



INFLUENCE OF A CHANGING CLIMATE ON WATERWAYS IN VERMONT

Dr. Lesley-Ann Dupigny-Giroux

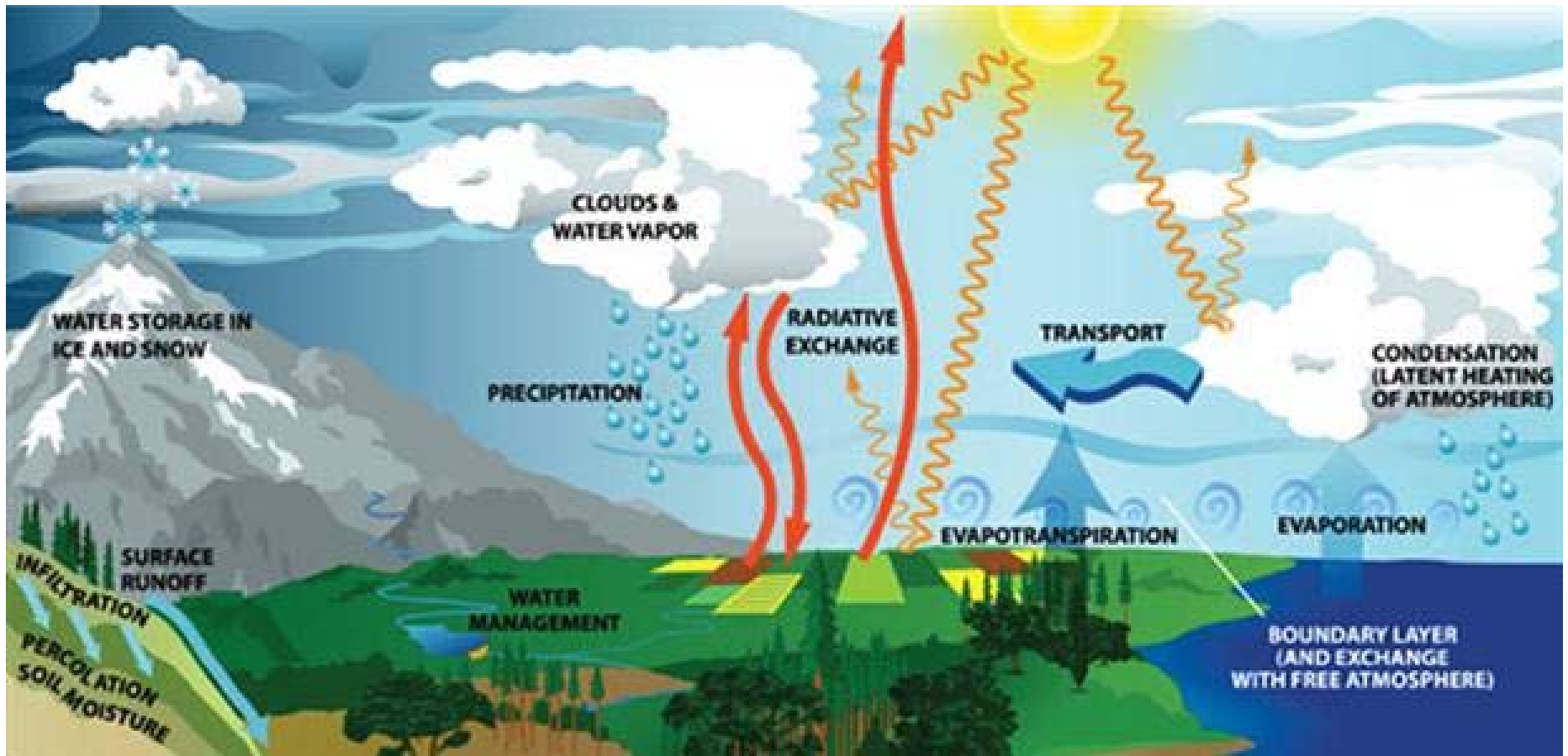
Professor – Department of Geography
VT State Climatologist

President-elect – American Association of State Climatologists

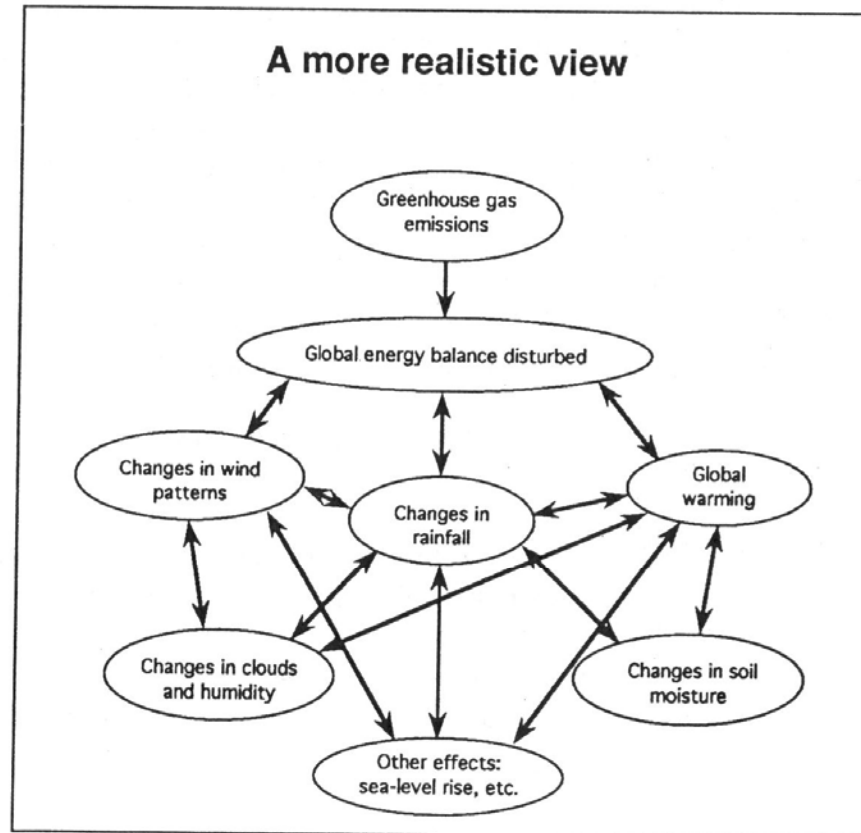
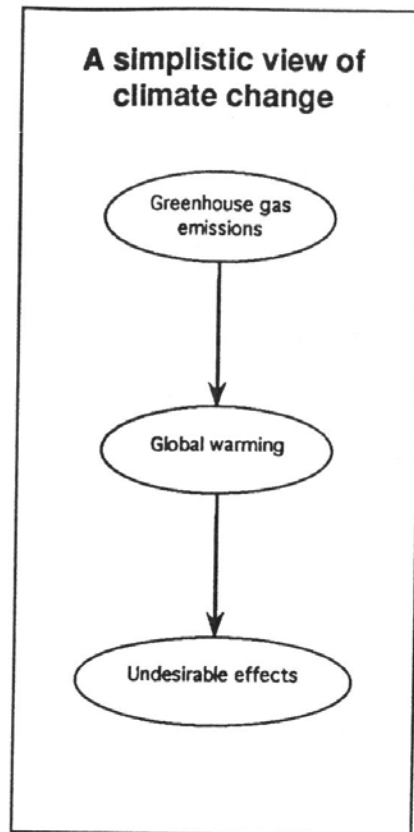
Weather vs. climate


- Weather = state of the atmosphere at some place & time
 - described as temperature, cloudiness, precipitation, wind speed & direction
- Meteorology = study of the atmosphere & processes that cause weather
- Climate = weather conditions at some locality averaged over a specified time period
- Climatology = study of climate, its controls & variability

1. Climate is a system

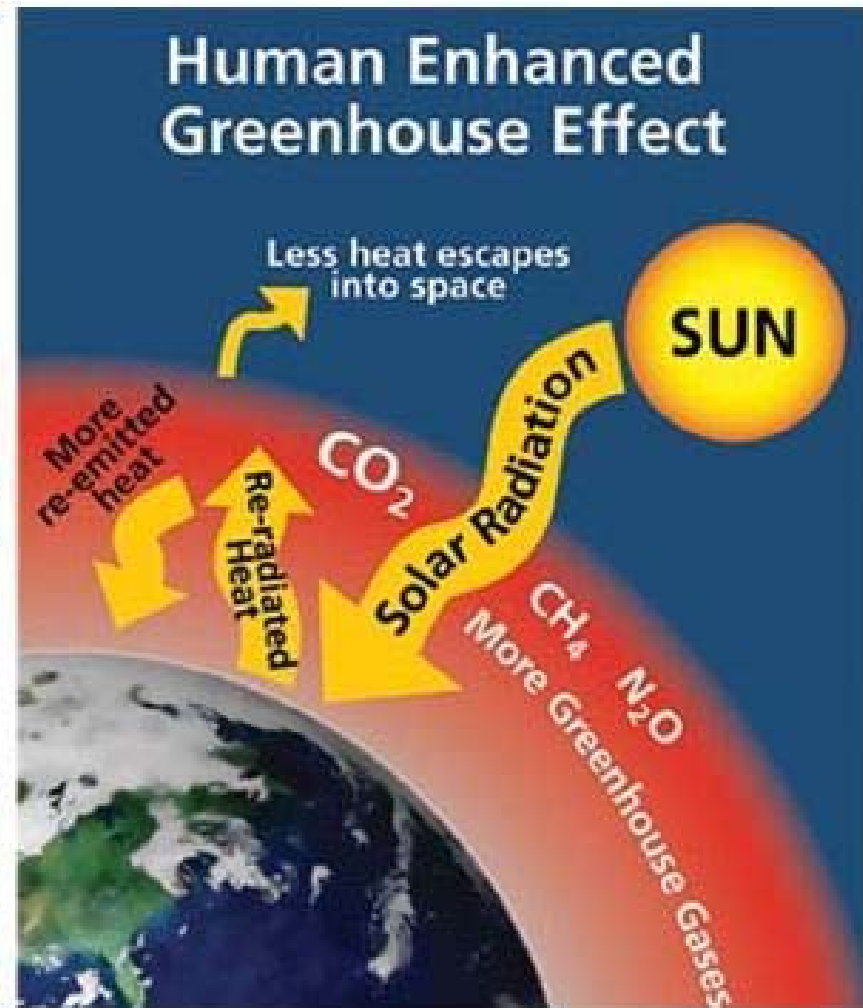
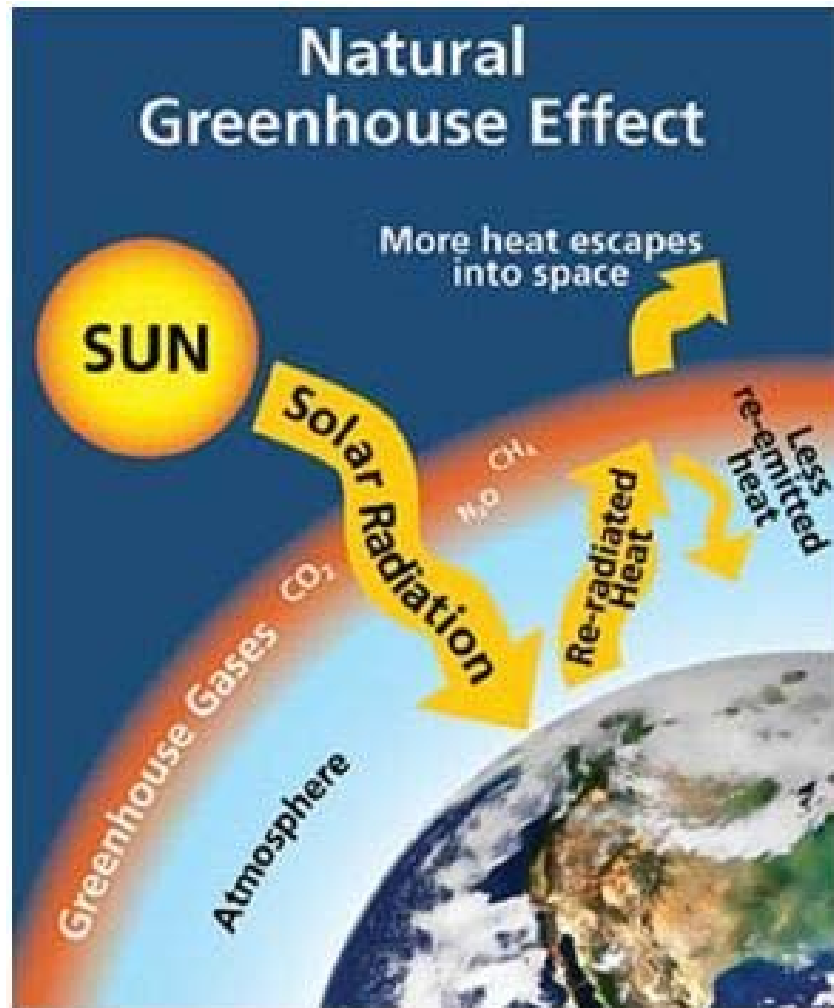


