Climate Change in the Miami Valley

Global Context, Local Lens, Risks and Adaptation

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OSU Extension | Byrd Polar and Climate Research Center | State Climate Office of Ohio

The Miami Valley Regional Planning Commission:

Climate Change Seminar

February 24, 2020

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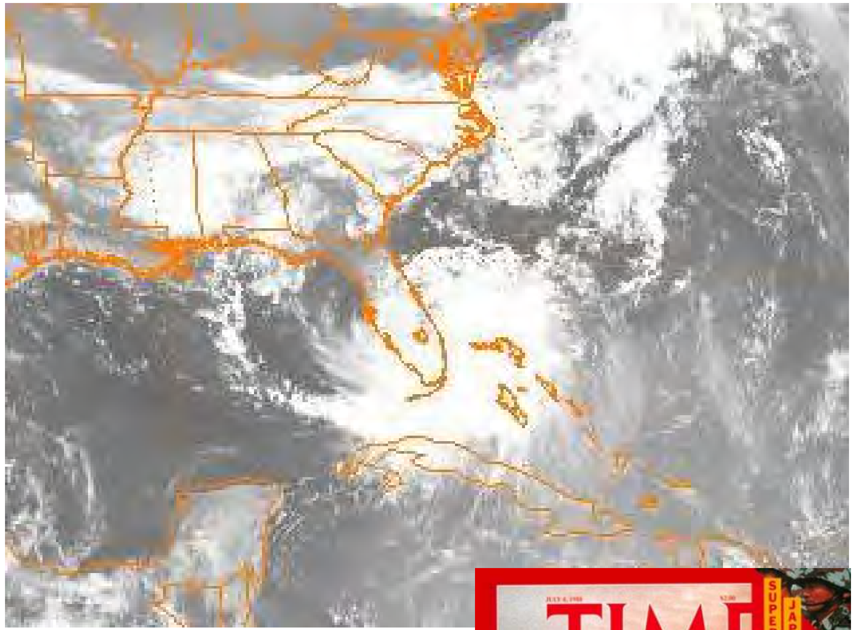
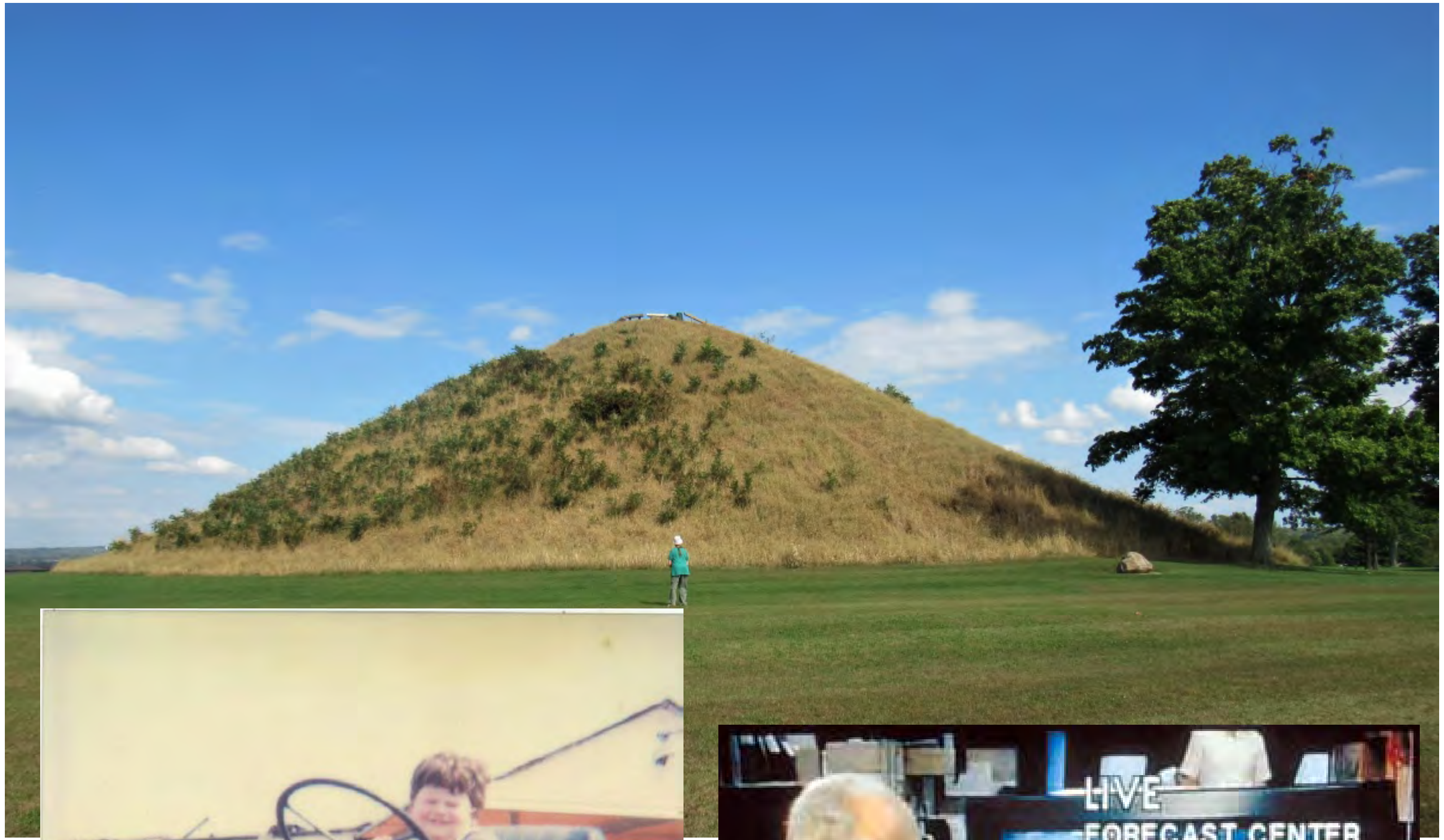
https://tinyurl.com/wcoyqwf

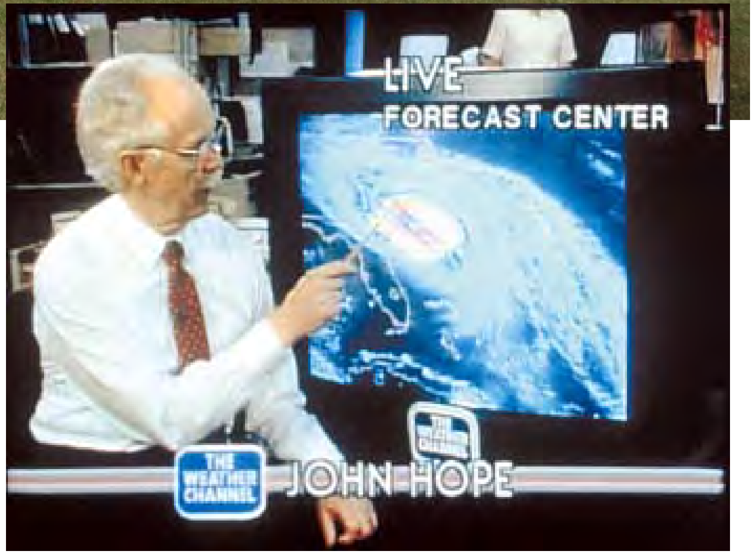
The Ohio State University

College of Food, Agricultural, and Environmental Sciences

My Background







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Opening Questions?

- In your lifetime, have weather patterns changed?
- What have you noticed? How do we know?
- Have you experienced impacts on commute/travel, water levels, gardens, basement conditions, soils, crops, and/or stress?

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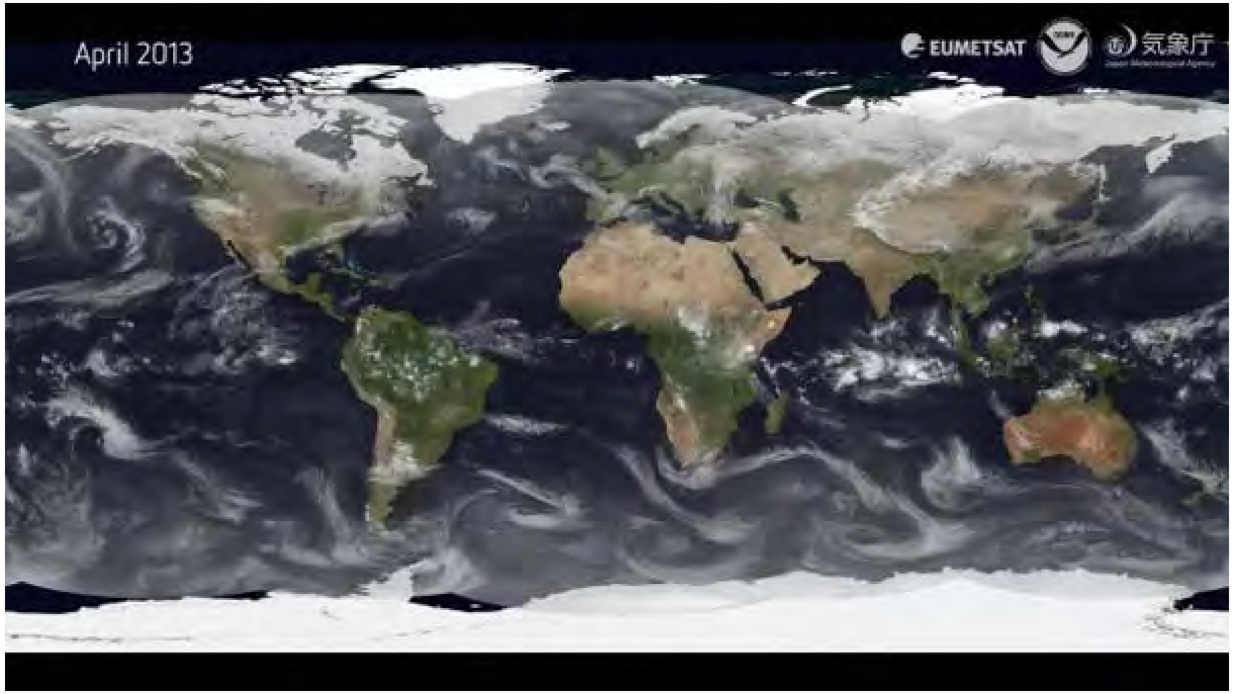
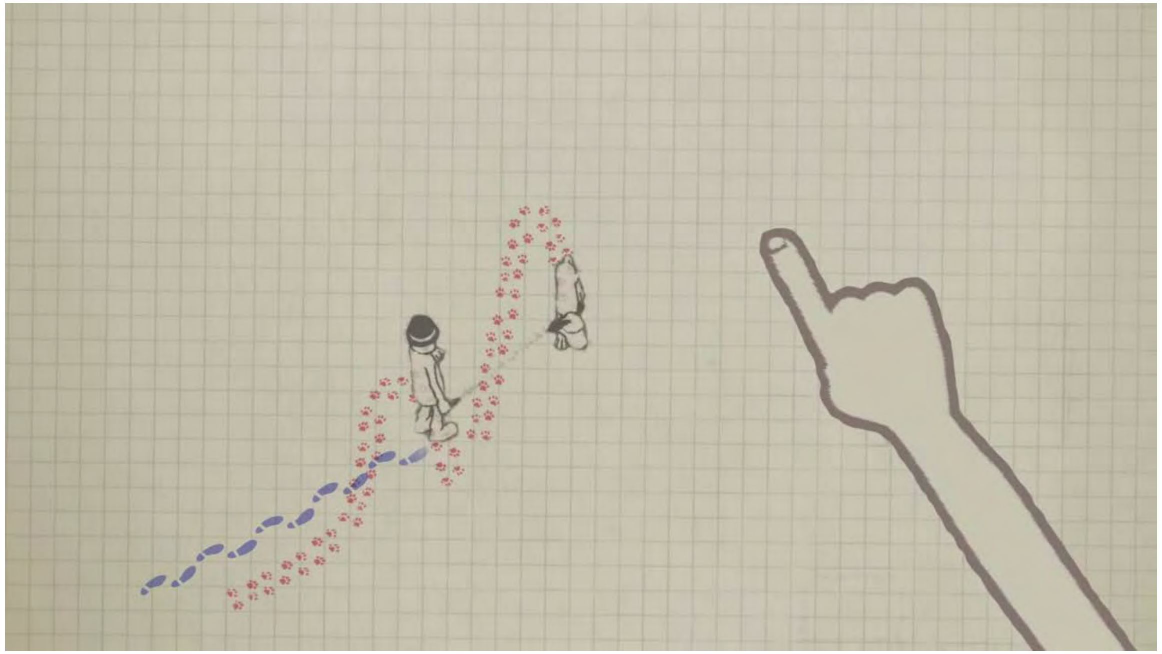
Weather and Climate



Weather: High-frequency changes in temperature, wind speed, etc; Caused by imbalance of energy across the globe.

Climate: Slower-varying aspects; Averages over longer periods.



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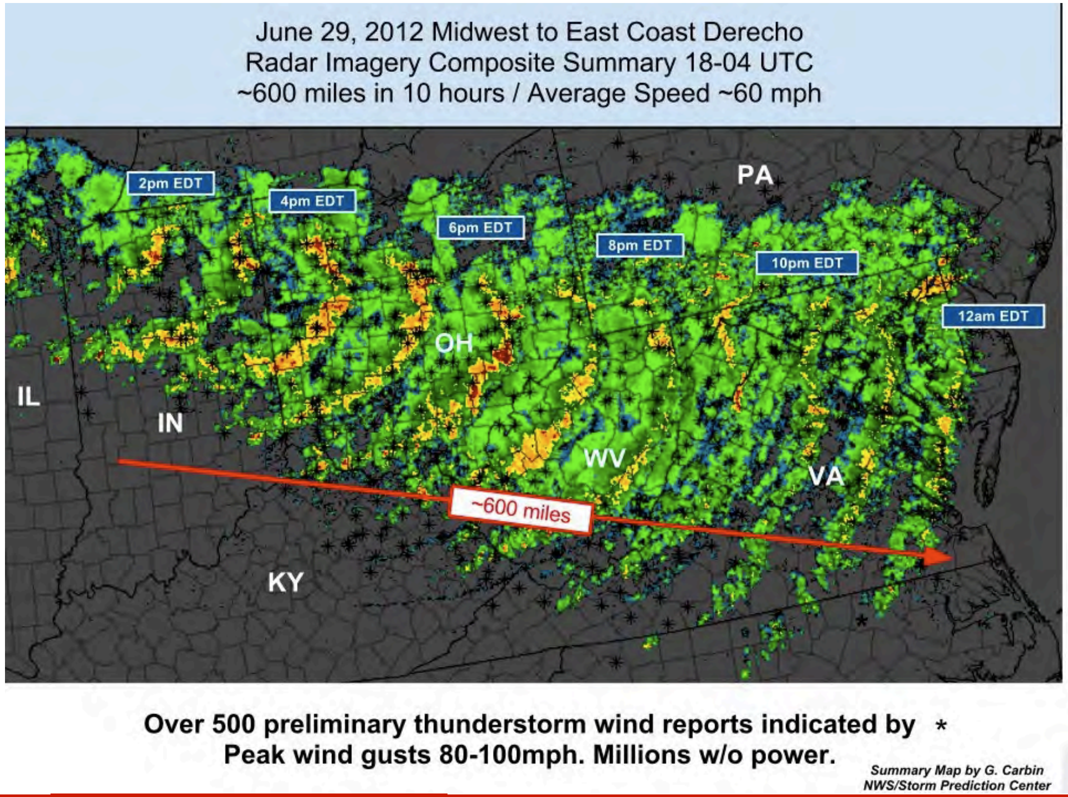
The Power of Weather Impacts Us All

Public Domain, https://commons.wikimedia.org/w/index.php?curid=10941105



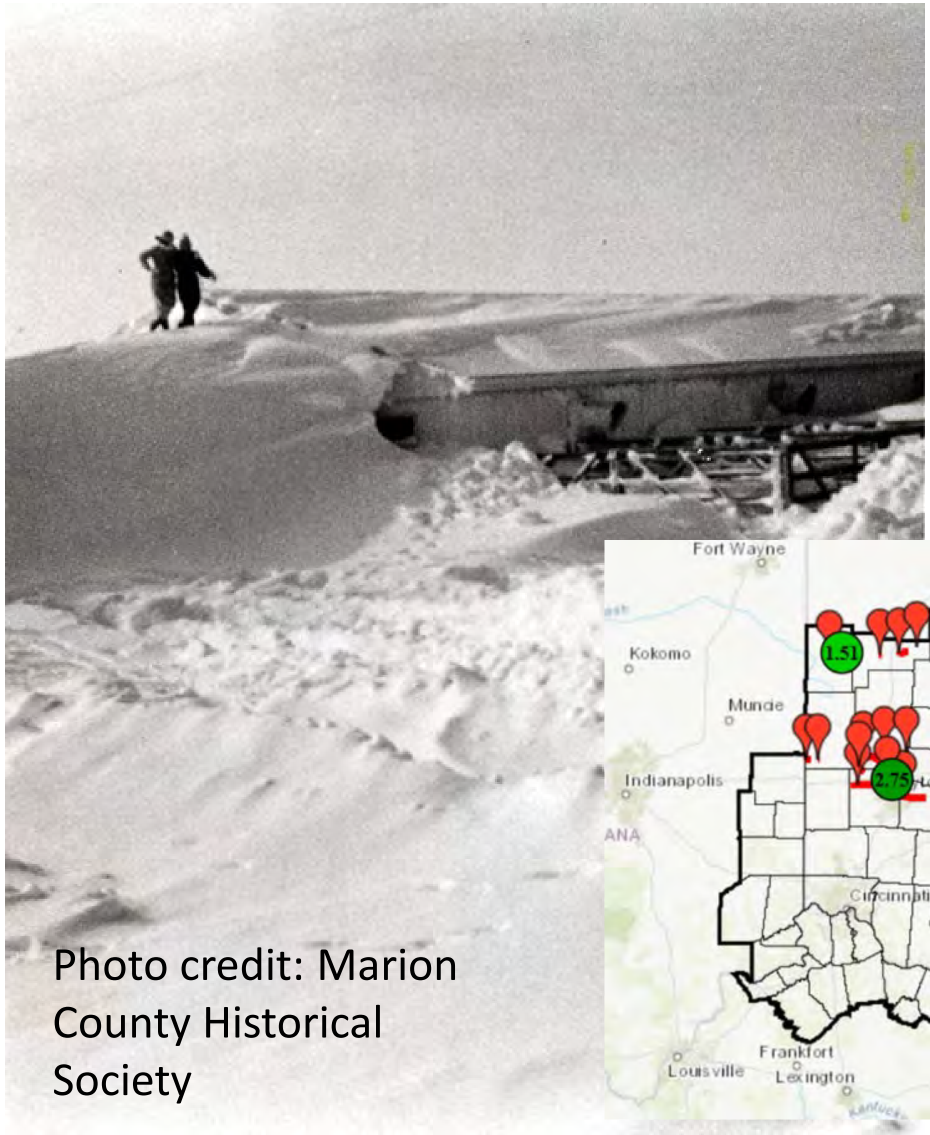
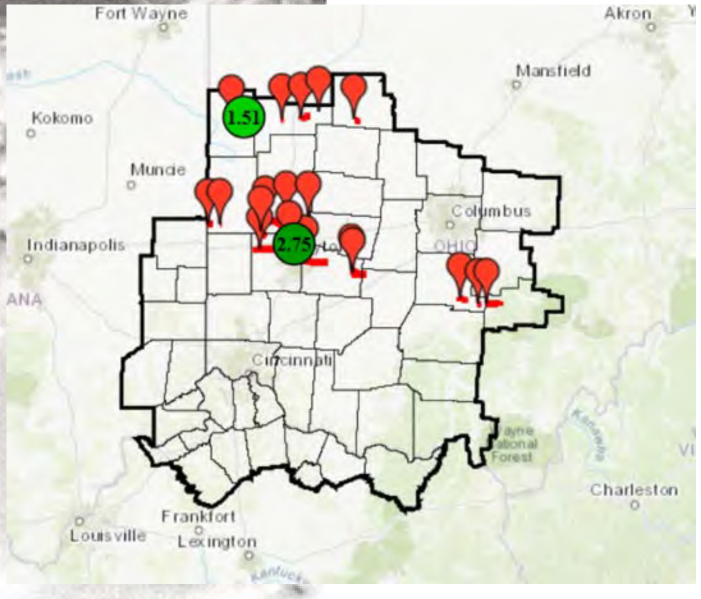
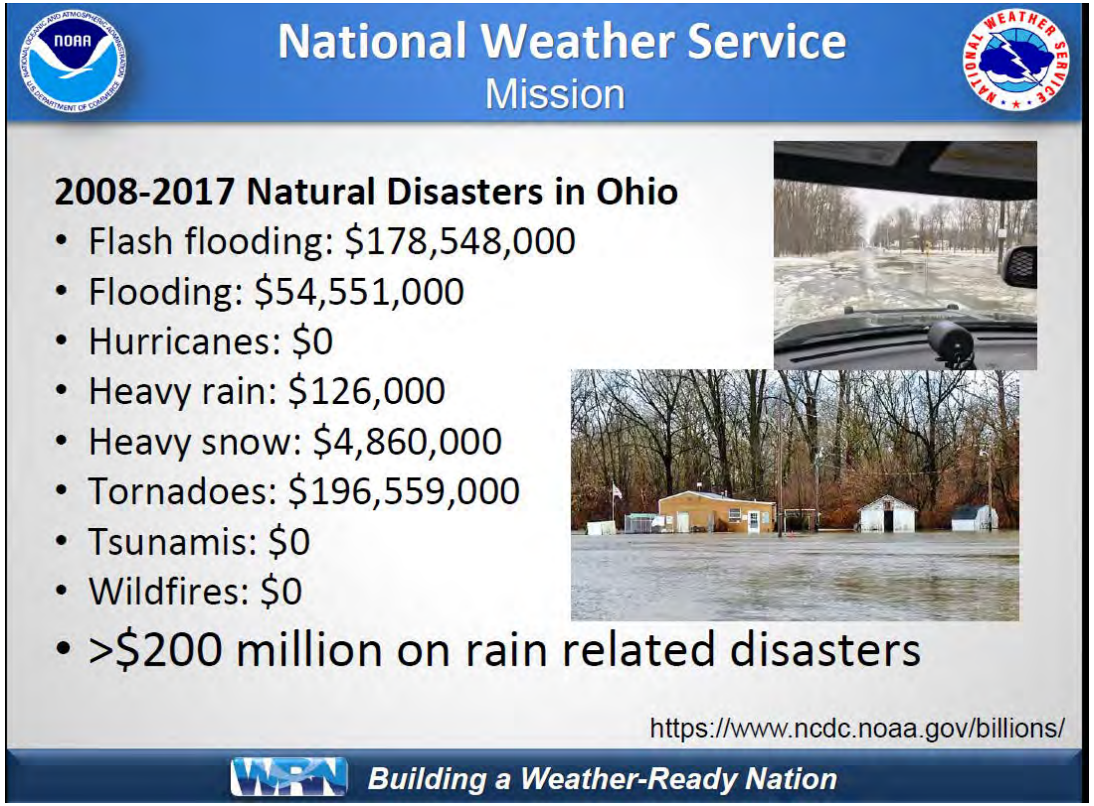
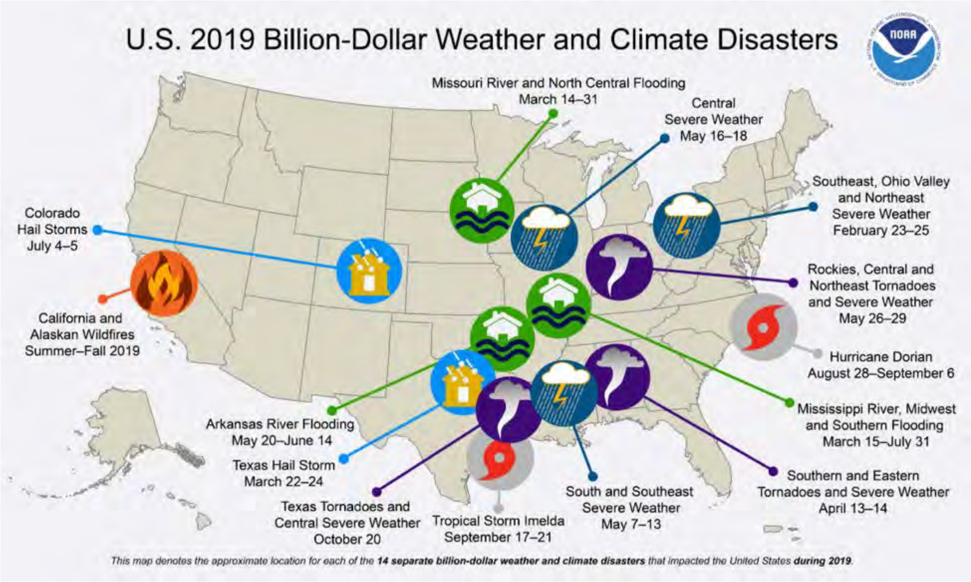


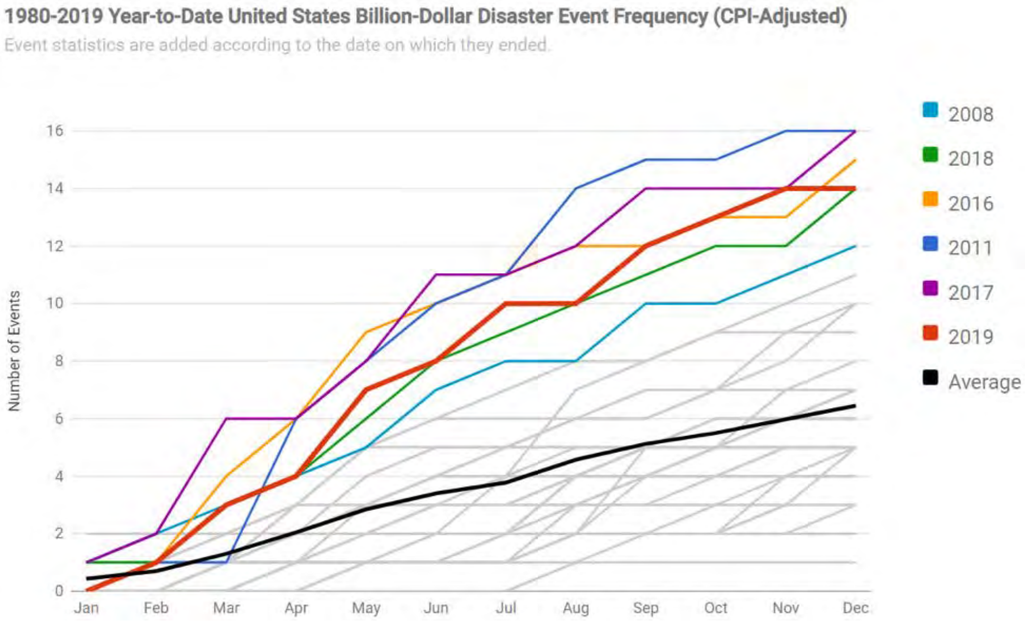
Photo credit: Marion County Historical Society



Billion Dollar Disasters







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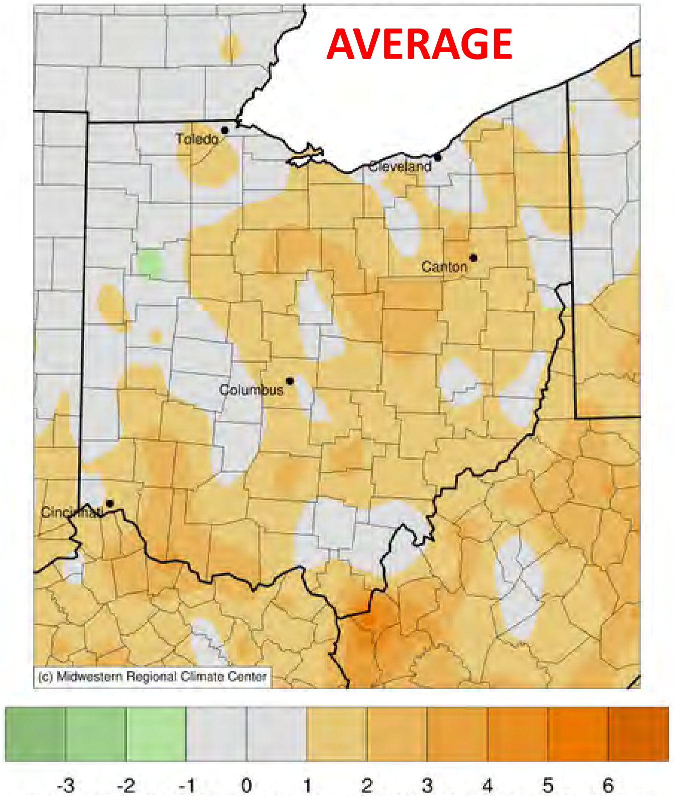
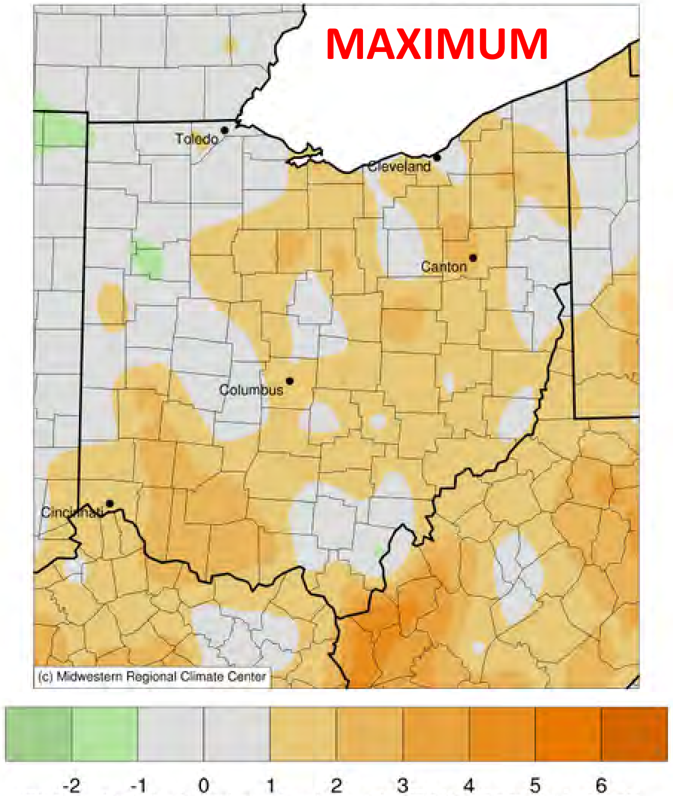
Average Temperature (°F): Departure from 1981-2010 Normals
January 01, 2019 to December 31, 2019



