

# Climate Change, Hurricanes and Extreme Weather

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

**Catholic Climate Covenant Webinar**

***November 2, 2017***



# Fundamentals

- **Burning fossil fuels: transforming climate**
  - Water cycle accelerates changes
  - Heading for high CO<sub>2</sub> “Carboniferous era climate”
  - Earth warming: 90% of heat stored in oceans
  - **Climate extremes increasing**
- **Linked to unmanaged technology/waste streams**
  - 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*
- ***Choices based on moral values essential***
  - *Science and economics need guiding*
  - *[Guidance is now based on profit and exploitation]*

# Our Present Challenge

- **How to integrate all that we know, understand and value**
  - *given the deep interconnectedness of life & climate on Earth*
  - *given immense opposition to change (and fear of change)*

## Earth's climate sustains life

- Burning fossil fuels increases greenhouse gases
- LW cooling to space reduced
- **Climate warms**
  - Oceans warm
  - Evaporation up
  - Water vapor up
  - Ice is melting
  - Extreme weather is increasing
- Weather patterns changing/slowing

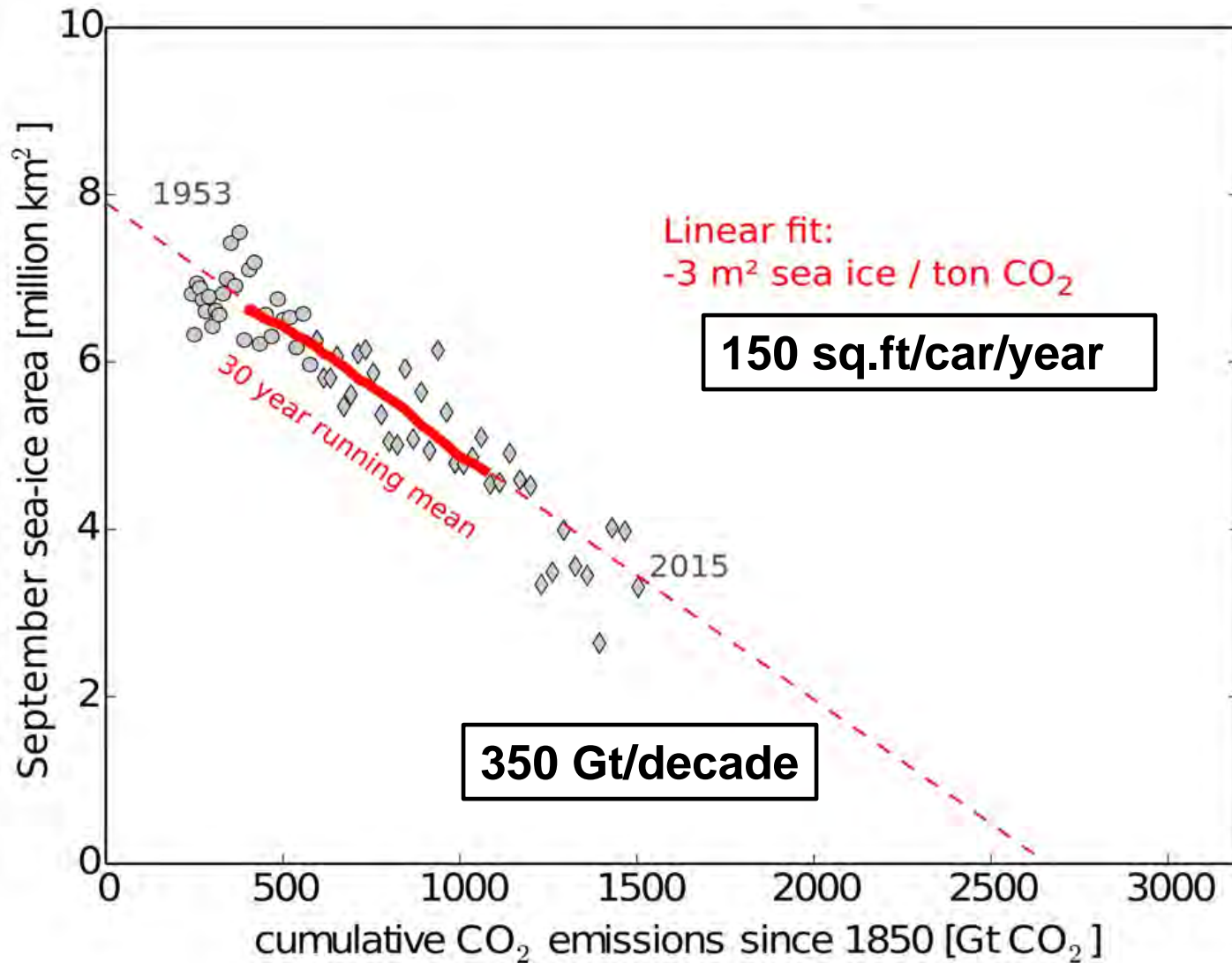


- **Half the Arctic Sea Ice Melted in 2012**
- **Open water in Oct. Nov. gives warmer Fall in Northeast**

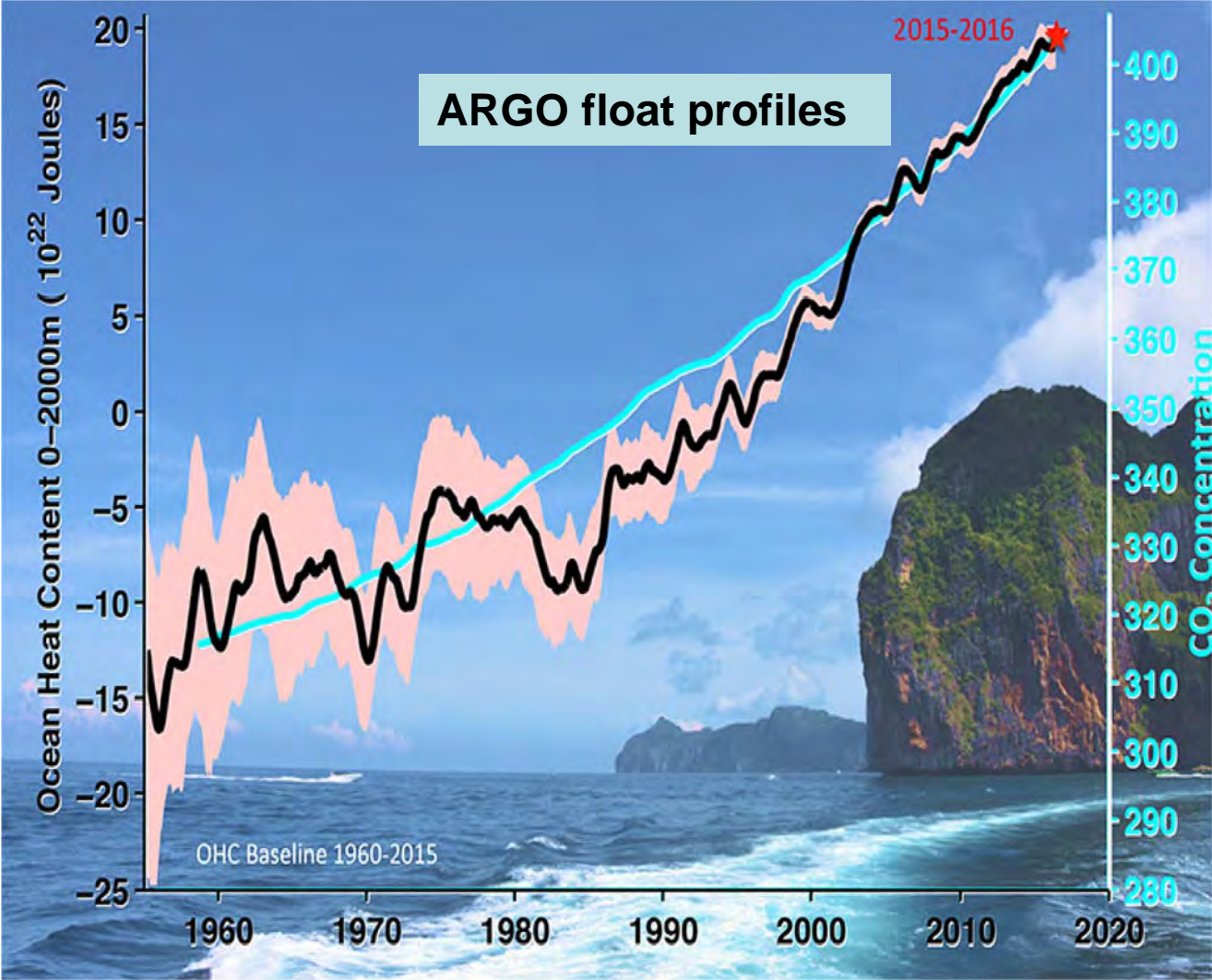
- *Feedbacks amplify:*
- *Less ice, less reflection of sunlight*
- *More evaporation, larger vapor greenhouse effect*
- *Same feedbacks as in our winters*



