Hurricane Irene and Tropical Storm Lee: How unique were they in the Catskill Mountains?

Allan Frei, Department of Geography Hunter College
CUNY Institute for Sustainable Cities

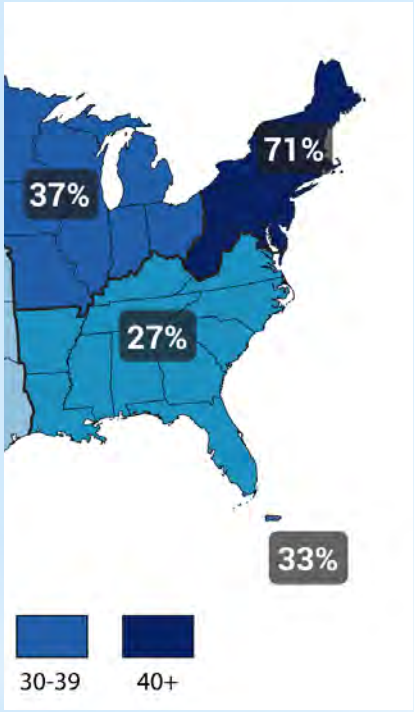
Collaborators

NYCDEP: BWS Water Quality Modeling staff, various other colleagues;
Post-doctoral Research Staff (CUNY-NYCDEP);
Jimmy Booth (CUNY CCNY); Katie Towey, Paradorn Wongchanapai (CUNY Grad Center);
Miri Dainson, Anastasia Tom, Nunny Reyes, Glenn Liu, Amy Jeu (Hunter College)

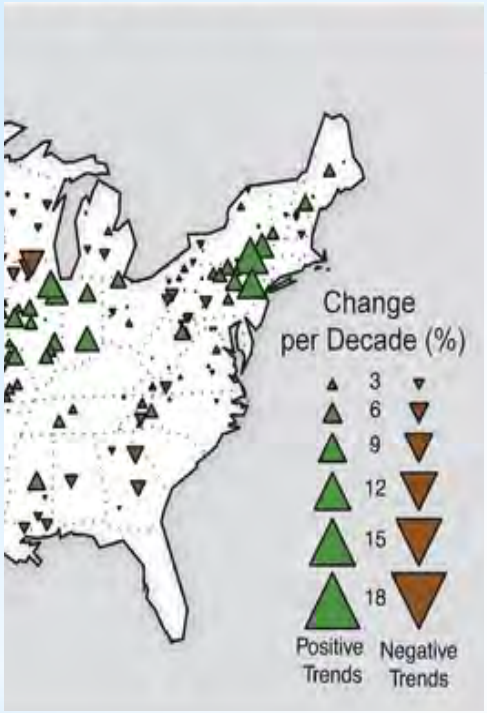
Presentation at the Catskills Environmental Research and Monitoring Conference
Belleayre Ski Center, Highmount, NY, October 27-28, 2016

Increase in Frequency of Extreme PRCP & SF events IS A WARM SEASON TREND

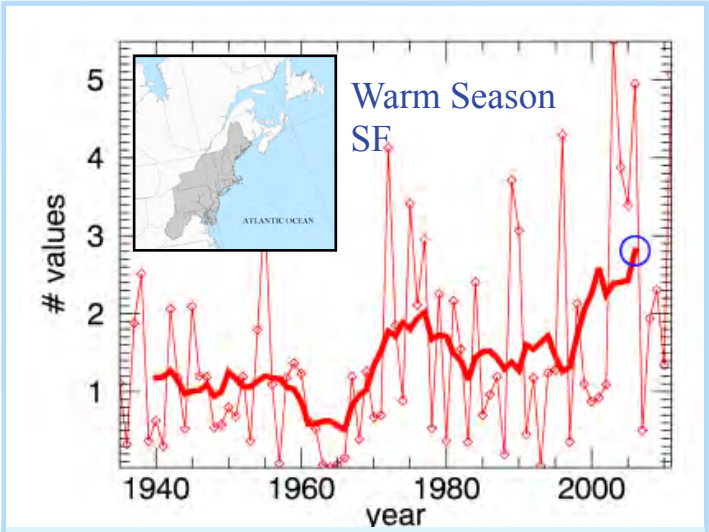
US National Climate Assessment 2014

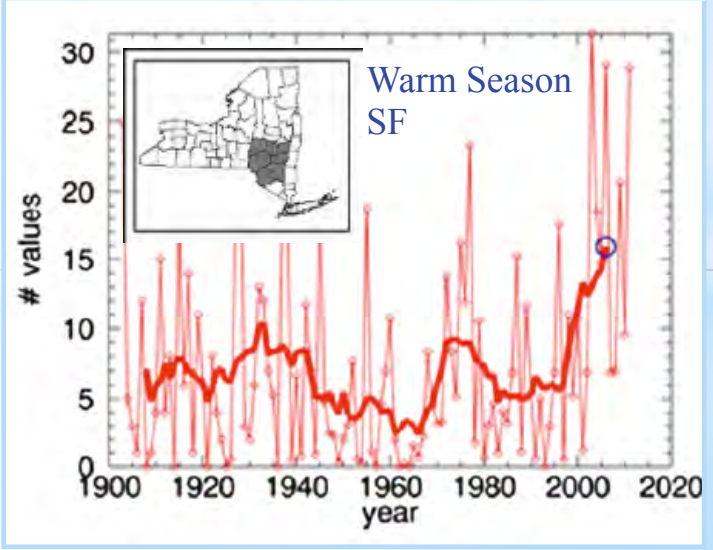


% change in precipitation falling in heaviest 1% 1958 -2012



% change in river flooding 1920s-2008



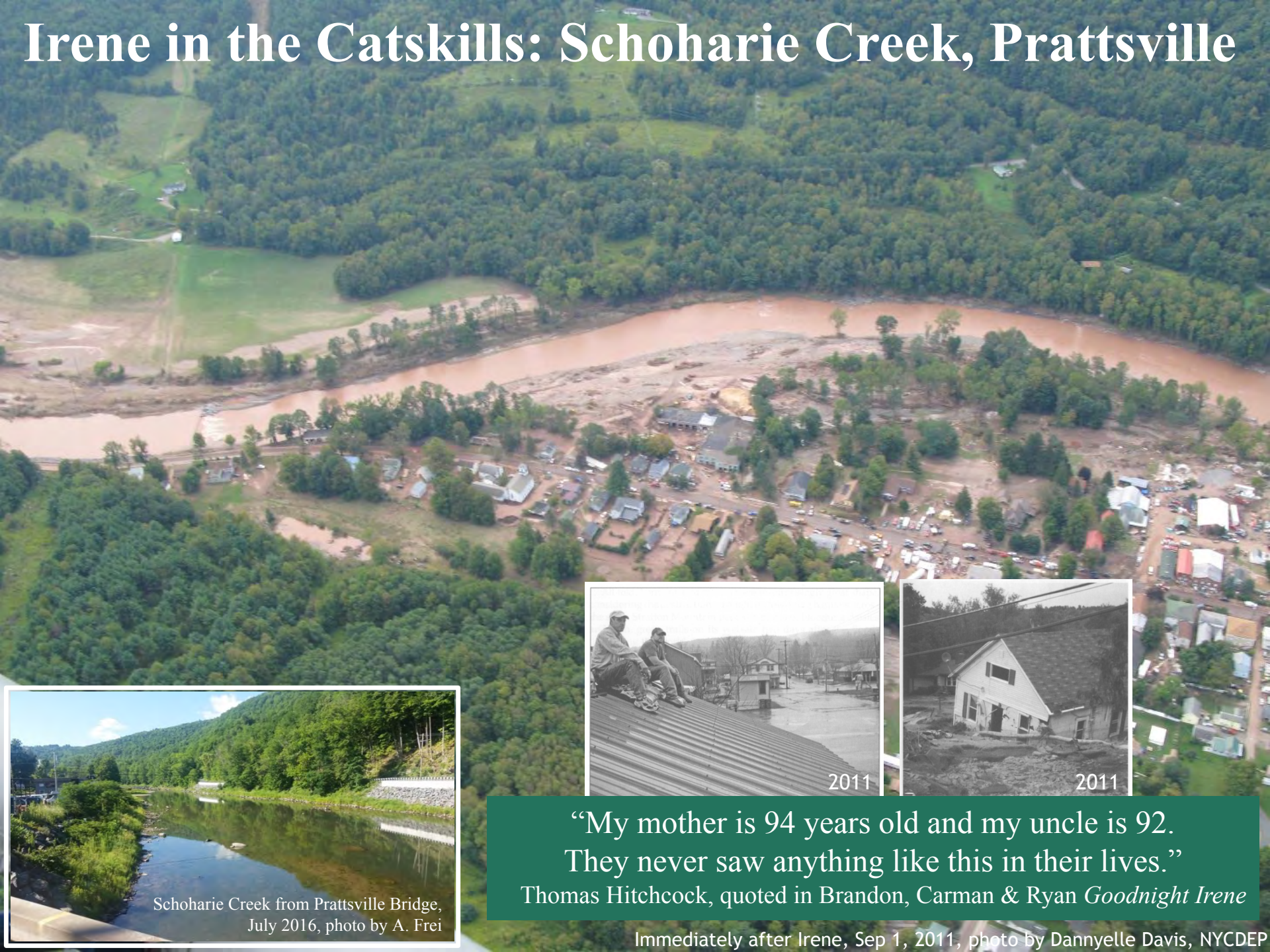


Matonse and Frei (2013); Frei et al (2015)

