

The Climate Challenge Deepens:

Alan K. Betts

Atmospheric Research

Pittsford, VT

<http://alanbetts.com>

Climate Café: 6pm

Brattleboro, VT

May 23, 2017



Outline of this talk

- *Research on “winter”*
- **What is happening to**
 - Global climate
 - Climate of Vermont
- **Broader issues**
 - System issues
 - Strategies, Responsibilities
 - Issues far beyond science



Fundamentals

- ***Burning fossil fuels: transforming climate***
 - *Many water cycle amplifying feedbacks*
 - *Heading for high CO₂ “Carboniferous era climate”*
 - *Climate extremes increasing*
 - *Decadal to centennial - long timescales*
- **Avoidance of responsibility for decades**
 - Politicians, professionals, public
 - Climate change: Incompatible with business-as-usual
- **Linked to unmanaged technology**
 - Soluble by changing system guidelines
 - Create efficient society, based on renewable energy
- **Choices are value based**
 - Science and economics need guiding
 - Resilience incompatible with exploitative model

System Issues

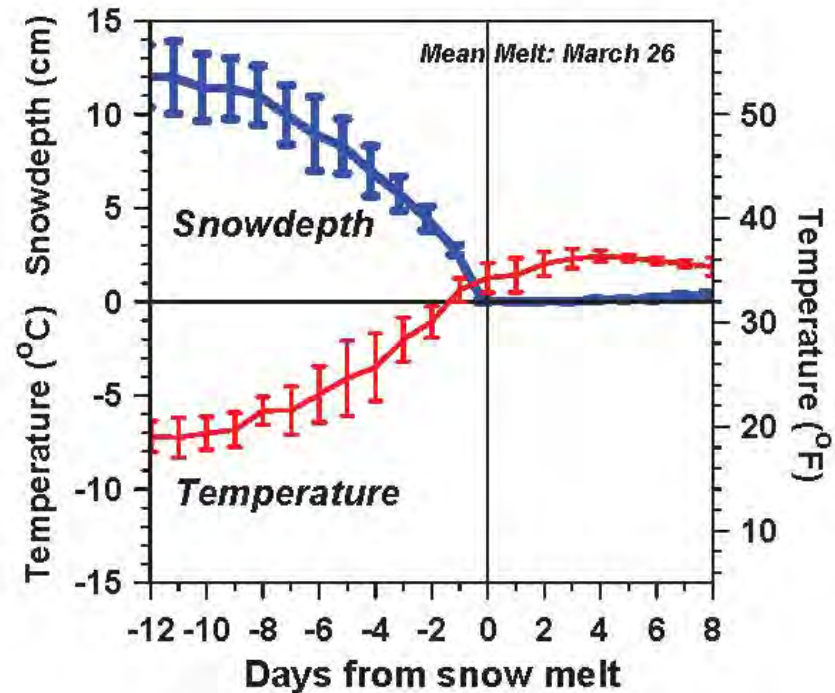
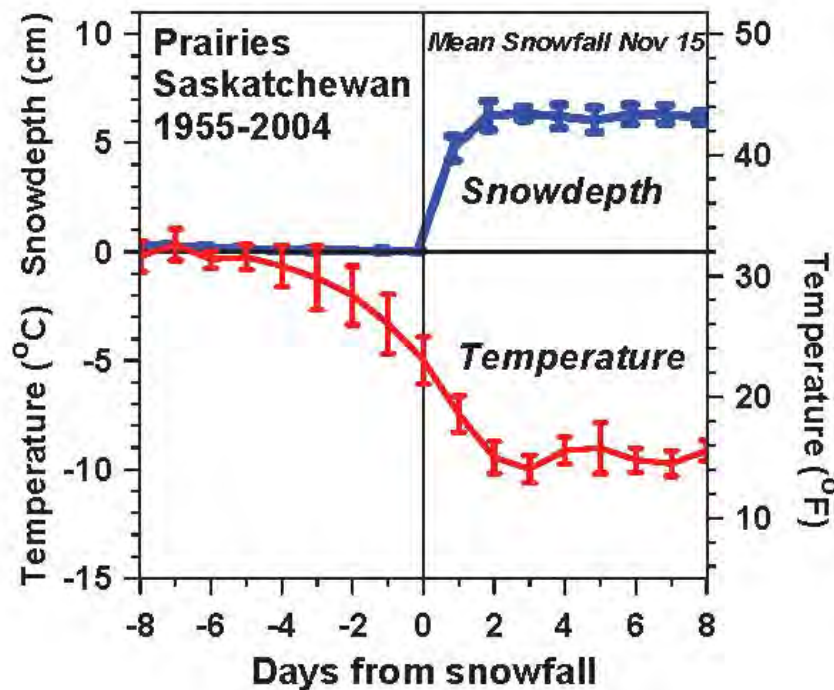
- **Human waste streams are transforming the Earth's climate, and human and natural ecosystems**
- **How will this affect landscape, water supplies, food system and human health?**
- **Strategies and mindset needed to mitigate, adapt and build resilience in Vermont?**
 - **Can we better manage our relation to the Earth?**
 - **Is this an efficient way of doing this?**
 - **Can we manage our waste streams better?**
 - **How can we adapt?**

Our Present Challenge

- **How to reintegrate
all that we know and understand**
 - *given the deep interconnectedness
of life & climate on Earth*
 - *given immense opposition to change*

Snowfall and Snowmelt

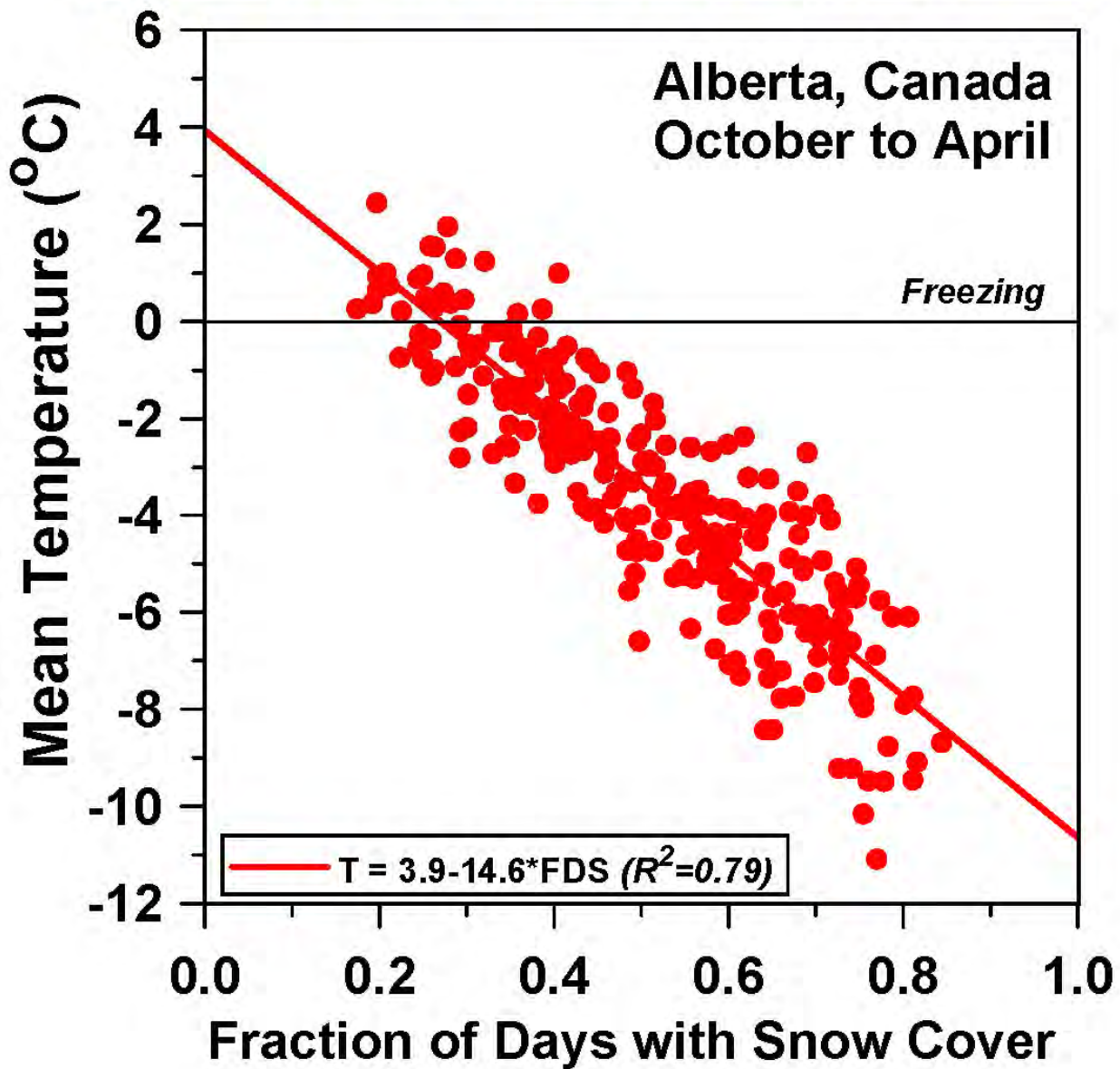
Winter and Spring transitions



- Temperature falls/rises about 18F with first snowfall/snowmelt
- **Snow reflects sunlight; shift to cold stable BL**
 - Local climate switch between warm and cold seasons
 - Winter comes fast with snow

