An Update on ENSO at NOAA Climate Prediction Center: Analysis, Perspectives, and Explorations

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** Note: Is a non-member participant and is not speaking on behalf of the United States Government.

A Relative Niño-3.4 index for ENSO monitoring and prediction

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Defining El Niño indices in a warming climate

Geert Jan van Oldenborgh[9,1], Harry Hendon[2], Timothy Stockdale[3], Michelle L'Heureux[4], Erin Coughlan de Perez[5,6,7], Roop Singh[5] and Maarten van Aalst[5,7,8]

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A Relative Sea Surface Temperature Index for Classifying ENSO Events in a Changing Climate

Michelle L. L'Heureux, Michael K. Tippett, Matthew C. Wheeler, Hanh Nguyen, Sugata Narsey, Nathaniel Johnson, Zeng-Zhen Hu, Andrew B. Watkins, Chris Lucas, Catherine Ganter, Emily Becker, Wanqiu Wang, and Tom Di Liberto

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Page(s): 1197–1211

Where can I find Relative ONI? https://www.cpc.ncep.noaa.gov/data/indices/RONI.ascii.txt
Github with Python code: https://github.com/michellelheureux/Relative-SST

I. **Background/Motivation**

II. Introducing Relative Sea Surface Temperatures

III. Can the Relative Niño-3.4 index be skillfully predicted?

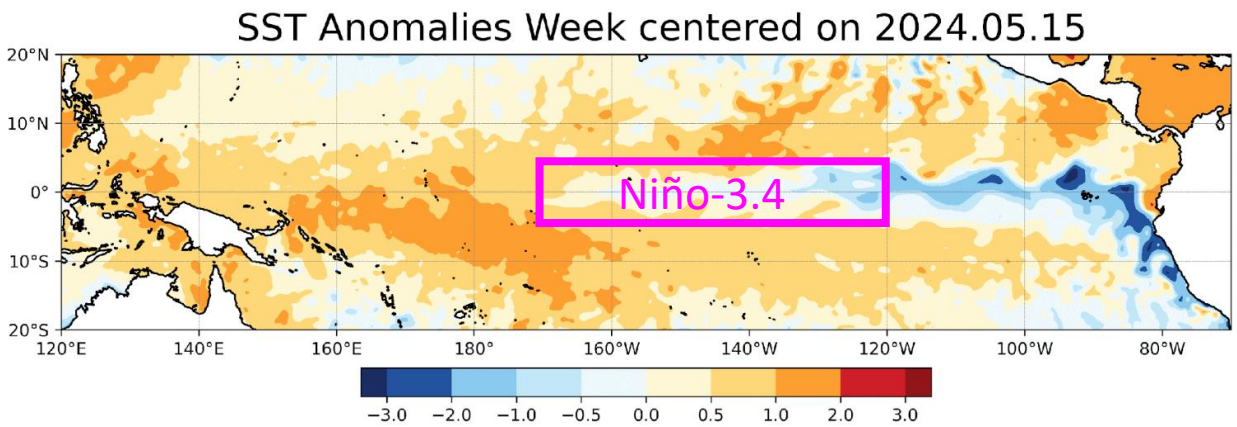
IV. What Is Occurring Now?

- ENSO is often measured as a Departure from Normal (or Anomaly) in Sea Surface Temperatures (SST): El Niño is above-average & La Niña is below-average

- What is defined as an EL Niño or La Niña event depends on the chosen "reference period," or what we define as normal or typical.

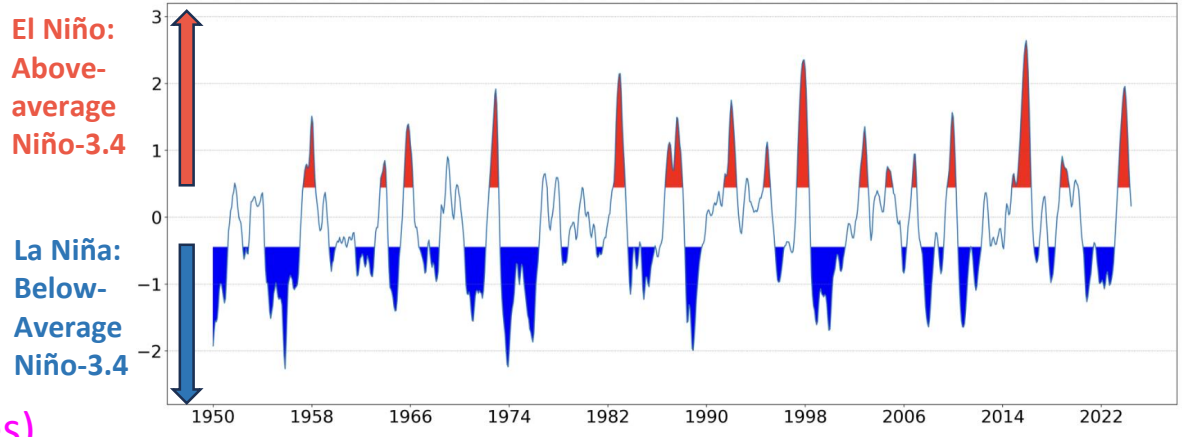
- "Base period" or "Climatology" are equivalent terms used to express the reference period.

- In this talk, will emphasize the **NOAA** ENSO definition: At least 5 consecutive overlapping seasons in the Niño-3.4 region in excess of +/-0.5˚C. *Not an optimal definition for every purpose (e.g. Coastal El Niño).*



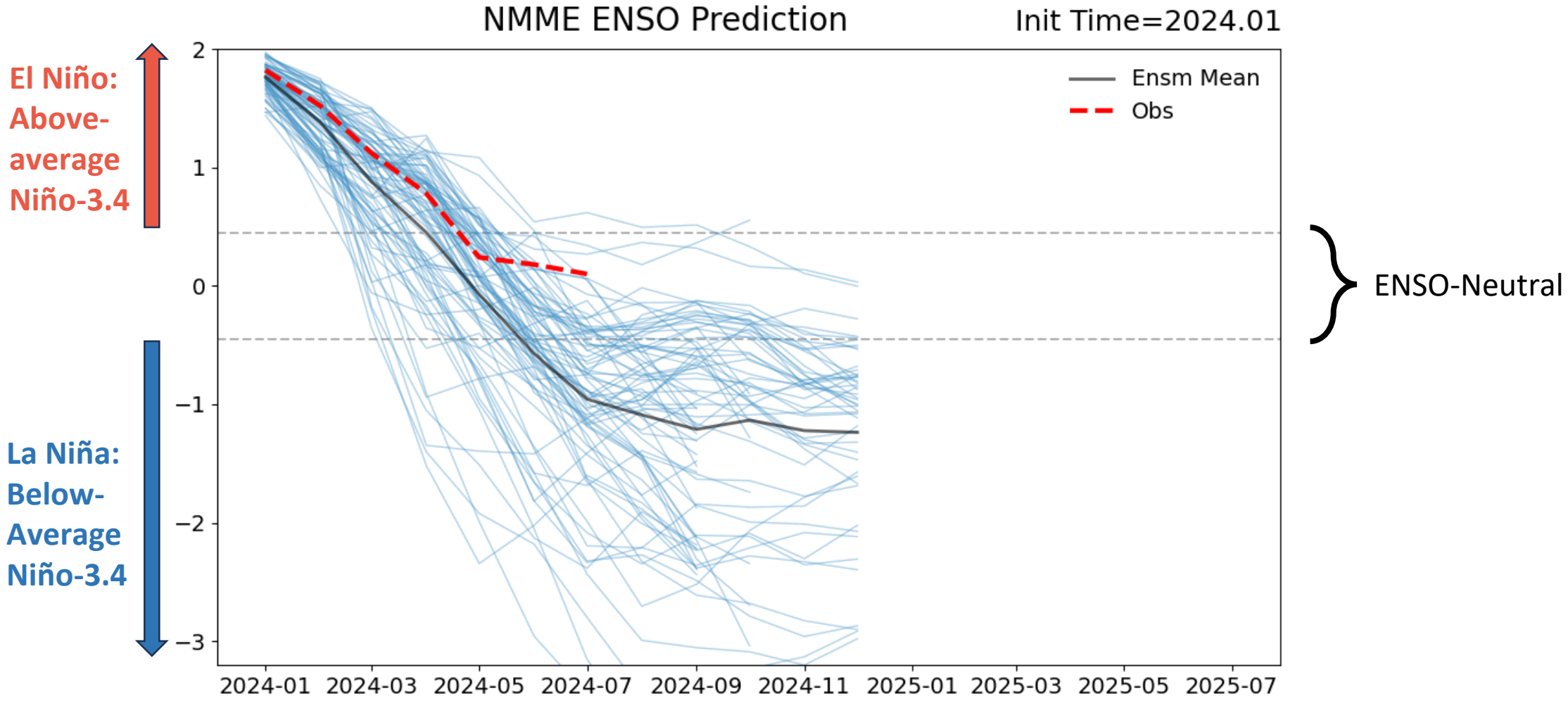
The average of SST anomalies in Niño-3.4 is an "index" (time series)

Seasonal averages in Niño-3.4 is the Oceanic Niño Index (ONI)



Base Period/Climatology: 1991-2020 averages

ENSO Forecasts as a departure from average:
January - August 2024 initializations from the North American Multi-model Ensemble*



Right now, NOAA is in a "La Niña Watch," which means that La Niña may develop in the coming months

