

# Hydrology of Tropical Storms Irene and Lee

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Photo by Tim Scrom of NWS  
Lake near Hensonville, Greene County



NYSFOLA Meeting

May 4, 2012

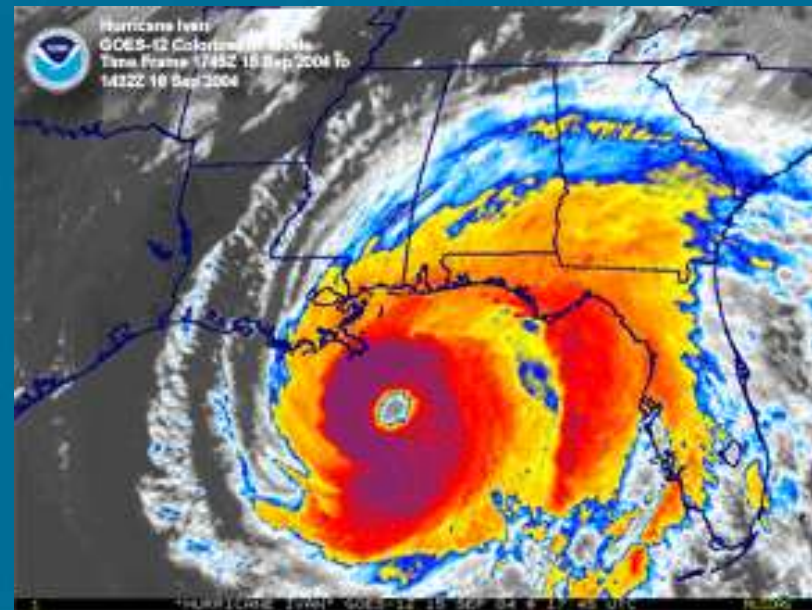


# National Weather Service



- High Impact Weather
- Warning the U.S. Public
- Decision Support Services
- Economic Preservation

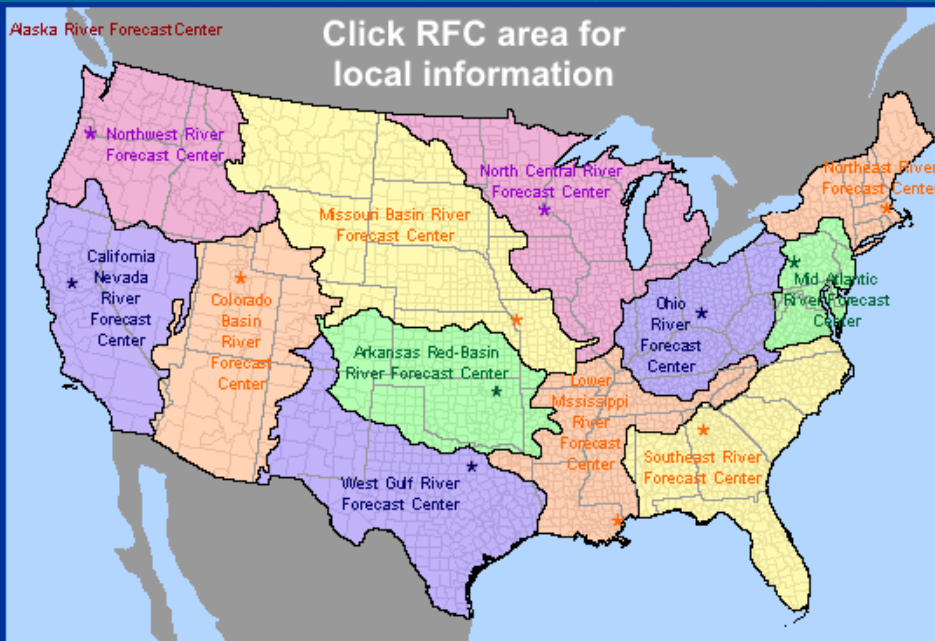
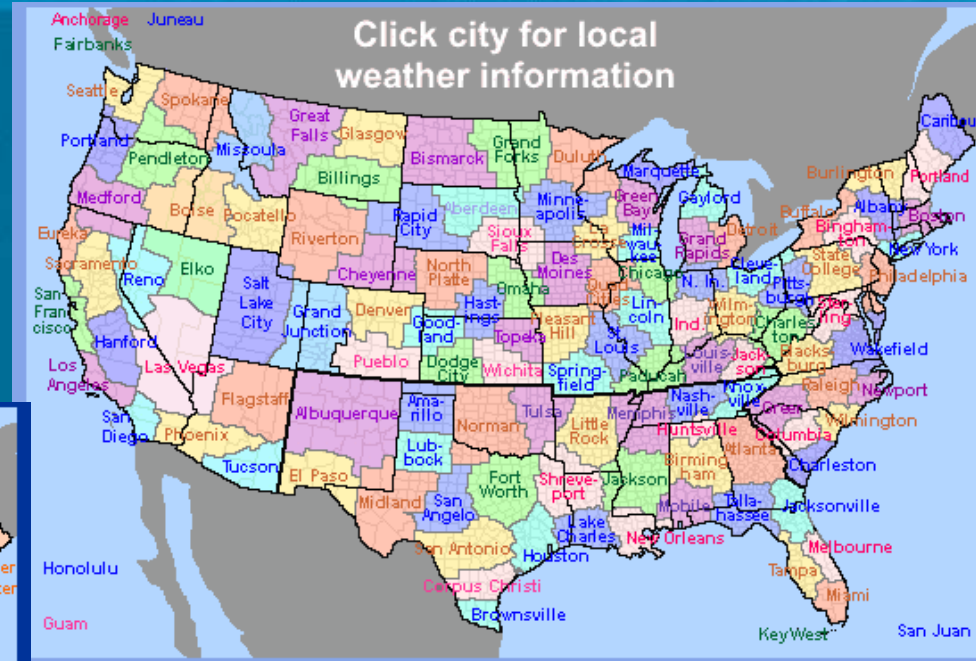
“To provide weather, water, and climate forecasts and warnings for the protection of life and property and the enhancement of the national economy.”





# National Weather Service

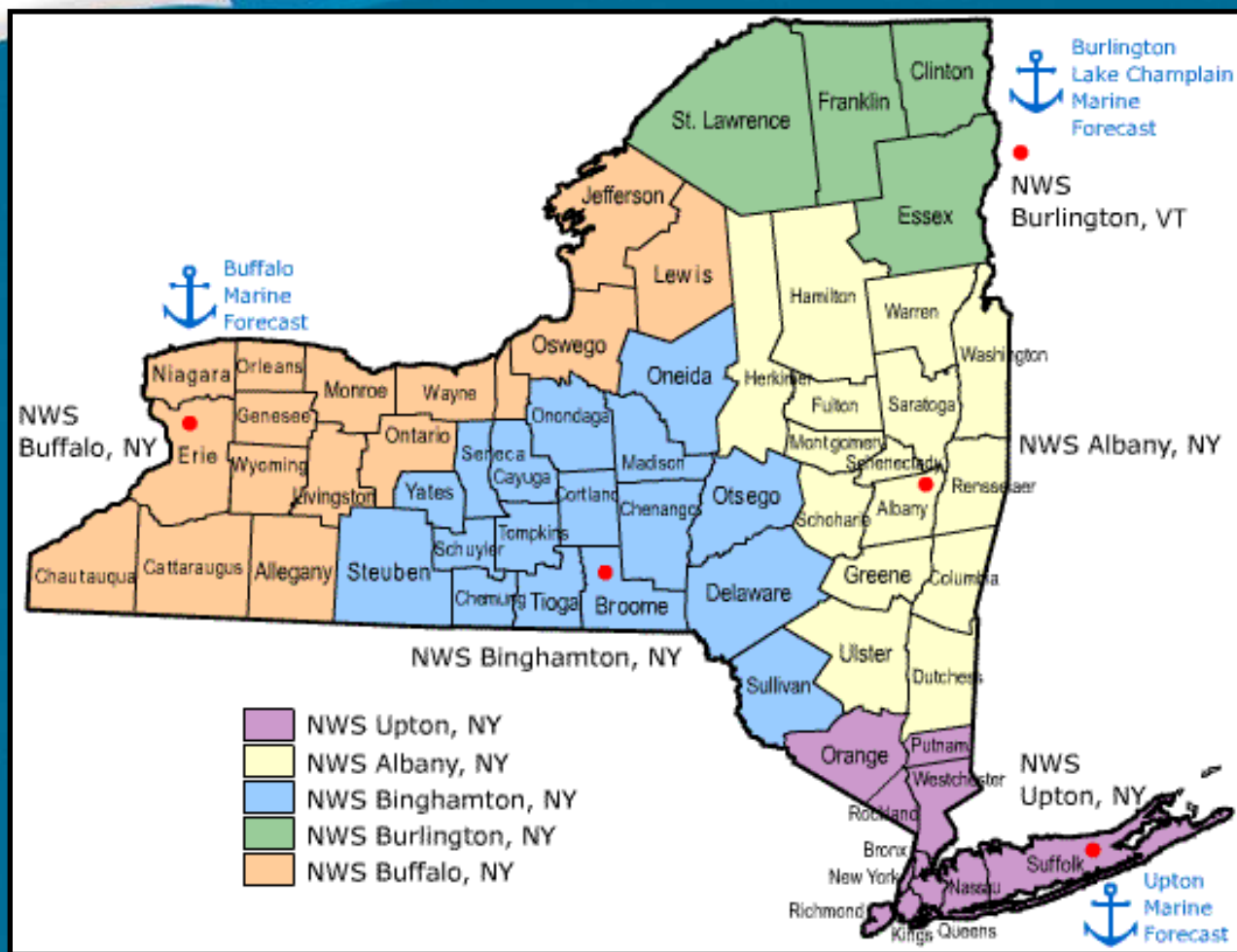
- 122 Forecast Offices
- 13 River Forecast Centers



- 9 National Centers, including:
  - Storm Prediction Center
  - National Hurricane Center
  - Hydrometeorological Prediction Center
  - Climate Prediction Center



# Local NWS Office



- Open 24 x 7 x 365
- Approx. 23 on staff
  - Meteorologists
  - Hydrologist
  - IT/Electronics
  - Administration

# Hydrology Topics

## Tropical Storm Irene

- Antecedent conditions
- Forecasts / Outlook
- Storm Track
- Rainfall
- Flood magnitude
- Storm surge on Hudson
- Operational challenges

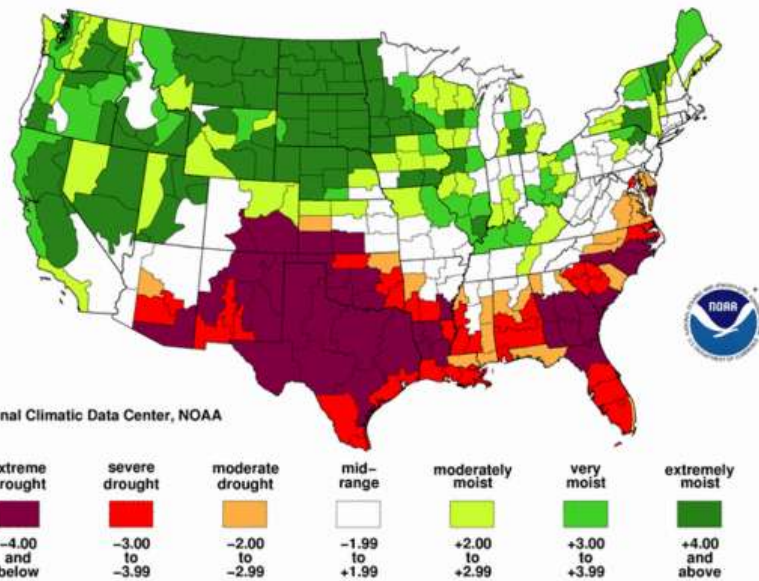
## Remnants of T.S. Lee

- Antecedent conditions
- Rainfall
- Flood magnitude
- Operational challenges

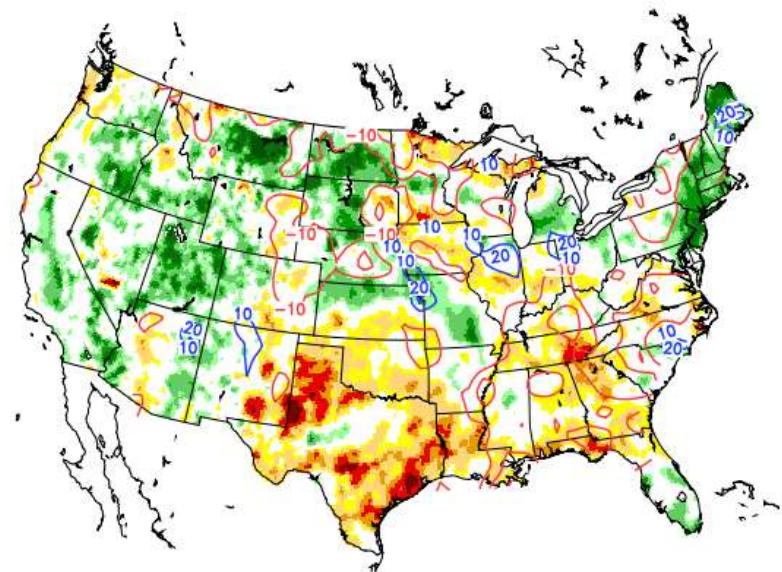


# Irene: Antecedent Conditions

Palmer Drought Severity Index  
July, 2011



Total Column Soil Moisture Percentiles on 20110825  
(wrt samples within a 49-day window in 1951-2004)



