

Climate Change is Affecting Vermont: What can we do?

Alan K. Betts

Atmospheric Research

Pittsford, VT

<http://alanbetts.com>

"Climate Conversations"

Rutland Area Climate Coalition

Rutland Library

March 29, 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

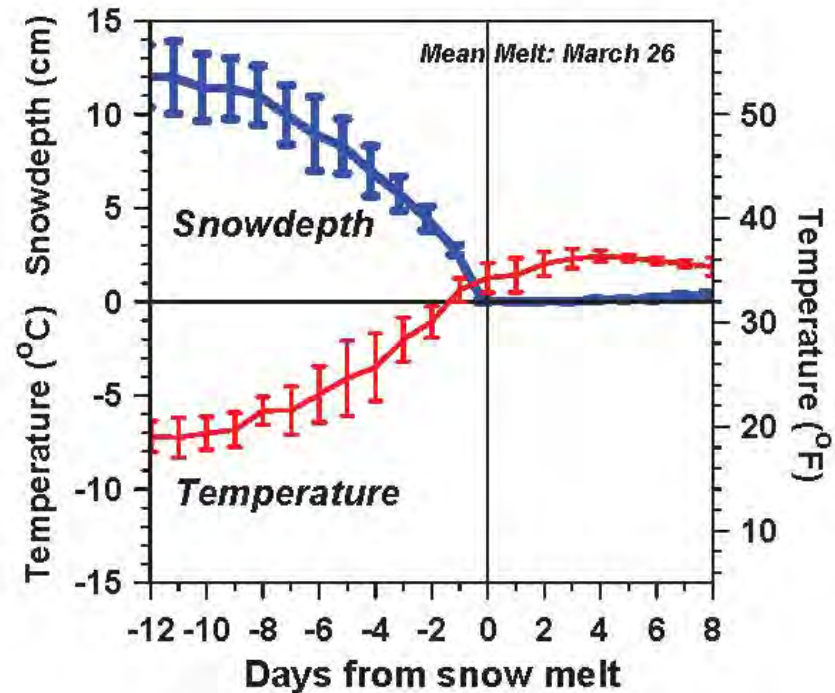
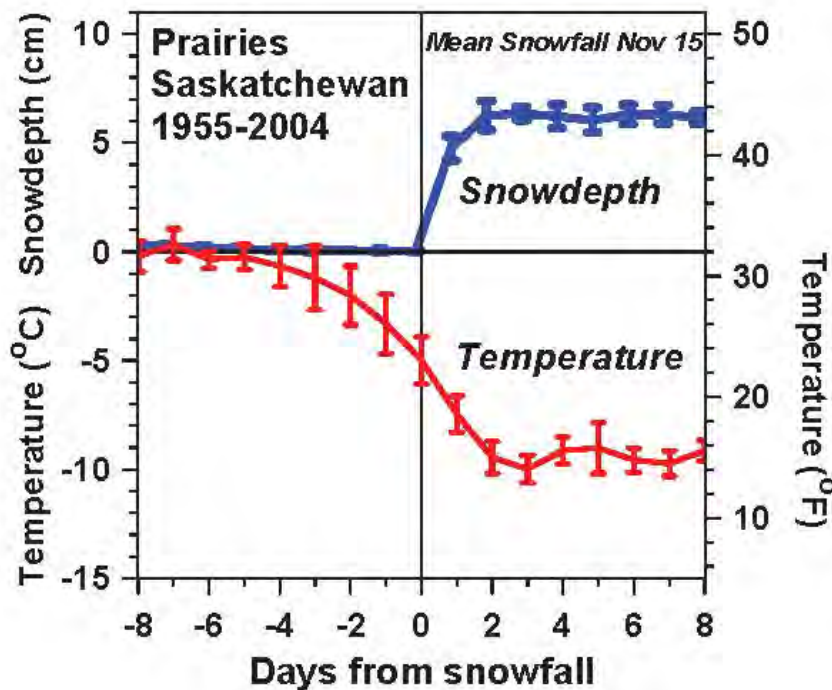
- **Human waste streams are transforming the Earth's climate, and human and natural ecosystems**
- **How will this affect landscape, water supplies, food system and human health?**
- **Strategies and mindset needed to mitigate, adapt and build resilience in Vermont?**
 - **Can we better manage our relation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

