

Predicting Conditions of Hurricane Evacuation and Return Routes



NASA NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
John C. Stennis Space Center

NASA Emergency Management & Planning Support (E-MAPS)

Florida Research Center
Stennis Flight Research Center
Storm Research Center
Storm Research Center
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JPL Propulsion Laboratory
Johnson Space Center
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Langley Research Center
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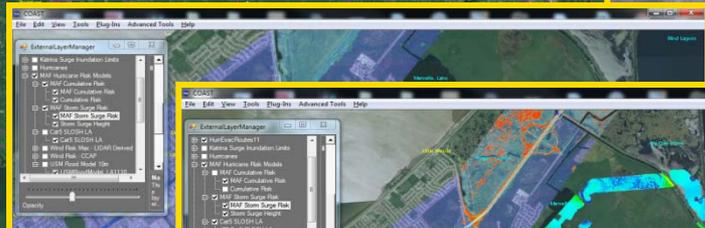
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Emergency Operations Center

NASA Emergency Management & Planning Support (E-MAPS)

PRE-STORM PREPARATION ACTIVATION POST-STORM RECOVERY

- FLOOD INUNDATION
- FLOOD PREDICTION
- 300 YEAR FLOOD MAP
- WIND
- WIND RISK PREDICTION
- 560 FACILITIES
- AND GIS SERVICES



2012 SSC Resilience & Adaptation to Climate Risks Workshop
NASA SSC
16 October 2012



- Project Background
- Scope of Project
- Demonstration
- Closing Remarks

BACKGROUND



NASA National Aeronautics and Space Administration
 Michoud Assembly Facility
 Emergency Operations Center

NASA Emergency Management & Planning Support (E-MAPS)

PRE-STORM PREPARATION	ACTIVATION	POST-STORM RECOVERY
FLOOD INUNDATION	EMERGENCY MANAGEMENT PLAN	POST-EVENT IMAGERY
FLOOD PREDICTION MODEL	EMC CHECKLIST	ON-SITE ANALYSIS
100 YEAR FLOOD MAPS		
3D FLOOD DRAINAGE		
WIND	STORM TRACKER	EVENT LOG
WIND RISK PREDICTIONS		
MAF FACILITIES	EVACUATION ROUTES	BASELINE IMAGES
AFC GIS SERVER	RIEDEDOUT CREW ROSTER	HISTORICAL ARCHIVES

[View Current LA](#)
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Weather Forecast Weather Maps - Weather Station - Hurricane Center
 AccuWeather.com

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INCEPTION

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Resource Posture

- Power & communication lines down
- Computer networks inoperative
- Staff displaced

Key Parameters

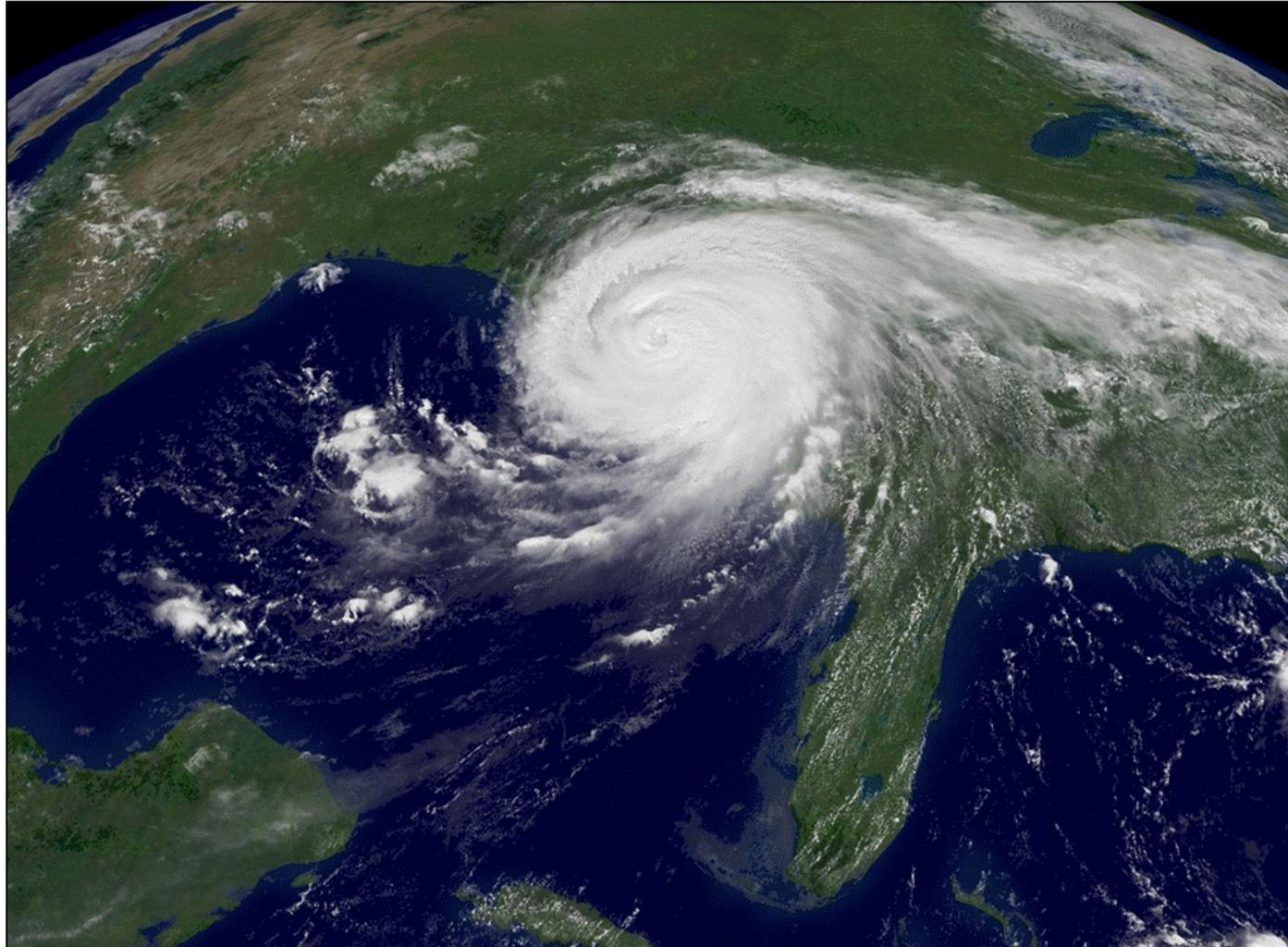
- Infrastructure
- Topography – lay of the land
- Geography – relative location
- Climatology
 - Wind
 - Water

