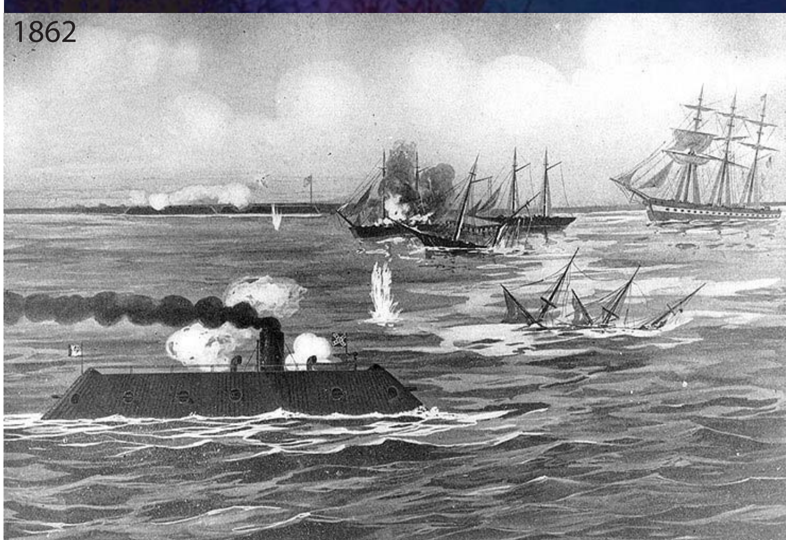
2nd International Workshop on Modeling the Ocean (IWMO)

Proceedings

May 24-26, 2010
Norfolk, Virginia, USA



Edited by: Tal Ezer (Old Dominion University) and Huijie Xue (University of Maine)

Meeting hosted by: Center for Coastal Physical Oceanography (CCPO),
Department of Ocean, Earth & Atmospheric Sciences (OEAS),
Virginia Modeling, Analysis & Simulation Center (VMASC)

CCPO/OEAS

OLD DOMINION UNIVERSITY

VMASC

2nd International Workshop on Modeling the Ocean (IWMO-2010)
May 24-26, Norfolk, Virginia, USA

Program and Abstracts

Edited by:
Tal Ezer (Old Dominion University)
and
Huijie Xue (University of Maine)

Support and Help Provided by:

Center for Coastal Physical Oceanography (CCPO)
(http://www.ccpo.odu.edu/)
Department of Ocean, Earth and Atmospheric Sciences (OEAS)
(http://sci.odu.edu/oceanography/)
Virginia Modeling, Analysis and Simulation Center (VMASC)
(http://www.vmasc.odu.edu/)
Virginia Applied Technology and Professional Development Center (VATPDC)
(http://www.vatpdc.com/pdc/)

Old Dominion University
(http://www.odu.edu/)

IWMO page: http://www.ccpo.odu.edu/~tezer/IWMO_2010/

International Workshop on Modeling the Ocean, ECSB 1202, **PROGRAM:**

Monday, 24-May, 2010

8:00 - 9:00 Registration

9:00 - 9:30 Welcome: C. Simpson, Provost, ODU;
R. Zimmerman, Chair, OEAS;
J. Klinck, Director, CCPO;
J. Sokolowski, Director, VMASC

9:30 - 9:40 Welcome and logistics: Tal Ezer

Session 1 (wave/mixing/sediment) Chair: L.-Y. Oey

9:40 - 10:00 **George Mellor,** *Wave Radiation Stress*

10:00 – 10:20 **Hitoshi Tamura**, L.-Y. Oey, and Y. Miyazawa, *Coupled wave-current interaction*

10:20 – 10:40 Coffee Break

10:40 – 11:00 **Li-Feng Lu**, Yasumasa Miyazawa, Hitoshi Tamura, and Kazuo Nadaoka, *An application of POM to wave-current interaction study around the Yaeyama Islands, Japan*

11:00 – 11:20 **Hendra Achiari**, Mauludin DY Sutanto, Ahmad Safii, and Jun Sasaki *Application of hydrodynamic-sediment model for wave and cohesive sediment in Ciasem Estuarine Indonesia*

11:20 – 11:40 **Robin Robertson**, *Vertical tidal mixing in ROMS: A reality check*

11:40 – 12:00 **Xiao Hua Wang**, Fangli Qiao, Jing Lu, and Fang Gong, *The Turbidity Maxima of the Northern Jiangsu Shoal-Water in the Yellow Sea, China*

12:00 – 13:30 Lunch (catering at the ECSB)

Session 2 (Outstanding Young Scientist Award presentations), Chair: Huijie Xue

*Please fill in the evaluation forms and hand them to Tal Ezer at the end of the session

1:30 – 1:50 (1) **Yu-Lin Eda Chang** and Lie-Yauw Oey, *Why can wind delay the shedding of Loop Current eddies?*

1:50 – 2:10 (2) **Ayumi Fujisaki** and Lie-Yauw Oey, *Formation of ice bands by wind*

2:10 – 2:30 (3) **Nickitas Georgas,** *NYHOPS v3: A new, high-fidelity, general, robust, automated, operational forecast model applied to the NY/NJ Harbor Estuary and its surroundings.*

2:30 – 2:50 (4) **Donghui Jiang**, Xiao Hua Wang, and Les J. Hamilton, *On the upwelling events along the Coast of Jervis Bay, New South Wales, Australia*

2:50 – 3:10 (5) **Mahmoud Kamel**, *The effect of an offshore wind turbine array on circulation in an idealized Virginia coastal ocean*

3:10 – 3:30: Coffee Break

3:30 – 3:50 (6) **Suriyan Saramul** and Tal Ezer, *Tidal-driven dynamics and mixing processes in a coastal ocean model with wetting and drying*

3:50 – 4:10 (7) **Yongjin Xiao,** Marjoerie Friedrichs, Katja Fennel, Kimberly Hyde, John O'Reilly, *A model study of phytoplankton phenology on the northeast U.S. continental shelf*

4:10 – 4:30 (8) **Fanghua Xu** and Lie-Yauw Oey, *The origin of along-shelf pressure gradient in the Middle Atlantic Bight*

4:30 – 4:50 (9) **Xunqiang Yin,** Fangli Qiao, Yongzeng Yang, and Changshui Xia, *Ensemble adjustment Kalman filter study for Argo data*

5:30 – 7:00 Reception at the **Center for Coastal Physical Oceanography (CCPO)**, Research Building #1, 3rd Floor, 4111 Monarch Way & 41st St.

Tuesday, 25-May, 2010

Session 3 (model development/testing)
Chair: Tal Ezer

8:30 – 8:50 **Helge Avlesen** and J. Berntsen, *Non-hydrostatic simulation of small scale eddies behind tidal inlet headlands*

8:50 – 9:10 B. K. Galton-Fenzi, **Michael Dinniman**, J. Hunter, *The pressure gradient force at the front of ice shelves in sigma-coordinate ocean models*

9:10 – 11:30 **Liang Kuang** and Alan F. Blumberg, *Assessing the vertical solution algorithm in ECOM/POM*

9:30 – 9:50 **Ayumi Fujisaki** and L.-Y. Oey, The MPI-PROFS

9:50 – 10:10 **Ricardo Da Silva**, A. Torres Jr, and L. Landau, *Princeton Ocean Model and PSU/NCAR mesoscale model: Computational coupling strategy and application to southwest Atlantic basin*

10:10 – 10:30 Coffee Break

Session 4 (data analysis/assim./diagnosis)
Chair: C.-R. Wu

10:30 – 10:50 Antoni Jordi and **Dong-Ping Wang,** *Application of the ensemble Kalman filter for satellite altimetry data assimilation in the Mediterranean Sea*

10:50 – 11:10 **Hidenori Aiki** and Kelvin J. Richards, *Maintenance of the mean kinetic energy in the global ocean by the barotropic and baroclinic energy routes*

11:10 – 11:30 **Yasumasa Miyazawa**, Xinyu Guo, RuoChao Zhang, Sergey M. Varlamov, Tomowo Watanabe, Takashi Setou, Daisuke Ambe, *Roles of the in-situ observations in the detection of the Kuroshio frontal variability south of Japan*

11:30 – 11:50 **Hua Liu** and Tal Ezer, *Integrating inundation models, Landsat satellite imagery, and GIS to assess tidal movements in Cook Inlet, Alaska*

12:00 – 1:30 Lunch (catering at the ECSB)

Session 5 (process studies/modeling)
Chair: Xiao Hua Wang

1:30 – 1:50 **Vlado Malačič** and B. Petelin, *Circulation in widely open bays in northern Adriatic*

1:50 – 2:10 **Tal Ezer** and Lie-Yauw Oey, *Numerical simulations reveal the role of the Alaskan Stream in modulating the Bering Sea climate*

2:10 – 2:30 **Dong-Ping Wang,** *Surface frontogenesis and thermohaline intrusion in a shelfbreak front*

2:30 – 2:50 **Guillaume Martinat**, Ying Xu, Chester E Grosch, and Andres Tejada Martinez, *LES of turbulent shear flow and pressure driven flow on shallow continental shelves*

2:50 – 3:10 **Y.-L. Eda Chang** and L.-Y Oey**,** *Loop Current Cycle: coupled response of Loop Current with deep flows*

3:10 – 3:30 Coffee Break

Session 6 (regional modeling)
Chair: Y. Miyazawa

3:30 – 3:50 **Jingping Gan**, *Modeling China Sea Circulation*

3:50 – 4:10 **Changshui Xia**, Fangli Qiao, Fredolin Tangang, Liew Juneng, *Simulation of the circulation in the Malaysian Peninsula East Continental Shelf*

4:10 – 4:30 **Chau-Ron Wu**, Lie-Yauw Oey and Tzu-Ling Chiang, *Modulation of the South China Sea Circulation through the Kuroshio*

4:30 – 4:50 **Chao Ma**, Jiayan Yang, Dexing Wu, *On the mechanism of seasonal variation of the Tsushima Warm Current*

6:30 – 8:30 Dinner at the "**Pagoda**", 265 W. Tazewell St., Downtown Norfolk. (Transportation will be provided from the SpringHill Hotel, 6:00pm).

