ATM-480 Lecture: Hydrology in the National Weather Service

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Water flows downhill.

Any questions?

Hydrology in the National Weather Service

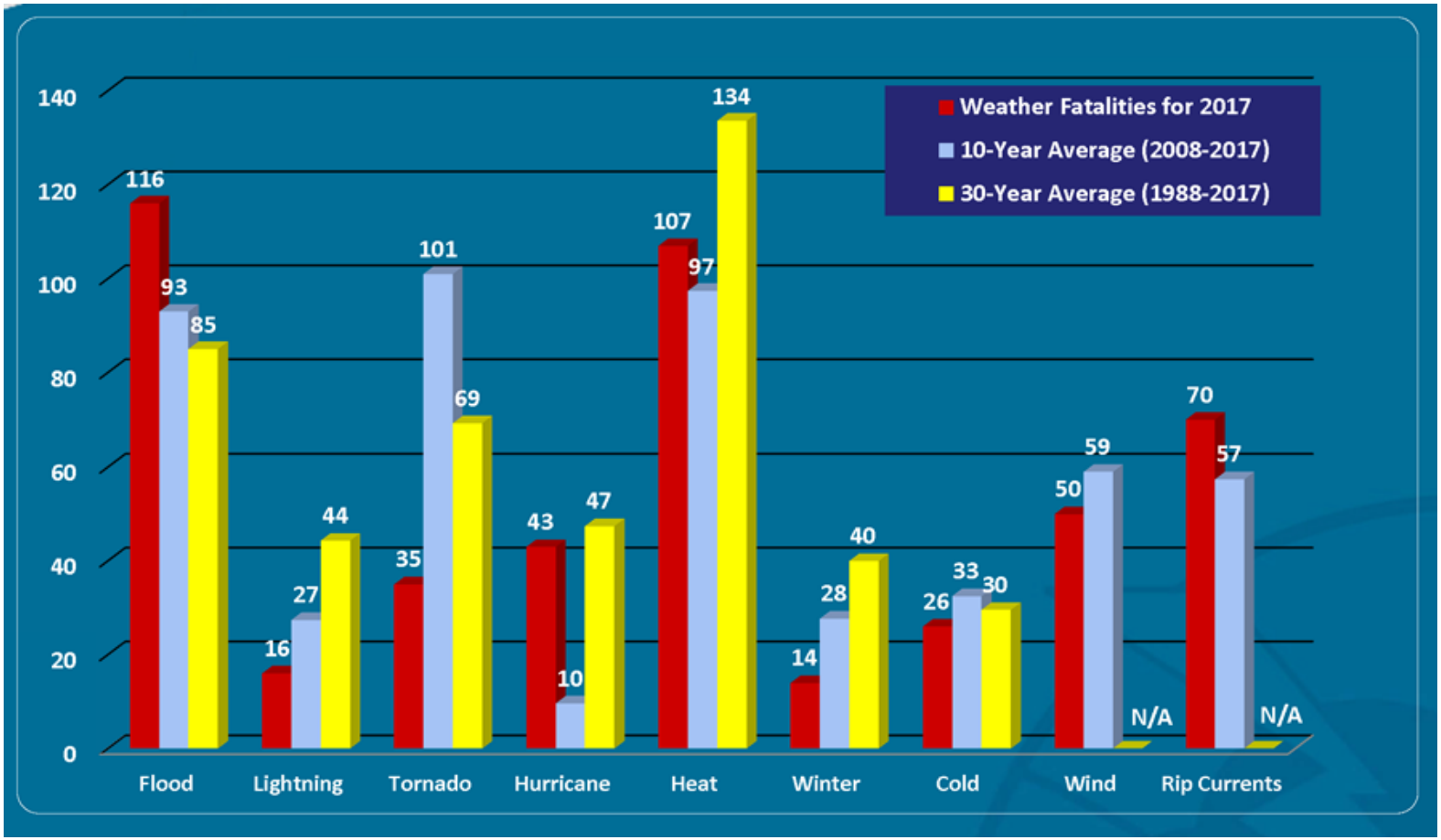
- Why NWS forecasts rivers & what causes flooding in the Albany NWS forecast area
- Fundamentals of hydrologic modeling
- NWS flood forecasts & warnings
- The future of NWS hydrology

Why Forecast Rivers?

- Protection of life and property
  - Each year, countless lives are saved due to accurate forecasts of rising rivers
  - Millions of dollars in property are also saved by accurate forecasts
- For Hydro Power Production/Industry
- Recreation
- Dam Operations
- Navigation

The National Weather Bureau Organic Act of 1890 (U.S. Code title 15, section 311) mandates that the National Weather Service is the responsible agent for *"the forecasting of weather, the issue of storm warnings, the display of weather and flood signals for the benefit of agriculture."*

Flooding is the #1 Severe Weather Hazard in U.S.

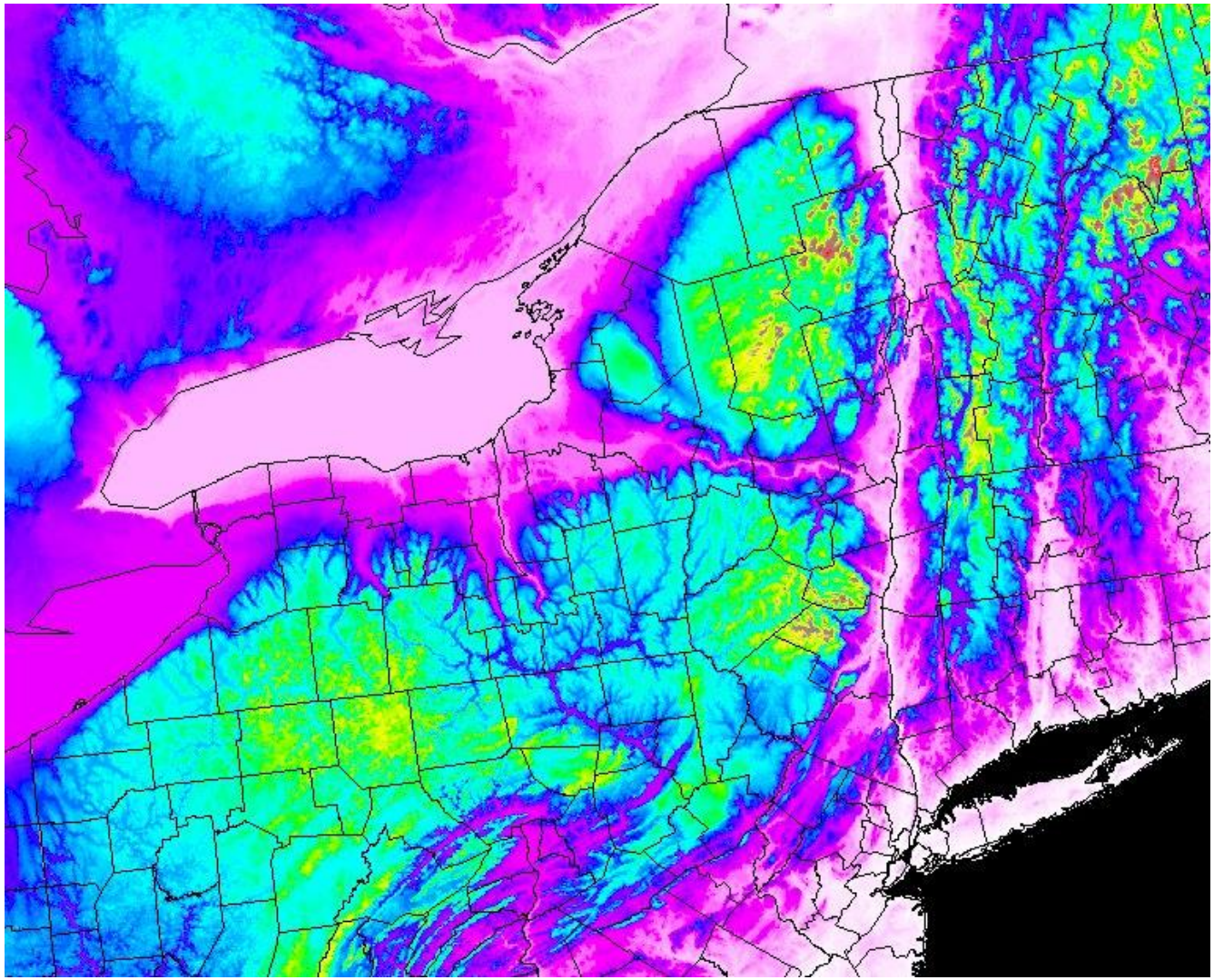


About three quarters of federally declared disasters in NYS are flood-related

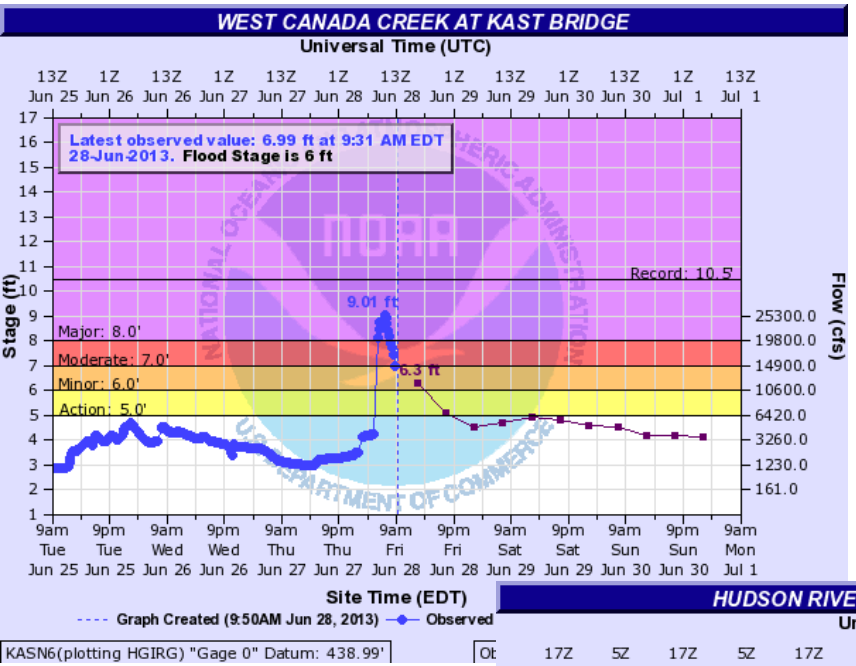
Common Causes of Northeast Floods

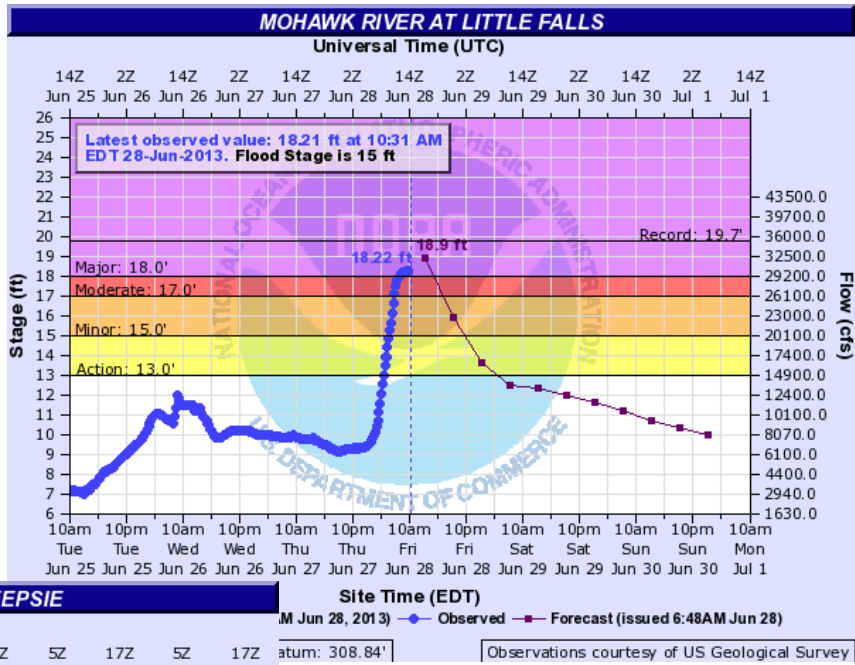
- Floods can occur any time of year:
  - Winter/Spring –
    - Rain plus snowmelt
    - Heavy rain with large storm systems
  - Spring/Summer - Thunderstorms
  - Summer/Fall - Tropical Storms

