

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

A JHT 2013 Project

Mid-Year Progress Report

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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. 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. Therefore, 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.

This document reports on the project's accomplishments to date, engagement with the NHC and our NOAA point of contact, Dr. Jesse Feyen (CSDL), and anticipated activities in the next 6-month period.

1) Overall approach for AdcircViz

The community of expert ADCIRC system operators is organizing around an ADCIRC Data Grid that effectively creates a single collection of ADCIRC results. This is illustrated in Figure 1. The content of each THREDDs server is harvested into a master catalog file that AdcircViz can retrieve and present to the user.

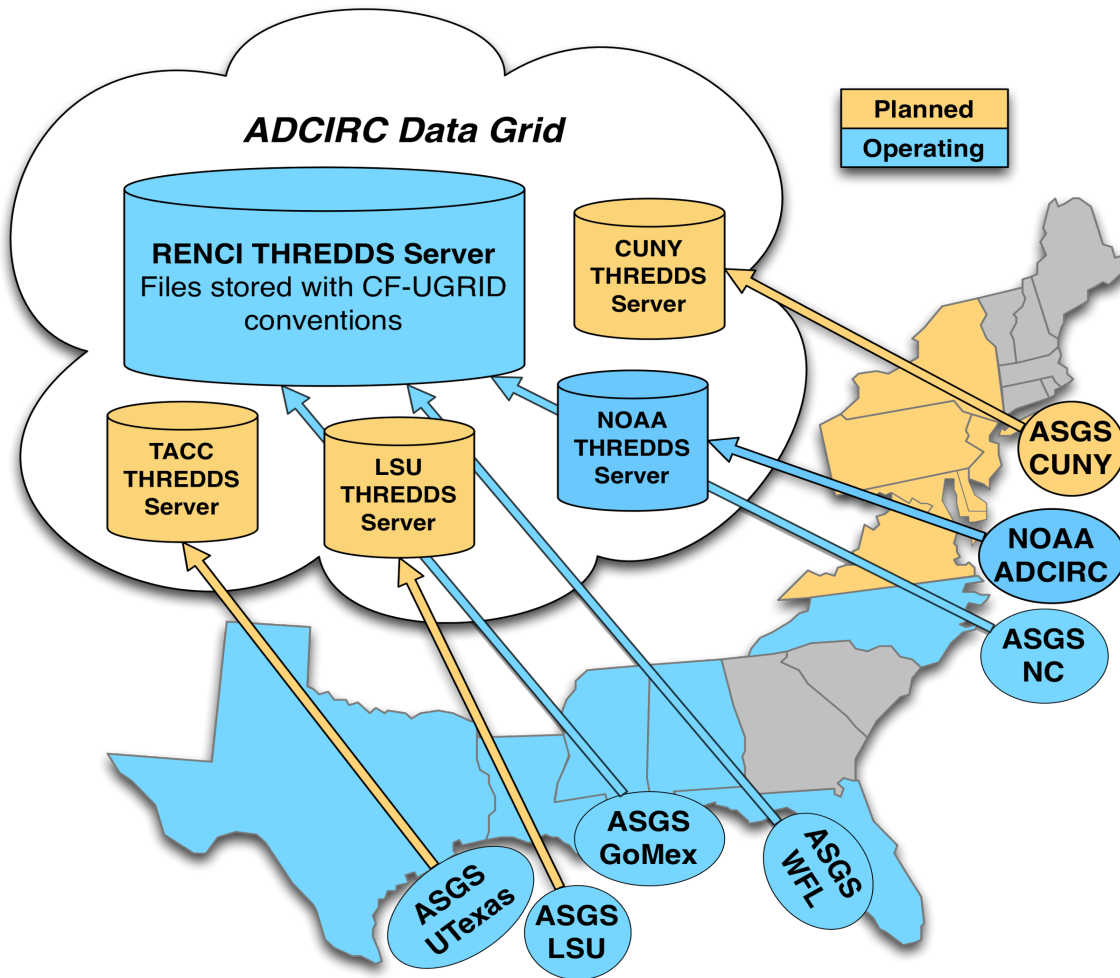


Figure 1: Current set of THREDDs servers (blue) that comprise the ADCIRC Data Grid. NOAA Coast Survey Development Laboratory has recently configured a server to host their experimental ADCIRC simulations. These simulations, computed for both tropical events and daily weather conditions, can be directly accessed and visualized with AdcircViz.