Stations from the following networks used: WBAN, COOP, FAA, GHCN, ThreadEx, CoCoRaHS, WMO, ICAO, NWSLI,
Midwestern Regional Climate Center
cli-MATE: MRCC Application Tools Environment
Generated at: 1/6/2020 10:24:11 AM CST

Average Maximum Temperature (°F): Departure from 1981-2010 Normals
January 01, 2019 to December 31, 2019



Stations from the following networks used: WBAN, COOP, FAA, GHCN, ThreadEx, CoCoRaHS, WMO, ICAO, NWSLI,
Midwestern Regional Climate Center
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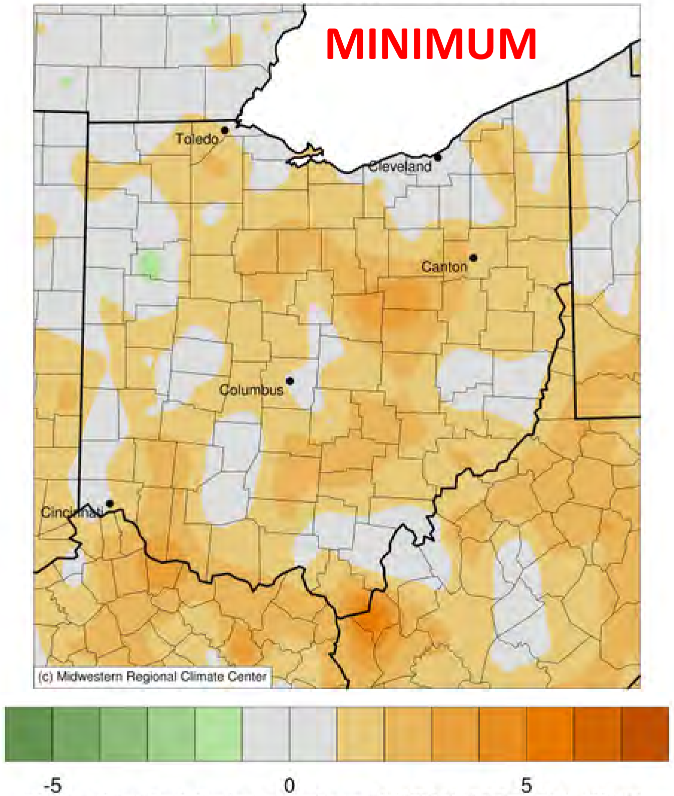
Average Minimum Temperature (°F): Departure from 1981-2010 Normals
January 01, 2019 to December 31, 2019



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Midwestern Regional Climate Center
cli-MATE: MRCC Application Tools Environment
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- 12th Warmest (1895-present)

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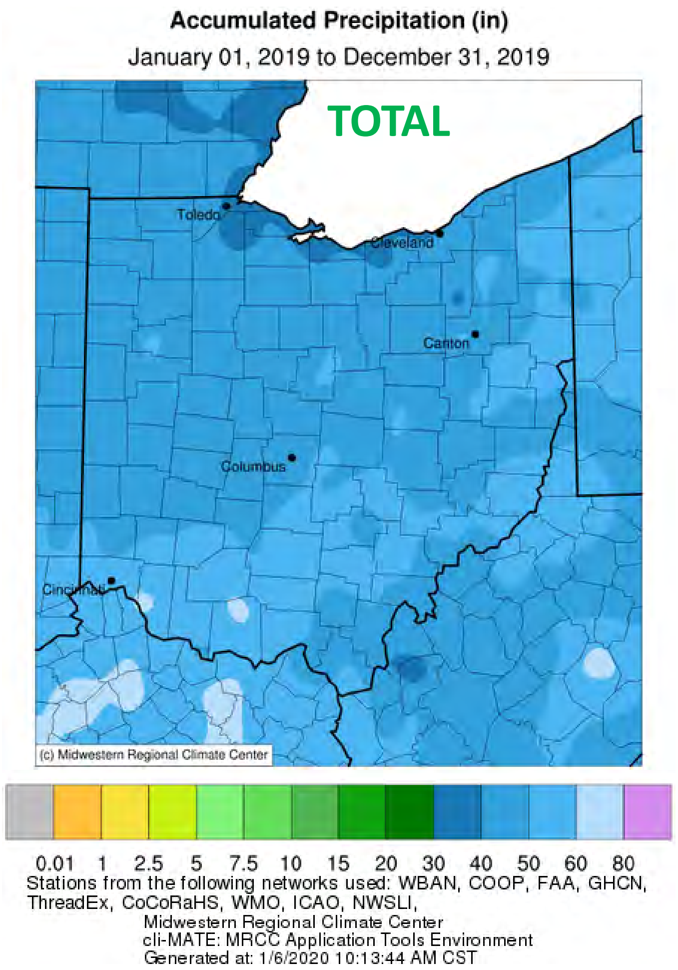
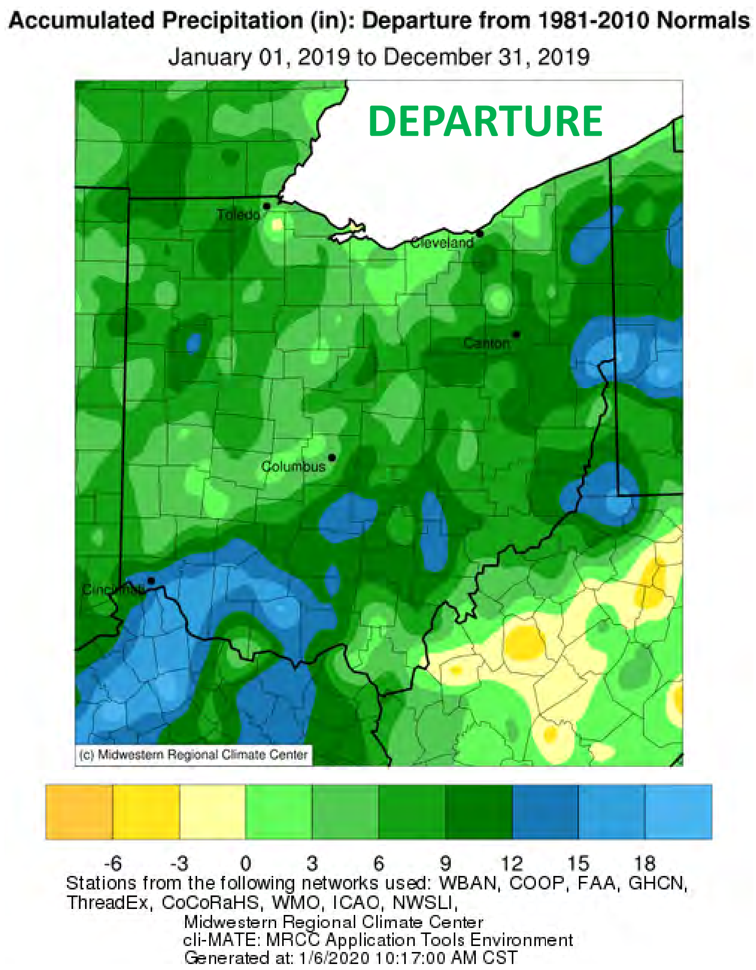
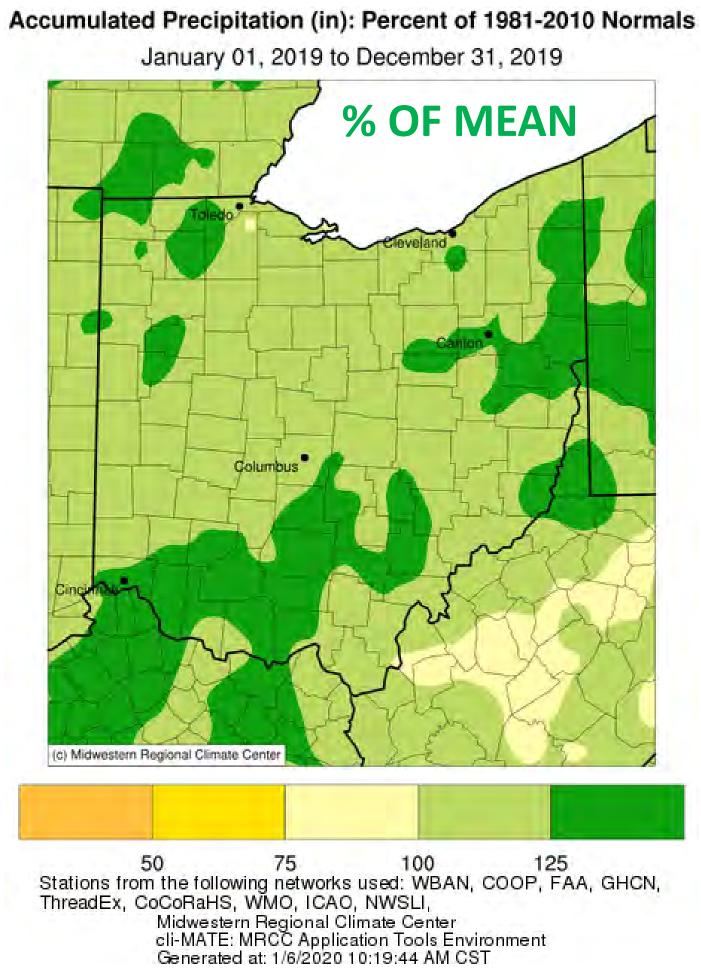
State of Ohio for 2019: Temperature

State of Ohio for 2019: Precipitation







- 6th Wettest (1895-present)

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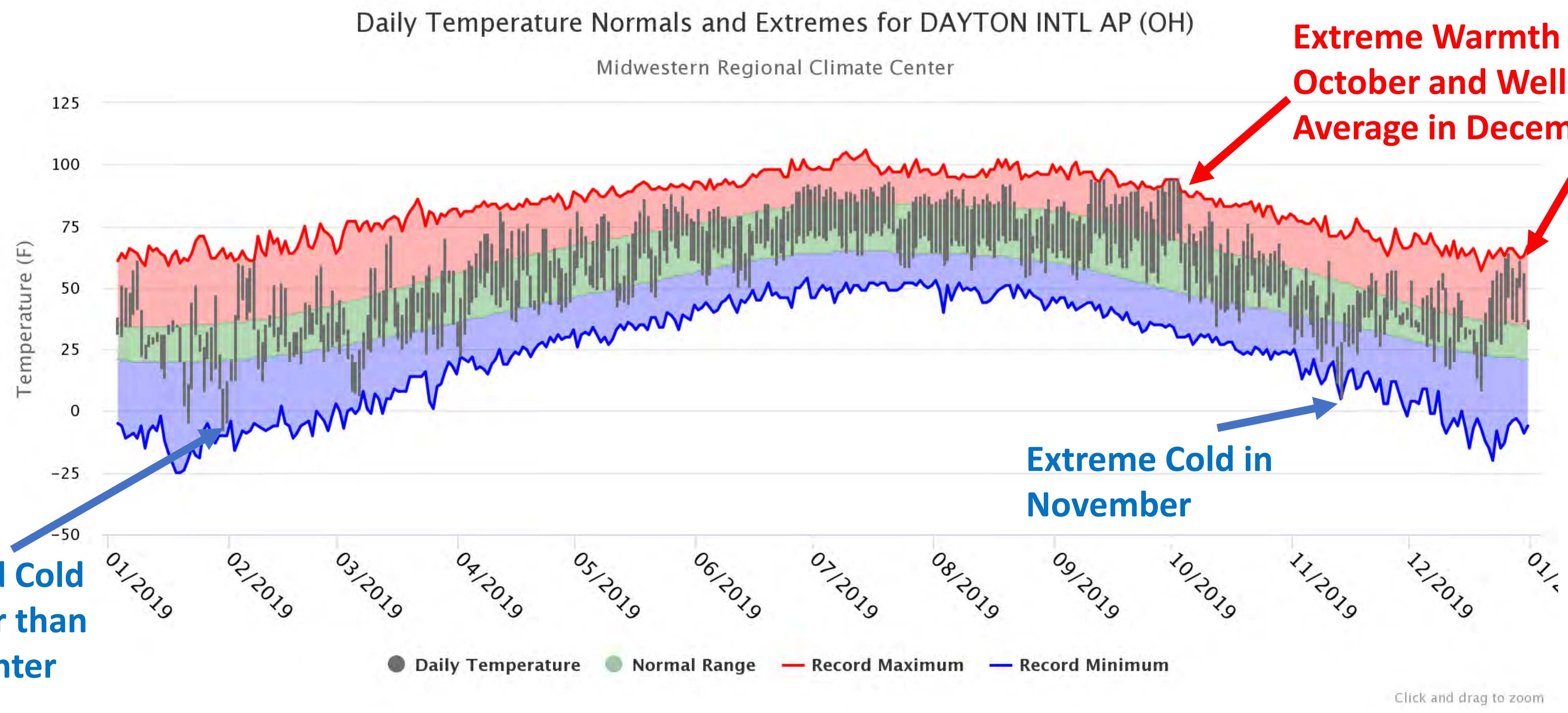
2019 In Review for Dayton (Intl. Ap.)



Extreme Warmth in October and Well Above Average in December

Extreme Cold in November

Near Record Cold in a Warmer than Average Winter

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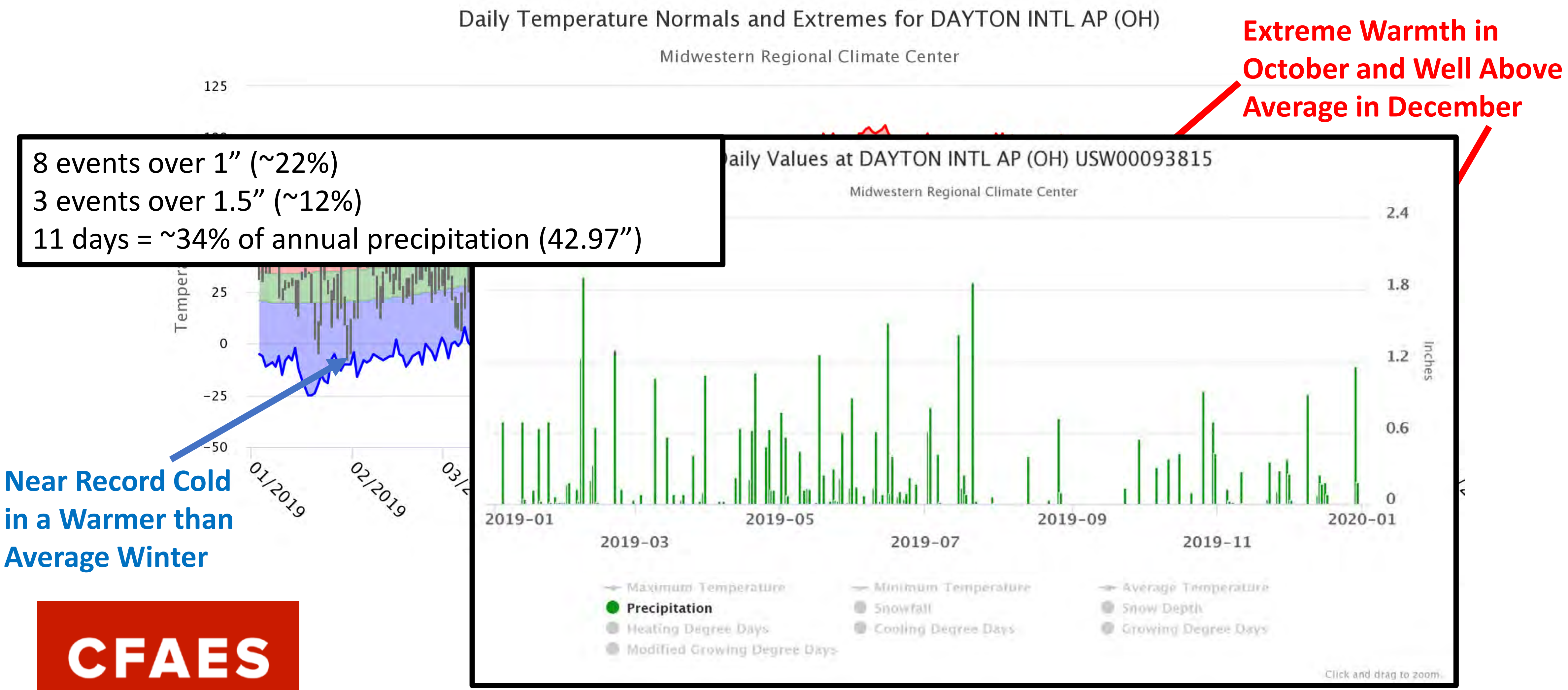

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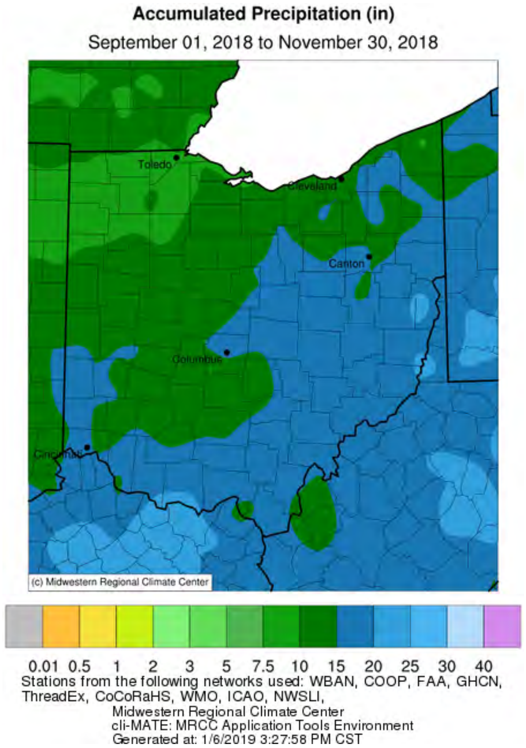
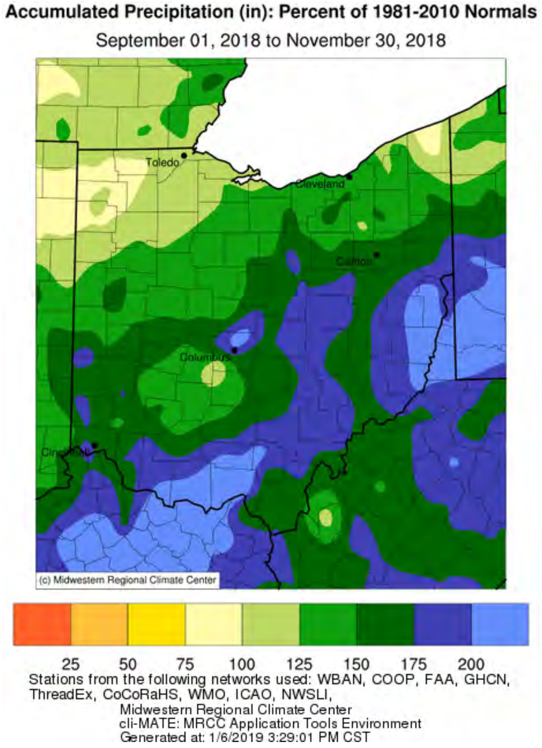
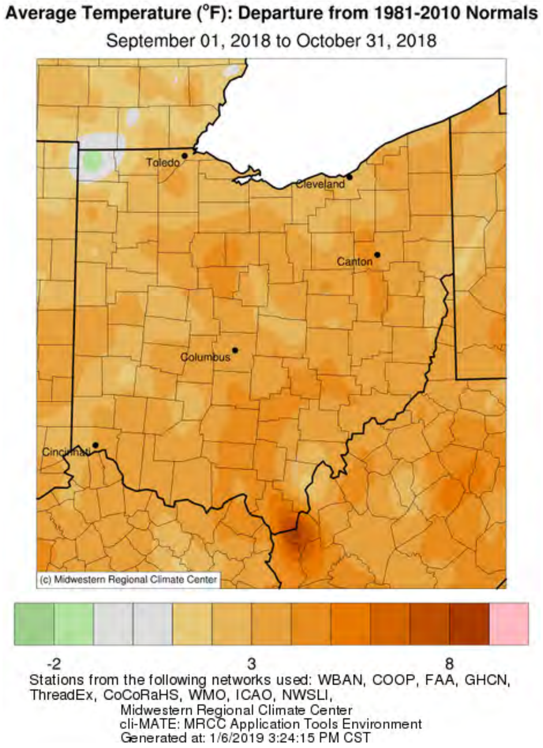
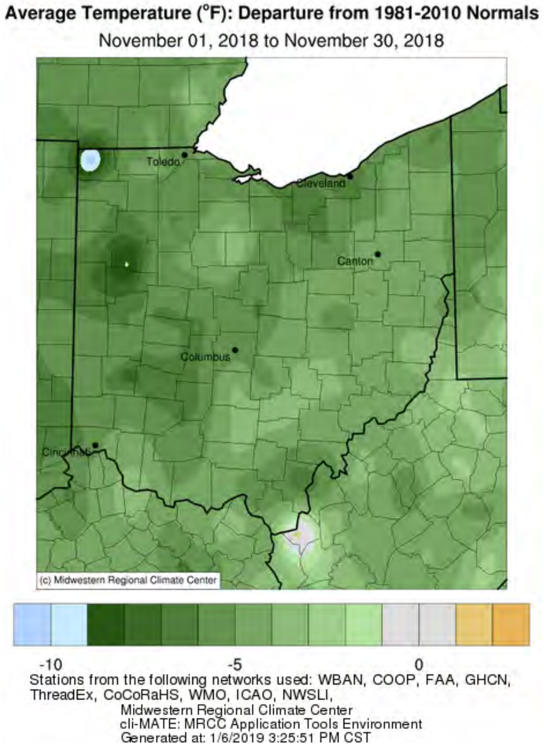
A Crazy Fall in Ohio



Fall 2018: Extreme Variability







- 3rd wettest on record since 1895.
- Sep. 2018 ranks as 2nd wettest.
- Driven largely by tropical activity

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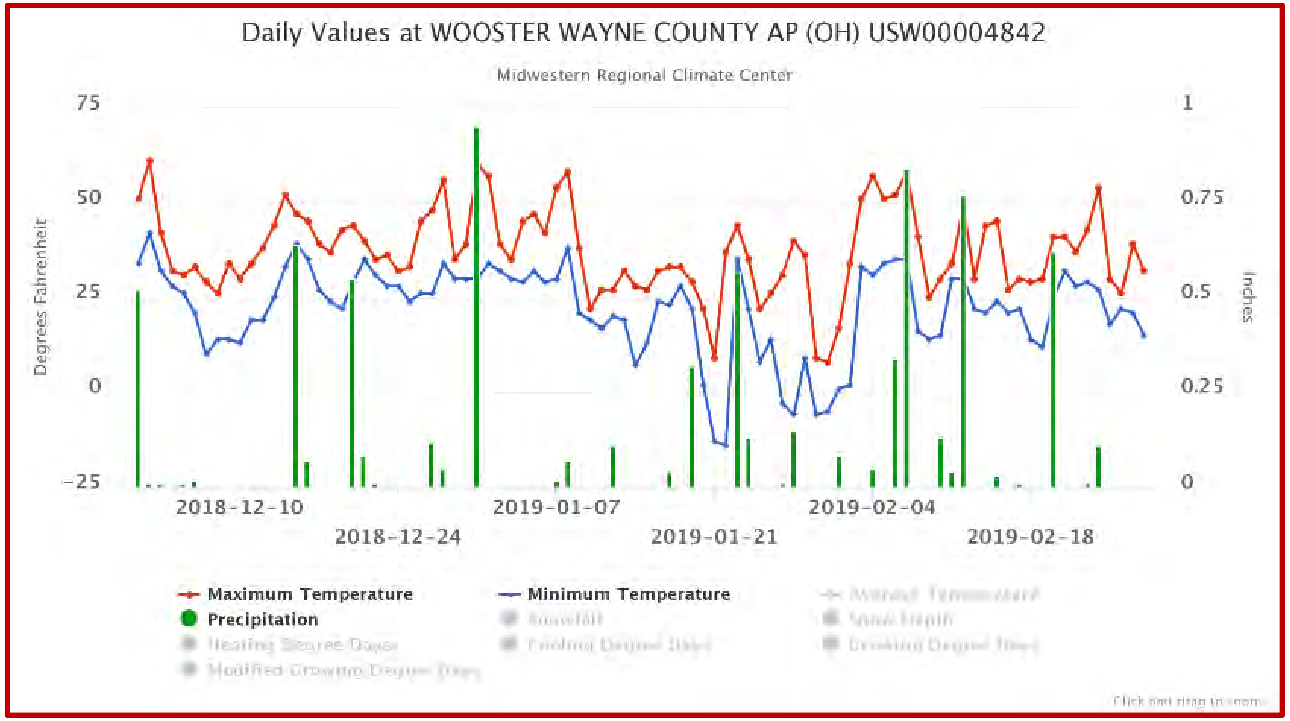
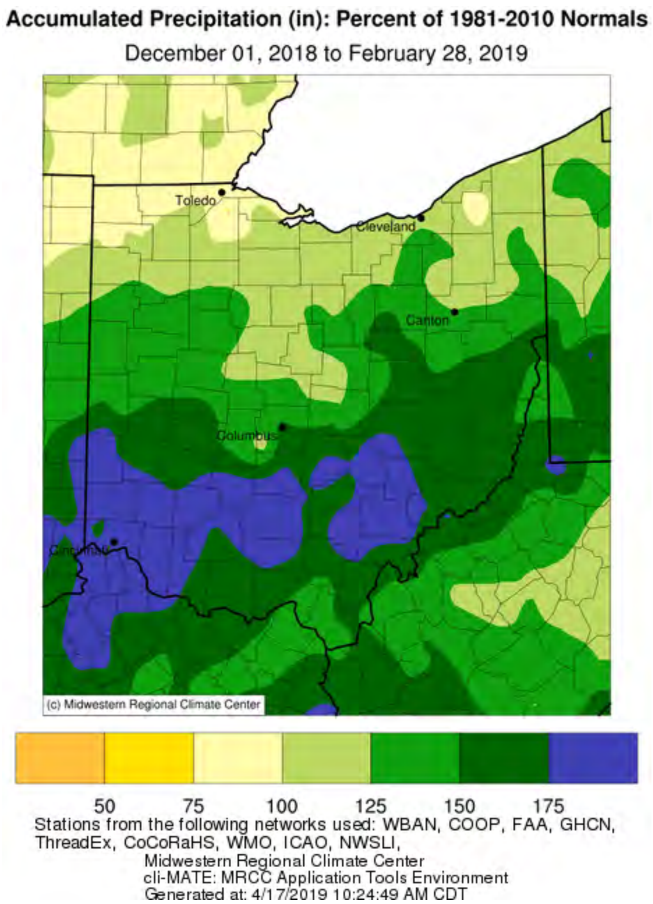
No Relief During Winter





- Winter 2019 ranks as the 11th wettest on record for Ohio, with precipitation 150-200% above average along and south of about I-70.

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- A short period of intense cold occurred during January, with frequent freeze-thaw cycles led to extreme heaving.

