Hydrology in the NWS
(ATM 362)

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Albany, NY National Weather Service

Water flows downhill.

Any questions?

Outline

- Why the NWS forecasts flooding & river levels
- What causes flooding in the NWS Albany service area?
- The fundamentals of hydrologic modeling
- NWS flood forecasts and warnings
- The future of NWS hydrology

Why forecast flooding & river levels?

- 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
- Hydropower production
- 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."*

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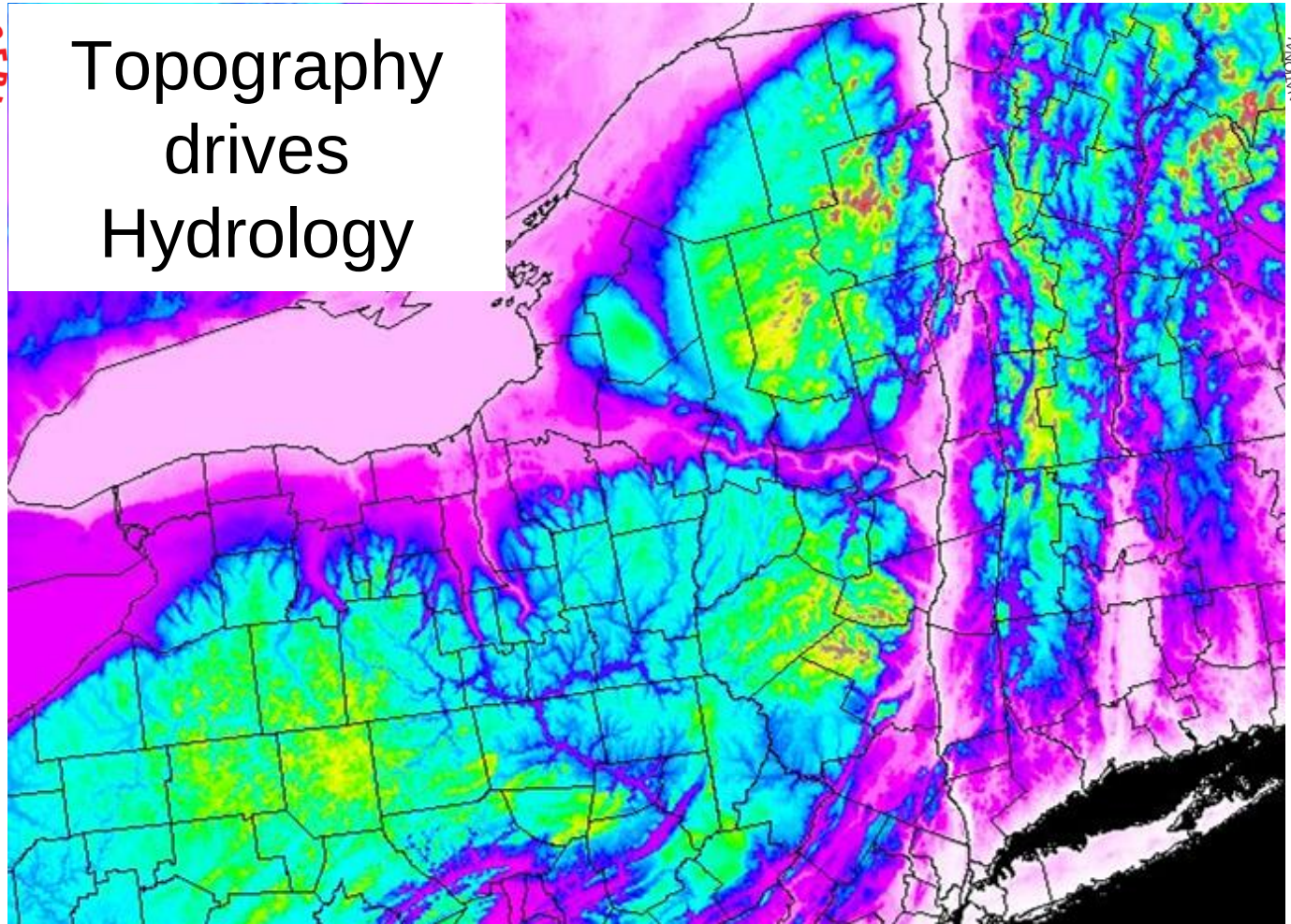
Common Causes of Flooding in the Northeast

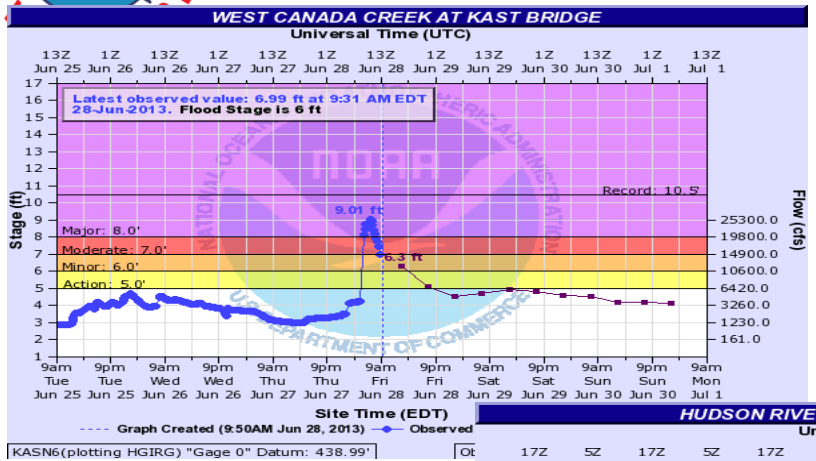
Floods can occur any time of year:

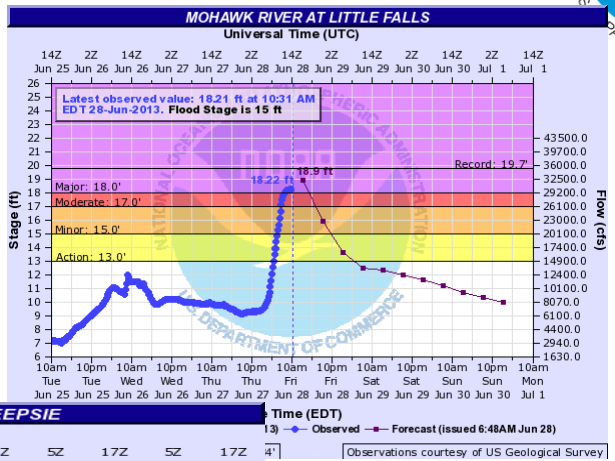
- Winter/Spring –
  - Rain plus snowmelt
  - Heavy rain with large storm systems
- Spring/Summer - Thunderstorms
- Summer/Fall - Tropical Storms
  - heavy rainfall
  - storm surge

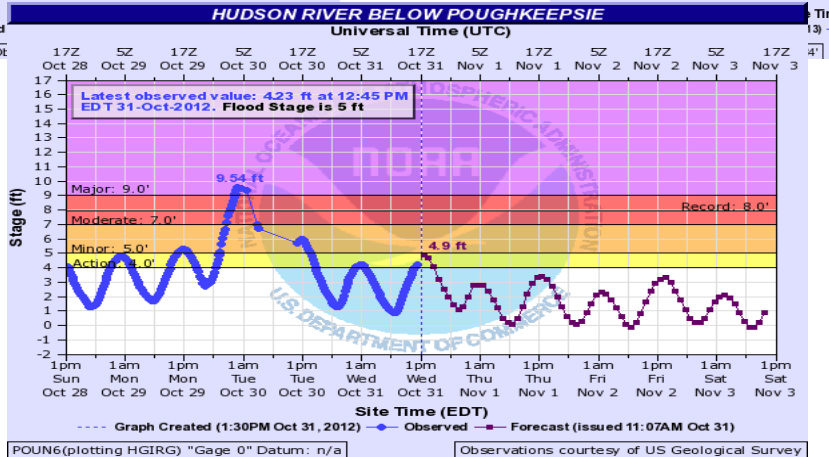
Topography drives Hydrology



Varied Topography = 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 (↑ 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 (time of year)
  - Trees/plants/crops absorb a significant portion of total rainfall when leaves are on trees

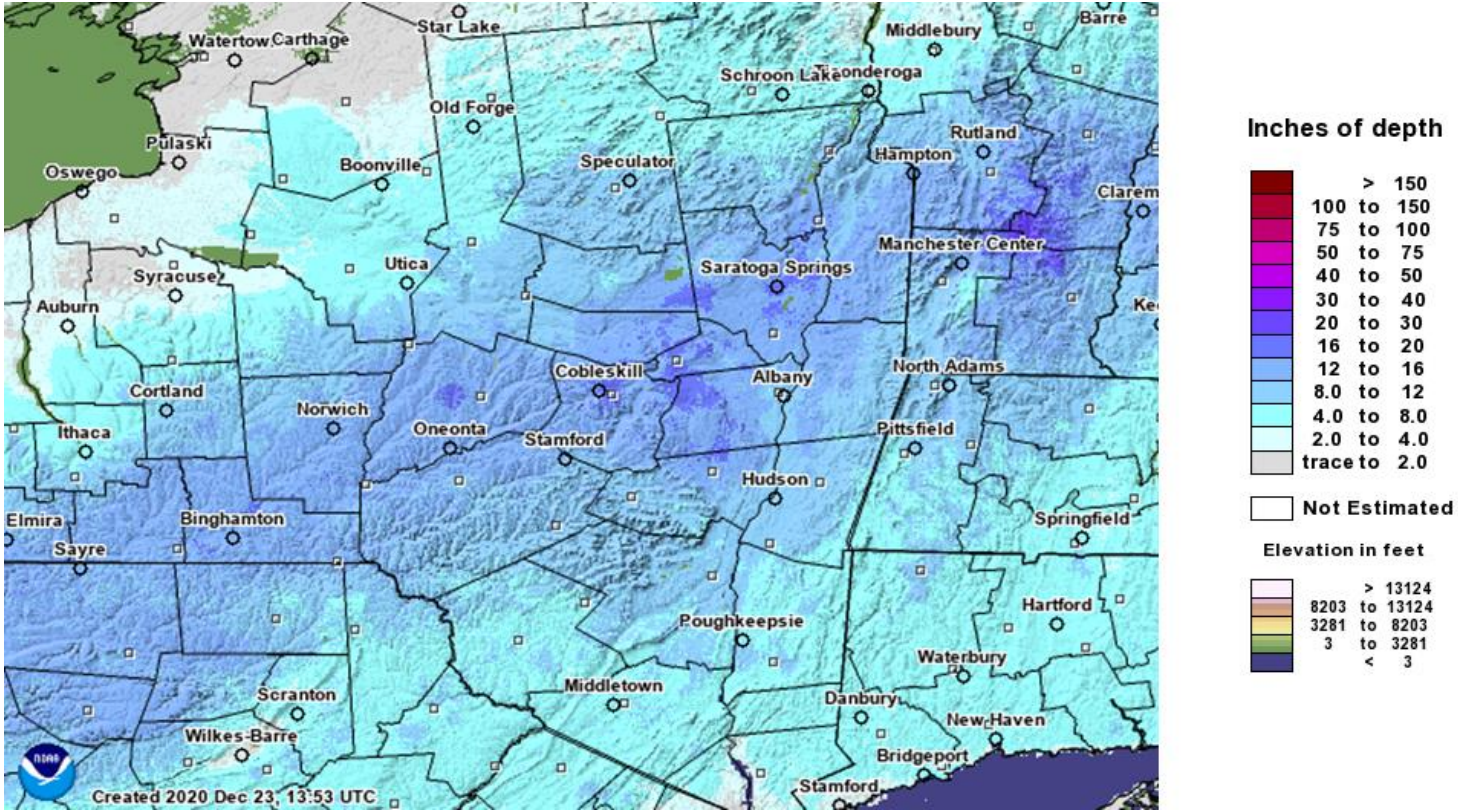
Antecedent Conditions (cont'd)

Is there any **snow melt** or river ice?