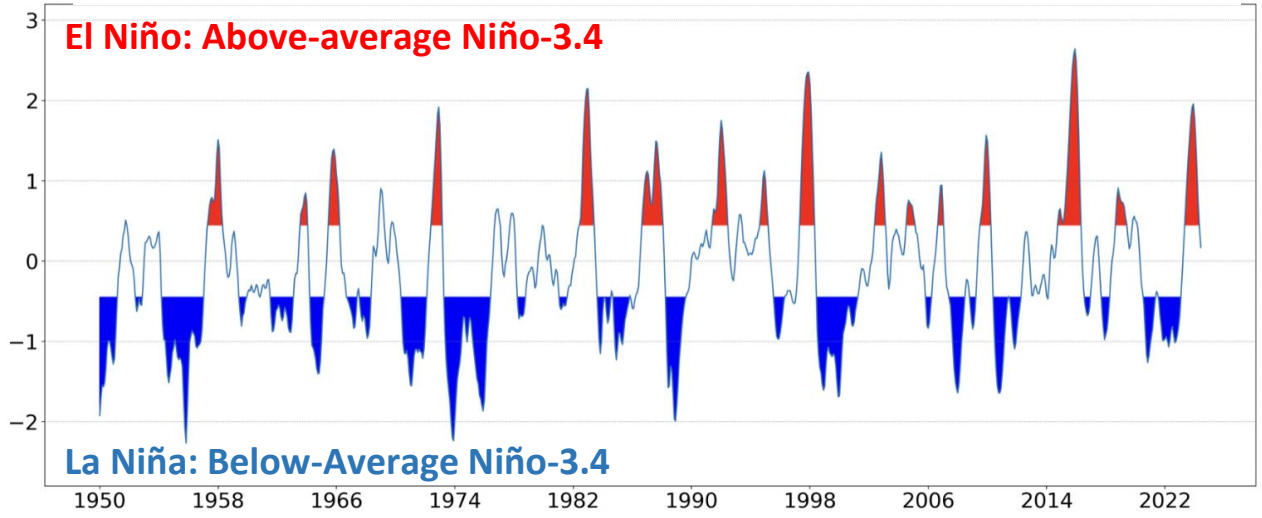
Base period: 1991-2020

* NMME data retrieved from the IRI Data Library

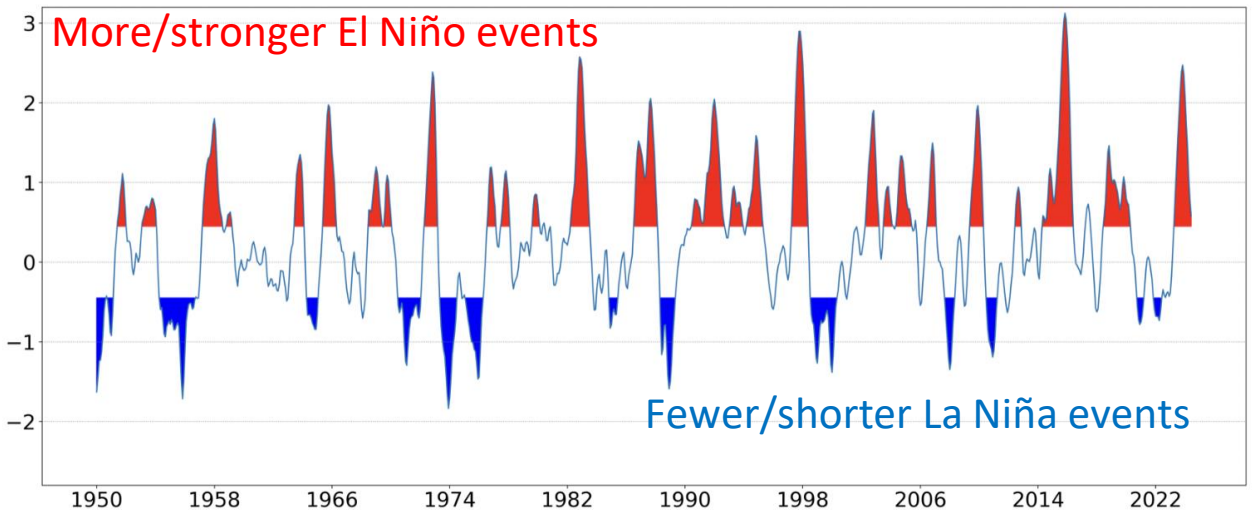
Problem: Past El Niño or La Niña events are classified differently depending on the selected Climatology/Base Period

What is considered an El Niño or La Niña event changes depending on when you lived and what you thought was normal!

El Niño and La Niña events with a 1991-2020 climatology



El Niño and La Niña events with a 1941-1970 climatology

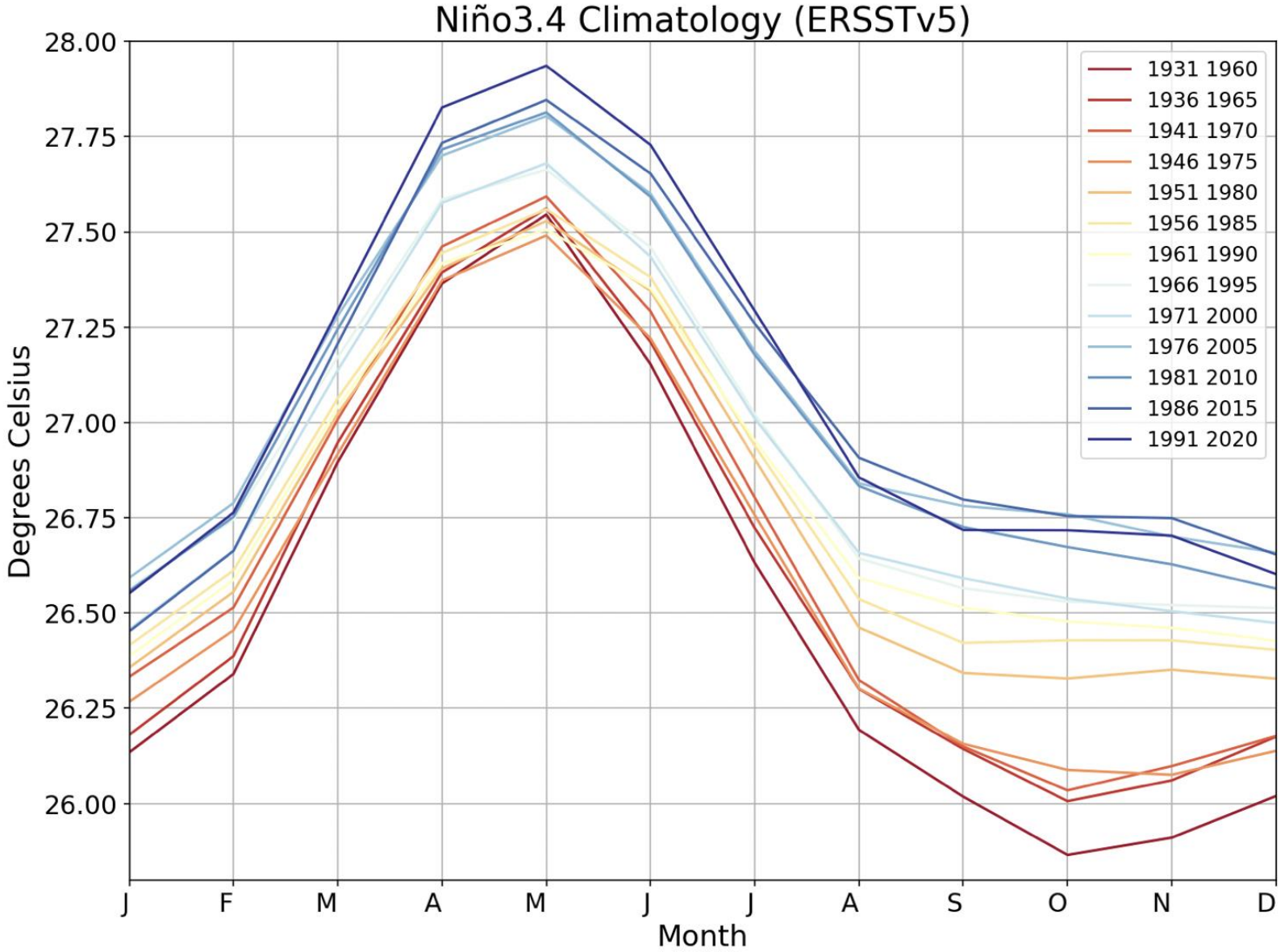


Why is this happening?

ERSSTv5 data

ERSSTv5 data

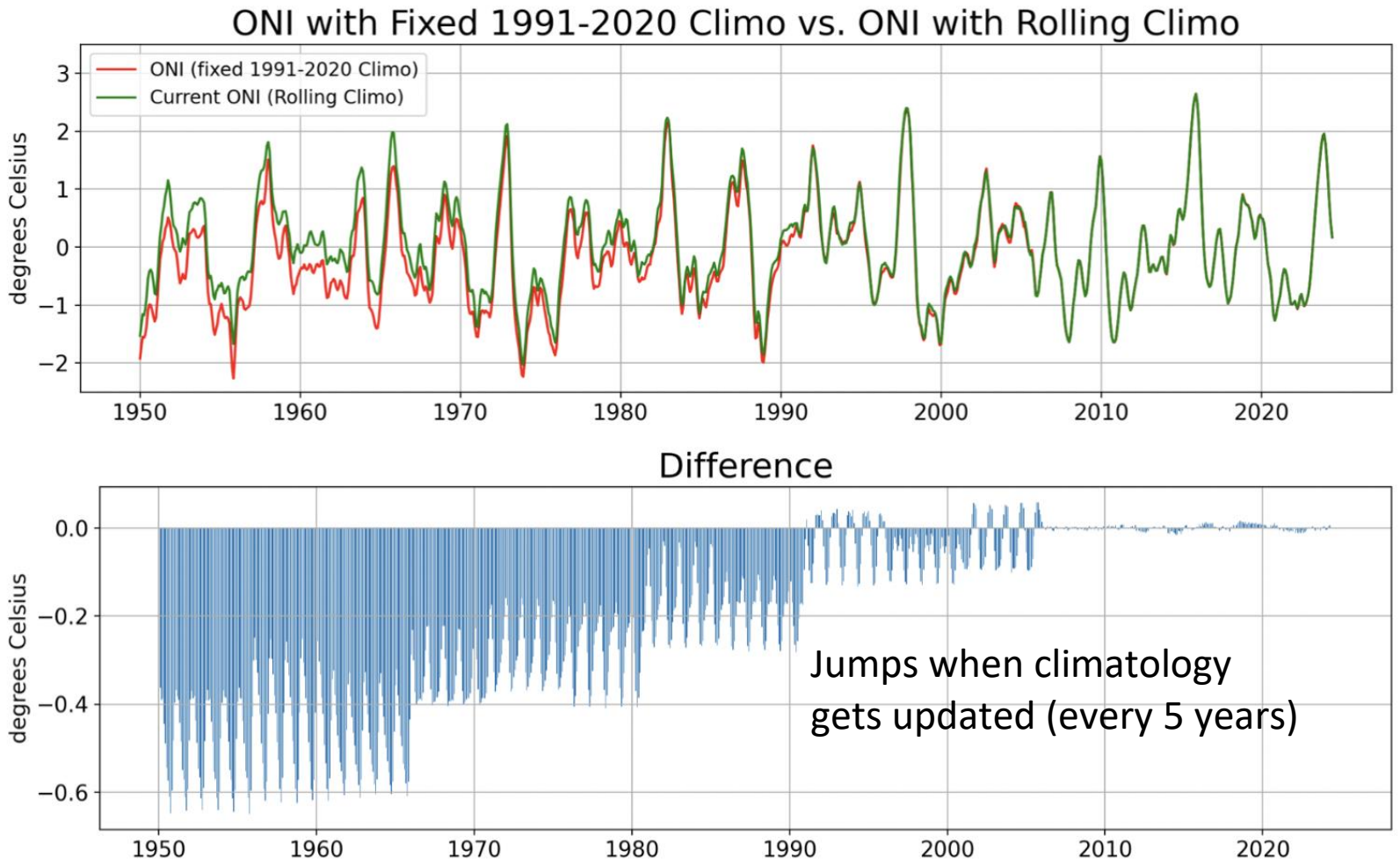
The Base Period Is Changing!



