

Climate Change and Community Resilience

Alan K. Betts
Atmospheric Research
Pittsford, VT
<http://alanbetts.com>

White Mountain School
Earth Day
April 22, 2019



March 15, 2019

- School strikes, 123 countries, 1.6 million students, demanding climate action



Capetown

Do you know this 16-yr-old?



On 20 August 2018, Greta Thunberg decided to not attend school until the 2018 Sweden general election on 9 September, after heat waves and wildfires in Sweden. Her demands were that the Swedish government reduce carbon emissions in accordance with the Paris agreement. She protested by sitting outside the Swedish parliament every day during school hours with the sign *Skolstrejk för klimatet* (school strike for the climate).

After the general elections, she continued to strike only on Fridays, gaining worldwide attention – prompting global ‘Friday’ protests by students who realized they and their children were to be sacrificed



“we can’t change the world by playing by the rules, because the rules have to be changed.”

Framing of this talk

- *“We have done our homework: they have not”*
- I am a scientist, but not just a scientist
 - Climate change is an existential issue for humanity
 - It is complex but we know what is happening
 - We have the technology to solve the issues
 - We lack the political will, because climate change and “business as usual” are incompatible
 - We lack the moral framework to make decisions
- *With understanding comes responsibility*
 - *So this talk is both science and all the other issues*

Strategies for Resilience

- Grasp technical/ecological/economics
 - Alternative facts lead to collapse
- Engineer for efficiency and resilience
 - Net value: not cost effective for today's bottom line
- Spend \$1 trillion on climate resilience
 - saves \$60 trillion later this century
- If we ignore climate change
 - costs to human civilization and Earth's ecosystem will be catastrophic
- Community resilience!

Fundamentals

- ***Burning fossil fuels: traps heat, stored in oceans***
 - *Many water cycle amplifying feedbacks*
 - *Heading for high CO₂ “Carboniferous era hothouse climate”*
 - *Climate extremes increasing.*
 - *Severe weather costs: \$300B in US in 2017*
 - *Decadal to centennial - long timescales*
- **Linked to unmanaged technology**
 - Soluble by changing system guidelines
 - Create efficient society, based on renewable energy
- **Avoidance of responsibility for decades**
 - Politicians, professionals, public
 - Climate change: Incompatible with business-as-usual
 - Policy controlled by oil interests
- **Choices are value- & community-based**
 - Beyond science and economics

System Issues

- ***Human waste streams*** are transforming the Earth's climate, and human and natural ecosystems
- **This affects landscape, water supplies, food system, energy, human health, ecology**
- What mindset is needed to mitigate, adapt and build resilience in NE, US and the world?
 - Can we manage our waste streams better?
 - **Is this an efficient way of doing this?**
 - How can we adapt; can ecosystems adapt?
 - *Can we better manage our relation to the Earth?*

Different Mindsets

- ***Technology will save us***
 - ***Oil has made us rich***
 - ***Economics based on individual consumerism produces ‘wealth’***
 - ***No need to change our behavior***
 - ***Inventions will power the future***
- **Climate, life & humanity interwoven**
 - **Environmental intelligence crucial**
 - **Community resilience and values essential**
 - **Intergenerational equity matters**

Aside: Economic Doctrines

- **We worship “freedom”**
 - *Freedom* to exploit Earth’s resources & poor
 - *Free market* to drive material growth
 - *Regulation* interferes with growth
- We protect assets and interests of the wealthy, since they fund politicians
- We demand “cost-effective” now: and discount future costs and value
- **Climate change and current economics are incompatible**
 - *Earth does not discount the future - accumulates energy imbalance in oceans for centuries*

Understand the Power of Oil

- US companies had global control of Oil
 - 1900 till 1973
 - Started with Standard Oil (JD Rockefeller)
 - *Key to wars and who won them*
 - To post-WWII growth of consumer society
 - The triumph of the automobile and suburbia
 - **Oil barons directed government policy for a century, and they still do**
 - Big Oil has \$10s of trillions of assets
 - Oil money obstructs climate change action

“Oil, Power and War”, Matthieu Auzenneau

Environmental Intelligence

- “Blend of natural science, social science and indigenous knowledge that helps humans interact constructively and creatively with the living natural world”
 - (Rather than exploiting the environment to support our lifestyle & corporate profits)
 - (Dumping current and future costs on the poor, the indigenous, our children and all life)
- Conscious challenge for all of us
 - Key to community resilience
 - But much has to be recovered

Community Resilience

- Shared local infrastructure, resources, knowledge and awareness
 - Localized shared food supply
 - Shared efficient transport system
 - Strategies to maximize efficiency and renewable energy use
 - Strategies to support ecosystems
- ***Community is essential***
 - ***Contrast to 'happy isolated individuals addicted to consumerism, escapism and the media'***
(Joanna Macy)

Local Food

- Rapid growth in local food
 - Year-round market in Rutland, VT
 - Farm to plate; to schools/institutions
- Local community and state support of shift to (organic) local food supply
 - *Diversification of crops and growers*
- Technology shift
 - *Unheated high tunnels and row covers*
- Favorable climate shift: +1 climate zone
 - Enough precipitation

Gardening in Vermont for 40 years

- How long was growing season in 1970s?
 - About 125 days: now 155 days
- How long was the ground frozen?
 - About 155 days: now 125 days +-
 - No longer hard freeze in November
- Winter climate zones in 1970's were?
 - Zones 4-5: now zones 5-6 (10F warmer)
- BUT winter variability increasing

My Wake-up Call: Gardening in January, Pittsford, VT



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)



January 10 and 12, 2018



January 10, 2018

**After cold snowy period
 T_{\min} down to -10 to -20F**

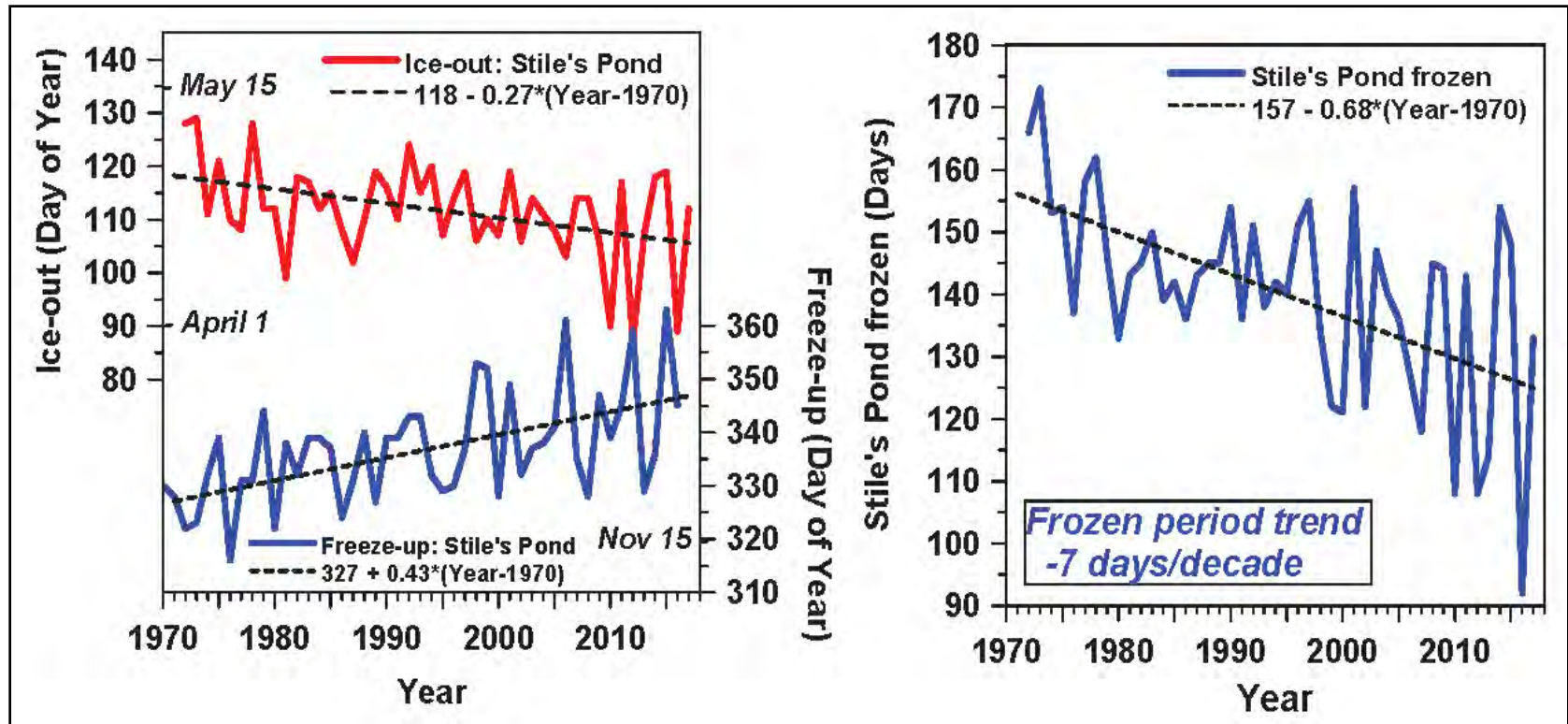


January 12, 2018

After T_{\max} up to 50F

Marker: Lake Freeze-up & Ice-out

Frozen Period Shrinking: variability huge



- Freeze-up later by +4 days / decade
- Ice-out earlier by -3 days / decade
- Lake frozen period trend - 7 days/decade
- *Interannual variability \approx 50 yr trend*

