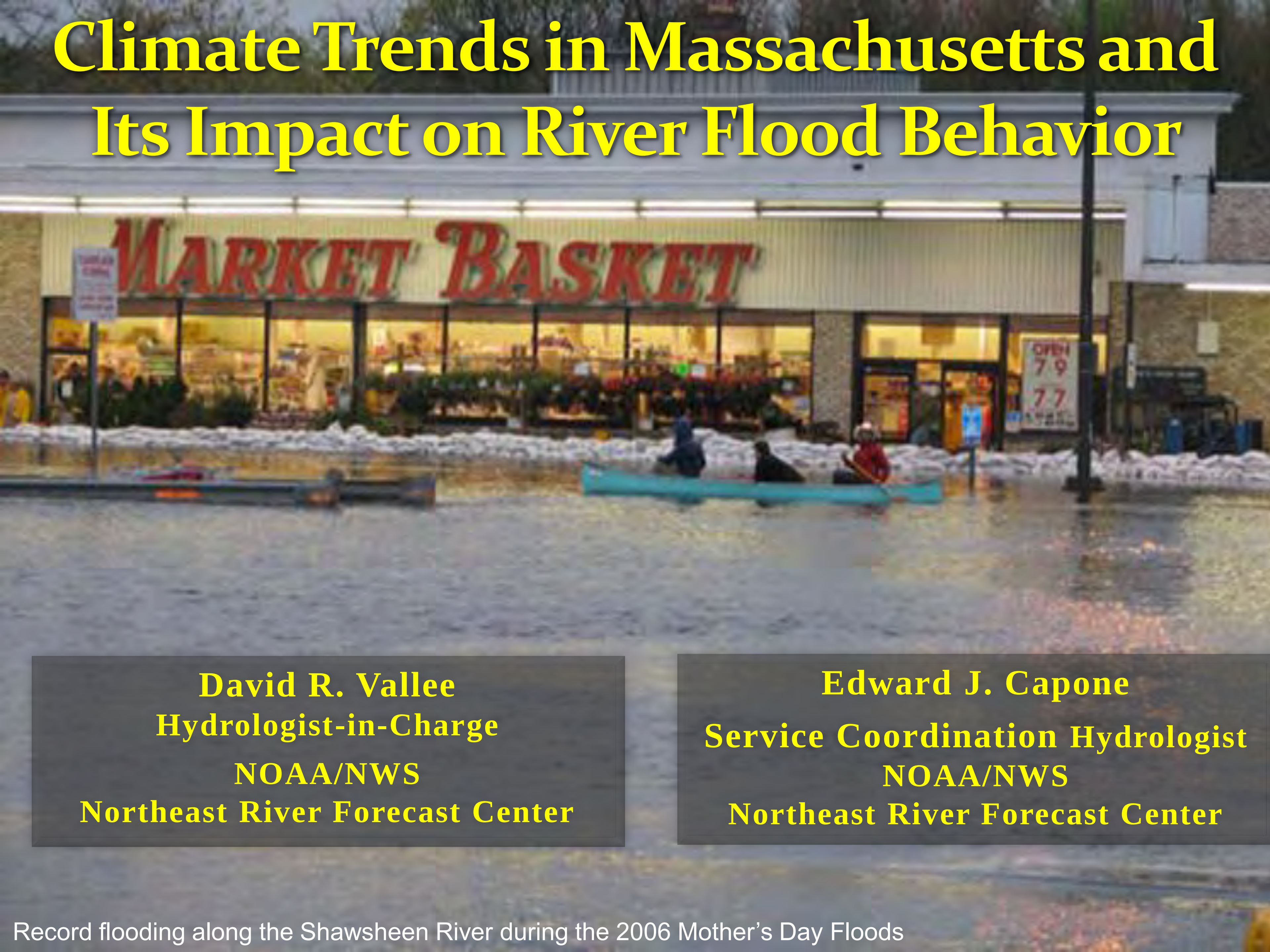
Climate Trends in Massachusetts and Its Impact on River Flood Behavior



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Hydrologist-in-Charge
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Service Coordination Hydrologist
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Record flooding along the Shawsheen River during the 2006 Mother's Day Floods

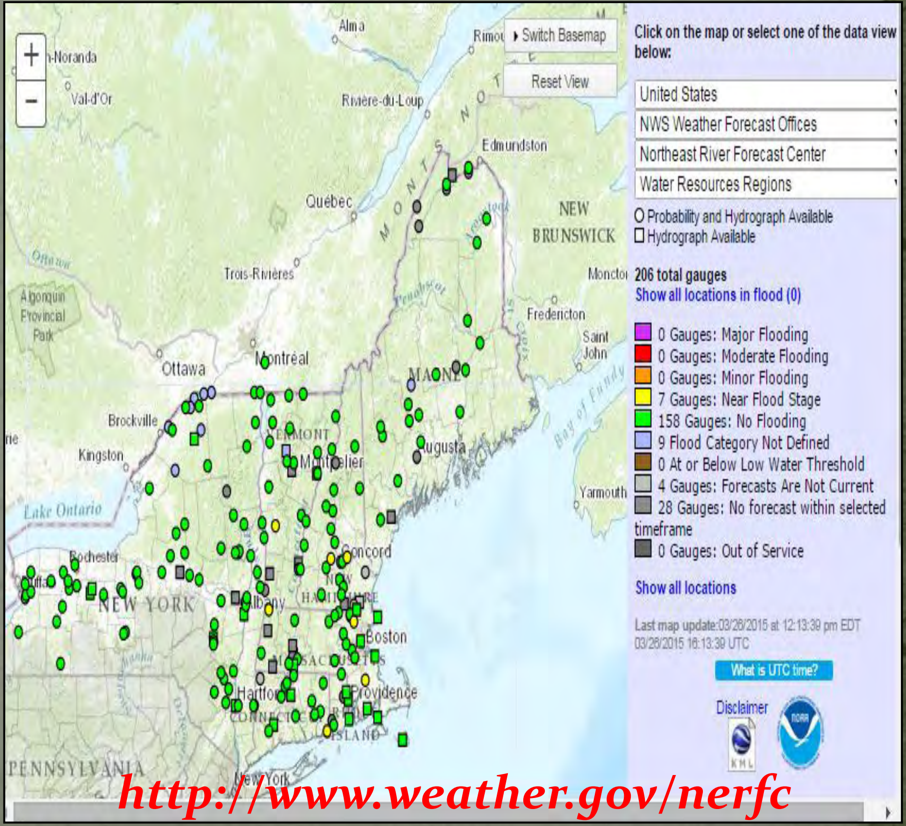
Overview of today's presentation

- Part I: A bit about the Northeast River Forecast Center & how we go about the business of river and water resource forecasting
- Part II: Our changing climate
  - Warm, wetter, more frequent extreme precipitation events, and changes in river flood frequency & magnitude
- Part III: New water resource services
  - From hours to years
  - From Summit to Sea / Tree Top to Bedrock

NOAA/NWS's Northeast River Forecast Center

Our Mission:

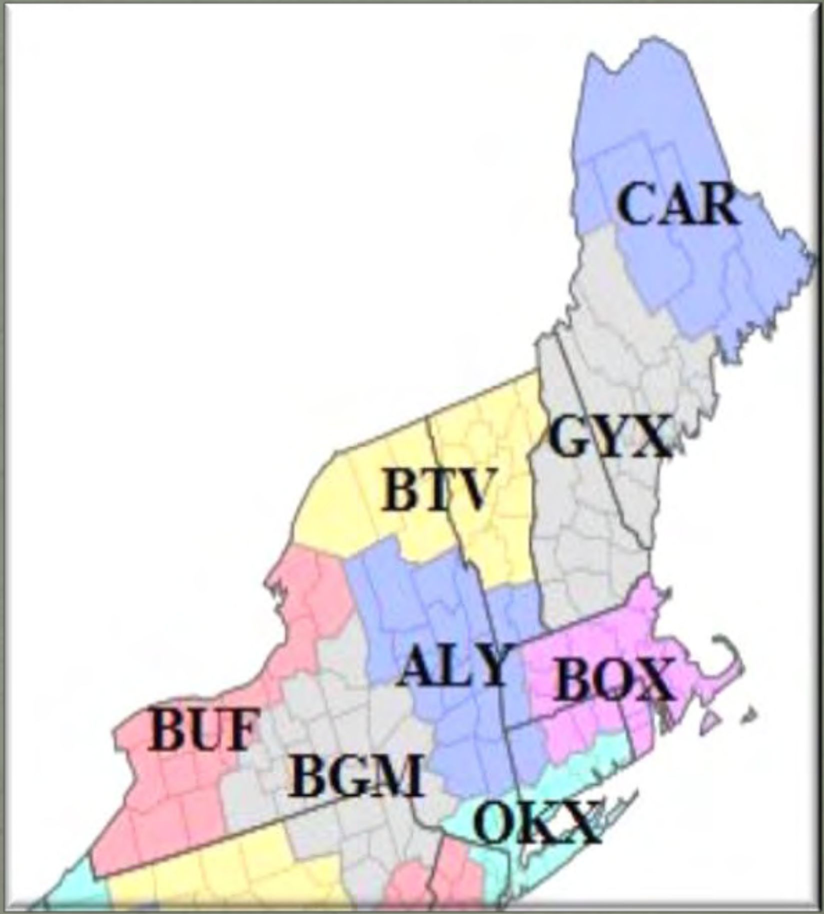
To provide our nation with river, flood and water resource forecasts for the protection of life and property and the enhancement of the national economy



http://www.weather.gov/nerfc

Weather Forecast Offices
New York/New England Service Areas

- WFO Caribou, ME
  - Northeast Maine counties
- WFO Gray, ME
  - Southwest Maine and all of New Hampshire
- WFO Burlington, VT
  - Northern 2/3rds of VT
- WFO Albany, NY
  - Srn 1/3 of VT, Berkshire, MA, Litchfield, CT
- WFO Taunton, MA
  - Rest of MA, all of RI, and the northern 2/3rds of CT
- WFO Upton, NY
  - All coastal CT Counties
- WFO Binghamton, NY
  - Finger Lakes region
- WFO Buffalo, NY
  - Buffalo Creeks, Genesee and Black



Forecast Services

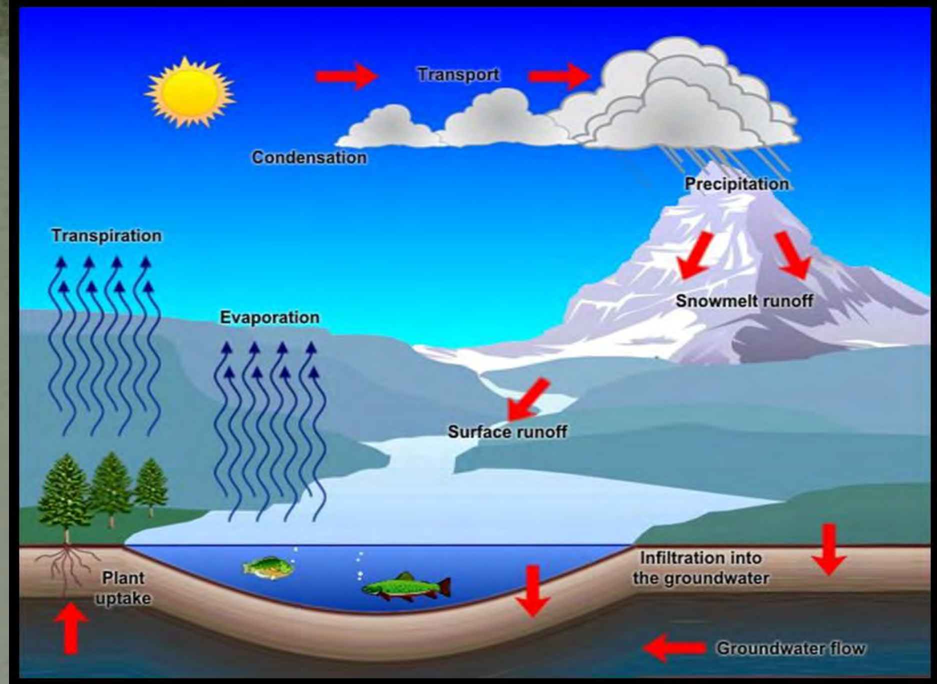
On A Watershed Scale

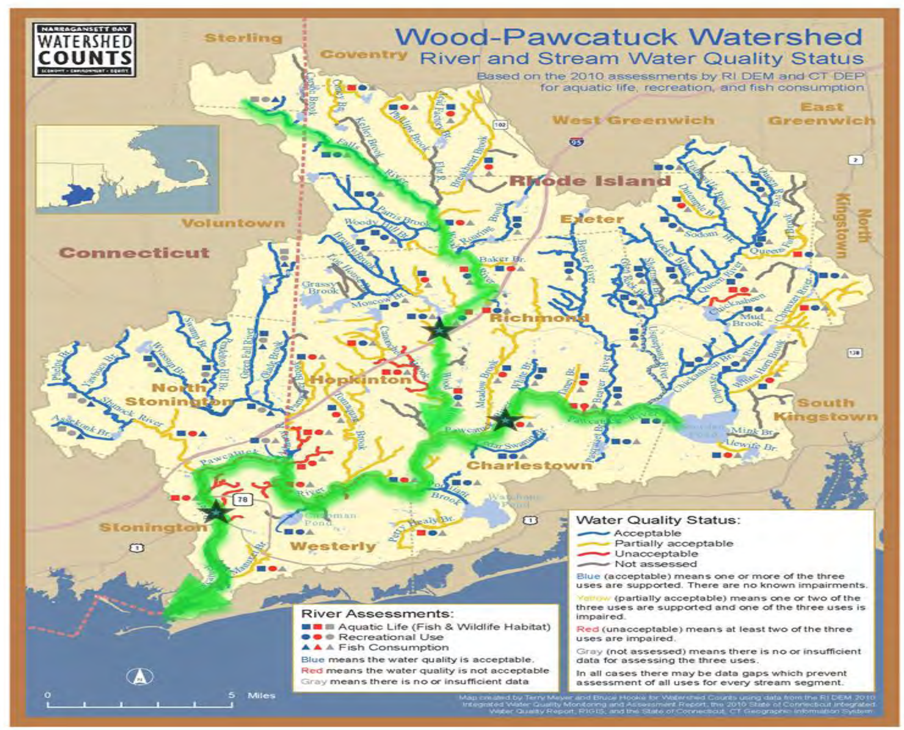
Requirements:

- Observed precipitation & temperatures
- Observed streamflows (USGS)
- Forecast temperatures and precipitation
- **Drainage area ≤ 100 sq mi**

Our models help us forecast:

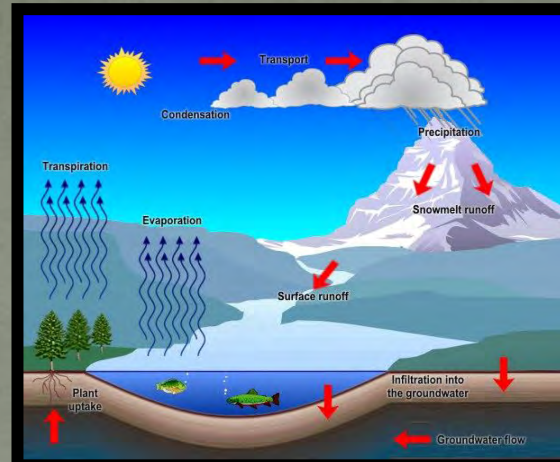
- The volume of water in the river & that's converted to stage/elevation
- Time of the peak elevation & duration
- Soil moisture & Snow melt
- Unit hydrograph theory
- Reservoir Operations
- Hydraulics (HES-RAS) for complex river systems
  - Tidal reaches
  - Lake Champlain, Farmington River
  - Combines tidal/storm surge with fresh water runoff on 5 tidal rivers

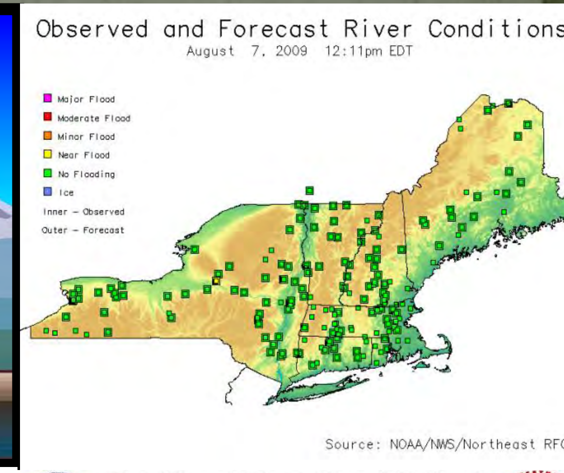


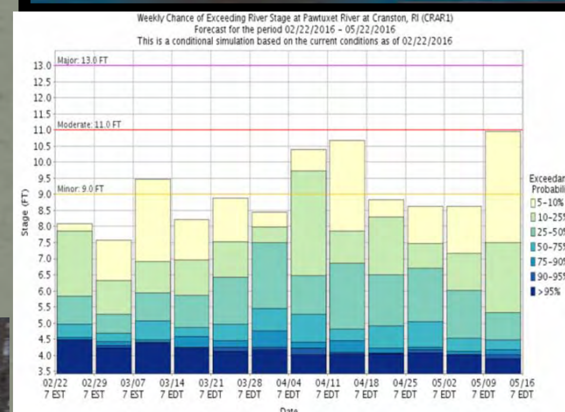


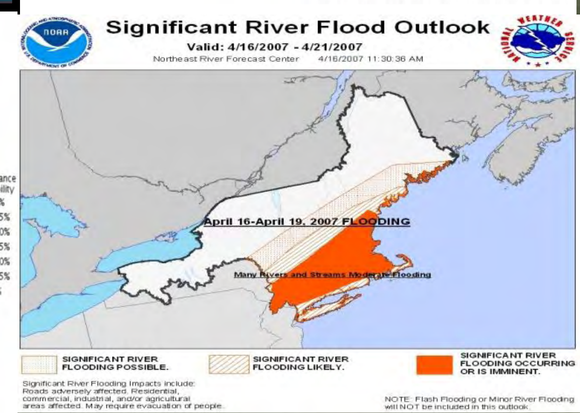
River Forecast Center Responsibilities

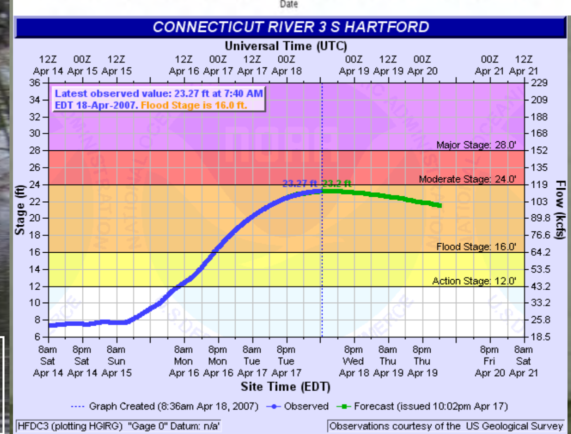
- Calibrate and implement a variety of hydrologic and hydraulic models to provide:
  - River flow and stage forecasts at 180 locations
  - Guidance on the rainfall needed to produce Flash Flooding
  - Ensemble streamflow predictions
  - Ice Jam and Dam Break support
  - Water Supply forecasts
  - Partner with NOAA Line Offices to address issues relating to Hazard Resiliency, Water Resource Services, Ecosystem Health and Management, and Climate Change

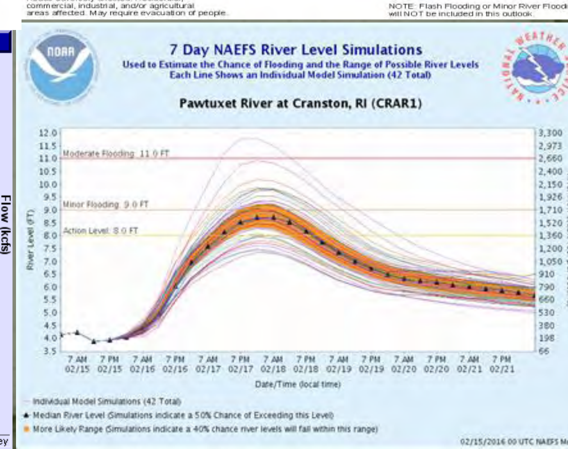












Moderate flooding – Connecticut River at Portland, CT.

Our changing climate:

- From a “Practitioner’s Perspective”
- Rainfall/Temperature trends
- Changes in flood & drought behavior
- Challenges going forward

A few caveats

- Neither Ed nor I are climate scientists!
  - We are practitioners
- We have the benefit of living in this part of the country – i.e.: *we are locals!*
  - It's different now – beyond temps & precip
  - Changes in vegetation, insects, bird life & ***river response***
  - Sea level rise
- The mission: Develop a better understanding of the current regime vs. the old & what that means to how we model our rivers
  - "Accumulation of Ingredients" – not one single "source"
  - Where we are headed: that's the million $$ question!

I've been a little busy these past 10 years!
Job Security in the face of changing flood behavior!!

Record flooding along the Fish and Saint John Rivers – northeast Maine, 4/30/2008

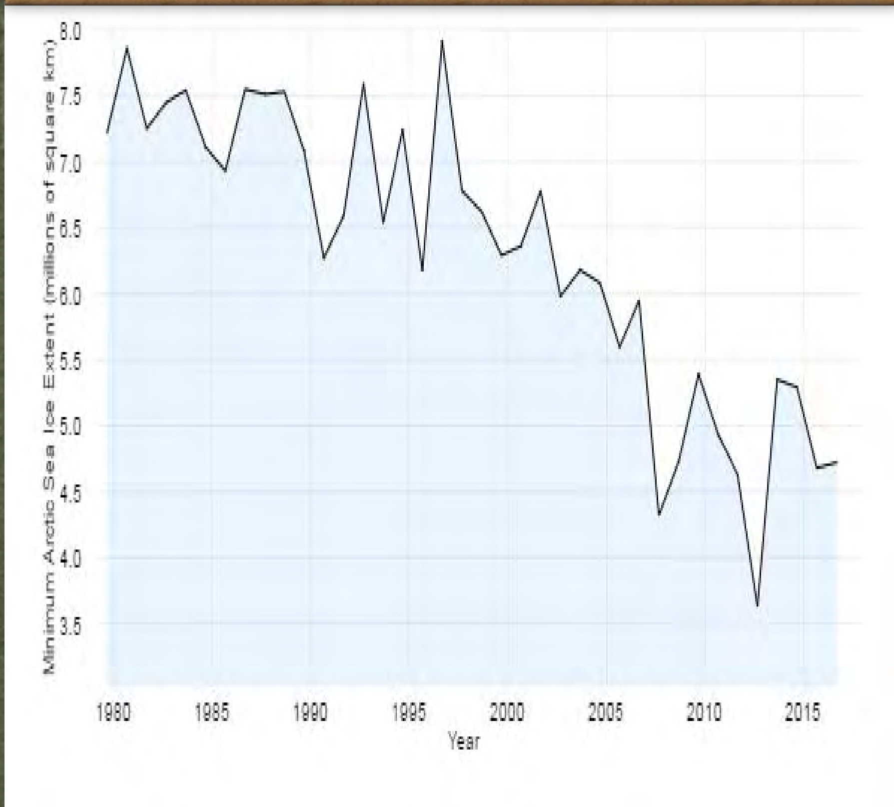
Providence Street – Warwick, RI at 1030 am Wednesday 3/31/10

Home washed off its foundation on the Schoharie Creek, Prattsville, NY – Tropical Storm Irene

Record Flash Flooding in Utica, NY, July 1st, 2017
Photo courtesy of Jill Reale (WKTV)

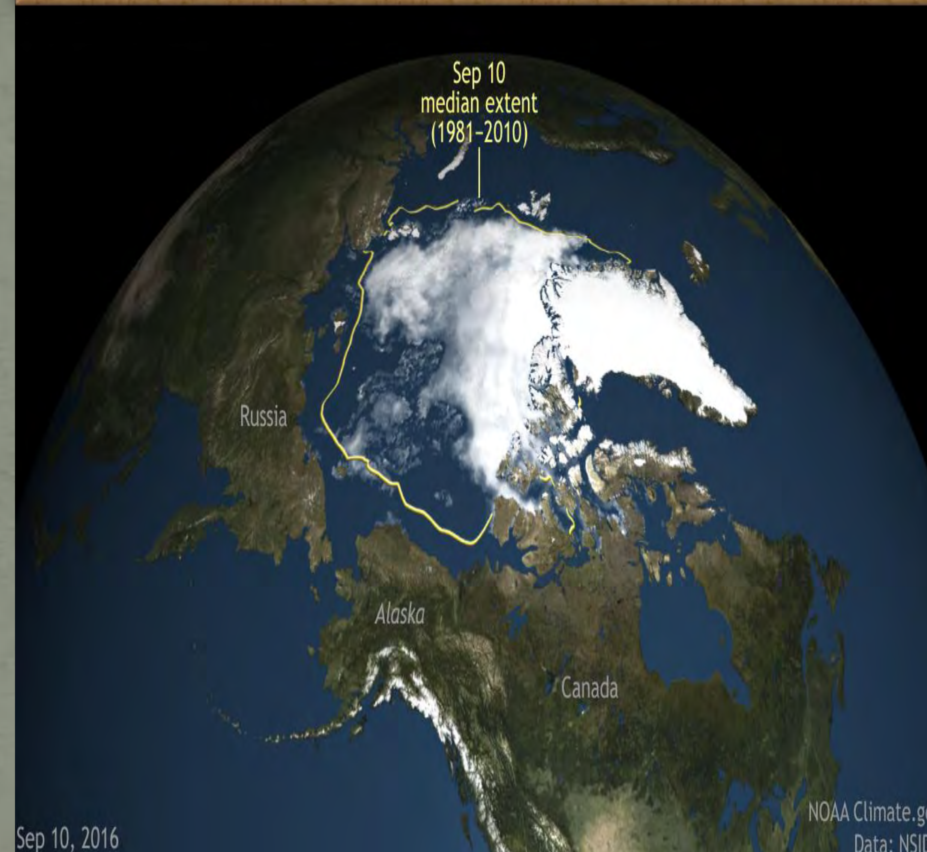
A warming planet and shrinking Arctic Sea ice

September Minimum Sea Ice Cover 1979-2016



This graph shows the average area covered by sea ice during September each year. Minimum sea ice extent has decreased 12% per decade since 1979. Data provided by the National Snow and Ice Data Center.

