Recent Increase in Vermont's Natural Disasters:
A Sign of Things to Come?

Part 2: Climate Change In Vermont
What Does Our Future Hold?

2015 Vermont Emergency Preparedness Conference

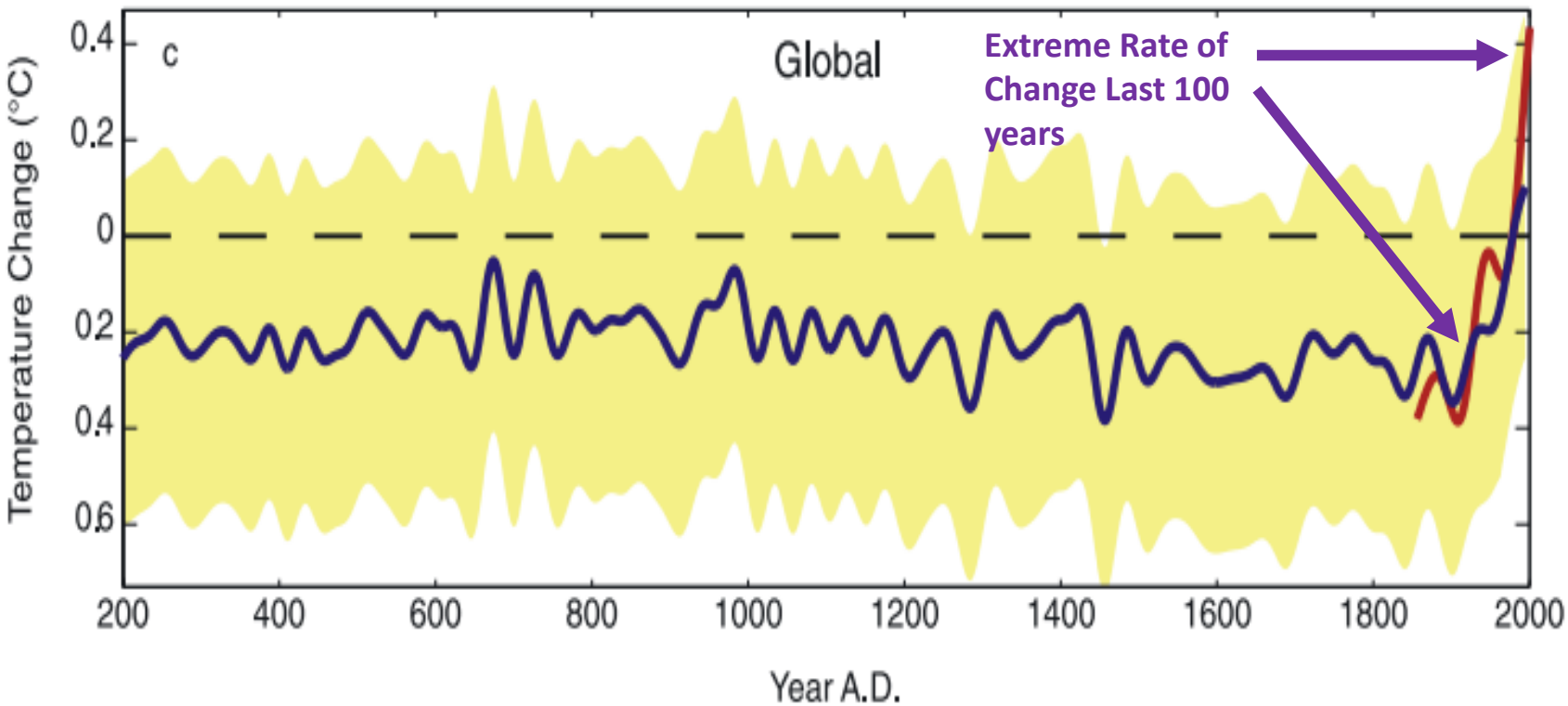
Andy Nash
National Weather Service - Burlington

Key Terms To Understand

- **Weather**
  - What we actually experience each day
- **Climate**
  - What we ***expect*** to experience over longer periods of time
- **Climate Variability**
  - **Natural forces** resulting in climate changes
- **Climate Change**
  - The **human-caused** forces that result in climate variability occurring at a far faster rate than natural climate variability

Climate Change – Greenhouse Gases on Steroids

What We Have Measured The Last 2000 Years



BLUE
Estimated

YELLOW
Error range for estimates

RED
Measured

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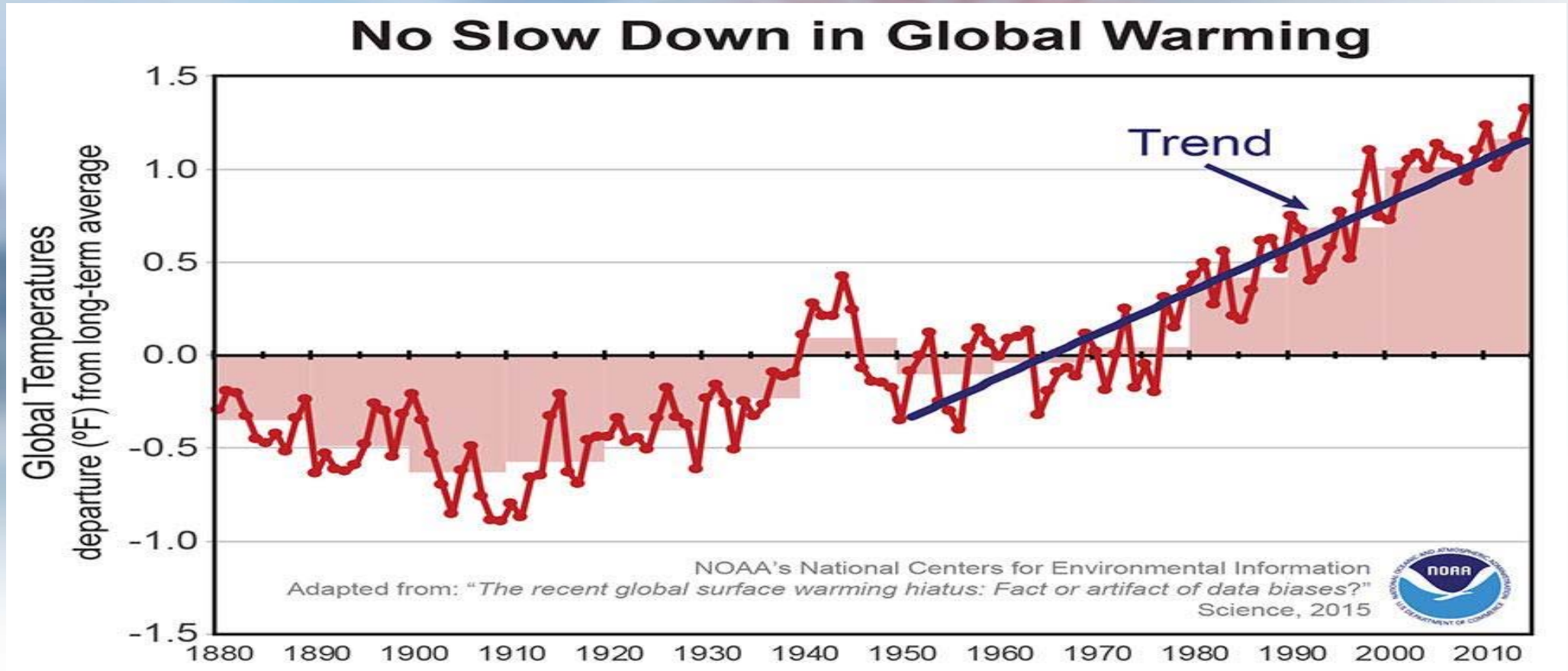
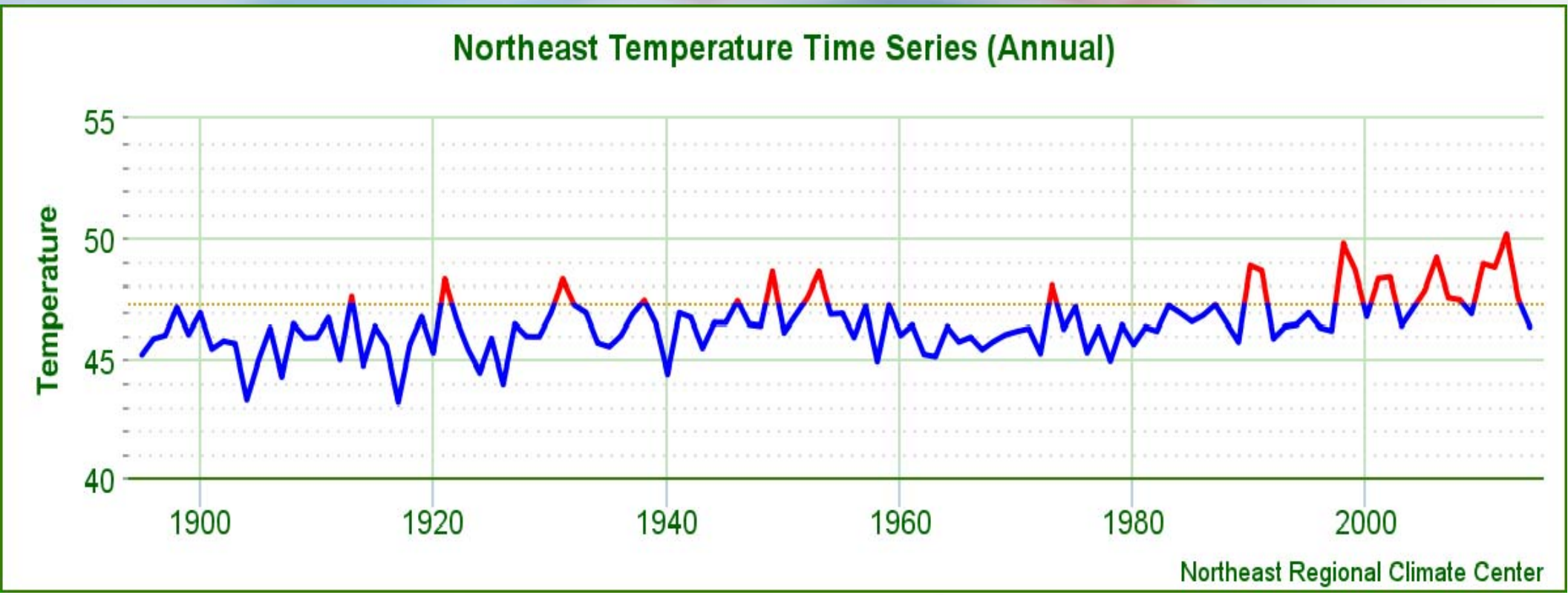
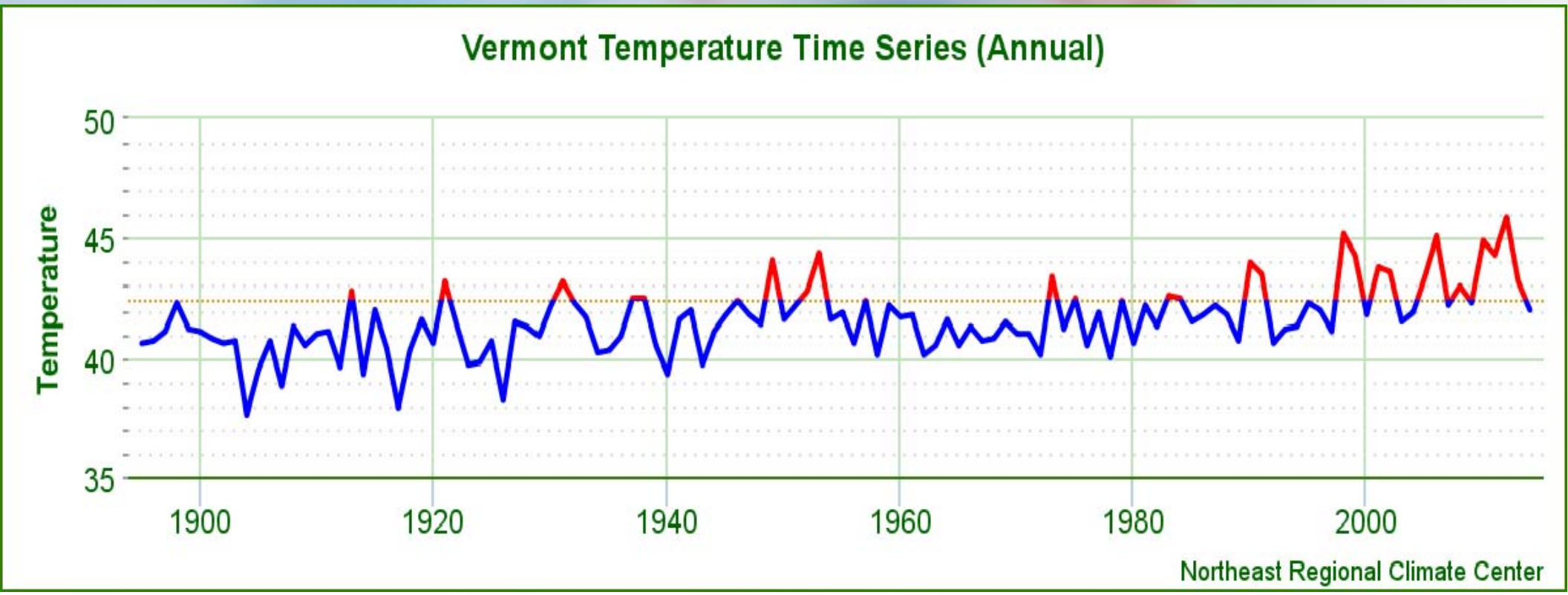
Some Recent Popular Media Stories Proclaimed: "A Slow Down!"



