

## **Three-dimensional modeling of a Chesapeake Bay tidal marsh-estuary ecosystem**

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Biogeochemical processes on the fringes of estuaries are relatively unconstrained especially in terms of tidal marsh-estuary exchanges and carbon budgets. A three-dimensional biogeochemical simulation can be a valuable tool to augment the observations on these exchanges at the marsh-estuary interface and can provide insights into the carbon fluxes and fate. The Finite Volume Community Ocean Model (FVCOM) coupled with the Integrated Compartment Model (ICM) for water quality is being adapted to simulate the physical and biological characteristics of the Kirkpatrick Marsh and Rhode River, a sub-estuary of Chesapeake Bay. The model includes a module to simulate the drag imposed by marsh grasses that, along with the unstructured grid and the FVCOM wetting and drying treatment, provides a realistic representation of intertidal marsh hydrodynamics. Model output and observed data are compared for hydrodynamic model validation and small-scale circulation features are examined. In addition, a coupled sediment and water chromophoric dissolved organic matter (CDOM) module is under continued development for inclusion into the biogeochemical model. The DOM module explicitly defines CDOM independent of non-chromophoric DOM (NCDOM) allowing future development of a dynamic simulation involving ultra-violet/visible light photobleaching kinetics and microbial interactions in the water column. The continued progress of the Rhode River model will provide insights into carbon and nitrogen exchanges across the marsh-estuary interface and build the framework for future expansions of this coupled physical-biogeochemical marsh-estuary model.

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## Modeling Coastal Flooding at the CT Coastline

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We have used a hydrodynamic- wave coupled numerical model (FVCOM-SWAVE) to simulate flooding at the Connecticut coastline during severe storms. The model employed a one-way nesting scheme and an unstructured grid. The parent domain spanned most of the southern New England shelf and the fine resolution grid covered LIS and extended across the Connecticut coast to the 10m elevation contour. The model solution for sea level, current and wave statistics from the parent grid has been tested with data from several field campaigns at different locations spanning the western, central and eastern portions of LIS. Waves are fetch limited and improvements of the model-data comparison required modifications to spectral coefficients in the wave model. Finally, the nested results were validated with two field campaigns in shallow water environments (*i.e.* New Haven and Old Saybrook). To assess the spatial variability of storm wave characteristics the domain was forced with the hindcast winds obtained from meteorological models (NAM and WRF) for 13 severe weather events that affected LIS in the past 15 years. Finally, two synthetic storms (*i.e.* Hurricanes Carol and Gloria) were generated in order to add statistical robustness to return period analysis of significant wave heights and storm surge levels in LIS.

## **Modeling high resolution coastal flow patterns along the eastern coast of Maine**

*LeAnn Conlon*<sup>1</sup>, Huijie Xue<sup>1</sup>, Phil Yund<sup>2</sup> (session 1)

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A high resolution FVCOM model of the eastern coast of Maine is used to determine flow patterns and the variability of these patterns in this region. This model varies in resolution of between 100 to 4000 meters, with the highest resolution in intertidal regions to accurately capture flow dynamics in this region. This model is nested within the NERACOOS Gulf of Maine model. The model is validated with ADCP transects and CTD casts within the model domain. The model will be used to determine the factors influencing the variability in the location of the Maine coastal current and predict mesoscale circulation patterns in the region. In the future, this model will simulate blue mussel (*Mytilus edulis*) population connectivity and larval dispersal along the coast of Maine using lagrangian particle tracking.

## **A bio-physical coupled model of the Damariscotta River Estuary**

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The Maine mid-coast region is an important area for shellfish aquaculture. As the industry continues to expand, there are many questions about the hydrodynamics and biogeochemistry of the region that need to be addressed in order to promote sustainable expansion. A circulation model of the Damariscotta River estuary and surrounding shelf using the Finite Volume Coastal Ocean Model (FVCOM) is under development. This model will be used to better understand estuarine exchange of fresh and ocean water, as this process governs the offshore-sourced nutrients available to support shellfish growing efforts in the estuary. The model will also be coupled to the Row Column Advanced Ecological Systems Operating Program (RCA) to simulate estuarine productivity. Specific questions to be answered with the coupled model include: What is the carrying capacity of the Damariscotta River for oysters and mussels? How does the composition of seston in the river impact oyster growth rates, and what are the possibly implications due to shift in seston composition? Increased temperature will likely increase oyster growth rates, will the food supply increase proportionately? The fundamental objective of this project is to determine whether the novel application of estuarine water quality models to aquaculture can increase the sustainability of this industry.

## **The pathways of long period and steady state barotropic flows through the Arctic Archipelago**

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Seawater input to the North Atlantic from the Arctic Ocean between Greenland and the Canadian mainland must pass through the Arctic Archipelago, a vast collection of large and small islands defining channels of many scales. The nature of the water mass exchange between these oceans will depend on the pathways of entrance into and exits from the Archipelago, as this will determine where the deep sea - shelf interactions will occur. The scale of global and basin models being used in climate related studies is not detailed enough to give a good representation of the area. In this work we use several models running on a detailed unstructured triangular mesh, to try to pin down the nature of the barotropic flow through the complex structure of the Arctic Archipelago. The aim is to help determine how the larger domain models might represent this area to more accurately compute the exchange of water masses.

