ECM14:
14$^{th}$ International Conference on Estuarine and Coastal Modeling


*University of Rhode Island*
*Kingston, Rhode Island, USA*
Organizing Committee

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Zhaoqing Yang, Pacific Northwest National Laboratory
ECM14 Draft Schedule

Day 1: Monday, June 13, 2016

Registration Opens & Breakfast
7:00 – 8:15 AM

Welcome and Opening Remarks
8:30 – 8:45 AM

Plenary:
8:45 – 9:15 AM “Predicting Coastal Inundation due to Storms”, Rick Luettich

Topic: 1A Coastal Flooding
9:15 – 10:35 AM Session Leader: Yong Kim

9:35-9:55 “Impact of Sea Level Rise on Future Storm-induced Coastal Inundation”, Changsheng Chen
9:55-10:15 “Sensitivity of the 100-year Storm Flood Zone to Sea Level Rise”, Annette Grilli
10:15-10:35 “Application of High Resolution SLOSH Modeling for Coastal Inundation Study under Future Sea-level Rise Conditions”, Yong Kim

Topic: 1B Estuarine and Coastal Systems
9:15 – 10:35 AM Session Leader: Rosemary Cyriac

9:55-10:15 “Understanding Oyster Growth in the Damariscotta River Using a Coupled Hydrodynamic – Biogeochemical Model”, Kate Coupland
10:15-10:35 “Models for Barotropic and Baroclinic Circulation in the Choctawhatchee Bay and River System”, Rosemary Cyriac

Break
10:35 – 11:00 AM
**Topic: 2A Coastal Flooding**  
Session Leader: David Ullman

11:00-11:20 “Real Time Guidance for Combined Flooding Hazards and Active Flood Control Structures Using the ADCIRC Surge Guidance System”, Jason Fleming


11:40-12:00 “Probabilistic Storm Surge Risk Assessment Using a Synthetic Hurricane Database”, Michelle Terry

12:00-12:20 “Effect of Wind, Waves, and Precipitation Runoff on Coastal Flooding due to Land-falling Tropical cyclones in the Narragansett Bay Region: Results from Coupled ADCIRC/SWAN Simulations”, David Ullman

**Topic: 2B Estuarine and Coastal Systems**  
11:00 – 12:20 PM Session Leader: Venkat Kolluru

11:00-11:20 “Residence Time Variability in Response to Circulation Scenarios in a Back-Barrier Estuary”, Zafer Defne

11:20-11:40 “Modeling Potential Circulation Improvements in Old Tampa Bay”, Todd DeMunda

11:40-12:00 “The Oceanography and Sediment Dynamics of Nass Bay and Iceberg Bay, British Columbia: Role of the Nass River”, David Fissel

12:00-12:20 “Investigation of Vertical Structure in the Baltic Sea”, Venkat Kolluru

**Luncheon (provided)**  
12:20 – 1:30 PM

**Topic: 3A Coastal Flooding**  
1:30 – 3:10 PM Session Leader: Nathan Dill

1:30-1:50 “Advancing Storm Surge and Inundation Models Through Enhanced Physics of the Air-Sea-Wave Coupling”, Isaac Ginis

1:50-2:10 “The Effects of Land Cover and Associated Bottom Friction on Computation of Surge Inundation Extent”, Yuepeng Li

2:10-2:30 “Model Setup, Validation, and Application for the South Florida Storm Surge Modeling Project”, Christopher Bender

2:30-2:50 “The Effect of Bottom Friction, Surface Roughness, and Meteorological Forcing in Hurricane Storm Surge Simulation Using SWAN+ADCIRC Model”, Simbarashe Kanjanda

2:50-3:10 “Assessing Coastal Flooding Vulnerability at Two Critical Locations in Islesboro, Maine”, Nathan Dill
**Topic: 3B Estuarine and Coastal Systems**

1:30 – 3:10 PM Session Leader: Harry Wang

1:30-1:50 “Tidal Datum Changes Induced by Location and Geometry Alterations of North Carolina Coastal Inlets”, Jindong Wang

1:50-2:10 “An Investigation into the Influence of Coastal Islands on River Water Distribution and Mixing in Western Long Island Sound”, Steven Schmidt

2:10-2:30 “Hindcast Simulations toward the Development of NOAA’s Gulf of Maine Operational Forecast System”, Zizang Yang

2:30-2:50 “A Cross-scale Baroclinic Model of the Chesapeake Bay and the Coastal Ocean”, Fei Ye

2:50-3:10 “The Effect of Cross-channel Bathymetry on Lateral Density Responses under Different Wind Directions in an Estuary”, Harry Wang

**Break**

3:10 – 3:30 PM

**Lightning Talk Introductions to Poster Session**

3:30 – 4:00 PM

**Poster Session**

4:00 – 5:30 PM

**Dinner (Butterfield Hall)**

5:45 – 7:00 PM
Day 2: Tuesday, June 14, 2016

Registration & Breakfast
7:00 – 8:00 AM

8:00 – 8:15 AM Board bus to Narragansett Bay Campus

8:15 – 9:00 AM Transit via bus to Narragansett Bay Campus

Plenary:
9:00– 9:30 AM Coupled Ecosystems Models from Climate to Fish: Lessons from an End-to-end Modeling Approach, Enrique Curchitser

Topic: 4A Coastal Flooding
9:30 – 10:30 AM Session Leader: Kyra Bryant

9:30-9:50 “Development of the Fully Adaptive Storm Tide (FAST) Model for High Resolution Storm Surge Inundation”, Yi-Cheng Teng

9:50-10:10 “Application of the Forward Sensitivity Method to a GWCE-Based Shallow Water Model”, Evan Tromble

10:10-10:30 “An Exploration of Wind Stress Calculation Techniques in Hurricane Storm Surge Modeling”, Kyra Bryant

Topic: 4B Ecosystems/ Harmful Algal Blooms
9:30 – 10:30 AM Session Leader: Jian Shen


9:50-10:10 “Space Time Evolution of the Trophic State Level of Lagoa da Conceição, a Choked Coastal Lagoon in the Island of Santa Catarina – Brazil”, Victor Silva


Break
10:30 – 11:00 AM

Topic: 5A Wave and Sediment Transport Modeling
11:00 – 12:20 PM Session Leader: Earl Hayter
11:00-11:20 “Directional Wave Modeling on Fringing Reefs at Hilo Harbor, Hawaii”, Lihwa Lin
11:20-11:40 “Wave Dynamics in Lake Erie: Inter-basin Propagation, Seasonality, and Potential Susceptibility to Climate Change”, Qianru Niu


12:00-12:20 “Modeling Sediment Transport using the Geophysical Scale Hydrodynamic and Sediment Transport Modeling System”, Earl Hayter

**Topic: 5B Modeling Techniques, Session 5**
11:00 – 12:20 PM Session Leader: Christine Szpilka

11:00-11:20 “Statistical Interpolation of Tidal Datums and Computation of Its Associated Spatially Varying Uncertainty”, Lei Shi

11:20-11:40 “Dynamic Spatial Interpolation of Observed Tidal Harmonic Constants in Coastal and Estuarine Waters”, Edward Myers

11:40-12:00 “A Seamless Cross-scale Modeling Framework from Creek to Ocean”, Yinglong Zhang

12:00-12:20 “Challenges and Improvements for the Updated ADCIRC Tidal Databases: Eastern North Pacific and Western North Atlantic, Caribbean and Gulf of Mexico”, Christine Szpilka

**Luncheon (provided)**
12:20 – 1:10 PM

**Topic: 6A Coastal Flooding, Session 6**
1:10 – 2:30 PM Session Leader: Michael Bradley

1:10-1:30 “Sensitivity of Coastal Tsunami Hazard to the Modeling of Tsunami Generation by Submarine Mass Failures of Various Rheology”, Michael Shelby

1:30-1:50 “Modeling of Historical Storms in Rhode Island”, Lauren Schambach


2:10-2:30 “Vulnerability assessment of National Park Service Infrastructure to Storm Surge and Sea Level Change”, Michael Bradley

**Topic: 6B Analysis and Visualization**
1:10 – 2:30 PM Session Leader: Rich Signell

1:10-1:30 “Data Driven Realistic Visualization”, Peter Stempel

1:30-1:50 “Multi-grid Data Analysis and Visualization with Python”, Christopher Barker
1:50-2:10 “Getting COMT on PARR: Increasing Public Access to COMT Results”, Brian McKenna
2:10-2:30 “A Standardized Framework for Reproducible Model Skill Assessment”, Richard Signell

**Break**
2:30 – 3:00 PM

**Topic: 7A Coastal Flooding**
3:00 – 4:40 PM Session Leader: Kendra Dresback

3:00-3:20 “Demonstrating the Impact of Flood Adaptation Using an Online Dynamic Flood Mapper”, Philip Orton
3:20-3:40 “Morphological Response of Barrier Islands During Tsunami Inundation”, Babak Tehranirad
3:40-4:00 “STORMTOOLS – Web Based Storm Flooding Tools”, Malcolm Spaulding
4:00-4:20 “A Comparison of Two Methods to Improve the Efficiency of a Coupled Hydrologic/Hydraulic Modeling System”, Kendra Dresback
4:20-4:40 open

**Topic: 7B Estuarine and Coastal Systems**
3:00 – 4:40 PM Session Leader: Craig Swanson

3:00-3:20 “A Numerical Study of the Circulation in Chatham Sound, BC, Canada”, Yuehua Lin
3:40-4:00 “Salinity Variability and Water Exchange in Interconnected Estuaries”, Yuntao Wang
4:00-4:20 “The Impacts of Ambient Coastal Currents and Local Wind on River Plume in the Pearl River Estuary During Summer”, Yongji Xu
4:20-4:40 “Impact of Inlet Dredging on Circulation and Flushing of the Narrow River, Narragansett, RI”, Craig Swanson

4:45 – 5:00 PM Board bus to Newport (Cliff Walk, Restaurants)

9:00 – 9:15 PM Board bus back to Narragansett Bay Campus
Day 3: Wednesday, June 15, 2016

Registration & Breakfast
7:00 – 8:15 AM

Plenary:
8:30 – 9:00 AM “Large-scale, Drifter-based Surface Dispersion Experiments in the Northern Gulf of Mexico”, Andrew Poje

Topic: 8A Lagrangian Transport
9:00 – 10:40 AM Session Leader: Hansong Tang

9:00-9:20 “AmDaDos (Adaptive Meshing and Data Assimilation for the Deepwater Horizon Oil Spill), a Pilot Case Study for the AllScale Project”, Emanuele Ragnoli

9:20-9:40 “Simulation of Atlantic Salmon Post-smolt Movement Along the North Shore of the Gulf of St. Lawrence”, Jinyu Sheng


10:00-10:20 “A Hybrid GFD and Fully 3D CFD System for Modeling Flows around Moving Objects in Oceans”, Hansong Tang

10:20-10:40 Open

Topic: 8B Estuarine and Coastal Systems
9:00 – 10:40 AM Session Leader: Nickitas Georgas

9:00-9:20 “Salt Marsh Response to Wind Waves in a Confined Tidal Flat: Bombay Hook National Wildlife Refuge, Delaware”, Mithun Deb

9:20-9:40 “Development of a Biophysical Model for Chesapeake Bay and its Adjacent Coastal Ocean”, Meng Xia

9:40-10:00 “FVCOM Modeling of the Changes in the Great South Bay’s Hydrodynamic Environment Due to a Breach in Fire Island”, Claudia Hinrichs

10:00-10:20 “Modelled Effects of Climate Change in Oslofjord”, Magdalena Kempa


Break 10:40 – 11:00 AM

Topic: 9A Coastal Flooding
11:00 – 12:20 PM Session Leader: Malcolm Spaulding
11:00-11:20 “A Comparison of Methods for Total Water Level Prediction Using ADCIRC”, Samuel Bush

11:20-11:40 “Sea State-Dependent Surface Wind Stress in the Coupled ADCIRC and SWAN Model for Storm Surge Modeling”, Jie Gao

11:40-12:00 “Inundation Modeling of Saco-Casco Bays, Maine USA: a FVCOM Based Case Study of Five Winter Storms in the Fall and Winter 2014-2015”, Huijie Xue

12:00-12:20 “STORMTOOLS - Coastal Environmental Risk Index (CERI)”, Malcolm Spaulding

**Topic: 9B Waves**

11:00 – 12:20 PM Session Leader: Tetsu Hara

11:00-11:20 “Modeling of Wave Climate for the Past 20 Years in Lake Michigan”, Arash Aliabadi Farahani


11:40-12:00 “Wave Characteristics in Chatham Sound, British Columbia, Canada”, Mustafa Samad

12:00-12:20 “Surface Wave Modeling under Tropical Cyclones in Coastal Rhode Island and Narragansett Bay Regions”, Tetsu Hara

**Luncheon (provided)**
12:20 – 1:30 PM

**Topic: 10A Sediment Transport**

1:30 – 3:10 PM Session Leader: Tarang Khangaonkar

1:30-1:50 “Numerical Simulation of Subaqueous Clayey Debris Flow”, Himangshu Das

1:50-2:10 “Modeling the Impact of a Tidal Stream Array on Bedload Sediment Transport”, M. Reza Hashemi

2:10-2:30 “Change of Sediment inside Harbors due to Long Waves and Tsunami motion; Case Study of Haydarpasa Harbor in Istanbul”, Rozita Kian

2:30-2:50 “3D Modelling on Dispersion of Dredge Sediment Plumes and Fate of Sediment Disposal”, Qimiao Lu

**Topic: 10B Water Quality**
1:30 – 3:10 PM Session Leader: James Bowen

1:30-1:50 “Influences of Nutrient Load and Various Wind Factors on Chesapeake Bay Summer Hypoxia”, Ping Wang

1:50-2:10 “A Numerical study of biochemical effects with physical modulation on variations of hypoxia during summer in the Pearl River Estuary”, Jiatang Hu

2:10-2:30 “Effects of data assimilation on real-time simulation of hypoxia in Tokyo Bay, Japan”, Masayasu Irie


2:50-3:10 Open

**Break**
3:10 – 3:30 PM

**Topic: 11A Forecast Systems**
3:30 – 4:30 PM Session Leader: Frank Aikman

3:30-3:50 “The Importance of Spatio-Temporal Resolution of Meteorological Inputs to Hydrological Streamflow Forecasts: A Multi-Scale Application”, Firas Saleh

3:50-4:10 “Operational Forecast Systems for the Coastal and Estuarine Environment in NOAA’s National Ocean Service”, Frank Aikman

4:10-4:30 “National Ocean Service’s Gulf of Maine Operational Forecast System (GoMOFS)”, Machuan Peng

**Topic: 11B Estuarine and Coastal Systems**
3:30 – 4:30 PM Session Leader: Mohamed Abdelrhm

3:30-3:50 “Combining Inverse and Transport Modeling to Estimate Bacterial Loading and Transport in a Tidal Embayment”, Mac Sisson

3:50-4:10 “Modeling Water Clarity in Oceans and Coasts”, Mohamed Abdelrhm

4:10-4:30 open

**ECM15 Discussion and Closing Remarks**
4:30 – 4:45 PM


**Poster Presentations**

"Long-term Morphology Modeling of Barrier Island Tidal Inlets", Mitch Brown

"Simulative Analysis of Storm Tide Levels along Roxas Boulevard Seawall", Jeane Camelo

"A Multiscale Approach to the Optimization of Tidal Energy Extraction", Geoff Cowles

"Impact of Mississippi River Diversions on Salinity Gradients and Estuarine Residence Time in Coastal Louisiana: A Numerical Modeling Study", Linlin Cui

"Investigating Natural and Anthropogenic Impacts on Salinity in Apalachicola Bay, FL", Justin Davis

"A Sensitive Study on the Mississippi River Plume Dynamics", Yi Du

"Dynamics of water and salt exchange in Maryland Coastal Bays", Xinyi Kang

“Effects of Harbor Shape on the Tsunami Induced Sedimentation”, Rozita Kian

"Analysis of slant-fetch waves using numerical wave model", Taerim Kim

"Far-field Impacts of Tidal Energy Extraction and Sea Level Rise in the Gulf of Maine", Boma Kresning

"Assessment of a novel 3D hydrodynamic numerical model for hydrodynamics and water-quality indicator applications in the San Francisco Bay-Delta", Rosanne Martyr-Koller

“Sediment Plume Behaviors in the Western Lake Erie: Typical Patterns, Seasonal, and Interannual Variability”, Qianru Niu

"Towards the Development of an Operational Forecast System for Florida Coast", Vladimir Paramygin

"Tsunami Propagation Database Application for the Aegean Coastlines", Naeimeh Sharghivand

"The Effect of Coastal Erosion on Storm Surge; A Southern Rhode Island Case Study", Alex Shaw

"Assessment of Damage from Storm Surge and Sea Level Rise Along Matunuck Beach Road and Surrounding Communities", Christopher Small

"Performance and validation of a numerical model code for tsunami inundation", Rozita Kian

"Modeling the Influence of Hurricane Barriers in Narragansett Bay on the Response to Tropical Cyclones with a Range of Watershed versus Coastal Ocean Forcing Characteristics", Christina Wertman

“The Application of a Couple-wave Current Model to Lake Michigan’, Meng Xia

"Towards a Directly-Coupled Hydrodynamic and Wetland Modeling System for Understanding the Role of Coastal Wetland in the Carbon Cycle ", Zhaoqing Yang

"Modeling the Long-term Transport Timescale of Fresh Water in an Estuary During the Yellow River Water and Sediment regulation", Xuequing Zhang
"A Modeling Study of Hydrodynamics at Subsea Pipelines in Tidal Currents", Enjin Zhao

"A High-Fidelity Simulation of Farfield and Nearfield Flows past MHK Turbines in Coastal Waters", Hui Zou
(1-A) Flood inundation modeling in a changing climate

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Low-gradient coastal regions around the world are susceptible to a variety of natural disasters that can cause devastating flooding. It is anticipated that the exposure of coastal cities to more frequent flooding will increase due to the effects of climate change, and in particular sea level rise (SLR). A novel framework was developed to generate a suite of physics-based storm surge models that include projections of coastal floodplain dynamics under climate change scenarios: shoreline erosion/accretion, dune morphology, salt marsh migration, and population dynamics [Bilskie et al., 2014; Passeri et al., 2014; Passeri et al., 2015].

First, the storm surge inundation model was extensively validated for present-day conditions with respect to astronomic tides and hindcasts of Hurricane Ivan (2004), Dennis (2005), Katrina (2005), and Isaac (2012). The model was then modified to characterize the potential future outlook of the landscape for four climate change scenarios for the year 2100 (B1, B2, A1B, and A2). Each climate change scenario was linked to a sea level rise of 0.2 m, 0.5 m, 1.2 m, and 2.0 m from Parris et al. [2012]. The adapted model was used to simulate hurricane storm surge conditions for each climate scenario using a diverse suit of tropical cyclones. The collection of results shows the intensification of inundation area, depth of flooding, and the vulnerability of the coast to potential future climate conditions. The methodology developed herein to assess coastal flooding under climate change can be performed across any low-gradient coastal region worldwide, and results provide awareness of areas vulnerable to extreme inundation in the future.

References


(1-A) Sensitivity of the 100-year storm flood zone to sea level rise

Annette Grilli, University of Rhode Island, agrilli@egr.uri.edu, Malcolm Spaulding, University of Rhode Island, spaulding@oce.uri.edu, Lauren Schambach, University of Rhode Island, laurenschambach@gmail.com, Bryan Oakley, Eastern Connecticut State University, oakleyb@easternct.edu, Christopher Damon, University of Rhode Island, edamon@edc.uri.edu, Fengyan Shi , University of Delaware, fyshi@udel.edu, Jim Kirby, University of Delaware, kirby@UDel.Edu

FEMA’s Flood Insurance Rate Maps (FIRMs) have regulatory standing for mapping flood zones. The coastal hazard zones presented on these maps are based on an accepted risk (i.e., the event’s return period) and are defined as deterministic limits (without a confidence interval) corresponding to the given return periods, 100 and 500 years. The limits are based on specific assumptions associated with the surge and wave models used and carry an inherent variability associated with such assumptions; this variability can be divided into the epistemic variability related to modeling assumptions and an aleatory variability associated with the natural variability of the modeled processes. Furthermore, the FIRM maps do consider sea-level rise.

We explore the variability of the 100-year storm flood zone in Charlestown, Rhode Island, as a function of the modeling methodology and for different sea level rise scenarios. The current coastal topography is modified in the simulations to represent a hypothetical eroded coastline based on estimates from historical post-storm
oblique aerial photographs and measurements of modern post-storm profiles. Two alternative methods to the FEMA methodology are tested and their results are compared.

In the first method, wave heights in the inundation zone are simulated using the phase-averaged 2-D wave model STWAVE (STeady state spectral WAVE model), combined with an empirical method for estimating wave runup. Storm surge, limits of the inundation zones, and the wave model’s spectral boundary conditions, are specified based on results of the fully coupled 2-D surge and wave models, ADCIRC (ADVanced CIRCulation model) and STWAVE, respectively, from the North Atlantic Coast Comprehensive Study (NACCS) performed by the U.S. Corps of Engineers.

The second method applies the 2-D phase-resolving model FUNWAVE-TVD, also using results of the NACCS study to specify both the wave spectrum and the sea level resulting from the storm surge, at the model grid’s offshore boundary. This model propagates waves in the time domain across the nearshore area and simulates all the physics pertaining to wave propagation: nonlinearity, dispersion, reflection, refraction, breaking and wave runup.

Beach and dune erosion are included in both methods, by assuming the modified beach/dune profile. Different scenarios are presented for different sea-level rise assumptions. The use of different models provides insight into the epistemic uncertainty associated with wave modeling.

(1-A) **Impact of Sea Level Rise on Future Storm-induced Coastal Inundation**

Changsheng Chen, SMAST, University of Massachusetts,Dartmouth, c1chen@umassd.edu, Robert C Beardsley, Woods Hole Oceanographic Institution, rbeardsley@whoi.edu

As supported by the NERACOOS Program, the team of University of Massachusetts-Dartmouth and Woods Hole Oceanographic Institution researchers has established the Northeast Coastal Ocean Forecast System (NECOFS). NECOFS is an integrated atmosphere-ocean model system in which the ocean model domain covers the northeast US coastal region (the New England Shelf, Georges Bank, the Gulf of Maine, and the Scotian Shelf) with a horizontal resolution of 10-15 km in the open ocean, 1-5 km on the shelf, and down to 10 m in estuaries, inner bays, inlets and harbors. NECOFS also includes fully coupled current-wave coastal inundation model systems for Scituate (MA), Mass Bay/Boston Harbor (MA), Hampton River (NH), and Saco Bay (ME). Using this system, we have examined the impact of sea level rise on future storm-induced coastal inundation in Scituate and Mass Bay/Boston Harbor. Experiments were made for hurricanes and nor’easter storms. Our experiments show that as a result of the mean sea level rise, for a given same storm as before, the surface wave height could be significantly increased and thus the surge level. We will face a greater threat from wave runup inundation during hurricanes and nor’easter storms in the future.