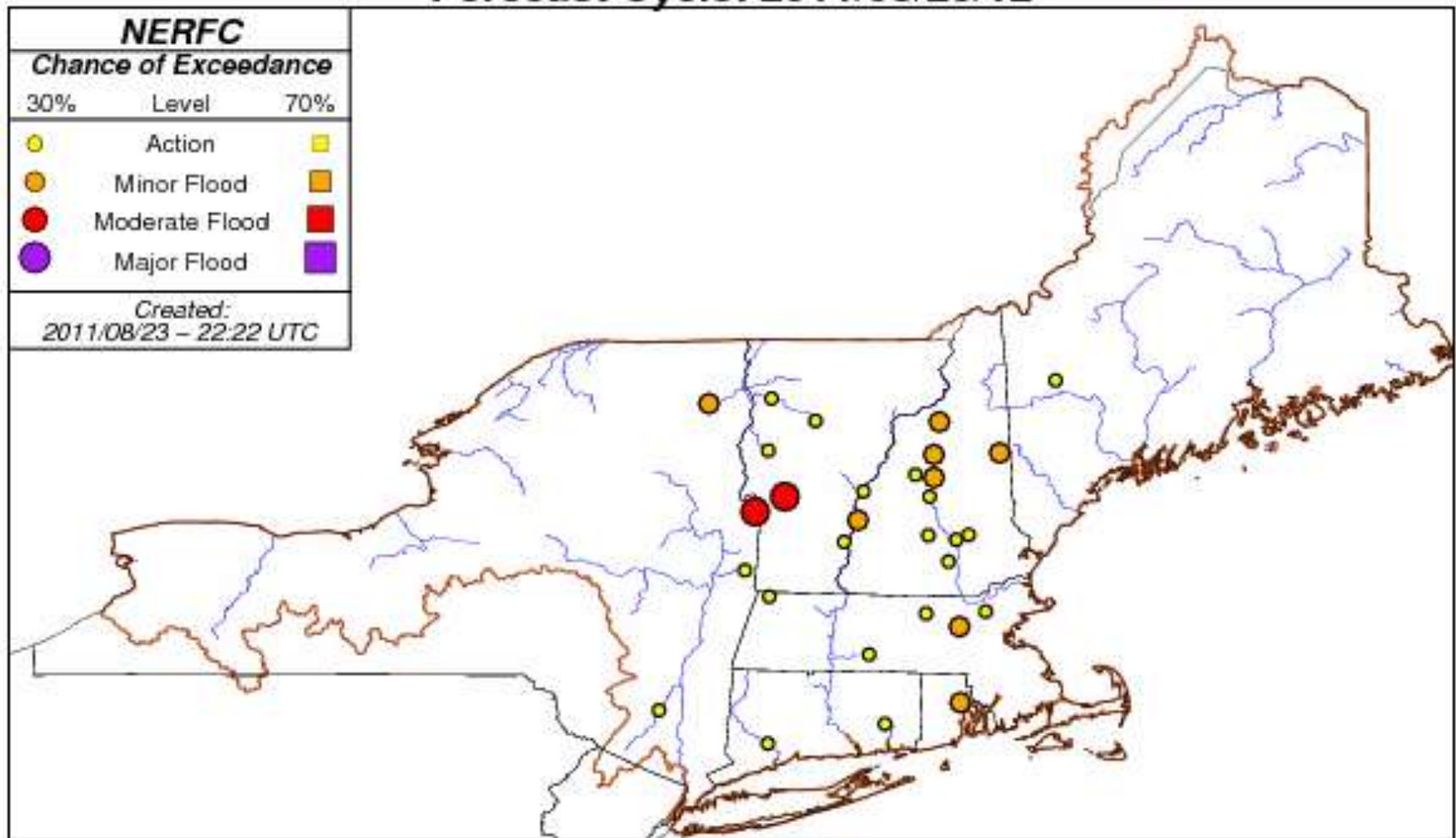
Contours show the changes in quantiles in the last 7 days.



<http://hydrology.princeton.edu/~luo/research/FORECAST/current.php>



**NAEFS Ensemble Summary for 8/23/2011 – 8/29/2011**  
**Forecast Cycle: 2011/08/23/12**



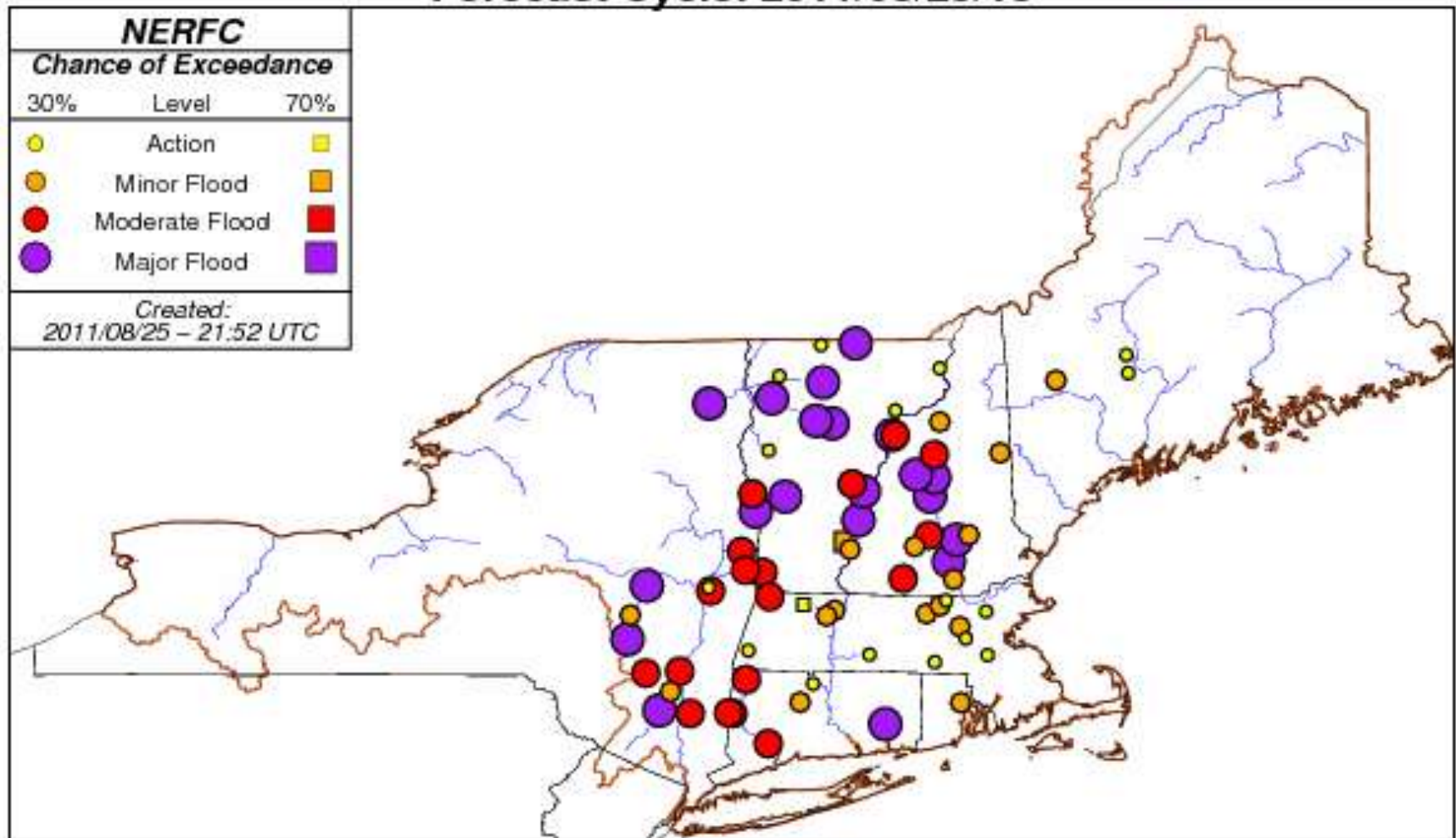
<http://www.erh.noaa.gov/mmefs/>



# Irene: MMEFS Outlook



**SREF Ensemble Summary for 8/25/2011 – 8/28/2011**  
**Forecast Cycle: 2011/08/25/15**



<http://www.erh.noaa.gov/mmefs/>



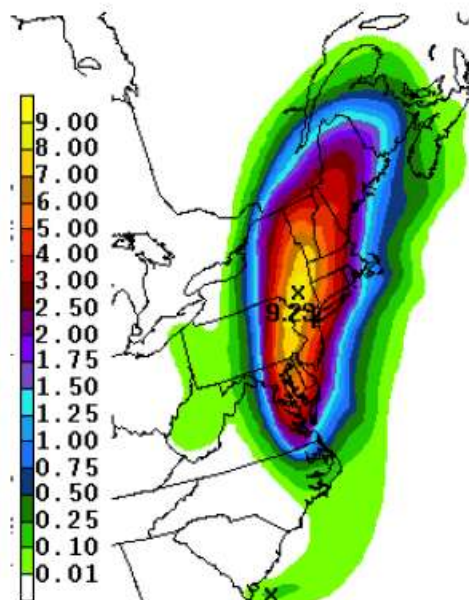
# Irene: MMEFS Outlook





# Irene: Forecast Rainfall Aug 27-29, 2011 (HPC)

HPC Rainfall Forecast  
8pm August 27 – 8 pm August 28



24-HR DAY 1 OPF  
VALID 00Z SUN AUG 28 2011  
THRU 00Z MON AUG 29 2011  
ISSUED: 2151Z SAT AUG 27 2011  
FORECASTER: TERRY  
NOAA/NWS/NCEP/HPC

Forecast maximum 9.29 – Actual maximum just over 18 inches!



# Irene: Hydrologic Forecasts

- Flood watch issued at 4:47 am Friday Aug. 26<sup>th</sup>

WIDESPREAD RAINFALL AMOUNTS OF 4 TO 7 INCHES ARE LIKELY.  
LOCALIZED AMOUNTS OVER THE HIGHER TERRAIN OF THE  
CATSKILLS...BERKSHIRES...LITCHFIELD HILLS AND GREEN MOUNTAINS  
COULD REACH 10 INCHES.

IF THIS AMOUNT OF RAIN OCCURS MANY MAIN STEM RIVERS WOULD FLOOD.  
FLASH FLOODING MAY ALSO BE A THREAT WHERE HEAVIER RAIN BANDS OCCUR.