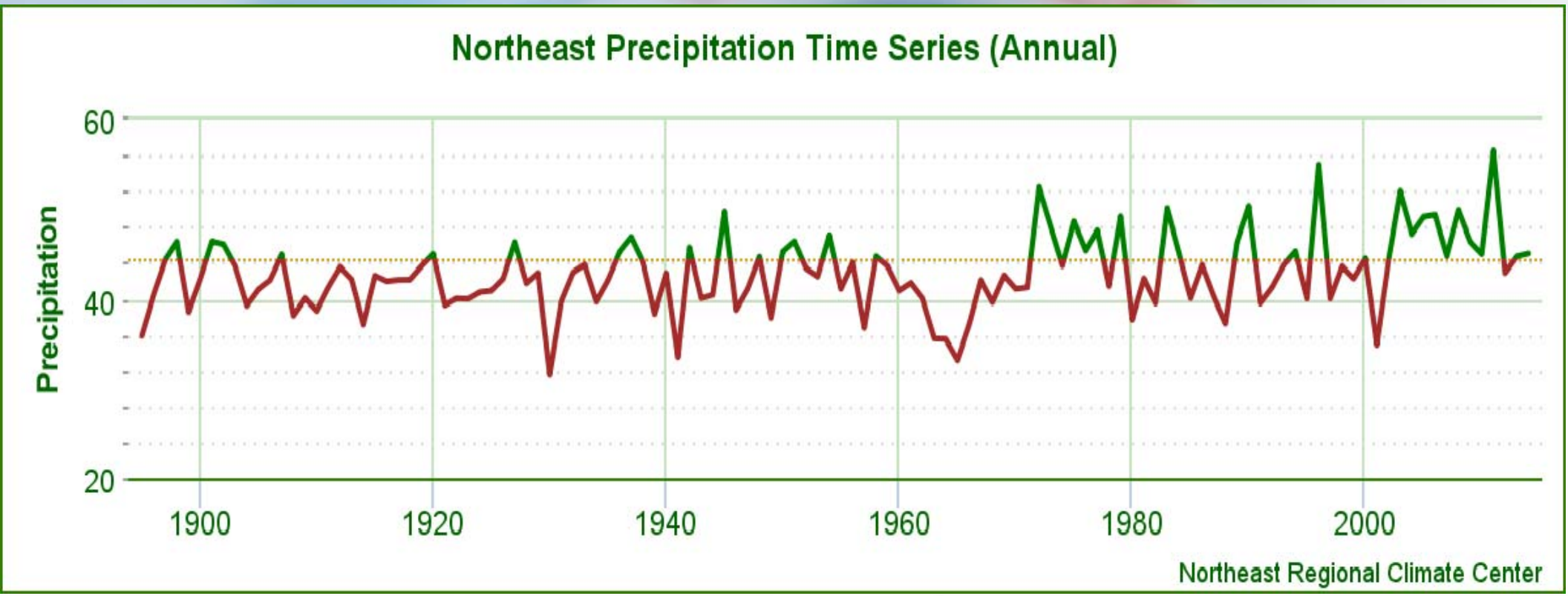
Regional Changes - Temperature



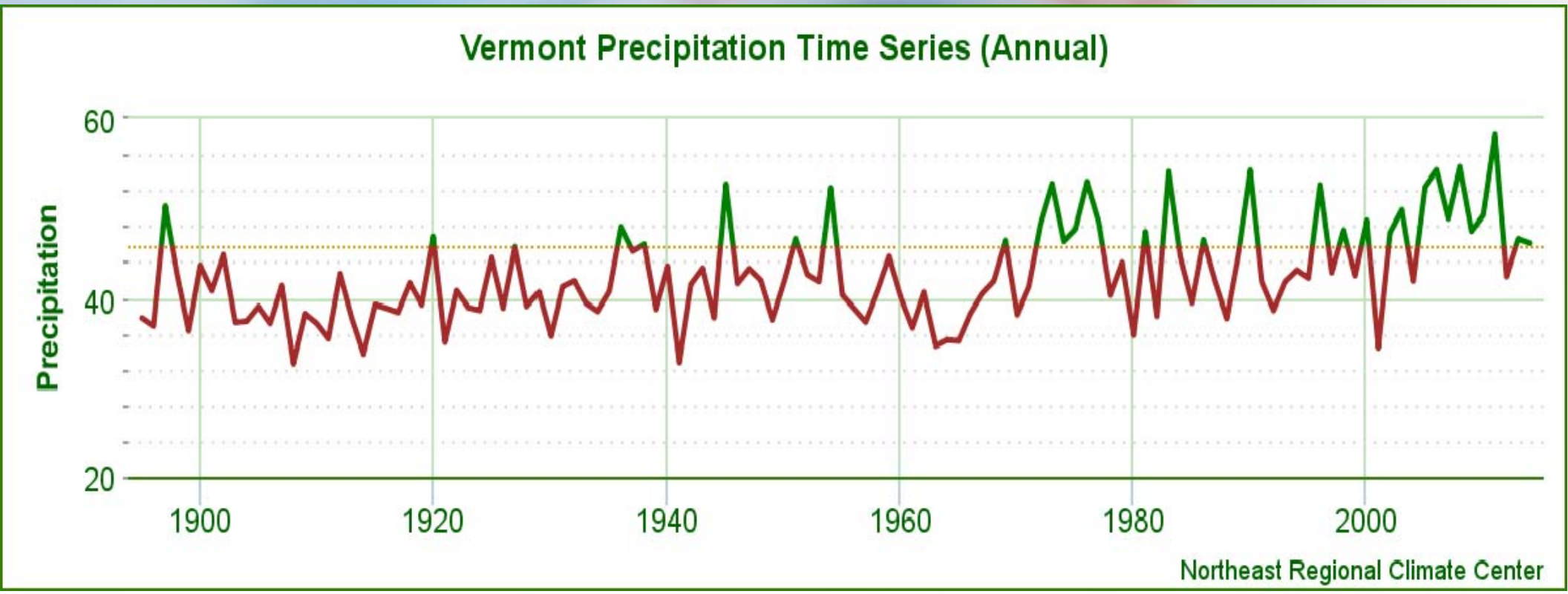
Vermont Changes - Temperature



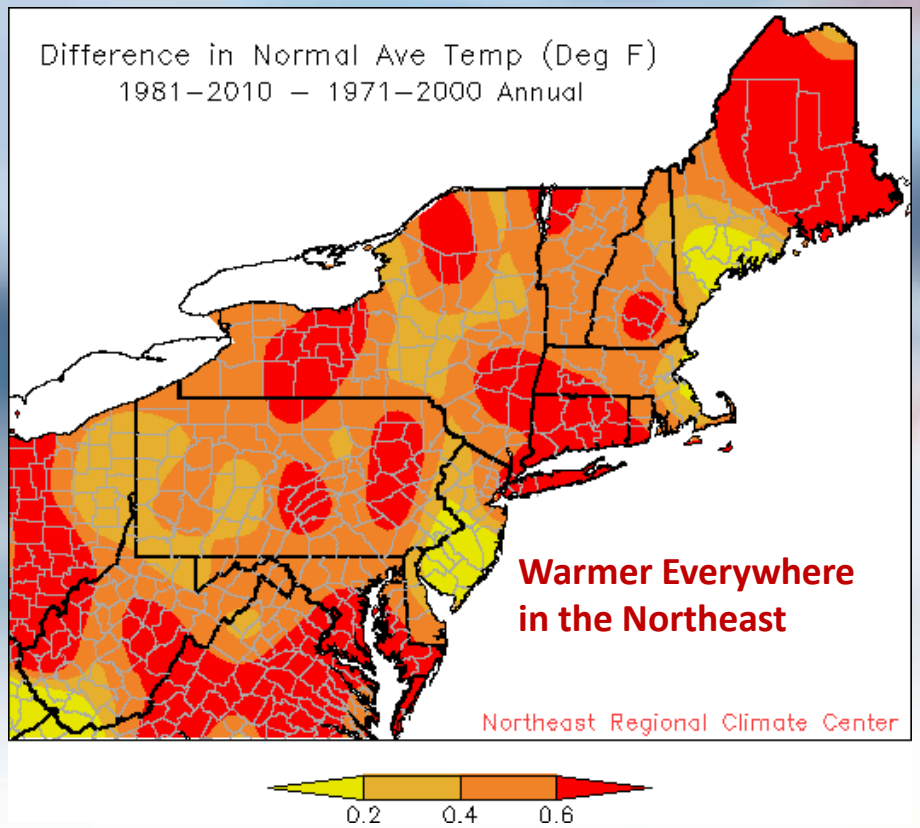
Regional Changes - Precipitation

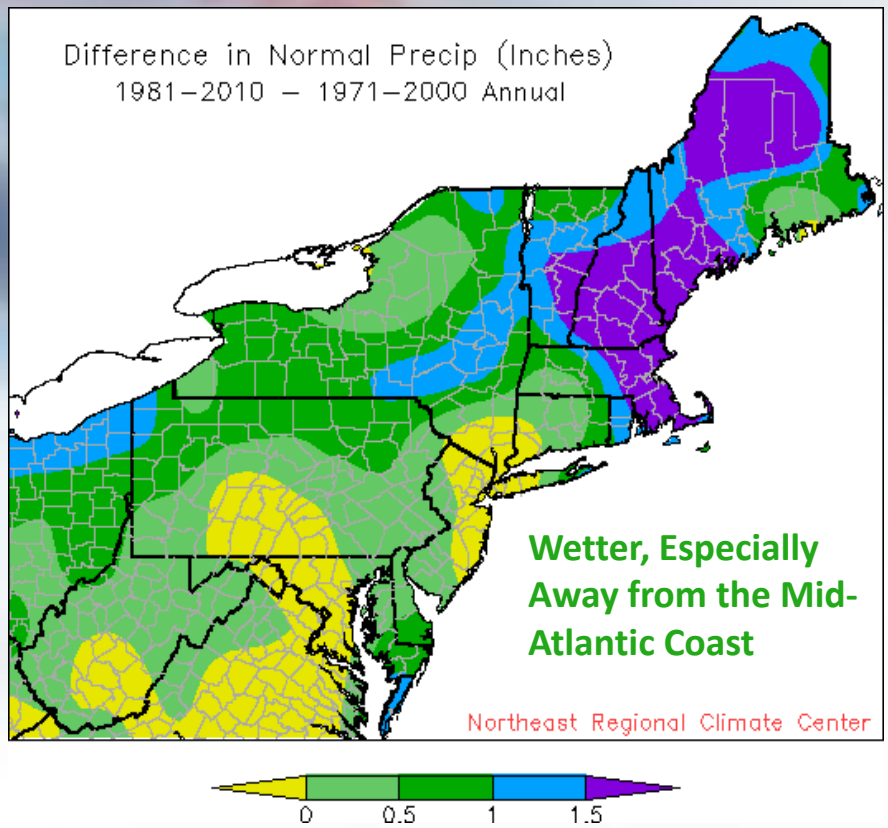


Vermont Changes - Precipitation



How Our "Normals" Are Changing





