AdcircViz: A Visualization Application for Distributed ADCIRC-based Coastal Storm Surge, Inundation, and Wave Modeling

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Abstract: High-resolution predictions of coastal storm surge, inundation, and waves generally require substantial computational resources, particularly in a forecast, real-time mode. Considering that a given storm only threatens a portion of the US coastline, high resolution is only needed in the coastal areas threatened by active storms and simultaneous and comprehensive spatial coverage of the entire US and Gulf of Mexico coasts is unnecessary. Regional forecast systems using the ADCIRC tide, storm surge, and wave model have been operating in several risk-prone areas of the eastern US and Gulf coasts for the past several years. The ADCIRC grids are high-resolution regional discretizations of the topography, bathymetry, critical hydraulic structures, and land cover embedded in a larger scale coarser ADCIRC grid to simplify offshore/open boundary conditions. These systems use high-performance-computing (HPC) resources that are often locally provisioned but can be located at any available facility (e.g., NOAA's "jet" HPC systems in Boulder, CO).

To simplify the mechanics of conducting ADCIRC predictions in real-time, ADCIRC developers at the University of North Carolina (UNC) have created the automated and portable ADCIRC Surge Guidance System (ASGS) to provide end-to-end ADCIRC forecasts. ASGS includes tidal, meteorological and hydrologic forcing, up-to-date initial conditions, user-specified ensembles, output transfer to data servers, and end-user notification of model product availability. ASGS instances are now operated by a select, experienced and growing group of users and are producing a complementary set of high resolution storm surge, wave and inundation results for many risk prone areas of the coastal US. In addition, a few other modeling groups maintain non-ADCIRC based modeling capabilities for localized areas of the US coast. While these users lack operational forecasting missions, they represent a substantial resource that could be used by agencies having operational missions. However, the distributed nature of ASGS instances requires *an efficient way to discover, gather, organize and visualize* the distributed results from multiple ASGS instances and other models.

To this end, UNC's Renaissance Computing Institute (RENCI) has developed a "data grid" to federate ASGS instances and provide uniform access to forecasts. This simplifies knowing which systems are running and when solutions become available. To access and visualize results, we have developed ***AdcircViz***, a MATLAB-based visualization application that provides robust access to ASGS forecasts in the data grid. ***In this two year project, we will deploy, extend, and support AdcircViz*** and work with the National Hurricane Center (NHC) storm surge team and JHT staff to make AdcircViz readily available for their operational environment. We will demonstrate the preliminary application version, gather requirements for and implement new capabilities, and provide documentation and support during active storms for which ASGS instances are running. While our project focus is on ASGS based results, the data grid methodology and AdcircViz application can be applied to other models if providers use recently developed community standards for storing and serving model results.

Archived ASGS output for 2012 and future Atlantic hurricanes will be used for feature testing and software modification during the Atlantic hurricane off seasons. We will work with all known ASGS operators to make their results available through AdcircViz. We will also keep an open dialog with NHC to support AdcircViz during the next hurricane seasons.

STATEMENT OF WORK

1 Proposed Duration of project: 2 years

2 Project Description

This proposal to NOAA OAR addresses the JHT 2013 Program Priority NHC-6/JTWC-10, "Advanced coastal inundation modeling and/or applications, visualization, or dissemination technology that enhances operational storm surge forecast accuracy or delivery". Specifically, in this 2-year project, we will deploy, extend, and support a MATLAB-based visualization and analysis application called *AdcircViz* that will provide NHC forecasters robust and seamless access to a growing and distributed set of ADCIRC-based storm surge predictions.

Simulations of storm surge, inundation, and wave predictions using the ADCIRC tide, storm surge, and wave model [Luettich et al., 1992, Westerink et al., 2008] generally require substantial computational resources. This is particularly true in a forecast, real-time operational mode using very high-resolution numerical grids (Figure 1), since the forecast products must be available well within the six-hour forecast cycle. This has largely limited the use of ADCIRC to non-forecast applications such as forensic studies of past hurricanes, process studies, and coastal risk evaluation and risk reduction analyses. For forecast applications, the resource bottleneck is exacerbated by needing an ensemble of storm realizations to address uncertainty in the hurricane forecasts. Since each model run generates large files, it is impractical to download the output from the computational facility(s) to a forecaster's desktop computer. It is also currently unfeasible to run these simulations at the NHC or at a single operational facility such as NCEP. Challenges with real-time operations and large ADCIRC grids have been discussed in Blanton et al. [2012].

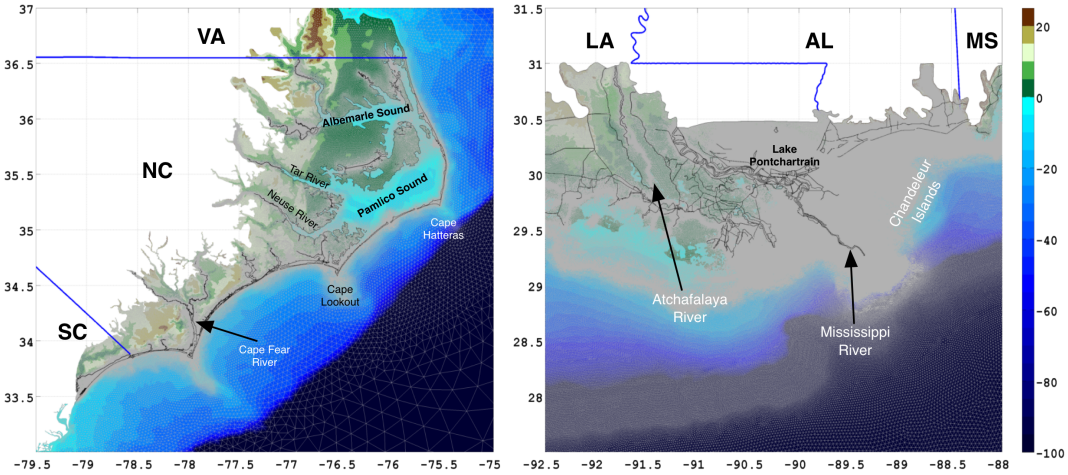

Figure 1: High-resolution Adcirc grids used in ASGS instances. The triangular finite element grid is shown with the gray lines. The colorscale is in meters relative to mean sea level. Left) The North Carolina grid has 608,114 nodes and 1,200,767 elements, with nearshore and inland resolution in the 50 to 200 m range. Right) The Louisiana grid has 5,059,166 nodes and 9,993,621 elements. The grid's node density obscures the underlying bathymetry and topography. The black lines are the explicit representation of the hurricane protection levee system.

In the past several years, ADCIRC developers at the University of North Carolina have created the automated and portable ADCIRC Surge Guidance System (ASGS) to provide end-to-end ADCIRC forecasts [Fleming et al., 2008]. ASGS includes tidal, meteorological and hydrologic forcing, up-to-date initial conditions, user-specified ensembles, output transfer to data servers, static graphical products, and end-user notification of model product availability. ASGS is now used by a select and experienced group of ADCIRC users at UNC, NOAA's Coastal Survey Development Laboratory, USACE ERDC, Louisiana State University, and University of Texas, all of whom have the computational resources to execute at least one ADCIRC run within a forecast cycle. While these users lack an operational forecasting mission, they represent a substantial consortium of operators participating in these activities, particularly during times when a storm threatens their geographical region. The ADCIRC forecasts thus naturally focus on the likely impact regions.

To use this distributed capability, forecasters need to find, visualize, and analyze results from one or all ASGS instances. To this end, we have developed ***AdcircViz*** (Figure 2, page 4), a MATLAB application that accesses the suite of ASGS outputs through a uniform interface. AdcircViz is the primary deliverable of this project, along with feature extensions and development with NHC's input.

The preliminary AdcircViz application (Figure 2) was deployed and evaluated during 2012 Hurricanes Isaac and Sandy. AdcircViz was extensively used in real-time with multiple ASGS instance results, by the USACE New Orleans District (M. Agnew) and the USCG Atlantic Command (Lt. K. Rogers). Additionally, NOAA's Coastal Survey Development Lab (J. Feyen) used AdcircViz to make ASGS storm surge images and provide them to NHC for additional information and consideration in guidance discussions.

2.1 Mechanics and Architecture of AdcircViz and the DataGrid

The distributed nature of ASGS instances has led RENCI to establish a *data grid* (Figure 3) to host results by individual ASGSs and to enable access to the results by applications like AdcircViz. This general approach of having a distributed set of data servers, with a virtual catalog that harvests standardized metadata from the set of servers, has several advantages. First, it lowers the barrier to participate in the data grid by only requiring that model output files meet a certain metadata and file format specification. Second, it pushes the burden of data cataloging and serving onto one location (the data grid itself), effectively making a distributed collection appear as one collection (i.e., "federated"). Third, the mechanics of data access, analysis, and processing can be placed on the client application (like AdcircViz), as opposed to server-side processing.

This data *federation* is enabled by using netCDF4 and UGRID (a netCDF Climate and Forecast metadata convention extension for unstructured grids) standards for file formats and metadata content; THREDDS and OPeNDAP for data cataloging, data discovery, and data access; and the community developed, NOAA-funded MATLAB toolbox nctoolbox, to access the ASGS predictions.

