# 5-Year Plan and Long-Term Vision to Advance Storm Surge Modeling

Annual HFIP Meeting
November 7, 2018

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NWS Office of Science and Technology Integration

# Outline

A. Hurricane Forecast Improvement Project (HFIP)
B. Consumer Option for an Alternative System to Allocate Losses (COASTAL) Act
C. Hurricane Supplemental (2018)

# A. Hurricane Forecast Improvement Project (HFIP)

# Weather Research and Forecasting Innovation Act of 2017

## SEC. 104. HURRICANE FORECAST IMPROVEMENT PROGRAM

(a) IN GENERAL.—The Under Secretary, in collaboration with the United States weather industry and such academic entities as the Administrator considers appropriate, **shall maintain a project to improve hurricane forecasting**.

(b) GOAL.—The goal of the project maintained under subsection (a) shall be to **develop and extend accurate hurricane forecasts and warnings** in order to reduce loss of life, injury, and damage to the economy, **with a focus on**—

(1) improving **the prediction of rapid intensification and track** of hurricanes;

(2) improving the **forecast and communication of storm surges** from hurricanes; and

(3) incorporating **risk communication research** to create more effective watch and warning products.

# HFIP Storm Surge Goals

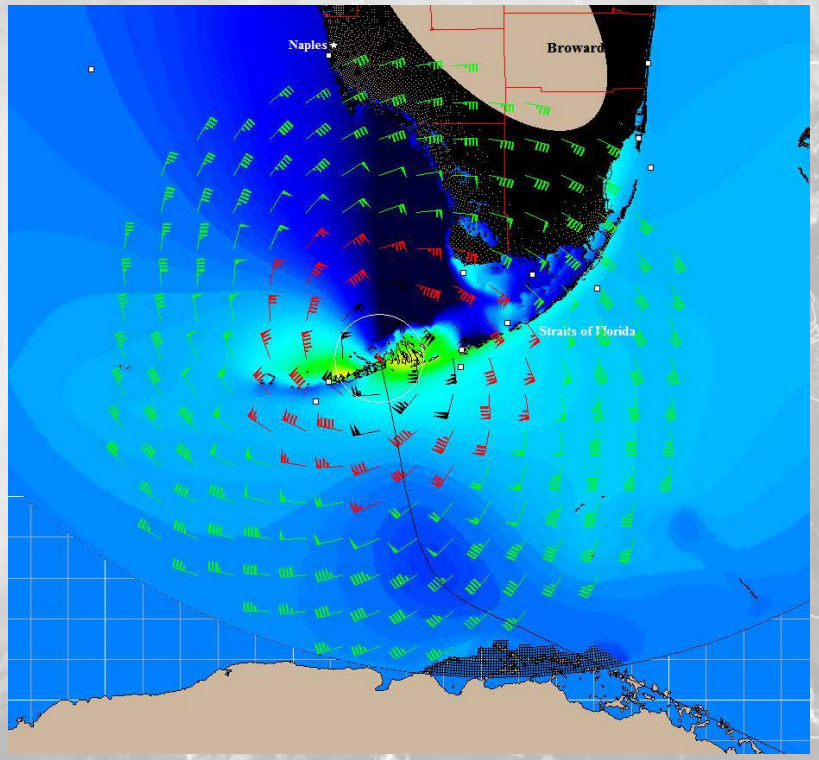
1. **Short-Term: Increase Lead-time of Real-time Forecasts from 2 (48 hrs) to 3 days (72 hrs)**
   a. Update SLOSH's parametric wind model
   b. Incorporate wind structure information into P-Surge Ensemble
   c. Move from a Statistical to a Dynamical Ensemble
   - Enable improved evacuation decision-making especially for areas with large clearance times

2. **Short-Term: Expand to Areas Outside the Continental United States (OCONUS)**
   a. Develop MOMs/MEOWs for risk analysis, planning, and mitigation
   b. Develop real-time probabilistic guidance
   c. Develop real-time products, services, and warnings similar to those for CONUS

3. **Long-Term: Evaluate the feasibility and application of a multi-model approach**
   a. Extensive P-Surge model upgrades; validation studies
   b. Enhancements to HSOFS (ensembles, optimization)
   c. Feasibility study and application evaluation for multi-model approach

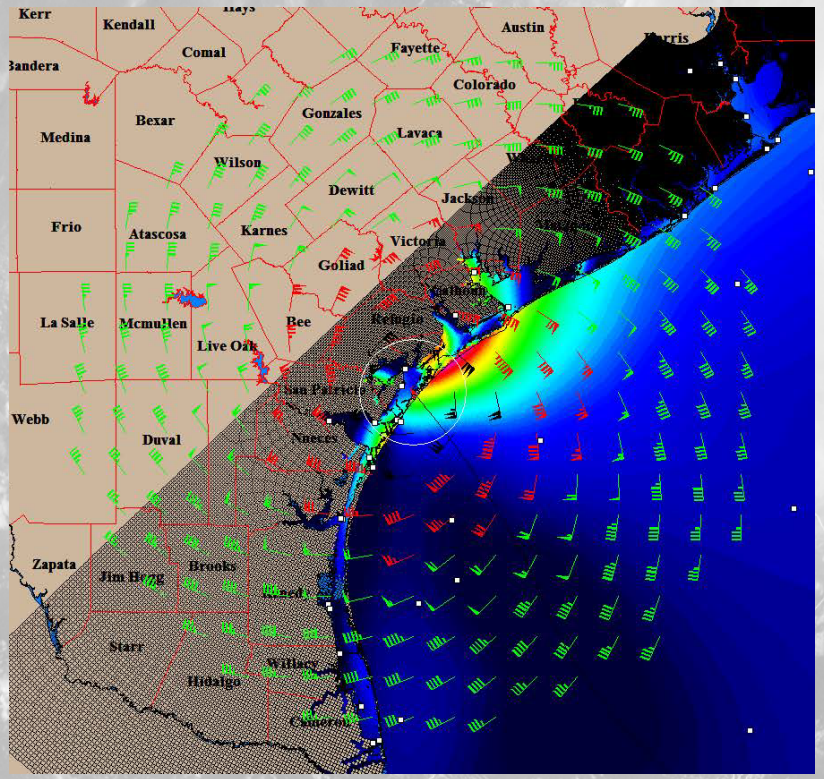
# 1a. Update SLOSH's parametric wind model

