Climate Variability, Climate Change in MO, and an Early Weather Outlook – Summer 2023

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Introduction

- Weather and Climate are both current issues that are pressing in recent years due to “extreme occurrences”.

USA TODAY

2021 was a deadly year for weather: 20 disasters killed more than 600 Americans

Doyle Rice, USA TODAY

Mon, January 10, 2022, 2:14 PM · 3 min read

2021 was another catastrophic and deadly year for weather and climate disasters in the USA, federal scientists announced Monday. There were 20 separate disasters that each cost at least $1 billion in damage, the National Oceanic and Atmospheric

- December 2021 – Record warmth across the Midwest – including two strong severe weather events.

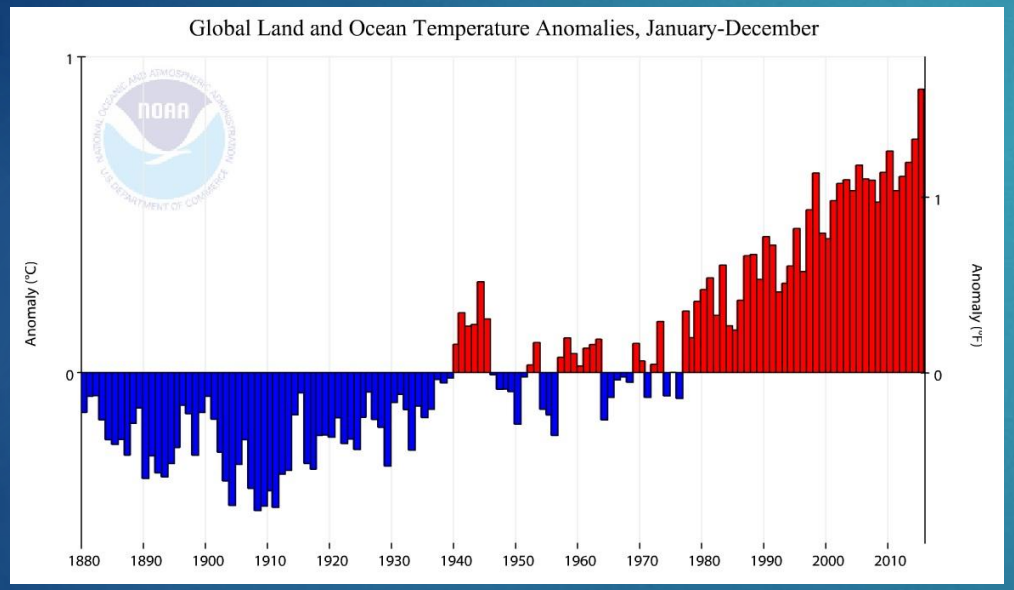
Introduction

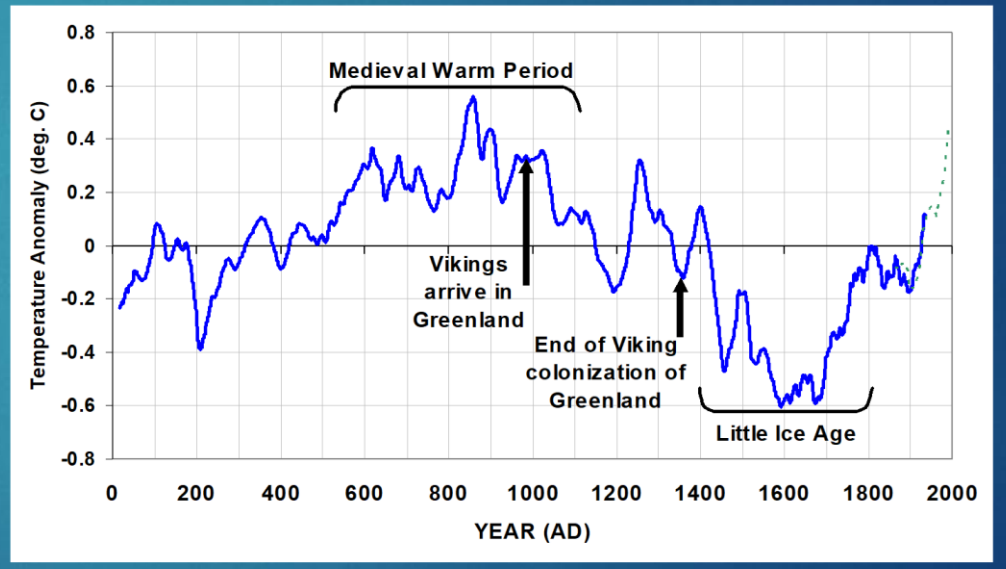
- Climate change as an issue has been wrestled with in political circles for a couple decades. http://ipcc.ch

- There is no doubt that Earth's climate has warmed since the mid-to-late 1800s – and the rates have been different at different times.

Introduction

- Most acknowledge some role for humans – although many believe that humans are the sole cause of current climate change.

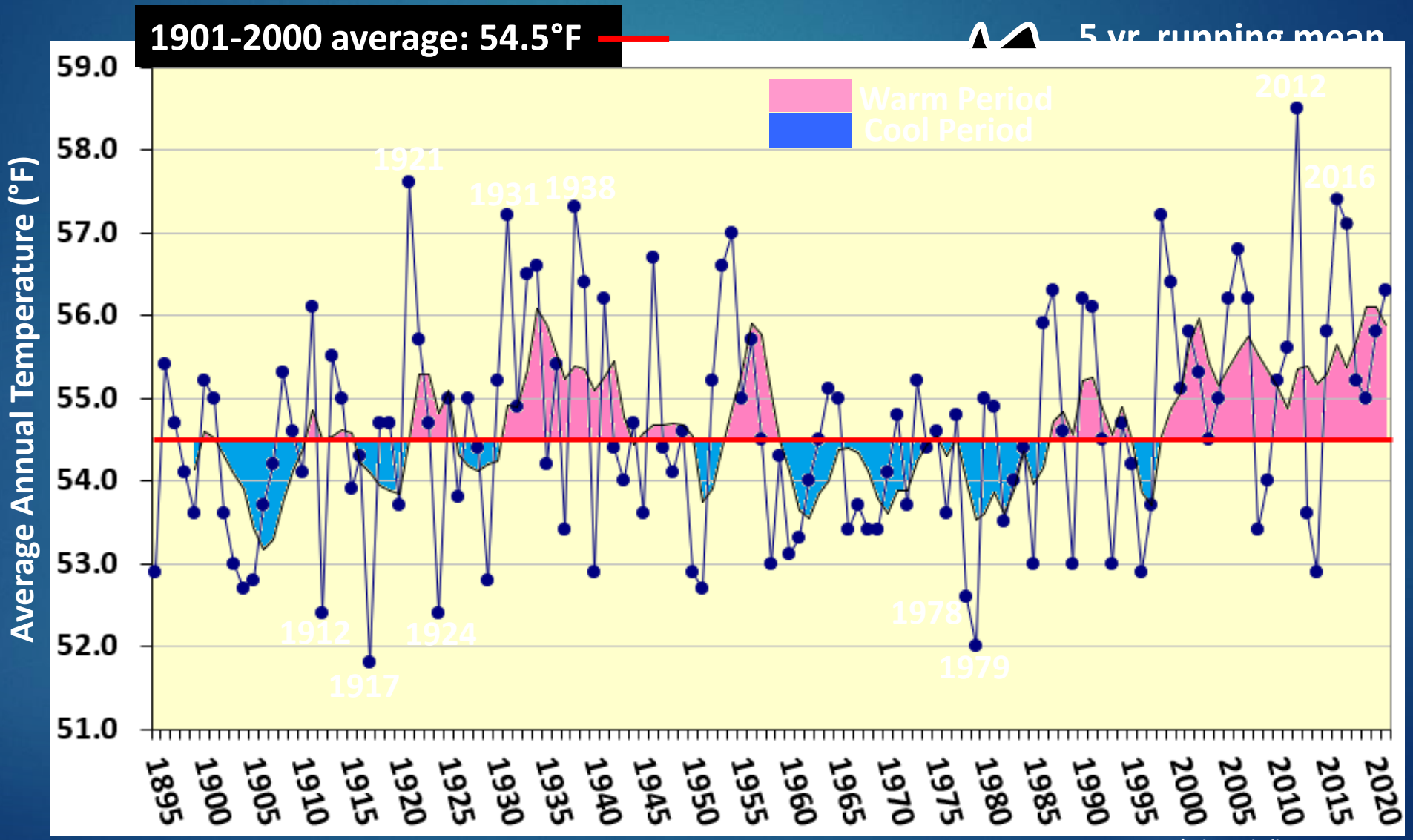




- Nonetheless climate has changed on earth for as long as there has been an atmosphere.

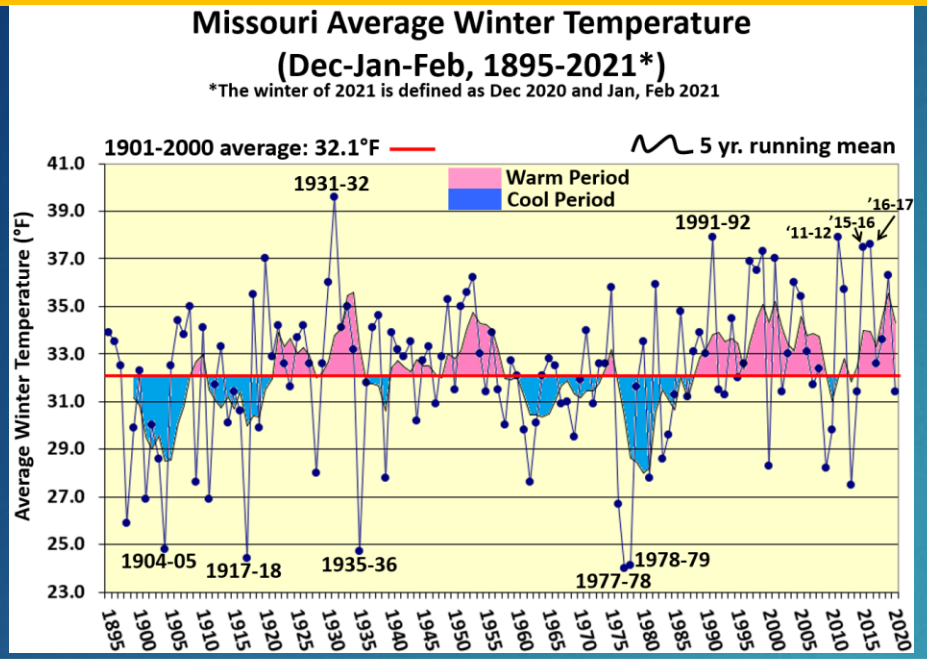
Missouri annual temperature trends have been warming since the late 1990's.

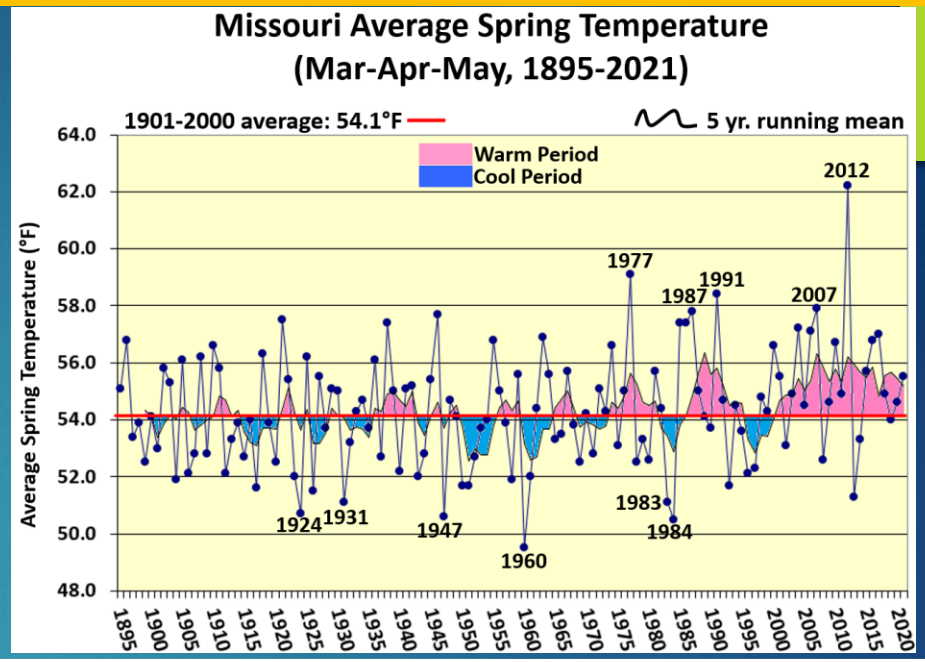
Missouri Average Annual Temperature (1895-2021)

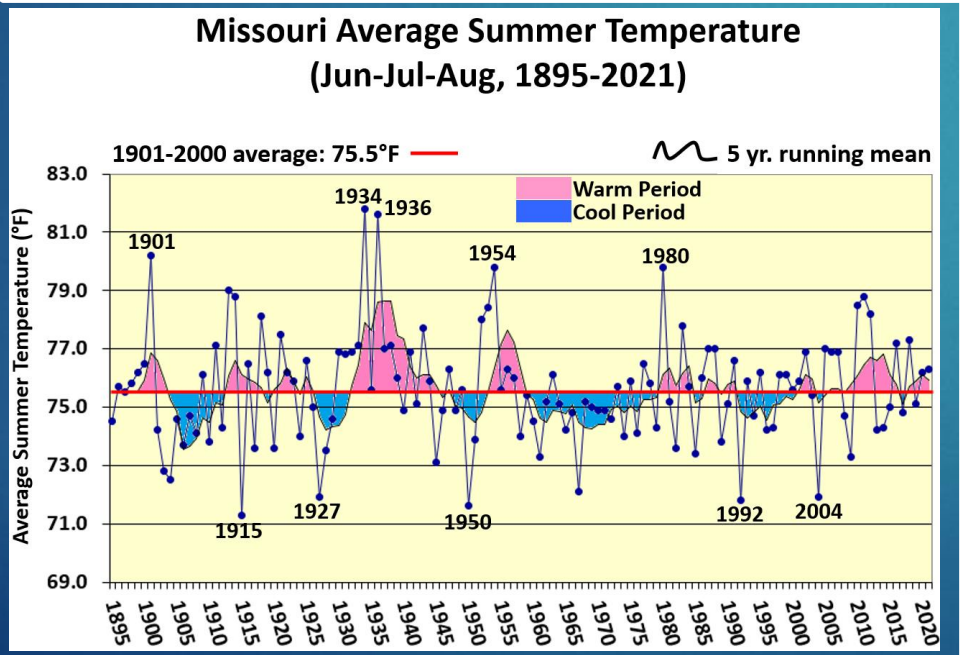


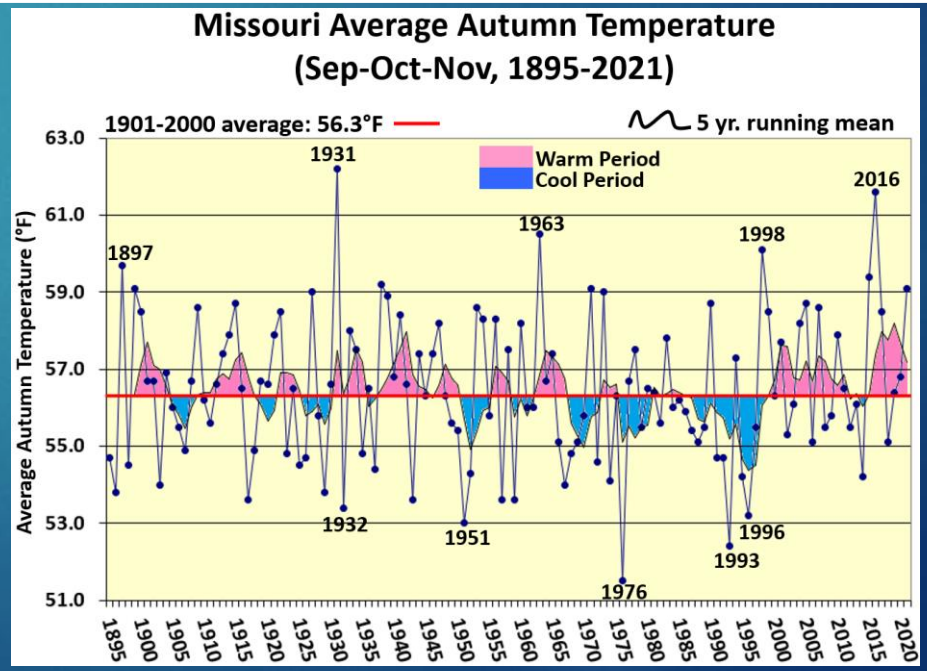
Source: NOAA/Missouri Climate Center

Missouri's strongest seasonal warming has been occurring in winter & spring.