Spring: Rinse & Repeat

- March-May 2019 rank as the 36th warmest and 32nd wettest for the state
- West-central and northwest Ohio ranked 7th and 3rd wettest on record, respectively.
- St. Marys, Ohio (Auglaize County), CoCoRaHS observer reported over 20 inches of precipitation between March 1 and May 31 - ***that's over half of their normal yearly rainfall in just three months.***
- Multiple observers in excess of 15 inches
- Reports of 20-26 days of at least a trace of precipitation during the month of May
- Only 7 days suitable for fieldwork during May

Photo: Greg McGlinch

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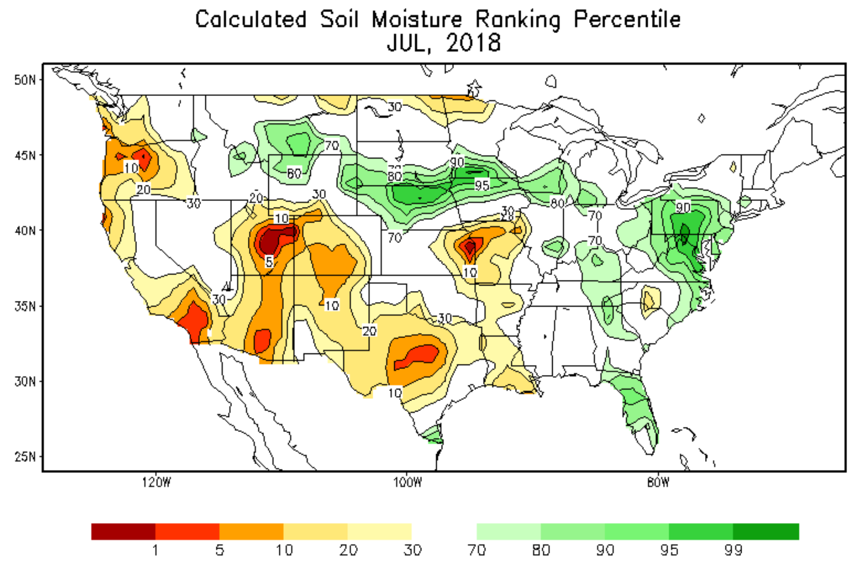
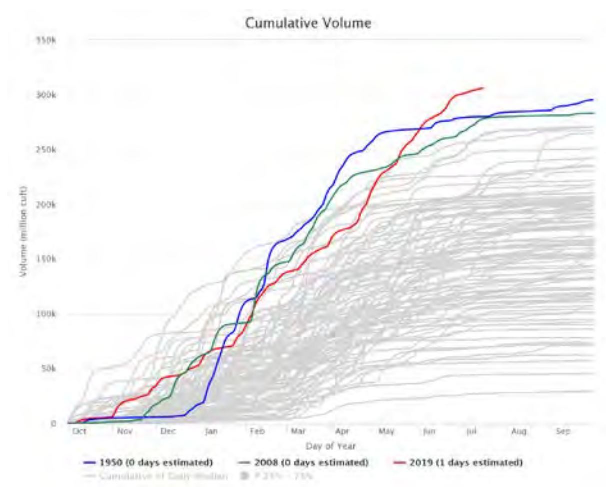
Consequences of All That Water

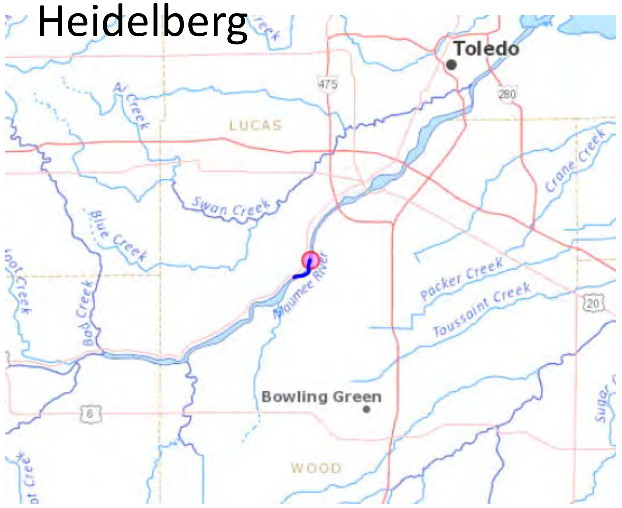


https://www.cpc.ncep.noaa.gov/products/Soilmst_Monitoring/US/Soilmst/Soilmst.shtml



NATIONAL WEATHER SERVICE

Dr. Laura Johnson - Heidelberg



Maumee River at Waterville

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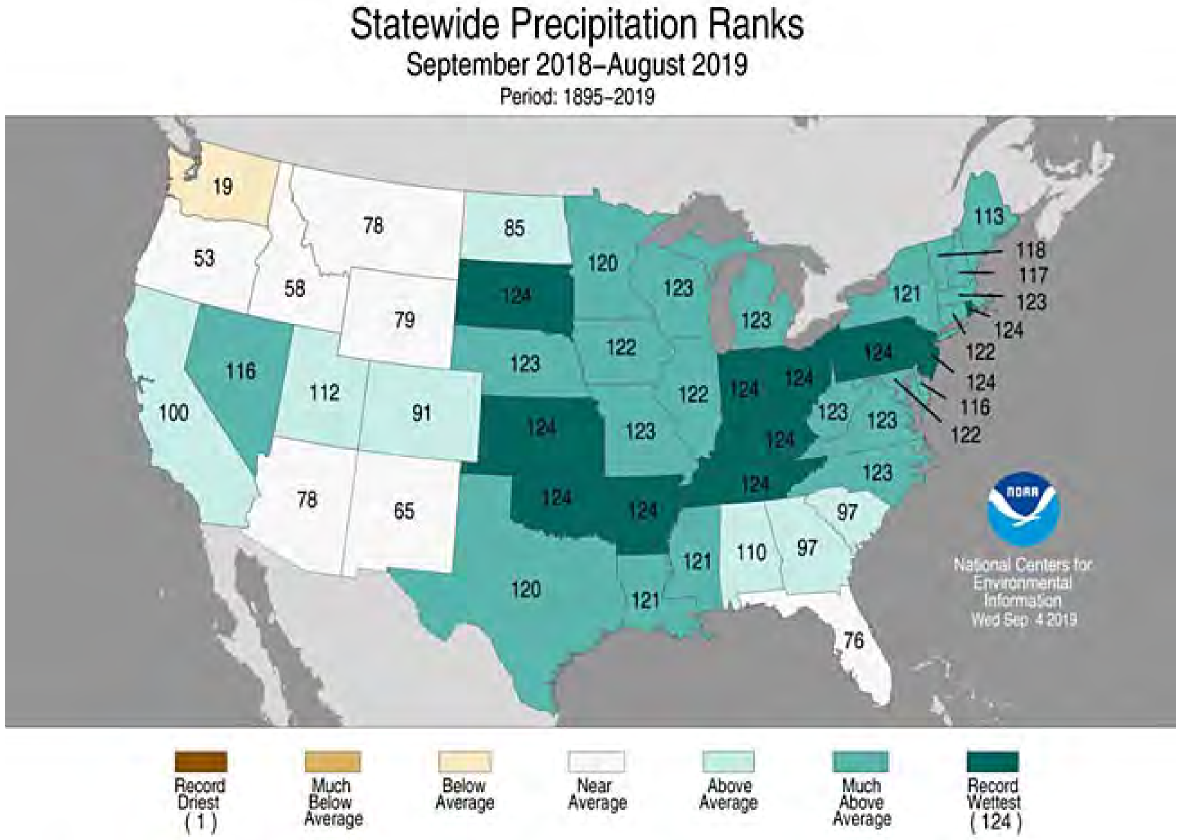
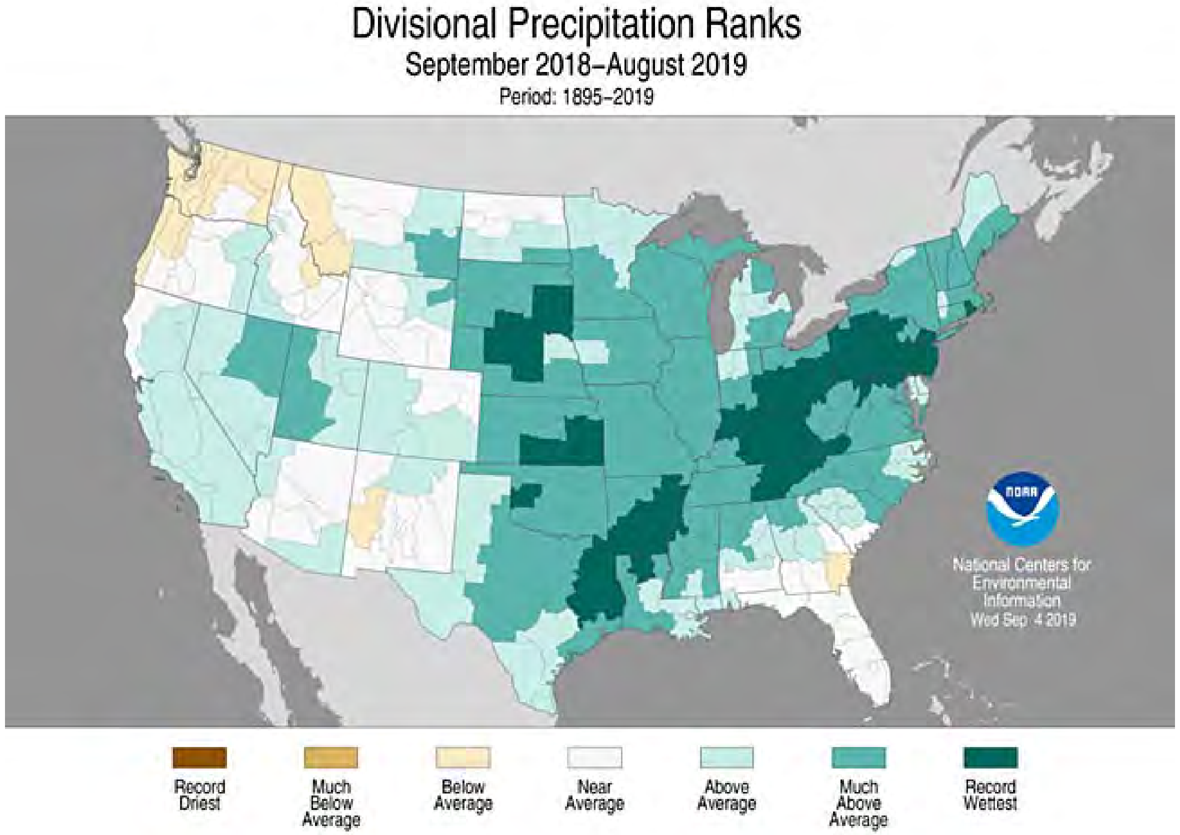
Was 2019 a Wet Year?





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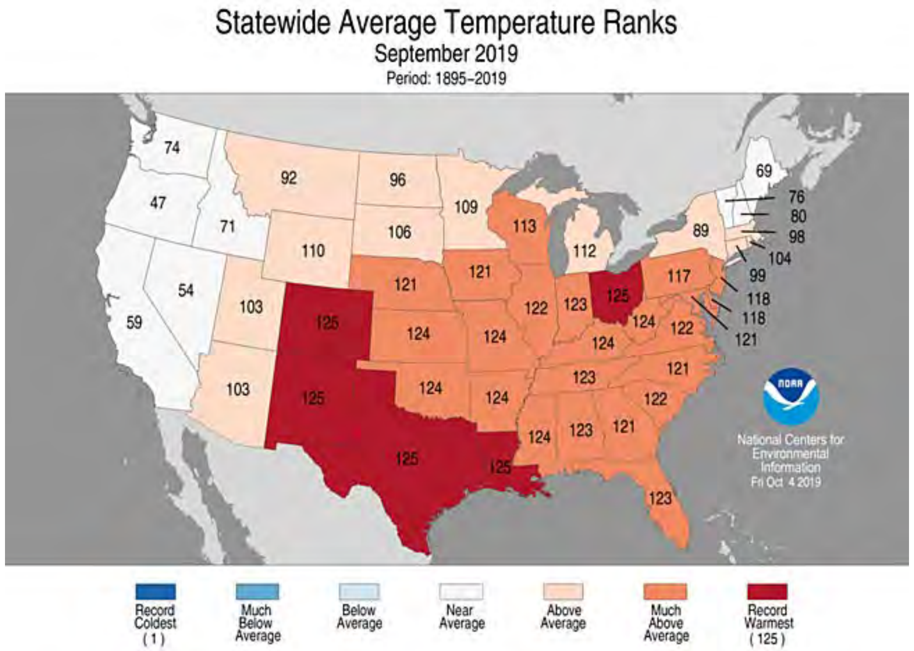
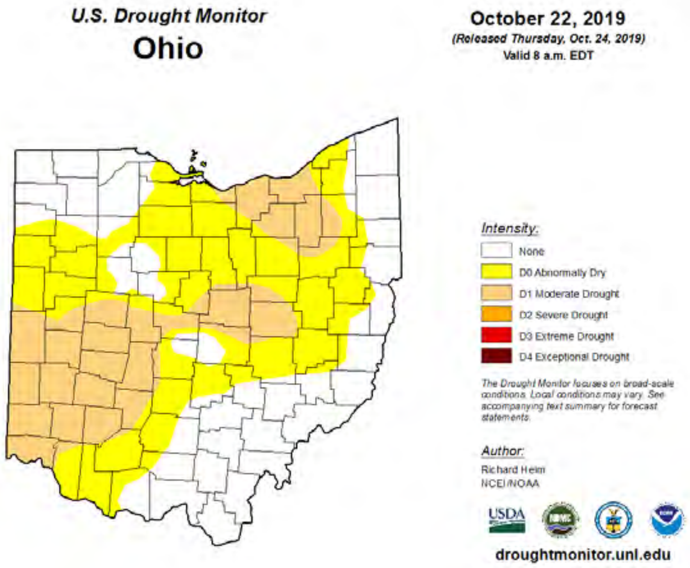
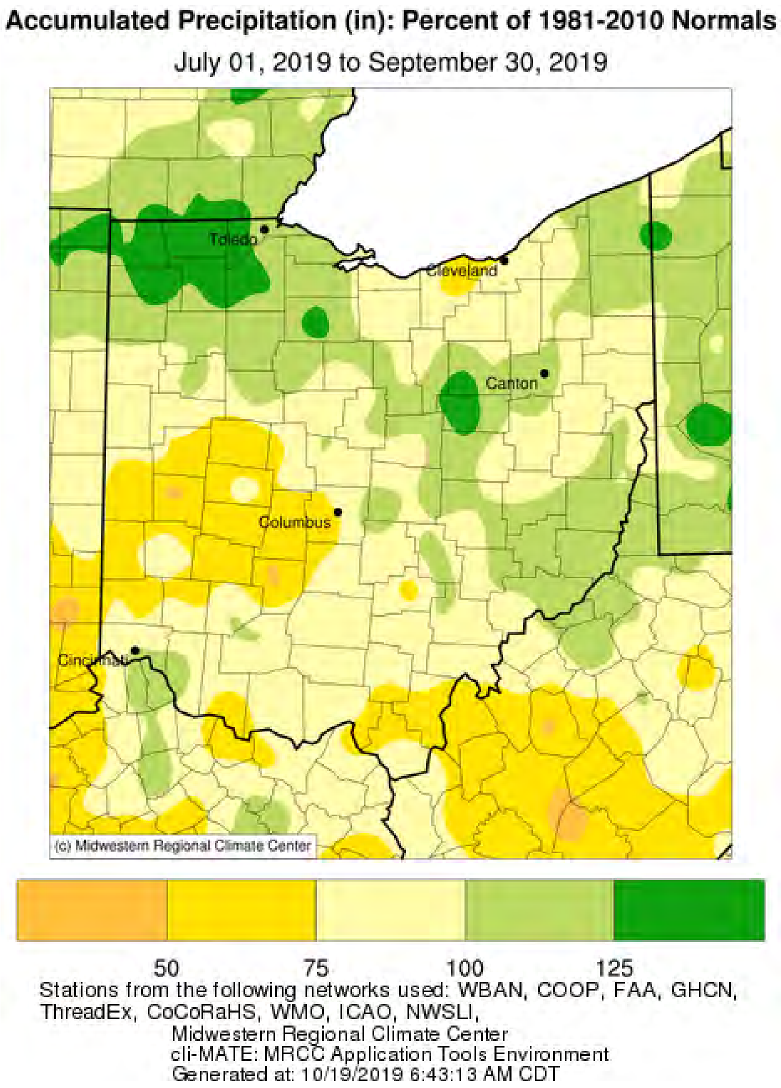
Rapid Summer Transition







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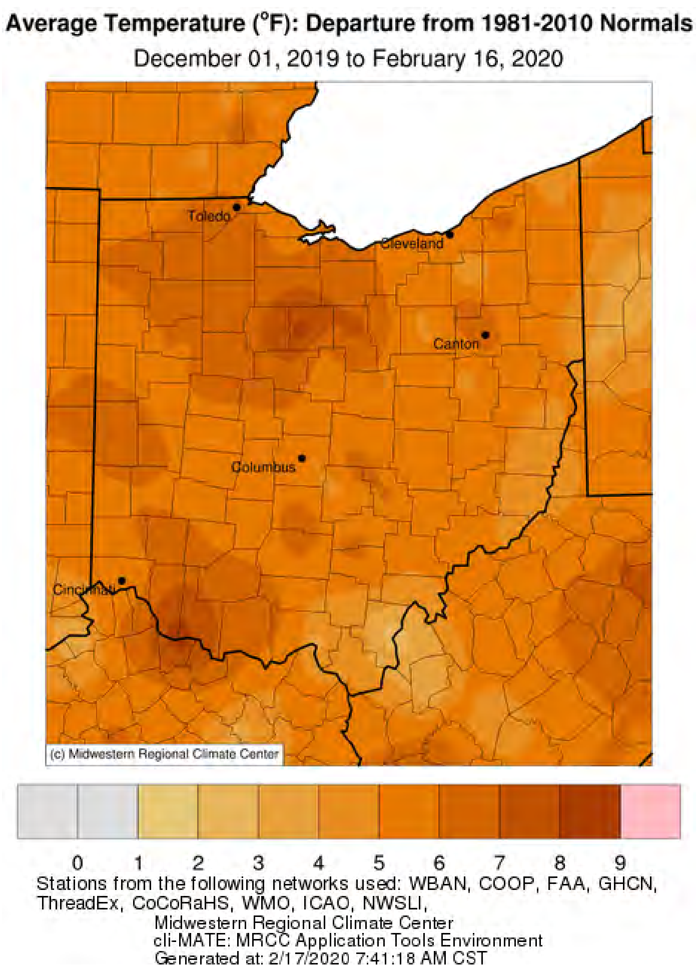

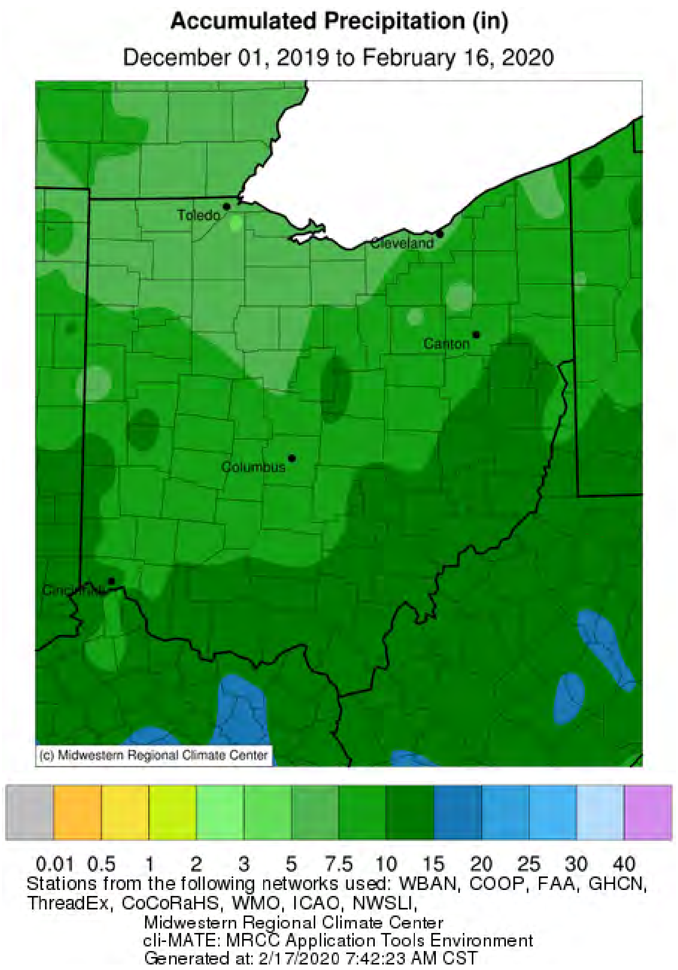

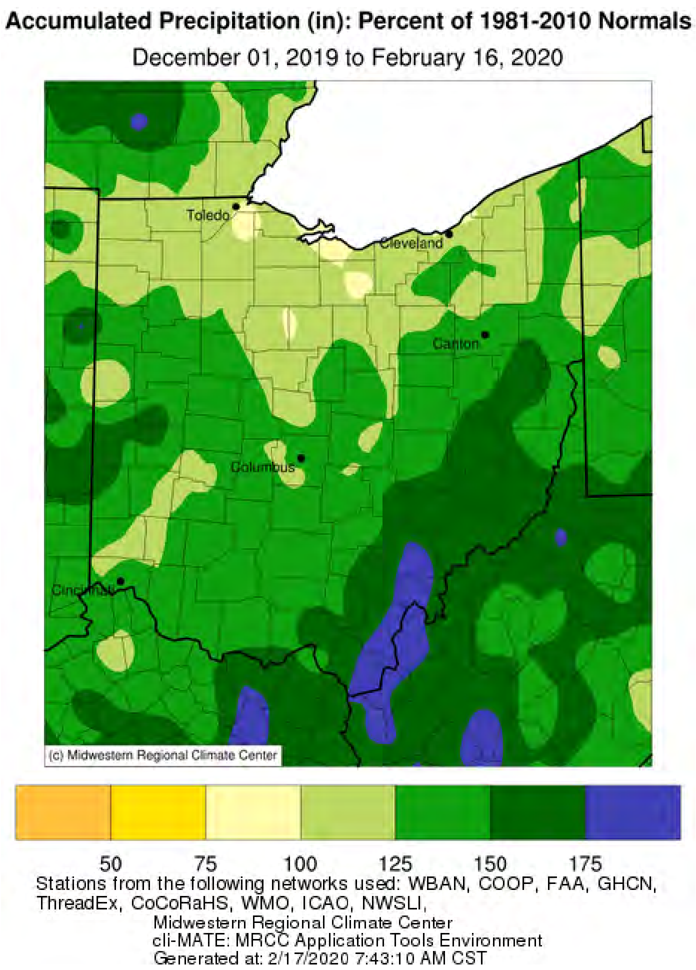

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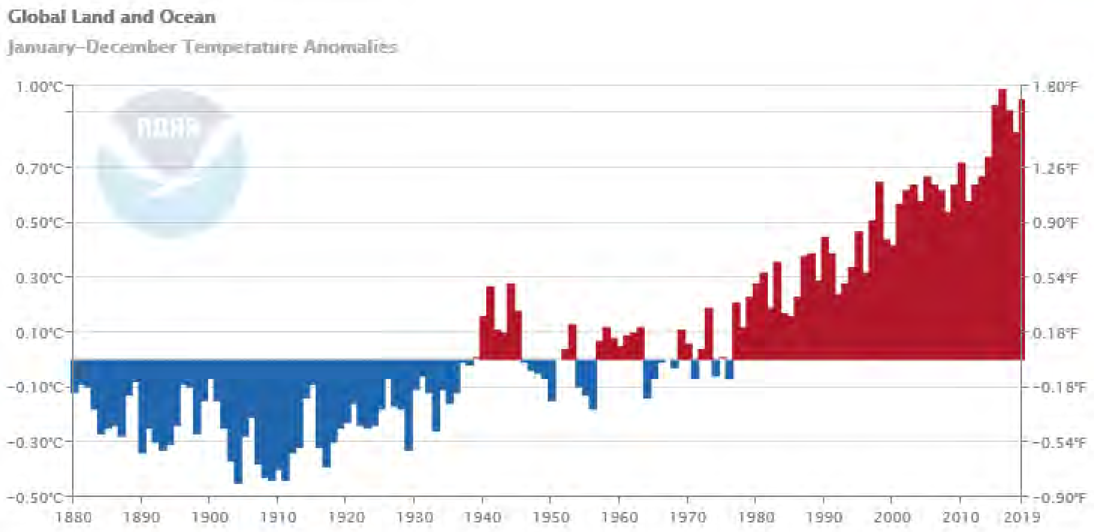
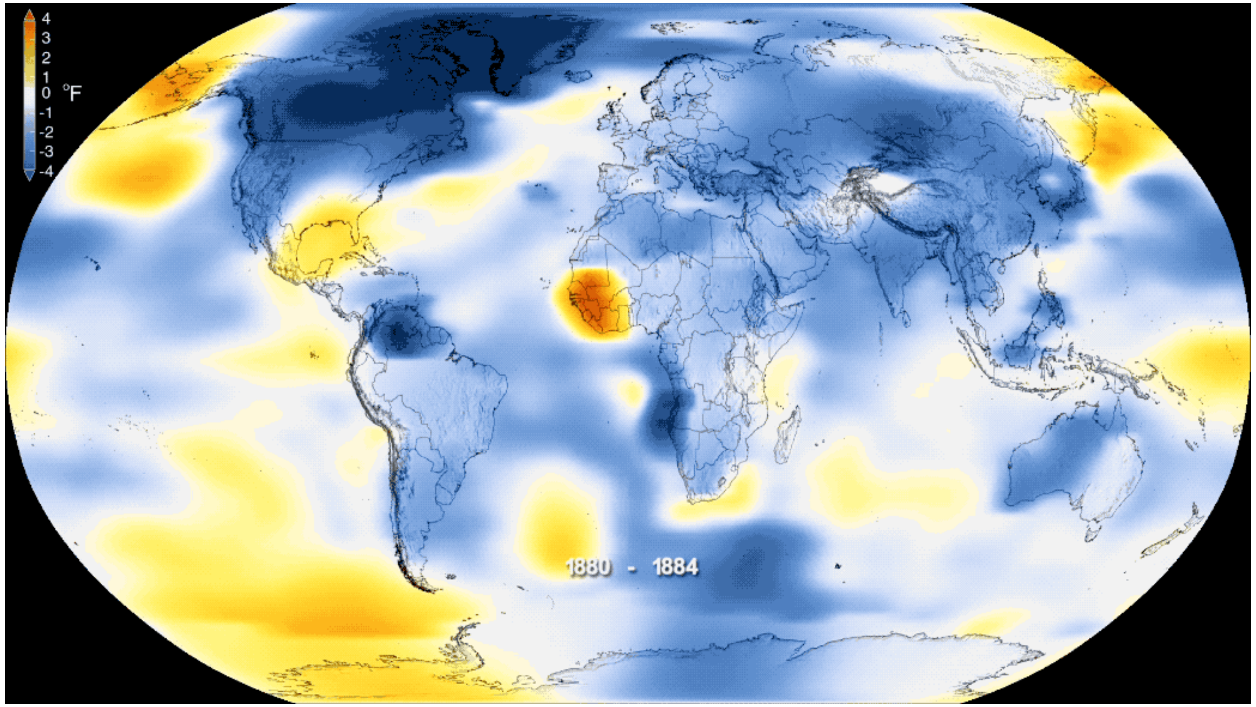
The 2020 Winter…so far

Global Temperatures Have Warmed





- 2019 Ranks as the 2nd Warmest since 1880
- 9 out of the top 10 warmest years have occurred since 2005

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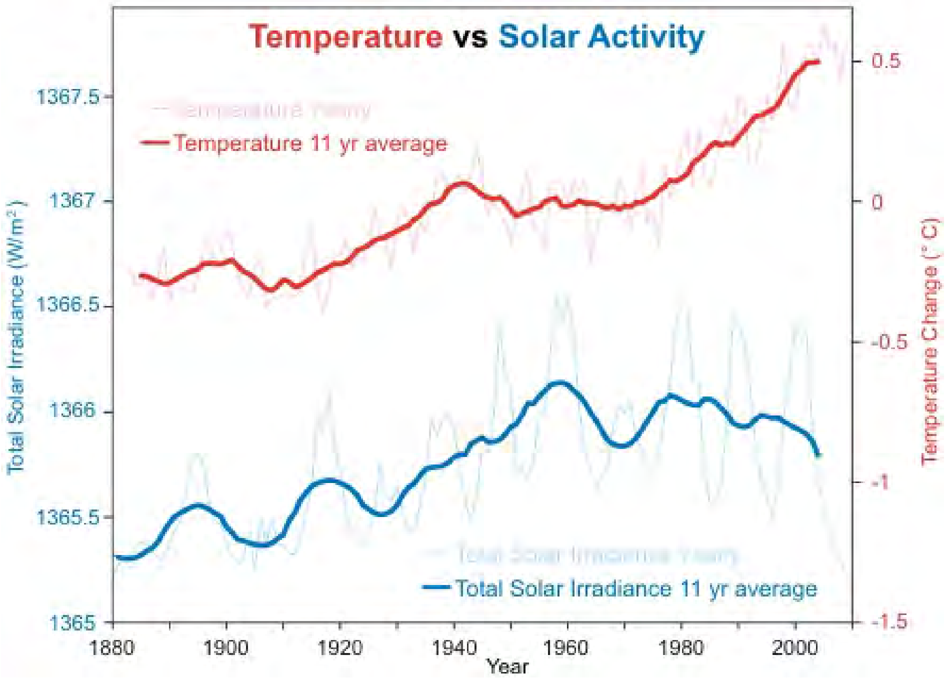
What Causes Our Climate To Change?

