A RESEARCH PROPOSAL SUBMITTED TO:
THE NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION (NOAA)
Through the

Cooperative Institute for Marine and Atmospheric Studies (CIMAS)

For the

Rosenstiel School of Marine and Atmospheric Science, University of Miami
4600 Rickenbacker Causeway, Miami, FL 3349-1098

Title: **U.S. GODAE: Global Ocean Prediction with the HYbrid Coordinate Ocean Model (HYCOM)**

Performance Period: June 1, 2003 – May 31, 2008

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Research Theme: Theme 6: Integrated Ocean Observations

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Total Federal Funds Requested (All partners): $11,875,760

FY04	FY05	FY06	FY07	FY08
$1,027,373	$1,940,646	$2,772,024	$2,966,719	$3,168,998

Total Federal Funds Requested (U. of Miami only): $2,610,628

FY04	FY05	FY06	FY07	FY08
$129,573	$421,321	$631,198	$692,652	$735,884

ABSTRACT

U.S. GODAE: Global Ocean Prediction with the HYbrid Coordinate Ocean Model (HYCOM)

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Partners: **U. of Miami** (E. Chassignet, G. Halliwell, M. Iskandarani, T. Chin, A. Mariano, D. Bi, Z. Garraffo, A. Srinivasan, P. Minnett, R. Evans), **NRL/STENNIS** (H. Hurlburt, A. Wallcraft, J. Metzger, B. Kara, J. Cummings, G. Jacobs, H. Ngodock, L. Parent, C.A. Blain, P. Hogan, J. Kindle), **NAVOCEANO** (E. Johnson, J. Harding), **FNMOC** (M. Clancy), **NRL/MONTEREY** (R. Hodur, M. Flatau, X. Hong, J. Pullen), **NOAA/NCEP/MMAB** (D.B. Rao, C. Lozano), **NOAA/NOS** (F. Aikman), **NOAA/AOML** (C. Thacker), **NOAA/PMEL** (S. Hankin), **Planning System Inc.** (O.M. Smedstad, B. Lunde), **LANL** (R. Bleck), **SHOM** (R. Baraille), **LEGI** (P. Brasseur), **OPeNDAP** (P. Cornillon), **U. of S. Mississippi** (W. Schmitz), **U. of N. Carolina** (C. Werner), **Rutgers** (J. Wilkin, D. Haidvogel), **U. of S. Florida** (R. Weisberg), **Fugro-GEOS/Ocean Numerics** (D. Szabo, G. Evensen), **Horizon Marine Inc.** (J. Feeney, S. Anderson), **ROFFS** (M. Roffer), **Orbimage** (L. Stathoplos), **Shell Oil Company** (M. Vogel), **ExxonMobil** (O. Esenkov).

Total Coast: $ 11,875,760 Proposed Period: June 1, 2003 – May 31, 2008

A broad partnership of institutions proposes to collaborate in developing and demonstrating the performance and application of eddy-resolving, real-time global and basin-scale ocean prediction systems using the HYbrid Coordinate Ocean Model (HYCOM). These systems will be transitioned for operational use by the U.S. Navy at both the Naval Oceanographic Office (NAVOCEANO), Stennis Space Center, MS, and the Fleet Numerical Meteorology and Oceanography Center (FNMOC), Monterey, CA, and by NOAA at the National Centers for Environmental Prediction (NCEP), Washington, D.C. The systems will run efficiently on a variety of massively parallel computers and will include sophisticated, but relatively inexpensive, data assimilation techniques for assimilation of satellite altimeter sea surface height (SSH) and sea surface temperature (SST) as well as in-situ temperature, salinity, and float displacement. The Partnership will address the Global Ocean Data Assimilation Experiment (GODAE) goals of three-dimensional (3D) depiction of the ocean state at fine resolution in real-time and provision of boundary conditions for coastal and regional models. It will also provide the ocean component and oceanic boundary conditions for a global coupled ocean-atmosphere prediction model. It will make these results available to the GODAE modeling community and general users on a 24/7 operational basis via a comprehensive data management strategy.

The Partnership under this proposal represents a truly broad spectrum of the oceanographic community, bringing together academia, federal agencies, and industry/commercial entities, spanning modeling, data assimilation, data management and serving, observational capabilities, and application of HYCOM prediction system outputs. The institutions participating in this Partnership have long histories of supporting and carrying out a wide range of oceanographic and ocean prediction-related research and data management. All institutions are committed to validating an operational hybrid-coordinate ocean model that combines the strengths of the vertical coordinates used in the present generation of ocean models by placing them where they perform best. This collaborative Partnership provides an opportunity to leverage and accelerate the efforts of existing and planned projects, in order to produce a higher quality product that will collectively better serve a wider range of users than would the individual projects. In addition to operational eddy-resolving global and basin-scale ocean prediction systems for the U.S. Navy and NOAA, respectively, this project offers an outstanding opportunity for NOAA-Navy collaboration and cooperation ranging from research to the operational level.

WORK STATEMENT

1) OBJECTIVES AND GOALS

A broad partnership of institutions proposes to collaborate in developing and demonstrating the performance and application of eddy-resolving, real-time global and basin-scale ocean prediction systems using the HYbrid Coordinate Ocean Model (HYCOM). These systems will be transitioned for operational use by the U.S. Navy at both the Naval Oceanographic Office (NAVOCEANO), Stennis Space Center, MS, and the Fleet Numerical Meteorology and Oceanography Center (FNMOC), Monterey, CA, and by NOAA at the National Centers for Environmental Prediction (NCEP), Washington, D.C. The systems will run efficiently on a variety of massively parallel computers and will include sophisticated, but relatively inexpensive, data assimilation techniques for assimilation of satellite altimeter sea surface height (SSH) and sea surface temperature (SST) as well as in-situ temperature, salinity, and float displacement. The Partnership will address the Global Ocean Data Assimilation Experiment (GODAE) goals of three-dimensional (3D) depiction of the ocean state at fine resolution in real-time and provision of boundary conditions for coastal and regional models. It will also provide the ocean component and oceanic boundary conditions for a global coupled ocean-atmosphere prediction model. It will make these results available to the GODAE modeling community and general users on a 24/7 operational basis via a comprehensive data management strategy.

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a) NAVOCEANO

HYCOM is planned as the model component of the next generation eddy-resolving (1/12° grid spacing, ~7 km mid-latitude resolution) operational global ocean nowcast/forecast system at NAVOCEANO [see attached letters of support from NAVOCEANO and the Commander Naval Meteorology and Oceanography Command (CNMOC)]. Transition of the HYCOM-based global system from Research and Development to NAVOCEANO is planned for FY06 and the resolution should increase to 1/25° (~3-4 km at mid-latitudes) by the end of the decade. These systems would include an embedded ice model and the capability to host nested littoral models with even higher resolution. The 2006 date for transition is timed to coincide with the planned FY06 High Performance Computer (HPC) upgrade, the second major upgrade beyond NAVOCEANO's existing 1,184 processor IBM Power 4 system. NAVOCEANO's mission encompasses a broad range of oceanographic activities supporting the U.S. Navy, with global numerical ocean prediction a key element. Scientists at NAVOCEANO provide specialized, operationally-significant products and services for military "warfighters." NAVOCEANO scientists also acquire global ocean and littoral data from sources such as: shipboard surveys, routine data collected by both operational Navy and commercial ships, remotely-sensed data available from a variety of airborne and satellite sensors, and drifting and fixed-location buoys. NAVOCEANO is the U.S. provider of operational real-time satellite altimeter and MCSST data, including to FNMOC and NCEP. The analyses of these data range from the creation of historical climatologies and real-time maps of specific measured parameters to the assimilation of real-time data into ocean prediction systems for temperature, salinity, tides, waves, and currents. The latter systems focus on coastal and regional nowcast/forecast systems nested within the global prediction systems.

b) FNMOC

A loosely-coupled and then a tightly-coupled global atmosphere/ocean data assimilation system based on the Navy Operational Global Atmospheric Prediction System (NOGAPS) and HYCOM will be evaluated by NRL/Monterey. Transition of this system to operations at FNMOC is planned in FY06 (see attached letter of

support). The ocean component will be addressed under this project and the atmospheric component and coupling under partnering projects. In addition, the global HYCOM ocean data assimilation system will be used for initialization and lateral boundary conditions for the globally relocatable ocean model in the Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS™). FNMOC is the Department of Defense (DoD) primary central production site for operational meteorological and oceanographic analysis and forecasts products worldwide.

c) NCEP

HYCOM is planned as the next generation operational ocean model at the NOAA/NWS/NCEP Marine Modeling and Analysis Branch (MMAB). The MMAB is responsible for the development of improved numerical marine modeling prediction and analysis systems within the National Weather Service (NWS). The ocean forecast system will include eddy-resolving basin-wide configurations for the North Atlantic and Pacific with forecasting capability for US coastal ocean areas, including Alaska and Hawaii. The operational North Atlantic Ocean Forecast System (NAOFS) (to be in place in 2005) will provide ocean forecasts for the entire eastern seaboard of the U.S. from the Gulf of Maine to the Gulf of Mexico, including the Caribbean Seas area. Evaluation of a Pacific Ocean Forecast System will also take place during this NOPP effort (years 4-5). The nowcast and forecast products will include sea levels, currents, temperature and salinity. The suite of ocean products will be provided to the National Weather Service's Ocean Prediction Center (OPC), the Tropical Prediction Center (TPC), the National Ocean Service (NOS) (see attached letters of support from these three centers), and the project Partners for critical evaluation. The products will be also distributed to forecast offices with marine responsibilities, and external research and applications oriented communities.

2) APPROACH

a) HYCOM Overview

HYCOM development is the result of collaborative efforts among the University of Miami, the Naval Research Laboratory (NRL), and the Los Alamos National Laboratory (LANL), as part of the multi-institutional HYCOM Consortium for Data-Assimilative Ocean Modeling. This effort was funded by the National Ocean Partnership Program (NOPP) in 1999 to develop and evaluate a data-assimilative hybrid isopycnal-sigma-pressure (generalized) coordinate ocean model (Bleck, 2002; Chassignet et al., 2003; Halliwell, 2003).

The numerical modeling studies carried out over the past several decades have demonstrated advances both in model architecture and in the availability of computational resources for the scientific community. Perhaps the most noticeable aspect of this progression has been the evolution from simulations on coarse-resolution horizontal/vertical grids outlining basins of simplified geometry and bathymetry and forced by idealized stresses, to fine-resolution simulations incorporating realistic coastal definition and bottom topography, forced by observational data on relatively short time scales (Hurlburt and Hogan, 2000; Smith et al., 2000; Chassignet and Garraffo, 2001).

Traditional ocean models use a single coordinate type to represent the vertical, but recent model comparison exercises performed in Europe (DYnamics of North Atlantic MOdels - DYNAMO) (Willebrand et al., 2001) and in the U.S. (Data Assimilation and Model Evaluation Experiment - DAMÉE) (Chassignet et al., 2000) have shown that no single vertical coordinate -- depth, density, or terrain-following sigma -- can by itself be optimal everywhere in the ocean. These and earlier comparison studies (Chassignet et al., 1996; Roberts et al., 1996, Marsh et al., 1996) have shown that the models considered are able to simulate the large-scale characteristics of the oceanic circulation reasonably well, but that the interior water mass distribution and associated thermohaline circulation are strongly influenced by localized processes that are not represented equally by each model's vertical discretization.

Isopycnal (density tracking) layers are best in the deep stratified ocean, z-levels (constant fixed depths) are best used to provide high vertical resolution near the surface within the mixed layer, and sigma-levels (terrain-following) are often the best choice in shallow coastal regions. HYCOM combines all three approaches by choosing the optimal distribution at every time step. The hybrid coordinate is one that is isopycnal in the open, stratified ocean, but that makes a dynamically smooth transition (via the layered continuity equation) to terrain-following coordinates in shallow coastal regions, and to pressure coordinates in the mixed layer and/or unstratified seas. HYCOM is designed to provide a major advance over the existing global operational ocean products, since it overcomes design limitations of the present systems as well as limitations in vertical or horizontal resolution. The result should be a more streamlined system with improved performance and an

extended range of applicability (*e.g.*, the present systems are seriously limited in shallow water and in handling the transition from deep to shallow water).

The capability of assigning additional coordinate surfaces to the oceanic mixed layer in HYCOM gives us the option of implementing sophisticated vertical mixing turbulence closure schemes [see Halliwell (2003), for a review]. HYCOM 2.1 (released in September 2002) has four primary vertical mixing algorithms, of which two are non-slab models and two are slab models. The two non-slab models govern vertical mixing throughout the water column and are the nonlocal K-Profile Parameterization (KPP) model of Large et al. (1994), and the level 2.5 turbulence closure algorithm of Mellor and Yamada (1982) (MY). KPP is our standard mixed layer model, and will be used throughout this project unless an alternative outperforms it.

HYCOM has been configured globally, on basin scales, and regionally. The fully global configuration is currently being integrated with ~60 km mid-latitude resolution. Coupling to the Los Alamos ice model (CICE) is underway. North Pacific and Atlantic basin-scale simulations have been integrated with ~7 km mid-latitude resolution, our target resolution for the global configuration. More details of these free-running simulations can be found at http://hycom.rsmas.miami.edu and in section 2e on the prediction system configurations.

b) Data Assimilation Techniques

While HYCOM is a highly sophisticated model, including a large suite of physical processes and incorporating numerical techniques that are optimal for dynamically different regions of the ocean, data assimilation is still essential a) because many ocean phenomena are due to flow instabilities and thus are not a deterministic response to atmospheric forcing, b) because of errors in the atmospheric forcing, and c) because of ocean model imperfections, including limitations in resolution. One large body of data is obtained remotely from instruments aboard satellites. They provide substantial information about the ocean's space-time variability at the surface, but they are insufficient by themselves for specifying the subsurface variability. Another significant body of data is in the form of vertical profiles from XBTs, CTDs, and profiling floats *(e.g.,* ARGO). While these are too sparse to characterize the horizontal variability, they provide valuable information about the vertical stratification. Even together, they are insufficient to determine the state of the ocean completely, so it is necessary to exploit prior knowledge in the form of statistics determined from past observations as well as our understanding of ocean dynamics. Our intent is to combine all sources of information synergistically to produce the best possible depiction of the evolving ocean.

Several techniques for assimilating data into HYCOM are either in place or under development. These techniques vary in sophistication and computational requirements and include: Optimum Interpolation (OI/Cooper-Haines) (PSI, O.M. Smedstad; SHOM, R. Baraille), MVOI/3D-VAR (NRL, J. Cummings; NOAA/NCEP, C. Lozano), SEEK filter (LEGI, P. Brasseur), Reduced Order Information Filter (ROIF) (U. of Miami, T. Chin, A. Mariano; NOAA/AOML, C. Thacker), Ensemble Kalman Filter (EnKF) (Ocean Numerics, G. Evensen), Reduced Order Adaptive Filter (ROAF) (including adjoint) (SHOM, R. Baraille), and the 4D-VAR Representer Method (USM, H. Ngodock; NRL, G. Jacobs). All of these techniques are available for this project and all developers are part of this Partnership.

Mostly because of its simplicity, robustness, and low computational costs, operational ocean prediction centers around the world (NLOM, MERCATOR, FOAM, etc.) are presently using OI-based assimilation techniques. For our prototype 1/12^{o} North Atlantic HYCOM system, we have adopted a similar approach by selecting an OI technique with Cooper and Haines (1996) for downward projection of SSH from altimetry (see http://hycom.rsmas.miami.edu/ocean_prediction.html for details). More sophisticated techniques are being evaluated within the oceanographic community that will eventually replace the OI-based techniques used operationally. For example, the SEEK (Singular Evolutive Extended Kalman) filter is scheduled to supersede the multivariate OI SOFA technique presently used in MERCATOR.

Most of the assimilation techniques, developed in a pre-operational context, are sequential in nature, implying that only past observations can influence the current estimate of the ocean state. Both the SEEK filter (Pham et al, 1998) and ROIF (Chin et al., 1999) are especially well suited for large dimensional problems and will be the two techniques that will be evaluated by the HYCOM partnership to replace the present OI scheme. The ROIF assumes a tangent linear approximation to the system dynamics, while the SEEK filter can use the non-linear model to propagate the error statistics forward in time (Ballabrera et al., 2001). For both schemes, the analysis step is multivariate in nature, *i.e.*, all model state variables are modified in a consistent manner after the analysis step. In the SEEK filter, the dominant eigenvectors describing the model variability can be used to specify the

initial background error covariance matrix in decomposed form. This leads to fully three-dimensional, multivariate dynamically consistent corrections. The ROIF method factors the covariance functions into horizontal and vertical components and represents the correction field *implicitly*, using techniques transplanted from statistical mechanics (Gaussian Markov Random Field). The implicit technique tends to allow a highly efficient way to represent smaller scale dynamic modes. The reduced order aspect of ROIF refers to the fact that the information matrix is approximated as a banded matrix. This allows more realistic tails for the correlation functions than similarly approximating the error covariance matrix. The ROIF has been successfully tested with HYCOM on a single CPU and the code is undergoing parallelization. The SEEK (Singular Evolutive Extended Kalman) filter has been implemented in a 1/3° North Atlantic HYCOM within the European project TOPAZ (Toward an Operational Prediction system for the North Atlantic European coastal Zones – http://topaz.nersc.no) and will soon be evaluated on our 1/12° North Atlantic configuration.

Besides the SEEK and ROIF methods, other techniques such as the EnKF and the ROAF will also be evaluated. Because of their cost, they will be used mostly within coastal HYCOM configurations (see sections 2f and 5) or in specific limited areas of high interest. The EnKF (Evensen, 1997) has already been implemented in HYCOM via the European TOPAZ project, and is available to the Partnership. The ROAF (Hoang et al., 1997) is under development at the Service Hydrographique de la Marine (SHOM) and estimates unknown parameters via the adjoint by minimizing the forecast errors. The filter is used to estimate the vertical correlation coefficients of the forecast error matrix. Development of the HYCOM adjoint swill be completed shortly by R. Baraille (SHOM) in collaboration with H. Ngodock and G. Jacobs (NRL). This will allow further development of several variational techniques (3D- and 4D-VAR) as well as evaluation of the EnKF and SEEK.

c) Configuration of the Prediction Systems

i) Basin-Scale Domains

The present prototype of the near real time NRL/Miami HYCOM Atlantic Ocean prediction system (http://hycom.rsmas.miami.edu/ocean_prediction.html) spans from 28°S to 70°N, including the Mediterranean Sea. The latest version of this domain is an exact subset of our global grid, with an Arctic dipole patch above 47°N. Figure 1a shows this latest configuration and the grid design. Below 47°N, the grid is Mercator with a grid aspect ratio of one, but above 47°N, the grid aspect ratio can be as high as 1.5. The vertical resolution consists of 26 hybrid layers, with the top layer typically at its minimum thickness of 3 m (*i.e.,* in fixed coordinate mode to provide near surface values). In coastal waters, there are 15 sigma-levels, and the coastline is at the 5 m isobath. The northern and southern boundaries are treated as closed, but are outfitted with 3 ° buffer zones in which temperature, salinity and pressure are linearly relaxed toward their seasonally varying climatological values. Six-hourly wind and thermal forcing is presently provided by the FNMOC Navy Operational Global Atmospheric Prediction System (NOGAPS) (see section 3a for details).

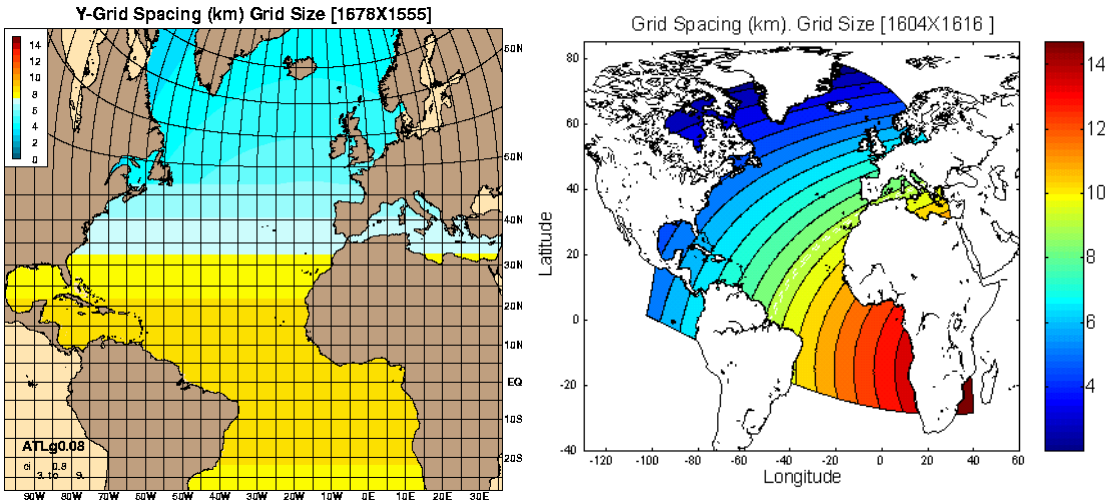

Figure 1: Latitudinal grid spacing for the NRL/Miami and NOAA/NCEP/MMAB configurations, respectively.

A second North Atlantic configuration will form the backbone of the NOAA/NCEP/MMAB North Atlantic Ocean Forecast System (NAOFS). By comparison to the NRL/Miami system, it will allow us to evaluate the impact of a) NCEP-based wind and thermal forcing and b) a different grid. By taking advantage of the general

orthogonal curvilinear grid in HYCOM, the MMAB group will be using the configuration displayed in Figure 1b which, for the same number of grid points as a regular Mercator projection, has finer resolution in the western and northern portions of the basin and on shelves (3-7 km) than toward the east and southeast (7-13 km). The forcing will consist of a) atmospheric fields derived from analyses and predictions of NCEP Global Model System (T540, about 30 km resolution) and b) eight tidal constituents (body force and boundary forcing, the latter derived from the GOTT99.2 global tidal model). As in the other North Atlantic configurations, the northern and southern boundaries will be outfitted with 3 ^{o} buffer zones in which temperature and salinity are linearly relaxed toward their seasonally varying climatological values. A similar projection will be used for the MMAB Pacific Ocean configuration later on in the project.

ii) Global Domain

There are several projections that allow the Arctic to be included in a global ocean model by moving the singularity at the pole over land. For the HYCOM global configuration, we use an Arctic dipole patch matched to a standard Mercator grid at 47°N. Unlike most other pole-shifting projections, this has the advantage that all grid points below 47°N are unchanged. Since HYCOM supports general curvilinear grids, it requires no changes to the standard model code and array structure except a special halo exchange at the northern edge of the domain. Locating the dipoles at 47°N gives good resolution in the Arctic and Hudson Bay (7 km at mid-latitude vs. 3.5 km at the North Pole). For our target resolution (1/12° at the equator), the array size is 4500 by 3298 with 26 hybrid layers in the vertical. The complete system will include the LANL CICE sea-ice model on the same grid. The ocean and ice models will run simultaneously, but on separate sets of processors, communicating via NCAR's Community Climate System Model (CCSM) coupler. A typical configuration would use 426 processors for the HYCOM component (plus a much smaller number for CICE, since it does not need to be run on the ice free ocean, chosen to make the two run in the same wall time). The domain is divided into 600 approximately equal-sized tiles, but 174 "all land" tiles are discarded, leaving 426 MPI tasks each owning a single tile (see Figure 2).

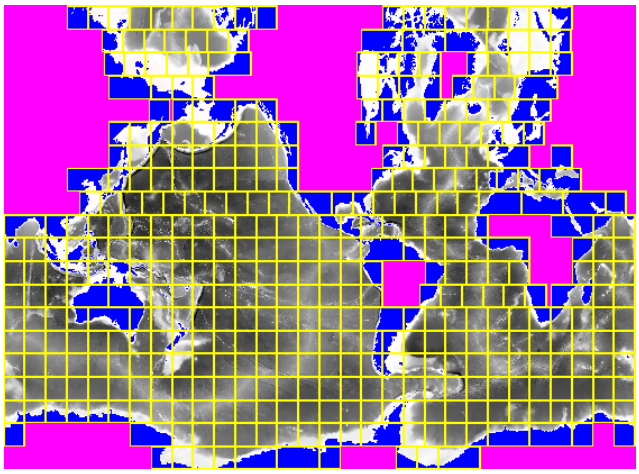

Figure 2: HYCOM global model decomposition

iii) Code parallelization and computer time availability

The basic parallelization strategy is domain decomposition, *i.e.*, the region is divided into smaller sub-domains, or tiles, and each processor "owns" one tile. Figure 2 shows one such tiling for the global domain. A halo is added around each tile: this allows communication operations (*e.g.*, updating the halo) to be completely separated from computational kernels, greatly increasing the maintainability and expandability of the code base. HYCOM also allows parallelization via loop-level OpenMP directives, which is useful on smaller problems, and it supports dual level parallelization via both domain decomposition and OpenMP, which is potentially useful on machines consisting of a cluster of multi-processor nodes. The communication mechanism implementing domain decomposition can either be MPI or Cray's SHMEM library. For basin-scale applications, it is important to avoid calculations over land. HYCOM's predecessor, MICOM, was a pioneer in optimizations that avoid land. It fully "shrink wrapped" calculations on each tile and discarded tiles that were completely over land. HYCOM goes further than MICOM and most other OGCMs in land avoidance by allowing more than one neighboring tile to the north and south. Figure 2 illustrates a global tiling with equal sized tiles that a) allows rows to be offset from each other if this gives fewer tiles over the ocean and b) allows two tiles to be merged into one larger tile if less than

50% of their combined area is ocean. A conventional 4 neighbor equal sized tiling would use 471 MPI tasks out of 600 original tiles (30 by 20), but we only need 426 MPI tasks. More memory is required on some tiles and the communication overhead is slightly increased, but the 10% saving in MPI tasks is a significant optimization given the computer requirements of this application.

- NRL/ONR computer resources: The DoD HPCMP program (http://www.hpcmo.hpc.mil) provides computer resources to all DoD activities, and these are partitioned into Service (*e.g.,* Navy) allocated resources and DoD Challenge projects that are awarded competitively after peer review. We currently have a DoD Challenge project associated with our existing Atlantic ocean prediction system, and we will be submitting a proposal for a separate DoD Challenge project for FY04-FY06 associated with the delivery of global HYCOM to NAVOCEANO for operational testing at the end of FY06. Combining this DoD Challenge proposal with NRL and ONR allocated recourses, but excluding the existing DoD Challenge project, we expect to have the equivalent of about 700 dedicated 1.3GHz IBM Power4 processors in FY04 for this project with a growth rate of 1.5x to 1.7x per year. A large fraction of this computer time will be at the NAVOCEANO Major Shared Resource Center (http://www.navo.hpc.mil), which has a computer system in the top 10 world-wide. It is due for a large upgrade next year, but NAVOCEANO's current largest system is similar to that at NCEP: an IBM Regatta with 1,184 1.3GHz Power4 processors, 1 GB of memory per processor, and 14 TB of disk.
- NCEP/MMAB computer resources: The main computer resource available for this project at NOAA/NCEP is an IBM Regatta cluster with 1,408 1.3GHz Power4 processors, 1 GB of memory per processor, 42 TB Disk Storage, and 1250 TB Tape Storage. At NCEP, this cluster is split evenly between operations and development. The work under this proposal will be carried out with approximately 10% of the resources available for development, or the equivalent of about 70 dedicated processors.

The combination of NCEP/MMAB and NRL/ONR computer resources provides an unprecedented concentration of computer power on the global and basin-scale ocean predication problem. No other partnership in the US, and probably world-wide, can come close to this level of commitment. It is also being applied to an ocean model with an optimal design from both the standpoint of the vertical coordinate system and model physics and from the standpoint of computer scalability and efficiency.

d) Roadmap

This roadmap includes modeling, data assimilation, evaluation, boundary conditions for coastal models, data acquisition, management and quality control (QC), product serving and upgrades to all the preceding in accord with the rest of the proposal. The proposed effort also includes support from operational centers, wide-ranging collaborations, post-docs, and students.

i) *Basin-scale configurations*:

Improvements to the model and data assimilation of the present near real-time 1/12° HYCOM North Atlantic (~7 km mid-latitude resolution) nowcast/forecast prototype (NRL/Stennis, U. Miami, PSI) will be made during the project in years 1-4. The system will be updated daily and forecasts up to 30 days will be made once a week. Both the SEEK filter and ROIF data assimilation techniques will be evaluated on this configuration. Through the end of FY04, all of the non-NCEP-related Atlantic work will be performed under the existing NOPP/HYCOM project, except for (1) providing boundary conditions to coastal and regional models and (2) participating in the Atlantic prediction system intercomparison with the European MERSEA project. In year 4, there is an overlap with the global configuration in order to assess the global forecasting system in the Atlantic. Existing DoD High Performance (HPC) Challenge grant in years 1&2 and a non-challenge grant in years 3&4 at the NAVOCEANO Major Shared Resource Center (MSRC) will provide the necessary computer time (see section 2c for details).

The NCEP's configuration will become operational in 2005. NCEP will upgrade the present OI scheme to a multi-variate OI (MVOI) data assimilation scheme in collaboration with J. Cummings (NRL), C. Thacker (NOAA/AOML), and O.M. Smedstad (PSI) in years 1&2 before the transfer of NAFOS to operational status. Calibration of the forecasting system and upgrade of the data assimilation scheme to either SEEK or ROIF will take place in year 3. Calibration of the North Pacific model configuration will take place in year 4 and transfer to pre-operational status in year 5. Necessary computer time will be provided (see section 2c for details).

ii) Global configuration:

Development of the global HYCOM prediction system will take place in years 1-3 (collaboration between NRL-Stennis, Miami, and PSI). This includes model development, data assimilation, ice model embedment, and hindcast demonstrations (typically starting from December 2000 when data from at least 3 altimeters first became available). The model will be fully global with the Los Alamos CICE ice model embedded and will run at three resolutions: ~60 km, ~20 km and ~7 km at mid-latitudes. Through the end of FY04, work using HYCOM at 60

km resolution will be performed under the existing NOPP/HYCOM project. The ~60 km grid will be used as a test bed. After developmental testing and climatological simulations, the model will then be run interannually in free-running mode and with ocean data assimilation at 20 km and 7 km resolution (FNMOC and NAVO requirements, respectively). Using 7 km resolution, at least one free-running simulation would start in 1990, and one data-assimilative model run would start in late 1992 when continuous satellite altimeter data first became available. The latter would provide a high resolution reanalysis of ocean data that would be used for evaluation, ocean research, and operational applications. Tests of forecast skill up to 30 days will be performed at both the 20 km and 7 km resolution. The free-running simulations will also be used for ocean model performance evaluation, to provide simulated data, to help diagnose possible problems in the data assimilation runs, and to assess the impact of data assimilation.

In year 4, the hindcast runs will become real-time and real-time nowcast/forecast demonstrations (forecasts up to 30-days) will be started at the resolutions planned for the FY06 transitions to FNMOC (20 km) and NAVOCEANO (7 km). The transition to FNMOC will be the ocean component of the coupled ocean-atmosphere prediction model. In year 5, the systems at FNMOC and NAVOCEANO will undergo operational testing and, once approved, would become operational products. In accord with the GODAE implementation plan, the HYCOM NOPP/GODAE project will use this year as a follow through/consolidation phase where improvements to the system would be made and transitioned to the operational centers based on assessments and lessons learned. As stated in section 2b, some of the more expensive data assimilation techniques, while impractical over a high resolution global domain, can be used in subregions of the global model domain where there is special interest or where they provide particular value added. This concept will be developed and tested throughout the project and added to the operational global system during year 5.

As explained in section 2c, a large multi-year grant of DoD High Performance Computing (HPC) Challenge time will be required for the global HYCOM effort with 7 km resolution. A 3-year proposal covering FY04-FY06 is being submitted concurrent with this proposal. An existing HPC Challenge grant covers the Atlantic effort at 7 km resolution. Members of the partnership have an excellent track record of obtaining such HPC grants and they have had them every year since these grants began in FY97. Other existing and planned partnering projects will assist in transitions to operational centers or will focus on coastal model efforts that receive boundary conditions via this project, coupling HYCOM to atmospheric models for coupled ocean-atmosphere prediction, oceanic research using results from this project, or related HYCOM modeling and evaluation, model development, data assimilation techniques development, and coupling to biochemical models. In addition there is potential for a project to put HYCOM into the Weather Research Framework (WRF) and the Earth System Modeling Framework (ESMF) that would facilitate linking HYCOM to other models, model components, and applications (further expanding opportunities for HYCOM collaborations and applications). Development of this framework is led by the National Center for Atmospheric Research (NCAR) and subscribed to by many researchers and multiple agencies, including NOAA and the U.S. Navy.

e) Product Evaluation

Evaluation of the products will rely on systematic verification of key parameters and computation of statistical indexes by reference to both climatological and real time data, and, in a delayed mode, to quality controlled observations. The scientific credibility will rely on careful checks of the consistency of the system outputs with state-of-the-art knowledge of the ocean state and its variability. The performance of the systems will rely on diagnostics based on key indicators such as estimates of forecasting skill, ability to constrain a sparsely observed field or non-assimilated field, and evaluation of real time versus reanalysis products. Diagnostics on free mode runs are of major interest for evaluating the strengths and weaknesses of the model configurations. Diagnostics on the assimilated products will also be used to evaluate the added value of the data assimilation process.

The accuracy of data assimilative model products is theoretically a non-decreasing function of the amount of data that is assimilated. A degradation caused by assimilation generally indicates inaccurate assumptions in the assimilation scheme. While models can be forced to agree with observations (*e.g.*, by replacing equivalent model fields with data), improvements with respect to independent observations are not trivial. An assessment of model improvement (or lack of degradation) with respect to non-assimilated, independent measurements is therefore an effective means of assessing the performance of an assimilation system. Variances of these model-data differences serve as common measures of the estimation accuracy. Following the metrics outlined below, non-

assimilative, free-running simulations can be used as the relative measure of improvement by data assimilation and of data assimilation success.

For the evaluation of flow accuracy and water mass characteristics, we will follow the guidelines put forward by the international GODAE metrics group (of which both E. Chassignet and H. Hurlburt are members) as well as the validation tests commonly used at the operational centers before official transition to operational use. W. Schmitz (Woods Hole Oceanographic Institution, Scientist Emeritus, presently affiliated with USM) will bring an observationalist's view to the Partnership and one of his roles will be to keep the modelers "honest"☺. Space precludes us from going into details, and the following is only a brief outline of what will be used for the validation. Note that it includes both research quality comparisons with independent data as well as direct comparisons with other GODAE models.

Large-scale circulation features: These tests will evaluate whether the global and basin-scale models correctly place the large-scale features of ocean circulation, such as gyres, strong fronts, and currents [Example at http://hycom.rsmas.miami.edu/ocean_prediction: *i.e.,* evaluation of the mean (specific day) path of the Gulf Stream and Loop Current compared with the mean (specific day) frontal position from AVHRR data].

Eddy kinetic energy/SSH variability: These tests will evaluate whether the models have a realistic level and distribution of energy (mean and variability) at depths where observations are available.

Current cross sections: These tests will evaluate model velocity cross-sections through qualitative and quantitative comparisons of biases when data are available.

Comparison with drifting buoys: These tests will evaluate the models' ability to produce ocean currents that yield drifter and ARGO floats trajectories similar to observations.

Sea Surface Temperature (analysis, forecast): These tests will evaluate whether the models are producing acceptable nowcasts and forecasts of sea surface temperature. We will also investigate whether using the model as a first guess for SST analysis provides value added over assimilating a model independent SST analysis. Feedbacks will be provided to the GODAE-sponsored High Resolution SST Project (GHRSST).

Sea Surface Height (analysis, forecast): We will assess the models' ability to represent observed sea surface heights. Comparisons will be made to a database of observed de-tided global sea level time series at various coastal and island stations.

Mixed Layer Depth (MLD} (analysis, forecast, free running model): Model analyses, forecasts, and simulations will be compared to mixed layer depths from profile data (e.g. XBTs, ARGO floats, CTDs, and moored buoys) and to an MLD climatology (http://www7320.nrlssc.navy.mil/nmld/nmld.html).

Vertical profiles, time series of profiles and vertical cross sections (analysis, forecast): Quantitative comparison of model temperature and salinity vs. unassimilated profile data from XBTs, CTDs, and ARGO floats, cross-sections of XBTs and CTDs, and time series from moored buoys.

Event comparisons: These tests qualitatively evaluate model analyses against alternate, unassimilated observations of flow features in regions of interest. A classical example is the impact of hurricanes on the ocean circulation (Zamudio et al. 2002). Comparisons of surface height and temperature with ocean color imagery can at times provide clear and dramatic qualitative model assessment.

f) Boundary Conditions for Coastal/Regional Models

Global HYCOM will at least marginally resolve the global coastal ocean [7 km at mid-latitudes, with 15 terrain-following (sigma) coordinates over the shelf], and is therefore an excellent starting point for even higher resolution coastal ocean prediction systems. To increase the predictability of coastal regimes, several partners will develop and evaluate boundary conditions for coastal prediction models using the global and basin HYCOM real-time prediction system outputs. These partners have (or will have) real-time operational coastal nowcast and forecast systems in place during FY03-08 [*i.e.*, COAMPS™ (FNMOC, M. Clancy; NRL, R. Hodur), MMAP (NOAA/NOS, F. Aikman), northeastern U.S. (Rutgers, J. Wilkin), southeastern U.S. (UNC, C. Werner), Gulf of Mexico (USF, R. Weisberg; NRL, P. Hogan, G. Jacobs, C.A. Blain), western U.S. (NRL, J. Kindle, P. Hogan; Rutgers, D. Haidvogel), and worldwide (Ocean Numerics, D. Szabo, G. Evensen)]. These systems include nesting of HYCOM in HYCOM (Ocean Numerics, NRL), fixed vertical coordinate models in HYCOM (NRL, Rutgers), and unstructured grid/finite elements models in HYCOM (UNC, NRL). The vertical coordinate of the various coastal and regional systems will typically be different from HYCOM's hybrid coordinate. We have already demonstrated that a 26-hybrid layer HYCOM basin-scale model can provide boundary conditions to two 40-level sigma-z coastal models (using NCOM and HYCOM, respectively, as the coastal component); see http://hycom.rsmas.miami.edu for details. Since alpha tests of nesting in the first two categories have already been performed and HYCOM Atlantic and Pacific basin simulations with ~7 km mid-latitude resolution already exist, nesting efforts will begin during the first year of the project. Other groups will use the HYCOM prediction system

output in value-added environmental products with a customer base and will participate in evaluating the system's performance (Horizon Marine Inc., J. Feeney, S. Anderson; Shell Oil Company, M. Vogel; ExxonMobil, O. Esenkov; ROFFS, M. Roffer; Orbimage, L. Stathoplos). For specifics on the tasks to be performed by each partner, the reader is referred to section 5.

g) International Links and Collaborations

Within GODAE, there is agreement to use the Atlantic Ocean as a prototype domain and pilot project for an inter-comparison of different ocean prediction systems, including tests and evaluation of the inter-comparison process. The Atlantic was chosen because of the developmental status of the required components of an ocean forecasting system: already well instrumented, large number of available models, high user interest. A pilot project has been initiated (INTERCAST) between the British FOAM and the French MERCATOR forecasting systems and will be complemented by a new initiative, MERSEA (Marine EnviRonment and Security for the European Area), funded by the European Community, in a wider context including assessments not only of the operational model systems, but also of the operational observation network, and demonstration of different system applications from user perspectives. The HYCOM Consortium has agreed to join the exercise (see GODAE Implementation Plan). The exercise will consist of comparing similar diagnostics and fields from corresponding realizations of each system. The main characteristics of this inter-comparison exercise are the following.: a) integrations of the models will be performed and assessed chiefly with assimilation of observational data; b) at least one integration will be performed by each group in which a similar subset of observations (namely, satellite altimetry) are assimilated, and c) a core set of diagnostics has been agreed upon by the project teams, following an initial recommendation by Le Provost et al. (2002). The intercomparison exercise will cover (i) analyses (hindcasts) and (ii) 7- and 14-day-range forecasts with analyzed or forecast atmospheric forcings.

