NOAA's Storm Surge Roadmap: Transition Research to NWS Operations

RITT Forum

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Outline

- Why a NOAA Roadmap for Storm Surge?

- Vision and Goals

- Purpose and Structure of the Roadmap

- Phase 1 Plan

- Transitioning to NWS operations
  - A new extratropical storm surge model, ESTOFS

The Imperative

- **Increasing Risks**
  - Increasing coastal populations and sea level rise require more deliberate planning

- **Increasing Demand**
  - Decision makers require fine-scale local information that communicates risk clearly

- **Improving Science & Technology**
  - Surge modeling, the social science of decision making, information technology

- **NOAA Must Collaborate**
  - Partner to organize and lead state of the art research and development while making best use of resources
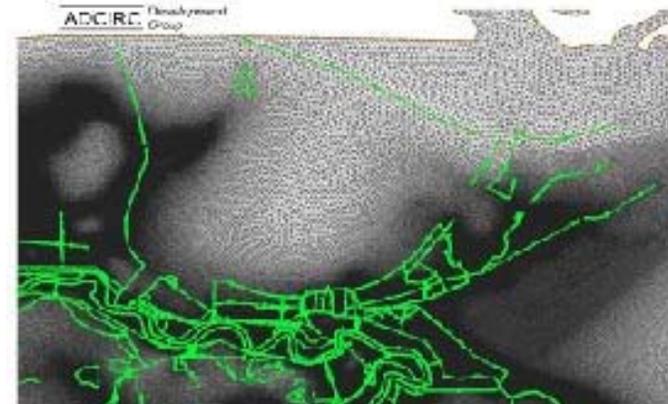
Purpose of the Roadmap

- Shows us our starting point and where we want to arrive

- Effective approach to long-range planning; shows a path to the future

- Effective for communicating and engaging across the agency, and with our partners

- **Bottom line**: first-ever comprehensive effort to holistically address rapidly expanding problem and establish a community approach

The Bottom Line

Customers Ask:

- Who will get flooded? How much?

- When will it arrive and leave?

- What will the impacts be?

- How often will it occur?

- How should I respond?

NOAA needs to:

- Improve determination of storm water levels
  - Total Water Level (TWL) can be much more than surge (tides, waves, rivers, prestorm setup)
  - Model and product accuracy needs to reflect uncertainties

- Describe flooding as inundation above ground
  - Statements, maps

- Communicate actionable information
  - Intuitive and consistent

Goals of the Roadmap

- **Total Water Level**: Produce water level analyses, forecasts, observations, and products that include:
  - *pre-storm forerunner, surge, tides, waves, fresh water inflow, speed, impact*
- **Inundation:** Provide information about the water depth over the land (inundation) to street level resolution
- **Communication Actionable Information:** Deliver information that people act on
  - *understandable, consistent information available in multiple formats*
  - *uncertainty, supports risk assessments, provides impact information, includes scenarios*

Roadmap Structure

Inter-agency, National Coastal Community Organizations

Executive Steering Team

Office Directors from NOS, NWS

(D. Berchoff, M. Davidson, Z. Willis)

Program/Portfolio Manager

NOAA PM for Storm Surge

Storm Surge Action and Planning Team

NWS: Regions, OCWWS, OHD, NCEP/EMC, NHC, OST/MDL

NOS: OCS, CSC, CO-OPS, IOOS

OAR: Sea Grant, NSSL

3 Phase Approach

Phase III (FY15-FY19)

Implementation of new products and services within operations

Phase II (FY12-14)

Research and develop new approaches; evaluate for transition to operations

Phase I (FY9-11)

Consensus building and quick wins to improve our products today; lay groundwork for longer term

Continual Refinement

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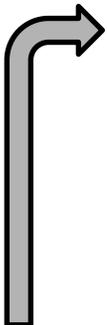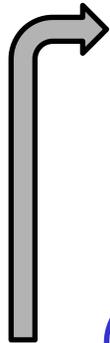
Moving Ahead: Roadmap Progress To Date

