CI-FLOW Project

Coastal & Inland FLooding Observation & Warning

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University of Oklahoma, Norman, OK

and CI-FLOW Partners

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Origin of the CI-FLOW Project

Initiated in response to Hurricanes Dennis & Floyd in Sep 1999

- Antecedent rainfall from Dennis saturated the soils
- Extreme rainfall from Floyd caused widespread flooding and flash flooding
- Storm surge moved water up rivers

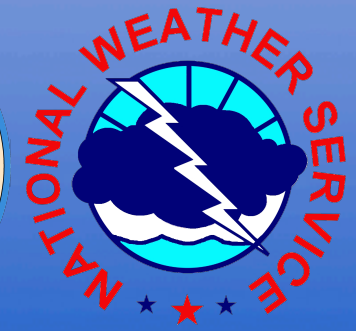
History of the CI-FLOW Project

2000: NOAA OAR & National Sea Grant Meeting

- Increase collaboration between Sea Grant Extension Network & OAR research labs
- Established Inland FLOod Warning (IFLOW) Project to force OU hydrologic model with NSSL precipitation estimates

2001: NCSU joins IFLOW

- Coupled hydrologic model forced with NSSL precipitation estimates to NCSU coastal & estuary model



History of the CI-FLOW Project

2006: IFLOW becomes CI-FLOW

- Sea Grant Liaison established at OU CIMMS/ NSSL

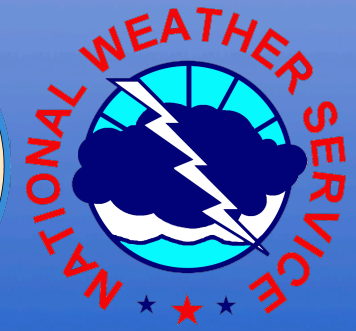
2007: OU & UNC researchers join CI-FLOW

- ADCIRC grid extended up rivers

2009: Hurricane Isabel test case conducted

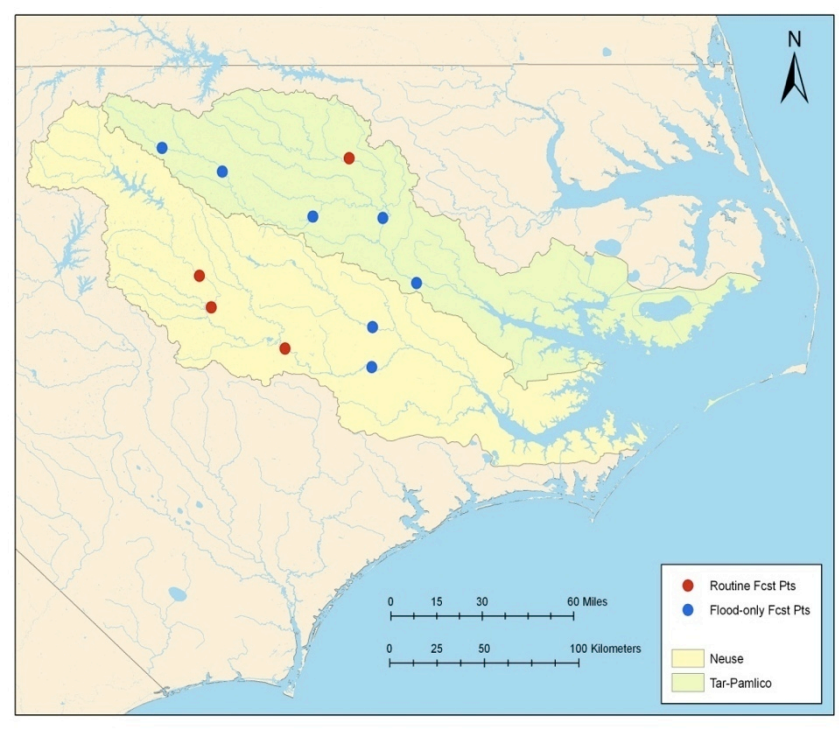
2010: Hurricane Earl is first real-time test

2011: Hurricane Irene is first robust test



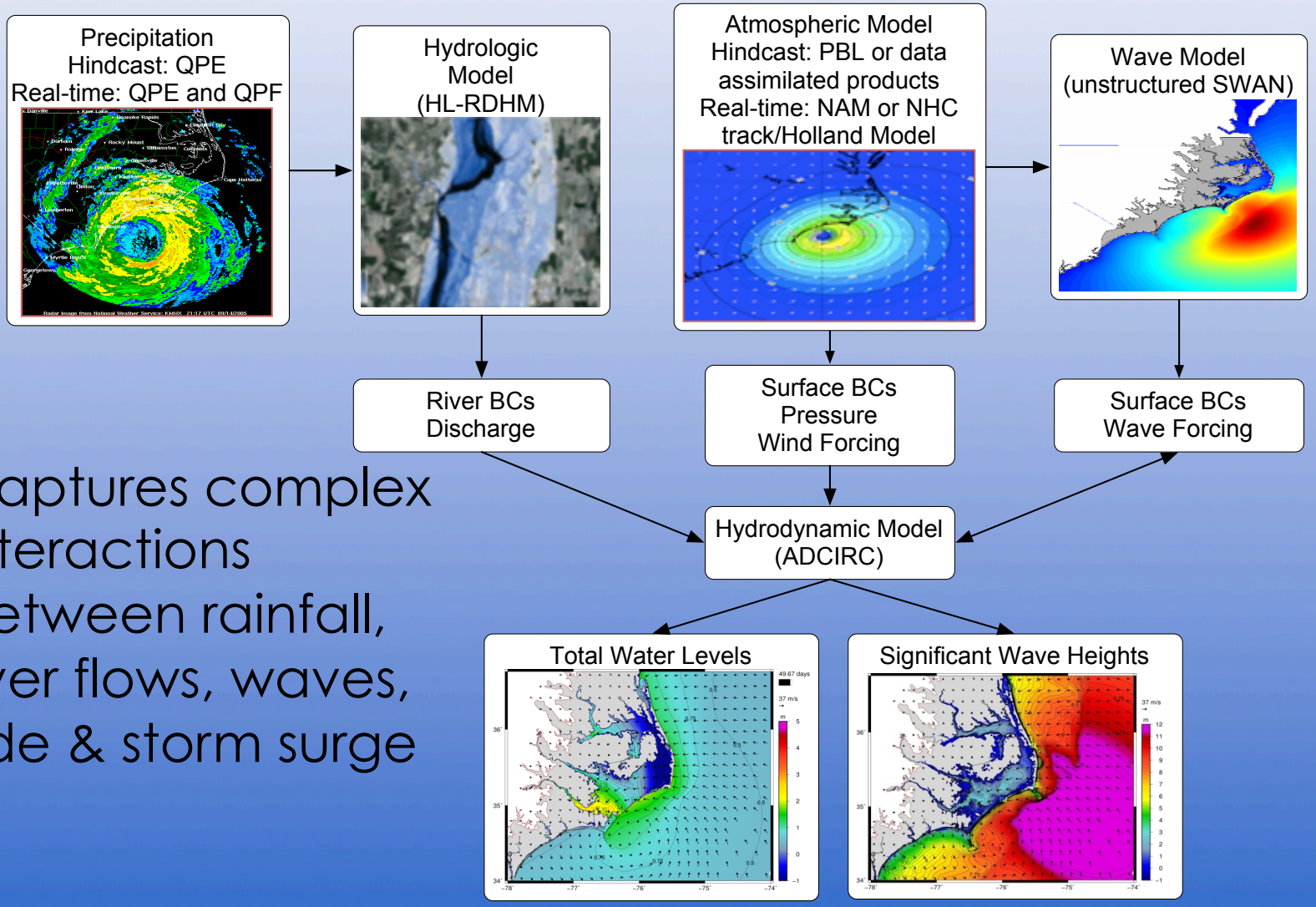
CI-FLOW Goal: Predict total water level for areas not currently served by NWS

NWS Forecast Points



CI-FLOW Forecast Points

CI-FLOW System



Captures complex interactions between rainfall, river flows, waves, tide & storm surge

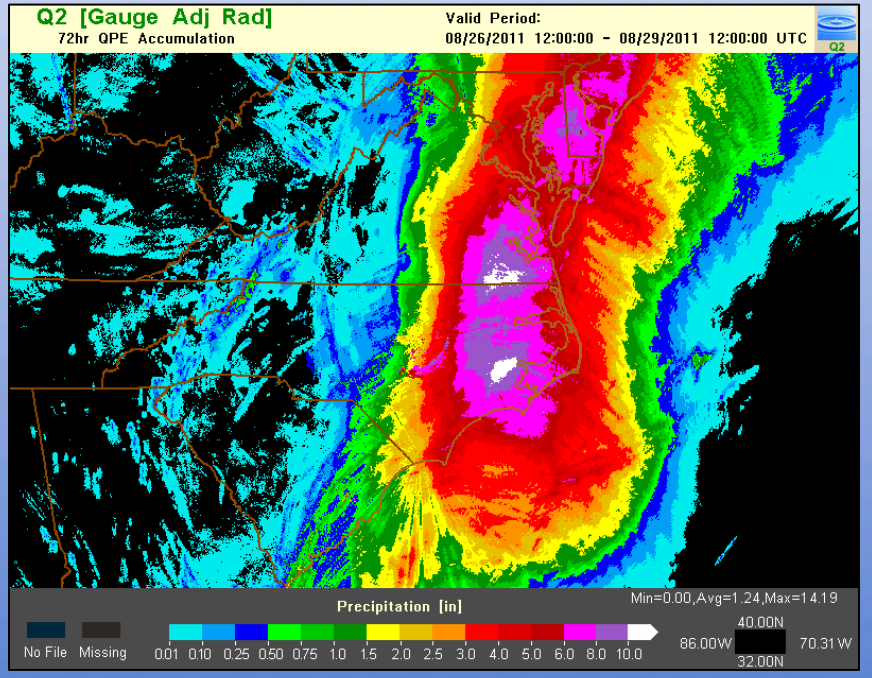
CI-FLOW Precipitation

Past rainfall: NSSL's Next Generation QPE (Q3)