## **Modeling of seasonal circulation in Shelburne NS using FVCOM**

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(session 7)

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Shelburne NS is an area of existing salmon aquaculture sites. With the presence of aquaculture in the area comes the need for information and predictions (hindcasts and forecasts) of the transport, dispersal, deposition and re-suspension of organic wastes and disease vectors resulting from existing and potential future salmon farming operations. As part of an effort to develop this information and prediction capability work has been undertaken to implement a barotropic version of FVCOM in the area. The model is forced with tides and seasonal winds. The model implementation will be described along with some field observations and model results concerning the seasonal circulation.

## **Barotropic and baroclinic responses to Hurricane Igor off Newfoundland**

*Guoqi Han*<sup>1</sup>, *Zhimin Ma*<sup>2</sup> and *Brad de Young*<sup>2</sup> (session 2)

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Modelling studies of hurricane impacts on storm surge and the upper ocean's responses in coastal waters have been frequent over the past decade. Nevertheless, most of these studies are based on either a two-dimensional depth-averaged model or a three-dimensional barotropic model. Here we use a three-dimensional, baroclinic finite-volume ocean model (FVCOM) to examine barotropic and baroclinic ocean responses to Hurricanes off Newfoundland. The model storm surge magnitude from the 3-D baroclinic model agrees approximately with tide-gauge observations at coastal tide-gauge stations, slightly better than that from an alternative 3-D barotropic case. Our analysis suggests the generation of a free continental shelf wave after the storm made landfall. The sudden drop of sea surface temperature caused by the storm, approximately  $6^{\circ}C$  as observed by buoys, is well simulated by the baroclinic model with a  $k-\epsilon$  turbulence closure. It is shown that the sea surface cooling is mainly associated with turbulent mixing, and to a lesser degree with Ekman upwelling. Baroclinicity is important for the hurricane-induced inertial oscillation in the near-surface currents.

## **Great South Bay: Changes in circulation, residence time and bay-ocean exchange due to a new breach in Fire Island**

*Claudia Hinrichs*<sup>1</sup>, Charles Flagg<sup>1</sup>, Roger Flood<sup>1</sup>, Robert Wilson<sup>1</sup> (session 2)

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The area of research is the Great South Bay, Long Island. The Great South Bay is about 70 km long, 3 to 8 km wide with a mean depth of approximately 2 m. The Bay is a bar-built estuary, sheltered from the Atlantic by Fire Island with four long-established inlets to the Mid-Atlantic Bight. Exchange with the Atlantic is restricted through these narrow inlets such that the tide range in the Bay is roughly a third of that of the ocean. During hurricane Sandy in October 2012 a new breach was cut through Fire Island in the eastern portion of the Bay. Thanks to an ongoing monitoring program in the Great South Bay we have observational data (sea level, temperature, salinity) from several points in the bay from before as well as after the new breach. Bathymetric measurements show that the breach opening is relatively small compared to the existing inlets. Post Sandy observations show a substantial increase in salinity in the eastern Bay with little change in tidal constituents with decreased turbidity, improved water quality and an overall healthier ecosystem. To understand the dynamics and kinematics of the Bay our group has employed the finite element model FVCOM to investigate the circulation and residence times in the Bay from before Sandy with good model skill. The grid has now been adapted to include the new breach in order to investigate changes in residence times, storm surge susceptibility and bay-ocean volume and heat exchanges. These results have important management implications as officials try to balance the ecological benefits of the breach versus the potential for increased flooding.

## **Connecticut River freshwater pathways through Long Island Sound**

*Rachel Horwitz*<sup>1</sup>, Grant McCardell<sup>2</sup>, James O'Donnell<sup>2</sup> (session 6)

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This study investigates the seasonal variation of the path of fresh water from the Connecticut River through eastern Long Island Sound (LIS). Previous observational and modeling studies have focused on Western and Central LIS and Block Island Sound, but few moored measurements have been made near The Race, where the exchange between LIS and the shelf is focused through a deeper, narrow gap. Using an FVCOM model verified by field observations, we demonstrate:

The along-sound baroclinic pressure gradient and the strength of exchange flow through the Race follow the accumulated freshwater input into LIS.

The initial trajectory and eventual residence time of Connecticut River water in LIS vary seasonally and depend on the density gradients influenced by preceding river discharge.

