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

Brian Blanton
Renaissance Computing Institute
University of North Carolina at Chapel Hill

Rick Luettich
Institute of Marine Sciences
DHS-Coastal Hazards Center
University of North Carolina at Chapel Hill

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Funded by NOAA Joint Hurricane Testbed (2013) Program

Motivation

Hazards to coastal areas a major concern

- Extreme weather events
- Sea level variability and rise

Critical need for detailed hazard/threat assessment information

Detailed → high spatial resolution

Real-time operational forecast products

Research → operations challenges

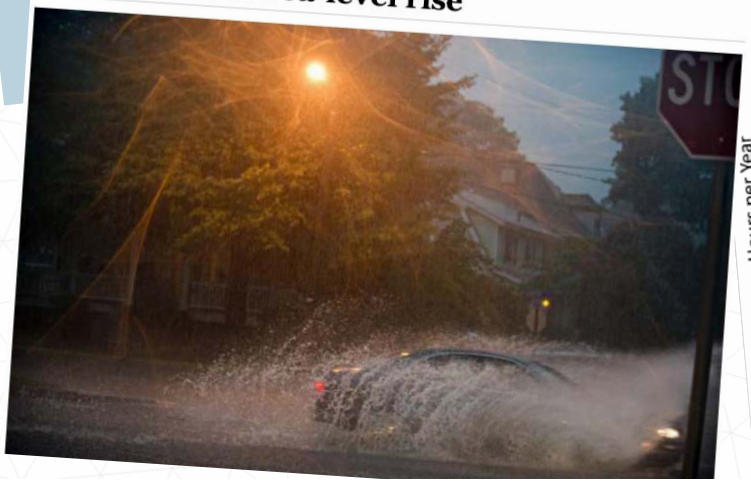

Courtesy: J. Hanson, USACE/FRF/Duck

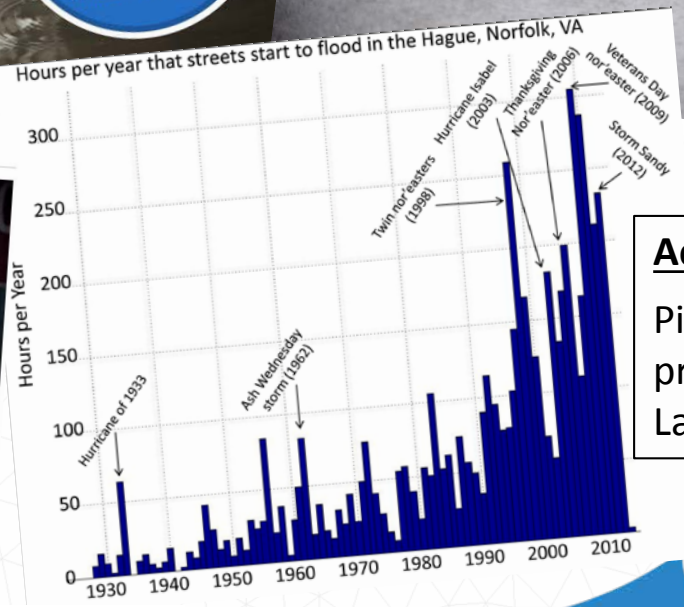

Photo by: Don McClosky

Motivation

Is Coastal Flooding a Problem…….

Built on sinking ground, Norfolk tries to hold back tide amid sea-level rise





GEOPHYSICAL RESEARCH LETTERS, VOL. 39, L19605, doi:10.1029/2012GL053435, 2012

Is sea level rise accelerating in the Chesapeake Bay? A demonstration of a novel new approach for analyzing sea level data

Tal Ezer[1] and William Bryce Corlett[1,2]

Acknowledgement

Pictures lifted from presentation by Larry Atkinson, ODU

Motivation

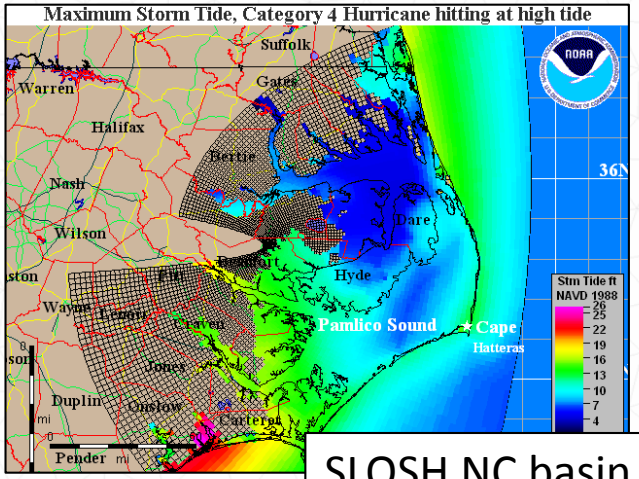
- How can the research community make information more easily available to end-users, decision-makers, planners ...

- And particularly

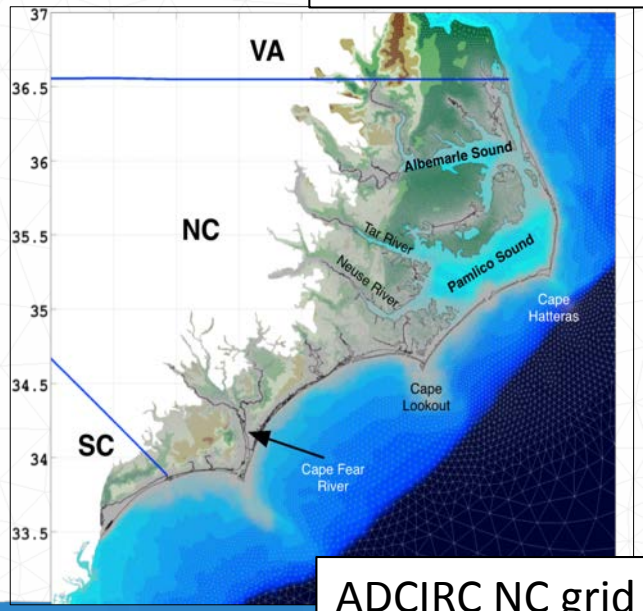
- NHC/SSU Forecasters

Many Storm Surge Tools Used

- GIS
- Statistical models
- Numerical models (Dynamic)
  - SLOSH
    - Operational at NOAA, NHC
    - Curvilinear, orthogonal grid
    - Can run easily on a PC/laptop
    - Ideally suited for rapid ensembles
  - FVCOM, SELFE
  - ADCIRC
    - Research forecasting modes
    - Operational at NCEP
    - Finite element (triangular)
    - Very high spatial resolution
    - Concomitant high computational cost
    - Not suited (yet) for large dynamic ensembles



