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

Annual HFIP Meeting
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NWS Office of Science and Technology Integration
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.
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.

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
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.
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

**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

**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

**High-level Unified Production Suite**
- Complete extensive validation
- Feasibility study; Validation
B. The COASTAL Act
COASTAL Act Process

Observations (Wind, Water Level, Wave, Precip, etc)

Wind & Pressure Analysis (HWRF, URMA/RTMA, downscaling)

Water Level & Wave Analysis (WAVEWATCHIII / ADCIRC)

Precip & Hydrological Products (NWM, HRRR, MRMS)

Validated NSEM Output (Post-storm Assessments)

CWWED

User (FEMA, industry, public, …)

NSEM

FY16-18 funding activities

NHC Guidance
Sub-Project 2: Development of improved and updated seamless digital elevation models (DEM$s$), 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 coastal (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

![Map showing NOS Tide & Surge Guidance Domains with regions ESTOFS-PAC, ESTOFS-ATL, HSOFS-ATL, NSEM, and ESTOFS-MIC]

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)
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!