## **Assessing skill and reliability of bottom temperatures from the Finite-Volume Community Ocean Model (FVCOM) on the U.S. Northeast Continental Shelf.**

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Coastal circulation models have become a common tool to simulate the temporally evolving 3-dimensional geophysical conditions of the marine environment. However, to use these models to link oceanography with living resources, a certain degree of confidence in model accuracy and reliability is necessary. In this study, shelf bottom-temperature output from the unstructured-grid Finite-Volume Community Ocean Model (FVCOM) was evaluated using a large collection of *in situ* hourly bottom temperatures from a wide range of depths on the U.S. Northeast Continental Shelf and Nova Scotia, Canada. A series of quantitative skill assessments, from univariate statistics to generalized additive models, were applied to evaluate the differences in observed and modeled bottom temperature for 201 locations spanning the period from 2001-2013. Overall, univariate comparison between observations and simulation at the hourly temporal scale showed that FVCOM is accurate in hindcasting the bottom temperature (root mean squared error = 2.28 °C). Spatiotemporal patterns of the residuals were analyzed and regions & periods of discrepancies were identified. Suggestions for future users are provided, and the uncertainties in empirical data are discussed.

# Effects of Inertial current on the oceanic surface waves: a dataset constructed by matching HF radar current and NDBC buoy records

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Surface waves can be significantly modulated by ocean currents via the following several mechanisms: (i) Wave generation by wind (the effective wind is that relative to the surface current), the wave age, and effective surface roughness. (ii) Wave propagation is sensitive and dependent on the spatial variation of currents. Also, the effective fetch changes in the presence of a current. (iii) Doppler shift—the effect of a steady current on intrinsic wave frequency (iv) Steepening of waves on an opposing current owing to shorter wavelength and increased wave height constrained by wave action conservation. Regions with persistent strong currents, such as the Agulhas Current off the east coast of South Africa, are known as areas of extreme waves and wave-height modulations of up to 50% observed in the shallow North Sea have been linked to tidal currents. In the open ocean, near-inertial motions, which propagate away from the surface and play a critical role in maintaining the ocean's abyssal stratification, may reach speeds of up to 0.5 m/s. Although ambient currents on various time scales can change the surface wave amplitude, direction, and frequency (Holthuijsen 2007), their interaction with the surface wave field has not previously been reported, with the exception of Gemmrich and Garrett (2012), in which the long records of surface wave heights from buoy observations are examined. It shows wave-heights can be modulated up to 20% by local inertial currents. However, their analysis is based on the buoy records only, without any surface current information. Here, in this study, a dataset is constructed by matching the HF radar surface currents provided by Coastal Observing Research and Development Center (CORDC) and buoy wave data from the National Data Buoy Center (NDBC), in order to find the direct evidence for the effects of inertial currents on surface waves, using the simultaneous wave and current information.

The Matched HF and NDBC buoy data start from 1st Nov 2011, limited by the CORDC data temporal range. Although CORDC provides several spatial resolution products of 1km, 2km and 6km hourly gridded data, here we choose the 6km product since it can cover much bigger area than the other two products. Therefore, more buoys could be included in the HF radar observational areas. The matched wave-current data almost covers the whole east and west coasts of USA and part of southern Canada. As a case study, one set of matched HF currents and wave data, specifically NDBC buoy No.46015, is chosen to assess the currents on surface waves. This buoy is located several hundred kilometers off the land with a depth of about 420 meters. Here, in order to explore the effect of surface current particularly close to the local inertial frequency on surface wave height, the power spectral density (PSD) of the significant wave height and the corresponding collocated HF radar current are shown in Fig. 1(a). This shows the maximum at low frequencies owing to the fluctuations at typical synoptic weather time scales of several days as indicated by the PSD of wind speed shown in Fig. 1(c). In particular, the PSD of wave height reveal a peak at the local inertial frequency (the yellow line), which is closely corresponding to the PSD peak of ocean current at local frequency band (Fig. 1(b)) (please note that the mesoscale eddies could modulate the effective inertial frequency). In addition, because there are no corresponding peaks in spectra of wind speed, thus, the peak PSD for wave heights

is not caused by the local wind, and these results suggest the obvious influence of near-inertial surface currents.