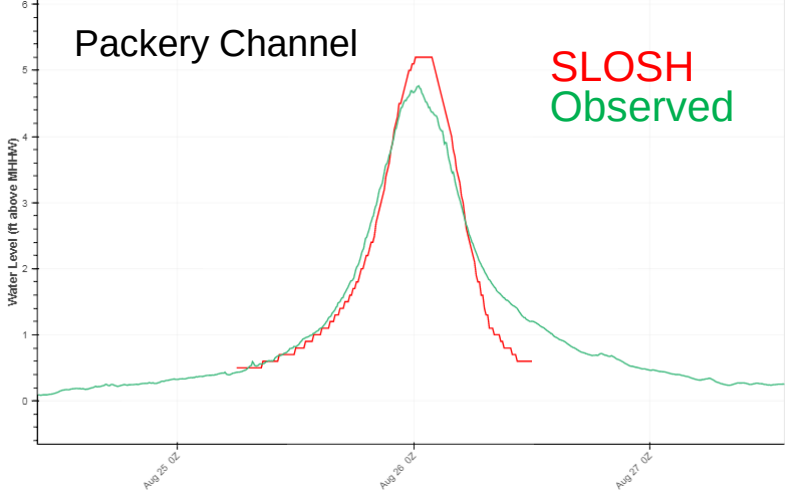
- SLOSH uses a parametric wind field
  - Relates Radius of Maximum Wind (RMW), Delta Pressure, and Intensity
  - Only these parameters dictate the wind field structure
  - Only include asymmetries arising from translational velocities
- Works well for classic symmetric hurricane structures and synthetic storm analysis (i.e. risk analysis and climatological studies)
- Does not accurately handle storms with large/asymmetric wind fields or storm undergoing extra-tropical transition (i.e. Sandy)

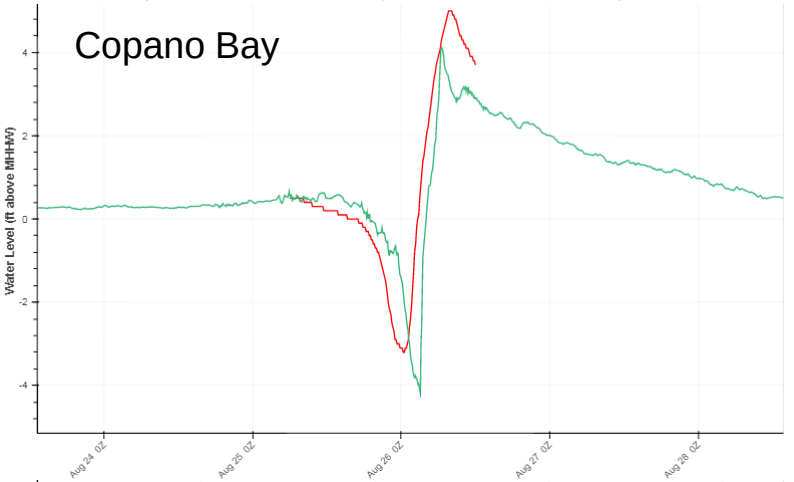


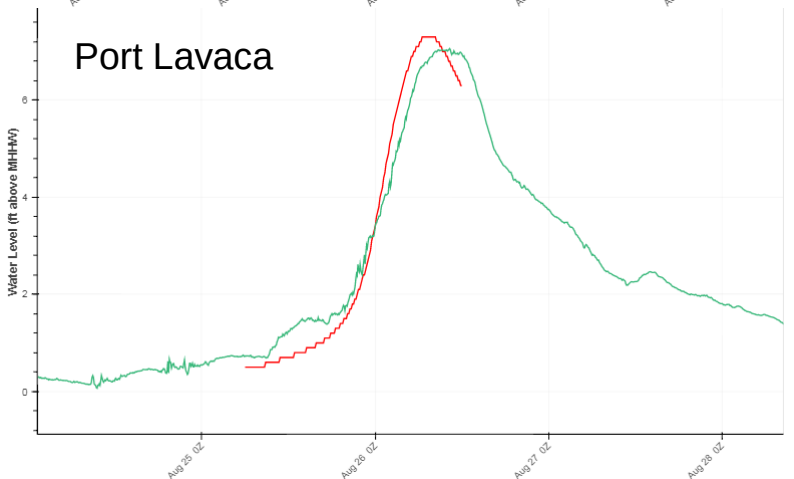
# Example 1: Harvey (2017)

SLOSH's parametric wind fit Hurricane Harvey relatively well and produced realistic results at the NOAA tide stations



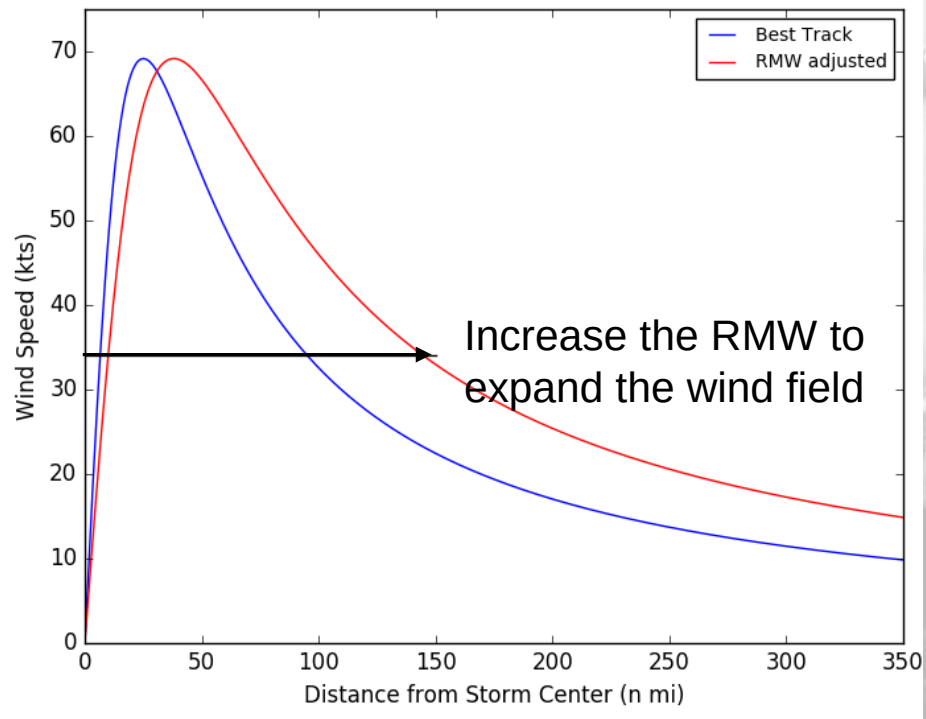



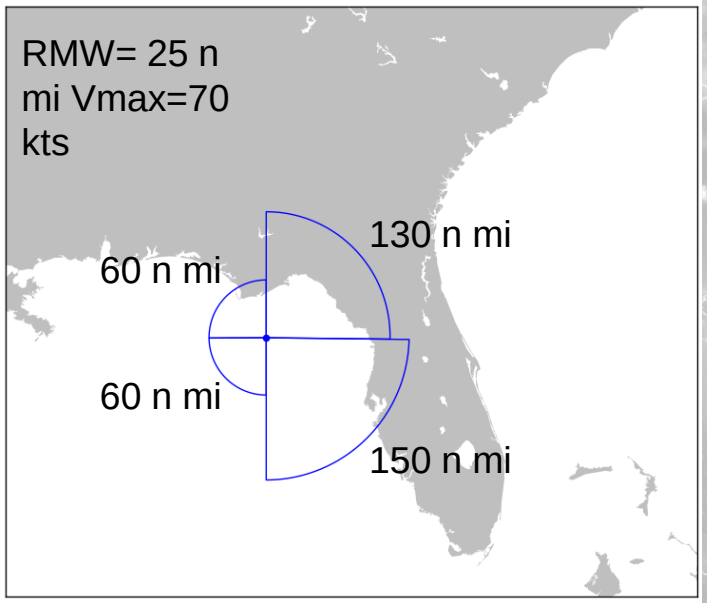



# Example 2: Hermine's Asymmetric Structure

- Parametric wind field based on Best Track RMW underestimates the surge at Cedar Key and in Tampa Bay
- Expanding the wind field fixes this, but overestimates surge at and west of the landfall location



