

# Climate Trends in Massachusetts and Its Impact on Flood Behavior



Flash flooding in Orleans – July 7, 2017  
Source: Erick Coe (Twitter)

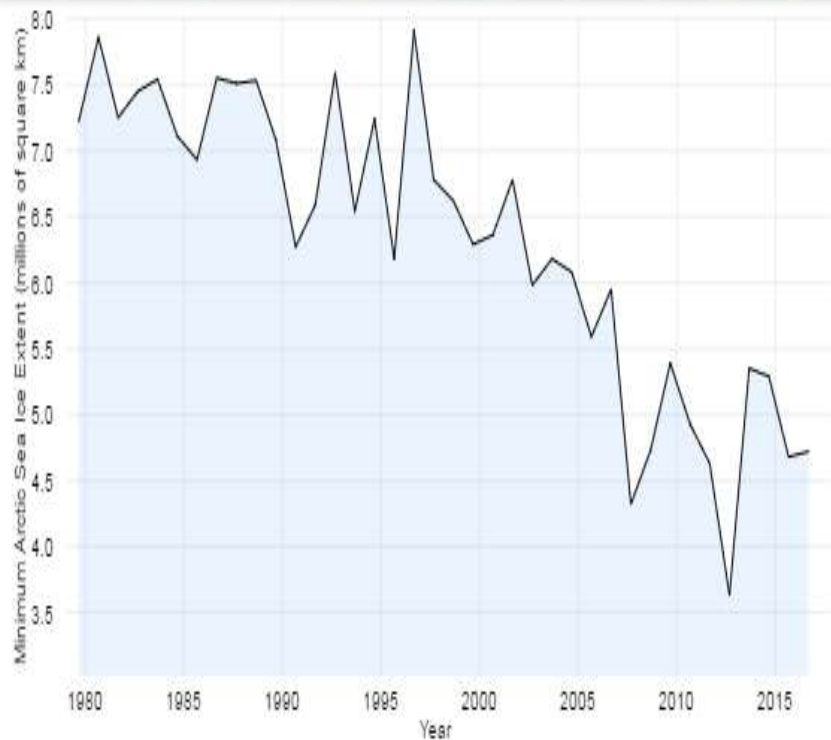


Coastal Flooding at Monument Beach from Hurricane Bob,  
August 19, 1991. Source: Cape Cod Times

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

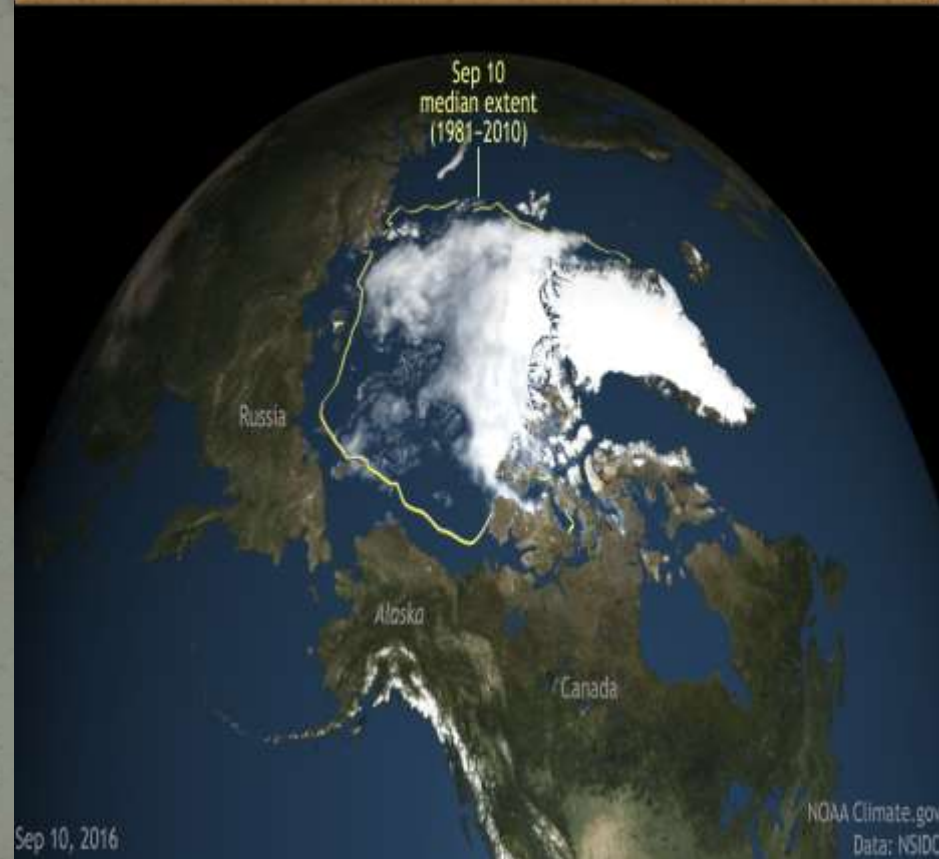
# A warming planet and shrinking Arctic Sea ice