Decision Support (DS)

- ~~Site Image-Based Maps~~
 - ~~General site analysis~~
 - ~~Graphical assistance~~
- ~~Infrastructure overlays~~
 - ~~Proximity to utilities~~
 - ~~Network analysis~~
- ~~Site suitability~~
 - ~~Temporary Housing~~
 - ~~Resource staging~~
 - ~~Heliport~~

Lessons Learned

- Some DS capability needed
- Tailor products to Managers

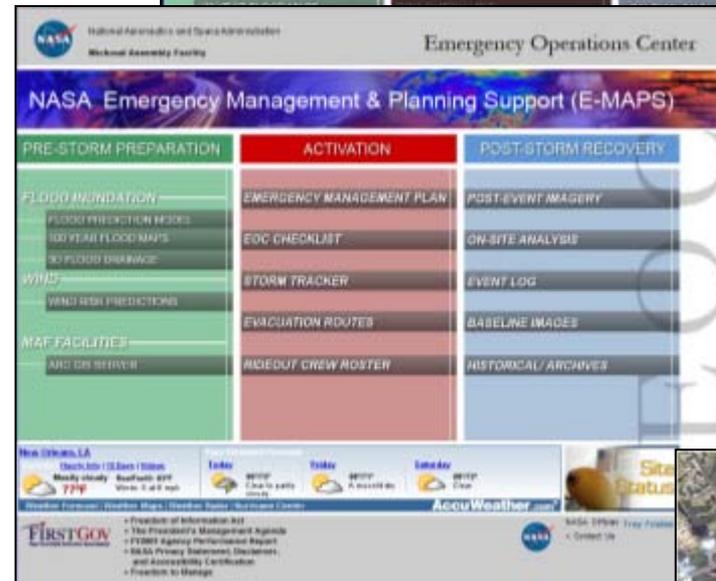




Emergency Management & Planning Support (EMAPS)

EMAPS Addresses:

- Baseline Site Images
- Flood Inundation Predictions
- 3D Flood Drainage (NASA MAF)
- Wind Risk Predictions
- Fire Detection Mapping
- Centralized location for EOC items
- Prototype Post Storm Analysis
- Ground Crew Site Survey Results
- Site Damage Viewable by NASA HQ
- Site Survey reports
- Ground Crew roster





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ARC GIS SERVER		



New Orleans, LA
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77°F

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NASA Emergency Management & Planning Support (E-MAPS)

Flood Prediction Storm Surge Inundation Maps

The Storm Surge Inundation Maps show potential inundation associated with the rise in water level during a hurricane. The extent of flooding is influenced by storm intensity, direction, and forward speed. The maps were derived from the Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model developed by the National Hurricane Center.

Select Storm Category:

- Category 1 (74-95 mph)
- Category 2 (96-110 mph)
- Category 3 (111-130 mph)
- Category 4 (131-155 mph)
- Category 5 (over 155 mph)

Select Storm Direction:

- East
- Northeast
- Northwest
- East Northeast
- North Northeast
- West
- North
- North Northwest
- West Northwest

Select Storm Speed:

- 5 mph
- 15 mph
- 25 mph

Select Map Resolution:

- Low (*Prints on 11"x17"*)
- High (*Prints on 22"x34"*)

Display Map





Sea, Lake, and
Overland Surges
from Hurricanes
Derived Model Output



Map Date: 4/5/2009

Category: 3
Storm Direction: North Northwest
Storm Speed: 25 mph
Tide Level: High Tide

- 2-Foot Contour
- Evacuation Route
- Potential Storm Surge Inundation



Storm Movement

Evacuation Route Conditions

Interstate 510: Clear
Highway 90: Clear

Data Sources
 SLOSH Model: NOAA
 National Hurricane Center
 June 26, 2008
 Aerial Photograph: National Agricultural
 Imagery Program, 1 meter resolution
 Nov 8, 2007

This chart indicates areas that may be susceptible to storm surge in a worst case scenario similar to the depicted storm category, speed, direction, and tide level. The product should be used for guidance only.

Note: This product is derived from SLOSH model outputs using LIDAR data circa 1999.