Wednesday, 26-May, 2010

Session 7 (bio-physical/nested models/forecast systems)
Chair: Dong-Ping Wang

8:30 – 8:50 **Huijie Xue**, Stephen Cousins, Lewis Incze, Richard Whale, and Andrew Thomas, *A coupled bio-physical model study of connectivity of lobster populations in the Gulf of Maine*

8:50 – 9:10 **Wen Long**, Jerry W. Wiggert, Jiangtao Xu, Lyon Lanerolle, Bala K. P. Prasad, Raghu Murtugudde, Christopher Brown, Raleigh Hood, *The development of a Chesapeake Bay physical-biogeochemical modeling system (ChesROMS) for hindcast, nowcast and forecast: Achievements, challenges and outlooks*

9:10 – 9:30 **Guan-Yu Chen,** Rei-Chun Wu, Jia-Jang Hung, Yuh-ling Lee Chen, Yu-Hwui Wang, *Internal solitary wave and the nutrient transport in Dongsha Atoll*

9:30 – 9:50 **Tommy Jensen**, Paul Martin, Clarke Rowley, Tim Campbell, Richard Allard, Travis Smith and Justin Small, *Recent Developments in the Navy Coastal Ocean Model and its Application as the Ocean Component in Regional Coupled Forecast Models*

9:50 – 10:10 **Sergey M. Varlamov**, Yasumasa Miyazawa, and Xinyu Guo, *Regional nested tide-resolving real-time modeling system for Pacific coastal waters southeast off Japan (JCOPE-T)*

10:10 – 10:30 Coffee Break

10:30 – 10:50 **Guansuo Wang**, Fangli Qiao, Changshui Xia, and Yongzeng Yang, *Operational marine environment forecast system in the seas off China*

10:50 – 11:10 F.H. Xu, Y.-L. Chang, Z.-B. Sun, **L.-Y. Oey**, J. Blanco, T. Ezer, L. Atkinson and D.-P. Wang, *A hindcast model of the Mid-Atlantic ocean region*

11:10 – 11:30 **Y.-L. Chang** and L.-Y. Oey,*The BP oil spill of 2010*

12:00 – 1:30 Lunch (catering at the ECSB)

1:30 – 3:00 Open Discussion:

1. Location of IWMO-2011
2. Publication of special issue
3. Other topics

IWMO-2010 Abstracts
(Outstanding Young Scientist Award presentations)

Why can wind delay the shedding of Loop Current eddies?

Yu-Lin Eda **Chang** and L.-Y. Oey

Princeton University, 300 Forrestal Rd., Sayre Hall, Princeton, NJ, 08544

We first show that wind in the Gulf of Mexico can delay the shedding of Loop current eddies. We analyze a time-dependent three-dimensional numerical experiment forced by a spatially and temporally constant westward wind stress within the Gulf, compare it with an otherwise identical no-wind run, and confirm the result with reduced-gravity experiments. We show that the wind produces westward transports over the northern and southern shelves of the Gulf, convergence in the west and a returned (i.e. eastward) upper-layer flow over the deep central basin towards the Loop Current. We then use Pichevin and Nof's (1997) and Nof's (2005) theory to explain that the returned flow constitutes a zonal momentum flux that delays eddy-shedding. Mass-balance analysis shows that wind also forces larger Loop Current and rings (because the delayed shedding allows more mass to be accumulated in them) and produces more efficient mass exchange between the Gulf and the Caribbean Sea. Finally, it is shown that eddies alone (without wind stress curl) can force a boundary current and downward flow in the western Gulf, and a corresponding deep flow from western to eastern Gulf.

Formation of ice bands by wind

Ayumi **Fujisaki** and L.-Y. Oey

Atmospheric and Oceanic Science Program, Sayre Hall, Princeton University, Princeton, NJ, USA 08544.

Ice bands have striped distributions, typically observed at the ice edge. Various generation mechanisms are: wave radiation pressure (Wadhams, 2000), ice-ocean coupling (Hakkinen, 1986), Muench et al. (1983), and lee waves (uncoupled; Sjoberg and Mork, 1985). Here, the lee-wave mechanism is revisited in a coupled ice-ocean system, analytically as well as using high-resolution (250m horizontal and 1m vertical grids) numerical experiments.

NYHOPS v3: A new, high-fidelity, general, robust, automated, operational forecast model applied to the NY/NJ Harbor Estuary and its surroundings

Nickitas **Georgas**

Davidson Laboratory, Center for Maritime Systems, Stevens Institute of Technology, 711 Hudson Street, Hoboken, NJ 07030

A new high-resolution OFS (Operational Forecast System) for the NY/NJ Harbor estuary, NJ coast, Long Island Sound, and their coastal ocean is presented. The new hydrodynamic model (NYHOPS v3) includes updated physics (waves and wave-boundary-layer friction, wetting and drying, 2D atmospheric heat fluxes), and inputs (hydrology, meteorology, and the steric effect). The extensively validated NYHOPS v3 OFS has been operational since June 2009, with 100% reliability, i.e. providing automated forecasts and nowcasts without service interruption, a significant improvement from prior system versions.

On the upwelling events along the coast of Jervis Bay, New South Wales, Australia

Donghui **Jiang**[1], Xiao Hua Wang[1], and Les J. Hamilton[2]

1. School of Physical, Environmental and Mathematical Sciences, Australian Defence Force Academy, University of New South Wales, Canberra, Australia

2. Aeronautical and Maritime Research Laboratory, Defence Science and Technology Organisation (DSTO), PO Box 44, Pyrmont, NSW 2009, Australia

Upwelling events to the coast of Jervis Bay, NSW were identified by deploying a thermistor chain into 70 meters water depth to the north entrance of the bay (S 35 4.47' E150 51.14') during the period from 24 Jan to 5 May, 2008. Six thermistors, equally spaced (10 meters) on the chain, were used to record the temperature time series at 10, 20, 30, 40, 50, 60 meters below the sea surface. Data were recovered on 5 May, 2008 and calibrated with their offsets which were determined by the lab test on the thermistors chain before the deployment. Comparison of the daily averaged temperature to that forecasted by Bluelink indicates similar temperature patterns and major features between them. Based on the comparison of the events to the velocity field (Bluelink forecast) and wind field

(predicted by ECMWF), the driving forces of those upwelling events were identified as upwelling favorable northerly wind. Princeton Ocean Model (POM) was then applied to investigate the dynamical processes of those events. POM reproduced the above temperature patterns and major features. Then we explored the driving forces of those upwelling events via numerical experiments.

The effect of an offshore wind turbine array on circulation in an idealized Virginia coastal ocean

Mahmoud **Kamel** and J. Klinck

Center for Coastal Physical Oceanography (CCPO), Old Dominion University, Norfolk, VA 23508, USA

A popular renewable energy source is the offshore wind turbines. The oceanic impacts of offshore wind farms have not been studied thoroughly. In this study the Regional Ocean Modeling System (ROMS) has been used in order to analyze these impacts. Numerical experiments have been conducted to examine the effect of various wind farm sizes as well as various magnitudes of the wind stress reduction. The reference case is forced by a uniform alongshore wind stress of 0.1 N/m2 (upwelling favorable conditions) on a coast with a linear bottom slope and a straight coast line. The reduction in the wind stress over the wind farm area is ranging from 5 % to 35 %. Downwelling occurs on the onshore side of the farm while upwelling occurs on the offshore side. As the wind continues to blow northward, the influence of these areas of downwelling and upwelling move northeastward beyond 3 days. The change in the size of the wind farm has more impact on the alongshore volume transport more than the magnitude of the wind stress reduction.

Tidal-driven dynamics and mixing processes in a coastal ocean model with wetting and drying

Suriyan **Saramul** and Tal Ezer

CCPO, Old Dominion University, USA

A three-dimensional sigma coordinate numerical model with wetting and drying (WAD) and a Mellor-Yamada turbulence closure scheme has been used in an idealized island configuration to evaluate how tidally driven dynamics and mixing are affected by inundation processes. Comprehensive sensitivity experiments evaluate the influence of various factors, including tidal amplitudes (from 1- to 9-m range), model grid size (from 2 to 16 km), stratification, wind, rotation, and the impact of WAD on the mixing. The dynamics of the system involves tidally driven basin-scale waves (propagating anticlockwise in the northern hemisphere) and coastally trapped waves propagating around the island in an opposite direction. The evolutions of the surface mixed layer (SML) and the bottom boundary layer (BBL) under different forcing have been studied. With small amplitude tides, wind-driven mixing dominates and the thickness of the SML increases with time, while with large-amplitude tides, tidal mixing dominates and the thickness of the BBL increases with time. The inclusion of WAD in the simulations increases bottom stress and impacts the velocities, the coastal waves, and the mixing. However, the impact of WAD is complex and non-linear. For example, WAD reduces near-coast currents during flood but increases currents during ebb as water drains from the island back to the sea. The impacts of WAD, forcing, and model parameters on the dynamics are summarized by an analysis of the vorticity balance for the different sensitivity experiments.

A Model Study of Phytoplankton Phenology on the Northeast U.S. Continental Shelf

Yongjin **Xiao**, Marjorie Friedrichs, Katja Fennel, Kimberly Hyde, John O’Reilly

1. Virginia Institute of Marine Science, College of William and Mary, Gloucester Point VA, 23062-1346;

2. Department of Oceanography, Dalhousie University, 1355 Oxford Street, Halifax, Nova Scotia B3H 4J1, Canada;

3. NOAA, National Marine Fisheries Service, 28 Tarzwell Drive, Narragansett, RI 02886, USA

The last two decades have witnessed significant advances in high-resolution numerical models of the coastal ocean carbon cycle. Recent efforts have been directed toward simulating the current state of the coastal carbon cycle as well as predicting how it may be affected in the future by anthropogenic and naturally occurring climate change. One of the largest challenges is the shift of phytoplankton structure, which may result from climate variability and may lead to dramatic changes in bloom cycles. Here we begin to investigate these possibilities by improving the realism of the phytoplankton component of the Northeastern North American shelf model (NENA). NENA has been used to study both carbon and nitrogen cycling on the U. S. East Coast, but until now has included only a single primary producer. We rigorously examined the effects of including an additional phytoplankton functional group

on the timing and magnitude of phytoplankton blooms along the Mid-Atlantic Bight (MAB) continental shelf and within the Gulf of Maine (GoM). Model results were evaluated with Sea-viewing Wide Field-of-View Sensor (SeaWiFS) and Moderate Resolution Imaging Spectroradiometer (MODIS) satellite ocean color data, which revealed that bloom timing varies interannually. These data also indicate that typically the month of maximum chlorophyll varies across the MAB shelf, with peaks in January on the mid-shelf, November on the outer shelf and April in the slope waters. In the Gulf of MAINE (GoM) the month of maximum chlorophyll varies between April in the central GoM to October in the northern reaches of the GoM. The dynamics causing these differences in bloom timing are investigated with a one-dimensional version of the NENA model.