Streamflow: http://nca2014.globalchange.gov/highlights/report-findings/extreme-weather

Precipitation: http://nca2014.globalchange.gov/highlights/overview/overview#intro-section-2

Irene in the Catskills: Schoharie Creek, Prattsville



Schoharie Creek from Prattsville Bridge, July 2016, photo by A. Frei

"My mother is 94 years old and my uncle is 92.
They never saw anything like this in their lives."
Thomas Hitchcock, quoted in Brandon, Carman & Ryan *Goodnight Irene*

Immediately after Irene, Sep 1, 2011, photo by Dannyelle Davis, NYCDEP

Irene in the Catskills: Batavia Kill, Windham

"Until catch basins were built higher up on the mountainsides in the 1960s, annual flooding was a problem."
Davis, *Around Windham*


Davis, *Around Windham* 1930

Windham http://www.buzzfeed.com/mjs538/frightening-hurricane-irene-destruction-photos

1930s: ‘32, ‘33, ‘35, ‘38 L.I. Express

Jul. 1935

CATSKILL MOUNTAIN NEWS

This Community Escapes Southern Tier High Water

Fire Followed Flood in Walton Stores Burned

Flood May Cost County Seat Near Million Dollars

Worst in 100 Years

Red Cross and Other Relief Agencies Hurry to Rescue of Stricken Communities

Margaretville and vicinity, visited by terrible floods two years ago and three years ago, stood out in the week's water damages like Mt. Aarat of old as the one dry place in a wide expanse of loss of life and property by the sudden rain fall of early Monday morning. The damaged area reaches from Woodstock to Ithaca. Nearly fifty lives have been lost and some estimates of the property damage run into $40,000,000.

Catskill Mountain News
July 12, 1935

Sep. 1938

The Delaware Express

VOL. V, NO. 38

COUNTY WAS SUBMERGED

Five-Inch Rainfall Did Heavy Damage

BRIDGES GO OUT

Cost of Flood Will Run Into Thousands

COUNTY WAS IN DARKNESS

Light Service Was Demoralized Wednesday Night---No Accidents Have Been Reported

The second worst flood in county history swept through this area Wednesday night culminating a fall of five inches of rain within four days. Accurate estimates of the damage could not be made, but it will ultimately be figured in tens of thousands of dollars.

The Delaware Express
Sep. 23, 1938

1955: August (sibling storms), October

Connie & Diane, Aug. 1955

JNTAIN NEWS 7c

EW YORK STATE WEEKLY PRINTED IN A VILLAGE THE SIZE OF MARGARETVILLE

FRIDAY, AUGUST 19, 1955 — 7c Per Copy. $3 Per Year

Debris of Saturday's Near-Flood

Hurricane Benefits Outweigh Damages

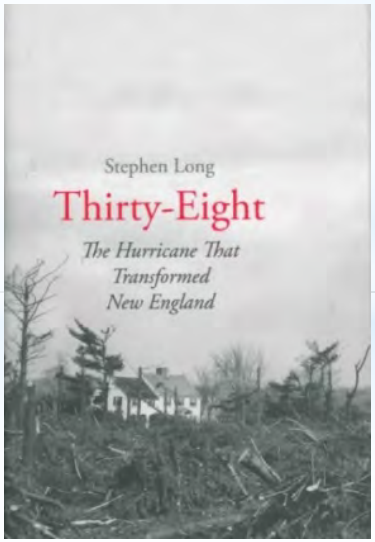
Established 1839

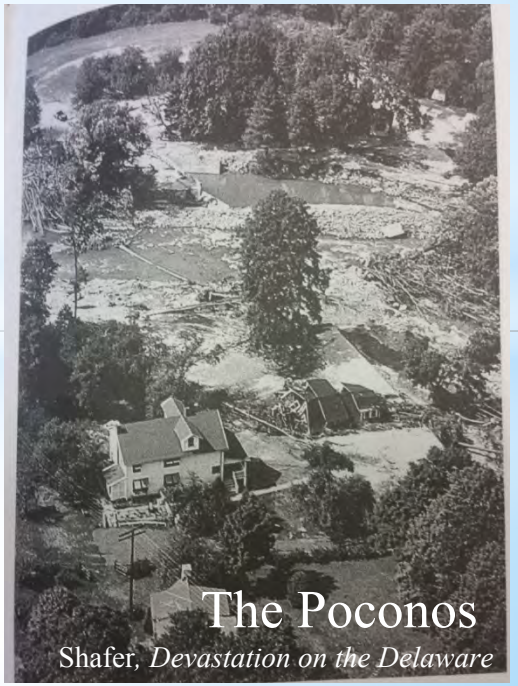
THURSDAY, AUGUST 25, 1955 [FOURTEEN PAGES]

‘Diane’ Drops 6 Inches of Rain Here; Little Damage in Area

Major Schroeder

Hurricane Diane, which left a trail of several hundred dead and caused billions of dollars damage in the northeastern





NYSERDA funded study :

Hydrology, Vulnerability and Adaptation Implications of Hurricane Irene and Tropical Storm Lee: Case Study of the Mid-Hudson Valley and Greater Catskills Regions

Solecki et. al. (2014)

Emergent Vulnerabilities Based on Interviews with Stakeholders:

1) Transportation, agricultural and tourism sectors were the most heavily impacted
2) Flooding in previously un-flooded (according to local knowledge) areas (e.g. in higher elevation areas that are not floodplains)
3) predicted return interval for floods not a good indicator of actual frequency.
4) infrastructural weaknesses (e.g. road washouts)
5) Disproportionate socioeconomic effects (on availability of affordable housing)

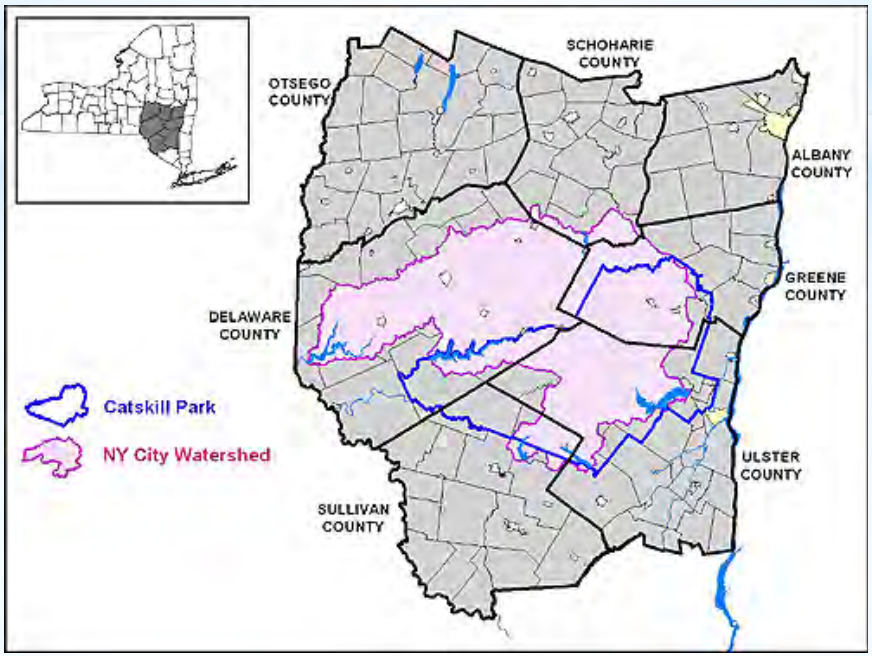
Climate Station Availability

Goal: develop a station-based dataset for historical climate analysis

Problem: station availability varies in time, and has dropped in recent years.