- Changes in…
  - Incoming solar radiation
  - Composition of the atmosphere
  - Earth’s surface characteristics



- Variations in Earth’s Orbit

- Plate Tectonics and Mountain Building

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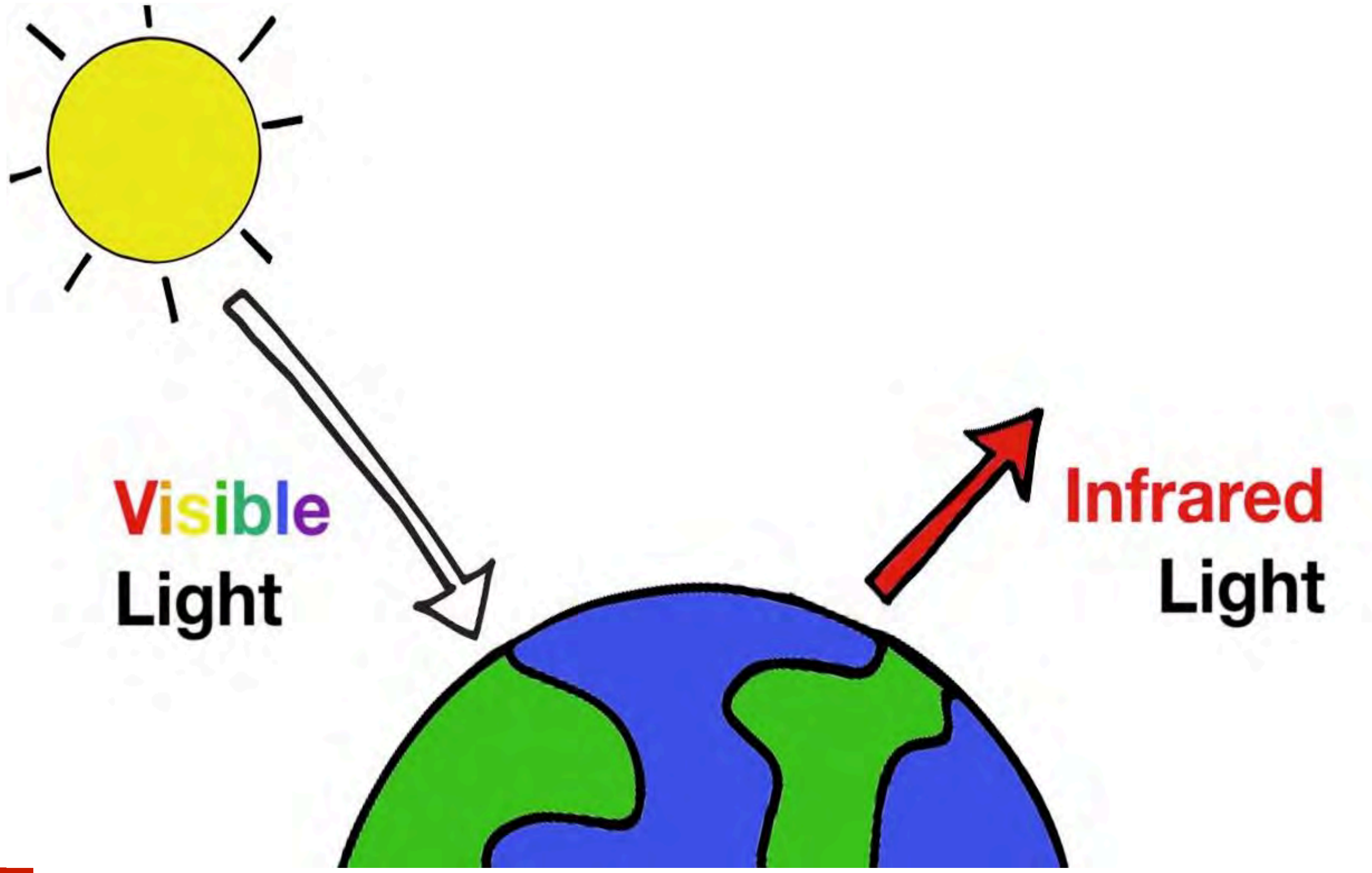
How the Atmosphere Warms



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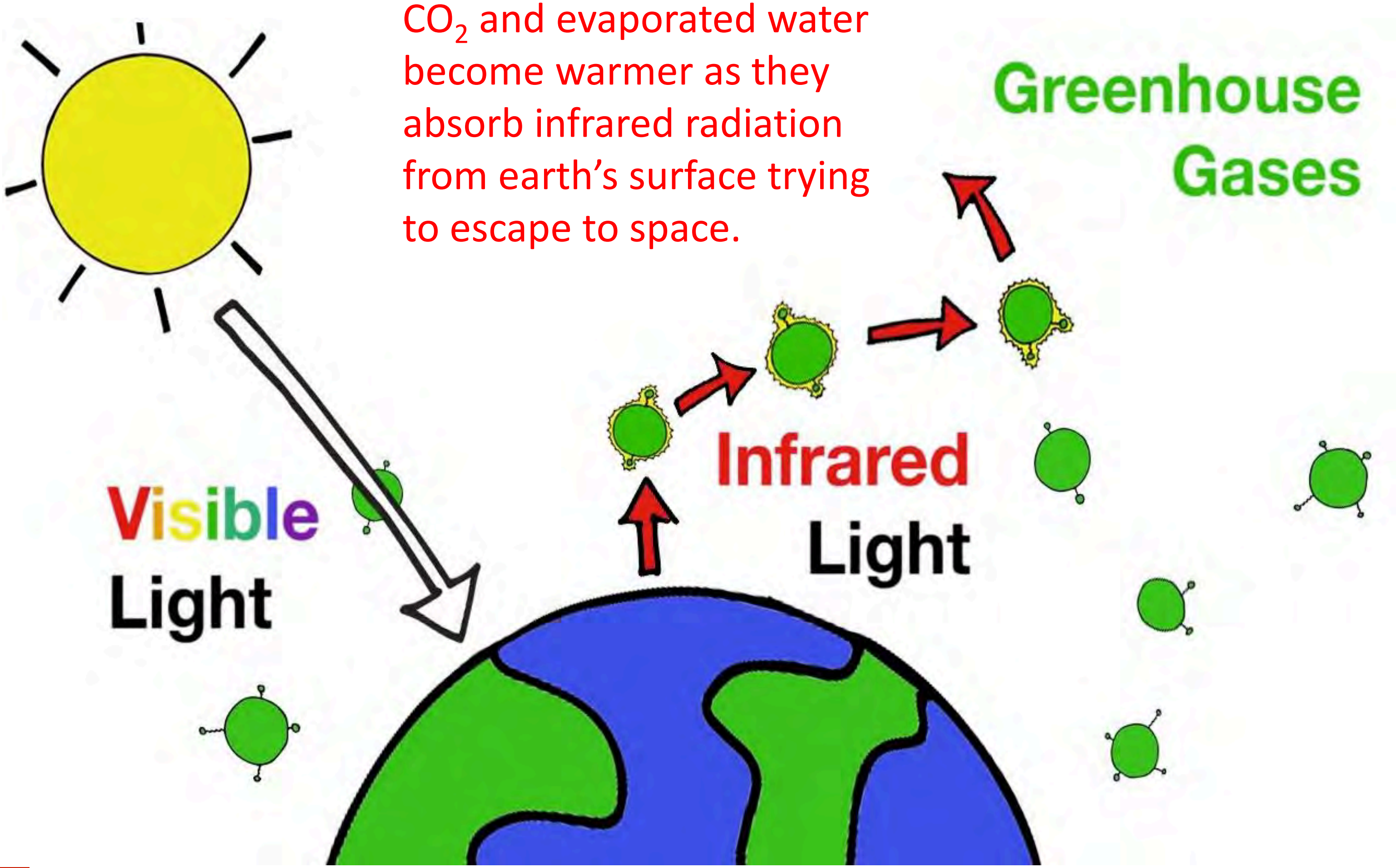
HowGlobalWarmingWorks.org, 2014

How the Atmosphere Warms

CO_2 and evaporated water become warmer as they absorb infrared radiation from earth's surface trying to escape to space.



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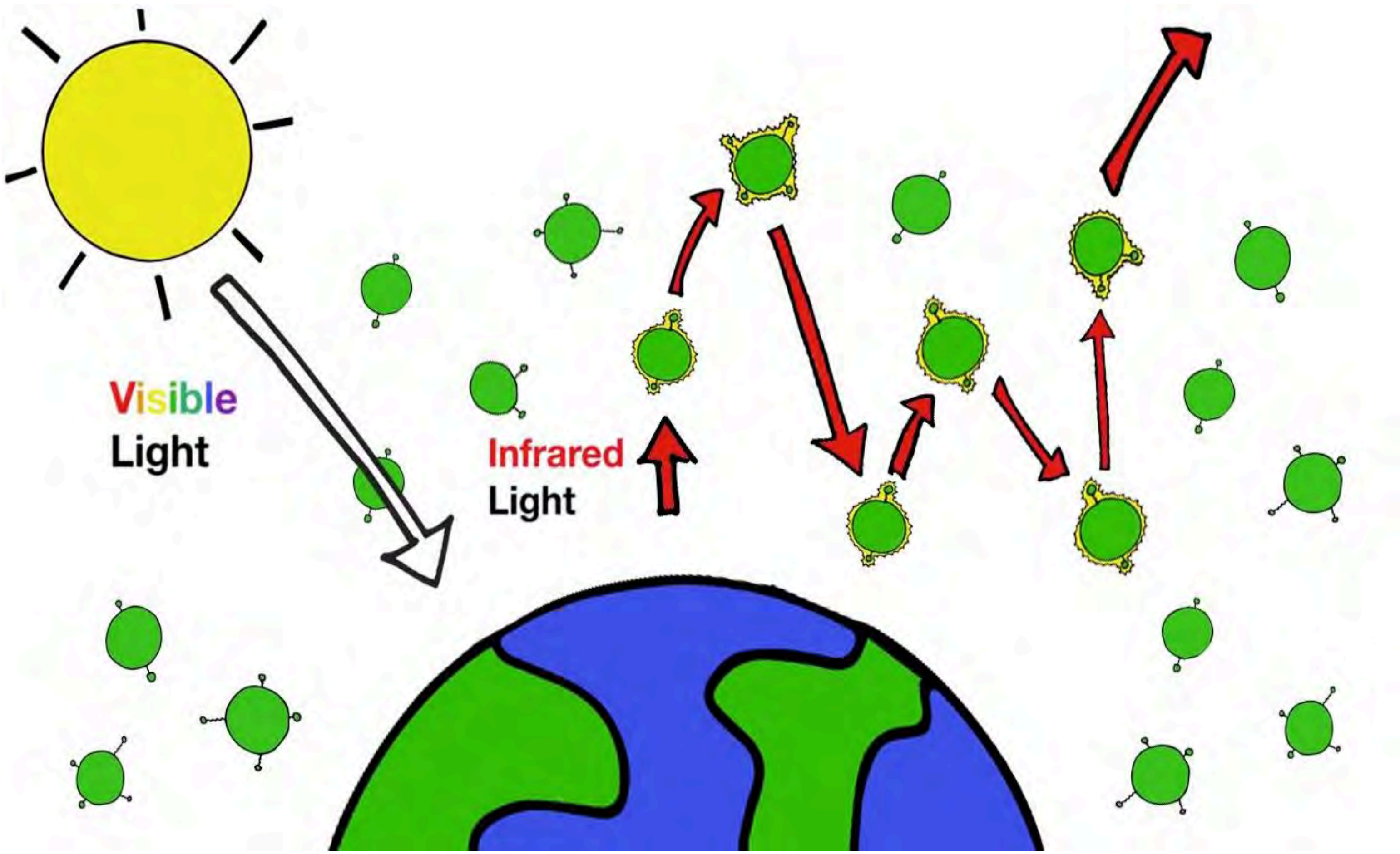
HowGlobalWarmingWorks.org, 2014

How the Atmosphere Warms



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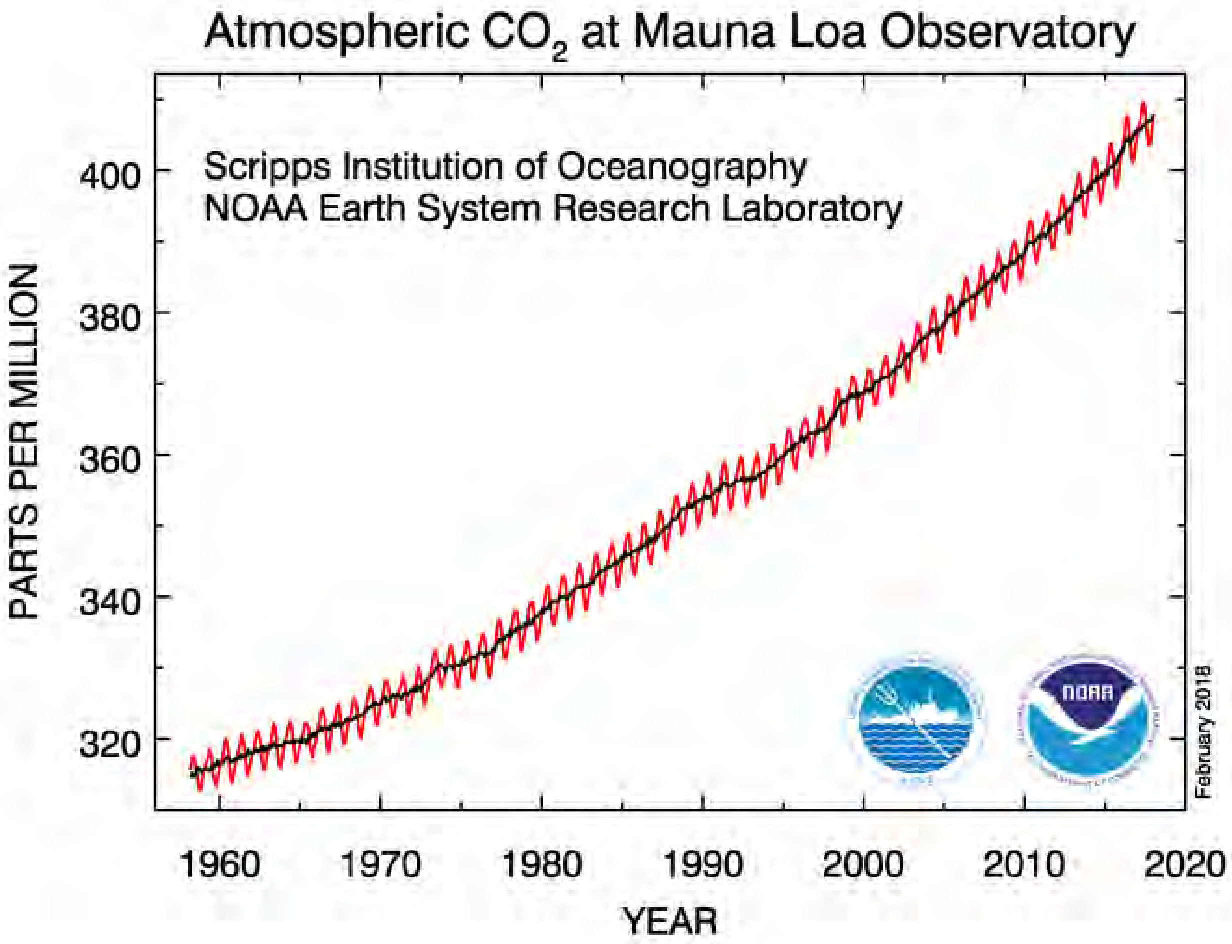
HowGlobalWarmingWorks.org, 2014

Contemporary Greenhouse Gas Concentrations

Water Vapor (humidity): Contributes about 40°F to current Earth's temperature: (Increased 5-10% in last 50 years)

Carbon Dioxide: Contributes 20°F to current temperature: (Increased 25-30% in last 50 years)



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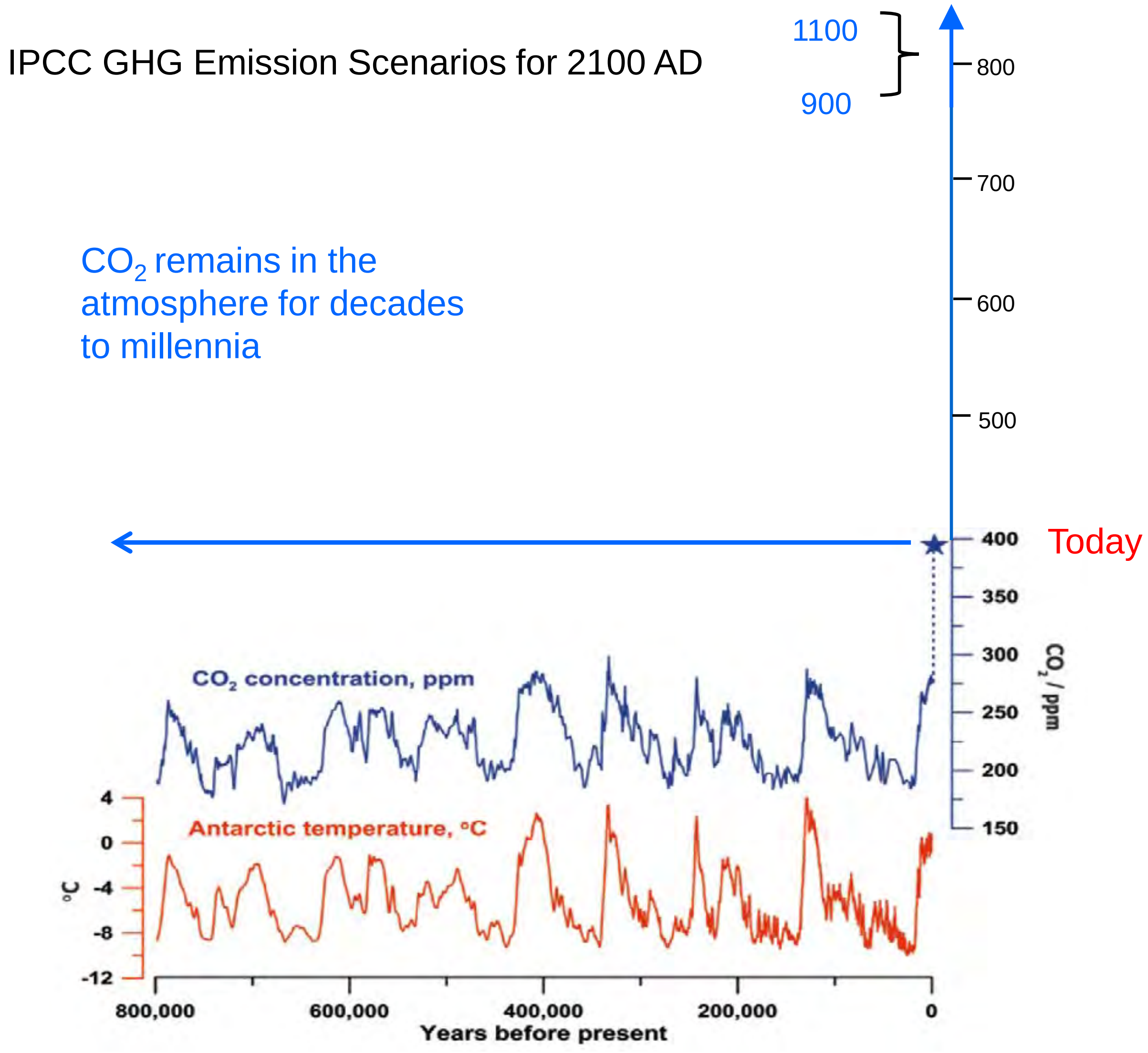
Historical Greenhouse Gas Concentrations



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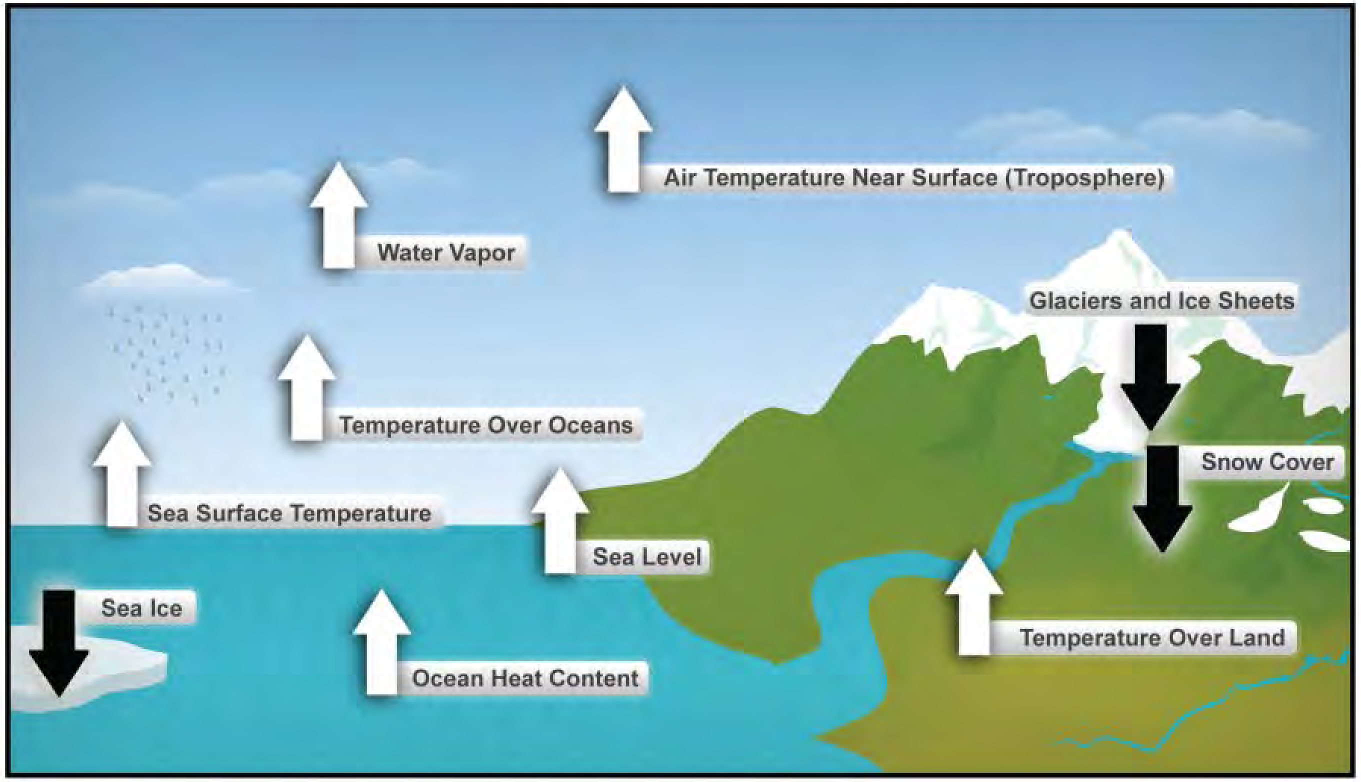
Warming Temperatures Have Feedbacks

Ten Indicators of a Warming World



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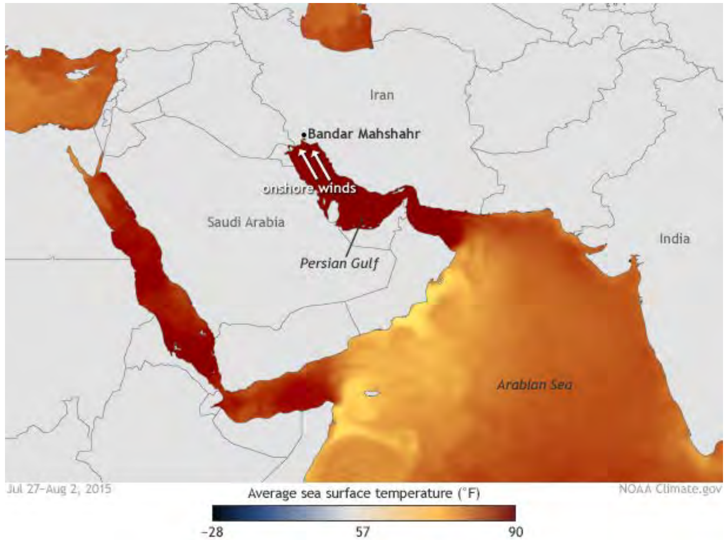
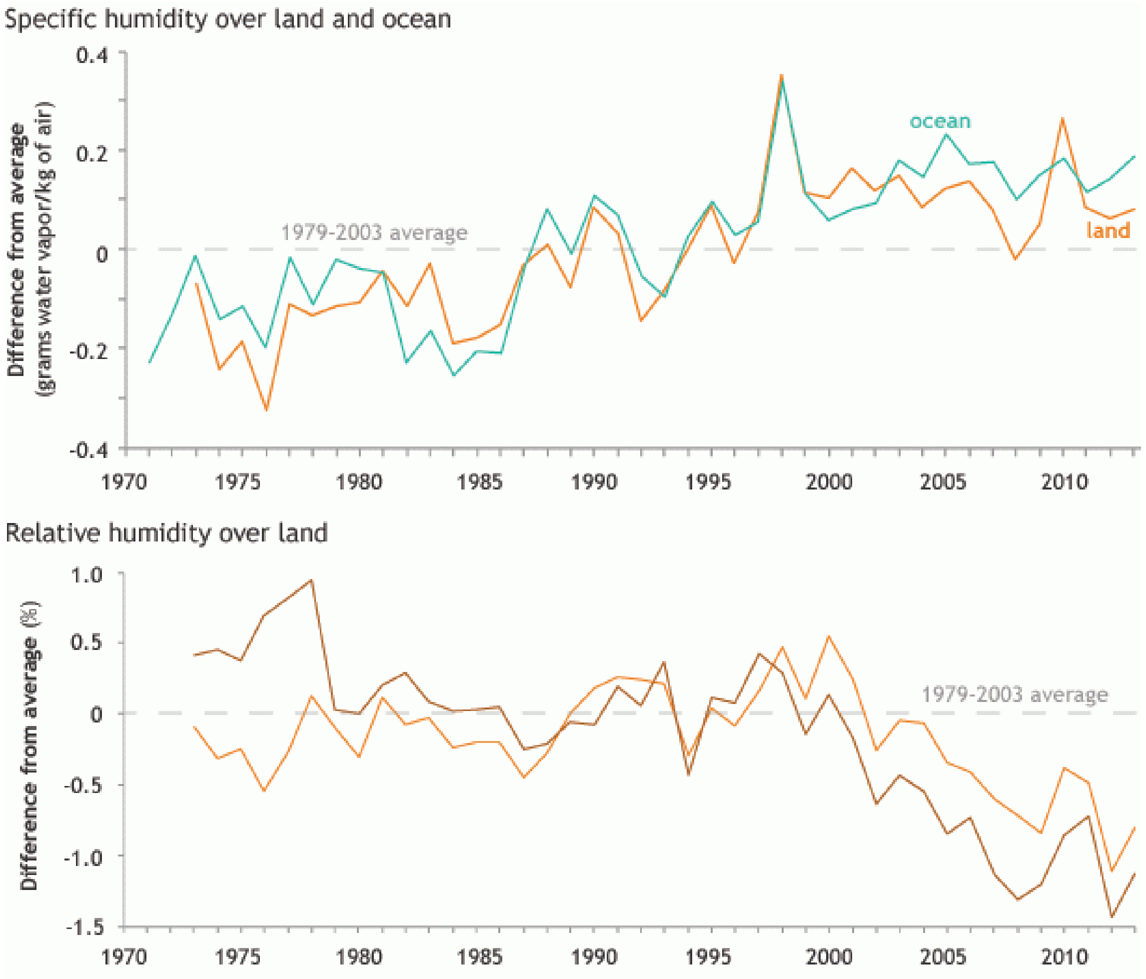
Impact: Water Vapor



On July 30 2015 in Bandar Mahshahr, at 4:30pm, the temperature was 111°F and the dew point 88°F, making the heat index value a whopping 155°F, an unfathomably high number. The next day, July 31, at 4:30pm, the heat index soared to 165°F, after a temperature of 115°F was reached while the dew point was 90°F.



NOAA

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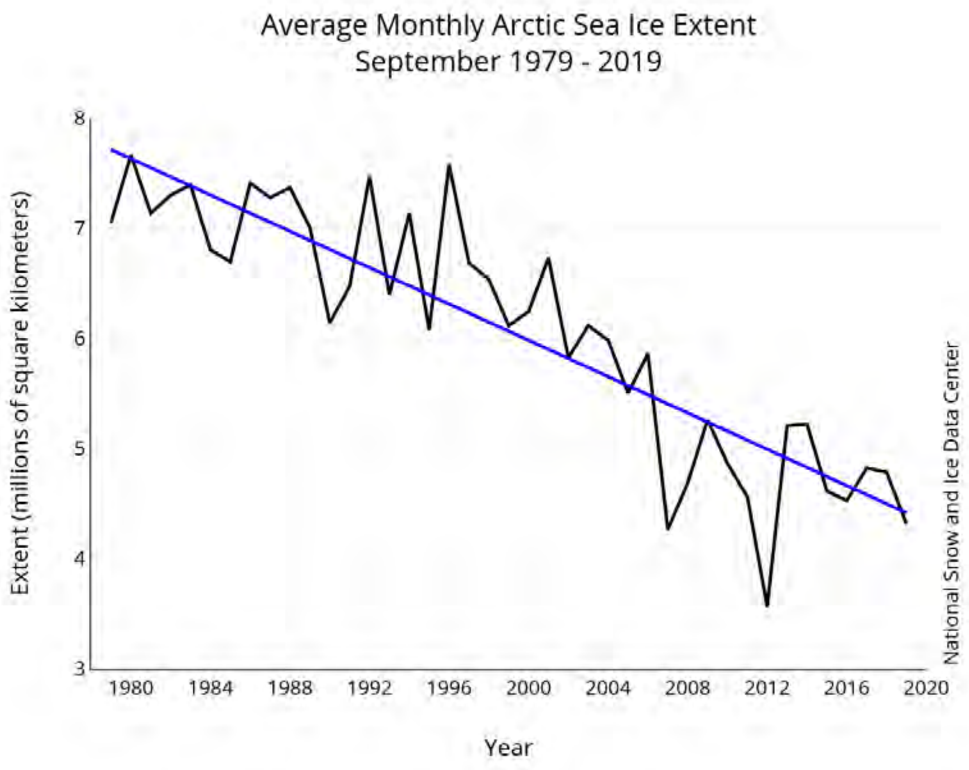
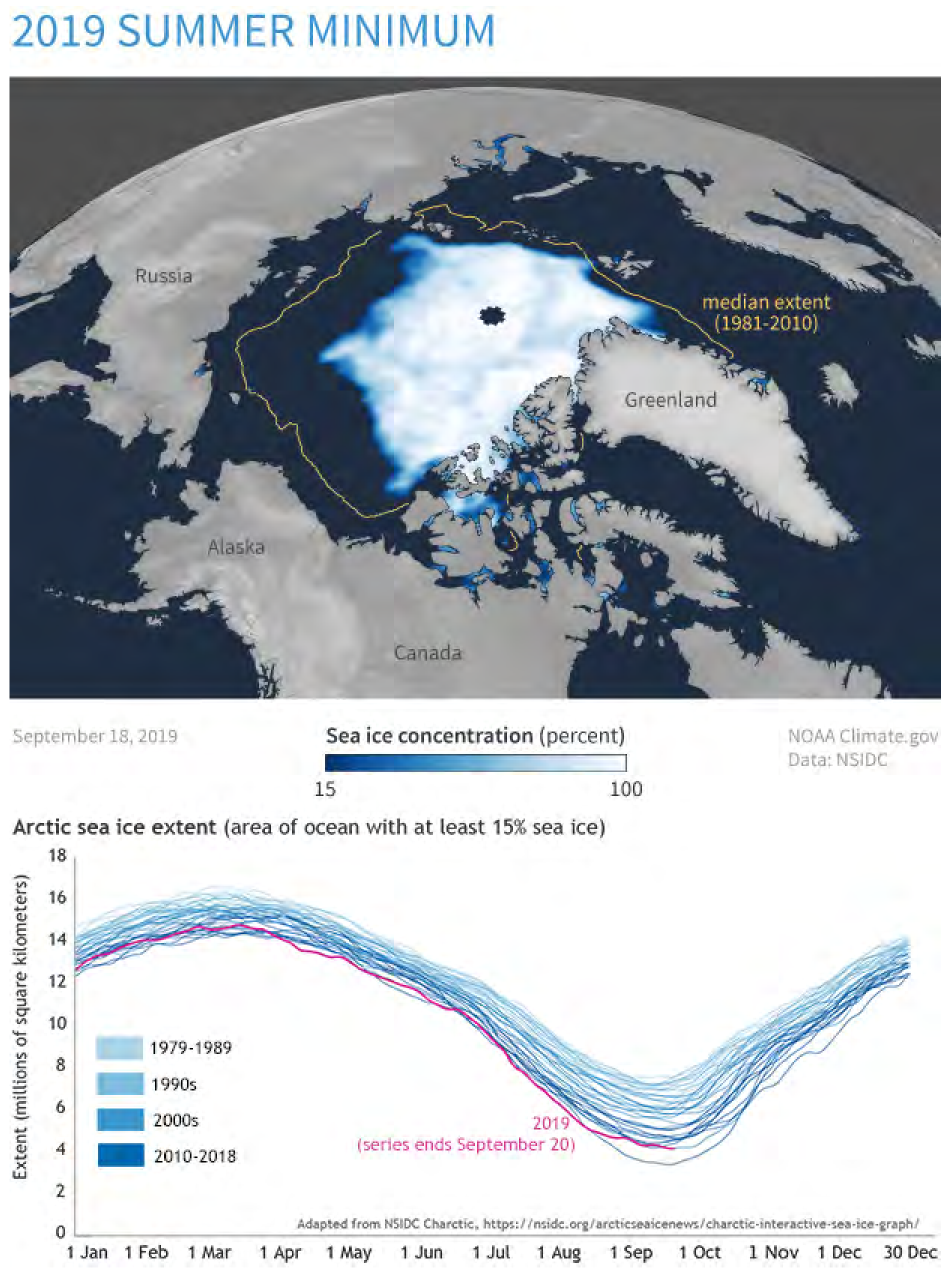
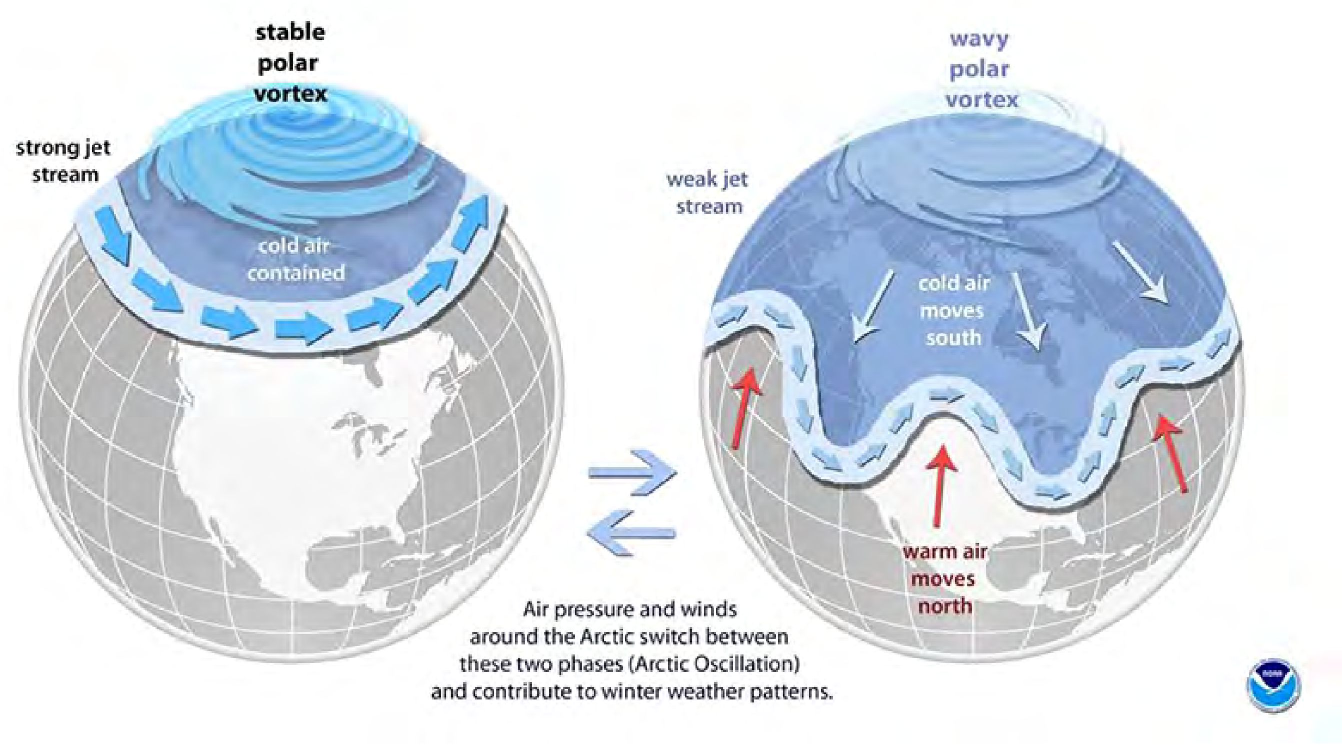
https://www.climate.gov/news-features/event-tracker/late-july%E2%80%99s-stupefying-heat-indexes-southwest-iran