# September Arctic Sea Ice Loss

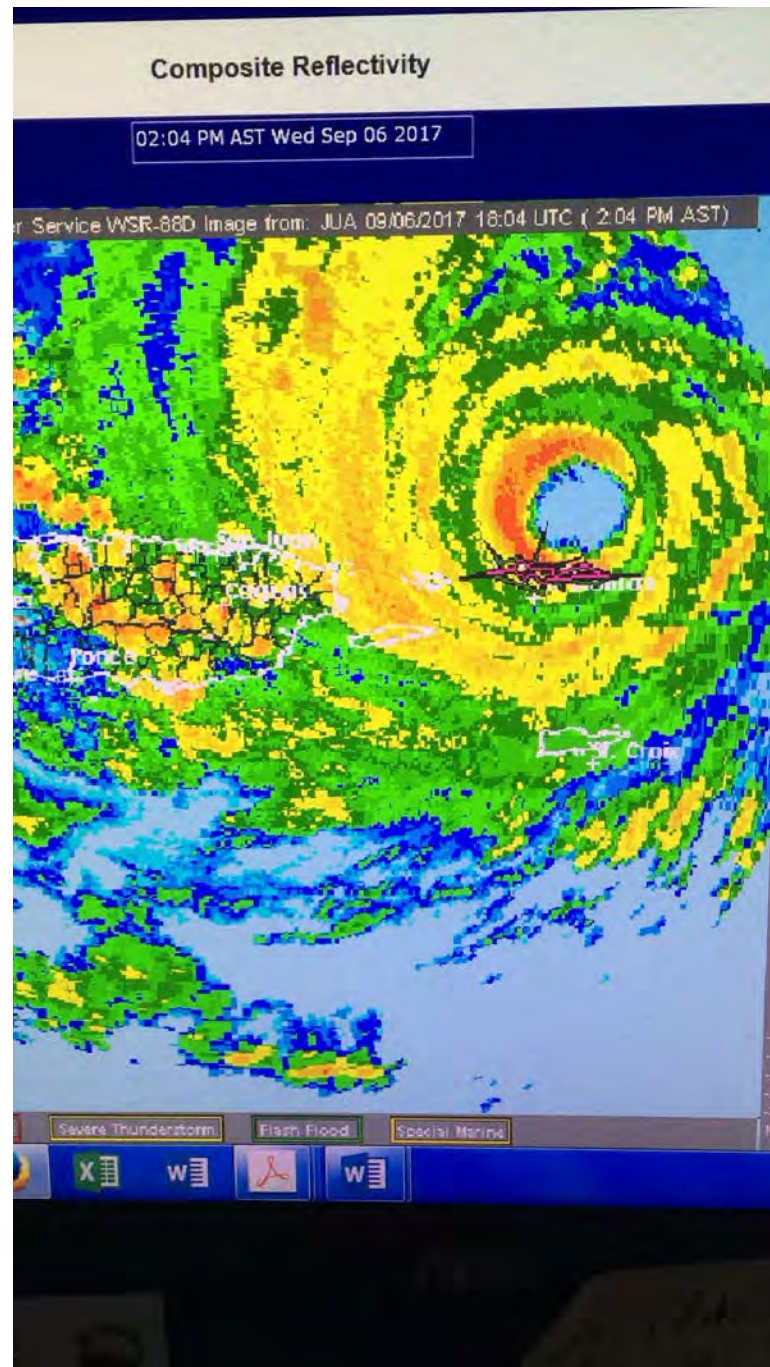


# Ocean Heat Storage – CO<sub>2</sub>



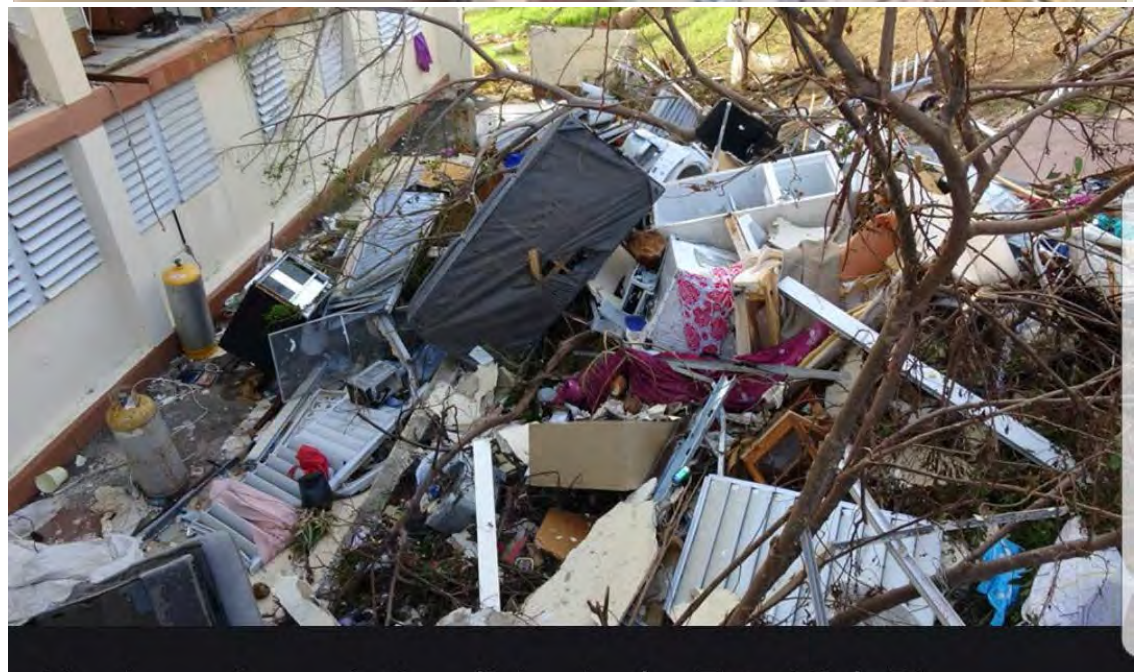
**2pm Sept. 6**  
**Category 5\***  
**IRMA**  
**grazing**  
**St Thomas**

