Satellites, Weather and Climate Module 40:

Agriculture & forestry in a changing climate

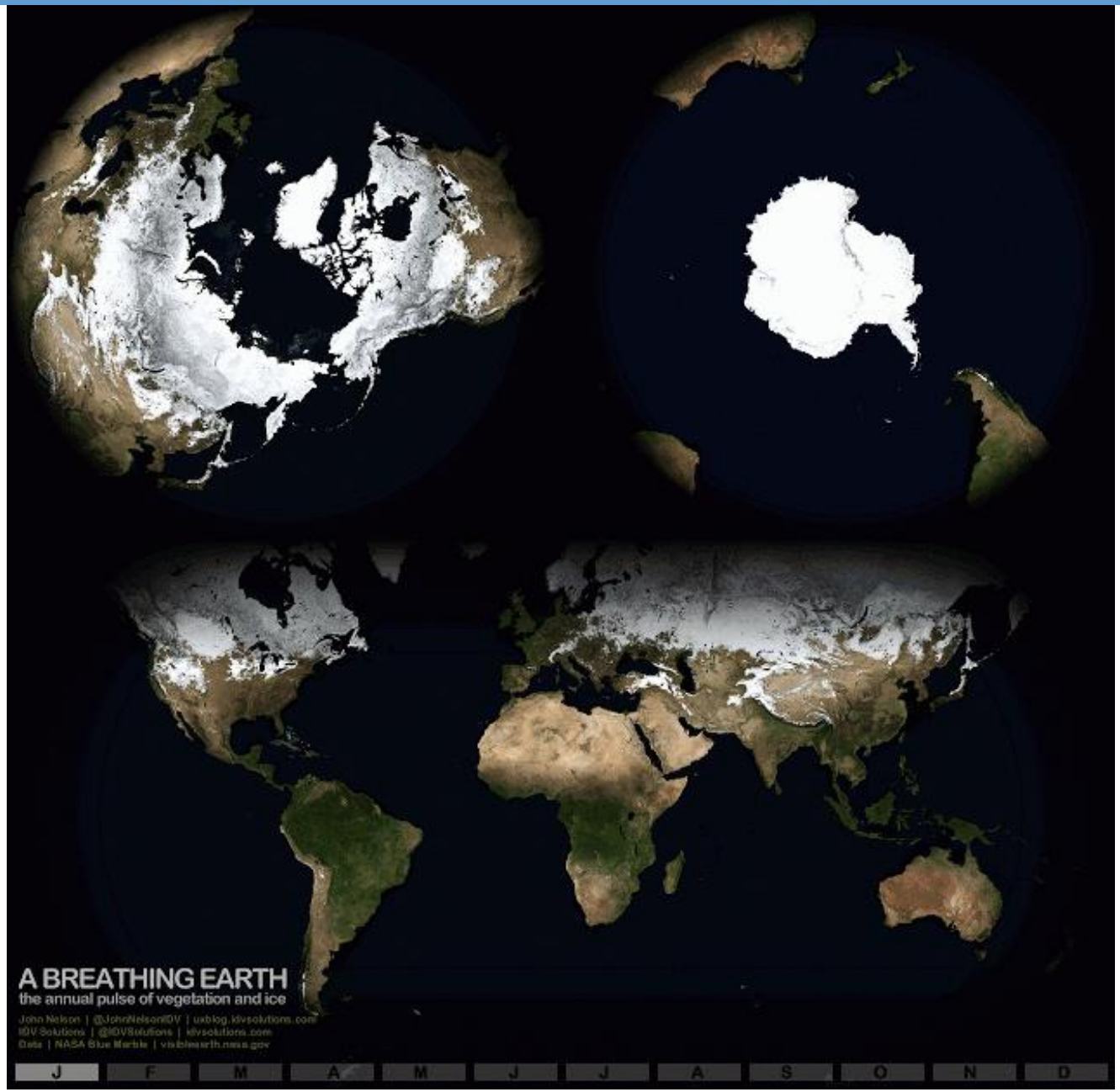
SWAC

The UNIVERSITY of VERMONT

NSF

VERMONT

http://www.youtube.com/watch?v=kSNbLYHRrU8



http://1.bp.blogspot.com/-LemiCA8B_H4/UfLN63QLXdI/AAAAAAAACyM/Xc3HtckubEg/s1600/Animated.gif

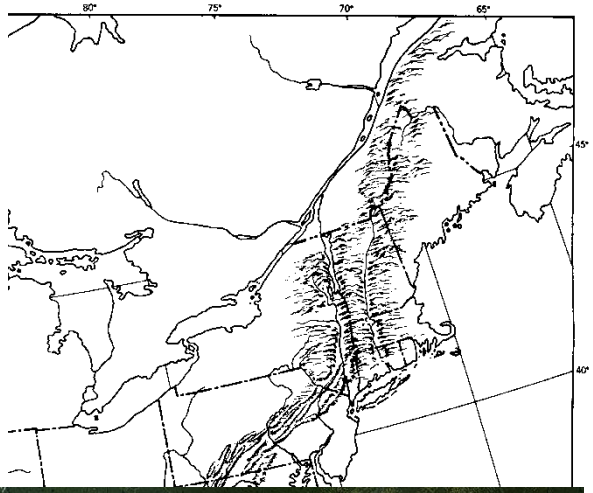
Today's topics

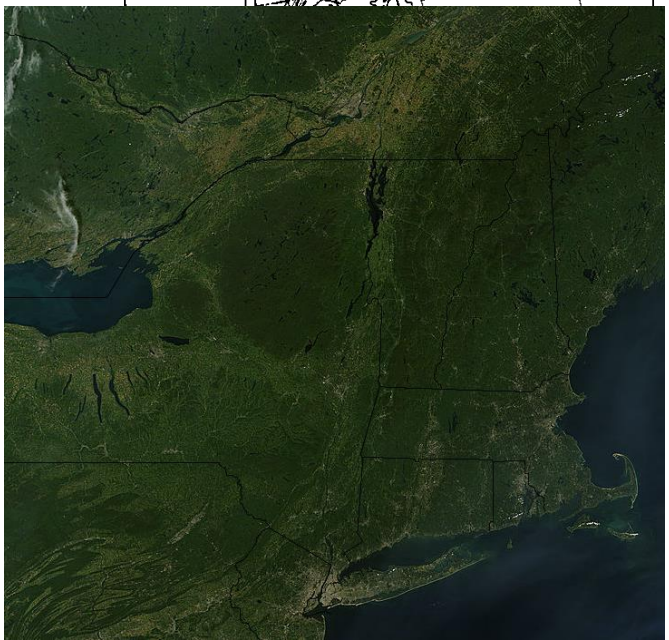
- role of weather and climate
- important linkages with environmental factors
- climate change projections

Factors that affect plant growth

- topography
- soil characteristics
- microclimate
- urban vs. rural
- seasonality
- plant hardiness
- weather & climate

1. Role of topography

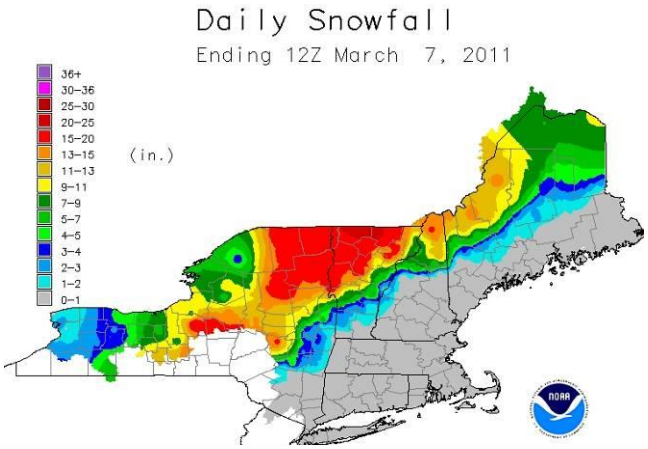




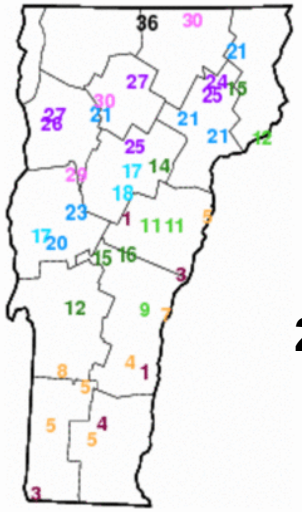
- Appalachian mountains can divert moisture – Ice Storm
- Green Mountains can restrict cold, dense air to the valleys
  - Champlain
  - air is funneled
  - orographic uplift along the Greens
- shirkshires
  - gravity winds blowing downslope

NASA MODIS image
12 Sept. 2012

Orographic enhancement or blocking

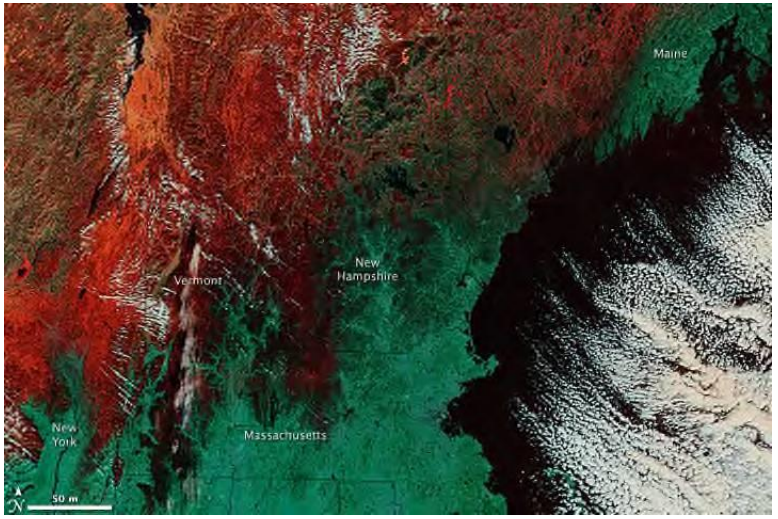


Seven-Day Snowfall for Vermont, March 5 – 11, 2011
Inches of Snow, Cut Off Time 1500Z



2011

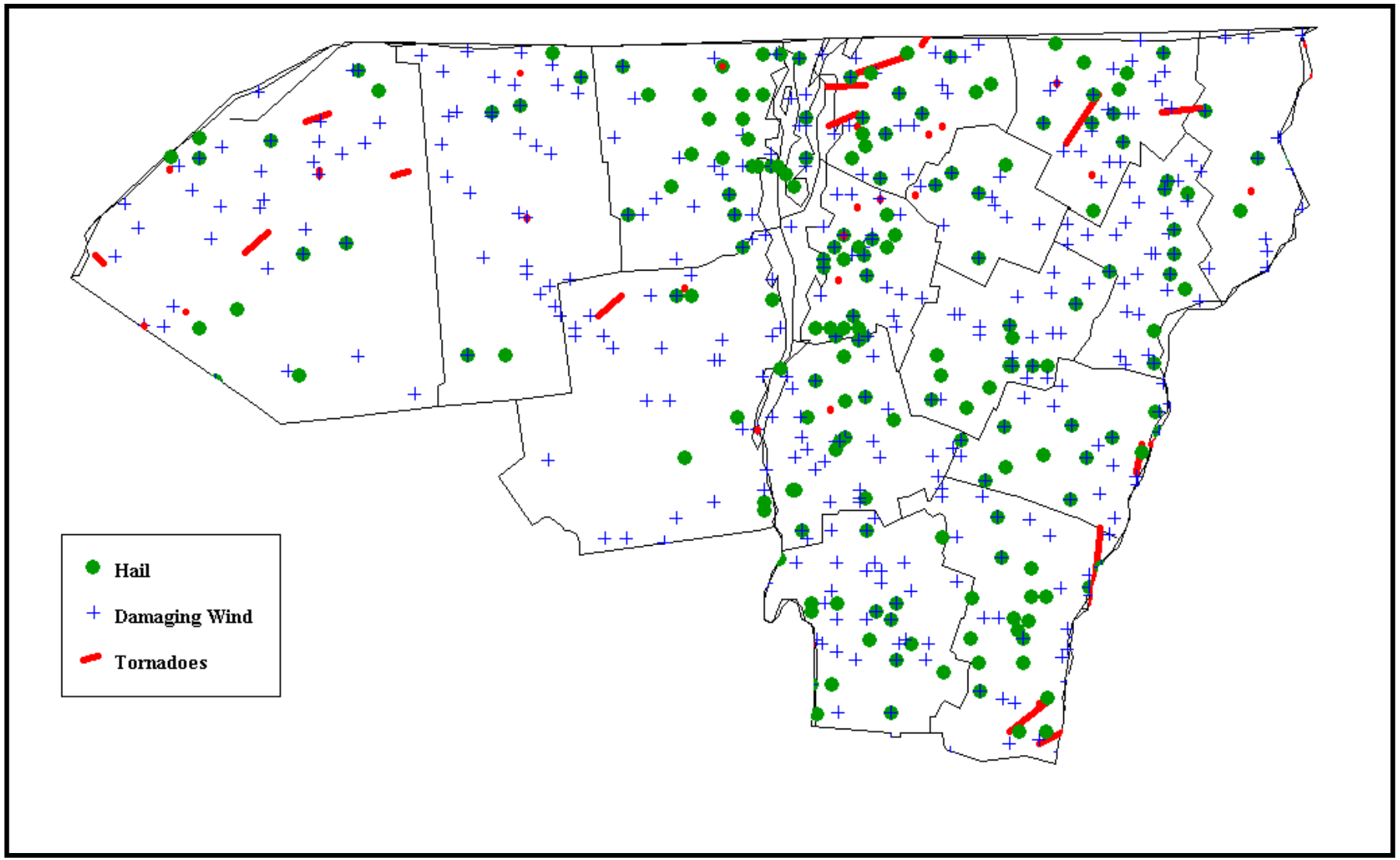
This map is based on preliminary reports.
Station values may differ from final Quality Controlled data.



New England ice storm 11-12 Dec 2008

2. How do weather & climate affect Vermont's vegetation?

Fifty Years Of Severe Weather
(1950-2000)



Courtesy: NWS/BTV

Downburst animation

Courtesy: NWS/BTV

Downburst damage

Straightline wind damage in Cavendish, Vermont.
Photo taken by Steve Hogan & Brooke Taber. (July 21, 2003)

Courtesy: NWS/BTV

Wind speeds 55-72 mph

Courtesy: NWS/BTV

Wind speeds +113 mph

Courtesy: NWS/BTV

Ice storms

- timing
  - Nov, Dec 1800s
  - February 1961
  - January 1998
  - October 2010
- duration
- amount
- species

Photos: L-A. Dupigny-Giroux

3. How does climate affect agriculture?

- moisture extremes can be detrimental
- timing of moisture inputs & temperature extremes is crucial
- deep snowpack - insulation, beneficial to sugar maple
- local characteristics - microclimate, topography, soils
- thermal stress on crops
- plant hardiness
- impacts vary by crop type
- rice?

3b. Weather factors that affect haying

- cool, wet conditions are ideal
- drought – few cuttings
- relative humidity
- wind
- frequency of storms
- soil moisture content

How does climate affect agriculture?

- moisture extremes can be detrimental
- timing of moisture inputs & temperature extremes is crucial
- deep snowpack - insulation, beneficial to sugar maple
- local characteristics - microclimate, topography, soils
- thermal stress on crops
- plant hardiness
- impacts vary by crop type
- rice?