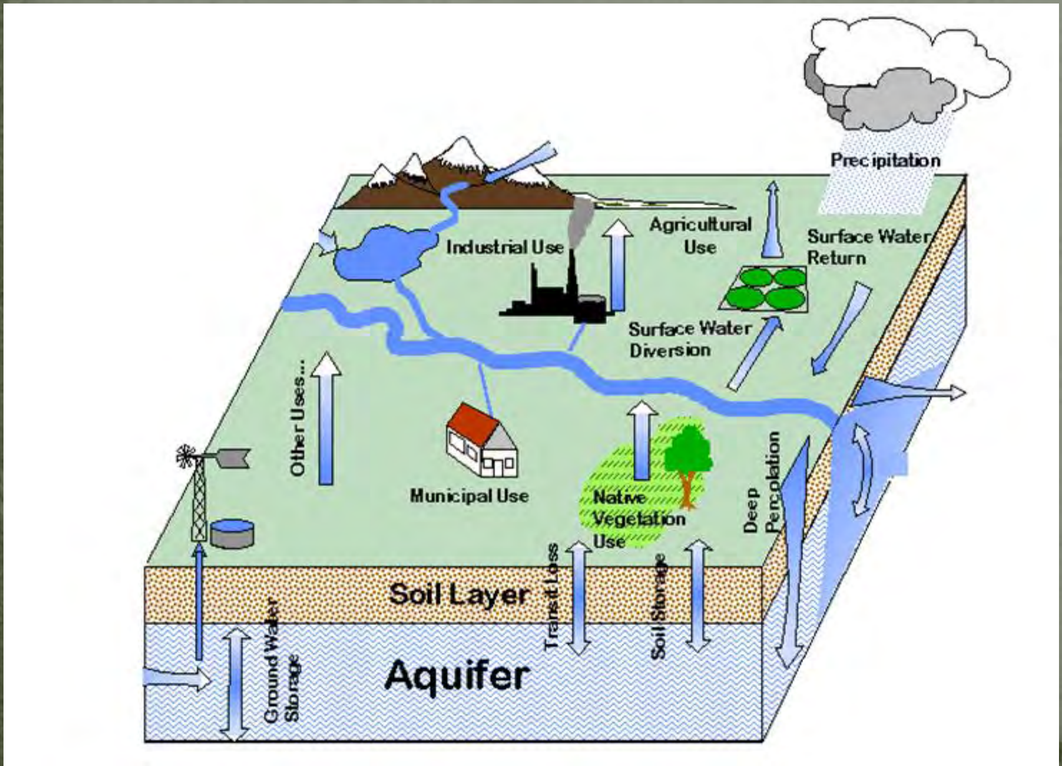
2016 Arctic Sea Ice Summer Minimum

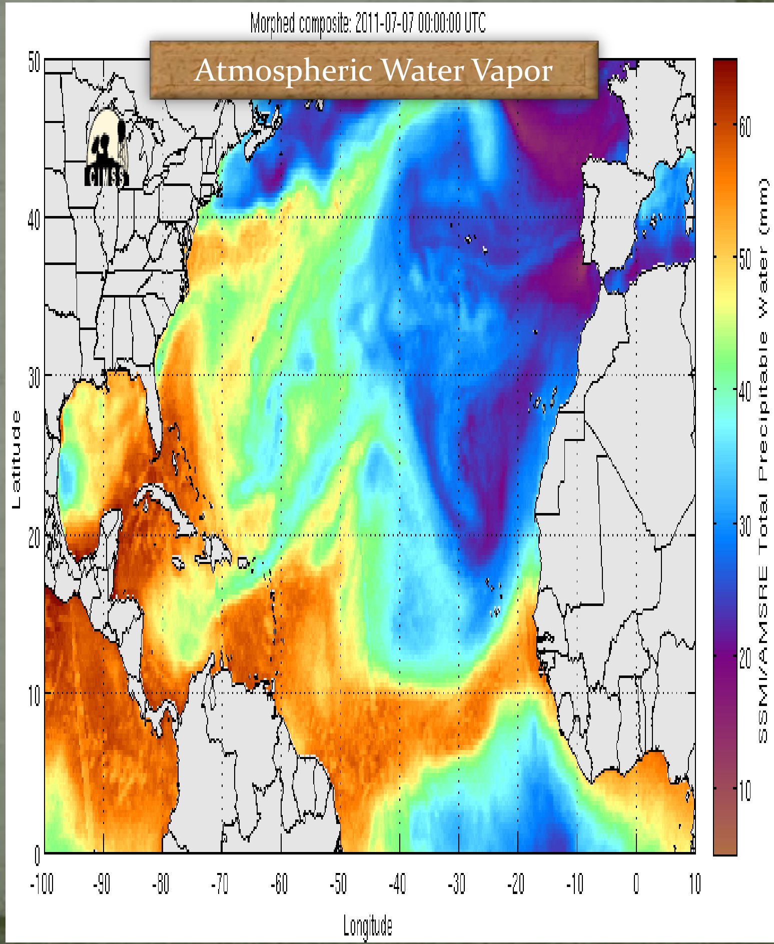


Arctic sea ice concentration on the date of the 2016 minimum extent, September 10, 2016. NOAA Climate.gov image based on NOAA and NASA satellite data from NSIDC.

Is there a common theme to recent ?

- Several:
  - Slow moving weather systems – a blocked up atmosphere
  - Multiple events in close succession or 1 or 2 slow movers
  - Resulted in saturated antecedent conditions
  - Each fed by a "tropical connection"
    - Plumes of deep moisture





The Changing Climate

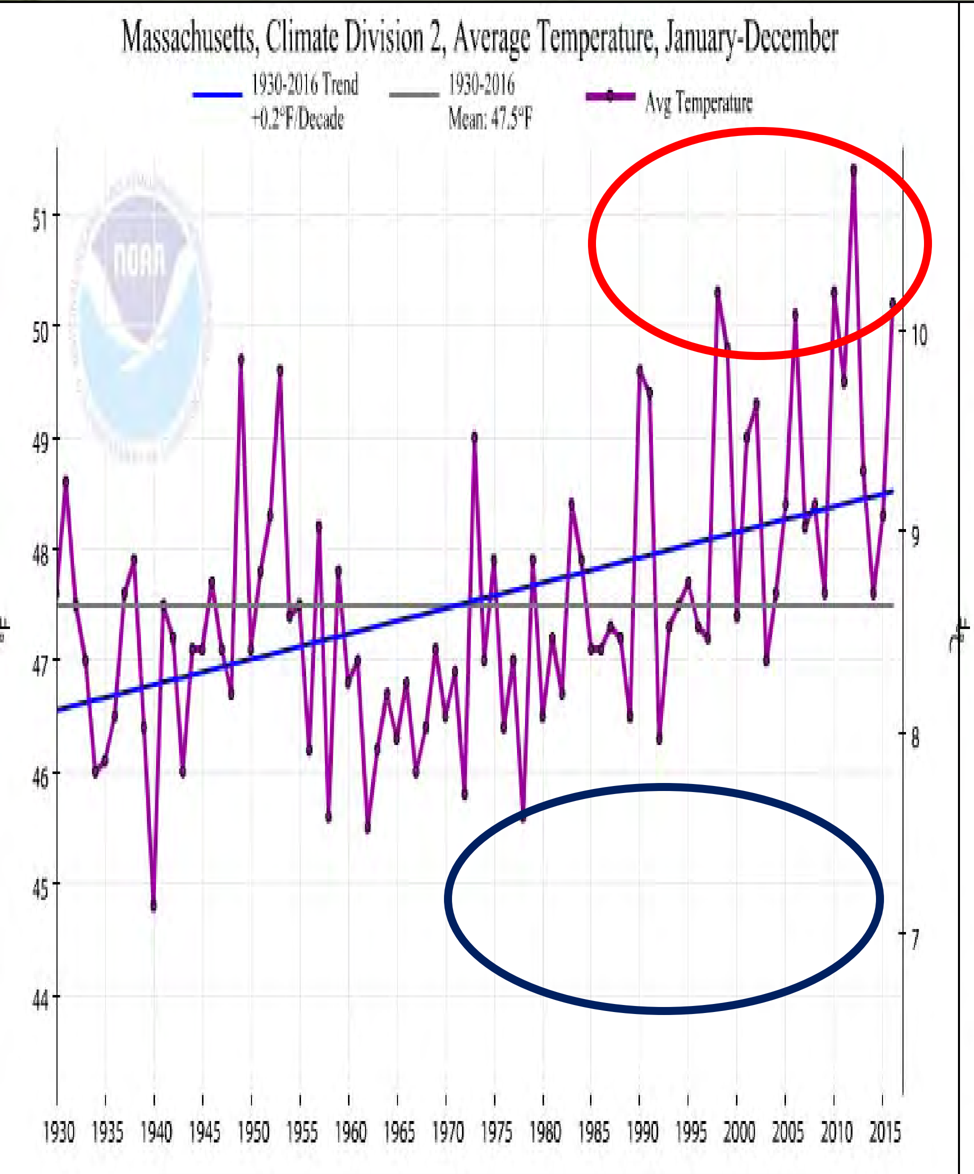
- Common themes across New England:
  - Increasing annual precipitation
  - Increasing frequency of heavy rains
  - Warming annual temperatures
  - Wildly varying seasonal snowfall
- Shift in precipitation frequency (50, 100 yr – 24 hr rain)
- For smaller (<800 sq mi) basins – trend toward increased flood magnitude and/or frequency
  - **Most pronounced where significant land use change and/or urbanization has occurred**

Flooding along the Sudbury River in Wayland, MA, March 31st 2010. Photo: NERFC

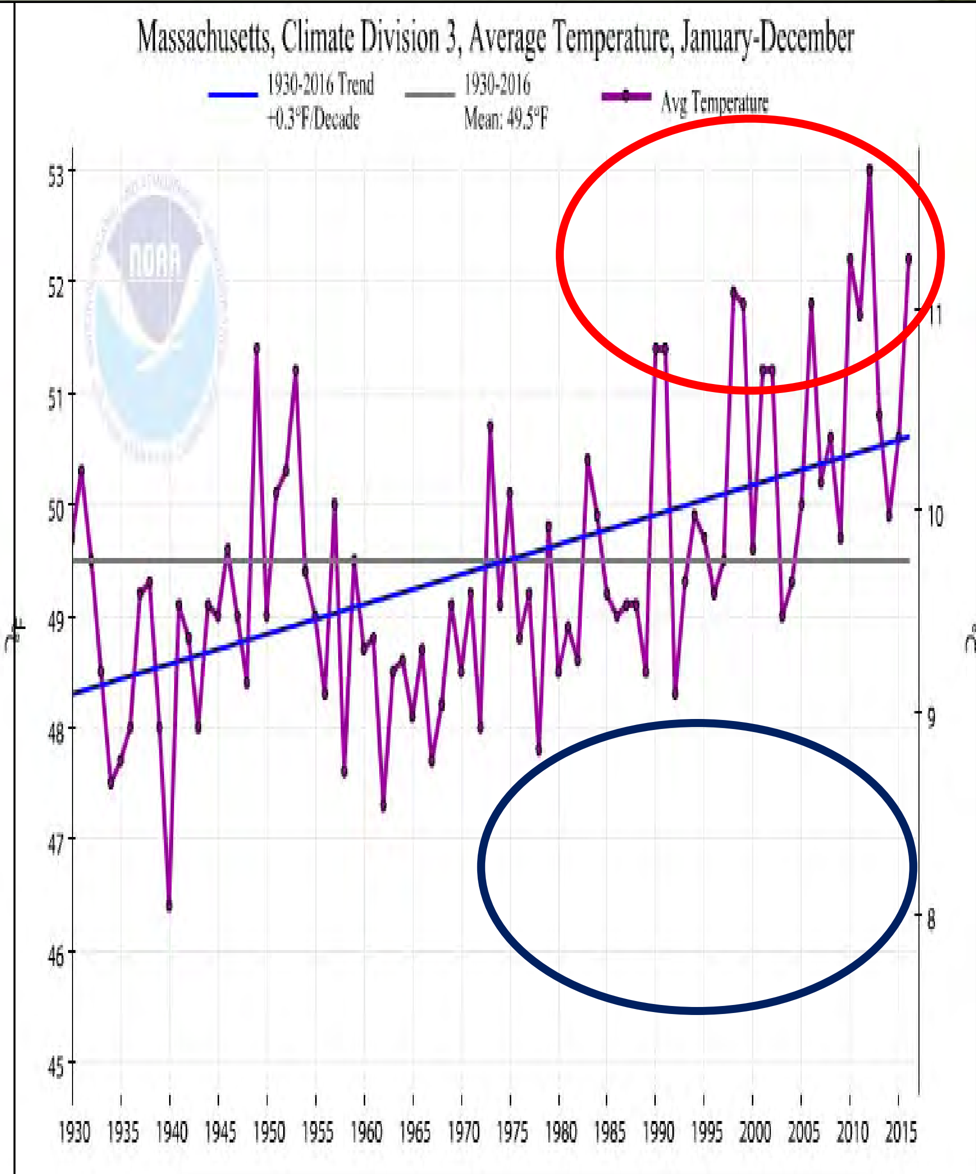
The Eagle-Tribune had it correct: "River Raging" – May 15th, 2006

A Look at Temperature Trends

http://www.ncdc.noaa.gov/cag



CT Valley to Merrimack Valley

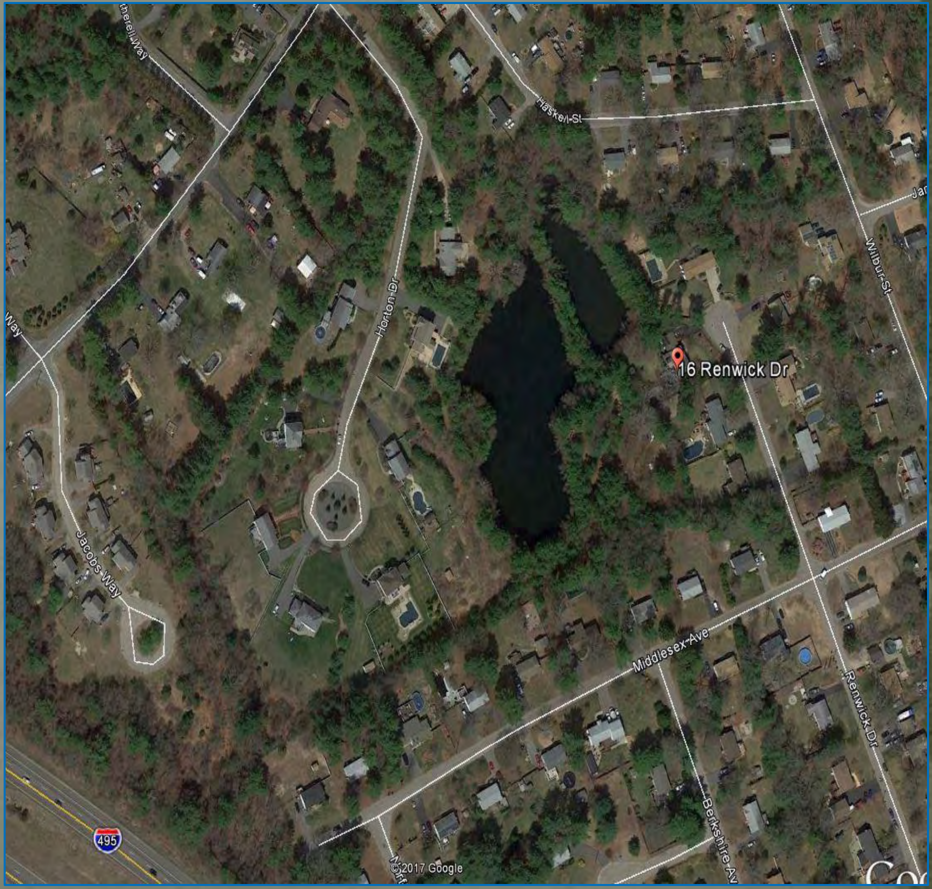


Eastern/Coastal Massachusetts

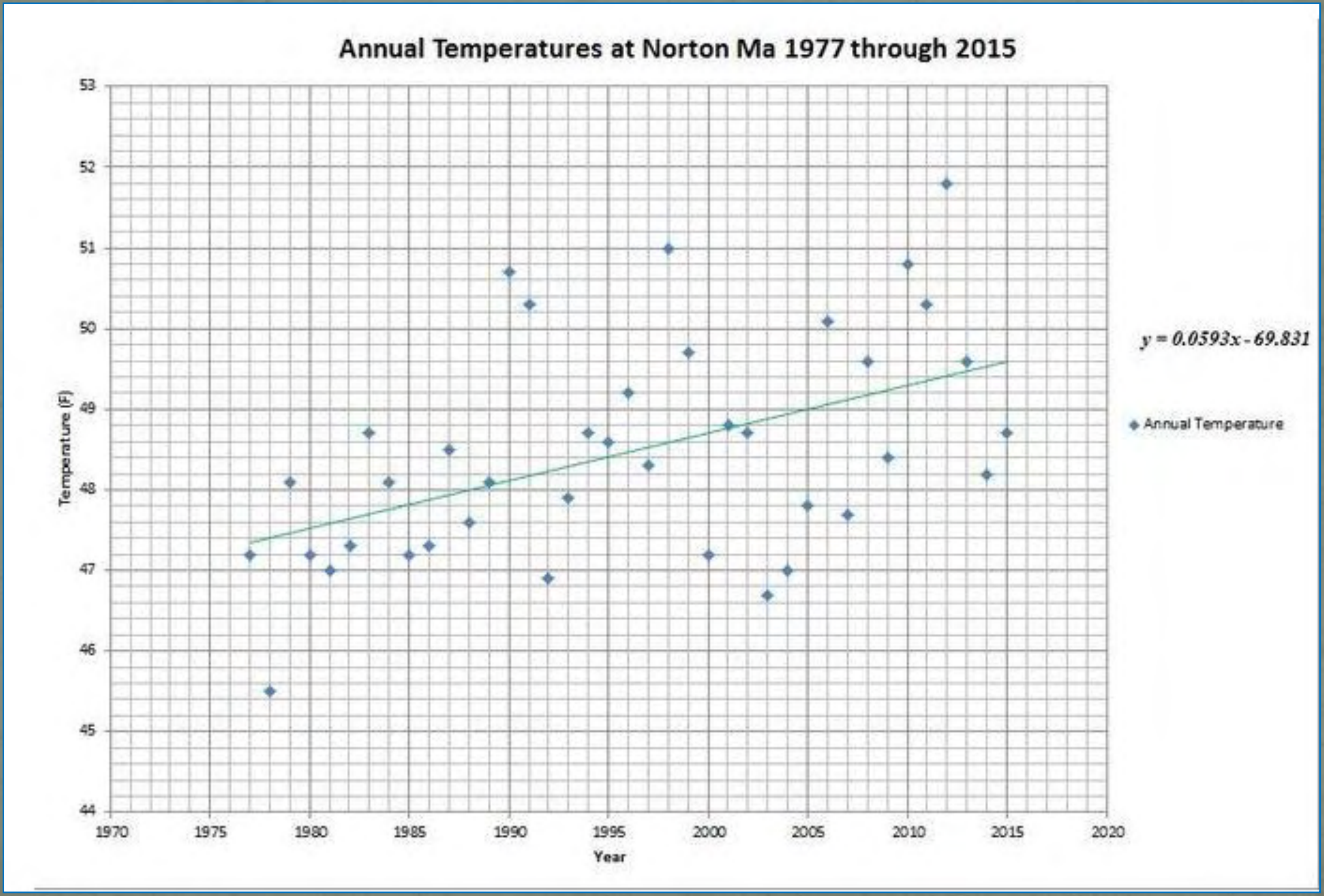
NWS Norton Coop Station Temperatures Vegetation Issues affect Climate Station also