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

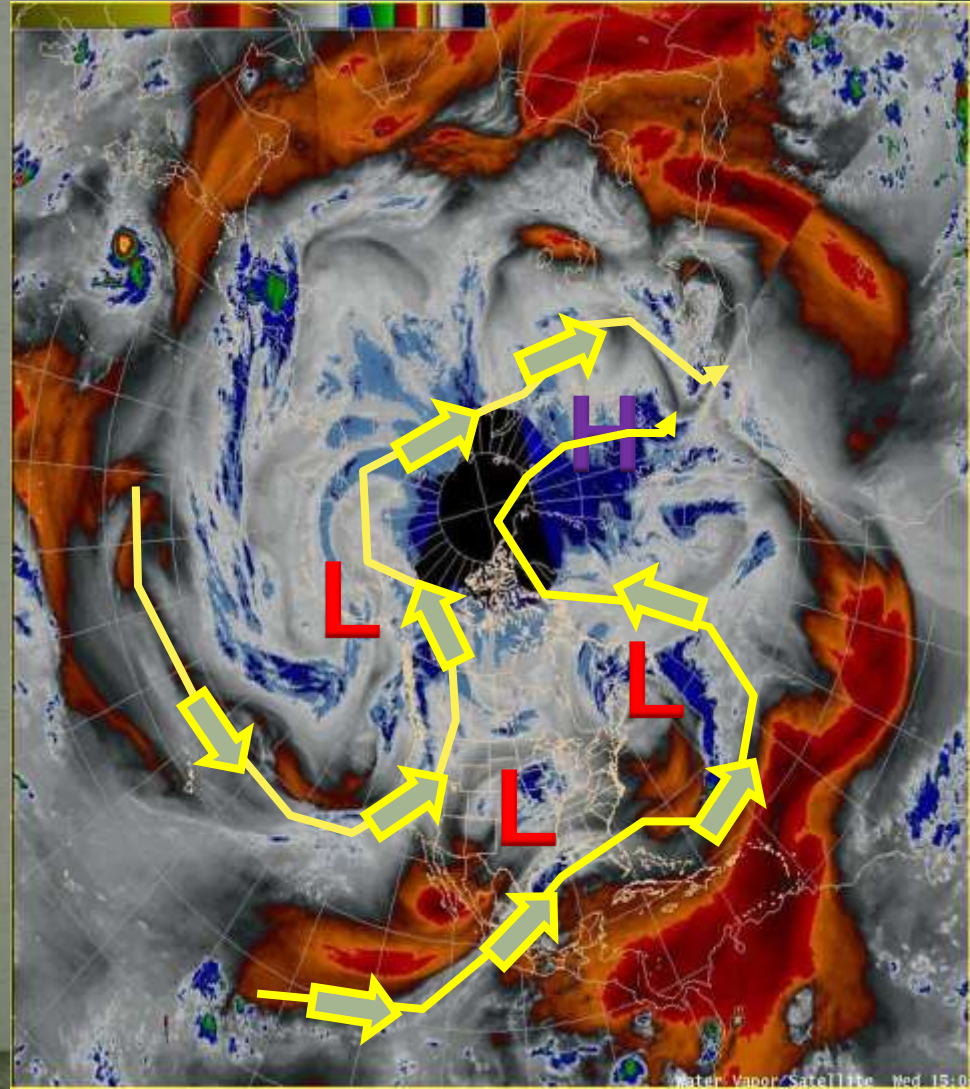
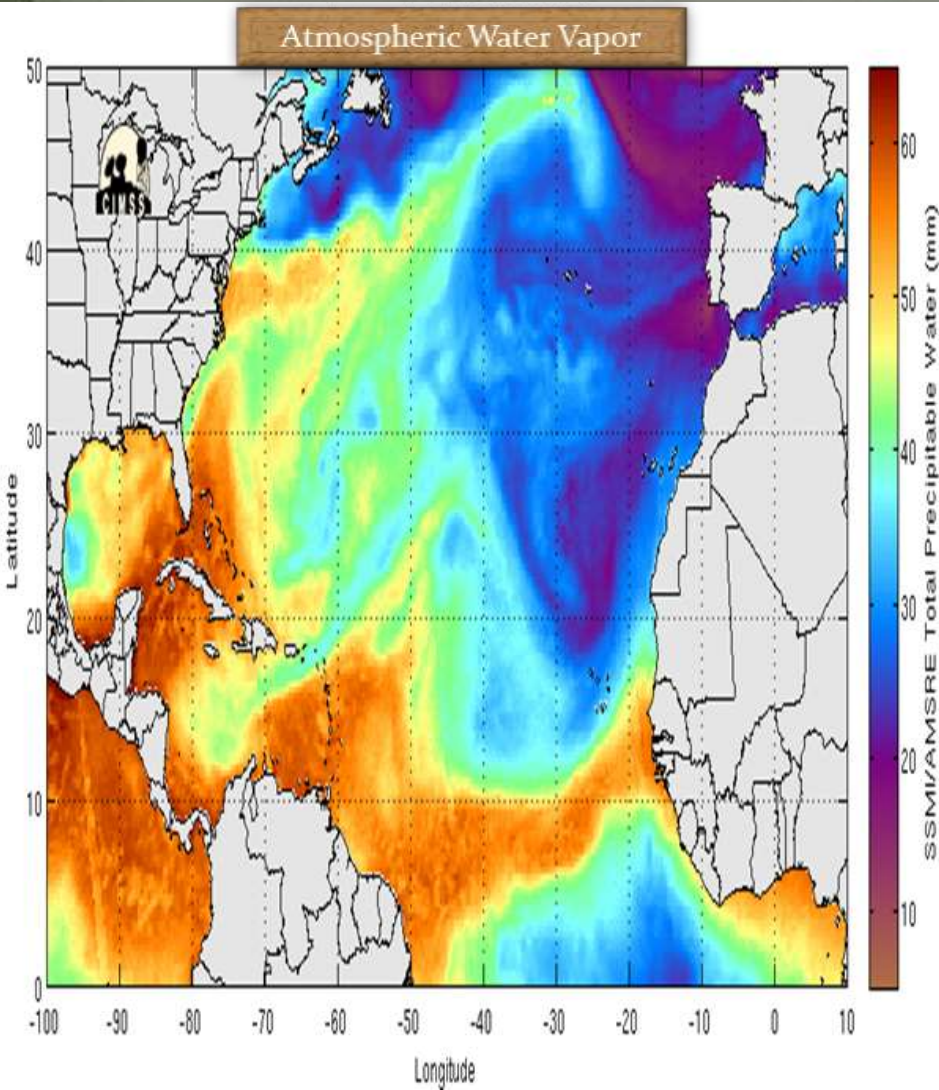


Arctic sea ice concentration on the date of the 2016 minimum extent, September 10, 2016. NOAA Climate.gov image based on NOAA and NASA satellite data from NSIDC.



