Hurricane Isaac’s Flood Impacts to the LA/MS Gulf Coast Area
Introduction

- Hurricane Isaac affected central Gulf Coast August 28th-31st, 2012
- Very slow moving
- Storm surge and heavy rainfall impacts
- Numerous flood crests of moderate and major severity
- A few new records
Outline

- Storm Timeline
  - Pre-Landfall
  - Landfall
  - Post-Landfall
- Storm surveys
- Follow-up Analyses
Hurricane Isaac: Pre-Landfall
Pre-Isaac Forecasts

- Tuesday, August 21 4AM CDT
- T.D. 9 forms
Pre-Isaac Forecasts

- **Wednesday, August 22**
  - 4AM CDT

- **Upgraded to T.S. as of 4PM CDT Tuesday**
Pre-Isaac Forecasts

- Thursday, August 23 4AM CDT
Pre-Isaac Forecasts

- Friday, August 24
  4AM CDT
Pre-Isaac Forecasts

- Saturday, August 25 4AM CDT
Pre-Isaac Forecasts

- Sunday, August 26 4AM CDT

Tropical Storm Isaac

Sunday, August 26, 2012
5 AM EDT Advisory 21
NWS National Hurricane Center

Potential Track Area:
- Day 1-3
- Day 4-5

Current Information:
- Center Location: 25.1°N 79.0°W
- Max Sustained Wind: 65 mph
- Movement NW at 18 mph

Forecast Positions:
- Tropical Cyclone
- Post-Tropical
- Sustained Winds: D < 39 mph
- 39-73 mph
- 74-110 mph
- > 110 mph

Watches:
- Hurricane
- Trop. Storm

Warnings:
- Hurricane
- Trop. Storm
Pre-Isaac Forecasts

- Monday, August 27 4AM CDT
Pre-Isaac Forecasts

- Tuesday, August 28 4AM CDT
Pre-Isaac Forecasts

- Tuesday, August 28 4PM CDT
- Upgraded to hurricane as of 1PM Tuesday
- First landfall
Pre-Isaac Forecasts

- **Wednesday, August 29 4AM CDT**
- **Second landfall**

Isaac’s Flood Impacts to the LA/MS Gulf Coast
Pre-Isaac Forecasts

- Thursday, August 30 4AM CDT
- Downgraded to T.S. as of 2PM Wednesday

Isaac’s Flood Impacts to the LA/MS Gulf Coast
Pre-Isaac Forecasts

- Center of track forecasts from Aug 23-29 compared with final NHC “best track”
Pre-Isaac Forecasts

- Consensus of forecast cones Aug 23-29
Pre-Isaac Forecasts

- 5-day rainfall (QPF) forecast
- Issued Friday, August 24th 7AM
- Highlights Florida landfall
- <0.5in across coastal LA/MS
Pre-Isaac Forecasts

- 5-day rainfall (QPF) forecast
- Issued Saturday, August 25th 7AM
- Increased totals
- ~0.0in across coastal LA/MS
Pre-Isaac Forecasts

- 5-day rainfall (QPF) forecast
- Issued Sunday, August 26th 7AM
- Increased totals
- Higher amounts now into coastal MS with sharp gradient
Pre-Isaac Forecasts

- 5-day rainfall (QPF) forecast
- Issued Monday, August 27th 7AM
- Very high maxima just offshore, with >15.0in forecasted in MS
- Sharp gradient into LA
Pre-Isaac Forecasts

- 5-day rainfall (QPF) forecast
- Issued Tuesday, August 28th 7AM
- Slight westward adjustment
- Final forecast before heavy rain bands begin impacting coast
Pre-Isaac Forecasts

- Forecast track became much closer to observed landfall by evening August 27th

- Once track forecast was more accurate, storm surge forecast accuracy also improved
  - Official forecasts indicated up to 9ft storm tide in Lake Pontchartrain and Lake Borgne by late August 27th
Pre-Isaac Forecasts

- First bands of Isaac reached coast by August 28th
- Official storm tide forecasts for Lake Borgne now 10-12ft
- Northern Lake Pontchartrain now nearing 10ft
- Southern Lake Pontchartrain now nearing 10ft
- Experimental ADCIRC runs indicated areas outside federal hurricane protection levees (Braithwaite, La Place) flooding (midday Aug 28 model runs)
Hurricane Isaac: Landfall
Isaac Landfall