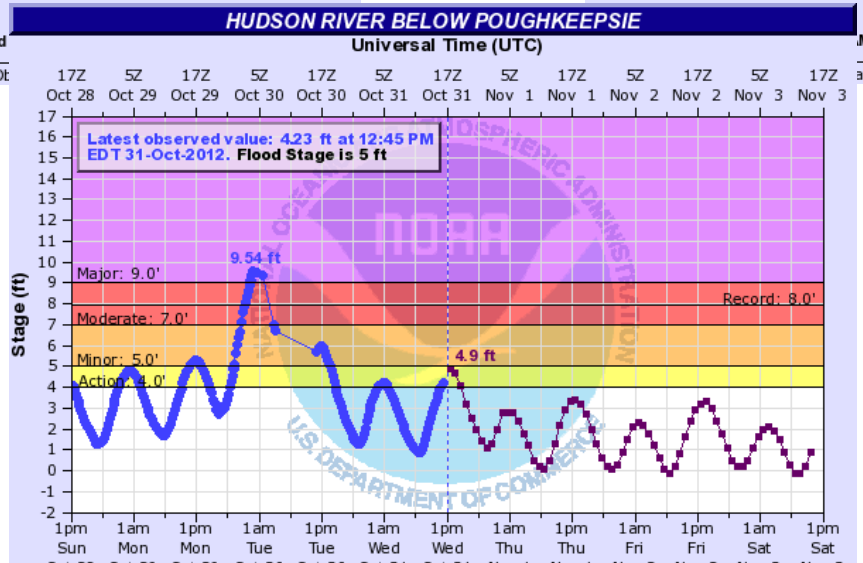
Topography drives Hydrology



Varied Topography makes for Varied Hydrology







Antecedent Conditions

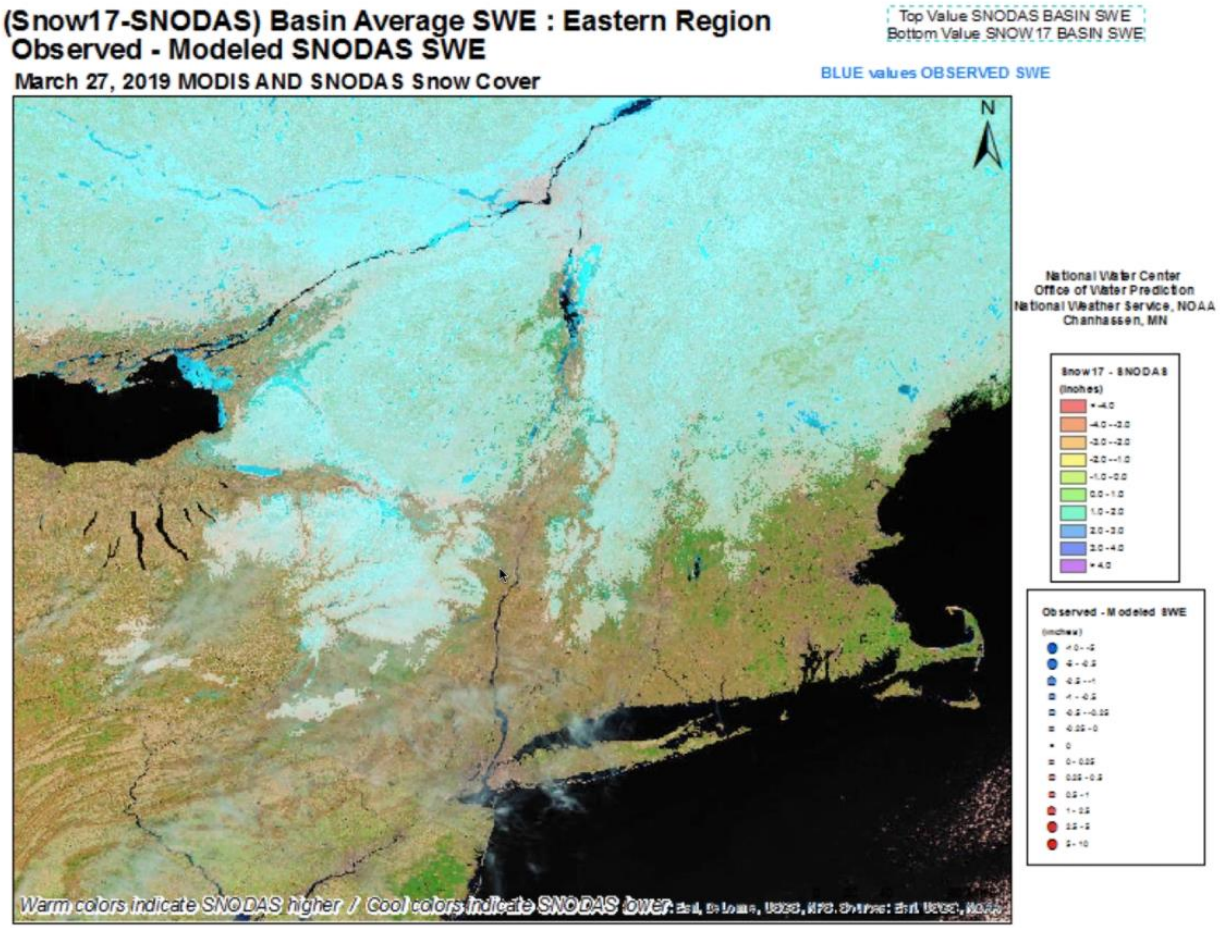
- How dry or wet is the soil?
  - Wet soils increase runoff
  - Dry ground can absorb rainfall and decrease runoff
- Is the ground frozen?
  - Frozen ground reduces infiltration of rainfall into ground (increases runoff)
  - Large increase in urban/basement flooding when heavy rain or snow melt on frozen/partially frozen ground
  - Mud slides possible in steep terrain during thaws
- Late Spring/Summer vs. Late Fall/Winter
  - Trees/plants/crops absorb a significant portion of total rainfall when leaves are on trees

Antecedent Conditions:
Is there any **snow melt** or river ice?

Heavy rain + warm temperatures + strong wind + large snow pack + river ice can be a deadly combination

January 1996

Monitoring Snowpack



National Operational Hydrologic Remote Sensing Center (NOHRSC)

River Ice Jams

Ice Jam Breaking Along the Mohawk River in Rotterdam Junction NY.


North Creek Bridge : the road on the top left is Old River Road, which was under 3 – 4’ of water in the low areas at time of photo, March 2011; photo courtesy of Warren County Emergency Management
NATIONAL WEATHER SERVICE
NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE


Looking northwest at the North Creek Bridge, March 2011; photo courtesy of Warren County Emergency Management

River Ice Jams

- River rise needs to be about 3 times the thickness of the river ice to break up the ice
- So…ice a foot thick needs about a 3 foot rise in stream level to break up the ice
- Ice jams cause localized flooding and can quickly cause serious problems
- Rapid rises behind the jams can lead to temporary lakes and flooding of homes and roads along rivers
- A sudden release of a jam can lead to flash flooding below with the addition of large pieces of ice in the wall of water which will damage or destroy most things in its path

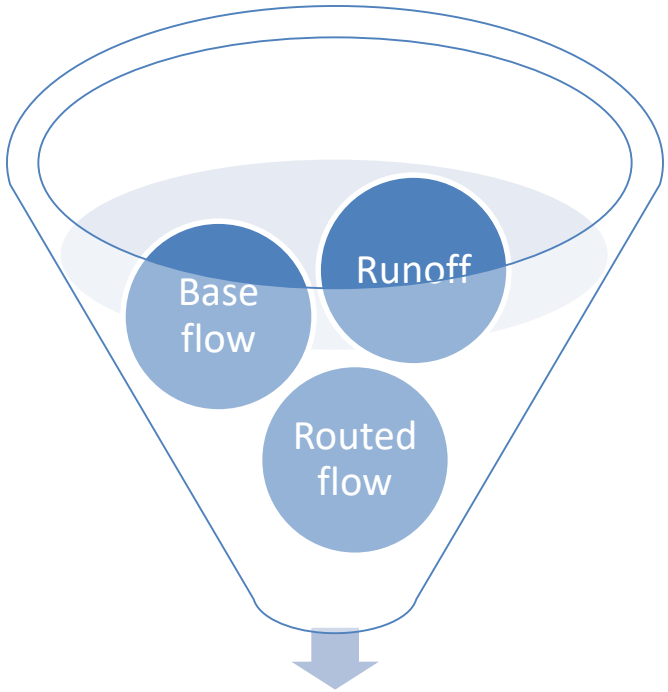
Hydrology in the National Weather Service

- Why NWS forecasts rivers & what causes flooding in the Albany NWS forecast area
- **Fundamentals of hydrologic modeling**
- NWS flood forecasts & warnings
- The future of NWS hydrology

A River Basin is a Funnel

The volume of these 3 things determines how much water passes through that outlet (flows downstream):

- Runoff – water flowing across the ground surface (incl. runoff from rain + snowmelt)
- Base Flow – water from groundwater
- Routed Flow – water from upstream



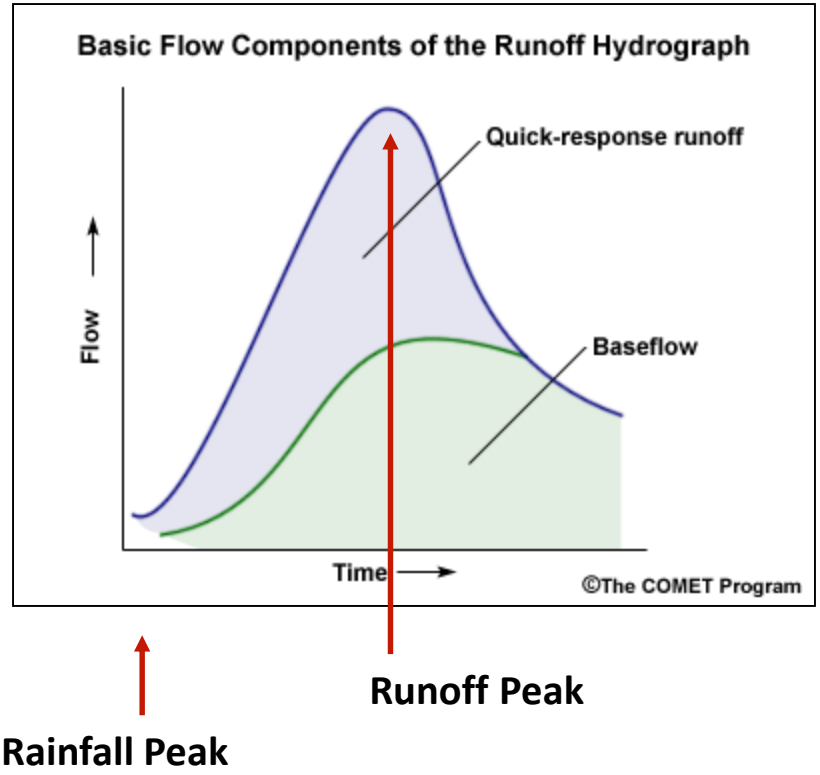
Volume of water flowing downstream in the river

