Dealing with Climate Change

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CCV Winooski

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https://vimeo.com/137501379 (video)

Outline

- **Science of climate change**
  - **Global and local**
  - **What is happening to Vermont?**
  - **Why is extreme weather increasing?**
- **The transition we face**
  - **Can we stabilize the climate?**
  - **Why is it difficult?**
  - **What are our responsibilities?**

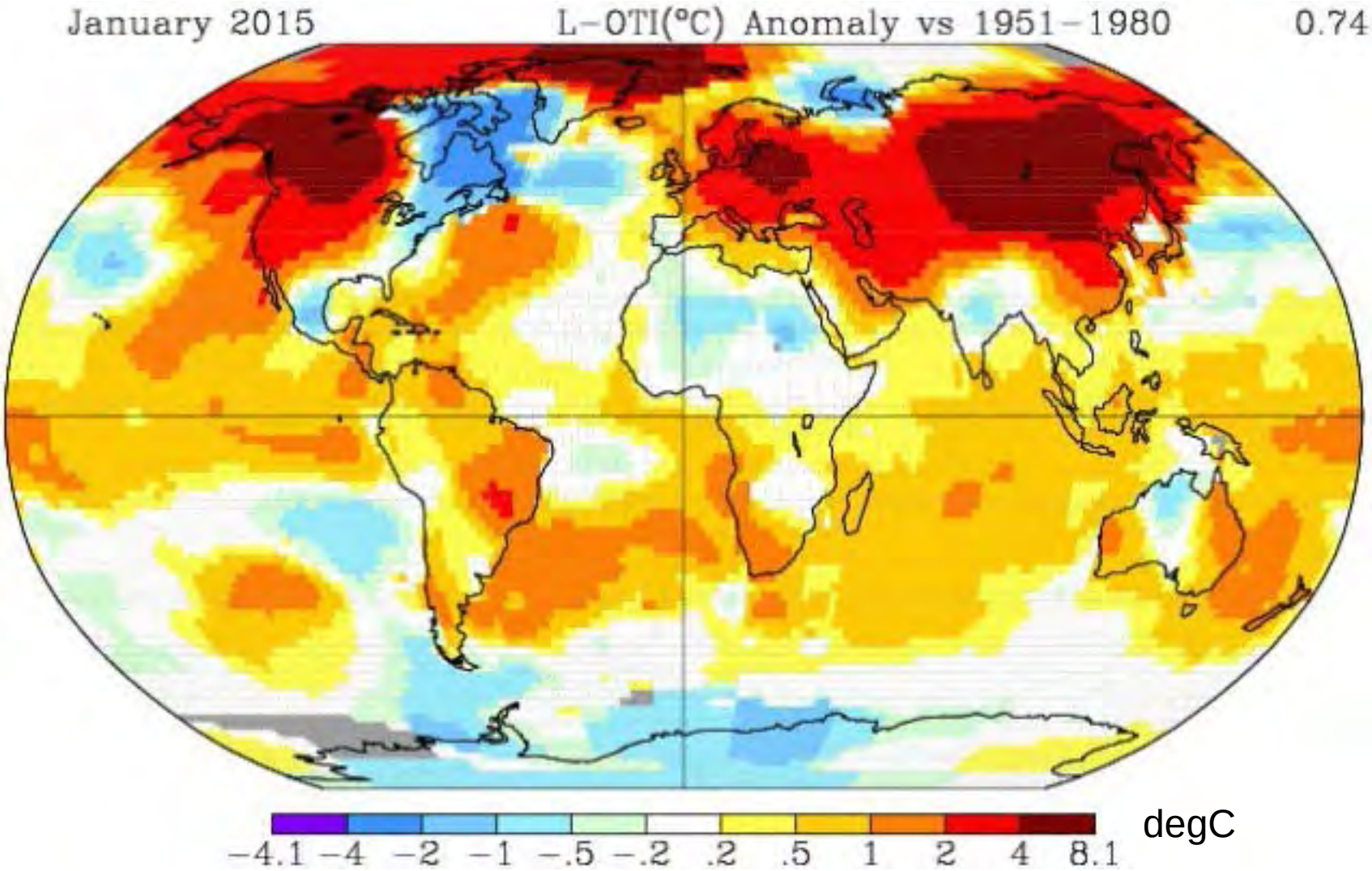
Discussion

Earth's climate sustains life

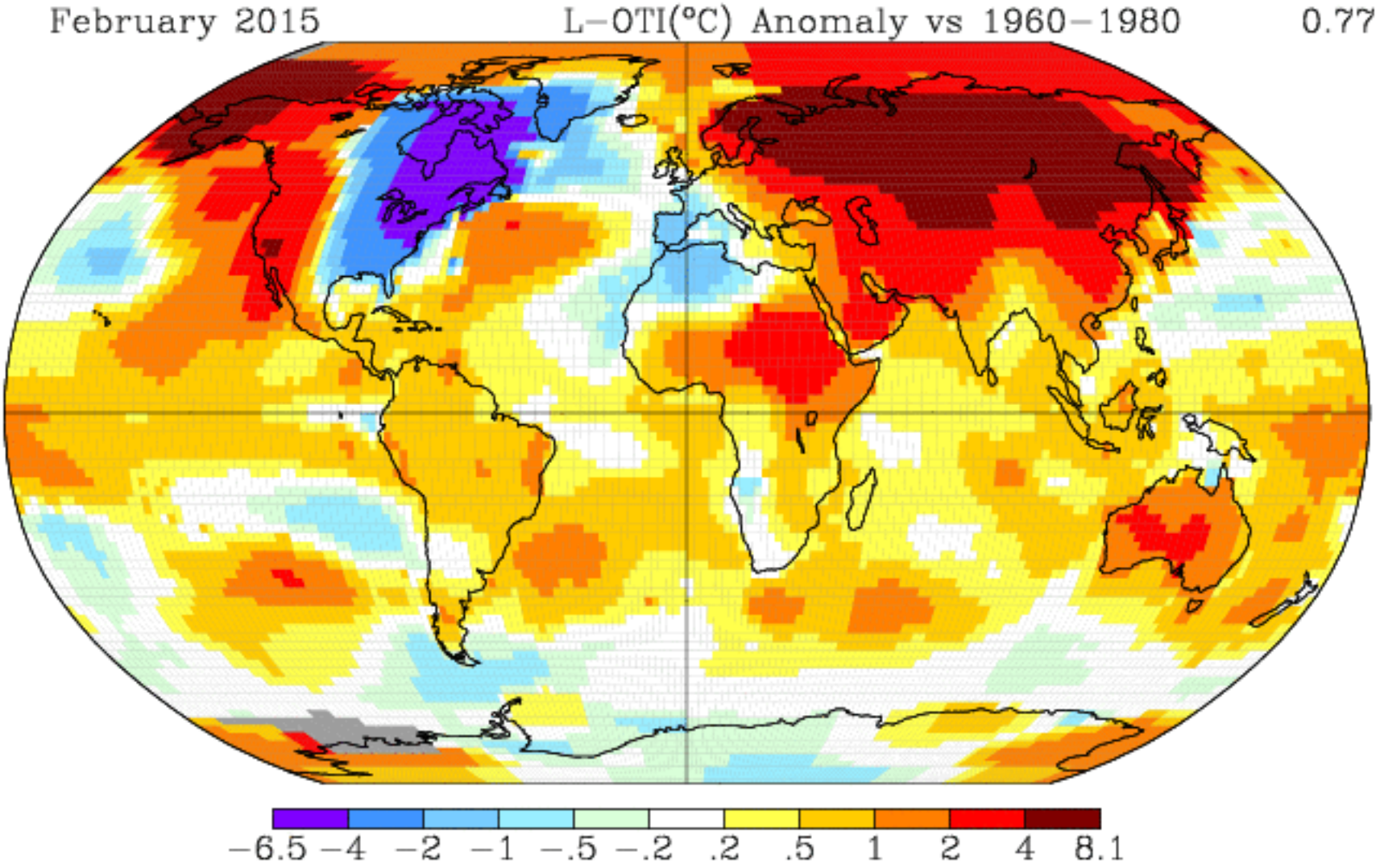
- Burning fossil fuels is increasing greenhouse gases
- Climate is warming: ice is melting, extreme weather is increasing
- Water plays crucial amplifying role

January 2, 2012: NASA

Last Winter Chilly but Look at the Rest of the Northern Hemisphere!