The preliminary and planned architecture of the ASGS data grid is shown in Figure 3. The data grid itself is a collection of THREDDS servers, and a catalog of the distributed results across multiple servers is maintained. RENCI hosts a THREDDS server to which the GoMex, WFL, and NC ASGS instances publish forecast output. However, the network of ASGS operators presently has access to high resolution grids covering the Texas, Louisiana,

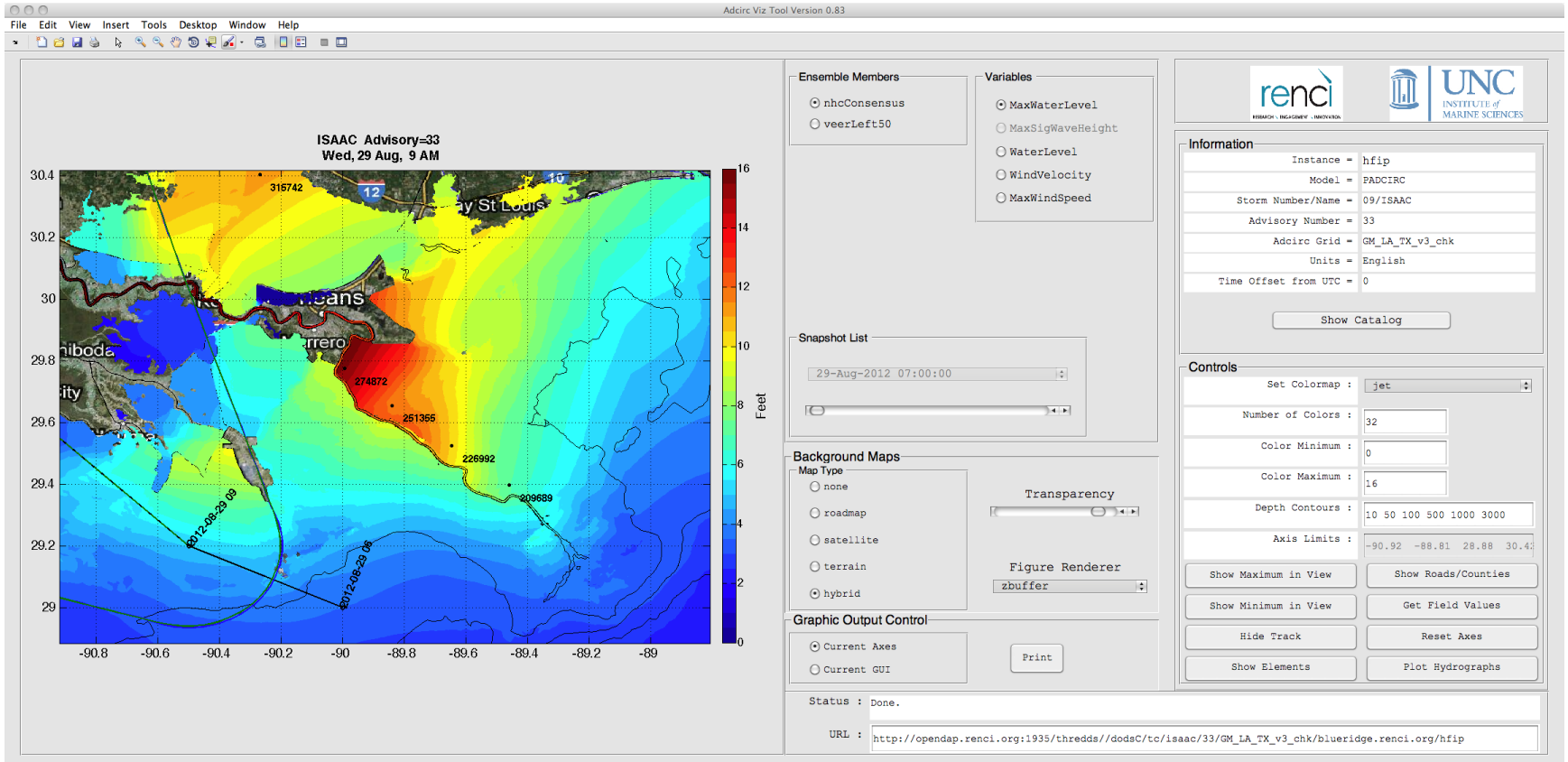

Figure 2: AdcircViz MATLAB application showing the maximum surge level over the ADCIRC forecast for Hurricane Isaac, advisory 33, from the Gulf of Mexico ASGS instance. The central panel of the application allows the user to select the variable and ensemble member to display and set background Google Maps. AdcircViz always retrieves enough model output data for a default visualization. If a different variable/ensemble member combination is selected, the application retrieves the needed data from the ASGS catalog and THREDDS server. The right panel displays information about the simulation and allows setting of certain properties of the display, including control of the color map and scaling, bathymetry contours and hydrograph plotting.

Mississippi, Florida panhandle, Tampa Bay, Northeast Florida, North Carolina, Maryland, Virginia and New Jersey coasts and new and improved grids are being developed at several collaborating institutions. Depending on the specific capabilities of these ASGS operators, this data will either be pulled to the RENCI THREDDS server or served directly from a THREDDS server at the participating institution.

AdcircViz queries the ASGS catalog to determine the most recent solutions posted to the data grid. This list can be filtered by (e.g.) region of interest, and/or storm and advisory numbers. The default spatial view for each ASGS instance is maintained in the catalog, but the user can alternatively specify which ASGS instance/region to access. Data access is done only when needed, without using pre-rendered images. This allows control over visualizations, including color scaling and color maps. AdcircViz automatically connects to available ensemble members and variables for the specified forecast and updates its catalog of results at regular intervals. The capabilities of the preliminary version of AdcircViz include (Figure 2) surface rendering of scalar fields, display of multiple ensemble members, timeseries plots of water levels (Figure 4), and Google Maps background maps.

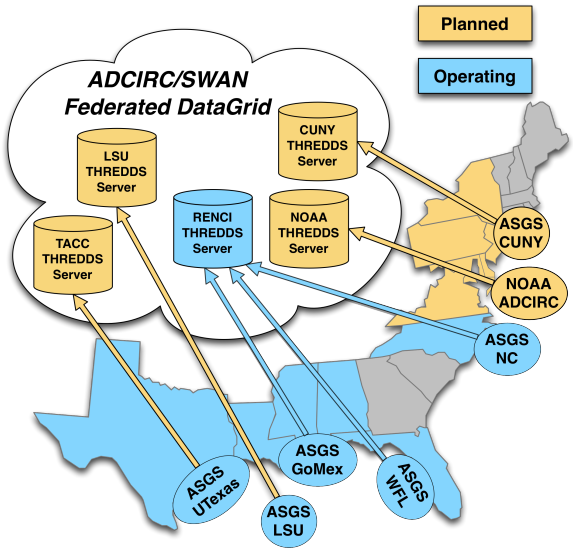

Figure 3: Architecture of the ASGS Data Grid. Operating regional instances of ASGS are shown in blue and planned components are in yellow.

While our initial target will be the ASGS ADCIRC results, there is no requirement that model output files be generated by ADCIRC. Rather, the only requirement is that output files are published to a THREDDS server using the UGRID netCDF4 conventions. These requirements are adhered to by ASGS and are available for other model groups to use. As part of ongoing IOOS / SURA Coastal Ocean Modeling Testbed (COMT), metadata and file format standards have been developed that can be applied to most ocean models. In particular, the COMT used ADCIRC, FVCOM (Qi et al. [2009]), SELFE and SLOSH model output to demonstrate the application of these conventions. Thus it should be possible to view results from all of these models using AdcircViz. This capability will dramatically lower the barrier for operational centers to identify, access and visualize forecast model runs made by the research community. In the near future, we expect that a New York/New Jersey area high-resolution grid and ASGS instance will be operating at the City University of New York's College of Staten Island, and an instance for a portion of Florida coastal waters will be operating at the University of Central Florida.

