

Very Early Weather Outlook – Winter 2022- 2023

ANTHONY R. LUPO

ATMOSPHERIC SCIENCE

SCHOOL OF NATURAL RESOURCES

MISSOURI CLIMATE CENTER

UNIVERSITY OF MISSOURI

Introduction

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



- ▶ 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.

Sixth Assessment Report: 2022

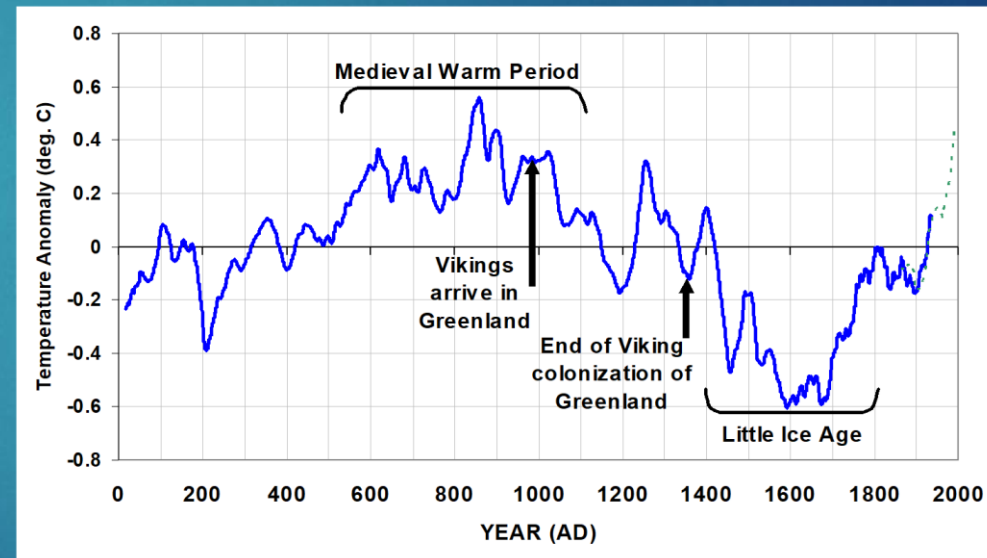
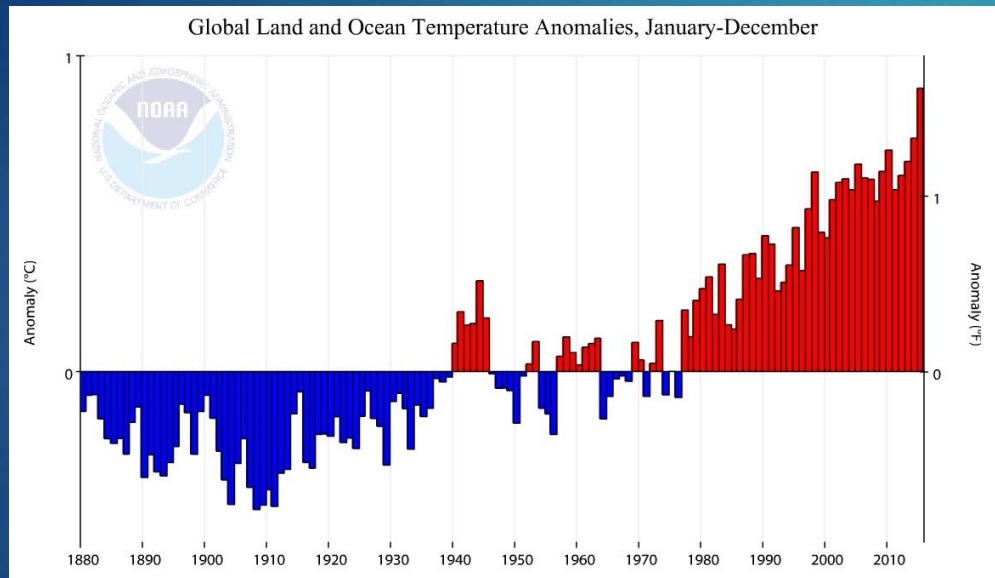
Synthesis Report

AR6 Synthesis Report: Climate
Change 2022

September 2022

Introduction

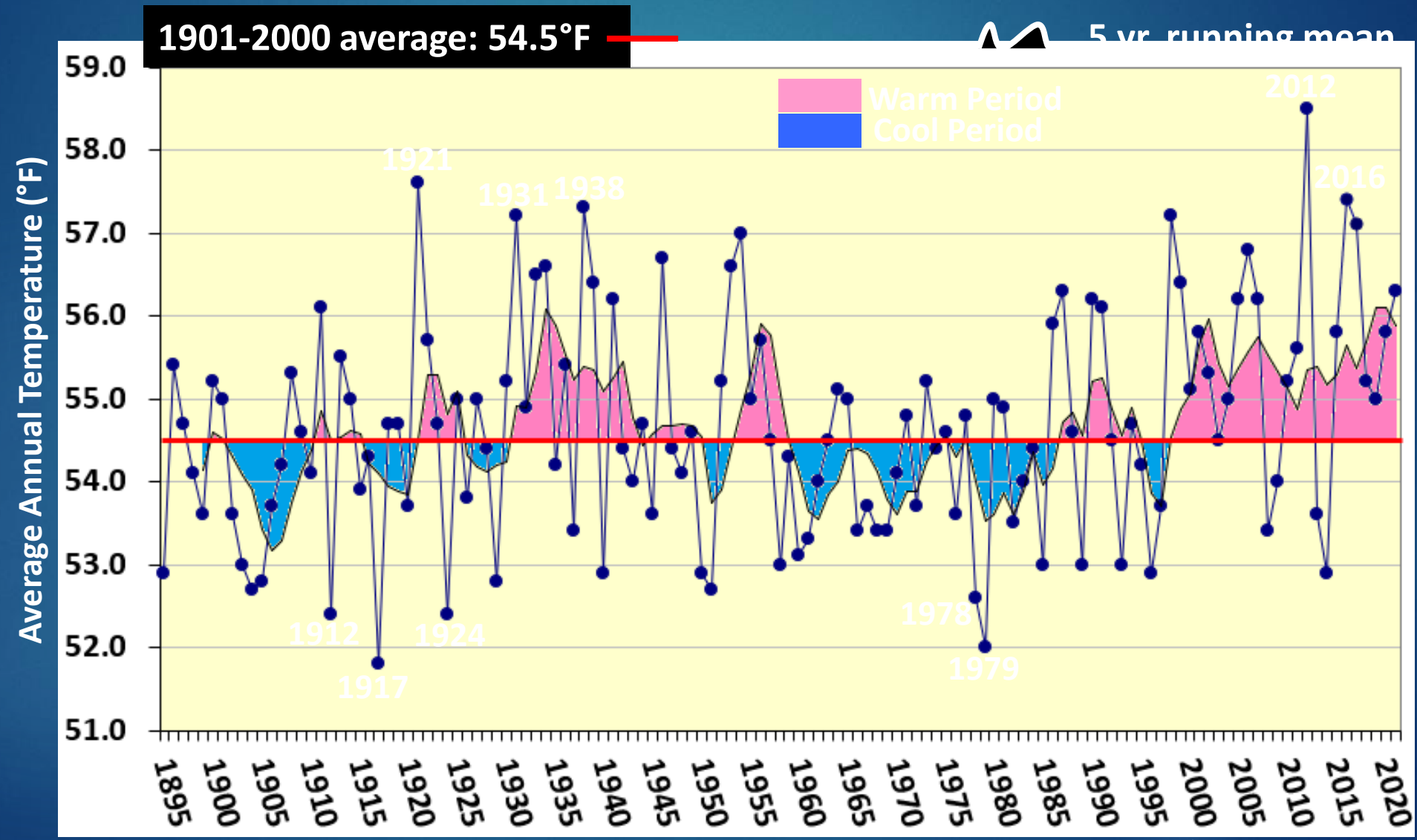
- Most acknowledge some role for humans – although many believe that humans are the sole cause of current climate change.



- 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.

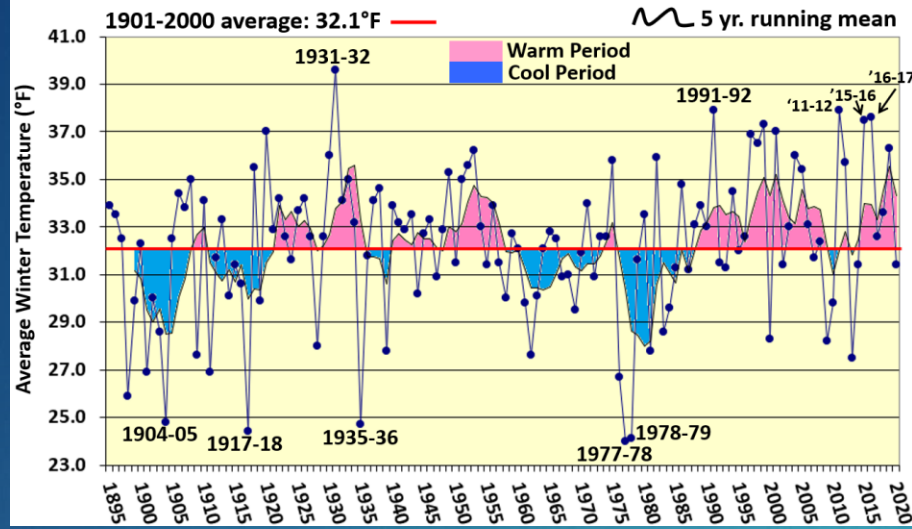
Missouri Average Annual Temperature (1895-2021)



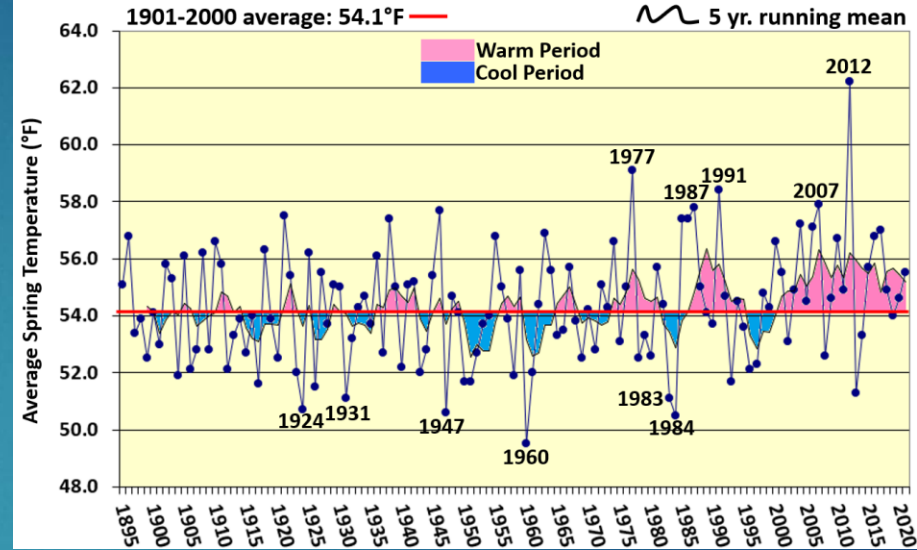
Missouri's strongest seasonal warming has been occurring in winter & spring.

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

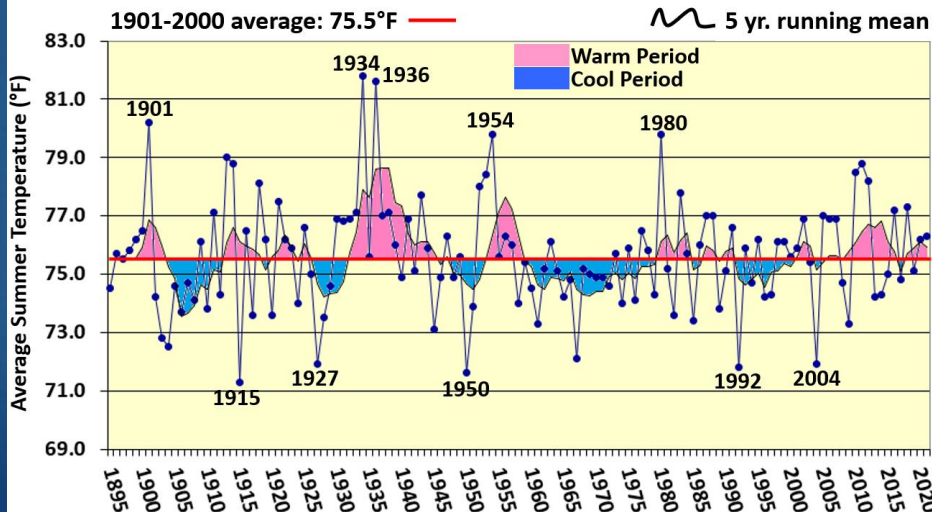
*The winter of 2021 is defined as Dec 2020 and Jan, Feb 2021