(Betts et al. 2014a)

More snow cover - Colder temperatures



Winter is
colder if
more snow
cover

Impact of Snow

- **Distinct warm and cold season states**
- **Snow cover is the “climate switch”**

With snow

- **Prairies: Temperature falls 18°F**
 - snow reflects 70%
- **Vermont: Temperature falls 10°F**
 - snow reflects 35% (because more forest)

Warm and Cold Seasons



- **Clouds** - reflect sunlight
- **Less cloud** - Warm in afternoon

- **Snow** - reflects sunlight
- **Clouds:** reduce cooling at night
- **Less cloud:** very cold at sunrise

January 2, 2012: NASA

Earth's climate sustains life

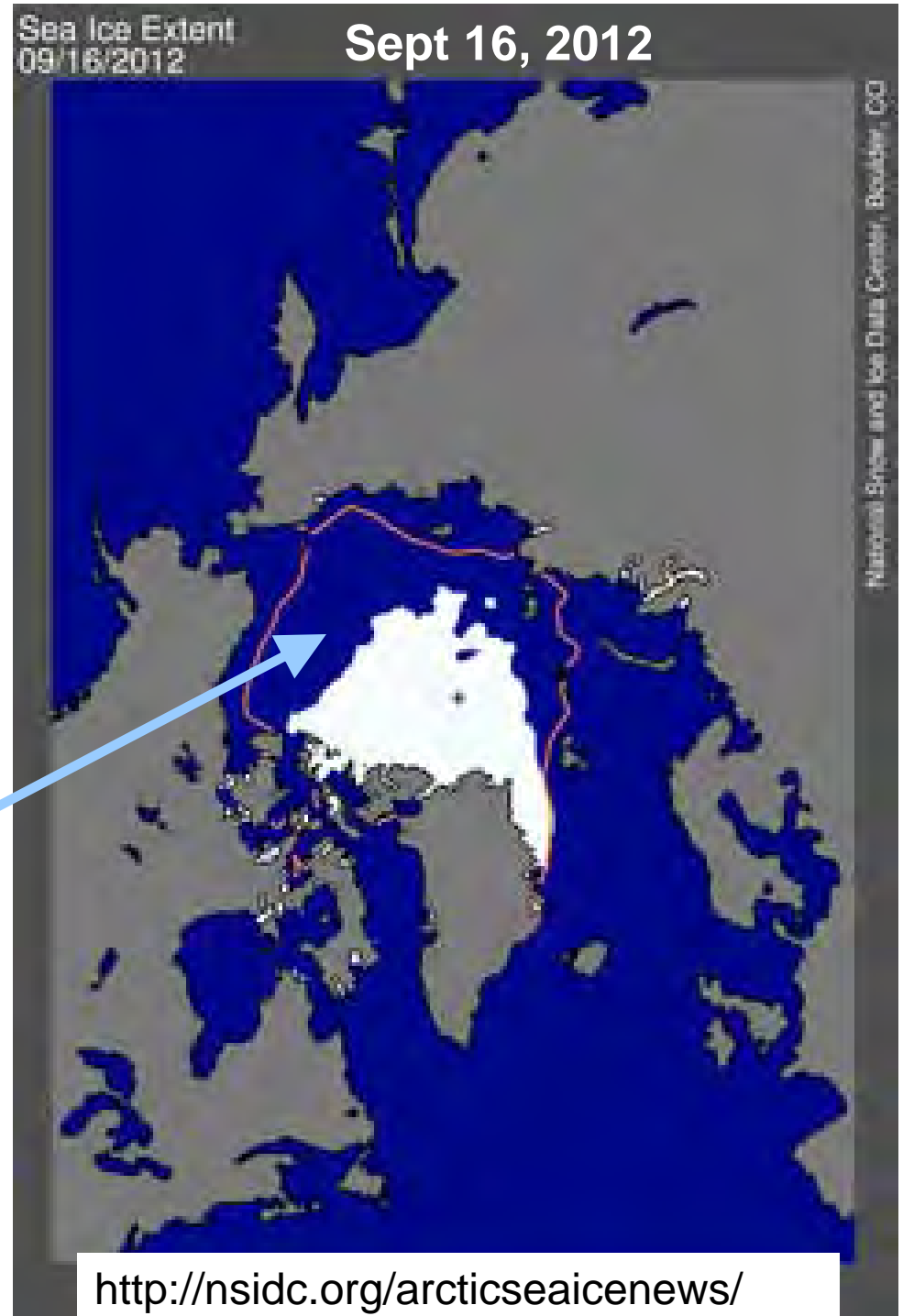
- Burning fossil fuels is increasing greenhouse gases
- **Climate is warming: ice is melting, extreme weather is increasing**
- Water plays crucial amplifying role
- Planetary modes crucial



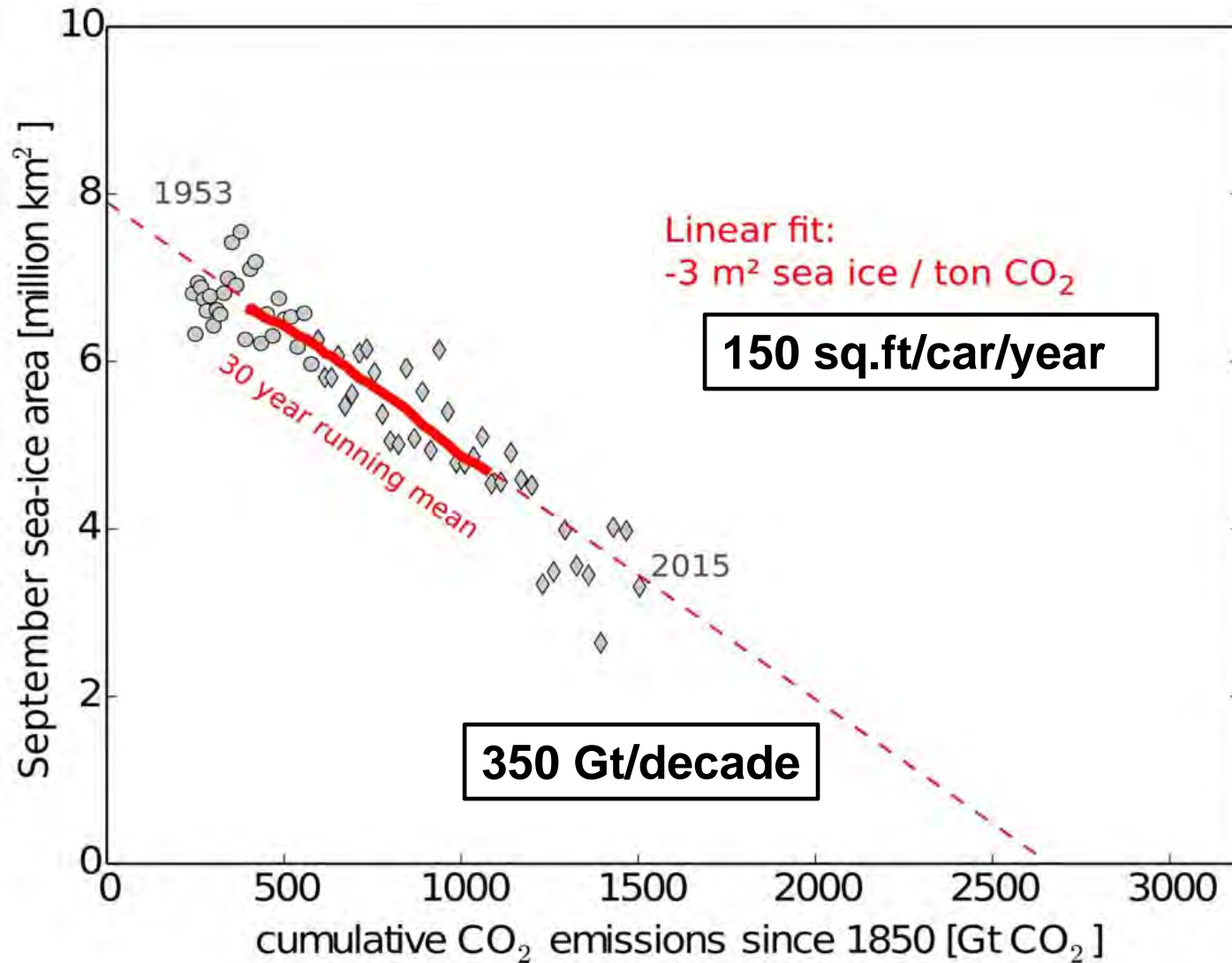
- **Half the Arctic Sea Ice Melted in 2012**
- **Open water in Oct. Nov. gives warmer Fall in Northeast**

