

An Operational Forecast Model for Coastal Water Levels



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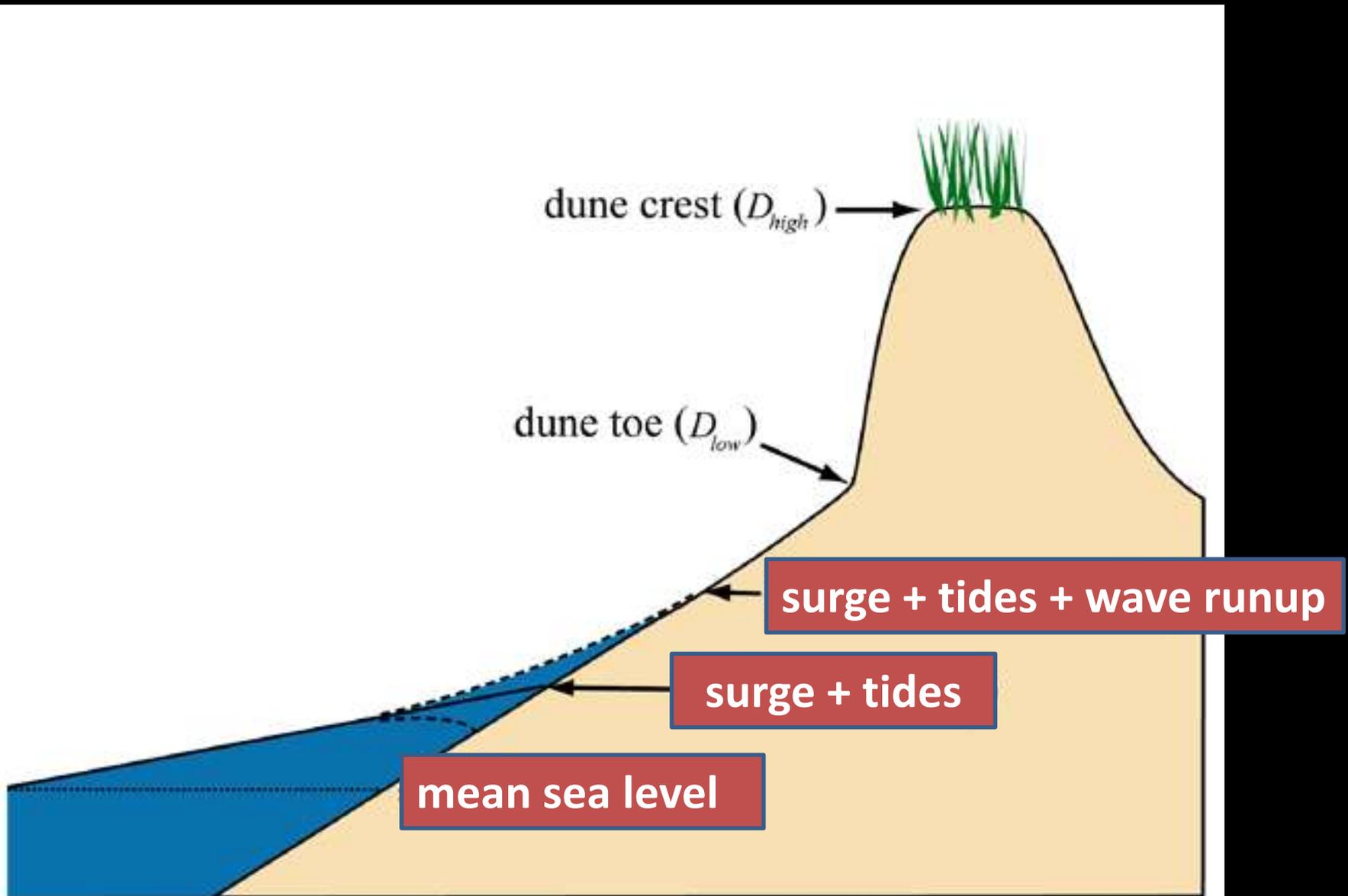
Jenna Brown¹

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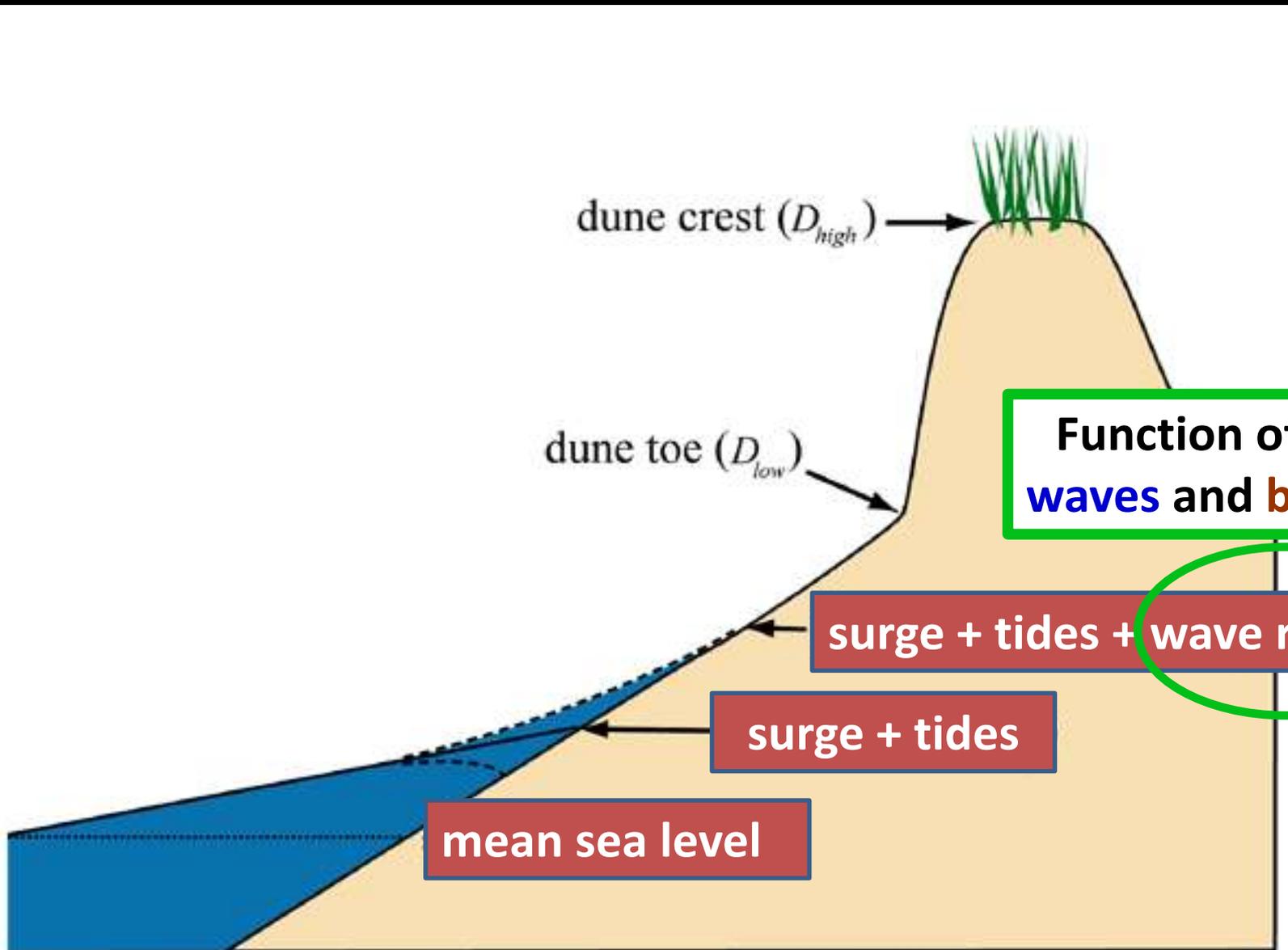
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Components of Coastal Water Levels



Components of Coastal Water Levels



*Kitty Hawk, NC
April 17, 2016*



surge + tides + wave runup

*Kitty Hawk, NC
April 17, 2016*

Wave-driven water levels are important drivers of coastal change and can impact ecosystem function

----- BUT -----

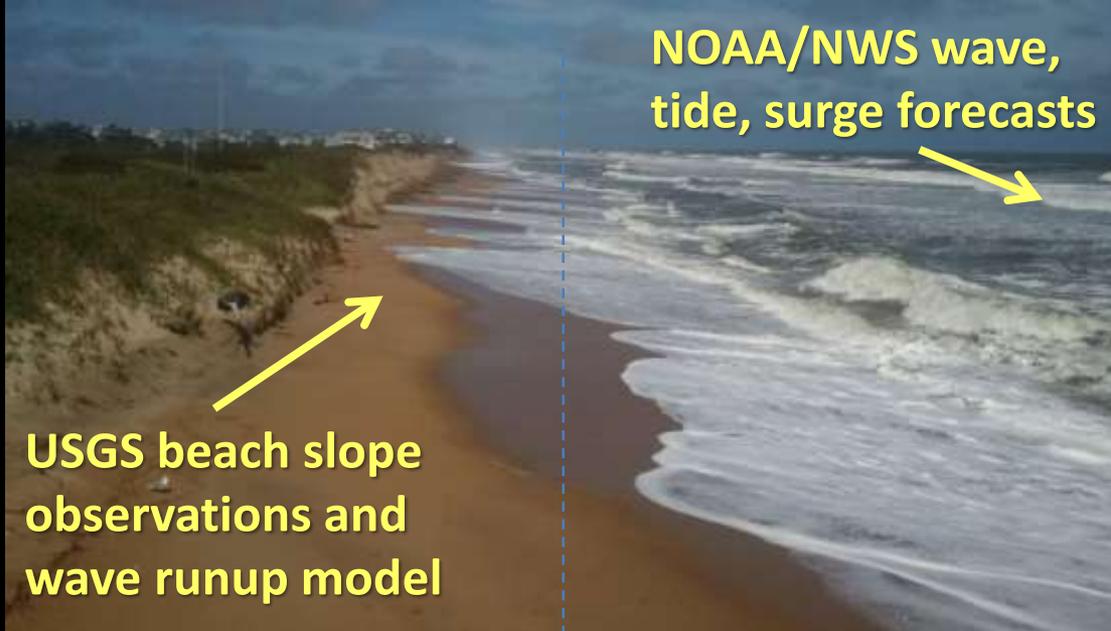
Existing operational models of coastal water levels do not forecast wave runup

Objective

Combine capabilities and expertise of USGS and NOAA/NWS/NCEP to develop an operational forecast for total water levels along the coast.