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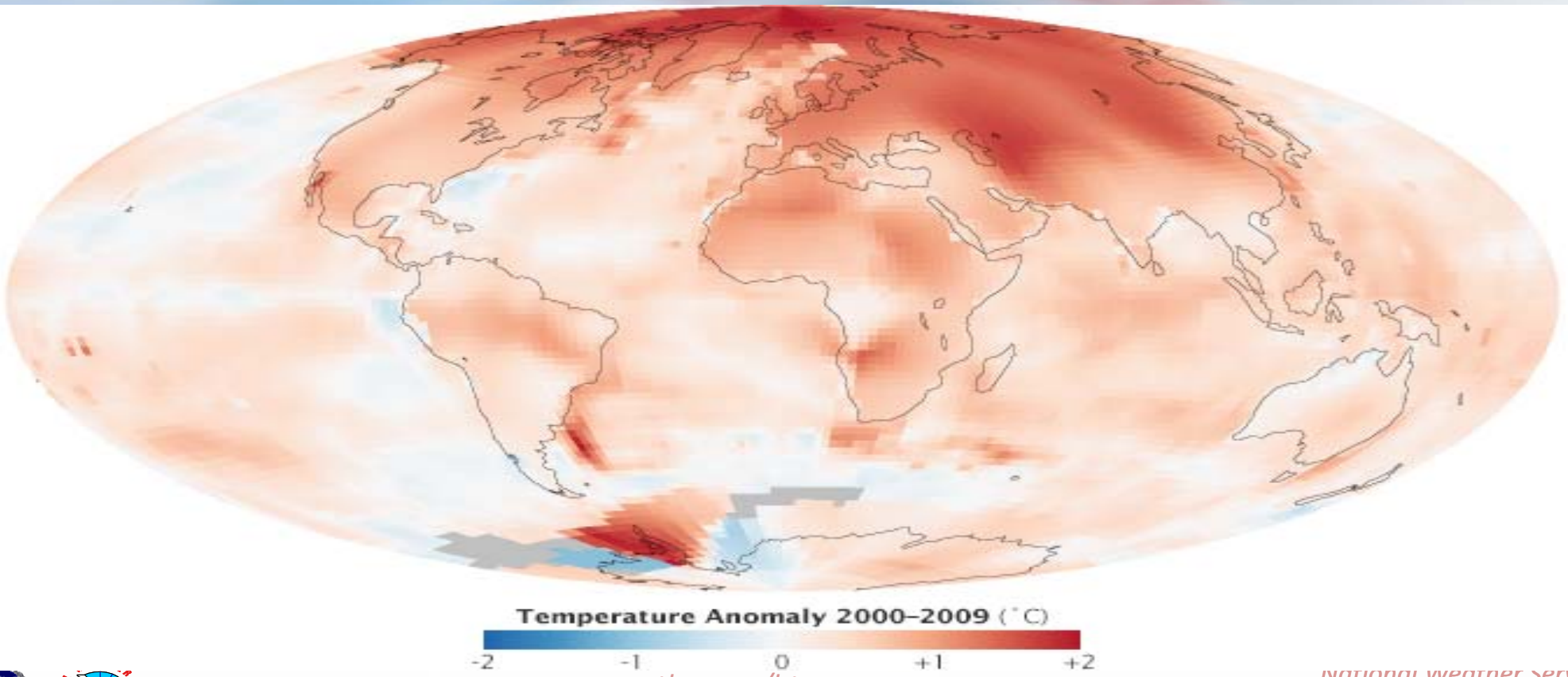
Why Such Changes

- Warmer → Atmosphere is capable of holding more moisture
  - So a wetter future is expected

BUT IT'S MORE COMPLEX THAN THAT!

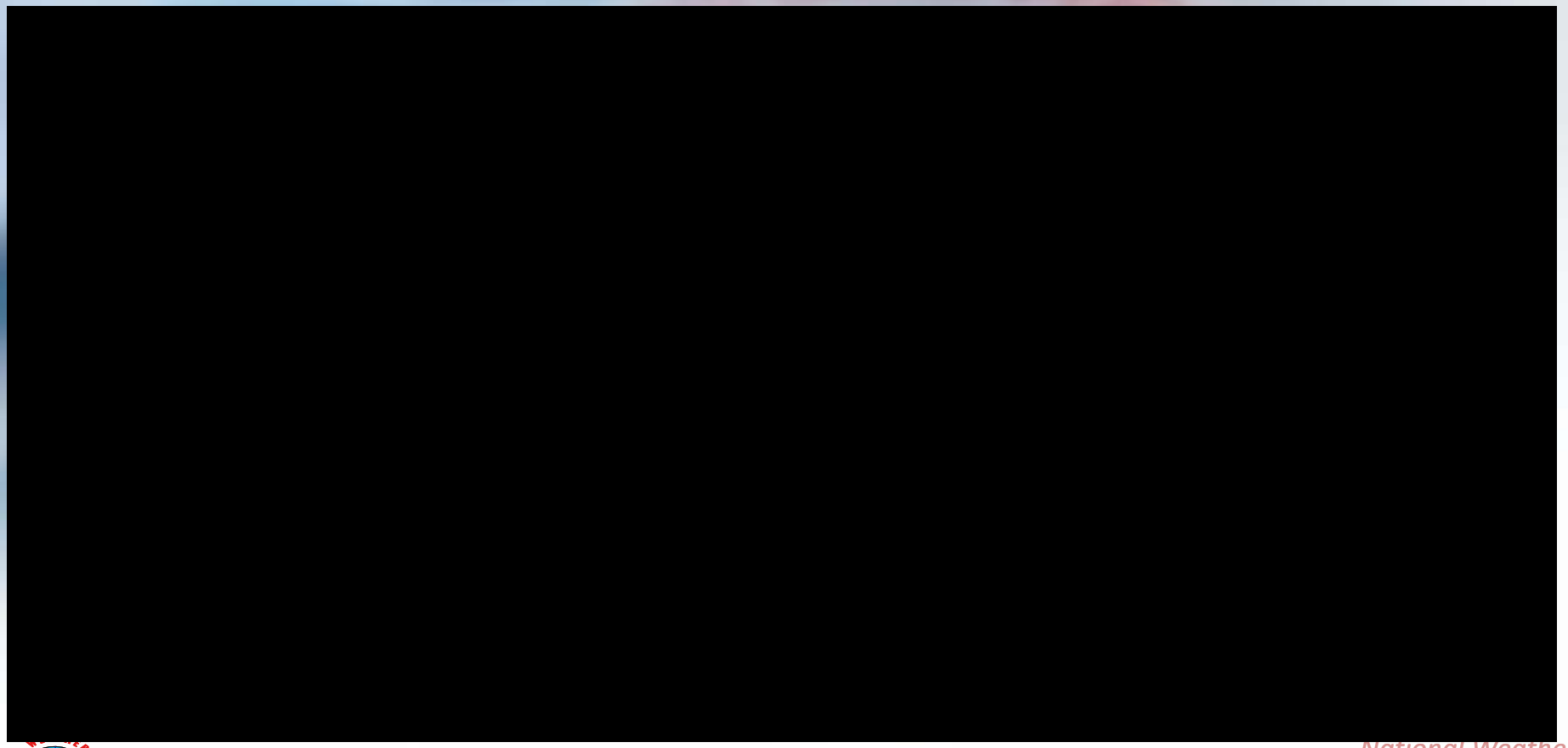
Climate Change Warming Is Not Equally Distributed