Heavy rain + warm temps + strong wind + large snowpack + river ice
= 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

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 1 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

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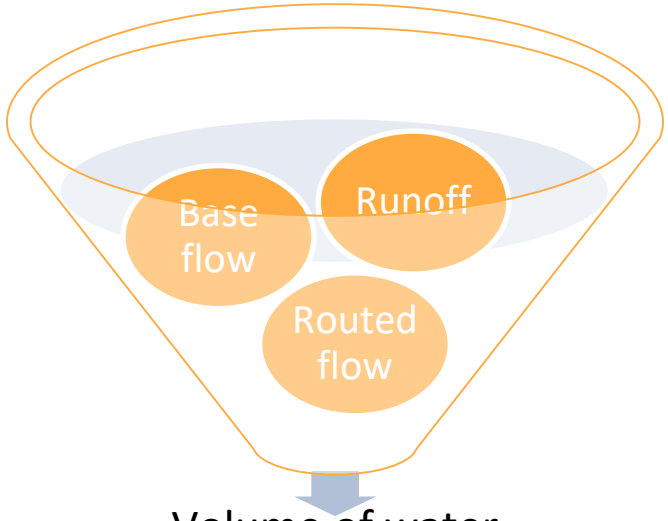
A River Basin is a Funnel

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



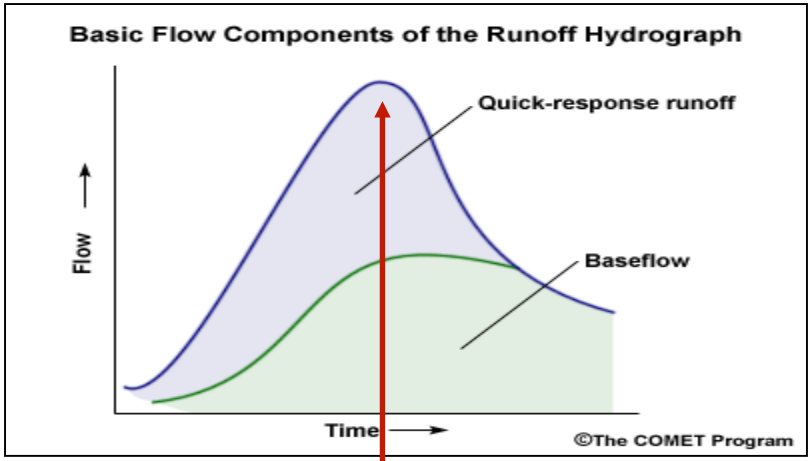
Runoff

- 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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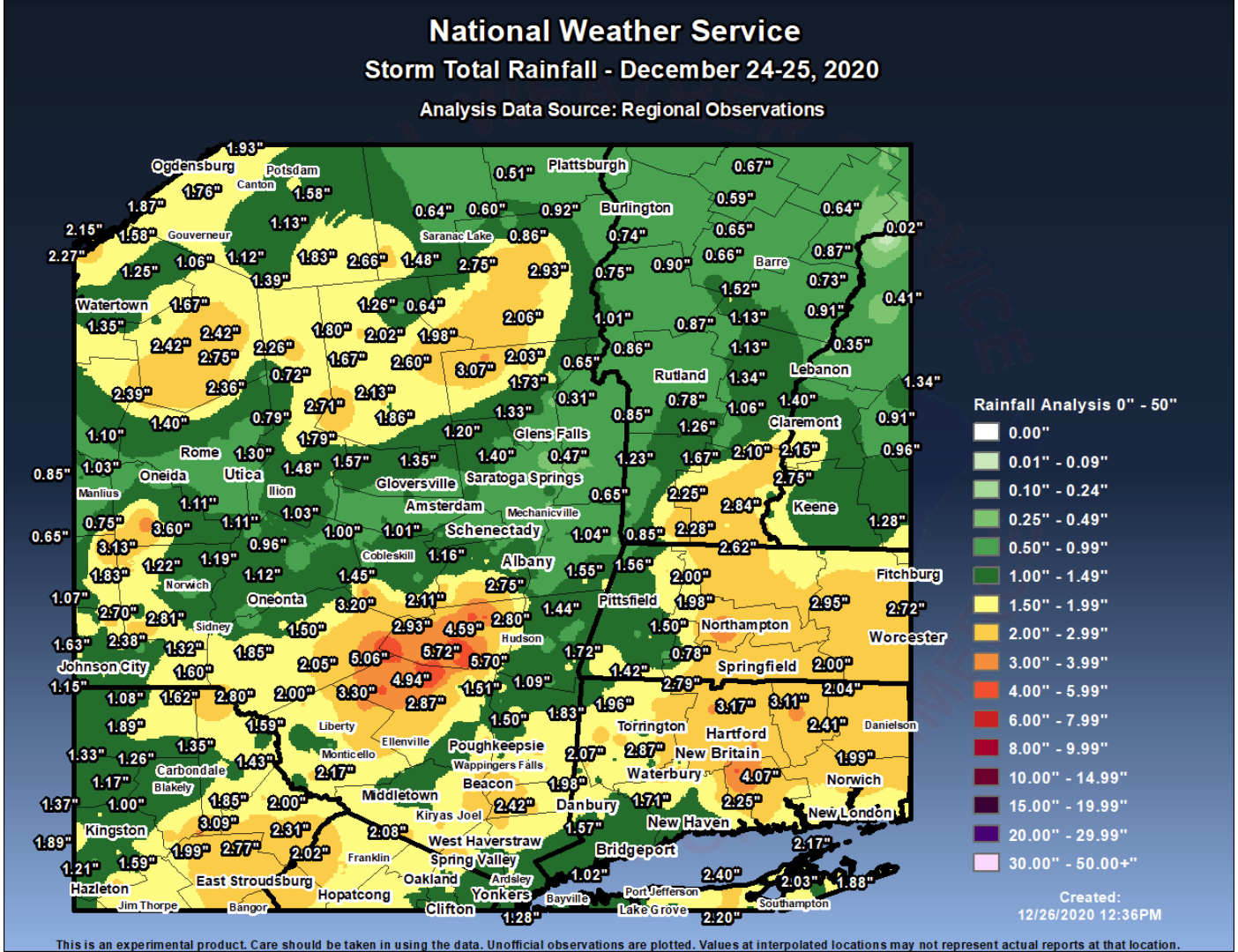
Inputs to River Forecasts

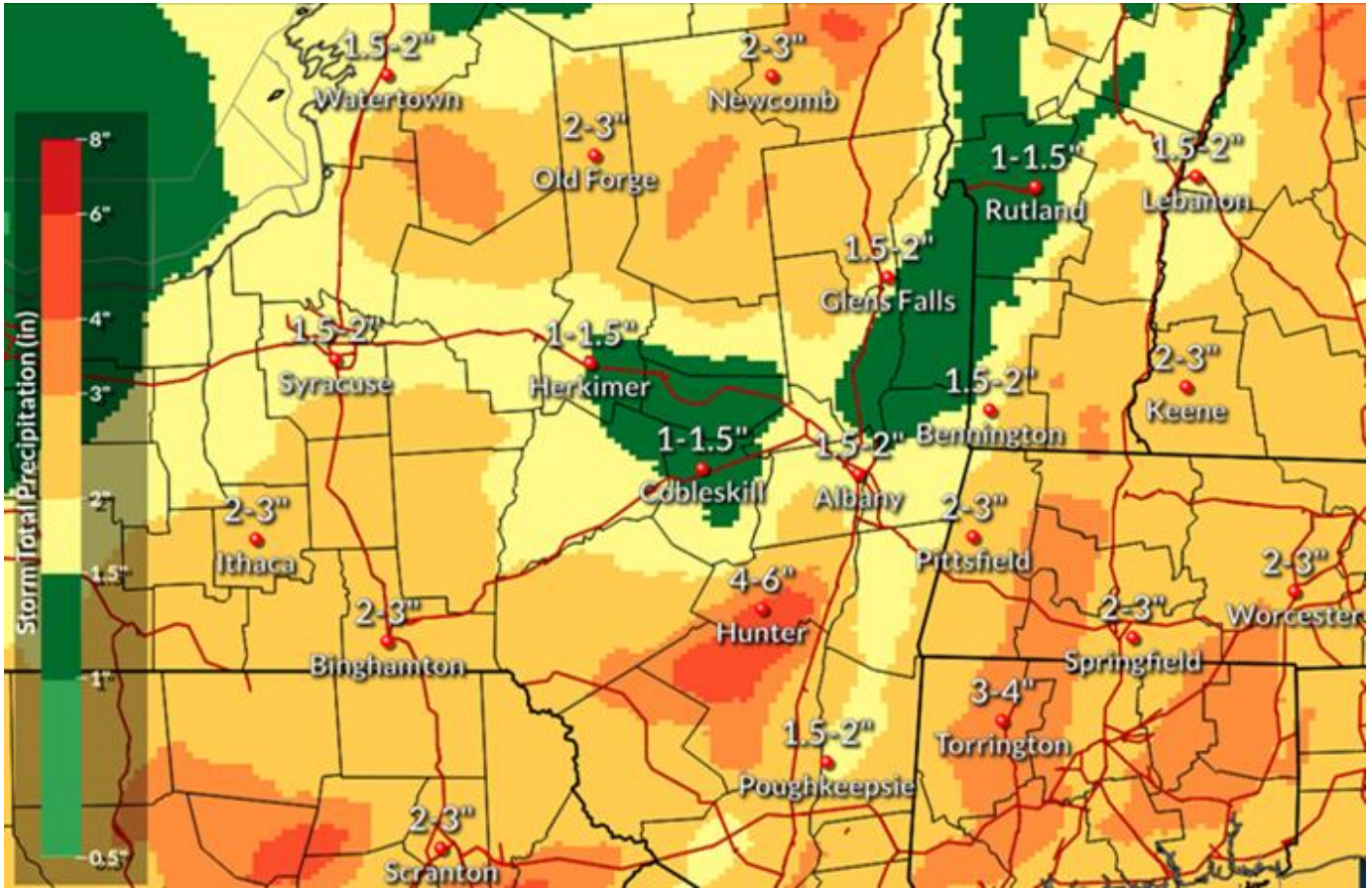
- Estimated (past) rainfall
  - Automated rain gages w/telemetry
  - Radar rainfall estimates
  - Cooperative weather observer & CoCoRaHS rainfall reports
- Forecast rainfall
- Observed river heights & flow
  - Automated river gages w/telemetry
  - Cooperative weather observer staff gage or wireweight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