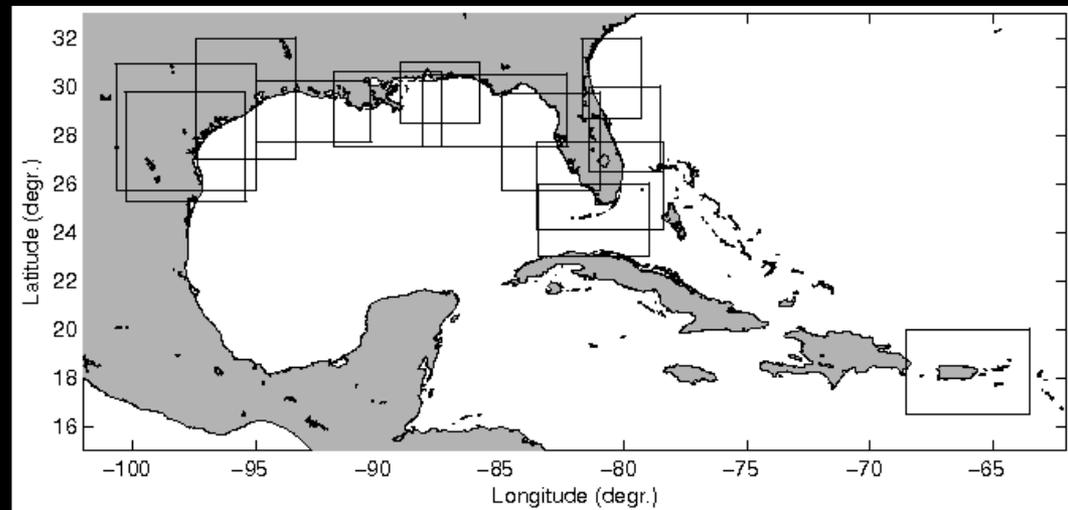
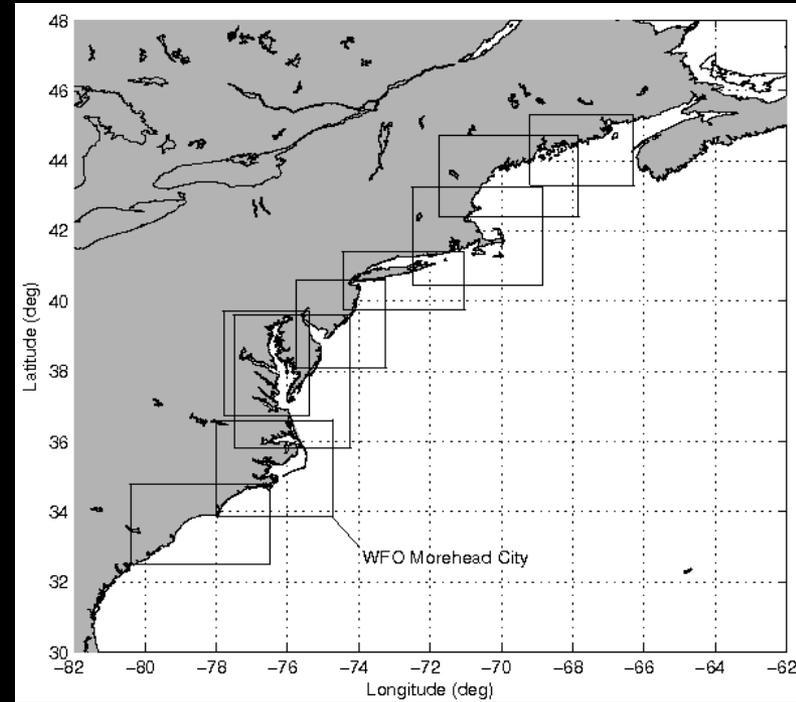
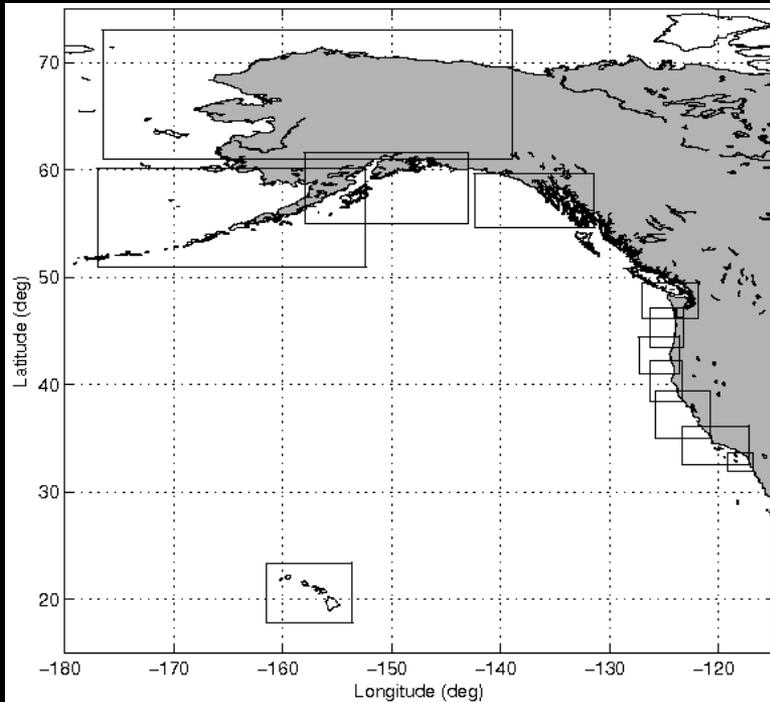
Outcomes/Benefits:

- Increase reliability of coastal hazard forecasts
- Predict the magnitude and timing of tides, surge, and wave runup
- Provide operational guidance that includes extratropical and tropical events



- Process-based & parameterized wave runup models
- Observations of beach slope, slope variability, topographic features
- Remote sensing expertise to measure wave runup
- Development of Nearshore Wave Prediction System and centralized computing infrastructure
- Operational forecasts and observations of waves, tides, surge
- Lines of communication with local emergency managers

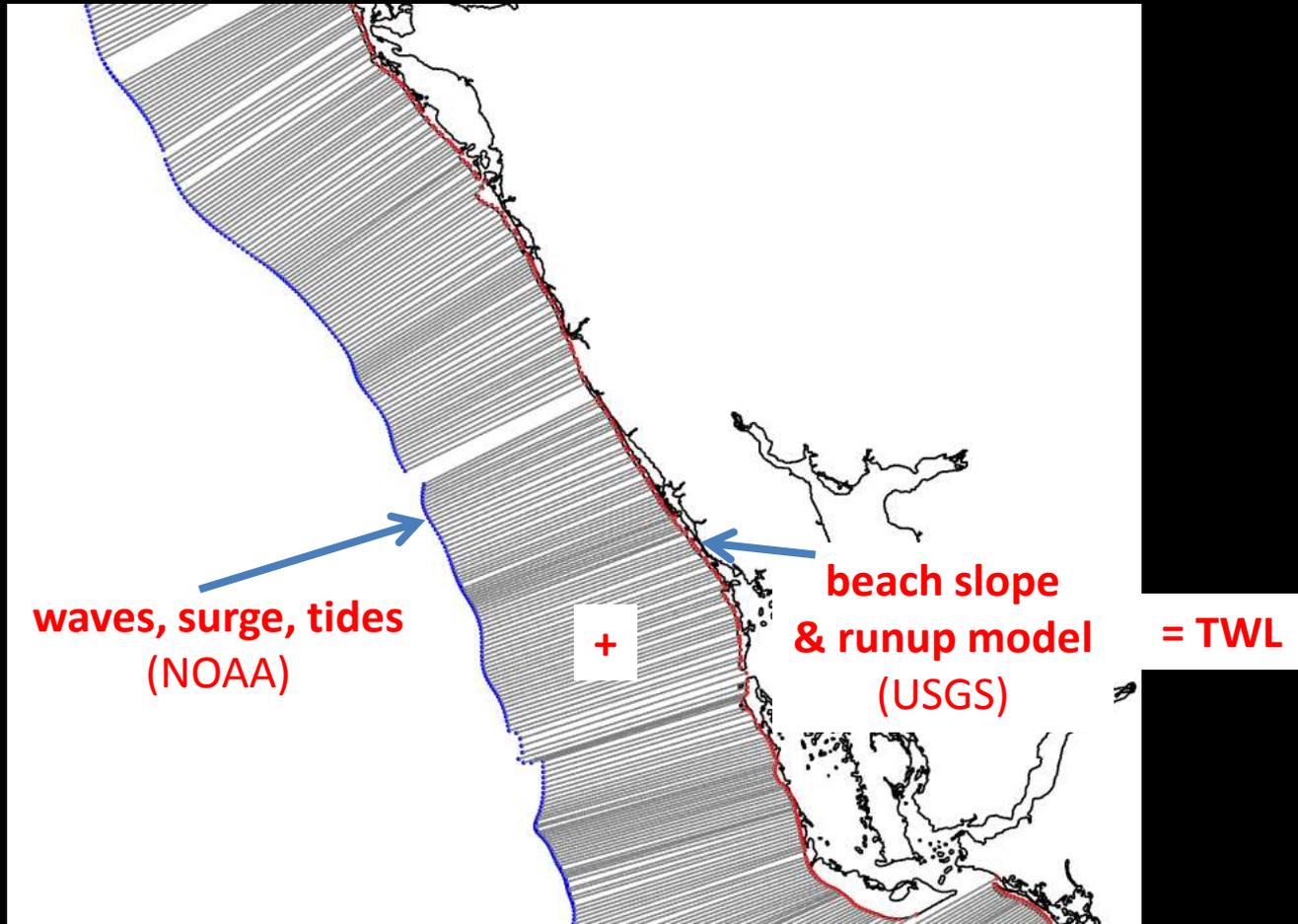
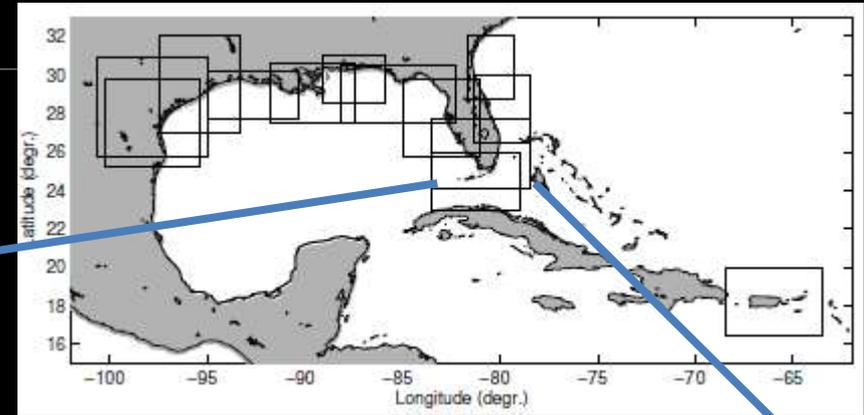
Local Knowledge, Better Forecasts



