FEMA DFIRM Mapping and Quality Assurance Process

Louisiana CPRA
DFIRM Committee Meeting
Louisiana Capital Building
House Committee Room 1
March 12, 2009, 10:00am

Presentation Agenda

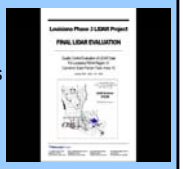
Introduction and History
Storm Surge Process
Statistical Process
Surge QA/QC Process
Wave Height Modeling Process
Wave Height Model QA/QC Process
Outreach
Current FIS Status

Introduction and History

- Current Effective maps
  - Up to 25 years old in places
  - Based on an old surge study from the 1970s
    - 1 mile grid spacing
    - 5 foot USGS quad topography
  - Do not accurately portray today's risk
    - Wetlands loss
    - Subsidence
    - Increased storm activity
    - $13 billion in NFIP losses paid in Louisiana after Katrina
- New maps are desperately needed

Why New Maps Now

- Part of Nationwide MapMOD program
- Mapping process started prior to Katrina
- Congressional mandate to provide accurate risk information for rating subsidized flood insurance
- New technology available
  - LiDAR data
  - Advanced surge and wave models
- Communities need up to date information to properly manage development and growth



Storm Surge Study Process

Joannes Westerink, Ph.D.
Professor of Civil Engineering
Concurrent Professor of Mathemathics
University of Notre Dame

Surge Study Use

- USACE HPO & PRO: Hurricane Protection System design heights
- FEMA: Base Flood Elevations for production of FIRMs
- LACPR: evaluation of future Hurricane Protection Systems

Storm Surge Study Participants

J. Westerink, J. Dietrich, S. Tanaka, H. Westerink; University of Notre Dame
C. Dawson, University of Texas at Austin
R. Luettich, B. Blanton, J. Flemming; University of North Carolina at Chapel Hill
R. Kolar, K. Dresback, E. Tromble, University of Oklahoma at Norman
B. Ebersole, J. Smith, R. Jensen, D. Resio, M. Cialone, T. Wamsley; USACE ERDC
E. Kubatko; The Ohio State University
S. Bunya; The University of Tokyo
L. Zevenbergen; Ayres Associates
J. Atkinson, H. Roberts; Arcadis
V. Cardone, A. Cox; Oceanweather Inc.
M. Powell; HRD/NOAA
H. Pourtaheri, N. Powell, A. Mislan, H. Winer, J. Ratcliff; USACE MVN
A. Sleath; USACE HPO
C. Bender; Taylor Engineering

FEMA

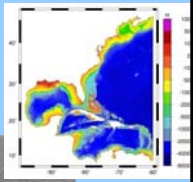
Requirements for a high accuracy storm surge models

1. Basin to shelf to floodplain domains to simplify boundary conditions and capture shelf waves
2. Accurate definition/resolution of the physical system and processes with an optimal unstructured high resolution grid
3. Coupled multi-process system including winds, wind waves, tides, and rivers
4. Objective description of the system and subgrid scale parameters
5. Robust, accurate (non-diffusive), fast, and highly scalable parallel unstructured grid models
6. Verification and Validation including quantification of the data errors

FEMA

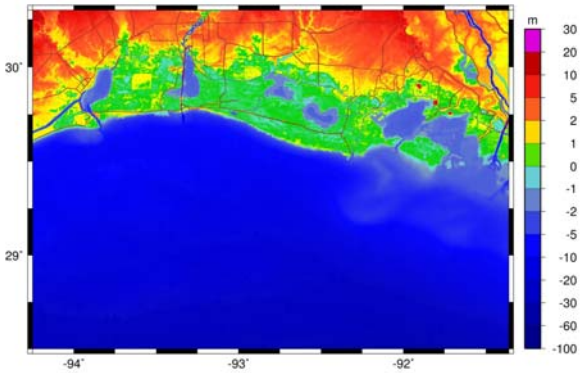
SL15v7 IPET/HPO/FEMA/LACPR Model

- Western North Atlantic – Gulf of Mexico
- Sabine Lake to Mobile Bay
- Resolution down to 30 to 50m
- High Resolution feature and channel definition
- Fully incorporates high resolution barrier islands
- Topography is Atlas Lidar based
- 2,409,635 nodes; timestep 1 sec
- SL15v7 Performance – 35 wall clock minutes per day of simulation on 512 PE Cray XT3



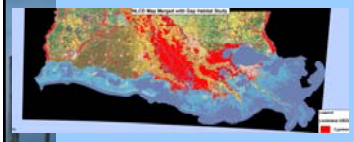
FEMA

SL15v7 Bathymetry and Topography



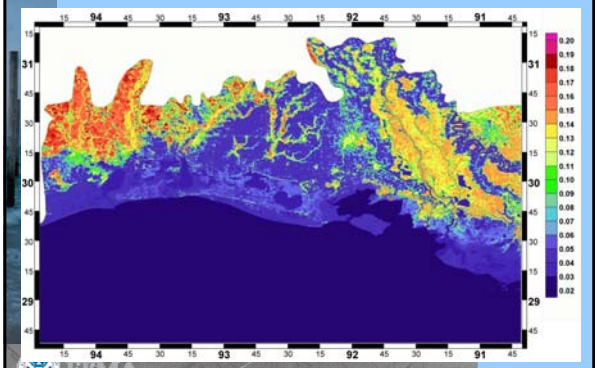
SL15v7 Bathymetry and Topography

SL15 Bottom Friction - SL15v7 Manning n



NLCD Class	Description	Manning-n
11	Open Water	0.022
12	Ice/Snow	0.020
21	Low Residential	0.120
22	High Residential	0.140
23	Commercial	0.050
31	Bare Rock/Sand	0.040
32	Gravel Pit	0.060
33	Transitional	0.100
41	Deciduous Forest	0.140
42	Evergreen Forest	0.160
43	Mixed Forest	0.140
51	Shrub Land	0.050
61	Orchard/Vineyard	0.100
71	Grassland	0.034
81	Pasture	0.030
82	Row Crops	0.035
83	Small Grains	0.035
84	Fallow	0.030
85	Recreational Grass	0.025
91	Woody Wetland	0.120
92	Herbaceous Wetland	0.035
95	Cypress Forest	0.120