- First flash flood warning issued 1:42 am Saturday
- Issued river flood warnings (including updated warnings as forecast crests increased in category) for 37 forecast points...flooding occurred at 35
- Average lead time from warning to flood stage was 3 hours 12 minutes



# Hurricane Irene Track

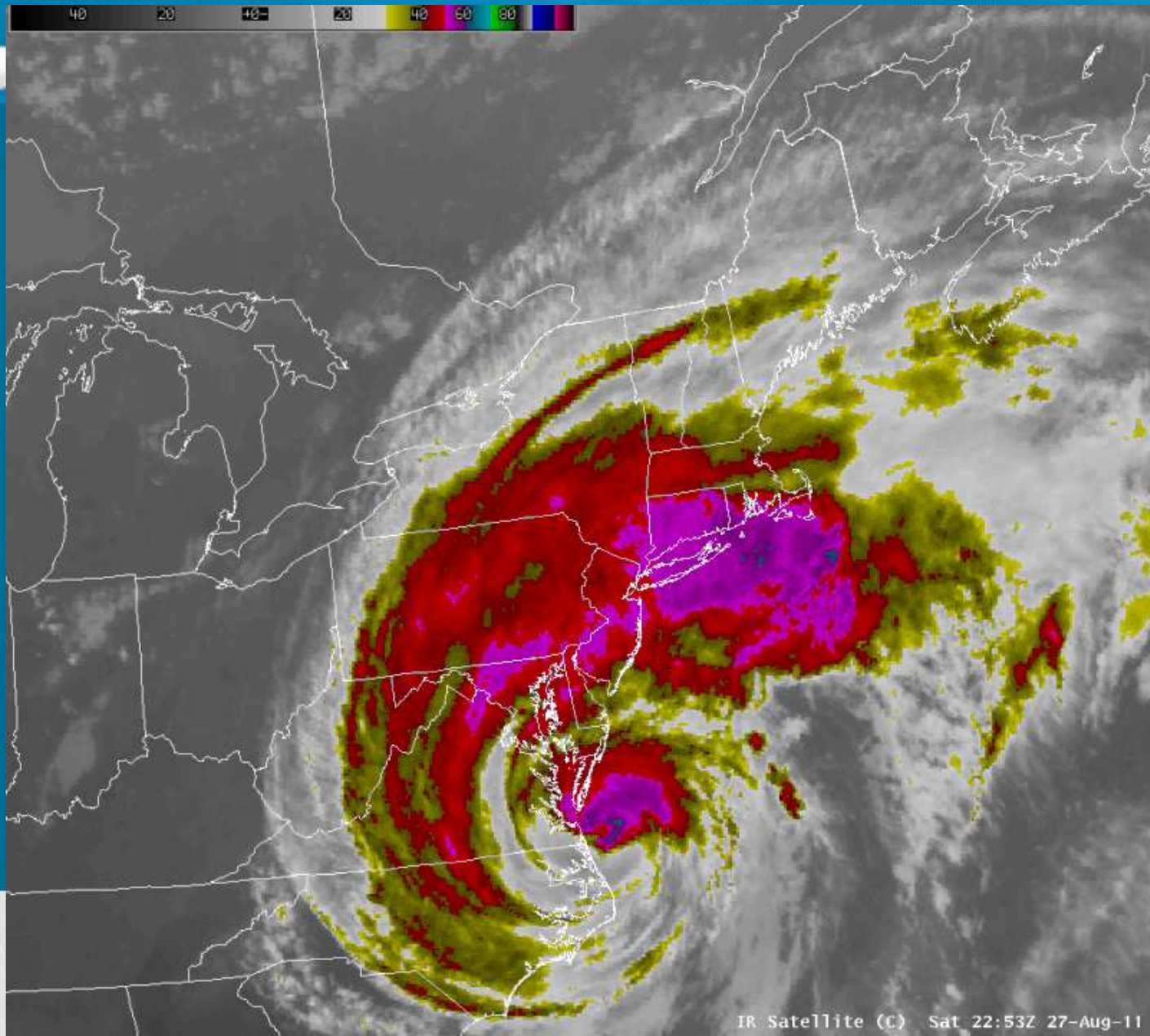


**Irene reached Category 3 strength but was a Tropical Storm when crossing Vermont**



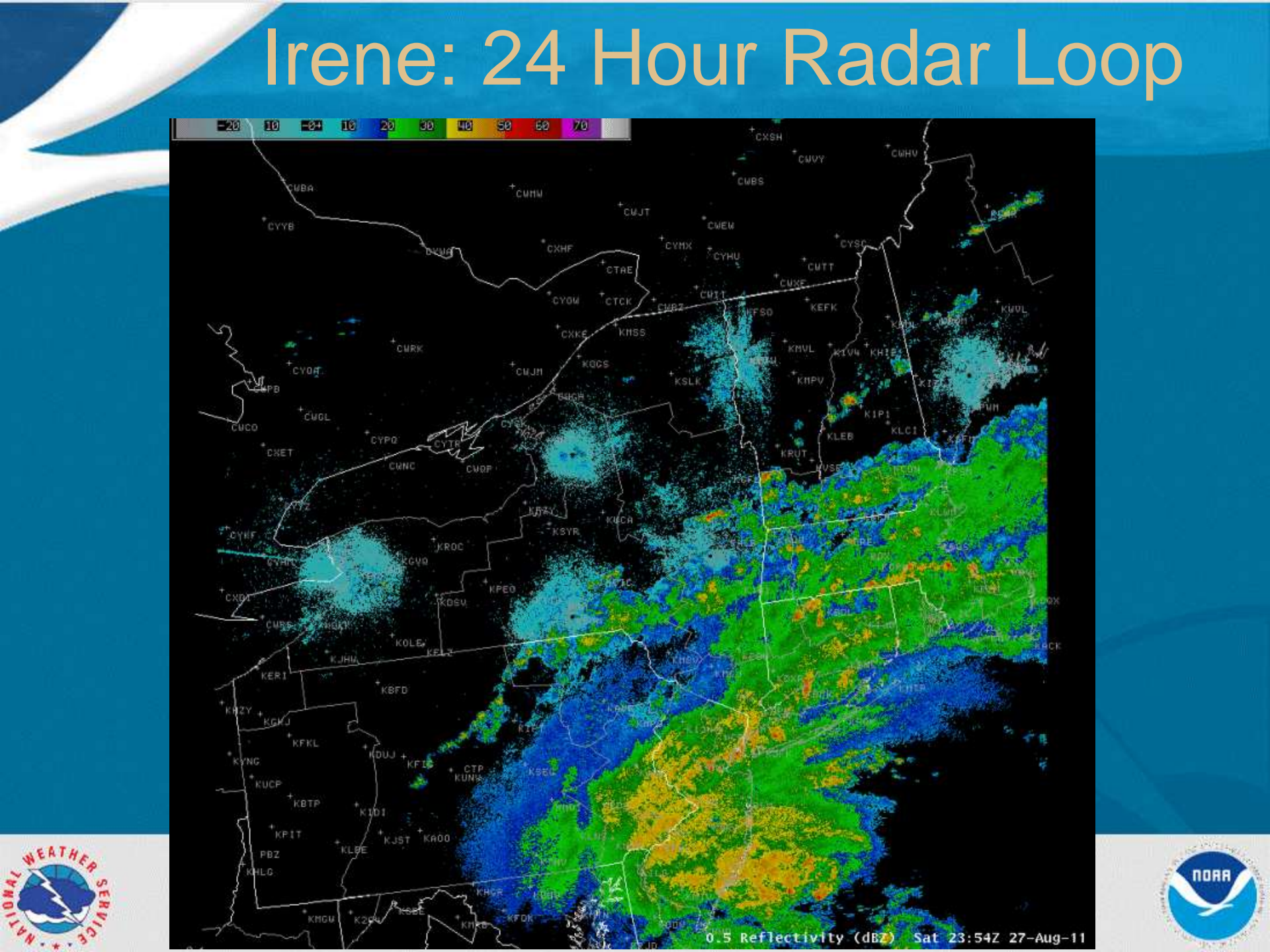


# Irene: Infrared Satellite Loop



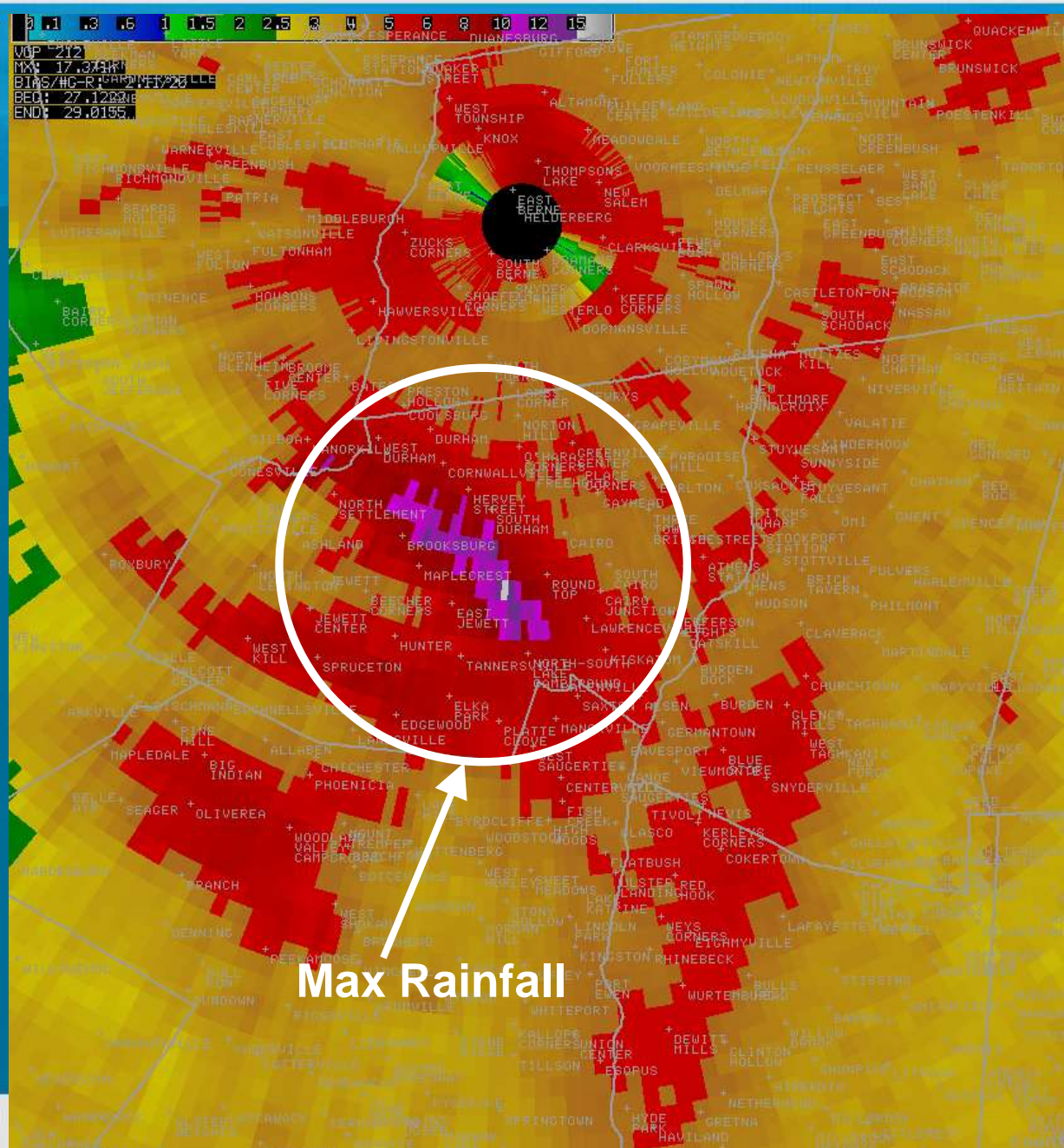
# Irene: 24 Hour Radar Loop

0.5 Reflectivity (dBZ) Sat 23:54Z 27-Aug-11



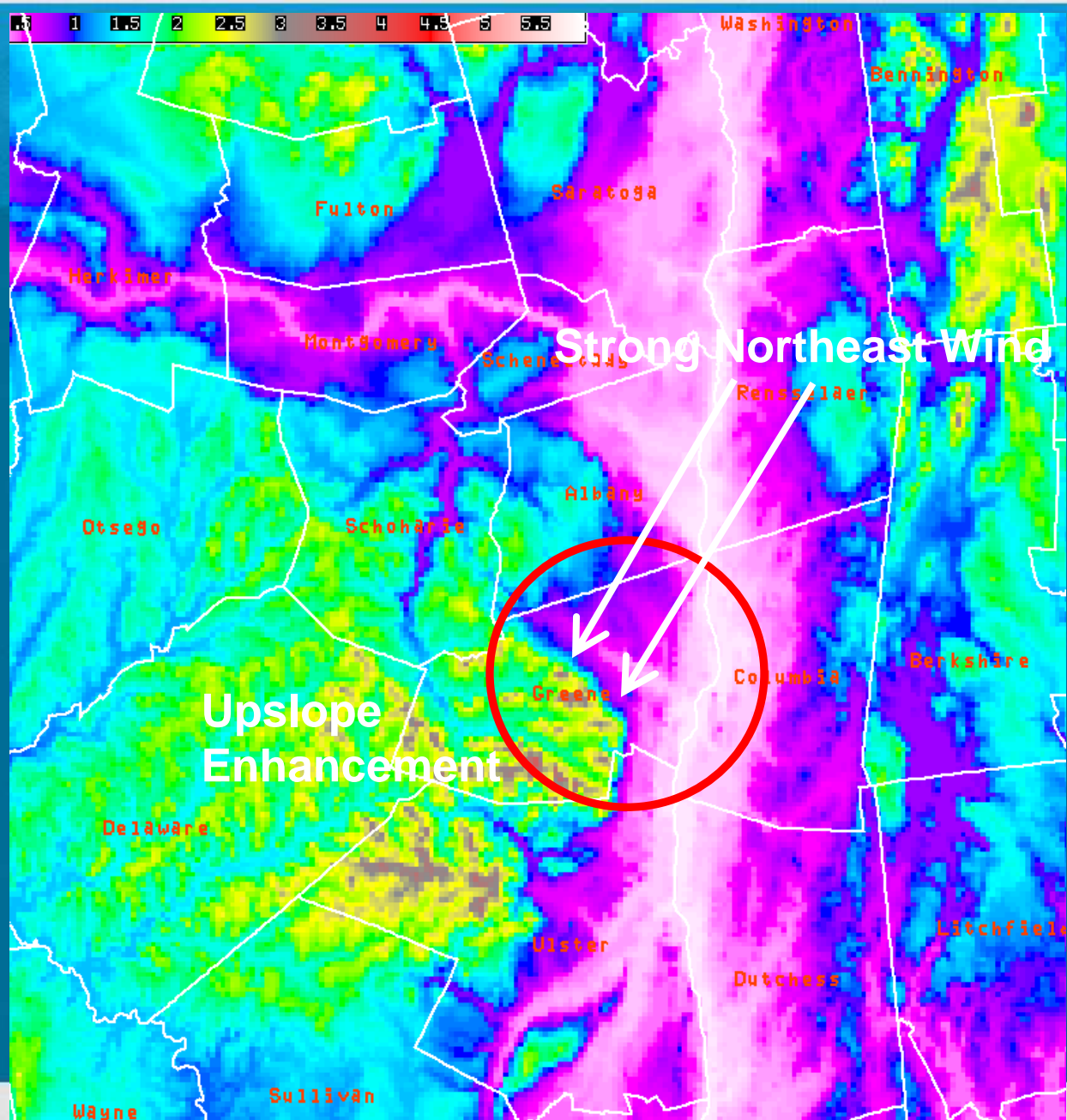


- One-day rainfall totals were between 3 to 6 inches in many locations