Vermont Department of Forests, Parks & Recreations

- **“Late spring frost injury to hardwoods** is widespread.
- Over 200,000 acres of damage have been observed during aerial surveys, with the heaviest damage to sugar maple.
- Christmas tree growers are reporting heavy frost damage to balsam fir, the worst in many years if not ever.”
- http://www.vtfpr.org/protection/documents/VTFPR_May2010FrostDamageUpdate.pdf.

June 2010

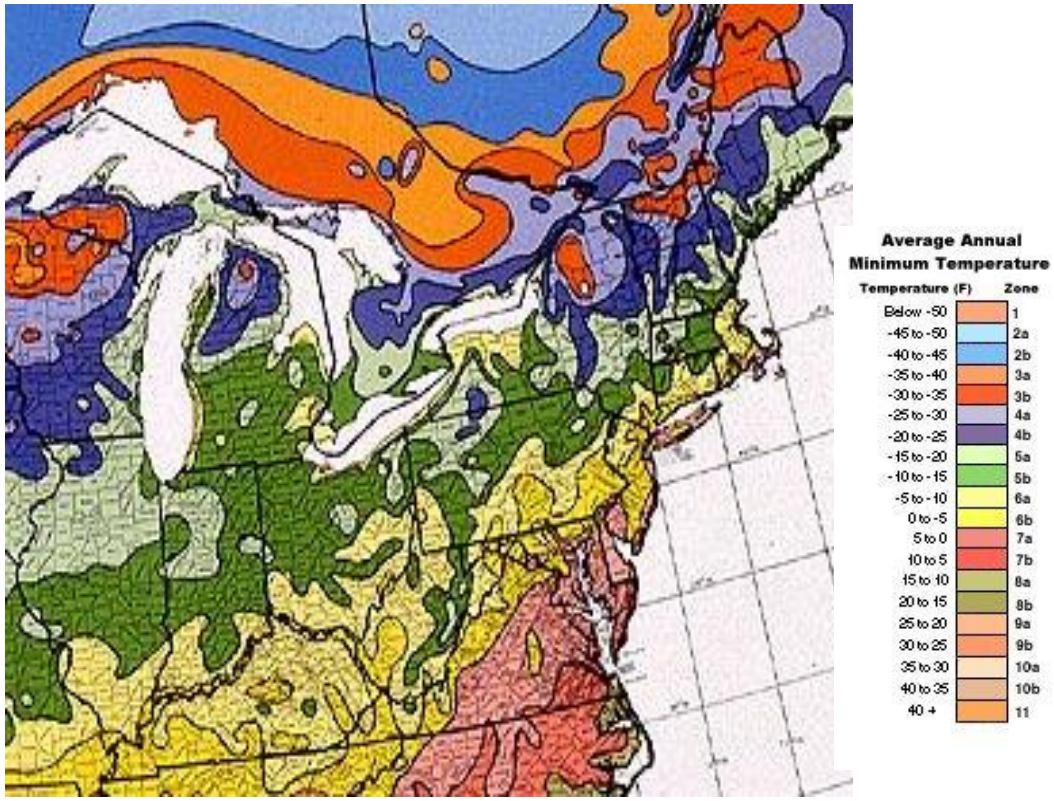
Temperature stress on trees

- **Summer**
  - **heat waves (drought)**
    - **can be beneficial after cool wet summer (August 1996, 2007)**
  - **frost (phenology)**

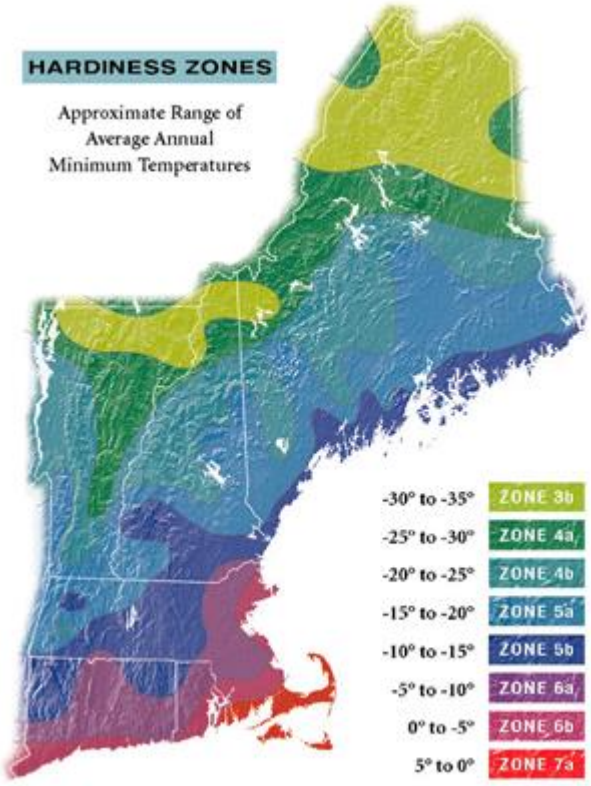
- **Winter**
  - **extreme cold**
  - **record warmth**
  - **freezing of soils – influence on cold tolerance (Paul Schaberg, USFS)**

http://usna.usda.gov/Hardzone/hzm-ne1.html
http://www.arborday.org/treeinfo/zonelookup.cfm

Plant hardiness maps



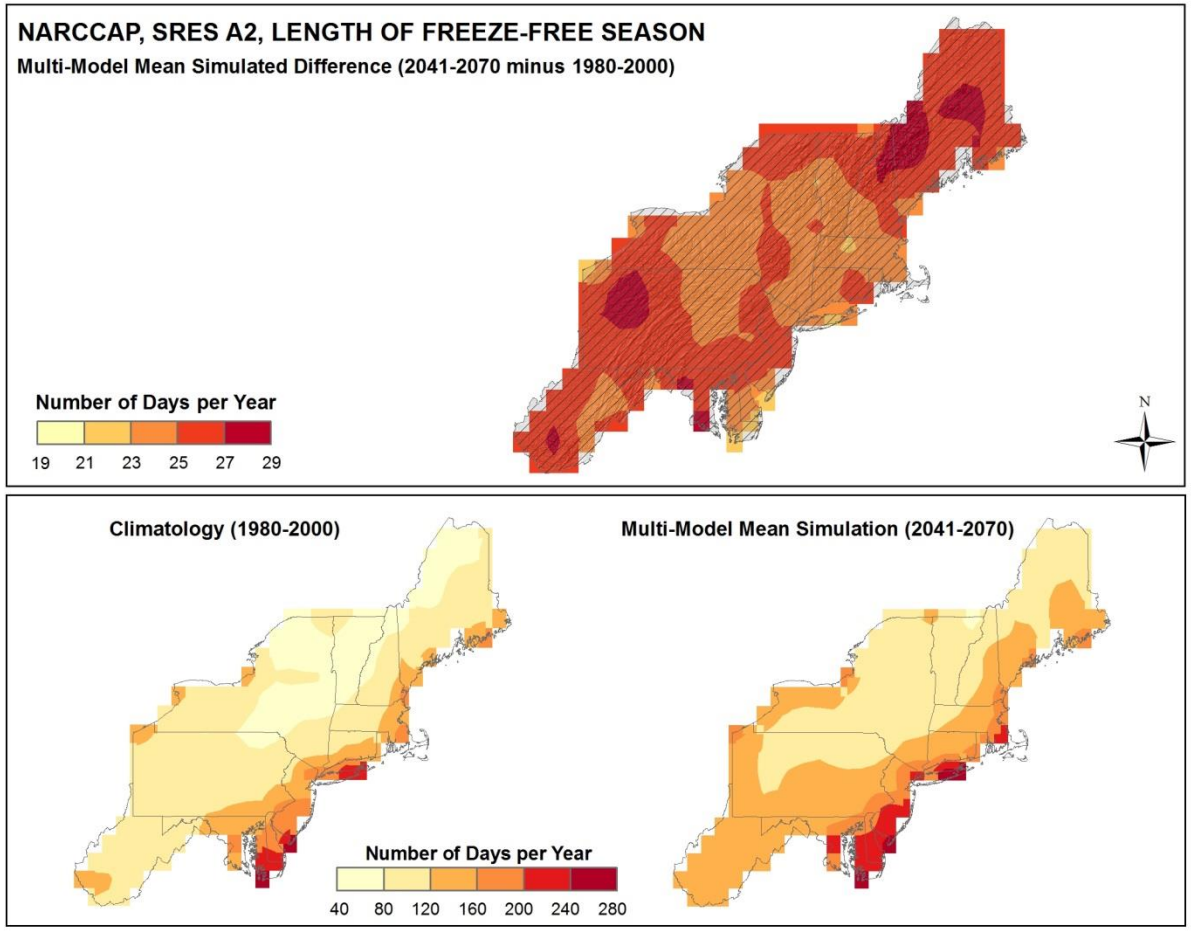
USDA National Arboretum



Arbor Day Foundation

4. Stressors related to climate change impacts

Simulated difference in the mean annual length of the freeze-free season



National Climate Assessment, 2013

Trends in forest canopy green cover over the eastern United States from 2000 to 2010

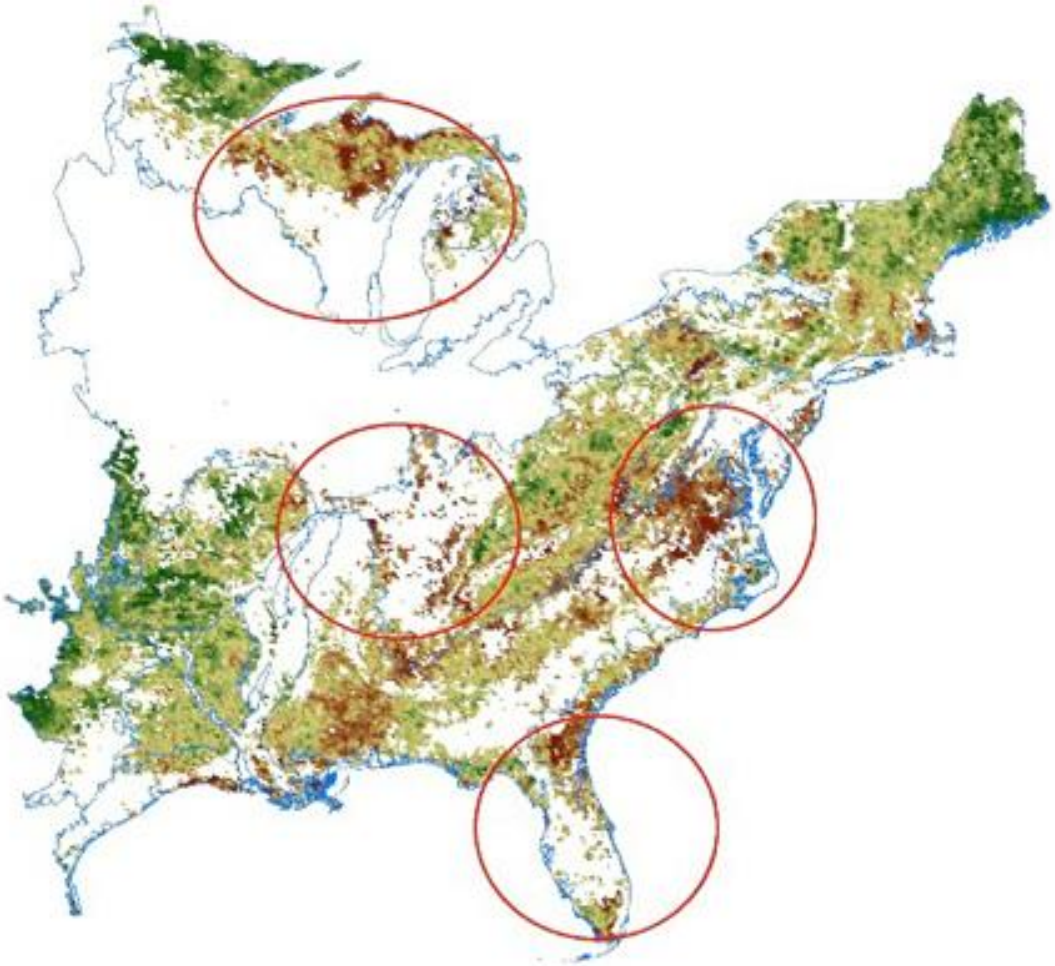
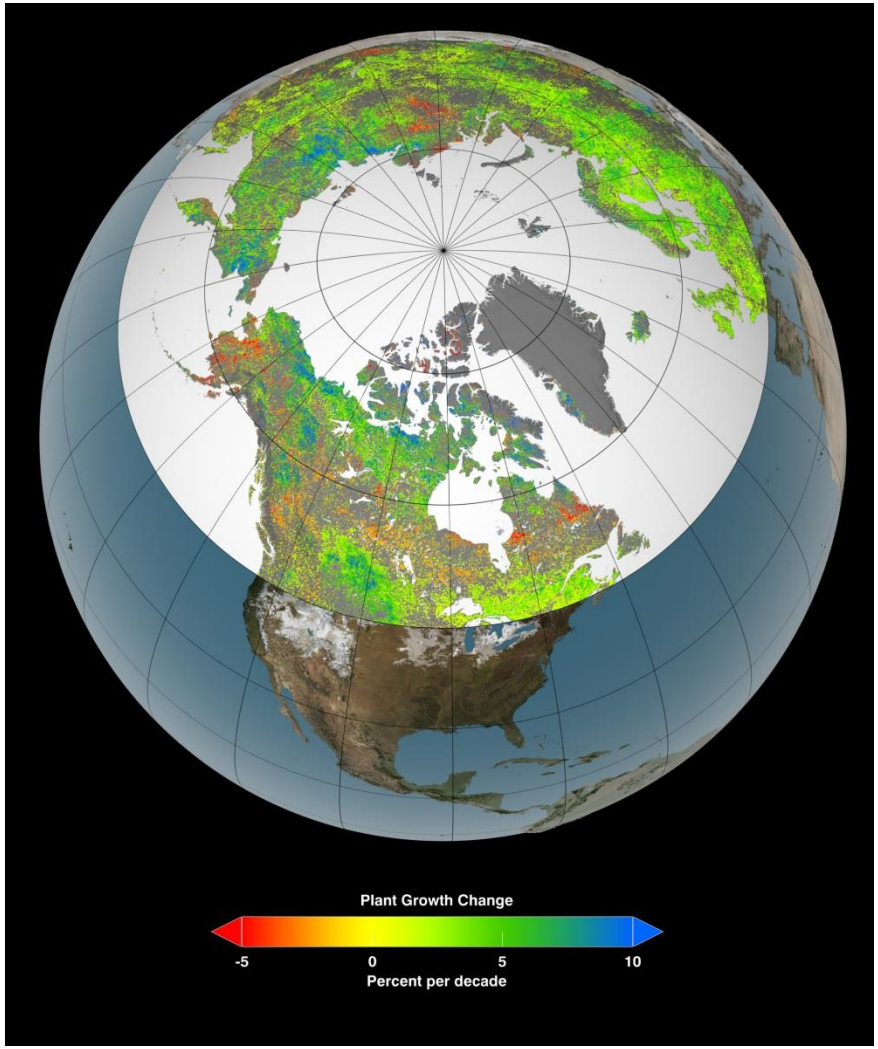


Image credit: NASA

http://newswatch.nationalgeographic.com/2013/03/07/declining-forests-in-the-eastern-united-states-as-seen-from-space/

