Climate Trends in New England and Its Impact on Storm and Riverine Flood Behavior;

Times They Are A Changing!

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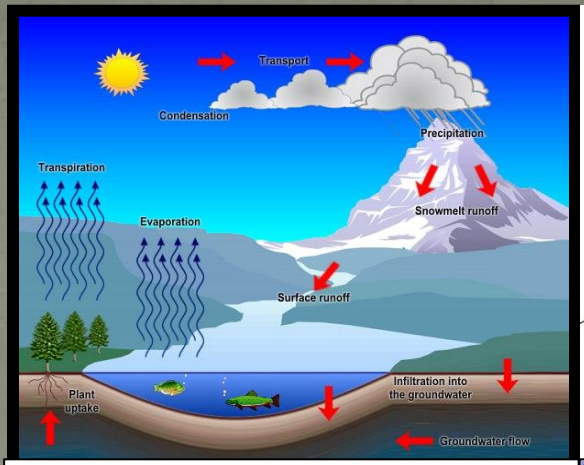
Providence Street – West Warwick, RI at 1030 am Wednesday 3/31/10

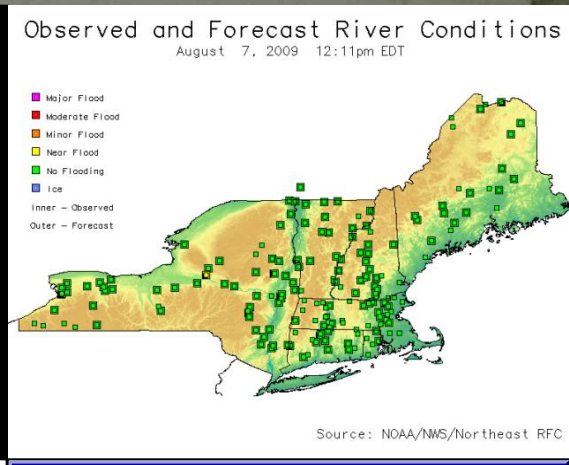
Outline

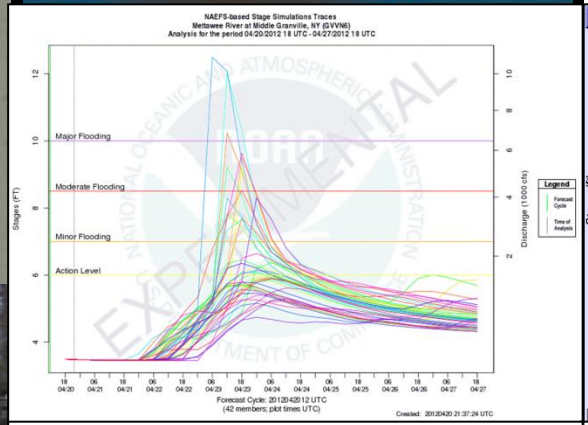
- From a “Practitioner’s Perspective”
- Touch upon some of our major flood events of the past 10 years
  - Big Rainstorms & High Impact Tropical Storms
  - Common themes & characteristics
- How may a changing climate be impacting storm behavior in the Northeast?
- What does this all mean?

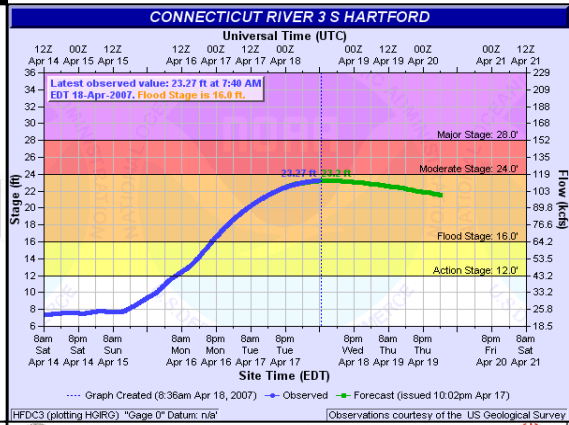
River Forecast Center Responsibilities

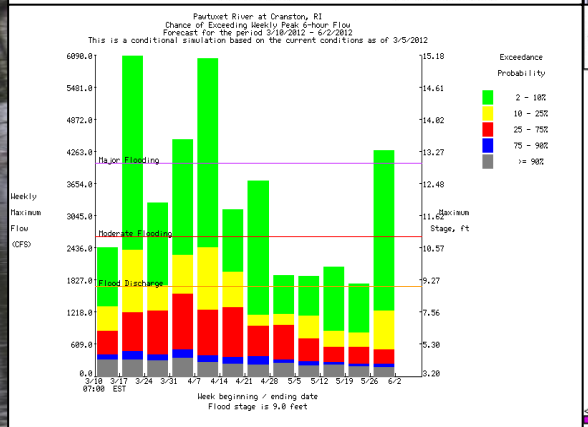
- Calibrate and implement variety of hydrologic and hydraulic models and produce temperature and precipitation forecasts to provide:
  - River flow and stage forecasts at 200 locations
  - Guidance on the rainfall needed to produce Flash Flooding
  - Ensemble streamflow predictions
  - Ice Jam and Dam Break support
  - Water Supply forecasts
  - Reservoir Inflow Forecasts

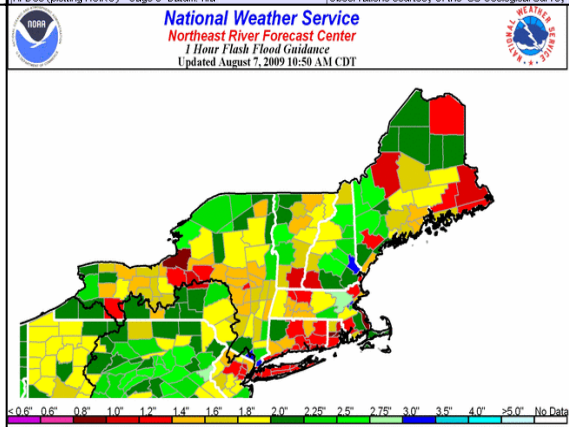








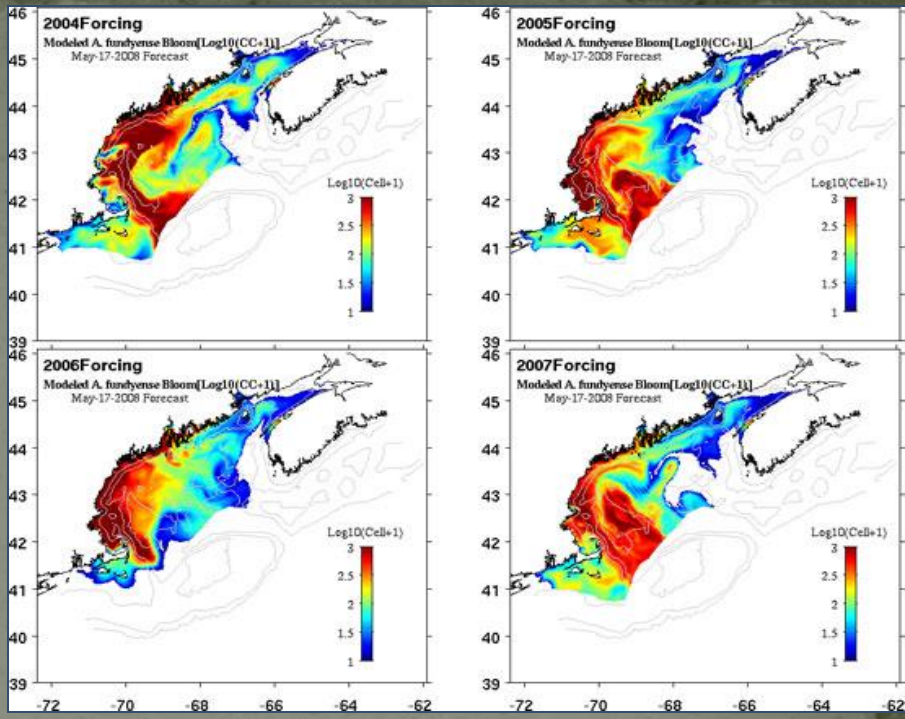


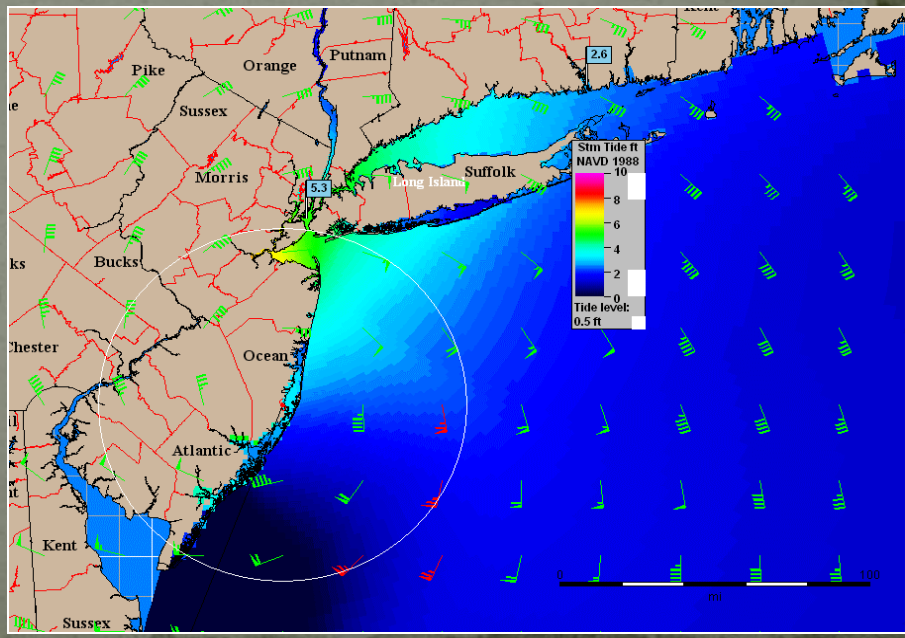


Moderate flooding - Connecticut River at Portland, CT.

Unique uses of services

- Northeast PSP / GOM HAB
  - Bi-weekly hydromet outlooks
  - Heavy runoff & northeast flow
- Storm Surge modeling
  - Leveraging UMASS FECOM, Stevens Inst., NOS and NWS predictions
  - Forecast combined surge and fresh water flows on tidal rivers
- Northeast Fisheries Science Center – Orono, ME
  - Leverage our 30-90 day predictions for timing of Atlantic Salmon Smolt releases
  - USGS/Unv. Maine CO-OP short-range ensemble forecasts for early Silver Eel departures





A few caveats

- I'm not a climate scientist!
  - I'm a practitioner in the weather & river forecast business
- I have the benefit of living in this part of the country my entire life
  - 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"
  - Has resulted in changes in river behavior

I've been a little busy these past 7 years!

Job Security in the face of changing flood behavior!!

