

Climate Variability, Climate Change in MO, and an Early Weather Outlook – Winter 2026-2027

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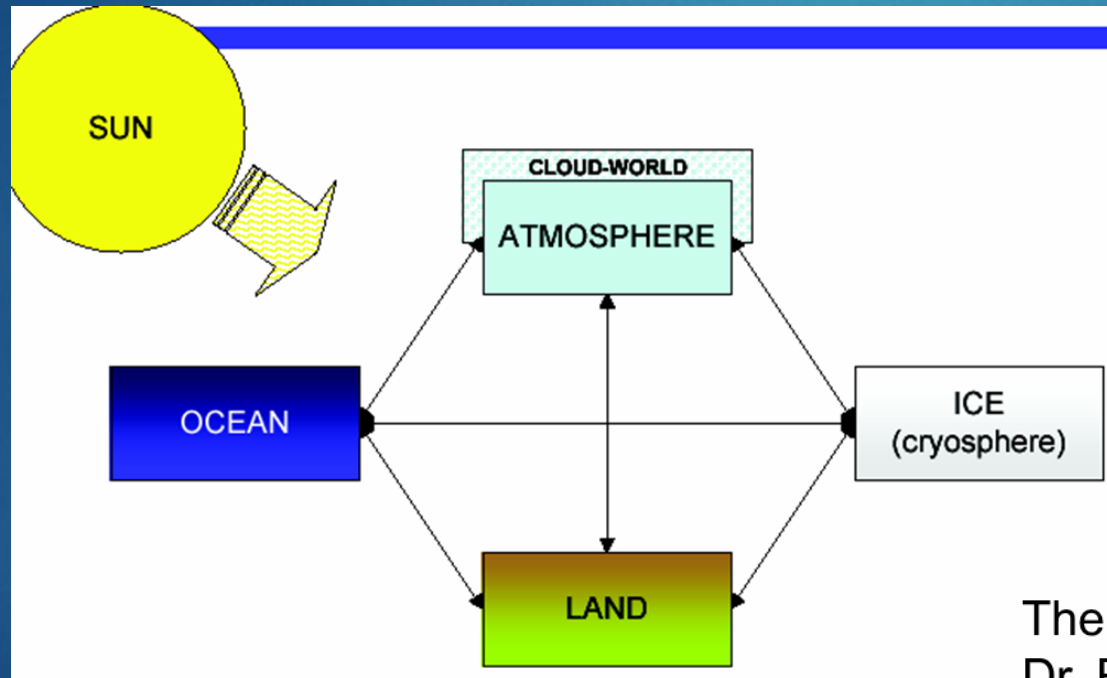
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Definitions

- ▶ 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:

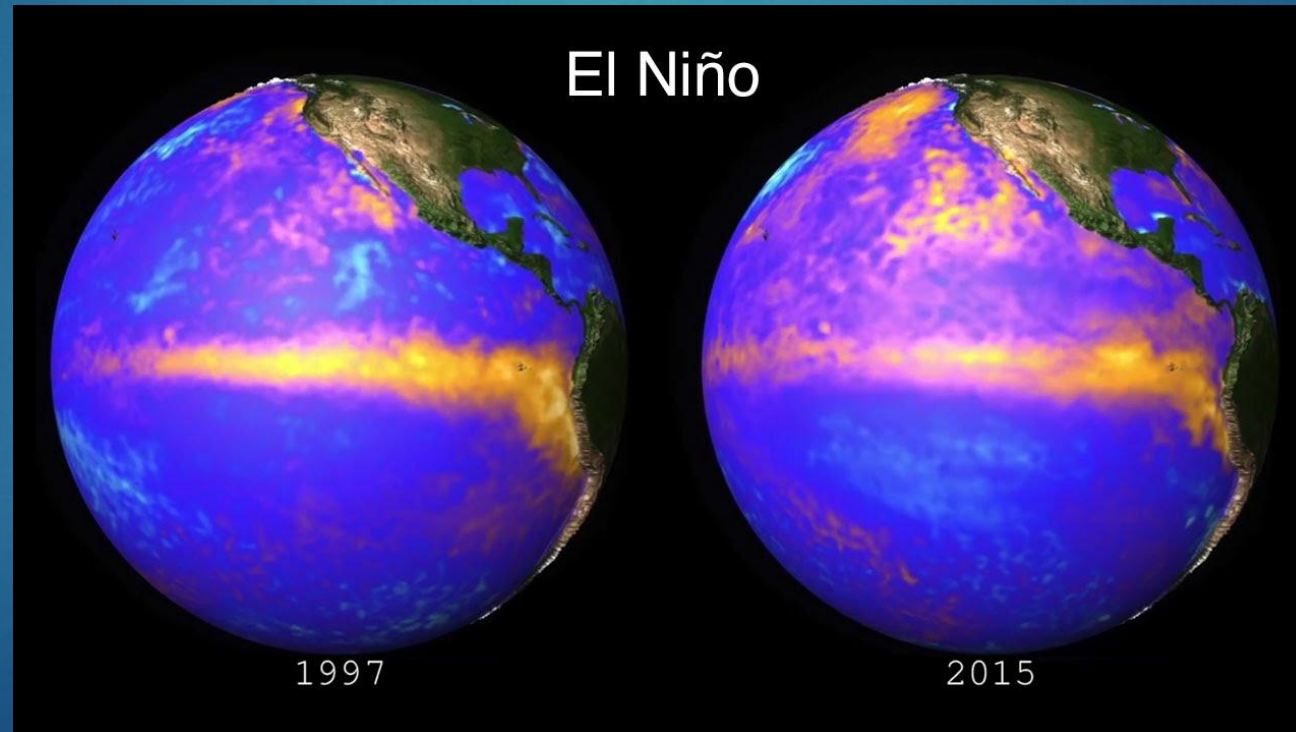
- Cryosphere (Glaciers, Antarctica)
- Oceans (and freshwater too)
- Lithosphere (dirt, continents)
- Biosphere (life → Plants and Animals)