- A maximum area of 9 to 18 inches fell across portions of the eastern Catskill River basins, including the Schoharie Creek according to the KENX radar

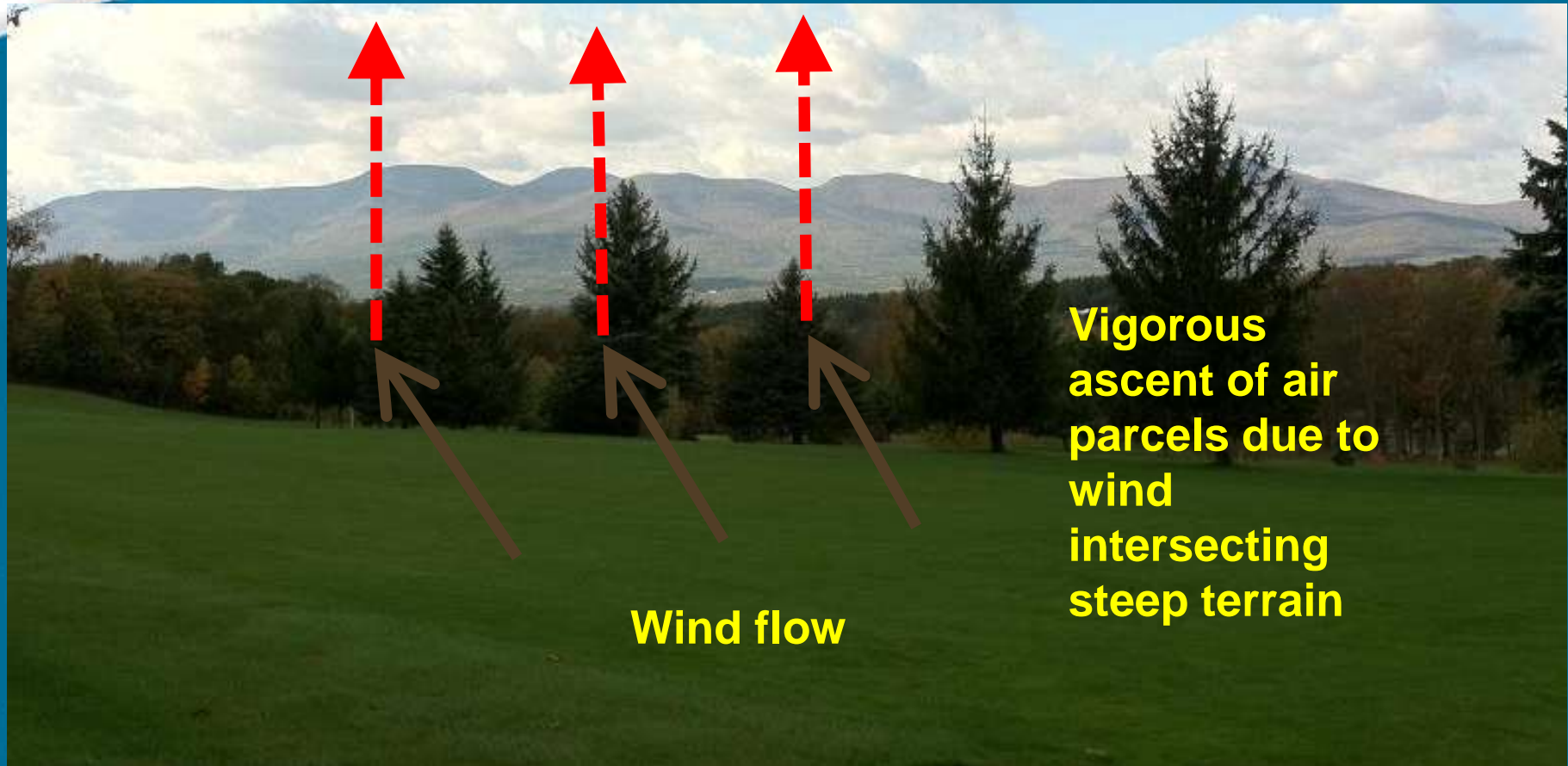




- Enhanced upslope flow into northeast Catskills contributed to extreme rainfall
- Northeast winds of 45 to 55 knots oriented perpendicular to escarpment
- Dramatic elevation rise of 900 meters over a short distance



# Schematic of Upslope Enhancement

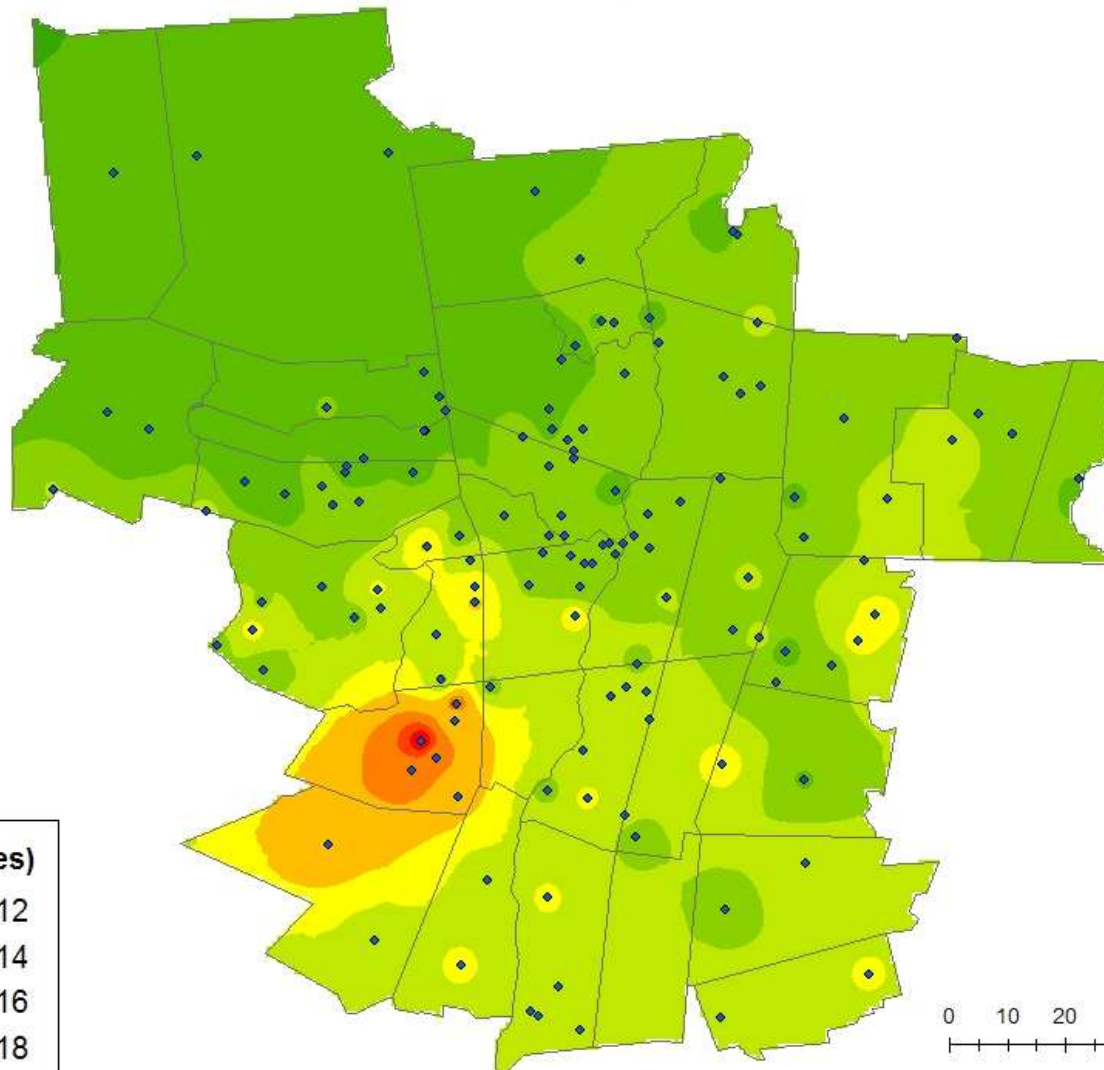








## Storm Total Rainfall From Tropical Storm Irene



### Precipitation (inches)



Note: Data points on this map are considered as valid observations. However care should be taken in using the interpolated data. Interpolated values may not represent actual rainfall totals.