The origin of along-shelf pressure gradient in the Middle Atlantic Bight

Fanghua **Xu** and Lie-Yauw Oey

Atmospheric and Oceanic Sciences Program, Princeton University, 300 Forrestal Road, Sayre Hall, Princeton, NJ 08544, USA

Currents on the Middle Atlantic Bight (MAB) shelf are southwestward in winter, and weaker (and especially in the southern MAB, reversed) in summer and fall. Momentum balance considerations suggest that forcing for these seasonal fluctuations of shelf currents is the along-shelf pressure gradient (ASPG) whose origin, however, remains a subject for debate. Sixteen years (1993-2008) of satellite data from AVISO and data-assimilated model reanalysis, as well as shorter-period tide-gauge and current-meter data, are analyzed. It is shown that the ASPG is produced by westward Rossby waves and Gulf Stream (GS) warm-core rings that preferentially impinge upon the southern portion of the MAB shelf break. The eddy kinetic energy (EKE) north of the Gulf Stream is seasonal: larger in summer and smaller in winter. Mode-1 EOF of sea-surface height shows a high (low) pressure in summer (winter) in the southern MAB coincident with the large (small) EKE in summer (winter). The pressure contours are parallel to the shelf break and slope but bend as they 'leak' onto the shelf. On the shelf, this leads to negative or weak (positive) ASPG in summer (winter). The along-slope currents at the shelf edge correlate well with the pressure signal: strongly southwestward in winter-spring, and weak and sometimes even reversed in summer-fall. The shelf currents also follow the same seasonal variation, but they correlate well with ASPG. Finally, the inter-annual variations of EKE and westerly winds correlate well: years of large EKE and weak westerly winds coincide, and vice versa. We hypothesize that the GS strengthens in years of strong downfront wind, leading to less warm core rings and small EKE.

Ensemble adjustment Kalman filter study for Argo data

Xunqiang **Yin**, F. Qiao, Y. Yang, C. Xia

1. The First Institute of Oceanography, Qingdao, 266061, China; 2. Key Laboratory of Marine Science and Numerical Modeling, SOA, Qingdao, 266061, China

An ensemble adjustment Kalman filter system is developed to assimilate Argo profiles into the North-West Pacific MASNUM wave-circulation coupled model, which is based on the Princeton Ocean Model (POM). This model was recoded in FORTRAN-90 style, and some new data types were defined to improve the efficiency of system designing and execution. This system is arranged for parallel computing by using UNIX shell scripts; it is easier for single model running separately with the required information exchanged through input/output files. Some tests are carried out to check the performance of the system: one for checking the ensemble spread and the other one for the performance of assimilation of the Argo data in 2005. The first experiment shows that the assimilation system performs well. The comparison with the Satellite derived sea surface temperature (SST) shows that modeled SST errors are reduced after assimilation; at the same time, the spatial correlation between the simulated SST anomalies and the satellite data is improved because of Argo assimilation. Furthermore, the temporal evolution/trend of SST becomes much better than those results without data assimilation. The comparison against GTSPP profiles shows that the improvement is not only in the upper layers of ocean, but also in the deeper layers. All these results suggest that this system is potentially capable of reconstructing oceanic data sets which are of high quality, and temporally and spatially continuous.

Application of hydrodynamic-sediment model for wave and cohesive sediment in Ciasem Estuarine Indonesia

Hendra **Achiari**[1], Mauludin DY Sutanto[1], Ahmad Safii[1], Jun Sasaki[2]

1. Ocean Engineering, Bandung Institute of Technology, Indonesia

2. Department of Civil Engineering, Yokohama National University, Japan

3D hydrodynamic and sediment model becomes widely use for the simulations of current and sediment movement, especially for the analysis of coastal environment problems. Recently the applications of 3D models are increasing in term of number and many authors proposed various kinds of models, each model has each their limitation and their advantage for special cases and applications. This paper aims at the application of 3D Hydrodynamic-sediment model especially for cohesive sediment using real data input in Ciasem Estuarine case study. A hydrodynamic model developed by HydroQual Inc, that is ECOM (Estuarine and Coastal Ocean Model), and SED (known as ECOMSED) was applied for simulating the current feature and sediment condition on Ciasem Estuarine. In term of Wave we applied SWAN model for predicted the characteristic of wave distribution. Water elevation and current profile data were collected from previous study. The calibration of model was included a comparison between measured ADCP after convert to suspended sediment data based on Gartner (2002) and the result of ECOMSED for hydrodynamic model and wave hindcasting for wave model. The forcing of model are the tide data as boundary conditions and the discharge from Citarurm River. Long-term simulation was simulated to capture a feature of seasonal variation in the field. The results showed that the feature of current profile correspond to field data and a prediction of sedimentation which is dominated by cohesive sediment. The prediction of sediment deposition and bathymetric change after half year simulation was gave a clarification for the source of sediment accumulation at Blanakan River-mouth in Ciasem Estuarine.

Maintenance of the mean kinetic energy in the global ocean by the barotropic and baroclinic energy routes

Hidenori **Aiki**[1] and Kelvin J. Richards[2]

1. JAMSTEC, Japan

2. Univ. of Hawaii, USA

This study presents results of a first comprehensive analysis of the budget of the annual mean kinetic energy (KE) in a high-resolution global simulation. The analysis is based on the mean KE which is separated into that associated with the barotropic (i.e. depth-averaged) and baroclinic (i.e. the residual) components of velocity. The analysis is also based on identification of two separate energy routes, namely a route from wind forcing to the pressure gradient (PG) work that represents the role of the wind-induced Ekman velocity and a route from the PG work to dissipative processes that represents the role of the total-drag ageostrophic velocity (which is defined in the present study to refer to the sum of the bottom-friction Ekman velocity and its variants). Such approaches are adopted to compare the pressure effect (i.e. JEBAR) and the frictional effect of bottom topography.The model result shows that the relative importance of the barotropic and baroclinic dynamics in the global ocean is quantified by the ratio (about 1:3) of the barotropic wind work to the baroclinic wind work. It is found that the global work of the barotropic PG -- which is connected to the work of JEBAR and then to the budget of potential energy (PE) -- is nearly zero. Thus the barotropic KE in the global ocean is maintained by the role of the barotropic components of both wind-induced Ekman and total-drag ageostrophic velocities which are of the same strength. It is also found that the work of the wind forcing on the barotropic component of the simulated Antarctic Circumpolar Current is canceled by the combined effect, in equal measure, of the conversion to PE and the dissipative processes for mean KE. The latter is attributed to a large contribution from biharmonic horizontal friction. Future studies should pay more attention to the role of biharmonic friction used in high-resolution OGCMs.

Non-hydrostatic simulation of small scale eddies behind tidal inlet headlands

Helge **Avlesen**[1] and J. Berntsen[2]

1. Bergen Center for Computational Science, UNI Research, Bergen, Norway

2. Department of Mathematics, University of Bergen, Norway

Inlets in fjords or lochs are natural laboratories for studies of interactions between stratified flow and topography. Measurements, numerical investigations, and analysis have been used to address these interactions. At tidal inlets, there is a strong transfer of energy from the scales of the incoming barotropic tide towards the scales associated with irreversible mixing. The wide range of spatial and temporal scales involved makes numerical investigations of the flow and processes through narrow channels in fjords very challenging. Many numerical studies have accordingly been undertaken with barotropic depth averaged models. The use of such models facilitates a high horizontal resolution at the cost of sacrificing vertical resolution and effects of stratification. In order to investigate generation and propagation of internal waves near sills in fjords, two-dimensional vertical slice models are often used. By using this approach, high resolution studies of internal waves and even overturning rolls in the lee of sills have been performed. However, with vertical slice models horizontal eddies that are ubiquitous near narrow channels in tidally driven fjords, are neglected.

Using massively parallel computer systems, fully three-dimensional studies of the eddies behind a step in the lateral boundary in a tidally driven fjord are undertaken. The sensitivity of the flow separation behind the step and the properties of the eddies to the grid size is investigated.

Internal solitary wave and nutrient transport in Dongsha Atoll

Guan-Yu **Chen**, Rei-Chun Wu, Jia-Jang Hung, Yuh-ling Lee Chen, and Yu-Hwui Wang

National Sun Yat-Sen University, Taiwan

The nutrient brought up by the internal bore after the breaking of internal solitary wave is very important for the isolated ecosystem of Dongsha Atoll because there is no other as efficient sources of nutrient. With a small scale numerical model, the nutrient transportation moved from the subsurface water to the surface water is calculated. These nutrient information are substituted into a large scale tide model to simulate the lateral transportation. Both models are first verified by comparing with in-situ flow and temperature measurements. Finally, the simulated nutrient distribution is compared with the field data. The detailed comparison will be given in the workshop.

Princeton Ocean Model and PSU/NCAR mesoscale model: Computational coupling strategy and application to southwest Atlantic basin

Ricardo **Da Silva**, A. Torres Jr, and L. Landau

Centro de Tecnologia, Bloco I, Sala 214, Av. Athos da Silveira Ramos, 149 - Cidade Universitária, Rio de Janeiro – RJ 21941-909, Brazil

This study presents the methodology to develop a coupled modeling system between the atmosphere and the ocean. MM5 (Mesoscale Modelling System – 5th Generation) and Princeton Ocean Model (POM) have been used as the basic tools for the proposed methodology. Computational aspects of the coupled system are investigated for the Southwest Atlantic Bight (region near shore Vitória-Trindade chain extending to Itajaí on 27°S latitude).