3) DATA AND MODEL OUTPUT MANAGEMENT

a) Real-time Data Access

Daily wind and thermal forcing for our prototype HYCOM Atlantic prediction system is presently provided by the Navy NOGAPS model, available from NAVOCEANO and the U.S. GODAE data server in Monterey. The HYCOM prediction system uses NOGAPS surface wind stress, air temperature, specific humidity (from dewpoint temperature and sea level pressure), short wave and long wave radiation. Surface heat flux is calculated via a bulk parameterization from NOGAPS fields and model SST. Real time satellite altimeter data is provided via the Altimeter Data Fusion Center (ADFC) at NAVOCEANO. Currently data from Geosat-Follow-On (GFO), ERS-2 and Jason-1 are available. Daily MCSST data are also available – globally at 8.8 km resolution and at 2 km in selected regions. The SSH ($1/4^{\circ}$) and SST ($1/8^{\circ}$) analysis from the operational Modular Ocean Data Assimilation System (MODAS) are also available.

Much of the preceding data are also available from the U.S. GODAE server. This server, which will be in operation for the duration of the GODAE demonstration period (2003-2007), provides several additional real-time data types. The U.S. GODAE Argo Global Data Assembly Center (GDAC) is currently operational, serving daily data (updated hourly) from the Argo DACs in the US (AOML), Canada (MEDS), and Japan (JMA). Observations from ships, fixed and drifting buoys, BT, and Argo floats are also available – received primarily via the Global Telecommunication System (GTS) and posted twice daily. Other data such as QuikScat winds, etc., are acquired by the NCEP/MMAB group. Under this Partnership, the Live Access Server (LAS) will be used to seamlessly blend selected data offerings from NCEP, NAVOCEANO, and the US GODAE server.

One area where feedbacks between the HYCOM ocean prediction system development and data providers are likely to benefit both groups is the generation of global high resolution SSTs by combining infrared and microwave measurements. Support will be provided to the RSMAS Remote Sensing Group at the University of Miami (P. Minnett, R. Evans) as part of this Partnership to ensure a) provision of high resolution MODIS SST, b) close collaboration with the GODAE-sponsored High Resolution SST Project (GHRSST), c) close collaboration with D. May (NAVOCEANO) on satellite SST data processing and with J. Cummings (NRL) on SST analysis, and d) an effective feedback process. The RSMAS Remote Sensing Group will provide in near real-time (less than one day) MODIS SST data as well as merged infrared and microwave data to provide complete global SST fields. The close collaboration between the modeling and remote sensing groups offers potential benefit to the remote sensing research on data fusion, as the model output SST fields may themselves provide the information and guidance necessary to optimize the data merging algorithms. This is of particular concern in regions of large temporal and spatial variability.

b) Model Outputs

The real-time global and basin model outputs will be made available to the community at large within 24 hours via the U.S GODAE and Miami Live Access Servers (LAS). Software development and integration of the server system will be performed by the NOAA/PMEL group (S. Hankin) in collaboration with those in charge of the U.S. GODAE and Miami servers. Collaboration with the OPeNDAP (formerly named DODS) group (URI, P. Cornillon) will ensure that the remote data sets and model outputs are accessible in real time, despite their size. OPeNDAP is vital in this regard when dealing with huge data sets (e.g., 7 km grid global 3D), because of its built-in ability to perform subsetting. Only the subset of data required for the user-requested product in his/her selected region need be sent over the network (*e.g.*, Gulf of Mexico SST on a particular date).

Enhancements to the LAS will made to a) generalize its support for curvilinear horizontal and hybrid vertical coordinates, b) support model-data and model-model comparison on the Web; c) provide HYCOM subsets to coastal or regional nowcast/forecast partners as boundary conditions, d) create a global GODAE community data presence on the Web, and e) increase the usability of HYCOM results by "application providers" (see sections 3 and 4b).

Typically storage of data will be on "native" (curvilinear) grids and interpolation to regular grids will occur on-the-fly. The LAS architecture supports custom code modules (per dataset), so the interpolation may be performed by optimized, numerically precise algorithms that are tailored to the numerics of HYCOM. The LAS server hosted at Monterey will make these data available through an interface that shares a common look and feel both for gridded outputs and for observations. LAS "sister server" capabilities will be extended so that HYCOM model output from the LAS in Miami is integrated with observations from the U.S. GODAE server in a single virtual server from the data user's point of view. The fused GODAE server/HYCOM server will include the ability to perform on-the-fly model-data comparisons. Two modes of model-data comparison will be implemented: 1) by sampling (point-wise interpolating) of the gridded field and 2) (for dense fields of observations) by on-the-fly gridding of observations. For certain desktop analysis applications LAS will also provide on-the-fly scripts that permit a scientist to smoothly go from the browsing data in LAS to more detailed analysis with selected desktop tools (*e.g.*, IDL, Ferret, GrADS). OPeNDAP will provide binary data access.

The LAS group (S. Hankin) will provide guidance as needed to the group(s) responsible for the management of the HYCOM outputs (*i.e.*, NRL, NAVOCEANO, NOAA/NCEP) in the implementation of browse-friendly management/archival strategies. For example, 5D data management (X/Y/Z/calendar-time/forecast time, where the 5th axis of forecast time refers to 0z, 6z, 12z ...) would enhance our ability to perform fast region-by-region evaluation of forecast skill. LAS and OPeNDAP can also deliver HYCOM real-time model results to coastal and regional modeling sites through a format-neutral strategy. Sites can set up batch jobs to automatically download HYCOM subsets in a choice of formats (e.g. netCDF, binary, etc.) immediately prior to initiating a model run. The LAS group will evaluate the incorporation of HYCOM model diagnostics code into LAS as custom "back-end" applications. This capability would expose the physics of HYCOM model runs in great detail, facilitating an unprecedented community-based analysis of the model's performance.

Using a combination of LAS "sister server" capabilities and OPeNDAP (with this choice depending upon the resources of the individual partners), a virtual LAS server presence will be created in which Partner modeling activities are presented through a single uniform LAS interface. Models can be compared one to another as a) graphical overlays, b) side-by-side graphics, and c) difference fields computed by regridding to a common grid. This will allow for comparisons with the international sites that are already planning (or considering) using LAS solutions in UK, France, Italy, and Norway. Such a (comprehensive) virtual site could be the uniform portal into the data contents of the entire International GODAE project. The LAS group in partnership with the U.S. GODAE Server would support and maintain this server.

4) EDUCATION AND OUTREACH

a) Education

Most of the partners will sponsor graduate students and post-docs during this project. For example, <u>all</u> of the funding requested by universities for the evaluation of boundary conditions in coastal prediction models, using the global and basin HYCOM real-time prediction system outputs, is earmarked for the support of graduate students and post-docs. For example, one or two students will be admitted in the Rutgers' newly established Master's in Operational Oceanography program. New courses have been added to the traditional Master's of Science program that are specifically aimed at training engineers and scientists to operate and interpret the expanding suite of

coastal ocean observing systems. It will include a coastal ocean modeling component aimed at training students to formulate, run, and interpret coastal ocean circulation models of the form that will comprise operational and research systems with applications in weather prediction, environmental quality, fisheries and ecosystem management, and homeland security. Travel funds have been specifically allocated for the students' and post-docs' participation in the twice a year meetings of the Partnership (in addition to travel funds for their participation in national and international meetings).

b) Outreach

As stated in section 3b, we will make our operational system outputs available to our partners and the community at large through the HYCOM web site via LAS. In support of "application providers", the outputs of both HYCOM and the coastal nowcast/forecast partners of this proposal have significant potential to improve the oil spill trajectory models used by NOAA/HAZMAT. These data will be ready for delivery to the HAZMAT trajectory model via LAS, a data management connection that has been previously prototyped; a further proposal is pending. The LAS (with a tailored user interface) can also be used as a tool for a) delivery of data to recreational users (*e.g.*, surfers), b) delivery of data to commercial users (*e.g.*, fishermen), c) search and rescue, and d) ecosystem management (harmful algal blooms). Interest in real-time global ocean products is high. During 2002, the NRL Oceanography Division experienced over 10 million web page hits, mostly to real-time ocean products developed at NRL, including web pages on satellite altimeter data, model independent analyses of SSH from satellite altimetry, SST from satellite MCSST, and two global ocean prediction models that assimilate satellite altimeter data and SST and use atmospheric forcing from FNMOC. Applications reported by the users include many never envisioned by the developers (Smedstad et al., 2003).

The LAS outputs will also be displayed for comparison and education purposes via the Miami-based educational site for ocean currents. This web site, http://oceancurrents.rsmas.miami.edu, provides the scientific, educational, and research community with an up-to-date collection of what is known about all ocean/coastal currents. We expect the HYCOM outputs integrated with observations and regional nowcast/forecasts to be an excellent resource in this regard. LAS have been used with high success as an educational tool in undergraduate classes. Rutgers University makes their operational systems available through the web site http://marine.rutgers.edu/mrs/ and also in a format aimed at mariners and the New Jersey Coastal Community at http://www.thecoolroom.org/. At the K-12 level, Rutgers developed the COOL Classroom at http://www.coolclassroom.org/, which includes the use of observational systems to demonstrate concepts in environmental observation and prediction. Rutgers also trains educators through the Jacques Cousteau National Estuarine Research Reserve Coastal Education Center http://marine.rutgers.edu/pt/education/education.htm.

5) COORDINATION, TIME TABLES, RESEARCH TASKS, AND TEAM QUALIFICATIONS

The success of such a partnership strongly depends upon the degree of commitment and communication among the partners. From the experience acquired in the HYCOM NOPP Consortium funded in 1999, two meetings per year are optimal in keeping the partners on track and in fostering communication and collaboration. The first yearly meeting includes all the partners and generates the following year's implementation plan. The second yearly meeting is usually held in conjunction with a national meeting (such as the Layered Ocean Model meeting) ~6 months later to evaluate our progress and to correct, if necessary, some of the steps taken to implement the strategy established in the previous meeting. These meetings are open to the community at large. Furthermore, it is our intent to organize in the fourth year an international users meeting that will focus on the performance of the global HYCOM-based prediction system. A bulletin board will be established on the Partnership web site to foster exchanges and receive feedback from users of the ocean prediction systems.

a) The University of Miami/RSMAS (E. Chassignet, G. Halliwell, M. Iskandarani, T. Chin, A. Mariano, D. Bi, Z. Garraffo, A. Srinivasan, P. Minnet, R. Evans) will participate in the area of ocean modeling (E. Chassignet, also overall coordinator and member of the U.S. and International GODAE Steering Teams; G. Halliwell), data assimilation (T. Chin, A. Mariano), remote sensing (R. Evans, P. Minnett), numerics (M. Iskandarani), ice modeling (D. Bi), analysis (Z. Garraffo), and outreach (A. Mariano). This team has been working together for over a decade on ocean modeling, SST remote sensing, data assimilation, oceanic predictability, and the study of ocean dynamics and variability from both Eulerian and Lagrangian viewpoints. This includes extensive experience in developing and using MICOM and HYCOM. Under the existing HYCOM NOPP project, members of the group partnered with LANL (R. Bleck) and NRL (A. Wallcraft) in the development of HYCOM from MICOM. MICOM was developed at the U. of Miami in the early 1980s. The U. of

Miami/RSMAS modeling team will work closely with NRL Stennis and NOAA/NCEP/MMAB to configure the HYCOM operational prediction systems. T Chin and A. Mariano will work closely with the other data assimilators and with Planning Systems Inc. (PSI) to ensure a smooth transition of the ROIF data assimilation method.

b) NRL/Stennis (H. Hurlburt, A. Wallcraft, J. Metzger, B. Kara, J. Cummings, G. Jacobs, H. Ngodock, L. Parent, C.A. Blain, P. Hogan, J. Kindle) will participate in the areas of modeling (Hurlburt, Wallcraft, Metzger, and Kara), data assimilation (Cummings, Jacobs, Ngodock and Parent), boundary condition for coastal models (Blain, HYCOM to the ADCIRC finite element model; Hogan, HYCOM to HYCOM; Kindle, HYCOM to NCOM which has hybrid z-level/terrain-following coordinates), data QC (Cummings), and satellite altimeter data (Jacobs). H. Hurlburt is the coordinator of the NRL/Stennis effort. He and J. Cummings are members of the U.S. and International GODAE Steering Teams and J. Cummings is the U.S. GODAE co-chair. Under the existing HYCOM NOPP project, NRL collaborated with U. Miami and Los Alamos National Laboratory in the development of HYCOM from MICOM and A. Wallcraft is, and will continue to be, in charge of developing and maintaining the standard version of HYCOM. A. Wallcraft will put HYCOM into the WRF framework, assuming the required partnering project is funded. NRL will collaborate with U. Miami and Planning Systems Inc. in the actual development of global HYCOM ocean prediction systems for transition to FNMOC and NAVOCEANO. This will include essential contributions from other participants and collaborators. The NRL/Stennis commitment to global ocean prediction and related research extends back to the early 1980s (Hurlburt, 1984), but realization of that goal required an adequate real-time database and sufficient computing power at a Navy operational center. The NRL/Stennis group transitioned the world's first eddy-resolving global ocean prediction system to NAVOCEANO in October 2000 and it became an operational system in September 2001. It is a first generation system that used the NRL Layered Ocean Model (NLOM). The NRL/Stennis group also played a key role in developing the real-time altimeter data capability at NAVOCEANO. It will contribute approximately half of the DoD computer resources for the global models with the rest primarily from an NRL-sponsored DoD Challenge project.

c) NAVOCEANO (E. Johnson, J. Harding) is the operational center that will run the eddy-resolving 1/12° global HYCOM prediction system as an operational product (see attached letter of support).

d) FNMOC (M. Clancy) will run HYCOM as the ocean component of an operational coupled global ocean-atmosphere prediction system (see attached letter of support).

e) NRL/Monterey (R. Hodur, M. Flatau, X. Hong, J. Pullen) will use the HYCOM-based global ocean data assimilation system developed in this project to help in the transition of a global coupled air-ocean data assimilation system to FNMOC and for initial and lateral boundary conditions in the ocean model used within the Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS™; Hodur, 1997). Currently, NRL/Monterey is working toward the development of a global air-ocean coupled system using the Navy Operational Global Atmospheric Prediction System (NOGAPS) and the Parallel Ocean Prediction model (POP), and toward the transition of this system to the Fleet Numerical Meteorology and Oceanography Center (FNMOC). Within this project, NRL/Monterey will adapt HYCOM as their ocean model. They will leverage existing and planned projects that address atmospheric model forcing (e.g., surface fluxes, radiation) and data assimilation, and they will evaluate the improved capabilities of HYCOM using these improved surface forcing fields and data assimilation techniques in this project.

f) NOAA/NCEP/MMAB (D.B. Rao, C. Lozano) will participate in the area of modeling, data assimilation, and boundary conditions for coastal models. MMAB is responsible for the development of improved numerical marine modeling prediction and analysis systems within the National Weather Service (NWS).and will transition to operation in 2005 a HYCOM eddy-resolving North Atlantic basin-wide forecast system. They will also evaluate a Pacific Ocean Forecast System in years 4-5. Before moving to NCEP, C. Lozano has been for 13 years the senior scientist responsible for the regional Harvard Ocean Prediction System (HOPS) and has therefore extensive experience in operational oceanography. C. Lozano will contribute to the development and implementation of the MVOI in collaboration with J. Cummings, NRL; C. Thacker, NOAA/AOML; and O.M. Smedsatd, PSI. D.B. Rao has been leading MMAB for over a decade and was a leading partner in a very successful NOPP effort that led to the transition of the Coastal Ocean Forecasting System (COFS) to operation.

g) NOAA/NWS/Ocean Prediction Center (J. Sienkiewicz). The NOAA/NWS Ocean Prediction Center (OPC) is an operational forecast center responsible for issuing warnings and forecasts of environmental

conditions for Offshore and High Seas areas of the North Atlantic and North Pacific Oceans. OPC customers include: merchant vessels on trans-oceanic and coastwise routes, the cruise ship industry, government vessels involved in law enforcement and search and rescue (U.S. Coast Guard) and research (NOAA), fishing vessels, sailing vessels on coastwise and blue water voyages, tugboat and barges transporting bulk cargoes, and the oil exploration and drilling industry. In addition to the primary warning and forecast function, the OPC is considered the office of expertise in marine weather for the NWS and daily serves in an advisory and coordination role for NWS Forecast Offices with Coastal Waters responsibility. The role of OPC in this partnership is fourfold. The OPC will refine present ocean feature observing techniques, evaluate HYCOM output, develop HYCOM based value added products, and educate NWS forecasters and OPC customers on the use of such products. During the proposed project, the OPC will act as focal point for the evaluation process for the National Weather Service (NWS) (see attached letter of support).

h) NOAA/NWS/TPC (M. Mayfield) - see attached letter of support

i) NOAA/AOML (C. Thacker, D. Hansen). The Atlantic Oceanographic and Meteorological Laboratory (AOML) is one of the Environmental Laboratories of the National Oceanic and Atmospheric Administration (NOAA). C. Thacker has over 15 years of experience with data assimilation methodologies and will collaborate actively with J. Cummings (NRL) and the ROIF development team. Specifically, C. Thacker will a) continue to develop and improve the capability to assimilate profile data into HYCOM and expand it to deal with satellite observations in a synergistic way, b) prepare capability for accurately estimating covariability of oceanic fields so that XBT data will provide better information about salinity and density and so that geopotential height will provide better information about subsurface behavior, and c) perform detailed model-data comparison to determine how the model might be improved, and to monitor the skill of the real time and operational forecasts and the assimilation system.

j) Consolidated NOAA/PMEL (S. Hankin), FNMOC (M. Clancy), and OPeNDAP (P. Cornillon). Working in close cooperation NOAA/PMEL (S. Hankin), OPeNDAP (P.Cornillon) and the U.S. GODAE server (M.Clancy), will build and manage a seamless data sharing framework for this Partnership. The framework will include Miami, FNMOC, NAVOCEANO, NCEP, regional and coastal nowcast/forecast partners, and international GODAE partners. It will embrace observations, model outputs, and reference data products. It will be managed in a 24/7 operational mode to the degree possible for a distributed system. It will provide access to data subsets and products from standard Web browsers using LAS; from several desktop applications utilizing OPeNDAP; and from batch scripts (to obtain real time forcing fields for coastal models); as well as from traditional FTP sites. The Web interface will support data browsing in 4 dimensions, model-model and model-data comparison tools, and standardized GODAE comparison metrics. It will be accessible to the general public, including commercial product developers. The framework will utilize the data management standards and protocols of the U.S. Integrated Ocean Observing System.

k) Planning Systems Inc. (O.M. Smedstad, B. Lunde) will be responsible for hindcast and pre-operational real-time runs of HYCOM systems destined for FNMOC and NAVOCEANO. This will include running and updating the public web page that has been developed, *i.e.* http://hycom.rsmas.miami.edu/ocean_prediction.html. PSI will also work on the implementation and testing of assimilation techniques in HYCOM. This includes improvements to the present prototype assimilation technique in collaboration with R. Baraille at SHOM, the implementation of a) the MVOI (in collaboration with J. Cummings, NRL; C. Lozano, NOAA/NCEP; C. Thacker, NOAA/AOML), b) the SEEK filter (in collaboration with P. Brasseur, LEGI; H. Ngodock, NRL; L. Parent, NRL), and the Reduced Order Information Filter (ROIF) (in coordination with T. Chin and A. Mariano, U. of Miami; C. Thacker, NOAA/AOML). PSI will also work closely with scientists at NRL and the U. of Miami/RSMAS to make sure the latest upgrades to the model is implemented in the real-time system. PSI played a crucial role in the implementation and transition of NAVOCEANO 's existing operational 1/16° NLOM-based ocean prediction system (http://www.ocean.nrlssc.navy.mil/global_nlom).

l) Los Alamos National Laboratory (R. Bleck). The Los Alamos National Laboratory is host to a group of geophysical fluid dynamics modelers whose principal mission has been the development and validation of massively parallel ocean and sea-ice models. R. Bleck has played a leading role in the development of MICOM and HYCOM (when at the U. of Miami and LANL) and will continue to work on refining HYCOM and will provide assistance in evaluating the global HYCOM configuration.

m) LEGI (P. Brasseur) has been involved in data assimilation research for about 10 years, covering theoretical, methodological, and oceanographic objectives. A suite of prototype assimilative systems based on SEEK and North Atlantic ocean circulation models (HYCOM and other models) have been developed by LEGI as part of the European DIADEM, TOPAZ and MERCATOR projects. The LEGI is also strongly involved at the research level in the building of MERSEA (Marine EnviRonment and Security for the European Area), which has objectives very similar to this proposal. Further developments of the SEEK will be carried out in collaboration with NRL/Stennis, NOAA/AOML, and Planning System Inc. (PSI) to improve a) our capacity to assimilate observations from various sources simultaneously: *i.e.,* along-track altimeter data, AVHRR SST swath data, climatological or SMOS-like sea-surface salinity data, in situ profiles (from ARGO and other field experiments), b) the design of hybrid error sub-spaces, combining large-scale error modes associated with the equatorial regimes with local error modes associated with the mid-latitude mesoscale, and c) the computation of corrected atmospheric forcing fields consistently with the assimilated SST and SSS data, in addition to model state corrections. Finally, a computer tool (SESAM) has been developed to interface the generic SEEK algorithm with HYCOM and other ocean models. The code is easily portable on a variety of UNIX platforms where a Fortran 90 compiler and the NetCDF library are available, and it will be made available to the HYCOM partnership. The code will be maintained and documented for distribution to research and operational users within the project.

n) SHOM (R. Baraille). R. Baraille has been an active HYCOM collaborator since its inception and put in place the OI technique with Cooper and Haines (1996) for downward projection of SSH from altimetry that is presently used in the HYCOM prototypes (1/3° maintained by the SHOM/CMO and 1/12° maintained by PSI, see http://hycom.rsmas.miami.edu/ocean_prediction.html). In collaboration with H. Ngodock and G. Jacobs (NRL), R. Baraille will complete the writing of the HYCOM adjoint model. This will allow the further development of the ROAF data assimilation technique which estimates unknown parameters via the adjoint by minimizing the forecast errors.

o) University of South Mississippi (W. Schmitz). HYCOM results will be compared with the observational database, much as has been done in several of past publications by W. Schmitz, *e.g.* Schmitz (1996) summary reports. The results of these intercomparisons will lead to suggestions concerning which characteristics of the numerical experiments need more attention (or not) and an identification of possible problem areas in parameter space. The comparisons will be coordinated with other project activities, including forecast evaluation.

p) University of North Carolina (C. Werner). The UNC-CH modeling group is implementing operational systems for site-specific, limited-area forecasting of the coastal ocean circulation along the South Atlantic Bight (SAB) using the finite element model ADCIRC. The SAB shelf circulation is driven by nearshore buoyancy (freshwater) discharge and winds, and is strongly influenced by the Gulf Stream along the outer shelf region. Therefore, boundary conditions from an Atlantic or global ocean model are essential and we plan to use HYCOM model output for that purpose. The result will be improved ability to describe the SAB shelf circulation, including the along- and cross- shelf transport, information which is needed in defining Marine Protected Areas. Through SEACOOS (http://www.seacoos.org), we have a formal relationship with the U. of South Florida, a partner in this proposal. Through SABSOON (http://www.ncsc.org/nopp/sablam), we have worked with the U of Miami on the study of forcing our shelf-scale models with basin-scale MICOM and HYCOM results (http://www.opnml.unc.edu/Projects/SABSOON/HTML/sabsoon.html). Efforts of Rutgers University and those of UNC-CH are complementary through common goals of US GLOBEC projects which have embedded lower and higher trophic models in shelf circulation models. NCEP meteorological products are used in our SABLAM and SEACOOS efforts.

q) Rutgers University (J. Wilkin, D. Haidvogel). The Rutgers University Ocean Modeling Group is engaged in several high resolution coastal modeling projects on the U.S. east and west coast. For the east coast, they include (i) Hindcasting New Jersey coastal upwelling and associated in-water optical properties with a coupled physical-ecosystem model (part of the ONR HyCODE program), (ii) air-sea heat and momentum transfer and boundary layer dynamics on the southern New England shelf (ONR CBLAST), (iii) transport of nutrients and contaminants in the Hudson River plume (NSF CoOP). On the U.S. west coast, the Rutgers Modeling Group, together with its partners in the US GLOBEC Program, has been developing a multi-scale coupled circulation/ecosystem modeling system for the Northeast Pacific Ocean. System components include a nested suite of circulation models (eventually, both atmosphere and ocean), an oceanic food web model, and individual-based models for important species (e.g., zooplankton and salmon). Direct assimilation of datasets within the physical and biological sub-models is planned. These studies employ the Regional Ocean Modeling System

(ROMS), a terrain-following coordinates ocean model with high-order numerics, generalized ocean turbulence closure model, sediment transport module, and ecosystem and bio-optical modules. Under separate funding from NSF (via NCSA), the ROMS circulation model is presently being coupled to the WRF mesoscale atmospheric model. Adjoint and tangent-linear codes exist for ROMS, and these underpin on-going development of variational assimilation methods. The Rutgers modeling group anticipates that boundary conditions from the global and basin-scale HYCOM prediction systems will provide significant improvement in hindcast skill in their coastal models. For example, these boundary conditions will provide information on ocean currents, mesoscale variability, and remotely-forced coastal trapped waves. They are also important in preconditioning seasonal to interannual variability in the water masses of the Gulf of Maine and Mid-Atlantic Bight, and thereby influencing the ecosystem in shelf waters.

r) University of South Florida (R. Weisberg). A USF program of observations and models is in place on the West Florida Shelf (WFS). Measurements began in 1993 and peaked during 1998-2001, when up to 13 moorings were deployed along with monthly hydrographic cruises. Observations continue as part of the Coastal Ocean Monitoring and Prediction System (COMPS) and the Southeast Atlantic Coastal Ocean Observing System (SEACOOS), and these will be expanded as part of a nationwide observing system. Real time elements of the data ranging from current profiles to full air-sea interaction variables are reporting at http://comps.marine.usf.edu and directly to NCEP through NDBC. Models parallel the observations. We use the Princeton Ocean Model for hindcasts and nowcast/forecasts. As a hindcast example (quantitatively gauged against *in-situ* data), Weisberg and He (2003) discuss local and deep-ocean forcing effects on anomalous conditions observed in 1998. Local forcing is primary, but under certain conditions the Loop Current can affect WFS properties by: 1) setting isopleth heights along the shelf-slope, facilitating upwelling across the shelf-break by local forcing, and 2) setting shelf currents in motion by contacting the shelf-break where the isobaths converge west of the Dry Tortugas. Once materials broach the shelf-break the conduit to the near-shore is the bottom Ekman layer. Walsh et al. (2003) use these results to model the primary productivity response to advected nutrients and light. He and Weisberg (2002a,b, and 2003) are other hindcast examples for the spring and fall transitions and tides. Our nowcasts/forecasts use Eta model winds, plus tides and are barotropic, awaiting better surface heat flux information through the use of satellite SST composites. Also, we are using a Finite Volume Model (C. Chen, per. comm.) for higher resolution near-shore to link the estuaries with the shelf, and we are implementing the ROMS code (H. Arango, per. comm.). Our coordinated data/model experience points out the needs for improved open boundary conditions, data assimilation, and improved surface forcing. With "warm up exercises" performed, we are poised to engage in these activities.

s) Fugro-GEOS/Ocean Numerics (D. Szabo, G.Evensen) provides a wide range of metocean services to the offshore oil and gas industry on a worldwide basis. Services requiring numerical ocean modeling both in hindcast and forecast modes are supported through a subsidiary company, Ocean Numerics. Ocean Numerics will establish a number of regional forecast systems in active deepwater oil and gas exploration and production areas such as West Africa, Southeast Brazil, north coast of South America including Brazil and Trinidad, Gulf of Mexico, North East Atlantic, South China Sea, Arabian Gulf, etc. ON will by participation in this project develop a commercial market for operational ocean products within the oil industry and this will provide a further justification for future support of the operational GODAE systems and GODAE operation centers.

t) Horizon Marine Inc. (J. Feeney, S. Anderson) – see attached letter of support

u) Shell Oil Company (M. Vogel) and ExxonMobil (O. Esenkov) will evaluate the potential of the forecast system outputs in deriving useful criteria for deep water oil and gas facilities and operations.

v) ROFFS (M. Roffer) – see attached letter of support

w) Orbimage (l. Stathoplos) – see attached letter of support

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DEPARTMENT OF THE NAVY
COMMANDER
NAVAL METEOROLOGY AND OCEANOGRAPHY COMMAND
1100 BALCH BOULEVARD
STENNIS SPACE CENTER MS 39529-5005

3900
Ser 5/012
FEB 04 2003

OCEAN.US
Attn: Dr. Stephen R. Piotrowicz
2300 Clarendon Blvd., Suite 1350
Arlington, VA 22201

Gentlemen:

The Naval Meteorology and Oceanography Command most strongly supports and urges your approval of the NOPP/GODAE proposal "Global Ocean Prediction with the Hybrid Coordinate Ocean Model (HYCOM)," Dr. Eric P. Chassignet, Coordinator. The Naval Oceanographic Office has indicated its willingness to commit significant resources in support of this effort, up to and including the operation and maintenance of the HYCOM system, in its letter to you of January 31, 2003 (reference NAVOCEANO ltr 3900 Ser OTT/90123199).

This HYCOM research proposal will deliver a significant improvement to the Navy's and the nation's global ocean modeling capabilities.

My point of contact for this effort is Dr. Bill Burnett, telephone 228-688-4766 or email burnettb@cnmoc.navy.mil.

Sincerely,

J.R.H. ATANGAN
Commander, U.S. Navy
Assistant Chief of Staff
for Plans and Programs

Copy to:
Naval Research Laboratory Detachment Stennis Space Center (Code 7300)
Naval Oceanographic Office

DEPARTMENT OF THE NAVY
NAVAL OCEANOGRAPHIC OFFICE
1002 BALCH BOULEVARD
STENNIS SPACE CENTER, MS 39522-5001

IN REPLY REFER TO:

3900
Ser OTT/90123199

Dr. Stephen R. Piotrowicz
OCEAN.US
2300 Clarendon Blvd., Suite 1350
Arlington, VA 22201

Dear Dr. Piotrowicz

The Naval Oceanographic Office (NAVOCEANO) most strongly supports a NOPP/GODAE effort over the next five years to develop a real-time, global ocean prediction capability based on a 1/12 degree HYCOM. As this project conforms to our long-term global ocean prediction plans, NAVOCEANO anticipates our active participation in this project as well as the running of the operational follow-on to this specific GODAE effort.

NAVOCEANO's present operational, assimilative, global, ocean prediction system is based on the 1/16 degree Navy Layered Ocean Model (NLOM) which is used for deep-water front and eddy prediction. The Naval Research Laboratory (NRL) is currently transitioning to NAVOCEANO a real-time, hybrid ocean prediction capability combining an operational global version of the Modular Ocean Data Assimilation System (MODAS), the operational global NLOM, and a 1/8 degree global version of the Navy Coastal Ocean Model (NCOM). This hybrid, assimilative, and real-time ocean prediction system presently runs in a pre-operational mode. It is scheduled, subsequent to its OPTEST, to be fully operational prior to the end of FY03. This hybrid system was designed as the Navy's global baseline ocean capability to provide global coverage (including shallow water and arctic) and boundary conditions for higher resolution regional or local area models.

The 1/12 degree global HYCOM system provides a logical and critical upgrade path for this baseline by allowing higher resolution, improved data assimilation and numerics, and improved operational system engineering efficiencies. NAVOCEANO commits to the development of the HYCOM global system. We will: (1) provide unclassified data such as altimetry, SST, and T,S profile data (same as that available to the baseline global MODAS/NLOM/NCOM system) for assimilation and evaluation and (2) participate in the systems engineering process to evaluate the global HYCOM system relative to the existing real-time baseline throughout the 5-year project and transition it to operations in the FY06/07 time frame. Upon successful transition, NAVOCEANO plans to operate and maintain the system.

My technical point of contact to serve as NAVOCEANO liaison with other project participants will be Dr. John Harding (hardingj@navo.navy.mil).

Sincerely,

J. EDWARD JOHNSON
Technical Director

4 February, 2003

Dr. Stephen Piotrowicz
OCEAN.US
2300 Clarendon Blvd. Suite 1350
Arlington, VA 22201

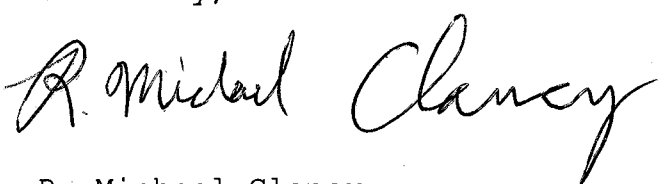
Dear Dr. Piotrowicz:

Fleet Numerical Meteorology and Oceanography Center (FNMOC) most strongly supports a NOPP/GODAE effort over the next five years to develop a real-time, global ocean forecast system based on a 1/12° HYCOM with data assimilation. As this project conforms to our long range plans for predicting the air-ocean environment, FNMOC anticipates our active participation in this project, as well as future operational implementation of the modeling system resulting from this GODAE effort.

In collaboration with the Naval Research Laboratory Marine Meteorology Division (NRL-MRY) and Oceanography Division (NRL-SSC), FNMOC is presently testing a near-global configuration of the Parallel Ocean Program (POP) in a data assimilation cycle with the NRL Coupled Ocean Data Assimilation (NCODA). We expect to begin automated, near-real time tests of this system late in FY03. This data assimilation and forecast system will provide a test-bed for experiments to tightly couple the Navy Operational Global Atmospheric Prediction System (NOGAPS) to a fully interactive ocean.

The 1/12° HYCOM system provides a logical and critical upgrade path for this work by allowing higher resolution, improved numerics, and improved operational efficiencies. Indeed, according to the Modeling Roadmap maintained by the Commander, Naval Meteorology and Oceanography Command (CNMOC), all Navy global ocean modeling efforts should converge on HYCOM by 2007. We expect to be running HYCOM operationally in this timeframe.

Sincerely,



R. Michael Clancy
Chief Scientist & Deputy Technical Director
Fleet Numerical Meteorology and Oceanography Center

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL WEATHER SERVICE
NATIONAL CENTERS FOR ENVIRONMENTAL PREDICTION
5200 AUTH ROAD, RM. 207, WWB
CAMP SPRINGS, MARYLAND 20746-4301

January 31, 2003

Prof. Eric Chassignet
University of Miami
RSMAS/MPO
4600 Rickenbacker Causeway
Miami, Florida 33149-1098

Dear Prof. Chassignet:

I am pleased to endorse your collaborative effort (with NRL, NAVOCEANO and other partners) to seek funding from NOPP for the development of an improved, scalable HYCOM-based data assimilation and forecast system for the Atlantic Ocean basin and the World Oceans. At the National Centers for Environmental Prediction (NCEP) we are particularly interested in the HYCOM system for possible future use in the production of high resolution, operational Regional Ocean Forecast Systems (ROFS) to 1) meet NWS's marine requirements and 2) improve the performance of NCEP's numerical weather prediction models, particularly for hurricane forecasting.

The charter of NCEP's Environmental Modeling Center (EMC) is to develop real-time, operational, dynamical atmospheric and ocean forecast systems to serve the needs of the National Weather Service. The EMC has a well established, international reputation for developing and implementing successively improved operational numerical weather prediction systems over the past decades. Currently, NCEP runs operationally regional scale numerical weather prediction models for short range (2-4 days) forecasting and global scale models for medium range (2 weeks and longer) and seasonal to inter-annual time scale forecasting. EMC has a long history of continually monitoring the performance of NCEP's operational models and carrying out a dedicated development program to produce the next generation models with improved numerics, physical parameterizations, and data assimilation procedures. We believe our experience and discipline obtained with our atmospheric forecast systems can be applied with equal success to real time ocean forecasting and coupled systems.

I am particularly excited about the plans of EMC's Marine Modeling and Analysis Branch (MMAB) to participate in your collaborative research. We have recently implemented our first real-time ocean forecast system to predict the coastal ocean conditions over a limited domain off the East Coast of the U.S. We wish to extend these forecast capabilities

to cover the entire domain of the eastern seaboard of North America (from Nova Scotia down to the Gulf of Mexico and the Inter American-Seas) to meet the needs of the marine community. Subsequently, we will extend our operational systems to cover the West Coast, Gulf of Alaska, and Hawaii regions. The proposed MMAB plan is to produce higher resolution and improved real-time ocean forecasts for the coastal domain of the entire eastern seaboard. Testing a HYCOM-based Atlantic Basin prediction system as a candidate to upgrade NCEP's current system appears to be a feasible and efficient way to achieve this objective.

The HYCOM consortium will benefit from the MMAB's participation in this NOPP proposal since experimental HYCOM model output will be subject to critical evaluation by NCEP forecasters and diagnosticians and the products will be disseminated to a diverse marine community. In this way, continued improvements based on user feed back and internal evaluations can accelerate HYCOM development.

Given sufficient experimentation, NCEP's HYCOM-based applications could also include an upgrade to the fully coupled ocean-atmosphere hurricane system recently implemented here. Unfortunately, the currently operational East Coast Ocean Forecast System is not amenable to incorporating these changes since its domain does not cover the entire area of interest for hurricane prediction. The development of a more general and widely applicable operational ROFS along the lines described in your collaborative NOPP proposal will provide the coverage needed for improved hurricane prediction in a coupled model configuration.

Considering the impressive team of investigators that you have put together in this proposal, I have no doubt whatsoever that you would succeed in accomplishing your objectives. Hence, I support your proposal most enthusiastically.

Sincerely yours,

Stephen J. Lord
Director
Environmental Modeling Center

cc:
W/NP - Louis Uccellini
W/NP21 - D. B. Rao

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL WEATHER SERVICE
NATIONAL CENTERS FOR ENVIRONMENTAL PREDICTION
OCEAN PREDICTION CENTER
CAMP SPRINGS, MD 20746

JANUARY 31, 2003

Prof. Eric Chassignet
University of Miami
RSMAS/MPO
4600 Rickenbacker Causeway
Miami, FL 33149-1098

Dear Prof. Chassignet,

I strongly endorse your joint (NCEP, University of Miami, NRL, NAVOCEANO) proposal to NOPP regarding the development of a high resolution ocean forecast system for the Atlantic Basin. The Ocean Prediction Center (OPC) is very interested in the plans of the EMC Marine Modeling and Analysis Branch (MMAB) to use the Hybrid Coordinate Ocean model-based Atlantic Basin model as a source to provide boundary conditions for even higher resolution coastal ocean forecasts over the East Coast of the U.S. including the Gulf of Mexico and the Carribean Sea.