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





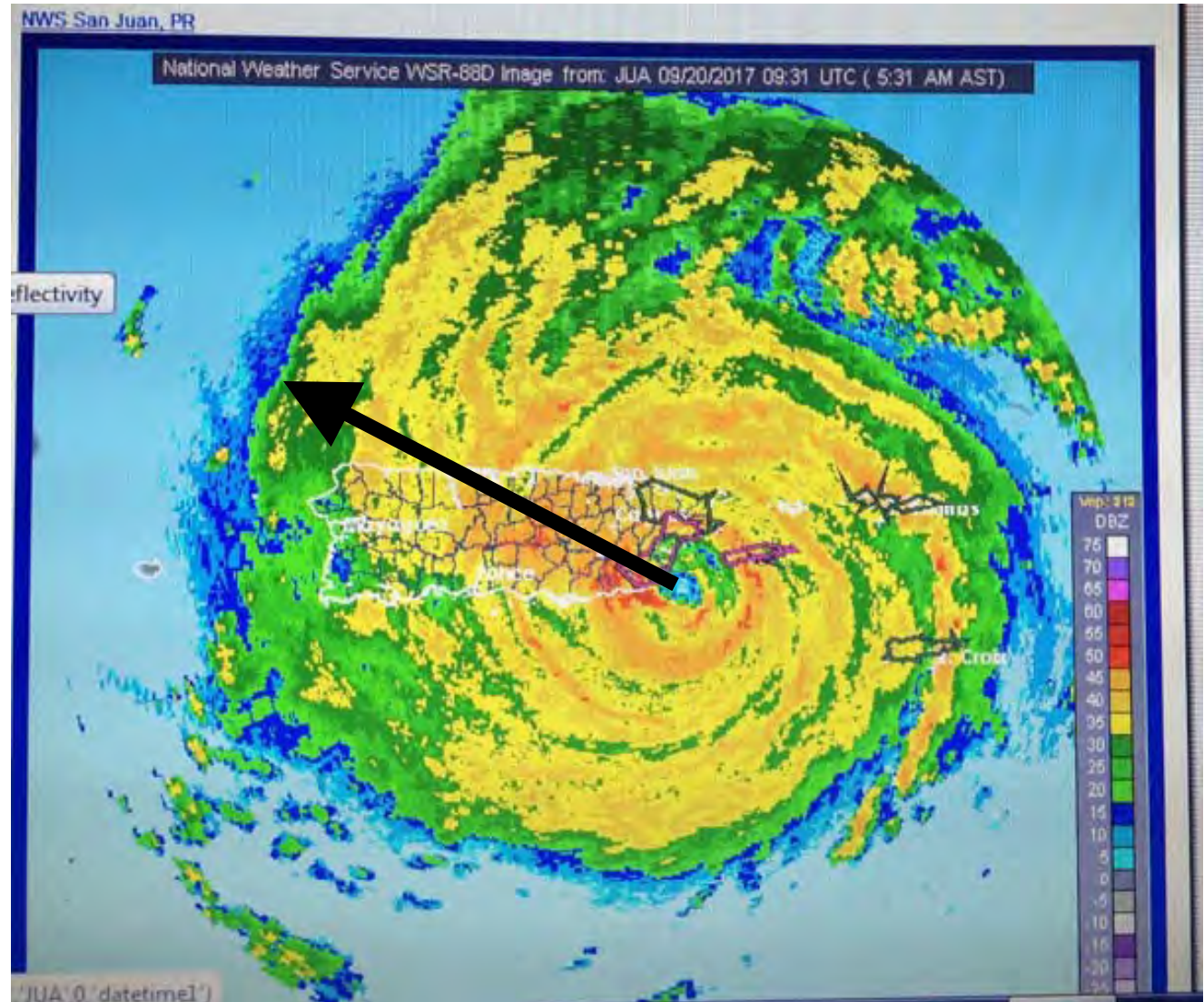
**Sept. 6**  
***Irma***  
***(cat.5)***  
**St Thomas**



