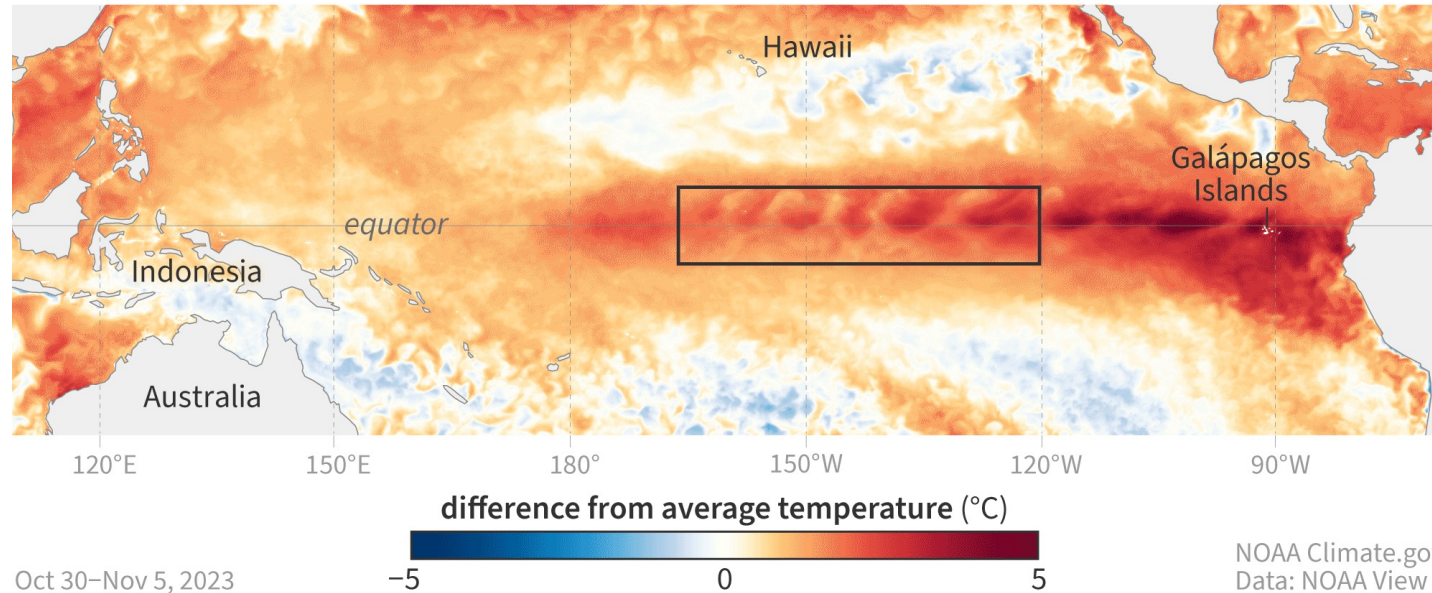




How Well Did 2023-24 Winter Climate Anomalies Match Expected El Niño Impacts

Weekly sea surface temperature patterns in tropical Pacific (Oct 30, 2023–Jan 7, 2024)



Near peak of
2023-24 El
Niño

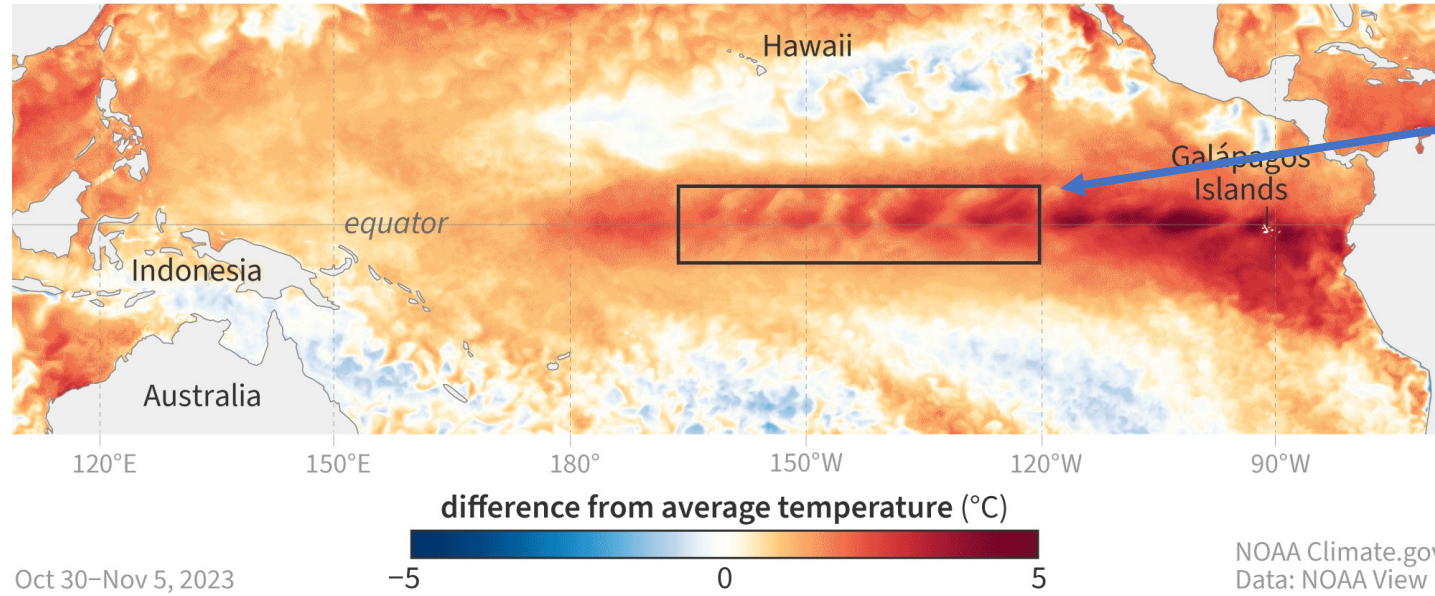
Michelle L'Heureux, Daniel Harnos, Emily Becker, Brian Brettschneider, Mingyue Chen,
Nathaniel Johnson, Arun Kumar, Michael Tippett
Part of this analysis submitted to BAMS

48th CDPW/ 21st CPASW
Tallahassee, Florida
29 March 2024

What Happened in 2023-24?

A strong El Niño!

Weekly sea surface temperature patterns in tropical Pacific (Oct 30, 2023–Jan 7, 2024)

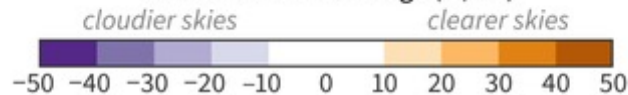
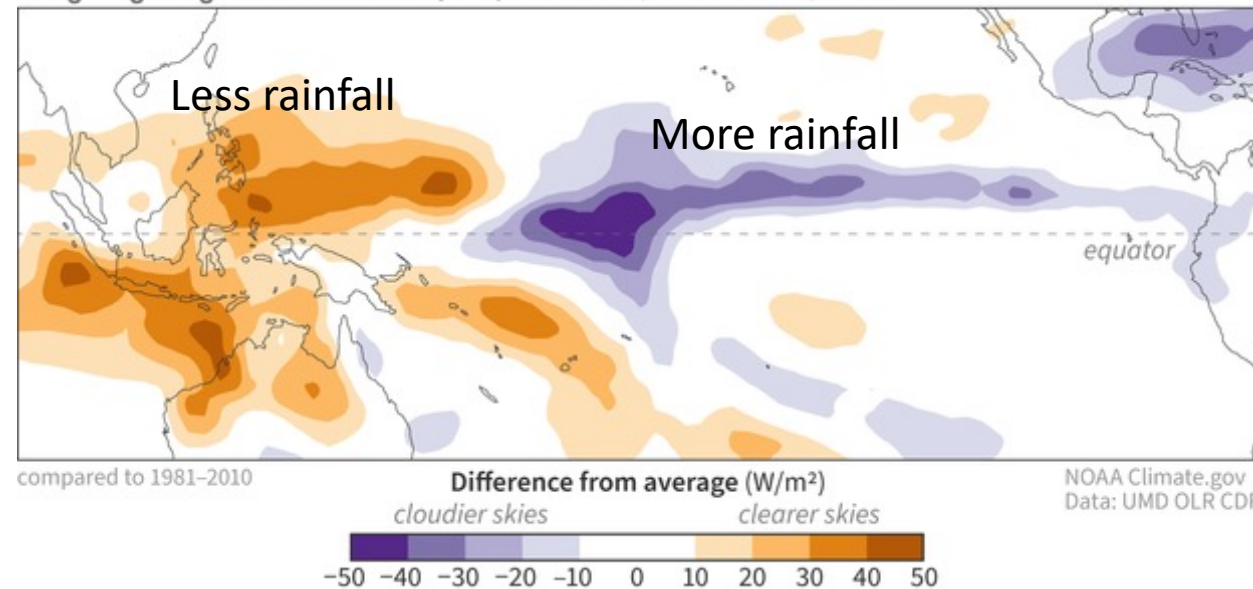


We take the box and average sea surface temperature anomalies to get a time series (or index) of ENSO.

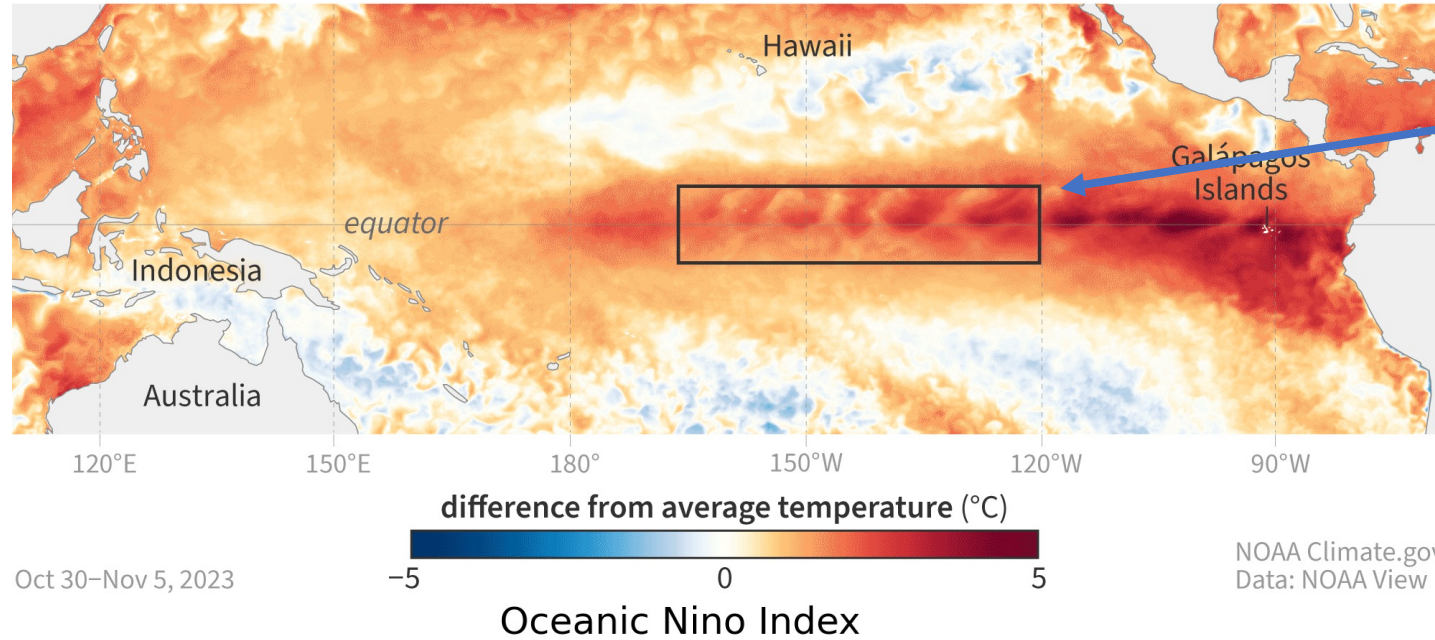
Called the Niño-3.4 region.