SL15 Bottom Friction - SL15v7 Manning n



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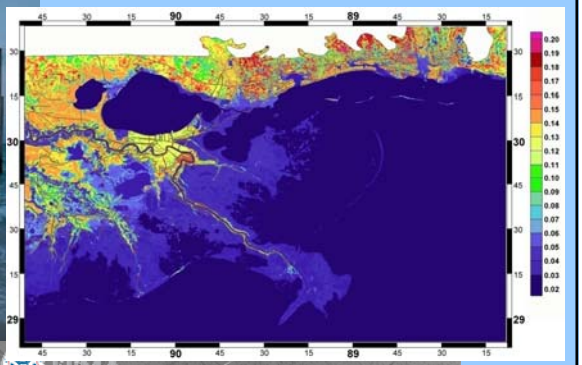


ADCIRC Coastal Ocean Model

- Algorithmic design criteria
  - Solutions are accurate and have been verified
  - Operates efficiently in parallel to solve large unstructured grids (up to 16000 processors)
- ADCIRC allows users to apply high grid resolution
  - Resolution is key to obtaining accurate solutions
- ADCIRC is coupled to ocean and coastal wave models WAM and STWAVE
  - Breaking waves push up additional water on the coast

Algorithms, Methods, and Models are Extensively Peer Reviewed

Bunya, S., J.C. Dietrich, J.J. Westerink, B.A. Ebersole, J.M. Smith, J.H. Atkinson, R. Jensen, D.T. Resio, R.A. Luettich, C. Dawson, V.J. Cardone, A.T. Cox, M.D. Powell, H.J. Westerink, H.J. Roberts, ***Monthly Weather Review***, In Review, 2008

Dietrich, J.C., S. Bunya, J.J. Westerink, B.A. Ebersole, J.M. Smith, J.H. Atkinson, R. Jensen, D.T. Resio, R.A. Luettich, C. Dawson, V.J. Cardone, A.T. Cox, M.D. Powell, H.J. Westerink, H.J. Roberts, ***Monthly Weather Review***, In Review, 2008.

Resio, D.T. and J.J. Westerink, ***Physics Today***, **61**, 9, 33-38, 2008.

Bunya, S. and J.J. Westerink, ***Coastal Engineering Journal of the Japan Society of Civil Engineers***, In Press, 2008

Kubatko, E.J., S. Bunya, C. Dawson, J.J. Westerink, C. Mirabito, ***Journal of Scientific Computing***, In Press, 2008.

Kubatko, E.J., C. Dawson, J.J. Westerink, ***Journal of Computational Physics***, **227**, 9697-9710, 2008.

Kubatko, E.J., S. Bunya, C. Dawson, J.J. Westerink, ***Computer Methods in Applied Mechanics and Engineering***, In Press, 2008.

Bunya, S., E.J. Kubatko, J.J. Westerink, C. Dawson, ***Computer Methods in Applied Mechanics and Engineering***, In Press, 2008.

Westerink, J.J., R.A. Luettich , J.C. Feyen, J.H. Atkinson, , C. Dawson, H.J. Roberts, M.D. Powell, J.P. Dunion, E.J. Kubatko, H. Pourtaheri, ***Monthly Weather Review***, **136**, 3, 833-864, 2008

Kubatko, E.J., J.J. Westerink and C. Dawson, ***Journal of Computational Physics***, **222**, 832-848, 2007

Kubatko, E.J. and J.J. Westerink, ***Journal of Hydraulic Engineering***, **133**, 305-311, 2007

Ebersole, B.A., D. Resio, and J.J. Westerink, ***Marine Technology Society Journal***, **40**, 4, 56-68, 2007

Kubatko, E.J., J.J. Westerink and C. Dawson, ***Computer Methods in Applied Mechanics and Engineering***, **196**, 437-451, 2006

Kubatko, E.J., J.J. Westerink and C. Dawson, ***Ocean Modeling***, **15**, 71-89, 2006

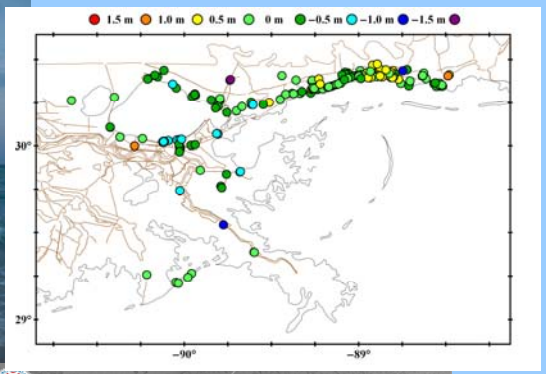
Dawson, C., J.J. Westerink, J.C. Feyen and D. Pothina, ***International Journal for Numerical Methods in Fluids***, **52**, 63-88, 2006.

Bunya, S., S. Yoshimura and J.J. Westerink, ***International Journal for Numerical Methods in Fluids***, **51**, 1277-1296, 2006.