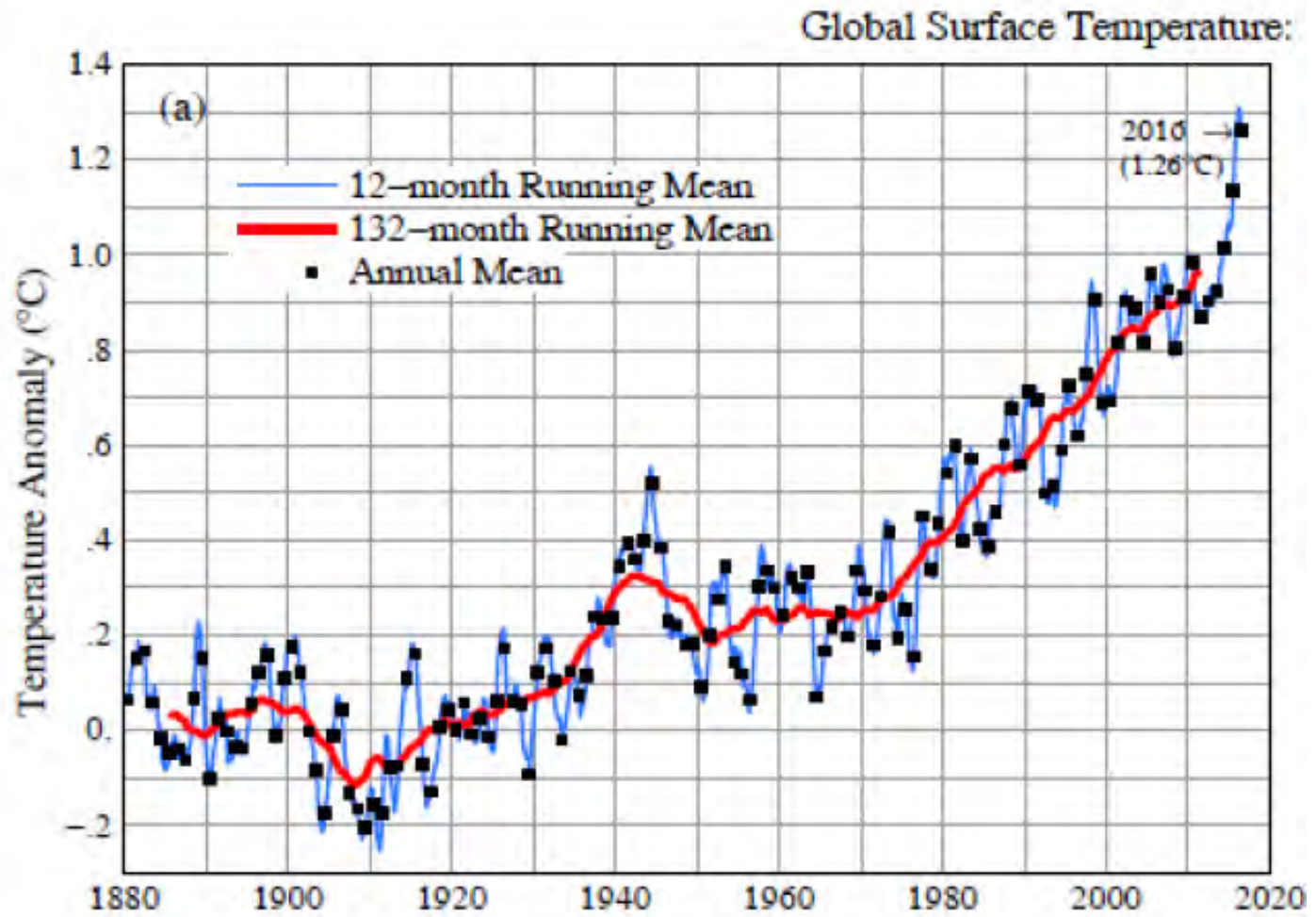
# ***Maria: 5:30am Sept. 20***

## ***Category 4 hits Puerto Rico***

**Cat 4**  
**>130mph**  
**Maria**  
**>150mph**



# 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)

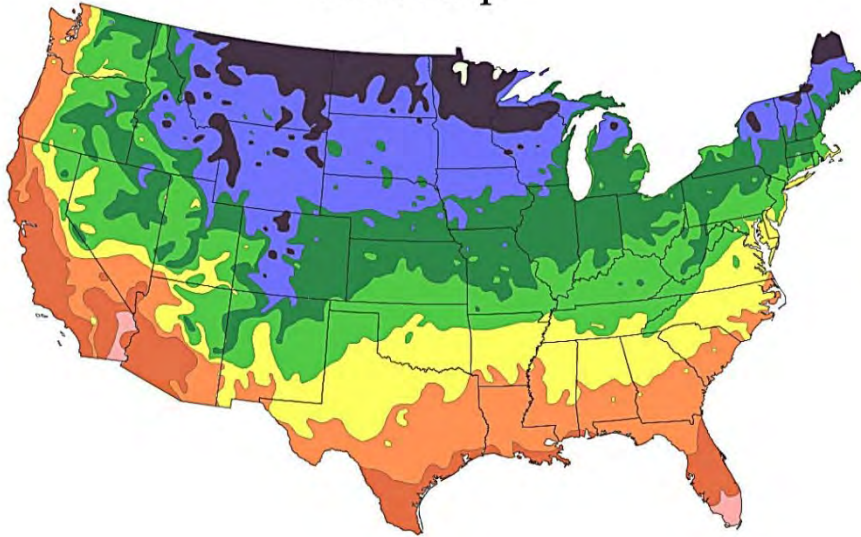


**March 3, 2017**



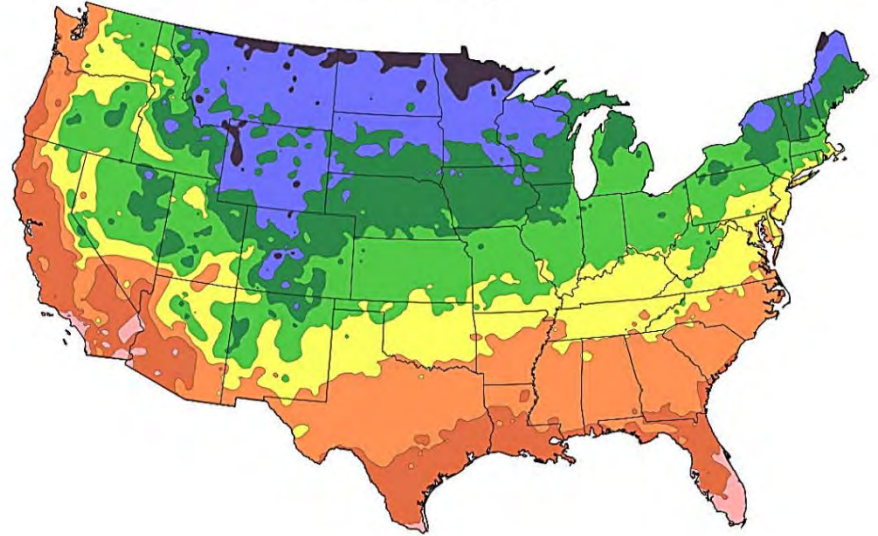
# Plant Hardiness Zones

1990 Map



After USDA Plant Hardiness Zone Map, USDA  
Miscellaneous Publication No. 1475, Issued  
January 1990.

2015 Map



Arbor Day Foundation Plant Hardiness Zone  
Map published in 2015.