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

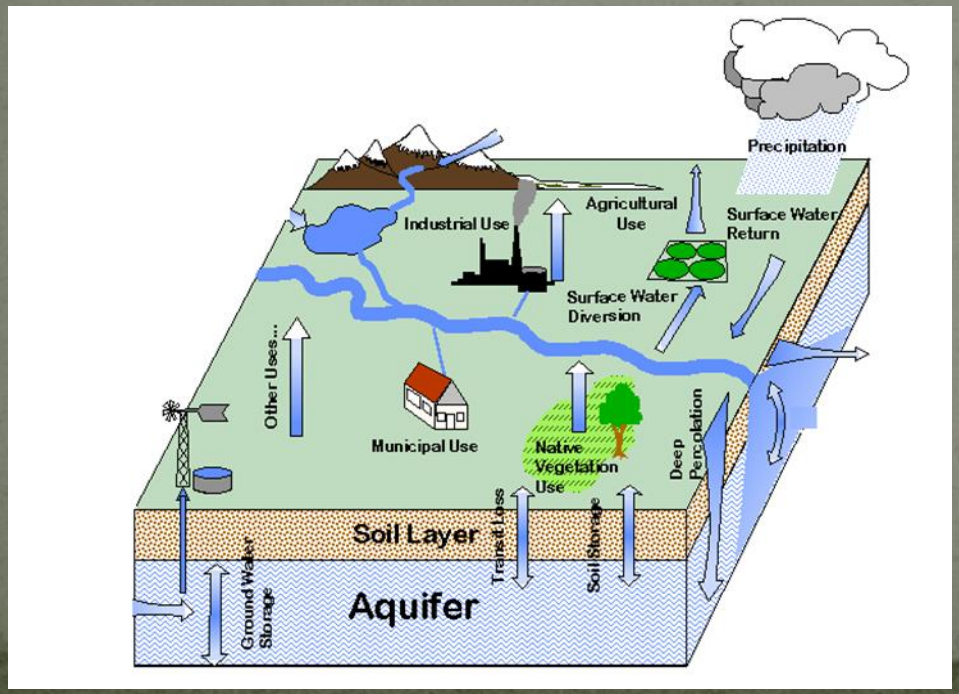
St-Jean-sur-Richelieu, Quebec, Canada, 5/6/11
Photo: AP//Canadian Press, R. Remoirz

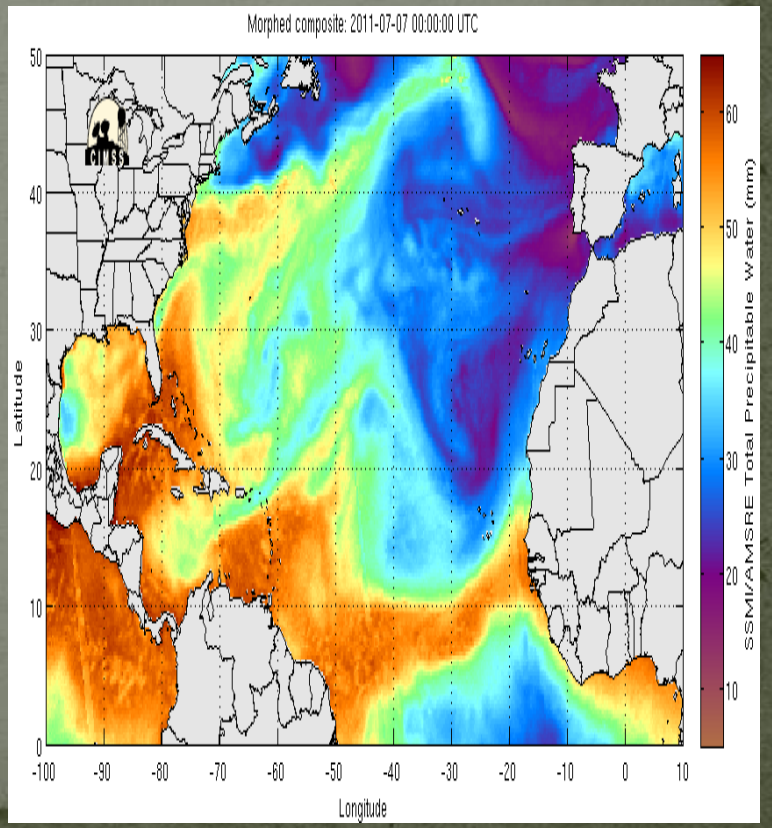
Providence Street – West Warwick, RI at 1030 am Wednesday 3/31/10

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

Is there a common theme to recent events?

- 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 before "main event"
  - Each fed by a "tropical connection"
    - Plumes of deep moisture

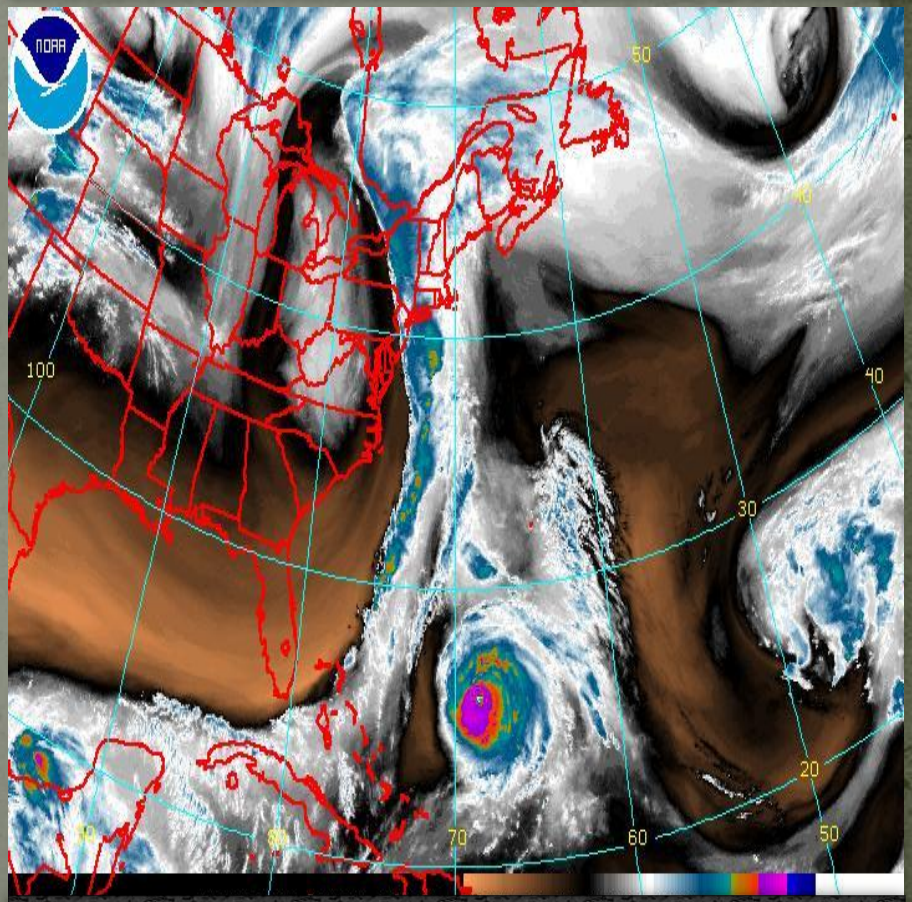




Is there a plausible "Climate Hypothesis"?

- Modest changes in air & sea temperatures = atmosphere can hold more moisture
  - New England is in close proximity to the ocean and the Gulf & Atlantic moisture streams
  - Affected by dual storm tracks and blocking high pressure over Greenland
  - These ingredients offer us more “opportunities” to latch onto these plumes
- Reduction of sea ice changes upper level wind flow
  - Blocked up pattern induces slower moving storms or back-to-back-to back events