- Best practices of OHD's Multi-sensor QPE & NSSL's Multi-Radar/Multi-sensor System (MRMS)
- Gauge-adjusted 1-hr accumulation

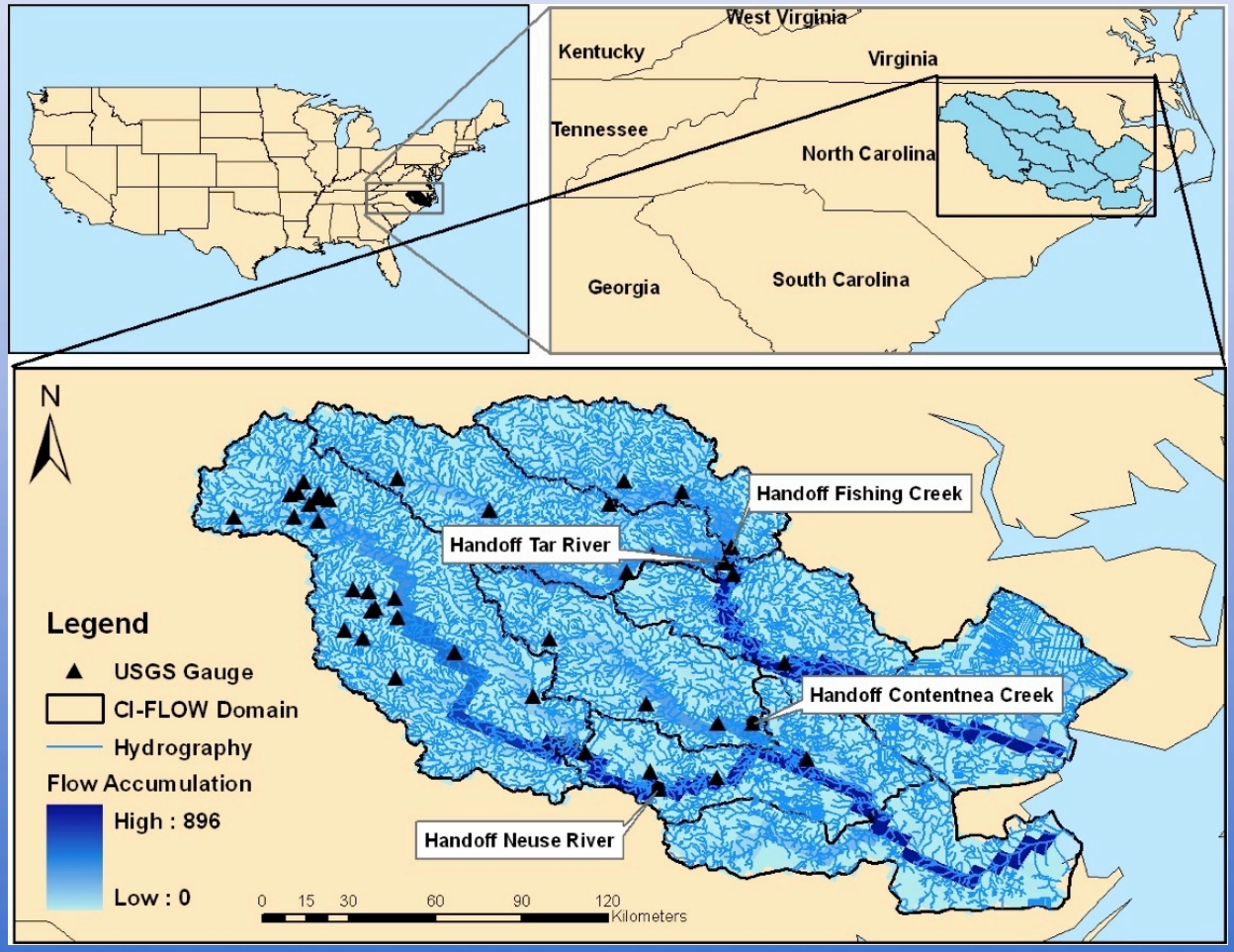
Future rainfall: WPC QPF

- 6-hour accumulation
- Day 1 & Day 2 only



http://nmq.ou.edu

CI-FLOW Hydrologic Modeling



CI-FLOW Hydrologic Modeling

- NWS Hydrology Laboratory – Research Distributed Hydrologic Model (HL-RDHM)
- Hybrid conceptual-physical distributed watershed model:
  - Sacramento Soil Moisture Accounting model (SAC-SMA)
  - Kinematic wave model for routing
  - 4-km HRAP grid
- Runs every 6 hours
- 2-day hindcast/spin-up, 5-day forecast

CI-FLOW
Hydrologic Model Ensemble

1. "Event-based" parameter set (Isabel) x 16 rainfall multipliers (0.8-1.2, uniformly distributed)
2. "Automatic" parameter set x 16 rainfall multipliers
3. Multiple basin scale parameter set x 16 rainfall multipliers
4. A-priori model (uncalibrated) x 5 rainfall multiplier x 16 channel routing perturbations = 80

Total Number of Members = 16x3 + 80 = 128

Ensemble mean at hand-off points passed to surge model

CI-FLOW Storm Surge Model

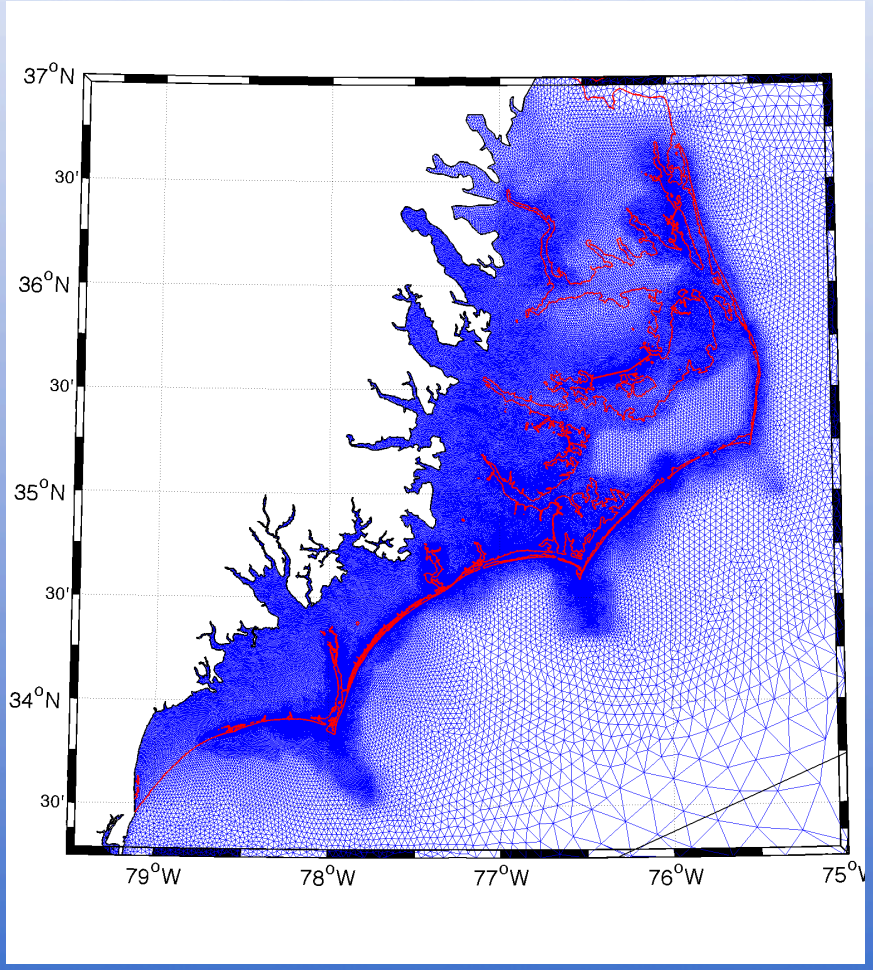
ADvanced CIRCulation + Simulating WAves Nearshore

- 2-D ADCIRC
  - River input (unit flux boundary condition) at 4 hand-off points (highest anticipated surge; Floyd; 8 m)
  - Tides & tidal potential
  - Wind waves
  - Wetting/drying of elements
- Winds
  - Tropical Mode: Asymmetric Vortex Wind Model uses official track, forward speed, radius to maximum winds, central pressure, etc. from NHC advisories
  - All other times: NAM model