AdcircViz relies on making connections to an OPeNDAP server using the MATLAB toolbox nctoolbox. This [toolbox](#), which uses the Unidata netCDF java class as the data access layer, is used extensively to open netCDF data files and access metadata, without accessing the data components until they are needed. Each graphic is generated using MATLAB functions and tools “on the fly”; the color map, color limits and color increment are specified by the user with default values appropriate to the scalar field being rendered. The default colormap is one similar to the NOAA colormap currently used for NHC surge maps (Figure 2).



Figure 2: Default AdcircViz Colormap based on the colormap used for NHC storm surge graphics.

2) Prototype AdcircViz functionality and capabilities

For the proposal to the JHT program, we developed a prototype AdcircViz implementation to demonstrate the feasibility of the approach. This version of AdcircViz (Figure 3) included the ability to visualize several scalar fields from ADCIRC (namely maximum water level, time-dependent water level, maximum significant wave height, time-dependent wind speed, and the maximum wind speed) for all ensemble members contained in an ASGS simulation directory. The data and metadata for populating the application are extracted from ADCIRC files posted on a THREDDs server (opendap.renci.org). The files are in netCDF format with strict adherence to the CF-UGRID conventions and standards, and in a specific directory (folder) hierarchy that defines information such as storm name and advisory number. This prototype version was extensively tested during the 2012 Atlantic hurricane season, particularly during Hurricane Isaac. We have also tested AdcircViz with large Hurricane Katrina simulations in a hindcast mode, and this has proven to be a useful way to examine existing non-forecast simulations, as long as the files adhere to the CF-UGRID conventions and are manually put onto a THREDDs server.

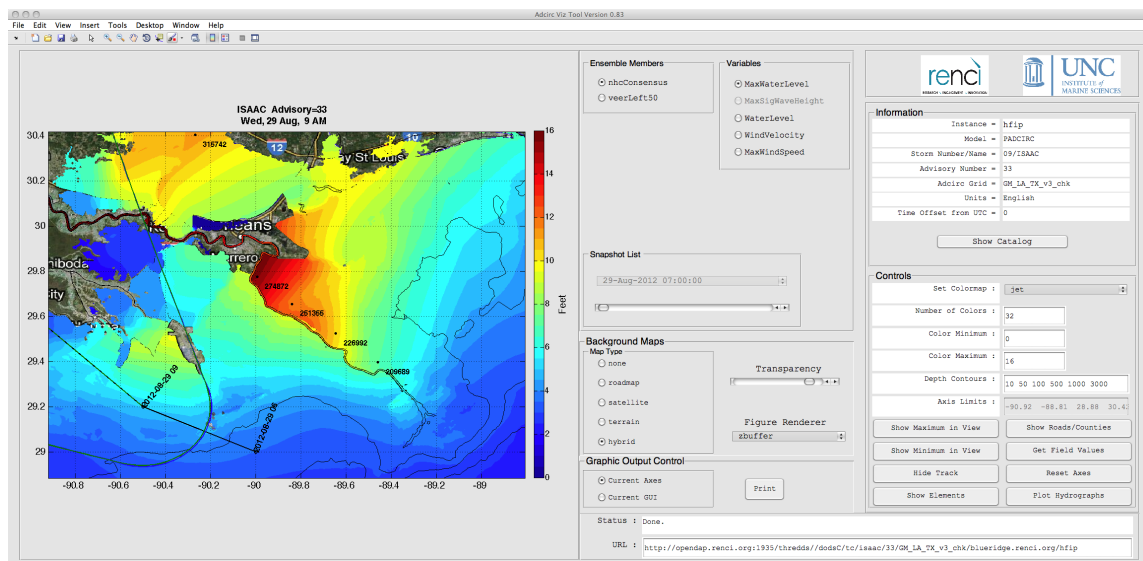


Figure 3: Prototype AdcircViz application developed for the original proposal to JHT. This version was extensively tested during this project period, and deployed to test/evaluation users for 2013.

3) Advancements and Progress to Date

Since the project start, we have implemented several additional features discussed in the proposal and that have been identified as critical capabilities to have. These new features include display of vectors for winds and currents, output of scalar fields as shapefiles, display of water levels as an inundation depth over land, and the metadata necessary for visualization and analysis of wind-wave fields (ADCIRC has recently been formally coupled to the unstructured version of SWAN). Figure 4 shows these new features relative to the prototype version in Figure 3. The new features are outlined with red boxes.