Overlapping 30-year climatologies/ base periods

Goal for an ENSO Index: Reduce the influence of the choice of a climatology and identify roughly the same El Nino and La Nina events no matter the choice.

NOAA currently defines climatology with 30-year base periods updating and rolling through the historical record



In real-time we use a *lagged* 30-year climatology.
Values can change a lot when the climatology is updated/rolled forward.
This is complicated and not ideal.

ERSSTv5 data

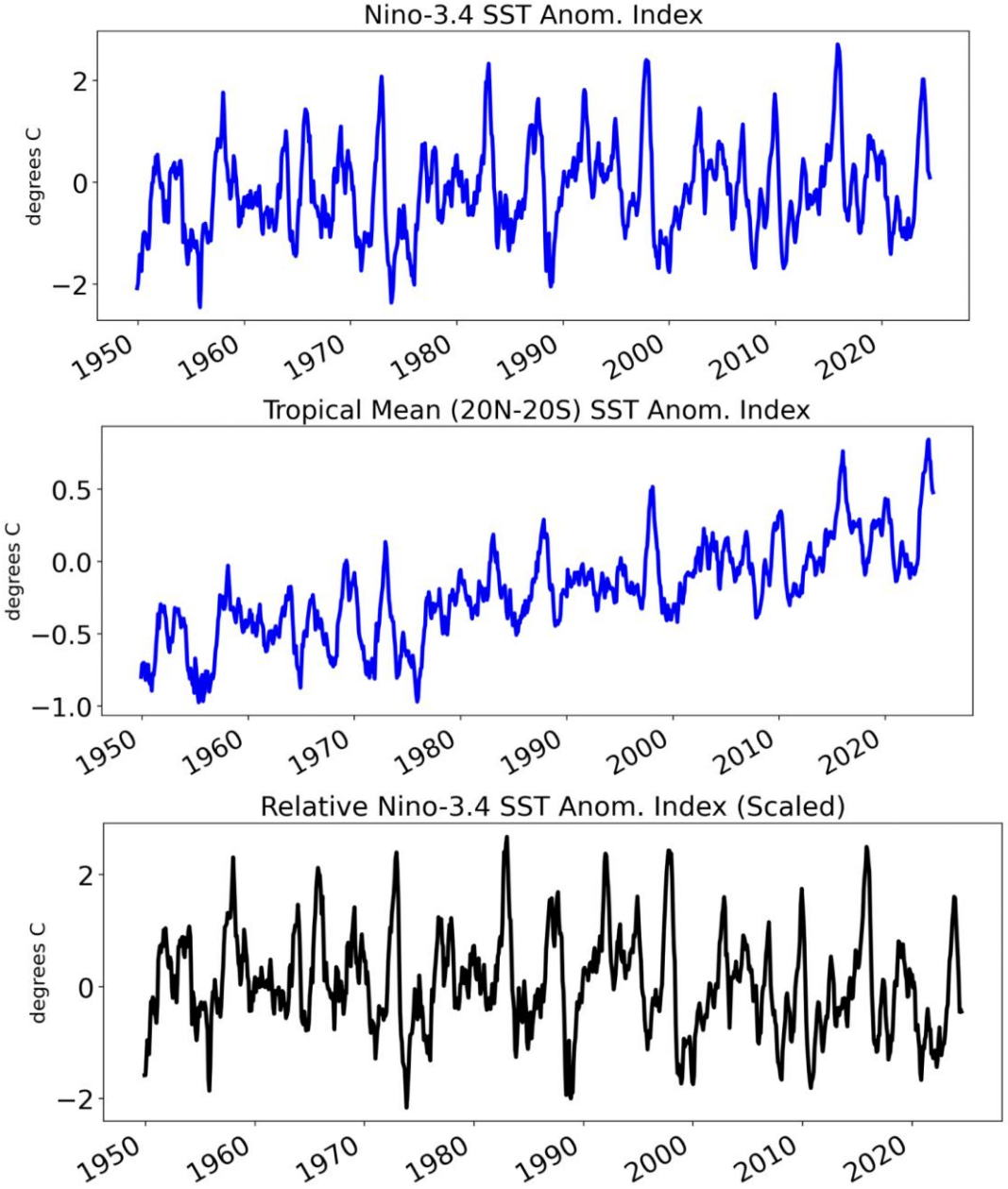
I. Background/Motivation

II. Introducing Relative Sea Surface Temperatures

III. Can the Relative Niño-3.4 index be skillfully predicted?

IV. What Is Occurring Now?

Introducing Relative Niño-3.4/ONI Sea Surface Temperatures



ERSSTv5 data

(1) Niño3.4 index and the tropical mean SST (20°S-20°N) index are both computed as departures from a 30yr climatology (e.g., 1991-2020).

(2) The tropical mean SST index is then subtracted from the Niño3.4 index.

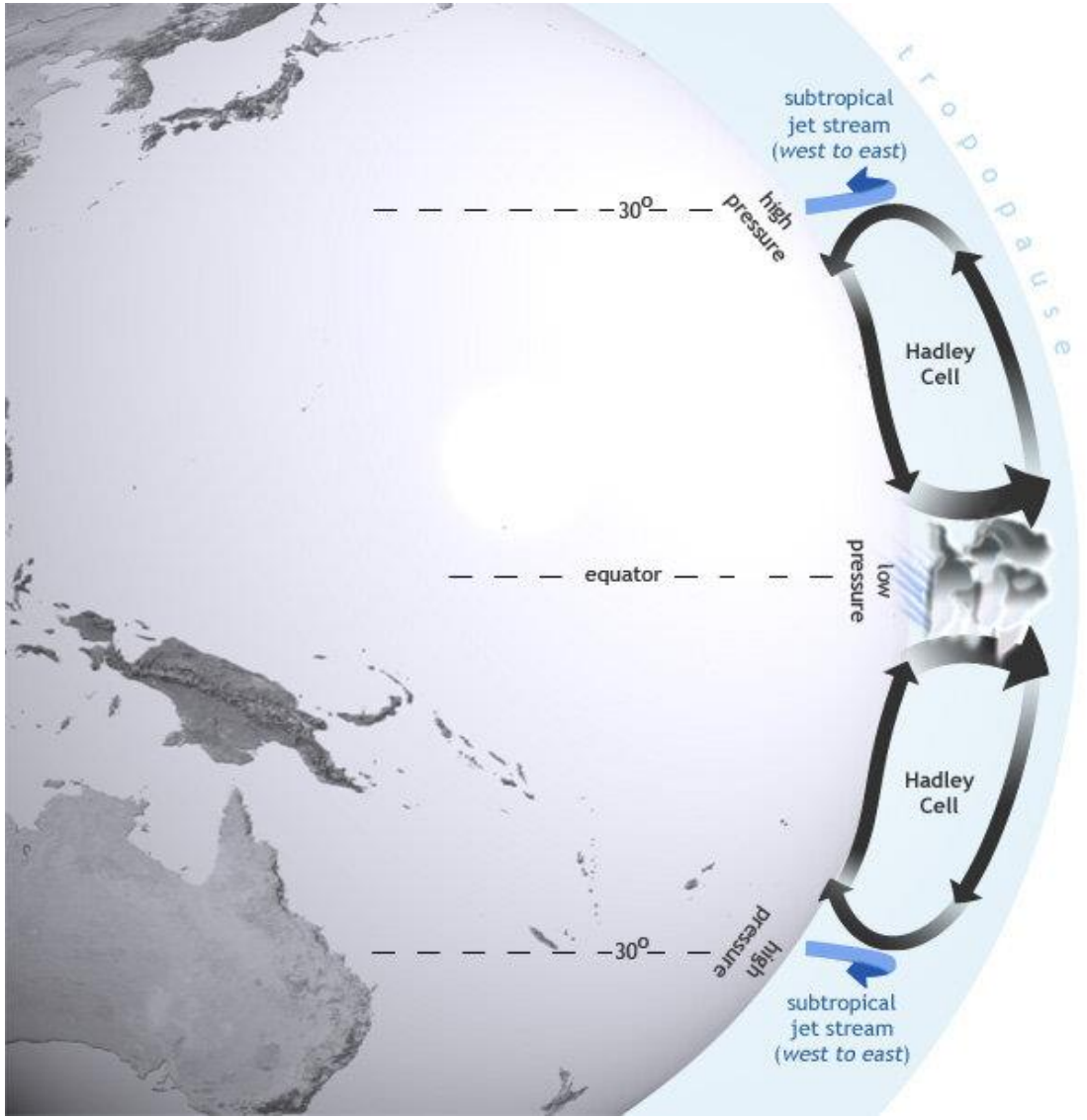
(3) Difference index is then re-normalized to match variance of original Niño-3.4 index (or else the variance is too low).