The Pressure Gradient Force at the Front of Ice Shelves in Sigma-coordinate Ocean Models

B.K**. Galton-Fenzi**[1], Michael S. Dinniman[2] and J. Hunter[1,3]

1. Antarctic Climate and Ecosystems Cooperative Research Centre, Australia

2. Old Dominion University, U.S.A.

3. University of Tasmania, Australia

A fundamental difference between modelling ocean circulation beneath ice shelves and in other parts of the ocean lies in the surface pressure forcing. In terrain following models the ice shelf is applied to the model surface as a body force. This leads to a situation where the sigma coordinates are vertically dislocated over the transition from the open ocean to the cavity beneath an ice shelf. A number of different pressure gradient algorithms are evaluated by comparison of two terrain following ocean models, the Australian version of the Princeton Ocean Model (OzPOM) and the Regional Ocean Modeling System (ROMS). Results show that higher order schemes are able to cope with the steep ice front. Furthermore, pressure gradient force errors in simpler schemes can be amplified by strong seasonal forcing in the open ocean.

Numerical simulations reveal the role of the Alaskan Stream in modulating the Bering Sea climate

Tal **Ezer**[1] and Lie-Yauw Oey[2]

1. Old Dominion University, Center for Coastal Physical Oceanography, 4111 Monarch Way, Norfolk, VA 23508, USA

2. Princeton University, Program in Atmospheric and Oceanic Sciences, P.O.Box CN710, Sayre Hall, Princeton, NJ 08544-0710, USA

The role of the Alaskan Stream (AS) in modulating the Bering Sea (BS) climate is studied using sensitivity experiments with an ocean circulation model with realistic topography, but idealized forcing representing different AS transports. The results show non-linear relations between the BS climate and the AS transport. For example, a warming of the BS shelf occurred when the AS transport increased from 10 to 25 Sv, but a slight cooling occurred when the AS transport further increased from 25 to 40 Sv. These results are caused by changes in the balance of transports and heat fluxes through the different passages of the Aleutian Islands connecting the North Pacific and the BS, with important implications for climate variations in the Bering Sea and the Arctic Ocean. The simulated flow patterns through the Aleutian passages seem more complex than previously described by observations; in particular, more observations in deep passages like Kamchatka Strait are needed to verify if the model simulations are correct or not.

The MPI-PROFS

Ayumi **Fujisaki** and L.-Y. Oey

Atmospheric and Oceanic Sciences Program, Princeton University, Princeton, NJ 08544, USA.

A parallelized version of the Princeton Regional Ocean Forecast System (http://www.aos.princeton.edu/WWWPUBLIC/PROFS/) based on the sbPOM (http://www.imedea.uib-csic.es/users/toni/sbpom/) is developed. The new code (MPI-PROFS) is configured at high resolution for simulating the Gulf Stream and Middle Atlantic Bight shelf circulation. The new model is forced by realistic winds, assimilates satellite data, and includes tides as well as daily river discharges, from 1993-2008. Results are checked against those obtained from the original code, as well as against observations.

Modeling China Sea Circulation

Jianping **Gan**

Hong Kong University of Science and Technology, Hong Kong, China

East China Sea (ECS) and South China Sea (SCS), linked together by Taiwan Strait to form China Sea (CS), are shelf sea and semi-enclosed marginal sea separated from the Pacific ocean basin by shelf break and by Luzon Strait, respectively. Besides deep basins in the SCS, CS has broad shelves which generally cover a sea area between continental margin with water depth of about 200 m and the land shore. The circulation in the CS is mainly driven by the south-east Asia monsoonal winds and largely modulated by its exchanges with the western Pacific Ocean through the variation of western boundary current, Kuroshio. The circulation is governed by the topographically-guided geostrophic currents flowing along the continental margins. Intrinsic dynamics that arise mainly from the local flow-topography interaction shape and characterize the distinct temporal and spatial natures of the CS circulation. A three-dimensional high resolution (~ 10 km) CS circulation model has been developed to investigate the processes and dynamics for characteristic variations of the circulation in CS. Forced with climatologically averaged monthly and high frequency, inter-annual atmospheric fluxes and lateral fluxes from larger scale models, we validated model results with the satellite remote sensing data in long-term seasonal mean and inter-annual time domains, respectively. In this talk, we present our recent findings of the circulation variability in these two time domains. In particular, time-dependent three-dimensional variability and associated dynamics regarding to Kuroshio intensity, width and exchanges with SCS in Luzon Strait and with coastal waters in ECS will be studied.

Recent developments in the Navy Coastal Ocean Model and its application as the ocean component in regional coupled forecast models

Tommy **Jensen**, Paul Martin, Clarke Rowley, Tim Campbell, Richard Allard, Travis Smith and Justin Small.

Oceanography Division, Naval Research Laboratory, Stennis Space Center, MS 39529, USA

The most recent version of the Navy Coastal Ocean Model (NCOM) has an optional general vertical coordinate (GVC) grid that combines a free sigma grid near the surface with a combination of fixed sigma and z-level subsurface grids. Partial cells in the z-level grid allow a match to the true bathymetry. NCOM has been further developed to include surface forcing with wave radiation stress gradients, enhancement of bottom drag coefficients by wave bottom current, and inclusion of Stokes (3D) drift current. NCOM is the key component in the relocatable ocean forecast and data assimilation system (RELO) used for operational forecast support for Navy. It is also the ocean component of the fully Coupled Ocean-Atmosphere Mesoscale Prediction System (COAMPS) that combines a prognostic atmosphere model, an ocean model, a surface wave model with data assimilation. Examples from applications of RELO and COAMPS ranging from the open ocean (Kuroshio Extension) region to coastal areas (Adriatic Sea) will be presented.

Application of the Ensemble Kalman Filter for satellite altimetry data assimilation in the Mediterranean Sea

Antoni **Jordi**[1] and Dong-Ping Wang[2]

1.IMEDEA (UIB-CSIC), Institut Mediterrani d'Estudis Avançats, Miquel Marquès 21, 07190 Esporles, Spain.

2.School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook, NY 11794, USA.

The Stony Brook Parallel Ocean Model (sbPOM) is coupled with an Ensemble Kalman Filter (EnKF) method to study the controllability of a high resolution simulation of the Mediterranean Sea through the assimilation of altimetry. A realistic 12-year run in the Mediterranean Sea based on the Parallel Ocean Program (POP) and forced with a perpetual annual atmospheric forcing is taken to be the 'truth'. Observations of sea level height (SSH) are generated from the last month of the POP simulation on the same grid points where satellite altimetry data is provided. The initial ensemble is constructed from the POP model states at different years. All experiments use the same lateral boundary conditions as in the POP run, although external forcing fields are randomly perturbed. Two methodologies are used to project the SSH information into the deep ocean: (1) correlations between SSH and subsurface temperature and salinity, and (2) the dominant empirical orthogonal functions (EOF) of the subsurface currents which approximates the first baroclinic mode. Results of both methodologies are compared to a free run (without data assimilation) and to the truth to quantify the skill of each. The EOF methodology provides better estimates than the correlations.

Assessing the vertical solution algorithm in ECOM/POM

Liang **Kuang** and Alan F. Blumberg

Davidson Lab, Stevens Institute of Technology, Hoboken, NJ, USA

Vertical mixing processes are of great importance in the marine environment, especially estuaries and coastal areas. The stability and precision of a vertical mixing algorithm in a numerical model can play an important role in modeling various oceanic processes. There is no time step limitation in ECOM/POM's vertical mixing algorithm due to the fact that the vertical mixing equation is discretized using an implicit method (the so called Thomas algorithm). By designing several numerical experiments and analyzing the accuracy of their results, we find that indeed there is no stability issue for ECOM/POM. However, there is an accuracy problem that we have found. We have solved the heat equation using a constant vertical mixing coefficient in ECOM with two different initial conditions, where one as a step function change in the initial temperature profile and the other is linear temperature profile from surface to bottom. Experiments with surface heating are also examined. By comparing the numerical solutions with analytic solutions, we find that the steady stability criterion, $\Delta t < \frac{(\Delta z)^2}{2K_H}$, where K_H is vertical eddy coefficient for explicit systems to be a good surrogate for an accuracy criterion. From the designed experiments and detailed analysis, ECOM/POM is coded and structured well to simulate the real vertical mixing processes as long as its accuracy criterion is not violated.

Modeling the seasonal variations of sea ice cover in the Prydz Bay, Antarctic

Qun **Li**[1], Huiding Wu[1,2], and Lu Zhang[1,3]

1. Polar Research Institute of China, Shanghai, 200136, China

2. National Marine Environment Forecast Center, Beijing, 100081, China

3. The second institute of oceanography, SOA, Hangzhou, 310012, China

Prydz Bay is almost partially covered by sea ice all year. The distribution of sea ice and its annual variation are controlled mainly by the meteorological conditions and ocean currents. To model the seasonal variation of sea ice, a coupled ice-ocean model has been developed. The ocean model based on the MITgcm, which is formulated in height coordinates with 50 vertical levels. The ice model is based on the viscous-plastic rheology of Hibler and Winton three-layer reformulated thermodynamics, an ice-shelf model in accordance with the ISOMIP protocol is also thermodynamically coupled. The model domain encompasses Prydz Bay and with a grid resolution of 1/6Ã—1/12 degree (latitude/longitude, average 6km). Forcing fields are computed from 6-hourly NCEP reanalysis. The model is integrated from 1995 to 2005. The main features of the model simulations include an increasing ice cover from March to August, an approximately constant ice cover from August to November and a decreasing ice cover from November to February. In mid-September, polynyas start to develop at three coastal regions (Cape Darnley, Mackenzie Bay, and Prydz Bay), temporal and spatial characteristics of the three polynyas are well reproduced and compare with available satellite data. Thick ice up to 3 m is piled up at the east end of the West Ice Shelf due to westward along coast current. The modeled ice distribution (concentration/ thickness) is compared with satellite data and good agreement is obtained.