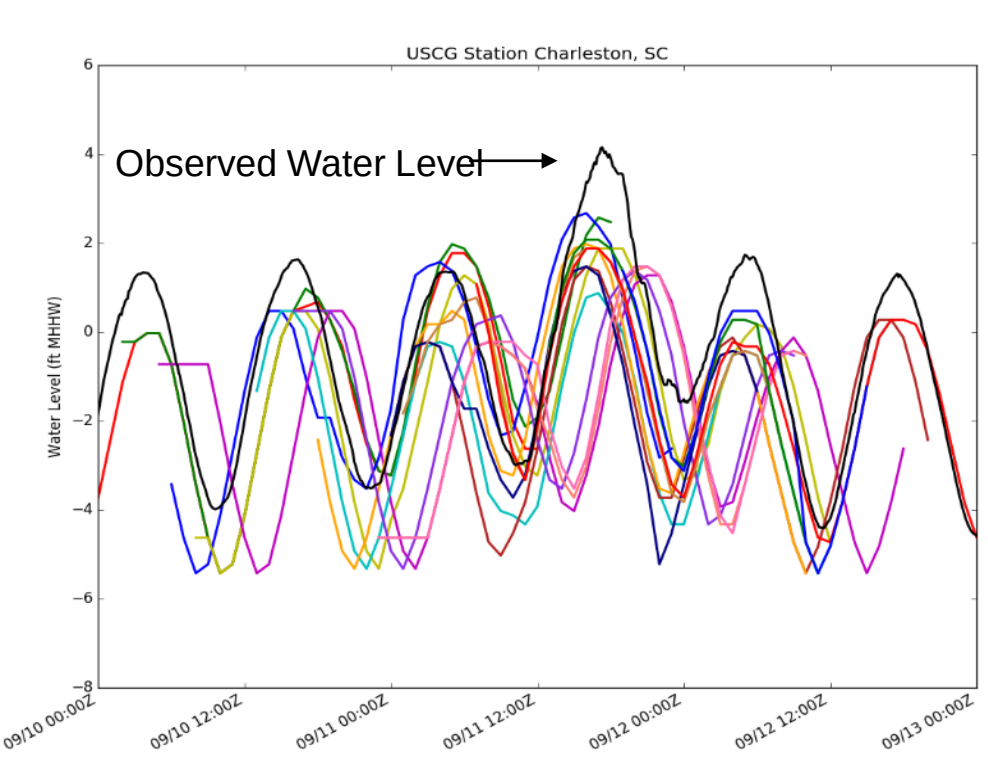

2016090200 NHC 34-kt Wind Quadrants

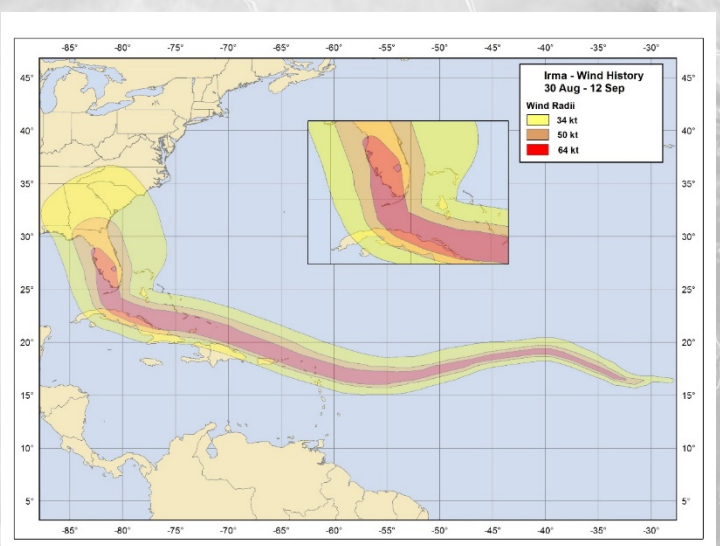


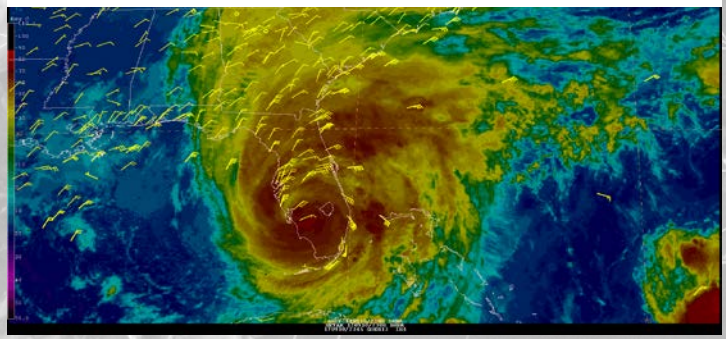

For Hermine, a single SLOSH run cannot accurately depict the surge footprint

# Example 3: Irma's Large Wind Field

- P-Surge is unable to predict the surge in Charleston, SC due to the size of the wind field
- Extra-Tropical Storm Surge (ETSS) model provides better guidance