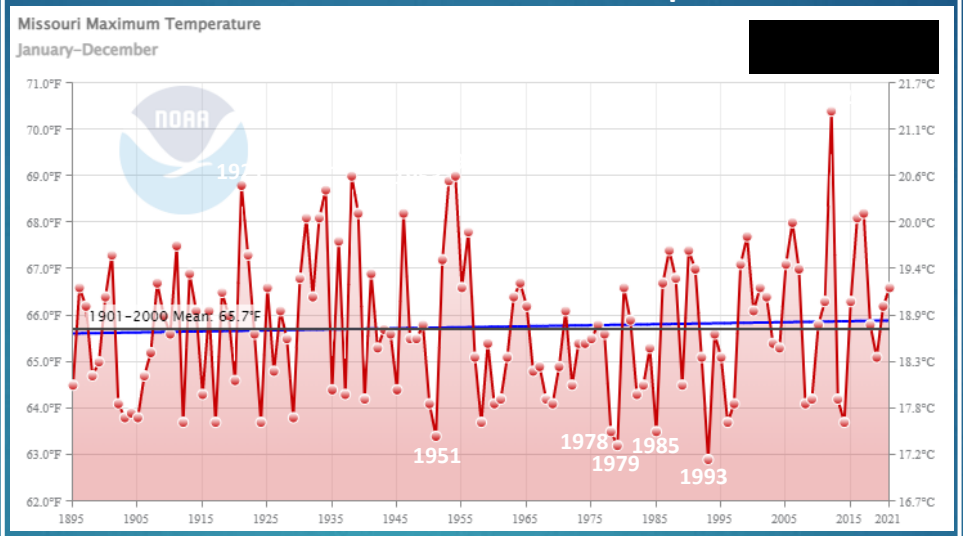


Source: NOAA/Missouri Climate Center

Missouri maximum and minimum annual temperature trends have been warming but the rate of warming has been faster with minimum temperature.

NOAA NATIONAL CENTERS FOR ENVIRONMENTAL INFORMATION
Climate at a Glance
www.ncdc.noaa.gov/cag/

Missouri Annual Maximum Temperature



1895-2021 Trend
(+0.2°F/Century)

For 17 out of the past 24 years (1998-2021), annual max temp has been above average, 71%.

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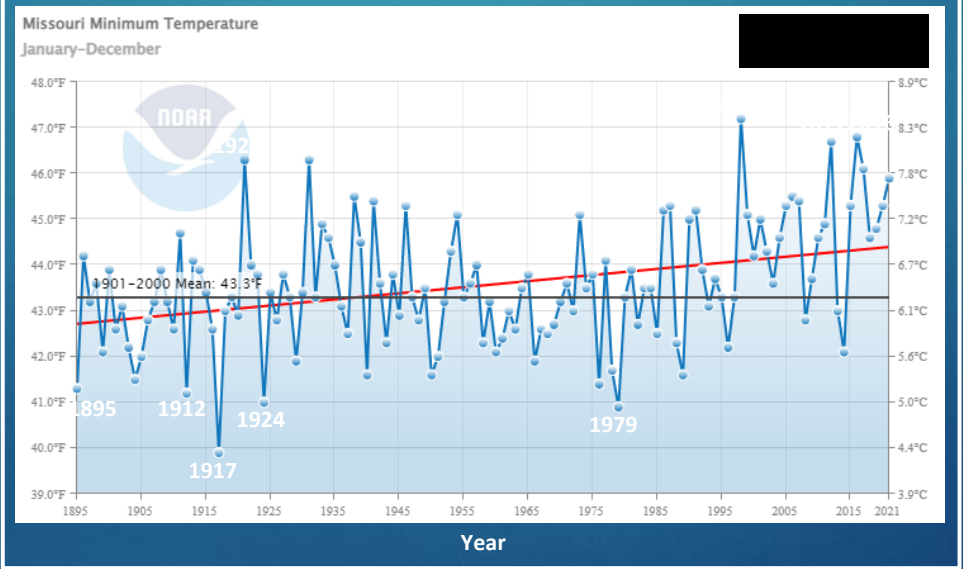
Missouri Annual Minimum Temperature



1895-2021 Trend
(+1.3°F/Century)

For 21 out of the past 24 years (1998-2021), annual min temp has been above average, 88%.

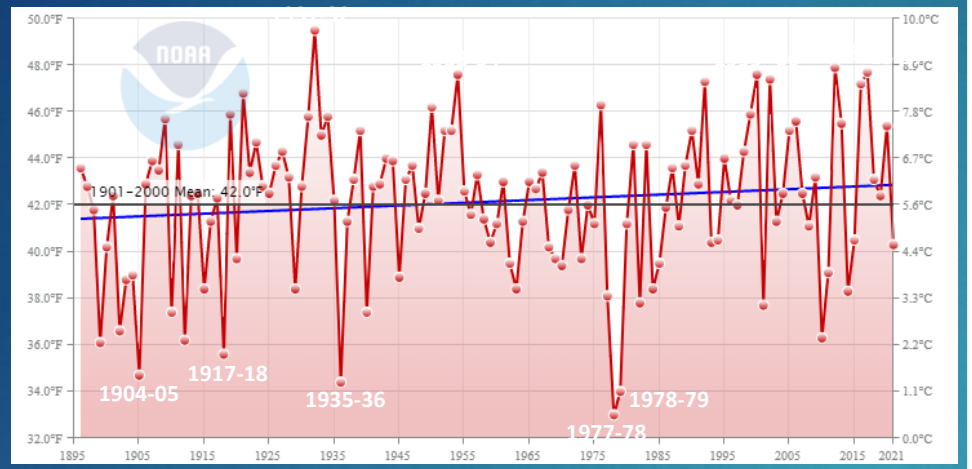
Missouri's strongest maximum temp warming has been occurring in winter & spring.

Missouri Winter Maximum Temperature (Dec-Jan-Feb, 1895-2021*)

*The winter of 2021 is defined as Dec 2020 and Jan, Feb 2021

1901-2000 mean: 42.0°F

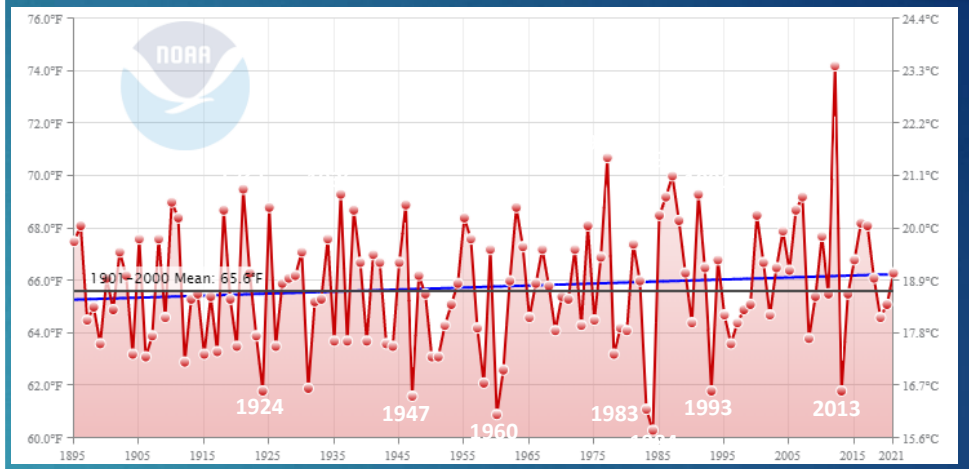
1896-2021 Trend (+1.2°F/Century)



Missouri Spring Maximum Temperature (Mar-Apr-May, 1895-2021)

1901-2000 mean: 65.6°F

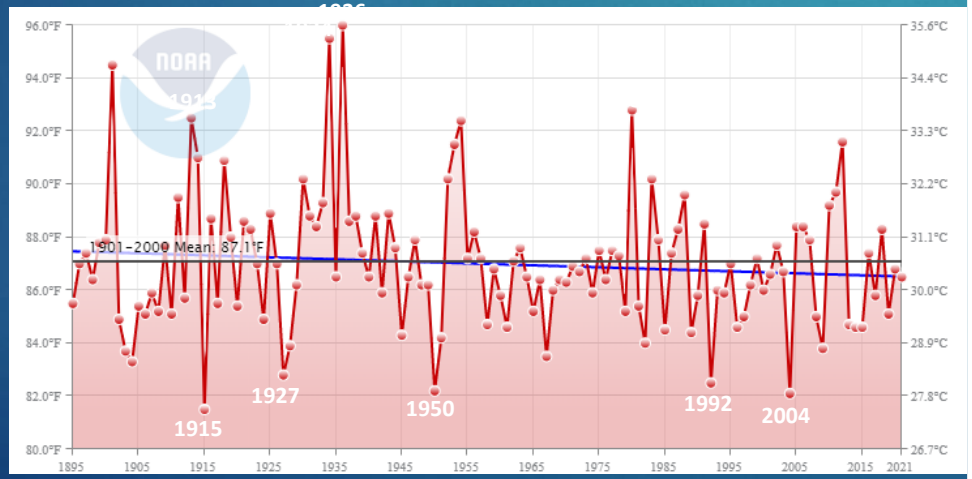
1895-2021 Trend (+0.8°F/Century)



Missouri Summer Maximum Temperature (Jun-Jul-Aug, 1895-2021)

1901-2000 mean: 87.1°F

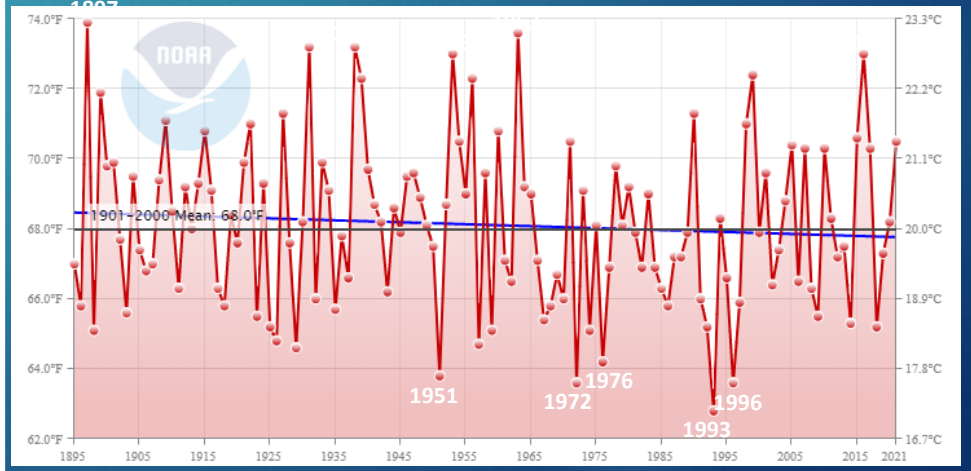
1895-2021 Trend (-0.8°F/Century)



Missouri Autumn Maximum Temperature (Sep-Oct-Nov, 1895-2021)

1901-2000 mean: 68.0°F

1895-2021 Trend (-0.6°F/Century)



Climate At A Glance: www.ncdc.noaa.gov/cag/

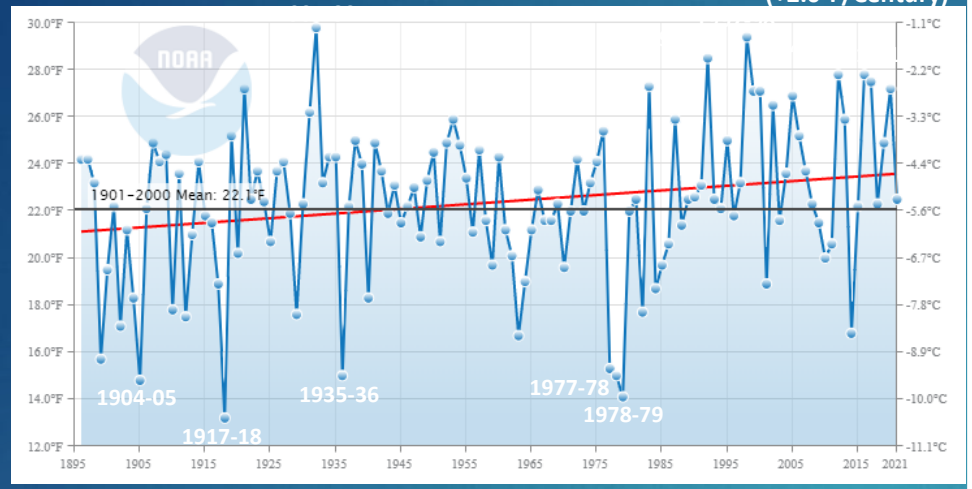
Missouri minimum temperature trends have been warming all four seasons.