- Significant flood impacts observed across numerous counties/parishes during and right after landfall
- Major flooding forecasted for several rivers due to rainfall
- Loss of some manual gauge readings due to high water levels
- Some areas farther (waterway distance) from the coast took several days to crest and recede from surge
- Surge evident on Mississippi River as far upstream as Red River Landing (~300 river miles).
Isaac Landfall

- Area of most significant flooding impacts
- Defined by streamflow above USGS 90th percentile
Hurricane Isaac: Post-Landfall
Post-Isaac Timeline

- **September 5^{th}-8^{th}, 2012:** The National Weather Service (NWS) Lower Mississippi River Forecast Center (LMRFC) coordinated flood survey teams
  - Document impacts
  - Discuss forecast services with customers/partners
  - Surveys occurred from September 5^{th}-8^{th}, 2012

- **September-December, 2012:** Survey note compilation and analysis
  - Summarizing notes
  - Addressing concerns and action items
  - GIS analysis
Post-Isaac Timeline

- January 2013: Report delivered to New Orleans Weather Forecast Office (WFO)
  - Summary compiled into 90+ page report including 5 appendices
  - Findings, lessons learned, future action items
- January 2013: New Orleans rain gauge site visit
- June 2013: Finalized coordination of crests with USGS
- September 2013: Collaboration with Sewerage and Water Board of New Orleans (SWBNO)
Hurricane Isaac: Post-Landfall Flood Surveys
Post-Isaac Flood Surveys

Survey Team:

- Dr. Suzanne Van Cooten, Hydrologist-in-Charge, NWS Lower Mississippi River Forecast Center
- Jeffrey Graschel, Service Coordination Hydrologist, NWS Lower Mississippi River Forecast Center
- Katelyn Costanza, Senior Hydrologist, NWS Lower Mississippi River Forecast Center
- W. Scott Lincoln, Hydrologist, NWS Lower Mississippi River Forecast Center
- David Schlotzhauer, Hydrologist, NWS Lower Mississippi River Forecast Center
- Jonathan Brazzell, Service Hydrologist, NWS Lake Charles
- Roger McNeil, Service Hydrologist, NWS Birmingham
- Marty Pope, Service Hydrologist, NWS Jackson
Post-Isaac Flood Surveys

- Several different survey team members means several different note-takers
- Different formats, different observations deemed important
- Different handwriting

April 2014
Post-Isaac Flood Surveys

Isaac’s Flood Impacts to the LA/MS Gulf Coast

Amite @ Port Vincent
Residents on Summerfield are cut off but not flooded. Some portions of the road still impassable on the 6th.

Approx WSLVL = 5.8’

Amite River @ Bayou Marchac
Amite River Road and Hornsby Bend were impassable. All homes have been elevated and 9.8 feet no longer floods. Their property is very much invaded.

Presby Outing 9/6/12
21” Run Extreme to Camp store
* Indicated 2” – 1” from flood crest
4”/hr during storm
George higher by one foot
Clubhouse Flood

George foot of water Indicate and North Lake Rd
Water coming up from marlbank
6300 Thomas Marlbank Rd
1 inch onto shop
3:30 pm 4” coast at 8300 T Marlbank Rd -15” high
5” in 50 mins
4” dropped 2014”
From 1971 on
Water to back stop of home
* Input Franklin Creek Back up to homes may
* Input Bridge Creek Back up to homes may

15 years get inside 6 hairs up 1 foot
8:30 am Thursday Wednesday
Water coming up from East
Thursday, stay down.
High Thursday
coming back Friday/Saturday
Hilldalebegin water coming up both sides
Bethel Church Katrina flooded more flood now 2.5’
Red Wing Rd 6500
Post-Isaac Flood Surveys

