APPENDIX II. SUBCONTRACTORS' AND NO-COST PARTICIPANT'S CVs, STATEMENTS of WORK, BUDGETS AND BUDGET JUSTIFICATIONS

This appendix contains subject materials from

Dr. Ruoying He/NCSU

Dr. Yi Chao/JPL & UCLA

Dr. Leo Oey/PU

Dr. Dong-Shan Ko/NRL

Drs. Ann Jochens, Matt Howard, and Steve DiMarco/TAMU

Mr. Rich Patchen/CSDL

Drs. Chris Mooers and Ed Zaron/PSU

Plus messages of support for operational model products from

Dr. Hendrik Tolman/NCEP

Dr. Frank Bub/NAVO

Office of Research and Graduate Studies

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April 9, 2009

Ms. Nicole Braman
Research Administrator
Maseeh College of Engineering and Computer Science
1930 SW 4th Ave, Suite 200
Portland, OR 97201
Telephone: 503-725-2417
Email: bramann@pdx.edu

Subject: Proposal Entitled "GOMEX 3-D Operational Ocean Forecast System Pilot Project"
NCSU OSP Log No. 34444
NCSU PI: Ruoying He

Dear Ms. Braman:

This letter transmits the subcontract proposal by North Carolina State University (NCSU) to your organization. The Principal Investigator for NCSU will be Ruoying He. A statement of work and proposal budget are attached. This letter and proposal should be forwarded to the appropriate administrative officer within your organization to inform them that the appropriate administrative officials at NCSU support this proposal and are prepared to negotiate the necessary agreement. Once an agreement is fully executed, your organization should deal with the NCSU Principal Investigator for technical issues and the Office of Sponsored Programs for any administrative issues.

The initial point of contact to begin negotiations and execute an agreement is:

Matthew Ronning
NCSU Office of Sponsored Programs
Box 7514
2701 Sullivan Dr., Suite 240
Raleigh, NC 27695-7514.
Phone 919-515-2444, Fax 919-515-7721, Email: sps@ncsu.edu

Business information useful to the preparation of an agreement with NCSU may be found on our web site: http://www.ncsu.edu/sparcs/ select link "NCSU Id Numbers etc."

For North Carolina State University

Stefanie D. Saunders
Manager Client Relations
and Facilitation
NCSU Sponsored Programs

Attachment(s)
cc: College of PAMS Research Office
SPARCS

A Subject Proposal to

Portland State University.

For A Research/Public Service Project Entitled

"GOMEX 3-D Operational Ocean Forecast System Pilot Project"

Covering the Period from 8/01/09 to 1/31/11.

SUBMITTED BY

Ruoying He, Principal Investigator

Stefanie D. Saunders
Manager Client Relations
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NCSU Sponsored Programs

North Carolina State University
Raleigh, NC

Federal Tax ID # 56-6000-756
NC Tax ID # 92-100021-26
DUNS # 04-209-2122
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Date Submitted: _____.

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Note: This is a fundamental research or scholarly project and, as such, the University shall be free to publish or disseminate the results of this research or otherwise treat such results as in the public domain, and it will conduct the research in an open forum consistent with the University's mission of research, instruction and public service.

Proposal Title: GOMEX 3-D Operational Ocean Forecast System Pilot Project

Lead PI: Professor Chris Mooers, Portland State University, cmooers@cecs.pdx.edu

NCSU PI: Ruoying He, rhe@ncsu.edu

Period of Performance: 18-month with a starting date of August 1, 2009

Statement of Work (SOW)

We propose to use the Regional Ocean Modeling System (ROMS) for this proposed Gulf of Mexico (GoM) data assimilation and forecasting system. ROMS is a new community ocean circulation model that is in widespread use for estuarine, shelf, and coastal applications. Its computational kernel includes high-order advection and time-stepping schemes, weighted temporal averaging of the barotropic mode to reduce aliasing into the slow baroclinic motions, and conservative parabolic splines for vertical discretization. A redefinition of the pressure-gradient term is also applied in ROMS to reduce the pressure-gradient truncation error, which has previously limited the accuracy of terrain-following coordinate models.

The GoM model configuration will use the South Atlantic Bight and Gulf of Mexico Circulation Nowcast/Forecast (SABGOM N/F) Modeling System developed, operated and maintained by Dr. Ruoying He's group at North Carolina State University (http://omglnx6.meas.ncsu.edu/sabgom_nfcast/). Spatial coverage is shown in Figure 1. The spatial resolution of this operational SABGOM N/F system is 5 km. Vertically, it has 36 layers weighted to better resolve surface and bottom boundary layers. Currently, the N/F system is using the open boundary condition from the quasi-operational 1/12 degree global data assimilative HYCOM NCODA analysis, superimposed by tidal harmonics from ADCIRC western Atlantic tidal database. Surface forcing is obtained from NOAA National Operational Model Archive and Distribution System (NOMADS). Detailed model implementation and operations are described in two manuscripts submitted for publications (Hyun et al., 2009; Zambon et al., 2009). A 3-month SABGOM circulation simulation takes roughly 15 hours to complete on a 20-processor Linux cluster.

We will work closely with Dr. Yi Chao of UCLA to implement a 3-dimensional variational data (3DVAR) assimilation scheme into the GoM ROMS. The ROMS 3DVAR incorporates weak constraints based on hydrostatic and geostrophic balance. The balance constraints are applied to the increment, rather than the total field. The internal dynamic consistency makes it particularly suitable for coastal regions, where complex coastlines, bottom topography, upwelling, fronts and eddies are always present.

While this SOW is for Phase I of the project, we are also interested in participating in Phase II to perform real-time, prototype forecast system demonstration and skill assessment.

Schedule and Tasks for Phase I: YR1/Q1 - YR2/Q2

YR1

Q1:

- Establish subcontracts and participate the kick-off TAC/SAC meeting
- Implement 3DVAR data assimilation into GoM ROMS (in collaboration with UCLA)
- Gather available observations
- Evaluate the lateral boundary conditions provided by the basin-scale and global models (in collaboration with UCLA)

Q2:

- Perform ROMS simulations during the target period without data assimilation Complete the 3DVAR data assimilation implementation into GoM ROMS (in collaboration with UCLA)
- Assess the model skill in terms of analyses (nowcasts) and forecasts

Q3:

- Perform ROMS simulations during the target period with data assimilation (in collaboration with UCLA)
- Assess the impact of data assimilation in terms of analyses (nowcasts) and forecasts (in collaboration with UCLA)

Q4:

- Revise the GoM, 3DVAR data assimilation and improve the lateral boundary conditions if needed (in collaboration with UCLA)
- Summarize skill assessments for target period (in collaboration with UCLA)

YR2

Q1:

- Perform future period model runs for skill assessment of analyses and forecasts (in collaboration with UCLA)

Q2:

- Assess the model skill for future period (in collaboration with UCLA)
- Participate TAC/SAC meeting

Budget: $125,000

Budget Justification

Personnel Dr. Ruoying He will provide the needed advice and leadership for this project but is not requesting salary. $40,000 in Year 1 will be used to support a postdoctoral researcher at NCSU (Dr. Kyung Hoon Hyun) at 80% effort. This amount is inflated 3% in Year 2. Postdoc fringe benefits are calculated at 15% of salary.

Travel A travel fund of $5000 is requested to support two 3-day trips to PSU (meeting with the lead PI) and two 3-day trips to UCLA (meeting with the GoM 3DVar PI Dr. Yi Chao) for Drs. Ruoying He and Kyung Hoon Hyun, respectively.

Publications Allowance for publication costs and graphics services are included in Year 2 for disseminating scientific results in peer-reviewed journals.

Computer Service We request $1000 in Year 1 and $500 in Year 2 to maintain the computing cluster that will be used to carry out proposed model simulations and analysis.

Indirect costs are calculated at NCSU's federally-negotiated rate of 49% MTDC (Modified Total Direct Costs).

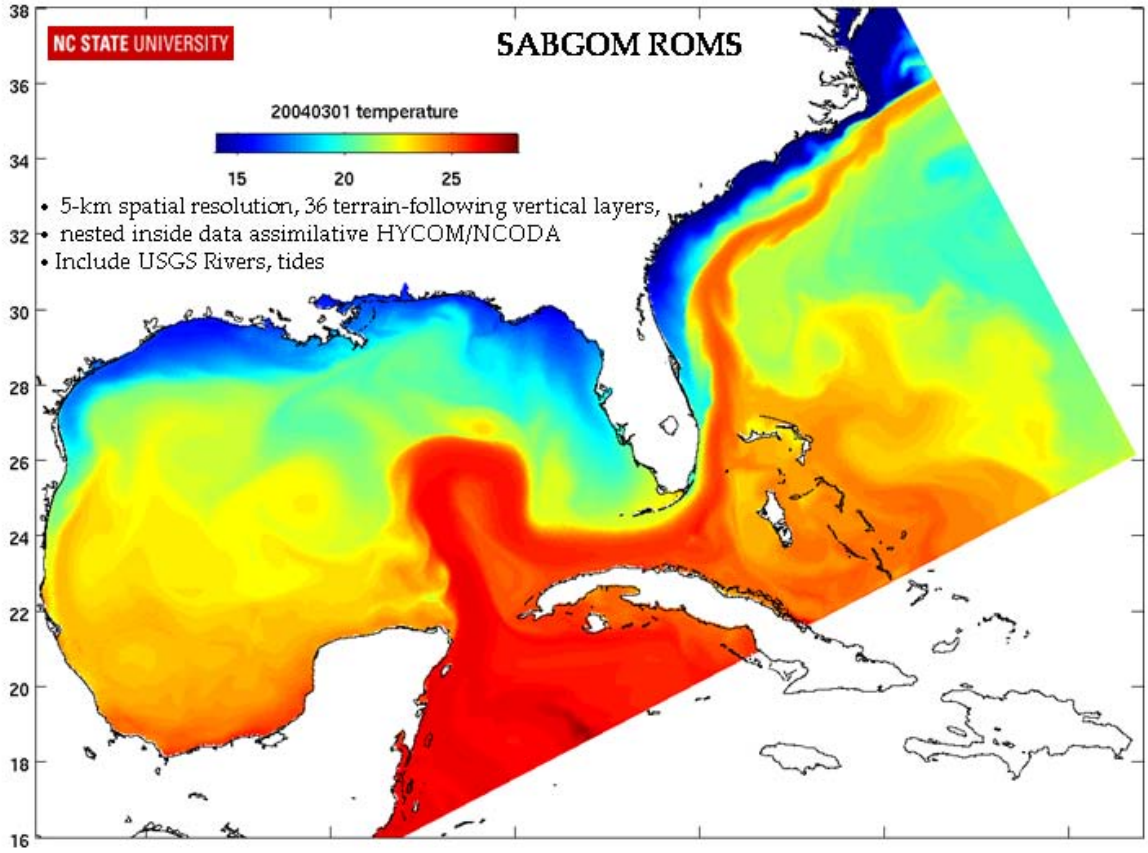

Fig. 1 – A snapshot of simulated sea surface temperature fields from the existing 3D SABGOM ROMS modeling system.

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PROFESSIONAL PREPARATION

1996	B.S.	Oceanography, Ocean University of China
2002	Ph.D.	Physical Oceanography, University of South Florida

PROFESSIONAL APPOINTMENTS

2007-present	Associate Professor, North Carolina State University
2004-2006	Assistant Scientist, Woods Hole Oceanographic Institution
2003-2004	Postdoctoral Scholar, Woods Hole Oceanographic Institution
2002-2003	Postdoctoral Research Associate, University of South Florida
1998-2002	Research Assistant, University of South Florida

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				Year 1			Year 2	
Effort (mo)	PI/Student/Postdoc	Salary	Fringe	Total				
1	PI	0	0	0	0	0	0	0
1	PI	0	0	0	0	0	0	0
1	PI	0	0	0	0	0	0	0
9.6	Postdocs	40,000	6,000	46,000	20,600	3,090	23,690	60,600
	Students	0	0	0	0	0	0	0
	Under Grad		0	0	0	0	0	0
	Fringe		6,000			3,090		9,090
	Salaries	40,000			20,600			60,600
	Fringe and Salaries			46,000			23,690	69,690
	Equipment							
	Travel			5,000			5,000	10,000
							0	0
	Participant Support							0
	Materials & Supplies						0	0
	Publications						2,702	2,702
	Consultant						0	0
	Computer Service			1,000			500	
	Subawards						0	
	Other						0	0
	Tuition							0
	Total Direct			52,000			31,892	83,892
	MTDC			52,000			31,892	83,892
	Indirect			25,480			15,628	41,108
	Direct plus Indirect			77,480			47,520	125,000

Statement of Work for the RPSEA Gulf of Mexico Forecasting Project

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Introduction

An ocean nowcast/forecast system (ONFS) has been developed at the Naval Research Laboratory (NRL) (Ko et al., 2008). The NRL ONFS is intended for producing forecast of 3D mesoscale ocean current, temperature, salinity, and sea level variation. The system is an integration of a data-assimilating, dynamical ocean model, a statistical data-analysis model, and various data streams for ocean bathymetry, climatological data, surface forcing, open boundary forcing, and observations for data assimilation. The NRL Modular Ocean Data Assimilation System (MODAS; Carnes et al., 1996; Fox et al., 2002) is used within the ONFS as the data-analysis model. MODAS uses satellite data, in-situ observations, and historical statistics to generate three-dimensional ocean temperature and salinity analyses. The analyses are then assimilated into the dynamic model to produce an estimation of the current ocean state or nowcast. From the nowcast, the forecast is conducted without data assimilation using meteorological forecasts. The system can be relocated to different locations and, once set up for a particular region, operates automatically.

The NRL ONFS was first implemented for the North Pacific Ocean. This was called the North Pacific Ocean Nowcast/Forecast System (NPACNFS; Ko et al., 2003a) and operated in real-time from 1999 to 2004. The NPACNFS produced a nowcast and 72-h forecast every 24 h and the predictions were subjected to several evaluations and used for a number of studies (Ko et al., 2003a; Lee, 2003; Wu, 2003; Hwang et al., 2004; Ramp et al., 2004; Lin et al., 2005; Pun et al., 2007). During 2000 and 2001, the ONFS was implemented in the northern South China Sea (NSCSNFS) to provide mesoscale ocean descriptions for the Asian Seas International Acoustics Experiment in the South China Sea (Chapman et al., 2004; Weller, 2005). The NSCSNFS was coupled to the NPACNFS. The dynamical ocean model used in these two applications was based on the Princeton Ocean Model (POM). Later the ONFS was implemented for several other regions including the Intra-Americas Sea (IASNFS; Ko et al., 2003b). The ocean model applied in the IASNFS and later ONFS (e.g., Jacobs et al., 2005; Keen et al., 2006; Teague et al., 2006; Arnone et al., 2007; Chao et al., 2007; Pun et al., 2007; D'Sa et al., 2008; Green at al., 2008; Ko et al., 2008; Lin et al., 2008; Ko et al, 2009; Lin et al., 2009; Mendoza et al., 2009; Mooers et al., 2009) is based on the Navy Coastal Ocean Model (NCOM; Martin, 2000). NCOM is similar to POM but has options to use hybrid vertical coordinates and multiple nesting.

In all these ONFS implementations, the data for the data assimilation are from satellite altimeters and AVHRR/MODIS. The surface forcing is either from the Navy Operational Global Atmospheric Prediction System (NOGAPS; Hogan and Rosmond, 1991; Rosmond, 1992) or from the Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS, Hodur, 1997).

The lateral open boundary conditions are either taken from a global ONFS or from a higher resolution regional ONFS if one is available.