Missouri Winter Minimum Temperature
(Dec-Jan-Feb, 1895-2021*)

*The winter of 2021 is defined as Dec 2020 and Jan, Feb 2021

1901-2000 mean: 22.1°F

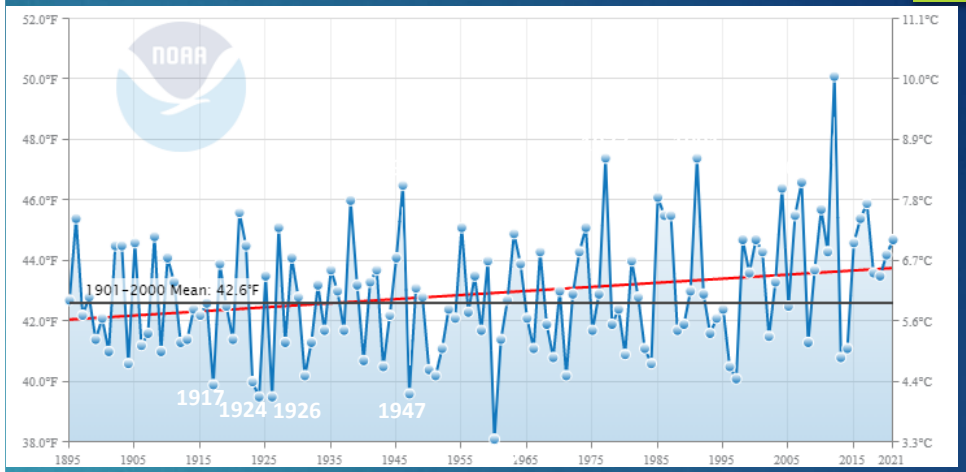
1896-2021 Trend (+2.0°F/Century)



Missouri Spring Minimum Temperature
(Mar-Apr-May, 1895-2021)

1901-2000 mean: 42.6°F

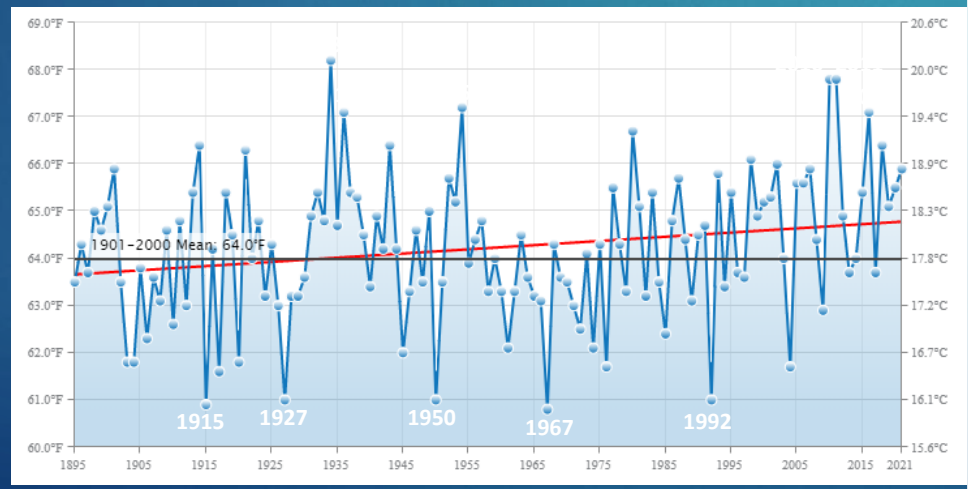
1895-2021 Trend (+1.4°F/Century)



Missouri Summer Minimum Temperature
(Jun-Jul-Aug, 1895-2021)

1901-2000 mean: 64.0°F

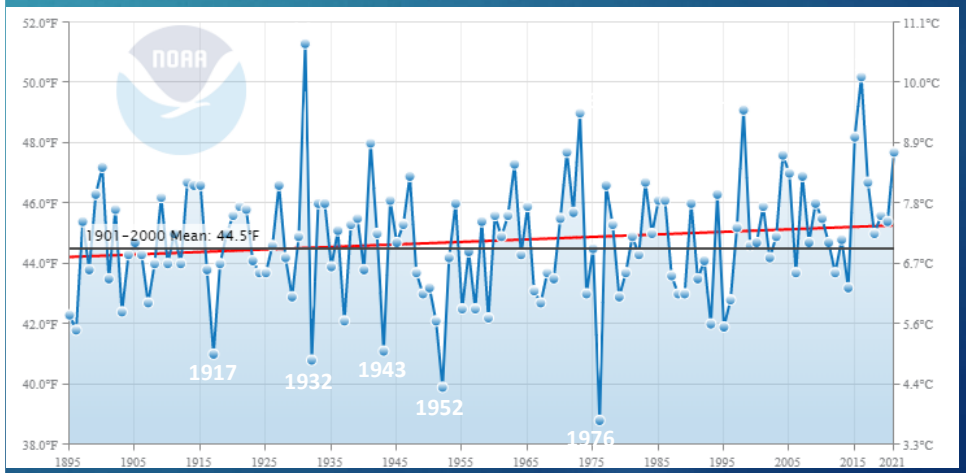
1895-2021 Trend (+0.9°F/Century)



Missouri Autumn Minimum Temperature
(Sep-Oct-Nov, 1895-2021)

1901-2000 mean: 44.5°F

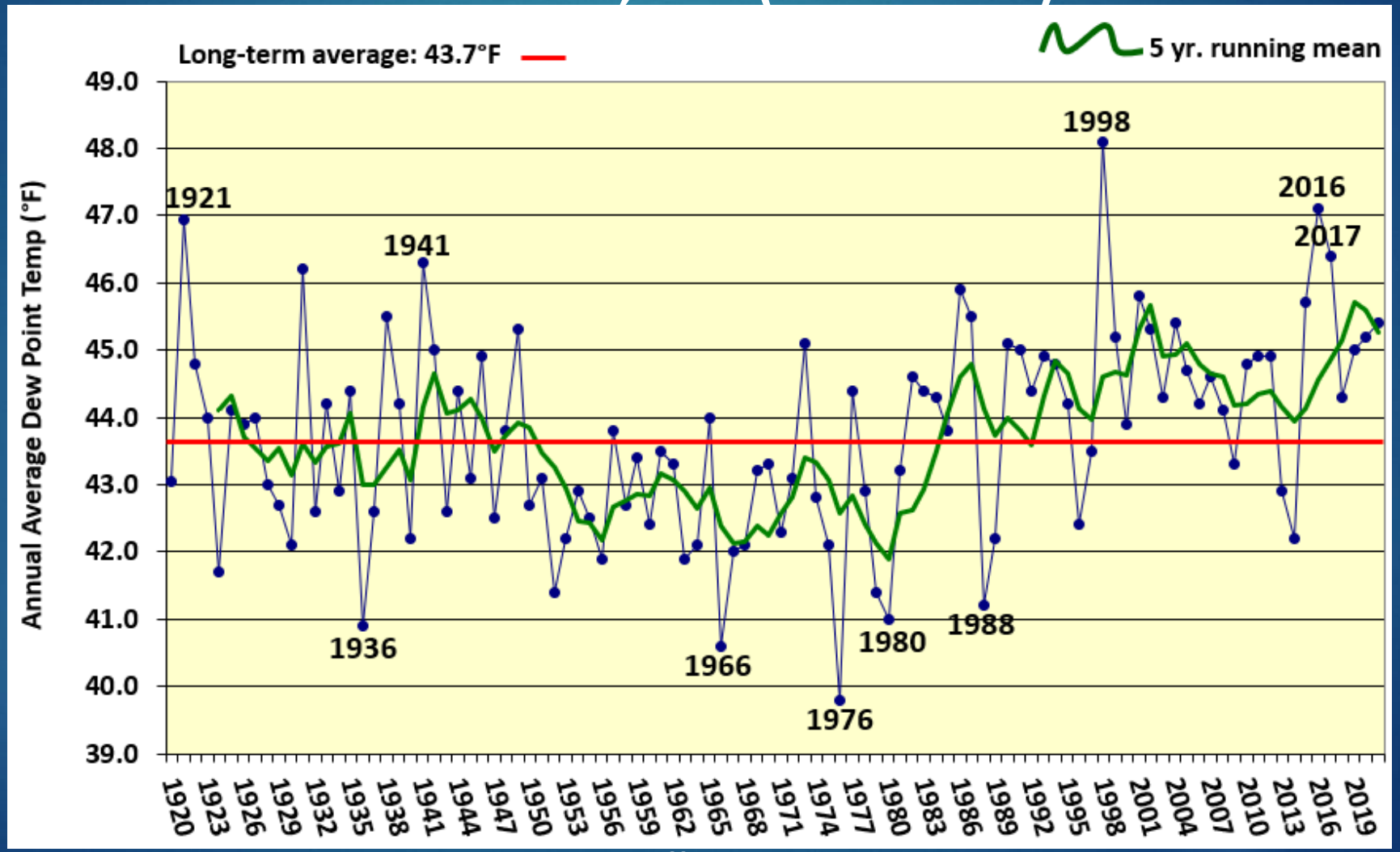
1895-2021 Trend (+0.8°F/Century)



Climate At A Glance: www.ncdc.noaa.gov/cag/

What are the climatic impacts of wetter precipitation trends?
-More humid environment.

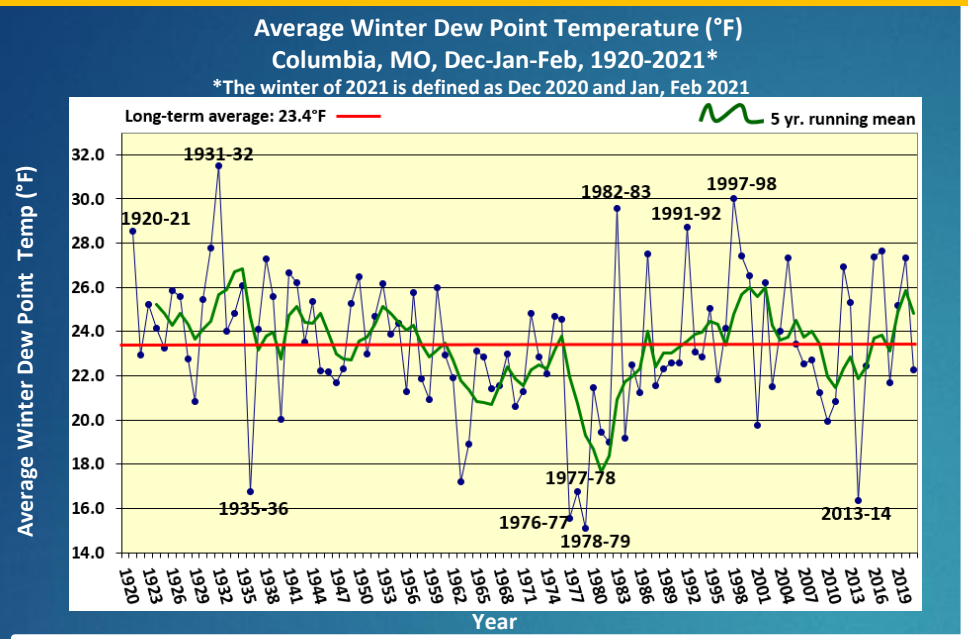
Average Annual Dew Point Temperature
Columbia, MO (1920-2021)

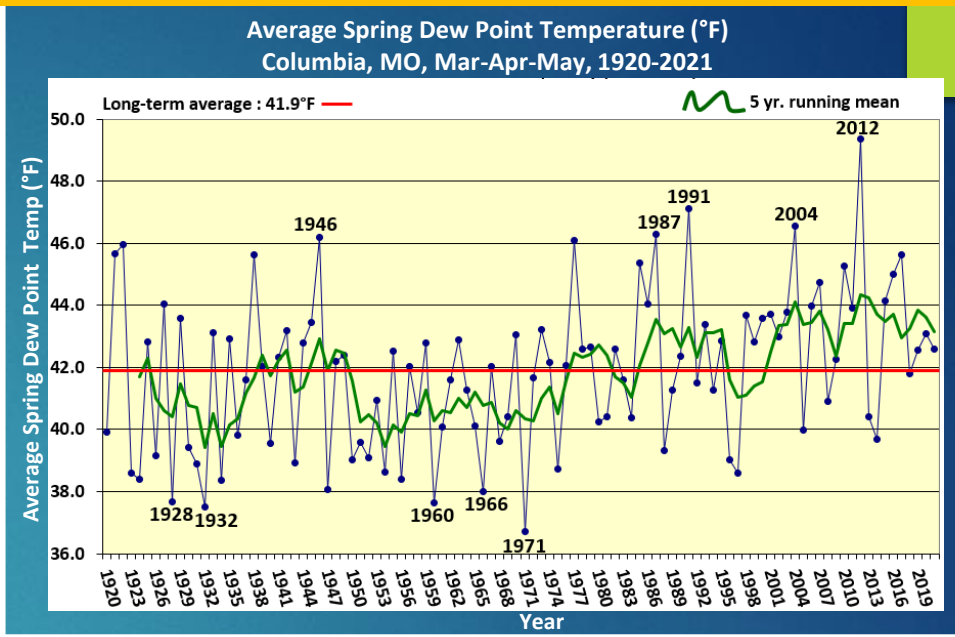


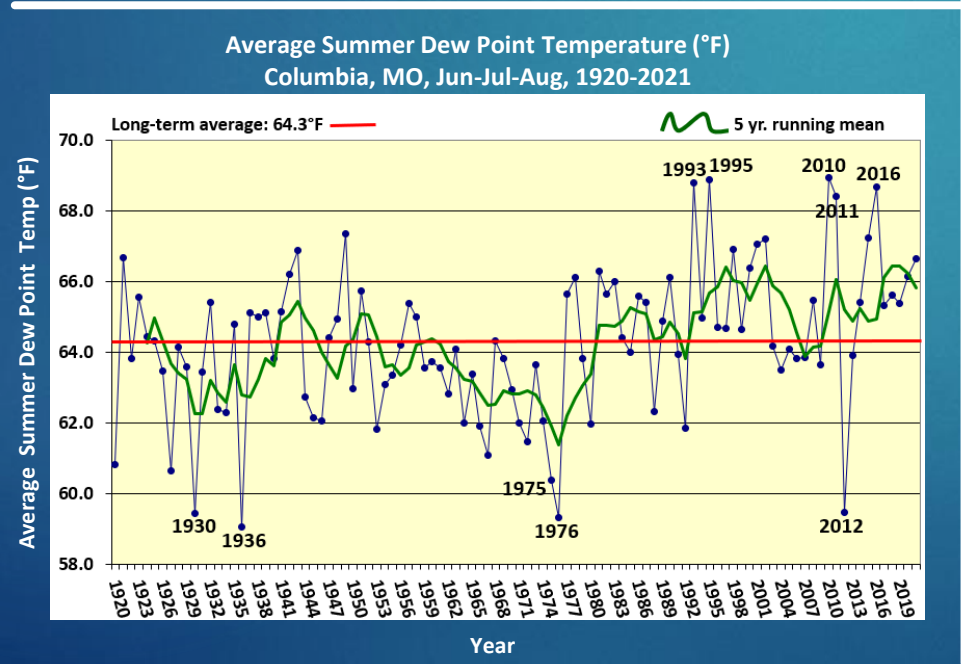
NOAA/Missouri Climate Center

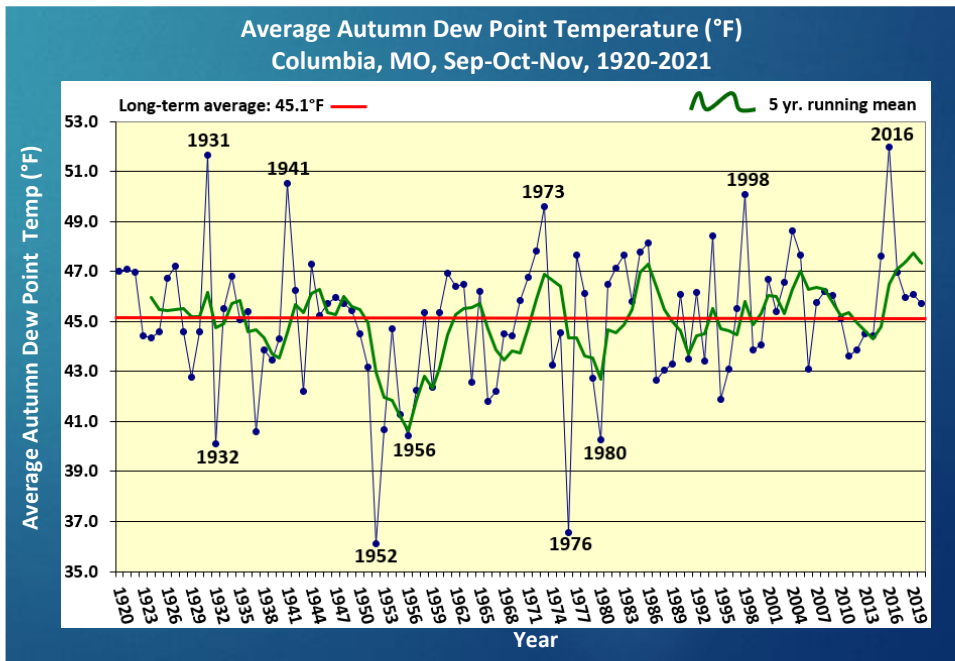
What are the climatic impacts of wetter precipitation trends?

-More humid environment, especially during the warm season.