Event illustration: Christmas 2020 flood



Measured rainfall Dec 24-25, 2020

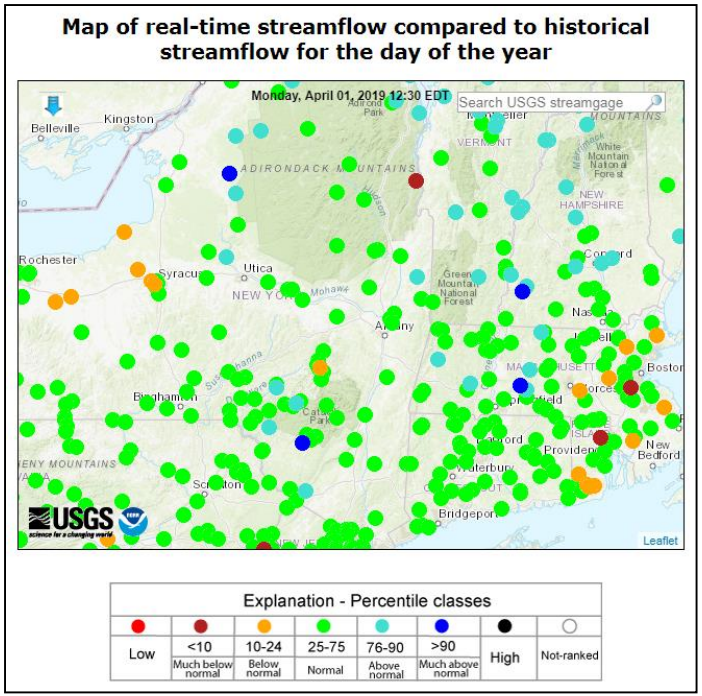
Forecast Rainfall



Forecasted rainfall Dec 24-25, 2021 (forecast from Dec 24)

in real time, this is coordinated between WFOs, WPC & RFCs

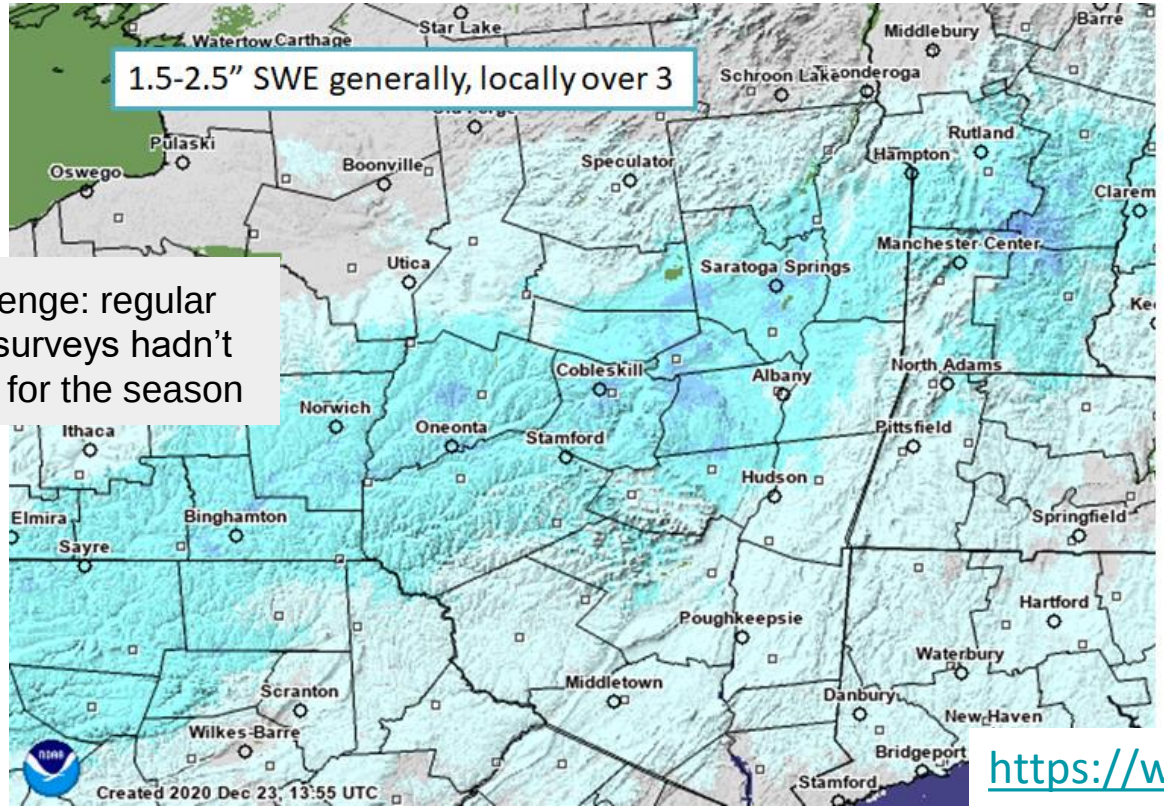
Observed River Heights & Flow



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

Snow liquid equivalent before the event



Challenge: regular snow surveys hadn’t started for the season

Inches of water equivalent

> 18
16 to 18
14 to 16
12 to 14
10 to 12
8 to 10
6 to 8
5 to 6
4 to 5
3 to 4
2 to 3
1 to 2
trace to 1
Not Estimated

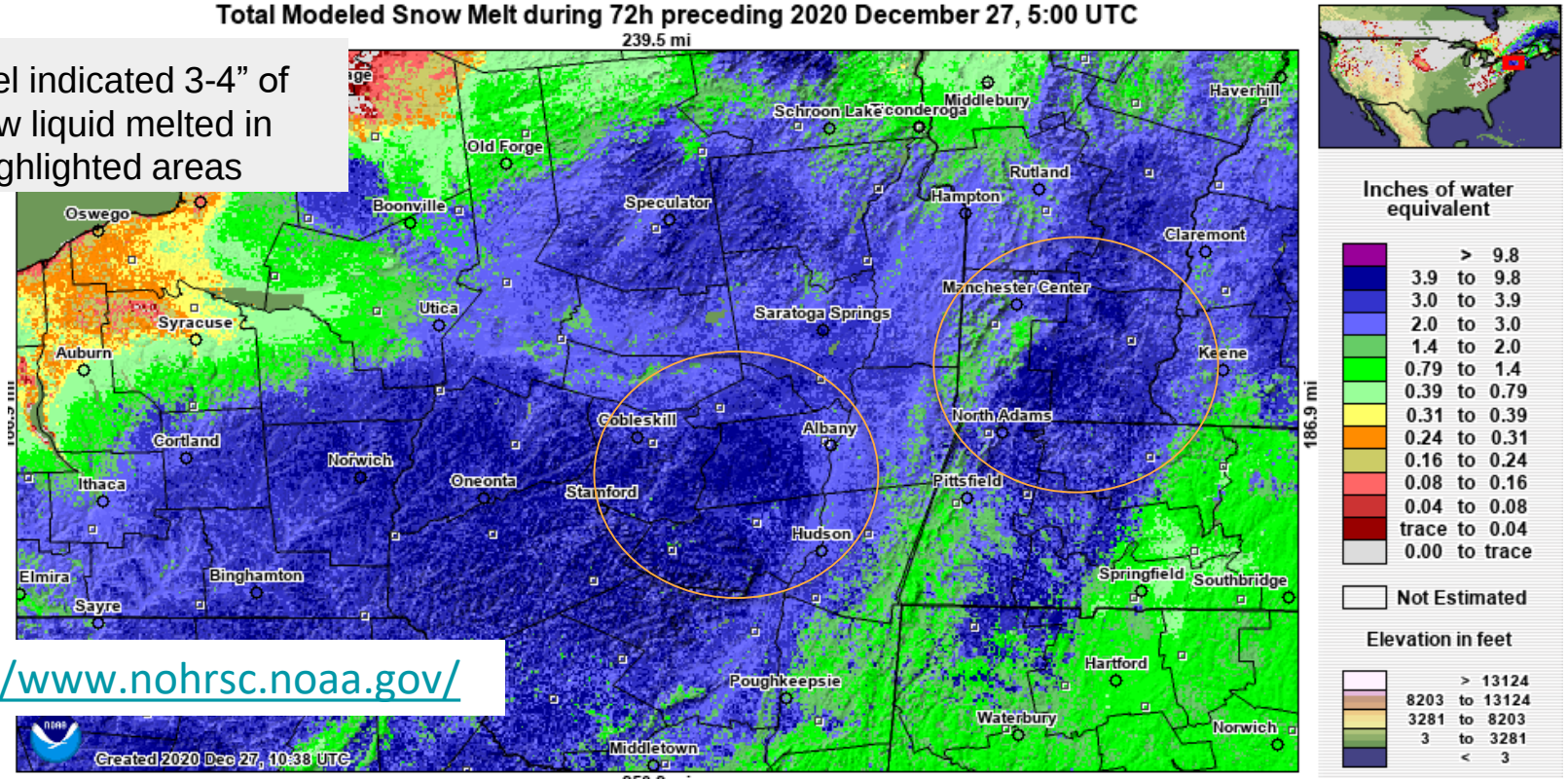
Elevation in feet

> 13124
8203 to 13124
3281 to 8203
3 to 3281
< 3

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

Estimated snowmelt (liquid equivalent)