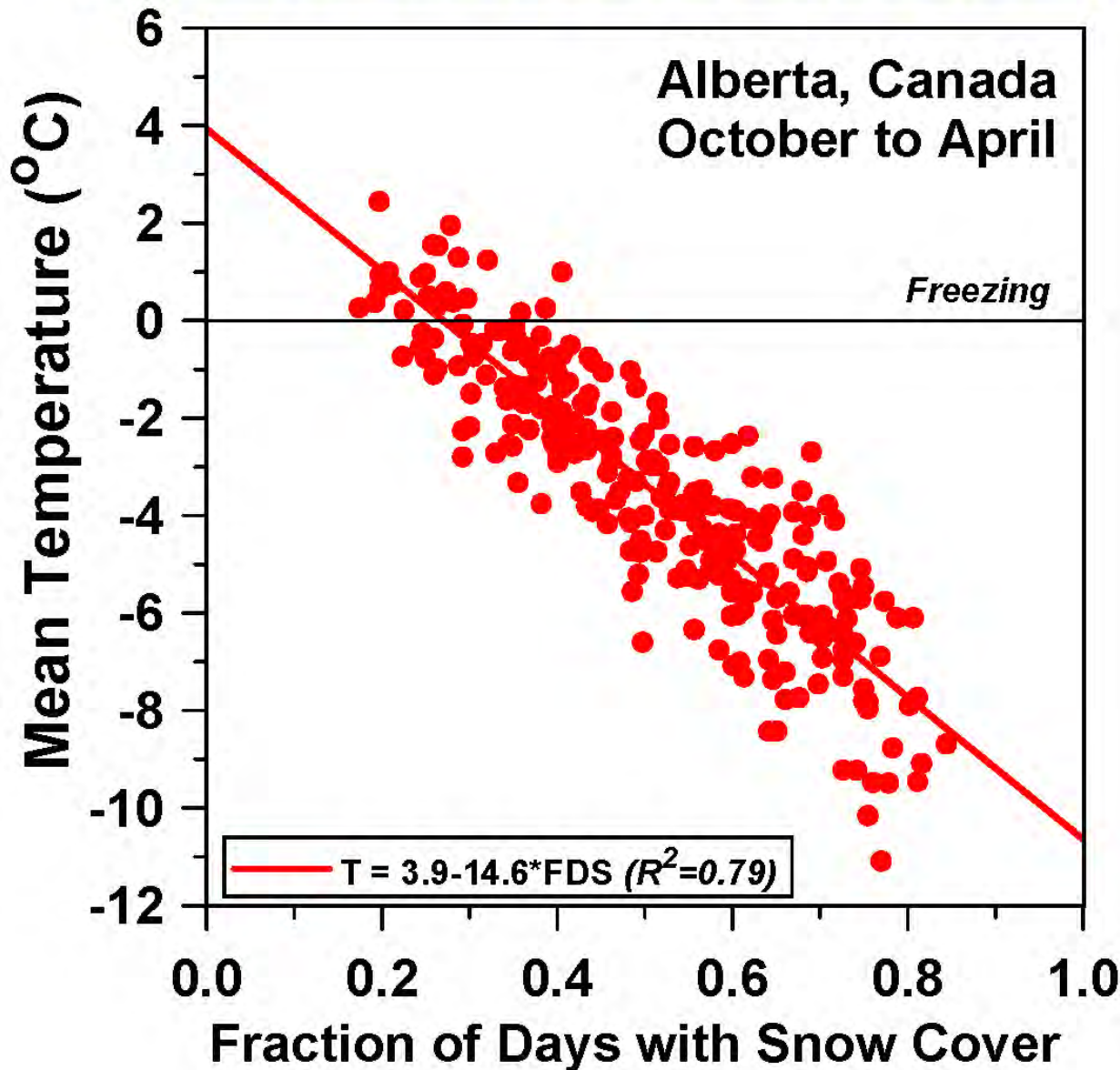
Zone



© 2015 Arbor Day Foundation®



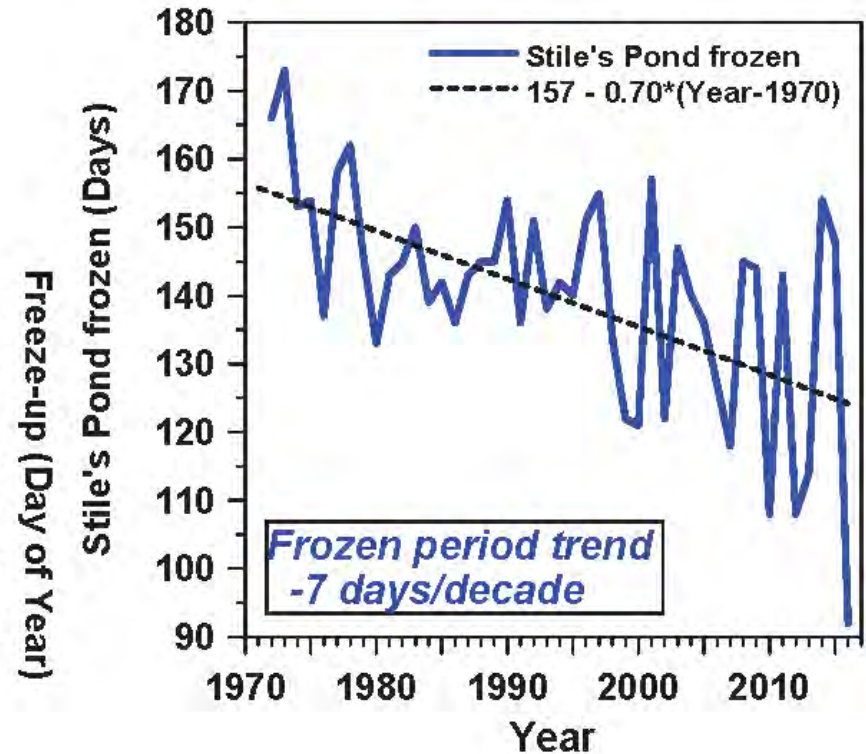
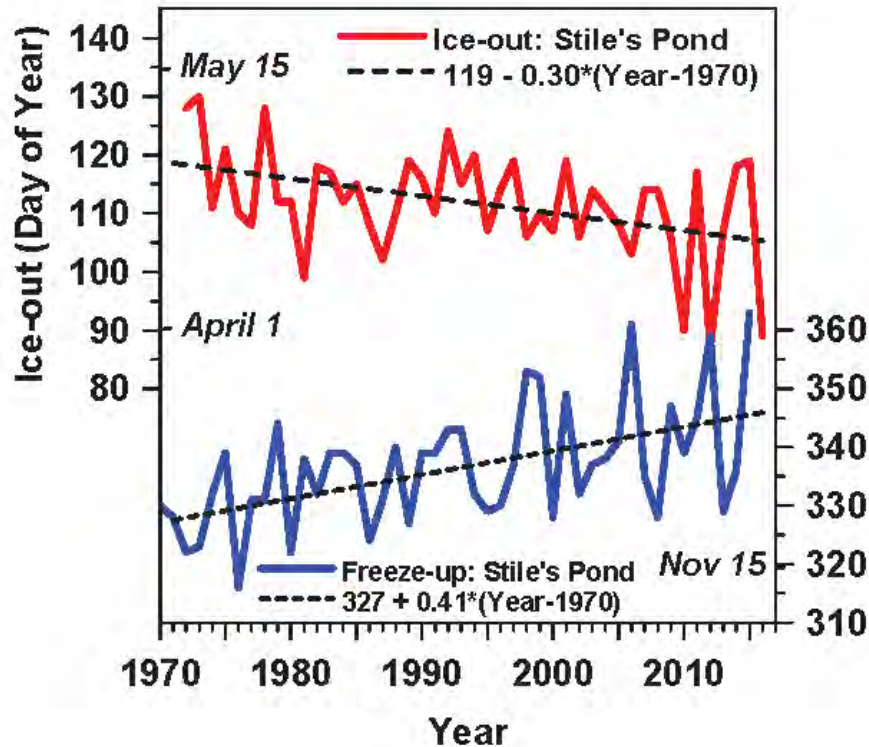
**More snow cover - Colder temperatures**