- Projects are scheduled for Phase 1, which has AA-level approval from NWS, NOS and OAR
  - 5 short-term quick win improvements in 2010, 8 in 2011
    - Improve determination of water level in existing products
    - Reducing confusion about relationship to flooding above ground
  - Strategic long term projects to develop complete inundation information communicated in actionable ways
    - Building framework for community-based next generation modeling system (e.g., ADCIRC) that includes surge, tides, waves, river inputs
    - Improving products to better communicate threat
    - Capturing user preferences on products
- Synchronizing efforts of the enterprise and conveying strategy internally and externally

Improving Determination of Water Levels: Phase 1 Quick Wins

- Moving towards more complete picture of Total Water Level

Project	FY10 Q1	FY10 Q2	FY10 Q3	FY10 Q4	FY11 Q1	FY11 Q2	FY11 Q3	FY11 Q4	Notes
Adding tides to surge									
Enhance WFO tide addition to SLOSH output	R&D	DT&E→ET&E	ET&E	O&M	O&M	O&M	O&M	O&M	
Real-time water level obs in SLOSH Display	ET&E	ET&E	ET&E	O&M	O&M	O&M	O&M	O&M	
SLOSH runs with tides incorporated			R&D	R&D	DT&E	DT&E	DT&E→ET&E	ET&E	Operational in FY12
Extratropical surge + tide model (ADCIRC - Atlantic)	DT&E	DT&E	DT&E	DT&E	ET&E	O&M	O&M	O&M	Pacific in Phase 2
Enhance TWL Modeling Capability									
Improve prestorm anomaly in SLOSH via NOS obs	DT&E	DT&E	DT&E	DT&E	DT&E	ET&E	ET&E→O&M	O&M	Partners: NHC, CO-OPS
Community model runs in SLOSH Display			R&D	R&D	R&D	DT&E	DT&E→ET&E	ET&E	E.G., CIPS, IOOS RAs

Hurricane Season (FY10 Q4 – FY11 Q1)   *Hurricane Season* (FY11 Q3 – FY11 Q4)

Legend:
- **R & D** — Reseach and Development
- **DT & E** — Developmental Testing and Evaluation
- **ET & E** — Experimental (Pre-operational) Testing and Evaluation
- **O & M** — Operations and Maintenance

Improving Determination of Water Levels: Phase 1 Long Term Strategies

Project	FY10 Q1	FY10 Q2	FY10 Q3	FY10 Q4	FY11 Q1	FY11 Q2	FY11 Q3	FY11 Q4	Notes
System for model improvement									
Catalogue of unstructured grids									Federal partnership
Verification of forecast guidance runs									
Community modeling framework									
Evaluating model enhancements									
Evaluate IOOS projects for transition									Supports future projects
IOOS model evaluation test bed									Informs DT & E
Evaluate SLOSH + wave model									
Coupled coastal surge + wave model system									Based on new extratrop model
Ensembling and uncertainty									
SLOSH mini-ensemble of forecast uncertainty									

Hurricane Season   *Hurricane Season*

R & D	Reseach and Development
DT & E	Developmental Testing and Evaluation
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Describing Flooding as Inundation Above Ground: Phase 1 Plan

- Users confused by datums and don't understand flood risk at their location; developing maps and products to describe local flooding above ground level

Project	FY10 Q1	FY10 Q2	FY10 Q3	FY10 Q4	FY11 Q1	FY11 Q2	FY11 Q3	FY11 Q4	Notes
Transition products to flood above ground									
Text statements listing flood above ground	DT&E	DT&E	DT&E/ET&E	ET&E	ET&E	ET&E	ET&E/O&M	O&M	
Deterministic maps showing flood above ground	O&M	O&M	O&M	O&M	O&M	O&M	O&M	O&M	
p-surge probability maps showing flood above grd			R&D	DT&E	DT&E	DT&E	DT&E/ET&E	ET&E	
Development of high resolution techniques									
Development of high res flood map methods		DT&E	DT&E	DT&E	DT&E	DT&E	DT&E	DT&E	Workshop FY11 Q1
Gulf Coast DEMs using unstructured format	R&D	R&D	R&D	R&D	R&D	DT&E			