(1-A) **Application of high-resolution SLOSH modeling for coastal inundation study under future sea-level rise conditions**

Yong Kim, Applied Science Associates, ykim@asascience.com, Cathleen Turner, RPS ASA, Cathleen.Turner@rpsgroup.com

Coastal infrastructures in addition to coastal communities, ecosystems (i.e. wetlands, critical species, habitat loss), transportation systems (highway systems, ports, rail), economic viability (tourism, transport of goods, natural resources), and energy infrastructure will be at increasing risk of impact from the coupled effects of sea-level rise and storm surge. Coastal areas are at risk for worse inundation in the near future due to sea-level rise, which provides a higher sea level base for future surge and inundation events. In order to assess the impact of coastal inundation due to the combined effect of sea-level rise and tropical storms, Sea, Lake and Overland Surge from Hurricanes (SLOSH) model was implemented to the southern coast of Korea. SLOSH calculates water level from depth-integrated, quasi-linear, shallow-water equations. In this study, a new developed high-resolution hyperbolic mesh grid was applied to Masan area in Korea. The minimum and maximum grid size is 36 and 91 m, respectively. A total of 60 representative potential storm tracks were developed based on preselected four historic storm tracks in the study area. Each storm tracks were assumed to be 2 different
(1-B) Verification of a hydrodynamic model for the Great Bay Estuary, New Hampshire using field data

Salme Cook, University of New Hampshire, sc10@wildcats.unh.edu, Thomas C. Lippman, University of New Hampshire, lippmann@ccom.unh.edu

New England coastal communities and managing entities are developing strategies to handle shifting demands on limited resources impacted by projected changes in sea level, storm intensity and frequency, and climate. Of particular interest in New Hampshire is the establishment of hydrodynamic forecasting capabilities for the Great Bay Estuary that connects to regional Gulf of Maine weather and oceanographic nowcasting models for assisting in emergency and rapid response activities, or can be driven by climate change scenarios for longer-term adaptation planning. In this work, the Regional Ocean Modeling System (ROMS), a three dimensional numerical hydrodynamic model used within the Coupled Ocean Atmosphere Wave and Sediment Transport (COAWST) modeling framework, is implemented into the Great Bay Estuary and compared with observations of currents, water levels, temperature and salinity. The tidally-dominated Piscataqua River connects the Great Bay estuary to the ocean, providing an important ecological, economic, military, and recreational role for both southern Maine and the Seacoast region of New Hampshire. At low stands of the tide almost 50% of the bay is exposed as mudflats which although provide important ecological habitats for fish, oysters, and lobsters, are difficult to study owing to the temporally varying and spatially extensive region where the tides inundate. The ROMS model includes a wetting and drying scheme that simulates the rising and falling tide over the extensive mudflats and allows for flooding across low-lying topographic areas, a successful approach adapted in other regions but not always inclusive of tidal channels that incise the bay. Bathymetric data obtained from UNH, USGS, NOAA, and USACE were used to define a rectilinear model grid with 10 meter resolution. The model is forced with tidal and subtidal data obtained at the Fort Point, NH, NOAA tide station. Observations from field studies conducted in 2007 and 2015 are compared to modeled results in various locations that span the estuary to verify accuracies of the model. The verified model can then be used for a variety of application; for example, basin wide estimates of near-bottom shear stresses are used to estimate first-order nutrient fluxes from sediment sources over a spring-neap cycle.

(1-B) Field and modeling studies of salt marshes in Bombay Hook National Wildlife Refuge, Kent County, Delaware.

Ali Abdolali, University of Delaware, abdll@udel.edu, James T. Kirby, University of Delaware, kirby@udel.edu, Fengyan Shi, University of Delaware, fyshi@udel.edu

We provide an overview of ongoing field and modeling efforts in the tidal salt marshes within the Bombay Hook National Wildlife Refuge (BBH), located along the western shore of Delaware Bay. Salt marshes in BBH are vulnerable to large storms and sea level rise, and have experienced significant degradation over the past 50 to 75 years. The impact of historical modifications to the marsh and a range of possible remedial steps to leading to a healthier marsh environment are being investigated through this study. The complex system is composed of upland habitats, freshwater impoundments and extensive tidal wetlands. The field observations in this study include extensive bathymetric surveying in channels, current velocity measurements using ADCPs deployed in several major channels, tide gauges mounted on marsh platform, and rapid-sampling pressure gauges deployed in a large tidal flat area located within the marsh and isolated from the open water of the Bay. For the modeling study, we have used the unstructured grid model, FVCOM, which covers the entire marsh system with sufficient grid resolution to resolve small channels and creeks. The grid bathymetric data in channels is based on data collected during an extensive bathymetric survey. The topographic portion of the grid
is extracted from LiDAR data sets. We have implemented sophisticated Artificial Neural Network techniques to remove the vegetation bias, well validated against ground truth survey. The model is driven by current and surface elevations derived from a larger scale ROMS model of Delaware Bay, along with local wind input. The Delaware Bay model incorporates tidal forcing along the outer model boundary (located at the 100m isobaths on the shelf edge), fresh water discharge introduced at the head of the Delaware River at Trenton, and model results archived from the HYCOM model in order to take remotely-forced subtidal processes into account. The model is validated using surface elevations at four tidal gauges and the ADCP current velocity data. Model performance for predicting flooding/draining processes during normal and storm conditions has been examined using the data collected on the marsh platform. Ongoing work is examining model estimated of residual circulation patterns and ebb/flood dominance in the complex, multiply-connected system. We are also investigating the application of subgridding strategies in order to improve modeled hydraulic connectivity between channels and enclosed marsh platform areas, which are presently isolated to too great a degree by channel boundary levees, suppressing inundation and drainage processes in the model relative to field observations.

(1-B) **Models for barotropic and baroclinic circulation in the Choctawhatchee Bay and River System**

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The goal of this study is to examine the mixing of fresh- and saltwater within a highly stratified estuary, and the delivery of freshwater onto the continental shelf during periods of low tide. The study area consists of the Choctawhatchee River and Bay System, which is a site of rich and diverse ecology and a source of economical and recreational benefits to communities in northwest Florida. The bay is situated along the Florida Panhandle and spans portions of northwest Florida and southern Alabama. Numerous rivers and creeks flow into the bay and form bayous along its periphery. The Destin Tidal inlet (also known as East Pass) connects the bay to the Gulf of Mexico and provides a passage for water exchange between the bay and the Gulf. The bay receives 95 percent of its freshwater inflow from the Choctawhatchee River. We study the circulation patterns within Choctawhatchee Bay using the two- and three-dimensional modeling capabilities of ADCIRC (ADvanced CIRCulation), a finite-element nearshore circulation model. The model will be used to study the surface flow characteristics within the Bay and at the Destin inlet before and after incorporating freshwater discharge from the Choctawhatchee River. Starting with an existing triangular finite element mesh with highly-resolved elements that was developed for floodplain mapping along the Florida Panhandle, we incorporated freshwater discharge by refining this mesh to resolve the upstream reaches of the Choctawhatchee River. The two-dimensional, depth-integrated version of ADCIRC is implemented on the modified mesh, and modeled water levels are validated by comparisons with observations at NOAA tidal gauges. The depth-averaged velocities are used to study the flow characteristics inside the bay and at the inlet. The model results show that the depth averaged velocities are significantly influenced by the freshwater discharge from Choctawhatchee River. Then the vertical flow characteristics within the Bay and at the tidal inlet are analyzed and compared with available measurements. The results indicate the presence of a two layered flow system within Choctawhatchee Bay with limited mixing. The water levels and depth averaged velocities from the two dimensional implementation of the circulation model are compared with the water levels and surface currents obtained from the three-dimensional implementation. The limitations of the barotropic approaches used in the present study for modeling estuarine conditions and the need for a three-dimensional, baroclinic approach are explored.

(1-B) **Understanding oyster growth in the Damariscotta River using a coupled hydrodynamic – biogeochemical model**

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As climate change continues to alter marine ecosystems through fluctuations in ocean temperature, salinity, pH, and sea level, understanding how estuaries will respond to these stressors is critical to sustainable management of human activities such as aquaculture. Approximately 70% of all oysters produced in Maine are grown in the Damariscotta River Estuary. Studying this system will help us to evaluate the interactions between shellfish aquaculture and this estuary in the context of these environmental stressors. Specifically, increased understanding of this system will allow us to define the limitations and opportunities for aquaculture expansion throughout the state. We are developing a coupled hydrodynamic-biogeochemical model (FVCOM-RCA) of the Damariscotta River that will focus on understanding aquaculture productivity. The model will incorporate parameters such as temperature, salinity, nutrient concentrations, fresh water flow, primary production rates, chlorophyll a standing stock, uptake rates by oysters, proportion of food coming from detritus vs phytoplankton, benthic pelagic coupling and remineralization rates, bottom type, and bathymetry. Several questions of interest to explore with the model include: What is the carrying capacity of the Damariscotta River for oysters? Where are the best places in the river for future lease sites? Will decreased pH due to increased freshwater runoff or low pH shelf water intrusion have an impact on growth rates?

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(2-A) **Real Time Guidance for Combined Flooding Hazards and Active Flood Control Structures using the ADCIRC Surge Guidance System**

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The ADCIRC Surge Guidance System (ASGS), a portable and extensible software automation system for ADCIRC and ADCIRC+SWAN, was initiated in 2006 and its capabilities have been steadily broadened since then. ASGS results from the lower Mississippi River flooding of January 2016 will be presented, showing the flow and inundation extents of the Mississippi and Atchafalaya rivers in southern Louisiana, including the historic opening of the Bonnet Carre spillway to divert water from the Mississippi River into Lake Pontchartrain. Driven by the ASGS, ADCIRC accurately simulated the resulting water level changes in real time, and the results were communicated to decision makers through the Coastal Emergency Risks Assessment (CERA) web visualization platform. In the aftermath of the event, the ASGS was used to simulate tropical cyclone storm surge in combination with varying river discharges and spillway activation strategies to characterize the interactions between simultaneous river flooding, storm surge flooding, and active flood control. The results demonstrate the capabilities of the ASGS and CERA to provide guidance to decision makers in real time for multiple simultaneous coastal flooding phenomena.

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(2-A) **A Coupled Model Framework for Hurricane Evacuation/Sheltering**

Randall Kolar, University of Oklahoma, Kendra Dresbach, University of Oklahoma, Rachel Davidson, University of Delaware, Brian Blanton, Renaissance Computing, Institute, Brian Colle, Stony Brook University, Tricia Wachtendorf, University of Delaware, Linda Nozick, Cornell University

Three important features of hurricane events that influence evacuations are as follows: (1) they are dynamic, (2) there is great uncertainty in how they evolve, and (3) they involve many interactions within and across the natural, infrastructure, and human systems. The inherent uncertainty and interconnected evolutions of these systems creates a complex situation when it comes to decisions about whether to evacuate or shelter in place. Although there has been a great deal of research on hurricane forecasting and evacuation, and substantial improvement in the state-of-practice of hurricane response has been realized, previous efforts have not fully captured these three key features—dynamics, uncertainty, and system interactions—which inhibits our ability to fully understand and effectively manage them. In this presentation, we outline a fundamentally new, integrated mathematical modeling framework that aims to capture these three aspects of the problem explicitly. More specifically, we model the hazard using an ensemble of probabilistic scenarios that describe the range of ways a hurricane may evolve. For each hurricane scenario, we develop total water level and wind speed maps at each
time step. The framework also captures the dynamic decision-making of emergency managers and residents, as the time and available information change, and the dynamic movement of residents over the course of the event. Overlaying and integrating the results of these models allows us to better examine the interactions within and among the systems through space and time. A multi-stage stochastic programming model integrates the hazard, resident behavior, and traffic modeling to support the dynamic decision-making of emergency managers, as they determine when and where to issue evacuation orders during the course of a hurricane event. In this presentation, we will summarize the individual models that make up the framework, how they are dynamically coupled, and the type of results that we may expect, based on a test case taken from Hurricane Isabel in 2003.

(2-A) **Effect of Wind, Waves, and Precipitation Runoff on Coastal Flooding due to Land-falling Tropical cyclones in the Narragansett Bay Region: Results from Coupled ADCIRC/SWAN Simulations**

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Coastal flooding resulting from the impacts of land-falling tropical cyclones in Narragansett Bay (Rhode Island) is investigated using the Advanced Circulation Model (ADCIRC) coupled with the Simulating Waves Nearshore (SWAN) model. ADCIRC is forced with tides from a TOPEX/Poseidon inverse solution (TPXO7.2) and wind forcing from both parametric hurricane models based on NOAA's Tropical Cyclone Extended Best Track dataset and hurricane prediction models. The model incorporates wetting and drying as well as inflows from the USGS Precipitation-Runoff Modeling System (PRMS). Model results are validated using water level observations from Narragansett Bay during Hurricane Bob, which made landfall in the region in August 1991. Additional results will be presented showing the response to "Hurricane Rhody", a hypothetical storm generated using NOAA hurricane prediction models, which will illustrate a high-impact scenario for this region. The relative importance of wind, waves, and runoff on coastal flooding will be shown with simulations forced by wind only, wind and waves, and de wind waves and runoff combined.

(2-A) **Probabilistic Storm Surge Risk Assessment Using a Synthetic Hurricane Database**

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Storm surge inundation is a major threat to coastal cities. Climate change effects on cyclone formation and sea levels will increase potential future impacts. Quantifying these risks is necessary for the most efficient use of limited resources available to stakeholders for mitigation planning. A fully probabilistic storm surge risk assessment approach was developed for the Port Authority of New York and Jersey (PANYNJ). This effort involved the application of a synthetic tropical cyclone track database, from which approximately 8,000 storms impacting the NY-NJ region were identified. Storm surge inundation histograms were developed at critical locations by simulating the peak surges of all hurricanes in the database using the SLOSH and ADCIRC models. This process was repeated for both current and future climate scenarios. The use of a large database of storm tracks enabled the estimation of the probability of specific flood scenarios known to have the greatest impact, instead of relying only on the traditional 100- and 500-year floodplains derived from limited historical data. A GIS-based analysis revealed the extent of flooding in specific scenarios at PANYNJ facilities. Flood probabilities were combined with detailed analyses of socio-economic consequence resulting from Port Authority asset failures to determine storm surge risk. Analysis results can be used to evaluate the effectiveness of proposed flooding countermeasures and to assess the cost-benefit of investing in proposed mitigation projects.
(2-B) Residence Time Variability in Response to Circulation Scenarios in a Back-Barrier Estuary


Hydraulic residence time, the amount of time a water parcel remains within a domain, can help explain water quality patterns. We analyzed the residence time in Barnegat Bay, New Jersey, USA through hydrodynamic and particle tracking modeling, while exploring the seasonal dependence by comparing results from two 2-month long simulations in the spring (March-April) and the summer (June-July) of 2012. We also explored changes in the residence time under three hypothetical scenarios to improve flushing of the bay: increased fresh water input and an additional inlet at two different locations. The fresh water input scenario was based on diversion of treated fresh water, which is currently being released offshore, back into the bay. This was implemented by increasing fresh water input by ~1 m3/s at Metedeconk and Toms Rivers in the north and Mill Creek in the south. For the inlet scenarios, an inlet with a uniform cross-section (2 m deep by ~125 m wide) was placed first across the Toms River tributary, concurrent with the relict Cranberry Inlet, and then alternatively at Normandy Beach near Long Island Cove. Preliminary results indicate an overall larger residence time in the northern half of the bay (up to >50 d) under the existing circulation conditions. The extent of the area with longer than 40 d of residence time is larger during summer resulting in a slight increase in the bay-wide mean residence time (17 d in spring versus 18 d in summer). Both inlet alternatives provided substantial reductions in residence time in the northern parts of the bay, however greater flushing over a larger area was achieved with the first inlet case. Fresh water diversion provided a noticeable change in the salinity climate of the northern bay (e.g. about 1.5 psu decrease in depth and time averaged salinity in August) because of the low salinity (0 psu) inflow. However, the impact on the residence time was considerably smaller than an additional inlet scenario because of the smaller impact on the residual circulation.

(2-B) The Oceanography and Sediment Dynamics of Nass Bay and Iceberg Bay, British Columbia: Role of the Nass River

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Nass Bay and Iceberg Bay are small adjoining tidal inlets located within the northern inland waters of British Columbia, Canada. In this study, we use advanced 3D numerical modeling methods combined with in-situ oceanographic measurements and satellite imagery to reveal the physical oceanographic and sediment transport regime of Nass and Iceberg Bays. The tides in Northern British Columbia are very large with tidal heights of up to 6 m. Nass Bay is a very shallow inlet of less than 10 km in length with typical water depths of less than 10 m or less. The Nass River, the second largest river of northern British Columbia entering Pacific Ocean waters, discharges into the western end of Nass Bay. Nass Bay, in turn feeds into Portland Canal and the fresh surface waters then flows westward to the Pacific Ocean via Dixon Entrance. The larger water depths in the immediate study area are confined to the adjoining Iceberg Bay, which extends down to 80 m depth. The existing knowledge of oceanographic processes in Nass Bay was rudimentary until three years ago, when the first modern oceanographic measurements were obtained. This is due in part to its shallow waters as compared to the typically much deeper, more accessible fjord-like inland water bodies of northern British Columbia. In this study, a very high resolution coupled hydrodynamic-sediment transport and fate model was developed for the combined areas of Nass Bay and Iceberg Bay within the widely used and accepted Delft3D modeling framework. The model uses 10 z-layers in the vertical and has a horizontal grid resolution of 35 m over most of its domain. with a higher resolution of up to 10 m in some nearshore areas. Open boundaries are defined at the estuary of the Nass River and at the mouth of Nass Bay at Portland Canal. The hydrodynamic portion of the Delft3D model was verified using moored Acoustic Doppler Current Profiler (ADCP) data collected in Nass Bay in 2015. The model simulated current profiles are shown to be in good agreement with observations. The ocean circulation of Nass and Iceberg Bays was found to be dominated by tidal currents, and by the highly seasonal and variable Nass River freshwater discharges. Complex lateral spatial patterns in the tidal currents occur due to the opening of the south side of Nass Bay onto the deeper adjoining waters of Iceberg Bay, Surface winds are limited to a secondary role in the circulation variability. The sediment dynamics of the Nass Bay system features a very prominent surface sediment plume present from the time of freshet in mid-spring through to large rainfall runoff events in the fall. The time varying turbidity distribution and transport paths of the Nass River sediment discharges in the study area were characterized using the model results combined with an
analysis of several high resolution Landsat satellite data sets, available over different times of the year from 2008 to 2015.

(2-B) Modeling Potential Circulation Improvements in Old Tampa Bay

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The Courtney Campbell Causeway (CCC), which spans the northern portion of Old Tampa Bay between the cities of Clearwater, FL and Tampa, FL, was constructed in the early 1930s, a time in which Old Tampa Bay was considered to have good water quality. Aerial photographs show evidence that the construction of the CCC changed the environment to the extent that seagrass could not grow in that area, even while adjacent waters supported extensive seagrass meadows. Previous studies concluded that the modification of the CCC to allow for the restoration of lost historical tidal influences in northeastern Old Tampa Bay is likely to result in an ecological response greater in magnitude than that which could be provided with treating stormwater runoff with traditional treatment systems.

This study involves the development and application of a Delft3D hydrodynamic numerical model to quantitatively evaluate how circulation within the portion of Old Tampa Bay northeast of the CCC is altered and improved by the addition of a conceptual bridge opening through the causeway. Of particular interest is the notion of flushing and residence time, and to what degree potential modifications to the system can increase water exchange with greater Old Tampa Bay, reduce residence time, and, by extension, improve water quality and seagrass suitability. To assist in model validation, a field data collection effort was also undertaken.

Two model domains were developed in order to properly simulate the circulation within Old Tampa Bay and resolve the spatial details in the vicinity of the eastern CCC. The larger Tampa Bay model domain encompasses the entirety of Tampa Bay and extends outward into the Gulf of Mexico to a maximum depth of about 30 m. The nested model, which is driven by the results of the main model, encompasses the areas immediately surrounding the eastern side of the CCC, where the proposed circulation enhancements would be located. This grid has a uniform spatial resolution of about 10 m.

Model results indicate that a 200 ft width bridge, similar to an existing bridge on the eastern side of the causeway, opening increases the exchange between the area of concern and greater Old Tampa Bay. Within the area of concern, adding the 200 ft opening reduces residence time (defined at time to reach 50% of initial concentration) from about 3 days to about 1 day, location dependent. After 7 days, the peak concentrations in the area of concern is about 50% lower with the 200 ft opening versus without. In addition, the increased flushing does not appear to have a significant negative impact on the areas outside of the area of concern.

(2-B) Investigation of Vertical Structure in the Baltic Sea

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The Baltic Sea, with its gentle temperament and astonishing beauty, has in many centuries served millions of people in the nine neighboring countries. It has brought prosperity and progress through its vast resources and the diversity of its nature. Yet the environmental costs have been high, partly by insufficient understanding of the Sea and its marine environment and partly fueled by non-sustainable growth demands. In spite of the Baltic Sea HELCOM agreement undersigned in 1974, the state of the Baltic Sea has worsened over the years. Nutrient levels in the water and sediments are high, and poor oxygen conditions and “dead bottoms” exist in large archipelago areas of both Sweden and Finland. In the beginning of 2009, a new project called SEABED was formulated to address the internal phosphorous loading in various archipelagos using coupled 3D hydrodynamic and water quality models. The hydrodynamic and transport characteristics of the Baltic Sea in the period 2000-2009 was studied using a fully calibrated and validated 3-D hydrodynamic model with a horizontal resolution of 5 km. The novelty of our approach lies in the implementation of fully transient river inflow boundary conditions, close examination of the bathymetry and the forcing meteorological condition. The other new aspects are the extensive application of the Particle Tracking Model (PTM) and vertical structure analysis. This
study provided new insight into the type and dynamics of vertical structure in the Baltic Sea, not considered in previous studies. The four main areas addressed were stratification, exchange processes, vertical structure, and particle tracking at selected depths. The study addressed both the thermal and salinity stratifications with the focus on the structural properties of the layers. The detection of cooler regions (dicothermal) within the layer structure has been an important finding. The detailed investigation of thermal stratification for a 10-year period (i.e., 2000-2009) revealed some new features. A multilayered structure that contains several thermocline and dicothermal layers prevails. Statistical analysis of the simulation results made it possible to derive the mean thermal stratification properties expressed as mean temperatures and the normalized layer thicknesses. The three-layered structure reported in literature appears to be rather over simplified. We have found the three-layered model to be valid only during the winter periods. Following the winter period, the three-layered structure is decomposed into several layers (i.e. upto 5). The process takes place in all the basins. The primary mechanism is the increased mixing during the ice free periods. The freshwater inflow contributes both by its high momentum and temperature differences with the ambient surface water. The latter increases the convective transport within the upper surface waters. The vertical temperature gradients are significantly lower in the southern basins (a factor of 3). The differences is due to the formation of an ice cover during winter and spring periods in the northern basins, which affects the surface heat transfer and its exchange with the overlying cold air. The good correlation between water and air temperatures suggests that the thermocline dependency on the atmospheric forcing fluctuations.

(3-A) Advancing Storm Surge and Inundation Models Through Enhanced Physics of the Air-Sea-Wave Coupling

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We present an innovative methodology for coupling storm surge and wave models to obtain a more accurate flooding representation under hurricanes. It is based on previous URI research to develop coupled hurricane-wave-ocean models for operational applications. Specifically, the new storm surge - wave model coupling is accomplished by extending the Air-Sea Interface Module (ASIM), originally developed at URI for deep-water conditions, to finite/shallow water conditions. The ASIM accounts for all significant surface wave effects on ocean currents and sea surface levels, including the radiation stress, time growth/decay of surface waves, and the Coriolis-Stokes force. In addition, it includes sea-state dependent air-sea fluxes and ocean mixing (Langmuir turbulence). The ASIM is implemented into the ADCIRC and ROMS coastal circulation and storm surge models coupled with the SWAN wave model. We present the results of sensitivity experiments to different components of the air-sea-wave coupling based on simulations of Hurricane Bob that made landfall in Rhode Island as a Category 2 hurricane on August 19, 1991.

(3-A) The Effects of land cover and associated bottom friction on Computation of Surge Inundation Extent

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The coastal and estuarine storm tide (CEST) model developed in International Hurricane Research Center (IHRC) is a model has a potential to satisfy the National Hurricane Center (NHC)’s operational needs for storm surge forecasting. The CEST model over orthogonal curvilinear grids can run on conformal grids such as those used by Sea, Lake, and Overland Surges from Hurricanes (SLOSH) without additional modification of the numerical algorithms. Here we present results from a fielded project to compare the maximum envelope of water (MEOW) and maximum of MEOWs (MOMs) produced by CEST with the SLOSH results using the same mesh. Using Apalachee Bay in northwest Florida as an example, the CEST model produced comparable surge heights for both the MEOWs and MOMS to those obtained by SLOSH. However, the maximum inundation
extent generated by CEST is smaller than the one produced by SLOSH. We further conducted numerical experiments and found that this discrepancy is likely caused by the different bottom friction parameterization used in CEST and SLOSH. In CEST, the effects of land cover on bottom friction were considered by introducing various Manning coefficients based on the national land cover dataset (NLCD). It is apparent that the effects of land cover and associated bottom friction have significant influence on the modeled inundation extent and should be considered to improve model performance.

(3-A) Model Setup, Validation, and Application for the South Florida Storm Surge Modeling Project

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As part the Federal Emergency Management Agency (FEMA) effort to better assess and communicate hazards and risks associated with coastal flooding, FEMA Region IV has contracted the BakerAECOM team to conduct a study along the south coast of Florida — from Palm Beach County through Monroe County. As a BakerAECOM team member, Taylor Engineering leads the project’s Phase 1 tasks to develop and execute the two-dimensional hydrodynamic and wave model necessary to develop new 1 percent annual chance event elevations for storm surge. The study is applying a fully coupled ADCIRC (hydrodynamic) and SWAN (spectral wave) model to develop surge and wave estimates from a suite of historical and synthetic storms.