# The Atmospheric Response

Increased frequency of slow moving and/or blocked up weather patterns  
Increased opportunities for storms to tap the deep moisture for longer durations



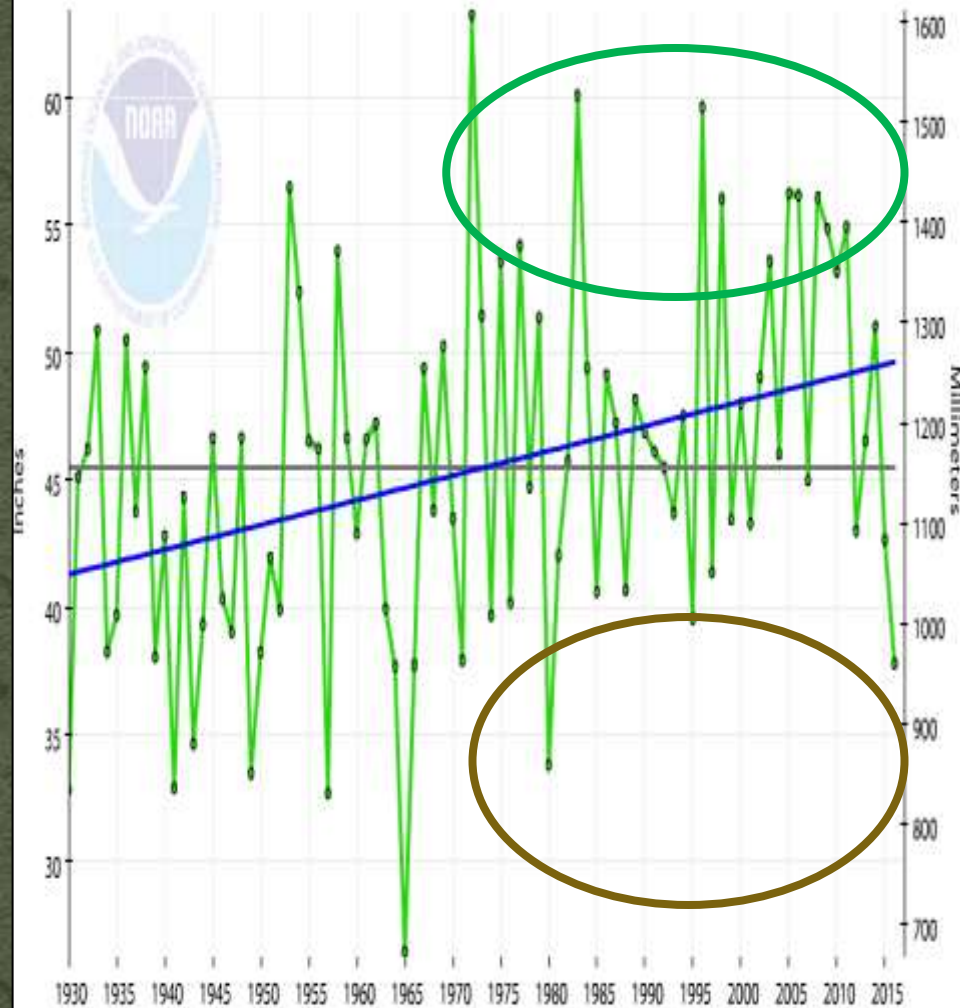


# A Look at Precipitation & Temperature Trends

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