SL15 IPET/HPO/FEMA/LACPR Validation

- Riverine flows (ADCIRC)
- Tides (ADCIRC)
- Katrina Hindcast
  - Winds (IOKA/H*WIND)
  - Short wind waves (WAM/STWAVE)
  - Rivers, Tides, Wave Setup, and Surge (ADCIRC)
- Rita Hindcast
  - Winds (IOKA/H*WIND)
  - Short wind waves (WAM/STWAVE)
  - Rivers, Tides, Wave Setup, and Surge (ADCIRC)

Katrina Hindcast – HWM Comparisons – USACE Data



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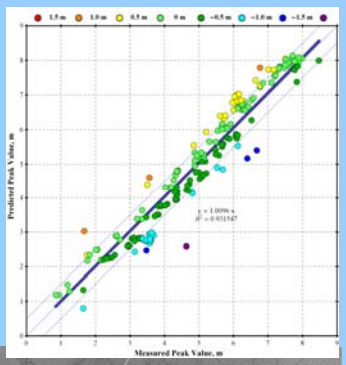

SL15 Model Validation of Katrina Hindcast

Storm	HWM Data Set	Slope	R^2	Average Error (m)	Standard Deviation (m)	HWM Error Estimate (m)	Model Standard Deviation (m)
Katrina	USACE IPET	1.01	0.932	0.02	0.47	0.18	0.43
Katrina	FEMA URS	1.04	0.946	0.19	0.44	0.10	0.41

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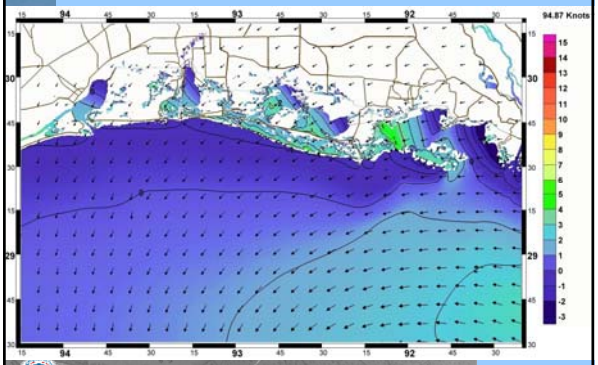
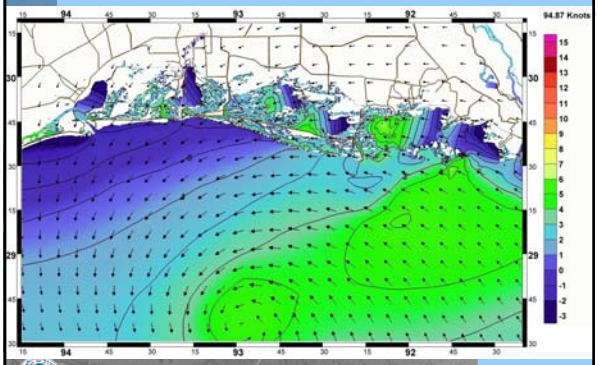
09/23/2005 18:00 Z RITA Surge (ft) WEST



09/24/2005 00:00 Z RITA Surge (ft) WEST



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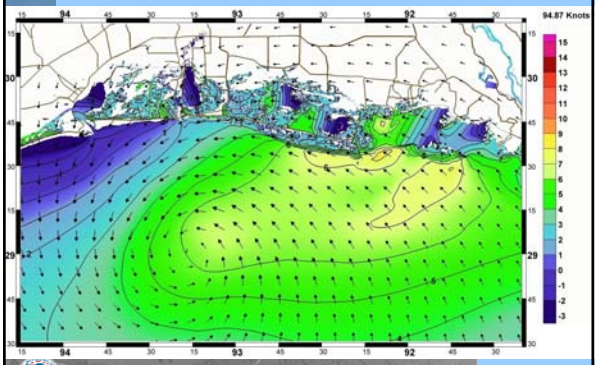
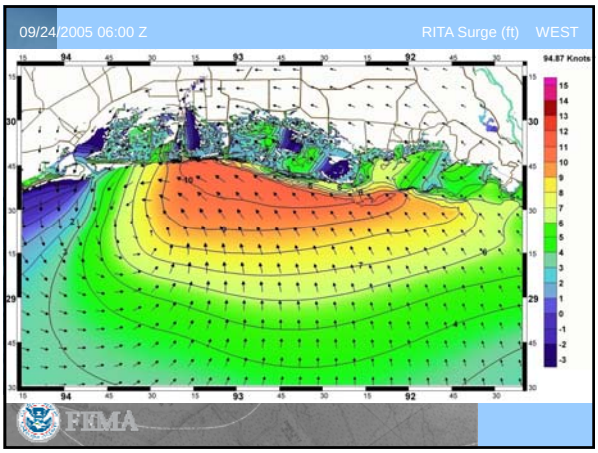
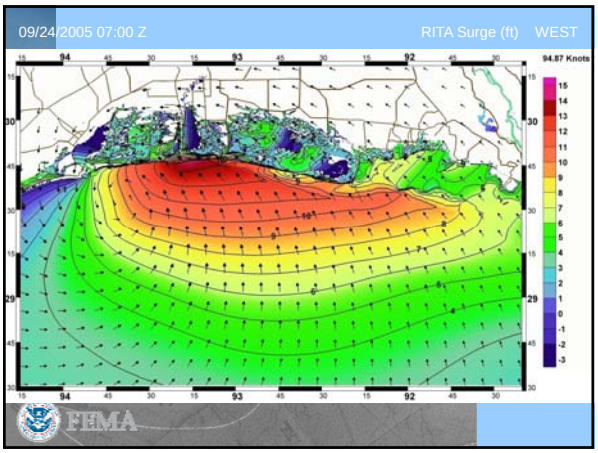