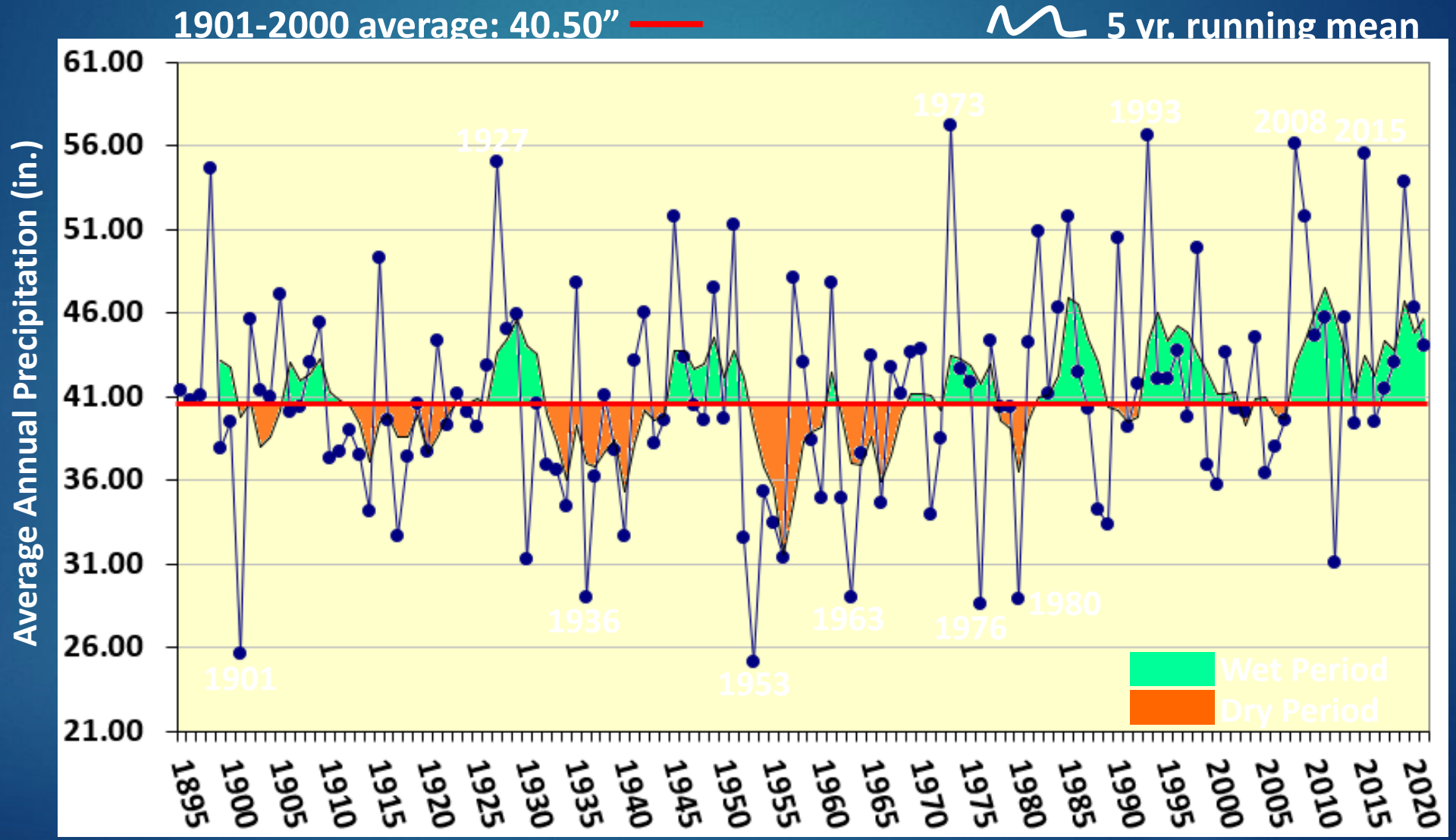






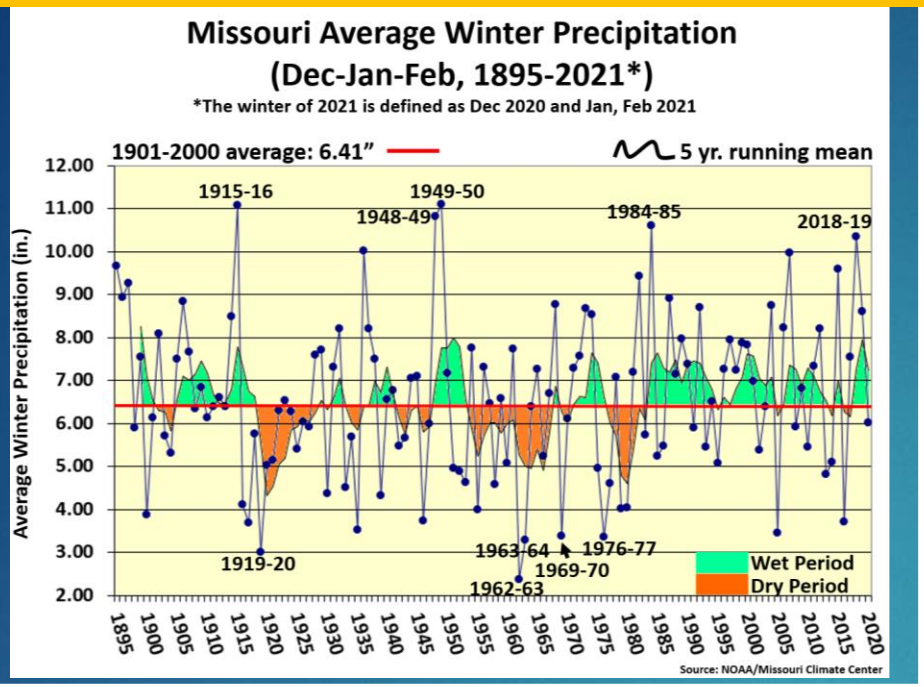
Missouri is experiencing an unprecedented wet period.

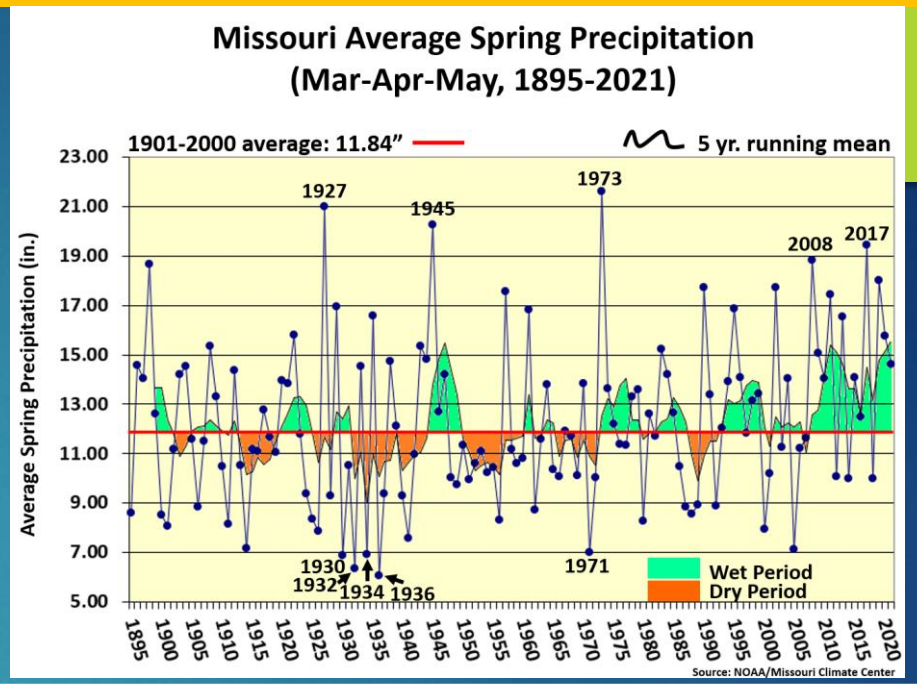
Missouri Average Annual Precipitation (1895-2021)

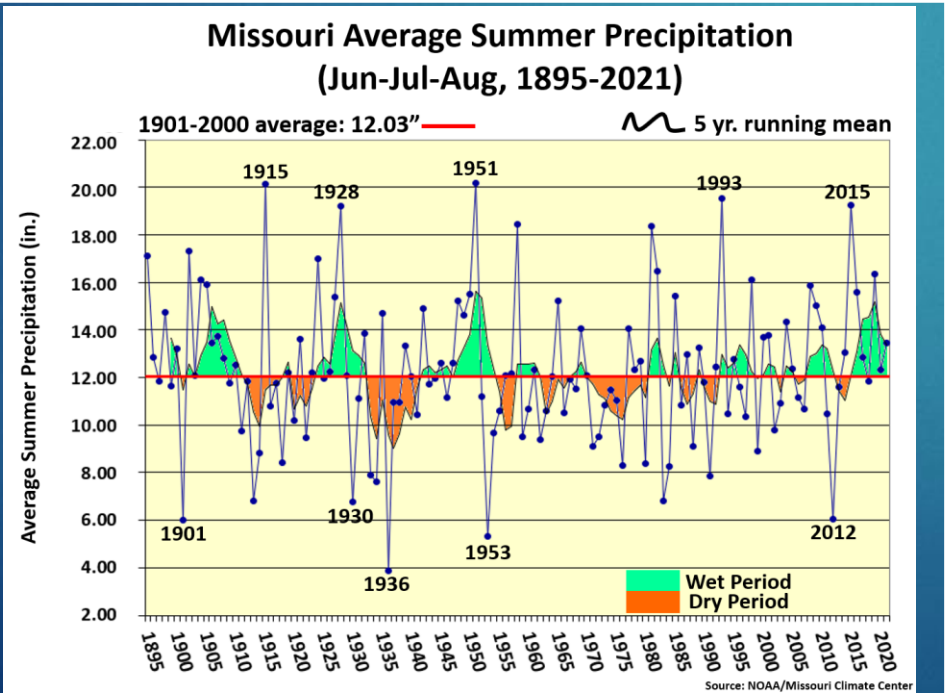


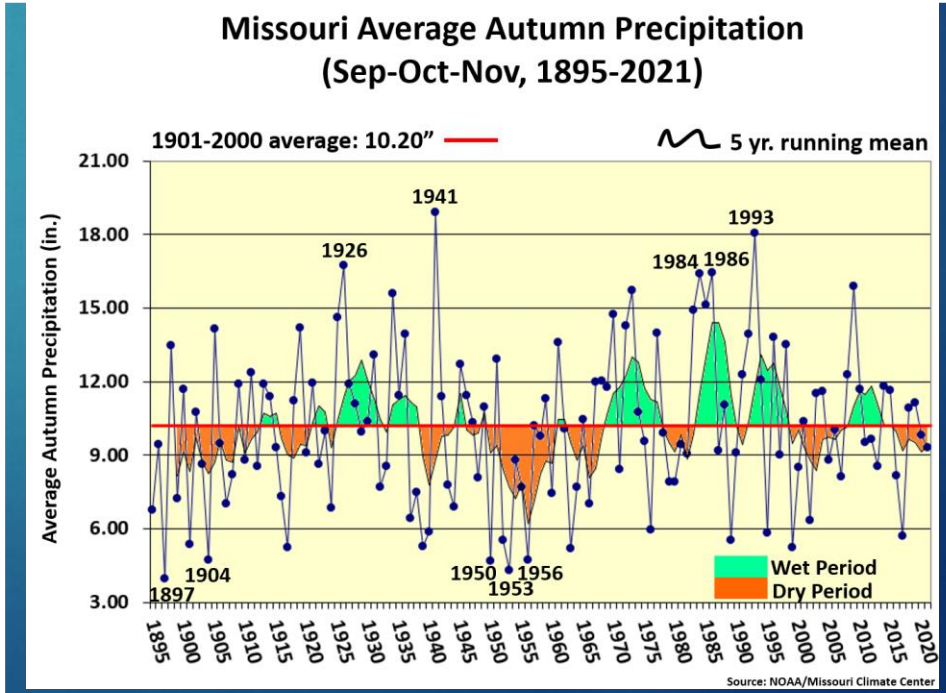
Source: NOAA/Missouri Climate Center

Missouri precipitation has been trending wetter all four seasons.









What are the climatic impacts of wetter precipitation trends?

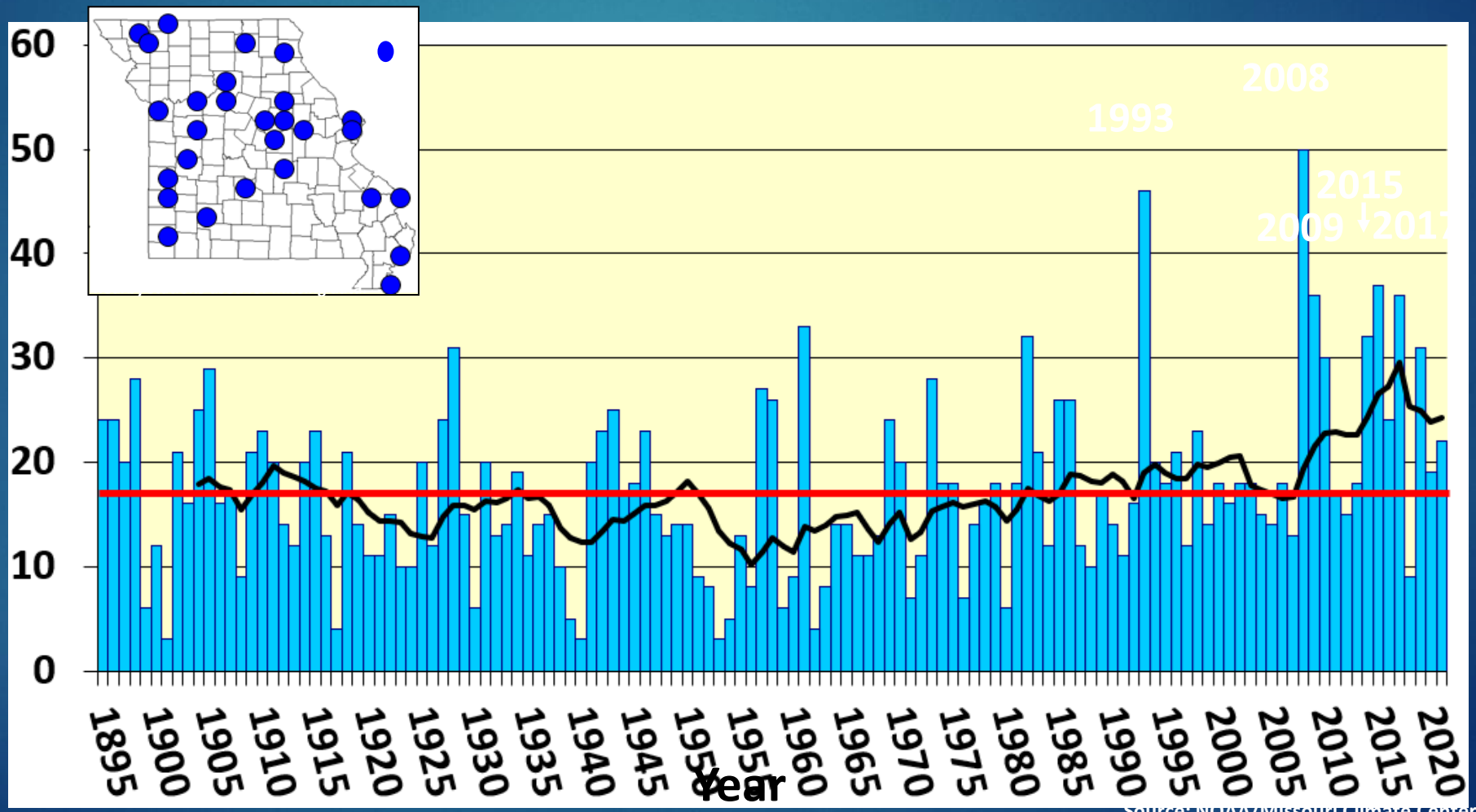
-More extreme precipitation events, more flooding.