Wind Sources: The ADCIRC model can use a variety of different wind input types, including a built-in vortex-based model driven by NHC ATCF track files. During an active tropical cyclone event, this built-in model is used because it does not require a dynamic, pre-computed wind and pressure field realization from an operational mesoscale model. The advantage is that the surge and wave forecasts can start within several minutes of the ASGS

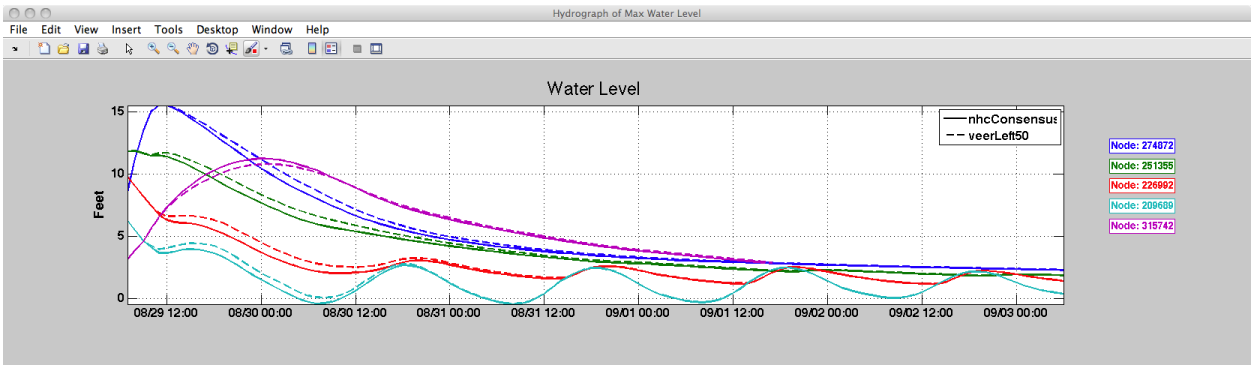

Figure 4: Hydrograph plot example from AdcircViz for Hurricane Isaac, advisory 33, from the Gulf of Mexico ASGS instance. Two ensemble members are shown at each of five nodes. The node locations are shown in Figure 2.

instance receiving the ATCF track file. However, an ASGS instance may be configured to use other forecast wind products; the North Carolina ASGS instance (run by RENCI, UNC IMS, and SeaHorseConsulting) operates year-round using NCEP NAM as the wind driver. While this instance may not be optimal for tropical cyclone events, it is useful for non-tropical systems as well as providing a routine testing data feed to the data grid. Regardless, any wind driver that an ASGS instance uses becomes available if it is posted to the data grid. In an experimental mode, it is feasible to configure an ASGS instance to use (for example) GFDL winds to evaluate, in near real time, surge and waves driven by GFDL output.

Validation of the ADCIRC model: Prediction skill of the ADCIRC model is primarily dependent on two items; 1) the model grid that represents the geometry of the regional topographic and bathymetric features that control the hydraulics; 2) the adequacy of the wind and pressure fields driving the forecast surge and waves. The ASGS instances currently operating generally take advantage of high- resolution ADCIRC grids that were developed for non-forecast studies. ADCIRC is approved by FEMA for use in National Flood Insurance Program (NFIP) studies and is currently being used for the development of Digital Flood Insurance Rate Maps in Texas, Louisiana, Mississippi, Alabama, Florida, Georgia, South Carolina, North Carolina, Virginia, Maryland, Delaware, New Jersey and New York (e.g., Blanton [2008], Niedoroda et al. [2010]). The North Carolina ASGS instance uses a version of the ADCIRC grid used for the North Carolina NFIP study; the validation of this grid has been provided to FEMA as part of the study [Blanton and Luettich, 2010]. The same is true for most of the other areas with operating or interested ASGS instances. If desired, we can control which ASGS solutions are available for AdcircViz, by stipulating that a published validation study must be provided in order for the solutions to be posted to the Data Grid. Research and applications with ADCIRC cover a range of coastal oceanographic and engineering problems, including regional and local tidal phenomena [Westerink et al., 1994, Blanton et al., 2004] and coupled storm surge and wave hindcasts [Atkinson et al., 2008, Dietrich et al., 2011]. ADCIRC's forecast skill has recently been analyzed for Hurricane Gustav [Forbes et al., 2010].

2.2 Project Team

Dr. Brian Blanton is a senior scientist and coastal oceanographer at RENCI with 15 years of experience in coastal ocean modeling and forecasting with ADCIRC and cyberinfrastructure applications in environmental sciences. He will manage the project, develop all reporting requirements, work with NHC on application requirements, and develop the overall application architecture. Dr. Rick Luettich is a distinguished professor and director at UNC's Institute of Marine Sciences, director of the Department of Homeland Security's Coastal Hazards Center of Excellence at UNC, and a co-developer of ADCIRC. He will serve as an advisor and ASGS liaison. A qualified graduate student will carry out specific feature implementations and enhance and maintain the application's documentation and training materials, with Blanton's direct oversight.

3 Work Plan

Throughout the life of the project, we will interact with JHT staff and NHC's storm surge group to ensure that AdcircViz can aid in storm surge forecasting and guidance discussions. We envision frequent web-based discussions about the application's functionality, using results from the 2012 season that currently reside in the data grid and additional results from the 2013 and 2014 for testing and evaluation. The ASGS forecast catalog is currently populated with several hindcast and forecast runs from Hurricanes Isaac and Sandy, and these will be used to initially demonstrate the application's operations and serve as testing data sets. We will also maintain and extend the software and web-based User's Guide documentation through interactions with the NHC storm surge group. We will maintain the catalog and data grid servers in an *active ready* state to mimic the active season. Through constant and intensive testing of the application with archived results, we will substantially increase the robustness of the application, catalog, and data grid servers. Our proposed workplan is as follows, and we anticipate refinement and enhancement to both the plan and objectives through discussions with the JHT program and NHC staff.

Year 1: In Year 1, we will focus on the preliminary deployment of AdcircViz, testing and evaluation, requirements gathering, and support during the 2013 hurricane season. We will also establish a testing environment that issues simulation update messages to mimic activities during an active storm. The period in Year 1 between the 2013 and 2014 Atlantic hurricane seasons will provide the opportunity to make substantive changes to AdcircViz, based on experiences during the 2013 season and interactions with NHC/JHT staff. We will address major issues, improve and enhance the documentation, and implement newly requested features.

1. Provide a MATLAB script to test http/OPeNDAP access methods to ensure that the appropriate internet connectivity is available and that firewall concerns are met.

2. Provide preliminary AdcircViz version and web-based documentation to NHC and work with NHC to ensure that it runs as expected.

3. Demonstrate application and its usage using 2012 season results already in the data grid.

4. Demonstrate the visualization of SLOSH deterministic and p-surge model output products in AdcircViz.

5. Gather requirements from NHC staff for changes and improvements to the user interface, the application's basic functionality, and visualization needs.

6. Implement visualization of vector wind fields, and display of Maximum of Maximums of ensemble results.

7. Address any software and documentation issues that arise and maintain the catalog and data grid servers in an *active ready* state to mimic the active season.

Year 2: In Year 2, we will focus on data grid and catalog extensions as well as feature additions and enhancements.

1. Generalize cataloging to include multiple THREDDS servers in the data grid.

2. Implement changes to incorporate simultaneous visualization of multiple ensemble members.

3. Add data/image export to shape files and Google Earth KML files.

4. Add animation capabilities.

5. Extend timeseries handling to include wind speed, direction, and other vector fields.

6. Extend catalog functionality to include other THREDDS-accessible data.

4 Deliverables Time Line

At the project start, we will immediately deliver the preliminary AdcircViz version to NHC staff, including documentation on its usage and a detailed example that accesses the existing data grid. A proposed timeline is shown in Table 1 below, and we anticipate revision and enhancement of the time line guided by discussions with JHT and NHC staff to best address JHT program priorities.

Deliverable	Date
Preliminary Project Software and Documentation	September 2013
First 6-month Project report	March 2014
Software Enhancements based on requirements gathering	May 2014
Second 6-month Project report	September 2014
Third 6-month Project report	March 2015
Final Project report	September 2015

Table 1: Time line of main project deliverables.

5 Travel

We request travel funds for the PI, co-PI, and graduate student to attend the annual Interdepartmental Hurricane Conference (IHC) held in early March of 2014 and 2015. We also request funds for the PI to visit the NHC operations center for detailed discussions about AdcircViz in the operational environment. The travel schedule is detailed in Table 2 below.

Personnel	Destination	Date	Funds	Purpose
Brian Blanton^{PI}	Miami FL	September 2013	$1,000	Initial visit to NHC
Rick Luettich^{co-PI}	Miami FL	early March 2014	$1,000	Initial visit to NHC
Brian Blanton	Miami FL	early March 2014	$1,000	IHC
Rick Luettich	Miami FL	early March 2014	$1,000	IHC
Graduate Student	Miami FL	early March 2014	$1,000	IHC
Brian Blanton	Miami FL	September 2014	$1,000	Mid-project visit to NHC
Rick Luettich	Miami FL	early March 2015	$1,000	Mid-project visit to NHC
Brian Blanton	Miami FL	early March 2015	$1,000	IHC
Rick Luettich	Miami FL	early March 2015	$1,000	IHC
Graduate Student	Miami FL	early March 2015	$1,000	IHC

Table 2: List of travel request trips.

6 JHT staffing needs

The primary need for JHT and NHC staff is in evaluating the software from within the NHC operational environment. This includes ensuring that the appropriate internet connectivity is is available and that firewall constraints are met. The MATLAB application accesses the ASGS solutions through an OPeNDAP http request, and we will provide a diagnostic MATLAB script verify the connection status to the data grid. We also anticipate that NHC storm surge team staff will participate in conference calls and web-based meetings to discuss software issues, features, and demonstration exercises.