# Top 5 Wettest Calendar Days at Albany (since 1874)

1. 5.60" SEP 16 1999 (Floyd)
2. 4.69" AUG 28 2011 (Irene)
3. 4.08" AUG 31 1950
4. 3.50" AUG 28 1971 (Doria)
5. 3.49" JUL 13 1996 (Bertha)

Wettest Year on Record



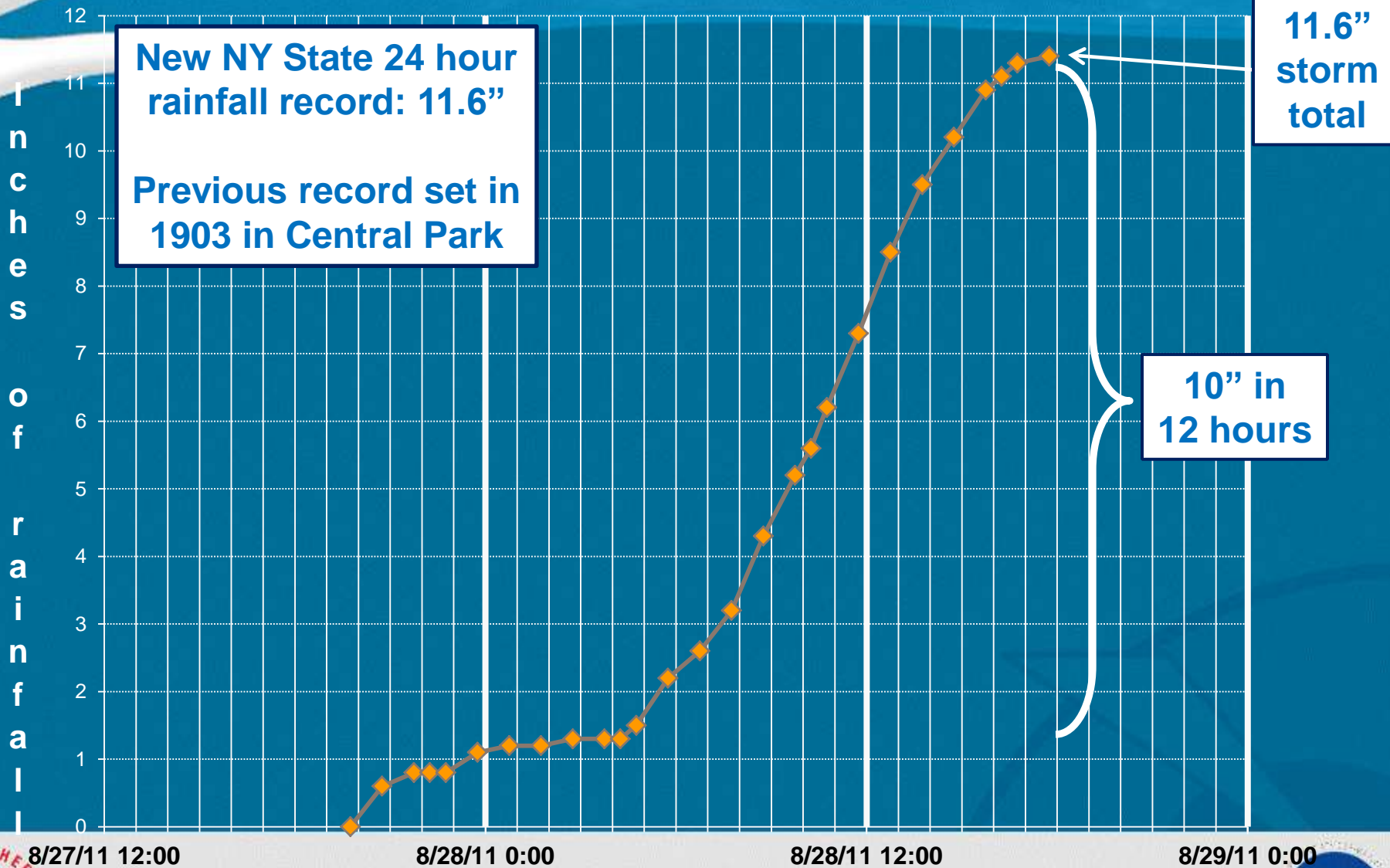
# Top Ten Wettest Storms @Albany

- 1) 6.28" September 18-21, 1938 Great New England Hurricane
- 2) 6.21" September 15-17, 1999 Remnants of Hurricane Floyd
- 3) 5.80" December 29, 1948-January 1, 1949 Nor'easter
- 4) 5.76" August 27-29, 1927 Heavy thunderstorms; Low Pressure moving up the Hudson Valley
- 5) 5.46" June 27-30, 1973 Showers and thunderstorms with a slow moving cold front
- 6) 4.96" August 31 – September 1, 1950 Showers and thunderstorms; Moist air mass from TS over Southeast
- 7) 4.92" September 11-13, 1960 Hurricane Donna
- 8) 4.84" August 27-28, 1971 Tropical Storm Doria
- 9) 4.83" August 27-28, 2011 Tropical Storm Irene
- 10) 4.76" October 8-9, 1903 Slow moving coastal low pressure system



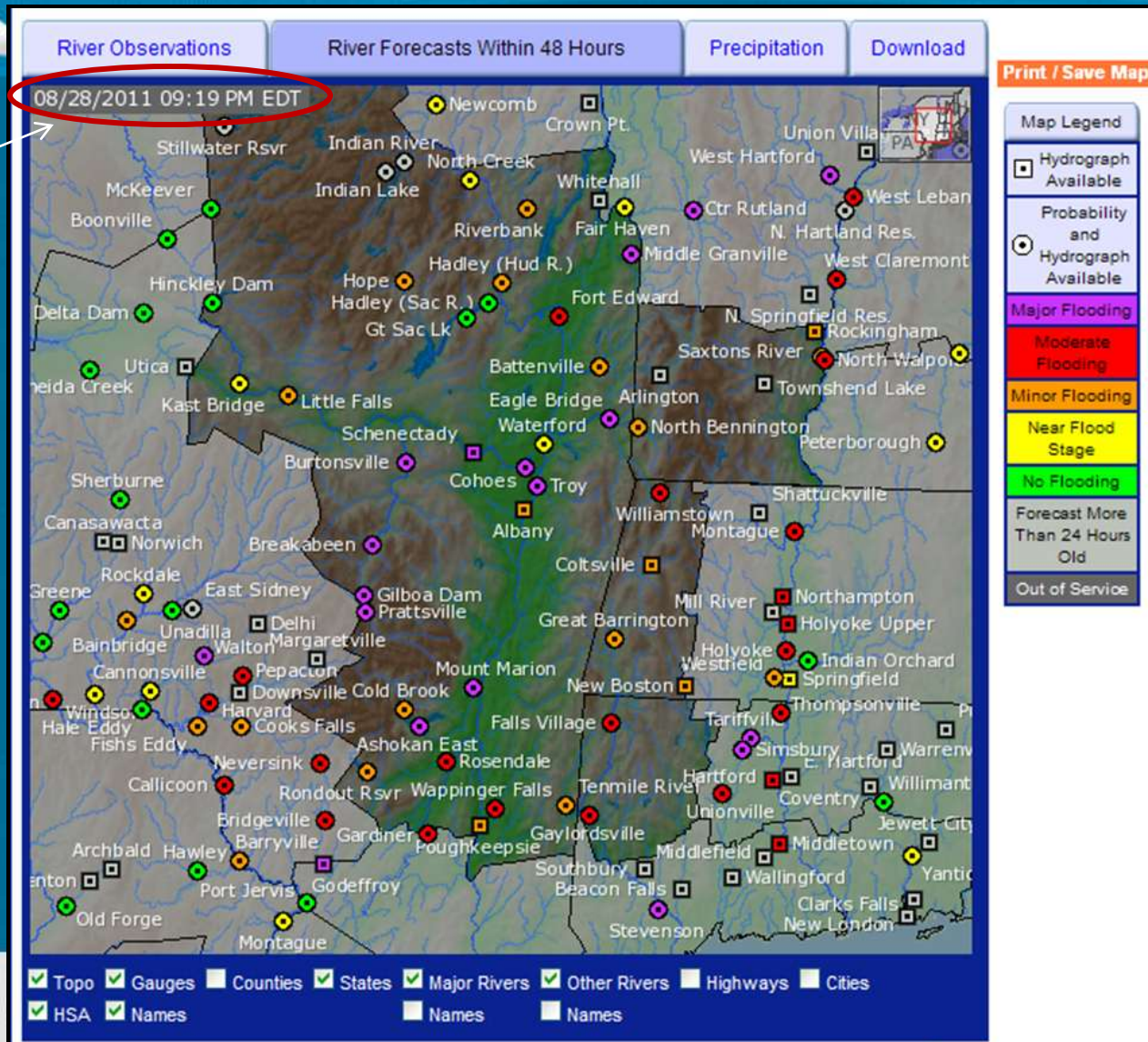


# Irene: Tannersville Rainfall



# Irene: AHPS forecasts

Sunday



<http://water.weather.gov/ahps2/index.php?wfo=aly>





# Irene: 13 Floods of Record

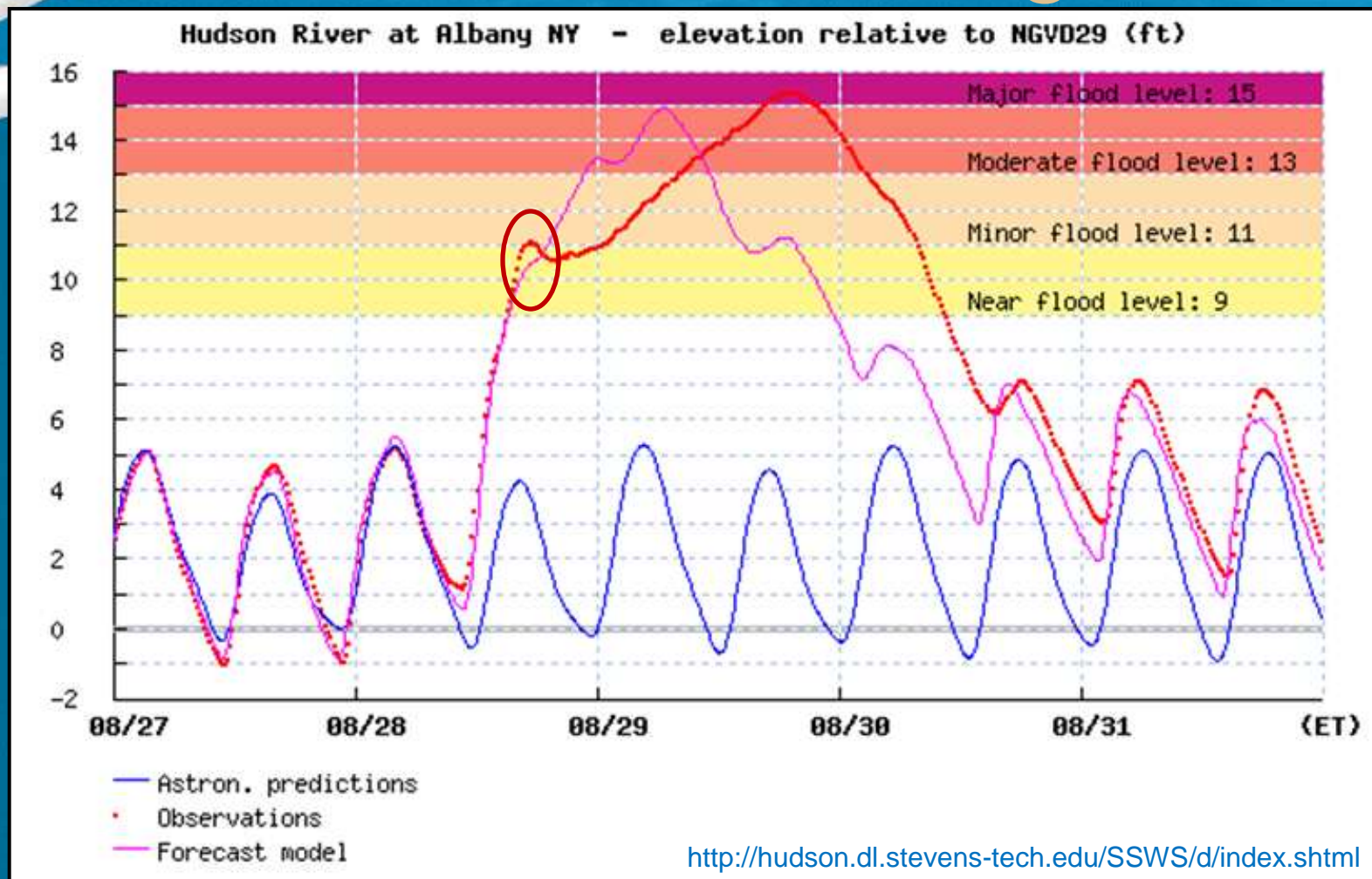
- Schoharie Creek @ Prattsville / Gilboa Dam / Gilboa Bridge / Breakabeen / Burtonsville
- Granville on the Mettawee River
- Cold Brook (Mt. Tremper) on the Esopus
- Rosendale on the Rondout Creek
- Canajoharie on the Canajoharie Creek
- Poughkeepsie on the Hudson River
- Rockingham on the Williams River (VT)
- Bennington on the Walloomsac River (VT)
- Saxtons on the Saxtons River (VT)

Non-record  
crests:

- 8 major
- 9 moderate
- 5 minor

Flooding at 35  
of 44 forecast  
points.

