

FEMA's Coastal Flood Hazard Analyses in the Atlantic Ocean and Gulf of Mexico

Probabilistic Flood Hazard Assessment – Panel 7

January 31, 2013





Agenda

- Introduction to FEMA's Mission & Coastal Flood Hazard Mapping
- JPM-OS for Storm Surge Modeling in the Atlantic Ocean & Gulf of Mexico
- Areas for Collaboration & Improvement





FEMA & Flood Hazard Mapping

NOTES TO USERS

This map is for use is administering the National Flood Insurance Program. It loses not necessarily identify all areas subject to flooding, particularly from local intrange sources of small size. The community map repeationy should be onsubed for possible updated or adobtional flood hazard information.

To data more distellar information in area where **Base Flood Elevations** (PES) and/or **Breverys** have benchmered users are excussed to consult the Flood Parties and Floodesy. Data and/or Sammay d'Allaket Elevations being cardinale allawing Flood Based (Sam) (Flood Flood Hauconsame Based (Sam) (Floodes) (Floodes) (Floodes) (Floodes) (Floodes) rounde where hot eventions. There BTEs are retended to flood in survice integration and the Accordingly, flood elevation bits presented in the Tits elevation information. Accordingly, flood elevation bits presented in the Tits (Floodes) (Floo

Coastal Ease Flood Elevations shown on this map uppy only landward 0.07 North Avercan Vertical Data of 1988 (BAND BD). Users of this FIRM sho to earer that canadi flood elevations are also graded in the Summary Staward Elevators bale in the Flood Insurance Study report for this unstation Elevators shown in the Summary of Subliver Elevations the shown are construction and/or floodpain management; purposes when they are higher the elevations shown on other FIRM.

Boundaries of the **Receivanty** were computed at cross sections and eterpolat between cross sections. The Bookinayi were lased on hydraulic caraciteritotic with regard to requirements of the National Rocol insurance Program. Ploader wordbis and other pertilement Rocolivity data are provided in the Flood Insuran Study reporting timi jurisdiction.

Cetain areas not in Special Rood Hazard Areas may be protected by field electrical structures. Refer to Section 2.4 "Hood Protection Measures" of th Rood Insulance Study report for information on flood control structures for th jurisdiction.

The projection used in the programmed on of this map was Fronta State Flore North time 0003 (First). The horizontal distant was NAA 053, GR550 spremoti offerences in distant, spremoti, projection of State Flore Pane areas used in the obsolution of Flores for adjuster strateCone anyor result in sight problem inferences in map features across juridiction boundaries. These differences do to directive accuracy of this Flore.

Fload evolutions on this map are inferenced to the North-American Vertical Dialan of 1980. These Hood elevations multic be compression to structure and ground elevations inferenced to the same vertical allaram. For information registring conversion behaviore the Halazona (coolidity, Vertica) based of the vertical and the conversion provide allaram of the same structure vertical and the conversion provide allaram of the same structure at the following allarsis.

OS Information Services DAA, NNIGS12 ational Geodet: Survey SMC-3, #8202 I15 East-West Highway

SeverSpring, Maryland 2091 (301) 713-3242

To obtain current elevation, description, and/or location information for bend markes shown on this map, please contact the information Services Branci of the National Geodetic Survey at (201) 713-3242, or visit its website a http://www.no.noaa.oog.

Base map information shown on this FIRM was derived from the Flicids Department of Revenue produced at a scale of 1:200 from photography dates 2010.

Cognetation in shown on this maps are based on the best data available at the times of patients on. Because changes due to annexations or do annexations may have occurred after the map was published, map users should contact appropriate community officials to verify current corporate involucions. Please reflet to the separately protect Map Index for an overview map of the

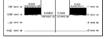
Courty showing the tayloat of map parents, community map repository address and a Lidoing of Communities table containing National Flood Insurance Prog dates for each community as well as a listing of the panels on which e community is located.

The All condicional consists in the manager of the second second

Include previously instant data of Map Changes, a Rocal Insurance Bhary Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the MSC website.

f you have questions about this map, how to order products or the National Floor invarance Program in general; reases call the FEMA Map Information exchange (FMK) at 1477-FEMA-MAP (1-877-358-2827) or visit the FEMA website at http://www.fema.go.du.uirees/hfg.