In 2000, application of NRL ONFS to the Intra-Americas Sea which covers the Gulf of Mexico, Caribbean Sea, and Straits of Florida was implemented. Since December, 2002, the IASNFS has been in continuous real-time operation at NRL providing 72-hr forecasts every day except in rare occasions such as during Hurricane Katrina when NRLSSC facility was shut down. The real-time IASNFS nowcasts and forecasts are available at the NRLSSC web site: http://www7320.nrlssc.navy.mil/IASNFS_WWW/. The IASNFS is supported by NASA REASON project which has an objective to provide consistent and comprehensive real-time oceanic information based on the satellite remote sensing and the ocean model prediction for ocean monitoring, environment assessment, and for research (e.g., Arnone et al., 2007). IASNFS prediction (nowcast and forecast) and many types of satellite remote sensing data have been delivered to NOAA National Coastal Data Development Center (NCDDC) daily to be archived and distributed. For example, IASNFS daily predictions are used for the real-time NOAA Harmful Algal Blooms Observing System (HABSOS) and NOAA AOML ocean oxidation estimation.
(http://www.ncddc.noaa.gov/interactivemaps/harmful-algal-blooms-observing-system-habsos)

Two real-time high-resolution coastal ocean nowacst/forecast systems, the Northern Gulf of Mexico Nowcast/Forecast System (NGOMNFS) and the LSU Nowcast/Forecast System (LSUNFS) are imbedded in the IASNFS. The NGOMNFS covers a region from central Louisiana coast to Florida panhandle; the LSUNFS covers MS/LA/TX Gulf Coast. Both systems are operated daily and applied for coastal monitoring and used for research (e.g., Green et al., 2008 and D'Sa et al.). In operation, NOAA MFS uses NGOMNFS prediction for shrimp/fish recruitment studies.
(http://www7320.nrlssc.navy.mil/IASNFS_WWW/NGOMNFS_WWW/ and http://www7320.nrlssc.navy.mil/IASNFS_WWW/LSUNFS_WWW/)
In addition to the two real-time coastal systems, a high-resolution system was developed for the EPA hypoxia project for the Louisiana coastal water coupled to IASNFS. The EPA General Environment Model is integrated with the dynamic coast model to be used for studying hypoxia off Louisiana coast. Once this coupled system is validated, it will be applied as a management tool for waste water discharge control.

IASNFS predictions including nowcast and forecast have been subjected to various degrees of validations. The IASNFS transports through straits and passages are compatible to the observations (http://www7320.nrlssc.navy.mil/IASNFS_WWW/IASNFS_transp.html) and it has a good skill in prediction coastal sea level variation evaluated against NOAA NOS tide gauge measurement (Ko et al., 2003b). The correlation between IASNFS prediction and tide gauge measurement along the Gulf Coast and Florida coast are very high.
(http://www7320.nrlssc.navy.mil/IASNFS_WWW/IASNFS_ssh.html#ssh). The NOAA MFS CTD measurement and NAVO AXBT was applied with a water mass analysis to evaluate IASNFS prediction. It is found that the IASNFS in general predicts very well the location of large scale features such as Loop Current and Loop Current eddies but may not precisely predict the LC/LCE frontal location and the smaller cyclonic/anticyclonic eddies which evolve rapidly.
(http://www7320.nrlssc.navy.mil/IASNFS_WWW/IASNFS_ctd.html)

Evaluated against satellite data such as MCSST, altimeter ssh and ocean color found the same conclusion. (http://www7320.nrlssc.navy.mil/IASNFS_WWW/IASNFS_ssh.html#sat)

Proposed Work

We propose to apply the IASNFS for Phase I experiments and Phase II demonstration of the operational forecast in real-time (although the IASNFS has been demonstrating over 6 years of real-time operation successfully). To better support the oil and gas industry's activities at Gulf we also consider a higher resolution (~2 km) grid covers the northern part of Gulf of Mexico imbedded inside the IASNFS. Long term prediction seems to be unpractical although it is desirable. In our view a better approach seems to be conducting daily short term forecast for a period up to 1 week limited by the available and acceptable atmospheric prediction. The daily shorter term forecast with realistic surface forcing is particularly useful for secondary applications for oil spill response and potential shallow water operations involving hypoxia and produced water.

The model to be used in this study is IASNFS. It is centered on the NCOM. NCOM is a 3D primitive equation model and has been in Navy operation for all scales ocean prediction from global to regional to coastal. The IASNFS covers not only the Gulf of Mexico but also the Caribbean Sea (Fig. 1). As such it is not sensitive to the inflow boundary condition at Yucatan Strait. The model has a 6 km horizontal resolution and 41 sigma-z vertical levels to better resolve the variation at the full column of water down to sea floor.

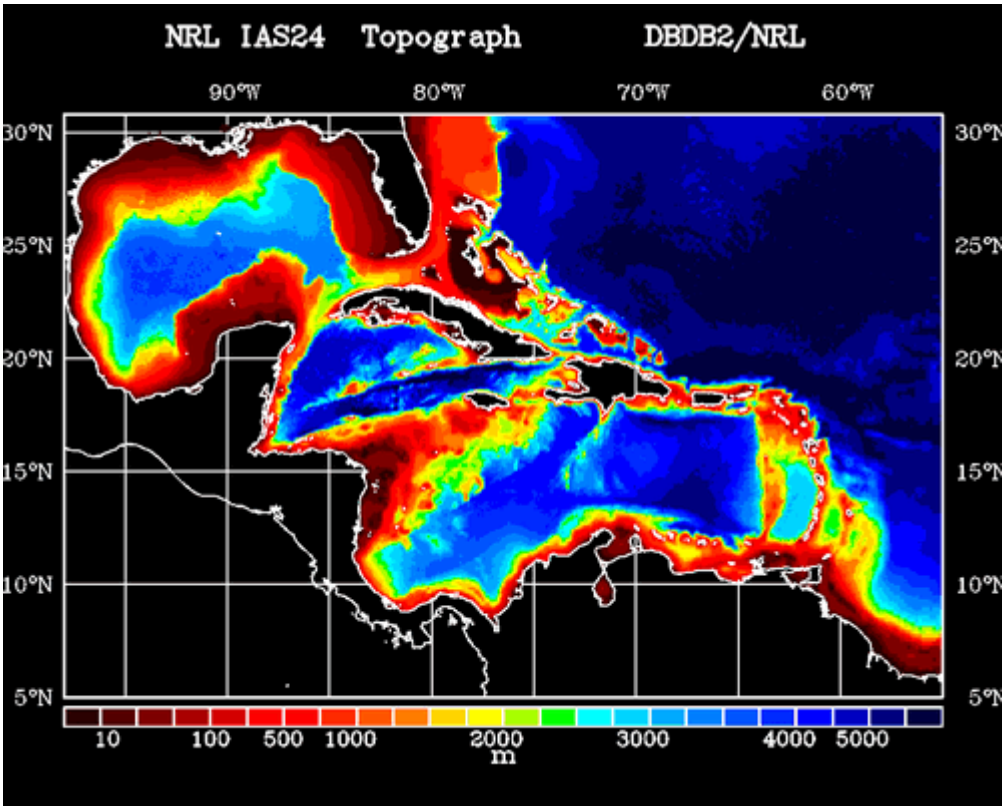

Fig. 1. IASNFS's coverage and model topography.

The open boundary conditions including sea surface elevation, transport, temperature, salinity and currents are provided by the Navy operational 1/8 degree Global NCOM (Rhodes et al., 2002) which is operated daily at NAVO. One way coupling scheme is used to ingest those boundary conditions into the IAS model. There are 53 rivers with monthly discharges includes in the IASNFS for a better prediction of salinity, particularly, in the coastal region.

The daily operation including data analysis for data assimilation, processing of surface forcing and open boundary conditions, and post processes takes no more than 6 hrs on desktop workstations which also including operation of two nested high-resolution coastal nowcast/ forecast systems. The entire operation including delivery of forecast and website update is fully automatic.

Budget:

	Phase I	**Phase II**	**Total**
Salary+Fringe	49,662	51,152	
Travel	4,000	2,000	
Computer	5,400	5,400	
Misc.	938	1,448	
Total	**60,000**	**60,000**	**120,000**

Budget includes 2 months of salary, fringe benefit and other indirect costs for each phase, travel expense for meetings at Houston, TX, and NRL charge for computer support (9%).

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Educations:

- Ph.D. (Applied Marine Physics) University of Miami, Miami, FL 1987
- M.S. (Ocean Engineering) University of Miami, Miami, FL 1981
- M.S. (Physical Oceanography) College of Chinese Culture, Taipei, Taiwan 1979
- B.S. (Marine Science) College of Chinese Culture, Taipei, Taiwan 1974

Employments:

- *1998 - present*: Oceanographer, Naval Research Laboratory, Stennis Space Center, MS
- *1994 - 1998*: Senior Engineer, Sverdrup Technology, Stennis Space Center, MS
- *1992 - 1994*: Senior Research Associate, RSMAS/University of Miami, Miami, FL
- *1988 - 1992*: Scientist, Institute for Naval Oceanography, Stennis Space Center, MS
- *1987 - 1988*: Postdoctoral Associate, Massachusetts Institute of Technology, Cambridge, MA
- *1979 - 1987*: Graduate Research Assistant, RSMAS/University of Miami, Miami, FL
- *1977 - 1979*: Graduate Research Assistant, College of Chinese Culture, Taipei, Taiwan
- *1976 - 1977*: Teaching Assistant, College of Chinese Culture, Taipei, Taiwan

Scientific Activities:

- Developed ocean nowcast/forecast systems for the Straits of Florida, the Pacific West Coast, the North Pacific Ocean, the Northern South China Sea, the East Asian Seas, the Intra-Americas Sea, the Northern Gulf of Mexico and many other areas. Conducted ocean forecast experiments and performed related researches.
- PI or Co-PI for the ONR West Pacific Ocean-Typhoon interaction study, Nonlinear Large-amplitude Internal Wave Initiative and ASIAEX South China Sea experiments, the NASA Gulf of Mexico REASON project, the NASA LSU LA coastal ocean study, and EPA Gulf of Mexico Hypoxia study in addition to various NRL and SPAWAR projects.
- Reviewer for *Journal of Geophysical Research*, *Geophysical Research Letters*, *Journal of Oceanography*, *Deep Sea Research*, *J. Mar. Syst*., *Acta Oceanography Taiwan* and *Terr. Atmos. Ocean. Sci*.
- Reviewer for National Science Foundation, National Science Council (Taiwan).
- Member of committee for 3 Ph.D. and 2 M.S. students. Supervised 1 postdoc.

Recent Publications:

- Lin, I.-I., Y.-H. Li, J. Wu, C. Hu, C.-W. Hwang, D.A. Chu, G.T.F. Wong, D.S. Ko, and J. P. Chen, Fertilization of an ocean desert by volcanic eruption, *Science*, submitted, 2009.
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Title of Proposal: **Gulf 3-D Operational Model Pilot Project**

Period of Performance: **1 Oct 2010 - 30 Sep 2012**

	FY10 Request			FY11 Request		
Personnel	Hrs	Hrly Rate	Cost	Hrs	Hrly Rate	Cost
Ko, Dong S.	560	131.05	$73,386	0	134.98	$0
	0	0.00	$0	0	0.00	$0
	0	0.00	$0	0	0.00	$0
	0	0.00	$0	0	0.00	$0
	0	0.00	$0	0	0.00	$0
		0.00	$0		0.00	$0
		0.00	$0		0.00	$0
		0.00	$0		0.00	$0
Total Personnel Cost			$73,386			$0
Domestic Travel			$3,000			$0
Foreign Travel			$0			$0
Expendable supplies, etc.			$1,514			$0
Permanent Equipment			$4,000			$0
Ship Time, if any			$0			$0
Co-op			$0			$0
Computer time, if any (Rate 9%)			$8,100			$0
Subcontractor costs			$0			$0
Post Doc			$0			$0
Consultant costs, if any			$0			$0
Publication costs			$0			$0
Total direct and indirect costs			$90,000			$0

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Jeffrey Friedland
Director
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April 8, 2009

Ms. Nicole Braman
Research Administrator
Portland State University
Maseeh College of Engineering and Computer Science
1930 SW 4th Ave, Suite 200
Portland, OR 97201

Subject:	Proposed Subcontract Agreement with Portland State University
Proposal Titled:	GOMEX 3-D Operational Ocean Forecast System Pilot Project
Prime Sponsor:	Research Partnership to Secure Energy for America
Princeton PI:	Lie-Yauw Oey
Portland State PI:	Chris Mooers
Award Period:	August 1, 2009 – January 31, 2011
Subaward Amount:	$150,049

To whom it may concern:

In the event that the subject proposal is funded by the Research Partnership to Secure Energy for America (RPSEA), Princeton University hereby expresses its willingness to establish with Portland State University a written inter-organizational agreement that will ensure compliance with all pertinent federal regulations and policies in order to perform the proposed research.

Should you have any questions or require additional information, please contact Kathy Niebo, Senior Grants and Contract Administrator for the Office of Research and Project Administration at (609)258-3110 or Kathyn@princeton.edu

Sincerely,

Jeffrey Friedland
Director

Princeton University's Statement of Work:

Phase I (YR1/Q1 thru YR2/Q2) – 18 months.

We will conduct two sets of experiments: (1) monthly 3-mo forecasts for a historical target year (to be selected after the project commences), and (2) fortnightly forecasts (i.e. a new forecast every 2 weeks) to the end of the original (i.e. "(1)" above) 3-mo. period "in the blind"; hence, in near-real-time.

Model and methodologies follow closely those described in Oey et al. [2005] and Yin and Oey [2007]; these are described below. The model region is shown in Figure 1, and a domain focusing on the Gulf of Mexico is shown in Figure 2, in which an example of SSH 8-week forecast during Hurricane Katrina is also shown.

The Model

Our circulation model for the Caribbean Sea and the Gulf of Mexico is based on the Princeton Ocean Model. The model has been extensively tested for process studies as well as in realistic simulations [please visit http://www.aos.princeton.edu/WWWPUBLIC/PROFS/publications.html for recent publications].

The model domain includes the northwestern Atlantic Ocean west of 55^oW as shown in Figure 1. At 55^oW, estimates of inflow and outflow transports are specified in combination with radiation conditions. The baroclinic velocities are specified using the radiation conditions. Climatological temperature and salinity are specified during inflow and advected out using one-sided differencing at outflow. Details of open boundary conditions are in Oey and Chen [1992]. The model is forced by wind, as well as by monthly discharges from *34* rivers along the northern Gulf coast according to the method given in Oey [1995; 1996]. The model horizontal grid-size is variable; it is approximately *10 km* in the Loop Current and northwestern Caribbean Sea, and about *5 km* in the northeastern Gulf of Mexico. There are *25* terrain-following (the so-called *sigma*-coordinate) layers with *10* of them in the top *250 m* for local water depth ≈ *2500 m*. The Mellor and Yamada's [1982] turbulence closure scheme modified by Craig and Banner [1994] to effect wave-enhanced turbulence near the surface is used. To account for mixing in

stable stratification [e.g. internal waves; MacKinnon and Gregg, 2003], Mellor's [2001] modification of a Richardson-number-dependent dissipation is used.