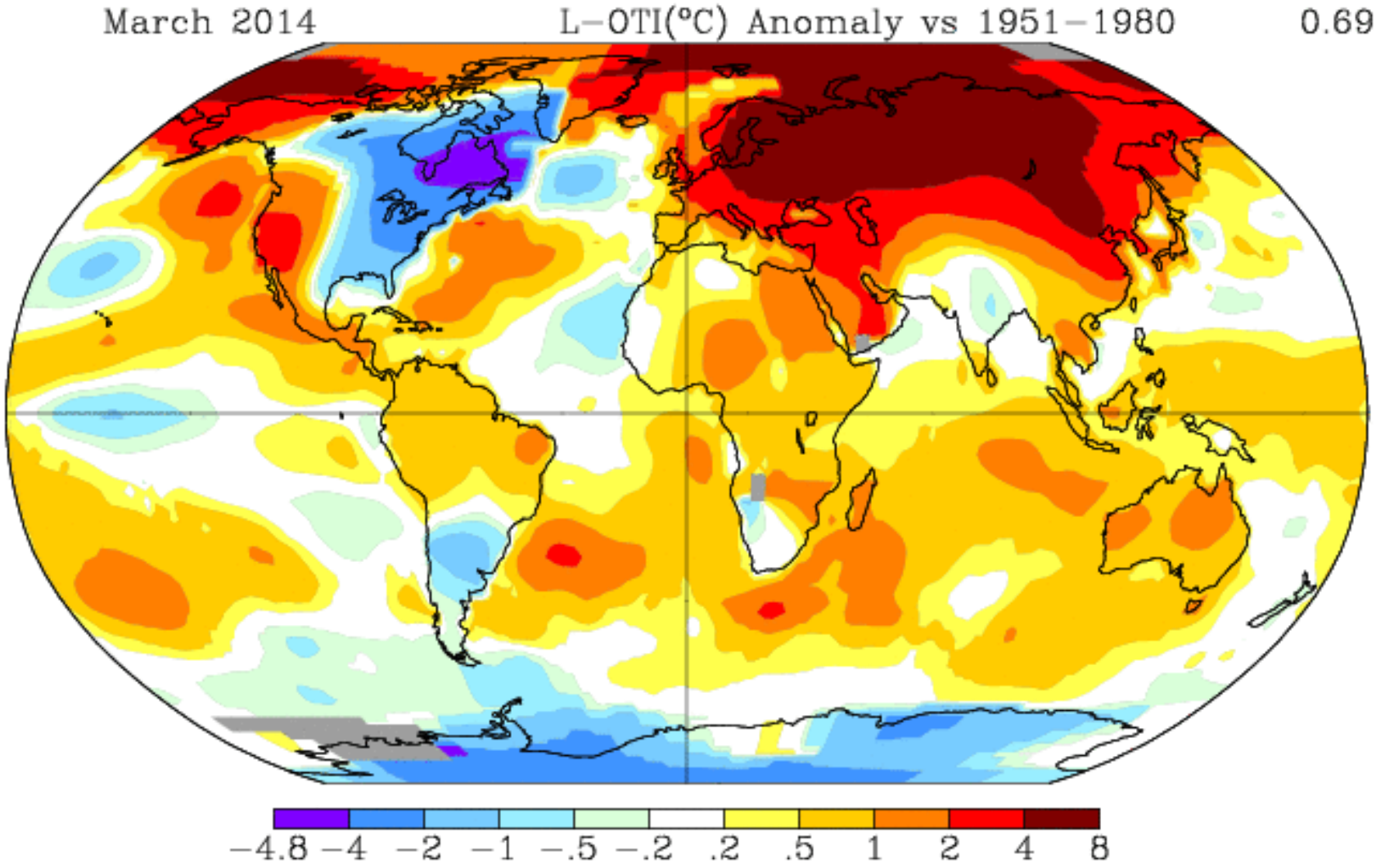


Extremes Larger in February - Pattern stationary Jan., Feb., March

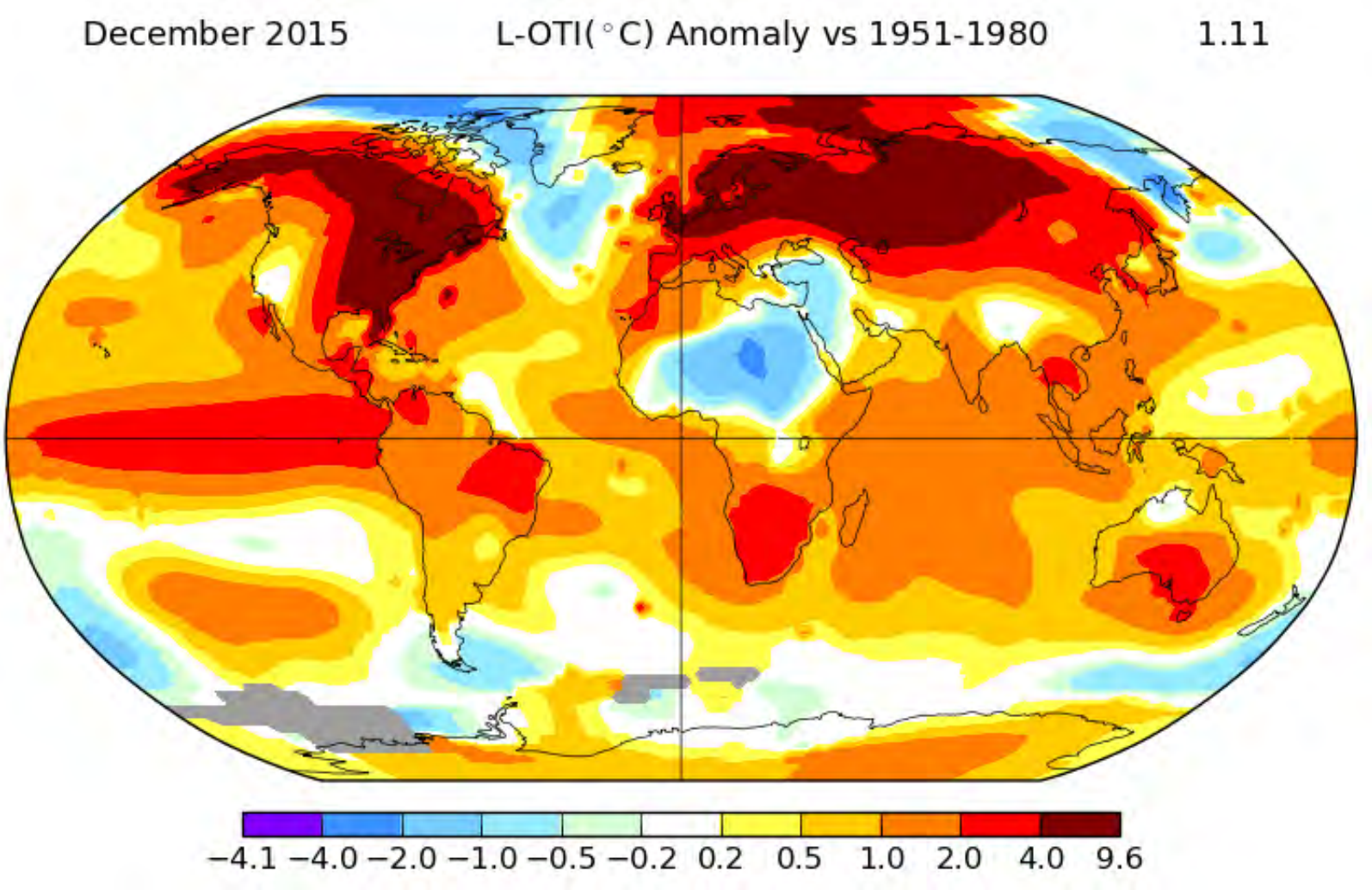


March similar

Pattern stationary for 3 months



2015-2016 very different!



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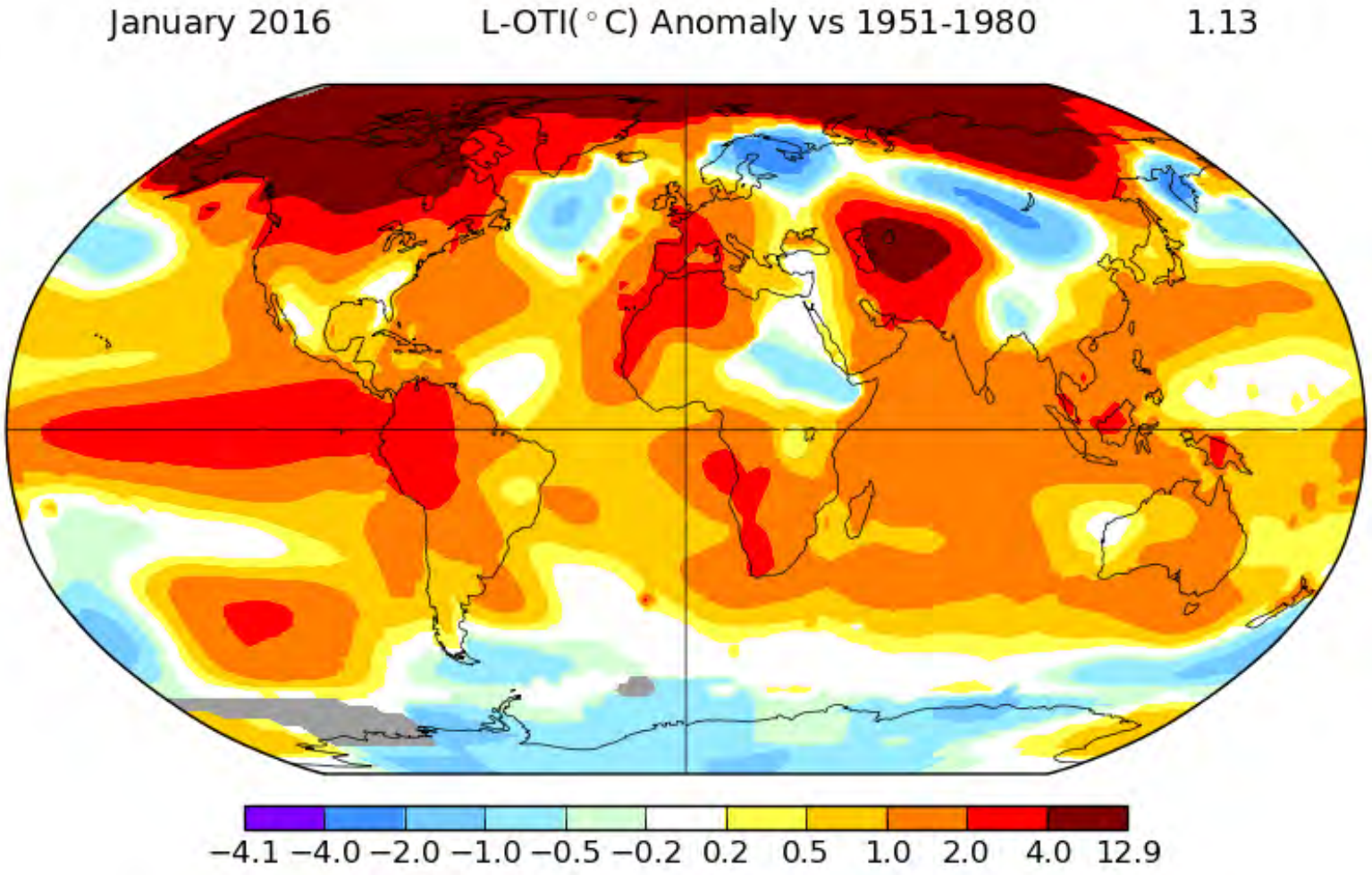
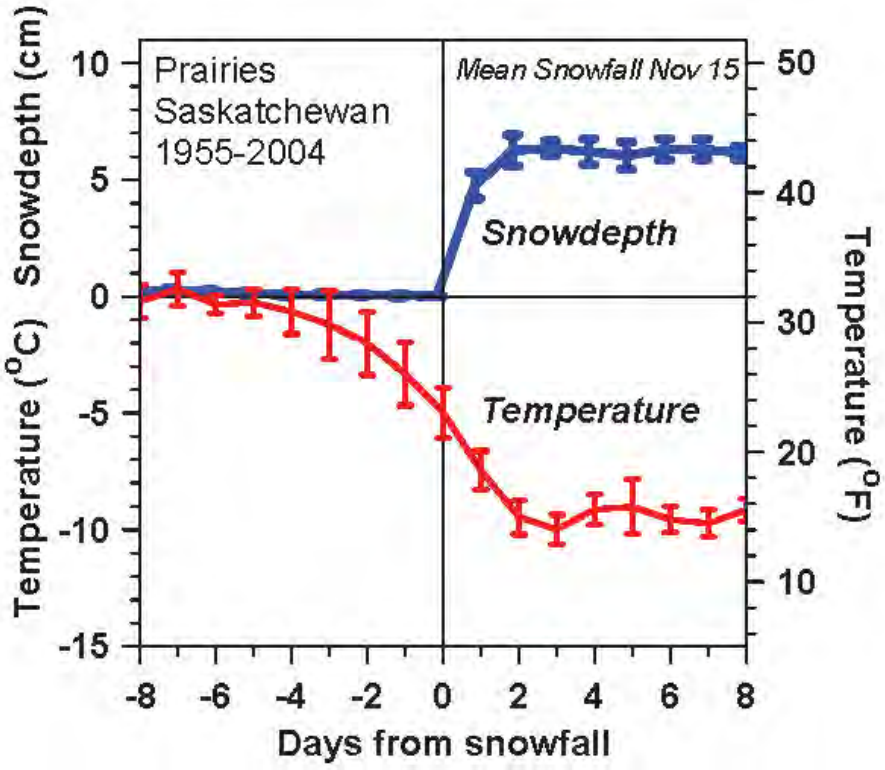
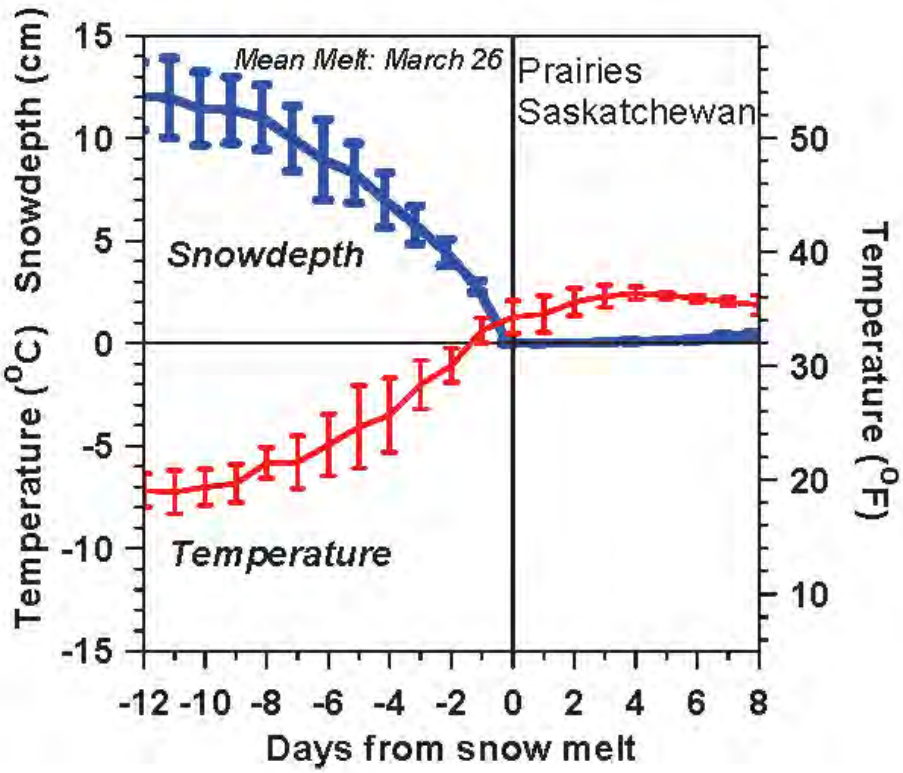