Runoff

- Rainfall runoff is estimated based on:
  - Slope of the land
  - Amount of urbanization
  - Soil types (clay vs. sand)
  - Amount of the last rainfall
  - Time since the last rainfall
  - Amount of evaporation occurring
  - Whether or not the ground is frozen
- Snowmelt runoff is estimated based on air temperature

Runoff + Base Flow

- Delay between onset of rain and runoff entering river
- Amount of delay depends upon where in the basin rain falls, the slope of the basin, and the amount of impervious surface in basin



- Base Flow is water entering the river from groundwater
- Not a constant value
- Peaks after surface runoff begins to decrease
- Slowly decreases until the next rainfall

Routed Water

- Routed Flow = the water that is coming downstream from the previous (upstream) river basin
- All of the water that passed through the upstream point must eventually pass through the downstream point, barring human intervention (dams/diversion)
- Heavy rains upstream can cause flooding downstream where rainfall was less

For more details…

COMET MetEd Basic Hydrologic Sciences Distance Learning Course

(free but you have to create an account)

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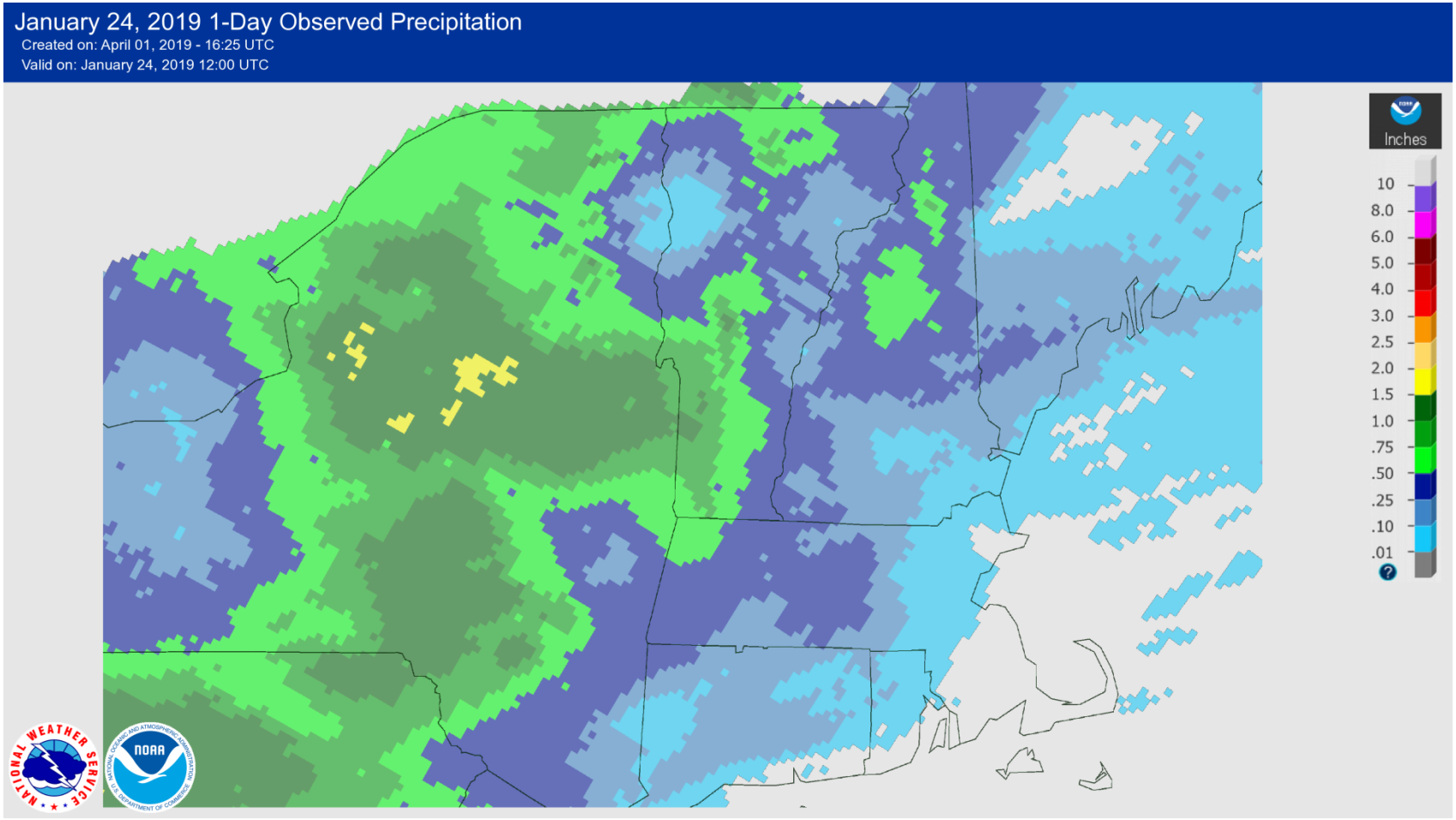
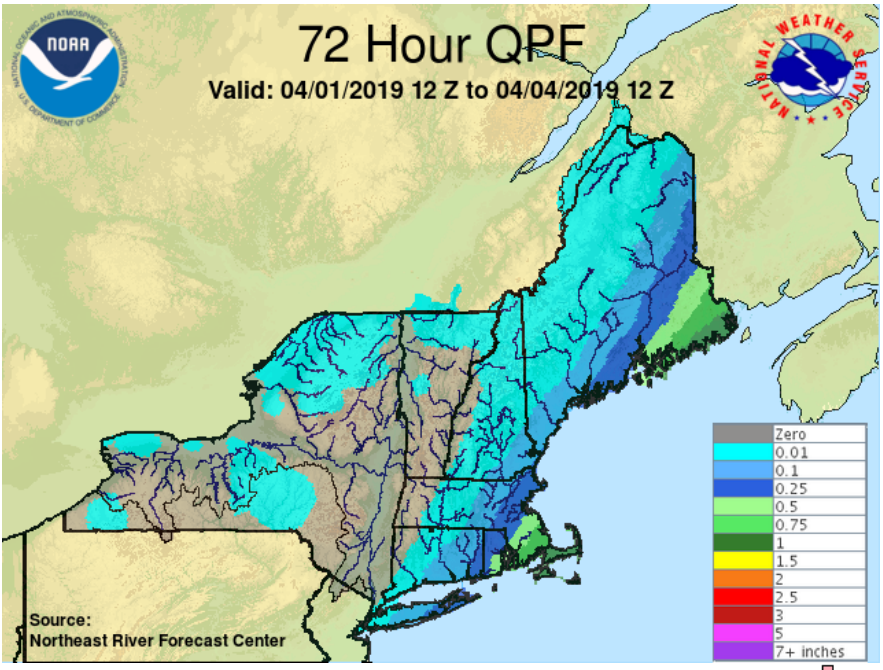
Inputs to River Forecasts

- Estimated (past) rainfall
  - Automated rain gages w/telemetry
  - Radar rainfall estimates
  - Cooperative weather observer & CoCoRaHS rainfall reports
- Forecast rainfall
- Observed river heights
  - Automated river gages w/telemetry
  - Cooperative weather observer staff gage or wireweight gage readings
- Temperatures / snow pack