3-month running averages is the **Oceanic Niño Index (ONI)**.

Outgoing longwave radiation (OLR) for Dec 11, 2023–Jan 5, 2024



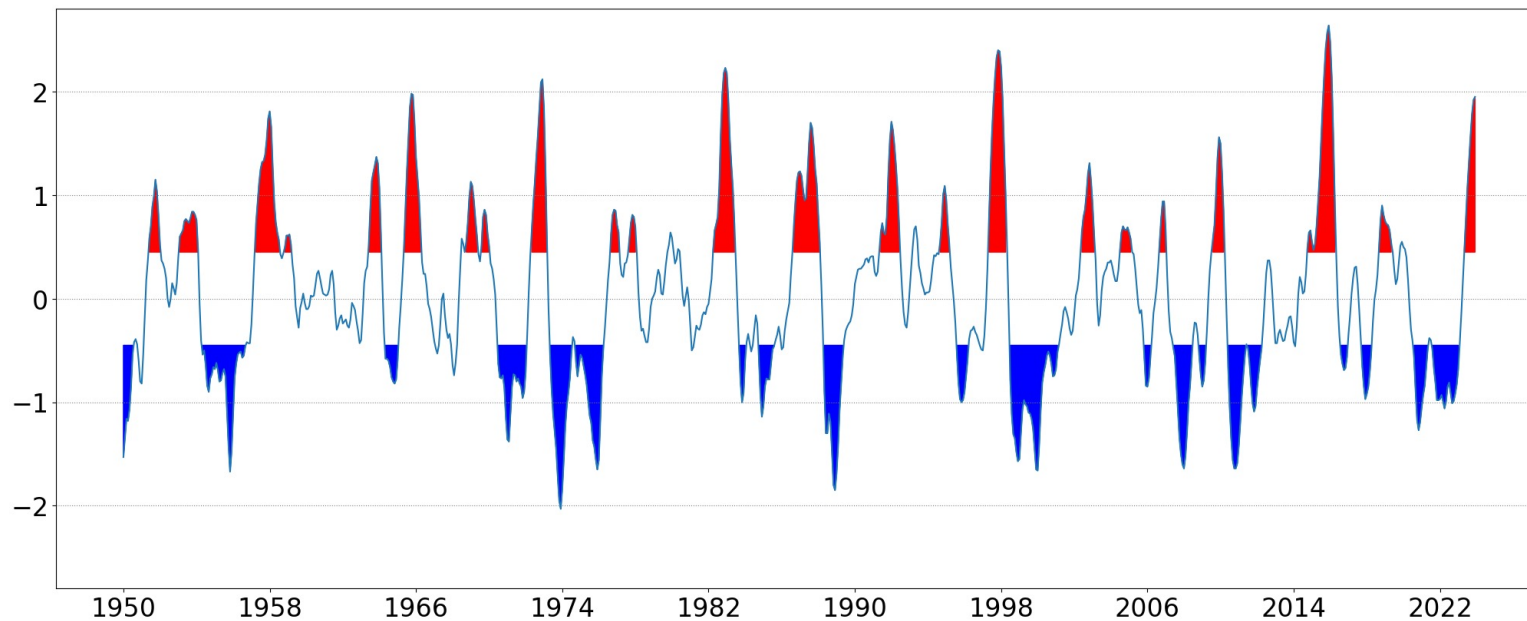
Weekly sea surface temperature patterns in tropical Pacific (Oct 30, 2023–Jan 7, 2024)



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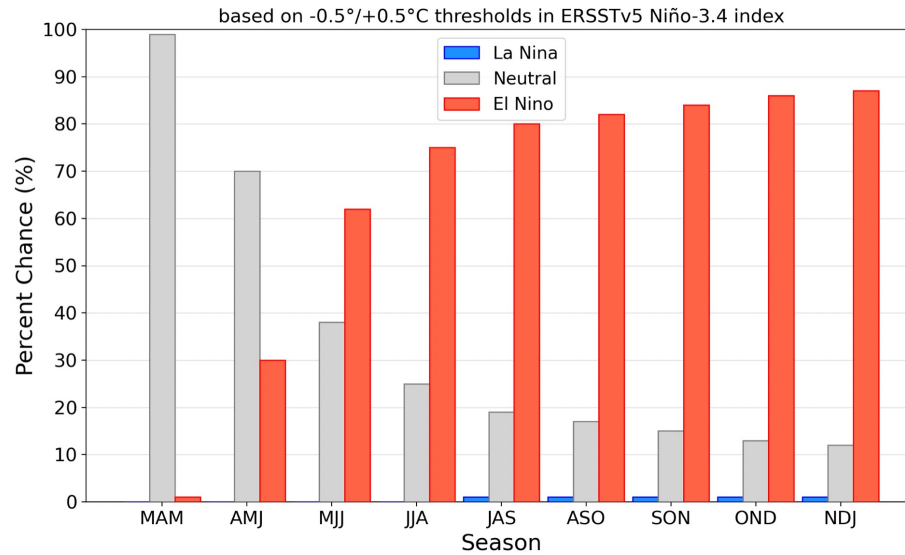
Called the Niño-3.4 region.

3-month running averages is the **Oceanic Niño Index (ONI)**.



Dataset:
NCEI ERSSTv5

Official NOAA CPC ENSO Probabilities (issued Apr. 2023)



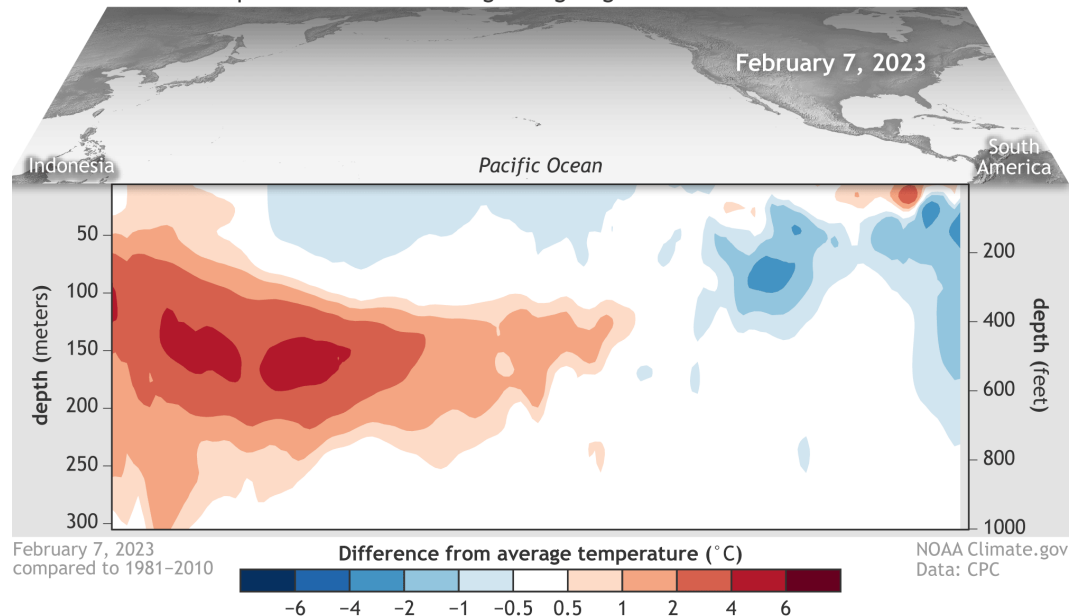
El Niño Watch Issued in April 2023

At that time, we wrote a 4 in 10 chance of a strong El Niño.

In May 2023, a strong event was favored (56% chance).

1) Support from subsurface ocean.

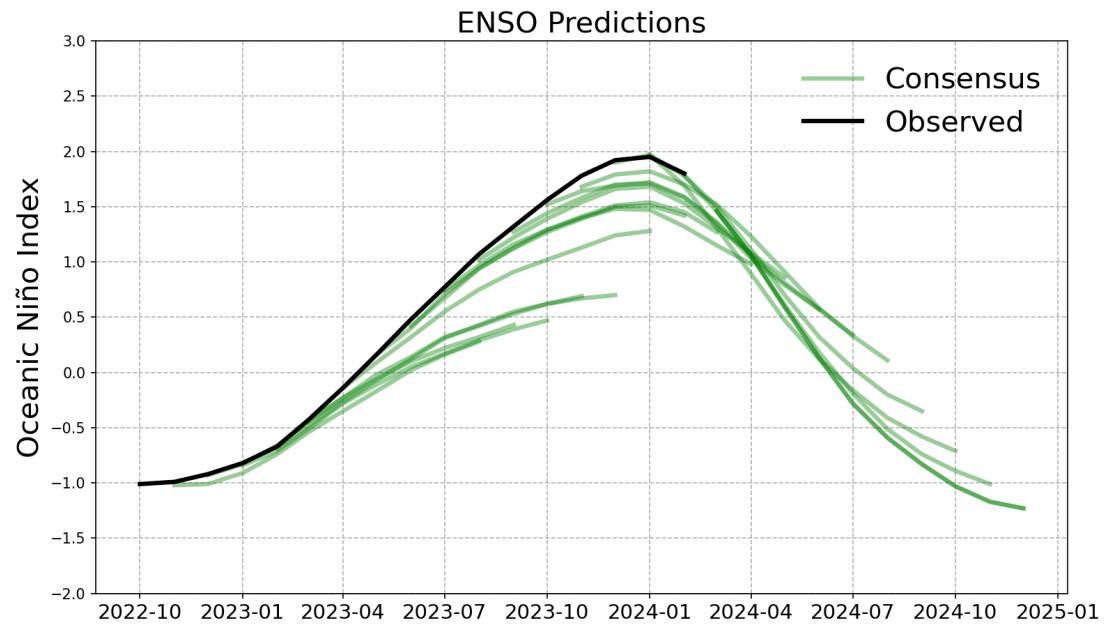
Below-surface warm pool in eastern Pacific growing larger