CI-FLOW Storm Surge Model

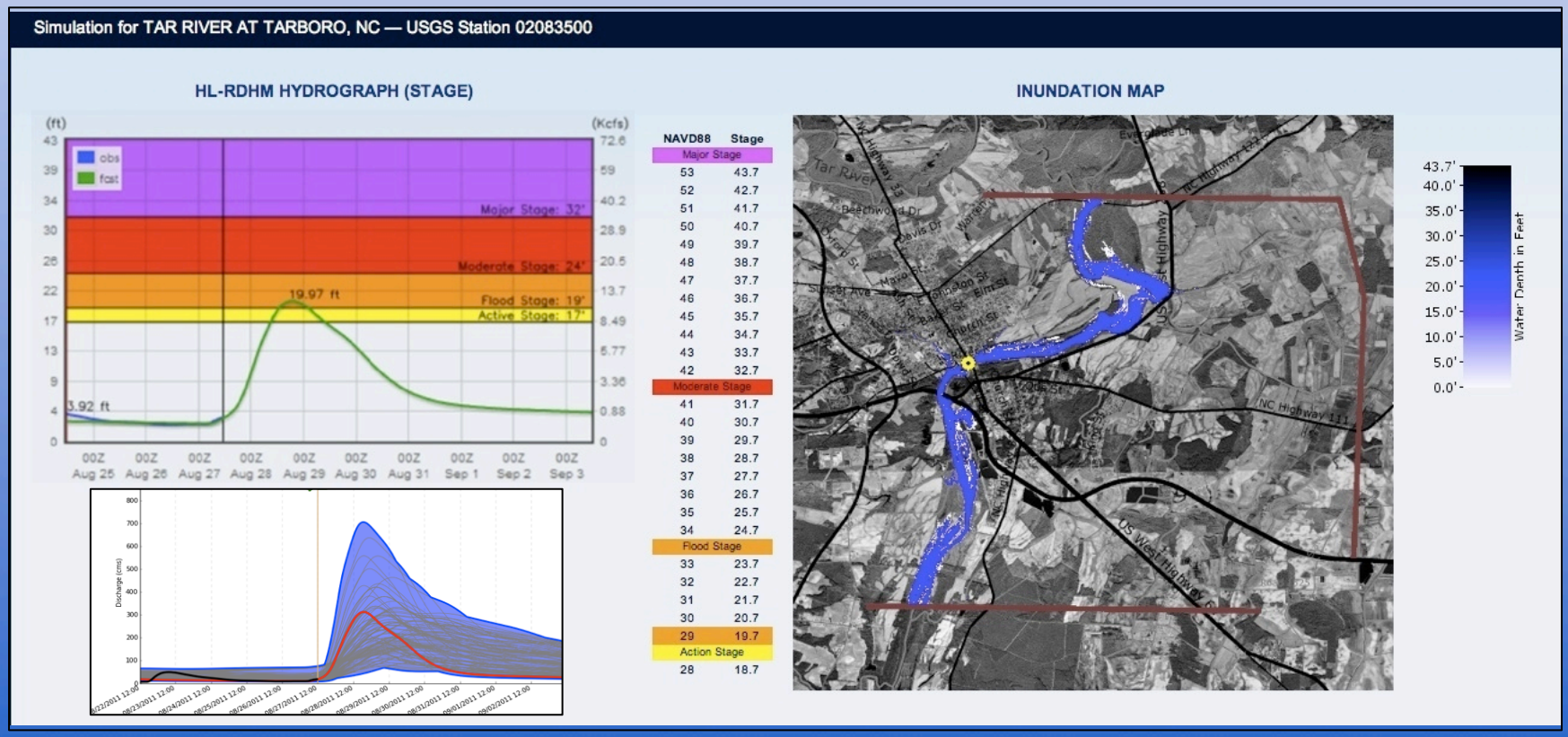
ADvanced CIRCulation + Simulating WAves Nearshore

- Unstructured finite element grid for ADCIRC +SWAN
- High resolution for the Tar & Neuse Rivers, Outer Banks, & Pamlico Sound (30-60 m)
- Runs every 6 hours
- Single deterministic forecast
- 295,328 nodes
- Tropical: 5-day forecast (1.5 hr, 192 processors)
- NAM: 3.5-day forecast (1.25 hr, 372 processors)



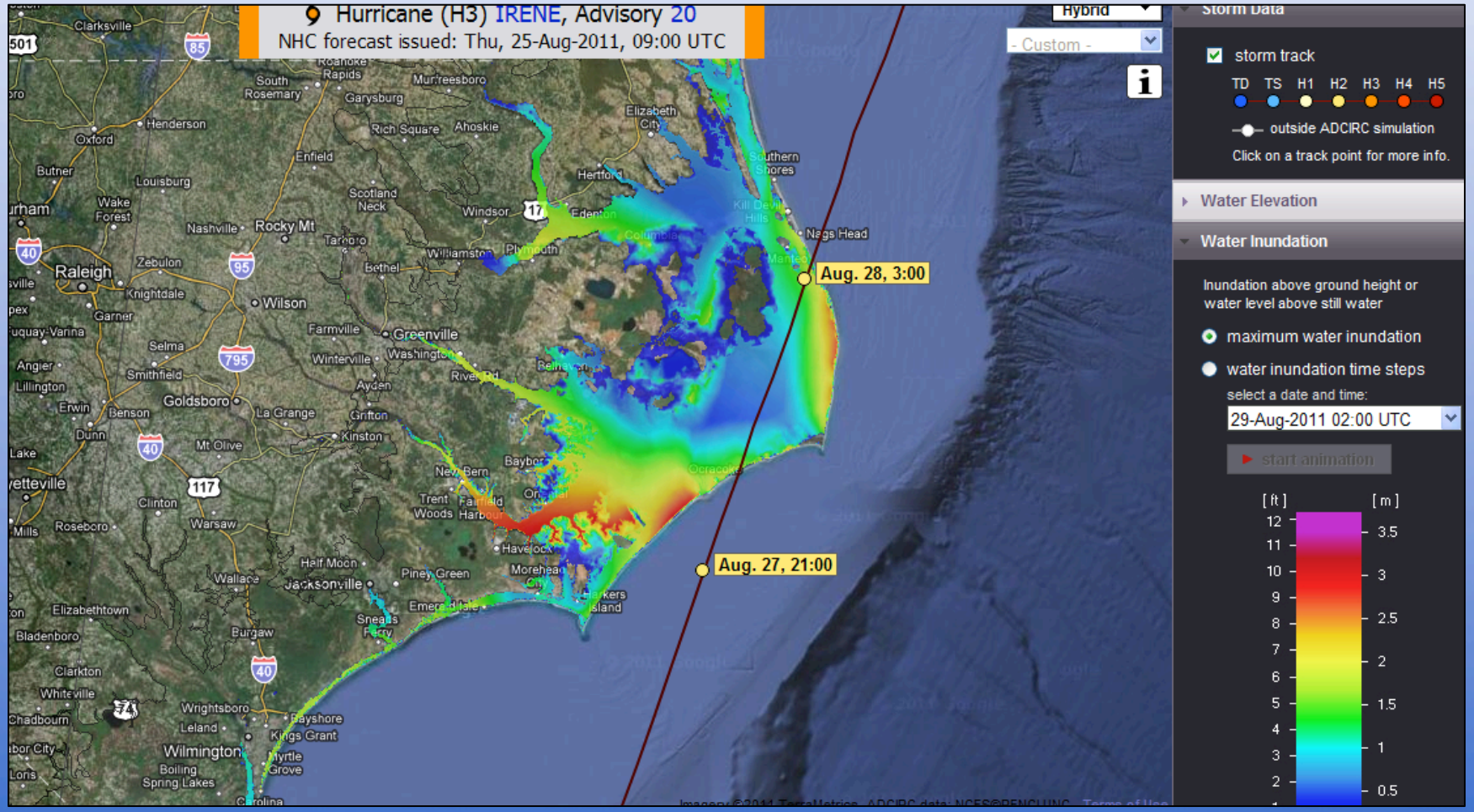
Distribution of Information

https://secure.nssl.noaa.gov/projects/ciflow/
http://www.nowcoast.noaa.gov/ciflow/
NOAA LDAP login