Stiles Pond:
"Eye on the Sky"

Stationary modes

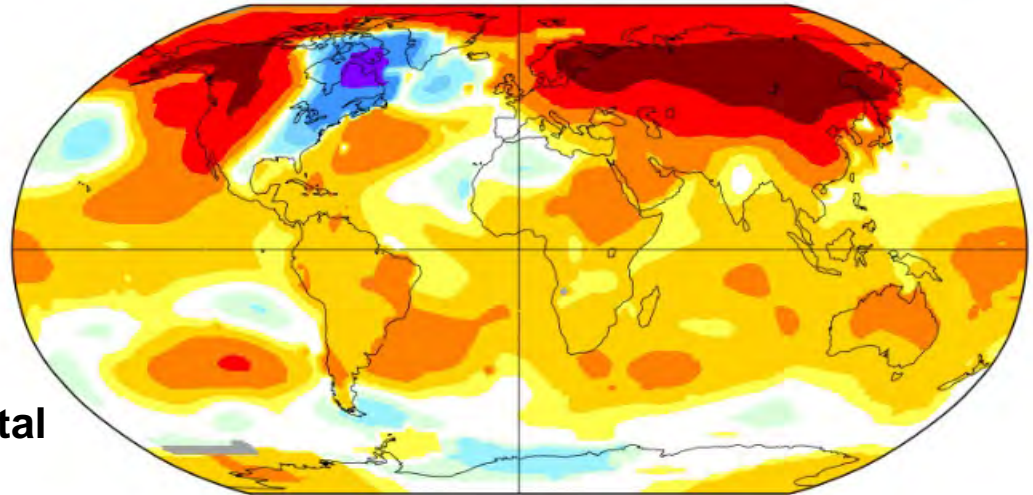
Jan-Feb-Mar 2015

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

Jan-Mar 2015

L-OTI(°C) Anomaly vs 1951-1980

0.86



-5.0 -4.0 -2.0 -1.0 -0.5 -0.2 0.2 0.5 1.0 2.0 4.0 6.4

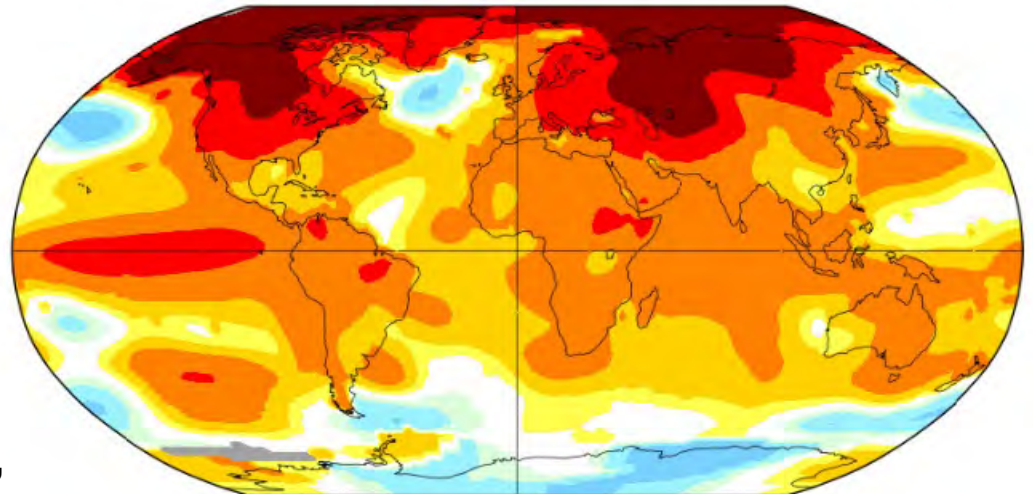
Jan-Feb-Mar 2016

Warm Atlantic, warm NE, little snow,
warm Arctic

Jan-Mar 2016

L-OTI(°C) Anomaly vs 1951-1980

1.24



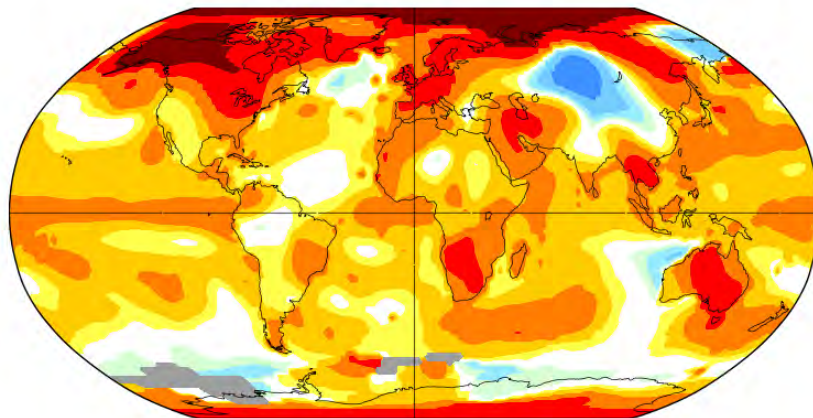
-4.1 -4.0 -2.0 -1.0 -0.5 -0.2 0.2 0.5 1.0 2.0 4.0 8.0