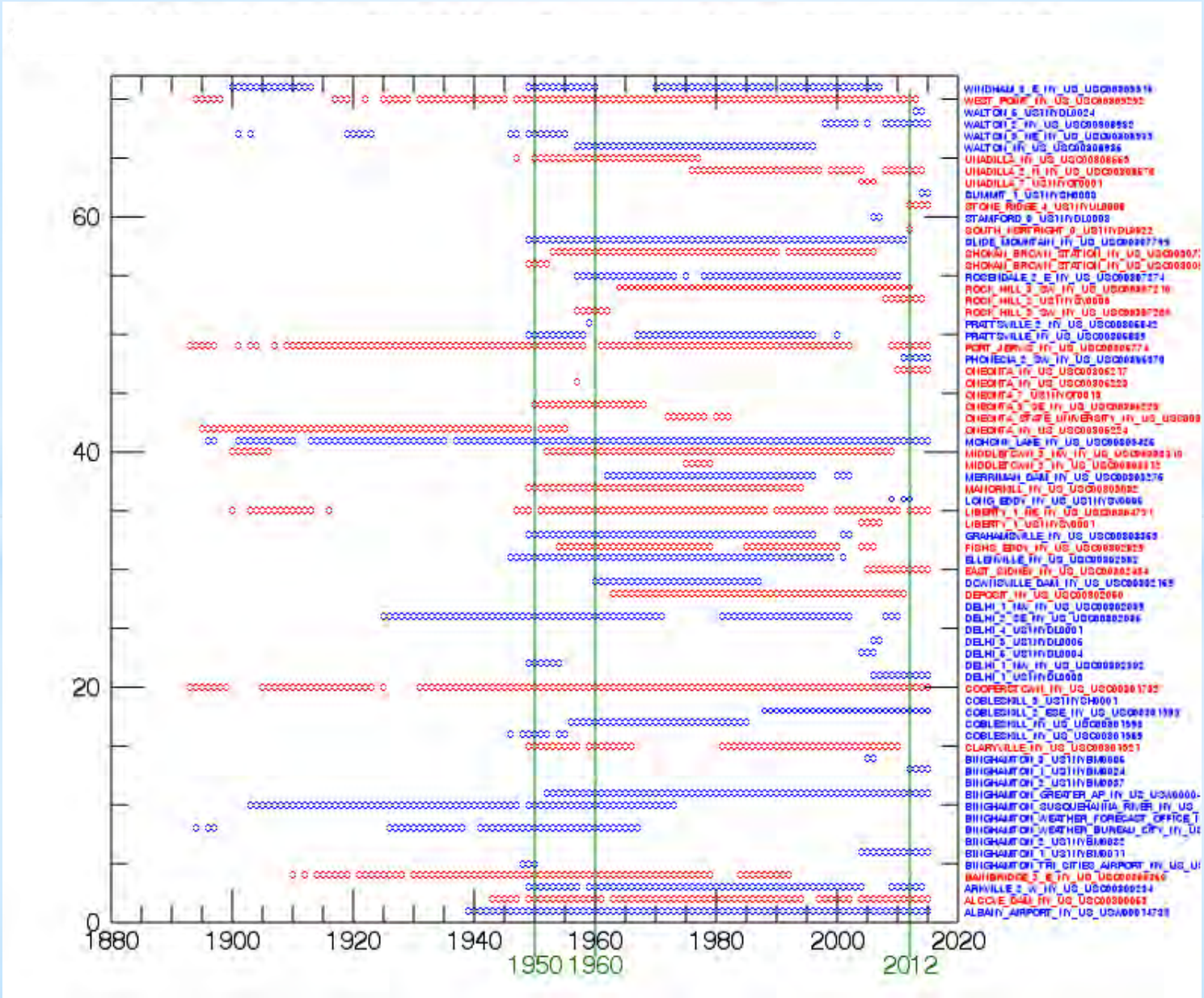
Method for Downloading:

- Download all stations in watershed counties with data 1960s – 2012, and all stations in previous analyses
- Add a few additional stations with long records (e.g. West Point);



http://www.catskillslark.org/maps/maps.htm

Data Availability for PRCP
Years with >=80% non missing days
For all 71 downloaded stations



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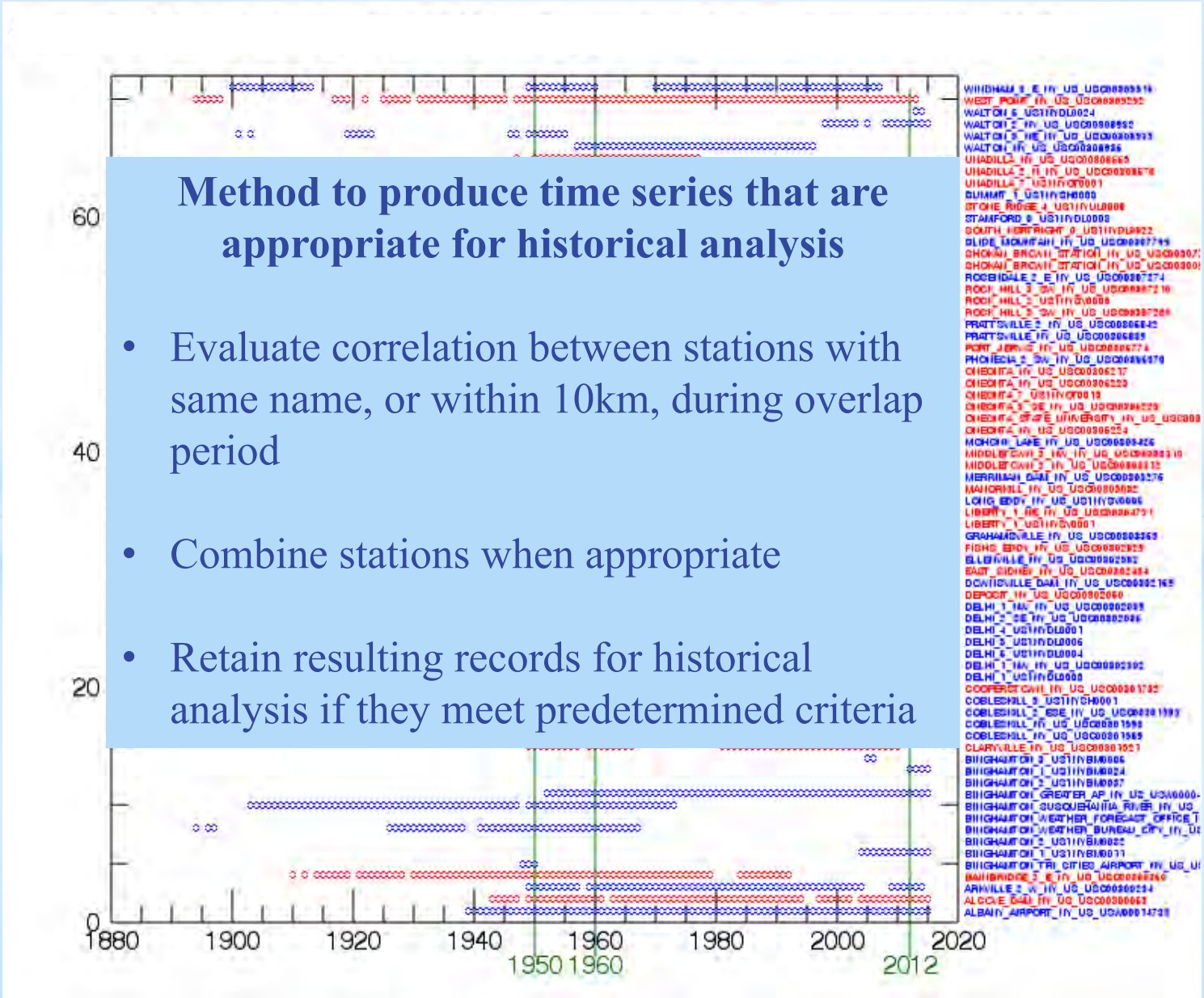
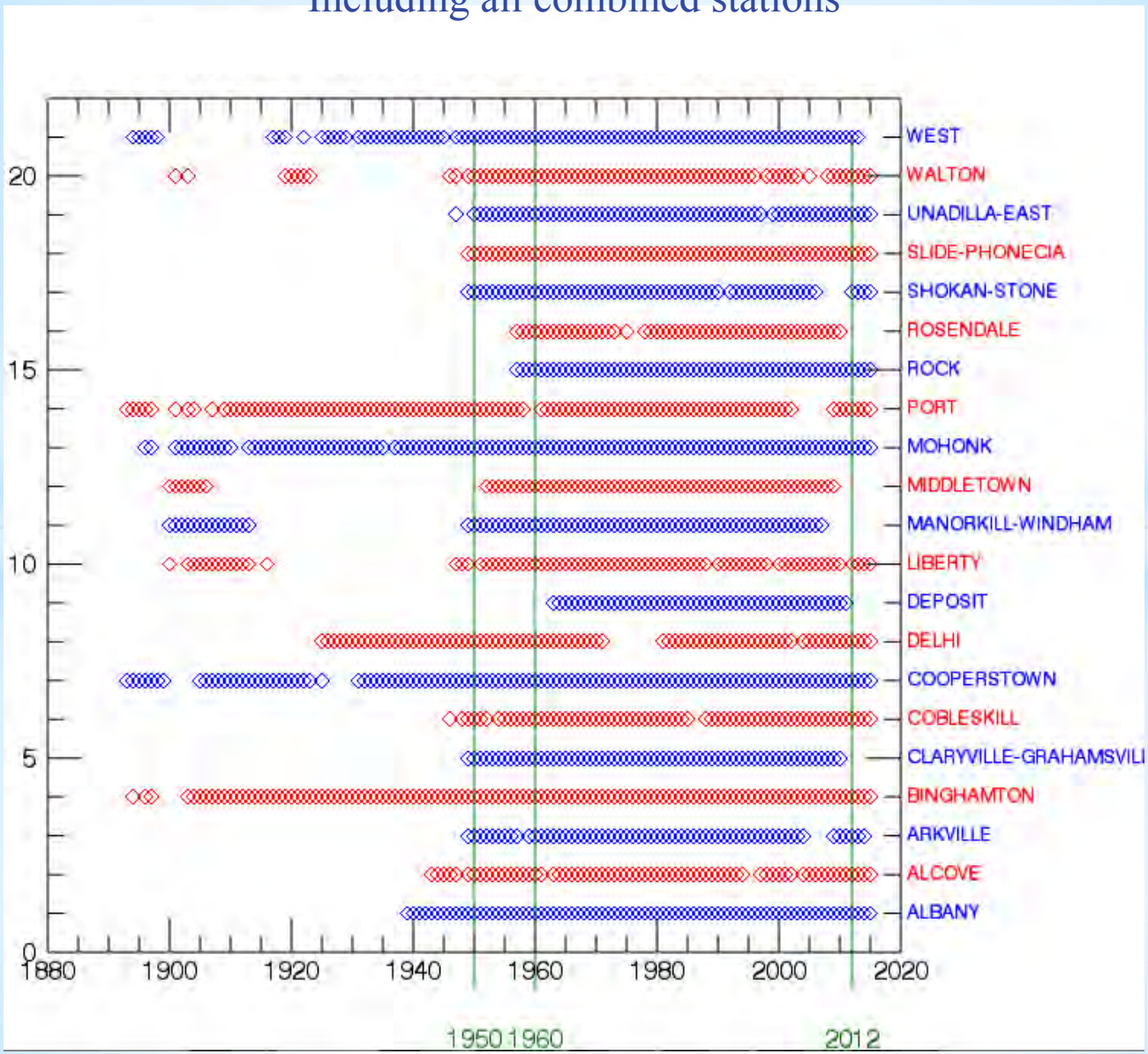