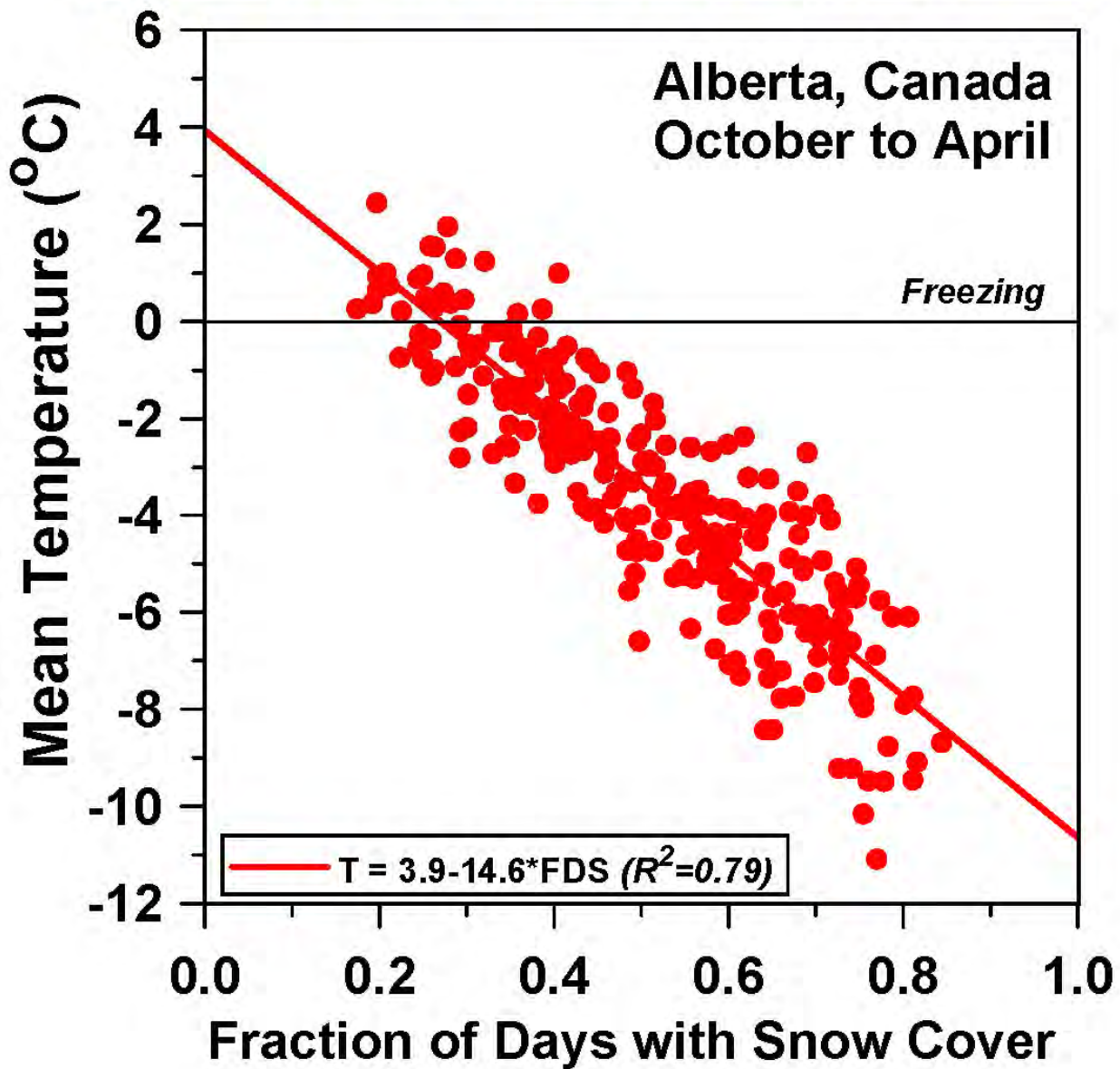
Winter and Spring transitions



- 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% with 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