09/24/2005 06:00 Z
RITA Surge (ft) WEST
94.87 Knots
FEMA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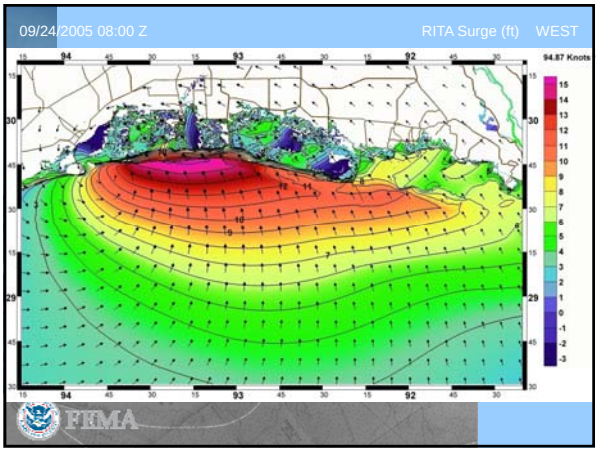
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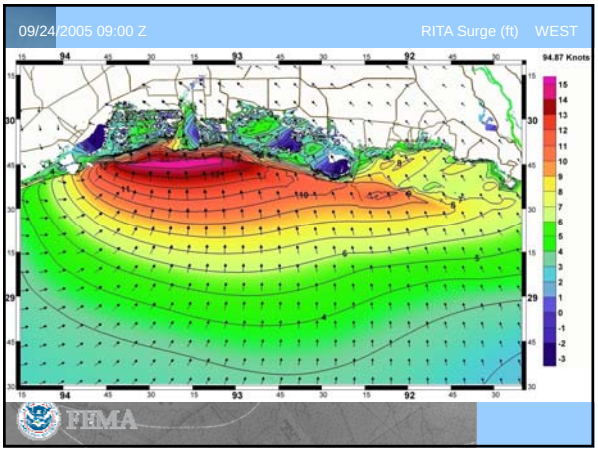
94.87 Knots
FEMA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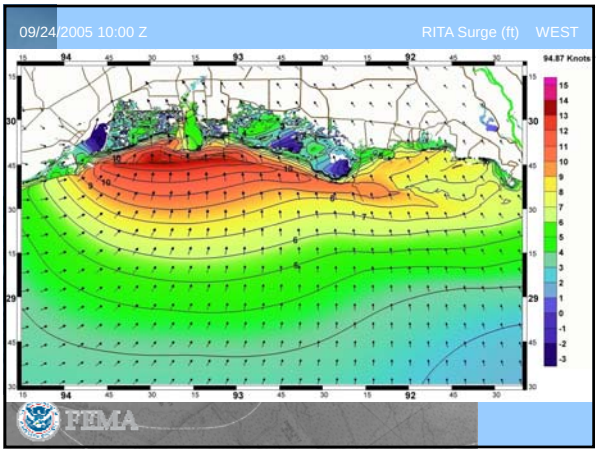
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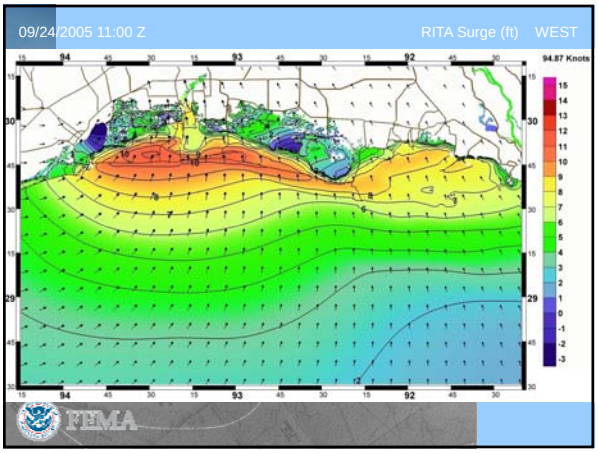
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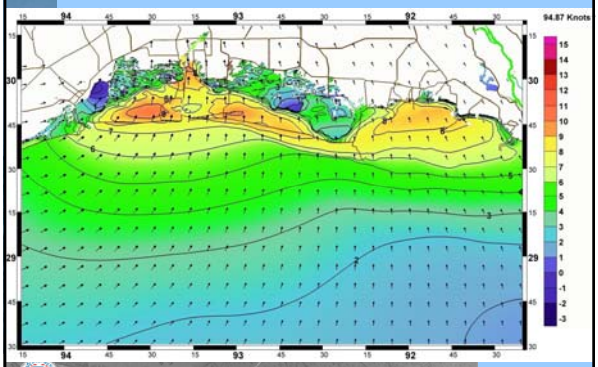
RITA Surge (ft) WEST
94.87 Knots
FEMA

09/24/2005 12:00 Z RITA Surge (ft) WEST



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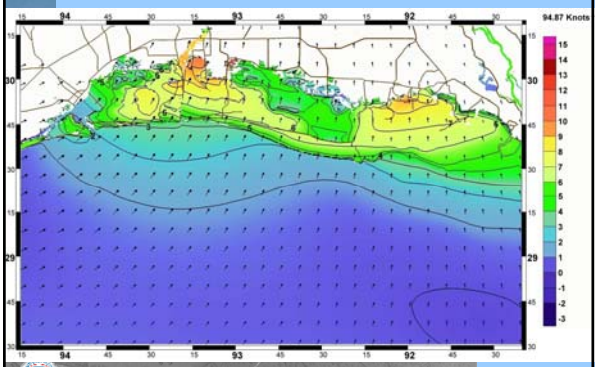
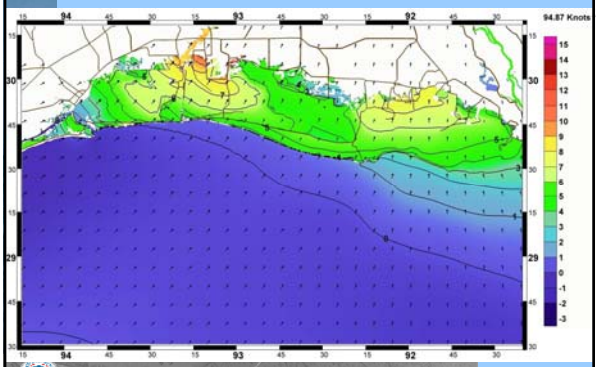
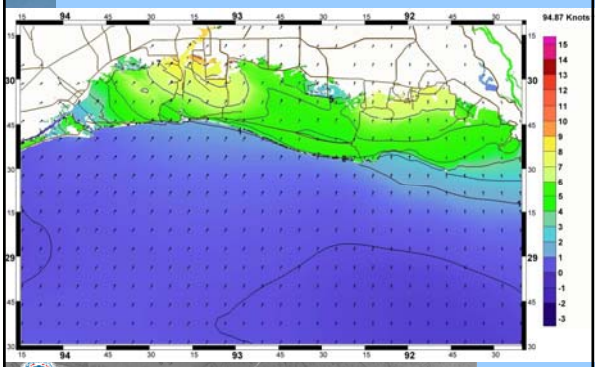