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

(This past winter, Arctic sea-ice reached new record lows)



September Arctic Sea Ice Loss



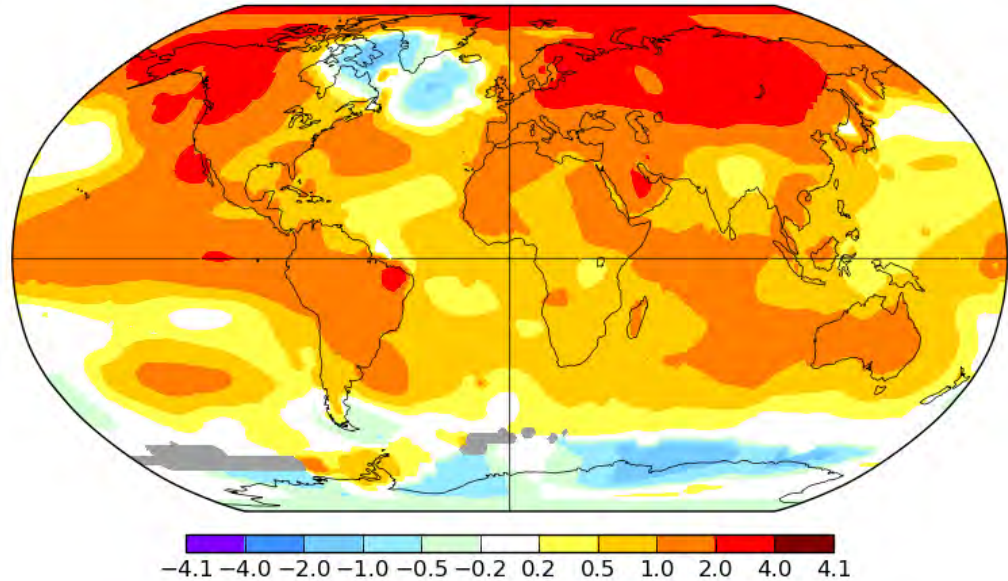
J. Stroeve/National Snow and Ice Data Center

2015
1.5F warmer

Annual J-D 2015

L-OTI (°C) Anomaly vs 1951-1980

0.85

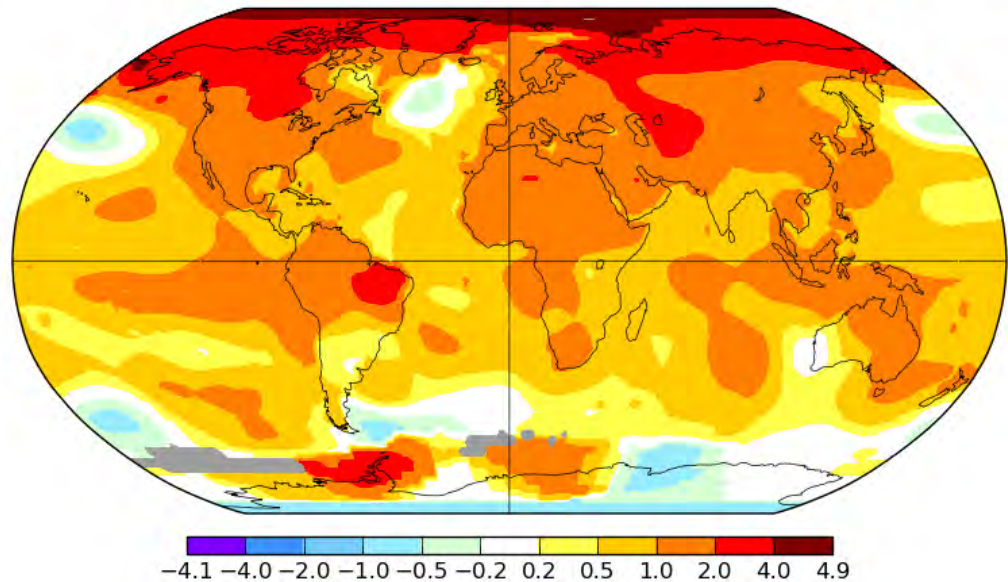


2016
1.8F warmer
(Arctic ice lowest ever in winter)

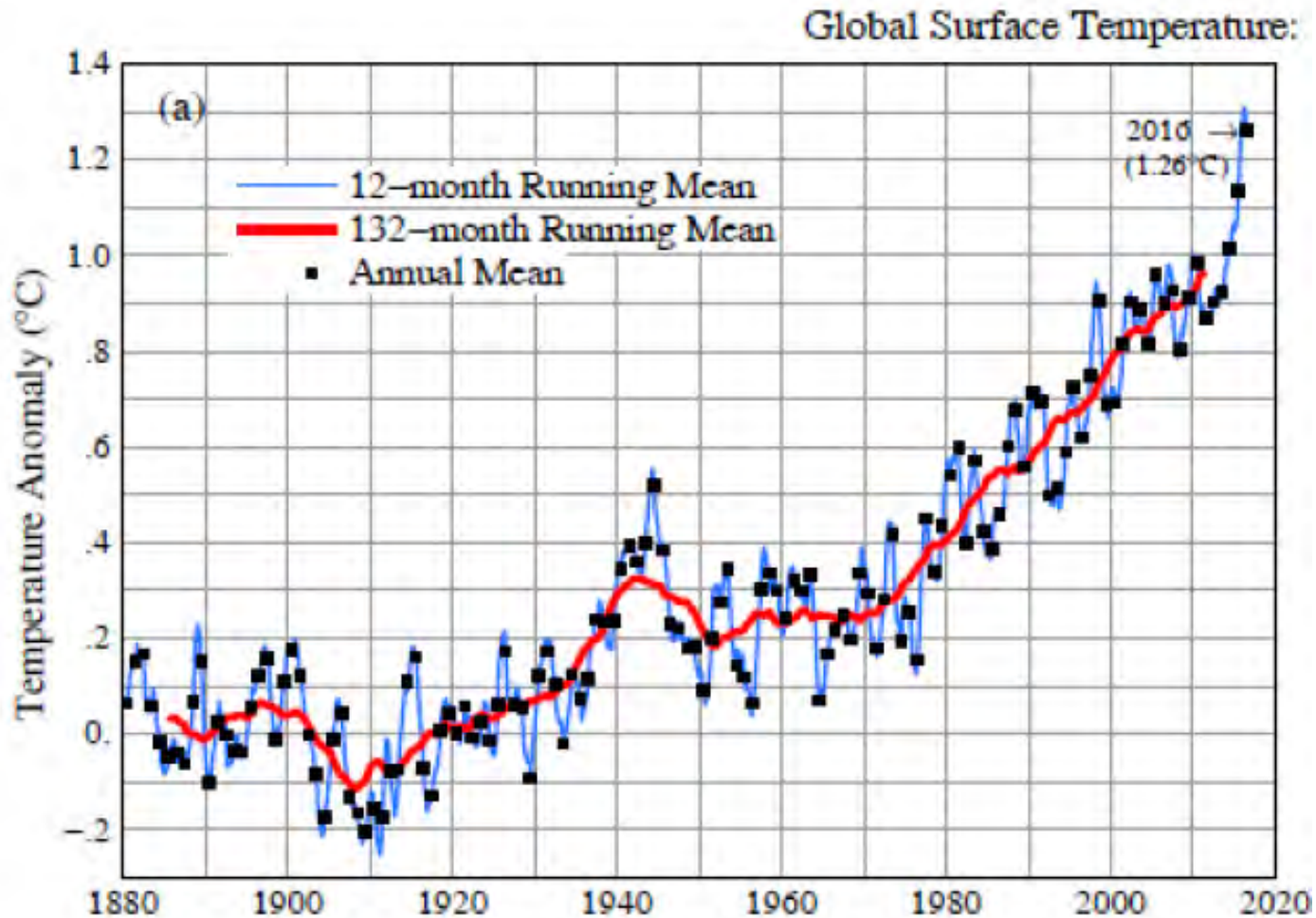
Annual J-D 2016

L-OTI (°C) Anomaly vs 1951-1980

1.00



Long-term Global Mean Trend 1880-2016



Gardening in Pittsford, Vermont in January



January 7, 2007

December 2006:

- Warmest on record



January 10, 2008

Warm Fall:

- Record Arctic sea-ice melt
- Snow cover in December,
ground unfrozen



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)