Loss of Arctic Sea Ice



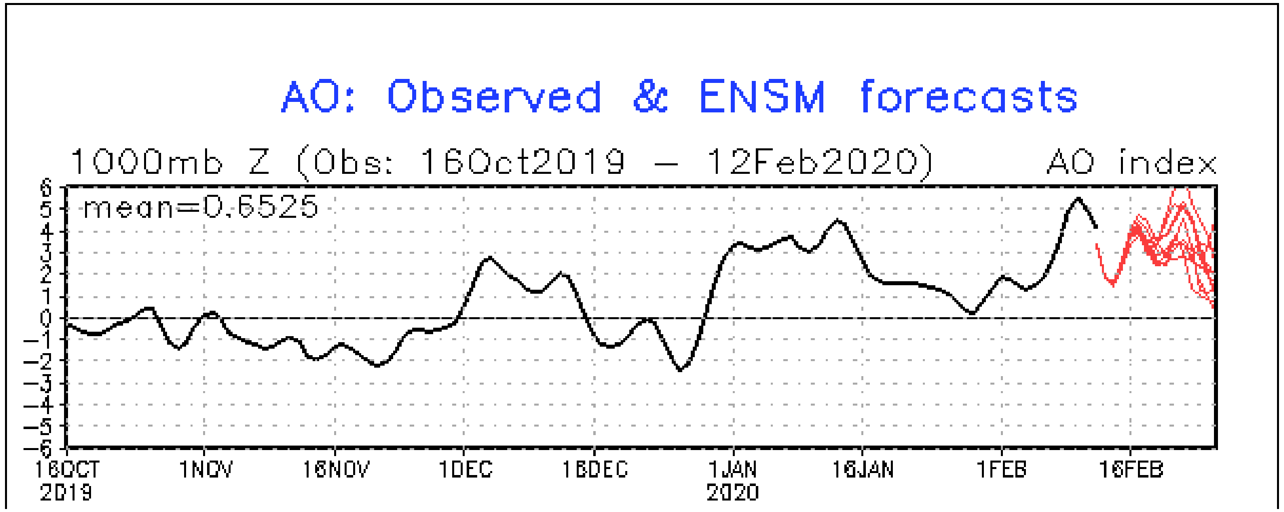




Arctic Oscillation mostly in a positive phase (left) this winter

Cold air has been bottled up in the Arctic

Likely to shift toward very positive phase by mid-month then perhaps weakening just a bit.



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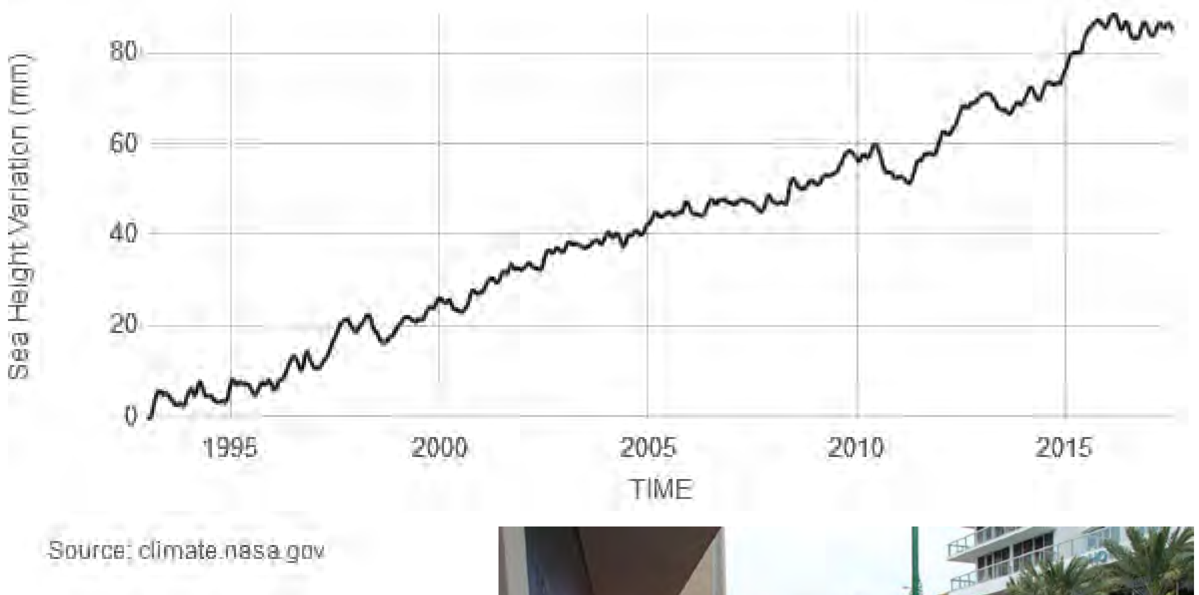
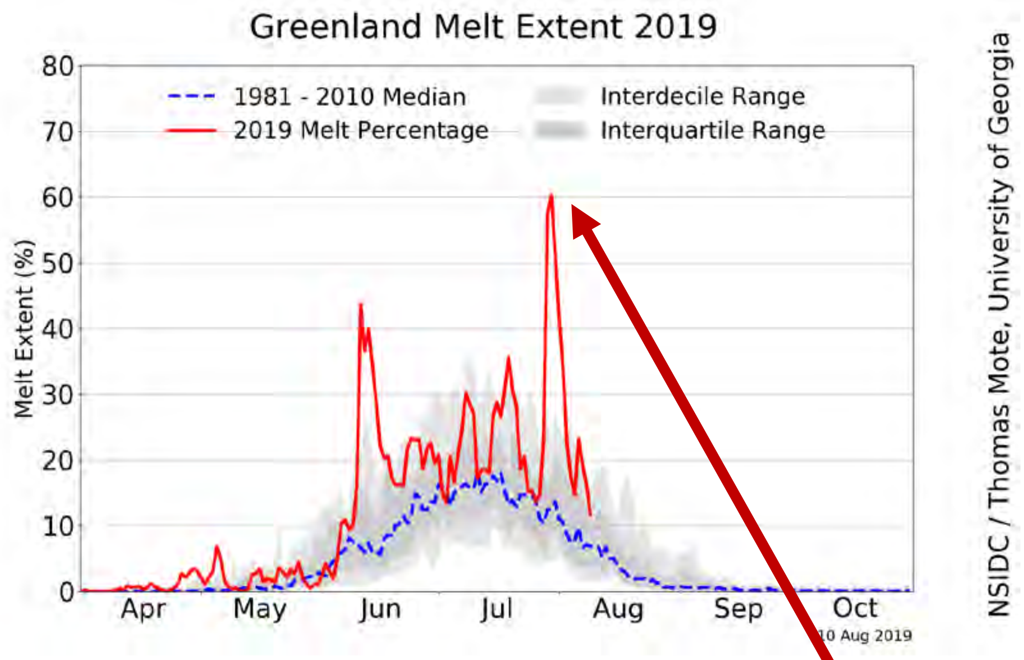
Global Evidence: Sea Level Rise

https://climate.nasa.gov/vital-signs/sea-level/





4.4 Million Olympic-sized swimming pools!

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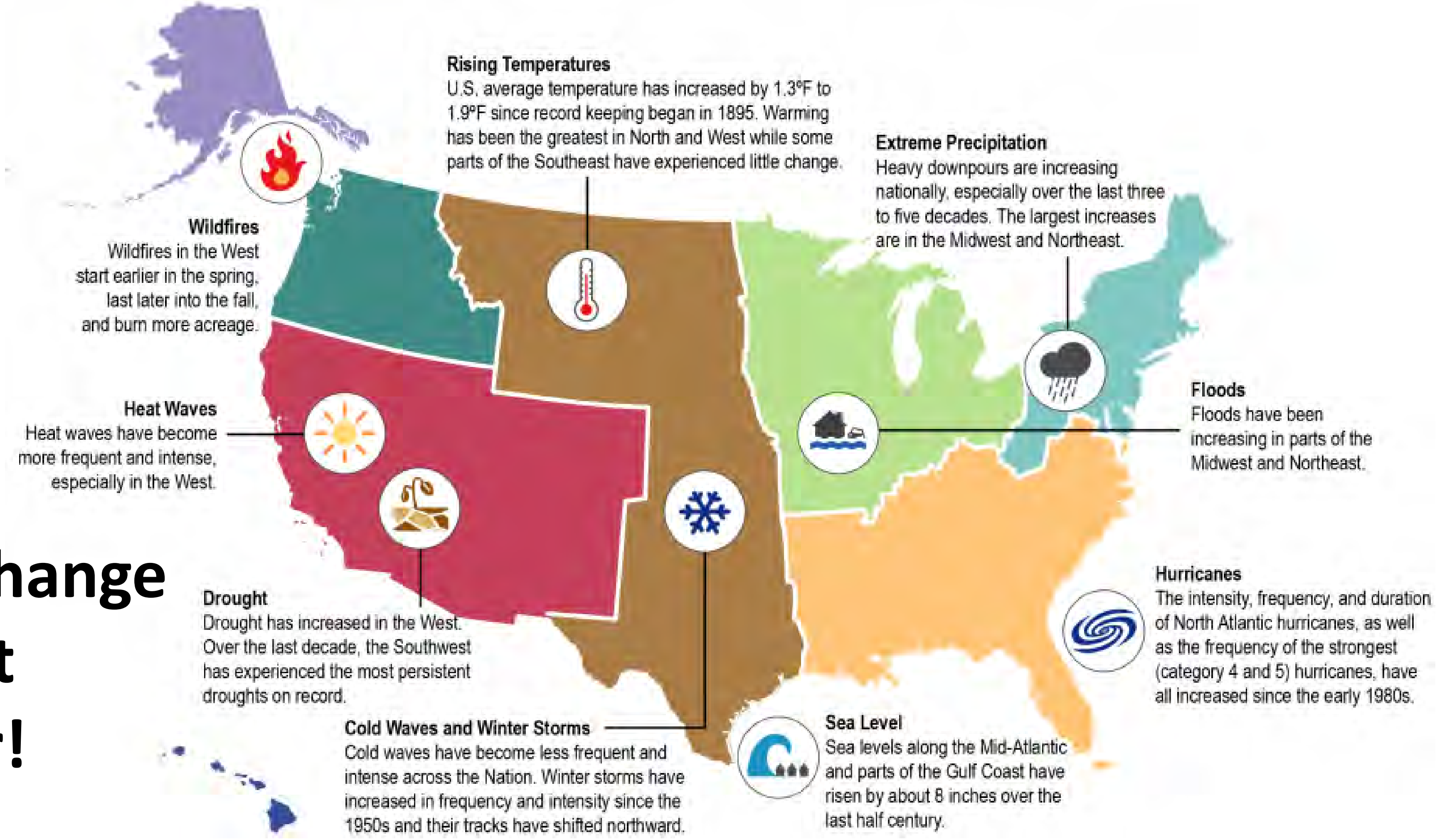
U.S. Regional Climate Trend Impacts



Climate Change is a Threat Multiplier!

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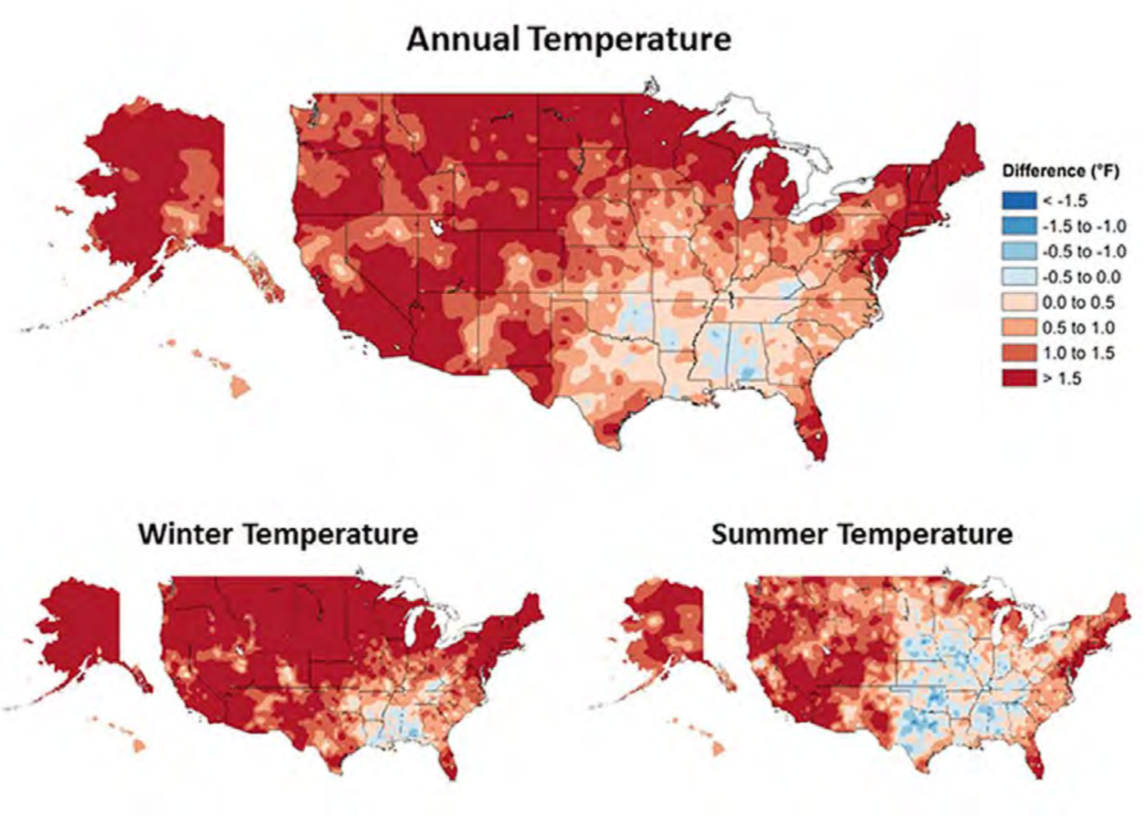
https://health2016.globalchange.gov/climate-change-and-human-health

Seasonal Differences in Warming



- More than 95% of the land surface demonstrated an increase in annual average temperature
- Paleoclimate records suggest recent period the warmest in at least the past 1,500 years
- Greatest and most widespread in winter

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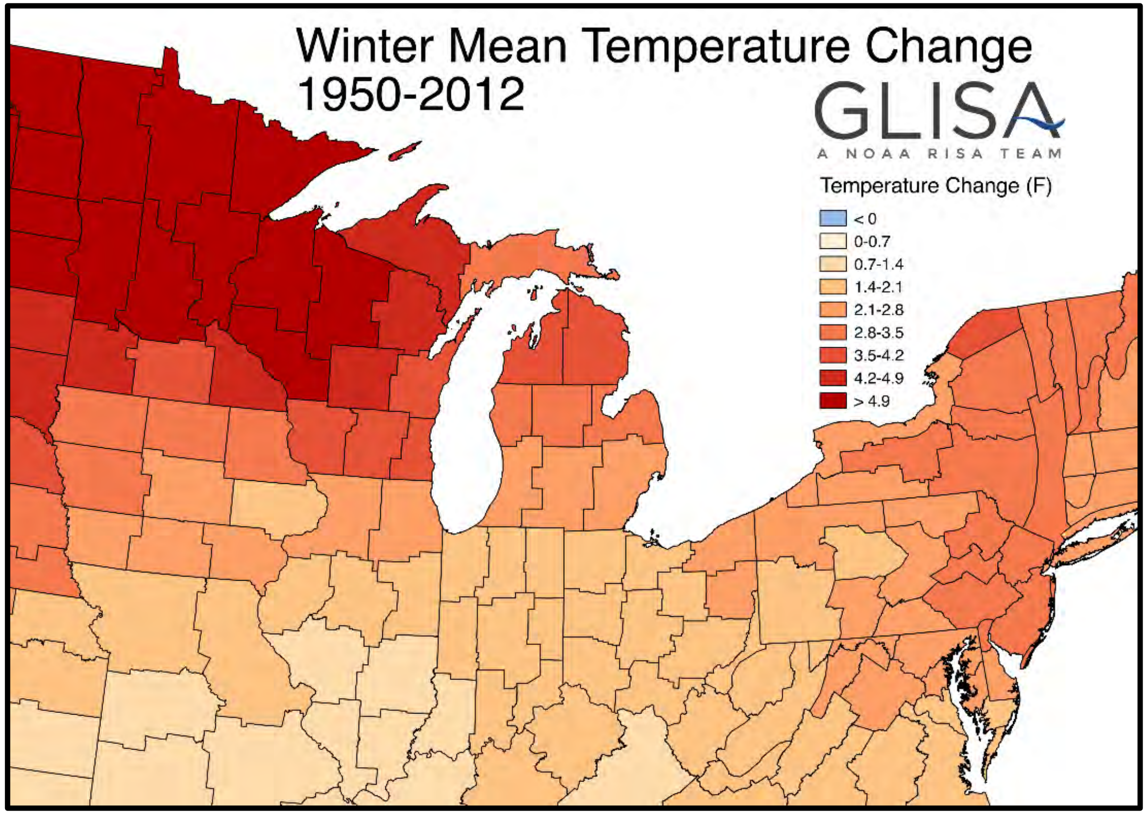
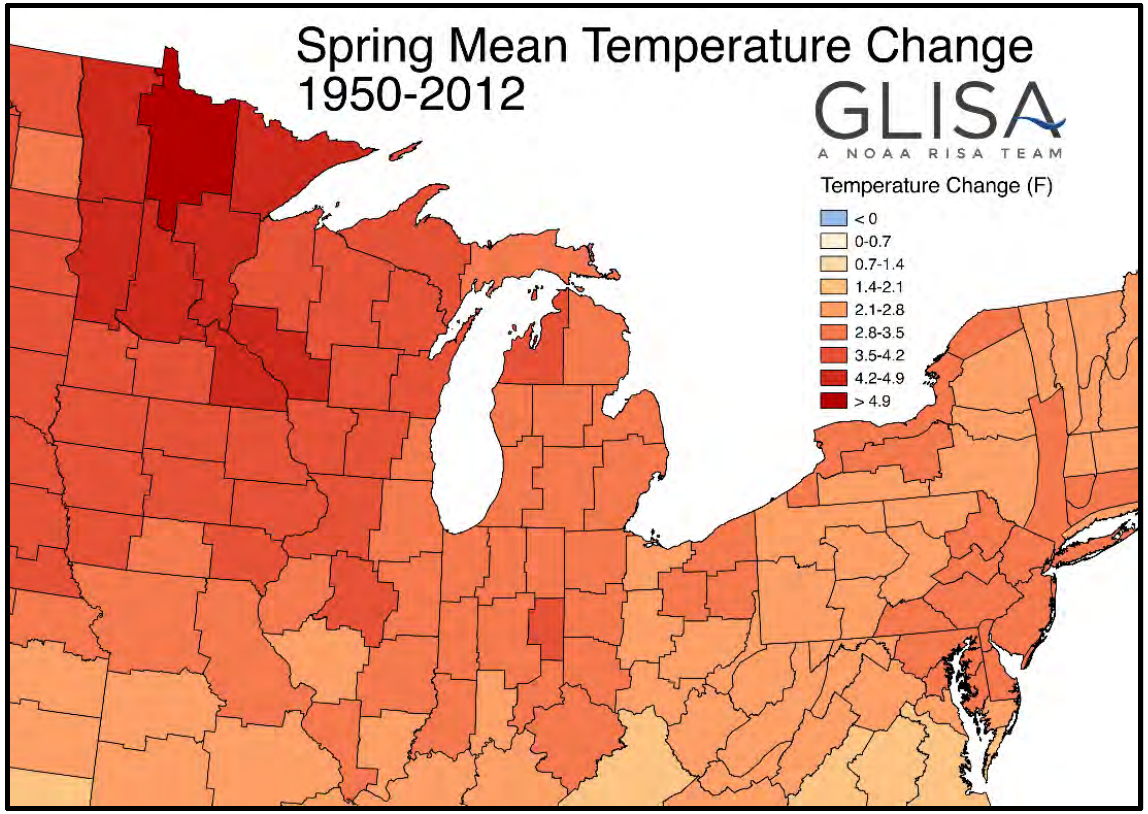
Annual average temperature over the contiguous United States has increased by 1.2°F (0.7°C) for the period 1986–2016 relative to 1901–1960 and by 1.8°F (1.0°C) based on a linear regression for the period 1895–2016: National Climate Assessment CCSR: https://science2017.globalchange.gov/

SEASONAL TEMPERATURE CHANGES ACROSS THE GREAT LAKES





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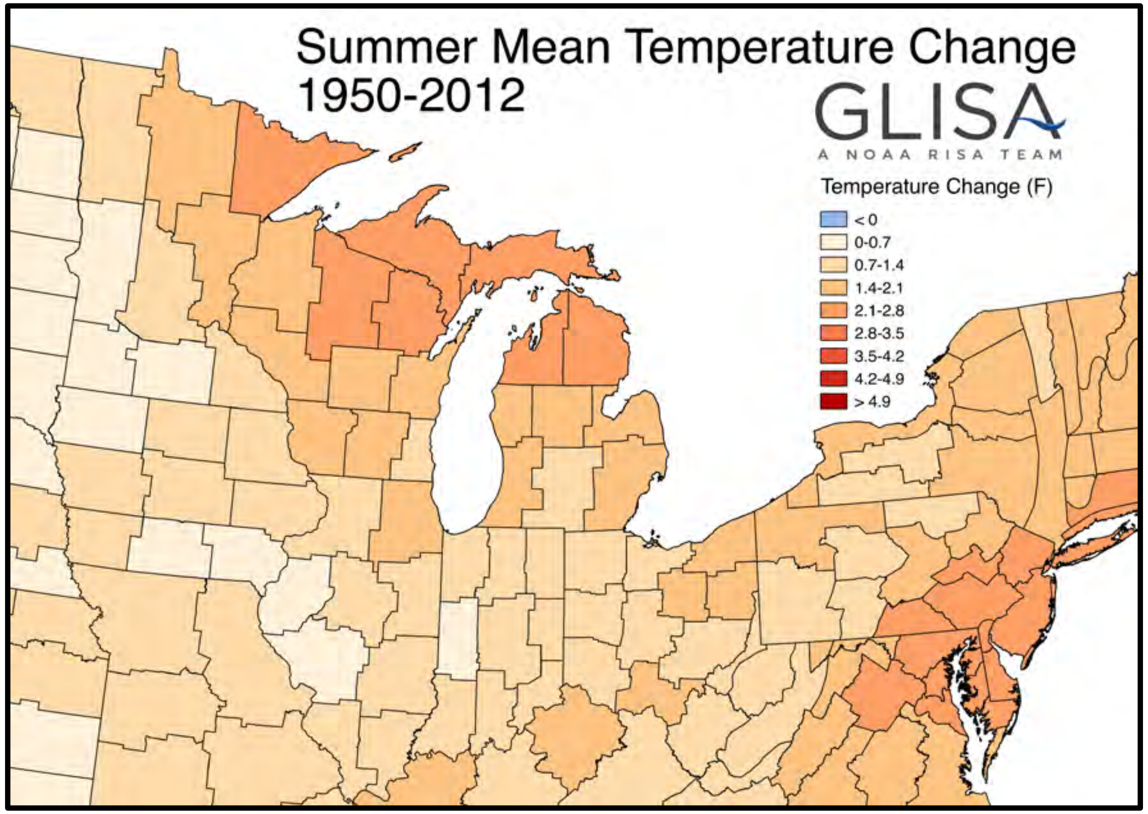
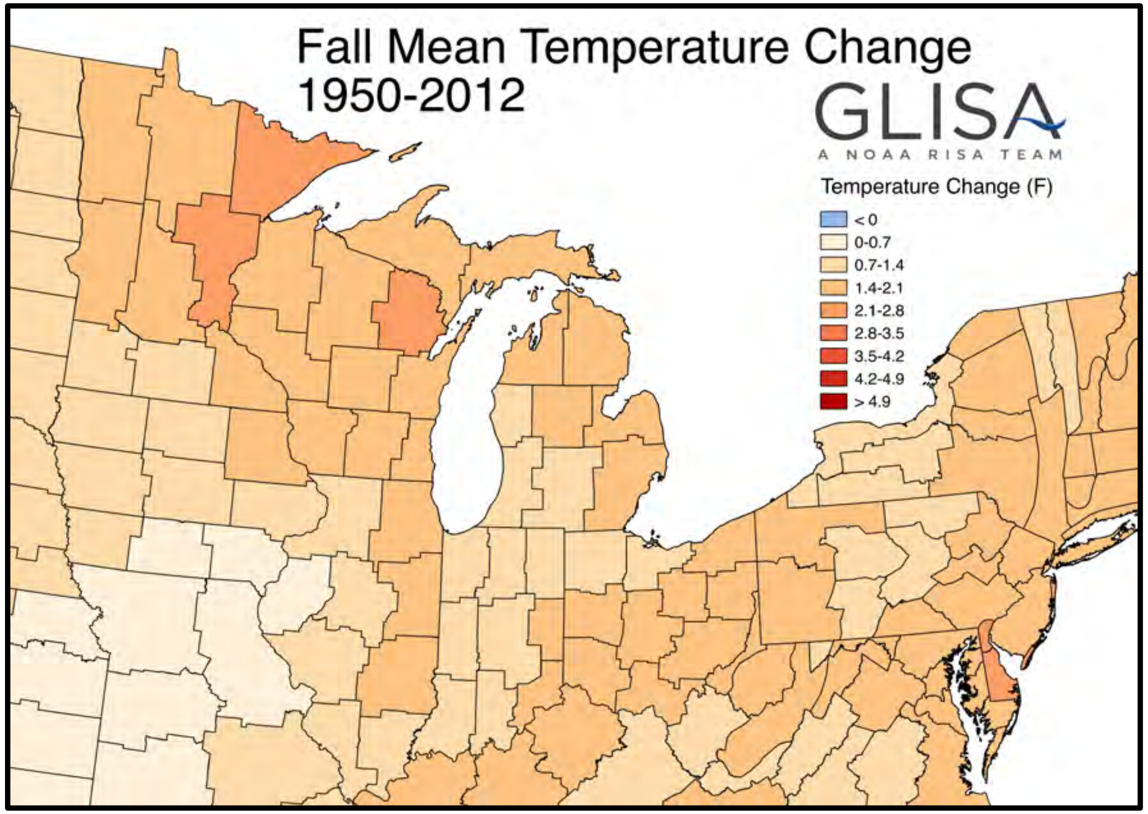
SEASONAL TEMPERATURE CHANGES ACROSS THE GREAT LAKES