Key Advantages:

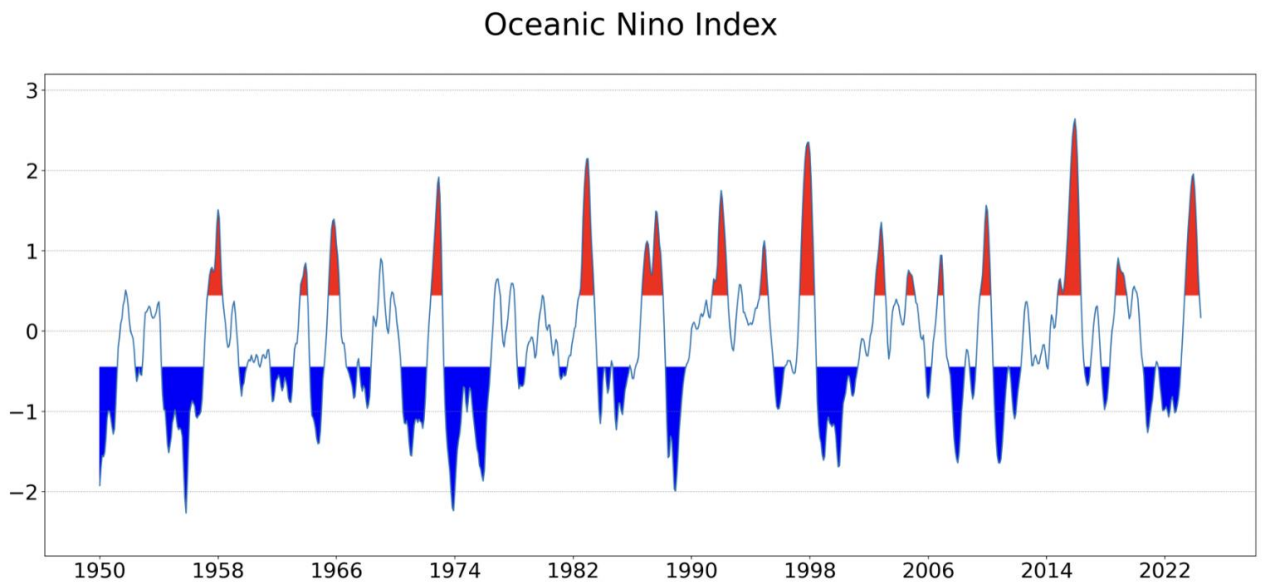
1. **Doesn't deviate too much from what users are already familiar with,**
2. **Physically defensible with minimal statistical choices (just pick a climatology),**
3. **Works in real time (no lagging)**

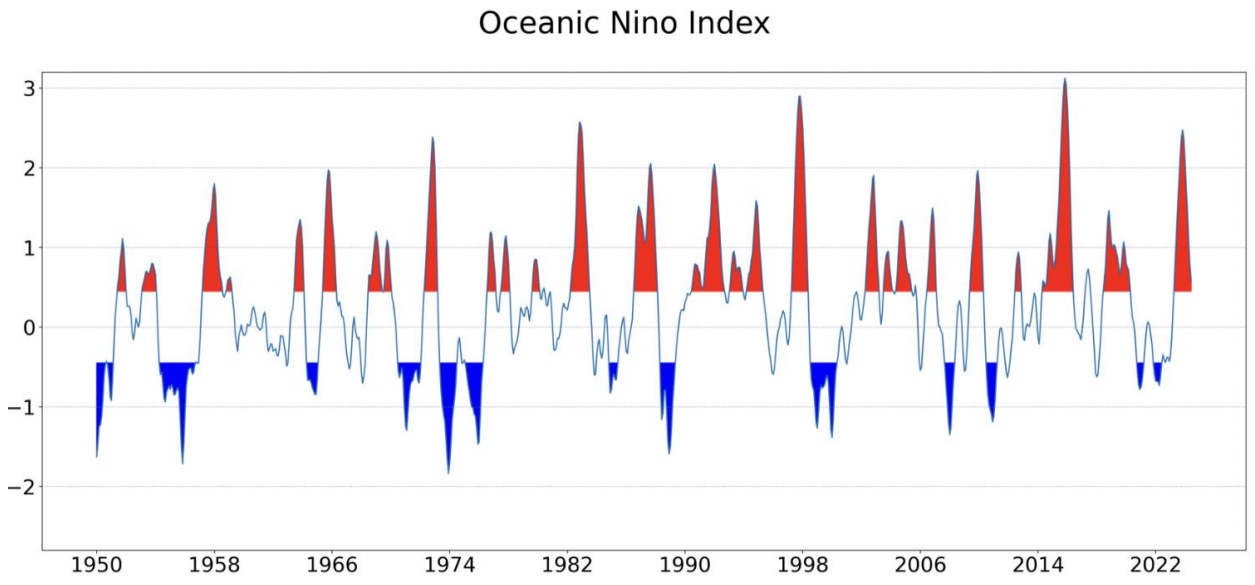
Prior research provides physical reasons for using relative SSTs

- Tropical SST anomalies can impact free tropospheric temperature only if it can induce deep convection.
- Fortunately, “rainy-region SSTs” (SSTs in precipitating regions only) is nearly equal to tropical mean SST.
- Lack of Coriolis means that free tropospheric temperature is nearly the same across the tropics. Occurs nearly instantaneously.
- **Instability/convective anomalies are sensitive to the difference between local SST anomalies (e.g. Nino3.4 region) and the tropical mean SSTs.**

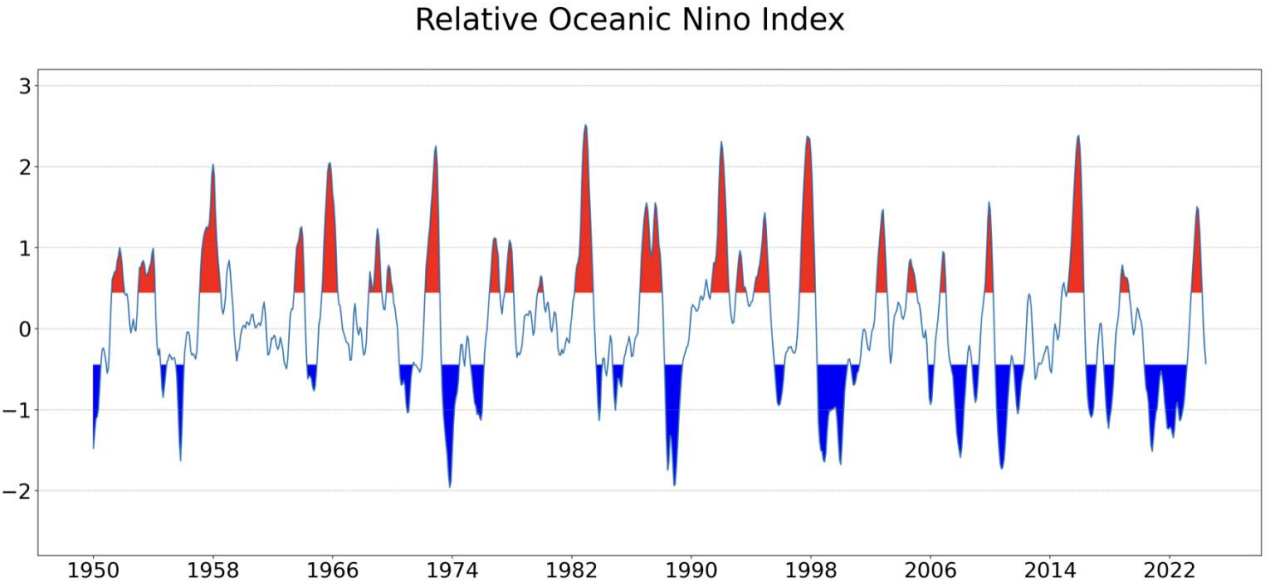


Sobel et al. (2001), Sobel et al. (2002), Johnson and Xie (2010), Johnson and Kosaka (2016), Izumo et al. (2020)

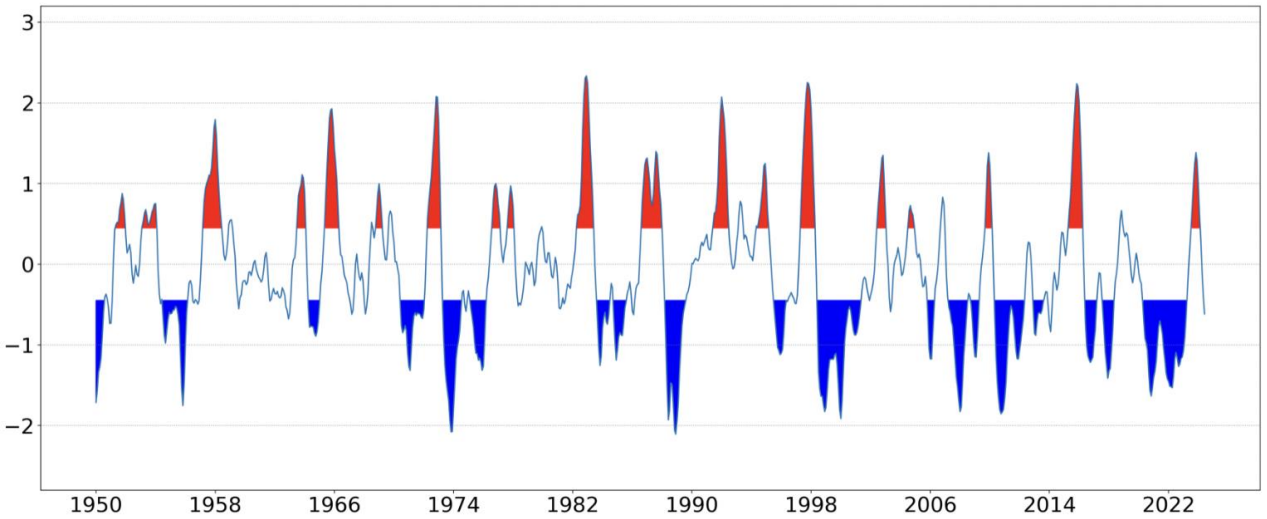




1991-2020 climatology



1941-1970 climatology



ERSSTv5 data

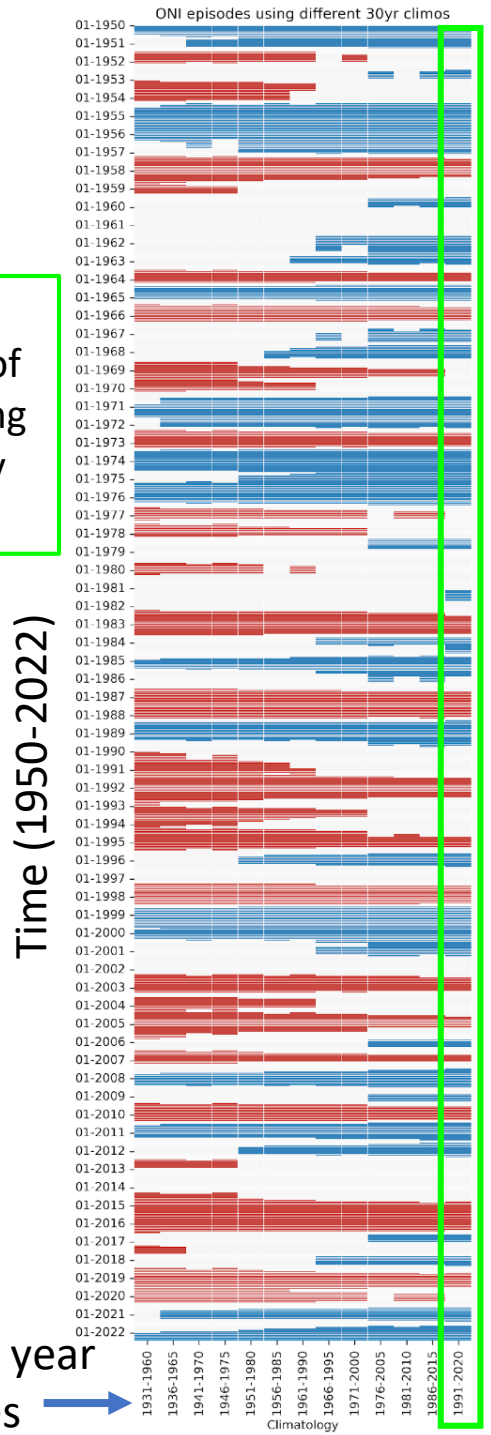
Despite changes in climatology, Relative Niño-3.4 more consistently identifies the same El Niño and La Niña events