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

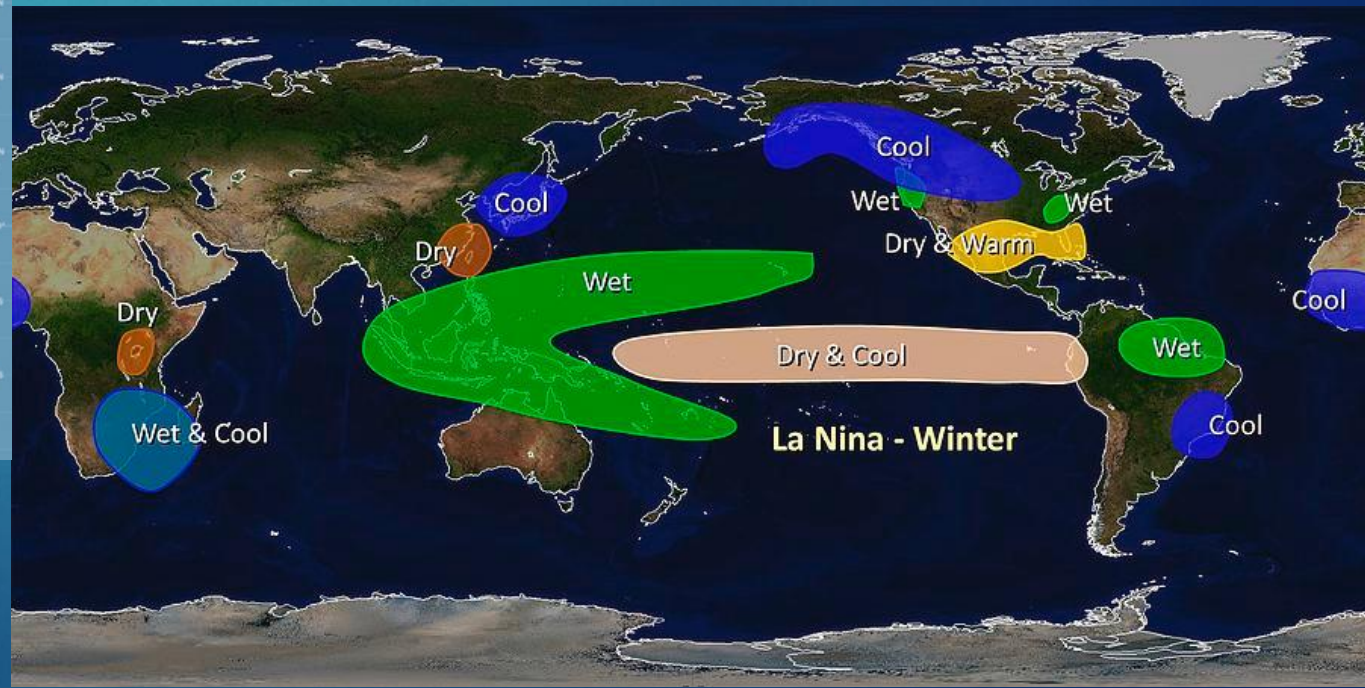
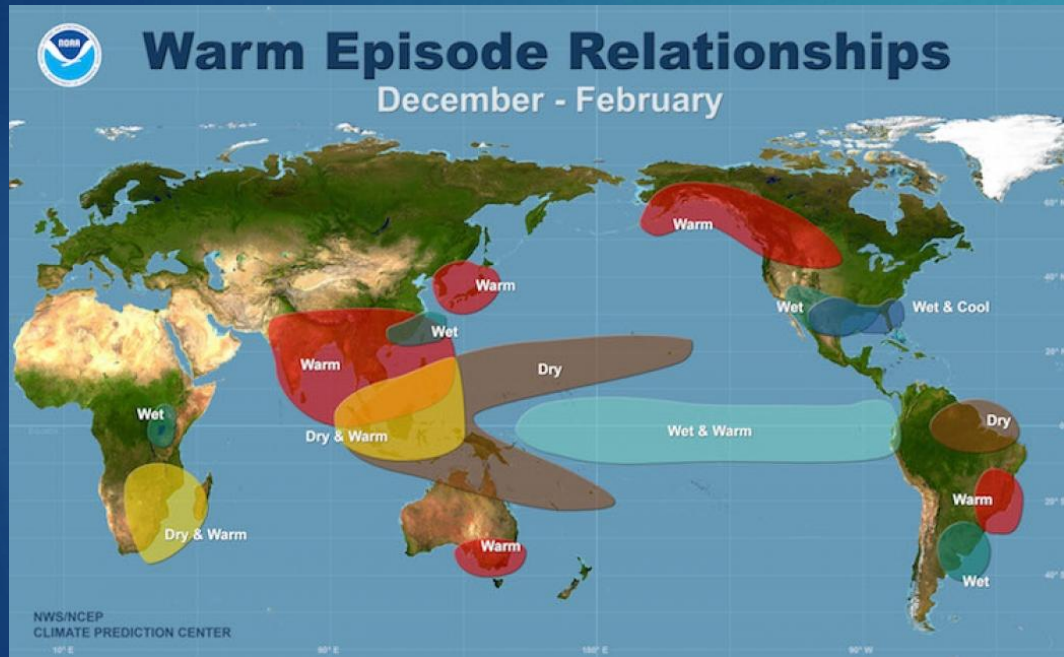
El Niño and Southern Oscillation (ENSO)

- ▶ 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

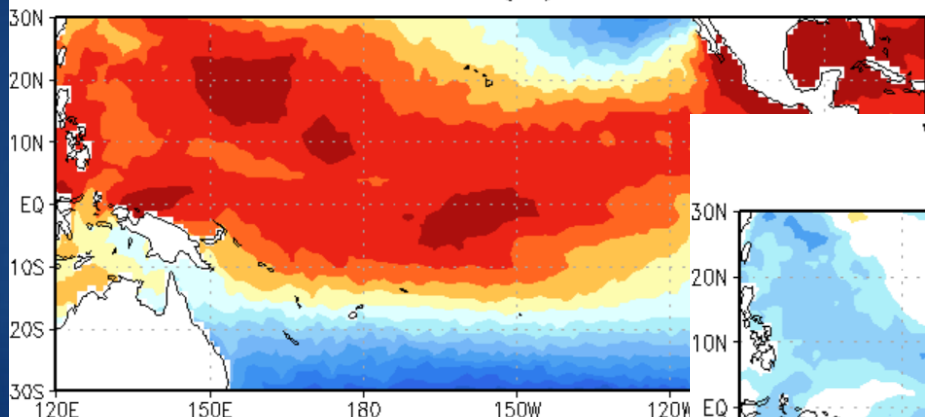


ENSO – Current State – Where are we going?