A very recent example: slow moving storm with two tropical connections



Heavy rains and minor flooding - October 15-17,2014

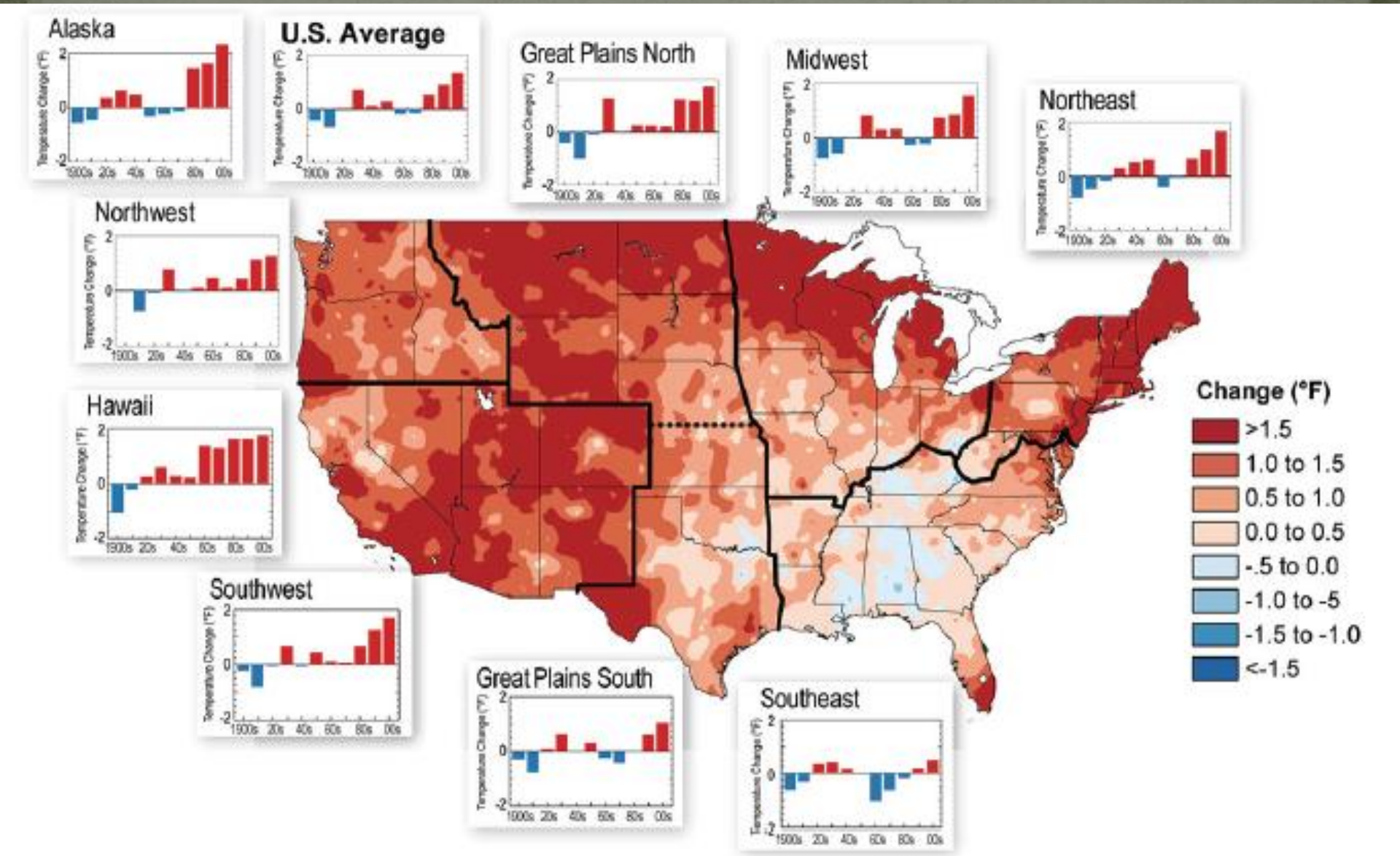
The Changing Climate

- 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

Major flooding – Merrimack River, Lawrence, MA, May 2006

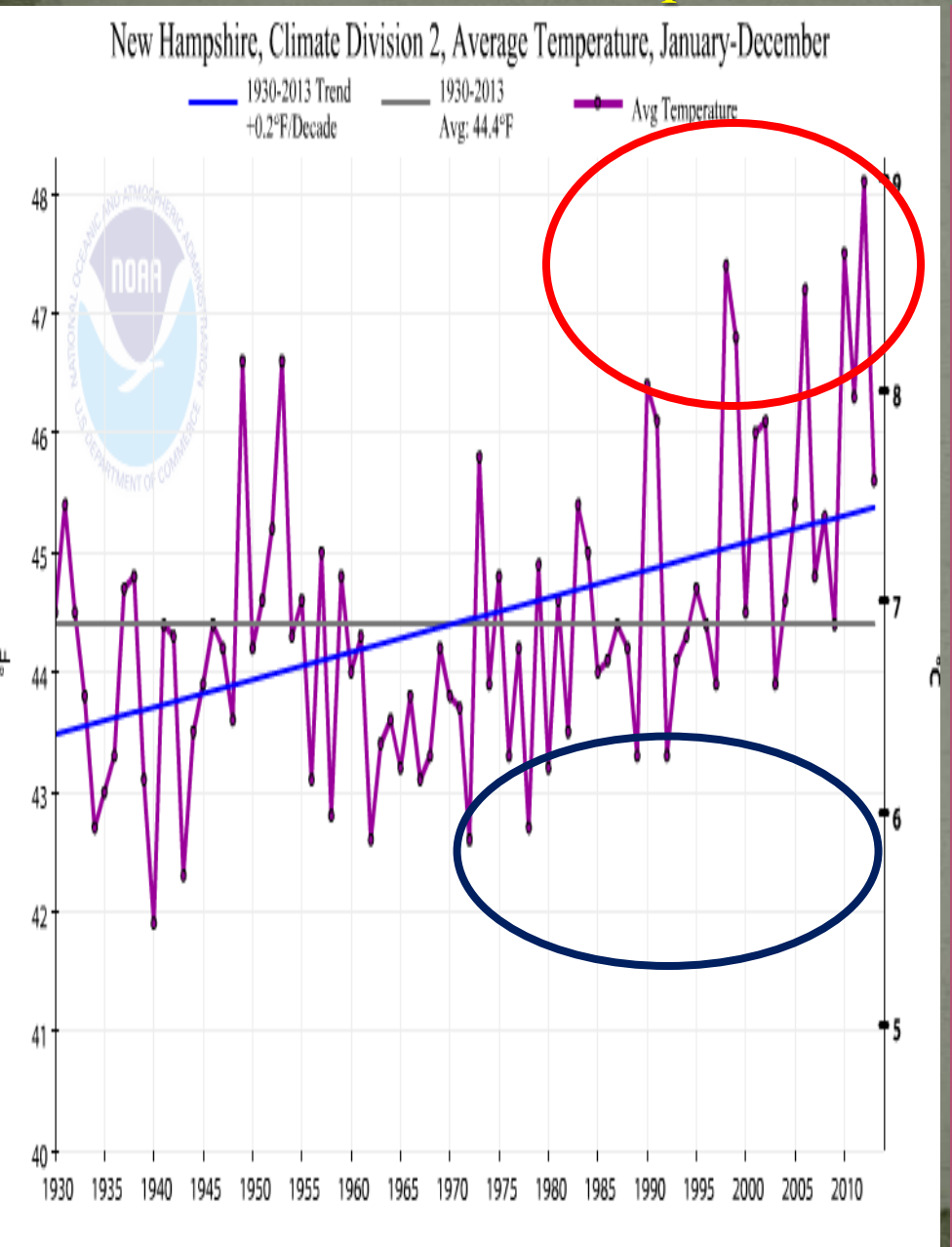
I-95 in Warwick with submerged Warwick Waste Water Treatment Facility 3/31/10 (Photo: RI ANG)

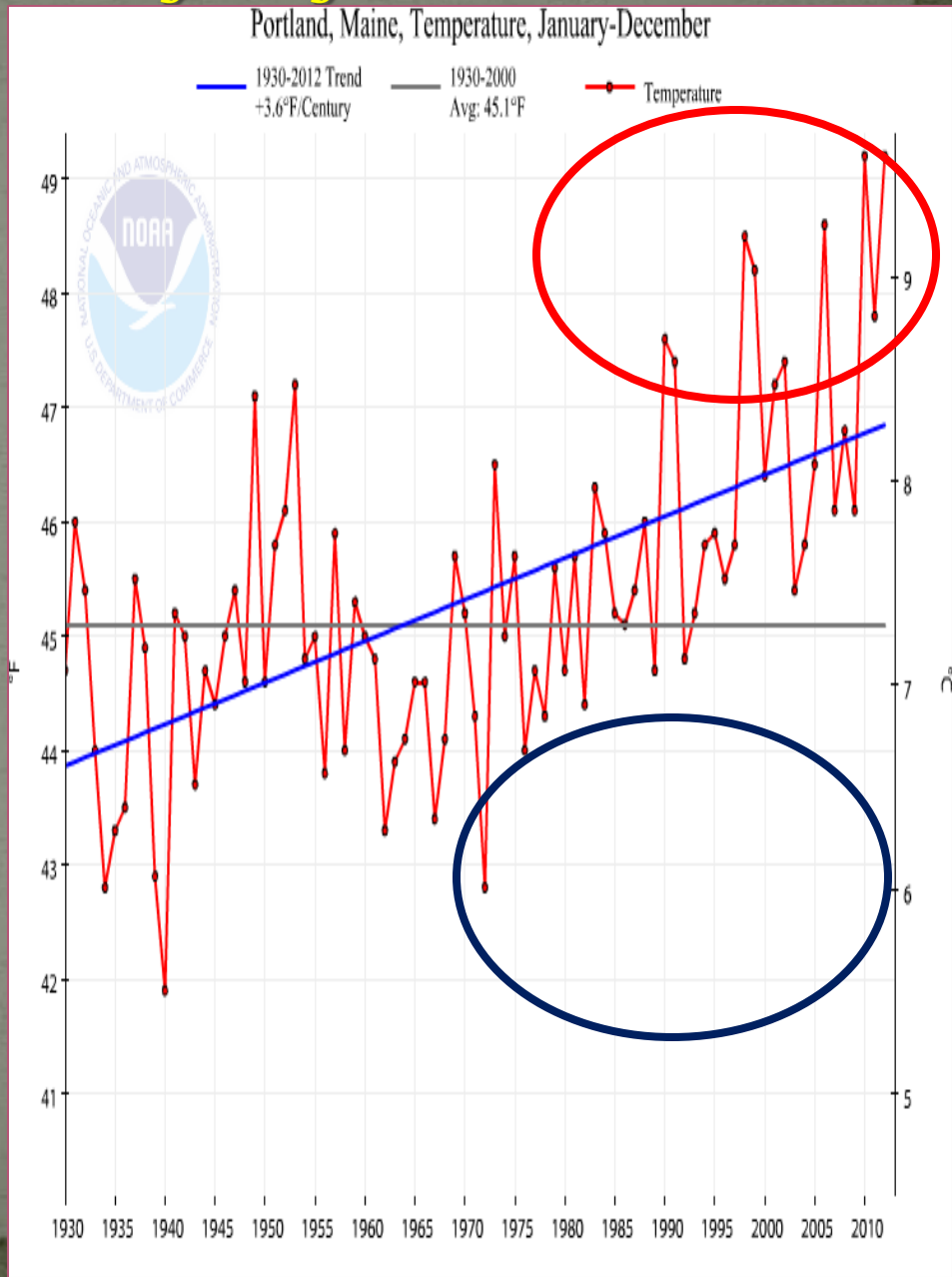
Trends in U.S. Temperature:
Decadal trends and 1991-2011 relative to 1901-1960



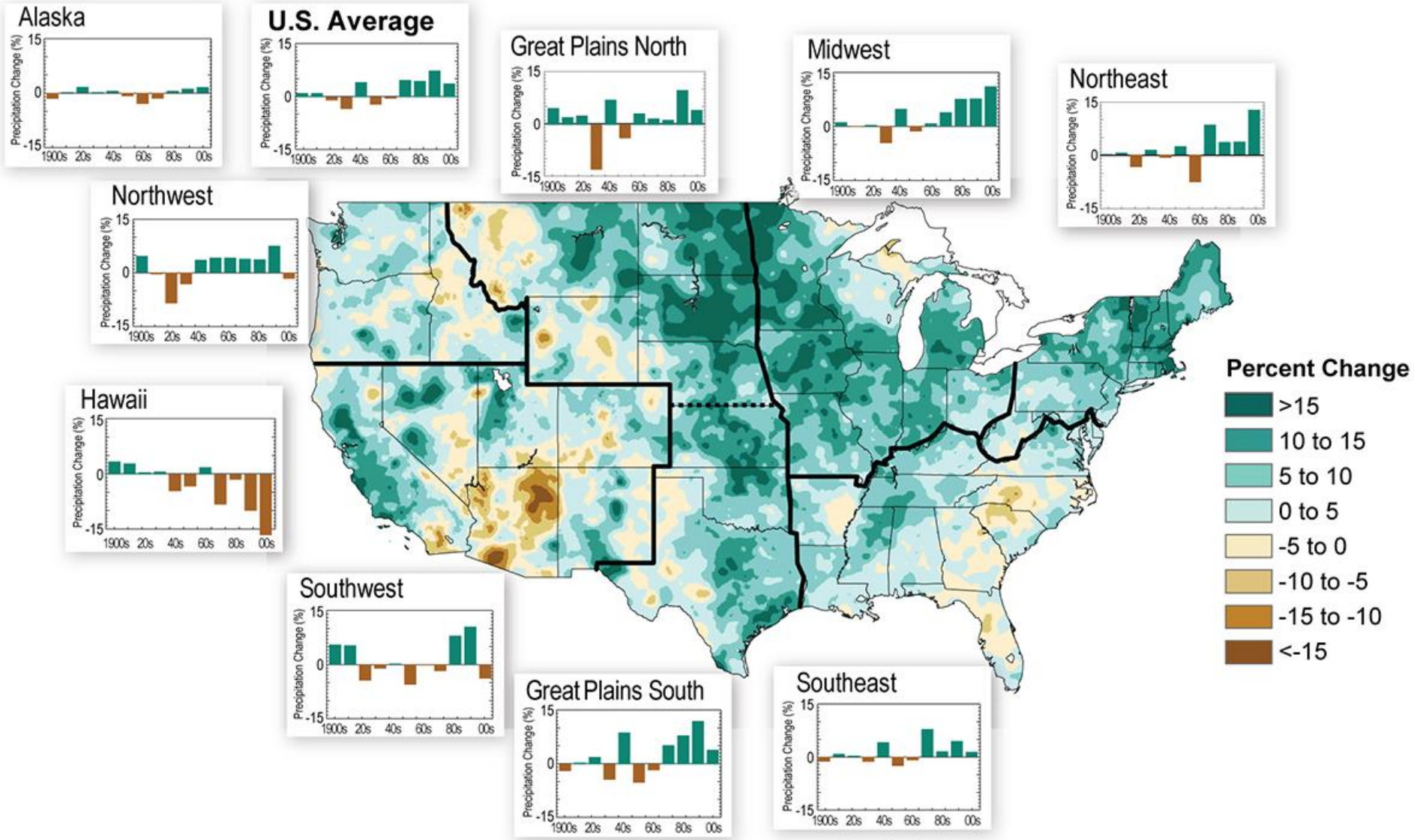
A Look at Temperature and Precipitation Trends