Model indicated 3-4” of snow liquid melted in highlighted areas

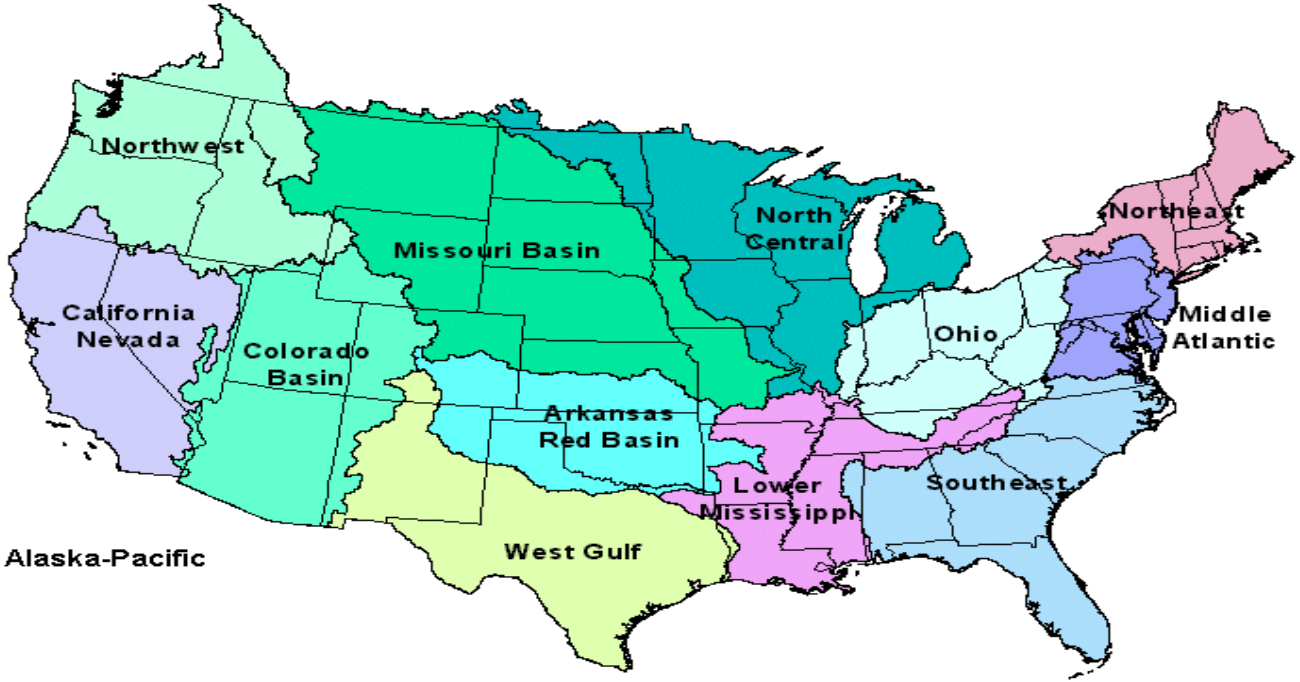


https://www.nohrsc.noaa.gov/

Those were the inputs,
now let's talk about…

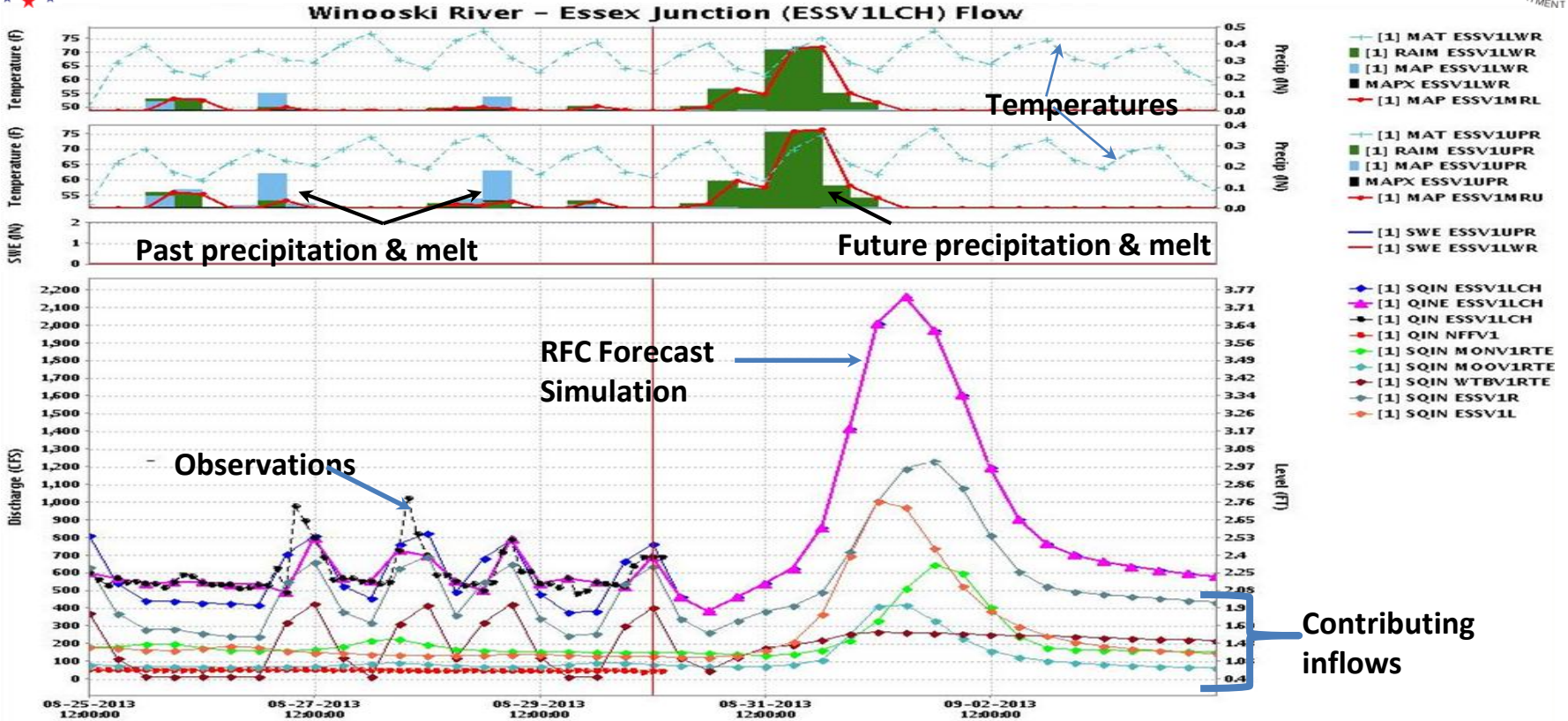
Outputs from River Forecasts

NWS River Forecast Centers



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

River Forecast Center Model

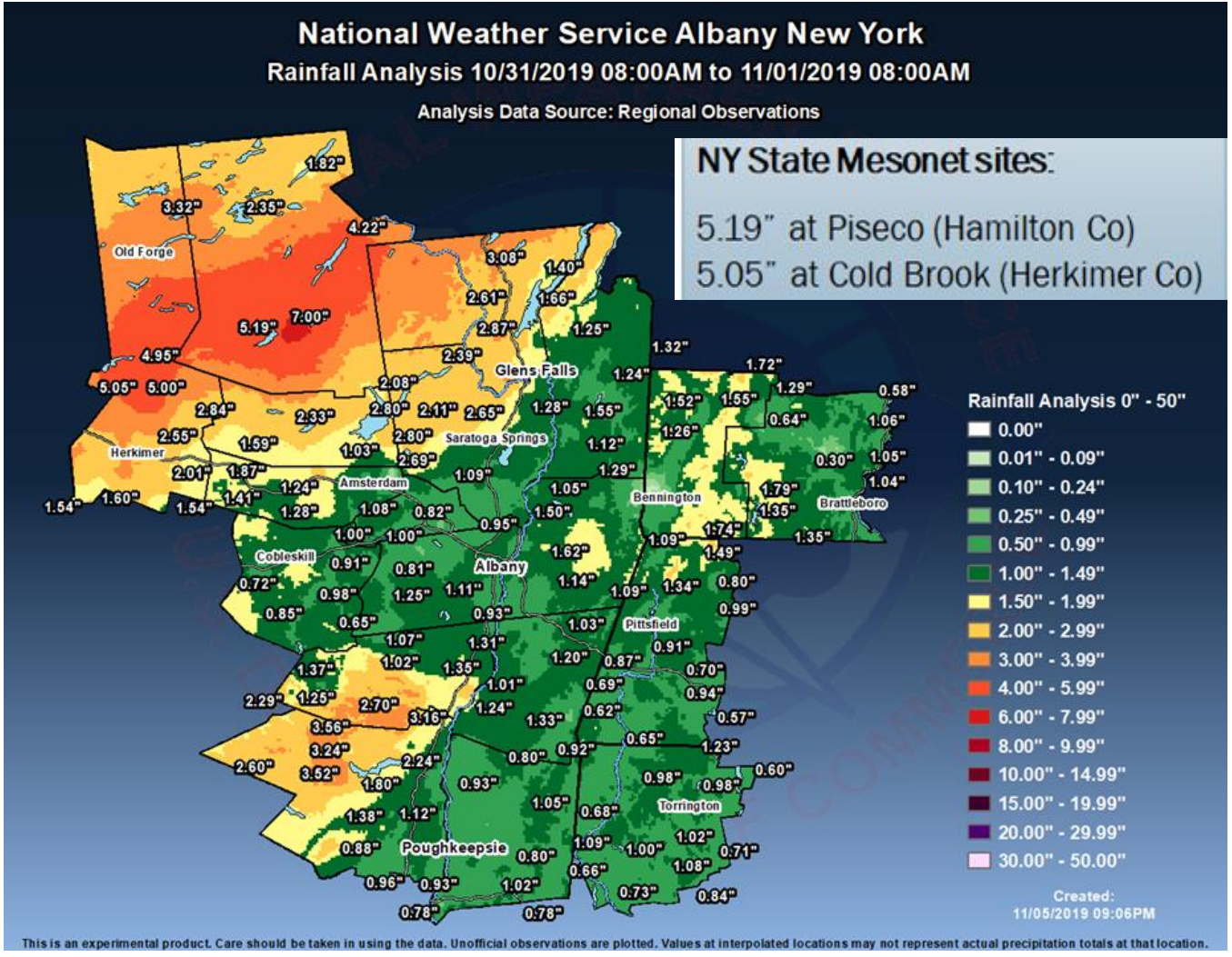


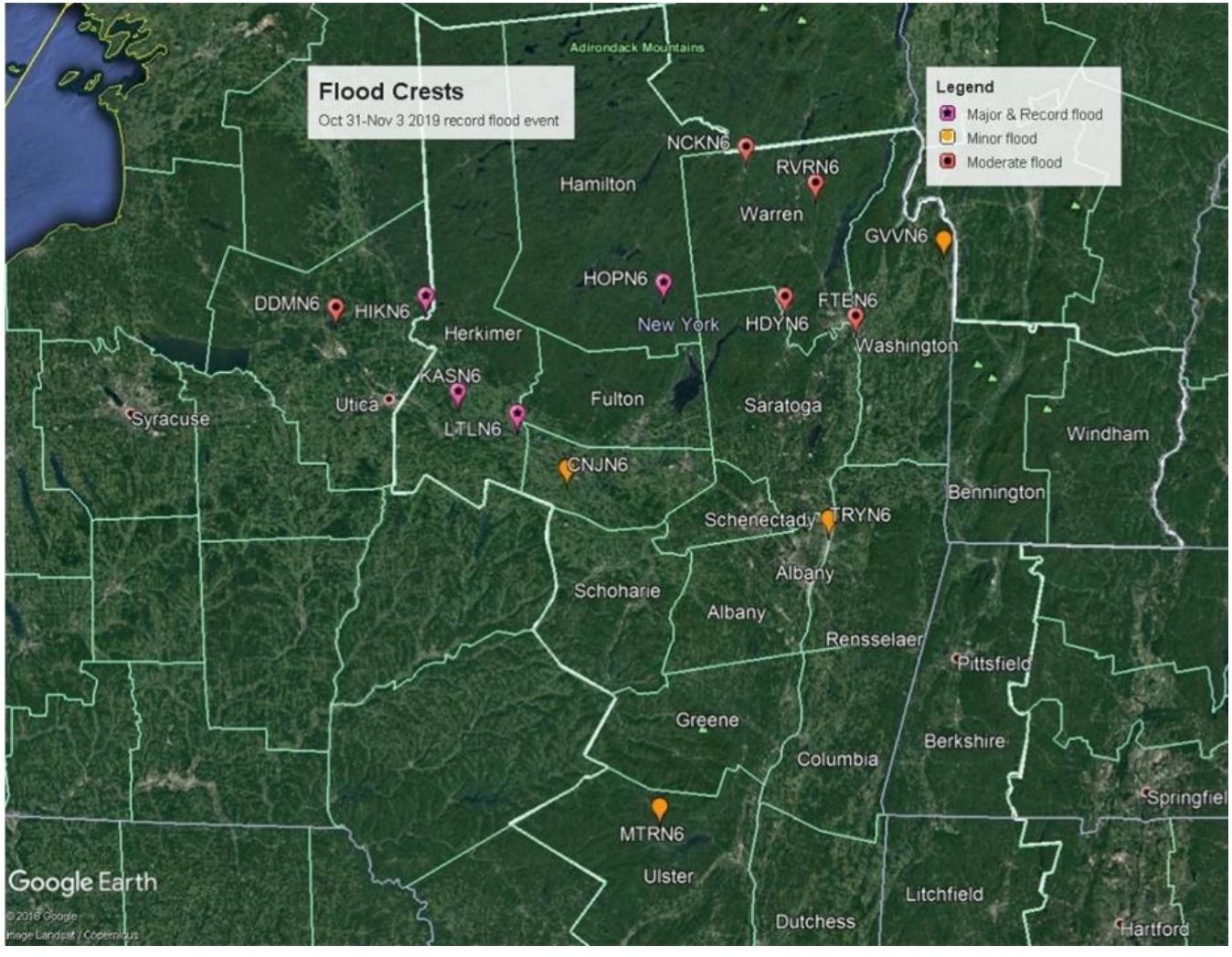