Last Winter

December 2018

L-OTI(°C) Anomaly vs 1951-1980

0.90

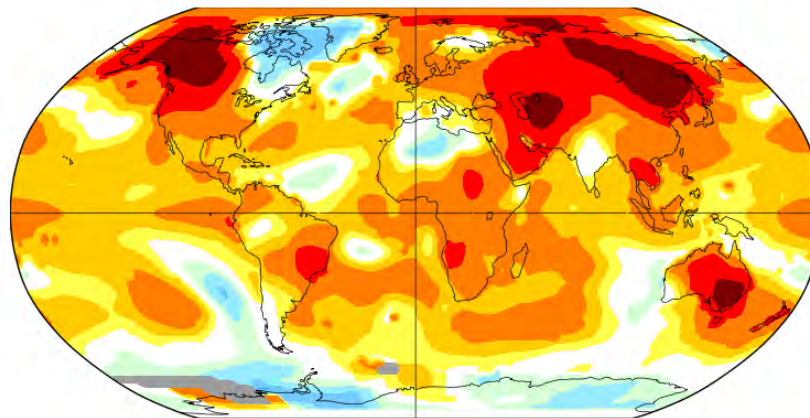


-4.1 -4.0 -2.0 -1.0 -0.5 -0.2 0.2 0.5 1.0 2.0 4.0 6.7

January 2019

L-OTI(°C) Anomaly vs 1951-1980

0.92

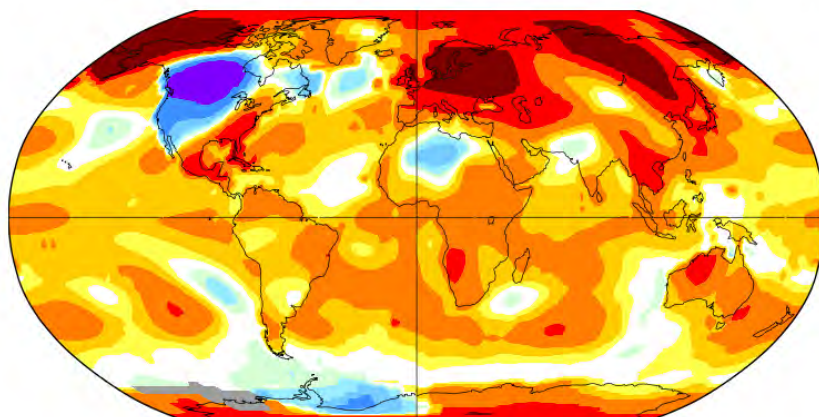


-4.1 -4.0 -2.0 -1.0 -0.5 -0.2 0.2 0.5 1.0 2.0 4.0 5.7

February 2019

L-OTI(°C) Anomaly vs 1951-1980

0.94

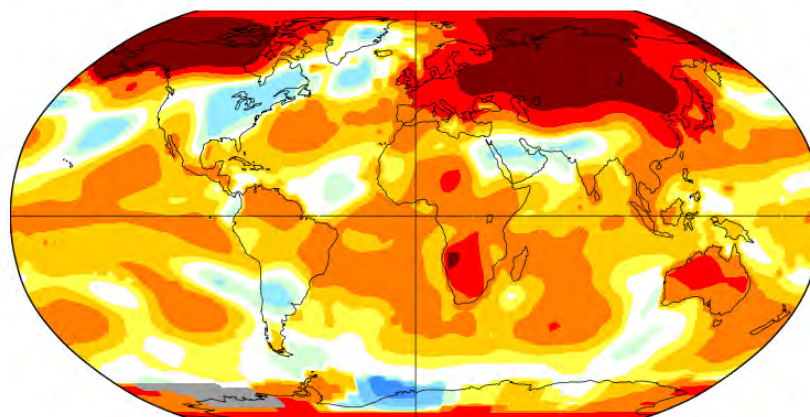


-8.2 -4.0 -2.0 -1.0 -0.5 -0.2 0.2 0.5 1.0 2.0 4.0 12.4

March 2019

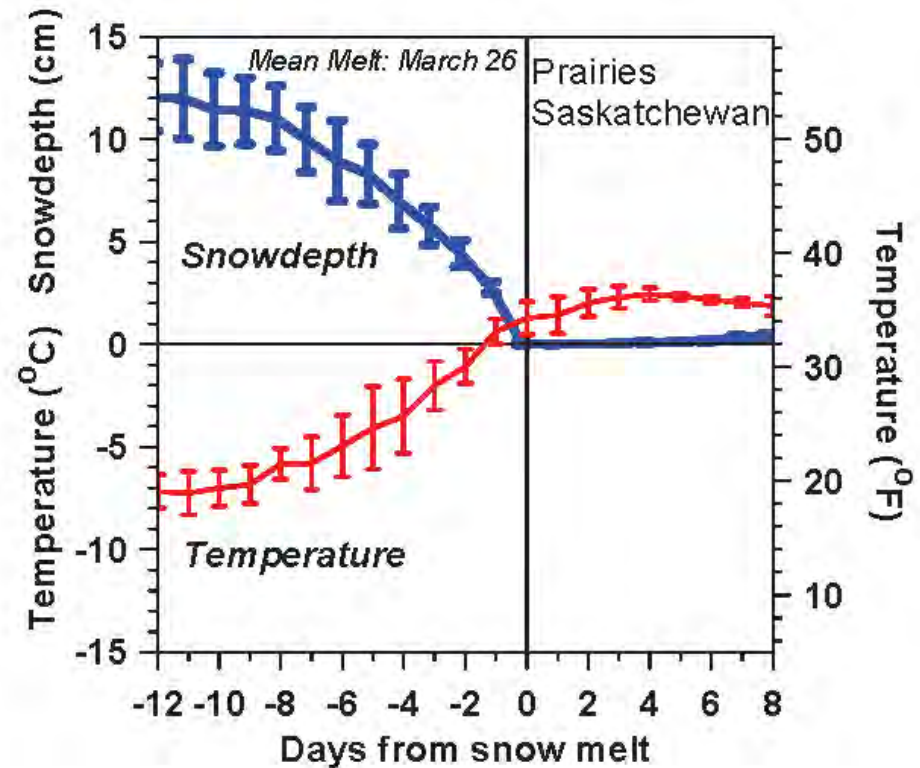
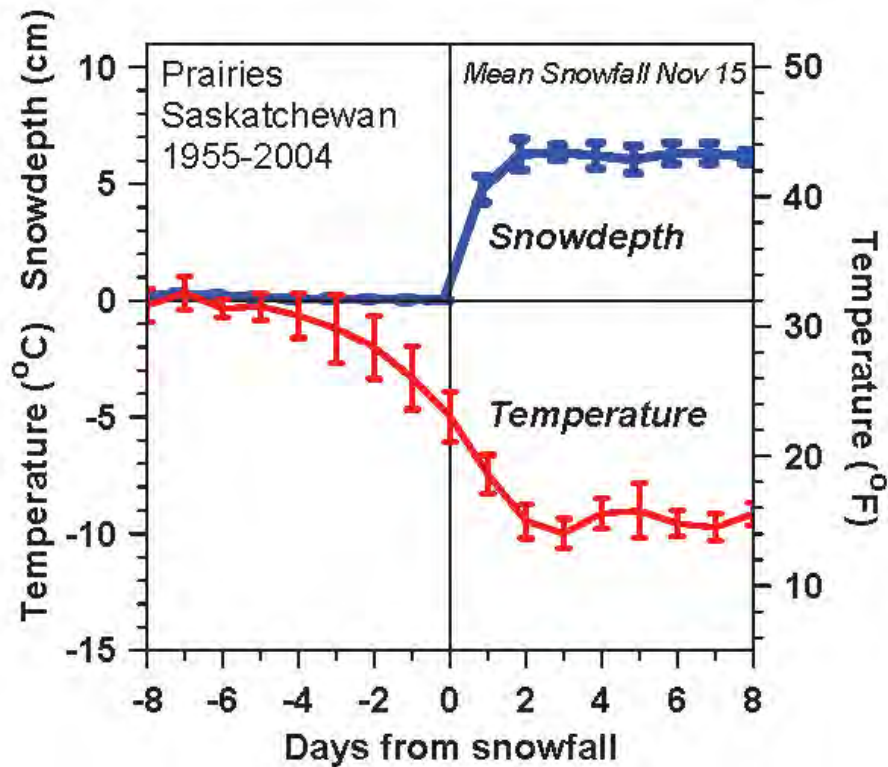
L-OTI(°C) Anomaly vs 1951-1980

1.18



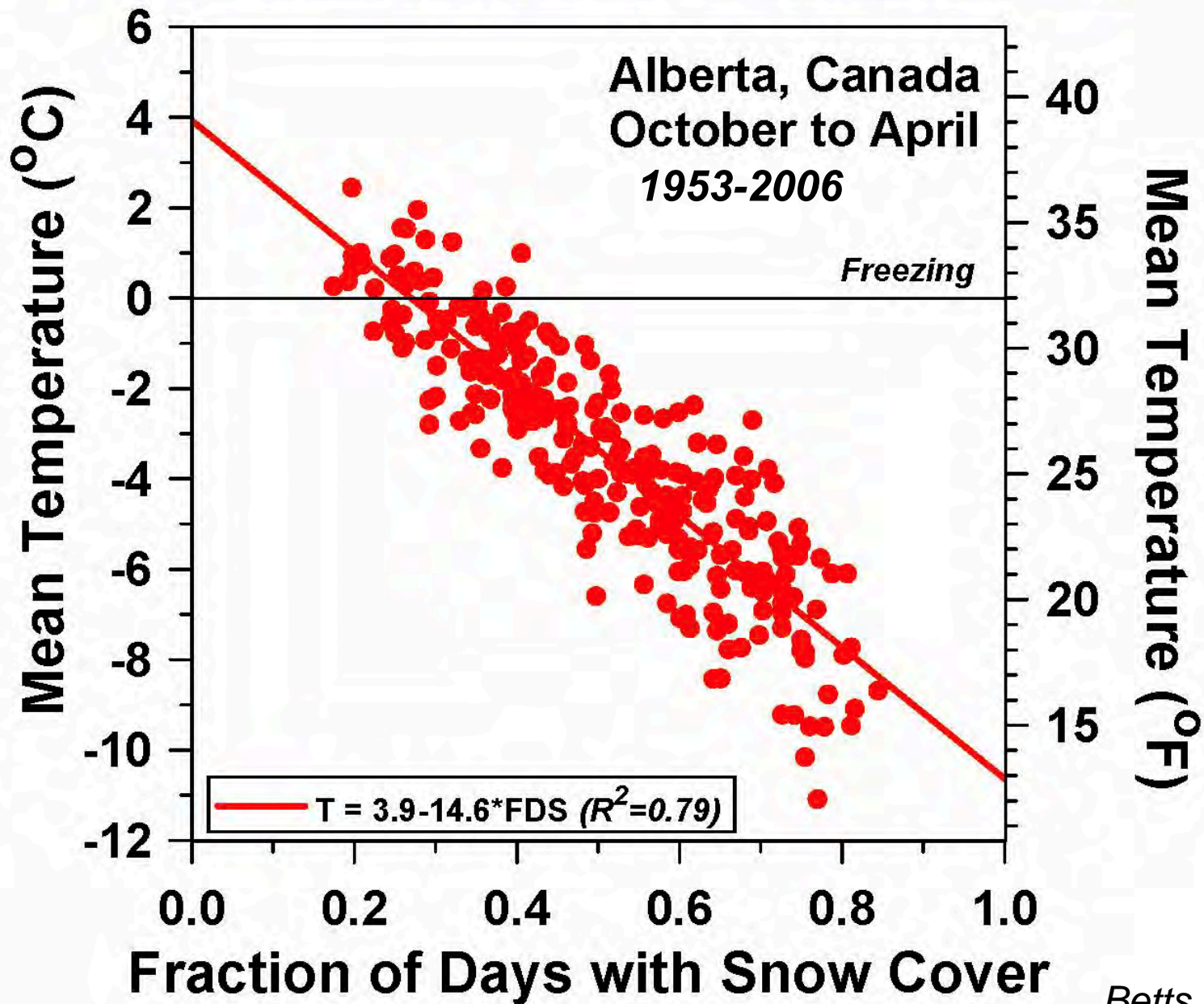
-4.1 -4.0 -2.0 -1.0 -0.5 -0.2 0.2 0.5 1.0 2.0 4.0 13.0

Snowfall and Snowmelt



- Temperature falls 10C (18F) with first snowfall
- And rises again with snowmelt
- *Fast transitions in 'local climate'*
 - *Snow reflects sunlight: Climate Switch*
 - *Reduces evaporation and water vapor greenhouse*