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





Trends in U.S. Precipitation:
Decadal trends and 1991-2011 relative to 1901-1960



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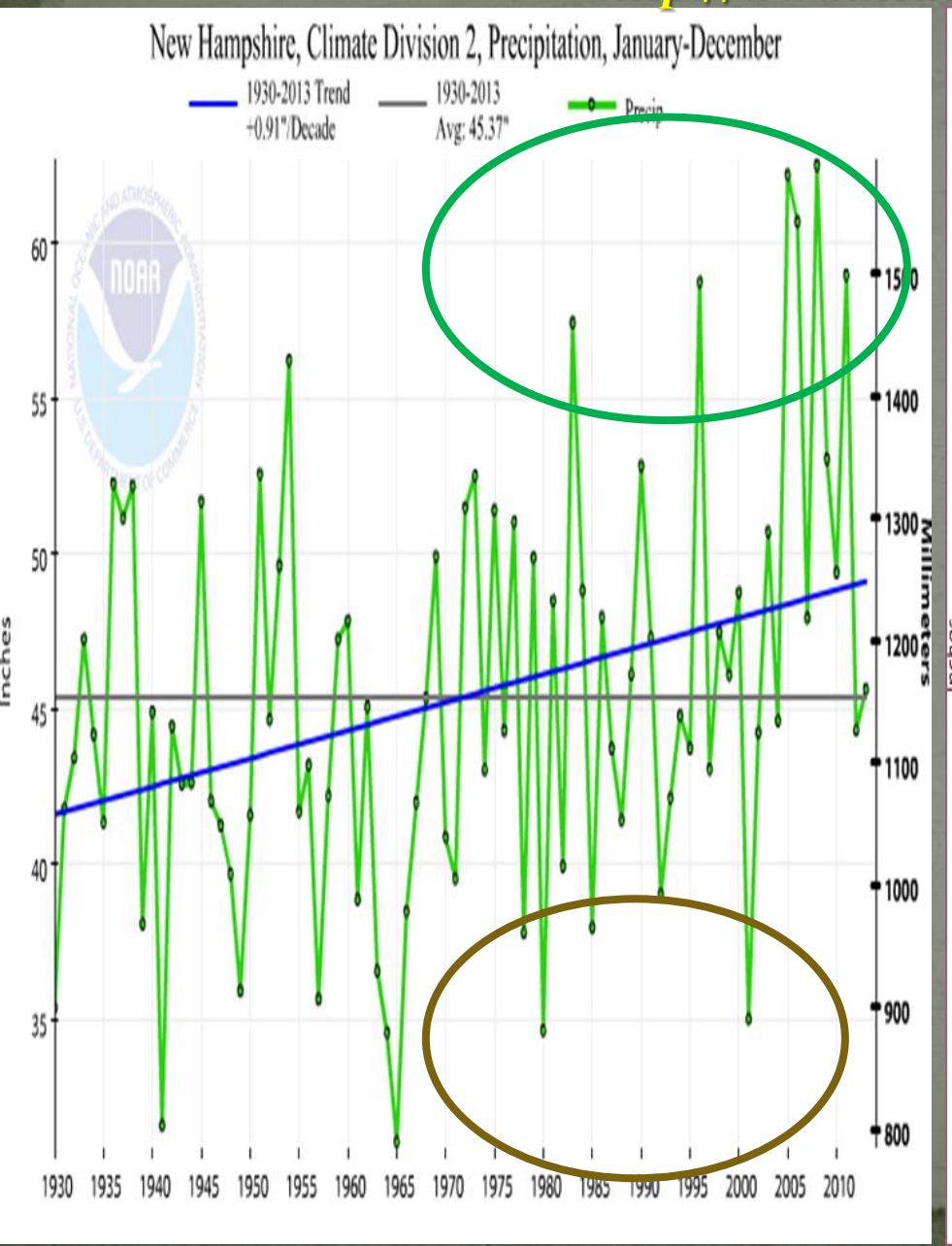
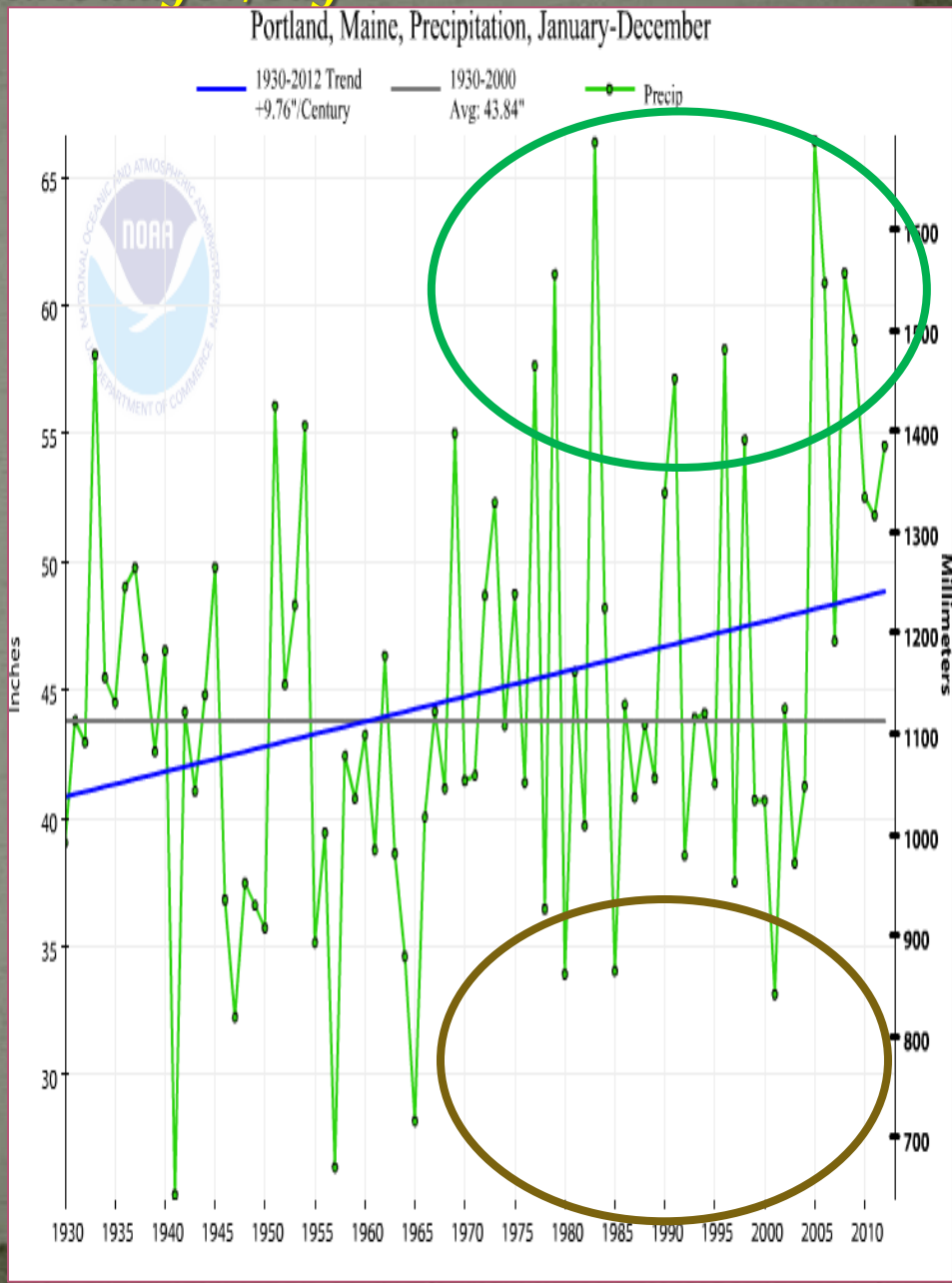
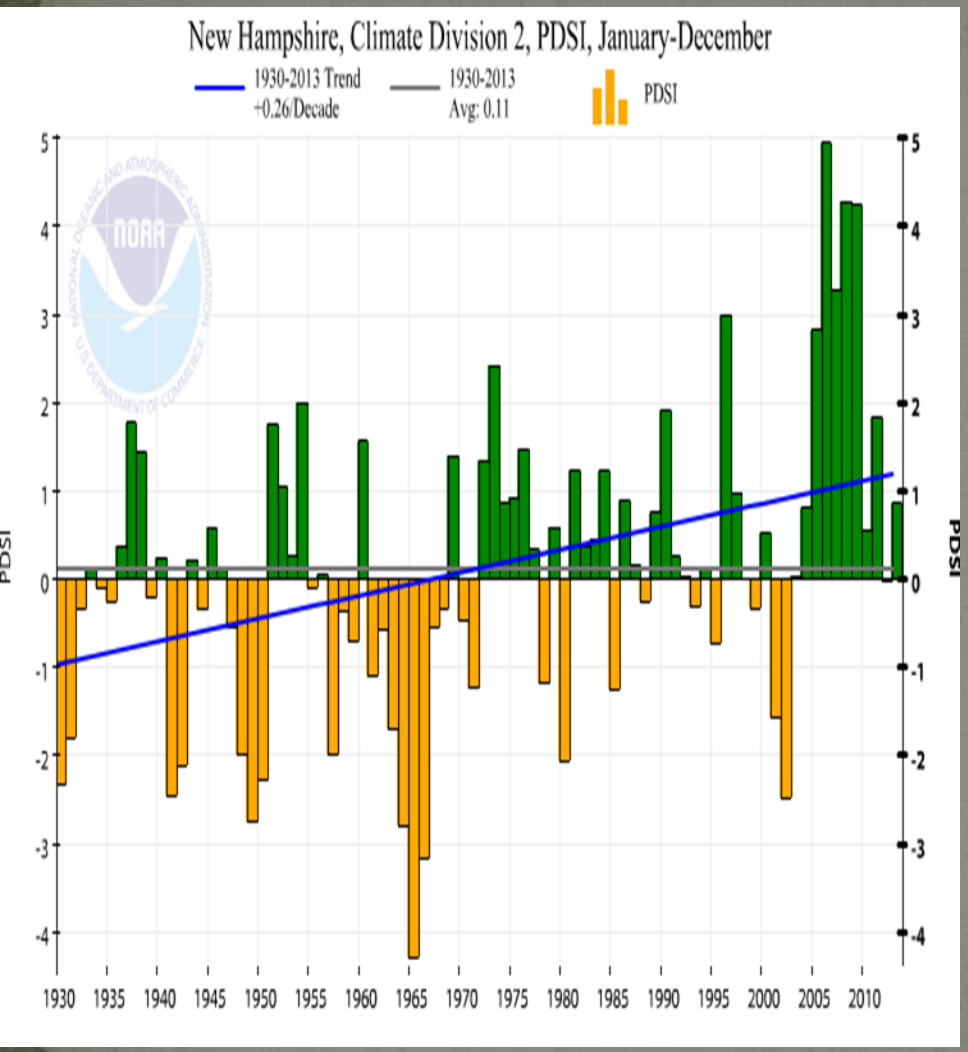
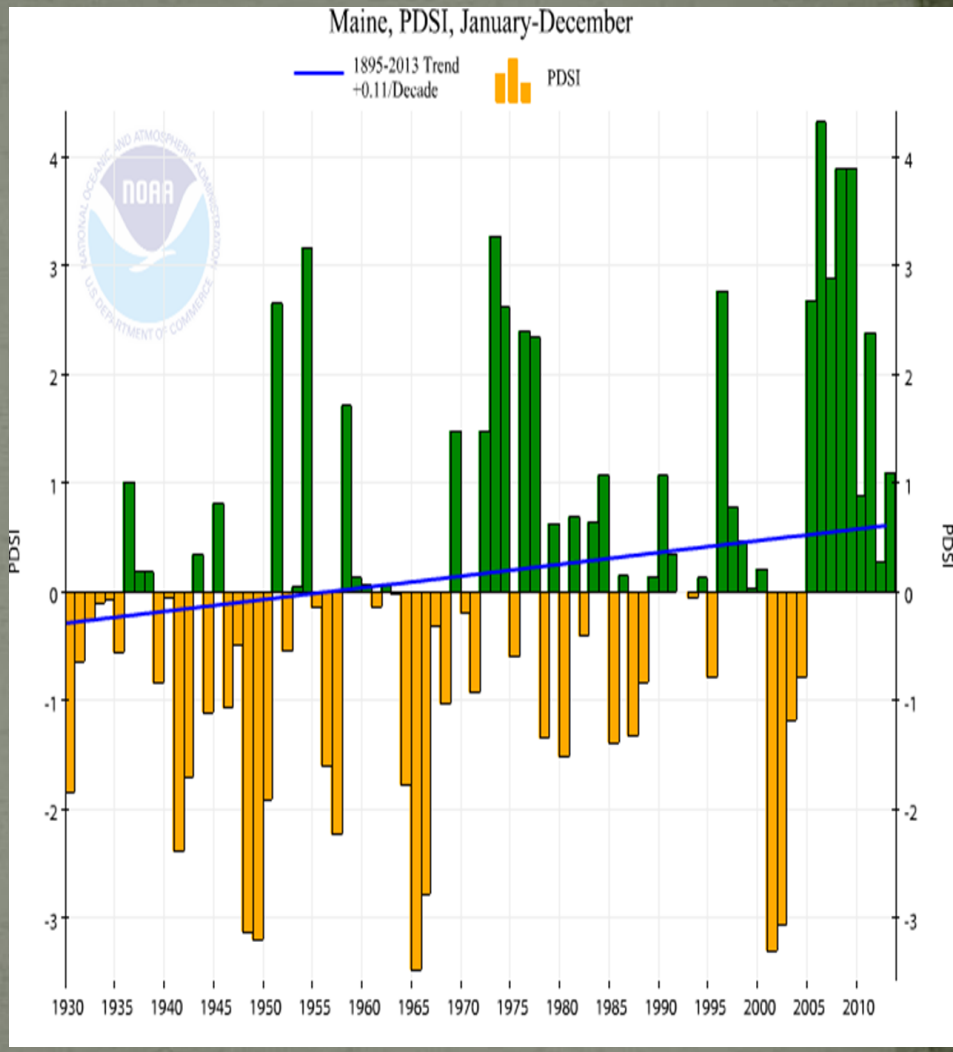