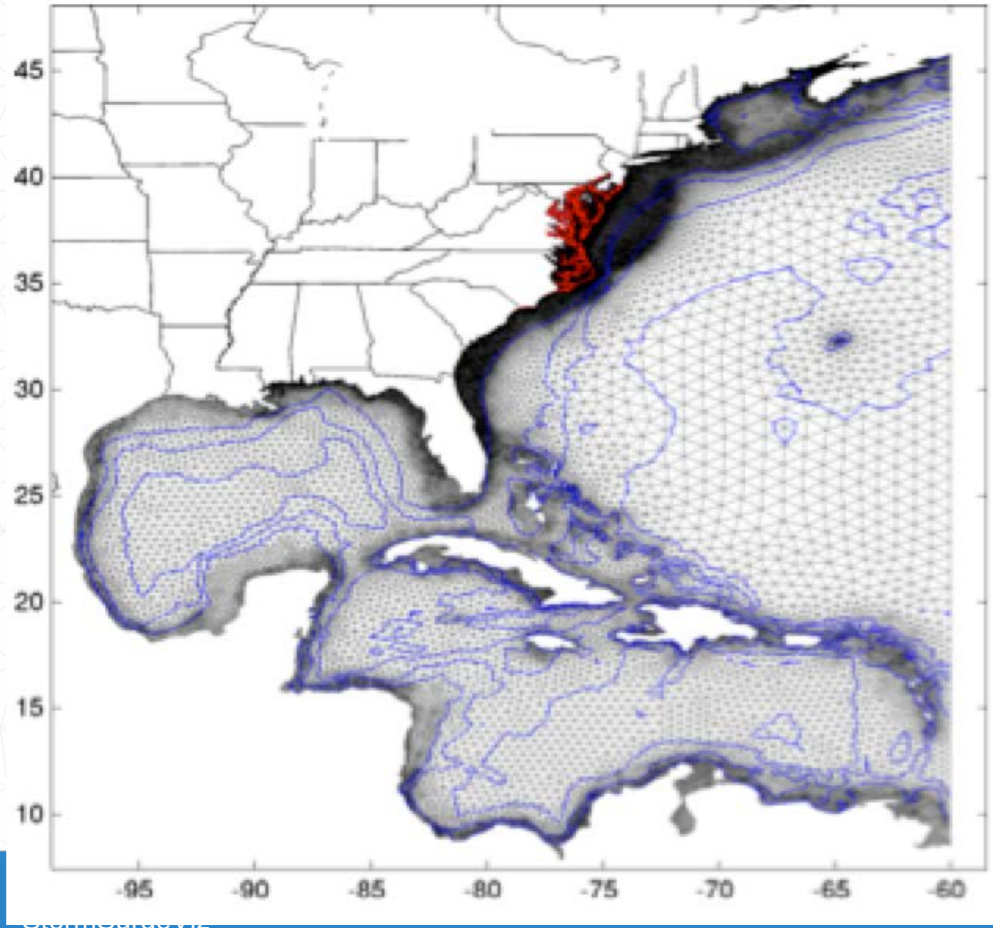
SLOSH NC basin

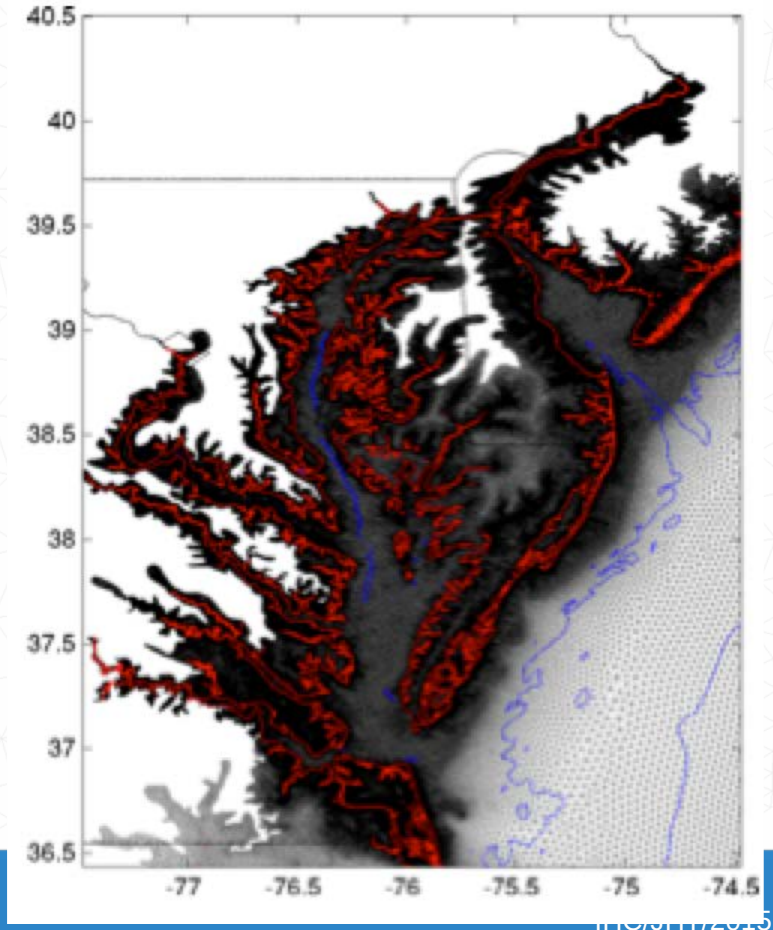


ADCIRC NC grid

ADCIRC (http://www.adcirc.org)

