NHC Storm Surge Products and NWS Storm Surge Warnings

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Making the Perfect Storm Surge Forecast
Hurricane Advisory – Approximately 12 hr. before landfall

NHC TRACK ERROR 12 hr. OUT

130 mph, 933 mb
R_{\text{max}} = 25 \text{ mi (forecast)}

Surge Based on NHC -12 hr. Advisory
Actual Hurricane Track 30 mi. E of -12 hr. Advisory Forecast Track

130 mph, 933 mb
R_{\text{max}} = 40 \text{ mi}

Surge Based on NHC Storm Best Track
Why Probabilistic?

ATCF Track

Modified ATCF Track

Modified ATCF Track - ATCF Track

Water Level above NAVD88 (ft)

Water Level Difference (ft)

hurricanes.gov/surge
How do we account for the uncertainties in the hurricane forecast to understand what areas have a realistic chance of getting storm surge?
P-surge
Probabilistic Storm Surge
Probabilistic Storm Surge (P-surge)

- Storm surge probabilities based on NHC official advisory
- Available approximately 48 hours prior to arrival of TS winds
- Accounts for uncertainty in:
  - Track / landfall location
  - Size
  - Forward speed
  - Intensity
- Uncertainties based on historical errors
- Version 2.x also accounts for the tide and is available above NAVD88 and above ground level
Probabilistic Storm Surge (P-surge) 
Multiple Tracks and Landfall Locations

Hurricane Irene 
Advisory #22

- Forecast Track
- Alternate P-surge Tracks
Probabilistic Storm Surge (P-surge) Multiple Tracks and Landfall Locations

**Size:** Small, Medium, Large

**Forward Speed:** Fast, Medium, Slow

**Intensity:** Strong, Medium, Weak
Detemrministic SLOSH run shows limited surge threat to Pensacola area.

R_{max} = 25 \text{ mi (forecast)}
Probabilistic product shows considerable surge threat to Pensacola area
Actual storm caused highest surge in Pensacola area
When is P-Surge Available?
(On the NHC Website)

- Whenever a hurricane (and sometimes tropical storm) watch or warning is in effect
  - Approximately 48 hours prior to arrival of TS winds
- Available approximately 30 minutes after full advisory release time
  - 05:30 EDT
  - 11:30 EDT
  - 17:30 EDT
  - 23:30 EDT
Potential Storm Surge Flooding Map
Do People Know Their Elevation? (within a 5-foot interval)

Accuracy of Perceived Elevation

- Low: 12
- Correct: 14
- High: 19
- No Guess: 55

Courtesy Jay Baker, FSU
Storm Surge Inundation
Which product will drive the flooding map?
- **Psurge 2.x** (includes tides)
- **10% Exceedance** (a reasonable worst-case scenario)
- **Grids**
  - Latest SLOSH basins updated to NAVD88
- **Topography/Digital Elevation Models (DEM)**
  - NOAA OCM Sea-level rise DEM
    - Resampled to smoother resolution
  - Augmented with USGS NED
- **Processing**
  - Locally using **ArcGIS** for Server and Desktop
  - Working toward leveraging NWS integrated dissemination program (IDP)
NHC Potential Storm Surge Flooding Map

- **What it does account for**
  - Flooding due to storm surge from the ocean, including adjoining tidal rivers, sounds, and bays
  - Normal astronomical tides
  - Land elevation
  - Uncertainties in the landfall location, forward speed, angle of approach to the coast, intensity, and wind field of the cyclone

- **What it does NOT account for**
  - Wave action
  - Freshwater flooding from rainfall
  - Riverine discharge
  - Flooding resulting from levee failures
  - For mapped leveed areas, flooding inside levee systems and overtopping of levees
Potential Storm Surge Flooding*

- **Intertidal Zone/Estuarine Wetland**
- **Greater than 1 foot 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 height that has about a 1-in-10 (10%) chance of being exceeded.
Potential Storm Surge Flooding*

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Ground Level

Greater than 1 feet
Greater than 3 feet
Greater than 6 feet
Greater than 9 feet

*Intertidal Zone/Estuarine Wetland
Greater than 1 foot above ground
Greater than 3 feet above ground
Greater than 6 feet above ground
Greater than 9 feet above ground
Leveed area
Consult local officials for flood risk
Interactive Interface and Data Access

- Interactive viewer available on hurricanes.gov
  - Intertidal layer can be turned on/off (NHC recommends leaving it on)
- GIS data available for download
- Available on NOAA’s nowCOAST
  - [https://nowcoast.noaa.gov/](https://nowcoast.noaa.gov/)
- Map Services (REST and WMS)
Lower Bound Cut-Off

- The data is only displayed in areas where there is at least a 10% chance of at least **1 foot** of inundation.

