Introduction of Emerging new Relative Niño-3.4 index for ENSO monitoring and prediction

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Key Takeaways

Viable Alternative

Relative sea surface temperatures provide a viable alternative for monitoring and forecasting ENSO in a changing climate.

More Stable Classification

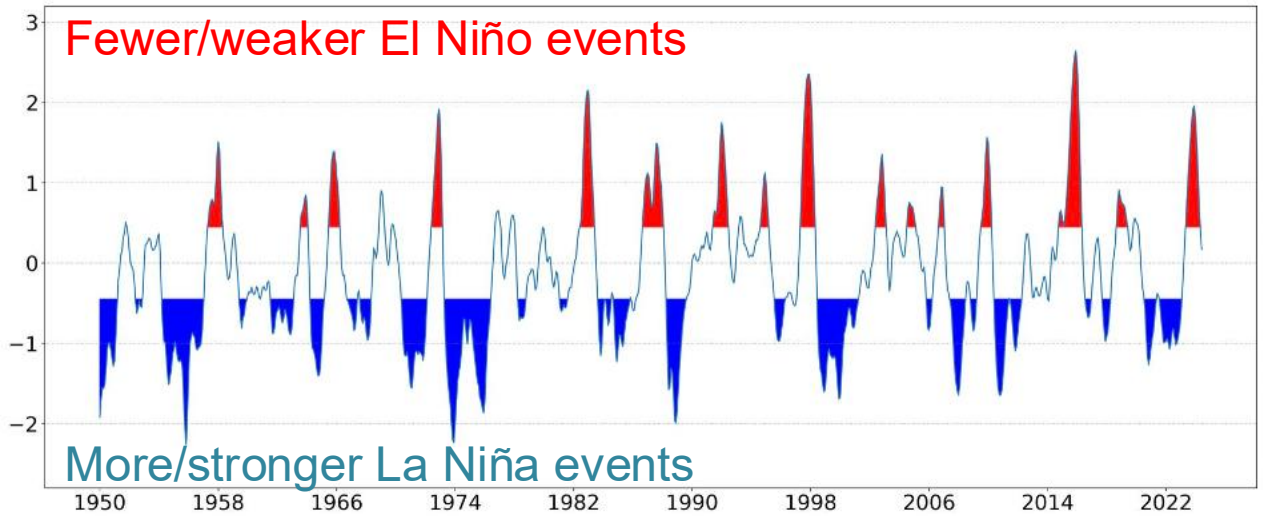
Classification of historical ENSO events is more stable using a relative Niño-3.4 index.

Cooler Than Traditional Index

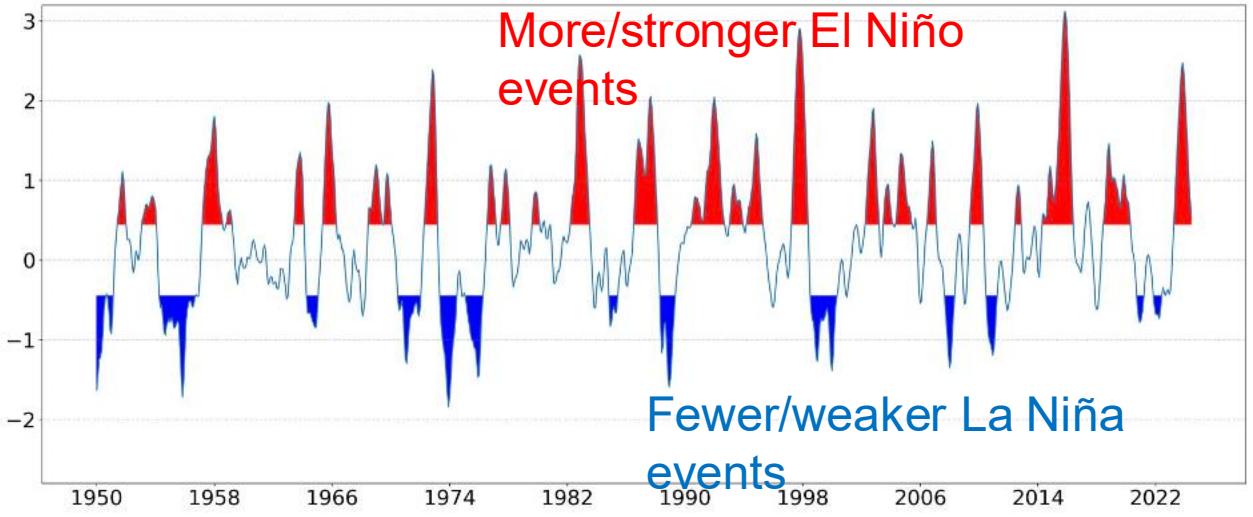
Recent increase in tropical average SSTs means that relative Niño-3.4 is at least 0.5°C cooler than the traditional index.