Method to produce time series that are appropriate for historical analysis

- Evaluate correlation between stations with same name, or within 10km, during overlap period
- Combine stations when appropriate
- Retain resulting records for historical analysis if they meet predetermined criteria

Data Availability for PRCP
Stations with >=80% non missing days
During >= 80% of the years 1960-2012
Including all combined stations



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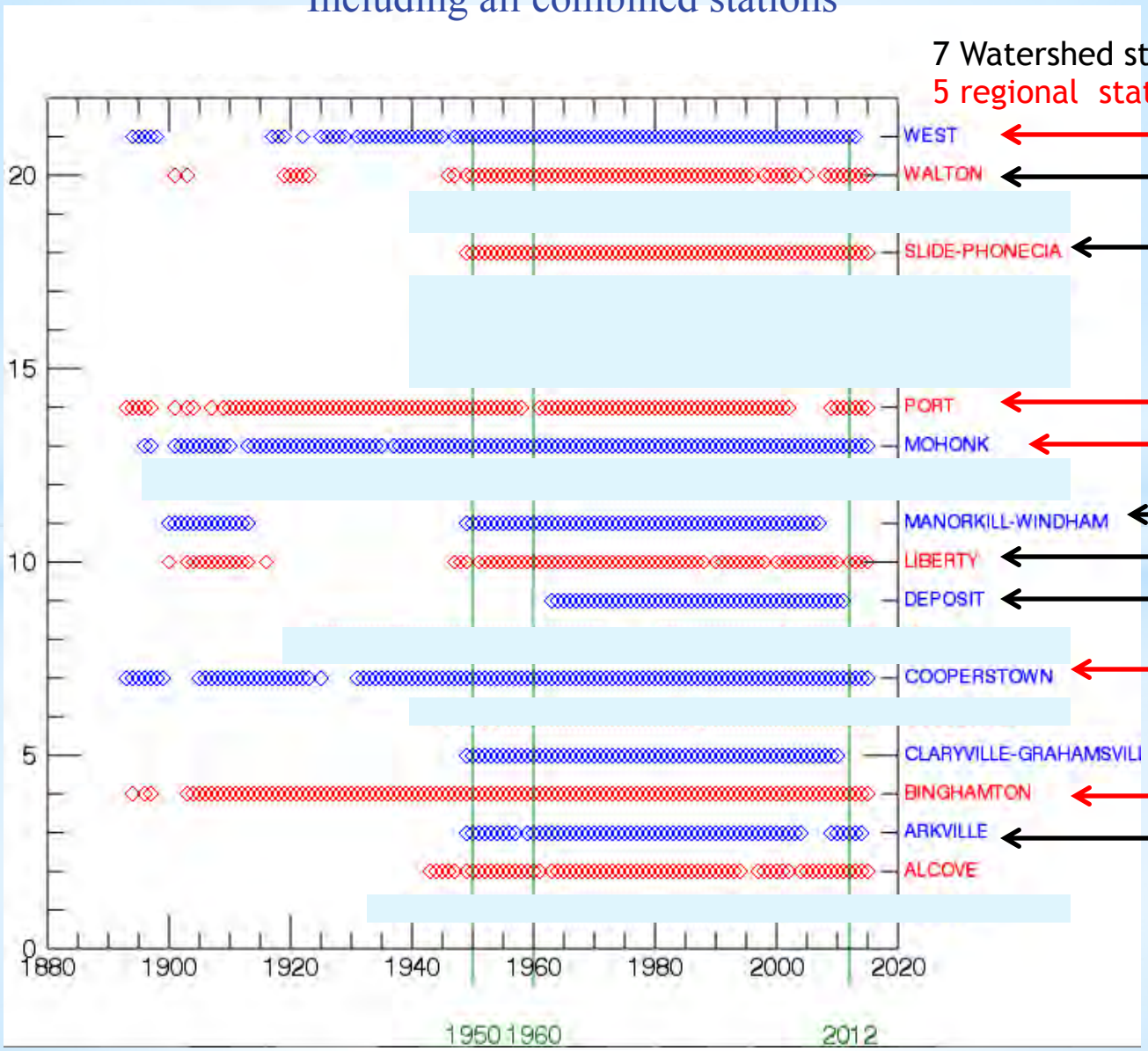
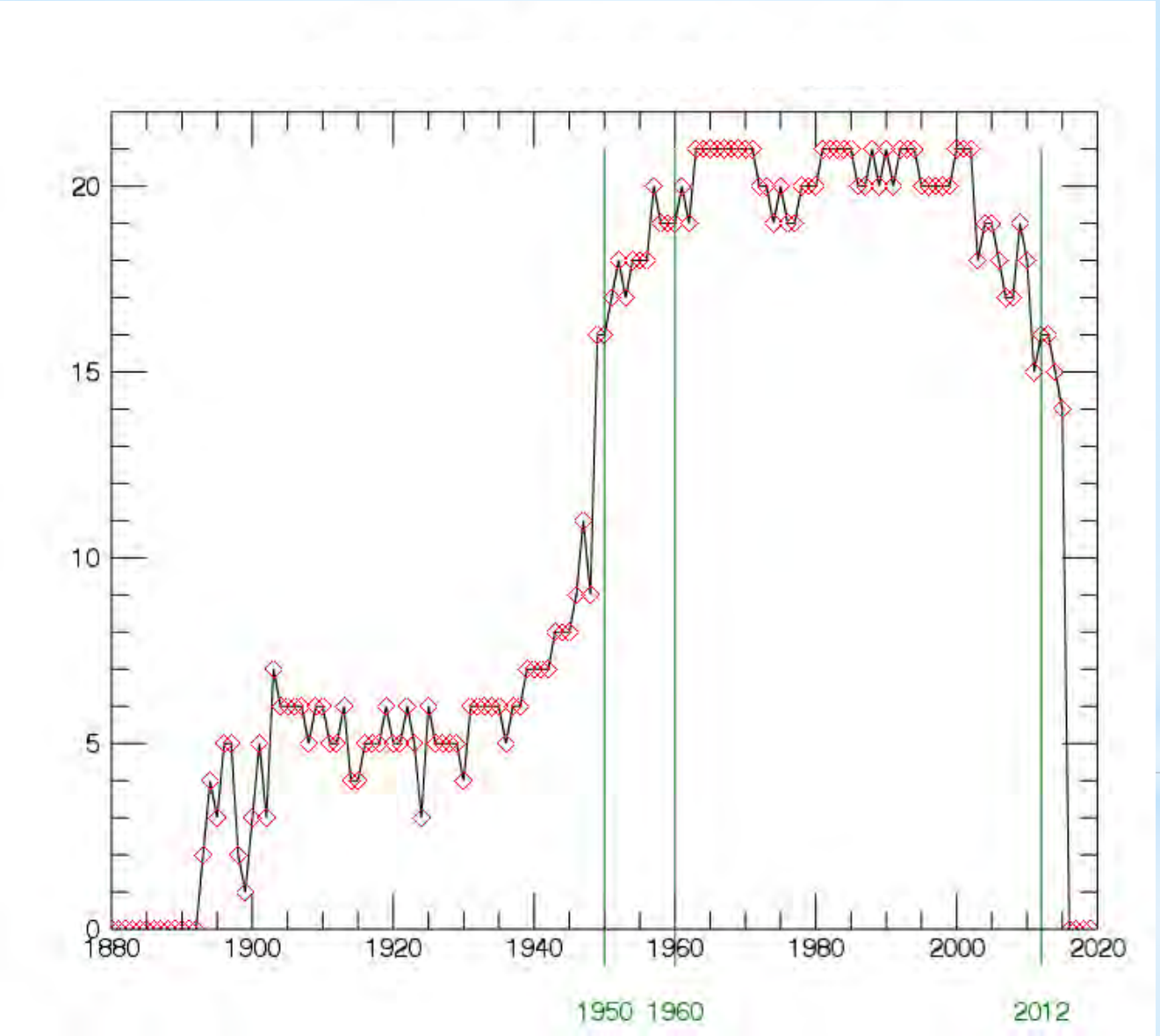
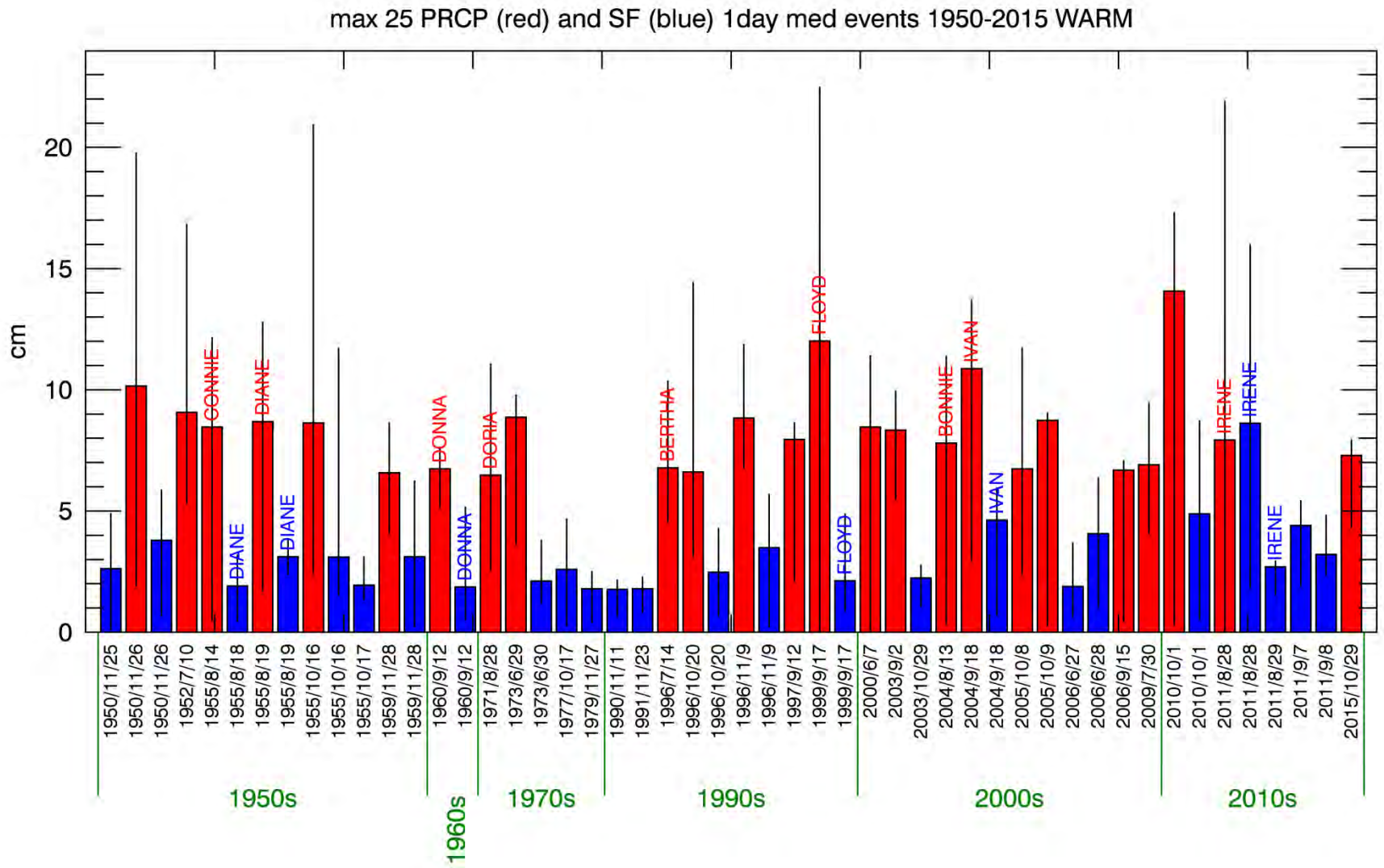


Data Availability for PRCP
of stations per year with >=80% non missing days
During >= 80% of the years 1960-2012