DATUM CONVERSION SCHEMATIC NOVO 29 Interest and a second s





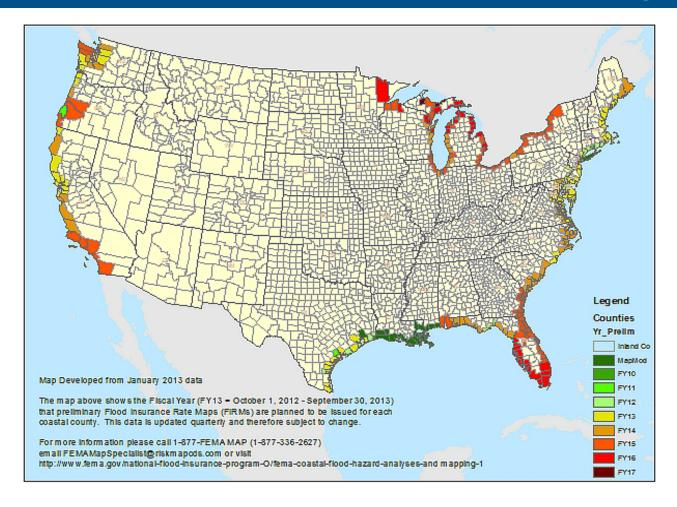


LEGEND



MAP REVISED

FEMA & Flood Hazard Mapping







Atlantic Ocean & Gulf of Mexico

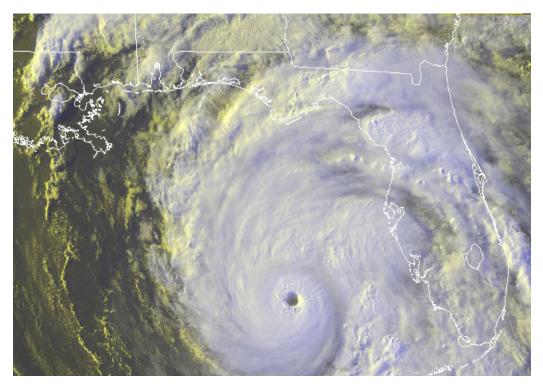


Atlantic Ocean and Gulf of Mexico Coastal Guidelines Update

Final Draft February 2007

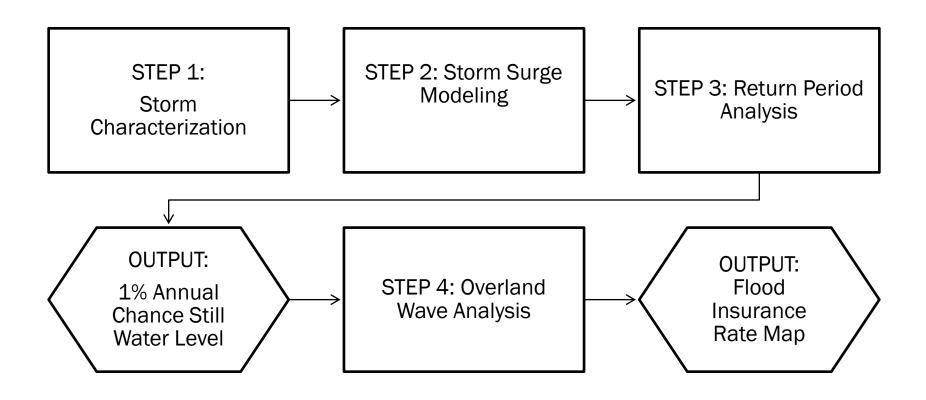
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Numerical Modeling Framework

