Operational Storm Surge Forecasting at the National Hurricane Center

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Potential Storm Surge Flooding*
Through 2 AM Friday August 24th - Advisory #X

- Up to 3 feet above ground
- Greater than 3 feet above ground
- Greater than 6 feet above ground
- Greater than 9 feet above ground

* Displayed flooding values indicate the water depth that has a one-in-ten (10%) chance of being exceeded.
National Hurricane Center Mission

- Provide accurate real-time storm surge forecasts during tropical cyclone events
  - Lead National Weather Service official forecast process
  - Provide briefings and decision support

- Support coastal community preparedness and resiliency through storm surge vulnerability and risk analysis
  - Drives U.S. evacuation zones and planning

- Increase awareness through outreach and education
Operational Forecast Guidance

Pre-Computed Storm Surge Simulations

- **MEOWs**: Maximum Envelopes Of Water
- **MOMs**: Maximum Of the MEOWs

Real-Time Storm Surge Simulations

- **P-Surge**: Probabilistic Storm Surge
Basic Operational Model Requirements

- Provide probabilistic storm surge model forecasts that fully samples the meteorological forecast uncertainty
  - Deterministic simulations and small ensemble runs do not meet this criteria at medium-to-long range lead times

- Probabilistic storm surge model forecast must run on NWS operational supercomputer WCOSS in under 1 wall clock hour using less than ~1000 CPUs (current computing standard)

- Model output resolution must be ~2.5 km for ingest into AWIPS II and CAVE (current resolution standard)
  - Fundamental program for NOAA/NWS operational weather forecasting
  - High-resolution model output must be re-sampled to meet this requirement
NWS/NHC Operational Model: SLOSH

- Computationally efficient surge model that has provided the foundation for reliable NWS storm surge forecasts for decades

- **SLOSH does include:**
  - Wetting and drying
  - Sub-grid scale water features, topographic obstructions, levees, etc.
  - Overtopping of barrier systems, levees, and roads
  - Captures shelf waves and coastal trapped waves
  - New grid resolutions of 250-500 m in critical areas
  - Astronomical tide and initial water level anomaly

- **SLOSH does not include:**
  - Wave setup or wave run-up
    - Experimental version coupled to SWAN
    - Experimental version coupled to 2nd Gen Wave Model
  - River flow, rainfall, and inland freshwater flooding
    - Part of the long-term strategic plan
SLOSH-Based Probabilistic Storm Surge Guidance (P-Surge 2.5)
Fundamental data used to create NWS/NHC storm surge products

Real-time probability products based on the NHC official advisory information

Accounts for meteorological uncertainty in:
- Track (cross- and along-track)
- Intensity (Vmax)
- Size (Rmax)

Uncertainties in track and intensity are based on the 5-year average NHC historical forecast errors

Simulate astronomical tide using 2015 ADCIRC tidal database
NHC Track and Intensity Forecast Errors

Track Errors (1989-2014)

Intensity Errors (1990-2014)

2010-2014 Year Average Error:
24-hr: 45.0 nm (83 km)
48-hr: 77.1 nm (143 km)

2010-2014 Year Average Error:
24-hr: 9.4 kts (4 m/s)
48-hr: 13.3 kts (6 m/s)
Sampling the Meteorological Uncertainty

- Samples error distributions in discrete pieces to create a representative set of hypothetical storms
  - Ensemble centered on NHC official advisory
  - Error spaces are based on normal distributions

- Meteorological perturbations in P-Surge 2.5:
  - Variable number of cross-track
  - 7 variations in storm speed
  - 3 variations in storm size
  - 3 variations in storm intensity

- About 500-1000 unique storm scenarios

- Total number of simulations increases when applied to various SLOSH basins

- Future modeling development will explore ways to improve reliability scores
P-Surge 2.5 Products

- **Probability product**
  - Probability of surge greater than 1-20 ft
  - Available as above ground level and above NAVD88

- **Exceedance product**
  - Storm surge height exceeded by 10-90% of storms
  - Available as above ground level and above NAVD88
  - Cumulative and incremental probabilities

- Output sent over SBN to NHC and WFOs

- Viewer/data available on MDL website
New NHC storm surge products use P-Surge 2.5 exceedance probability product data

- Experimental potential storm surge flooding graphic
- Prototype storm surge watch and warning

The 10% exceedance level provides a reasonable worst-case scenario of flooding

Other exceedance levels can be used for specific applications and advanced users

Probabilistic nature of these products are transparent to the less informed users of the information

Underlying data can change and products remain the same
Provides a **quantitative risk** assessment for decision makers and to help guide evacuation decisions

- Social science has guided nearly all aspects of the graphic
- Inundation values binned into 4 ranges with zoom level restrictions
- First map issued at the same time as the initial hurricane watch or in some cases, with a tropical storm watch
- Available about 60 to 90 minutes following the advisory release
Prototype Storm Surge Watch / Warning Graphic

- Intended to enhance public response to instructions from local officials, and, ultimately, to help guide EM decisions.
- Highlights areas that have a significant risk of life-threatening inundation from surge.
- Introduces the concept of a storm surge watch/warning. Intended as a visualization aid, a call to action, and to stimulate feedback from users.
- Issued 48 hours before possibility of life-threatening surge, or other hazards that would hinder evacuations.
- Represents collaboration of NHC’s Hurricane Specialists, Storm surge experts, and local NWS WFOs.

hurricanes.gov/surge
NHC’s Storm Surge Unit

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