A component of the overall approach is to establish THREDDs servers at individual modeling sites and expose the catalog to AdcircViz in a consistent way. At the time of the proposal to JHT, there was only one THREDDs server, hosted at [RENCI/UNC](http://renci.unc.edu). NOAA's Coast Survey Development Lab (CSDL) has recently installed a [THREDDs server](http://www.csdllab.com) to serve experimental ADCIRC-based simulations. We anticipate at least one new THREDDs server for ASGS simulations in the Gulf of Mexico.

In addition to the user interface and functionality updates, we have moved the AdcircViz code to a GitHub repository. This will simplify the distribution of the code to NHC. GitHub provides no-cost public repositories for project management, including issue tracking and automatic update notification to users. The project landing page ([here](#)) is shown in Figure 5. We have used the issue-tracking mechanism internally during testing phases to ensure that issues are recorded and subsequently addressed.

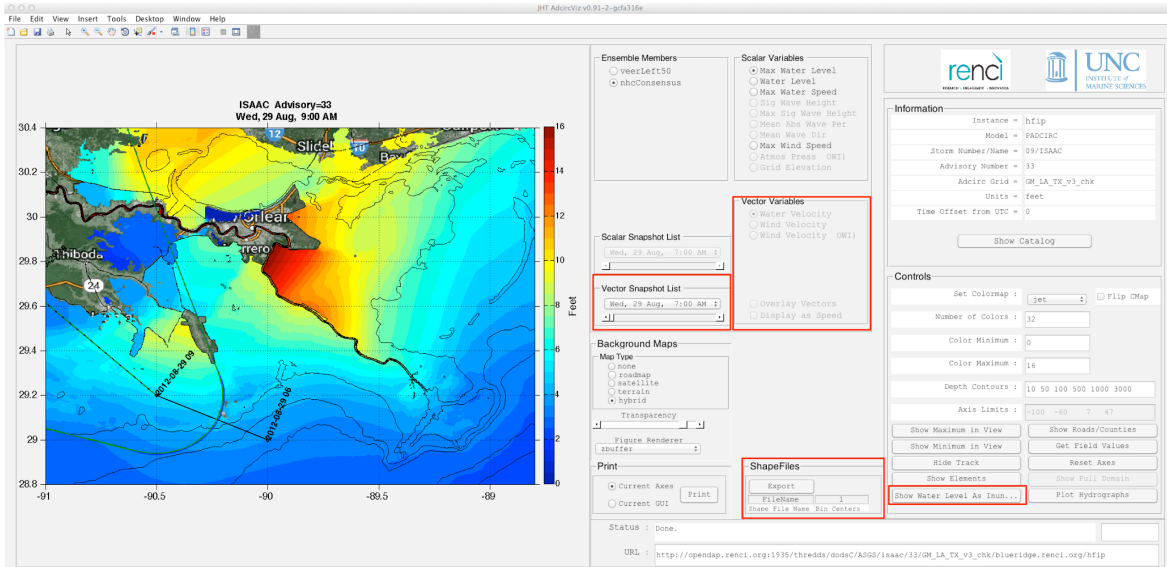


Figure 4: Version 0.91 of AdcircViz, showing indicating the features added and their placement on the GUI.



Figure 5: AdcircViz project GitHub landing page. This page provides easy access to the code, as well as links to documentation and support.

4) Deployment Status

The current version of AdcircViz has been made available to the NHC storm surge unit for deployment and initial evaluation prior to the 2014 Atlantic hurricane season. A presentation describing the project was made at the recent 2014 Interdepartmental Hurricane Conference, and afterward we met with the storm surge unit to discuss specific requirements for AdcircViz, including specific features, code access, machine/operating system dependencies, and how to optimally engage for bug fixes and feature requests. [There are no known machine dependencies at this time; we have tested AdcircViz on Linux, Mac, and recent Windows operating systems.] This meeting resulted in action items to ensure the operation of AdcircViz for the upcoming season. We will work with NHC to test AdcircViz by creating a mock ASGS simulation sequence for recent hurricanes such as Isaac (2012) and Sandy (2012). During the 2014 season, we will be on “stand-by” to work with NHC and CSDL to support use of AdcircViz during tropical events.