Number of Daily Rainfall Events ≥ 3-inches in Missouri
1895-2021

1895-2019 average: 17.2/year

2000-2019 average: 23.6/year (37% increase)

10 yr. running mean

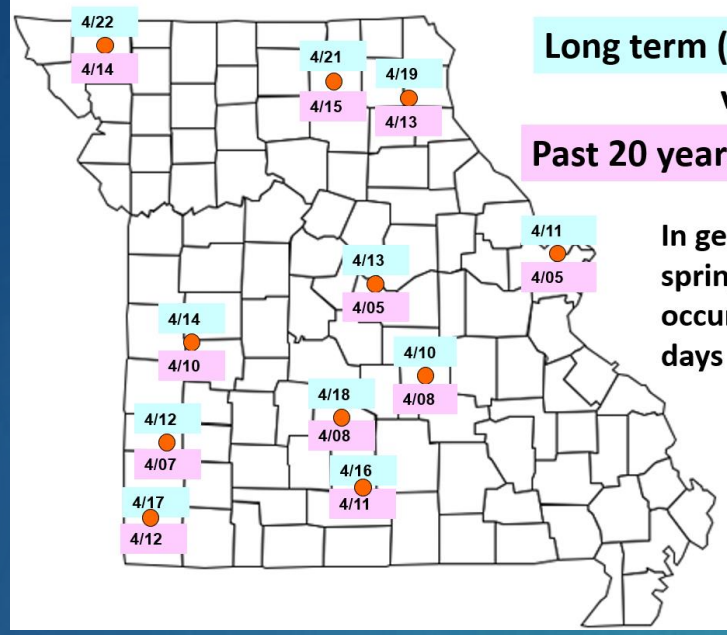


Source: NOAA/Missouri Climate Center

What are the climatic impacts from warmer spring and fall minimum temperatures?

-Longer growing season.

Median Date of Last Spring Frost (≤ 32°F)



Long term (1895-2019)

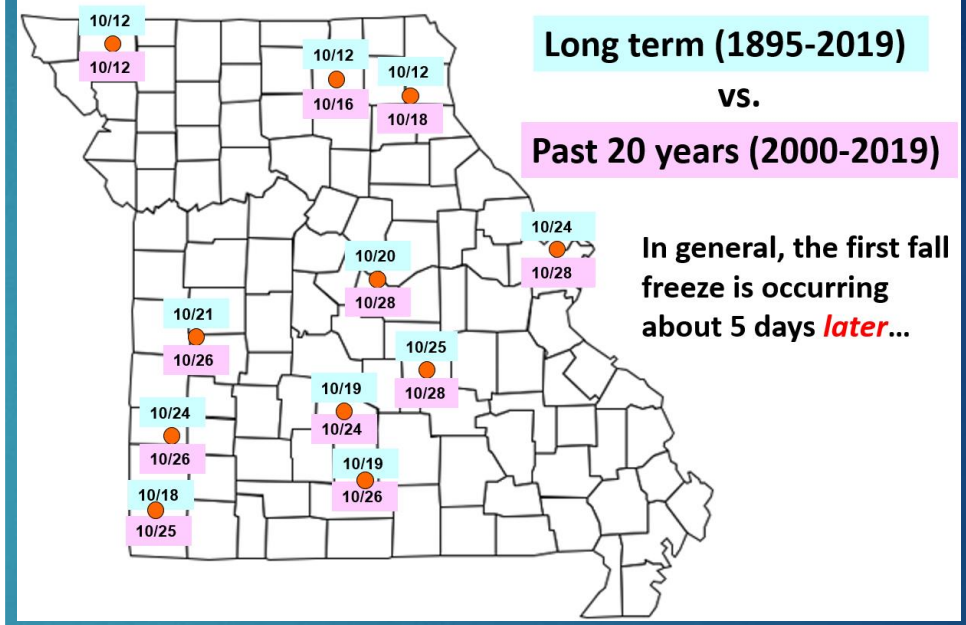
vs.

Past 20 years (2000-2019)

In general, the last spring freeze is occurring about 6 days ***earlier***…

Source: NOAA/Missouri Climate Center

Median Date of First Fall Frost (≤ 32°F)



Long term (1895-2019)

vs.

Past 20 years (2000-2019)

In general, the first fall freeze is occurring about 5 days ***later***…

Source: NOAA/Missouri Climate Center

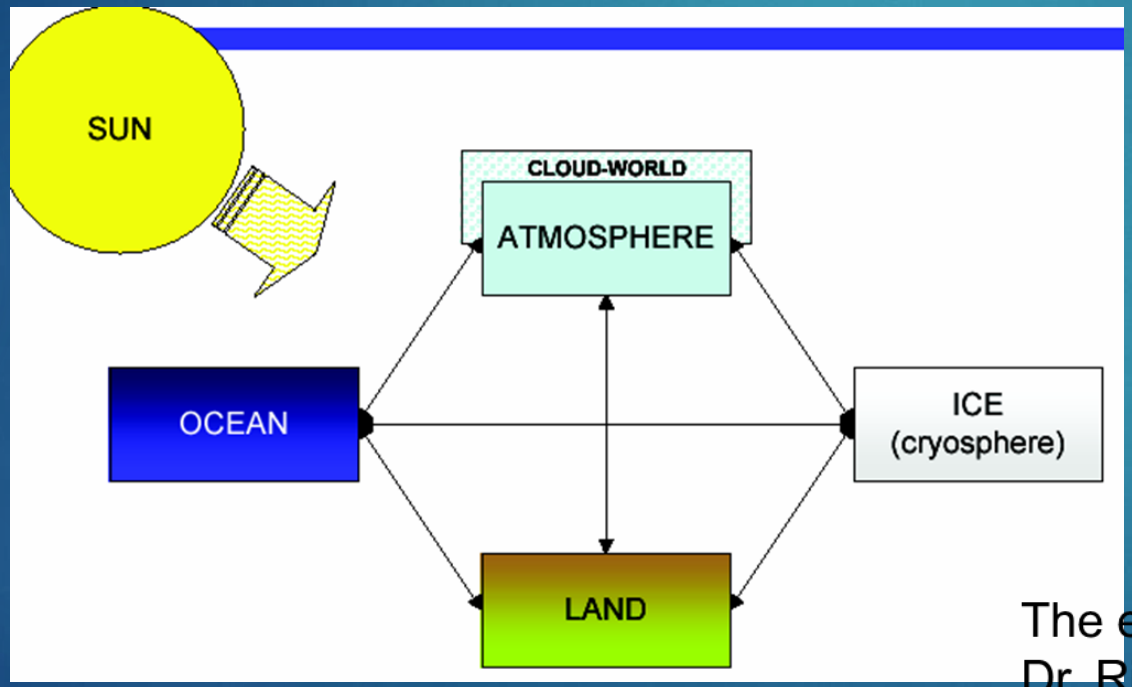
Definitions

- Weather – instantaneous conditions which can be measured using state variables.

- Climate - Is the long-term or time mean state of the earth-atmosphere system and the state variables along with higher order statistics. Also, we must describe extremes and recurrence frequencies

The Climate System – What is it?

- **The Earth-Atmosphere system is an integrated system of which the atmosphere is only one part!**



The earth-atmosphere system, courtesy of Dr. Richard Rood. (http://aoss.engin.umich.edu/class/aoss605/lectures/)

The Climate System

- The other parts of the climate system are:

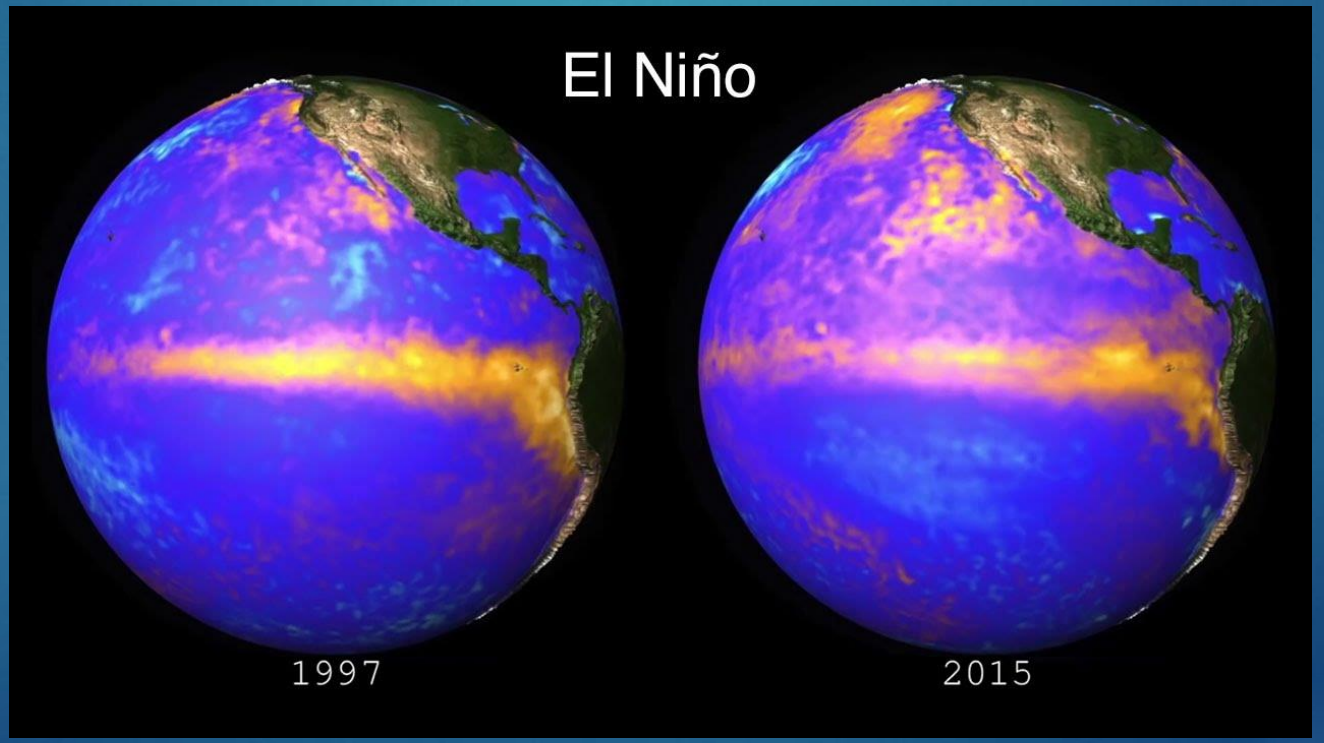
  - Cryosphere (Glaciers, Antarctica)
  - Oceans (and freshwater too)
  - Lithosphere (dirt, continents)
  - Biosphere (life → Plants and Animals)

Sub-seasonal and Seasonal Forecasting

- In this part of the world – there are three basic phenomena which drive sub-seasonal (one to four weeks) and seasonal range forecasting:
- El Niño and Southern Oscillation
- Atmospheric Blocking
- Teleconnections

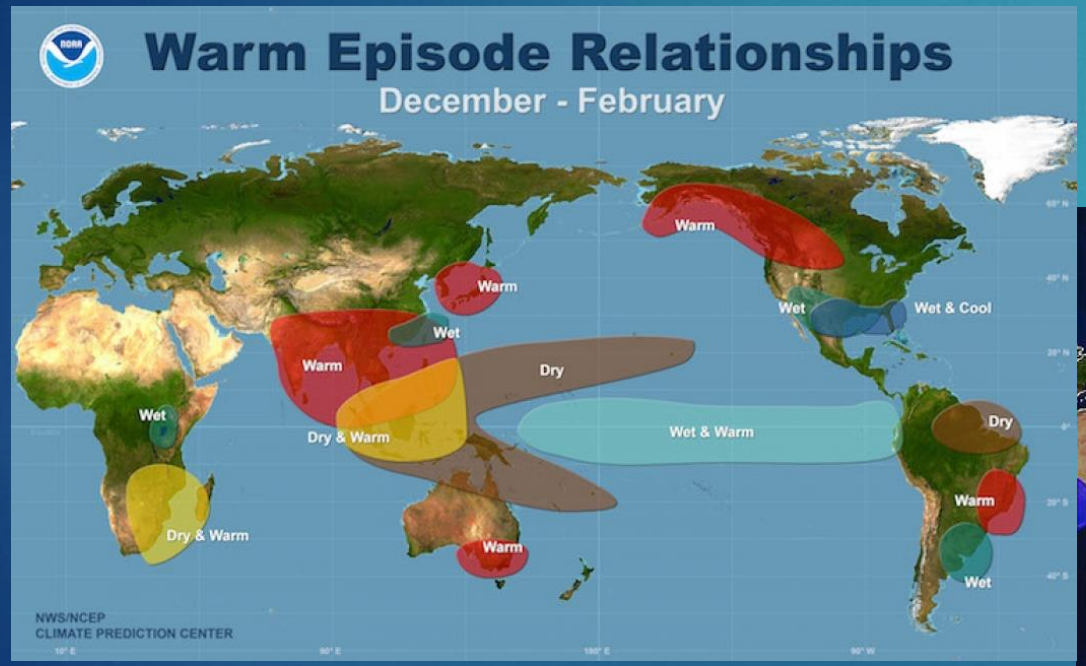
El Niño and Southern Oscillation (ENSO)

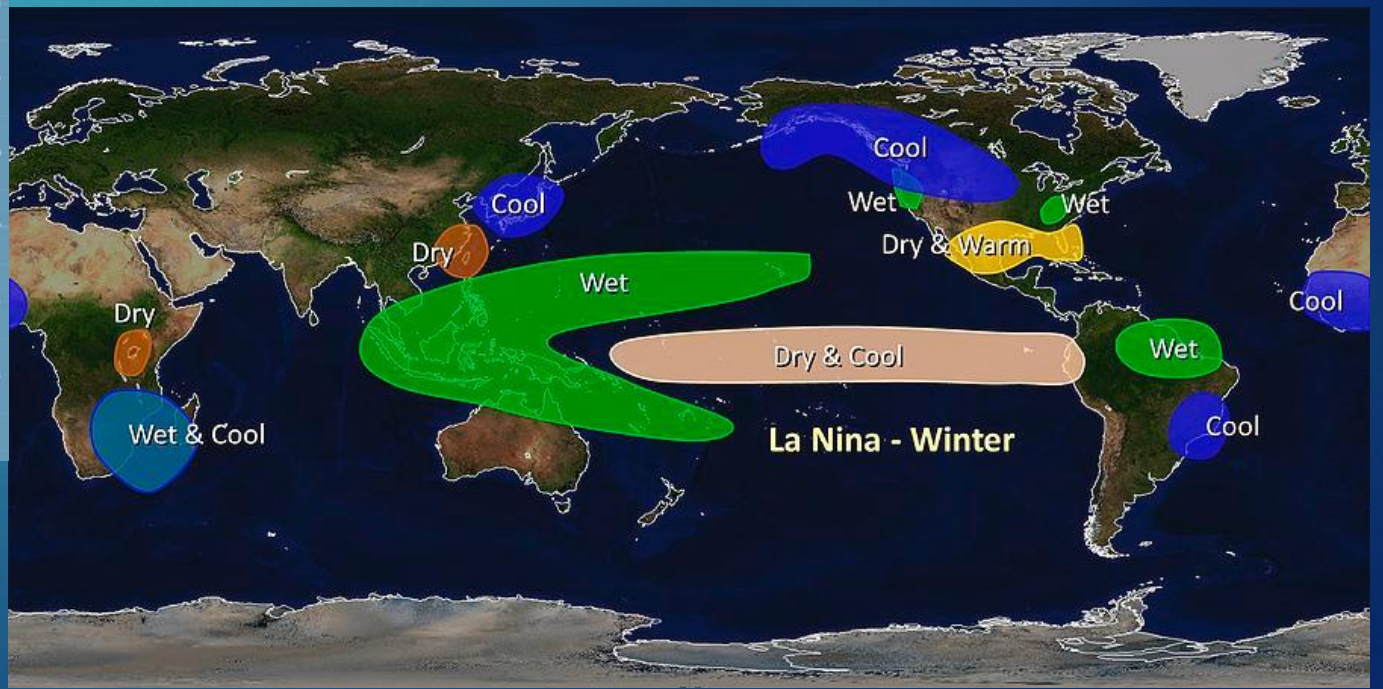
- is a two-to-seven year warming of water in the Eastern Tropical Pacific that impacts weather and climate world-wide.