Problem: The Classification of past El Niño or La Niña events depends on the selected Climatology

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



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

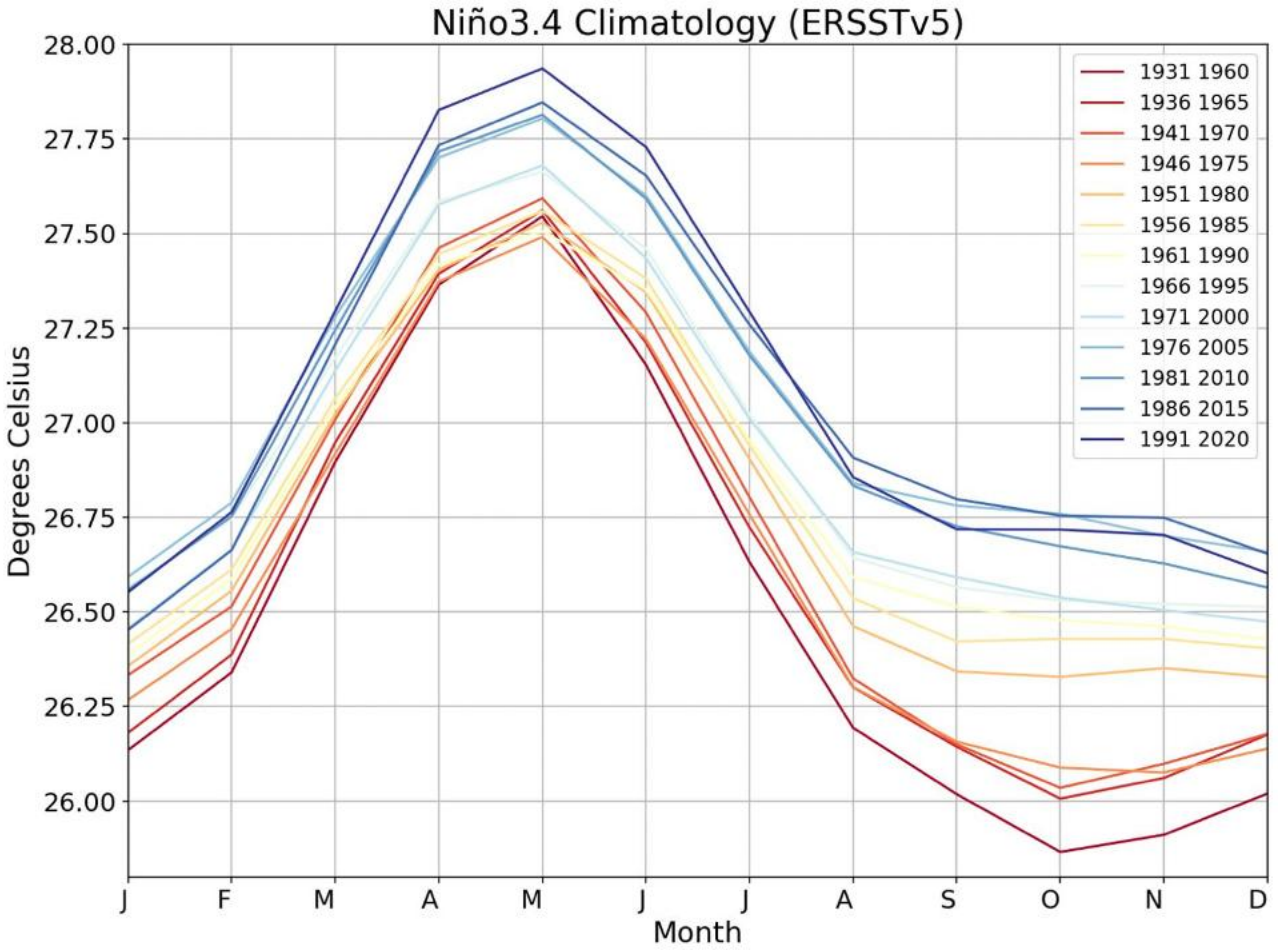