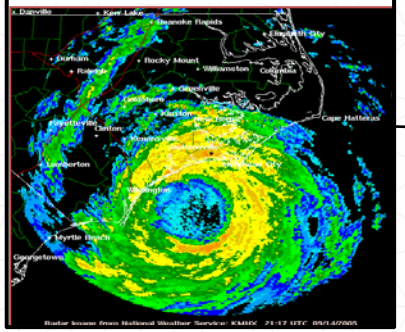
Triangular Finite Elements





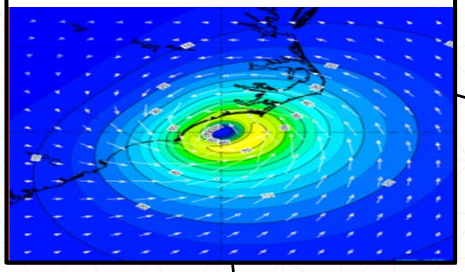
ADCIRC Surge Guidance System (ASGS)

Precipitation

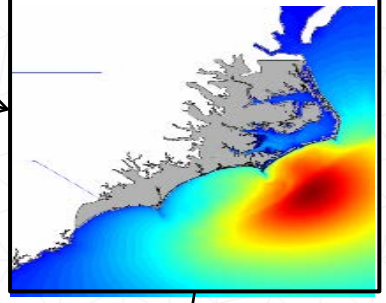


Hydrologic Model

Atmospheric Model



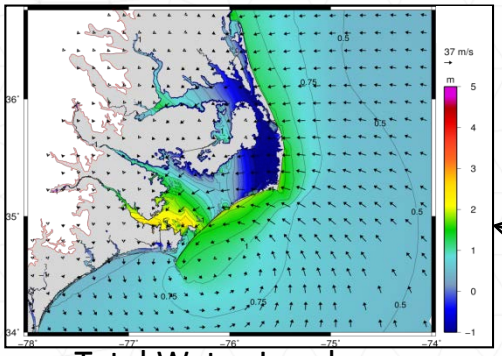
Wave Model



River BCs
Discharge

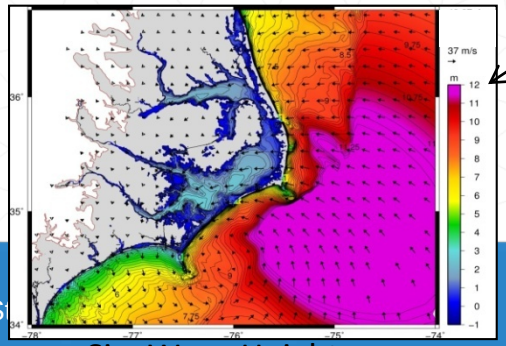
Surface BCs
Pressure
Wind Forcing

Surface BCs
Wave Forcing



Total Water Levels

Hydrodynamic Model (ADCIRC)



Sig. Wave Heights

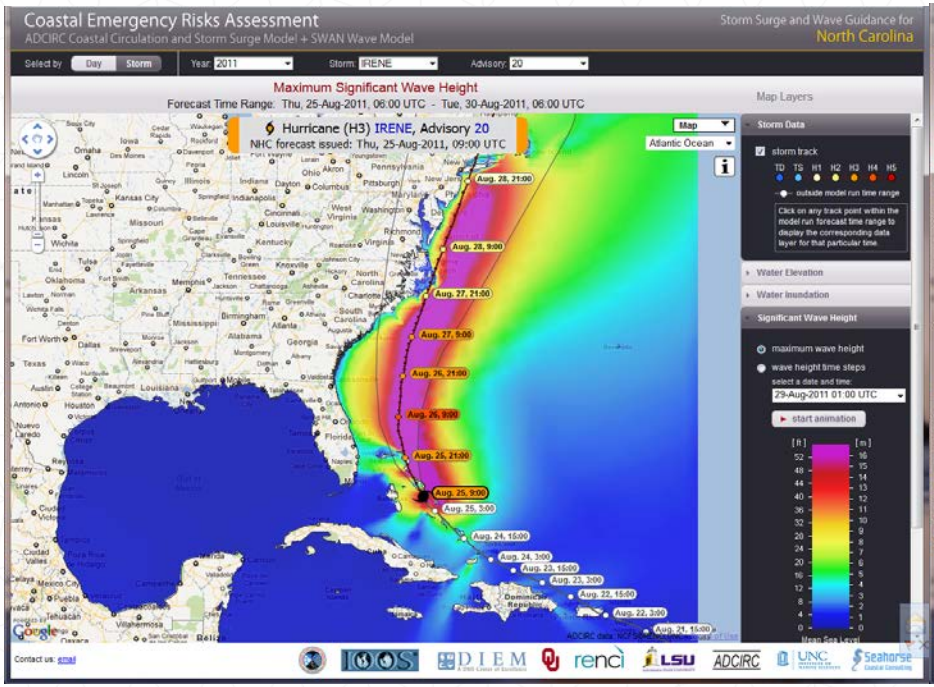
Precipitation Source: QPE/QPF
Atmospheric Model: NAM or NHC track
Hydrologic Model: HL-RDHM
Wave Model: unstructured SWAN

ADCIRC Surge Guidance System (ASGS)