1995

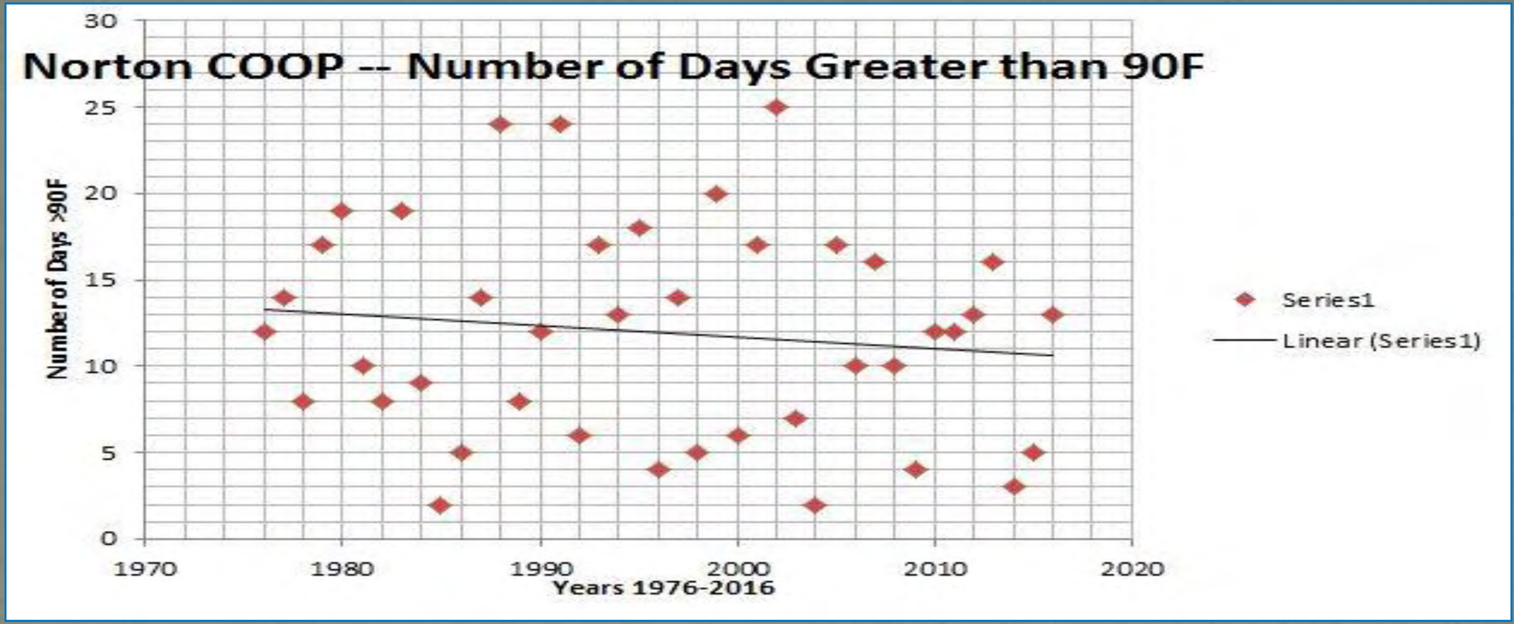
2017

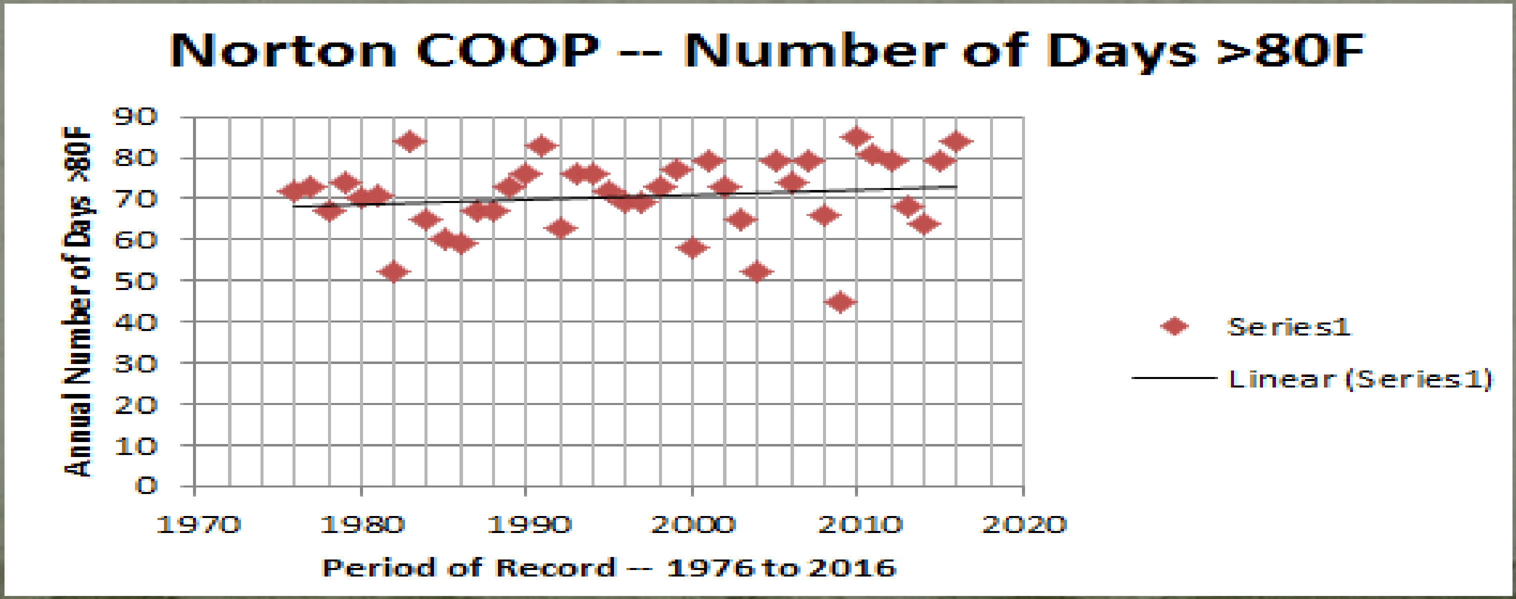


A Norton NWS Station Perspective on Temperatures since 1976

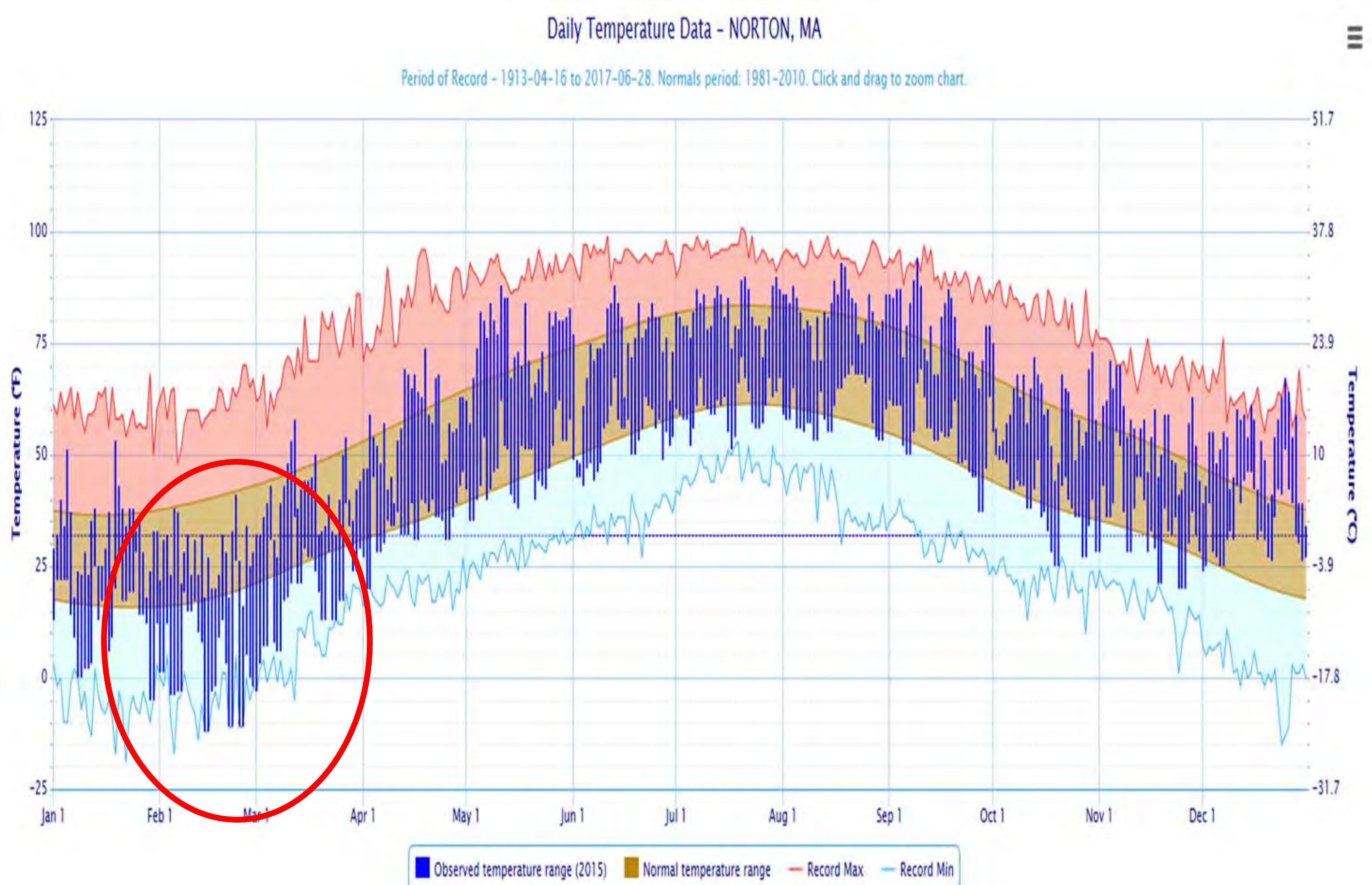


Vegetation Affects on Highest Daytime Temperatures





A Look at Temperature Trends



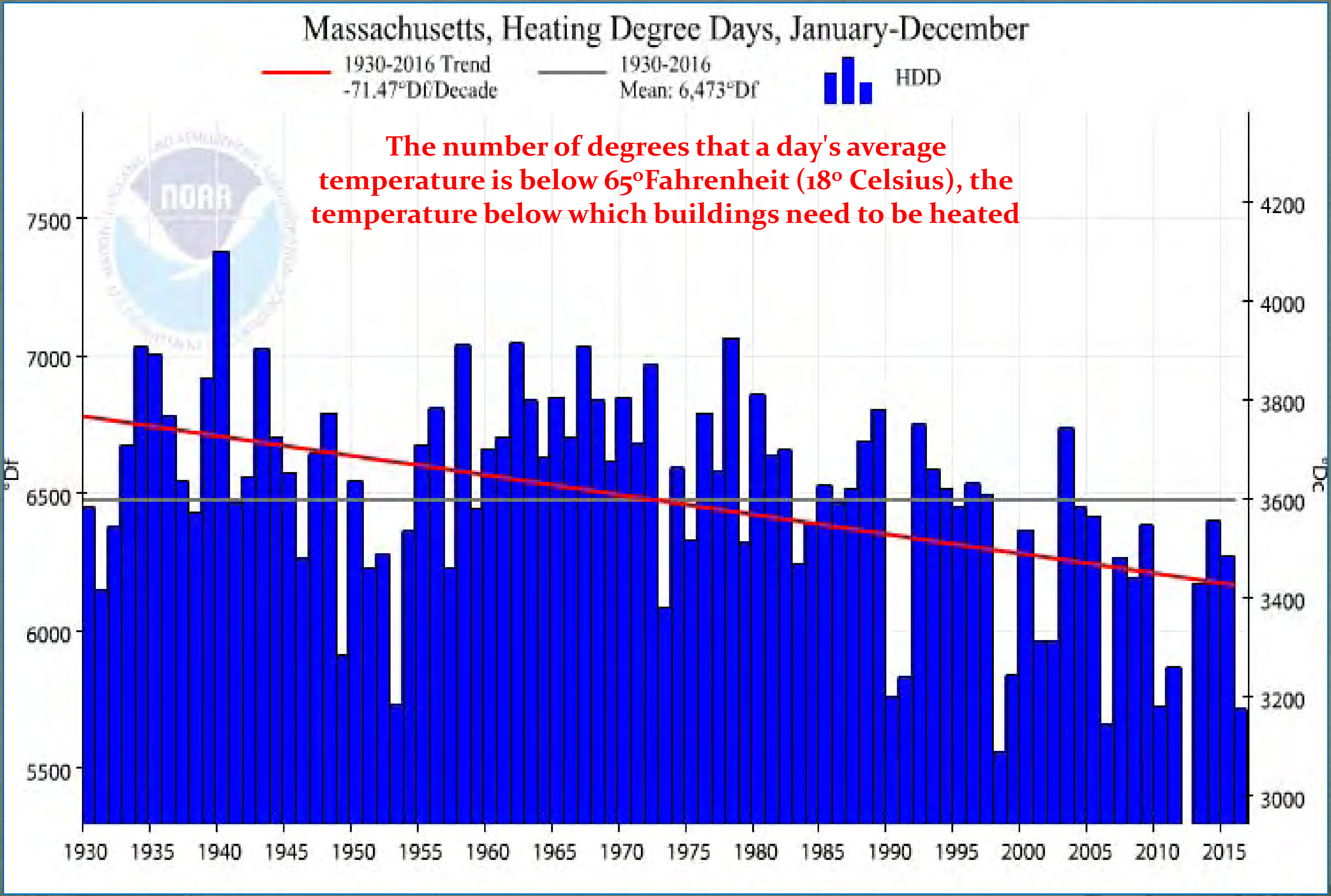
Period of Record Cold – Norton

Climatological Data for NORTON, MA - February 2015

Click column heading to sort ascending, click again to sort descending.

e	Max Temperature	Min Temperature	Avg Temperature	Avg Temperature Departure	HDD	CDD	Precipitation	Snowfall	Snow Depth
2-01	22	1	11.5	-15.3	53	0	T	T	16
2-02	31	1	16.0	-10.9	49	0	0.33	3.9	18
2-03	32	12	22.0	-5.0	43	0	0.55	6.6	25
2-04	23	-4	9.5	-17.6	55	0	0.00	0.0	24
2-05	38	-4	17.0	-10.2	48	0	T	T	23
2-06	37	-3	17.0	-10.3	48	0	0.05	1.0	24
2015-02-07	21	-3	9.0	-18.5	56	0	0.00	0.0	24
2015-02-08	28	19	23.5	-4.1	41	0	0.24	2.9	24
2015-02-09	32	15	23.5	-4.3	41	0	0.27	2.9	26
2015-02-10	23	15	19.0	-8.9	46	0	0.78	10.5	30
2015-02-11	31	17	24.0	-4.1	41	0	T	T	28
2015-02-12	23	10	16.5	-11.8	48	0	0.04	1.0	27
2015-02-13	32	8	20.0	-8.4	45	0	0.02	0.4	27
2015-02-14	18	-12	3.0	-25.6	62	0	0.00	0.0	26
2015-02-15	27	-12	7.5	-21.3	57	0	0.56	11.1	35
2015-02-16	20	-3	8.5	-20.5	56	0	0.08	2.0	34
2015-02-17	20	-2	9.0	-20.2	56	0	0.00	0.0	33
2015-02-18	23	9	16.0	-13.4	49	0	0.10	3.0	34
2015-02-19	32	13	22.5	-7.2	42	0	0.11	2.8	35
2015-02-20	28	3	15.5	-14.4	49	0	T	T	33
2015-02-21	18	-11	3.5	-26.6	61	0	0.00	0.0	32
2015-02-22	33	-11	11.0	-19.4	54	0	0.54	1.7	31
2015-02-23	41	26	33.5	2.9	31	0	0.02	0.2	29
2015-02-24	26	-11	7.5	-23.4	57	0	0.00	0.0	28
2015-02-25	16	-11	2.5	-28.6	62	0	0.14	3.9	31
2015-02-26	34	5	19.5	-11.9	45	0	0.00	0.0	29
2015-02-27	25	0	12.5	-19.2	52	0	0.01	0.2	29
2015-02-28	28	-2	13.0	-19.0	52	0	0.00	0.0	29
Sum	762	65	-	-	1399	0	3.84	54.1	-
Average	27.2	2.3	14.8	-14.1	-	-	-	-	28.0
Normal	40.1	17.8	28.9		1009	0	3.76	10.1	-

Impacts on Energy to Heat or Cool



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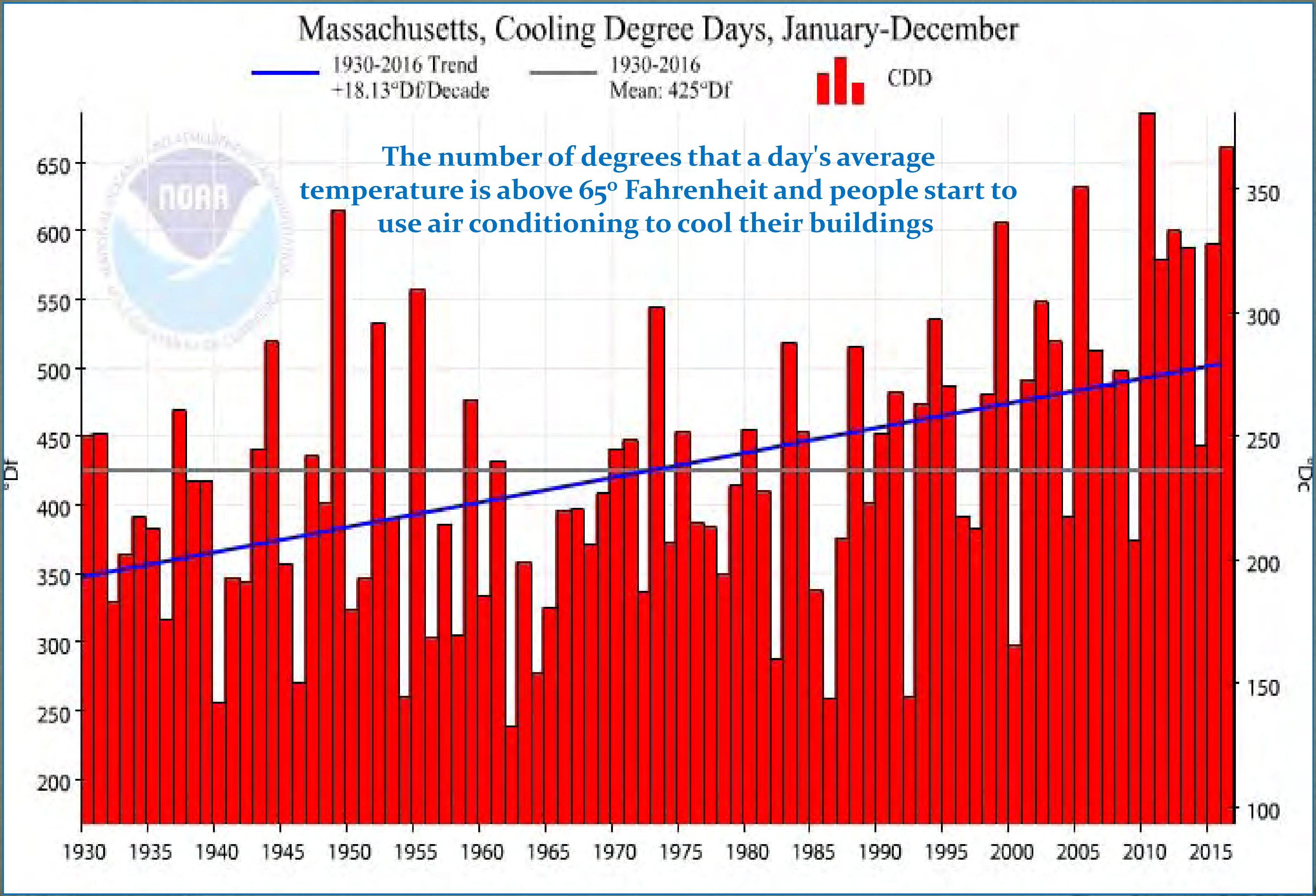
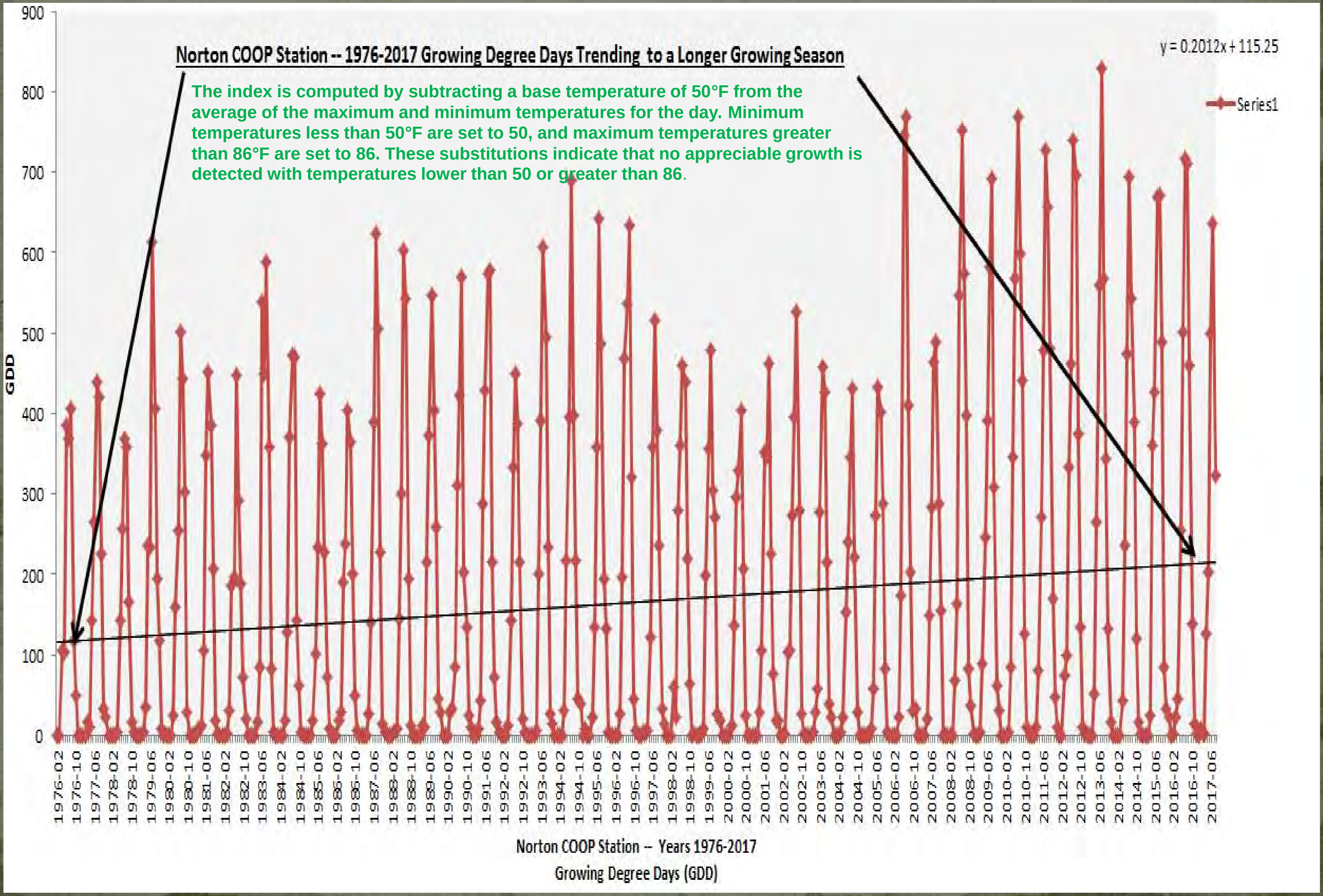
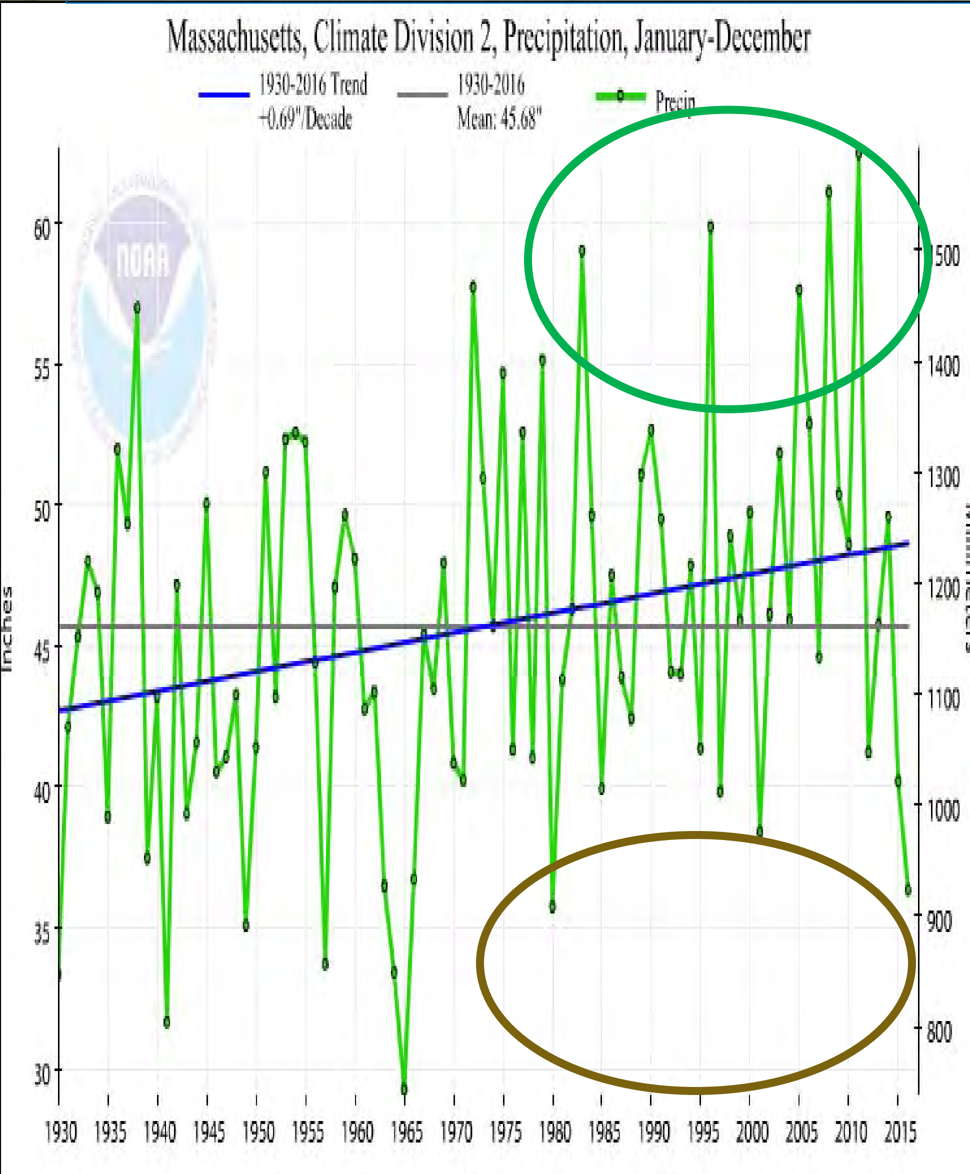