http://data.giss.nasa.gov/gistemp/maps/

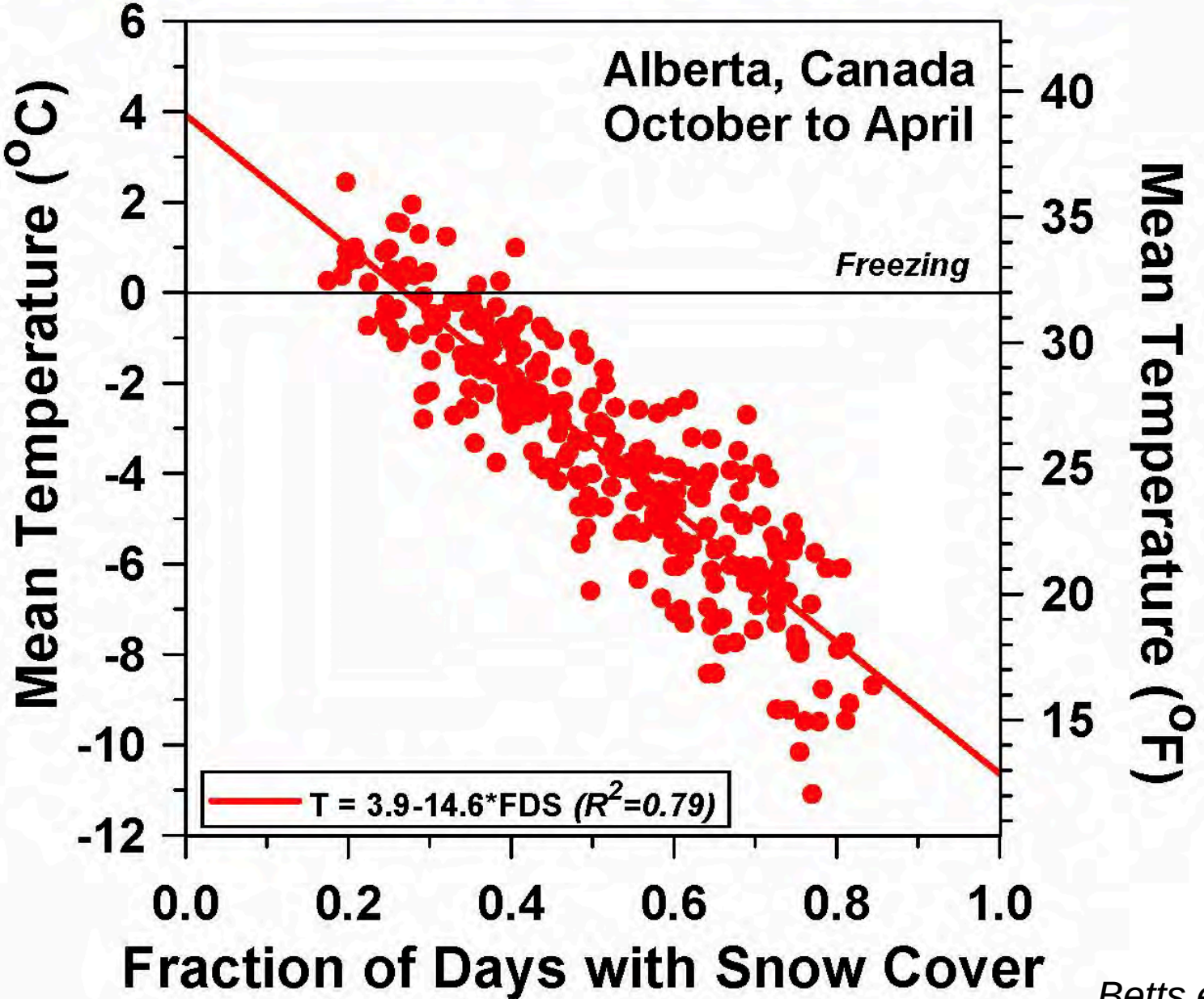
Snowfall and Snowmelt





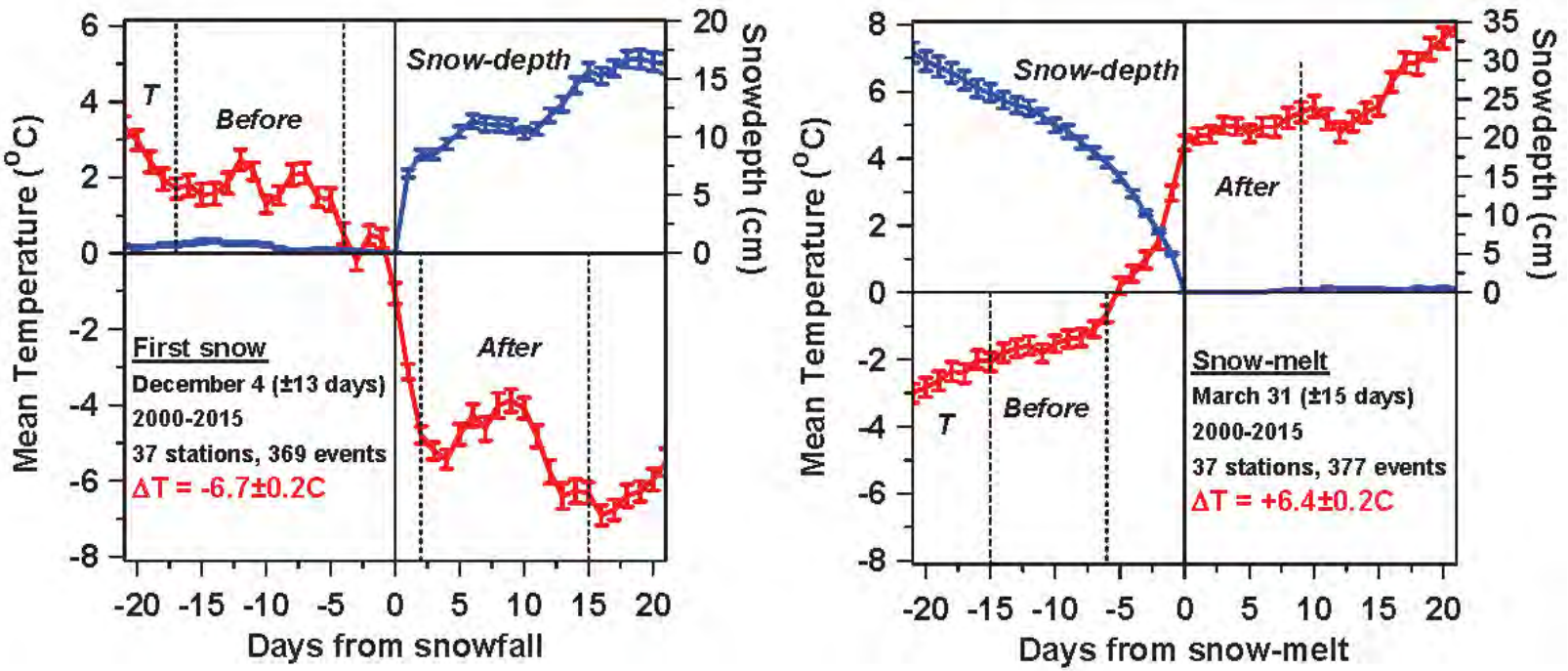
- **Temperature falls 18F (10C) with first snowfall**
- **Reverse change with snowmelt**
- ***Fast transitions in 'local climate'***
  - ***Snow reflects sunlight***
  - ***Reduces evaporation and water vapor greenhouse***