Estimated (past) Rainfall

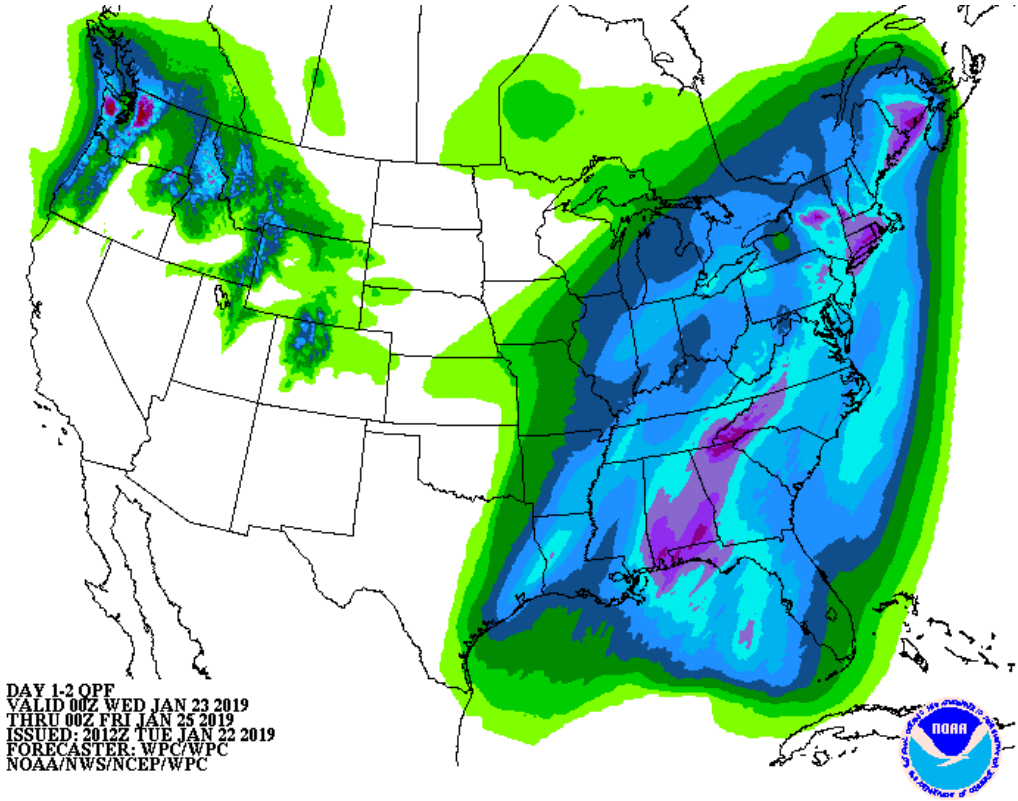


Forecast Rainfall

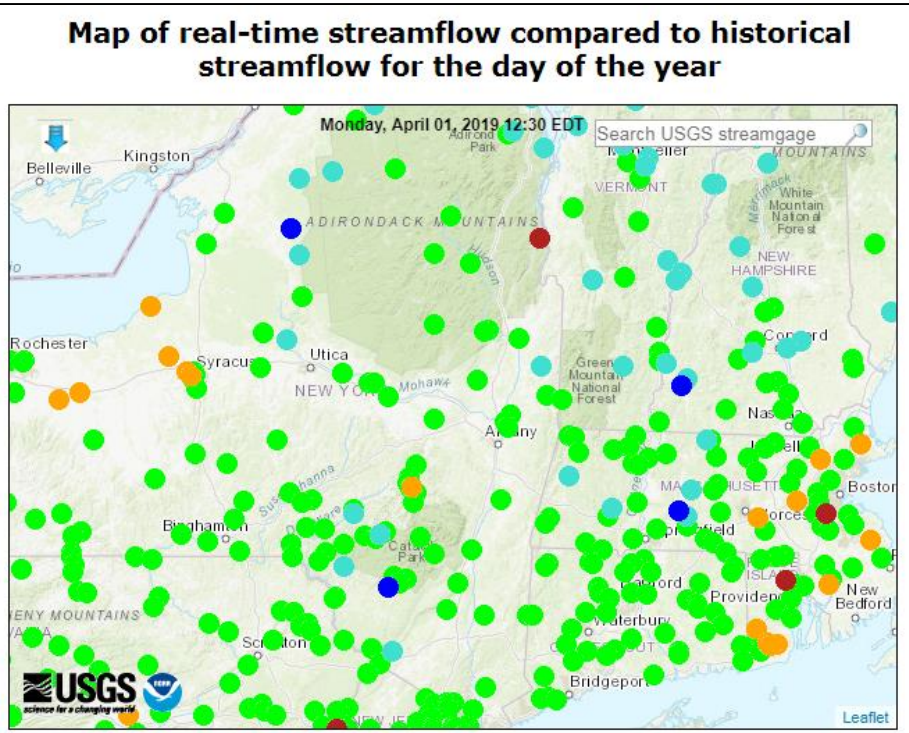


Northeast River Forecast Center

Weather Prediction Center



Observed River Heights



USGS science for a changing world

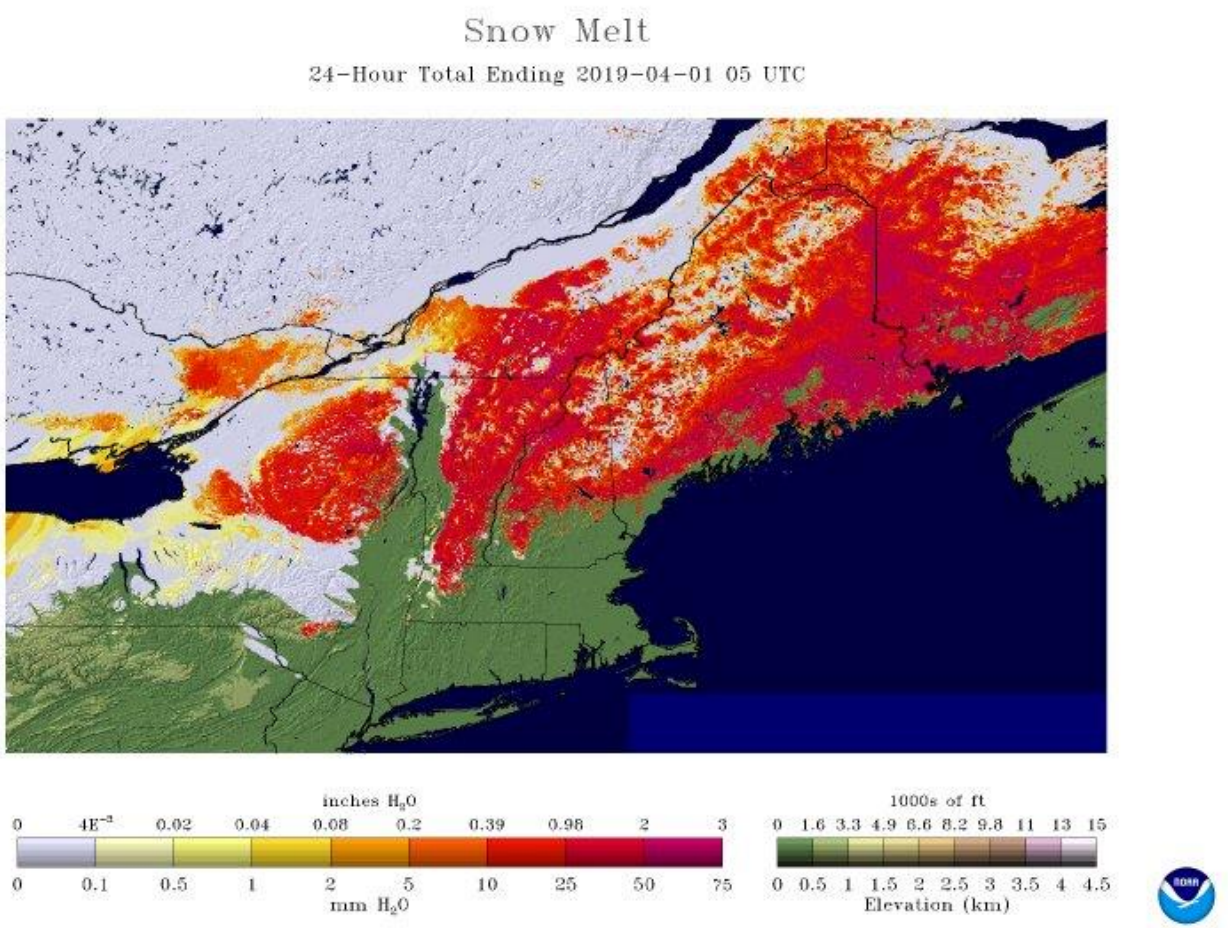
The USGS operates and maintains more than 85% of the nation's stream-gaging stations, which includes 98% of those that are used for real-time river forecasting