Impacts on Growing Season



A Look at Precipitation Trends

http://www.ncdc.noaa.gov/cag



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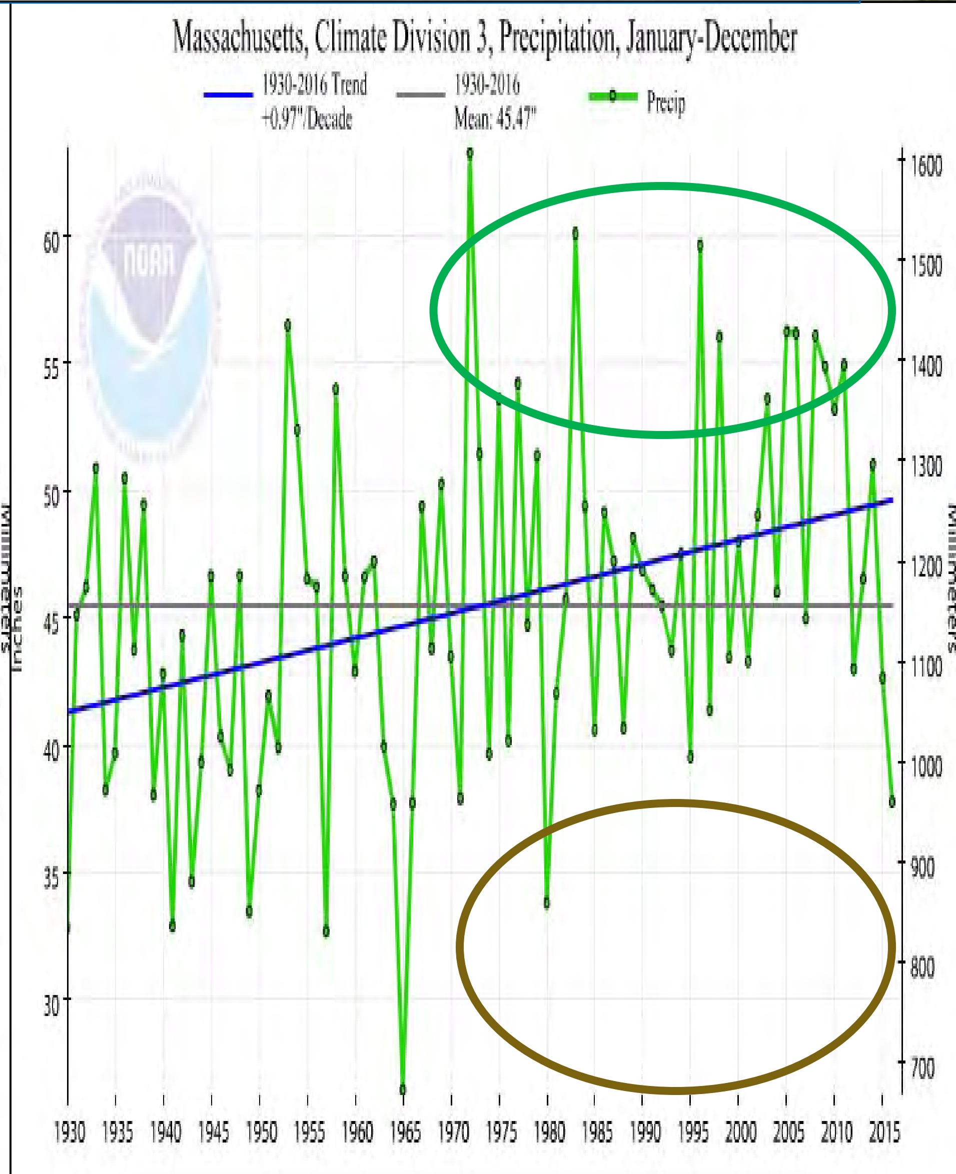
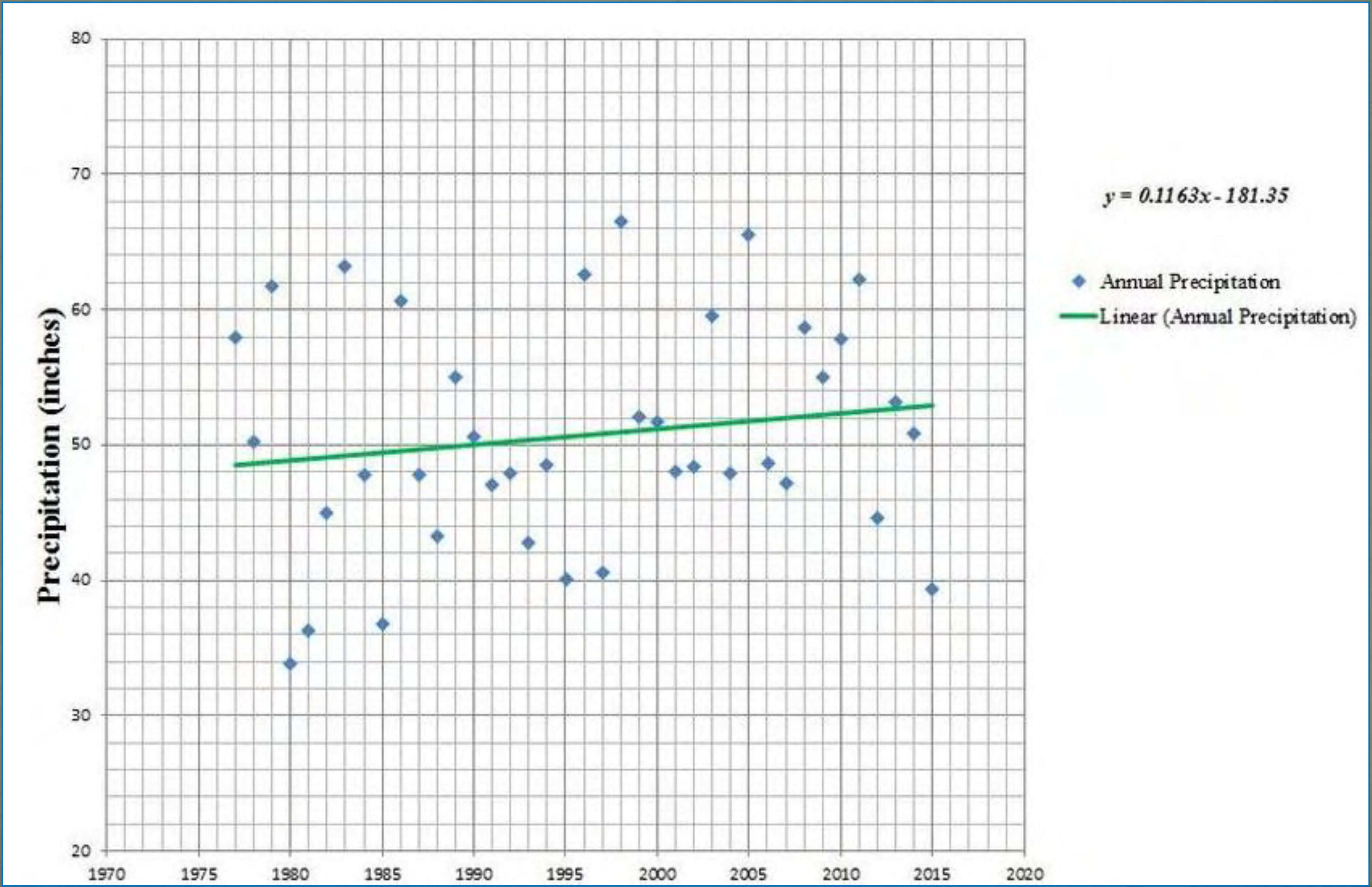
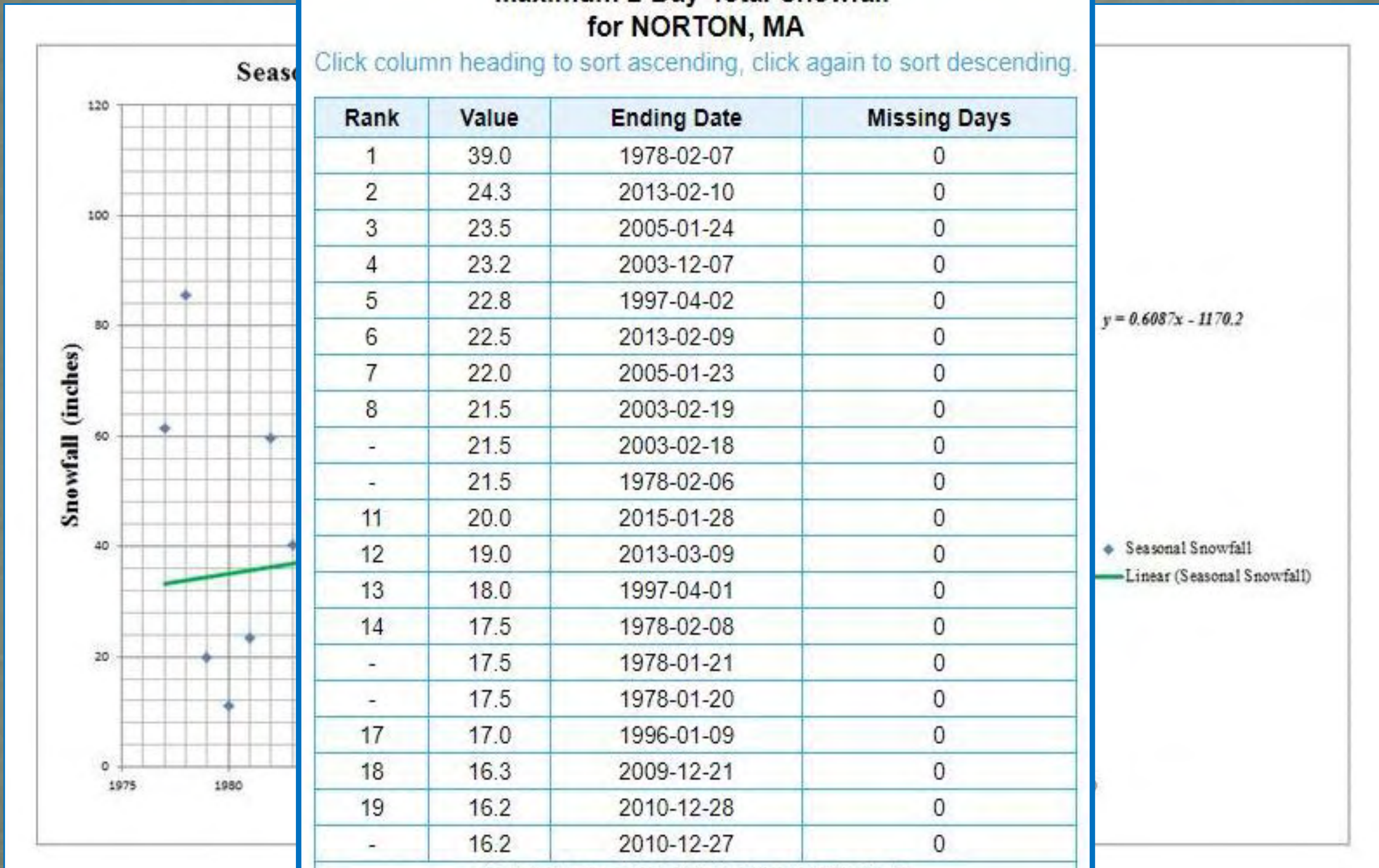


Eastern/Coastal Massachusetts

Norton Perspective on Precipitation



Norton Perspective on Snowfall



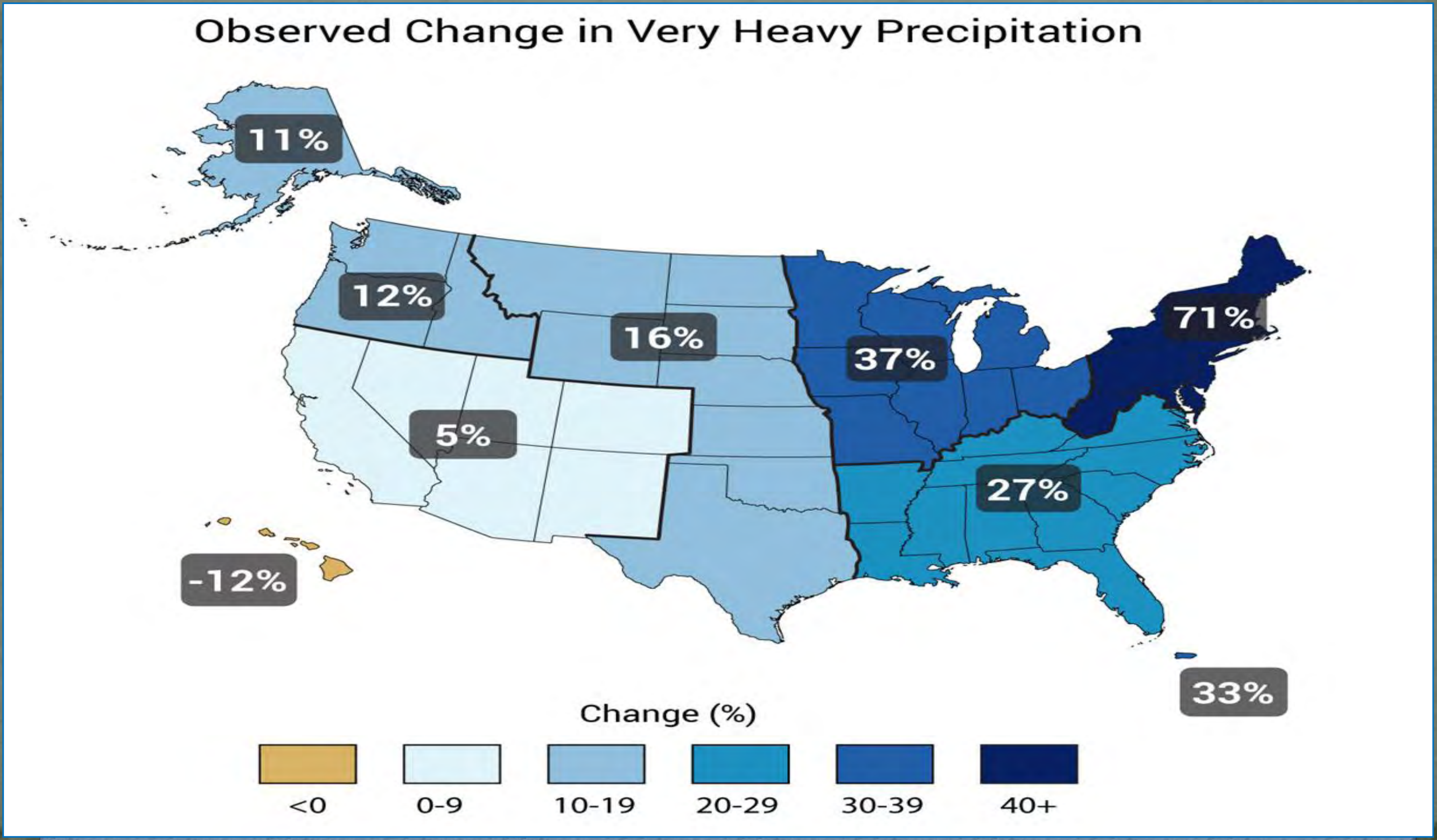
Maximum 2-Day Total Snowfall
for NORTON, MA

Click column heading to sort ascending, click again to sort descending.

Rank	Value	Ending Date	Missing Days
1	39.0	1978-02-07	0
2	24.3	2013-02-10	0
3	23.5	2005-01-24	0
4	23.2	2003-12-07	0
5	22.8	1997-04-02	0
6	22.5	2013-02-09	0
7	22.0	2005-01-23	0
8	21.5	2003-02-19	0
-	21.5	2003-02-18	0
-	21.5	1978-02-06	0
11	20.0	2015-01-28	0
12	19.0	2013-03-09	0
13	18.0	1997-04-01	0
14	17.5	1978-02-08	0
-	17.5	1978-01-21	0
-	17.5	1978-01-20	0
17	17.0	1996-01-09	0
18	16.3	2009-12-21	0
19	16.2	2010-12-28	0
-	16.2	2010-12-27	0
Period of record: 1917-05-01 to 2017-10-06			

Change in frequency of Heavy Precipitation

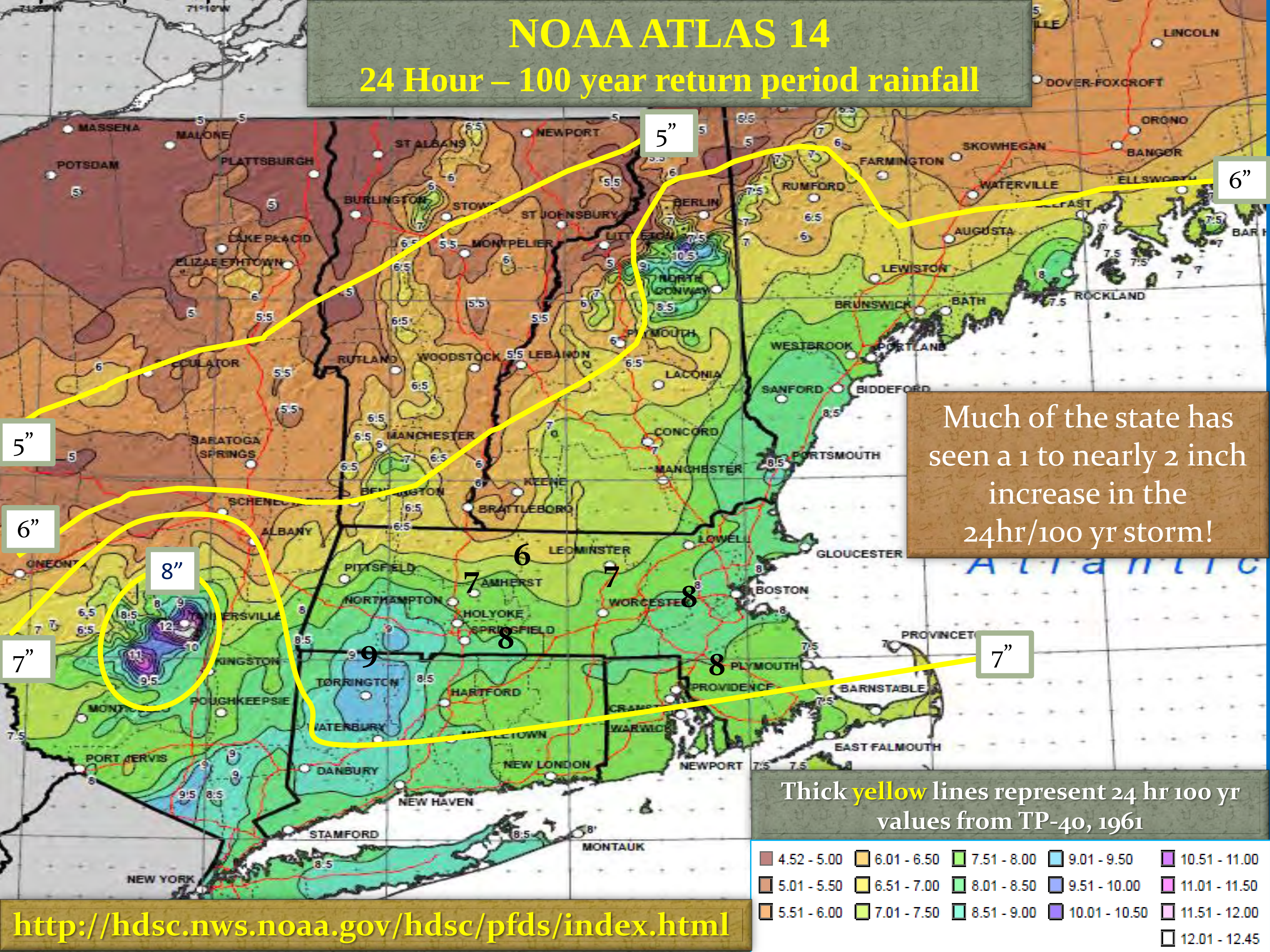
- Intense precipitation events (the heaviest 1%)
- Used to average 6-8 days a year of >1" of rain or more
- Today we are averaging nearly 12-15 days! (Norton 14 days)



Source: http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts

NOAA ATLAS 14

24 Hour – 100 year return period rainfall



Much of the state has seen a 1 to nearly 2 inch increase in the 24hr/100 yr storm!

Thick yellow lines represent 24 hr 100 yr values from TP-40, 1961

http://hdsc.nws.noaa.gov/hdsc/pfds/index.html

Norton Perspective on Heavy Rain events

PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]										
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.307 (0.247-0.375)	0.380 (0.305-0.464)	0.498 (0.399-0.612)	0.597 (0.475-0.737)	0.732 (0.563-0.950)	0.837 (0.629-1.11)	0.941 (0.686-1.30)	1.09 (0.740-1.53)	1.29 (0.837-1.87)	1.44 (0.909-2.13)
10-min	0.435 (0.350-0.531)	0.538 (0.433-0.658)	0.706 (0.566-0.866)	0.845 (0.673-1.04)	1.04 (0.797-1.35)	1.19 (0.891-1.57)	1.33 (0.972-1.85)	1.54 (1.05-2.17)	1.82 (1.19-2.65)	2.04 (1.29-3.01)
15-min	0.511 (0.412-0.625)	0.633 (0.509-0.774)	0.830 (0.666-1.02)	0.995 (0.792-1.23)	1.22 (0.938-1.58)	1.40 (1.05-1.85)	1.57 (1.14-2.17)	1.82 (1.23-2.55)	2.15 (1.39-3.11)	2.39 (1.51-3.54)
30-min	0.715 (0.576-0.873)	0.887 (0.714-1.08)	1.17 (0.937-1.44)	1.40 (1.12-1.73)	1.72 (1.32-2.24)	1.97 (1.48-2.62)	2.22 (1.62-3.07)	2.57 (1.75-3.60)	3.04 (1.97-4.41)	3.39 ([illegible])
60-min	0.918 (0.740-1.12)	1.14 (0.919-1.40)	1.51 (1.21-1.85)	1.81 (1.44-2.23)	2.23 (1.71-2.89)	2.55 (1.92-3.38)	2.87 (2.09-3.97)	3.33 (2.26-4.66)	3.93 (2.55-5.70)	4.38 (2.77-6.48)
2-hr	1.17 (0.946-1.41)	1.47 (1.20-1.79)	1.98 (1.60-2.41)	2.40 (1.92-2.94)	2.97 (2.30-3.83)	3.42 (2.59-4.51)	3.86 (2.84-5.31)	4.51 (3.08-6.26)	5.37 (3.51-7.71)	6.02 (3.83-8.81)
3-hr	1.35 (1.10-1.64)	1.71 (1.39-2.07)	2.30 (1.86-2.79)	2.79 (2.24-3.40)	3.46 (2.69-4.43)	3.97 (3.02-5.22)	4.49 (3.32-6.15)	5.25 (3.60-7.25)	6.26 (4.10-8.93)	7.02 (4.49-10.2)
6-hr	1.78 (1.46-2.14)	2.22 (1.82-2.67)	2.94 (2.40-3.54)	3.53 (2.86-4.27)	4.34 (3.40-5.52)	4.97 (3.80-6.46)	5.60 (4.15-7.58)	6.50 (4.49-8.88)	7.69 (5.08-10.9)	8.59 (5.52-12.3)
12-hr	2.35 (1.94-2.80)	2.85 (2.35-3.40)	3.67 (3.02-4.39)	4.35 (3.55-5.23)	5.29 (4.16-6.64)	6.01 (4.62-7.71)	6.73 (5.00-8.96)	7.69 (5.35-10.4)	8.97 (5.97-12.5)	9.94 (6.43-14.1)
24-hr	2.88 (2.40-3.41)	3.47 (2.88-4.11)	4.44 (3.67-5.27)	5.24 (4.31-6.25)	6.34 (5.02-7.90)	7.19 (5.56-9.14)	8.04 (6.01-10.6)	9.17 (6.42-12.3)	10.7 (7.14-14.7)	11.8 (7.68-16.6)
2-day	3.27 (2.74-3.84)	3.99 (3.34-4.69)	5.17 (4.31-6.10)	6.15 (5.09-7.29)	7.50 (5.98-9.28)	8.54 (6.66-10.8)	9.58 (7.24-12.6)	11.0 (7.77-14.6)	13.0 (8.73-17.7)	14.4 (9.46-20.1)

4.7”

NRNM3 - Norton Coop Station 2016

NOAA Atlas-14 Replaces TP-40

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL WEATHER SERVICE
1325 East-West Highway
Silver Spring, Maryland 20910-3283

March 21, 2016

To Whom It May Concern

Reference: NOAA Precipitation Frequency Estimates for the Northeastern States

This letter is to confirm that the precipitation frequency estimates for the states of Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont published in the NOAA Atlas 14 Volume 10: *Precipitation-Frequency Atlas of the United States, Northeastern States* supersede corresponding estimates from the following publications:

a. Weather Bureau's Technical Paper No. 40: *Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years* (Hershfield, 1961);

b. Weather Bureau's Technical Paper No. 49: *Two- to Ten-Day Precipitation for Return Periods of 2 to 100 Years in the Contiguous United States* (Miller, 1964);

c. NOAA Technical Memorandum NWS HYDRO-35: *Five- to 60-Minute Precipitation Frequency for the Eastern and Central United States* (Frederick et al., 1977).

NOAA Atlas 14 Volume 10 precipitation frequency estimates with supplementary information were published on September 30, 2015 and are available for download from the NOAA/NWS/ Hydrometeorological Design Studies Center's Precipitation Frequency Data Server (PFDS) web page.

For any further questions, please contact hdsc.questions@noaa.gov.

Sincerely,

Sanja Perica

Sanja Perica, PhD
Director, Hydrometeorological Design Studies Center
National Water Center, NWS, NOAA

NOAA Atlas-14 Northeast

http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=ma

Norton Historic Rainfall Information (1913-2016)

https://www.ncdc.noaa.gov/IPS/coop/coop.html?_page=2&state=MA&foreign=false&selectedCoopId=195984&_target3=Next+%3E

Norton Rainfall Data using NOAA Atlas-14

http://hydromet.weebly.com/1hr-rainfall.html

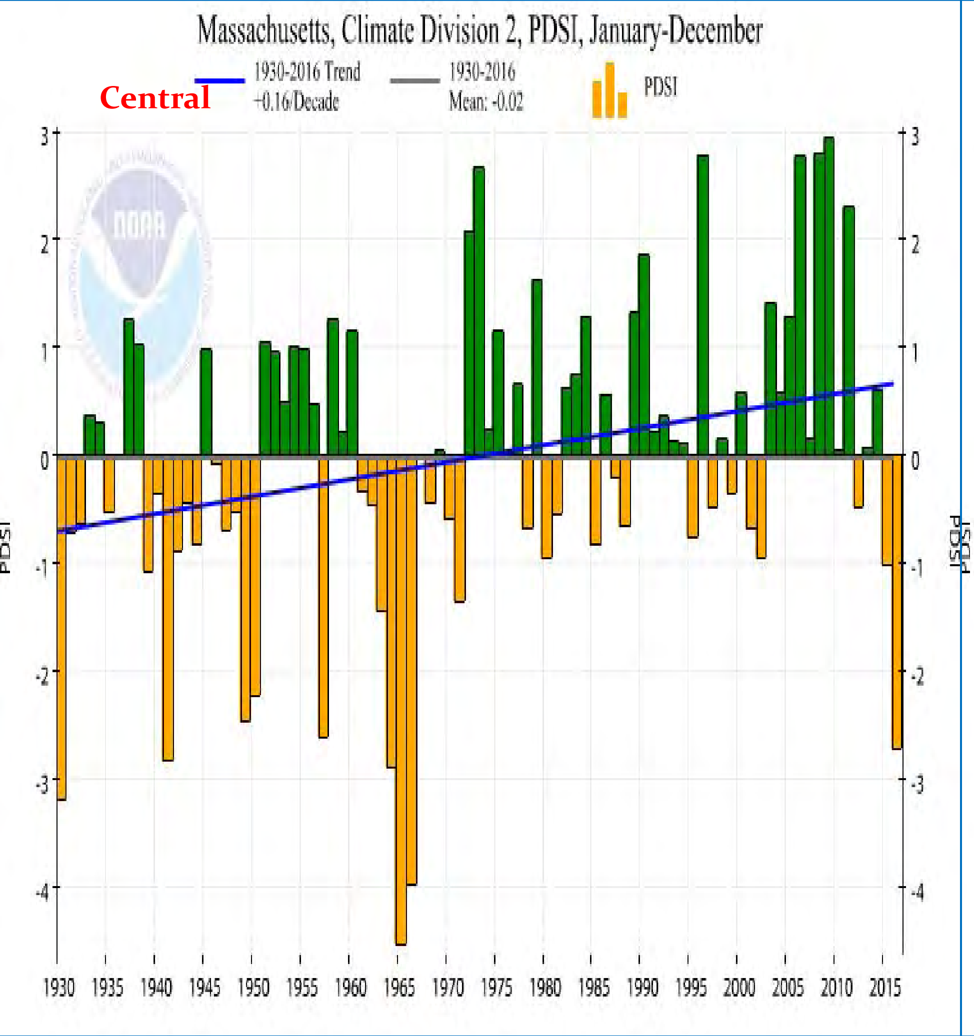
Norton Current Weather Information

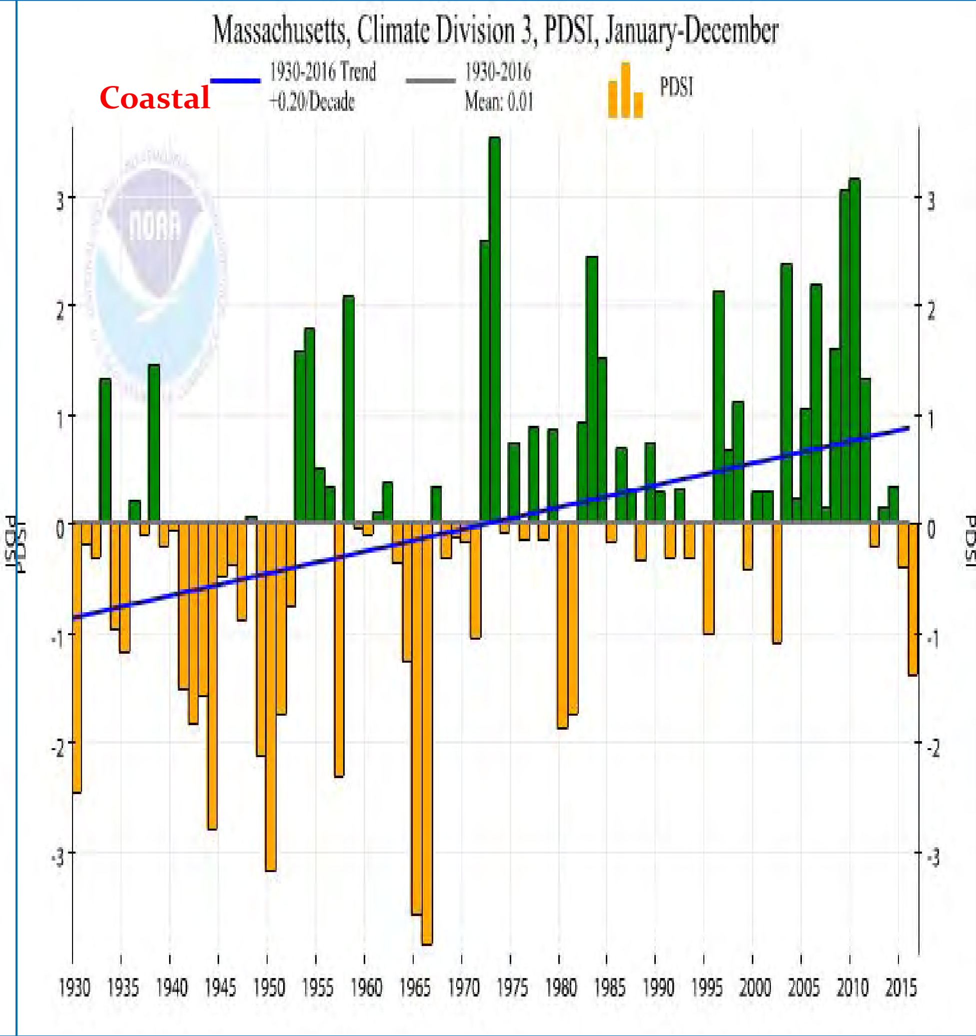
http://hydromet.weebly.com/

Changes in the Palmer Drought Index

http://www.ncdc.noaa.gov/cag

The Palmer Drought Severity Index (PDSI) uses readily available temperature and precipitation data to estimate relative dryness. It is a standardized index that spans -10 (dry) to +10 (wet). It has been reasonably successful at quantifying long-term drought.