What is considered an El Niño or La Niña event changes depending on when you lived and what you thought was normal!

Using a Relative index, classification of past El Niño and La Niña events remains roughly the same no matter the choice of climatology.

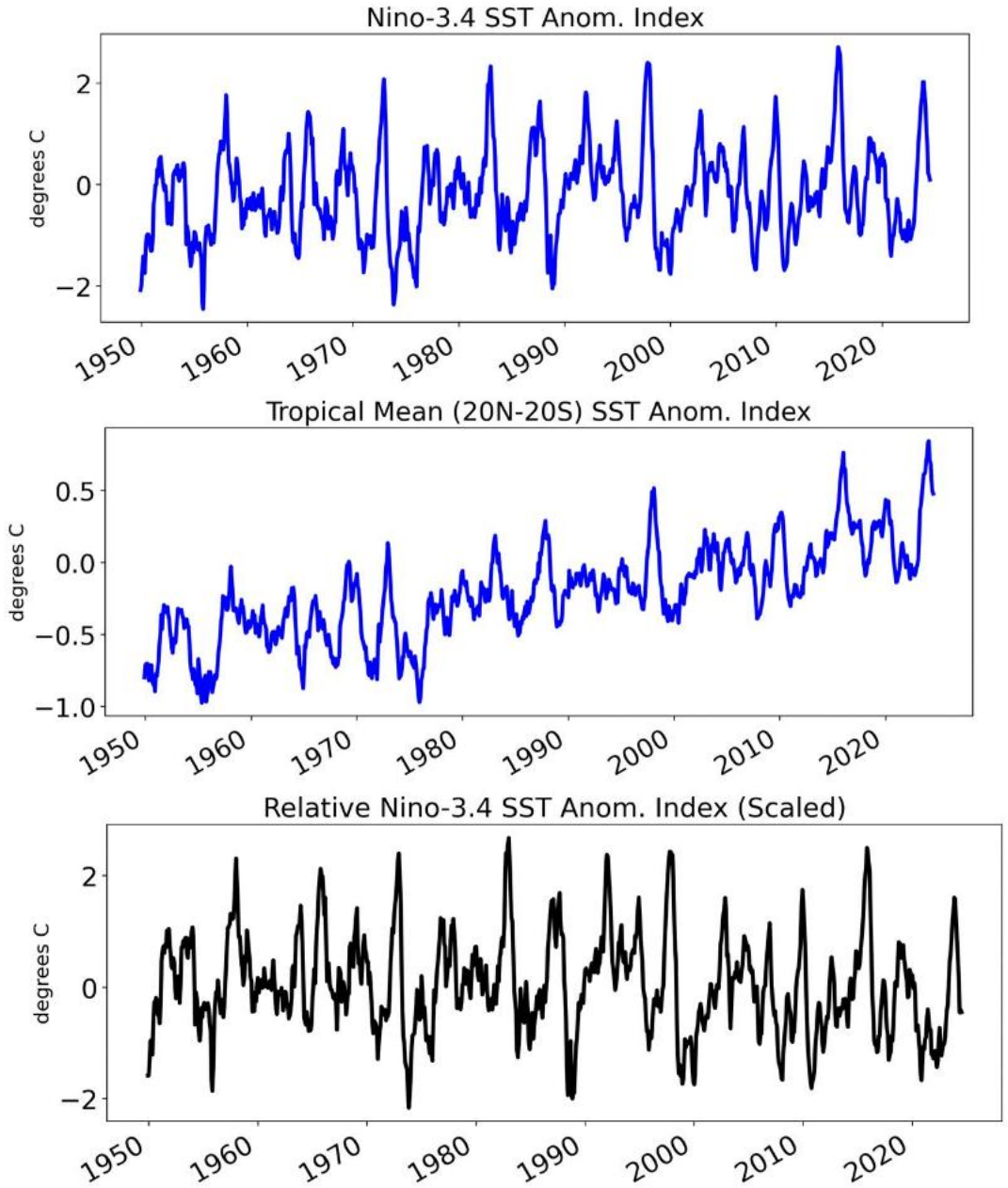
ERSSTv5 data

The Climatology Has Changed!