March 3, 2017



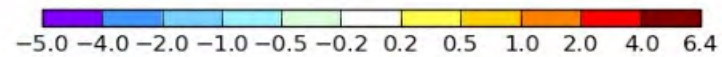
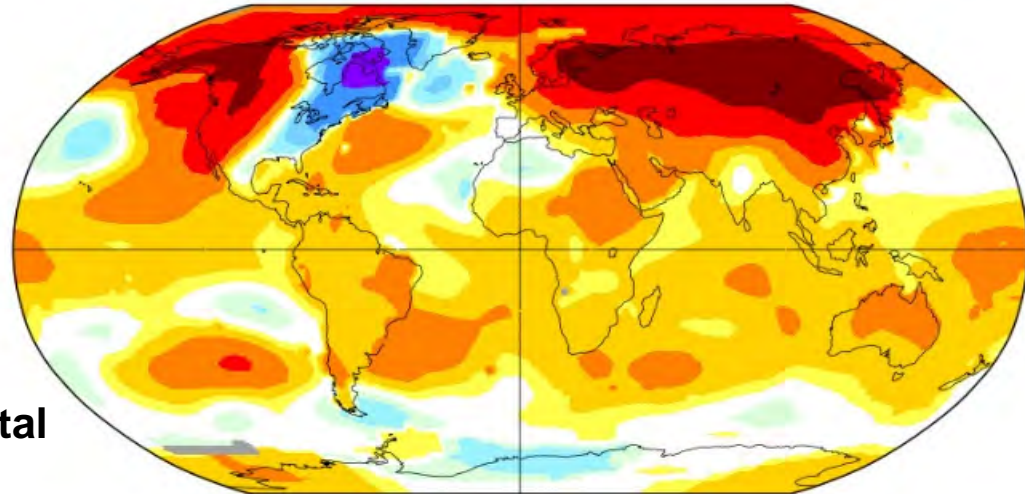
Jan-Feb-Mar 2015

Warm Atlantic, cold NE, strong coastal storms - Boston record snow

Jan-Mar 2015

L-OTI(°C) Anomaly vs 1951-1980

0.86



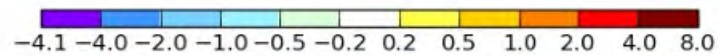
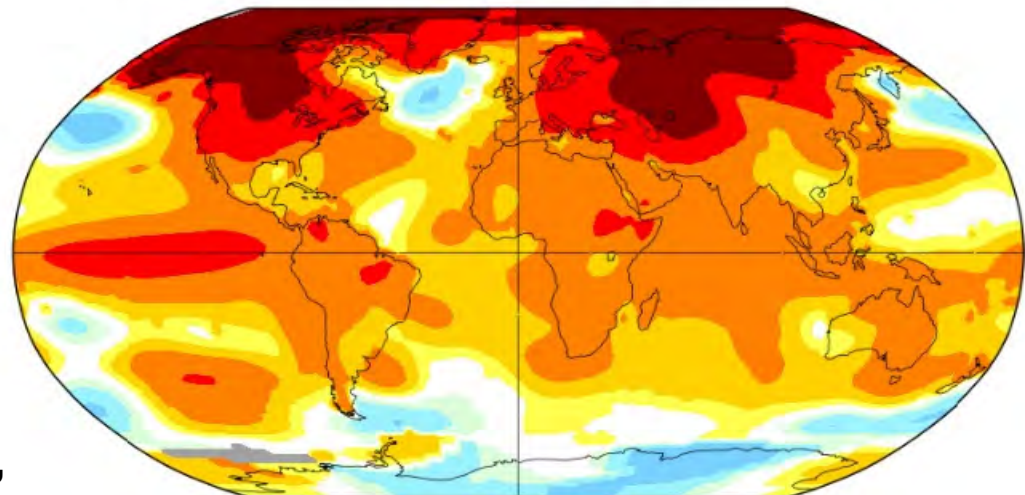
Jan-Feb-Mar 2016

Warm Atlantic, warm NE, little snow, warm Arctic

Jan-Mar 2016

L-OTI(°C) Anomaly vs 1951-1980

1.24



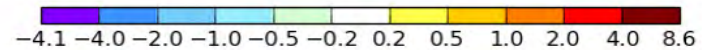
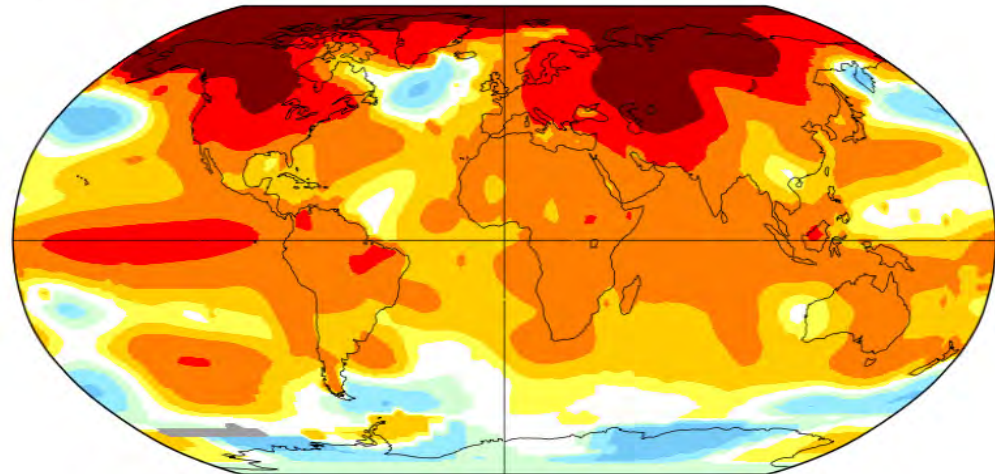
Jan-Feb-Mar 2016

Warm Atlantic, warm NE, little snow,
warm Arctic

Jan-Mar 2016

L-OTI(°C) Anomaly vs 1951-1980

1.24



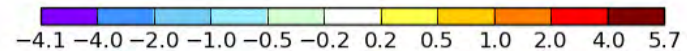
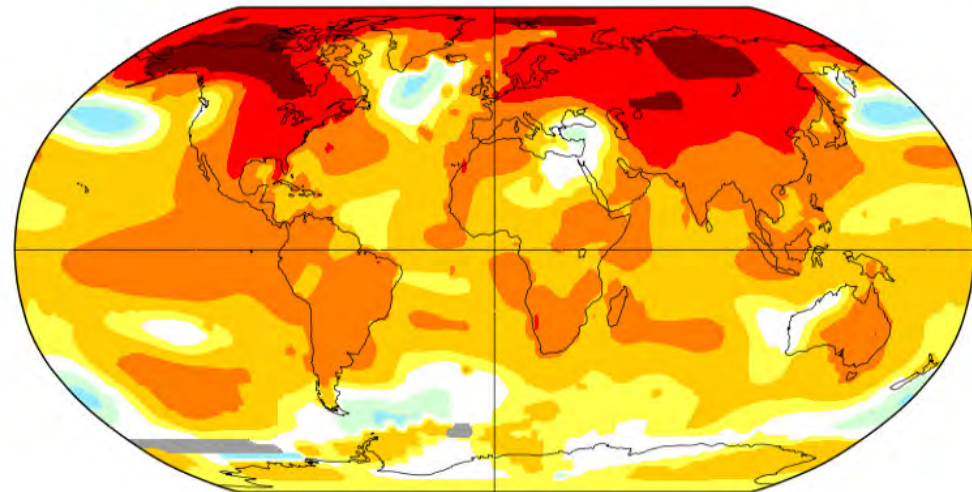
Dec-Jan-Feb- 2017

Warm Atlantic, warm NE, little snow
(till March)

Dec-Jan-Feb 2016-2017

L-OTI(°C) Anomaly vs 1951-1980

1.06

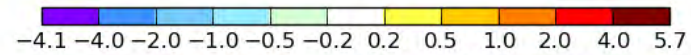
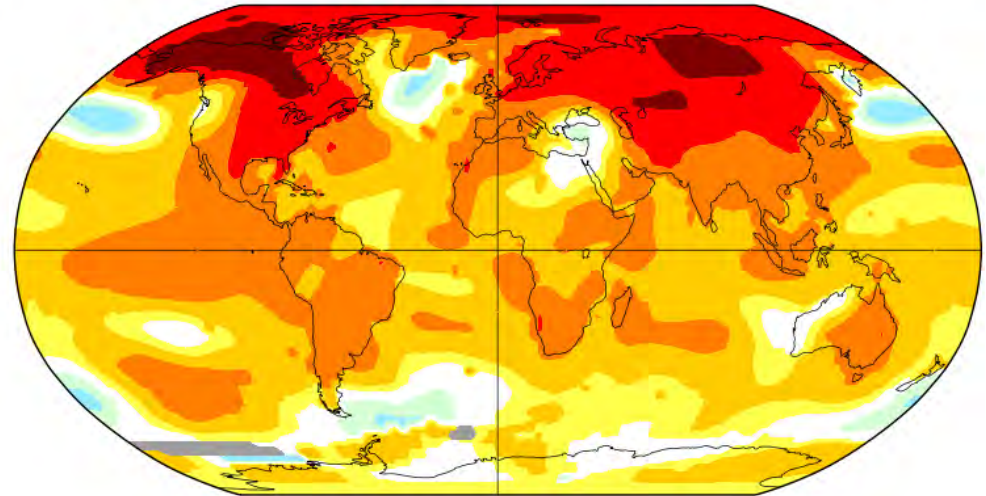