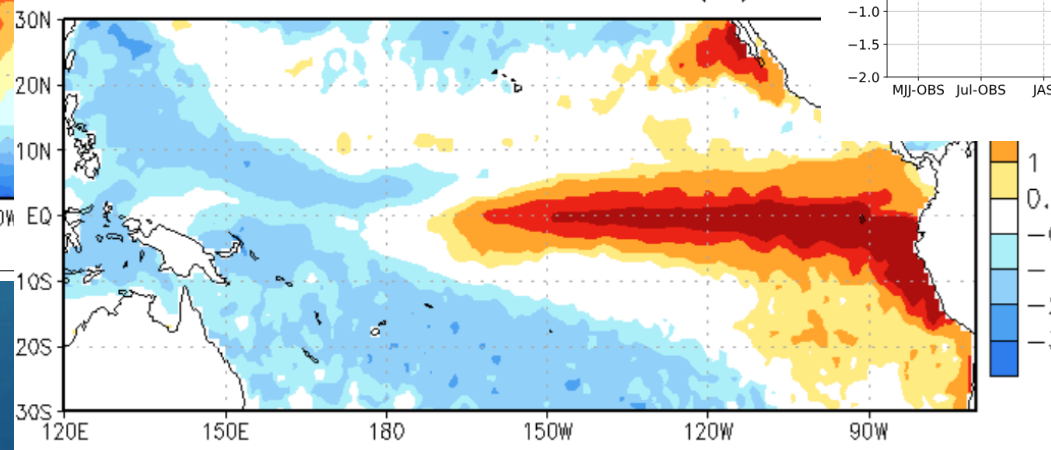
► August 2026 – Super El Niño!



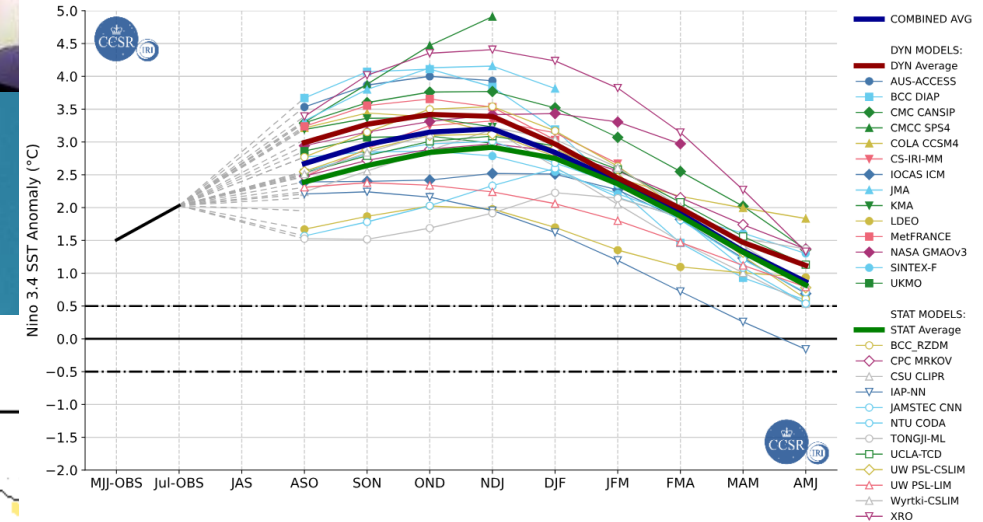
Week centered on 02 SEP 2026
SST (°C)



Week centered on 02 SEP 2026
Relative SST Anomalies (°C)



CCSR/IRI Model Predictions of ENSO from Aug 2026

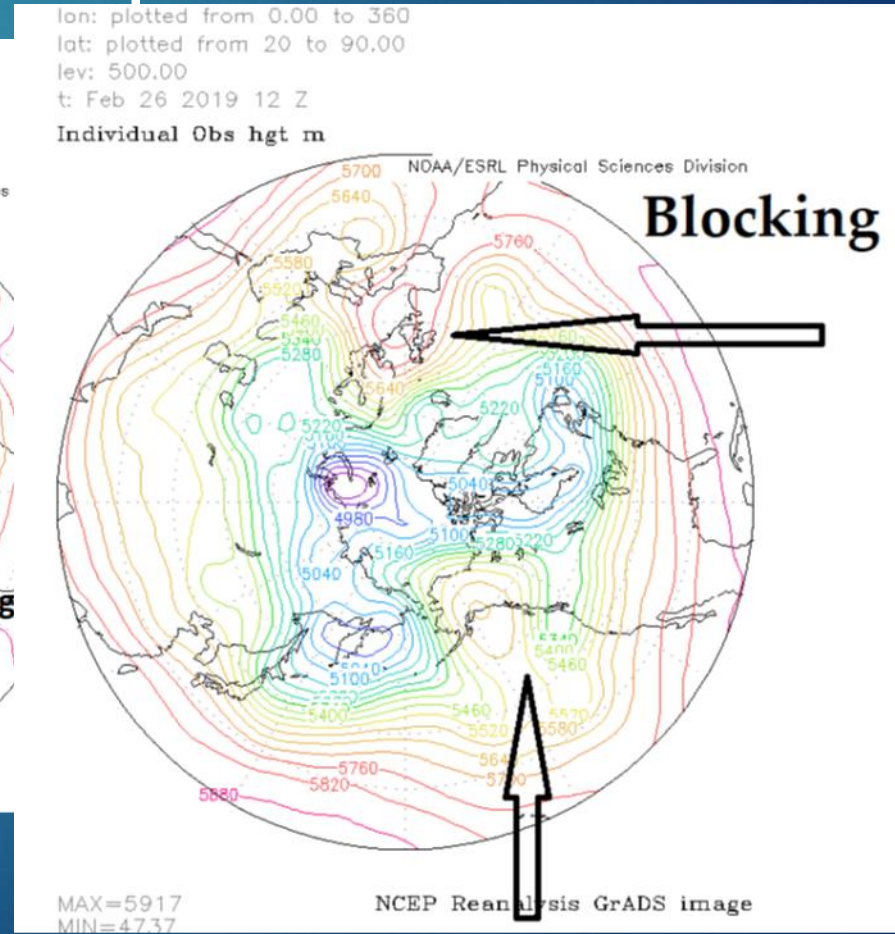
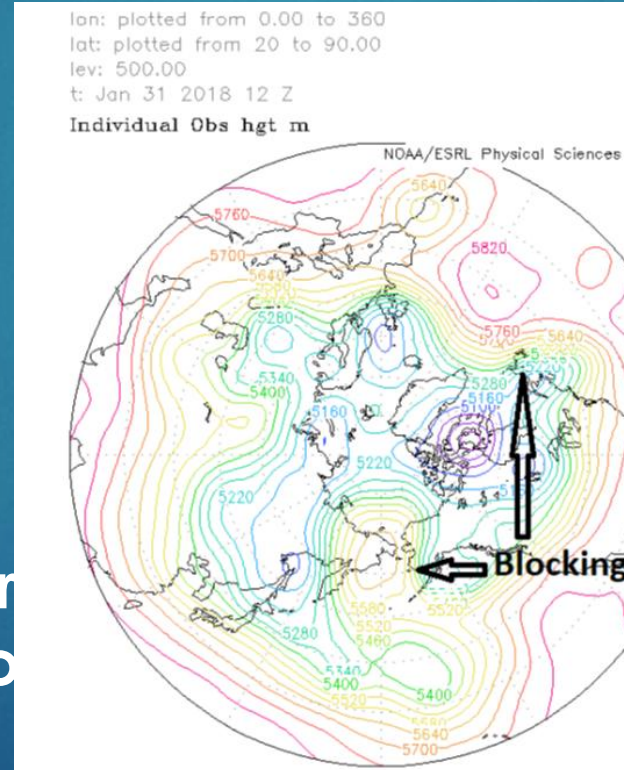