Advantage: Using a Relative index, classification of past El Niño and La Niña events remain roughly the same no matter the choice of climatology.

Definition of relative Nino3.4 index



Instability/convective anomalies are sensitive to the difference between local SST anomalies (e.g. Nino3.4 region) and the tropical mean SSTs.

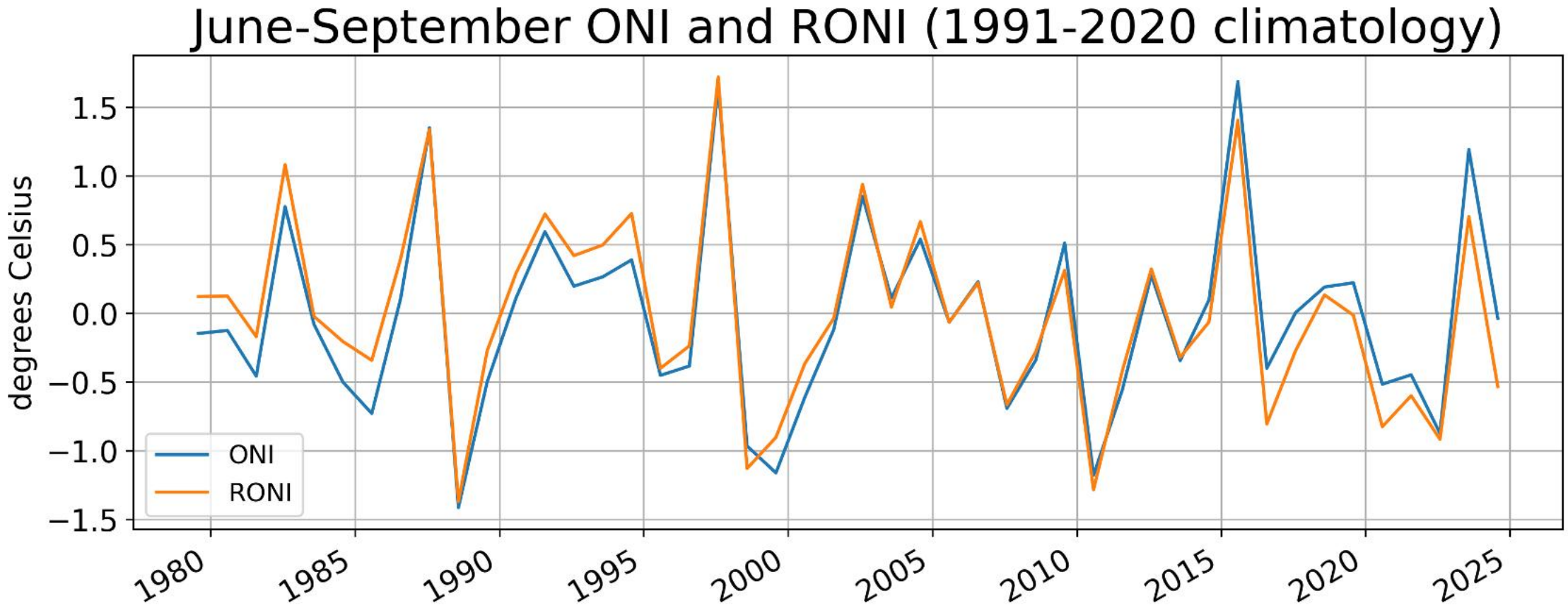
(1) Niño3.4 index and the tropical mean SST (20°S-20°N) index are both computed as departures from a 30yr climatology (e.g., 1991-2020).