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Abbreviated CVs

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EDUCATION

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University of North Carolina at Chapel Hill	Marine Sciences	Post-Doc (2004)

APPOINTMENTS

Senior Scientist, Renaissance Computing Institute, University of North Carolina at Chapel Hill (06/2007 – present)

Oceanographer, Science Applications International Corporation (05/2006 – 05/2007)

Research Assistant Professor, Department of Marine Sciences, University of North Carolina at Chapel Hill (01/2005-05/2006)

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Van Cooten, S, K.E. Kelleher, K. Howard, J. Zhang, J.J. Gourley, J.S. Kain, K. Nemunaitis- Monroe, Z. Flamig, H. Moser, A. Arthur, C. Langston, R. Kolar, Y. Hong, K. Dresback, E. Tromble, H. Vergara, R.A Luettich, Jr., B. Blanton, H. Lander, K. Galuppi, J.P. Losego, C.A. Blain, J. Thigpen, K. Mosher, D. Figursky, M. Moneypenny, J. Blaes, J. Orrock, R. Bandy, C. Goodall, J.G. Kelley, J. Greenlaw, M. Wengren, D. Eslinger, J. Payne, G. Olmi, J. Feldt, J. Schmidt, T. Hamill, R. Bacon, R. Stickney, L. Spence, "The CI-FLOW Project: Tracking Precipitation from the Sky to the Summit to the Sea", *Bulletin of the American Meteorological Society,* November 2011:1427-1442, DOI: 10.1175/2011BAMS3150.1

Blanton, B., R. Luettich, P. Vickery, J. Hanson, 2010, "North Carolina Floodplain Mapping Program, Intermediate Data Submission Number Two, Draft Report on Tidal and Storm Validation Studies", March 26, 2010, 183p.

Atkinson, J., T. Wamsley, J. Westerink, M. Cialone, C. Dietrich, K. Dresback, R. Kolar, D. Resio, C. Bender, B. Blanton, S. Bunya, W. de Jong, B. Ebersole, A. Grzegorzewski, B. Jensen, H. Pourtaheri, J. Ratcliff, H. Roberts, J. Smith, and C. Szpilka, Hurricane storm surge and wave modeling in southern Louisiana: A brief overview, *Estuarine and Coastal Modeling, ASCE*, pp. 467-506, doi:10.1061/40990(324)28, 2008.

FIVE OTHER PUBLICATIONS

Aretxabaleta, A., B. Blanton, H. Seim, F. Werner, J. Nelson, E. Chassignet, Cold event in the South Atlantic Bight during summer of 2003: Model simulations and implications, *J. Geophys. Res.*, 112*,* C05022*,* 3264, doi:10.1029/2006JC003903, 2007.

Ramakrishnan, L., B. Blanton, H. Lander, R. Luettich, D. Reed, and S. Thorpe, Real-time storm surge ensemble modeling in a grid environment, *2nd International Workshop on Grid Computing Environments*, 2006.

Blanton, B., F. Werner, H. Seim, R. Luettich, D. Lynch, K. Smith, G. Voulgaris, F. Bingham, and F. Way, Barotropic tides in the South Atlantic Bight, *J. Geophys. Res.,* 109, C12024, 3264, 2004.

Lynch, D., K. Smith, B. Blanton, F. Werner and R. Luettich, Forecasting the coastal ocean: Resolution, tide and operational data in the South Atlantic Bight, *J. Ocean. Atmos. Tech.*, 21(7), pp. 1074-1085, 2004.

Blanton, B., A. Aretxabaleta, F. Werner, and H. Seim, Monthly climatology of the continental shelf waters of the South Atlantic Bight, *J. Geophys. Res.*, *108*(C8), 3264, doi:10.1029/2002JC001609, 2003.

RELATED ACTIVITIES

- **Coastal Flood Hazard Analysis:** Lead investigator at UNC-Chapel Hill for FEMA-funded coastal flood insurance studies in North Carolina (part of FEMA's Region 4) and FEMA Region 3 (Chesapeake and Delaware Bays). Developed state-of-the-art numerical model systems for storm surge and wind waves, and statistical analyses for computing statistical flood hazards for use in FEMA flood insurance rate maps. Both project teams include academic, federal, state, and industry participants.
- **Louisiana Coastal Protection and Restoration/US Army of Corps of Engineers:** Member of expert team applying advanced numerical models for storm surge and wind waves for the US Army Corps of Engineers' Louisiana Coastal Protection and Restoration (LACPR) project, a federally directed effort to investigate a full range of flood control and hurricane protection strategies for the New Orleans and surrounding coastal Louisiana region. Developed a simulation management strategy and software to compute coastal storm surge for hundreds of hypothetical hurricanes in a consistent software framework on high-performance supercomputers.
- **Interagency Performance Evaluation Task Force (IPET)**: Provided expertise for use of flood hazard statistics storm surge modeling system in the IPET risk-based decision-making model. This included evaluation of the risk model performance and skill assessment. Led to the Department of the Army, Commander's Award for Public Service, August 2007, given for commitment to the US Army Corps of Engineers IPET Engineering and Operational Risk and Reliability Analysis project, investigating inherent risk of the Louisiana Hurricane Protection system.

RECENT COLLABORATORS:

Tom Allen (East Carolina University), John Atkinson (Arcadis, Inc), Larry Atkinson (Old Dominion University), Vince Cardone (Ocean Weather Inc), Tom Crawford (East Carolina University), Rachel Davidson (University of Delaware), John Dorman (North Carolina Emergency Management), Bruce Ebersole

(US Army Corps of Engineers), Jesse Feyen (NOAA), Jeffery Hanson (US Army Corps of Engineers), Ruoying He (NC State University), Andrew Kennedy (UND), David Levinson (USDA), Richard Luettich (UNC-Chapel Hill), Linda Nozick (Cornell), Margery Overton (NC State University), Hugh Roberts (Arcadis, Inc), Dana Savidge (Skidaway Institute of Oceanography), Harvey Seim (UNC-Chapel Hill), Gavin Smith (UNC-Chapel Hill), Alexander Taflanidis (UND), Peter Vickery (Applied Research Associates), Joannes Westerink (Univ. Notre Dame), Don Wright (SURA)

GRADUATE AND POSTDOCTORAL ADVISORS:

Francisco E. Werner (currently Director, NOAA Southwest Marine Fisheries Science Center, La Jolla, CA), Ph.D. and Postdoctoral advisor.

STUDENT COMMITTEES:

Karen Edwards, UNC-Chapel Hill, Marine Sciences, PhD, 2006.
Catherine Edwards, UNC-Chapel Hill, Marine Sciences, PhD, 2008.
Jesse Bikman, UNC-Chapel Hill, Marine Sciences, MS, in progress.
Jie Gao, UNC-Chapel Hill, Marine Sciences, PhD, in progress.
Onur Kurum, NC State University, Civil Engineering, PhD, in progress.

CURRICULUM VITAE - RICHARD A. LUETTICH, JR.

Sewell Family Term Professor of Marine Sciences

ADDRESS:

University of North Carolina at Chapel Hill
Institute of Marine Sciences
3431 Arendell Street
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tel.: 252-726-6841 ext. 137
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email: rick_luettich@unc.edu

University of North Carolina at Chapel Hill
Center for the Study of Natural Hazards and Disasters
100 Europa Drive, Suite 540
Chapel Hill, NC 27517
tel: 919-445-9609

EDUCATION:

1979 B.C.E. Civil Engineering, with Highest Honors, Georgia Institute of Technology.
1981 M.S. Civil Engineering, Georgia Institute of Technology.
1987 Sc.D. Civil Engineering, Massachusetts Institute of Technology.

RESEARCH AND PROFESSIONAL EXPERIENCE:

2010 - pres Sewell Family Term Professor of Marine Sciences
2008 – pres *Director*, Center for the Study of Natural Hazards and Disasters, UNC Chapel Hill
2007 – pres Chief Domain Scientist, Coastal Modeling, Renaissance Computing Institute
2004 - pres *Director*, Institute of Marine Sciences, UNC Chapel Hill
1999 - pres. Professor of Marine Sciences and Environmental Sciences and Engineering, University of North Carolina at Chapel Hill.
1997 - 1999 Associate Professor of Marine Sciences and Env. Sciences & Eng., UNC Chapel Hill.
1993 - 1997 Associate Professor of Marine Sciences, UNC Chapel Hill.
1987 - 1993 Assistant Professor of Marine Sciences, UNC Chapel Hill.
1981 - 1987 RA/TA, Dept. of Civil Eng., Massachusetts Institute of Technology.
1980 - 1981 Hydrologist, US Geological Survey, Regional Office, Atlanta, Ga.
1979 - 1980 RA, Dept. of Civil Eng., Georgia Institute of Technology.

PROFESSIONAL INTERESTS AND ACTIVITIES:

My research has dealt broadly with modeling and measurement of circulation and transport in coastal waters. My modeling efforts have emphasized the development and application of techniques that are optimized for geometrically complex systems such as sounds, estuaries, inlets and inundated regions and for high performance computing architectures. Specifically, I have co-developed the ADCIRC circulation and storm surge model that is widely used by the academic, government and private sectors and has become a cornerstone of storm surge studies over the past decade. For example, ADCIRC has been used by the US Army Corps of Engineers to design the Hurricane and Storm Risk Reduction System for the southern Louisiana, by FEMA to update the National Flood Insurance maps along the US coast from New England to Texas, and as the basis of several storm surge forecast systems along the Gulf of Mexico and Eastern US coasts. In addition to coastal hazards modeling, I've conducted numerous interdisciplinary modeling studies in physically mediated biological migration, larval dispersal and water quality. I am an active leader in coastal natural hazards and coastal modeling community, leading the Dept of Homeland Security Coastal Hazards Center of Excellence, initiating the Center for the Study of Natural Hazards and Disasters to promote multidisciplinary hazards research at UNC and leading a multi-institutional, Coastal Ocean Modeling Testbed for the US Integrated Ocean Observing System program to facilitate the transition of advancements in coastal modeling from research to operations. In parallel with modeling activities, my observational activities have focused on process based studies in coastal waters, often to understand the role of physics in areas of water quality (e.g., phytoplankton blooms, dissolved oxygen depletion) and fisheries recruitment. I have developed an autonomous vertical profiling system that has provided novel data on high frequency anoxic water upwelling, diel vertical plankton migration, sediment

resuspension and wind driven mixing in shallow NC sounds. I have also actively participated on numerous coastal science advisory committees including two National Academy/National Research Council review committees, the Southeast Louisiana Flood Protection Authority-East, the Science and Engineering Advisory Council for the Water Institute of the Gulf and as a publically elected member of the Carteret County Board of Education.