More snow cover - Colder temperatures



Climate and Food

- **Some milder winters and longer growing season in Northeast**
 - Over-winter more crops; start spring crops earlier under cover
 - But increasing variability of winter weather
- **Summer changing also**
 - Increasing precipitation extremes
 - Flood-plain and soil water management
- **Increasing drought in central and western US**
 - Fire threats rising
 - *Critical fresh water issues world-wide*
 - *Many pumped aquifers near exhausted*

Extreme Precipitation Increasing

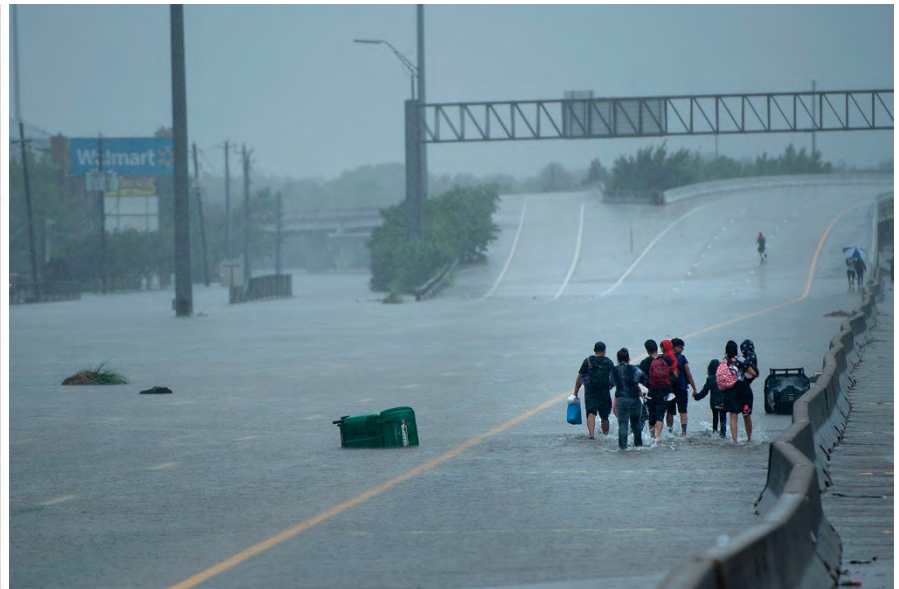
- Vapor pressure and rain rates go up steeply with temperature
- Background drivers
 - Lakes are warming as winter ice shrinks
 - Oceans are warming as GHGs reduce cooling of Earth to space: store 90% of energy imbalance
 - Evaporation goes up steeply as water warms
 - Coastal storms and hurricanes become stronger
 - *Hurricane Maria intensified from Cat 1 to 5 in 24h*
- More *quasi-stationary* weather patterns
 - So it rains for longer
 - *Hurricane Harvey, 4 days over Houston, 10 in/day (2017); Florence, 3 days over NC, 2018*

Hurricane season: 2017

- Earth is warming as greenhouse gases increase and reflective ice cover falls
- Oceans are storing 90% of heat
 - Warmer Atlantic, Caribbean, Gulf of Mexico and Gulf Stream means stronger hurricanes; when vertical shear is low
- *2017: Harvey, Irma, (Jose), Maria*

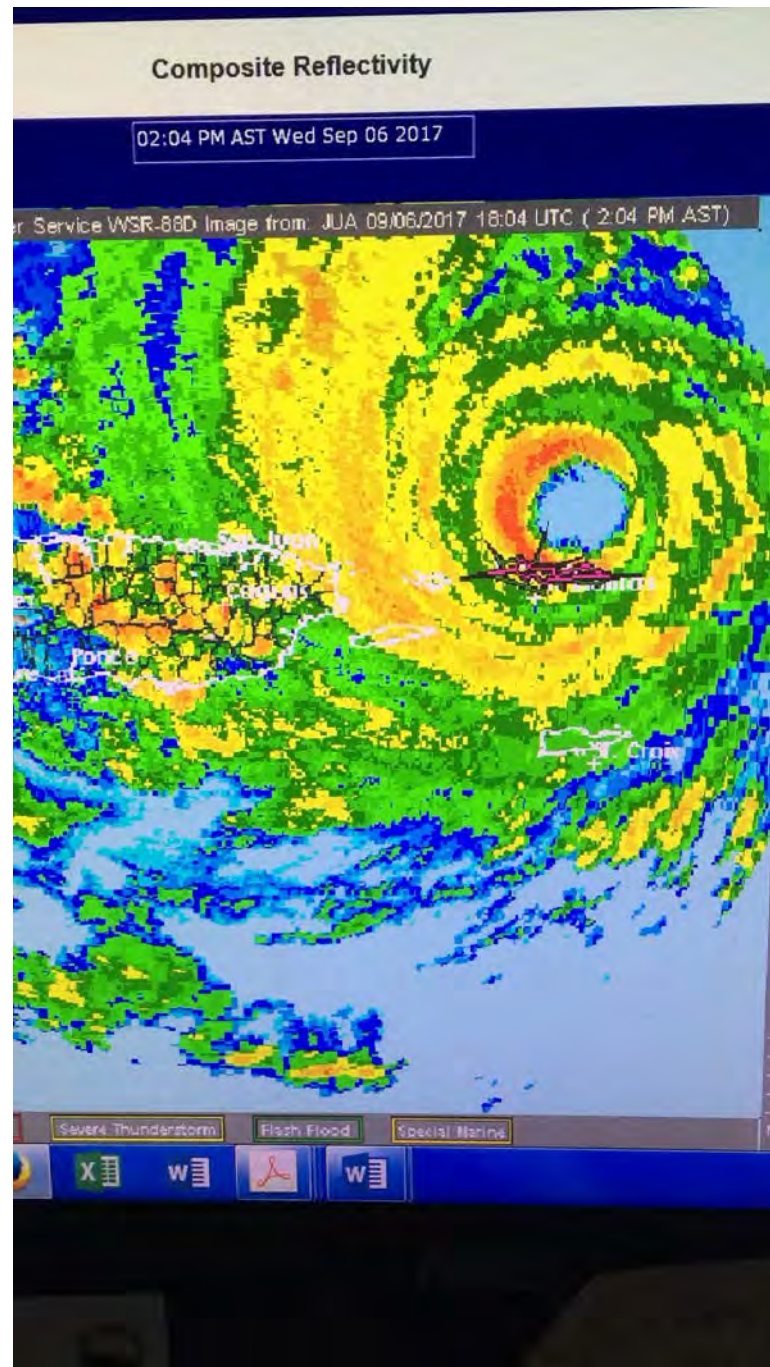
Why was Harvey so Damaging?

- Huge evaporation off warm ocean
- Category 4 hurricane landfall: Aug 25, 2017
Very heavy rain-rate: 10-12 inches per day
- Two stationary high pressure systems to the north **trapped** Harvey for 4 days over Houston
- Result **40+ inches** of rain & massive flooding