Changes in the Palmer Drought Severity Index

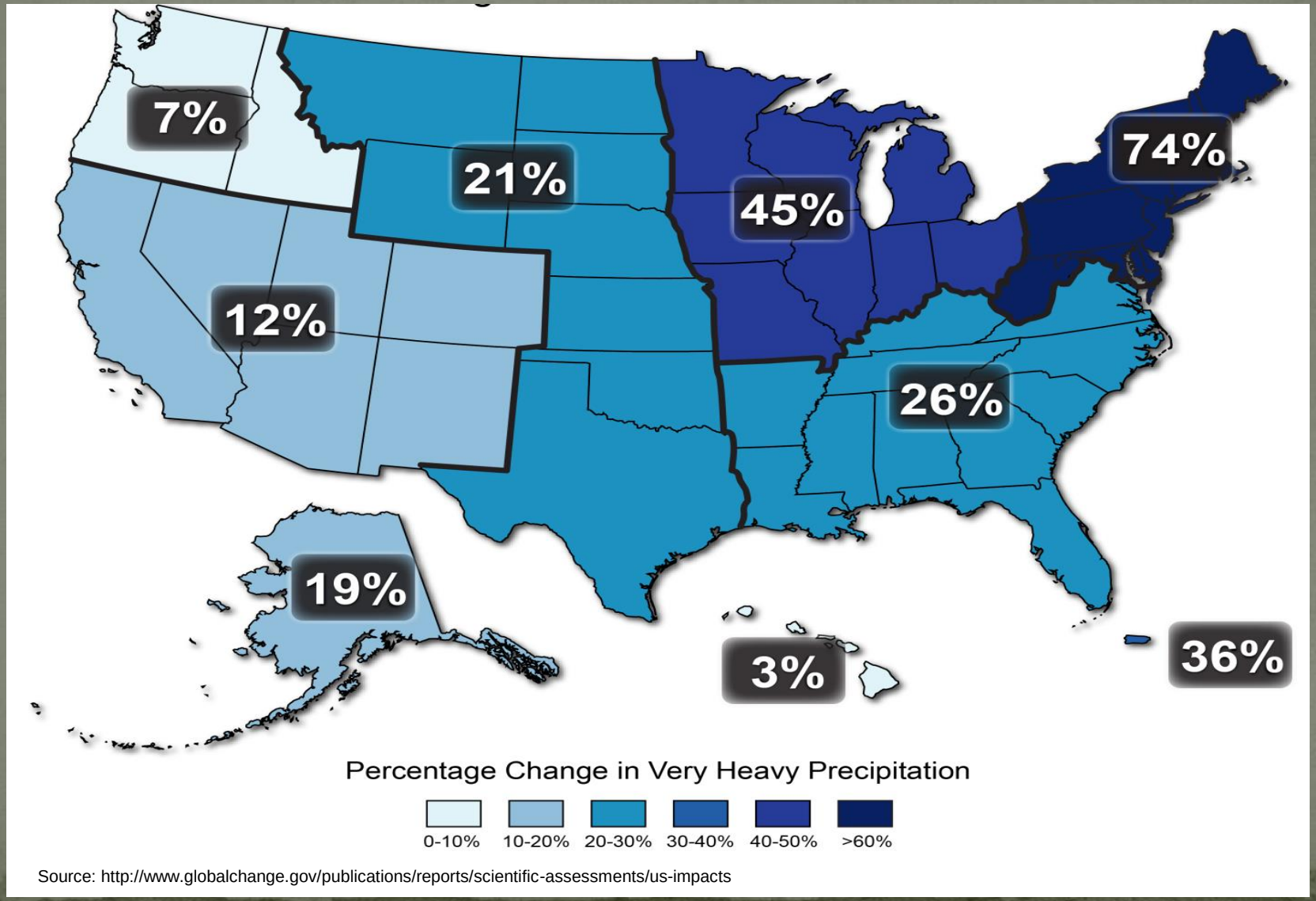




Since the late 60s, similar signature of much shorter, less intense dry periods and longer higher amplitude wet periods

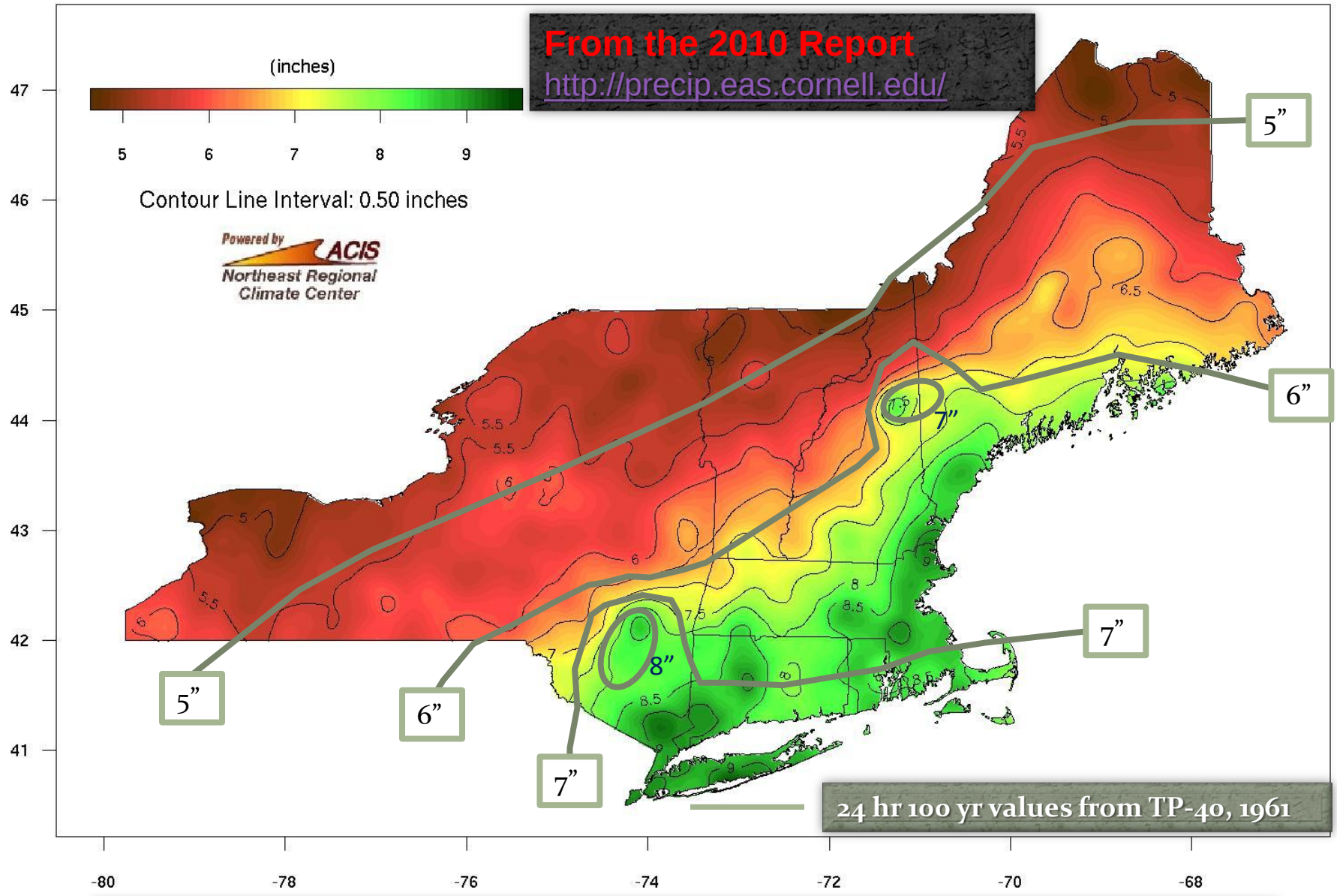
Change in Precipitation Patterns

Intense precipitation events (the heaviest 1%) in the continental U.S. increased by 20% over the past century while total precipitation increased by 7%.