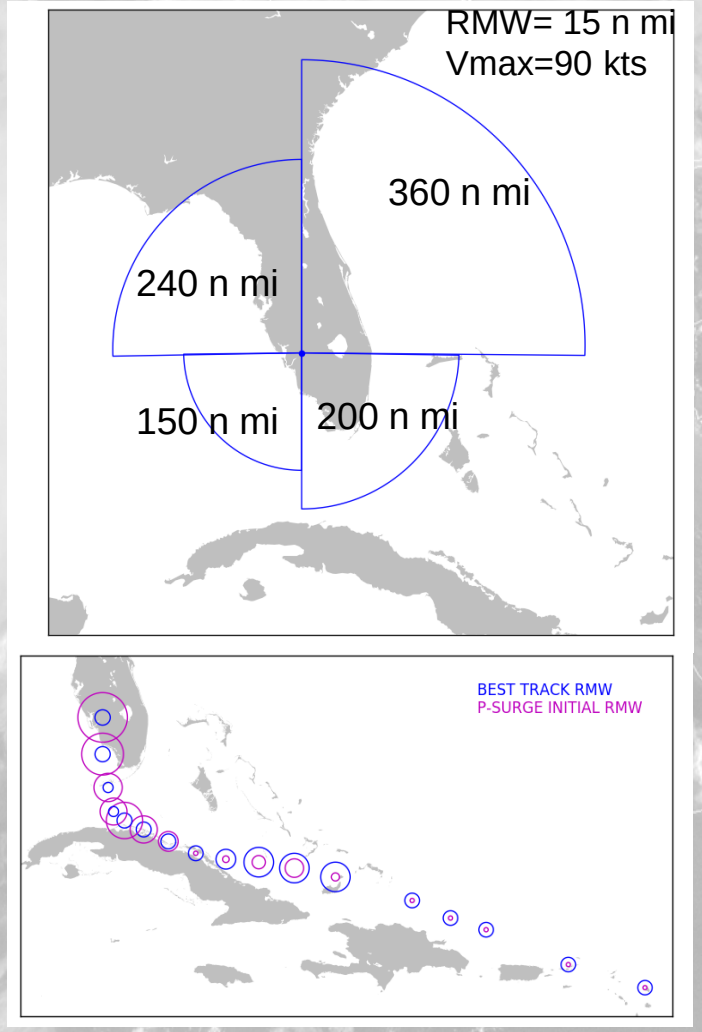



# 1b. Incorporate wind structure information into P-Surge Ensemble

- P-Surge does not include initial RMW from NHC Best Track
  - Uses the current pressure and intensity to calculate the RMW (parametric wind)
  - led to large RMW initialization errors during Irma

- P-Surge does not include NHC initial 34-, 50-, or 64-kt wind radii or their forecasts

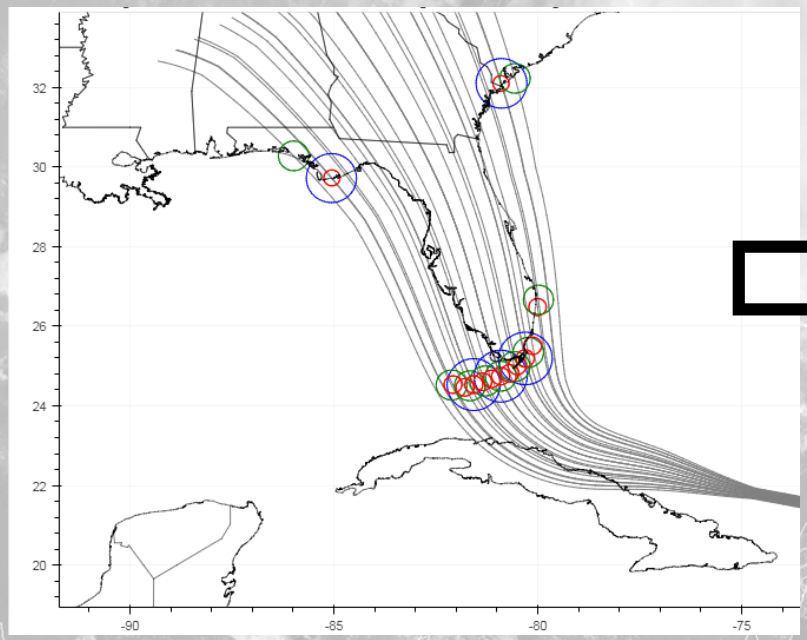
2017091100 NHC 34-kt Wind Quadrants

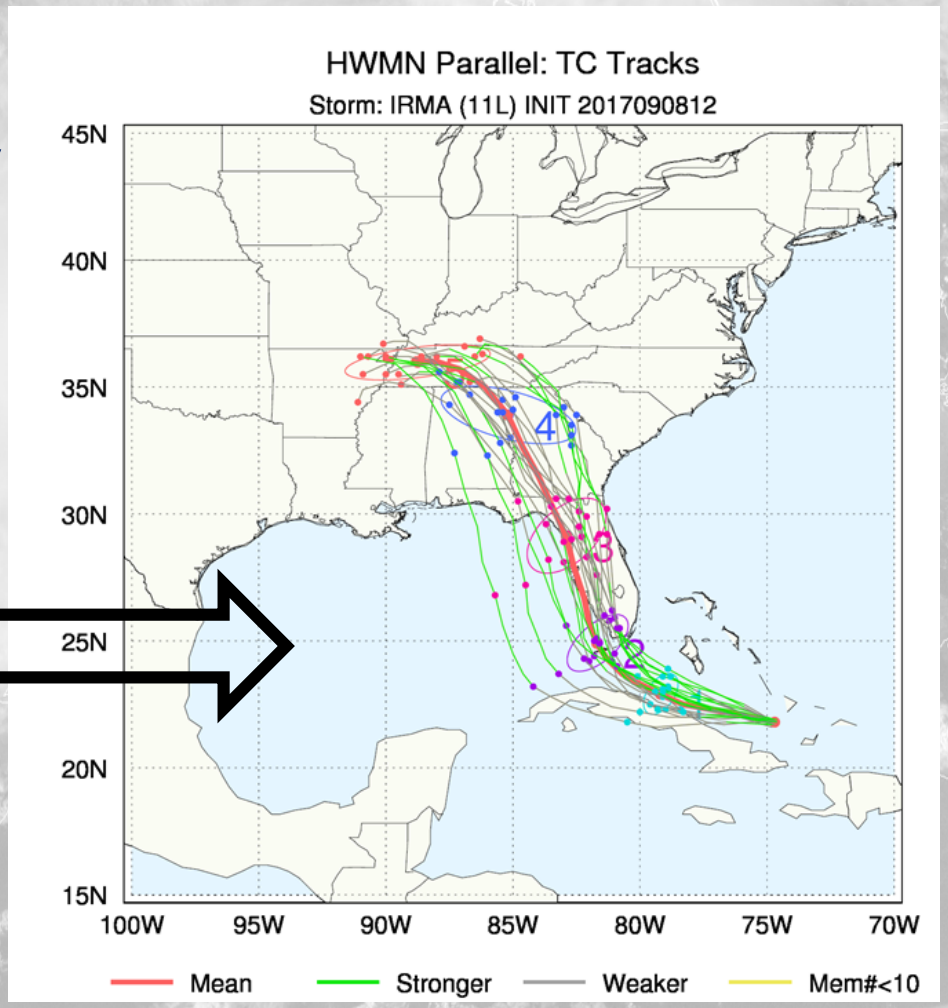


# 1c. Move from a Statistical to a Dynamical Ensemble

As ensemble forecasts improve, they can provide more information on ideal cross track spread, intensity uncertainty, and wind field size relative to the event at hand