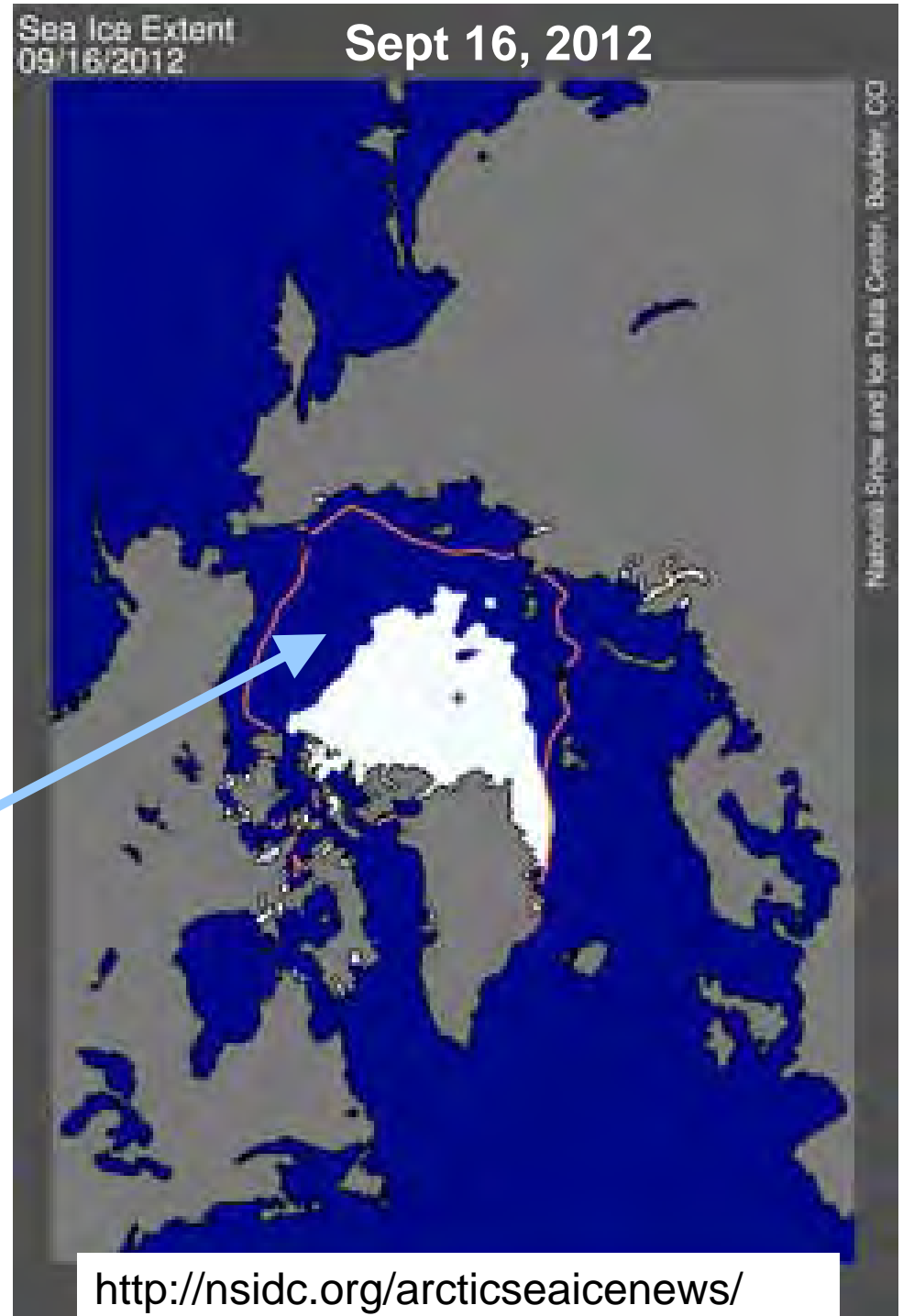
Earth's climate sustains life

- 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

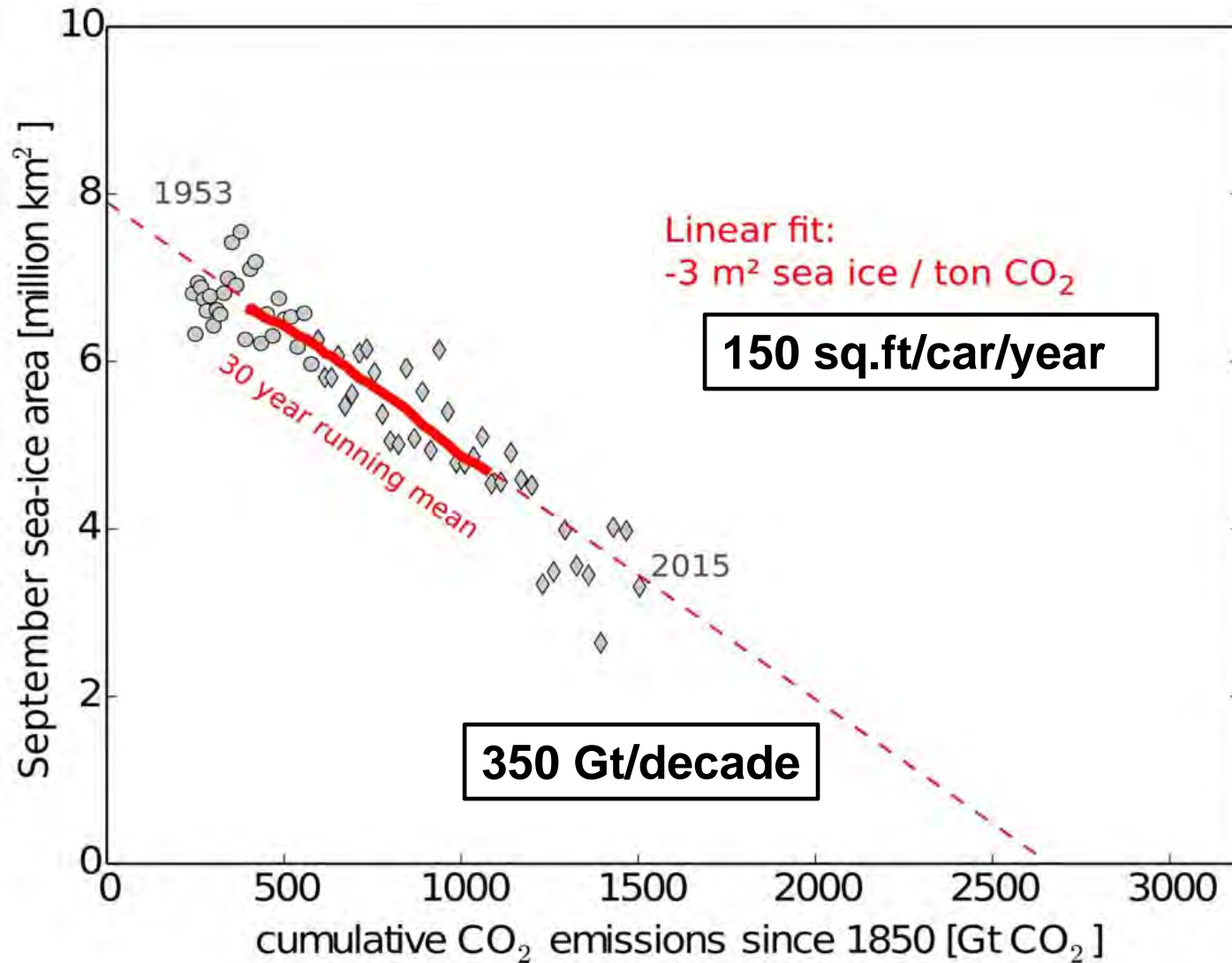


- **Half the Arctic Sea Ice Melted in 2012**
- **Open water in Oct. Nov. gives warmer Fall in Northeast**

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



September Arctic Sea Ice Loss



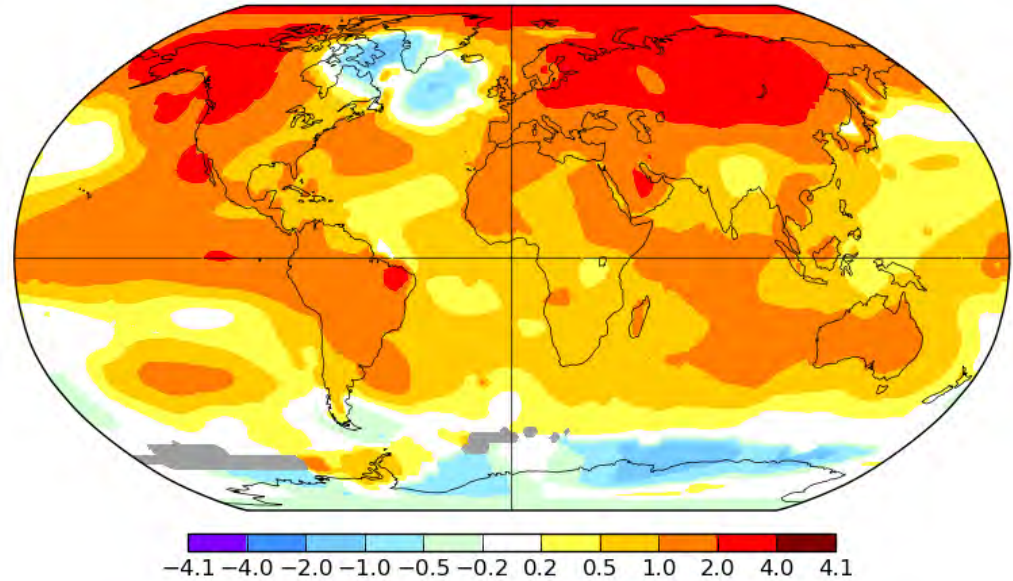
J. Stroeve/National Snow and Ice Data Center

