ADVANCED FORECASTING AND MAPPING OF CATASTROPHIC FLOODING IN SOUTH CAROLINA

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Recent Regional Flooding History and Response
Recent Regional Flooding History

October 2015

A combination of factors created a “perfect storm” of conditions:

- Stalled frontal boundary near the coast
- Hurricane Joaquin

Resulting precipitation event yielded widespread loss of life and property damage:

- 19 deaths
- Damage estimates in excess of $1 Billion
Recent Regional Flooding History

October 2015

- Most flooding in impacted area was “flashy”
- Rapid and sudden inundation of low-lying areas
- Pre-emptive information dissemination not possible due to the nature of the event
Recent Regional Flooding History

October 2015 Data Generation and Response

- Provided a map of impacted counties, with post-event inundation extents in select locations
  - No refinement
  - Inundation extent mapping data coverage limited to Richland County, provided well after the event
Recent Regional Flooding History

Hurricane Matthew (October 2016)

- Storm surges of 6.1’ in Charleston, 4.4’ in Myrtle Beach
- Significant flooding throughout sizeable portions of the State
- 12”-18” of precipitation in the Little Pee Dee (LPD) and Waccamaw watersheds over a 72hr period
- Waccamaw at Conway crested at 17.9 ft, LPD at Galivant’s Ferry crested at 17.1 ft
  - Both broke all-time records set by the 1928 Okeechobee Hurricane
Recent Regional Flooding History

Hurricane Matthew Data Generation and Response

- Provided inundation mapping and a timeline for arrival of flood waters to direct response resources to flooded areas
- Used by SCDOT, SLED, SCDNR Law Enforcement and SCDNR WFF
- Development initiated after flooding started, and delivered during the event
Recent Regional Flooding History

Hurricane Florence (September 2018)

Made landfall as a Category 1 on September 14, yielding record precipitation totals:
- 22.8” nr Lumberton, NC
- 19.6” at Marion, SC
- 18.4” nr Dillon, SC

Flooding surpassed previous records across the region.
Recent Regional Flooding History

Hurricane Florence (September 2018)

- “Slow Moving Disaster” in most impacted SC communities
- Advanced forecasting of expected precipitation totals
- Improvements in modeling software applications and methods enabled a preemptive and proactive response
Recent Regional Flooding History

Objectives

- Preemptive / Proactive Approach
  - Evacuations vs Rescues

- Provide planning level forecasts of flooding extent, depth, and timing for areas forecasted to be impacted

- Generate data that could be used by state agencies to pre-stage response assets

Source: www.postandcourier.com
Forecast Model and Mapping Development
Forecast Modeling and Mapping Development

Challenges

- **UNCERTAINTY!!!**
  - Evaluation of options began 7 to 10 days prior to landfall

- **Scale of the effort**
  - Divergent forecast predictions showed the entire state at risk

- **Timeline**
  - Hard deadline
Forecast Modeling and Mapping Development

Solution

Utilize *Rain-on-Grid 2D modeling* to leverage available datasets to provide the necessary information

- Generate a broad array of data for all of the conveyance pathways across the entire area of interest
Forecast Modeling and Mapping Development

Project Area

Spatial extent of the modeling required the cooperation of multiple teams

- Pee Dee River and Edisto River watersheds modeled by SCDNR contractors
- Santee River watershed modeling domain was covered by USACE
Forecast Modeling and Mapping Development

- Modeling domain reflected Florence’s forecasted impacts across 18,000 sq. mi. of drainage area.
- Inundation depth and extent mapping generated for over 8,600 sq. mi. of NE South Carolina.
- Mapping produced for approximately 1/3 of the state.
LESS FLOODING

Forecast Modeling and Mapping Development

Project Area

- 8,390 sq. mi. of drainage area
- 10 HUC-8 watersheds encompassed
- Mapping produced for approximately 1/4 of the state
- Tidal Influences on coastal areas
Forecast Modeling and Mapping Development

Software Tools
Terrain data was acquired from various federal, state, and county data repositories. Datasets were clipped and combined as needed in order to provide complete coverage for the area of interest.
Forecast Modeling and Mapping Development

Input Data

Land Cover data extracted from the National Land Cover Dataset for the area of interest

Classifications condensed and processed for usability in hydrologic and hydraulic analyses
Forecast Modeling and Mapping Development

Level of Detail

- Balanced mesh cell size with processing time constraints for delivery of planning level results

- Utilized break lines to define major road or railway crossings and topographic features
Gathered and processed necessary spatial datasets

Processed precipitation data for use in Rain-on-Grid analysis

Executed 2D modeling

Processed and delivered RAS output raster datasets for use on the SCDNR website
Put It All Together...
Forecast Modeling and Mapping Development

Results

1st inundation depth and extent map, derived from NWS and NOAA rainfall predictions, generated days in advance of Hurricane Florence’s landfall

Inundation forecasts were updated twice daily as Florence moved across the region
State Emergency management agencies received estimates of the number and locations of structures that would likely be impacted by 2ft or more of flood water. Modeling / mapping results generally accurate to within +/- 18” throughout the Area of Interest.
Forecast Modeling and Mapping Development

Results

Forecasted depth: approx. 8’ – 10’
Forecast Modeling and Mapping Development

Results

- Forecasted depth: approx. 8’ – 10’

- Photos taken by area residents during the event show flooding that agrees with forecasted flood depths / WSELS
Forecast Modeling and Mapping Development

**Results**

**USGS 02135200 PEE DEE RIVER AT HWY 701 NR BUCKSPORT, SC**

- **Qₚ**: 137,000 cfs
- **Peak WSEL**: 16.2 ft (NAVD88)
Forecast Modeling and Mapping Development

Results

Q_p: 115,000 cfs

Peak WSEL: 17.5 ft (NAVD88)
Lessons Learned & Path Forward
Lessons Learned and Path Forward

ArcGIS Online Portal

- Inundation forecast data for impacted watersheds incorporated into AGOL portal for Emergency Management Agencies
- Provided a single centralized location for dissemination of data

Intended exclusively for official use!
Lessons Learned and Path Forward

AGOL portal set up did not include access restrictions

Lack of restriction allowed data to be viewed by the general public

- Data used for purposes beyond its original intent
- Not formatted to be easily consumed by the general public. Data misinterpreted or misunderstood.

Source: CBS news
Lessons Learned and Path Forward

Data Usage Details

Usage details for the period:
September 13, 2018 - October 4, 2018

Start Date: 9/13/2018
End Date: 10/4/2018

Item Views this Period: 440,713
Avg Item Views Per Day: 20,986.33

Usage Time Series
Lessons Learned and Path Forward

**Lessons Learned**

1. Ensure data is disseminated through a secure medium
Lessons Learned and Path Forward

Clearly Communicate Limitations

- The day after public became aware of the AGOL portal, a disclaimer was added to the data
- Users notified of the limitations of the modeling
- Misinformation already began to spread
Lessons Learned and Path Forward

Lessons Learned

1. Ensure data is disseminated through a secure medium

2. Ensure that end users understand the limitations of the data
Lessons Learned and Path Forward

Event-Specific Data, Event-Specific Results

- Analysis utilized hydrologic data derived from evolving precipitation forecasts
  - Multiple Iterations
- Calibration / refinements made during and after delivery of results
  - Forecast vs Observed data yielded increased precision
Lessons Learned and Path Forward

Lessons Learned

1. Ensure data is disseminated through a secure medium

2. Ensure that end users understand the limitations of the data

3. While this effort is essentially an event-specific “EAP-on-the-fly”, model accuracy will be improved if data is developed well ahead of the event
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COMMENTS & QUESTIONS