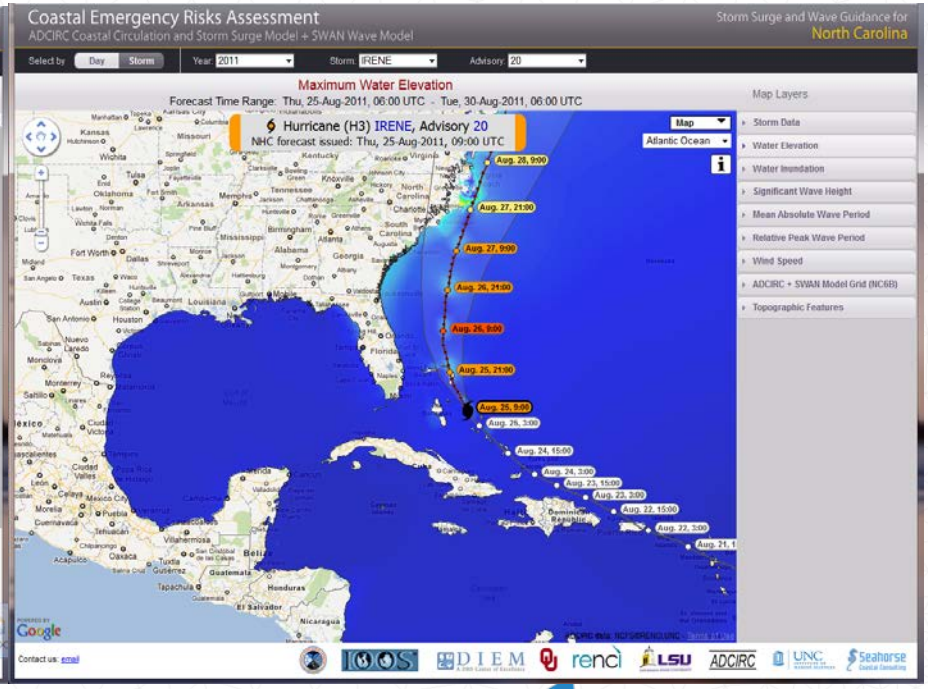
Primary Outputs

http://nc-cera.renci.org

Significant Waves



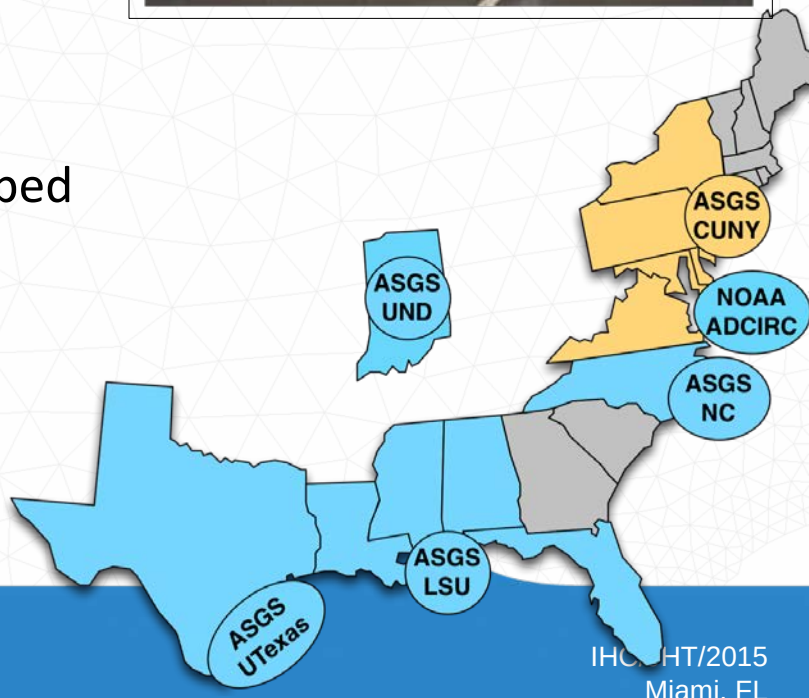
Total Water Level



Hurricane Irene (2011)

Project Purpose

- Enable NOAA/NHC to access and visualize ADCIRC results in a consistent and robust way
  - different ADCIRC-based systems
  - run by different groups
  - on different ADCIRC grids
- Desktop application (MATLAB)
- Leverage community efforts:
  - NOAA IOOS Coastal Ocean Modeling Testbed
- Funded by NOAA's Joint Hurricane Testbed (2013) Program



Year 1

- Delivered AdcircViz to NHC/SSU
- Extended AdcircViz to:
  - wind vectors
  - output of Shapefiles
  - Multiple catalogs
- Moved code to Github for dissemination, documentation, and issue tracking

Standardization

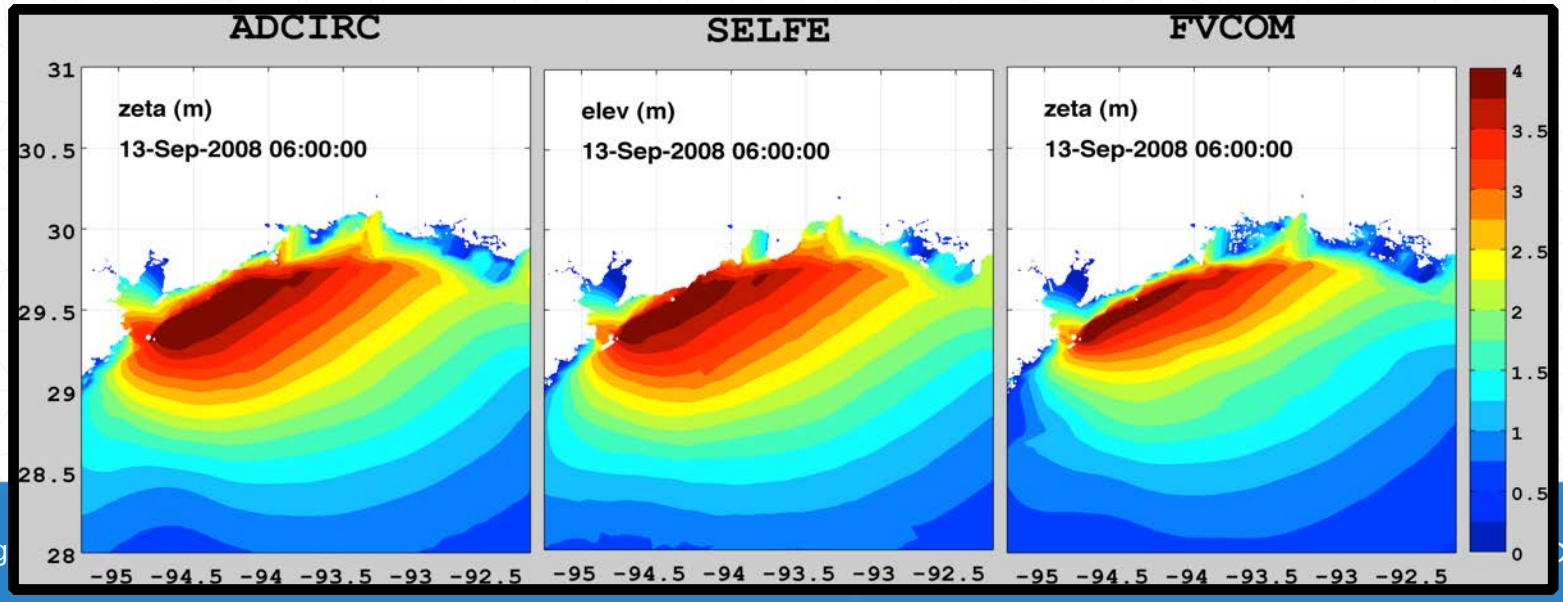
NCTOOLBOX: a MATLAB toolbox that provides access to common data model datasets