The presentation will discuss the hydrodynamic and spectral wave model setup, validation, and execution. The discussion will build on the team’s 2015 Conference presentation that detailed how floodplain and coastal features are included within the refined model mesh created for the study area. Specifically, the presentation will detail how model validation results demonstrate the model’s ability to reproduce measured water level and wave data in the study area, which contains a varied bathymetry and topography that creates a challenging environment for numerical models. Discussion will also detail the storm suite designed to produce the 1% annual chance water levels in the study area. Presentation slides will discuss implications of model resolution limits and, within the context of the model validation effort, the model’s ability to capture floodplain and beach profile features important to storm surge propagation in south Florida.

The presentation topic should prove relevant to those conference attendees interested in coastal management and coastal processes analysis and modeling. Study results will provide the basis for revised surge/return period estimates, FIRMs, and coastal planning regulations that affect coastal homeowners, local and state officials, and floodplain managers.

(3-A) The Effect of Bottom Friction, Surface Roughness, and Meteorological Forcing in Hurricane Storm Surge Simulation Using SWAN+ADCIRC Model

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This study investigates the effect of different meteorological forcing options in Hurricane Rita (2005) storm surge simulation using the ADVanced CIRCulation (ADCIRC) hydrodynamic model, coupled with the Simulating WAves Nearshore (SWAN) spectral wave model. This includes a parametric study of bottom friction and surface roughness length to assess their effects on storm surge simulation. Capturing the bottom friction and surface roughness by using the best meteorological forcing option is fundamental in obtaining accurate water levels in storm surge modeling. Reliable model results are critical to emergency management officials and the public to aid decision-making and ensure loss of life is minimized. In addition, accurate results are essential in designing risk analysis in coastal structure protection, which drives local development and government subsidized insurance. In this investigation, ADCIRC runs as a two-dimensional depth integrated (2DDI) model on an unstructured, finite mesh. It utilizes the depth-integrated continuity equation in Generalized Wave-Continuity Equation (GWCE) form to attain elevation, while velocity is the solution of the 2DDI momentum equations. SWAN employs wave propagation while considering wave generation by wind, whitecapping, and depth-induced wave breaking. Integrated and tightly coupled, SWAN and ADCIRC run on
the same global unstructured mesh, resulting in the SWAN+ADCIRC model. The base model of this study is taken from Kerr et al. (2013). A spatially varying Manning’s n coefficient and directional surface roughness lengths are used, along with different meteorological forcing options for parametric simulation. By applying a broader range of values compared to those used by Kerr et al., a parametric matrix was developed to analyze frictional and surface roughness effects. Hurricane Rita hindcasts from SWAN+ADCIRC illustrate the effects of different meteorological forcing. A large amount of data are available for this hurricane. The water level results are compared to published data and the base model results for validation in an effort to determine the best parameters for storm surge modeling.

(3-A) *Assessing coastal flooding vulnerability at two critical locations in Islesboro, Maine*

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Coastal communities often rely on available information from regional numerical modeling studies to understand their vulnerability to coastal flooding hazards. Recent studies undertaken by the Federal Emergency Management Agency (FEMA) and the United States Army Corps of Engineers (USACE) now provide hazard information for nearly all of the East coast and Gulf of Mexico coast in the United States. Along the Maine coast the best available coastal flood hazard information comes from the USACE North Atlantic Coast Comprehensive Study (NACCS), which utilizes tightly coupled ADCIRC and STWAVE modeling to simulate tides, storm surge, and waves for extreme events including both tropical and extratropical cyclones. Such studies are regional in scale, and as such they may not provide a sufficient level of detail to assess the flood hazard for individual communities, particularly in areas with highly complex coastal features like the Maine coast. When it is necessary to evaluate the hazard at specific locations communities can benefit from additional local-scale analyses based on refined modeling driven by the regional model results. Here we present an example application utilizing the model output data from the NACCS to drive local-scale modeling and analysis of the storm surge and wave hazard at two critical locations in the Town of Islesboro, Maine. These locations include Grindle Point and the Narrows. Grindle Point is the home of the Ferry Terminal which provides access to the mainland. The Narrows is a narrow section of the island that provides part of the town with the only over-road access to public services including the school, fire department, and health center. We describe the methods employed to downscale the NACCS information for these specific locations, present the results in terms of coastal flooding risk, and then discuss possible actions to mitigate the risk.

(3-B) *A cross-scale baroclinic model of the Chesapeake Bay and the coastal ocean*

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The Chesapeake Bay is challenging for baroclinic models due to its large size, complex geometry and periodic strong stratification. We demonstrate a seamless tributary-Bay-ocean model (SCHISM) with newly developed techniques that enhance the model’s cross-scale capability. To achieve the desired accuracy, the model grid has high resolutions at selective tributaries of management interest, the Bay main stem, and the shelf outside the Bay mouth. The domain includes coastal ocean up to 5000 meters depth with coarser resolution, to alleviate boundary effects on the simulated shelf dynamics. In the horizontal dimension, the domain is discretized by a hybrid quadrilateral-triangle mesh, with quadrilaterals resolving the main channels so as to accurately simulate salt intrusion. In the vertical dimension, localized sigma coordinates with shaved cells (LSC2) are adopted to reduce unphysical diapycnal mixing and pressure gradient errors where bathymetry gradient is large. To ensure the efficiency and accuracy of the cross-scale transport calculation, an implicit TVD solver with both temporal and spatial limiters is developed basing on the existing works on 1D advection and applied in this model. The model shows good skills at NOAA and EPA stations in the Bay main stem. Moreover, the model proves capable of capturing dynamics at different scales other than the Bay main stem itself. At the smaller-scale tributaries and sub-tributaries, the simulated salinity and temperature match well with the observations at the continuous monitoring stations. While at larger scales, the model manages to capture several distinctive features of the shelf dynamics, including coastal freshwater plume and upwelling. Sensitivity tests show that model efficiency is not significantly affected by the degree of scale contrast.
(3-B) **Tidal datum changes induced by location and geometry alterations of North Carolina coastal inlets**

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In support of NOAA’s VDatum program, tidal datums (e.g. Mean High Water and Mean Low Water) in the North Carolina coastal regions and Pamlico Sound need to be updated to cover more areas and reflect tide changes induced by bathymetry and shoreline changes. The finite element model ADCIRC is used to investigate tidal variations in these regions. The triangular model grid has spatially varying resolution from offshore 30 km to inland 10 m and is able to resolve well the important inlets and channels. The tide model is validated by comparing modeled harmonics and datums with NOAA observations. The tidal highs and lows from modeled water levels are used to calculate tidal datums. The model results show that the new tidal datums have significant changes relative to those from the previous VDatum model which used the old shoreline and bathymetry data. Further investigation revealed that these tidal datum changes are mainly due to location and geometry alterations of the inlets, suggesting that the tides propagating into Pamlico Sound through various inlets have strong interactions with each other.

(3-B) **An Investigation into the Influence of Coastal Islands on River Water Distribution and Mixing in Western Long Island Sound**

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The Saugatuck, Norwalk, and Five Mile Rivers enter western Long Island Sound (LIS) adjacent to a chain of islands. These islands can influence the exchange of river water with the broader estuary. A modeling approach is taken to determine the influence of these islands on the flow pathways and mixing of these coastal river waters. Prior research used a LIS-wide application of the Regional Ocean Modeling System (ROMS) and passive tracers to track the distribution of waters from individual major rivers (e.g. Connecticut and Housatonic) and groups of smaller coastal rivers. The western group of small coastal rivers (including the Saugatuck, Norwalk and Five Mile Rivers) was found to contribute less than 10% of the freshwater in western LIS. The farther removed but larger Connecticut and Housatonic collectively account for more than 75% of the freshwater. These small coastal rivers, however, were found to enhance coastal stratification in early summer more so than the larger rivers. The LIS-wide model, however, lacked adequate resolution to include the island chain and its effects on circulation and freshwater distribution. Recent observations have suggested that these islands can enhance mixing in specific areas around the islands. A new high resolution nested grid is applied to this area in ROMS to resolve the islands and to isolate their effects. Model output and data collected during the summer of 2015 low discharge season are used for comparative purposes and to determine the overall influence of these islands on the flow pathways and mixing of coastal river waters. Preliminary results show the islands causing a change in the tidal range and average of surface salinity behind them. The islands were also found to enhance mixing power in some of the island passes per the Simpson-Hunter parameter and to increase flow perpendicular to the mainland's shoreline. Changes in the average salinity field suggest that the islands increase the movement of more saline water inland.

(3-B) **The Effect of Cross-channel Bathymetry on Lateral Density Responses under Different Wind Directions in an Estuary**

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For an estuary with an asymmetric cross-channel bathymetry (for example, a reservoir-like shape), the density responses are different under the forcing of winds from two opposite wind directions. For a moderate wind blowing from the shallow to the deep, the water column tends to be vertically stratified; by contrast, for a wind
blowing from the deep to the shallow, the water column tends to be vertically well-mixed. The different
response of vertical density profile to the winds of opposite directions (but the same magnitude) is the result of
density re-adjustment (in a stratified water) to the modulation of the vorticity changes induced by the upslope
and downslope bottom boundary layer (BBL) flow. For an upslope flow, the BBL flow tends to decelerate and
locally well-mixed, leading to a more stable stratified condition in the ambient outer flow; whereas during the
downslope flow, the BBL flow tends to accelerate and locally re-stratified, leading to a well-mixed condition in
the ambient outer layer. Both the analysis and the numerical results will be presented.

(3-B) Hindcast Simulations toward the Development of
NOAA’s Gulf of Maine Operational Forecast System

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NOAA National Ocean Service (NOS) is developing an operational nowcast/forecast system (GoMOFS) for the
Gulf of Maine. The system aims to produce real-time nowcast and short-range forecast guidance for water
levels, 3-dimensional currents, water temperature, and salinity over the broad GoM region. It will support the
GoM harmful algal bloom (HAB) forecast, and marine navigation, emergency response, and environmental
management communities.

GoMOFS will be implemented using the Regional Ocean Model System (ROMS). The model grid has
dimensions of 1173 by 777 with 700-m resolution. The domain goes from the western Rhode Island coast and
the mid-coast of Nova Scotia, Canada, with an open ocean boundary extending beyond the shelfbreak south of
Georges Bank. It resolves major coastal embayments such as Cape Code Bay, Boston Harbor, Casco Bay,
Penobscot Bay, and the Bay of Fundy. However, the 700-m resolution prohibits the model from resolving small
scale coastal features such as navigation channels and river courses.

We conducted a one-year (2012) hindcast simulation. The model was configured with 30 sigma layers. It used
the ROMS wetting and drying feature, quadratic bottom friction scheme, and the two-equation model of the
Mellor-Yamada Level 2.5 turbulence closure scheme. For the open ocean boundary, we adopted the implicit
Chapman condition for a free surface, the Flather condition for the 2-D momentum, and the radiation-nudging
condition for the 3-D temperature, salinity, and velocity.

The data and forcing used for the hindcast simulation includes atmospheric forecast guidance from the
NOAA/NWS North American Mesoscale (NAM) numerical weather prediction modeling system, real-time
oceanographic observations from the NOS Center for Operational Oceanographic Products and Services (CO-
OPS), river discharge observations from U.S. Geological Survey gauges, and open ocean boundary conditions
derived from the NWS Global Real-Time Operational Forecast System (G-RTOFS) and the TPX08-ATLAS
tidal database of the Oregon State University.

We assessed the model skills for water level, currents, temperature, and salinity using in-situ observations
collected by the CO-OPS water level and weather stations, the National Data Buoy Center, and the Northeastern
Regional Association of Coastal and Ocean Observing Systems. The results indicate favorable agreement
between observations and model forecasts. The root-mean-squared errors are about 0.11 m for water level, less
than 1.5 oC for temperature, less than 1 psu for salinity, and about 0.1 m/s for currents.

We are currently working on transitioning the hindcast model configuration into the standard NOS
nowcast/forecast setup. NOS anticipates completing the system development and the transition into operations
in early 2018.

(4-A) An Exploration of Wind Stress Calculation Techniques in Hurricane Storm Surge Modeling

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This study examines and assesses the current wind stress formulae in the ADvanced CIRCulation hurricane storm surge model, coupled with the Simulating WAves Nearshore spectral wave model (SWAN+ADCIRC). The project will (1) examine old and new wind forcing formulae, (2) examine default wind stress parameterizations in SWAN+ADCIRC, (3) analyze errors and shortcomings in the default wind stress settings, (4) modify current formulations or devise a new formulation to reduce errors, and (5) compare simulated results using default parameterizations versus new parameterizations.

The conventional method for measuring wind stress is $\tau = \rho \cdot C_d \cdot U_{10}^2$, where $\tau$ is wind stress, $\rho$ is the density of air, $C_d$ is the drag coefficient, and $U_{10}$ is the wind speed at 10 meters. Density is a constant variable, wind speed is a measured variable, and the drag coefficient is calculated at choice. This research focuses on the flexibility in calculating the drag coefficient.

A historical variety of drag coefficient formulae from published research articles are reviewed. It is hypothesized that the default settings in SWAN+ADCIRC overestimates the drag coefficient. Thus, hindcasts using the default drag coefficient formula are analyzed in SWAN+ADCIRC. Simulations incorporating a modified parameterization are analyzed. The trials are compared against each other for errors and shortcomings.

The final result is a drag coefficient formula recommendation for SWAN+ADCIRC. This will improve intensity forecasts in storm surge modeling, benefiting local and national government authorities, assisting insurance agencies, and most importantly, preventing the loss of life.

This study is supported by an HBCU-UP Research Initiative Award grant from NSF to Dr. Muhammad Akbar, Assistant Professor, Tennessee State University.

(4-A) Development of the Fully Adaptive Storm Tide (FAST) Model for High Resolution Storm Surge Inundation

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A new state-of-the-art model (the Fully Adaptive Storm Tide model, FAST) for the prediction of storm surges over complex landscapes is presented. The FAST model utilizes an explicit Riemann solver type finite-volume method to solve the flux conservative (divergence) form of the non-linear shallow water equations. The model employs a structured Cartesian mesh with tree-based adaptive mesh refinement (AMR) with the option of using localized time steps to accommodate the high-resolution LiDAR data. The model is well-balanced and handles wetting and drying naturally over complex topography as an inter-cell Riemann problem. The FAST model can be driven by tidal boundary conditions and wind and pressure fields that are generated by the parametric Holland or SLOSH wind models, or the grid-based fields from observations or wind forecast models. Additionally, both single processor-based and fully parallelized FAST using the openMPI framework have been developed. The FAST model has been carefully verified against a series of benchmark type problems and been employed to simulate the storm tide and associated inundation due to Hurricane Sandy (2012). The model incorporates high resolution LIDAR data for the major portion of the New York City. The comparison of Results indicated that the computed storm surges matched with the water elevations measured by NOAA tidal gauges and by the mobile sensors deployed by the USGS.

(4-A) Application of the forward sensitivity method to a GWCE-based shallow water model

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ADCIRC, a widely-used estuarine and coastal model, is based on the generalized wave continuity equation (GWCE), which contains a numerical parameter (G or tau0) that controls the balance between the pure
primitive form (G -> infinity) and a pure waveform (G -> 0). Many attempts over the years, both empirical and analytical, have tried to define the "optimum" value of G for a given application. While much progress has been made, there is still limited understanding of the how the choice of G affects the dynamics represented by the underlying equations. Herein, we employ a new technique, the Forward Sensitivity Method (FSM), to a GWCE-based shallow water model to analyze the sensitivity to the numerical parameter, G, that determines the balance between the wave and primitive forms of the continuity equation. Results show that the sensitivity to G calculated in the sensitivity evolution portion of the FSM is consistent with the actual sensitivity to G computed from multiple simulations using finite differences. The data assimilation step in the FSM is shown to be effective in correcting selection of G based on model sensitivities and model errors. Additionally, the FSM sensitivity results show 2Ax oscillations in the elevation and velocity fields develop when G is increased too high, suggesting the FSM may be an effective tool for determining the upper limit of G for real-world applications.

(4-B) The Nutrient and Biomass Cycle in San Francisco Bay: A Modeling Study

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San Francisco Bay (SFB) is a populous region surrounding the San Francisco and San Pablo estuaries in Northern California with high anthropogenic nutrient inputs, which has important interplay with human population and economics. A coupled physical-biogeochemical model is used to study the nutrient and biomass cycles in the San Francisco Bay and Delta Ecosystem (SFE). The hydrodynamical processes are simulated by Semi-implicit Cross-scale Hydroscience Integrated System Model (SCHISM), and the biogeochemical processes use the Carbon, Silicate, Nitrogen Ecosystem Model (CoSiNE). Rivers in the bay play an important role in modulating the magnitude of blooms by regulating the nutrients concentrations, residence time and the washout flows. In addition, USGS data show that during two years with contrasting hydrological conditions, that is, the year of 2011 (wet year) and 2012 (dry year), the nutrients and chlorophyll concentrations are different with lower concentrations in 2011. To look at the rivers’ impacts on the ecosystem in SFB, we simulate the ecosystem during 2011 and 2012.

(4-B) Space time evolution of the trophic state level of Lagoa da Conceição, a choked coastal lagoon in the island of Santa Catarina - Brazil

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This research aims to evaluate the temporal evolution of the trophic state level of Lagoa da Conceição, a choked coastal lagoon located in the central eastern region of the island of Santa Catarina - Brazil. Recent researches indicate that 61% of the world population lives in coastal regions (Bianchi, 2007). The 2010 Census of IBGE (Brazilian Institute of Geography and Statistics) showed that Florianópolis has an average population density of 624 hab./km about ten times higher than the state average. Moreover, according to CASAN (Company of Santa Catarina Water and Sanitation) watershed monitored has about 13.5% coverage by sewerage networks. Among the different types of impact can be observed algal bloom, toxicity and anoxia (Fonseca, 2004), (Fontes, 2007), (Dias, 2010). Was calculated the Trophic State Index (TRIX - Vollenweider, 1998) over the period 2001 to 2015 and compared to urban expansion rate in the watershed. The analysis was made on bibliographical data source - from 2001 to 2014, and, data collection done on field during the year 2015. It was also made a literature review in morphological and hydrodynamic data. By nonparametric tests was found at the level of 99% confidence a change of the trophic level oligo-mesotrophic to meso-eutrophic from the year 2007. In addition, through a principal components analysis was observed a change in the metabolism of ecosystems: the predominance of a autotrophism in the first period to a predominance of heterotrophism in the second. A cluster
(4-B) The Interaction of Hydrodynamics and Harmful Algal Bloom in the Tidal James River, Virginia

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The James River is a western tributary of the Chesapeake Bay. In recent years, harmful algal blooms (HABs) have frequently occurred in both its upstream tidal fresh region and downstream polyhaline regions. In the tidal fresh portion of the James River, chlorophyll-a persistently elevated during the May-October period due to a limited mobility of phytoplankton caused by the transition from a riverine-type (narrow channel) morphology to a broad channel with shallow lateral areas providing favorable dynamic and light conditions for the cyanobacteria (Microcystis). The dinoflagellate Cochlodinium polykrikoides bloom often starts in the Lafayette River and the bloom extends to the James River due to the unique geometry of the lower James River and the eddy system, which transport algal from Lafayette River and Elizabeth River to the mesohaline region of the James River. To understand the interactions of hydrodynamics and phytoplankton and their swimming capability and ability to uptake organic nutrient, a three-dimensional model system is developed for the James River under the support of Virginia Department of Quality. The model has been calibrated for a long-term period of 15 years. The model can adequately simulate mixing and estuarine processes, transport time, and residence time. The influences of hydrodynamics on HAB have been investigated through model simulations of phytoplankton and their transport timescales. Findings as to how estuarine circulation, residence time, and vertical stratification contribute to phytoplankton bloom and bloom extent, including HABs, will be presented.

(5-A) Directional Wave Modeling on Fringing Reefs at Hilo Harbor, Hawaii

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Hilo Harbor is a major deep-draft commercial port located in Hilo Bay on the northeastern coast of the Big Island of Hawaii, USA. It is protected by a two-mile long rubble-mound breakwater, also known as the tsunami barrier to the local, build on a submerged reef ridge along the NNE perimeter of Hilo Bay. A Federal project provides an entrance channel approximately 0.5-mile long and 37 ft deep leading southward from deep water into Hilo Bay east of the tsunami barrier. Inside the bay, the navigation channel, maintained at depth of 35 ft, turns eastward for 1.5 miles over the reef bottom reaching the Harbor. The State of Hawaii's Harbors Division within the Department of Transportation owns and operates four piers within Hilo Harbor. The outer bay is exposed to the NE trades. Tidal range at the bay, between mean lower low water (MLLW) and mean higher high water (MHHW), is 2.3 ft. Although the harbor is sheltered by the long breakwater, seasonal swell from N, NNW, and NNE can be diffracted by the breakwater and deflected from the west shore causing significant surge and seiching at the Harbor. The average crest elevation of the Hilo breakwater is 11 ft above the MLLW in the 1.5-mile long western segment and 15 ft in the 0.5-mile long eastern segment. North Pacific winter storms and potential tsunami threat can push high water over the breakwater and transmit harmful waves to the Harbor. The seiching problem is more pronounced with deeper draft vessels, and over the years, it has been blamed for vessel groundings and damages to both vessels and piers. Numerical wave modeling was conducted to investigate breakwater or channel or turning basin modifications to improve navigation and docking at Hilo Harbor. The fringing reefs present outside the bay, at the entrance, and inside the bay control waves and currents which impact navigation to the harbor. Unfavorable navigation and berthing conditions in this harbor are caused by high-energy swell and storms from NNW, N, and NNE, as well as strong trade winds from NE. Three months of field data collection in summer 2007 and four months of data collected in 2013-14 provided water level and wave data for calibration and validation of the wave model applied in the study. Surveys of breakwater and bay bathymetry were conducted in 2013. A depth-integrated Navier-Stokes directional wave
model was used to investigate wave transmission from Pacific Ocean into the bay and wave seiching inside the bay. The model input is based on directional wind wave data collected from two buoys located offshore of Hilo Bay, and water level data collected from two tidal stations at Hilo Bay and Kuhio Bay. Model simulations were conducted for several seiching conditions induced by sea swell and one moderate tsunami caused by an 8.2-magnitude earthquake occurred offshore the coast of Chile on 1 April 2014. Preliminary model results show good comparison to data. More detail of model results will be provided in the full paper.

(5-A) Modeling Sediment Transport using the Geophysical Scale Hydrodynamic and Sediment Transport Modeling System

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The U. S. Army Corps of Engineers (USACE) Coastal & Hydraulics and Environmental Laboratories at the US Army Engineer Research and Development Center have jointly developed the Multi-Block Geophysical Scale Transport Modeling System (GSMB). GSMB was developed to accommodate the need for large scale projects and regions and overcome the computational inefficiency of existing single processor transport models. Utilizing this system, we have successfully completed a number of large scale hydrodynamic, sediment and water quality transport studies in support of USACE District Projects. These studies include sediment transport in Upper Cook Inlet, AK; water quality and sediment transport in Mobile Bay, AL; stability of placed dredge material in Duluth Harbor, MN; contaminated sediment transport in Grand Traverse Bay, Lake Superior, MI; and sediment transport in Calumet Harbor and River in southern Lake Michigan, IL. The model framework of GSMB is composed of multiple well established and USACE accepted process models. These include: the two-dimensional (2D) deep water wave model WAM; shallow water wave models STWAVE and CMS-WAVE; and the ADCIRC hydrodynamic model, which are utilized to provide forcing to the three-dimensional components CH3D-MB, the multi-block (MB) version of a highly modified and improved CH3D-WES, the MB CH3D-SEDZLJ sediment transport model and the CE-QUAL-ICM water quality model. The GSMB modeling methodology, future development and its significance to the advancement of large scale hydrodynamic, sediment and water quality transport modeling is described. In addition, two of the more recent studies performed for the Detroit District are described in this presentation. First, a model study of Arsenic and Copper contaminated sediment transport in Grand Traverse Bay. The source of the contaminated sediment is the Copper mining remnant Stamp Sands placed along the shoreline near Gay, MI. The Stamp Sands have been transported along and offshore of the Keweenaw Peninsula eastern shore for several decades. GSMB was applied to estimate the future alongshore and offshore distribution of the deposits due to waves and nearshore currents as well as the impact of alternative management actions. The second, modeling resuspension and transport of dredge material placed in beneficial use areas within Duluth Harbor. This model study provided estimates of the location and quantity of net erosion that occurs in proximity to the designed islands and shoals features and the transport of the resuspended sediment over the simulated events.