Data Assimilation:

We assimilate satellite *SSHA* [$\delta\eta_o$, from www.aviso.oceanobs.com] and *SST* [from the United States GODAE, www.usgodae.org] to derive ConA (Control-Analysis) to initialize the model forecast. Satellite data are assimilated into the model following the methodology given in Mellor and Ezer [1991] and Ezer and Mellor [1994]. In this method, *SSHA* is projected into the subsurface temperature field using pre-computed correlation factors derived from a long-time ($\approx$ *10 years*) prognostic integration that has yielded a statistical equilibrium eddy field. Thus the resulting temperature anomaly (δT) is (<.> is time-averaging, and T is the potential temperature):

$$\delta T(x,y,z,t) = F_T(x,y,z)\ \delta\eta_o(x,y,t), \qquad (1)$$

where the correlation factor is ($\delta\eta$ = model *SSHA*)

$$F_T = <\delta T\ \delta\eta>/<\delta\eta^2>, \qquad (2a)$$

and the corresponding correlation coefficient is

$$C_T = <\delta T\ \delta\eta>/[<\delta T^2><\delta\eta^2>]^{1/2}. \qquad (2b)$$

Ezer and Mellor [1994] assimilate along-track $\delta\eta_o$ data assuming a linear-saturation error growth model for the first-guess error. Our experience has been that if AVISO $\delta\eta_o$ maps are assimilated the following simplified formula [due originally to Ezer, 2003, private communication; see Wang et al. 2003] suffices:

$$T^a = T + [2\ R_A C_T^2/(1 + 2\ R_A C_T^2 - C_T^2)]\ (T_O - T) \qquad (3)$$

where T is the model (first-guess) temperature, T^a denotes the analysis temperature, R_A is the ratio of the assimilated time step Δt_A to the de-correlation time scale Δt_E of the model eddy field, and T_O is the 'observed' temperature inferred from (1),

$$T_O = \langle T \rangle + F_T \, \delta\eta_o. \qquad (4)$$

Instead of using the model mean for $\langle T \rangle$ in (4), our past experience has been that setting $\langle T \rangle = T_C$, the observed temperature climatology, helps to control long-term (~ *10 years*) drift in the model. For the present application, the differences are small. Formula (3) assumes that the AVISO map errors are small compared to the model errors, and that $\Delta t_A \ll \Delta t_E$. We follow Ezer and Mellor [1994] and set $\Delta t_A = 1$ *day*. The Δt_E is estimated from the above-mentioned *10-year* prognostic model run and is ≈ *30 days* in regions of the Gulf of Mexico dominated by the Loop Current and rings. This may be compared with the value of *20 days* used by Ezer and Mellor's [1994] for the Gulf Stream which therefore appears to have shorter meander and eddy evolution time scales. The Δt_E is also proportional to the time scale of the model error growth, and the *30-day* value is consistent with Oey et al's [2005] findings of predictability time scales of about one month for the Loop Current and its associated rings. As pointed out by Ezer and Mellor [1994], the assimilation (3) is such that $T^a \approx T_O$ in regions where the correlation is high ($C_T^2 \approx 1$), but $T^a \approx T$ where the correlation is low. A similar assimilation of *SST* is also carried out after (3) with C_T and F_T replaced by the corresponding functions that use $\delta(SST)$ in place of $\delta\eta$ in (2). The *SSHA* and *SST* assimilations complement each other: *SSHA* assimilation is most effective over deep waters (for isobath > *500 m*) while *SST* assimilation influences waters on shallow shelves. For more details see Wang et al. [2003], Fan et al. [2004], and Oey et al. [2005].

The above DA-scheme is simple, but it is efficient. It (in combination with POM) is one of the few schemes that has been *quantitatively* evaluated against various observations: drifters, altimeter data, ship-board ADCP's and temperature sections, and current measurements (current meteres and ADCP's). Please refer to the PROFS website given above).

We have also extended the scheme to include (1) bred-ensemble forecasting [Yin and Oey, 2007]; (2) drifter assimilation [Lin et al. 2007]; and more recently Ensemble Kalman Filter [Sun and Oey, unpublished manuscript, 2009]. In this last work, we have also extensively evaluated the scheme (and POM) against *deep* observations.

Model Summary:

Vertical resolution: 25 sigma-levels;
Horizontal resolution: variable, 5~10 km in the Gulf of Mexico;
Data needs: Satellite altimeter and SST; winds + surface heat and mass fluxes; drifters and frontal analyses from Horizon Marine Inc.; Climatological data;
Data Assimilation: Mellor-Ezer correlation projection; OI; Lin et al [2007] drifter scheme; Yin & Oey [2007] bred-ensemble; and Ensemble Kalman Filter;
Model run-time: 1 hour (Intel) CPU for 30day forecast (with Mellor-Ezer); about 3 hours for ENKF; about 8 hours for bred-ensemble;

Phase II (YR2/Q3 thru YR3/Q2) – 12 months.

Here we will develop the prototype operational forecast system running, and being skill assessed, online in real-time.

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Lin, X.-H., L.-Y. Oey & D.-P. Wang, 2007: Altimetry and drifter assimilations of Loop Current and eddies. *JGR,* 112, C05046, doi:10.1029/2006JC003779, 2007.
MacKinnon, J.A. and M.C. Gregg, 2003: Shear and baroclinic energy flux on the summer New England shelf. *J. Phys. Ocenogr.* 33, 1462-1475.
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Oey, L.-Y. and P. Chen, 1992: A model simulation of circulation in the north-east Atlantic shelves and seas, *J. Geophy. Res.,* 97, 20,087-20,115, 1992.
Oey, L.-Y., T. Ezer, G. Forristall, C. Cooper, S. DiMarco and S. Fan, 2005. An exersise in forecasting loop current and eddy frontal positions in the Gulf of Mexico. Geophys. Res. Let., 32, L12611, 10.1029/2005GL023253.
Wang, D.-P., L.-Y. Oey, T. Ezer and P. Hamilton, 2003. Nearsurface currents in DeSoto Canyon. *JPO*, 33: 313-326.
Yin and Oey, 2007: Bred-Ensemble Ocean Forecast of Loop Current and Eddies. Ocean Modelling, Volume 17, Issue 4, 2007, Pages 300-326.

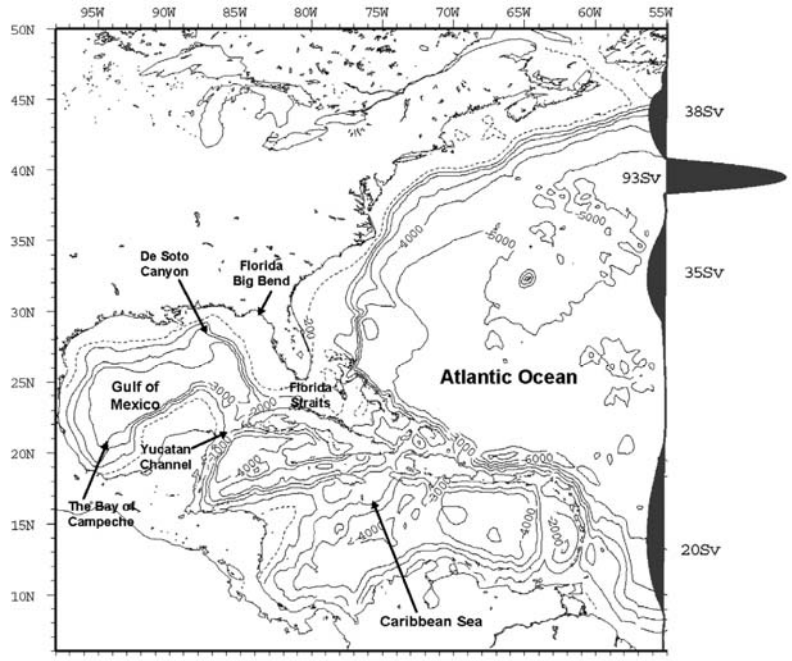

Fig. 1. A locator map of the study region: the Gulf of Mexico and surrounding ocean regions. The domain shown is also the model domain. Time-independent inflow and outflow that account for the large-scale transports (Svedrup + thermohaline) are specified across the open boundary at 55 °W as a function of latitude (as indicated with silhouette profiles). Contours show isobaths in meters.

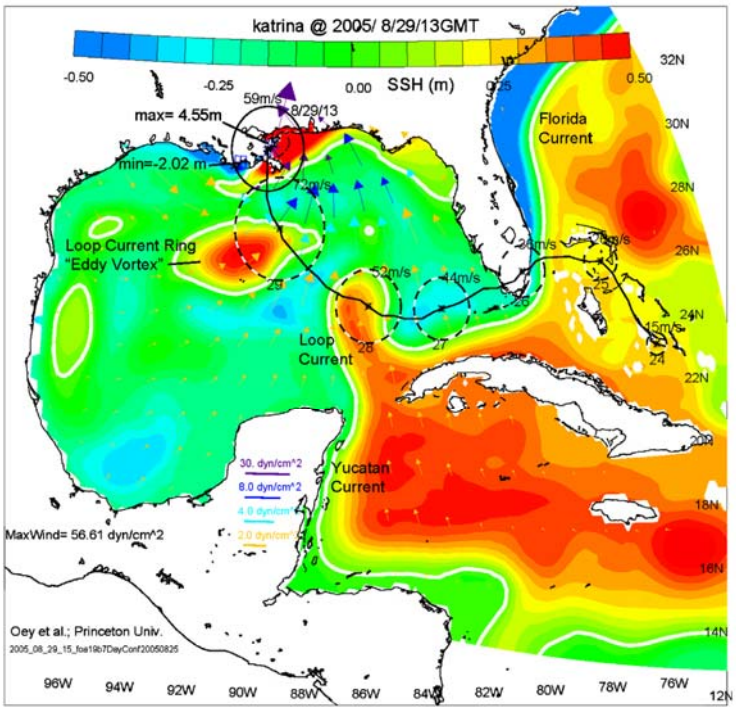

Fig. 2. An illustrative figure of the Loop Current and its associated ring during the study period. Shown here in color is the forecast (ConF) sea-surface height (SSH; white contour is SSH = 0) on Aug/29/13GMT just after Hurricane Katrina made landfall (solid circle) at New Orleans. Note the high SHH (red; max ≈4.6 m) near New Orleans. The storm's path is shown as solid black line and its intensities are shown proportional to the size of circles (dashed) plotted at daily intervals beginning at Aug/24. Colored vectors indicate wind stresses with the indicated scales.

Resume: Lie-Yauw Oey (lyo@princeton.edu)

Education

1978 Princeton University, Ph.D.

Thesis: Numerical simulation of shock wave-turbulent boundary layer interaction

1974 London University, B.Sc. 1st Class Hon.

Thesis: Laboratory experiment of turbulence behind bluff bodies

Appointments

1978-1980 Scientist, Sci.App.Inc., LaJolla,; Research - Internal Waves

1980-1984 Scientist, GFDL, Princeton; Research -Estuarine Circ.

1984-1988 Assoc. Professor, Skidaway Inst. & ODU; Research - Gulf Stream

1988-1994 Assoc. Professor, Stev. Inst; Research - Kuroshio/GS/Shelf/Slope Circ.

1994-present Scientist, Princeton Univ.; Research- Shelf/Slope Circ, Semi-encl. Seas

Professional Activities & Awards

Assoc. Editor, J.Geophys.Res., 1986-1990; London U. 1974 Draper Award; IEEE Ocean Engnr.Soc. 1984 Outstanding Engnr Award; IEEE Centennial Key to the Future Award, 1985; J.Geophys.Res. 1995 Excellence in Review Award; member - AGU, AMS and AMA; member - Japan Frontier Program Committee; member, 96/98 – International Pacific Research Center Selection Committee; Co-Editor (w/Alan Davies), Continental Shelf Research Special Vols3&4, 2005-2006.

Recent Publications

1. Chang, Wu & **Oey**, 2009: Bimodal behavior of the seasonal upwelling off the northeastern coast of Taiwan, JGR, in press.
2. **Oey,** Inoue, Lai, Lin, Welsh & Rouse Jr. 2008: Stalling of near-inertial waves in a cyclone. *GRL*, 35, L12604, doi:10.1029/2008GL034273.
3. Ezer, T., R. Hobbs and **L.-Y. Oey**, 2008: On the movement of Beluga whales in Cook Inlet, Alaska: Simulations of tidal and environmental impacts using a hydrodynamic inundation model. Oceanography, 21(4), 14-23, 2008.
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13. **Oey, L-Y.**, 2006: An OGCM with movable land-sea boundaries. *Ocean Mod*, 13, 176-195.
14. **Oey, L.-Y.**, T. Ezer, D.-P. Wang, S.-J. Fan, and X.-Q. Yin, 2006: Loop current warming by Hurricane Wilma. *GRL*, 33, L08613, doi:10.1029/2006GL025873.
15. Dong, C. and **L-Y. Oey**, 2005: Sensitivity of coastal currents near Point Conception to forcing by three different winds: ECMWF, COAMPS, and Blended SSM/I-ECMWF-Buoy Winds. *J. Phys. Oceanogr*, 35(7), 1229-1244.
16. **Oey, L-Y.**, 2005: A wetting and drying scheme for POM. *Ocean Mod*, 9, 133-150.
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20. **Oey, L-Y.**, 2004: Vorticity flux through the Yucatan Channel and Loop Current variability in the Gulf of Mexico. *JGR*, 109, C10004, doi:10.1029/2004JC002400.
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22. **Oey, L-Y.**, C. Winant, E. Dever, W. R. Johnson, D-P. Wang, 2004: A model of the near-surface circulation of the Santa Barbara Channel: Comparison with observations and dynamical interpretations. *J. Phys. Oceanogr*, 34(1), 23-43.
23. **Oey, L.-Y.**, and H. C. Zhang, 2004: The generation of subsurface cyclones and jets through eddy-slope interaction. *Continental Shelf Research*, 24(18), 2109-2131.

24. Ezer, T., **L-Y. Oey**, and H-C. Lee, and W. Sturges, 2003: The variability of currents in the Yucatan Channel: Analysis of results from a numerical ocean model. *Journal of Geophysical Research*, 108(C1), 3012, 10.1029/2002JC001509.
25. **Oey, L-Y.**, H-C. Lee, and W. J. Schmitz, Jr., 2003: Effects of winds and Caribbean eddies on the frequency of Loop Current eddy shedding: A numerical model study. *J Geophys Res*, 108(C10), 3324, doi:10.1029/2002JC001698.
26. Wang, D-P., **L-Y. Oey**, T. Ezer, and P. Hamilton, 2003: Near-surface currents in DeSoto Canyon (1997–99): Comparison of current meters, satellite observation, and model simulation. *Journal of Physical Oceanography*, 33(1), 313-326.
27. **Oey, L.-Y.**, and H. C. Lee, 2002: Deep eddy energy and topographic Rossby waves in the Gulf of Mexico. *Journal of Physical Oceanography*, 32(12), 3499-3527.

GOMEX 3-D Operational Ocean Forecast System Pilot Project

		YEAR 1 8/1/09-7/31/10	YEAR 2 8/1/10-1/31/11	TOTALS
Salaries & Benefits				
Lie-Yauw Oey	1 mo./½ mo.	$9,941	$4,971	$14,912
Postdoctoral Researcher	9 mos./3 mos.	$39,750	$13,250	$53,000
Sub-Total Salaries		$49,691	$18,221	$67,912
Benefits @ 33.7%		$16,746	$6,140	$22,886
Total Salaries & Benefits		$66,437	$24,361	$90,798
Other Costs				
Materials and Supplies		$200	$200	$400
Publication Costs		$1,000	$1,000	$2,000
Total Other Costs		$1,200	$1,200	$2,400
Total Direct Costs		$67,637	$25,561	$93,198
Indirect Costs - 61%		$41,259	$15,592	$56,851
Total		$108,896	$41,153	$150,049

Princeton University - Budget Justification

Salaries and wages
Requested support for salaries includes 1½ months support for the Princeton Principal Investigator, Dr. Lie-Yauw Oey, and 12 months support for a postdoctoral research associate. They will conduct the model experiments as described in the Statement of Work.

Fringe Benefits
Benefits are requested at the rate of 33.7% for the period August 1, 2008 – January 31, 2011.

Materials and Supplies
Minimal costs for materials and supplies are budgeted at $200/year.

Publications
Partial cost for pages charges for publications appearing in referred journals are budgeted in the proposed budget at $1,000/year.

Indirect Costs
The current indirect cost rate is 61% on modified total direct costs (MTDC) as negotiated with DHHS (agreement dated July 9, 2008).

Statement of Work
Texas A&M University Data Group
8 April 2009

Project: GOMEX 3-D Operational Ocean Forecast System Pilot Project
Goal : Establish operational ocean current prediction system for Gulf of Mexico.

