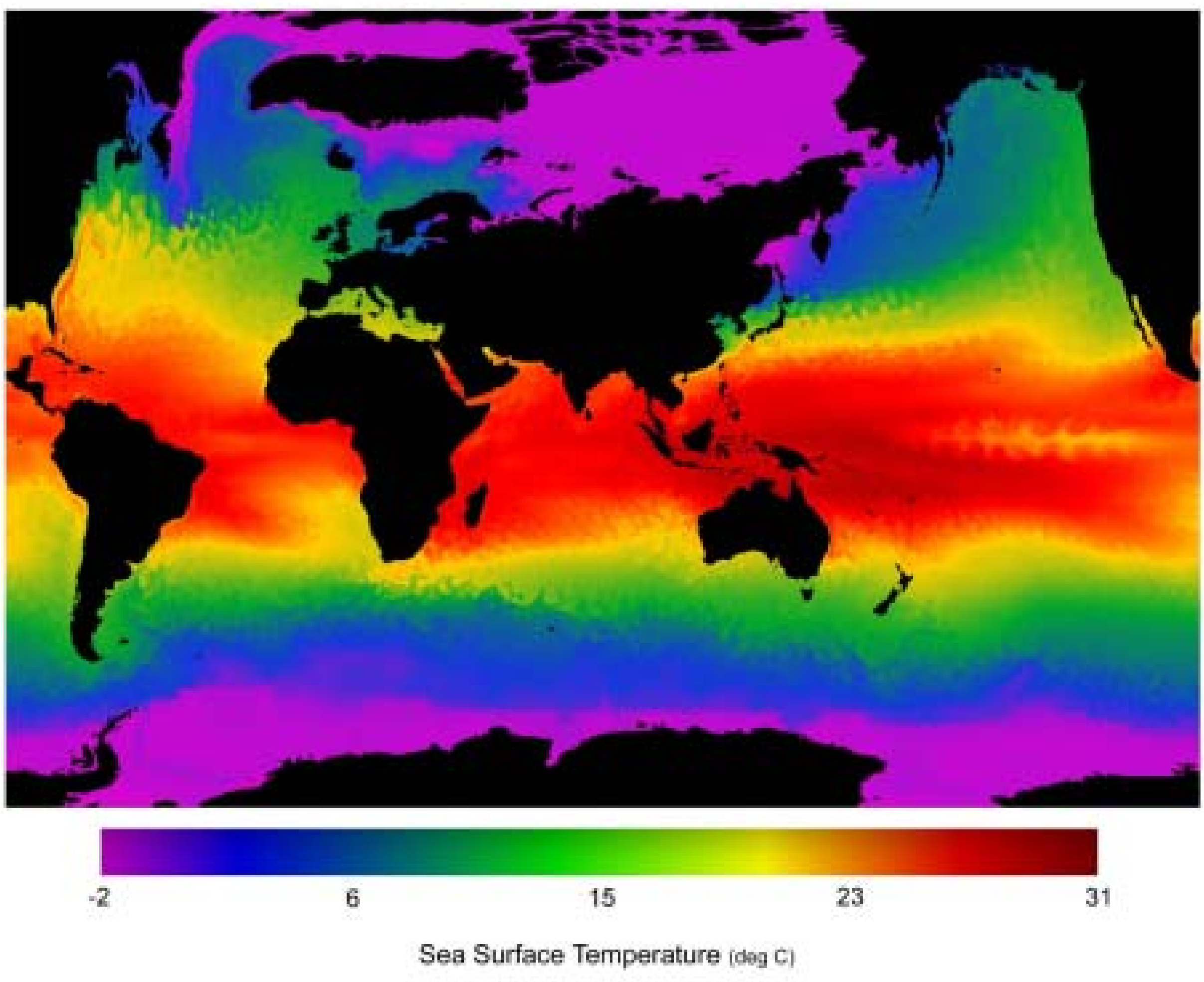

Figure 2: Snapshot of Sea Surface Temperature (deg C) for the global POP simulation on January 1, 1983. Note the highly resolved details of the frontal structures.

Statistical analyses from an earlier 0.1°, 40-level North Atlantic POP model and the North Atlantic surface drifting buoy data set was submitted for publication. Other statistical analyses of the North Atlantic model continue, particularly evaluations of the mixed layer formulation.

RESULTS

Snapshots of model surface temperature and surface velocity from 1 January, 1983 of the spin-up are seen in Figure 2 and 3, respectively. In Figure 2, the richness and realism of the frontal structures in both the western boundary currents and the equatorial regions are apparent. A large meander of the Kuroshio Current to the south of Japan is observed. Movie loops indicate that the model reproduces the three different observed paths where the Kuroshio hugs the coast, forms a slight meander, or a large meander (Tomczak and Godfrey, 1994). The Agulhas Current (south of Africa) and the East Australian Current display a realistic retroflection and separation from the coast, respectively. The Gulf Stream is seen to flow too far north before separating from the North American coast. A North Atlantic sector POP model, taken from the global grid in this region, is being run using different choices of run parameters and initial conditions to try and understand this behavior.