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**Potential Storm Surge Flooding**

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- Greater than 3 feet above ground
- Greater than 6 feet above ground
- Greater than 9 feet above ground
- Leveed area
- Consult local officials for flood risk

*Displayed flooding values indicate the water height that has about a 1-in-10 (10%) chance of being exceeded.*
Areas that are often inundated by seawater without a storm are masked in gray. This allows users to focus on areas that could experience consequential flooding of normally dry ground.
Intertidal Zone/Estuarine Wetland Mask

No Tidal Mask

Tidal Mask
Intertidal Zone

- Land that is exposed at low tide and under water at high tide

**FIGURE 12:**
The intertidal zone.
Due to the influences of the land and sea, the intertidal zone contains a rich assemblage of biodiversity and is highly productive.
ILLUSTRATION: Soren Henrich.
Estuarine Wetlands

Wetlands in tidal areas where salinity due to ocean-derived salts is at least 0.5%
Salt Marshes

Sapelo Marsh, Georgia
Mangroves

Southwest Florida
Estuarine Forests

Shell Bank Bayou, Louisiana
Leveed Areas

- Flooding levels inside leveed areas due to overtopping and failure of the levee is nearly impossible to predict
- Consult local officials for the flood risk in these leveed areas

Hurricane & Storm Damage Risk Reduction System (Louisiana)

Port Arthur Hurricane Protection Structure (Texas)
Potential Storm Surge Flooding Map

- Provides a quantitative risk assessment for decision makers.
- Shows height above ground that the water could reach.
- Depicts the reasonable worst-case scenario at any individual location.
- Shows inundation levels that have a 10% chance of being exceeded.
- 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.

hurricanes.gov/surge
Storm Surge Watch/Warning
Storm Surge Warning program is intended to enhance public response to instructions from local officials, and, ultimately, to help guide EM decisions.

W/W Graphic highlights areas that have a significant risk of life-threatening inundation from storm surge.

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.
Storm Surge Watch and Warning will become operational in 2017.

W/W will be communicated using:

- Graphic on NHC website
- Watch/warning section of the NHC Public Advisory using coastal breakpoints
- NWS WFO Hurricane Local Statements
- Approximate representation in terms of zones in National and WFO TCV products.
- NDFD grid

SUMMARY OF WATCHES AND WARNINGS IN EFFECT:

- A Hurricane Warning is in effect for...
  * Anclote River to Indian Pass Florida

- A Storm Surge Warning is in effect for...
  * Aripeka to Indian Pass Florida
**STORM SURGE WEA**

**Red** = All areas that can be alerted for a Storm Surge Watch/Warning via VTEC, EAS and NWR (entire zone is alerted)

**Green** = All areas that can be alerted for a Storm Surge Watch/Warning via WEA and the NWS front page (WWA) map and “Point and Click” pages (zones and portions of zones that lie within the largest possible area for tropical cyclone storm surge flooding)
How Carriers Geotarget WEA

While efforts are underway to make NWS triggered WEA activations more targeted, there is still the potential for the message to be spread outside the intended warning area.

Note: Map is not drawn to scale and is for illustrative purposes only.
SSWWs on the NWS’ [weather.gov](https://weather.gov) Front Page (WWA) Map will be populated using CAP 1.2 data.

The WWA Map will display the geographic coverage of the entire area in each zone that is vulnerable to storm surge when the zone is included in the WFO TCV.

- It will be larger than the intended gridded warning area.
- The point forecast will be based on this area and will direct some users outside the gridded warning to the TCV for warning information.

SS Warning will be **Dark Purple**

SS Watch will be **Light Purple**

**NOTE:** There is no SSWW in this example.
Storm Surge Warning

There is a danger of life-threatening inundation from rising water moving inland from the shoreline somewhere within the specified area, generally within 36 hours.

This is a life-threatening situation. Persons located within these areas should take all necessary actions to protect life and property from rising water and the potential for other dangerous conditions. Promptly follow evacuation and other instructions from local officials.

Storm Surge Watch

There is the possibility of life-threatening inundation from rising water moving inland from the shoreline somewhere within the specified area, generally within 48 hours.
Run SLOSH P-Surge on NOAA Supercomputer using official NHC forecast

NHC Proposed Grid

Collaboration

WFO Miami Collaborated Grid

Dissemination of Storm Surge Watch/Warning
**A Tale of Two Maps**

**Storm Surge Watch/Warning**

- Primary audience is the general public.
- Highlights the areas that have a significant risk of life-threatening surge, but does not provide any quantitative inundation levels.
- Although driven by objective guidance, W/W areas also based on subjective factors such as forecaster confidence, continuity with previous issuances, wind trigger, smoothing, isolated areas, etc.

**Potential Storm Surge Flooding Map**

- Intended for decision makers.
- Objective guidance on where inundation from surge could occur and height above ground the water could reach.
- Based solely on the latest NHC forecast and historical error characteristics. No guaranteed continuity from cycle to cycle, or consistency with W/W graphic.
Questions?