Project Duration : 18 Months (Phase I), with possible 12 Months follow-on (Phase II)
Start Date : 01-August-2009
Phase I (18 Mo) : R&D and Selection, comprised of two experiments.
Phase II (12 Mo) : Demonstration of operational prototype with skill assessment.

Approach: Select best-of-breed data-assimilative full water column numerical ocean circulation forecasting model from several partners/subcontractors. Participants in Phase I compete for an invitation to Phase II. Skill assessment metrics are based on model-data comparisons.

Note: The GCOOS Data Portal is based at Texas A&M University under the direction of Howard and Jochens and is being built to provide easy discovery and access to *in situ* physical oceanographic and meteorological observations and remotely-sensed oceanographic products from publically-available federal and non-federal data providers. It aggregates model output and will soon begin producing fused products composed of overlays of observed data and modeled output. The GCOOS Data Portal is currently funded through December of 2010. We anticipate but cannot guarantee this activity will continue to receive funding, however, transition plans are part of the 2010 activity. Also, we routinely acquire, subset, and distribute NCEP NAM weather forecasts for the Texas General Land Office (TGLO). Only minor changes would be needed to provide the Gulf of Mexico or larger subset of NAM forecasts to the Project.

Phase I SOW: Phase I will begin with a kick-off meeting to determine: the model requirements, the modeler's needs for observed data and forcing fields, the metrics to be used in the skill assessments, and the requirements on the Data Group for archive and display of model output. We assume six (6) hydrodynamic models will be supported and assessed (Global-NCOM, Nested-NCOM, HYCOM, NGOM, ROMS, and POM). The DG will establish and maintain a basic Project website to display project status, host blogs, permit online browse of skill assessment results and the like. We propose to display model output on the GCOOS website as permitted by the participants. During this Phase, we assume the modelers may ask us to acquire and provide historical forcing fields (e.g. SSH, winds, climatological temperature and salinity, etc.) for the target year which we shall do as needed and as resources allow. We will acquire model output from the various modeling groups for display, archive, and skill assessment. Jochens and DiMarco will be responsible for calculating the metrics used for skill assessment. The particular metrics will be specified during the kick-off meeting. A master's

level graduate student will be hired to assist in performing the calculations and producing routine graphics under our joint direction. During the second experiment in Phase I selected models will make forecasts based on real time conditions. The DG will supply modelers with forecast winds (if needed) and with near real-time observed data for use in model assimilation. The DG will acquire and archive the model output and perform skill assessments. The DG will produce a report containing the skill assessment results after each of the two experiments for use by the SAC/TAC to inform the decision-making process.

The Data Group (DG) will:

establish and maintain a project website,
acquire, aggregate, and distribute forcing fields and observations, and
acquire, archive, analyze, and display participant-provided model output.

Task 1: Attend kick-off meeting (determine user requirements and metrics)
Task 2: Assemble historical forcing fields & met-ocean observations for target year.
Task 3: Acquire model output from modeling participants
Task 4: Performed model/data comparisons and evaluation of metrics
Task 5: Assemble real-time forcing fields & met-ocean observations for future runs.
Task 6: Prepare report on skill assessment results for target period.
Task 6: Acquire future period model output from modeling participants
Task 7: Perform model/data comparisons and evaluation of metrics
Task 8: Prepare report on skill assessment results for future period runs.

The Phase I Budget and Budget Justification are given after the brief overview of the possible DG Phase II follow-on tasks.

Phase II SOW: In Phase II the selected model(s) will be run in a prototype operational sense. The DG will continue to collect and share forcing fields, forecasts, and observed data in support of the selected models. The output of the models will be acquired and archived. A skill assessment will be performed on the model output in a continuous basis in accordance with the metrics selected by the SAC/TAC. These results will be continually posted on the Project website. Any fields or results deemed publically available will be displayed on the GCOOS Data Portal and used to produce secondary products for use by targeted user groups – perhaps identified during the requirements part of the kick-off meeting. Staffing and responsibilities will continue as in Phase I. At 24 months following the Project start date, the reporting and technology transfer part of the Project will begin.

Task 9: Continuously acquire and distribute forcing and observed data
Task 10: Continuously acquire and archive model output from participants.
Task 11: Continuously compute and report model skill assessment results
Task 12: Prepare report on skill assessment for prototype operational models(s).

The Phase II Budget and Budget Justification for the DG follow-on work will be separately negotiated.

TAMU Data Group Phase I Budget

Texas A&M Research Foundation RF # 0901360

GOMEX 3-D Operational Ocean Forecast System Pilot Project

Project Dates: 8/01/2009 - 1/31/2011

	Phase I 8/1/09 7/31/10	Phase I 8/1/10 1/31/11	TOTAL
DIRECT COSTS			
Salaries			
Matthew K. Howard PI/Data Portal Team Leader Y1: 25% Time, 12 Cal Mo. Y2: 25% Time, 6 Cal Mo.	19,863	10,229	30,092
Ann E. Jochens Co-PI/Program Manager Y1: 15% Time, 12 Cal Mo. Y2: 14% Time, 6 Cal Mo.	14,528	6,983	21,511
Steven F. DiMarco Co-Principal Investigator Y1: 5% Time, 12 Cal Mo. Y2: 5% Time, 6 Cal Mo.	5,700	2,936	8,636
To Be Named Graduate Student - Ocean Observing MS Y1: 50% Time, 12 Cal/Mo. Y2: 50% Time, 6 Cal/Mo.	19,776	10,185	29,961
Subtotal	59,867	30,333	90,200
Total Salaries and Wages	59,867	30,333	90,200
Fringe Benefits	17,644	8,849	26,493
Total Personnel Costs	77,511	39,182	116,693
Materials & Supplies	1,250	1,093	2,343
Software	500	500	1,000
Data Purchase CCAR – 1 yr SSH	2,000	0	2,000
Data Purchase Horizon Marine – 1 yr drifter	5,000	0	5,000
Travel			
4 people 3.5 days Houston	500	500	1,000
Other Costs			
Communications	200	100	300
Modified Total Direct Costs (MTDC)	86,961	41,375	128,336
Tuition & Fees - $333/hour	7,992	3,996	11,988
Total Direct Costs	94,953	45,371	140,324
INDIRECT COSTS			
Indirect Costs MTDC *46.5%	40,437	19,239	59,676
TOTAL PROJECT COSTS	$135,390	$64,610	$200,000

TAMU Data Group Phase I Budget Justification
GOMEX 3-D Operational Ocean Forecast System Pilot Project
1 August 2009 through 31 January 2011 (18 months)

PERSONNEL: Dr. Matt Howard will be the Principal Investigator and the Data Manager for the TAMU Data Group (DG). He will (1) oversee the project progress, (2) assemble the historical data and model output, (3) arrange for access to the database by project participants, and (4) develop and maintain the web site for the project. It is anticipated that he will spend 25% of his time on this project over the 18 months. Professor Steve DiMarco will be a Co-Principal Investigator. He will oversee development of metrics and supervise the Master's level graduate student. It is anticipated this will take 5% of his time. Dr. Ann Jochens will be a Co-Principal Investigator. She will work with DiMarco and the graduate student on metrics, graphics production, and interpretation. She will work with Howard on program management aspects of the project. She will be responsible for seeing that the report from the DG is comprehensive and timely. It is anticipated this will take ~15% of her time. The graduate student will be tasked to perform calculations, assist in production of graphics, statistics, and reports, and provide interpretations as guided by the investigators. The student will be a Graduate Assistant-Research and will be 50% time on the project.

Salary: Salary support is based on the actual salaries of Howard, DiMarco, and Jochens. Salary support is budgeted at the monthly rate for Master of Science level graduate students in the Department of Oceanography at TAMU. Phase I is broken into two time periods for the purposes of this budget. Year 1 is 12 months from the estimated 1 August 2009 start date of the project. Year 2 is last 6 months of the 18-month total for Phase I. This split allows us to factor in allowable salary raises, projected to be approximately 3%.

Fringe: Fringe benefits for TAMU personnel are calculated at 17.6% of salary for staff plus applicable medical insurance benefits and at 10.1% for graduate students plus applicable medical insurance benefits.

Tuition and fees: Part of the support provided for Oceanography graduate students at TAMU covers tuition and fees for the number of hours they take. This is $333/hr with 24 hours per year.

TRAVEL: One trip per year is planned for a project meeting in Houston. Four people would attend. Transportation would be by car and the meeting is assumed to be 3.5 days.

MATERIALS & SUPPLIES: Funds are budgeted to allow purchase of disk storage, paper, and toner. These are necessary for the storage of data and model output and for the production of graphics, data and analysis products, and reports.

SOFTWARE: Funds are allocated to purchase licenses for software used in calculations, graphics, and reporting.

DATA PURCHASES: It is expected that sea surface height (SSH) fields will be needed by the modelers. We have allocated $2,000 to purchase one year of historical SSH data from Dr. Robert Leben, Colorado Center for Astrodynamics Research, University of Colorado. It is also expected that historical drifting buoy data will be needed. We have allocated $5,000 to purchase one year of historical drifting buoy data from Horizon Marine, Inc.

COMMUNICATIONS: Funds are allocated to cover costs associated with project teleconferences, long-distance calls, and postage.

INDIRECT CHARGES: The standard TAMU indirect rate of 46.5% is charged on all direct costs, except for tuition and fees for the graduate student on which there is no indirect charged.

Matthew K. Howard
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College Station, TX 77843-3146
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Position:
Associate Research Scientist

Education:

Humboldt State University, CA,	Physical Oceanography	B.S.	1976
Texas A&M University, TX,	Physical Oceanography	Ph.D.	1992

Professional Experience:
2006-Present Associate Research Scientist, Dept. of Oceanography, Texas A&M Univ.
1994-2006 Assistant Research Scientist, Dept. of Oceanography, Texas A&M Univ.
1991-1994 Assistant Research Scientist, Geochemical Environmental Res. Group, TAMU
1989-1991 Assistant Research Scientist, Applied Research Corp., College Station, TX
1982-89 & 90-91 Graduate Research Assistant, Texas A&M University
1980-1982 Research Engineer, Dynamics Technology Inc., Torrance, CA
1977-1980 Associate Oceanographer, Interstate Electronics Corp., Anaheim, CA

Awards and Honors:
2007 Dean's Distinguished Achievement Award – Research Scientist

Graduate Student's Advised:
Ms. Kelly Cole, Ms. Julia O'Hern

Synergistic Activities:
IOOS Data Management & Communications Executive Committee & Steering Team
National Science Foundation Ocean Observing Interactive Cyber-Infrastructure Committee
Gulf of Mexico Coastal Ocean Observing System Regional Association Technical Lead
Marine Metadata Interoperability Program Steering and Executive Committee
IOOS Regional Observation Registry Technical Advisory Committee

Publications
DiMarco, S.F., **M. K. Howard**, and R. O. Reid, 2000. "Seasonal variation of wind-driven diurnal cycling on the Texas-Louisiana continental shelf". Geophys. Res. Lett. 21(7), 1017-1020.

Howard, M.K., S.F. DiMarco, and R.O. Reid, 2000: Seasonal variations of wind-driven diurnal current cycling on the Texas-Louisiana continental shelf, Geophys. Res. Lett., 27, 1017-1020.

Nowlin, W.D., A.E. Jochens, **M.K. Howard**, S.F. DiMarco, and W.W. Schroeder, 2000: Hydrographic Properties and Inferred circulation Over the Northeastern Shelves of the Gulf of Mexico During Spring to Midsummer of 1998. Gulf of Mexico Science, 18(1), 40-54.

Douglas C. Biggs, Ann E. Jochens, **Matthew K. Howard**, Steven F. DiMarco, Keith D. Mullin, Robert R. Leben, Frank E. Muller-Karger, and Chuanmin Hu, 2004. Eddy forced variations in on-margin and off-margin summertime circulation along the 1000 m isobath of the northern Gulf of Mexico, 2000-2003, and links with sperm whale distributions along the middle slope. (AGU Monograph on Circulation of the Gulf of Mexico).

Etter, P. C., **M. K. Howard**, and J. D. Cochrane (2004), Heat and freshwater budgets of the Texas-Louisiana shelf, J. Geophys. Res., 109, C02024, doi:10.1029/2003JC001820.

Nowlin, W. D., Jr., A. E. Jochens, S. F. DiMarco, **M. K. Howard**, R. O. Reid, 2004. Low-frequency Circulation Over the Texas-Louisiana Continental Shelf. (AGU Monograph on Circulation of the Gulf of Mexico)

P.V. Sundareshwar, R. Murtugudde, G. Srinivasan, S. Singh, K.J. Ramesh, D. Agarwal, D. Baldocchi, C.K. Baru, K.K. Baruah, G.R. Chowdhury, V.K. Dadhwal, C.B.S. Dutt, J. Fuentes, P.K. Gupta, W.W. Hargrove, **M. Howard**, C.S. Jha, S. Lal, W.K. Michener[y], A.P. Mitra, J.T. Morris, R.R. Myneni, M. Naja, R. Nemani, S. Raha, R. Ramesh, S.K. Santhana Vanan, M. Sharma, A. Subramaniam, R. Sukumar, R.R. Twilley, S.B. Verma, P.R. Zimmerman, 2007, INDOFLUX: A Biogeochemical Monitoring Network for India., Science, 316, 204-205.

Collaborators:
Dr. Steve F. DiMarco (TAMU), Dr. Ann E. Jochens (TAMU), Dr. Worth D. Nowlin Jr. (TAMU)

Graduate and Postdoctoral Advisors:
David A. Brooks, Ping Chang, Robert. O. Reid, Worth D. Nowlin Jr., Braham Nassersharif, Gerald North – All Texas A&M University

Externally-funded Research Projects:
NOAA/CSC GCOOS Data Portal (2007-2008) (Co-PI)
NOAA/CSC Local Data Nodes (2007-2010) (Co-PI)
Oman-Lighthouse Inc. Cabled Observatory (2007-2008)
NOAA/CSC GCOOS Regional Association Establishment (2006-2009) (Technical Lead)
NSF Marine Metadata Interoperability Program (2006-2009) (Co-PI)
NOAA Mechanisms that Control Hypoxia (2004-2008)
SURA Coastal Ocean Observation and Prediction Program (2004-2006 PI)
MMS Deep Oxygen (2003-2004)
MMS Sperm Whale Seismic Study (2002-2008)
DEEPSTAR Caribbean Under-flight (2000-2002)
NOAA Distributed Ocean Data System (2000-2003)
TX General Land Office Operational Nowcast/Forecast Current Prediction (1998-present)
MMS Deepwater Reanalysis (1998-2003)
MMS DGOMB (1999-2003)
MMS Jets Program (1999-2003)
MMS NEGOM (1997-2001)

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Position
Associate Professor

Profession Preparation

Doctor of Philosophy in Physics	University of Texas at Dallas	Aug 1991
Master of Science in Physics	University of Texas at Dallas	May 1988
Bachelor of Arts (Physics major)	University of Dallas	Dec 1985

Professional Appointments (present position first)

2004-present	Associate Professor, Department of Oceanography, TAMU
2000-2004	Associate Research Scientist, Department of Oceanography, TAMU
1994-2000	Assistant Research Scientist, Department of Oceanography, TAMU
1993-1994	Postdoctoral Research Associate, GERG, Louisiana-Texas Shelf Physical Oceanography Program, Texas A&M University (TAMU)
1992	Visiting Scientist, Max-Planck-Institut für Quantenoptik, Munich, Germany, June - August, 1992
1991-1993	Postdoctoral Research Associate, Center for Advanced Studies, Department of Physics and Astronomy, University of New Mexico and Department of Physics, TAMU, Advisor: Professor Marlan O. Scully.

