Hurricane Harvey: A call for new data, science and services

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Acknowledgements: Texas Division of Emergency Management, Chief Nim Kidd, Jeff Newbold, Michael Ouimet, Warren Weidler, Jeanette Chamorro; ESRI, Kisters, TACC; colleagues and students at UT Austin, Harry Evans, Xing Zheng, David Arctur, Erika Boghici, Lukas Godbout, Jeff Zheng
Hurricane Harvey Precipitation

Harvey 2-day precipitation was the worst recorded storm in US history.

Harvey 3-day Precipitation averaged 5 inches more than previous storms.

Harvey 5-day Precipitation averaged 11 inches more than previous storms.

Data Sources: NWS River Forecast Centers; Applied Weather Associates, Inc., NASA.
Analysis: John Nielsen-Gammon and Brent McRoberts, Texas A&M University.
Texas Division of Emergency Management

- State Operations Center
- Regional Coordinators
- Disaster Districts
- Counties

Chief Nim Kidd
Director, TDEM
Maximum Flood Inundation Extent from Hurricane Harvey

First regional scale map of flooding in impacted zone

Responded to a request by Governor for estimate of the total flooded area

“Dear Director Uccellini: The Texas Division of Emergency Management requests the mobilization of the National Water Center to assist with flood inundation mapping in response to Hurricane Harvey. “

-- Chief Kidd; Sunday, August 27, 2017
“Over the last year, Dr. David Maidment and his team have provided invaluable support for groundbreaking work developing a Texas Flood Response System for TDEM. Because of the catastrophic nature of this disaster, TDEM needs additional technical support for water data on an expedited basis and we believe Dr. Maidment’s team and other personnel from the university can provide this for the state’s response.”
Texas Address Points

9.2 million points

Data compiled by UT Austin from Emergency Communications Districts

Point on every building used for dispatching emergency response vehicles by 911 systems
Inundation Maps for Search and Rescue

Observations from the U.S. Geological Survey
Guidance from NOAA and the National Water Center
Forecasting by NWS West Gulf River Forecast Center
Inundation Mapping by US Army Corps of Engineers
Overlay on Address Points by University of Texas at Austin

Experimental product, not confirmed by local observation

US National Grid used for Search and Rescue
Goal: Real-Time Flood Inundation Mapping for Texas at Local Scale
National Water Center Innovators Program

• Successful partnership between federal water agencies and the academic community to accelerate Research to Operations

• Summer Institutes for graduate students at National Water Center in 2015, 2016, 2017, involved 105 students from 49 universities

• Establishes a community of practice around the National Water Model and the National Water Center.

• Annual cycle of innovation, research and assessment spanning USGS, USACE, NOAA and the academic community
Conclusions

- Harvey was an unprecedented and devastating storm

- **Real-time inundation maps** are required now more than ever
  - Flood predictive capability is within grasp at National Water Center
  - Continued investment in rainfall prediction is needed
  - Observational capability is woefully inadequate requiring renewed investments in USGS stream gages and other networks

- Academic community can make a significant contribution
  - Research to operations spans federal and research communities
  - Computational support in development and processing
  - Summer Institute research at National Water Center
National River Hydraulic Framework for Flood Inundation Mapping

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Subcommittee on Spatial Water Data, 22 September 2017

Acknowledgements: USACE Fort Worth District, Helena Mosser, Jerry Cotter, Colleagues and students at UT Austin, Harry Evans, Xing Zheng, David Arctur, Erika Boghici, Lukas Godbout, Jeff Zheng
Inundation Areas
Guadalupe River
Colorado River
Brazos River
Harris County
Trinity River
Neches River

Flood Modeling Credits: Interagency Flood Risk Management (INFORM) Group
With permission of TDEM
First Composite Map of Flood Inundation Extent

First regional scale map of flooding in impacted zone

Responded to a request by Governor for estimate of the total flooded area
Provisional flooding impacts

Early, rough estimates for 56 state and federal disaster-declared counties:

~ 9,000 sq mi flooded
~ 40,000 river-miles
~ 966,000 addresses
Unprecedented rainfall and flooding. Texas Flood Response System project helped get valuable resources in place.

Major test for National Water Model. Need to improve coastal flood modeling, include ponding, and have *library of inundation polygons ready in advance.*

*Imagine if these maps could’ve been presented 3 days prior to the storm arrival, instead of 3 weeks later!*
Large areas of Texas lack flood information
Real-Time Flood Inundation Mapping
Onion Creek at Highway 183


Cost per map: $40,000 – $160,000
What is a Floodplain?

Characteristics of a Floodplain

Floodplain

Flood Fringe

Flood Fringe

Floodway

Base Flood Elevation (BFE)

Normal Channel

Fill

Source: NFIP Guidebook, FEMA
Method for Determining Flood Risk: Height Above Nearest Drainage (HAND)

Flooding occurs when Water Depth is greater than HAND
Continental-Scale Flood Inundation Mapping

Catchments and Flowlines

Digital Elevation Model

Height Above Nearest Drainage (HAND)
(relative elevation of land surface cell above cell in stream to which it flows)
USGS Rating Curve at a Stream Gage
Onion Creek at Highway 183
# Reach Hydraulic Parameters

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- **Comid**: Unique identification number for the reach.
- **y**: Depth of the reach.
- **A**: Cross Section Area.
- **R**: Hydraulic Radius.
- **P**: Wetted Perimeter.
- **T**: Top Width.
- **V**: Volume.
- **Ab**: Wetted Bed Area.
- **As**: Surface Area.

\[
A = \frac{V}{L} \quad \text{Cross Section Area}
\]
\[
P = \frac{A_b}{L} \quad \text{Wetted Perimeter}
\]
\[
T = \frac{A_s}{L} \quad \text{Top Width}
\]
\[
R = \frac{A}{P} \quad \text{Hydraulic Radius}
\]
Rating Curve – Connects Discharge with Depth

Rating Curve for Eanes Creek, ComID = 5781289

\[ Q = \frac{1.49}{n} AR^{2/3} S_0^{1/2} \]

Flood Depth, \( y \) (ft)

Forecast Discharge, \( Q \), from National Water Model
Integrity Checking

Comparing with USACE flood models

Blanco River

Comparing with observed water depth at USGS, LCRA and other gaging sites
Synthetic Rating Curves for Reach 1630223

Rating Curve Space of Reach 1630223

- **HEC-RAS** Median
- **HAND**-derived

Graph showing stage height versus discharge with data points and trend lines for HEC-RAS and HAND.
First Responder Input to Inundation Mapping

Rock on road at current water level ➔ Point location sent in by text ➔ Inundation map

Chief Todd Pomroy, Austin Fire Department
NHDPlus Version 2.1

Foundation for a Geospatial Hydrologic Framework for the United States

NHDPlus

2.7 million reach catchments in US
average area 3 km²
reach length 2 km
Uniquely labelled

National Elevation Dataset

Watershed Boundary Dataset

National Hydrography Dataset

National Land Cover Dataset
National River Hydraulic Framework

- NHDPlus Version 2.1 is the **hydrologic basis** for the National Water Model

- **Reach lengths vary** a lot from < 100m to more than 10km

- For flood inundation mapping need **regular reach lengths** defined on high resolution NHD

- Each reach needs a **flood inundation map library** defined using increments of water depth

- Need to define a **schema** for this

- A task for the **Subcommittee on Spatial Water Data?**