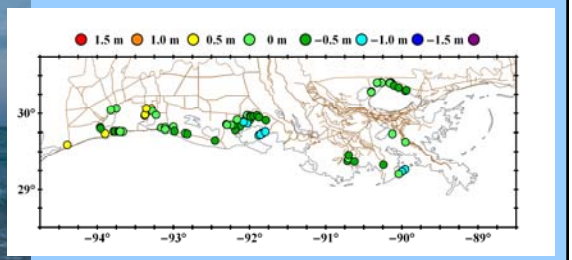
09/24/2005 18:00 Z RITA Surge (ft) WEST



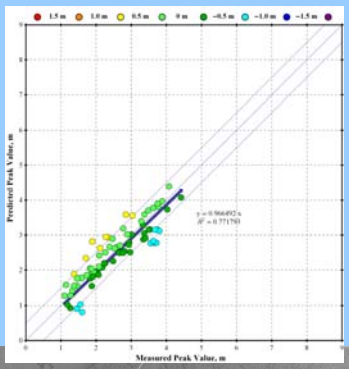
09/24/2005 21:00 Z RITA Surge (ft) WEST



Rita Hindcast – FEMA/URS HWM locations and difference in measured to modeled peak surges



Rita Hindcast – HWM Comparisons – FEMA/URS Data



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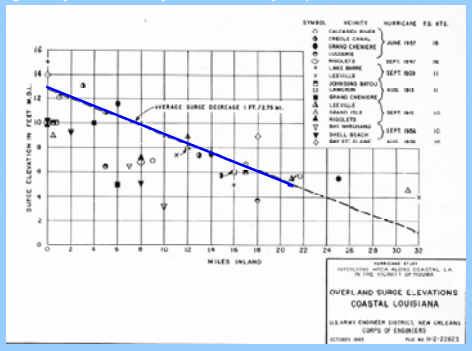
Katrina	FEMA URS	1.04	0.946	0.19	0.44	0.10	0.41
Rita	FEMA	0.98	0.742	-0.01	0.40	0.18	0.36
Rita	FEMA w/o Vermilion	1.05	0.861	0.13	0.34	0.15	0.28

Morgan City, La & Vicinity Interim Survey Report, USACE 1963



Cameron 100 year still water elevations T73 from this study

Compared to 1ft/2.75mi "best fit" curve

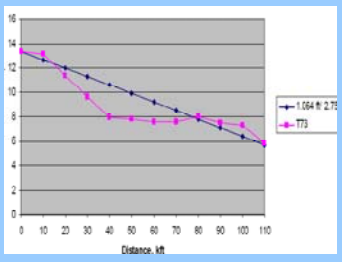
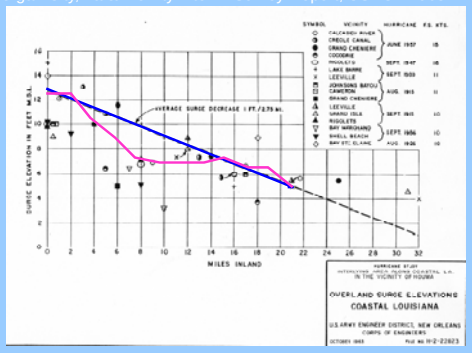


Figure from presentation by Joe Suhayda

Grand Challenges Workshop LSU , January 20, 2009

Morgan City, La & Vicinity Interim Survey Report, USACE 1963



Statistical Analysis

Don Resio, Ph.D.
Senior Scientist
US Army ERDC

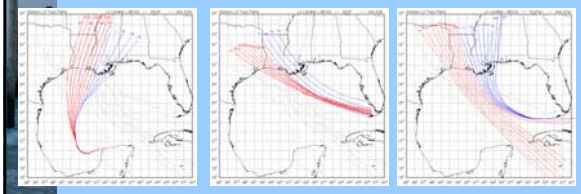
Major Aspects of New JPM-OS Approach

- The parameters used to represent the wind fields are much improved over previous JPM efforts
- Uncertainty is incorporated directly into all estimates of surge level probabilities
- Statistical estimates of hurricane parameters, including co-dependencies, have been cross-validated
- Method has been vetted and is now being published in several peer-reviewed articles
- Sampling of storm populations use optimized spatial windows

Previous Eastern and Western LA Work

152 JPM Storms based on 3 track path classifications

Western LA track paths shown in red, Eastern LA in blue



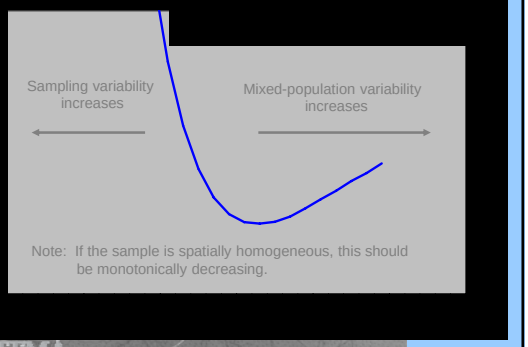
"SW 45" ANGLE

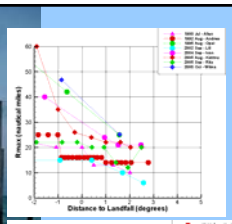
"SE 45" ANGLE

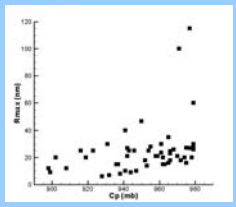
"MEAN" ANGLE RICKFAN TRACKS

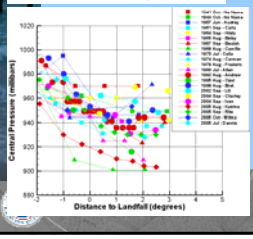
Objective is to have consistent wave fields to combine with local surges

Initial Tracks for LA east and west.