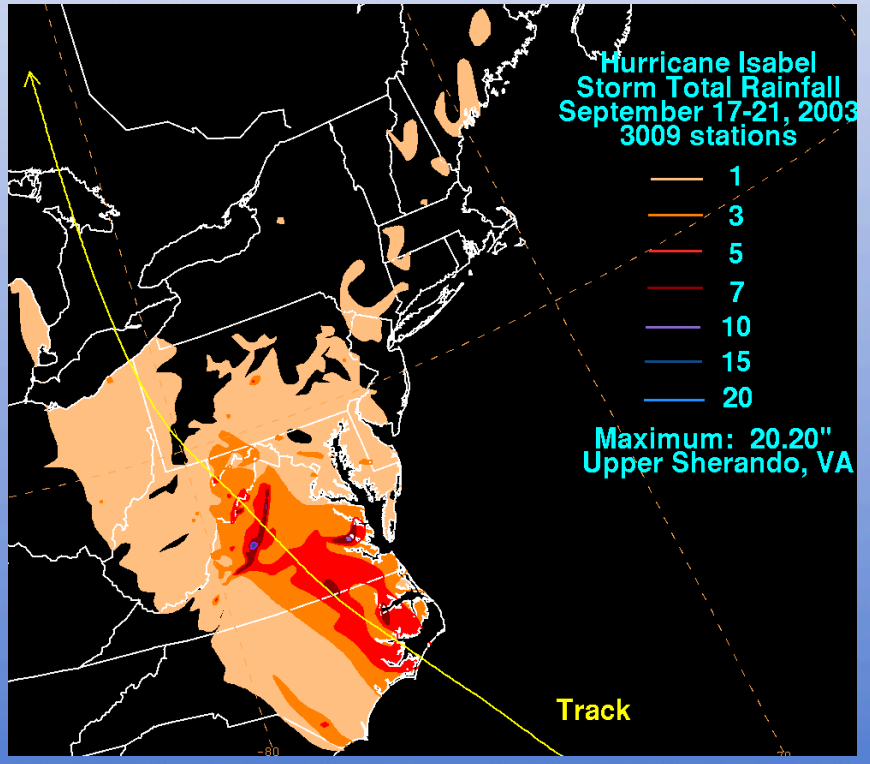
Coastal Emergency Risks Assessment

http://coastalemergency.org



Hurricane Isabel

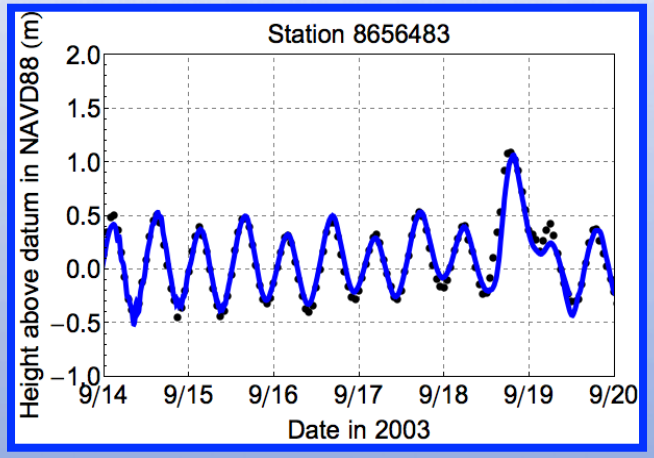
- Peaked as Cat 5 hurricane
- Cat 2 hurricane at landfall near Drum Inlet, NC on 18 Sep 2003
- 4-7 in rainfall in eastern NC
- Storm surge of 6-10 ft within the western parts of Pamlico Sound
- 16 deaths in the US