Effect of changing growing seasons 1982-2011



- warming + longer growing season
- changes in land carbon cycle

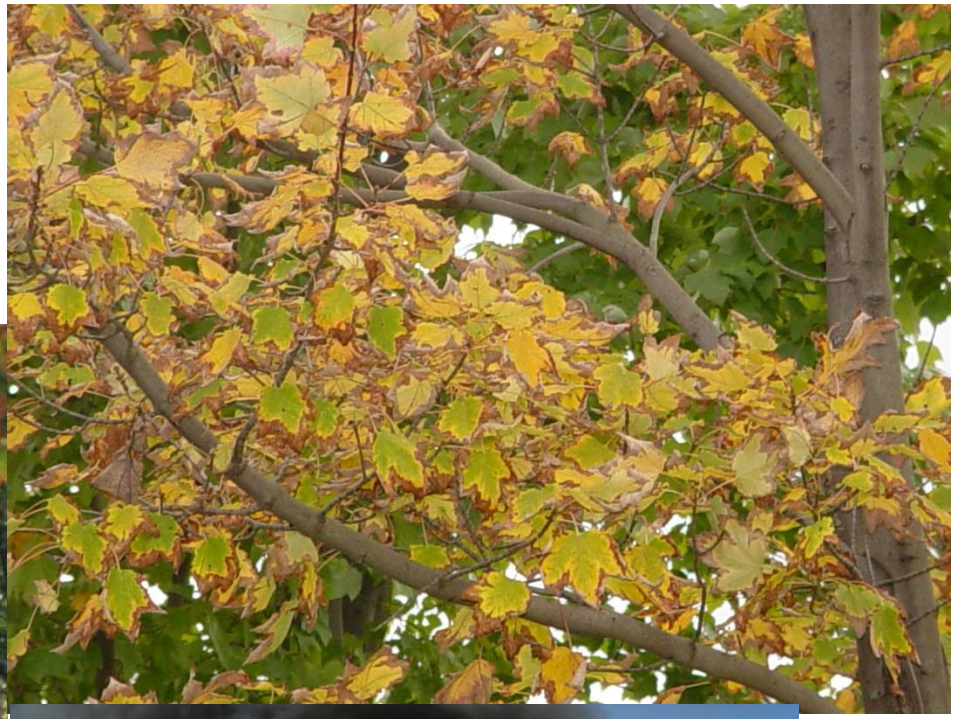
- could be tempered by
  - forest fires
  - pest infestations
  - summer droughts

Credit: NASA's Goddard Space Flight Center Scientific Visualization Studio

http://science.nasa.gov/science-news/science-at-nasa/2013/10mar_greenhouseshift/

Is Vermont susceptible to drought?

Droughts are cyclical & vary in severity

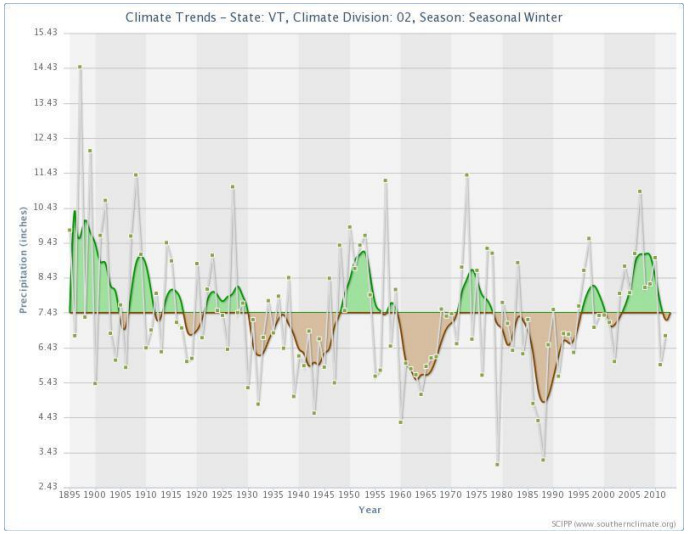


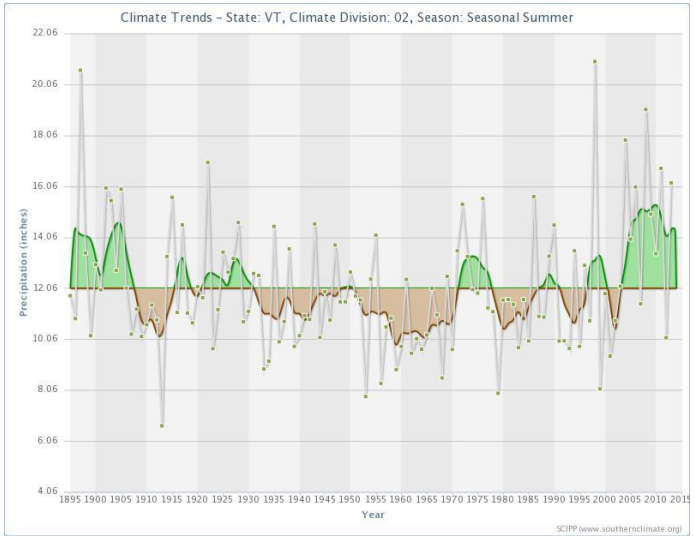
Photos: L-A. Dupigny-Giroux

NWS/BTV

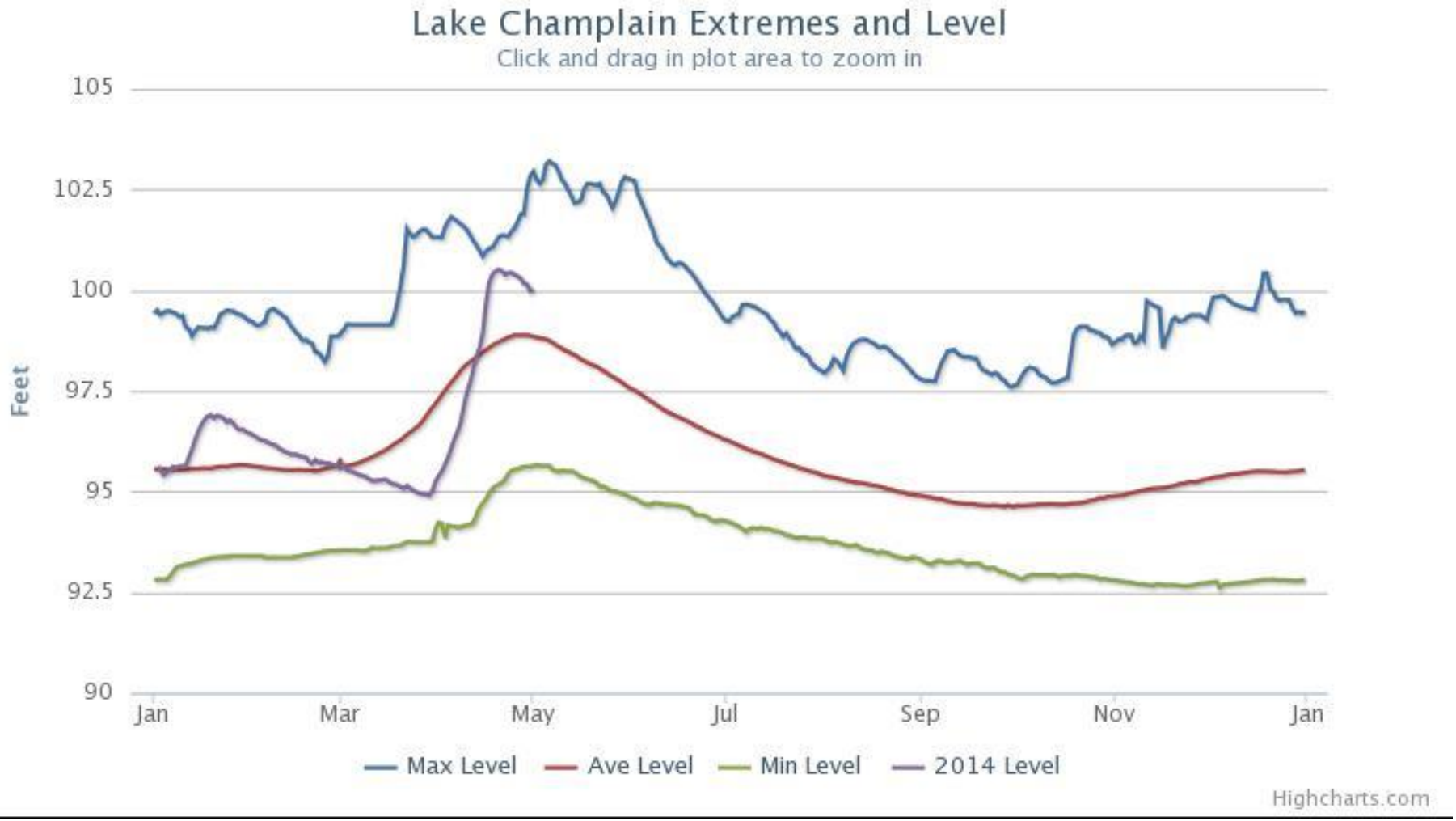
Rutland County 4/17/08

Drought in Vermont

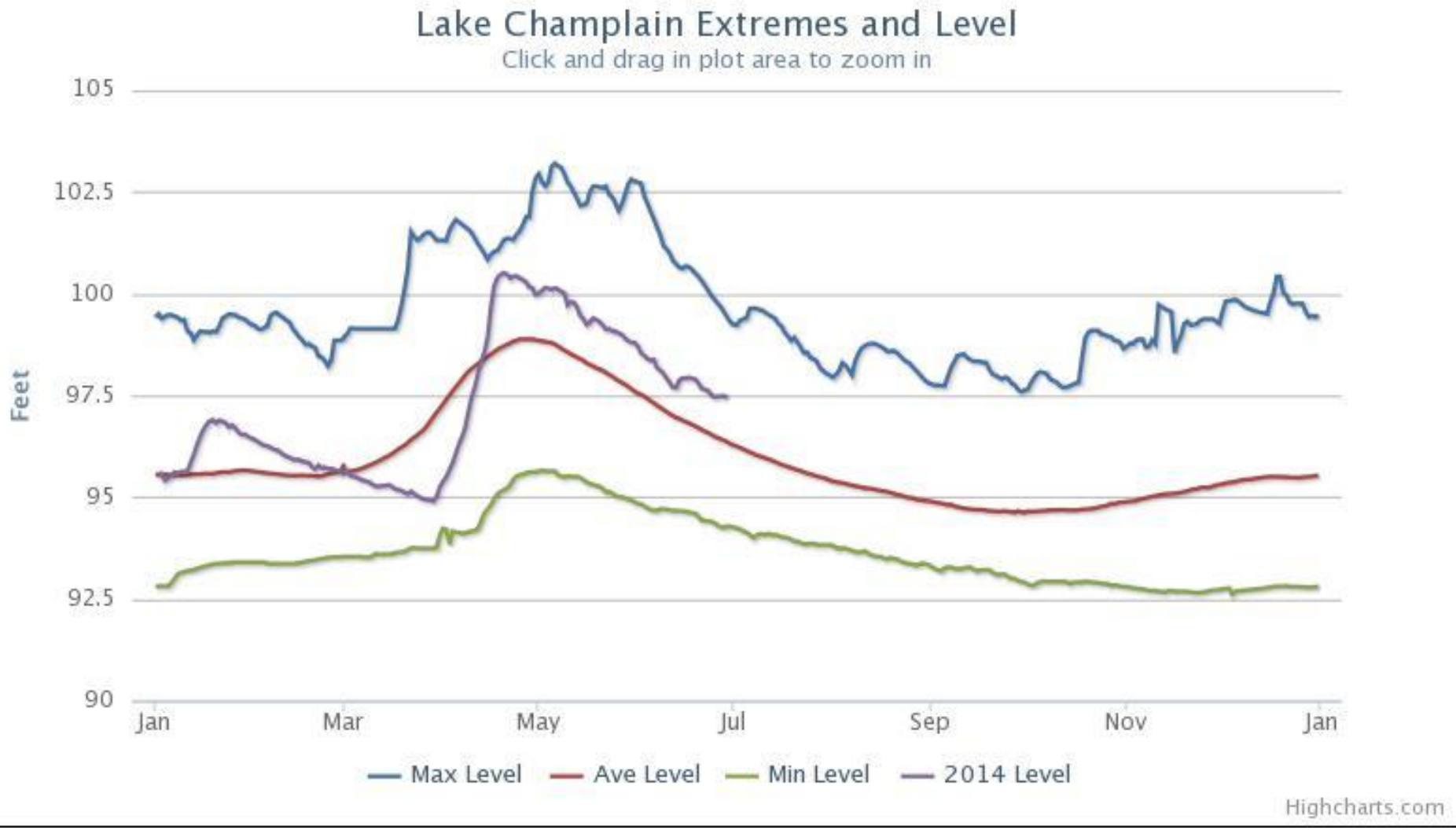




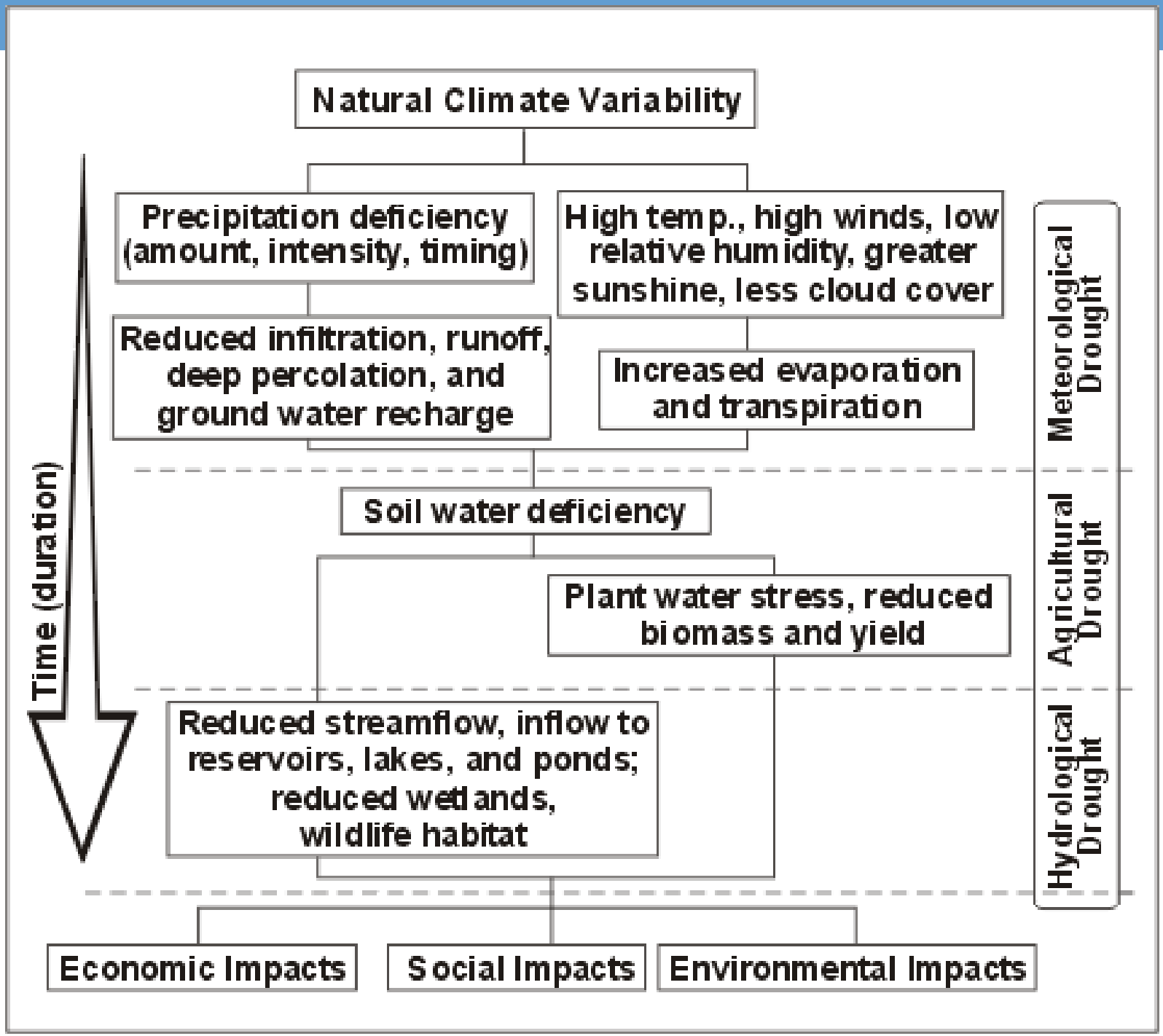
- severe droughts
  - rare
  - statewide
  - multiyear
- less severe droughts
  - more frequent
  - localized
- tends to be a summer occurrence, but can occur at any time
- timing influences who is affected
  - farmers
  - water management
- tendency for drought & floods to occur in the same year