(5-A) Assessing performance of different wave breaking parameterizations over shallow water in spectral ocean wave models

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Depth-induced wave breaking is one of important dissipation mechanisms for ocean surface gravity waves in shallow waters. Various parametric energy dissipation schemes were suggested for parameterizing this process in ocean wave models. In this study the performance of five parametric schemes for depth-induced wave breaking specified in the third generation spectral wave models is assessed. The main differences between these five schemes are different representations of breaker index and fraction of breakers. The parameterization suggested by Battjes and Janssen (1978, BJ78) considers a constant value of breaker index and uses a truncated Rayleigh distribution to estimate the fraction of breakers in random wave field. The other four schemes are those suggested respectively by Nelson (1987, NE87), Thornton and Guza(1983, TG83), Ruessink et al. (2003, NE87), Thornton and Guza(1983, TG83), Ruessink et al. (2003, NE87).
RU03) and Salmon et al. (2015, SA15). These five schemes are implemented in a triply-nested ocean wave model for the Gulf of Mexico based on SWAN for assessing their performance. The wave model results are compared with observational data over different types of bottom profiles under different wave breaking conditions. The simulated significant wave heights using both the BJ78 and SA15 schemes agree better with the observational data with the averaged error of less than 9%, in comparison with other three schemes. The significant wave heights using TG83 and RU03 are under-predicted due to its overestimation of fraction of breakers, resulting in the equivalent error of about 15%. An additional energy dissipation is needed for plunging breakers, however, since the current parametric schemes overestimate the significant wave heights with the equivalent errors between 9%~79%. In terms of the spectral evolution of waves, nonlinear energy transfers become evident with the development of sub and super harmonics during the shoaling, and the dissipation of super-harmonic frequency energy due to wave breaking can be approximated better by the BJ78 scheme than others.

(5-A) Wave Dynamics in Lake Erie: Inter-basin Propagation, Seasonality, and Potential Susceptibility to Climate Change

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Hindcast of wave climate in Lake Erie from 2002 to 2012 was conducted using a state-of-art finite-volume coastal ocean surface wave (FVCOM-SWAVE) model. Based on the calibrated and validated model, the surface gravity wave dynamics in Lake Erie were examined from the aspects of inter-basin swell propagation, wave climate and seasonality, as well as its potential tendency to interact with regional climate change. Swells generated in the central and eastern basins could propagate into each other under various wind directions, whereas that generated in the central basin could hardly impact wave dynamics in the western basin. The propagation from the central to the western basin through the northern channel is regulated by the depth-induced wave breaking. Besides, compared to the central and eastern basins, the western basin has relatively calm wave climate. However, the western basin and the nearshore areas are most susceptible to the wave-induced bottom oscillations. Profound seasonality was found in both mean and extreme wave climate in the lake. Significant wave height is most intense during winter, and calmest during summer, which are controlled by both wind speed and wind direction, and possibly by air stability as well. In addition, the regression analysis of surround meteorological buoys data indicates the potential increasing significant wave height at the intersection of the western and central basins, and at the northeast of the central basin.

(5-B) Challenges and Improvements for the Updated ADCIRC Tidal Databases: Eastern North Pacific and Western North Atlantic, Caribbean and Gulf of Mexico

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This research details the development of updated tidal databases for the Eastern North Pacific Ocean (ENPAC2015) and the Western North Atlantic, Caribbean and Gulf of Mexico (EC2015). The databases are developed using the two-dimensional, depth integrated form of the coastal hydrodynamic model, ADCIRC, which solves the shallow-water equations in the generalized wave continuity equation form. For each of the databases, five main areas of improvement are examined: 1) higher coastal resolution, 2) updated friction formulations, 3) use of advective terms in ADCIRC, 4) updated boundary forcing and 5) placement of the open ocean boundary. Finer coastal resolution is added by incorporating the most recent VDatum development meshes along the United States coastline: nine are available for the EC2015 database and three for the ENPAC2015 database. Additionally, the British Columbia region of the Salish Sea as well as Johnstone Straight and Queen Charlotte Strait are resolved using data from the Bedford Institute of Oceanography. For each database, two friction schemes are examined: 1) variable CF using VDatum friction files where available and 2) variable Manning’s n using USGS usSEABEDS data and available friction input files from various hurricane studies. Additionally, the harmonic results are compared for runs that utilize the advective terms in the ADCIRC formulation versus those that do not; enabling the advective terms provides significant improvement.
in overall skill assessment for all geographic regions. Along the open ocean boundary, a comparison is made between two global tidal databases used to force the regional ADCIRC model – FES2014 and TPXO8; in general it was found that both global databases provide comparable results. Finally, for the EC2015 database, the open ocean boundary is extended past the traditional 60 degree meridian to get away from the instabilities in the Lesser Antilles island chain; while for the ENPAC2015 boundary, two placements are examined – the old ENPAC2003 boundary that was placed off the continental shelf, but did not include any amphidromic points, and a larger boundary that encompasses the Hawaiian Islands in addition to the coastal regions. The challenge in the later placement is that several amphidromic points exist within the domain. While comparing the results for the two open boundary placements, it was determined that it was not possible to adequately capture the tidal harmonics in the nearshore regions throughout the global domain without artificially increasing the boundary forcing. The skill of each improved database is compared to that of its predecessor and is calculated using harmonic data from NOAA CO-OPS stations and the Bedford Institute of Oceanography.

(5-B) **Statistical Interpolation of Tidal Datums and Computation of Its Associated Spatially Varying Uncertainty**

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In NOAA’s Vertical Datum transformation project (VDatum), tidal datums are calculated by blending modeled tidal datums and observed tidal datums following a prediction and correction procedure. The tidal datum product uses the tidal datums derived from hydrodynamic model as the prior estimate, and this is then adjusted with a correction field spatially interpolated from model-data discrepancies of tidal datums at the tidal stations. In the current standard operational procedures, a deterministic interpolation method (Laplace’s equation interpolation) is used to calculate the correction field. As a deterministic interpolation, we are unable to estimate the spatially varying uncertainty associated with the tidal datum product. Here we propose a statistical interpolation method to integrate the modeled and the observed tidal datums. The interpolation method, derived from a variational method, follows the framework of optimal interpolation which is widely used in oceanographic data assimilation.

Through the implementation of this statistical interpolation method in the Chesapeake and Delaware Bays, we conclude that the statistical interpolation method for tidal datums has great advantages over the currently used deterministic interpolation method. The foremost, and inherent, advantage of the statistical interpolation is its capability to integrate data from different sources and with different accuracies without concern for their relative spatial locations. Any additional source of data, as long as we know the uncertainty associated with it, can be integrated into the product, resulting in a better accuracy for the end product. The second advantage is that it provides a spatially varying uncertainty for the entire domain in which data is being integrated. The spatially varying uncertainty will not only provide an overall picture of the uncertainty in the domain, but it also identifies locations of high uncertainty. The latter is especially helpful for the management of instrument installation and could help in the decision-making process of where new instruments would be most effectively placed. Lastly, in this Chesapeake and Delaware Bays test case, the output results show that the statistical interpolation reduced the bias, maximum absolute error, mean absolute error, and root mean square error in comparison to the current deterministic approach.

(5-B) **A seamless cross-scale modeling framework from creek to ocean**

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We present a new cross-scale modeling framework based on a 3D unstructured-grid model (SCHISM). A new higher-order implicit advection scheme for transport (TVD2) is proposed to effectively handle a wide range of Courant numbers as commonly found in typical cross-scale applications. The new advection scheme for the momentum equation includes an iterative smoother to reduce excess mass produced by higher-order kriging method, and a new viscosity formulation is shown to work robustly for generic unstructured grids and effectively filter out spurious modes without introducing excessive dissipation. The addition of quadrangular elements into the model, together with a recently proposed, highly flexible vertical grid system leads to model polymorphism that unifies 1D/2DH/2DV/3D cells in a single model grid. Results from several test cases
demonstrate the model’s good performance in the eddying regime, which presents greater challenges for unstructured-grid models and represents the last missing link for our cross-scale model. We demonstrate this seamless cross-scale modeling technology with a few examples.

(5-B) Dynamic Spatial Interpolation of Observed Tidal Harmonic Constants in Coastal and Estuarine Waters

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Spatial interpolation of observed tidal harmonic constants (HCs) has been used in NOAA to generate spatially-continuous HCs in coastal and estuarine waters for decades using tidal gauge observed HCs. The interpolation method adopted is a first order harmonic equation (Laplace’s equation) interpolation. More recently, we have proposed a higher order harmonic interpolation method for spatially continuous HCs. Although higher order harmonic interpolation improves the HCs field, the method still has a fundamental flaw in that it lacks representation of the physics governing tidal propagation. Here we develop a dynamic interpolation method based on the hydrodynamic equations. The method provides a dynamic interpolation tool for tides in coastal and estuarine waters. The method has been tested in the Chesapeake Bay and Delaware Bay areas. The results demonstrate that the dynamic interpolation method generates better results than the non-dynamic interpolation. Besides a better tidal HCs field, the model also provides a depth-averaged tidal current field for the region. The new dynamic interpolation method can provide a better tool for various purposes in NOAA, for example with data assimilation of tides and hydrographic survey planning in the Office of Coast Survey and the Center for Operational Oceanographic Products and Services.

(6-A) Sensitivity of coastal tsunami hazard to the modeling of tsunami generation by Submarine Mass Failures of various rheology

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Abstract. Since 2010, under the auspice of the US National Tsunami Hazard Mitigation Program (NTHMP), the authors and co-workers have developed inundation maps for the US East Coast (USEC). This entailed modeling tsunami generation, propagation, and coastal impact, in terms of envelope of maximum inundation, for several Probable Maximum Tsunamis (PMTs) in the Atlantic Ocean. Among these, the highest hazard for the upper USEC was found to result from near-field submarine mass failures (SMFs) that could potentially be triggered on the continental slope by moderate seismic activity. SMFs pose high risk because of the high and narrowly focused run-up they induce combined with short warning times (owing to their proximity to shore). To date, SMFs have been modeled as rigid slumps, partly due to the paucity of site-specific geological/geotechnical data on sediment type and rheology, but also because these provide the most conservative estimate of tsunami generation. Following a screening analysis based on probabilistic (Monte Carlo) slope stability and tsunami generation analyses (Grilli et al., 2009), four large SMFs were sited offshore of USEC areas deemed at higher risk and having sufficient sediment and proper slope parameters to allow for such large failures. SMF parameters were selected to match those of the largest historical slope failure identified in the area: the 165 km3 Currituck slide complex off of Chesapeake Bay (Grilli et al., 2015). Recent developments in the modeling of tsunamis generated by deforming SMFs (Ma et al., 2013, 2015; Kirby et al., 2016) have shown that assuming rigid slumps (or slides) in all cases may lead to overly conservative estimates of tsunami inundation. Here, we report on initial work towards better assessing the range of tsunami inundation that may be expected along the coast for different types of SMF rheology, given the same initial geometry, density and location. As a case study, we focus on the area around New York City and on SMFs occurring in the Hudson River Canyon, as were studied before by Grilli et al. (2015). Specifically, we compare inundation resulting from rigid slumps to that of deforming slides, in which the failed material is modeled as a heavy fluid or as a flow of granular material (Ma et al., 2015; Kirby et al., 2016). Rigid slumps are modeled as in earlier NTHMP work using NHWAVE (Ma et al., 2012; Grilli et al., 2015), a 3-D non-hydrostatic model. As before, the

(6-A) Surge and flood modelling of Typhoon Haiyan 2013 using a surge-wave-tide coupled model

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This study examines how wind speed-capped wave dependent drag (CD) and wave-surge interacted bottom roughness drag influence the surge and wave by Super Typhoon Haiyan 2013 that struck the coasts of the Leyte Gulf, Philippines, using a surge-wave-tide coupled model (SuWAT, Kim et al. 2008). In a series of surge simulations, we used bathymetry downscaled from 2,430 m to 30 m on 5 nested domains for flooding in low-lying regions in Leyte and Samar Islands of the Leyte Gulf.

A parametric wind (Fujii and Mitsuta, 1986) and pressure (Schloemer, 1954) model were used to estimate the Haiyan’s wind and pressure fields that are input to SuWAT. Because of lack of observations for wind fields, we first validated the sea level pressure recorded 910 hPa at Guiuan, and then estimated the wind at 10 m height (U10) reached around 65 m/s.

To cap the wave dependent drag (Janssen, 1989; 1991) at wind speeds of 20, 25 and 30 m/s, the methodology introduced by Kim et al. (2015) was used. To estimate the bottom drag induced by the wave-surge interaction, we followed Signell et al.’s method (1990). The wave dependent and bottom drags in the sea surface and in the bottom layer, respectively, were used to concurrently drive surge modules in SuWAT and the updated sea surface levels and currents were given to wave modules.
With this manner, we conducted a flood modeling in two ways: 1) use of Manning's numbers on land and 2) use of wave-surge interacted bottom drags on land. Then, the calculated surge levels are compared with the observed ones obtained from the field survey more than 160 stations. In this study, it was found that the coupled model of wave and surge can calculate the observed surge levels using the wave-surge interacted bottom drag as well as the capped-wave dependent drag at 20-25 m/s. The wave-surge interacted-bottom drag is significantly enhanced, especially, in shallow water, resulting in the adequate surge levels.

**(6-A) Modeling of Historical Storms in Rhode Island**

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The impact of selected historical storms on the Rhode Island shoreline is modeled using the fully nonlinear and dispersive phase-resolving wave model FUNWAVE-TVD. The model is used to simulate wave propagation in the time domain offshore of the Rhode Island coastline up to the inundation zone. FUNWAVE-TVD contains all of the physics pertaining to wave propagation: nonlinearity, dispersion, reflection, refraction, breaking and runup.

The model is run in several nested grids using offshore boundary and initial conditions based on wave spectra defined at a local Wave Information Studies (WIS) station as well as measured data at local buoy [e.g. Newport, RI] The model is verified using time series measurements at local buoys for Hurricane Irene (August 2011).

Recent developments of FUNWAVE-TVD include a sub-model allowing simulation of real time sediment pick-up, suspension, transport, and deposition/erosion (for non-cohesive sediment). The above simulations are re-run using the sediment sub-model and results are compared with observed beach/dune transects.

**(6-A) Vulnerability assessment of National Park Service infrastructure to storm surge and sea level change**

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The National Park Service manages several iconic and well-known cultural resources in the greater New York area including the Statue of Liberty and Ellis Island, and numerous sites within Gateway National Recreation Area (GATE) and Fire Island National Seashore (FIIS). Most of these sites were impacted by storm-induced flooding associated with the landfall of Superstorm Sandy in October, 2012. To assess the vulnerability of these properties to future coastal storm impacts, the NPS and the University of Rhode Island have partnered to develop a GIS-based, online tool to aid park managers in planning decisions. Dual frequency, survey-grade GPS equipment and total stations were used to collect first floor elevations (FFE) relative to NAVD88 for buildings and structures at FIIS and GATE parks during the summers of 2013 and 2014. NOAA’s SLOSH (Sea lakes and Overland Surge from Hurricanes) model was then used to simulate storm surge from an ensemble of synthetic hurricanes to examine the potential for inundation of structures under future (higher) sea levels and changes in storm intensities. The SLOSH model is used operationally by the National Hurricane Center (NHC) and was selected for this analysis because of its accessibility to NPS staff and computational efficiency. More than 55,000 projections of storm surge were modeled to represent various combinations of sea level change and hurricane parameters at time horizons of 15- and 35-years from 2015. Storms were modeled using the NY3 SLOSH basin under four base water levels, representing low and high estimates for each future date at the Sandy Hook tide gauge. Tropical storm variables (track/landfall, pressure differential, radius of maximum
winds, translational speed) were based on parameters selected by the National Hurricane Center, and supplemented with data from the historical record. The model results were aggregated into 16 inundation grids, each representing the worst case flooding for a particular hurricane category (1-4) and SLR scenario. This method of assessment is comparable to the “composite approach” used by the NHC to produce the Maximum Envelopes of Water (MEOWs) and the Maximum of MEOWs (MOMs). Each inundation grid was exported to GIS and interpolated across the study area to create a water surface raster. The FFE points were then intersected and compared against each water surface raster. Each point was coded as Wet/Dry/Uncertain based on a comparison of water surface elevation and FFE after taking into account the uncertainty of the SLOSH predictions. Preliminary findings include that projected sea level scenarios for 2030 and 2050 had little effect on a FFE changing code (wet/dry/uncertain) within a hurricane category. A majority of FFEs were coded ‘dry’ or ‘uncertain’ for a C1 storm (57% and 37% respectively). A majority of FFEs were coded ‘wet’ or ‘uncertain’ for a C2 storm (55% and 40% respectively). For C3 and C4 storms, most FFEs were coded ‘wet’ (>90%). The final online tool allows users to filter the scenario and display all the locations at risk thus enabling park staff and managers the ability to assess and make decisions quickly and easily.

(6-B) **Multi-grid Data Analysis and Visualization with Python**

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In order to conform to irregular coastlines, coastal circulation models are most often built on non-rectangular model grids. These include curvilinear grids typically used by finite difference models (e.g. ROMS) and triangular mesh grids used by finite volume (e.g. FVCOM) and finite element (e.g. ADCIRC) models. In addition, different models can produce results on varying parts of the mesh: on nodes, on cells, and staggered (e.g. the Arakawa C-grid). While these varying grid types do an excellent job of allowing models to have effective computational schemes that conform to the boundaries of the domain, they pose complications for post-processing and analysis tools, particularly tools intended to work with a variety of models or inter-comparison of multiple models that may use different grid schemes.

The first step in resolving these complications to establish data format standards. The CF metadata conventions for netcdf files has been very successful in enabling data interchange, but it does not currently support non-rectangular grid types. Over the years, the community has created conventions to help facilitate this interchange: The UGRID Conventions (http://ugrid-conventions.github.io/ugrid-conventions/), and the SGRID Conventions (http://sgrid.github.io/sgrid/). In order for these conventions to be useful tools need to be available that understand them, and provide functionality for developing analysis and visualization tools that support them. Two such projects for the python language are pyugrid (https://github.com/pyugrid/pyugrid) and pysgrid (https://github.com/sgrid/pysgrid). These packages provide a similar API for working with unstructured and staggered grids, respectively, allowing other tools to be more easily developed.

In addition to being able to read results from various model types, the tools provide utilities for navigating and interpolating the grid, so that users can work with the data set as a filed of variables, rather than concern themselves with the intricacies of grid structure. This talk will give a quick overview of the two data conventions, the API provided by the tools, and examples of their use in data analysis, visualization, re-gridding, inter-comparison, and particle tracking.

(6-B) **Data Driven Realistic Visualization**

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Procedural visualization techniques, more commonly known as “procedural modelling”, allow realistic 3d visualizations to be data driven. These techniques have shown their value in creating rapidly changeable, easily understood visualizations used in stakeholder planning processes. Scripts used to drive these visualizations may incorporate algorithms to calculate a range of outcomes based on planning decisions (E.G., physical, economic) (Grêt-Regamey, Celio, Klein, & Hayek, 2013). This research proposes a framework for connecting procedural visualizations to hydrodynamic models and demonstrates algorithms for the depiction of impacts. The ability to incorporate impacts and visualize multiple scenarios makes it possible to visualize risk; risk is defined as the...

(6-B) A Standardized Framework for Reproducible Model Skill Assessment

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Skill assessment is traditionally done by individual researchers or modeling groups using custom scripts and workflows, which can be difficult to build, maintain and share with others. The U.S. Integrated Ocean Observing System (US-IOOS) is addressing this issue by developing a framework and a collection of tools for skill assessment based on standardized data services that work with the environments scientists and engineers typically use for analysis and visualization. We will describe how to install and configure free and open source software that provide standardized data and catalog services, then show examples of skill assessment in Matlab, Python and R, accessing data from multiple, distributed model and observational data sources. These examples are in the form of reproducible science notebooks that can be run from any modern browser.

(6-B) Getting COMT on PARR: Increasing public access to COMT results

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ISSUE: In response to the White House Office of Science and Technology Policy Memorandum (2013), NOAA has released a plan for increasing Public Access to Research Results (PARR). The U.S. IOOS Coastal and Ocean Modeling Testbed (COMT) Cyber-Infrastructure (CI) team supports a wide range of project teams from hypoxia research, to coastal inundation research plans to move towards compliance with these NOAA recommendations. SETTING: COMT serves as a conduit between the federal operational and research communities and allows sharing of numerical models, observations and software tools. The goal of COMT is to accelerate the transition of advances from the coastal and ocean modeling research community to improved operational ocean products and services. PROJECT: The COMT CI group focuses on facilitating collaboration between project members across various institutions, enabling the presentation and archive of research results alongside observational data, and providing community access and tools for the COMT research. Significant progress has been made tasks during funding years 2013-2015 to accelerate the development of tools for model assessment and model availability. These tools are publicly available for the COMT, IOOS and the international geoscience community. RESULTS: With the release of the PARR recommendations, the COMT CI group continues to review and update the data management procedure, infrastructure and tools available to participants to ensure compliance with these NOAA recommendations. The PARR implementation includes
policies relevant to COMT for data-specific tasks and tasks related to the linkage between publications and data. The work done by COMT CI and the interactions with project modelers has been used to develop procedures and tools and to allow existing and future research teams to quickly submit their results. Tools are provided to easily include necessary metadata enabling these research datasets to adhere to standards allowing the COMT CI to ensure compliance to the NOAA PARR policies. Challenges associated with integrating various coastal and oceanographic models include disparate horizontal grids, vertical grids and data formats which often making inter-comparison of model results and heterogeneous presentation difficult. We look at the steps taken to reach a consensus between many institutions, models and researchers that have led to datasets which are comparable and compliant by existing community standards. This compliance, now being extended to include PARR policies, enables rapid presentation, cataloging, validation and preservation for the geosciences community. The specifications and tools developed within or alongside COMT are presented and shown how their integration expedites the data management of widely varying COMT research datasets.

(7-A) *A comparison of two methods to improve the efficiency of a coupled hydrologic/hydraulic modeling system.*

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In order to produce a holistic representation of coastal flooding, one needs to capture the dominant physical processes within the modeling system in order to generate estimates of the “total water level” in coastal regions. From previous research done as part of DHS and NOAA projects, a real-time forecast system was developed to obtain a total water level product. This real-time system brings together rainfall, wind, waves, tides and surge through coupled hydrologic, hydrodynamic, wave models and precipitation estimations. Within this coupled model system, a hydrologic model and precipitation estimates compute the upland flooding associated with the rainfall associated with tropical or extratropical storms. The discharges from the hydrologic model are then used as upstream boundary conditions for the hydrodynamic model, ADCIRC. While this approach produces adequate results, it is computationally expensive to utilize ADCIRC to model the small (grid resolution of 10-30 m) rivers. Within this study, we will investigate two possible options to address the computationally expense of the rivers. For the first option, we will examine utilizing the simpler, 1D hydraulic model of HEC-RAS within the coastal riverine area in order to reduce the computational cost of the system. In addition to examining the computational efficiency of utilizing the HEC-RAS model instead of the ADCIRC model, we will investigate the accuracy of the new system with the HEC-RAS model, as we need to preserve the accuracy of the real-time forecast system. In the second option, which will be the primary focus of this presentation, we will examine improving the computational efficiency of the ADCIRC model by utilizing the new Xeon Phi™ co-processors from Intel®. The current ADCIRC model runs in parallel through MPI, and it achieves on most computer architectures a MPI efficiency of 90%. However, above this threshold ADCIRC’s parallel efficiency degrades due to MPI communication overhead. In this presentation, we will discuss the implementation of a hybrid MPI-OpenMP model and the utilization of the Intel® Xeon Phi co-processors.