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

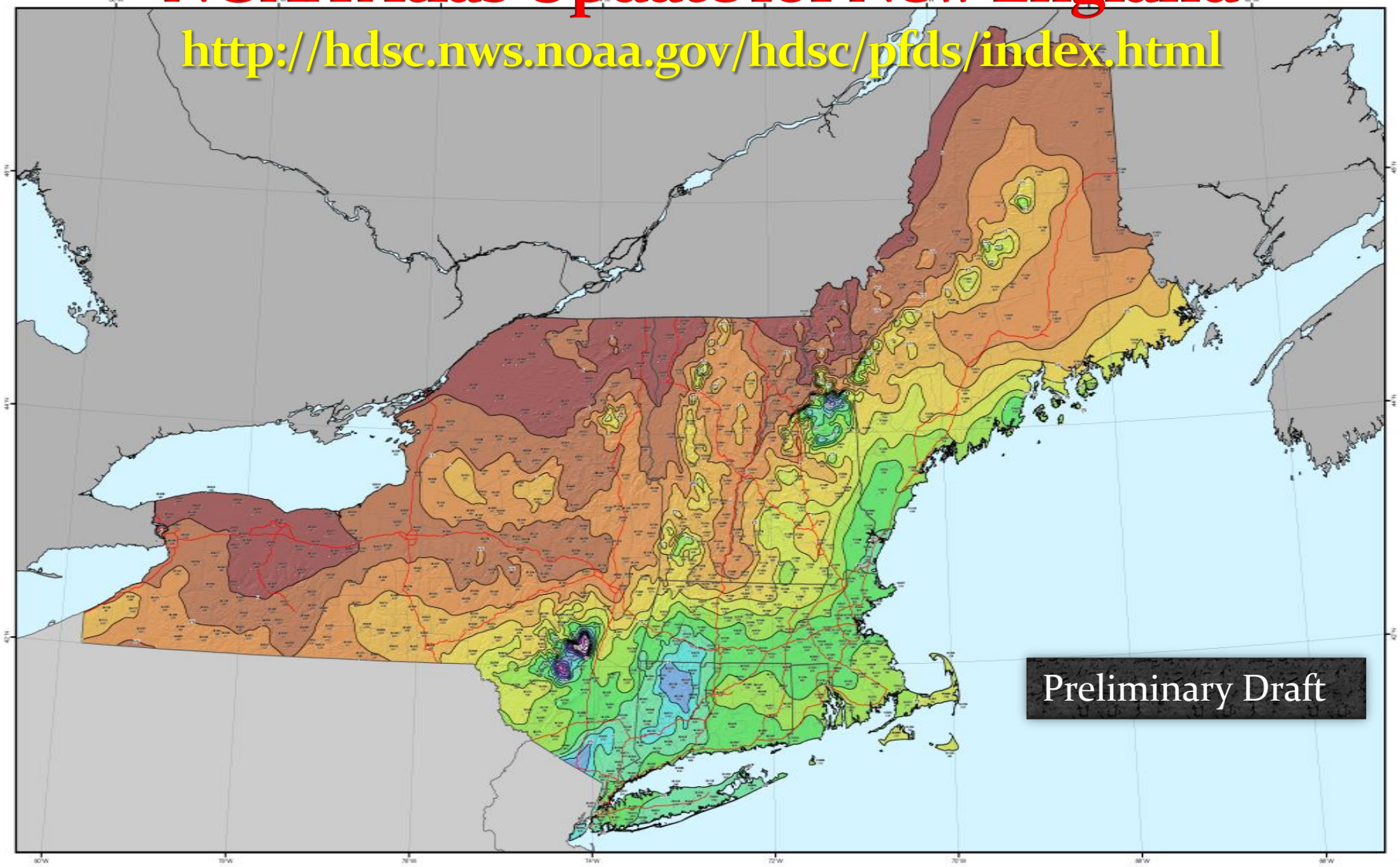
Extreme Precipitation Estimates
24hr 100yr



Southeast ½ of NE experience a 1 to 2 inch upward shift!

NOAA Atlas Update for New England

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



CONNECTICUT, MAINE, MASSACHUSETTS, NEW HAMPSHIRE, NEW YORK, RHODE ISLAND, VERMONT

NOAA Atlas 14, Volume 10, Version 1
Northeastern States

Prepared by U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE
OFFICE OF HYDROLOGIC DEVELOPMENT
HYDROMETEOROLOGICAL DESIGN STUDIES CENTER
September 2014

Isopluvials of 100-year 24-hour precipitation in inches

N

SCALE 1:2,500,000

0 10 20 40 60 80 100 Miles

0 15 30 60 90 120 150 Kilometers

4.50 - 5.00	7.51 - 8.00	10.51 - 11.00
5.01 - 5.50	8.01 - 8.50	11.01 - 11.50
5.51 - 6.00	8.51 - 9.00	11.51 - 12.00
6.01 - 6.50	9.01 - 9.50	12.01 - 12.50
6.51 - 7.00	9.51 - 10.00	12.51 - 12.97
7.01 - 7.50	10.01 - 10.50	

Projection: Lambert Conformal Conic; Datum NAD83; Standard Parallels: 41° and 48°; Central Meridian -73°.

Trends in Flood Frequency:
From the Practitioner's perspective

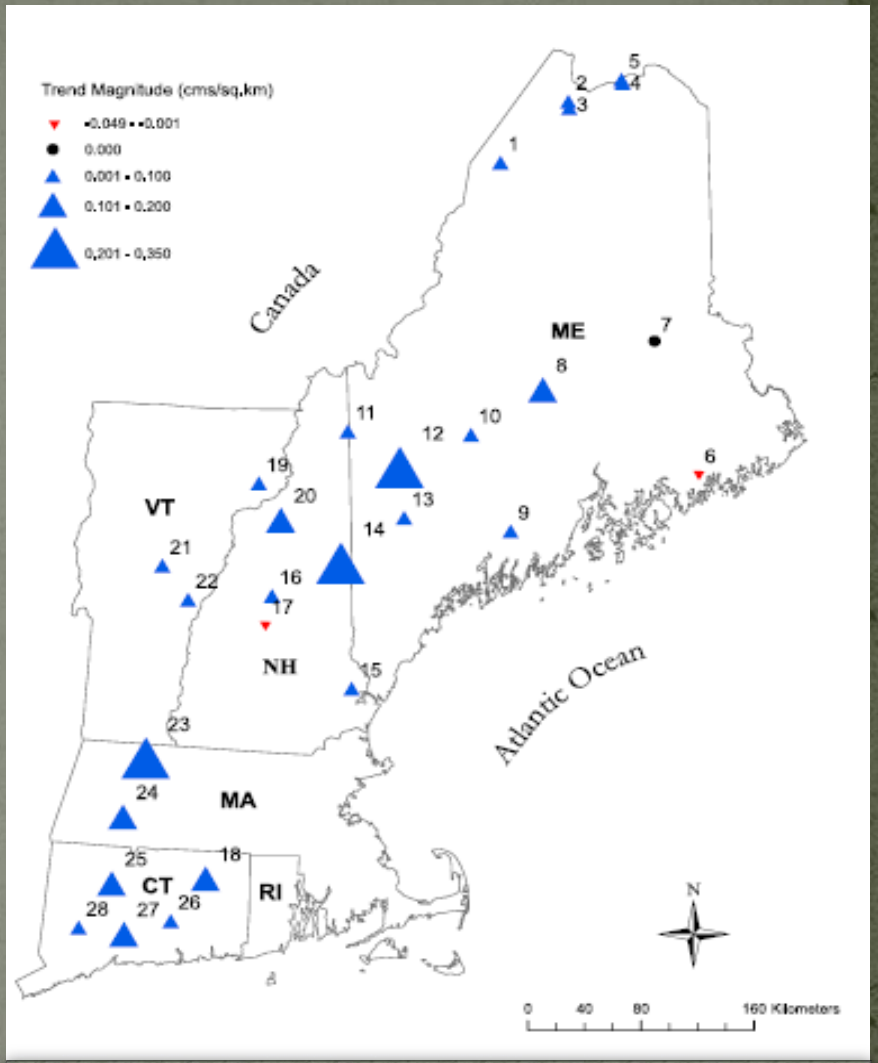
- Small watersheds feeling the effects
  - Changes in frequency/magnitude
  - Part land use/urbanization
    - Compounded by encroachment in the floodplain
  - Part changing climate
- Larger basins with flood control haven't seen as noticeable a shift
  - Most USACE reservoirs are built for 6-8 inch runoff events
  - Greater capacity to handle more rain

Perkins Avenue, Warwick, RI
Tuesday, March 30, 2010


Flooding along the Housatonic River following Lee, Sept 8, 2011.
Photo: A. Driscoll, Connecticut Post

Instantaneous peak flows

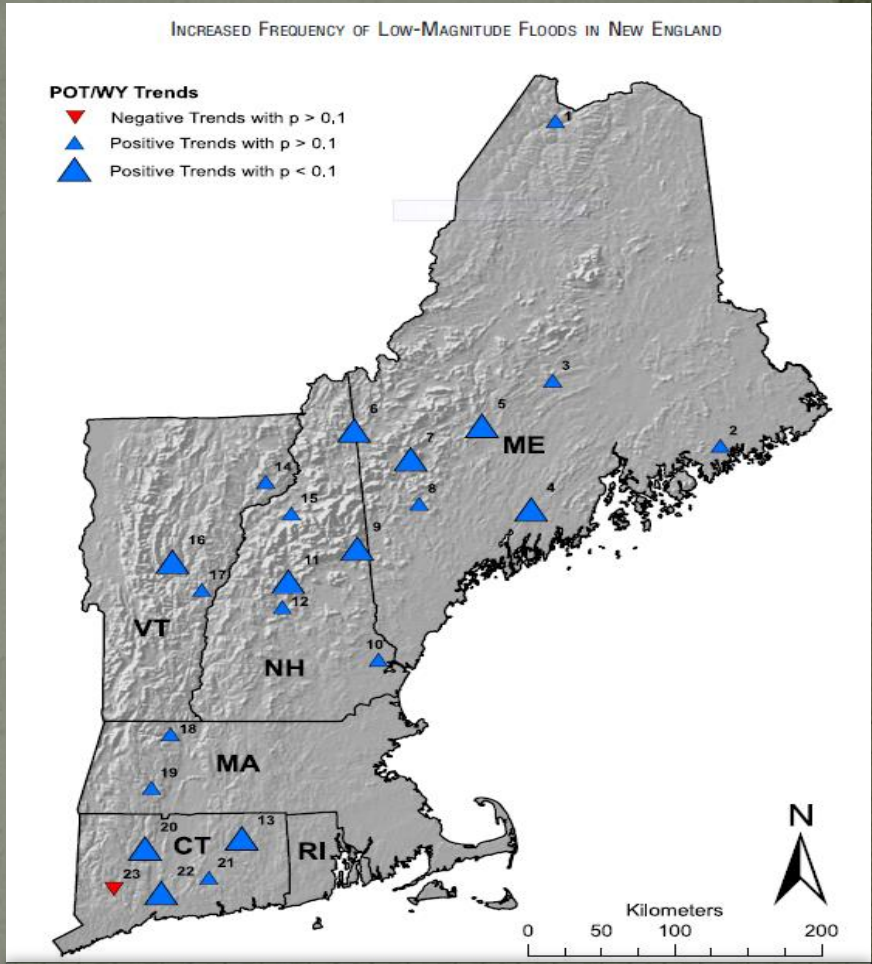
- Mathias Collins – NOAA NFMS – Restoration center
  - 2009 study of 28 watersheds with minimal human influences
  - Results indicate basins in central and western Maine experienced increased peak annual flows
    - Strongest statistical trends noted by the large blue triangles