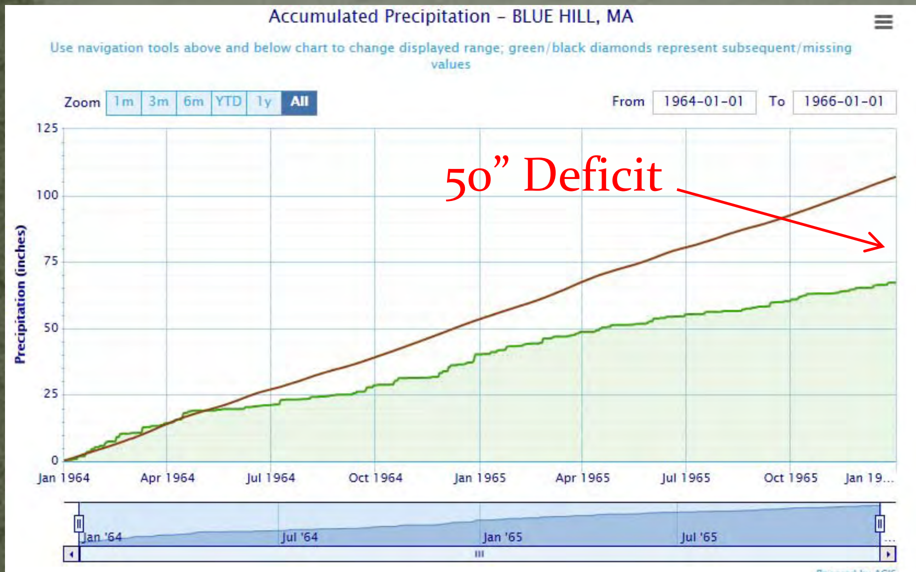


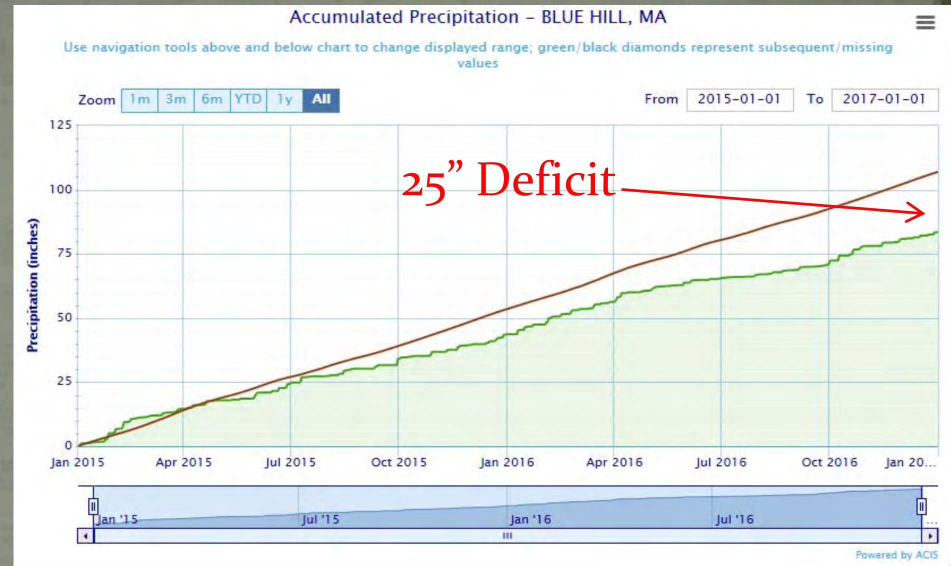


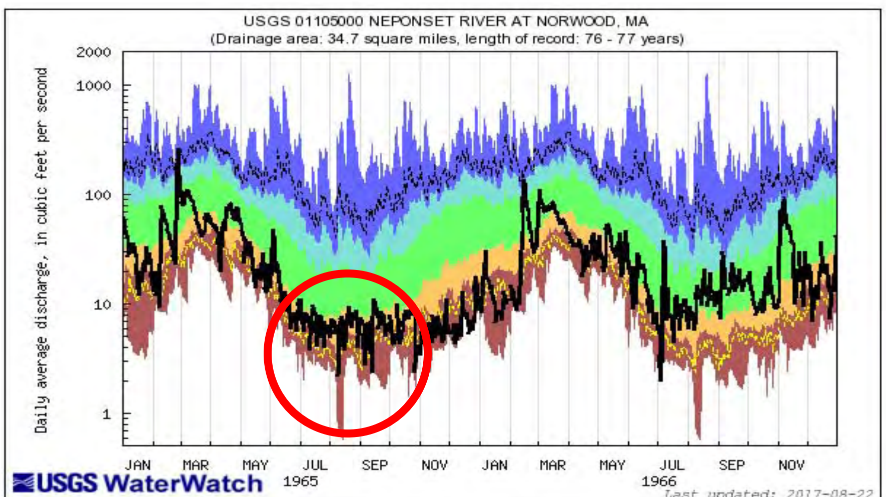
Since the late 60s, similar signature of much shorter, mostly less intense dry periods and longer higher amplitude wet periods

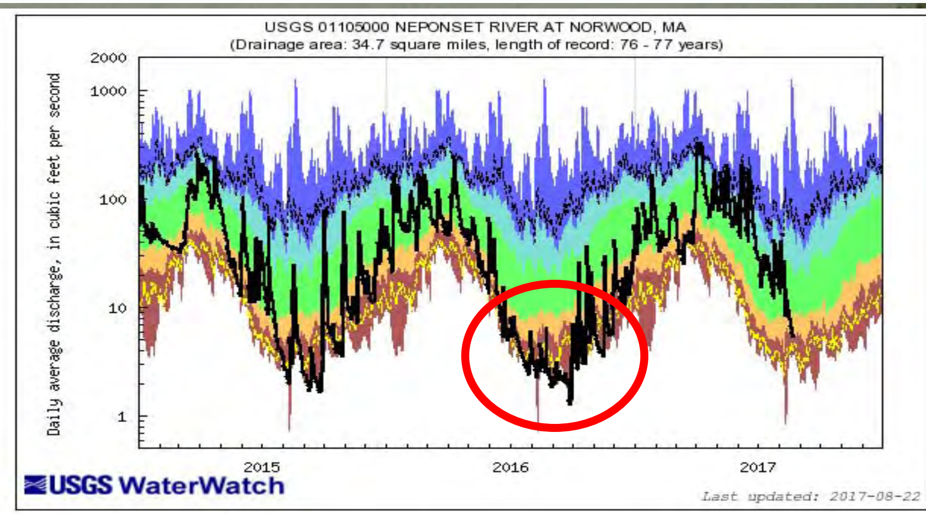
Local Basin Development/Drought/Use

Norwood, MA

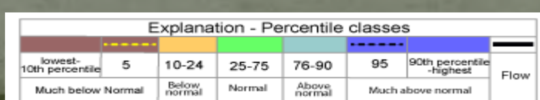






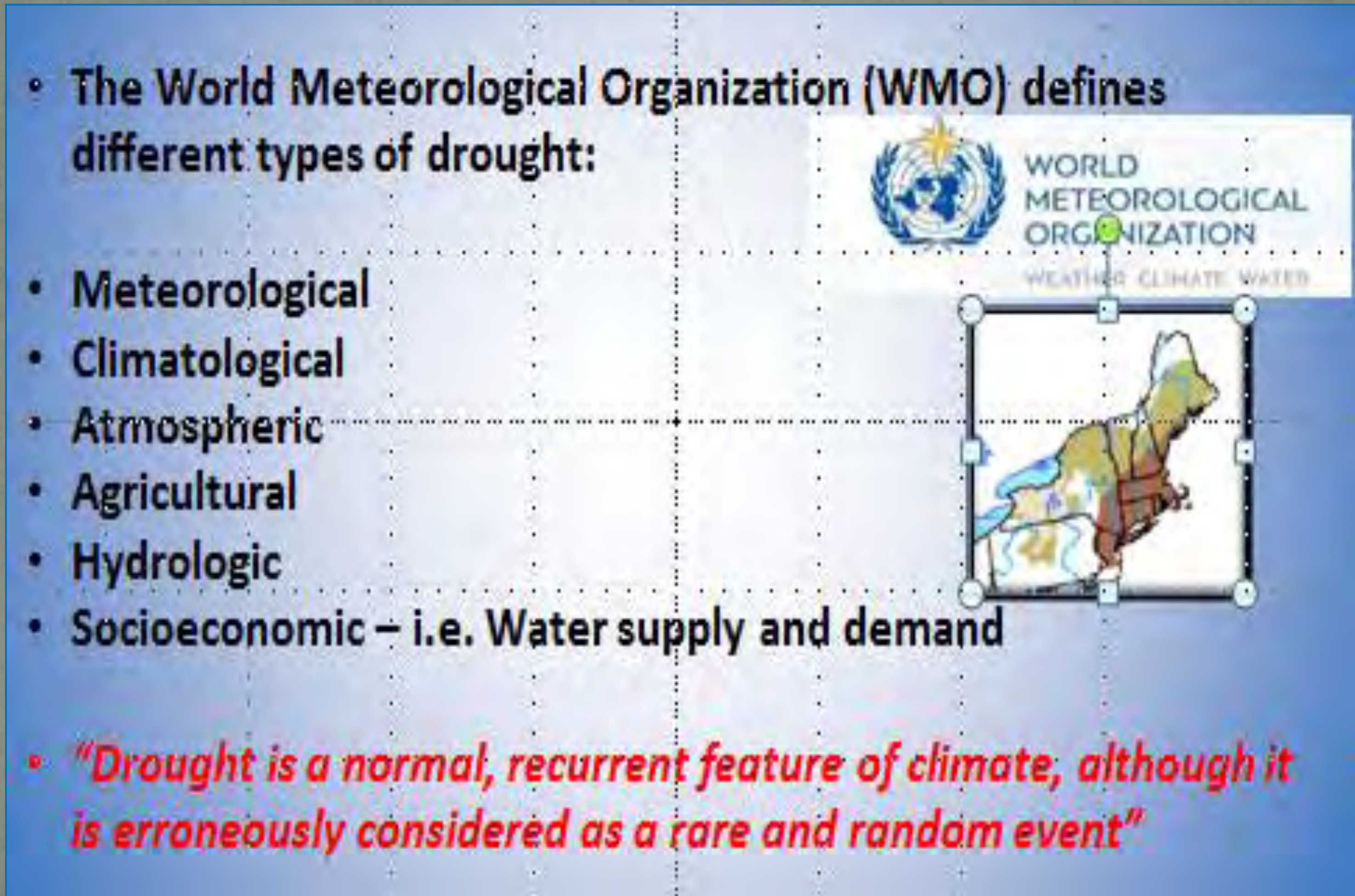


1960s Drought

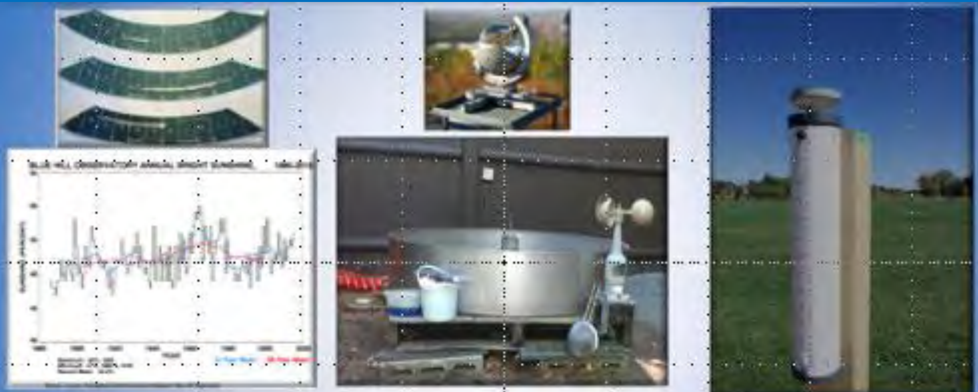


2015-2017 Drought

Drought – many ways to define it!



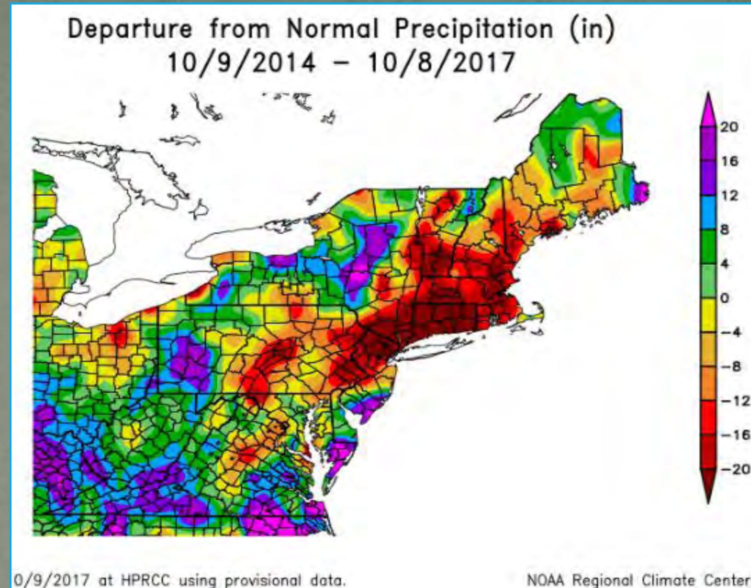
Water Budget Concerns



- 2016
  Bright shine ++
  Solar Production ++

2016
Lake Evaporation
JJA – 20-25% increase
JJA - Near 20"

2016
Evapotranspiration
Increase/Decrease
Vegetation Stress



- But.....with Normal Precip of +50"/yr......
- -25" goes to streamflow to the Atlantic
- -25" goes to ET/+Evaporation/GW/Sub (usage/diversion)
- Almost all got short-changed in 2016
- Now drought indices are "Normal" **EXCEPT**
- Weather pattern and water usage "key" during "AG" YR

Current conditions -- Local

<u>2017 Progressively DRY</u>

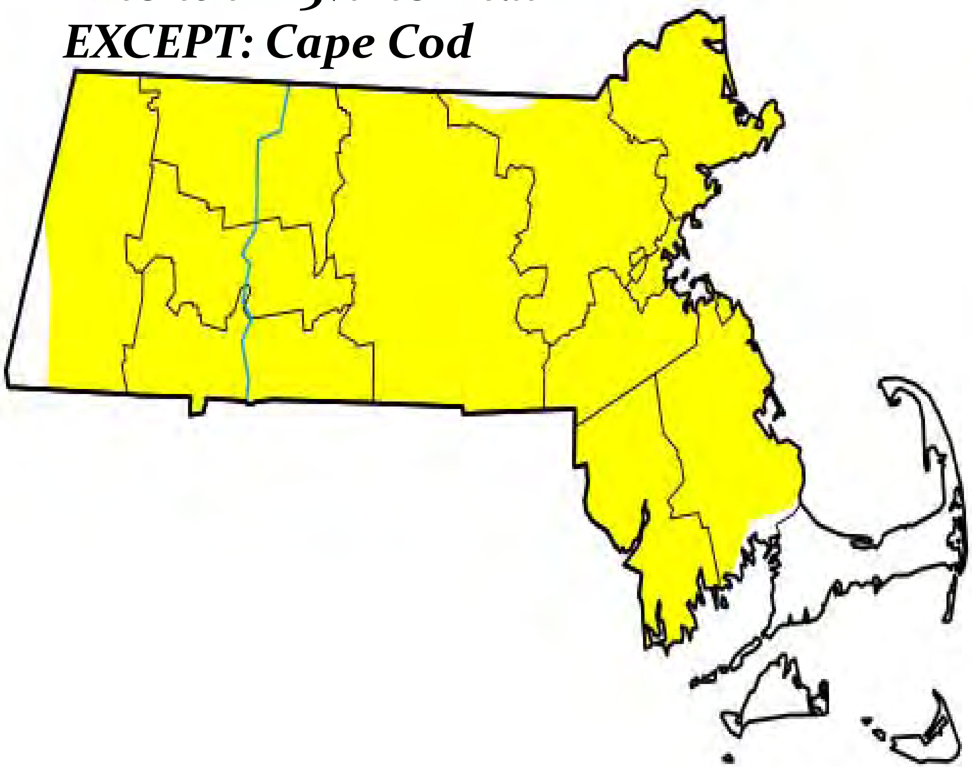
Annual - 90-100% normal

6 Months - 80-90% normal

3 months - 50-80% normal

1 month - 25% normal

EXCEPT: Cape Cod



Intensity:

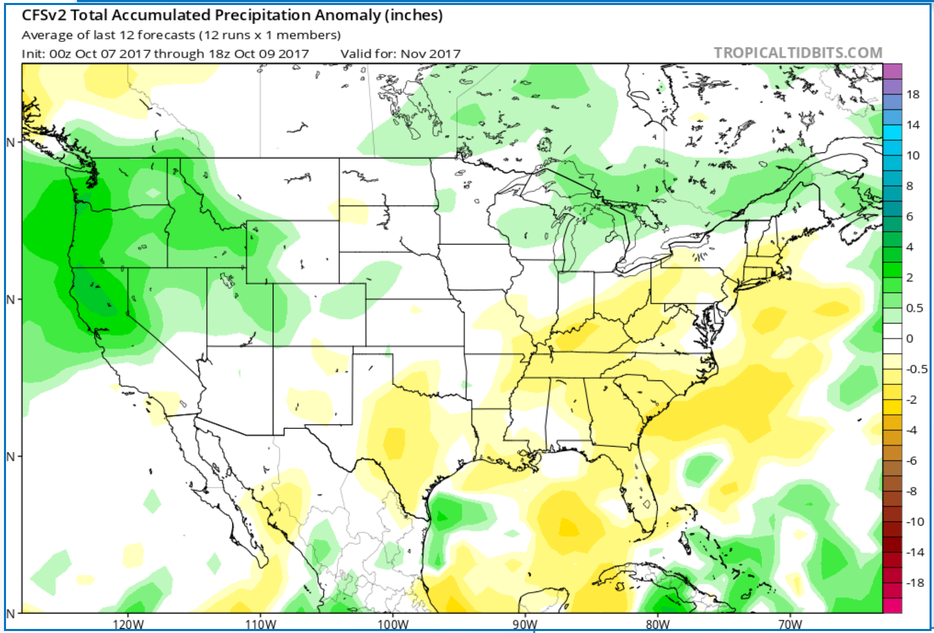
- None
- D0 (Abnormally Dry)
- D1 (Moderate Drought)
- D2 (Severe Drought)
- D3 (Extreme Drought)
- D4 (Exceptional Drought)

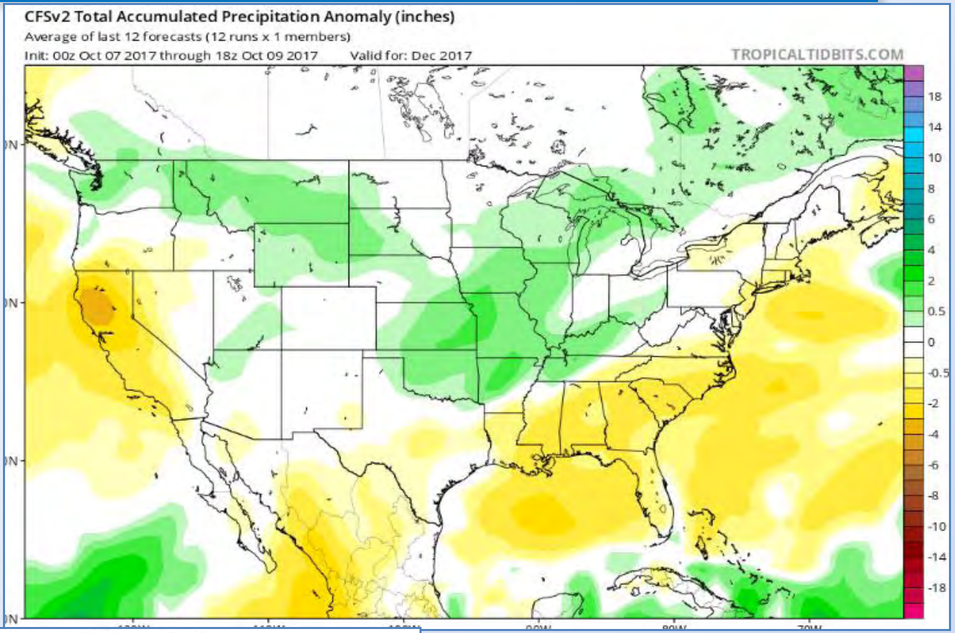
Author(s):

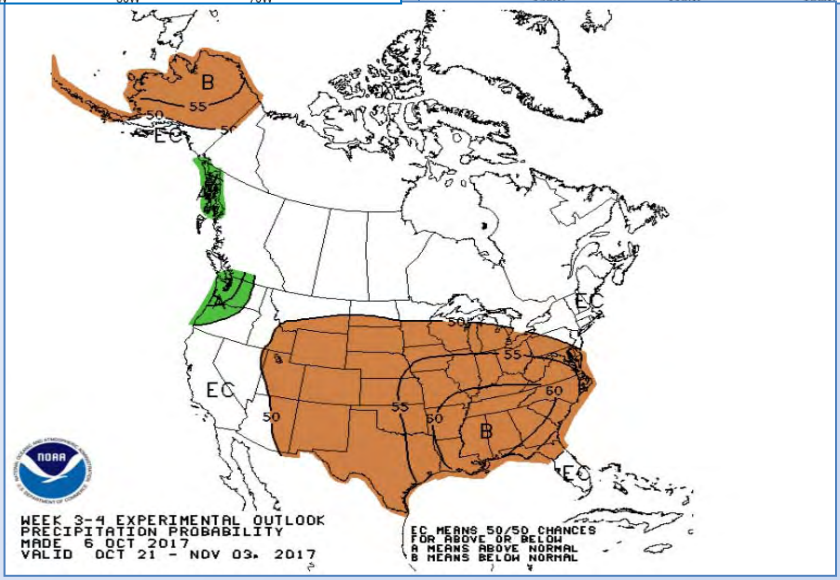
Anthony Artusa, NOAA/NWS/NCEP/CPC

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Climate Model Trends – CFSv2