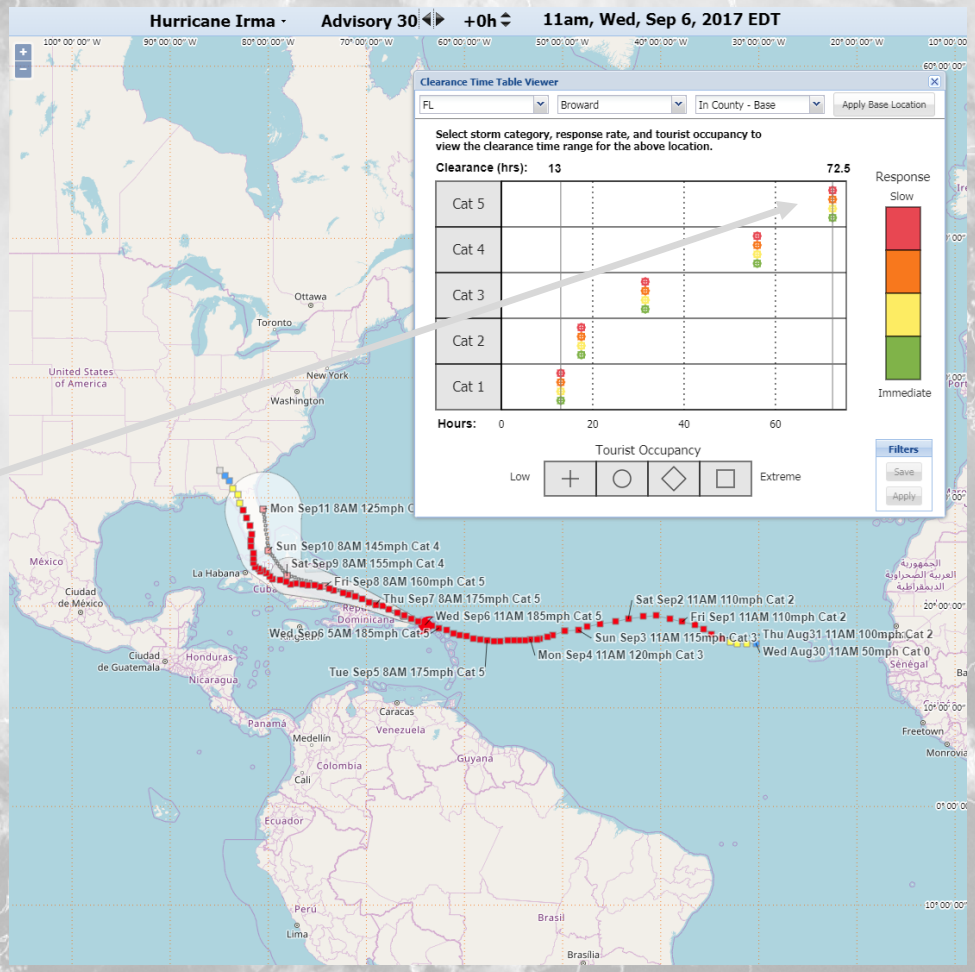
2017090812 P-Surge Tracks



# ➢ Enable improved evacuation decision-making especially for areas with large clearance times

- Clearance times for counties in South Florida exceed 48 hours for Cat 4 and 5 hurricanes.
- For example, it can take more than 3 days to evacuate Broward County.



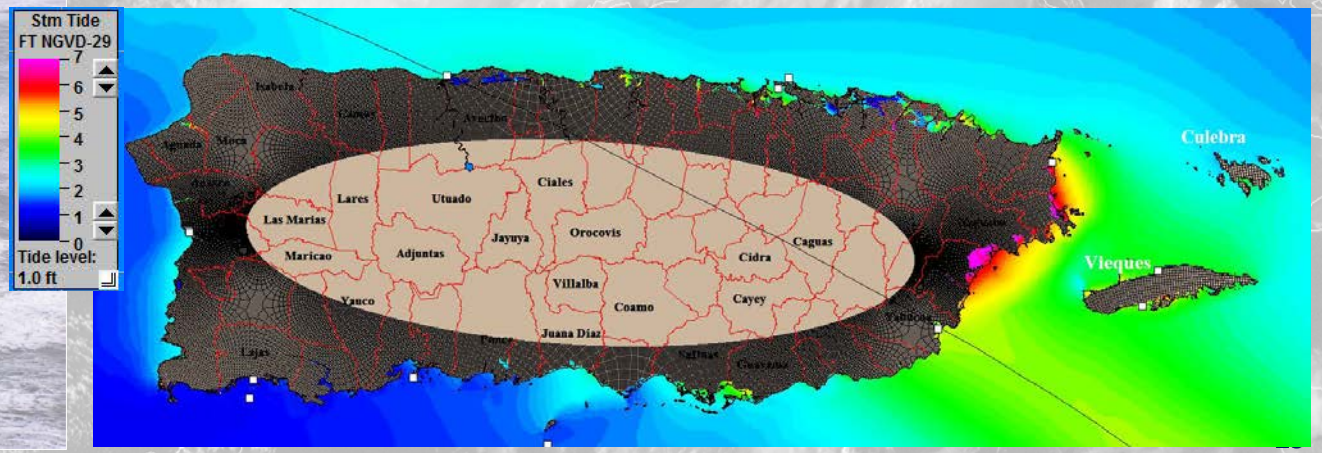
# 2. OCONUS Goal

- Waves can be a significant contributor to the total water level rise and cause substantial damage to property
- During Hurricane Maria, MEOWs were used to advise risk but are unable to run P-Surge
- Also ran single track SLOSH+SWAN run (computationally expensive) to advise emergency response post-storm

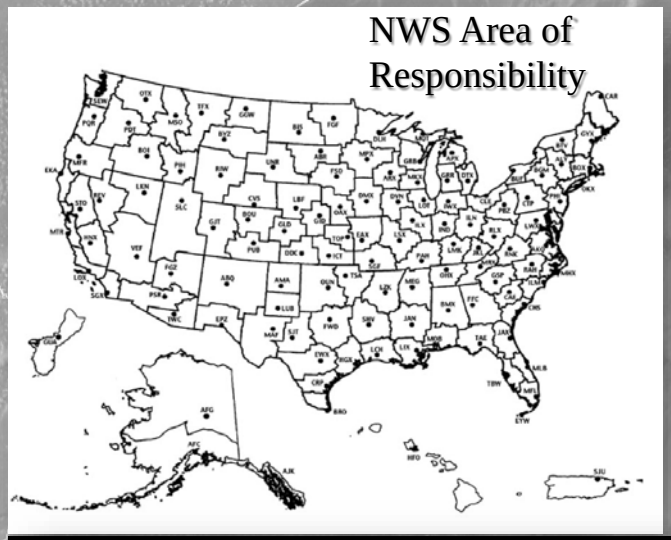
➢ Develop MOMs/MEOWs for risk analysis, planning, and mitigation