Hurricane Season   *Hurricane Season*

R & D	Reseach and Development
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Communicating Actionable Information: Phase 1 Plan

- Users misinterpret statements and graphics; can't readily plan with risk in mind

Project	FY10 Q1	FY10 Q2	FY10 Q3	FY10 Q4	FY11 Q1	FY11 Q2	FY11 Q3	FY11 Q4	Notes
Outreach									
Centralize web site on NOAAWatch			R&D	R&D	DT&E	ET&E	ET&E/O&M	O&M	
Improving products									
NWS Storm Surge Team - watch/warning	R&D	R&D	R&D	R&D	DT&E	DT&E	DT&E	DT&E	Linked to soc sci studies
Social science eval'n of existing products		DT&E	ET&E	ET&E	ET&E	ET&E	O&M		Tropical & extratrop.
Social science new products recommend					DT&E	ET&E	ET&E	ET&E	
Coastal resilience									
Planning and recovery best practices	DT&E	DT&E	DT&E	DT&E	ET&E	ET&E	ET&E	ET&E	

Hurricane Season (FY10 Q4)   *Hurricane Season* (FY11 Q4)

R & D	Reseach and Development
DT & E	Developmental Testing and Evaluation
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What's Possible in Phase 2 and Phase 3?

Hurricane Ike Inundation over DEM

Legend
IkeFinal minus NED_1arc
VALUE

High resolution inundation mapping

m NAVD 88

High resolution model of Pensacola Bay Inlet

Impact Visualization and Assessment
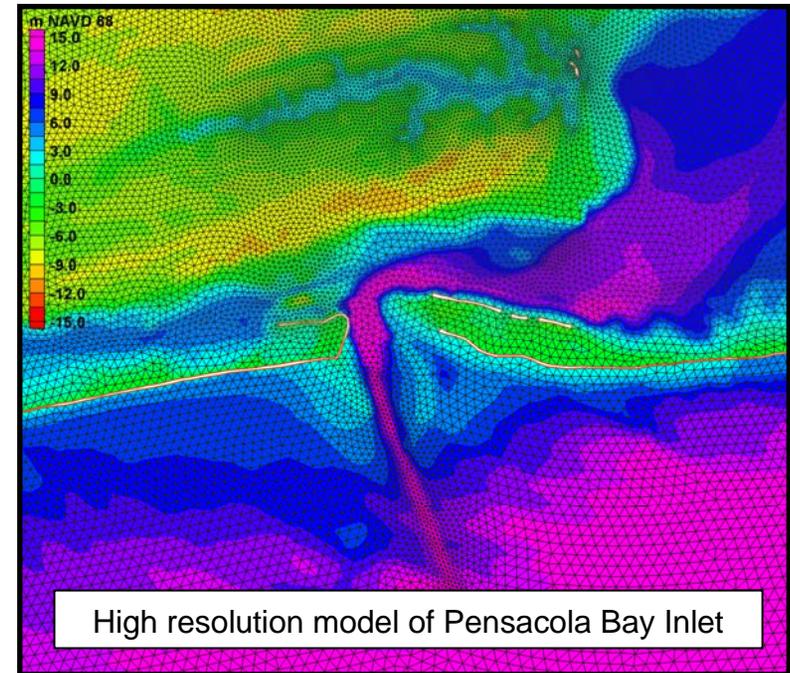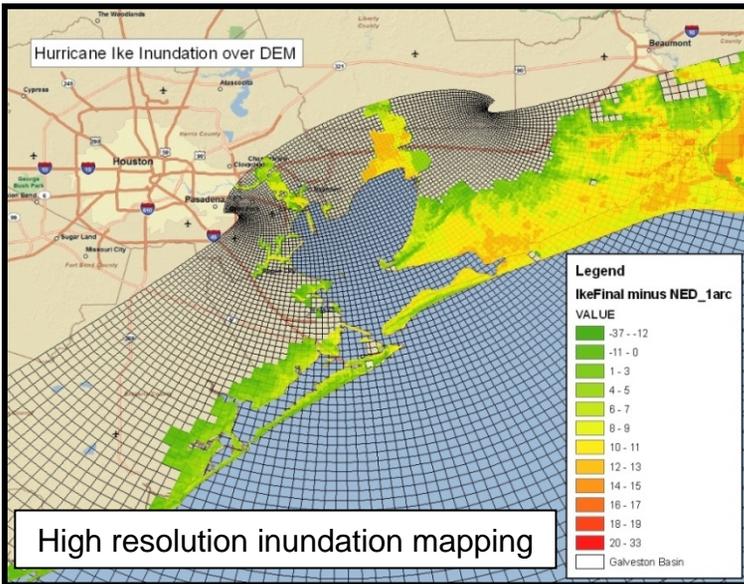
Combine best available technology from the community into a robust, sustainable operational system