After RFC issues forecast:

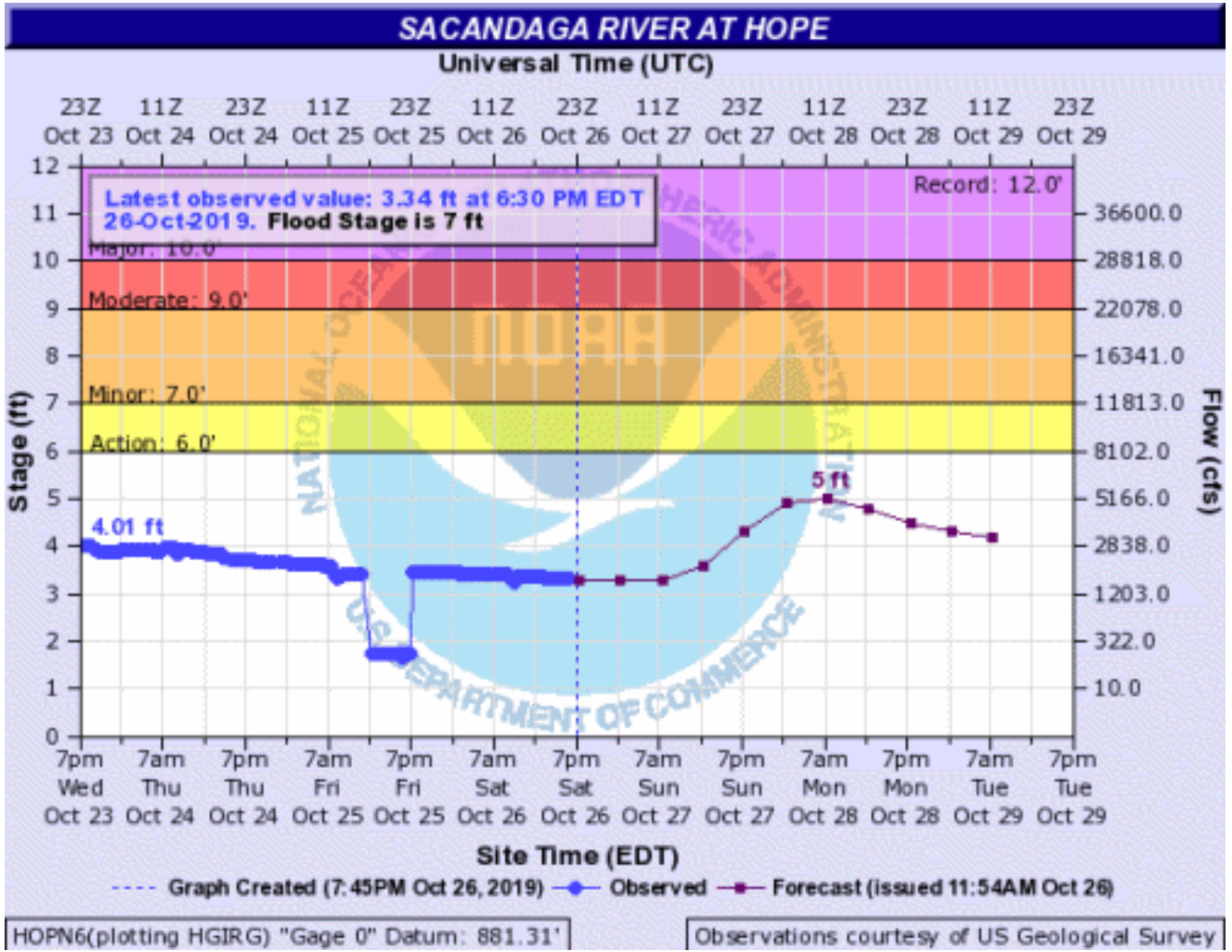
- If the forecast is over flood stage (determined by the local Weather Forecast Office - WFO), a warning is needed:
  - software automatically creates a “first draft”
  - warning can be sent in under 1 minute if needed
  - activates the Emergency Alert System

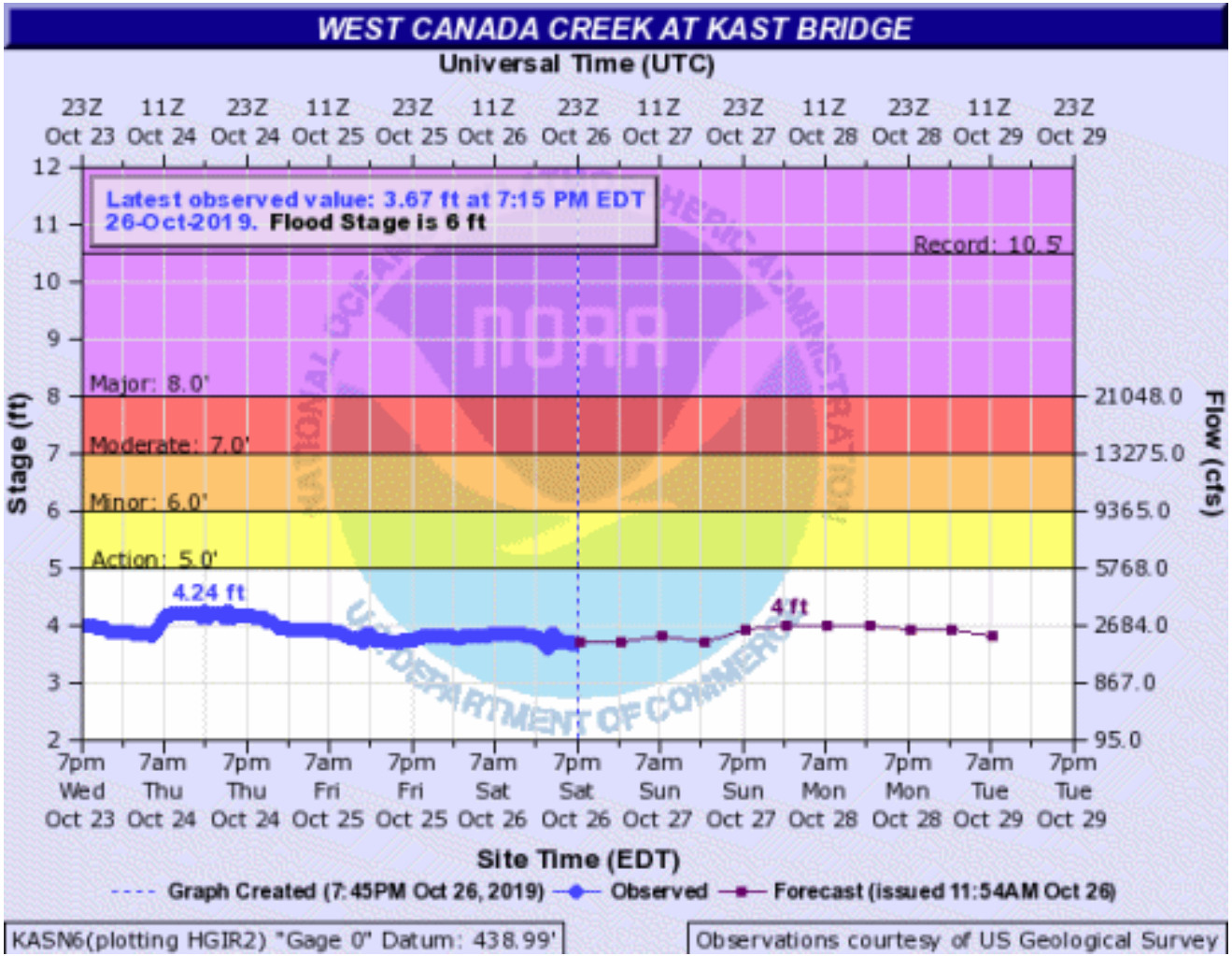
- Most forecasts are also sent to our website water.weather.gov/ahps/