Massachusetts, Climate Division 3, Precipitation, January-December

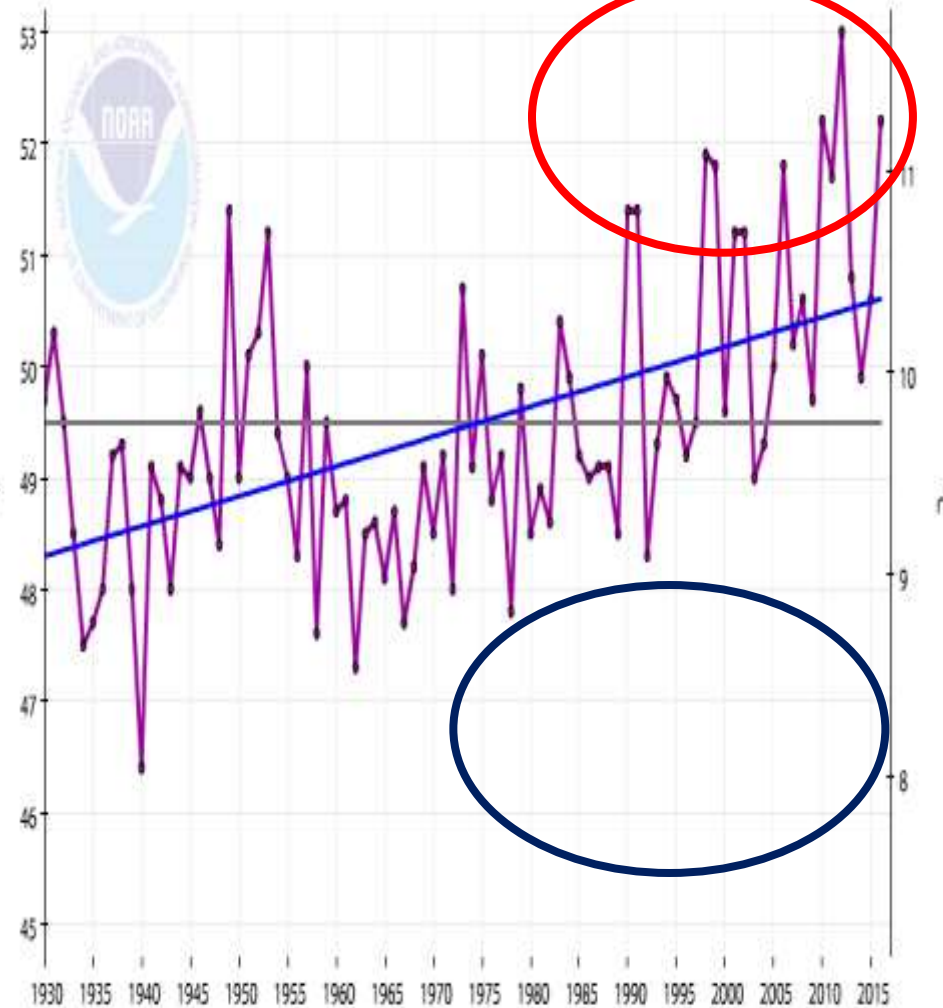
— 1930-2016 Trend  
-0.97"/Decade  
— 1930-2016  
Mean: 45.47"  
— Precip



Eastern/Coastal Massachusetts

Massachusetts, Climate Division 3, Average Temperature, January-December

— 1930-2016 Trend  
+0.3°F/Decade  
— 1930-2016  
Mean: 49.5°F  
— Avg Temperature