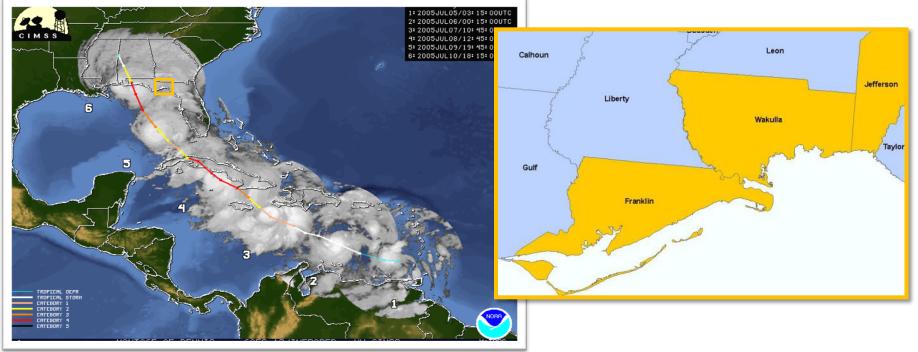






Step 1: Storm Forcing

- A. Storm Rate and Storm Characterization
- **B.** JPM-OS and Representative Synthetic Storms
- C. Validation of "OS" using SLOSH or a coarse ADCIRC mesh





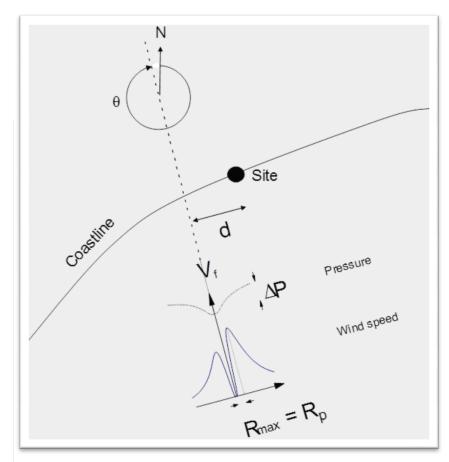


Step 1A: Storm Characterization

- storm occurrence rate λ
- pressure deficit ΔP
- radius of the exponential pressure profile R_{max}
- forward velocity V_f
- storm heading θ
- landfall location d



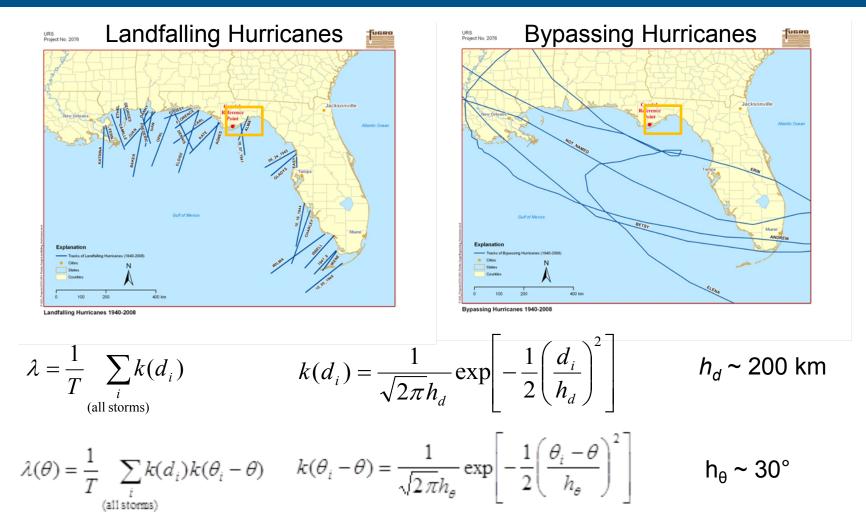
Landfalling Hurricanes 1940-2008





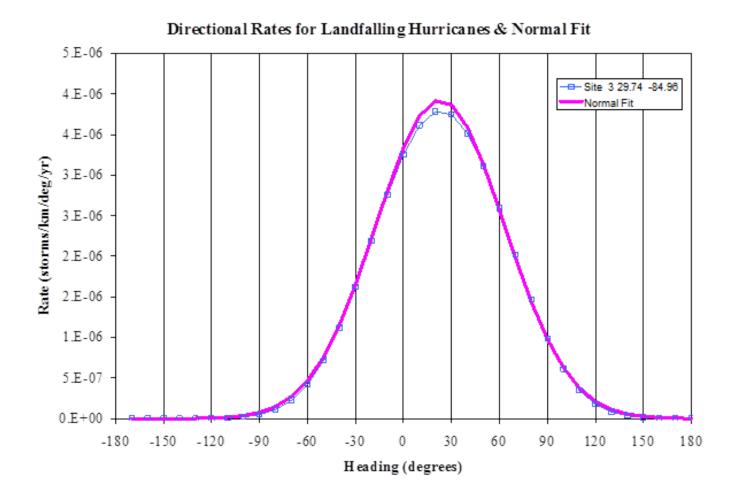


Step 1A: Establishing Storm Rate (storms/year/km)