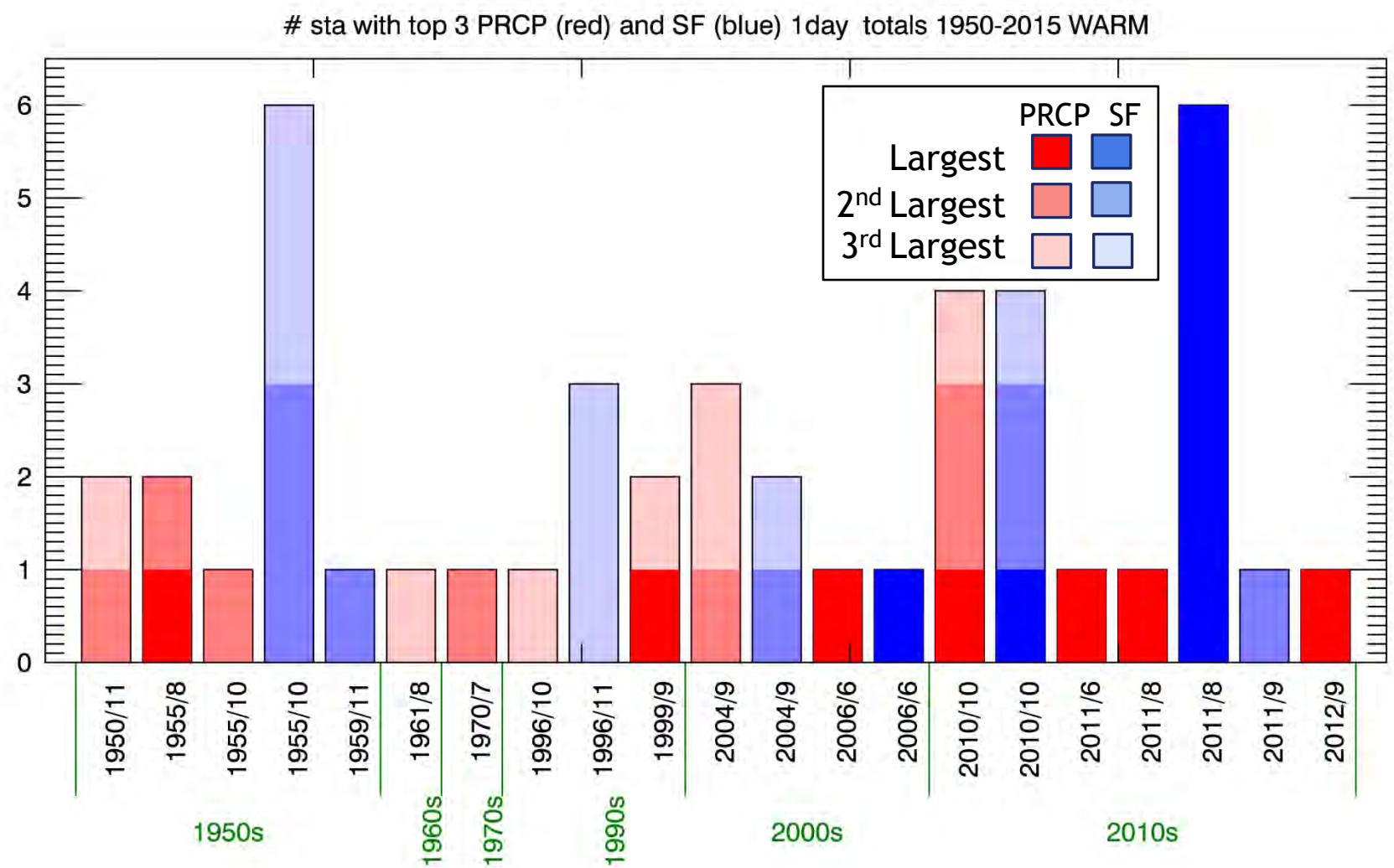


Top 25 1-day events, Warm Season only (Jun-Nov)

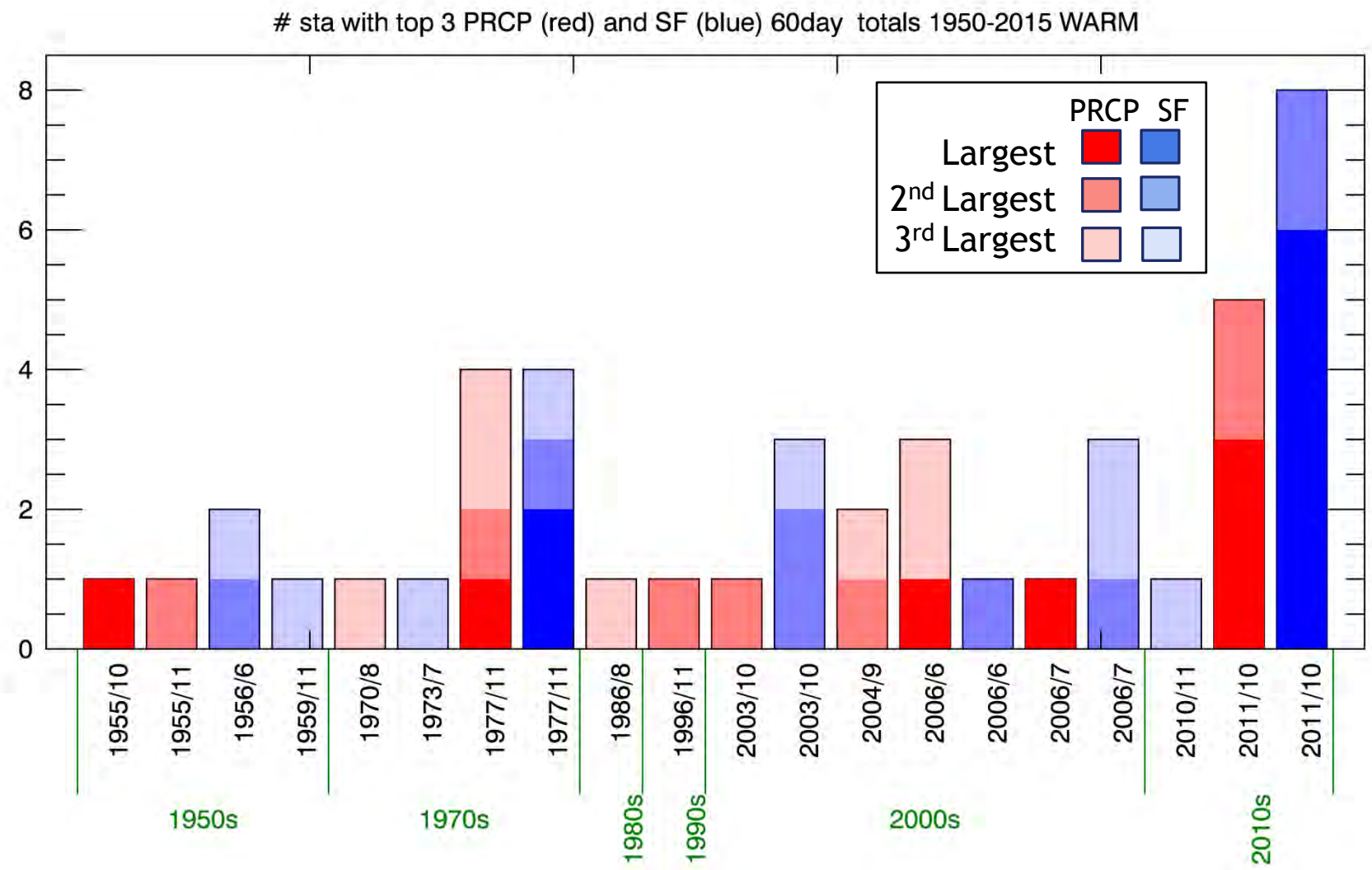


Top events ranked by median station value. Ranked by top station value may be slightly different.

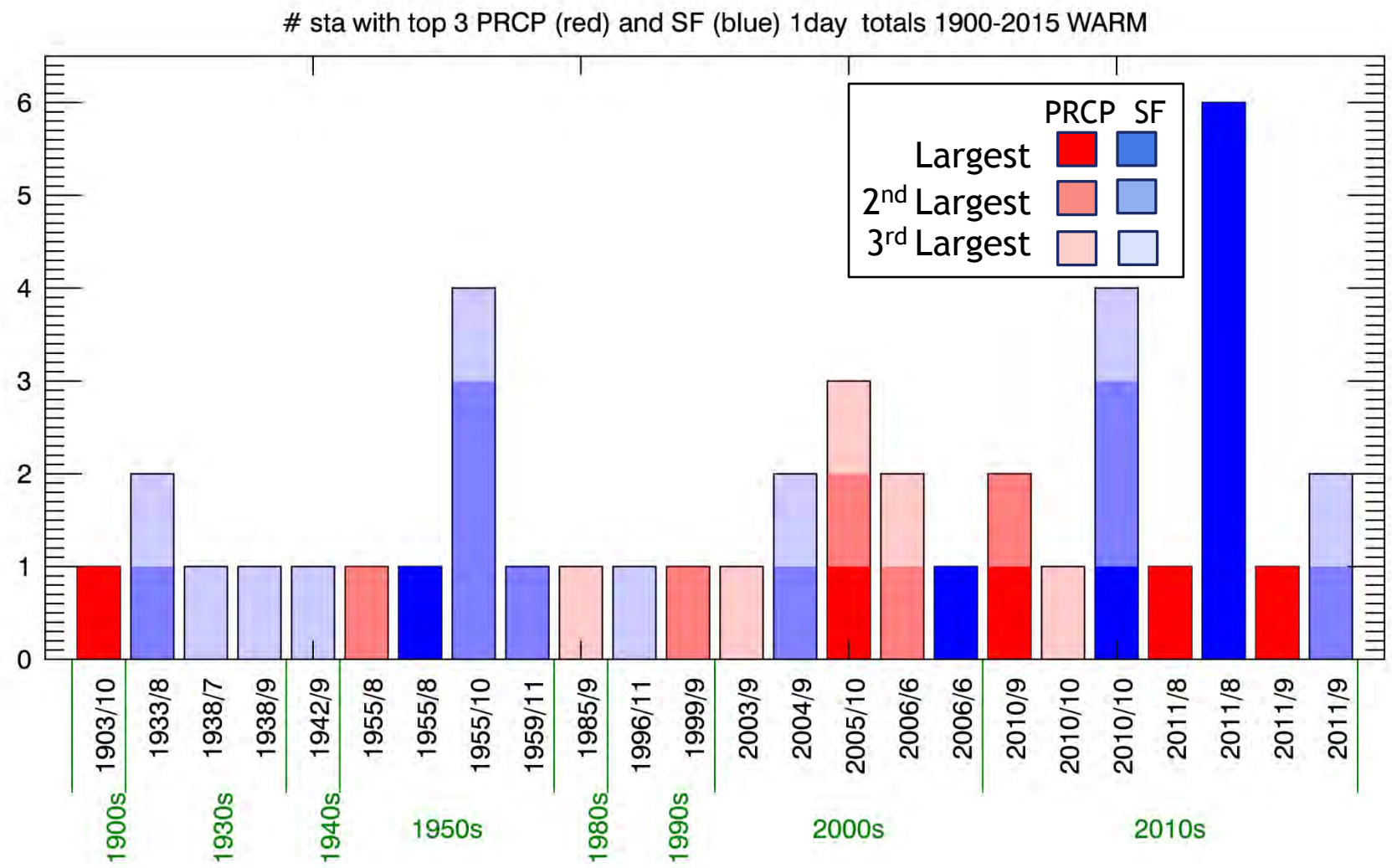
Top 3 1-day events, Warm Season only (Jun-Nov)