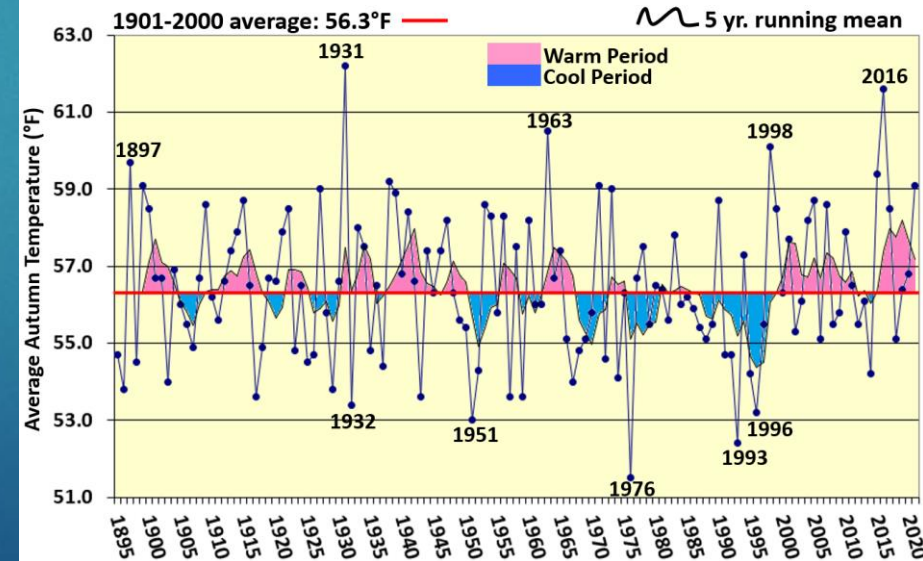
Missouri Average Spring Temperature (Mar-Apr-May, 1895-2021)



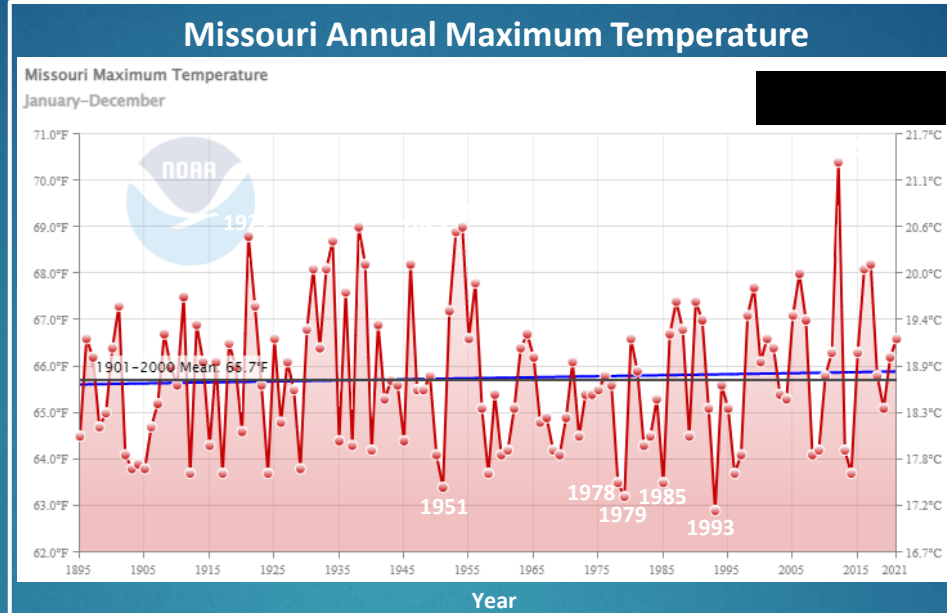
Missouri Average Summer Temperature (Jun-Jul-Aug, 1895-2021)



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

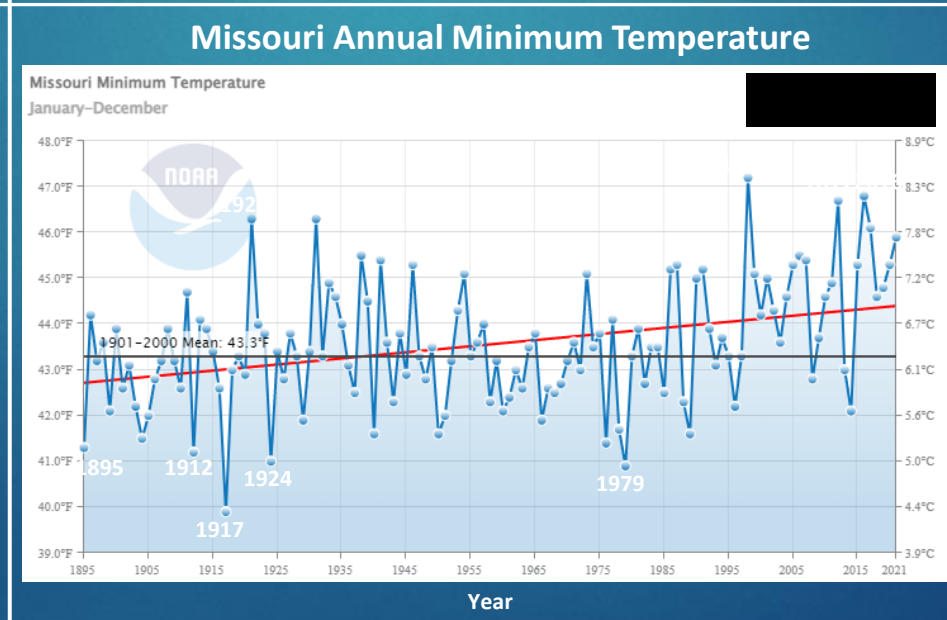


Missouri maximum and minimum annual temperature trends have been warming
but the rate of warming has been faster with minimum temperature.



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%.



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%.

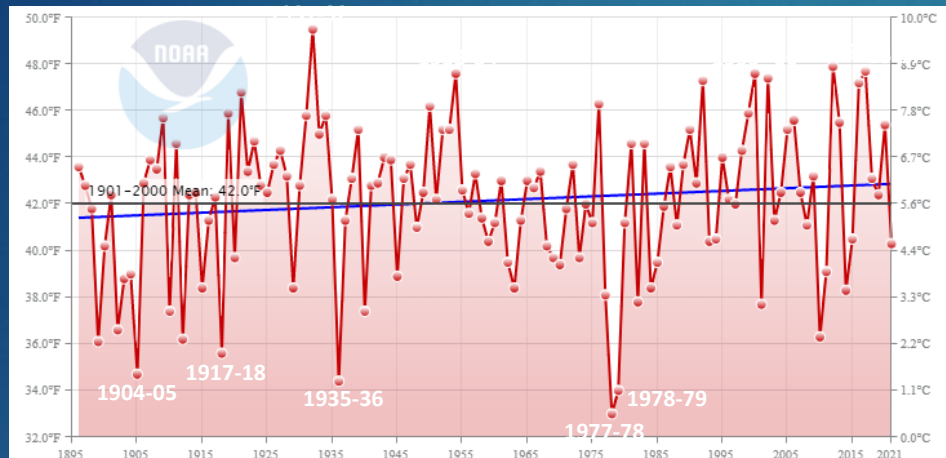
Missouri's strongest maximum temp warming has been occurring in winter & spring.

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

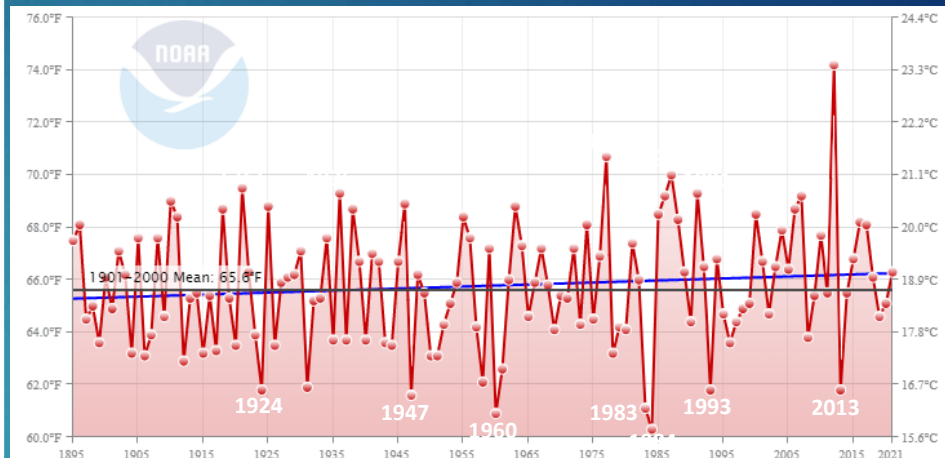
1895-2021 Trend
(+1.2°F/Century)



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

1901-2000 mean: 65.6°F

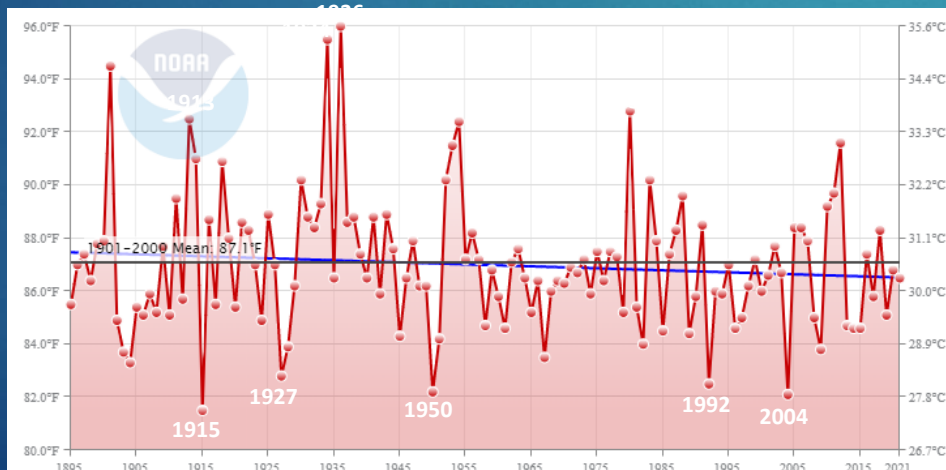
1895-2021 Trend
(+0.8°F/Century)



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

1901-2000 mean: 87.1°F

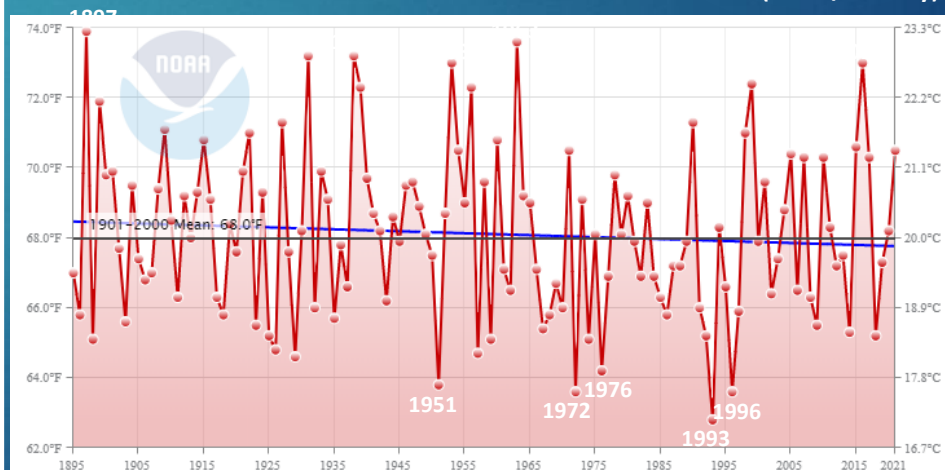
1895-2021 Trend
(-0.8°F/Century)



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

1901-2000 mean: 68.0°F

1895-2021 Trend
(-0.6°F/Century)



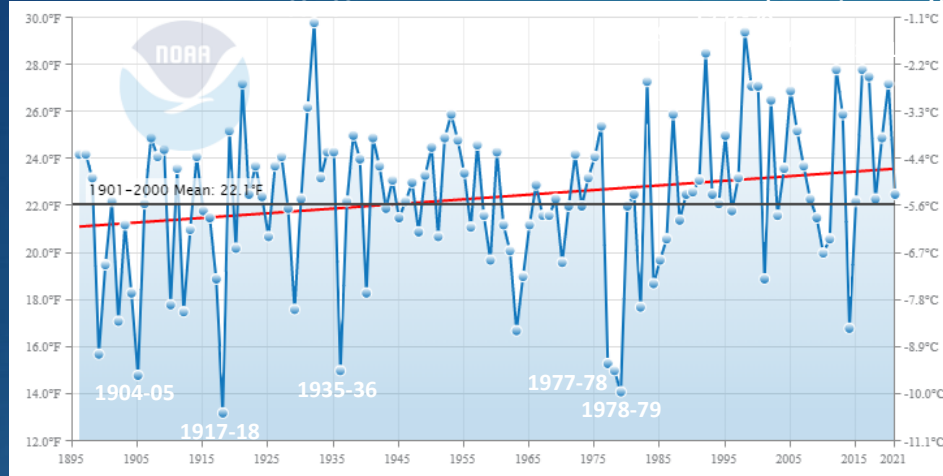
Missouri minimum temperature trends have been warming all four seasons.