Dec-Jan-Feb 2017

Dec-Jan-Feb 2016-2017

L-OTI(°C) Anomaly vs 1951-1980

1.06

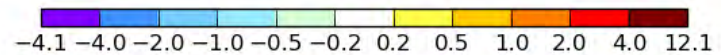
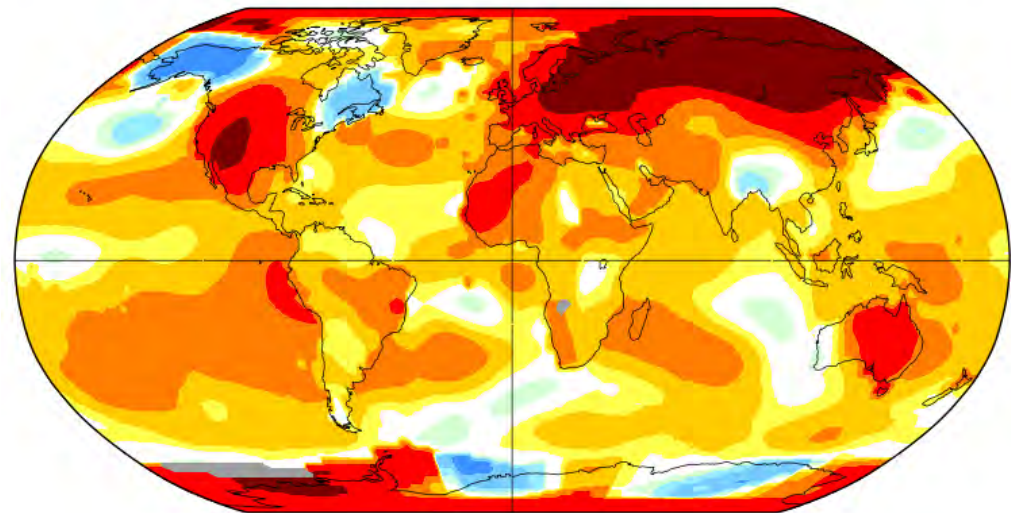


March 2017

L-OTI(°C) Anomaly vs 1951-1980

1.13

March 2017

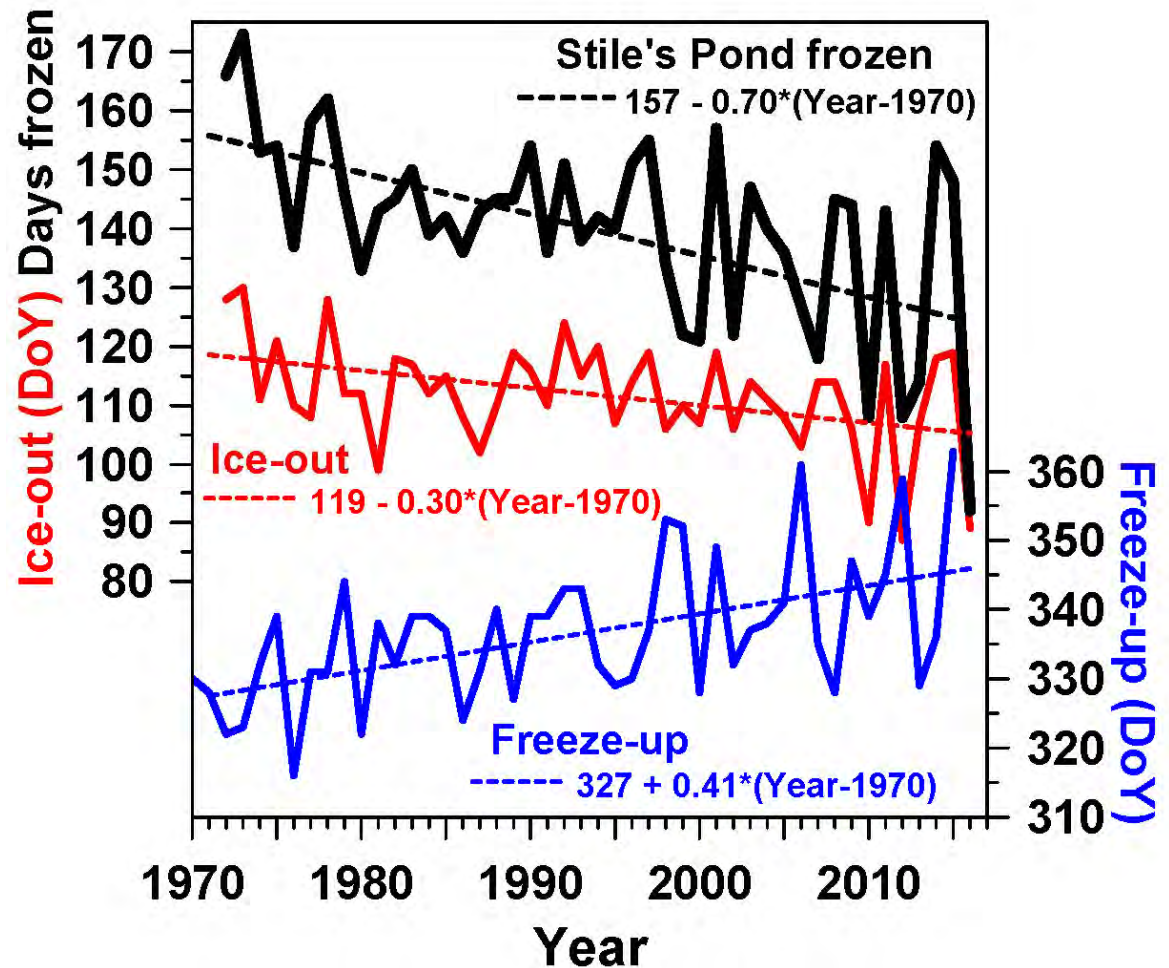


Lake Freeze-up & Ice-out Changing

Frozen Period Shrinking: variability huge

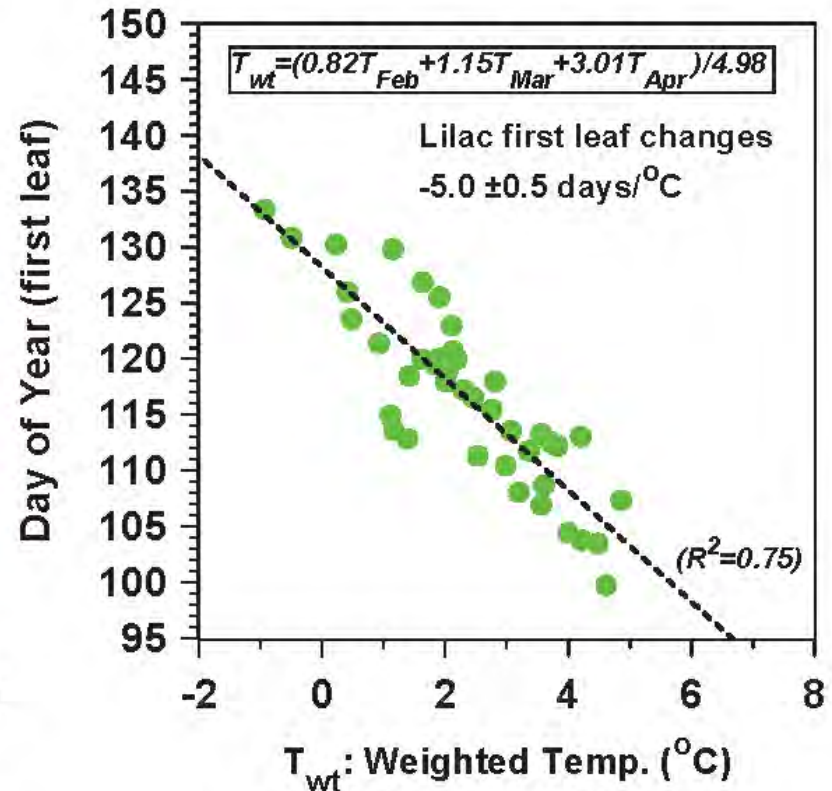
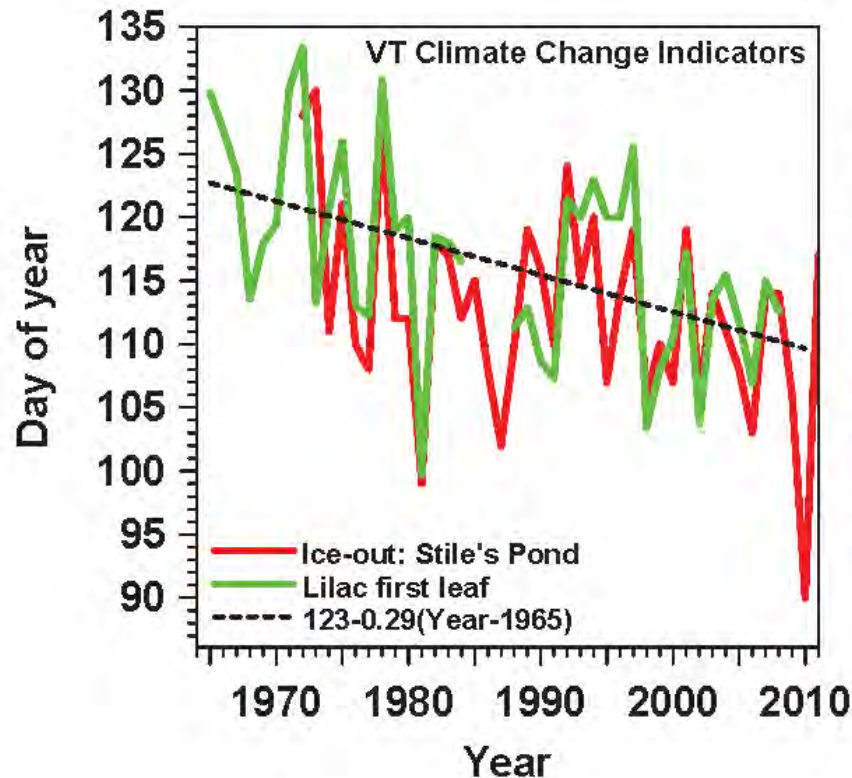
STILES POND