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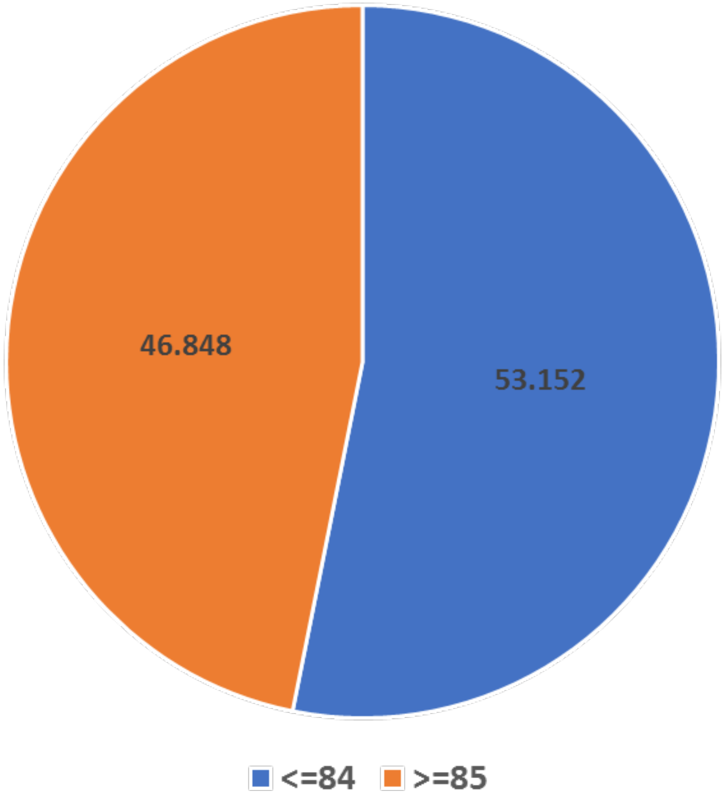
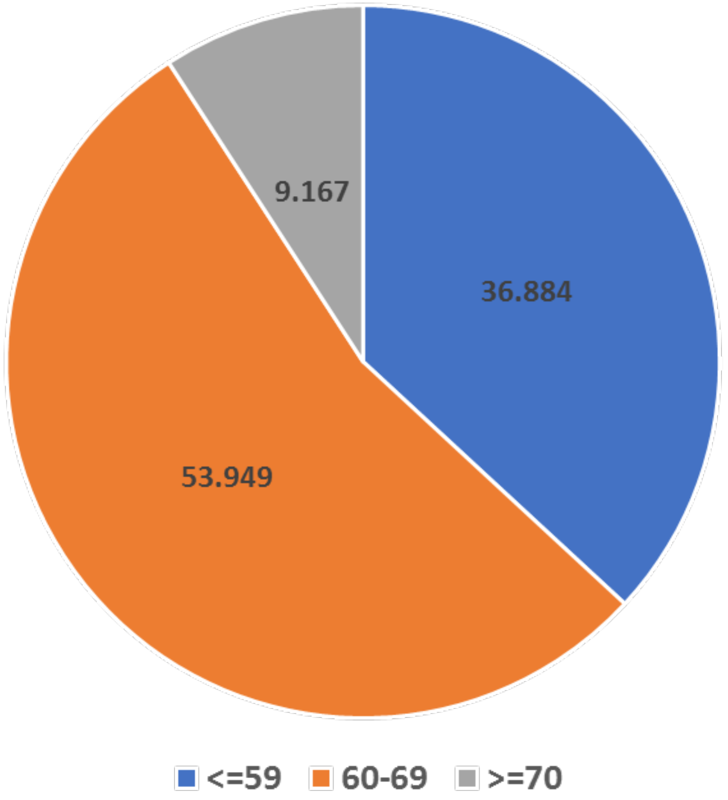
SUMMER TEMPERATURE CHANGES ACROSS OHIO

Data Source: NOAA

Early Period Summer Highs



Early Period Summer Lows

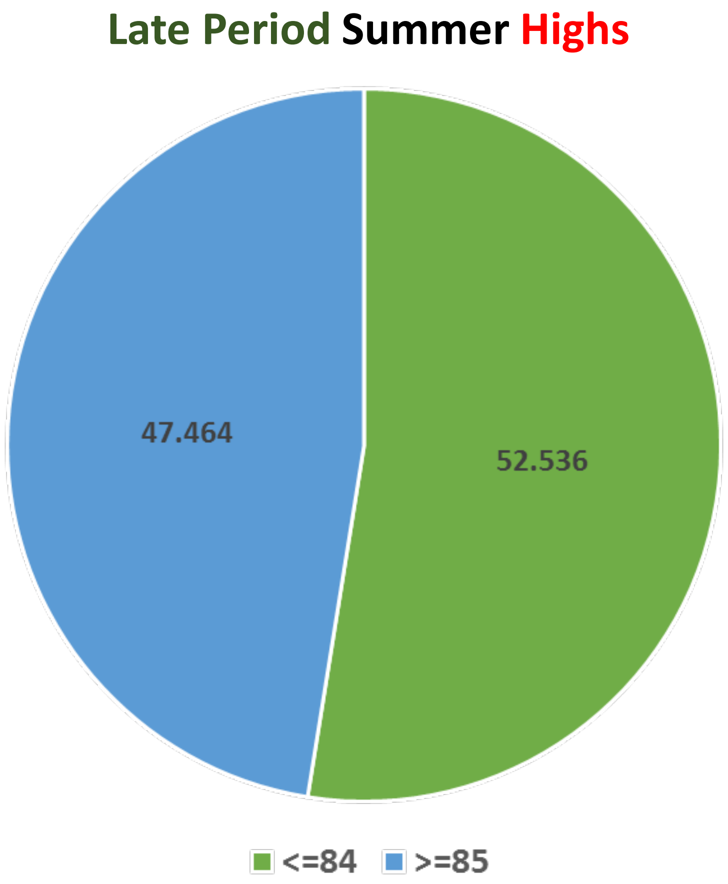


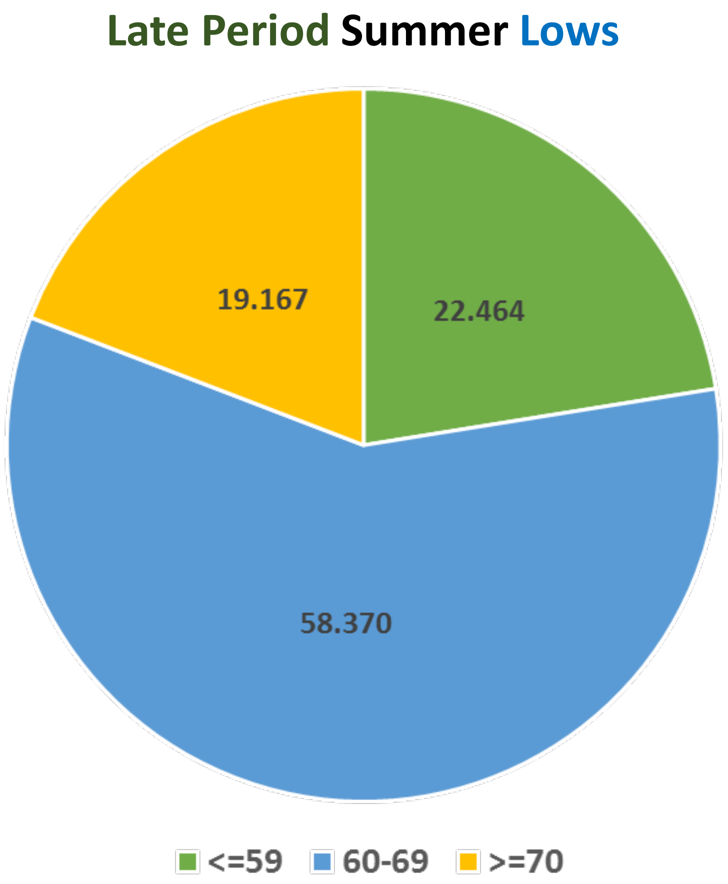
***All in Degrees Fahrenheit**

Early (1949-1978) Late (1989-2018)

SUMMER TEMPERATURE CHANGES ACROSS OHIO

Data Source: NOAA

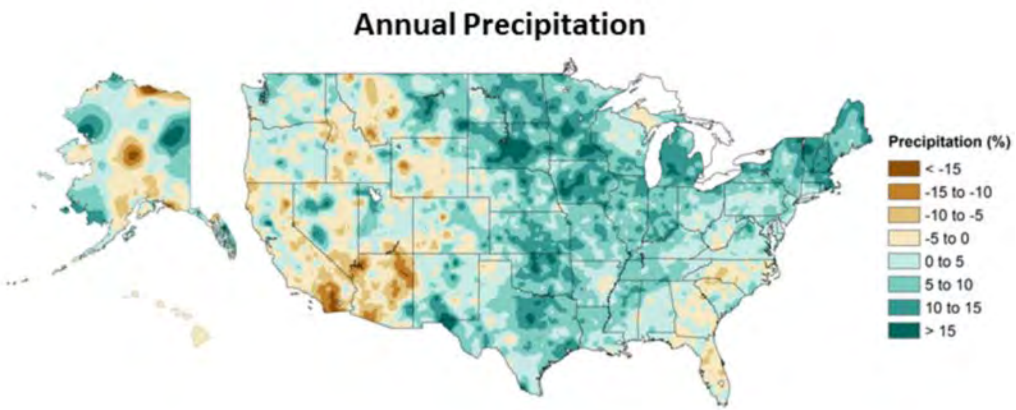


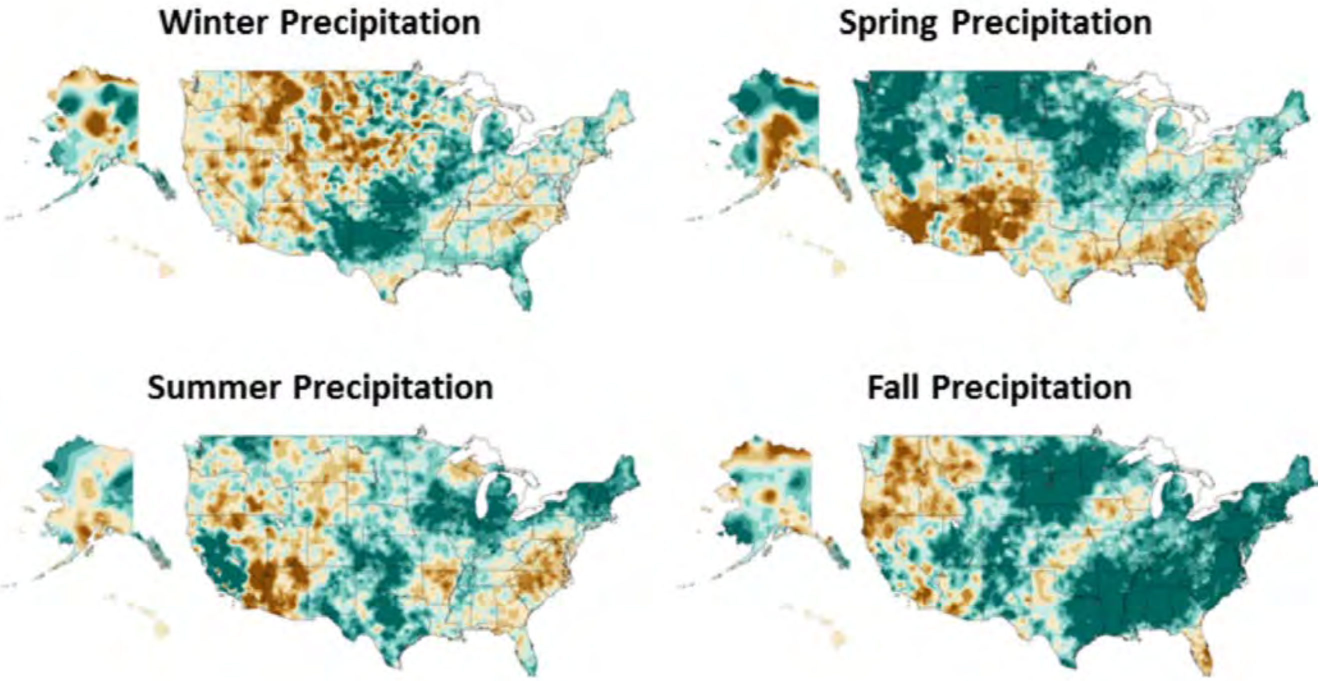


***All in Degrees Fahrenheit**

Early (1949-1978) Late (1989-2018)

Annual and Seasonal Changes in Precipitation





National Climate Assessment CCSR:
https://science2017.globalchange.gov/

- National average increase of 4% in annual precipitation since 1901: Ohio: 5-15%
- Driven strongly by fall trends (10-15% in some locations)
  - Regional Spring, Summer, and Fall Trends across Ohio
  - Increased Intensity of rainfall events

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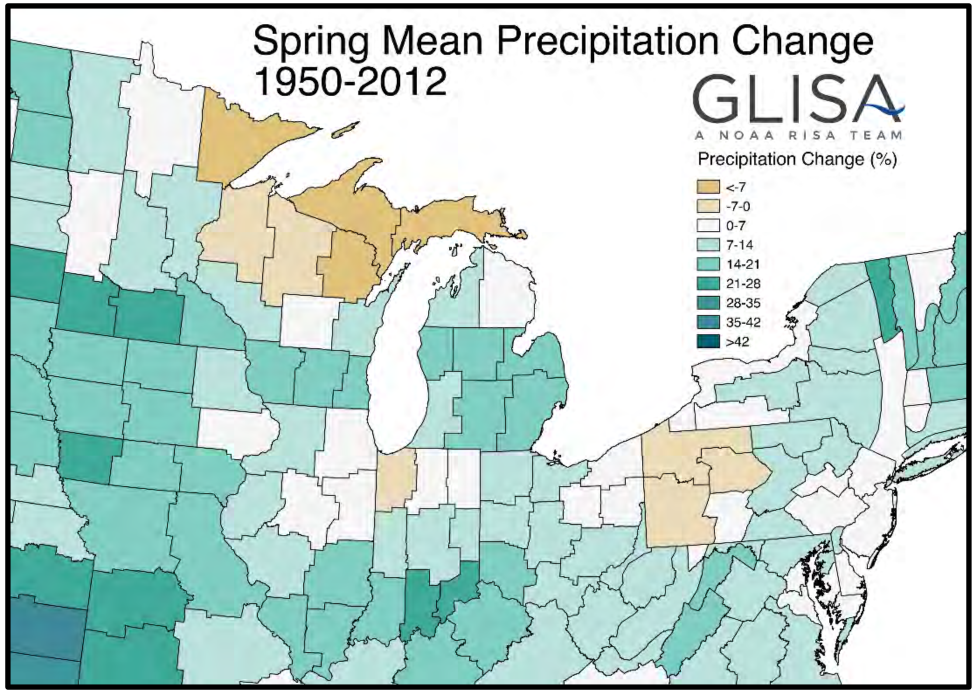
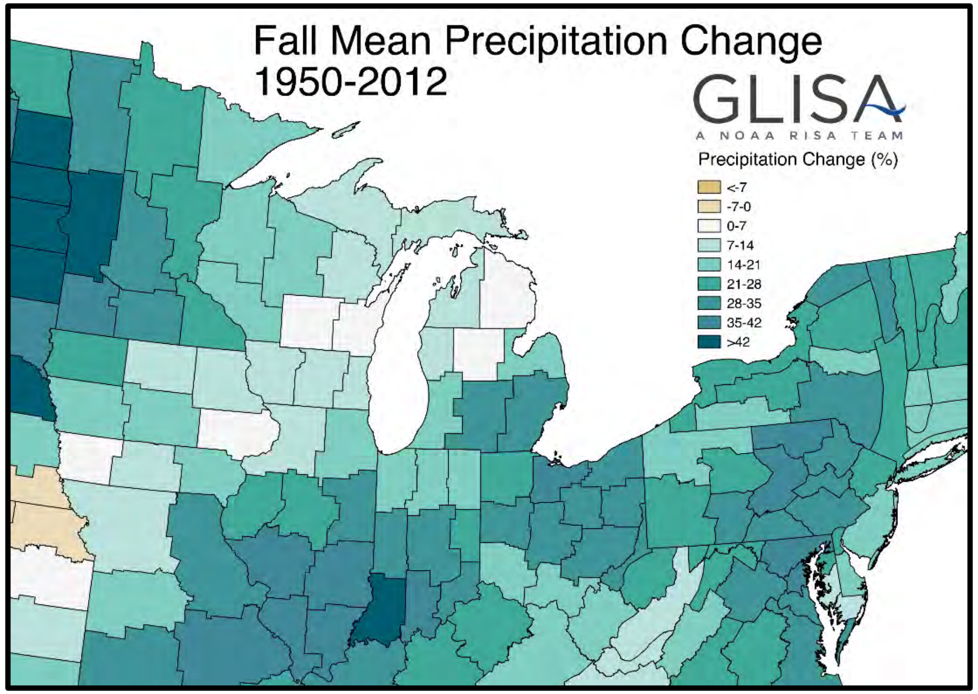
Seasonal Changes Across the Great Lakes





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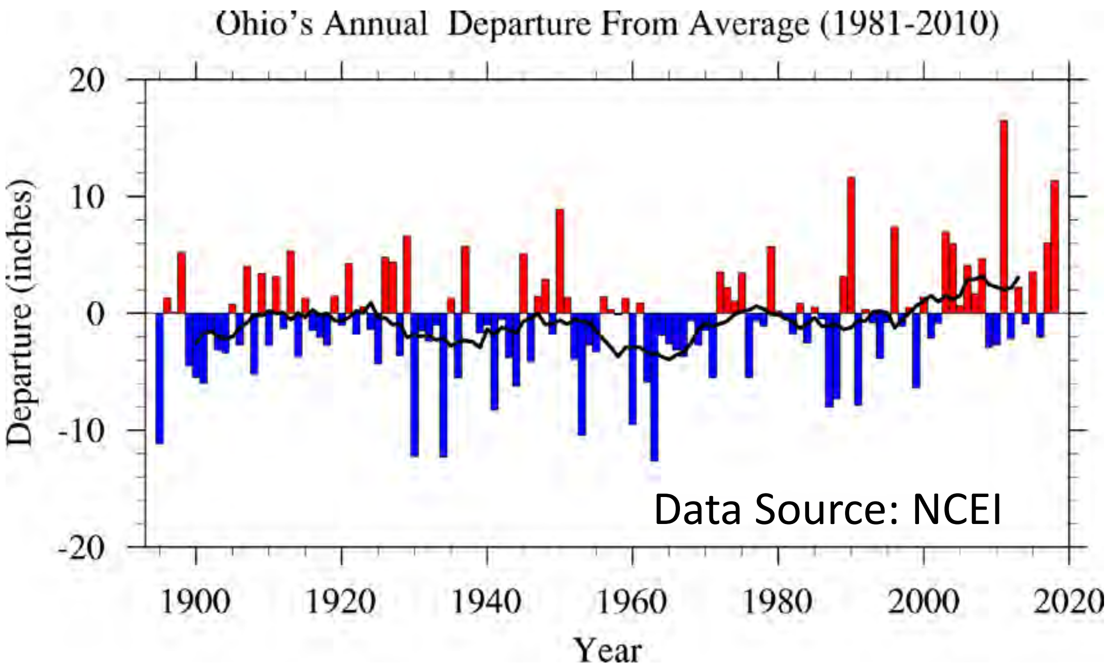
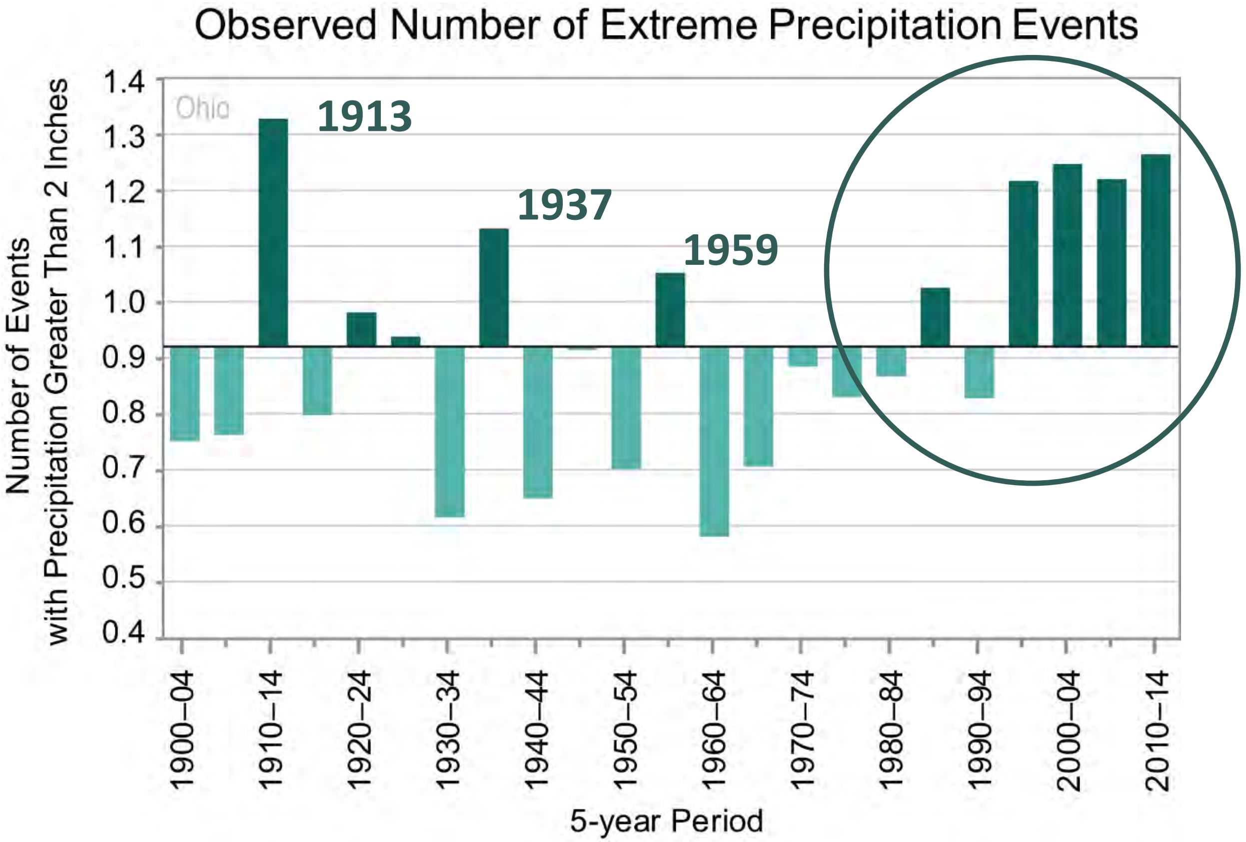
Long-term Precipitation Trends in Ohio





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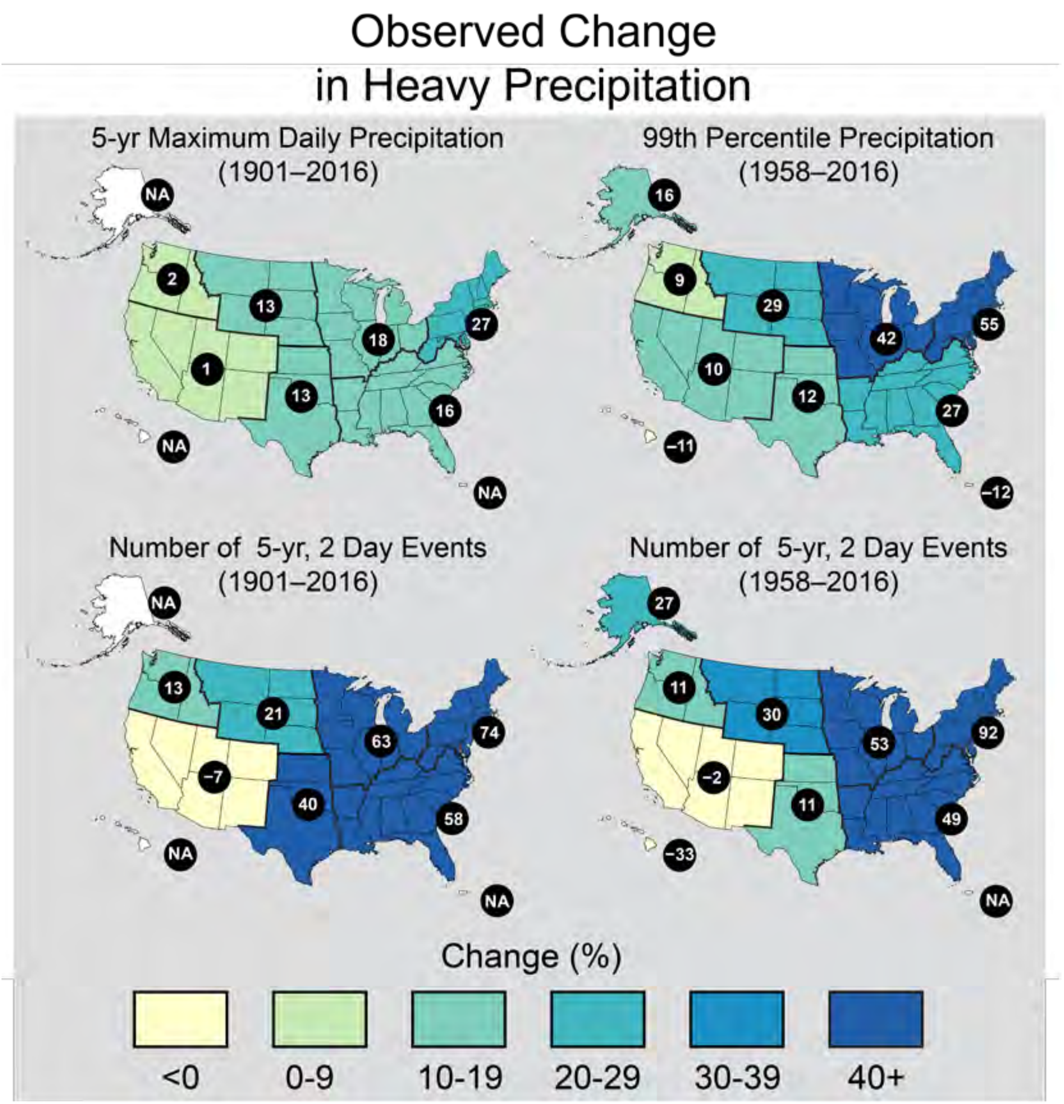
NOAA

https://statesummaries.ncics.org/oh

Other Heavy Precipitation Metrics

- Maximum daily precipitation totals were calculated for consecutive 5-year blocks from 1901
- The total precipitation falling in the top 1% of all days with precipitation



National Climate Assessment CCSR: https://science2017.globalchange.gov/

Easterling, D.R., K.E. Kunkel, J.R. Arnold, T. Knutson, A.N. LeGrande, L.R. Leung, R.S. Vose, D.E. Waliser, and M.F. Wehner, 2017: Precipitation change in the United States. In: *Climate Science Special Report*: Fourth National Climate Assessment, Volume I [Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 207-230, doi: 10.7930/J0H993CC.

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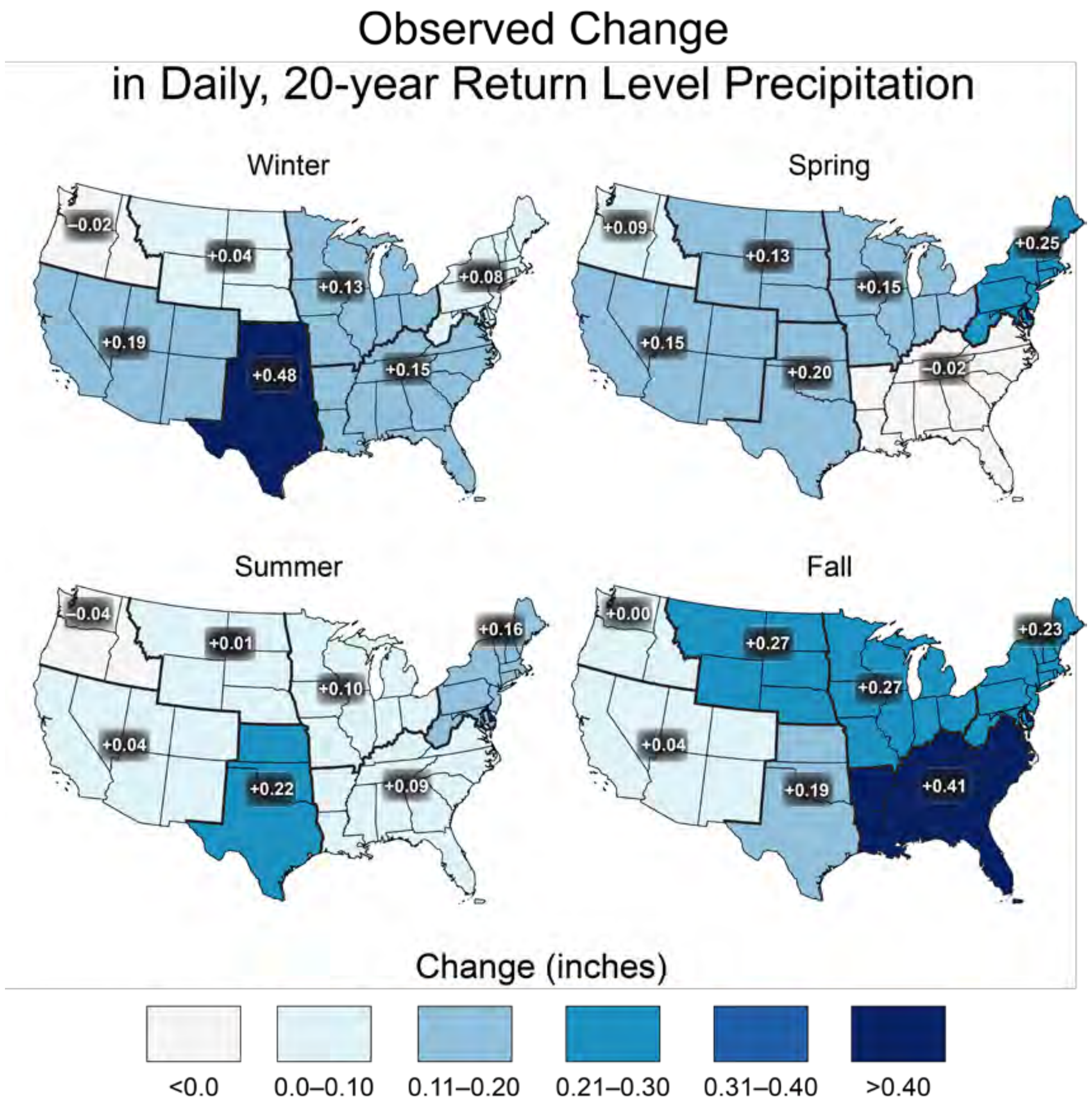
Heaviest Events Bring Heavier Totals

- Extreme precipitation events are generally observed to increase in intensity by about 6% to 7% for each degree Celsius of temperature increase.
- Change in seasonal maximum 1-day precipitation (1948-2015)
- Shows how much more precipitation occurs in a 1 in 20-year daily event. e.g., across the Midwest 0.27" more per this type of event.