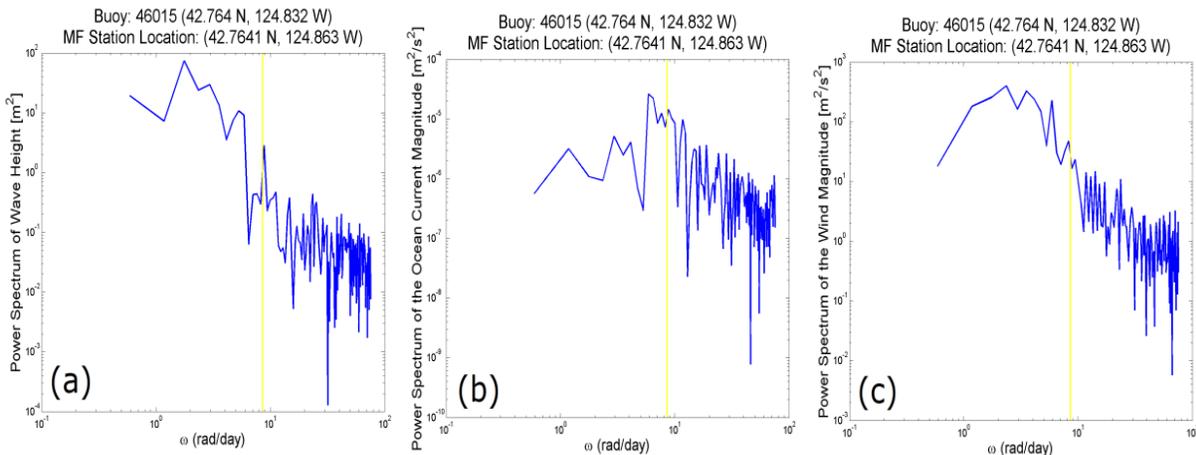


Fig.1 (a) PSD of significant wave height, (b) PSD of corresponding collocated HF radar current magnitude (c) and the PSD of wind speed.

Based on the matched HF radar current and NDBC buoy data and a spectral analysis method, our finding shows, first-time, direct evidence for the effect of near-inertial currents on surface waves. These are typically the most energetic currents in the open ocean. Via CORDC, additional available data is constructed to cover the US and southern Canada coasts, spanning 3 successive years, which is of great importance for understanding wave-current interactions near these coasts. These results have implications for wave modeling and forecasting and also give valuable information on the frequency, strength, and intermittency of the associated near-inertial motions.

## References

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## **A High Resolution Hydrodynamics Model of the Duplin River Estuary, Sapelo Island GA**

*C. Jared Mcknight*<sup>1</sup>, Daniela Di Iorio<sup>1</sup> (session 1)

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A high resolution three dimensional hydrodynamics model for the Duplin is an important tool, which will be used by scientists from many disciplines, within the Georgia Coastal Ecosystems Long Term Ecological Research (GCE LTER) project. The major goal of the project is to model salinity and inundation patterns within the domain dominated by *Spartina Alterniflora* salt marsh. Extensive bathymetry mapping was carried out within the Duplin using LiDAR, swath mapping, and an acoustic echo sounder to create a complete digital elevation model. Temperature, salinity, and sea surface height are forced using conductivity-temperature-depth (CTD) data from a monitoring station within the GCE LTER domain. This CTD is located outside of the model domain in Doboy Sound, near the mouth of the Duplin, so it is an ideal choice for forcing at the open boundary. As groundwater is the major contributor of freshwater to the system in question, a large portion of the effort has been dedicated to create tools to make the groundwater input and then to incorporate these inputs into FVCOM3.2.2, due to the improved groundwater input module. We will present results of the effects of groundwater on the salinity within the domain.

## **A comparative study of high and low resolution models in Vancouver Harbour**

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DFO Canada is developing a national network of operational systems based on the state-of-the-art hydrographic data, prediction and forecast methods. The system will provide timely information and warning to marine traffic navigating in and around selected ports. The aim is to mitigate the risks associated with existing and changing hydrographic conditions. A hydrodynamic model using FVCOM in Vancouver Harbour is presented in this poster. The region contains narrows and complex coastal structures. These features significantly increase the difficulty of accurately modeling the area, causing the calibration and testing features to be challenging and computationally expensive. In our study, two model meshes with different spatial resolutions are used, one with a moderate model resolution (hundreds of meters) and the other with a very high resolution (tens of meters). The model with lower resolution is used for the model implementation and model parameter tuning tests. The tuned parameters are then used for the high resolution model. In this poster, the two models are compared and the differences are discussed.

## **Winter to spring transition effect on estuarine hydrodynamics of a deep-silled fjord of southern Chile: the Relocavi fjord**

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We used one of the most extensive set of measurements in a Chilean fjord which combined currents, sealevel, winds, fresh water supply and hydrography data made at the Reloncavi fjord (41.5° S, 72.5° W) to validate a high resolution FVCOM simulation of the period between winter and spring of 2008. The Reloncavi fjord has been used for aquaculture since the early 80's most are salmon farms. It is deep (450 m at the mouth), narrow (3 km ) and large (55 km). In addition, the fjord present a “J” shape and the high discharge (annual mean of  $650 \text{ m}^3 \text{ s}^{-1}$ ) it is found at the middle whereas the secondary freshwater input (annual mean of  $250 \text{ m}^3 \text{ s}^{-1}$ ) is located at the head. The observations showed high and sustain stratification along-fjord, with a shallower pycnocline (located  $< 10 \text{ m}$  depth), gravitational circulation it is strong and modulated by internal seiche oscillations which are related with strong into the fjord winds. The simulation, includes tides and also inputs of discharge and winds time series. Outputs reveals that the circulation of the fjord is highly modified during the winter to spring transition, in both along- and cross-fjord axis. The advective terms seems to be enhanced during spring when discharge is lower and winds blows to the fjord's head.