Atmospheric Blocking

- Atmospheric jet stream behavior is complicated

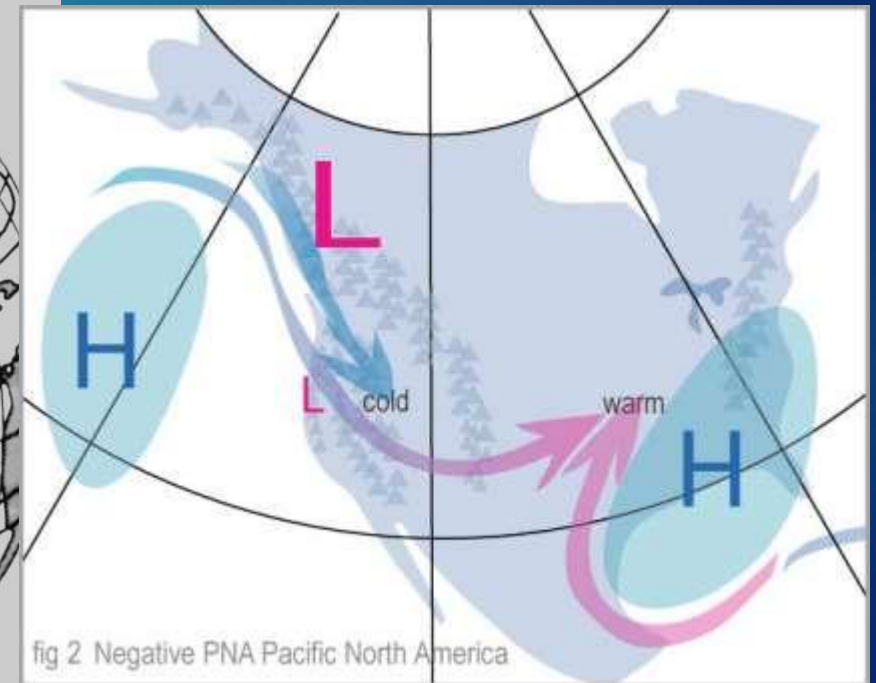
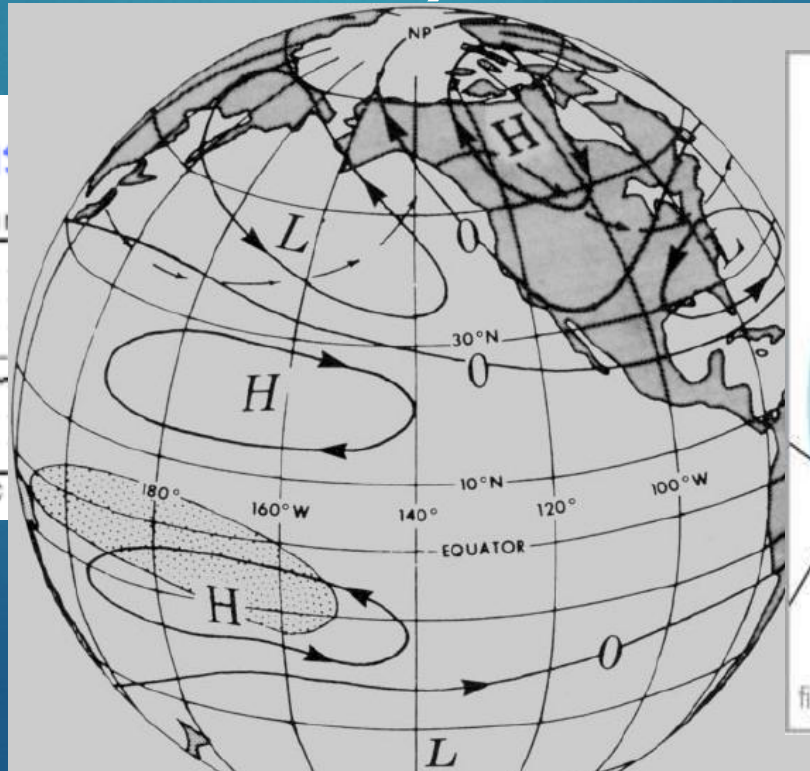
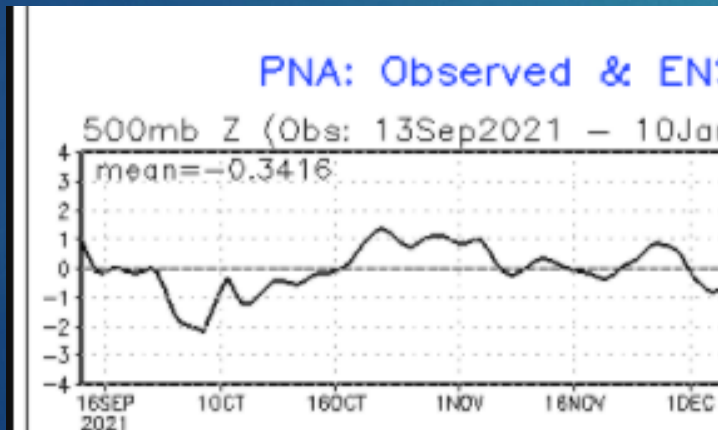