Top 3 60-day events, Warm Season only (Jun-Nov)



LONG TERM STATIONS: Top 3 1-day events, Warm Season only (Jun-Nov)



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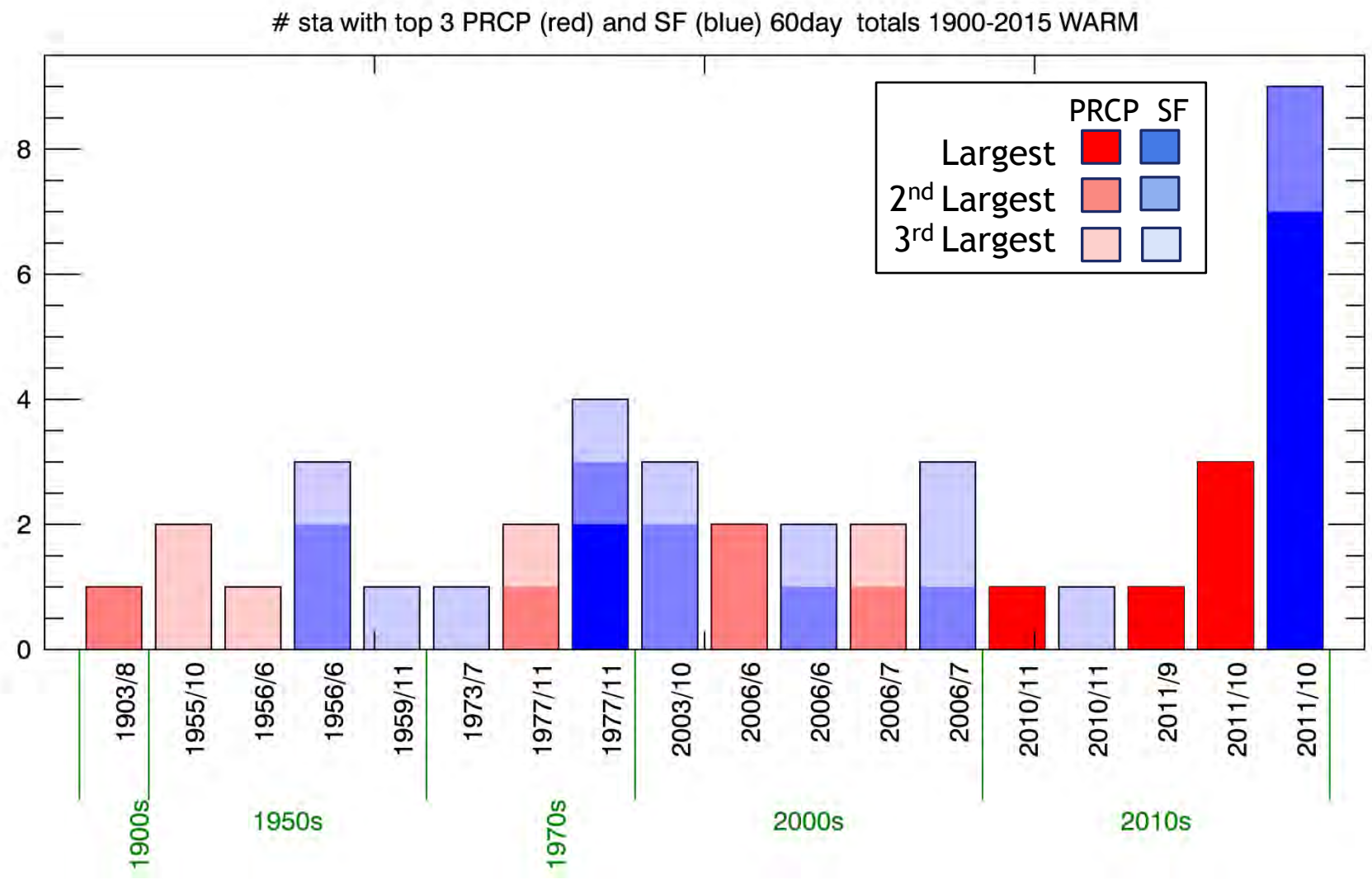
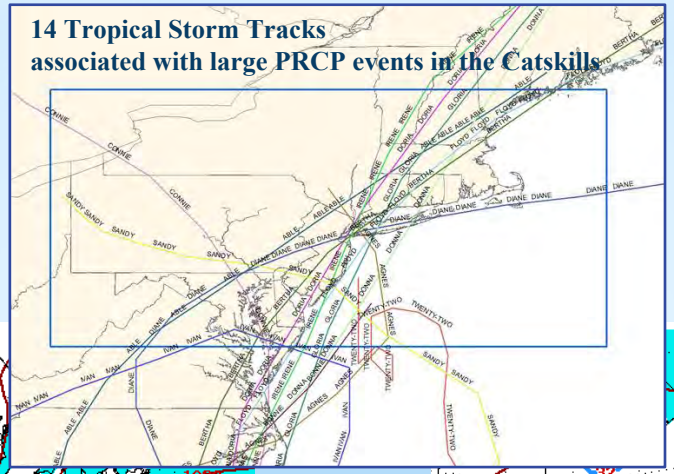


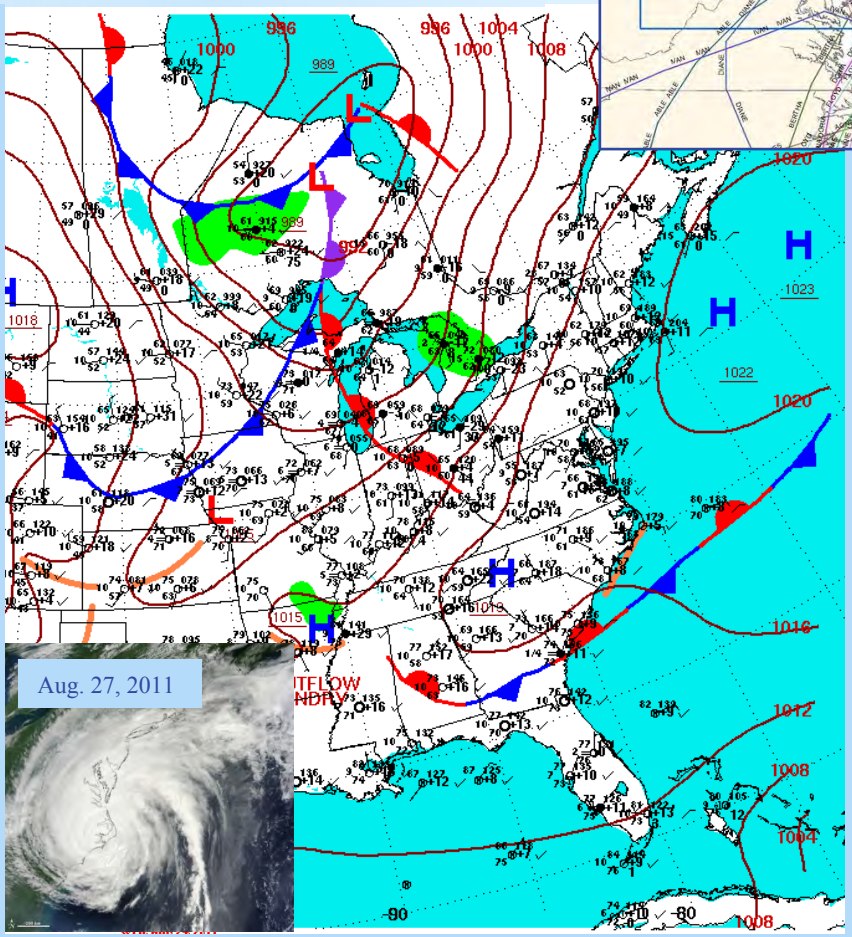
Conclusions

- Irene and Lee were unique extreme streamflow (i.e. flooding) events. They were extreme, but not unique, precipitation events
- Discrepancy between the precipitation and streamflow records because streamflow magnitude depends on antecedent conditions
- Fall 2011 was unique: 1-5 day events in the top 3 for SF
  30-60 day events in top 3 for both PRCP and SF
- The period 1996-2011 was uniquely wet and extreme
- The 1930s, 1950s (especially 1955) (and to a lesser extent the 1970s) were also extreme periods