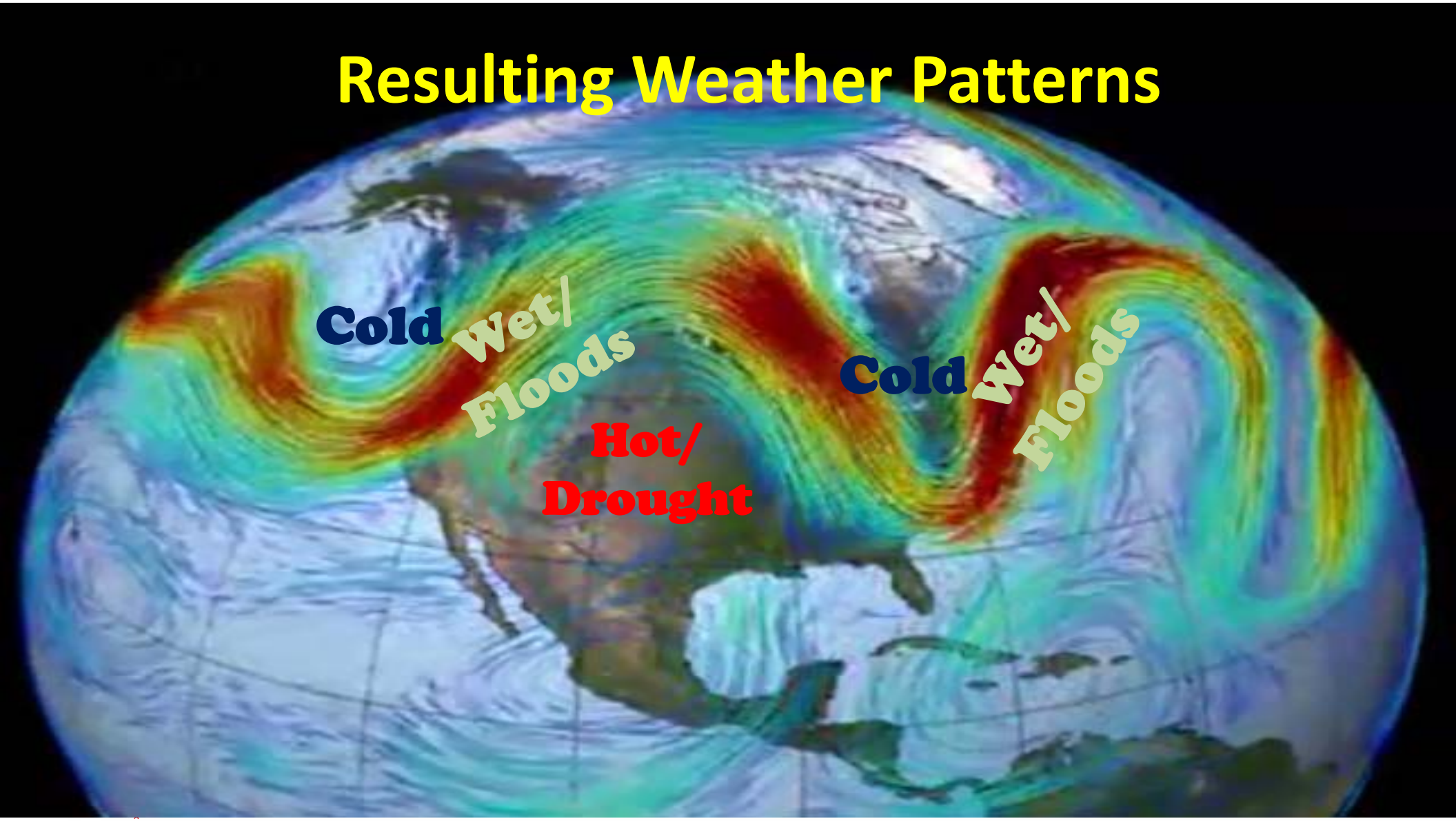
Why Such Changes

- Polar areas warming more quickly → Weakens Jet Stream
  - Jet Stream powered by global temperature differences
- Weaker Jet Stream → Longer lasting weather patterns
  - Weaker Jet Stream is just like a slow meandering river
- Results are **increased extremes:**
  - When it's hot, it's HOT When it's cold, it's COLD
  - When it's dry, it's DRY When it's wet, it's WET