Integrating inundation models, Landsat satellite imagery, and GIS to assess tidal movements in Cook Inlet, Alaska

Hua **Liu**[1] and Tal Ezer[2]

1. Department of Political Science and Geography, Old Dominion University, Norfolk, VA 23529, USA

2. Center for Coastal Physical Oceanography, Old Dominion University, Norfolk, VA 23508, USA

The study demonstrates a creative approach to assess and map tidal movements and associated changing water coverage over extensive mudflats, based on the integration of inundation models, remote sensing imagery, and geographic information systems (GIS) technologies. Cook Inlet, Alaska, with its approximate 10 m tidal range is chosen as the study area. The movement of the shorelines of Cook Inlet is detected from a series of Landsat satellite imagery with acquisition dates corresponding to different tidal stages. Traditional supervised classification method is then used to classify each pixel in the images into one of two categories: water and land. Then, individual shorelines from those raster water images are derived and matched with water level predictions along those shorelines. The water level is obtained from data at one tide gauge station that are extrapolated to the rest of the upper inlet using statistic analysis based on an inundation numerical model. The analytical water level predictions are then integrated with the remotely sensed water images and visualized using GIS technologies. The resulting data will allow the mapping of the topography of flood zones, and improve inundation models that are used to simulate catastrophic floods such as those associated with hurricane storm surges and tsunamis.

The development of a Chesapeake Bay physical-biogeochemical modeling system (ChesROMS) for hindcast, nowcast and forecast: Achievements, challenges and outlooks

Wen **Long** (UMCES), Jerry W. Wiggert (USM), Jiangtao Xu (NOAA), Lyon Lanerolle (NOAA), Bala K. P. Prasad (UMD), Raghu Murtugudde (UMD), Christopher Brown (NOAA), Raleigh Hood (UMCES), USA

The presentation will introduce the development of an open source Chesapeake Bay physical-biogeochemical modeling system (ChesROMS) based on the Rutgers University Regional Ocean Modeling System (ROMS). Details will be presented on simulation of hydrodynamic circulations in the Chesapeake Bay including hindcasts from 1991 to 2005 and nowcasts and short-range forecasts from 2007 to 2009. An N-P-Z-D type of ecological model in ROMS is further developed for simulating lower trophic level foodweb and nutrient cycles in the Chesapeake Bay. Achievements obtained in hindcasting year 1999 forecasting year 2009 biogeochemical properties in the Bay will be shown. Lessons learned and challenges confronted in the development will be discussed. We intend to conclude the presentation with outlooks for future development and applications of this model.

An application of POM to wave-current interaction study around the Yaeyama Islands, Japan

Li-Feng **Lu**[1], Yasumasa Miyazawa[1], Hitoshi Tamura[1], and Kazuo Nadaoka[2]

1. Japan Agency for Marine-Earth Science and Technology, Yokohama, Japan

2. Department of Mechanical and Environmental Informatics, Tokyo Institute of Technology, Tokyo, Japan

The Yaeyama Islands are located in the southwestern part of Japan. The currents in this region are governed by multiple forcing factors, including Kuroshio, meso-scale eddies, tides, and wind waves. To better understand the physical processes concerning these forces, the new version of POM, which includes wave-current interaction effects, has been used to simulate the surface currents and temperature around the Yaeyama Islands. To let the model applicable to our case, the following modifications have been made to the source codes: (1) the Doppler velocity is replaced by the surface current velocity; (2) the averaged wave number over all directions is used instead of the peak wave number when calculating the wave radiation stress. The modeled results show that by including wave-current interaction effects (1) the surface currents are intensified near the coast; (2) the surface temperature around the Yaeyama Islands decreases, especially in the coastal region; (3) comparisons between modeled results and field observations show that more realistic surface temperature is obtained near the coast.

On the mechanism of seasonal variation of the Tsushima Warm Current

Chao **Ma**[1,2], Jiayan Yang[2], Dexing Wu[1]

1. Physical Oceanography Laboratory, Ocean University of China, Qingdao 266100, China

2. Department of Physical Oceanography, Woods Hole Oceanographic Institution, Woods Hole, MA 02543, USA

There is seasonal variability for the Tsushima Warm Current, and the mechanisms were elucidated by a 3-D full forcing baroclinic model. The results show that both local and remote forcings play important role in the seasonal variation. The local forcing is by the wind stress affecting the pressure difference across the Tsushima Strait, and the remote forcing is by the Kuroshio Current induced Kelvin waves propagating to the strait. The two forcings are roughly in phase, hereinto, the remote forcing is dominant, the local forcing is important but secondary, and the ratio of the former to the latter is about 2 to 1.

Circulation in widely open bays in northern Adriatic

Vlado **Malačič** and B. Petelin

National Institute of Biology, Marine Biology Station Piran, Slovenia

The circulation inside two small bays at the closed end of the Adriatic Sea, the Bay of Piran and the Bay of Koper, is explored numerically using the Princeton Ocean Model. The bays are small (dimensions □ 5-7 km) and shallow (10 m depth) and are wide open. The open-boundary line is of the order of a length of a bay, while the length of their closed side is much narrower. The exchange of their water masses with the Gulf of Trieste is yet unknown. Numerical models of the circulation of bays (horizontal resolution of 37 m) are one-way nested in the model of the Gulf of Trieste (the 'Gulf', horizontal resolution of 150 m), while ours is nested in the circulation forecast model for the northern Adriatic (NAPOM, horizontal resolution of 600 m).

Inside the Gulf and in its surroundings, clockwise gyres dominate during the spring-summer period in the surface layer, while there is mostly an inflow at depth, which is topographically controlled (Malačič and Petelin, 2009). The typical dimension of the gyres (internal Rossby deformation radius) reaches 3 km during spring-summer and is smaller during autumn-winter. However, the circulation in wide open bays that neighbor the Gulf depends upon this characteristic of the 'general' circulation in the Gulf, as well as on tidal forcing and, finally, on their topography, in particular on the curvature radius of promontories that confine the bays (Valle-Levinson and Moraga-Opazo, 2006). Inertial circulation depends on the curvature of promontories and on the curved coastline of the bays. This may cause bipolar (residual) circulation in a bay when only tides are forcing the motion under calm weather conditions, as in summer. The hypothesis that is explored numerically is that there is the existence of this bipolar circulation and compensating currents below the surface layer that oppose surface currents (estuarine-like circulation). The upwelling and downwelling regions were also explored numerically during windy episodes (sirocco and bora winds). It is also expected that the Bay of Koper has a different circulation pattern since it is also wider than the Bay of Piran.

Malačič and Petelin 2009. JGR 114(C07002):1-15. V.-Levinson and M.-Opazo 2006. CSR. 26:179-193.

LES of turbulent shear flow and pressure driven flow on shallow continental shelves

Guillaume **Martinat**[1], Ying Xu[1], Chester E Grosch[1], and Andres Tejada Martinez[2]

1. Old Dominion University, Center for Coastal and Physical Oceanography, 4111 Monarch Way Norfolk VA 23508, USA

2. University of South Florida, Department of Civil and Environmental Engineering, 4202 E. Fowler Ave., ENB 118, Tampa, FL 33620, USA

Turbulent shear flows on shallow continental shelves (here shallow means that the interaction with the solid, no-slip bottom is important) are of great importance because tides and wind driven flows on the shelf are drivers of the transfer of momentum, heat, and mass (gas) across the air-sea interface. These turbulent flows play important transport role because vertical mixing and current are vectors for the transport of sediment and bioactive material on continental shelves (Gargett, Wells, Tejada-Martinez and Grosch, 2004). Understanding the dynamics of this class of flows presents complications because of the presence of a free surface and also because the flow can be driven by a pressure gradient (a tidal current), a stress at the free surface (a wind driven current) or a combination of both. In addition those flow can be modified by the presence of a wave field that can induce Langmuir circulation. Large Eddy Simulation is used to quantify the effects of pressure gradient and wind shear on the distinctive structures of the turbulent flow. From those computations an understanding of the physics governing pressure driven and wind driven flows, how they can interact in a normal or a tangential direction and the effect of wave forcing on those flows is obtained.

Wave Radiation Stress

George **Mellor**

Princeton University, USA

There are differences in the literature concerning the vertically dependent equations that couple currents and waves. In this paper, I purposely omit currents and address only the process of phase averaging the wave relations leading to the determination of the vertically dependent "wave radiation stress". In the absence of currents, one obtains the null result that horizontal gradients of the stresses are zero. Nevertheless, there are lessons to be learned by isolating the wave radiation stress terms. Included is an explanation of Stokes drift with apparent vorticity obtained from an otherwise irrotational flow and the determination of vertically dependent radiation stress which, when vertically integrated, conforms to that obtained by Longuet-Higgins and Stewart (1962, 1964) and Phillips (1977) nearly fifty years ago and, more recently, by Smith (2006).

Discussion begins with the simple case of flow beneath a stationary wavy wall.

Roles of the in-situ observations in the detection of the Kuroshio frontal variability south of Japan

Yasumasa **Miyazawa**[1], Xinyu Guo[1,2], RuoChao Zhang[1], Sergey M. Varlamov[1], Tomowo Watanabe[3], Takashi Setou[3], Daisuke Ambe[3]

1. Research Institute for Global Change, JAMSTEC, Kanazawa-ku, Yokohama, Kanagawa 236-0001, Japan.

2. Center for Marine Environmental Studies, Ehime University, Matsuyama, Ehime, 790-8577, Japan

3. National Research Institute for Fisheries Science, Fisheries Research Agency, Kanazawa-ku, Yokohama, Kanagawa 236-8648, Japan

We have investigated the sensitivity of including in-situ observations on the quality of the ocean reanalysis produced by a data assimilative eddy-resolving ocean model, with an emphasis on the Kuroshio frontal variability south of Japan. By increasing the number of the in-situ hydrographic profiles for the data assimilation, more enhanced Kuroshio front variations with approximately 20 days time scale were reproduced. The enhanced features exhibited the wavelike disturbances east of the Kii Peninsula with the wave length of 400 km and considerably affected coastal areas through the consequent warm water intrusion, which were consistent with the observed phenomena. Another kind of the warm water intrusion with the period of approximately 50 days associated with the Kuroshio small meander paths was well reproduced by the reanalysis. The addition of the in-situ profiles into the reanalysis did not change the intensity of these intrusions but did change their spatial patterns. The assimilation of operational in-situ observations in coastal regions south of Japan is effective to capture the Kuroshio frontal variability. In the past 10 more years, the operational in-situ observation using the ARGO floats has been significantly developed to monitor the large-scale oceanic variations in the open ocean. The profiling floats are not much suitable for monitoring the western boundary currents owing to their drifts by the strong currents. The present study suggests the complementary role of the in-situ observations in the nearshore region and the open ocean for the global ocean monitoring network.