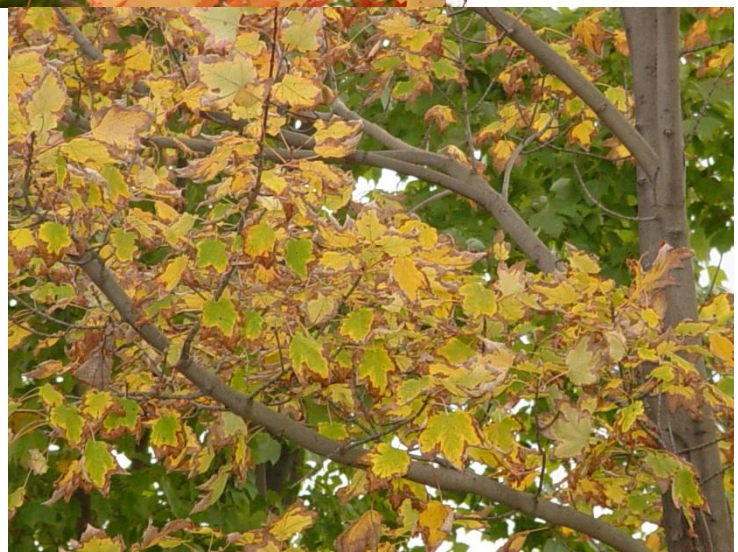
Courtesy: National Weather Service. As of 30 April 2014



Courtesy: National Weather Service. As of 29 June 2014


Natural Climate Variability
Precipitation deficiency (amount, intensity, timing)
High temp., high winds, low relative humidity, greater sunshine, less cloud cover
Reduced infiltration, runoff, deep percolation, and ground water recharge
Increased evaporation and transpiration
Soil water deficiency
Plant water stress, reduced biomass and yield
Reduced streamflow, inflow to reservoirs, lakes, and ponds; reduced wetlands, wildlife habitat
Economic Impacts
Social Impacts
Environmental Impacts
Time (duration)
Meteorological Drought
Agricultural Drought
Hydrological Drought

Who is affected by drought?



- AGRICULTURE
  - dairy farming & other animal husbandry
  - forage crops
  - corn
- FORESTRY
  - wildfires
  - health
- TOURISM
  - fall foliage
  - ski industry

Drought implications

- heat and moisture stress decrease plant ability to absorb CO_2
- mitigate against “greening trend”
- forest dieback, accelerated soil carbon loss could potentially occur

Concurrent stressors in 2006

Photos: L-A. Dupigny-Giroux

2004 moisture stress

Tent caterpillar damage

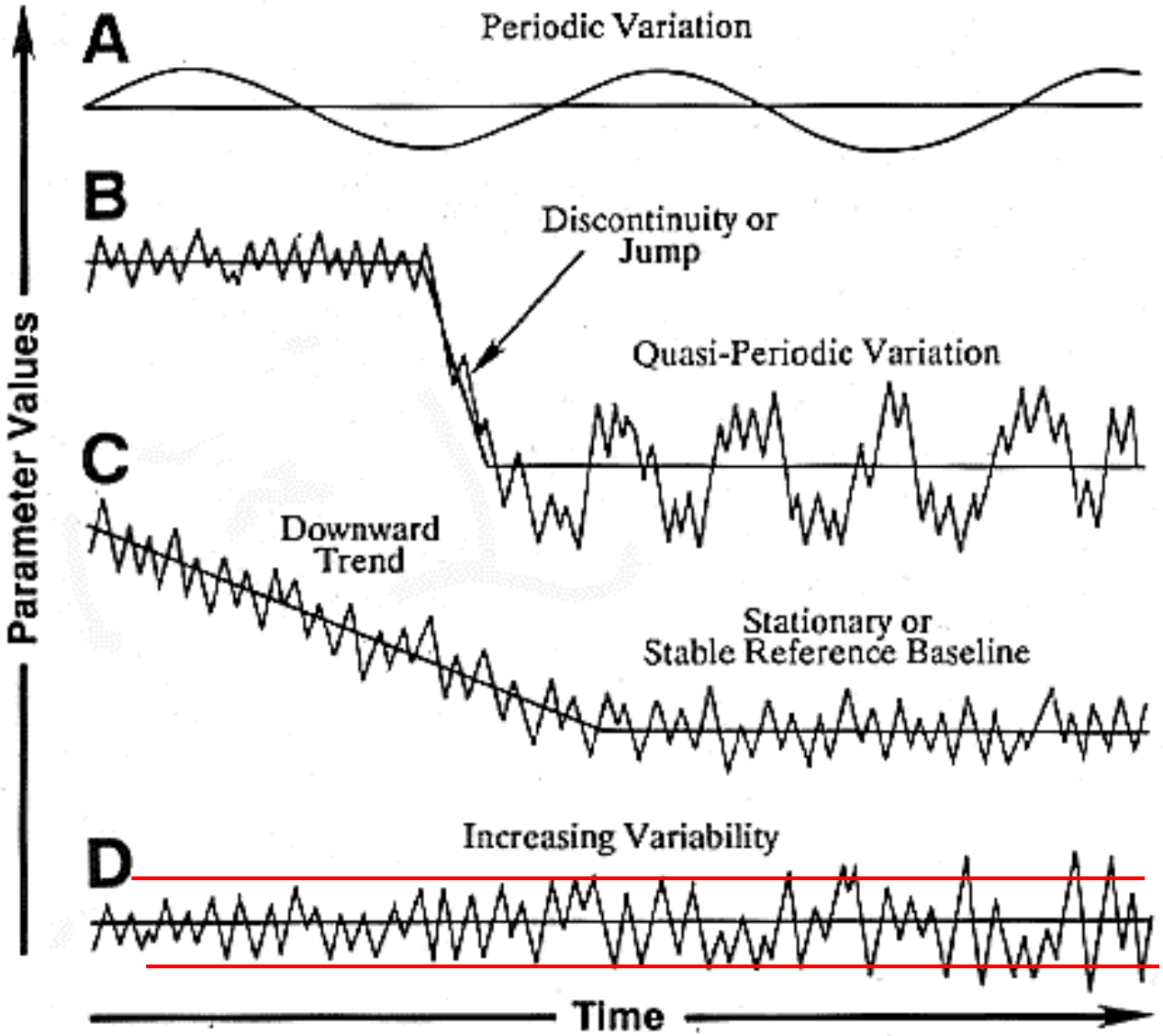
White pine damage

Photos: L-A. Dupigny-Giroux

5. The climate change conversation

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 observed over comparable time periods.”

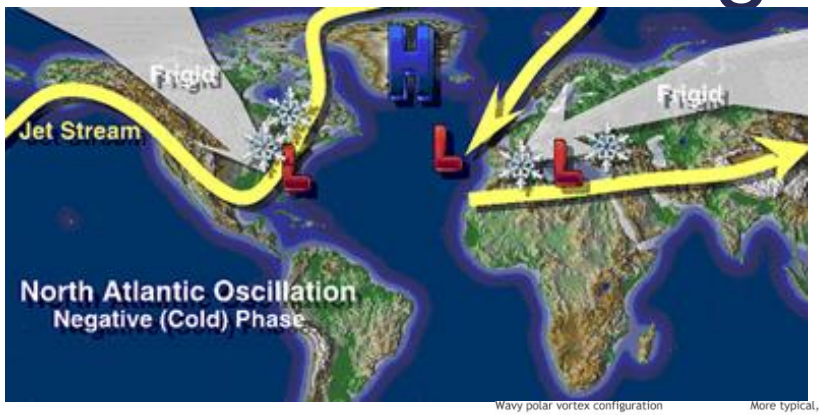


Types of climatic variation

Increased human vulnerability

Credit: David Robinson, NJSC

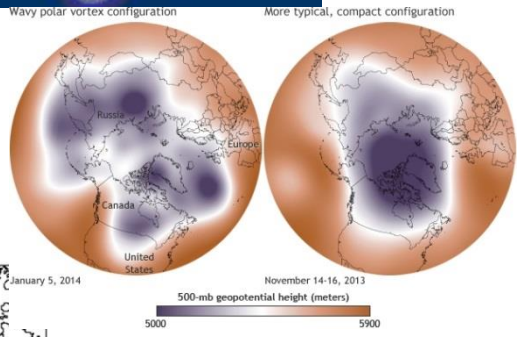
Observing climate variability

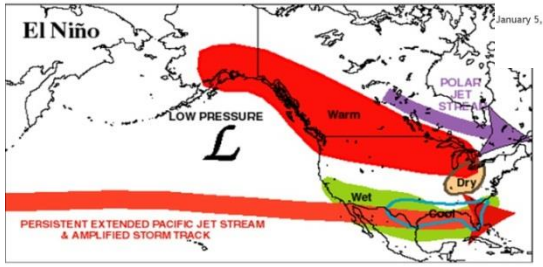


Jack Creilson

- “The temporal variations of the atmosphere– ocean system around a mean state. Typically, this term is used for timescales longer than those associated with synoptic weather events (i.e., months to millennia and longer). The term “natural climate variability” is further used to identify climate variations that are not attributable to or influenced by any activity related to humans.” AMS Glossary

NOAA





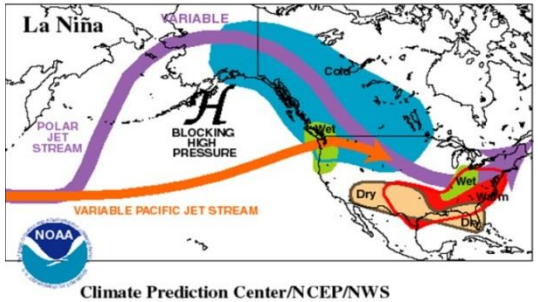
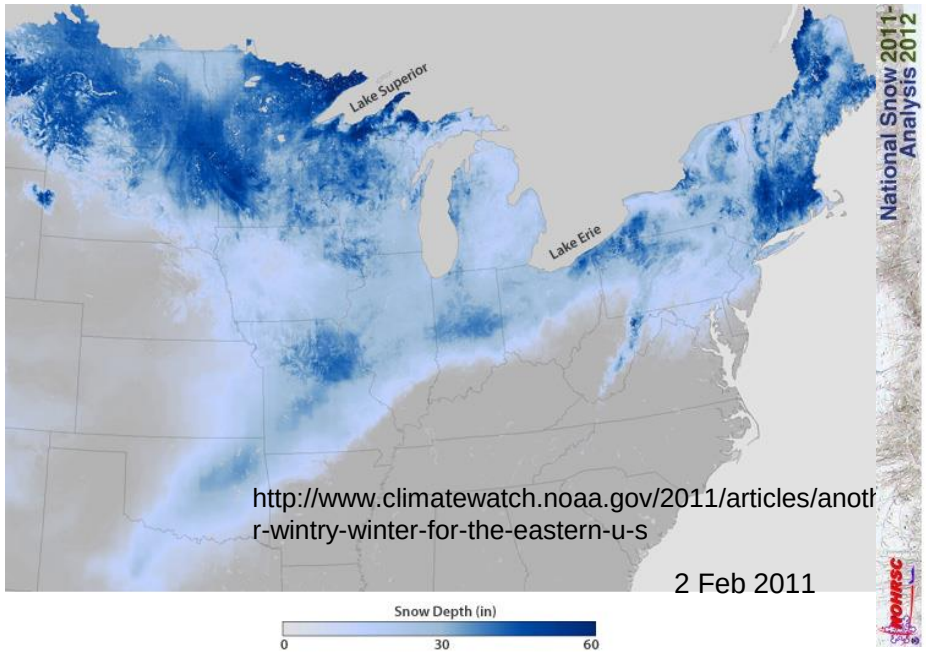