Climate change as a...system

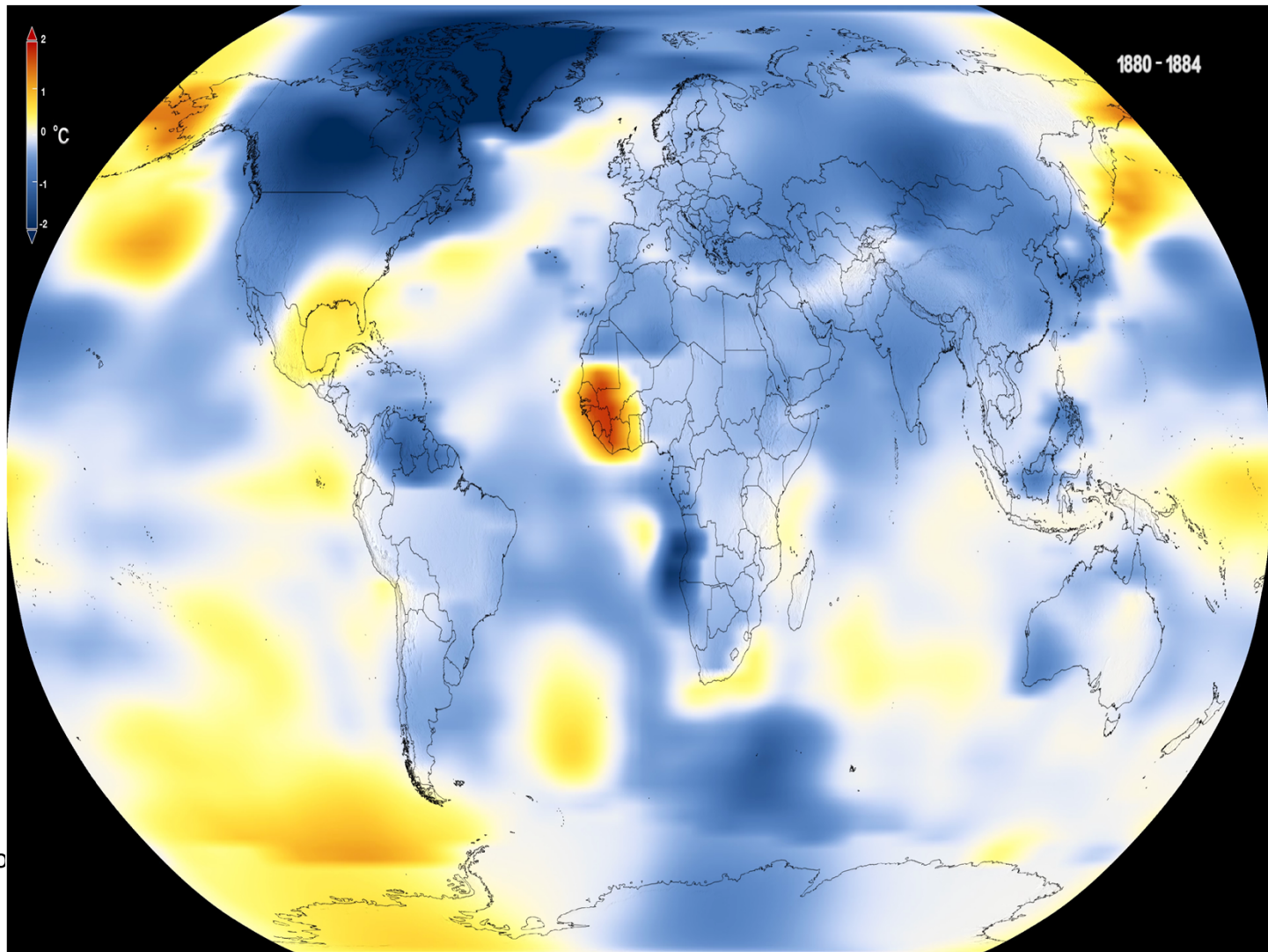




2. Global warming differs from climate change



Five-Year Average Global Temperature Anomalies from 1880 to 2017



<https://svs.gsfc.nasa.gov/4609>

3. What is climate change?

IPCC (2007, 2013) definition

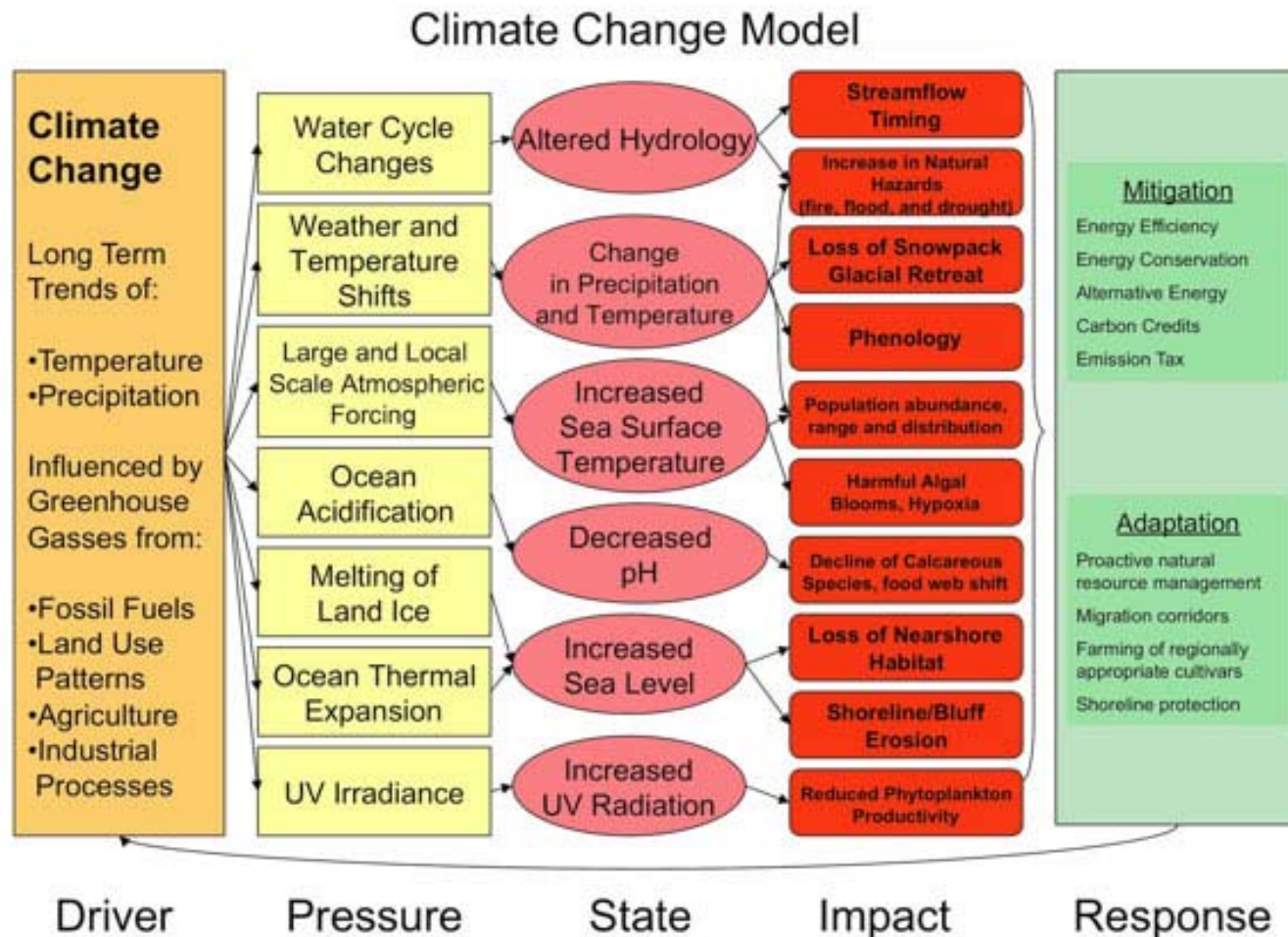
”Climate change in IPCC usage refers to a change in the state of the climate that can be identified (e.g. using statistical tests) by **changes in the mean and/or the variability of its properties**, and that persists for an extended period, typically decades or longer. It refers to **any change in climate** over time, whether due to **natural variability or as a result of human activity**. This usage differs from that in the United Nations Framework Convention on Climate Change (UNFCCC), where climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability

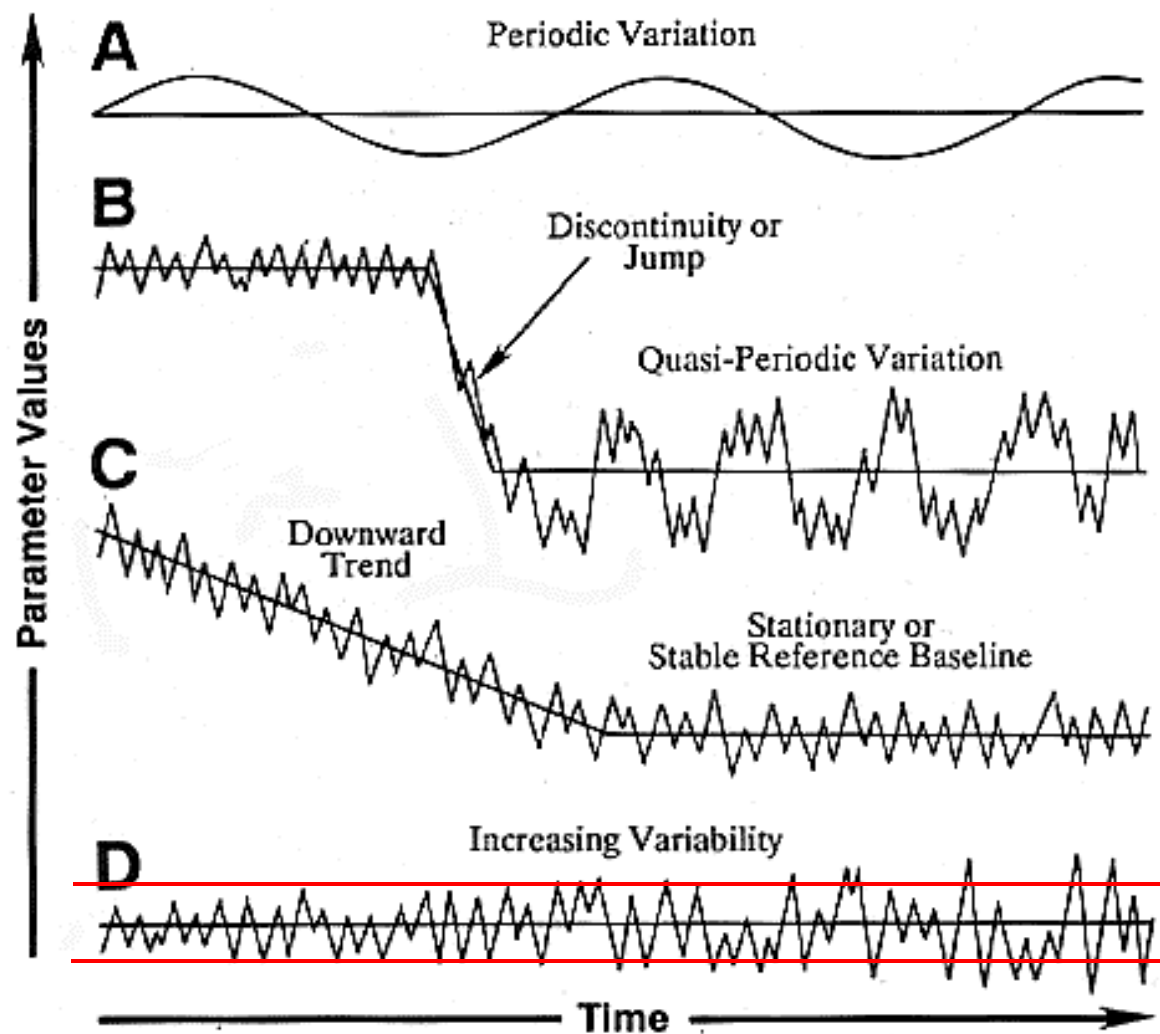


3b. The three aspects of climate change

- process
- impacts
- strategies for mitigation & adaptation

Process, impact, strategies





Increased
human
vulnerability

Types of climatic variation



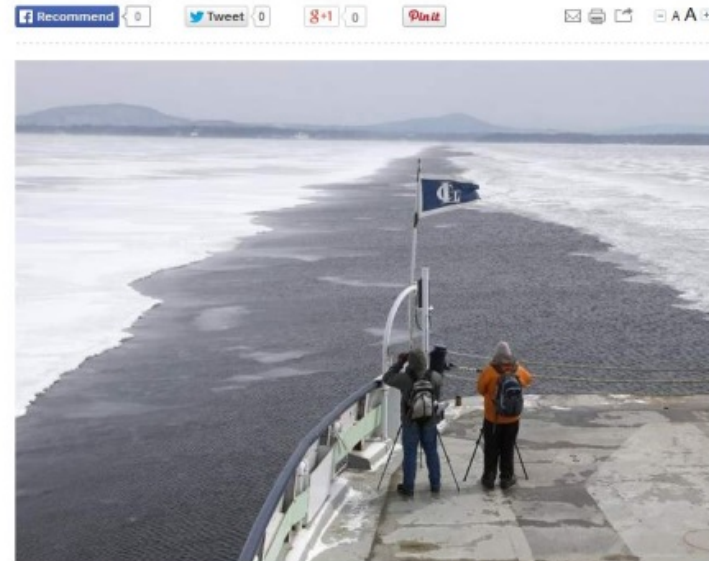
4. What does climate change look like in Vermont?