2015
1.5F warmer

Annual J-D 2015

L-OTI (°C) Anomaly vs 1951-1980

0.85

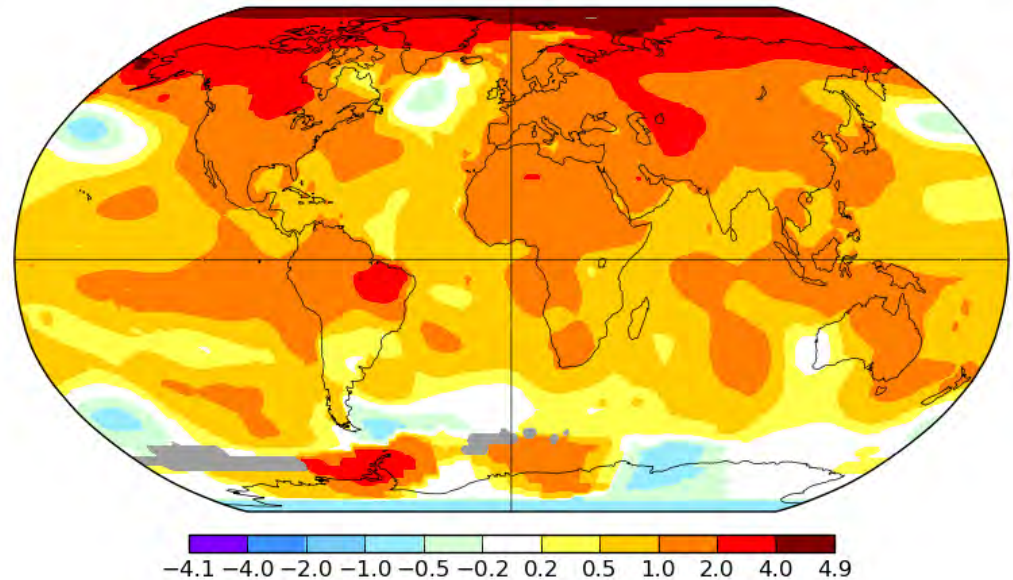


2016
1.8F warmer
(Arctic ice lowest ever in winter)