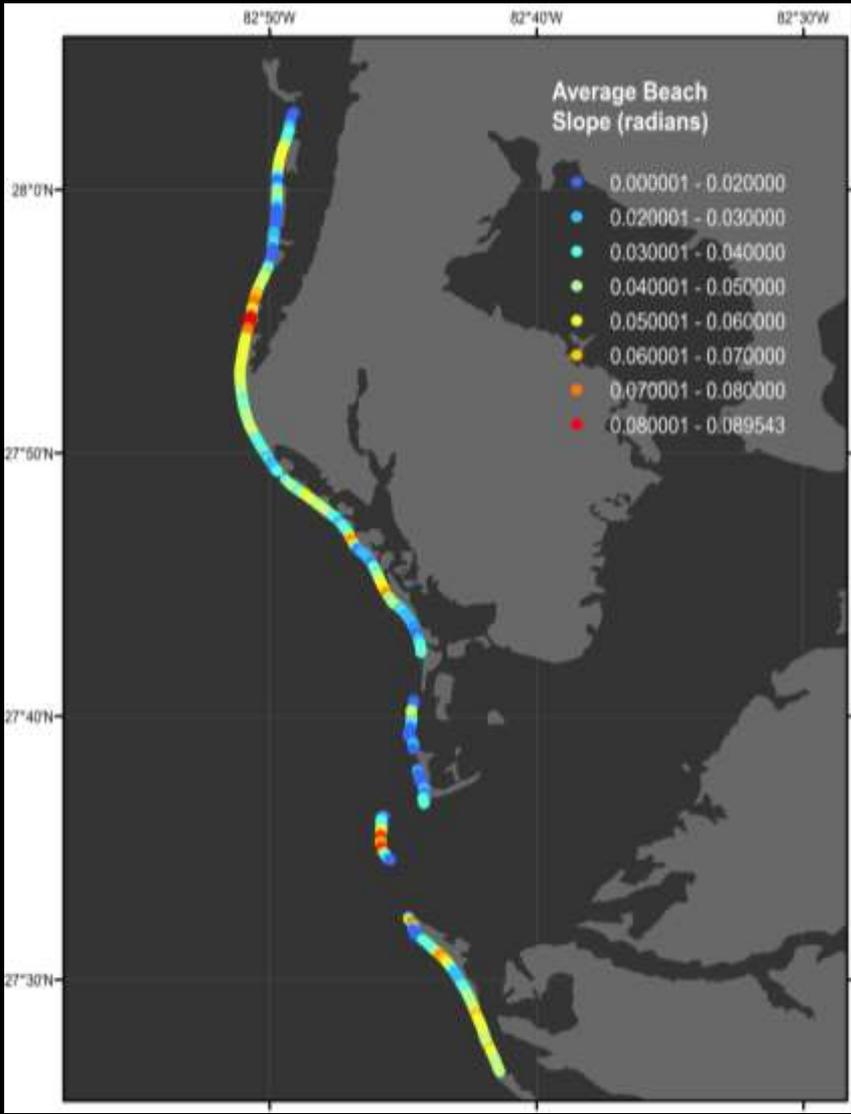
- 36 coastal Weather Forecast Offices (WFO).
- Meteorologists in each WFO prepare wave & surge model inputs - submit to centralized computer.

Automated Approach

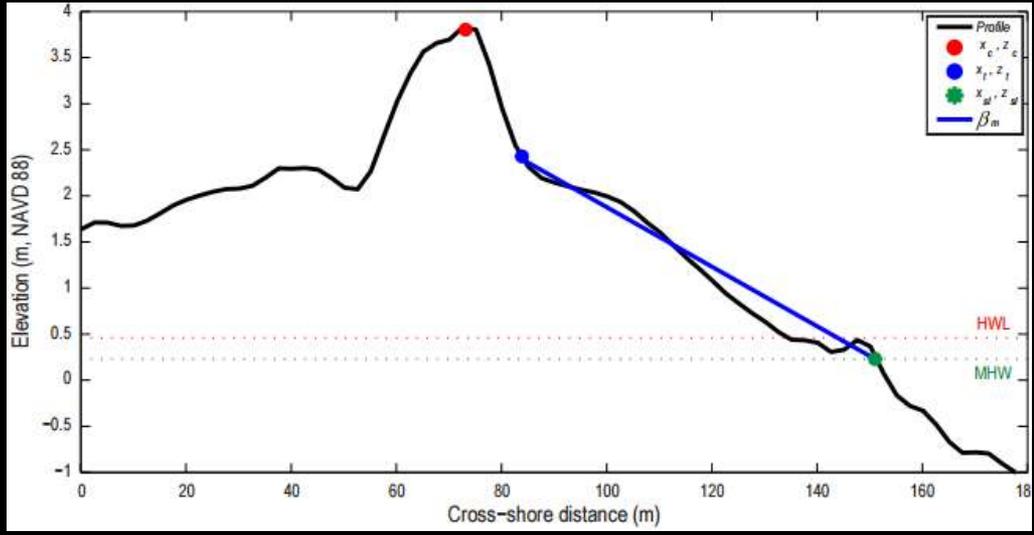
- Wave runup model & beach slope data is housed on the NWS centralized computing infrastructure