EXTRAMURAL ACTIVITIES AND HONORS PAST 3 YEARS:

2010 – Dept Homeland Security Science and Technology Impact Award

2011 – Georgia Sea Grant review panel

2012 – pres., Northern Gulf Coastal Hazards Collaboratory Advisory Board

2012 – pres., Southeast Louisiana Flood Protection Authority – East

2012 – pres., The Water Institute of the Gulf, Scientific and Engineering Advisory Council

2012 – pres., Chesapeake Bay Program Modeling Laboratory Action Team

2012 – Dept Homeland Security Science and Technology Impact Award

PUBLICATIONS LAST 3 YEARS PLUS 5 OTHER RELEVANT PUBLICATIONS:

1994 Blain, C.A., J.J. Westerink and R.A. Luettich, Jr., "The Influence of Domain Size on the Response Characteristics of a Hurricane Storm Surge Model", *Journal of Geophysical Research*, 99(C9):18,467-18,479.

2003 Hench, J.L. and R.A. Luettich, Jr., "Transient tidal circulation and momentum balances at shallow inlets", *Journal of Physical Oceanography,* 33(April):913-932.

2008 Westerink, J.J., R.A. Luettich, Jr., J.C. Feyen, J.H. Atkinson, C. Dawson, M.D. Powell, J.P. Dunion, H.J. Roberts, E.J. Kubatko, H. Pourtaheri, "A Basin- to Channel- Scale Unstructured Grid Hurricane Storm Surge Model as Implemented for Southern Louisiana", *Monthly Weather Review*, 136:833-864, DOI: 10.1175/2007MWR1946.1

2008 Fleming, J.G., C.W. Fulcher, R.A. Luettich, B.D. Estrade, G.D. Allen, H.S. Winer, "A Real Time Storm Surge Forecasting System using ADCIRC", *Estuarine and Coastal Modeling X*, M. Spaulding [ed], ASCE, pg 893-912.

2009 Committee on New Orleans Regional Hurricane Protection Projects, "The New Orleans Hurricane Protection System: Assessing pre-Katrina Vulnerability and Improving Mitigation and Preparedness", Final Report, Water Science and Technology Board, National Academy of Engineering and National Research Council, 53p.

2010 Bunya, S., J.C. Dietrich, J.J. Westerink, B.A. Ebersole, J.M. Smith, J.H. Atkinson, R. Jensen, D.T. Resio, R.A. Luettich, C. Dawson, V.J. Cardone, A.T. Cox, M.D. Powell, H.J. Westerink, H.J. Roberts, "A High-Resolution Coupled Riverine Flow, Tide, Wind, Wind Wave and Storm Surge Model for Southern Louisiana and Mississippi: Part I - Model Development and Validation", *Monthly Weather Review,* 138(2):345-377, DOI: 10.1175/2009MWR2906.1 .

2010 Dietrich, J.C., S. Bunya, J.J. Westerink, B.A. Ebersole, J.M. Smith, J.H. Atkinson, R. Jensen, D.T. Resio, R.A. Luettich, C. Dawson, V.J. Cardone, A.T. Cox, M.D. Powell, H.J. Westerink, H.J. Roberts, "A High-Resolution Coupled Riverine Flow, Tide, Wind, Wind Wave and Storm Surge Model for Southern Louisiana and Mississippi: Part II - Synoptic Description and Analysis of Hurricanes Katrina and Rita", *Monthly Weather Review,* 138(2):378-404, DOI: 10.1175/2009MWR2907.1

2010 Kennedy, A.B., U.Gravois, B. Zachry, R.A. Luettich, Jr., Q.J. Chen, R. Avissar, A. Whipple, R. Weaver, J. Fleming, Rapidly Installed Temporary Gauging for Waves and Surge during Hurricane Gustav" *Continental Shelf Research,* 30 (2010) :1743-1752.

2010 Dresback, K.M., R.L. Kolar, C.A. Blain, C.M. Szpilka, A.M. Szpilka, R.A. Luettich, T. Shay, "Development and Application of the Coupled HYCOM and ADCIRC System", *Estuarine and Coastal Modeling XI*, M. Spaulding [ed], ASCE, pg .259-277.

2010 Forbes, C., R. Luettich, C. Mattocks, "Storm Surge Simulations of Hurricane Ike (2008): Its Impact in Louisiana and Texas", *Estuarine and Coastal Modeling XI*, M. Spaulding [ed], ASCE, pg .704-723.

2010 Tromble, E., R. Kolar, K. Dresback, Y. Hong, B. Vieux, R. Luettich, J. Gourley, K, Kelleher, S. Van Cooten, "Aspects of Coupled Hydrologic-Hydrodynamic Modeling for Coastal Flood Inundation", *Estuarine and Coastal Modeling XI*, M. Spaulding [ed], ASCE, pg .724-743.

2010 R.J. Weaver, R.A. Luettich, Jr., "2D vs. 3D Storm Surge Sensitivity in ADCIRC: Case Study of Hurricane Isabel", *Estuarine and Coastal Modeling XI,* M. Spaulding [ed], ASCE, pg .762-779.

2010 Dietrich, J.C., M. Zijlema, J.J. Westerink, L.H. Holthuijsen, C. Dawson, R.A. Luettich, Jr., R. Jensen, J.M. Smith, G.S. Stelling, " Modeling Hurricane Waves and Storm Surge using Integrally-Coupled, Scalable Computations", *Journal of Coastal Engineering*, DOI: 10.1016/j.coastaleng.2010.08.001

2010 Forbes, C., R.A. Luettich, Jr., C. Mattocks, J.J. Westerink, "A Retrospective Evaluation of the Storm Surge Produced by Hurricane Gustav (2008): Forecast and Hindcast Results". *Weather and Forecasting*, 25(December): 1577-1602, DOI: 10.1175/2010WAF2222416.1.

2010 Becker, M.L., R.A. Luettich, Jr., M.A. Mallin, "Hydrodynamic Behavior of the Cape Fear River and Estuarine System: an Observational Synthesis", *Estuarine, Coastal and Shelf Science,* 88(2010):407-418.

2010 Seim, H.E., D. Hernandez, D. Porter, R.A. Luettich, Jr. A regional coastal ocean observing system of the US Integrated Ocean Observing System (IOOS®) and its support of coastal managers, IEEE, Argentina

2010 Blanton, B., R. Luettich, P. Vickery, J. Hanson, 2010, "North Carolina Floodplain Mapping Program, Intermediate Data Submission Number Two, Draft Report on Tidal and Storm Validation Studies", March 26, 2010, 183p.

2011 Kennedy, A.B., U.Gravois, B. Zachry, J.J. Westerink, M. Hope, J. Dietrich, M.D. Powell, A.T. Cox, R.A. Luettich, Jr., R.G.Dean, "Origin of the Hurricane Ike Forerunner Surge", *Geophysical Research Letters*, 38, L08608, DOI:10.1029/2011GL047090.

2011 Tanaka, S., S. Bunya, J.J. Westerink, C. Dawson, R.A. Luettich, Jr. "Scalability of an Unstructured Grid Continuous Galerkin Based Hurricane Storm Surge Model" *Journal of Scientific Computing*, 46(2011):329-358, DOI: 10.1007/s10915-010-9402-1.