- Blocking - general mid-latitude and



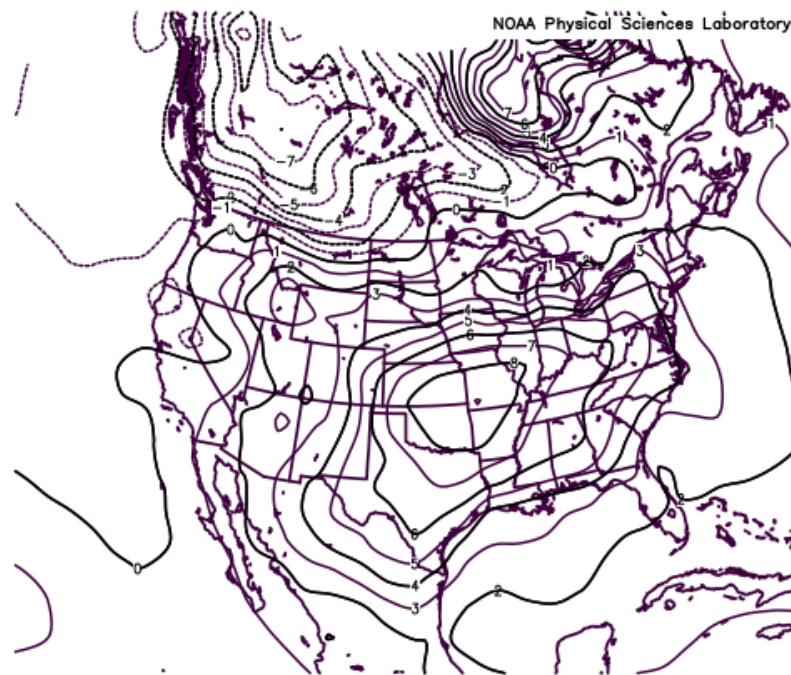
Teleconnections

- 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).