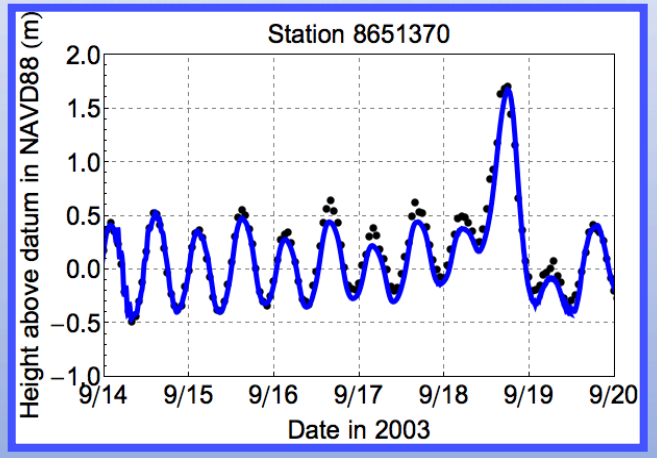


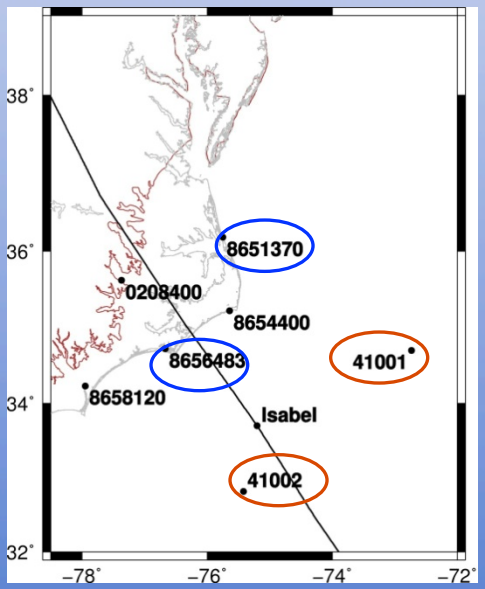
Source: NOAA/NWS/NCEP HPC and NHC

Hurricane Isabel Hindcast

Storm surge results (ADCIRC) compared to field data

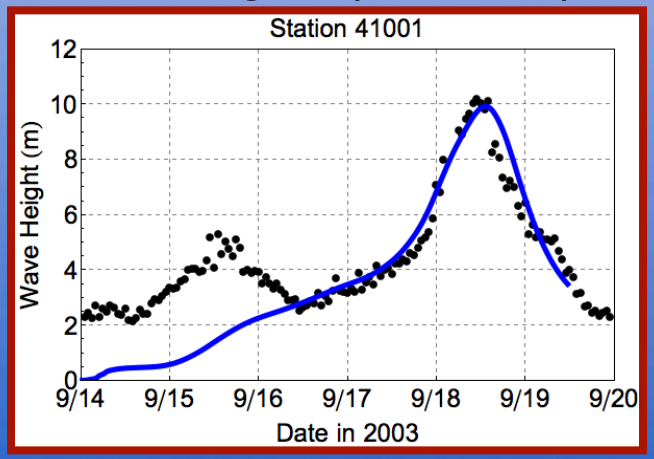


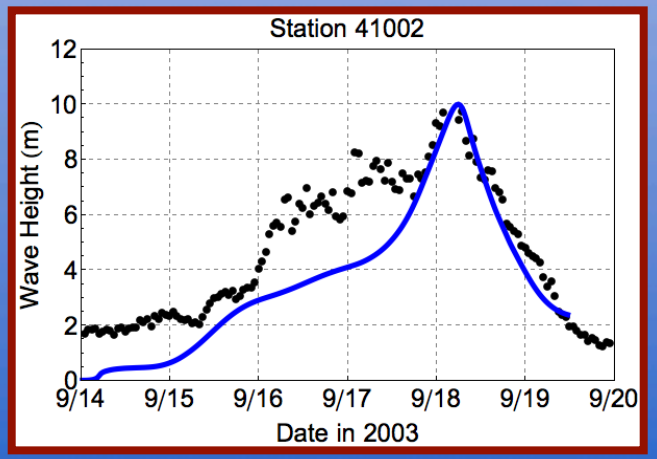




Dots - field data
Blue lines – ADCIRC or unSWAN

Wave heights (unSWAN) compared to field data

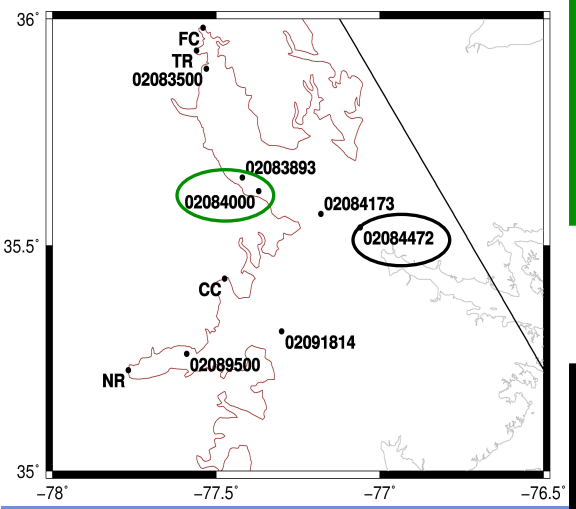


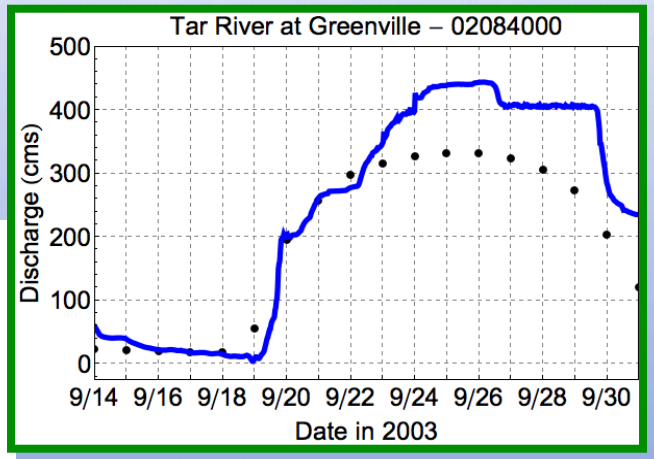


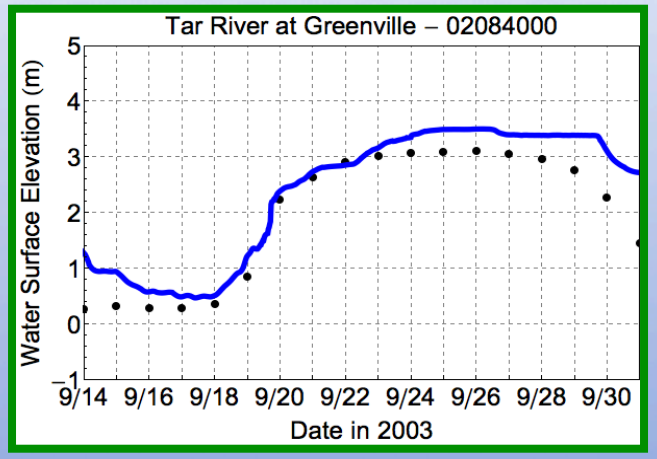
Source: Van Cooten et al. 2011

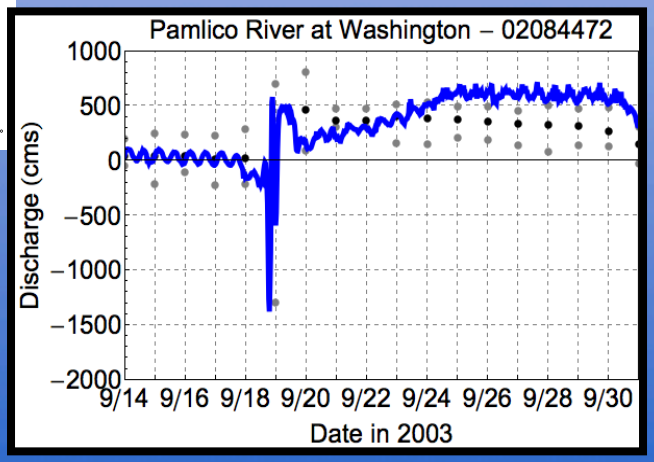
Hurricane Isabel Hindcast

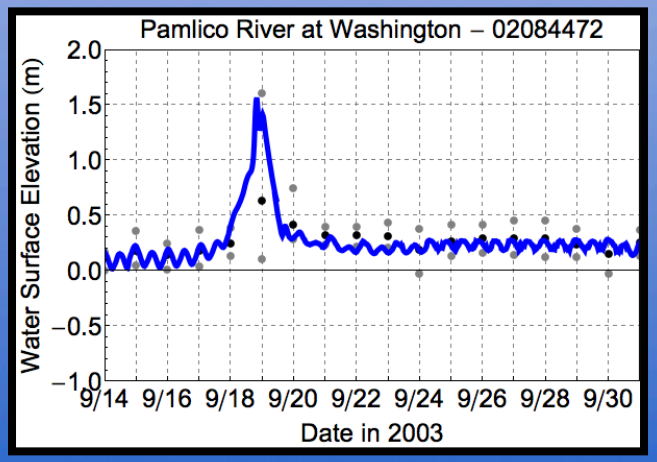
River results (ADCIRC) compared to field data









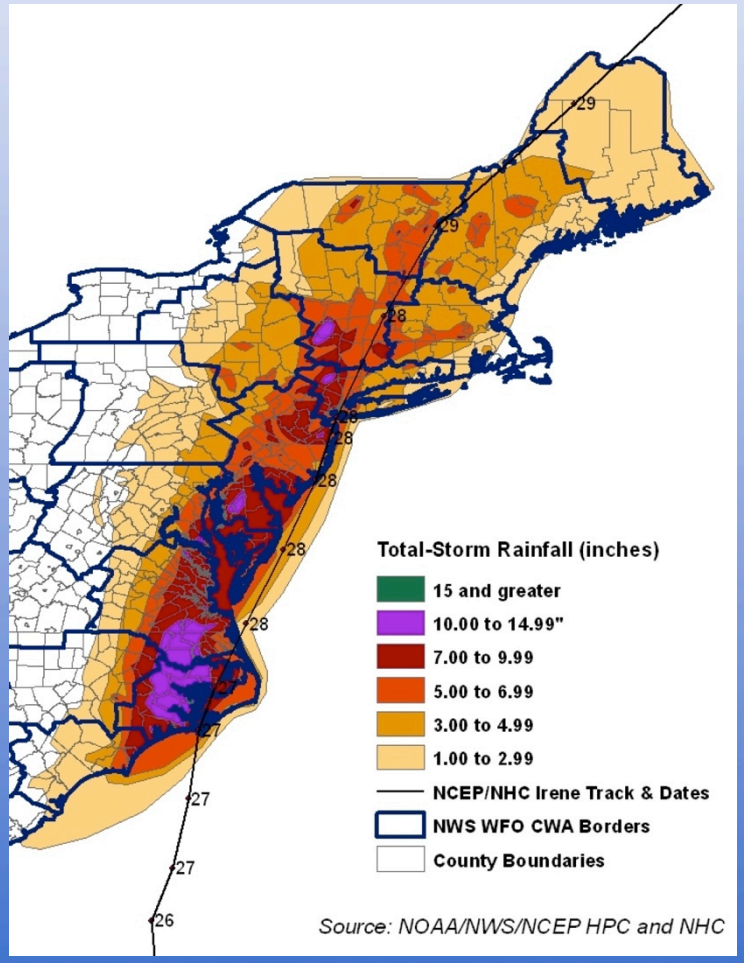


Dots - field data
Gray Dots – max/ min
Lines – ADCIRC

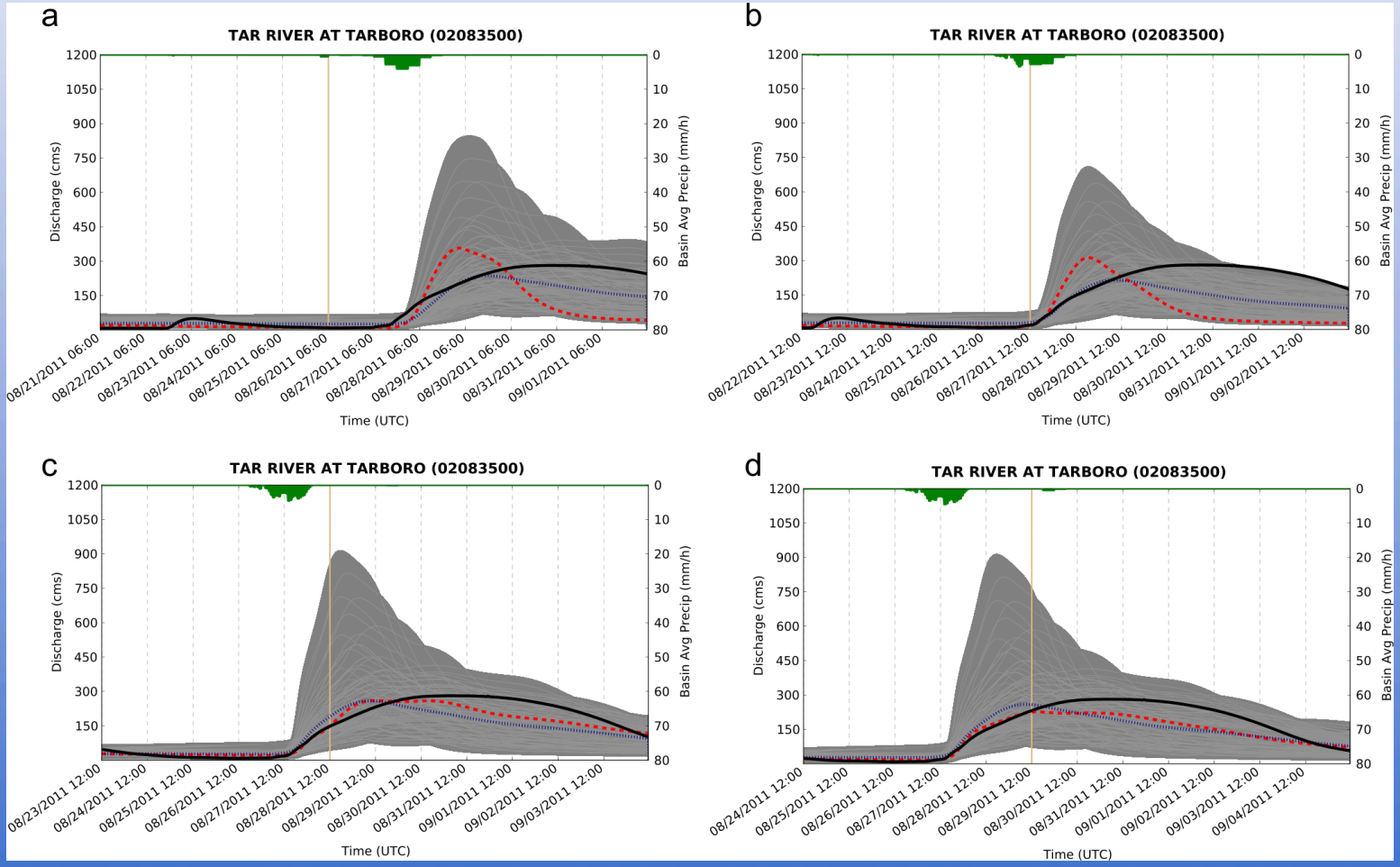
Source: Van Cooten et al. 2011

Hurricane Irene

- Peaked as Cat 3 hurricane
- Cat 1 hurricane at landfall near Cape Lookout, NC on 27 Aug 2011
- 15.74 in rainfall in Bayboro, NC
- Storm surge of 8-11 ft within portions of Pamlico Sound
- 41 deaths in the US; 21 due to rainfall-induced floods