Eddy and wind-forced heat transports in the Gulf of Mexico

Y.-L. Chang and Lie-Yauw **Oey**

Program in Atmospheric & Oceanic Sciences, Princeton University, Princeton, NJ, USA

The Gulf of Mexico receives heat from the Caribbean Sea via the Yucatan-Loop Current system, and the corresponding ocean heat content (OHC; and the associated moisture) is important to weather and climate of the continental United States. Yet the mechanism(s) that affect this heat influx and how it is distributed in the Gulf have not been studied. Using the Princeton Ocean Model, we show that a steady, uniform westward wind in the Gulf increases (~100 KJ cm-2) the upper OHC (temperature T > 18oC) of the Gulf. This is because wind increases the water exchange between the Gulf and the Caribbean Sea, and the heat input into the Gulf is also increased, by about 50 TW. The westward heat transport to the western Gulf is ~30 TW, and a substantial portion of this is due to wind-induced shelf currents, which converge to produce downwelling near the western coast. Finally, eddies are effective transporters of heat across the central Gulf. Wind forces larger Loop Current and rings with deeper isotherms. This and downfront-wind mixing on the southern side of anticyclonic rings, northward spread of near-zero potential vorticity waters, and downwelling on the northern shelf break, result in wide and deep eddies that transport large OHCs across the Gulf.

Vertical tidal mixing in ROMS: A reality check

Robin **Robertson**

University of New South Wales at the Australian Defence Force Academy, Canberra, ACT 2600, (02) 6268 8289, Australia

Recently, there has been a great interest in vertical mixing in the ocean and including tidal mixing in the larger scale ocean circulation and climate models without simulating the tides themselves. Mixing estimates from observations are few and far between and the capability to accurately reproduce mixing in the models, even if just the vertical tidal mixing, would be a huge step in addressing mixing in the ocean. But vertical mixing estimates from models depend on the vertical mixing parameterization used and many vertical mixing parameterizations exist. The goal of this study was to identify the best performing vertical mixing parameterizations for the Regional Ocean Model

System (ROMS) when considering the simulation of internal tides and tidal mixing.

Terrain-following ocean models have been used to simulate internal tides and provide estimates of the tidal velocities for circulation and mixing studies. These models have successfully reproduced elevations with most of the remaining inaccuracies attributed to topographic errors. They have also reproduced the tidal peaks in velocities and the transfer of energy from the tidal frequencies to other frequencies, including the high frequencies. The spectral slope was found to be dependent on the vertical mixing parameterization. For this study, the combined tides for four constituents, M2, S2, K1, and O1, were modeled over Fieberling Guyot. Ten vertical mixing parameterizations were evaluated using four criteria, comparing model estimates of velocities and diffusivities against observations. The vertical mixing parameterization was found to have minor effects on the velocity fields, with most effects occurring over the crown of guyot and in the lower water column; however, it had dramatic effects on the estimation of vertical diffusivity of temperature. Several parameterizations were eliminated based on comparison of the vertical diffusitivy estimates with observations. The best performers were Mellor-Yamada, and the generic version of the generic length scale scheme with the new coefficients.

Coupled wave-current interaction

Hitoshi **Tamura**[1]; L. Oey[2]; Y. Miyazawa[1]

1. JAMSTEC, Yokohama, Kanagawa, Japan.

2. Princeton University, Princeton, NJ, USA

Ocean waves have important impacts on air-sea fluxes. Explicit evaluation of wave effects is crucial especially for high resolution regional models because exchanges of various air-sea fluxes are controlled by the highly variable wave field. Models that include a wave component have been used in practical applications; e.g. in hurricane simulations in which air-sea interaction should preferably be explicitly included [e.g., Bao et al. 2000, MWR ; Moon et al. 2008, MWR]. Recently, Mellor [2003, JPO; 2008, JPO] and Mellor et al. [2008, JPO] have developed a wave-current coupled model which incorporates wave effects on the three-dimensional current field (e.g. the radiation stress and wave shear stress terms) and on the turbulence field due to wave breaking. Whereas numerous studies have pointed out the importance of waves on atmospheric boundary layer, few have investigated the impact on the oceanic surface layer. The purpose of this study is to investigate the coupling of the sea surface wave field with currents at an oceanic front using the Mellor\'s model. High-resolution numerical experiments were conducted in a two-dimensional (x-z) domain with both downfront and upfront wind forcing.

Regional nested tide-resolving real-time modeling system for Pacific coastal waters southeast off Japan (JCOPE-T)

Sergey M. **Varlamov**, Yasumasa Miyazawa, and Xinyu Guo

ODPRT, CVPARP, Research Institute for Global Change, JAMSTEC, Japan

In frame of the JCOPE project, the nested 1/36 degree regional tide-resolving ocean model was developed for more detailed temporary and spacial resolution of ocean variability in coastal waters SE off Japan.

Model explicitly simulates tidal processes that are specified by boundary conditions and as tidal gravitational force for major tidal constituents (up to 16 main short-term tidal harmonics). Boundary conditions utilize both tidal volume fluxes at model boundaries and sea level tidal information there (both available around Japan from the JNAO tidal model, 1/12 degree resolution) and are Flather-type boundary conditions.

As result, tidal sea level variability is well reproduced in Japan coastal waters except that some overestimation of tidal amplitude is found in the semi-enclosed Seto Inland Sea. Barotropic tidal motion over the sloping topography generates strong internal tidal waves that are important feature of nested regional model. Predictability of internal tides seems to be possible close to the generation zones over the continental slopes, when off-shore only statistical features of such variations could be resolved due to the complex dependence of wave propagation features from the oceanic conditions.

Close to the tidal frequencies are found inertial oscillations that potentially could be predicted locally following significant disturbances of oceanic circulation caused by passage of strong atmospheric disturbances fronts, typhoons etc. To achieve this goal, model's meteorological forcing is provided by best of available meteorological weather prediction models: JMA non-hydrostatic MSM system (spatial data resolution ~10 km, hourly forecasts up to 33 h updated every 3 h) followed by JMA GSM (0.2x0.25 degree) and/or by NCEP GFS data (~0.3125 degree resolution short-term forecasts followed by ~0.625 degree resolution medium range forecasts).

Model is nested to the real-time North-West Pacific JCOPE system and uses same incremental assimilation analysis as this model. Assimilation cycle for the regional nested model is performed once per week with rolling back and assimilating for about month of satellite SST, SSH anomalies and JFRA in-city profiles data. All other week days model runs in forecast mode providing daily updated analyses and forecasts up to two weeks.

Modeling results in experimental mode are provided to researchers and potential users through the interactive WEB site at http://www.jamstec.go.jp/frcgc/jcope/vwp/ (registration is required).

Surface frontogenesis and thermohaline intrusion in a shelfbreak front

Dong-Ping **Wang**

School of Marine & Atmospehric Sciences, Stony Brook University, USA

Surface frontogenesis and thermohaline intrusion are examined in a submesoscale eddy-resolving O(1 km), primitive-equation model simulation of an idealized summer shelfbreak front of the Middle Atlantic Bight (U.S.A). The model is a free run with no external/restoring force. At the equilibrium, large meandering frontal waves are developed, characterized by a larger Rossby number, strong vortical asymmetry, and a k-3 eddy kinetic/potential energy spectrum (k is the horizontal wavenumber), in good agreement with the semi-geostrophic theory. A coherent surface jet is maintained that conversion from the mean to eddy available potential energy due to baroclinic instability is balanced by transfer from the eddy to mean kinetic energy. Vigorous thermohaline intrusions are induced at the front. The warm salty slope water is subducted in the wave trough while the cold fresh shelf water is upwelled in the wave crest. The profile and frequency of salty intrusions over the shelf compare well with the observed subsurface salinity maximum. The net onshore salt flux also is comparable to the estimated salt balance.

Operational marine environment forecast system in the seas off China

Guansuo **Wang**, Fangli Qiao, Changshui Xia, and Yongzeng Yang

The First Institute of Oceanography (FIO), State Oceanic administration (SOA), China

A forecast system of Western Pacific is constructed based on the paralleled wave-circulation coupled model, which is tested with comprehensive experiments during 2009 for the operational use of the ROSE project. The main feature of the system is that the wave-induced mixing is considered in the circulation model. The system is at 1/2 degreed resolution for the global ocean, with nested models up to 1/24 degree resolution in the Western Pacific. Daily analyses and 3-day forecasts of 3-D temperature, salinity, currents and wave height are produced. The remote-sensing data of sea surface temperature were taken to relax to an analyzed product as restarting fields of forecasting system by Nudging-based data assimilation techniques. The forecast production shows well agreement with observations. The productions of the operational system will be widely used in the field of disaster reduction, navigation and marine environment protection.

The turbidity maxima of the northern Jiangsu Shoal-water in the Yellow Sea, China

Xiao Hua **Wang**[1], Fangli Qiao[2], Jing Lu[2] and Fang Gong[3]

1. School of Physical, Environmental and Mathematical Sciences, University of New South Wales at Australian Defence Force Academy, Canberra, ACT 2600, Australia

2. First Institute of Oceanography, State Oceanic Administration Qingdao, China

3. State Key Laboratory of Satellite Ocean Environment Dynamic, Second Institute of Oceanography, State Oceanic Administration, Hangzhou, China

The Yellow Sea general circulation model coupled to a sediment transport model with and without surface gravity wave simulated by a third generation wave model was implemented to study sediment distribution and resuspension in the northern Jiangsu shoal-water (NJSW) in March and April 2006-2008. With the surface wave, the general features of model simulated turbidity maxima off the Jiangsu coast agreed well with the

MODIS remote sensing data. The study found that the joint effects of wave and current in the bottom boundary layer (BBL) increased the bottom stress over NJSW, resulting in strong sediment resuspension there. Without wave effect, the turbidity maxima moved offshore with much reduced suspended sediment concentration (SSC) by a factor of 4, and decreased sediment flux by a factor of 3. This demonstrated that surface waves played a dominant role over the tides to form the turbidity maxima along the muddy coast of NJSW. The study also found that NJSW region exported sediments to the Yellow Sea and East China Sea through offshore and southern boundaries. The coastal sediment flux south of the Yangtze River (Changjiang) mouth was at least an order of magnitude larger than offshore flux. We showed that southward transport of sediments along the Jiangsu coast as previously reported by other authors only occurred in the winter months when the southward coastal current was dominant. As March and April 2008 was a wind anomalous year when wind speed was decreased by 15% and 9% from its peak value over last three years, the wind generated waves in the region was also reduced in 2008, leading to a weaker sediment resuspension and lower SSC in March and April in that year. As the green tide in the 2008 Olympics Sailing Regatta venue, Qingdao, China, was caused by the drift and proliferation of the macroalgae (Enteromorpha) from NJSW, we speculated that a lower turbidity in March and April of 2008 might have contributed to the excessive growth of Enteromorpha in NJSW.

