Project Name:

A very high resolution estuary circulation nowcast/forecast model for Tampa Bay and vicinity.

Contact Information:

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Project Location:

Florida's west coast from Pinellas to Sarasota Counties, with emphases on Tampa Bay, Sarasota Bay and the ICWW.

Project Description:

We propose a very high resolution and accurate numerical circulation model for the Tampa Bay estuary and vicinity [including the Intra-Coastal Waterway (ICWW), Boca Ciega Bay, Tampa Bay, Sarasota Bay and all of the major inlets and waterways]. The model exists and is vetted through publications in refereed professional journals. The next step is to set it up as an automated, daily nowcast/forecast publically available on the internet. Applications include safe and efficient navigation, water quality, larval fish recruitment, harmful algal blooms and other ecological phenomena. What makes this model unique is its fine resolution (20m), enabling the inclusion of all relevant conveyances of mass. For instance, no other estuary model includes the ICWW and all of the relevant inlets, which are necessary to properly address the flushing of water bodies and the three dimensional distribution of water properties and their transport that are so important to pollutant and water quality studies. As an example, consider the 1993 fuel oil spill in lower Tampa Bay. No tools existed then to predict how that oil would move once it left the bay and how and when it would be transported into Blind Pass and Johns Pass. Our model has that capability. Another example is a recent sewage spill from a pipe break that sent raw sewage into Boca Ciega Bay. An automated nowcast/forecast model with daily updates would provide pertinent information to emergency personnel.

Other models exist, for instance the NOAA TBOFS. However, our approach is more accurate and more complete, in part because of higher resolution and hence inclusion of the various inlets and in part because it more accurately links the adjacent Gulf of Mexico with Tampa Bay, Sarasota Bay and the ICWW. The proposed model is also supported by the larger scale COMPS system of coastal ocean observations and larger scale models to which ours may be nested.

Our applications go beyond the estuarine circulation driven by tides, winds and rivers, or water quality considerations. Estuary and coastal ocean ecology does not just happen. It begins with the uniting of nutrients with light, fueling primary productivity and thence all subsequent trophic level interactions. The underpinning is the coastal ocean circulation that determines the evolution of the water properties in which organisms live, including nutrients and pollutants. The deep ocean connects with the continental shelf, the continental shelf connects with the estuaries, and it is through these connections, across space, time and trophic levels, that ecosystem services derive. If we are to manage our coastal ocean resources and predict the consequences of either human-induced or natural occurrences then we must know how the system works. This requires a comprehensive, multidisciplinary set of observations, coordinated with science-based models for integration, hypotheses testing and prediction. Proposed herein is that modeling framework which properly links the estuaries with the adjacent ocean.

Estimated Project Cost:

The estimated cost is based on a 5-year project duration, and the budget is broken into three phases. Phase 1 occurs in year 1 and it consists of implementing our existing Tampa Bay estuary model as an automated, daily nowcast/forecast. The phase 1 cost is $121,921. Phase 2 occurs over years 2 and 3. It adds a water quality sub-model, and it also reinstitutes a coupled wave model that we had to abandon this past year for lack of support. The phase 2 cost is $413,432. Phase 3 is the sustaining part in which we will seek additional partners and applications. For instance, we would hope to partner with NOAA to transition our model into their TBOFS. We would also seek agency partnerships on matters such as fish larvae recruitment, harmful algae blooms, search and rescue, engineering assessments of permitting applications, all while providing relevant information to the general public for use in recreational outings such as paddle boarding, kayaking, sailing, fishing etc. The phase 3 cost is $407,289. The total cost over 5 years is $942,646. Given that the area of operations includes Pinellas, Hillsborough, Manatee and Sarasota County, we seek multi-county contributions to be determined. For instance, given an equal apportionment per county the average cost per county would be less than 50,000 per year. Different apportionments would have different results. Long term maintenance would be at a much lesser amount and could even result in transition to a particular agency.

Other Funding:

Other funding sources do not presently exist, other than USF support for the PI and associate which facilitated the model development. We will also engage in competitive grant proposal submittals and will seek agency partnerships. However, funding for the physical oceanography of Tampa Bay has been relatively non-existent, at least for academic scientists.

Technical Feasibility:

The proposed high resolution Tampa Bay model presently exists, two papers are already published in professional refereed literature and a third is in review (model development was the PhD dissertation of Jun Zhu, a former USF-CMS graduate student under the supervision of the PI, Professor Robert H. Weisberg). It is the implementation as a nowcast/forecast model that remains to be done, and we are experienced in doing this. Thus, everything proposed is technically feasible using existing, proven capabilities. Development time is not required.