As an operational forecast center, OPC is responsible for providing warnings and forecasts for the marine community to minimize the loss of property and lives and ensure the safety of marine operations. To accomplish this goal, we critically need accurate and reliable oceanographic parameters including SST and surface currents in our coastal and offshore waters and, especially, in the vicinity of the Gulf Stream. Of particular interest to us is the onset of hazardous marine weather and sea conditions. Parameters such as stability of the marine boundary layer and associated winds, sea state, fog and visibility exert a profound influence in determining the severity of the environmental conditions encountered by mariners.

Information obtained from the recently implemented operational Coastal Ocean Forecast System combined with the availability of high resolution scatterometer winds over the Gulf Stream region have helped improve our products. OPC forecasters and marine customers have both become more knowledgeable about the impact of oceanographic features on atmospheric parameters and are interested in obtaining additional high resolution oceanographic forecast information. Mariners have also expressed interest in obtaining products covering areas such as the coastal zone not included in the present regional forecast system. The proposed effort by the MMAB goes a long way to filling these needs.

Once the model becomes available in real time, we would like to examine the model forecast fields and to provide evaluations on their performance from an operational forecasting perspective. We hope our participation will lead to improvements in the model products for the benefit of our user communities.

With my best wishes for the success of your proposal and the work ahead.

James E. Hoke
Director, OPC

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE
Office of Coast Survey
Silver Spring, Maryland 20910-3282

Dr. Eric Chassignet
Rosenthiel School of Marine and Atmospheric Sciences
1600 Rickenbacker Causeway
Miami, FL 33149-1098

January 22, 2003

Dear Eric,

I would like to offer my support for, and cooperation in, your intended development work in the proposal entitled ***"U.S.GODAE: Global Ocean Prediction with the Hybrid Coordinate Ocean Model (HYCOM)".*** I understand that you are submitting this proposal as a joint effort with NRL, NAVOCEANO, Marine Modeling and Analysis Branch (MMAB) of the National Centers for Environmental Prediction (NCEP) , and others to the NOPP office for funding.

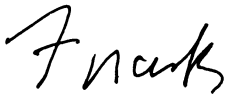
MMAB's intention to implement an operational Regional Ocean Forecast System (ROFS) for the East and Gulf Coasts of the U.S. based on using HYCOM model fields for the Atlantic Basin as boundary conditions would be of great interest and value to us in NOAA's National Ocean Service (NOS). The fact that you are partnering with the National Weather Service's National Centers for Environmental Prediction gives us confidence that this will result in an operational ROFS that will make the operational connections with the NOS even more robust. We already have established operational connections between these two line offices of NOAA.

From our operational NOS perspective, the ROFS for the eastern sea board will play an important role in providing forecast boundary conditions for NOS bay, harbor and estuarine forecast systems being implemented for its Physical Oceanographic Real-time Systems (PORTS). Two of these forecast systems are now operational in the Chesapeake Bay and NY Harbor and a third will be coming on line in Galveston Bay in 2003. They all need more complete (right now we only use forecast water levels but we need forecast temperature, salinity, and currents) and more accurate forecast boundary conditions than they presently have available. In a more general sense, the near-shore information on water level elevations, currents, temperature and salinity will be very important to the NOS in meeting its responsibilities for safe navigation and management of coastal environmental resources. ROFS will also provide offshore forecast guidance on surface currents and Gulf Stream and Loop Current structure that could prove valuable for hazardous materials response, for predicting transport of harmful algal blooms, and for analysis associated with hypoxia.

Because of our near-coastal interests in ROFS, and MMAB's intended development using HYCOM, I would like to offer my laboratory's help in evaluation of the model system. We can quantitatively assess the value of the model as a forecast boundary condition for our estuarine forecast models and also compare model coastal outputs with available operational NOS data (water level; temperature, salinity and currents).

Thus, with the cooperative intention of evaluation stated above, and the variety of NOS applications that may result from the success of your collaborative effort, I offer my complete support to your proposal.

Sincerely,



Frank Aikman III
Chief, Marine Modeling and Analysis Programs
Coast Survey Development Laboratory
National Ocean Service, NOAA
1315 East-West Highway
Silver Spring, MD 20910
301-713-2809 x101
frank.aikman@noaa.gov

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL WEATHER SERVICE

Tropical Prediction Center
National Hurricane Center
11691 S.W. 17th Street
Miami, Florida 33165-2149

January 16, 2003

Prof. Eric Chassignet
Univ. of Miami
RSMAS/MPO
4600 Rickenbacker Causeway
Miami,FL, 33149-1098

Dear Prof. Chassignet,

I am very pleased to offer my strong support to your joint proposal to NOPP for the development of a high resolution ocean forecast system over the Atlantic Basin. You have assembled an excellent set of collaborators from U. Miami, NRL, NAVOCEANO and NCEP for this proposal. We are very interested in the proposed plans of NCEP Marine Modeling and Analysis Branch (MMAB) to provide HYCOM-based oceanographic fields over the Atlantic Basin model as well as boundary conditions for higher resolution ocean forecasts over an extensive coastal domain covering the East Coast of the U.S. including the Gulf of Mexico and the Inter-American Seas.

The Tropical Prediction Center (TPC) is an operational center of the NOAA's National Weather Service. TPC issues warnings and forecasts for hurricanes in the Atlantic and Pacific basins for the safeguarding of life and property in coastal communities. Hurricane intensity, track and landfall location are profoundly influenced by the thermal structure of the underlying ocean. The heat content of the upper ocean, location of cold and warm pools, and fronts such as the Gulf Stream and Loop current must be forecast accurately for TPC to be successful in its mission. Consequently, accurate and reliable information on these oceanographic parameters is critically needed. We are aware of NCEP's recent success in implementing a prototype fully coupled ocean-hurricane system to improve our hurricane forecasting capability and we strongly encourage efforts to improve that system along the lines you are proposing. Unfortunately, gridded data from the recently implemented operational East Coast Ocean Forecast System is insufficient for hurricane applications since its domain coverage is limited. Therefore, what is needed is a more general and widely applicable, operational regional ocean forecast system running daily, in real-time, and covering all regions of interest to the TPC. For the Atlantic region, the proposed effort by the MMAB to upgrade their operational model to the HYCOM-based Atlantic Basin model fills these needs. We look forward to introducing better forecast products at TPC based on these planned operational ocean forecast products.

Once the model starts running and producing real-time ocean products, we will be interested in examining the model forecast fields obtained from the NCEP Environmental Modeling Center and providing evaluations on their usefulness from a forecaster's perspective. We hope that our participation and strong collaboration with MMAB will lead to improvements in your products for the benefit of our user communities.

With my best wishes for the success of your proposal and the work ahead.

Sincerely,

Max Mayfield

Max Mayfield
Director

SPACE SCIENCE AND ENGINEERING CENTER

UNIVERSITY of WISCONSIN – MADISON
1225 West Dayton Street
Madison, Wisconsin 53706-1695

February 4, 2003

Professor Eric Chassignet
University of Miami
RSMAS/MPO
4600 Rickenbacker Causeway
Miami, FL, 33149-1098

Dear Professor Chassignet:

Last Friday while spending the week at NOAA's National Centers for Environmental Prediction, Dr. Desiraju Rao brought to my attention a research and development effort that aims to develop and advance HYCOM's isopynical modeling of the global ocean circulation jointly with other investigators including the Marine Prediction Center at NCEP. As an atmospheric scientist engaged in the development of hybrid isentropic sigma coordinate models for the atmosphere at the University of Wisconsin-Madison and now NCEP's Special Project Scientist involved with the development of next generation coupled models for the atmosphere and ocean, please consider my unbounded support and interest in this proposed effort. I commend your undertaking in leading this community effort and wish to endorse support from the ONR. If I may be of assistance, please contact me.

Regards,

Donald R. Johnson
Emeritus Professor and
NCEP Special Project Scientist

cc: Dr. Desiraju Rao
Dr. Louis Uccellini

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Executive Director (608) 262-0544 Fax (608) 262-5974
Business Services (608) 263-3037 Information (608) 263-6750

HORIZON MARINE INC

February 5, 2003

Mr. Eric Chassignet
University of Miami
RSMAS/MPO
4600 Rickenbacker Causeway
Miami, FL 33149-1098

Dear Eric:

The model improvements proposed for the HYCOM NOPP/GODAE work has a direct value to the oil and gas industry. Horizon Marine's business is based upon being able to report to clients in real time the status of ocean currents which will adversely affect their deepwater drilling efforts.

We produce a product called Eddy Watch[sm] which monitors major ocean currents and forecasts the start and duration of high current events at offshore sites. We perform this service in the Gulf of Mexico (the Loop Current and its eddies) and offshore Trinidad (the North Brazil Current and its eddies). We use satellite-tracked drifting buoys, sea surface temperature, ocean color, sea surface heights, and current meters mounted on drilling platforms and ships.

Offshore operators use our reports and forecasts to plan for the timing of critical marine drilling operations such as running and retrieving marine drilling riser and blowout preventer (BOP) stacks, anchoring and anchor tensioning, station keeping, and other current-sensitive operations. When the strong current associated with an eddy encroaches upon the site, operations often have to be suspended, leaving weeks of downtime at a cost of $250,000 to $400,000 per day for the high end drillships and support vessels.

Drillers are concerned with fatigue from vortex-induced vibrations (VIV), high flex angles at the upper and lower ends of drill strings, cyclic bending loads, and wear on the flex joints and casings. These things affect operational safety, and the measurement and a better understanding of environmental loads are needed for the design of offshore structures.

15 Creek Road, Marion, Massachusetts 02738
Telephone: (508) 748-1860 Fax: (508) 748-1525

HORIZON MARINE INC

In our Eddy Watch program, we use the output of numerical models to assist with the forecasting of major eddy events. It is in our interest to advance the model skill so that we can put more confidence in the nowcast and forecast products. As outlined above, we see a substantial economic benefit to the oil and gas industry and a significant safety benefit to the community.

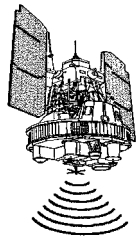
We wish to support the further development of the Hybrid Coordinate Ocean Model (HYCOM). We currently use the NLOM model output, and we believe that the HYCOM plan proposed for the GODAE effort has the highest likelihood of success for use in our programs.

Regards,

James W. Feeney
President

/hna

ROFFS™
ROFFER'S OCEAN FISHING FORECASTING SERVICE, INC.
2871 SW 69th Court, Miami, Florida 33155
U.S. Toll Free 800 677-7633 • Office 305 262-8336 • Fax 305 265-9077
Internet fish@roffs.com • www.roffs.com •



Eric Chassignet, Professor
University of Miami
Rosenstiel School for Marine and Atmospheric Sciences
Department of Meteorology and Physical Oceanography
4600 Rickenbacker Causeway
Miami, Florida 33146

February 10, 2003

Dear Eric:

As an oceanographer and President of a fisheries oceanographic consulting service, I am writing this letter of support for the HYCOM project to develop an eddy-resolving, real-time global and basin -scale ocean prediction system. Small companies like ours can not afford the time and expensive to develop and operate data assimilation systems and models that incorporate satellite altimeter sea surface height, sea surface temperature, in-situ temperature in three dimensions, salinity, float displacement and satellite derived sea surface color. It is critical to the advancement of oceanography (basic and applied) to further refine the presently used operational ocean models.

We are particularly interested in evaluating the HYCOM output compared with our ocean circulation features analyses for fishing forecasting nowcasts and forecasts. We would be interested in being a private industry partner in determining the utility of the HYCOM output for directing fishing boats to ocean features to increase the efficiency of fishing operations worldwide. We are interested in the many aspects of the HYCOM modeling project including the merging of infrared data derived from NOAA_AVHRR, Terra_MODIS, Aqua_MODIS and microwave data. We would also be interested to see an integration of the infrared data from the GOES sensors as well.

Please keep me informed and you have our support.

Sincerely,

Mitchell A. Roffer, Ph.D.
President

ORBIMAGE
GLOBAL IMAGING INFORMATION

January 29, 2003

Dr. Eric Chassignet
RSMAS/MPO, University of Miami
4600 Rickenbacker Causeway
Miami, FL 33149-1098

To Whom It May Concern:

ORBIMAGE is pleased to participate as a data evaluator in the National Ocean Partnership Program proposal to produce near-real time ocean products using the HYCOM next-generation operational ocean model. Our role will be to provide feedback on the accuracy and utility of the HYCOM system outputs for providing oceanographic operational support to commercial fisheries.

Our company point of contact will be Dr. Linda Stathoplos, who can be reached by phone at (703) 480-7530, by fax at (703) 480-7544, and by e-mail at stathoplos.linda@orbimage.com.

We look forward to working with the team you have assembled.

Sincerely,

Gregory Hammann
Director, Product Development

Budget

U.S. GODAE: Global Ocean Prediction with the HYbrid Coordinate Ocean Model (HYCOM)

Federal Funds Requested:

Institution	Year 1	Year 2	Year 3	Year 4	Year 5
U. Miami	$129,573	$421,321	$631,198	$692,652	$735,884
NRL/STENNIS	$200,060	$400,062	$627,541	$677,858	$729,274
NRL/MONTEREY	$50,000	$75,000	$225,000	$250,000	$300,000
NOAA/NCEP	$155,000	$255,000	$270,000	$285,000	$301,000
NOAA/AOML	$0	$152,275	$157,313	$164,704	$171,464
NOAA/PMEL	$80,151	$111,765	$222,087	$225,818	$227,923
NOAA/OPC	$50,000	$55,000	$75,000	$80,000	$85,000
PSI	$87,416	$169,705	$177,874	$186,450	$195,456
OPeNDAP	$49,972	$51,795	$76,304	$79,106	$81,988
U. S. Mississippi	$30,000	$30,000	$30,000	$30,000	$30,000
U. N. Carolina	$50,000	$55,000	$75,000	$80,000	$85,000
Rutgers	$52,717	$53,716	$54,530	$55,369	$56,236
U. S. Florida	$42,484	$55,007	$75,177	$79,762	$84,773
Ocean Numerics	$50,000	$55,000	$75,000	$80,000	$85,000
	$1,027,373	$1,,940,646	$2,,727,024	$2,966,719	$3,168,998

A RESEARCH PROPOSAL SUBMITTED TO:
THE NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION (NOAA)
Through the

Cooperative Institute for Marine and Atmospheric Studies (CIMAS)

For the

Rosenstiel School of Marine and Atmospheric Science, University of Miami
4600 Rickenbacker Causeway, Miami, FL 3349-1098

Title: **U.S. GODAE: Global Ocean Prediction with the HYbrid Coordinate Ocean Model (HYCOM)**

Performance Period: June 1, 2003 – May 31, 2008

Submitting Date: February 24, 2003

CIMAS Project Number: NA17RJ1226

Research Theme: Theme 6: Integrated Ocean Observations

Coordinating P.I.: _____

Prof. Eric P. Chassignet
Meteorology & Physical Oceanography
Phone: (305) 361-4041 Fax: (305) 361-4696
E-mail: echassignet@rsmas.miami.edu

Prof. Bruce Albrecht, Chairman
Meteorology & Physical Oceanography
Ph. (305)361-4043 FAX (305)361-4696
E-mail: balbrecht@rsmas.miami.edu

Dr. Joseph Prospero, Director
Cooperative Institute for Marine and Atmospheric Studies
Ph.: (305)361-4159 Fax (305)361-4457
Email: jprospero@rsms.miami.edu

Dean Otis Brown, Institutional Representative
Rosenstiel School of Marine and Atmospheric Science
Ph. (305)361-4000 Fax (305)361-4711
Email: obrown@rsmas.miami.edu

Total Federal Funds Requested (All partners): $11,875,760

FY04	FY05	FY06	FY07	FY08
$1,027,373	$1,940,646	$2,772,024	$2,966,719	$3,168,998

Total Federal Funds Requested (U. of Miami only): $2,610,628

FY04	FY05	FY06	FY07	FY08
$129,573	$421,321	$631,198	$692,652	$735,884

RSMAS BUDGET JUSTIFICATION

E. Chassignet will be the coordinating PI for the Partnership and for the RSMAS team. He is a member of both the U.S. and International GODAE Steering Teams. The RSMAS team has been working together for over a decade on ocean modeling, SST remote sensing, data assimilation, oceanic predictability, and the study of ocean dynamics and variability from both Eulerian and Lagrangian viewpoints. This includes extensive experience in developing and using MICOM and HYCOM. He will contribute to the design of the assimilative and non-assimilative model experiments and to the interpretation and evaluation of the results. **G. Halliwell** is one of the major developers of HYCOM and has extensive experience in implementing and evaluating mixed layer parameterizations. G. Halliwell will work closely with the NRL and NOAA/AOML group in the evaluation and configuration of the global configuration. **M. Iskandarani** is a gifted ocean modeler who will contribute to improvements in the numerical development of HYCOM, especially in numerical advection schemes and unstructured grid. M. Iskandarani will also work closely with A. Wallcraft and P. Hogan (NRL) in evaluating HYCOM's performance in shallow coastal regions. **T Chin** and **A. Mariano** will work closely with the other data assimilators (C. Thacker, NOAA/AOML; C. Lozano, NOAA/NCEP, J. Cummings, NRL; P. Brasseur, LEGI) and with Planning Systems Inc. (PSI) to ensure a smooth transition of the ROIF data assimilation method. **D. Bi** is currently a post-doc working with E. Chassignet and R. Bleck (LANL) to implement the Los Alamos sea-ice CICE model in HYCOM using the NCAR CCSM coupler. D. Bi will evaluate the performance of CICE in the global configuration in collaboration with R. Bleck (LANL), J. Metzger (NRL), and A. Wallcraft (NRL). **Z. Garraffo** has been working to evaluate MICOM high resolution model outputs for the past 6 years in collaboration with E. Chassignet and has published several papers on the results. Z. Garraffo will be evaluating the HYCOM outputs in collaboration with the partners. **A. Srinivasan** has been responsible for setting up and maintaining the Miami LAS. He will continue in this role and will be the point of contact in the collaboration with S. Hankin (PMEL) and with the Monterey GODAE server. **E. Ryan** has been the HYCOM webmaster for the past 4 years and will be in charge of its continued maintenance and extension to accommodate the Partnership's needs. **A. Mariano** will integrate the HYCOM LAS outputs in the Miami-based educational site for ocean currents for comparison and education purposes. This web site, http://oceancurrents.rsmas.miami.edu, provides the scientific, educational, and research community with an up-to-date collection of what is known about all ocean/coastal currents. We expect the HYCOM outputs integrated with observations and regional nowcast/forecasts to be an excellent resource in this regard.

The RSMAS Remote Sensing Group (**P. Minnett, R. Evans**) via **W. Baringer** will provide in near real-time (less than one day) MODIS SST data as well as merged infrared and microwave SSTs. MODIS SST fields are among the best available from broad swath sensors: resulting from several factors, including better radiometric resolution and good on-board calibration, good spatial resolution and global 1-km data. Currently a pilot project is being set up for automatic regional extraction of SST from the MODIS data stream. As more resources (people) become available via this project and other GHRSST efforts, infrared-SST fields from different sources will be merged to give 6- or 24-hourly products. The next step will be to merge infrared and microwave data to attempt to provide complete global SST fields, initially for 24-hour data sets. The sensors involved would be MODIS on Terra and Aqua for the infrared data, and AMSR, AMSR-E and TMI for the microwave data. The complicating issues here are i) different emission depths for infrared (tens of microns) and microwave (millimeters) radiation, ii) the different spatial resolution of the infrared and microwave sensors; iii) 'side-lobe' effects in the microwave data in the vicinity (10's of km) of coasts, iv) residual wind-speed and rainfall errors in the microwave measurements, and v) residual aerosol, water vapor and cloud effects in infrared measurements. The development of optimal schemes to provide complete input for the GODAE model will take place in collaboration with the users to ensure their requirements are taken into account. The resultant SST fields will be accompanied by quality flags, including the provenance of the information at each pixel, and estimates of uncertainties.

This University of Miami proposal has strong linkages with ongoing NOAA research activities at NCEP, PMEL, and AOML. Close collaboration with C. Thacker (AOML) is made effective via S. Lee who is presently a Cooperative Institute for Marine and Atmospheric Studies (CIMAS) post-doc. This proposal fits under CIMAS theme 6: Integrated Ocean Observations.

The travel funds will be used for the twice a year project meetings, travel to attend U.S. and International GODAE Steering Team meetings, travel to meetings with the European MERSEA project on ocean prediction system intercomparisons, and to present project results to scientific meetings. A significant portion of the travel funds is targeted to support extended visits to RSMAS and Stennis of R. Bleck (LANL, global ocean modeling development), P. Brasseur (LEGI, SEEK filter implementation), R. Baraille (ROAF development, including HYCOM adjoint). A small amount of funds for equipment is requested for maintenance of the LAS access server and of the workstations used by the invertigators.

BUDGET YEAR ONE (06/01/03-05/31/04)
U.S. GODAE: Global Ocean Prediction with the HYbrid Coordinate Ocean Model (HYCOM)

BUDGET BREAKDOWN

A.	SALARIES AND FRINGE BENEFITS			
	1. Professional			
	Dr. E. P. Chassignet, Principal Invest	0%		
	Dr. G. Halliwell, Co Principal Invest.	0%		
	Dr. M. Iskandarani, Co-Princ. Invest.	0%		
	Dr. T. Chin, CoPrincipal Invest.	0%		
	Dr. A. Mariano, Co-Principal Invest.	0%		
	Dr. R. Evans, Co-Principal Invest.	0%		
	Dr. P. Minnett, Co-Principal Invest.	0%		
	2. Supporting Personnel			
	E. Ryan	17%	$10,532	
	W. Baringer	50%	38,675	
	Research Coordinator	10%	2,161	
	3. Graduate Student			
	TOTAL SALARIES			$64,981
	4. Fringe Benefits			13,613
	TOTAL SALARIES AND FRINGE BENEFITS			51,368
B.	PERMANENT EQUIPMENT			5,000
C.	EXPENDABLE SUPPLIES			2,000
D.	TRAVEL			20,000
E.	PUBLICATION COST			2,000
	SUBTOTAL			93,981
F.	INDIRECT COST (40% of Modified total direct Cost)			35,592
	TOTAL			129,573

BUDGET YEAR TWO (06/01/04-05/31/05)
U.S. GODAE: Global Ocean Prediction with the HYbrid Coordinate Ocean Model (HYCOM)

BUDGET BREAKDOWN

A.	SALARIES AND FRINGE BENEFITS			
	1. Professional			
	Dr. E. P. Chassignet, Principal Invest	25%	$35,800	
	Dr. G. Halliwell, Co-Principal Invest.	21%	15,913	
	Dr. M. Iskandarani, Co-Princ. Invest.	21%	18,198	
	Dr. T. Chin, Co-Principal Invest.	17%	13,849	
	Dr. A. Mariano, Co-Principal Invest.	08%	9,644	
	Dr. R. Evans, Co-Principal Invest.	0%		
	Dr. P. Minnett, Co-Principal Invest.	0%		
	2. Supporting Personnel			
	E. Ryan	25%	$16,745	
	W. Baringer	50%	40,996	
	Z. Garraffo	25%	16,432	
	Postdoctoral Associate TBA	50%	28,090	
	Research Coordinator	10%	2,290	
	3. Graduate Student	100%	22,750	
	TOTAL SALARIES			$220,707
	4. Fringe Benefits			52,665
	TOTAL SALARIES AND FRINGE BENEFITS			273,372
B.	PERMANENT EQUIPMENT			5,000
C.	EXPENDABLE SUPPLIES			2,000
D.	TRAVEL			20,000
E.	PUBLICATION COST			2,000
	SUBTOTAL			302,372
F.	INDIRECT COST (40% of Modified total direct Cost)			118,949
	TOTAL			421,321

BUDGET YEAR THREE (06/01/05-05/31/06)
U.S. GODAE: Global Ocean Prediction with the HYbrid Coordinate Ocean Model (HYCOM)

BUDGET BREAKDOWN

A.	SALARIES AND FRINGE BENEFITS			
	1. Professional			
	Dr. E. P. Chassignet, Principal Invest.	25%	$37,948	
	Dr. G. Halliwell, Co-Principal Invest.	21%	16,868	
	Dr. M. Iskandarani, Co-Princ. Invest.	21%	19,289	
	Dr. T. Chin, Co-Principal Invest.	13%	11,010	
	Dr. A. Mariano, Co-Principal Invest.	8%	10,223	
	Dr. R. Evans, Co-Principal Invest.	0%		
	Dr. P. Minnett, Co-Principal Invest.	0%		
	2. Supporting Personnel			
	E. Ryan	25%	17,750	
	A. Srinivasan	75%	49,129	
	W. Baringer	75%	65,183	
	Z. Garraffo	33%	23,224	
	Postdoctoral Associate TBA	100%	59,551	
	Research Coordinator	10%	2,428	
	3. Graduate Student	100%	23,400	
	TOTAL SALARIES			$336,003
	4. Fringe Benefits			87,281
	TOTAL SALARIES AND FRINGE BENEFITS			423,284
B.	PERMANENT EQUIPMENT			5,000
C.	EXPENDABLE SUPPLIES			2,000
D.	TRAVEL			20,000
E.	PUBLICATION COST			2,000
	SUBTOTAL			452,284
F.	INDIRECT COST (40% of Modified total direct Cost)			178,914
	TOTAL			631,198

BUDGET YEAR FOUR (06/01/06-05/31/07)
U.S. GODAE: Global Ocean Prediction with the HYbrid Coordinate Ocean Model (HYCOM)

BUDGET BREAKDOWN

A.	SALARIES AND FRINGE BENEFITS			
	1. Professional			
	Dr. E. P. Chassignet, Principal Invest	25%	$40,225	
	Dr. G. Halliwell, Co-Principal Invest.	21%	17,880	
	Dr. M. Iskandarani, Co-Princ. Invest.	21%	20,447	
	Dr. T. Chin, Co-Principal Invest.	13%	11,671	
	Dr. A. Mariano, Co-Principal Invest.	8%	10,836	
	Dr. R. Evans, Co-Principal Invest.	0%		
	Dr. P. Minnett, Co-Principal Invest.	0%		
	2. Supporting Personnel			
	E. Ryan	25%	18,815	
	A. Srinivasan	75%	52,077	
	W. Baringer	75%	69,094	
	Z. Garraffo	50%	36,926	
	Postdoctoral Associate TBA	100%	63,124	
	Research Coordinator	10%	2,573	
	3. Graduate Student	100%	24,050	
	TOTAL SALARIES			$367,718
	4. Fringe Benefits			99.462
	TOTAL SALARIES AND FRINGE BENEFITS			467,180
B.	PERMANENT EQUIPMENT			5,000
C.	EXPENDABLE SUPPLIES			2,000
D.	TRAVEL			20,000
E.	PUBLICATION COST			2,000
	SUBTOTAL			496,180
F.	INDIRECT COST (40% of Modified total direct Cost)			196,472
	TOTAL			692,652

BUDGET YEAR FIVE (06/01/07-05/31/08)
U.S. GODAE: Global Ocean Prediction with the HYbrid Coordinate Ocean Model (HYCOM)

BUDGET BREAKDOWN

B.	SALARIES AND FRINGE BENEFITS			
	1. Professional			
	Dr. E. P. Chassignet, Principal Invest	25%	$42,638	
	Dr. G. Halliwell, Co-Principal Invest.	21%	18,952	
	Dr. M. Iskandarani, Co-Princ. Invest.	21%	21,674	
	Dr. T. Chin, Co-Principal Invest.	13%	12,371	
	Dr. A. Mariano, Co-Principal Invest.	8%	11,486	
	Dr. R. Evans, Co-Principal Invest.	0%		
	Dr. P. Minnett, Co-Principal Invest.	0%		
	2. Supporting Personnel			
	E. Ryan	25%	19,944	
	A. Srinivasan	75%	55,202	
	W. Baringer	75%	73,240	
	Z. Garraffo	50%	39,142	
	Postdoctoral Associate TBA	100%	66,911	
	Research Coordinator	10%	2,728	
	3. Graduate Student	100%	24,700	
	TOTAL SALARIES			$388,988
	4. Fringe Benefits			109,072
	TOTAL SALARIES AND FRINGE BENEFITS			498,060
B.	PERMANENT EQUIPMENT			5,000
C.	EXPENDABLE SUPPLIES			2,000
D.	TRAVEL			20,000
E.	PUBLICATION COST			2,000
	SUBTOTAL			527,060
F.	INDIRECT COST (40% of Modified total direct Cost)			208,824
	TOTAL			735,884

BUDGET YEARS COMBINED
U.S. GODAE: Global Ocean Prediction with the HYbrid Coordinate Ocean Model (HYCOM)

BUDGET BREAKDOWN

A.	SALARIES AND FRINGE BENEFITS			
	1. Professional			
	Dr. E. P. Chassignet, Principal Invest		156,611	
	Dr. G. Halliwell, Co-Principal Invest.		69,613	
	Dr. M. Iskandarani, Co-Princ. Invest.		79,608	
	Dr. T. Chin, Co-Principal Invest.		48,901	
	Dr. A. Mariano, Co-Principal Invest.		42,189	
	Dr. R. Evans, Co-Principal Invest.		-0-	
	Dr. P. Minnett, Co-Principal Invest.		-0-	
	2. Supporting Personnel			
	E. Ryan		83,786	
	A. Srinivasan		156,408	
	W. Baringer		287,188	
	Z. Garraffo		115,724	
	Postdoctoral Associate TBA		217,676	
	Research Coordinator		12,180	
	3. Graduate Student		94,900	
	TOTAL SALARIES			$1,364,784
	4. Fringe Benefits			362,093
	TOTAL SALARIES AND FRINGE BENEFITS			1,726,877
B.	PERMANENT EQUIPMENT			25,000
C.	EXPENDABLE SUPPLIES			10,000
D.	TRAVEL			100,000
E.	PUBLICATION COST			10,000
	SUBTOTAL			1,871,877
F.	INDIRECT COST (40% of Modified total direct Cost)			738,751
	TOTAL			$2,610,628

Current and pending support:

NOPP

N00014-99-1-1066, 09/01/99-09/30/04 -- HYCOM Consortium for Data Assimilative Ocean Modeling -- $1,804,748 -- Chassignet (25%), Halliwell (25%), Mariano (25%), Chin (30%).

MMS

E13770, 11/1/99-09/30/02 -- Analysis and validation of a Mechanism that Generate Mid-Depths Current and a Deep Cyclonic Gyre in the Gulf of Mexico -- $136,540 -- Chassignet (0%).

ONR

N00014-99-1-0048, 10/1/98-3/31/03 – MICOM Based Nowcast/Forecst Systems for Coastal/Open Regions -- $912,899 – Chassignet (40%).

N00014-02-1-0485, 3/25/02-9/30/04 – HYCOM Data Assimilation and Web Outreach -- $20,000 – Chassignet (0%).

N00014-03-1-0284, 1/1/03-9/30/04 – Inhomogeneous & Nonstationary Feature Analysis: Melding of oceanic variability and Structure (INFAMOVS) – $158,179 - Mariano (33%)

N00014-99-1-0049, 10/1/98-9/30/04 – Predictability of particle trajectories in the ocean - $327,487 – Mariano (8%)

NSF

ATM-99-05210, 04/15/99-03/31/03 -- Vortex Interactions with Abrupt Topography -- $187,000 -- Chassignet (12%).

OCE-00-00042, 04/15/00-03/31/03 -- Collaborative research: Observations and Models of Upper Ocean Water Mass Formation and Evolution in the Western North Atlantic -- $275,267 -- Chassignet (8%).

OCE-01-36700, 8/1/02-7/31/05 – A random field framework for boundary conditions in numerical models of coastal and ocean circulation -- $362,407 – Mariano (8%)

U.S. GODAE: Global Ocean Prediction with the HYbrid Coordinate Ocean Model (HYCOM)

NRL Stennis
Principal Investigator: (Harley E. Hurlburt)

HARLEY E. HURLBURT
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Institutional Representative: (_____)

STEVEN W. PAYNE
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Starting date: June 1, 2003

Total Federal Funds Requested: $ 2,625,000.00

Year 1	Year 2	Year 3	Year 4	Year 5
$200K	$400K	$625K	$675K	$725K

NRL/Stennis Budget Justification

Ocean Modeling

Harley Hurburt is the NRL Senior Scientist for Ocean mOdeling and Prediction and a member of the U.S. and International GODAE Steering Teams. He is a numerical ocean modeler oriented toward model applications, especially in the area of ocean dynamics and prediction. He will be the PI and coordinator of the NRL effort and the NRL collaborations with the project partners. He will also contribute to the design of assimilative and non-assimilative model experiments, the interpretation of results, the diagnosis and solving of problems, and the evaluation effort.

Alan Wallcraft is a computer expert and an ocean modeler oriented toward ocean model and computer code development, including parallelization and portability. He is, and will continue to be in charge of developing and maintaining the standard version of HYCOM. Alan is the computational "lynch pin" of this project.

Joe Metzger will be the lead performer of the non-assimilative global model simulations with 20 and 7 km resolution. He will also play a major role in the analysis of model output and in model-data comparison work. Joe is already running a HYCOM Pacific model at 7 km and coarser resolution. Previously, he had a decade of experience running NLOM Pacific simulations and publishing journal articles on the results.

Birol Kara (postdoc) played a major role in developing, improving, and evaluating the embredded mixed layer model in the NRL Layered Ocean Model (NLOM) working with Alan Wallcraft and John Kindle's group. He is also expert in the area of air-sea fluxes and designed the momentum heat flux formulations used in HYCOM and the international Ocean Model Intercomparison Project (OMIP). He is now working with Alan Wallcraft on HYCOM mixed layer improvement (*e.g*. inclusion of turbidity) and detailed evaluation of HYCOM's mixed layer and SST performance, so far using a HYCOM Black Sea model with 3.2 km resolution and global HYCOM with ~60 km resolution. He will also work on HYCOM salinity forcing and evaluation. He will receive half-time support from this project.

Data Assimilation, data QC, and satellite altimetry

Jim Cummings is collocated with FNMOC and is the co-chair of the U.S. GODAE Steering Team and a member of the International GODAE Steering Team. His main role will be a collaborative effort to provide FNMOC with the ocean component of a coupled ocean-atmosphere prediction system. The collaboration will include Joe Metzger on modeling, Carlos :Lozano (NOAA/NCEP), Carlisle Tahcker (NOAA/AOML), and Ole Martin Smedstad (PSI) on MVOI/3DVAR data assimilation for HYCOM, Alan Wallcraft on code parallelization, and Ole Martin Smedstad (PSI) for building and testing the global ocean prediction model for transition to FNMOC in 2006. Jim developed the MVOI ocean analysis system which is operational at FNMOC. Jim will also take the project lead in automated QC of real-time in situ data, an area where he has extensive experience and expertise.

Gregg Jacob's group will work on advanced data assimilation methods for HYCOM (see Hans Ngodock and Laurent Parent below). Gregg is an expert on satellite altimeter data processing and analysis, including multi-mission analysis of altimeter data. He played an instrumental role in developing the NAVOCEANO Altimeter Data Fusion Center (ADFC) for real-time altimeter data. The ADFC also provides this data to FNMOC, NOAA/NCEP, the UK MET Office, and the Monterey GODAE server. Mainly via a partnering project, Gregg will work to ensure the most accurate and consistent sets of altimeter data for assimilation into HYCOM.

Hans Ngodock and **Laurent Parent** (postdoc, halftime on this project) will work on HYCOM advanced data assimilation methods including the Singular Extended Evolutive Kalman (SEEK) filter, the ensemble Kalman filter (EnKF), the HYCOM adjoint and representer functions constructed using the adjoint for comparison to forecast error covariance from the reduced order methods. Much of this work will be done in a nested HYCOM domain of the northeast Gulf of Mexico under the partnering SEED project and in the Intra-Americas Seas under 6.2 ONR HYCOM and Advanced Data Assimilation Project.

Under this project, Hans and Laurent will collaborate on SEEK filter data assimilation with former colleague Pierre Brasseur (LEGI), Carlisle Thacker (NOAA/AOML) and Ole Martin Smedstad (PSI). SEEK is planned as one of the leading project data assimilation approach. Hans will also work on the EnKF in collaboration with Geir Evensen (Ocean Numerics) and the HYCOM adjoint with Remy Baraille (SHOM). The EnKF may be used in limited areas of the global domain as outlined in the year 5 roadmap, a mode that also be used for the SEEK filter on larger subdomains. Hans has extensive theoretical expertise in advanced data assimilation methods and Laurent Parent has extensive experience implementing the SEEK filter method in ocean models.

Boundary Conditions for Littoral Models

Cheryl Ann Blain and her group will use HYCOM to provide boundary conditions for coastal models using the finite element unstructured grid model, ADCIRC (also used by our U. of North Carolina partner, C. Werner). This will be tested in diverse coastal regimes in collaboration with partnering projects. The northeast Gulf of Mexico and the coast of Spain will be the first regions where nesting will be tested. Leading follow-on candidates are the Persian Gulf, the East Indian coast, and the Red Sea. Cheryl Ann has extensive experience using ADCIRC and has taken the lead in adding baroclinicity to ADCIRC.

Pat Hogan and **John Kindle** are co-PIs of a 4-year 6.2 partnering project (CO-NESTS) which begins in FY04. In this project, they will use boundary conditions from global and basin-scale HYCOM to provide boundary conditions for littoral and regional models using HYCOM (P. Hogan) and the Navy Coastal Ocean Model (NCOM) (J. Kindle). NCOM is a mixed coordinate model with terrain-following coordinate above a specified depth and z-level below that depth. Regions planned for application include the northeast Gulf of Mexico (also a collaboration with the 6.1 SEED project), the California Current System off the U.S. West Coast (a region where J. Kindle has extensive experience nesting NCOM and POM in NCOM and NLOM), Monterey Bay, CA, and the Yellow Sea/East China Sea/Japan East Sea (YECJ) region. P. Hogan has extensive experience running HYCOM as a standalone Japan East Sea model and has already nested the YECJ region at 3.5 km resolution in a HYCOM Pacific model with 7 km resolution. Pat has also 7 years of experience using HYCOM or NLOM for eddy resolving simulations in the Atlantic. **Alan Wallcraft** has already “alpha tested” HYCOM nested in HYCOM and NCOM nested in HYCOM.

The travel funds will be used for the twice a year project meetings, travel for J. Cummings and H. Hurlburt to attend U.S. and International GODAE Steering Team meetings, travel to meetings with the European MERSEA project on ocean prediction system intercomparisons, and to present project results to scientific meetings.

The 15% computer covers the extensive in-house computer and visualization infrastructure and computer support. It is required from all projects in the branch and is very beneficial to project effectiveness and productivity. It is not for high performance computing, which is provided via grants from the High Performance Computing Modernization Office.