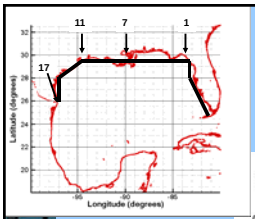




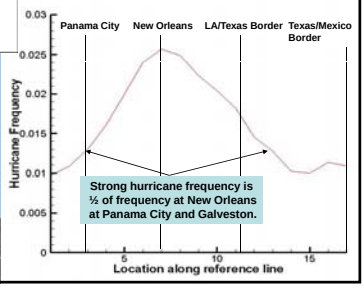


Hurricane characteristics have been carefully analyzed and compared with results from studies by other groups.

Parameters are allowed to vary during their approach to the coast.

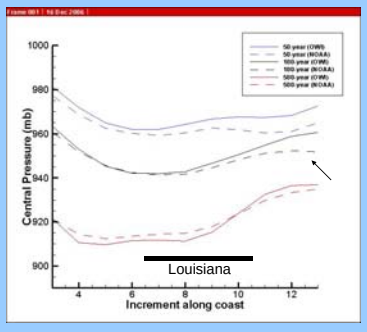


Frequency of Landfalling Hurricanes with Central pressures offshore less than or equal to 955 mb along a portion of US Gulf coast (1941-2005)

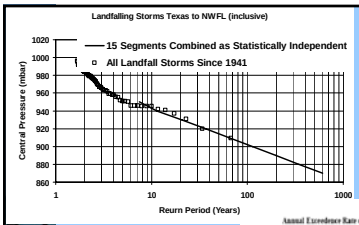


Strong Hurricanes making landfall along the Gulf coast reflect the same tendency for maximum hurricane impacts along the Mississippi- New Orleans coastal areas

Strong hurricane frequency is ½ of frequency at New Orleans at Panama City and Galveston.

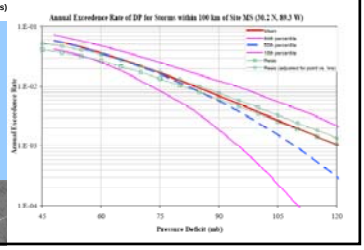


Estimates of Landfalling pressures for selected recurrence intervals.



Independent check on extremal distribution of central pressures by Peter Vickery, Applied Research Associates

Independent check on extremal distribution of central pressures by Gabe Toro, Risk Engineering



Independent Technical Review

Bob Dean, Ph.D.
Professor of Coastal Engineering
University of Florida

Billy Edge, Ph.D.
Professor of Ocean Engineering
Texas A & M University

Technical Review Organization

TECHNICAL REVIEW COORDINATOR – Ryan Clark

FEMA ITR Team Coordinator Joe Suhayda LSU/URS	USACE ITR Team Coordinator Pam Deloach MVN	EPR (ASCE) Team Coordinator - Billy Edge ASCE/IPET/TAMU
Don Slinn ASCE U of F	Bill McAnally Mississippi State U	Bob Dean ASCE/IPET UF
John Richardson ASCE Blue Hill Hydraulics	Thomas Gambucci USACE Rock Island, IL	Jurgen Battjes IPET-TU Delft - Netherlands
Lee Butler ASCE Veritech	John McCormick – GIS USACE Wilmington, DE	Lawrence Roth ASCE Director
Hans Graber U of Miami	John Winkelman USACE New England Dist.	Robert Traver Villanova
Bob Gilbert ASCE UT	Jon Hubertz Consultant	

FEMA Oversight ITR Team Coordinator Dale Kerper DHI

- Yu Chun Su PBSJ
- Zach Toups Michael Baker & Associates
- *
- Chris Jones Christopher Jones & Assoc.

ITR Independent Technical Review
ASCE American Society of Civil Engineers
NRC National Research Council
EPR External Peer Review
IPET Interagency Performance Evaluation Task force
* NRC Formal Review occurred as part of review for IPET Volume 8, Hazard Definition Process

ITR/EPR Organization & Involvement

4 Teams
- FEMA ITR
- USACE ITR
- ASCE EPR
- FEMA Oversight ITR

Involvement in Process
- Orientation Webinar
- Technical Webinars
- Attend Project Team Meetings
- Attend weekly project conference calls
- Full access to technical team

Scope of Review

20 ITR reviewers
5 ASCE EPR reviewers
2,000 total review hours
3- 6 project meetings attended by all reviewers

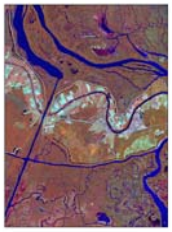
Scope of Review

Processes Reviewed
- Grid
- Climatology & Statistical Methods
- Wave Modeling Methodology
- Surge Modeling Methodology
- Validation with Historical Storms
- Model Output (Results)
- Reports

End Product Review
- SELA ITR – 110 comments, 296 page review report
- SWLA ITR – 36 comments, 27 page review report
- SELA/SWLA EPR – 850 pages, comments and attachments

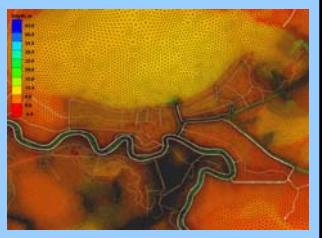
Products Reviewed

ADCIRC Grid Development Data Sets
- Imagery
- Bathymetry
- LIDAR
- USGS Land Use
- TANA 2006 (Water Polygons, Railroads, …)



Products Reviewed

ADCIRC Grid Components
- Node Elevations
- Manning's N
- Canopy
- Wind Reduction Coef
- Subgrid Elements (Levees)



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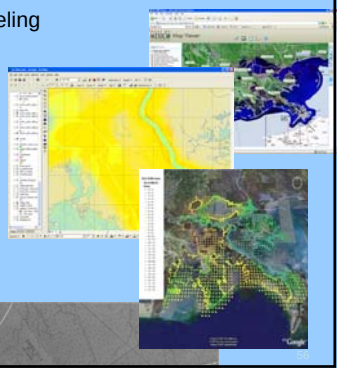
Products Reviewed