➢ Develop real-time probabilistic guidance

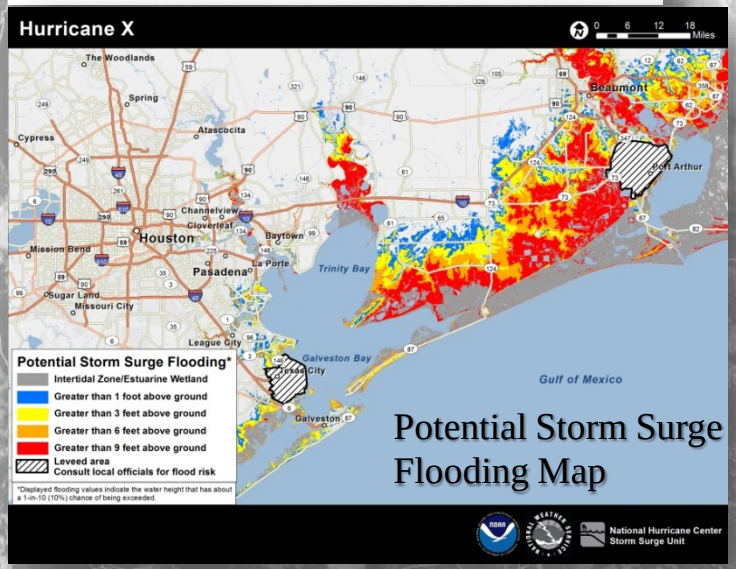
➢ Develop real-time products, services, and warnings similar to those for CONUS

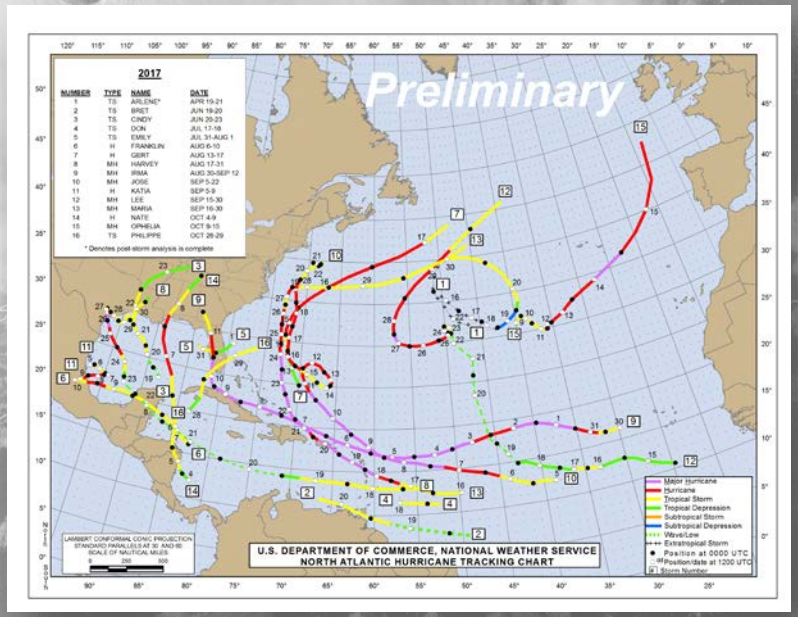


# Develop real-time products, services, and warnings similar to those for CONUS




Example: Maria (2017) highlights the need for consistency in real-time products and services for OCONUS



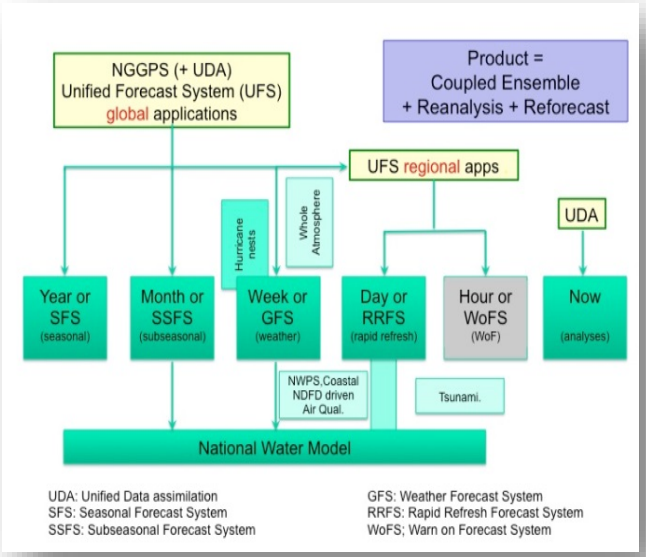



# 3. Long-Term Storm Surge Vision (5-10 years)

## P-Surge

- Short-term oper needs (OCONUS, waves, meteorological drivers)
- P-Surge code optimization
- Increase lead times from 2 to 3 days
- Incorporation of 2013-2017 track and intensity statistics; extensive validation; establish 3-5 year baseline
- Evolve to an atmospheric dynamically-driven wind model
- Develop fully dynamical ensembles for P-Surge
- Address axisymmetric wind structure in the SLOSH model
- Inclusion of waves

**Complete extensive validation**




**High-level Unified Production Suite**

## HSOFS

- Initiate feasibility study; Establish metrics; Perform validation
- ADCIRC code optimization
- Increase number of ensembles to account for along-track, structure, and intensity
- On-demand capability to submit / execute ensembles
- HSOFS in AWIPS II / SBN
- Adaptive gridding structure
- Coupling of HSOFS with WAVEWATCH III and National Water Model