- NetCDF-Java as access layer
- NetCDF, OPeNDAP, HDF5, GRIB, GRIB2

Any UGRID-compliant model output can be handled by exactly the same method.

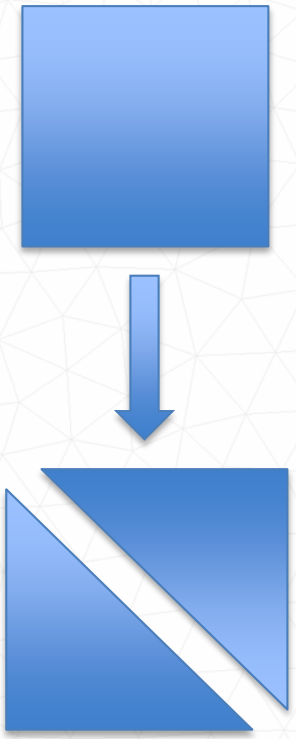
Example from NOAA IOOS Coastal Ocean Modeling Testbed

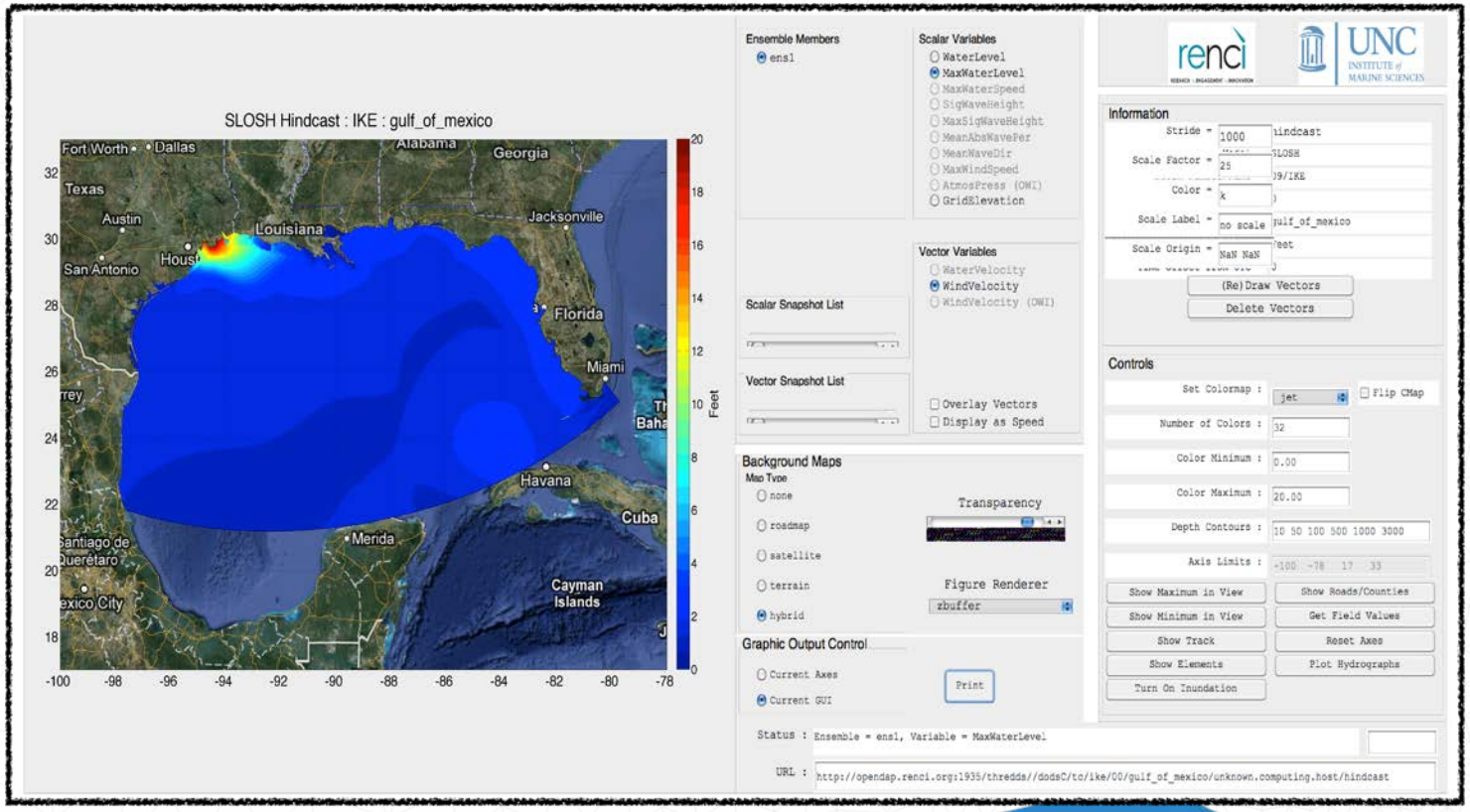
Hurricane Ike Hindcast



SLOSH in AdcircViz

- Any regular-grid can be trivially mapped to CF-UGRID
- Makes available all of the existing finite element analysis tools