# Irene: Storm Surge

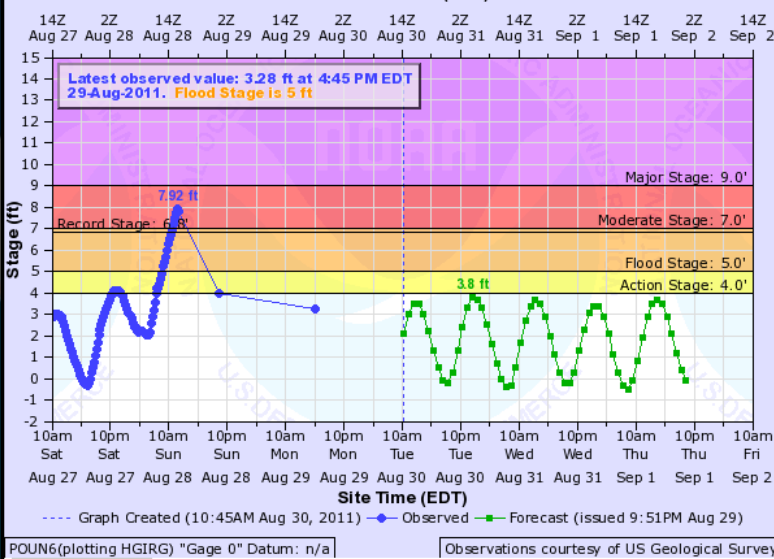


- Storm Surge = feet above astronomical tide
- Storm Tide = feet above datum  
(= actual gage elevation if gage datum is zero)



# HUDSON RIVER BELOW POUGHKEEPSIE

Universal Time (UTC)



# Irene: Storm Surge

@POU: 5.39 ft surge (7.96 tide)

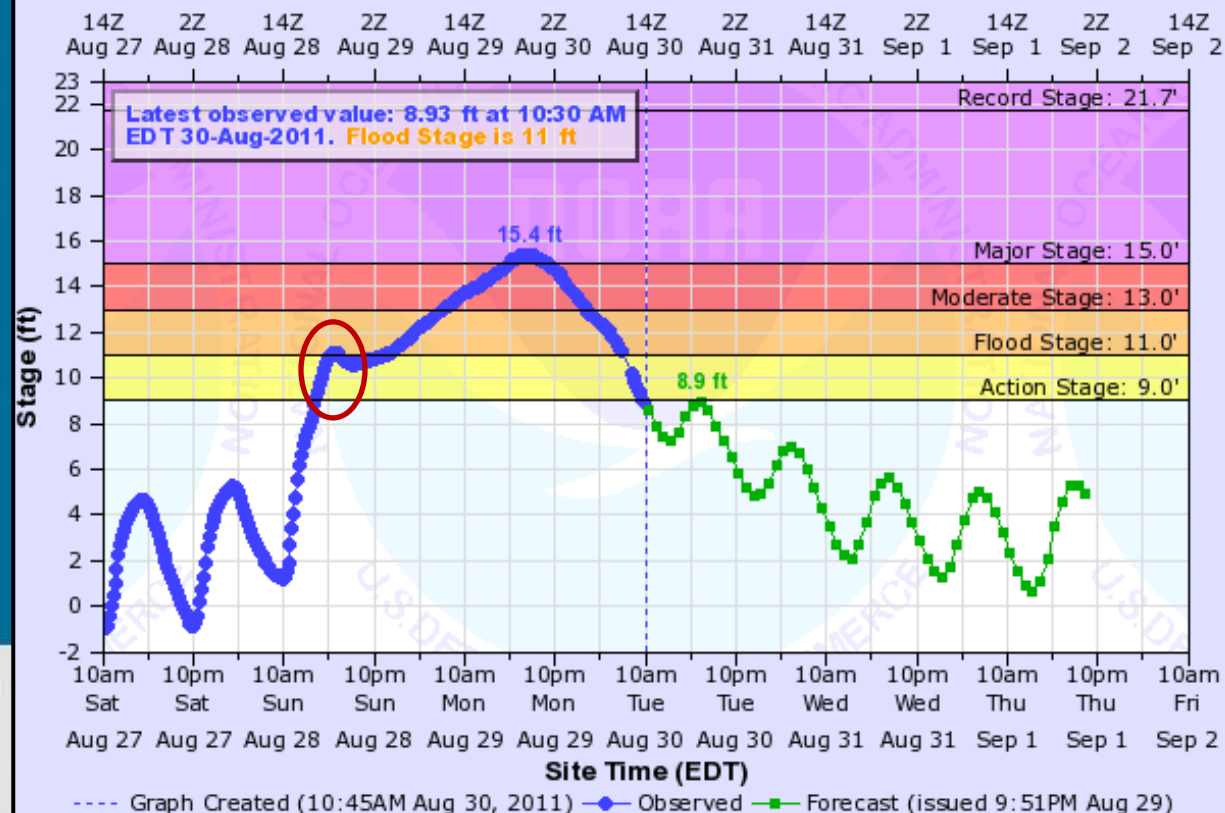
29<sup>th</sup> highest Irene surge (of 98 meas.)

@ALY:  
7.23 ft surge  
(11.11 ft tide)

16<sup>th</sup> highest  
Irene surge  
(of 98 meas.)

## HUDSON RIVER AT ALBANY

Universal Time (UTC)

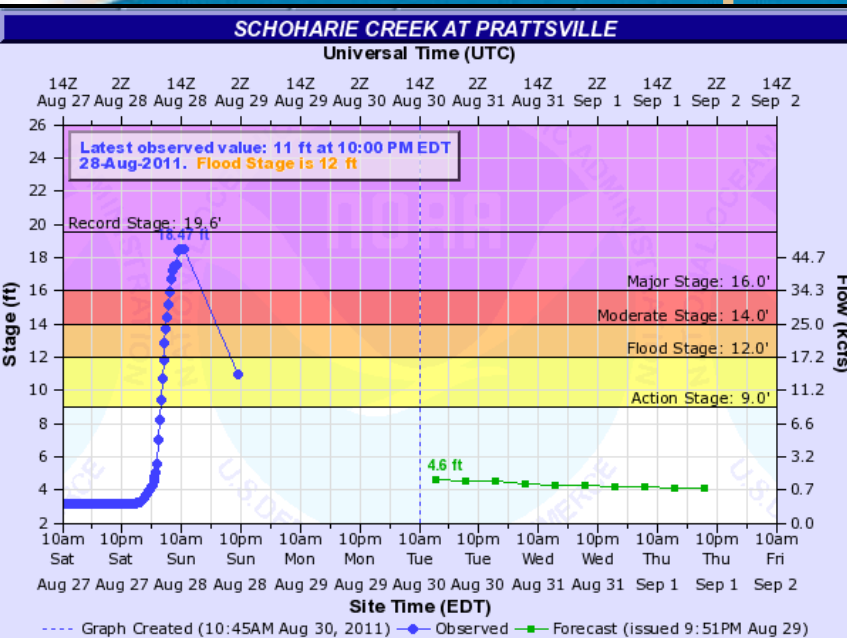


# Irene: Operational Challenges

- Rainfall forecasting
  - Placement – 24 hours out, very good
  - Timing – reasonable; onset about 6 hours earlier than forecast
  - Amount – maximum rainfall in Catskills under-forecast (forecasted maximum around 10 inches)



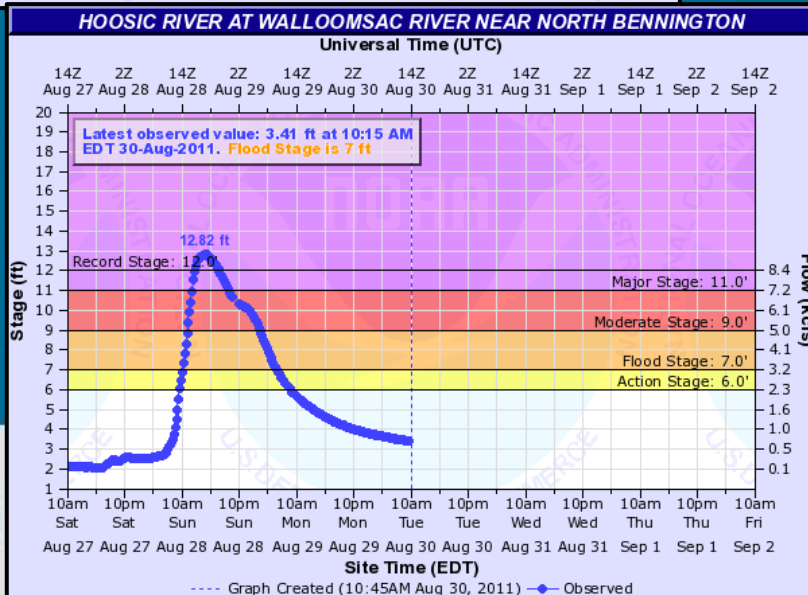
# Irene: Operational Challenges



- Extreme rates of rise on many rivers

Schoharie Creek at Prattsville, NY on Aug. 28, exceeded:

- 12 ft flood stage at 7:02am
- 14 ft moderate flood at 7:36am
- 16 ft major flood at 8:17am



Walloomsac River at Bennington, VT on Aug. 28, exceeded:

- 7 ft flood stage at 10:48am
- 9 ft moderate flood at 11:50am
- 11 ft major flood at 12:46pm



# Irene: Operational Challenges



- River gages washed away or damaged:
  - Prattsville
  - Gilboa Bridge
  - Burtonsville
  - Poughkeepsie
  - Gaylordsville



# Irene: Operational Challenges

- Conveying the potential severity of multiple hazards
- Communications outages...partners in hardest hit areas
- Issues at various locks and dams:
  - Misinformation about Gilboa failure
  - EAS alert watches for Condition B at several projects taxed the capabilities of our software