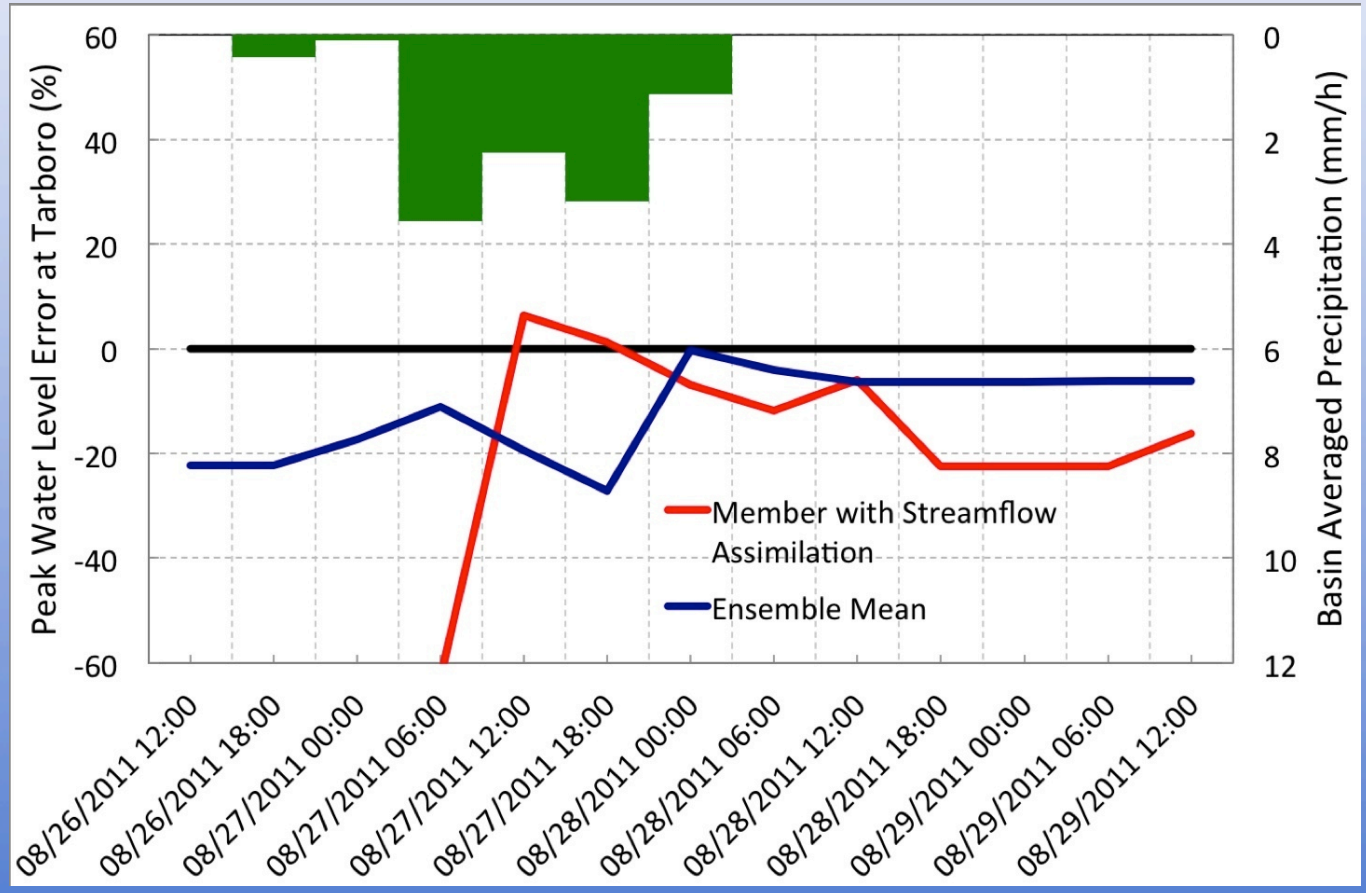


Hurricane Irene – Streamflow



Source: Dresback et al. 2013

Hurricane Irene – Water Level

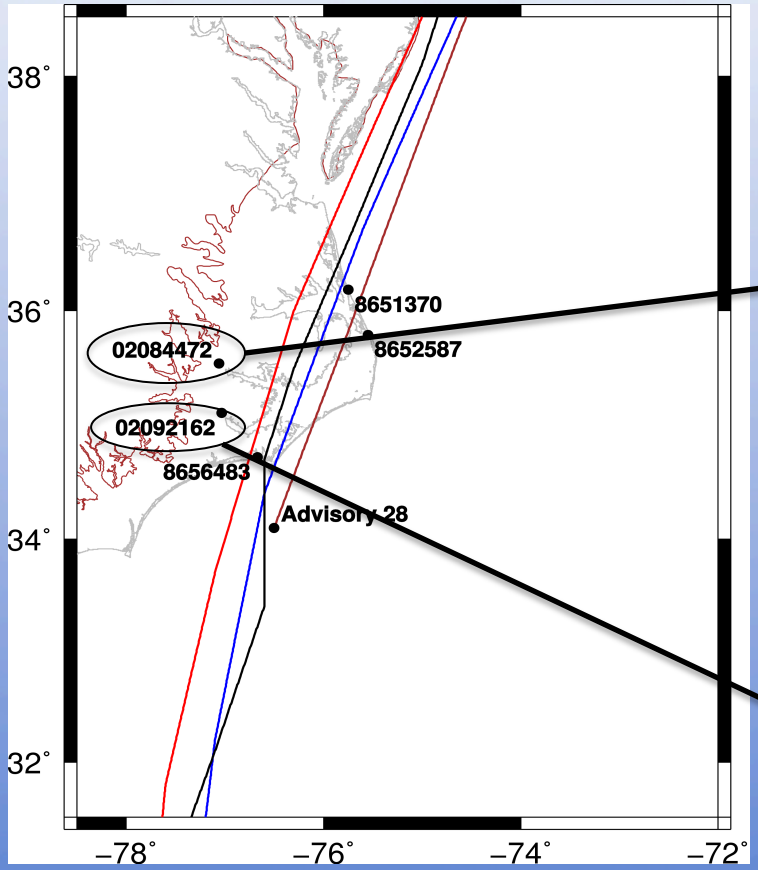


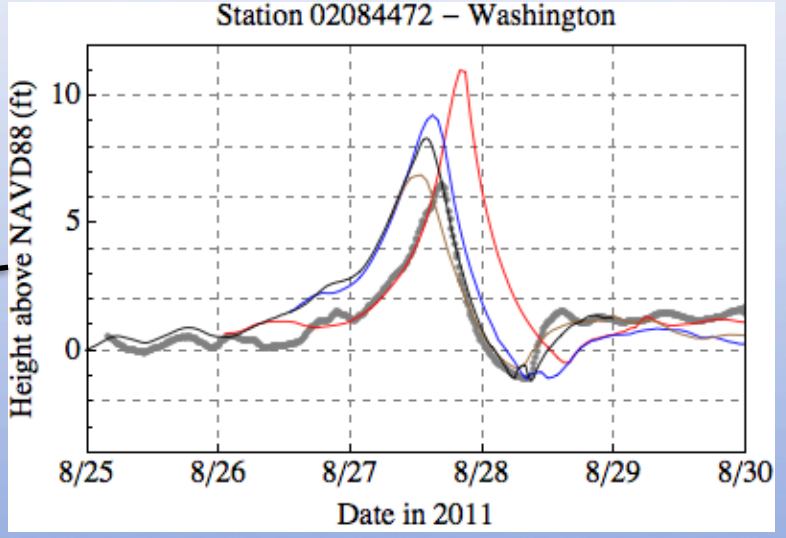
Errors of ~20% when the precipitation QPF only