## **Towards an operational model of the Saint John Harbour and the Bay of Fundy**

*Fred Page*<sup>1</sup>, Susan Haigh<sup>1</sup>, Tristan Losier<sup>1</sup>, Randy Losier<sup>1</sup> (session 9)

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As part of the Government of Canada World Class Tanker Safety E-Nav initiative, work is being undertaken toward the development of a real-time operational implementation of the FVCOM hydrodynamic model of the Saint John Harbour and the Bay of Fundy. The work has just recently begun and hence the presentation will focus on progress to date, including a preliminary grid, linkages to the regional scale NEMO operational model and forecasted winds and freshwater inputs as well as preliminary results concerning the barotropic tidal and baroclinic circulation patterns and comparisons to observed Eulerian and Lagrangian currents.

## **Circulation in the South coast of Newfoundland: the role of tides, wind, and water structure**

*Andry Ratsimandresy*<sup>1</sup>, Sébastien Donnet<sup>1</sup>, Pierre Goulet<sup>2</sup> (session 1)

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The finfish aquaculture industry in Newfoundland has undergone a rapid growth with increase in the production, in the number of licenses, and in the area used to carry out the activity. This also led to a potential increase in the interaction among aquaculture sites and between aquaculture activities and the environment. A circulation model, based on FVCOM, has been developed in order to understand the water circulation in the region and to inform about transport of particles to and from aquaculture sites. The region of interest is the South coast of Newfoundland with fjord-like area and semi-opened bays subject to freshwater run-off and atmospheric storms. The work will present the development of the circulation model with comparison of early stage of model run with observation. The main focus is to understand the role of the different forcings (tides and storm wind) on the circulation as well as that of the water structure observed in the area. The role of the tides in the variation of surface elevation is well reproduced by the model. Other features such as tidal currents and baroclinicity need further development.

## **Towards an Operational 3D Hydrodynamic Model for Puerto Rico and the United States Virgin Islands**

*Adail Rivera-Nieves*<sup>1, 2, 4</sup>, Miguel Canals-Silander<sup>1, 2, 3, 4, 5</sup> (poster)

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<sup>5</sup>Center for Applied Ocean Sciences and Engineering

In the framework of the Caribbean Coastal Ocean Observing System (CariCOOS), an operational three-dimensional (3D) hydrodynamic forecasting system is being developed for the San Juan Bay Estuary System located in Puerto Rico's north coast. This forecasting system consists of the application of the Finite-Volume Coastal Ocean Model (FVCOM) to obtain daily forecasts of hydrodynamic variables. This system will be indirectly nested to the Navy Coastal Ocean Model (NCOM) American Seas (AMSEAS) to obtain salinity, temperature and currents to force a regional mesh of Puerto Rico and the United States Virgin Islands (USVI) with variable resolution from 500m to 5km. In addition, tides will be forced using the Tidal Model Driver (TMD) with the 2011 Atlantic Ocean solutions from Oregon State University-Tidal Inversion Software Regional Tidal Solutions. All atmospheric variables will come from CariCOOS Weather Research and Forecasting Model (WRF) 1km Operational Wind Model. This Regional model will be directly nested to an estuary mesh with resolution from 500m to 10m. Currents, temperature, salinity will be validated with the CariCOOS bouy network consisting of 6 buoys across PR and USVI. Sea surface height will be validated using NOAA tide stations.

## **PySeidon: a suite of pythonic tools for the tidal energy community and FVCOM users**

*Thomas Roc*<sup>1</sup> (session 4)

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This tool box originally aimed to meet two main objectives, on the one hand, enhancing data accessibility thanks to simple client protocols and on the other hand, developing standardised numerical toolbox gathering specific analysis functions for measured and simulated data (FVCOM model) in the context of tidal energy projects. This package has been developed as part of the EcoEnergyII research project and is dedicated to the tidal energy community and FVCOM users.

## **Simulation of the vertical distribution of buoyant *Microcystis* colonies in an FVCOM offline Lagrangian particle model for short-term forecasts of harmful algal blooms in Lake Erie**

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Cyanobacterial harmful algal blooms (HABs), primarily *Microcystis*, are a recurring problem in western Lake Erie. Short-term forecasts of HABs are useful to water treatment plant operators, anglers, recreational boaters, and beach users. Experimental forecast products indicate the present location and extent of HABs from satellite imagery, then predict the movement of the HAB using forecast meteorology, a hydrodynamic model, and a Lagrangian particle tracking model. Vertical distribution of *Microcystis* colonies is a balance between buoyancy and turbulent mixing, mechanisms not represented in current forecast models. We compared model skill for 2D (advection only) versus 3D simulations that included vertical mixing with buoyancy. Turbulent diffusivity and 3D currents were provided by the FVCOM hydrodynamic model. We evaluated model skill using in-situ measurements and in a 2011 hindcast scenario that tested the ability of the model to predict subsequent satellite images after initialization from a satellite image. Inclusion of vertical mixing with buoyancy enabled the model to simulate observed changes in surface chlorophyll concentration in response to variable wind speed and stratification, and improved model skill statistics.