Weather service warns of spring floods for Vermont and upstate New York

Above-average amounts of snow and frozen rivers are cited

Mar. 20, 2014 | 1 Comment

Recommend Be the first of your friends to recommend this.



The Charlotte ferry as it travels from New York to Vermont on Wednesday, March 5. Lake Champlain is frozen solid, except for two stretches of open water where two ferries carry passengers between Vermont and New York. / AP

Written by
Associated Press

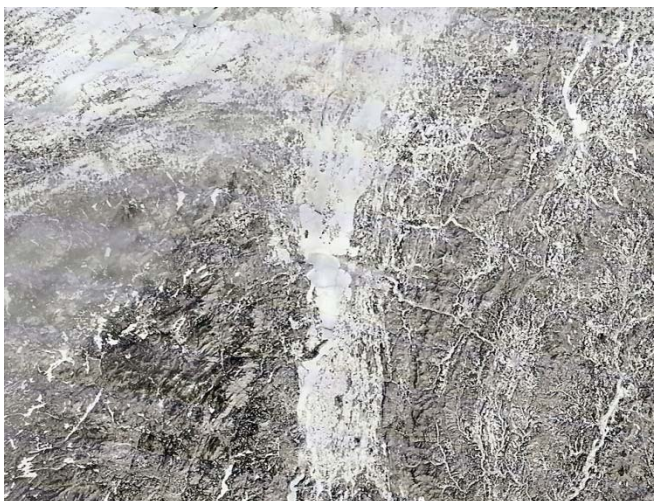
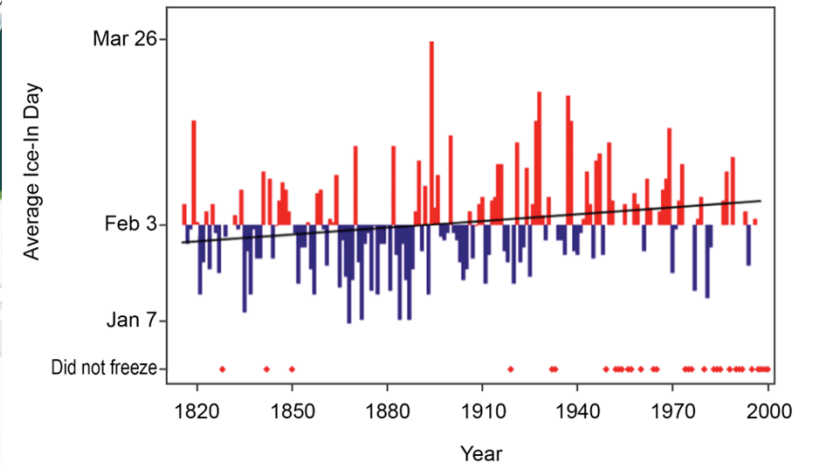
MONTPELIER — The National Weather Service is warning of an increased threat of spring flooding in Vermont and upstate New

Home Equity Credit Line
3.99% APR*
Variable

PEOPLES TRUST Company
FDIC The bank with a heart. Learn More

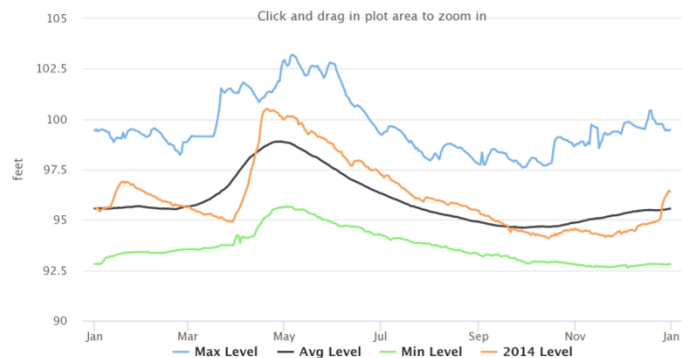
- ADVERTISEMENT
- Most Popular Most Commented More Headlines
- 1 Hops and Barley: Meet the new brewers on the block
 - 2 CCTA bus drivers' union put proposal on the table
 - 3 500 bags of heroin found in car stopped in NY
 - 4 Supporters outnumber foes as House committee hears from both sides on raising minimum wage
 - 5 Legislator resigns from UVM board

National Climate Assessment, 2013



17 March, 2014

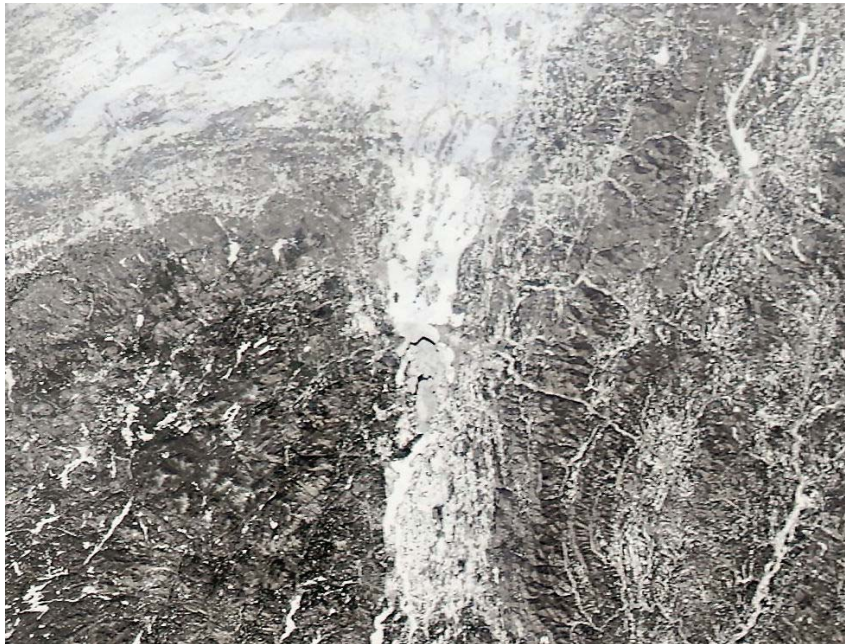
Lake Champlain Extremes and 2014 Level



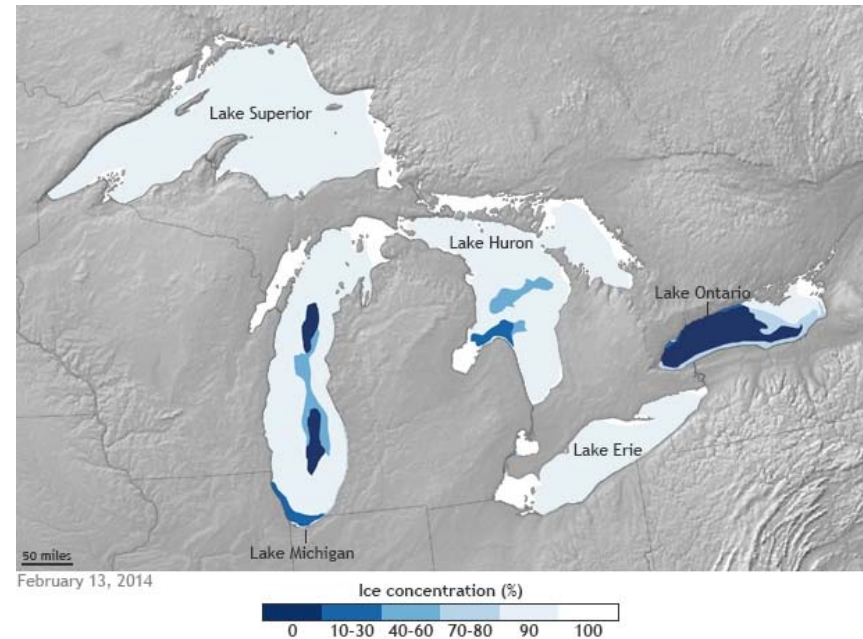
Highcharts.com

National Weather Service

Frozen lakes & climate

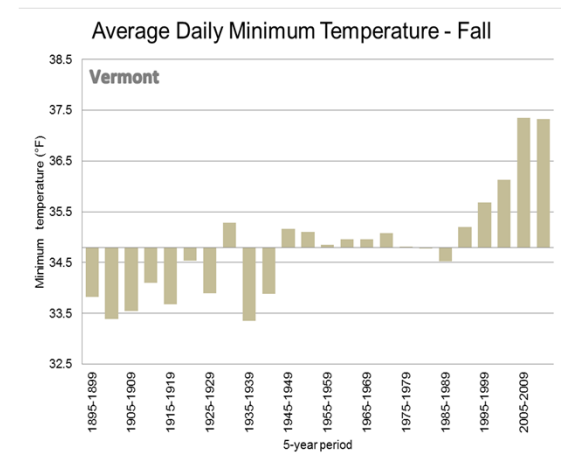
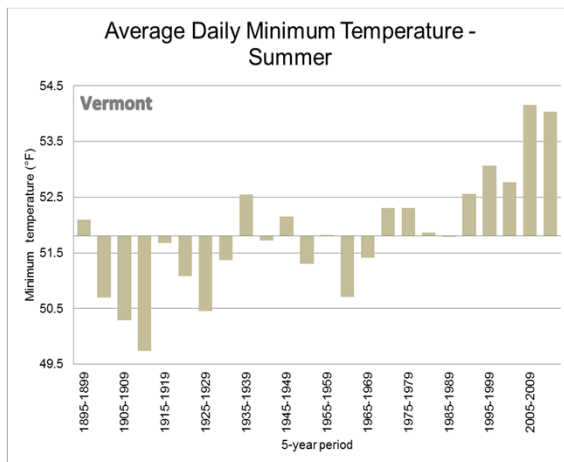
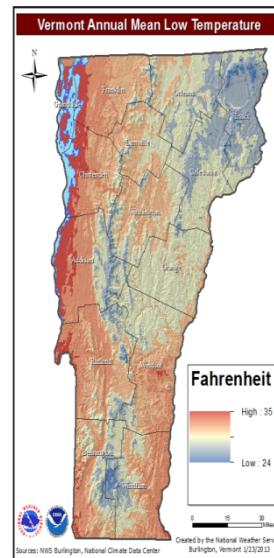
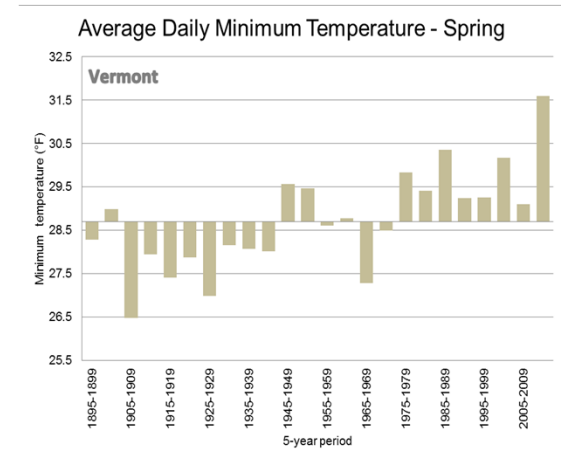
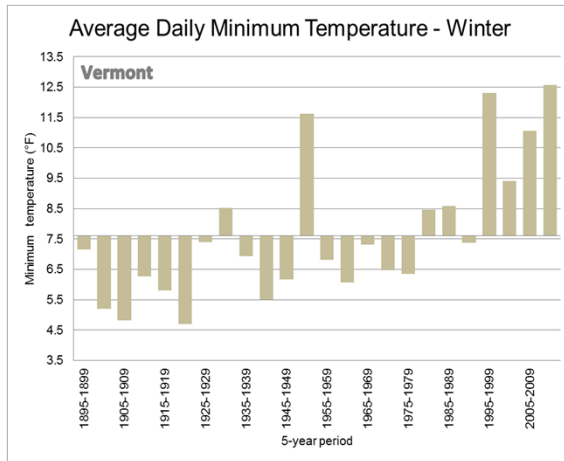


12 February 2014



88% frozen (2014)
82% frozen (1996)