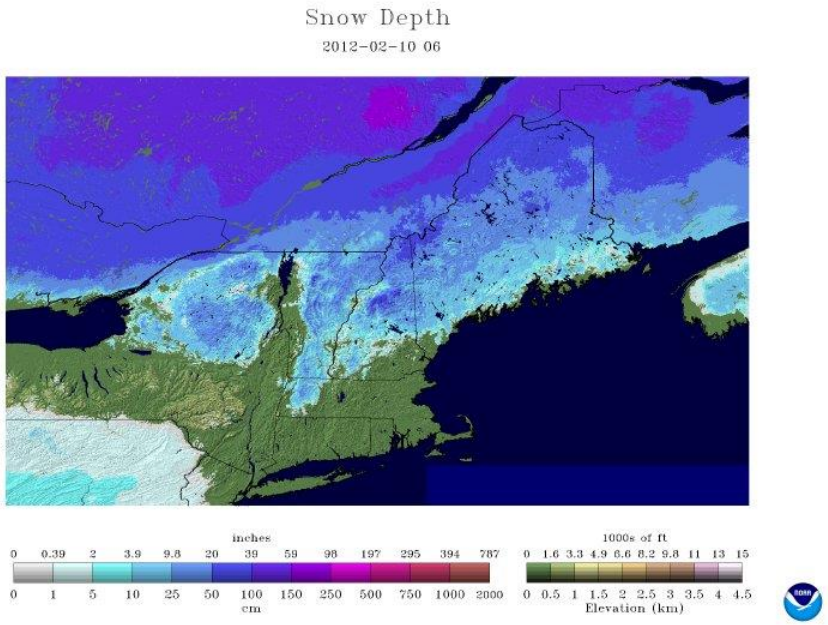
Photo credit: L-A. Dupigny-Giroux

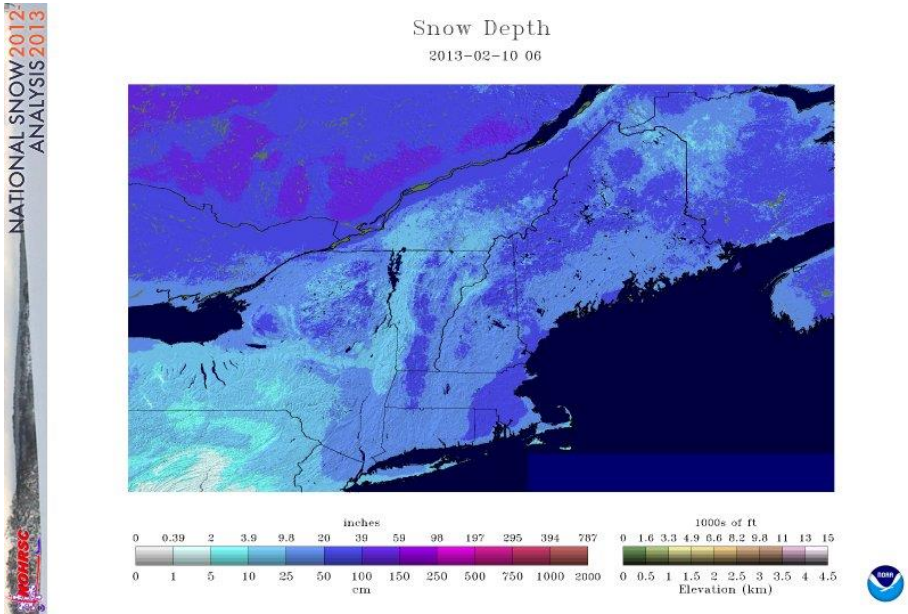
Snow cover – February 2011 - 2014

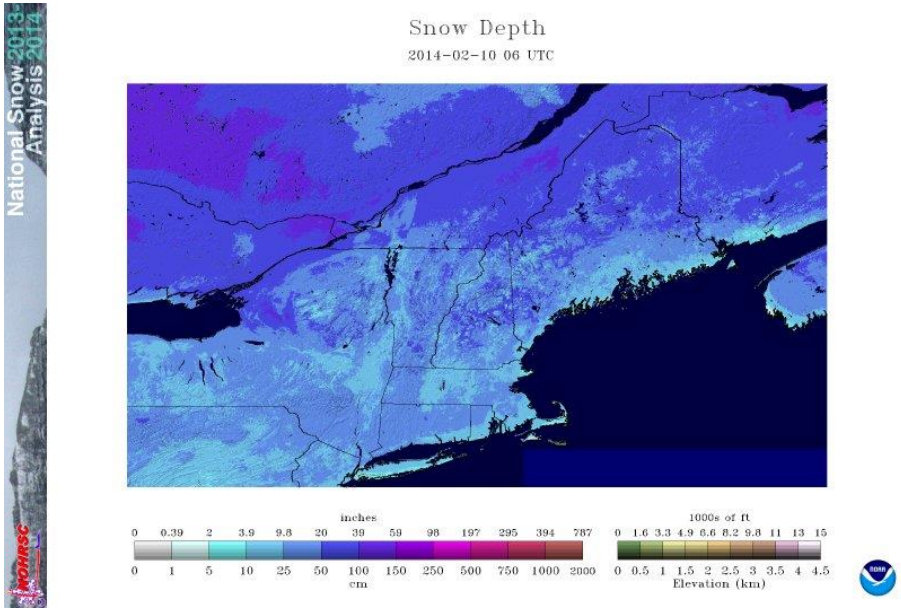


http://www.climatewatch.noaa.gov/2011/articles/anoth
r-wintry-winter-for-the-eastern-u-s

2 Feb 2011







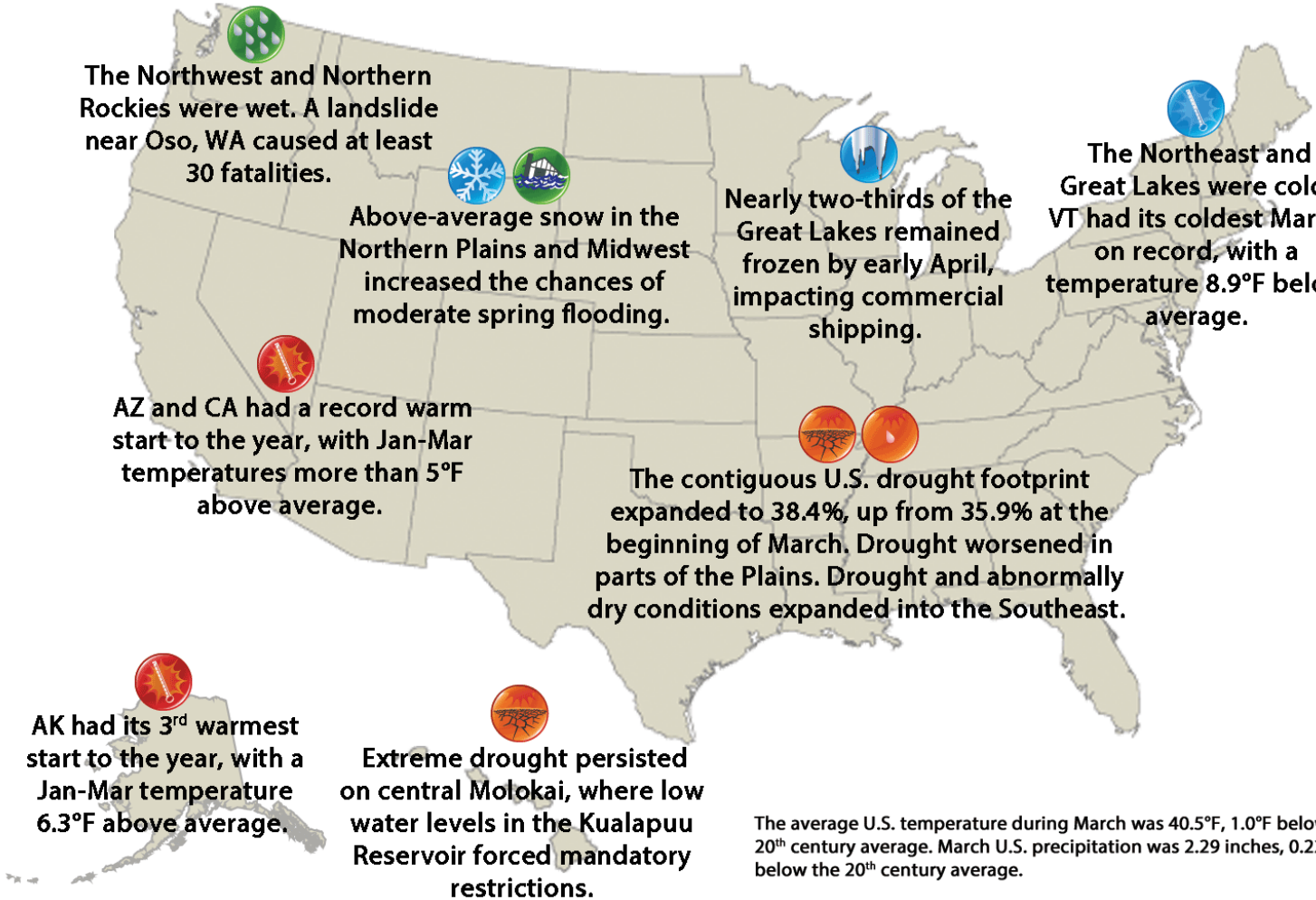
Backward spring 2010

Photos: L-A. Dupigny-Giroux

- low temperatures in January – June
- land-locked stations colder
- winter freeze/thaw cycles – predictor
- snow, freezing rain – April to June
- summer killing frosts
- summer drought
- NW flow

Significant Events for March 2014

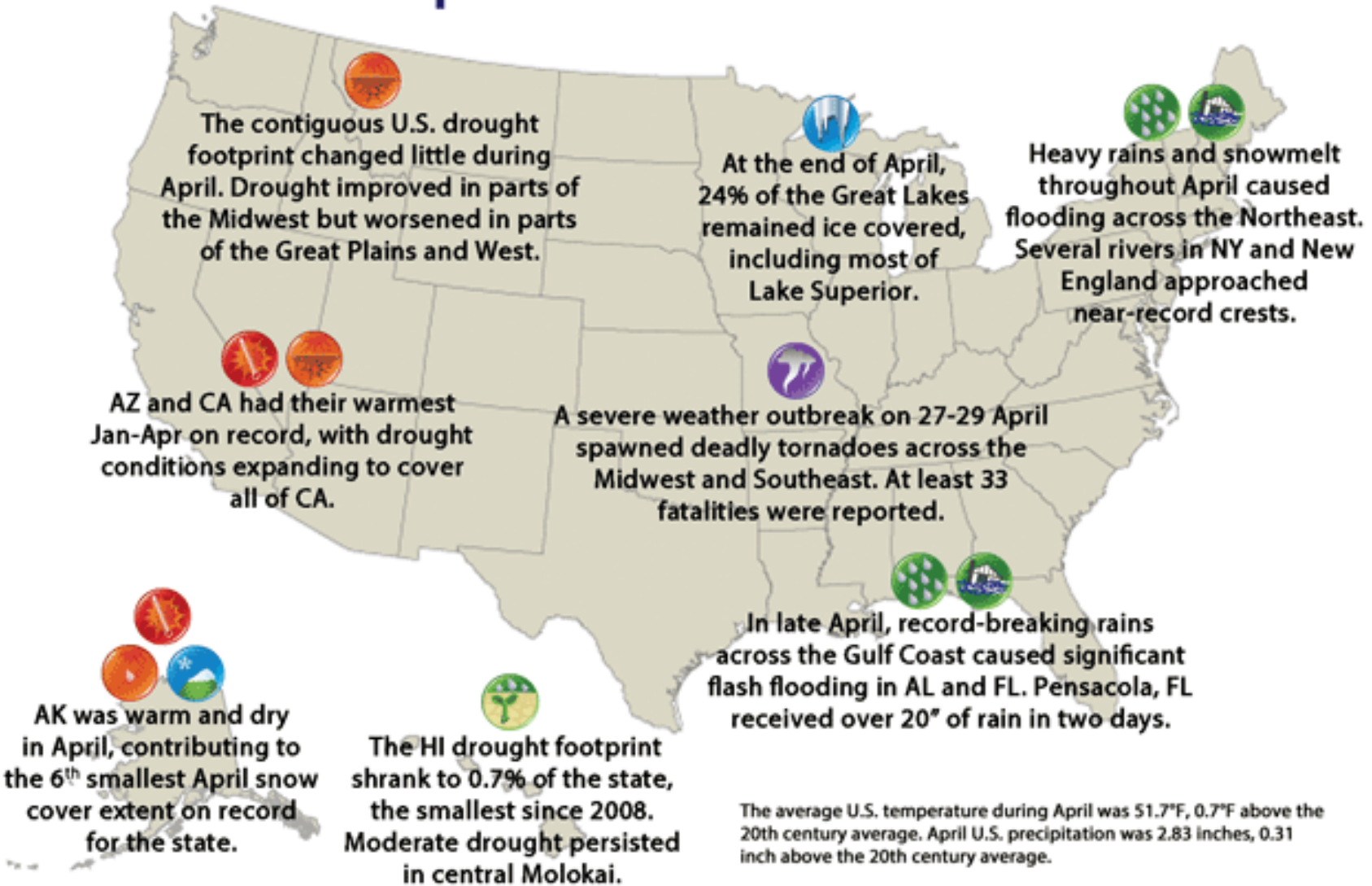
NOAA's National Climatic Data Center



The average U.S. temperature during March was 40.5°F, 1.0°F below the 20th century average. March U.S. precipitation was 2.29 inches, 0.22 inch below the 20th century average.

Significant Events for April 2014

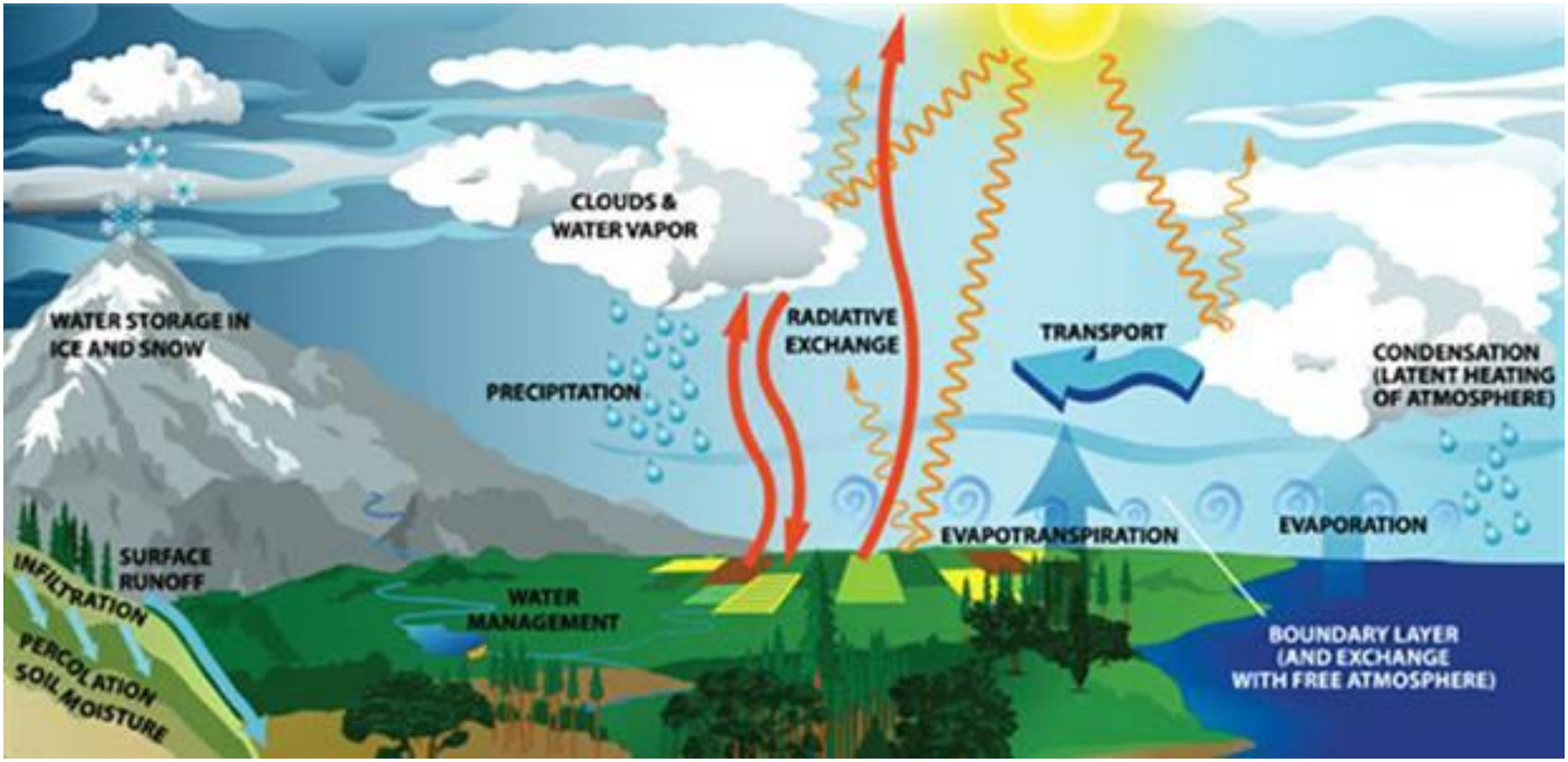
NOAA's National Climatic Data Center



The average U.S. temperature during April was 51.7°F, 0.7°F above the 20th century average. April U.S. precipitation was 2.83 inches, 0.31 inch above the 20th century average.