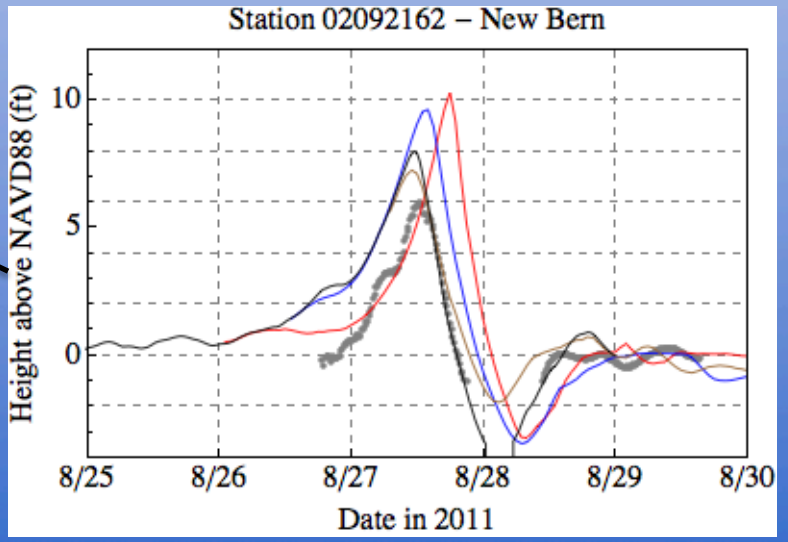
Errors < 10% when dominated by QPE

Source: Dresback et al. 2013

Total Water Level: USGS Stations

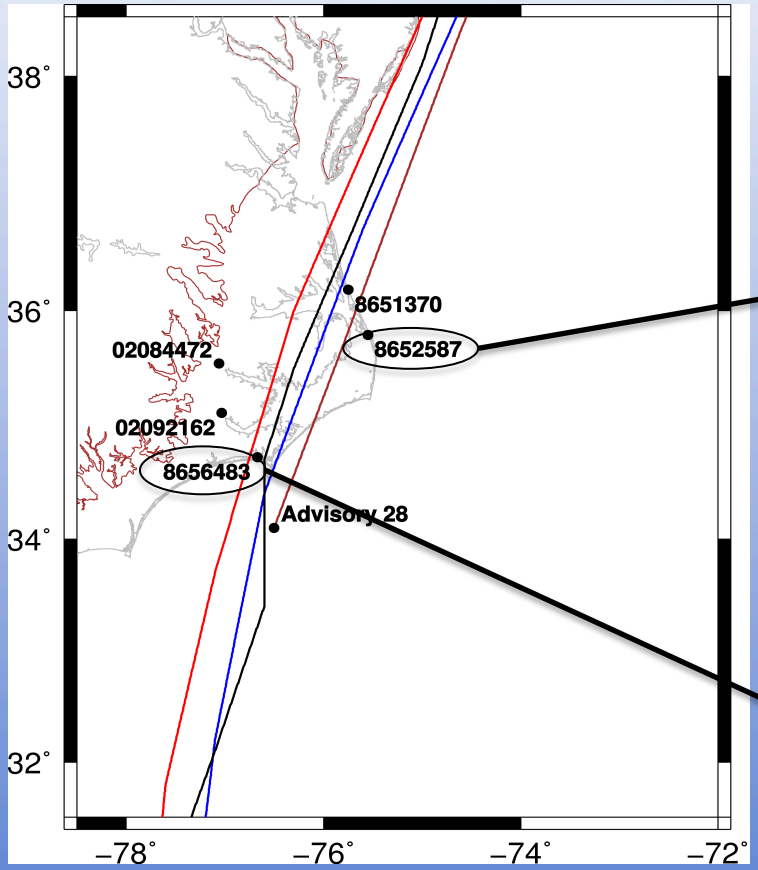


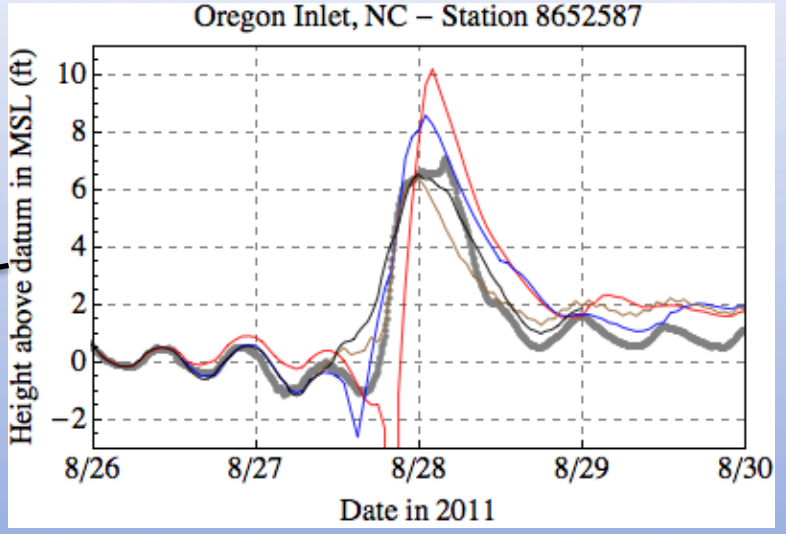


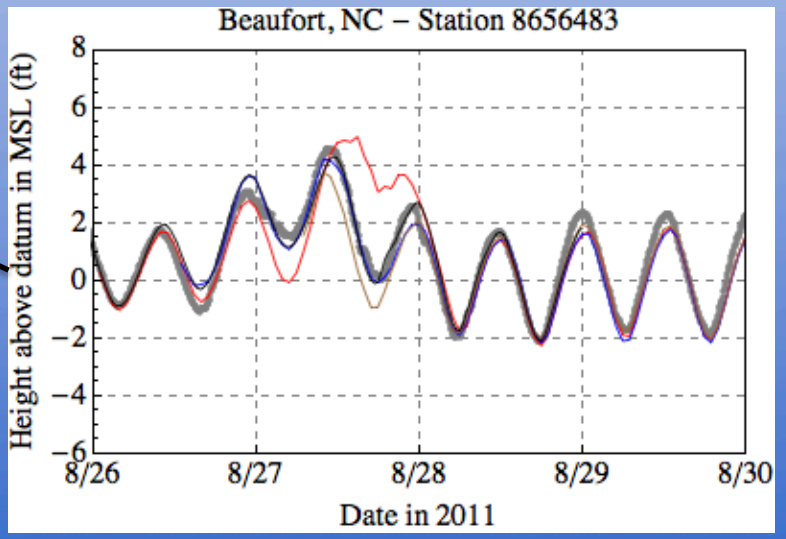


Source: Dresback et al. 2013

Total Water Level: NOS stations

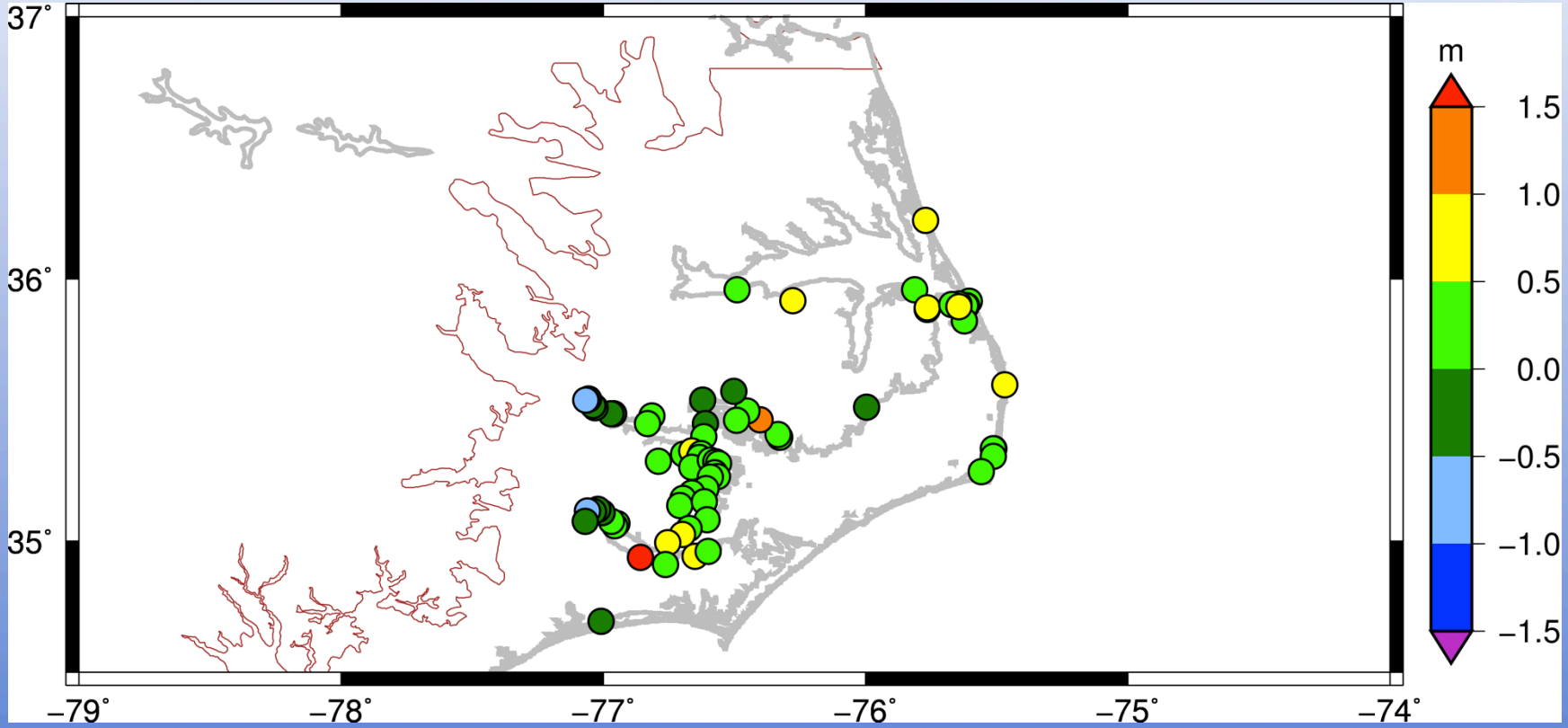






Source: Dresback et al. 2013

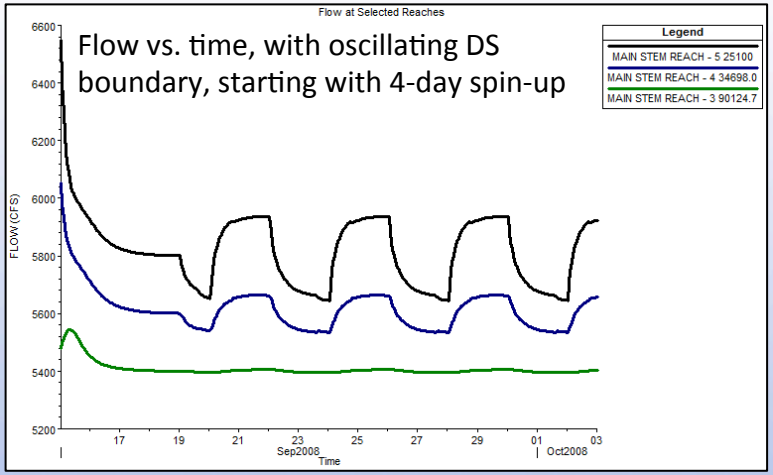
Hurricane Irene – Water Level



81% HWMs ±0.5 m, 16% HWMs ±1.0 m, 3% HWMs ±1.5 m
Large differences between the HWMs & ADCIRC occur in small inlets