Modulation of the South China Sea circulation through the Kuroshio

Chau-Ron **Wu**[1], Lie-Yauw Oey[2], and Tzu-Ling Chiang[1]

1. Department of Earth Sciences, National Taiwan Normal University, Taipei, Taiwan

2. Program in Atmospheric and Oceanic Sciences, Princeton University, Princeton, USA

The South China Sea (SCS) circulation is largely influenced by the East Asian monsoon winds. Beyond the seasonal time scale, circulation of the SCS demonstrates an interannual variation related to El Niño/Southern Oscillation (ENSO). We examine ENSO modulation of the SCS circulation and hydrography, using three-dimensional numerical ocean models. The models include a fine-scale regional model, the East Asian Marginal Seas model (EAMS), and a North Pacific Ocean model (NPO). The model results are consistent with previous observations. The heat advection by the basin circulation anomaly plays an essential role in modulating the SST variation, especially in the central SCS basin. The modeled temperature variation below the mixed layer is synchronized with the SST change.

The Kuroshio occasionally makes a loop within the Luzon Strait, which would intermittently modulate the circulation in the northern SCS basin. Whether or not the Kuroshio intrudes into the Luzon Strait depends mainly on the strength of the Kuroshio transport in the upstream region. The modeled Kuroshio varies with the transport of the North Equatorial Current (NEC) and the location of its bifurcation point. A seasonal maximum in Kuroshio transport usually occurs during summertime when the bifurcation point of the NEC is southernmost. Furthermore, the NEC transport and its bifurcated latitude exhibit interannual variability related to ENSO. The NEC intensifies (relieves) and tends to shift northward (southward) during an El Niño (La Niña) event.

Simulation of the circulation in the Malaysian Peninsula East Continental Shelf

Changshui **Xia**[1], Fangli Qiao[1], Fredolin Tangang[2], and Liew Juneng[2]

1. Key Lab. Marine Science & Numerical Modeling, the First Institute of Oceanography, China

2. Research Centre for Tropical Climate Change System (IKLIM), the Malaysian National University, Malaysia

A Wave-tide-circulation coupled model based on POM is established to study the seasonal variation of the circulation in the Malaysian Peninsula East Continental Shelf (MPSCE) region. The model domain is (99E~116E, 3S~15N), the horizontal resolution is 6Km*6Km. The simulated tide temperature and flow generally agree with the observations. The model result shows that the upper layer flow field is controlled by the north-east monsoon in winter and south-west monsoon in summer. In winter, the temperature in the Malaysian Peninsula East Shelf is nearly vertical uniform due to the surface cooling. In summer the upper mixed layer depth can reach 40-50m with thermocline and bottom mixed layer below the upper mixed layer. Sensitive study shows that wave-induced mixing has significant effect on the formation of the upper mixed layer in summer. Tide induced mixing is important to the bottom mixed layer and the front. Short wave penetration also contributes to the formation of the upper mixed layer. The model successfully reconstructs the seasonal variation of the circulation in the Malaysian Peninsula East Shelf and it can be upgraded to the marine environment forecast system in this region.

A hindcast model of the Mid-Atlantic ocean region

Fanghua **Xu**[1], Y.-L. Chang[1], Z.-B. Sun[1], L.-Y. Oey[1], J. Blanco[2], T. Ezer[2], L. Atkinson[2] and D.-P. Wang[3]

1. Atmospheric and Oceanic Sciences Program, Princeton University, Princeton, NJ, USA

2. Center for Coastal Physical Oceanography, Old Dominion University, Norfolk, NJ, USA

3. School of Marine and Atmospheric Sciences, Stony Brook University, USA

We present here a comprehensive, multi-year model simulation of the Mid-Atlantic shelf, the Slope Sea and Gulf Stream region off the U.S eastern coast north of Cape Hatteras. The model is based on the Princeton Ocean Model. It has a nested domain that includes the northern portion of the South Atlantic Bight to the south and the Gulf of Maine to the north, with Dx~dy~5 km and 26 vertical sigma levels. The nested domain is embedded inside a larger-scale parent-grid domain of half the horizontal resolution ~10 km but the same 26 sigma levels. Model integration is from 1993 through 2008 and includes daily discharges from 17 major rivers and estuaries along the U.S. and Canadian (the St. Lawrence River) eastern coast. The model is forced by six-hourly CCMP3 winds and also by tides. The model's surface temperature is relaxed to monthly climatological SST with a time scale of 30 days. The global-ocean analysis product from SODA is used to provide open boundary conditions for the coarser-resolution parent grid. To specify the Gulf Stream and eddies, satellite sea-surface-height anomaly (SSHA) is assimilated into the model for regions with water depths greater than 500 m. Comparison with observations shows that the model reproduces seasonal as well as subtidal variability fairly well, including the simulation of the cold pool and southwestward shelf and slope currents.

A Coupled Bio-physical Model Study of Connectivity of Lobster Populations in the Gulf of Maine

Huijie **Xue**[1], Stephen Cousins[1], Lewis Incze[2], Richard Whale[1], and Andrew Thomas[1]

1. School of Marine Sciences, University of Maine, Orono, ME 04469-5706, USA

2. University of Southern Maine, Portland, ME, USA

A coupled biophysical individual based model has been developed to investigate lobster (Homarus americanus) larval transport and connectivity patterns in the Gulf of Maine and Georges Bank stock assessment areas. The biophysical model was embedded in the realtime simulations of the physical environment from the Gulf of Maine Nowcast/Forecast System. In addition to circulation and dispersion, the model considers patterns of egg production, temperature-dependent larval growth, stage-explicit vertical distributions of larvae, and mortality. Distribution and abundance patterns of competent postlarvae in the model agree well with the observed, along-shore patterns of lobster settlement density. Connectivity matrix is defined to quantify the source-sink relationship among various subregions in the Gulf of Maine. The relationship varies greatly with the vertical distribution of larvae partly because the larval growth is highly sensitive to temperature, which results in shorter connections in warmer waters of the western Gulf of Maine and everywhere as seasonal warming progresses. Sensitivities to the interannual variability, boundary condition, and model resolution are also examined.

List of Participants

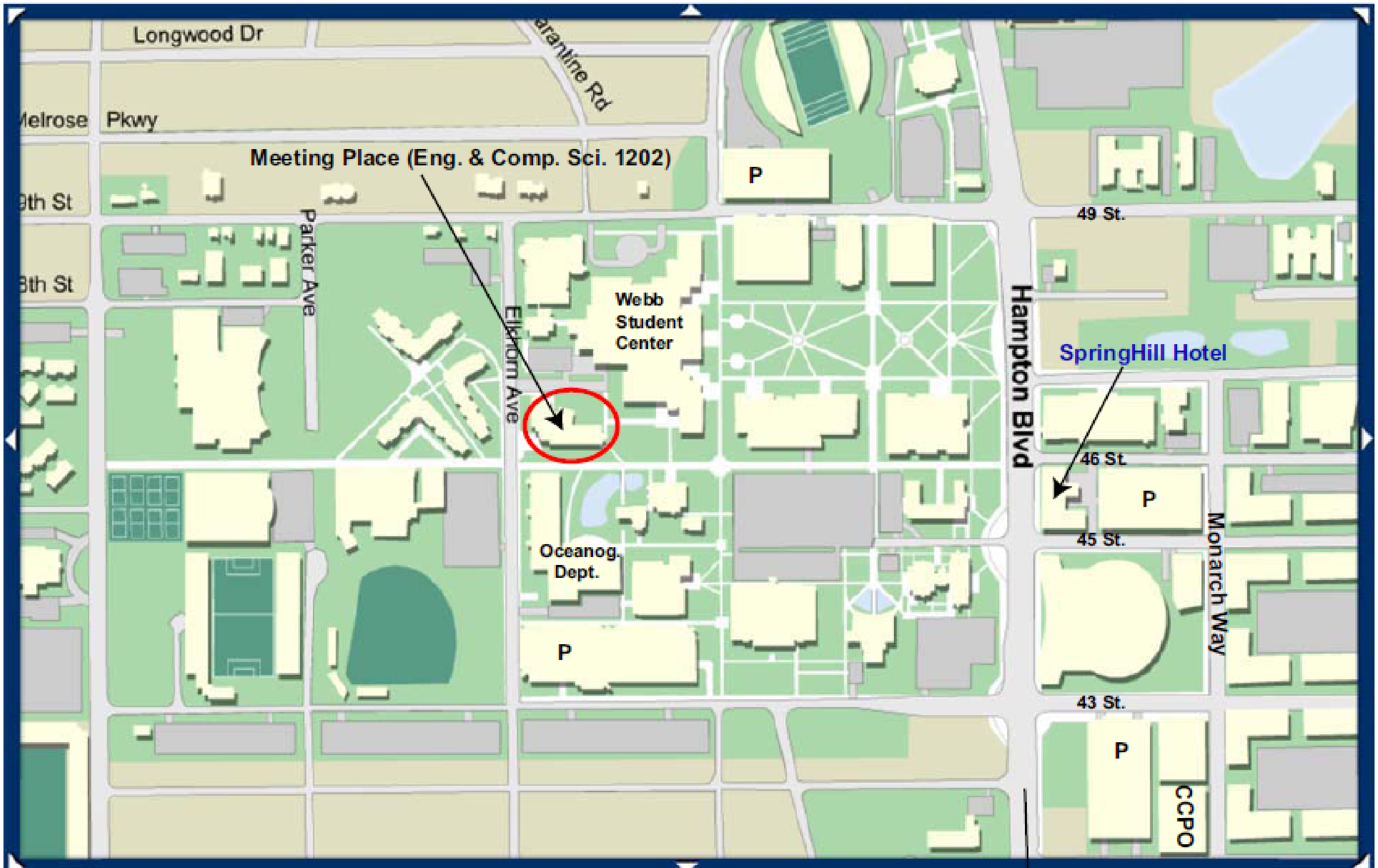
LAST	FIRST	EMAIL	INSTITUTION	COUNTRY
Abouali	Mohammad	mabouali@sciences.sdsu.edu	San Diego State University	USA
Achiari	Hendra	ha_itb@yahoo.com	Bandung Institute of Technology	Indonesia
Aiki	Hidenori	aiki@jamstec.go.jp	JAMSTEC	Japan
Avlesen	Helge	helge.avlesen@uni.no	University Research	Norway
Blanco	Jose	jblancog@odu.edu	CCPO/Old Dominion University	USA
Chang	Yu-Lin Eda	ychang@princeton.edu	National Taiwan Normal University	Taiwan
Chen	Guan-Yu	guanyu@faculty.nsysu.edu.tw	National Sun Yat-Sen University	Taiwan
Da Silva	Ricardo	rmsilva@lamce.coppe.ufrj.br	Federal University of Rio de Janeiro	Brazil
Dinniman	Michael	msd@ccpo.odu.edu	CCPO/Old Dominion University	USA
Ezer	Tal	tezer@odu.edu	CCPO/Old Dominion University	USA
Friedrichs	Marjorie	marjy@vims.edu	Virginia Institute of Marine Science	USA
Fujisaki	Ayumi	fayumi@princeton.edu	AOS/Princeton University	USA
Gan	Jianping	magan@ust.hk	HK Univ. Science and Tech.	Hong-Kong, China
Georgas	Nickitas	ngeorgas@stevens.edu	Stevens Institute of Technology	USA
Gomez-Valdes	Jose	jgomez@cicese.mx	CICESE	Mexico
Green	David	david.green@noaa.gov	NOAA	USA
Grosch	Chester	enright@ccpo.odu.edu	CCPO/Old Dominion University	USA
Hamilton	Peter	phamilton@saic.com	SAIC	USA
Hsin	Yi-Chia	ychsin@ntnu.edu.tw	National Taiwan Normal University	Taiwan
Jensen	Tommy	Tommy.Jensen@nrlssc.navy.mil	NRL, Stennis Space Center	USA
Jiang	Donghui	pomsediment@yahoo.ca	ADFA/Univ. New South Wales	Australia
Jung	Yun	ycjung@hhu.ac.kr	Korea Maritime University	Korea