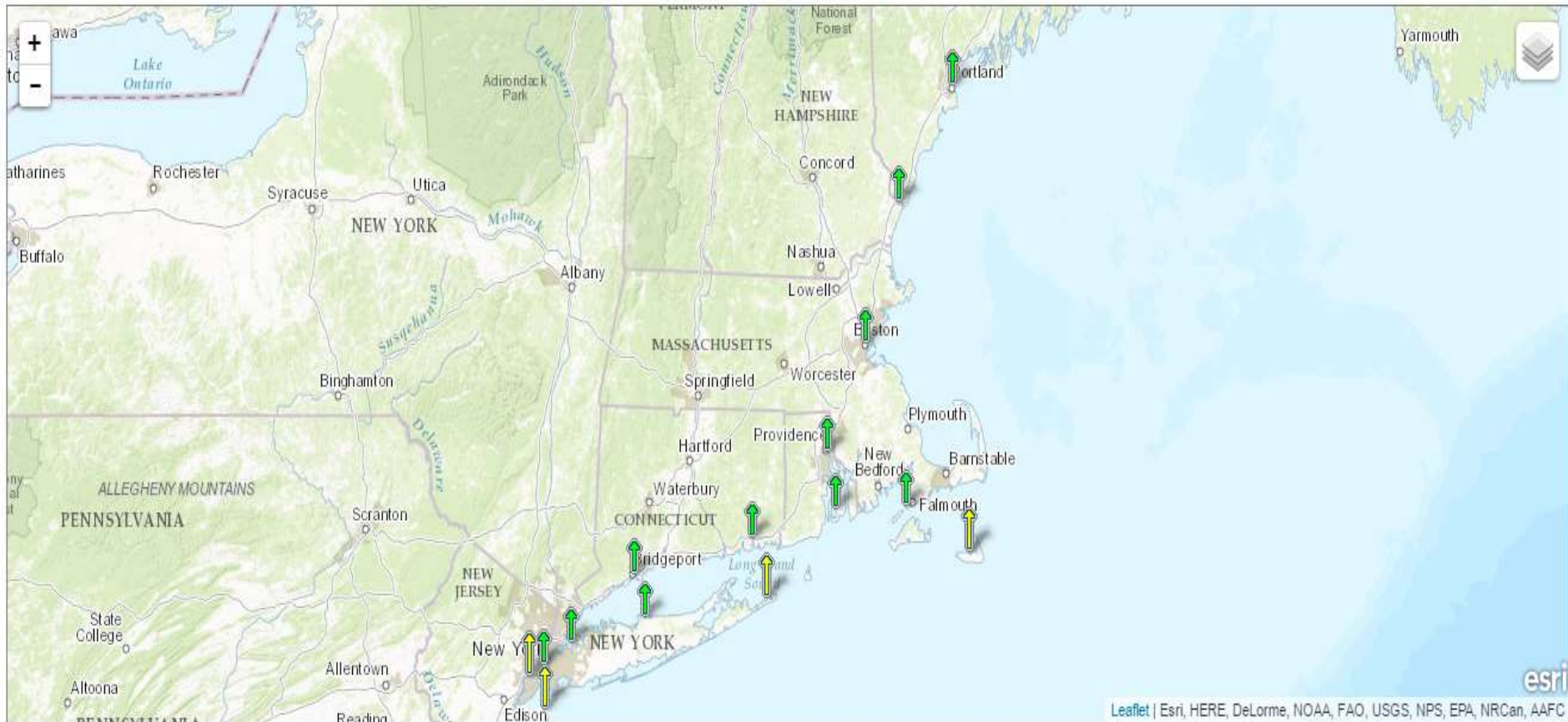
Eastern/Coastal Massachusetts

# Sea Level Trends

<http://tidesandcurrents.noaa.gov/sltrends/index.shtml>

East Coast West Coast Gulf Coast Alaska Hawaii Global

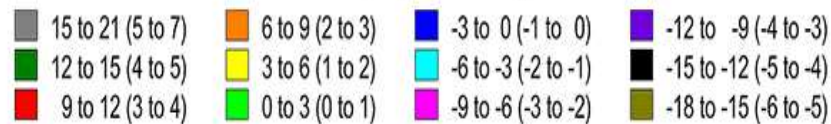
 View in Google Earth



The map above illustrates regional trends in sea level, with arrows representing the direction and magnitude of change. Click on an arrow to access additional information about that station.