ENSO Impacts

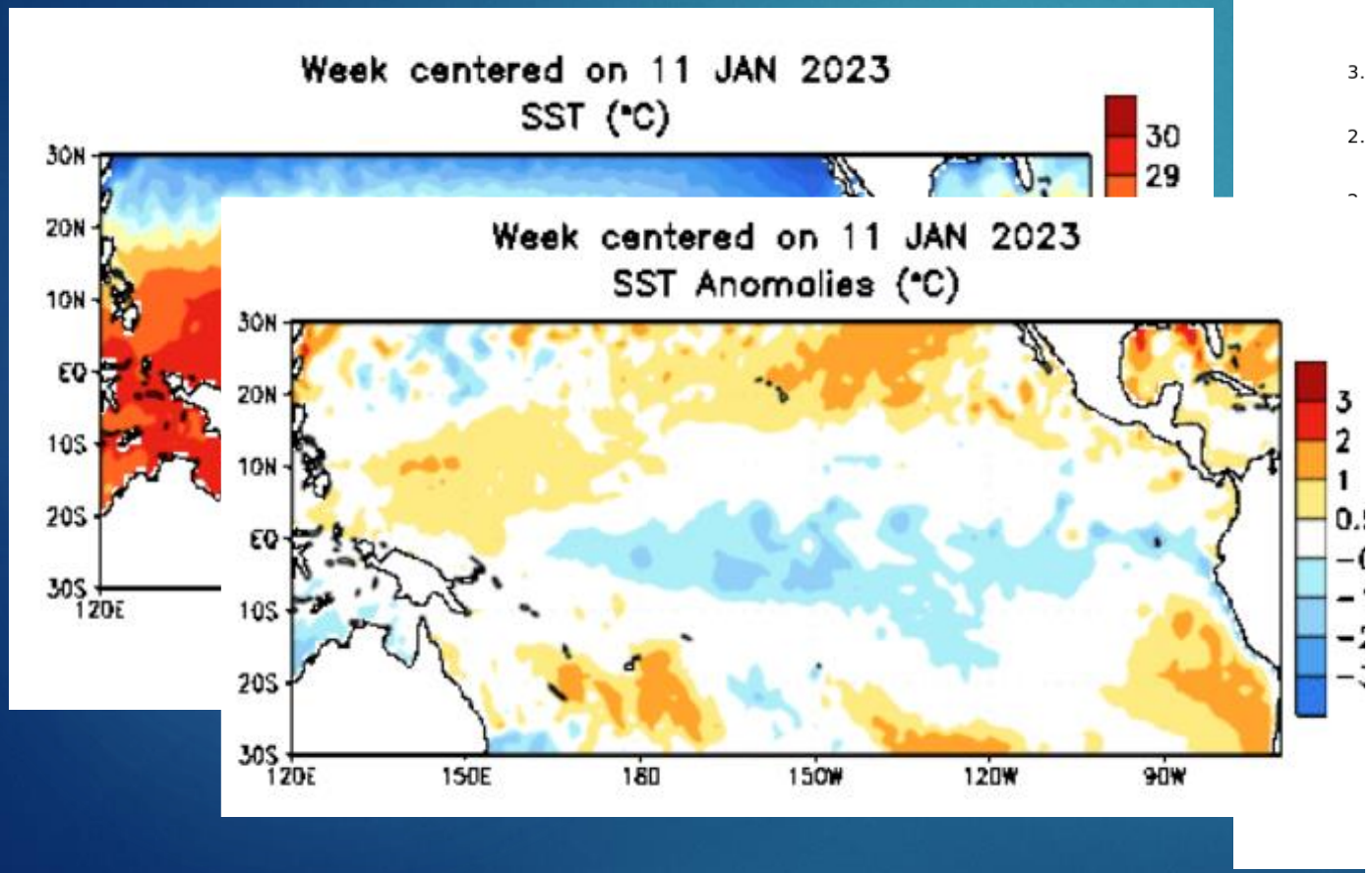
- Influences weather worldwide

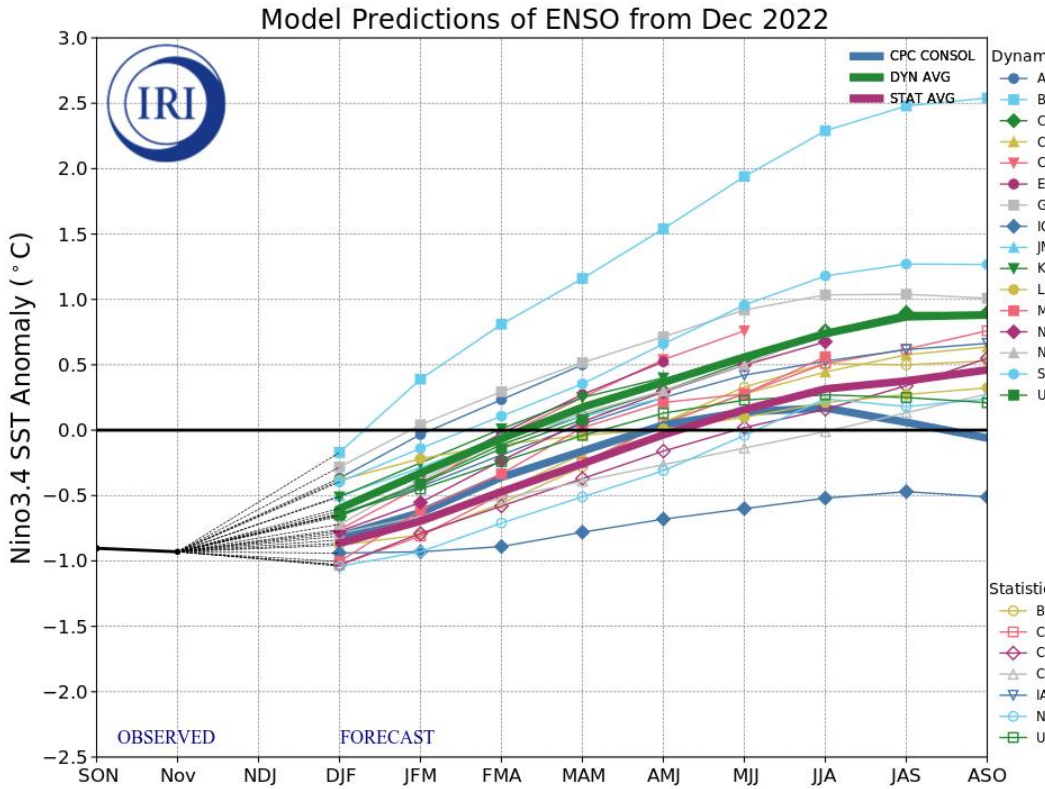




ENSO – Current State – Where are we going?

- January 2023 – La Niña “three-peat”