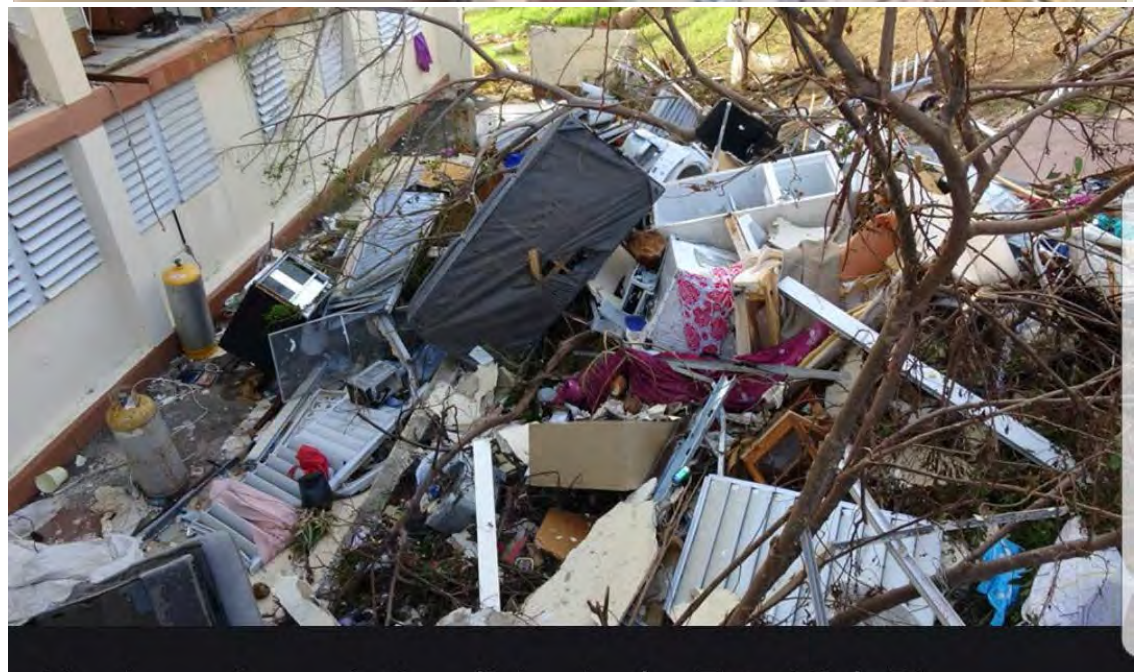


2pm Sept. 6
Category 5*
IRMA
grazing
St Thomas

****Cat 5 >155mph***
IRMA >180mph



Irma(Cat.5)
Sept. 6
St Thomas



Irma and Jose: Sept 7



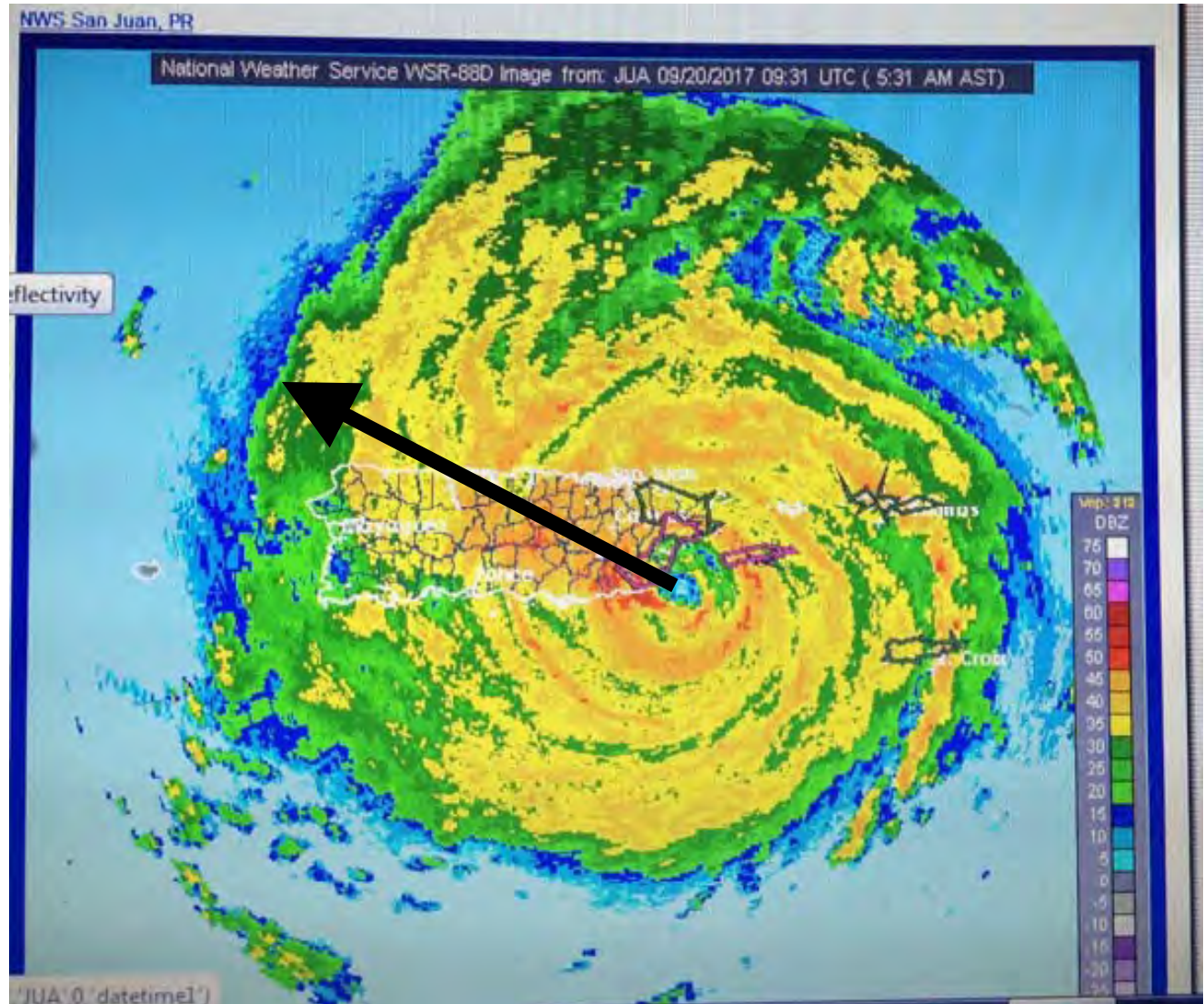
After Jose passed; Catamaran to Puerto Rico on Sept 11

Maria: 5:30am Sept.20,2017

Category 4 hits Puerto Rico

Cat 4
>130mph
Maria
>150mph

***Wiped cell
towers and
power grid
(90% back
after 6 mos!)***



2011 Classic Flood Situations

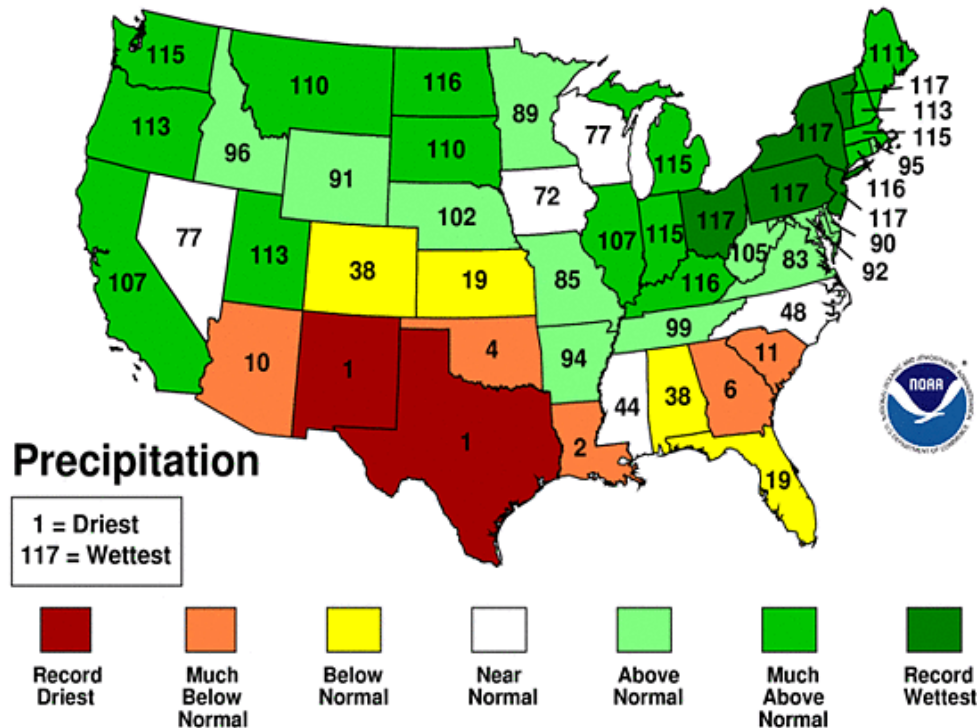
- **Spring flood:** heavy rain and warm weather, melting large snowpack from 2010 winter
 - 70F (4/11) and 80F(5/27) + heavy rain
 - record April, May rainfall: 3X at BTV
 - Severe floods on Winooski and Adirondack rivers
 - Lake Champlain record flood stage of 103ft
- **Irene flood: tropical storm** moved up east of Green Mountains and Catskills
 - dumped 6-8 ins rain on wet soils
 - *Extreme flooding*
 - (Floyd on 9/17/1999 had similar rain - but with dry soils there was less 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
- ‘Quasi-stationary’ pattern
- Arctic is warming faster than tropics

TS Irene

Roads in valleys

Massive damage

**Some roads took
months to repair**

**“Resilient
Communities”**

*Rte 131,
Cavendish, VT
Sept, 2011*



Irene: Resilience

- 13 VT towns cut off overnight
- State emergency systems flooded
- FEMA: no road access
- Communities reorganized overnight
- Those with equipment stepped in
 - “Can fix this in 72 hrs”: will need engineer to check bridge (Brandon)
 - “We worked 120hrs last week...” (Wardsboro)
 - Social networks collected supplies; and rescue services across mountains
 - Communication networks critical

- **The Wardsboro excavator Harvey Plimpton spoke for Vermont's community spirit when he said:** *"Nobody gave us permission. We just started because we knew what had to be done. We put in 120 hours last week. We worked until we couldn't work. We still have a long way to go."*
- ***When a stranded guest took Beth aside to ask what would happen when she ran out of food, she just looked at him, incredulous. "We're a farm," she said finally. "This is where food comes from."***

(Liberty Hill dairy farm, Rochester)

Emergency response

Brandon: Markowski rebuilds gravel Rte 7 in 72 hrs

Pittsfield wedding 8/27:
60 stranded to help!