Conflicts or Complements to Existing Efforts:

The CMS-USF, Coastal Ocean Monitoring and Prediction System (COMPS) to which this project will be a part of contributes information to both the Southeast Atlantic Coastal Ocean Observing Regional Association (SECOORA) and the Gulf of Mexico Coastal Ocean Observing System (GCOOS), both of which have assets deployed in the Gulf of Mexico. SECOORA and GCOOS, in turn, are two of eleven regional associations that are part of the U.S. Integrated Ocean Observing System (IOOS). The proposed nowcast/forecast model will become a part of these other information sources and will be readily available to the general public.

Complies with Federal, State, Local and Tribal Laws/Regulations:

There are no conflicts with regulations. This project sustains and expands present assets that comply with all federal, state, local and tribal laws and regulations.

Readiness for Implementation:

The technical expertise is already in place and needs only sustained support. Phase 1 can begin immediately.

Environmental Benefits:

Water properties are determined by physical, biological and chemical connections that occur across space, time and trophic levels. Coastal ocean environmental stewardship is predicated on understanding this complex system functionality and applying that understanding toward prediction in a quantitative, scientifically defensible manner. Only in this way can forecasts be made regarding the consequences of either human or natural occurrences. Understanding the coastal ocean ecosystem begins with understanding the coastal ocean circulation because the circulation sets the background state for all else. Five recent examples of this are: 1) our emergent ability to forecast the occurrence (2014) or lack of occurrence (2010 and 2013) of WFS HABs, 2) our explanation of gag grouper recruitment success, 3) our explanation of WFS fish lesions and liver chemistry anomalies subsequent to the Deepwater Horizon oil spill, 4) the use of our model trajectory forecasts by NOAA during the Deepwater Horizon event itself and 5) our numerous briefings to emergency management and private citizen groups on hurricane storm surge and wave risks. The environmental benefit is thus improved, scientifically defensible environmental stewardship of value to county, state and federal agencies and the general public.

Economic and Social Benefits:

As a peninsula nearly surrounded by water there is little of the Florida economy that is not influenced by the ocean. Inland agriculture is even influenced by land-sea breeze and the ensuing rainfall. Tourism, in particular, is related in large measure to the attraction of the sea and Florida's bountiful living marine resources. The understanding of ecosystem functionality begins with observations used in conjunction with predictive models. Matters of real property and personal safety under extreme conditions require the ability to track storm systems, forecast storm surge and waves and provide information for use by emergency managers. Direct near real time observations of winds, waves and currents, along with the associated model forecasts that these observations facilitate are important for recreational and commercial boaters and fishers to inform safe and successful outings. Understanding Gulf and estuary ecosystem functionality is also critical for assessing and measuring environmental and social impacts caused by either human-induced or natural variations. Direct employment will include technical and scientific staff related to operations and related science. Indirect employment will derive through improved tourist attraction by facilitating improved environmental stewardship. These COMPS data and models plus the high resolution Tampa bay and vicinity model proposed here will also serve the present and next generation of students through outreach, education and training.

Community Resilience:

COMPS observations and models can be further tailored to be effective tools for improving community resilience. The system has already shown to be effective in tracking both surface and subsurface oil spills and this applies directly to any potential future hazardous material spills. The utility of our tracking products and their delivery to the appropriate decision makers was clearly demonstrated in (the Deepwater Horizon oil spill) time of crisis. Such utility is presently being demonstrated via the aforementioned HAB prediction and tracking tool in partnership with FWC. The proposed nowcast/forecasts will provide detailed information about severe weather conditions useful to emergency personnel, weather reporters and the general public, and the near real-time availability will also inform USCG SAROPS, all mitigating potential property damage and loss of life. In offline studies these information provide critical, detailed assessments of the severity and location of storm surge and waves for a multitude of extreme weather scenarios, thus providing a valuable tool for emergency planning. They can be expanded for assessing and anticipating changes in living resource distributions as demonstrated in the aforementioned gag grouper recruitment study. These examples are all tangential benefits to the primary function of providing baseline information about the complex coastal ocean ecosystem in order to better assess damages and carry out effective restoration.

Public Acceptance:

A common theme of public input from Gulf Restoration Council hearings in 2013 was the call for a system that provides observations from the deep waters of the Gulf of Mexico to the coastal region to assist in resource management, protect lives and property and sustain a healthy environment. One need only observe a map of the entire Gulf to realize that COMPS fills a critical gap for Florida’s west coast, which constitutes a significant portion of the continental shelf waters of the Gulf of Mexico. Additionally, COMPS has demonstrated public acceptance by the use of COMPS real time data and model products. USF scientists, in collaboration with county, state and federal officials, will actively seek to engage more public stakeholders in the use of the proposed information. The coastal ocean is where society meets the sea, and we are committed to contributing our scientific expertise to the benefit of society.