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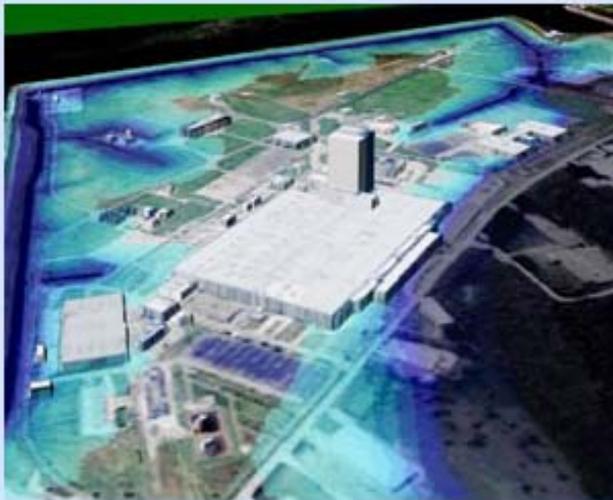
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NASA Emergency Management & Planning Support (E-MAPS)

3D Flood Drainage Maps

Land



Levee



Rain





NASA Emergency Management & Planning Support (E-MAPS)

MAF Inundation | Levee



[Back to 3D Flood Drainage](#)

- Levee overtops near dock, fills canal
- Assumes, for whatever reason, that the pumps are inoperable
- Assumes uniform distribution of rainfall and run-off
- Assumes -5' MSL as standard-water borrow canal elevation
- Approximates borrow canal banks at -2' MSL
- Increments are approximately 6" in vertical elevation
 - First 4 red/brown level is the canal exceeding its banks
 - 1 Blue level as the canal exceeds its banks
 - 8 Remaining cyan levels start at approximately -2' MSL to ~2' MSL
 - The 2' MSL elevation appears as the 2nd of 3 inflection points in the data, with the 3rd associated with the highest point on MAF
- This elevation represented in the models appears analogous to observed flooding in Katrina across Old Gentilly Road
- This suggests that flooding beyond ~2' MSL would require catastrophic levee failures, local or remote, similar or exceeding Katrina observations
- This is a critical point and one that requires significant study
- Another concept to model is the volumetric analysis with the pumps operational vis-à-vis flood water from the different sources



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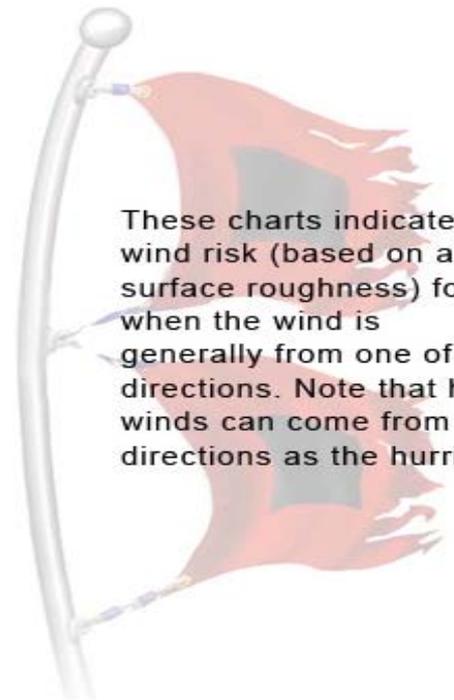
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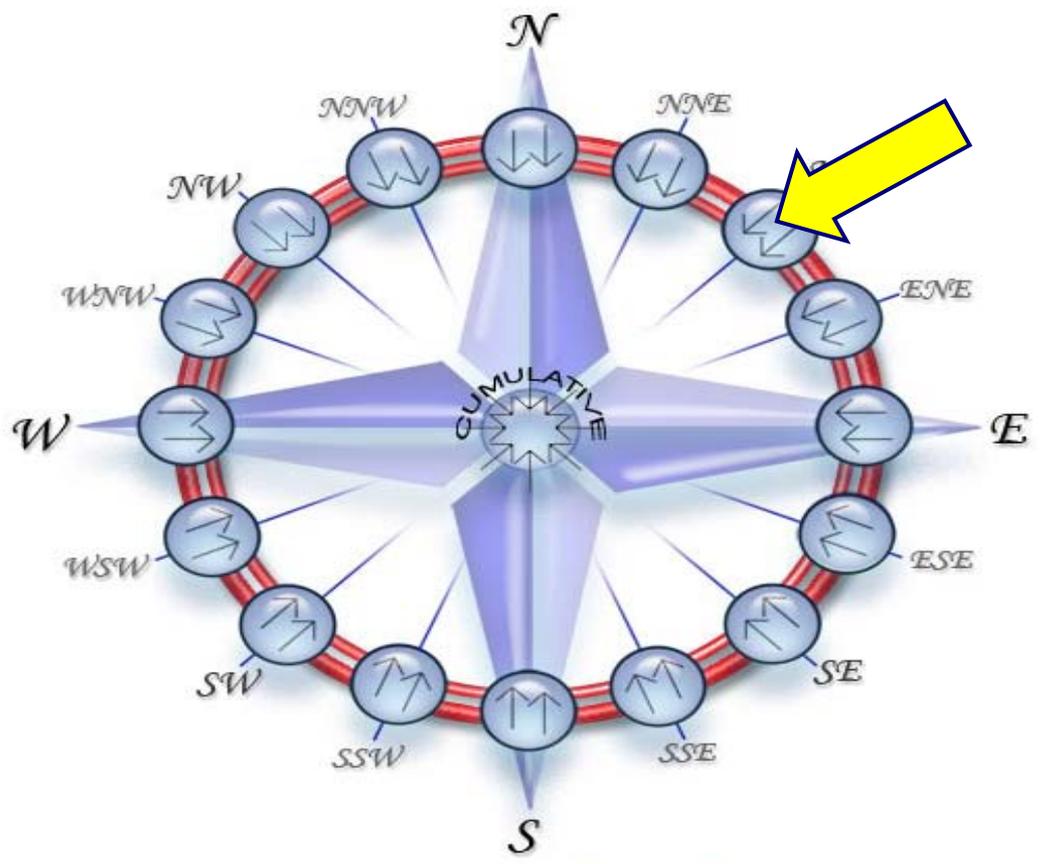