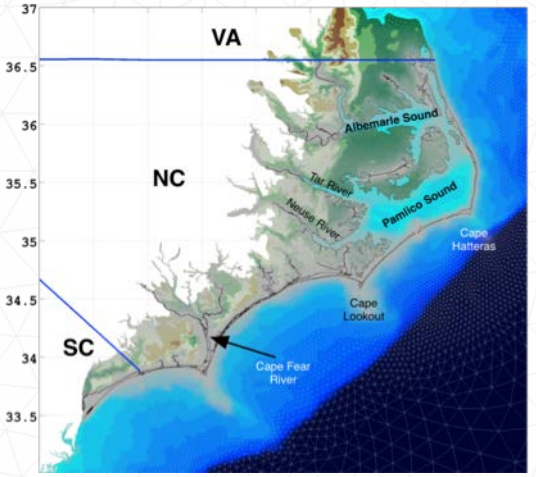


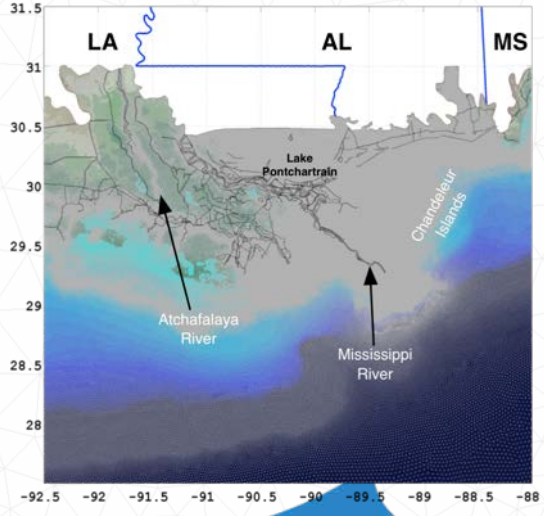
AdcircViz Requirements

- Application needs to:
  - Provide unified view of operating ADCIRC forecast system outputs
  - Allow user-driven data analysis
  - Allow user control of visualization
  - Minimize data transfers

- ***<u>Embrace many models by requiring conformance to community standards and conventions</u>***