Title of Proposal: U.S. GODAE: Global Ocean Prediction with the HYbrid Coordinate Ocean Model (HYCOM) NRL-Stennis Participation

Period of Performance: 1 Jun 2003 - 30 Sept 2007

	FY03			FY04			FY05			FY06			FY07		
	Hrs	Hourly Rate	Yearly Rate	Hrs	Hourly Rate	Yearly Rate	Hrs	Hourly Rate	Yearly Rate	Hrs	Hourly Rate	Yearly Rate	Hrs	Hourly Rate	Yearly Rate
Personnel															
Hurlburt, Harley E.	121	$53.04	$6,418	161	$55.16	$8,881	271	$57.37	$15,546	312	$59.66	$18,614	345	$62.05	$21,407
Wallcraft, Alan J.	135	$45.55	$6,150	182	$47.38	$8,623	301	$49.27	$14,831	349	$51.24	$17,884	353	$62.05	$21,903
Metzger, E. Joseph	345	$32.04	$11,055	461	$33.33	$15,363	835	$34.66	$28,940	935	$36.04	$33,702	1,015	$37.49	$38,049
Hogan, Patrick J.	168	$32.04	$5,383	171	$33.33	$5,699	331	$34.66	$11,472	338	$36.04	$12,183	361	$37.49	$13,533
Jacobs, Gregg A.	135	$45.55	$6,150	283	$47.38	$13,408	407	$49.27	$20,054	450	$51.24	$23,059	469	$53.29	$24,994
Kindle, John	135	$45.55	$6,150	137	$55.16	$7,557	357	$49.27	$17,590	264	$51.24	$13,528	299	$53.29	$15,934
Cummings, James A.	168	$38.40	$6,451	354	$39.94	$14,137	715	$41.53	$29,696	783	$43.19	$33,821	813	$44.92	$36,521
Blain, Cheryl Ann	0	$32.04	$0	264	$33.33	$8,798	332	$34.66	$11,507	375	$36.04	$13,517	407	$37.49	$15,257
	1207		$47,757	2013		$82,465	3549		$149,635	3806		$166,308	4062		$187,598
Fringe Benefits (46%)			$40,682			$62,753			$117,665			$132,658			$144,176
Total Personnel Costs			$88,438			$145,218			$267,300			$298,966			$331,774
Post Doc, NRL			$15,000			$70,000			$70,000			$70,000			$70,000
Domestic Travel			$14,250			$28,500			$28,500			$28,500			$28,500
Foreign Travel			$0			$4,000			$4,000			$4,000			$4,000
Expendable supplies, copying, telephones, etc.			$0			$0			$0			$0			$0
Permanent Equipment			$0			$0			$0			$0			$0
Ship Time, if any			$0			$0			$0			$0			$0
Computer time, if any (rate plus total amount) (15%)			$30,000			$60,000			$93,750			$101,250			$108,750
Subcontractor costs (attach full budgets - Sverdrup			$0			$0			$0			$0			$0
Consultant costs, if any			$0			$0			$0			$0			$0
Publication costs			$0			$5,000			$10,000			$10,000			$10,000
Indirect costs (G&A and Production)			$52,372			$87,344			$153,991			$165,142			$176,250
Total direct and indirect costs			$200,060			$400,062			$627,541			$677,858			$729,274
Cumulative Cost			$200,060			$600,122			$1,227,662			$1,905,521			$2,634,795

Current and Pending Support:

H.E. Hurlburt:

"Global HYCOM and Advanced Data Assimilation", Office of Naval Research, Navy Ocean Modeling Program, FY01-$515K, FY02-$325K, FY03-$325K, FY04-$325K. Develop, validate and transition an upgraded global ocean nowcast/forecast system to Navy operations that will take advantage of the latest community developments in the areas of hybrid vertical coordinate ocean models and advanced data assimilation. This requires a two-pronged effort: One focusing on the next generation model, the other focusing on advanced data assimilation. The ocean model that will be developed for global applications is HYCOM.

"HYCOM NOPP", Office of Naval Research, National Ocean Partnership Program, FY00-$211K, FY01-$211K, FY02-$211K, FY03-$211K, FY04-$211K. The HYCOM consortium is a multi-institutional effort funded by the National Ocean Partnership Program (NOPP) to develop and evaluate a data-assimilative hybrid isopycnal-sigma-pressure (generalized) coordinate ocean model (called HYbrid Coordinate Ocean Model or HYCOM). The primary purpose of the consortium is the establishment of a global real-time ocean forecast system based on HYCOM, with sophisticated data assimilation techniques that can be efficiently executed on massively parallel computers. The consortium seeks to address both the US-GODAE (Global Ocean Data Assimilation Experiment) principal objective, namely the depiction of the three-dimensional ocean state at fine resolution in near-real time, as well as the climate modeling objective of producing an unbiased estimate of the state of the ocean at coarse resolution for long-term climate variability research.

"Dynamics of Low Latitude Western Boundary Currents", Office of Naval Research, Core Funding, FY00-$750K, FY01-$750K, FY02-$750K, FY03-$750K, FY04-$750K. Use a combination of ocean modeling and satellite altimetric analysis to increase our understanding of LLWBCs. This includes their role in the global ocean circulation, dynamics, pathways, cross-equatorial flows and the similarities/differences in the Atlantic, Pacific and Indian Oceans.**"Thermodynamic and Topographic Forcing in Global Ocean Models"**, Office of Naval Research, Core Funding, FY00-$280K, FY01-$250K, FY02-$203K, FY03-$200K. To increase our understanding of the roles and impact of thermodynamic and topographic forcing on the global ocean circulation using the most suitable ocean and ice models, one of which will be HYCOM.

G.A. Jacobs:

"Slope to shelf Energetics and Exchange Dynamics", beginning 2003, Naval Research Laboratory, NRL 6.1 ARI, FY04-$1474K, FY05-$2064K, FY06-$1769K, FY07-$1253K. This project will provide the in situ measurements needed to properly evaluate the differences between the EnKF and the SEEK filters in the local study area of the northeastern Gulf of Mexico shelf slope/break area between the Mississippi outflow and the De Soto Canyon.

"Error Propagation in the Continental Shelf", 2000 to present, FY01-$350K, FY02-$480K, FY03-$480K, FY04-$480K. This project has provided an understanding of the basic mechanisms through which information of measurements propagates through ocean dynamical equations and influences environmental estimates.

"Dynamical Linkage of the East Asian Marginal Seas", 1998 to present, FY99-$600K, FY00-$775K, FY01-$880K, FY02-$750K, FY03-$750K. This project is aimed to understand the

fundamental physical mechanisms connecting the Asian marginal seas from the South China Sea, East China Sea, Yellow Sea, and Sea of Japan. An in situ deployment array of 12 acoustic Doppler current profilers (ADCPs) within the Korea Strait has provided the most extensive measurements ever taken in the area, and a comprehensive set of numerical model experiments have demonstrated the basic dynamics.

"Altimeter Data Fusion Center Support", 1998 to the present, FY98-$225K, FY99-$225K, FY00-$225K, FY01-$225K, FY02-$225K, FY03-$225K. This project has constructed the operation altimeter processing system (ALPS), which is producing daily operational products at the Naval Oceanographic Office.

P.J. Hogan:
"Coastal Ocean Nesting Studies (CO-NESTS)", Naval Research Laboratory, NRL 6.2 Base Program, FY04-$450K, FY05-$468K, FY06-$487K, FY07-$506K. CO-NESTS will investigate and develop accurate coupling methodologies for nesting very high-resolution coastal models of like and unlike design to global models. Additionally, HYCOM will be developed into a full-featured coastal ocean model by adding capabilities germane to that dynamical regime. For all the nested coastal regions, accurate boundary conditions could be provided by global HYCOM, the ocean model component of the NOPP GODAE.

A.J. Wallcraft:
"High Fidelity Simulation of Littoral Environments (HFSoLE)", High Performance Computing Modernization Office, CHSSI, FY01-$100K, FY02-$100K, FY03-$100K. Funded HYCOM code scalability and documentation.

C.A. Blain:
"A Nested Global to Shore Ocean Dynamics System Demonstration (GOM)", Naval Research Laboratory, NRL 6.1 Base Program, $175K, 10/1/02-9/30/03

"Improvements to the Conservation Properties of FE-Based Models", Office of Naval Research, ONR 6.2 Navy Ocean Modeling Program, $480K, 10/1/01-9/30/04

"High Fidelity Simulation of Littoral Environments", DoD MSRC CHSSI Program, $450K, 10/1/00-9/30/03

"Dynamics of in and around Coastal Embayments (BAYS)", Naval Research Laboratory, NRL 6.2 Base Program, $1495K, 10/1/00-9/30/03

J. Cummings:
"Ocean Data Assimilation for Coupled Systems", Office Naval Research, Naval Ocean Modeling Program, Award #: N0001401WX20693. $150K/year, FY00-FY03. Develop 3D oceanographic multivariate optimum interpolation system and develop automated ocean data quality control system.

"Ocean Data Assimilation for COAMPS", N096 RDT&E, Program Element 0603207N, $150K/year, FY00-FY03. Transition 3D ocean MVOI to FNMOC as part of COAMPS. Transition QC system to FNMOC. Add new ocean data types to QC and analysis.

"Data Assimilation and Ocean Data Quality Control Upgrades in SWAFS (Shallow Water Analysis and Forecast System)", N096 RDT&E and ONR RTP, $430K/year, FY02-FY04. Integrate 3D ocean MVOI and automated QC into SWAFS and transition 3D MVOI and QC to NAVOCEANO.

Pending. **National Oceanographic Partnership Program (NOPP) proposal, "A Prototype System for Improving Satellite Derived Sea Surface Temperature Through Enhanced In Situ Validation Measurements"**. Peter Minnett, RSMAS, Principle Investigator. $40K/year. Develop methods for data assimilation of skin SSTs in COAMPS

Pending. Joint Center Satellite Data Assimilation, **"Detection and Correction of Aerosol Contamination in Infrared Satellite Sea Surface Temperature Retrievals."** James Cummings and Doug Westphal, Co-Principle Investigators. $150K/year. Develop methods for bias detection and removal in satellite SSTs.

U.S. GODAE: Global Ocean Prediction with the HYbrid Coordinate Ocean Model (HYCOM)

NRL Monterey Principal Investigator: (Richard M. Hodur)

RICHARD M. HODUR
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Starting date: June 1, 2003

Total Federal Funds Requested:

FY04	FY05	FY06	FY07	FY08
$50K	$75K	$225K	$250K	$300K

Work statement for NRL MRY (Richard Hodur, Maria Flatau, Xiaodong Hong, Julie Pullen)

NRL/Monterey will use the global ocean data assimilation system developed in this project to help in the transition of a global coupled air-ocean data assimilation system to FNMOC, and for initial and lateral boundary conditions in the ocean model used within the Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS™; Hodur 1997). Currently, NRL MRY is working toward the development of a global air-ocean coupled system using the Navy Operational Global Atmospheric Prediction System (NOGAPS) and the Parallel Ocean Prediction model (POP), and the transition of this system to the Fleet Numerical Meteorology and Oceanography Center (FNMOC). Within this project, we will adapt HYCOM as our ocean model. We will leverage existing and planned projects that address atmospheric model forcing (e.g., surface fluxes, radiation) and data assimilation, and we will evaluate the improved capabilities of HYCOM using these improved surface forcing fields and data assimilation techniques in this project. NRL MRY will also develop a generalized interface to utilize the HYCOM fields as initial conditions for the ocean model in COAMPS™. Initialization methods, such as the digital filter, will be tested with the COAMPS™ ocean model to minimize the impact of the imbalance in the initial conditions on the subsequent ocean forecast. Such a procedure is necessary when adapting COAMPS™ to a new area of the globe, as is routinely done for the atmospheric components of COAMPS™. Following this initial "cold-start", all subsequent COAMPS™ forecasts will use the previous COAMPS™ ocean forecast for first-guess conditions. HYCOM will also be necessary to supply time dependent conditions at the lateral boundaries of the outermost COAMPS™ grid. An interface will be developed to extract the time tendency information from the global HYCOM predictions in the regions where the lateral boundary conditions are to be used by the COAMPS™ ocean model. Tests will be performed to validate the ability of our technique in preserving the structure the incoming momentum and thermohaline characteristics across the lateral boundaries for a number of different geographical areas. We will ensure consistency between the bathymetry and land-sea boundaries of the COAMPS™ and the HYCOM grids to reduce the excitation of spurious waves at and near the COAMPS™ ocean lateral boundaries.

References:

Hodur, R. M., 1997: The Naval Research Laboratory's Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS). *Mon. Wea. Rev.*, **125**, 1414-1430.

Budget ($K):

NRL MRY	FY04	FY05	FY06	FY07	FY08
	50	75	225	250	300

Current Funding:

Coupled Data Assimilation: $225K
Global Coupled Modeling: $275K
Mesoscale Coupled Modeling: $300K
Advanced Surface Flux Parameterization: $200K

Pending Funding:

All coupled projects are proposed on an annual basis. Advanced Surface Flux Parameterization funding has been approved through FY 2005, with level funding.

Budget (salary + overhead) for NRL MRY portion of GODAE proposal ($K)

	Year 1	Year 2	Year 3	Year 4	Year 5
Flatau		25	125	125	150
Hodur	10	10	10	10	10
Hong	40	40	50	75	80
Pullen			30	30	50
Travel			5	5	5
Materials			5	5	5
Total	**50**	**75**	**225**	**250**	**300**

NRL MRY Milestones:

Year 1:

1. Begin development of a generalized interface to utilize the HYCOM fields as initial and boundary conditions for the ocean model in COAMPS™.

Year 2:

1. Complete development of a generalized interface to utilize the HYCOM fields as initial and boundary conditions for the ocean model in COAMPS™ and begin testing impact on COAMPS™ ocean model forecasts.
2. Adapt HYCOM for use as the ocean model in global air-ocean coupled system that uses NOGAPS as the atmospheric model and evaluate ocean forecasts.

Year 3:

1. Test NOGAPS/HYCOM air-ocean global coupled system and validate performance relative to currently used NOGAPS/POP system.
2. Transition NOGAPS/HYCOM coupled system (global) to FNMOC.
3. Validate the ability of COAMPS™ in preserving the structure the incoming momentum and thermohaline characteristics across the lateral boundaries when using HYCOM for the lateral boundary conditions. Test for a number of different geographical areas.

Year 4:

1. Study the use of initialization methods, such as the digital filter, on the COAMPS™ ocean model when using HYCOM for initial conditions. Test for a number of different geographical areas.
2. Evaluate NOGAPS/HYCOM coupled system using improved data assimilation methods developed by other groups in GODAE project.

Year 5:

1. Document, and transition to FNMOC, the COAMPS™ air-ocean coupled system using HYCOM fields for initial and lateral boundary conditions.
2. Document, and transition to FNMOC, improved data assimilation for HYCOM to NOGAPS/HYCOM air-ocean coupled system running at FNMOC.

U.S. GODAE: Global Ocean Prediction with the Hybrid Coordinate Ocean Model

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Co-Principal Investigator: Desiraju B. Rao
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Marine Modeling & Analysis Branch/Environmental Modeling Center
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301-763-8000, x-7207
301-763-8545 (Fax)

This proposal is submitted pursuant to the Broad Area Announcement, dated December 11, 2002, entitled "Global Ocean Data Assimilation Experiment" by NOAA on behalf of the National Oceanographic Partnership Program (Docket No.021202295-2295-01) for Fiscal Year 2003.

Funding requested: $1,266 K

Funding provided in kind: $ 5276 K

Period of performance: 1 June 2003-31 May 2007

2/20/03
Carlos Lozano Date
Marine Modeling & Analysis Branch

2/20/03
Desiraju B. Rao, Chief
Marine Modeling & Analysis Branch Date

2/20/03
Stephen Lord, Director Date
Environmental Modeling Center

Environmental Modeling Center/NCEP is a government institution

NCEP/MMAB Budget Justification

NCEP will contribute to the computational resources of this project by allocating approximately 10% of the development half of the (IBMsp) central computers. The cost sharing from this resource is approximately $500K/year. The computer cost estimates are conservatively kept constant at $500K/year.

NCEP is providing about 90% of the salary for Dr. Carlos Lozano who is the key scientist responsible to carry out the proposed work. To support his research, NCEP also is contributing the support for one full time Research Scientist, two full time equivalent programmer (contractors) and a half-time equivalent civil servant(s). The Research Scientist is a new full time research position, starting on Year 1, to work on the development of the forecast system for the duration of the grant. We are seeking support from NOPP for one full time research Scientist, starting on Year 1, to work on the calibration of the model; and for another full time Research Scientist, starting on Year 2, to focus on data assimilation. In addition NCEP is seeking support from NOPP for partial support (60%) a new scientific programmer. The effort involved in developing, testing and running a complex forecast system, ensuring the automatic execution of daily runs to provide the model fields to the GODAE community, and users, post-processing model output for monitoring and diagnostics, trouble shooting when necessary, maintenance of the codes, etc requires at the minimum the support of 3 full time programmers. Dr. Desiraju Rao time is for administrative support, technical supervision, and consultations.

This work also receives support from other valuable NCEP's resources, such as access to all real time weather prediction model fields, infrastructure support from the Computer Center.The Computer Center ensures the receipt of all data - meteorological/oceanographic- from around the world in real time, running the models, post-processing and distribution. These assets are difficult to quantify and they are not included explicitly in dollar amount.

Year-1 budget

	Cost Sharing			Requested	
Salaries and Fringe Benefits	mm	Amount K$		mm	Amount K$
Senior Personnel					
Dr. Carlos Lozano, PI	11	135		1	15
Dr. Desiraju B. Rao, co-PI	0.5	8		0	0
Research Scientist I	12	90		0	0
Research Scientist II	0	0		12	90
Support Personnel					
Dr. Grumbine & Dr. Chao	3	70		0	0
Research Associate	4.8	30		7.2	45
Scientific Programmer (2)	24	160		0	0
Total Salaries and Benefits		492			150
Computer Hardware and Software (IBMsp)		500			0
Travel		1			4
Publications		1			1
Total Direct and Indirect Costs		994			155

Year-2 budget

	Cost Sharing			Requested	
Salaries and Fringe Benefits	mm	Amount K$		mm	Amount K$
Senior Personnel					
Dr. Carlos Lozano, PI	11	142		1	16
Dr. Desiraju B. Rao, co-PI	0.5	8		0	0
Research Scientist I	12	95		0	0
Research Scientist II	0	0		12	95
Research Scientist III	0	0		12	90
Support Personnel					
Dr. Grumbine & Dr. Chao	3	74		0	0
Research Associate	4.8	37		7.2	48
Scientific Programmer (2)	24	168		0	0
Total Salaries and Benefits		522			249
Computer Hardware and Software (IBMsp)		500			0
Travel		1			4
Publications		2			2
Total Direct and Indirect Costs		1,025			255

Year-3 budget

	Cost Sharing			Requested	
Salaries and Fringe Benefits	mm	Amount K$		mm	Amount K$
Senior Personnel					
Dr. Carlos Lozano, PI	11	148		1	17
Dr. Desiraju B. Rao, co-PI	0.5	9		0	0
Research Scientist I	12	100		0	0
Research Scientist II	0	0		12	100
Research Scientist III	0	0		12	95
Support Personnel					
Dr. Grumbine & Dr. Chao	3	79		0	0
Research Associate	4.8	39		7.2	51
Scientific Programmer (2)	24	177		0	0
Total Salaries and Benefits		552			263
Computer Hardware and Software (IBMsp)		500			0
Travel		1			5
Publications		2			2
Total Direct and Indirect Costs		1,054			270

Year-4 budget

	Cost Sharing			Requested	
Salaries and Fringe Benefits	mm	Amount K$		mm	Amount K$
Senior Personnel					
Dr. Carlos Lozano, PI	11	156		1	18
Dr. Desiraju B. Rao, co-PI	0.5	9		0	0
Research Scientist I	12	105		0	0
Research Scientist II	0	0		12	105
Research Scientist III	0	0		12	100
Support Personnel					
Dr. Grumbine & Dr. Chao	3	84		0	0
Research Associate	4.8	41		7.2	54
Scientific Programmer (2)	24	187		0	0
Total Salaries and Benefits		582			277
Computer Hardware and Software (IBMsp)		500			0
Travel		3			5
Publications		0			3
Total Direct and Indirect Costs		1,085			285

Year-5 budget

	Cost Sharing			Requested	
Salaries and Fringe Benefits	mm	Amount K$		mm	Amount K$
Senior Personnel					
Dr. Carlos Lozano, PI	11	164		1	19
Dr. Desiraju B. Rao, co-PI	0.5	10		0	0
Research Scientist I	12	111		0	0
Research Scientist II	0	0		12	111
Research Scientist III	0	0		12	105
Support Personnel					
Dr. Grumbine & Dr. Chao	3	90		0	0
Research Associate	4.8	44		7.2	57
Scientific Programmer (2)	24	197		0	0
Total Salaries and Benefits		616			292
Computer Hardware and Software (IBMsp)		500			0
Travel		1			6
Publications		1			3
Total Direct and Indirect Costs		1,118			301

U.S. GODAE: Global Ocean Prediction with the HYbrid Coordinate Ocean Model (HYCOM)

Principal Investigator: W. C. Thacker

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Institutional Representative: Kristina Katsaros

Dr. Kristina Katsaros
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Starting date: June 1, 2003

Total Federal Funds Requested: $ 645,756

Year 1	Year 2	Year 3	Year 4	Year 5
$0	$152,275	$157,313	$164,704	$171,464

AOML Budget Justification

The major costs for AOML are salaries and benefits, as the nature of the work is highly labor-intensive. AOML will continue the tasks it is currently doing as part of the HYCOM NOPP project and will evolve toward being an active participant in NCEP's operational effort. Activities can be categorized into three areas: (1) continuing todevelop and improve the capability of assimilating profile data into HYCOM and expand it to deal with satellite observations in a synergistic way; (2) prepare capability for accurately estimating covariability of oceanic fields so that XBT data will provide better information about salinity and density and so that geopotential height will provide better information about subsurface behavior; and (3) perform detailed model-data comparisons to determine how the model might be improved, to determine how the assimilation system might be improved, and to monitor the skill of the operational forecasts.

Twenty-five percent of the principal investigator's salary is requested from NOPP with the remaining 75% covered by AOML. The largest expense to NOPP is the salary of a postdoctoral research associate, who will focus on tasks (1) and (3). One month of a programmer's salary is charged for assistance with computational and data-handling issues, while secretarial support is contributed by AOML. These costs are not shown for the first year, as they are already covered by the HYCOM NOPP project. Dr. Donald Hansen, who is a senior observational oceanographer, will contribute to areas (2) and (3); his salary is entirely covered by AOML. A RSMAS postdoc, not indicated in this budget, will provide additional help with (2).

Budget breakdown for 5 year proposal to NOPP

Budget Breakdown - Year 1		Cost Sharing AOML mm		Requested NOPP mm	
Salaries and Fringe Benefits					
A. Senior Personnel					
AOML	Dr. Carlisle Thacker, Sen Res Sci, PI / PD	0.0	0	0.0	0
CIMAS	Dr. Don Hansen (CIMAS)	6.0	42,000	0.0	0
B. Support Personnel					
CIMAS	Postdoctoral Research Associate	0.0	0	0.0	0
AOML	Computer Specialist	0.0	0	0.0	0
AOML	Secretary	0.0	0	0.0	0
	TOTAL SALARIES	6.0	42,000	0.0	0
C. Fringe Benefits			3,570		0
	TOTAL SALARIES AND FRINGE BENEFITS		45,570		0
D. Permanent Equipment					
	Computer Hardware/Software		0		0
E. Travel - Domestic			0		0
F. Publications			0		0
G. Other					
	Computer hardware/software maintenance		0		0
H. Total Direct Costs			45,570		0
I. Indirect Costs			13,759		0
J. Total Direct and Indirect Costs			59,329		0

Budget breakdown for 5 year proposal to NOPP

Budget Breakdown - Year 2		Cost Sharing AOML mm		Requested NOPP mm	
Salaries and Fringe Benefits					
A. Senior Personnel					
AOML	Dr. Carlisle Thacker, Sen Res Sci, PI / PD	9.0	98,975	3.0	32,992
CIMAS	Dr. Don Hansen (CIMAS)	6.0	42,000	0.0	0
B. Support Personnel					
CIMAS	Postdoctoral Research Associate	0.0	0	12.0	45,000
AOML	Computer Specialist	0.0	0	1.0	8,288
AOML	Secretary	1.0	3,106	0.0	0
	TOTAL SALARIES	16.0	144,081	15.0	86,279
C. Fringe Benefits			27,559		21,401
	TOTAL SALARIES AND FRINGE BENEFITS		171,640		107,680
D. Permanent Equipment					
	Computer Hardware/Software		0		4,000
E. Travel - Domestic			0		2,500
F. Publications			0		3,000
G. Other					
	Computer hardware/software maintenance		0		2,000
H. Total Direct Costs			171,640		119,180
I. Indirect Costs			59,144		33,095
J. Total Direct and Indirect Costs			230,784		152,275

Budget breakdown for 5 year proposal to NOPP

Budget Breakdown - Year 3		Cost Sharing AOML mm	Cost Sharing AOML	Requested NOPP mm	Requested NOPP
Salaries and Fringe Benefits					
A. Senior Personnel					
AOML	Dr. Carlisle Thacker, Sen Res Sci, PI / PD	9.0	103,923	3.0	34,641
CIMAS	Dr. Don Hansen (CIMAS)	6.0	42,000	0.0	0
B. Support Personnel					
CIMAS	Postdoctoral Research Associate	0.0	0	12.0	47,250
AOML	Computer Specialist	0.0	0	1.0	8,702
AOML	Secretary	1.0	3,262	0.0	0
	TOTAL SALARIES	16.0	149,185	15.0	90,593
C. Fringe Benefits			28,758		22,471
	TOTAL SALARIES AND FRINGE BENEFITS		177,943		113,064
D. Permanent Equipment					
	Computer Hardware/Software		0		2,000
E. Travel - Domestic			0		2,500
F. Publications			0		3,000
G. Other					
	Computer hardware/software maintenance		0		2,000
H. Total Direct Costs			177,943		122,564
I. Indirect Costs			61,414		34,749
J. Total Direct and Indirect Costs			239,357		157,313

Budget breakdown for 5 year proposal to NOPP

Budget Breakdown - Year 4		Cost Sharing AOML mm	Cost Sharing AOML	Requested NOPP mm	Requested NOPP
Salaries and Fringe Benefits					
A. Senior Personnel		**mm**		**mm**	
AOML	**Dr. Carlisle Thacker, Sen Res Sci, PI / PD**	**9.0**	**109,119**	**3.0**	**36,373**
CIMAS	**Dr. Don Hansen (CIMAS)**	**6.0**	**42,000**	**0.0**	**0**
B. Support Personnel					
CIMAS	**Postdoctoral Research Associate**	**0.0**	**0**	**12.0**	**49,613**
AOML	**Computer Specialist**	**0.0**	**0**	**1.0**	**9,137**
AOML	**Secretary**	**1.0**	**3,425**	**0.0**	**0**
	TOTAL SALARIES	**16.0**	**154,544**	**15.0**	**95,123**
C. Fringe Benefits			**30,018**		**23,594**
	TOTAL SALARIES AND FRINGE BENEFITS		**184,562**		**118,717**
D. Permanent Equipment					
	Computer Hardware/Software		**0**		**2,000**
E. Travel - Domestic			**0**		**2,500**
F. Publications			**0**		**3,000**
G. Other					
	Computer hardware/software maintenance		**0**		**2,000**
H. Total Direct Costs			**184,562**		**128,217**
I. Indirect Costs			**63,796**		**36,487**
J. Total Direct and Indirect Costs			**248,358**		**164,704**

Budget breakdown for 5 year proposal to NOPP

Budget Breakdown - Year 5		Cost Sharing AOML mm	Cost Sharing AOML	Requested NOPP mm	Requested NOPP
Salaries and Fringe Benefits					
A. Senior Personnel		**mm**		**mm**	
AOML	**Dr. Carlisle Thacker, Sen Res Sci, PI / PD**	**9.0**	**114,575**	**3.0**	**38,192**
CIMAS	**Dr. Don Hansen (CIMAS)**	**6.0**	**42,000**	**0.0**	**0**
B. Support Personnel					
CIMAS	**Postdoctoral Research Associate**	**0.0**	**0**	**12.0**	**52,093**
AOML	**Computer Specialist**	**0.0**	**0**	**1.0**	**9,594**
AOML	**Secretary**	**1.0**	**3,596**	**0.0**	**0**
	TOTAL SALARIES	**16.0**	**160,171**	**15.0**	**99,879**
C. Fringe Benefits			**31,340**		**24,774**
	TOTAL SALARIES AND FRINGE BENEFITS		**191,512**		**124,653**
D. Permanent Equipment					
	Computer Hardware/Software		**0**		**1,000**
E. Travel - Domestic			**0**		**2,500**
F. Publications			**0**		**3,000**
G. Other					
	Computer hardware/software maintenance		**0**		**2,000**
H. Total Direct Costs			**191,512**		**133,153**
I. Indirect Costs			**66,298**		**38,311**
J. Total Direct and Indirect Costs			**257,810**		**171,464**

Budget breakdown for 5 year proposal to NOPP

Budget Breakdown - Year 1-5		Cost Sharing AOML mm		Requested NOPP mm	
Salaries and Fringe Benefits					
A. Senior Personnel					
AOML	Dr. Carlisle Thacker, Sen Res Sci, PI / PD	36.0	426,593	12.0	142,198
CIMAS	Dr. Don Hansen (CIMAS)	30.0	210,000	0.0	0
B. Support Personnel					
CIMAS	Postdoctoral Research Associate	0.0	0	48.0	193,956
AOML	Computer Specialist	0.0	0	4.0	35,721
AOML	Secretary	4.0	13,388	0.0	0
	TOTAL SALARIES	70.0	649,981	60.0	371,874
C. Fringe Benefits			121,246		92,239
	TOTAL SALARIES AND FRINGE BENEFITS		771,227		464,113
D. Permanent Equipment					
	Computer Hardware/Software		0		9,000
E. Travel - Domestic			0		10,000
F. Publications			0		12,000
G. Other					
	Computer hardware/software maintenance		0		8,000
H. Total Direct Costs			771,227		503,113
I. Indirect Costs			264,412		142,642
J. Total Direct and Indirect Costs			1,035,638		645,756

U.S. GODAE: Global Ocean Prediction with the HYbrid Coordinate Ocean Model (HYCOM)

Co-Principal Investugator: (_____)

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Institutional Representative: (_____)

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Starting date: June 1, 2003

Total Federal Funds Requested: **$867,744**

Year 1	Year 2	Year 3	Year 4	Year 5
$80,151	**$111,765**	**$222,087**	**$225,818**	**$227,923**

PMEL Budget Justification

The PMEL data management budget (LAS) includes 1 month of salary per year for the PI (Hankin), and respectively 7, 10, 16, 16 and 16 months of total support per year (assuming 5 years) for employee-members of the Thermal Modeling and Analysis Project (TMAP) at PMEL. TMAP members involved in this Partnership include NOAA employee Ansley Manke (mathematician), and NOAA-U. Washington Joint Institute (JISAO) employees Dr. Jonathan Callahan (software developer), Kevin O'Brien (systems manager) and Joseph Mclean (support for Partners). TMAP member Roland Schweitzer, software developer at UCAR/NOAA (CIRES) Joint Institute, is involved at a 2 month/year level for his special expertise in community networks (including software components from Unidata) and XML communications. Contract services are included in years 3 through 5 of the proposal for focused LAS enhancements that will address the task of user interface design for model-data intercomparison within LAS. (The limited capabilities of the user interface tools available for the browser/HTML development environment make this an especially challenging task.)

For years one and two of this work we estimate that $90K/year of support are contributed in-kind each year by the Office of Naval Research (ONR) (six months of for JISAO employee Jon Callahan and 1.5 months of support for the PI, Hankin). ONR supports PMEL as a software development organization within the US GODAE server effort in Monterey. The $90K/year represents approximately 60% of the PMEL effort on the US Monterey Server -- the fraction which directly contributes to the proposed HYCOM work.

The travel budget includes visits to permit developers from the TMAP group to coordinate with Partnership members. In the third year a trip is included to present results at a technical meeting.

The equipment budget includes the purchase of an Internet server for server software development in the first year and a replacement desktop personal computer in the third year. The latter is consistent with a life span of 3 years for computer equipment – the total personnel time in the budget.

Note: The Live Access Server (LAS) (along with the OPeNDAP ("DODS") protocol) has become a core component of the data sharing tool kit for the emerging GODAE community. It is therefore natural that multiple GODAE-related projects have included LAS and the TMAP group in responses to this BAA. This proposal is one of 3 responses to this Dec. 11 2002 NOPP GODAE BAA in which the TMAP group is involved for the provision of data management tools and services. There is some overlap in the software development tasks required on the three proposals. We regard this (the HYCOM) proposal as the core software development activity of the three. In the other two proposals approximately 2/3 of the resources of that proposal are devoted to project-specific needs and 1/3 are devoted to software development needs that are covered in the HYCOM proposal. Thus, if one or both of the other BAA responses in which the TMAP group is involved are funded in addition to this (HYCOM) proposal, the PMEL/TMAP portions of those proposal budgets may be reduced by 1/3. A note to that effect is included in the budget justification text for those proposals.

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PMEL-HYCOM BUDGET	Year One	Year Two	Year Three	Year Four	Year Five
Direct Labor					
PI salary (Hankin) (1 mo/year)	10,019	10,420	10,837	11,271	11,721
other NOAA Salary	6,745	21,043	29,180	30,347	31,561
JISAO Salary	25,576	29,649	55,195	57,403	59,699
NOAA Benefit @ 22.3% of Sal+Lv	3,738	7,016	8,924	9,281	9,652
JISAO Benefit @ 24.5% of Sal	6,266	7,264	13,523	14,064	14,626
Total Salary and Benefits	**52,344**	**75,393**	**117,659**	**122,365**	**127,260**
Other Direct Costs					
Travel	1,100	2,200	3,300	2,200	2,200
Supplies & Materials	500	500	500	500	500
Equipment	2,500	500	2,500	500	500
Computing expenses	2,800	4,004	6,436	6,693	6,961
Contract	0	0	45,000	45,000	40,000
Total Other Direct Costs	**6900**	**7,204**	**57,736**	**54,893**	**50,161**
Indirect Costs					
F&A/NOAA 41% of Base (30.3, 31.5, 40.0)	6,873	12,900	16,407	17,063	17,746
F&A/JISAO 26% of Sal+Ben (35.5, 40.7, 68.7)	8,279	9,597	17,867	18,581	19,325
F&A/JISAO 22.5% of Sal (28.5, 32.7, 55.2)	5,755	6,671	12,419	12,916	13,432
Total Indirect Costs	**20,907**	**29,168**	**46,693**	**48,560**	**50,503**
Total Request	**80,151**	**111,765**	**222,087**	**225,818**	**227,923**
Grand total:		**867,744**			

Current and Pending proposals – PM Hankin, PMEL

Current

"Support for the US GODAE Server in Monterey"
Office of Naval Research
10/1/01-9/30/03 PMEL support: $437K PI months: 1.5 ('03), 1.5 ('04)

"Coordination and Management of the U.S. JGOFS Synthesis and Modeling"
NSF - proposal number 73-65-66
3/1/01 - 2/28/04 PMEL support: $205K PI months: 0.5 ('03)

"THematic Real-time Environmental Distributed Data Services (THREDDS)"
NSF/NSDL: proposal number 0121623
7/1/01 - 6/30/04 PMEL support: $40K PI months: 0.2 ('03)

"From Web Servers to Web Services: Communicating between distributed computing resources with SOAP/XML"
NOAA/HPCC
10/1/02-9/30/03 PMEL support: $35K PI months: 1.0 ('03)

Pending

"Ocean Web Portal"
NASA NRA-02-OES-04
04/1/03-03/31/06 PMEL support: $88 PI months: .25,.5,.5,.25 ('03-'06)

"A Thematic Data Portal to Satellite-Derived Ocean Surface Properties: Discovery and Access"
NASA CAN-02-OES-01
04/1/03-03/31/08 PMEL support: $549 PI months: 1,2,2,2,2,1 ('03-'08)

"Toward the Future of Hazardous Spill Response in U.S. Navable Waters – Integrating NASA Environmental Assets with NOAA Hazardous Materials"
NASA CAN-02-OES-01
04/1/03-03/31/08 PMEL support: $749 PI months: 1.5,2.5,2,2,2,1 ('03-'08)

Global Ocean Predication with the HYbrid Coordinate Ocean Model (HYCOM)
National Ocean Partnership Program – GODAE BAA Dec. 2002
06/1/03-05/31/06 PMEL support: $484 PI months: .3,1,1,.7 ('03-'06)

US GODAE: Weak 4DVAR for Real-time ENSO Initialization and Prediction
National Ocean Partnership Program – GODAE BAA Dec. 2002
06/1/03-05/31/06 PMEL support: $349 PI months: .3,1,1,.7 ('03-'06)

U.S. GODAE: Implementation of a Pacific Islands Ocean Information Service
National Ocean Partnership Program – GODAE BAA Dec. 2002
06/1/03-05/31/06 PMEL support: $350 PI months: .3,1,1,.7 ('03-'06)

U.S. GODAE: Global Ocean Prediction with the HYbrid Coordinate Ocean Model (HYCOM)

Principal Investigator: _____ Date: 2/12/03

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Institutional Representative: _____ Date: 2/12/03

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Starting date: June 1, 2003

Total Federal Funds Requested: $345,000.00

Year 1	Year 2	Year 3	Year 4	Year 5
$50K	$55K	$75K	$80K	$85K

Budget Justification

The National Centers For Environmental Prediction (NCEP) Ocean Prediction Center (OPC) portion of this proposal is to improve existing oceanographic features observing techniques (years one and two), evaluate the NCEP North Atlantic Ocean Forecast System (NAOFS) output provided by the NCEP/Marine Modeling and Applications Branch (MMAB) and develop appropriate NAOFS based products for use by NWS offshore and coastal forecasters (years three through five).

This effort will require one part time oceanographer/programmer for years one and two to be converted to full time years three through five for the full evaluation and product development process. NCEP OPC will provide 5% of Mr. Sienkiewicz's time for administrative support, supervision, and consultation. In addition, OPC operational forecasters will be called upon to review model output and provide feedback for potential products (approximately 5% of one equivalent full time employee for years one and two and 10% for years three through five). NCEP OPC will also provide workspace, and infrastructure support including access to NCEP wide computer facilities and resources.