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 —

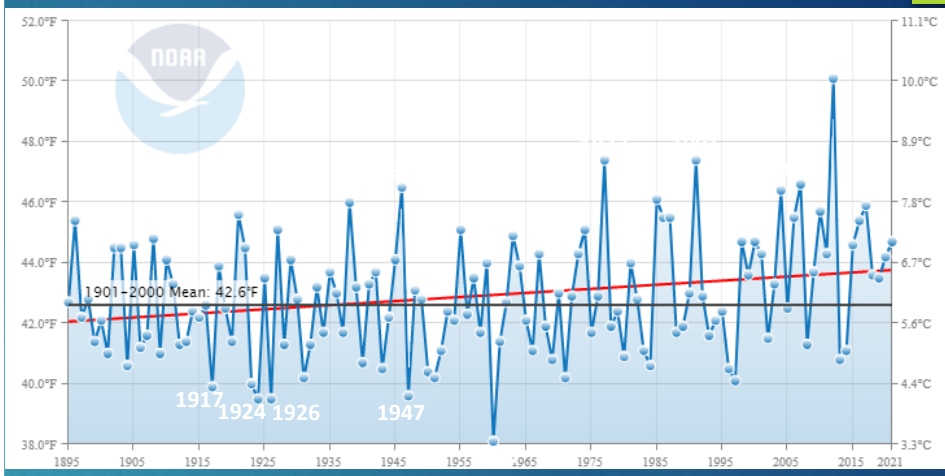
1896-2021 Trend
(+2.0°F/Century)



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

1901-2000 mean: 42.6°F —

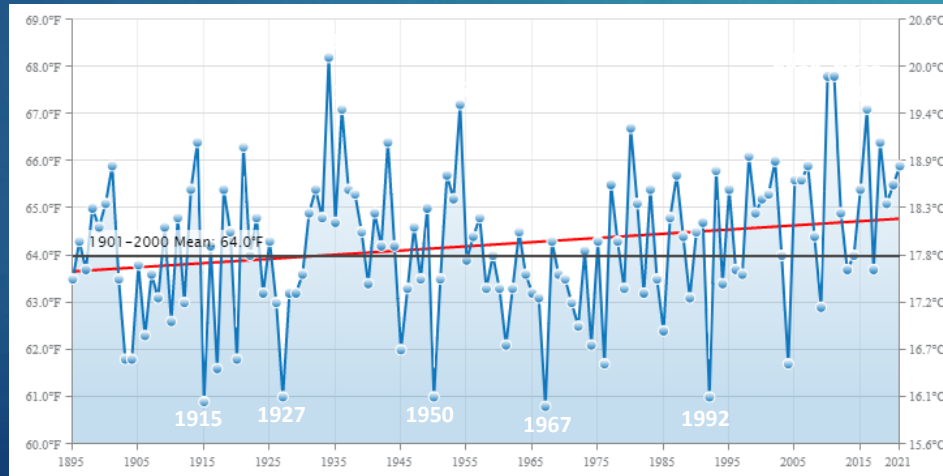
1895-2021 Trend
(+1.4°F/Century)



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

1901-2000 mean: 64.0°F —

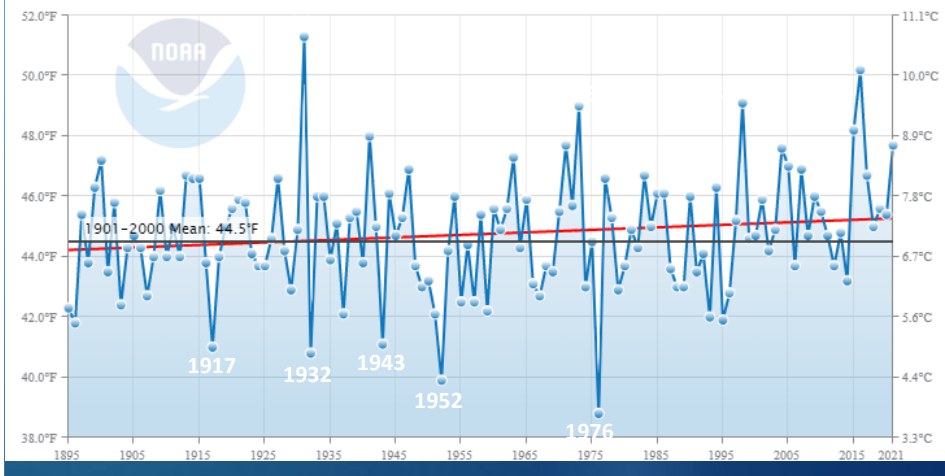
1895-2021 Trend
(+0.9°F/Century)



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

1901-2000 mean: 44.5°F —

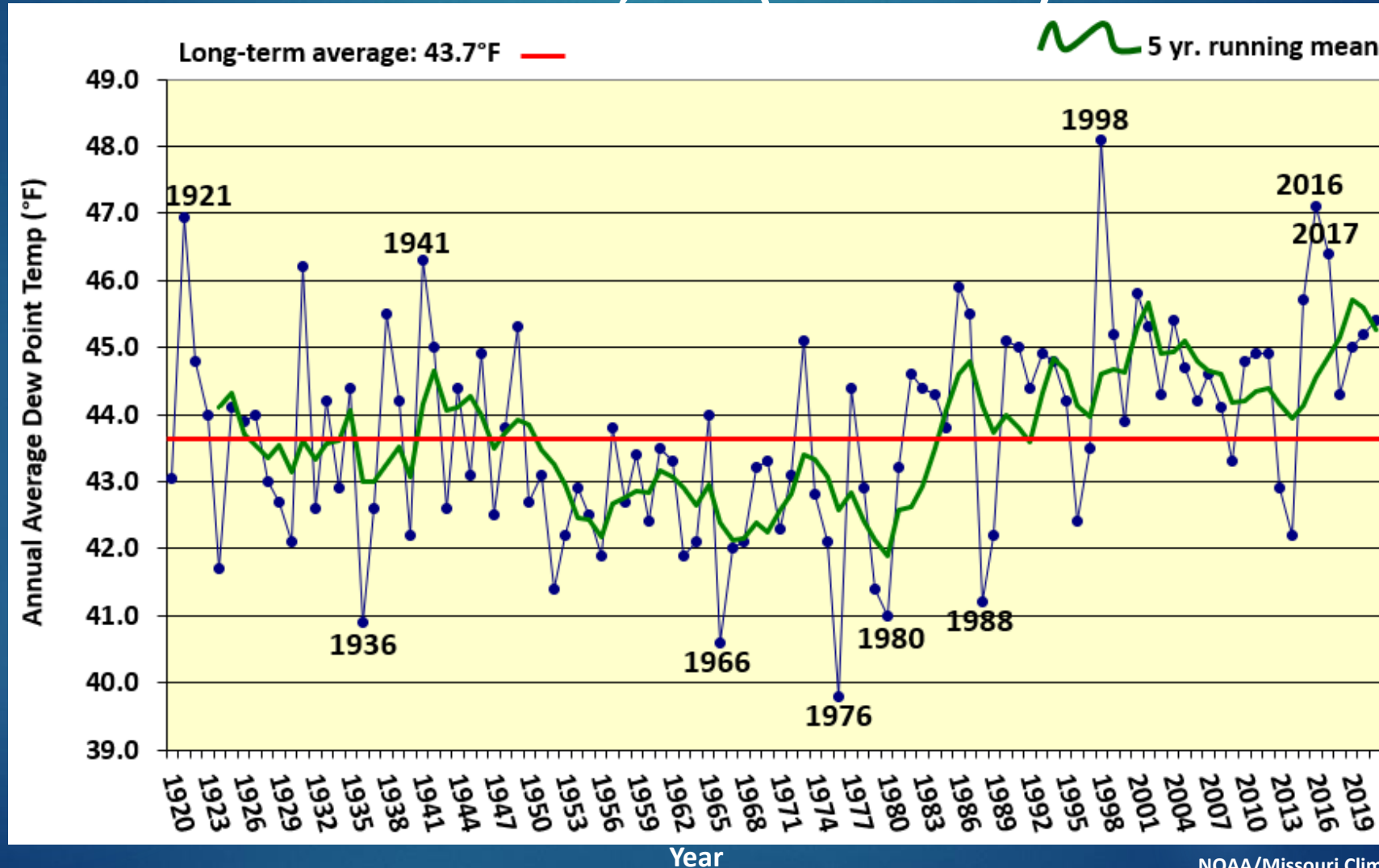
1895-2021 Trend
(+0.8°F/Century)



What are the climatic impacts of wetter precipitation trends?

-More humid environment.

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

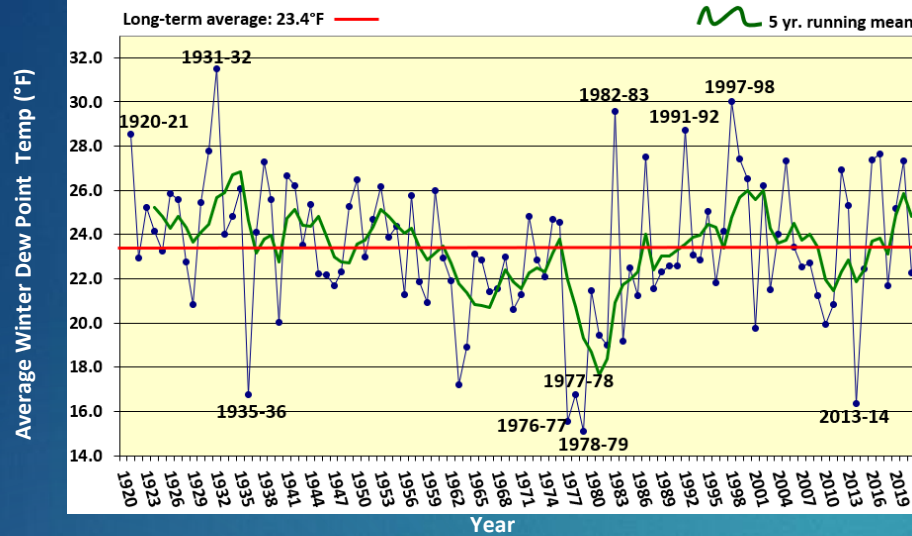


What are the climatic impacts of wetter precipitation trends?

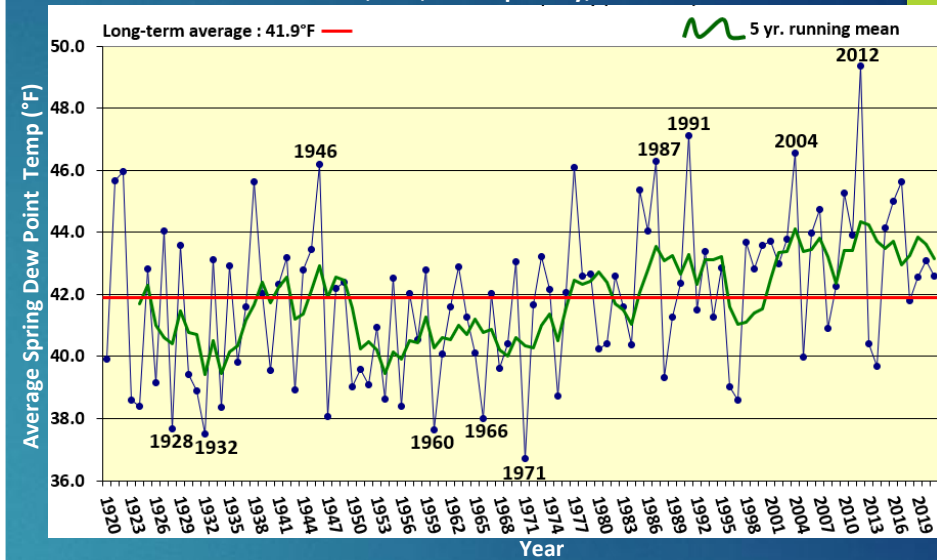
-More humid environment, especially during the warm season.

Average Winter Dew Point Temperature (°F)
Columbia, MO, Dec-Jan-Feb, 1920-2021*

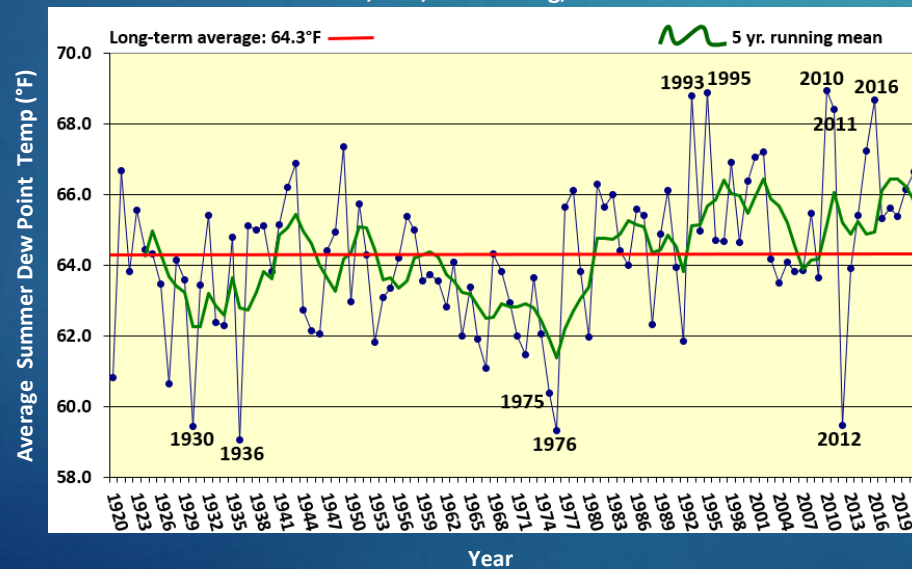
*The winter of 2021 is defined as Dec 2020 and Jan, Feb 2021