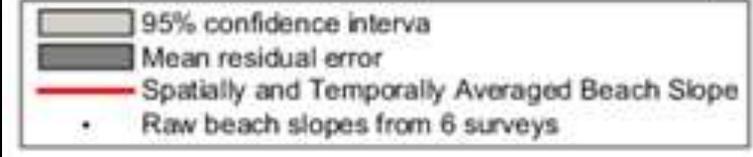
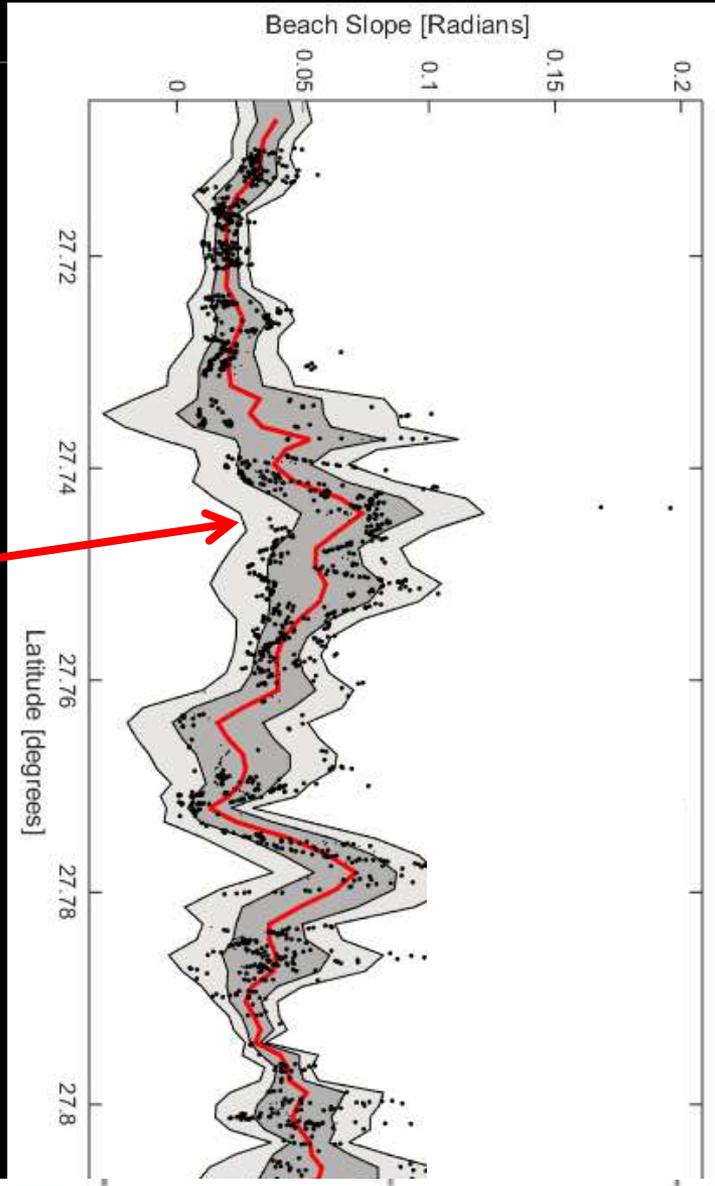
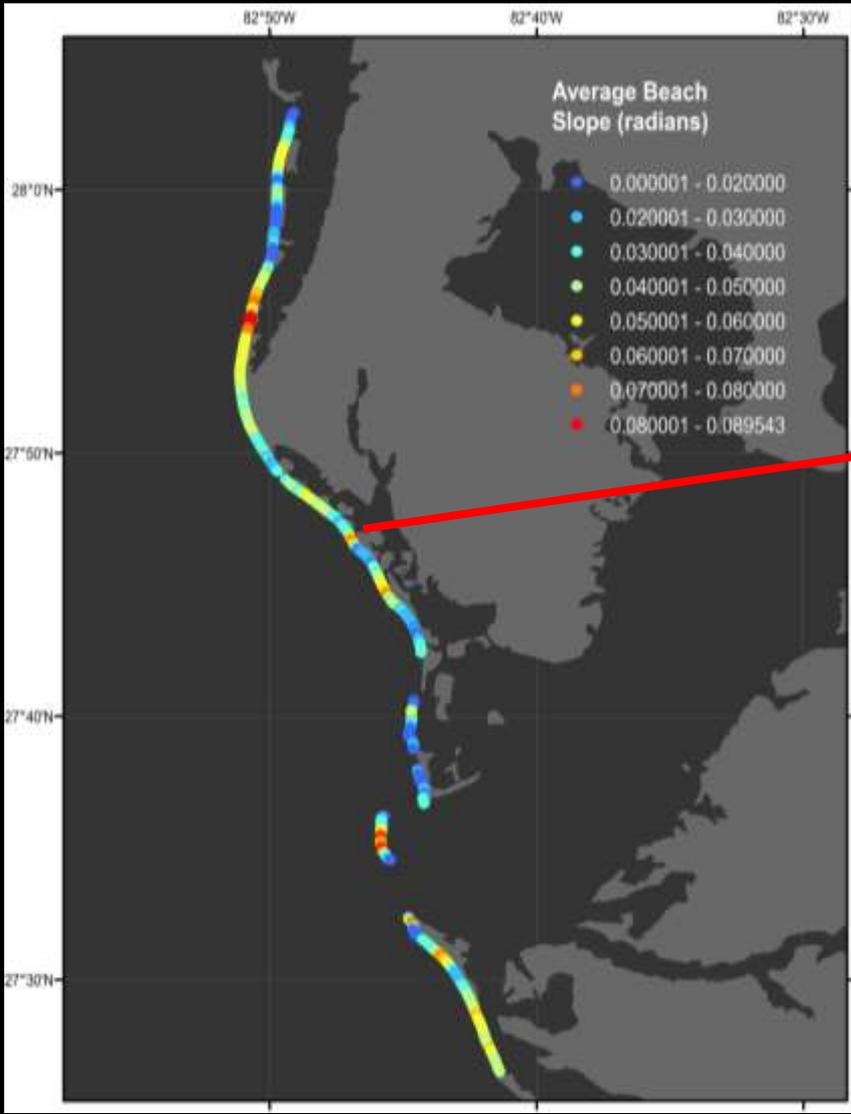
Beach slope input:

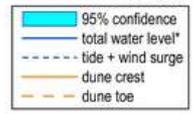
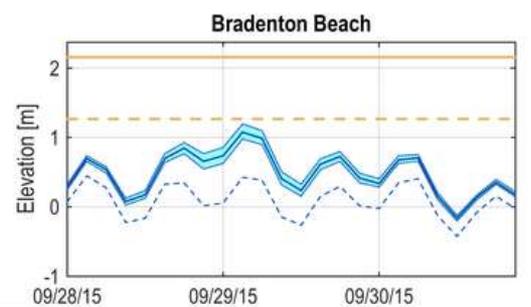
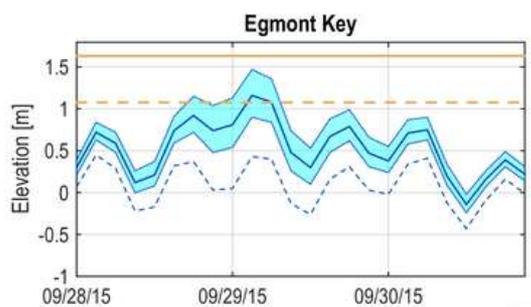
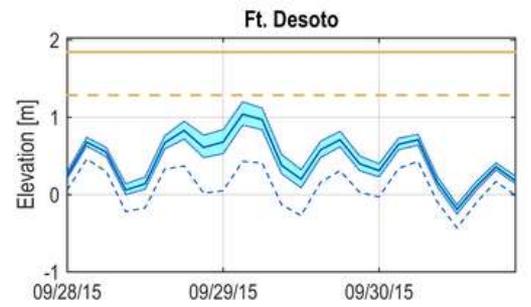
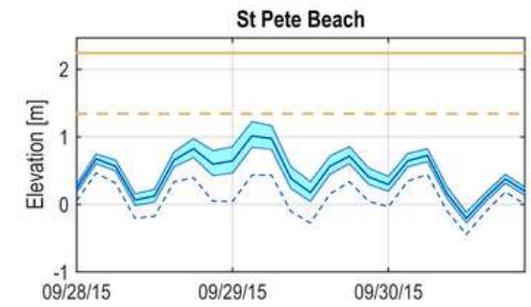
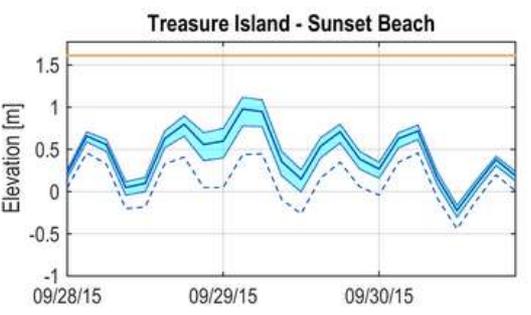
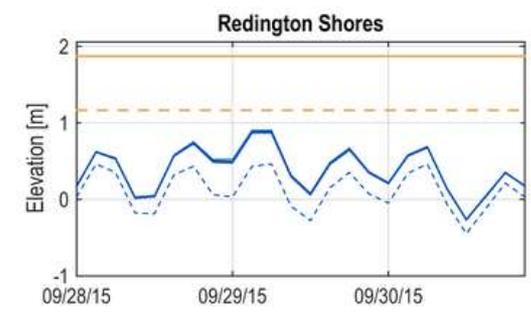
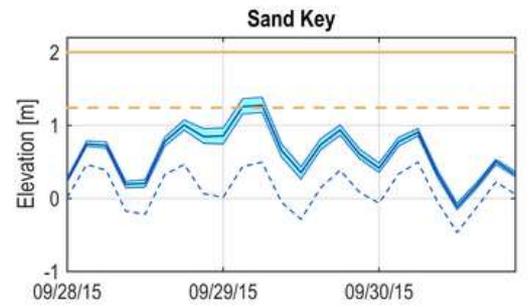
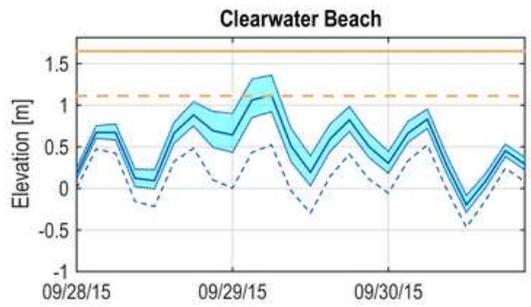


- Define a mean beach slope based on historical surveys
- Quantify spatial and temporal variability



Spatial and Temporal Variability:

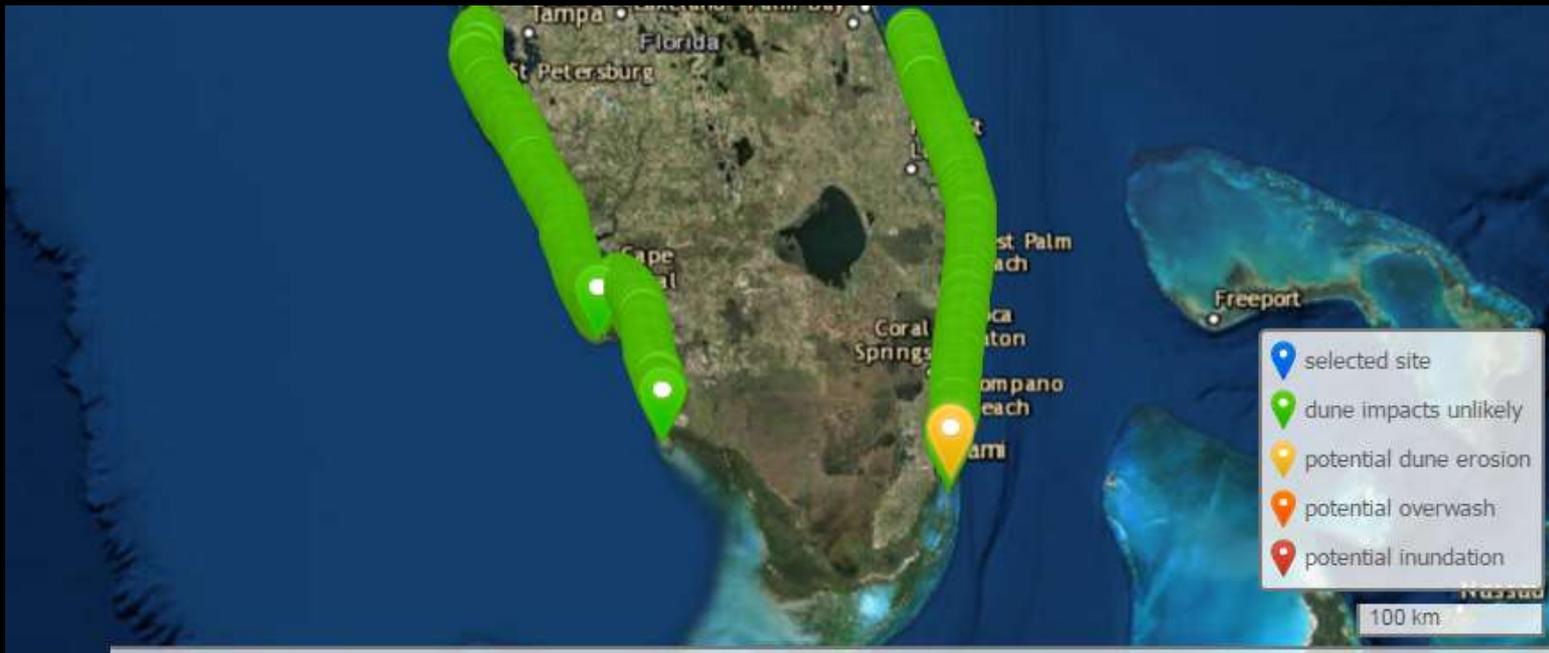




*includes tides, wind surge, and wave runoff

Forecast Dissemination:

- Forecasts are available on internal NWS systems and integrated into local warnings, watches, and advisories
- USGS public-facing viewer that provides:
 - Visualization of forecasts
 - Timing and magnitude of peak water levels
 - Time and duration of coastal change hazards (dune erosion, overwash)



Forecast Dissemination:



Total Water Level and Coastal Change Forecast Viewer



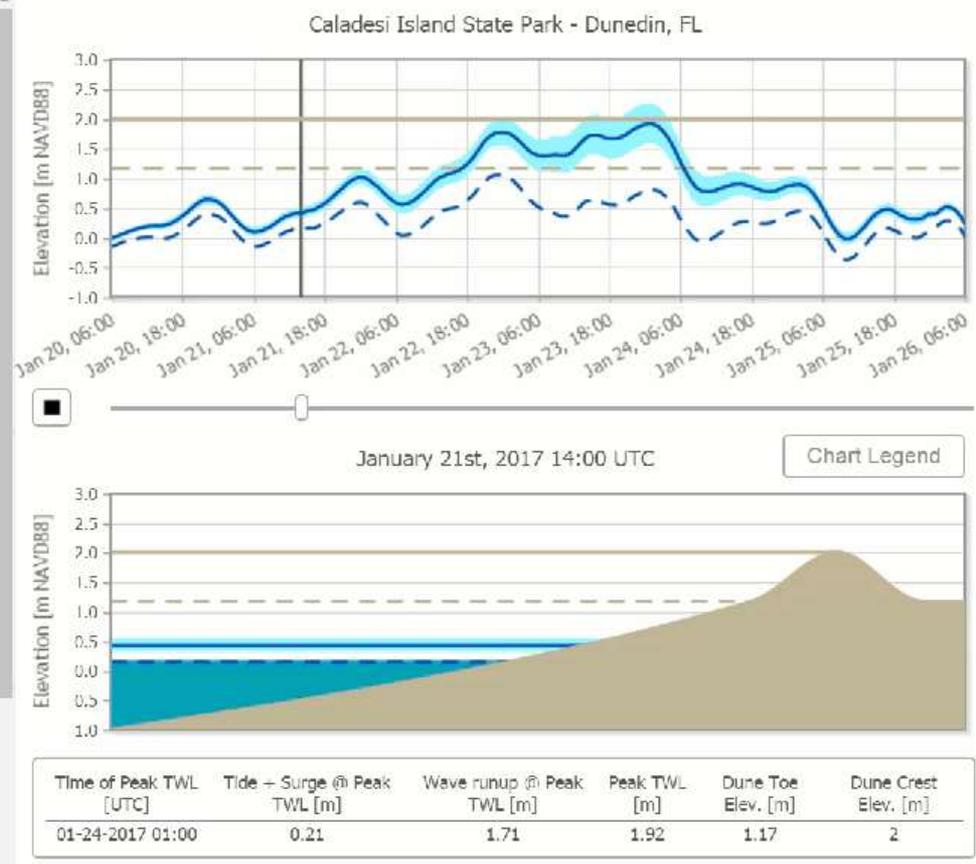
Regions Favorites

Show Most Recent Forecast Select Forecast Date

Regional Coastal Change Forecast

Potential Overwash - 10 Site(s)

| Region | Site ID | Forecast Begins [UTC] | Forecast Duration [hours] | Collision Duration [hours] | Overwash Duration [hours] | Inundation Duration [hours] |
|--------|---------|-----------------------|---------------------------|----------------------------|---------------------------|-----------------------------|
| TBW | 224 | 01-20-2017 06:00 | 144 | 31 | 2 | 0 |
| TBW | 225 | 01-20-2017 06:00 | 144 | 38 | 10 | 0 |
| TBW | 226 | 01-20-2017 06:00 | 144 | 39 | 18 | 0 |
| TBW | 227 | 01-20-2017 06:00 | 144 | 38 | 8 | 0 |
| TBW | 242 | 01-20-2017 06:00 | 144 | 37 | 4 | 0 |
| TBW | 272 | 01-20-2017 06:00 | 144 | 24 | 4 | 0 |
| TBW | 308 | 01-20-2017 06:00 | 144 | 37 | 4 | 0 |

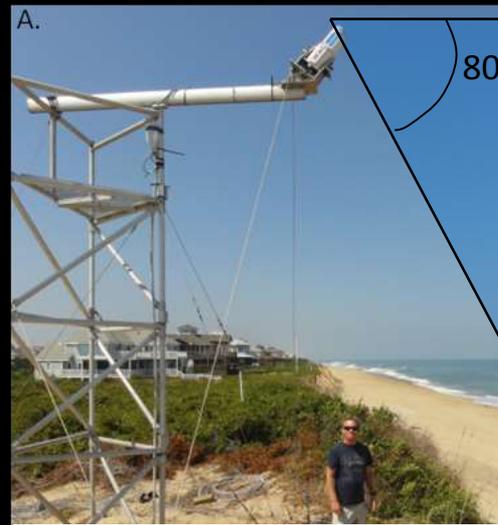


<https://coastal.er.usgs.gov/hurricanes/research/twlvviewer/>

Is the forecast any good?



Validating Total Water Level Forecasts:



Courtesy Kate Brodie, FRF

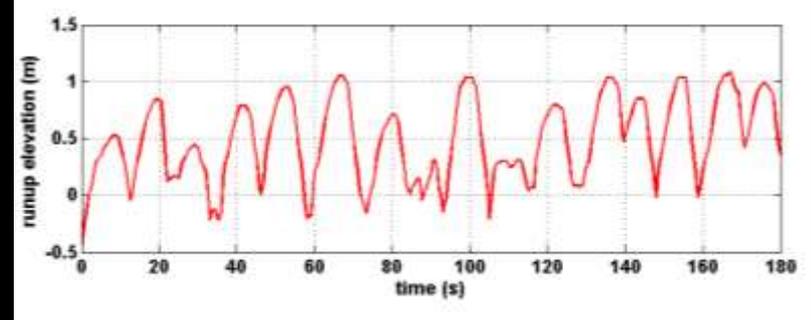
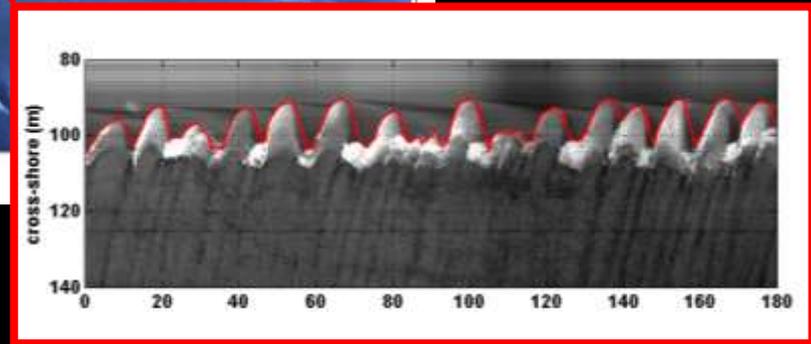
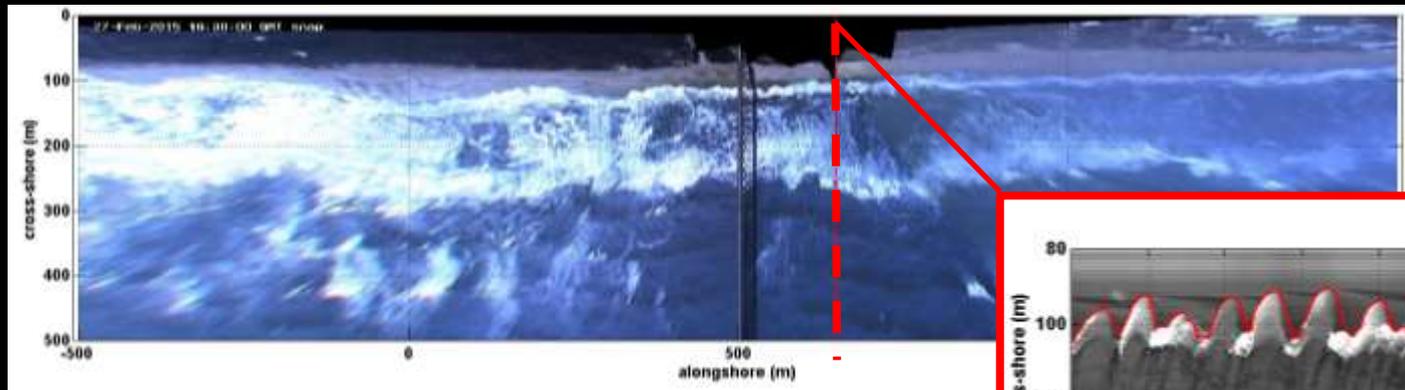
Video and lidar-based remote sensing provide spatially and temporally robust measurements of where water levels intersect the coast.