## **Modelling the seasonal occurrence and distribution of humanpathogenicbacteria within the German Bight, southern North Sea**

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In recent years, the occurrence of human-pathogenic bacteria of the genus *Vibrio* in the North Sea and the Baltic Sea has come into the focus of many marine research activities, as different *Vibrio* strains caused harmful infections, especially in summers 2003, 2006, 2010 and 2014. Furthermore, it is anticipated that under global warming conditions, the risk of the occurrence of human-pathogenic in summer season will increase very likely. To present knowledge temperature and salinity are the most powerful predictors of the occurrence of *Vibrio spp.* in coastal waters. However, studies support the interaction of human-pathogenic *Vibrio spp.* with different host and vector organisms like chitinous zooplankton or with predator organisms such as *Vibrio*-specific bacteriophages. A modeling system has been developed to understand and predict the occurrence and distribution of harmful *Vibrio spp.* within the North Sea with a special focus on the German Bight including the shallower Wadden Sea areas and the estuaries of Ems, Weser and Elbe. On the one hand, this modeling system is based on the unstructured-mesh hydrodynamic model FVCOM, which can predict the oceanic circulation and distributions of temperature and salinity within the German Bight for appropriate present and future climate conditions. On the other hand, a biological module has been attached, which can simulate the distribution and abundances of *Vibrio spp.*. In detail, apart from specific *Vibrio* strains, this biological module incorporates functional groups of phyto- and zooplankton and bacteriophages as potential host- and predator-organisms. In a first study, this modeling system has been applied to a hot summer season in 2006. It has been demonstrated that this system can reproduce the valid hydrodynamic conditions within the North Sea region of interest including temperature and salinity distribution patterns. In addition, reasonable temporal and spatial patterns of *Vibrio* abundances have been obtained.

## **Barotropic simulation of the pre- and post-hurricane Juan in the Northwest Atlantic using FVCOM**

*Yujuan Sun*<sup>1</sup>, Will Perrie<sup>1</sup> (session 2)

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This study is focused on barotropic simulations of the oceanic response to hurricane Juan in the Northwest Atlantic Ocean using FVCOM. We coupled the FVCOM ocean model and SWAN wave model together, to investigate the wave-current interactions for conditions present for pre- and post-hurricane Juan. Comparisons of the simulated significant wave heights with observations at buoy 44137, 44142, and 44258, show good agreement during hurricane process. The impact of the ocean – wave coupling is relatively small change in the wave model simulations, compared to buoy observations. The correlation coefficients are 0.96, 0.92, 0.96, respectively, for the coupled model simulations. FVCOM is shown to be able simulation the ocean response to the hurricane well.

## **Modeling seasonal circulation along the northern coast of British Columbia, Canada**

*Pramod Thupaki*<sup>1</sup>, Charles Hannah<sup>1</sup>, Mike Foreman<sup>1</sup> (session 9)

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A three-dimensional, unstructured-grid, numerical ocean model based on the Finite Volume Coastal Ocean Model (FVCOM) has been developed to simulate circulation in the network of channels and fjords that lie along the northern coast of British Columbia. Atmospheric forcing for the numerical model is calculated from the results of the weather forecasting model (HRDPS-West); tidal phase and amplitude at the open boundaries are interpolated from a large scale tidal model; and discharge from rivers and overland flows are estimated from a hydrology model. Three month-long simulations were run for conditions representative of spring, summer, and fall conditions. Accuracy of the numerical models is evaluated using ADCP and CTD measurements made between July 2013 and June 2014 and the results have been presented. This numerical model has been developed to assist with the prevention, preparedness and response to oil spills along the northern coast of British Columbia.

## **Modeling wind-induced hydrodynamics of shallow Lake Balaton**

*Peter Torma*<sup>1</sup>, Tamas Kramer<sup>1</sup> (session 9)

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Lake Balaton is the largest freshwater lake in Central Europe. Its surface area is approximately 600 km<sup>2</sup> while the mean depth is only 3.5 m. Up to 300-m- wide, waist-deep beaches characterise about half of the shoreline. The elongated shape is narrowed by a peninsula separating the lake into two main sub-basins. Most studies used 2D depth-averaged modeling to describe large-scale motions and transport. For a more detailed view, and in order to describe the vertical variation of currents, heat, suspended sediment and other physical and biological substances, we adopted FVCOM. In this presentation the first validation applications are shown. In order to produce good hydrodynamic hindcasts an algebraic semi-empirical wind stress field calculation and interpolation technique was also developed based on routine point wind measurements. The FVCOM predicted surface elevation fluctuations and currents are in good agreement with the observed ones for different wind storms. At present FVCOM's heat transport modeling capabilities in such shallow circumstances are tested. Near-surface temperatures and diurnal stratifications are captured fairly well, but we conducted further sensitivity analyses to understand the discrepancy between modeled and measured vertical temperature profiles and mixed layer depths. As a likely cause, we found that the estimation of the turbulent kinetic energy flux due to surface waves and the bottom boundary condition for temperature has to be improved. Furthermore, numerical experiments are also required to identify the effect of the wave-current interaction on stratification and mixing.