- Ice-out earlier
 - by -3 days / decade
- Freeze-up later
 - by +4 days / decade
- Lake frozen trend
 - - 7 days/decade



Steve Maleski: "Eye on the Sky"

Lilac First Leaf Earlier



- First leaf and ice-out changing: -3 days/decade
- Large variability linked to temperature:
- -5 days/ °C or -3 days/ °F
 - (No-snow – Snow) winter = 6*5 ≈ -30 days earlier leaf-out

Warm winter with little snow

Early Spring: *79°F on March 22, 2012*



Pittsford Vermont

3/22/12



Pittsford Vermont

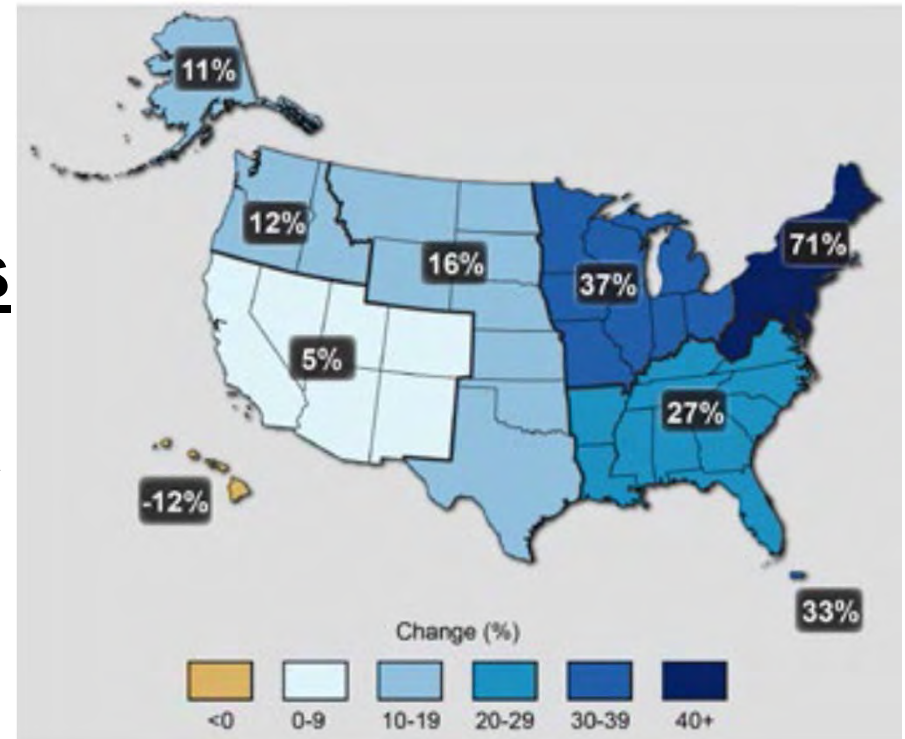
3/24/12

2012: Daffodils, forsythia bloomed 3/23/2012

2017: Daffodils and forsythia bloomed 4/17/2017

Very Heavy Precipitation Is Increasing

- **Precipitation Extremes**
- Most of the observed precipitation increase during the **last 50 years** has come from the increasing frequency & intensity of heavy downpours.
- **71% increase in Northeast**



(Walsh et al., 2014)



Brattleboro, VT, Courtesy of Caleb Clark, CNN



Brattleboro, M. Reston



Wilmington, J. Cantore

TS Irene

Roads in valleys

Massive damage

Some roads took
months to repair

*Rte 131,
Cavendish
Sept, 2011*



2011 Classic Flood Situations

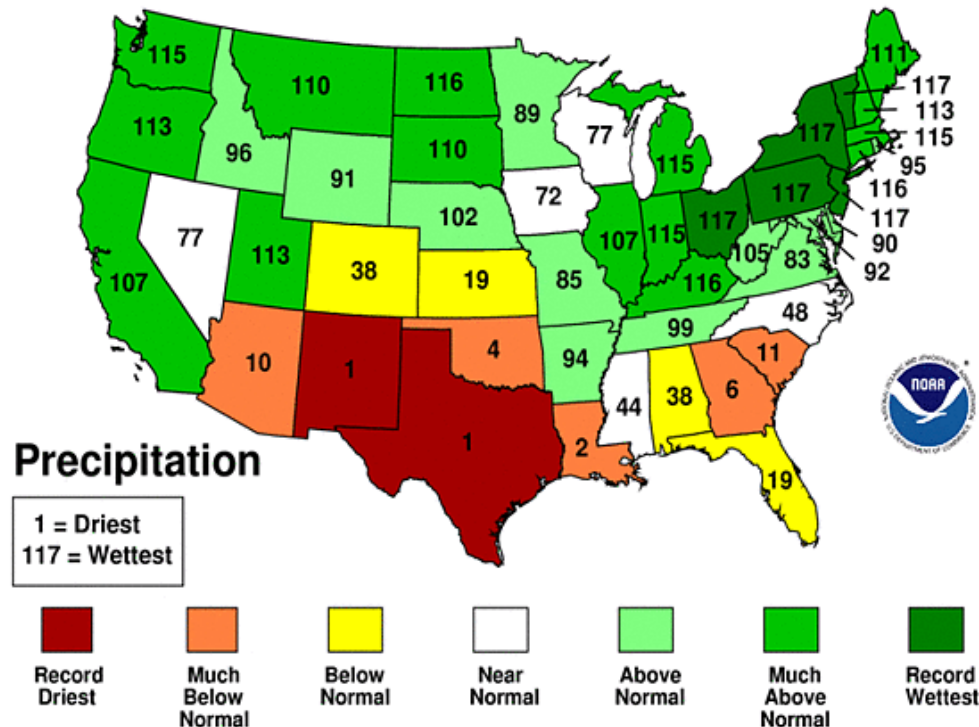
- **Spring flood:** heavy rain and warm weather, melting large snowpack from 2010 winter
 - 70F (4/11) and 80F(5/27) + heavy rain
 - record April, May rainfall: 3X at BTV
 - Severe floods on Winooski and Adirondack rivers
 - Lake Champlain record flood stage of 103ft
- **Irene flood: tropical storm** moved up east of Green Mountains and Catskills
 - dumped 6-8 ins rain on wet soils
 - Extreme flooding

2011 Floods: VT and NY

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

March-August 2011 Statewide Ranks

National Climatic Data Center/NESDIS/NOAA



March-August, 2011

- Record wet : OH to VT
- Record drought: TX & NM
- Pattern nearly stationary

Value of Flood Plains



- **Otter Creek after Irene on August 30, 2011**
 - **River rose ten feet: flood plain saved Middlebury**