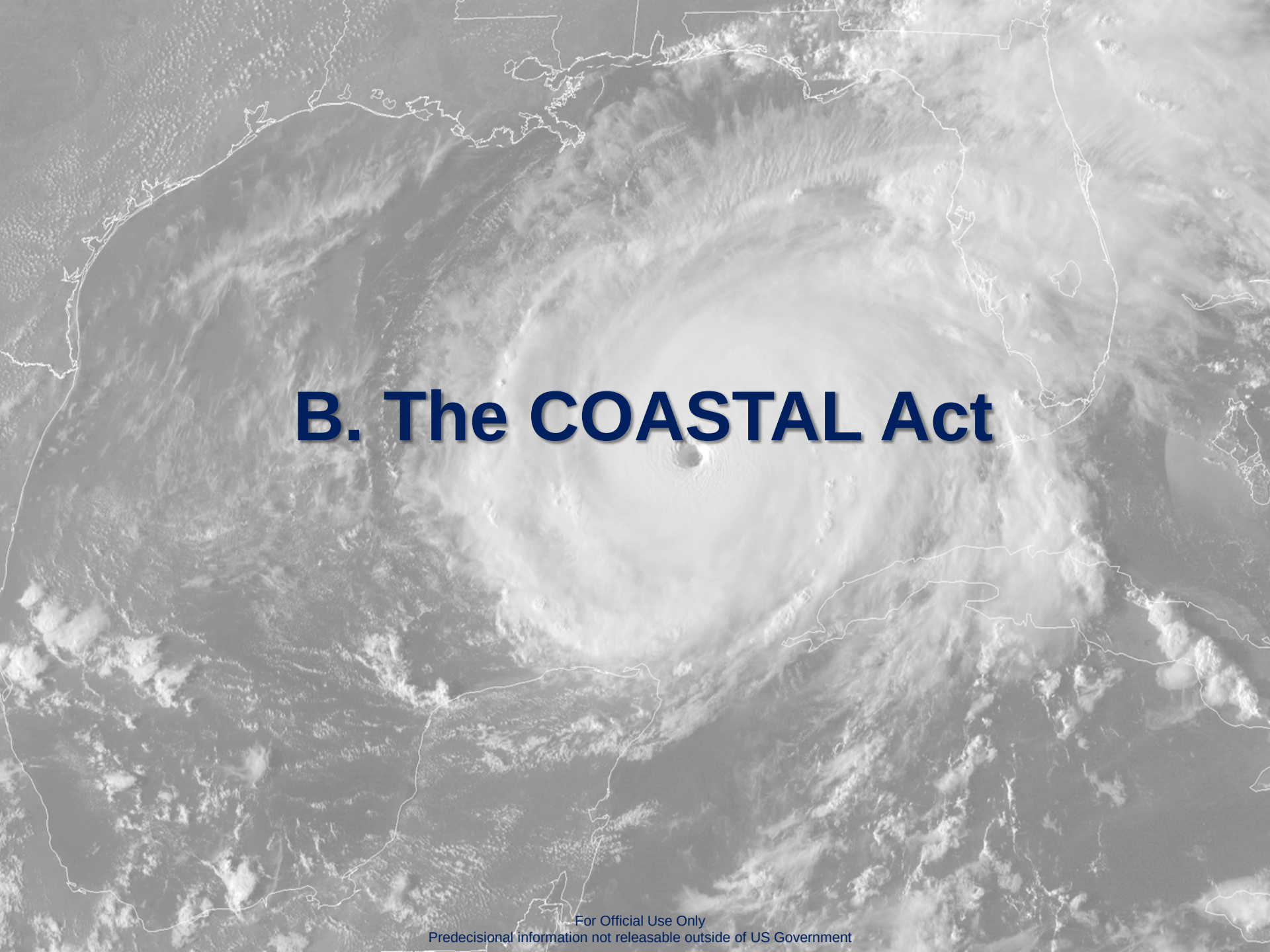
**Feasibility study; Validation**

**Decision Points:**

(1) **Operational forecasts model(s):**

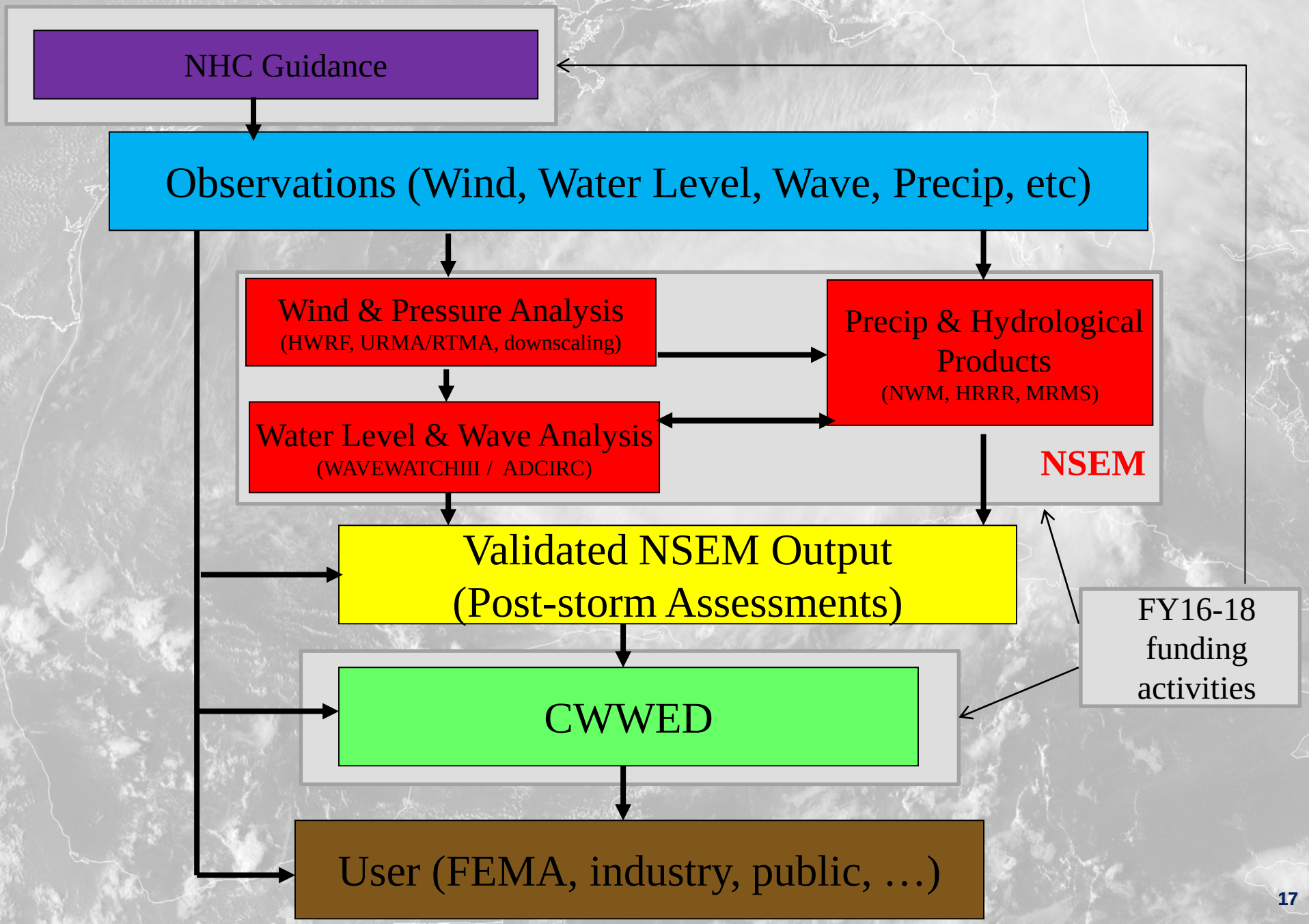
- P-Surge (PETSS, when applicable)
- HSOFS
- Multi-model ensemble based on HSOFS and P-Surge

(2) **Hindcasts**, to support post-storm assessments and response/recovery: HSOFS likely to replace SLOSH-based models



# B. The COASTAL Act

# COASTAL Act Process



# FY16-18-Funded COASTAL Act Activities

**Sub-Project 2:** Development of improved and updated seamless digital elevation models (**DEMs**), used in retrospective hurricane and storm surge models.

**Sub-Project 3: Coupling of wave (WAVEWATCH III – WW3) and storm surge (ADCIRC) models**.

**Sub-Project 4**: Testing with **improved scalability of WW3 for very high resolution domains** to develop accurate simulations of total inundation.

**Sub-Project 5: Develop updated surge/wave grid along the Atlantic and Gulf Coasts** by refining to nearshore and overland regions, updating levees and structures, incorporating latest bathymetry/topography.

**Sub-Project 6: Validation studies** on high-resolution inundation grids; collection of water level and accurate wind data; skill assessment techniques will be employed for hurricane hindcast simulations; testing/revising of storm surge model; resolution requirements analysis.