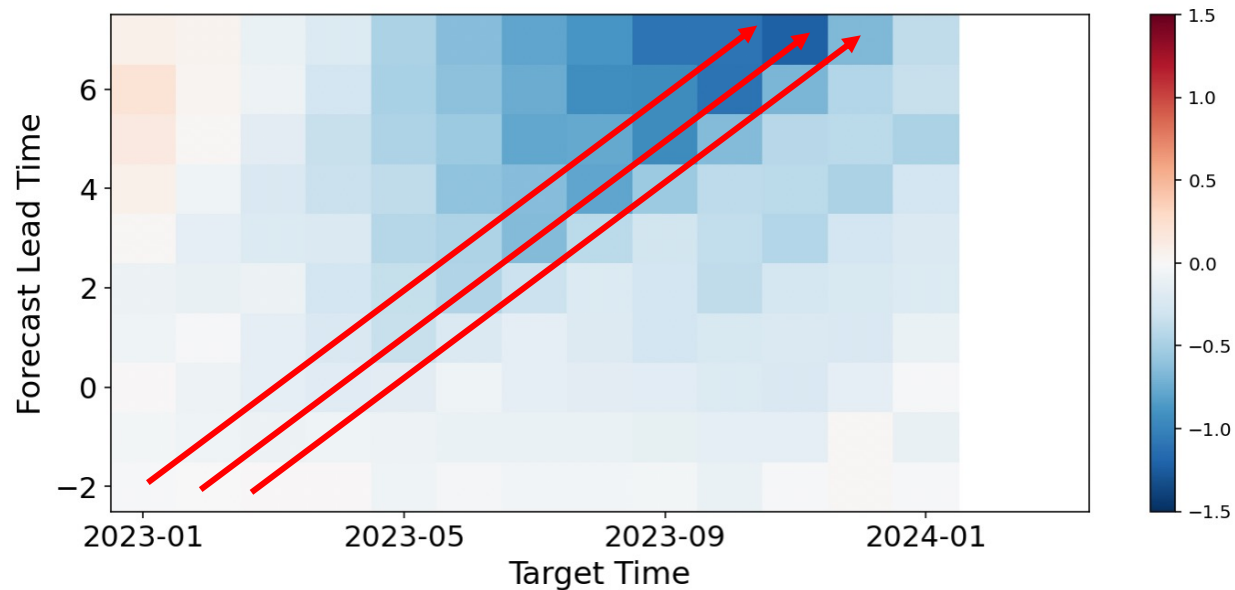
2) Support from subseasonal tropical weather which was anticipated to increase equatorial westerly wind anomalies.

Further bolstering the chance for El Niño is a short-term forecast for the [Madden-Julian Oscillation \(MJO\)](#). The MJO is an area of storminess that travels west-to-east along the equator. It's flanked by wind anomalies, as surface level winds rush toward the area of storminess. The MJO is predicted to be in a phase that will weaken the trade winds (the consistent east-to-west winds near the equator) over the next couple of weeks. Weaker trade winds allow the surface to warm and can contribute to the growth or propagation of downwelling Kelvin waves.

ENSO forecast team slightly under-predicted the amplitude of the event.



Consensus Fcst Error

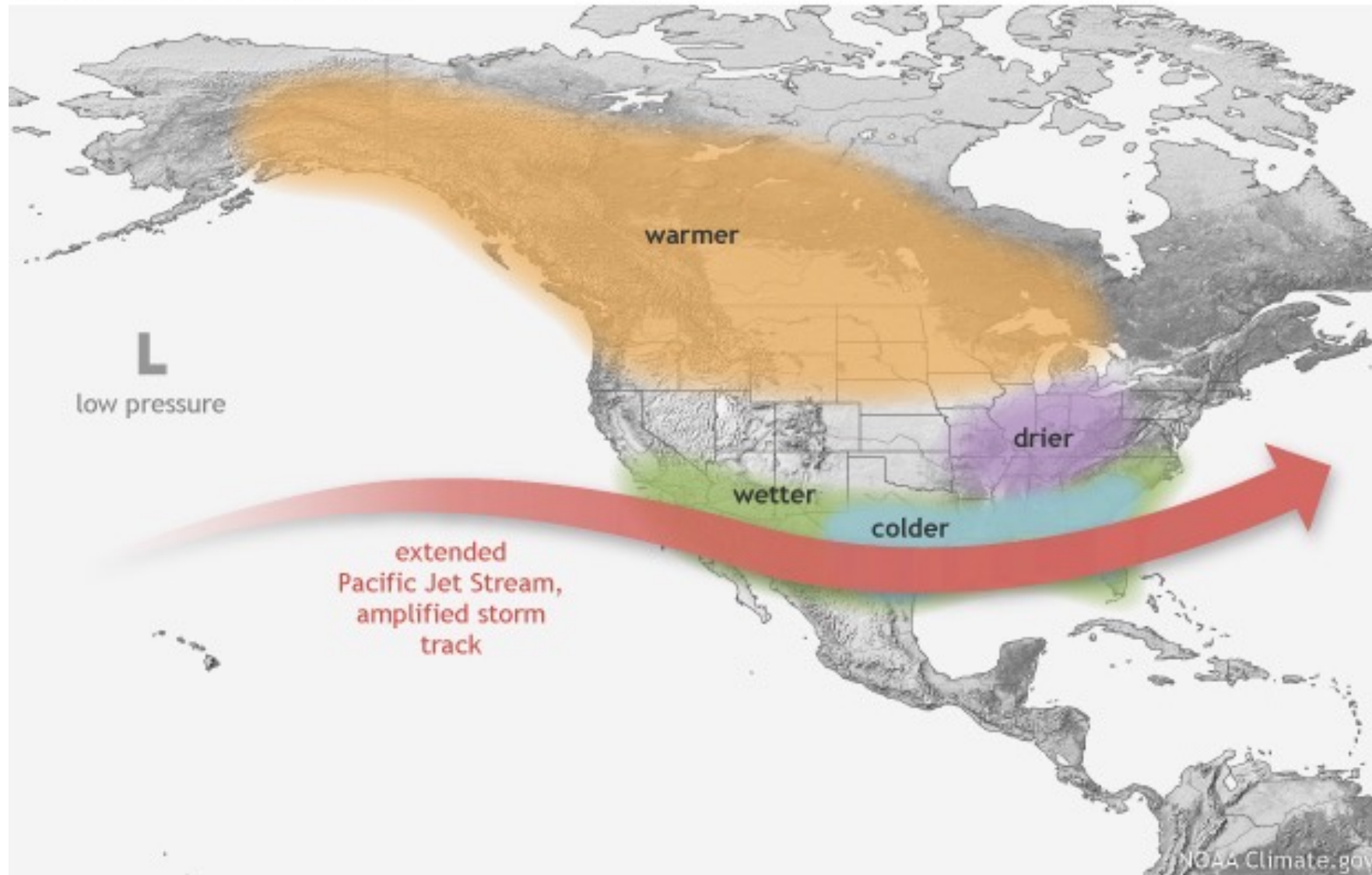


Particularly evident for forecasts initialized in January-March 2023

**Did we see El Niño impacts over the United States during
December 2023- February 2024?**

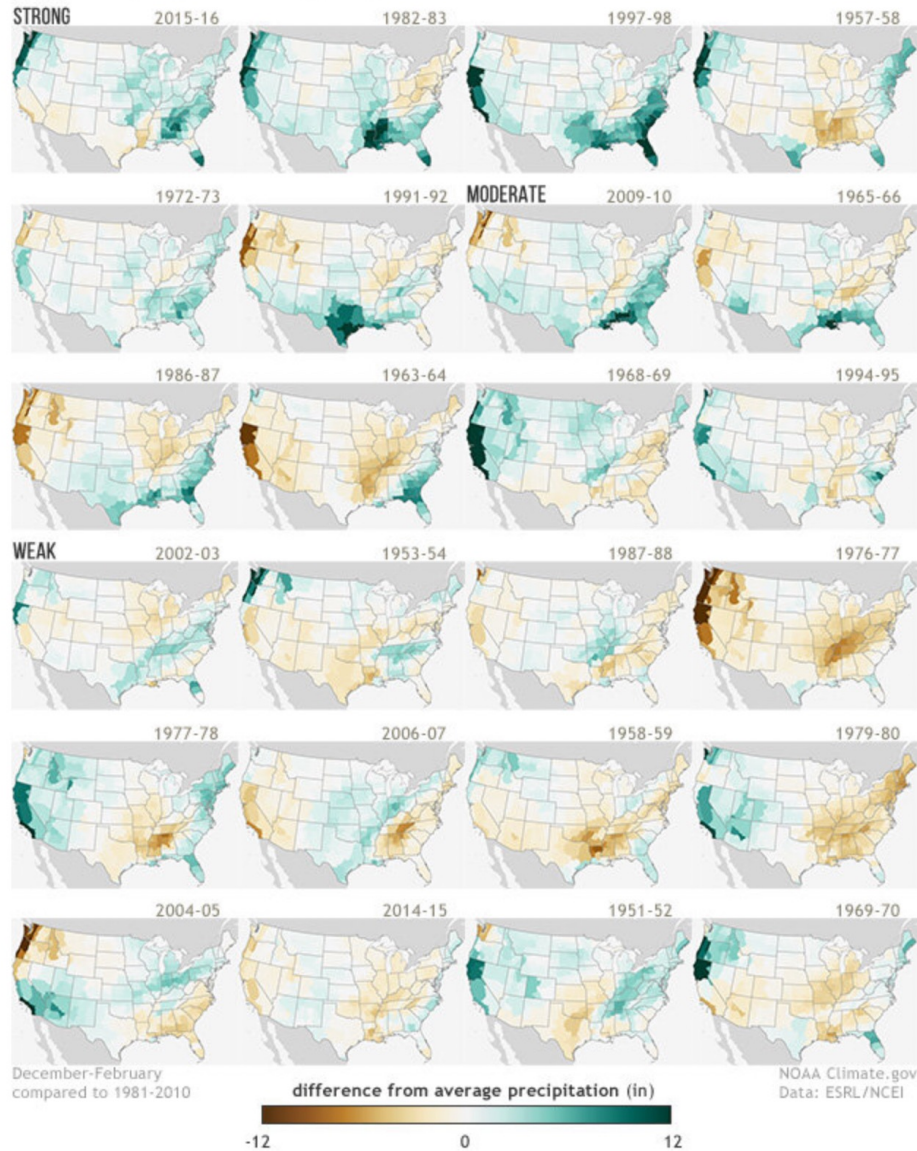
Want to show event-to-event variability vs. this simplified schematic