(7-A) *Morphological Response of Barrier Islands During Tsunami Inundation*

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Previous inundation mapping results for the US East Coast have shown that barrier islands would be among the most impacted areas during a possible tsunami. Many of these barriers are home to large population centers such as Atlantic City, NJ and Ocean City, MD. A tsunami can significantly change coastal morphology. Post-tsunami surveys have shown that large amounts of sediment can be moved in bays and estuaries by tsunami action, especially over coastal dunes. During tsunami inundation, large amounts of sediment have been eroded from sandy coasts and deposited further onshore. In some cases, sand dunes have been completely eroded by a tsunami, with the eroded sediment being deposited either onshore behind the dunes, or offshore during the
rundown process. Knowing the potential of tsunamis in changing coastal morphology, it is essential to consider barrier islands topographic changes during inundation mapping process. In this presentation, we will show the results of our recent study on the morphological response of barrier islands during possible tsunamis that threaten the US East Coast. For this purpose, we have coupled FUNWAVE-TVD with a classic convection-diffusion sediment transport model and a morphology module to capture bed evolution under tsunami condition. We have used our model to study barrier island topographic behavior under different tsunamis, such as a cone collapse of Cumbre Vieja volcano in the Canary Islands, a tsunami generated by an earthquake in the Puerto Rico subduction zone, and a tsunami caused by a landslide on the East Coast shelf break. Our results suggest that significant bathymetric changes could be expected on a barrier island during tsunami inundation.

(7-A) *STORMTOOLS – Web Based Storm Flooding Tools*

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The vision for *STORMTOOLS* is to provide access a suite of coastal planning tools (numerical models, model products, etc.), available as a web service, that allows wide spread accessibility and applicability at high resolution for user selected coastal areas of interest. Using predictions from the recently completed US Army Corps of Engineers (USACE) ADCIRC/WAM/STWAVE numerical hydrodynamic/wave modeling study performed as part of the North Atlantic Coast Comprehensive Study (NACCS) for synthetic tropical and extratropical (historical) storms as the foundation, the following tools and products have been developed for RI: (1) inundation maps for varying return periods (25, 50, and 100 yr) for coastal waters, including the effects of sea level rise; (2) inundation maps for major historical hurricane events including: 1938, Carol (1954), Bob (1991), and Sandy (2012) and nuisance flooding events with return periods of 1, 3, 5, and 10 yr; (3) contour maps for 25, 50, and 100 yr return periods for water levels and significant wave height and associated extremal analysis at selected locations to support coastal engineering design; (4) artificial intelligence neural network based model to predict peak surge and wave heights at selected locations for tropical storm events using NOAA National Hurricane Center (NHC) storm forecasts as input; and (5) high resolution (10 m) inundation and associated wave predictions using STWAVE and FUNWAVE (including effects of run-up) for selected locations along the southern RI coast line forced by fully coupled offshore wave and water levels predictions. Maps generated as part of the effort are web accessible via ArcGIS and being widely used in municipal and state wide planning (http://www.beachsamp.org/resources/stormtools/). The maps are based on a 1 m horizontal resolution Lidar based digital elevation model for the state and follow the NOAA sea level rise mapping protocol.

(7-A) *Demonstrating the impact of flood adaptation using an online dynamic flood mapper*

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Coastal natural and nature based features (NNBF) are widely being considered for flood risk reduction and the many ecosystem services they provide, yet there is limited quantitative information available to help make these decisions. Here, we describe a new hydrodynamic (or more simply, dynamic) flood mapping web tool that demonstrates the modeled effects of NNBF on flood hazard zones for the highly populated areas surrounding Jamaica Bay, New York City. The efficacy of adaptation measures is quantified with a complete flood risk assessment, including sea level rise. We use the Stevens Estuarine and Coastal Ocean Model (sECOM) on a supercomputer to simulate hundreds of historical and synthetic storms to pre-compute water depths over the floodplain for 5-year through 1000-year events. The web-tool also provides information on damages from flooding as well as cost benefit analyses for NNBF adaptations for the bay. The project researchers are involved with development of a Jamaica Bay Coastal Master Plan, and the mapper will play an important role for increasing the public understanding of adaptation options. More broadly, dynamic flood mappers have many
more possibilities than “static” mappers that simply add sea level rise onto pre defined flood levels and bathtub them over flood plains. Hydrodynamic modeling can enable inclusion of the response of coastal systems, imposed human adaptation, as well as flooding by surge, tide and precipitation.

(7-B) **Impact of Inlet Dredging on Circulation and Flushing of the Narrow River, Narragansett, RI**

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The Narrow River is a small estuary, approximately 9.5 km long, located in the three towns Narragansett, North Kingstown and South Kingstown, RI. It is connected to Rhode Island Sound just below the entrance to the West Passage of Narragansett Bay. Circulation is primarily driven by tides. The tide range at the upper end of the estuary is only ~20% of the tide range at its mouth due to its shallow bathymetry and topographic constrictions. The US Fish and Wildlife Service (FWS), in collaboration with the US Army Corp of Engineers (ACOE) and the Rhode Island Coastal Resources Management Council (CRMC), is presently undertaking a study to investigate the impact of dredging and applying the dredged material by thin layer spraying to raise the level of the marsh system in the lower reaches of Narrow River (Pettaquamscutt Cove) to restore and enhance the long term viability and ecological health of the marsh in the presence of sea level rise.

Local and state representatives from the Town of Narragansett expressed interest to also consider dredging the river inlet and lower reach to increase the tidal flushing of the Cove and River to reduce high concentrations of nutrients that may lead to degradation of the salt marsh and its benthic habitats. The sand removed from this dredging could be used to nourish adjacent Narragansett Beach.

In order to determine what the impact of dredging might be on the circulation, flushing, and water quality in the river a numerical circulation modeling study was performed. The objectives of the study were: to apply, calibrate, and validate ADCIRC, a two dimensional (2-D), vertically averaged hydrodynamic model to the river for typical tidal and wind forcing using existing observation data; and to use the calibrated/validated hydrodynamic model to predict what the impact of dredging at the mouth of the river is on the circulation and flushing in the river.

Following model calibration with existing water level and current observations, simulations, without and with dredging of the inlet, were compared and contrasted to determine the impact of dredging on tidal range vs distance up the river, flows at discrete locations (mouth, Sprague Bridge, Middlebridge, and Lacy Bridge), and tidal volume exchange for the whole system.

(7-B) **A Numerical Study of the Circulation in Chatham Sound, BC, Canada**

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Chatham Sound is a semi-enclosed inland sea located off Northern British Columbia, connected to the Pacific Ocean via the more exposed offshore areas of Dixon Entrance and Hecate Strait. Chatham Sound spans a total distance of approximately 70 km from south to north and has a width of 15-25 km, but water depths generally are less than 200 m except for deeper waters at its northern limit. The most important channels allowing the exchanges of water to Dixon Entrance and Hecate Strait are: north of Dundas Island adjoining eastern Dixon Entrance; and Brown Passage in central Chatham Sound. The ocean currents in Chatham Sound are highly variable due to a combination of forcing by wind, tides and large freshwater discharges. The major source of freshwater in Chatham Sound is in the southeast, from the Skeena River, the largest river draining into the Pacific waters of northern British Columbia. The existing knowledge of oceanographic processes over all of Chatham Sound is still largely based on the pioneering work of Trites (1952 and 1956) with some more localized metocean studies identified in Birch et al. (1985). Further research into this complex oceanic and river dominated environment is being driven by the recent studies related to potential development of liquefied natural gas (LNG) export marine terminals in this area. These require detailed design criteria and environmental understanding to support the environmental regulatory review process. In this numerical study, first, high resolution 3D finite-difference numerical modeling (COCIRM) was conducted to investigate the tidal and wind driven currents in Chatham Sound. The model was verified using historical ocean current data collected by the Institute of Ocean Science (IOS) and Canadian Hydrographic Service (CHS), DFO, at different locations,
depths, and seasons. It is shown that the model simulated water levels and near surface/bottom currents are in good agreement with observations. Southern Chatham Sound was found to be dominated by tidal currents, while the surface wind plays an important role on the circulation variability in the Northern Chatham Sound. Further, originally the water column in the Brown Passage was assumed to be well mixed and uniform and minimal near bottom flows were predicted. However, inclusion of density stratification layers to previous modeling for Brown Passage (Jiang and Fissel, 2010; Lin and Fissel, 2013), has considerably improved the ability of the model to generate episodes of relatively strong currents in the bottom layers, which is comparable to the recent observations from the PNW LNG measurement program (Mudge et al., 2015). The model results show the progression of the lower saline near-surface waters being advected northward, especially on the western side of Chatham Sound and more saline waters on the eastern side of the Sound especially in areas of exchanges through side channels with the waters of Hecate Strait. These surface circulation results are in good agreement with the large scale representation of the outer diffuse Skeena River plume as seen in high resolution Landsat satellite imagery.

(7-B) On the mechanism of an oblique tidally-recurring internal hydraulic jump: an idealized case study

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We present an ongoing study of an oblique, tidally-recurring internal hydraulic jump in a stratified estuary mouth. An estuarine-scale internal hydraulic jump is as an important mechanism for vertical mixing in coastal waters, and yet less well understood partly due to difficulties in field observation. Inspired by findings during the RIVET II field campaign at the Mouth of Columbia River(MCR), we make both theoretical and numerical modeling efforts to explore the generation mechanism of this type of jumps. For theoretical analysis, a simplified two-layer flow model is set up to formulate the main momentum balance during the process. Both classical and up-to-date theories on internal hydraulic jumps are reviewed. The closure problem for the jump equations is explored with different assumptions. The applicability of an oblique-shock formation theory in two-layer hydraulics is argued in details. A solution from the theory with an additional mixing layer is provided. For numerical modeling, a high-resolution Non-hydrostatic Wave Model(NHWAVE) is employed to investigate the three-dimensional flow structures of the jump. A series of idealized experiments are conducted to explore the sensitivity of the jump formation on barotropic, baroclinic and geometric parameters. The critical state for regime transition is carefully captured. It is shown that the model performs reasonably well in reproducing the observed characteristics of an internal hydraulic jump, consistent with the theoretical solutions.

(7-B) Salinity Variability and water exchange in interconnected estuaries

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A high resolution coastal ocean model is used to investigate salinity variability and water exchange in a complex coastal system off the southern U.S. characterized by three adjacent sounds that are interconnected by a network of channels, creeks and intertidal areas. With a few exceptions, model results are highly correlated with observations from the Georgia Coastal Ecosystem Long Term Ecological Research (GCE-LTER) program, revealing a high degree of salinity variability at the Altamaha River and Doboy Sound, decreasing sharply toward Sapelo Sound. A Lagrangian particle tracking method is used to investigate residence time and connectivity in the system. Residence time is highly variable, increasing with distance from the Altamaha River and decreasing with river flow, demonstrating that discharge plays a dominant role on transport processes and estuary-shelf exchange. Connectivity between the Altamaha River and Doboy Sound is high in all seasons, with exchange occurring both via the oceanic and the marsh pathways. While particles released in the Altamaha and Doboy rarely reach Sapelo Sound, particles released at Sapelo Sound and the creeks surrounding the main channel can influence the entire estuarine system.
**The impacts of ambient coastal currents and local wind on river plume in the Pearl River Estuary during summer**

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The responses of plume dynamics in the Pearl River Estuary (PRE) and adjacent coastal area to ambient coastal currents and local wind are examined using a high-resolution 3-D circulation model, which is based on the Finite-Volume Community Ocean Model (FVCOM). The model is calibrated and validated to different sets of field data. The model results of tidal elevation, salinity, and currents are in good agreement with the observational data, suggesting that the model is robust enough to capture the plume dynamics in the PRE and adjacent coastal area. The results in the Control Run (CR) numerical experiment show that the asymmetry alongshore currents exist over the shelf, which are associated with intensity of the negative cross-shelf pressure gradient force. Weak westward alongshore surface currents form over the shallow western shelf with averaged magnitude of ~0.1 m/s. The strongest alongshore currents are located over the eastern shelf and southeast of HK, with velocity speeds reaching 0.5-0.7 m/s. Consequently, the spreading pattern of plume is the East Offshore Spreading. The plume water originated from the PRE could extend eastward to 115°35_E and southward to 21°30_N, respectively, when selecting 30 psu isohaline as the plume water boundary. The plume dynamics are sensitive to ambient coastal currents. The effects of ambient coastal currents are twofold: (1) the intensity of northeastward surface flow is much weaker without ambient coastal current, especially on the eastern shelf. Consequently, the eastern spreading of the plume is limited at ~114°55_E, which is ~75 km less than that in CR experiment; (2) without ambient coastal currents, the relatively strong northeastward surface currents are absent on the outer shelf, which means the blocking band for seaward spreading of plume disappears. As a result, the offshore extent of plume is wider to reach ~21°13_N, which is more southward with ~30 km. It should be noted that the impacts induced by ambient coastal currents are very weak inside the PRE because the influences are prominent over the shelf outside of the PRE, especially on the eastern shelf, while hardly reach upper inside the PRE. Northeastward currents would be induced by the local wind, which would have variable impacts on different parts of PRE and adjacent coastal ocean. As for the western shelf, the plume could extend seaward to reach ~21°18_N, with ~22 km more southward as the absence of local wind. Contrary to the conditions on the western shelf, the seaward extending of plume is restricted without addition of local wind. However, the plume could extend to the eastern boundary of the model domain due to more focused alongshore currents, which is at least ~100 km eastward than that in CR experiment.

(8-A) Simulation of Atlantic salmon post-smolt movement along the north shore of the Gulf of St. Lawrence

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Atlantic salmon (Salmo salar) post-smolts are juveniles that have left their natal rivers and entered a saltwater environment. In this study we simulate the movement of Atlantic salmon post-smolts in the northern Gulf of St. Lawrence using a combination of circulation fields simulated by a numerical ocean circulation model and a numerical particle-tracking scheme. The main objective of this study is to determine effects of physical and biological conditions on the migration of post-smolts in the Gulf. The model domain covers the Gulf of St. Lawrence (GSL), the Scotian Shelf, the Gulf of Maine and adjacent deep waters. The circulation model is forced by tides, atmospheric forcing at the sea surface, river runoff and large-scale circulation over the eastern Canadian shelf. Particles representing post-smolts are released near a river mouth on the north shore of the Gulf of St. Lawrence (GSL), and their movement due to both the ambient currents and active swimming behaviour are tracked with a time step of one hour. We conduct experiments with various swimming behaviours specified for the particles, with the aim of matching an observational study in which a post-smolt released from a river on the north shore of the GSL was observed at the Strait of Belle Isle (northeastern exit of the GSL) after 44 days. Our results suggest that post-smolts need to adjust their swimming behaviour according to the direction of ambient currents, and that variations in the circulation fields on the scale of O(weeks) have a significant effect on the eastward movement of post-smolts against the prevailing westward currents in this area.
(8-A) **Challenge of Accurate Simulation of Spill Trajectories in Salish Sea – The 2003 Pt. Wells Spill**

Tarang Khangaonkar, Jonathan Whiting, Wenwei Xu, Amoret Bunn, Lawrence Sim, Rodrigo Duran, Kelly Rose, Jen Bauer

Salish Sea is a particularly challenging water body for predictive oil spill trajectory simulations. These waters are highly stratified with fjord like long narrow deep channels and presence of mid-channel islands. Availability of real time accurate predictions of near surface currents is therefore essential for minimizing the uncertainty and risks associated with oil spill impact assessment. The Salish Sea model developed by PNNL using FVCOM accommodates complex shoreline geometry and generates hydrodynamic solutions for use in circulation, flushing, and water quality assessments. In this study we evaluate the adequacy of those routinely available (intermediate scale) solutions for use in hind casting and predictive oil spill trajectory modeling. The Pt. Wells Spill that occurred in December of 2003 is used as a case study. The trajectory modeling was conducted using two separate oil fate and transport models, 1. The General NOAA Operational Modeling Environment (GNOME) designed for simulating the trajectory and dispersion of oil at the water surface and 2. Blowout and Offshore Spill Occurrence Model (BLOSOM). The BLOSOM model developed by U.S. DOE’s National Energy Technology Laboratory is a 3D model with the ability to generate jet mixing and buoyant plume dilution and also includes detailed weathering/crude modules. Preliminary tests using GNOME and BLOSOM models showed that use of available hydrodynamic solutions while suitable for large scale water quality assessments may not be sufficient for surface oil transport predictions. Sensitivity tests were conducted with model grid resolution, dispersion coefficients, and wind forcing to improve the hydrodynamic solutions for use in Oil Spill Trajectory predictions. The results were found to be highly sensitive to local wind conditions.

The model results using GNOME were compared with BLOSOM and found to be comparable validating the performance of BLOSOM and GNOME with linkage to using Salish Sea Model solutions.

(8-A) **AmDaDos (Adaptive Meshing and Data Assimilation for the Deepwater Horizon Oil Spill), a pilot case study for the AllScale project**

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The Deepwater Horizon oil spill is the largest accidental spill in the history of the petroleum industry. The BP blow-out lasted for 87 days, releasing approximately 4.9 million barrels (780,000 m³) into the surrounding environment. Authorities collected huge volumes of data concerning the extent and evolution of the oil spill. While previous research has made use of some of the data, a system that harnesses the full potential of the dataset by integrating it with a set of highly accurate, efficiently computable models and meta-models is yet to be put in place. This is of paramount importance to understand related phenomena and take preventive actions or otherwise minimize damage to the environment and to local societies at risk. Data assimilation (DA) is a mathematical technique that enables the incorporation of physical observations within complex models. In each simulation step, observation data is combined with output from the model, yielding results which are considered as 'the best' estimate of the current state of the system. Adaptive Meshing (AM), on the other hand, is a method of dynamically changing the precision of a model by selective refinement of the numerical grid resolution. Both techniques, DA and AM, result in unevenly balanced workloads imposing load management challenges on the respective implementation. AllScale is a FET H2020 (Frontiers and Emerging Technologies in Horizon 2020) funded project that runs from 2016 till 2019, that aims to provide a sophisticated approach enabling the decoupling of the specification of parallelism from the associated management activities during program execution on extreme scale HPC systems. Such systems, while necessary to cope with the computational load, impose significant challenges for developers aiming at obtaining applications efficiently utilising all available resources. In particular, the development of such applications is accompanied by the complex and labour intensive task of managing parallel control flows, data dependencies and underlying hardware resources – each of these obligations constitute challenging problems on their own, especially when dealing with unbalanced workloads. The foundation of AllScale is a parallel programming model based on nested recursive parallelism, opening up the potential for a variety of compiler and runtime system based
techniques adding to the capabilities of resulting applications. In particular, those include dynamic load balancing and integrated error recovery features. In the AllScale AmDaDos pilot application, AM and DA are used jointly in a modelling implementation of the advection diffusion equations for simulating the Deepwater Horizon accident.

The system autonomously adapts the special resolution of locations to the necessary level of detail (AM) for computational efficiency. Additionally, it continuously incorporating observations into the model forecast (DA) to enhance the simulation’s accuracy. While advection diffusion codes for transport phenomena (such as oil spills) exist and are well developed, a novel one, which embeds AM and DA techniques, is specifically designed by facilitating the dynamic features offered by the AllScale environment.

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**A Hybrid GFD and Fully 3D CFD System for Modeling Flows around Moving Objects in Oceans**

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Numerical simulation of coastal ocean flows has been focusing either on large-scale processes or small-scale events, however, it is now becoming needed to simultaneously model both large- and small-scale phenomena, especially those at small scales, and take their interaction into account. The need comes from many emerging coastal ocean flow problems such as oil spill in deep oceans and tidal power extraction in coastal waters, and also from the fact that we do lack capabilities to simulate the problems. In order to simulate these problems, we have developed a hybrid modeling system that is able to resolve multiscale and multiphysics coastal ocean flows in high fidelity and high resolution, which basically cannot be handled by other existing computer software packages. The modeling system is an integration of a fully 3D computational fluid dynamics (CFD) model and a geophysical fluid dynamics (GFD) model, and it is referred as to the SIFOM (the Solver for Incompressible Flow on Overset Meshes)-FVCOM (the Finite Volume Coastal Ocean Model) system. SIFOM is a fully 3D CFD model, FVCOM is a GFD model, and in the SIFOM-FVCOM system, SIFOM captures small-scale, local flows, and FVCOM resolves large-scale ocean currents. The integration involves coupling of distinct governing equations, different numerical algorithms, and dissimilar computational grids, and it is two-way and realized using an overset-grid method and a Schwartz iteration scheme. In this research, in order to track moving objects in oceans, dynamic mesh capability is added into the existing SIFOM-FVCOM system. In particular, dynamic grid function is implemented into SIFOM via a Chimera-grid scheme, allowing its meshes to move with an inertia frame. In this presentation, the computational methods will be presented, and numerical experiments of benchmark flows will be given for validation of the methods and the corresponding computer software package, especially in aspects of moving objects. An application of the modeling system to an actual coastal flow past an moving object will be given, presenting a numerical solution for the flow in high fidelity, all the way and seamlessly, from the background currents in the far field to the fully 3D, local phenomena at the object in the near field. The realization of such modeling system is supposed to be a major advance in development of modeling capability; it will be able to simulate many problems such as flows at tidal power turbines and those around submarines, which we cannot handle before.

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**Development of a biophysical model for Chesapeake Bay and its adjacent coastal ocean**

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Chesapeake Bay is one of the largest and most productive estuaries on the North American Continent. To improve the understanding of a series of biophysical questions, such as phytoplankton outflow plume in Chesapeake Bay, we implemented a 3-D hydrodynamic-biogeochemical model by using the offline linked Finite Volume Coastal Ocean Model (FVCOM)-Integrated Compartment Model (CE-QUAL-ICM). The response of biogeochemical simulations to grid resolution was contrasted by using two mesh grids. In
additional, a variety of numerical experiments were conducted to test the sensitivity of simulation results to model settings including winds, tides, river discharge, riverine and non-point-source nutrient loadings, and underwater light climate, as well as to further validate the biophysical model. The model showed acceptable model skill in simulating total suspended solids (TSS), nutrients (carbon, nitrogen, phosphorus and silicon), dissolved oxygen (DO) and chlorophyll-a (including diatoms, dinoflagellates and cyanobacteria) in a 10-year simulation period from 2003 to 2012. Our coupled modeling package turned out to be a robust tool to analyze the spatiotemporal variation of key water quality parameters and solve their key physical drivers. Applying the biophysical framework, we will investigate the potential climatic impacts on phytoplankton variability and the bio-chemical plume in Chesapeake Bay in the future.

(8-B) *Salt marsh response to wind waves in a confined tidal flat: Bombay Hook National Wildlife Refuge, Delaware*

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We describe an ongoing study of wave climate in a tidally-inundated flat contained within the Bombay Hook National Wildlife Refuge and the influence of wave action on marsh boundaries. The study employs field measurements, data analysis and numerical modeling in an effort to estimate the long term potential for wind wave-driven shoreline erosion and resulting enlargement of the tidal flat. Salt marsh degradation is often thought to be connected to erosion and collapse of marsh shorelines due to wave erosion. Potentially, erosive effects from wind waves, in regularly flooded flats, is responsible for collapse of marsh platform and formation of variably-inundated tidal mud flats. The edge erosion would lead to enlargement of mud flats in the long term. The dynamics taking place at the boundary between salt marsh and tidal flat is of significant importance, where marsh vegetation, elevation of the tidal flat and fetch distance largely influence the wave energy and erosion rates. In this study, we use two RBR pressure sensors, located on the tidal flat, to continuously record tidal elevation and superposed short wind waves at a frequency of 16Hz. Wave modeling has been carried out using the SWAN model, to examine wave growth in both idealized and observed conditions, and compared with a fetch limited wind wave model to evaluate the effect of fetch distances. The SWAN model is shown to predict a reasonable estimate of spatially varying wave period and height at field measurement locations, and is thus potentially useful as a tool for quantifying shoreline wave climate. We use a coupled salt marsh and tidal flat erosion model to evaluate the long-term potential for impact of wind waves on the marsh boundaries.