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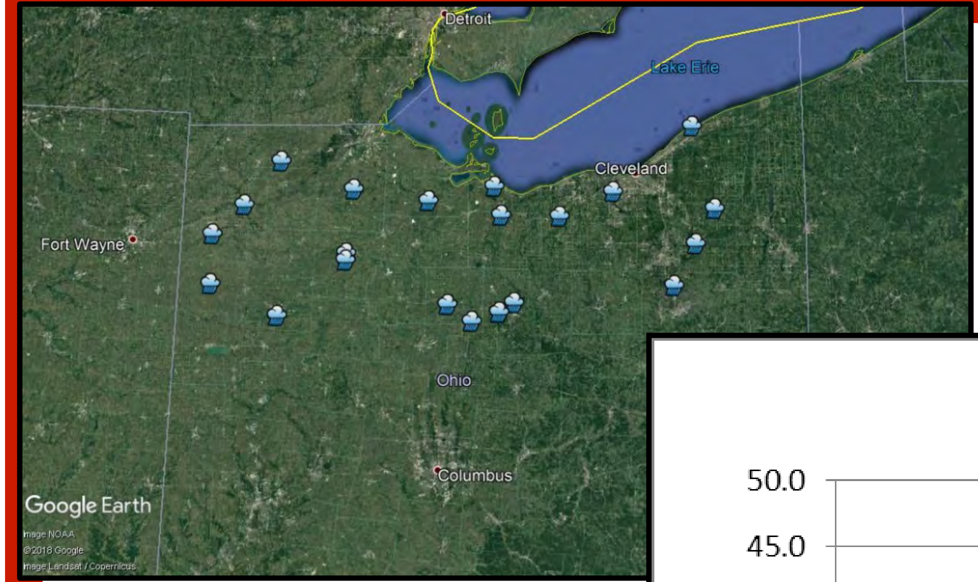
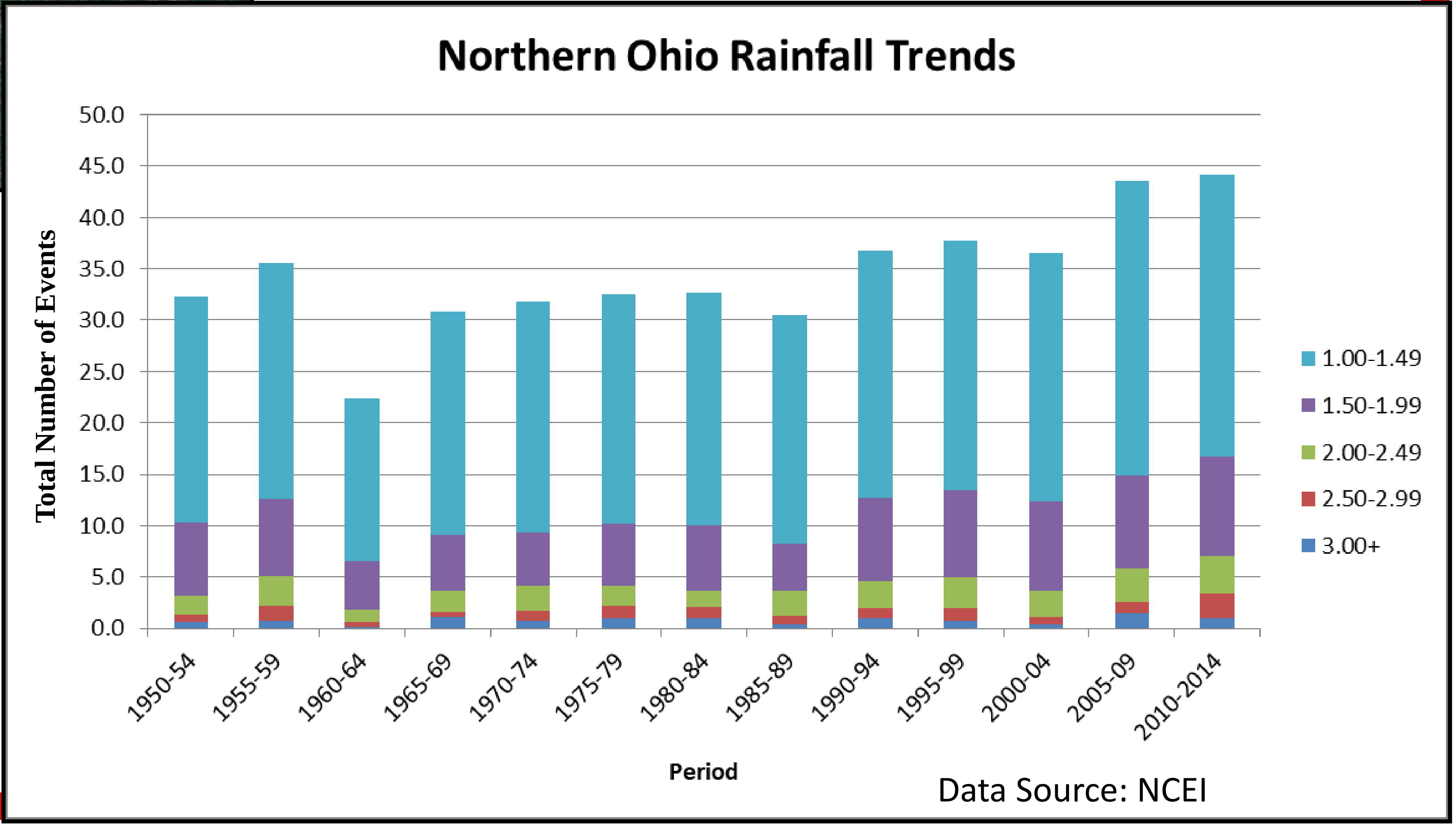
Intensity of Rainfall





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North Edge of Arcanum: July 6, 2017
Photos Courtesy of Sam Custer/Janelle Brinksneader

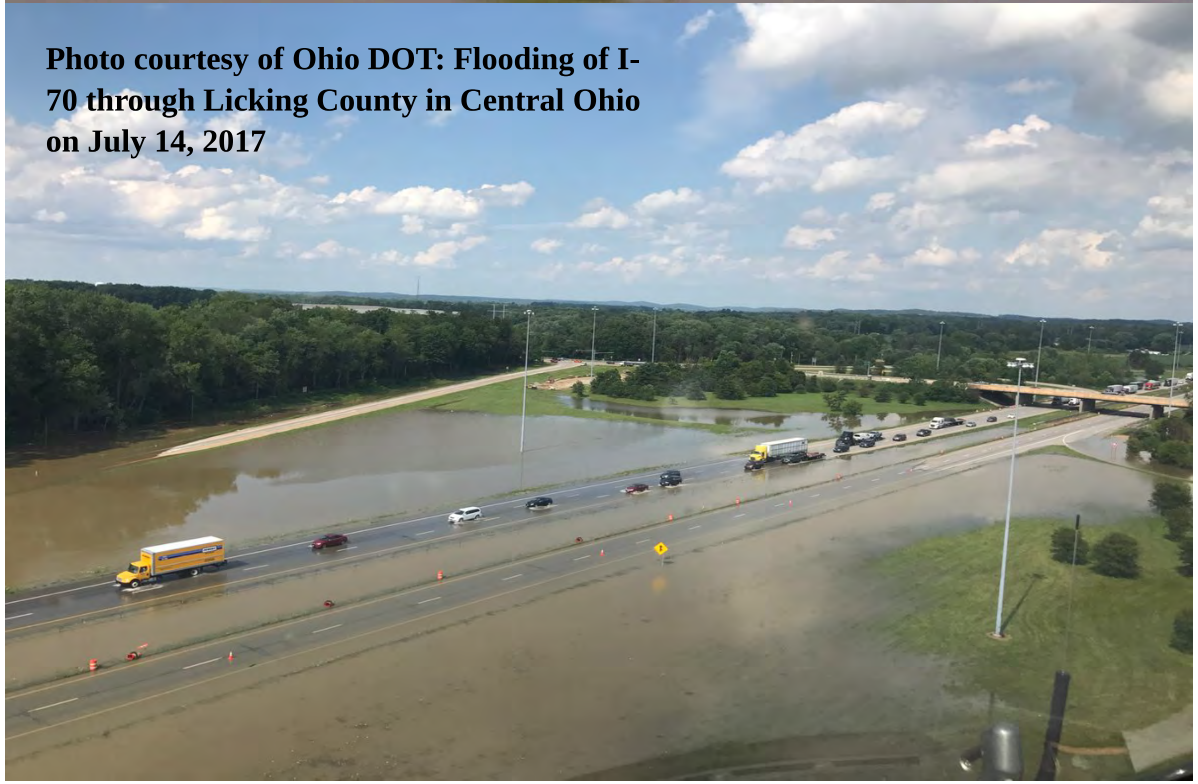
Photo courtesy of Ohio DOT: Flooding of I-70 through Licking County in Central Ohio on July 14, 2017

TEMPERATURE			
RANK	YEAR	AVERAGE	DIFFERENCE
1	1998	54.1	2.9
2	2012	54.0	2.8
3	2016	53.6	2.4
4	1921	53.5	2.3
5	2017	53.2	2.0
6	1991	53.1	1.9
7	1931	52.9	1.7
8	2006	52.7	1.5
8	1990	52.7	1.5
10	1949	52.6	1.4

PRECIPITATION			
RANK	YEAR	AVERAGE	DIFFERENCE
1	2011	55.95	16.50
2	1990	51.07	11.62
3	2018	50.83	11.38
4	1950	48.34	8.89
5	1996	46.85	7.40
6	2019	46.75	7.30
7	2003	46.42	6.97
8	1929	46.42	6.62
9	2017	45.51	6.06
10	2004	45.45	6.00

- 4 of the top 10 warmest/ 6 of the top 10 wettest have occurred since 2003
- 7 of the top 10 warmest/ 8 of the top 10 wettest since 1990 (1895-2019)

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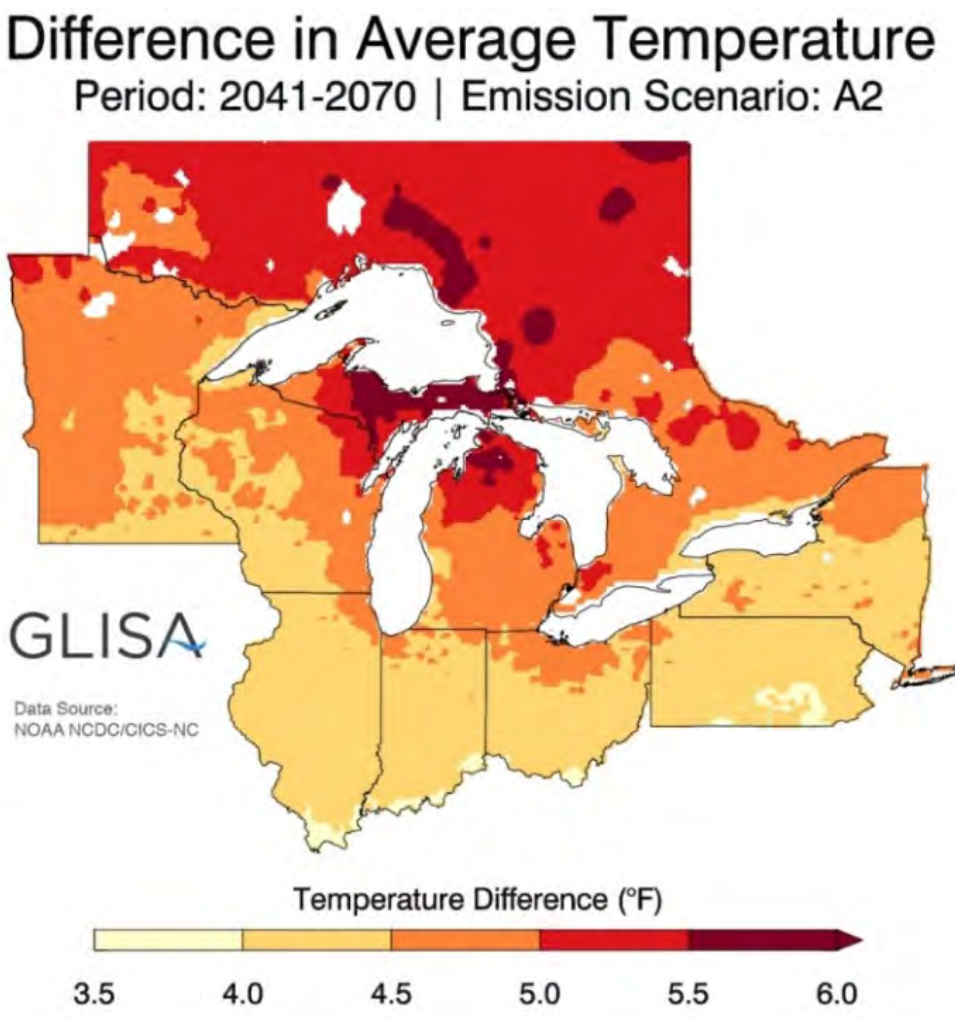
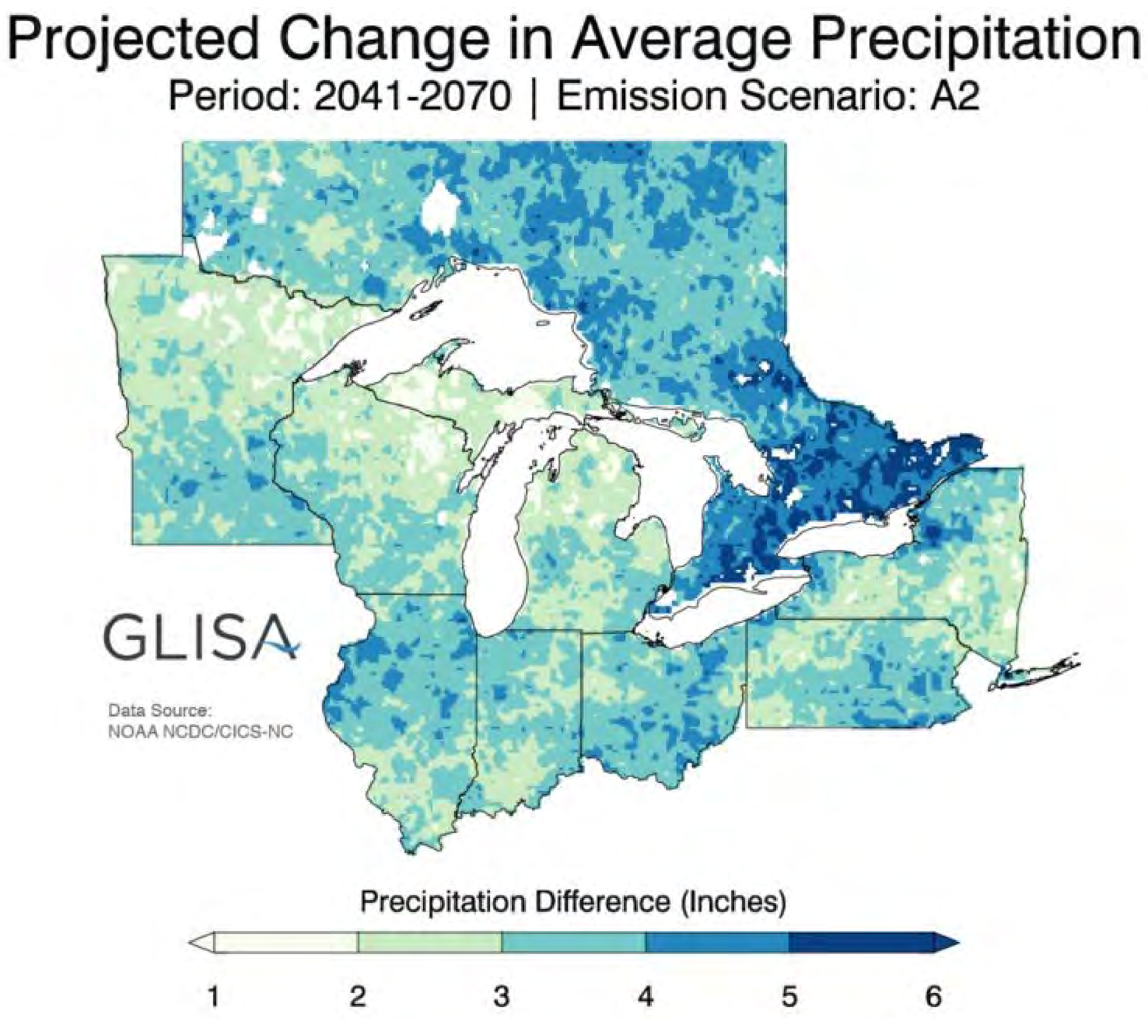
State of Ohio for 2019





Future Climate

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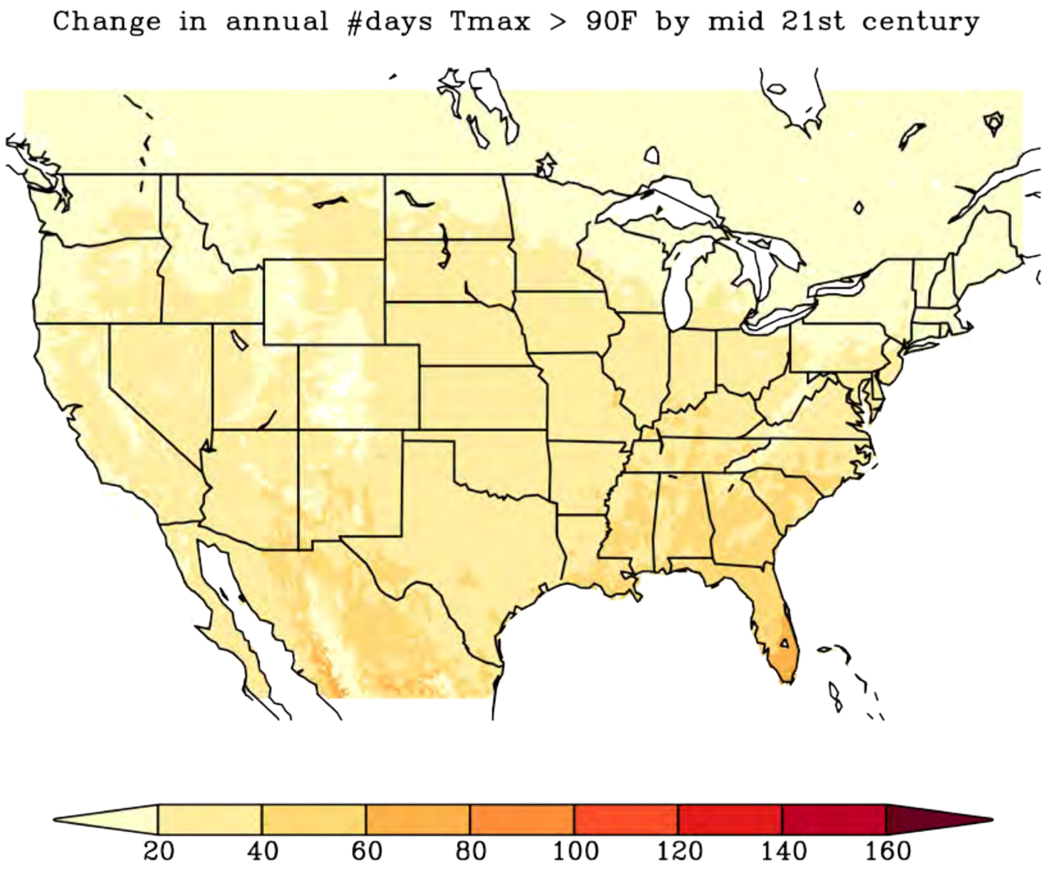
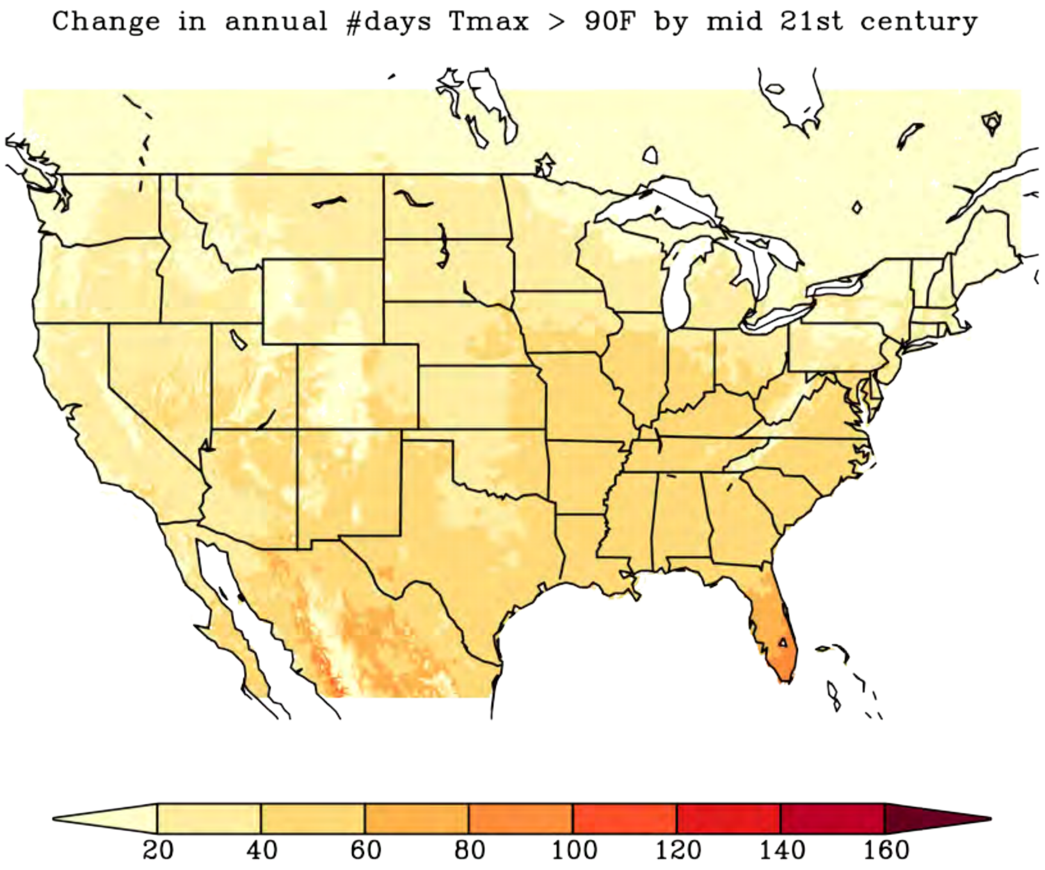
Change in Annual Number of Days > 90°F

Lower Emissions



Higher Emissions



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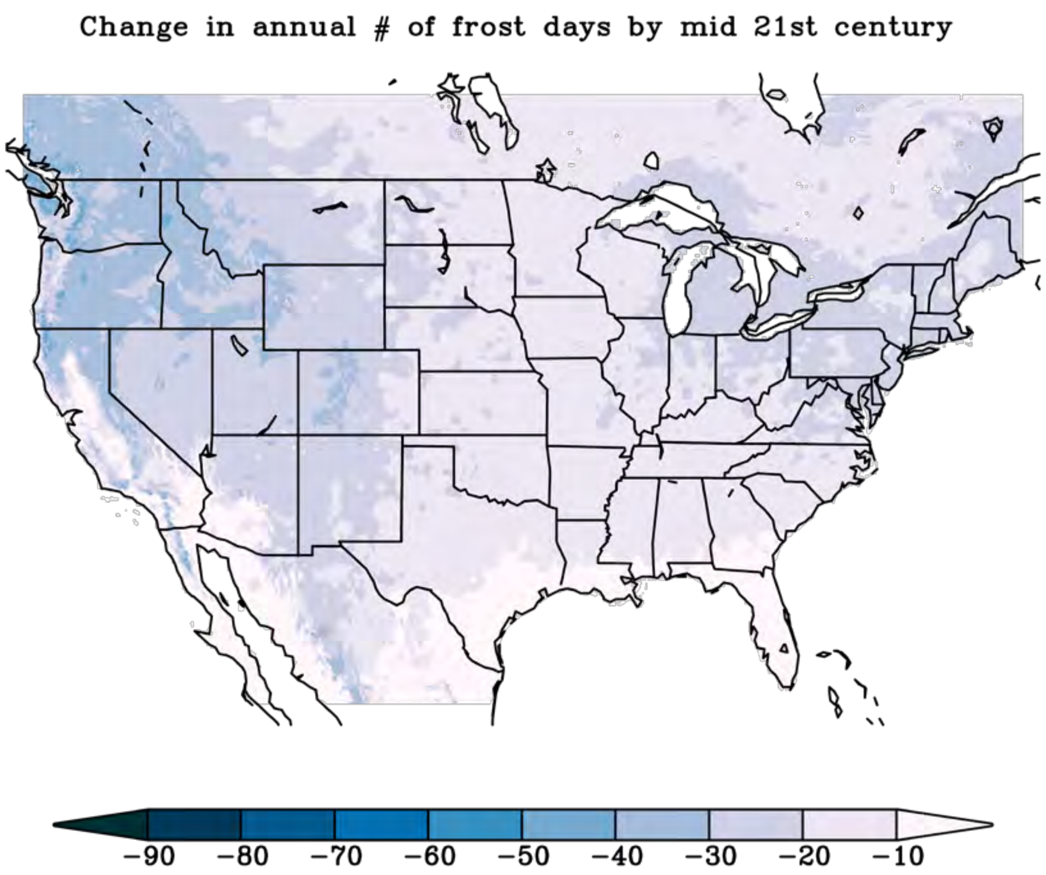
(1976-2005): 20-40 days per year

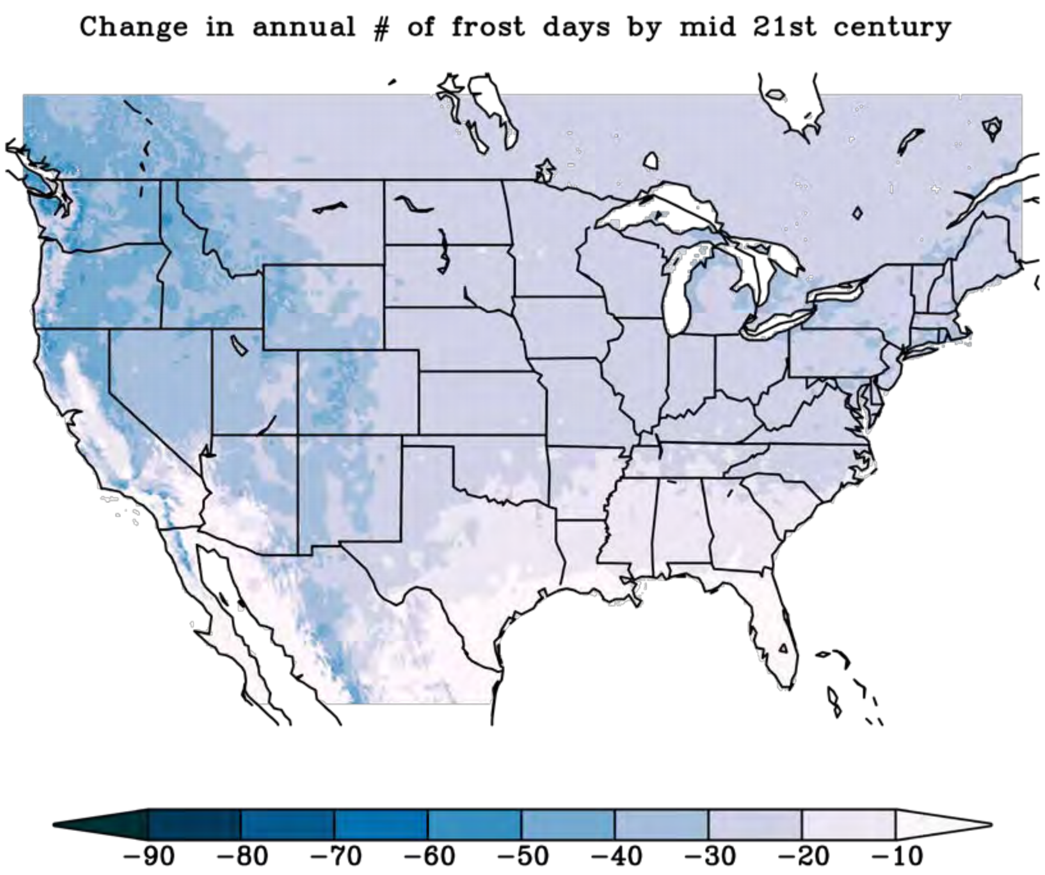
https://scenarios.globalchange.gov/loca-viewer/