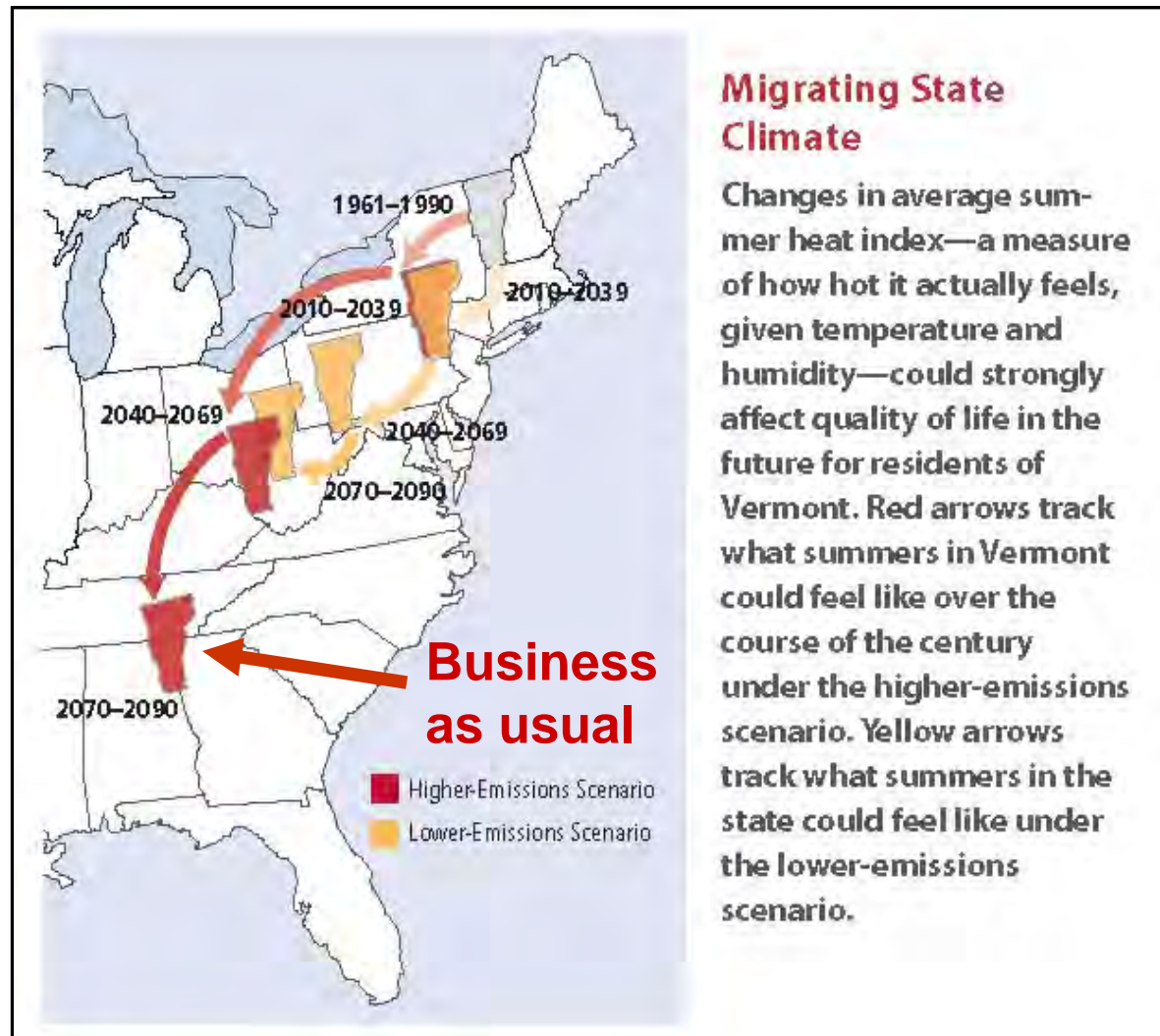
Flooding Issues

- **Maintain mountain forest cover**
 - Devastating floods in 1920's, 30's with reduced forest cover
- **Manage water on landscape**
 - Maximize infiltration: urban and on farms
 - Don't wall-in rivers!
- **Preserve flood plains**
 - Saves downstream towns (Middlebury)
 - Stop building houses and trailer parks in flood plains

Vermont's Future with High and Low GHG Emissions

What
about VT
forests?

Sub-tropical
drought areas
moving into
southern US



*NECIA,
2007*

Can We Stop “Dangerous Climate Change”?

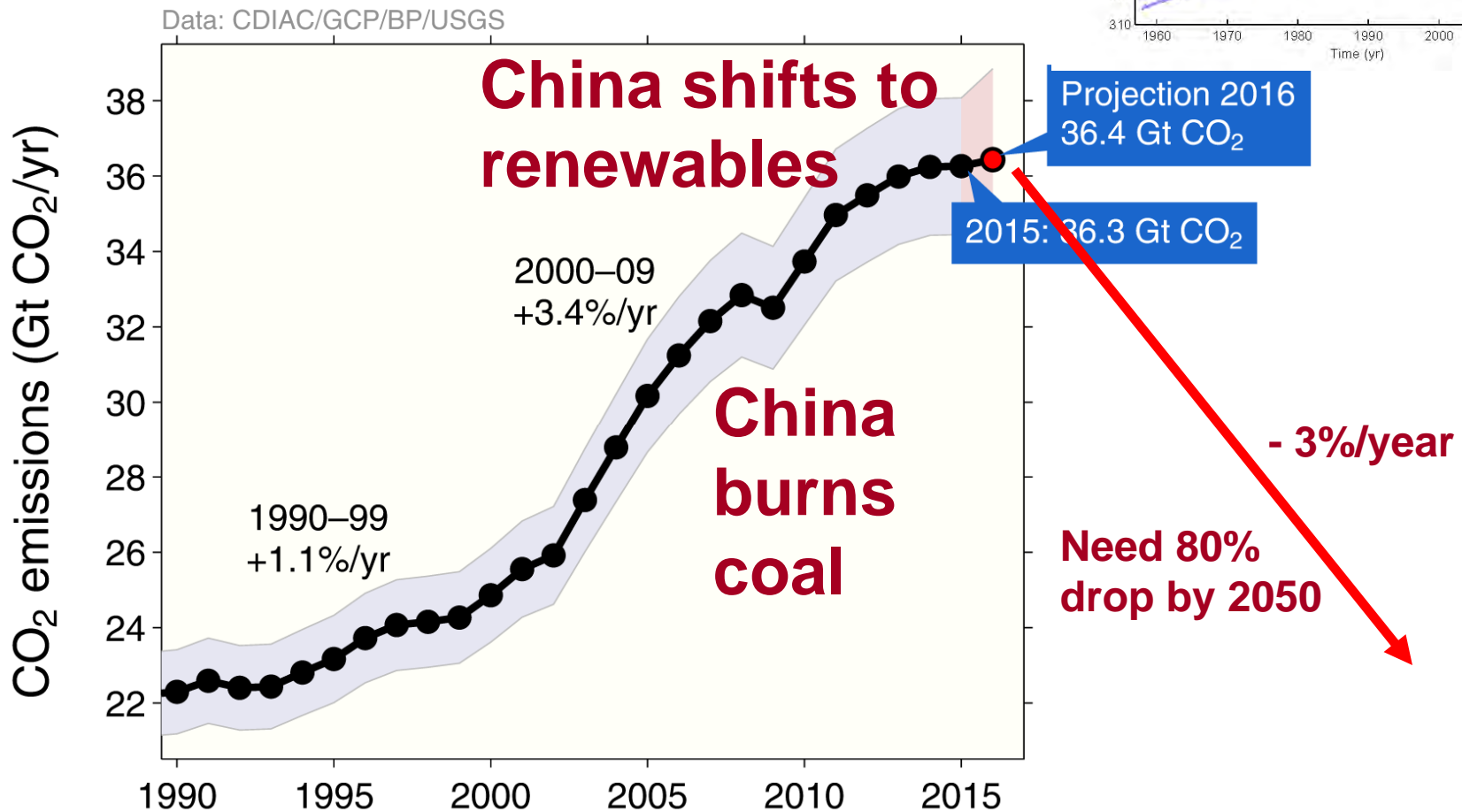
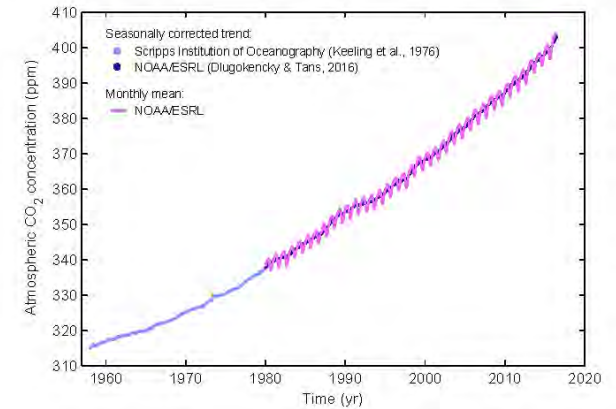
(UNFCCC 1992)

- **Yes: Quickly stabilize atmospheric CO₂**
- **This means an 80% drop in CO₂ emissions!**
- **This is possible but very difficult**
 - **Fossil fuels have driven our industrial growth and population growth for 200 years**
 - **“Lifestyle” has become dependent on fossil fuels**
 - **Powerful vested interests: \$trillions at stake**

2015 was Transition Year

- **Climate meeting in Paris in December**
 - 188 Nations made ‘national commitments’
- **Pope Francis encyclical on the environment, climate change and our responsibilities to the Earth**
 - Exploitation of the Earth and the poor are inseparable
 - Short-term profit as primary motive is immoral
- *2017: US wants to avoid the commitments it made; China and Europe have to take lead*

Growth of CO₂ Emissions Flat for 3 years



What can we “safely” burn?

- Only 750 Gt more for an even chance of keeping warming below 2°C [3.8°F]
- Requires leaving 2/3 of remaining fossil fuels in ground
- Only 21 years left at 36 Gt/year
- *Rapid phase-down extends period*

System Issues

- **Human waste streams are transforming the Earth's climate, and human and natural ecosystems**
- **How will this affect landscape, water supplies, food system and human health?**
- **What strategies and mindset are needed to mitigate, adapt and build resilience in Vermont?**
 - **Can we better manage our relation to the Earth?**
 - **Is this an efficient way of doing this?**
 - **Can we manage our waste streams better?**
 - **How can we adapt?**

'Managing' Our Relation to the Earth System

- Our technology and our waste-streams are having large local and global impacts on the natural world and **must be carefully managed** — *because we are dependent on the natural ecosystems*
- **We need new 'rules' because**
 - *Our numbers and industrial output are so large*
 - *Maximizing consumption and profit have led to present predicament*

What is a pollutant?