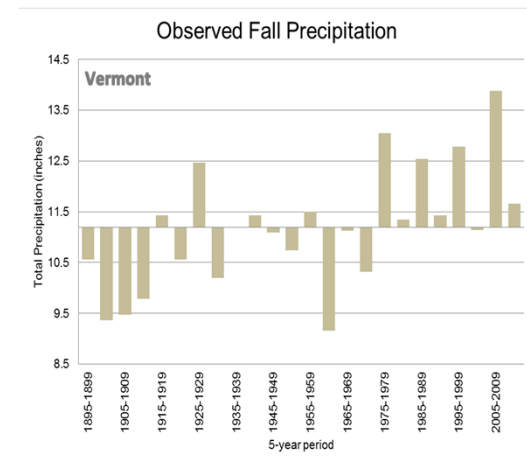
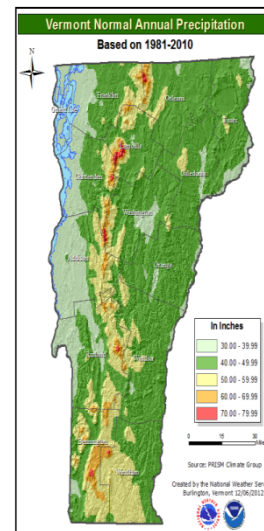
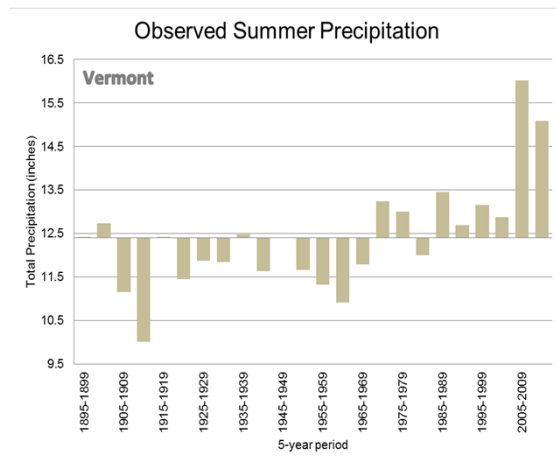
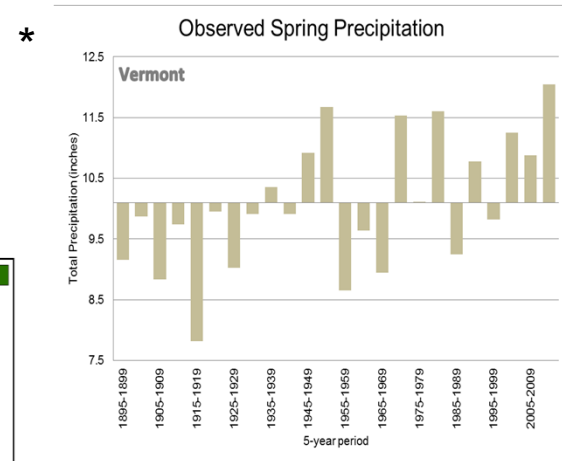
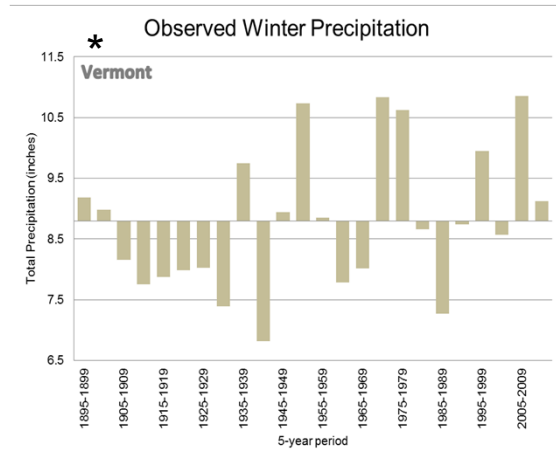
Daily low temperatures are getting warmer



1895-2014,
averaged
over 5-year
periods

<https://statesummaries.ncics.org/vt>

Variations in the amount of precipitation



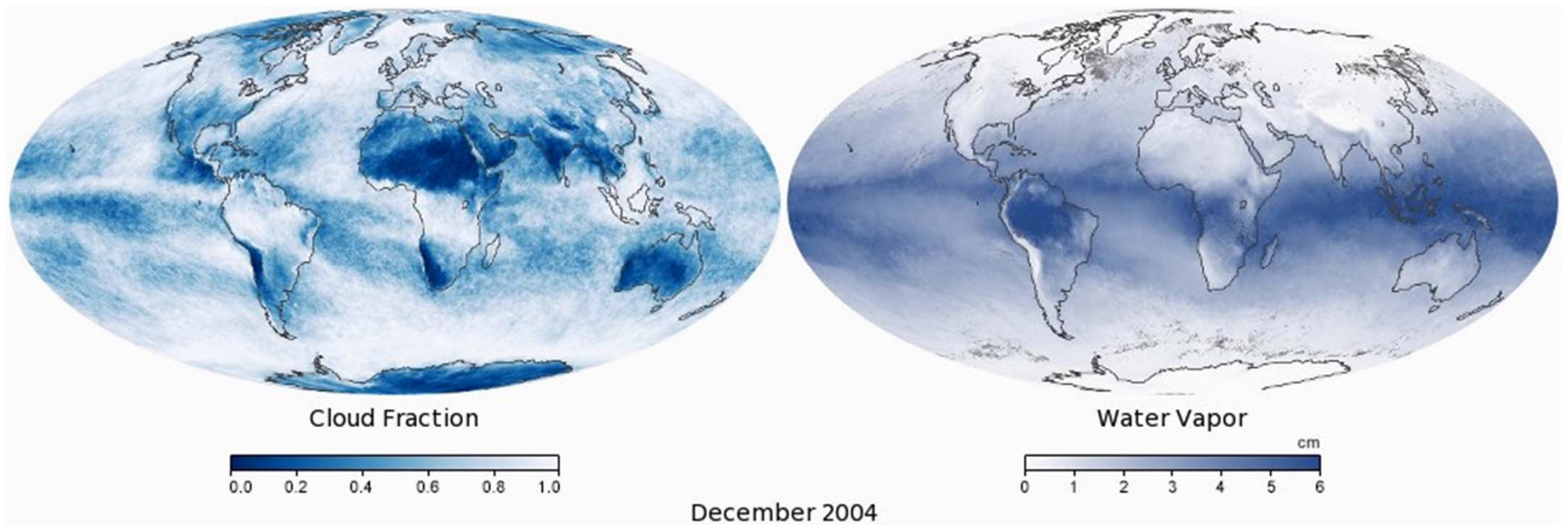
1895-2014,
averaged over
5-year periods

<https://statesummaries.ncics.org/vt>

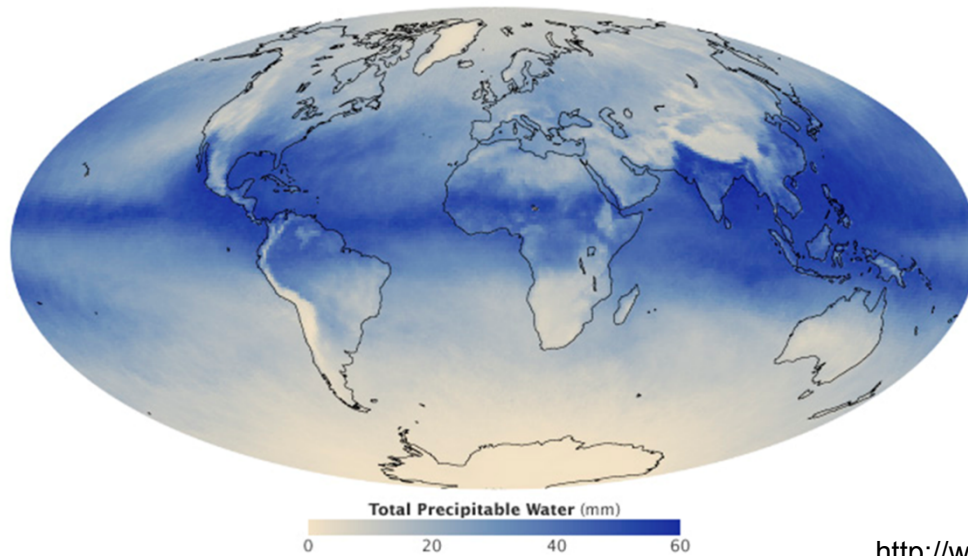


5. Why is precipitation increasing?

Precipitable water = 1/1000 of 1% total water on earth

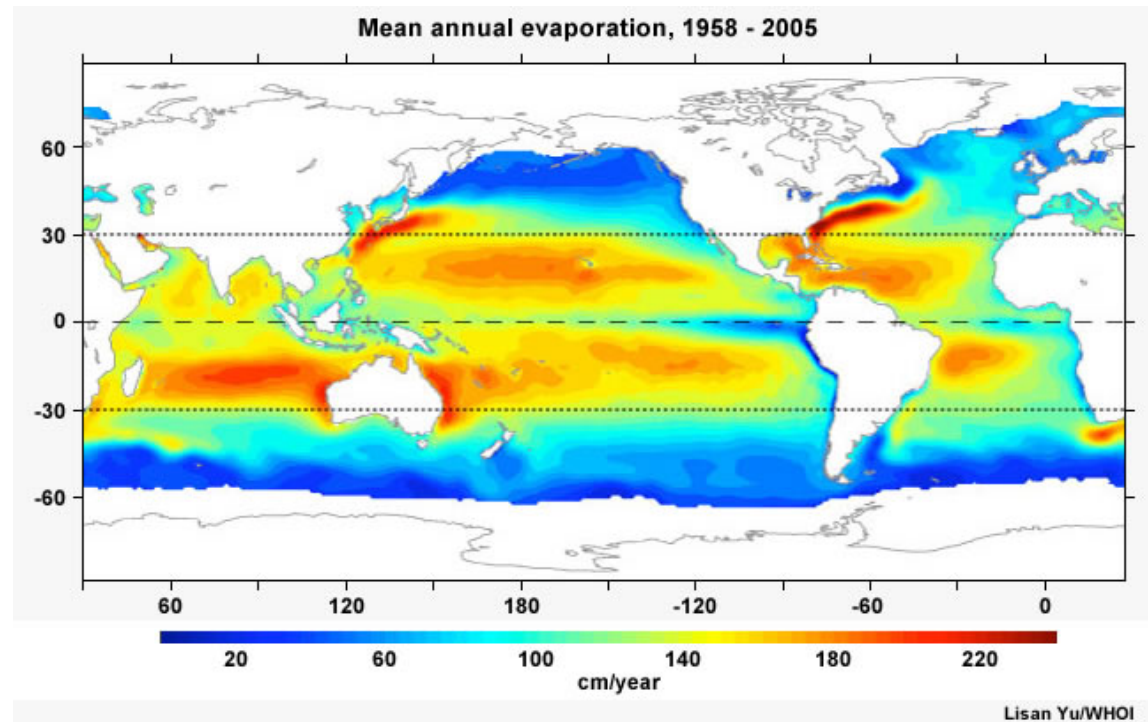


<http://earthobservatory.nasa.gov/Features/Gallery/aqua.php>



http://www.meted.ucar.edu/tropical/textbook_2nd_edition/print_5.htm

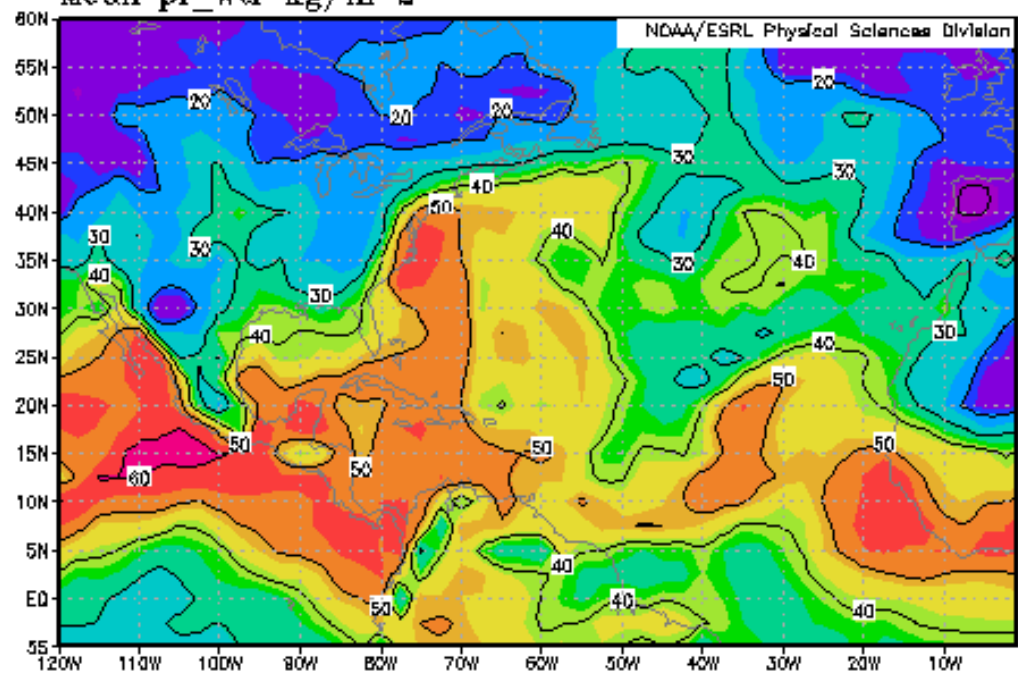
Relationship between
evaporation & PWAT



PWAT during Irene

lon: plotted from -120 to -1
lat: plotted from -5 to 60.00
t: averaged over Aug 27 2011 to Aug 28 2011
lev: 0