Temperature / Snowpack

National Operational Hydrologic Remote Sensing Center

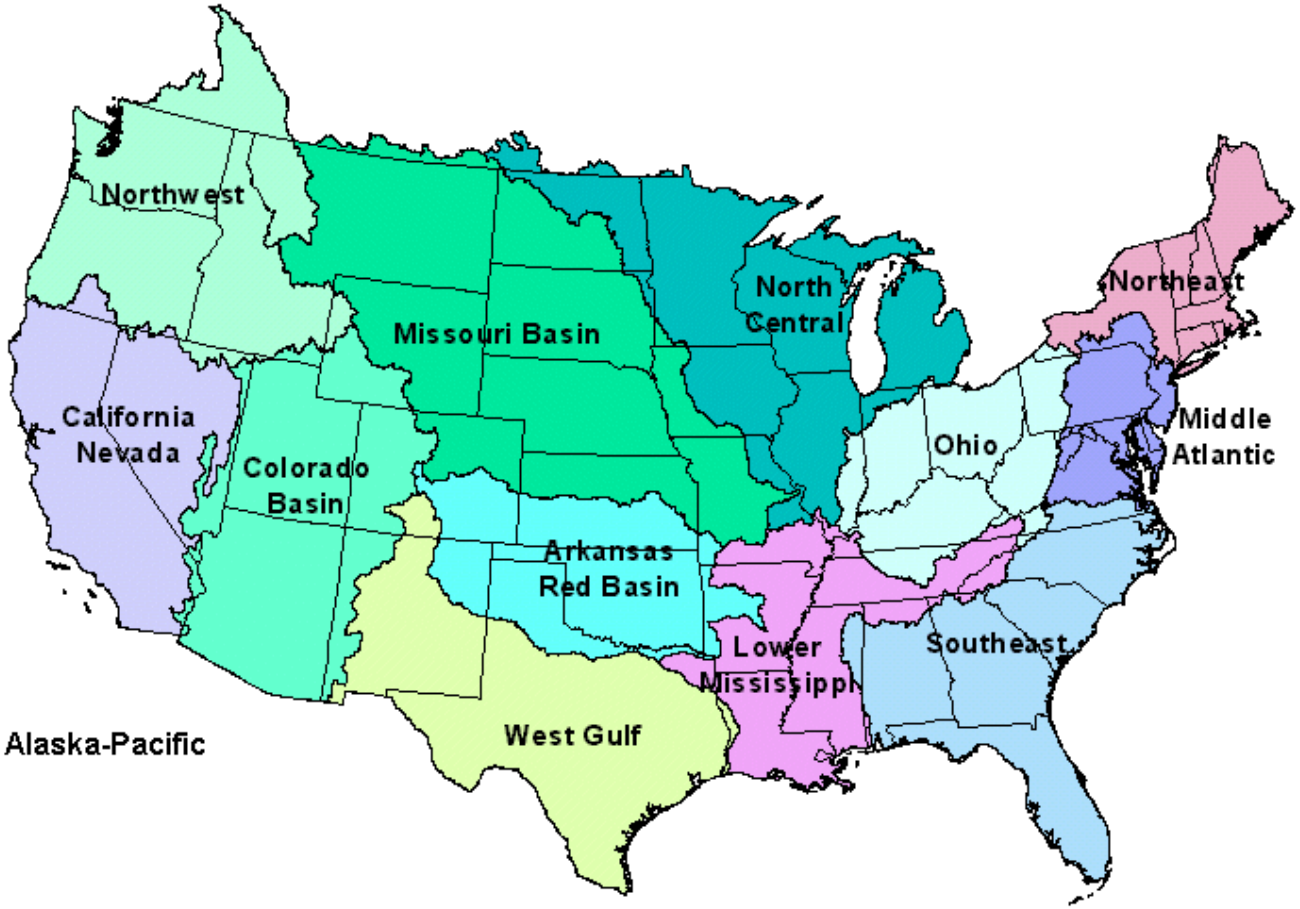
National Snow 2018-2019 Analysis

OWP | OFFICE OF WATER PREDICTION



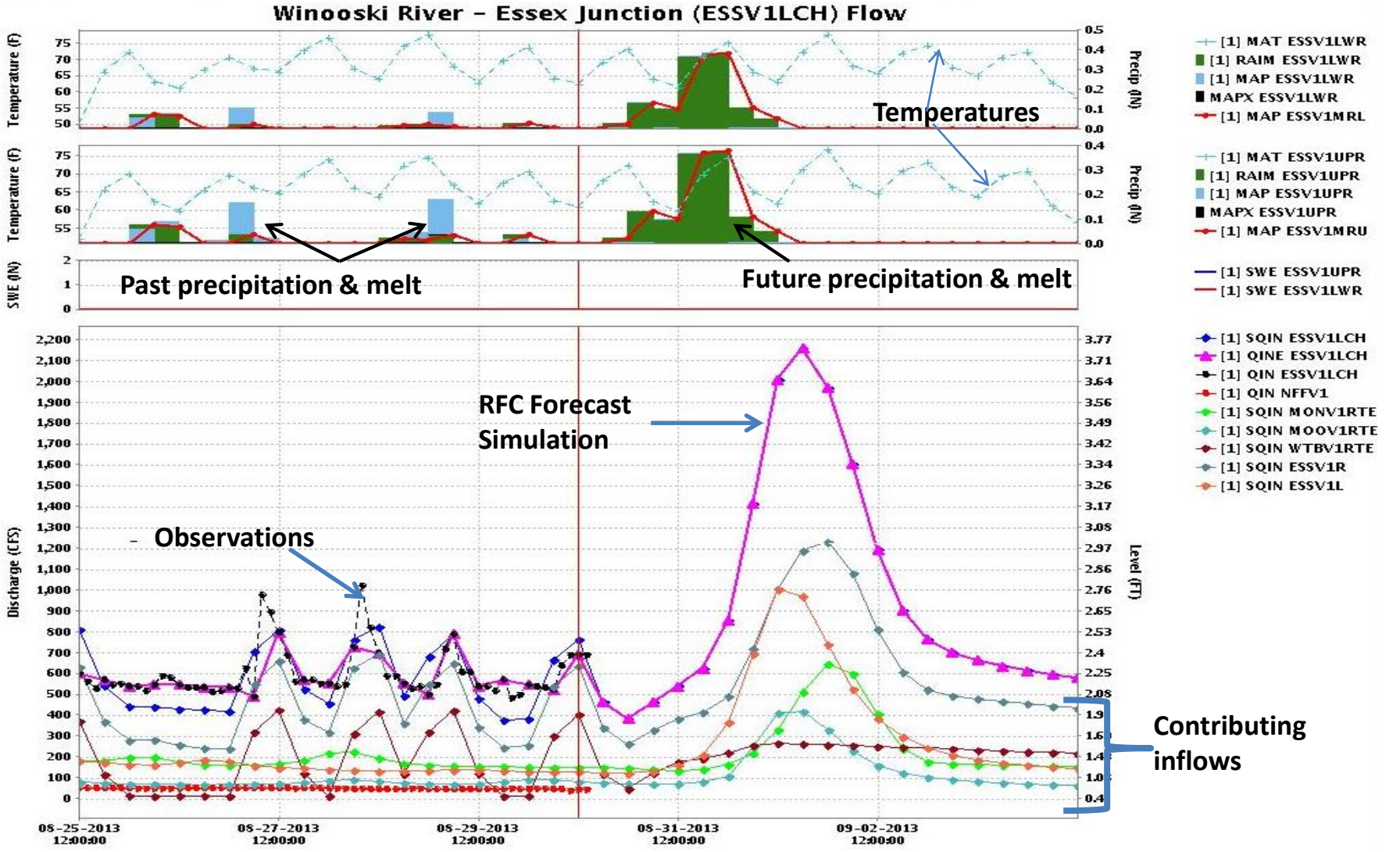
https://www.nohrsc.noaa.gov/

NWS River Forecast Centers



13 River Forecast Centers (RFCs) generate daily river forecasts and additional forecasts during flood events

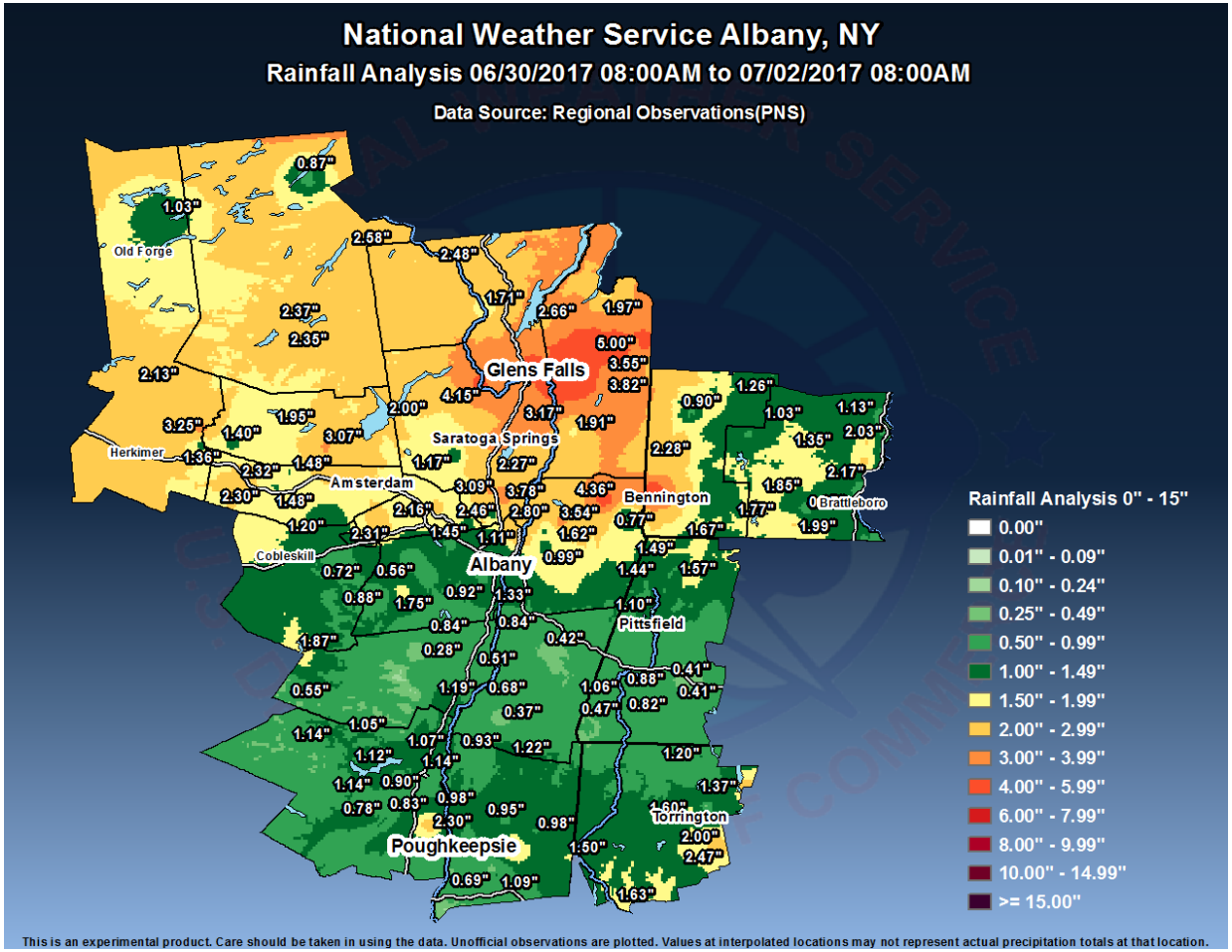
River Forecast Center Model



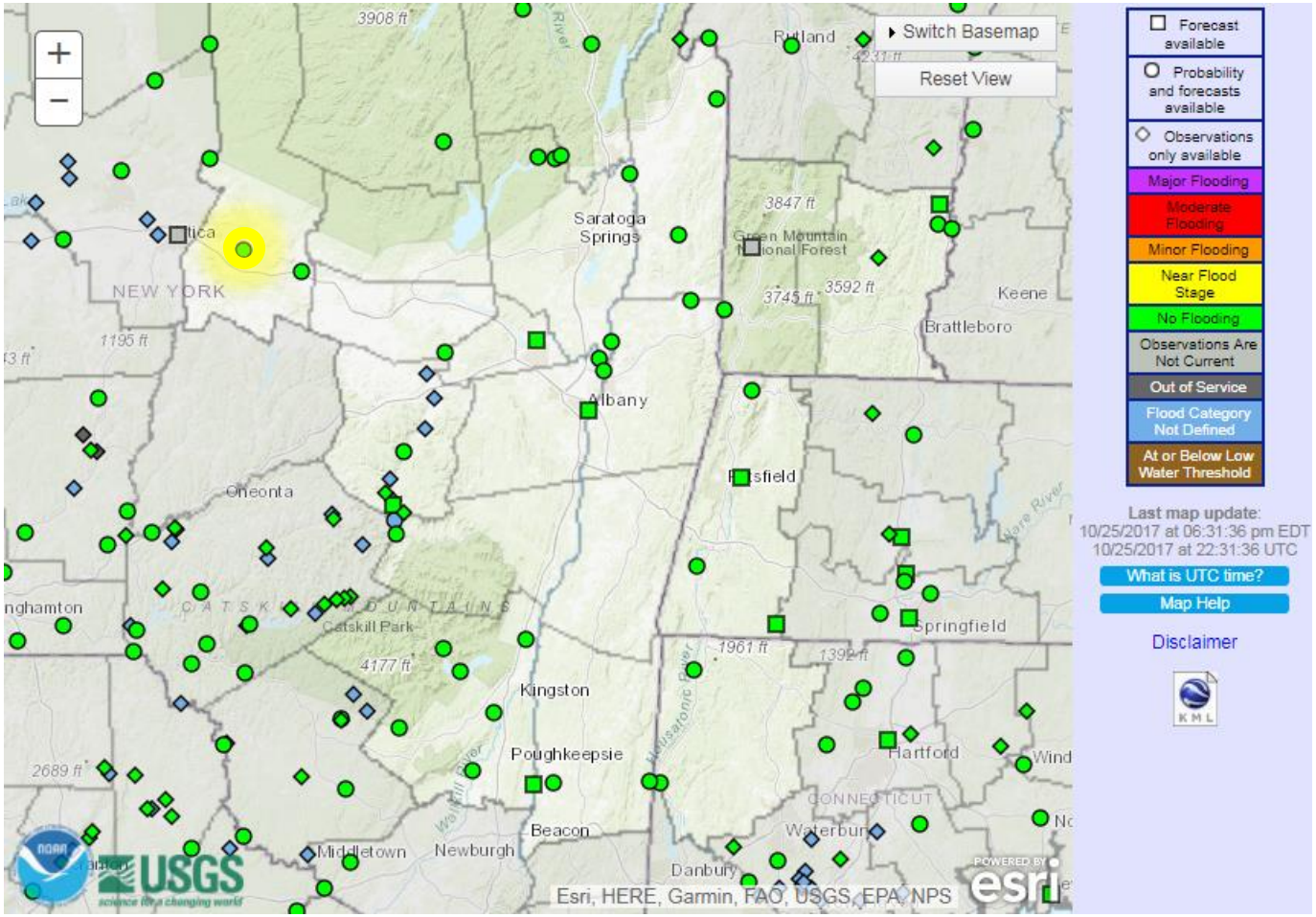
After RFC issues forecast:

- If the forecast is over flood stage (determined by the local Weather Forecast Office - WFO), a warning is needed:
  - software automatically creates a “first draft”
  - warning can be sent in under 1 minute if needed
  - activates the Emergency Alert System
- Most forecasts are also sent to our website water.weather.gov/ahps/