2011 J.C. Dietrich, J.J. Westerink, A.B. Kennedy, J.M. Smith, R.E. Jensen, M. Zijlema, L.H. Holthuijsen, C. Dawson, R.A. Luettich Jr., M.D. Powell, V.J. Cardone, A.T. Cox, G.W. Stone, H. Pourtaheri, M.E. Hope, S. Tanaka, L.G. Westerink, H.J. Westerink, Z. Cobell, "Hurricane Gustav (2008) Waves and Storm Surge: Hindcast, Synoptic Analysis and Validation in Southern Louisiana", *Monthly Weather Review,* 139:2488-2522, DOI: 10.1175/2011MWR3611.1

2011 Van Cooten, S, K.E. Kelleher, K. Howard, J. Zhang, J.J. Gourley, J.S. Kain, K. Nemunaitis-Monroe, Z. Flamig, H. Moser, A. Arthur, C. Langston, R. Kolar, Y. Hong, K. Dresback, E. Tromble, H. Vergara, R.A Luettich, Jr., B. Blanton, H. Lander, K. Galuppi, J.P. Losego, C.A. Blain, J. Thigpen, K. Mosher, D. Figursky, M. Moneypenny, J. Blaes, J. Orrock, R. Bandy, C. Goodall, J.G. Kelley, J. Greenlaw, M. Wengren, D. Eslinger, J. Payne, G. Olmi, J. Feldt, J. Schmidt, T. Hamill, R. Bacon, R. Stickney, L. Spence, "The CI-FLOW Project: Tracking Precipitation from the Sky to the Summit to the Sea", *Bulletin of the American Meteorological Society,* November 2011:1427-1442, DOI: 10.1175/2011BAMS3150.1

2011 Peterson, C.H., F.C. Coleman, J.B.C. Jackson, R.E. Turner, G.T. Rowe, R.T. Barber, K.A. Bjorndal, R.S. Carney, R.K. Cowen, J.M. Hoekstra, J.T. Hollibaugh, S.B. Laska, R.A. Luettich Jr., C.W. Osenberg, S.E. Roady, S. Senner, J.M. Teal and P. Wang, "A Once and Future Gulf of Mexico Ecosystem: Restoration Recommendations of an Expert Working Group", Pew Environment Group. Washington, DC. 112 pp.

2012 Dietrich, J.C., S. Tanaka, J.J. Westerink, C.N. Dawson, R.A. Luettich Jr., M. Zijlema, L.H. Holthuijsen, J.M. Smith, L.G. Westerink, H.J. Westerink, "Performance of the Unstructured-Mesh, SWAN+ADCIRC Model in Computing Hurricane Waves and Surge", *Journal of Scientific Computing*, 52(2012):468-497, DOI 10.1007/s10915-011-9555-6.

2012 Haase, A., D.B. Eggleston, R. Luettich, R.L. Weaver, B.J. Puckett, "Estuarine Circulation and Predicted Oyster Larval Dispersal Among a Network of Reserves", *Estuarine Coastal and Shelf Science*, 101(2012):33-43, DOI 10.1016/j.ecss.2012.02.011

2012 Dietrich, J.C., C.J. Trahan, M.T. Howard, J.G. Fleming, R.J. Weaver, S. Tanaka, L. Yu, R.A. Luettich Jr, C.N. Dawson, J.J. Westerink, G. Wells, A. Lu, K. Vega, A. Kubach, K.M. Dresback, R.L. Kolar, C. Kaiser, R.R. Twilley,. "Surface Trajectories of Oil Transport along the Northern Coastline of the Gulf of Mexico." *Continental Shelf Research*, 41(1), 17-47, DOI:10.1016/j.csr.2012.03.015.

2012 Blanton, B., J. McGee, J. Fleming, C. Kaiser, H. Kaiser, H. Lander, R. Luettich, K. Dresback, R. Kolar, 2012, "Urgent computing of storm surge for North Carolina's coast", *Proceida Computer Science* 9 (2012) 1677-1686.

2012 Dresback, K.M., E.M., Tromble, D.G. Reid, R.L. Kolar, T.C.G. Kibbey, C.A. Blain, R.A. Luettich, Jr., C.M. Szpilka, "Evaluation of Baroclinic ADCIRC Using a Process-Oriented Test Along a Slope", *Estuarine and Coastal Modeling XII*, M. Spaulding [ed], ASCE, pg. 86-98.

2012 Sheng, Y.P., J.R. Davis, R. Figueiredo, B. Liu, H. Liu, R. Luettich, V.A. Paramygin, R. Weaver, R. Weisberg, L. Xie, L. Zheng, "A Regional Testbed for Storm Surge and Coastal Inundation Models – An Overview", *Estuarine and Coastal Modeling XII,* M. Spaulding [ed], pgs 476-495.

2012 Tromble, E., R. Kolar, K. Dresback, R. Luettich, "River Flux Boundary Conditions in a Coupled Hydrologic-Hydrodynamic Modeling System", *Estuarine and Coastal Modeling XII*, M. Spaulding [ed], ASCE, pg. 510-527.

2012 Blanton, B., P. Vickery, R. Luettich, J. Hanson, K. Slover, North Carolina Floodplain Mapping Program Coastal Flood Insurance Study, Submittal Number 3: Production Simulations and Statistical Synthesis.

2013 Reynolds-Fleming, J.V., R.A. Luettich, Jr., "Comparative hydrodynamics during events along a barrier island: explanation for overwash", accepted for publication in *Estuarine, Coastal and Shelf Science*

Current and Pending

Current and Pending Support

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Blanton, Brian

Other agencies to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:
Sea Level Rise Risk Management Study

Source of Support: FEMA

Total Award Amount: $425,187 Total Award Period Covered: 09/01/09-10/01/12

Location of Project: The University of North Carolina at Chapel Hill

Person-Months Per Year Committed to the Project. Cal: 3.84 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:
CIF21 DIBBs: Geospatial Analysis Ecosystem for Science and Engineering

Source of Support: University of Notre Dame (Prime: National Science Foundation)

Total Award Amount: $3,415,758 Total Award Period Covered: 01/01/13-12/31/17

Location of Project: The University of North Carolina at Chapel Hill

Person-Months Per Year Committed to the Project. Cal: 0.96 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:
AdcircLite

Source of Support: UNC Center for Natural Hazards (Prime: DHS)

Total Award Amount: $ 196,234 Total Award Period Covered: 01/01/13-06/30/14

Location of Project: The University of North Carolina at Chapel Hill

Person-Months Per Year Committed to the Project. Cal: 0.75 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support: :

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Current and Pending Support

See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Richard A. Luettich, Jr.	Other agencies (including NSF) to which this proposal has been/will be submitted. None

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Collaborative Research: Linkage of bacterial pathogens to human infectious disease in an estuary subjected to extreme climatic events

(co-PI)

Source of Support: NSF - EID

Total Award Amount: $233,740 Total Award Period Covered: 9/2008 - 8/2013

Location of Project: UNC Institute of Marine Sciences

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 0.25

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: ADCIRC Surge Guidance System

(PI)

Source of Support: US Army Corps of Engineers

Total Award Amount: $320,131 Total Award Period Covered: 9/2009 – 6/2013

Location of Project: UNC Institute of Marine Sciences

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Center of Excellence in Natural Disasters, Coastal Infrastructure, and Emergency Management

(PI)

Source of Support: Dept of Homeland Security

Total Award Amount: $15,550,000 Total Award Period Covered: 7/2008 – 6/2014

Location of Project: UNC Center for the Study of Natural Hazards and Disasters

Person-Months Per Year Committed to the Project. Cal: 1.0 Acad: Sumr: 1.0

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: A US IOOS Coastal Modeling Testbed

(PI)

Source of Support: Southeast Universities Research Association (from NOAA IOOS)

Total Award Amount: $975,000 Total Award Period Covered: 8/1/2011 – 7/31/2013

Location of Project: Institute of Marine Sciences

Person-Months Per Year Committed to the Project. Cal: 3.0 Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Collaborative Research: Interacting Effects of Local Demography and Larval Connectivity on Estuarine Metapopulation Dynamics

(co-PI)

Source of Support: NSF Ocean Sciences

Total Award Amount: $251,757 Total Award Period Covered: 1/1/2012 – 12/31/2015

Location of Project: UNC Institute of Marine Sciences

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Richard A. Luettich, Jr.	Other agencies (including NSF) to which this proposal has been/will be submitted. None

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Defense Coastal / Estuarine Research Program Phase III

(co-PI)

Source of Support: Department of Defense SERDP

Total Award Amount: $200,000 Total Award Period Covered: 11/2012 – 12/2017

Location of Project: Institute of Marine Sciences

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

(PI)

Source of Support:

Total Award Amount: Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

(PI)

Source of Support:

Total Award Amount: Total Award Period Covered:

Location of Project: Renaissance Computing Institute

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

(PI)

Source of Support:

Total Award Amount: Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

(PI)

Source of Support:

Total Award Amount: Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

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*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Budget Justification

NOAA JHT 2013 Adcirc Proposal

1) Salary and wages for Senior Personnel - The salary costs are a direct proportion of the effort of the senior personnel. The Principal Investigator (PI), Brian Blanton is one senior personnel proposed by the University of North Carolina for this effort. The PI will contribute 2.0 person months for each of the two years of this project. The salary cost is estimated at $19,766 for the first year and escalated at 3% per year thereafter for a total PI salary of $40,125. The co-Principal Investigator is Rick Luettich, who will contribute 0.50 academic months per project year. The salary cost is estimated at $7,013 for the first year and escalated at 3% per year thereafter for a total co-PI salary request of $14,236. The total salary request for senior personnel is **$54,360.**

2) Salary and wages for Other Personnel – One graduate student will contribute 6.0 person months per project year. The salary cost is estimated at $14,025 for the first year and escalated at 3% per year thereafter for a total salary of **$28,471.**

3) Fringe Benefits – The University fringe benefit rate is 22.04% for senior personnel and other professionals and 8.78% for Graduate Students. Health insurance is estimated at $5,192/year for senior personnel and other professionals and $2,694 for Graduate Students. Health insurance is escalated at 3% per year after year one. Total estimated fringe benefits are **$19,550.**
Please see http://research.unc.edu/offices/sponsored-research/resources/DATA_RES_OSR_INFOSHEET#fringe2

4) Travel – Domestic travel is estimated at $5,000 per year for a total of **$10,000**. Travel is estimated for both PI Blanton, co-PI Luettich, and a TBD Graduate Student. Trips will include annual Interdepartmental Hurricane Conference ($1,000 each for PI, co-PI, and student); and one engagement visit in each project year to NHC for the PI and co-PI ($1,000 each).