- Check bldg 1 Apartments on bank 1 slough off bank eating into bank

- Friday morning 3ft from bed of room few steps less across from apartment

- Light pole 1-2' of light pole showing

- 5-6 years apartment

- 10ft: 13.5ft to 14.5ft xLight damage

- 0.38ft Apartment 16.5 - 16.65 ft sharf

- Alt slope from bank to bush

- Top 14.35ft 13 approach on light pole

- Impact same homes may flood on River Road

- Check for possible bottom shift or cone

- Hwy 440 - no indications of impact on road; bridge deck estimated is above HWJ

- Saipango OR Amite gauge cist: 800 + 25.3 = 105.3

- Wall/mud crack on east vs. bank reached drainage

- EM indicated that LALB not supported

- Low driving far left time in 16ft silky mud wet office

- Couple feet over road to wet office

- Water cut off some homes on vet office road (Thomas Rd)

- Up to ground above 10ft at lots just east of Thomas Rd
Post-Isaac Flood Surveys

What to do with all of this different information?
Post-Isaac Flood Surveys

Digitize it and plop it on a map, of course!

- Manually digitized survey notes
- Survey team members collaborated on map to add details missing from notes

April 2014
Post-Isaac Flood Surveys

This leads to a nearly year long period of:

- Compiling notes and mapped locations into a survey report
- Analyzing data
- Answering questions raised by the survey
- Compiling recommendations for improving our service
Flood Survey Report Summary

Sept 5th
- Wolf

Sept 6th
- Wolf River
- Tchoutacabouffa
- Biloxi
- Escatawpa
- Tangipahoa
- E./W. Hobolochitto

Sept 7th
- Wolf River
- Tangipahoa
- E./W. Hobolochitto
- Pearl

Sept 8th
- Tangipahoa
Flood Survey Report Summary

Wolf River

- Surveys Sept 5-7th
- I-59 flooded
- New record at MS26 bridge
- Many bridges over-topped
- New record at Cable Bridge Rd
- I-10 threatened
- Numerous homes flooded near Bells Ferry Rd
- Bells Ferry Rd crest?

April 2014  Isaac’s Flood Impacts to the LA/MS Gulf Coast
Wolf River

Silver Run Rd (left). Scouring on road surface.
Cable Bridge Rd (below). Flattened trees/brush.
Wolf River

Conducted interviews with numerous residents near staff gauge.

- Many comparisons to 1995 flood
- Several anecdotes of water a few inches higher than 1995
- Some anecdotes suggesting discrepancy with gauge datum
- Numerous surveyed elevations and estimate water levels
- Two very clear high water marks near staff gauge

High water mark location near Bells Ferry Rd (above)
Wolf River

Questions remain...
- What is the crest for Wolf @ Bells Ferry Rd?
- What’s the datum of the staff gauge?
Flood Survey Report Summary

- High water mark surveyed to staff gauge
- High water mark across road used for QC
- High water marks of 15.9ft and 16.1ft (referenced to the gauge) surveyed

High water marks in good agreement.
Flood Survey Report Summary

Why discrepancy between USGS and others? Will address later.

Bells Ferry Rd high water marks

SOURCE

USGS
NWS/Survey
Public (High Confidence)
Public (Low Confidence)

April 2014
Isaac’s Flood Impacts to the LA/MS Gulf Coast
Flood Survey Report Summary

Tchoutacabouffa River

- Survey Sept 6th
- Cut-bank scouring
- Lamey Bridge Rd threatened
- A few homes possibly flooded
- Lamey Bridge Rd crest?
Tchoutacabouffa River

Lamey Bridge Rd (Left).
Resident indicates to survey team the crest behind the Riverbend Cove Apartments.
Flood Survey Report Summary

- High water mark surveyed to staff gauge
- High water anecdote on dock across river used for QC
- High water marks of 16.5ft and 14.4ft (referenced to the gauge) surveyed

Why discrepancy between sides of the river? Will be addressed later.
Flood Survey Report Summary

Biloxi River

- Surveys Sept 6th
- MS605 flooded (official hurricane evacuation route)
- A few residences possibly flooded
Flood Survey Report Summary

Isaac’s Flood Impacts to the LA/MS Gulf Coast

Escatawpa River

- Survey Sept 6th
- Campground threatened
- Numerous homes flooded

April 2014 Isaac’s Flood Impacts to the LA/MS Gulf Coast 50
Escatawpa River

Resident near I-10 gauge recorded water levels near his home at frequent intervals. Anecdote matched almost perfectly to gauge readings.
Flood Survey Report Summary

Tangipahoa River

- Surveys Sept 6-8th
- Lake Tangipahoa dam threatened
- Numerous residences flooded, both from river and surge
- Numerous high water marks between gauging stations
Flood Survey Report Summary

E./W. Hobolochitto Creeks

- Surveys Sept 6-7th
- High water at two high hazard dams
- A few residences flooded downstream of gauged locations
E./W. Hobolochitto Creeks

Water near top of spillway guide channel at Lake Hide-a-Way (left). Capture from video by Bruce Devillier.