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These charts indicate the relative wind risk (based on aerodynamic surface roughness) for the area when the wind is generally from one of the 16 directions. Note that hurricane winds can come from multiple directions as the hurricane moves.



Select Map Resolution: Low High
Select Wind Direction to Display Wind Risk Prediction Map.
Click in the center when wind is from all directions.



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This chart indicates areas that may be more susceptible to damage during periods of high winds and should be used for guidance only. It is based on wind direction and obstacles to wind flow (such as trees or buildings) located upwind.

Data Sources

LiDAR: USACE
 St. Louis District
 Raw LiDAR used to derive surface roughness
 March 1999
 Aerial Photograph: National Agricultural Imagery Program, 1 meter resolution
 2007

Potential Wind Damage Computed from Aerodynamic Surface Roughness Model for Winds Exceeding Tropical Storm Status (73 mph)



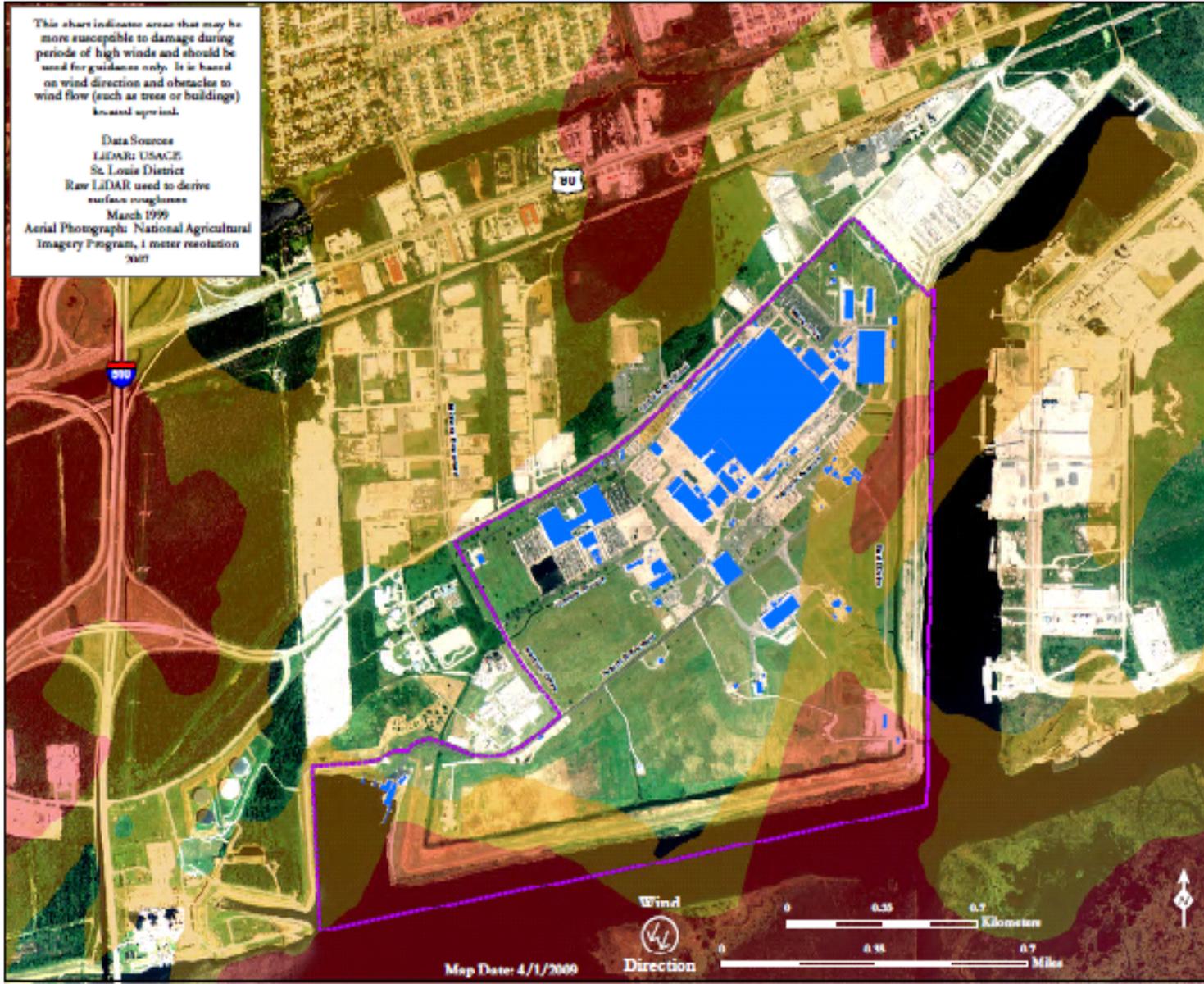
- Legend**
- Michoud Assembly Facility Boundary
 - Buildings
 - Extreme Risk Winds
 - High Risk Winds