WINTER EL NIÑO PATTERN

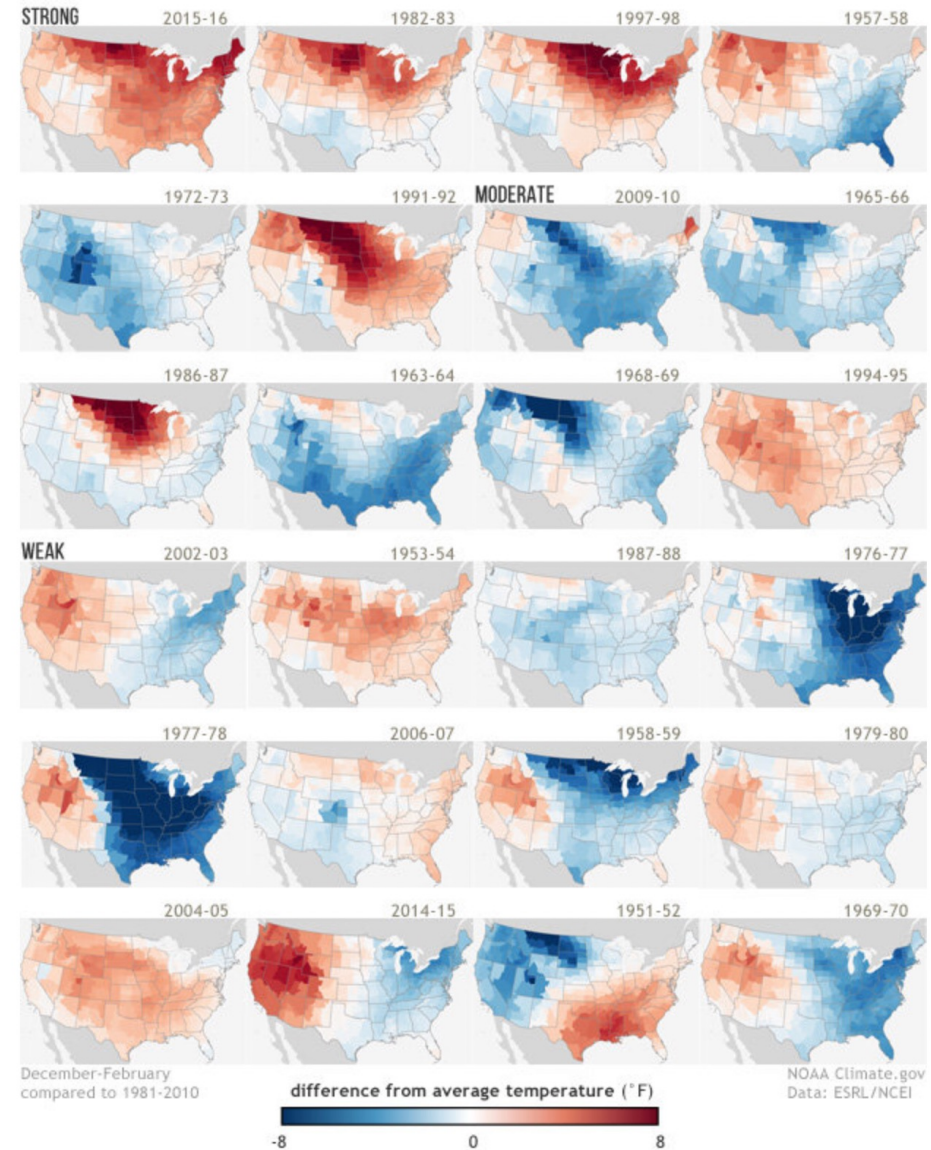


Postage stamp plots show everything, but this is a bit overwhelming.

U.S. winter precipitation during every El Niño since 1950



U.S. winter temperature during every El Niño since 1950

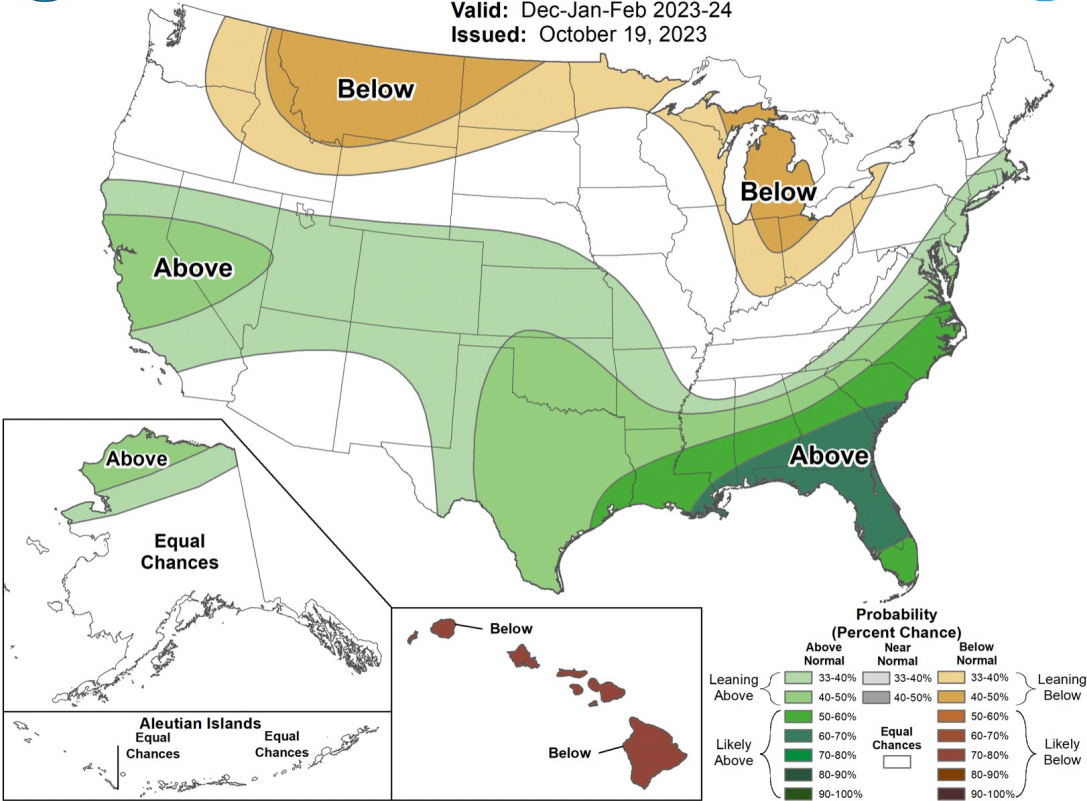


NOAA Climate Outlooks Emphasize Probabilities



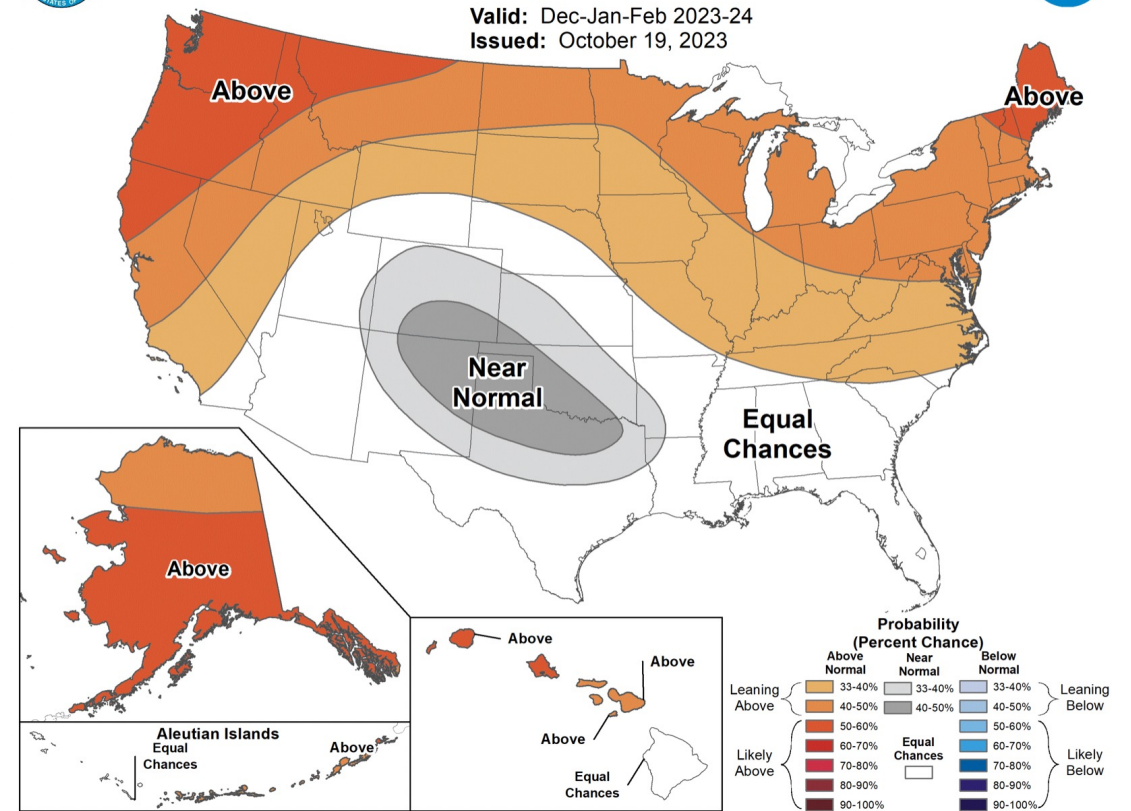
Seasonal Precipitation Outlook

Valid: Dec-Jan-Feb 2023-24
 Issued: October 19, 2023



Seasonal Temperature Outlook

Valid: Dec-Jan-Feb 2023-24
 Issued: October 19, 2023



Users (and, truthfully, many climate professionals) end up evaluating a given winter's forecast in a deterministic fashion...

Let's evaluate the quality of the relationship between the winter's climate anomalies and the "expected" (or typical) ENSO pattern.

Correlation!

Ranges from + 1 to -1

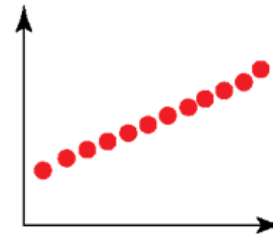
+1 or -1 means a perfect relationship.

0 = no relationship

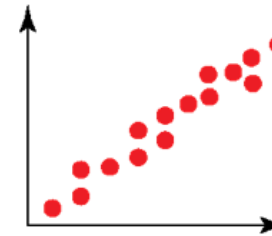
+ 1 = looks like El Niño

-1 = looks like La Niña

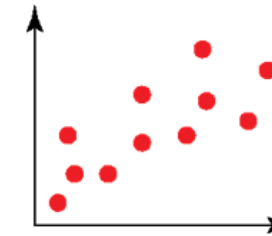
$r^2 \times 100$ = Percentage of Variability Explained.