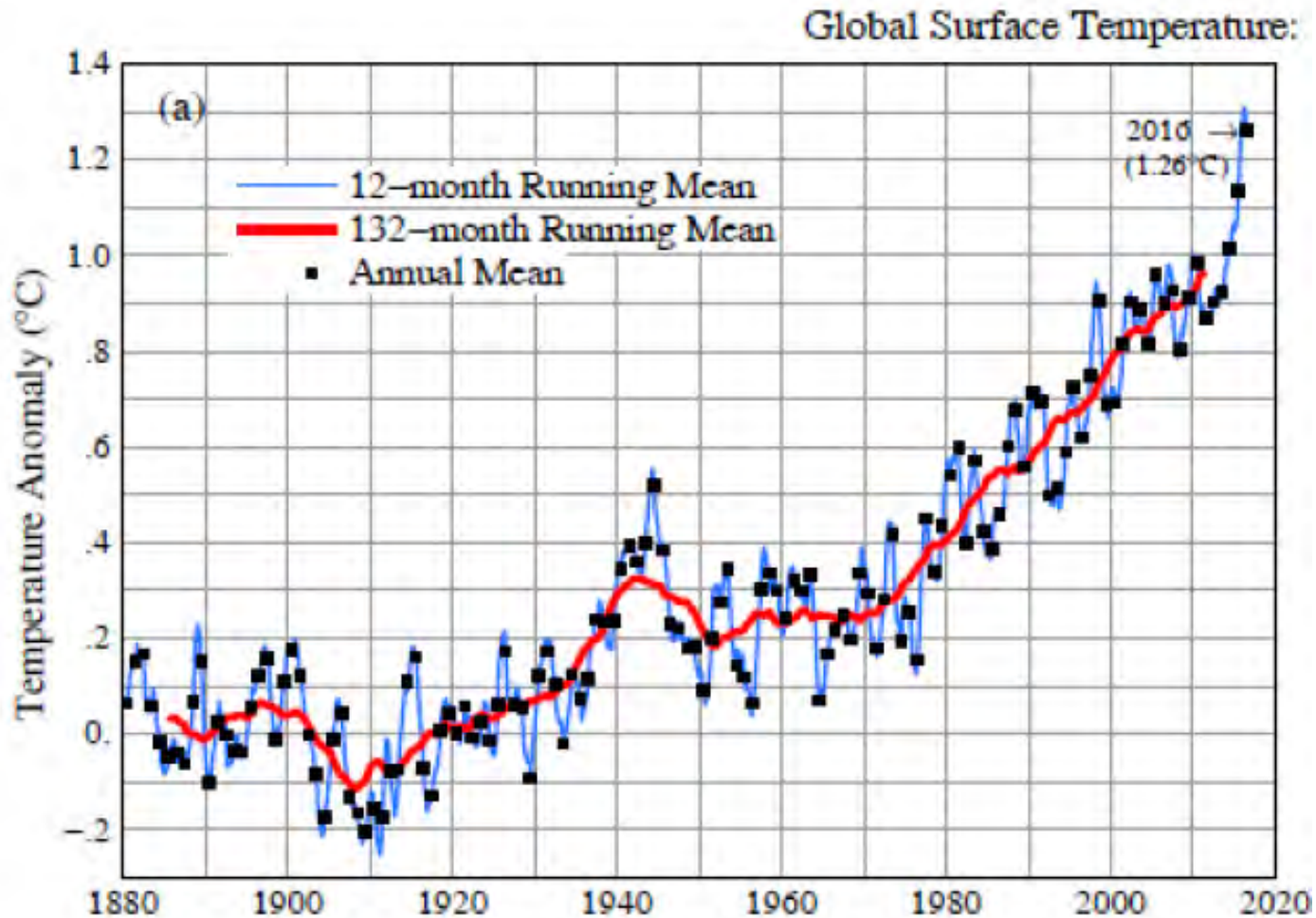
Annual J-D 2016

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



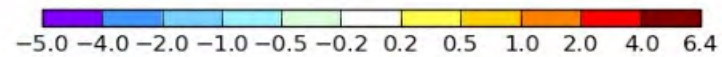
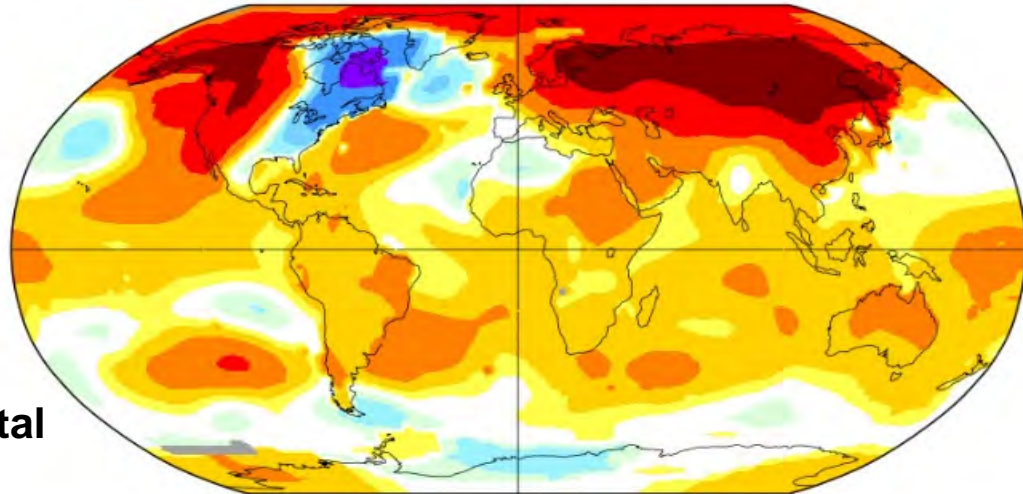
Jan-Feb-Mar 2015

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

Jan-Mar 2015

L-OTI(°C) Anomaly vs 1951-1980

0.86



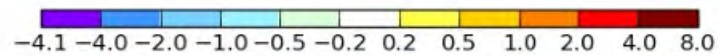
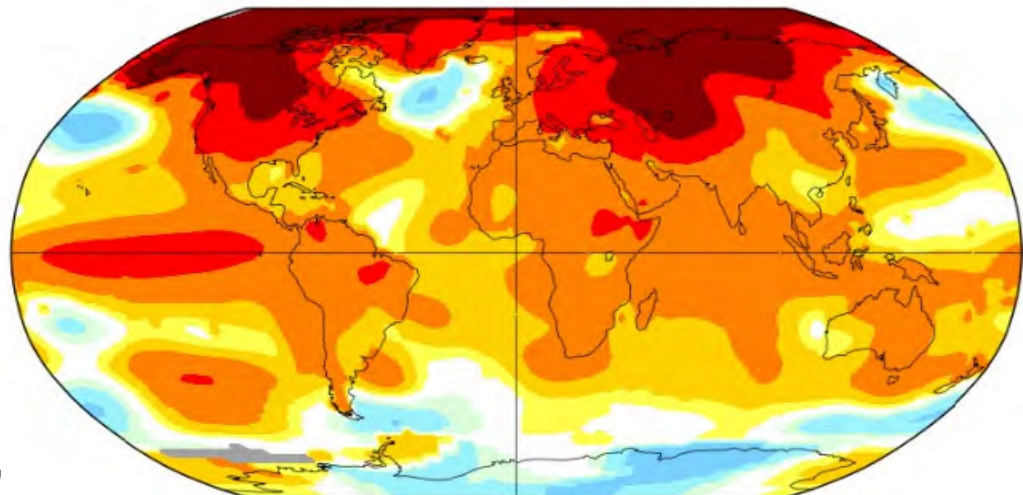
Jan-Feb-Mar 2016