Buildings Potentially Affected by Extreme Risk Winds

178	409	450
179		

Buildings Potentially Affected by High Risk Winds

171	179	406
173	218	420
175	220	480
176	222	483
177	404	485
178	404A	490



Map Date: 4/1/2009





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ROSES FOLLOW-ON

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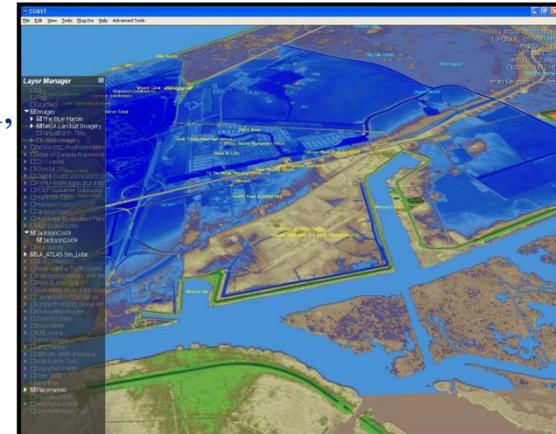
- NASA MAF showed a huge interest in a follow-on to EMAPS,
- Research Opportunities in Space and Earth Sciences (ROSES) 2008 submission, *Evaluation of Hurricane Evacuation Routes' Resiliency to Storm Damage*,
- ROSES follow-on project awarded; proof of concept completed 2011,
- Project Team:
 - Troy Frisbie, NASA, Principle Investigator
 - Richard Brown, SSAI (now CSC), Co-Investigator
 - Don Holland, SSAI, Co-Investigator
 - Kelly Boyd, AGT (now A2R), GIS & Modeling
 - Wei Wu, University of Southern Mississippi (USM), Modeling

ROSES FOLLOW-ON, cont.



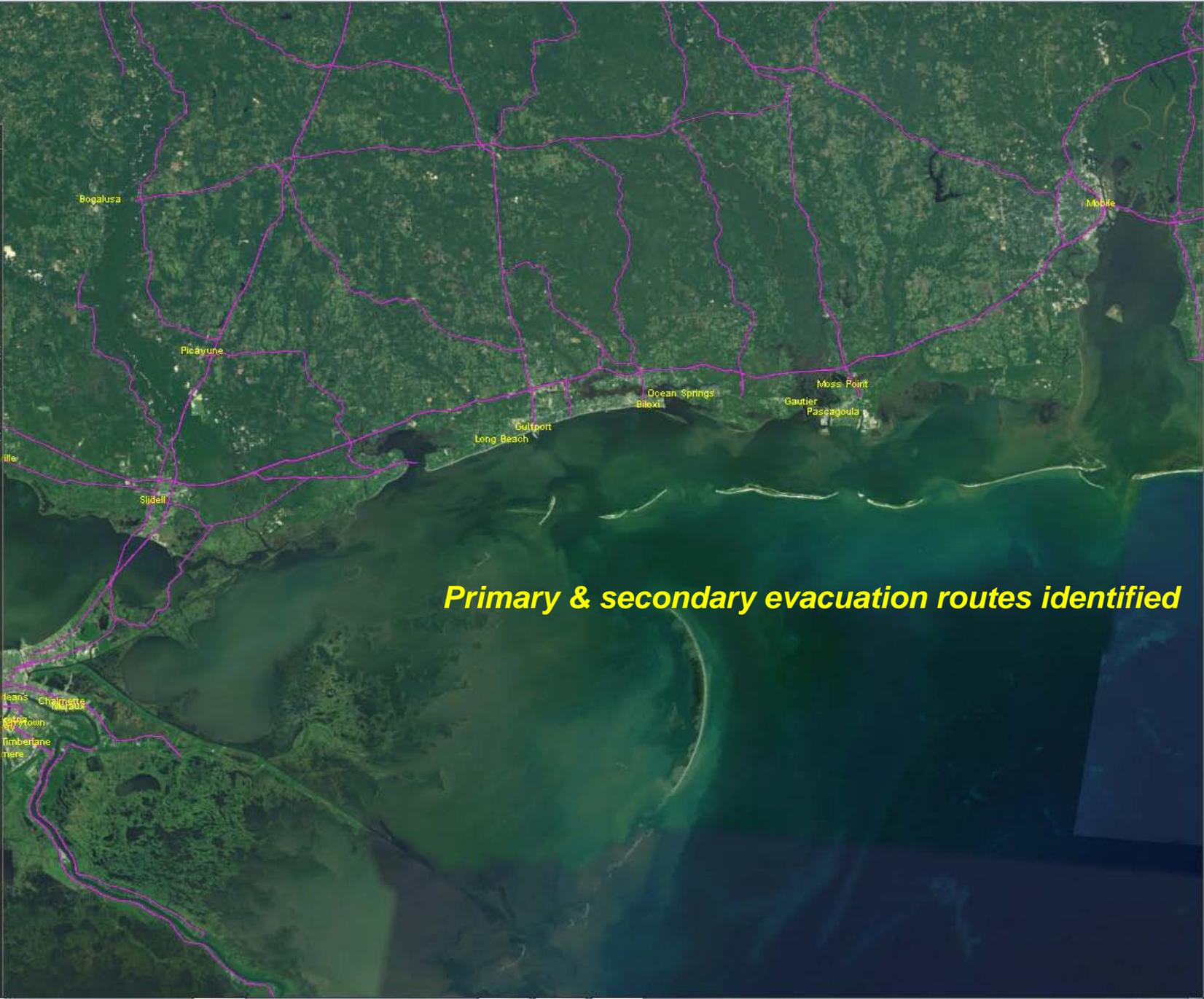
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- Uses Coastal On-line Analysis & Synthesis Tool (COAST) as Geo-browser,
- Flood modeling (USM)
 - Delineate river floodplains due to stream overflowing channels, determine river flood depths in floodplains, and assess vulnerability of evacuation routes to river flood during hurricane,
 - Main model applied is HAZUS-MH MR4 (v1.4) Flood model (general flood risk),
 - HEC-HMS/HEC-RAS developed by US Army Corps of Engineers was also run. (rainfall from NEXRAD added- more realistic sim for river flooding.),
- Wind Risk derived from Coastal Change Analysis Program Regional Land Cover (C-CAP)
 - Unique spatial averaging of Z_o (surface roughness) for given compass direction for each pixel in image,
 - Resultant image represents wind risk for that specific compass direction,
- Wind Risk derived using Light Detection and Ranging (LIDAR)
 - Identify objects (usually trees) that are in close proximity to evacuation routes and could potentially fall on road during storm,
- Storm surge inundation risk (SLOSH)
 - Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model,
- Addresses cumulative Risk.