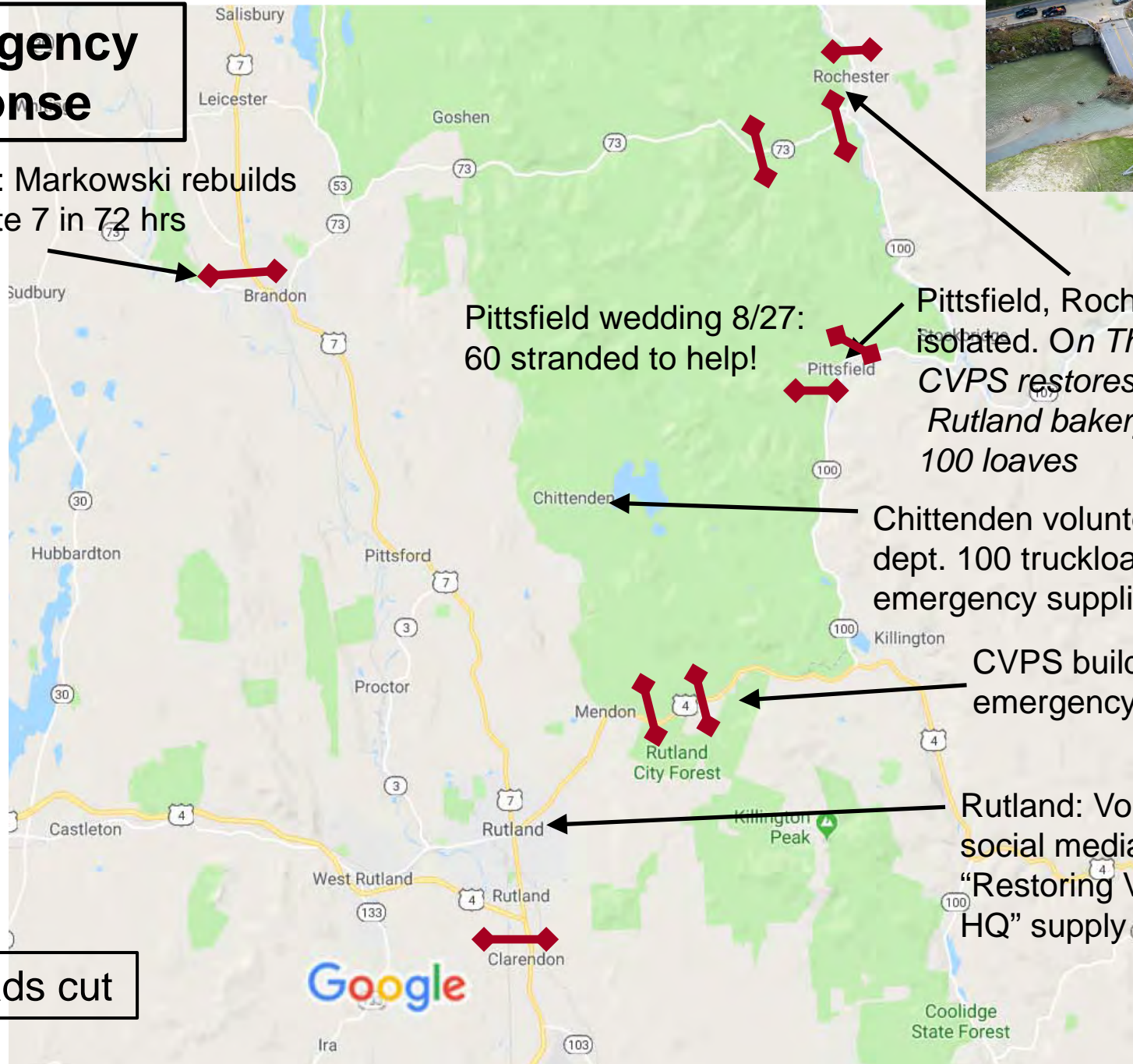
Pittsfield, Rochester isolated. On Thursday CVPS restores power; Rutland bakery supplies 100 loaves

Chittenden volunteer fire dept. 100 truckloads emergency supplies

CVPS builds emergency route 4

Rutland: Volunteers+ social media create: "Restoring Vermont HQ" supply facility

 Roads cut



Morning After Irene

8/29/2011



**Streambank collapse brought
down trees and powerlines**

Value of Flood Plains



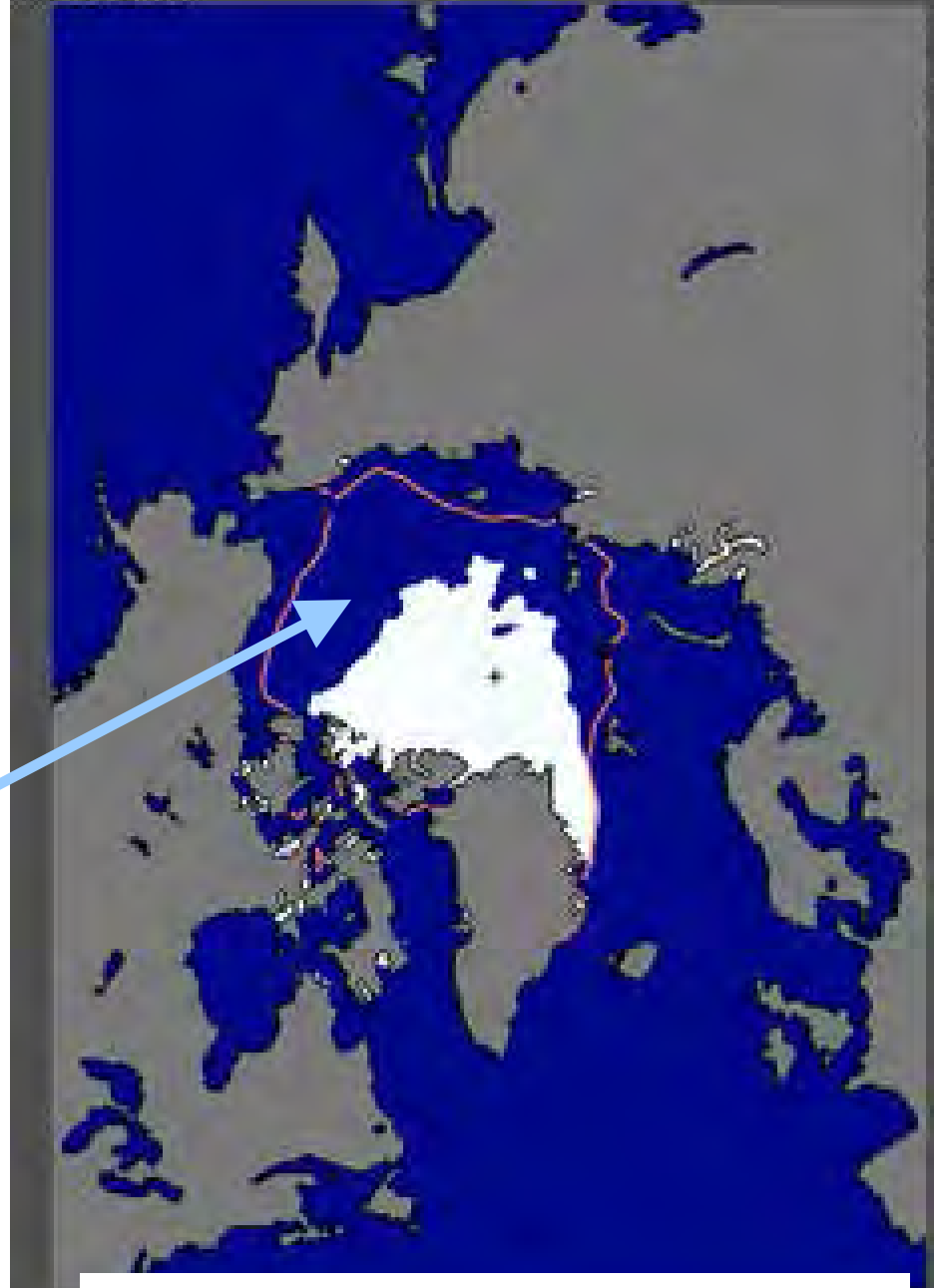
Otter Creek: Aug 30, 2011 after Irene
– rose 10 feet: floodplain saved Middlebury