Spatial distribution of trend directions & magnitudes for based with minimal human influences.
Reference: *M. Collins, Journal of The American Water Resources Association (JAWRA) April 2009.*

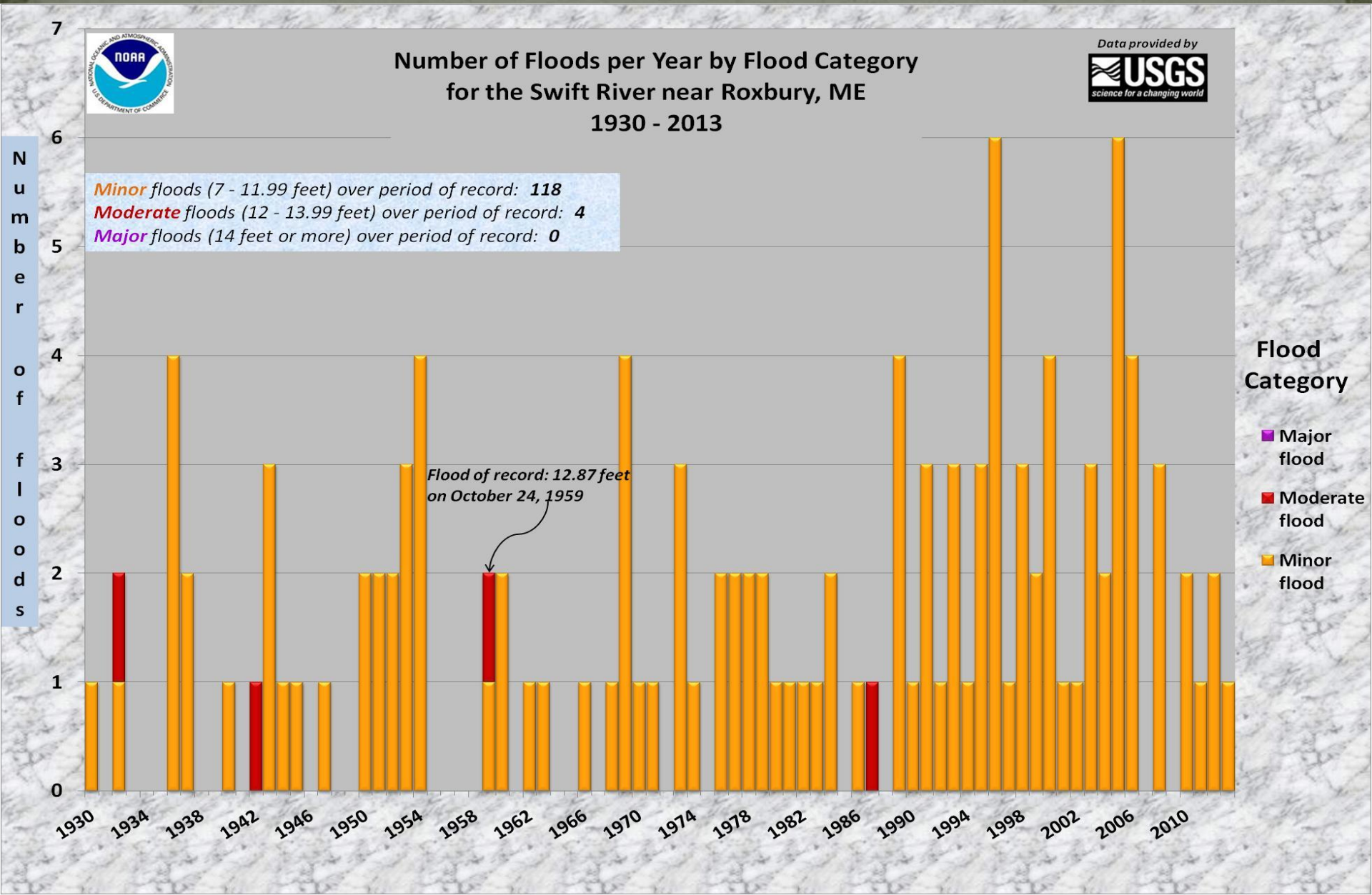
Increased low magnitude floods

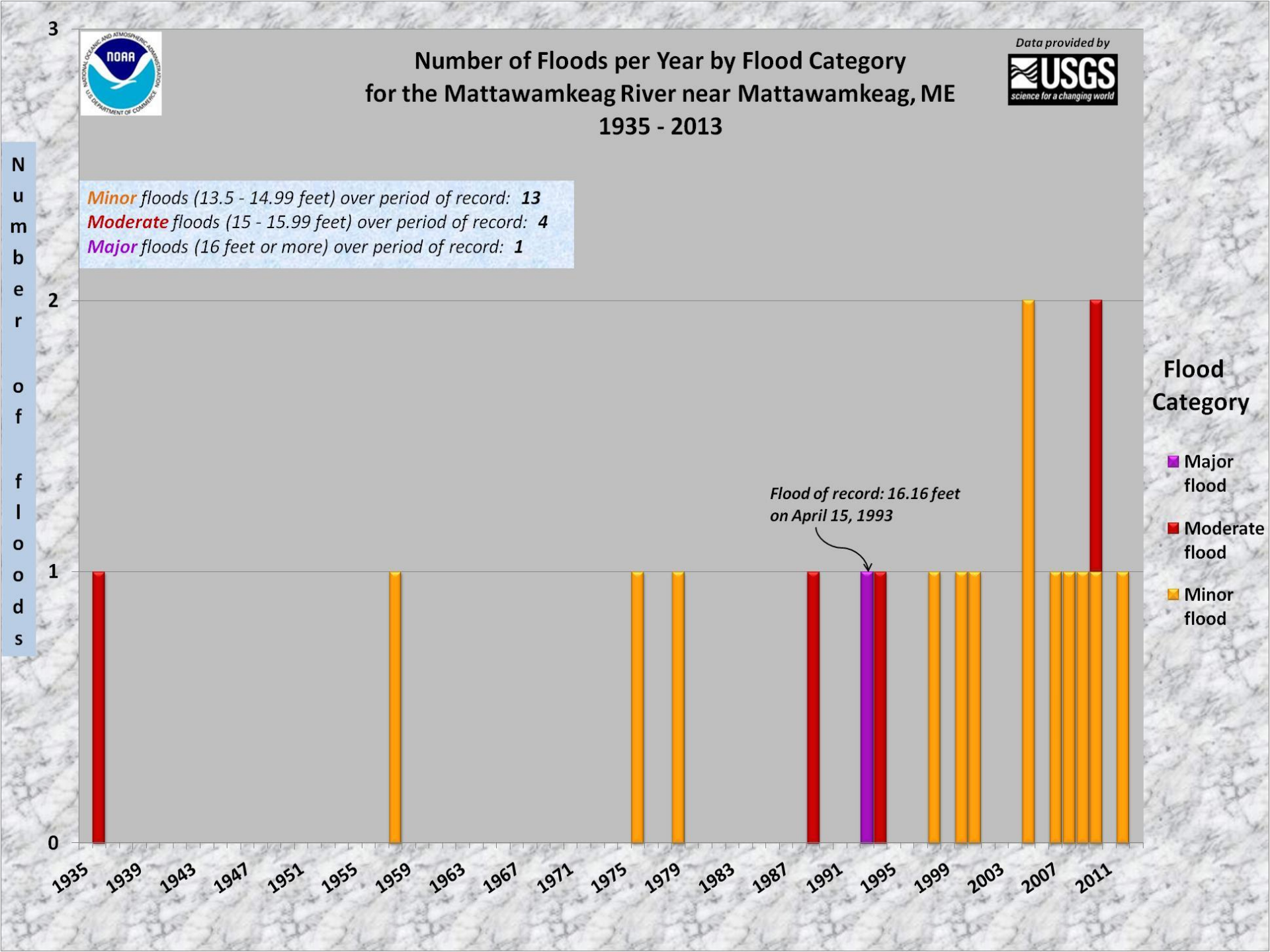
- Mathias Collins – NOAA NFMS – Restoration center
  - 2011 study of 23 watersheds with minimal human influences
  - Examined peaks over defined thresholds per water year (direct measure of flood frequency)
  - More frequent flooding at 22 of 23 locations
  - Increasing flood magnitude at 17 of 23 locations