Selected Peer Reviewed Publications

A. E. Jochens and **S. F. DiMarco**, 2008. Physical oceanographic conditions in the Gulf of Mexico during 2002-2004. *Deep Sea Research Part II. Topical Studies in Oceanography*, **55**(24-26), 2541-2554.

T.S. Bianchi, **S. F. DiMarco**, M. A. Allison, P. Chapman, J. H. Cowan Jr., R. D. Hetland, J. W. Morse, and G. Rowe (2008), Controlling Hypoxia on the U.S. Louisiana Shelf: Beyond the Nutrient-Centric View, *Eos Trans. AGU*, *89*(26), doi:10.1029/2008EO260005.

R. D. Hetland and **S. F. DiMarco**, 2008. How does the character of oxygen demand control the structure of hypoxia on the Texas-Louisiana continental shelf? *J. of Marine Systems*, **70**, 49-62.

A. M. Kaltenberg, D. C. Biggs, and **S. F. DiMarco**, 2007. Deep scattering layers of the northern Gulf of Mexico observed with a ship-board 38-kHz acoustic Doppler current Profiler (ADCP). *Gulf of Mexico Science*, **25**, 97-108.

S. F. DiMarco, L. Campbell, and N. L. Guinasso, Jr., 2005. A new Master's level Certificate in Ocean Observing Systems at Texas A&M University. *Marine Technol. Soc. Journal* 39(3), 13-15.

S. F. DiMarco, R. O. Reid, W. D. Nowlin, Jr., 2005**.** A Statistical Description of the Near-surface Velocity Field from Drifters in the Gulf of Mexico. Geophysical Monograph Series, Volume 161, *Circulation of the Gulf of Mexico: Observations and Models*. Eds. W. Sturges and A. Lugo-Fernandez. American Geophysical Union, pp. 101 - 110.

S. F. DiMarco, P. Chapman, W. D. Nowlin, Jr., P. Hacker, K. Donohue, M. Luther, G. Johnson, and J. Toole, Volume and property distributions of the Mozambique Channel. Deep Sea Research Part II, 49, 1481-1511, 2002.

S. F. DiMarco, E. Meza Conde, and J. Zhang, 2001. Estimating wave elevation from pressure using second-order nonlinear wave-wave interaction theory with applications to Hurricane Andrew, *J. Coastal Research* 17(3), 657-671.

S. F. DiMarco, P. Chapman, and W. D. Nowlin, Jr., 2000. Satellite observations of upwelling on the continental shelf south of Madagascar. *Geophysical Research Letters*. 27(24), 3965-3968.

S.F. DiMarco, M. K. Howard, and R. O. Reid, "Seasonal variation of wind-driven diurnal cycling on the Texas-Louisiana continental shelf", 2000. Geophys. Research Letters 21(7), 1017-1020.

Synergistic Activities

Reviewer: Journal of Physical Oceanography, Journal of Geophysical Research, Geophysical Research Letters, Journal of Coastal Research, Journal of Marine Systems, Journal of Gulf of Mexico Science, National Science Foundation, Sea Grant, NASA

Professional Organization Membership: Sigma Xi 2000-, AGU 1993-, Oceaogr. Soc. 2006-.

Database development: participated in development of two series of CDROMs containing highly quality-controlled physical oceanographic data of the Gulf of Mexico, which are currently available through the MMS and NODC. Total of eight CDROMs.

Teaching innovations: developed/taught graduate course entitled "Data Methods and Graphical Representation in Oceanography" and undergraduate course in Data Methods for Geosciences.

Cochair of 2007 George Bush U.S.-China Relations Research Roundtable 22-25 October 2007, Washington D.C. and Climate Change and the Coastal Ocean Workshop, Qingdao, China, 23-26 October 2008.

Collaborators and Other Affiliations

i. Collaborators: S. Anderson (Horizon Marine, Inc.), W.-J. Cai (UGa), A. C. Coward (SOC), J. Cox (Evans-Hamilton), M. Dagg (LUMOCN), R. E. Davis (SIO), K. Donohue (URI), K. Fennel (Dalhousie), G. Z. Forristall (Forristall Engineering), S. Frolov (Accurate Environmental Forecasting, Inc.), C. Harris (VIMS), R. He (NCSU), G. Johnson (PMEL), R. Leben (CU), S. Lohrenz (USM), L.-Y. Oey (Princeton), A. Quigg (TAMU-Galveston), L. Shay (RSMAS-Miami), W. Schmitz (WHOI-retired), W. Sturges (FSU-retired), O. Wang (JPL), N. Walker (LSU), H. Wei (Tianjin University), Kevin Xu (Coastal Carolina Univ.).

ii. Graduate and Postdoc Advisors: Cyrus D. Cantrell, III, Univ. of Texas at Dallas (PhD); Marlon O. Scully, Univ. of New Mexico (now at Texas A&M University) (Postdoc-Quantum Optics); W. D. Nowlin, Jr., Texas A&M Univ. (Postdoc-Oceanography)

iii. Graduate Students Chaired (Total: 8)

Valeriya Kiselkova: Chair: PhD (2004-2008)
Kelly Cole: Chair MS thesis (2005-2008)
Ashlie Sears: Chair MGeos. non-thesis (2006-2008)
Sudeshna Lahiry: Chair MS thesis (2004-2007)
Alyson Azzara: co-chair MS thesis (2004-2006)
Amanda Olson: co-chair MS thesis (2002-2004)
Laurie Sindlinger: co-chair MS thesis (2001-2003)
Rebecca Scott: co-chair MS thesis (1998-2001)

Ann E. Jochens

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email: ajochens@tamu.edu

Position: Research Scientist in Oceanography at Texas A&M University

Education

Ph.D. Texas A&M University, Oceanography, 1997
M.S. Texas A&M University, Oceanography, 1989
J.D. University of Oregon, Law with background specialty in Ocean Law, 1977
B.S. Southern Methodist University, Mathematics and Statistics, with Honor, 1974

Professional Experience

Texas A&M University (6/89 to present)

Research Scientist, Oceanography, (7/06 to present); Associate Research Scientist, Oceanography, (10/93 to 07/06); Assistant Research Scientist, Oceanography, (06/89 to 10/93); Appointed Associate Member of the Graduate Faculty on 7 April 2000.

Major Research Projects: Regional Coordinator and Principal Investigator, Gulf of Mexico Coastal Ocean Observing System Regional Association (09/05 to present); Program Manager and Principal Investigator, Sperm Whale Seismic Study (04/02–01/09); Program Manager and Principal Investigator, Deepwater Program: Understanding the Processes that Maintain the Oxygen Levels In the Deep Gulf of Mexico (07/02–07/05); Deputy Program Manager and Co-Principal Investigator, Northeastern Gulf of Mexico Chemical Oceanography and Hydrography Study (10/97 to 10/02); Acting Program Manager/Deputy Program Manager and Co-Principal Investigator, Texas-Louisiana Shelf Circulation and Transport Processes Study of the Louisiana-Texas Shelf Physical Oceanography Program (10/91 to 10/98); Project Scientist, U.S. World Ocean Circulation Experiment (6/89 to 4/92); Graduate Assistant, Research, Oceanography (8/86 to 6/89)

Independent Environmental Consultant (8/85 to 6/89)

Gulf Oil Corporation (8/80 to 8/85): Environmental/Safety/Permitting coordination

Wyoming Mineral Corporation (2/78 to 8/80): Environmental administration

Selected Peer-Reviewed Publications

Jochens, A.E., and S.F. DiMarco. 2008. Physical oceanographic conditions of the deepwater Gulf of Mexico in summer 2000-2002. *Deep-Sea Research II*, 55, 2541-2554.

Jochens, A.E., W.D. Nowlin, Jr. 2007. Development of a coastal ocean observing system for the Gulf of Mexico. Invited. *Marine Technology Society Journal*, 40 (4), 100-109.

Biggs, D., **A. Jochens**, M. Howard, S. DiMarco, K. Mullin, R. Leben, F. Muller-Karger, and C. Hu. 2005. Eddy forced variations in on-margin and off-margin summertime circulation along the 1000-m isobath of the northern Gulf of Mexico, 2000-2003. In Sturges & Lugo-Fernandez, eds., Circulation in the Gulf of Mexico: Observations and Models, Geophysical Monograph Series, V. 161, American Geophysical Union, 360 pp.

Nowlin, Jr., W.D., **A.E. Jochens**, S.F. DiMarco, R.O. Reid, and M.K. Howard. 2005. Low-frequency circulation over the Texas-Louisiana continental shelf. In W. Sturges and A. Lugo-Fernandez, eds., Circulation in the Gulf of Mexico: Observations and Models, Geophysical Monograph Series, Volume 161, American Geophysical Union, 360 pp.

Ressler, P., **A.E. Jochens**. 2003. Hydrographic & acoustic evidence for enhanced plankton stocks in a small cyclone in the northeastern Gulf of Mexico. *Cont. Shelf Res.*, 23, 41-61.

Qian, Y., **A.E. Jochens**, M.C. Kennicutt II, D.C. Biggs. 2003. Spatial and temporal variability of phytoplankton biomass and community structure over the continental margin of the northeast Gulf of Mexico based on pigment analysis. *Cont. Shelf Res.*, 23, 1-17.

Nowlin, W., **A. Jochens**, M. Howard, S. DiMarco, and W. Schroeder. 2000. Hydrographic properties and inferred circulation over the northeastern shelves of the Gulf of Mexico during spring and mid-summer of 1998. *Gulf of Mexico Science*, 23 (1), 40-54.

Selected Synergistic Activities

Reviewer: National Science Foundation, National Oceanographic Partnership Program, Journal of Environmental Management, Journal of Climate, Marine Technology Society Journal, Journal of Geophysical Research

Committees: Member of Organizing Committee of the International Conference on Sea-Level Rise in the Gulf of Mexico: Impacts, Adaptations, and Management; Gulf of Mexico Alliance partner active in Water Quality and Nutrient Reduction Priority Issue Teams; Gulf Hypoxia Implementation Plan Steering Committee Member; Chair of TAMU Oceanography Honors and Awards Committee; Chair of TAMU College of Geosciences Research Professionals Committee; Session Chair of MTS-IEEE Oceans '06

Professional Societies: Sigma Xi The Scientific Research Society, American Meteorological Society, American Geophysical Union, The Oceanography Society Charter Life Member, American Statistical Association, Marine Technology Society, Association of State Floodplain Managers, Colorado & Oregon Licensed Attorney (status inactive)

Professional Honors

Offshore Leadership Award, U.S. Minerals Management Service, 2009

Dean's Distinguished Achievement Award–Research Scientist, TAMU Geosciences, 2006

Distinguished Graduate Student Award–Master's Level, The Association of Former Students and The Office of Graduate Studies of Texas A&M University, 1990

Collaborators and Other Affiliations

Graduate Student Committees Leila Belabbassi, M.S., Ph.D., Oceanography, 2001, 2006 Member (Post-Doc 2007-2009); Xiaoqian Zhang, Ph.D., Oceanography, 2009, Member; Sudeshna Lahiry, M.S., Oceanography, 2007, Member; Michael Lalime, M.S., Oceanography, in progress, Co-chair; Sagar Nauduri, Ph.D., Petroleum Engineering, 2009, Member; Ray Tommy Oskarsen, M.S., Ph.D., Petroleum Engineering, 2001, 2004, Member; Ruktai Ace Prurapark, Ph.D., Petroleum Engineering, 2009, Member; Matthew D. Martin, M.S., Petroleum Engineering, 2006, Member; José Salas, M.S., Petroleum Engineering, 2004, Member; Liliana Vera Vera, M.S., Petroleum Engineering, 2002, Member; Muhammad Omer Javaid, M.E., Petroleum Engineering, 2004, Member

Graduate Advisor Committee Chairs

M.S.: Aubrey L. Anderson, Chair, TAMU Oceanography

Ph.D. Worth D. Nowlin, Jr., & Robert O. Reid, Co-Chairs, TAMU Oceanography

Major Scientific Collaborators (TAMU, unless otherwise noted)

Leila Belabbassi, Douglas C. Biggs, Steven F. DiMarco, Matthew K. Howard, Worth D. Nowlin, Jr. (TAMU, retired), Joel Ortega-Ortiz (FL FWI), Robert O. Reid (deceased), David C. Smith III, Marion Stoessel, Ou Wang (JPL), Bernd Würsig (TAMU-Galveston), Xiaoqian Zhang.

UNIVERSITY OF CALIFORNIA, LOS ANGELES **UCLA**

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SANTA BARBARA • SANTA CRUZ

OFFICE OF CONTRACT AND GRANT ADMINISTRATION
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11000 KINROSS, SUITE 102
LOS ANGELES, CALIFORNIA 90095-1406

PHONE: (310) 794-0102
FAX: (310) 794-0631

www.research.ucla.edu/ocga

April 10, 2009

Dr. Christopher Mooers
Attn: Ms Nicole Braman, Research Administrator
Maseeh College of Engineering and Computer Science
Portland State University
1930 SW 4th Ave, Suite 200
Portland, OR 97201

SUBJECT: Proposal " GOMEX 3-D Operat6ional Ocean Forecast System Pilot Project"

UCLA PI: Yi Chao

Dear Dr. Mooers:

On behalf of The Regents of the University of California, I am pleased to present the above subject proposal under the direction of PI Yi Chao from the Joint Institute for Regional Earth System Science and Engineering Program.

The level of funding requested is $125,000 for the period August 1, 2009 through January 31, 2011. The offsite F&A rate of 26% will be assessed to this project.

If awarded, the subaward should be issued in the name of *The Regents of the University of California* at the address on the letterhead. For administrative questions please contact Nancy Home at (310) 794-5273 or email nancy@jifresse.ucla.edu and for award matters please contact Barbara Harris-Holdrege at (310) 794-0179 or by email at: bharris-holdrege@research.ucla.edu.

Thank you very much.

Barbara Harris-Holdrege
Contract and Grant Officer

Encl.
cc: Nicole Branman
Prof. Yi Chao
Ms. Nancy Hom

Proposal Title: GOMEX 3-D Operational Ocean Forecast System Pilot Project

Lead PI: Professor Chris Mooers, Portland State University, cmooers@cecs.pdx.edu

UCLA PI: Yi Chao, JIFRESSE

Period of Performance: 18-month with a starting date of August 1, 2009

Statement of Work

UCLA will implement a 3-dimensional variational data (3DVAR) assimilation scheme into the GoM ROMS developed by Dr. Ruoying He at North Carolina State University (NCSU).

We selected the 3DVAR data assimilation methodology because of its ability to propagate observational information, which is often sporadically and irregularly distributed, in both the horizontal and vertical directions and its computational efficiency that enables real-time operational forecasting. The ROMS adjoint code is also available. However, its high computational cost prohibits a real-time operational implementation in the foreseeable future.

The ROMS 3DVAR incorporates weak constraints based on hydrostatic and geostrophic balance. The balance constraints are applied to the increment, rather than the total field. The internal dynamic consistency is particularly important for coastal regions, where there are complex coastlines, bottom topography, upwelling, strong fronts and eddies. Assimilation of satellite-based remote sensing measurements into advanced numerical oceanic models is a challenging task. This is mostly because satellites only measure ocean surface properties, and most satellites provide measurements only along certain orbital tracks, leaving data gaps between tracks. The basic requirement of a data assimilation system is to spread information along satellite tracks to these data void regions, and penetrate information from surface to deep water. This is accomplished through the 3D error covariance. We have developed a new method based on the Kronecker product for construction of 3D error self-correlations and cross-correlations (Li et al., 2008, 2009).

To effectively assimilate sea surface height (SSH) from satellite altimetry, we introduce the non-steric SSH increment as a control variable. While the steric SSH is in balance with the temperature and salinity increments, the non-steric SSH is due to the water mass convergence in the water column. In the open ocean, the steric SSH is the main signal, while the non-steric SSH becomes more significant as approaching the coast (Li et al., 2008). Thus, a weak constraint is required for coastal ocean data assimilation.