(8-B) *FVCOM modeling of the changes in the Great South Bay’s hydrodynamic environment due to a breach in Fire Island*

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The Great South Bay is a shallow, multi-inlet estuary along the south shore of Long Island sheltered by a barrier island, Fire Island, from the Atlantic Ocean. During hurricane Sandy a breach through the barrier island opened in the eastern end of the Bay in the Fire Island Wilderness area and has been allowed to remain open since. Thanks to a decade-long monitoring program observational data is available throughout the Bay from before and after Sandy permitting us to investigate changes in the bay induced by this new opening to the Atlantic. In concert with the data collection and analyses we have developed two high-resolution Great South Bay FVCOM grids – one representing the Bay before the breach and one after - to study changes in circulation, tides, storm surge and bay-ocean exchange under a range of atmospheric forcing scenarios. Observations and model results both show persistent changes in salinity distribution and a marked reduction in residence time in central and eastern Great South Bay. Model results further elucidate the effects of the new inlet on the residual circulation in the interior of the lagoon, on the directional response of water level to wind forcing, and on tidal exchange through other inlets.
(8-B) A Multi-decadal Hindcast for the Long Island Sound and the New York/ New Jersey Harbor Physical Environment Based on NARR and NYHOPS

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This work presents the results and validation of a multi-decadal hindcast simulation performed using The New York Harbor Observing and Prediction System (NYHOPS) three-dimensional OFS. Meteorological forcing to NYHOPS was based on 3-hourly gridded data from the North American Regional Reanalysis (NARR) of the US National Centers for Environmental Prediction (NCEP). Distributed hydrologic forcing to NYHOPS was based on daily United States Geologic Survey (USGS) records. With regard to offshore boundary conditions for NYHOPS at the Mid-Atlantic Bight shelf break, hourly subtidal water levels from a larger-scale model ran for the same period using NARR were added to tides, while temperature and salinity profiles were based on the Simple Ocean Data Assimilation (SODA) datasets. The NYHOPS model’s application to hindcast total water level, and 3D water temperature and salinity conditions in its region over three decades is validated against observations from NOS, NYCDEP, and CT DEEP, as well as climatology. The model’s results are overall excellent: the average index of agreement for storm surge alone is 0.93, (9cm RMSE, 90% of errors less than 15cm), for water temperature is 0.99 (1.1°C RMSE, 99% of errors less than 3°C), and for salinity is 0.86 (1.8psu RMSE, 96% of errors less than 3.5psu). Further, the model’s skill in simulating water temperature, validated against historic data from the Long Island Sound (LIS) bottom trawl survey, has not drifted over the years, a significant and encouraging finding for multi-decadal model applications used to identify climatic trends. However, the validation reveals residual biases in some areas, for example small tributaries that receive urban discharges from the NYC drainage network. With regard to the validation of storm surge at coastal stations, both the considerable strengths and remaining limitations of the use of NARR to force such a model application are discussed.

(8-B) Modelled effects of Climate Change in Oslofjord

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The Oslofjord is an inlet in the south-east of Norway. More than 40% of Norway’s population resides under 45 minutes of driving from the Oslofjord. The Oslofjord has Norway’s busiest traffic of ferries and cargo boats. It is an important recreational area with boat and cottage life, camping, swimming and fishing. The Norwegian government is currently undertaking various studies to evaluate the impacts of climate change on the water quality of Oslofjord so that viable adaptation measures can be implemented for a sustainable livelihood. The Norwegian Institute of Water Research (NIVA) was commissioned to model the effects on water quality in the Oslofjord due to future climate change. A 3-D hydrodynamic and transport model, GEMSS was used to run climate change scenarios for the three 30-year periods: 1961-1990, 2021-2050 and 2071-2100. Input to the model was hourly climate data from the Norwegian University of Life Sciences (NMBU), hourly water level at the southern open boundary and daily water flow in rivers. Water quality data was measured nearly every month at the open boundary, in the main rivers and from sewage outfalls. The model was calibrated and tested against observed values for 2008-2009. In the Oslofjord near Oslo, simulated temperatures were in good accordance with observations. Also salinity values were well simulated. The model simulated ice infested days compared well with observations. The model reproduced the main development of phytoplankton concentrations. The results were deemed satisfactory for the use of the model to evaluate the effects of climate change scenarios. The climate scenario data were produced by the regional model HIRHAM by the Norwegian Meteorological Institute. The regional model used data from the global model HadCM3 from the Hadley Centre in the UK. Daily values of the variables in the climate scenarios were used as inputs to the hydrodynamic and water quality
model. For the future scenarios only climate parameters were changed. Other inputs to the model were the same for all the scenarios. The simulated mean temperatures in the surface water (0-2 m) of the fjord increased from 7.7 °C in the 1960-1990 period with ca. 0.8 °C and 1.0 °C during the following periods, respectively. The differences were greatest during autumn and winter and smallest during spring and early summer. According to the simulations years with ice cover will be reduced from 2 of 3 year in the 1961-1990 period to 1 of 3 year during 2021-2050 and to 1 of 10 years at the end of the century. The salinities were rather the same in all the scenarios. This reflected the small differences in the freshwater discharges. There were small differences between the scenarios concerning phytoplankton. The maximum values were about the same. The growing season started about a week earlier in the spring and had a slower reduction during the autumn in the future scenarios. The tendency to a prolonged growth season in the future was caused by increased water temperatures.

(9-A) Sea State-Dependent Surface Wind Stress in the Coupled ADCIRC and SWAN Model for Storm Surge Modeling

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Surface wind stress is the primary force that drives upper-ocean circulation, non-tidal water level fluctuations in coastal areas and the formation of surface wind waves. Current parameterizations of the surface wind stress in the ADCIRC storm surge model utilize empirical formulas for the surface drag coefficient Cd as a function of the 10m height wind speed, (e.g., the Garratt’s 1977 formula, and the Powell’s storm sector-based formula). While numerous formulas for Cd exist, in storm surge modeling it is generally believed that Cd increases linearly with wind speed at low to moderate winds and then levels off or even decreases at high winds. Other sea state-dependent empirical formulas for the surface roughness length z0 have also been proposed based on field and laboratory studies, since the influence of waves on momentum flux at the air-sea interface has long been recognized. In this study, we evaluate two prevailing methods from the literature that calculate z0 from wave characteristics to examine the behavior of Cd in tropical cyclones: the “wave age” dependent formula from Drennan et al. (2003), and the “wave steepness” formula from Taylor and Yelland (2001). We also evaluate two new methods that compute the surface wind stress as the vector sum of the frictional stress and form stress based on the directional wavenumber spectrum, the RHG and DCCM methods from Reichl et al. (2014), which include the impact of all waves. All of these methods have been implemented in the coupled ADCIRC + SWAN model. Initial comparison of different Cd from different methods and their impact on storm surge predictions will be discussed in this talk.

(9-A) A Comparison of Methods for Total Water Level Prediction Using ADCIRC

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The purpose of this research is to develop and compare an ADCIRC and ADCIRC/HEC-RAS paired model for the purpose of total water level forecasting using the Tar River and Pamlico Sound area as a test case.

ADCIRC is a 2D hydrodynamic model that is widely used for coastal storm surge prediction, but it suffers from long runtimes in high-resolution areas, such as rivers and river/ocean boundaries. HEC-RAS is a 1D hydraulic modeling system and is effective at modeling rivers and streams, but it cannot model inherently 2D oceanic interactions. Both models are capable of simulating river systems. While some of the differences between ADCIRC and HEC-RAS can be intuited simply by studying their underlying equations, a case-study comparison of each model’s ability to accurately and quickly simulate storm impact on a riverine / estuarine system may serve as a valuable tool for researchers and forecasters. As part of this project, two methods were used to hindcast the response of the Tar River and Pamlico Sound area in North Carolina to a battery of tropical storms. For the first method (ADCIRC-only), a grid developed for
One of the challenges facing municipal and state planning and management agencies is the development of an objective, quantitative assessment of the risk, to both structures and infrastructure, that coastal communities face from storm surge in the presence of changing climatic conditions, particularly sea level rise. Ideally the assessment tool or index would also allow planners and managers to evaluate a variety of regulatory and nature and engineered based options to mitigate the risk. Using STORMTOOLS surge and wave maps, which are based on fully coupled water level wave models (ADICIRC and STWAVE), the Beach SAMP shoreline change maps and future shoreline projections, and recent advances in assessing damage from storm events by the US Army Corp of Engineers, North Atlantic Comprehensive Coastal Study (NACCS) using recent data from superstorm Sandy, as building blocks the Coastal Environmental Risk Index (CERI) is being constructed. The goal of this effort is to develop and apply the index to assess the risk that structures and infrastructure face from storm surges, including flooding and the associated wave environment, in the presence of sea level rise, and shoreline erosion/accretion. To allow quantification of the risk, CERI uses percent damage for structures and infrastructure associated with storm flooding. It estimates damages from inundation, waves, and erosion and all damages combined. Access to the electronic emergency data base (E-911) allows the analysis to be readily performed for individual structures. CERI has been designed as an on line GIS based tool, and hence is fully
compatible with STORMTOOLs flooding maps. As an alternative to STORMTOOL maps, FEMA’s Flood Insurance Rate Maps (FIRMs) can also be used to specify the surge and wave conditions. Damages can be estimated for low, most likely, and maximum based on the NACCS damage assessment curves. Estimates of the cost of the damage can readily be determined given information on the value of each structure. The basic framework and associated GIS methods can readily be applied to any coastal area. The framework can be used by municipal and state planners to objectively evaluate different policy options for effectiveness and cost/benefit. CERI is currently being applied, in a collaborative effort, to two communities: Charlestown, RI representing a typical barrier system directly exposed to ocean waves and high erosion rates, with predominantly single family residences and Warwick, RI located within Narragansett Bay, with limited wave exposure, low erosion rates and a wide mix of structure and infrastructure types. Results of these applications will be highlighted.

**9-B) Modeling of wave climate for the past 20 years in Lake Michigan**

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Lake Michigan coastal communities are highly vulnerable to the effects of climate change and variability. The latest climate change projections for the Lake Michigan indicate that both storm event frequency and intensity are expected to increase, as well as episodes of rapid water level fluctuations. For example, within only a 3-year time span, the “big heat” decade leading up to 2012 and the “big chill” of 2014 winter events caused mean water levels in Lakes Michigan-Huron to fall to record lows and then rise an unprecedented 2.65 feet (0.81 m) over an 18-month period. Such significant water level fluctuations and climate change affect the wave climate in the Lake and subsequently impact the resiliency of coastal communities.

Assessment of coastal resiliency highly relies on the understanding of wave climate. Waves may cause major hazards in coastal region. They contribute significantly to coastal sea level extremes and subsequent flooding. They can cause coastal erosion, leading to the breach of dunes and collapse of near-coast structures. Waves also play an important role in climate system. They are involved in several key processes at air-sea interface, such as momentum fluxes, energy and heat fluxes, mass fluxes and radiation budget.

The objective of this study is to understand the effects of climate change and water level fluctuations on wave climate along the Lake Michigan coast. Third-generation wave model, SWAN is used to reconstruct the wave climate for the past 20 years in Lake Michigan. Statistical analysis of the wave climate will be performed to understand the changes of extreme wave heights in a changing climate.

**9-B) Estimation of Wave Shoaling Coefficients for Steep Coastal Slopes**

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Understanding of wave shoaling over beach slopes is essential for many coastal engineering applications. Wave shoaling heights over mild slopes can be estimated fairly using linear wave theory but no formulation is available for predicting shoaling wave heights over steep slopes. Combined reflection and shoaling lead to complex variation in wave heights, when the wave travels on steep slopes, which cannot be represented by the linear wave theory as it is reportedly suitable for gentle slopes (slope<1/10) (CEM, 2002). In this study, wave shoaling characteristics have been analyzed using an experiment study for regular waves shoaling over steep slope (slope-1/2.8 has been used). The experiments have been carried out using an in-house two dimensional wave flume of 50 m length using sinusoidal waves and wave heights were recorded using wave gauges. Experimental test was conducted for various combinations of water depths, wave height and wave periods. Variation of shoaling coefficients was analyzed with respect to various wave parameters such as Ursell number, Surf similarity parameters, relative depth and wave periods. A methodology for estimation of wave shoaling coefficient has been proposed in the study for wave shoaling over steep slopes. The experimental conditions are then simulated in a numerical wave flume and
similar results have been obtained in the numerical flume. Numerical flume is made using the model COULWAVE which is based on Boussinesq equation. COULWAVE model uses fully nonlinear Boussinesq equations given by Wei and Kirby (1995) and finite difference methods. Also, this model incorporates various important nearshore processes like bottom friction and wave breaking.

(9-B) Wave Characteristics in Chatham Sound, British Columbia, Canada

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This paper presents wave climate and wave dissipation behavior in Chatham Sound on the Pacific Ocean coast of British Columbia, Canada. The study area is located near Prince Rupert, BC and is sheltered from the Dixon Entrance-Hecate Strait-Queen Charlotte Sound coastal system by a series of small islands. The Delft3D-Wave module that uses the third generation wave model SWAN was used for wave simulations in this study. The model accounted for swells; wave generation by winds; wave propagation and modification due to refraction and shoaling; and wave energy dissipation due to whitecapping, depth-induced breaking, and bottom friction. Non-linear wave-wave interactions, wave blocking by flow and transmission through or blockage by obstacles were also included in the model. Both offline coupling of hydrodynamic results and standalone computations were performed to obtain the wave model results on nested grids with progressively finer resolutions. The course grid outer model was selected such that the offshore boundary extends well into the Pacific Ocean. Available bathymetry, climatological and wave data from Canadian Hydrographic Services, General Bathymetric Chart of the Oceans, Environment Canada, and National Weather Service Environmental Modeling Center Wave Watch III hindcast reanalysis archived data were collected and used in this study. Model simulations were performed for model calibration against available wave data and to simulate wave climate for statistical extreme wind conditions. Model results indicate that large swells from the Pacific Ocean that enters through the Dixon Entrance would quickly dissipate as they propagate towards Hecate Strait and wave climate in Chatham Sound is primarily governed by the local sea state. Due to very large tidal range in the study area, which is over 7 meters, the region could also experience locally generated moderately high wave heights during high tides before the waves are dissipated on steep shorelines.

(9-B) Surface Wave Modeling under Tropical Cyclones in Coastal Rhode Island and Narragansett Bay Regions

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Ocean surface waves may significantly modify coastal ocean dynamical processes including currents and sea levels (storm surge) under hurricanes. Therefore, efforts are being made to couple surface wave models and coastal ocean (or storm surge) models. In this presentation, performance of two operational surface wave models, WAVEWATCH III and SWAN, is investigated under land-falling hurricanes in coastal Rhode Island and Narragansett Bay regions during Hurricane Bob. Bob is the most recent hurricane to hit the New England states directly as a hurricane. Wind forcing fields are generated based on the Tropical Cyclone Extended Best Track Dataset as well as from the hurricane prediction models. The wave simulations also include surface current effects, using the output from the ocean (or storm surge) model that is coupled with the wave model. The results are validated against available buoy observations. Once validated, the simulated wave fields are used to investigate the surface
(10-A) Numerical Simulation of Subaqueous Clayey Debris Flow

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Debris flows under both the subaerial and subaqueous environments can be catastrophic due to their highly energetic dynamics. Understanding their similarities and discriminating their disparities are vital for prediction and prevention purpose. To this end, we present a two dimensional numerical model to simulate the muddy subaerial and subaqueous debris flows. In this model, we describe the rheology of the debris flow with the Herschel-Bulkley model, and we utilize the explicit finite difference scheme to solve the modified shallow water equations in conservative form. We apply this model to a series of the flume experiments conducted by Mohrig et al., 1999. Modelling results indicate remarkably improved performance for the subaerial runs in comparison with the BING model (Imran et al., 2001). However, direct application of the subaerial model to the subaqueous runs suggests similar limitations as the BING model, which signifies that more physical mechanisms should be considered. And further incorporation of the shear wetting effect (De Blasio et al., 2005) into the subaqueous model is demonstrated to attain much better results.

(10-A) Modeling the Impact of a Tidal Stream Array on Bedload Sediment Transport

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The slowing down of tidal currents resulting from in-stream tidal energy extraction can alter both the local and far-field morphology of the sea bed. For instance, sand banks, which are formed by tidally generated eddy systems in the vicinity of headlands and islands, are highly sensitive to small changes in current velocity. As such banks and other similar coastal morphology features provide a natural protection against coastal erosion, the effect of tidal energy extraction on their evolution and permanence is of concern. It is important to assess the magnitude of any impact against the natural variability of the system, e.g. storm, spring/neap, seasonal and interannual variability. The majority of studies of changes to “sediment dynamics” due to TEC array installations are based more on simulating changes to bed shear stress, due to uncertainty with sediment transport and morphodynamic modelling. Current ocean models cannot realistically simulate effects of ocean renewable energy devices, as they focus on larger scale processes, while fluid-structure foundation (bed sediment) interactions with a Tidal Energy Convertor (TEC) are considered small scale (i.e. sub-grid scale), when compared to oceanic scales. Therefore, there is a gap between high resolution computational fluid dynamic (CFD) modelling which can only be considered at the device scale and ocean modeling at the regional scale, although both approaches share the same fluid dynamics and numerical modelling principles. Much of the uncertainty in the bed load estimation arises from uncertainty in the prediction of the bed stress, the partitioning of the bed stress into form drag and skin friction (the latter being used in the bed load formula), and the reliance on uncertain bed roughness (ripples) estimation in the bed stress estimation in the first place. In recent work, TECs have been simulated as momentum sinks in regional ocean models, but this did not address TEC impact on sediment transport modeling. Due to the paucity of observational data, particularly in the presence of TECs, the skill of sediment transport models in predicting such impact is yet to be explored and assessed. Additionally, many observations regarding the hydro-morphodynamic impact of a TEC are based on laboratory studies, which do not take into account realistic oceanic conditions (e.g., background turbulence, the presence of obliquely incident waves, and wave-current interactions). In this work, we first apply a few ocean models to characterize a tidal energy test site in the UK (Skerries project); then, a simplified analytical approach is developed to assess the impact of a tidal-stream TEC array on bed load sediment transport, which is considered as the main factor controlling seabed morphodynamics. Issues such as the proper choice of bed load transport parameterization and wave effects on sediment transport, are discussed.

(10-A) Change of Sediment inside harbors due to Long Waves and Tsunami motion; Case Study of Haydarpasa Harbor in Istanbul

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Tsunamis in shallow water zone lead to sea water level rise and fall, strong currents, forces (drag, impact, uplift, etc.), drawdown, scour, and morphological changes (erosion, deposition), debris and debris flow, dynamic water pressure, resonant oscillations and seiches. As a result, ground material under the tsunami motion move and scour/erosion/deposition patterns can be observed in the region. Ports, harbors as enclosed basins are the main examples of coastal structures that people need for efficiently using the coastal areas. These coastal structures usually have encounter natural hazards with small or huge damaging scales. Morphological changes are one of the important tasks in the basins under short and long waves attack. Tsunamis as long waves lead to sedimentation as erosion and accretion in the basins which in this study its relation to the current pattern is noticed. A methodology based on computation of instantaneous Rouse number during tsunami simulation is presented to investigate the tsunami motion and calculate the respective sediment movement by computing the spatial and temporal change of Rouse number under tsunami inundation according to the approach given in Yeh et al. (2008). The spatial distribution of sediment properties (diameter, fall velocity and density) is used and a sediment property matrix is developed for the computation of Rouse Number. The instantaneous current velocities at every grid point are used to compute the instantaneous Rouse number from sediment property matrix at each time step during simulation. In this study the response and behavior of water motions inside the enclosed basins under long wave conditions are investigated by using numerical model (NAMI DANCE). The spatial and temporal changes of main tsunami parameters and their adverse effects on harbor performance are studied specifically monitoring the variation of sediment motion in terms of Rouse number. In the case studies the harbor shape is L-shape with a flat bathymetry and the effects of incident wave period and basin geometry are investigated. The results are presented with discussions. It is important to compute and evaluate the effects of long wave parameters in shallow zone. The spatial distribution of maximum water elevation, maximum current velocity and the minimum Rouse Number computed at each grid in the domain during the simulations. The corner points on the sides of the basin are always the critical points. The exterior corner of the L-shape is where the water surface elevation amplifies extremely, but there is no current amplification. The interior corner of the L-shape is where the current velocity amplifies extremely, but there is no wave amplification. The pattern of sediment motion in these mentioned two corner points depend on both current pattern and amount. In vortex currents, if the current is large enough the sediment motion is in wash load form but if the current is small the sediment motion is in bed load mode and therefore, erosion is expected in these regions.

**3D Modelling on Dispersion of Dredge Sediment Plumes and Fate of Sediment Disposal**

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Sediment dredge is a common practice of coastal engineering to maintain water depth in harbor basins and navigation channels. During dredge operation, turbid plumes of suspended sediment are generated through the overflow from dredge barges, the disturbance of dredge heads, the dumping of dredged materials, and the fate of disposed materials due to resuspension. The dispersion of sediment plumes and the fate of disposed materials may have significant impact on the water environment. The environment impact assessment is generally required for the dredge operation. This paper will describe the approach and results of combined 3D modeling of plumes from hopper dredging overflow, split hull dumping and sediment mound dispersal completed over successive dredge cycles to support environmental impact assessments in a case study of Sao Luis, Brazil. (See detailed abstract in the attached file)

**Modeling Sedimentation and Freshwater Conveyance in Swinomish Navigation Channel in Puget Sound – Restoration versus Maintenance**

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The 11-mile, 100 ft wide Swinomish Navigation Channel between Skagit Bay and Padilla Bay near the mouth of Skagit River estuary in Puget Sound provides the shortest and safest route for vessels traveling between northern and southern Puget Sound. Over the years, river training dikes and jetties designed to minimize sedimentation in the channel have deteriorated with increased shoaling related impacts to navigation reliability and dredging costs. The need to repair, maintain, and construct new dikes for navigation channel maintenance
however is in conflict with salmon habitat restoration goals aimed at improving access, connectivity and brackish water habitat for migrating salmon. A number of nearshore restoration projects have been proposed involving breaching, lowering, or removal of dikes. A hydrodynamic model of the Skagit River estuary was developed using the Finite Volume Coastal Ocean model (FVCOM). The model domain extends from Padilla Bay at the north boundary to Saratoga Passage to the south. In this study we present the refinement and calibration of the model to address conveyance of brackish water and sediment transport into the Swinomish Channel. The model was calibrated using oceanographic data collected from the years 2006 and 2009. The model was then applied to assess the feasibility of achieving the desired dual outcome of (a) reducing sedimentation and shoaling in the Swinomish Channel and (b) providing direct migration pathway and improved conveyance of freshwater into the Swinomish Channel. The potential reduction in observed shoaling through site-specific dike repairs is evaluated along with potential increase in sediment deposition due to selected proposed restoration actions. This information informs planners to evaluate if such changes in sedimentation can be accommodated by current and ongoing maintenance dredging for the channel.

(10-B) Influences of Nutrient Load and Various Wind Factors on Chesapeake Bay Summer Hypoxia

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Extensive nutrient input and algal blooms in the Chesapeake Bay, and the subsequent decay of organic material in the summer causes deep water hypoxia. While stratification prevents the exchange of oxygen between surface and bottom waters, leading to hypoxia. Wind, on the other hand, causes mixing and the reduction of hypoxia. A model calibration run of a multi-year simulation, e.g., 1986-2005, provides hypoxic conditions over a 20 year period, in which variations in hypoxia among the years were mainly due to differences in nutrient loads and wind conditions. Model scenarios of the 20 year period using a wind condition of a specific year for all 20 simulated years provide the impacts of nutrient loads to hypoxia under specified wind conditions. The summertime observed wind in 1991 was the lowest among 1996-2005 years and was used to represent weak summer background winds for the Bay. The model estimates of hypoxia for any year in the 20 year period using 1991 wind approximates the maximum hypoxia estimated for that year if it experienced weak summer wind condition. The scenario using a strong summertime wind, e.g., the observed winds of 2002, yields lower hypoxia, which can be considered the minimum hypoxia estimates for each of the years under strong summer wind conditions despite the different nutrient loading conditions among the simulated years. Besides the importance of wind strength, wind’s direction and duration also influence summer hypoxia. The modulation of asymmetric cross-channel bathymetry on wind-induced cross-channel circulation can cause different degrees of destratification and hypoxia reduction for opposite wind directions. The effect may be most important in the early wind period. Relative strengths of destratification and hypoxia reduction between two opposite wind directions are the combined effects by wind-induced cross- and along-channel circulations and the effect of cross-channel bathymetry, which varies depending on wind speed and duration. This paper compares anoxia reduction for four idealized wind directions under various wind speeds and duration, and analyzes model scenarios that use observed wind fields with modified speed and direction. Wind events of hourly reversing direction and/or with intermittent calm periods were also analyzed.