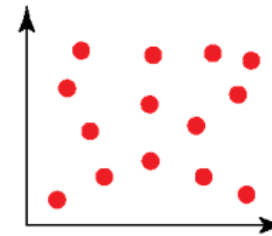
Perfect
Positive
Correlation



Strong
Positive
Correlation



Weak
Positive
Correlation

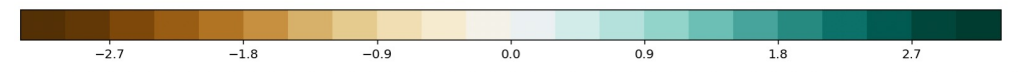
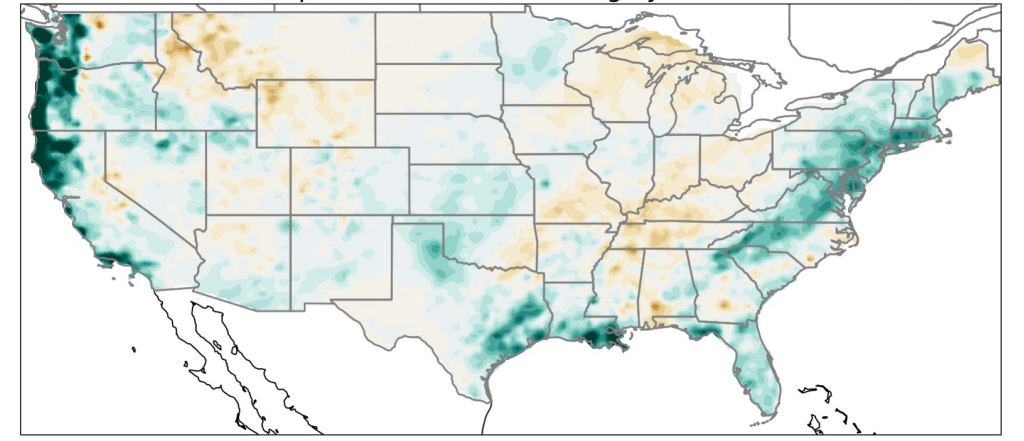
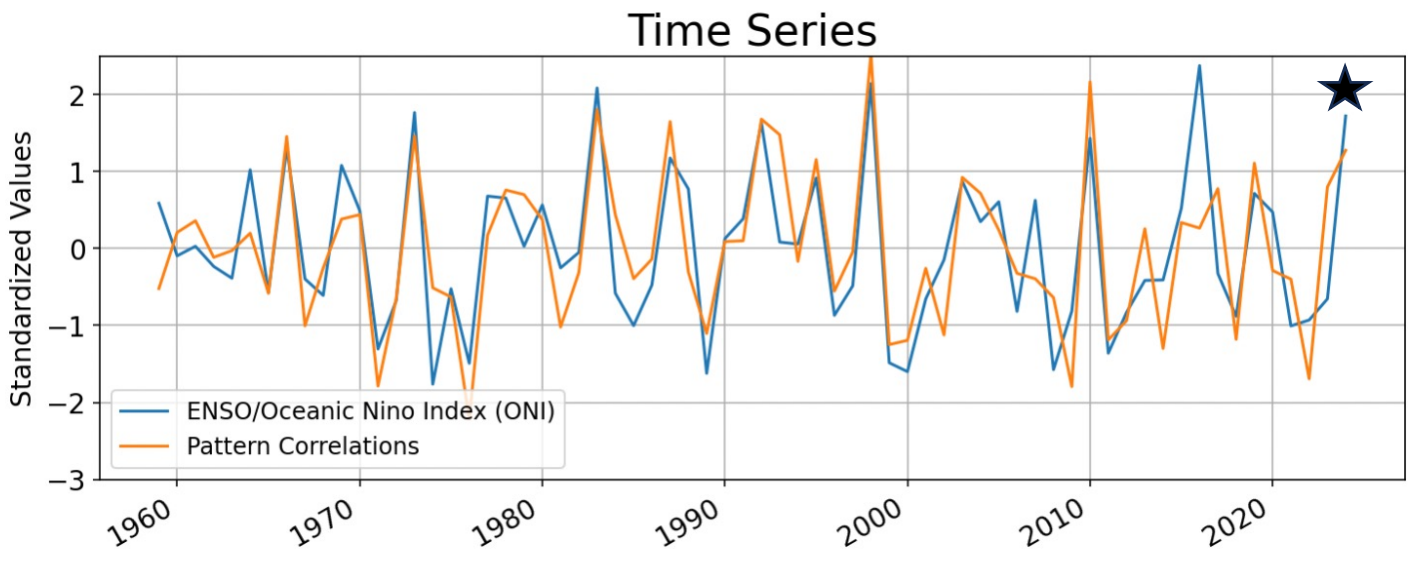


No
Correlation

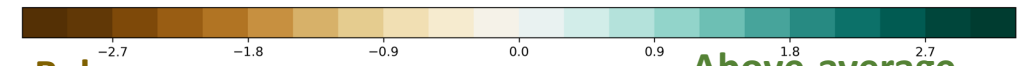
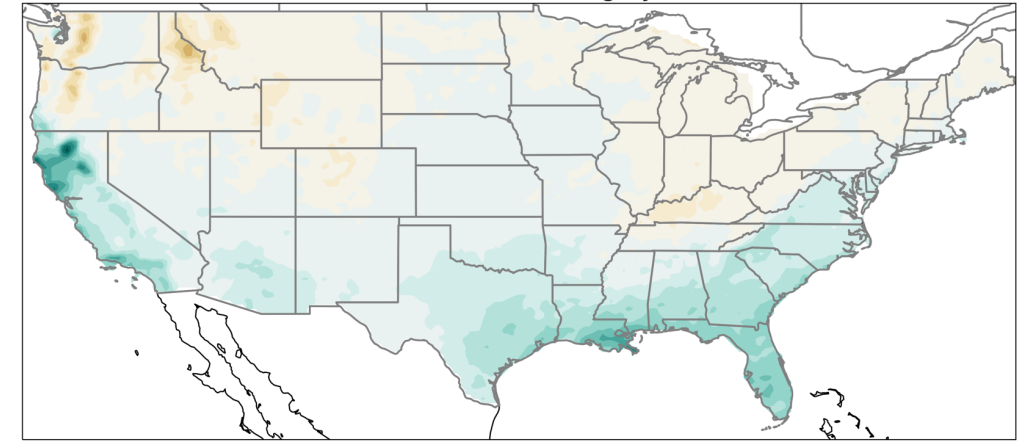
Pattern correlation: How much does Map A look like Map B?

December 2023- February 2024 Precipitation Anomalies

★ DJF 2023-24 Pattern Correlation = +0.39



Expected El Niño Impact

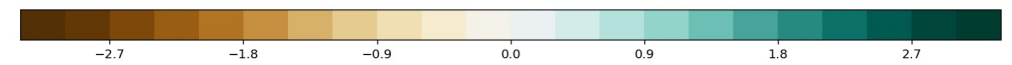
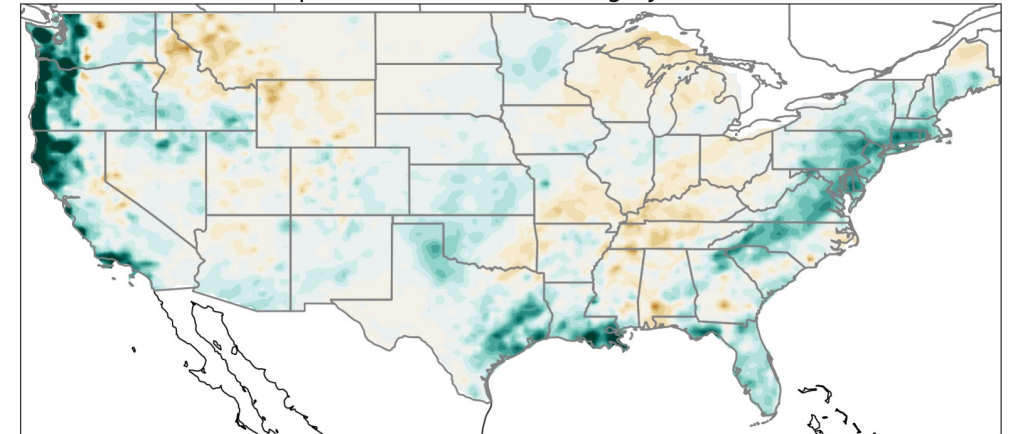
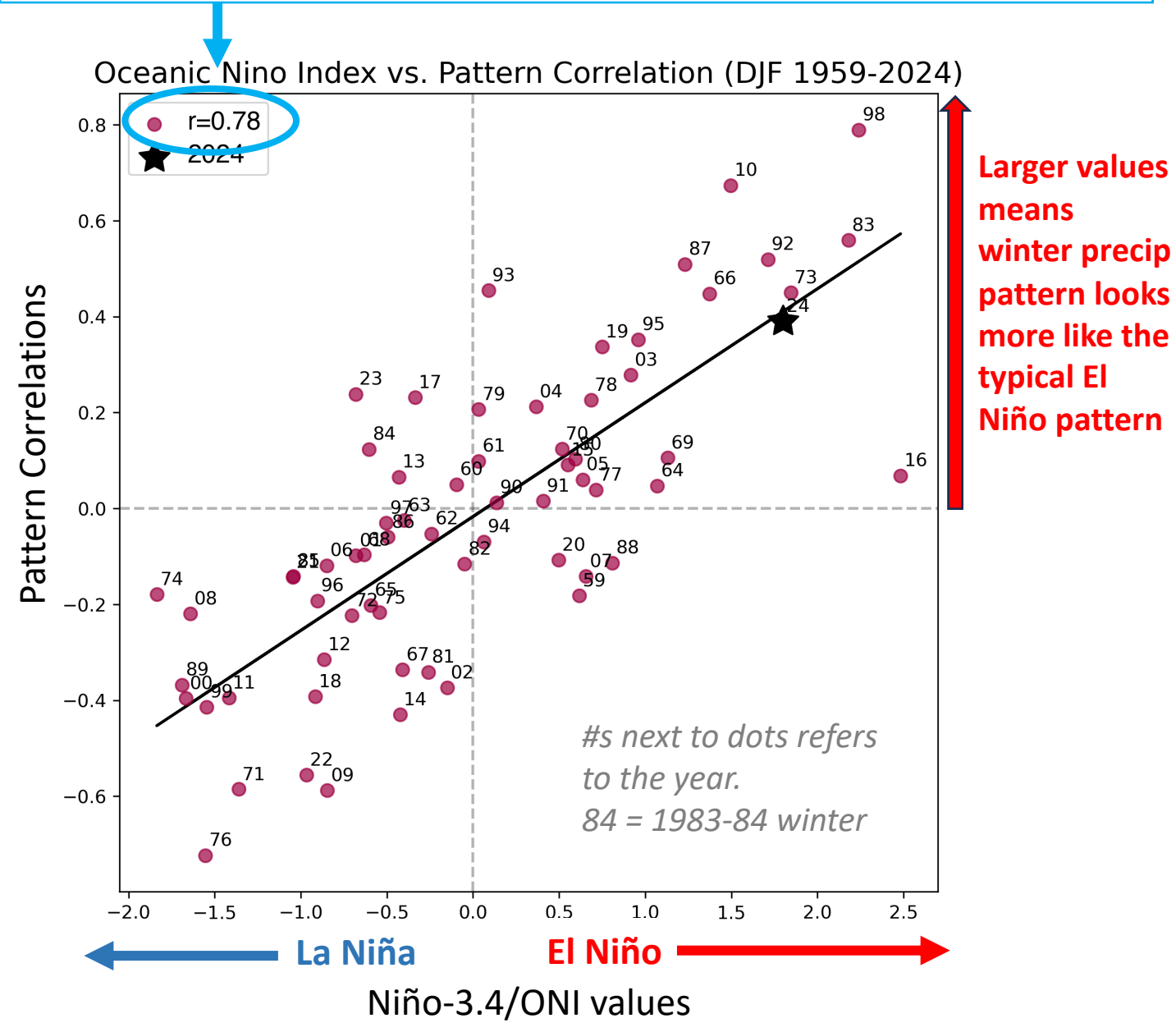