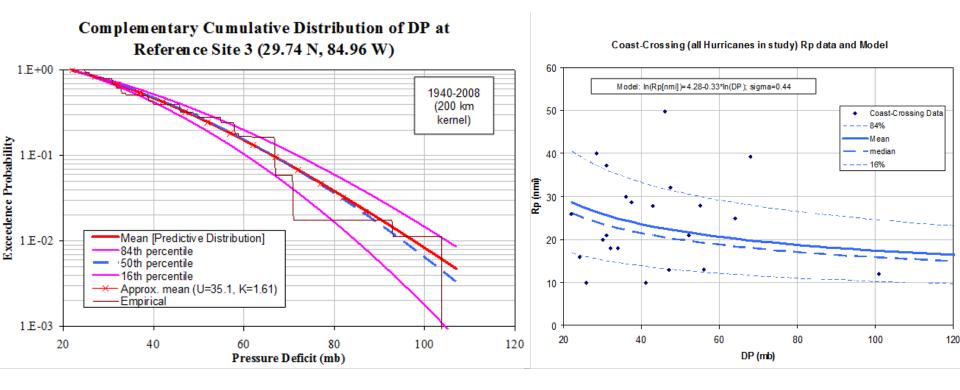


Step 1A: Establishing Storm Heading





Step 1A: Characterization of Storm Parameters

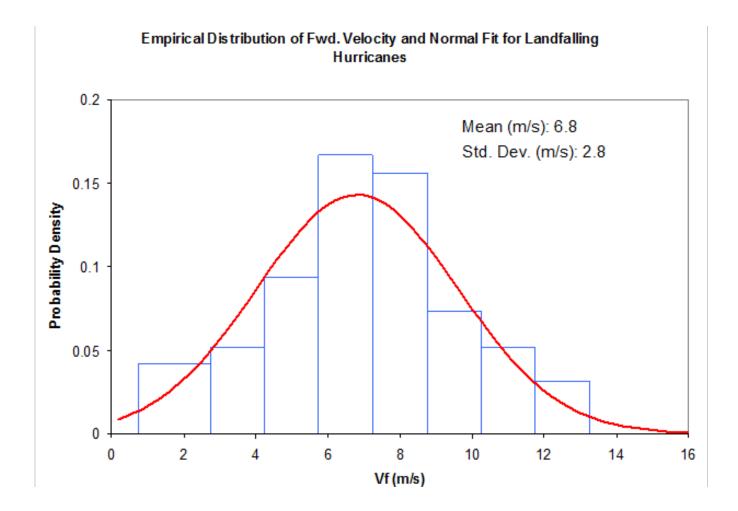


$$P[\Delta P > x] = \exp[-(x/u)^{k} + (\Delta P_0/u)^{k}] \qquad x > \Delta P_0$$





Step 1A: Characterization of Storm Parameters





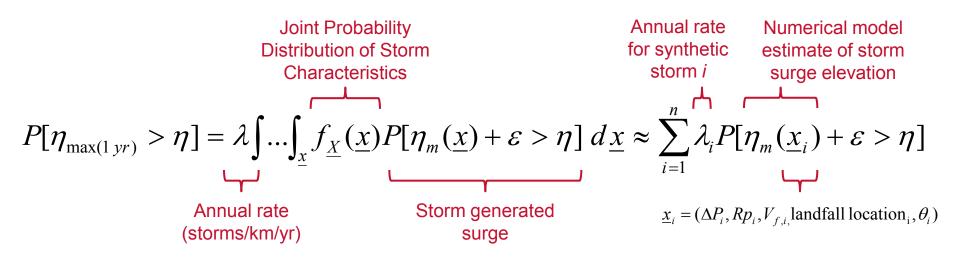
Step 1B: Storm Tracks

- **1**. The geometry of the tracks is defined based on:
 - a) Similar work performed by USACE for probabilistic storm surge studies for MS & LA
 - b) Historical tracks for the regions (as performed in NC, SC)
- 2. Storm parameters, Rp, Δ P, and B are specified for each point along the track, based on the specified conditions at landfall from the probabilistic analysis.