More snow cover - Colder temperatures



Betts et al. 2014

Snowfall and Snowmelt
ΔT Vermont



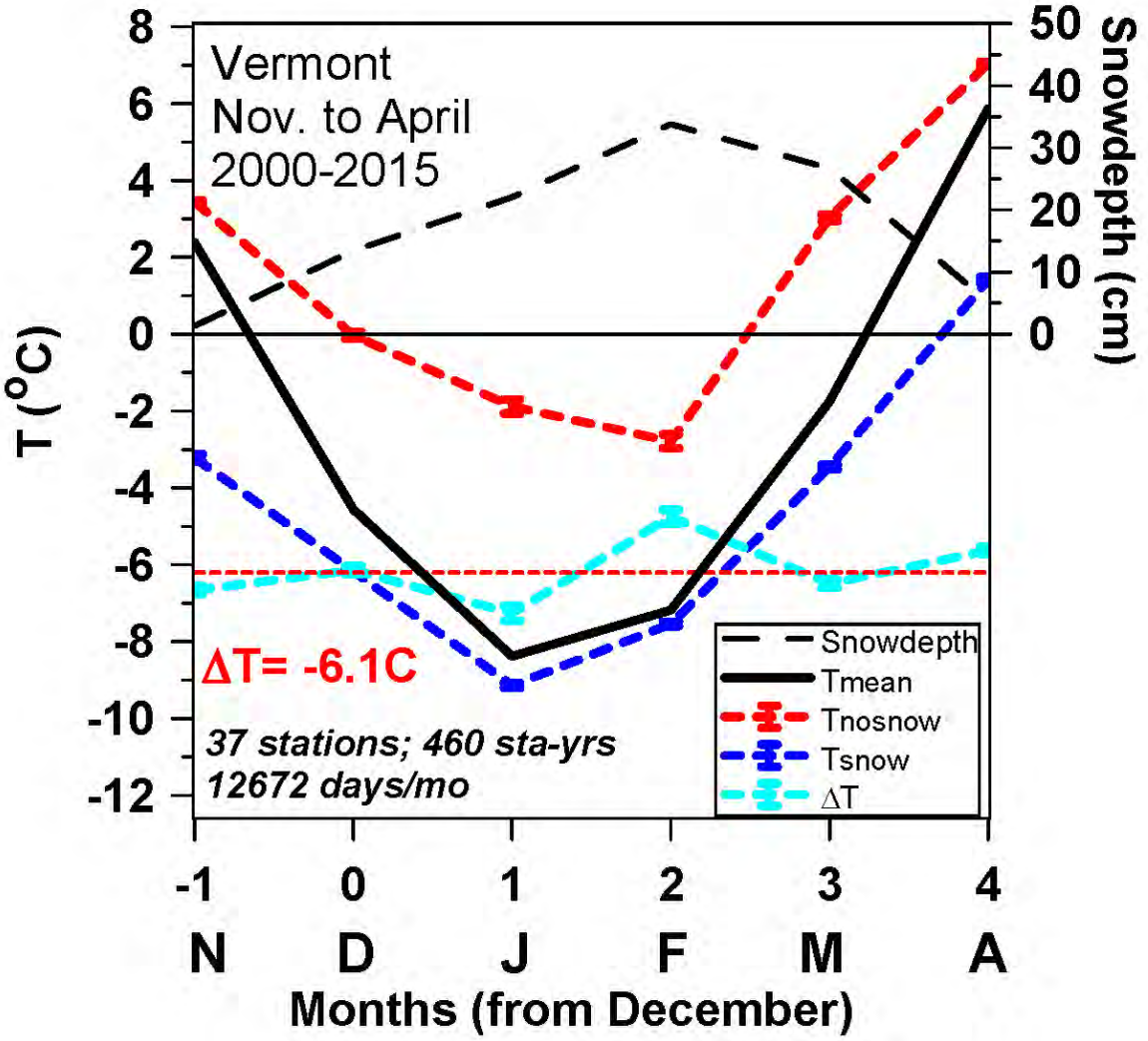
- **Temperature falls/rises 6.5 °C with first snowfall/snowmelt**
- **Albedo with snow less than Prairies**

Climatological Impact of Snow: Vermont

Separate mean climatology into days with no-snow and with snow

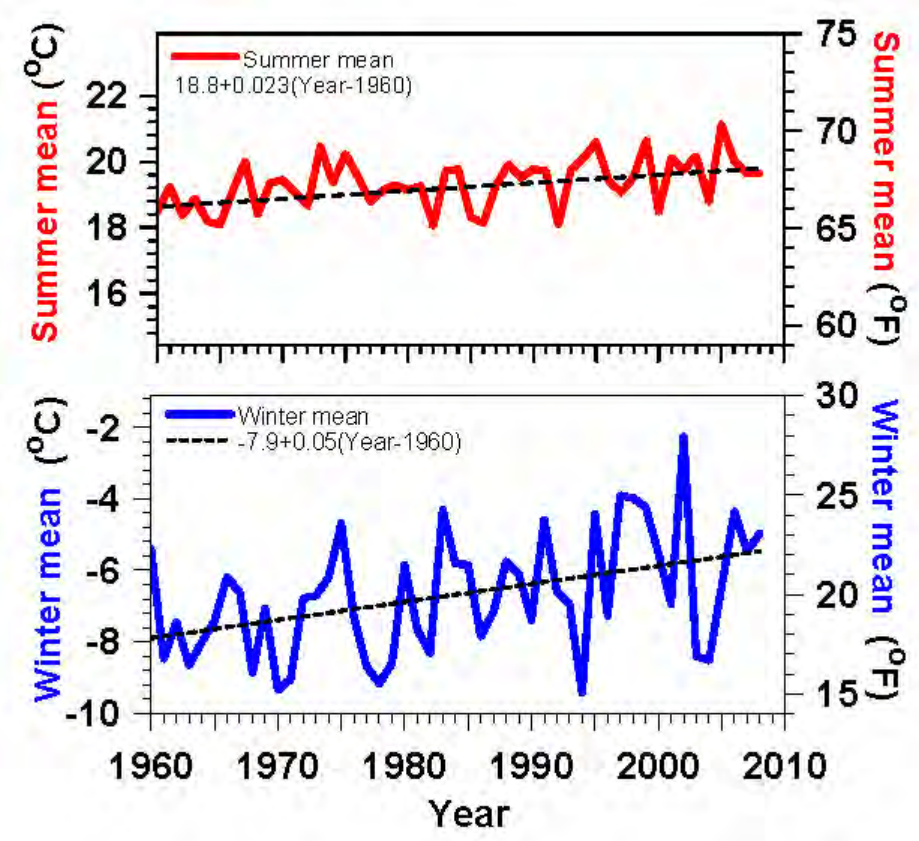
Difference ΔT= -6.1(±0.7)°C

= -11 (±1.3)°F



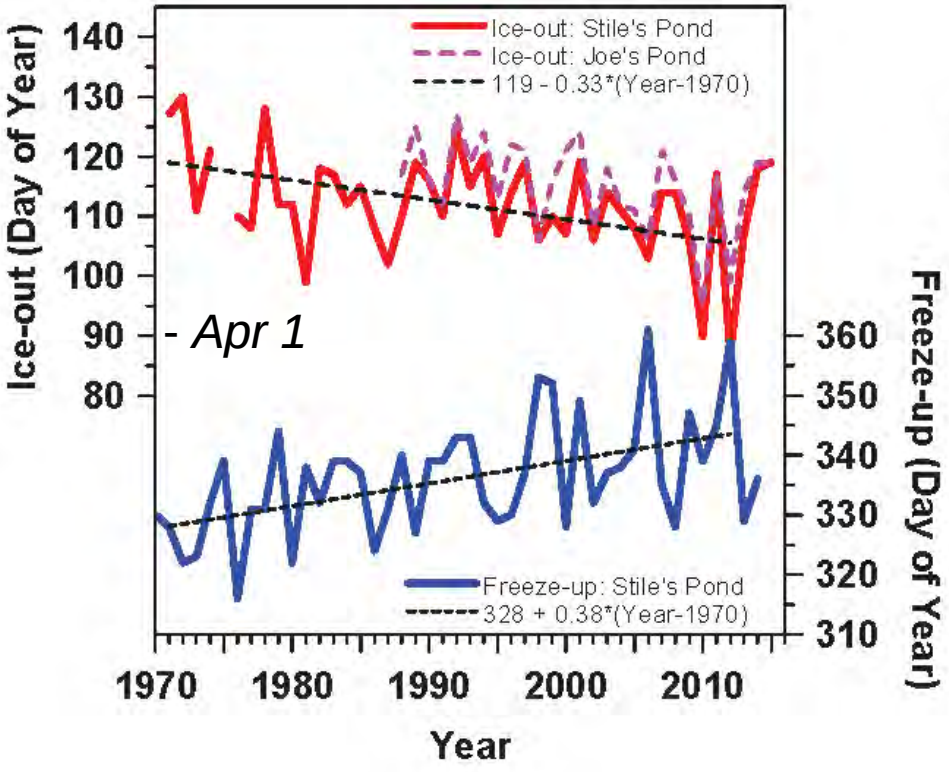
Vermont Temperature Trends 1961-2008

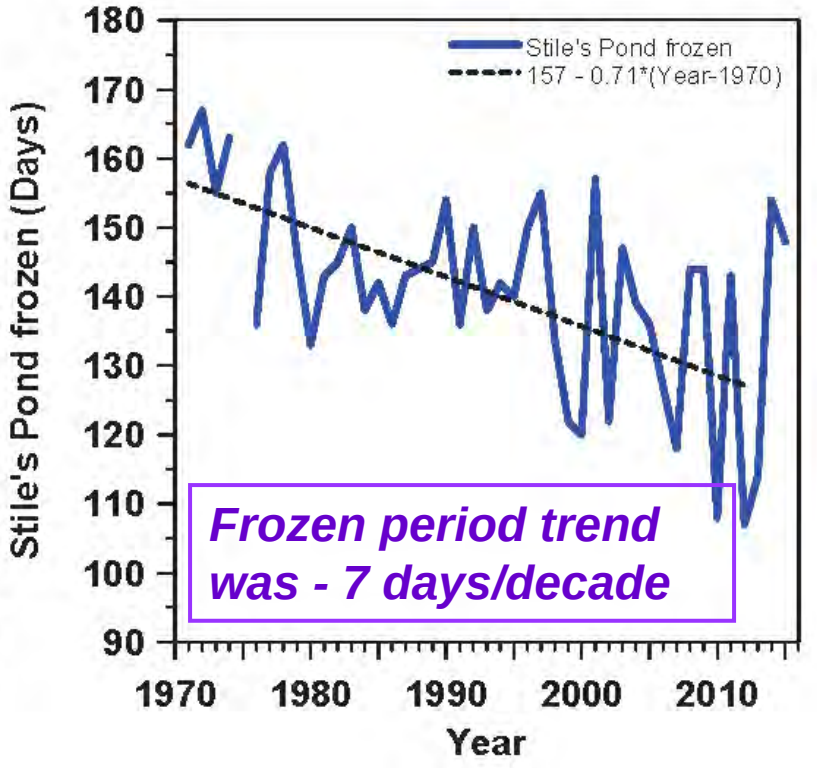
- **Summer +0.4°F / decade**
- **Winter +0.9°F / decade**
- **Larger variability, larger trend**
- ***Less snow (and increased water vapor) drive larger winter warming***