Validating Total Water Level Forecasts:

- Using elevated and ground-based sensors to track water levels on hourly timescales.

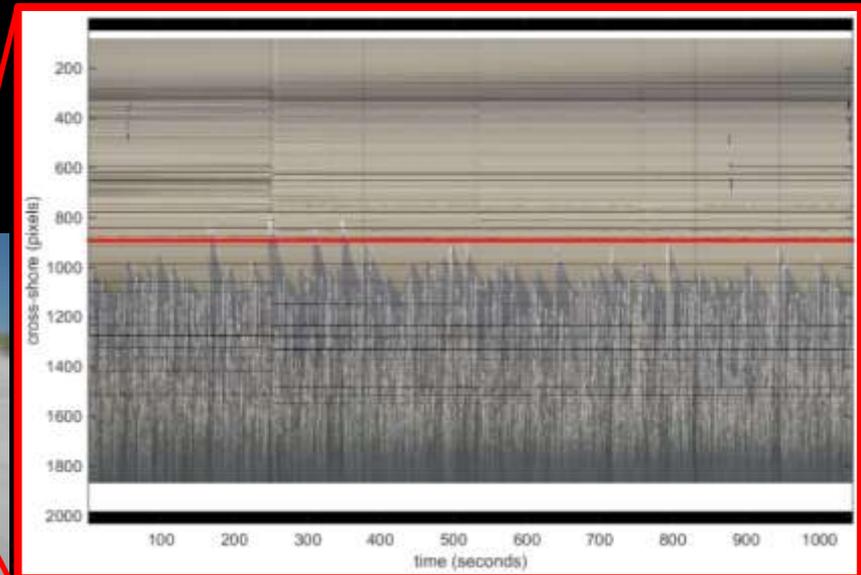


US Army Corps
of Engineers®



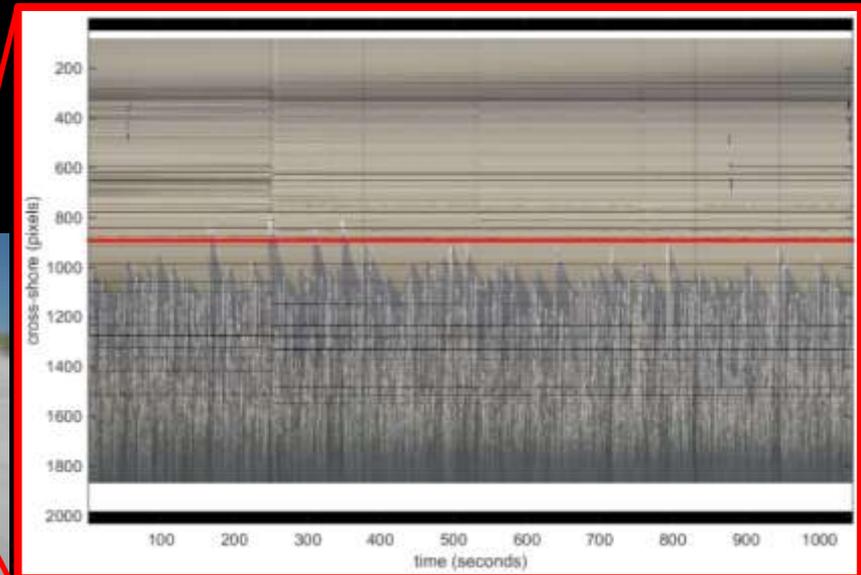
Validating Total Water Level Forecasts:

- Using elevated and ground-based sensors to track water levels on hourly timescales.
- Using both permanent and rapid/temporary sensors.



Validating Total Water Level Forecasts:

- Using elevated and ground-based sensors to track water levels on hourly timescales.
- Using both permanent and rapid/temporary sensors.
- Currently evaluating 2 locations in Outer Banks, North Carolina and 2 locations in Tampa Bay, Florida

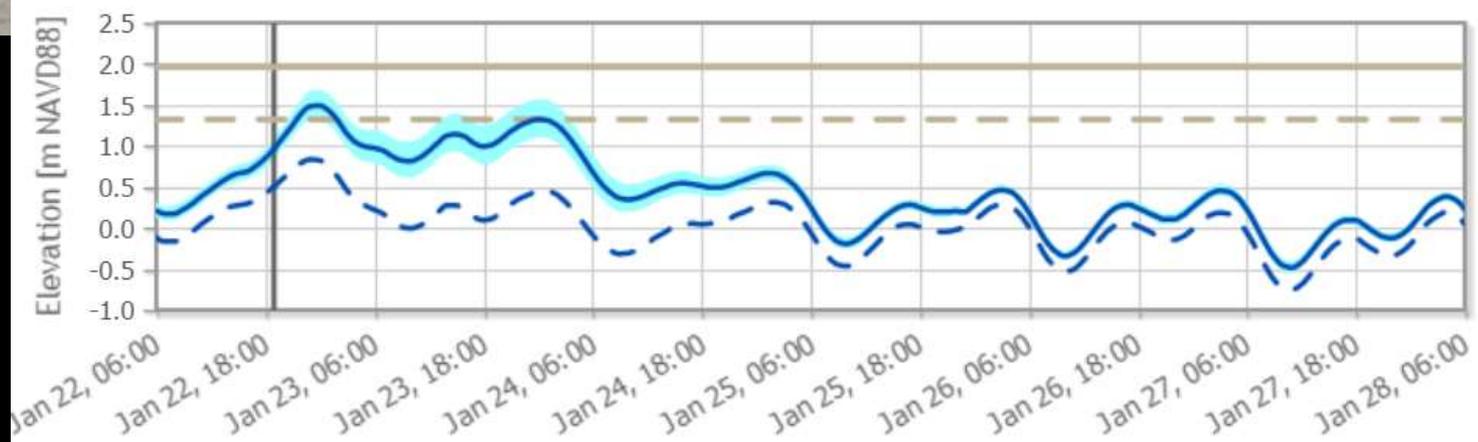


Example Tampa Bay Video Data:

January 22, 2017



Moon Park - Redington Beach, FL

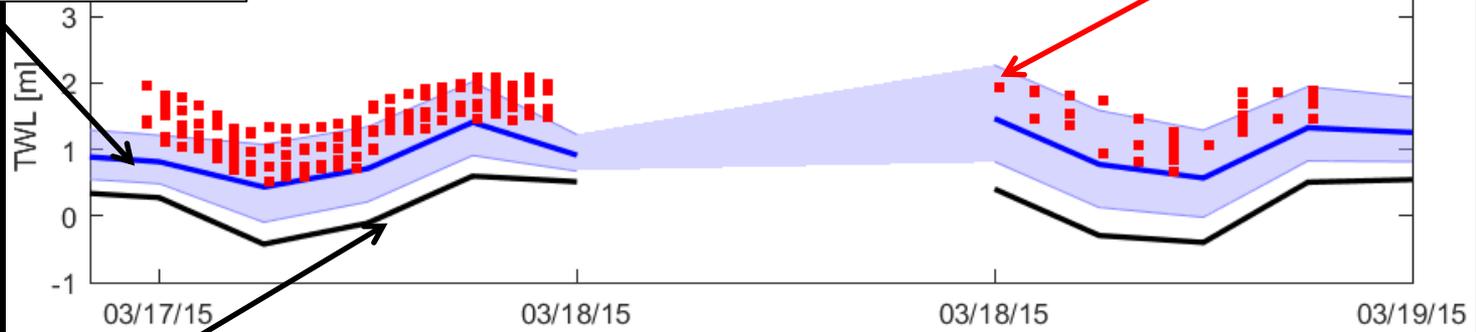


Preliminary Validation:

