Extreme Precipitation and Flooding: It’s more than just about the heavy rainfall

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Hydrologist-in-Charge
NOAA/NWS
Northeast River Forecast Center
Calibrate and implement a variety of hydrologic and hydraulic models to provide:

- River flow and stage forecasts at 180 locations
- Guidance on the rainfall needed to produce Flash Flooding
- Ensemble streamflow predictions
- Ice Jam and Dam Break support
- Water Supply forecasts
- Partner with NOAA Line Offices to address issues relating to Hazard Resiliency, Water Resource Services, Ecosystem Health and Management, and Climate Change
NERFC Forecast Services
On A Watershed Scale

Requirements:
- Observed precipitation & temperatures
- Observed streamflows (USGS)
- Forecast temperatures and precipitation
- Drainage area ≥100 sq mi

Our models help us forecast:
- The volume of water in the river & that’s converted to stage/elevation
- Time of the peak elevation & duration
- Soil moisture & Snow melt
- Unit hydrograph theory
- Reservoir Operations
- Hydraulics (HES-RAS) for complex river systems
  - Tidal reaches
    - Combines tidal/storm surge with fresh water runoff on 5 tidal rivers
  - Lake Champlain, Farmington River
National Water Model: WRF-Hydro Modeling System
Forecasting for 2.7 million catchments across the nation!

MODEL PHYSICS

Meteorological Forcing Engine
Geospatial Pre-Processing
Hydro-DART Data Assimilation
Model Evaluation & Calibration
Web-Mapping Services

NoahMP LSM
Terrain Routing Module
NHDPlus Catchment Aggregation
Channel & Reservoir Routing Modules

Geospatial Pre-Processing
Hydro-DART Data Assimilation
Model Evaluation & Calibration
Web-Mapping Services
Ingredients for increased intense precipitation

- Several:
  - Slow moving weather systems – a blocked up atmosphere
    - One slow mover or multiple events in close succession
  - Results in saturated antecedent conditions before “main event”
  - Each fed by a “tropical connection”
    - Plumes of deep moisture carrying 5 to 7% more water vapor

[Map showing moisture distribution]
2018: 3rd wettest year!

2018: New Record 22 days >1”
But it is not just about intense rainfall

- Antecedent soil moisture conditions
- Basin size
  - Small basins far more susceptible
- Footprint of the causative rainfall/runoff event
- One intense event or a sequence of events
- Seasonal considerations
  - Heavy rain and snowmelt
  - Heavy rain prior to green up or after leaf-off
- Flood control footprint
- Nature of the way the rain event moved across the basin
Number of Floods per Year by Flood Category for the Pawtuxet River at Cranston, RI (106 mi²) 1940 - 2019

Minor floods (9 - 10.99 feet) over period of record: 36
Moderate floods (11.00 - 12.99 feet) over period of record: 12
Major floods (13 feet or more) over period of record: 6

Flood of record: 20.79 feet on March 31, 2010

And then there is Land Use Change!

Post Shopping Malls I-95 & I-295 construction
So what brought us to the tipping point in 2010?
- A wet fall & early winter
- Sequence of 4 big rain events in 5 weeks: “Persistent Jetstream Pattern”
- Orientation of rainfall in each event hit the Pawtuxet and Pawcatuck Basins

**Pawtuxet River at Cranston**

![Graphs showing flow and gage height](image)
Small scale extremely intense event:
Coastal Connecticut – September 25th, 2018

Killingsworth, CT received 6.78 inches in ~ 12 hours
3hr ~ 50 yr event and the 6-12 hr ~ 75-100 yr event

<table>
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<th>Duration</th>
<th>Obs</th>
<th>Approx AR</th>
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<tr>
<td>1h</td>
<td>1.56</td>
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<td>*5-yr</td>
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<td>2h</td>
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<td>*25-yr</td>
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</table>

Westport firefighters rescued two adults and two children from vehicles that were swept off the road by floodwaters. Crews had to break a window to extricate one victim, but no injuries were reported.

Photo credit: Town of Westport Fire Department
...But you cannot design for everything!
Example: August 13th, 2014 – Islip, NY – Rainfall 11 inches/3 hours

<table>
<thead>
<tr>
<th>Duration</th>
<th>1/2</th>
<th>1/5</th>
<th>1/10</th>
<th>1/25</th>
<th>1/50</th>
<th>1/100</th>
<th>1/200</th>
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<td>0.400 (0.312-0.537)</td>
<td>0.544 (0.423-0.693)</td>
<td>0.654 (0.505-0.836)</td>
<td>0.798 (0.567-1.06)</td>
<td>0.907 (0.726-1.23)</td>
<td>1.02 (0.727-1.42)</td>
<td>1.16 (0.784-1.65)</td>
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<td>10-min</td>
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<td>0.771 (0.589-0.981)</td>
<td>0.926 (0.715-1.15)</td>
<td>1.13 (0.946-1.50)</td>
<td>1.29 (0.944-1.74)</td>
<td>1.44 (1.03-2.02)</td>
<td>1.65 (1.11-2.33)</td>
<td>1.92 (1.25-2.60)</td>
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<td>15-min</td>
<td>0.866 (0.520-0.646)</td>
<td>0.997 (0.785-1.15)</td>
<td>1.33 (0.942-1.39)</td>
<td>1.69 (1.11-2.05)</td>
<td>1.95 (1.21-2.37)</td>
<td>2.34 (1.32-2.74)</td>
<td>2.64 (1.47-3.09)</td>
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<td>2.39 (1.71-3.34)</td>
<td>2.73 (1.84-3.86)</td>
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<td>1.98 (1.53-2.53)</td>
<td>2.42 (1.91-3.21)</td>
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<td>3.08 (2.37-4.98)</td>
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</table>
Southern New England River Basin Normalized Number of Minor, Moderate, and Major Floods Prior to 1970

Data provided by USGS

The graph shows the normalized number of floods per year at various locations in the Southern New England River Basin. The locations are listed along the x-axis, and the y-axis represents the number of floods per year. The data is categorized by type of flood: Major Floods (green), Moderate Floods (red), and Minor Floods (blue).

Locations include NRWM3, DOVM3, WELM3, WLTM3, BDGM3, NBRM3, WOOR1, CRAR1, HOPR1, WODR1, W5TR1, PUTC3, JYC3, WLMC3, YTCC3, GTBM3, FLVC3, TENN6, GAYC3, STVC3, and BEAC3.
Real-time forecast based Flood Inundation Mapping

- For years partners via stakeholder engagements have asked for FIM services based on our forecasts
- Experiences with Harvey, Florence and the Midwest Floods illustrate utility
- Developed two approaches applying the Height At Nearest Drainage Method (HAND)
  - RFC forecast flows
  - NWM forecast flows
- “Don’t let perfection be the enemy of good”
- The journey will commence for New York and New England in FY20!
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Providence Street – West Warwick, RI at 1030 am Wednesday 3/31/10