Winter is colder if more snow cover

# Lake Freeze-up & Ice-out Changing

## 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**

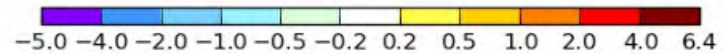
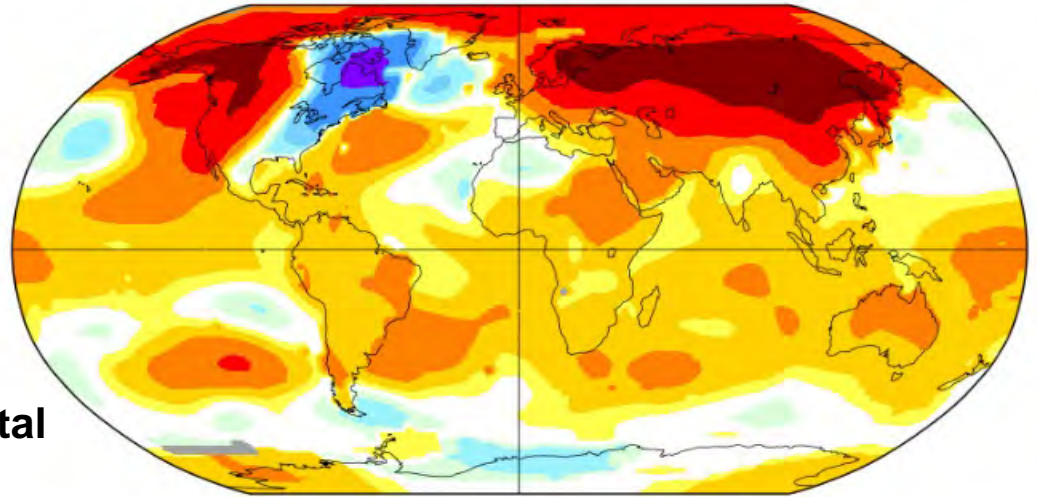
# Jan-Feb-Mar 2015

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

Jan-Mar 2015

L-OTI(°C) Anomaly vs 1951-1980

0.86



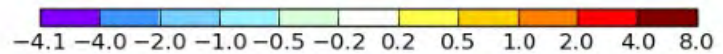
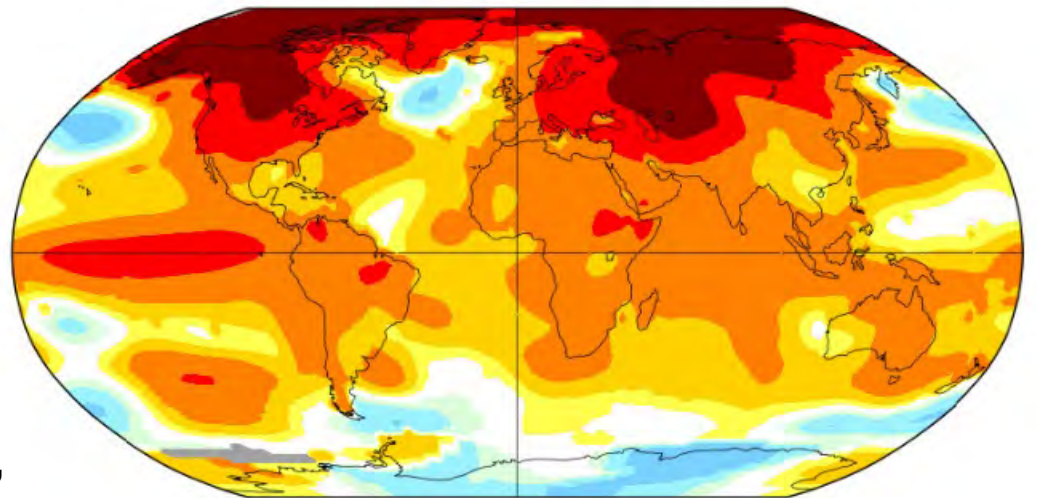
# Jan-Feb-Mar 2016