The ROMS 3DVAR can also assimilate ocean current data, from HF radar for example. Rather than using velocity components, we use streamfunction and velocity potential as control variables (Li et al., 2006). As such, the incremental ageostrophic velocity can be written using the incremental ageostrophic streamfunction and velocity potential.

Because velocity potential is a control variable, the divergence can be explicitly constrained. Divergence is relatively strong in the coastal ocean and can be generated by a variety of dynamical processes such as tides, Ekman transports and bottom boundary layers. The constraint on divergence is therefore a unique but important feature for coastal ocean data assimilation.

In summary, the ROMS 3DVAR has five control variables, representing the non-steric SSH, ageostrophic streamfunction, ageostrophic velocity potential, temperature, and salinity. All control variables are 3D, except the non-steric SSH that is 2D. A unique characteristic of our 3DVAR implementation is that we use the non-steric SSH and ageostrophic streamfunction and velocity potential as control variables. Because of this characteristic, our 3DVAR can explicitly constrain on both steric and non-steric SSH as well geostrophic and ageostrophic velocities. Our 3DVAR scheme is particularly suitable for an OGCM coupled with tides, since it explicitly constrains not only non-tidal SSHs and currents, but also tidal SSHs and currents that are non-steric and ageostrophic by nature (Wang et al., 2009). Since inhomogeneous and anisotropic error correlations are constructed using our new method, along with the weak dynamic constraints, the ROMS 3DVAR system has the capability to assimilate observed sea surface temperatures (SSTs) and SSH from different satellites, and a variety of *in situ* observations that are characterized by sporadic and irregular distributions (Chao et al., 2008, 2009).

Schedule and Tasks for Phase I: YR1/Q1 - YR2/Q2

YR1

Q1:

- Establish subcontracts and participate the kick-off TAC/SAC meeting
- Implement 3DVAR data assimilation into GoM ROMS
- Gather available observations
- Evaluate the lateral boundary conditions provided by the basin-scale and global models (in collaboration with NCSU)

Q2:

- Perform ROMS simulations during the target period without data assimilation (in collaboration with NCSU)
- Complete the 3DVAR data assimilation implementation into GoM ROMS
- Assess the model skill in terms of analyses (nowcasts) and forecasts (in collaboration with NCSU)

Q3:

- Perform ROMS simulations during the target period with data assimilation
- Assess the impact of data assimilation in terms of analyses (nowcasts) and forecasts (in collaboration with NCSU)

Q4:

- Revise the GoM, 3DVAR data assimilation and improve the lateral boundary conditions if needed (in collaboration with NCSU)

- Summarize skill assessments for target period (in collaboration with NCSU)

YR2

Q1:

- Perform future period model runs for skill assessment of analyses and forecasts (in collaboration with NCSU)

Q2:

- Assess the model skill for future period (in collaboration with NCSU)
- Participate TAC/SAC meeting

Budget: $125,000

Budget Justification

$120,000 will be used to support a part-time researcher at UCLA/JIFRESSE (Hongchun Zhang) over a period of 18-month.

Dr. Yi Chao will be supported by his NASA grants and provide the needed advice and leadership for this project.

A travel fund of $5000 is requested to support two 3-day trips to PSU (meeting with the lead PI) and two 3-day trips to NCSU (meeting with the GoM ROMS PI Dr. Ruoying He) for Dr. Yi Chao and Hongchun Zhang, respectively.

References

Chao, Yi, Zhijin Li, John D. Farrara, Mark A. Moline, Oscar M. E. Schofield, and Sharanya J. Majumdar. 2008. Synergistic applications of autonomous underwater vehicles and the regional ocean modeling system in coastal ocean forecasting. Limnol. Oceanogr. 53: 2251-2263.

Chao, Y., Z. Li, J. Farrara, J. C. McWilliams, J. Bellingham, X. Capet, F. Chavez, J.-K. Choi, R. Davis, J. Doyle, D. Frantaoni, P. P. Li, P. Marchesiello, M. A. Moline, J. Paduan, S. Ramp, Development, implementation and evaluation of a data-assimilative ocean forecasting system off the central . Deep-Sea Research II, doi:10.1016/j.dsr2.2008.08.011, 2009.

Li, Z., Y. Chao, J.C. McWilliams, and K. Ide, A Three-Dimensional Variational Data Assimilation Scheme for the Regional Ocean Modeling System. Journal of Atmospheric and Oceanic Technology, 25, 2074-2090, 2009.

Li, Z., Y. Chao, J. C. McWilliams, and K. Ide, A three-dimensional variational data assimilation scheme for the Regional Ocean Modeling System: Implementation and basic experiments, J. Geophys. Res., 113, C05002, doi:10.1029/2006JC004042, 2008.

Li, Z., Yi Chao, and J.C. McWilliams, Computation of the Streamfunction and Velocity Potential for Limited and Irregular Domains, *Monthly Weather Review*, 134, 3384-3394, 2006.

Wang, X., Y. Chao, C. Dong, J. Farrara, Z. Li, J. C. McWilliams, J. D. Paduan, L. K. Rosenfeld, Modeling tides in Monterey Bay, California. Deep-Sea Research II, doi:10.1016/j.dsr2.2008.08.012, 2009.

CURRICULUM VITAE

Yi Chao
Joint Institute for Regional Earth System Science and Engineering, UCLA
Phone: (310) 794-9832; Fax: (310) 794-9796; E-mail: ychao@jifresse.ucla.edu

Education

Ph.D. 1988-1990, Atmospheric and Oceanic Science (AOS) Program, Princeton University
M.A. 1985-1987, Geophysical Fluid Dynamics (GFD) Program, Princeton University
B.Sc. 1980-1985, Atmospheric Physics, University of Science and Technology of China

Professional Experience

2006-present, Adjunct Professor, Dept. of Atmospheric and Oceanic Sciences, UCLA
2006-2009, Deputy & Manager, Climate, Oceans and Solid Earth Section, JPL
2005-2006, Supervisor, Ocean-Atmosphere Interaction Group, JPL
1993-present, Scientist, Research Scientist, & Principal Scientist, JPL
1990-1992, Post-doctoral Scholar, University of California at Los Angeles

Recent Refereed Publications related to this proposal

Chao, Y., Z. Li, J. Farrara, J. C. McWilliams, J. Bellingham, X. Capet, F. Chavez, J.-K. Choi, R. Davis, J. Doyle, D. Frantaoni, P. P. Li, P. Marchesiello, M. A. Moline, J. Paduan, S. Ramp, Development, implementation and evaluation of a data-assimilative ocean forecasting system off the central . Deep-Sea Research II, doi:10.1016/j.dsr2.2008.08.011, 2009.

Wang, X., Y. Chao, C. Dong, J. Farrara, Z. Li, J. C. McWilliams, J. D. Paduan, L. K. Rosenfeld, Modeling tides in Monterey Bay, California. Deep-Sea Research II, doi:10.1016/j.dsr2.2008.08.012, 2009.

Doyle, J. D., Q. Jiang, Y. Chao, J. Farrara, High-resolution real-time modeling of the marine atmospheric boundary layer in support of the AOSNII field campaign. Deep-Sea Research II, doi:10.1016/j.dsr2.2008.08.009, 2009.

Li, Z., Y. Chao, J.C. McWilliams, and K. Ide, A Three-Dimensional Variational Data Assimilation Scheme for the Regional Ocean Modeling System. Journal of Atmospheric and Oceanic Technology, 25, 2074-2090, 2009.

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Li, Z., Y. Chao, J. C. McWilliams, and K. Ide, A three-dimensional variational data assimilation scheme for the Regional Ocean Modeling System: Implementation and basic experiments, J. Geophys. Res., 113, C05002, doi:10.1029/2006JC004042, 2008.

Pfeiffer-Hoyt, A. S., M.A. McManus, P.T. Raimondi, Y. Chao, and F. Chai, Dispersal of barnacle larvae along the central California coast: A modeling study. *Limnol. Oceanogy.*,52(4), 2007, 1559-1569, 2007.

Yi Chao

UCLA subcontract to Portland State University, Chris Mooers

GOMEX 3-D Operational Ocean Forecast System Pilot Project

									Year 1	Year 2	TOTAL
Salaries	Yr 08-09 Annual Salary	Montly Salary Rate	**Yr 1 Mo**	COLA	**Yr 2 Mo**	5% COLA	**Yr 3 Mo**	5% Rate Increase	**08/01/09 to 07/31/10**	**08/01/10 to 01/31/11**	
PI: Yi Chao, Adjunct Professor	0	0		0		0		0	0	0	0
Hongchun Zhang, Proj Spec	79000	8778	**4.44**	8,778	**2.16**	9,217		9,678	38,973	19,908	58,881
TBN, Project Manager	70000	5833	**1.20**	5,833	**0.54**	6,125	**0.00**	6,370	7,000	3,308	10,308
Total Salaries									**45,973**	**23,216**	**69,189**
Benefits	Rate			Rate		Rate		Rate			
Y. Chao	7.30%			7.30%		7.30%		7.30%	0	0	0
H. Zhang	33.00%			33.00%		33.00%		33.00%	12,861	6,570	19,431
Project Manager	33.00%			33.00%		33.00%		33.00%	2,310	1,091	3,401
Benefit Total									**15,171**	**7,661**	**22,832**
Total Salaries & Benefits									**61,145**	**30,877**	**92,021**
Technology Infrastructure Fee											
Y. Chao	40.75								0	0	0
H. Zhang	40.75								181	88	269
Project Manager	40.75								49	22	71
TIF Total									**230**	**110**	**340**
Travel									**2,500**	**2,500**	**5,000**
2 Trips to PSU	3 days (air 300, hotel 450, meals 180, ground 150) $1080/trip										
2 Trips to NCSU	3 days (air 640, hotel 450, meals 180, ground 150) $1420/trip										
Other Cost											
Computer Fee									500	535	1,035
Materials & Supplies									400	410	810
Total Other Cost									**900**	**945**	**1,845**
Total Direct Costs									**64,774**	**34,432**	**99,206**
Total Modified Direct Cost**									64,774	34,432	99,206
Total Modified IDC	**26%**								**16,841**	**8,952**	**25,794**
	0%								**0**	**0**	
TOTAL REQUESTED AMOUNT									**81,616**	**43,384**	**125,000**

UCLA Budget Justification

Title: GOMEX 3-D Operational Ocean Forecast System Pilot Project
Dates: 08/01/09 – 01/31/10

Salaries (All salaries include a 5% COLA for Year 2)
Funds request for:

0.0 cal mo/yr for PI: Yi Chao, Adjunct Professor – no cost to the project

4.44 cal mo Year 1: Researcher, Hongchun Zhang
2.16 cal mo Year 2

1.20 cal mo Year 1: Project Manager, TBN
0.54 cal mo Year 2

*JIFRESSE is a charter between 2 colleges - College of Letter and Science and the Henry Samueli School of Engineering and Applied Science. In order to build a collaboration on climate control issues with various agencies, administrative support is needed. JIFRESSE is a research institution and does not receive any permanent funding allocations from the two colleges (College of Letters and Sciences OR the Henry Samueli School of Engineering and Applied Science). The Project Manager is partially supported by a collective of contracts and grants. Project Manager needed to oversee budget, arrange travel, research related conference meetings set up, personnel issues - visa processing.

Benefits
Rates for Zhang and Project Manager: 33%

Travel
Travel funds are requested for PI Chao to travel to PSU and NCSU for research collaboration.

	UCLA – PSU (2 trips)	**UCLA – NCSU (2 trips)**
Airfare:	$300	$640
Lodging:	$450 ($150/night for 3 nights)	$450 ($150/night for 3 nights)
Meals:	$180 ($60/day for 5 days)	$180 ($60/day for 5 days)
Ground Transportation:	$150	$150
Total:	$1080/trip	$1420/trip

Other Cost

Material and Supplies: toner, software, and research related telecommunication

Computer Services: Access, support, and maintenance of high-performing network of computers needed for project

Other: Technology Infrastructure Fee (TIF) is accessed to each project fund number to support the technology infrastructure services that support the entire campus, including the CLA backbone, Commodity Internet, Internet2, BOL services, Connect2, and underground inter-building wiring/cabling and maintenance. Project specific Information Technology Services are also changed to this project. Cost $40.75/month/FTE

Indirect Cost
Facilities and Administration (F&A) Cost of Off-Campus rate of 26.0% of the Modified Total Direct Cost (MTDC). A copy of agreement can be found: http://www.research.ucla.edu/ocga/sr2/idcinfo.htm

Letter of Support, Statement of Work and Budget Request
NOAA/NOS/OCS/Coast Survey Development Laboratory
Richard Patchen
Chief Scientist

April 3, 2005

The NOAA/NOS is extremely interested in the participating in the proposal to RPSEA in the evaluation of three-dimensional assimilative models as applied to the Gulf of Mexico. As you well know, NOS has a strong interest in having a well documented, validated model for the Gulf of Mexico. A major use of a Gulf-wide model is to provide model-data to seamlessly couple to finely resolved coastal models. NOS presently has implemented and runs daily on NOAA's NCEP high performance computer system, a Gulf of Mexico nowcast/forecast system that has evolved over the last decade from a research model to define statistically realistic currents throughout the Gulf, with particular emphasis on the Louisiana-Texas shelves, to provide hindcast during synoptic severe events, to predicting realistic, synoptic Loop current and eddies with the implementation of various data assimilation approaches. I have enclosed a short summary of the model evolution to its present use of support NOS efforts in spill response to Harmful Algal Bloom research.

The hydrodynamic model used as the basis for the Nowcast/Forecast model for the Gulf of Mexico is a three-dimensional, deterministic model. It is based on the widely used Princeton Ocean Model that was jointly developed by Princeton University and Dynalysis of Princeton. The model domain, as shown in Figure 1, encompasses the entire Gulf, with particular emphasis on an accurate representation of the Louisiana-Texas shelf. The model has a resolution of 2-3 km in the northwestern gulf; and for the northeastern gulf and central basin the model resolution is 5-6 km. The vertical resolution is 37 levels with sufficient resolution to model both surface and bottom boundary layers.

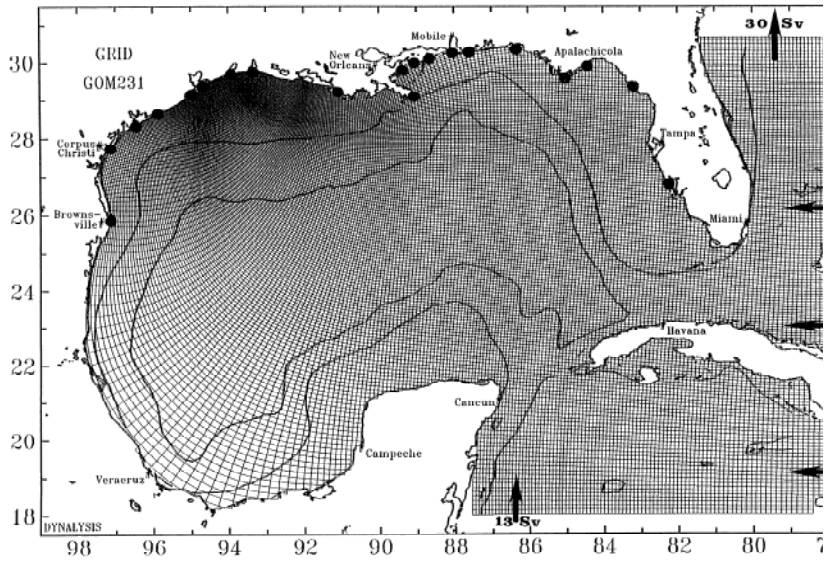

Figure 1 The Gulf of Mexico Nowcast/Forecast model uses an orthogonal, curvilinear grid. Along the boundaries of the model, the locations and magnitude of the time invariant transport imposed is shown on the heavy arrows in Sv; and the locations of river discharges into the Gulf are shown as solid circles.