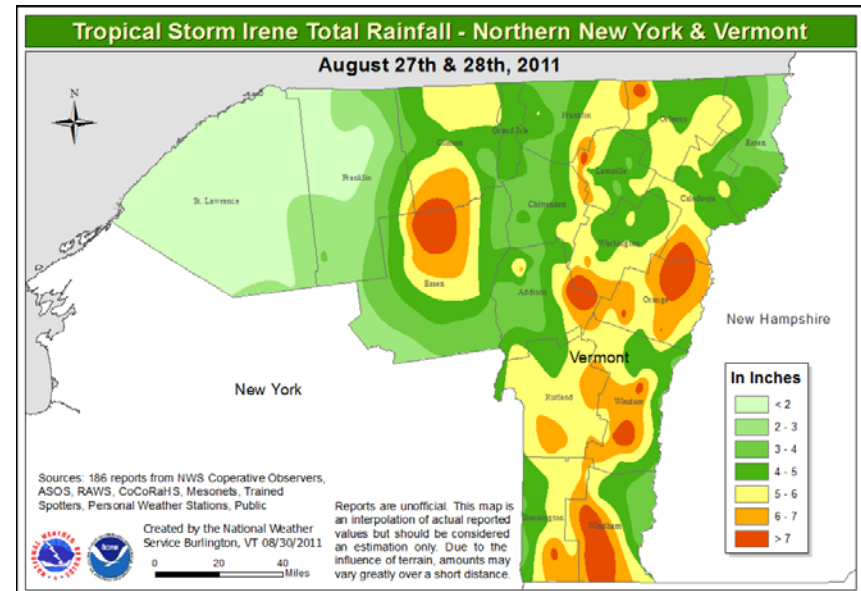
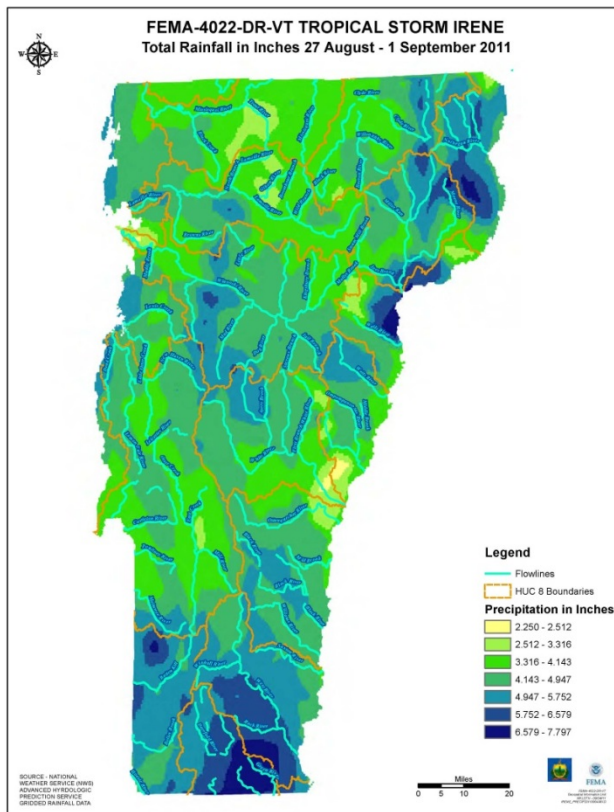
Mean pr_wtr kg/m²



MAX=62.925
MIN=8.94

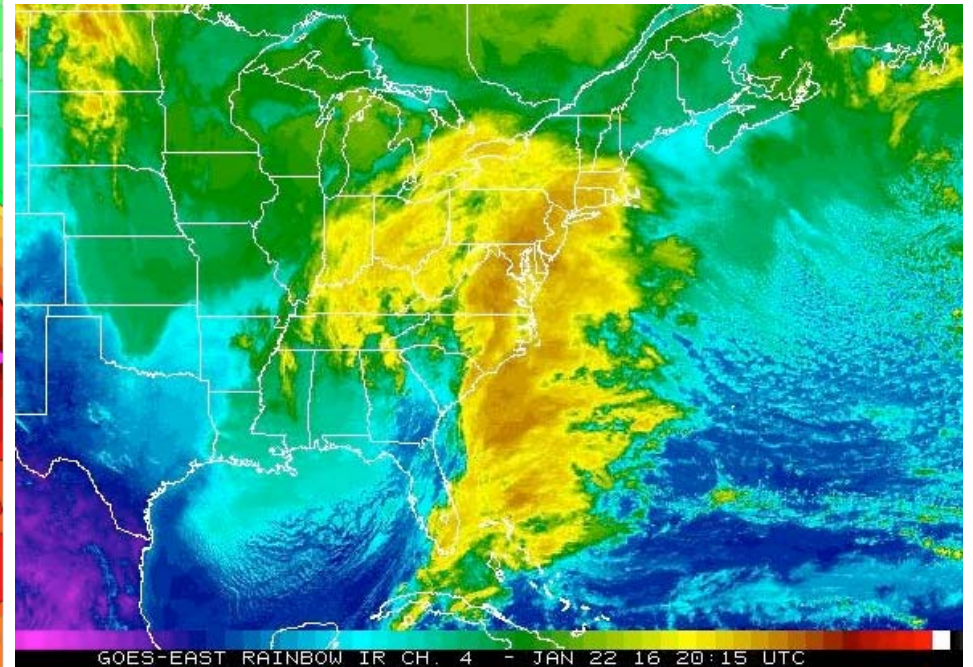
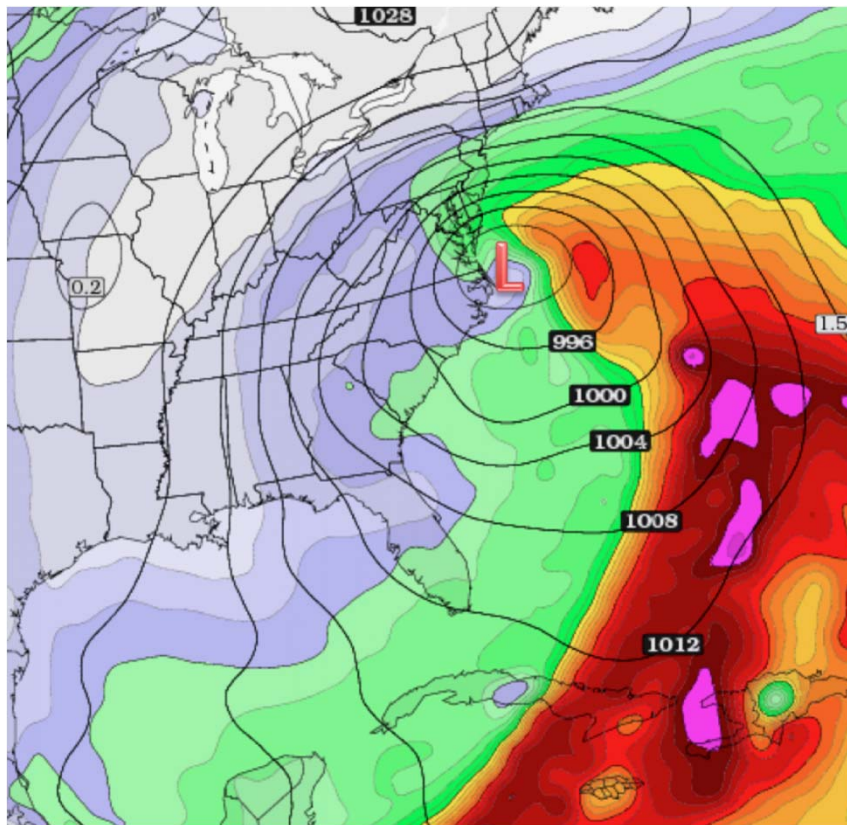
NCEP GrADS image

Irene's rainfall in Vermont

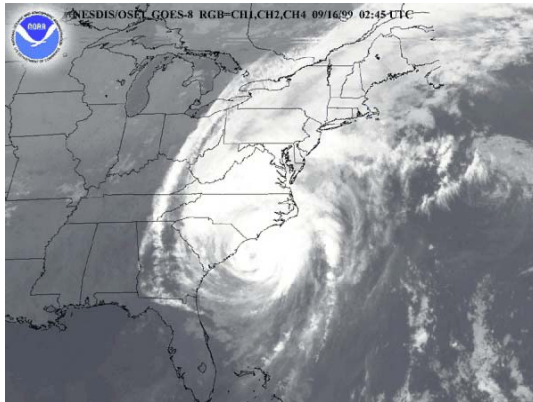


Images courtesy FEMA & NWS/Burlington

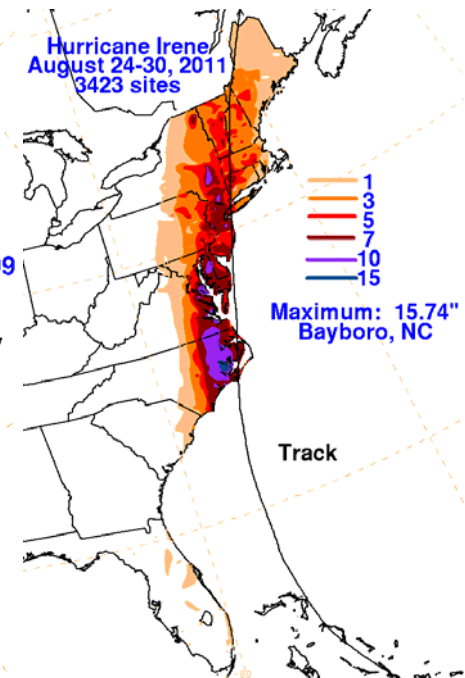
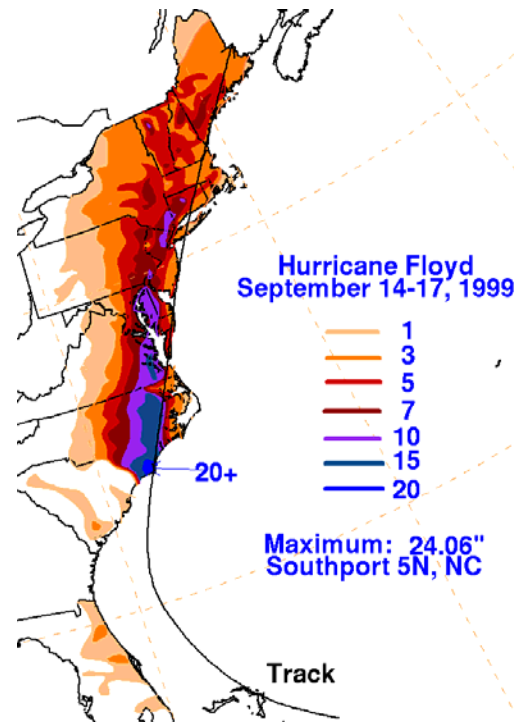
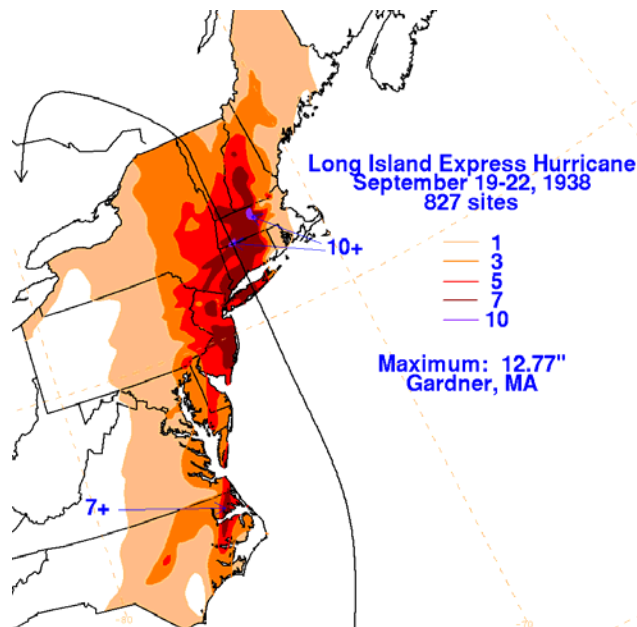
PWAT during Blizzard of 2016



Tropical cyclones & remnants



- November 1927
- August 1955 (Connie, Danny)
- June 1972 (Agnes)
- August 1998 (Bonnie)
- September 1999 (Dennis, Floyd)
- August 2011 (Irene)