Flattened brush downstream of Anchor Lake spillway and emergency spillway (right).
Bogue Chitto River

- A few roads threatened
- A few residences flooded
Flood Survey Report Summary

Black Creek

- Surveys late Sept
- Lake Serene dams threatened
- Little Black Creek Lake emergency spillway utilized
- A few residences flooded
- Isaac rainfall did not cause crest as high as expected based upon past events. Will address later.
Hurricane Isaac: Post-Landfall Rainfall Analysis
Rainfall Analysis

- During/after storm, high rainfall totals in some areas was apparent, but some controversy
  - Anecdotes of 20+ inches near Pascagoula from private sources
  - One official gauge of 20+ inches in New Orleans area discounted by NWS local office
- Rainfall data available from numerous sources:
  - Official rain gauges (point data)
  - Radar-only data (gridded data)
  - QC-ed radar+gauge data (gridded data)
Rainfall Analysis

- Second official site in New Orleans area also reported high rainfall totals, but was discounted
- No major flood issues reported in New Orleans during storm
- “New Orleans has never received that rainfall rate and not had significant flooding” – common justification.
Rainfall Analysis

Analysis Questions:

1. How can we compare different rainfall estimates of different types?

2. How can we confirm/discount rainfall maxima in New Orleans?

~4.8in/1hr
Rainfall Analysis

1. How can we compare different rainfall estimates of different types?

Convert point data to gridded data using interpolation.

- **IDW** best for data where minima and maxima are well sampled. Can cause contour bullseyes. Can create mass.

- **Spline** best for data where minima and maxima need to be interpolated. Typically has higher interpolation errors than IDW, but not quantified. Can create mass.

- **Kriging** good for data that is spatially-correlated. Can provide information on how correlation changes with distance. Can assume measurement and interpolation uncertainty right at measurement point (nugget). Provides built-in methods for minimizing creation of mass.
Rainfall Analysis

Kriging

Semivariogram (left)
Equations that describe how data correlates spatially

Interpolation error analysis (right)
Removal of each point, comparison of predicted to actual

NUGGET

Difference from zero point

Distance
Rainfall Analysis

New analysis question...

1A. How can interpolation “create” mass?

Character of rainfall distribution typically “ramps up” toward maxima. This effect is somewhat masked by visualizations due to progressive color scales.
New analysis question…

1A. How can interpolation “create” mass?

Character of rainfall distribution typically “ramps up” toward maxima. This effect is somewhat masked by visualizations due to progressive color scales.
Rainfall Analysis

New analysis question...
1A. How can interpolation “create” mass?

- Interpolation works best with Gaussian distribution
- Square root transform (square rooting the input data before interpolation) gets data closer to Gaussian; less “created” mass
- Semi-variogram equations in Kriging interpolation – the equations that describe how data correlates spatially – also reduce this issue

Based upon this reasoning, we chose Kriging for interpolation.
Rainfall Analysis

- Official gauge locations
- USGS, USACE, NOAA
Rainfall Analysis

- Official gauge locations

Kriging Interpolation

Assumption of gauges being fairly accurate: “0.0” for Nugget
Rainfall Analysis

- Radar only
  NMQ/Q₂
Rainfall Analysis

- NWS Multi-sensor Best Estimate

Gridded radar data from multiple NWS offices mosaiced, then bias-corrected official gauge stations
Rainfall Analysis

- Radar only compared to multi-sensor Best Estimate

Can have widespread error without bias correction.

Radar helpful, but cannot replace gauging stations!
Rainfall Analysis

2. How can we confirm/discount rainfall maxima in New Orleans?

Get additional rainfall data.