Lake Freeze-up & Ice-out Changing

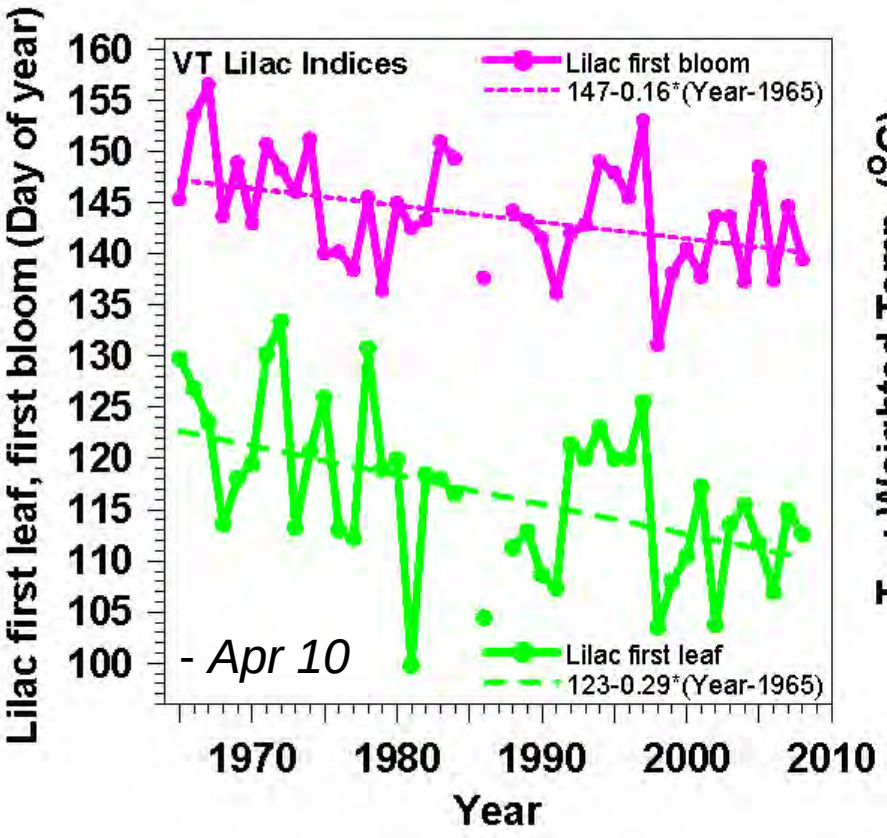
Frozen Period Shrinking: variability large

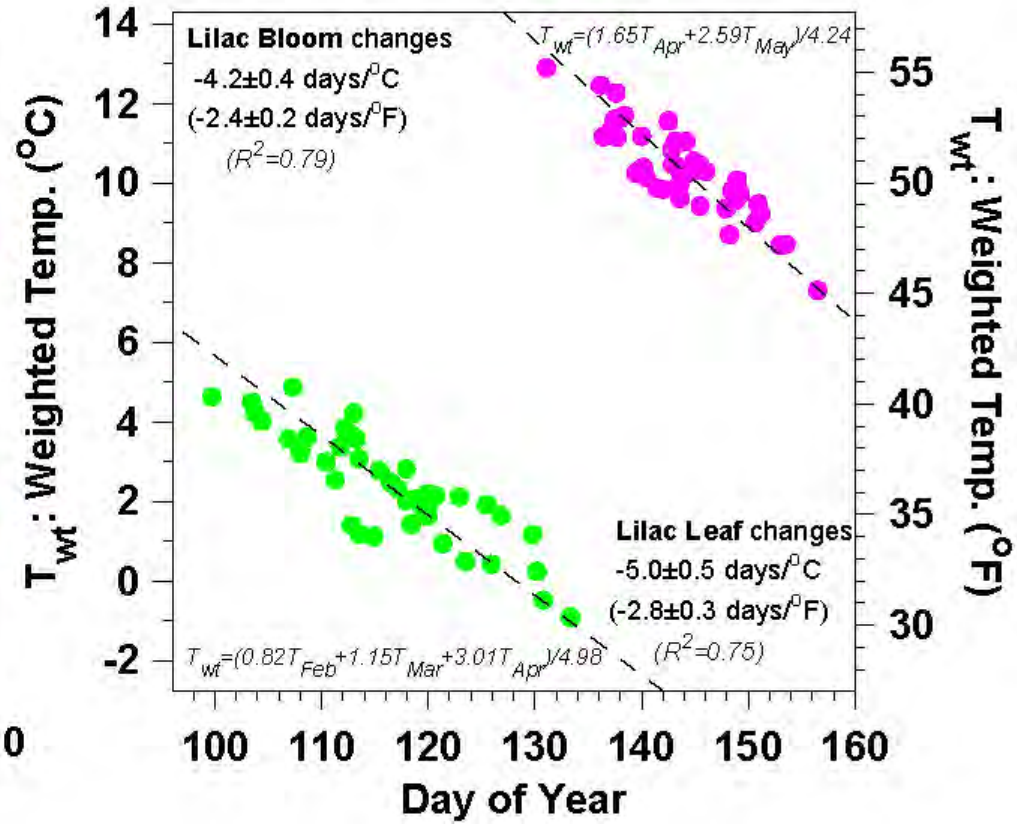




- Trend lines to 2012: 2013, 2014 'cold'
- Ice-out earlier by 3 days / decade
- Freeze-up later by 4 days / decade

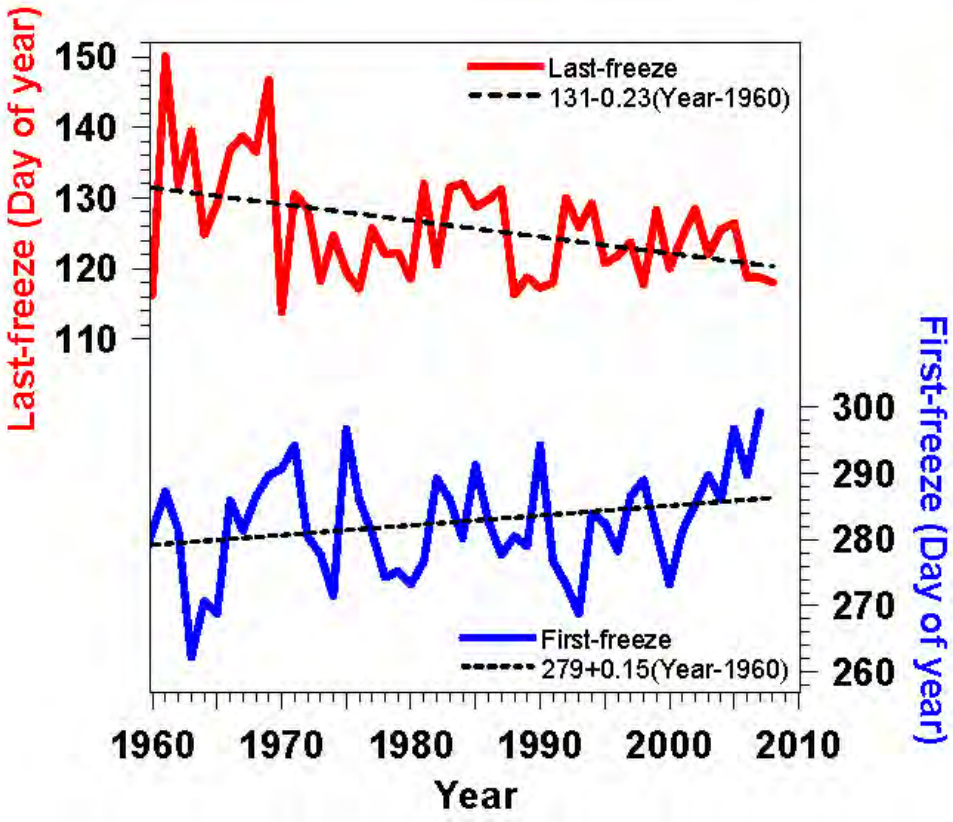
Lilac Leaf and Bloom

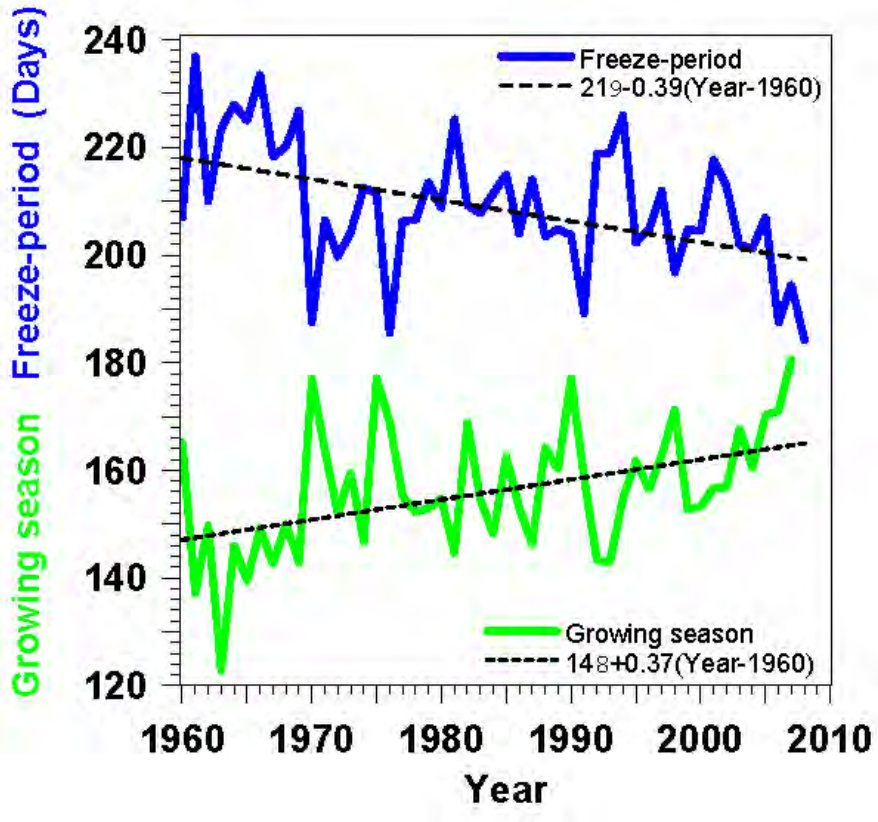




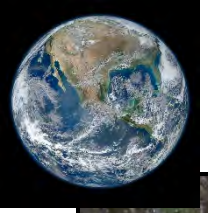
- **Leaf-out -2.9 days/decade; Bloom -1.6 days/decade**
- **Large year-to-year variation related to temperature: 2 to 3 days/ °F**