Transition Roadmap Projects to NWS Operations

- It appears collaboration between the Roadmap and the RITT would be beneficial for NWS projects

- Roadmap provides an overarching strategy that endorses projects with coordinated approach

- Will grown in importance as we progress through Phase 2

- Could start today with *ESTOFS…*

ESTOFS

- ADCIRC-based Extratropical Surge+Tide Operational Forecast System (ESTOFS) modeling system for Western North Atlantic

- Driven by both atmospheric and tidal forcing

- Delivers real-time water levels and depth-averaged currents as fields and at key point locations

- Designed for coupling with EMC's WaveWatch III for coastal surge+tide+wave predictions

- Provides boundary conditions for coastal models

ESTOFS Approach

- Implement widely-used and tested community-based model ADCIRC

- Unstructured grid model is suitable to simultaneously resolve and predict the important processes in the deep, intermediate, and shallow domain

- Model will be implemented within NCO by collaboration with NCEP/EMC, NOS/CO-OPS, NCEP/OPC, and NHC/TAFB

Use of ADCIRC

- Finite element (FE) coastal ocean model
  - Unstructured grids are fundamentally advantageous for modeling circulation in coastal ocean
  - Local resolution to resolve important physical scales along with large domains to allow for simplified boundary conditions
- Widely used in depth-integrated form to predict water level (tides, surge)
- Under continued development and use at academic institutions, in federal agencies, (e.g., USACE, Navy, FEMA) and private sector
- High performance code uses up 16,000+ cores
- http://adcirc.org/