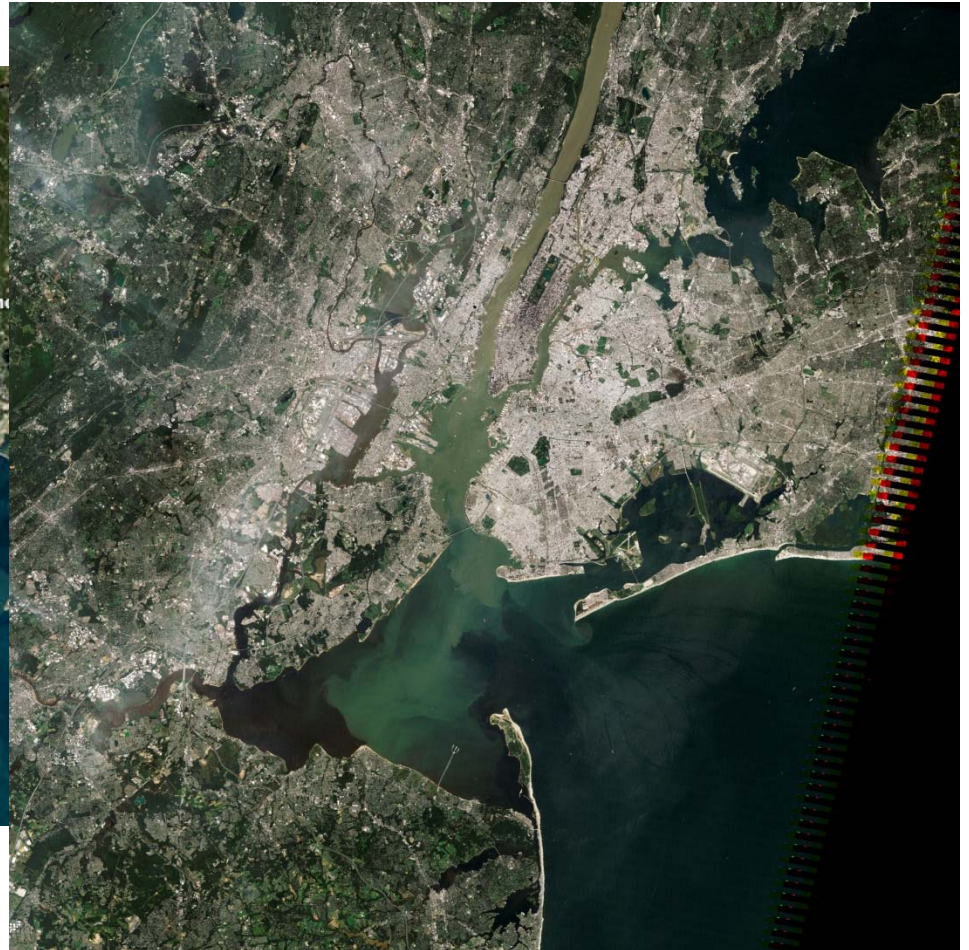


Our watershed connections

Sediment transport due to Irene



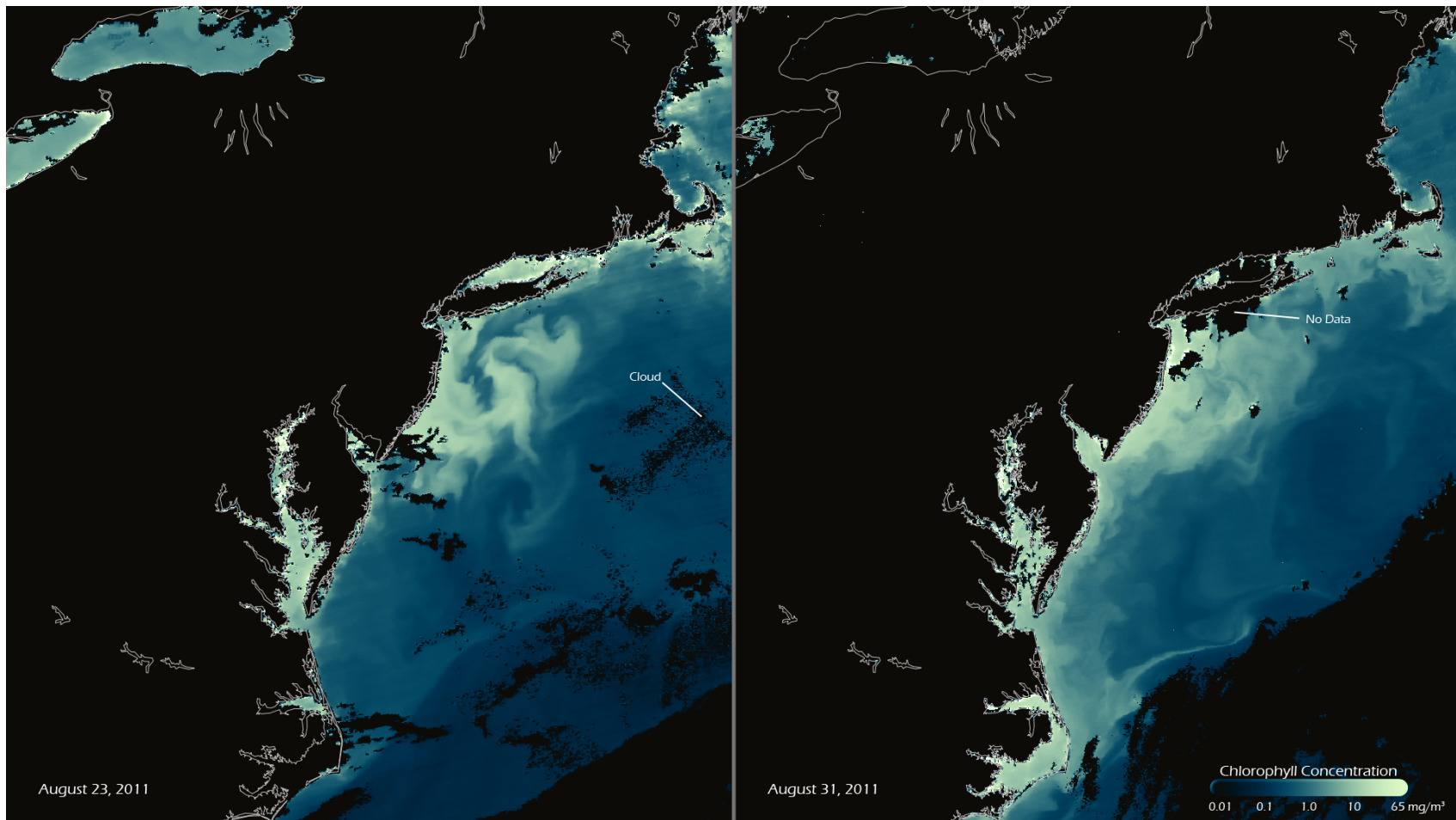
2 Sept. 2011



31 August 2011

http://earthobservatory.nasa.gov/IOTD/view.php?id=51975&eocn=image&eoci=related_image
http://eoimages.gsfc.nasa.gov/images/imagerecords/52000/52059/groton_tm5_2011245.jpg

Algal blooms following Irene



<http://www.nnvl.noaa.gov/MediaDetail2.php?MediaID=830&MediaTypeID=1>

TS Irene – moisture disturbance



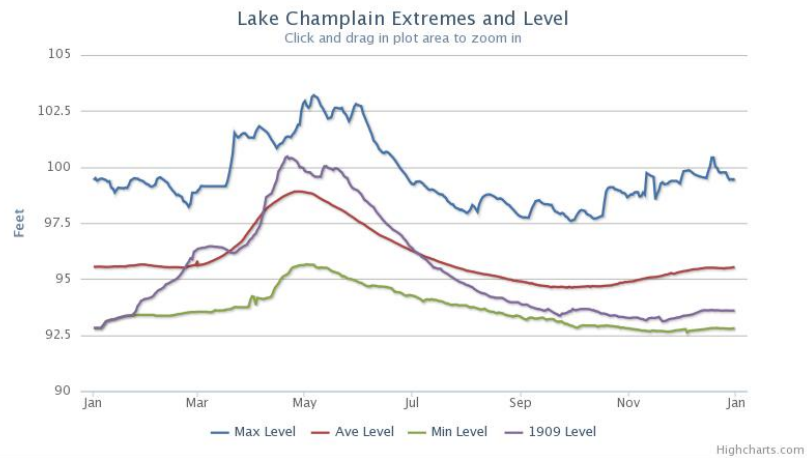
https://www.youtube.com/watch?v=H71fsL-0r_4