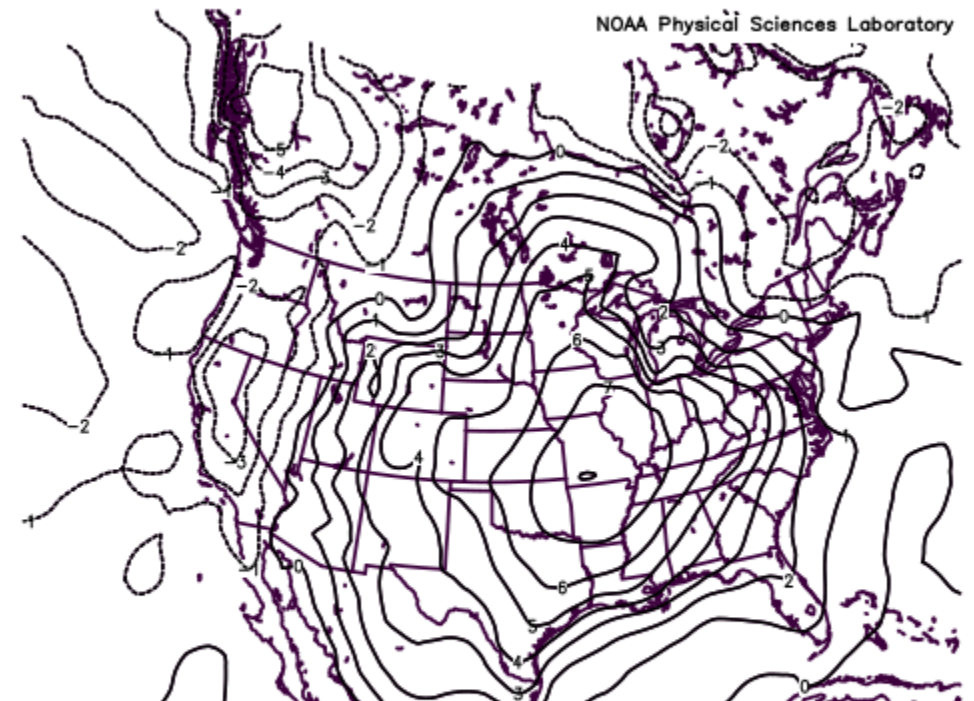


December 2021 versus 1889

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

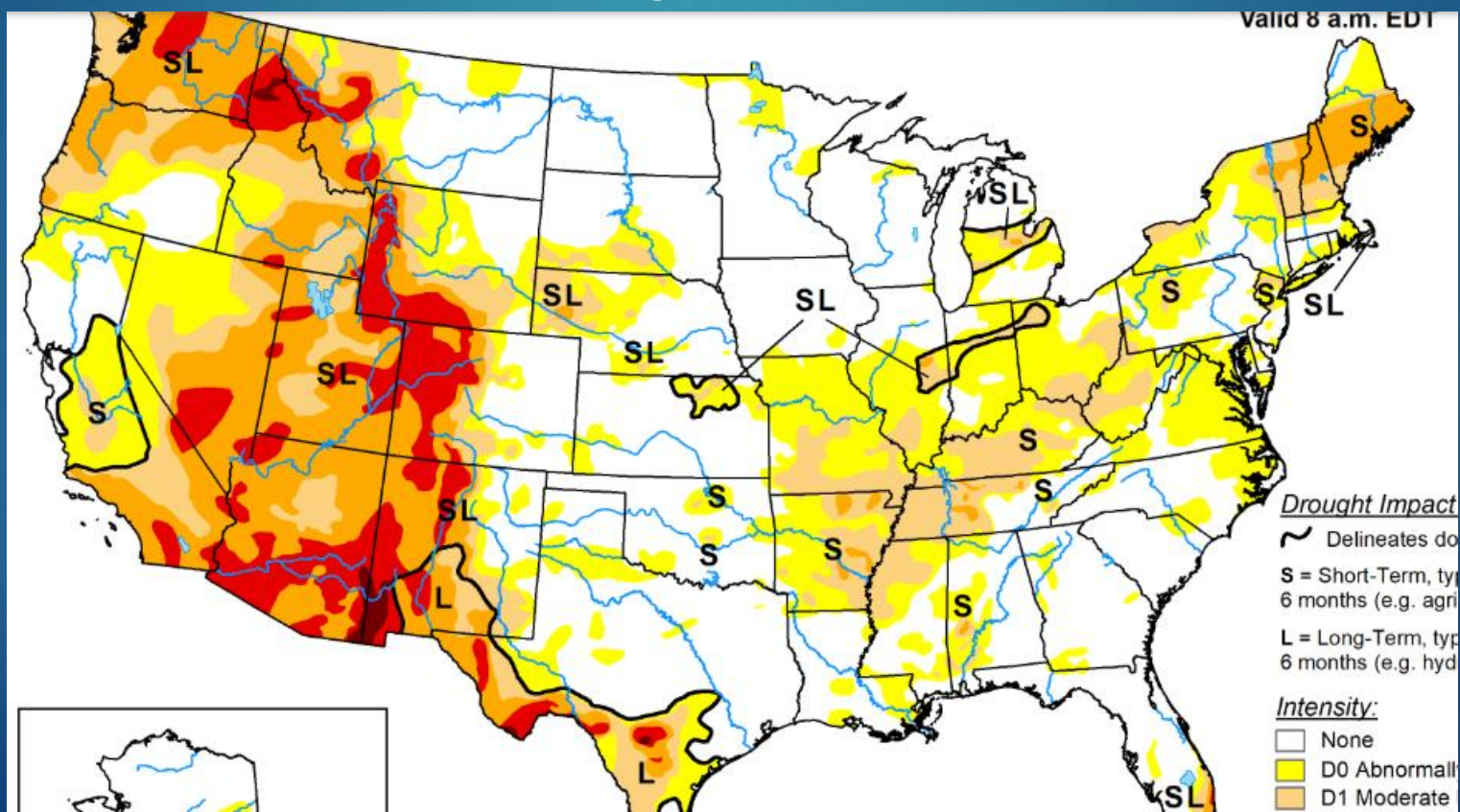


2m Composite Anomaly (1981–2010 Climatology)
12/1/21 to 12/31/21



National Drought Monitor

- Current Drought Conditions – same as last year – much worse than the start of August



Scoring the Long-Range Forecast

- ▶ How do we score the long-range forecast?
- ▶ Climatological normals are tough to beat. We divide up categories this way
 - ▶ Normal → is $-1/2$ to $+1/2$ standard deviations of the mean for temperature and precipitation.
 - ▶ Above (Below) Normal → is $1/2$ to 1 ($-1/2$ to -1) standard deviations from normal.
 - ▶ Much Above (Below) Normal → 1 to 2 (-1 to -2) standard deviations from normal.
 - ▶ Excessive Above (Below) Normal → > 2 (< -2) standard deviations from normal.

Our Forecast – Winter 2025 - 2026

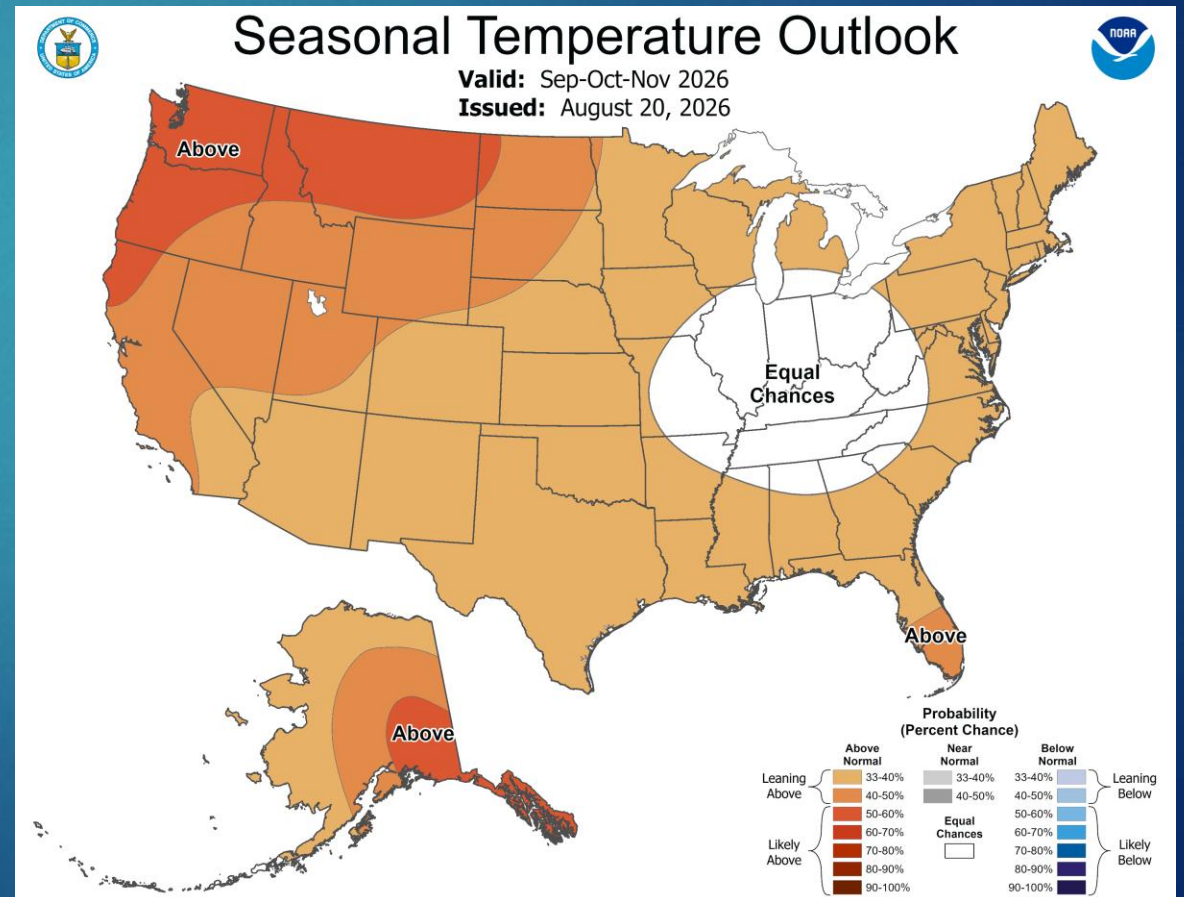
- ▶ We forecast a winter very close to normal based on the recent “classic” La Ninas of 2007, 2010, 2017, 2020, and 2021. And last year! This seems to be a strong indicator. Temperature will be within 0.5 sigma of normal which is -1.6 to +1.6F.
- ▶ The actual temperature was +2.0 F on the strength of a very warm February. December and January were very close to normal. So we got only one point of two.
- ▶ We leaned toward precipitation being below normal mimicking the previous year. We'll also forecast snow at around 15 – 20 inches.
- ▶ The actual was a bone-dry 2.70 inches as all three months received less than 1 inch. Similar to last year. We can call that a win at two points. We got 3 of 4 for the winter! WE only received about 10 inches of snow.