5) Other Direct Costs – Other Direct Costs in this proposal are for Graduate Student tuition. This is for half-time involvement at $3,917 in the first year and $4,035 in the second year, for a total tuition request of **$7,952.**

6) Total Direct Costs – Total direct costs are estimated at **$120,334.**

7) Indirect Costs – The University has an indirect cost rate of 52% on Modified Total Direct Costs (MTDC). The total base is $112,383 with total indirect costs equaling **$58,439.**
Please see http://research.unc.edu/offices/sponsored-research/resources/DATA_RES_OSR_INFOSHEET#facilities

8) Total Direct and Indirect Costs - Total Direct and Indirect Costs are estimated at **$178,773.**

9) Total Project Cost - $178,773.

OMB Number: 4040-0004
Expiration Date: 03/31/2012

Application for Federal Assistance SF-424

* 1. Type of Submission:
- [ ] Preapplication
- [x] Application
- [ ] Changed/Corrected Application

* 2. Type of Application:
- [x] New
- [ ] Continuation
- [ ] Revision

* If Revision, select appropriate letter(s):

* Other (Specify):

* 3. Date Received: 12/06/2012

4. Applicant Identifier:

5a. Federal Entity Identifier:

5b. Federal Award Identifier:

State Use Only:

6. Date Received by State:

7. State Application Identifier:

8. APPLICANT INFORMATION:

* a. Legal Name: The University of North Carolina at Chapel Hill

* b. Employer/Taxpayer Identification Number (EIN/TIN): 566001393

* c. Organizational DUNS: 6081952770000

d. Address:

* Street1: 104 Airport Drive, Suite 2200, CB#1350
Street2:
* City: Chapel Hill
County/Parish:
* State: NC: North Carolina
Province:
* Country: USA: UNITED STATES
* Zip / Postal Code: 27599-1350

e. Organizational Unit:

Department Name: Renaissance Computing Institut

Division Name:

f. Name and contact information of person to be contacted on matters involving this application:

Prefix:
* First Name: Martha
Middle Name:
* Last Name: Martin
Suffix:

Title: Contract & Grant Specialist

Organizational Affiliation: Office of Sponsored Research

* Telephone Number: (919) 962-7255
Fax Number: (919) 962-5011

* Email: martha_martin@unc.edu

Application for Federal Assistance SF-424

*** 9. Type of Applicant 1: Select Applicant Type:**

H: Public/State Controlled Institution of Higher Education

Type of Applicant 2: Select Applicant Type:

Type of Applicant 3: Select Applicant Type:

* Other (specify):

*** 10. Name of Federal Agency:**

Department of Commerce

11. Catalog of Federal Domestic Assistance Number:

11.459

CFDA Title:

Weather and Air Quality Research

*** 12. Funding Opportunity Number:**

NOAA-OAR-OWAQ-2013-2003469

* Title:

FY 2013 Joint Hurricane Testbed

13. Competition Identification Number:

2297052

Title:

14. Areas Affected by Project (Cities, Counties, States, etc.):

Add Attachment | Delete Attachment | View Attachment

*** 15. Descriptive Title of Applicant's Project:**

Adcirc Viz: A Visualization Application for Distributed ADCIRC-based Coastal Storm Surge, Inundation, and Wave Modeling

Attach supporting documents as specified in agency instructions.

Add Attachments | Delete Attachments | View Attachments

Application for Federal Assistance SF-424

16. Congressional Districts Of:

* a. Applicant: NC-004 | b. Program/Project: NC-004

Attach an additional list of Program/Project Congressional Districts if needed.

Add Attachment | Delete Attachment | View Attachment

17. Proposed Project:

* a. Start Date: 08/01/2013 | * b. End Date: 07/31/2015

18. Estimated Funding ($):

* a. Federal	178,773.00
* b. Applicant	0.00
* c. State	0.00
* d. Local	0.00
* e. Other	0.00
* f. Program Income	0.00
* g. TOTAL	178,773.00

*** 19. Is Application Subject to Review By State Under Executive Order 12372 Process?**

☐ a. This application was made available to the State under the Executive Order 12372 Process for review on .

☐ b. Program is subject to E.O. 12372 but has not been selected by the State for review.

☒ c. Program is not covered by E.O. 12372.

*** 20. Is the Applicant Delinquent On Any Federal Debt? (If "Yes," provide explanation in attachment.)**

☐ Yes ☒ No

If "Yes", provide explanation and attach

Add Attachment | Delete Attachment | View Attachment

21. *By signing this application, I certify (1) to the statements contained in the list of certifications and (2) that the statements herein are true, complete and accurate to the best of my knowledge. I also provide the required assurances** and agree to comply with any resulting terms if I accept an award. I am aware that any false, fictitious, or fraudulent statements or claims may subject me to criminal, civil, or administrative penalties. (U.S. Code, Title 218, Section 1001)**

☒ ** I AGREE

** The list of certifications and assurances, or an internet site where you may obtain this list, is contained in the announcement or agency specific instructions.

Authorized Representative:

Prefix: Dr. | * First Name: Barbara

Middle Name:

* Last Name: Entwisle

Suffix: Ph.D

* Title: Vice Chancellor for Research

* Telephone Number: (919) 966-3411 | Fax Number: (919) 962-5011

* Email: resadminosr@unc.edu

* Signature of Authorized Representative: Martha Martin | * Date Signed: 12/06/2012

BUDGET INFORMATION - Non-Construction Programs

OMB Number: 4040-0006
Expiration Date: 06/30/2014

SECTION A - BUDGET SUMMARY

Grant Program Function or Activity (a)	Catalog of Federal Domestic Assistance Number (b)	Estimated Unobligated Funds		New or Revised Budget		
		Federal (c)	Non-Federal (d)	Federal (e)	Non-Federal (f)	Total (g)
1. 08/01/13-07/31/14 Year 1	11.459	$	$	$ 88,178.00	$ 0.00	$ 88,178.00
2. 08/01/14-07/31/16 Year 2	11.459			90,595.00	0.00	90,595.00
3.						
4.						
5. Totals		$	$	$ 178,773.00	$	$ 178,773.00

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SECTION B - BUDGET CATEGORIES

6. Object Class Categories	GRANT PROGRAM, FUNCTION OR ACTIVITY (1) 08/01/13-07/31/14 Year 1	(2) 08/01/14-07/31/16 Year 2	(3) N/A	(4) N/A	Total (5)
a. Personnel	$ 40,804.00	$ 42,028.00	$	$	$ 82,832.00
b. Fringe Benefits	9,631.00	9,919.00			19,550.00
c. Travel	5,000.00	5,000.00			10,000.00
d. Equipment	0.00	0.00			
e. Supplies	0.00	0.00			
f. Contractual	0.00	0.00			
g. Construction	0.00	0.00			
h. Other	3,917.00	4,035.00			7,952.00
i. Total Direct Charges (sum of 6a-6h)	59,352.00	60,982.00			$ 120,334.00
j. Indirect Charges	28,826.00	29,613.00			$ 58,439.00
k. TOTALS (sum of 6i and 6j)	$ 88,178.00	$ 90,595.00	$	$	$ 178,773.00
7. Program Income	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$

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SECTION C - NON-FEDERAL RESOURCES

(a) Grant Program	(b) Applicant	(c) State	(d) Other Sources	(e)TOTALS
8.	$	$	$	$
9.				
10.				
11.				
12. TOTAL (sum of lines 8-11)	$	$	$	$

SECTION D - FORECASTED CASH NEEDS

	Total for 1st Year	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
13. Federal	$ 88,177.00	$ 22,044.25	$ 22,044.25	$ 22,044.25	$ 22,044.25
14. Non-Federal	$	0.00	0.00	0.00	0.00
15. TOTAL (sum of lines 13 and 14)	$ 88,177.00	$ 22,044.25	$ 22,044.25	$ 22,044.25	$ 22,044.25

SECTION E - BUDGET ESTIMATES OF FEDERAL FUNDS NEEDED FOR BALANCE OF THE PROJECT

(a) Grant Program	FUTURE FUNDING PERIODS (YEARS)			
	(b)First	(c) Second	(d) Third	(e) Fourth
16. FY 2013 Joint Hurricane Testbed	$ 88,177.00	$ 90,595.00	$	$
17.				
18.				
19.				
20. TOTAL (sum of lines 16 - 19)	$ 88,177.00	$ 90,595.00	$	$

SECTION F - OTHER BUDGET INFORMATION

21. Direct Charges: 120,334

22. Indirect Charges: 58,439

23. Remarks:

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OMB Number: 4040-0007
Expiration Date: 06/30/2014

ASSURANCES - NON-CONSTRUCTION PROGRAMS

PLEASE DO NOT RETURN YOUR COMPLETED FORM TO THE OFFICE OF MANAGEMENT AND BUDGET. SEND IT TO THE ADDRESS PROVIDED BY THE SPONSORING AGENCY.