Warm Atlantic, warm NE, little snow, warm Arctic

Jan-Mar 2016

L-OTI(°C) Anomaly vs 1951-1980

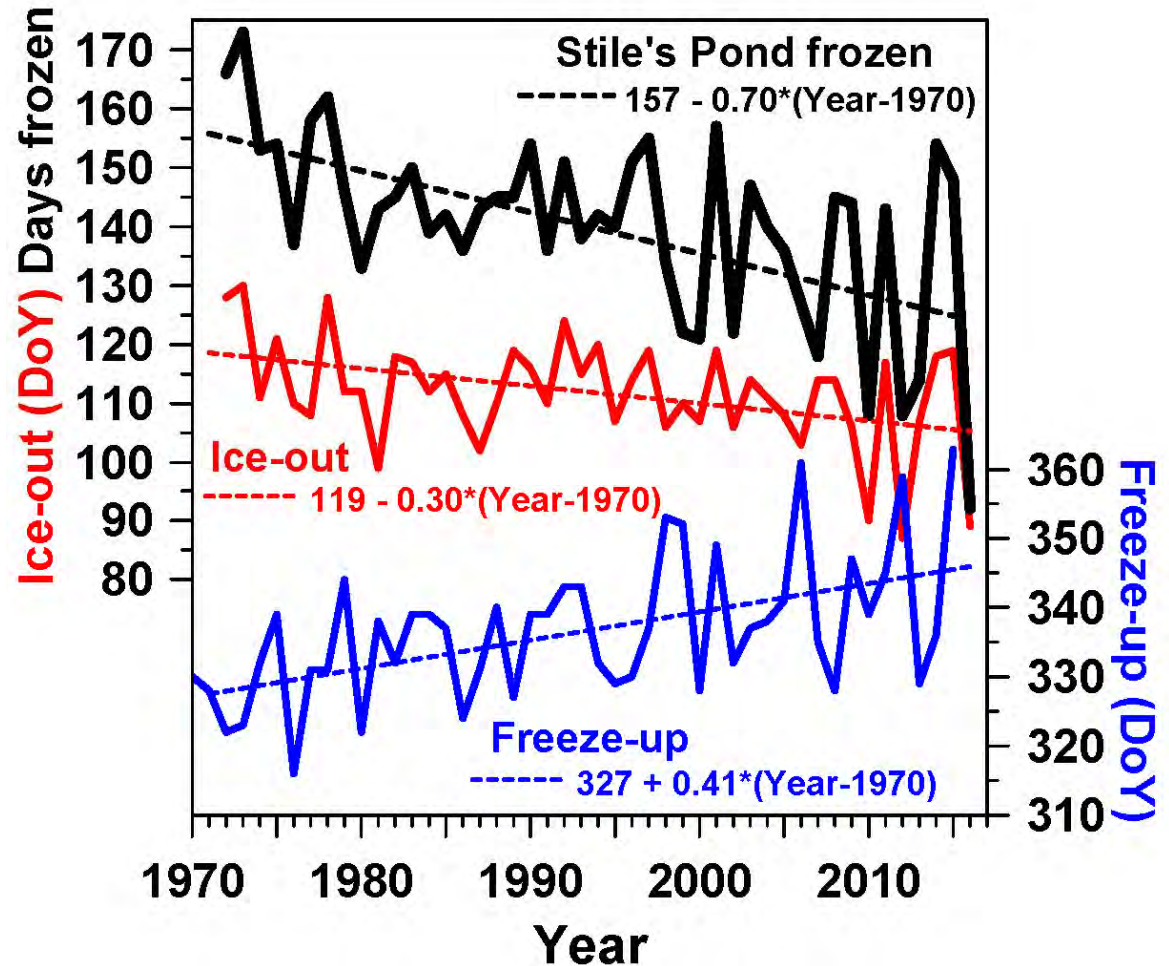
1.24



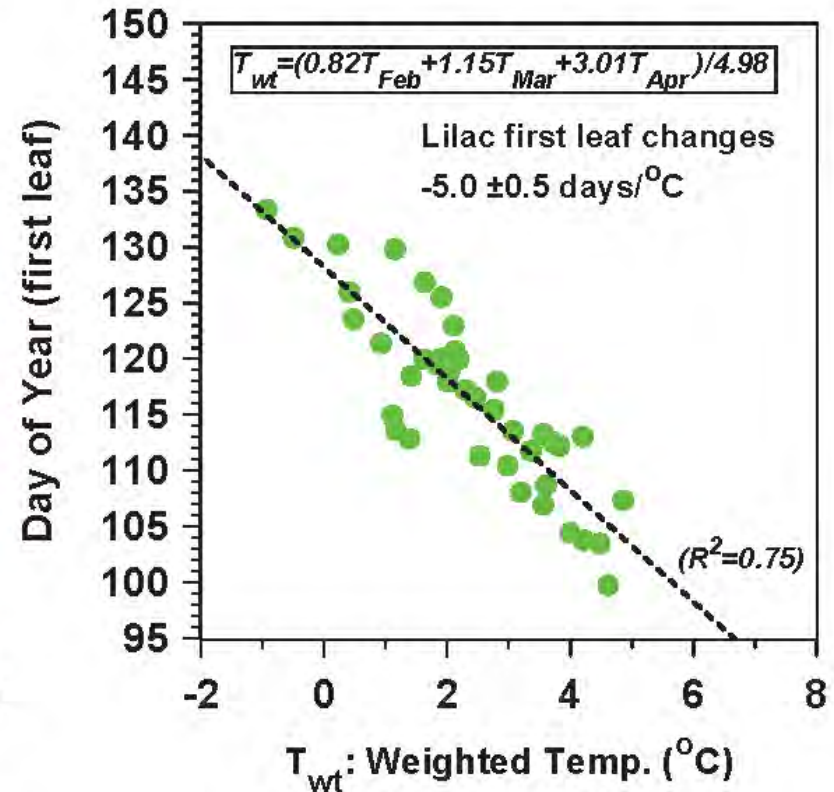
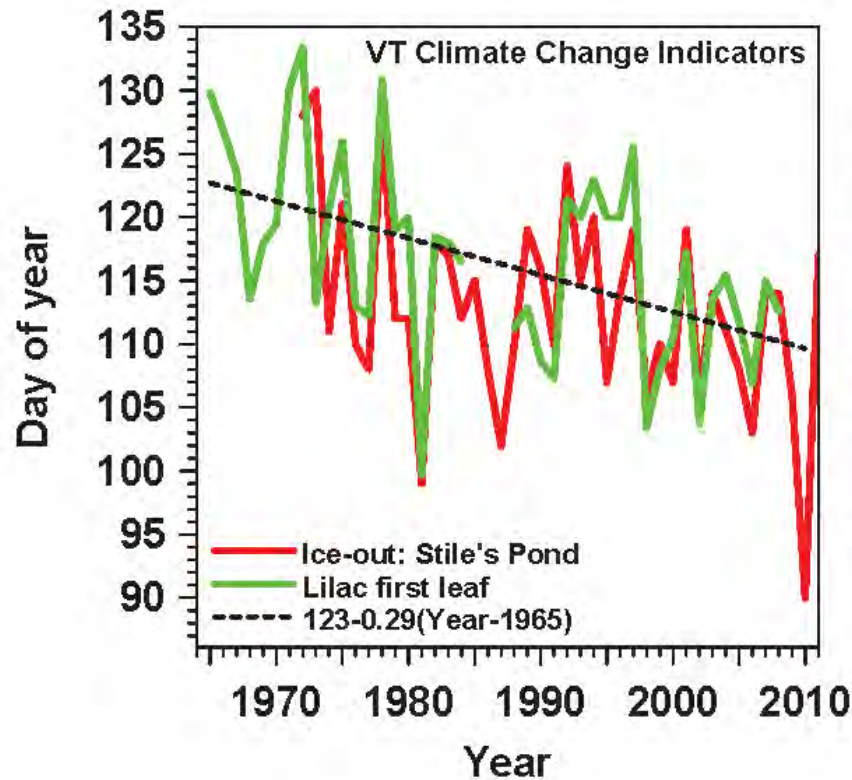
Lake Freeze-up & Ice-out Changing