Currently each day at NOS produces a Nowcast and a 48-hr forecast of the entire Gulf. In addition to the daily forecast, once a week a 30-day forecast is made available. To produce these forecasts, until recently the U.S. Navy's Coupled Ocean/Atmospheric Prediction System (COAMPS) provided the meteorological forcing – presently the system is being upgraded to use NOAA's 12 Km surface winds and atmospheric forecasts from the North American Mesoscale (NAM) model; and synoptic river flow discharges are specified from 29 rivers along the U. S. coastline based on USGS and USACE gages. To ensure an accurate representation of Loop Current (LC) and Loop Current Eddies (LCEs) morphology, once every other day, *weighted* primarily along the most recent satellite track, satellite-derived sea surface temperature and salinity data that are available through the U.S. Navy's Modular Ocean Data Assimilation System (MODAS) are assimilated during the model update mode. In addition to the capability to assimilate synthetic temperature and salinity profiles from MODAS; a new method is being incorporated to use real-time satellite altimeter track measurements based entirely on correlations between the altimeter surface height anomaly and observed hydrographic casts. This method consisted of: assembling the most comprehensive set of hydrographic data possible, vetting of the data, eliminating duplicates and placing the results in a uniform format; then preparing a hydrographic climatology in the form of a probability distribution of the different water masses occupying the Gulf; followed by the development of a correlation between the satellite sea surface anomaly and integral density anomaly of each of the water mass profiles, using contemporaneous altimeter and hydrographic cast measurements; and finally, incorporation of an algorithm for assimilating the temperature and salinity profiles with associated temporal and spatial weighting fields for use in the update component of the forecast system.

The NOS agrees to support the pilot study sponsored by RPSEA on a time available basis without any personal cost or computer related costs. The only cost that needs to be covered is to participate in the three meetings in Houston, TX. It is estimated that each meeting will be approximately $2000.00 for a total cost of $6000. Our contribution to Phase I is that would participate in the selection of the series of hindcast/forecast studies and the appropriate metrics, perform the studies/hindcasts as agreed upon, then provide the model-output as CF compliant netCDF files to your team for independent skill assessment. It is unclear what is needed for phase II at this point. The NGOM nowcast/forecast system has been implemented in an adaptive infrastructure and runs routinely at NCEP. It has the function of making both short-term nowcast/forecast and long-term (30 - 90 day) forecasts.

Richard C. Patchen
NOAA/NOS/OCS Coast Survey Development Laboratory
Chief Scientist
1315 East West Hwy, Silver Spring, Maryland 20910
Telephone: 301-713-2650x118 ■ Email: rich.patchen@noaa.gov

Over the course of his 35-year career, Richard Patchen has held numerous senior technical and management positions in both the government and the private sector. He is a renowned pioneer in the use of emerging technologies to solve multidisciplinary problems. During his tenure as a civilian employee with the U.S. Navy and the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA), he was responsible for several high visibility technical projects to ensure the government's technical excellence in applying the appropriate technologies to address major issues. As recognition of his efforts, in May of 1985, Mr. Patchen was co-recipient of the Colbert Medal given by the Society of American Military Engineers for the success of a NOAA program to use modeling and real-time observations to ensure safe and efficient navigation in the Delaware River and Bay. While at NOAA, he coordinated numerous efforts among federal and state agencies, universities, and scientific consulting firms to propose and implement solutions for national issues involving the health and safety of U.S. coastal waterways. He has developed numerical circulation models that have been applied to Cook Inlet, Columbia River, and Long Island Sound. The models allow for the investigation of the important nonlinear processes that control the circulation, especially in shallow regions, such as wetting and drying, the dynamics of moving shoals.

Throughout his career, Mr. Patchen's continuing objective has been to facilitate technology and information transfer among government, academic, and private sectors scientists and managers In 1988, Mr. Patchen joined Dynalysis of Princeton as Senior Technical Manager and Vice President at Dynalysis of Princeton. While at Dynalysis, he continued to use his expertise in emerging technologies to address both scientific and business issues. He was the Principal Scientist for modeling the Eastern Atlantic Continental Shelf, the Southern California Bight, the South China Sea, the Juan De Fuca System, and the Gulf of Mexico. He has developed and implemented several data and environmental information systems. One of the systems was for the U.S. Coast Guard, to allow the onsite officer a method for identification of site-specific information to address immediate needs, such as, the identification of available oceanographic or meteorological information. In response to a need for an efficient and effective method of transferring model data and information to the oil companies, Mr. Patchen designed, developed, and wrote a software system, including a comprehensive database with GIS capabilities, for transmitting model data. The system, called DynOMITE, which stands for Dynalysis Oceanographic Modeling and Information Transfer made Easy, enables the user to search and plot results from the database that included hindcasts of over 100 hurricanes in the Gulf of Mexico. In August of 1998, as a part of a National Oceanographic Partnership Program (NOPP) funded effort to implement a Gulf of Mexico Ocean Monitoring System, he designed and implemented a Nowcast-Forecast System to predict the circulation for the Gulf of Mexico. Then, in October of 2000, as part of a contract with the U.S. Navy Oceanographic Office, he installed this model system on the Navy's Computer System as the Navy's operational model for the Gulf of Mexico. As part of his Navy effort, model enhancements were made to the Gulf of Mexico modeling system, including the incorporation of data assimilation techniques and the implementation of technological advances in model infrastructure.

In 2004, Mr. Patchen returned to NOAA/NOS/OCS Coast Survey Development Laboratory as Chief Scientist. Since his return to NOAA, he has gained a leadership role in the agency in addressing the present and future challenges. In 2006-7, he lead a group of oceanographers in the establishment of a Model Evaluation Environment for the Delaware River and Bay. The project consisted of the implementation of a various classes of circulation models with the objective of performing a quantitative inter-comparison of the models with observations. He also was a Principle Investigator in a project to predict the onset and fate of HABs along the West Florida Shelf. A component of the program was the development; implementation and vetting of innovative approaches to couple the Gulf of Mexico model that he had developed with a highly resolved model of the West Florida Shelf.

Mr. Patchen received a B.S. from the City College of New York (CCNY) in 1970; a M.S. in 1972 from the University of Michigan; and was a doctoral candidate at the University of Washington in 1987. His research topic was modeling the dynamics of the Columbia River Estuary. He was a Visiting Fellow at Princeton University from January 1984 to June 1985 and an invited lecturer at the Naval Postgraduate School. He has presented technical papers to both scientific and business conferences, and has numerous articles published as technical government reports and in the refereed scientific literature.

CHRISTOPHER N.K. MOOERS
University of Miami

Main Fields of Research: Coastal ocean circulation and ocean mesoscale dynamics; numerical simulations of the circulation of marginal and semi-enclosed seas; coastal ocean prediction

Educational History:

U.S. Naval Academy	Naval Science	B.S. w/Distinction	1957
Univ. of Connecticut	Physics	M.S.	1964
Oregon State Univ.	Physical Oceanography	Ph.D.	1969

Employment History:

1957-1964	U.S. Naval Officer	Various
1969-1970	NATO Postdoc	University of Liverpool/Oceanography
1970-1976	Assistant/Assoc. Prof.	University of Miami/RSMAS/Physical Oceanography
1976-1979	Associate/Professor	University of Delaware/CMS
1979-1986	Professor and Chairman	Naval Postgraduate School/Oceanography Department
1986-1989	Director/Scientific Advisor	UCAR/Institute for Naval Oceanography
1989-1991	Research Professor	University of New Hampshire/EOS
1991-1993	Chair	University of Miami/RSMAS/Applied Marine Physics
1991 - 2008	Professor	University of Miami/RSMAS/Applied Marine Physics
1991 - 2008	Coordinator	RSMAS/Coastal Ocean Sciences Program
1992 - 2008	Director	RSMAS/ Ocean Prediction Experimental Laboratory (OPEL)
1993 - 2008	Fellow	University of Miami/RSMAS/CIMAS
2008 – to date	Professor Emeritus	University of Miami/RSMAS/Applied Marine Physics
2008 – to date	Research Professor	Portland State University, Department of Civil and Environmental Engineering

Public service:

Secretary, President-Elect, President, Ocean Sciences Section, AGU, 1978 to 1984
Chairman, Eastern Pacific Oceanic Conference, 1979 to 1986
Interim Councilor, The Oceanography Society, 1988 to 1989
Member, USNC/IUGG, 1991 to 1995; Chair, USNC/IUGG, 1996 to 1999
Chair, UNOLS Fleet Improvement Committee, 1994 to 1997
Co-Chair, PICES WG-10 on The Circulation and Ventilation of the Sea of Japan and Adjacent Waters, 1995 to 1998
Chair, AMS/STAC on Coastal Environments (née Meteorology and Oceanography of the Coastal Zone), 1996 to 2002
Member, NRC-AIC/USA-Mexican Joint Working Group on Cooperative Ocean Science, 1995 to 1998
Chair, NODC Working Group on Coastal Ocean Data Acquisition, 1997 to 1999
Co-Chair, SCOR WG 111 (Coupling of Winds, Waves, and Currents in Coastal Models),1998 to 2009
Chair, IOOS Modeling and Analysis Steering Team, 2006 to 2008
President, University of Miami Chapter, Sigma Xi, 2006 to 2008

Editorial service:

Consulting Editor, Weatherwise (1978 to 2005)
Managing Editor, Coastal and Estuarine Studies, Springer-Verlag, then AGU (1979 to 1999)
Editor, Journal of Physical Oceanography (1991 to 1996)

All publications in past five years

(2003) (with C. Andrade and D. Barton) Evidence for an Eastward Undercurrent along the South American Caribbean Coast) J. Geophys.Res. Vol. 108, No. C6, 3185, pp. 16-1 – 16-11.

(2003) (with H. Seim, B. Bacon, C. Barans, M. Fletcher, K. Gates, R. Jahnke, E. Kearns, R. Lea, M. Luther, J. Nelson, D. Porter, L. Shay, M. Spranger, J.Thigpen, R. Weisberg, and F. Werner) SEACOOS: A Model for a Multi-State, Multi-Institution Regional Observation System. Mar. Tech. Soc. Jour., 37 (3), pp. 92-101.

(2003) (with J. Fietcher) Simulation of Frontal Eddies on the East Florida Shelf. Geophys. Res. Lett., 30(22), 2151, doi: 10.1029/2003GLO18307, pp. OCE 3-1 – OCE 3-4.

(2003) On the Dynamics of Semi-Enclosed Seas. IN: Proceedings of the International Conference "Mathematical Methods in Geophysics", Part I. Novosibirsk, Russia, Publisher Institute of Computational Mathematics and Mathematical Geophysics, pp. 27-39.

(2004) Coastal Oceanography, in Encyclopedia of Earth and Atmospheric Sciences, in Oceanography, edited by Jacques C.J. Nihoul and Chen-Tung Arthur Chen, in Encyclopedia of Life Support Systems (EOLSS), Developed under the auspices of the UNESCO, Eolss Publishers, Oxford, UK, [http://www.eolss.net]. pp. 1145-1163.

(2005) (with H. Kang) Diagnoses of Simulated Water Mass Subduction/Formation/ Transformation in the Japan/East Sea (JES). Deep-Sea Res. ,II, 52, pp.1505-1524.

(2005) (with I. Bang and F. Sandoval) Synoptic Comparisons of Numerical Simulations with CREAMS II Observations of JES Circulation (Flow and Mass Fields). Deep-Sea Res. II, 52, pp.1639-1661.

(2005) (with I. Bang and S.L. Vaughan) Initial Steps Toward Validation of a Seasonal Cycle Simulation for Prince William Sound, Alaska. Circulation (Flow and Mass) Fields. Con. Shelf Res., 25, pp. 901-934.

(2005) (with I. Bang) An Assessment of a Nowcast/Forecast System for the Straits of Florida/Florida Current Regime. J. Ocean University of China (English edition), 4(4), pp. 288-292.

(2005) (with J. Fiechter) Numerical Simulations of Mesoscale Variability in the Straits of Florida.Ocean Dynamics.Doi: 10.1007/s10236-005-0019-0, pp. 309-325.

(2005) (with C.S. Meinen, M.O. Baringer, I. Bang, R. Rhodes, C.N. Barron and F.Bub) Cross Validating Ocean Prediction and Modeling Systems. EOS, Transactions, American Geophysical Union, 86(29), pp.269, 272-273.

(2006) (with Y. Liu and R.H. Weisberg) Performance Evaluation of the Self-Organizing Map for Feature Extraction. J. Geophys. Res., 111, C05018, doi: 10.1029/2005JC003117, pp. 1 - 14.

(2006) (with H.S. Kang, I. Bang, and D.P. Snowden) Some Lessons Learned from Comparisons of Numerical Simulations and Observations of the JES Circulation. Oceanography, 19(3), pp. 86-95.

(2006) (with J. Fiechter and K.L. Steffen, and B. K. Haus) Hydrodynamics and Sediment Transport in a Southeast Florida Tidal Inlet. Estuarine, Coastal, and Shelf Science, 70, pp. 297-306.

(2007) (with M.M.Criales, J.A.Browder, M.B. Robblee, H. Cardenas, and T. L. Jackson) Cross-Shelf Transport of Pink Shrimp Larvae: Interactions of Tidal Currents, Larval Vertical Migrations and Internal Tides. Mar Ecol Prog Ser , 345, doi:10.3354/meps06916, pp. 167-184.

(2007) (with J. Fiechter) Primary Production Associated with the Florida Current along the East Florida Shelf: Weekly to Seasonal Variability from Mesoscale-Resolution Biophysical Simulations. Journal of Geophysical Research-Oceans, 112, C12002, doi:10.1029/2006JC003576, pp 1 - 21.

(2007) (with X. Wu and I. Bang) Performance of a Nowcast/Forecast System for Prince William Sound, Alaska. Con. Shelf Res., doi: 10.1016/j.csr.2007.09.008, pp. 1-19.

(2008) (with J. Fiechter, B.K. Haus, and N. Melo) Physical Processes Impacting Coral Larvae Transport and Reef Connectivity in the Upper Florida Keys. Continental Shelf Research, 28, 1261-1272, doi: 10.1016/j.csr.2008.02.018.

(2008) (with H. Seim) Prologue to SEACOOS. Marine Technology Society Journal, 43(3), pp.14 – 16.

(2008) (with H. Seim, J. Nelson, M.Fletcher, L.. Spence, R.H.Weisberg, F. Werner, S.M. Smith, R. Lea) SEACOOS Program Management. Marine Technology Society Journal, 43 (3), pp. 17-27.

(2009) (with H.E.Seim, J.R. Nelson, R. H. Weisberg, and M.Fletcher) Towards a Regional Coastal Ocean Observing System Design for the Southeast Coastal Ocean Observing Regional Association. Journal of Marine Systems, 77, pp. 261-277, doi: 10.1016/j.jmarsys.2007.12.016.

(2009) (with W. G. Mendoza, J.E. Corredor, J. Morell, D.-S. Ko, R. G. Zika) Developmental Strategy for Effective Sampling to Detect Possible Nutrient Fluxes in Oligotrophic Coastal Reef Waters in the Caribbean. Journal of Operational Oceanography, 2 (1), pp.35-47.

(2009) (with H.-S. Kang and D.-S. Ko). The Response of the JES to Synoptic Scale Atmospheric Forcing as Estimated by EASNFS. Journal of Marine Systems, (under minor revision).