Warm Atlantic, warm NE, little snow, warm Arctic

Jan-Mar 2016

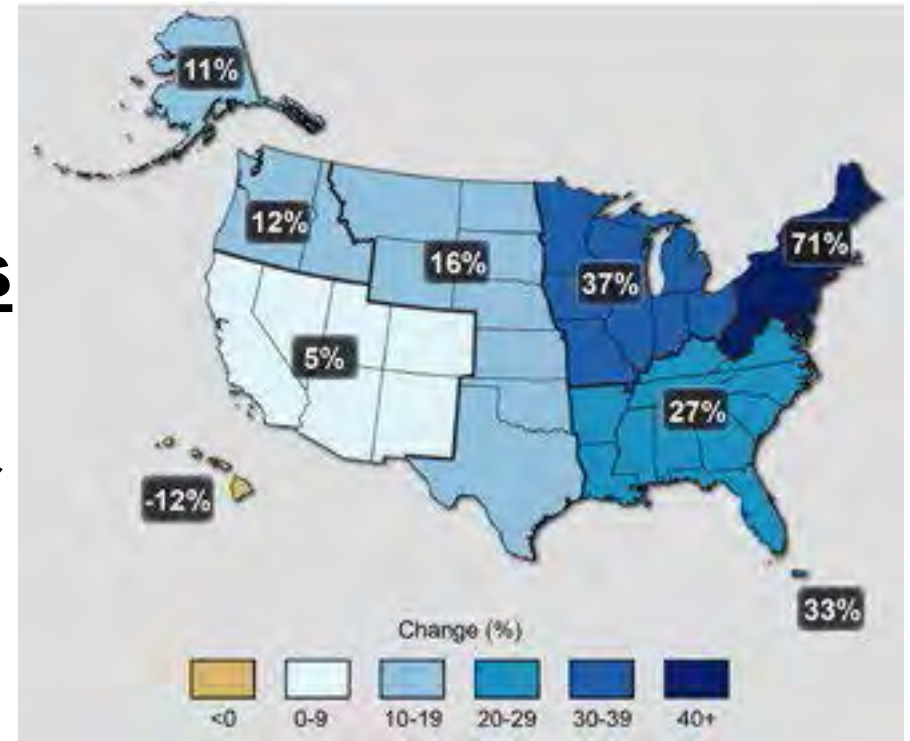
L-OTI(°C) Anomaly vs 1951-1980

1.24



# 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.**



*(Walsh et al., 2014)*

- **71% increase in Northeast**

# TS Irene: 2011



Brattleboro, VT, Courtesy of Caleb Clark, CNN



Brattleboro, M. Reston



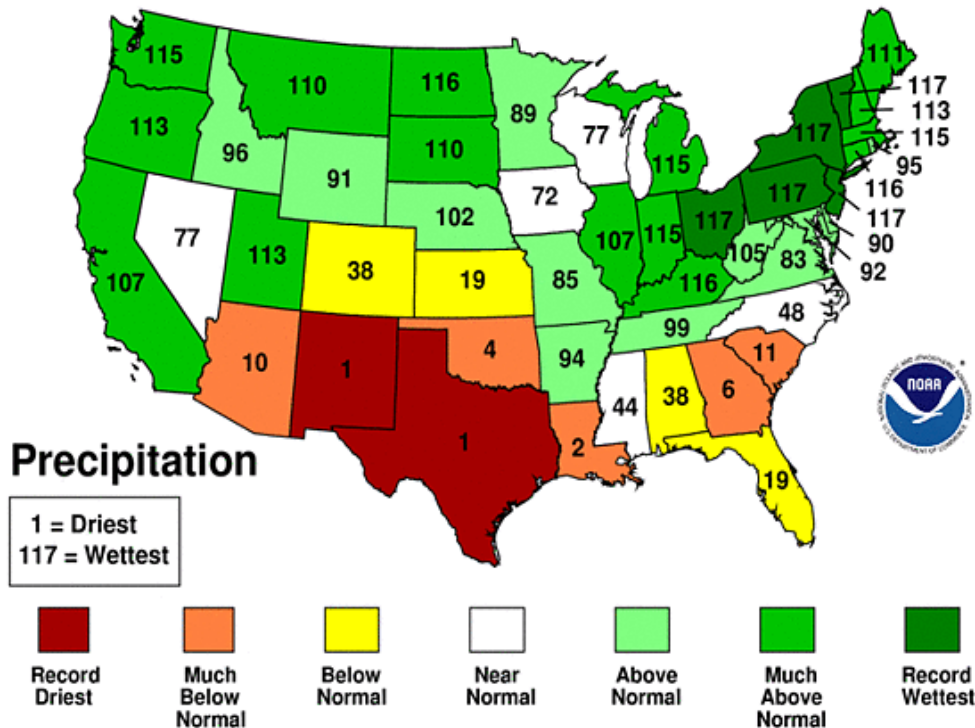
Wilmington, J. Cantore

# 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**

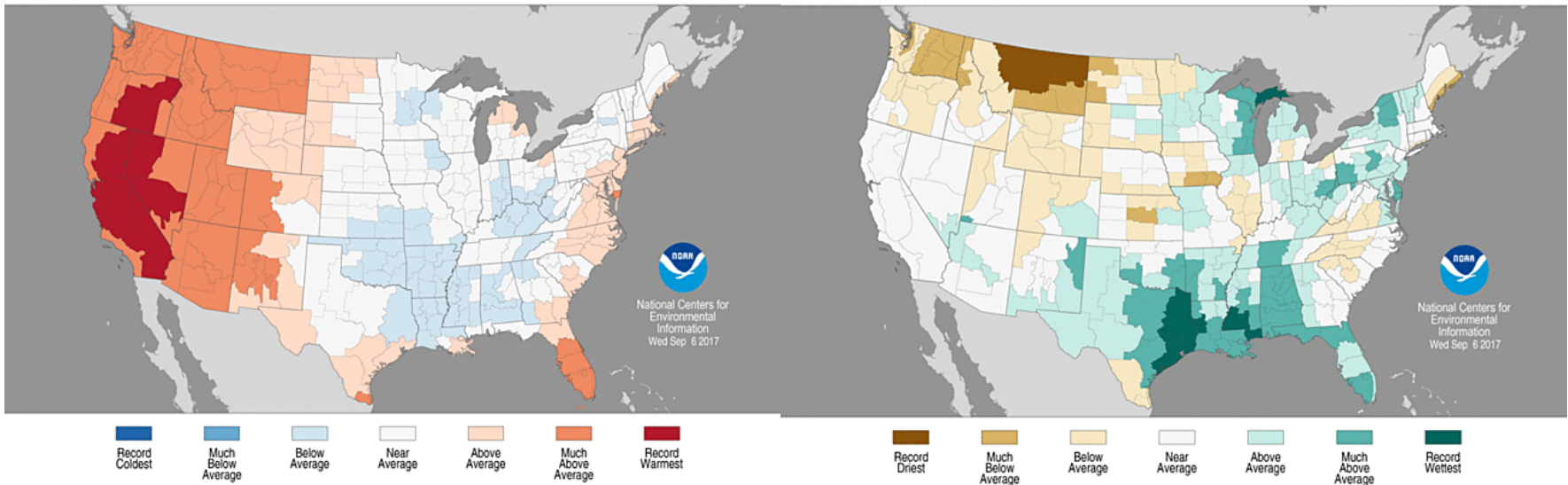
# Warm Dry Climate Extremes Lead to Widespread Fires

**Jun-Jul-Aug, 2017**

*(West: hot and dry after wet winter  
South: cool and wet with Harvey)*

Divisional Average Temperature Ranks  
June–August 2017  
Period: 1895–2017

Divisional Precipitation Ranks  
June–August 2017  
Period: 1895–2017



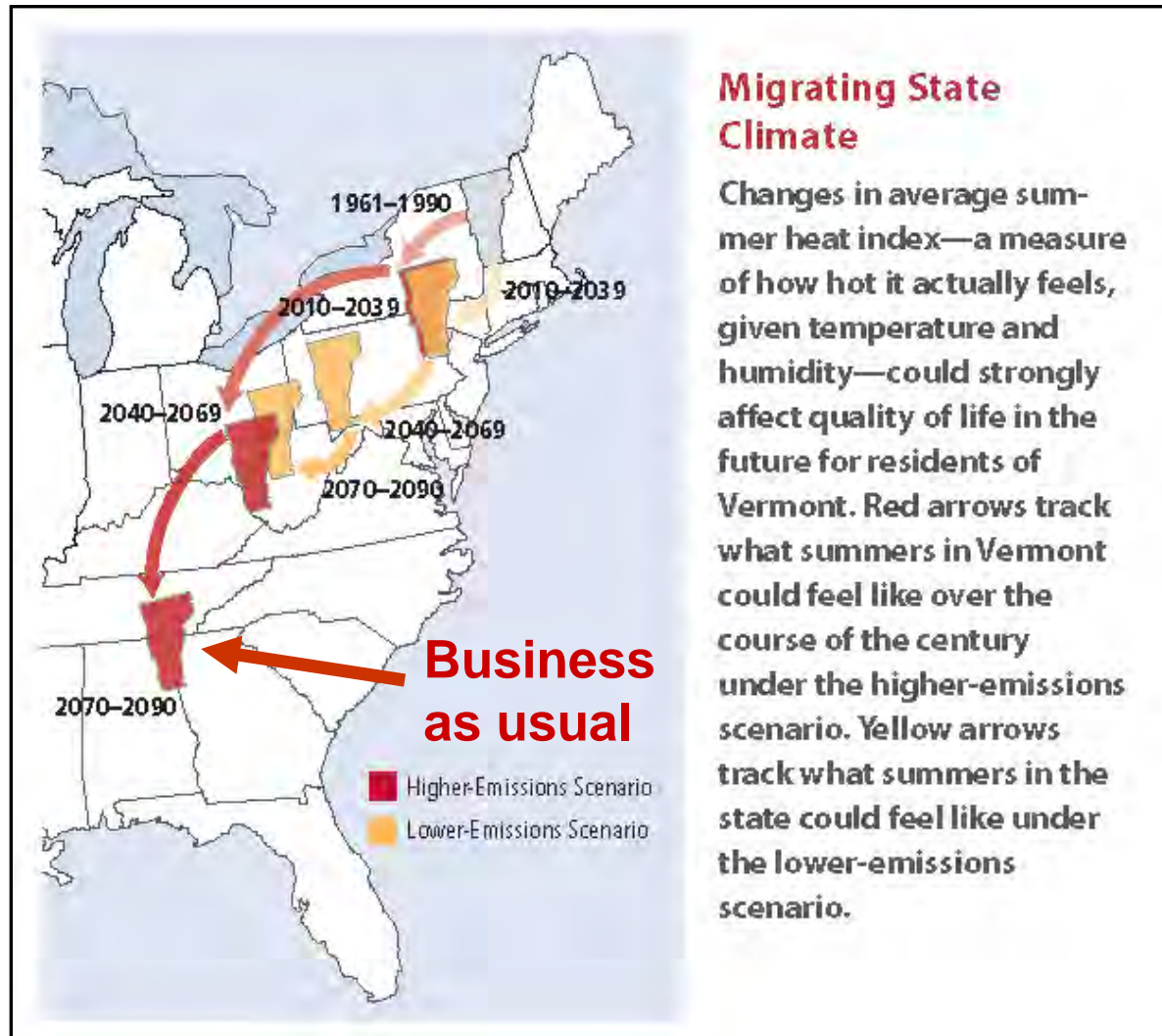
**Caused severe fires in western US and Canada**



# Vermont's Future with High and Low GHG Emissions

What  
about VT  
forests?