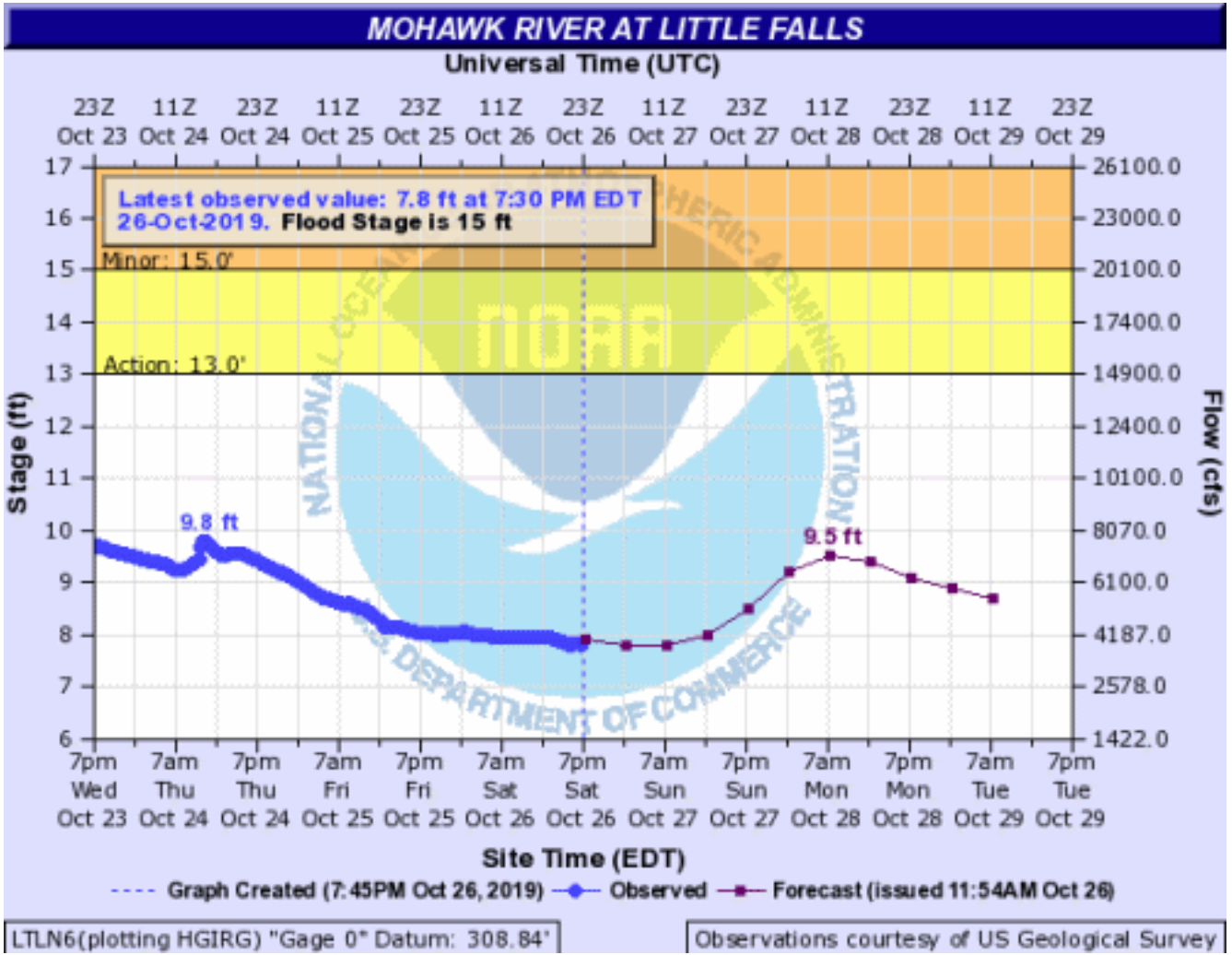
Event illustration: Halloween 2019 flood


National Weather Service Albany New York
Rainfall Analysis 10/31/2019 08:00AM to 11/01/2019 08:00AM
Analysis Data Source: Regional Observations
NY State Mesonet sites:
5.19" at Piseco (Hamilton Co)
5.05" at Cold Brook (Herkimer Co)
Old Forge
Herkimer
Amsterdam
Glens Falls
Saratoga Springs
Bennington
Brattleboro
Cobleskill
Albany
Pittsfield
Torrington
Poughkeepsie
Rainfall Analysis 0" - 50"
0.00"
0.01" - 0.09"
0.10" - 0.24"
0.25" - 0.49"
0.50" - 0.99"
1.00" - 1.49"
1.50" - 1.99"
2.00" - 2.99"
3.00" - 3.99"
4.00" - 5.99"
6.00" - 7.99"
8.00" - 9.99"
10.00" - 14.99"
15.00" - 19.99"
20.00" - 29.99"
30.00" - 50.00"
Created:
11/05/2019 09:06PM
This is an experimental product. Care should be taken in using the data. Unofficial observations are plotted. Values at interpolated locations may not represent actual precipitation totals at that location.

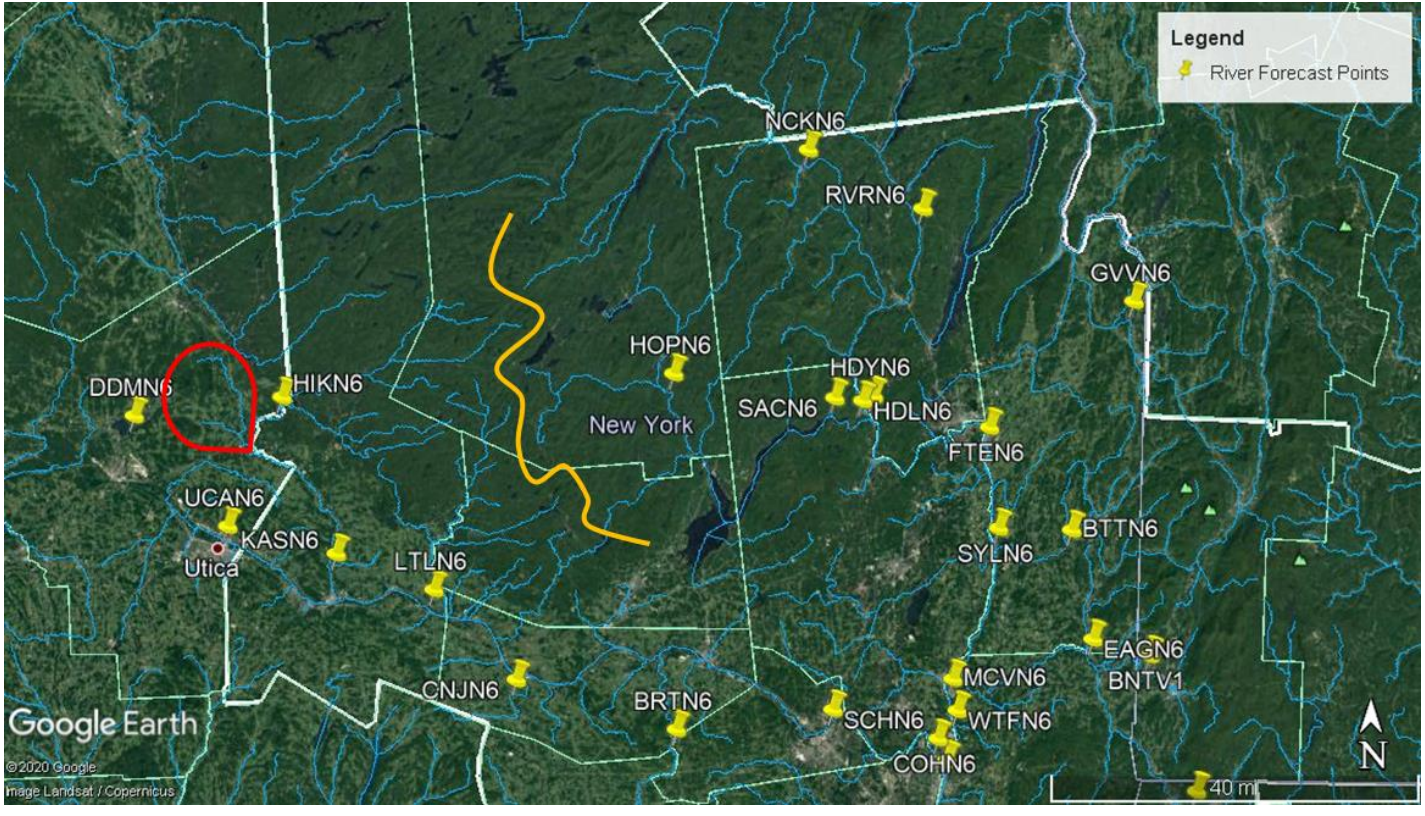

Flood Crests
Oct 31-Nov 3 2019 record flood event
Legend
Major & Record flood
Minor flood
Moderate flood
Adirondack Mountains
Hamilton
NCKN6
RVRN6
Warren
GVVN6
HOPN6
DDMN6
HIKN6
Herkimer
New York
HDYN6
FTEN6
Washington
KASN6
Utica
Syracuse
Fulton
Saratoga
LTLN6
CNJN6
Windham
Bennington
Schenectady
TRYN6
Albany
Schoharie
Albany
Rensselaer
Pittsfield
Greene
Columbia
Berkshire
Springfiel
MTRN6
Ulster
Litchfield
Dutchess
Hartford
Google Earth
© 2019 Google
Image Landsat / Copernicus