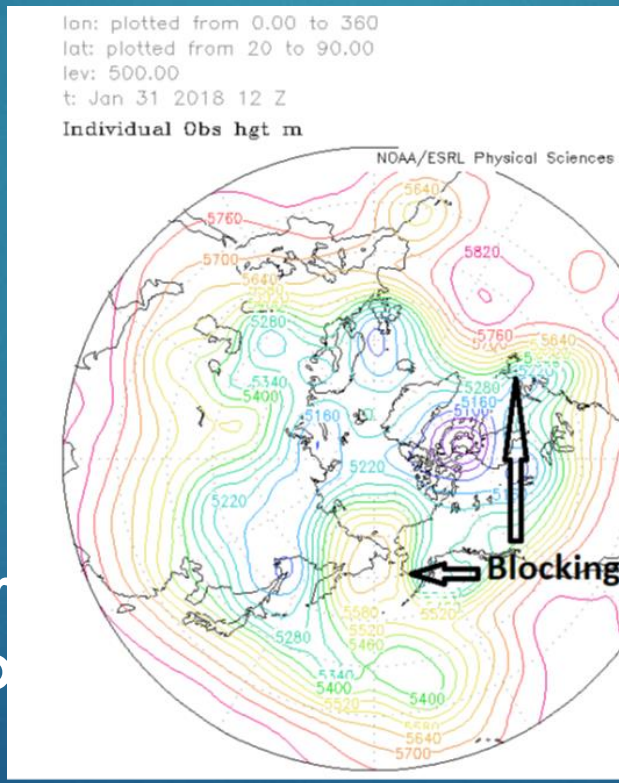


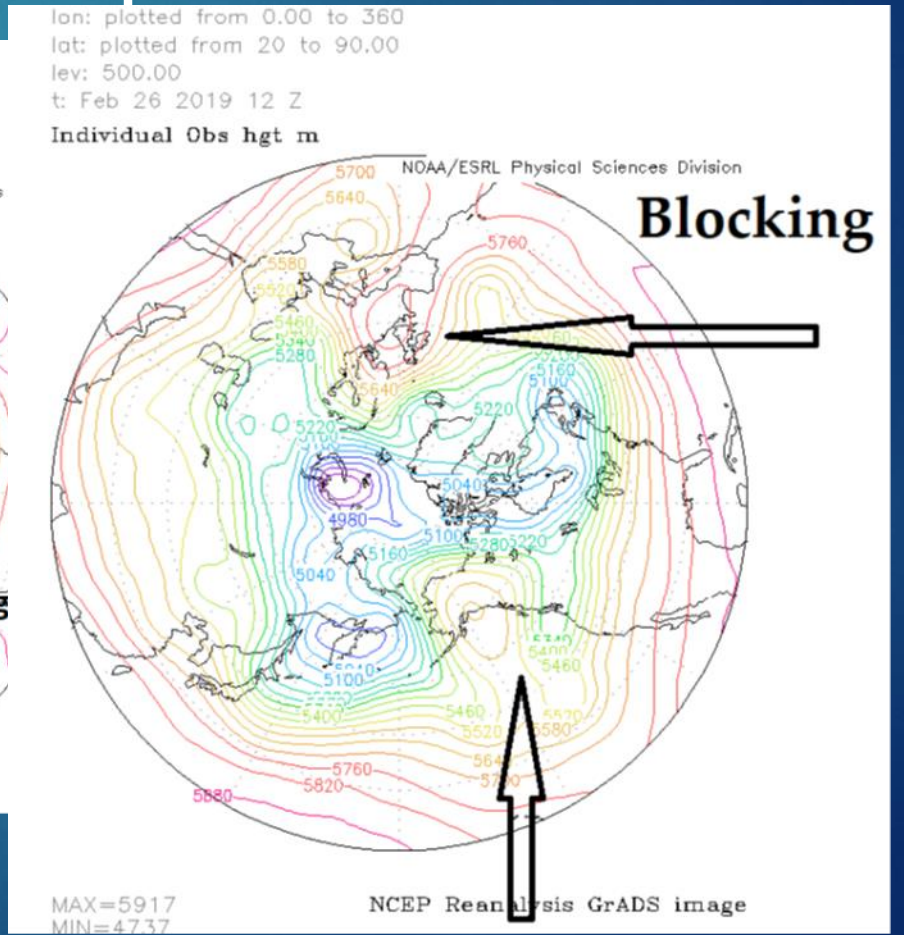


Atmospheric Blocking

- Atmospheric jet stream behavior is complicated

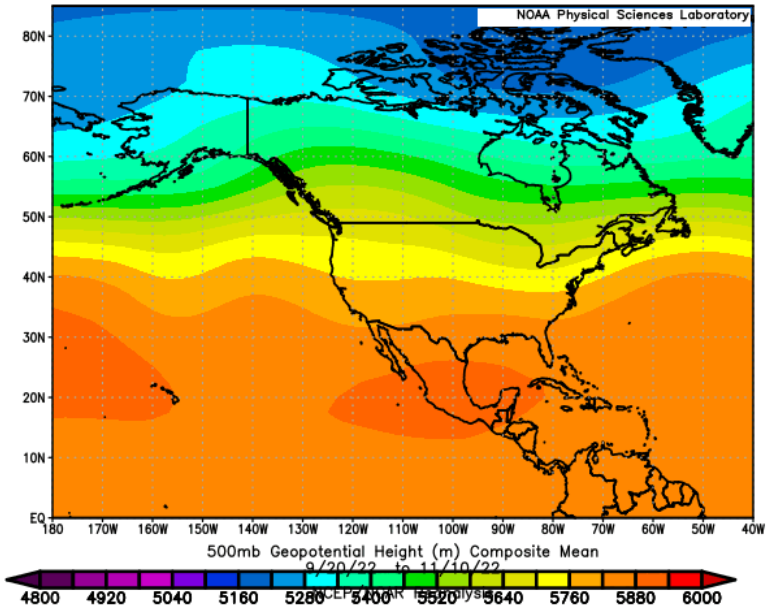
- Blocking - gener
  mid-latitude ano

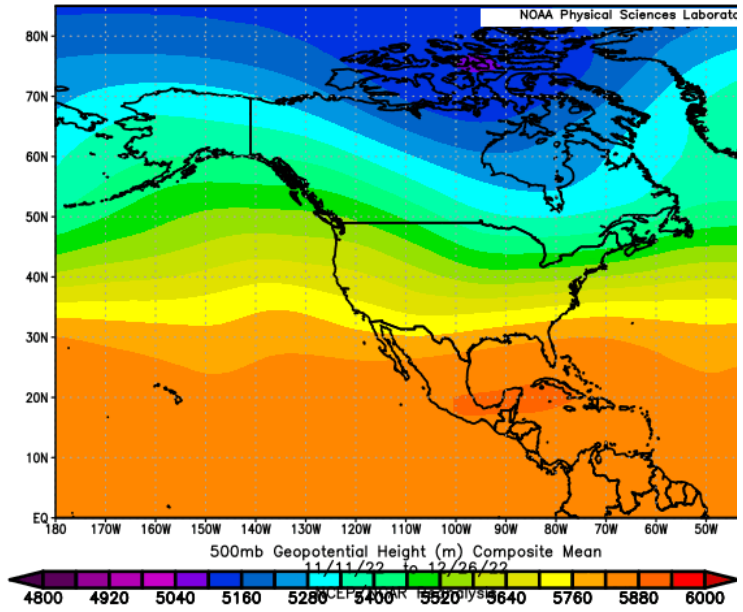


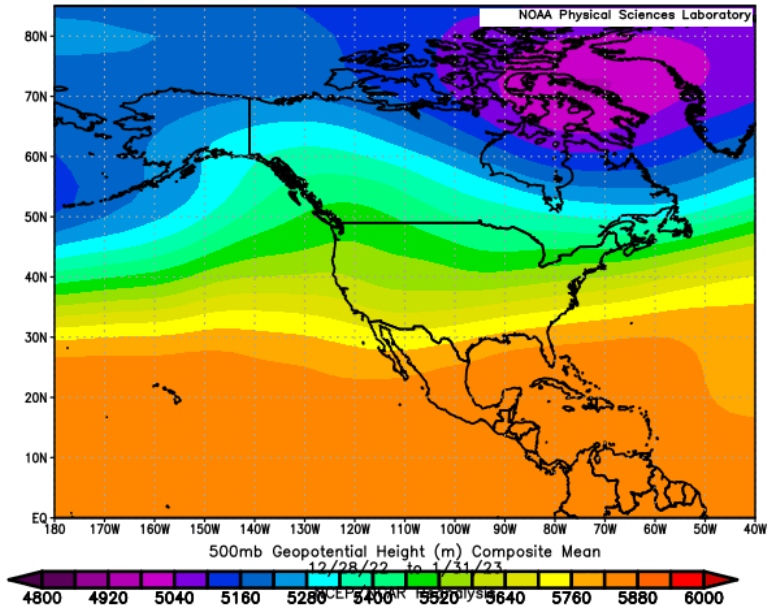


ATMOSPHERIC BLOCKING

- Fall 2022 versus Early Winter 2022 versus - early 2023
- +2.5 F -4.2 F +6.9 F

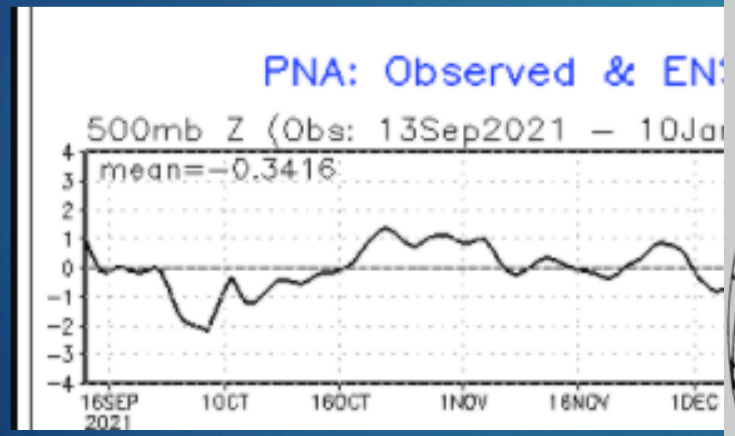


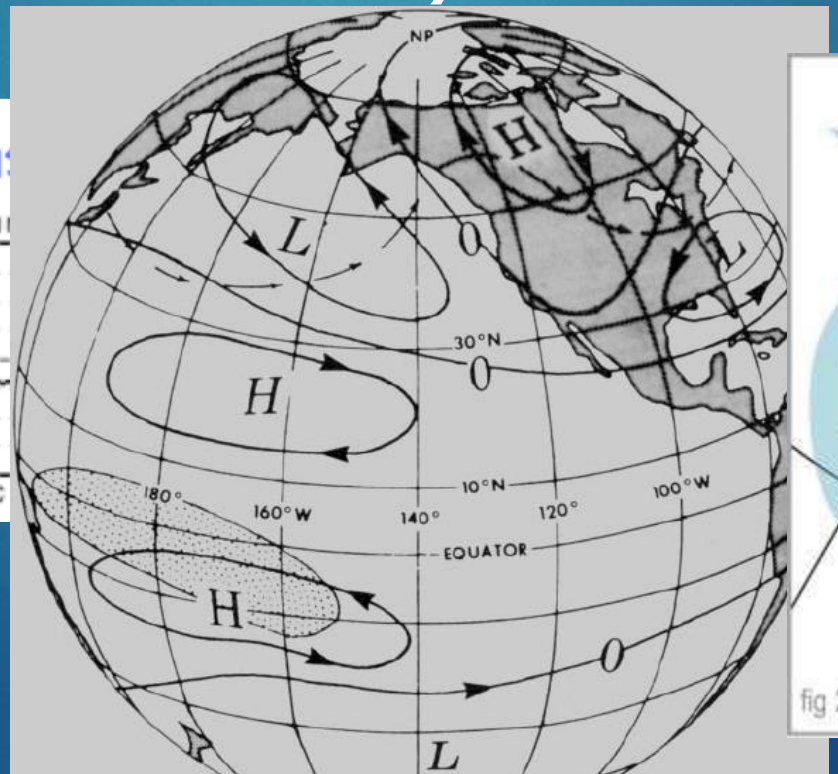


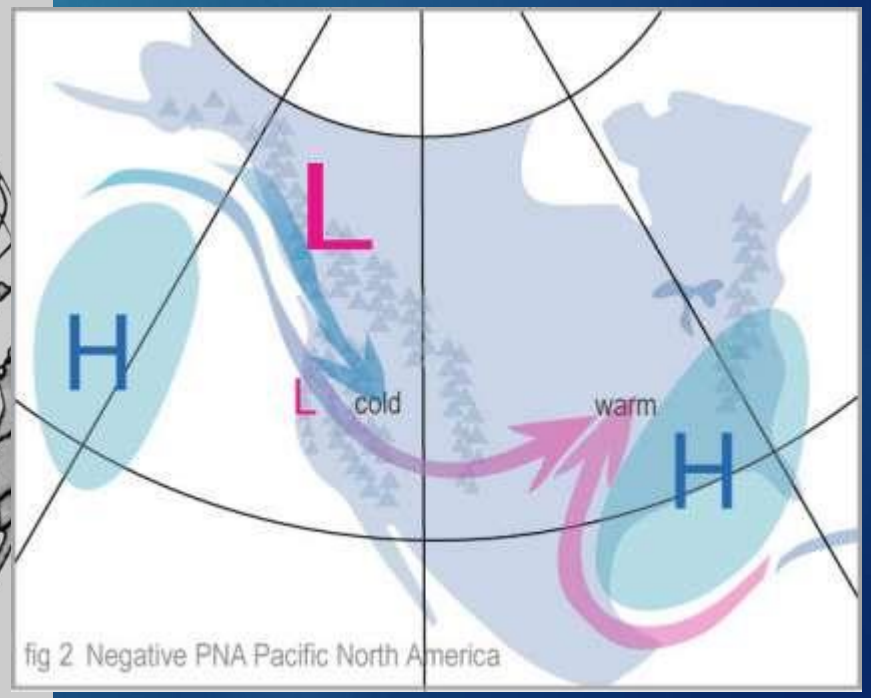


Teleconnections

- Teleconnections – are typical jet stream wave patterns that impact certain large-scale areas of the world (6,000 – 10,000 km, one to two weeks).

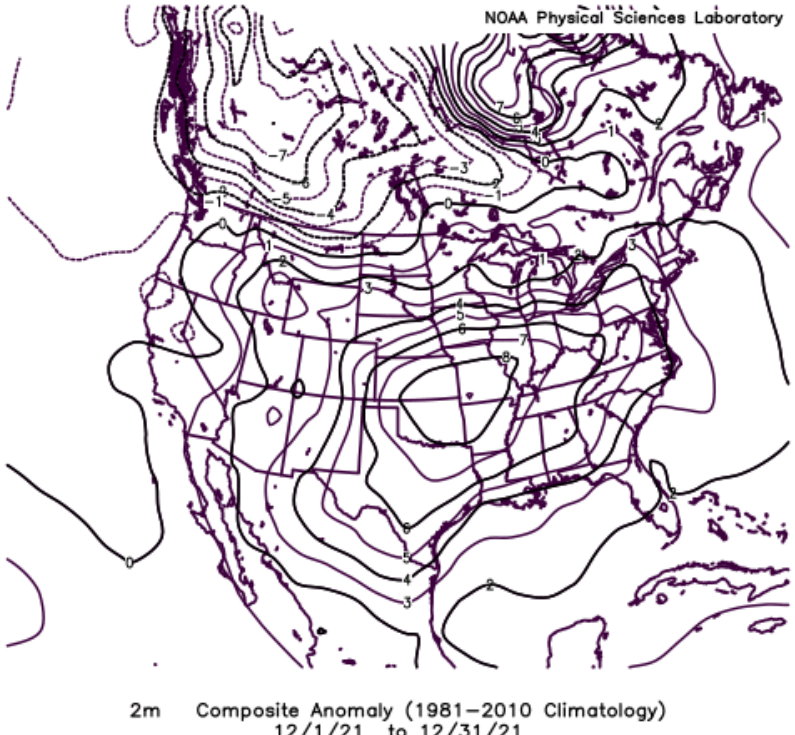


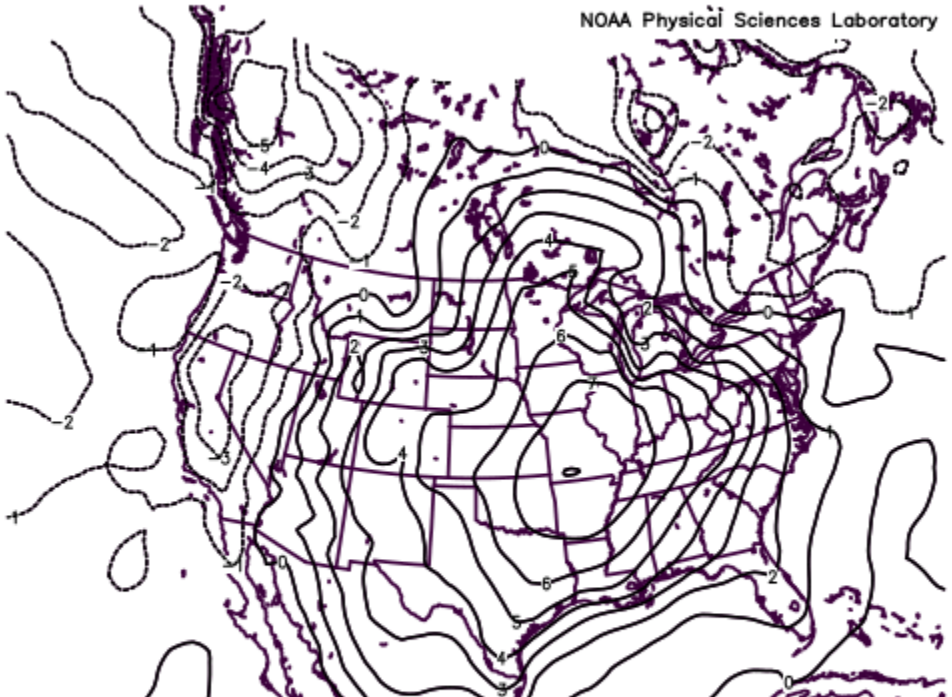




December 2021 versus 1889

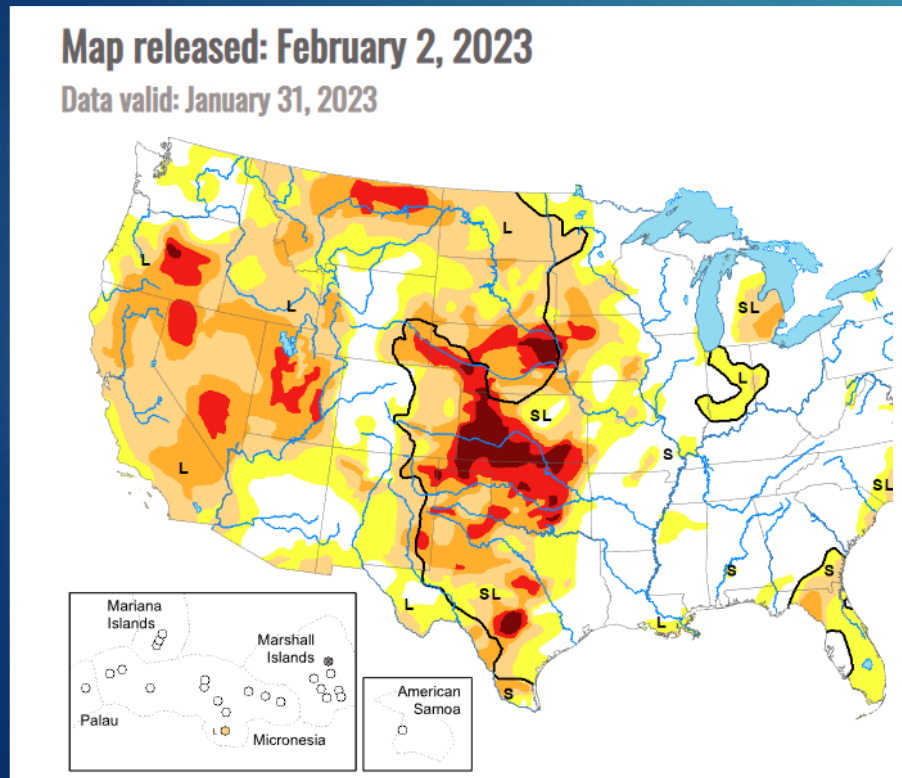
- December 2021 was anomalously warm – but we've seen it before.

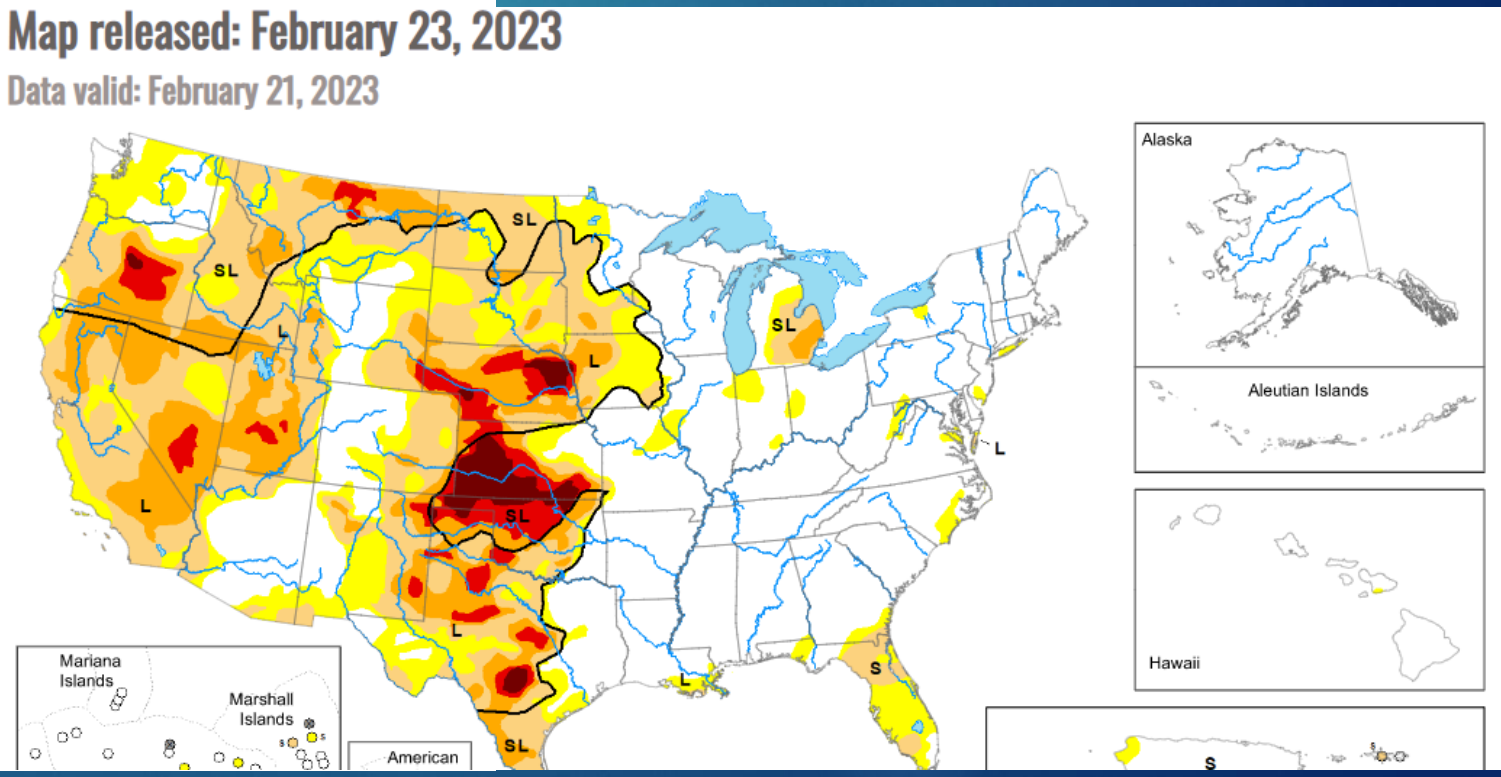




National Drought Monitor

- Current Drought Conditions – short-term big improvements!!





Our Forecast – Summer 2022 - Recap

- We're going to go with a repeat of 2021, toward the warm side but maybe not as strongly as last year. Temperature will be about +0.5 to +1.0 sigma above normal – which is about 1 – 2 F, with more humid conditions. We were +2.9 F above normal, we can legitimately give ourselves a point

- We're going to lean toward precipitation being above normal following last year. This is the closest analogue. (about +0.5 sigma to +1.0 sigma: about +2.6 inches to +5.2 inches), this is somewhat good news for agriculture, depending on how spring goes. The winter has been somewhat dry across MO.

Our Forecast – Summer 2022 - Recap

- The precipitation is well under normal (-4.96 inches). We shouldn't get a single point for this for forecasting above normal. Our total forecast got 1 of 4 points. NCEP and climatology get 0 out of 4. We were at least directionally good on temperature.