Step 1B: JPM Development

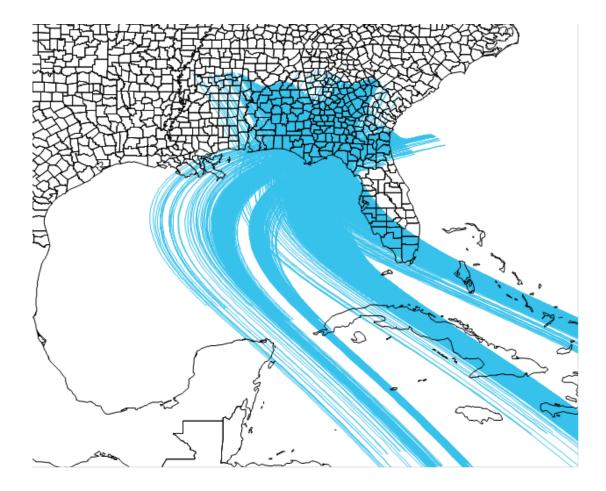


- **1.** Discretize ΔP into multiple broad slices
- 2. Within each slice, discretize the joint probability distribution of ΔP , R_p , V_f and θ using Bayesian Quadrature.
- 3. Discretize landfall location by offsetting each synthetic storm by R_p , as measured perpendicular to the track.
- 4. Compute the probability, pi, assigned to each synthetic storm as the product of the probabilities from the first 3 steps.





Step 1B: Reference Synthetic Storms







Step 1B: JPM-OS Development

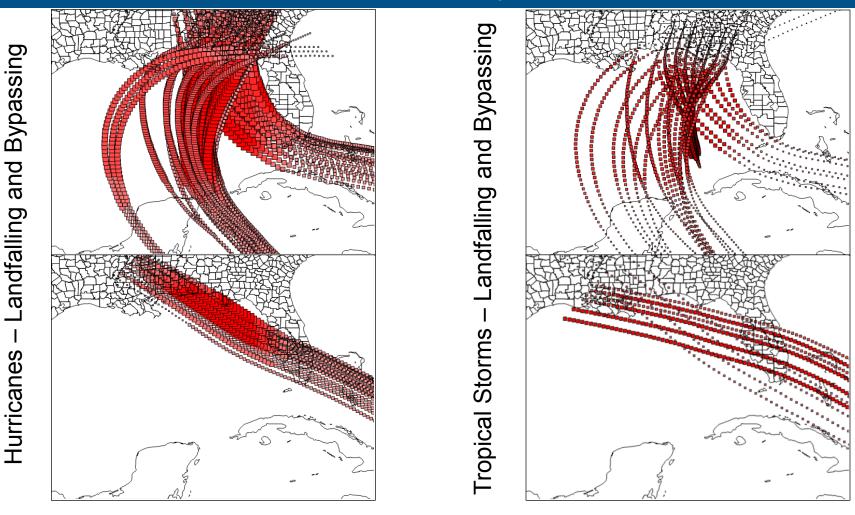
Example: JPM-OS representation of joint probability distribution of storm characteristics for landfalling hurricanes

Probability	$\Delta {f P}$ (mb)	Rp (nmi)	Vf (m/s)	Theta (deg)
0.248	26.0	36.6	6.8	23.0
0.209	35.3	16.3	6.8	23.0
0.139	42.0	33.2	6.8	23.0
0.094	46.8	14.9	6.8	23.0
0.049	48.9	10.3	5.9	26.6
0.033	56.5	36.4	4.2	61.1
0.057	57.8	19.2	3.9	-12.7
0.046	58.8	17.5	7.1	86.8
0.035	61.7	14.4	11.3	-8.0
0.030	63.4	34.0	9.5	-10.9
0.026	80.4	9.5	5.5	23.7
0.034	87.0	20.2	6.8	28.3