First and Last Frosts Changing





- **Growing season for frost-sensitive plants increasing 3.7 days / decade**
- **A help for growing "local food"**



January 2, 2012

March 11, 2012

October 2011– March 2012

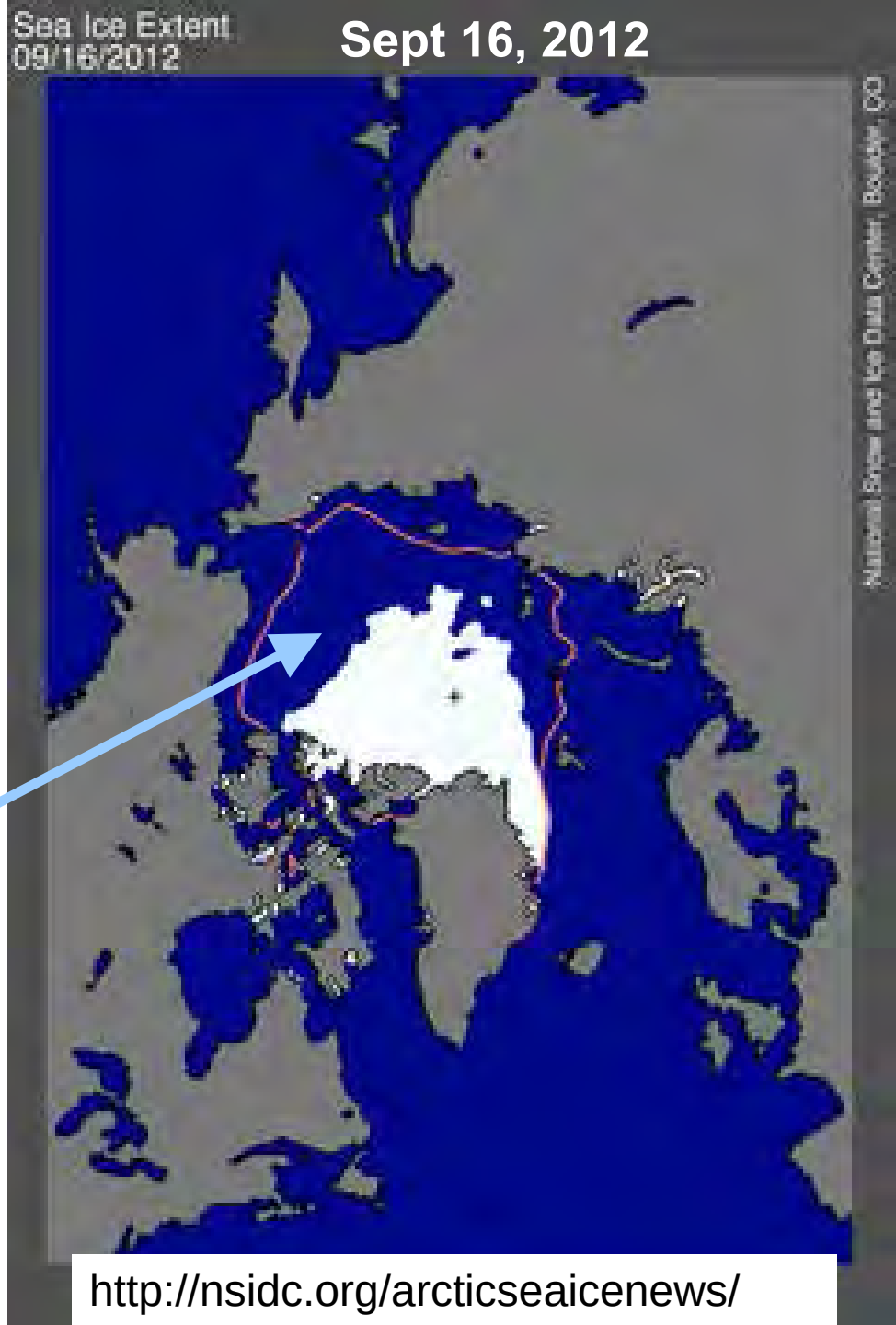
- **Warmest 6 months on record**
- **My garden frozen only 67 days**

- **January 15, 2013**

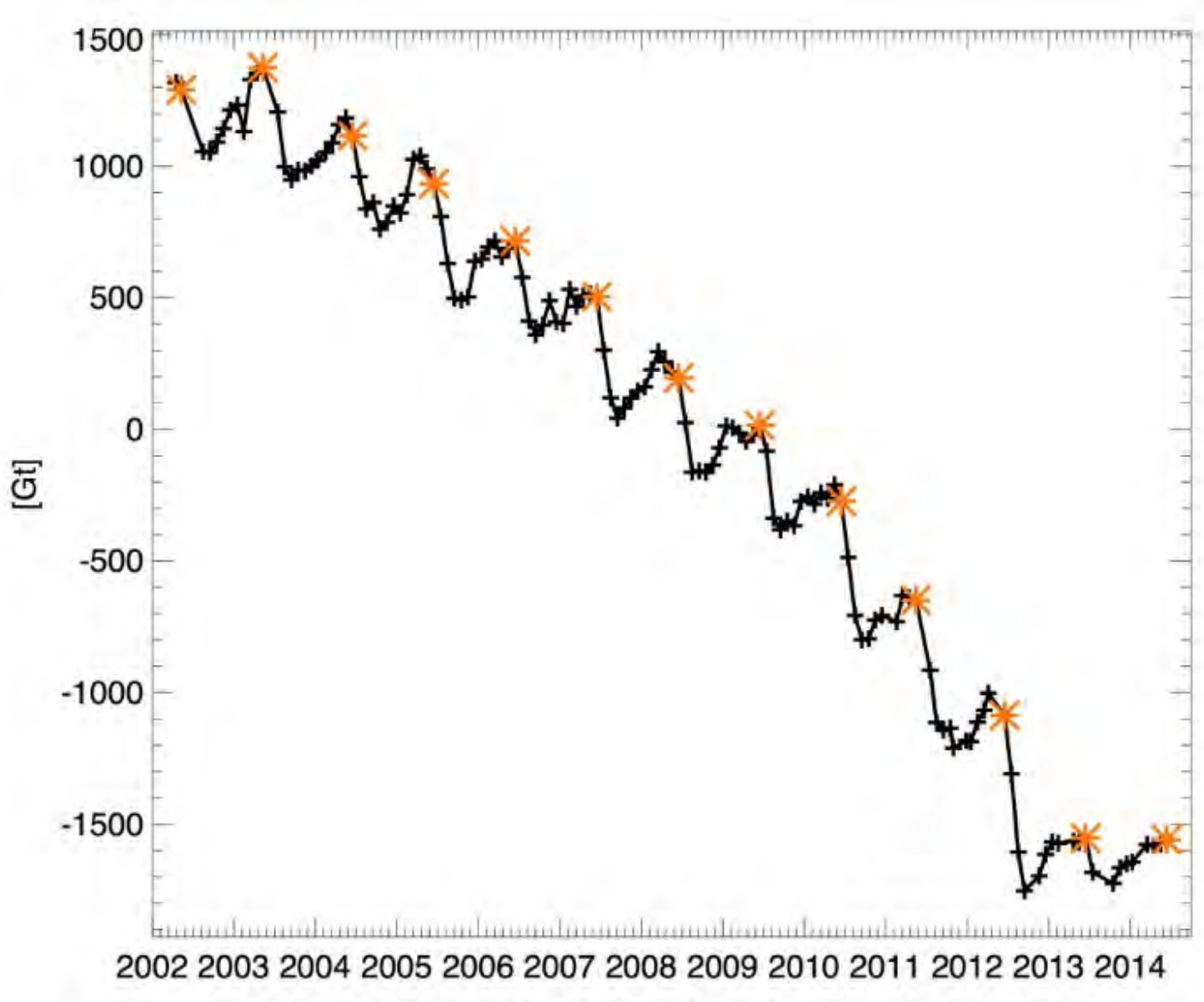
February 5, 2016
(Digging in Feb. first time ever)

- **Half the Arctic Sea Ice Melted in 2012**
- **Open water in Oct. Nov. gives warmer Fall in Northeast**