ESTOFS Domain
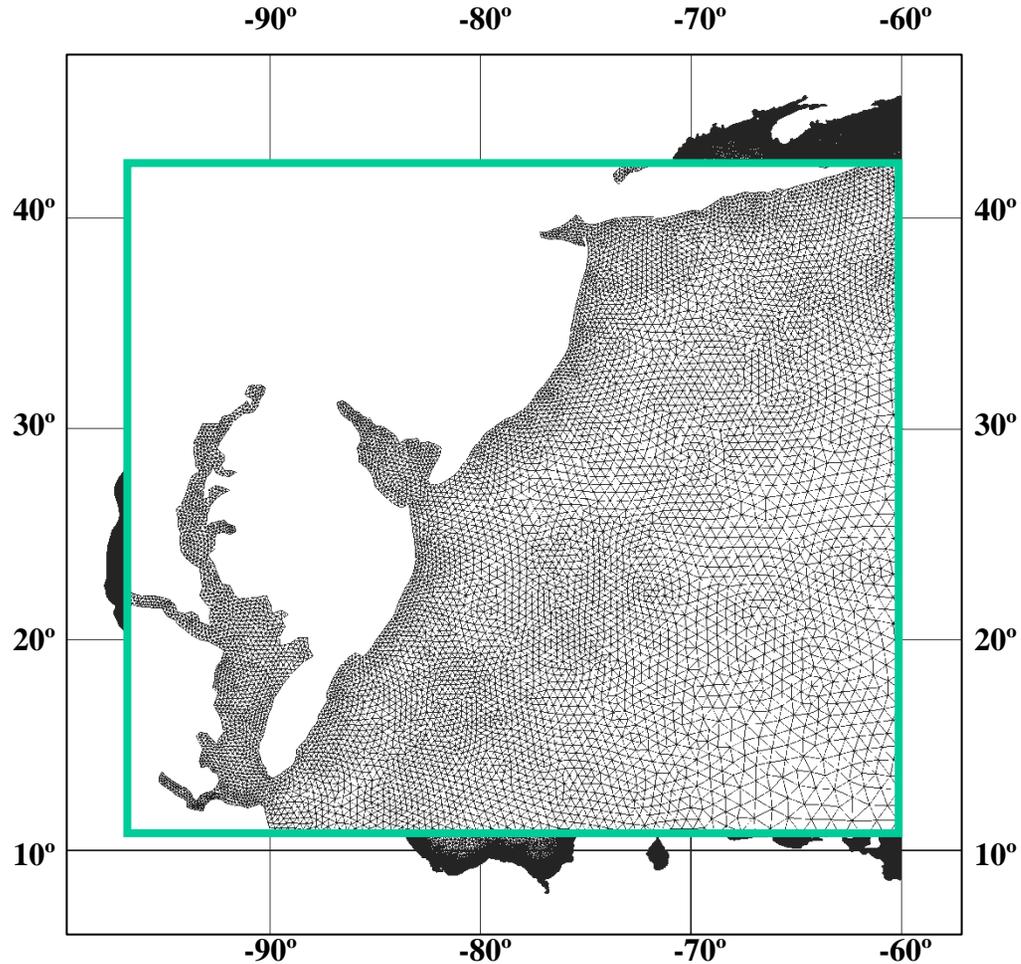
EC2001: 254,565 nodes

ESTOFS Set-Up

- Forcing
  - Tidal boundary conditions from global model (e.g. OSU TOPEX/Poseidon TPXO)
  - Meteorological forcing from GFS (10 m winds and sea level pressure every 30 mins)

- Run Cycle
  - 4X per day on GFS cycle in conjunction with WWIII
  - 9 hr hindcast followed by 180 hr forecast

- Output
  - Fields stored 3 hourly and stations hourly
  - Interpolate FE grid fields to 5km regular grid for transfer to NDFD coastal grids in GRIB2

ESTOFS Progress to Date

- Hindcast of 2009 completed, including Nor'Ida

- Running on NCEP HPC and evaluating real-time operational framework

- Aim to have in parallel testing this year

- Working with NCEP to deliver output to OPC

BACKUP

Vision for NOAA's Storm Surge Enterprise

- Highly accurate, relevant and timely storm induced coastal inundation information, clearly communicated, which results in significant reductions in loss of life and ensures all coastal communities are optimally resistant and resilient to inundation impacts

  - *Drive community planning to reduce risk to life and property*
  - *Train and educate population to respond to threats appropriately*
  - *Infuse state of the art science and technology to refine risk assessment and reduce unnecessary evacuations*
  - *Communicate street level impacts that result in appropriate personal and community response before, during and after the events*

Multiple Users/ Multiple Time Scales

Decision-makers need information on multiple time scales for:

Coastal land-use (months – years before event)

Emergency management planning (months before event),

Evacuations (3-5-7? days before event),

Real time response (36 hours before event through duration)

Post-storm recovery (hours to days post landfall)