Year-1 budget for evaluation of NAOFS model output[a]

	OPC Cost Sharing	NOPP Requested
Salaries and Fringe Benefits		
Senior Personnel		
Mr. Joseph Sienkiewicz, PI (5% FTE)	5	0
Support Personnel		
Research Scientist (new hire) (part time)	0	27
Forecaster evaluation (5% FTE)	5	0
Total Salaries and fringe	10	27
Computer Hardware/Software (procurement)	0	4
Computer time	2.5	
Travel	0	1
Publications	0	0
Total Direct Costs	12.5	32
Indirect Costs [c]	6.13	18
Total direct and indirect costs	18.4	50

[a] thousands of $
[b] NOAA 61.25% SAIC 60.6%

Year-2 budget for evaluation of NAOFS model output

	OPC Cost Sharing	NOPP Requested
Salaries and Fringe Benefits		
Senior Personnel		
Mr. Joseph Sienkiewicz, PI (5% FTE)	5	0
Support Personnel		
Research Scientist (part time)	0	31.5
Forecaster evaluation (5% FTE)	5	0
Total Salaries and fringe	10	31.5
Computer Hardware/Software	0	1
Computer time	2.5	
Travel	0	2
Publications	0	0
Total Direct Costs	12.5	34.5
Indirect Costs [b]	6.1	20.5
Total direct and indirect costs	18.6	55

[b] NOAA 61.25% SAIC 60.6%

Year-3 budget for evaluation of NAOFS model output

	OPC Cost Sharing	NOPP Requested
Salaries and Fringe Benefits		
Senior Personnel		
Mr. Joseph Sienkiewicz, PI (5% FTE)	6	0
Support Personnel		
Research Scientist (full time)	0	42.5
Forecaster evaluation (10% FTE)	10	0
Total Salaries and fringe	16	42.5
Computer Hardware/Software	0	2.5
Computer time	2.5	
Travel	0	2.5
Publications	0	0
Total Direct Costs	18.5	47.5
Indirect Costs [a]	9.8	27.5
Total direct and indirect costs	28.3	75

[a] NOAA 61.25% SAIC 60.6%

Year-4 budget for evaluation of NAOFS model output

	OPC Cost Sharing	NOPP Requested
Salaries and Fringe Benefits		
Senior Personnel		
Mr. Joseph Sienkiewicz, PI (5% FTE)	6	0
Support Personnel		
Research Scientist	0	45.5
Forecaster evaluation (10% FTE)	10	0
Total Salaries and fringe	16	45.5
Computer Hardware/Software	0	1.5
Computer time	2.5	
Travel	0	2
Publications	0	1.5
Total Direct Costs	18.5	50.5
Indirect Costs [a]	9.8	29.5
Total direct and indirect costs	28.3	80

[a] NOAA 61.25% SAIC 60.6%

Year-5 budget for evaluation of NAOFS model output

	OPC Cost Sharing	NOPP Requested
Salaries and Fringe Benefits		
Senior Personnel		
Mr. Joseph Sienkiewicz, PI (5% FTE)	6	0
Support Personnel		
Research Scientist	0	48.5
Forecaster evaluation (10% FTE)	10	0
Total Salaries and fringe	16	48.5
Computer Hardware/Software	0	1
Computer time	2.5	
Travel	0	2.5
Publications	0	1.5
Total Direct Costs	18.5	53.5
Indirect Costs [a]	9.8	31.5
Total direct and indirect costs	28.3	85

[a] NOAA 61.25% SAIC 60.6%

Current and Pending Support:

NOPP – The Operational Utilization of High Resolution Ocean Surface Wind Vectors (25km or better) in the Marine Forecasting Environment

Approved: Fall 2002
Funded: January 2003

Lead PI: Paul Chang – NOAA/NESDIS/ORA
PI: Richard Knabb – NOAA/NWS/NCEP/Tropical Prediction Center
PI: Joseph Sienkiewicz – NOAA/NWS/NCEP/Ocean Prediction Center
PI: Peter W. Gaiser – Naval Research Laboratory
PI: David Long – BYU Center for Remote Sensing
PI: Mark Freeburg – OCENS Inc.

The Ocean Prediction Center role in this proposal is to develop a gridded ocean vector wind product based on QuikSCAT data and to include SEAWINDS data when it becomes available. This product will be distributed to the U.S. Coast Guard to aid in Search and Rescue efforts and to marine customers via the internet and OCENS Inc.

U.S. GODAE: Global Ocean Prediction with the HYbrid Coordinate Ocean Model (HYCOM)

Principal Investigator: (Ole M. Smedstad)

Ole Martin Smedstad
Principal Scientist
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Institutional Representative: (Paul J. Banas)

Paul J. Banas
Vice President
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Starting date: June 1, 2003

Total Federal Funds Requested: $816,898

Year 1	Year 2	Year 3	Year 4	Year 5
$87,415	$169,705	$177,873	$186,450	$195,455

Planning Systems Incorporated
Costing submitted in response to ONR NOPP BAA 02-011
U.S. GODAE: Global Ocean Prediction with the HYbrid Coordinate Ocean Model (HYCOM)
University of Miami (prime), E. Chaussignet POC

PSI Cost Proposal Summary

Direct Labor - In-House	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	
Administration	$981	$1,030	$1,081	$1,135	$1,192	
Direct Labor - Field Site						
Program Manager	$1,817	$1,908	$2,004	$2,104	$2,209	
Direct Labor - Government Site						
Principal Scientist (Smedstad)	$22,872	$45,483	$47,757	$50,145	$52,652	
Oceanographer (Lunde)	$17,896	$35,589	$37,368	$39,237	$41,199	
Total Overhead	$26,116	$49,616	$52,097	$54,702	$57,437	
Total Travel	$1,320	$4,185	$4,185	$4,185	$4,185	
Total Other Direct Costs	$500	$1,000	$1,000	$1,000	$1,000	
G & A @ 13.2 %	$9,438	$18,323	$19,205	$20,131	$21,103	
Fixed Fee @ 8 %	$6,475	$12,571	$13,176	$13,811	$14,478	**Total Cost Estimate (5 years)**
Total Estimated Cost Plus Fixed Fee	$87,415	$169,705	$177,873	$186,450	$195,455	**$816,898**
Estimated PSI Cost Contribution						**$250,000**

Cost Justification: Justifications for each cost element appear on the detailed cost pages provided for each year proposed.

PSI Contribution to Partnership: Automated and interactive ocean feature identification and assimiliation technologies developed by PSI through ongoing partnership with NRL under direct contract (N00014-96-D-6031) and associated intellectual property leveraged for the work proposed herein. This contribution is estiamted to be approximately $50,000 per year, for a total of $250,000 over the 5-year term of the proposed contract.

Planning Systems Incorporated
Costing submitted in response to ONR NOPP BAA 02-011
U.S. GODAE: Global Ocean Prediction with the HYbrid Coordinate Ocean Model (HYCOM)
University of Miami (prime), E. Chaussignet POC
PSI Cost Proposal Year 1

Direct Labor - In-House	**PSI Category**	**Hours**	**Rate**	**Amount**
Administration	Associate Staff	40	$24.52	$981
Total Direct Labor - In-House		40		$981
Direct Labor - Field Site				
Program Manager	Principal Staff	40	$45.43	$1,817
Total Direct Labor - Field Site		40		$1,817
Direct Labor - Government Site				
Principal Scientist (Smedstad)	Principal Staff	528	$43.32	$22,872
Oceanographer (Lunde)	Staff Member	528	$33.89	$17,896
Total Direct Labor - Government Site		1,056		$40,768
Total Direct Labor		1,136		$43,566
Overhead				
In-House @ 100%			$981	
Field Site @ 82%			$1,490	
Government Site @ 58%			$23,645	
Total Overhead				$26,116
Total Direct Labor Plus Overhead				$69,682
Travel				
SSC, MS to Miami, FL - 1 person x 5 days x 1 trip				
Airfare ($300)			$300	
Per Diem ($144/day x 5 days)			$720	
Rental car ($60/day x 5 days)			$300	
Total Travel				$1,320
Other Direct Costs				
Miscellaneous consumables/telephone/postage/copying			$500	
Total Other Direct Costs				$500
Total Direct Costs Plus Overhead				$71,502
G & A @ 13.2 %				$9,438
Total Estimated Cost				$80,940
Fixed Fee @ 8 %				$6,475
Total Estimated Cost Plus Fixed Fee				**$87,416**

Planning Systems Incorporated
Costing submitted in response to ONR NOPP BAA 02-011
U.S. GODAE: Global Ocean Prediction with the HYbrid Coordinate Ocean Model (HYCOM)
University of Miami (prime), E. Chaussignet POC
PSI Cost Proposal Year 2

Direct Labor - In-House	**PSI Category**	**Hours**	**Rate**	**Amount**
Administration	Associate Staff	40	$25.75	$1,030
Total Direct Labor - In-House		40		$1,030
Direct Labor - Field Site				
Program Manager	Principal Staff	40	$47.70	$1,908
Total Direct Labor - Field Site		40		$1,908
Direct Labor - Government Site				
Principal Scientist (Smedstad)	Principal Staff	1,000	$45.48	$45,483
Oceanographer (Lunde)	Staff Member	1,000	$35.59	$35,589
Total Direct Labor - Government Site		2,000		$81,072
Total Direct Labor		2,080		$84,010
Overhead				
In-House @ 100%			$1,030	
Field Site @ 82%			$1,565	
Government Site @ 58%			$47,022	
Total Overhead				$49,616
Total Direct Labor Plus Overhead				$133,626
Travel				
SSC, MS to Miami, FL - 1 person x 5 days x 2 trips				
Airfare ($300 x 2)			$600	
Per Diem ($144/day x 5 days x 2 trips)			$1,440	
Rental car ($60/day x 5 days x 2 trips)			$600	
SSC, MS to San Diego, CA - 1 person x 5 days				
Airfare ($500)			$500	
Per Diem ($149/day x 5 days)			$745	
Rental car ($60/day x 5 days)			$300	
Total Travel				$4,185
Other Direct Costs				
Miscellaneous consumables/telephone/postage/copying			$1,000	
Total Other Direct Costs				$1,000
Total Direct Costs Plus Overhead				$138,811
G & A @ 13.2 %				$18,323
Total Estimated Cost				$157,135
Fixed Fee @ 8 %				$12,571
Total Estimated Cost Plus Fixed Fee				**$169,705**

Planning Systems Incorporated
Costing submitted in response to ONR NOPP BAA 02-011
U.S. GODAE: Global Ocean Prediction with the HYbrid Coordinate Ocean Model (HYCOM)
University of Miami (prime), E. Chaussignet POC
PSI Cost Proposal Year 3

Direct Labor - In-House	**PSI Category**	**Hours**	**Rate**	**Amount**
Administration	Associate Staff	40	$27.03	$1,081
Total Direct Labor - In-House		40		$1,081
Direct Labor - Field Site				
Program Manager	Principal Staff	40	$50.09	$2,004
Total Direct Labor - Field Site		40		$2,004
Direct Labor - Government Site				
Principal Scientist (Smedstad)	Principal Staff	1,000	$47.76	$47,757
Oceanographer (Lunde)	Staff Member	1,000	$37.37	$37,368
Total Direct Labor - Government Site		2,000		$85,126
Total Direct Labor		2,080		$88,211
Overhead				
In-House @ 100%			$1,081	
Field Site @ 82%			$1,643	
Government Site @ 58%			$49,373	
Total Overhead				$52,097
Total Direct Labor Plus Overhead				$140,308
Travel				
SSC, MS to Miami, FL - 1 person x 5 days x 2 trips				
Airfare ($300 x 2)			$600	
Per Diem ($144/day x 5 days x 2 trips)			$1,440	
Rental car ($60/day x 5 days x 2 trips)			$600	
SSC, MS to San Diego, CA - 1 person x 5 days				
Airfare ($500)			$500	
Per Diem ($149/day x 5 days)			$745	
Rental car ($60/day x 5 days)			$300	
Total Travel				$4,185
Other Direct Costs				
Miscellaneous consumables/telephone/postage/copying			$1,000	
Total Other Direct Costs				$1,000
Total Direct Costs Plus Overhead				$145,493
G & A @ 13.2 %				$19,205
Total Estimated Cost				$164,698
Fixed Fee @ 8 %				$13,176
Total Estimated Cost Plus Fixed Fee				**$177,874**

Planning Systems Incorporated
Costing submitted in response to ONR NOPP BAA 02-011
U.S. GODAE: Global Ocean Prediction with the HYbrid Coordinate Ocean Model (HYCOM)
University of Miami (prime), E. Chaussignet POC
PSI Cost Proposal Year 4

Direct Labor - In-House	**PSI Category**	**Hours**	**Rate**	**Amount**
Administration	Associate Staff	40	$28.38	$1,135
Total Direct Labor - In-House		40		$1,135
Direct Labor - Field Site				
Program Manager	Principal Staff	40	$52.59	$2,104
Total Direct Labor - Field Site		40		$2,104
Direct Labor - Government Site				
Principal Scientist (Smedstad)	Principal Staff	1,000	$50.15	$50,145
Oceanographer (Lunde)	Staff Member	1,000	$39.24	$39,237
Total Direct Labor - Government Site		2,000		$89,382
Total Direct Labor		2,080		$92,621
Overhead				
In-House @ 100%			$1,135	
Field Site @ 82%			$1,725	
Government Site @ 58%			$51,842	
Total Overhead				$54,702
Total Direct Labor Plus Overhead				$147,323
Travel				
SSC, MS to Miami, FL - 1 person x 5 days x 2 trips				
Airfare ($300 x 2)			$600	
Per Diem ($144/day x 5 days x 2 trips)			$1,440	
Rental car ($60/day x 5 days x 2 trips)			$600	
SSC, MS to San Diego, CA - 1 person x 5 days				
Airfare ($500)			$500	
Per Diem ($149/day x 5 days)			$745	
Rental car ($60/day x 5 days)			$300	
Total Travel				$4,185
Other Direct Costs				
Miscellaneous consumables/telephone/postage/copying			$1,000	
Total Other Direct Costs				$1,000
Total Direct Costs Plus Overhead				$152,508
G & A @ 13.2 %				$20,131
Total Estimated Cost				$172,639
Fixed Fee @ 8 %				$13,811
Total Estimated Cost Plus Fixed Fee				**$186,450**

Planning Systems Incorporated
Costing submitted in response to ONR NOPP BAA 02-011
U.S. GODAE: Global Ocean Prediction with the HYbrid Coordinate Ocean Model (HYCOM)
University of Miami (prime), E. Chaussignet POC
PSI Cost Proposal Year 5

Direct Labor - In-House	PSI Category	Hours	Rate	Amount
Administration	Associate Staff	40	$29.80	$1,192
Total Direct Labor - In-House		40		$1,192
Direct Labor - Field Site				
Program Manager	Principal Staff	40	$55.22	$2,209
Total Direct Labor - Field Site		40		$2,209
Direct Labor - Government Site				
Principal Scientist (Smedstad)	Principal Staff	1,000	$52.65	$52,652
Oceanographer (Lunde)	Staff Member	1,000	$41.20	$41,199
Total Direct Labor - Government Site		2,000		$93,851
Total Direct Labor		2,080		$97,252
Overhead				
In-House @ 100%			$1,192	
Field Site @ 82%			$1,811	
Government Site @ 58%			$54,434	
Total Overhead				$57,437
Total Direct Labor Plus Overhead				$154,689
Travel				
SSC, MS to Miami, FL - 1 person x 5 days x 2 trips				
Airfare ($300 x 2)			$600	
Per Diem ($144/day x 5 days x 2 trips)			$1,440	
Rental car ($60/day x 5 days x 2 trips)			$600	
SSC, MS to San Diego, CA - 1 person x 5 days				
Airfare ($500)			$500	
Per Diem ($149/day x 5 days)			$745	
Rental car ($60/day x 5 days)			$300	
Total Travel				$4,185
Other Direct Costs				
Miscellaneous consumables/telephone/postage/copying			$1,000	
Total Other Direct Costs				$1,000
Total Direct Costs Plus Overhead				$159,874
G & A @ 13.2 %				$21,103
Total Estimated Cost				$180,978
Fixed Fee @ 8 %				$14,478
Total Estimated Cost Plus Fixed Fee				**$195,456**

Current and Pending Support:

Agency: National Ocean Partnership Program
Award Number: N00014-00-C-0033
FY03 Funding: $89,453
FY04 Funding: $93,811

This funding supports Principal Investigator Ole Martin Smedstad for three man-months and Oceanographer Bruce Lunde for three man-months.

Title: Ocean Modeling
Agency: Naval Research Laboratory
Contract #: N00014-96-D-6031
FY03 Funding: $90,000 (to date)
FY04 Funding: Expected, amount uncertain.

This funding supports Principal Investigator Ole Martin Smedstad for nine months is FY03. Continued support in FY04 is expected; however, the amount has not yet been determined.

Title: Additional tasking for support to the Hybrid Coordinate Ocean Model (HYCOM)
Agency: University of Miami/RSMAS
Contract/Purchase Order: TBD
FY03 Funding Expected: $66,600
FY04 Funding Expected: $69,905

This funding is expected to support oceanographer Bruce Lunde for six man-months over a two-year time frame.

U.S. GODAE: Global Ocean Prediction with the HYbrid Coordinate Ocean Model (HYCOM)

Principal Investigator: (Peter Cornillon)

Peter Cornillon
OPeNDAP, Inc.
P.O. Box 112
Saunderstown, RI 02874
401 862-0672
p.cornillon@dcz.dods.org

Institutional Representative: (Daniel Holloway)

Daniel Holloway
Treasurer
OPeNDAP, Inc.
P.O. Box 112
Saunderstown, RI 02874
401 862-0672
d.holloway@dcz.dods.org

Starting date: October 1, 2003

Total Federal Funds Requested: $339,177

FY04	FY05	FY06	FY07	FY08
$49,972	$51,797	$76,304	$79,106	$81,998

Budget Justification

The OPeNDAP[1] budget includes travel and labor. The travel is for the OPeNDAP PI and OPeNDAP software engineer(s) to attend team meetings and for OPeNDAP software engineers to travel to sites requiring special assistance in the implementation of next generation OPeNDAP servers. These servers will be based on DAP 4.0 and higher, the upcoming release of the OPeNDAP Data Access Protocol. DAP 4.0 is important to the proposed effort because it will support Grid-FTP transfers and because metadata bound to the data will be encoded in XML. The Grid-FTP capability will allow for very high transfer rates of data from OPeNDAP-compliant servers.

Labor for this effort will focus on the maintenance of OPeNDAP software and, as noted above, on the configuration and installation of specialized servers at participant sites. OPeNDAP software consists of core components, those pieces of software that define the basic data transfers in the system, and of services, software that performs specialized operations such as intra and inter-site aggregation. The core software operates on a variety of platforms and consists of a large number of modules. Given that specialized services such as those associated with LAS and described in the proposal will be required and that these services will likely require the modification of the core software we propose the allocation of 2 months per year of software engineer time to these tasks. Labor allocated for assistance in the installation of servers and development of specialized services has also been set at 2 months per year. We anticipate ramping up to these levels of effort over the first several years of the project.

We note that the effort proposed here will be leveraged off of a number of other ongoing projects. This is particularly true of the Grid-FTP modification to the system which this project will make use of. Although the implementation of a Grid-FTP capability is being undertaken with other funds, the application of this capability to the GODAE effort will be addressed with funding (approximately 2 months per year) being sought here.

[1] The Open Source Project for a Network Data Access Protocol (OPeNDAP) is a not for profit 501 (c)3 corporation created in 2000 to maintain and evolve the DODS (Distributed Oceanographic Data System) data access protocol. Over the course of development it became clear that the core infrastructure developed for DODS was discipline neutral hence applied to a broad range of discipline needs in distributed access to heterogeneous data archives. In order to make this distinction explicit as well as to separate out the portion of the DODS effort that dealt with the core infrastructure OPeNDAP and NVODS (the National Virtual Ocean Data System) were created. NVODS assumed the discipline specific part of the DODS effort and is housed at the University of Rhode Island.

U.S. GODAE: Global Ocean Prediction with the HYbrid Coordinate Ocean Model (HYCOM)
OPeNDAP Contribution

A. Salaries		**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Total**
1. PI (Cornillon)	.25 mo.	$1,732	$1,793	$1,854	$1,919	$1,986	$9,284
2. Software Engineer	3.5,3.5,5,5,5 mo.	$26,268	$27,187	$40,172	$41,578	$43,033	$178,238
Total Salaries		$28,000	$28,980	$42,026	$43,497	$45,019	$187,522
B. Fringe Benefits							
33% of A1		$572	$592	$612	$633	$655	$3,064
33% of A2		$8,668	$8,972	$13,257	$13,721	$14,201	$58,819
Total Fringe Benefits		$9,240	$9,564	$13,869	$14,354	$14,856	$61,883
C. Travel							
Domestic		$1,200	$1,300	$2,800	$3,000	$3,200	$11,500
Foreign		$0	$0	$0	$0	$0	$0
Total Travel		$1,200	$1,300	$2,800	$3,000	$3,200	$11,500
Total Direct Costs		$38,440	$39,844	$58,695	$60,851	$63,075	$260,905
Indirect Costs		$11,532	$11,953	$17,609	$18,255	$18,923	$78,272
Indirect rate @30% of A,B & C							
Total Cost		$49,972	$51,797	$76,304	$79,106	$81,998	$339,177

Current and Pending Support for Cornillon at the University of Rhode Island

Investigator: Peter Cornillon	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Development of an Integrated Regional, National, and International Data System for Oceanography
(N000140010889)

Source of Support: NOPP
Total Award Amount: $3,688.043.00 Total Award Period Covered: 07/01/00-03/31/04
Location of Project: University of Rhode Island/GSO
Person-Months Per Year Committed to the Project. Cal: 4 mo/yr Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Distributed Oceanographic Data System Development: Client/Server Data Location Component
(NCC5307)

Source of Support: NASA
Total Award Amount: $2,699,760.00 Total Award Period Covered: 03/01/98-06/30/03
Location of Project: University of Rhode Island/GSO
Person-Months Per Year Committed to the Project. Cal: 1,5 mo/ Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Frontal Observations on the Continental Shelf
(N000149911021) with D. Hebert, P. Stegmann, & D. Ullman

Source of Support: NOPP
Total Award Amount: $803,435 Total Award Period Covered: 07/01/99-08/14/03
Location of Project: University of Rhode Island/GSO
Person-Months Per Year Committed to the Project. Cal: 0.5 mo/ Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Wind Forcing of Physical and Biological in the Upper Ocean
(NS033A06)

Source of Support: Oregon State University
Total Award Amount: $953,461.00 Total Award Period Covered: 11/21/95-12/31/04
Location of Project: University of Rhode Island/GSO
Person-Months Per Year Committed to the Project. Cal: 1 mo/yr Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Extension of the 1KM Pathfinder AVHRR SST Archive both in Time and Space Interaction Process
(NAG59633)

Source of Support: NASA
Total Award Amount: $405,000 Total Award Period Covered: 05/01/00-04/30/03
Location of Project: University of Rhode Island/GSO
Person-Months Per Year Committed to the Project. Cal: 0 Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support for Cornillon at the University of Rhode Island (Continued)

Investigator: Peter Cornillon	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒Current ☐Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Large-Scale Spatial and Temporal Patterns Evident in the Chlorophyll a Imagery from the First Four Global Satellite Ocean Color Missions (CZCS, OCTS, POLDER & SeaWiFS).
(OCE9986737)
Source of Support: NSF
Total Award Amount: $ 147,626.00 Total Award Period Covered: 04/01/00-03/31/03
Location of Project: University of Rhode Island/GSO
Person-Months Per Year Committed to the Project. Cal: 0 Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project: University of Rhode Island/GSO
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project: University of Rhode Island/GSO
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: Total Award Period Covered:
Location of Project: University of Rhode Island/GSO
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project: University of Rhode Island/GSO
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support for Cornillon at OPeNDAP

Investigator: Peter Cornillon

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Distributed Access to Large Volume, Heterogeneous Data Archives via the OPeNDAP Data Access Protocol. (AIST-0000-0139)

Source of Support: NASA

Total Award Amount: $1,366,606.00 Total Award Period Covered: 04/01/03-03/31/06

Location of Project: OPeNDAP, Inc.

Person-Months Per Year Committed to the Project. Cal: .75 mo/yr Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: yr Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: yr Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

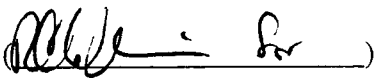
Total Award Amount: Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: 0 Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

U.S. GODAE: Global Ocean Prediction with the HYbrid Coordinate Ocean Model (HYCOM)

Principal Investugator: ()

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Hattiesburg, MS 39406
Phone: 601-266-4119, Fax: 601-266-4
Pam.Miller@usm.edu

Starting date: June 1, 2003

Total Federal Funds Requested: $150,000

Year 1	Year 2	Year 3	Year 4	Year 5
$30,000	$30,000	$30,000	$30,000	$30,000

NOPP US GODAE

Period of Performance: 1 June 2003 - 30 May 2008

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	TOTAL
A. SALARIES	17,893	17,701	17,848	18,002	18,164	89,608
B. BENEFITS	2,267	2,268	2,315	2,364	2,416	11,630
C. TRAVEL	3,355	3,500	3,148	3,000	2,845	15,846
D. OTHER DIRECT COSTS	295	341	499	444	385	1,964
E. EQUIPMENT	0	0	0	0	0	0
F. TOTAL DIRECT COSTS	23,810	23,810	23,810	23,810	23,810	119,050
G. INDIRECT	6,190	6,190	6,190	6,190	6,190	30,950
H. TOTAL	$30,000	$30,000	$30,000	$30,000	$30,000	$150,000

BUDGET JUSTIFICATION

YEAR 1

Corpus Christi, TX to Stennis Space Center, MS		Days / Miles			Rate per day / mile
Hotel	180.00	3	days	@	$ 60.00
Mileage	288.00	800	miles	@	$ 0.36
Per diem	135.00	4.50	days	@	$ 30.00
Parking/Tolls/tips	0.00				
Total cost for one trip	603.00				
Number of trips per year	3				
Year 1 Stennis trips costs	$1,809				

Corpus Christi, TX to Miami, FL		Days / Miles			Rate per day / mile
Hotel	475	5	days	@	$ 95.00
Airfare	550				
Rental car	240	5	days	@	$ 48.00
Mileage	18	50	miles	@	$ 0.36
Per diem	220	6	days	@	$ 40.00
Parking/Tolls/Tips/Gas	43				
Total cost for one trip	1,546				
Number of trips per year	1				
Year 1 Miami trip cost	$1,546				
Total Year 1 Travel Cost	**$3,355**				

YEAR 2

Corpus Christi, TX to Stennis Space Center, MS		Days / Miles			Rate per day / mile
Hotel	240	4	days	@	$ 60.00
Mileage	288	800	miles	@	$ 0.36
Per diem	135	4.50	days	@	$ 30.00
Parking/Tolls/Tips	0				
Total cost for one trip	663				
Number of trips per year	3				
Year 2 Stennis trips costs	$1,989				

Corpus Christi, TX to Miami, FL		Days / Miles			Rate per day / mile
Hotel	425	5	days	@	$ 85.00
Airfare	550				
Rental car	245	5	days	@	$ 49.00
Mileage	9	25	miles	@	$ 0.36
Per diem	228	6	days	@	$ 38.00
Parking/Tolls/Tips/Gas	54				
Total cost for one trip	1,511				
Number of trips per year	1				
Year 2 Miami trip cost	$1,511				
Total Year 2 Travel Cost	**$3,500**				

YEAR 3

Corpus Christi, TX to Stennis Space Center, MS		Days / Miles			Rate per day / mile
Hotel	180	3	days	@	$ 60.00
Mileage	288	800	miles	@	$ 0.36
Per diem	135	5	days	@	$ 30.00
Parking/Tolls/Tips	0				
Total cost for one trip	603				
Number of trips per year	3				
Year 3 Stennis trips costs	$1,809				

Corpus Christi, TX to Miami, FL		Days / Miles			Rate per day / mile
Hotel	340	4	days	@	$ 85.00
Airfare	550				
Rental car	196	4	days	@	$ 49.00
Mileage	9	25	miles	@	$ 0.36
Per diem	190	5	days	@	$ 38.00
Parking/Tolls/Tips/Gas	54				
Total cost for one trip	1,339				
Number of trips per year	1				
Year 3 Miami trip cost	$1,339				
Total Year 3 Travel Cost	**$3,148**				

YEAR 4

Corpus Christi, TX to Stennis Space Center, MS		Days / Miles			Rate per day / mile
Hotel	180	3	days	@	$ 60.00
Mileage	288	800	miles	@	$ 0.36
Per diem	135	5	days	@	$ 30.00
Parking/Tolls/Tips	0				
Total cost for one trip	603				
Number of trips per year	3				
Year 4 Stennis trips costs	$1,809				

Corpus Christi, TX to Miami, FL		Days / Miles			Rate per day / mile
Hotel	255	3	days	@	$ 85.00
Airfare	550				
Rental car	196	4	days	@	$ 49.00
Mileage	9	25	miles	@	$ 0.36
Per diem	152	4	days	@	$ 38.00
Parking/Tolls/Tips/Gas	29				
Total cost for one trip	1,191				
Number of trips per year	1				
Year 4 Miami trip cost	$1,191				
Total Year 4 Travel Cost	**$3,000**				

YEAR 5

Corpus Christi, TX to Stennis Space Center, MS		Days / Miles			Rate per day / mile
Hotel	240	4	days	@	$ 60.00
Mileage	288	800	miles	@	$ 0.36
Per diem	135	5	days	@	$ 30.00
Parking/Tolls/Tips	0				
Total cost for one trip	663				
Number of trips per year	2				
Year 5 Stennis trips costs	$1,326				

Corpus Christi, TX to Miami, FL		Days / Miles			Rate per day / mile
Hotel	425	5	days	@	$ 85.00
Airfare	550				
Rental car	245	5	days	@	$ 49.00
Mileage	9	25	miles	@	$ 0.36
Per diem	228	6	days	@	$ 38.00
Parking/Tolls/Tips/Gas	62				
Total cost for one trip	1,519				
Number of trips per year	1				
Year 5 Miami trip cost	$1,519				
Total Year 5 Travel Cost	**$2,845**				

CURRENT AND PENDING SUPPORT

NRL N00173-02-1-G910 titled "Parallel Research in Oceanography and Numerical Modeling – Task 2"at $15 K

U.S. GODAE: Global Ocean Prediction with the Hybrid Coordinate Ocean Model (HYCOM)

Principal Investigator: (signature)
Dr. Francisco E. Werner
Principal Investigator
Professor and Chair
Department of Marine Sciences
The University of North Carolina at Chapel Hill
CB#3300, 12-7 Venable Hall
Chapel Hill, NC 27599-3300
Telephone: (919) 962-0269
Fax: 919-962-1254
Email: cisco@unc.edu

Institutional Representative: (signature) Acting For Tony G. Waldrop
Dr. Tony Waldrop
Vice Chancellor for Research and Graduate Studies
Office of Sponsored Research
The University of North Carolina at Chapel Hill
440 W. Franklin Street, CB# 1350
Chapel Hill, NC 27599-1350
Telephone (919) 966-3411
Fax (919) 962-5011
Email: ResAdminOSR@unc.edu

Starting date: June 1, 2003

Total Federal Funds Requested: $345,000.00

Year 1	Year 2	Year 3	Year 4	Year 5
$50,000.00	$55,000.00	$75,000.00	$80,000.00	$85,000.00

Budget Justification
(UNC-CH, F. Werner)

The requested UNC-CH budget of $345,000 over five years is to mainly cover personnel in the form of a post-doctoral associate (9mos/yr in Years 1-3 and full-time in Years 4-5) and in Years 3-5 one month of summer salary per year for F. Werner (for a total of 3 summer months over the five year request). Also budgeted are funds for travel every year for one person to one group meeting and one national meeting. Supplies, communication and publication costs are also requested. Additional support to cover permanent equipment, computing time, graduate students will be sought from sources such as SEACOOS and other pending proposals.

The post-doctoral associates targeted for participation in this effort are presently graduate students completing their PhDs as part of the UNC-CH Ocean Processes Numerical Modeling Laboratory (OPNML) efforts. Brian Blanton is scheduled to complete his PhD this summer (2003). Alfredo Aretxabaleta or Karen Pehrson will complete their PhDs in 2005/2006, ensuring stable continuation of efforts between SEACOOS, SABLAM and the present HYCOM-GODAE proposal.

Research Tasks. The UNC-CH modeling group is implementing operational systems for site-specific, limited-area forecasting of the coastal ocean. We have focused over the past two years on the South Atlantic Bight (SAB) shelf region through the SABLAM (http://www.ncsc.org/nopp/sablam) and SEACOOS (http://www.seacoos.org) projects. In-situ and remotely sensed observations are being assimilated, as well as results from atmospheric and global ocean models. Simulation of tidal and wind-driven processes with a variety of numerical models has been well established in the SAB, and process studies of buoyancy-driven dynamics have provided useful insight (e.g., Werner et al. 1993; Blanton et al. 2003). However, operational modeling of the shelf dynamics and coastal response in the SAB has been largely limited to wind- and tide driven dynamics with climatological mass fields and meteorological model heat fluxes.

A specific objective of our limited-area prediction system (SABLAM, http://www.ncsc.org/nopp/sablam) is to publish nowcasts and forecasts from blended circulation models for the SAB domain. This requires specification of the open water boundary conditions on the limited-area model domain including sea level, momentum, and temperature and salinity (TS) fluxes. Real-time nowcast/forecasts from the operational HYCOM effort will be used to prescribe initial mass distributions, shelfbreak pressure, and TS fluxes into the limited area domain. It is expected that forecast skill of mid- and outer-shelf currents as well as lower frequency coastal water levels can be improved by specification of the limited-area model outer boundary information from the operational nowcast/forecast output of HYCOM. This is essential as we strive to describe the along- and across-shelf fate of mass and momentum.

Several technical issues need addressing to properly combine the basin scale model results with the limited area model, among them are physical consistency between the models, bathymetric consistency, and proper interpolation of the large scale parameters to the limited area scale. Additionally, verification of both the HYCOM integration in the coastal regions as well as shelf-break dynamic features supplied by HYCOM will be a component of the SAB effort. A series of instrumented Navy towers is currently providing real-time oceanic and atmospheric parameters to the existing SAB limited-area modeling system. This data stream will provide useful guidance to the HYCOM effort. Larger-scale features of the HYCOM solutions. such as meander propagation, upwelling and downwelling along the SAB shelfbreak caused by both Gulf Stream meandering and Ekman transports, and alongshelf sealevel variability will be investigated in the context of HYCOM and limited area prediction skill.

1

PROPOSAL BUDGET

FOR NSF USE ONLY

ORGANIZATION	PROPOSAL NO	DURATION (MONTHS) Proposed	Granted
University of North Carolina at Chapel Hill			
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR	AWARD NO.		
Francisco E. Werner, PI			

A. SENIOR PERSONNEL: PI/PD, Co-PI'S, Faculty and Other Senior Associate List each separately with name and title. (A.7. show number in brackets)	NSF-Funded Person-months CAL	ACAD	SUMR	Funds Requested By Proposer	Funds Granted by NSF (If Different)
1. Francisco Werner					$
2.					
3.					
4.					
5.					
6. ( )OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. (1)TOTAL SENIOR PERSONNEL (1-6)			0	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (1)POSTDOCTORAL ASSOCIATES	9			26,300	
2. ( )OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC)					
3. ( )GRADUATE STUDENTS					
4. ( )UNDERGRADUATE STUDENTS					
5. ( )SECRETARIAL-CLERICAL (IF CHARGED DIRECTLY)					
6. ( )OTHER					
TOTAL SALARIES AND WAGES (A+B)				26,300	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				3,150	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				29,450	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT					
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				2,000	
2. FOREIGN					
F. PARTICIPANT SUPPORT					
1. STIPENDS $_____					
2. TRAVEL _____					
3. SUBSISTENCE _____					
4. OTHER _____					
TOTAL NUMBER OF PARTICIPANTS ( )					
TOTAL PARTICIPANT COSTS					
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				2,000	
2. PUBLICATION/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER SERVICES					
5. SUBAWARDS					
6. OTHER (Communications, $1,462 student tuition)				914	
TOTAL OTHER DIRECT COSTS				2,914	
H. TOTAL DIRECT COSTS (A THROUGH G)				34,364	
I. INDIRECT COSTS (F&A) (SPECIFY RATE AND BASE) 45.5% MTDC on all except equipment and student tuition					
TOTAL INDIRECT COSTS (F&A)				15,636	
J. TOTAL DIRECT AND INDIRECTS COSTS (H + I)				50,000	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.D.7.j.)					
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$50,000	$

M. COST SHARING: PROPOSAL LEVEL $	AGREED LEVEL IF DIFFERENT: $			
PI/PD TYPED NAME & SIGNATURE*	DATE	FOR NSF USE ONLY		
		INDIRECT COST RATE VERIFICATION		
ORG. REP. TYPED NAME & SIGNATURE*	DATE	Date Checked	Date of Rate Shee	Initials - ORG

*SIGNATURE REQUIRED ONLY FOR REVISED BUDGET(GPG III.C)

2

PROPOSAL BUDGET

FOR NSF USE ONLY

ORGANIZATION	PROPOSAL NO	DURATION (MONTHS)	
University of North Carolina at Chapel Hill		Proposed	Granted
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR	AWARD NO.		
Francisco E. Werner, PI			

A. SENIOR PERSONNEL: PI/PD, Co-PI'S, Faculty and Other Senior Associate List each separately with name and title. (A.7. show number in brackets)	NSF-Funded Person-months			Funds Requested By Proposer	Funds Granted by NSF (If Different)
	CAL	ACAD	SUMR		
1. Francisco Werner					$
2.					
3.					
4.					
5.					
6. ( )OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. (1)TOTAL SENIOR PERSONNEL (1-6)			0	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (1)POSTDOCTORAL ASSOCIATES	9			27,000	
2. ( )OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC)					
3. ( )GRADUATE STUDENTS					
4. ( )UNDERGRADUATE STUDENTS					
5. ( )SECRETARIAL-CLERICAL (IF CHARGED DIRECTLY)					
6. ( )OTHER					
TOTAL SALARIES AND WAGES (A+B)				27,000	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				3,204	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				30,204	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT					
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				2,000	
2. FOREIGN					
F. PARTICIPANT SUPPORT 1. STIPENDS $_____ 2. TRAVEL _____ 3. SUBSISTENCE _____ 4. OTHER _____					
TOTAL NUMBER OF PARTICIPANTS ( ) TOTAL PARTICIPANT COSTS					
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				2,500	
2. PUBLICATION/DOCUMENTATION/DISSEMINATION				2,097	
3. CONSULTANT SERVICES					
4. COMPUTER SERVICES					
5. SUBAWARDS					
6. OTHER (Communications, $1,462 student tuition)				1,000	
TOTAL OTHER DIRECT COSTS				5,597	
H. TOTAL DIRECT COSTS (A THROUGH G)				37,801	
I. INDIRECT COSTS (F&A) (SPECIFY RATE AND BASE) 45.5% MTDC on all except equipment and student tuition TOTAL INDIRECT COSTS (F&A)				17,199	
J. TOTAL DIRECT AND INDIRECTS COSTS (H + I)				55,000	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.D.7.j.)					
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$55,000	$

M. COST SHARING: PROPOSAL LEVEL $	AGREED LEVEL IF DIFFERENT: $	
PI/PD TYPED NAME & SIGNATURE*	DATE	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION
ORG. REP. TYPED NAME & SIGNATURE*	DATE	Date Checked / Date of Rate Shee / Initials - ORG

*SIGNATURE REQUIRED ONLY FOR REVISED BUDGET(GPG III.C)

3

PROPOSAL BUDGET

FOR NSF USE ONLY		
PROPOSAL NO	DURATION (MONTHS) Proposed	Granted
AWARD NO.		