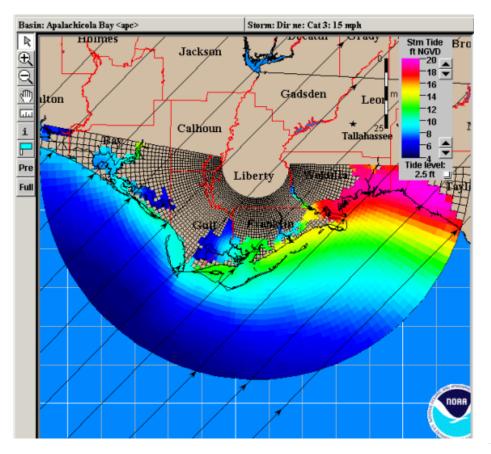
Step 1B: JPM-OS Synthetic Storms

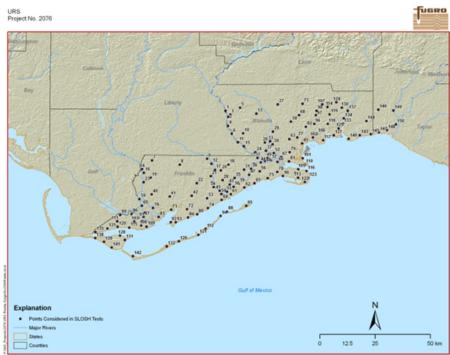






Step 1C: Comparing Reference and JPM-OS Synthetic Storm Suites



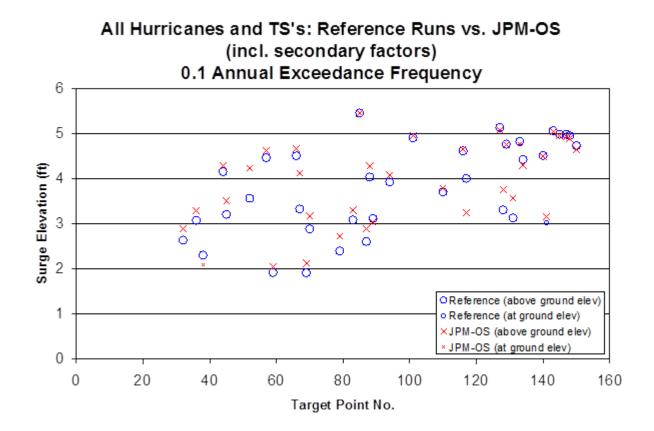


Points Considered in SLOSH Tests



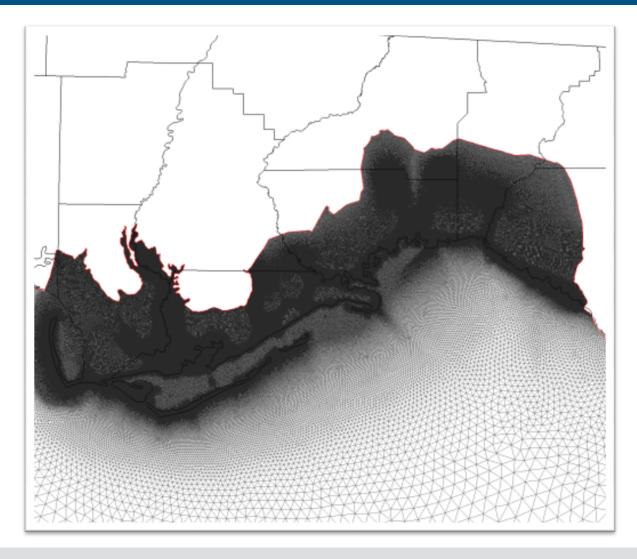


Step 1C: Comparing JPM and JPM-OS





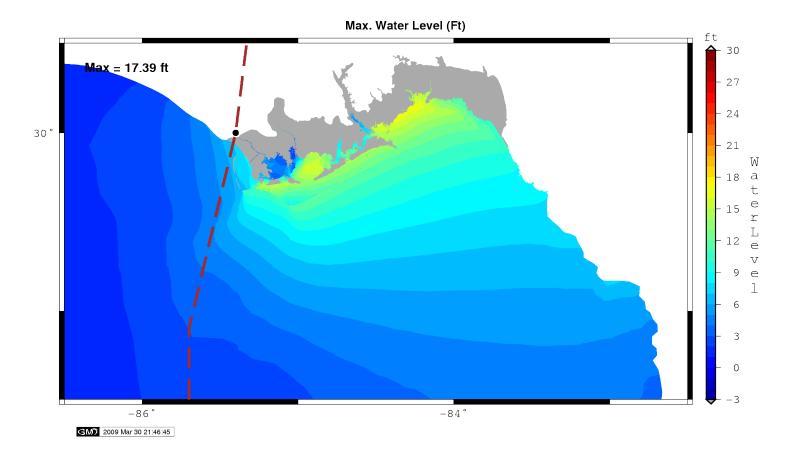
Step 2: Hydrodynamic & Wave Modeling







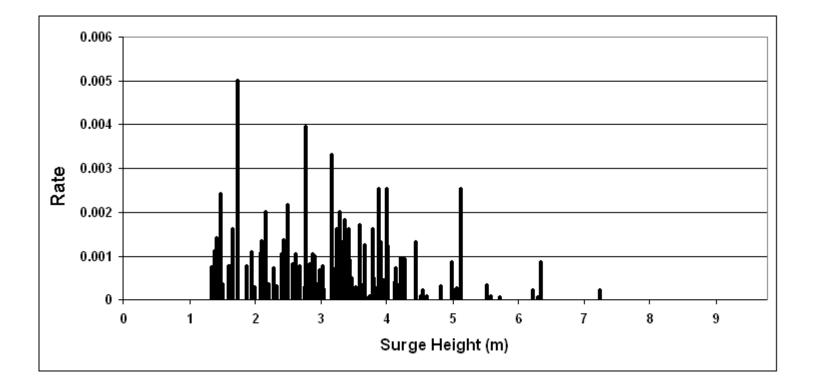
Step 2: Single Storm SWL Result







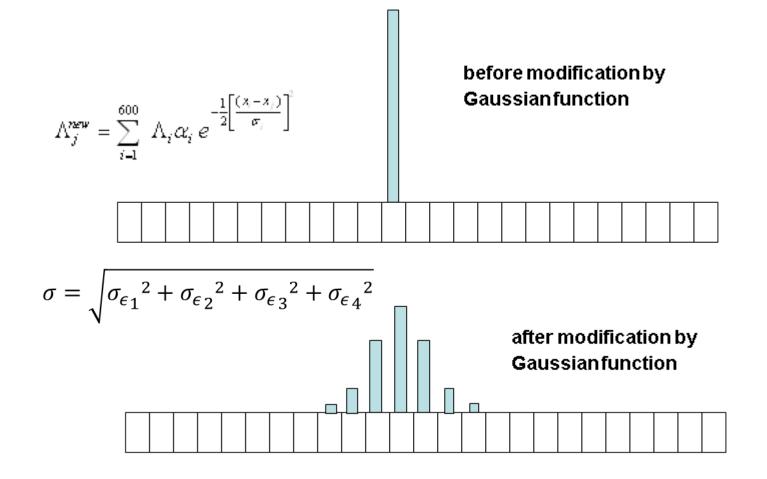
Step 3: JPM-OS SWL Results







Step 3: Accounting for Uncertainty







Step 3: Accounting for Uncertainty

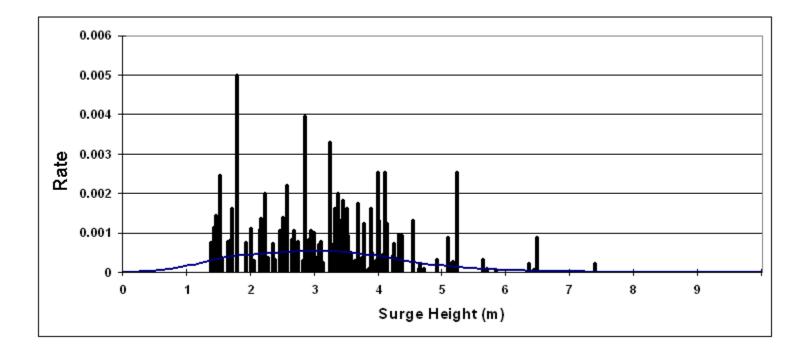
- ε₁ This is the contribution from the astronomical tide. A storm can make landfall at any phase of the tide. This epsilon term is used to represent the effect of random phasing of the maximum storm surge and the astronomical tide.
- ε₂ This epsilon term represents the changes in surge heights due to unaccounted variability in the value of Holland B. This parameter is used in the PBL numerical model of hurricane winds and pressures to account for the radial gradients.
- ε₃ This epsilon term represents the departures between modeled and measured surge levels and is used to express variations in the surge heights due to lack of accuracy in the modeling results.
- ε₄ This epsilon term represents the uncertainty associated with using idealized wind fields for the surge simulations, instead of the "best" or measured wind fields.