## **Coupling FVCOM with FABM: Multiplying the choices of marine ecosystem models within fvcom**

*R. Torres*<sup>1</sup>, *Y. Artioli*<sup>1</sup>, *P. Cazenave*<sup>1</sup>, *J. Bruggeman*<sup>1</sup>, *J.I. Allen*<sup>1</sup> (session 3)

<sup>1</sup>Plymouth Marine Laboratory, UK.

The Framework for Aquatic Biogeochemical Models (FABM) is a new general framework that provides a flexible and traceable approach to coupling arbitrary physical host models (FVCOM in our case), and any number of arbitrary biogeochemical models. The host maintains abiotic variables such as temperature, light and salinity, and handles space-explicit operations such as advection and diffusion (if applicable). Biogeochemical models are unaware of the spatial context: they operate based on spatially and temporally local conditions only. FABM provides additional functionality to couple different biogeochemical models running side by side: the user can configure models at runtime to share variables, allowing, for instance, for one model to provide the prey density to another model's predator, or for one model to change the concentration of dissolved organic carbon used by another model to calculate CO<sub>2</sub> dissolution and PH. Above all, it facilitates the construction of traceable and scalable models.

In my presentation I will introduce FABM and give details of its philosophy, approach, models available and recent history. I will then give details of how FABM has been introduced in FVCOM and provide examples of recent uses of FVCOM-FABM in PML. I will finish by giving a brief overview of PML current and future work with FVCOM.

## **An Automated, Northeast Gulf of Mexico Nowcast/Forecast Model, with HABs, Fisheries and DWH Oil Spill Applications.**

Robert H. Weisberg<sup>1</sup>, *Lianyuan Zheng*<sup>1</sup> (session 3)

<sup>1</sup>College of Marine Science, University of South Florida, St. Petersburg, FL, USA

A West Florida Coastal Ocean Model (WFCOM), constructed by nesting FVCOM in HYCOM and run at USF, provides daily automated nowcast/forecasts on the web and via THREDDS server. Designed to downscale from the deep-ocean, across the continental shelf and into the estuaries, WFCOM extends from west of the Mississippi River delta to south of the Florida Keys, with resolution varying from that of HYCOM along the open boundary to 150 m in the primary estuaries. Along with nowcast/forecasts, hindcasts exist from 2004 through the present. With full water column observations available for veracity testing, WFCOM is applied to a number of societal relevant topics. Examples to be presented include: what controls HABs on the west Florida shelf, how gag grouper larvae transit from offshore spawning to inshore settlement sites, how Deepwater Horizon oil arrived on northern Gulf beaches and how Deepwater Horizon oil transited to the west Florida shelf. Given the complexity of the coastal ocean circulation that is driven by a combination of deep-ocean and local forcing, and recognizing that no single model may realistically be capable of covering all regions, we demonstrate the utility of downscaling by making use of a data assimilative deep ocean model nested with a high resolution coastal ocean model.

## **Representing kelp forests in a regional circulation model based on FVCOM**

*Yongsheng Wu*<sup>1</sup>, Charles G. Hannah<sup>2</sup>, Mitchell O'Flaherty-Sproul<sup>1</sup>, Pramod Thupaki<sup>2</sup> (session 8)

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Kelps, known as the large brown seaweeds, are commonly distributed on the north coast of British Columbia, Canada. The presence of the kelps enhances the hydrodynamic drag and thus changes the tidal circulation structures. In the present study, changes in tidal circulation have been investigated with a high resolution three-dimensional hydrodynamic model based on FVCOM in which the effect of kelps is parameterized as an extra drag term in the standard momentum equations. The locations of kelp beds are derived from Landsat images archived in USGS and the drag coefficient due to kelps uses existing laboratory data. The model is validated with the field observational data. Using the model results, effect mechanisms of kelp forests on the tidal circulation are discussed.

## **Numerical modeling the interaction between the South China Sea Throughflow (SCSTF) and the Indonesian Throughflow (ITF)**

*Danya Xu*<sup>1</sup>, Paola Malanotte-Rizzoli<sup>2</sup> (session 7)