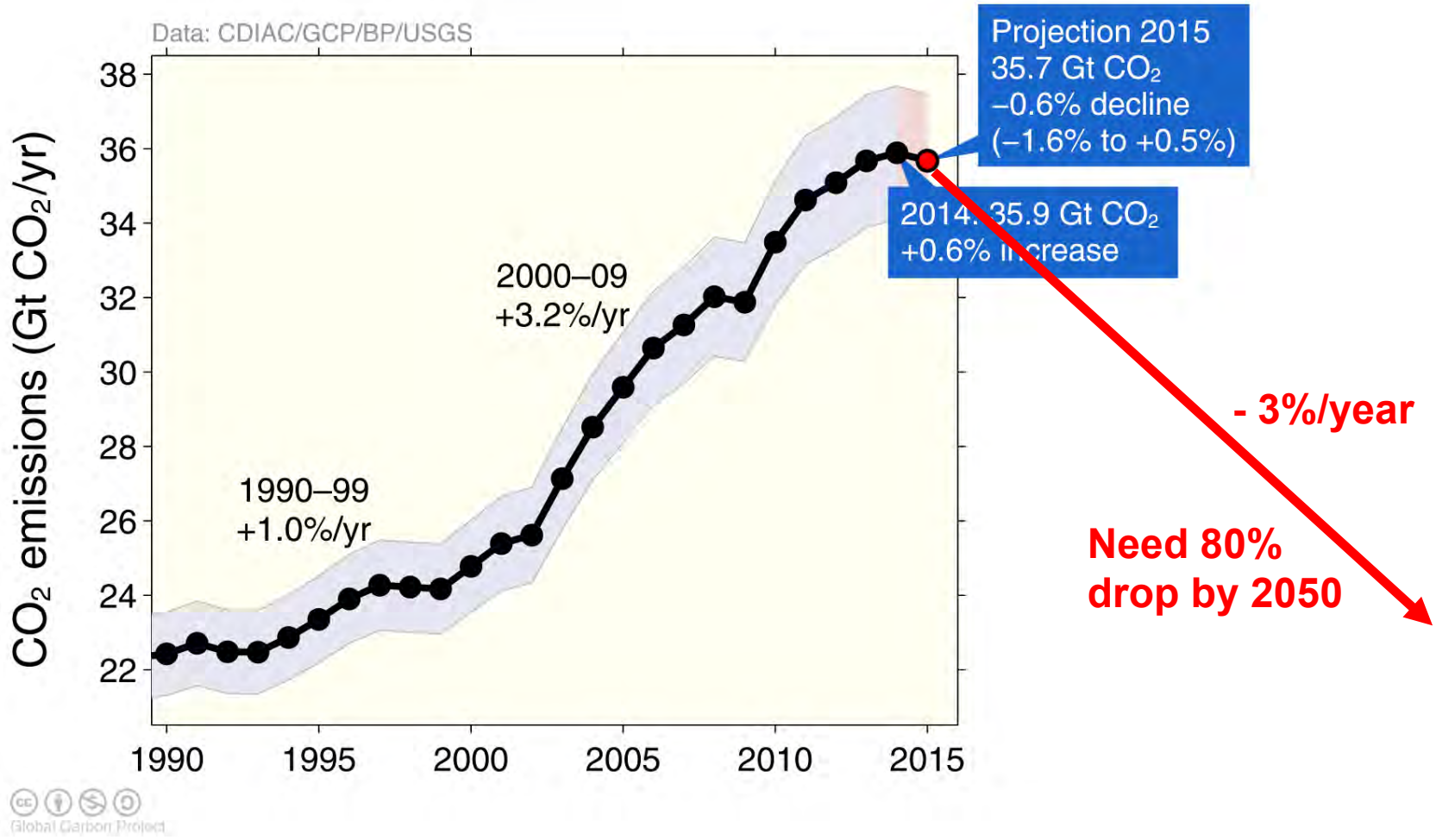
- ***Positive feedbacks:***
- ***Less ice, less reflection of sunlight***
- ***More evaporation, larger vapor greenhouse effect***
- ***Same feedbacks as in our winters***



Greenland Ice Loss



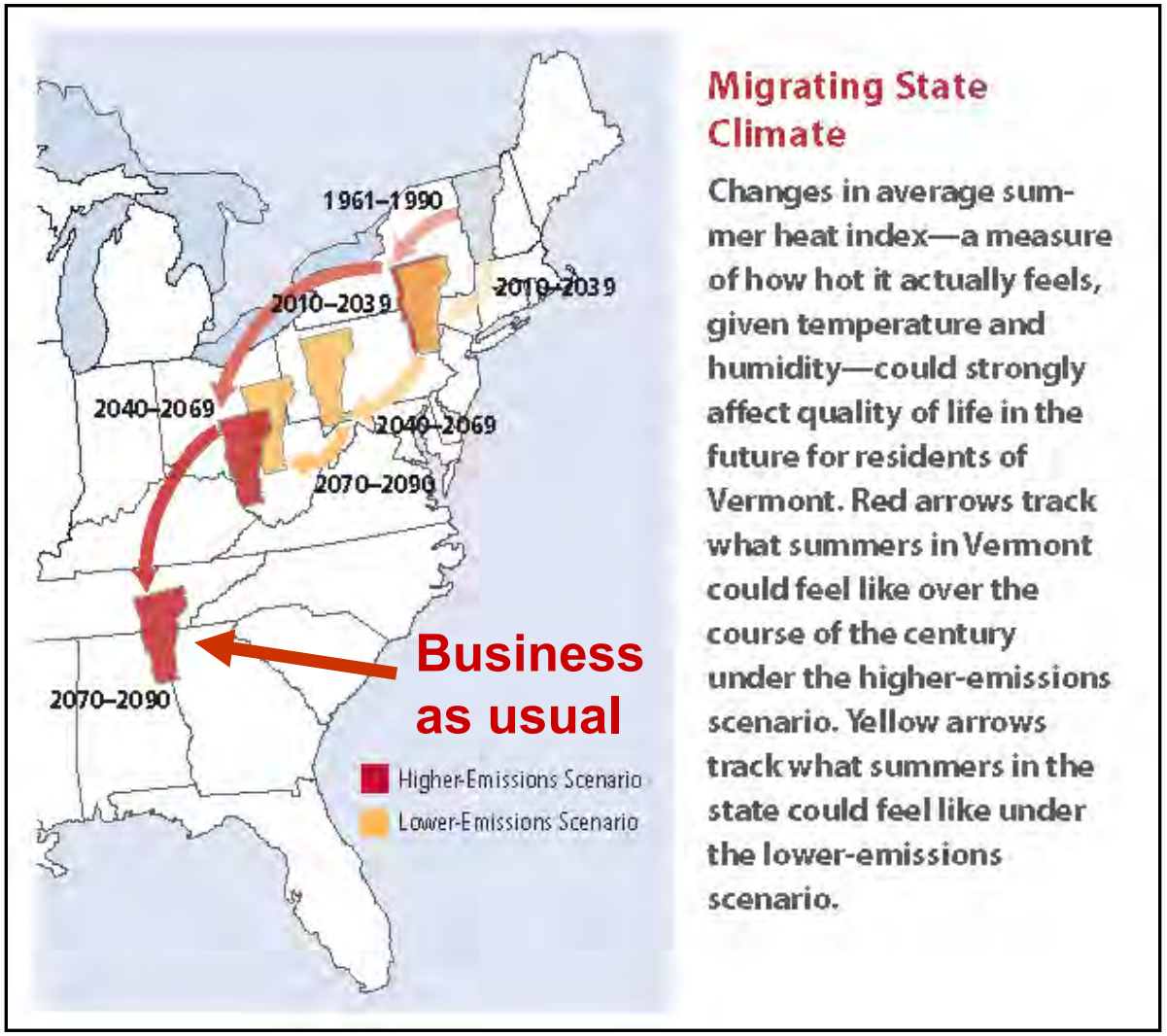
Growth of CO_2 Emissions Slowing?



Vermont's Future with High and Low GHG Emissions

What about VT forests?

Sub-tropical drought areas moving into southern US

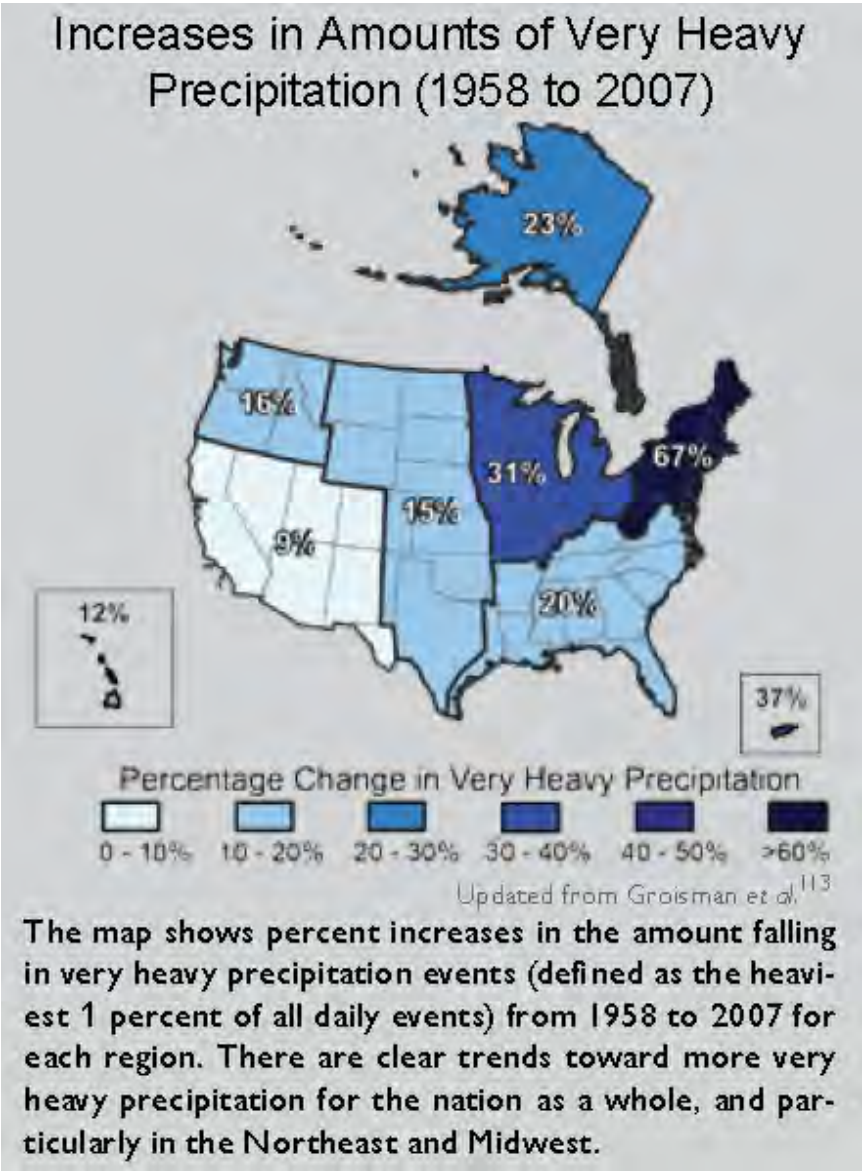


NECIA, 2007

Very Heavy Precipitation Is Increasing

(USGCRP, 2009)