Frozen Period Shrinking: variability huge

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



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

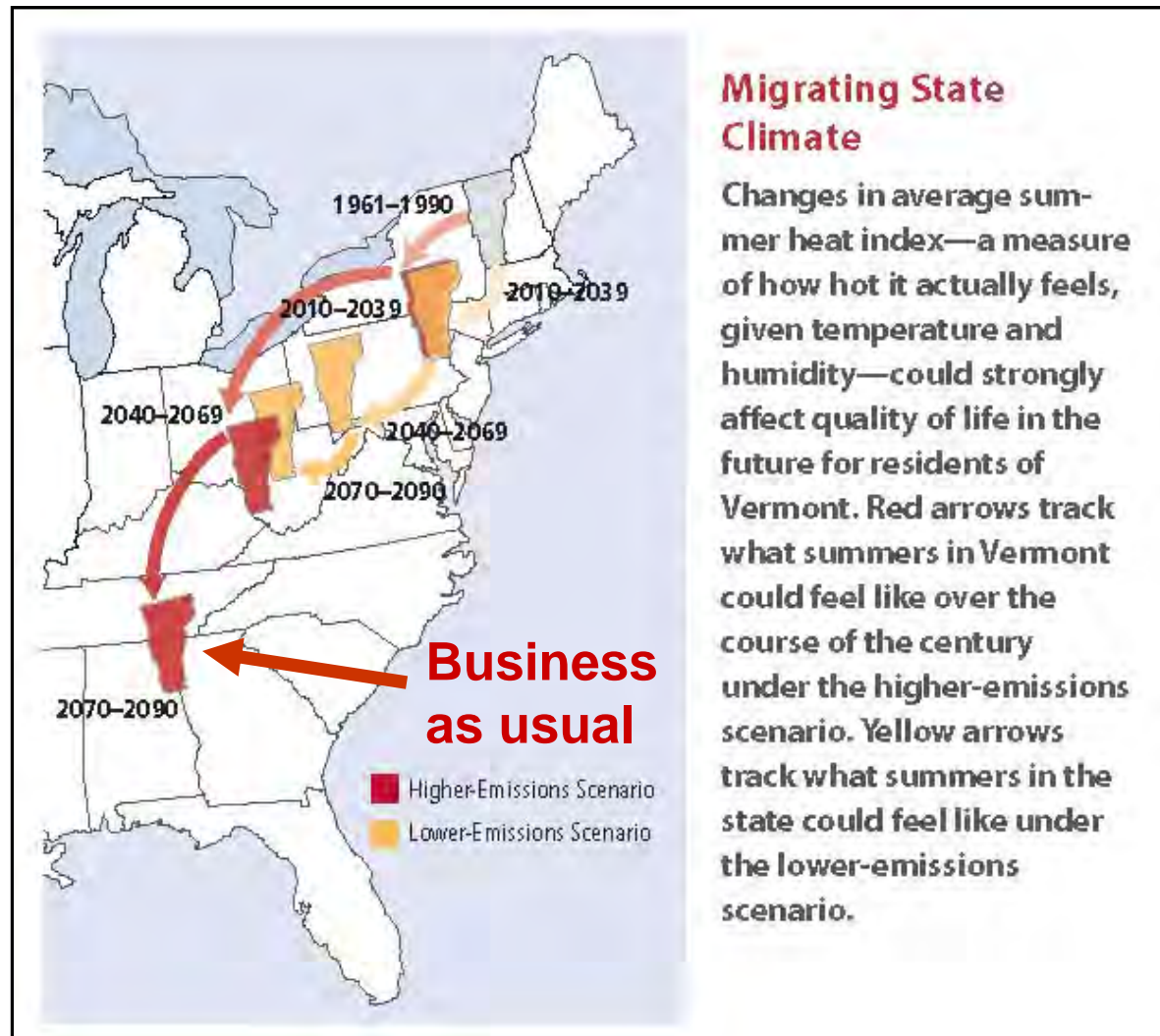
3/24/12

Daffodils, Forsythia in bloom

Vermont's Future with High and Low GHG Emissions

What
about VT
forests?