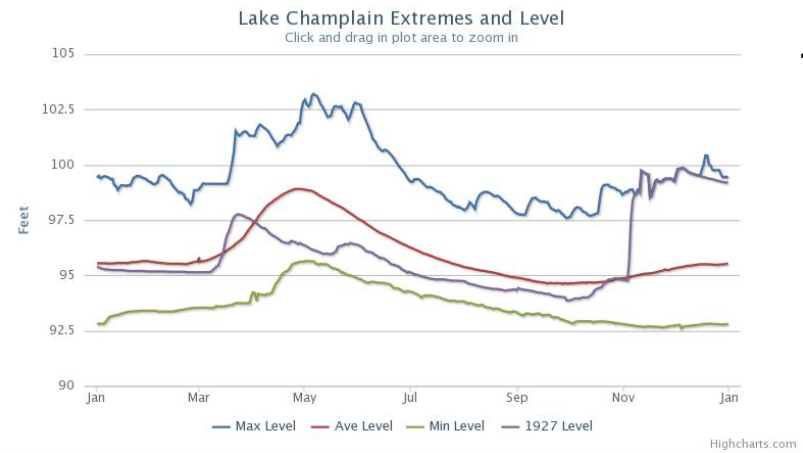
6. Flipping the switch

Floods & droughts

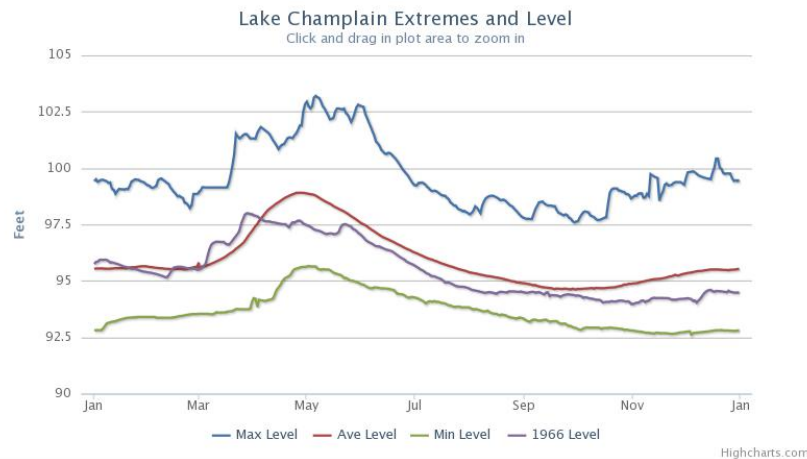
1909



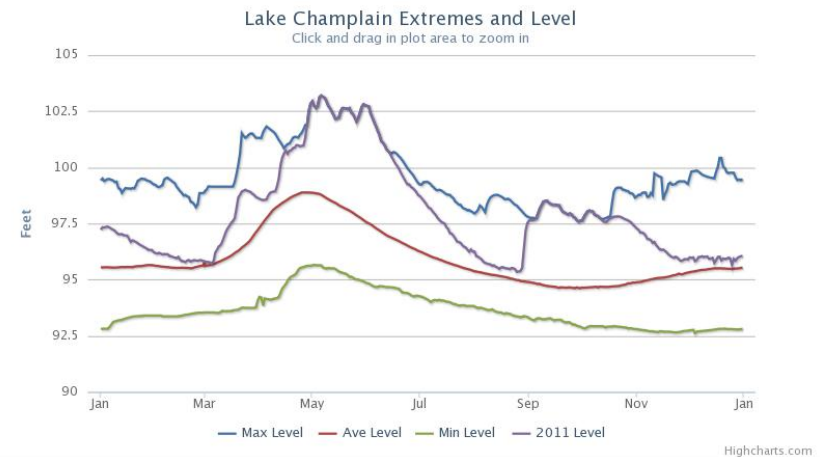
1927



1966



2011

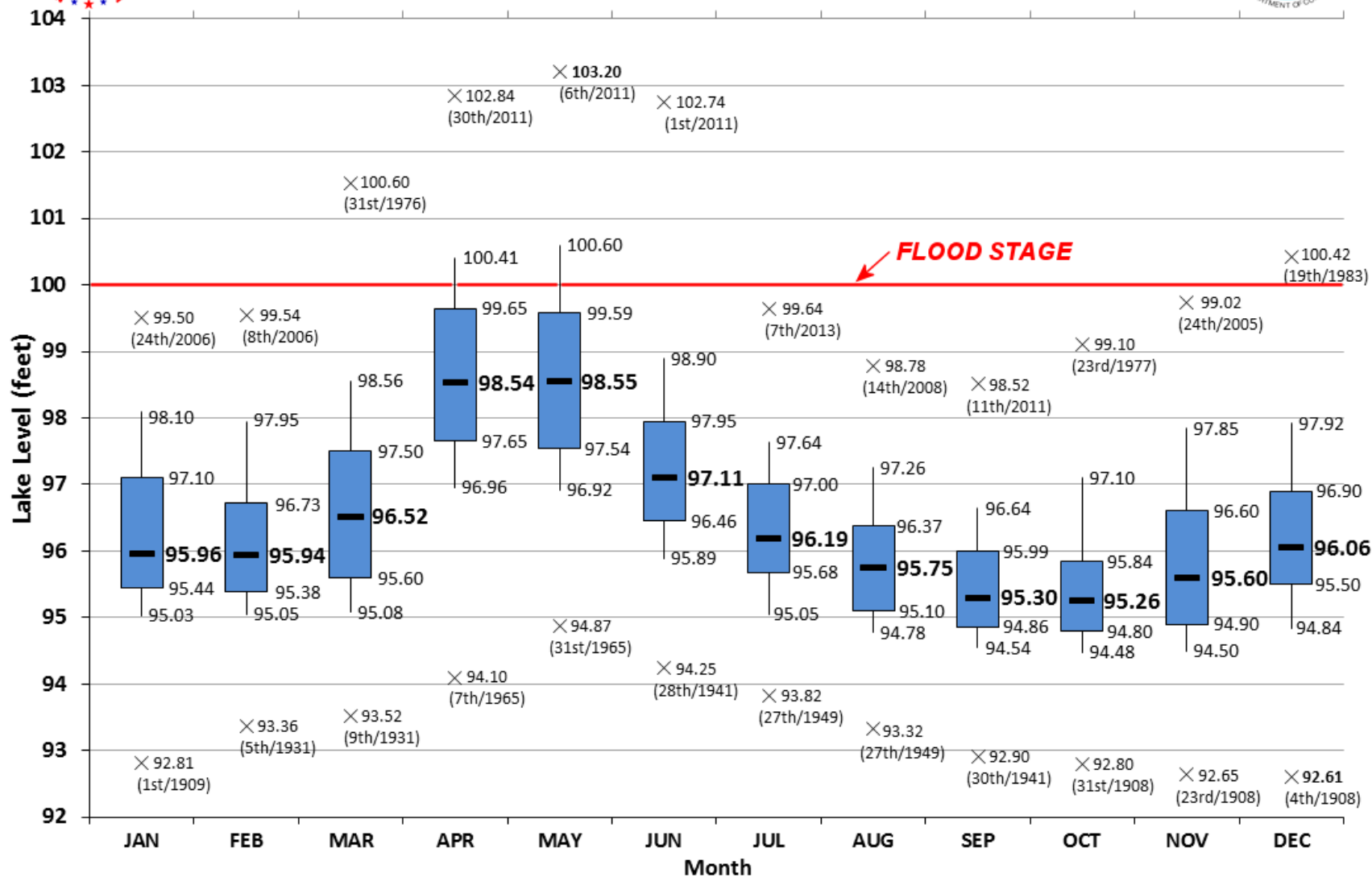


Courtesy: National Weather Service



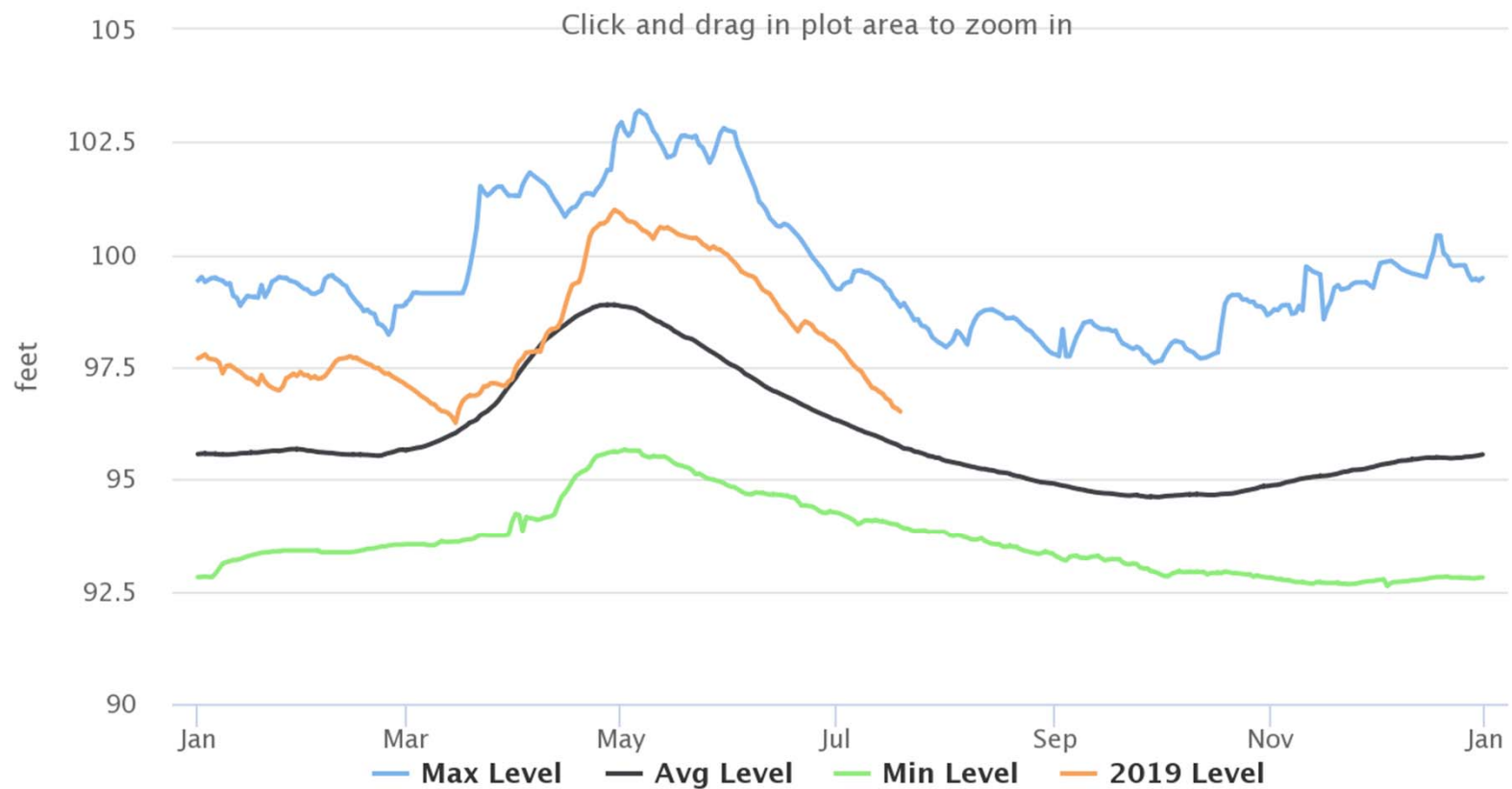
Lake Champlain Lake Level - King St. Ferry Dock (1970-2011)

Solid Bar - Median Monthly Value; Boxes 25th-75th Percentile; Whiskers 10th/90th Percentile
(x - monthly record values 1908-2013)

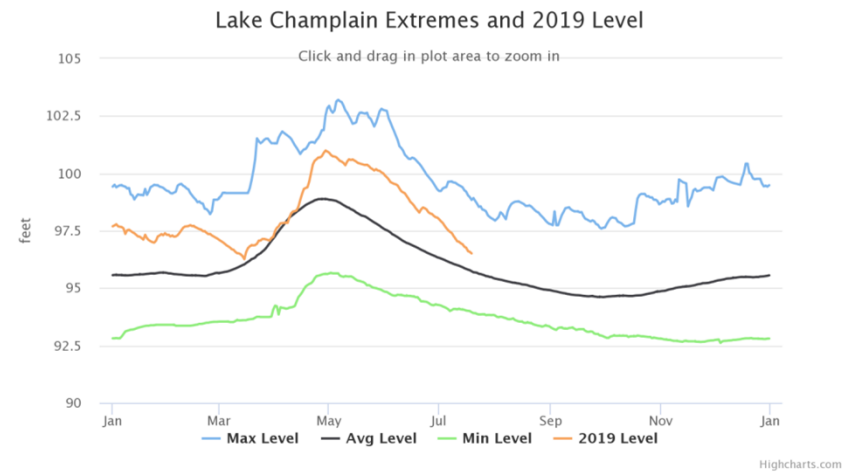
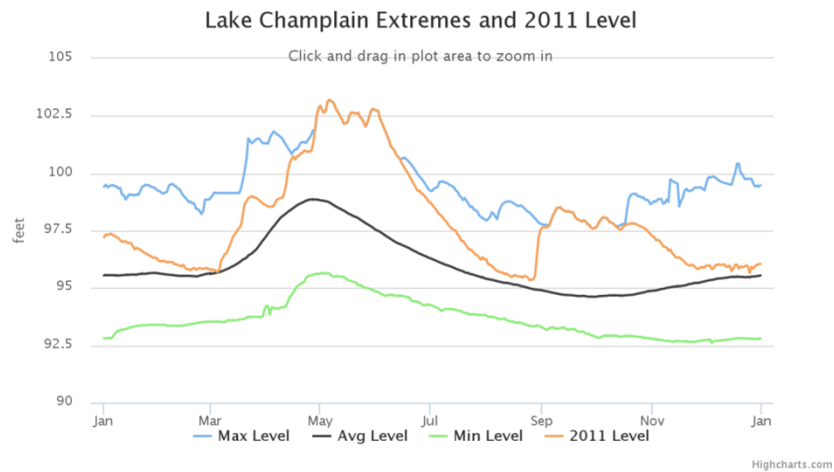


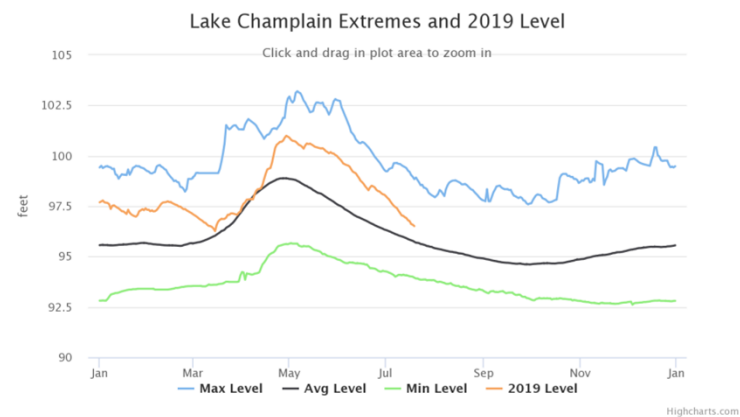
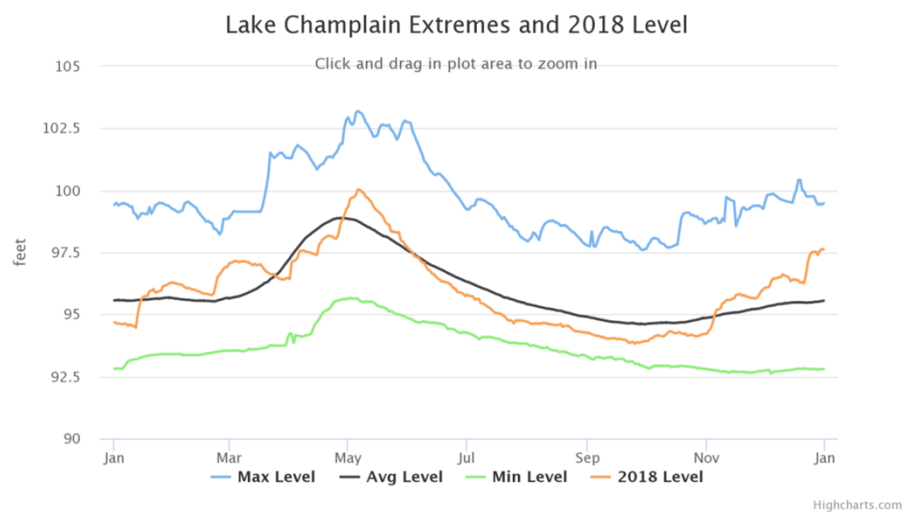
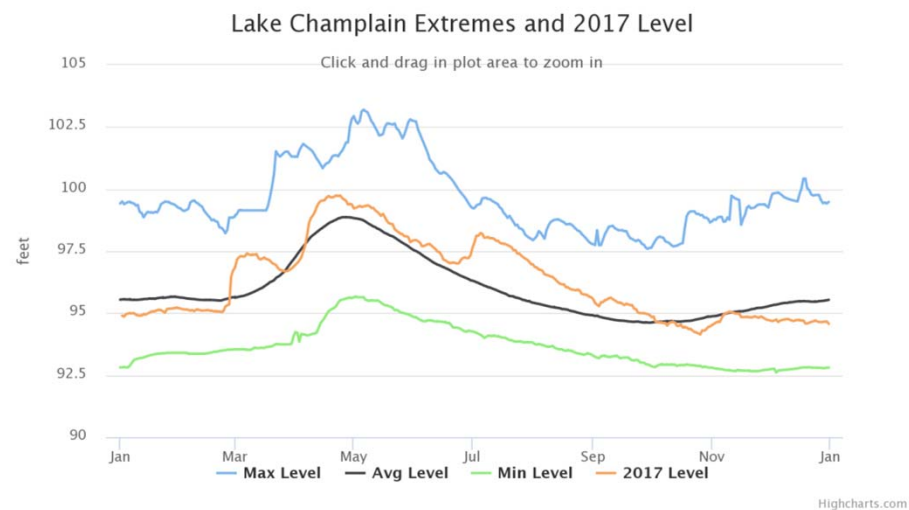
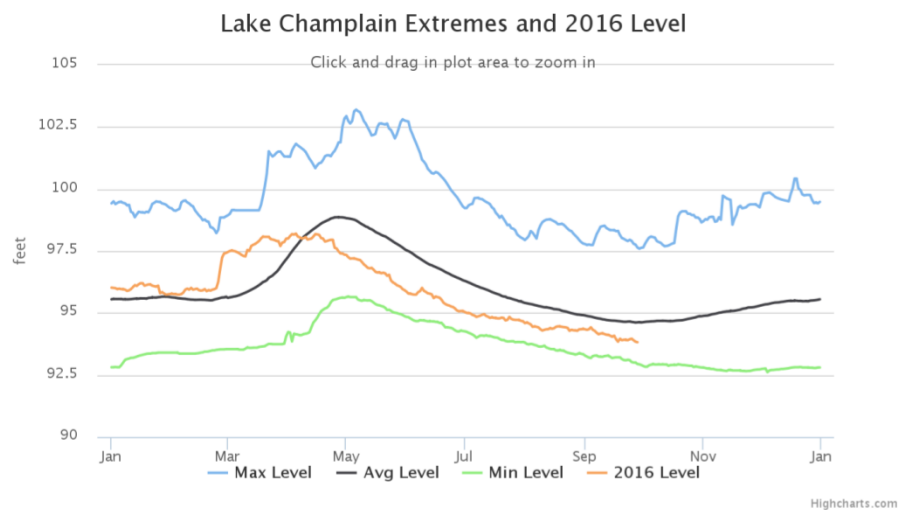
As of 21 July 2019