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The wind-driven circulation and thermal structure of the South China Sea (SCS), Indonesian Seas (IS) and Indonesian Throughflow (ITF) are simulated using the FVCOM in a regional domain covering the Maritime Continent. We choose the two decades 1960-1969 in the pre-warming phase and 1990-99 in the full warming phase to simulate the two decadal climatological regimes in the regional domain. The circulation of the SCS is primarily driven by the monsoon system and reflects its seasonality reversing from Winter to Summer, with a net cyclonic tendency in Winter and anticyclonic in Summer. The Wind system over the ITF is rather complex. The surface layer also reflects the monsoon seasonality, with a very important interaction between the South China Sea Throughflow and the ITF. The southward ITF in fact can be completely blocked by the SCSTF at the Makassar Strait in the upper 50m during winter. In summer the ITF reinforces the reversed SCSTF entering the SCS through the Karimata Strait. Below the surface layer however the ITF is consistently southward, indicating that its dominant driving force is the sea level difference between the Pacific and Indian oceans and the resulting boundary pressure gradients. The inter-ocean volume transports through the main straits, Luzon (inflow), Karimata and Mindoro (outflow) for the SCS; the ITF inflow straits (Makassar and Lifamatola) and outflow ones (Lombok, Ombai and Timor) are evaluated from the model simulation. The model estimates of the total SCSTF and ITF inflow/outflow are also in good agreement with the recent in situ observations, especially for the 90s. The comparison of the wind-driven circulations of the 60s and 90s show weaker currents in the 90s in the SCS, reflecting the weaker monsoon of the second decade. The ITF currents and transports are instead stronger in the 90s, evidence of the greater importance in the 90s of the sea level difference between the Pacific and Indian oceans. Both wind curls and circulation patterns are overall very similar in the two decades. These similarities indicate that the difference in the circulation is a manifestation of interdecadal variability around a stable climatology.

# Impacts of Wind Field Correction on the Numerical Simulation of "Rammasun" Storm Surge Inundation

Wang Yuxing<sup>1</sup>, LIU Qinzhen<sup>1</sup>, GAO Ting<sup>1</sup>, HAN Zhenyu<sup>2</sup> (session 9)

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The accuracy of wind forcing is the important prerequisite of storm surge inundation simulation. However, the traditional methods of wind field correction, such as resolution increase and observation assimilation, are not suitable for quick assessment due to high time cost or absence of observation. Therefore, a simple wind field correction method is developed in this paper. In this method, the lower resolution wind field is corrected according to different underlying surfaces. The impacts of this correction method on the simulation of storm surge inundation are investigated using FVCOM (Finite-Volume Coastal Ocean Model), taking the No. 1409 typhoon "Rammasun" as an example. The hourly inundation ranges and submerged depths before and after wind field correction which is used to drive the storm surge inundation model are compared to observation as well as investigation and assessment results. It is found that if the wind field on harbor and inundation area is corrected according to different underlying surfaces, the simulated storm surge will increase, and then the inundation area and submerged depth increase rapidly, which is more coincide with measurements. Besides, the distribution of water flow over land could better fit the variation of inundation range after wind field correction. Above of all, the local correction method of wind field due to different underlying surfaces could improve the wind accuracy, and the oceanic model could simulate varying inundation characteristic more close to the reality.

## **A High Resolution Tampa Bay and Vicinity Circulation Model with Applications to Salt Balance, Flushing and Tracking**

*Lianyuan Zheng*<sup>1</sup>, Robert H. Weisberg<sup>1</sup> (session 6)

<sup>1</sup>College of Marine Science, University of South Florida, St. Petersburg, FL, USA

The Tampa Bay estuary is a complex, interconnected region consisting of Tampa Bay, Sarasota Bay, Boca Ciega Bay, the Intra-coastal Waterway and all of the inlets and waterways connecting these with each other and with the adjacent Gulf of Mexico. Modeling this complex requires resolution sufficient to include all of the important conveyances of mass. We present such a model, quantitatively gauged against available observations on tide, wind and river driven circulations, along with several application examples. Such model is pre-requisite for ecological applications because the circulation is what controls the water properties in which organisms reside. We demonstrate this by considering the point by point salt balances and the salt fluxes throughout the bay recognizing that the salt fluxes are indicative of the spatial structures for other important material properties such as nutrients and fish larvae. The model also provides a tool for tracking substances such as larvae or spilled substances and how these may be carried either offshore or into the various inlets. Examples will be provided on scales ranging from residential canals to bay-wide.

# **Application of the Finite Volume Community Ocean Model to Norwegian Coastal Ocean: Challenges and Results**

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Norwegian coastal ocean is characterized by its complex coastline composing of thousands of islands, narrow channels and deep fjords, which leads to difficulties in simulating coastal processes with traditional numerical models. By taking advantages of flexibility of unstructured grid and efficiency of finite volume algorithm, we are the first research group in Norway who applies the unstructured grid model (FVCOM, the Finite Volume Community Ocean Model) in modeling Norwegian coastal circulation with a view to environmental monitoring and management.

In this presentation, we will present three aspects of our application of FVCOM: 1) a method for making high-quality mesh grid for the complex coastline; 2) challenges we have experienced during the application; 3) model results and validations. The presented model domain comprises of coastal and shelf seas of Finnmark county of Norway, which is situated at the northernmost part of continental Europe (about north of  $69^{\circ}N$  in latitude and  $16.9^{\circ}E$  to  $31.5^{\circ}E$  in longitude). Model horizontal resolution varies from around 4 km at the open boundary to 60 m in the narrow fjords. In total, there are 921,420 non-overlapping triangular cells and 477,277 triangular nodes in the horizontal.