Flooding Resilience

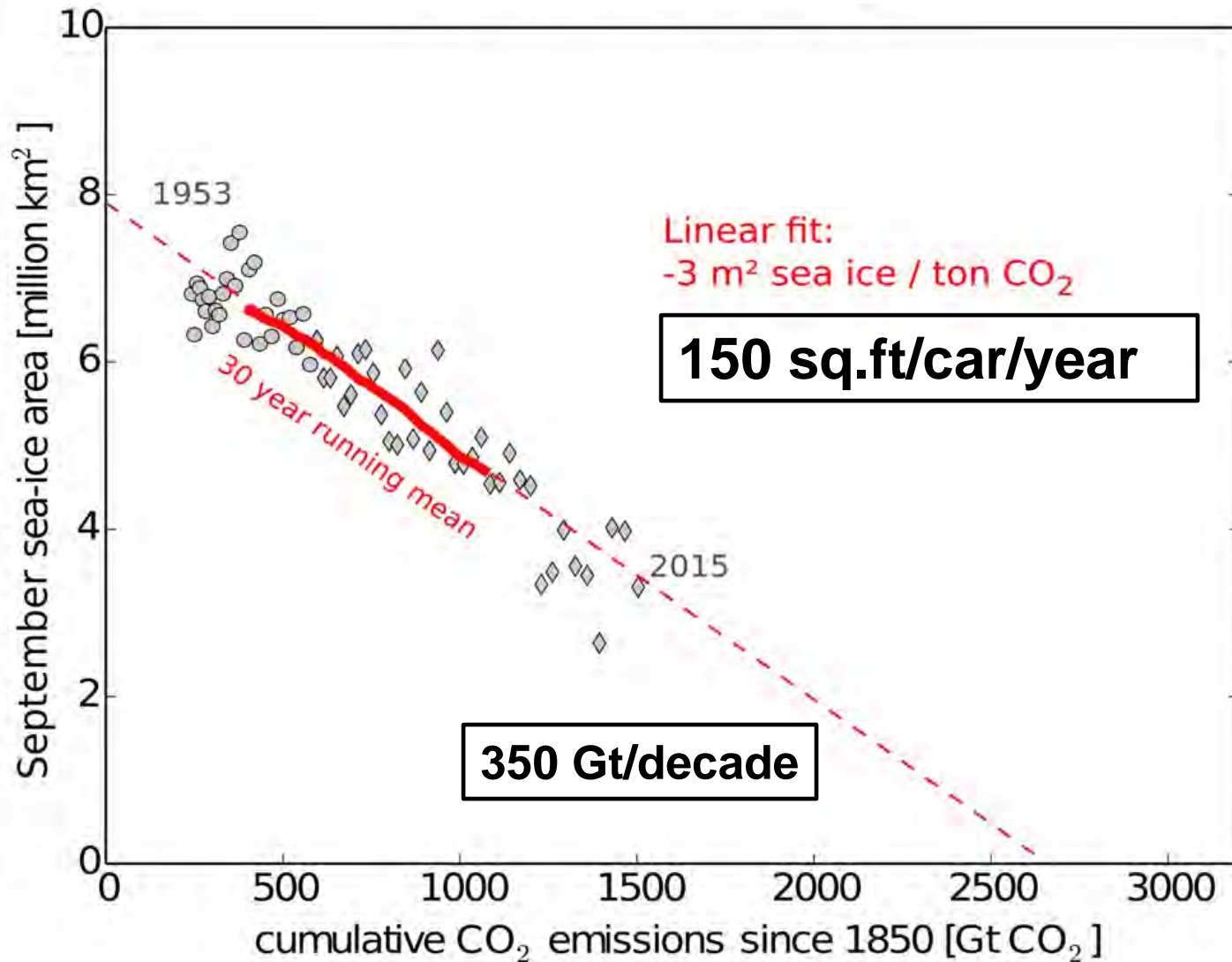
- **Preserve flood plains**
 - Saves downstream towns (Middlebury)
 - Stop building houses and trailer parks in flood plains
- **Manage water on landscape**
 - Maximize infiltration: urban and on farms
 - Don't wall-in rivers!
- **Maintain mountain forest cover**
 - Devastating floods in 20's, 30's with reduced forest cover

- 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
- Polar vortex weakening



September Arctic Sea Ice Loss



Efficient transport

- Gasoline to hybrid: 50% gain to 50mpg
- Hybrid to plug-in hybrid: now 125mpg
- Electricity from community solar array



>3000lbs and 125 mpg Payload: 750 lbs at 55 mph
Prius Prime

Lightweight: near-zero energy (half the speed)



**20+ mph US Radwagon
72 lb cargo bike**



**20+ mph Organic Transit ELF:
180lb – carries kids**

Need bike paths to separate from trucks

Change of mindset: improves health and resilience

Big Picture Issues

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 & oil shale reserves are enough to push CO₂ to 1,000 ppm**
 - **in time melt icecaps, raise sea-level 150ft**

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 economic, technological and financial system driven by short-term profit
 - *Put systems-thinking above profit!*
- Needs deep community discussion
 - *New values that respect the Earth*

Ethical issues must be faced

- **Do we just exploit the Earth's wealth**
 - For greater 'economic growth' & a wealthy few
 - How will our children live? Are we going to sacrifice them to protect 'our way of life' ?
 - Or will we train, empower and fund them to drive the change that is needed?
- **Fundamental moral Issue**
 - Don't we need to co-operate with the Earth and save its ecosystems? Of course!
 - *Shift in understanding and mind-set needed*

Sustainability Issues

- **Reeducation of society and its 'systems'**
 - 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
 - Fresh water supply not critical in VT, but is elsewhere
- **Examine all waste-streams**
 - Aim to recycle/remanufacture & fully cost waste-streams
- **Default energy use should be 'OFF'**
 - Maximize energy efficiency: housing, transport, power
 - Add renewable power and microgrids; backup networks
- **Relocalize food system**
 - Compost all organic waste
- **Manage forests for changing climate**
- *Reconnect with natural world*
 - *Fundamental if we are to accept transition*

Community is Central

- You can't deal with environmental issues alone
 - They were created by societies over time
 - You need a community to weigh the evidence, search for creative solutions, and tell the truth
 - For moral support: *to confront with clarity & hope those **who resist and oppose***
 - *You need grounding in yourself & in a group*
- *You need Earth system support*

- *“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

Discussion

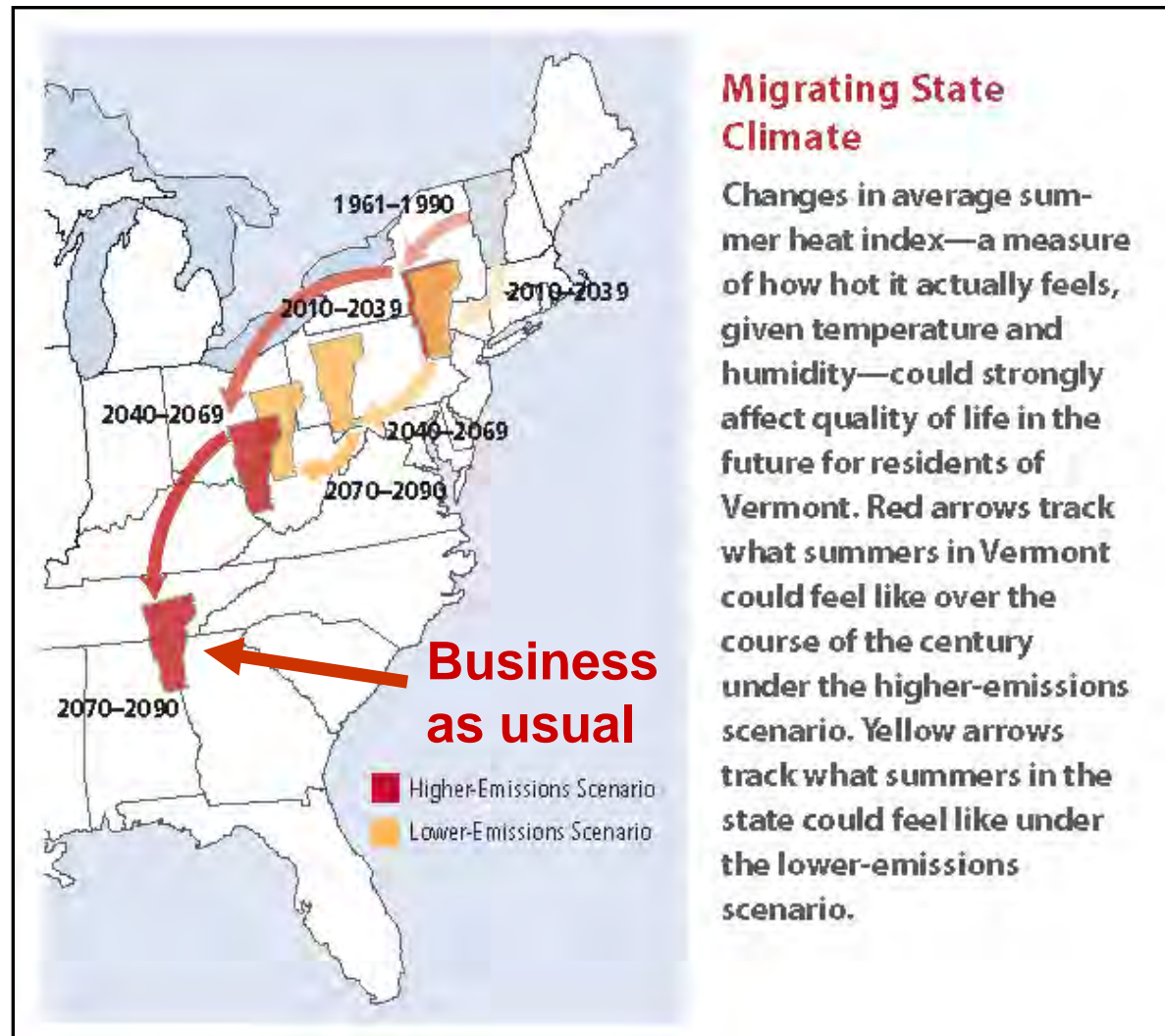
alanbetts.com

writings, talks and research

Vermont's Future with High and Low GHG Emissions

What
about VT
forests?