Surface Water Modeling System (SMS)

ArcGIS

ArcIMS / ArcWMS

Google Earth



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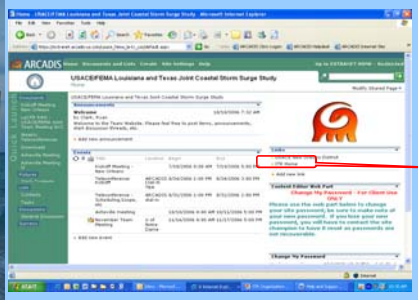
Managing ITR: The Website



Click "ITR Home" Link

FEMA

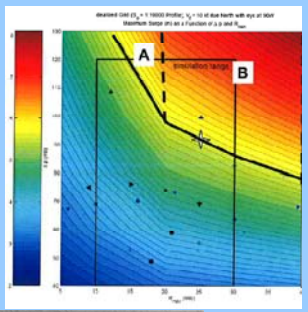
Review Process Example – Climatology & Statistical Analysis

Several Review Meetings of methodology prior to project start.

ITR/EPR fully embedded in decision making process.

Project Team of leading hurricane experts provided "White Paper" to ITR, ASCE, NRC.

JPM-OS methodology thoroughly reviewed prior to project production.



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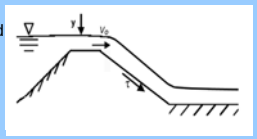
Review Process Example – Levee Resilience & Overtopping

ASCE EPR - when reviewing structural overtopping Boussinesq modeling, EPR had questions concerning levee resilience

Provided comments to ITR Coordinator

MVN and Project Team prepared response:

a) Meeting to Discuss issues
b) Input from ASCE and Dutch, recent science of overtopping
c) MVN created updated Levee Owner's Manual for maintenance, etc. (adopted for use on all levee projects subsequently)



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Wave Height Analysis Process

Christopher Jones, P.E.

FEMA

Riverine vs. Coastal Flooding

Coastal flooding: *waves*, velocity, *erosion*, debris, inundation, *wind* (V zones)

Riverine flooding: inundation, velocity, debris, duration (A zones)

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Given the Storm Surge Level, What Do We Do Next?

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Wave Height Analysis

- Analyses are done along transects
- WHAFIS 4 update
  - Increased data point density
  - Calculates 500 year wave crest elevations
- WHAFIS Modeling
  - High transect density
  - High data point density
    - Data points as needed
    - Data points at vegetation changes
    - Data points at major topographic changes

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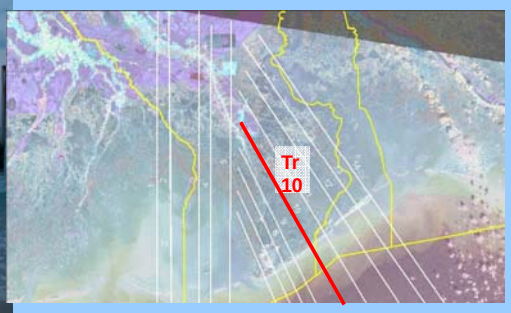
Wave Height Analysis

- WHAFIS is the accepted FEMA standard for wave height modeling in overland areas
- Facilitates maps revisions by communities and owners through LOMR process

FEMA

SELA Transects



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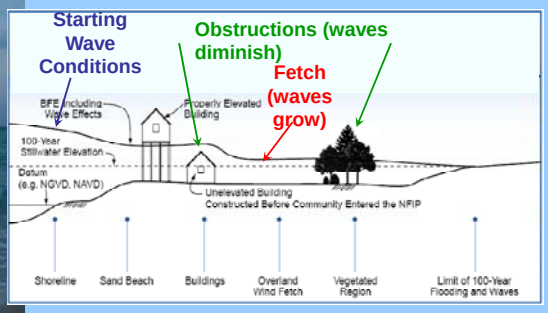
Compile Data for Transect



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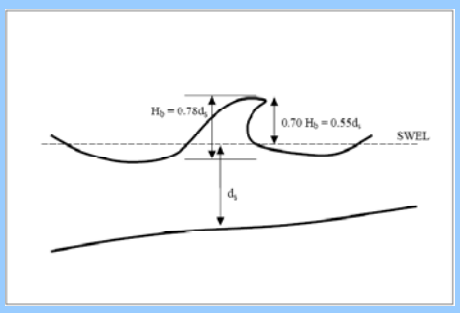
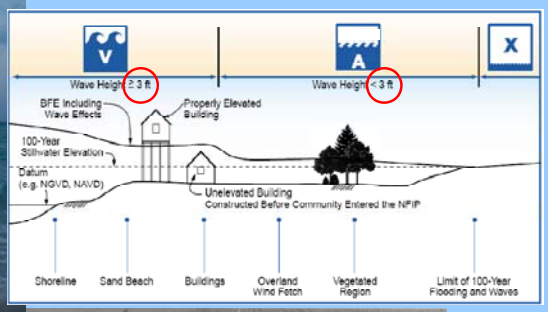
Compile Data

- Topography along Transect
- “Fetches” and “Obstructions”
- Storm Surge Elevation(s)
- Incident Wave Conditions at Shoreline
  - from 2-D wave model

WHAFIS



Mapping Wave Height



Need for Zone V

Mapping QA/QC Procedures

Guillermo Simon, P.E.
Taylor Engineering

WHAFIS and DFIRM production QA/QC

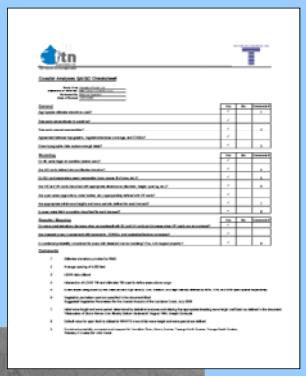
Participants

Taylor Engineering, Inc.
Michael Baker/Region VI RMC
PBS&J/DHI
Christopher P. Jones, P.E.
FTN Associates