Below-average precipitation

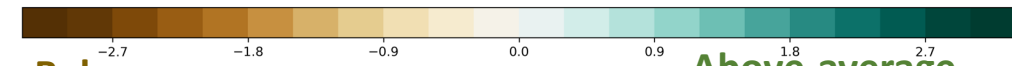
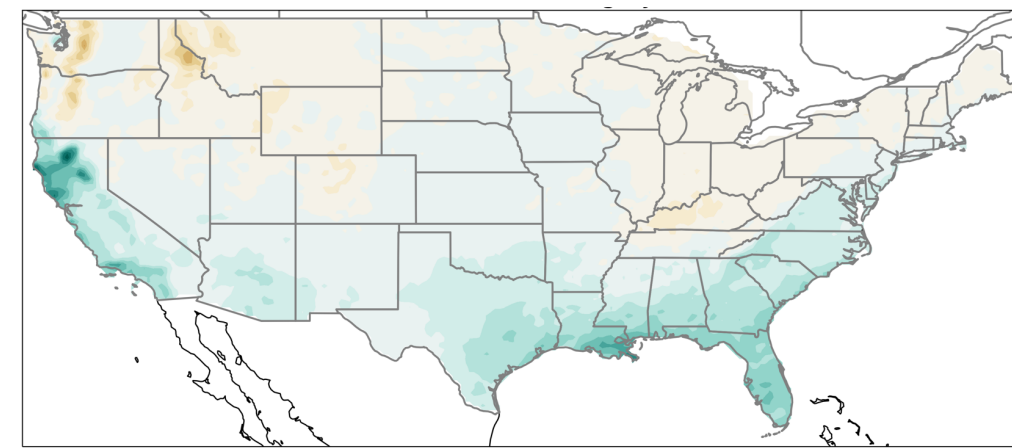
Above-average precipitation

Scatterplot correlation: How much does the ONI/ENSO index describe the variability in pattern correlations?

December 2023- February 2024 Precipitation Anomalies



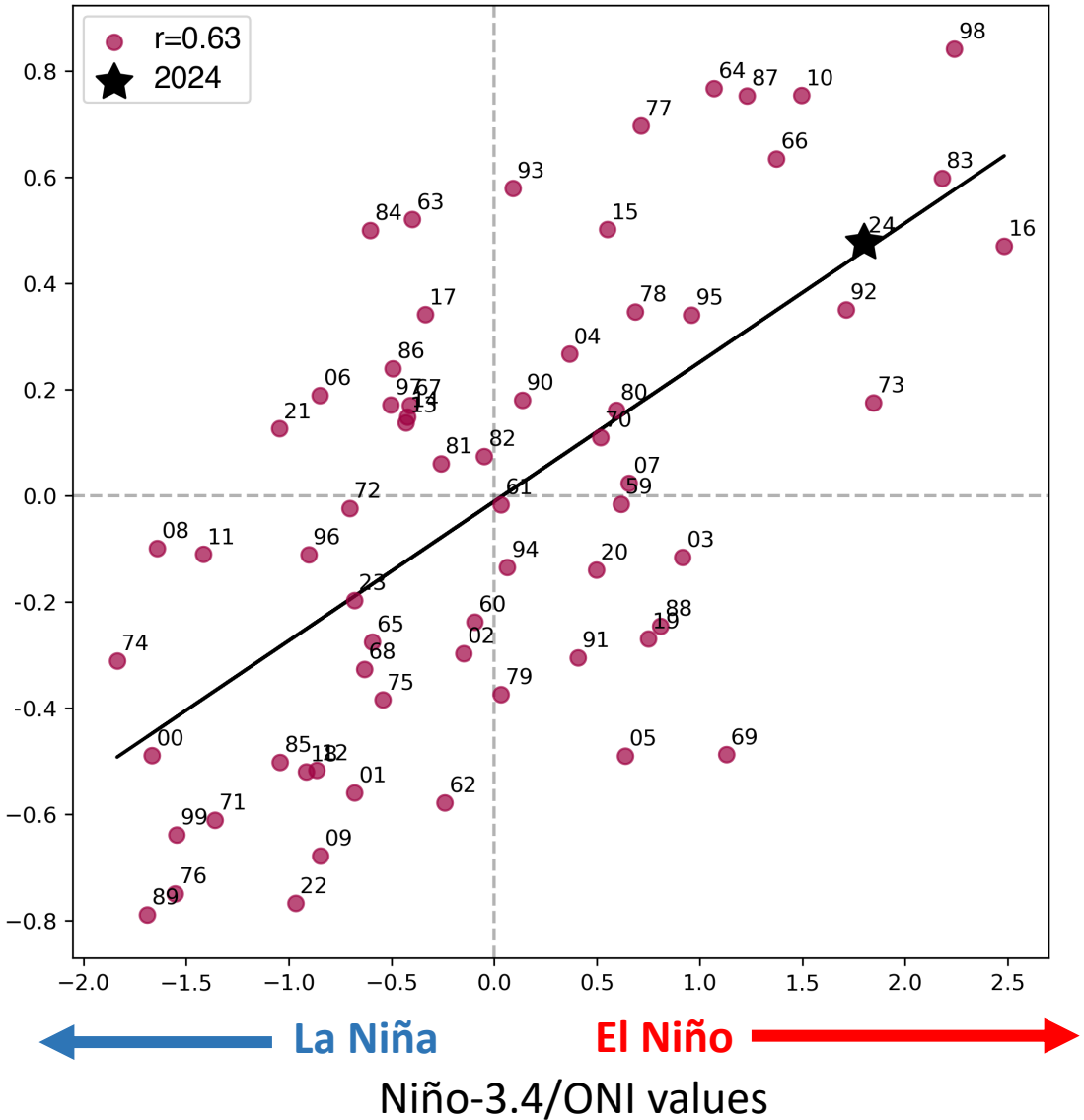
Expected El Niño Impact



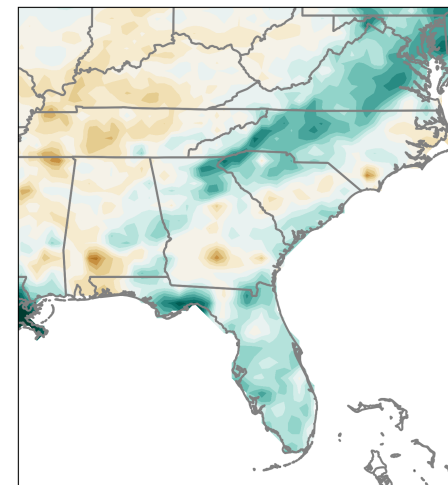
Below-average precipitation

Above-average precipitation

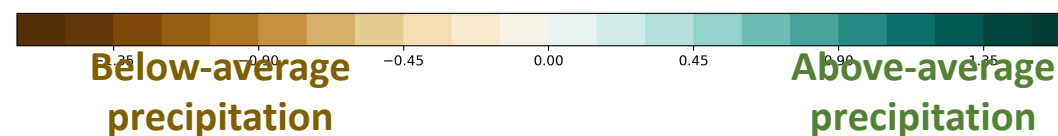
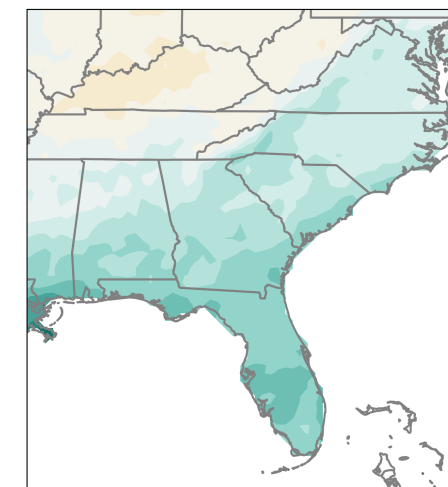
Oceanic Nino Index vs. Pattern Correlation (DJF 1959-2023)



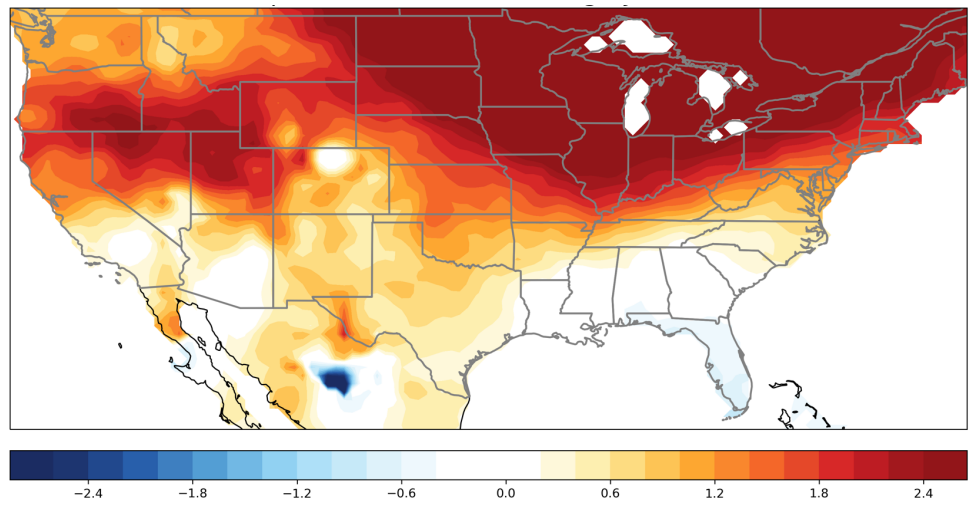
December 2023- February 2024 Precipitation Anomalies