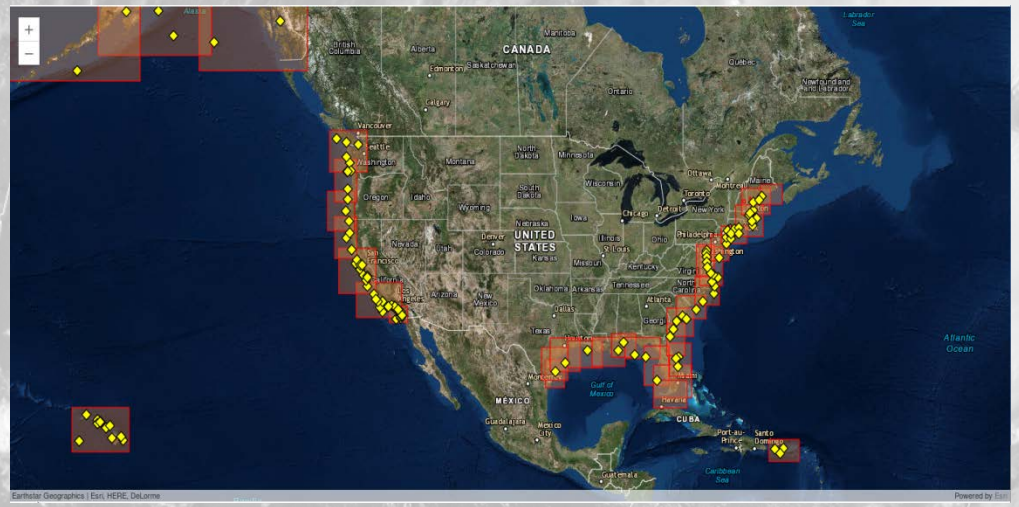
**Sub-Project 10:** Develop model infrastructure to **couple freshwater** (NWM) **and coasta**l (ADCIRC) processes for named storm event simulation.

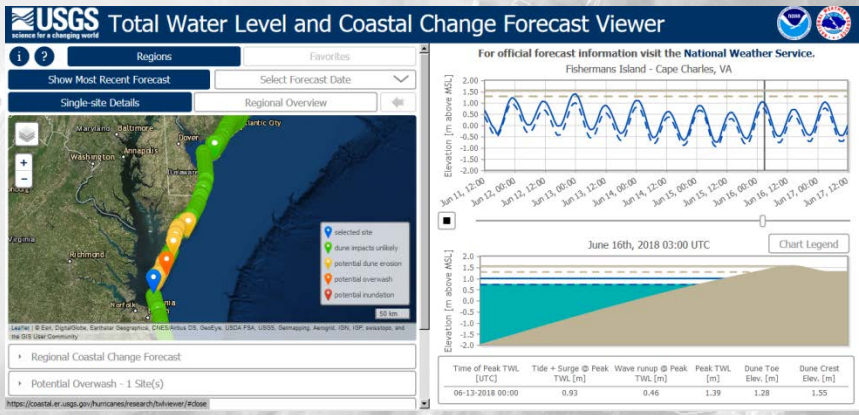
# C. Hurricane Supplemental

# Hurricane Supplemental

## Goal 1: Extend coupled hurricane model to surge, hydrology, waves and inundation

- HSOFS in AWIPS II / SBN
- NWPS unstructured grids to advance TWL




## Goal 2: Extend storm surge forecast lead times to 3 days with same skill as 2-day

PETSS basin development for post-tropical storms

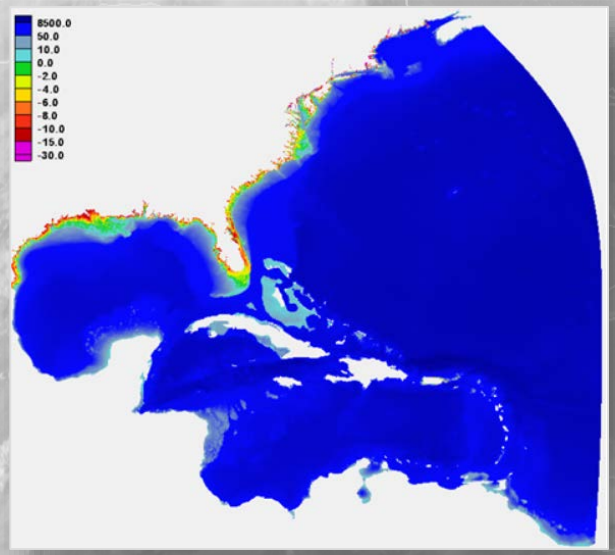
# Hurricane Supplemental

## Goal 3: Accelerated storm surge model upgrades for OCONUS

- Development of HSOFS for Micronesia, OCONUS


## Goal 4: Accelerate development of ensembles

- Model-agnostic ensemble feasibility study
- HSOFS ensemble hindcast enhancements



# Summary

**Goal 1: Extend coupled hurricane model to surge, hydrology, waves and inundation**

- Wave Surge Coupling (EMC)
- Numerical developments of the WAVEWATCH III model (EMC/USACE)
- Validation of a Coupled ADCIRC – WAVEWATCH III modeling system (NOS)
- Development of an Updated Surge/Wave Grid to be used for NSEMs along the Atlantic and Gulf (NOS)
- Seamless bathy/topo digital elevation models supporting surge and inundation modeling (NCEI)
- OWP support of COASTAL Act Named Storm Event Modeling (NSEM) requirements (OWP)
- HSOFS in AWIPS II / SBN (STI/NOS)
- NWPS unstructured grids to advance TWL (EMC)

**Goal 2: Extend storm surge forecast lead times to 3 days with same skill as 2-day**

- Update wind forcing for P-Surge (NHC)
- Validation/analysis (NHC)
- PETSS basin development for post-tropical storms (MDL)

# Summary (cont'd)

**Goal 3: Accelerated storm surge model upgrades for OCONUS** (Guam, American Samoa, S. California)

- Add wave capability to Psurge (NHC)
- Psurge optimization to support P-Surge + waves in OCONUS (Guam, American Samoa, S. California) (NHC, MDL)
- SLOSH grids/MOMs/MEOWS OCONUS (Guam, American Samoa, S. California) (NHC)
- Development of HSOFS for Micronesia, OCONUS (NOS, EMC)

**Goal 4: Accelerate development of ensembles**

- Model-agnostic ensemble feasibility study (RFP; TBD)
- HSOFS ensemble hindcast enhancements (NOS)

**Goal 5: Seamless Storm Surge Guidance/Products (Tropical/Post-Tropical)**

- Seamless Inundation Graphic (Tropical/Post-Tropical/Sub-Tropical) (NHC)
- Seamless storm surge watch / warning (Tropical / Post-Tropical/Sub-Tropical) (NHC)
- PETSS development (MDL)
- Extend ETSS EC basin (MDL)

# Thank you!