Our Forecast – Recap Summer 2026

- ▶ Reasoning:
- ▶ We thought that the weak La Niña would fade and we'd move toward El Niño. Transitions from La Niña to El Niño are generally favorable summers. We looked at analog years of 2008, 2018, and 2023. Two of the three were near normal temperatures and wet. One (2018) was hot and dry.
- ▶ So we said that summer would be on the warm side of normal (up to one half of one sigma or 0.0 to +1.2 F and the precipitation within the range of normal (+/- 2.5 inches above and below normal). Summer was 0.6 F above normal – a home run! On the “strength” of a very wet June and a brutally dry end of August – we were +2.75 inches from the 30-year mean, and +3.74 inches from the long-term mean. Tempting to call it a hit (just 1/4 inch!) – but we'll say we get one point not two. So our summer forecast was 3 of 4 points.

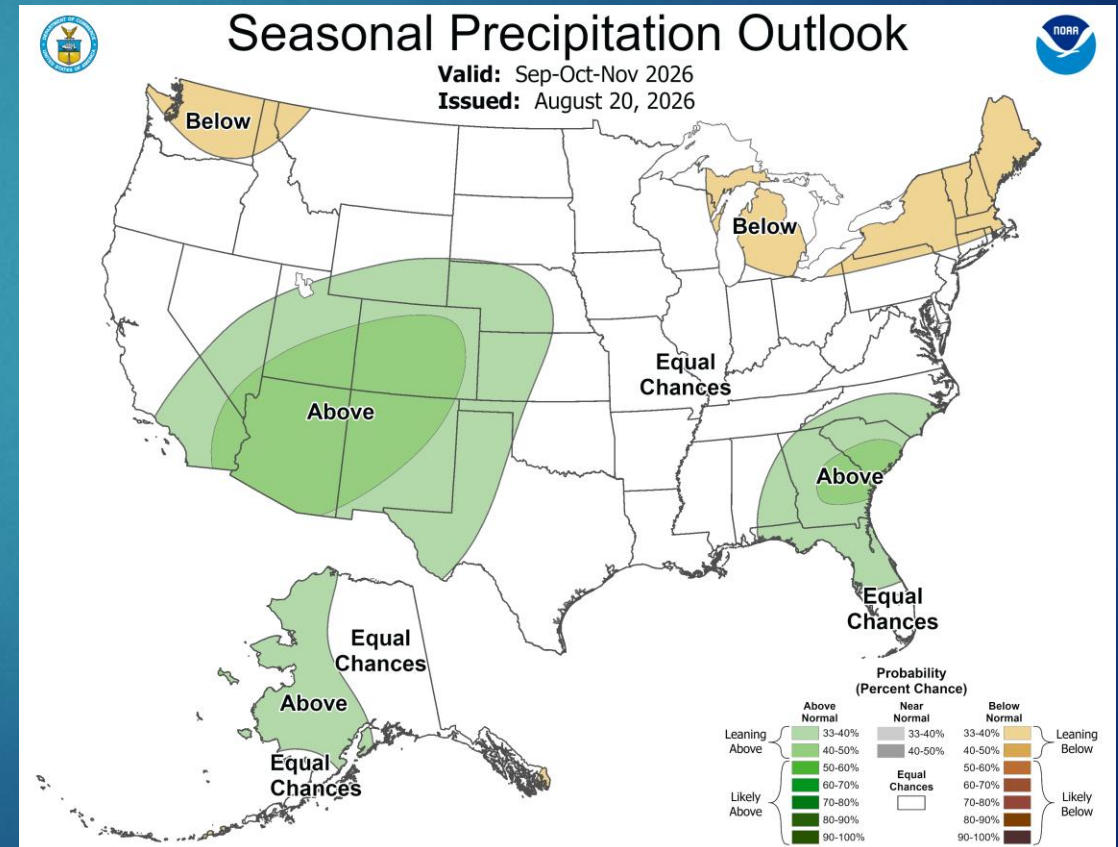
Fall 2026 – CPC outlooks

- ▶ Temperature – projections are for above average temperature across most of the USA except for the Midwest including Missouri.
- ▶ Similar to summer 2026!