Step 3: Accounting for Uncertainty

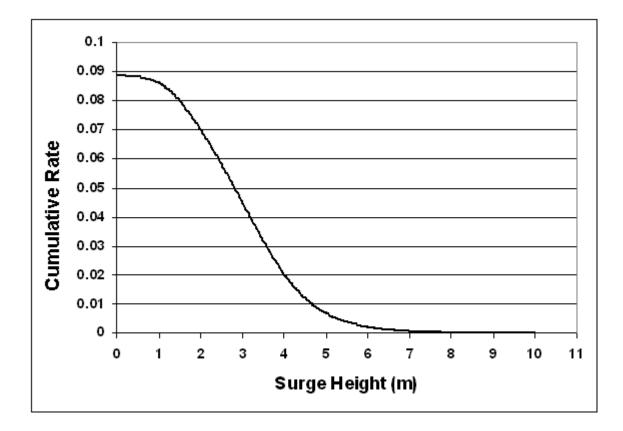
 The effect of the inclusion of the uncertainty term is shown by the blue line in the figure below







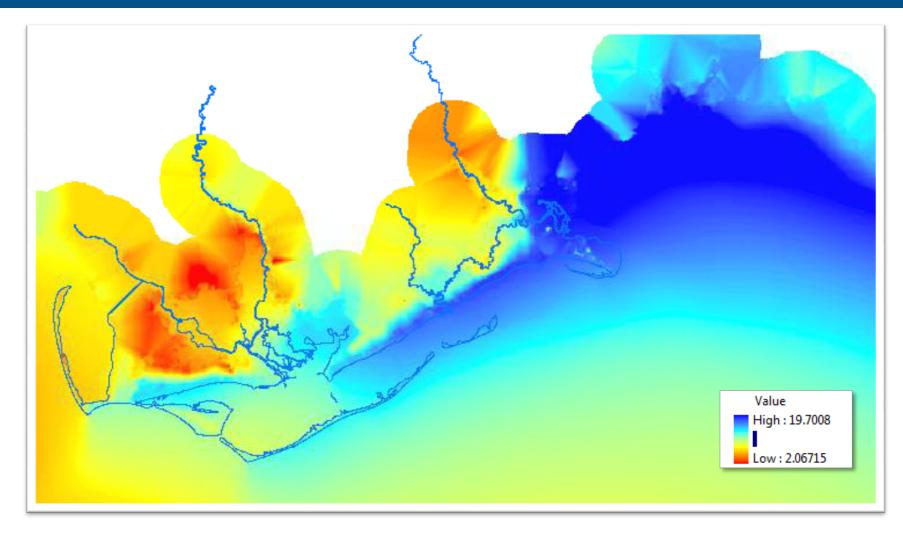
Step 3: Final SWL Results







Step 3: Final SWL Results







What can we share with Partners?

• 2D storm surge modeling

- Seamless Digital Elevation Model
- Model mesh
- Model choice
- Overland wave modeling
- Storm characterization & tropical system behavior
 - Progress in understanding
 - Knowledge transfer needed
 - Area for plentiful future research
- Treatment of Uncertainty







Thank you to Chris Reed (URS), Alan Niedoroda (URS), Chris Jones, Mark Osler (Baker), Darryl Hatheway (AECOM) & Cheryl Johnson (Accenture) for their shared expertise in this presentation.

Thank you to all FEMA mapping partners, who are the reason this substantial program has been so successful.

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