Meandering Jet Stream

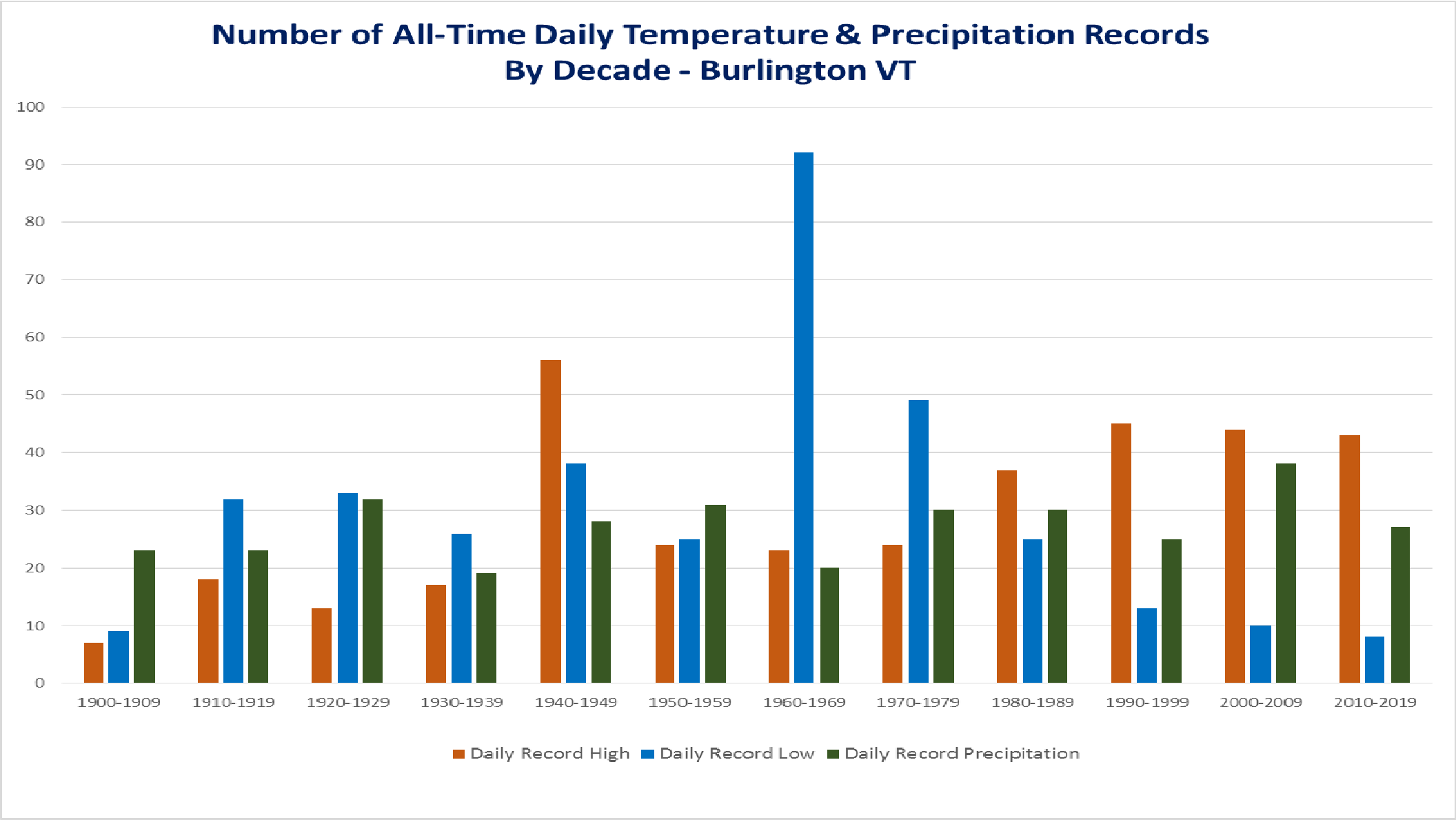


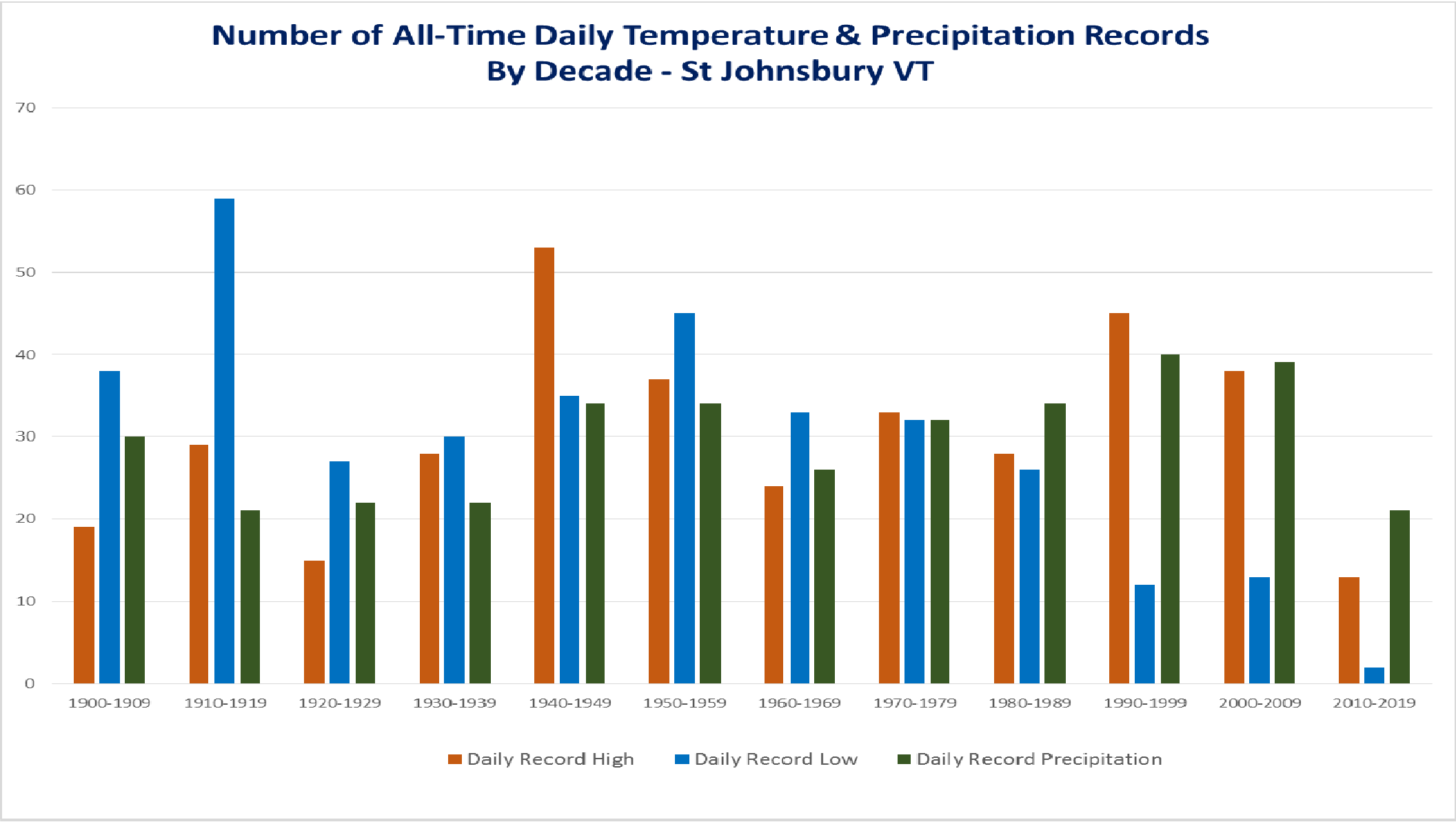
Resulting Weather Patterns

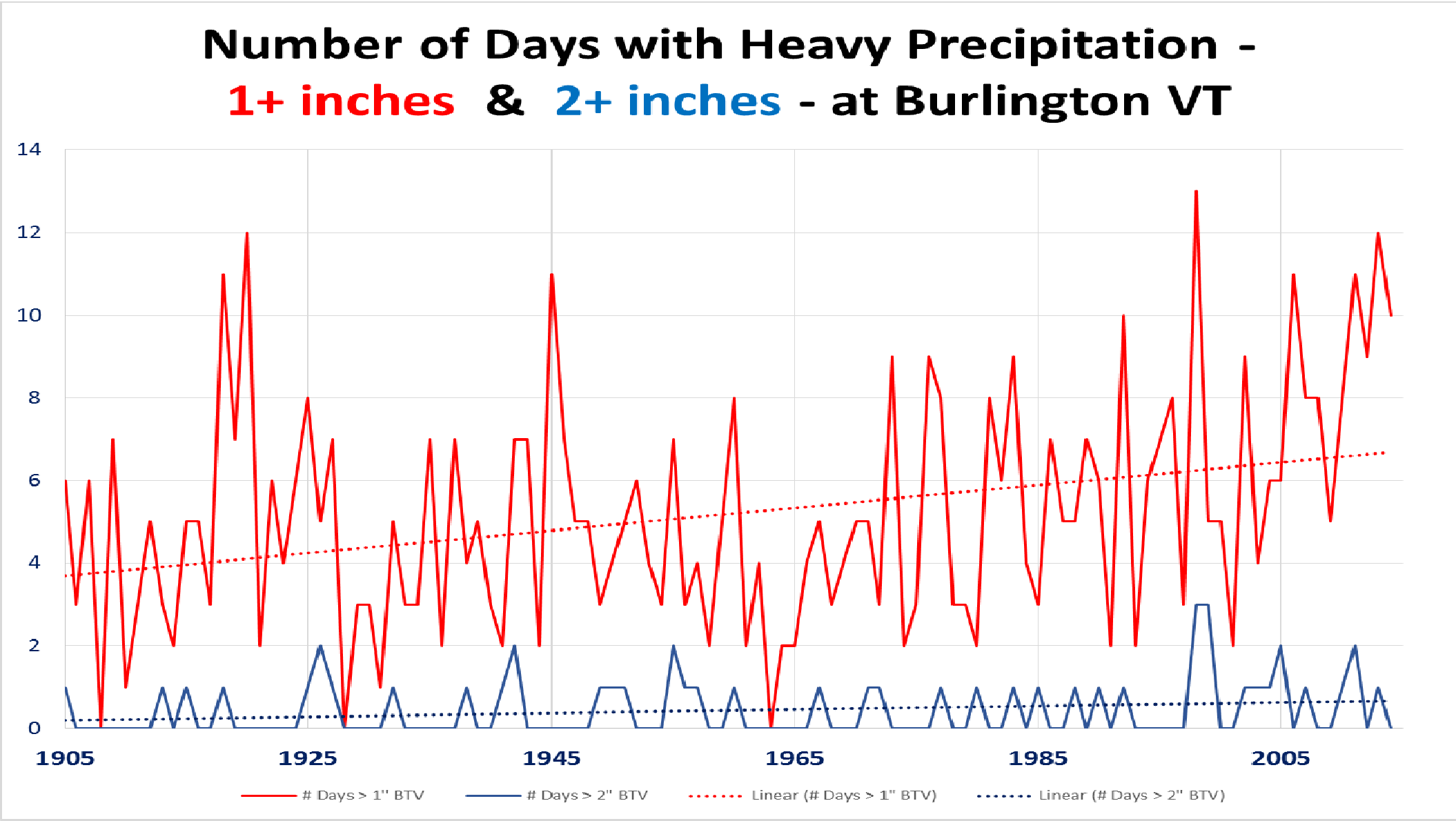


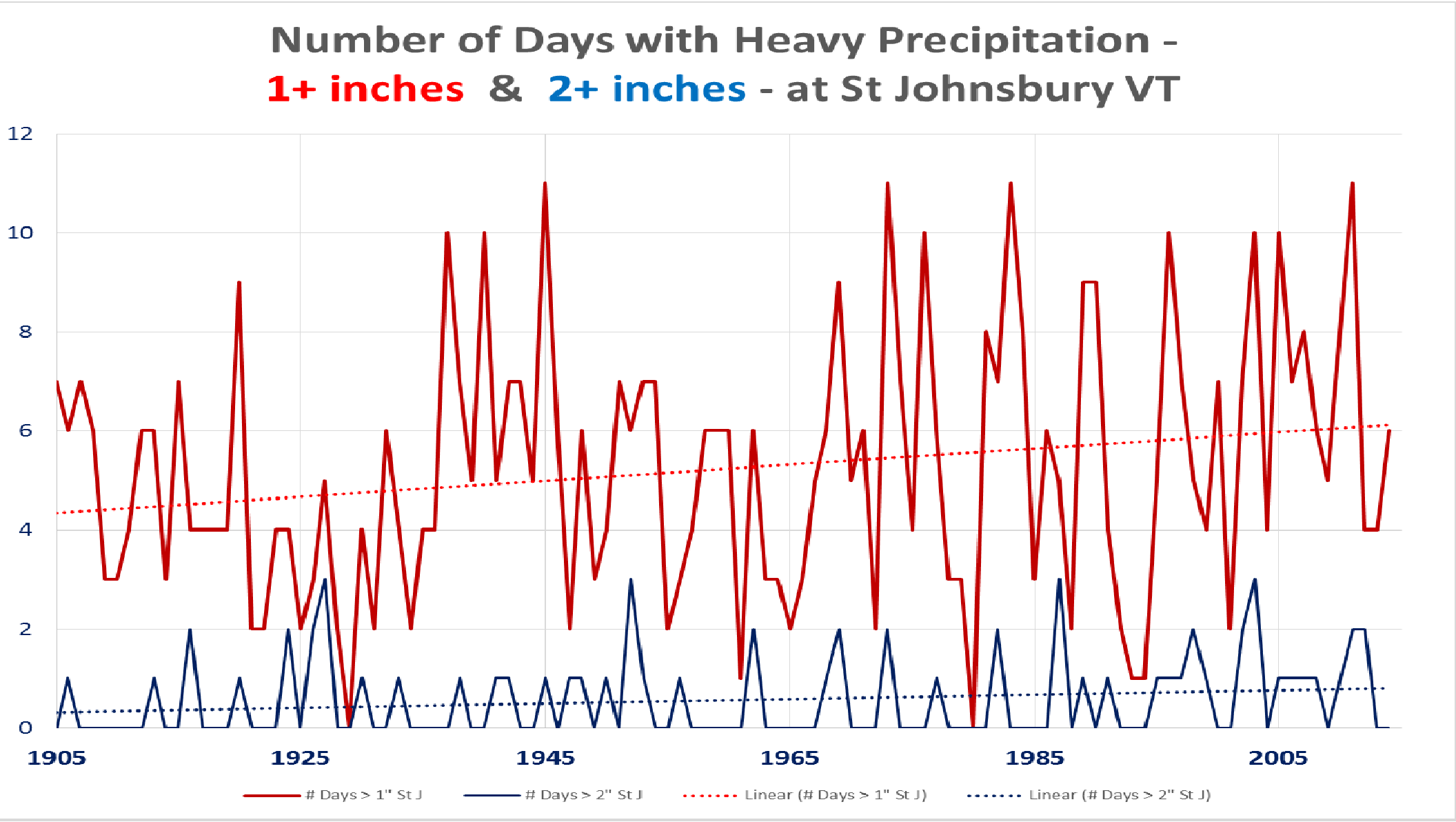
Are We Seeing More Extreme Events?