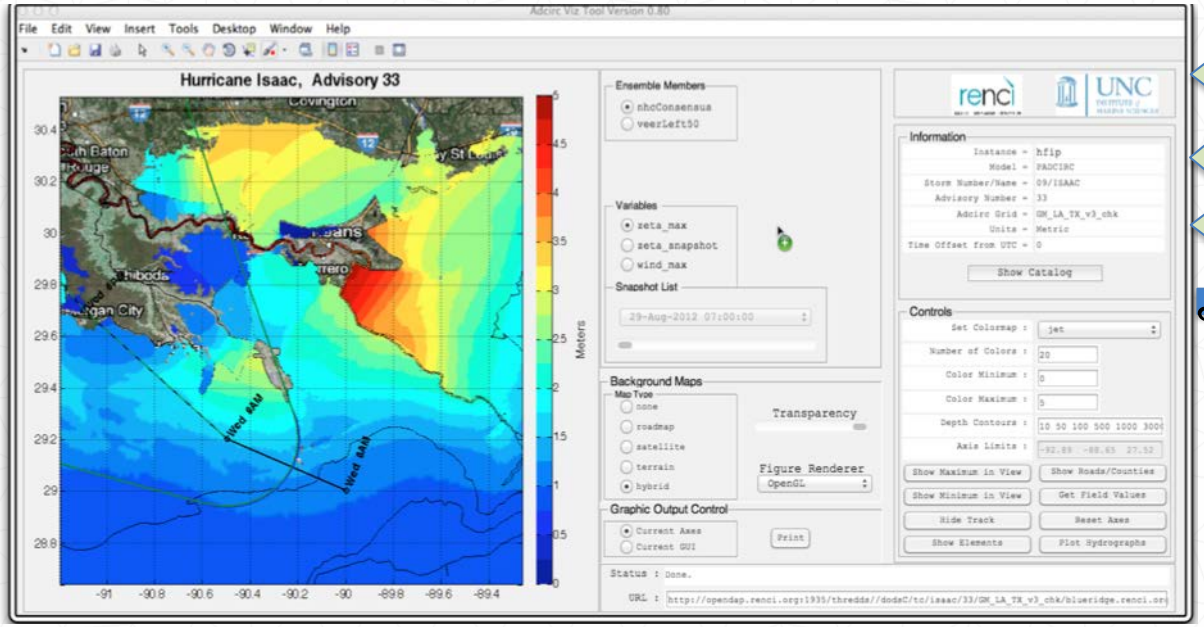
- FVCOM, SELFE
- ADCIRC
- SLOSH

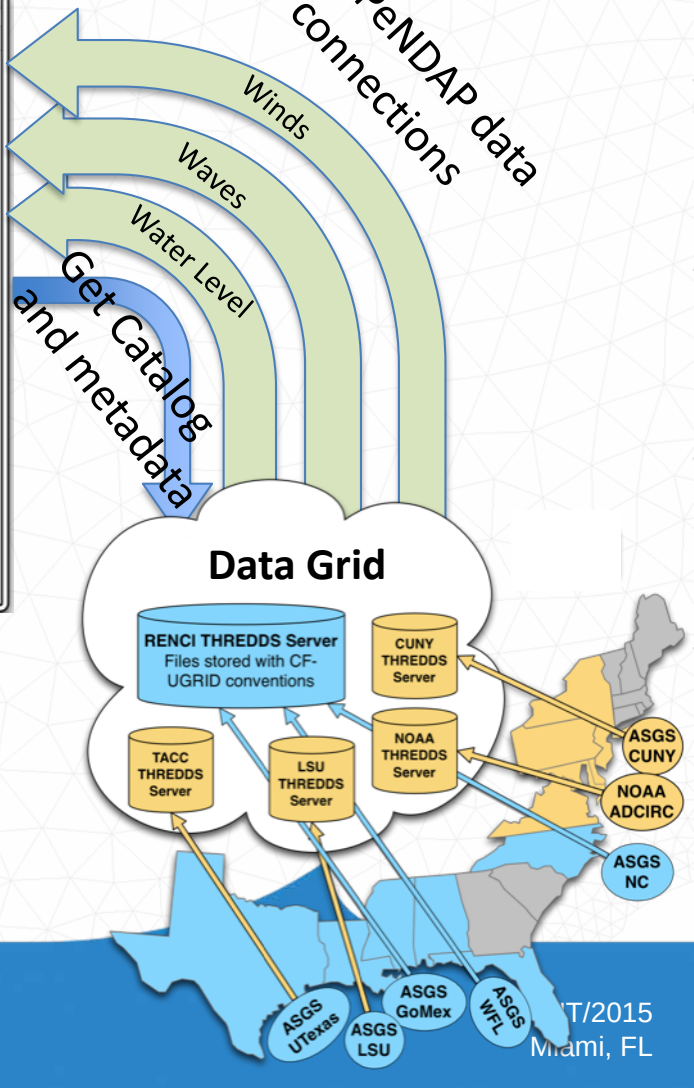




AdcircViz App

Hurricane Isaac (2011)





MATLAB GUI populated by metadata in netCDF files

OPeNDAP, netCDF-Java

Only accesses data as it is needed

Year 1 (2014) Field Tests

- Hurricane Arthur
  - North Carolina impacts (small)
  - AdcircViz used by researchers (us) to monitor forecast system activity
- Hurricane Gonzalo
  - Impacted Bermuda
  - Used to test AdcircViz at NHC/SSU
  - Application responsiveness considered too slow for operational/real-time use

Year 2 Activities

- Shift focus to provide a mechanism for other models (not just UGRID/ADCIRC) to be accessed/viz'd in a consistent manner
- Develop ***community onboarding process***
  - Extension of existing data dissemination methods to include gridded/regular model output
  - "Build it and they will come"
- Renamed application StormSurgeViz

Year 2 Activities

- Extend StormSurgeViz to gridded models
- SLOSH, ROMS, sEcom, CEST (from FIU)
- Still requires netCDF/CF/THREDDS compliance
- Variables (e.g., water level) must be described identically (via CF conventions)

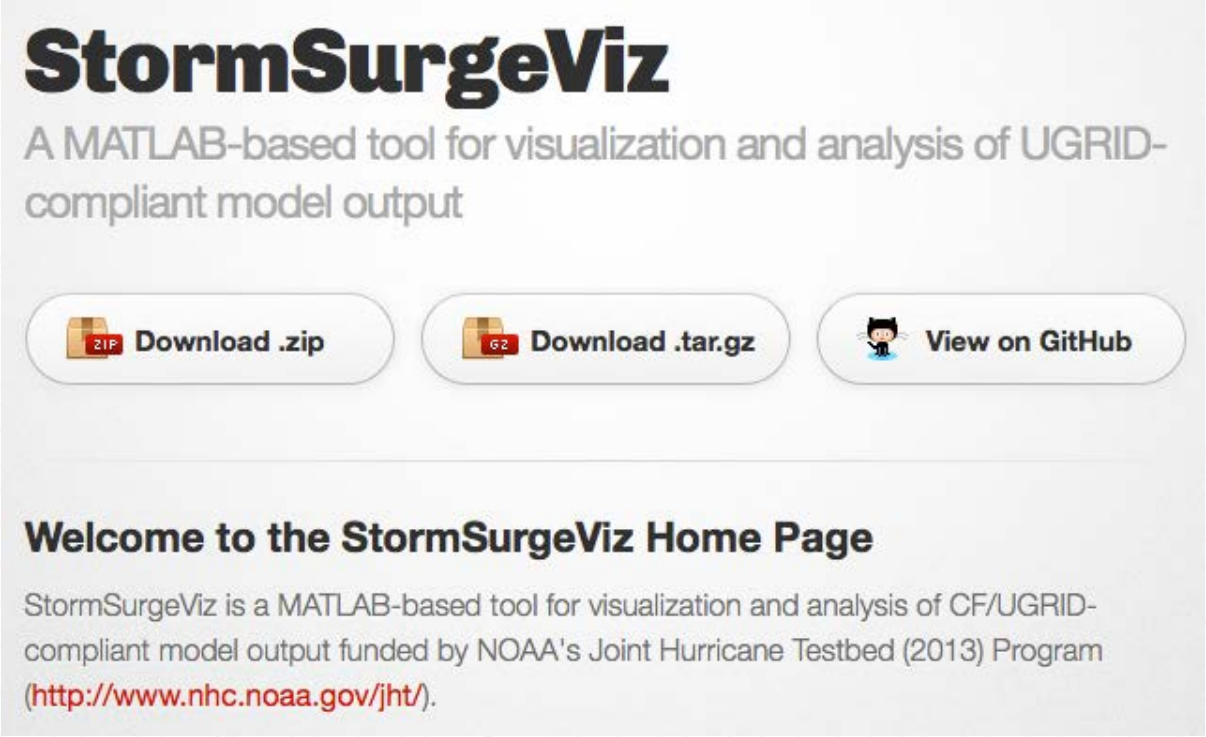
Community Onboarding Process

- Onboarding is a ***protocol*** for broad participation
- A concrete set of How-To steps to follow
- Expressed in documentation
  - More extensive than end-user documentation
  - But inclusive of end-user documentation