## Sea Level Trends

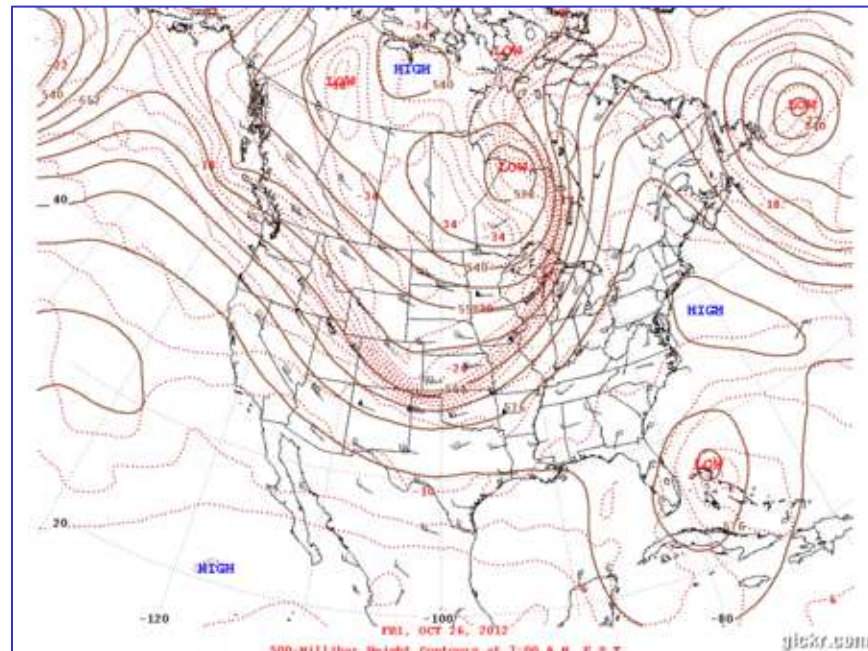
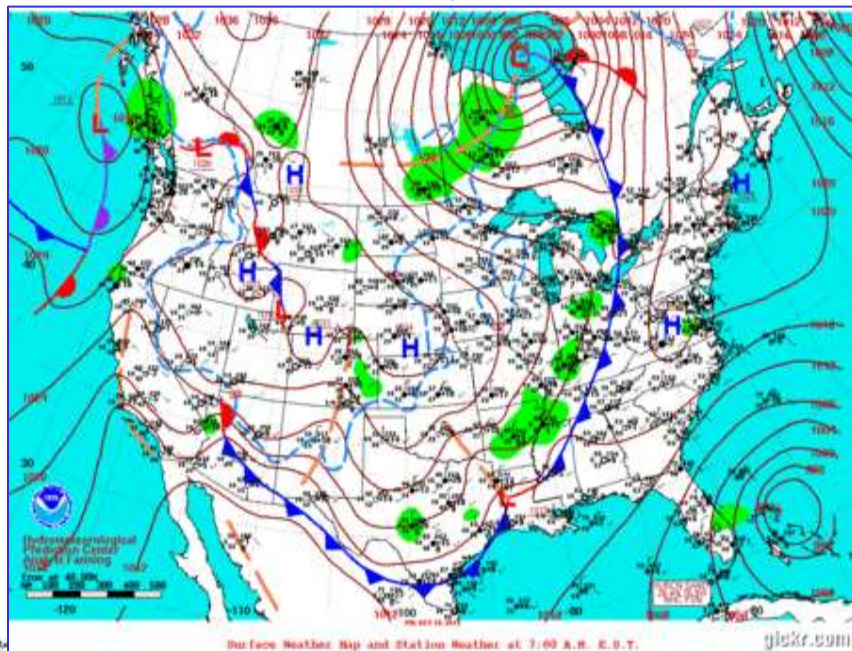
mm/yr (feet/century)





# Sandy: A Perfect Storm of Sorts

- ❑ **Formed in the western Caribbean**
  - o Not at all unusual for late October
- ❑ **Encountered a very deep trough of Low Pressure in the eastern United States and very strong High Pressure moving southward from the Canadian Maritimes**
  - o A winter-type dual jet stream set up (classic for a New England Hurricane)
  - o Captured Sandy & blocked her attempt to race out to sea



# Storm Surge Risk: Menauhant section of Falmouth, Massachusetts





Wondering what this might look like during  
an actual Storm Surge???