- **In General --- YES!**


Number of All-Time Daily Temperature & Precipitation Records
By Decade - Burlington VT
100
90
80
70
60
50
40
30
20
10
0
1900-1909
1910-1919
1920-1929
1930-1939
1940-1949
1950-1959
1960-1969
1970-1979
1980-1989
1990-1999
2000-2009
2010-2019
Daily Record High
Daily Record Low
Daily Record Precipitation


Number of All-Time Daily Temperature & Precipitation Records
By Decade - St Johnsbury VT
70
60
50
40
30
20
10
0
1900-1909
1910-1919
1920-1929
1930-1939
1940-1949
1950-1959
1960-1969
1970-1979
1980-1989
1990-1999
2000-2009
2010-2019
Daily Record High
Daily Record Low
Daily Record Precipitation


Number of Days with Heavy Precipitation -
1+ inches & 2+ inches - at Burlington VT
14
12
10
8
6
4
2
0
1905
1925
1945
1965
1985
2005
Days > 1" BTV
Days > 2" BTV
Linear (# Days > 1" BTV)
Linear (# Days > 2" BTV)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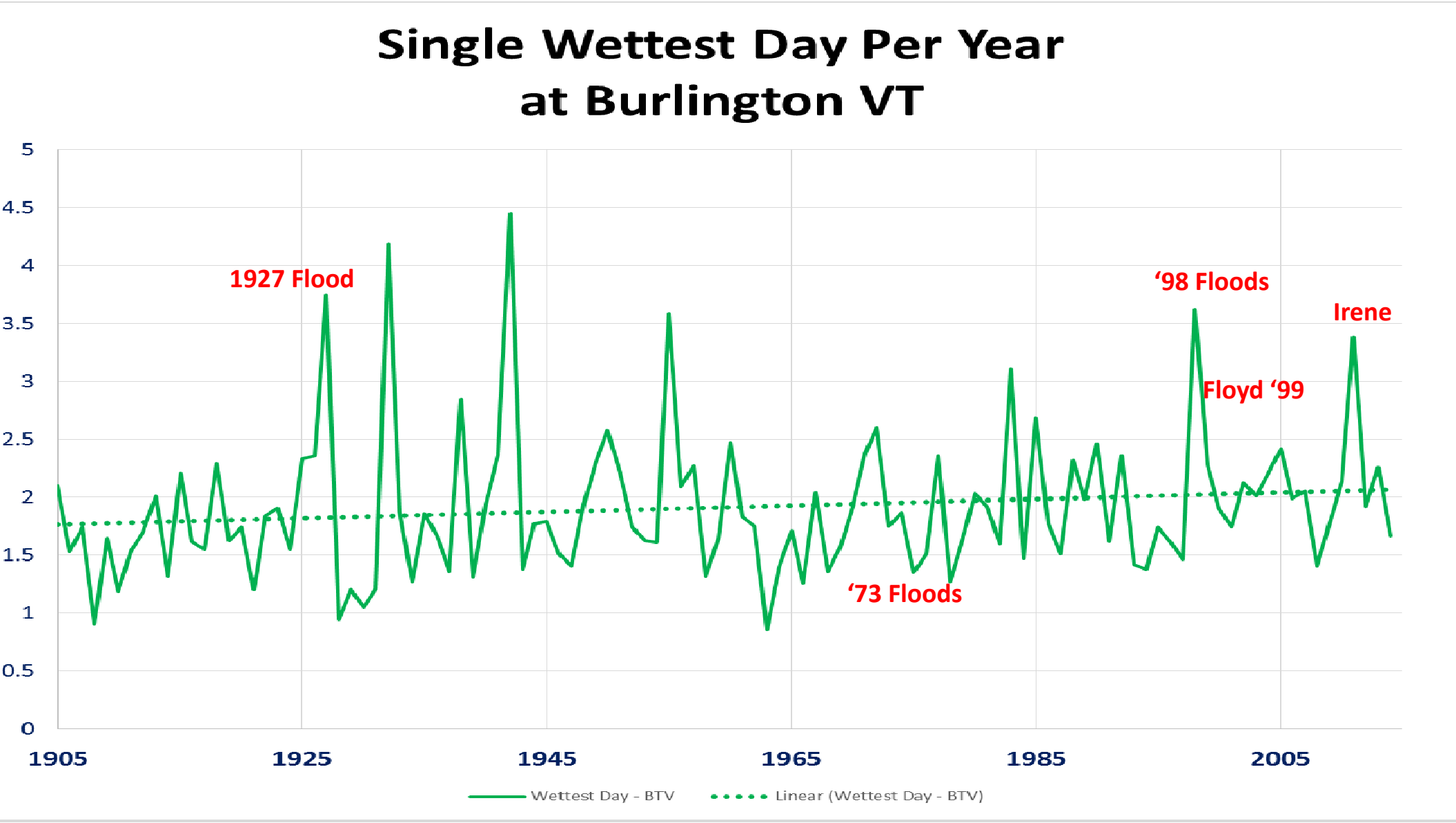
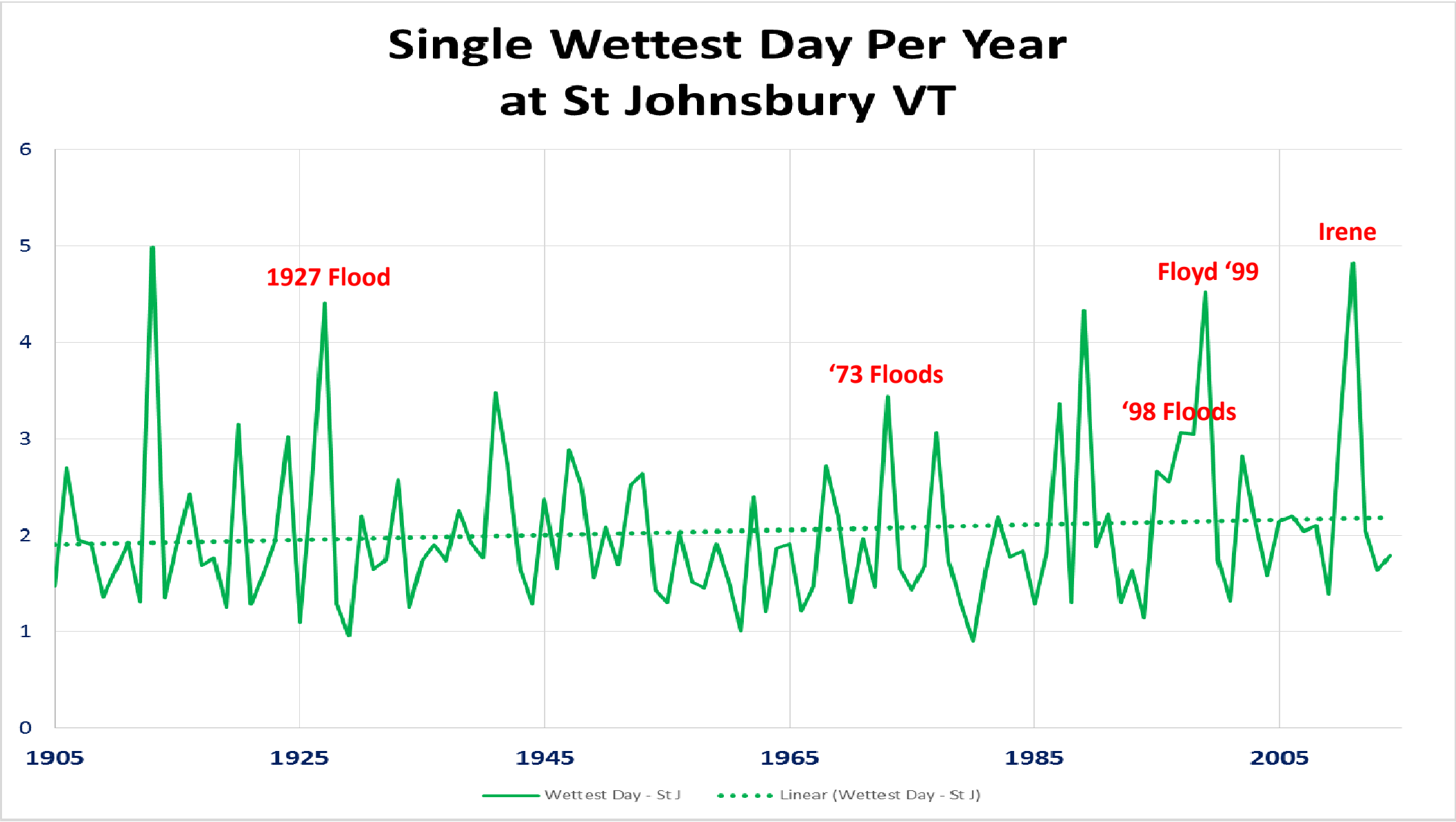