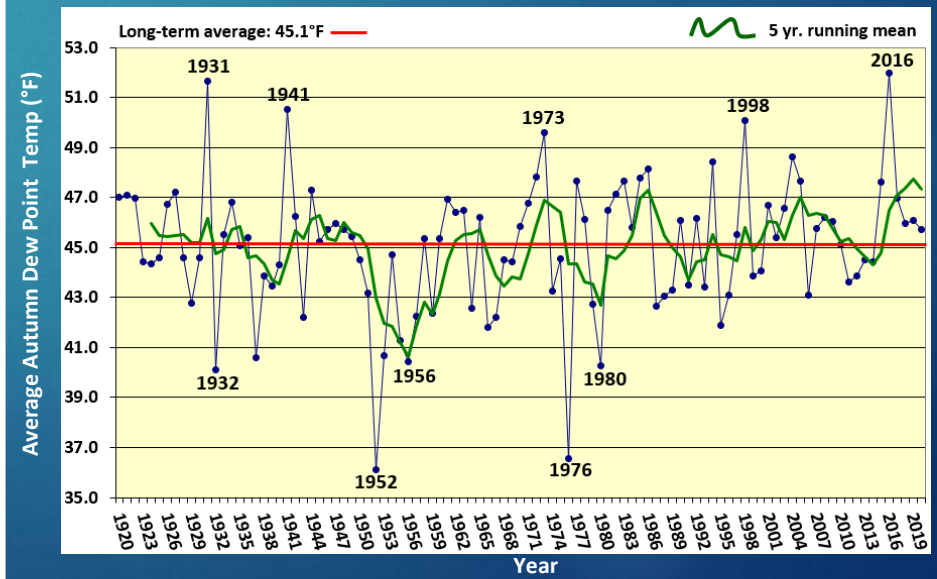
Average Spring Dew Point Temperature (°F)
Columbia, MO, Mar-Apr-May, 1920-2021



Average Summer Dew Point Temperature (°F)
Columbia, MO, Jun-Jul-Aug, 1920-2021

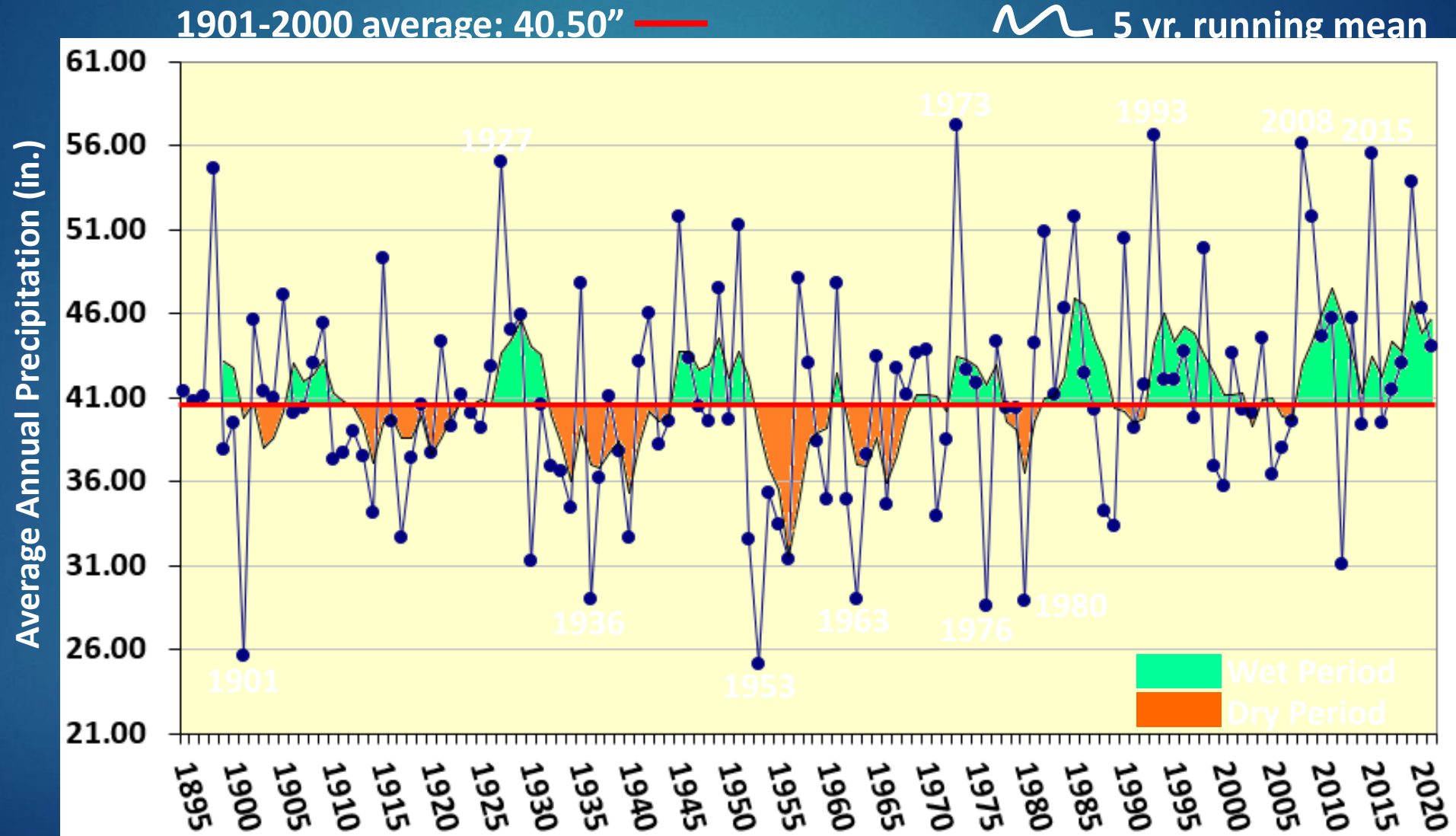


Average Autumn Dew Point Temperature (°F)
Columbia, MO, Sep-Oct-Nov, 1920-2021



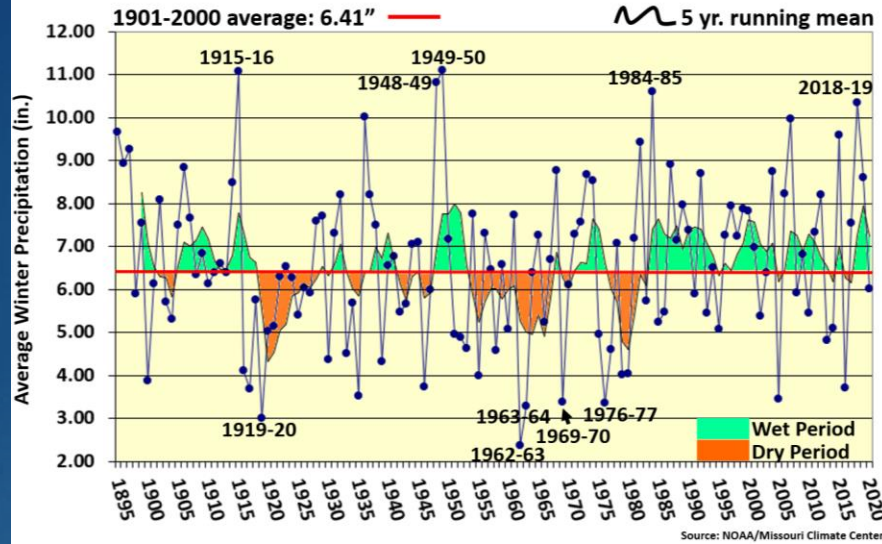
Missouri is experiencing an unprecedented wet period.

Missouri Average Annual Precipitation (1895-2021)

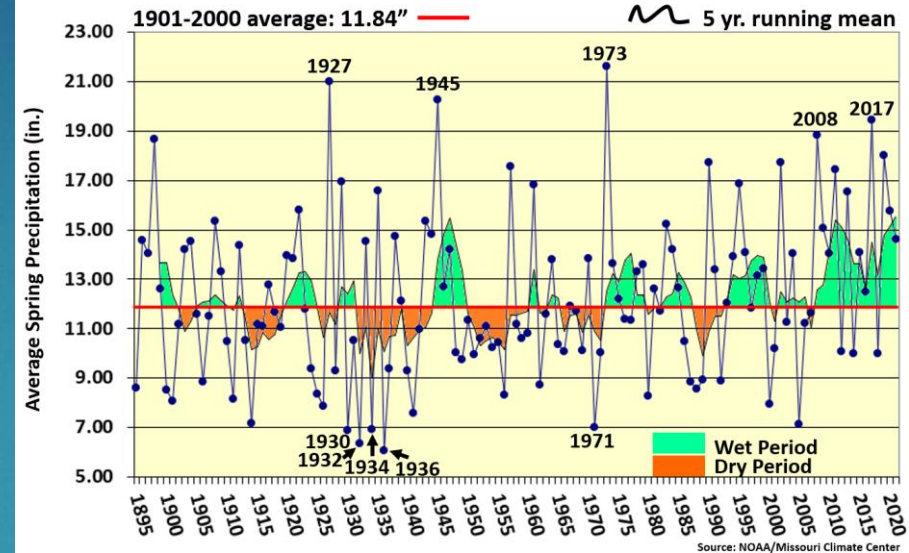


Missouri Average Winter Precipitation (Dec-Jan-Feb, 1895-2021*)

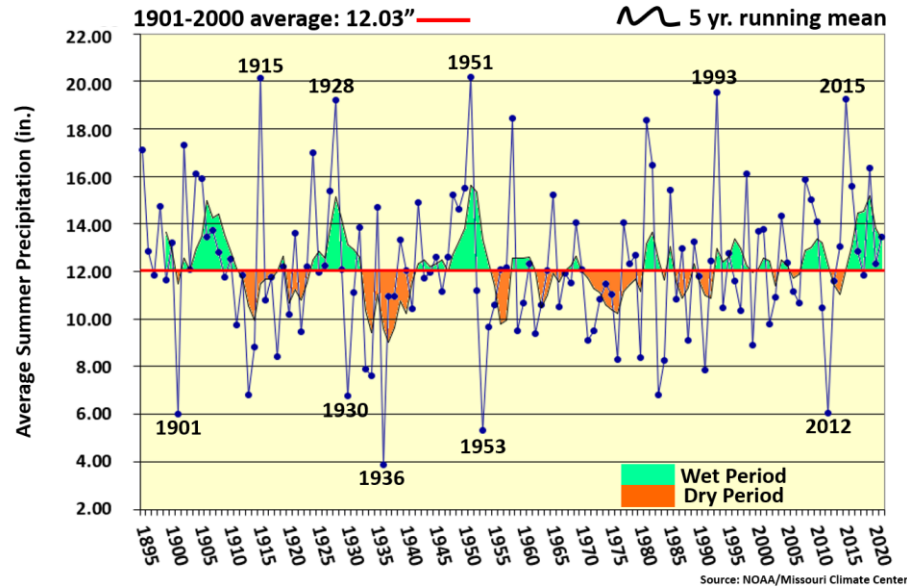
*The winter of 2021 is defined as Dec 2020 and Jan, Feb 2021



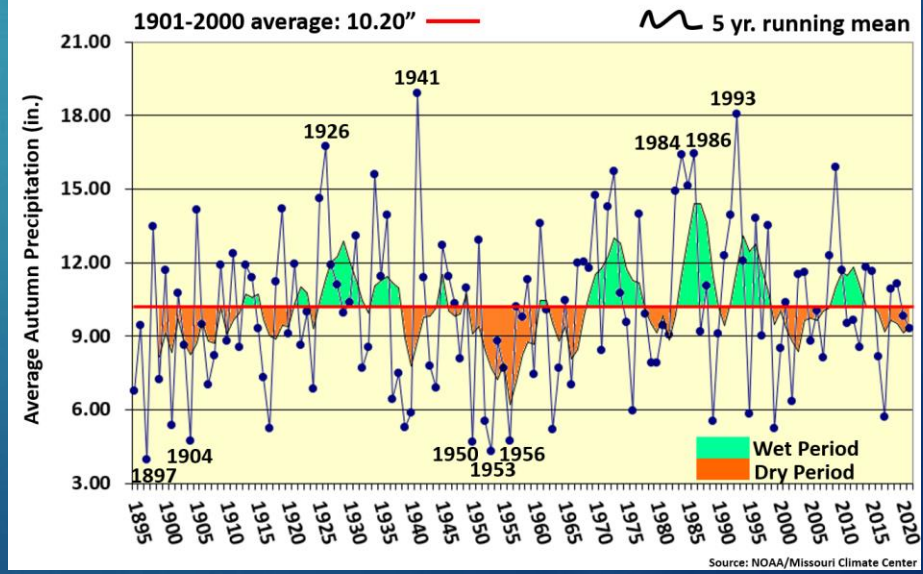
Missouri Average Spring Precipitation (Mar-Apr-May, 1895-2021)



Missouri Average Summer Precipitation (Jun-Jul-Aug, 1895-2021)



Missouri Average Autumn Precipitation (Sep-Oct-Nov, 1895-2021)



What are the climatic impacts of wetter precipitation trends?

