Applying the National Water Model in Texas

David R. Maidment
Center for Research in Water Resources
University of Texas at Austin

Presentation for TWDB Water for Texas Conference, Austin, Texas, 22 January 2017

Acknowledgments: Ed Clark, National Weather Service; Yan Liu, University of Illinois; David Tarboton, Utah State University; David Arctur, Harry Evans, Xing Zheng, University of Texas at Austin; City of Austin, National Weather Service, NCAR, CSEC, Texas Division of Emergency Management, ESRI, Kisters, National Science Foundation, colleagues and students at UT Austin.
The Opportunity

New National Water Center established on the Tuscaloosa campus of University of Alabama by the National Weather Service and federal agency partners

Has a mission to assess hydrology in a new way at the continental scale for the United States
NWS River Forecast Centers (RFCs)

- Prepare river and flood forecasts using models based on average basin characteristics
- Provide forecast guidance to Weather Forecast Offices (WFOs)
- Issue daily stage and streamflow forecasts, rainfall and drought data and information, and flash flood guidance
- Work with water managers and other Federal Agencies

6600 sub-basins in continental US
Centralized Water Forecasting
This meeting led to an engagement between the academic community of the United States and the National Weather Service to help build the National Water Model.
National Water Prediction Model Configurations

Short-Range 'Flood Prediction' Analysis & Assimilation
- Hourly
- ~Daily (x16)

Medium Range 'Flow Prediction'
- Daily
- 0-10 days

Long Range 'Water Resources'
- Four Forecasting Horizons for National Water Model
- 0-2 days
- 0-30 days

Spatial Discretization & Routing
- 1km/250m/
- NHDPlus Reach

Meteorological Forcing
- MRMS blend/
- HRRR - NAM bkgnd
- Downscaled HRRR/RAP/NAM blend
- Downscaled & bias-corrected CFS

Operational on 16 August 2016

Legend
Streamflow (cfs)
- 0 - 119
- 119 - 7,520
- 7,521 - 88,700
- 88,701 - 201,900
- 201,901 - 460,000
- 460,001 - 1,200,000

Map: US National Water Model
Operational on 16 August 2016

05/01/2015 00:00
Forecasts from National Water Model

Now

Analysis

Best estimate of current conditions

Short Range

Hourly for 15 hours ahead

Medium Range

3 Hourly for 10 days ahead

Long Range

Daily for 30 days ahead

Ensemble of 4 forecasts each 6 hours (16 forecasts total)

(5 TB of forecast information per day)
NOAA National Water Model in Texas

Continuous real-time water forecasting on **190,000 miles** of streams and rivers divided into **98,000 reaches**. Data are publicly accessible now.

A transformative improvement for flood resilience in our state!
Texas Division of Emergency Management

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

Chief Nim Kidd
Director, TDEM
Flood Emergency Response in Texas

Local governments (counties, cities, or towns) respond to emergencies daily using their own resources.

They rely on mutual aid and assistance agreements with neighboring jurisdictions.

When local jurisdictions cannot meet incident response resource needs, they may ask the state for assistance.
Information Flow During a Flood Emergency

Weather and Flood Forecasting

Flood Impacts

Communications cycle

Assessment of Conditions

Emergency Response
Storm in San Bernard Basin, 18 Jan 2017

San Bernard River near Boling

http://gisdev.srh.noaa.gov/rfcddss2.html
Area of Concern: San Bernard Basin in Brazoria, Fort Bend, Wharton and Matagorda Counties in Texas

San Bernard River
San Bernard River near Boling
Fort Bend
Brazoria
Wharton
Matagorda
San Bernard Basin

NWS Forecast Point BOLT2
NWS Forecast Points and Basins in San Bernard Basin
West Gulf River Forecast Center Largest Impact: Forecast of Moderate Flooding (at BOLT2) (made at 7:19PM 18 Jan 2017)

National Water Model Forecast Map

http://water.noaa.gov/map
Forecast of National Water Model for San Bernard River at Boling (peak of 4727 cfs at 10AM) (made at 3 AM Central Time, accessed at 5:30AM 18 Jan 2017)
National Water Model in San Bernard Basin
(800 catchments and stream reaches)

Forecasts are available for each individual stream
TDEM Flood Inundation Mapping System

Forecast of discharge from National Water Model Converted to depth using a synthetic rating curve

(these data are from the 2AM NWM forecast because of the time lag to do the conversion to depth)
Comparison of WGRFC and NWM/TDEM forecast of Water Depth on San Bernard River near Boling, TX

Stage Height of Forecast = 22.9 ft
Minus Stage Height at Zero Discharge ~ 2.8 ft
Equals Water Depth in Stream of 20.1 ft from WGRFC Forecast

Water Depth in Stream from synthetic rating Curve applied to National Water Model forecast = 20.3 ft

There is less than 1 foot difference between these two forecast depths!
Flood Response Mapping

- Level 1 – approximate inundation mapping
- Level 2 – approximate impact mapping
- Level 3 – detailed inundation mapping
- Level 4 – detailed impact mapping

Uses National Elevation Dataset and rating curves
Impact at County scale

Uses LIDAR and detailed hydraulic modeling
Impact at Stream Reach scale
Texas Address Points

8.6 million points

Used for dispatching emergency response vehicles in 911 systems
Method for Determining Flood Risk: Height Above Nearest Drainage (HAND)

Flooding occurs when Water Depth is greater than HAND
Real-Time Flood Inundation Mapping
Onion Creek at Highway 183

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)
Height Above Nearest Drainage for Texas

HAND_ft
- ≤10.0
- ≤20.0
- ≤40.0
- ≤60.0
- > 60.0
Height Above Nearest Drainage for Address Points in Williamson Creek
This Information Can be Used for Detailed Flood Response Planning by First Responders
USGS Rating Curve at a Stream Gage

Onion Creek at Highway 183

Measure Water Level

Determine Discharge

Provisional
## Reach Hydraulic Parameters

<table>
<thead>
<tr>
<th>Comid</th>
<th>y</th>
<th>A</th>
<th>R</th>
<th>P</th>
<th>T</th>
<th>V</th>
<th>Ab</th>
<th>As</th>
</tr>
</thead>
<tbody>
<tr>
<td>5781175</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5781175</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Equations

- Cross Section Area: $A = \frac{V}{L}$
- Wetted Perimeter: $P = \frac{A_{b}}{L}$
- Top Width: $T = \frac{A_{s}}{L}$
- Hydraulic Radius: $R = \frac{A}{P}$
Rating Curve – Connects Discharge with Depth

Rating Curve for Eanes Creek, ComID = 5781289

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

Flood Depth, \( y \) (ft)

Forecast Discharge, \( Q \), from National Water Model
Continental-Scale Flood Inundation Mapping

1. Forecast discharge with National Water Model

2. Convert discharge to depth using rating curve

3. Convert depth to inundation using HAND

4. Add Address Points to assess impact
Flood Response Mapping

- Level 1 – approximate inundation mapping
- Level 2 – approximate impact mapping
- Level 3 – detailed inundation mapping
- Level 4 – detailed impact mapping

Uses National Elevation Dataset and rating curves
Impact at County scale

Uses LIDAR and detailed hydraulic modeling
Impact at Stream Reach scale