BIOGRAPHICAL SKETCH

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Department of Civil and Environmental Engineering
Portland State University
Post Office Box 751
Portland, OR 97207-0751
Email: zaron@cee.pdx.edu
Phone: (503) 725-2435

A. Professional Preparation

Oregon State University	1988-1995	PhD. in Physical Oceanography
Harvey Mudd College	1984-1988	B.S. in Applied Mathematics, cum laude

B. Appointments

2007-present	Senior Research Associate, Portland State University
2006-2007	Research Associate, Portland State University
2003-2006	Research Associate (Post-Doc), Oregon State University
1994-1996	Research Assistant, Oregon State University

C. Publications

(i) Five papers most relevant to this proposal

[1] C. Chavanne, P. Flament, E. D. Zaron, G. Carter, M. Merrifield, D. Luther, and K.-W. Gurgel. The surface expression of internal tides in the Kaua'i Channel, Hawai'i. I: observations and numerical models. *Journal of Physical Oceanography*, submitted, 2009.

[2] E. D. Zaron, C. Chavanne, G. D. Egbert, and P. Flament. Baroclinic tidal generation in the Kauai Channel inferred from HF-Radar. *Dynamics of Atmospheres and Oceans*, to appear, 2009. http://dx.doi.org/10.1016/j.dynatmoce.2009.03.002.

[3] E. D. Zaron and G. D. Egbert. The impact of the internal tide on data-assimilative model estimates of the surface tide. *Ocean Modelling*, 18:210–216, 2007.

[4] E. D. Zaron and G. D. Egbert. Verification studies for a z-coordinate primitive-equation model: tidal conversion at a mid-ocean ridge. *Ocean Modelling*, 14:257–278, 2006.

[5] E. D. Zaron and G. D. Egbert. Estimating open-ocean barotropic tidal dissipation: The Hawaiian Ridge. *Journal of Physical Oceanography*, 36:1019–1035, 2006.

(ii) Five other papers

[1] E. D. Zaron and J. N. Moum. A new look at Richardson number mixing schemes for Equatorial ocean modeling. *Journal of Physical Oceanography*, to appear, 2009.

[2] B. S. Chua, L. Xu, T. Rosmond, and E. D. Zaron. Preconditioning representer-based variational data assimilation systems: application to NAVDAS-AR. In S. Park and L. Xu, editors, *Data Assimilation in Geosciences*. Springer-Verlag, to appear, 2008.

[3] J. C. Muccino, H. Arango, A. B. Bennett, B. S. Chua, B. Cornuelle, E. DiLorenzo, G. D. Egbert, L. Hao, J. Levin, A. M. Moore, and E. D. Zaron. The inverse ocean modeling system. II: Applications. *Journal of Atmospheric and Oceanic Technology*, 25(9):1623 – 1637, 2008.

[4] E. D. Zaron. A comparison of data assimilation methods using a planetary geostrophic model. *Monthly Weather Review*, 134:1316–1328, 2006.

[5] R. N. Miller, E. D. Zaron, and A. F. Bennett. Data assimilation in models with convective adjustment. *Monthly Weather Review*, 122:2607–2613, 1994.

D. Synergistic Activities

System:

Inverse Ocean Model software maintenance, `http://sourceforge.net/projects/iocean`.
Software repository hosting for researchers, `http://ocean.cee.pdx.edu/~ezaron/websvn`.
MacPorts maintainer for scientific libraries on the MacIntosh, `https://ocean.cee.pdx.edu/svn/dports`.

K-12 Science and Mathematics Education:

Instructor, 2000-2003, grades 7-12, St. Francis Academy, Portland, OR.
Instructor and program director, 1999-2000, grades 7-8, Montessori School of Raleigh, Raleigh, NC.
Instructor and program director, 1996-1999, grades 6-8, Brush Creek School, Santa Rosa, CA.

E. Collaborators & Other Affiliations

(i) Collaborations in the Last 48 Months

Hernan Arango, Rutgers University; Andrew F. Bennett, Oregon State University; Alan Blumberg, Stevens Institute; Cedric Chavanne, University of Hawaii; Gary D. Egbert, Oregon State University; Pierre Flament, University of Hawaii; David Jay, Portland State University; Doug Luther, University of Hawaii; Rich Loft, National Center for Atmospheric Research; Patrick Miller, Stevens Institute; Andrew Moore, University of California, Santa Cruz; James N. Moum, Oregon State University; Julia Muccino, Arizona State University; Scott Smith, Naval Research Laboratory, Stennis; and Liang Xu, Naval Postgraduate School, Monterey.

(ii) Graduate and Postdoctoral Advisors

Ph.D.	Andrew F. Bennett, Oregon State University
Post-Doc	Gary D. Egbert, Oregon State University

Subject: [Fwd: Re: Gulf 3-D Operational Model Pilot Project]
From: Christopher Mooers <cmooers@rsmas.miami.edu>
Date: Fri, 17 Apr 2009 15:52:47 -0400
To: Nicole Braman <bramann@pdx.edu>

Nicole - Place at the back of Appendix II. - Chris

--
Professor Christopher N. K. Mooers, Director
Ocean Prediction Experimental Laboratory (OPEL)
Division of Applied Marine Physics (AMP)
Rosenstiel School of Marine and Atmospheric Science (RSMAS)
University of Miami (Univ. Miami)
4600 Rickenbacker Causeway (Cswy.)
Miami, FL 33149-1098
USA

NOTE: I HAVE RELOCATED TO PORTLAND,OREGON AND MY COMMUNICATION MODES ARE IN TRANSITION.

MY PRESENT TELEPHONE CONNECTIONS ARE

C: 503-953-2556
O: 503-954-2772
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http://anole.rsmas.miami.edu/people/cmooers.html
http://efsis.rsmas.miami.edu
http://epws-nfs.rsmas.miami.edu

Subject: RE: Gulf 3-D Operational Model Pilot Project
From: "Bub, Frank L CIV N62306" <frank.bub@navy.mil>
Date: Tue, 10 Mar 2009 14:18:17 -0400
To: "Christopher Mooers" <cmooers@rsmas.miami.edu>
CC: "Cort Cooper" <cortcooper@chevron.com>, "Dave Driver" <driverdb@bp.com>, "Leo Oey" <lyo@princeton.edu>, "Yi Chao" <Yi.Chao@jpl.nasa.gov>, "Ruoying He" <rhe@ncsu.edu>, "Sergei Frolov" <sfrolov@accufore.com>, "Steven DiMarco" <sdimarco@tamu.edu>, "Steven Anderson" <Steve@horizonmarine.com>, "Matt Howard" <mkhoward@tamu.edu>, "Payne, Steven W CIV CNMOC" <steven.w.payne@navy.mil>, "Jacobs, Gregg" <Gregg.Jacobs@nrlssc.navy.mil>, "Dong-Shan Ko" <ko@nrlssc.navy.mil>, "Hendrik Tolman" <Hendrik.Tolman@noaa.gov>, "Frank Aikman" <Frank.Aikman@noaa.gov>, "Richard Patchen" <Rich.Patchen@noaa.gov>, "Lugo Fernandez, Alexis" <Alexis.LugoFernandez@mms.gov>, "Turner, Chris" <Arden.C.Turner@uscg.mil>, "Worth D. Nowlin, Jr." <wnowlin@tamu.edu>, "Buzz Martin" <buzz.martin@glo.state.tx.us>, "Bill Schmitz" <wschmitzjr@stx.rr.com>, "Bob Leben" <leben@colorado.edu>, "Alan Clarke" <clarke@ocean.fsu.edu>

Chris,

1. First off, the statement "The occurrence of a Northern Gulf land-falling hurricane during the target year would be a bonus attribute." may be true for you out west, but not so much for us folks who might be in the path.

2 Regarding: "we hope that Navy can participate with Global-NCOM from CNMOC (Steve Payne) & NAVO (Frank Bub),..."

I'm going to assume that currents are your main interest (we have been concentrating on T-S for sound speed in support of Navy ASW efforts). The 1/8 degree Global NCOM model is operational and 3-day forecasts are available daily via:
http://edac.northerngulfinstitute.org/opendap_index.html

Region 1 covers the GOMEX and Caribbean. We currently do not plan to add more forecast time to this model.

Weekly, we run a 1/32 degree global NLOM to 30-days and we or NRL could provide you with products. Vertical resolution is 6 layers plus a MLD. NLOM is good for surface elevation but not so much for currents. Beyond FNMOC's forcing data, wind reverts to climatology.

NRL is in the final stages of evaluation prior to turning the 1/12 degree global HYCOM over to NAVO by this fall, with possible forecasts to 5-days depending on computer assets. We will run an OPTEST and should be ready to serve its products by early 2010.

In addition, we are planning to implement a high-resolution American Mediterranean NCOM early 2010. While it is unlikely we will be able to do

the whole Gulf of Mexico and Caribbean at 3km or 1/36 degree, we will try.

We expect that data from these model versions will be made available to the public (although volume will be an issue, both for storage and delivery).

3. Regarding, "We would like Navy and NOAA to provide GOM analyses in Phases I and II. They would also be welcome to participate in the multi-week R&D forecast experiments of Phase I and the prototype multi-week operational forecasts of Phase II. As planned with the GCOOS proposal last year, we hope that NAVO, NCEP, and CSDL can participate at no-cost. From the no-cost partners, I will need letters of commitment, preferably by FRI/20 MAR."

As noted above, the data are available and will continue to be, barring any national crisis.

How NAVO might participate in evaluations is undetermined. We are not an R&D outfit and can only address Navy operational needs. We would be very interested in the proper evaluation of our model products and have on-going efforts that assess them both automatically and via special studies (although not too often in GOMEX). A large commitment of effort to the specific work in your proposal is highly unlikely.

While I expect any NAVO participation will be "no-cost," I am unable to commit (or even write you a letter to that effect). I will send a proposal for endorsement up my chain of command although getting a letter to you by next Friday is unlikely. With the apparent demise of MAST, I (FLB) have no "official" way of dealing with external resources so CNMOC (via Steve Payne) will have to make any Navy commitments.

4. So anyway, NAVO modeling is interested, especially in the context of assessing our models' skills, but I (FLB) can't make any specific commitments of our time or assets other than way is currently being served to the public.

Frank Bub

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
Frank L. Bub, PhD
Ocean Modeling Technical Lead (NP1M)
Naval Oceanographic Office
228-688-4758 / frank.bub@navy.mil
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

-----Original Message-----
From: Christopher Mooers [mailto:cmooers@rsmas.miami.edu]
Sent: Monday, March 09, 2009 19:40
To: Leo Oey; Yi Chao; Ruoying He; Sergei Frolov; Steven DiMarco; Steven Anderson; Matt Howard; Payne, Steven W CIV CNMOC; Bub, Frank L CIV N62306; Jacobs, Gregg; Dong-Shan Ko; Hendrik Tolman; Frank Aikman; Richard Patchen; Lugo Fernandez, Alexis; Turner, Chris; Worth D. Nowlin, Jr.; Buzz Martin; Bill Schmitz; Bob Leben; Alan Clarke
Cc: Cort Cooper; Dave Driver
Subject: Gulf 3-D Operational Model Pilot Project

Dear Colleagues - Attached is a prospectus for a proposal to RPSEA (as described therein) for the subject pilot project. --- My Co-PIs and I invite you to join us in this effort in one or more capacities as described in the attachment. --- If possible by COB TUE (tomorrow), it would be much appreciated if you could read the prospectus and apprise me of whether you would like to participate. Comments and questions would be welcome. Thanks for your consideration. - Sincerely, Chris

--
Professor Christopher N. K. Mooers, Director Ocean Prediction Experimental Laboratory (OPEL) Division of Applied Marine Physics (AMP) Rosenstiel School of Marine and Atmospheric Science (RSMAS) University of Miami (Univ. Miami) 4600 Rickenbacker Causeway (Cswy.) Miami, FL 33149-1098 USA

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http://efsis.rsmas.miami.edu
http://epws-nfs.rsmas.miami.edu

Re: Gulf 3-D Operational Model Pilot Project.eml	**Content-Type:** message/rfc822 **Content-Encoding:** 7bit

Subject: [Fwd: Re: Gulf 3-D Operational Model Pilot Project]
From: Christopher Mooers <cmooers@rsmas.miami.edu>
Date: Fri, 17 Apr 2009 15:54:29 -0400
To: Nicole Braman <bramann@pdx.edu>

Nicole - Place this at the very back of Appendix II. - Chris

--
Professor Christopher N. K. Mooers, Director
Ocean Prediction Experimental Laboratory (OPEL)
Division of Applied Marine Physics (AMP)
Rosenstiel School of Marine and Atmospheric Science (RSMAS)
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http://epws-nfs.rsmas.miami.edu

Subject: Re: Gulf 3-D Operational Model Pilot Project
From: Hendrik Tolman <Hendrik.Tolman@noaa.gov>
Date: Tue, 10 Mar 2009 16:29:44 -0400
To: Christopher Mooers <cmooers@rsmas.miami.edu>
CC: Leo Oey <lyo@princeton.edu>, Yi Chao <Yi.Chao@jpl.nasa.gov>, Ruoying He <rhe@ncsu.edu>, Sergei Frolov <sfrolov@accufore.com>, Steven DiMarco <sdimarco@tamu.edu>, Steven Anderson <Steve@horizonmarine.com>, Matt Howard <mkhoward@tamu.edu>, Steve Payne <steven.w.payne@navy.mil>, Frank Bub <Frank.Bub@navy.mil>, "Jacobs, Gregg" <Gregg.Jacobs@nrlssc.navy.mil>, Dong-Shan Ko <ko@nrlssc.navy.mil>, Frank Aikman <Frank.Aikman@noaa.gov>, Richard Patchen <Rich.Patchen@noaa.gov>, "Lugo Fernandez, Alexis" <Alexis.LugoFernandez@mms.gov>, "Turner, Chris" <Arden.C.Turner@uscg.mil>, "Worth D. Nowlin, Jr." <wnowlin@tamu.edu>, Buzz Martin <buzz.martin@glo.state.tx.us>, Bill Schmitz <wschmitzjr@stx.rr.com>, Bob Leben <leben@colorado.edu>, Alan Clarke <clarke@ocean.fsu.edu>, Cort Cooper <cortcooper@chevron.com>, Dave Driver <driverdb@bp.com>, Stephen Lord <Stephen.Lord@noaa.gov>, Bill Lapenta <Bill.Lapenta@noaa.gov>, Avichal Mehra <Avichal.Mehra@noaa.gov>, Carlos Lozano <Carlos.Lozano@noaa.gov>

Chris, Cort,

Some thoughts about your write up.

1) As with Frank Bub, our operational products are available online daily, so we could collaborate in that sense without doing a thing. Without funding, it can only be that; we do not have the luxury to produce anything specially for you with our present funding level and resources. There may be one exception. If there are any data available that we do not get operationally, we would be very interested in assessing its impact in our operational system. If such data are proprietary, we will make sure they remain so. We would be willing to assess impact of such data on our system at our cost. Tentatively, we would do a "data denial" experiment by running a parallel model version with these additional data.

2) Because previously I agreed to being on the TAC, I will do so again. However, you will need to cover my travel costs and per diem; there is no way I can do that out of hide. The write up you provided is not clear on this.

Cheers,

Hendrik

Christopher Mooers wrote:
> Dear Colleagues - Attached is a prospectus for a proposal to RPSEA (as described therein) for the subject pilot project. --- My Co-PIs and I invite you to join us in this effort in one or more capacities as described in the attachment. --- If possible by COB TUE (tomorrow), it would be much appreciated if you could read the prospectus and apprise me of whether you would like to participate. Comments and questions would be welcome. Thanks for your consideration. - Sincerely, Chris

--
+--------------------------------------+
| Hendrik L. Tolman |
Chief |--
| Marine Modeling and Analysis Branch +----------------------------+
| NOAA-NCEP-EMC   Phone : (301)763-8133x7253 |
| 5200 Auth Road Room 209   FAX   : (301)763-8545 |
| Camp Springs, MD 20746, USA   Hendrik.Tolman@NOAA.gov |
+--+

Re: Gulf 3-D Operational Model Pilot Project.eml	**Content-Type:** message/rfc822 **Content-Encoding:** 7bit