Sub-tropical  
drought areas  
moving into  
southern US



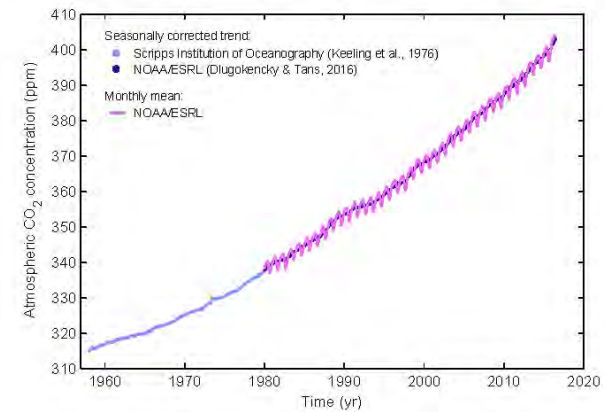
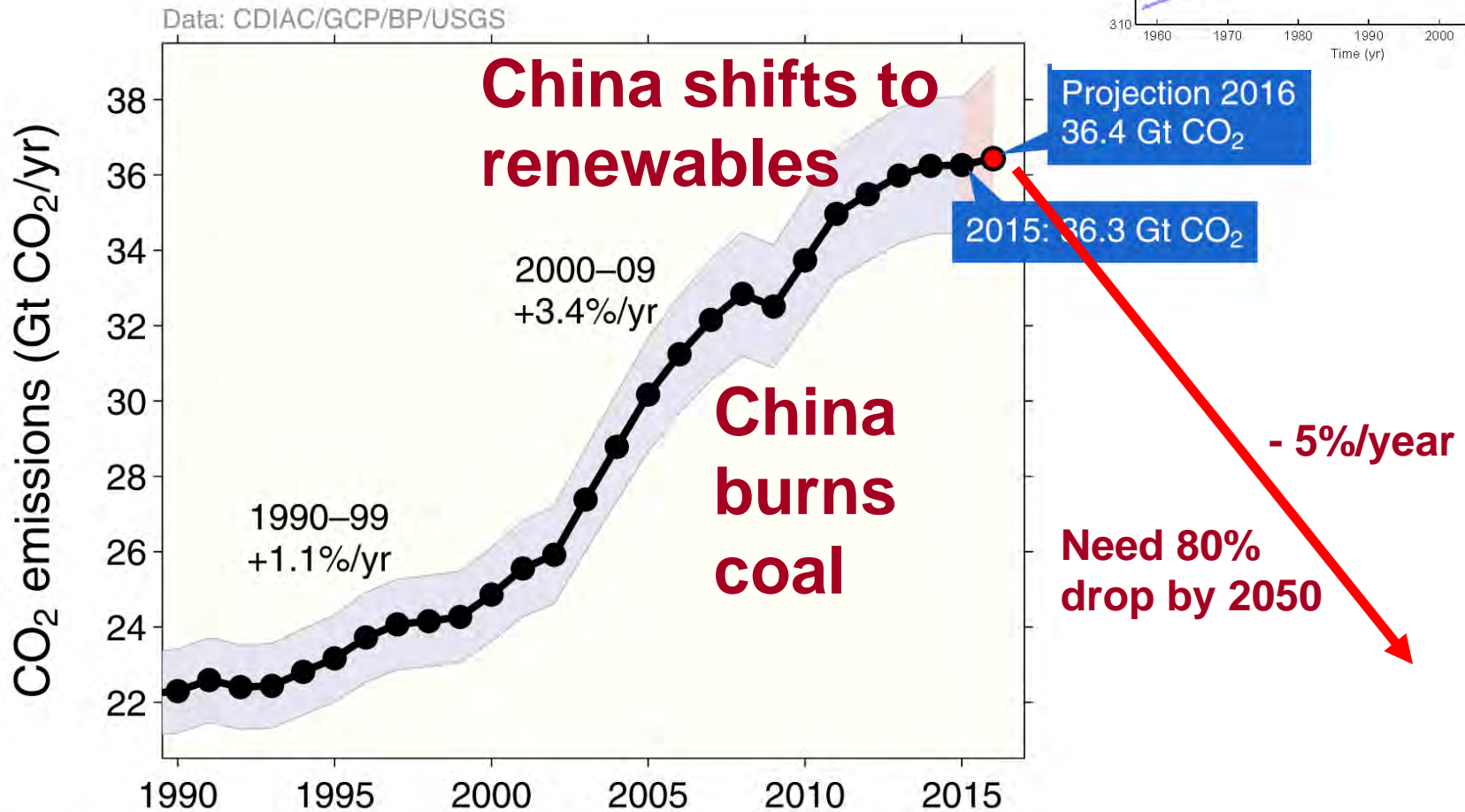
**NECIA,  
2007**

# Can We Stop “Dangerous Climate Change”?

(UNFCCC 1992)

- **Yes:** Quickly stabilize atmospheric CO<sub>2</sub>
- This means an 80% drop in CO<sub>2</sub> 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

# Growth of CO<sub>2</sub> Emissions Flat for 3 years



# 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*

# 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
- At 36 Gt/year - only 21 years left
- *Rapid phase-down extends period*

# New Guidelines Needed

- ***Re-education of society***
  - *The transition we face is huge*
  - *What will raise awareness: change paradigm?*
- **Develop renewable energy**
  - Maximize energy efficiency: housing, transport, power
- **Examine all waste-streams**
  - Aim to recycle/remanufacture everything
  - Fully cost all waste streams, including CO<sub>2</sub>
- **Relocalize food system**
  - Compost all organic waste
- ***Reconnect with natural world***
  - *Fundamental if we are to embrace transition*
  - *Ask for spiritual guidance*

# **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 faith values above short-term profit*
- ***Creation will overwhelm human folly***
  - *So accept (repent!) with joy*

*“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***



**alanbetts.com**

***(articles and talks)***

# 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 Creation?
  - *Shift in understanding and mind-set needed*

# Efficient transport

- Gasoline to hybrid: 50% gain to 50mpg
- Hybrid to plug-in hybrid: now 140mpg
- Electricity from community solar array



>3000lbs and 140 mpg  
Payload: 750 lbs at 55 mph



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