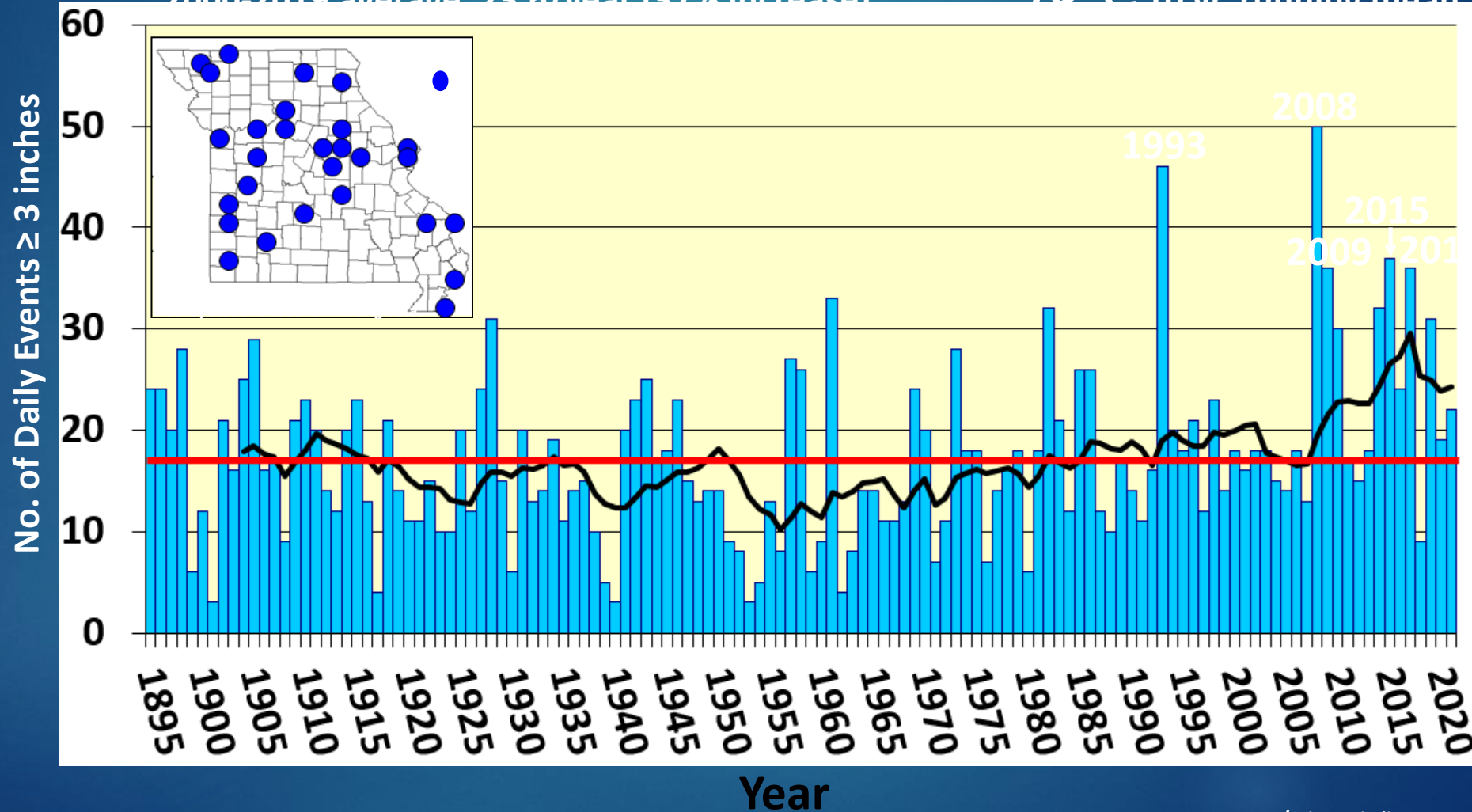
-More extreme precipitation events, more flooding.

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)

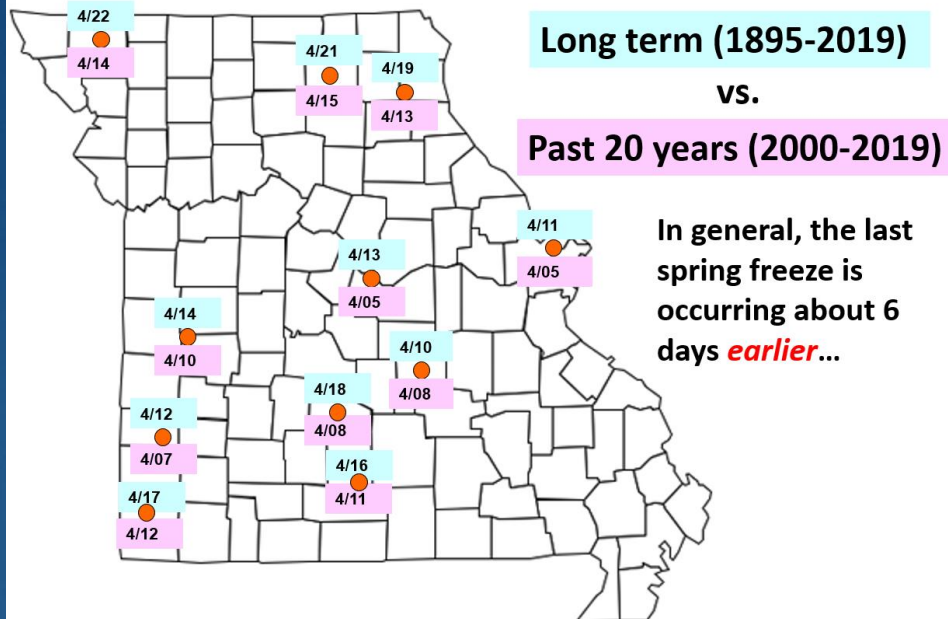
10-yr running mean



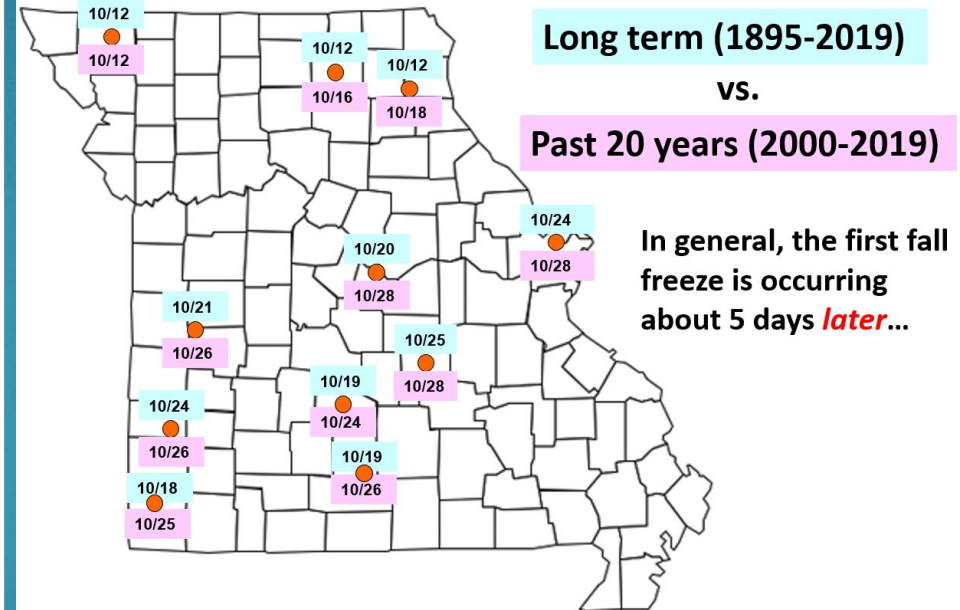
What are the climatic impacts from warmer spring and fall minimum temperatures?

-Longer growing season.

Median Date of Last Spring Frost ($\leq 32^{\circ}\text{F}$)



Median Date of First Fall Frost ($\leq 32^{\circ}\text{F}$)

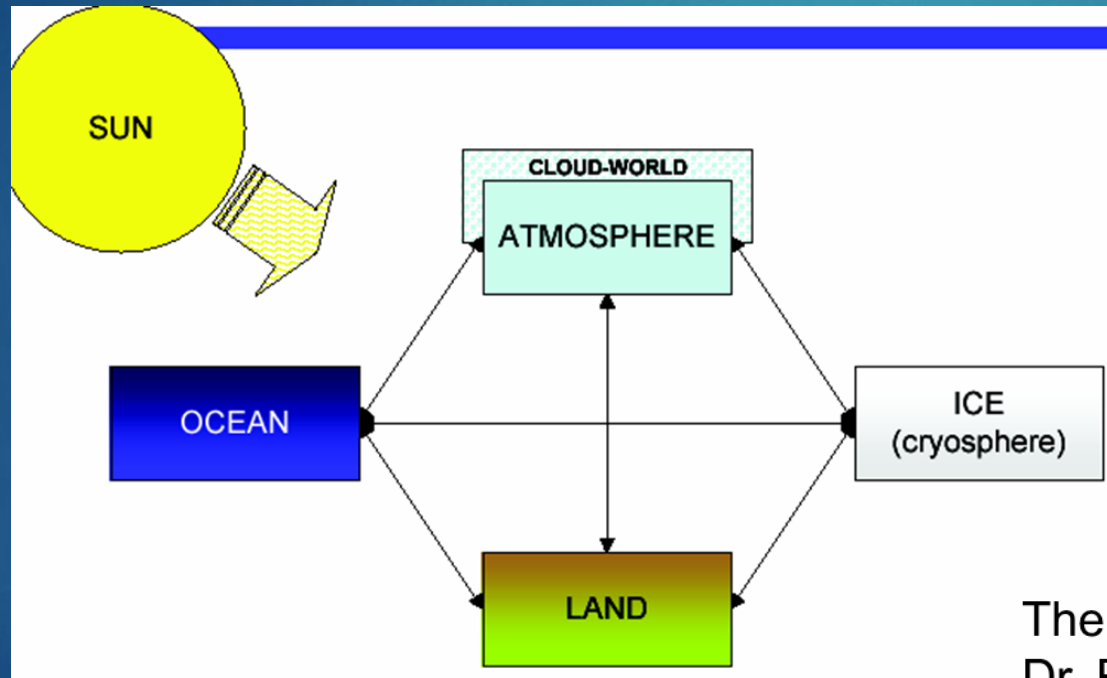


Definitions

- ▶ 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:

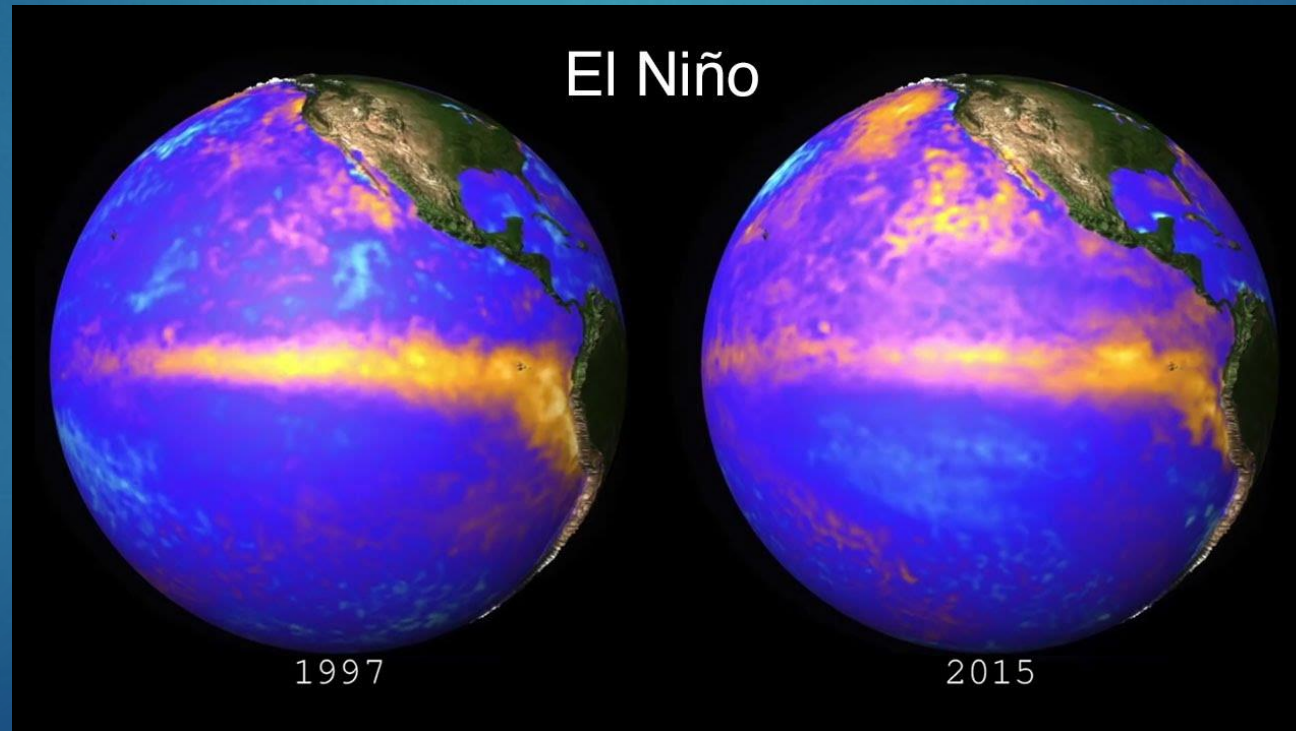
- Cryosphere (Glaciers, Antarctica)
- Oceans (and freshwater too)
- Lithosphere (dirt, continents)
- Biosphere (life → Plants and Animals)