July 2017 Flood Event



West Canada Cr @Kast Bridge



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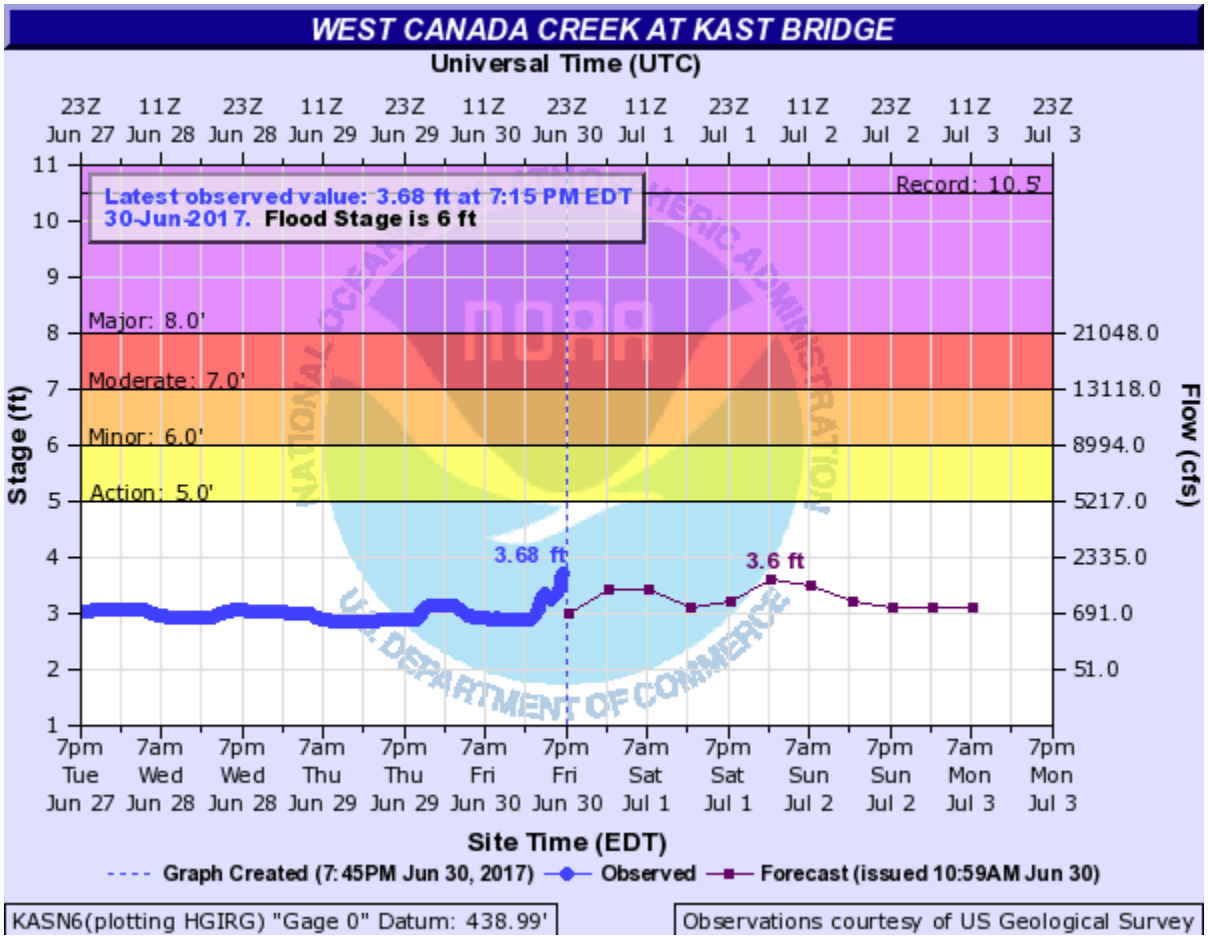
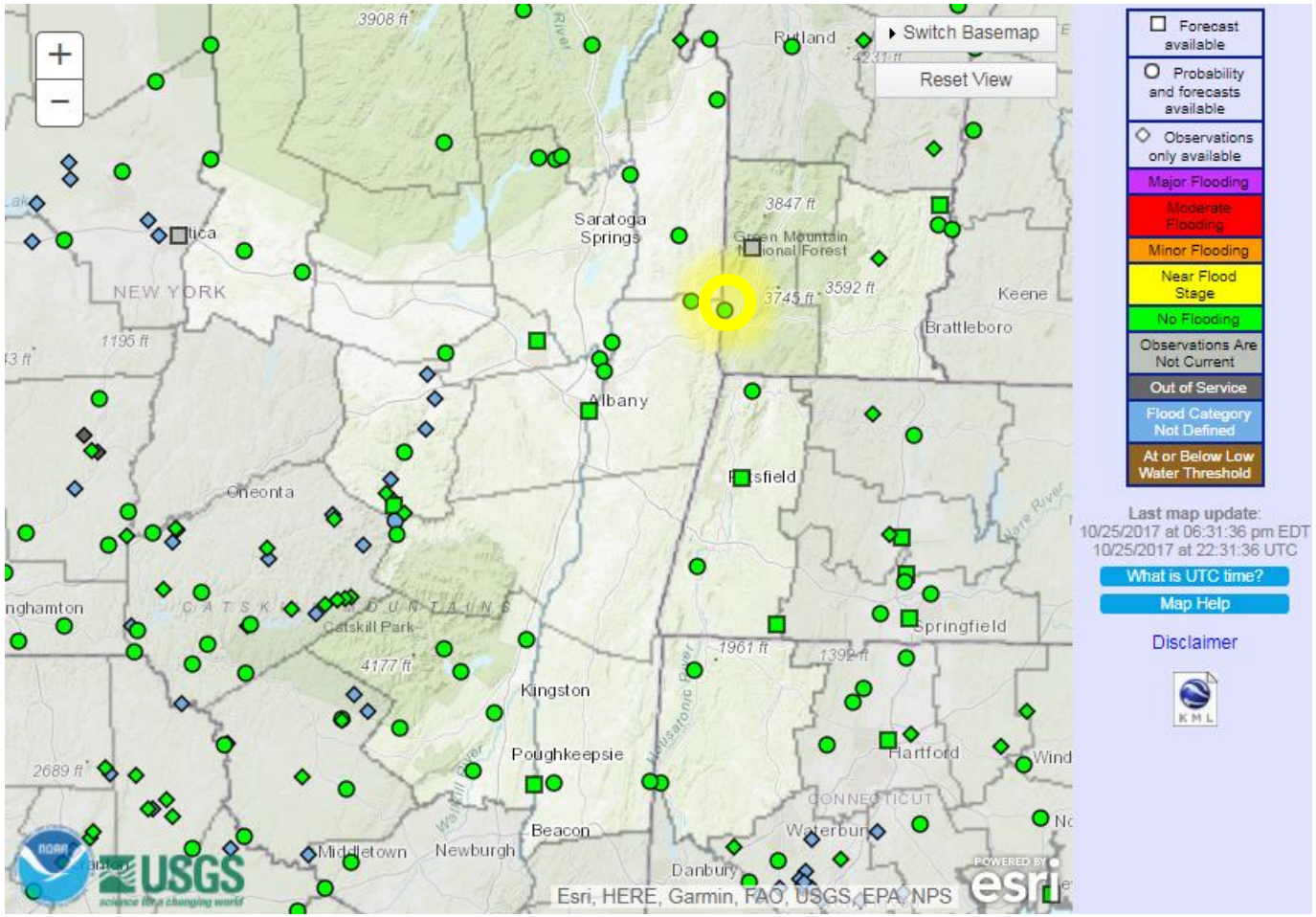


Walloomsac R nr N Bennington



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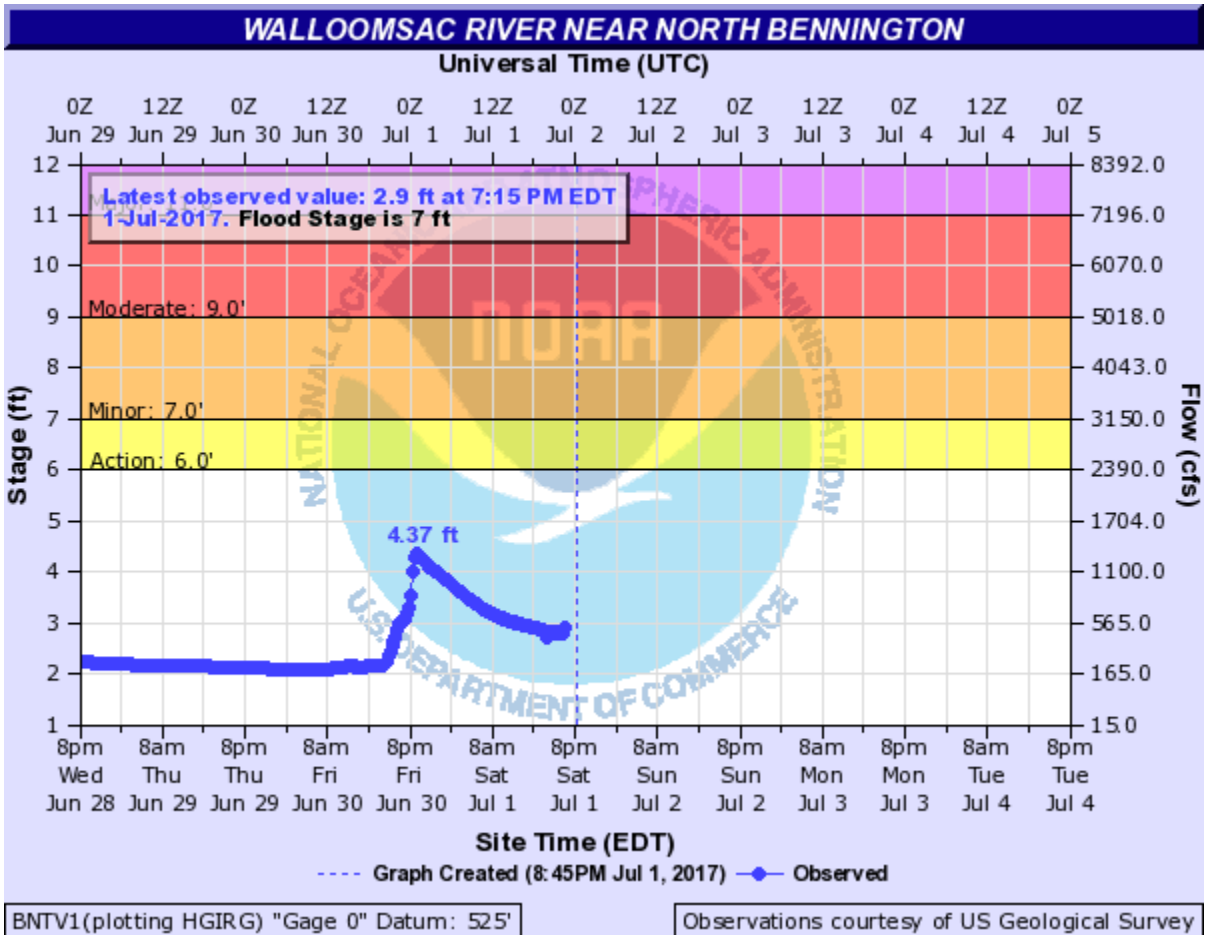
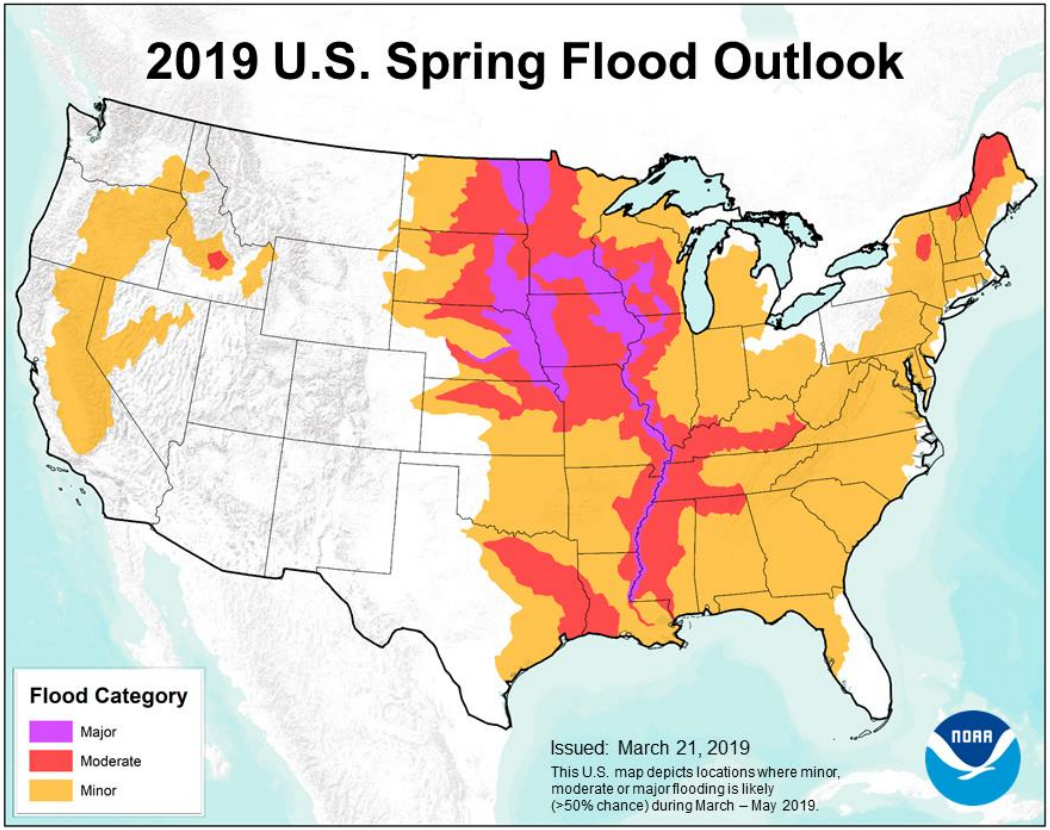
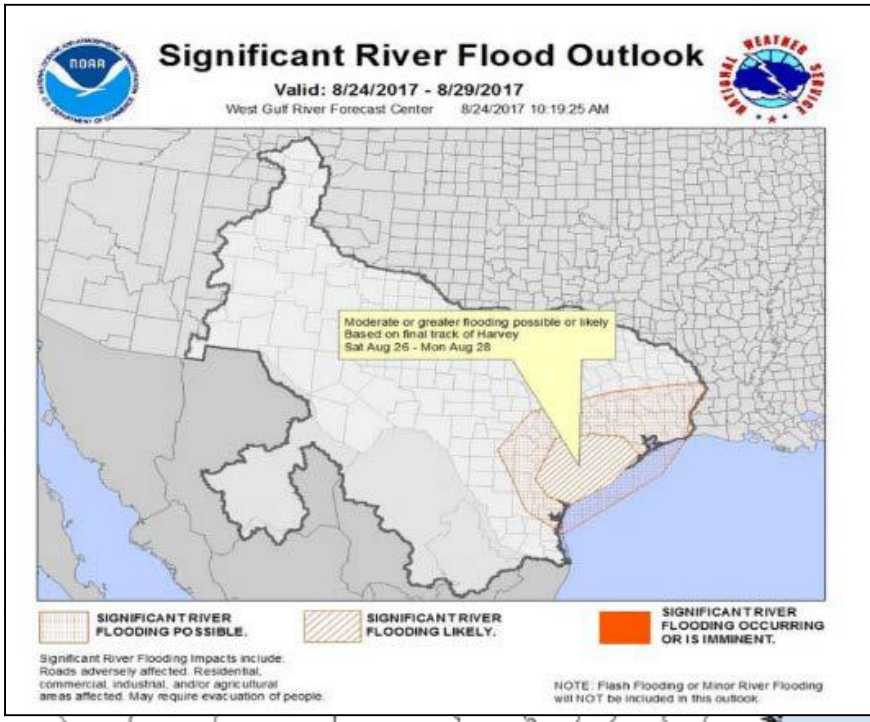
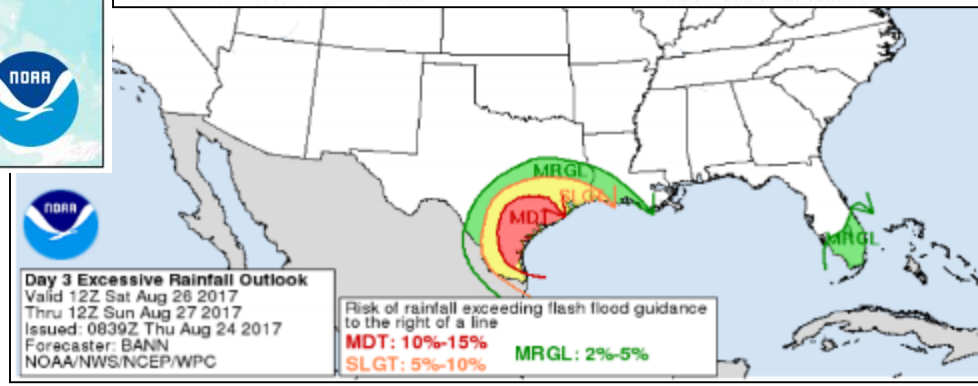