Additional Information

Tables and Figures:

1. Table 1. 5 Year Budget.
    - https://drive.google.com/file/d/0B5PGt0arj3QZUWp2QmI0VVJMS00/view?usp=sharing

Online Data and Product Sources, and tracking tools:

1. Collaboration for Prediction of Red Tides (CPR). Tracking tool in partnership with FWC to help federal, state and local end users monitor and manage red tide blooms on the west Florida shelf.
    - http://ocgweb.marine.usf.edu/hab_tracking/HAB_trajectories.html
2. COMPS program homepage. All real-time sites shown on interactive map for simple, clickable access to current ocean-atmosphere observations.
    - http://comps.marine.usf.edu/
3. Ocean Circulation Group homepage. Interactive website displaying OCG monitoring and modeling efforts.
    - http://ocgweb.marine.usf.edu/
4. SECOORA regional association homepage. COMPS data is displayed in real-time.
    - http://secoora.org/
5. GCOOS regional association homepage. COMPS data is displayed in real-time.
    - http://data.gcoos.org/

Relevant Publications: Recent

1. Weisberg, R. H. (2011). Coastal Ocean Pollution, Water Quality, and Ecology. MTS Journ., 45(2), pp. 35-42.
    - https://drive.google.com/file/d/0B5PGt0arj3QZdDloX0RfVW1UQzg/view?usp=sharing
2. Weisberg, R. H., Zheng, L., Liu, Y., Lembke, C., Lenes, J. M., Walsh, J. J. (2014). Why no red tide was observed on the West Florida Continental Shelf in 2010. J. Harmful Algae, 38 (2014), pp. 119-126.
    - http://www.sciencedirect.com/science/article/pii/S1568988314000572
3. Weisberg, R. H., Zheng, L., Peebles, P. (2014). Gag grouper larvae pathways on the West Florida Shelf. Cont. Shelf Res., 88 (2014), pp. 11-23, doi.10.1016/j.csr.2014.06.003.
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4. Weisberg, R. H., Zheng, L., Liu, Y., Murawski, S., Hu, C., Paul, J. (2014). Did Deepwater Horizon hydrocarbons transit to the west Florida continental shelf? Deep-Sea Res., Part II, doi:10.1016/j.dsr2.2014.02.002.
    - http://www.sciencedirect.com/science/article/pii/S0967064514000356
5. Zheng, L. and R.H. Weisberg (2012), Modeling the West Florida Coastal Ocean by Downscaling from the Deep Ocean, Across the Continental Shelf and into the Estuaries, *Ocean Modeling*, 48 (2012), 10-29, doi:10.1016/j.ocemod.2012.02.002.
    - http://www.sciencedirect.com/science/article/pii/S1463500312000327
6. Huang, Y., Weisberg, R. H., Zheng, L. (2010). Coupling of surge and waves for an Ivan-like hurricane impacting the Tampa Bay, Florida region. J. Geophys. Res., 115, C12009, doi:10.1029/2009JC006090.
    - https://drive.google.com/file/d/0B5PGt0arj3QZVXFzcXpUNk1lbG8/view?usp=sharing

Relevant Publications: Florida Estuaries

1. Weisberg, R.H. and L. Zheng (2003). How estuaries work: a Charlotte Harbor example, *J. Mar. Res.*, 61, 635-657.
    - https://drive.google.com/file/d/0B5PGt0arj3QZVGVSZTljS19zZjQ/view?usp=sharing
2. Zheng, L. and R.H. Weisberg (2004). Tide, buoyancy, and wind driven circulation of the Charlotte Harbor estuary, a model study, *J. Geophys. Res.*, 109, C06011, doi:10.1029/2003JC001996.

- http://scholarcommons.usf.edu/cgi/viewcontent.cgi?article=1129&context=msc_facpub

3. Weisberg, R.H. and L. Zheng (2006). Circulation of Tampa Bay driven by buoyancy, tides, and winds, as simulated using a finite volume coastal ocean model. *J. Geophys. Res*., 111, C01005, doi:10.1029/2005JC003067.
   - http://scholarcommons.usf.edu/cgi/viewcontent.cgi?article=1133&context=msc_facpub
4. Zheng, L. and R.H. Weisberg (2009). Rookery Bay and Naples Bay circulation simulations: applications to tides and fresh water inflow regulation, *Ecological Modelling*, 221, 986-996, doi:10.1016/j.ecolmodel.2009.01.024.
   - http://www.sciencedirect.com/science/article/pii/S0304380009000763
5. Zhu, J., R.H. Weisberg, R.H., L. Zheng, and S. Han (2014). On the flushing of Tampa Bay. *Estuaries and Coasts*, in press, doi: 10.1007/s12237-014-9793-6.
   - https://drive.google.com/file/d/0B5PGt0arj3QZX3l6T1RQRzFXUEk/view?usp=sharing
6. Zhu, J., R.H. Weisberg, R.H., L. Zheng, and S. Han (2014). Influences of channel deepening and widening on the tidal and non-tidal circulation of Tampa Bay. *Estuaries and Coasts*, in press, doi: 10.1007/s12237-014-9815-4.
   - https://drive.google.com/file/d/0B5PGt0arj3QZNXg5MnJCVU45ekk/view?usp=sharing