NOTE: Certain of these assurances may not be applicable to your project or program. If you have questions, please contact the awarding agency. Further, certain Federal awarding agencies may require applicants to certify to additional assurances. If such is the case, you will be notified.

As the duly authorized representative of the applicant, I certify that the applicant:

1. Has the legal authority to apply for Federal assistance and the institutional, managerial and financial capability (including funds sufficient to pay the non-Federal share of project cost) to ensure proper planning, management and completion of the project described in this application.

2. Will give the awarding agency, the Comptroller General of the United States and, if appropriate, the State, through any authorized representative, access to and the right to examine all records, books, papers, or documents related to the award; and will establish a proper accounting system in accordance with generally accepted accounting standards or agency directives.

3. Will establish safeguards to prohibit employees from using their positions for a purpose that constitutes or presents the appearance of personal or organizational conflict of interest, or personal gain.

4. Will initiate and complete the work within the applicable time frame after receipt of approval of the awarding agency.

5. Will comply with the Intergovernmental Personnel Act of 1970 (42 U.S.C. §§4728-4763) relating to prescribed standards for merit systems for programs funded under one of the 19 statutes or regulations specified in Appendix A of OPM's Standards for a Merit System of Personnel Administration (5 C.F.R. 900, Subpart F).

6. Will comply with all Federal statutes relating to nondiscrimination. These include but are not limited to: (a) Title VI of the Civil Rights Act of 1964 (P.L. 88-352) which prohibits discrimination on the basis of race, color or national origin; (b) Title IX of the Education Amendments of 1972, as amended (20 U.S.C.§§1681-1683, and 1685-1686), which prohibits discrimination on the basis of sex; (c) Section 504 of the Rehabilitation Act of 1973, as amended (29 U.S.C. §794), which prohibits discrimination on the basis of handicaps; (d) the Age Discrimination Act of 1975, as amended (42 U. S.C. §§6101-6107), which prohibits discrimination on the basis of age; (e) the Drug Abuse Office and Treatment Act of 1972 (P.L. 92-255), as amended, relating to nondiscrimination on the basis of drug abuse; (f) the Comprehensive Alcohol Abuse and Alcoholism Prevention, Treatment and Rehabilitation Act of 1970 (P.L. 91-616), as amended, relating to nondiscrimination on the basis of alcohol abuse or alcoholism; (g) §§523 and 527 of the Public Health Service Act of 1912 (42 U.S.C. §§290 dd-3 and 290 ee- 3), as amended, relating to confidentiality of alcohol and drug abuse patient records; (h) Title VIII of the Civil Rights Act of 1968 (42 U.S.C. §§3601 et seq.), as amended, relating to nondiscrimination in the sale, rental or financing of housing; (i) any other nondiscrimination provisions in the specific statute(s) under which application for Federal assistance is being made; and, (j) the requirements of any other nondiscrimination statute(s) which may apply to the application.

7. Will comply, or has already complied, with the requirements of Titles II and III of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (P.L. 91-646) which provide for fair and equitable treatment of persons displaced or whose property is acquired as a result of Federal or federally-assisted programs. These requirements apply to all interests in real property acquired for project purposes regardless of Federal participation in purchases.

8. Will comply, as applicable, with provisions of the Hatch Act (5 U.S.C. §§1501-1508 and 7324-7328) which limit the political activities of employees whose principal employment activities are funded in whole or in part with Federal funds.

9. Will comply, as applicable, with the provisions of the Davis-Bacon Act (40 U.S.C. §§276a to 276a-7), the Copeland Act (40 U.S.C. §276c and 18 U.S.C. §874), and the Contract Work Hours and Safety Standards Act (40 U.S.C. §§327-333), regarding labor standards for federally-assisted construction subagreements.

10. Will comply, if applicable, with flood insurance purchase requirements of Section 102(a) of the Flood Disaster Protection Act of 1973 (P.L. 93-234) which requires recipients in a special flood hazard area to participate in the program and to purchase flood insurance if the total cost of insurable construction and acquisition is $10,000 or more.

11. Will comply with environmental standards which may be prescribed pursuant to the following: (a) institution of environmental quality control measures under the National Environmental Policy Act of 1969 (P.L. 91-190) and Executive Order (EO) 11514; (b) notification of violating facilities pursuant to EO 11738; (c) protection of wetlands pursuant to EO 11990; (d) evaluation of flood hazards in floodplains in accordance with EO 11988; (e) assurance of project consistency with the approved State management program developed under the Coastal Zone Management Act of 1972 (16 U.S.C. §§1451 et seq.); (f) conformity of Federal actions to State (Clean Air) Implementation Plans under Section 176(c) of the Clean Air Act of 1955, as amended (42 U.S.C. §§7401 et seq.); (g) protection of underground sources of drinking water under the Safe Drinking Water Act of 1974, as amended (P.L. 93-523); and, (h) protection of endangered species under the Endangered Species Act of 1973, as amended (P.L. 93-205).

12. Will comply with the Wild and Scenic Rivers Act of 1968 (16 U.S.C. §§1271 et seq.) related to protecting components or potential components of the national wild and scenic rivers system.

13. Will assist the awarding agency in assuring compliance with Section 106 of the National Historic Preservation Act of 1966, as amended (16 U.S.C. §470), EO 11593 (identification and protection of historic properties), and the Archaeological and Historic Preservation Act of 1974 (16 U.S.C. §§469a-1 et seq.).

14. Will comply with P.L. 93-348 regarding the protection of human subjects involved in research, development, and related activities supported by this award of assistance.

15. Will comply with the Laboratory Animal Welfare Act of 1966 (P.L. 89-544, as amended, 7 U.S.C. §§2131 et seq.) pertaining to the care, handling, and treatment of warm blooded animals held for research, teaching, or other activities supported by this award of assistance.

16. Will comply with the Lead-Based Paint Poisoning Prevention Act (42 U.S.C. §§4801 et seq.) which prohibits the use of lead-based paint in construction or rehabilitation of residence structures.

17. Will cause to be performed the required financial and compliance audits in accordance with the Single Audit Act Amendments of 1996 and OMB Circular No. A-133, "Audits of States, Local Governments, and Non-Profit Organizations."

18. Will comply with all applicable requirements of all other Federal laws, executive orders, regulations, and policies governing this program.

19. Will comply with the requirements of Section 106(g) of the Trafficking Victims Protection Act (TVPA) of 2000, as amended (22 U.S.C. 7104) which prohibits grant award recipients or a sub-recipient from (1) Engaging in severe forms of trafficking in persons during the period of time that the award is in effect (2) Procuring a commercial sex act during the period of time that the award is in effect or (3) Using forced labor in the performance of the award or subawards under the award.

* SIGNATURE OF AUTHORIZED CERTIFYING OFFICIAL	* TITLE
Martha Martin	Vice Chancellor for Research
* APPLICANT ORGANIZATION	* DATE SUBMITTED
The University of North Carolina at Chapel Hill	12/06/2012

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FORM **CD-511**
(REV 1-05)

U.S. DEPARTMENT OF COMMERCE

CERTIFICATION REGARDING LOBBYING

Applicants should also review the instructions for certification included in the regulations before completing this form. Signature on this form provides for compliance with certification requirements under 15 CFR Part 28, 'New Restrictions on Lobbying.' The certifications shall be treated as a material representation of fact upon which reliance will be placed when the Department of Commerce determines to award the covered transaction, grant, or cooperative agreement.

LOBBYING

As required by Section 1352, Title 31 of the U.S. Code, and implemented at 15 CFR Part 28, for persons entering into a grant, cooperative agreement or contract over $100,000 or a loan or loan guarantee over $150,000 as defined at 15 CFR Part 28, Sections 28.105 and 28.110, the applicant certifies that to the best of his or her knowledge and belief, that:

(1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, 'Disclosure Form to Report Lobbying.' in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers (including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements) and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure occurring on or before October 23, 1996, and of not less than $11,000 and not more than $110,000 for each such failure occurring after October 23, 1996.

Statement for Loan Guarantees and Loan Insurance

The undersigned states, to the best of his or her knowledge and belief, that:

In any funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this commitment providing for the United States to insure or guarantee a loan, the undersigned shall complete and submit Standard Form-LLL, 'Disclosure Form to Report Lobbying,' in accordance with its instructions.

Submission of this statement is a prerequisite for making or entering into this transaction imposed by section 1352, title 31, U.S. Code. Any person who fails to file the required statement shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure occurring on or before October 23, 1996, and of not less than $11,000 and not more than $110,000 for each such failure occurring after October 23, 1996.

As the duly authorized representative of the applicant, I hereby certify that the applicant will comply with the above applicable certification.

* NAME OF APPLICANT

The University of North Carolina at Chapel Hill

* AWARD NUMBER

None

* PROJECT NAME

N/A

Prefix: Dr.

* First Name: Barbara

Middle Name:

* Last Name: Entwisle

Suffix: Ph.D

* Title: Vice Chancellor for Research

* SIGNATURE: Martha Martin

* DATE: 12/06/2012