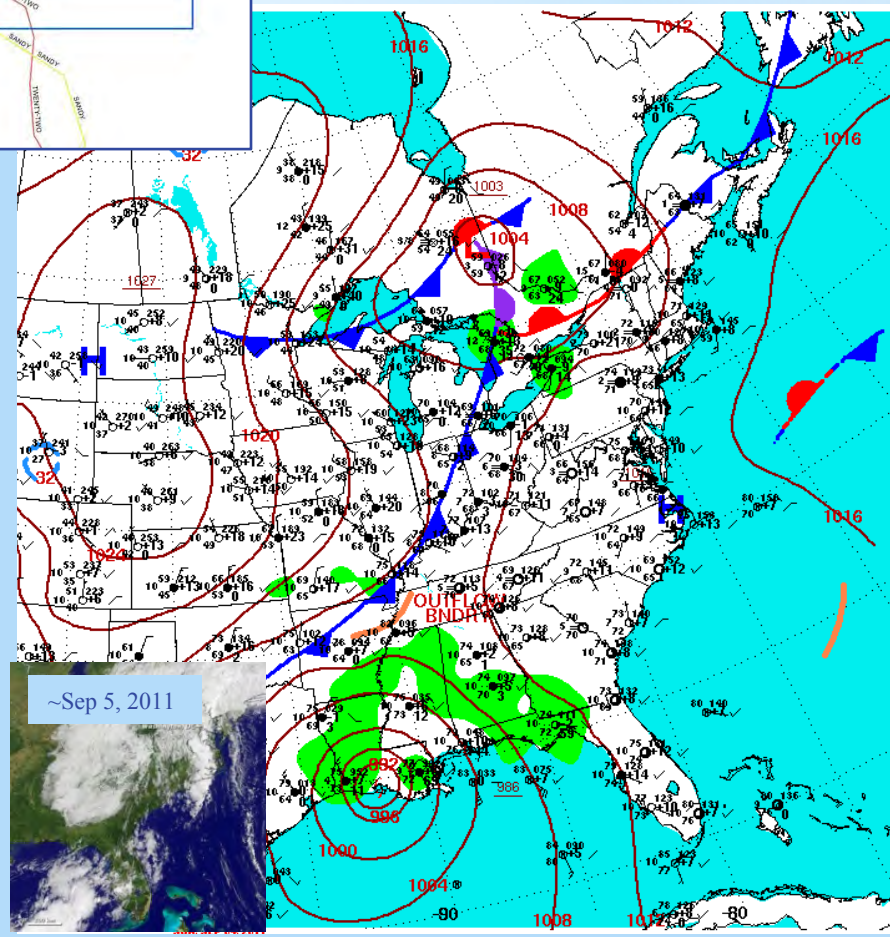
Deep gorge created in Frost Valley (Ulster County Route 47) when floods after Hurricane Irene blew out a culvert below the road in Oliverea, NY. http://en.wikipedia.org/wiki/Effects_of_Hurricane_Irene_in_New_York#Orange_County



Irene



Lee



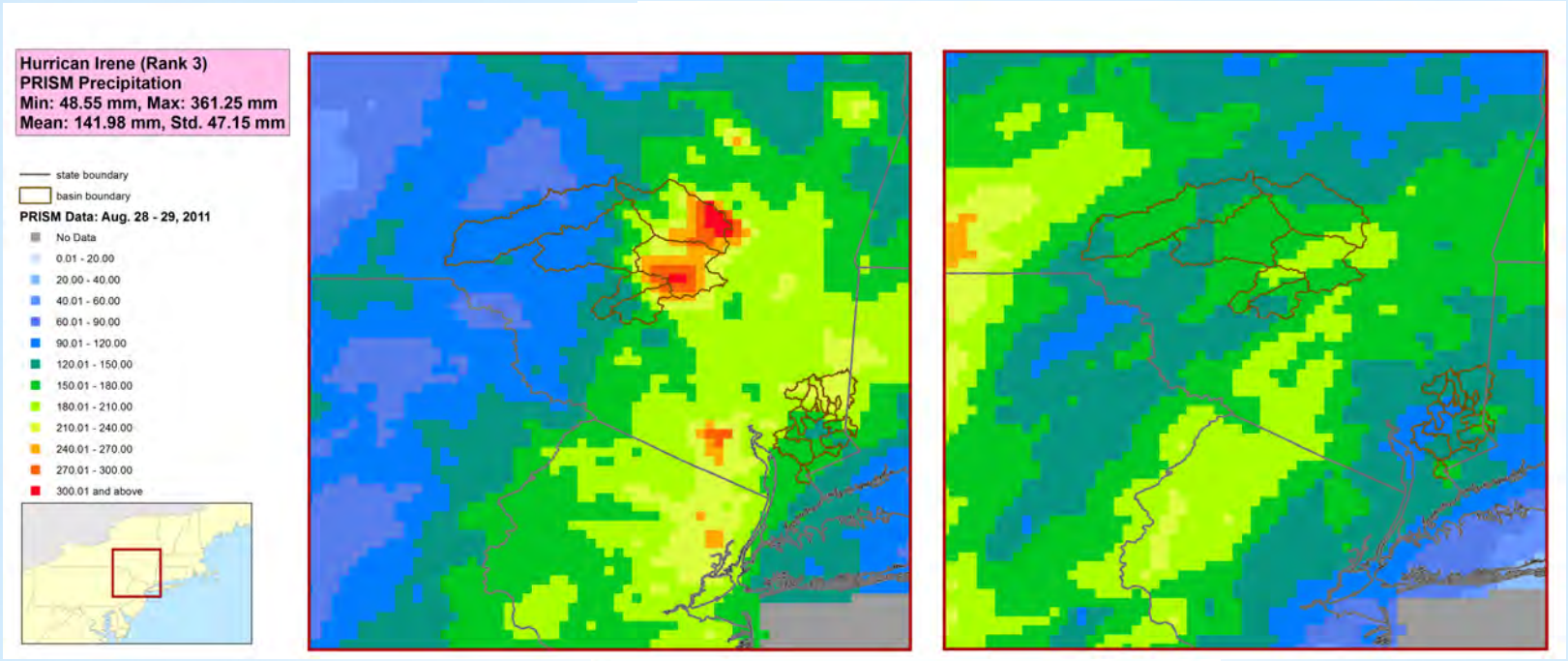
Satellite images from NASA:
http://earthobservatory.nasa.gov/NaturalHazards/event.php?id=51826
http://visibleearth.nasa.gov/view.php?id=52066

Maps from NOAA daily weather maps; movies by Glenn Liu
Track image by A. Jeu, Hunter College, made from HURDAT2 data

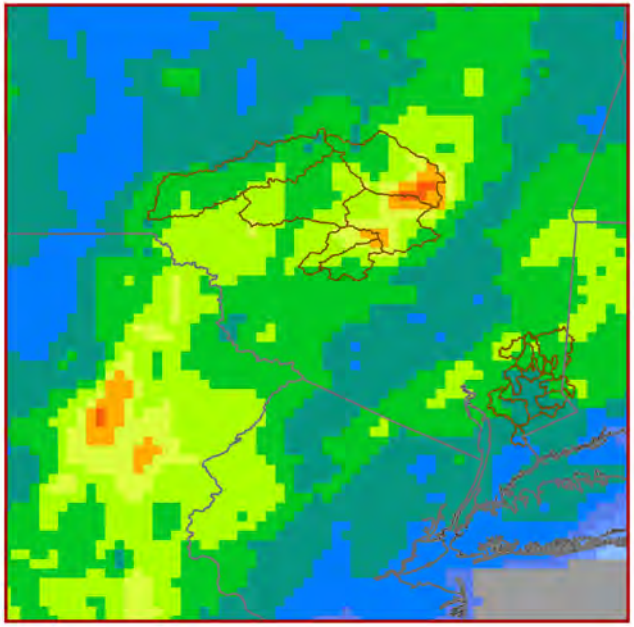
Storm Total PRCP

Irene

Lee



Oct 2010



Data Source: PRISM