Single Wettest Day Per Year
at Burlington VT
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1905
1925
1945
1965
1985
2005
1927 Flood
'98 Floods
Irene
Floyd '99
'73 Floods
Wettest Day - BTV
Linear (Wettest Day - BTV)


Single Wettest Day Per Year
at St Johnsbury VT
6
5
4
3
2
1
0
1905
1925
1945
1965
1985
2005
1927 Flood
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'98 Floods
Floyd '99
Irene
Wettest Day - St J
Linear (Wettest Day - St J)

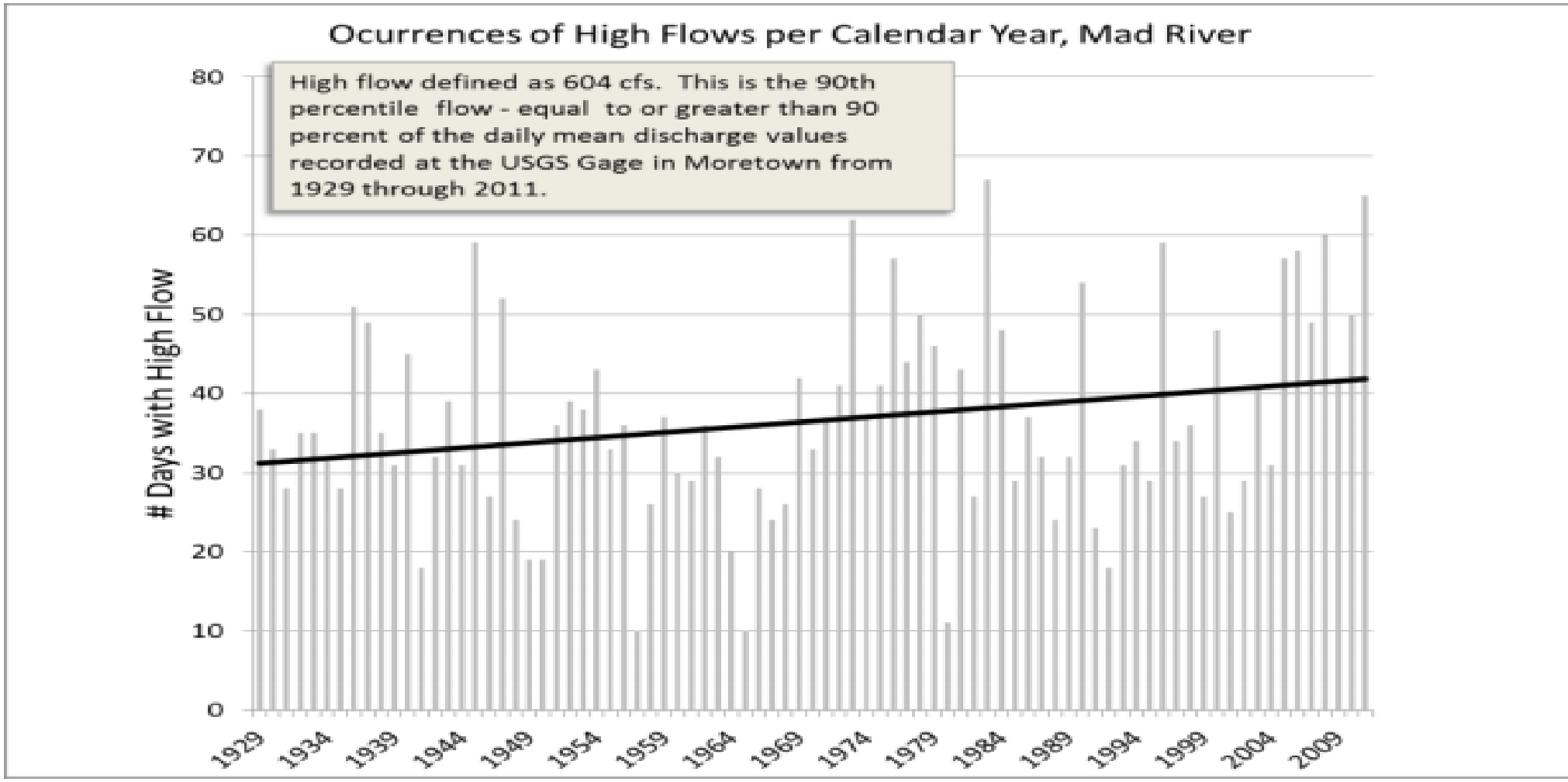
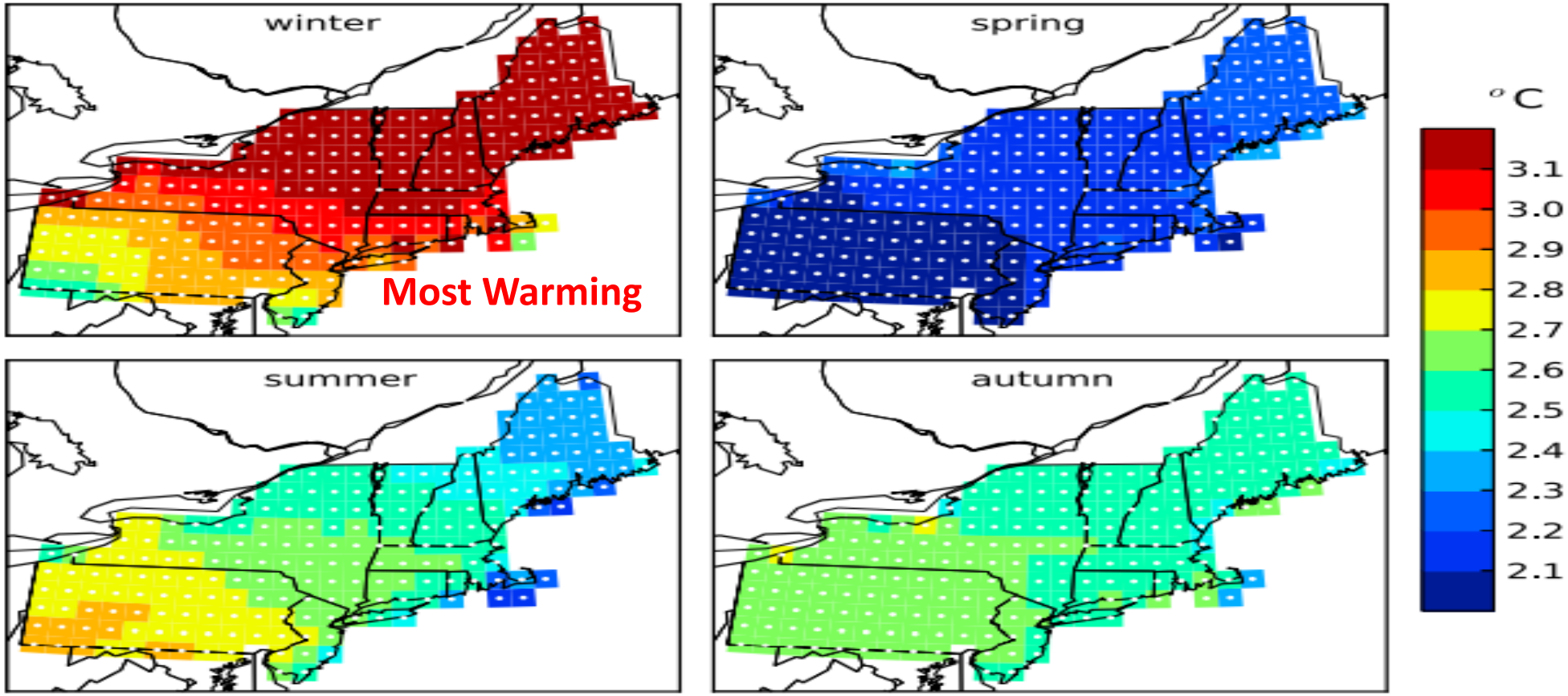


Figure 5.8. *Historic trend in frequency of occurrence of high-flow events at the USGS gage on the Mad River in Moretown, VT. ($p<0.05$; Mann-Kendall)*

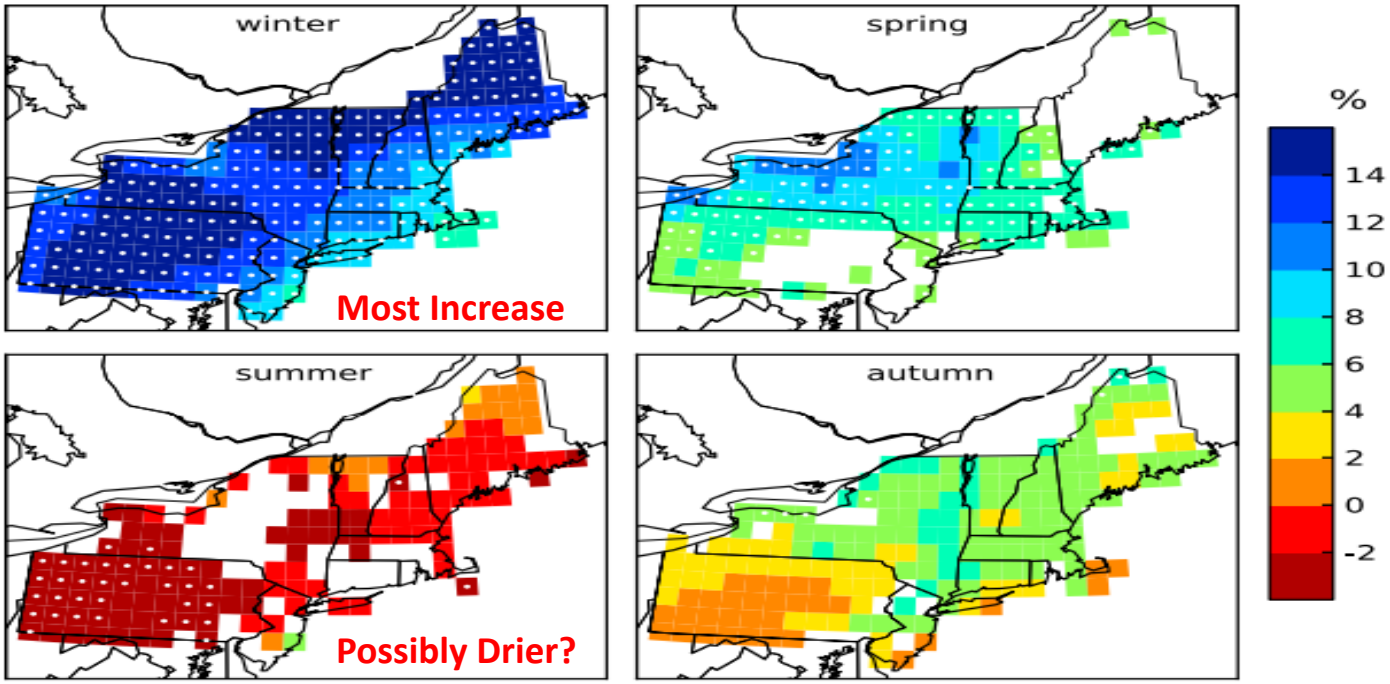
Forecast for the next 25-100 years

- Climate Models indicate for Northeastern U.S.:
  - **Near certainty of continued warming**, especially during the winter
  - **Near certainty of increasing precipitation**
    - Both overall amount for a year & maximum amount in a day
    - **Though potential for increased seasonal droughts as well**
  - Strong indication of increasing frequency of extreme weather patterns

Climate Model Temperature Change Predictions – by 2070



Climate Model Precipitation Change Predictions – by 2070



What Are The Anticipated Impacts?