(10-B) A numerical study of biochemical effects with physical modulation on variations of hypoxia during summer in the Pearl River Estuary

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Hypoxia in the Pearl River Estuary (PRE) during summer has been reported and studied in recent years, but the biochemical mechanism of hypoxia still remains unclear. Therefore, we apply a one-dimensional and three-dimensional coupled physical model that incorporates a three-dimensional oxygen model to identify the roles
played by biochemical processes in hypoxia. However, the biochemical processes will influence both local dissolved oxygen (DO) as well as DO in adjacent waters. The physical modulation of biochemical processes is therefore introduced to describe and investigate this process. The results show that there is a hypoxic zone located on the shelf off the Madaomen sub-estuary. However, the hypoxia in the PRE is not severe, and the hypoxic area is only 213 km² when hypoxia is defined as dissolved oxygen (DO) < 3 mg/L. To elucidate underlying causes for this phenomenon, the physical modulation of biochemical processes is introduced and then a budget of biochemical processes is conducted to quantify each biochemical process. The physical modulation of biochemical processes is distinct in the PRE, where water exchanges quickly. The similar spatial patterns of modulated biochemical processes and DO at the bottom confirms that hypoxia mainly occurs off the Madaomen sub-estuary. The physical processes transport hypoxic bottom water in the Lingdingyang and Madaomen sub-estuary, which is depleted mainly by the sediment oxygen demand (SOD), to the shelf off the Madaomen. Hypoxia is consequently generated in this location. This process can be regarded as a transport of SOD, which is referred to as the physical modulation of biochemical processes in this study. The budget analysis of biochemical processes illustrates the dominant role of SOD, which accounts for 71% of DO depletion at the bottom. This suggests that SOD is critical to the formation of hypoxia. After quantifying each biochemical process, the net DO consumption is evaluated. The low net DO consumption value (<0.2 mg/(L•day)) is why the hypoxia in the PRE is not severe. Furthermore, quantitative relations of bottom DO with net DO consumption and stratification in the hypoxic zone have been established since the stratification has been studied extensively. The net DO consumption can account for over 86% of the variation in bottom DO within the hypoxic zone, while stratification accounts for less 8%.

(10-B) Effects of data assimilation on real-time simulation of hypoxia in Tokyo Bay, Japan

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Real-time monitoring stations were established in major estuaries of Japan 7-8 years ago, and real-time ocean data has been made available on the Internet. Although there are five monitoring stations in Tokyo Bay, they are not enough to understand the true state of hypoxia and other states in the bay, so that real-time simulation with data assimilation is necessary to ensure the fullest possible use of monitoring data. We have been developing a real-time simulator for current and water quality. In this presentation, we mainly focus on the reproducibility of distributions of dissolved oxygen (DO) and the upwelling of anoxic water along the north coast of the bay and describe what issues occur in the real-time simulation under the limited availability of real-time data for boundary and forcing conditions. We use the Regional Ocean Modeling System (ROMS) with modification of a biological model. To avoid using costly HPCS and secure broad applicability of a real-time simulator, we do not run tests with the atmosphere model, but use observations on land and at sea with ground roughness varied by wind direction. Since we use a nudging method for assimilation of hourly real-time monitoring data, we investigate spatial distributions of the nudging coefficient and an assimilation period to reproduce the distributions of water temperature, salinity and DO. Finally, we attempt to reproduce the upwelling of hypoxia. Free run, without data assimilation, shows large differences of bottom water temperature in the central part of the bay when data is not assimilated in that part. Data assimilation using data in the other parts cannot improve this, which shows that it is important that correct boundary conditions are set using real-time data at the entrance of the bay. Results of sensitivity simulation regarding nudging parameters show that the radius of influence should be 7.5km and 10km. In the inner part of the bay, assimilation improves reproducibility of vertical profiles of water temperature, salinity and dissolved oxygen because salinity and temperature are also assimilated as well as DO. The assimilation run reproduces the better horizontal and longitudinal distributions of DO and reproduces hypoxia that forms in the central part of the bay. Anoxic water upwells along the northeast coast of the bay several times during the summer. Hydrogen sulfide contained in anoxic water is oxidized near the sea surface or around the anoxic water near the bottom to form small white particles of elemental sulfur. This phenomenon is presumed to have occurred on September 23, 2012 at 7am. In comparing results at a monitoring station (Sta. 2), while the free run simulated that the water with the low concentration of DO upwelled at that time, the assimilated run reproduced the time of occurrence and the vertical profiles and temporal change of DO as well. Only the assimilation run, however, estimates the correct time and obtains a good isopleth at another station (Sta. 4). These results show that data assimilation has a significant role in the real-time simulation.
Comparing the Impact of Organic vs. Inorganic Nitrogen Loading to the Neuse Estuary with a Mechanistic Eutrophication Model

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Anthropogenic nutrient loading and the resulting cultural eutrophication of lakes, estuaries, and coastal oceans is generally recognized to be a serious worldwide and national problem. In North Carolina, nutrient-related water quality impairment exists across the state, and is seen as responsible for 41% of the impairment of North Carolina lakes on an areal basis. While impacts of cultural eutrophication are not new in North Carolina, they continue to be a problem despite ongoing management actions such as phosphorus detergent ban in 1988 and more recent limits on nitrogen loading from wastewater treatment plants. Four of the state’s waters (Jordan Lake, Tar-Pamlico River, the Neuse River, Falls Lake) have been given a special “nutrient sensitive water” use classification that allows for site-specific watershed management. A water quality modeling study of the Neuse River Estuary is currently underway. Algal blooms have plagued the Neuse River and Estuary for decades. Persistent water quality problems in the 1990s lead to a total maximum daily load (TMDL) for nitrogen (N) loading performed in 1999, an analysis that included water quality model based scenario testing. In the ensuing years inorganic nitrogen loading to the estuary has been reduced by 15-25%, but this reduction has been offset by an increase in organic N loading of approximately 15% and an increase in N loading of approximately 30% associated with development in one particular tributary of the upper estuary. Algal blooms still occur throughout the estuary and chl-a concentrations still exceed the water quality criteria value of 40 µg/L. An updated application of CE-QUAL-W2 is being implemented to study the relative sensitivity of the estuary to changes in organic vs. inorganic N loading. The model utilizes more than fifteen years of monitoring data to investigate whether nutrient assimilation by phytoplankton is equally effective for the organic and inorganic fractions of the N loading to the estuary. In addition, the model will examine the extent to which changes in distribution of phytoplankton biomass, and the biomass values seen in the estuary in the 2000’s are attributable to changes in changes in the N loading that have occurred over the last fifteen years. The presentation will describe the latest findings with the updated mechanistic model of water quality in the Neuse River Estuary.

The Importance of Spatio-Temporal Resolution of Meteorological Inputs to Hydrological Streamflow Forecasts: A Multi-Scale Application

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This work investigates the importance of meteorological inputs from Numerical Weather Prediction (NWP) models, at different spatio-temporal resolutions, to streamflow forecasts reliability. We implemented a novel, automated, short-term hydrologic prediction framework using a regional scale hydrological model (HEC-HMS) to feed river discharge inputs into the New York Harbor Observing and Prediction System (NYHOPS). The hydrologic framework was applied to sub-basins ranging from local (~150 km2) to regional (1300 km2) scale, within the Hudson River Basin. We used precipitation inputs from the Global Forecast System (GFS) with a spatial resolution of 55 km and 3-hourly temporal resolution, the European Center for Medium range Weather Forecasting High Resolution model (ECMWF-HRES) (~14 km and 3-hourly), the North American Mesoscale Model (NAM) (12 km and 3-hourly), the Coupled Ocean Atmosphere Mesoscale Prediction System (COAMPS®) (3 - 27 km and 1 hour). The results of this work show the importance of NWP inputs resolution to streamflow forecasts, particularly in smaller drainage basins with high spatial variability and faster runoff processes. This work outlines the efficiency of the approach to establish confidence in precipitation inputs as function of the basins’ drainage areas and resolution, which is beneficial for operational streamflow ensemble forecasts.
(11-A) **Operational Forecast Systems for the Coastal and Estuarine Environment in NOAA’s National Ocean Service**

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NOAA’s National Ocean Service (NOS) applies hydrodynamic models for the development, transition and implementation of operational forecast systems (OFS) in U.S. estuaries, ports, lakes and the coastal ocean. These models and systems have applications in the support of safe and efficient marine navigation and emergency response as well as marine geospatial and ecological applications. There are currently thirteen water bodies in which operational forecast systems are functioning (e.g. CBOFS - OFS in the Chesapeake Bay).

Once fully evaluated and deemed accurate by NOS standards, forecast systems are transitioned into the operational environment. The technical components of a real-time estuarine modeling system are described in terms of a “standard” Coastal Ocean Modeling Framework (COMF) which increases the efficiency of research, development, transition and operations. The COMF includes the essential operational management of observations and forecasts of atmospheric, coastal and riverine inputs, as well as the operational quality control and dissemination of results. It also includes protocols and software for the skill assessment of operational forecast systems. The COMF abides by Integrated Ocean Observing System and Earth System Modeling Framework standards. It is intended to stimulate a community approach to coastal modeling by providing tools, observational data, and a model evaluation environment with which to configure, execute, and determine model uncertainties. A good example of the results of the community approach will be our developing NOS partnership with Stevens Institute of Technology to disseminate their observational data (held to Physical Oceanographic Real-Time System [PORTS] standards), and model-based forecast system (NYHOPS – in the Ports of NY and NJ) results, as an NOS product.

To enhance the efficiency of development and operations, the NOS will be implementing several changes over the next few years, to include: (1) Evolution from individual estuarine systems on UNIX servers and nested coastal/estuarine systems (e.g. Nested NGOFS – Northern Gulf of Mexico) to large scale coastal/estuarine systems (i.e. West, Gulf and East Coasts) using unstructured grids on NOAA’s High Performance Computer System (Weather & Climate Operational Supercomputing System - WCOSS); (2) upgrades to the Great Lakes from the POM to the FVCOM model to include higher resolution, a longer forecast horizon, and ice; (3) operational data assimilation (e.g. under development now for the West coast); and (4) operational coupling of the physical models (OFSS) to ecological models (e.g. harmful algal blooms in Lake Erie and the Gulf of Maine; hypoxia in the Chesapeake Bay and Northern Gulf of Mexico.)

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(11-A) **National Ocean Service’s Gulf of Maine Operational Forecast System (GoMOFS)**

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A new operational forecast system has been developed in the Gulf of Maine by NOAA’s Coastal Survey Development Laboratory (CSDL). The model is being run in nowcast and forecast modes by NOAA’s Center for Operational Products and Services (CO-OPS) on the NCEP’s Climate Operational Supercomputing System (WCOASS). The ROMS model was
chosen as the core model structure for GoMOFS, predicting water levels, currents, temperatures and salinity to support CO-OPS’ Physical Oceanographic Real Time System (PORTS). High resolution of rectangular grid is used to stabilize the model in this high tidal energy region. Surface forcing is interpolated from the North American Mesoscale Forecast System (NAM), while 2D subtidal water level, vertically-averaged currents and 3D temperature and salinity along open boundaries are obtained from NCEP’s Global Real-Time Ocean Forecast System (G-RTOFS). Hindcasts indicate that modeled water level, currents, temperature and salinity agree well with measurements. Two months of quasi-operational nowcast/forecast results also shows good agreement between model results and observations.

(11-B) **Combining Inverse and Transport Modeling to Estimate Bacterial Loading and Transport in a Tidal Embayment**

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Poquoson River is a tidal coastal embayment located along the Western Shore of the Chesapeake Bay about 4 km south of the York River mouth in the City of Poquoson and in York County, Virginia. Its drainage area has diversified land uses, including high density of residence, agricultural, salt marsh, and a National Wildlife Refuge. This embayment experiences elevated bacterial concentration due to excess bacterial inputs from storm water runoff, nonpoint sources, and wash off from marsh due to tide and wind-induced set-up and set-down.

The bacteria can also grow in the marsh and small tributaries. It is difficult to use a traditional watershed model to simulate bacterial loading, especially in this low-lying marsh area with abundant wildlife, while runoff is not solely driven by precipitation. An inverse approach is introduced to estimate loading from unknown sources based on observations in the embayment. The estimated loadings were combined with loadings estimated from different sources (human, wildlife, agriculture, pets, etc.) and input to the watershed model. The watershed model simulated long-term flow and bacterial loading and discharged to a three-dimensional transport model driven by tide, wind, and freshwater discharge. The transport model efficiently simulates the transport and fate of the bacterial concentration in the embayment and is capable of determining the loading reduction needed to improve the water quality condition of the embayment. Combining inverse, watershed, and transport modeling is a sound approach for simulating bacterial transport correctly in the coastal embayment with complex unknown bacterial sources, which are not solely driven by precipitation.

(11-B) **Modeling water clarity in oceans and coasts**

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In oceans and coastal waters, phytoplankton is the primary producer of organic compounds which form the base for the food chain. The concentration of phytoplankton is a major factor controlling water clarity and the depth to which light penetrates in the water column. The light intensity available at any depth is a major factor determining the health of phytoplankton populations. For example, there is a strong coupling between light intensity and phytoplankton concentration (e.g., self-shading of the cells), which reduces available light and in return affects the growth rate of the cells. Accurate modeling of light intensity in the water column is essential to understand and predict primary productivity in oceans and coastal systems. This paper provides a complete method to track the change in light intensity, as phytoplankton concentrations change in the water column, which can be included in existing water quality models. The methodology implements relationships from bio-optical models, which use phytoplankton chlorophyll a (Chl-a) concentration and other factors as a surrogate for light attenuation due to their effects on absorption and scattering. The mathematical algorithm presented estimates the reduction in water column light intensity due to absorption by pure water, Chl-a pigment, non-algal particles (NAPs), and colored dissolved organic matter (CDOM), as well as backscattering by pure seawater, phytoplankton particles, and NAPs. Since light is the fundamental factor supporting phytoplankton production, the method presented will facilitate studies of the effects of various environmental and management scenarios (e.g., global warming, altered precipitation patterns, greenhouse gases) on the wellbeing of phytoplankton in the oceans and coastal systems.
Long-term Morphology Modeling of Barrier Island Tidal Inlets

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The U.S. Army Corps of Engineers’ Coastal Modeling System (CMS) is used to simulate the long-term morphodynamics of coastal barrier-inlet systems. The CMS consists of an integrated numerical modeling system for simulating wave, current, water levels, sediment transport and morphology change. In order to quantify the physical effects of long-term, regional climactic changes, numerical morphodynamic models must be able to reproduce the known generic characteristics that drive barrier inlet processes, including equilibrium inlet dimensions and sediment budget for the tidal shoals. In this study, model results are presented for a 100-year simulation of several idealized inlets with dimensions similar to that of US tidal inlet/bay systems. The model reproduces reasonably well several geomorphic and hydrodynamic features and is in agreement with established barrier inlet stability theory. The model results demonstrate the feasibility of applying the CMS for simulating long-term morphology at coastal inlets for practical applications.

Simulative Analysis of Storm Tide Levels along Roxas Boulevard Seawall

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The city of Manila bounded by the Manila bay is frequently hit by typhoons exiting towards the West Philippine Sea. In 2011, Typhoon Nesat (Local Name: Pedring) produced high waves that overtopped and breeched Roxas Boulevard Seawall causing heavy inland flooding. The study presents a simulative analysis of the storm tide levels at Roxas Boulevard seawall due to historical typhoon events from the year 1977-2014 which fell within the 180km radius of the city of Manila. The study used the ADCIRC (ADvanced Circulation) numerical model to predict for the storm tide levels along several key points at Roxas Boulevard Seawall. Due to the archipelagic nature of the country, a smaller domain was generated in the west coast of the Philippines. The modelling domain extended 126km southwest from the study site towards the Manila Bay opening up to the West Philippine Sea and the surrounding coastline was simplified to ease computation, but kept important geometric contours such as breakwaters and piers along the study site. Among the the thirty storms studied, two typhoons that were outside the search area but caused the breach of the sea wall: Nesat 2011 (Local Name: Pedring) tracked 220km north of the study site, and Saola 2012 (Local Name: Gener) tracked 300km east of the site were also considered in the study. From the simulation, the highest storm tide level was recorded during the 2014 typhoon Rammasun, entered Manila bay to the south of Roxas Boulevard seawall, (Local Name: Glenda) which produced 2.36m in height. Xangsane / Milenyo 2006, is another storm that traversed the Manila Bay entering by way of Cavite before exiting the West Philippine Sea. This typhoon also produced high storm tides along the study site at 2.09 on the north side of the wall. Similarly, this storm produced high storm tide levels at the mouth of the Pasig River at 2.1m. However, it is surprising that the two storms that caused the breech of the seawall did not rank on the five highest storm tide levels. The seawall elevation is about 2.0m at its crest and would not overtop due to the said storms. Typhoon induced waves during these two events should be studied to further understand the seawall overtopping that caused massive flooding at areas behind the wall.

A Multiscale Approach to the Optimization of Tidal Energy Extraction

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Tidal in-stream energy conversion (TISEC) facilities provide a highly predictable and dependable source of energy. Given the economic and social incentives to migrate towards renewable energy sources there has been tremendous interest in the technology. Key challenges to the design process stem from the wide range of problem scales extending from device to array. In the present work we apply a multi-model approach to bridge the scales of interest and demonstrate the method by estimating the technical resource for several realistic sites.
In the coastal waters of Massachusetts, USA. The approach links three computational models. To identify potential sites for turbine arrays, a 3D barotropic setup of the unstructured grid ocean model FVCOM is employed. The model is validated using shipboard and fixed ADCP as well as pressure data. Turbine layout at specific sites is determined using a shallow water equation solver coupled with a global optimization algorithm. Turbines are modeled using a sub-gridscale approach. For device scale, the structured multiblock flow solver SUmb is employed. A large ensemble of simulations of 2D cross-flow tidal turbines is used to construct a surrogate design model. The surrogate model is then queried using site specific conditions to determine the optimal geometry for the tidal array. Following the turbine and layout design, the annual technical yield of the array is evaluated with FVCOM using a linear momentum actuator disk approach to model the energy extraction. Demonstration of the method is made at two sites in southern New England. The approach is general enough to be applicable to sites with greater power potential around the globe.

**Impact of Mississippi River Diversions on Salinity Gradients and Estuarine Residence Time in Coastal Louisiana: A Numerical Modeling Study**

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The recently released Louisiana’s Comprehensive Master Plan for a Sustainable Coast (2012) proposed to use river diversions that would convey orders of magnitude more fresh water to the coastal wetlands than the existing ones. These proposed sediment diversions may cause significant displacement and salinity stress to commercially and recreationally important fish and shellfish species due to the wide-spread and prolonged freshening of habitats. In this study, a three-dimensional, unstructured grid, Finite Volume Coastal Ocean Model (FVCOM) is developed to study the effect of the proposed diversions on salinity distribution and to infer their influence on fisheries within the Barataria Basin. To accurately consider the impact of coastal ocean processes on bay salinity variation, the estuary-scale FVCOM is coupled with the output product from Navy near real-time 1/12° Atlantic HYCOM ocean forecasting system. Thus, the effect of tidal- and wind-driven circulation over the Louisiana continental shelf that bring saline oceanic waters into the deltaic estuary can also be considered. The numerical model domain covers most of the Alabama-Mississippi-Louisiana-Texas continental shelf with very high horizontal resolution (on the order of 15 meters) in Barataria Bay. Model simulation results are compared with observational data for model calibration and validation. A number of different diversion scenarios are assessed, including individual and concurrent operations of Davis Pond, mid-Barataria, and lower-Barataria diversions. Numerical modeling results indicate that river diversions and coastal ocean processes both have the potential to greatly alter bay salinity regime and strongly influence estuarine residence times. This model can provide policy-makers and resource managers an important tool in coastal restoration planning.

**Investigating Natural and Anthropogenic Impacts on Salinity in Apalachicola Bay, FL**

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The changing patterns of salinity distribution in response to several water management operation scenarios as well as storm and sea level rise in Apalachicola Bay, Florida is investigated using an integrated hydrodynamic modeling system. Hydrodynamics and salinity in the Bay are simulated with a CH3D-based modeling system, using a high spatial resolution estuarine domain and input from river inflow, ocean forcing, as well as forcing by a US Navy NOGAPS atmospheric model. The hydrodynamic model is verified with long-term water level and salinity data, including during the 2004 hurricane season when four hurricanes impacted the system. Strong freshwater flow from the Apalachicola River and good connectivity of the Bay to the ocean allow the estuary to restore its normal salinity condition within a few days after a hurricane passage. Several scenarios (all spanning a period of 10 years) that differ in freshwater inflows at the Apalachicola River are analyzed. One of these is based on actual observed data and three others representing different consumption modes and respective ACF Basin hydrology and reservoir operations. For a 10-year historical scenario, simulated long-term salinity agrees well with the observed values at stations. For two scenarios that reflect an increased water demand (~1%)
upstream of the Apalachicola River, simulations show a slight increase in salinity (less than 5%) increased salinity (leading to a potential reduction in oyster growth rate) inside the Bay. A worst case sea level rise scenario (~1m by 2100) is shown to potentially increase the bay salinity by up to 20%.

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A Sensitive Study on the Mississippi River Plume Dynamics

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Outflow dynamics of the Mississippi River and its associated buoyant coastal currents have attracted a lot of research interests. Freshwater enters the northern Gulf of Mexico continental shelf after leaving the Mississippi River Delta through multiple active passes, the largest being the Southwest Pass debouching about 45% of the total delta discharge. For the buoyant flows through these passes Kelvin number is an order of magnitude smaller than unity (~ 0.2, Garvine, 1995), the momentum-dominated effluents have Froude number close to or larger than 1 and are characterized by fully turbulent jets that exhibit low lateral spreading angles and progressive lateral and longitudinal deceleration (Wright, 1977). Satellite Imagery captured by the Moderate-resolution Imaging Spectroadiometer (MODIS) along the Louisiana coast detects several jet-like effluents that can extend up to more than 20 km offshore (Walker et al., 2005). Whether or not these effluents will develop into anticyclonically rotating bulges is on a case-by-case basis, therefore hard to determine. These observations suggest that the Mississippi River plume is a highly nonlinear dynamic phenomenon, especially in the near-field region. In order to better predict the transport pathway and ultimate dispersion and mixing of riverine freshwater into the coastal ocean and beyond, it is imperative that a detailed and accurate plume structure in the near-filed to be obtained. As a first step toward a comprehensive study of the Mississippi River plume, in this study we employ the Finite-Volume Coastal Ocean Model (FVCOM) to simulate the Mississippi River plume near-field structure, utilizing its flexible unstructured triangular mesh. Special attention is paid to the flow at the southwest pass. Sensitive study, comparing results among three different horizontal resolution meshes (~2000 meters, ~500 meters and ~100 meters), indicates that FVCOM’s ability to capture the jet-like flow and its development near the Mississippi River pass depends critically on the horizontal resolution and how accurate the pass mouth geometry is depicted by the unstructured grid.

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Dynamics of Water and Salt Exchange in Maryland Coastal Bays

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The dynamics of Maryland Coastal Bays System (MCBs) were simulated using a three-dimensional (3D) unstructured-grid based hydrodynamic model (FVCOM), and model was calibrated with the observed data including salinity, temperature and water level. Idealized experiments were carried out to investigate the impact of various levels of wind forcing on exchange processes by employing quantitative analysis of water exchange and salt flux. These experiments focused on the exchange between two inlets in the MCBs: Ocean City Inlet (OCI) and Chincoteague Inlet (CI). It was found that wind forcing significantly influenced the water exchange and salt flux. At strong wind speed, the effect of wind directions on exchange processes is substantial; for example, northerly winds gain a lot of traction and push flux to the south part of the bay, while southerly winds pile up flux towards northern Chincoteague Bay (CB). Given that wind and tide are two key external forces known to impact estuarine exchange, the effect of each physical force on the exchange processes was studied separately to evaluate the individual influence on the inlet dynamics. It was concluded that both forces make a considerable contribution to water and salt flux. With increasing wind speeds, the effect of wind forcing on the exchange processes grows stronger and can even overcome the effect of tidal forcing. Finally, the effect of tidal forcing gradually weakens with increasing wind speed.
Effects of Harbor Shape on the Tsunami Induced Sedimentation

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Tsunamis in shallow water zone lead to sea water level rise and fall, strong currents, forces (drag, impact, uplift, etc.), drawdown, scour, and morphological changes (erosion, deposition), debris and debris flow, dynamic water pressure, resonant oscillations and seiches. As a result, ground material under the tsunami motion move and scour/erosion/deposition patterns can be observed in the region. Ports, harbors as enclosed basins are the main examples of coastal structures that people need for efficiently using the coastal areas. These coastal structures usually have encounter natural hazards with small or huge damaging scales. Morphological changes are one of the important tasks in the basins under short and long waves attack. Tsunamis as long waves lead to sedimentation as erosion and accretion in the basins which in this study its relation to the current pattern is noticed.

A methodology based on computation of instantaneous Rouse number during tsunami simulation is presented to investigate the tsunami motion and calculate the respective sediment movement by computing the spatial and temporal change of Rouse number under tsunami inundation according to the approach given in Yeh et al. (2008). The spatial distribution of sediment properties (diameter, fall velocity and density) is used and a sediment property matrix is developed for the computation of Rouse Number. The instantaneous current velocities at every grid point are used to compute the instantaneous Rouse number from sediment property matrix at each time step during simulation.