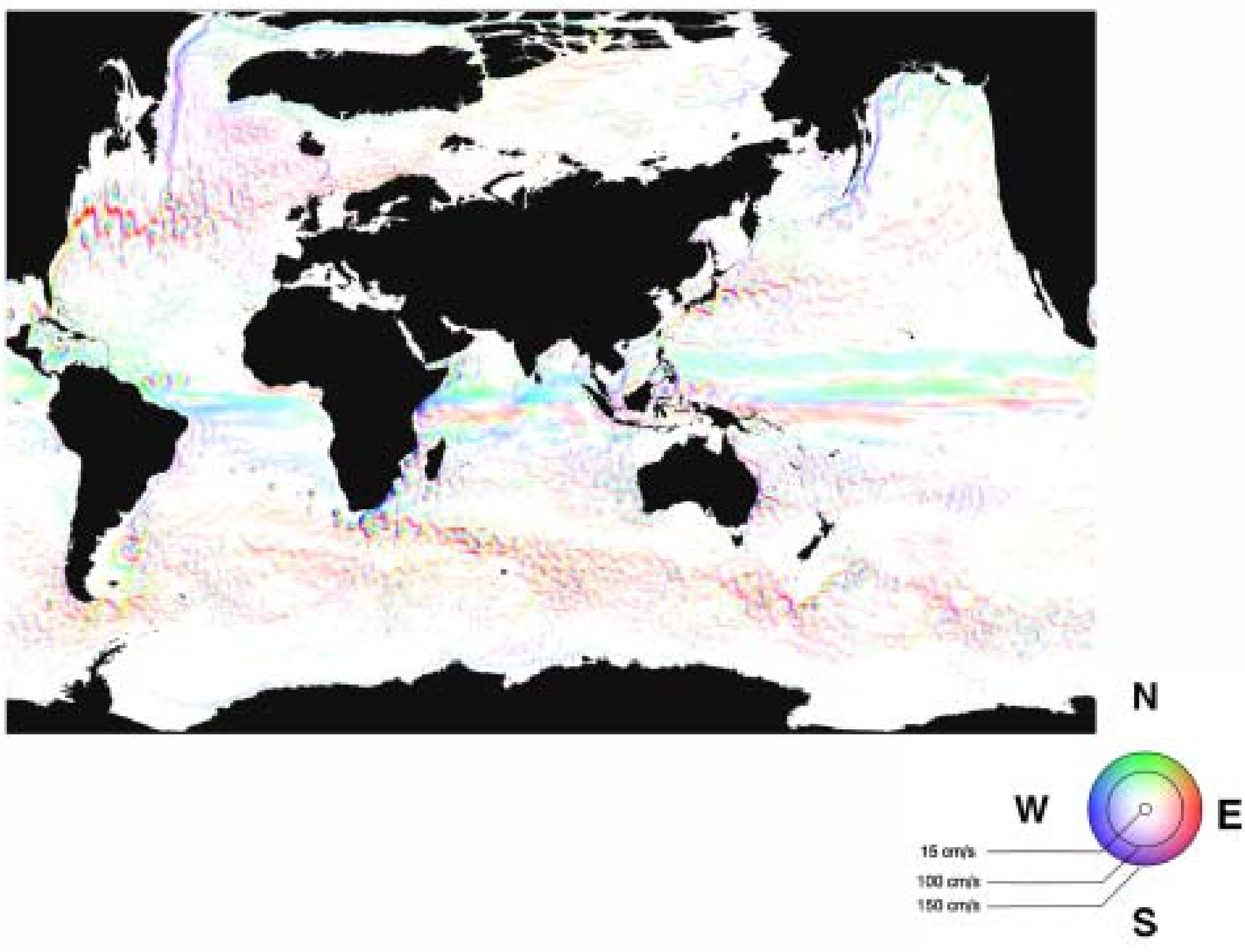

Figure 3: Snapshot of speed and direction of surface currents in the global POP run on January 1, 1983. Colors and hues provide the magnitude and direction of the flows.

In Figure 3, we see both the speed and direction of the surface flow. Particularly striking are the Agulhas Current eddies that are shed south of Africa and then move to the northeast across the South Atlantic Ocean. Their sense of rotation can be determined from the alternating red and green shading. Preliminary comparisons of sea surface height variability from TOPEX/POSEIDON and the model show the spin-up to be realistically simulating the magnitude and location of the observed variability. Transports through key passages, particularly the Indonesian Through Flow passages, are very realistic. Other results from the model spin-up including movie loops can be seen at http://www.oc.nps.navy.mil/navypop.

IMPACT/APPLICATIONS

This spin-up will be provided to Fleet Numerical Meteorology and Oceanography Center (FNMOC) for future operational use and to the wider community for ocean and short-term climate studies.

TRANSITIONS

The 0.1-degree, 40-level POP spin up will be provided to FNMOC and NRL (Monterey) for testing towards the operational use of POP. Fields from this run will be provided to Preller (NRL-Stennis) for nesting with the regional Navy Coastal Ocean Model (NCOM) model of the East Asian Seas.

RELATED PROJECTS

Mathew Maltrud (LANL) has a companion grant at his institution for this global POP project. NRL (Monterey) is working on coupled NOGAPS and POP simulations. NRL Monterey is developing a global multivariate Optimal Interpolation (MVOI) that will cycle with the global POP.

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