- Vermont Climate Assessment – UVM Project in 2014
  - http://vtclimate.org/

- Evaluated concerns & impact potential from a number of viewpoints

Community Development	**Energy**
Water Resources	**Forests**
Agriculture	**Recreation/Tourism**
Human Health	**Transportation**

Vermont Climate Assessment:
Community Development/Resilience Concerns

- Extreme weather events becoming more frequent

- Infrastructure systems are highly vulnerable to climate change.
  - Vulnerability exacerbated by the rural/mountainous geography
  - And limitations existing in transportation & communication systems.

Vermont Climate Assessment:
Energy Sector Concerns

- Projecting 0.7% annual increases in peak energy load through 2030.
- Increased summer energy demands will outweigh decrease in energy use from warmer winters.
- Increased risk of major storm events in Vermont will threaten utility infrastructure.

Vermont Climate Assessment:
Water Resources Concerns

- Projecting 80% increase in the probability of high stream flows by 2100
- Increased winter flooding events (more rain vs snow)
- Spring thaws and melts will shift earlier in the season
- Increased potential for short-term dry spells
  - rivers/streams & water tables will see larger yearly fluctuations

Vermont Climate Assessment:
Forest Related Concerns

- Expecting a change in tree species distribution
  - More oak, hickory and red maple, less spruce and fir
- Precipitation cycle changes will place more stress on sugar maples
  - This has large economic implications
- Earlier buds/flowering make trees susceptible to cold snaps/freezes

Vermont Climate Assessment:
Agriculture & Food Systems Concerns

- Growing season will continue to lengthen
  - PRO: Could increase crop productivity and create new crop opportunities
  - CON: Possibly more disease outbreaks & pest infestations.

- Warmer summers and higher heat stress for livestock could lead to slight decreases in productivity.

- More variable precipitation patterns & more extreme events has implications on farm business viability.

Vermont Climate Assessment:
Recreation & Tourism Concerns

- Summer tourism & recreation seasons will lengthen
  - However, expansion of pests may reduce the quality of outdoor activities
- Anticipate increasing snowfall trends in the mountains for the next 25 years
  - Provides some enhanced opportunities
  - But overall length of winter will become shorter
- By 2040-2050, temperatures will rise enough that snowfall trends will reverse
  - More precipitation falls as rain even in the mountains
  - Longer term negative implications in winter recreation

Vermont Climate Assessment:
Human Health Impacts

- Expecting a serious impact on the health of citizens
  - Extreme heat and other weather events (eg: floods) are a direct threat to personal safety
  - Changing infectious diseases
    - Population changes of mosquitos, ticks, other warmer climate virus transmitting organisms
  - Allergy and respiratory symptoms may increase in relation to increasing plant and mold allergens and irritants in air.
  - Increased algae blooms

Vermont Climate Assessment:
Transportation Impacts

- Flooding poses the greatest risk to transportation infrastructure
  - Erosion along roadways and washout of overstrained culverts.
- High soil moisture levels may lead to increased vulnerability of structural foundation for roads, bridges and tunnels.
- Extreme heat events and winter storms will also create damage.
- Increasing freeze-thaw events will
  - weaken bridges
  - Lead to more frost heaves and potholes

In Summary

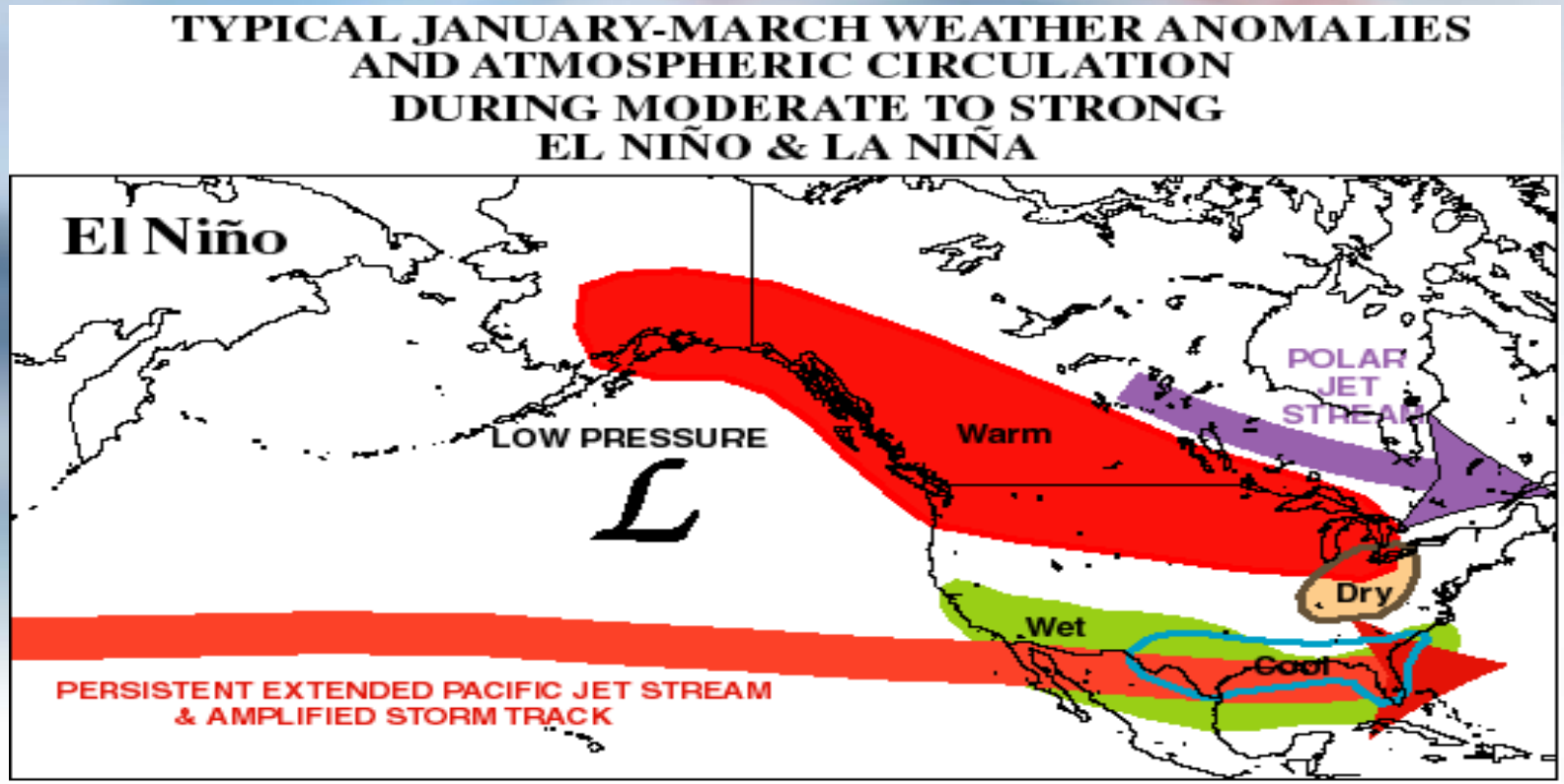
- The answer to our question: "A Sign of Things to Come?"

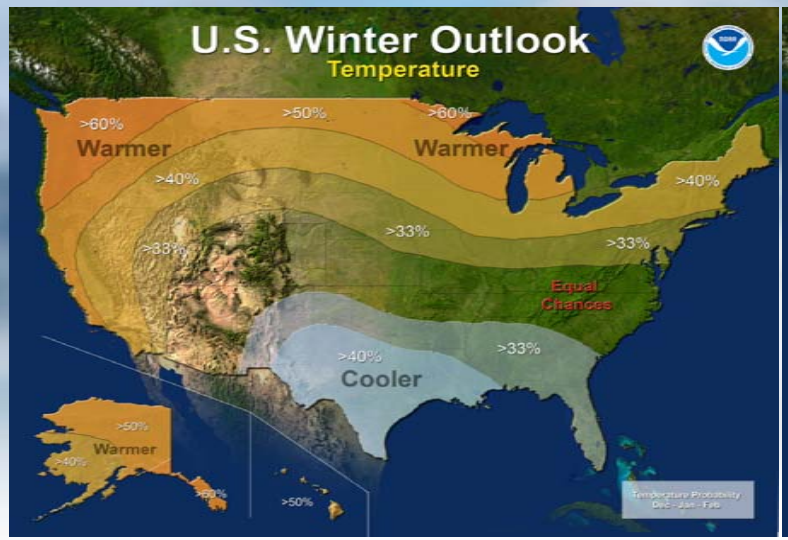
We strongly believe -- YES

Thank You

Questions?

Typical El Nino and Winter Pattern



Winter Outlook 2015-16

http://www.cpc.ncep.noaa.gov/