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

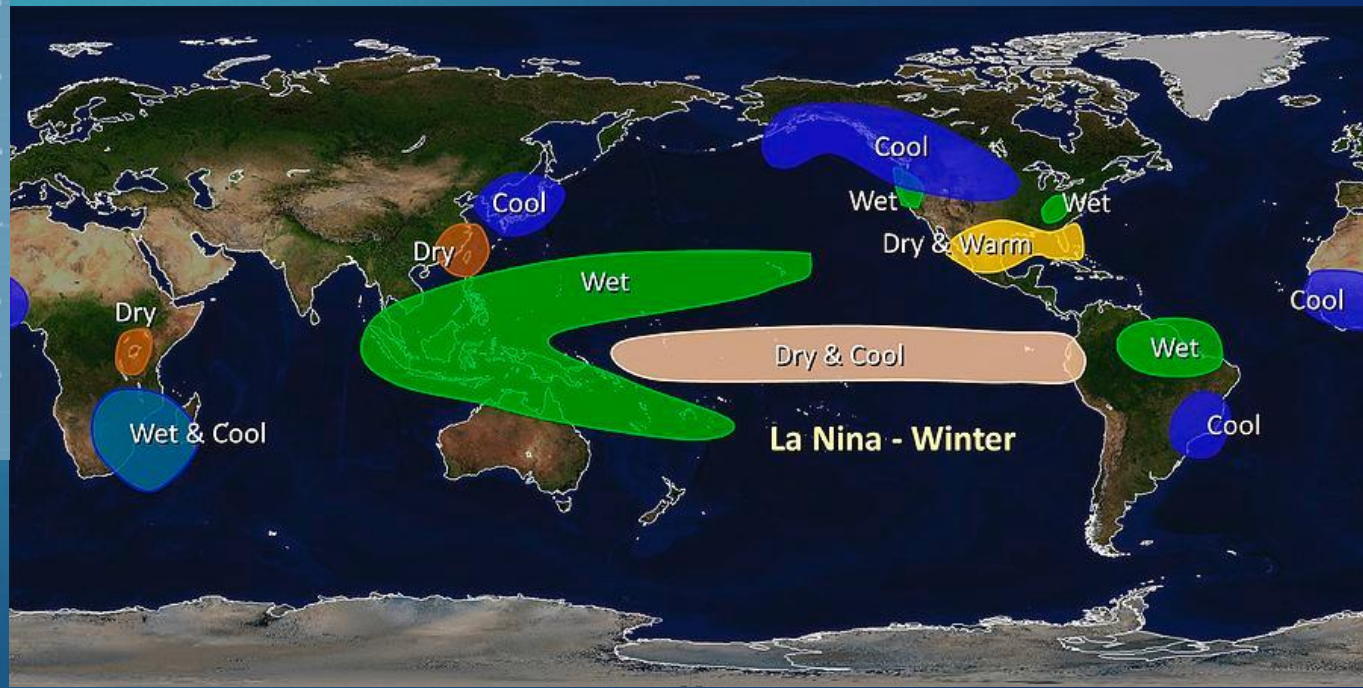
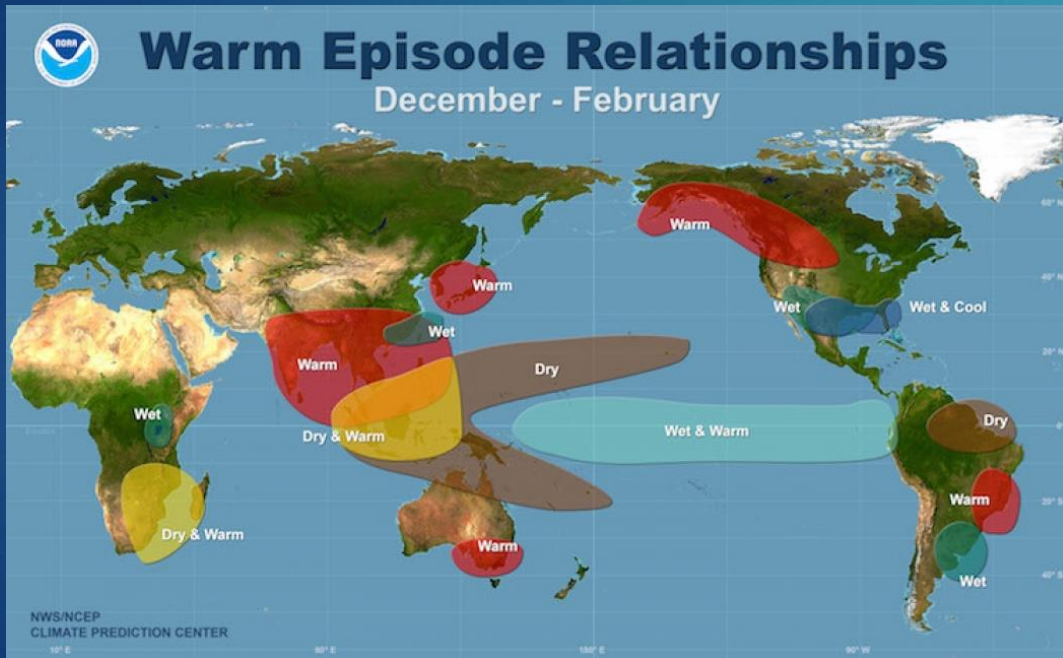
El Niño and Southern Oscillation (ENSO)

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



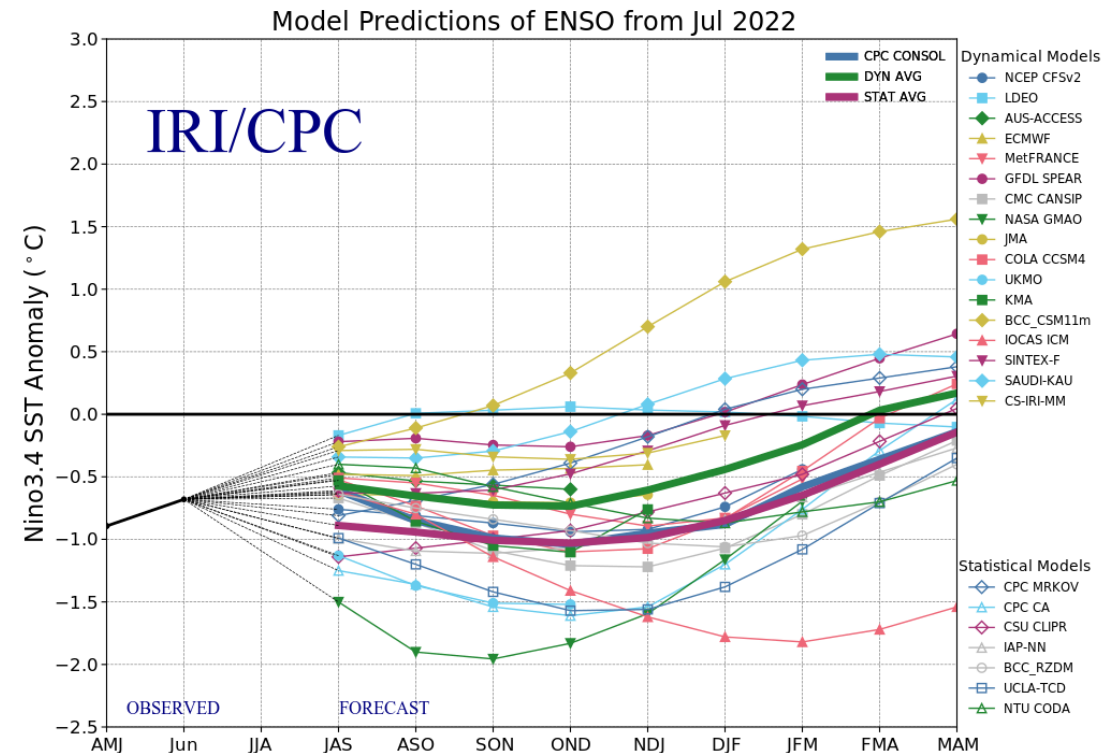
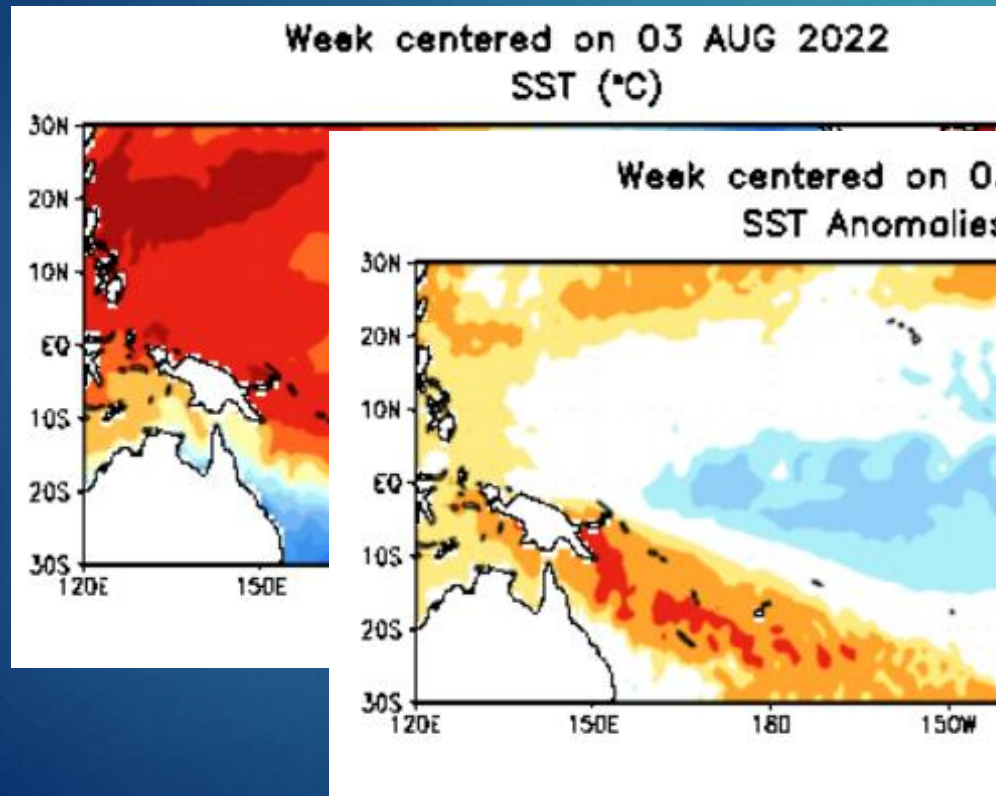
ENSO Impacts

► Influences weather worldwide



ENSO – Current State – Where are we going?

► August 2022 – La Niña “three-peat”

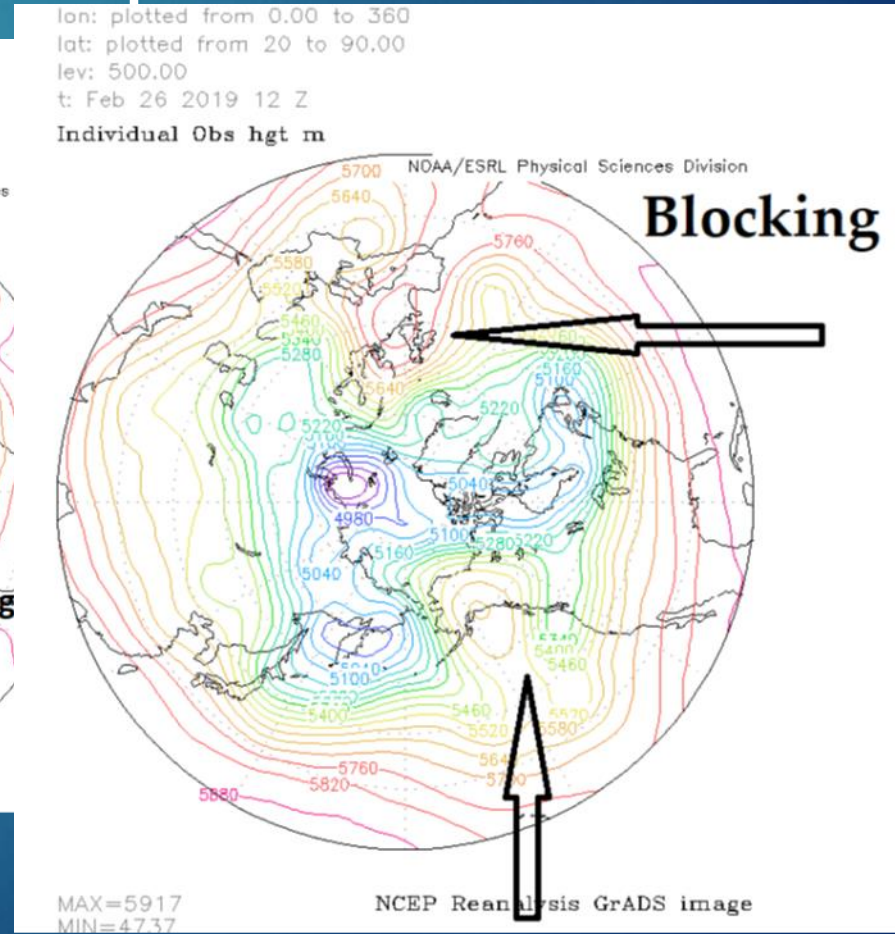
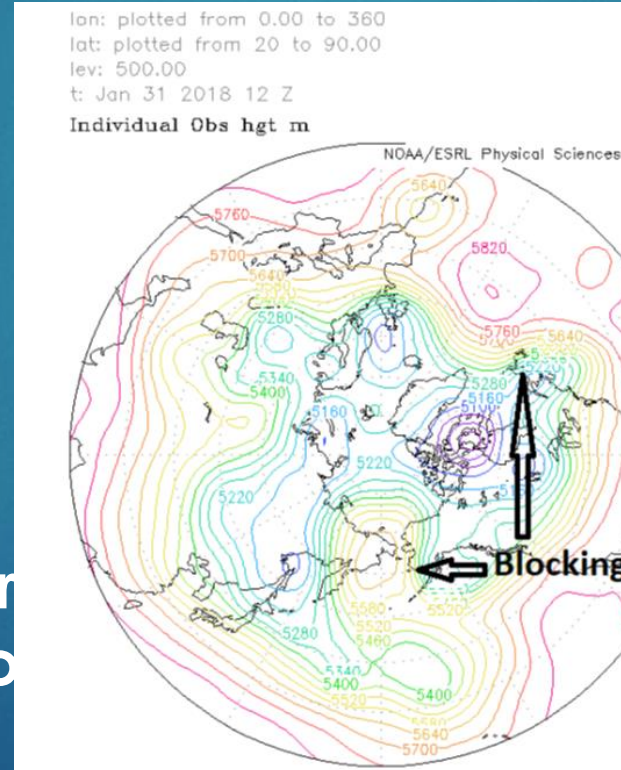