ORGANIZATION: University of North Carolina at Chapel Hill

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR: Francisco E. Werner, PI

A. SENIOR PERSONNEL: PI/PD, Co-PI'S, Faculty and Other Senior Associate List each separately with name and title. (A.7. show number in brackets)	NSF-Funded Person-months CAL	ACAD	SUMR	Funds Requested By Proposer	Funds Granted by NSF (If Different)
1. Francisco Werner			1	$9,070	$
2					
3.					
4.					
5.					
6. ( )OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. (1)TOTAL SENIOR PERSONNEL (1-6)			1	9,070	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (1)POSTDOCTORAL ASSOCIATES	9			28,000	
2. ( )OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC)					
3. ( )GRADUATE STUDENTS					
4. ( )UNDERGRADUATE STUDENTS					
5. ( )SECRETARIAL-CLERICAL (IF CHARGED DIRECTLY)					
6. ( )OTHER					
TOTAL SALARIES AND WAGES (A+B)				37,070	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				5,248	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				42,318	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT					
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				4,000	
2. FOREIGN					
F. PARTICIPANT SUPPORT 1. STIPENDS $ 2. TRAVEL 3. SUBSISTENCE 4. OTHER					
TOTAL NUMBER OF PARTICIPANTS ( ) TOTAL PARTICIPANT COSTS					
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				1,228	
2. PUBLICATION/DOCUMENTATION/DISSEMINATION				2,500	
3. CONSULTANT SERVICES					
4. COMPUTER SERVICES					
5. SUBAWARDS					
6. OTHER (Communications, $1,462 student tuition)				1,500	
TOTAL OTHER DIRECT COSTS				5,228	
H. TOTAL DIRECT COSTS (A THROUGH G)				51,546	
I. INDIRECT COSTS (F&A) (SPECIFY RATE AND BASE) 45.5% MTDC on all except equipment and student tuition TOTAL INDIRECT COSTS (F&A)				23,454	
J. TOTAL DIRECT AND INDIRECTS COSTS (H + I)				75,000	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.D.7.j.)					
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$75,000	$

M. COST SHARING: PROPOSAL LEVEL $	AGREED LEVEL IF DIFFERENT: $	
PI/PD TYPED NAME & SIGNATURE*	DATE	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION
ORG. REP. TYPED NAME & SIGNATURE*	DATE	Date Checked / Date of Rate Shee / Initials - ORG

*SIGNATURE REQUIRED ONLY FOR REVISED BUDGET(GPG III.C)

PROPOSAL BUDGET

4

FOR NSF USE ONLY

ORGANIZATION	PROPOSAL NO	DURATION (MONTHS) Proposed	Granted
University of North Carolina at Chapel Hill			
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR	AWARD NO.		
Francisco E. Werner, PI			

A. SENIOR PERSONNEL: PI/PD, Co-PI'S, Faculty and Other Senior Associate List each separately with name and title. (A.7. show number in brackets)	NSF-Funded Person-months CAL	ACAD	SUMR	Funds Requested By Proposer	Funds Granted by NSF (If Different)
1. Francisco Werner			1	$9,433	$
2.					
3.					
4.					
5.					
6. ( )OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. (1)TOTAL SENIOR PERSONNEL (1-6)			1	9,433	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (1)POSTDOCTORAL ASSOCIATES	12			37,333	
2. ( )OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC)					
3. ( )GRADUATE STUDENTS					
4. ( )UNDERGRADUATE STUDENTS					
5. ( )SECRETARIAL-CLERICAL (IF CHARGED DIRECTLY)					
6. ( )OTHER					
TOTAL SALARIES AND WAGES (A+B)				46,766	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				6,411	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				53,177	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT					
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				1,000	
2. FOREIGN					
F. PARTICIPANT SUPPORT 1. STIPENDS $_____ 2. TRAVEL _____ 3. SUBSISTENCE _____ 4. OTHER _____					
TOTAL NUMBER OF PARTICIPANTS ( )					
TOTAL PARTICIPANT COSTS					
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				506	
2. PUBLICATION/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER SERVICES					
5. SUBAWARDS					
6. OTHER (Communications, $1,462 student tuition)				300	
TOTAL OTHER DIRECT COSTS				806	
H. TOTAL DIRECT COSTS (A THROUGH G)				54,983	
I. INDIRECT COSTS (F&A) (SPECIFY RATE AND BASE) 45.5% MTDC on all except equipment and student tuition					
TOTAL INDIRECT COSTS (F&A)				25,017	
J. TOTAL DIRECT AND INDIRECTS COSTS (H + I)				80,000	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.D.7.j.)					
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$80,000	$

M. COST SHARING: PROPOSAL LEVEL $	AGREED LEVEL IF DIFFERENT: $			
PI/PD TYPED NAME & SIGNATURE*	DATE	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. TYPED NAME & SIGNATURE*	DATE	Date Checked	Date of Rate Shee	Initials - ORG

*SIGNATURE REQUIRED ONLY FOR REVISED BUDGET(GPG III.C)

5

PROPOSAL BUDGET

FOR NSF USE ONLY		
PROPOSAL NO	DURATION (MONTHS) Proposed	Granted
AWARD NO.		

ORGANIZATION: University of North Carolina at Chapel Hill

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR: Francisco E. Werner, PI

A. SENIOR PERSONNEL: PI/PD, Co-PI'S, Faculty and Other Senior Associate List each separately with name and title. (A.7. show number in brackets)	NSF-Funded Person-months CAL	ACAD	SUMR	Funds Requested By Proposer	Funds Granted by NSF (If Different)
1. Francisco Werner			1	$9,905	$
2.					
3.					
4.					
5.					
6. ( )OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. ( )TOTAL SENIOR PERSONNEL (1-6)			1	9,905	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (1)POSTDOCTORAL ASSOCIATES	12			38,333	
2. ( )OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC)					
3. ( )GRADUATE STUDENTS					
4. ( )UNDERGRADUATE STUDENTS					
5. ( )SECRETARIAL-CLERICAL (IF CHARGED DIRECTLY)					
6. ( )OTHER					
TOTAL SALARIES AND WAGES (A+B)				48,238	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				6,577	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				54,815	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT					
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				1,750	
2. FOREIGN					
F. PARTICIPANT SUPPORT 1. STIPENDS $_____ 2. TRAVEL _____ 3. SUBSISTENCE _____ 4. OTHER _____					
TOTAL NUMBER OF PARTICIPANTS ( ) TOTAL PARTICIPANT COSTS					
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				500	
2. PUBLICATION/DOCUMENTATION/DISSEMINATION				1,154	
3. CONSULTANT SERVICES					
4. COMPUTER SERVICES					
5. SUBAWARDS					
6. OTHER (Communications, $1,462 student tuition)				200	
TOTAL OTHER DIRECT COSTS				1,854	
H. TOTAL DIRECT COSTS (A THROUGH G)				58,419	
I. INDIRECT COSTS (F&A) (SPECIFY RATE AND BASE) 45.5% MTDC on all except equipment and student tuition					
TOTAL INDIRECT COSTS (F&A)				26,581	
J. TOTAL DIRECT AND INDIRECTS COSTS (H + I)				85,000	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.D.7.j.)					
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$85,000	$

M. COST SHARING: PROPOSAL LEVEL $	AGREED LEVEL IF DIFFERENT: $	
PI/PD TYPED NAME & SIGNATURE*	DATE	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION
ORG. REP. TYPED NAME & SIGNATURE*	DATE	Date Checked / Date of Rate Shee / Initials - ORG

*SIGNATURE REQUIRED ONLY FOR REVISED BUDGET(GPG III.C)

TOTAL BUDGET

SUMMARY PROPOSAL BUDGET

FOR NSF USE ONLY		
PROPOSAL NO	DURATION (MONTHS) Proposed	Granted
AWARD NO.		

ORGANIZATION: University of North Carolina at Chapel Hill

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR: Francisco E. Werner, PI

A. SENIOR PERSONNEL: PI/PD, Co-PI'S, Faculty and Other Senior Associate List each separately with name and title. (A.7. show number in brackets)	NSF-Funded Person-months CAL	ACAD	SUMR	Funds Requested By Proposer	Funds Granted by NSF (If Different)
1. Francisco Werner			3	$28,408	$
2					
3.					
4.					
5.					
6. ( )OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. (1)TOTAL SENIOR PERSONNEL (1-6)			3	$28,408	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)				$0	
1. (1)POSTDOCTORAL ASSOCIATES				$156,966	
2. ( )OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC)				$0	
3. ( )GRADUATE STUDENTS					
4. ( )UNDERGRADUATE STUDENTS					
5. ( )SECRETARIAL-CLERICAL (IF CHARGED DIRECTLY)					
6. ( )OTHER					
TOTAL SALARIES AND WAGES (A+B)				$185,374	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				$24,590	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				$209,964	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				$0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				$10,750	
2. FOREIGN					
F. PARTICIPANT SUPPORT					
1. STIPENDS $					
2. TRAVEL					
3. SUBSISTENCE					
4. OTHER					
TOTAL NUMBER OF PARTICIPANTS ( )					
TOTAL PARTICIPANT COSTS					
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				$6,734	
2. PUBLICATION/DOCUMENTATION/DISSEMINATION				$5,751	
3. CONSULTANT SERVICES					
4. COMPUTER SERVICES				$0	
5. SUBAWARDS					
6. OTHER (Communications, $1,462 student tuition)				$3,914	
TOTAL OTHER DIRECT COSTS				$16,399	
H. TOTAL DIRECT COSTS (A THROUGH G)				$237,113	
I. INDIRECT COSTS (F&A) (SPECIFY RATE AND BASE) 45.5% MTDC on all except equipment and student tuition					
TOTAL INDIRECT COSTS (F&A)				$107,887	
J. TOTAL DIRECT AND INDIRECTS COSTS (H + I)				$345,000	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.D.7.j.)					
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$345,000	$

M. COST SHARING: PROPOSAL LEVEL $	AGREED LEVEL IF DIFFERENT: $			
PI/PD TYPED NAME & SIGNATURE*	DATE	FOR NSF USE ONLY		
		INDIRECT COST RATE VERIFICATION		
ORG. REP. TYPED NAME & SIGNATURE*	DATE	Date Checked	Date of Rate Sheet	Initials - ORG

NSF Form 1030 (10/99) ***Supersedes All Previous Editions***

*SIGNATURE REQUIRED ONLY FOR REVISED BUDGET(GPG III.C)

U.S. GODAE: Global Ocean Prediction with the HYbrid Coordinate Ocean Model (HYCOM)

Principal Investigator: (_____)

John L. Wilkin
IMCS Rutgers University
71 Dudley Road
New Brunswick NJ 08901
Tel: 732-932-6555 ext 251 fax: 732-932-1792
E-mail: wilkin@marine.rutgers.edu

Principal Investigator: (_____)

Dale B. Haidvogel
IMCS Rutgers University
71 Dudley Road
New Brunswick NJ 08901
Tel: 732-932-6555 ext 256 fax: 732-932-1792
E-mail: dale@marine.rutgers.edu

Institutional Representative: (_____)

Maryellen O'Brien
Research Contract/Grant Specialist
Rutgers, The State University of New Jersey
Office of Research and Sponsored Programs
3 Rutgers Plaza
New Brunswick NJ 08901
Tel: 732-932-1000 ext 567 fax: 732-932-4176
E-mail: sponpgms@orsp.rutgers.edu

Starting date: June 1, 2003

Total Federal Funds Requested: $272,569

Year 1	Year 2	Year 3	Year 4	Year 5
$52,717	$53,716	$54,530	$55,369	$56,236

BUDGET JUSTIFICATION – RUTGERS UNIVERSITY

Personnel: Funds are requested for 1 student in the Rutgers University Graduate Program in Oceanography in each year of the project. This may be a PhD or Masters of Operational Oceanography student.

Fringe Benefits. Rutgers University standard fringe benefits are 25.5%.

Travel. Travel funds are requested in each year for collaborative meetings between the student and HyCOM principals, and/or for attendance at a domestic scientific conference.

Computer Support. Funds are requested for local IMCS computer support for maintenance and licensing of workstations, Sun Enterprise parallel computers, and data storage and backup.

Other costs (supplies). Funds are requested for phone charges, photocopy charges, and publication costs.

Indirect Costs: The indirect cost rate at Rutgers is 55.5%, excluding permanent equipment and tuition remission.

BUDGET SUMMARY

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Personnel: Graduate student assistant	16,428	16,555	16,705	16,855	17,005	83,548
Fringe Benefits @25%, 26%	4,107	4,304	4,343	4,382	4,421	21,558
Computing	5,000	5,000	5,000	5,000	5,000	25,000
Travel	1,000	1,000	1,000	1,000	1,000	5,000
Supplies	1,000	1,000	1,000	1,000	1,000	5,000
Tuition Remission	9,900	10,395	10,915	11,460	12,034	54,704
Direct	37,435	38,254	38,963	39,698	40,460	194,810
MTDC	27,535	27,859	28,048	28,237	28,426	140,106
Indirect	15,282	15,462	15,567	15,672	15,777	77,759
Total	52,717	53,716	54,530	55,369	56,236	272,569

Current and pending support: Wilkin

Support: current
Title: Coastal Ocean Modeling and Observation Program
Co-PIs: S. Glenn, D. Haidvogel, O. Schofield
Source of support: ONR
Total award: $1,080,000
Total period: 1-Oct-2000 to 30-Sep-2003
Location: Institute of Marine and Coastal Sciences, Rutgers University
Academic months: 1 per year

Support: current
Title: A Relocatable Ocean Nowcast/Forecast System Using ROMS and Assimilation of Satellite Altimetry and Infrared Imagery
Co-PIs: H. Arango, D. Griffin
Source of support: ONR
Total award: $160,661
Total period: 1-Jan-2003 to 31-Dec-2004
Location: Institute of Marine and Coastal Sciences, Rutgers University
Academic months: 1 per year

Support: current
Title: Lagrangian studies of the transport, transformation, and biological impact of nutrients and contaminant metals in a buoyant plume
Co-PIs: R. Chant, S. Glenn, O. Schofield, J. Reinfelder
Source of support: NSF
Total award: $ 2,241,125
Total period: 1-Mar-2003 to 28-Feb-2008
Location: Institute of Marine and Coastal Sciences, Rutgers University
Academic months: 0.8 per year

U.S. GODAE: Global Ocean Prediction with the HYbrid Coordinate Ocean Model (HYCOM)

Principal Investigator:

Robert H. Weisberg
College of Marine Science
University of South Florida
140 7th Ave. S.
St. Petersburg, FL 33701
727-553-1568 (Phone), 727-553-1189 (Fax)
weisberg@marine.usf.edu

Institutional Representative:

Priscilla Pope
Director
Division of Sponsored Research
University of South Florida
140 7th Ave. S.
St. Petersburg, FL 33701
727-553-1150 (Phone), 727-553-3968 (Fax)
ebunch@research.usf.edu

Starting date: October 1, 2003

Total Federal Funds Requested: $337,203

FY04	FY05	FY06	FY07	FY08
$42,484	$55,007	$75,177	$79,762	$84,773

Budget Justification

Personnel include the co-P.I. (Prof. R. Weisberg) and a post-doctoral associate to be named. The post doctoral associate will be support for 6 months in year 1, 8 months in year 2, and 10 months per year thereafter over the total 60 month proposal period. Fringe benefits are calculated @ 15.45%, plus 509/mo. for medical insurance. Indirect costs are charged @ 45% of TDC.

Domestic travel is for P.I. interactions and dissemination of findings at professional meetings. Other costs are for publications and for apportioned computer maintenance charges.

Budget

	FY04	FY05	FY06	FY07	FY08
Salaries					
a. R. Weisberg					
b. post-doctoral assoc.	21,000	27,600	37,900	39,600	41,900
Total Salaries	21,000	27,600	37,900	39,600	41,900
Fringe	6,299	8,336	10,946	11,208	11,564
Total Salaries + Fringe	27,299	35,936	48,846	50,808	53,464
Travel					
a. Domestic	1,000	1,000	1,000	1,200	1,500
Other					
a. Publication			1,000	2,000	2,500
b. computer maintenance	1,000	1,000	1,000	1,000	1,000
Total Other	1,000	1,000	2,000	3,000	3,500
Total Direct Costs	29,299	37,936	51,846	55,008	58,464
Indirect Costs	13,185	17,071	23,331	24,754	26,309
Total Costs	42,484	55,007	75,177	79,762	84,773

Current and Pending Support
R.H. Weisberg

1) State of Florida: A real-time oceanographic data system for Florida, P.R. Betzer, A.C. Hine, M. Luther and R.H. Weisberg, P.I.'s, continuing award=300,000 for annually occurring E&G funds supporting 5.3 positions beginning 7/1/97.

2) State of Florida**:** I-4 Corridor funding for the Coastal Ocean Modeling and Prediction System (COMPS), P.R. Betzer, M.E. Luther, and R.H. Weisberg, Co-P.I.s, continuing award=69,276.00 per year for an engineer position and 78,520.50 for expenses beginning 7/1/98.

3) NOAA Grant # NA76RG0463, ECOHAB: Florida, J. Walsh, G. Vargo, and R. Weisberg, co-P.I.s (USF); K. Steidinger et al., co-P.I.s (FDEP and Mote Marine Lab). The portion under the supervision of R.H. Weisberg is 715,000 for the four year continuing period beginning 3/1/98. (no-cost-extension for FY02).

4) ONR Grant # N0014-98-1-0158, Observations and modeling of the West Florida continental shelf circulation, R.H. Weisberg and M. Luther, co-P.I.s, 2,971,084 for the period 11/1/97-7/31/03 (498,995 for FY03).

5) ONR Grant # N0014-00-1-0253, Bottom stationed ocean profiler, R.H. Weisberg, R.H. Byrne, and C. Lembke co-P.I.s, 1,725,478 for the period 12/1/99-7/31/03 (498,309 for FY03).

6) NOAA Grant # NA16GP1571: Diagnostic studies of the equatorial Atlantic cold tongue, R.H. Weisberg, G. Mitchum, and G. Lagerloef (ERS) co-P.I.s, 358,300 for the 3 year period beginning 9/1/01 (130,943 for FY03).

7) NSF Grant # OCE-0118566, Collaborative research: Particulate organic carbon fluxes and sediment accumulation in the Cariaco Basin, co-investigator with F. Muller-Karger, R.H. Weisberg portion = 232,816 for the period 10/1/01-9/30/03 (120,460 for FY02).

8) ONR Task Order #:3-12110-10 (administered by Univ. of North Carolina), Southeast Atlantic Coastal Ocean Observing System (SEA-COOS), R. H. Weisberg and M. Luther, co-P.I.s, 550,000 for the period 9/1/02-8/31/03.

9) NOAA, MERHAB grant approved and pending, J.J. Walsh, R.H. Weisberg, C. Lembke, and D. Fries, co-P.I.s, 1,150,000 for 5 years. R.H. Weisberg portion is 478,618.

10) Present proposal in renewal to 5) above.

U.S. GODAE: Global Ocean Prediction with the HYbrid Coordinate Ocean Model (HYCOM)

Principal Investigator: _____

Prof. Geir Evensen, Research Director*
Nansen Environmental & Remote Sensing Center
Edvard Griegsvei 3A
N-5059 Bergen, Norway
[47] 55 29 72 88 tel
[47] 55 20 00 50 fax
geir@nersc.no
* also Director of Ocean Numerics

Principal Investigator: _____

Mr. D. Szabo, Division Director**
Fugro GEOS Inc.
6100 Hillcroft (77081)
Houston, TX 77274
713 346-3609 tel
713 346-3605 fax
d.szabo@geos.com
** also Managing Director of Ocean Numerics

Institutional Representative: _____

Mr. J. van Smirren, Regional Director
Fugro GEOS Inc.
P.O. Box 740010
6100 Hillcroft (77081)
Houston, TX 77274
713 346-3611 tel
713 346-3605 fax
j.vansmirren@geos.com

STARTING DATE: JUNE 1, 2003

Total Federal Funds Requested: $345K

Year 1	Year 2	Year 3	Year 4	Year 5
$50K	$55K	$75K	$80K	$85K

BUDGET JUSTIFICATION

Our budget is based on a man year effort per year during each project year and includes costs for travel and CPU. The requested NOPP funding ranges from 25% to 36% of the proposed effort. Additional support is being sought through research initiatives in Europe, i.e. the MERSEA project funded through the European Community. Any remaining funding required will be supported internally.

Fugro GEOS provides a wide range of metocean services to the offshore oil and gas industry on a worldwide basis. Services requiring numerical ocean modeling both in hindcast and forecast modes are supported through a subsidiary company, Ocean Numerics (ON). ON is presently developing a current forecasting capability for the Atlantic based on the HYCOM model system developed in the TOPAZ project.

The TOPAZ grid is similar to the coverage provided by the NRL Miami HYCOM prediction system. A primary difference in the TOPAZ and the NRL Miami model systems lies in the strategy for balancing grid resolution with the sophistication of the assimilation scheme. The NRL Miami system has employed a relatively high resolution grid (1/12 degree) with a less sophisticated OI assimilation scheme. On the other hand TOPAZ uses a relatively coarse grid with a more sophisticated assimilation technique, EnKF. Very high resolution results (1/24 to 1/48 degree) are then achieved through incorporation of high resolution nested grids using less sophisticated assimilation schemes. The proposed work in the first year will investigate the relative merit of these two approaches.

In subsequent years, ON would establish a number of regional forecast systems in active deepwater oil and gas exploration and production areas. This could include a few of the most active areas, e.g. a few selected from the following list: West Africa, Southeast Brazil, north coast of South America including Brazil and Trinidad, Gulf of Mexico, North East Atlantic, South China Sea, Arabian Gulf, etc. NOPP funding would help support the implementation, validation and initial operation of these regional models. Further commercial operation of the models would be undertaken by ON.

ON would develop these regional models in conjunction with the NOPP global systems. The regional models would benefit from the availability of boundary conditions taken from the large scale HYCOM model system, and ON will use its own data assimilation capabilities in the regional models.

ON would customize and develop ocean forecasting products suitable for use by the offshore oil industry and provide a synoptic transfer of these products to offshore clients for demonstration.

ON will by participation in this project develop a commercial market for operational ocean products within the oil industry and this will provide a further justification for future support of the operational GODAE systems and GODAE operation centers.

Tables by year:

June 03 - May 04 ($)	Rate/ month	Man Mths	ON Cost Sharing	Man Mths	NOPP Requested	Total
Oceanographer	16,200	9.00	145,800	3.00	48,600	194,400
Travel	2,800		1,400		1,400	2,800
CPU	6,250		6,250			6,250
Total			153,450		50,000	203,450
Cumulative Total			153,450		50,000	203,450

Jun 04 - May 05 ($)	Rate/ month	Man Mths	ON Cost Sharing	Man Mths	NOPP Requested	Total
Oceanographer	16,524	9.00	148,716	3.00	49,572	198,288
Travel	2,856		1,428		1,428	2,856
CPU	8,000		4,000		4,000	8,000
Total			154,144		55,000	209,144
Cumulative Total			307,594		105,000	412,594

Jun 05 - May 06 ($)	Rate/ month	Man Mths	ON Cost Sharing	Man Mths	NOPP Requested	Total
Oceanographer	16,854	8.00	134,836	4.00	67,418	202,254
Travel	2,914		1,457		1,457	2,914
CPU	12,250		6,125		6,125	12,250
Total			142,418		75,000	217,418
Cumulative Total			450,012		180,000	630,012

Budget Tables by year (con't):

Jun 06 - May 07 ($)	Rate/ month	Man Mths	ON Cost Sharing	Man Mths	NOPP Requested	Total
Oceanographer	17,192	7.80	134,094	4.20	72,205	206,299
Travel	2,973		1,487		1,487	2,973
CPU	12,617		6,309		6,309	12,617
Total			141,889		80,000	221,889
Cumulative Total			591,901		260,000	851,901

Jun 07 - May 08 ($)	Rate/ month	Man Mths	ON Cost Sharing	Man Mths	NOPP Requested	Total
Oceanographer	17,535	7.62	133,620	4.38	76,717	210,337
Travel	3,033		1,516		1,516	3,033
CPU	13,532		6,766		6,766	13,532
Total			141,902		85,000	226,902
Cumulative Total			733,804		345,000	1,078,803

CURRENT AND PENDING SUPPORT

Outside of the requested NOPP funding, this effort is being funded internally by Ocean Numerics. Additional support is being sought through the MERSEA project in Europe. Funding by MERSEA would be at the level of 50%.

BIOGRAPHICAL SKETCH
ERIC P. CHASSIGNET

Citizenship: U.S.
Affiliation: Professor**,** University of Miami, Division of Meteorology and Physical Oceanography
4600 Rickenbacker Causeway, Miami, Fl 33149-1098
Tel.: (305) 361-4041 FAX: (305) 361-4696 E-mail: echassignet@rsmas.miami.edu

HIGHER and PROFESSIONAL EXPERIENCE

2001 Professor, University of Miami
1995 Associate Professor, University of Miami
1990 Assistant Professor, University of Miami
1988 Postdoctoral Associate, National Center for Atmospheric Research
1988 University of Miami, Miami, USA, Ph. D.

SYNERGISTIC ACITIVITIES (selected current and recent)

WOCE Working Group in Numerical Modeling, **1992-97;** NSF Panelist, **1993**; ONR/DAMÉE-NAB Steering Committee **1994-98**; National Center for Atmospheric Research Scientific Computing Division Advisory Panel **1995-97, 1999-present**; NSF APROPOS Workshop Science Steering Committee **1997-98**; US-GODAE Science Steering Committee **1998-present**; WOCE/CLIVAR Ocean Model Development Working Group **1999-present**; HYCOM Consortium for Data Assimilative Modeling Coordinator **1999-present**; International Liège Colloquium on Ocean Hydrodynamics Scientific Organizing Committee **2000-2001**; International GODAE Science Steering Committee **2001-present**; WOCE Conference 2002 Organizing Committee **2001-2002**, International GODAE Symposium Organizing Committee **2001-2002,** ESMF Advisory Board **2002-present**, Gordon Research Conference Organizing Committee **2002-present.**

SELECTED RELEVANT PUBLICATIONS

(Author or co-author of ~50 refereed publications, complete list of publications available at ftp://obelix.rsmas.miami.edu/eric/html/cv.html)

2003 Chassignet, E.P., L.T. Smith, G.R. Halliwell, and R. Bleck: North Atlantic Simulations with the Hybrid Coordinate Ocean Model (HYCOM): Impact of the Vertical Coordinate Choice, Reference Density, and Thermobaricity. *J. Phys. Oceanogr.*, submitted.

2002 Paiva, A.M., and E.P. Chassignet: North Atlantic Modeling of Low-Freqeuncy Variability in in Mode Water Formation. *J. Phys. Oceanogr.*, **32**, 2666-2680.

Chassignet, E.P., M.J. Bell, P. Brasseur, G. Evensen, S.M. Griffies, H.E. Hurlburt, C. Le Provost, G. Madec, J. McClean, J. Verron, and A. Wallcraft, 2002: The Modeling Component of Ocean Forecasting. In *"In Route to GODAE"*, Symposium on the Global Ocean Data Assimilation Experiment, Biarritz, France, June 13-15, 2002.

2001 Paiva, A.M., and E.P. Chassignet: The Impact of Surface Flux Parameterizations on the Modeling of the North Atlantic Ocean. *J. Phys. Oceanogr.*, **31**, 1860-1879.

Garraffo, Z.D., A.J. Mariano, A. Griffa, C. Veneziani, and E.P. Chassignet: Lagrangian Data in a High Resolution Numerical Simulation of the North Atlantic. I: Comparison with *In-Situ* Drifter Data. *J. Mar. Sys.*, **29**, 157-176..

2000 Chassignet, E.P., and P. Malanotte-Rizzoli (Eds.): *Ocean Circulation Model Evaluation Experiments for the North Atlantic Basin.* Special issue of *Dyn. Atmos. Oceans.*, Elsevier Science Ltd., **32**, 155-432.

Stammer, D., and E.P. Chassignet: Ocean State Estimation and Prediction in Support of Oceanographic Research. *Oceanography*, **13**, 51-56.

UNIVERSITY OF MIAMI
Curriculum Vitae
Rosenstiel School of Marine & Atmospheric Science
4600 Rickenbacker Causeway
Miami, Florida 33149

GEORGE HALLIWELL,
Research Associate Professor, Division of Meteorology & Physical Oceanography.

EDUCATION

Oregon State University	Ph.D.	1987
University of Delaware	M.S.	1979
Pennsylvania State University	B.S.	1971

EXPERIENCE

University of Miami	Research Associate Professor	2000-Present
University of Miami	Research Assistant Professor	1990-00
University of Rhode Island	Assistant Marine Scientist	1987-90

RELATED PUBLICATIONS

Halliwell, Jr., G.R., 2003: Evaluation of Vertical Coordinate and Vertical Mixing Algorithms in the Hybrid-Coordinate Ocean Model (HYCOM). Submitted to *Ocean Modelling.*

Halliwell, Jr., G.R., R. H. Weisberg, amd D.A. Mayer, 2003: A synthetic float analysis of upper-limb meridional overturning circulation interior ocean pathways in the tropical/subtropical Atlantic. Submitted for publication in *Interhemispheric Water Exchange in the Atlantic Ocean*, G. Goni and P. Malanotte-Rizzoli, editors, Elsevier Publishing Company.

Halliwell, Jr., G.R., 2003: Time-Scale dependence of the Atlantic Ocean response to NAO-Related Atmospheric forcing. To be submitted to *J. Climate.*

Chassignet, E.P., L. Smith, G.R. Halliwell, and R. Bleck, 2003: North Atlantic simulation with the hybrid coordinate ocean model (HYCOM): Impact of the vertical coordinate choice and resolution, reference density, and thermobaricity. Submitted to *J. Phys. Oceanogr.*

Thacker, W.C., S-K Lee, and G.R. Halliwell, Jr., 2003: Constraining HYCOM: Twenty years of Atlantic XBT data. To be submitted to *Ocean Modelling*.

Halliwell, Jr., G.R., 1998: Simulation of North Atlantic decadal/multi-decadal SST anomalies driven by basin-scale atmospheric circulation anomalies. *J. Phys. Oceanogr.*, **28**, 5-21.

BIOGRAPHICAL SKETCH

MOHAMED ISKANDARANI

Rosenstiel School of Marine and Atmospheric Science
University of Miami
4600 Rickenbacker Causeway Miami, FL 33149-1098

RESEARCH INTERESTS

- Development and application of numerical methods for geophysical fluid flow simulations.

EDUCATION

- PhD, Civil Engineering, Cornell University, Ithaca NY **May 1991**
- M.S., Civil Engineering, Cornell University, Ithaca NY **Aug 1987**
- B.E., Civil Engineering, American University of Beirut, Beirut, Lebanon **Jun 1984**

WORK EXPERIENCE

- **Associate Research Professor** **Sep 2000-Present**
  University of Miami.
- **Assistant Research Professor** **Oct 1991-Sep 2000**
  Rutgers University, Associate member of the graduate program in Physical Oceanography.
- **Visiting Scientist** **July 1995**
  Istituto Per Lo Studio Delle Metodologie Geofisiche Ambiantali, Consiglio Nazionale Delle Ricerche, Modena Italy.
- **Lecturer and Post-doctoral Associate** **Jan 1991-Aug 1991**
  School of Civil and Environmental Engineering, Cornell University.
- **Research Assistant** **Jun 1987-Dec 1990**
  School of Civil and Environmental Engineering, Cornell University.

SELECTED PUBLICATIONS

- M. Iskandarani, D. B. Haidvogel, and J. Levin, "A three-dimensional spectral element model for the solution of the hydrostatic primitive equations". accepted for publication in *Journal of Computational Physics*.
- M. Iskandarani, D. B. Haidvogel, J. Levin, E. N. Curchitser, and C. A. Edwards, "Multiscale geophysical modeling using the spectral element method", *Computing in Science and Engineering*, **4**, No 5, 42–48, 2002.
- O. Le Maître, J. Levin, M. Iskandarani, and O. M. Knio, "Multiple scales enhancement of a spectral element ocean model. I. Formulation and 1D tests", *Journal of Computational Physics*, in press, (2001).
- J. G. Levin, M. Iskandarani, and D. B. Haidvogel, "A nonconforming spectral element ocean model", *International Journal for Numerical Methods in Fluids*, **34**, No 6, pp 495-525, (2000).
- Iskandarani, M., Haidvogel, D. and Boyd, J.P., "A staggered spectral element model for the shallow water equations", *International Journal for Numerical Methods in Fluids*, **20**, No. 5, 393-414, 1995.
- E. N. Curchitser, D. B. Haidvogel, and M. Iskandarani, "On the transient adjustment of a mid-latitude abyssal ocean basin with realistic geometry and bathymetry", *Journal of Physical Oceanography*, **31**, No 3, (2001).
- E. N. Curchitser, D. B. Haidvogel, and M. Iskandarani, "On the Transient Adjustment of a Mid-Latitude Abyssal Ocean Basin with Realistic Geometry and Bathymetry", *Dynamics of Atmosphere and Oceans*, **29**, No 2-4, 147, (1999).
- C. Wunsch, D. B. Haidvogel, M. Iskandarani, and R. Hughes "Dynamics of the Long-Period Tides", *Prog. Oceanog.*, **40**, 81–108 (1997).
- J. Levin, M. Iskandarani, and D. B. Haidvogel, "A spectral filtering procedure for eddy-resolving simulations with a spectral element ocean model", *Journal of Computational Physics*, , **137**, No 1, 130–154, (1997).
- Haidvogel, D. B., Curchitser, E., Iskandarani, M., Hughes, R. and Taylor, M., "Global modeling of the ocean and atmosphere using the spectral element method", *Atmosphere-Ocean*, **35**, 505–531, (1997).

Toshio Michael Chin

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PERSONAL

Rank:	Research Associate Professor
e-mail:	tchin@rsmas.miami.edu
Phone:	305-361-4816; 818-393-2510
Citizenship:	Japan

EDUCATION

Ph.D.	1992	Massachusetts Institute of Technology	Electrical Engineering and Computer Science
M.S.	1983	University of California at Berkeley	Electrical Engineering (Bioelectronics)
B.S.	1982	University of California at Berkeley	Electrical Engineering

PROFESSIONAL EXPERIENCE

University of Miami, Rosenstiel School of Marine and Atmospheric Science, Miami, Florida.
Research Associate Professor, 2001-present.
Research Assistant Professor, 1997-2001.
Research Scientist, 1996-1997.
Postdoctoral Associate, 1992-1994.

Jet Propulsion Laboratory, Pasadena, California.
Research Scientist, 1998-present.

National Center for Atmospheric Research, Boulder, Colorado.
Postdoctoral Fellow, 1994-1996.

PUBLICATION RELEVANT TO PROPOSED RESEARCH

Chin, T.M., A.C. Haza, A.J. Mariano (2002). A reduced-order information filter for multi-layer shallow water models: profiling and assimilation of sea surface height. Journal of Atmospheric and Oceanic Technology 19: 517-533.

Chin T.M. (2001). On Kalman filter solution of space-time interpolation. IEEE Trans. Image Processing 10: 663-666.

Chin, T.M., A.J. Mariano, E.P. Chassignet (1999). Spatial regression and multi-scale approximations for sequential data assimilation in ocean models. Journal of Geophysical Research 104(C4): 7991-8014.

Milliff, R.F., W.G. Large, J. Morzel, G. Danabasoglu, T.M. Chin (1999). Ocean general circulation model sensitivity to forcing from scatterometer winds. Journal of Geophysical Research 104(C4): 11337-11358.

Chin, T.M., R.F. Milliff, W.G. Large (1998). Basin-scale, high-wavenumber sea-surface wind fields from a multiresolution analysis of scatterometer data. Journal of Atmospheric and Oceanic Technology 15: 741-763.

Chin, T.M., W.C. Karl, A.S. Willsky (1992). Sequential filtering for multi-frame visual reconstruction. Signal Processing 28: 311-333.

Mariano, A.J., T.M. Chin, T.M. Ozgokmen (2003). Stochastic boundary conditions for modeling of coastal flows. Geophysical Research Letters, submitted.

CURRICULUM VITAE of Arthur J. Mariano
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PERSONAL
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EDUCATION
1979-1986 Ph.D., Physical Oceanography, University of Rhode Island,
Graduate School of Oceanography, Narragansett, RI, 02882
1978-1979 B.S., Mathematics, Stockton State College, Pomona, NJ, 08240
1974-1978 B.S., Marine Science, Stockton State College, Pomona, NJ, 08240

ACADEMIC AND PROFESSIONAL EXPERIENCE
2001- now Professor, RSMAS/MPO, University of Miami, Miami FL, 33149-1098
1996-2001 Associate Professor, RSMAS/MPO, University of Miami
1990-1996 Assistant Professor, RSMAS/MPO, University of Miami
1988-1990 Rosenstiel Fellow, RSMAS/MPO, University of Miami
1985-1988 Post Doctoral Fellow, Theoretical Oceanography, Division of
Applied Sciences, Harvard University, Cambridge, MA, 02138

PUBLICATIONS RELEVANT TO PROPOSED RESEARCH
Chin, T.M, A. Haza, and A.J. Mariano, 2002. A reduced-order information filter for multi-layer shallow water models: profiling and assimilationof sea surface height. J. of Atmos. and Ocean. Tech, 19 (4), 517-533.

Chin, T.M., A.J. Mariano and E.P. Chassignet, 1999. Spatial regression and multi-scale approximations for sequential data assimilation in ocean models. J. Geophysical Research, 104(C4),7,991-8,014.

Chin,T. M. and A.J. Mariano, 1997. Space-time Interpolation of Oceanic Fronts. IEEE, Trans. on Geosciences and Remote Sensing., 35(3), 734-746.

Mariano, A.J. and O.B. Brown, 1992. Efficient objective analysis of dynamically heterogeneous and nonstationary fields via the parameter matrix. Deep-Sea Res., 39(7/8), 1992, pp. 1255-1271.

Mariano, A. J., and T. M. Chin, 1996. Feature and Contour based data analysis and assimilation in physical oceanography. Stochastic Modelling in Physical Oceanography, (Adler, Muller and Rozovskii, eds.), Birkhauser, 311-342.

Molcard A., L. Piterbarg, A. Griffa, T.M., Ozgokmen, and A.J. Mariano, 2003. Assimilation of drifter positions for the reconstruction of the Eulerian circulation field. Accepted, J. Geophys. Res.

Moore, A.M. and A.J. Mariano, 1999. The Dynamics of Error Growth and Predictability in a Model of the Gulf Stream. I: Singular Vector Analysis.J. Physical Oceanography, 29(2), 158-176.

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Biography

Undergraduate degree in Physics from University of Buenos Aires; Master of Arts in GFD from GFD program, Princeton University; Ph. D. in Meteorology from University of Buenos Aires (1987).
Thesis advisor: Dr. Isidoro Orlanski.

Previous affiliation:

Associate Reasearch Scientist, Columbia University and Nasa Goddard Institute for Space Studies (1991-1996).

Interests

Ocean modeling, Comparison of ocean models with observations
(http://panoramix.rsmas.miami.edu/micom).

Publications relevant to the proposed work

Schmid, C., Z. D. Garraffo, E. Johns, R.L. Molinari, and S. Garzoli, 2003: Pathways and variability at intermediate depths in the tropical Atlantic. Interhemispheric Water Exchange in the Atlantic Ocean (Malanotte-Rizzoli and Goni, Eds). In press, Elsevier Oceanographic Series.