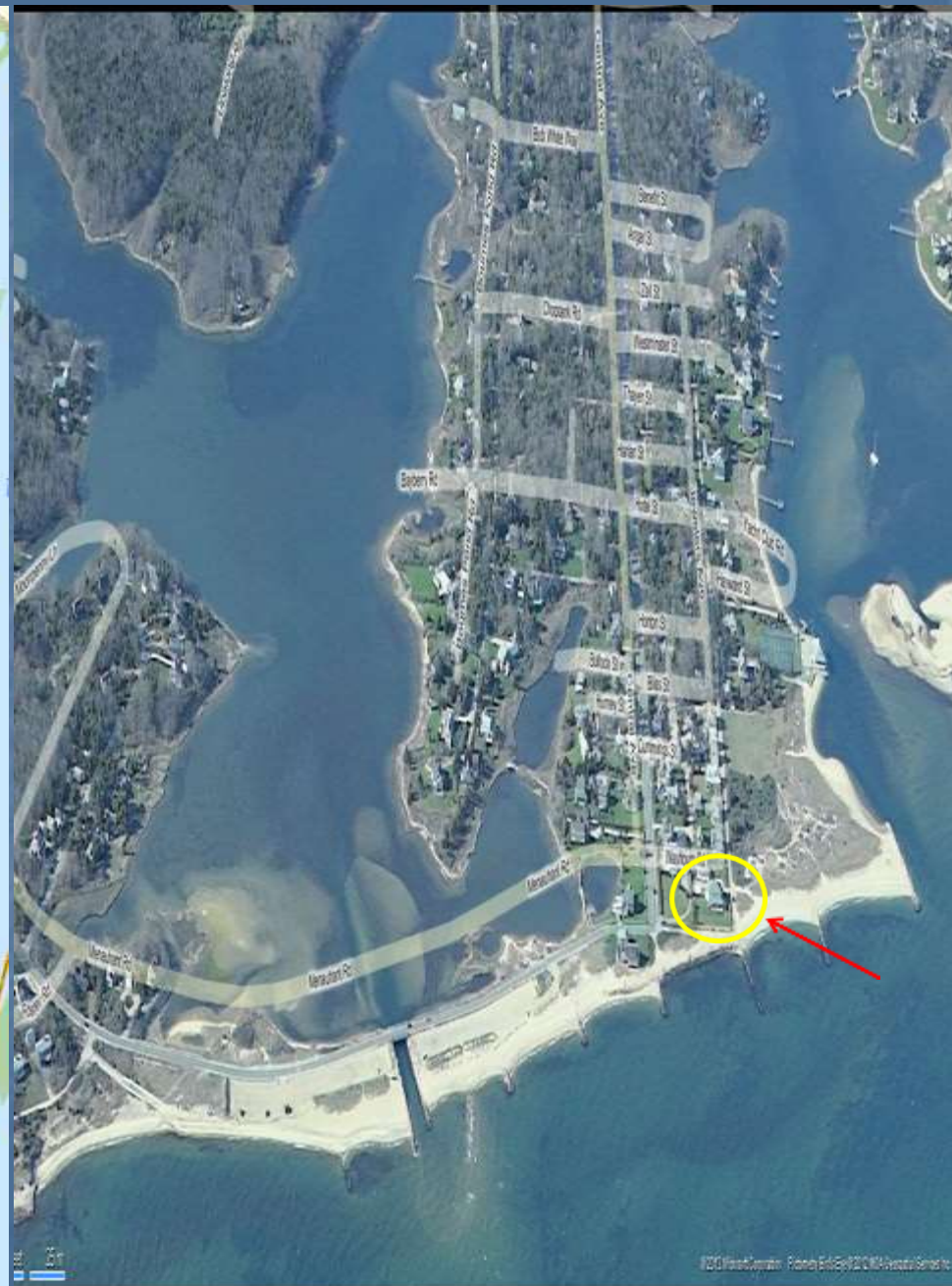


# Hurricane Bob's Six Foot Storm Surge!





# Consider the risk in the face of sea level rise





# So What's The Real Potential?



Worst Case Cat 3 – 16 foot surge

Hurricane Carol's 12 foot surge

Hurricane Bob's 6 foot surge

# The Great New England Hurricane of 1938 had it all!



Tremendous storm surge damage at the mouth of the Connecticut River, at Old Lyme



Route 1A – Scenic in Narragansett, RI following the Great New England Hurricane of 1938.



Devastating storm surge damage flattens the beach-side village of Island Park, Portsmouth, RI



Powerful waves breaking over the sea wall at the U.S. Fishery Building during the 1938 Hurricane in Woods Hole, MA



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