- Reasoning: We forecast La Niña to end even if there were hints of a La Niña three-peat.

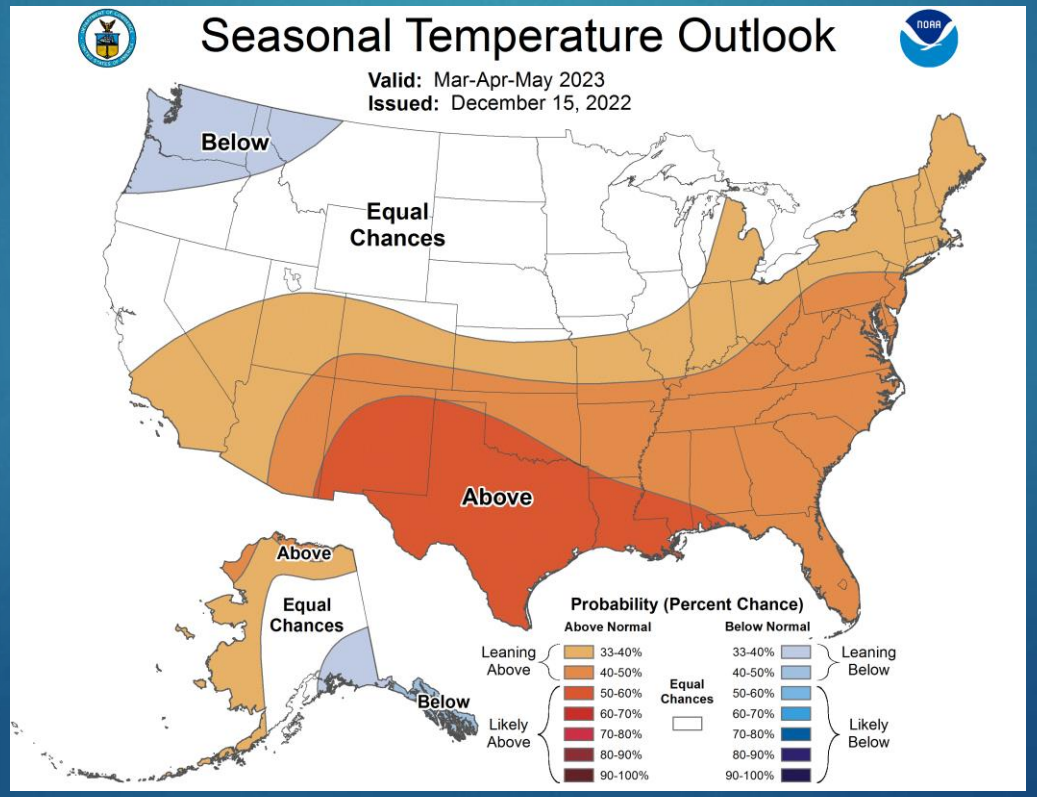
Our Forecast – Winter 2022 - 2023

- We're going to go with a repeat of 2021-2022, toward the warm side into the December period, then cooler and snowy on the back end. Temperature will be about 0.5-1.0 sigma above normal – which is about 1.5-3 F, with more humid conditions.
- Ended at +5.1 F. Direction good, not good enough +1

- We're going to lean toward precipitation being around normal following last year. This is the closest analogue. We'll also forecast snow to be around 15 inches this winter.
- Right now 5.02 inches – which is -0.73 inches. Perfect! +2 And 7.1 inches of snow – not easy to tell where we'll end up..

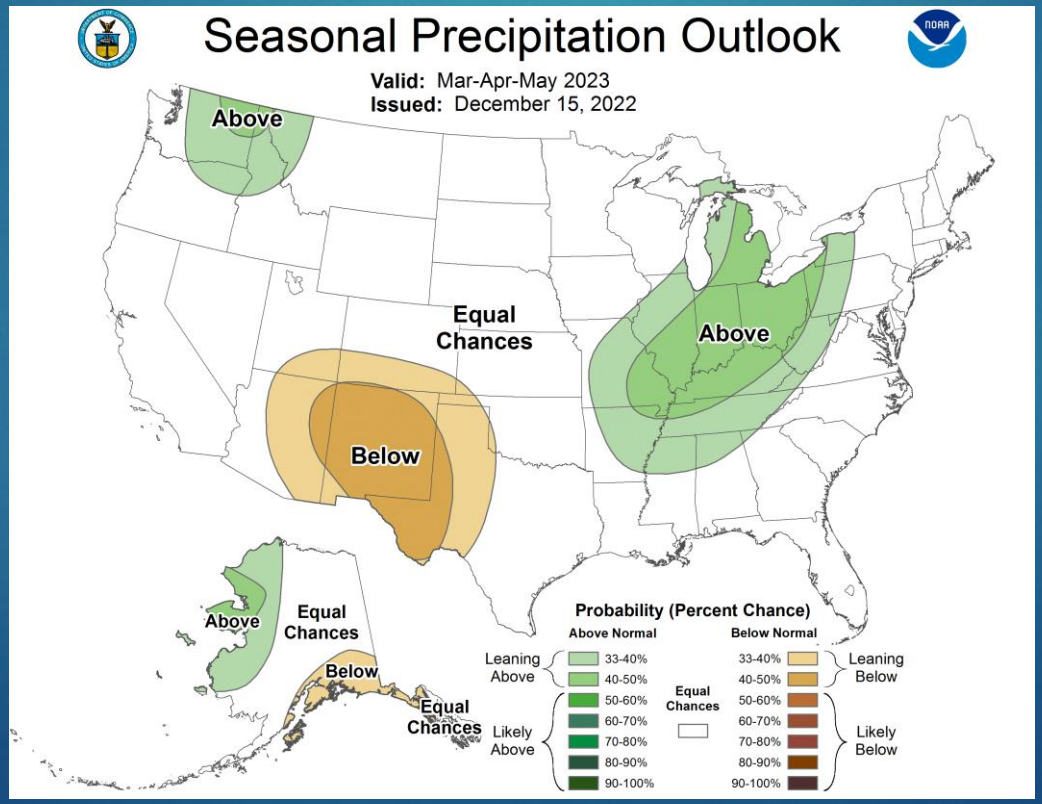
Spring 2023 – CPC outlooks

- Temperature – projections are for above average temperature across the southern and northeastern USA



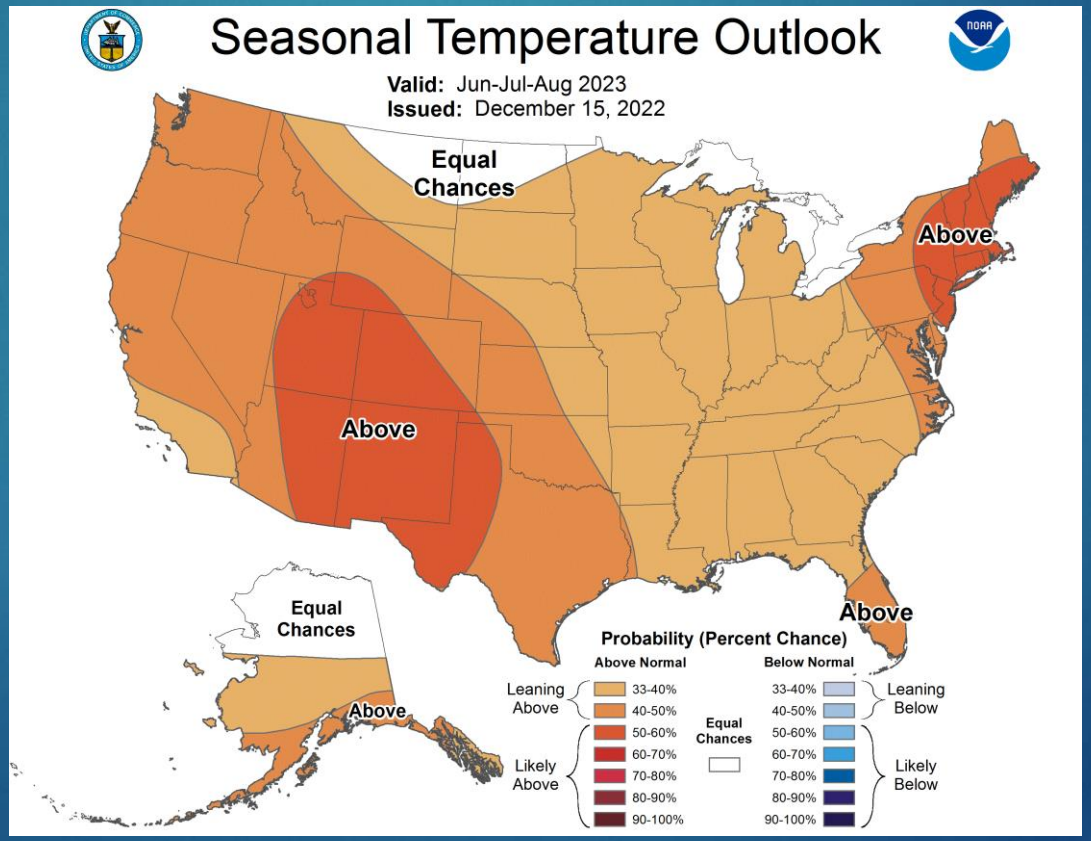
Spring 2023 – CPC Outlooks

- **Precipitation – look for drought to continue to improve? (so far so good….)**



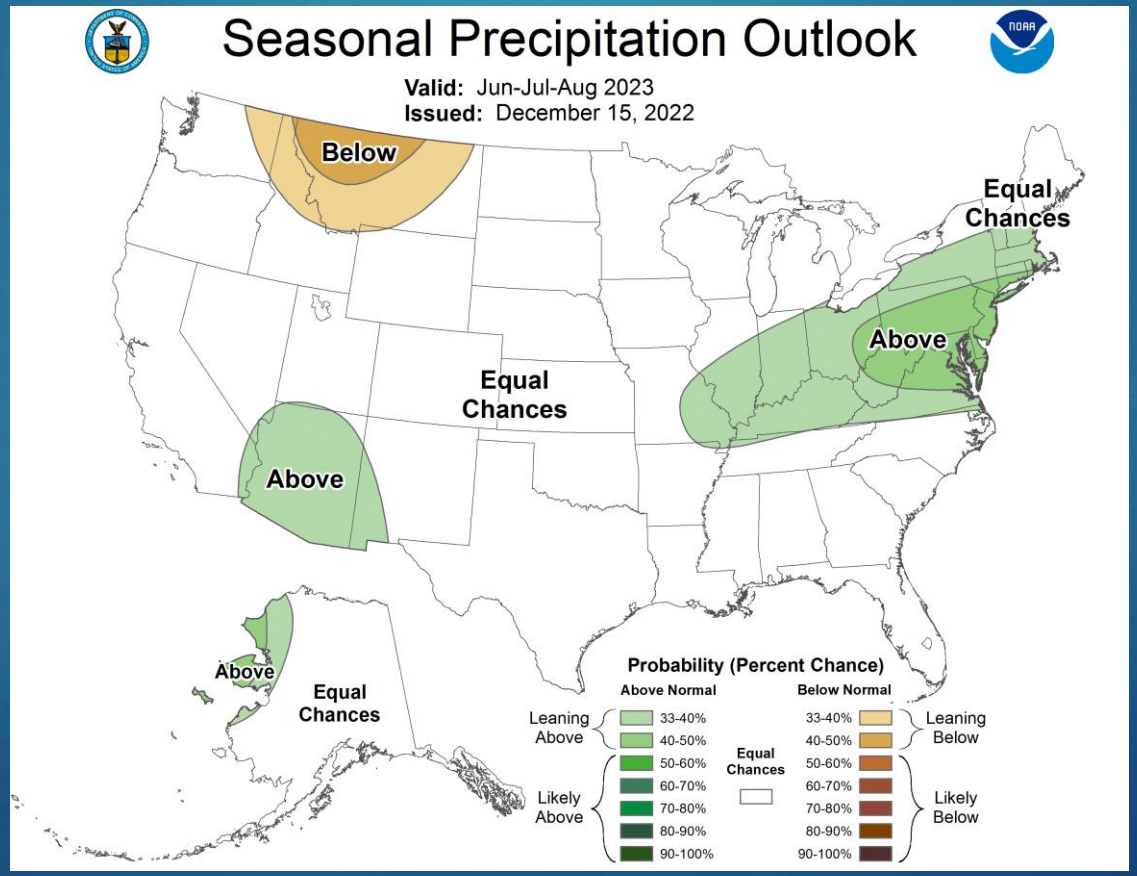
CPC Summer Outlook – 2023

- Temperature – the fourth straight year the forecast has look like this.



CPC Summer Outlook 2023

- **Precipitation – again consistent with dry conditions across the south, but wet in the Ohio valley?**



Summer 2023 Outlook

- CPC forecast is for a warm spring across the south and east coast and equal chances for the upper midwest. They are going for continued drought in the plains states but wet in the middle Mississippi and into the Ohio Valley. But, we're in a La Nina three-peat, and last year is looking like a good analog where MO is trapped between dry conditions west and wet conditions east.

- La Nina conditions were in place this time last year.

Summer 2023 Outlook

- A third factor has entered the fray – the Tonga – Hunga Volcano. This belched a lot of water vapor into the stratosphere. A greenhouse gas. See this link:

- https://scitechdaily.com/massive-tonga-volcano-eruption-blasted-enough-water-to-fill-58000-olympic-size-swimming-pools-into-stratosphere/?fbclid=IwAR2YO0fOm9fs-8tQNMQ_xQE-tmBwv4GgvpJyroGjWUAmBcKjuBMxtEli5GQ

Our Forecast – Summer 2023

- **Reasoning:**

- **We think that the La Nina three-peat means similar conditions in place to last year, that is a good start. Three straight La Nina years is very unusual. The best models project us to move out of La Nina conditions into warm neutral conditions. As we go into mid-January, there is some evidence that La Nina is on the way out. We can also compare to the La Nina repeat of 1998-1999 (summer 2000), and Summer of 1976 after the threepeat of the 1970s.**

Our Forecast – Summer 2023

- We can also look to Summer 2008, 2011, and 2018 recently.
- Of these five summers two were dry and two wet, one near normal. Three were cooler than normal while two were warmer than normal.
- We think temperature will be near normal to maybe a bit above normal (~ 1.0 F), while precipitation will also be close to normal to above normal (up to +2.0 inches).

Community Collaborative Rain, Hail, and Snow Network

- Please consider joining CoCoRaHS. This data is used by agencies to decide crop loss information. It's worth it to you to join Missouri CoCoRaHS. (State Climatologist Patrick Guinan). MO has been a CoCoRaHS state since 2006.

- http://cocorahs.org

- Email: lupoa@missouri.edu

Missouri Climate Center

- Missouri Climate Center
- http://climate.missouri.e

Climate Change

- **U.S Global Change Research Program:** http://www.globalchange.gov/
- **2018 National Climate Assessment:** https://nca2018.globalchange.gov/
- **2014 National Climate Assessment:** http://nca2014.globalchange.gov/
- **National Oceanic and Atmospheric Administration (NOAA):** http://www.noaa.gov/climate
- **NOAA Climate Portal:** https://www.climate.gov
- **NOAA U.S. Climate Resilience Toolkit:** https://toolkit.climate.gov
- **Midwestern Regional Climate Center﷯s Climate Trends Tool:** http://mrcc.isws.illinois.edu/mw_climate/climateTrends.jsp
- **USDA Midwest Regional Climate Hub:** https://www.climatehubs.oce.usda.gov/hubs/midwest
- **National Centers for Environmental Information State Climate Summaries:** https://statesummaries.ncics.org
- **NASA Global Climate Change:** http://climate.nasa.gov/
- **US EPA Climate Change:** https://19january2017snapshot.epa.gov/climate-impacts/climate-change-impacts-state_.html
- **Real Climate:** http://www.realclimate.org/
- **Climate Science Centers:** http://www.doi.gov/csc/index.cfm