Sub-tropical
drought areas
moving into
southern US



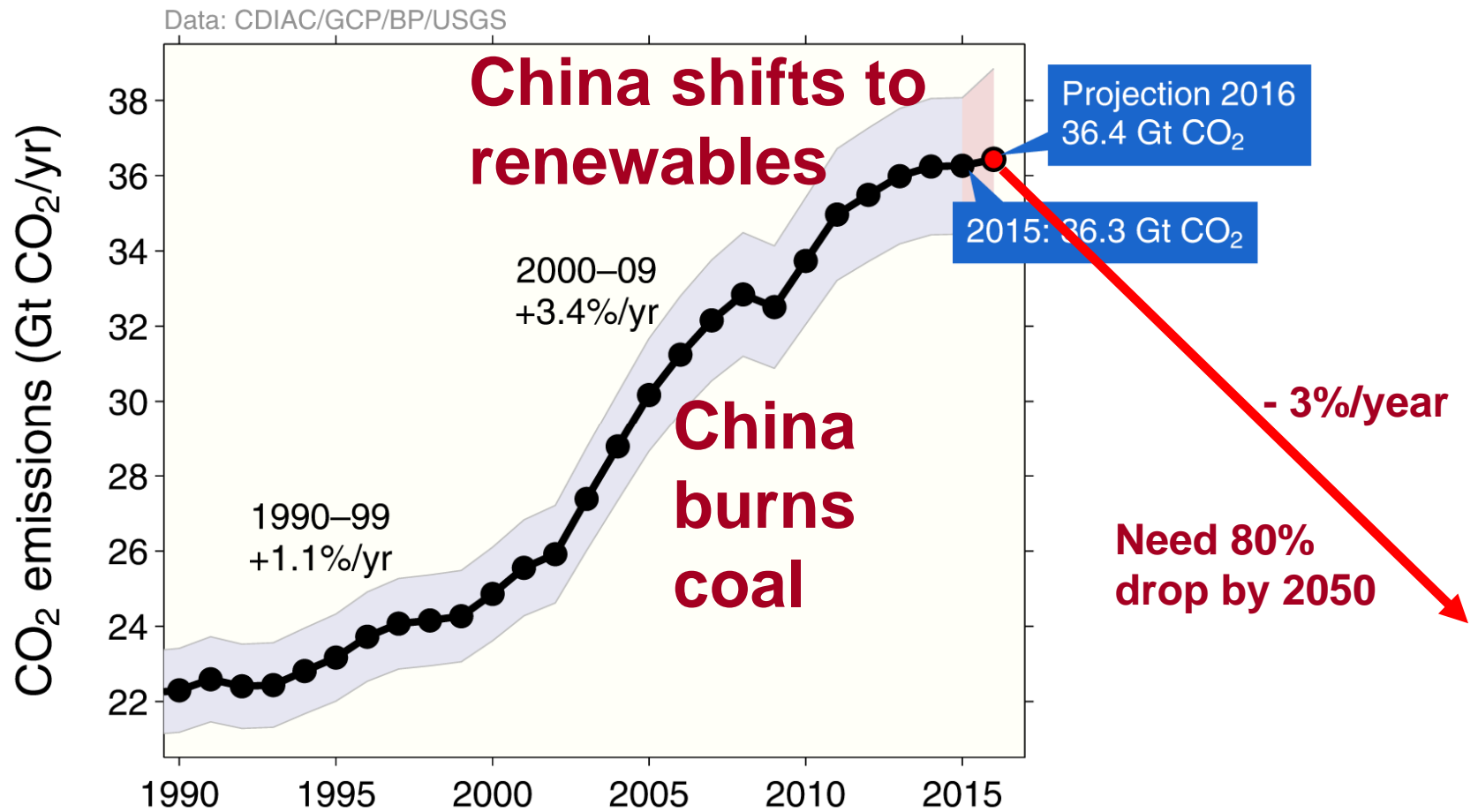
*NECIA,
2007*

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**

Growth of CO₂ Emissions Flat for 3 years



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*

“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 species*
 - *In time melt icecaps, raise sea-level 150ft*

Simple Suggestions

- **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?
- **Understand water and landscape**
 - Limit phosphorus loads on streams/lakes
 - Growth of algae in lakes, big issue in VT (and elsewhere)
- **Examine all waste-streams**
 - Aim to recycle/remanufacture everything
 - Fully cost all waste streams
- **Relocalize food system**
 - Compost all organic waste
- **Default energy use should be 'OFF'**
 - Maximize energy efficiency: housing, transport, power
 - Add and monitor renewable power
- **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**
 - Regulating emissions of CO₂ is an “unfair cost to the free market”
- ***Our politics are facing collapse:
fantasy disconnected from real world***
- **Real Earth system issues being ignored**

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
- **Leading to** *(Dark Money, Jane Mayer, 2016)*
 - ***Climate science is a (fictitious) conspiracy***
 - ***Doctrine in direct conflict with Earth’s ecosystem***

Step back from dark side

- **Cannot be solved with mindset that created it**
 - **Opposition needed to 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**

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 120mpg
- Electricity from community solar array



>3000lbs and 120 mpg
Payload: 750 lbs at 55 mph



250lbs gets "1800 mpg" or 100 mp(1000Cals)
Payload: 400lbs 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*
 - *As community and as individuals?*

Community is Central

- You cannot deal with environmental issues alone
 - They were created by the community over time
 - You need a community to weigh the evidence, search for creative solutions, and tell the truth
 - For moral support: *to face resistance or opposition with fiery hope (not fear or despair)*
- *You need grounding*
 - *in yourself, as a group and with the Earth*

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 happens to the ecosystems we depend on?
- **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 draw connections**
- **Talk to your neighbors and ask what you can do**
- **Stay connected to Vermont's natural environment**

Discussion

alanbetts.com

(articles and talks)

How do we plan/adapt?

- **Futures needs creative approaches**
 - **Community support**
 - **People reconnected to landscape**
 - **Efficient transport: cooperative**
 - **Separate 'electric bike' roads**
- **We need to work with the Earth**
 - **Manage water on landscape**
 - **Manage forest diversity for a warmer climate**
 - **Manage diversified year-round agriculture**
 - **Manage energy crops and solar farms**

TS Irene

Roads in valleys

Massive damage

Some roads took months to repair

*Rte 131,
Cavendish
Sept, 2011*



Value of Flood Plains



- **Otter Creek: April 14, 2014 with snow-melt**
 - **With Irene rose 8+ more feet: saved Middlebury**