Relevant Publications: Hurricanes and Storm Surge and Waves

1. Virmani, J. I., and R. H. Weisberg (2006), The 2005 hurricane season: An echo of the past or a harbinger of the future?, *Geophys. Res. Lett*., 33, L05707, doi:10.1029/2005GL025517.
   - https://drive.google.com/file/d/0B5PGt0arj3QZZmRsZHhYcjlYdlU/view?usp=sharing
2. Weisberg, R.H. and L. Zheng (2006). Hurricane storm surge simulations for Tampa Bay. *Estuaries and Coasts*, 29, 899-913.
   - http://psgs.usf.edu/content/rtb-11/Weisberg2.pdf
3. Weisberg, R.H. and L. Zheng (2006). A simulation of the hurricane Charley storm surge and its breach of North Captiva Island, *Florida Scientist*, 69, 152-165.
   - http://ocgweb.marine.usf.edu/Products/StormSurge/CharleyFLS1-13-06.pdf
4. Weisberg, R. H., and L. Zheng (2008), Hurricane storm surge simulations comparing three-dimensional with two-dimensional formulations based on an Ivan-like storm over the Tampa Bay, Florida region, *J. Geophys. Res*., 113, C12001, doi:10.1029/2008JC005115.
   - http://scholarcommons.usf.edu/cgi/viewcontent.cgi?article=1136&context=msc_facpub
5. Huang, Y., R. H. Weisberg, and L. Zheng (2013), Gulf of Mexico hurricane wave simulations using SWAN: Bulk formula based drag coefficient sensitivity for Hurricane Ike. *J. Geophys. Res.-Oceans*, 118, 1–23, doi:10.1002/jgrc.20283.
   - https://drive.google.com/file/d/0B5PGt0arj3QZRFpjZ0VpbWJUU2c/view?usp=sharing
6. Zheng, L., R.H. Weisberg, Y. Huang, et al., (2013), Implication from the comparisons between two- and three-dimensional model simulations of the Hurricane Ike storm surge. *J. Geophys. Res.-Oceans*, 118, 3350–3369, doi:10.1002/jgrc.20248.
   - https://drive.google.com/file/d/0B5PGt0arj3QZVDFiNlBwNk9JUFE/view?usp=sharing
7. Kerr, P.C., A.S. Donahue, J.J. Westerink, R.A. Luettich Jr., L.Y. Zheng, R.H. Weisberg, Y. Huang, H.V. Wang, Y. Teng, D.R. Forrest, A. Roland, A.T. Haase, A.W. Kramer, A.A. Taylor, J.R. Rhome, J.C. Feyen, R.P. Signell, J.L. Hanson, M.E. Hope, R.M. Estes, R.A. Dominguez, R.P. Dunbar, L. N. Semeraro, H.J. Westerink, A.B. Kennedy, J.M. Smith, M.D. Powell, V.J. Cardone, and A.T. Cox. (2013) U.S. IOOS coastal and ocean modeling testbed: Inter-model evaluation of tides, waves, and hurricane surge in the Gulf of Mexico. *J. Geophys. Res.-Oceans*, 118, 5129–5172, doi:10.1002/jgrc.20376.
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Relevant Publications: Harmful Substance Tracking

1. Weisberg, R. H. (2011). Coastal Ocean Pollution, Water Quality, and Ecology. MTS Journ., 45(2), pp. 35-42.

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2. Liu, Y., R.H. Weisberg, C. Hu, and L. Zheng (2011), Tracking the Deepwater Horizon oil spill: A modeling perspective, *EOS Transactions, American Geophysical Union,* 92(6), 45-46, doi: 10.1029/2010ES003187.
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3. Liu, Y., R.H. Weisberg, C. Hu, and L. Zheng (2011), Satellites, models combine to track Deepwater Horizon oil spill. SPIE Newsroom, doi:10.1117/2.1201104.003575.
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4. Weisberg, R.H., L. Zheng, and Y. Liu, (2011), Tracking subsurface oil in the aftermath of the Deepwater Horizon well blowout, in *Monitoring and Modeling the Deepwater Horizon Oil Spill: A Record-Breaking Enterprise, Geophysical Monograph Series*, 195, 205-215, doi:10.1029/2011GM001131.
    - http://www.agu.org/books/gm/v195/2011GM001131/2011GM001131.pdf
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