Table of Historical El Niño and La Niña Episodes

Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
1950	-1.5	-1.3	-1.2	-1.2	-1.1	-0.9	-0.5	-0.4	-0.4	-0.4	-0.6	-0.8
1951	-0.8	-0.5	-0.2	0.2	0.4	0.6	0.7	0.9	1.0	1.2	1.0	0.8
1952	0.5	0.4	0.3	0.3	0.2	0.0	-0.1	0.0	0.2	0.1	0.0	0.1
1953	0.4	0.6	0.6	0.7	0.8	0.8	0.7	0.7	0.8	0.8	0.8	0.8
1954	0.8	0.5	0.0	-0.4	-0.5	-0.5	-0.6	-0.8	-0.9	-0.8	-0.7	-0.7
1955	-0.7	-0.6	-0.7	-0.8	-0.8	-0.7	-0.7	-0.7	-1.1	-1.4	-1.7	-1.5
1956	-1.1	-0.8	-0.6	-0.5	-0.5	-0.5	-0.6	-0.6	-0.5	-0.4	-0.4	-0.4
1957	-0.2	0.1	0.4	0.7	0.9	1.1	1.3	1.3	1.3	1.4	1.5	1.7
1958	1.8	1.7	1.3	0.9	0.7	0.6	0.6	0.4	0.4	0.4	0.5	0.6
1959	0.6	0.6	0.5	0.3	0.2	-0.1	-0.2	-0.3	-0.1	0.0	0.0	0.0
Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
1960	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.1	0.2	0.3	0.2	0.1	0.1
1961	0.0	0.0	0.0	0.1	0.2	0.3	0.1	-0.1	-0.3	-0.3	-0.2	-0.2
1962	-0.2	-0.2	-0.2	-0.3	-0.3	-0.2	0.0	-0.1	-0.1	-0.2	-0.3	-0.4
1963	-0.4	-0.2	0.2	0.3	0.3	0.5	0.9	1.1	1.2	1.3	1.4	1.3
1964	1.1	0.6	0.1	-0.3	-0.6	-0.6	-0.6	-0.7	-0.8	-0.8	-0.8	-0.8
1965	-0.6	-0.3	-0.1	0.2	0.5	0.8	1.2	1.5	1.9	2.0	2.0	1.7
1966	1.4	1.2	1.0	0.7	0.4	0.2	0.2	0.1	-0.1	-0.1	-0.2	-0.3
1967	-0.4	-0.5	-0.5	-0.4	-0.2	0.0	0.0	-0.2	-0.3	-0.4	-0.3	-0.4
1968	-0.6	-0.7	-0.6	-0.4	0.0	0.3	0.6	0.5	0.4	0.5	0.7	1.0
1969	1.1	1.1	0.9	0.8	0.6	0.4	0.4	0.5	0.8	0.9	0.8	0.6
Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
1970	0.5	0.3	0.3	0.2	0.0	-0.3	-0.6	-0.8	-0.8	-0.7	-0.9	-1.1
1971	-1.4	-1.4	-1.1	-0.8	-0.7	-0.7	-0.8	-0.8	-0.8	-0.9	-1.0	-0.9
1972	-0.7	-0.4	0.1	0.4	0.7	0.9	1.1	1.4	1.6	1.8	2.1	2.1
1973	1.8	1.2	0.5	-0.1	-0.5	-0.9	-1.1	-1.3	-1.5	-1.7	-1.9	-2.0
1974	-1.8	-1.6	-1.2	-1.0	-0.9	-0.8	-0.5	-0.4	-0.4	-0.6	-0.8	-0.6
1975	-0.5	-0.6	-0.7	-0.7	-0.8	-1.0	-1.1	-1.2	-1.4	-1.4	-1.6	-1.7
1976	-1.6	-1.2	-0.7	-0.5	-0.3	0.0	0.2	0.4	0.6	0.8	0.9	0.8
1977	0.7	0.6	0.3	0.2	0.2	0.3	0.4	0.4	0.6	0.7	0.8	0.8
1978	0.7	0.4	0.1	-0.2	-0.3	-0.3	-0.4	-0.4	-0.4	-0.3	-0.1	0.0
1979	0.0	0.1	0.2	0.3	0.2	0.0	0.0	0.2	0.3	0.5	0.5	0.6

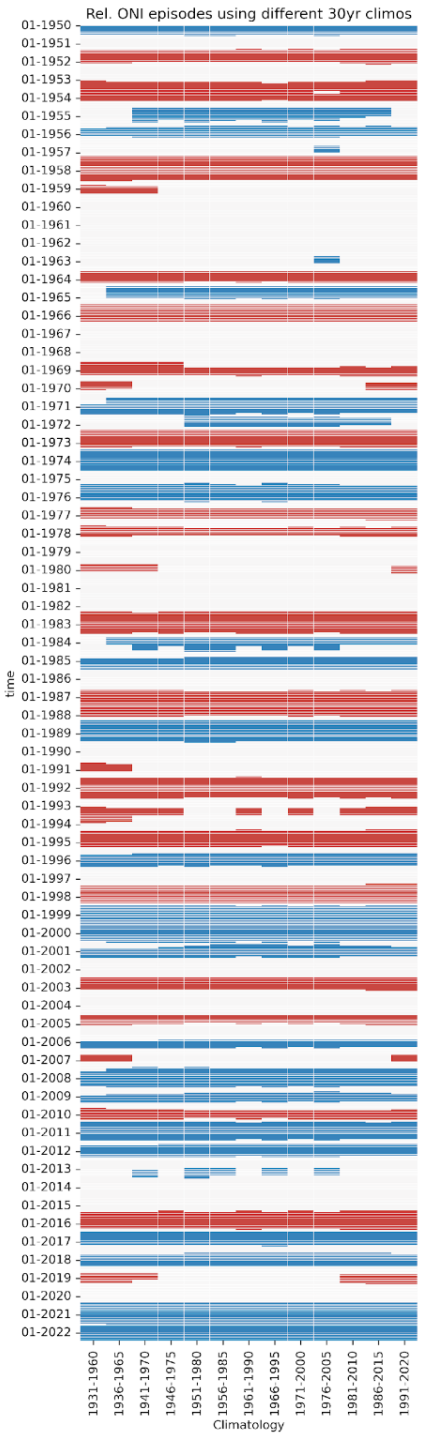
ERSSTv5 data

Alternative way of showing the table of ENSO episodes using a single climatology (e.g. 1991-2020)