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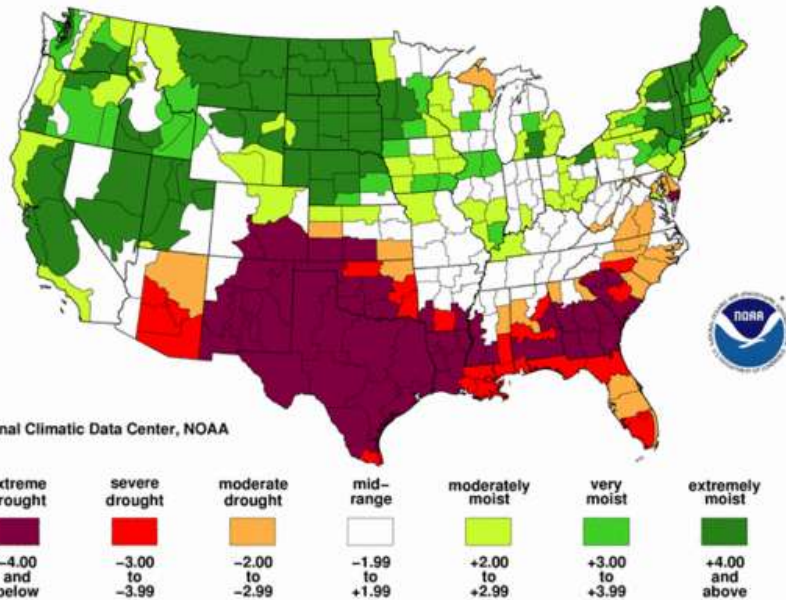
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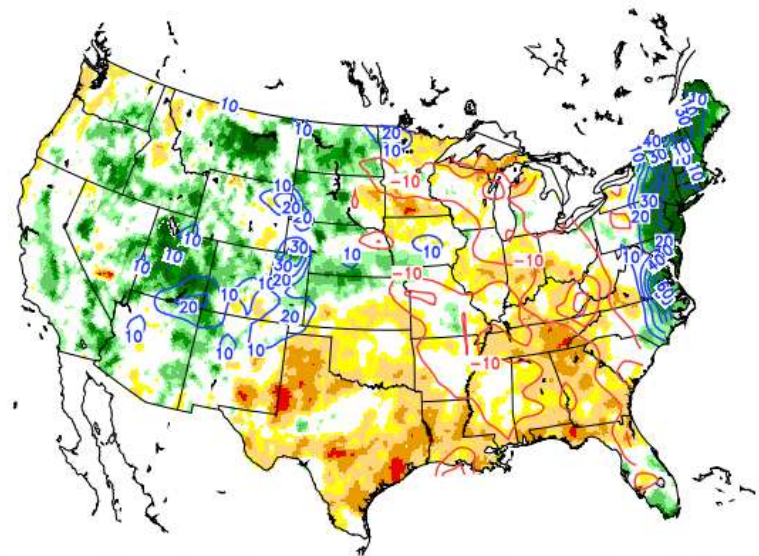


# Lee: Antecedent Conditions

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August, 2011



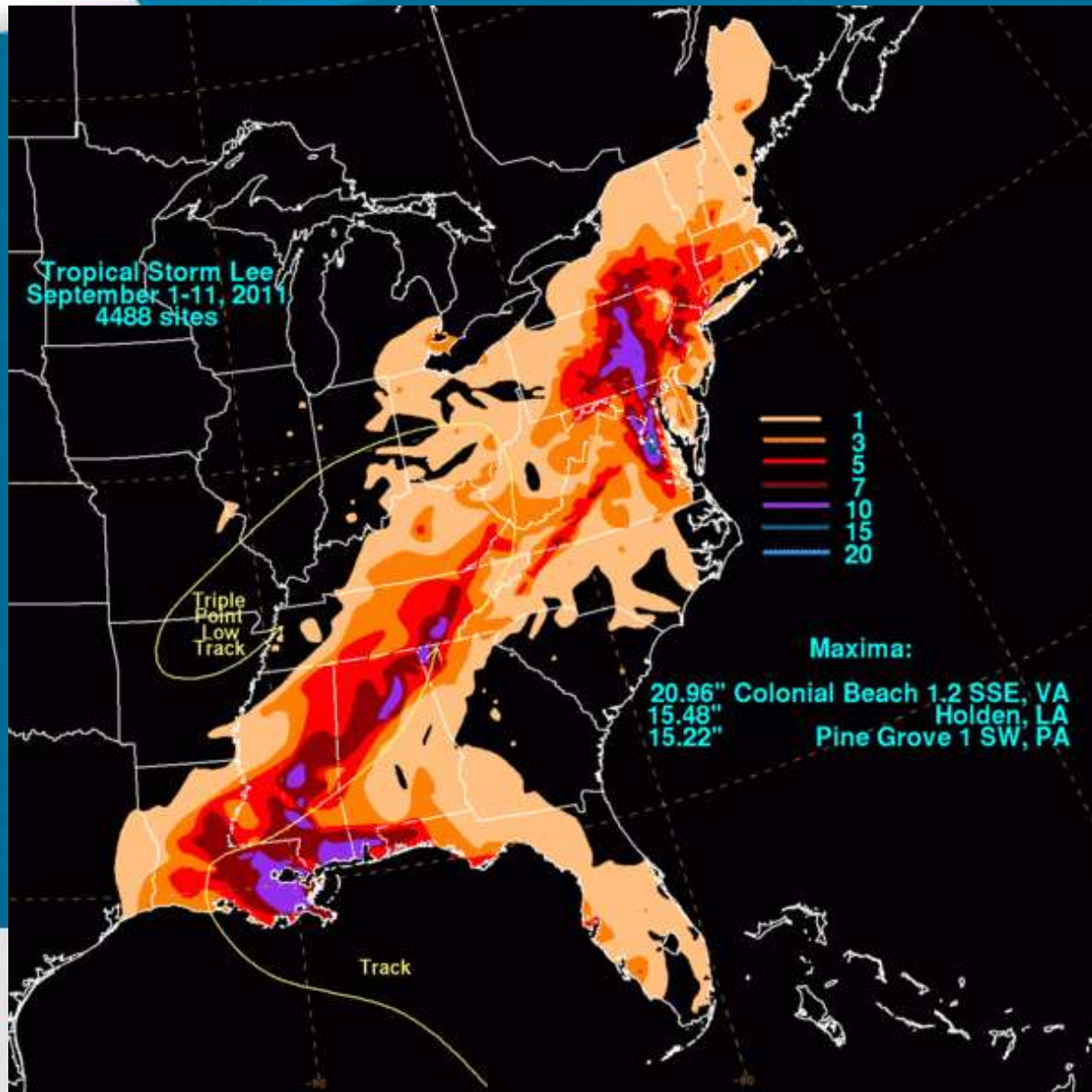
Total Column Soil Moisture Percentiles on 20110901  
(wrt samples within a 49-day window in 1951–2004)



<http://hydrology.princeton.edu/~luo/research/FORECAST/current.php>



# Lee: Track



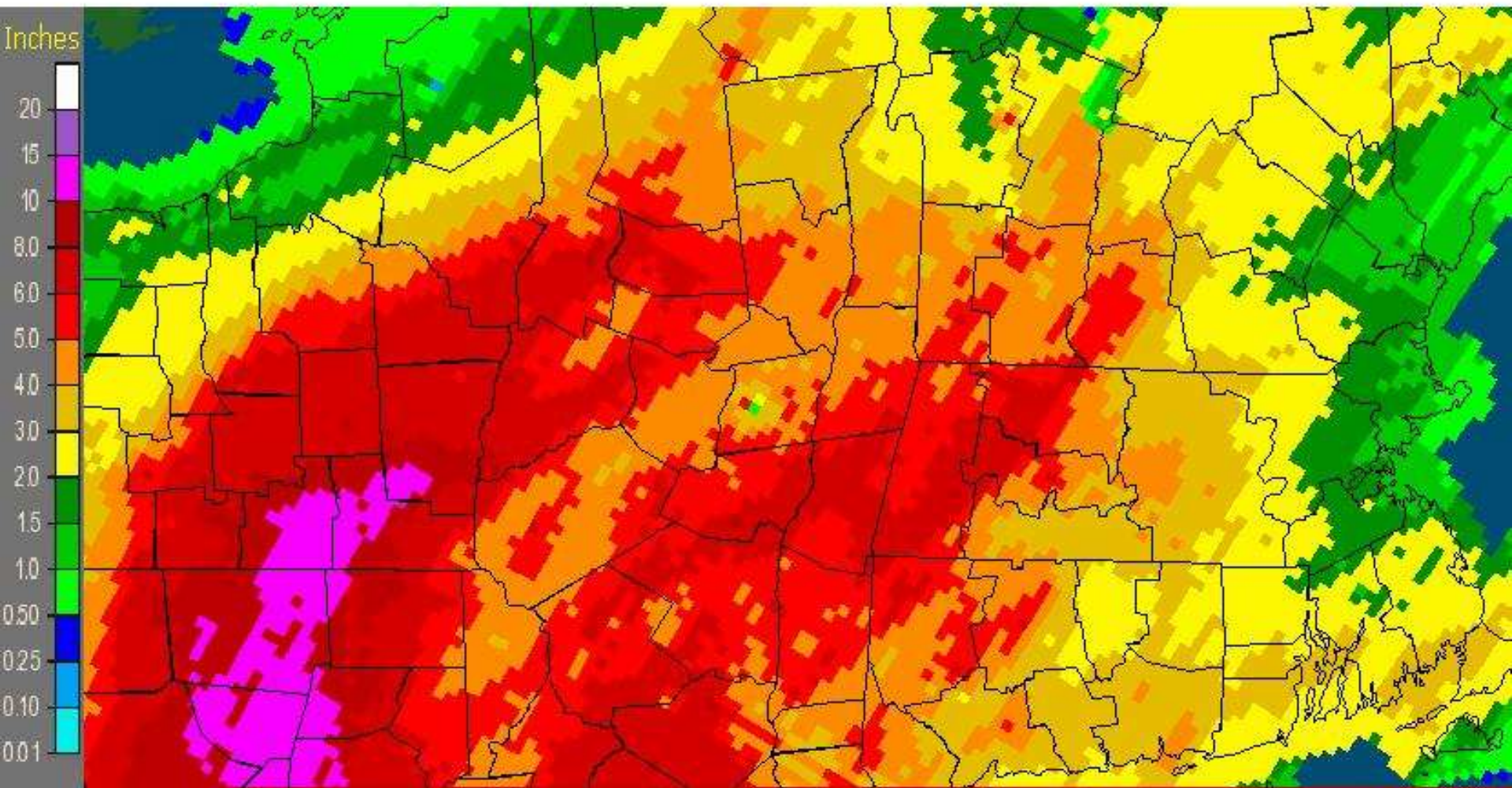
Record flooding  
More than 1  
billion dollars of  
damage

21 deaths in  
the U.S.

0 in NY!!



Albany, NY (ALY): Current 7-Day Observed Precipitation  
Valid at 9/8/2011 1200 UTC- Created 9/8/11 23:56 UTC