Garraffo, Z.D., W.E. Johns, E.P. Chassignet, G.J. Goni, 2002. North Brazil Current rings and transport of southern waters in a high resolution numerical simulation of the North Atlantic. Submitted to Interhemispheric Water Exchange in the Atlantic ocean. Elsevier Oceanographic Series.

Bracco, A., E.P. Chassignet, Z.D. Garraffo, and A. Provenzale, 2002: Lagrangian velocity distributions in a high-resolution numerical simulation of the North Atlantic. Submitted, J. Atmos. Ocean. Tech.

Chassignet, E. P., and Z. D. Garraffo, 2001: Viscosity parameterization and the Gulf Stream separation. In "From Stirring to Mixing in a Stratified Ocean". Proceedings 'Aha Huliko'a Hawaiian Winter Workshop. U. of Hawaii. January 15-19, 2001. P. Muller and D. Henderson, Eds., 37-41.

Garraffo, Z.D., A.J. Mariano, A. Griffa, C. Veneziani and E.P. Chassignet,2001: Lagrangian Data in a High Resolution Numerical Simulation of the North Atlantic. I: Comparison with In-Situ Drifter Data. Journal of Marine Systems, Vol 29, pp 157-176.

Garraffo, Z.D., Griffa, A., Mariano, A.J., Chassignet, E.P, 2001. Lagrangian Data in a High Resolution Numerical Simulation of the North Atlantic. II: On the Pseudo-Eulerian Averaging of Lagrangian Data. Jour. Marine Systems, Vol 29, pp 177-200.

Garraffo, Z.D. and V.M. Kamenkovich, 1996. A note on the transport of the Brazil Current. Geophys. Res. Lett., 23, 1629-1632.

Other publications

Garzoli, S. L, Z. Garraffo, G. Podesta, and O. Brown, 1992. Analysis of a general circulation model product. Part 1: Frontal systems in the Brazil/Malvinas and kuroshio/Oyashio systems. J. Geophys. Res., 97, 20117-20138.

Garraffo, Z., S. L. Garzoli, W. Haxby and D. Olson, 1992: Analysis of a general circulation model product. Part 2: The distribution of Kinetic energy in the South Atlantic and Kuroshio/Oyashio systems. J. Geophys. Res., 97, 20139-20153.

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Higher Education

Oxford University, UK, B.A., 1973
Southampton University, UK, M.Sc., 1975
Southampton University, UK, Ph.D., 1978

Experience

University of Miami	Professor	1999 to present
University of Miami	Research Professor	1995 to 1999
University of Oxford, Oxford, UK	Visiting Fellow in Physics	1995 to present
North Carolina State University	Adjunct Professor	1994 to 1999
State University of New York at Stony Brook	Adjunct Associate Professor	1994 to 1999
Brookhaven National Laboratory	Scientist	1990-1995
NATO Saclant Undersea Research Centre	Principal Scientist	1985-1990
Rutherford Appleton Laboratory, UK	Senior Scientific Officer	1981-1985
Christian-Albrechts University, Kiel, Germany	Scientist	1977-1981

Recent Relevant Publications

Kearns, E.J., J.A. Hanafin, R.H. Evans, P.J. Minnett and O.B. Brown, 2000. An independent assessment of Pathfinder AVHRR sea surface temperature accuracy using the Marine-Atmosphere Emitted Radiance Interferometer (M-AERI). *Bull. Am. Met. Soc*. **81**, 1525-1536

Minnett, P. J., R. O. Knuteson, F.A. Best, B.J. Osborne, J. A. Hanafin and O. B. Brown, 2001. The Marine-Atmosphere Emitted Radiance Interferometer (M-AERI), a high-accuracy, sea-going infrared spectroradiometer. *Journal of Atmospheric and Oceanic Technology*,**18**, 994-1013.

Minnett, P.J., 2001, Satellite Remote Sensing: Sea Surface Temperatures. Encyclopedia of Ocean Sciences, J. Steele, S. Thorpe, K. Turekian (eds). Academic Press, London, UK. 2552-2563.

Donlon, C. J., P. J. Minnett, C. Gentemann, T. J Nightingale, I. J. Barton, B. Ward and J. Murray, 2002. Towards improved validation of satellite sea surface skin temperature measurements for climate research. *J. Climate.* 15, 353-369

Kumar, A., P. J. Minnett, G. Podestà, and R. H. Evans, 2002, Error characteristics of the atmospheric correction algorithms used in retrieval of sea surface temperatures from infrared satellite measurements; global and regional aspects. *Journal of the Atmospheric Sciences.* Accepted.

Hagan, D., and P.J. Minnett, AIRS Radiance Validation Over Ocean from Sea Surface Temperature Measurements. *IEEE Transactions on Geoscience and Remote Sensing.* Accepted

Minnett, P.J., 2002, Radiometric measurements of the sea-surface skin temperature for the validation of measurements from satellites – the competing roles of the diurnal thermocline and the cool skin. *International Journal of Remote Sensing*. Accepted.

Ward, B., R. Wanninkhof, P.J. Minnett and M.J. Head., 2002. SkinDeEP: A Profiling Instrument for Upper Decameter Sea Surface Measurements. *Journal of Atmospheric and Oceanic Technology.* In review

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Higher Education

North Carolina State University, B.S., 1966
North Carolina State University, M.S., 1970
North Carolina State University, Ph.D., 1973

Experience

University of Miami	Research Professor	1987 to present
University of Miami	Research Associate Professor	1980 to 1987
University of Miami	Research Assistant Professor	1975 to 1980

Research Performed Last Five Years:

Focus of research is to develop quantitative methods that permit timely access to satellite remote sensing observations of transient events in the ocean, using imaging infrared sensors and multi-spectral infrared and color scanner observations. Evolutionary development of processing and analysis capabilities is continuing with the goal being generation of long term time series of oceanic meso-scale variability, to permit application of classical multi-dimensional series analysis techniques and subsequent testing of model hypotheses against satellite observations.

Selected Juried Publications

Kumar, A., P. Minnett, G. Podesta and R. Evans. Analysis of Pathfinder ST Algorithm for Global and Regional Conditions. *Special Issue on the International JGOFS Symposium on 'Biogeochemistry of the Arabian Sea' Proceedings of the Indian Academy of Sciences: Earth and Planetary Sciences*, **109**, 395.405.

Kilpatrick, K.A., G.P. Podesta and R. Evans. Overview of the NOAA/NASA Pathfinder Version 4.2 algorithm for Sea Surface Temperature and associated Matchup Database." *J. Geophys Research* 106: 9179-9198

Wilson-Diaz, D., A.J. Mariano, R.H. Evans, M. Luther, 2001. A principal component analysis of sea surface temperature in the Arabian Sea. *Deep Sea Research II*, Vol. **48**, No. **6-7:** 1097-1114.

Moulin, C., H. Gordon, R. Chomko, V. Banzon, R.H. Evans, 2000. Atmospheric correction of ocean color imagery through thick layers of Saharan dust. *Geophys. Res. Lett.* Vol. **28** , No. **1**, 5-8.

Yang, Q., B. Parvin, A.J. Mariano, E. Ryan, R.H. Evans and O.B. Brown, 2001. Seasonal and interannual studies of vortices in sea surface temperature data. *International Journal of Remote Sensing*, Oceanography from Space Venice 2000 special issue. (*accepted*)

Chen, Shuyi S., W. Zhao, J.E. Tenerelli, R.H. Evans, and V. Halliwell (2001). Impact of the AVHRR sea surface temperature on atmospheric forcing in the Japan/East Sea. *Geophysical Research Letters* Vol. **28:** No. **24**, 4539-4542.

Halliwell, G., R. Evans, and D. Olson. Atmospheric Forcing of Global ENSO-Related SST Anomolies Diagnosed using Atmospheric Reanalysis and Satellite Derived Datasets. (*submitted*)

Glover, D.M., S.C. Doney, A.J. Mariano, R.H. Evans, and S.J. McCue, Mesoscale variability in time-series data: Satellite-based estimates for the U.S. JGOFS Bermuda Atlantic Time-Series Study (BATS) site, J. Geophys. Research, **107: C8**, 1-21, 2002.

S. Marullo, E. Napolitano , R. Santoleri, B. Manca, R. Evans. (2002) The Variability of Rhodes and Ierapetra gyres studied by remote sensing observations, hydrographic data, and model simulations during LIWEX (October 1994-April 1995)

R. Santoreli, Banzon, P. V. F., S. Marullo, E. Napolitanos, F.D.X. D'Ortenzio, and R.H. Evans, 2002. Year-to-year variability of the phytoplankton bloom in southern Adriatic Sea (1998-2000): SeaWiFS observations and modeling study. *J. Geophys. Res*. (special edition) *(Submitted).*

Banzon, P. V. F., R.H. Evans, H.R. Gordon, R.M. Chomko, 2002. SeaWiFS Observation of the Arabian Sea Southwest Monsoon Bloom for the year 2000. *Deep Sea Research Part II*. (*Submitted)*

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Primary Appointment:	Atmospheric and Climate Sciences Group (EES-8), Earth and Environmental Sciences Division
Citizenship:	U.S.A.
Education:	Freie Universitaet, Berlin, M.S. (Meteorology), 1964 Pennsylvania State Univ., Ph.D. (Meteorology), 1968

EXPERIENCE - Academic:

Nat'l Center for Atmosph. Research	Research Scientist	7/67-8/75
University of Miami	Associate Professor/Professor	8/75-12/98
University of Miami	Division Chairman	1990-1995
Los Alamos National Laboratory	Technical Staff Member	1/99- present

RECENT PUBLICATIONS (last 5 years):

Chassignet, E., L. T. Smith, G. R. Halliwell, and R. Bleck, 2003: North Atlantic simulations with the hybrid coordinate ocean model (HYCOM): Impact of the vertical coordinate choice, reference pressure, and thermobaricity. Submitted to *J. Phys. Oceanogr.*

Bleck, R., and S. Sun, 2003: Diagnostics of the oceanic thermohaline circulation in a coupled climate model. Resubmitted to *Global and Planet. Change*.

Cheng, W., R. Bleck, and C. Rooth, 2002: Multidecadal thermohaline variability in a coupled model consisting of the NCAR CCM3 and MICOM. *J. Climate*, In revision.

Bleck, R., 2002: An oceanic general circulation model framed in hybrid isopycnic-Cartesian coordinates. *Ocean Modelling*, **4**, 55-88.

Hu, A., C. Rooth, R. Bleck, C. Deser, 2001: NAO influence on sea ice extent in the Eurasian coastal region. *Gephys.Res.Lett*, **29**, 10-1 - 10-4.

Sun, S., and R. Bleck, 2001: Thermohaline circulation and its response to increasing CO2 in a coupled atmospheric and isopycnal ocean model. *Geophys.Res.Ltrs*., **28**, 4223-4226.

Sun, S., and R. Bleck, 2001: Thermohaline circulation studies with an isopycnic coordinate ocean model. *J. Phys. Oceanogr*., **31**, 2761-2782.

Smith, L. T., E. P. Chassignet, and R. Bleck, 2000: The impact of lateral boundary conditions and horizontal resolution on North Atlantic water mass transformations and pathways in an isopycnic coordinate ocean model. *J. Phys. Oceanogr*., **30**, 137-159.

Vigan, X., C. Provost, R. Bleck, and P. Courtier, 2000: Sea surface velocities from sea surface temperature image sequences. 1, Method and validation using primitive equation model output. *J. Geophys. Res*., **105**, 19499-19514.

Sun, S., R. Bleck, C. Rooth, J. Dukowicz, E. Chassignet, P. Killworth, 1999: Inclusion of thermobaricity in isopycnic-coordinate ocean models. *J.Phys.Oceanogr*., **29**, 2719--2729.

Brydon, D., S. Sun, and R. Bleck, 1999: A new approximation of the equation of state for sea water, suitable for numerical ocean models. *J. Geophys. Res*., **104**, 1537-1540.

Paiva, A.M., J.T. Hargrove, E.P.Chassignet, and R.Bleck, 1998: Turbulent behavior of a fine mesh (1/12º) numerical simulation of the North Atlantic. *J. Mar. Systems*, **21**, 307-320.

Bleck, R., 1998: Ocean modeling in isopycnic coordinates. Ocean Modeling and Parameterization, E.P. Chassignet and J. Verron (Eds.), Kluwer Academic Publishers, 423-448.

Drange, H. and R. Bleck, 1997: Multidimensional forward-in-time upstream-in-space-based differencing for fluids. *Mon. Wea. Rev*., **125**, 616-630.

Bleck, R., S. Sun, and S. Dean, 1997: Global ocean simulations with an isopycnic coordinate model. Some New Directions in Science on Computers, G. Bhanot, S. Chen and P. Seiden (Eds.), World Scientific, Singapore, 297-317.

CURRICULUM VITAE

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Position: 2000-present: Senior Scientist for Ocean Modeling and Prediction at the Naval Research Laboratory (NRL)

Previous: 1977 - 2000: Ocean modeler in the Ocean Dynamics and Prediction Branch at the Naval Research Laboratory. This includes two earlier organizations which ultimately merged with NRL in 1992.

Postdoc: Advanced Studies Program at the National Center for Atmospheric Research (NCAR) in Boulder, CO., Dr. Peter Gilman, advisor

Education: Ph.D., Florida State University, Meteorology, 1974
M.S., Florida State University, Meteorology, 1971
Dr. James J. O'Brien MS and Ph.D advisor
B.S., Union College, Schenectady, N.Y., Physics, 1965

Selected other professional:

- Adjunct faculty member: Florida State University (1995 -), University of Southern Mississippi (1993 -)
- Weather Officer in the USAF (1965 - 69)
- NRL 75th Anniversary Innovation Award 1998
- Meritorious Civilian Service Award 1991.
- Distinguished Scientist Medal at the 13th International Liege Colloquium in 1981.
- Six publication awards: 1980,1990,1991,1994,1997,2000
- Member International and U.S. Scientific Steering Teams for the Global Ocean Data Assimilation Experiment (GODAE) 1998-
- Member NASA Science Working Group on High Resolution Ocean Topography 2001
- PI or Co-PI on 4 previous DoD HPC Challenge Projects and 2 NOPP projects
- Case study on "Eddy-resolving Global Ocean Modeling and Prediction" archived in the Permanent Research Collection of the Smithsonian National Museum of American History, Science Category Finalist, 2000.
- Letter of commendation from Delores Etter, Deputy Director, DDR&E for the DoD HPC Challenge projects, which were essential to the research recognized by the Smithsonian 2000
- Chief Scientist for transition of the world's first operational eddy-resolving (1/16°) global ocean prediction model to the Naval Oceanographic Office, transitioned in 2000, operational in 2001
- In Who's Who in America, Who's Who in Science and Engineering, and American Men and Women in Science.
- ~100 publications excluding abstracts

Research Interests:

Eddy-resolving global, Atlantic and Pacific ocean modeling and using models for oceanic data assimilation, ocean prediction and to better understand the dynamics of the ocean circulation, including western boundary currents, upper ocean - topographic coupling, deterministic vs nondeterministic ocean responses to atmospheric forcing, the global thermohaline circulation, coupling between the major ocean basins and the marginal seas, model – data comparisons, and using the data to improve the models and the models to better interpret the data.

CURRICULUM VITAE

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Position: 1997 - present: Computer Scientist in the Ocean Dynamics and Prediction Branch of the Naval Research Laboratory

Previous: 1991 - 1997: Principal Scientist with Planning Systems Inc, supporting contracts with the Ocean Dynamics and Prediction Branch
1980 - 1991: Senior Scientist with JAYCOR Inc, supporting contracts with the Ocean Dynamics and Prediction Branch

Education: Ph.D., Imperial College, University of London, England, Numerical Analysis, 1981
B.Sc., University of Essex, England, Mathematics and Computer Science, 1997

Member National Oceanographic Partnership Program (NOPP) Ocean Information Technology Infrastructure Steering Committee (1999 -)
Member DoD HPC Modernization Program Shared Resource Center Advisory Panel (1999 -)
PI or Co-PI on three previous DoD HPC Challenge Projects
Case study on "Eddy-resolving Global Ocean Modeling and Prediction" archived in the Permanent Research Collection of the Smithsonian National Museum of American History, 2000 NRL 75th Anniversary Innovation Award 1998

Research Interests:

Numerical solution of finite difference forms of partial differential equations, and their application to the development of eddy resolving numerical ocean circulation models. Ocean model design, development and maintenance. Application of scalable supercomputers to numerical ocean modeling.

Curriculum Vitae

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Education

M.S. (Meteorology)	University of Wisconsin	Madison, WI	1984
B.A. (Geography)	Ohio State University	Columbus, OH	1982

Professional Experience

NORDA/NOARL/NRL (Naval Research Laboratory): 1986 - Present

Mr. Metzger is a meteorologist in the Ocean Dynamics and Prediction Branch and a member of the Large-Scale Modeling group. He is involved in running numerical ocean models (both the NRL Layered Ocean Model [NLOM] and the HYbrid Coordinate Ocean Model [HYCOM]), post-processing model output, model-data comparisons, preparation of model forcing files, diagnostic software development and analysis of model results to help answer basic and applied research questions. He was an integral member of the team that transitioned to the Naval Oceanographic Office the world's first near-global 1/16º eddy-resolving ocean nowcast/forecast system. In addition, he has taken the lead on development of the Pacific basin HYCOM. His basic research has focused on the South China Sea and its connectivity with the Pacific Ocean.

Computer Sciences Corporation; 1985 - 1986

Mr. Metzger was a meteorologist under the Data Buoy Support Contract. He was a member of the data quality team that monitored meteorological measurements of wind, pressure, temperature, etc. on a network of moored buoys and coastal sites.

Professional Societies

Member of the American Geophysical Union and Sigma Xi, the Scientific Research Society

Selected Publications

Metzger, E.J. and H.E. Hurlburt, 2001: The importance of high resolution and accurate coastline geometry in modeling South China Sea inflow. *Geophys. Res. Letters*, **28**, 1059-1062.

Metzger, E.J. and H.E. Hurlburt, 2001: The nondeterministic Kuroshio penetration and eddy-shedding in the South China Sea. *J. Phys. Oceanog*., **31**, 1712-1732.

Metzger, E.J., O.M Smedstad, H.E. Hurlburt, A.J. Wallcraft, R.C., J.F. Shriver, C.N. Barron, J.F. Cayula, and A.B. Kara, 2000: A real-time 1/16º Pacific Ocean nowcast/forecast system. *2000 Marine Technology Society Gulf Coast Chapter Meeting Conference Proceedings*, Stennis Space Center, MS, pp. 97-102.

Metzger, E.J., H.E. Hurlburt, J.C. Kindle, R.C. Rhodes, G.A. Shriver, and O.M. Smedstad, 1998: The 1997 El Niño in the NRL Layered Ocean Model. *1998 NRL Review*, NRL, Washington.

Metzger, E.J. and H.E. Hurlburt, 1996: Coupled dynamics of the China Sea, the Sulu Sea, and the Pacific Ocean. *J. Geophys. Res*., **101**, 12,331-12,352.

Metzger, E.J., H.E. Hurlburt, J.C. Kindle, Z. Sirkes, and J.M., 1992: Hindcasting of wind-driven anomalies using a reduced-gravity global ocean model. *Mar. Technol. Soc. J*., **26(2)**, 23-32. (Figure on the cover).

Dr. John Harding is presently Chief Scientist of the Naval Oceanographic Office. Dr. Harding's major area of scientific expertise involves the real-time prediction of complex oceanographic processes from global down to coastal and estuarine scales. From 1995-2002, Dr. Harding was employed as Head of the Ocean Dynamics and Prediction Branch of the Naval Research Laboratory and prior to that as Head of the Coastal and Semi-Enclosed Seas Section. From this experience, Dr. Harding has an extensive publication record detailing operational ocean forecast systems transitioned from NRL to the U.S. Navy. Dr. Harding earned an M.S. in Marine Science from the Scripps Institution of Oceanography and, in 1987, earned a Ph.D. in Marine Science from the Louisiana State University with an emphasis on coastal and estuarine physical oceanography.

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Education:

1984	Ph.D. (Meteorology), Naval Postgraduate School
1975	M.S. (Meteorology), The University of Oklahoma
1973	B.S. (Meteorology), Northern Illinois University

Professional Employment and Experience:

1996-Present	Atmospheric Dynamics and Prediction Branch Head, Naval Research Laboratory, Monterey, CA.
1988-1997	Mesoscale Modeling Section Head, Naval Research Laboratory, Monterey, CA.
1977-1988	Research Scientist, Naval Research Laboratory, Monterey, CA.
1976-1977	Meteorologist, TECHRAD, Oklahoma City, Oklahoma.
1975-1976	Graduate Research Assistant, University of Oklahoma, Norman OK.

Formal Recognition:

Navy Superior Civilian Service Award, 2002.
NRL 75th Anniversary Award for Innovation, 1998.
NRL Alan Berman Outstanding Research Publication Award, 1998.
Navy Meritorious Civilian Service Award, 1983.

Recent Publications:

Hodur, R.M., J. Pullen, J. Cummings, X. Hong, J. D. Doyle, P. Martin and M.A. Rennick: The Coupled Ocean/Atmospheric Mesoscale Prediction System (COAMPS). *Oceanography*, **15**, 88-89.

Burk, S. D., T. Haack, and R. M. Hodur, 2001: Orographically forced variability in the coastal marine atmospheric boundary layer. Advances in Mathematical Modelling of Atmosphere and Ocean Dynamics. Kluwer Academic Publ., Ed. P.F. Hodnett, 111-118.

Hong, X., S. W. Chang, S. Raman, L.K. Shay, and R.M. Hodur, 2000: The interaction between hurricane Opel (l995) and a warm core ring in the Gulf of Mexico. *Mon. Wea. Rev.*, **128**, 1347-1365.

Hodur, R.M. & J. D. Doyle, 1999: The Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS). Coastal Ocean Prediction, C. Moerss, ed., CRC Press, Boca Raton FL. 125-155, (31 pages).

Hodur, R. M., 1997: The Naval Research Laboratory's Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS). *Mon. Wea. Rev.*, **125**, 1414-1430.

Curriculum Vitae: Maria K. Flatau

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Degrees:

Ph.D., atmospheric science, Colorado State Univ. (1992)
M.Sc., atmospheric science, Colorado State Univ. (1985)
M.Sc., physics, Warsaw University (1980)

Professional Employment and Experience:

2001-present	Meteorologist, NRL MRY
2000-2001	Project Scientist, UCSD, Scripps Institution of Oceanography
1998-2000	Postgraduate Researcher, UCSD, Scripps Institution of Oceanography
1996-1998	NOAA/UCAR Post-Doctorate Fellow in Climate and Global Change
1992-1996	Postgraduate Researcher, UCSD, Scripps Institution of Oceanography
1992	Post-doc, Colorado State University
1983-1992	Graduate Research Assistant, Colorado State University

Field of Research: Atmospheric Dynamics: Tropical dynamics, Atmosphere-ocean interaction, Mesoscale and large scale modeling

Languages: Polish, English, some French and Russian (reading professional literature)

Selected recent publications:

Flatau, M, L. Talley and P. P. Niiler, 2002: The North Atlantic Oscillation, surface current velocities and SST changes in the subpolar North Atlantic, *Journal of Climate*, in press.

Flatau, M., P. Flatau and D. Rudnick 2001: The dynamics of the multiple monsoon onsets. *Journal of Climate*, **14**, 4130-4146.

Flatau, M., LD Talley and D. Musgrave, 2000. Interannual variability in the Gulf of Alaska during the 1991-1994 El Nino. *J. Climate,* **13**, 1664-1673

Curriculum Vitae: Xiaodong Hong

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Education:

1998	Ph.D., North Carolina State University, Atmospheric and Marine Science
1992	M.S., North Carolina State University, Atmospheric Science
1982	B.S., Nanjing Institute of Meteorology, PRC, Climatology

Professional Employment and Experience:

2000-present	Meteorologist, Naval Research Laboratory (NRL), Monterey
1998-2000	Postdoc, UCAR/NRL, Monterey
1991-1998	Graduate Research Assistant, North Carolina State University
1982-1989	Researcher, Guangdong Institute of Tropical Marine Meteorology, PRC

Research Interests:

Coupled Ocean/Atmospheric Mesoscale Numerical Modeling. Coupled data assimilation. Air-sea interaction at Mediterranean Sea. Air-sea interaction on hurricane intensity. Differential land-surface cover.

Selected Publications:

Hodur, M. R., J. Pullen, J. Cummings, X. Hong, J. Doyle, P. Martin, M. A. Rennick, 2002: The Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS). *Oceanography*. 15, 88-89.

Hong, X., S.W. Chang, S. Raman, L. K. Shay and R.M. Hodur, 2000: The interaction between hurricane Opal (1995) and a warm core eddy in the Gulf of Mexico. *Monthly Weather Review*. 128, 1347–1365.

Hong, X., S. Raman, R. M. Hodur and L. Xu, 1999: The Mutual Response of the Tropical Squall Line and the Ocean. *Pure and Applied Geophysics* (PAGEOPH). 155, 1-32.

Hong, X., M. J. Leach and S. Raman, 1999: A numerical modeling study of vegetation as a surface forcing for cloud formation. *Journal of Applied Meteorology*. 34, 2008-2028.

Hong, X., M. J. Leach and S. Raman, 1995: The role of vegetation on the generation of mesoscale circulations. *Atmospheric Environment*. 29, 2163-2176.

Curriculum Vitae: Julie Davis Pullen

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Education:

1993-2000 Ph.D. Physical Oceanography, Oregon State University, Corvallis, OR
1991-1993 M.S. Applied Mathematics, University of Arizona, Tucson, AZ
1987-1991 B.A. Physics and Math major, Macalester College, St. Paul, MN

Professional Employment and Experience:

2002- Research Scientist, Naval Research Laboratory, Monterey, CA.
2000-2002 Consortium for Oceanographic Research and Education postdoctoral researcher, Naval Research Laboratory, Monterey, CA
1992-1993 Summer graduate research assistant, Los Alamos National Laboratory, Los Alamos, NM

Publications:

Hodur, R.M., J. Pullen, J. Cummings, X. Hong, J. D. Doyle, P. Martin and M.A. Rennick: The Coupled Ocean/Atmospheric Mesoscale Prediction System (COAMPS). *Oceanography*, **15**, 88-89.

Pullen J. and J. S. Allen, "Modeling Studies of the Coastal Circulation off Northern California: Statistics and Patterns of Wintertime Flow," 2001, *Journal of Geophysical Research*, **106**, 26959-26984.

Pullen, J. and J. S. Allen, "Modeling Studies of the Coastal Circulation off Northern California: Shelf Response to a Major Eel River Flood Event," 2000, *Continental Shelf Research*, **20**, 2213-2238.

Pullen J. and M. LaBarbera, "Modes of Feeding in Aggregations of Barnacles and the Shape of Aggregations," 1991, Biological Bulletin, **181**, 442-452.

Memberships:

1998- The Oceanography Society
1997- American Geophysical Union
1997- American Meteorological Society

Research Cruise Experience:

1999 Strata Formation on Margins (Eel River, Northern California) on the R/V Wecoma (March 28-April 3); assisted with mooring recovery/deployment, sediment core processing, and CTD casts. Chief Scientist: Andrea Ogston, University of Washington

1996 Santa Barbara Channel - Santa Maria Basin Circulation Study on the R/V Sproul (January 8-15); assisted with data sampling design, mooring recovery/deployment, CTD casts, drifter deployment and XBT launches. Chief Scientist: Myrl Hendershott, Scripps Institution of Oceanography

CURRICULUM VITAE

DESIRAJU B. RAO

Education:B.Sc.- Mathematics, Physics, & Chemistry(1956); M.Sc.- Meteorology & Oceanography (1959), Andhra Andhra University, India.
M.S. (1962) and Ph.D(1965)- Geophysical Sciences, University of Chicago, 1965.

Scientific Capabilities :Analytical and numerical studies on dynamics of long waves, ocean tides, storm surges; circulations in lakes and oceans; stability of fluid flows; numerical weather prediction, coastal Ocean prediction modeling.

Professional Experience:
2001-: Chief, Marine Modeling & Analysis Branch, National Centers for Environmental Prediction/NOAA
1996-2001: Chief, Ocean Modeling Branch, Environmental Modeling Center National enters for Environmental Prediction/NOAA, Washington, D.C.
1984-96: Chief, Marine Products Branch, National, Meteorological Center, NOAA, Washington, D.C.
1981-92: Adjunct Professor of Meteorology, University of Maryland, College Park, MD.
1980-84: Head, Oceans & Ice Branch, Laboratory for Atmospheric Sciences, Goddard Space Flight Center/NASA
1975-80: Head, Physical Limnology & Meteorology Group, Great Lakes Environmental Research Lab./NOAA, Ann Arbor, MI.
1976-80: Adjunct Professor of Physical Limnology & Meteorology, University of Michigan, Ann Arbor, MI.
1974-76: Professor, Department of Mechanical Engineering & The Center for Great Lakes Research University of Wisconsin-Milwaukee, Milwaukee, WI. (On leave of absence during 1975-76)
1971-74: Associate Professor, Department of Mechanical Engineering & the Center for Great Lakes Studies, University of Wisconsin-Milwaukee, WI.
1968-71: Assistant Professor, Department of Atmospheric Sciences, Colorado State Univ., Fort Collins, CO.
1967-68: Research Scientist, Marine Sciences Branch, Department of Energy, Mines, & Resources, Ottawa,Canada.
1965-67: Post-doctoral Fellow, National Center for Atmospheric Research, Boulder, CO.
1960-65: Graduate Research Assistant, Department of Geophysical Sciences, University of Chicago, Chicago, Il.
1959-60: Research Scholar, Indian Naval Physical Laboratory, Cochin, India.

Honors & Awards:
Elected Full Member of Sigma Xi (1969). Fellow of the American Meteorological Society (1983)
Listed in Marquis Who is Who in the Mid West (1974), Men of Achievement for Distinguished Achievement. Cambridge, U.K. (1975), Dictionary of International Biographies, Cambridge, U.K. (1975), American Men & Women of Science (1977), Personalities of America (1978), Marquis Who is Who in America (1980).

CURRICULUM VITAE

Carlos J. Lozano

Education: BS(Physics), 1965, National University of Mexico (UNAM); MS(Physics), 1971, U. Wisconsin-Madison; PhD(Applied Mathematics), 1976, U. Wisconsin-Madison.

Research interests: operational oceanography, data assimilation, and ocean numerical modeling.

Professional experience:
2002-: Visiting Scientist, Marine Modeling and Analysis Branch of the National Meteorological Center, NOAA.
1990-2001: Senior Project Scientist, Oceanography, Division of Engineering and Applied Science, Harvard University.
1988-1990: Project Scientist, Physical Oceanography, Division of Applied Science, Harvard University.
1987:1988: Principal in C.J. Lozano and Associates.
1985-1986: Technical Director at ODSI Advanced Concepts Group.
1981-1985: Technical Director at ODSI Global Weather Dynamics.
1979-1981: Adjunct Professor, Physical Oceanography, College of Marine Studies, U. Delaware.
1976-1981: Assistant Professor, Applied Mathematics, U. Delaware.

Selected Publications:

2002, E.E. Popova, C.J. Lozano, M.A. Srokosz, M.J.R. Fasham, P.J. Haley and A.R. Robinson, Coupled 3D physical and biological modelling of the mesoscale variability observed in North-East Atlantic in spring 1997: biological processes, Deep Sea Research Part I : Oceanographic Research 49(10) 1741-1768.

2001, S. Bekistepe, C. J. Lozano and A. R. Robinson, On the Summer Mesoscale Variability of the Black Sea, J. Mar. Res., 59, 475-515.

2000, P.F.J. Lermusiaux, D.G.M. Anderson and C. J. Lozano, On the mapping of Geophysical Fields: Error and variability subspace estimates, Q.J.R. Meteorol. Soc., 126, 1387-1429.

1996, C. J. Lozano, A. R. Robinson, H. G. Arango, A. Gangopadhyay, N. Q. Sloan, P.J. Haley, and W. G. Leslie, An interdisciplinary Ocean Prediction System: Assimilation Strategies and Structured Data Models, in Modern Approaches to Data Assimilation in Ocean Modelling, P. Malanotte-Rizzoli, Editor, Elsevier, 413-452.

W. Carlisle Thacker

Employer:	Atlantic Oceanographic and Meteorological Laboratory
	National Oceanic and Atmospheric Administration
	4301 Rickenbacker Causeway, Miami, Florida 33149 USA
	(305) 361-4323
Length of Service:	Since 1974
Adjunct Professor:	Rosenstiel School of Marine and Atmospheric Sciences
	University of Miami

Honors: Senior U. S. Scientist Award (Humboldt Preiz) 1982
Alexander von Humboldt-Stiftung

Postdoctoral Fellow	University of Chicago	Chicago IL
Postdoctoral Fellow	National Center for Atmospheric Research	Boulder CO
Postdoctoral Fellow	National Research Council	Miami FL

Degrees:

1965	B.S.	Applied Mathematics	Georgia Institute of Technology	Atlanta GA
1967	M.S.	Physics	University of Illinois	Urbana IL
1971	Ph.D	Physics	University of Illinois	Urbana IL

Some recent publications:

Thacker, W. C. (2003) Data-model-error compatibility", *Ocean Modelling 5*, 233–247.

Thacker, W. C. and O. E. Esenkov (2002) Assimilating XBT data into HYCOM, *Journal of Atmospheric and Oceanic Technology 19*, 709–724.

Hansen, D. V. and W. C. Thacker (1999) On estimation of salinity profiles in the upper ocean. *Journal of Geophysical Research 104*, 7921–7933.

Thacker, W. C. (1999) Principal Predictors. *International Journal of Climatology 19*, 821–834.

Thacker, W. C. and R. Lewandowicz (1997) A comparison of low-dimensional representation of sea-surface temperature anomalies in the North Atlantic. *International Journal of Climatology 17*, 953–967.

Thacker, W. C. (1996) Metric-based principal components: Data uncertainties. *Tellus 48A*, 584–592.

Sirkes, Z., E. Tziperman and W. C. Thacker (1996) Combining data and a global primitive equation ocean general circulation model using the adjoint method. *Modern Approaches to Data Assimilation in Ocean Modeling*, P. Malanotte-Rizzoli, editor. Elsevier, Amsterdam, 119–145.

Thacker, W. C. (1996) Climatic fingerprints, patterns, and indices. *Journal of Climate 9*, 2259–2261.

Thacker, W. C. and R. Lewandowicz (1996) Climatic indices, principal components, and the Gauss-Markov theorem. *Journal of Climate 9*, 1942–1958.

Thacker, W. C. and R. Raghunath (1994) The rigid-lid's contribution to the ill-conditioning of oceanic inverse problems. *Journal of Geophysical Research 99*, 10,131–10,141.

Thacker, W. C. and R. Lewandowicz (1994) Dynamics of information and uncertainty. *Tellus 46A*, 651–670.

Bergamasco, A., P. Malanotte-Rizzoli, W. C. Thacker, and R. B. Long (1993) The seasonal steady circulation of the Eastern Mediterranean determined with the adjoint method. *Deep-Sea Research 40*, 1269–1298.

Thacker, W. C. (1992) Oceanographic inverse problems. *Physica D 60*, 16–37.

Tziperman, E., W. C. Thacker, R. B. Long, S.-M. Hwang, and S. R. Rintoul (1992) Oceanic data analysis using a general circulation model. Part II: A North Atlantic model. *Journal of Physical Oceanography 22*, 1458–1485.

Curriculum Vitae

Joseph M. Sienkiewicz
Chief (Acting), Ocean Applications Branch
Science and Operations Officer
National Weather Service, Marine Prediction Center

Education:

Boston Latin School, 1975
B.S., State University of New York Maritime College, Meteorology and Oceanography (with Honors) 1980
M.S. University of Washington, Atmospheric Science, 1988

Professional Experience:

McAllister Brothers' Inc., New York,NY, Tugboat Mate, 1980-1981
Spentonbush/Red Star Company, New York, NY, Tugboat Mate and relief Captain, 1981-1985
National Weather Service, National Centers for Environmental Prediction, Forecaster, 1988-1996
National Weather Service, Marine Prediction Center, Lead Forecaster, 1996-2002
National Weather Service, Marine Prediction Center, Science and Operations Officer

Licenses:

USCG Third Mate unlimited tonnage, oceans
USCG Master Freight and Towing Vessels

Publications:

The Organization of Clouds and Precipitation on the Mid-Atlantic Coast of the United States: I: The Evolution of a Frontal System from the Rocky Mountains to the Mid-Atlantic Coast. (Journal of Atmospheric Science, 1989) Co-author.

The Organization of Clouds and Precipitation on the Mid-Atlantic Coast of the United States: II: The Mesoscale and Microscale Structure of Rainbands. (Journal of Atmospheric Science, 1989) Lead author.

An Example of the Importance of Ship Observations. (Weather and Forecasting, 1990).

The Observation (NOAA's Mariner's Weather Log, 1992)

Advances in Forecasting Extratropical Cyclones at the National Meteorological Center. (The Life Cycles of Extratropical Cyclones Conference, Bergen, Norway, June 1994). Uccellini, Kocin, and Sienkiewicz.

Mariner's Guide to the Use of 500 Millibar Charts. (NOAA's Mariner's Weather Log, 1995).

Destiny's Storm Analysis (Cruising World Magazine, September, 1995.

Another Look at Hurricane Marilyn. (Ocean Navigator Magazine, Jan., 1996).

Surface Analysis at NCEP's Marine Prediction Center (Weather and Forecasting Conference, August, 1996).

500 MB Charts, Cruising World Magazine, 1999

The Effects of Marine Winds from Scatterometer Data on Weather Analysis and Forecasting. (Bull. Amer. Meteor. Soc., 82, 1965-1990., Atlas, R.R., N. Hoffman, S.M. Leidner, J. Sienkiewicz, T.W. Yu, S.C. Bloom, E. Brin, J. Ardizzone, J. Terry, D. Bungato and J.C. Jusem (2001).

Awards:

Isaac Cline Award for Meteorology, (NCEP level), 1999
NWS Modernization Award, 1994.
SUNY Maritime College, Lee and Palmer Award for excellence in meteorology, 1980.
SUNY Maritime College, Wm. Tuthill Award for proficiency in meteorological and oceanographical studies and projects on training ship cruises, 1980.
Marine Society of New York Award for excellence in seamanship, 1980.

Steven C. Hankin, Computer Scientist, NOAA/PMEL

Education

1984 M.S., Applied Mathematics, University of Washington, Seattle, WA
1975 B.A., Physics, Reed College, Portland, Oregon

Selected Professional Committees

2002- Chair of the Data and Communications Subsystem Steering Committee for the Ocean.US Integrated Sustained Ocean Observing System (IOOS)
2001- Member of Executive Committee of National Virtual Ocean Data System
2001- Unidata/THREDDS Technical Task Force
…
1989-93 American National Standards Institute, Computer Graphics Committee, X3H3

Selected Current Research and Development Activities

- Software developer and project manager for the **Live Access Server (LAS)** and **Ferret**
- **US National Virtual Ocean Data System (NVODS)** – an integrated ocean data system involving LAS and OPeNDAP
- **US Global Ocean Data Assimilation Experiment (GODAE)** – developing real-time data access systems to support model data access and model intercomparison

Selected Recent Publications

Hankin, S. (WG chair), L. Bahner, L. Bernard, P. Bogden, R. Cohen, P. Cornillon, L. Dantzler, S. Glenn, F. Grassle, D. Legler, W. Nowlin, T. Orsi, B. Sherman, M. Spaulding, and S. Starke (2002): data and communications infrastructure for the U.S. Integrated Sustained Ocean bserving System. Sustained Integrated Ocean Observing System (IOOS) Workshop, Data and ommunications (DAC) Working Group, 10–14 March 2002, Warrenton, VA, 10 pp.