Different 30 year climatologies

Using Relative Index



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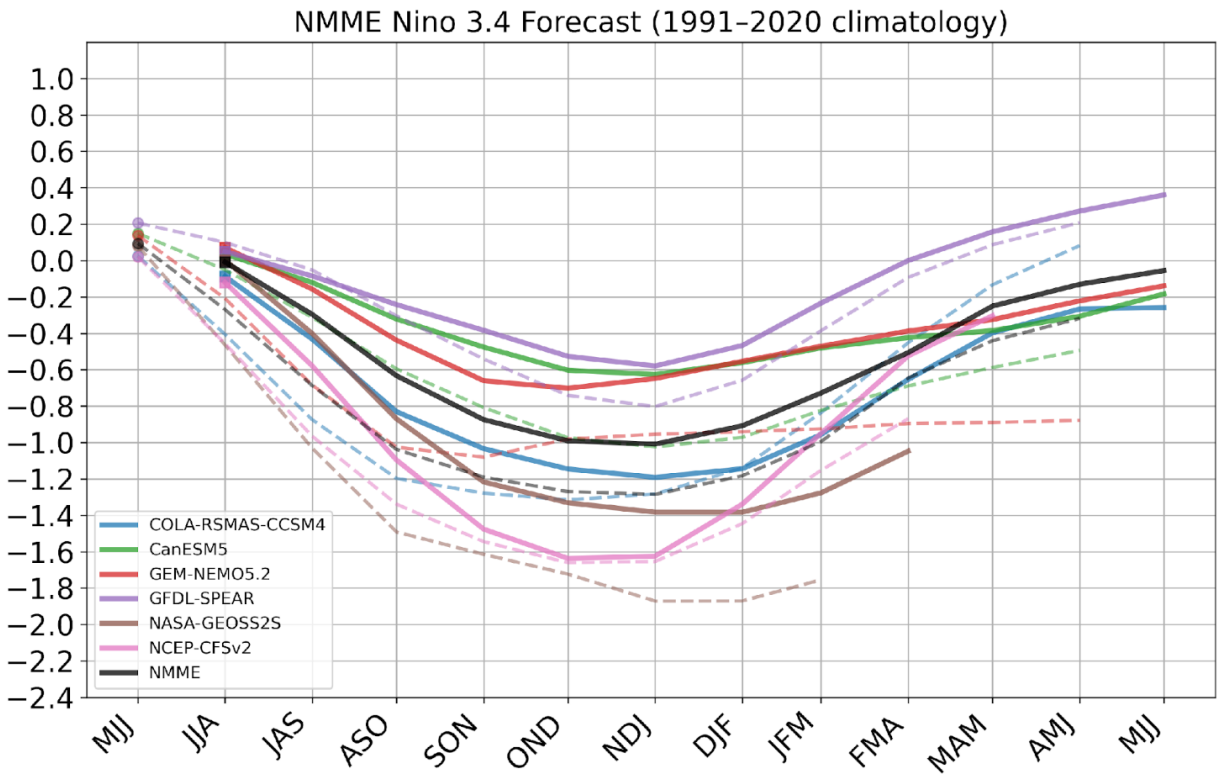
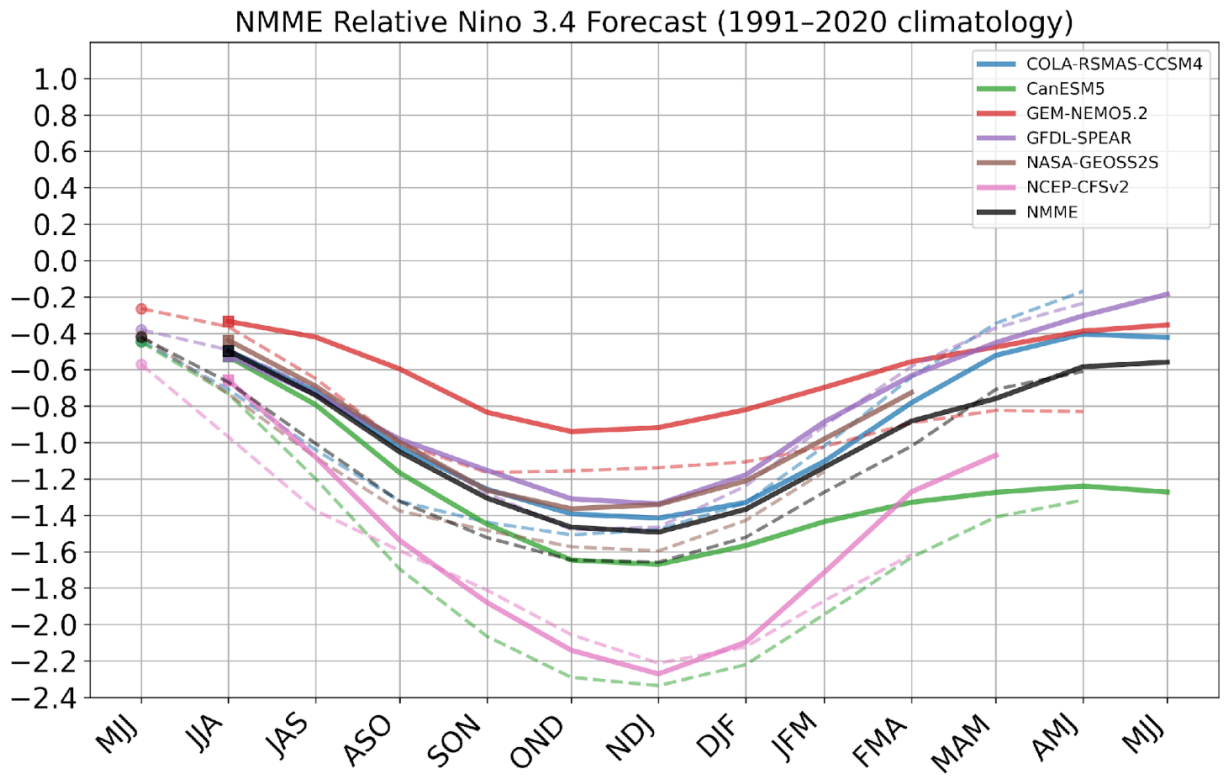
July and August 2024 runs from the North American Multi-model Ensemble

Traditional



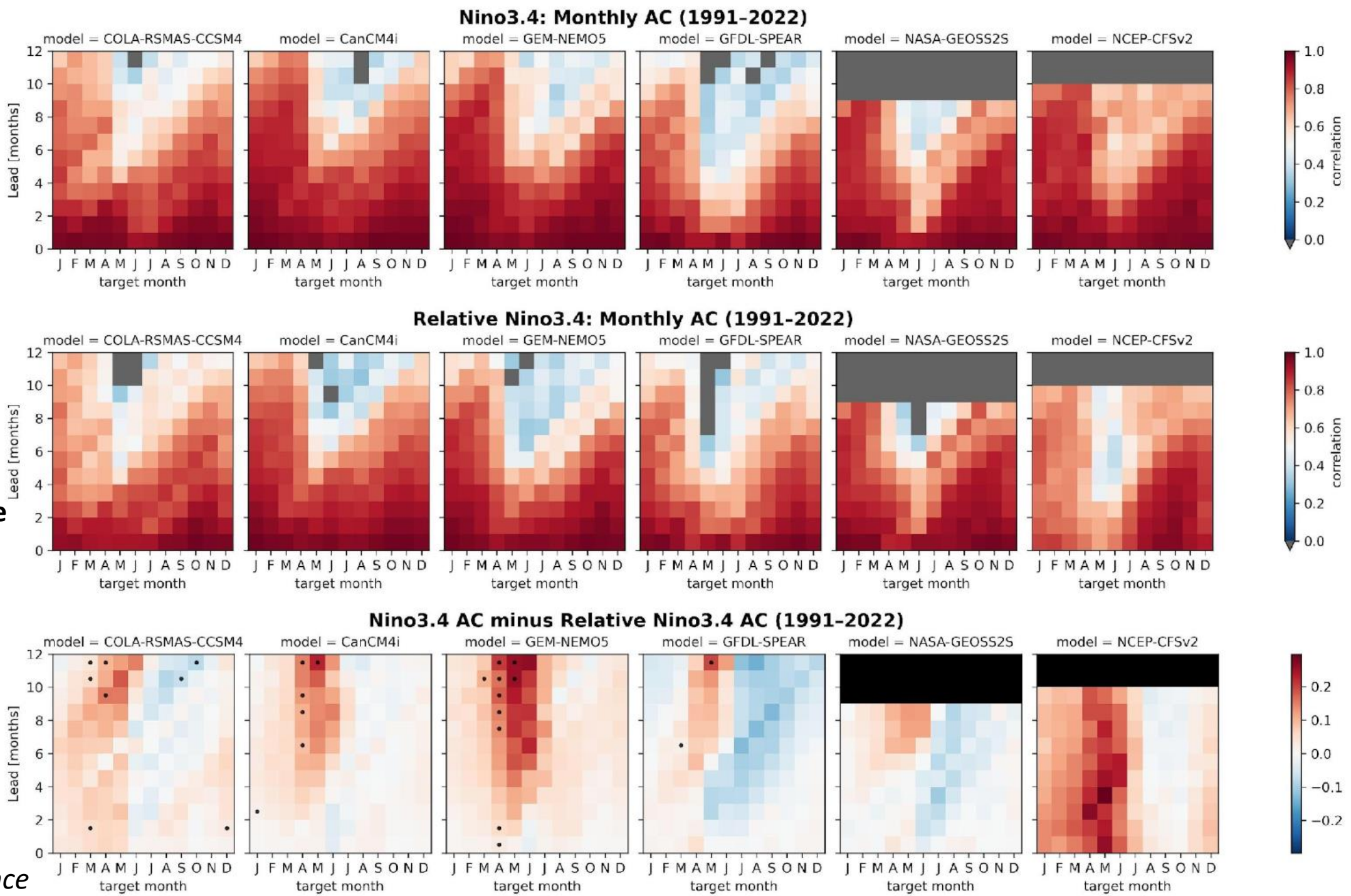
Relative



While still predicting La Niña, the traditional Niño-3.4 index is warmer than the Relative Niño-3.4 index

Traditional and Relative Niño-3.4 index have roughly equal skill, with the exception of some target months in the spring.

Dots = Statistically significant difference



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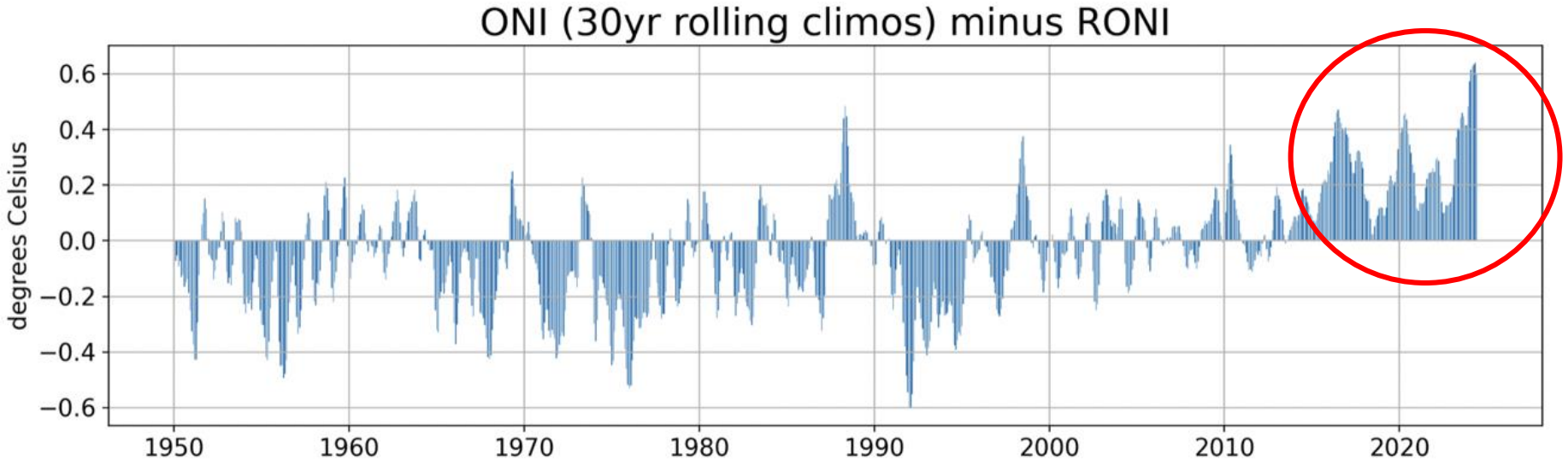
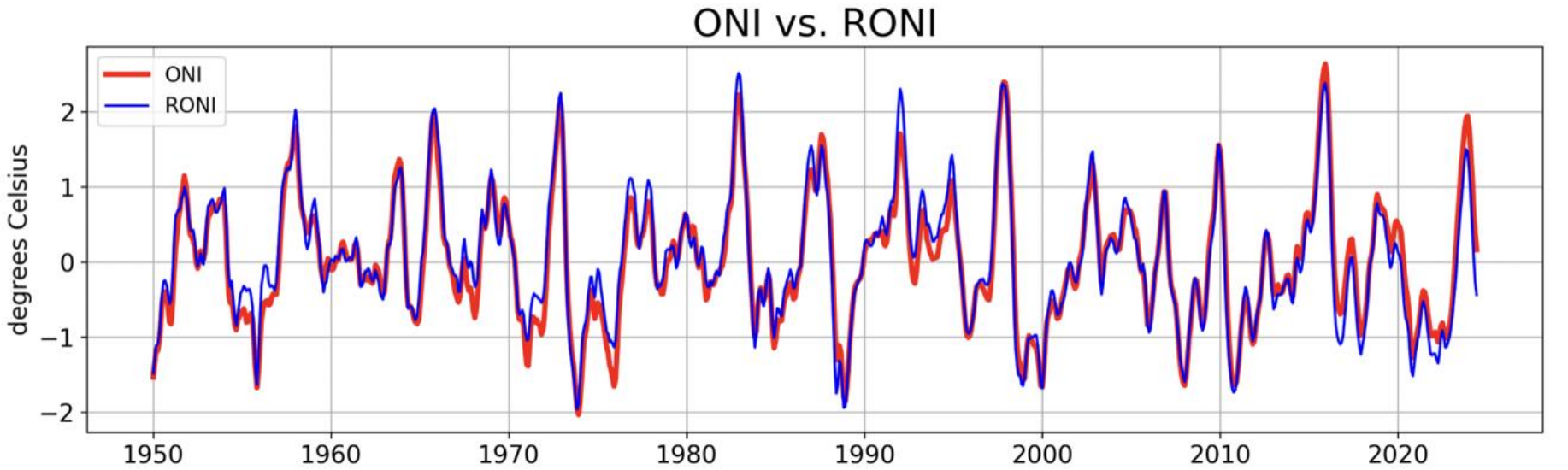
The biggest differences between NOAA's ONI (rolling climatology) and Relative ONI is in the last 10 years. Recently, record differences.