## Lee Storm Total Rainfall: Multisensor Estimate

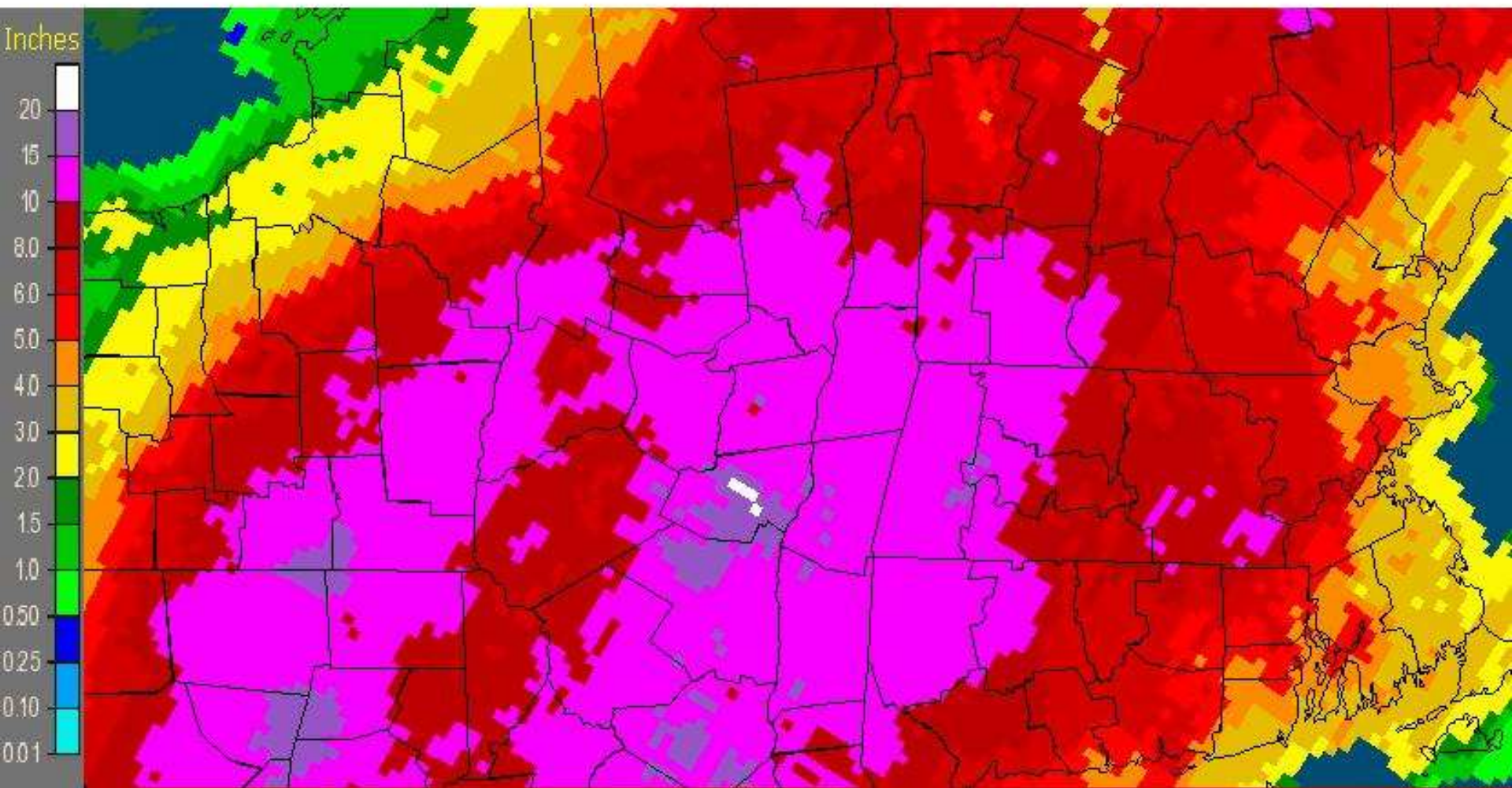


[http://www.srh.noaa.gov/ridge2/RFC\\_Precip/](http://www.srh.noaa.gov/ridge2/RFC_Precip/)





Albany, NY (ALY): Current 14-Day Observed Precipitation  
Valid at 9/8/2011 1200 UTC- Created 9/9/11 0:01 UTC



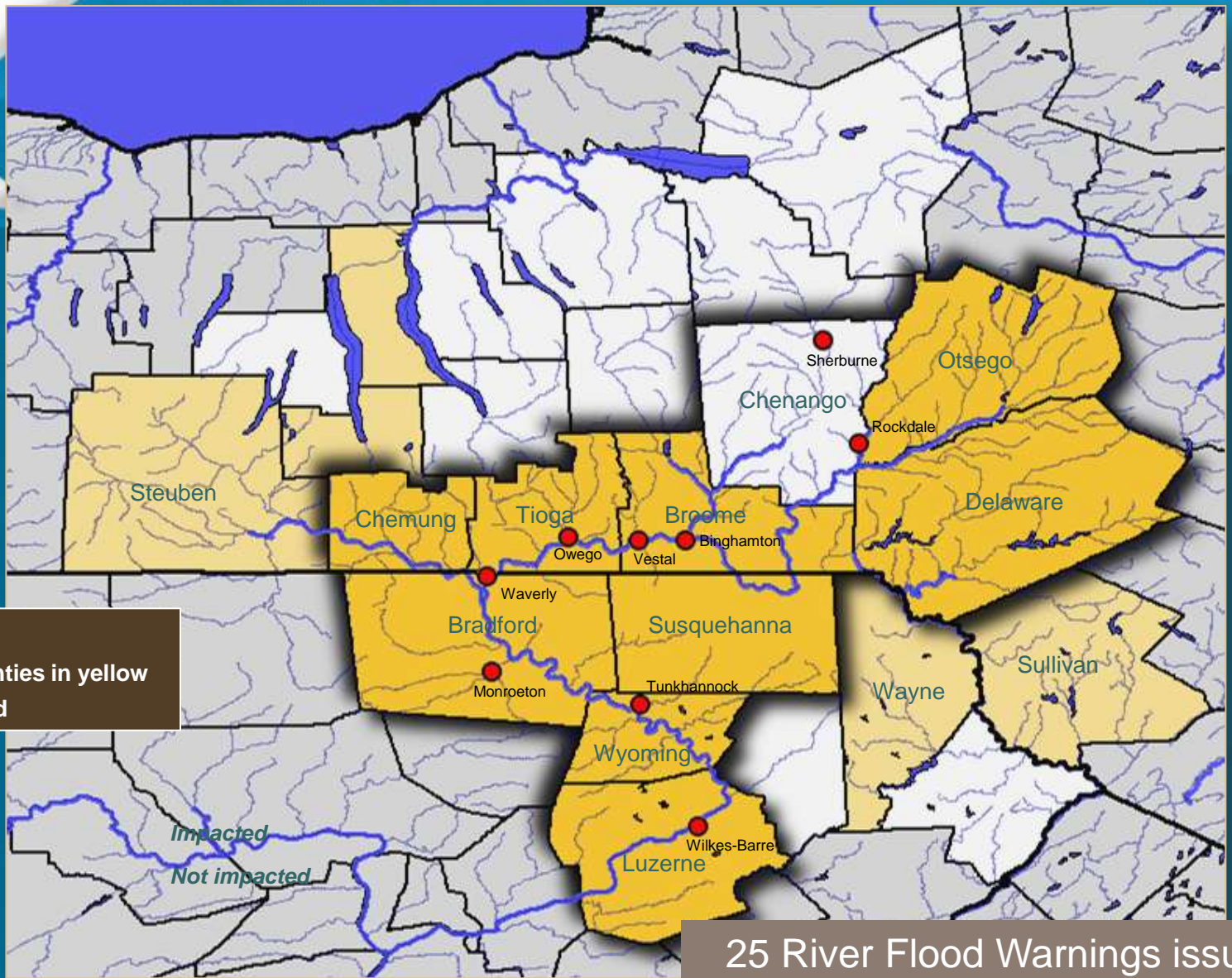
## 14 Day Total Rainfall: Multisensor Estimate

14 days from Thurs. Aug. 25 to Thurs. Sept. 8

[http://www.srh.noaa.gov/ridge2/RFC\\_Precip/](http://www.srh.noaa.gov/ridge2/RFC_Precip/)







## Lee: Flood Magnitude in the Binghamton County Warning Area





# Lee: Flood Magnitude in the Albany County Warning Area

- Moderate to major flood crests:
  - Major:
    - Canajoharie Creek at Canajoharie
    - Mohawk River at Utica
    - Mohawk River at Little Falls
    - Housatonic River at Stevenson Dam
  - 8 Moderate floods including 3 locations on Schoharie Creek that had just experienced record flooding with Irene
  - Widespread minor flooding elsewhere in the Albany County Warning Area



# Lee: Operational Challenges

## (the view from Albany)

- Precipitation forecast uncertainty
  - Placement
  - Timing
  - Amount
- Irene debris
- Understanding reports of flooding
- Ongoing recovery efforts (incl. in-channel)
- Public sensitivity to flooding



# NY Impacts of the Combined Events...





<i><b>KEY IMPACT STATS</b></i>	<i><b>HURRICANE IRENE</b></i>	<i><b>TROP. STORM LEE</b></i>
<b>POWER OUTAGES</b> (PEAK)	<b>997,000</b>	<b>68,000</b>
<b>BRIDGES CLOSED</b> (PEAK)	<b>24</b>	<b>37</b>
<b>ROAD SEGMENTS IMPACTED</b> (PEAK)	<b>157</b>	<b>181</b>
<b>REPORTED SWIFTWATER RESCUES</b>	<b>150</b>	<b>959</b>



Slide courtesy of NYS Office of Emergency Management



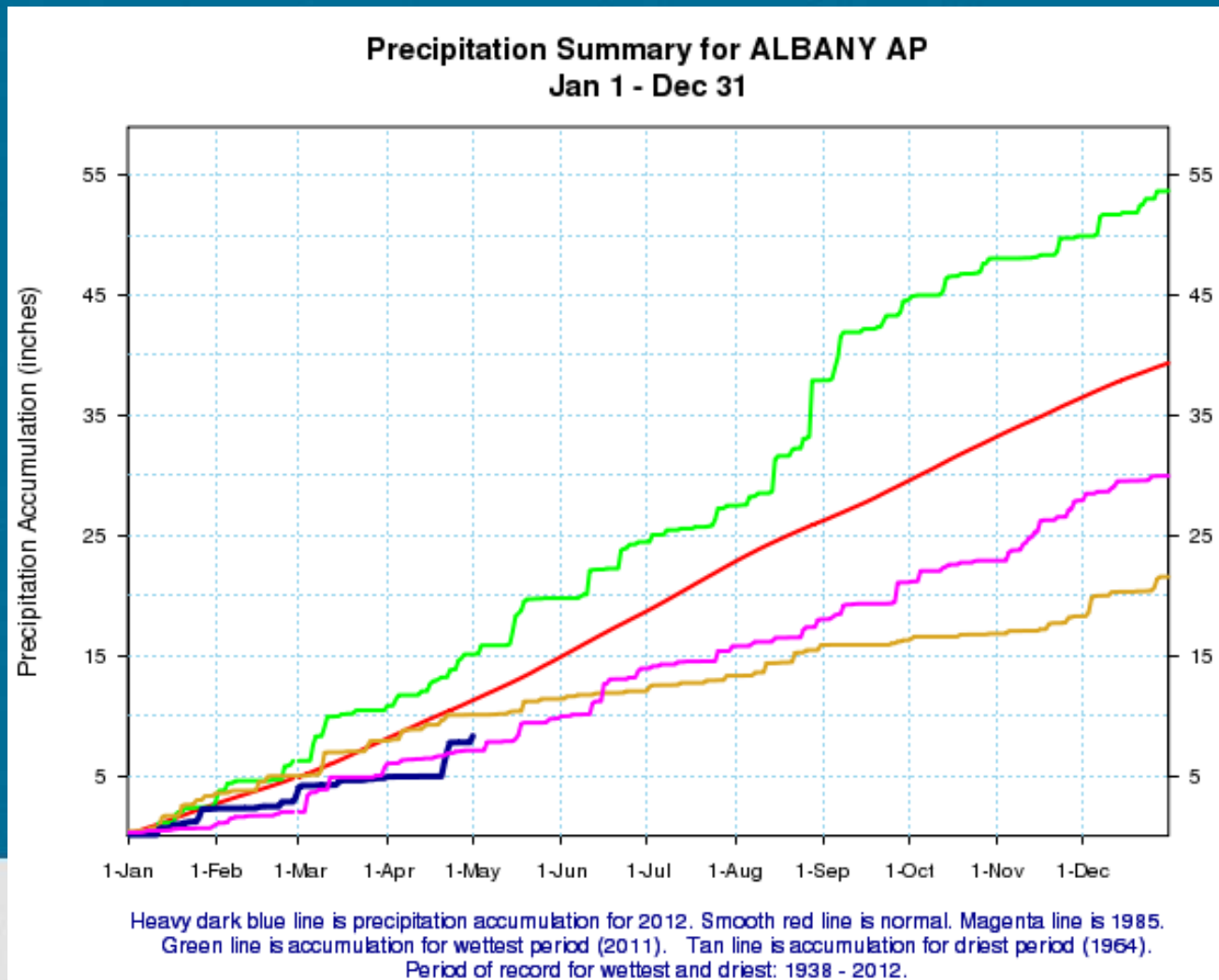
<i><b>IMPACT STATS CONT.</b></i>	<i><b>HURRICANE IRENE</b></i>	<i><b>TROP. STORM LEE</b></i>
<b>WATER SYSTEMS IMPACTED</b>	<b>123</b>	<b>168</b>
<b>BOIL WATER ADVISORIES ISSUED</b>	<b>68</b>	<b>88</b>
<b>EVACUATIONS ORDERED</b>	<b>370,000+</b>	<b>21,000+</b>



Slide courtesy of NYS Office of Emergency Management



# What a difference a year makes...





# Comments? Questions?

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(518) 435-9571 ext 234