WHAFIS and DFIRM production QA/QC

Taylor Engineering, Inc. (FTN/Taylor JV)

- Developed Quality Assurance Plan
- Internal review
  - Modeling and mapping
  - Assumptions and methods



WHAFIS and DFIRM production QA/QC

Independent QA/QC team

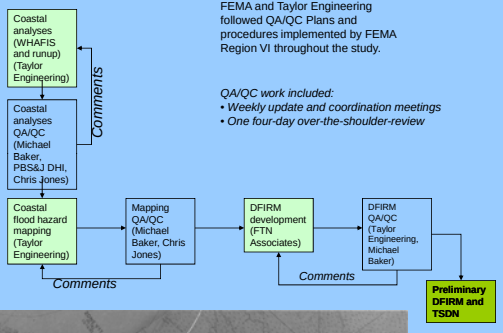
Michael Baker/Region VI RMC
Lead independent QA/QC reviewer for coastal floodplain mapping and overall QA/QC coordinator

PBS&J/DHI
Performed detailed review of WHAFIS models (including on site over-the-shoulder review)

Christopher P. Jones, P.E.
Provided expert's opinion regularly

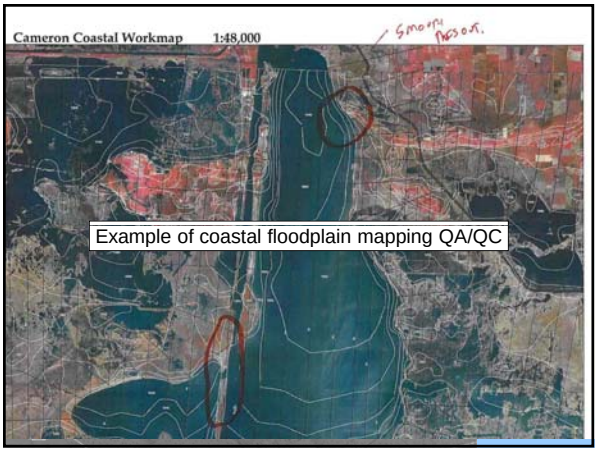
FTN Associates/Taylor Engineering
Performed internal and independent QA/QC of DFIRM products

WHAFIS and DFIRM production QA/QC



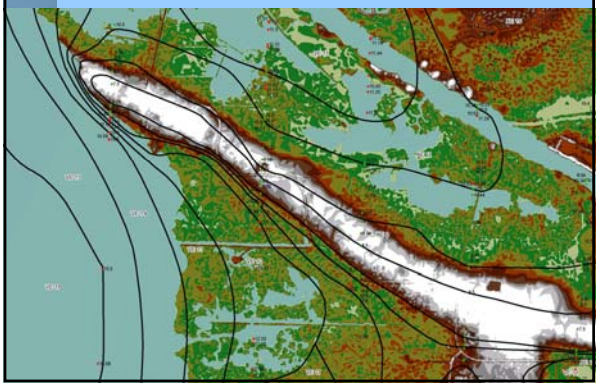
FEMA and Taylor Engineering followed QA/QC Plans and procedures implemented by FEMA Region VI throughout the study.

QA/QC work included:
- *Weekly update and coordination meetings*
- *One four-day over-the-shoulder-review*

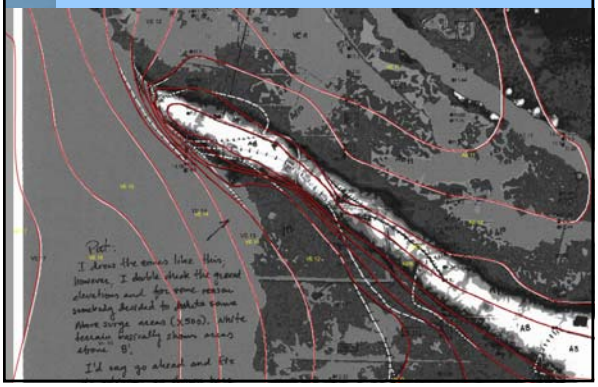


Example of coastal floodplain mapping QA/QC

Coastal floodplain mapping QA/QC



Coastal floodplain mapping QA/QC



Outreach

Gary Zimmerer, P.E.
Senior Engineer
FEMA

LaMP

- FEMA setup Louisiana Mapping Project – LaMP (www.lamappingproject.com)
- Conducted LaMP introduction meeting with each parish in late 2006
- Conducted Executive meetings for parish and community officials in early 2007
- Conducted Technical workshops in summer 2007
- Conducted Insurance workshops in 2007

LaMP

- Conducted Open House meetings in all parishes after map release
- Developed 20+ fact sheets and handouts on various topics
  - Developed video: *The Louisiana Mapping Project – Charting Our Coastal Future*

FEMA Transitional Recovery Office (TRO)

- Conducted map pre-release and map release meeting with each parish and community
- Conducted training sessions for individual parishes
- Staff local call center
  - *1-866-751-3989*

Post Preliminary Process

- Preliminary Maps Released starting Jan 2008
- CCO meeting
  - public release of maps
- Appeal/Protest period
- Appeal resolution period
- 6 month adoption period
- 12-18 month process overall
- Maps do not go effective and do not control insurance rates until the end of the process

Study Status

All coastal preliminary maps are released

Pre-appeal parishes

Lafourche
Terrebonne
St. John the Baptist
Orleans
Plaquemines
St. Bernard
St. Charles
Jefferson

In Appeal Period

Cameron

Study Status

Appeals being resolved

Lafayette
Vermilion
St. Mary
St. Tammany
Iberia
Livingston
Tangipahoa
Calcasieu

Conclusion

- Flood Insurance Study (FIS) process was a collaborative effort involving several key national, state and local stakeholders and leading coastal experts
- Louisiana DFIRM production is the most technically advanced FIS ever performed in the state
- Modeling methodology and results incurred multiple levels of very thorough and extensive review prior to their release.

Thank You