LAST	FIRST	EMAIL	INSTITUTION	COUNTRY
Kamel	Mahmoud	mkamel@ccpo.odu.edu	CCPO/Old Dominion University	USA
Kuang	Liang	lkuang@stevens.edu	Stevens Institute of Technology	USA
Linlin	Liang	lianglin@ust.hk	HK Univ. Science and Tech., Hong-Kong,	China
Liu	Hua	hxliu@odu.edu	Old Dominion University	USA
Long	Wen	wenlong@hpl.umces.edu	University of Maryland	USA
Lu	HungFu	zyfix.lu@gmail.com	Princeton University	USA
Lu	Lifeng	lifeng_lu@jamstec.go.jp	JAMSTEC	Japan
Ma	Chao	machao@ouc.edu.cn	Ocean University of China	China
Malacic	Vlado	malacic@mbss.org	National Institute of Biology	Slovenia
Guillaume	Martinat	martinat@ccpo.odu.edu	CCPO/Old Dominion University	USA
Mdalla	Mohamed	mdalla@lycos.com	INSTM	Tunisia
Mellor	George	glmellor@princeton.edu	Princeton University	USA
Miyazawa	Yasumasa	miyazawa@jamstec.go.jp	JAMSTEC	Japan
Petelin	Boris	petelin@mbss.org	National Institute of Biology	Slovenia
Qiao	Fangli	qiaofl@fio.org.cn	First Institute of Oceanography	China
Oey	Lie-Yauw	lyo@princeton.edu	AOS/Princeton University	USA
Robertson	Robin	R.robertson@adfa.edu.au	UNSW/ADFA	Australia
Saramul	Suriyan	ssara002@odu.edu	CCPO/Old Dominion University	USA
Smith	Elizabeth	lizsmith@odu.edu	CCPO/Old Dominion University	USA
Tamura	Hitoshi	htamura@jamstec.go.jp	JAMSTEC	Japan
Varlamov	Sergey	vsm@jamstec.go.jp	JAMSTEC	Japan

LAST	FIRST	EMAIL	INSTITUTION	COUNTRY
Wang	Dong-Ping	dong-ping.wang@stonybrook.edu	Stony Brook University	USA
Wang	Guansuo	wanggs@fio.org.cn	First Institute of Oceanography	China
Wang	Xiao Hua	hua.wang@adfa.edu.au	UNSW/ADFA	Australia
Warrior	Hary	warrior@naval.iitkgp.ernet.in		India
Wu	Chau-Ron	cwu@ntnu.edu.tw	National Taiwan Normal University	Taiwan
Xia	Changshui	xiacs@fio.org.cn	First Institute of Oceanography	China
Xiao	Yongjin	yxiao@vims.edu	Virginia Institute of Marine Sciences	USA
Xu	Fanghua	fxu@princeton.edu	AOS/Princeton University	USA
Xue	Huijie	hxue@maine.edu	University of Maine	USA
Yin	Xunqiang	yinxq@fio.org.cn	The first institute of oceanography	China

MAPS

Old Dominion University Campus and IWMO Places



P- parking garages (use visitor metered spaces only)

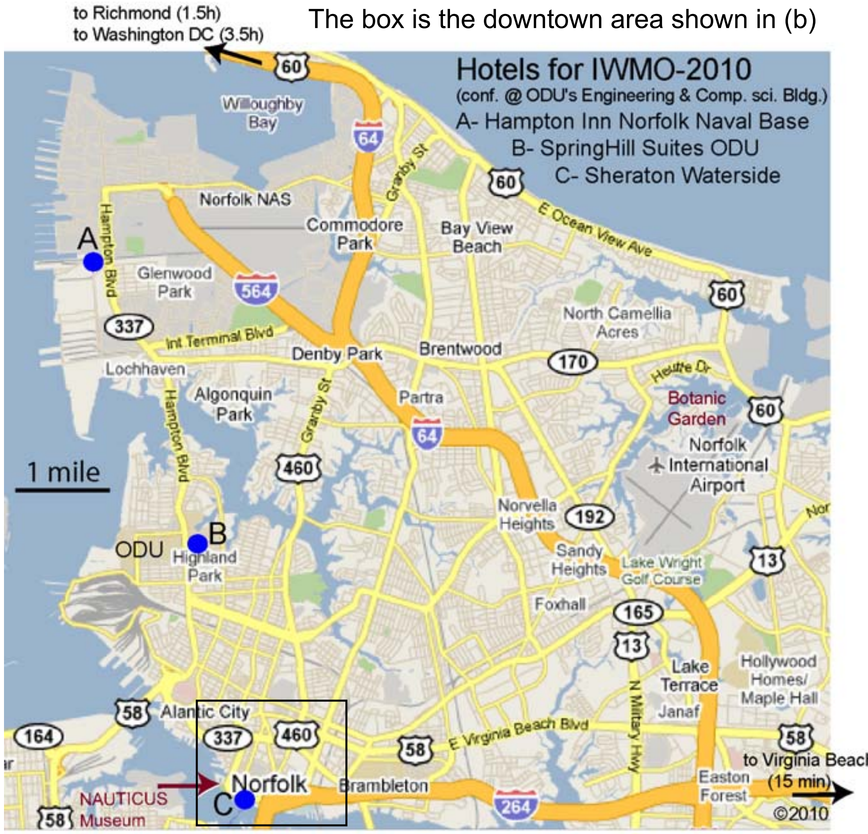
to downtown Norfolk

Restaurants: 1. Campus: Webb Center or Monarch Way (cafe, Japanese, Mexican)
2. Ghent area (drive 1.5mile south then left) on 21st-Colley Ave (many)
3. Downtown (3.5mile south) on Granby-Main St (many)

N

Warning: do not walk east of Monarch Way at night (safety)

(a)


to Richmond (1.5h)
to Washington DC (3.5h)
The box is the downtown area shown in (b)
Hotels for IWMO-2010
(conf. @ ODU's Engineering & Comp. sci. Bldg.)
A- Hampton Inn Norfolk Naval Base
B- SpringHill Suites ODU
C- Sheraton Waterside
1 mile
ODU
NAUTICUS Museum
Norfolk
to Virginia Beach (15 min)
©2010

(b)


Downtown Norfolk
A Attucks Theatre
B Chrysler Hall
C Chrysler Museum of Art
D Civic Center (City Hall, Courts, Public Safety Building)
E Harbor Park
F Harrison Opera House
G Hunter House Victorian
H Kirn Memorial Library
I MacArthur Center
J MacArthur Memorial
K Moses Myers House
L Nauticus Battleship Wisconsin Hampton Roads Naval Museum Half Moone Cruise and Celebration Center
M Pagoda and Oriental Garden
N Scope
O Selden Arcade
P Tidewater Community College
Q Town Point Park
R Waterside Festival Marketplace
S Waterside Convention Center
T Wells Theatre
U The Willoughby-Baylor House
V Future site of Wachovia Center
Norfolk Electric Transit (NET) Route • Free Downtown Shuttle
Cannonball Trail • Historic Walking Trail
Granby Street Connector
Visitor Information Center
Dinner
May 25
6:30 pm
ELIZABETH RIVER
Downtown Parking
1 Waterside Garage
2 Main Street Garage
3 Town Point Garage
4 West Plume Street Garage
5 Boush Street Garage
6 Freemason Street Garage
7 York Street Garage
8 Harrison Opera House Lot
9 Cedar Grove Lot
10 Brambleton Lot
11 Scope Garage
12 St. Paul's Lot
13 MacArthur North Garage
14 MacArthur South Garage
15 Education Lot
16 Plume Street Lot
17 Commercial Place Garage
18 City Hall North Garage
19 City Hall South Garage
20 Harbor Park Lots
Meter ParkCard