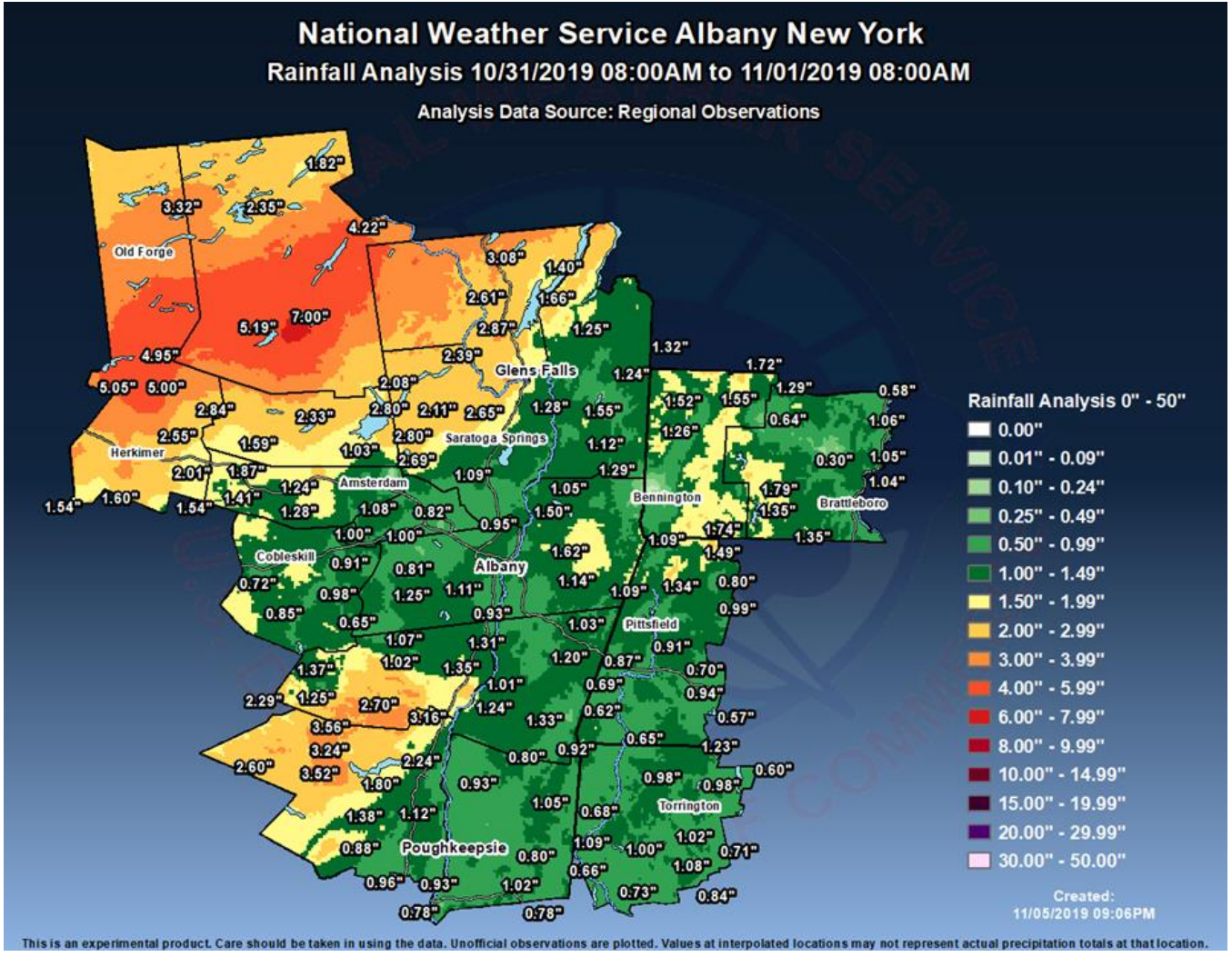

SACANDAGA RIVER AT HOPE
Universal Time (UTC)
23Z Oct 23
11Z Oct 24
23Z Oct 24
11Z Oct 25
23Z Oct 25
11Z Oct 26
23Z Oct 26
11Z Oct 27
23Z Oct 27
11Z Oct 28
23Z Oct 28
11Z Oct 29
23Z Oct 29
Latest observed value: 3.34 ft at 6:30 PM EDT 26-Oct-2019. Flood Stage is 7 ft
Record: 12.0'
Major: 10.0'
Moderate: 9.0'
Minor: 7.0'
Action: 6.0'
Stage (ft)
Flow (cfs)
12
11
10
9
8
7
6
5
4
3
2
1
0
36600.0
28818.0
22078.0
16341.0
11813.0
8102.0
5166.0
2838.0
1203.0
322.0
10.0
4.01 ft
5 ft
7pm Wed Oct 23
7am Thu Oct 24
7pm Thu Oct 24
7am Fri Oct 25
7pm Fri Oct 25
7am Sat Oct 26
7pm Sat Oct 26
7am Sun Oct 27
7pm Sun Oct 27
7am Mon Oct 28
7pm Mon Oct 28
7am Tue Oct 29
7pm Tue Oct 29
Site Time (EDT)
Graph Created (7:45PM Oct 26, 2019)
Observed
Forecast (issued 11:54AM Oct 26)
HOPN6(plotting HGIRG) "Gage 0" Datum: 881.31'
Observations courtesy of US Geological Survey


WEST CANADA CREEK AT KAST BRIDGE
Universal Time (UTC)
23Z Oct 23
11Z Oct 24
23Z Oct 24
11Z Oct 25
23Z Oct 25
11Z Oct 26
23Z Oct 26
11Z Oct 27
23Z Oct 27
11Z Oct 28
23Z Oct 28
11Z Oct 29
23Z Oct 29
Latest observed value: 3.67 ft at 7:15 PM EDT 26-Oct-2019. Flood Stage is 6 ft
Record: 10.5
Major: 8.0'
Moderate: 7.0'
Minor: 6.0'
Action: 5.0'
4.24 ft
4 ft
Stage (ft)
Flow (cfs)
12
11
10
9
8
7
6
5
4
3
2
21048.0
13275.0
9365.0
5768.0
2684.0
867.0
95.0
7pm Wed Oct 23
7am Thu Oct 24
7pm Thu Oct 24
7am Fri Oct 25
7pm Fri Oct 25
7am Sat Oct 26
7pm Sat Oct 26
7am Sun Oct 27
7pm Sun Oct 27
7am Mon Oct 28
7pm Mon Oct 28
7am Tue Oct 29
7pm Tue Oct 29
Site Time (EDT)
Graph Created (7:45PM Oct 26, 2019)
Observed
Forecast (issued 11:54AM Oct 26)
KASN6(plotting HGIR2) "Gage 0" Datum: 438.99'
Observations courtesy of US Geological Survey


MOHAWK RIVER AT LITTLE FALLS
Universal Time (UTC)
23Z Oct 23
11Z Oct 24
23Z Oct 24
11Z Oct 25
23Z Oct 25
11Z Oct 26
23Z Oct 26
11Z Oct 27
23Z Oct 27
11Z Oct 28
23Z Oct 28
11Z Oct 29
23Z Oct 29
Latest observed value: 7.8 ft at 7:30 PM EDT 26-Oct-2019. Flood Stage is 15 ft
Minor: 15.0'
Action: 13.0'
Stage (ft)
17
16
15
14
13
12
11
10
9
8
7
6
Flow (cfs)
26100.0
23000.0
20100.0
17400.0
14900.0
12400.0
10100.0
8070.0
6100.0
4187.0
2578.0
1422.0
9.8 ft
9.5 ft
7pm Wed Oct 23
7am Thu Oct 24
7pm Thu Oct 24
7am Fri Oct 25
7pm Fri Oct 25
7am Sat Oct 26
7pm Sat Oct 26
7am Sun Oct 27
7pm Sun Oct 27
7am Mon Oct 28
7pm Mon Oct 28
7am Tue Oct 29
7pm Tue Oct 29
Site Time (EDT)
Graph Created (7:45PM Oct 26, 2019)
Observed
Forecast (issued 11:54AM Oct 26)
LTLN6(plotting HGIRG) "Gage 0" Datum: 308.84'
Observations courtesy of US Geological Survey

Lab preview: know your drainage divide




National Weather Service Albany New York
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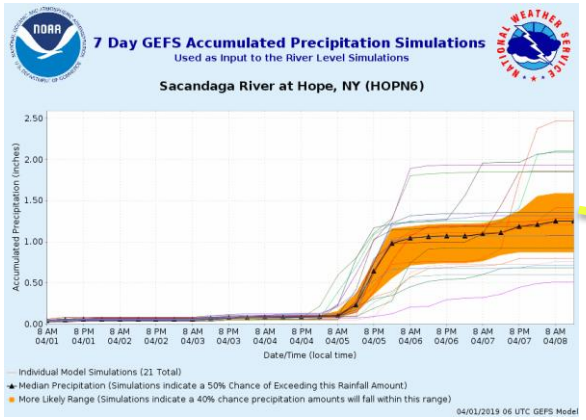
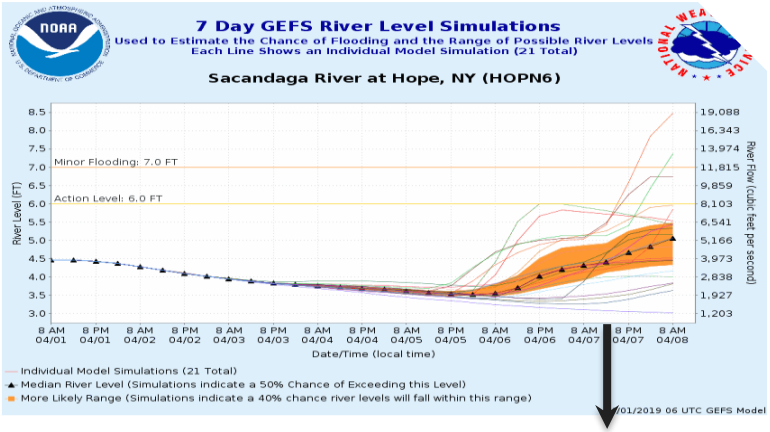
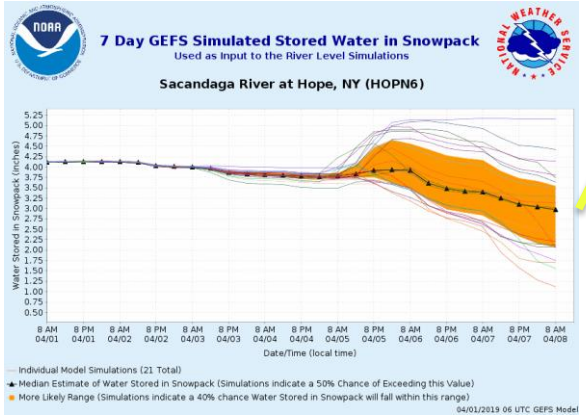
Cobleskill
Albany
Pittsfield
Torrington
Poughkeepsie
Rainfall Analysis 0" - 50"
0.00"
0.01" - 0.09"
0.10" - 0.24"
0.25" - 0.49"
0.50" - 0.99"
1.00" - 1.49"
1.50" - 1.99"
2.00" - 2.99"
3.00" - 3.99"
4.00" - 5.99"
6.00" - 7.99"
8.00" - 9.99"
10.00" - 14.99"
15.00" - 19.99"
20.00" - 29.99"
30.00" - 50.00"
Created:
11/05/2019 09:06PM
This is an experimental product. Care should be taken in using the data. Unofficial observations are plotted. Values at interpolated locations may not represent actual precipitation totals at that location.