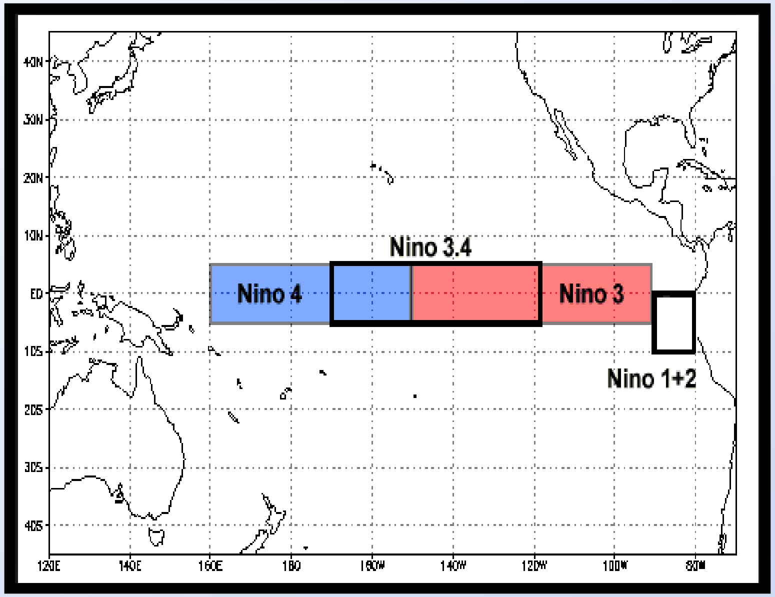






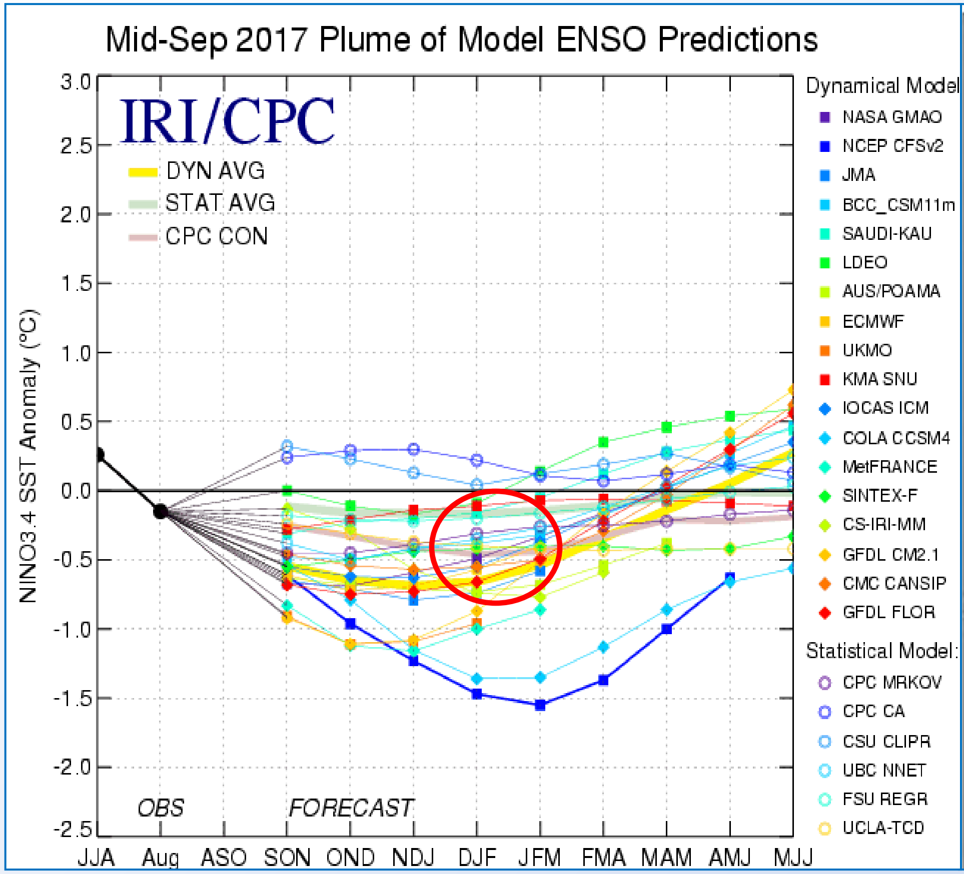
Pattern Recognition --Teleconnections

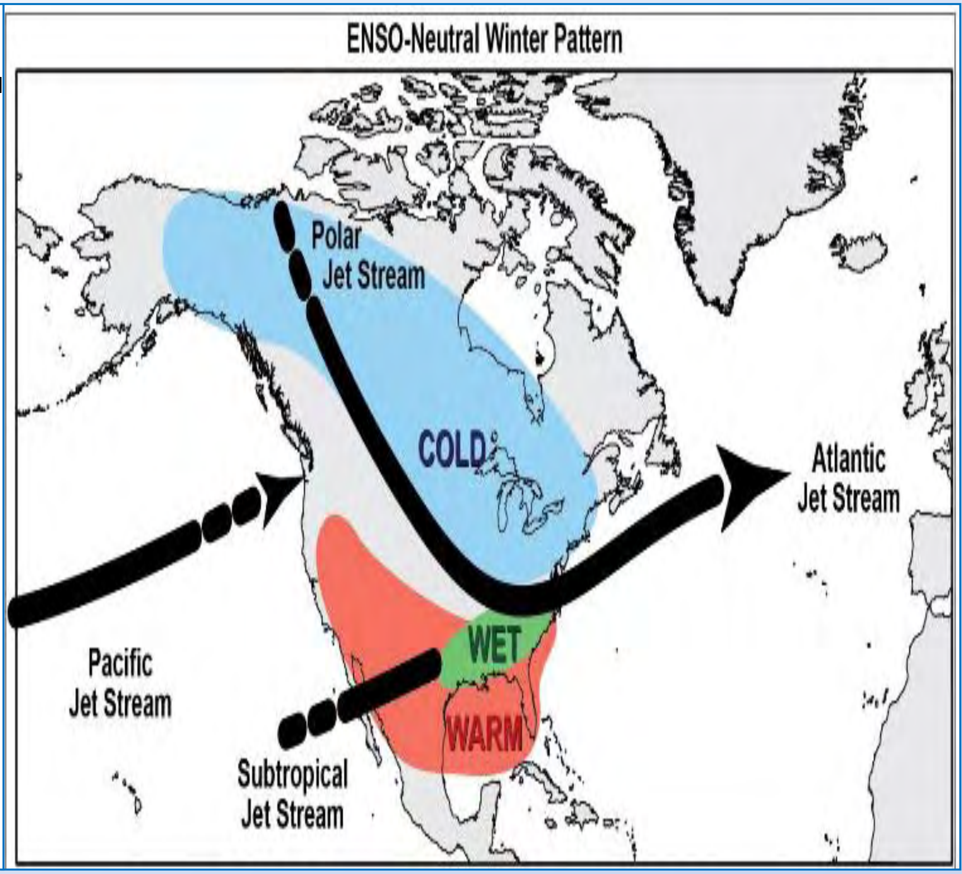
– Affect Precip/Temp Can Have Implications on River Flow



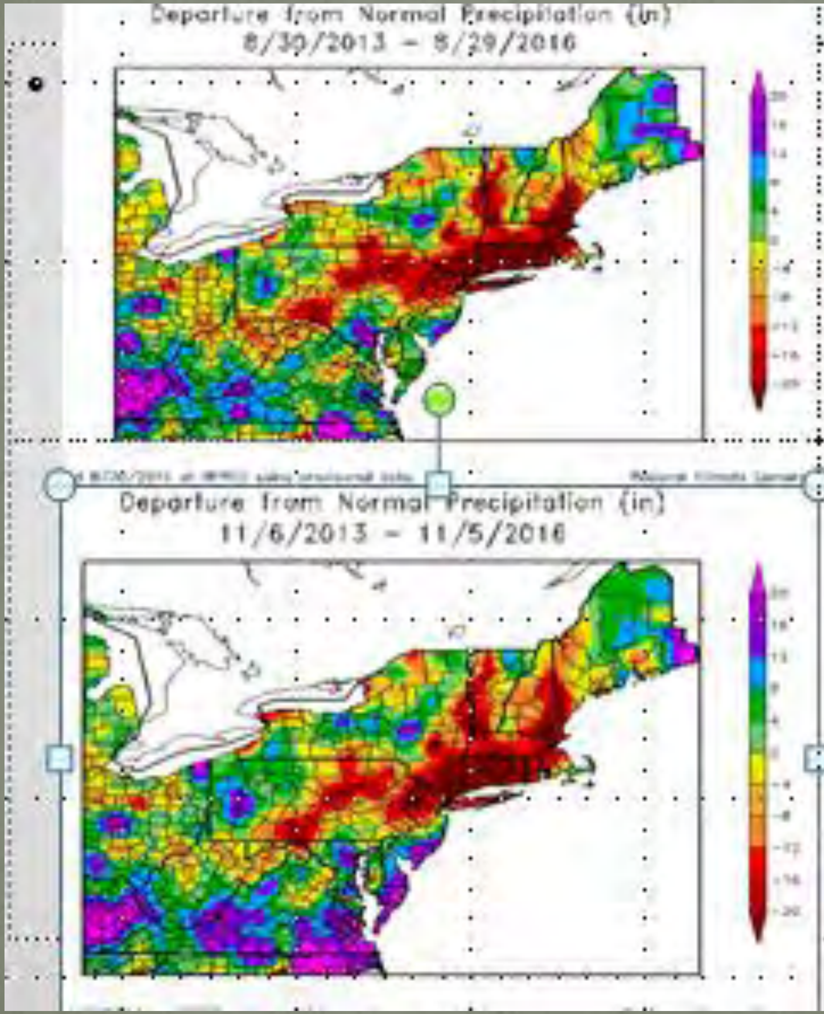
- El Nino Southern Oscillation (ENSO)
- North Atlantic Oscillation (NAO)
- Arctic Oscillation (AO)
- East Pacific Oscillation (EPO)
- Pacific North American Index (PNA)
- SST Anomalies (SSTA) Pacific/Atlantic
- Pacific Decadal Oscillation (PDO)
- Atlantic Multi-Decadal Oscillation (AMO)
- Quasi-Biennial Oscillation (QBO)
- Southern Oscillation Index (SOI)
- Madden-Julian Oscillation (MJO)
- Stratospheric Trends and Temp Anomalies
- Solar Trends – geomagnetic activity, solar flux, sunspots
- Pattern Persistence – Analog Years

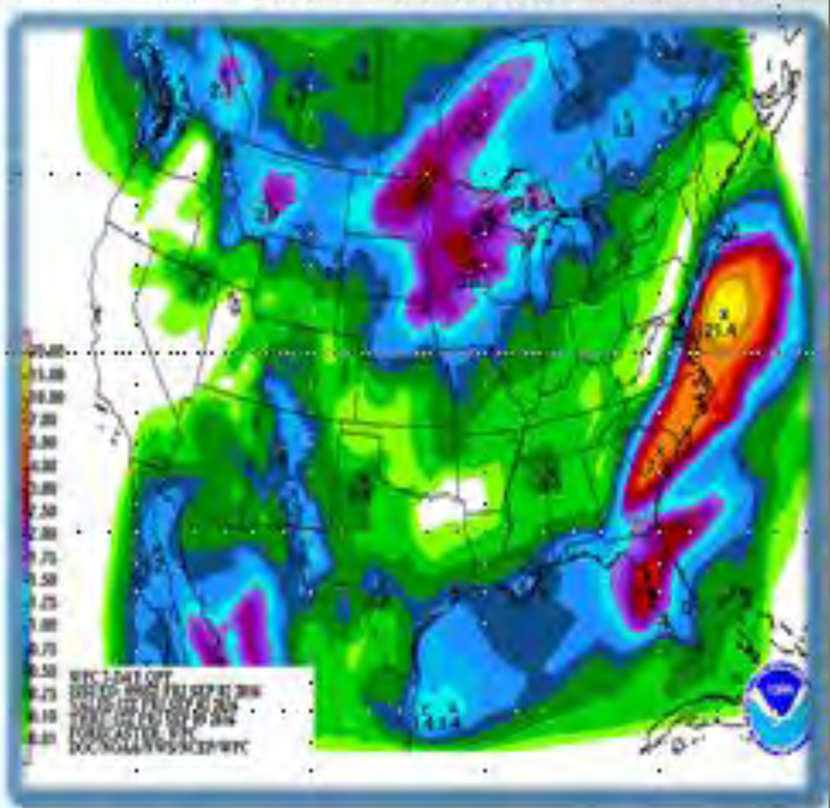
ENSO Update – Weak La Nina to La Nada



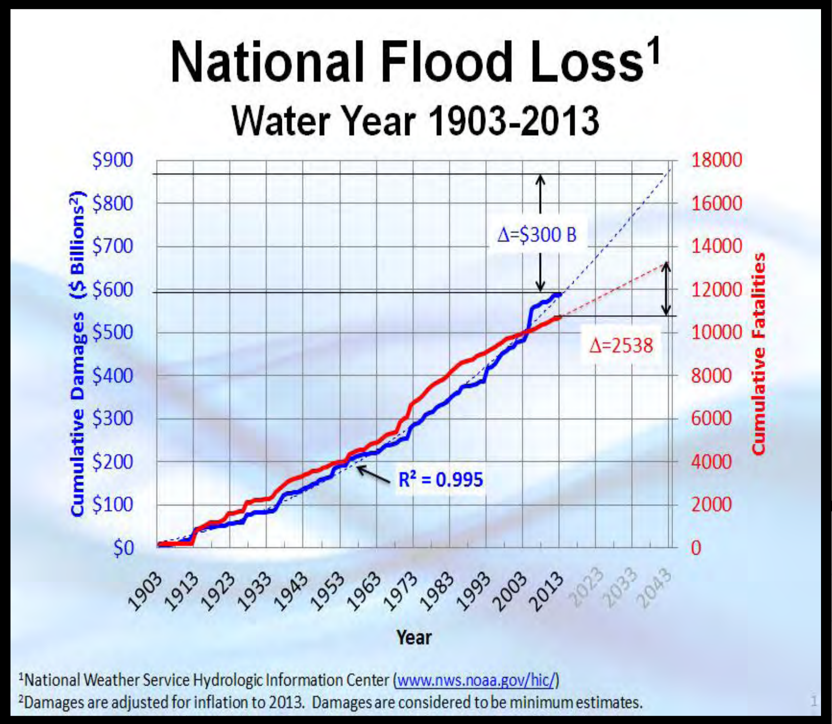


Do all Droughts end with a Flood? Fact or Folklore

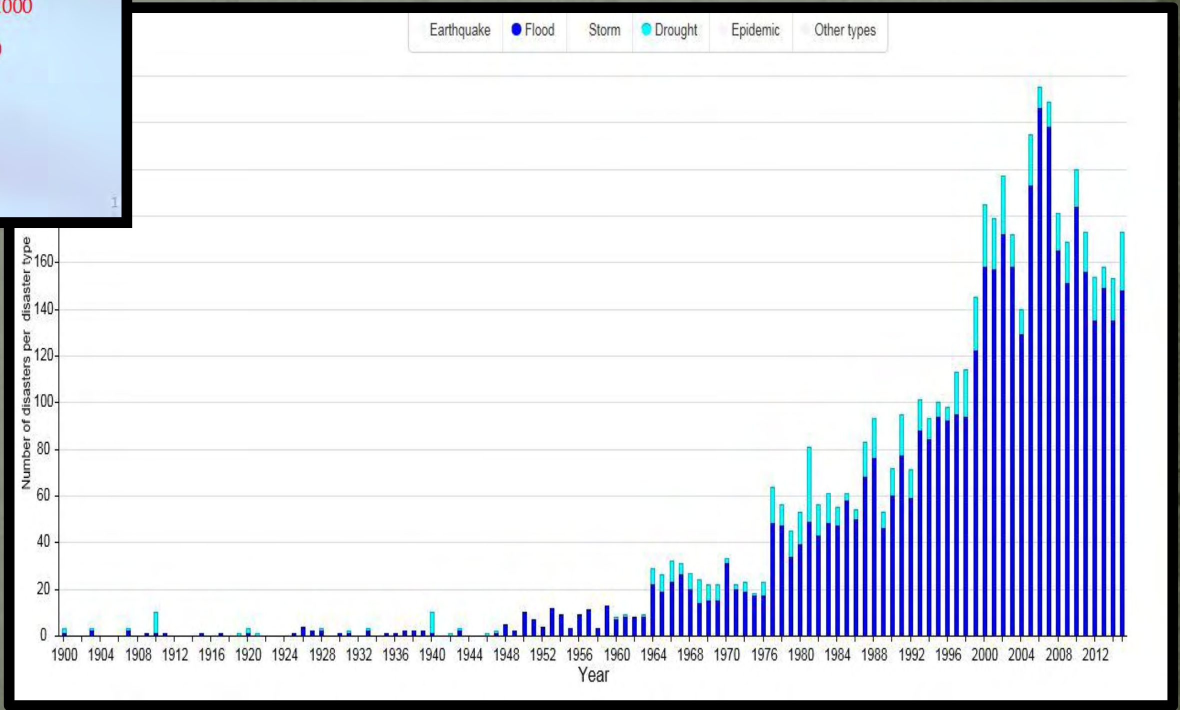




Nationally – increased flood events/losses



The trend in these disasters is clearly up and that reflects more extreme weather events, including more 'big rain' events that show up as flooding, and also reflects where people live and how valuable their assets are," Deke Arndt, chief of the climate monitoring branch of [NOAA National Climate Data Center] 2017

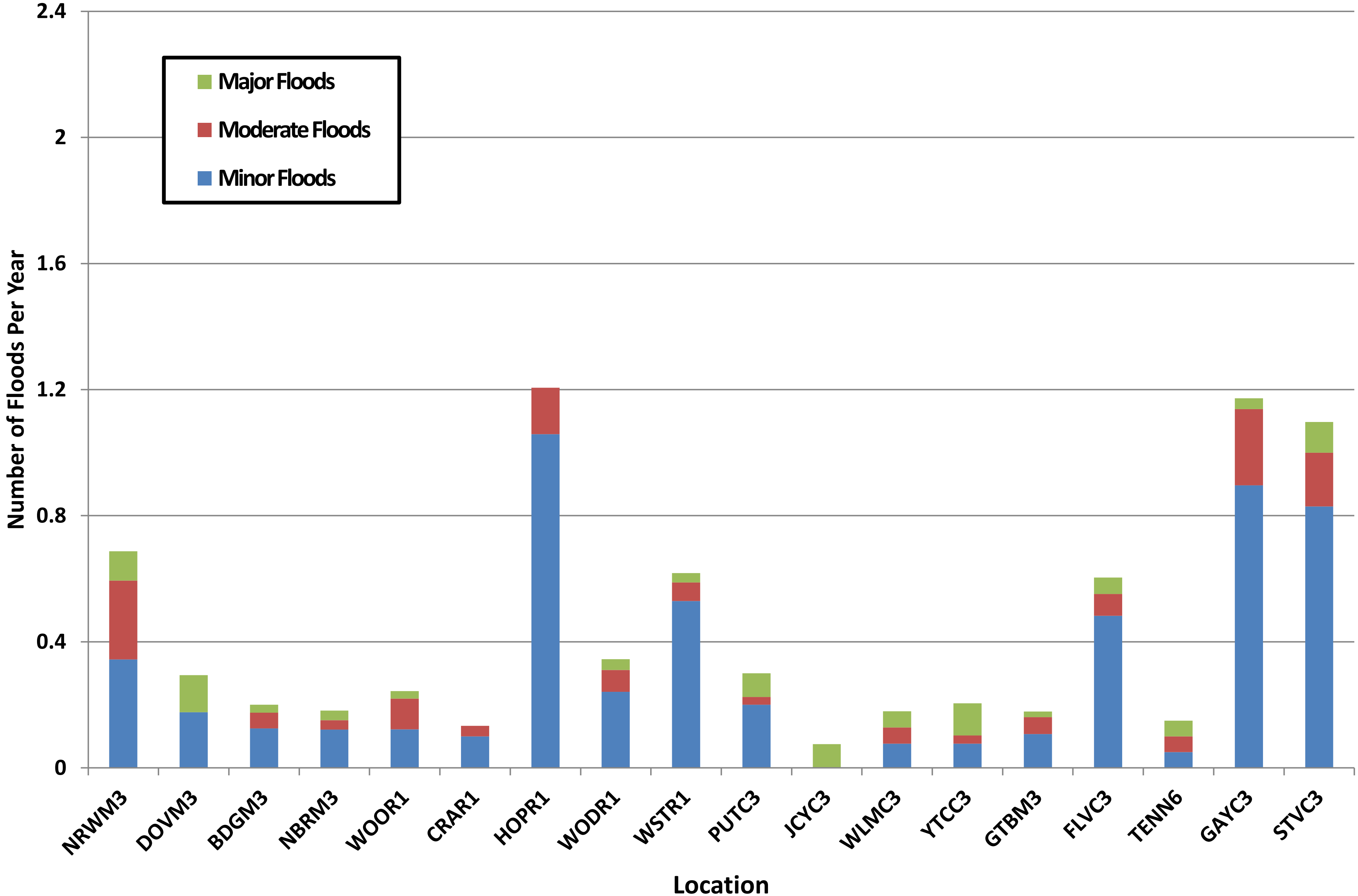


2017 Great Flood Disasters

--California
--Missouri-Arkansas
--Texas/Louisiana
--Florida/Georgia
--Puerto Rico/US Virgin Islands

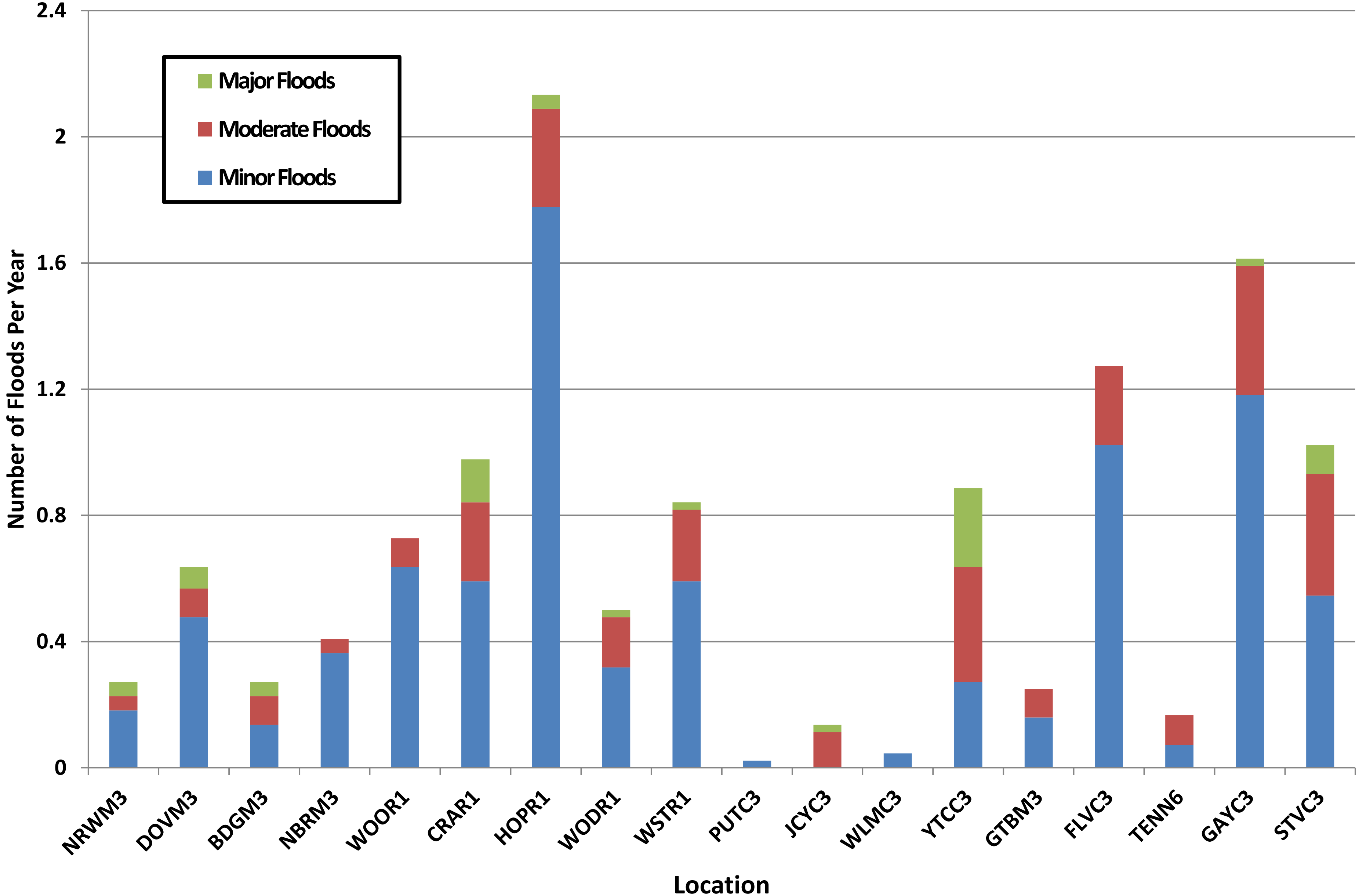
Southern New England River Basin Normalized Number of Minor, Moderate, and Major Floods Prior to 1970

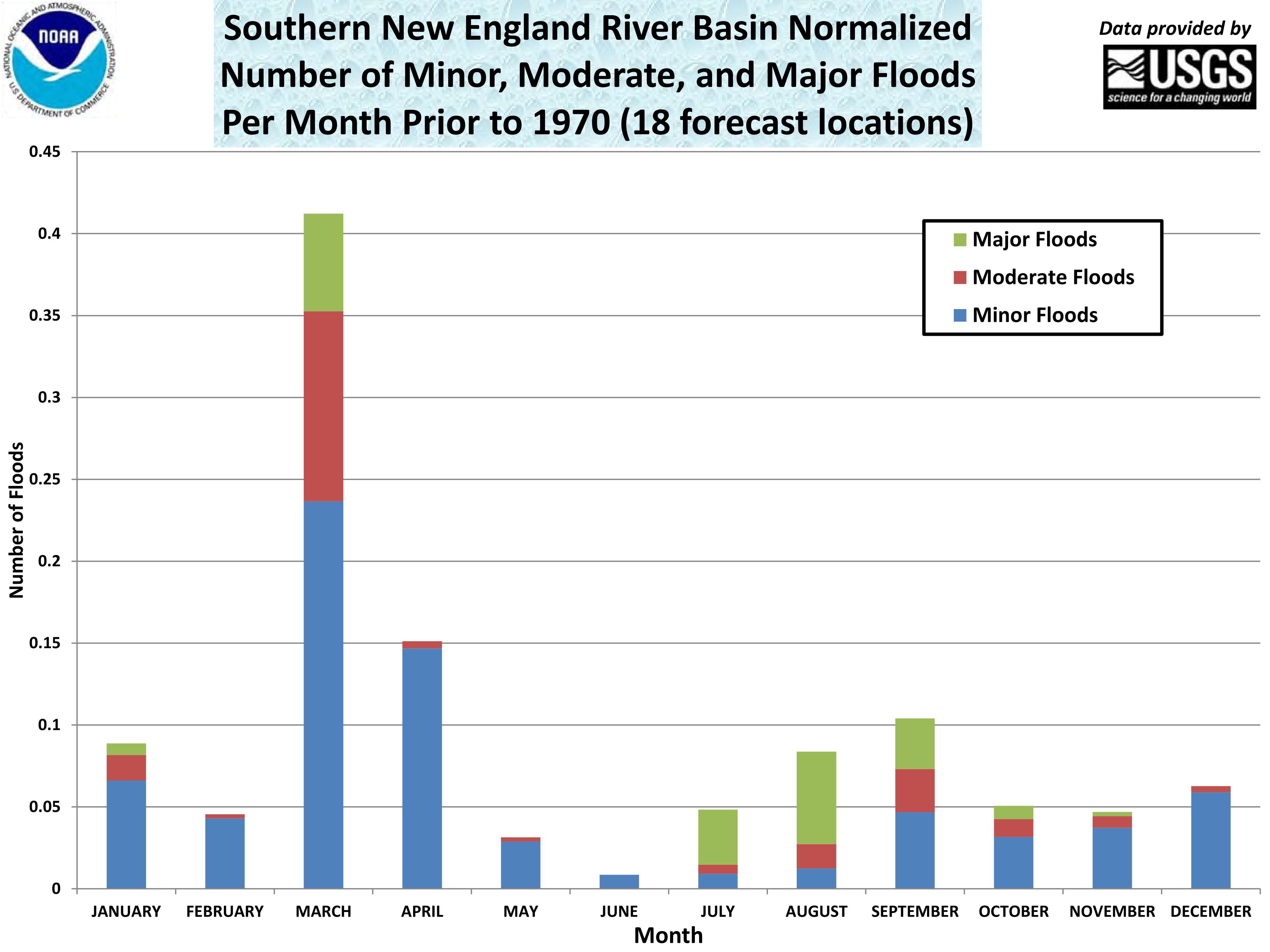
Data provided by USGS science for a changing world