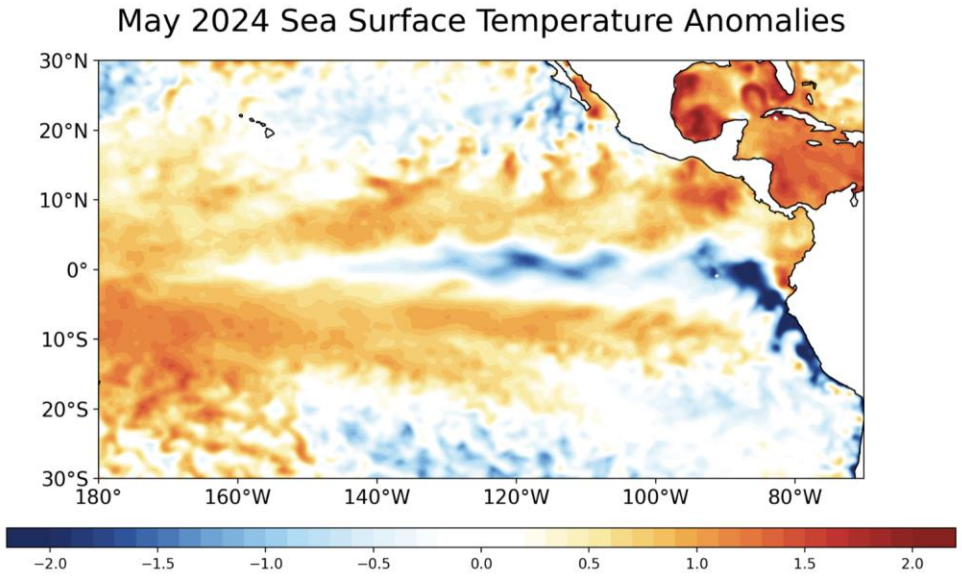
Large 0.6˚C differences so far in 2024.

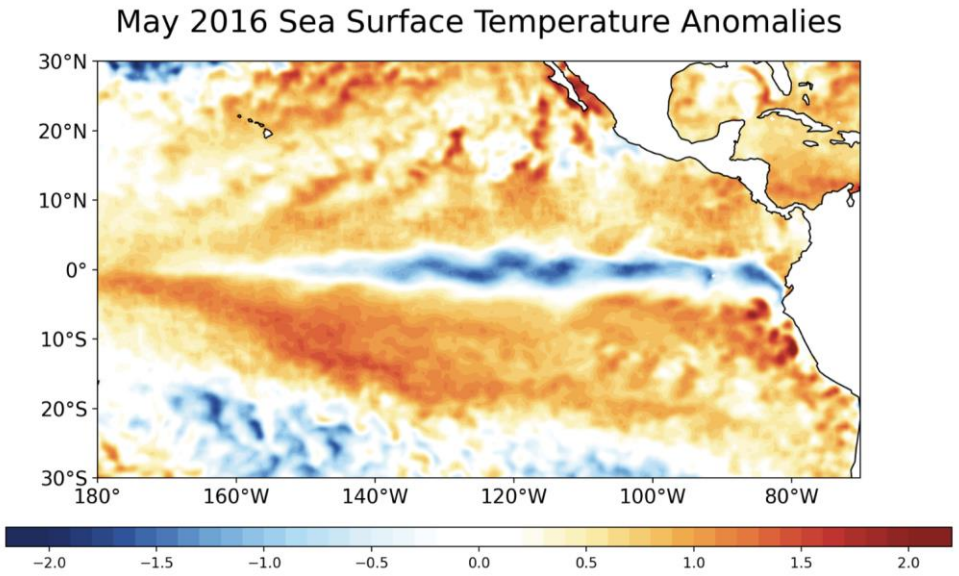


MJJ 2024
ONI: 0.2˚C
RONI: -0.4˚C

ERSSTv5 data

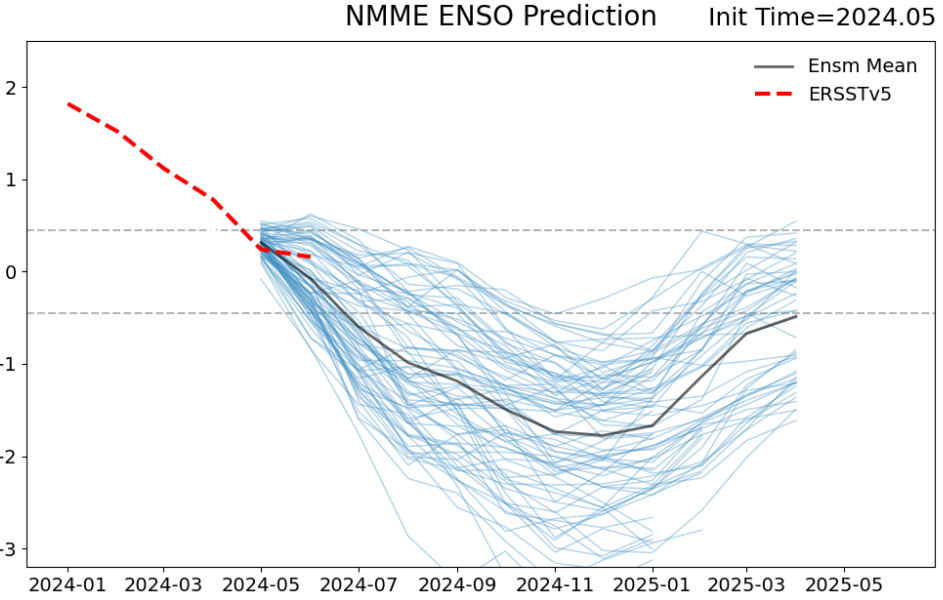
In first half of 2024, we have seen a *lot* of warmth in the global Tropics and in the off equatorial regions of the Pacific.
Similar to what we saw in the decay phases of the 2015-16 El Niño. Is surface mixing impacting La Niña predictions?