Other Forecasts & Outlooks…







Above: current spring flood threat
Right side of slide: pre-Hurricane Harvey flood outlook products

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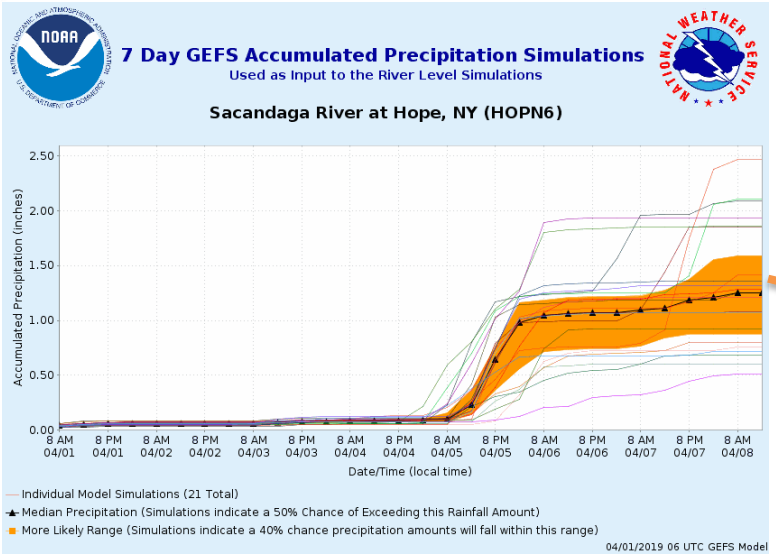
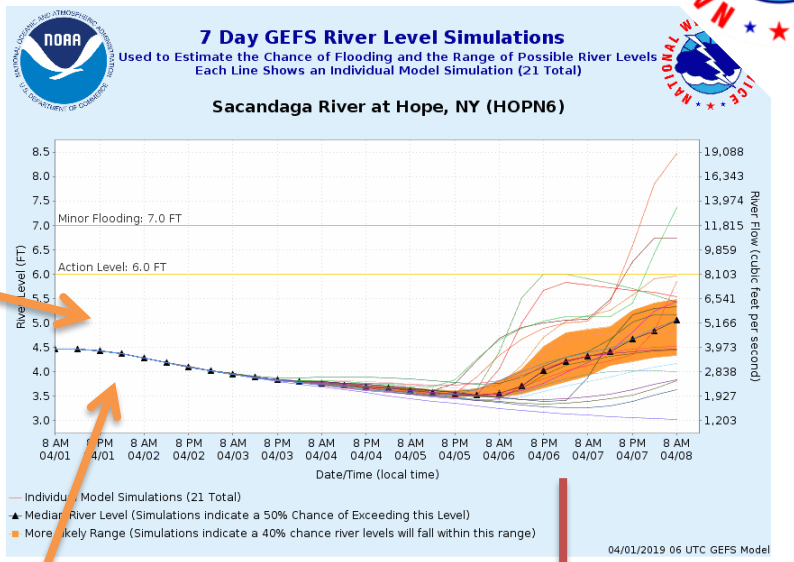
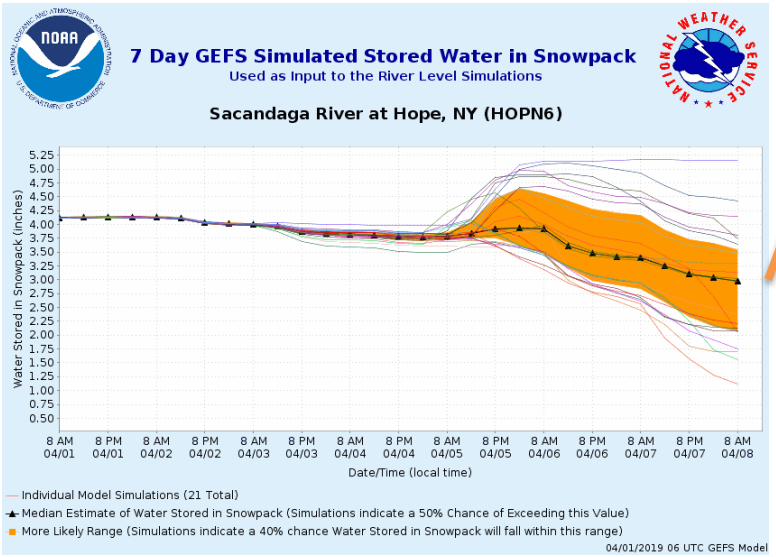
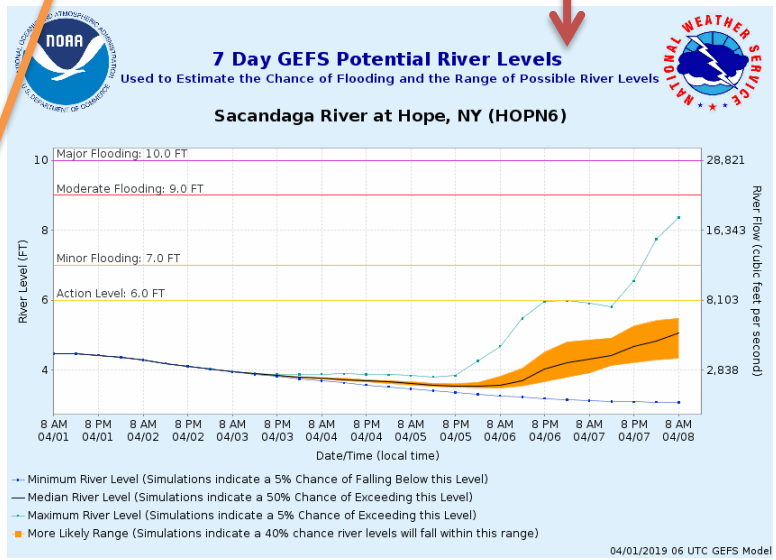
Ensemble Streamflow Forecasts