Atmospheric Blocking

- Atmospheric jet stream behavior is complicated

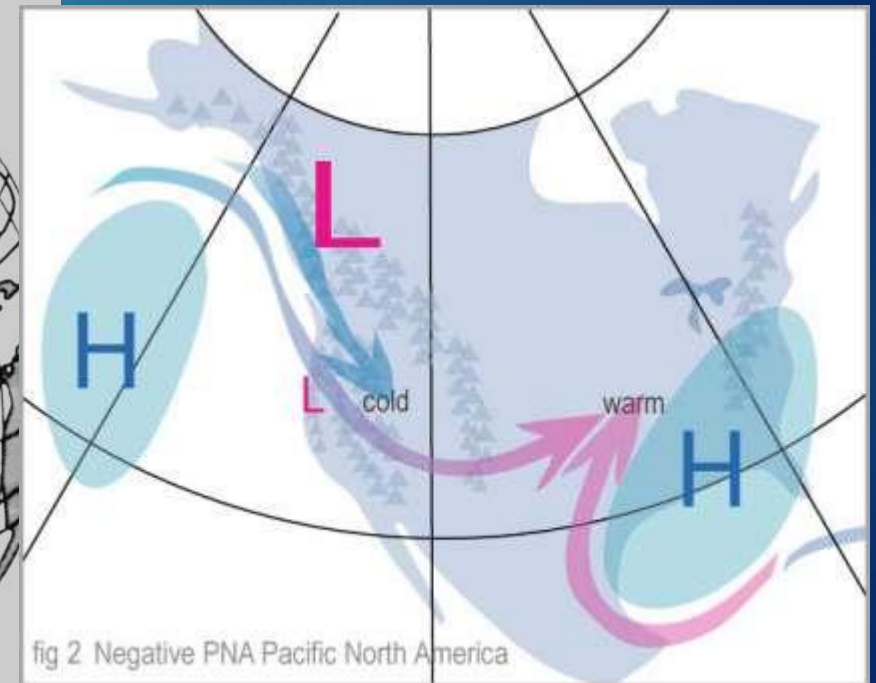
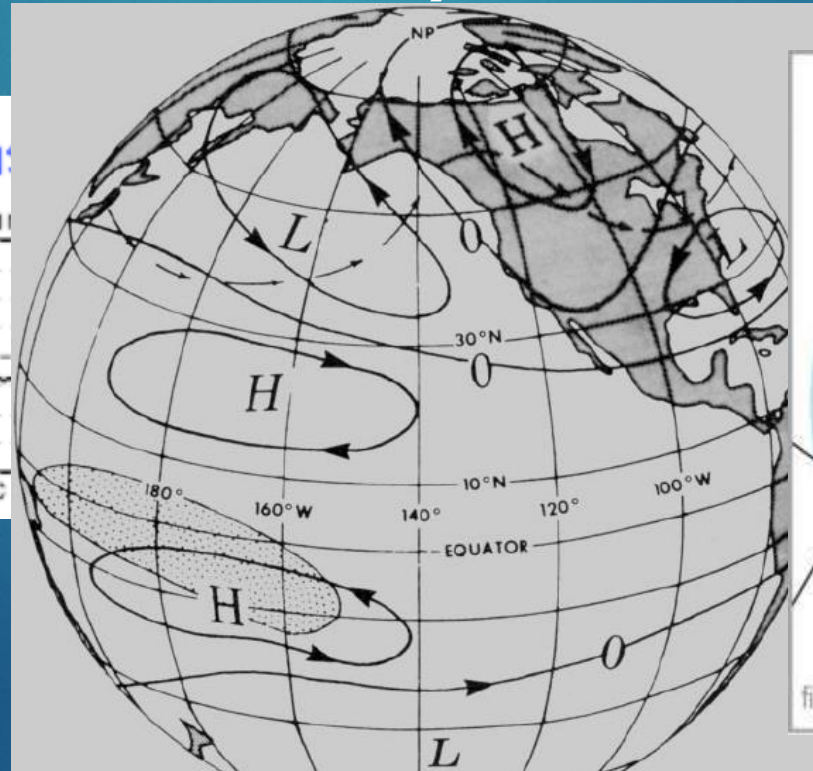
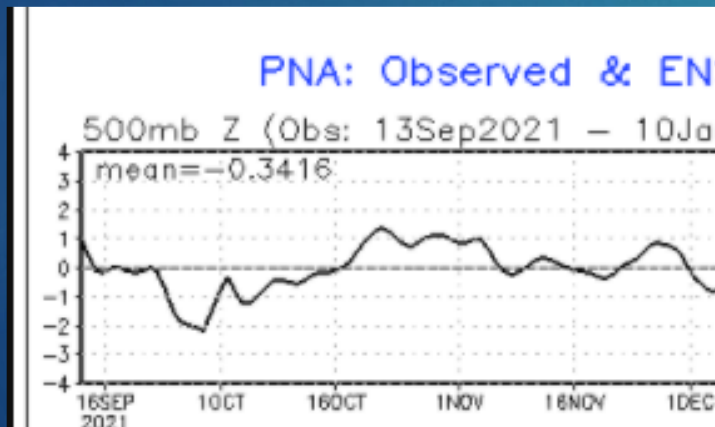


- Blocking - general mid-latitude and



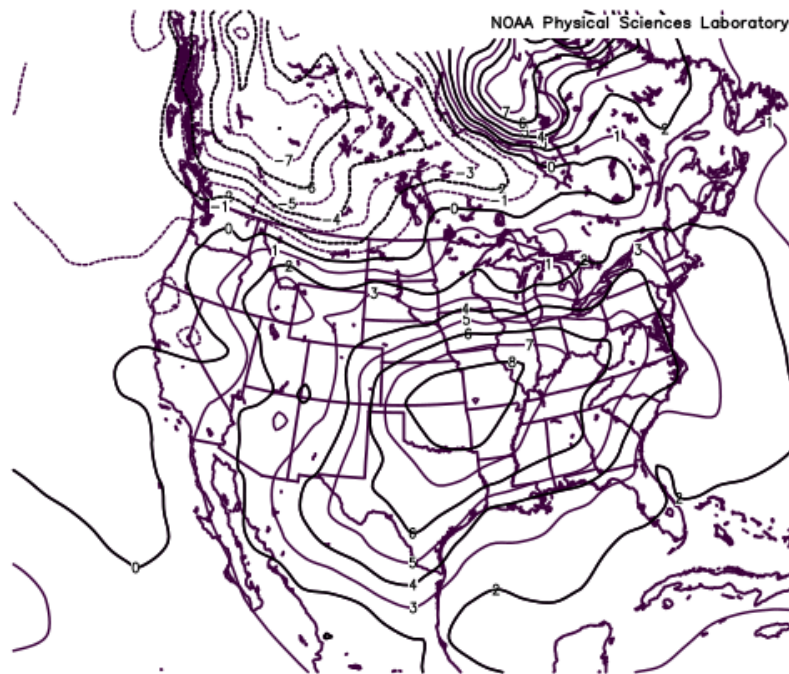
Teleconnections

- 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).

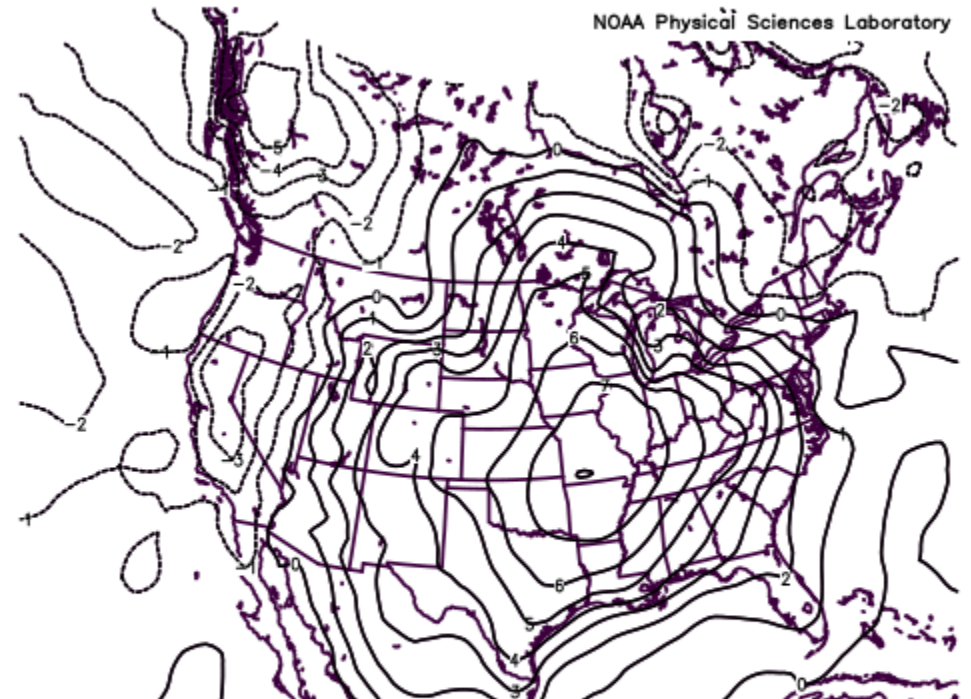


December 2021 versus 1889

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



2m Composite Anomaly (1981–2010 Climatology)
12/1/21 to 12/31/21

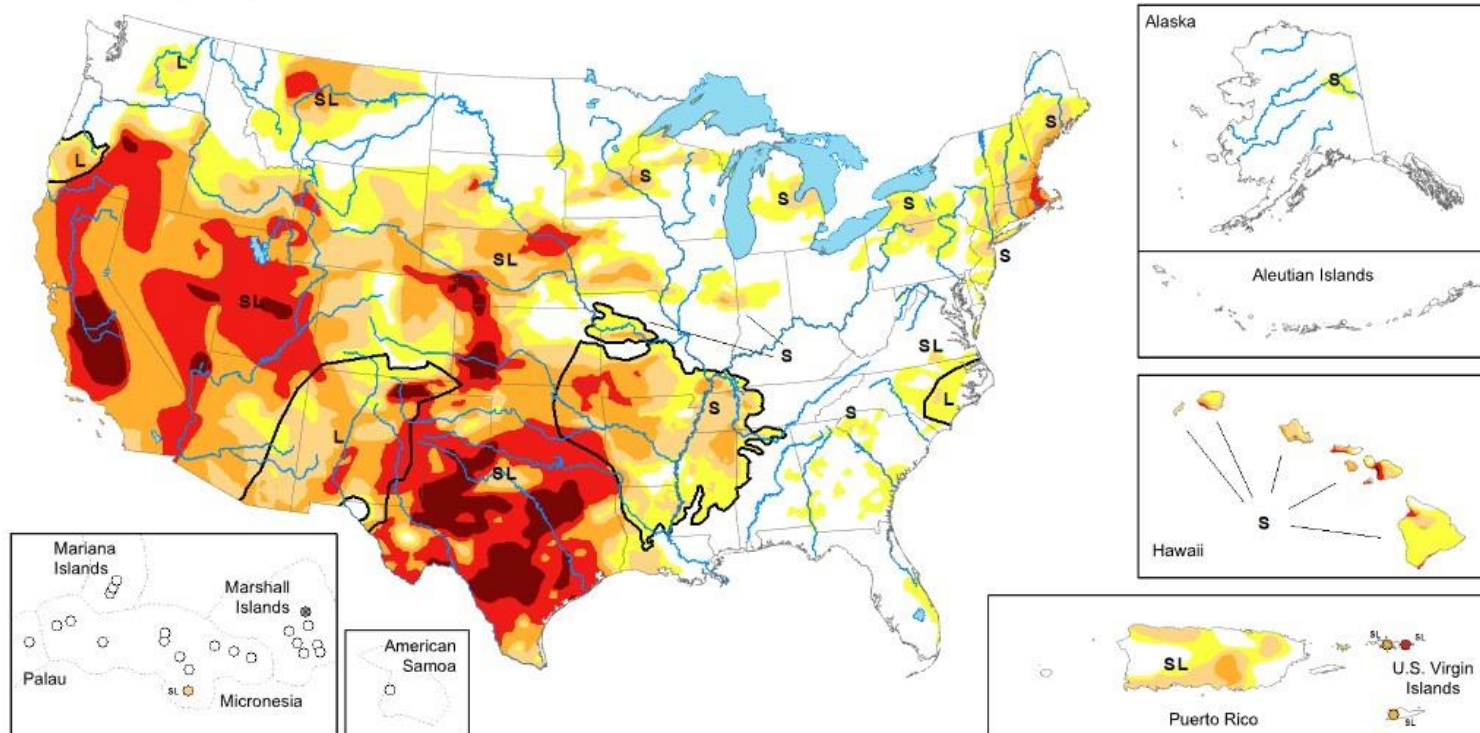


National Drought Monitor

► Current Drought Conditions – short-term no improvement

Map released: August 11, 2022

Data valid: August 9, 2022



Our Winter Forecast 2021 – 2022

Recap

- ▶ For temperature, we'll stay to the warm side on normal, roughly 0.5 sigma (1.0 – 2.0 F above normal). Similar to the last few years: some early and late season cold. **Winter was +3.3 F above normal which is 1.0 sigma, so we'll say we get only 1 point**
- ▶ Precipitation, we're going to stay slightly on the wet side of normal, up to 0.5 sigma above normal. (from about -0.5 inches to +1.1 inches). Similar to last year. **Winter was within this range so we'll give ourselves two points!**
- ▶ Snow: Warmer doesn't always mean less snow, we'll say roughly 15 – 20 inches this year. **We were good on this forecast as well!**