3 Main Steps:

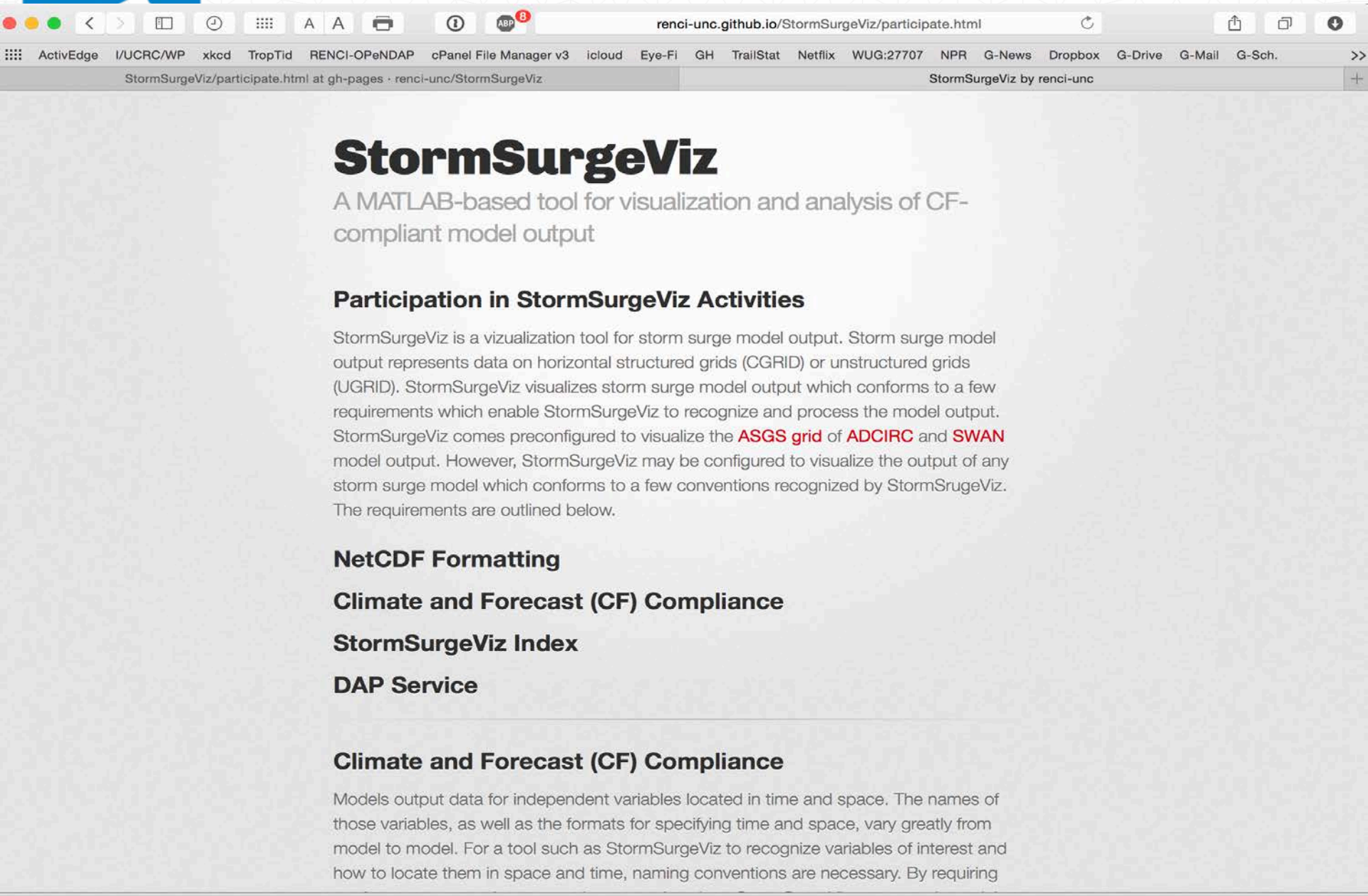
FORMAT	Package model output in NetCDF format
METADATA	Make model output CF-compliant (for both CGRID and UGRID data)
DISSEMINATION	Publish model output to known data server (THREDDS or HYRAX) Specified file and directory structure

Community Onboarding Process



http://renci-unc.github.io/StormSurgeViz/

Community Onboarding Process


renci-unc.github.io/StormSurgeViz/participate.html

ActivEdge I/UCRC/WP xkcd TropTid RENCI-OPeNDAP cPanel File Manager v3 icloud Eye-Fi GH TrailStat Netflix WUG:27707 NPR G-News Dropbox G-Drive G-Mail G-Sch.

StormSurgeViz/participate.html at gh-pages · renci-unc/StormSurgeViz

StormSurgeViz by renci-unc

StormSurgeViz

A MATLAB-based tool for visualization and analysis of CF-compliant model output

Participation in StormSurgeViz Activities

StormSurgeViz is a vizualization tool for storm surge model output. Storm surge model output represents data on horizontal structured grids (CGRID) or unstructured grids (UGRID). StormSurgeViz visualizes storm surge model output which conforms to a few requirements which enable StormSurgeViz to recognize and process the model output. StormSurgeViz comes preconfigured to visualize the ASGS grid of ADCIRC and SWAN model output. However, StormSurgeViz may be configured to visualize the output of any storm surge model which conforms to a few conventions recognized by StormSrugeViz. The requirements are outlined below.

NetCDF Formatting

Climate and Forecast (CF) Compliance

StormSurgeViz Index

DAP Service

Climate and Forecast (CF) Compliance

Models output data for independent variables located in time and space. The names of those variables, as well as the formats for specifying time and space, vary greatly from model to model. For a tool such as StormSurgeViz to recognize variables of interest and how to locate them in space and time, naming conventions are necessary. By requiring

Immediate next steps

- Delivery of onboarding documents by end of next week (13 Mar)
- Test onboarding procedure with some other model/group
- Evaluate effectiveness/utility to NHC/SSU

Final Thoughts

- ***Despite challenges with very high-resolution models like ADCIRC,***
  - Still think ~~AdcircViz~~ StormSurgeViz can provide value to NHC/SSU
  - Assuming, of course, other groups will embrace the onboarding concept and contribute model outputs to the "data grid"

- ***Standards enable innovation***
  - Community standards and conventions are essential for "unifying" distributed efforts
  - Community standards exist ... So USE them!

- ***Funded by NOAA's Joint Hurricane Testbed (2013) Program***

Thank you very much