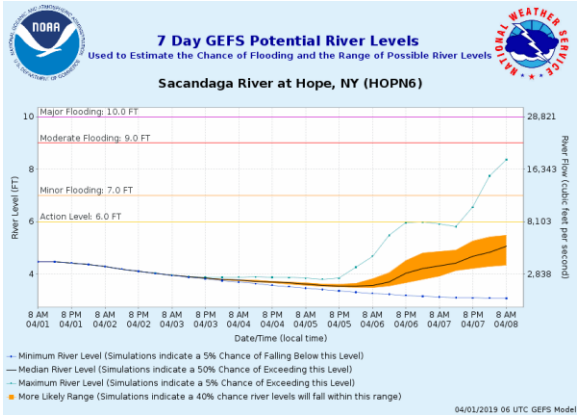
Ensemble Streamflow Forecasts

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

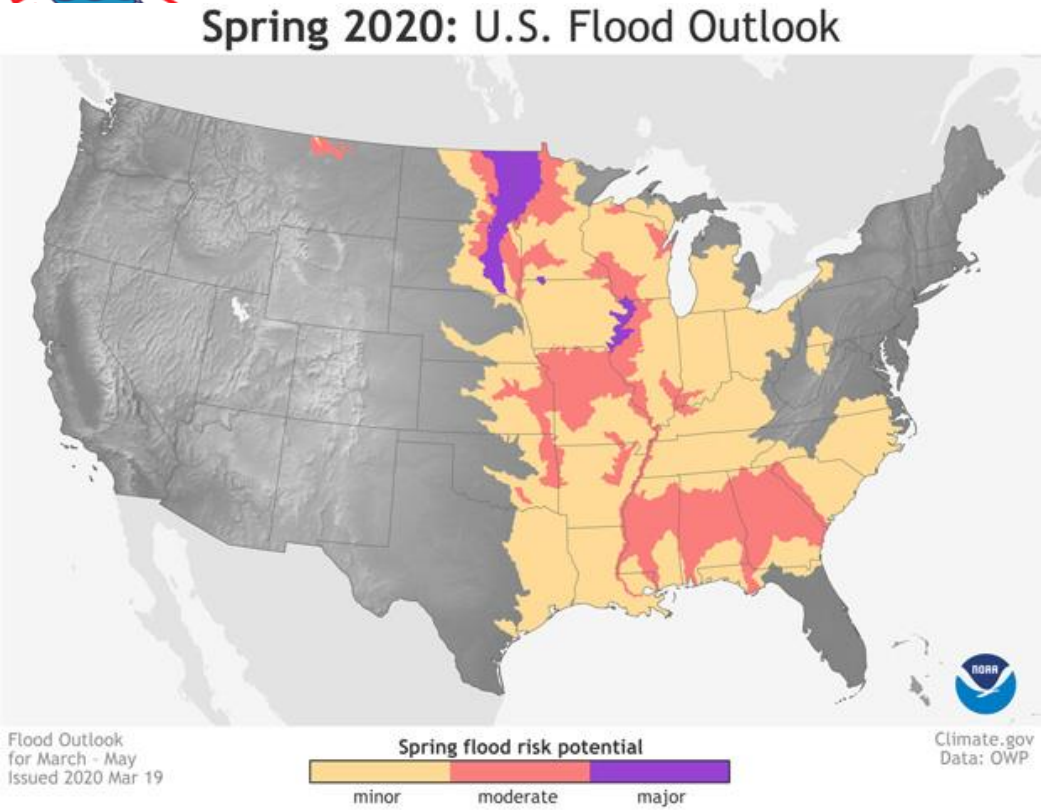


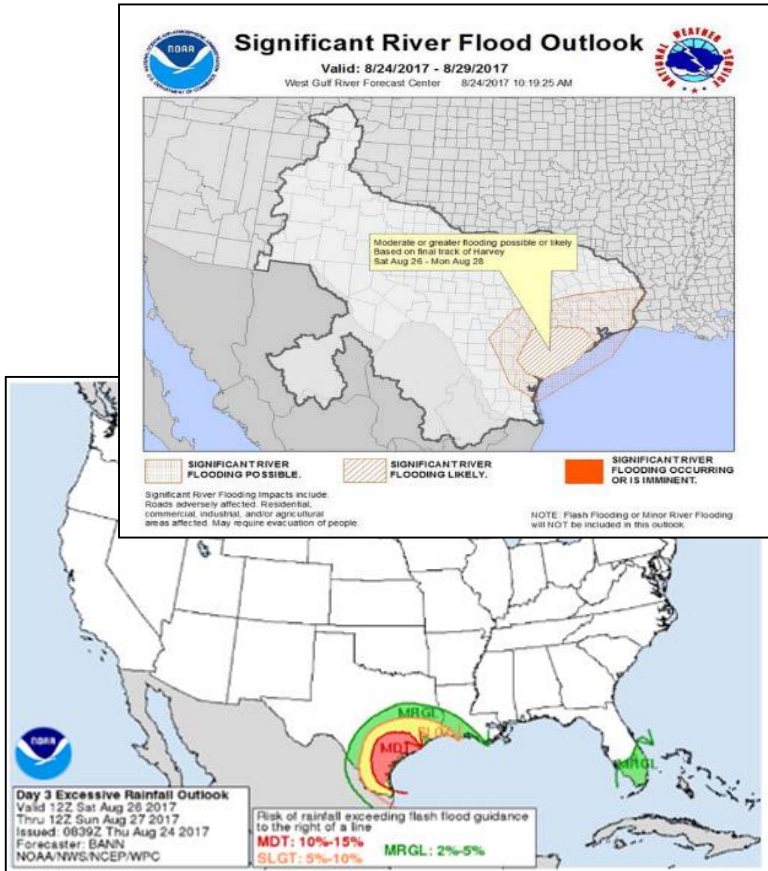






Other Forecasts & Outlooks…





Above: this spring's flood threat

Right: pre-Hurricane Harvey flood outlook products

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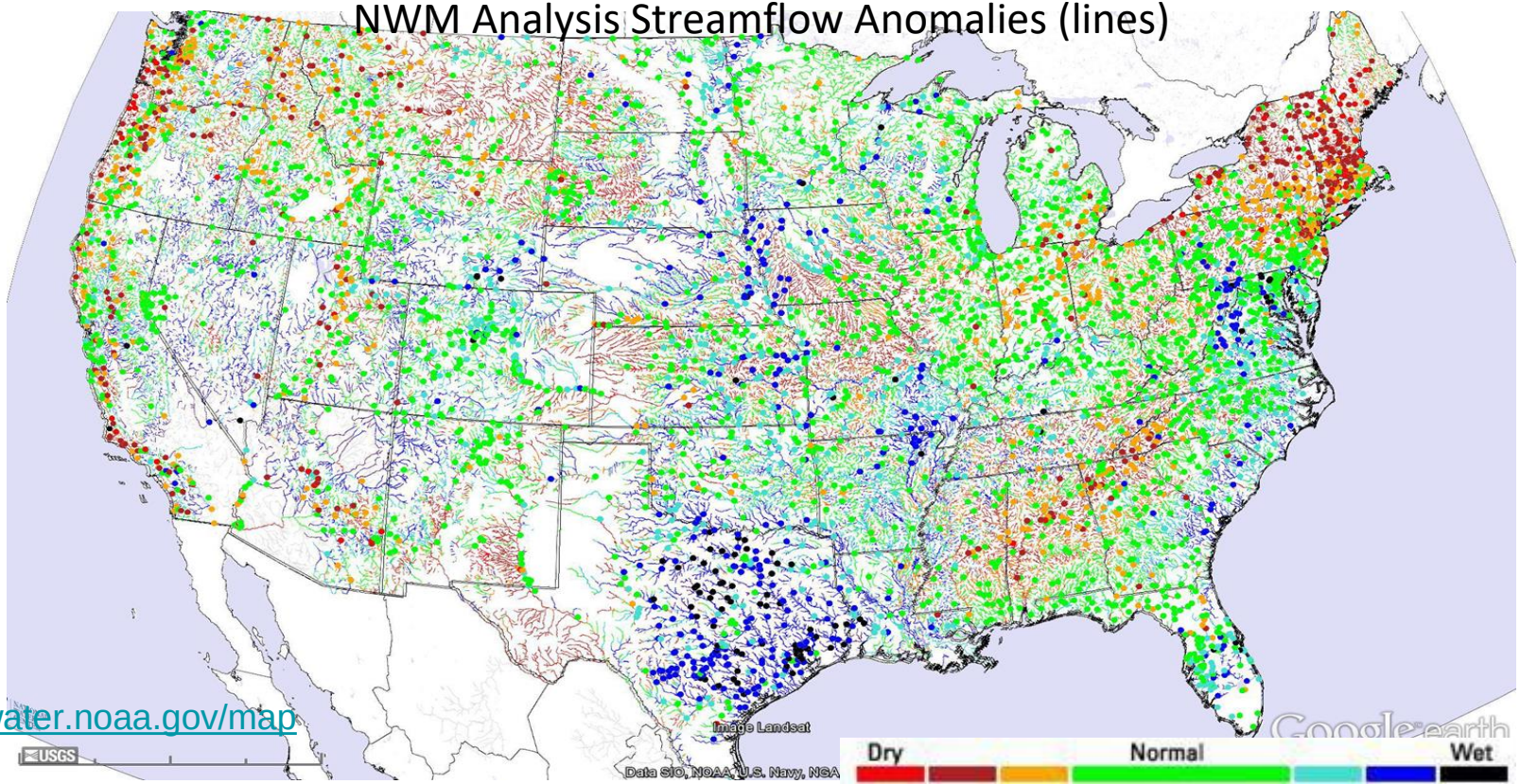
Inundation Mapping

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

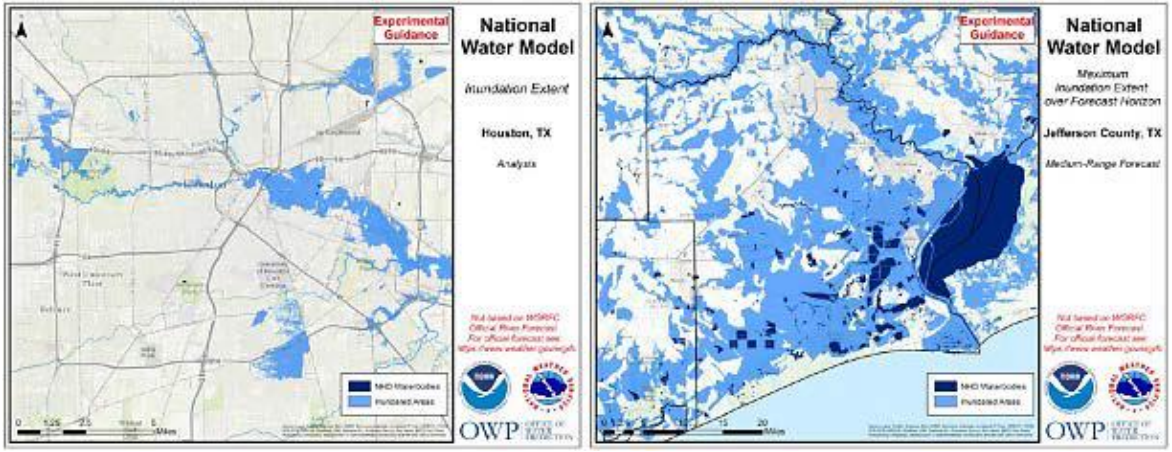
National Water Model

USGS Observed Streamflow Anomalies (dots)
NWM Analysis Streamflow Anomalies (lines)

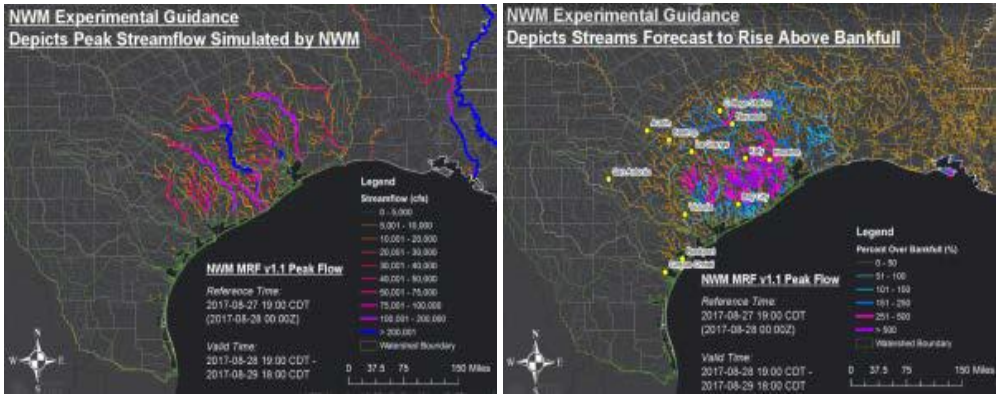


https://water.noaa.gov/map

National Water Model



Experimental flood inundation and streamflow guidance from Hurricane Harvey



Hydrology in the National Weather Service

What we discussed:

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

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:
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