Southern New England River Basin Normalized Number of Minor, Moderate, and Major Floods from 1970-2013

Data provided by USGS science for a changing world

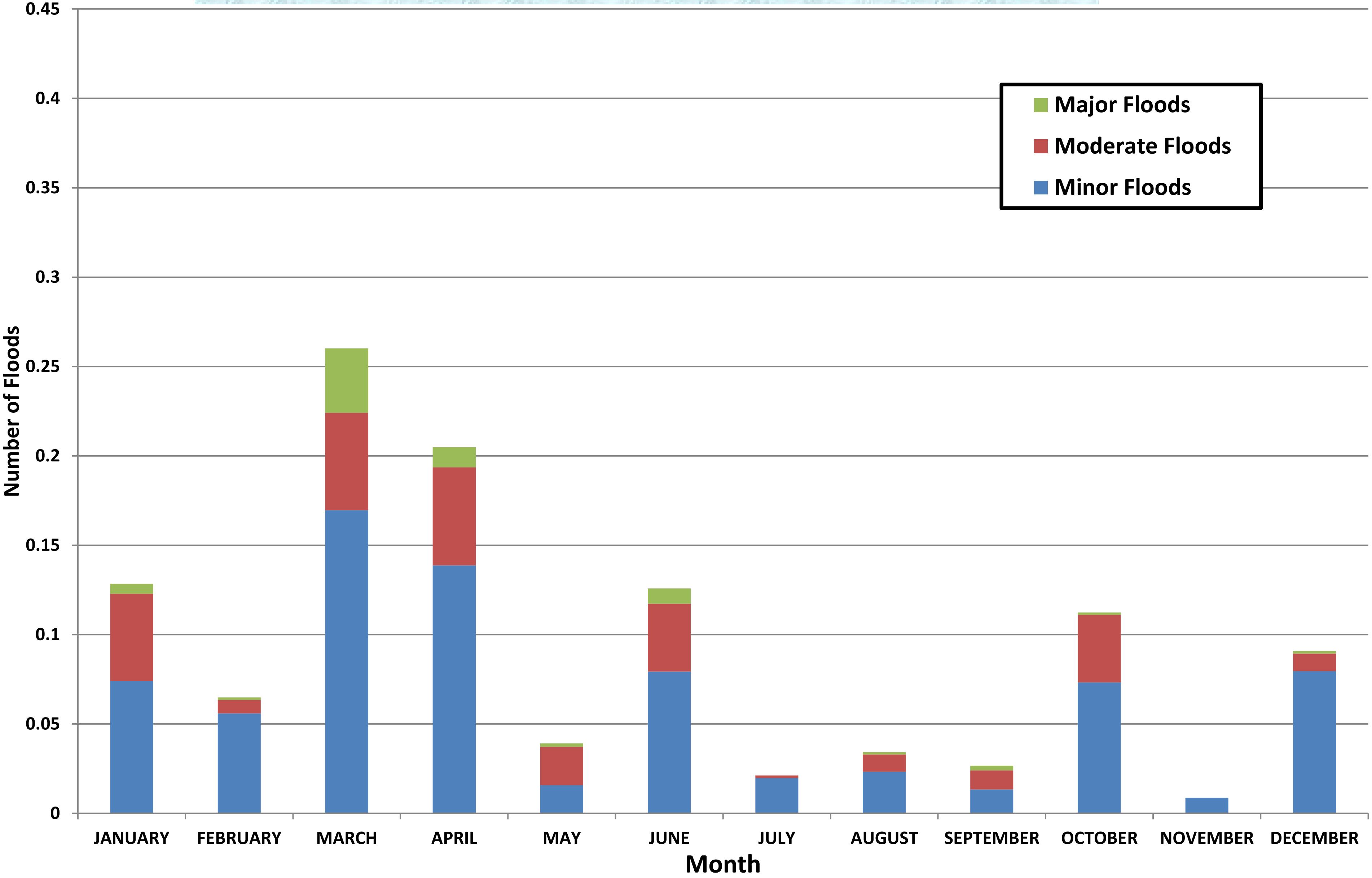


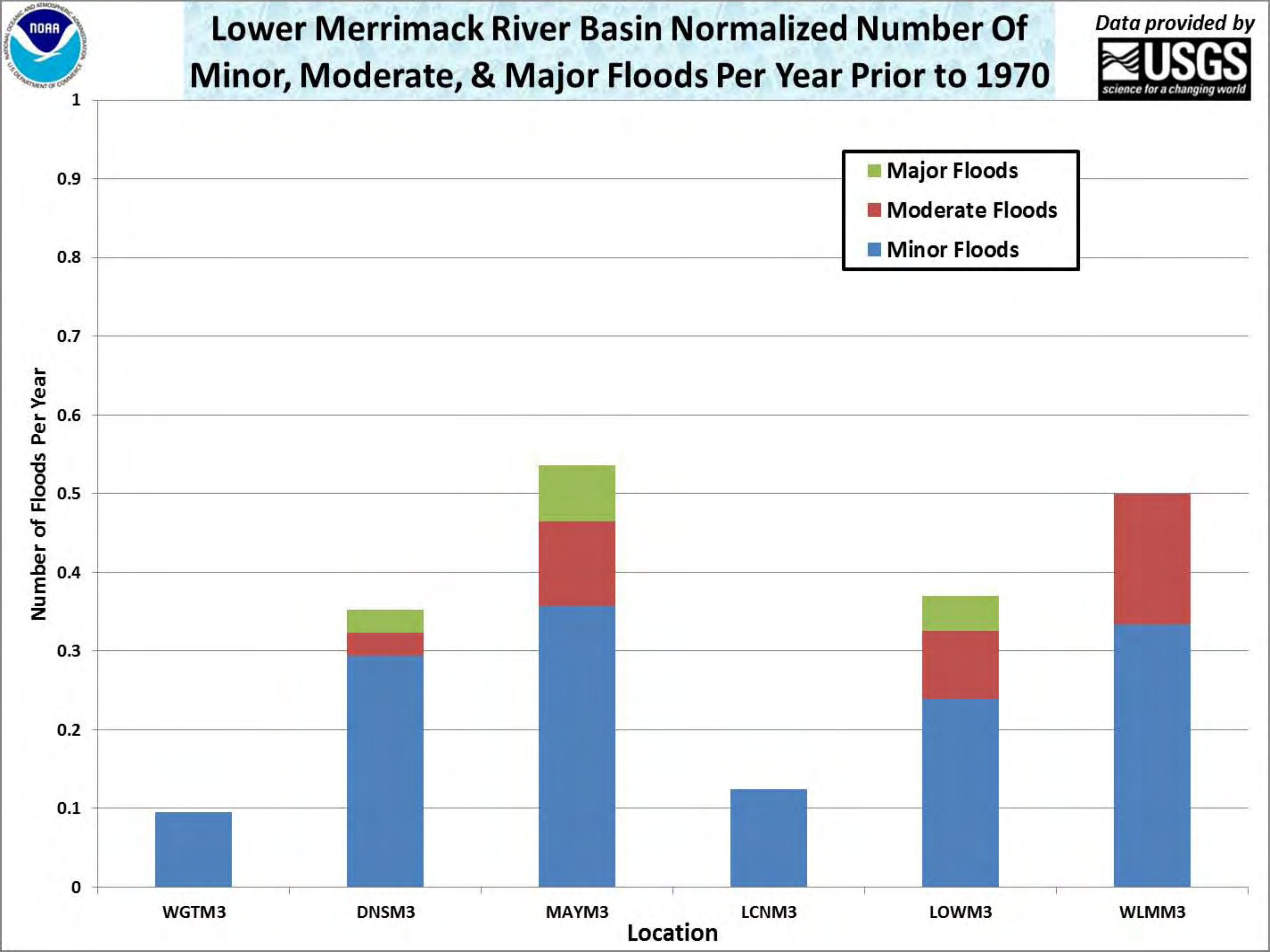


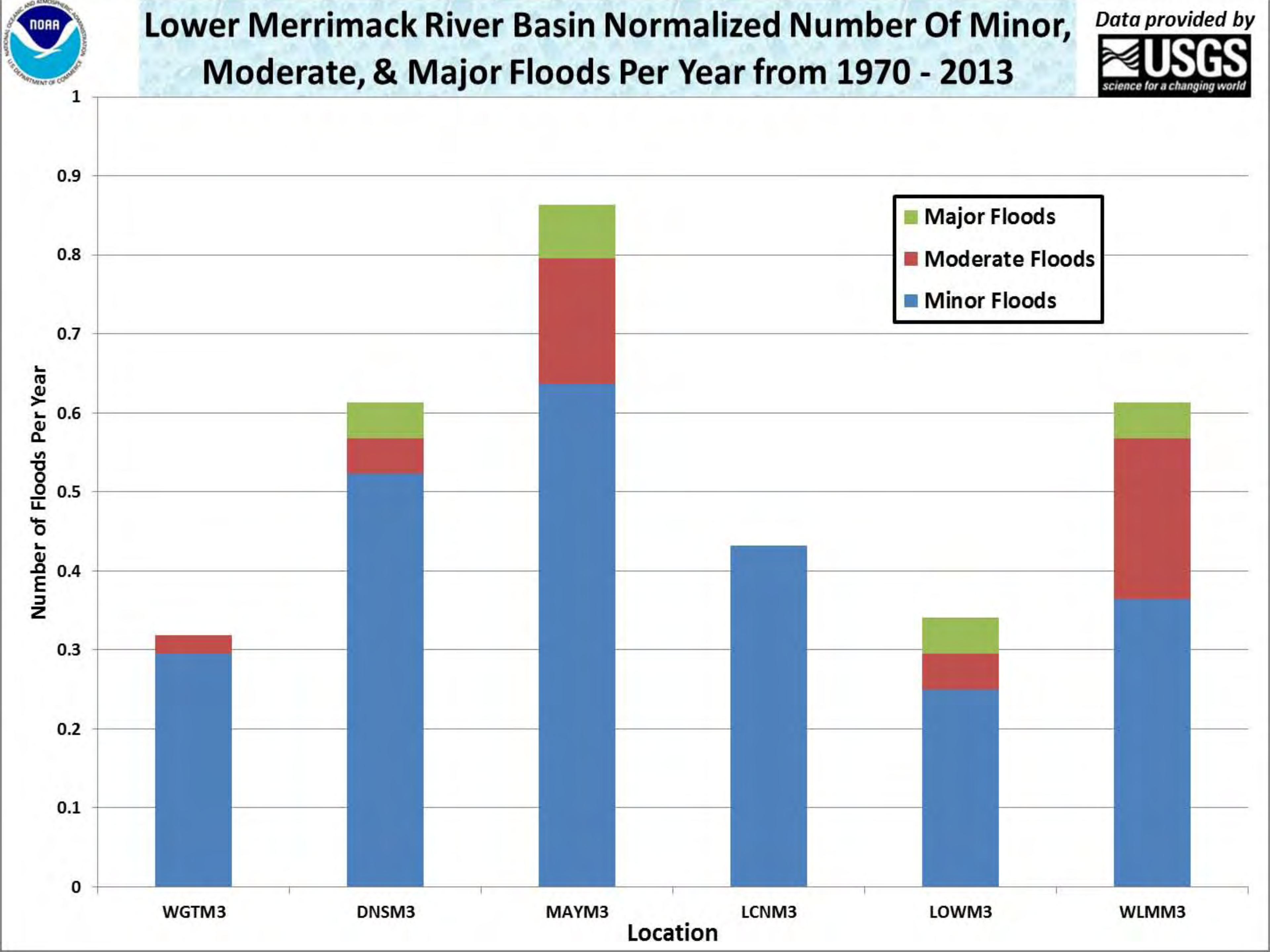
Southern New England River Basin Normalized Number of Minor, Moderate, and Major Floods Per Month Prior to 1970 (18 forecast locations)
Data provided by
USGS
science for a changing world
Major Floods
Moderate Floods
Minor Floods
Number of Floods
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
Month

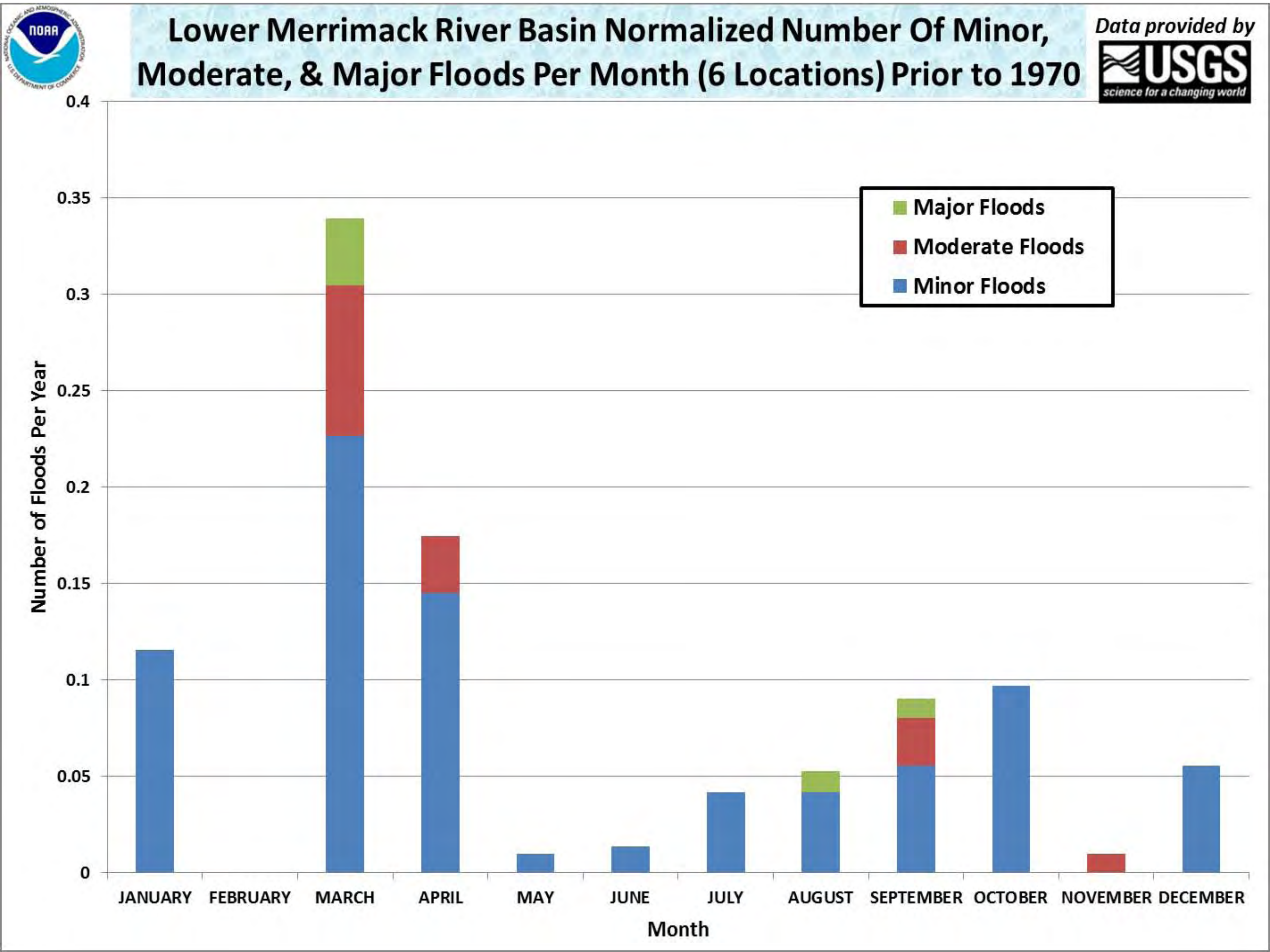
Southern New England River Basin Normalized Number of Minor, Moderate, and Major Floods Per Month from 1970 - 2013 (18 forecast locations)

Data provided by USGS

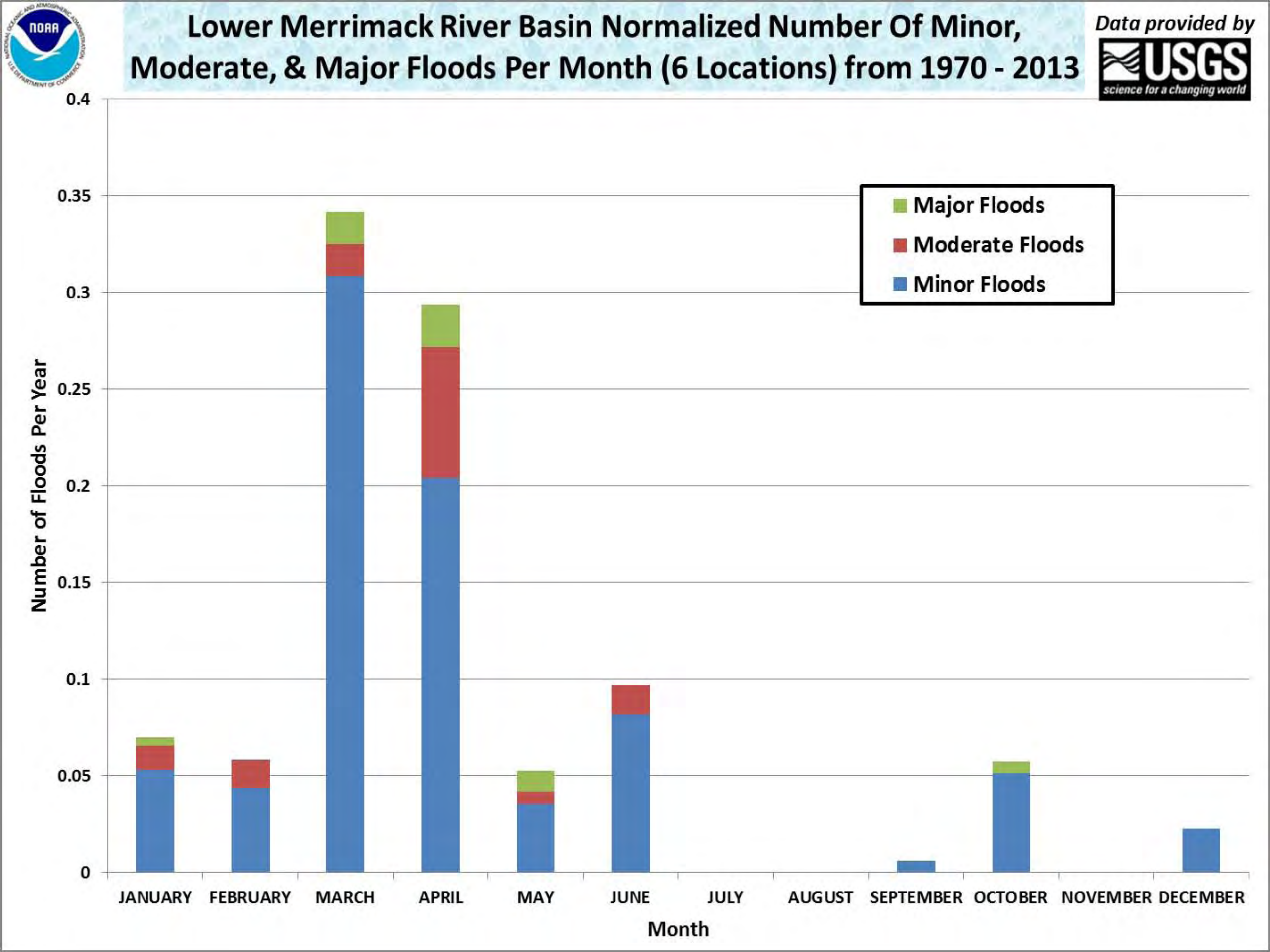



Lower Merrimack River Basin Normalized Number Of
Minor, Moderate, & Major Floods Per Year Prior to 1970
Data provided by
USGS
science for a changing world
NOAA
Major Floods
Moderate Floods
Minor Floods
Number of Floods Per Year
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
WGTM3
DNSM3
MAYM3
LCNM3
LOWM3
WLMM3
Location


Lower Merrimack River Basin Normalized Number Of Minor, Moderate, & Major Floods Per Year from 1970 - 2013
Data provided by
USGS
science for a changing world
NOAA
Number of Floods Per Year
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Major Floods
Moderate Floods
Minor Floods
WGTM3
DNSM3
MAYM3
LCNM3
LOWM3
WLMM3
Location



Lower Merrimack River Basin Normalized Number Of Minor, Moderate, & Major Floods Per Month (6 Locations) Prior to 1970
Data provided by
USGS
science for a changing world
Major Floods
Moderate Floods
Minor Floods
Number of Floods Per Year
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
Month



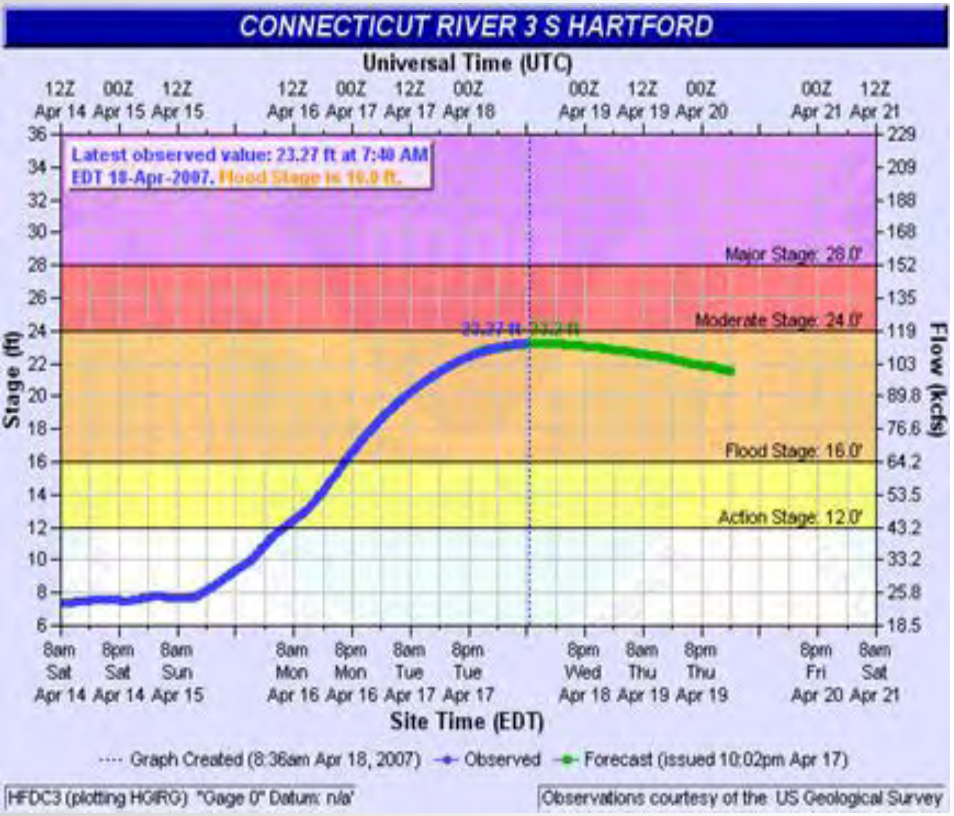
Lower Merrimack River Basin Normalized Number Of Minor, Moderate, & Major Floods Per Month (6 Locations) from 1970 - 2013
Data provided by
USGS
science for a changing world
Major Floods
Moderate Floods
Minor Floods
Number of Floods Per Year
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
Month

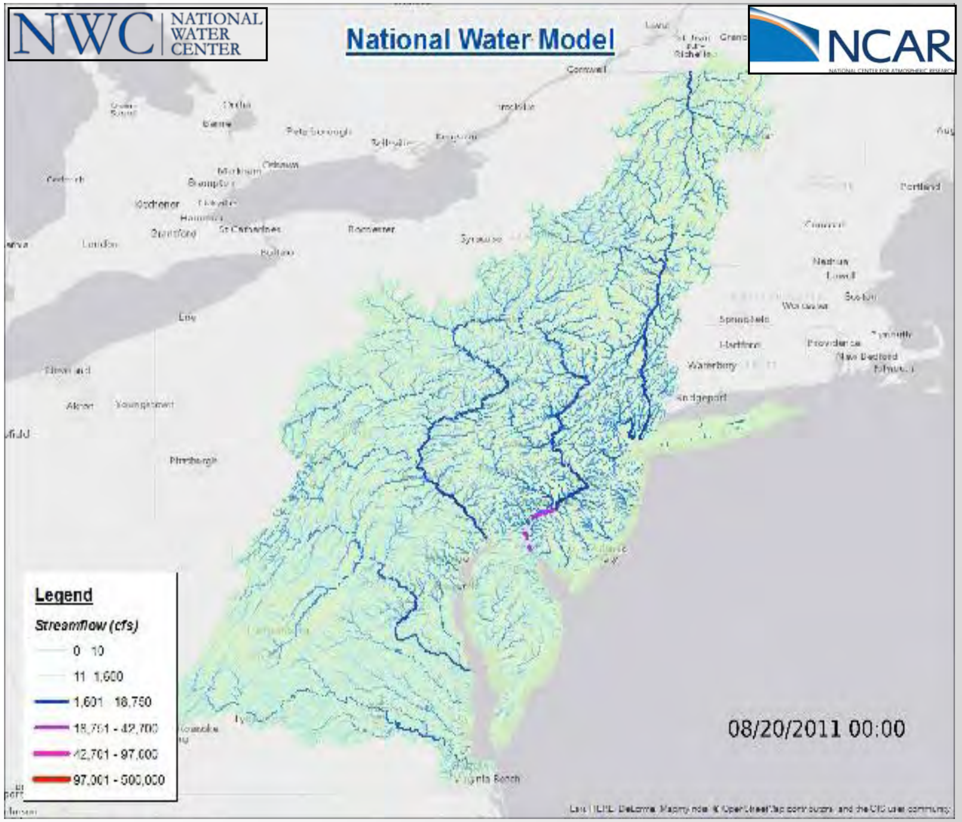
Summary:

- The Northeast has become a "hot spot" for record floods & heavy rainfall in the past 10 years
- Noticeable trends include increased yearly rainfall and increased annual temperatures
  - Portions of Massachusetts have experienced a 1 to 2 inch shift upwards in the 100 yr – 24 hour rainfall
- Smaller watersheds & those with significant urbanization are most vulnerable to increased river & stream flooding
- Drought episodes have become shorter in duration and of a "Flash/Rapid Onset" variety

A Look At Future Water Prediction Services:

Moving from Point Specific to Street Level Hydrologic Forecasting

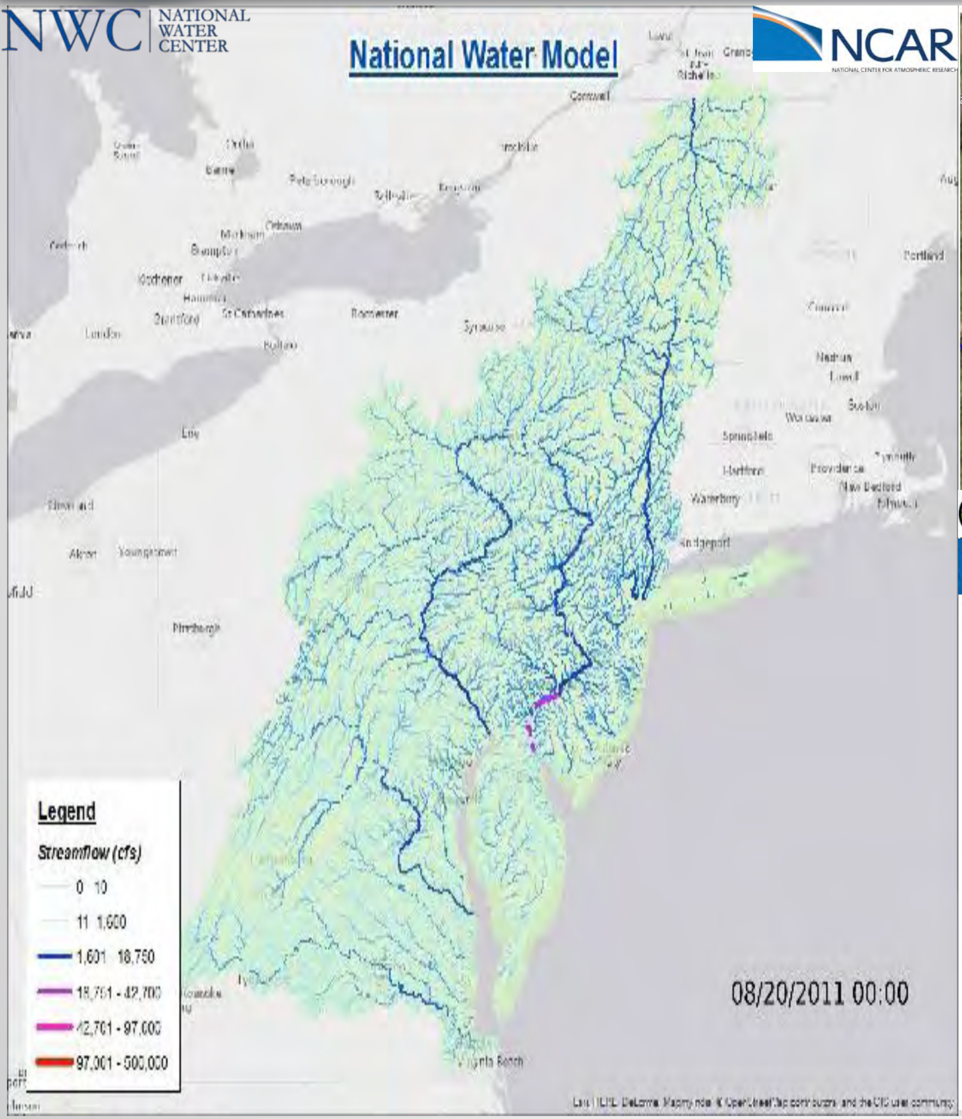




New services to include the Hydrologic Ensemble Prediction System & the new National Water Model

But it truly is a matter of scale

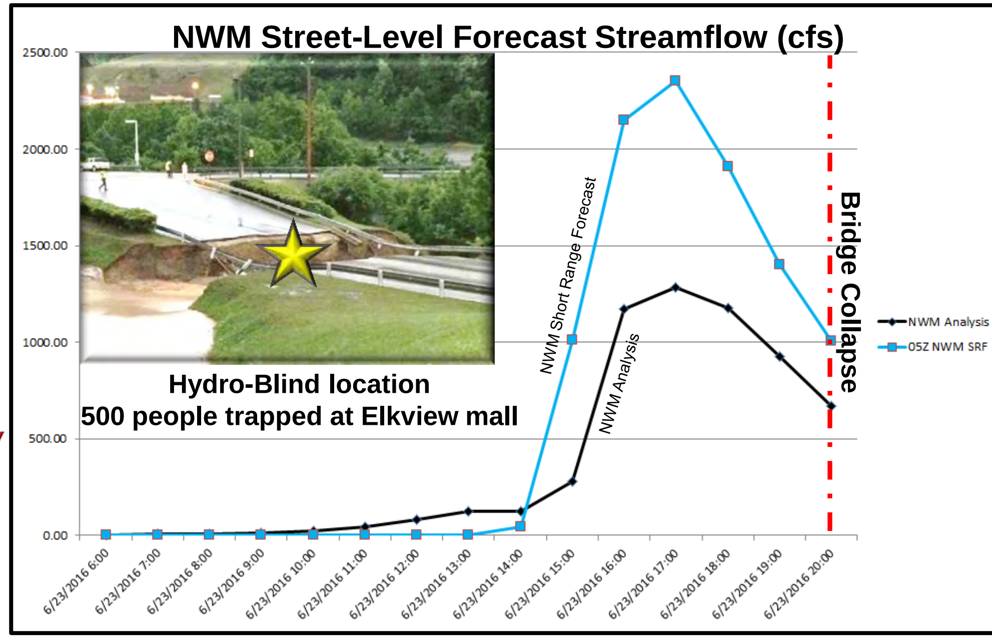
Tomorrow's Scale – 1 km or less!

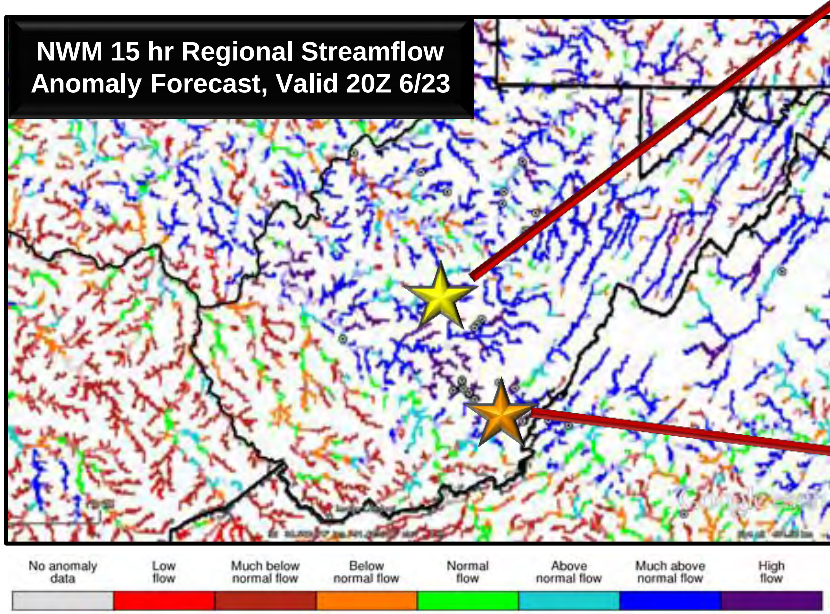


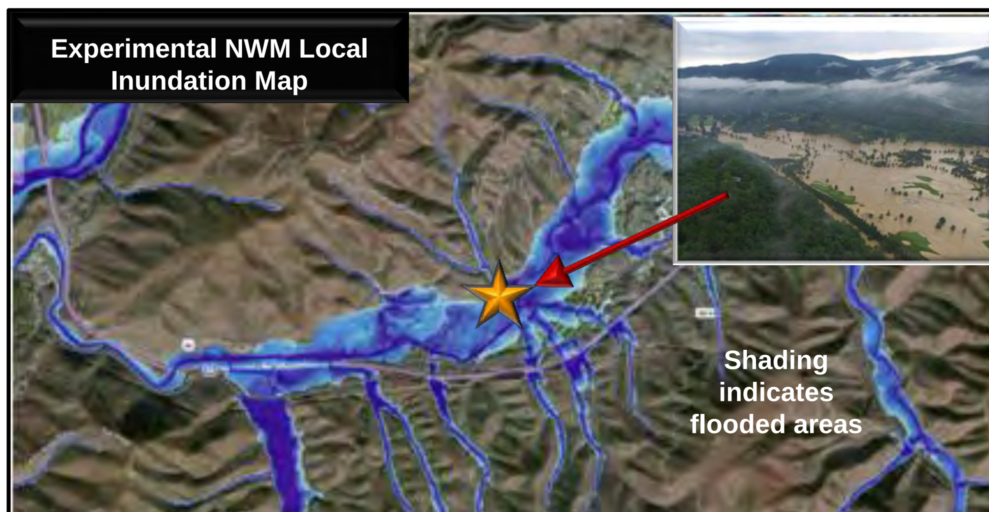
Experimental simulation from the National Water Model

NWM-Based Street Level Hydrologic Prediction
Record Setting West Virginia Flood Event, June 23rd 2016

- Thousands of homes damaged or destroyed, $111+ million in FEMA aid
- NWM allows users to drill down from regional to local to street scale
- Information complements hydrologic guidance at existing forecast locations and provides new insight at millions of hydro-blind locations

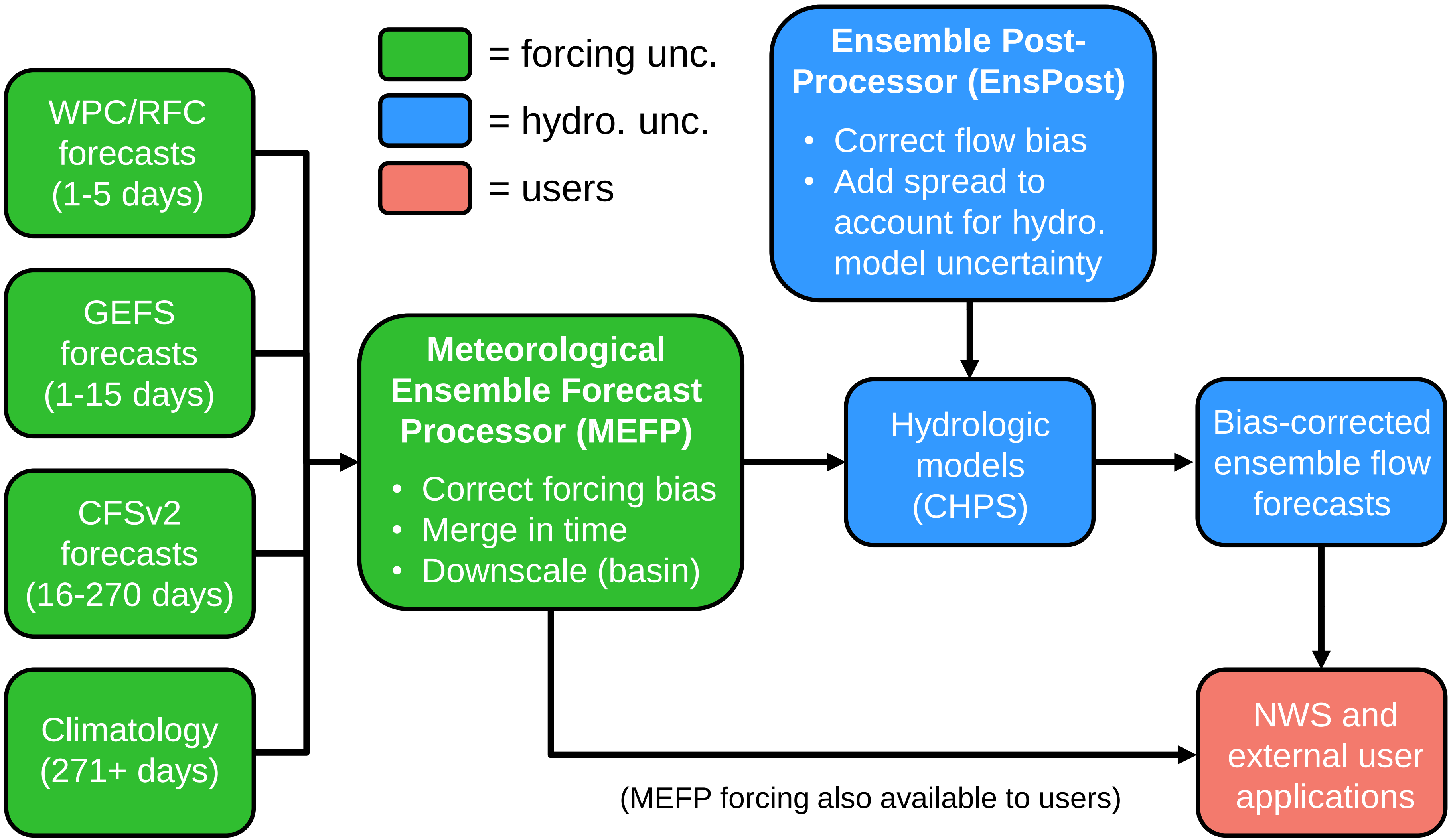






http://www.water.noaa.gov/map

What is the HEFS?



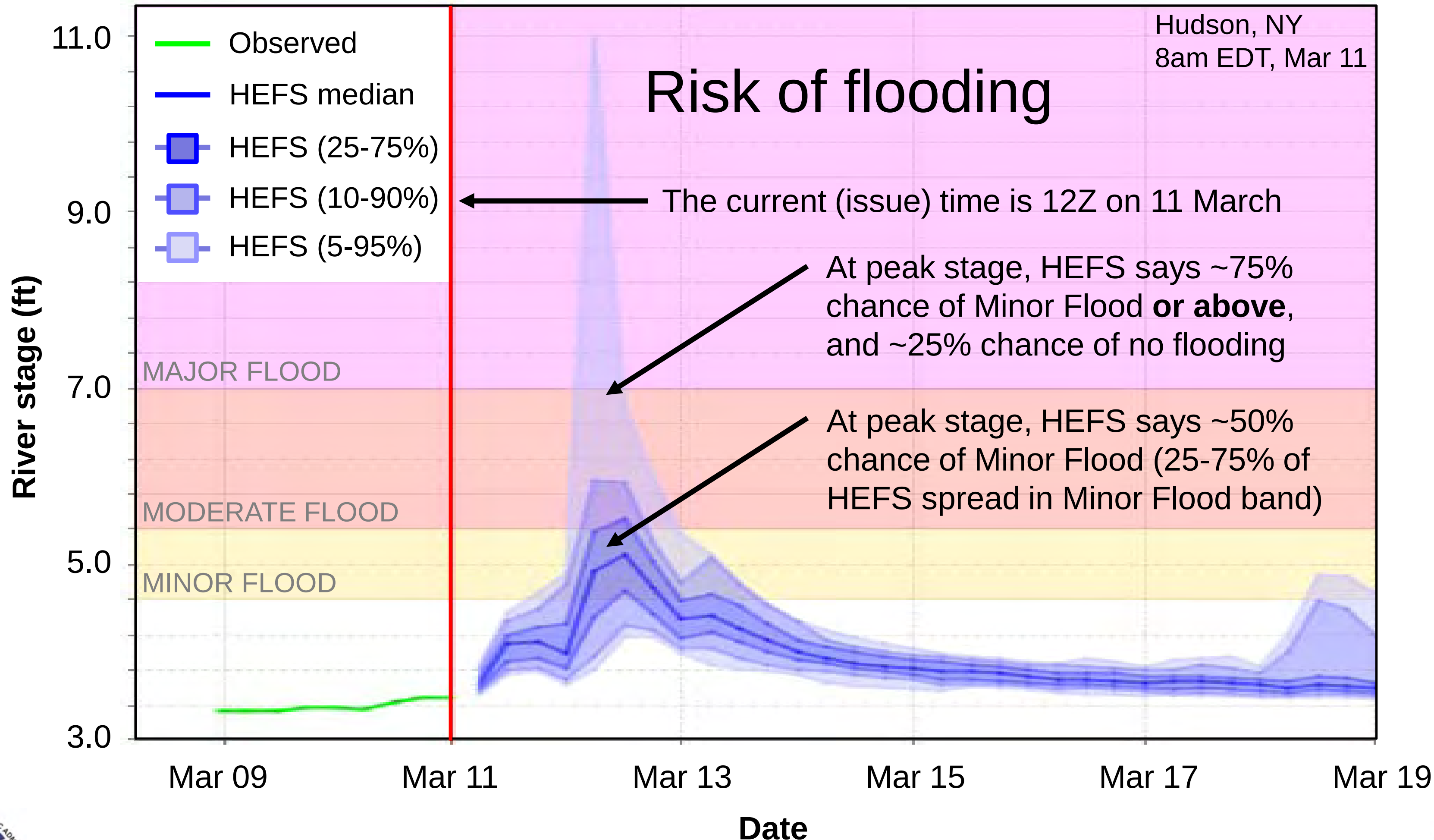
Why use hydrologic ensemble forecasts?

Goal: improve NWS hydrologic services

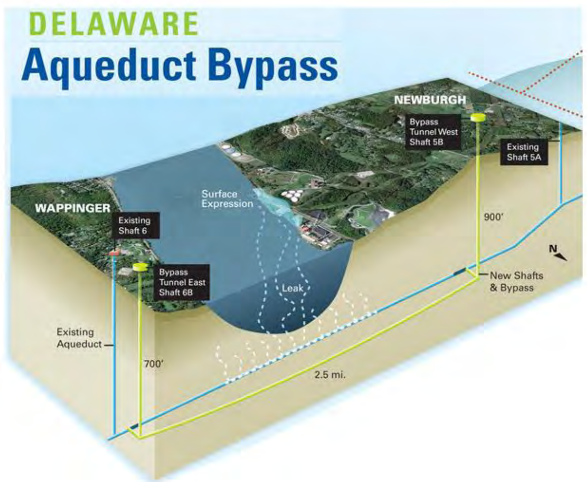
Feature	ESP (old service)	HEFS (new service)
Forecast time horizon	Weeks to seasons	Hours to years, depending on the input forecasts
Input forecasts ("forcing")	Historical climate data (i.e. weather observations) with some variations between RFCs	Short-, medium- and long-range weather forecasts
Uncertainty modeling	Climate-based. No accounting for hydrologic uncertainty or bias. Suitable for long-range forecasting only	Captures total uncertainty and corrects for biases in forcing and flow at all forecast lead times
Products	Limited number of graphical products (focused on long-range) and verification	A wide array of data and user-tailored products are planned, including standard verification

Short Range Ensemble Forecasts

Goal: better-informed water decisions



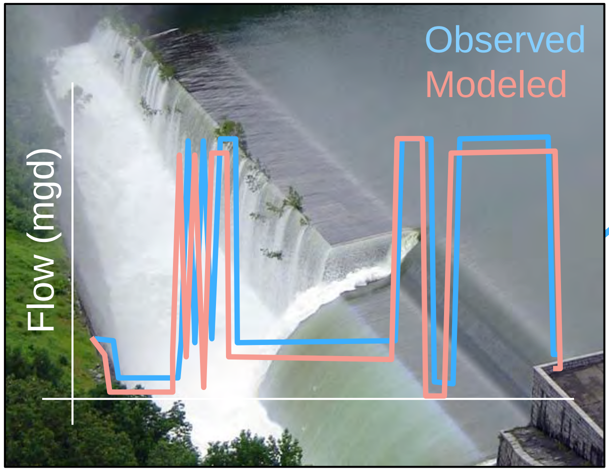
Example of early application of HEFS



"Mission critical decision to manage shutdown of RBWT Tunnel based on HEFS forecasts"

"HEFS forecasts critical to protecting NYC drinking water quality during high turbidity events"

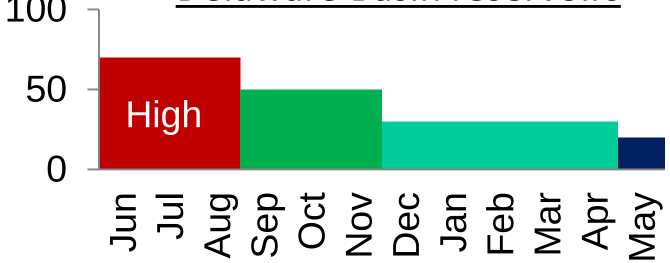
HEFS streamflow forecasts are used to optimize and validate the NYC OST for million/billion dollar applications



(Cannonsville Reservoir Spillway)

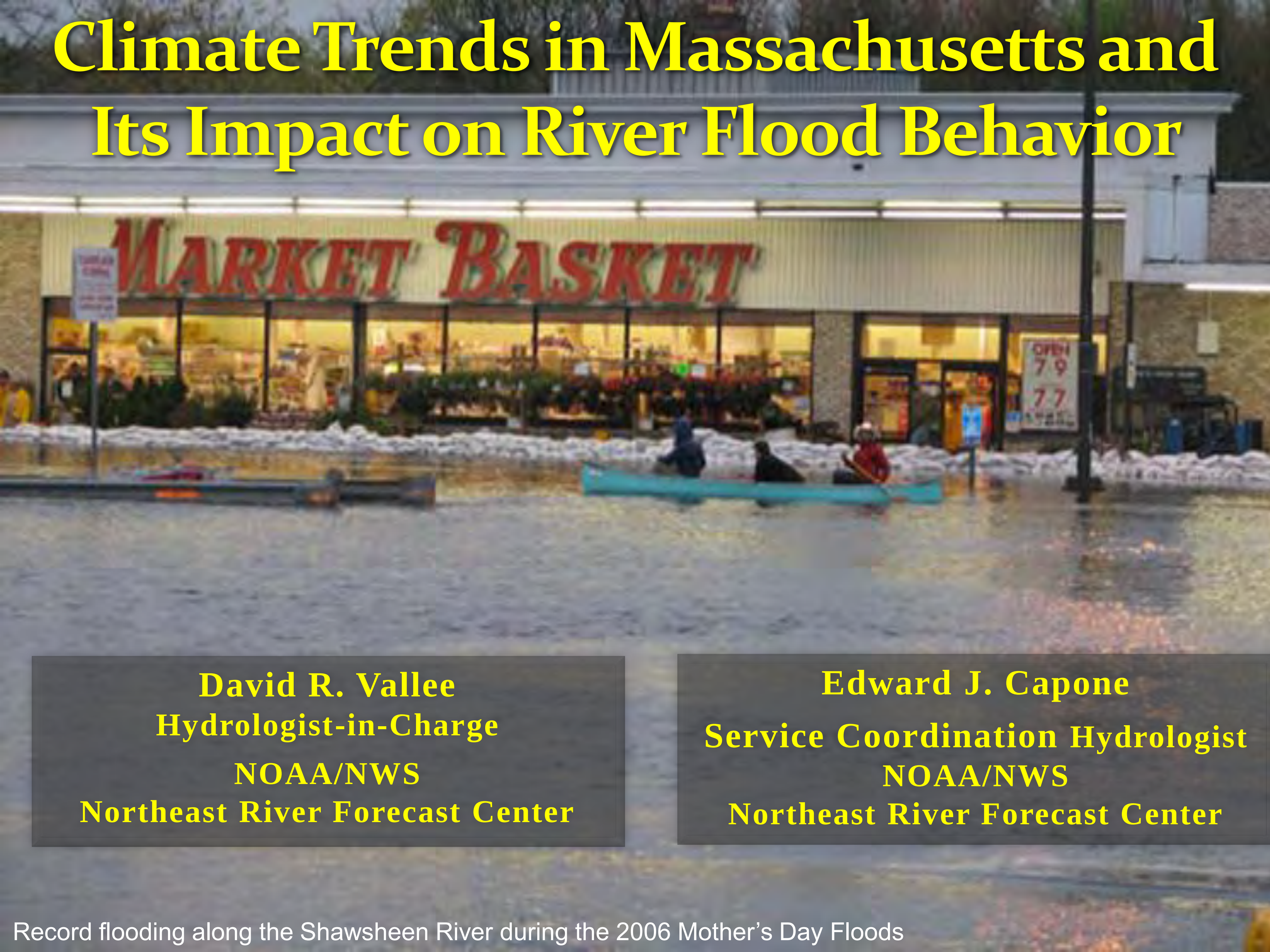
"HEFS forecasts help optimize rule curves for seasonal storage objectives in NYC reservoirs"

Risk to water availability from Delaware Basin reservoirs



"HEFS forecasts used to determine risks to conservation releases"

Climate Trends in Massachusetts and Its Impact on River Flood Behavior



David R. Vallee
Hydrologist-in-Charge
NOAA/NWS
Northeast River Forecast Center

Edward J. Capone
Service Coordination Hydrologist
NOAA/NWS
Northeast River Forecast Center

Record flooding along the Shawsheen River during the 2006 Mother's Day Floods