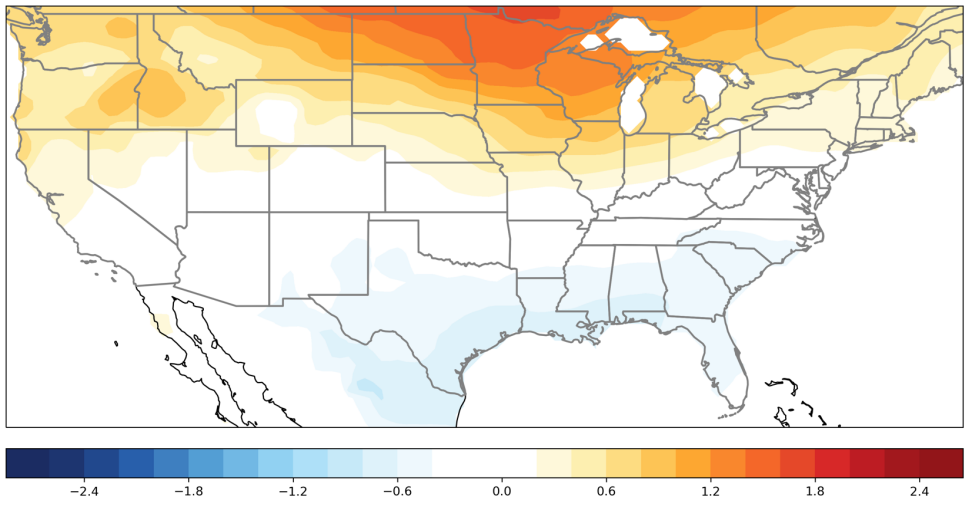
Expected El Niño Impact



December 2023- February 2024 Temperature Anomalies



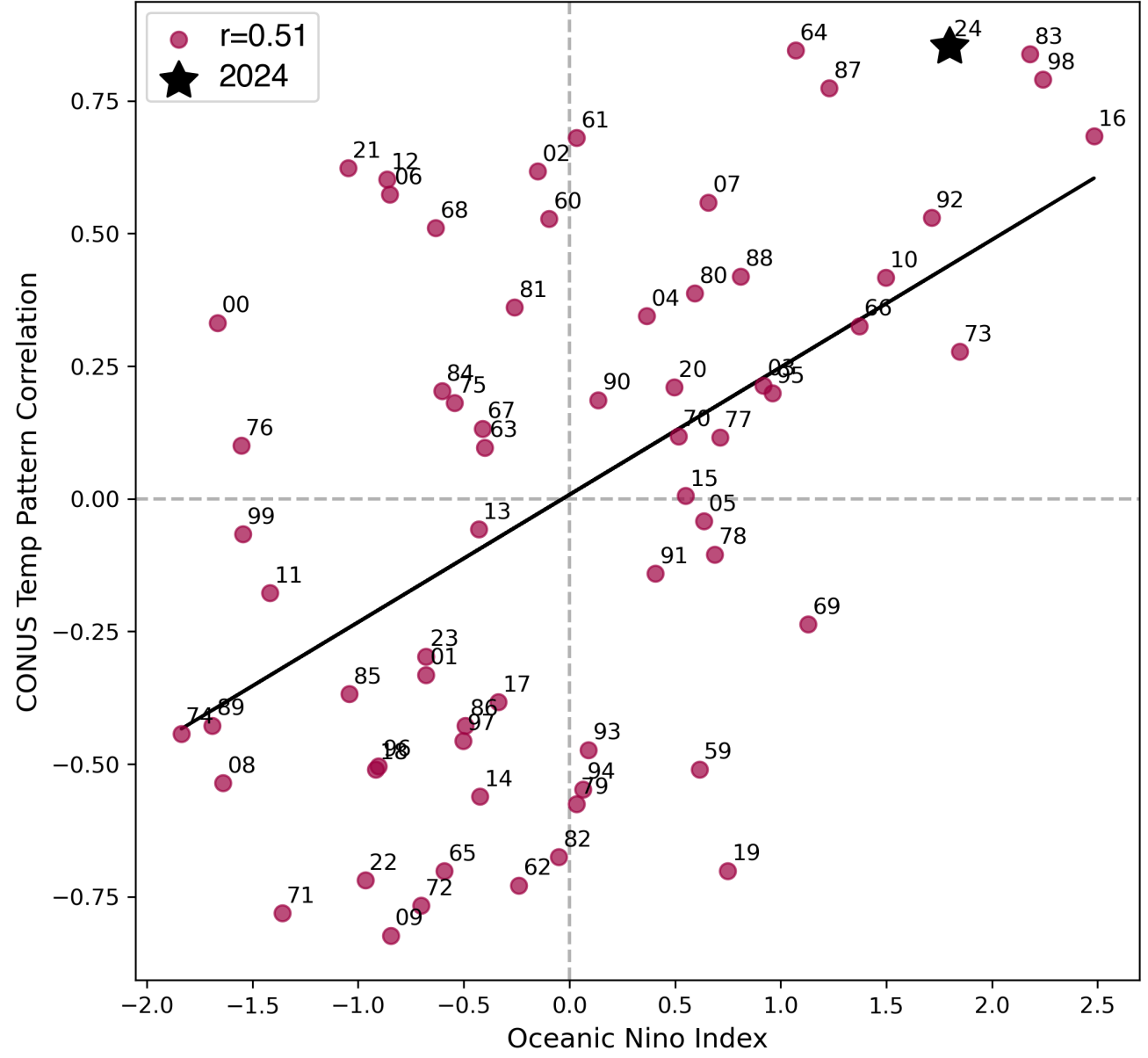
Expected El Niño Impact



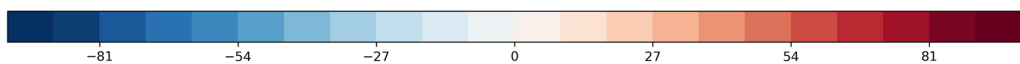
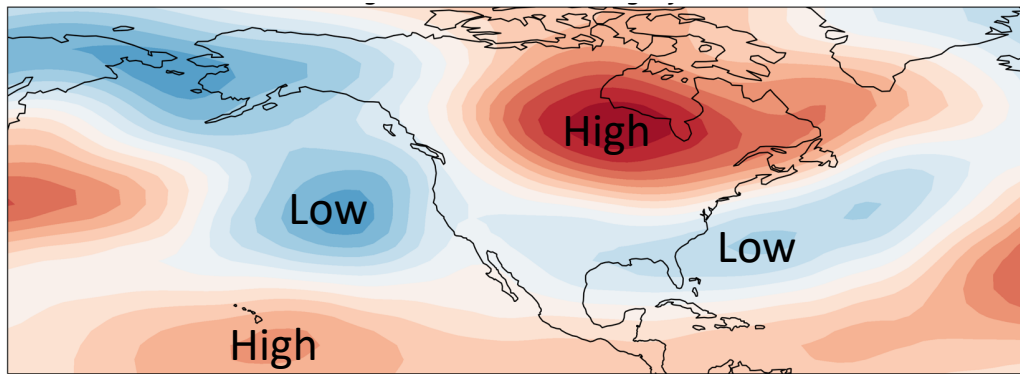
Below-average temperature

Above-average temperature

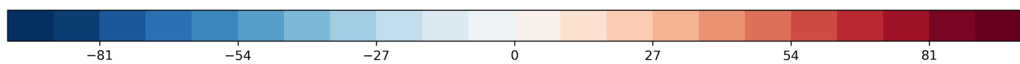
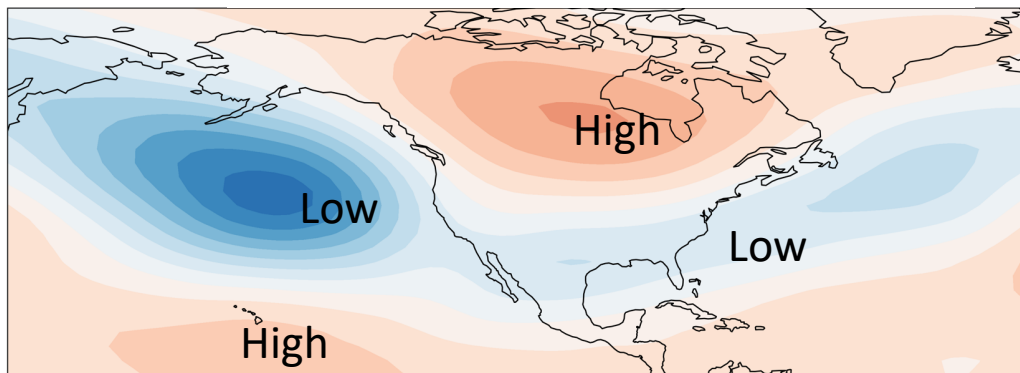
Oceanic Nino Index vs. Pattern Correlation (DJF 1959-2024)



December 2023- February 2024 Mid-Level Pressure Anomalies Oceanic Nino Index vs. Pattern Correlation (DJF 1959-2024)