- WeatherUnderground maintains a Personal Weather Station (PWS) network of private weather observers.
  - Thousands of stations across the country.
  - Data available for download online.
- AWS/Weather Bug maintains a few stations in the area.
- Private rainfall data from survey interviews
Rainfall Analysis

- Private gauge stations
- Weather Underground, AWS, others

Kriging Interpolation

Assumption of gauges being fairly accurate: “0.0” for Nugget
Rainfall Analysis

- Official and private gauge stations

All possible stations
Rainfall Analysis

- Official and private gauge stations

Stations near the coast considered “good” after manual QC
Rainfall Analysis

- Official and private gauge stations

Krigeing Interpolation

More detail than official only, but not as much detail as radar-based products.
Rainfall Analysis

- New Orleans: Official and private gauge stations

Several gauges back up isolated heavy rainfall maxima in New Orleans

Sharp gradient...10” difference in just 2-3 miles
Rainfall Analysis

- Cumulative and hourly rainfall plots of New Orleans gauges

Remember 4.8in/1hr jump in data labeled “not likely?” (AUD#2)
Gauge total rainfall consistent with other gauges.

In context of big picture?
Appears to be good data.
Rainfall Analysis

2. How can we confirm/discount rainfall maxima in New Orleans?

Estimate storm runoff as proxy for minimum basin-averaged rainfall.

- In typical watersheds with gauges at outlet point, we can estimate runoff using a rating curve and the discharge hydrograph.
- New Orleans is not a typical watershed
  - Runoff does not flow downhill into streams
  - Runoff flows into storm drains which have to be pumped into canals, then pumped into Lake Pontchartrain
Rainfall Analysis

2. How can we confirm/discount rainfall maxima in New Orleans?

Estimate storm runoff as proxy for minimum basin-averaged rainfall.
Rainfall Analysis

2. How can we confirm/discount rainfall maxima in New Orleans?

For New Orleans, will have to use pumping logs from Sewerage & Water Board in combination with pump curves to estimate volume pumped from city. 

*This remains an area of ongoing analysis.*
Hurricane Isaac: Post-Landfall
Establishing Crests
Establishing Crests

Wolf @ Bells Ferry Rd HWMs

Why discrepancy between USGS and others? Raises question of the staff gauge datum.

SOURCE
USGS
NWS/Survey
Public (High Confidence)
Public (Low Confidence)

April 2014 Isaac’s Flood Impacts to the LA/MS Gulf Coast
Establishing Crests

Further information from USGS suggests that staff gauge is off of NAVD88 by ~0.9 ft (0.0 ft stage = -0.9 ft elevation NAVD88)

This is based upon both Isaac flooding and 1995 flood event.

Taking into account measurement uncertainty, crest established at 16.0 ft stage (15.0 ft NAVD88)

Gauge datum now -1.0 ft NAVD88
Establishing Crests

Why discrepancy between sides of the river? Meander bend may be to blame.

Tchoutacabouffa @ Lamey Bridge Rd HWMs
Establishing Crests

Further comparison of this event to previous events using an upstream gauge and a downstream gauge suggested 14.5ft crest. Hydrograph shape before/after event suggested 14.0-15.0ft crest.

Crest established at 14.5ft stage
Hurricane Isaac: Other Post-Storm Analyses
Flood Survey Report Summary

Black Creek

Why the lower crest with similar rainfall to past events?
Flood Survey Report Summary

Numerous private ponds/lakes constructed over decades. Effect is holding of sediment and storm water.

Black Creek impoundments

Known Dams

Manually Digitized Dams
Conclusions and Final Remarks
Conclusions and Final Remarks

- Hurricane Isaac’s slow movement at landfall set the stage for storm surge and heavy rainfall impacts to coastal Louisiana/Mississippi
- NWS staff surveyed flood impacts after the storm to document impacts
- Numerous individuals kept close watch on river forecasts using the NWS’s AHPS
- Numerous individuals were aware of their surveyed elevation and how to correlate to nearby gauges
Conclusions and Final Remarks

- Proper analysis requires putting data in the context of the big picture.
- Realtime, in-situ observation networks are essential; remote-sensed data (such as radar) more uncertain without ground truth.
- Post-event analysis can improve with more data.
- Larger variety of tools/models, used properly, improve forecasting and analysis.
Questions/Comments/Complaints?

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Showing off safe procedures while surveying Isaac flooding.