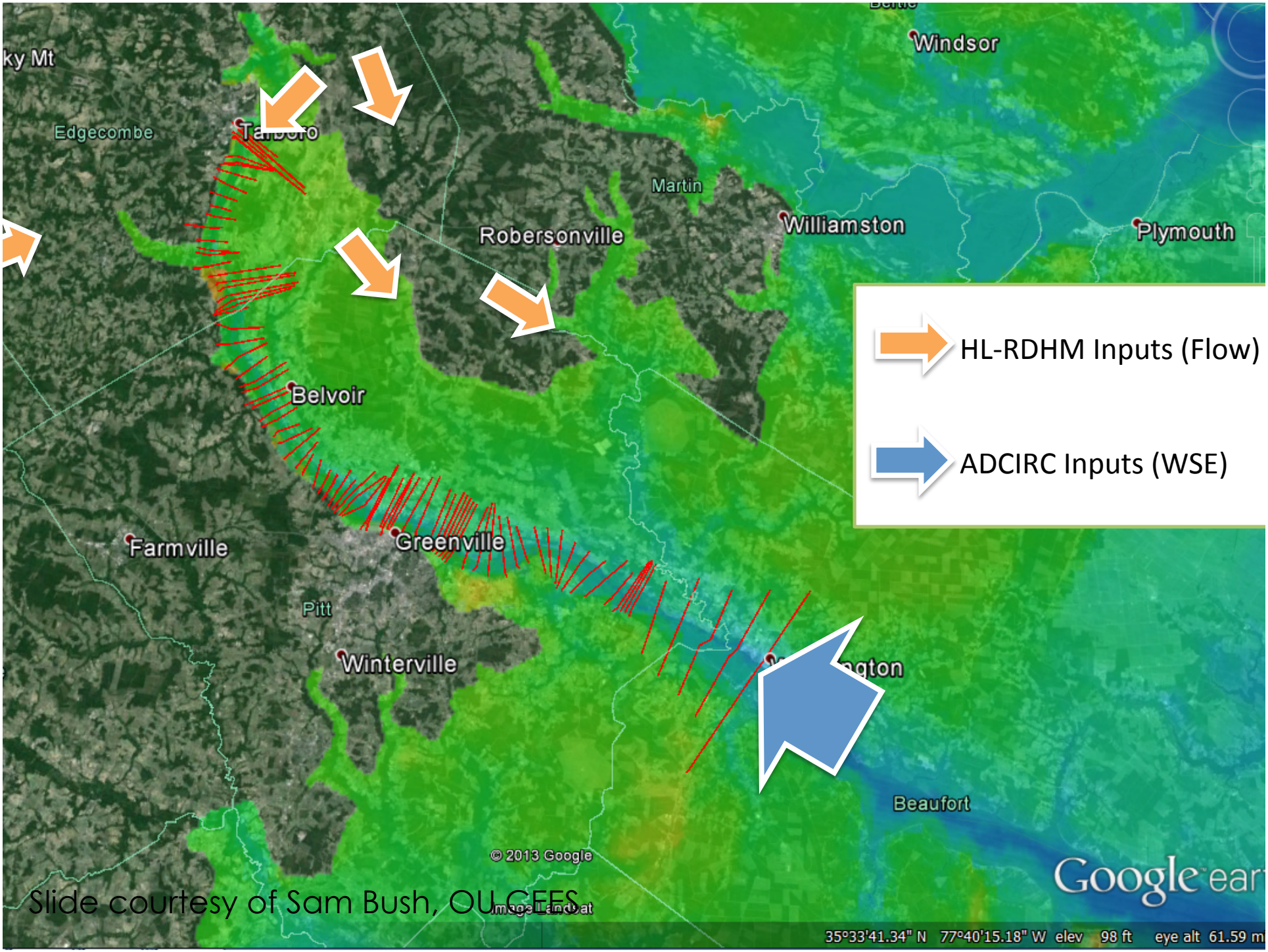
Source: Dresback et al. 2013

Current Research: HEC-RAS Coupling



- **Goal:** Reduce ADCIRC runtime for ensemble "total water level" forecasting
- **Method:** Insert middleware (HEC-RAS) for fine-featured, 1-D flow area
- **Challenges:** ADCIRC grid modification, ideally defining handoff points
- **Status:** Idealized HEC-RAS runs with synthetic boundary conditions to find modeling constraints

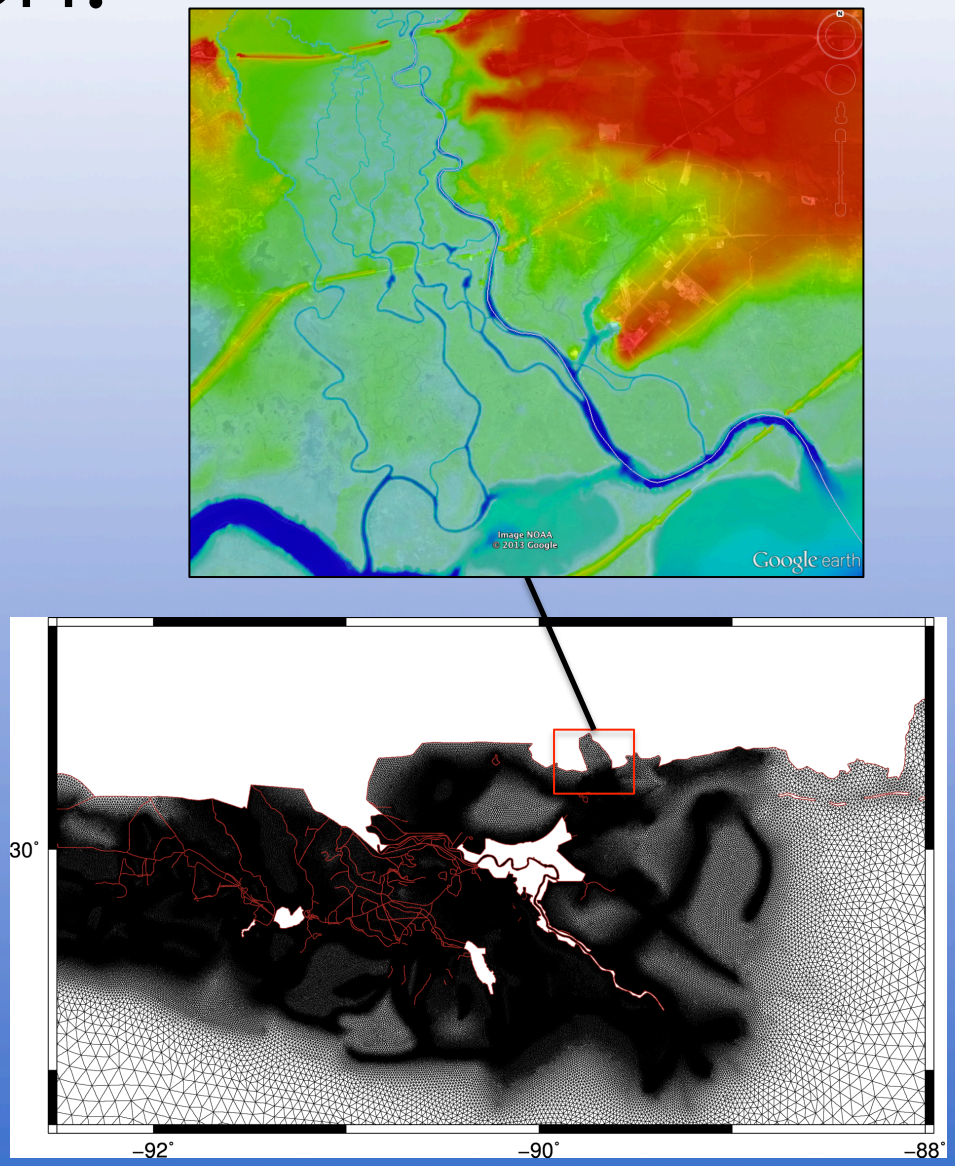
Slide courtesy of Sam Bush, OU CEES



Slide courtesy of Sam Bush, OU CEES

Current Research: CI-FLOW South

- Funding source: DHS Coastal Hazards Center
- Duplicate the system in the Pearl River Basin
- HL-RDHM is calibrated
- Hurricane Isaac will be run by July 2014



Current Research: Rainfall within ADCIRC

- PI: Notre Dame
- ADCIRC does not account for rainfall-runoff processes over its domain
- Can runoff processes due to rainfall over the ADCIRC domain be incorporated into the ADCIRC model physics?

Current Research: Rainfall Model

- PI: MSU
- Variation of the tracks and intensity of storm will require variation in the rainfall pattern
- Given tropical storm parameters, can synthetic rainfall model (RCLIPER) produce precipitation patterns for hydrologic models which results in runoff hydrographs that capture key features of observations (e.g., peak flow)?

NOAA Storm Surge Activities Coordination

- Riverside & URS awarded Storm Surge Model Development project
- Build capacity to couple storm surge model with RFC hydraulic models
- ~200-500 m resolution
- Discussions on best practices for grid development & river coupling

CI-FLOW Project

Questions or comments?

http://www.nssl.noaa.gov/projects/ciflow/

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