5) Features under development

There are several aspects of AdcircViz under development.

- **Local Mode:** We are implementing a “local mode” that does not need a catalog entry, allowing users to point at CF-UGRID compliant files on local disk or at an OPeNDAP URL.
- **GeoPortal:** We are investigating using ESRI’s open-source GeoPortal to provide searchable catalog services. GeoPortal can harvest netCDF metadata using the ncISO THREDDs service, and automatically perform the aggregation of multiple THREDDs server content.
- **Python-based AdcircViz:** Python has become widespread in the coastal modeling community, and in the earth sciences in general. One of the main benefits of python is its open-source status and the large community of developers in a variety of scientific areas. This includes development work on a python class for CF-UGRID netCDF files. Python presents an alternative to MATLAB, and we are investigating the feasibility of a python version of AdcircViz, with a similar GUI.
- **SLOSH visualization:** Since SLOSH uses a rectangular grid; it is straightforward to “convert” SLOSH to CF-UGRID. We have recently demonstrated this capability by mapping a SLOSH output file from the NOAA IOOS Coastal Ocean Modeling Testbed into a UGRID-compliant triangular description. We are developing a workflow that can be used to perform this conversion “on-the-fly” so that the existing internal AdcircViz mechanics can be used for SLOSH. Figure 6 shows a Hurricane Ike (2008) maximum water level result from SLOSH within AdcircViz.

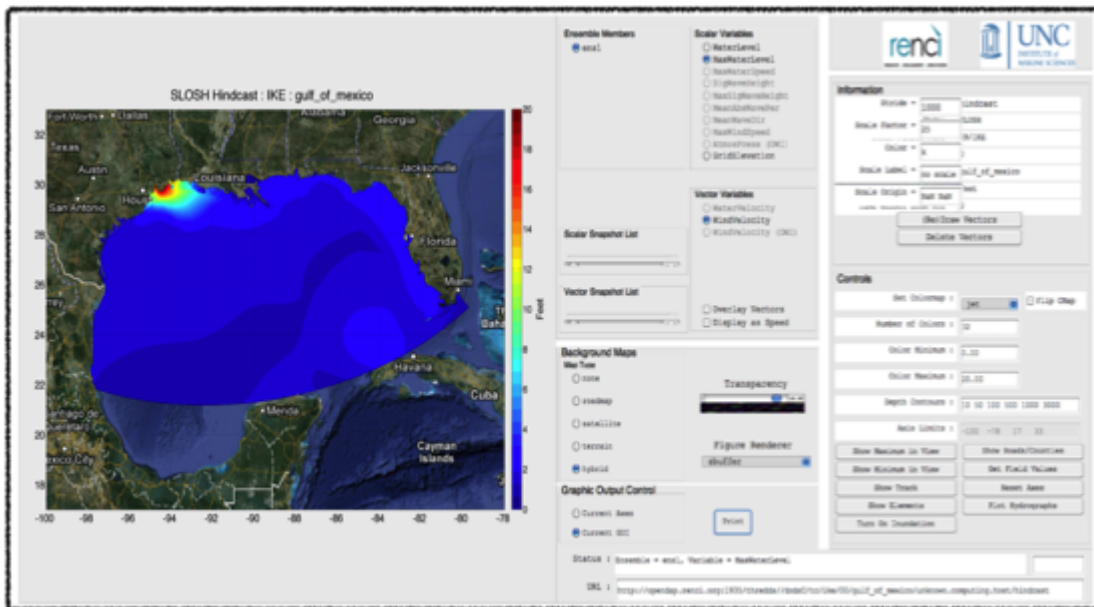


Figure 6: Demonstration visualization of SLOSH output in AdcircViz. A SLOSH Hurricane Ike (2008) simulation from the NOAA IOOS Coastal Ocean Modeling Testbed project was converted to CF-UGRID and posted on a THREDDs server.

URLs referenced above:

AdcircViz GitHub webpage: <http://brianoblanton.github.io/AdcircViz/>

NCTOOLBOX: <http://nctoolbox.github.com/nctoolbox>

RENCI/UNC THREDDs server: <http://opendap.renci.org:1935/thredds>

NOAA/CSDL THREDDs server: <http://coastalmodeldev.data.noaa.gov/thredds>

ESRI GeoPortal: https://geo-ide.noaa.gov/wiki/index.php?title=ESRI_Geoportal