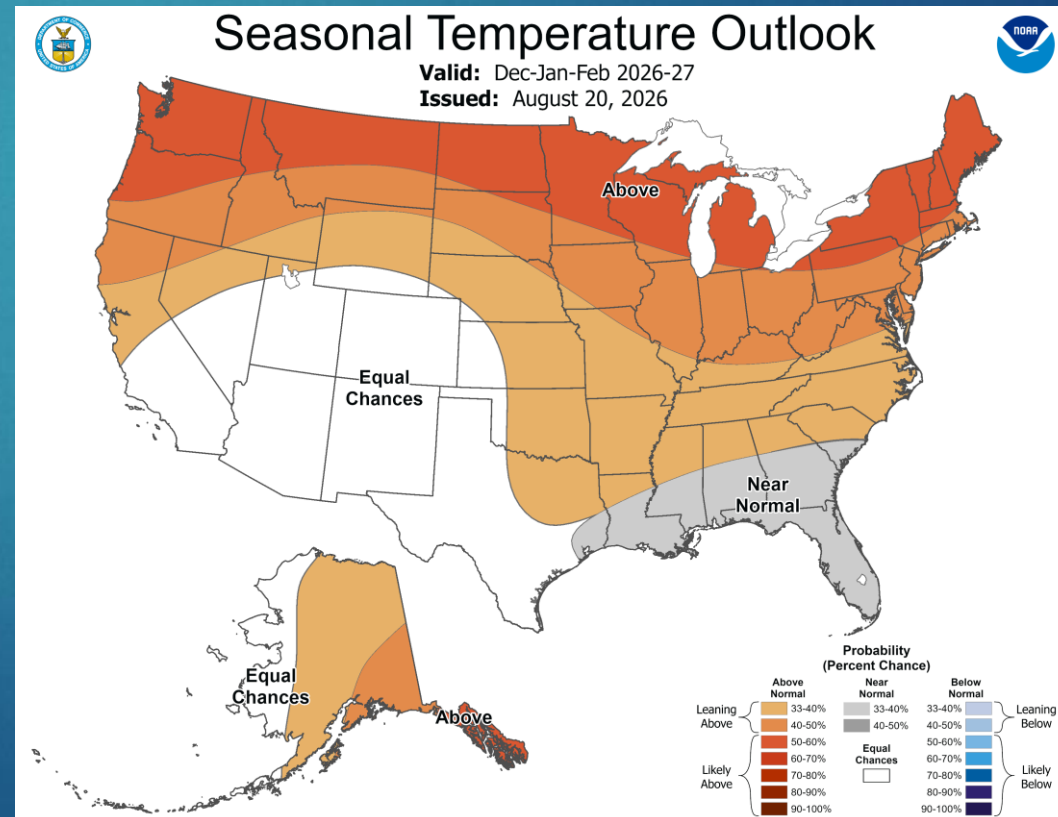
Fall 2026 – CPC Outlooks

- Precipitation – look for equal chances here as an El Nino pattern becomes established.



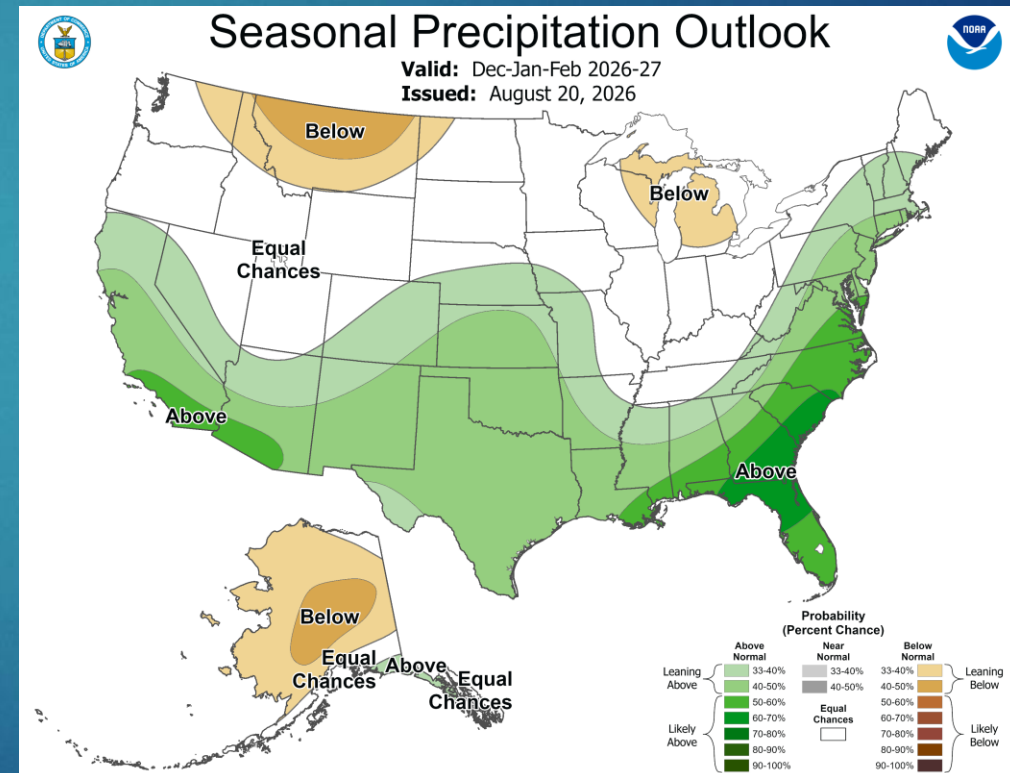
CPC Winter Outlook – 2026 - 2027

- Temperature – “Classic” El Niño. Warm Northern tier of states and mild here.



CPC Winter Outlook 2026 - 2027

- Precipitation – again consistent with El Niño? A wet southern tier of states – including Missouri?



Winter 2026 - 2027 Outlook

- ▶ Early in spring, it was apparent we'd be headed toward El Nino. This El Nino developed fast and strong and there is talk that this El Nino will be a super El Nino – one of the strongest ever. The dynamic and statistical models agree. As this is a “classic El Nino” – the forecast should be simple and have high confidence. Warm in the north and wet in the south.
- ▶ The winter of 2014-2015, and 2015-2016 look like good analogues. The former was near normal in temperature and precipitation, the other was warm and wet.

Our Forecast – Winter 2026 - 2027

- ▶ We're going to go with a warm winter. Many recent "classic" El Niños have been warm, and many of the recent years have either been cool or warm. Not much in the middle. So temperature will be +1.6 – 3.2 F Above normal. This may be a little conservative admittedly. We'll see.
- ▶ We're going to lean toward precipitation being in the range of normal (but I think above normal). This is 6.4 inches +/- 2 inches. I feel better about this. We'll also forecast snow to be around 10 inches this winter. However, look out! The big ones around here tend to happen with El Niño. Are we due for 10+ inch event?

Our Forecast – Winter 2026 - 2027

- ▶ Further notes:
- ▶ El Niño tends to see an early snow and then a late snow. Some of the big ones in central MO can occur with El Nino if we get the right combination of a southerly storm track and a cold air outbreak.
- ▶ The temperature forecast – I am confident – but points of failure could be being too conservative (e.g., its even warmer than forecast). The other issue is Indonesian volcanoes – like Krakatoa have come to life. If they belch a lot of ash, the later winter could be cooler than normal.
- ▶ Last winter – we forecast alternating warm / cold and that happened in December and January. December was brutally cold on the front end as was January on the back end. In between was more springlike.

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 Zach Leasor). 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>