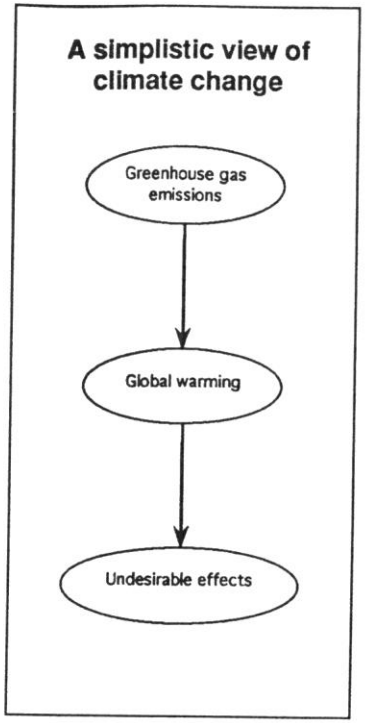
6. Understanding climate change as a complex system

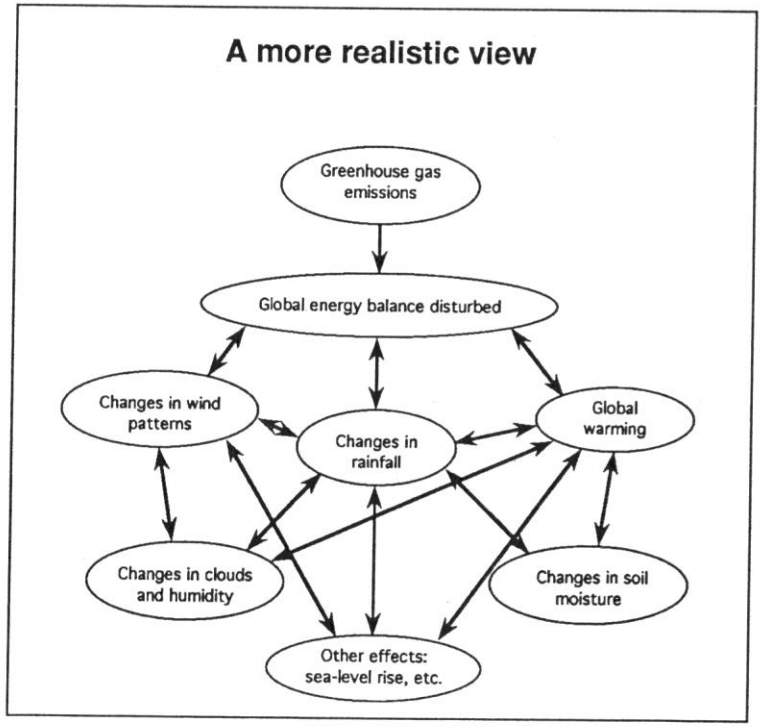
NOAA Climate Model



http://research.noaa.gov/sites/oar/EasyDNNNews/10430/620300c1768EDNmainearth_system_interactions.jpg

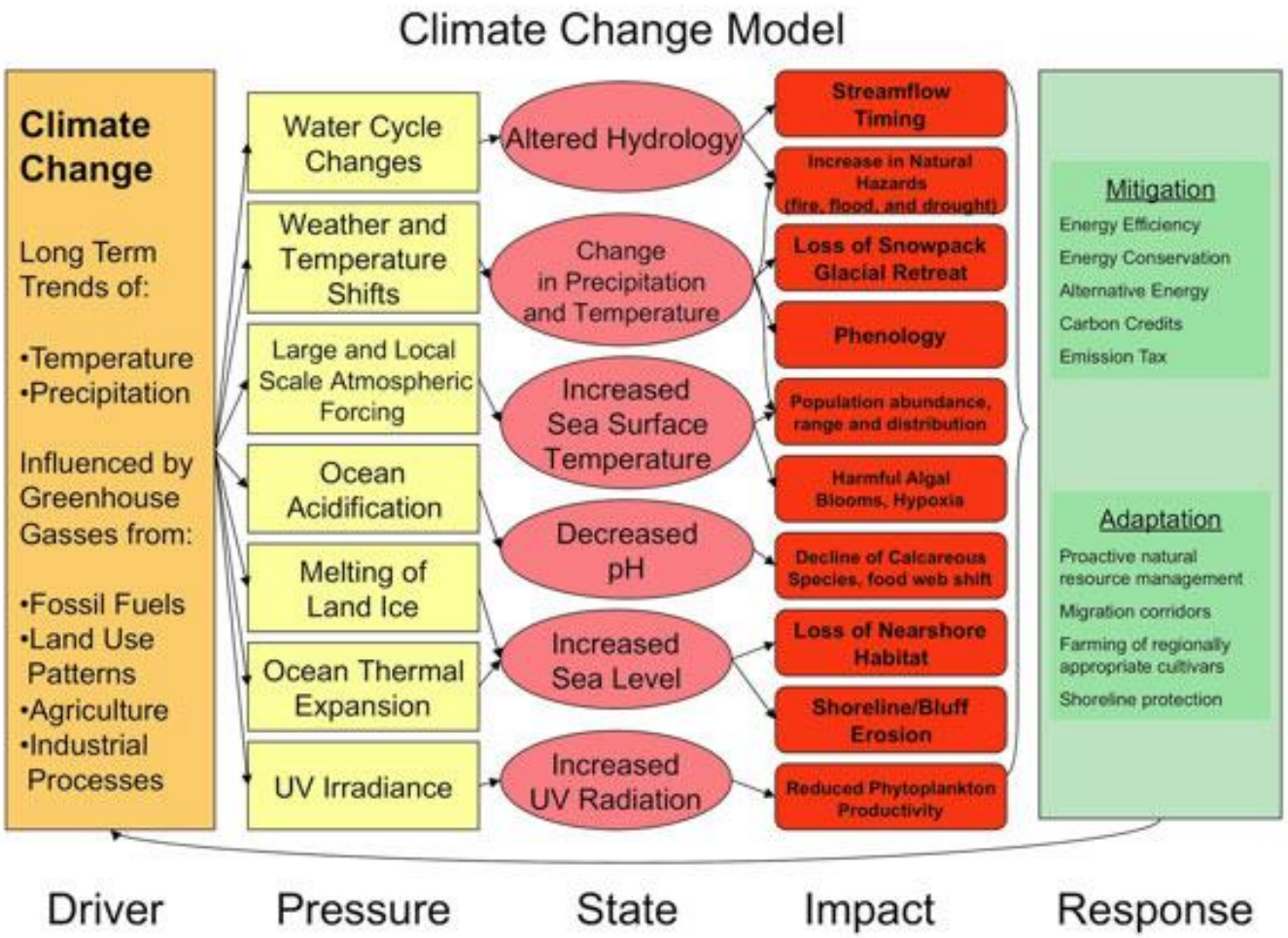
Climate change as a system





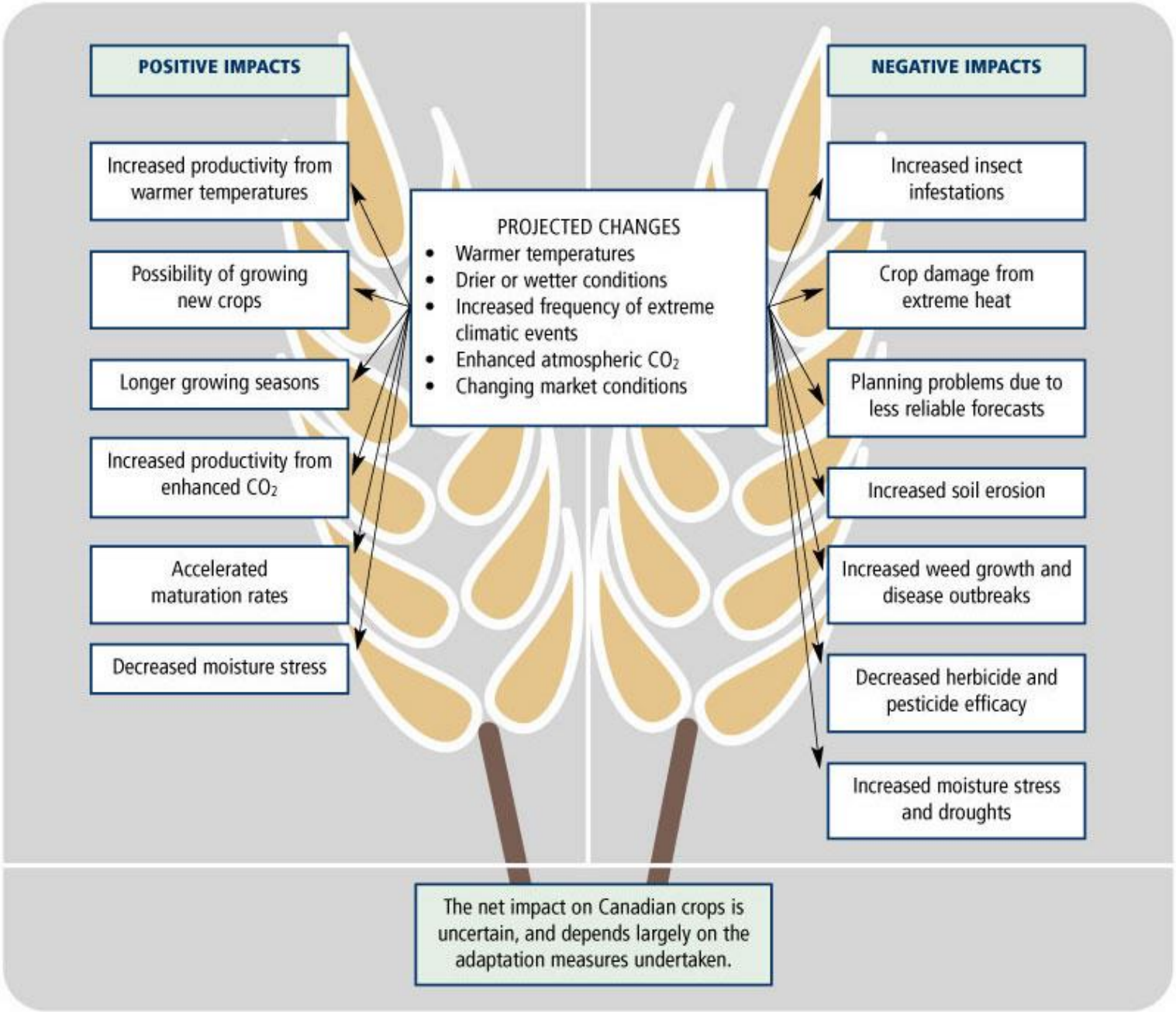
United Nations/UNEP

Three aspects of climate change - process, impact, strategies



http://pugetsoundscienceupdate.com/pmwiki.php?n=Chapter3.Section2

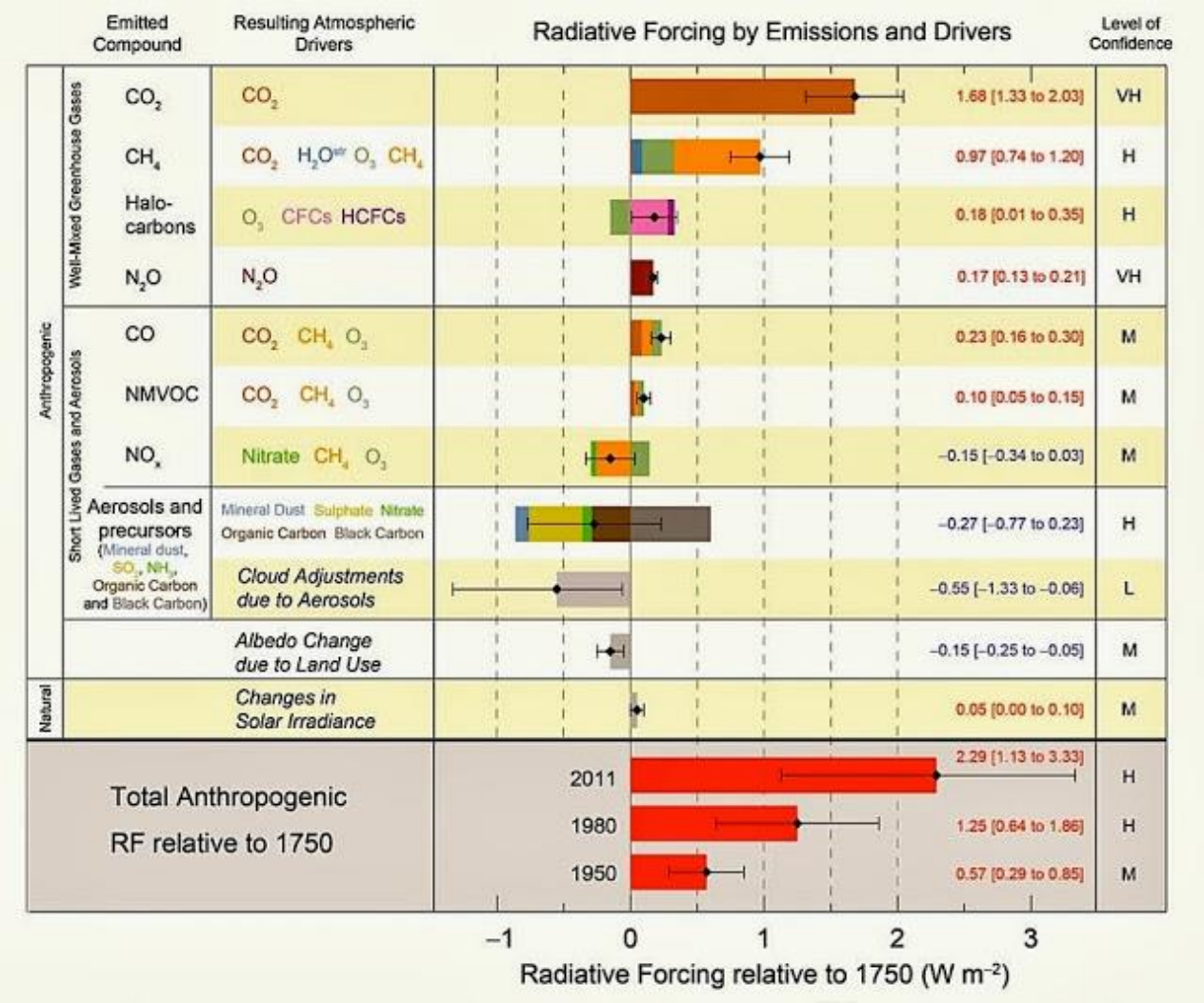
Figure 1: Potential impacts of climate change on agricultural crops in Canada



http://www.nrcan.gc.ca/sites/www.nrcan.gc.ca.earth-sciences/files/jpg/perspective/images/figure1_potential_impacts_e.jpg