In this study the response and behavior of water motions inside the enclosed basins under long wave conditions are investigated by using numerical model (NAMI DANCE). The spatial and temporal changes of main tsunami parameters and their adverse effects on harbor performance are studied specifically monitoring the variation of sediment motion in terms of Rouse number. In the case studies the harbor shape is L-shape with a flat bathymetry and the effects of incident wave period and basin geometry are investigated. The results are presented with discussions.

It is important to compute and evaluate the effects of long wave parameters in shallow zone. The spatial distribution of maximum water elevation, maximum current velocity and the minimum Rouse Number computed at each grid in the domain during the simulations. The corner points on the sides of the basin are always the critical points. The exterior corner of the L-shape is where the water surface elevation amplifies extremely, but there is no current amplification. The interior corner of the L-shape is where the current velocity amplifies extremely, but there is no wave amplification. The pattern of sediment motion in these mentioned two corner points depend on both current pattern and amount. In vortex currents, if the current is large enough the sediment motion is in wash load form but if the current is small the sediment motion is in bed load mode and therefore, erosion is expected in these regions.

Acknowledgements: Partial support by Japan–Turkey Joint Research Project by JICA on earthquakes and tsunamis in Marmara Region in (JICA SATREPS - MarDiM Project), 603839 ASTARTE Project of EU, UDAP-C-12-14 project of AFAD, Turkey, 108Y227, 113M556, 213M534 projects of TUBITAK Turkey, RAPSO (CONCERT_Dis-021) of CONCERT-Japan Joint Call and Istanbul Metropolitan Municipality are acknowledged.

Analysis of Slant-fetch Waves Using Numerical Wave Model

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A consistent onshore winds sometimes produce long period swell on the coastal waters by the slant-fetch effect. In spite of short fetch from the coast, the waves propagate along the coast and are developed by the slant-fetch wind. This paper studies the characteristics of slant-fetch waves observed near the East coast of Korea by using wind field and wave buoy data. WAVEWATCH-III model is used to simulate the observed slant-fetch waves.
The model adopts unstructured grids to express the details of the coast line and utilizes UM(Unified Model) wind produced by LDAPS(Local Data Assimilation and Prediction System) with 1.5 km space and 3 hours interval. Comparison of significant wave heights, peak periods, peak wave directions and directional spectrum between model results and observed data shows similar results of slant-fetch waves. SMB method is also tested using slant-fetch length and wave height distribution along the coast.

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**Far-field Impacts of Tidal Energy Extraction and Sea Level Rise in the Gulf of Maine**

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The dynamics of tides in the Gulf of Maine is unique due to the tidal resonance, which generates the largest tidal range in the world (about 16 m). Consequently, a large tidal energy resource is available in this area, particularly in the Bay of Fundy, and is expected to be harvested in the future. Currently, more than 6 projects are operational or under development in this region (in both US and Canadian waters). Understanding the far-field impacts of tidal-stream arrays is important for future development of tidal energy development. This includes possible changes in water elevation, currents, and sediment transport. Accordingly, a number of previous research have assessed the impacts of the tidal energy development in the Gulf of Maine. Further, due to the Seal Level Rise (SLR), those impacts may also change during the project life-time, which is usually about or more than 25 years. The objective of this study is to assess the combined effects of SLR and tidal energy extraction on the dynamics of tides in the Gulf of Maine.

A tidal model of the Gulf of Maine was developed using Regional Ocean Model System (ROMS) at one arcminute scale. The model extends from 71.5W to 63.0W and from 39.5N to 46.0N. After validation of the model at NOAA tidal gauge stations, and using other observed data, several scenarios, including SLR, and tidal extraction, were examined. Recent research suggest that the global dynamics of tides will change due to the SLR; therefore, SLR not only affects the bathymetry of the model inside the domain, it also changes the boundary forcing, which was considered in this effort. The results of the impacts of the tidal energy extraction with and without the SLR were presented, and compared with those from literature. Some recommendations about the implications of those impacts (e.g. sediment transport, storm surge) were discussed.

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**Assessment of a Novel 3D Hydrodynamic Numerical Model for Hydrodynamics and Water-quality Indicator Applications in the San Francisco Bay-Delta**

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Many drivers and stressors, both long-term and abrupt, are known to have complex effects on water quality and ecological well-being in the San Francisco Bay, Sacramento and San Joaquin Rivers, and their connected Delta system (hereafter referred to as the Bay-Delta). The USGS-led CASCaDE II (Computational Assessments of Scenarios of Change for the Delta Ecosystem) project comprises a model-based approach for determining how multiple drivers of environmental change will impact the Bay-Delta ecosystem (http://cascade.wr.usgs.gov/). The project focuses on the evaluation of changes in physical configurations of water conveyances within the Delta, as well as changes in climate, and the responses of the Bay-Delta hydrodynamics, water quality, and ecosystem processes for key species within the Delta.

CASCaDE II implements a new, 3D, unstructured grid, finite-volume hydrodynamic model - Delft3D-FM, developed by Deltares Inc. - that describes the evolution of hydrodynamic and water-quality characteristics as the critical drivers in the Bay-Delta system. Delft3D-FM connects with several other models to provide linkages across climate, hydrodynamics, sediment and ecosystem processes. The model domain encompasses the coastal ocean, estuary, and lower watershed, and includes regional rivers, freshwater withdrawal at major local, state, and federal sites, and the effects of temporary barriers and gates. Delft3D-FM use of a combined curvilinear and unstructured grid provides both improved alignment along main flow directions and more natural depictions of irregular shorelines and allows for the flooding of below-sea-level leveed islands.
The model has been applied in the San Francisco Bay-Delta to replicate historical regional stage, flow, salinity and temperature characteristics over multiple seasons and wide-ranging hydrological conditions. Model performance is assessed through:
1) Model timing and scalability on various parallel computing platforms
2) Model comparisons to measurements of waterlevels, flow, salinity and temperature for many locations throughout the Bay-Delta,
3) Model skill, provided through numerous statistical metrics, for the aforementioned parameters.

Water-quality indicators of interest to regional water-supply and ecosystem health management goals include salinity distribution and intrusion characterized by X2 - the distance to the 2 psu isohaline at the bottom of the water column from the Golden Gate Bridge, and daily and seasonal water temperature ranges and patterns. The 3D model was applied to simulations of Bay-Delta hydrodynamics and salinity under varying regional projections of sea level rise. Analyses indicate increased salinity intrusion and an inability to meet mandated water-quality standards under historical freshwater release patterns. These results, along with proof-of-concept integration of Delft3D-FM generated hydrodynamics with sediment, phytoplankton, and habitat suitability models, indicate that the Delft3D-FM framework is a useful tool to improve understanding of the effects of regional hydrodynamics and water quality changes on Bay-Delta ecosystems.

Sediment Plume Behaviors in the Western Lake Erie: Typical Patterns, Seasonal, and Interannual Variability

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A coupled hydrodynamics, surface gravity wave, and sediment model was developed to simulate the sediment plume dynamics in the western Lake Erie, and has been calibrated and validated quantitatively with mooring data and qualitatively with the satellite images. Based on the validated model and satellite images, typical behaviors of the Detroit and Maumee River plumes, as well as the seasonal and interannual variations in the resuspended and riverine plumes in the basin were discussed. Five typical behaviors of the Detroit River plume were characterized, and these are related to the surface wind forcing and baroclinic processes. Besides, four types of typical Maumee River plumes were recognized, changing with both the surface wind forcing and its river flux. Significant seasonal variations were found in the size of the Maumee River plume and the orientation of the Detroit River plume. Additionally, interannual variability of seasonal mean sediment dynamics in the western Lake Erie is most significant during spring and summer, and is moderate during fall and winter. Compared to the Maumee River and the resuspension plumes, the Detroit River plume has substantially lower interannual variations.

Towards the Development of an Operational Forecast System for Florida Coast

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A 24/7 nowcasting (NC) and forecasting (FC) system for storm surge, inundation, waves and baroclinic flow for the Florida coast has been developed. The system is based on dynamically coupled CH3D and SWAN models and is capable of using a variety of modules to provide input forcing, boundary and initial conditions. The system is fully automated and can be run unattended at pre-scheduled intervals as well as in event-triggered mode in response to tropical storm advisories released by the National Hurricane Center. The system provides 24-hour nowcasts and up to 72-hour forecasts forward depending on the input dataset. Spatially, the system spans the entire Florida coast by employing four high-resolution domains with resolutions as low as 10-30m in estuaries and over land to allow the system to resolve fine estuarine details such as the Intracoastal Waterway and minor tributaries. The system has been tested in both hindcast and nowcast/forecast modes using a variety of water level and salinity data, and has been found to run robustly during the test periods and has shown good agreement with data. Low level products (e.g. raw output datasets) are disseminated using THREDDS/HYRAX while a custom defined web-based GUI was developed for high level access.
This paper presents an overview of the NC/FC system including its design, setup, testing and validation for different scenarios, several hindcasting scenarios including non-storm conditions and during tropical storms, and some forecasting scenarios. In addition, the computational efficiency of the system and its ability to generate forecasts in a timely manner is discussed.

**Tsunami Propagation Database Application for the Aegean Coastlines**

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According to the historical evidence, Aegean and Mediterranean coastlines have been affected by devastating tsunamis in the past. The largest historical tsunamigenic earthquake in the Aegean Sea might be attributed to the Crete earthquake on 365 AD. Recent surveys revealed that it might have been an extremely destructive event and suggested the epicenter of the event in the South West of Crete, with an estimated moment magnitude of Mw 8.3-8.5. Today, Aegean region has densely populated shorelines with substantial touristic activities. Hence, establishment of a tsunami propagation database can help capacity building to develop for both long- and short-term tsunami-forecasting capabilities in the region. We followed the tsunami forecasting methodology which is developed by the United States National Oceanic and Atmospheric Administration Center for Tsunami Research (NCTR) at the Pacific Marine Environmental Laboratory, Seattle, Washington and prepared a tsunami propagation database for the Aegean Sea and the Eastern Mediterranean. Then, we develop a tsunami forecasting model for the town of Fethiye, Muğla, Turkey using the prepared tsunami propagation database. We used Community Modeling Interface for Tsunamis (ComMIT) (Titov et al., Pure Appl Geophys 2011), which is an user-friendly interface to the validated and verified tsunami numerical model (Synolakis et al., Pure Appl Geophys 2008) of the Method of Splitting Tsunami (MOST) (Titov and Synolakis, Geophys Res Lett 1997). We tested the Fethiye forecast model extensively, and observed its stability.

**The Effect of Coastal Erosion on Storm Surge; A Southern Rhode Island Case Study**

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The southern coast of Rhode Island consists of many coastal lagoons and barriers; this coast is eroding at an alarming rate due to the combined effects of coastal storms and sea level rise (SLR). The propagation of waves and storm surge in the nearshore can potentially be affected by the coastal erosion and is neglected in many previous studies. The objective of this work was to assess the effect of shoreline retreat and dune erosion on coastal flooding in a case study located on the south coast of RI. Storm surge scenarios, such as the 100-yr storm and Hurricane Bob were considered in conjunction with multiple beach erosion scenarios, including shoreline retreat in 25 years and the failure of dunes. A simplified methodology based on the historical trend of the shoreline retreat in this area was incorporated in the model. A geological assessment of dune erosion profiles after significant storm events was implemented to include the eroded dune profiles in the Digital Elevation Model (DEM). The results showed that for an extreme storm (i.e. a 100-yr event), where coastal dunes are overtopped and low-lying areas are flooded, the flooding extent is not significantly sensitive to coastal erosion. However, failure of the dunes leads to a significant increase of the flooding extent for smaller storms, where the dunes are not overtopped by surge. The hydrodynamics of tidal inlets explains the substantial dampening of the storm surge elevation in coastal lagoons, reducing the surge depth and thereby limiting the flooding extent, provided that dunes are not breached. When dunes are overtopped - due to surge height - or breached by surge and wave actions, the storm surge was no longer limited by the effect of inlets. SLR has generally more impact on more frequent smaller storms compared with large events (e.g. 100-yr storm). It was shown that the dune erosion has a considerable impact on the flooding extent of smaller more frequent storm events compared with larger events. The shoreline change did not significantly affect the extent of flooding.
Assessment of Damage from Storm Surge and Sea Level Rise Along Matunuck Beach Road and Surrounding Communities

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Matunuck, a coastal village in South Kingstown, RI has one of the highest erosion rates in the state. The structures and infrastructure are at risk from inundation and wave damage from storms. The only evacuation route for the eastern end of Matunuck is highly susceptible to flooding. Sea level rise is predicted by NOAA to be as high as 7 feet by 2100. Given these issues, the objective of this project is to estimate inundation, wave, and erosion damage to the existing structures and infrastructure in Matunuck, RI caused by a 100 year storm event, with and without sea level rise and the total damage. Mitigation strategies are identified to reduce the damage from inundation, wave, and erosion due to both storm scenarios and the reduction of damage associated with each mitigation strategy is analyzed. This project is a senior capstone design course for ocean engineering students at the University of Rhode Island. To complete the study objectives the students are creating a tool that uses the amount of flooding relative to the first floor elevation of every structure in their study area to show the maximum, most likely, and minimum damage as a percentage. This tool, the Coastal Environmental Risk Index, can be generalized for any coastal community and it is unique because it gives information on damage to each individual structure in a particular area. In order to create this tool the students are utilizing a GIS environment with STORMTOOLs inundation layers to find the estimated inundation depths along with Steady State Spectral Wave Model (STWave) to find the estimated wave heights for the area of interest. These inundation depths and wave heights are then transferred into an individual structure basis through the utilization of the electronic emergency data base (E-911) in the GIS environment. The values are then converted into inundation and wave percent damage to each individual structure by using the North Atlantic Comprehensive Coastal Study (NACCS) damage functions, created by the US Corp of Engineers. Preliminary results show that damage in the study area is heavily dependent on the local topography and the estimated wave action. The benefit of elevating structures in the flooded areas is also quantified from the results. The project will help South Kingstown and the Matunuck community decide if they should install shoreline protection structures or alter the evacuation route. It will also help home and business owners decide if they should move upland from the coast or elevate their properties.

Performance and Validation of a Numerical Code for Tsunami Inundation

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NAMI DANCE is a computational tool developed especially for tsunami modeling. It provides numerical modeling and efficient visualization of tsunami generation, propagation, and inundation mechanisms. It is developed in C++ programming language using leap-frog scheme numerical solution procedure. NAMI DANCE computes all necessary tsunami parameters. It can also provide 3D plots of sea state at selected time intervals from different camera position and light conditions, and also animates the tsunami propagation from source to target including inundation. In the theory of long waves, the vertical motion of water particles has no effect on the pressure distribution. Based upon this approximation and neglecting the vertical acceleration, the equations of mass conservation and momentum are reduced to two-dimensional depth-averaged equations. NAMI DANCE uses finite difference computational method to solve linear and nonlinear forms of depth-averaged shallow water equations (NSWE) in long wave problems. In this study, this code is applied to a benchmark problem which is discussed in 2015 National Tsunami Hazard Mitigation Program (NTHMP) Annual meeting in Portland, USA. The problems is an experiment of a single solitary wave propagating up a triangular shaped shelf with an island feature located at the offshore point of the shelf. The computed water surface elevation and velocity data are compared with the measured data. The comparisons showed that NAMI
DANCE is in fairly good agreement with the benchmark data. All results are presented with discussions and comparisons.

Acknowledgements: Partial support by Japan–Turkey Joint Research Project by JICA on earthquakes and tsunamis in Marmara Region (JICA SATREPS - MarDIM Project), 603839 ASTARTE Project of EU, UDAP-C-12-14 project of AFAD Turkey, 108Y227, 113M556 and 213M534 projects of TUBITAK Turkey, RAPSODI (CONCERT_Dis-021) of CONCERT-Japan Joint Call and Istanbul Metropolitan Municipality are all acknowledged.

**Modeling the Influence of Hurricane Barriers in Narragansett Bay on the Response to Tropical Cyclones with a Range of Watershed versus Coastal Ocean Forcing Characteristics**

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Flooding of Narragansett Bay due to storm surge can effect a majority of the population of Rhode Island. Past hurricanes such as Hurricane Bob in 1991 and Hurricane Sandy in 2012 induced storm surges of 2-5 m and 2-3 m respectively. To prevent flooding damage especially in Providence, RI engineers have built the Fox Point Hurricane Barrier finished in 1966. With the use of the Regional Ocean Modeling System (ROMS) we model the effectiveness of the Fox Point Hurricane Barrier (FPHB) through the comparison of storm surges for Hurricane Bob with and without the barrier in place. ROMS is forced with tides from a TOPEX/Poseidon inverse solution (TPXO7.2) and wind forcing from parametric hurricane models and hurricane prediction models, and incorporates wetting and drying as well as inflows from rivers. Model results are validated using water level observations from Narragansett Bay during Hurricane Bob, which made landfall in the region in August 1991. A number of process simulations are then run, comparing water level/flooding scenarios for various combinations of storm parameters (e.g., river runoff versus ocean surge magnitudes), with the FPHB open or closed. A specific focus is the impact of the FPHB on sensitive resources (waster water treatment, oil/propane storage, specialty chemicals, etc.) that exist from just outside the barrier down to Fields Point. We also test alternate strategies aimed at protecting these resources, such as the impact of a proposed new artificial barrier south of Fields Point. Preliminary results show how flooding is prevented or induced elsewhere in Narragansett Bay due to the barrier. Water levels are most amplified within the Providence Harbor area when the barrier is closed.

**The Application of a Couple Wave-current Model to Lake Michigan**

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Accurate simulations of wind-waves are vital in evaluating their impacts on coastal dynamics, especially when wave observations are sparse. Recent emergence of unstructured meshes provides an opportunity to better simulate shallow-water waves by superiorly resolving the complex geometry near islands and coastlines. In this study, wind-waves in Lake Michigan were simulated using the unstructured version of SWAN (un-SWAN), and modeled results were calibrated with the in-situ wind and wave observations. Based on the wave physics settings in un-SWAN, we evaluated the wave-current-surge interactions (WCSI) coupled model by implementing various unstructured-mesh based models. Sensitivity experiments using different wind sources indicated that the simulated storm surge forced with CFSv2 winds had the best agreement with NOAA-NOS observations. Driven by this superior wind forcing, the calibration and validation of the circulation model were subsequently made for the hindcasts of the 2011 northeasterly and 2013 southwestery wind events, respectively. For the effect of WCSI, it mostly modifies the storm surge and wave height in the shallow water along the coastline and around islands, wherein wave-induced setup and the depth-induced breaking are intense. When ADCIRC is coupled with SWAN, the underestimations of surge peak are reduced from 12% to 5% and 14% to 11% in the 2011 and 2013 cases, respectively. Due to different model discretization algorithms and bottom friction term treatments in ADCIRC/SWAN and FVCOM/SWAVE, the variations of storm surge and wave dynamics resulted from alternative WCSI-coupled models are stronger and more extensive than those due to the effect of WCSI. Further investigations reveal that the synergistic interactions of winds, site-specific
geometric and bathymetric features (e.g. the large concave southwestern coast) lead to a progressive trend of increased storm surges towards the downwind coasts. In particular, the coastal surge in Lake Michigan is attributed to both the remote and local winds, whereas the high seich in the narrow and shallow Green Bay is dominated by local wind.

Towards a Directly-Coupled Hydrodynamic and Wetland Modeling System for Understanding the Role of Coastal Wetland in Carbon Cycle

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Carbon fluxes among land-coastal and wetland-ocean interfaces are substantial components of the global carbon budget, yet remained poorly understood and quantified, largely due to the highly heterogeneous and dynamic nature of these interfaces. Carbon movement from terrestrial systems to the oceans, through coastal wetlands, is a critical pathway of the global carbon cycle that needs to be better quantified. This paper presents a modeling approach to dynamically couple coastal hydrodynamic and wetland models for simulating the fluxes and transport processes of carbon cycling in the coastal zone. The coupled hydrodynamic-wetland modeling framework consists of a coastal circulation and water quality model, a sediment module and marsh module. The modeling system will address key physical transport (e.g., exchanges at air-sea and sediment-water interfaces, settling, decomposition and burial of organic matter) and biogeochemical processes including the interactions and feedbacks between them. In the initial effort, the sediment module, which accounts for the exchange of dissolved organic carbon (DOC) marsh sediments with overlying water column, will be incorporated into the hydrodynamic and water quality model. The model is first tested with idealized case and then will be applied to Sequim Bay in the Pacific Northwest coast of Washington State, USA. In-situ measurements of water quality variables, including temperature, salinity, dissolved oxygen, color dissolved organic carbon (CDOM) will be used to support the model development. Preliminary results will be presented and discussed.

Modeling the Long-term Transport Timescale of Fresh Water in Estuary During the Yellow River Water and Sediment Regulation

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The yellow river is the second-longest river in china following the Yangtze River, and the sixth-longest in the world. In order to reduce the downstream river sedimentation, the Yellow River water and sediment division project started in 2002. Many studies focus on the environmental effect of the water and sediment flushing events .Zou et al. 2015;Sun et al.2011;Wei et al. 2008).So far, mass or concentration distribution is more concerned, however, researches on mass transport time are relatively less. The mass transport timescale is very import to the ocean ecosystem (De Brye et al., 2013; Rapaglia et al., 2010; Lucas et al., 2009; Crump et al., 2004). The concept of water age based on the CART (The Constituent-oriented Age and Residence Time Theory) is applied to the yellow estuary to study the long-term transport properties. The water age requires solving two advection-diffusion equations for the tracer concentration and the age concentration respectively. We verified the estuary model using the salt monitoring data. The fig.1 is the residual current in the estuary in July. Fig2 and fig.3 are salt distribution and the water age distribution individually. More detailed introduction to the effect of the process will be presented on the poster.

A Modeling Study of Hydrodynamics at Subsea Pipelines in Tidal Currents

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Pipelines are widely used in coastal engineering for various purposes such as transport of crude oil, and it is necessary to study hydrodynamics of flows around them. This study presents high-fidelity, high-resolution simulation of flows at pipelines at bottom of tidal currents, and it reveals basic features of the flows and provides an understanding of their mechanism. The simulation is made using a unique, unprecedented multiphysics modeling system recently developed by us, which is an integration of the Solver for
Incompressible Flow on Overset Meshes (SIFOM) and the Finite Volume Coastal Ocean Model (FVCOM). In this modeling system, SIFOM is employed to capture small-scale, local phenomena at the pipelines, and FVCOM is used to simulate the large-scale background tidal currents. The SIFOM-FVCOM system is able to resolve realistic tidal flows at pipelines that are beyond the reach of other computer models and capability of laboratory experiment. In this research, first, simulation for several flows including those past pipelines and cubics has been made to calibrate the modeling system. Then, the SIFOM-FVCOM system is applied to a flow at an actual marine pipeline in realistic coastal setting, and discussion will be made on behaviors of the flow and their engineering implication.

A High-Fidelity Simulation of Far- and Near-Field Flows past MHK Turbines in Coastal Waters

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Tidal energy extraction is growing rapidly in the world, and it is significant to simulate hydrodynamics at tidal power turbines and nearby to assist turbine design, site selection for its deployment, and estimate of potential environmental impact. Such simulation has been beyond existing modeling capability. Recently, the authors have developed a unique, unprecedented multiphysics modeling system that can fill the gap and allow us to realize such simulation. The modeling system is an integration of the Solver for Incompressible Flow on Overset Meshes (SIFOM), which uses a fully 3D computational fluid dynamics (CFD) approach, and the Finite Volume Coastal Ocean Model (FVCOM), which adopts a geophysical fluid dynamics (GFD) approach. In order to handle rotation of turbine blades, moving mesh capability is added into the SIFOM-FVCOM system. In this presentation, the numerical methods will be explained, and validation of the modeling system by benchmark flows will be reported. Furthermore, as a showcase and preliminary modeling, a high-resolution, high-fidelity simulation will be made for the flow past a marine hydrokinetic (MHK) energy turbine considering realistic turbine configuration and real coastal water setting. The simulated flow extends, all the way and seamlessly, from the far field to the near field, or, from the background ocean currents to the fully 3D, local phenomena at the turbine. Such modeling will provide an unparalleled view on tidal-energy-extraction flows, and discussion will be made on the computed results to shed light in the involved hydrodynamics. In addition, the showcase modeling is the first of its kind, and it will demonstrate the powerful and indispensable role of computer modeling in promotion of tidal power development.