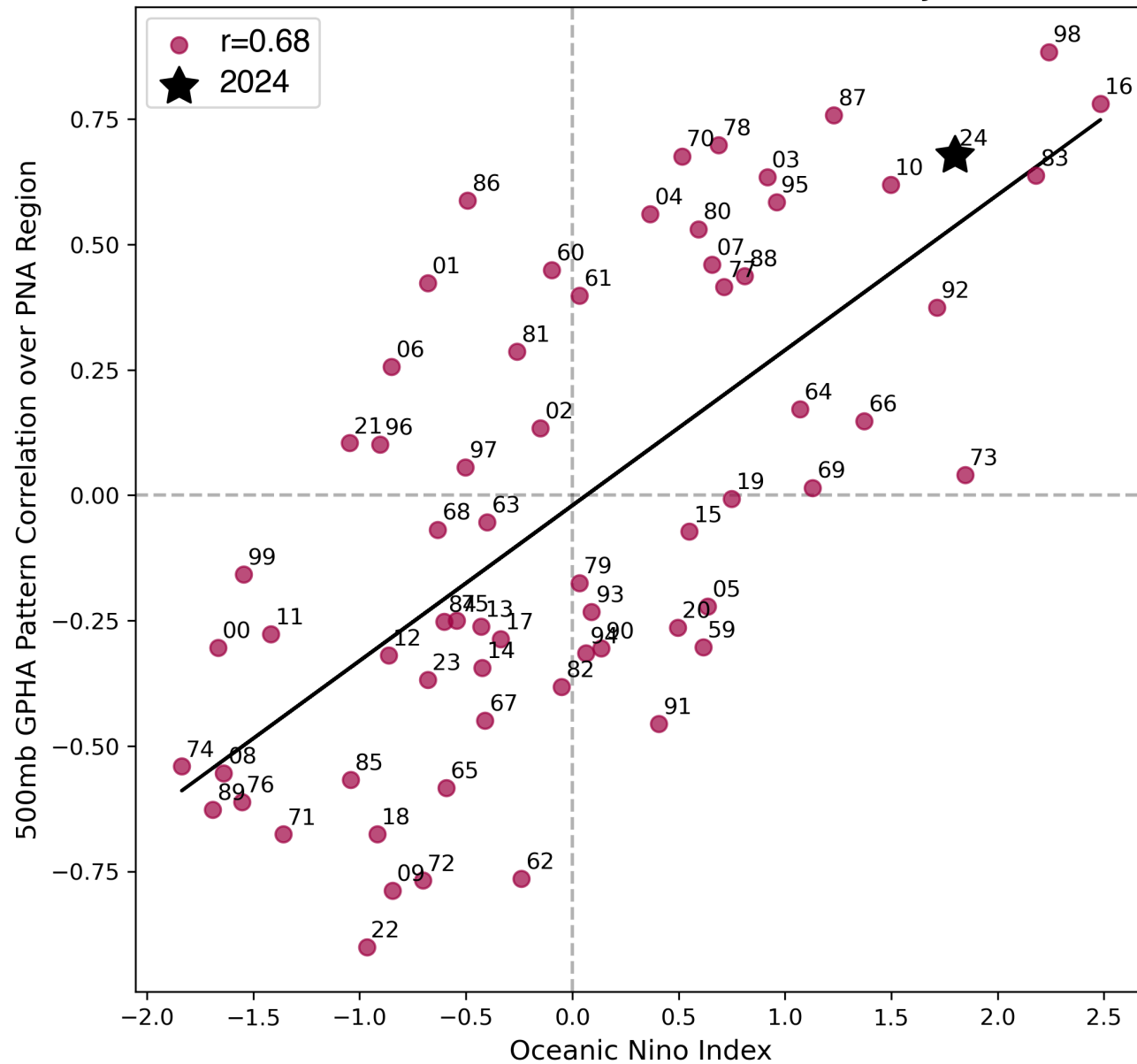


Expected El Niño Impact

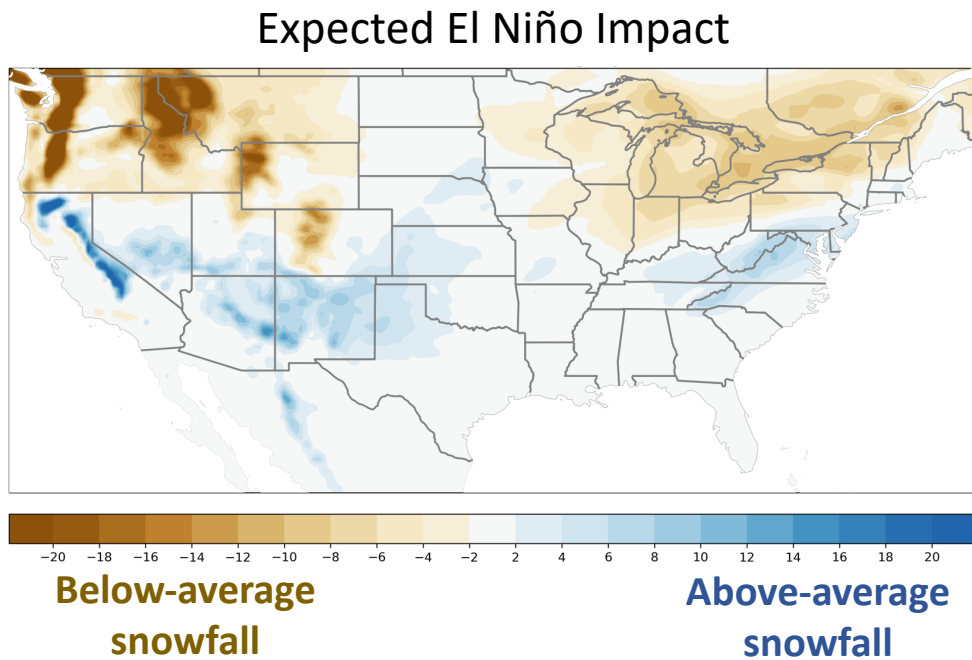
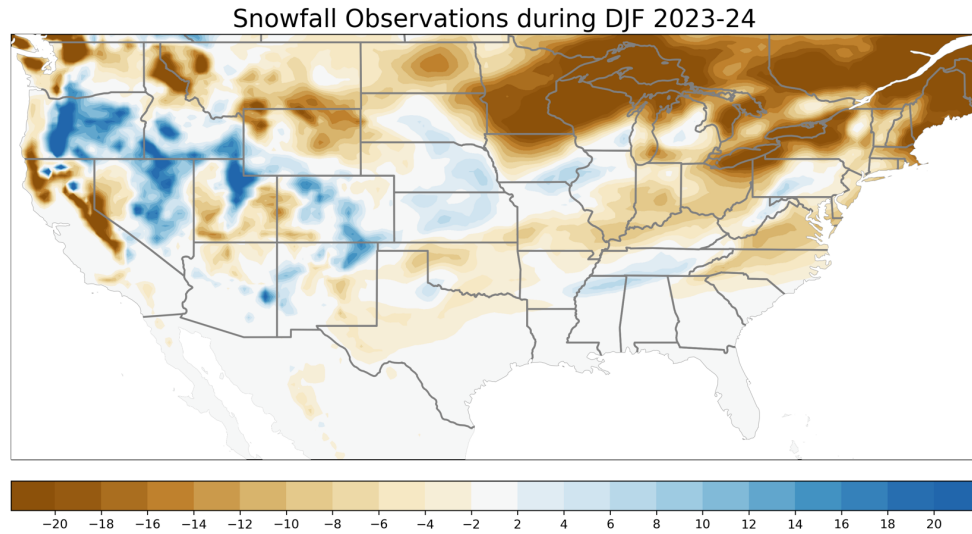


Below-average pressure

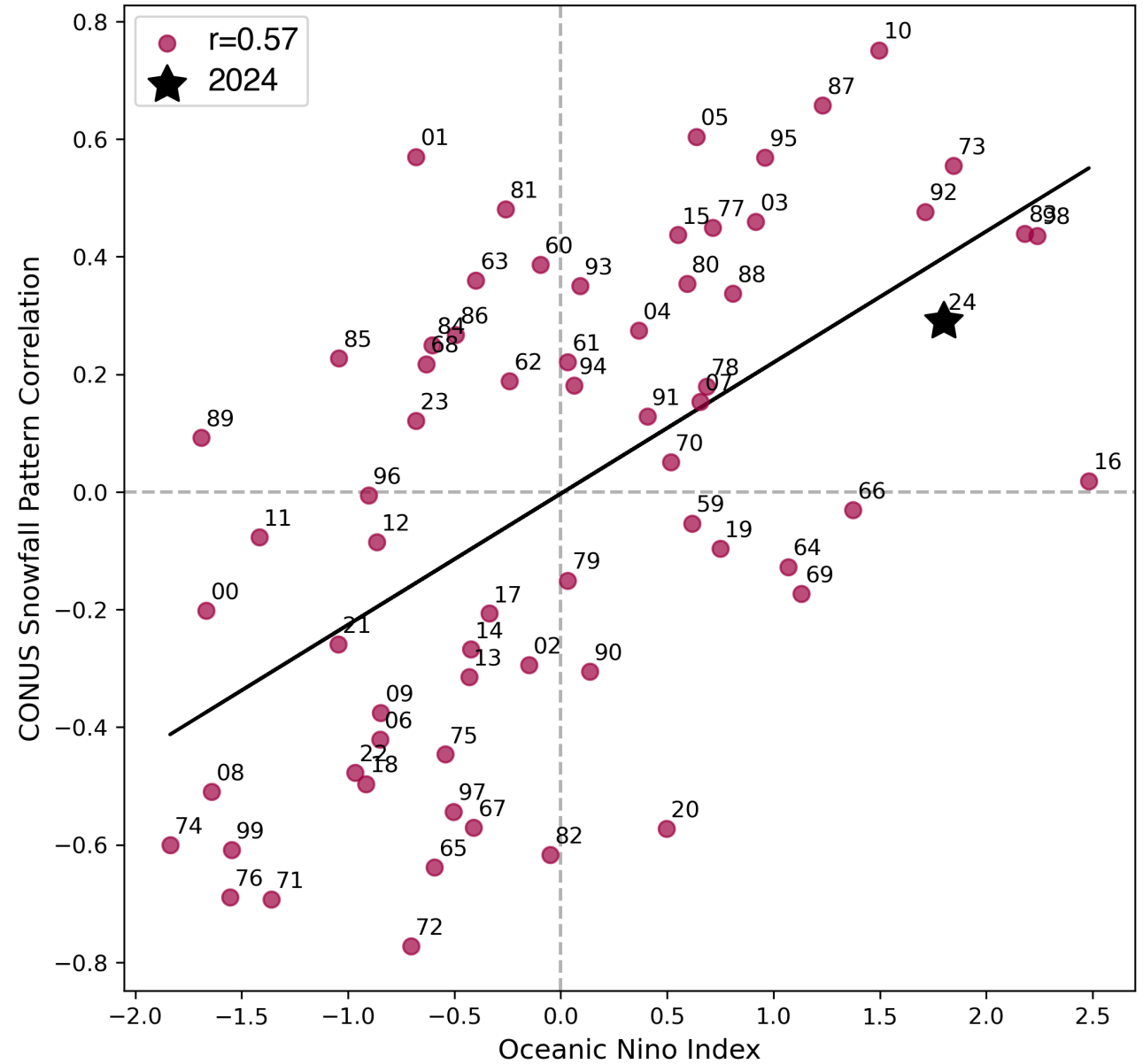
Above-average pressure



December 2023- February 2024 Snowfall Anomalies



Oceanic Nino Index vs. Pattern Correlation (DJF 1959-2024)





Summary



- The strong 2023-24 El Niño was well predicted by NOAA (slightly underpredicted), with 9 months of lead time given from when an El Niño Watch was issued to the start of the Winter season.
- Pattern correlations convey the quality of the fit between the observed anomalies and deterministic, “expected” ENSO pattern.
- Pattern correlation scales by ENSO strength with stronger events leading to a better match between observations and ENSO.
- The 2023-24 winter generally performed as expected for an event of this strength.