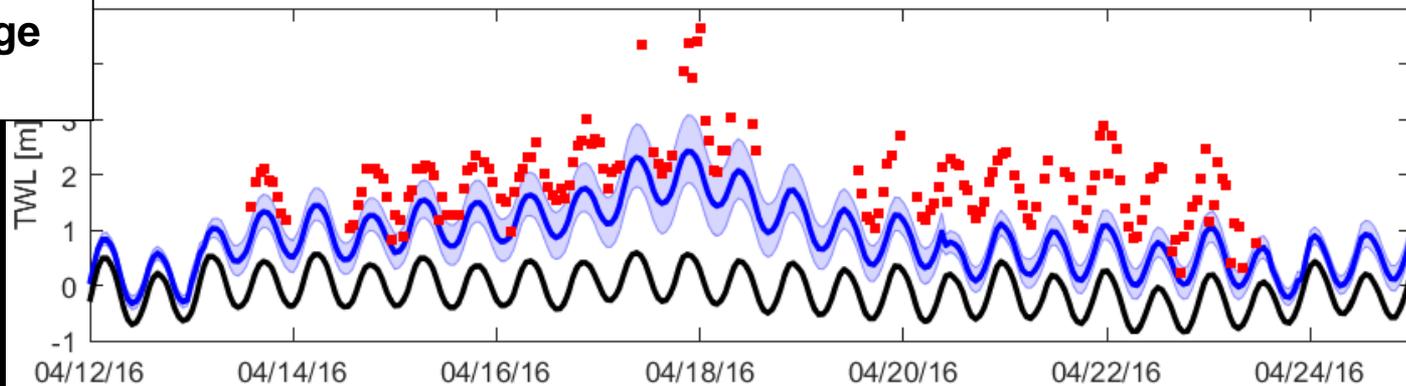
WFO Morehead City

Tides + wind surge +
wave runup

observations



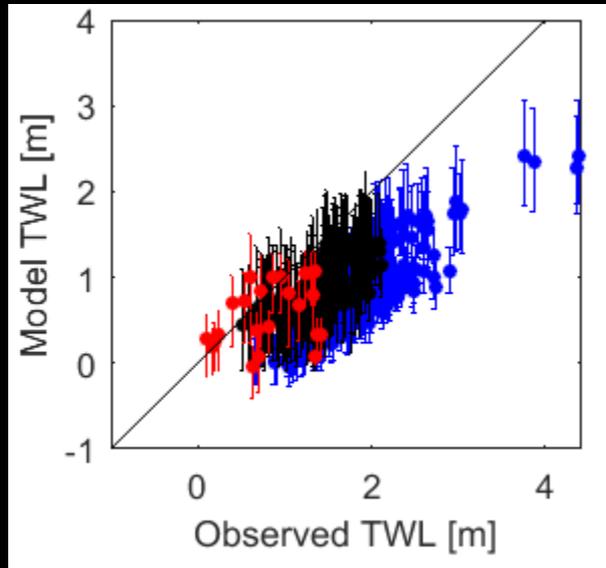
Tides &
wind surge
ONLY



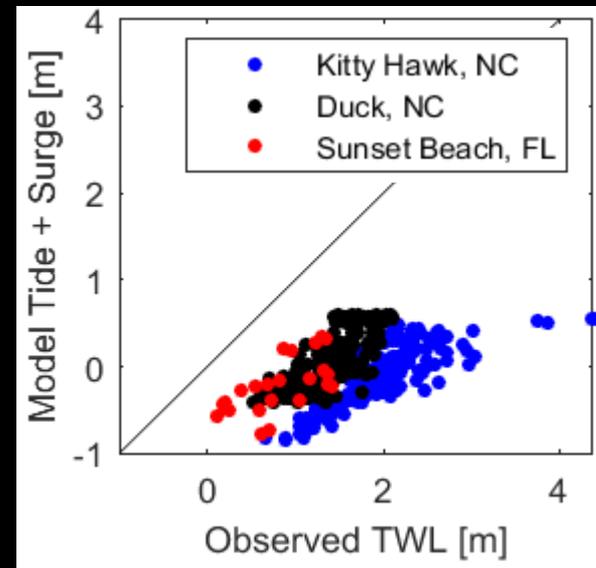
- Can now use these observations to investigate model errors and improvement.
- Total water level predictions at the shoreline improve with the addition of wave runup.

Preliminary Validation:

Tides + surge + wave runup

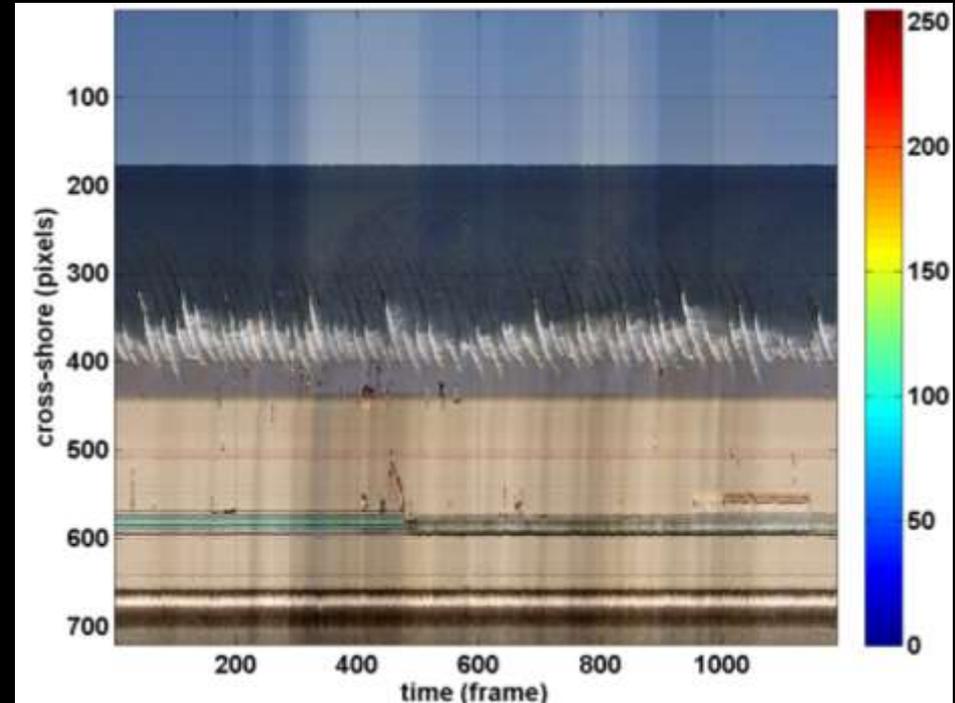


Tides + surge



- Data collected for over 300 hours in 3 different locations.
- In general, the model shows a bias towards underprediction of total water level.
- Total water level predictions based only on tides and surge have significant errors at the coast.

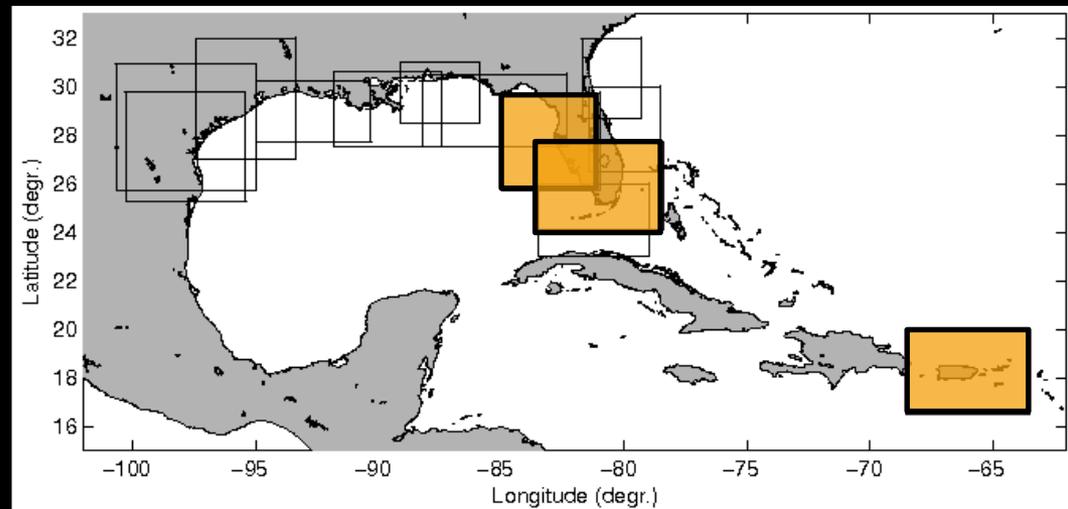
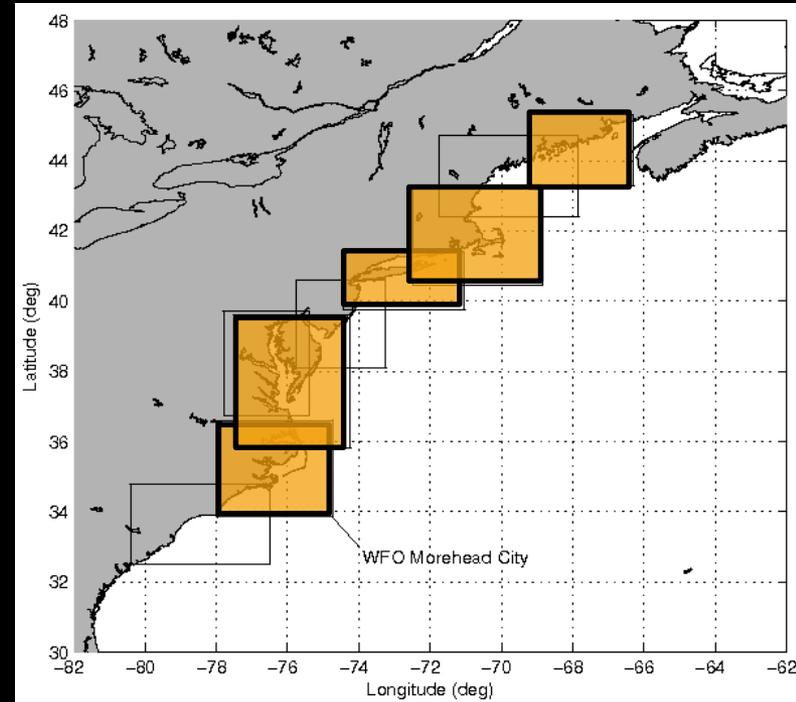
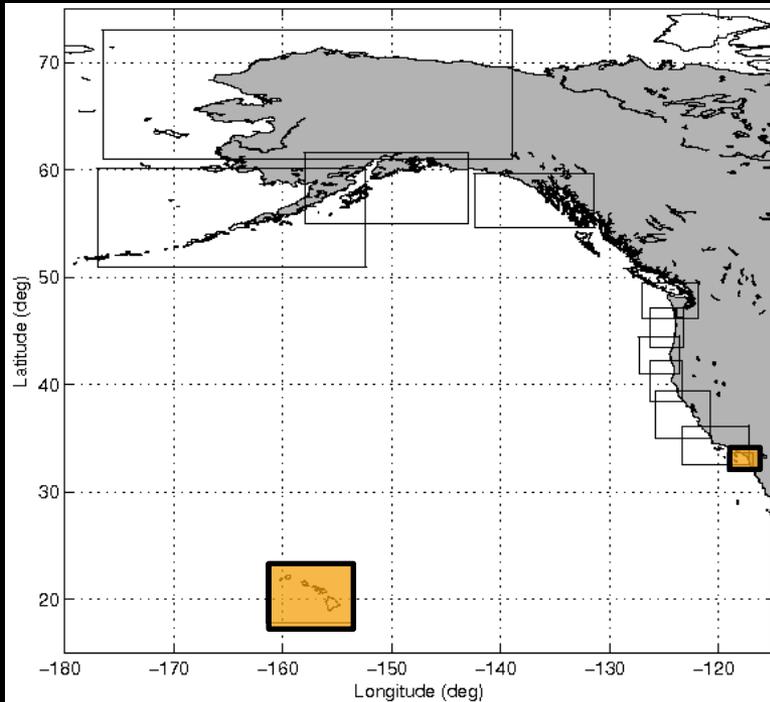
Expanded Validation Sites:



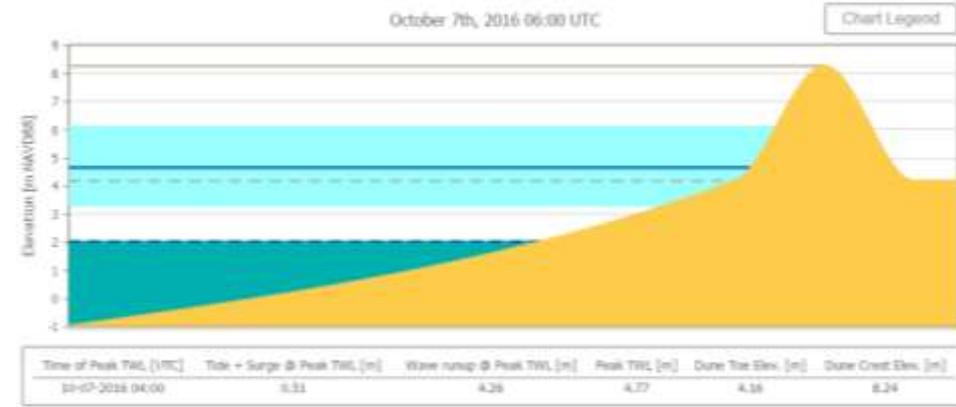
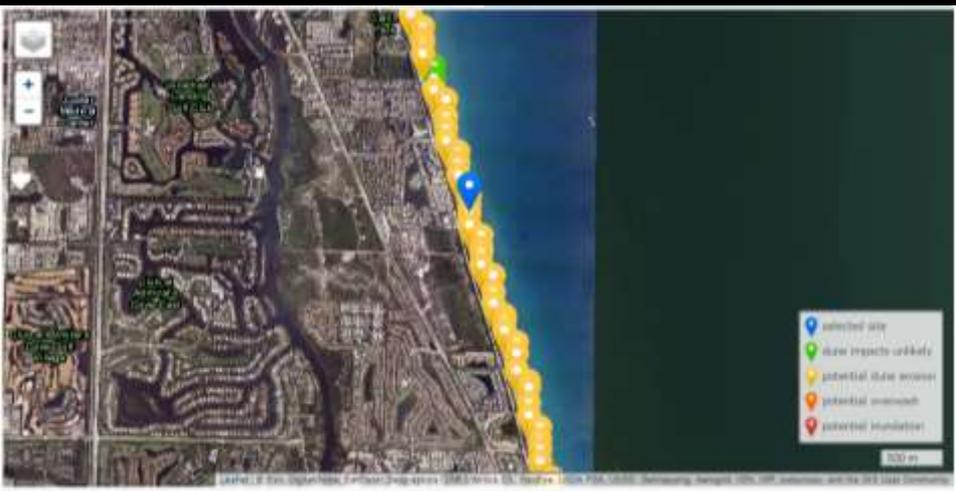
Example analysis of Surfline video data; Mantoloking, NJ

- Recently established a partnership between Surfline and the USGS to use video data collected by existing camera network.
- Will increase the number of validation sites using 'cameras of opportunity' that are already imaging the coast!

Expansion of Forecast Sites:

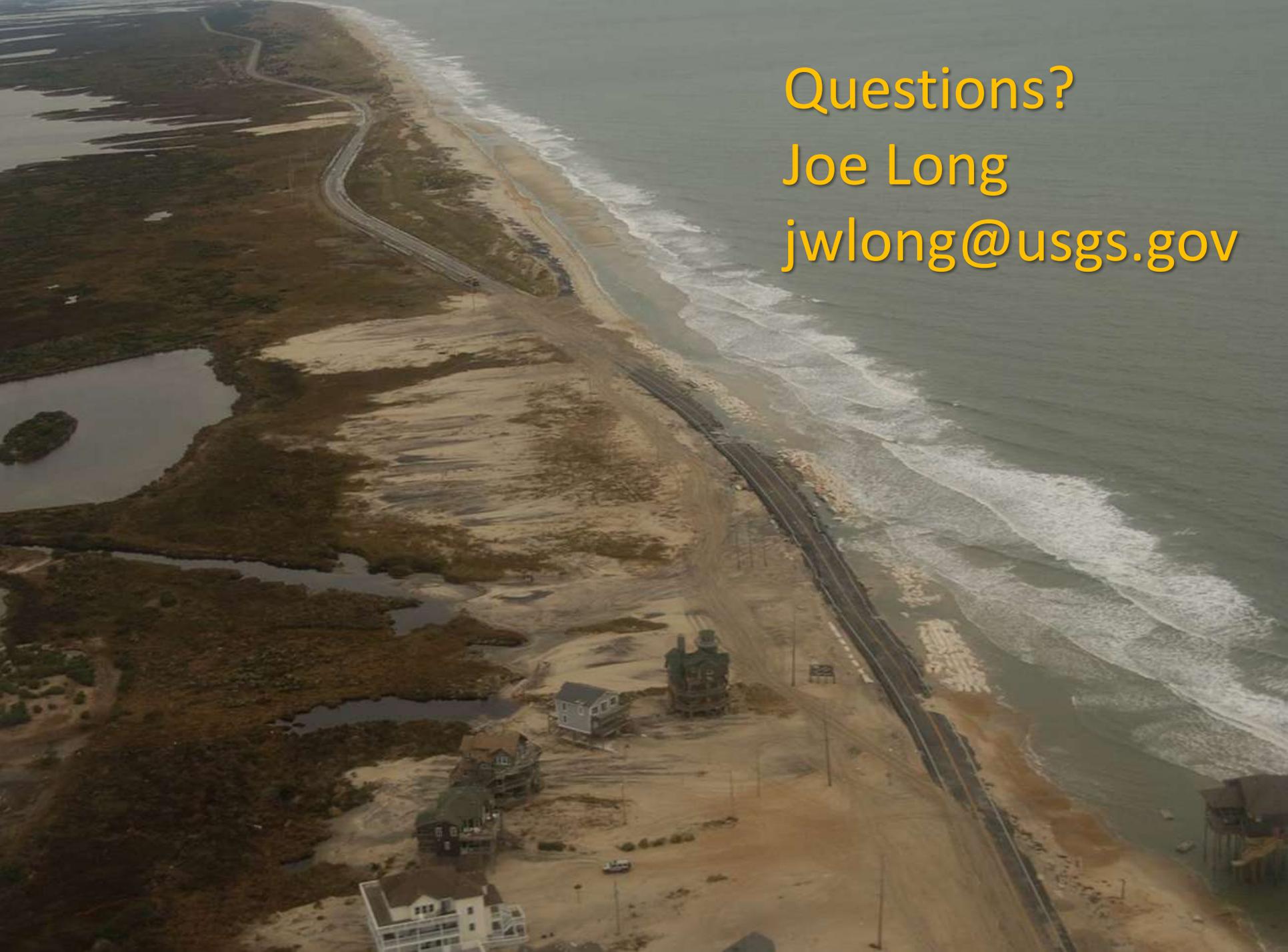


- Started at 5 pilot sites; expansion to 10 of 36 coastal WFOs.
- Use of unstructured grids.
- Incorporating additional wave runup formulations



USGS/NOAA/NWS Wave Runup Forecasts

- Interagency effort providing forecasts every ~1km along the coast.
- Forecasts include combination of tides, wind surge, and **wave runup**.
- Predicts the **magnitude, timing, and duration** of potential water level impacts
- Provides **operational** predictions that can trigger local coastal change warnings for all storm events (tropical, extratropical storms, high tide flooding)
- Fully operational at five pilot sites; methodology designed to **scale nationally**

An aerial photograph of a coastal region. A road runs parallel to the shore, with a railway line just inland from it. The beach is visible between the road and the ocean. To the left of the road, there is a large area of brown, marshy land with several small ponds. In the lower-left quadrant, there are several houses, some of which appear to be damaged or in various stages of construction. The ocean is on the right side of the image, with waves breaking onto the shore.

Questions?
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