Our Forecast – Summer 2022 - Recap

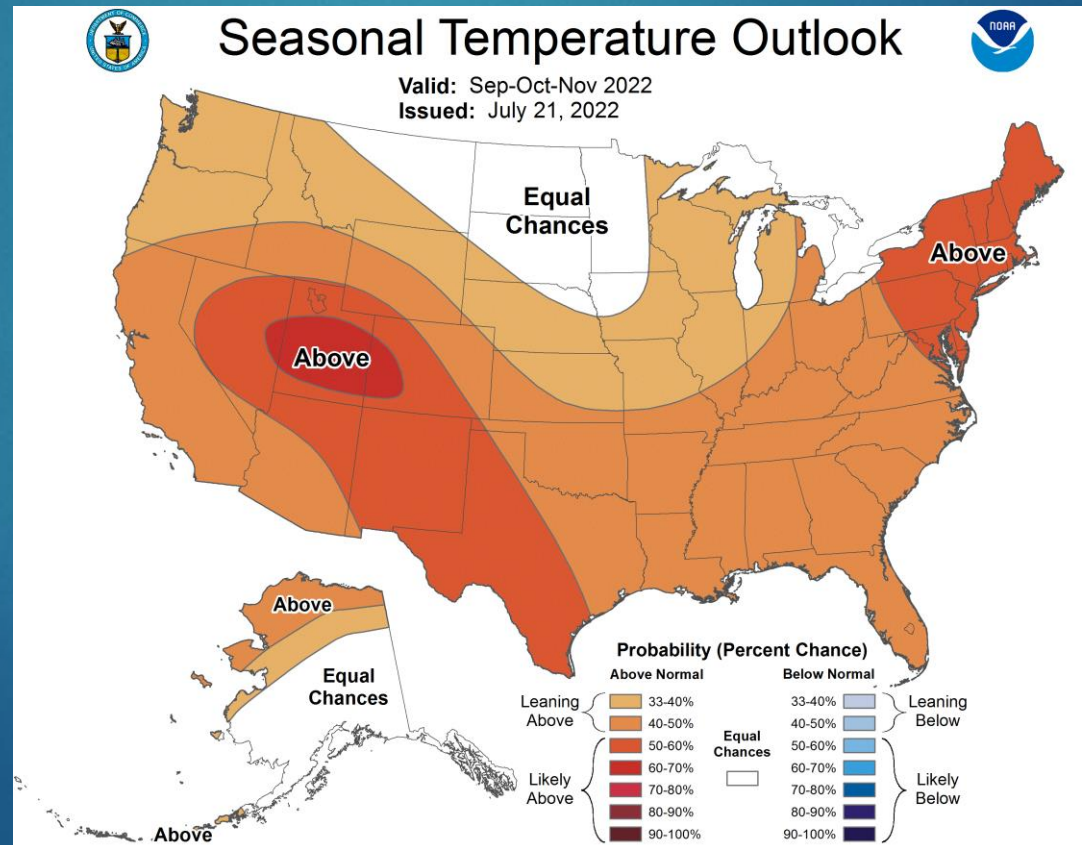
- ▶ We're going to go with a repeat of 2021, toward the warm side but maybe not as strongly as last year. Temperature will be about +0.5 to +1.0 sigma above normal – which is about 1 – 2 F, with more humid conditions. **We're on pace to end around +3 F above normal, we'll grudgingly give ourselves a 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. 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.

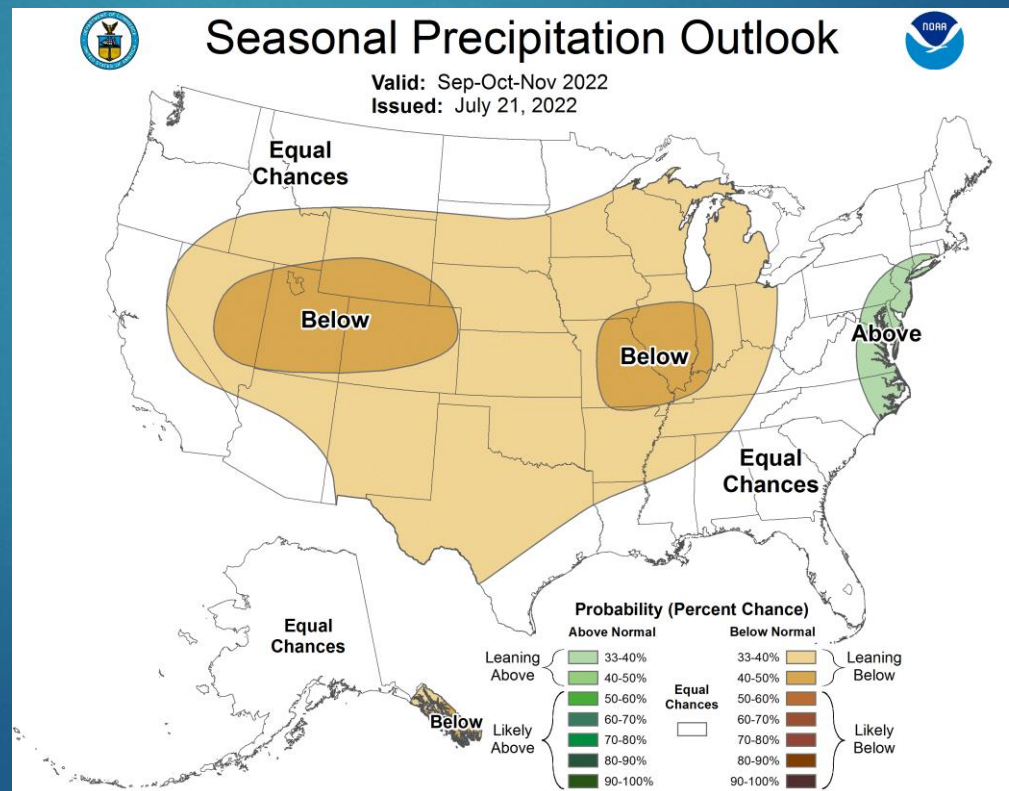
Fall 2022 – CPC outlooks

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



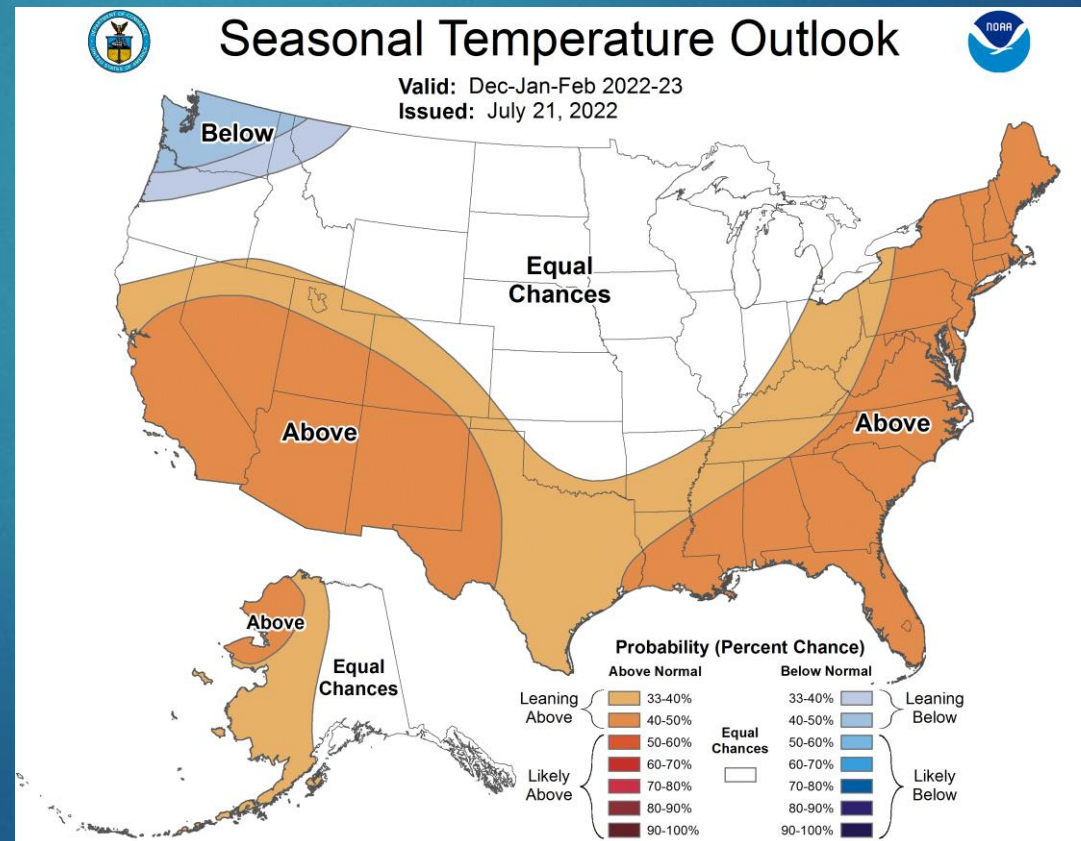
Fall 2022 – CPC Outlooks

- Precipitation – look for drought to continue in spite of recent improvement?



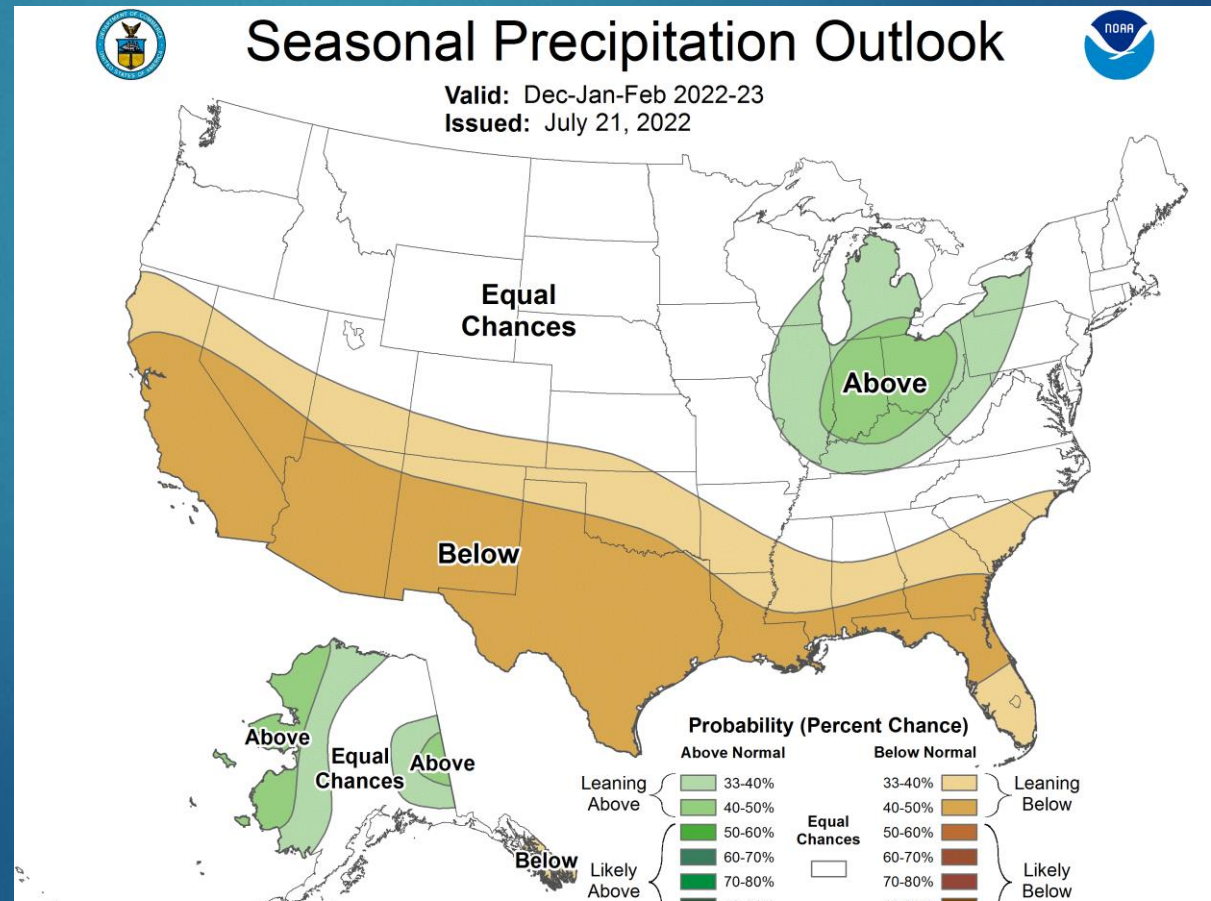
CPC Winter Outlook – 2022 - 2023

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



CPC Winter Outlook 2022 - 2023

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



Winter 2022 - 2023 Outlook

- ▶ CPC forecast is for a warm fall in most places and equal chances for the upper midwest. They are going for continued drought in the center of the USA but wet in the east. But, we're in a La Nina three-peat, and last year is looking like a good analog where MO is trapped between a ridge in the rockies and a trough in the east. This meant warmups and cool downs after December.
- ▶ La Nina conditions were in place this time last year and they are predicted to be as strong or stronger than last year.

Winter 2022 - 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 – 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.
- ▶ 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.

Our Forecast – Winter 2022 - 2023

- ▶ Reasoning:
- ▶ We think that with similar conditions in place to last year, that is a good start. Also, La Nina conditions have persisted since Fall 2020. Three straight La Nina years is very unusual. The best models project us to stay in La Nina conditions. As we go into mid-August, there is some evidence those up and down temperature swings that dominated last winter wish to continue this year.

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.edu>

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>