Greenhouse gases and vegetation

Drivers of climate change



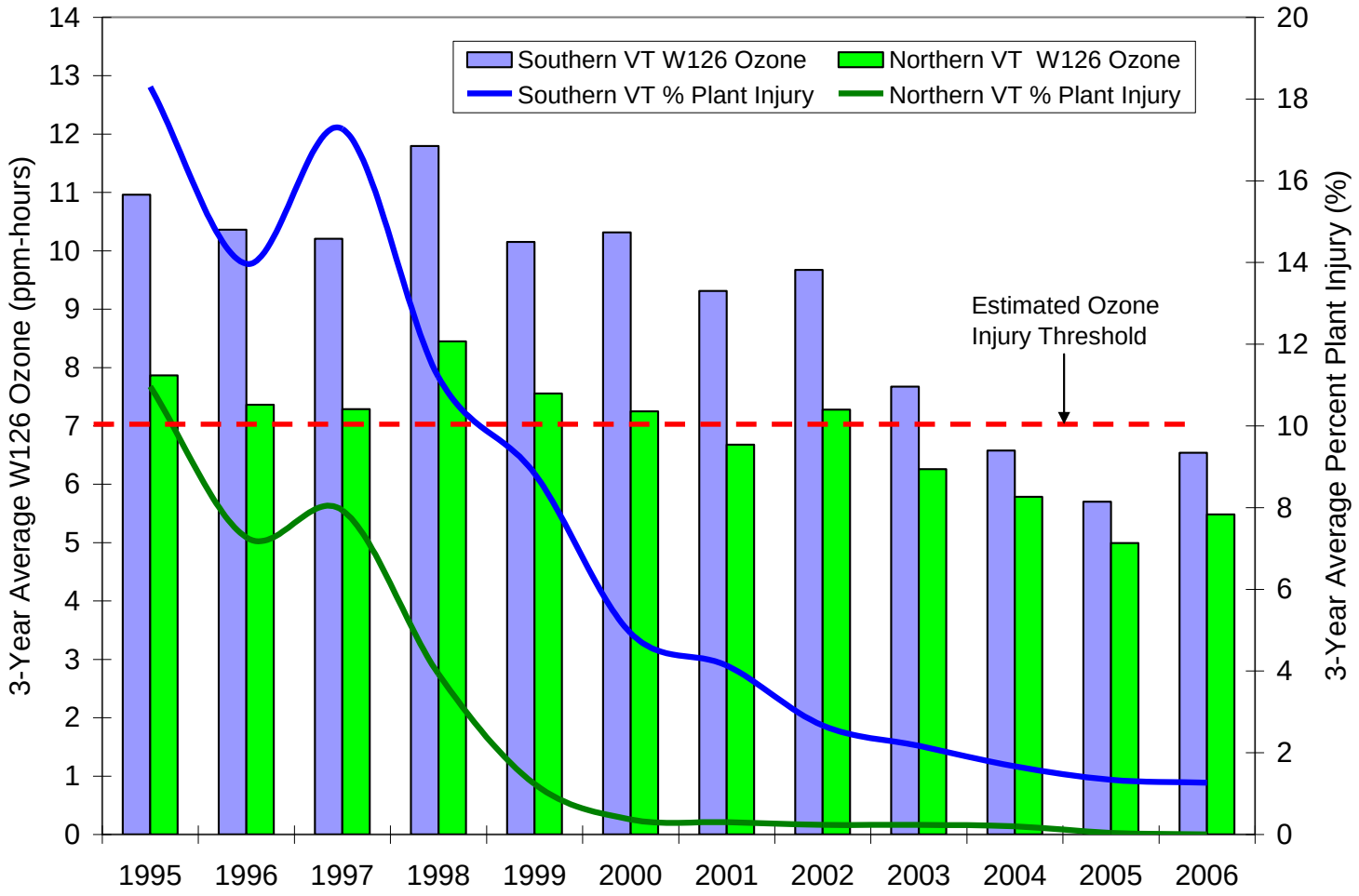
http://www.climatechange2013.org/images/figures/WGI_AR5_FigSPM-5.jpg

Ground-level ozone

Ozone Injury to White Ash
Photo by Gretchen Smith

- reduces plant growth & vigor
- reduces seed production
- increases susceptibility to insects & disease
- cumulative effect over growing season
- Black cherry, white ash, yellow poplar

Three-Year Average Trends in Ozone Pollution & Plant Injury in Northern & Southern VT



Courtesy R. Poirot – VT ANR/Air Quality

Ozone injury

Ozone injury to milkweed.

Ozone injury to yellow-poplar.

USFS

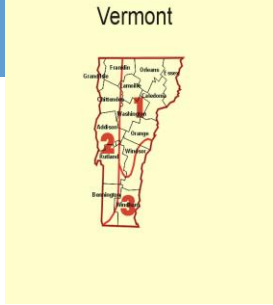
7. Climate change projections for the Northeast & Vermont

2035 (Northeast)

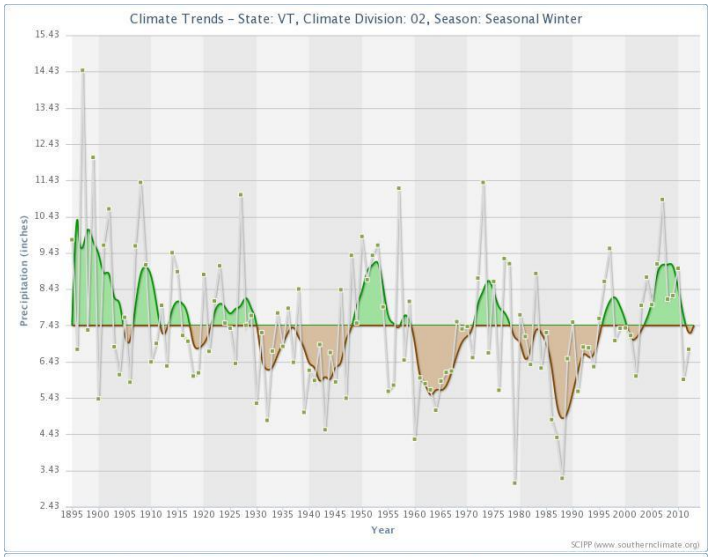
- “changes in precipitation are not significant for most models (category 1) over the majority of grid points. This means that most models are in agreement that any **changes will be smaller than the normal year – to -year variations that occur**.”

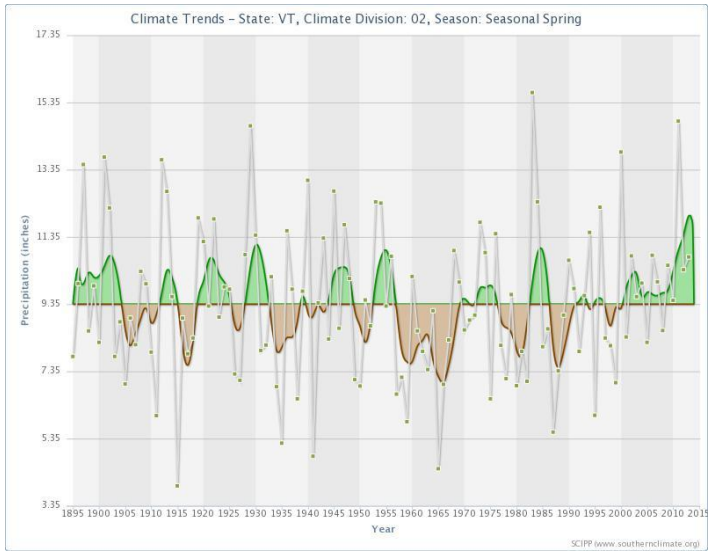
National Climate Assessment, 2013

Western Vermont



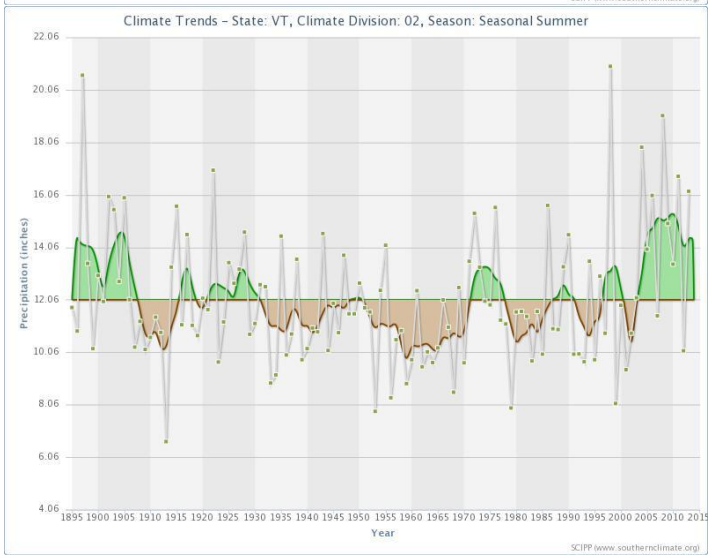
Winter

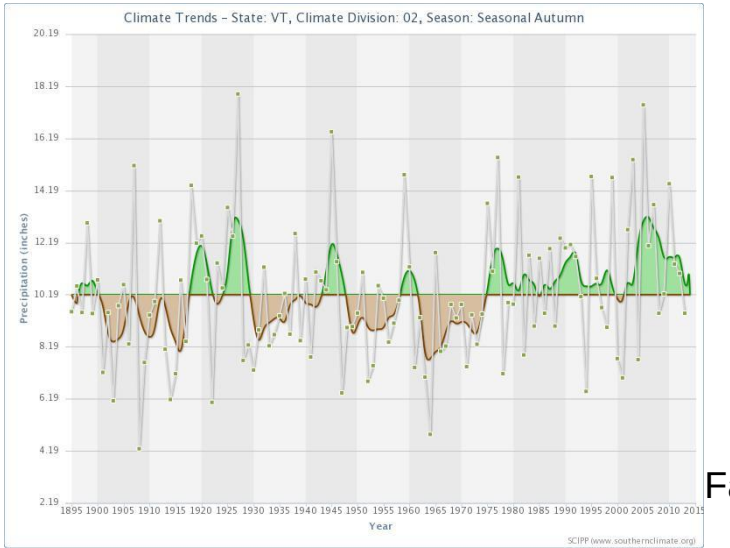




Spring

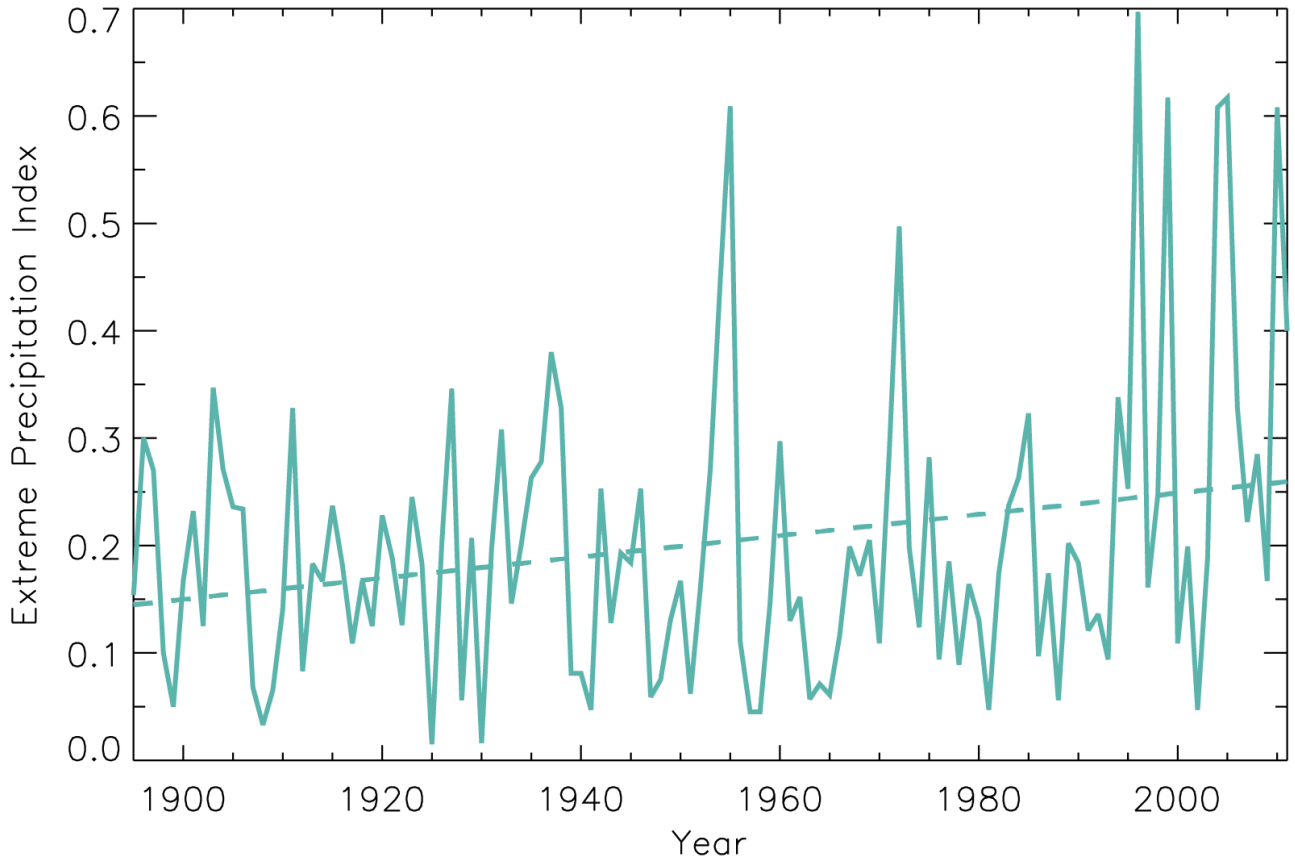
Summer





Fall

Extreme precipitation index for the occurrence of 1-day, 1 in 5-year extreme precipitation



Trend line is not statistically significant

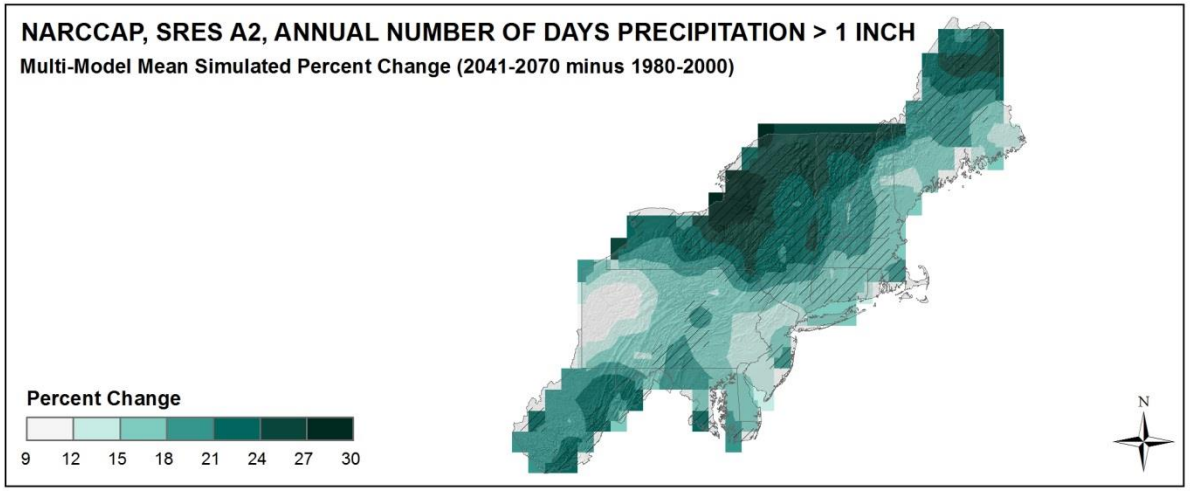
National Climate Assessment, 2013

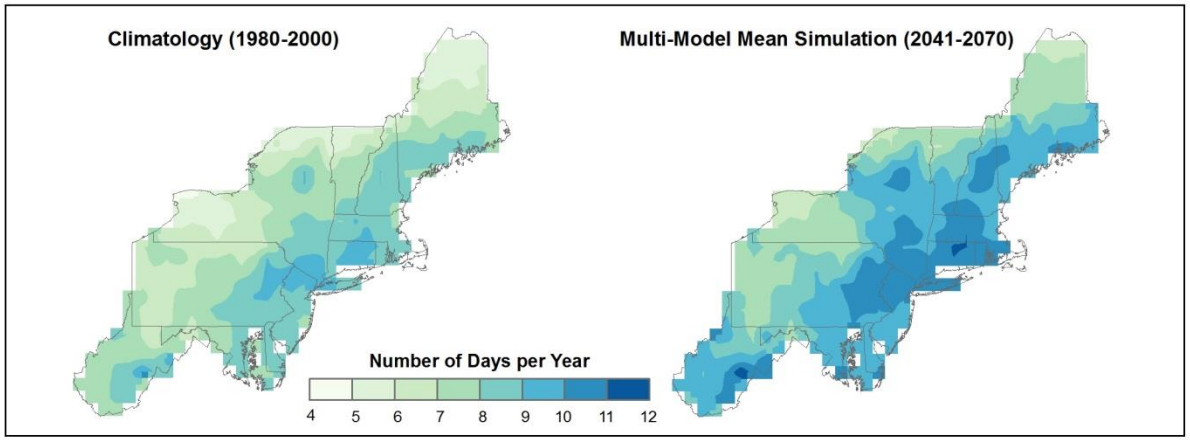
2055 & 2085 (Northeast)

- "for **emissions scenarios in 2055 and 2085**, most models indicate changes that are larger than these normal variations (category 3), i.e., the models are mostly in agreement that **precipitation will increase over the entire region**."