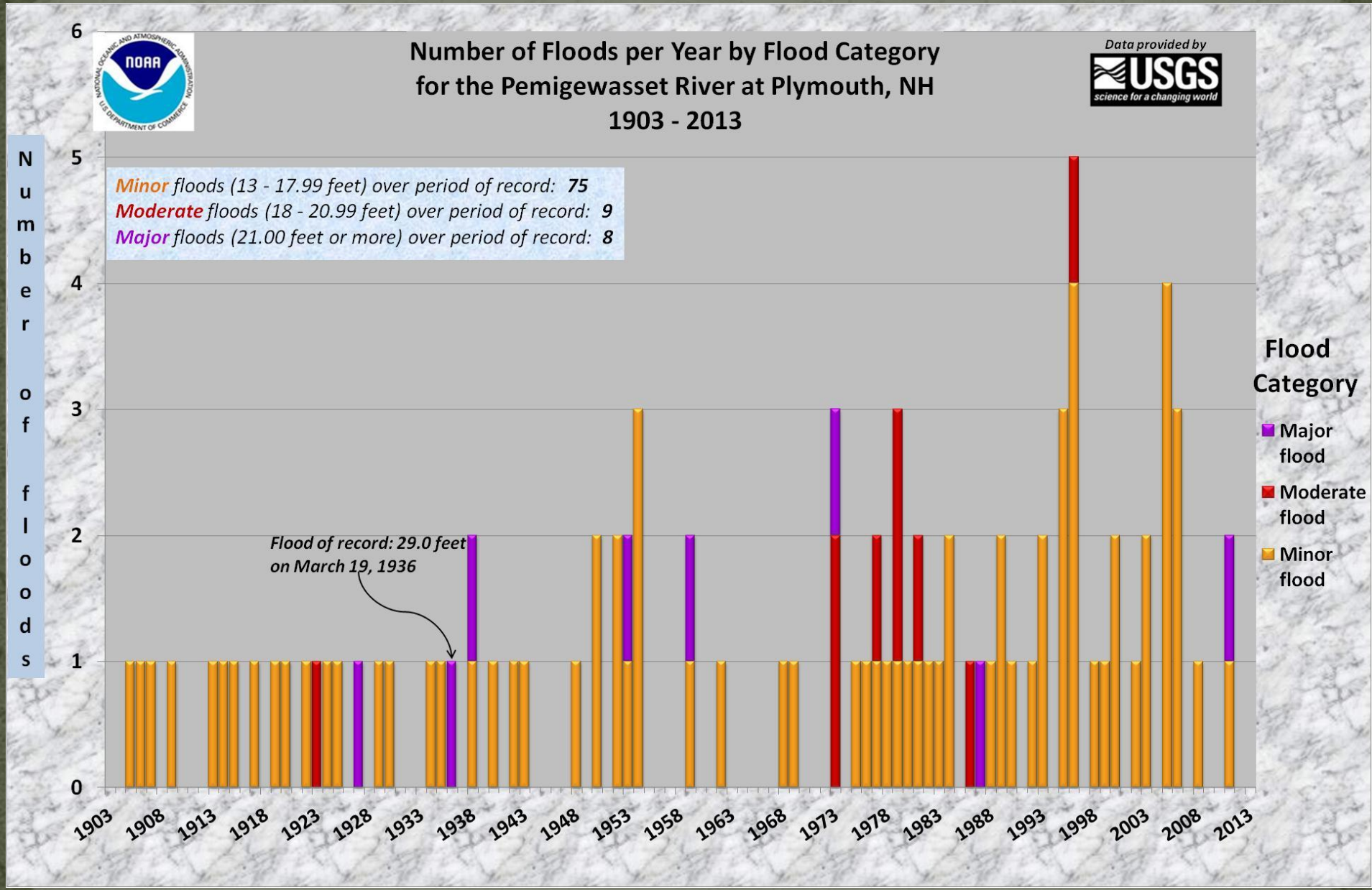


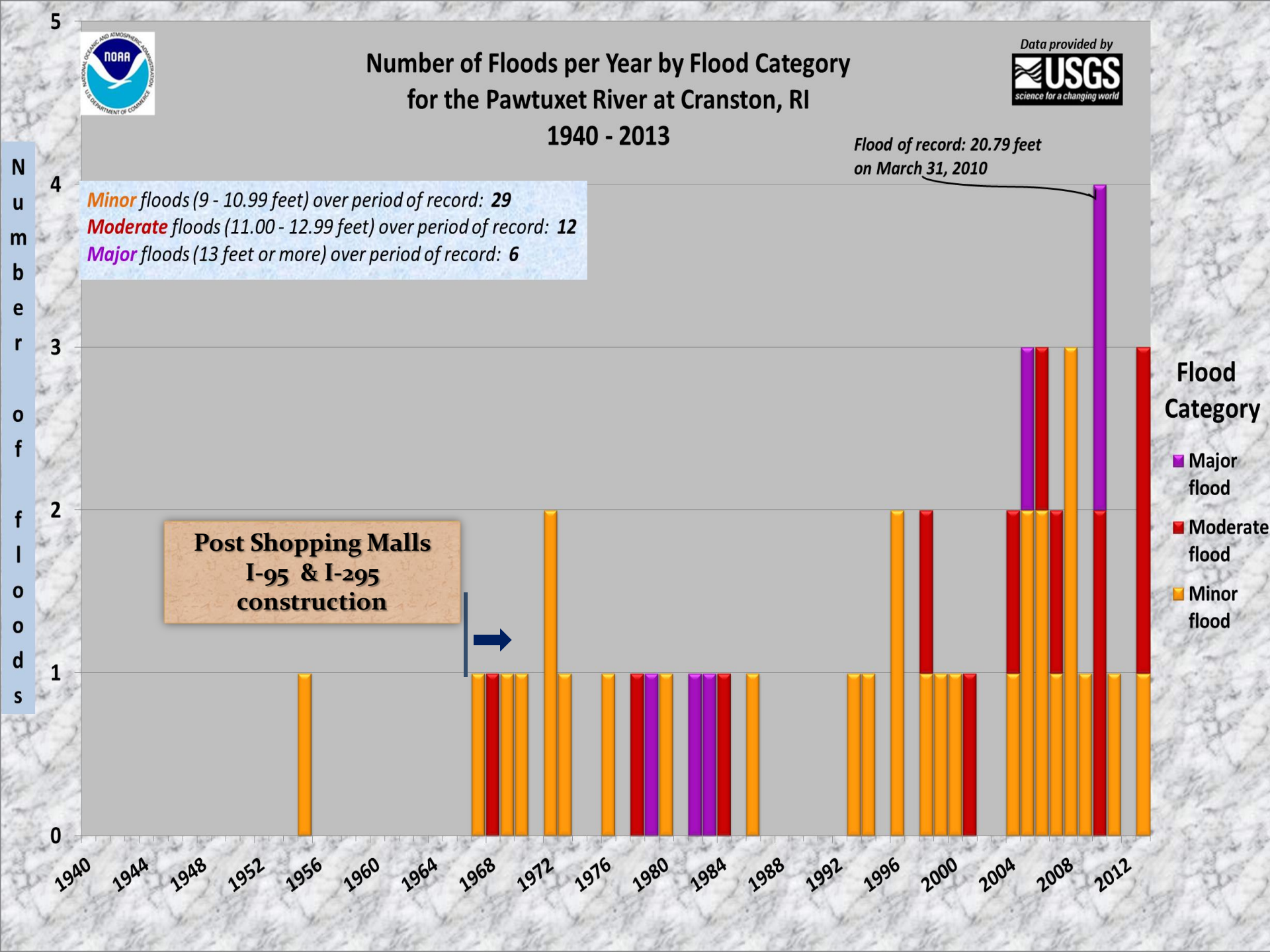
Spatial Distribution of Flood Frequency – as measured by peaks over threshold per water year.
Reference: W. Armstrong, M. *Collins, and N. Snyder Journal of The American Water Resources Association (JAWRA) April 2011.*

NERFC: Examining Flood Frequency& Magnitude of flood events at NWS forecast points




Number of Floods per Year by Flood Category
for the Mattawamkeag River near Mattawamkeag, ME
1935 - 2013
Data provided by
USGS
science for a changing world
Minor floods (13.5 - 14.99 feet) over period of record: 13
Moderate floods (15 - 15.99 feet) over period of record: 4
Major floods (16 feet or more) over period of record: 1
Number of floods
3
2
1
0
Flood of record: 16.16 feet
on April 15, 1993
1935
1939
1943
1947
1951
1955
1959
1963
1967
1971
1975
1979
1983
1987
1991
1995
1999
2003
2007
2011
Flood Category
Major flood
Moderate flood
Minor flood


Number of Floods per Year by Flood Category
for the Pemigewasset River at Plymouth, NH
1903 - 2013
Data provided by
USGS
science for a changing world
Minor floods (13 - 17.99 feet) over period of record: 75
Moderate floods (18 - 20.99 feet) over period of record: 9
Major floods (21.00 feet or more) over period of record: 8
Flood of record: 29.0 feet
on March 19, 1936
Number of floods
0
1
2
3
4
5
6
1903
1908
1913
1918
1923
1928
1933
1938
1943
1948
1953
1958
1963
1968
1973
1978
1983
1988
1993
1998
2003
2008
2013
Flood Category
Major flood
Moderate flood
Minor flood

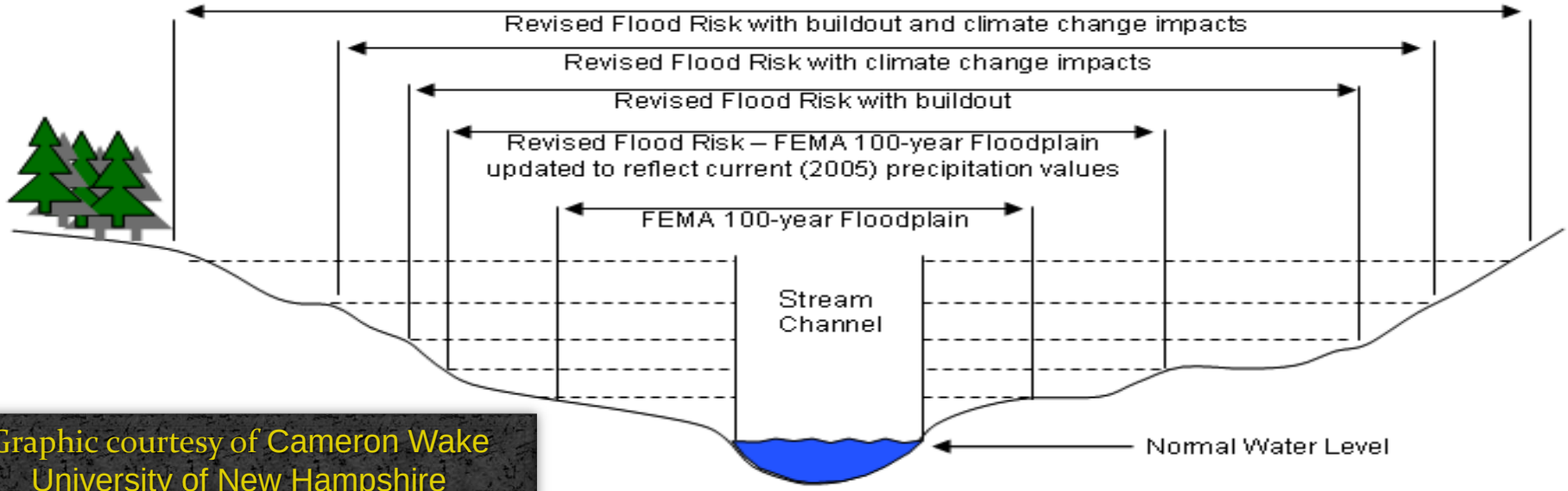

Number of Floods per Year by Flood Category
for the Pawtuxet River at Cranston, RI
1940 - 2013
Data provided by
USGS
science for a changing world
Flood of record: 20.79 feet
on March 31, 2010
Minor floods (9 - 10.99 feet) over period of record: 29
Moderate floods (11.00 - 12.99 feet) over period of record: 12
Major floods (13 feet or more) over period of record: 6
Post Shopping Malls
I-95 & I-295
construction
Number of floods
0
1
2
3
4
5
1940
1944
1948
1952
1956
1960
1964
1968
1972
1976
1980
1984
1988
1992
1996
2000
2004
2008
2012
Flood Category
Major flood
Moderate flood
Minor flood

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
  - Coastal New England has 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

Far reaching implications:
Protect, Adapt or Retreat???

- Floodplain, land use, infrastructure, dam spillway requirements, drainage requirements, non-point source runoff, bridge clearances, "hardening" of critical facilities in the floodplain, property values etc…
- Flood Insurance – work to increase participation
- How much risk are we willing to insure and accept?



Graphic courtesy of Cameron Wake
University of New Hampshire

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