Change in Annual Number of Days < 32°F

Lower Emissions



Higher Emissions

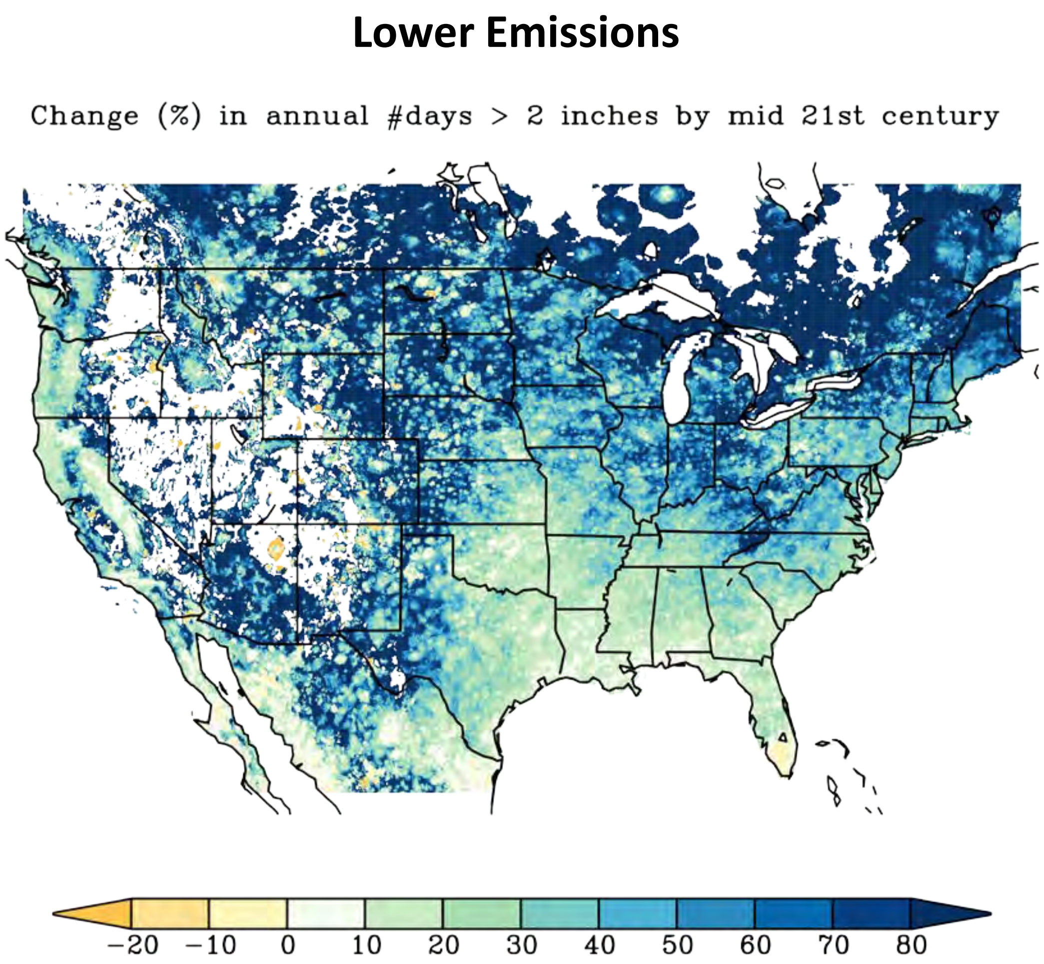


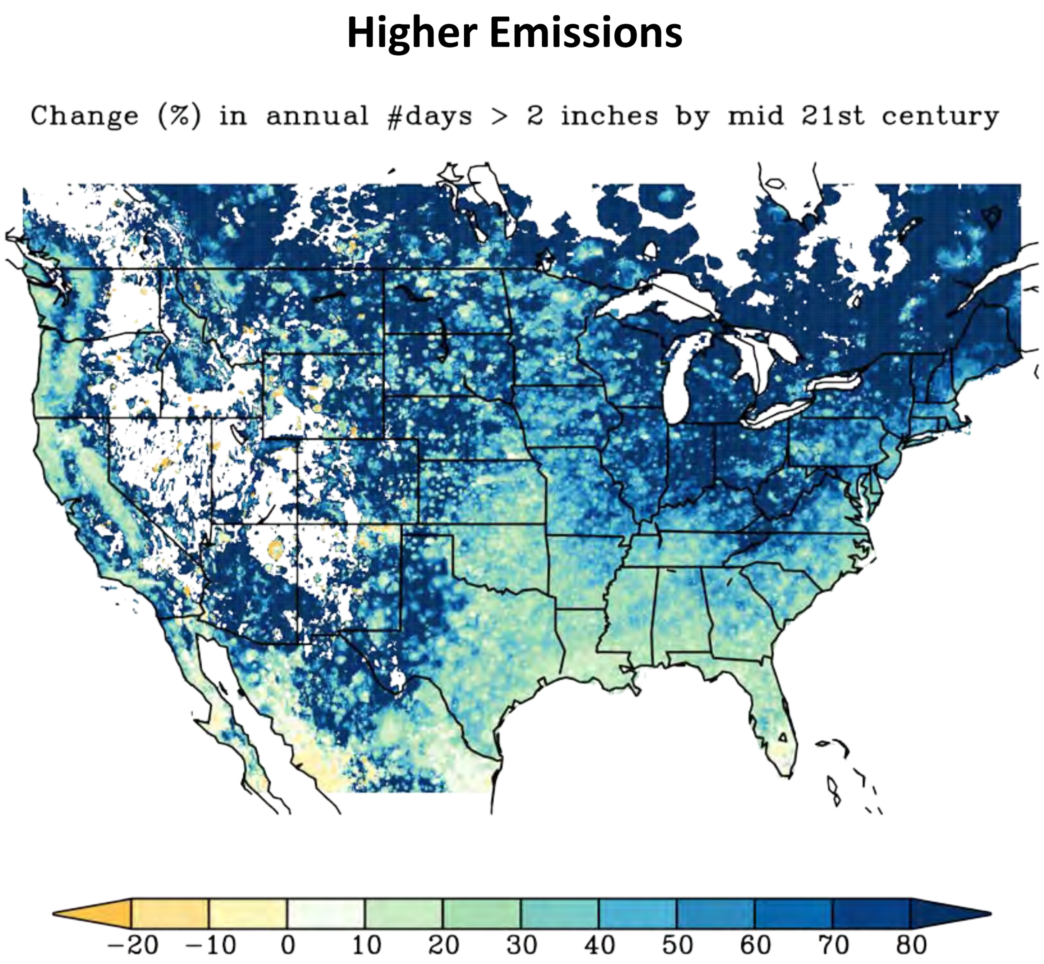
CFAES

Ohio (1976-2005): 80-160 days per year

https://scenarios.globalchange.gov/loca-viewer/

Change in Mean Annual Days with Precipitation > 2”





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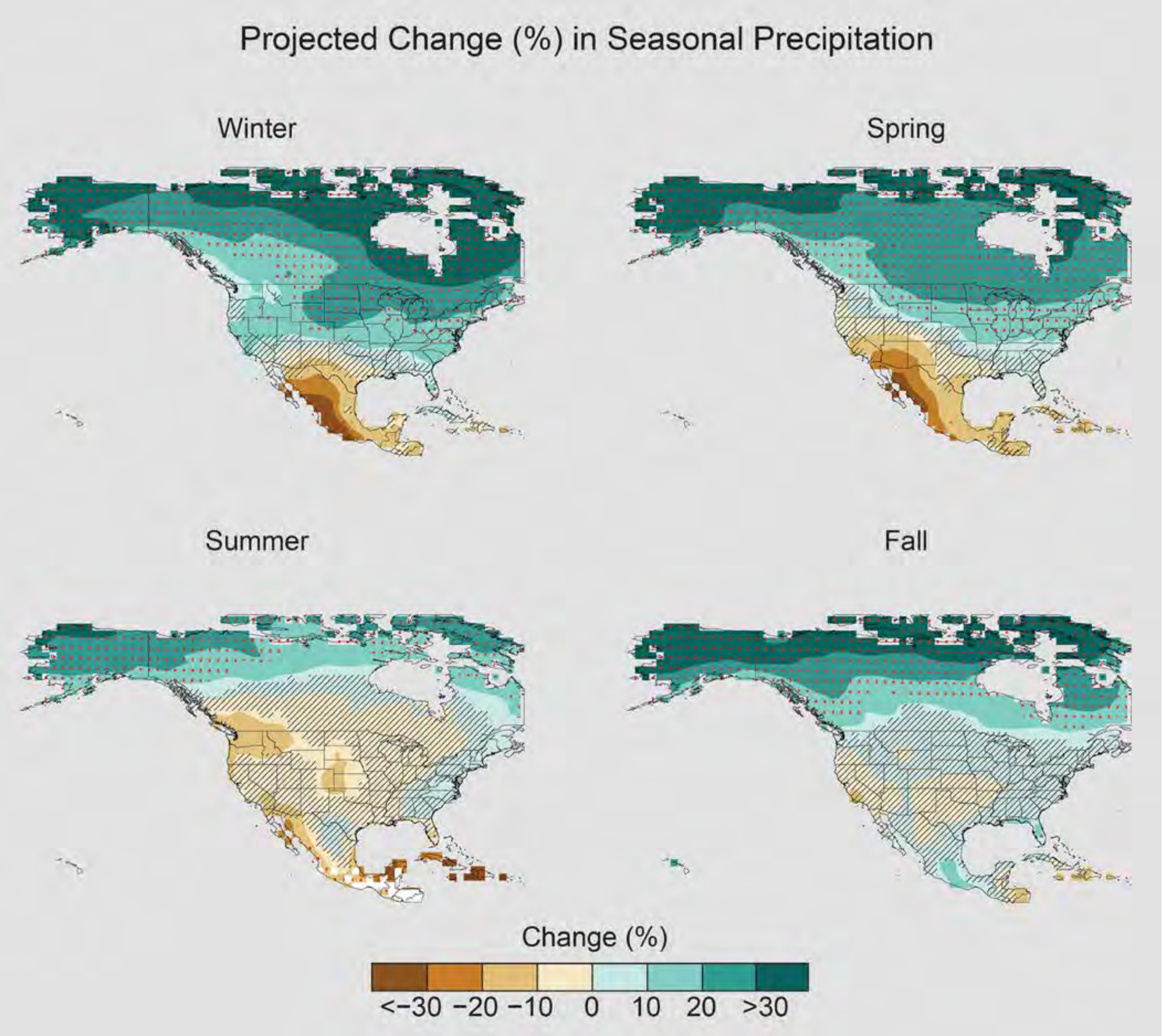
(1976-2005): < 1 day

https://scenarios.globalchange.gov/loca-viewer/

Seasonal Redistribution of Precipitation



-Fourth National Climate Assessment

https://nca2018.globalchange.gov/

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So what if I told you THIS is our new normal?

- Longer Growing Season
- Warmer Temperatures (Winter and at Night)
- Higher Humidity
- More Rainfall
- More Intense Rainfall Events
- More Autumn Precipitation

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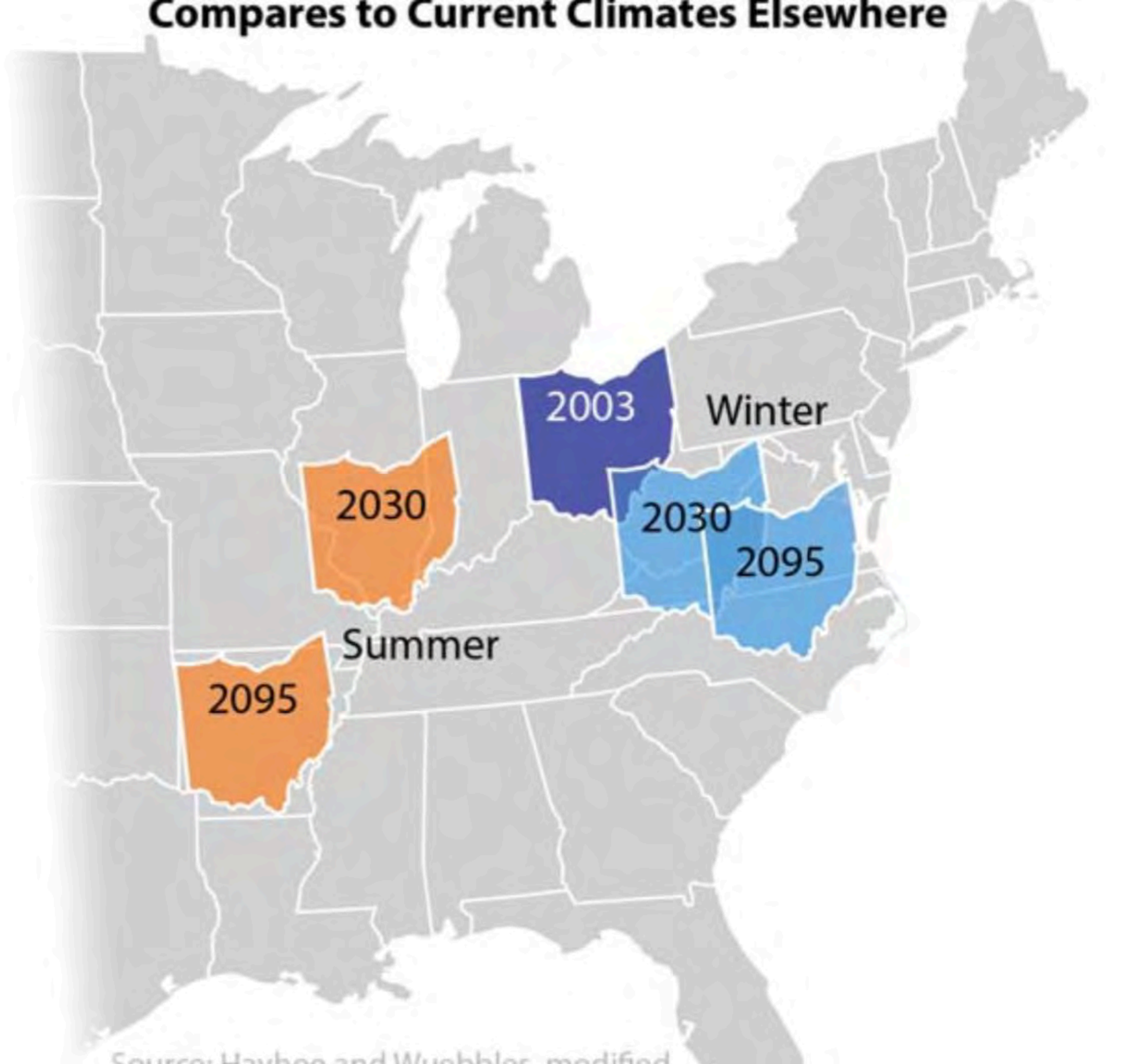

Temperature Impacts

- Additional (sustained) stress on humans and livestock; Intensified Urban Heat Islands -> Increased need for adequate cooling

- Pollination and grain, fiber, or fruit production sensitive to high temperatures – lower productivity and reduced quality

- Increased weed pressure, insects, and potential disease

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Other Concerns

- Higher average temperatures and shifting precipitation patterns are causing plants to bloom earlier, creating unpredictable growing seasons.
- Invasive, non-native plants and animals’ ranges are expanding and making them more apt to take advantage of weakened ecosystems and outcompete native species.
- Native and iconic plants may no longer be able to survive in portions of their historic range. (e.g., Ohio without the Ohio buckeye)
- Important connections between pollinators, breeding birds, insects, and other wildlife and the plants they depend on will be disrupted. Pollinators such as hummingbirds and bees may arrive either too early or too late to feed on the flowers on which they normally rely.
- Leaf wetness duration and plant disease epidemiology; mud

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NWF: https://www.nwf.org/Our-Work/Environmental-Threats/Climate-Change/Greenhouse-Gases/Gardening-for-Climate-Change

Extreme Precipitation Risks

Greater Flood Risk (Increased Frequency of Flooding)

- Increased risk (damage to water infrastructure and changing floodplains (roads, floodwalls, dams, electric grid, water intakes, etc.)
- Health risks associated with floods (mold, exposure to chemicals and waterborne pathogens, vector control, drinking water and food contamination)
- Increased transportation issues (major disruptions to local economy, difficult for police and ambulances to respond to emergencies when areas are flooded).

Reduced Water Quality

- Intensity means more runoff and potential contamination
- Increased need for water treatment due to deteriorated water quality.
- Potential for summer droughts and seasonal water shortages, particularly for agricultural and industrial use.

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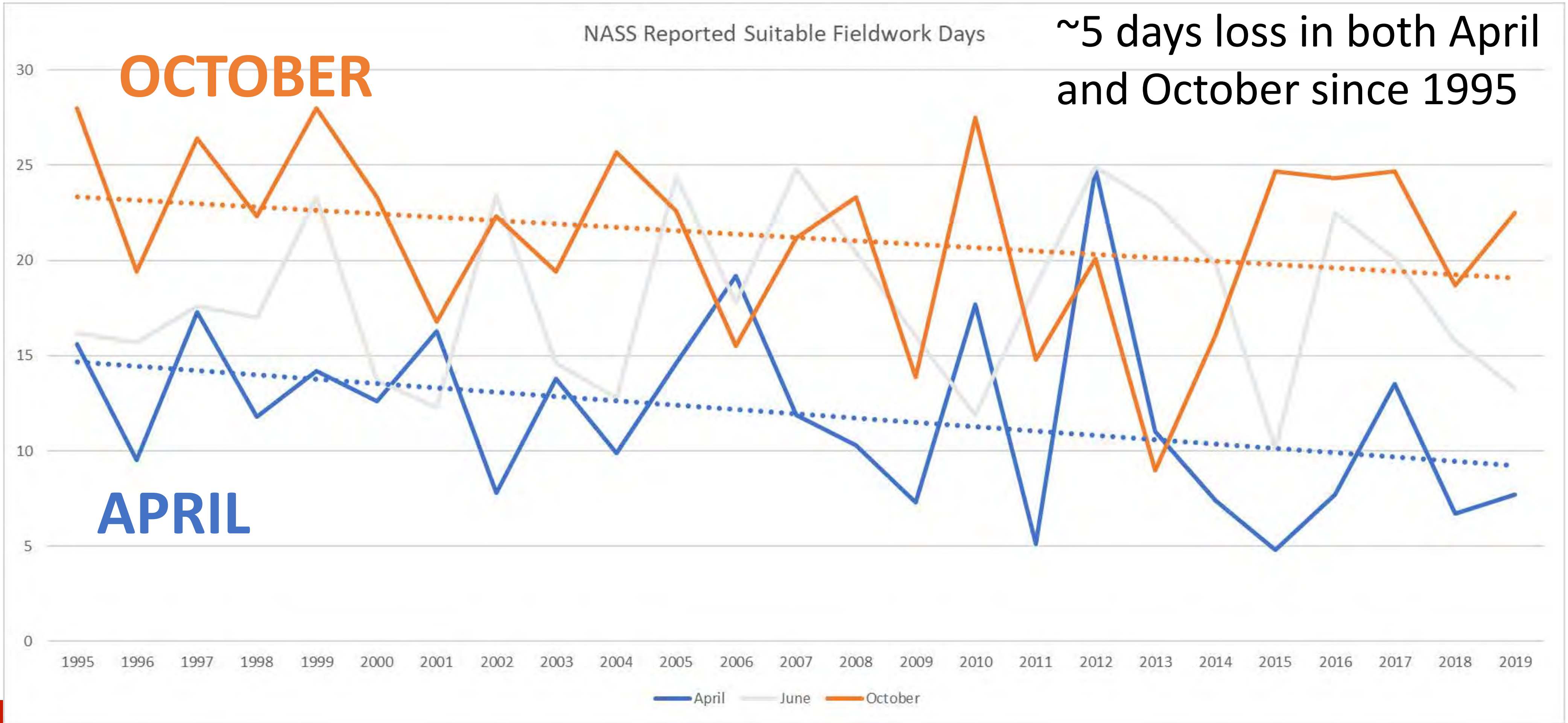
Fieldwork Days for Ohio

Trend = -0.2 days per year

~5 days loss in both April and October since 1995



Data Source: NASS

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Horticulture and Adaptation

Manage higher temperatures

•crop regulation and canopy management, such as using temperature data loggers to optimize temperatures; greenhouse modifications

•using irrigation to ameliorate temperature extremes; sprinkler irrigation can reduce canopy temperatures.

•Vegetable/Fruit hybrids with greater heat tolerance

https://www.agric.wa.gov.au/climate-change/climate-change-and-horticulture

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Improve water harvesting and storage

- dams and catchments to cope with projected rainfall and evaporation rates
- use in-row water harvesting for grapes and tree crops
- harvest water run-off from greenhouses
- increase investment in tanks and dam storages.

Improve irrigation efficiency

- watering at night; drip irrigation; subsurface drip irrigation
- reduced evaporation of soil water through mulching with organic materials, mulching with plastic, rapid crop canopy development/closure
- reducing run-off by using appropriate irrigation rates, mulches, contour sowing, minimum tillage, claying.

Grow crops under shelters or greenhouses

- use netting to provide shade (reduced canopy temperature and evaporation) and reduce risk of hail and bird damage
- grow crops in greenhouses to increase productivity by using plastic tunnels, plastic structures with computerized temperature control and shading systems; glass structures with computerized temperature control and shading systems

Impacts on Soil Processes

Pareek N (2017) Climate Change Impact on Soils: Adaptation and Mitigation. MOJ Eco Environ Sci 2(3): 00026. DOI: 10.15406/mojes.2017.02.00026

Increasing Temperature	Loss of soil organic matter Reduction in labile pool of SOM Reduction in moisture content Increase in mineralization rate Loss of soil structure Increase in soil respiration rate
Increasing CO2 Concentration	Increase in soil organic matter Increase in water use efficiency More availability of carbon to soil microorganisms Accelerated nutrient cycling.
Increasing Rainfall	Increase in soil moisture or soil wetness Enhanced surface runoff and erosion Increase in soil organic matter Nutrient leaching Increased reduction of Fe and nitrates Increased volatilization loss of nitrogen Increase in productivity in arid regions
Reduction in Rainfall	Reduction in soil organic matter Soil salinization Reduction in nutrient availability

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Soil & Water Health

- Seasonal precipitation changes and impacts on water availability for crop production

- Healthy soils impacted by erosion, compaction, and loss of organic matter.
    - Organic material impacted by soil temperature & water availability
    - Increased erosion from intense extreme rainfall events
    - Increased potential for associated, off-site, non-point-source pollution.
    - Tillage intensity, crop selection, as well as planting and harvest dates can significantly affect runoff and soil loss.

- Surface and groundwater systems impacted over time through changes in evapotranspiration and recharge)

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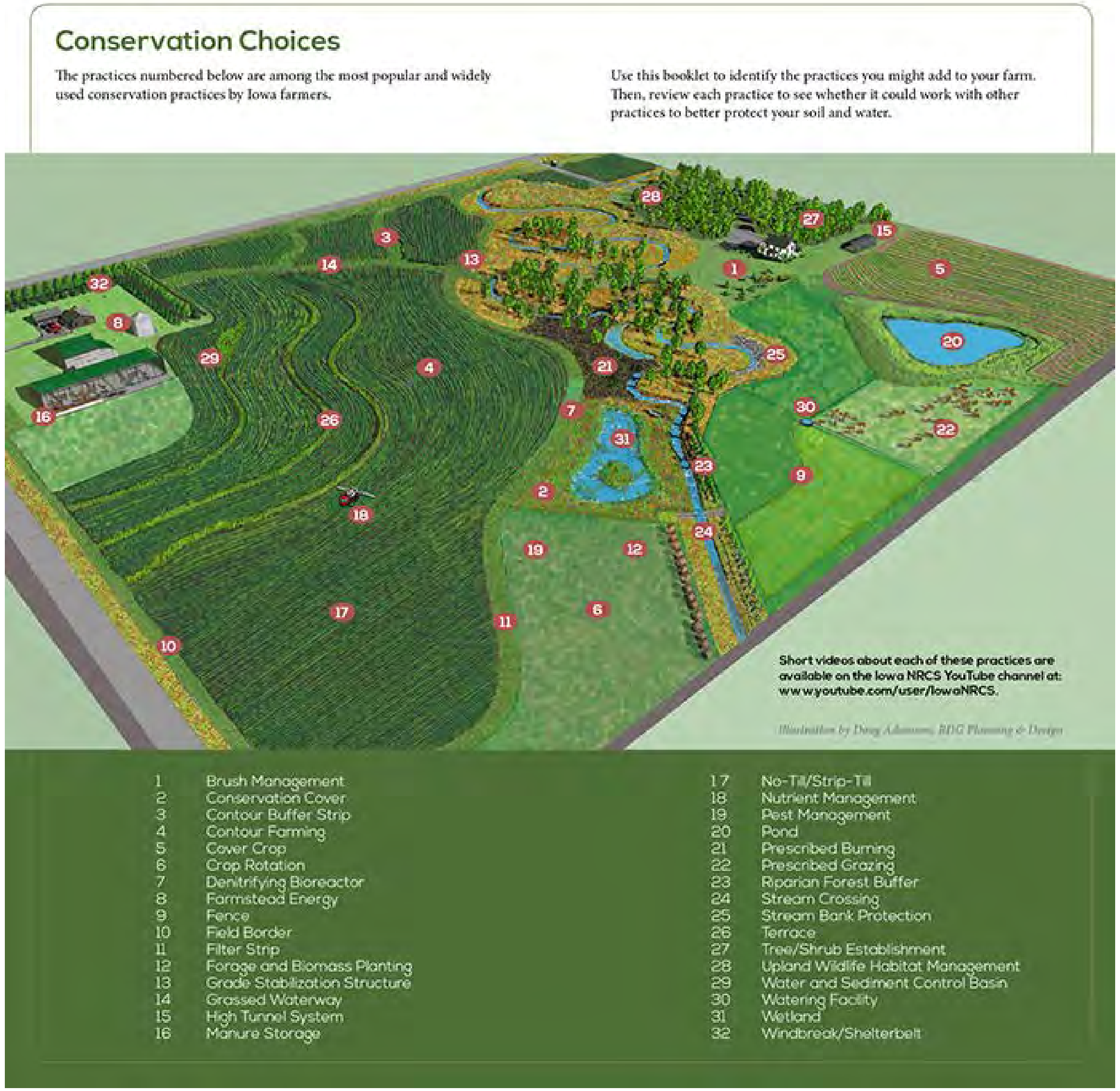
Conservation Practices for Discussion

- What strategies slow the progress of water from fields to streams?

- What strategies improve the quality of the soil, thereby improving plant health and water storage capacity?



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Ag and Mitigation

Food and Agriculture Organization of the United Nations: “It is estimated that soils can sequester around 20 Pg C in 25 years, more than 10 % of the anthropogenic emissions.”

http://www.fao.org/home/en/

1 Pg = 1 trillion kg

Rattan Lal: https://senr.osu.edu/our-people/rattan-lal

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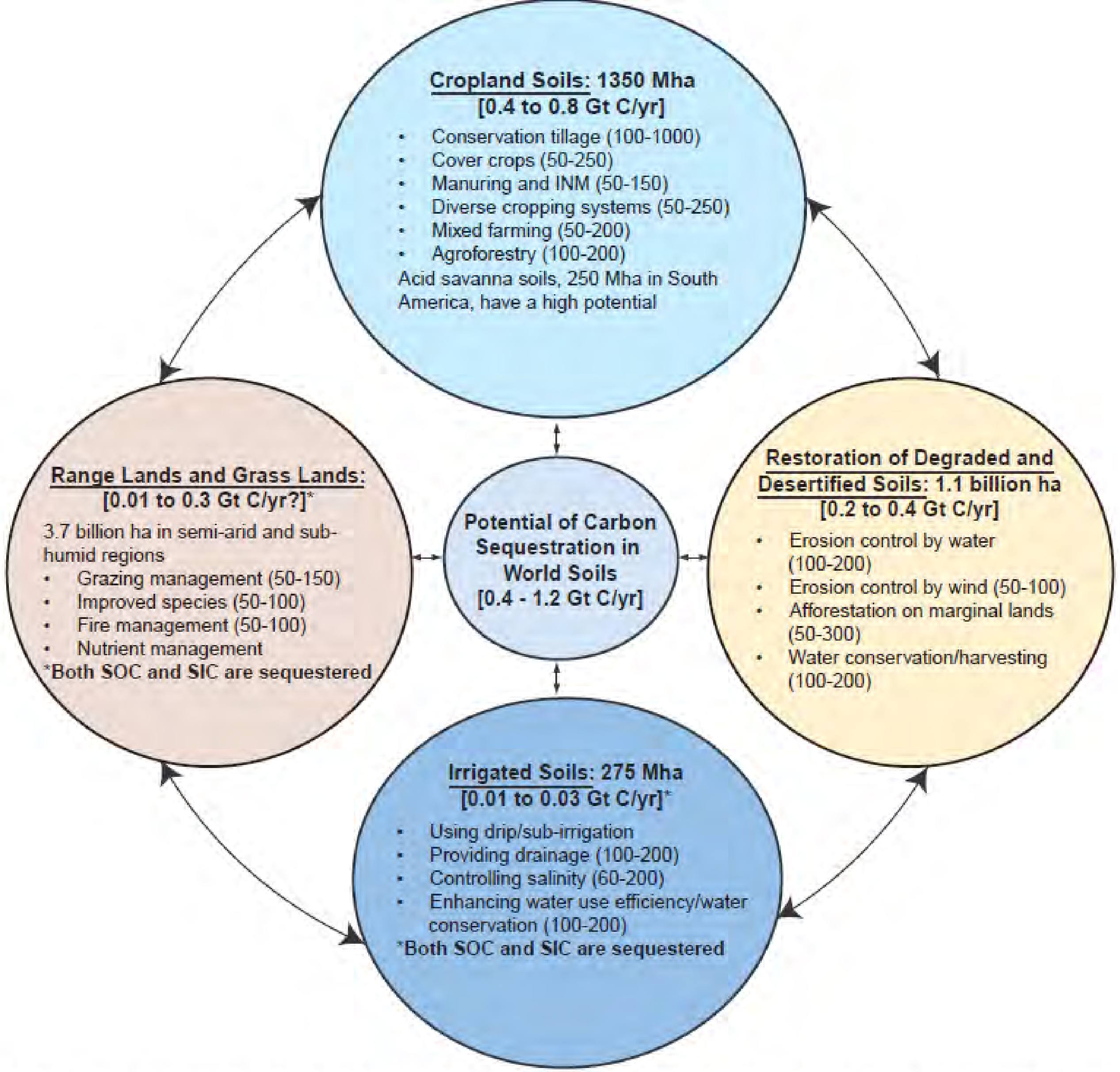

Fig. 2. Ecosystems with a high and attainable soil C sequestration potential are cropland, grazing/range land, degraded/desertified lands, and irrigated soils. Forest soils are included under afforestation of agriculturally marginal and otherwise degraded/desertified soils. Reforestation of previously forested sites have small additional soil C sequestration. The potential of C sequestration of range lands/grassland is not included in the global total because part of it is covered under other ecosystems, and there are large uncertainties. Rates of C sequestration given in parentheses are in kg C/ha per year, are not additive, and are low under on-farm conditions. [Rates are cited from (*2–9, 15, 25, 37–39*) and other references cited in the supporting material.]

"Our changing weather patterns directly impact our *economic and environmental* sustainability."

Photo courtesy of
Amanda Douridas

Actions

1. Climate change is happening.
2. We are currently experiencing the effects.
3. Humans are the cause.
4. The scientific evidence is overwhelming.
5. We can do something about it.

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Our Three Options

- **Mitigate:** Stop or limit climate change impacts by reducing greenhouse gas emissions.
- **Adapt:** Change infrastructure, planning, and behaviors to adjust to climate change impacts.
- **Suffer:** Face the consequences of failing to mitigate or adapt. Populations already experiencing adversity are likely to be the most negatively impacted.

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