National Climate Assessment, 2013

Model difference in mean annual number of days with precipitation of greater than one inch

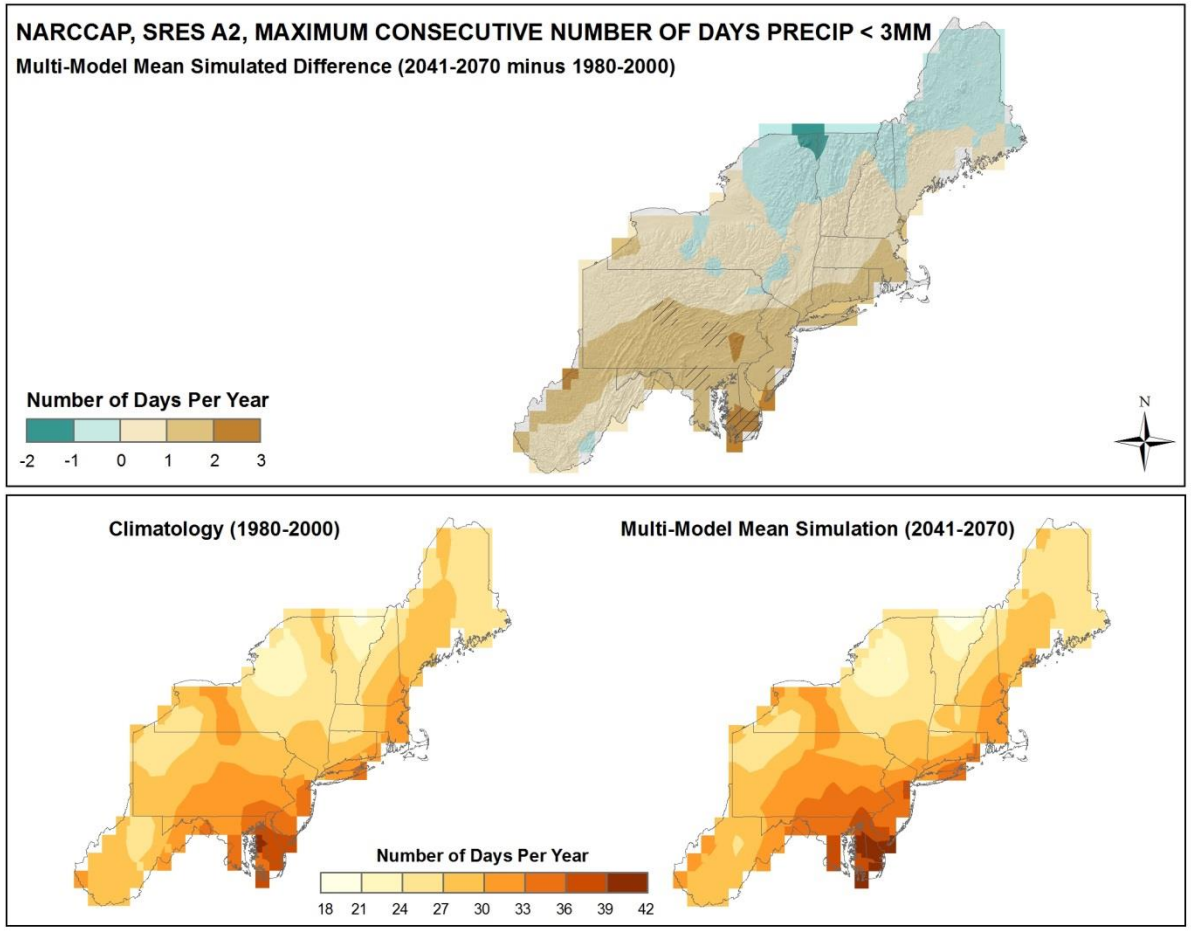




Statistically significant change //

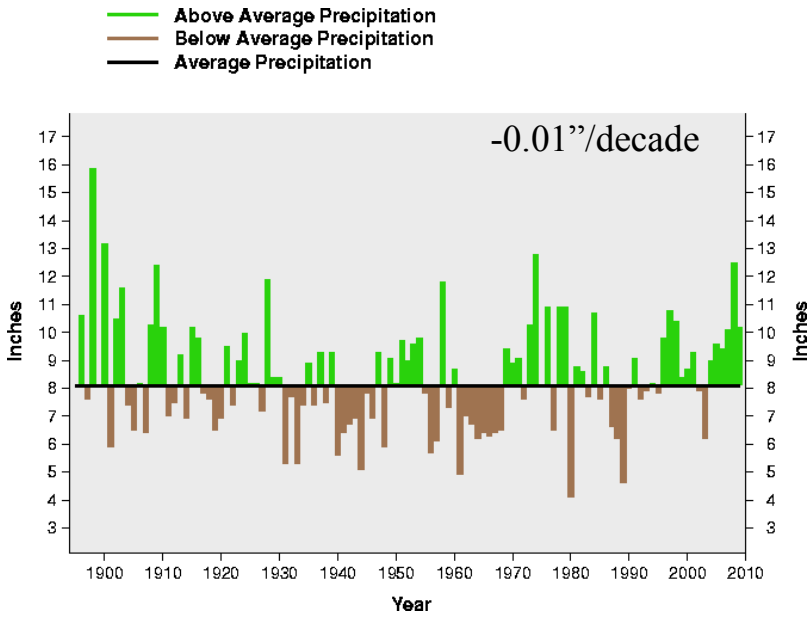
National Climate Assessment, 2013

Model difference in the mean annual maximum number of consecutive days with precipitation of less than 0.1 inches

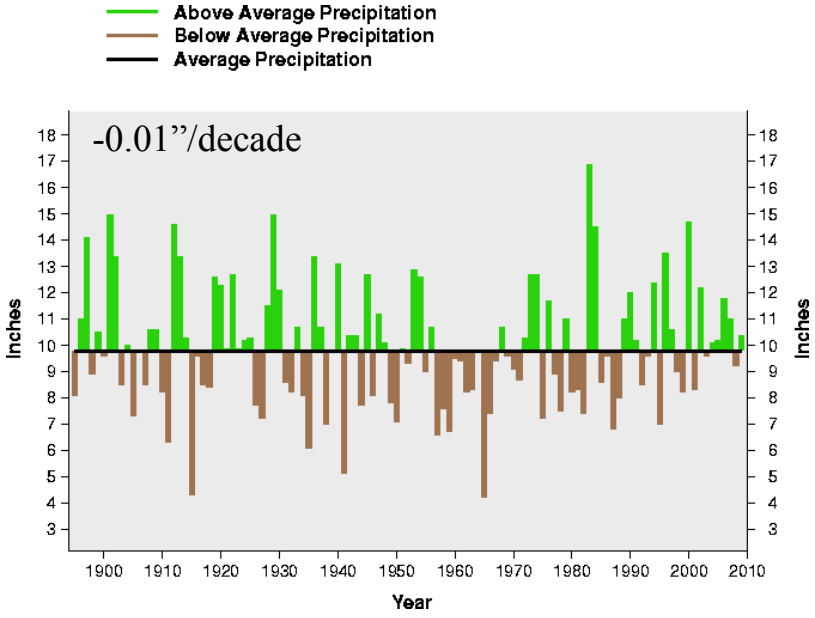


National Climate Assessment, 2013

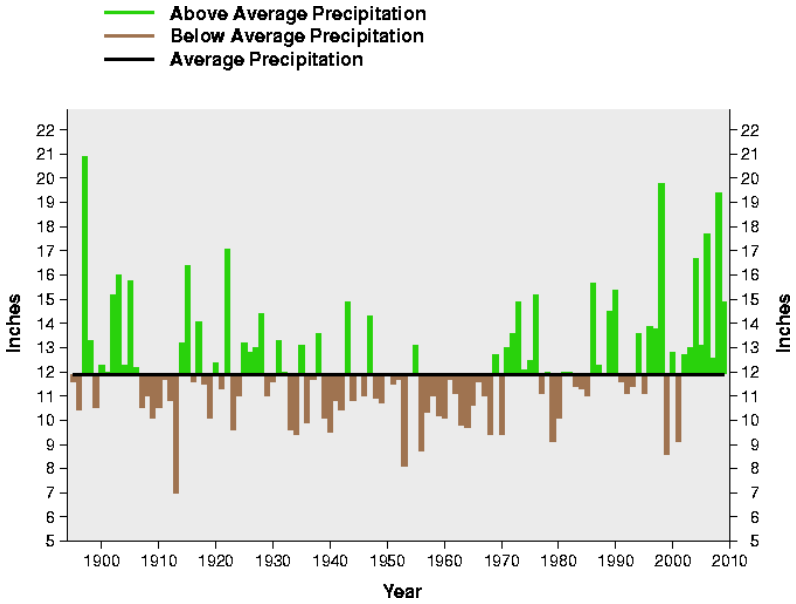
DJF



MAM

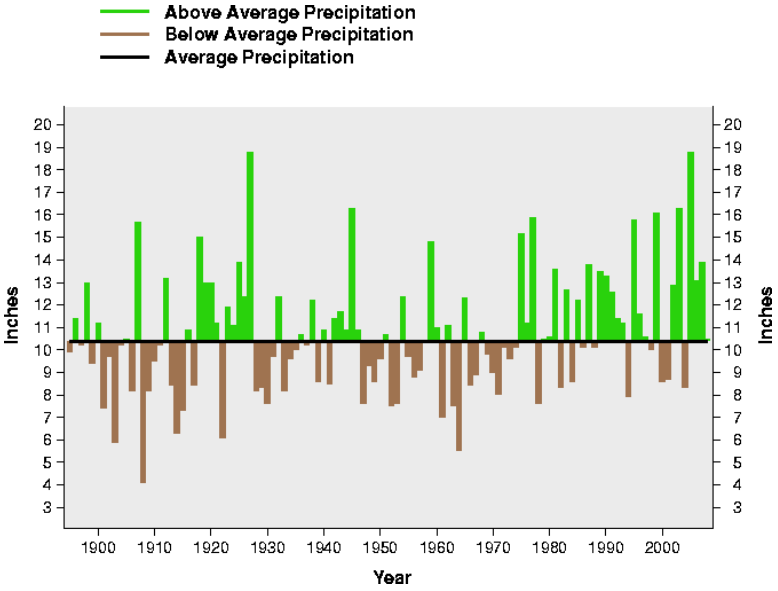


JJA



0.09”/decade

SON



0.20”/decade

Changing recurrence intervals

- "Thus the amount of rain that was expected to **occur once in 100 years, may now occur on average once every 60 years**. This could lead to the premature failure of infrastructure or more frequent infrastructure disruptions."

National Climate Assessment, 2013

Changing recurrence intervals

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- “**DeGaetano (2009) shows that what would be expected to be a 100 - year event based on 1950 -1979 data, occurs with an average return interval of 60 years when data from the 1978 - 2007 period are considered.”**

National Climate Assessment, 2013

Changing recurrence intervals

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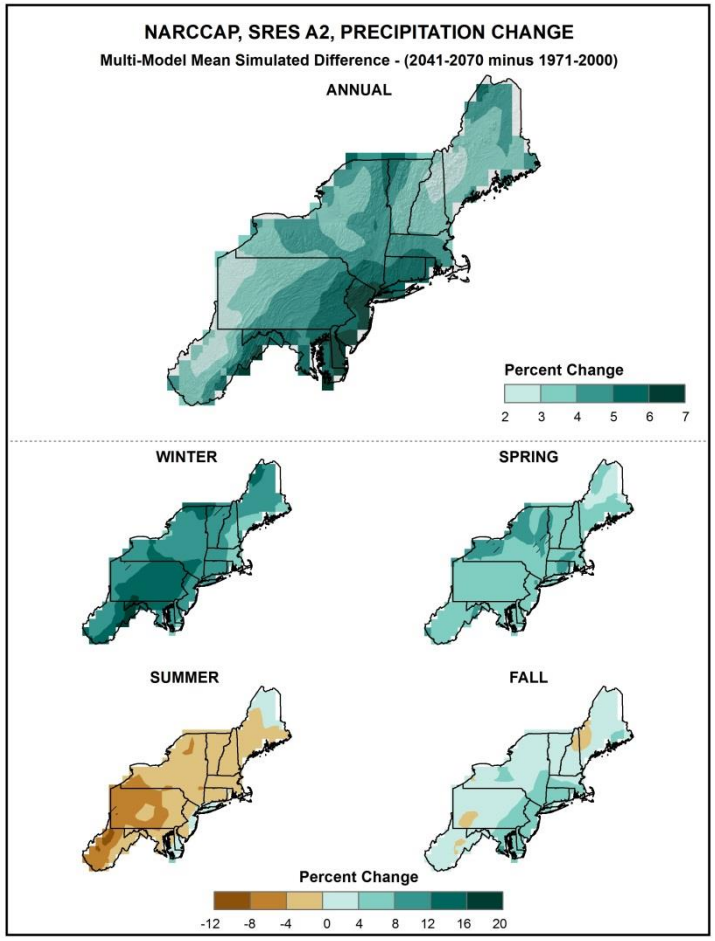
- “DeGaetano (2009) shows that what would be expected to be a 100 - year event based on 1950 -1979 data, occurs with an average return interval of 60 years when data from the 1978 - 2007 period are considered. “

- “Similarly, the **amount of rain that constituted a 50 -year event during 1950-1979 is expected to occur on average once every 30 years based on the more recent data.”**

National Climate Assessment, 2013

Model difference in annual and seasonal mean precipitation



National Climate Assessment, 2013

Take home messages

- spatial and temporal variability important
- regional and continental scale processes affect us
- nonlinear system (atmosphere, pests, carbon)
- need to factor in topography

- vegetation can be affected in every season by temperature & moisture extremes
- impacts can be species-specific
- flexibility in planting and species selection

Department of Agriculture Photograph Collection

VT State Archives