- **First it was the obvious hazards to health**
 - Smoke/smog from burning coal and exhausts
 - Toxic contaminants dumped in drinking water
 - These were regulated by the Clean Air and Clean Water legislation in 1980's & 1990's
- **But many of our waste products that look harmless to humans are hazards to life on Earth!**
 - CFCs that destroy the ozone layer that protects life
 - CO₂ from burning fossil fuels, driving climate change
 - Plastics dumped into the oceans
- ***In our disconnected human world, these are harder for us to deal with***

“Systems Engineering” for a Sustainable Society

- **Minimize the lifetime of human waste products in the Earth system: remove dangerous wastes**
- **Maximize the efficiency** with which our society uses energy and fresh water, and
- **Maximize the use of renewable energy**
- **Minimize the use of non-renewable raw materials, and**
- **Maximize recycling and re-manufacturing**

Efficiency Comes First

- **We need to double or triple our energy efficiency because...**
 - **We cannot replace current fossil fuel use with biofuels & renewable energy**
 - **Fossil fuel reserves are enough to push CO₂ to 1,000 ppm**
 - *Radically change climate/wipe out many species*
 - *In time melt icecaps, raise sea-level >100ft*

System Guidelines

- **Reeducation of society and its 'systems'**
 - The transition we face is huge
 - What will raise awareness/change paradigm?
 - How can we better manage our relation to Earth?
- ***Develop renewable energy***
 - *Maximize energy efficiency: housing, transport, power*
 - *Add and monitor renewable power*
- **Examine all waste-streams**
 - Aim to recycle/remanufacture everything
 - Fully cost all waste streams
- **Relocalize food system**
 - Compost all organic waste
- **Understand water and the landscape**
 - Limit phosphorus loads on streams/lakes
 - Growth of algae in lakes, big issue in VT (and elsewhere)
- ***Reconnect with natural world***
 - *Fundamental if we are to accept transition*

Why Is It Difficult for Us?

- The “American dream” is crumbling
 - “Economic growth” based on **fossil fuels, debt, and consumerism is unsustainable** — and a 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

Powerful interests are threatened

- **Fossil fuels reserves are worth \$20-30T**
 - Big money: of course we will burn them
 - Regulating or taxing emissions of CO₂ is an 'unfair cost to the free market'
 - (Too bad if the Earth's ecosystems are destroyed: 'others' can pay the price)
- ***Our politics are facing collapse:
fantasy disconnected from real world***
 - *We are deeply embedded in system!*

The Cabal of Libertarian Billionaires

- **Aim: *purchase control of the Republican Party***
 - US Congress (“Freedom Party”); many state legislatures
- **Doctrine: *limited role for government***
 - protect wealth, property and the rule of law
- **Freedom to exploit the earth:**
 - Shall not be limited by environmental regulation
 - *Doctrine in direct conflict with Earth’s ecosystem*
- **Leading to**
 - *Climate science is a (fictitious) conspiracy*

(Dark Money, Jane Mayer, 2016)

Step back from dark side

- **Cannot be solved with mindset that created it**
 - **Oppose new fossil fuel “solutions”**
 - ***But stand for the Earth and the truth***
- **Push practical solutions**
 - **Efficiency and renewables**
 - **And a fossil-carbon tax**
- **Social, moral, spiritual shift needed**
 - **Your personal role**
 - **Role of community**

How do we plan/adapt?

- **Future needs creative approaches**
 - **Community support**
 - **Efficient society run on renewable energy**
- **We need to work with the Earth**
 - *People reconnected to landscape*
 - **Manage water on landscape**
 - **Manage forest diversity for a warmer climate**
 - **Manage diversified year-round agriculture**
 - **Manage energy crops and solar farms**

Practical Local Solutions

- **Vermont is well on its way**
 - **Large solar development**
 - **Battery storage on its way**
 - **California installing 100MWh storage units**
 - **Energy efficiency for homes and businesses underway**
 - ***Need net-zero building codes***
 - ***Need transportation shift***

Efficient transport

- Gasoline to hybrid: 50% gain to 50mpg
- Hybrid to plug-in hybrid: now 130mpg
- Electricity from community solar array



>3000lbs and 130 mpg
Payload: 750 lbs at 55 mph



180lbs gets "1800 mpg" or 100 mp(1000Cals)
Payload: 350lbs at 25mph

Social, moral, spiritual shift

- **The Future Is Not Our Past**
 - *an economic, technological and financial system driven by short-term profit*
- *Collectively, we create the future*
 - *plan for a transition to a sustainable society*
 - *Put community values and systems thinking above short-term profit*

What resources do we need ?

- **Community**

- for moral support; to tell the truth

- *to face challenges with fiery hope (not despair)*

- **Grounding**

- *in yourself, and with the natural world*

Voice the Ethical Issues

- **Do we just exploit the Earth's 'wealth'**
 - For greater 'economic growth'
 - For a wealthy few
 - What will be left for our children?
 - What about the Earth's ecosystems?
- **Fundamental practical moral issue**
 - Don't we need to co-operate with the Earth?
 - *Shift in understanding and mind-set needed*

- *“Many things have to change course, but it is we human beings above all who need to change. We lack an awareness of our common origin, of our mutual belonging, and of a future to be shared with everyone.”*

Pope Francis, Encyclical 2015

As Climate Changes....

- *Everything is interconnected*
- **Human society and waste streams: people's choices and actions**
- **Precipitation, seasons, streams, and forests; habitat and wildlife**
- **Keep your eyes open to the big picture and see connections**
- **Speak out: talk to your neighbors; ask what we can do**
- **Stay connected to Vermont's natural environment**

Discussion

alanbetts.com

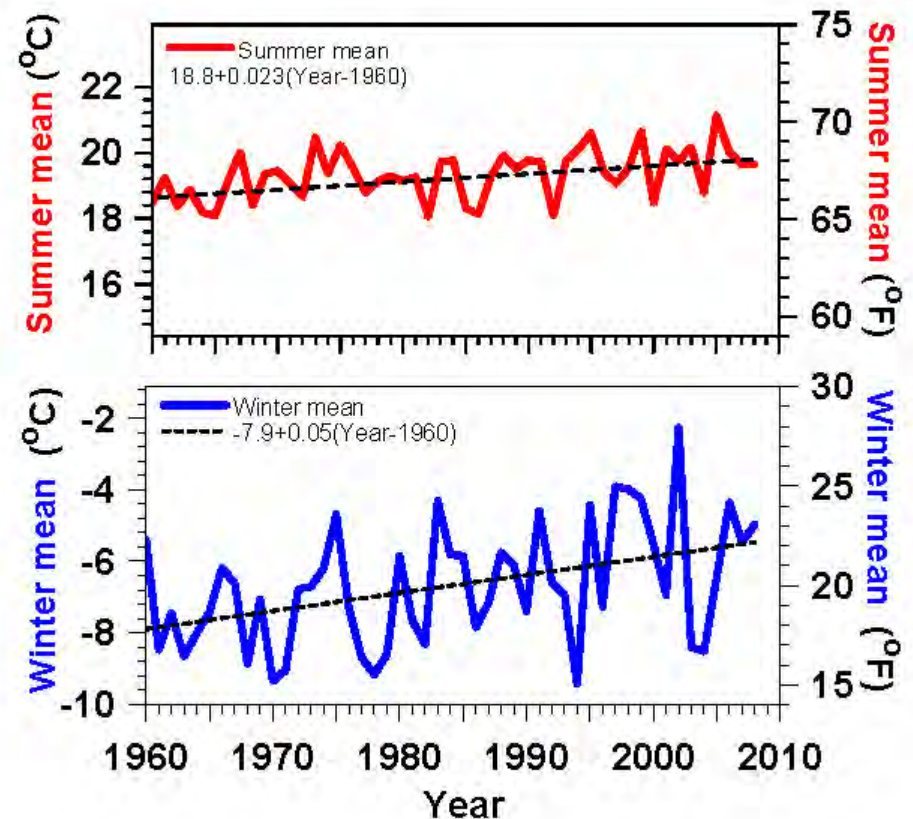
(articles and talks)

Paradigm shift for science?

- **Great value of science is its honesty, integrity and its cooperative global vision**
 - It deals with the measurable world
 - It communicates openly
 - Priceless to a society lost in corruption & deceit
- **Greatest challenge is that humanity is embedded in a deeply interconnected living Earth's system**
 - That cannot be separated and objectified
 - In fact the separation of our social frames from the Earth's ecosystem is driving climate change

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***



Frost-free days increasing

Figure 2.10. The frost-free season length, defined as the period between the last occurrence of 32°F in the spring and the first occurrence of 32°F in the fall, has increased in each U.S. region during 1991-2012 relative to 1901-1960. Increases in frost-free season length correspond to similar increases in growing season length. (Figure source: NOAA NCDC / CICS-NC).