https://www.weather.gov/erh/mmefs

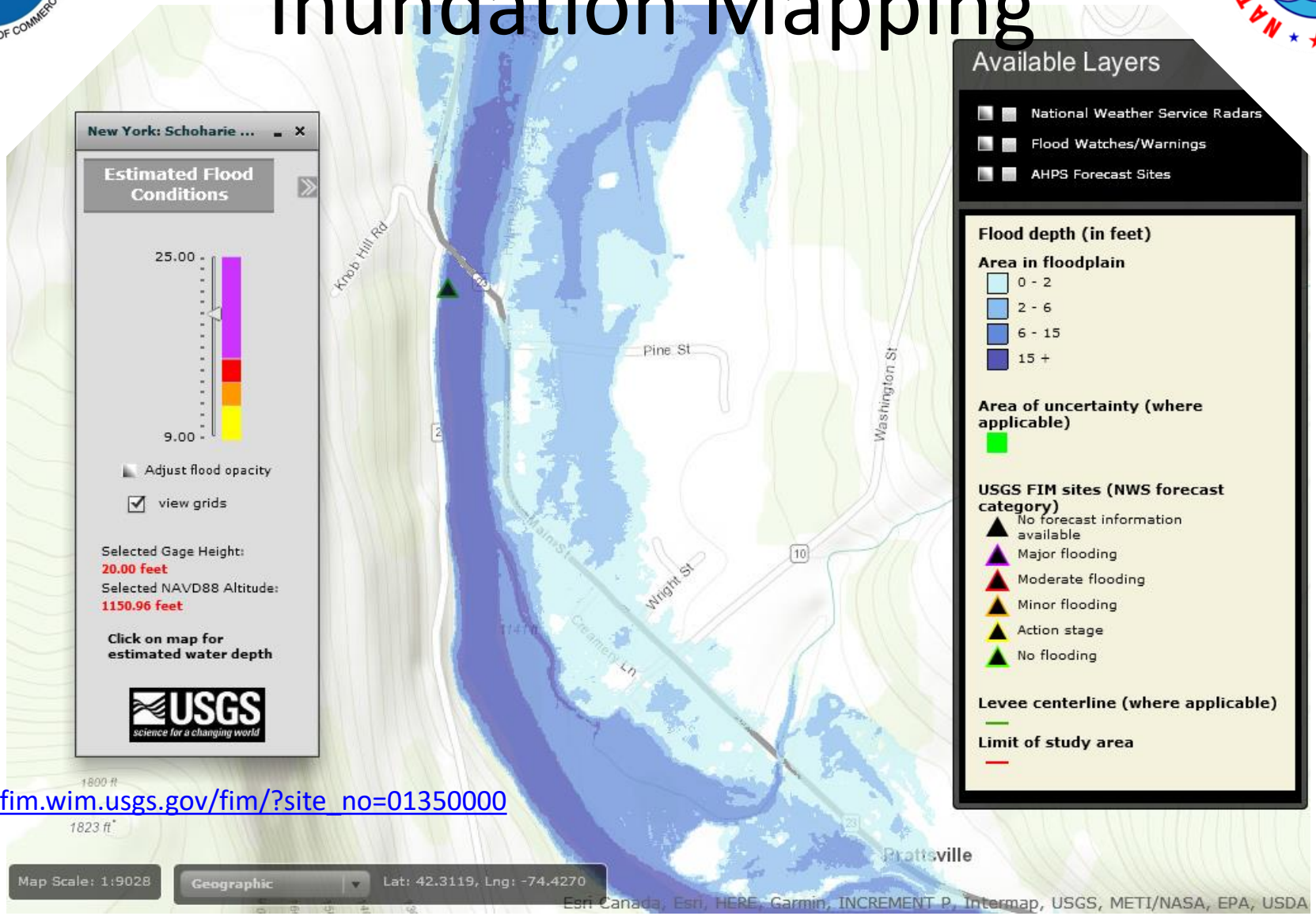








Inundation Mapping

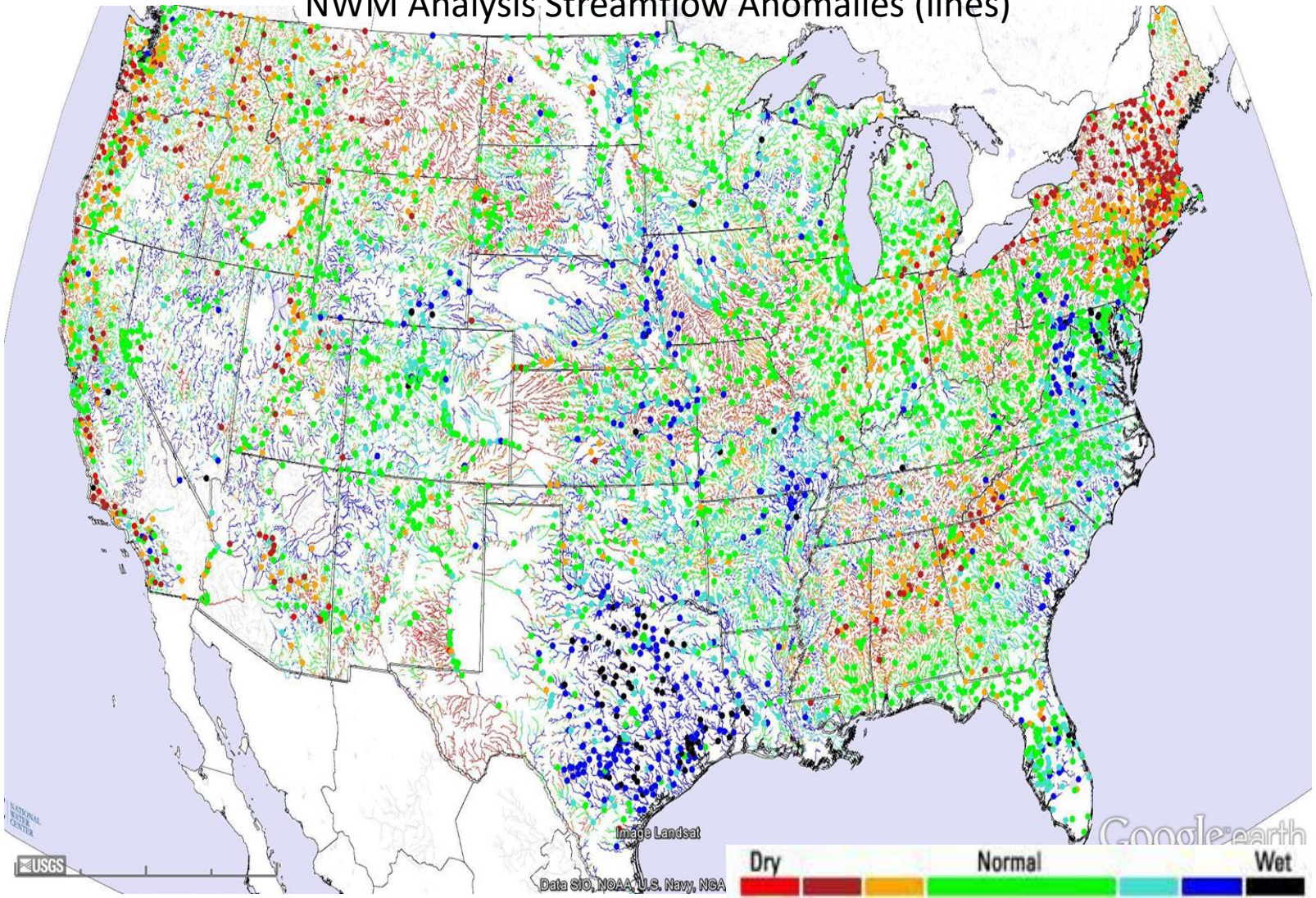


https://fim.wim.usgs.gov/fim/?site_no=01350000

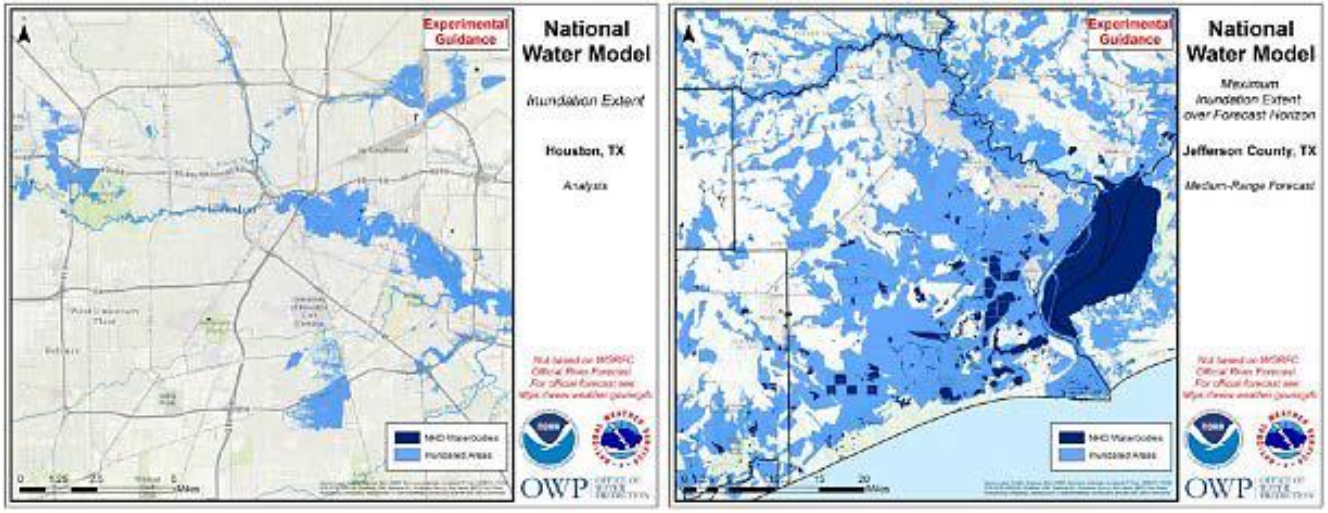
National Water Model

USGS Observed Streamflow Anomalies (dots)

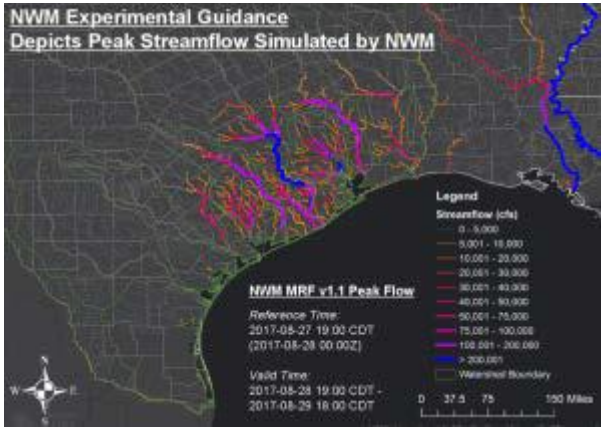
NWM Analysis Streamflow Anomalies (lines)

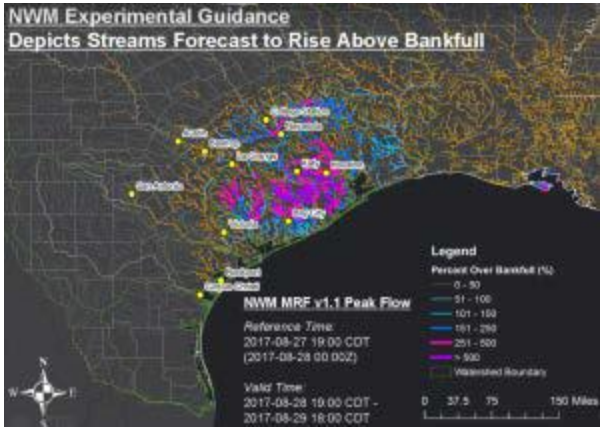


National Water Model



Experimental flood inundation and streamflow guidance from Hurricane Harvey





Hydrology in the National Weather Service

What we discussed:

- Why NWS forecasts rivers & what causes flooding in the Albany NWS forecast area
- Fundamentals of hydrologic modeling
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Topics we didn't cover:

- Flash flood operations
- Details of hydrologic modeling
- Hydraulic modeling
- Drought operations
- Dam failure operations
- Extreme event operations
- Hydrologic component of IDSS, outreach and education
- Careers in Hydrology
- So many more…

What questions do you have?

Always happy to discuss more about hydrology as a science and as a career.

Please be in touch:
britt.westergard@noaa.gov