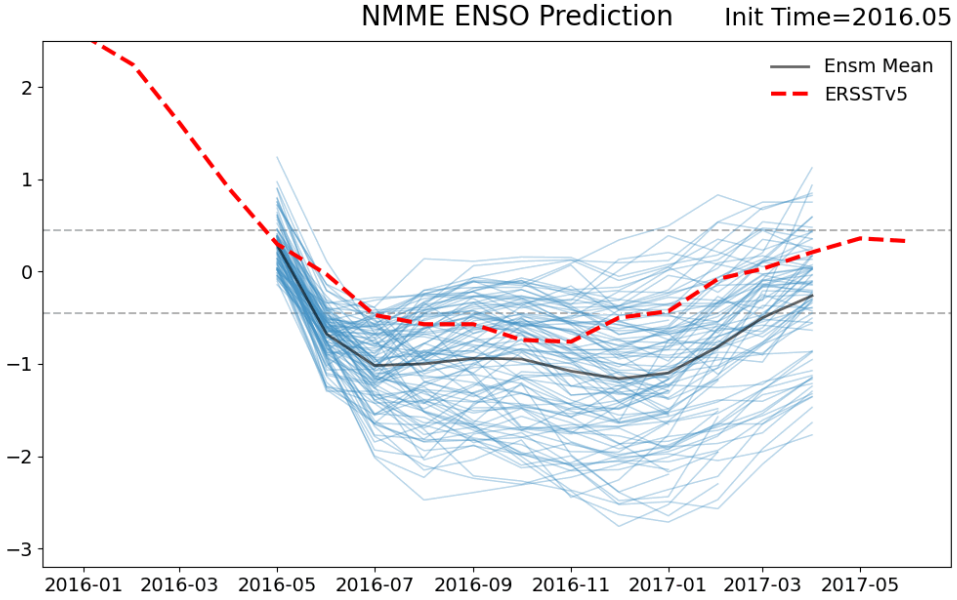




El Niño: Above-Average Niño-3.4

La Niña: Below-Average Niño-3.4



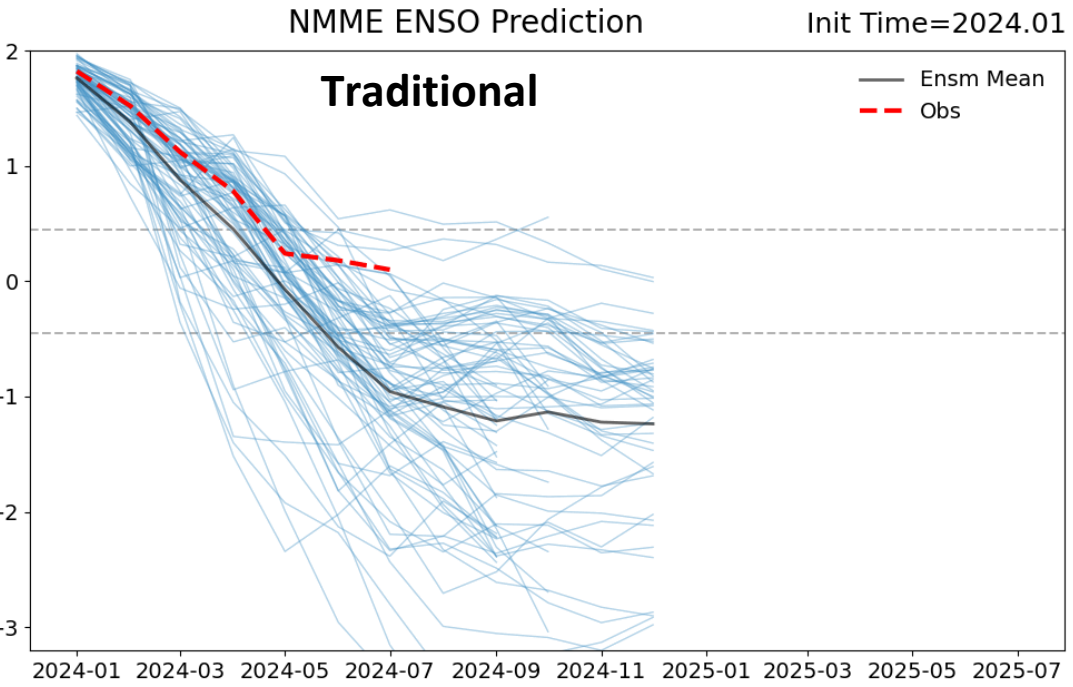


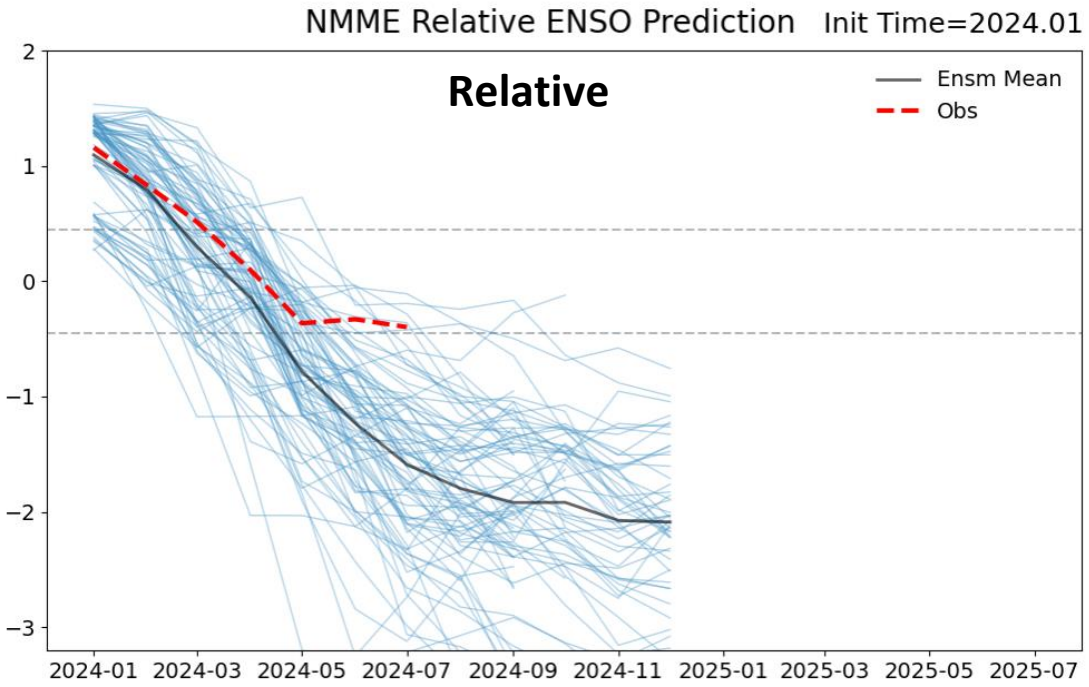
Base period: 1991-2020

Off-equatorial warmth may not matter as much for the global ENSO teleconnections & impacts b/c the key is to generate shifts in tropical convection and heating.

El Niño: Above-Average Niño-3.4

La Niña: Below-Average Niño-3.4





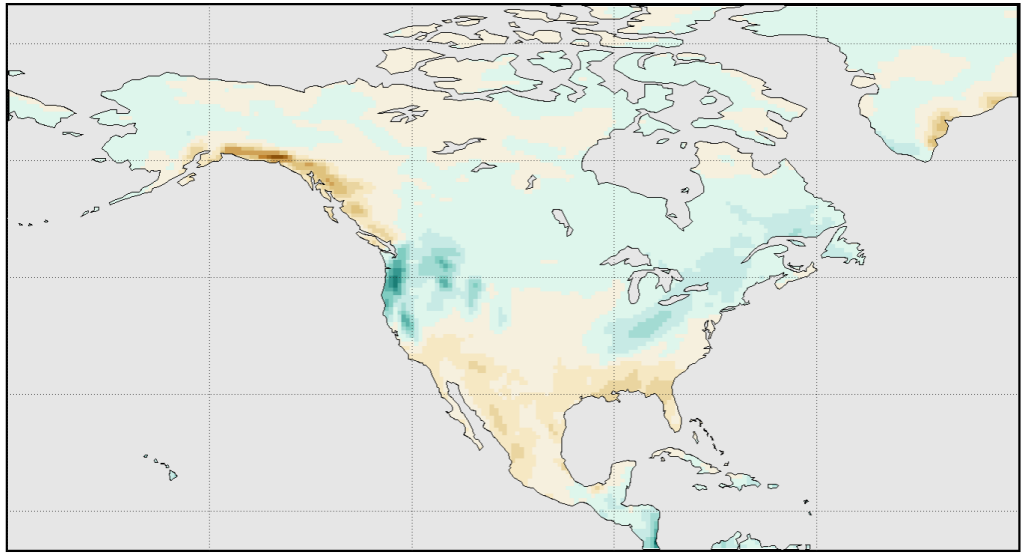
- Will relative SSTs do a better job this year of capturing anomalies reflected in the tropica atmosphere? Will this translate to impacts?

- We have never seen differences so large, so stay tuned. It'll be interesting to watch.

1 August 2024
Initial Condition from
NOAA/GFDL/SPEAR model

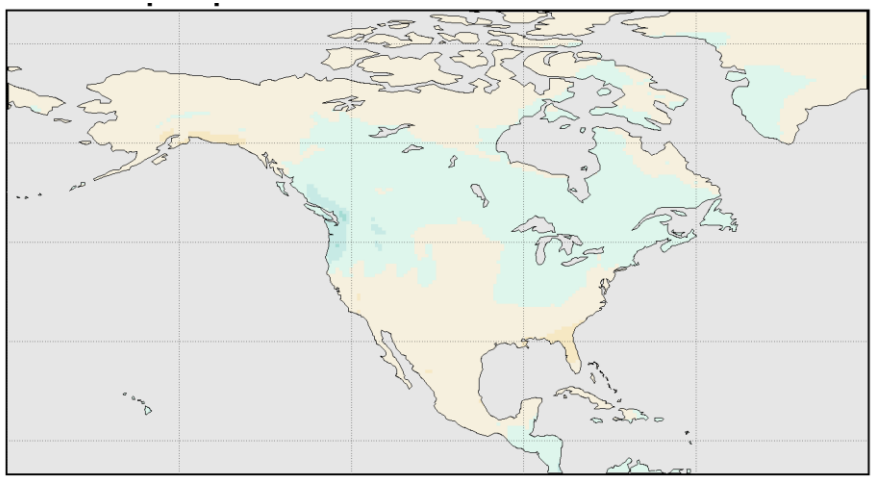
Predicted December 2024 - February 2025 Precipitation Anomalies

Insight & Analysis provided by Nat Johnson (NOAA/GFDL)

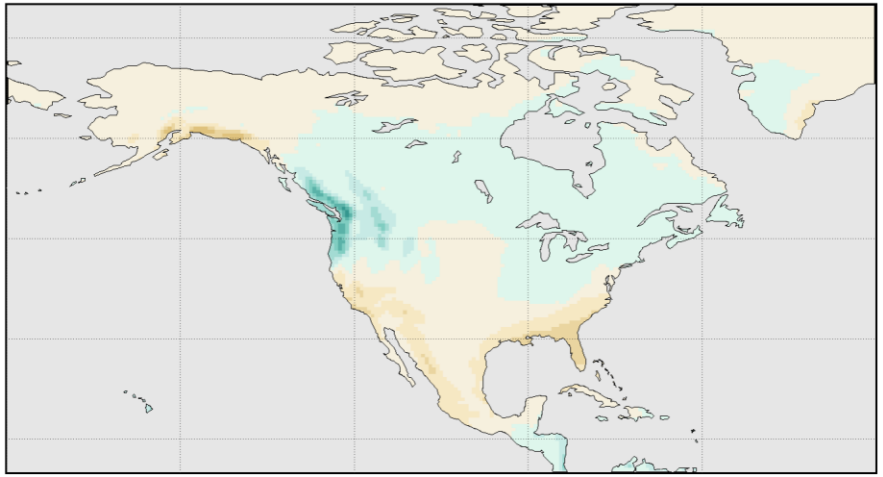


mm/day
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
Wetter
Drier

Linearly reconstructed from predicted Nino-3.4 index



Linearly reconstructed from predicted **Relative** Nino-3.4 index



Relative Niño-3.4 seems to better match the intensity of the predicted December-February SPEAR precipitation anomalies

Wrap-Up

- Relative sea surface temperatures provides a viable alternative for monitoring and forecasting ENSO in a changing climate.
- Classification of historical ENSO events is more stable using a relative Niño-3.4 index.
- Predictions of the relative Niño-3.4 index is nearly equal in skill to the traditional Niño-3.4 index.
- Recent increase in tropical average SSTs means that relative Niño-3.4 is ~0.6˚C cooler than the traditional index.
- In the coming months, atmospheric anomalies may become consistent with La Niña before our traditional SST anomalies reach La Niña thresholds.
- El Niño impacts may be weaker than what the traditional Niño-3.4 index implies.

Note: M. L'Heureux is a non-member participant and is not speaking on behalf of the United States Government.