Lake Champlain Extremes and 2019 Level



2011 vs. 2019





Courtesy: National Weather Service. As of 21 July 2019

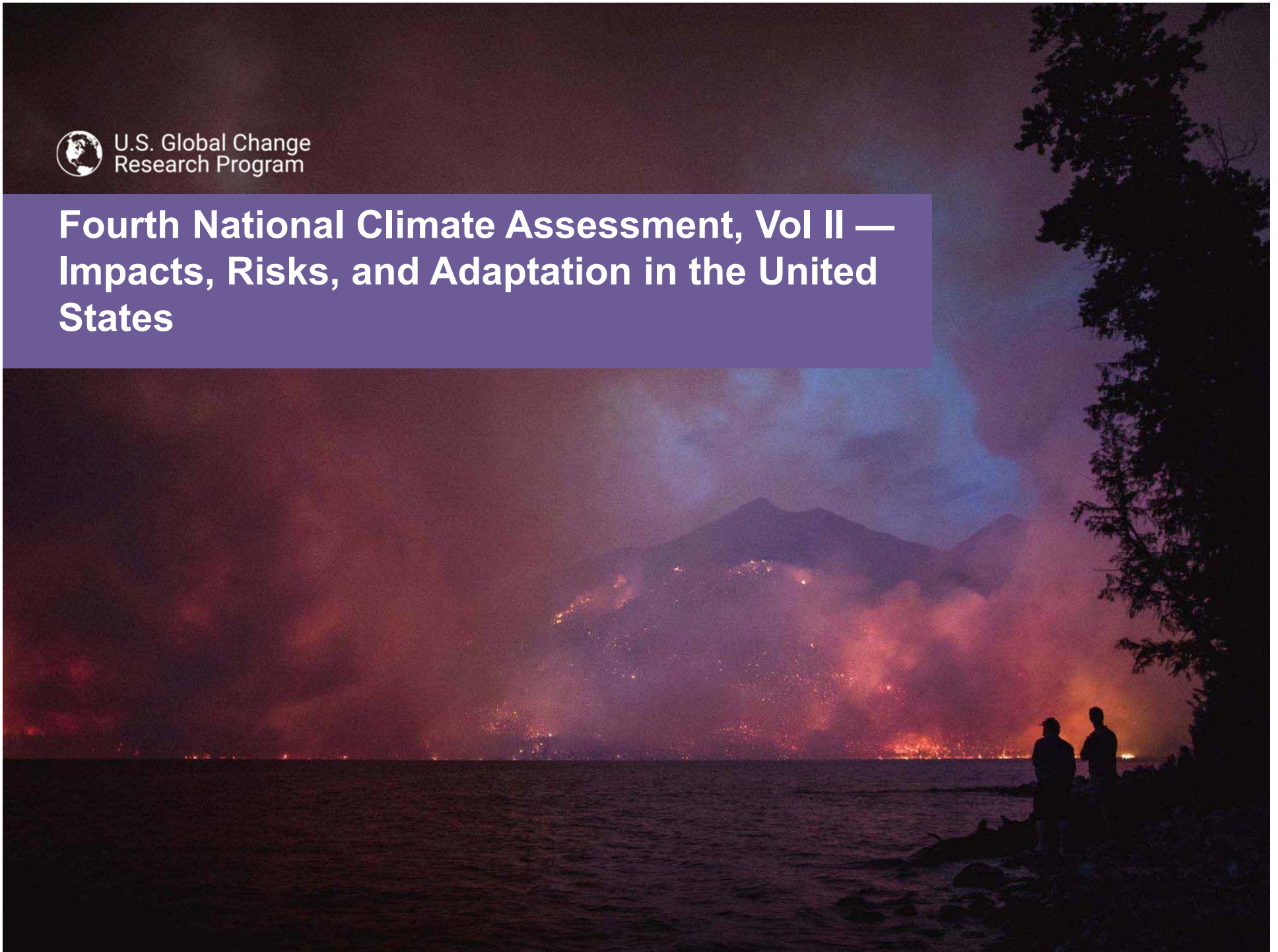


Of additional interest ...



U.S. Global Change
Research Program

Fourth National Climate Assessment, Vol II — Impacts, Risks, and Adaptation in the United States



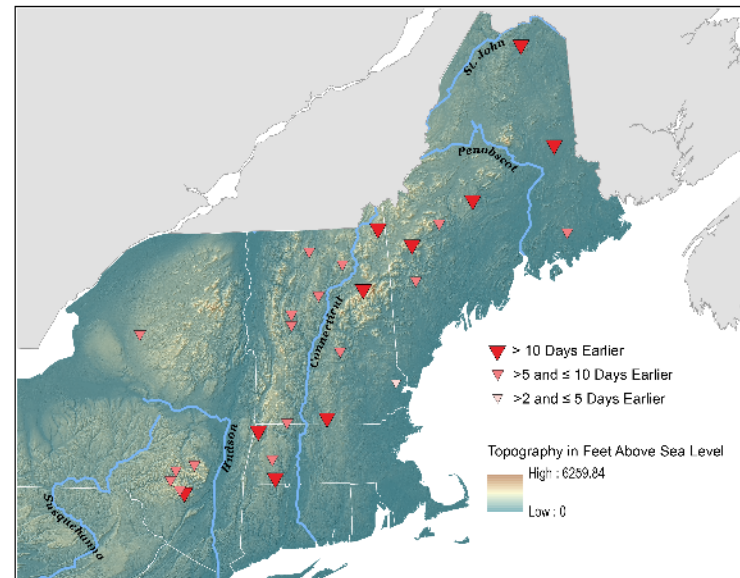


Fig. 18.2: Historical Changes in the Timing of Snowmelt-Related Streamflow

This map of part of the Northeast region shows consistently earlier snowmelt-related streamflow timing for rivers from 1960 to 2014. Each symbol represents the change for an individual river over the entire period. Changes in the timing of snowmelt potentially interfere with the reproduction of many aquatic species¹¹³ and impact water-supply reservoir management because of higher winter flows and lower spring flows.¹¹⁴ The timing of snowmelt-related streamflow in the Northeast is sensitive to small changes in air temperature. The average winter–spring air temperature increase of 1.67°F in the Northeast from 1940 to 2014 is thought to be the cause of average earlier streamflow timing of 7.7 days.¹¹² The timing of snowmelt-related streamflow is a valuable long-term indicator of winter–spring changes in the Northeast. Source: adapted from Dudley et al. 2017;¹¹² Digital Elevation Model CGIAR–CSI (CGIAR Consortium for Spatial Information). Reprinted with permission from Elsevier.



U.S. Global Change
Research Program

Recommended chapter citation

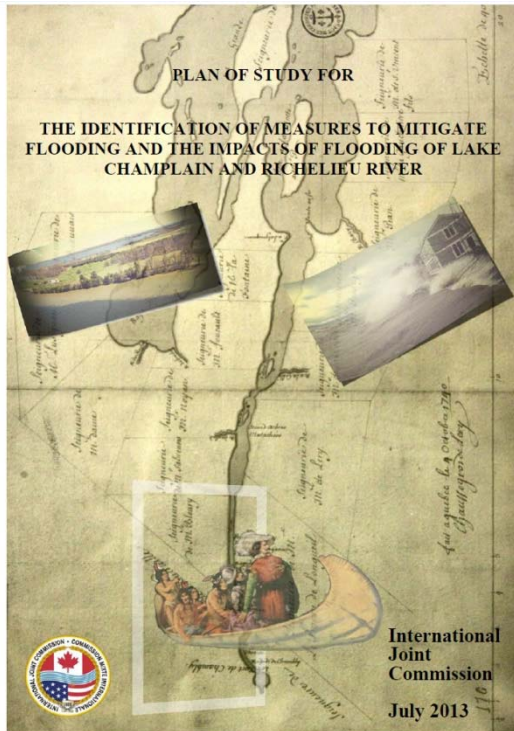
DUPIGNY-GIROUX, L.A., E.L. MECRAY, M.D. LEMCKE-STAMPONE, G.A. HODGKINS, E.E. LENTZ, K.E. MILLS, E.D. LANE, R. MILLER, D.Y. HOLLINGER, W.D. SOLECKI, G.A. WELLENIUS, P.E. SHEFFIELD, A.B. MACDONALD, AND C. CALDWELL, 2018: NORTHEAST. IN *IMPACTS, RISKS, AND ADAPTATION IN THE UNITED STATES: FOURTH NATIONAL CLIMATE ASSESSMENT, VOLUME II* [REIDMILLER, D.R., C.W. AVERY, D.R. EASTERLING, K.E. KUNKEL, K.L.M. LEWIS, T.K. MAYCOCK, AND B.C. STEWART (EDS.)]. U.S. GLOBAL CHANGE RESEARCH PROGRAM, WASHINGTON, DC, USA. DOI: [10.7930/NCA4.2018.CH18](https://doi.org/10.7930/NCA4.2018.CH18)

Read the full chapter

[HTTPS://NCA2018.GLOBALCHANGE.GOV/CHAPTER/NORTHEAST](https://NCA2018.GLOBALCHANGE.GOV/CHAPTER/NORTHEAST)

nca2018.globalchange.gov

International Joint Commission



In response to these devastating floods of 2011 the governments of Canada and the United States requested that the International Joint Commission review and make recommendations regarding a comprehensive study of measures to mitigate flooding and the impacts of flooding within the Lake Champlain and Richelieu River watershed. To answer this request, the International Joint Commission established in May 2012 the International Lake Champlain Richelieu River Workgroup and tasked the Workgroup with a Directive to answer the governments' request through a Plan of Study.

The Directive to the International Lake Champlain Richelieu River Workgroup was to develop a Plan of Study that will establish specifically what studies are necessary to allow an evaluation of the causes and impacts of the flooding of the Lake Champlain and Richelieu River and what studies are necessary to develop appropriate flood mitigation measures and recommendations.

FINAL REPORT

Progress towards an operational real-time flood forecasting and flood inundation mapping system for the Lake Champlain and Richelieu River

Preparatory works and static flood inundation maps



Prepared for the
International Joint Commission
by the
International Lake Champlain - Richelieu River
Technical Working Group

November 30, 2015



International Lake Champlain-Richelieu River Flood Mitigation Study

Technical Workshop
Where we are and what needs to be addressed?

Burlington, August 21-23 2107



International Lake Champlain-Richelieu River
Study Board
Groupe d'étude international
du lac Champlain et de la rivière Richelieu



IJC documents & photos



Thank you!

For more information contact:

Dr. Lesley-Ann Dupigny-Giroux

state.climatologist@uvm.edu

656-2146