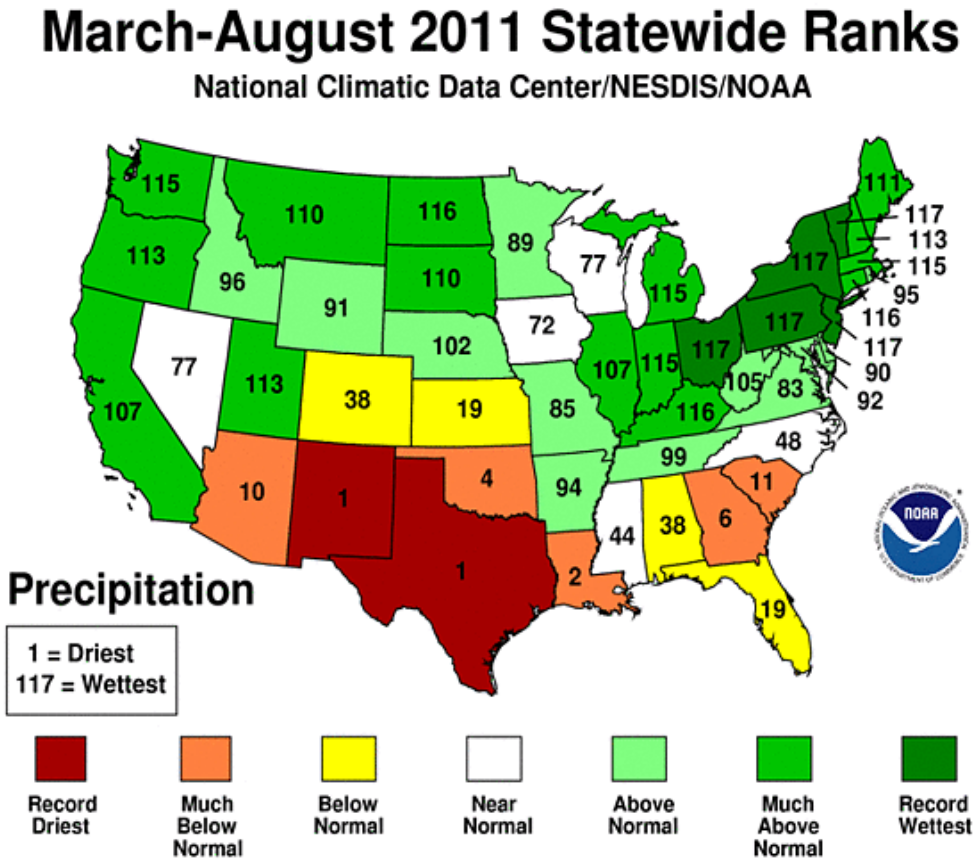
- **Precipitation Extremes**
- **Most of the observed precipitation increase during the last 50 years has come from the increasing frequency and intensity of heavy downpours.**
- **67% increase in Northeast**



The map shows percent increases in the amount falling in very heavy precipitation events (defined as the heaviest 1 percent of all daily events) from 1958 to 2007 for each region. There are clear trends toward more very heavy precipitation for the nation as a whole, and particularly in the Northeast and Midwest.

2011 Floods: VT and NY

- **Record spring flood: Lake Champlain**
- **Record flood with tropical storm Irene**

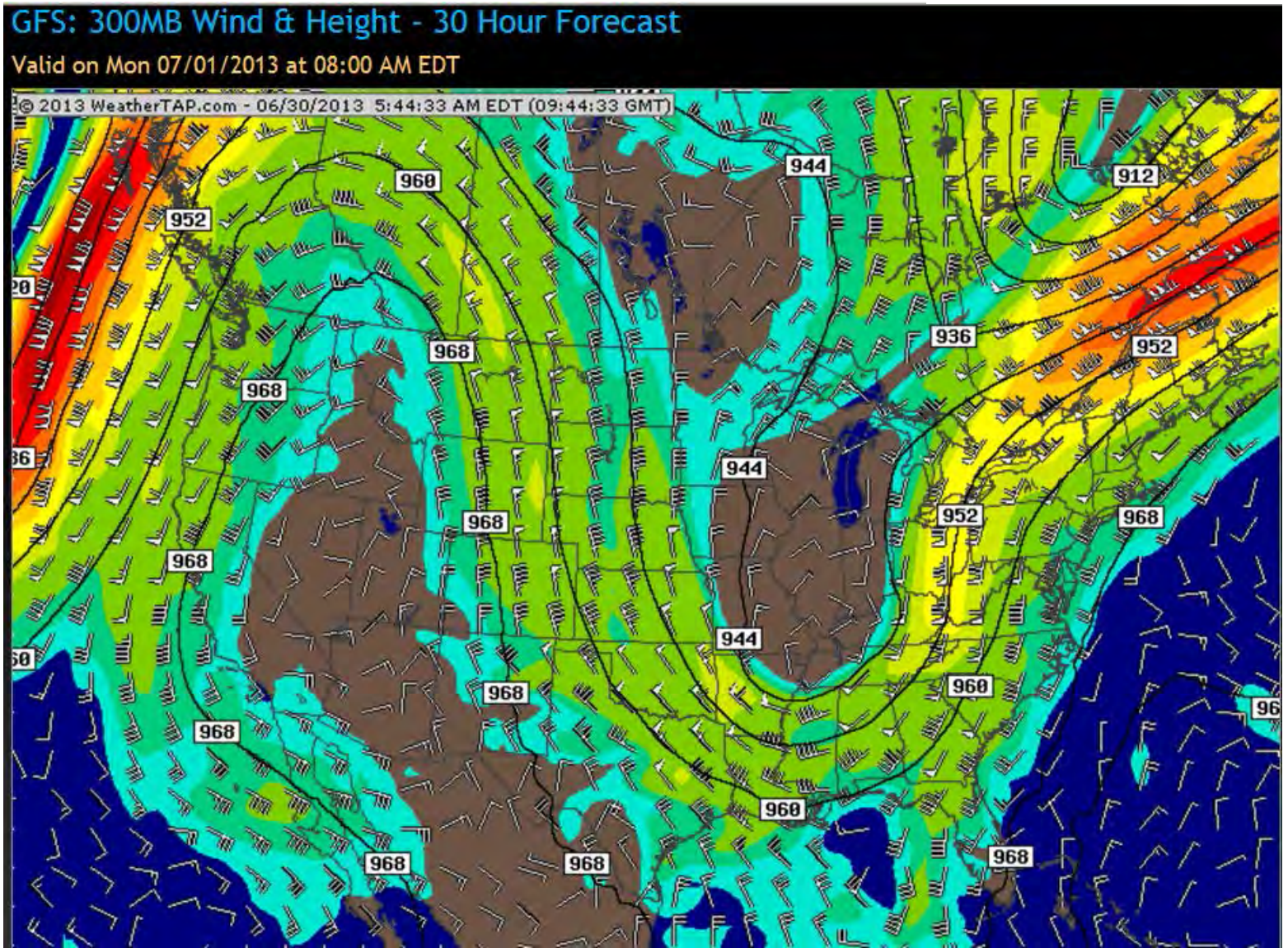


March-August, 2011

- **Record wet : OH to VT**
- **Record drought: TX & NM**
- **'Quasi-stationary' pattern**

Jet Stream Patterns Slowing Down and Amplifying, Giving More Extreme Weather

(Francis and Vavrus, 2012)



Global Climate Change

- **One of the many great challenges for the 21st century - present path is unsustainable**
- **Known about it for 35 years:**
  - *First National Academy of Science Report in 1979*
- **Earth science conflicts with political values (and vested interests in fossil fuel economy)**
- **It is a global issue and local issue**

Rise of Greenhouse Gases (GHG) Shift Energy Balance of Planet

- **The atmosphere is transparent to light from the sun, but not to infrared radiation from the earth**
- **GHG: H_2O, CO_2, CH_4, O_3, CFCs trap the infrared from the surface, giving climate suitable for life by warming planet 60°F**
- **Rise of CO_2 alone has only a small warming effect**

BUT…

Water, Snow & Ice Give Positive Radiative Feedbacks

- As Earth warms, evaporation and water vapor increase and this is 3X amplifier on CO_2 rise
- As Earth warms, snow & ice decrease and reduced SW reflection amplifies warming in Arctic in summer and mid-latitudes in winter
- Doubling CO_2 will warm globe about 5°F (3°C)
  - Much more in the cold regions and over land, which responds faster than oceans

Efficiency Comes First

- **We need to double or triple our energy efficiency because…**
  - **We cannot replace current fossil fuel use with biofuels & renewable energy**
  - **Oil and gas reserves are limited, but coal, shale-gas & shale-oil reserves are sufficient to push CO_2 to 1,000 ppm—and in time melt icecaps**
    - **Need to leave 1/3 oil; 1/2 gas; 4/5 coal in ground**

Why Is It Difficult for Us?

- **Fossil fuels reserves are worth $20-30T**
  - **Regulating emissions of CO_2 is an "unfair cost" to the "free market"**
  - **Carbon tax needed to change economics**
- **Politics lost in fantasy and deceipt**
  - **Ignoring Earth system and climate issues**
  - **Ignoring future costs**
    - **Manhattan within 1-ft of flooding with Irene**
    - **Did they put waterproof doors on tunnels? No**

Why Is It Difficult for Us?

- The "American dream" is crumbling
  - "Economic growth" based on fossil fuels, debt, and consumerism is unsustainable
  - Global market capitalism is disaster for the planet
- Individual "rights" and the needs of humanity must be balanced against the needs of the earth's ecosystem
- We don't know how to guide and manage technology —so the result is tremendous successes and catastrophic failures

Broad Guidelines or Rules to Minimize Impacts

- **Minimize the lifetime of human waste products in the Earth system and eliminate waste with critical biosphere interactions**

- **Minimize the use of non-renewable raw materials, and**
- **Maximize recycling and re-manufacturing**

- **Maximize the efficiency with which our society uses energy and fresh water, and**
- **Maximize the use of renewable resources**

Change of Attitude Needed?

- **Do we just exploit the Earth's wealth**
  - **For greater 'economic growth'**
  - **For a wealthy few**
  - **What is left for our children?**
  - **What happens to the ecosystems we depend on?**
- **Moral Issue**
  - **Don't we need to co-operate with the Earth?**
  - **Shift in understanding and mind-set needed**

What Do We Need?

- So we need honest, truthful, smart pathways forward
  - That will not frighten people into paralysis
  - That will spread hope, not anger or despair
  - That sidestep ideological barriers with new language
  - That develop adaptive governance
    - The US Constitution gives no rights to the Earth
  - That respect Earth system limits
  - That accept our moral responsibilities

The Future Is Not Our Past

- **Collectively, we create the future, so we need to plan for a transition to a sustainable society**
- **In the face of a powerful economic and financial system driven by short-term profit**
- **Needs deep community discussion**
  - ***New values that respect the Earth***

2015 was Transition Year

- Climate meeting in Paris in December
  - 196 nations made commitments to cut emissions
  - Need follow-through!
- **Pope Francis issued the first Papal Encyclical on the environment, climate change and our responsibilities to the Earth**
  - **Shifts the position of the Catholic church**
  - **Protestant traditions will follow his lead**
  - **Shift from short-term profit as primary motive**
- ***New values that respect the Earth***

Discussion

- **This talk http://alanbetts.com/talks**
- **Rutland Herald articles at**

  http://alanbetts.com/writings
- **Interesting papers at**

  http://alanbetts.com/research

  – ***Vermont Climate Change Indicators***

  – ***Seasonal Climate Transitions in New England***

UsefulTechnology

30 mph Danish electric tricycle:

with 150 mile range