Layer Manager [X]

- Images
 - The Blue Marble
 - NASA I-Cubed Landsat
 - Landsat
 - NAIP
 - USGS DRG Quads
 - GOES CONUS
 - NEXRAD
 - CPC Global Cloud Cover
 - Borders
- Hurricane Evacuation Risk
- Hurricane Evacuation Routes
- HurrEvacRoutes11
- Katrina Surge Inundation L
- Hurricanes
- MAF Hurricane Risk Models
- NEXRAD - IEM WMS Servic
- Storm Surge Cat5_HurrEv
- Cat5 SLOSH LA
- USM Flood Modeling
- WindRisk_Max_South
- KML Icons
- User Data
 - Boundaries
 - Grid lines
- Placenames
 - Measure Tool
- Land Use Editing

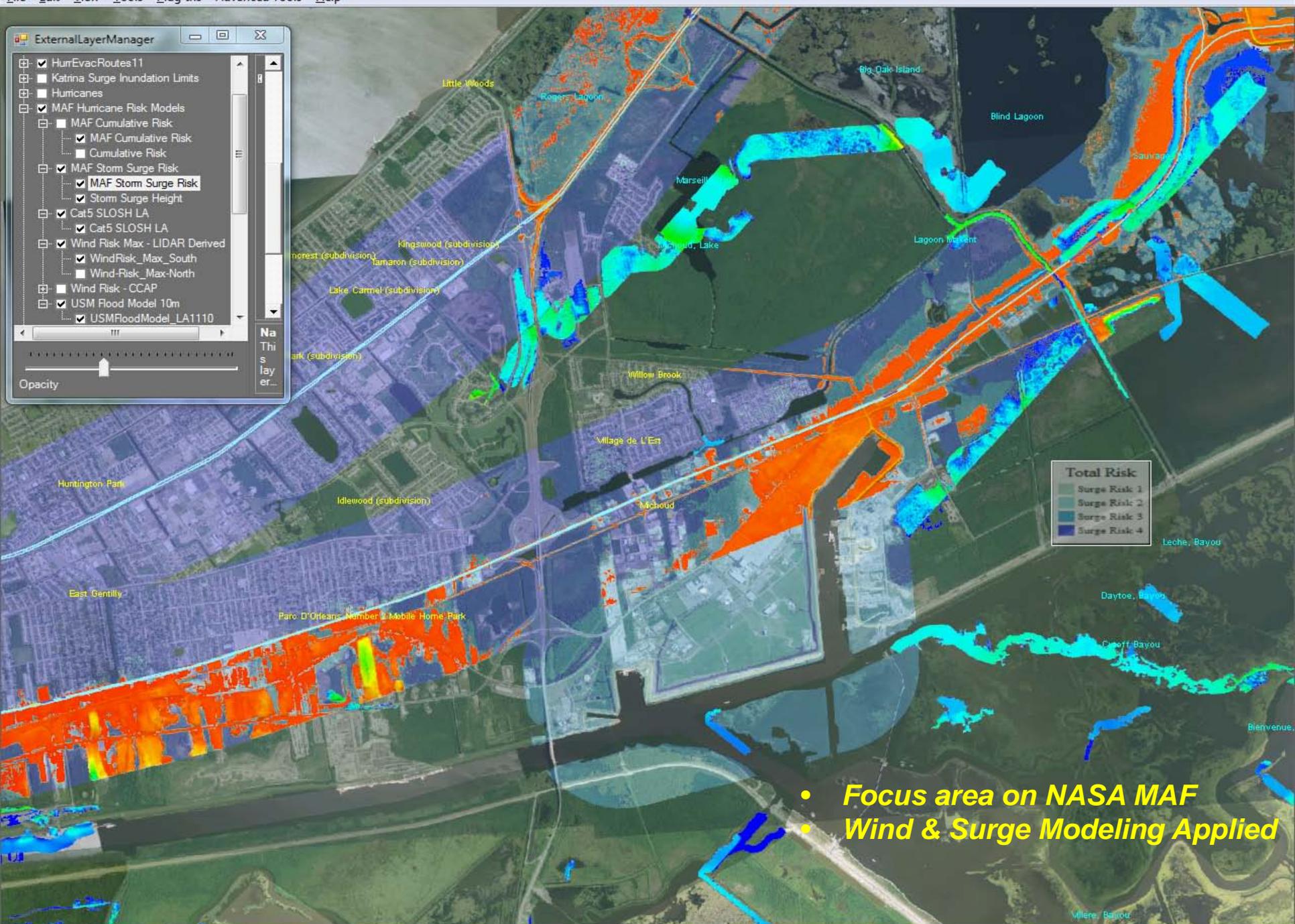


Primary & secondary evacuation routes identified

ExternalLayerManager

- HurrEvacRoutes11
- Katrina Surge Inundation Limits
- Hurricanes
- MAF Hurricane Risk Models
 - MAF Cumulative Risk
 - MAF Cumulative Risk
 - Cumulative Risk
 - MAF Storm Surge Risk
 - MAF Storm Surge Risk
 - Storm Surge Height
- Cat5 SLOSH LA
 - Cat5 SLOSH LA
- Wind Risk Max - LIDAR Derived
 - WindRisk_Max_South
 - WindRisk_Max-North
- Wind Risk - CCAP
- USM Flood Model 10m
 - USMFloodModel_LA1110

Opacity



- Focus area on NASA MAF
- Wind & Surge Modeling Applied

Evacuation routes analyzed under Cat 5 conditions

ExternalLayerManager

- Katrina Surge Inundation Limits
- Hurricanes
- MAF Hurricane Risk Models
 - MAF Cumulative Risk
 - MAF Cumulative Risk
 - Cumulative Risk
 - MAF Storm Surge Risk
 - MAF Storm Surge Risk
 - Storm Surge Height
- Cat5 SLOSH LA
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- Wind Risk - CCAP
- USM Flood Model 10m
 - USMFloodModel_LA1110
- NEXRAD - IEM WMS Service

Opacity: [Slider]