Hankin, S., J. Callahan, and J. Sirott (2001): The Live Access Server and DODS: Web Visualization and data fusion for distributed holdings. 17th Conference on Interactive Information and Processing Systems (IIPS) for Meteorology, Oceanography, and Hydrology, AMS, 14-19 January 2001, Albuquerque, NM, 380–382.

CURRICULUM VITAE
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EDUCATION:

Ph.D., Florida State University, Geophysical Fluid Dynamics	1989
Cand. Scient., University of Oslo, Physical Oceanography	1983
Cand. Mag., University of Oslo, Geophysics, Applied Mathematics	1981

POSSITION:

Principal Scientist, Planning Systems Incorporated	2000-present
Senior Scientist, Planning Systems Incorporated	1992-2000
Senior Science Professional, Sverdrup Technology, Inc.	1989-1992
Graduate Research Assistant, Florida State University	1984-1989
Research Associate, University of Oslo, Norway	1983-1984
Lecturer, University of Oslo, Norway	1982-1983

RESEARCH INTERESTS:

Numerical Modeling, Sea Ice Drift, Ice Edge Upwelling, Storm Surges, Coastal Currents, Equatorial Oceanography, Data Assimilation, Operational Oceanography
Played a key role in the development and transition of the operational global 1/16˚ nowcast/forecast system presently running at the Naval Oceanographic Office (NAVOCEANO).

Selected Publications:

1991 Variational data assimilation and parameter estimation in an equatorial Pacific Ocean model. *Progress in Oceanography*, Vol. **26**, 179-241, (with J. J. O'Brien).

1994 Assimilation of altimeter data in a 2-layer primitive equation model of the Gulf Stream. *Journal of Physical Oceanography*, **24**, 305-325, (with D. N. Fox).

1996 Data assimilation in a North Pacific Ocean monitoring and prediction system. In *Modern approaches to data assimilation in ocean modeling*, P. Malanotte-Rizzoli, ed. Elsevier Oceanography Series, **61**, 319-345, (with M. R. Carnes, D. N. Fox and R. C. Rhodes).

2002 Navy real-time global modeling systems. *Oceanography*, **15**(1), 29-43, (with R. C. Rhodes, H. E. Hurlburt, A. J. Wallcraft, C. N. Barron, P. J. Martin, S. L. Cross, E. J. Metzger, J. F. Shriver, A. B. Kara and D. S. Ko).

2002 Real-Time Ocean Modeling Systems. *Computing in Science & Engineering* , March/April 2002, 50-57, (with A. J. Wallcraft, H. E. Hurlburt, E. J. Metzger, R. C. Rhodes and J. F. Shriver).

2002 On the evolution of coastally trapped waves generated by Hurricane Juliette along the Mexican West Coast. *Geophysical Research Letters*, **29**(23), 2141-2144. (with L. Zamudio, H. E. Hurlburt and E. J. Metzger).

2002 A real-time 1/16˚ global ocean nowcast/forecast system. *Journal of Marine Systems*, (in press), (with H. E. Hurlburt, E. J. Metzger, R. C. Rhodes, J. F. Shriver, A. J. Wallcraft and A. B. Kara).

CURRICULUM VITAE

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Current position :

1995 : Research Associate at CNRS (French National Centre for Scientific Research).

Education :

1994 : Postdoctoral Fellow, Laboratory of Geophysical and Industrial Fluid Flows, Grenoble (France)
1993 : Ph.D. Oceanography, University of Liège (Belgium)

Honors and Awards :

1998 CNRS Bronze Medal
1998 Seymour-Cray numerical simulation prize

Research interests :

Three-dimensional numerical modelling of the ocean circulation ; assimilation of data into ocean circulation models for hindcasting/forecasting experiments ; study of the variability of the ocean from mesoscale to decadal scales ; coupling between hydrodynamic, biogeochemical and ecosystem processes in the marine environment ; observations of the sea-surface properties from space (satellite altimetry, sea-surface temperature and ocean colour)

Recent projects :

1993-1996 : Co-ordinator of the MODB project funded by the European Commission, to establish a climatological atlas of the Mediterranean Sea.

1996-2003 : Co-investigator of the NASA/CNES Topex/Poseidon and Jason-1 Science Working teams for satellite altimetry.

1998-2001 : Co-investigator of the DIADEM project funded by the European Union, to develop advanced assimilation methods for operational ocean forecasting systems.

2000-2003 : Principal investigator of the TOPAZ project funded by the European Union, to develop a pre-operational forecasting system for the North Atlantic Ocean and European coastal zones.

2001-2003 : Principal investigator of a project to develop the data assimilation system of the French MERCATOR system

Selected relevant publications (author or co-author of ~30 scientific publications) :

Brasseur P., E. Blayo and J. Verron, 1996: Predictability experiments in the North Atlantic Ocean: outcome of a QG model with assimilation of TOPEX/Poseidon altimeter data, *J. Geophys. Res.*, **101**(C6), 14161-14174.

Brasseur P., J.M. Beckers, J.M. Brankart, R. Schoenauen, 1996: Seasonal Temperature and Salinity Fields in the Mediterranean Sea: Climatological Analyses of an Historical Data Set, *Deep Sea Res.*, **43**(2), 159-192.

Brasseur P., Ballabrera J., and Verron J., 1999: Assimilation of altimetric observations in a primitive equation model of the Gulf Stream using a Singular Evolutive Extended Kalman filter, *J. Mar. Systems*, **22**(4), 269-294.

Ballabrera-Poy J., Brasseur P. and Verron J., 2001: Dynamical evolution of the error statistics with the SEEK filter to assimilate altimetric data in eddy-resolving ocean models, *Q. J. R. Met. Soc.*, **127**, 233-253.

Carmillet V., Brankart J.M., Brasseur P., Drange H., Evensen G. and Verron J., 2001 : A Singular Evolutive Extended Kalman filter to assimilate ocean colour data in a coupled physical-biochemical model of the North Atlantic ocean, *Ocean Modelling*, **3**, 167-192.

Brankart J.-M., Testut C.-E., Brasseur P. and Verron J., 2003: Implementation of a multivariate data assimilation scheme for isopycnic coordinate ocean modes: application to a 1993-96 hindcast of the North Atlantic Ocean circulation, *J. Geophys. Res.*, in press.

Penduff Th., Brasseur P., Testut C.-E., Barnier B. and Verron J., 2003 : Assimilation of sea-surface temperature and altimetric data in the South Atlantic Ocean : impact on basin-scale properties, *J. Mar. Res.*, in press.

Testut C.-E., Brasseur P., Brankart J.-M., and Verron J., 2003 : Assimilation of sea-surface temperature and altimetric observations during 1992-1993 into an eddy-permitting primitive equation model of the North Atlantic Ocean, *J. Mar. Syst.*, in press.

Biographical Sketch: Peter Cornillon

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Education:

Cornell University, B.S., 1969, Engineering Physics
Cornell University, Ph.D., 1973, Experimental High Energy Physics
Summer School of Space Physics, Strasbourg, France, August-September, 1978
Mathematical and Physical Principles of Remote Sensing

Employment:

2000-Present: Director: Open Source Project for a Network Data Access Protocol (OPeNDAP)
1990-Present: Professor of Oceanography and Ocean Engineering, University of Rhode Island (URI)
1987-1990: Associate Professor of Oceanography and Ocean Engineering, URI
1983-1987: Associate Research Professor of Ocean Engineering and Oceanography, URI
1979-1986: Partner and Senior Scientist, Applied Science Associates
1981-1983: Assistant Research Professor of Ocean Engineering and Oceanography, URI
1980-1981: Visiting Assistant Professor, Dept. of Met. and Phys. Oceanogr., MIT
1975-1980: Assistant Research Professor of Ocean Engineering, URI
1972-1975: Systems Analyst, General Motors Research Laboratory, Warren, Michigan

Membership in Professional or Scientific Societies:

American Geophysical Union
American Meteorological Society
The Oceanographic Society

Publications: (ten most recent)

Osychny, V. and P. Cornillon, "Properties of Rossby waves in the North Atlantic estimated from satellite data", In Revision, 2003.

Codiga, D.L. and P. Cornillon, "Effects of Stratification and Topography on the Sea Surface Height Signature and Ekman Pumping Efficiency of Baroclinic Rossby Waves", *J. Phys. Oceanogr.*, In press, 2003.

Park, K-A and P. Cornillon, "Stability-induced modification of sea surface winds over Gulf Stream rings", *Geophy. Res. Lett*., 29, 64-1 to 64-4, doi:10.1029/2001GL014236, 2002.

Hare, J.A., J.H. Churchill, R.K. Cowen, T.K. Berger, P.C. Cornillon, P. Dragos, S.A. Glenn, J.J. Govoni and T.N. Lee, "Routes and Rates of Larval Fish Transport from the Southeastern to the Northeastern United States Continental Shelf", *Limnology and Ocean*., 47, PART 6; 1774-1789, 2002.

Alfultis, M. and P. Cornillon. "A Characterization of the North Atlantic STMW Layer Climatology Using World Ocean Atlantic 1994 Data", *J. Atmos. Oceanic Tech*., 18, 2021-2037, 2001.

Cornillon, P. and K.-A. Park. "Warm core ring velocities inferred from NSCAT", *Geophy. Res. Lett.,* 28, 575-578, 2001.

Casey, K.S. and P. Cornillon, "Global and Regional Sea Surface Temperature Trends", *J. Climate*, 14, 3801-3818, 2001.

Alfultis, M. and P. Cornillon. "Annual and Interannual Changes in the North Atlantic STMW Layer Properties", *J. Phys. Oceanogr.,* 31, 2066-2086, 2001.

Ullman, D. S. and P. C. Cornillon. "Continental Shelf Surface Thermal Fronts in Winter off the Northeast U.S. Coast", *Cont. Shelf Res*., 21, 1139-1156, 2001.

Ullman, D.S. and P. Cornillon "Evaluation of Front Detection Methods for Satellite-Derived SST Data Using In Situ Observations", *J. Atmos. Oceanic Technol*., 17, 1667-1675, 2000.

William Joseph Schmitz, Jr.
Physical Oceanographer
Scientist Emeritus
Woods Hole Oceanographic Institution
Research Scientist
The University of Southern Mississippi

Birth: December 20, 1937

Sc.B., University of Miami, 1961
Ph.D., Physical Oceanography, University of Miami, 1966

Research Aide, 1959—61; NDEA Fellow, 1961—64; Instructor, 1964—66, Institute of Marine Science, University of Miami
Postdoctoral Fellow, 1966—67, Nova University
Assistant Scientist, 1967—71; Associate Scientist, 1971—79, awarded tenure, 1974; Senior Scientist, 1979—96; W. Van Alan Clark Chair for Excellence in Oceanography, 1992—97; Scientist Emeritus, 1997—, Woods Hole Oceanographic Institution

Senior Queen's Fellow, Commonwealth of Australia, 1984
Interim Director, Institute for Naval Oceanography, 1986
Fellow, American Geophysical Union, 1987— Member, Naval Research Advisory Committee, 1990—96

Meritorious Public Service Award, Department of the Navy, March, 1991
Meritorious Public Service Citation, Department of the Navy, July, 1996
Superior Public Service Award, Department of the Navy, September, 1996

Visiting Investigator, Institut für Meereskunde, Universität Kiel, September, 1993 Visiting Investigator, Scripps Institution of Oceanography, University of California, San Diego, February—March, 1995

Research Interests: Low frequency, large scale ocean circulation Author or co-author of 60 refereed scientific publications

John L. Wilkin

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Professional Positions:

2001-: Assistant-Professor, Department of Marine and Coastal Sciences, Rutgers University, New Jersey

2000-2001: Research Scientist, NIWA, Auckland, New Zealand.

1998-1999: Senior Lecturer, School of Environmental and Marine Sciences, University of Auckland.

1990-1997: Senior Research Scientist, CSIRO Division of Marine Research, Hobart, Tasmania.

1988-1990: Scientist, DSIR Division of Water Sciences, New Zealand Oceanographic Institute.

Education:

Ph.D., 1988, Massachusetts Institute of Technology/Woods Hole Oceanographic Institution.

S.M., 1985, Department of Civil Engineering, Massachusetts Institute of Technology.

B.E. (Hons), 1982, School of Engineering, University of Auckland.

Selected Publications:

Bowen, M. M., W. J. Emery, J. L. Wilkin, P. C. Tildesley, I. J. Barton and R. Knewtson (2002), Extracting multi-year surface currents from sequential thermal imagery using the Maximum Cross Correlation technique, *Journal of Atmospheric and Oceanic Technology*, **19**, 1665-1676.

Ridgway, K.R., J. R. Dunn J. and J. Wilkin (2002), Ocean interpolation by 4-dimensional weighted least squares: Application to the waters around Australasia, *J. Atmos. Oceanic Tech.*, **19**, 1357-1375.

Wilkin, J. L., M. M. Bowen and W. J. Emery (2002), Mapping mesoscale currents by optimal interpolation of satellite radiometer and altimeter data, *Ocean Dynamics*, **52**, 95-103.

Griffin, D., J. Wilkin, C. Chubb, A. Pearce and N. Caputi (2001), Ocean currents and the larval phase of Australian western rock lobster, Panulirus cygnus, *Marine and Freshwater Res.*, **52**, 1187-1200.

Carter, L. and J.L. Wilkin (1999), Abyssal circulation around New Zealand: A comparison between observations and a global circulation model, *Marine Geology*, **159**, 221-239.

Ridgway, K.R., J.R. Dunn, J.L. Wilkin and A.E. Walker (1999), A Satellite Based Ocean Analysis System for Australian Waters, *Bulletin of the Australian Meteorological Society*, **11**, 125-128.

Moore, M.I. and J.L. Wilkin (1998), Variability in the South Pacific Deep Western Boundary Current from Current-meter Observations and a High Resolution Global Model, *Journal of Geophysical Research*, **103**, 5439-5457.

Walker, A.E. and J.L. Wilkin (1998), Optimal averaging of NOAA/NASA Pathfinder satellite sea surface temperature data, *Journal of Geophysical Research*, **103**, 12,869-12,883.

Wilkin, J.L. and J.V. Mansbridge and J.S. Godfrey (1995), Pacific Ocean Heat Transport at 24^0N in a High-resolution Global Model, *Journal of Physical Oceanography*, **25**, 2204-2214.

Professional Activities:

Editor, Ocean Dynamics, Springer-Verlag, 2000-.

Member, NASA Scientific Working Group for TOPEX/Jason-1 Mission, 1997-.

Member, WOCE (World Ocean Circulation Experiment) Numerical

DALE B. HAIDVOGEL

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EDUCATION:

1971, B.S. Massachusetts Institute of Technology
1976, Ph.D. MIT and the Woods Hole Oceanographic Institution

PROFESSIONAL APPOINTMENTS:

1990-	Professor II, Rutgers University, Institute of Marine and Coastal Sciences, New Brunswick, NJ
1986-90	Principal Research Scientist, The Johns Hopkins University, Baltimore, MD
1982-86	Scientist II, National Center for Atmospheric Research, Boulder, CO
1986-	Affiliate Scientist, National Center for Atmospheric Research, Boulder, CO
1978-82	Associate Scientist/Assistant Scientist, Woods Hole Oceanographic Institution, Department of Physical Oceanography, Woods Hole, MA
1976-78	Research Fellow, Harvard University, Center for Earth and Planetary Physics, Cambridge, MA

EXECUTIVE ACTIVITIES (selected):

Director,	Graduate Program in Oceanography, Rutgers University, 1995--present
Member,	NOPP Interagency Steering Committee on Information Technology and Infrastructure for the Ocean Sciences, 2000--present
Member,	GLOBEC Science Steering Committee, 1996--present
Co-Editor,	*Dynamics of Atmospheres and Oceans*, 1980--present

RESEARCH INTERESTS, PUBLICATIONS and WEB SITES:

- Advanced algorithms for geophysical modeling (*e.g.*, the spectral finite element method; see Iskandarani *et al.*, 2002. *Comp. Sci. Eng.*, **4**, 42--48)
- Coupled modeling of regional climate impacts (*e.g.*, for the U.S. GLOBEC program; see Hermann *et al.*, 2002. *Prog. Oceanogr.*, **53**, 335--367)
- Numerical and laboratory studies of fundamental processes (*e.g.*, flow-topography interaction; see Curchitser *et al.*, 2001. *J. Phys. Oceanogr.*, **31**, 725--745 and Perenne *et al.*, 2000. *J. Atm. Oceanic Tech.*, **18**, 235--255)
- Observing systems and data assimilation (*e.g.*, http://marine.rutgers.edu/mrs/)
- Quantitative metrics for ocean model performance (see our ocean model test problem web site: http://marine.rutgers.edu/po/index.php)

Promotion and distribution of models and products (http://www.ocean-modeling.org/

CURRICULUM VITAE

Robert H. Weisberg

Professor, Physical Oceanography
College of Marine Science, University of South Florida
140 7th Ave. S.
St. Petersburg, FL. 33701

Born 05/20/47. B.S. Cornell Univ., 1969 (Mat. Sci. and Engr.); M.S. and Ph.D, Univ. of Rhode Island, 1972 and 1975 (Phys. Oceanogr.); U.S. Army Reserve 08/69-08/77 (Rank 03); Grad. Assist./Assoc., Univ. of Rhode Island, 09/69-06/76; Adjunct Prof., Univ. of Rhode Island, 11/76-08/82; Assist. and Assoc. Prof., North Carolina State Univ. 08/76-08/81 and 08/81-12/86; Assoc. Prof., Univ. of South Florida, 08/84-08/85 and 01/87-08/88; Prof., Univ. of South Florida 08/88-present. Member Sigma Xi, AGU, AMS, TOS. Assoc. ed., Terr., Atm., and Oceanic Sci. Jour., Taiwan. Editor's citation for excellence in refereeing, Geophys. Res. Lett., 5/95. Professorial Excellence Award, USF, 1998,

Selected Related Publications

Li, Z. and R.H. Weisberg (1999a). West Florida Shelf response to upwelling favorable wind forcing, Part 1: Kinematics. *J. Geophys. Res*., 104, 13,507-13,527.

Li, Z. and R. H. Weisberg (1999b). West Florida Shelf response to upwelling favorable wind forcing, Part 2: Dynamics. *J. Geophys. Res*., 104, 23427-23442.

Yang, H. and R. H. Weisberg (1999). West Florida continental shelf circulation response to climatological wind forcing, *J. Geophys. Res*., 104, 5301-5320.

Yang, H., R.H. Weisberg, P.P. Niiler, W. Sturges, and W. Johnson (1999). Forbidden zone over the West Florida Shelf, *Cont. Shelf. Res*., 19, 1221-1245.

Weisberg, R.H., B. Black, Z. Li (2000). An upwelling case study on Florida's west coast, *J. Geophys. Res.*, 105, 11459-11469

Meyers, S.D., E.M. Siegel, and R.H. Weisberg (2001). Observations of currents on the west Florida shelf break. *Geophys. Res. Lett.,* 28, 2037-2040.

Weisberg, R.H., Z. Li, and F.E. Muller-Karger (2001). West Florida shelf response to local wind forcing: April 1998. *J. Geophys. Res.,* 106, 31239-31262.

He, R and R.H. Weisberg (2002). West Florida shelf circulation and temperature budget for the 1999 spring transition. *Cont. Shelf Res*., 22, 719-748.

He, R and R.H. Weisberg (2002). Tides on the west Florida shelf. *J. Phys. Oceanogr*., 32, 3455-3473

Virmani, J.I. and R.H. Weisberg (2003). Features of the Observed Annual Ocean-Atmosphere Flux Variability in the West Florida Shelf. *J. Climate*, in press.

He, R and R.H. Weisberg (2003). A Loop Current intrusion case study on the West Florida Shelf. *J. Phys. Oceanogr.,* in press.

Weisberg, R.H. and R. He (2003). Local and deep-ocean forcing contributions to anomalous water properties on the West Florida Shelf. *J. Geophys. Res.,* in press.

He, R and R.H. Weisberg (2003). West Florida Shelf circulation and temperature budget for the 1998 fall transition. *Cont. Shelf Res.,* in press.

GEIR EVENSEN

BACKGROUND

Prof. G. Evensen is Research Director at the Nansen Center, in Bergen Norway, with responsibility for the Modelling and Data Assimilation Group. He is also a director of Ocean Numerics. He has a Ph. D. in applied mathematics from the University of Bergen (1992), and has many years experience from theoretical work in data assimilation and ocean modeling, including the development of assimilation schemes suitable for highly nonlinear systems.

He has recently introduced the ensemble Kalman filter and smoother, which are assimilation techniques now being applied in a number of model systems worldwide.

He was coordinator of the EC MAST-III DIADEM project and has actively participated in 9 previous or ongoing European Community (EC) funded research projects. He is currently the coordinator of the EC FP-V TOPAZ project.

He has experience coordinating several ocean hindcast modeling projects for the international oil industry, and has through these projects obtained experience using MICOM and HYCOM in regional high resolution applications.

Current activities focus on the development of systems for operational marine monitoring and forecasting. Several projects and staff are contributing in this activity, which has been organized on an international scale with collaborators in Europe and the US. He is also a member of the International GODAE Steering Team (IGST).

RECENT PUBLICATIONS

The Ensemble Kalman Filter: Theoretical Formulation and Practical Implementation, Geir Evensen, Submitted to Ocean Dynamics, 2002

Assimilation of ice concentration in a coupled ice-ocean model, using the Ensemble Kalman Filter, Knut Arild Lisaeter, Julia Rosanova, and Geir Evensen, Submitted to Ocean Dynamics, 2002

A demonstration of ensemble based assimilation methods with a layered OGCM from the perspective of operational ocean forecasting systems , K. Brusdal, J.M. Brankart, G. Halberstadt, G. Evensen, P. Brasseur, P. J. van Leeuwen, E. Dombrowsky and J. Verron, JMS, In print, 2002

Assimilation of ocean colour data into a biochemical model of the North Atlantic. Part 1. Data assimilation experiments, Lars-Jorgen Natvik and Geir Evensen, JMS, In print, 2002

Assimilation of ocean colour data into a biochemical model of the North Atlantic. Part 2. Statistical analysis, Lars-Jorgen Natvik and Geir Evensen, JMS, In print, 2002

Assimilation of SST and SLA data into an OGCM for the Indian Ocean, Vibeke E. J. Haugen and Geir Evensen, Ocean Dynamics, 52, 133-151, 2002. (Springer holds the copyright of this article and the original version is available on LINK http://link.springer.de. A pdf version of the manuscript can be provided on request.)

Indian Ocean. Part 1: Validation of the Miami isopycnic coordinate ocean model, and Part 2: ENSO events during 1958-1998, V.E.J. Haugen, G. Evensen and O.M. Johannessen, JGR, 107 (C5), 11-1 to 11-23, 2002

DAVID SZABO

EDUCATION

1970 BS Meteorology and Oceanography, New York University
1978 MS Physical Oceanography, Florida State University

PROFESSIONAL RECORD

2000 – Present	**Fugro GEOS Inc** – Division Director and **Ocean Numerics** – Managing Director
1995 - 2000	**Fugro GEOS Inc** – Regional Director
1981 - 1995	**Mobil Research and Development Corporation, Dallas, Texas** Oceanographer
1974 - 1981	**Department of Oceanography – FSU, Tallahassee, Florida** Graduate Research Assistant
1970 - 1974	**US Coast Guard, Washington, DC** Officer - Military Oceanographer

PROJECT EXPERIENCE

- Directed development of joint industry projects, including GUMBO (Gulf of Mexico Bottom Currents), CARIMOS (Caribbean Metocean Statistics) and TACOS (Trinidad Atlantic Comprehensive Oceanographic Study).

- Responsible for development of ocean engineering, marine environment and coastal oceanographic business lines for Fugro GEOS within North and South America.

- Responsible for technical representation to joint-industry-projects including: Eddy Joint Industry Project, Climatology and Simulation of Eddies and Hurricane Alleys in the Gulf of Mexico; North European Storm Study; North West Approaches Group (UK); West Africa Wind and Waves Extremes; and South East Asia Metocean Study.

- Provided technical representation to subcommittees of the American Petroleum Institute, International Standards Organization and the E&P Forum.

- Responsible for developing deepwater current measurement programs and engineering criteria in high current regions such as the Gulf Stream off the US East Coast and in the Slope Current west of the Shetlands. Participated and led several surveys of Loop Current Eddies in the Gulf of Mexico.

PUBLICATIONS

Szabo D & Weatherly G L (1979). Energetics of the Kuroshio South of Japan. Jour of Mar Res Vol 37-3 pg 531-556.
Cardone V J, Cooper C K & **Szabo D** (1995). A Hindcast Study of the Extreme Wave Climate of Offshore West Africa (WAX). OTC 7687 Offshore Technol Conf Houston.
Calverley, MJ, **Szabo D**, Cardone VJ, EA Orlup, and MJ Parsons (2002). Wave Climate Study of the Caribbean Sea. Preprints of the 7th International Workshop on Wave Hindcasting and Forecasting. October 21-25, 2002 Banff, Alberta, Canada. Proceedings available from Environment Canada, Downsview, Ontario.

JAMES W. FEENEY

EDUCATION:

1977 to 1978	Northeastern University Management Development Program, Graduate Level Business Management
1966 to 1968	University of Hawaii, M.S. Oceanography
1962 to 1966	University of Wisconsin, B.S. Geology

MILITARY EXPERIENCE:

01/69 to 01/70	Lt jg USN Platoon Commander, UDT22, Little Creek, VA
01/70 to 01/71	Operations Officer, Underwater Demolition Team Twenty-two, Little Creek, VA
01/71 to 07/72	Lt. USN, Naval Special Warfare, Washington, D.C.

PROFESSIONAL EXPERIENCE:

11/82 to Present	President, Horizon Marine, Inc., Marion, MA
12/86 to 03/90	President, Transtrack Inc.
11/78 to 11/82	Vice President, Marketing, Sippican Ocean Systems, Inc.

RECENT PROJECTS:

06/95 to Present	Conduct air and sea operations for the monitoring and study of ocean currents in the Gulf of Mexico and western Caribbean Sea.
04/91 to Present	Develop Global Positioning System product line for oceanographic applications.
06/91 to 06/93	Develop an air-deployable oceanographic mooring and release system for ocean bottom current measurement program for an oil industry consortium; successfully deploy in hurricane and recover.
05/86 to 06/90	Develop a two-way digital communications and automatic vehicle location system. Market this to the trucking transportation industry. Form a corporation to accomplish this, raise capital, introduce system through an exclusive pilot program with largest trucking company.
04/84 to Present	Conduct Ocean Response to Hurricane Studies, Joint Industry Programs, Government and Industry cooperative study; modify AXCP for survival in hurricane wind and waves.
09/84 to Present	Conceive, develop, and operate Eddy Watch[sm] Gulf of Mexico oceanographic advisory service for the oil and gas industry.
11/82 to Present	Organize and develop oceanographic service company to provide offshore ocean measurements and studies.

PUBLICATIONS:

Kantha, L., J.-K. Choi, and R. Leben, University of Colorado; C. Cooper, Chevron; M. Vogel, Shell; and J. Feeney, Horizon Marine, 1999. Hindcasts and Real-time Nowcast/Forecasts of Currents in the Gulf of Mexico. Offshore Technology Conference 10751.

Feeney, J.W. and T.B. Sanford 1984. Velocity Profiling in Strong Ocean Currents. Offshore Technology conference, paper #OTC 4835.

Sanford, T.B., P.G. Black, J.R. Haustein, J.W. Feeney, G.Z. Forristall, and J.F. Price 1987. Ocean Response to a Hurricane. Part I: Observations Journal of Physical Oceanography, Vol. 17, No. 11, pgs. 2065-2083.

STEVEN P. ANDERSON

EDUCATION:

1993 Postdoctoral Fellow, Woods Hole Oceanographic Institution
1992 Ph.D. Oceanography, Scripps Institution of Oceanography, U.C. San Diego
1987 B.S. Mechanical Engineering, Lafayette College

PROFESSIONAL EXPERIENCE:

2000 to Present Chief Scientist, Horizon Marine, Inc., Marion, MA
1998 to 2000 Institution Scholar, Office of Naval Research
1998 to 2000 Associate Scientist, Woods Hole Oceanographic Institution
1994 to 1998 Assistant Scientist, Woods Hole Oceanographic Institution
1993 to 1994 Postdoctoral Investigator, Woods Hole Oceanographic Institution
1987 to 1992 Research Assistant, Scripps Institution of Oceanography

RECENT PROJECTS:

1999 - 2002 Currently funded by ONR, in collaboration with meteorologists at the University of Miami, to couple an upper ocean mixed layer model to a meso-scale atmospheric model in order to determine the mechanisms of two-way air/sea feedback in regions of high sea surface temperatures and low winds.

1999 - 2000 As principle investigator, worked with ONR and the Navy to collect and analyze marine environmental observations during a Mine Countermeasures Readiness and Effectiveness Measurement exercise that took place on the Texas Shelf during 1999.

1996 – 2001 Co-investigator of a NOAA-funded project to monitor air/sea interaction and upper ocean variability in the eastern tropical Pacific. Maintained a pair of surface moorings deployed at two sites straddling the equator for 18 months in 1997 and 1998 during El Nino conditions.

1996 - 2000 Principle investigator of a project that involved the design and deployment of a unique horizontal mooring equipped with temperature, salinity, and current velocity recorders to observe the internal solitary waves in Massachusetts Bay during the summer of 1998.

RECENT PUBLICATIONS (author or co-author of 22 scientific publications and 9 technical reports)**:**

C. Zhang and S. Anderson, 2003: Sensitivity of intraseasonal perturbations in SST to the structure of the MJO. *J. Climate*, submitted.

Lentz, S., K. Shearman, S. P. Anderson, A. Pleuddemann, and J. Edson, 2003: The evolution of stratification over the New England shelf during the Coastal Mixing and Optics study, August 1996 – June 1997. *J. Geophys. Res*., in press.

Grosenbaugh, M., S. Anderson, R. Trask, J. Gobat, W. Paul, B. Butman, R. Weller, 2002: Design and Performanceof a Horizontal Mooring for Upper-Ocean Research. *J. Atmos. Ocean. Tech*., **19**, 1376-1389.

Brunke, M. A., X. Zeng and S. P. Anderson, 2002: Uncertainties in Sea Surface Turbulent Flux Algorithms and Datasets. *J. Geophys. Res*., **107**(C10), 5-1-21.

Anderson, S. P., 2001: On the internal boundary layer over the equatorial front. *J. Climate*, **14**, 1688-1694.

Baumgartner, M. F. and S. P. Anderson, 1999: Evaluation of NCEP regional numerical weather prediction model surface fields over the Middle Atlantic Bight. *J. Geophys. Res.*, **104** (C8), 18 141-18 158.

AWARDS AND HONORS:

1998 Office of Naval Research/Secretary of the Navy Scholar
1995 Visiting Scientist at University of Hawaii
1992 Woods Hole Oceanographic Postdoctoral Fellowship
1987 Lafayette College-G. W. Pepper Award for Scholastic Leadership
1985 Ingersoll-Rand Scholarship

Results from prior research (selected NRL and Miami)

"Global HYCOM and Advanced Data Assimilation", Office of Naval Research, Navy Ocean Modeling Program.

Chassignet, E.P., P.J. Hogan, H.E. Hurlburt, E.J. Metzger, O.M. Smedstad and A.J. Wallcraft, 2002: Basin-scale ocean prediction with the Hybrid Coordinate Ocean Model. 2002 DoD HPC User's Group Conference Proceedings. (submitted)

Hurlburt, H.E., R.C. Rhodes, and G.A. Jacobs, 2001: Global HYCOM and advanced data assimilation. Ocean Atmosphere Space Fiscal Year 2001 Annual Reports, Office of Naval Research, Arlington, VA. (Published on cd-rom)

LeProvost, C., M. Bell, E. Chassignet, J. Cummings, I. Fukumori, H. Hurlburt, and M. Kamachi, 2002: Assessment and testing of GODAE products. Proceedings of the "En route to GODAE" International Symposium, 13-15 June 2002, Biarritz, France, pp. 61-67.

Wallcraft, A.J., H.E. Hurlburt, and J.F. Shriver, 2001: Eddy-resolving global and basin scale ocean modeling. FY01 NRL DoD HPC Modernization Program Annual Reports. (submitted)

"HYCOM NOPP", Office of Naval Research, National Ocean Partnership Program.

Chassignet, E.P., L.T. Smith, G.R. Halliwell, and R. Bleck, 2002. North Atlantic simulations with the HYbrid Coordinate Ocean Model (HYCOM): Impact of the vertical coordinate choice, reference density, and thermobaricity. *J. Phys. Oceanogr.*, submitted.

Halliwell, G., 2002. Evaluation of vertical coordinate and vertical mixing algorithms in the HYbrid Coordinate Ocean Model (HYCOM). *Ocean Modelling* (submitted)

Bleck, R., 2002. An oceanic general circulation model framed in hybrid isopycnic-cartesian coordinates. *Ocean Modelling*, **4**, 55-88.

Thacker, C., and O. Esenkov, 2002: Assimilating XBT data into HYCOM. J. Atmos. Oceanic Tech., 19, 709-724.

Chassignet, E.P., A.J. Wallcraft, H.E. Hurlburt, P.J. Hogan, E.J. Metzger and O.M. Smedstad, 2002: High resolution North Atlantic simulation with the Hybrid Coordinate Ocean Model (HYCOM). High Performance Computing Contributions to Mission Success 2002. (submitted)

Chassignet, E.P., M.J. Bell, P. Brasseur, G. Evensen, S.M. Griffies, H.E. Hurlburt, C. LeProvost, G. Madec, J. McClean, J. Verron, and A.J. Wallcraft, 2002: The modeling component of ocean forecasting. Proceedings of the "En route to GODAE" International Symposium, 13-15 June 2002, Biarritz, France, pp. 41-46.

Hurlburt, H.E., 2000: HYCOM consortium for data-assimilative ocean modeling. Ocean Atmosphere Space Fiscal Year 2000 Annual Reports, Office of Naval Research, Arlington, VA. (published on cd rom)

Hurlburt, H.E., 2001: HYCOM consortium for data-assimilative ocean modeling. Ocean Atmosphere Space Fiscal Year 2001 Annual Reports, Office of Naval Research, Arlington, VA. (published on cd-rom)

Stammer, D. and E. Chassignet, 2000: Ocean state estimation and prediction in support of oceanographic research. Oceanography, Vol. 13, No. 2, 51-56,

"Dynamics of Low Latitude Western Boundary Currents", Office of Naval Research, Core Funding,

Fratantoni, D.M., W.E. Johns, T.L. Townsend, and H.E. Hurlburt, 2000: Low-latitude circulation and mass transport pathways in a model of the tropical Atlantic Ocean. J. Phys. Oceanogr., 30, 1944-1966.

Hogan, P.J. and H.E. Hurlburt, 2000: Impact of upper ocean - topographic coupling and isopycnal outcropping in Japan/East Sea models with 1/8º to 1/64º resolution. J. Phys. Oceanogr., 30, 2535-2561.

Hurlburt, H.E., R.C. Rhodes, O.M. Smedstad, A.J. Wallcraft, E.J. Metzger, J.F. Shriver, and A.B. Kara, 2001: A real-time, eddy-resolving 1/16º global ocean prediction system. Report of the NASA High-Resolution Ocean Topography Science Working Group, D.B. Chelton, ed., College of Oceanic and Atmospheric Sciences, Oregon State U., Corvallis, OR, Ref. 2001-4, Oct. 2001, pp. 52-60.)

Johns, W.E., T.L. Townsend, D.M. Fratantoni, and W.D. Wilson, 2002: On the Atlantic inflow into the Caribbean Sea. Deep Sea Research, 49 (1), 211-243.

Kara, A.B., P.A. Rochford, and H.E. Hurlburt, 2002: Air-sea flux estimates and the 1997-1998 ENSO event. Boundary Layer Meteorology, 103, 439-458.

Leonardi, A.P., H.E. Hurlburt, J.J. O'Brien, and B. Subrahmanyam, 2000: Comparison of modeled and remotely sensed Rossby waves in the subtropical North Pacific. Research Activities in Atmopspheric and Oceanic Modelling, H. Ritchie, ed., WMO/TD-No.987, pp. 9.3-9.4.

Melsom, A., E.J. Metzger and H.E. Hurlburt, 2002: Remotely forced sea level and mesoscale variability in the Gulf of Alaska. J. Geophys. Res. (submitted)

Metzger, E.J., 2002: Upper ocean sensitivity to wind forcing in the South China Sea. J. of Oceanogr. (submitted)

Metzger, E.J. and H.E. Hurlburt, 2001: The nondeterministic nature of Kuroshio penetration and eddy-shedding in the South China Sea. J. Phys. Oceanog., 31, 1712-1732.

Metzger, E.J. and H.E. Hurlburt, 2001: The importance of high horizontal resolution and accurate coastline geometry in modeling South China Sea inflow. Geophys. Res. Letters, 28, 1059-1062.

Okkonen, S.R., G.A. Jacobs, E.J. Metzger, H.E. Hurlburt, and J.F. Shriver, 2001: Mesoscale variability in the boundary currents of the Alaska gyre. Continental Shelf Research, 21, 1219-1236.

Smedstad, O.M., H.E. Hurlburt, E.J. Metzger, R.C. Rhodes, J.F. Shriver, A.J. Wallcraft, and A.B. Kara, 2002: A real-time 1/16º global ocean nowcast/forecast system. J. Mar. Sys. (in press)

Townsend, T.L., 2001: Census of North Brazil Current Rings 1993-1998 using a high resolution data assimilating ocean model. Fall 2001 Western Boundary Current-Virtual Poster Session, University of Rhode Island. (published online at http://www.po.gso.uri.edu/wc)

Townsend, T.L., H.E. Hurlburt, and P.J. Hogan, 2000: Modeled Sverdrup flow in the North Atlantic from eleven different wind stress climatologies. Dyn. Atmos. Ocean., 32, 373-417.

Wallcraft, A.J., H.E. Hurlburt, and J.F. Shriver, 2002: Eddy-resolving global and basin-scale ocean modeling. FY00 NRL DOD High Performance Computing Modernization Program Annual Reports, Naval Research Laboratory, Washington, DC, NRL/PU/5594--02-451, pp. 74-75.

Wu, L., Z. Liu, and H.E. Hurlburt, 2000: Kelvin and Rossby wave interaction in extratropical-tropical Pacific. Geophys. Res. Lett., 27, 1259-1262.

Zamudio, L., H.E. Hurlburt, E.J. Metzger, and O.M. Smedstad, 2002: On the evolution of coastally trapped waves generated by Hurricane Juliette along the Mexican west coast. Geophys. Res. Letters. (in press)