Sub-tropical
drought areas
moving into
southern US



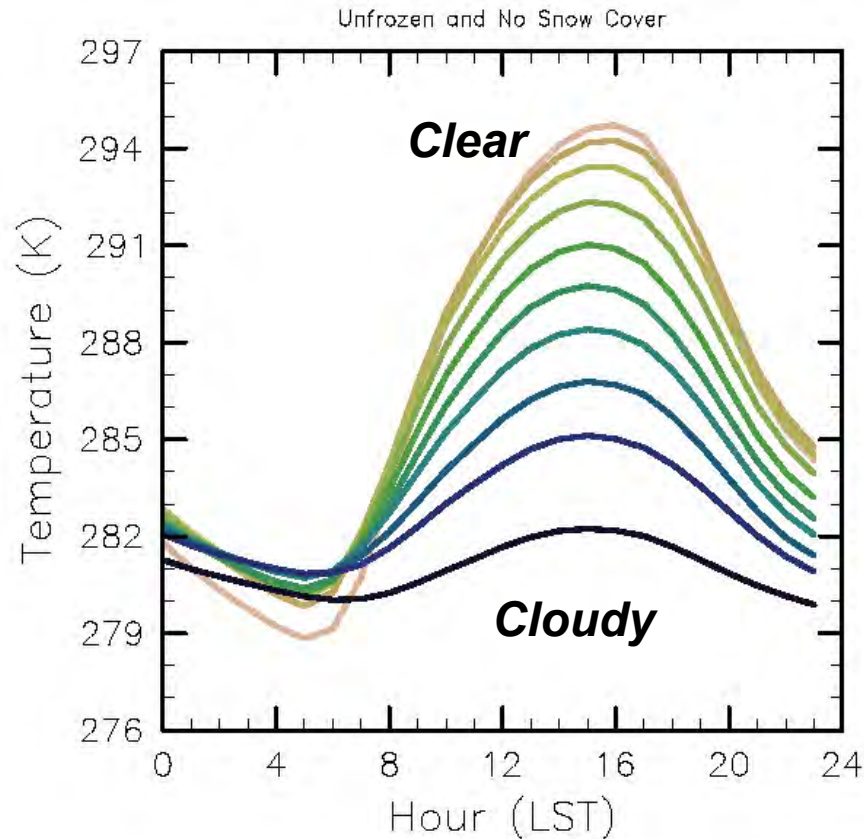
**NECIA,
2007**

Health Issues

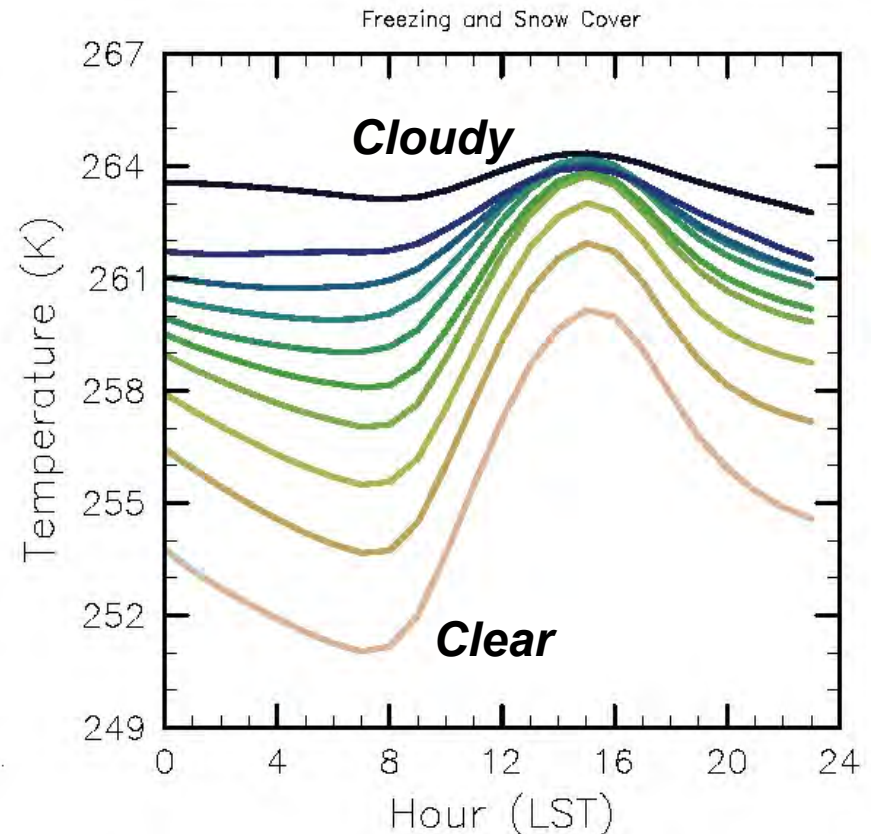
- **Higher temperature extremes**
 - Offset by wet summers in Northeast
- **Winter survival of pests**
 - **Blacklegged Tick (Deer Tick):** A warming climate, combined with the spread of the invasive shrub Barberry, has allowed this pest to expand its range to the entirety of Vermont. This invasive is responsible for the spread of Lyme disease throughout New England.
- **Mosquito-borne diseases – EEE/West Nile**
 - Increased summer breeding: *nine out of ten recent summers have had well-above 'average' rainfall*

Warm & Cold Climates: $T > < 0^{\circ}\text{C}$

$T_m > 0^{\circ}\text{C}$: no snow: 150,000 days



$T_m < 0^{\circ}\text{C}$: snow: 75,000 days

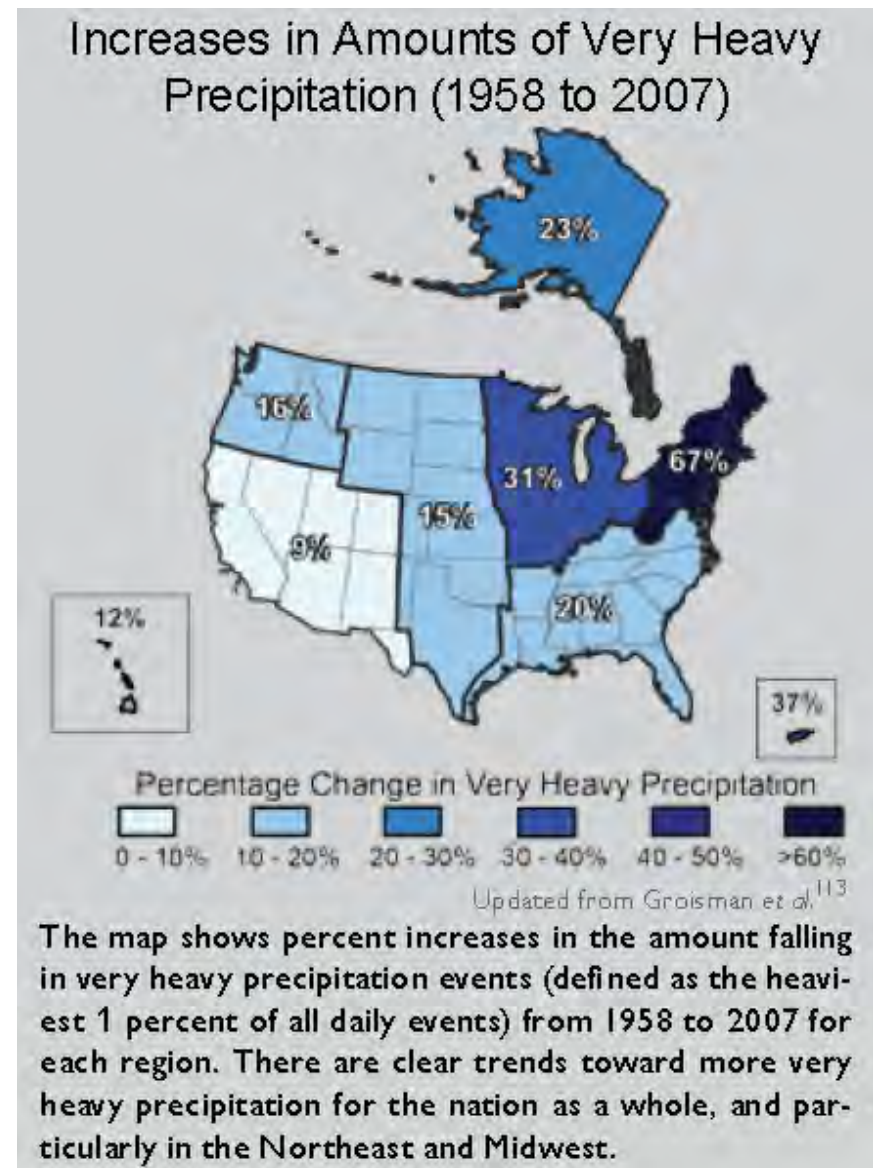


- **Warm $> 0^{\circ}\text{C}$: Clouds reflect sunlight**
- **Cold $< 0^{\circ}\text{C}$: Clouds are greenhouse & snow reflects sun**

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**



Systems Engineering Guidelines for a Sustainable Society

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

Vermont Newspaper Columns

Environmental journalism revisited (Betts and Gibson 2012)

2008-2019: 110 articles: “They blend science with a systems perspective, and encourage the reader to explore alternative and hopeful paths for themselves, their families and society”

(Rutland Herald and the Barre-Montpelier Times Argus)

Today’s communities must understand the connections between energy use, climate and food to make the transition to an efficient, resilient and sustainable society.

(alanbetts.com/writings)