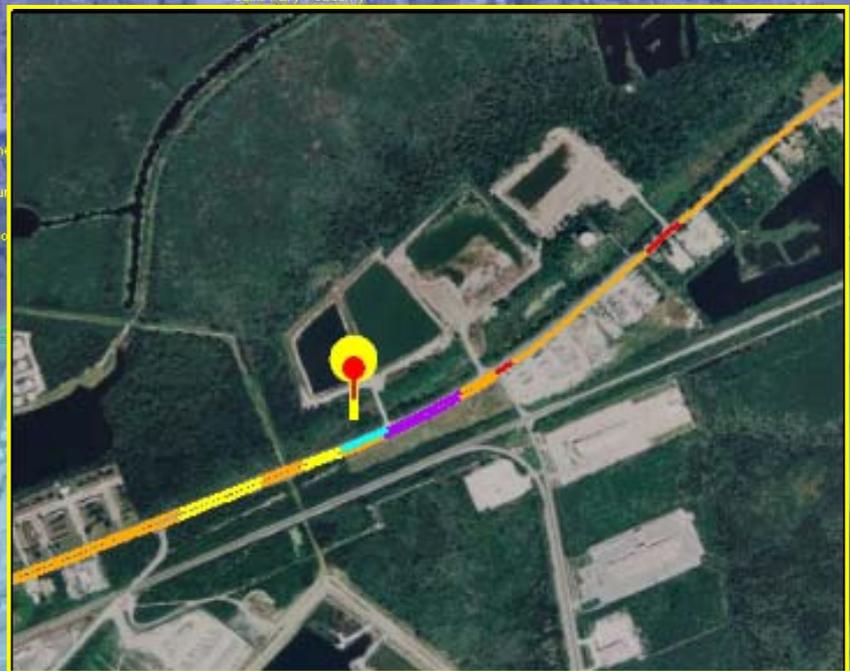
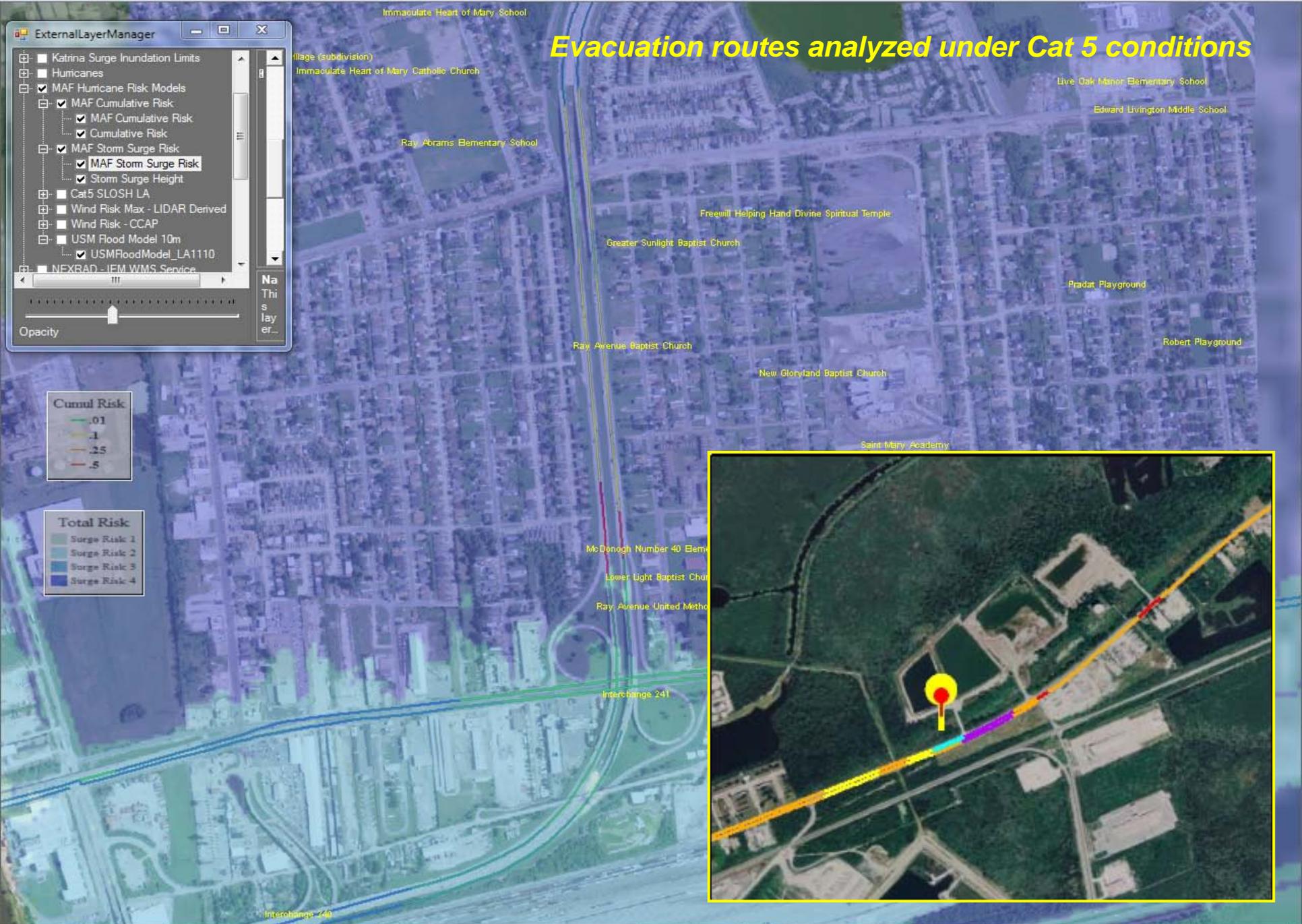
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Cumul Risk

- .01
- .1
- .25
- .5

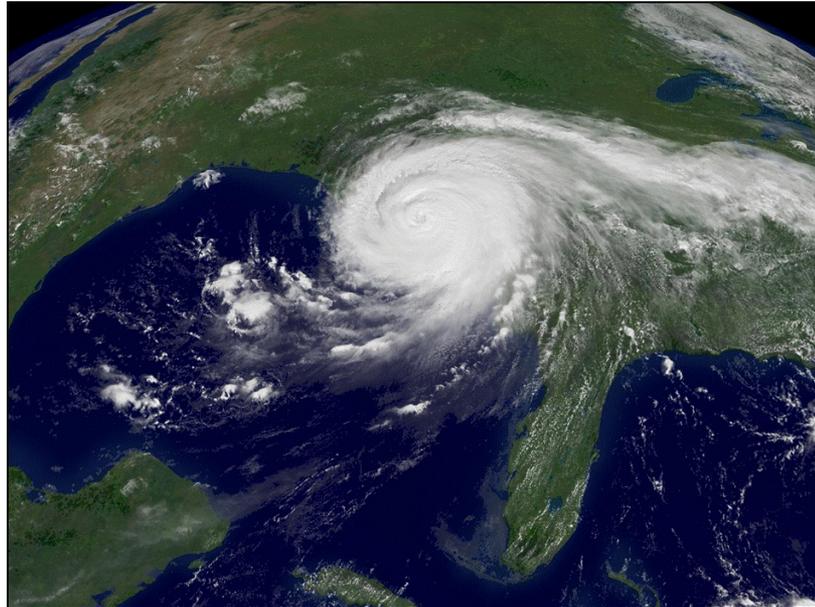
Total Risk

- Surge Risk 1
- Surge Risk 2
- Surge Risk 3
- Surge Risk 4

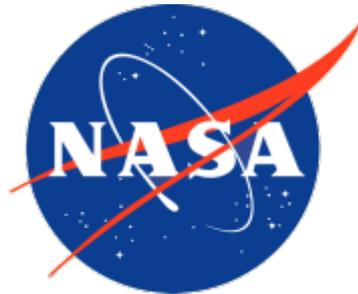


Interchange 240

CLOSING REMARKS



Questions?



***Troy E. Frisbie
Project Manager
Mail Code RA10
NASA, Stennis Space Center
Ph: 228-688-1898
e-mail: troy.e.frisbie@nasa.gov***