(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 (so threshold requirements remain the same)

$$\text{Relative ONI} = (\text{ONI - TropAve}) \times \frac{\sigma_{\text{ONI}}}{\sigma_{(\text{ONI - TropAve})}}$$

ERSSTv5 data



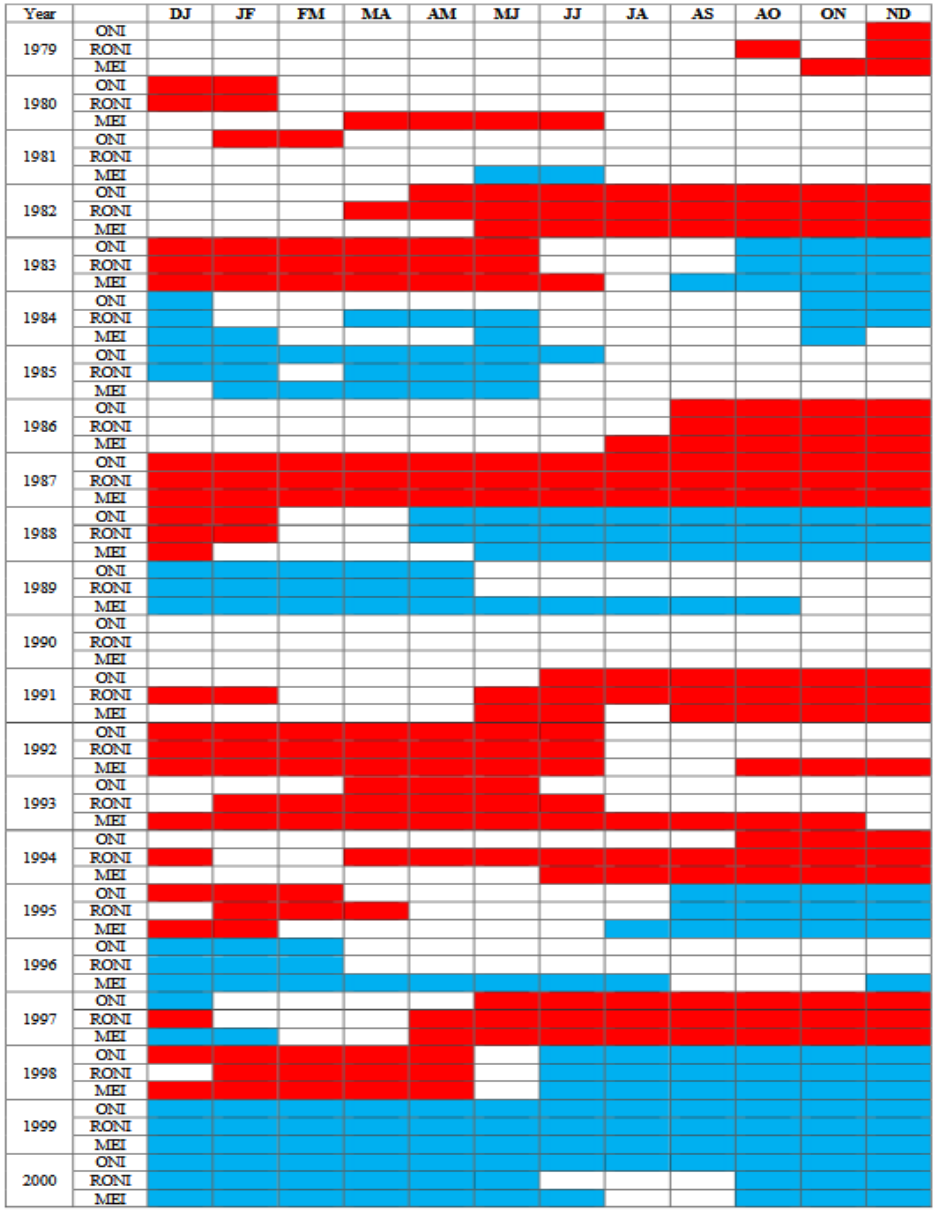
For JJAS 2024, the ONI was near 0˚ C and the RONI was -0.54˚ C

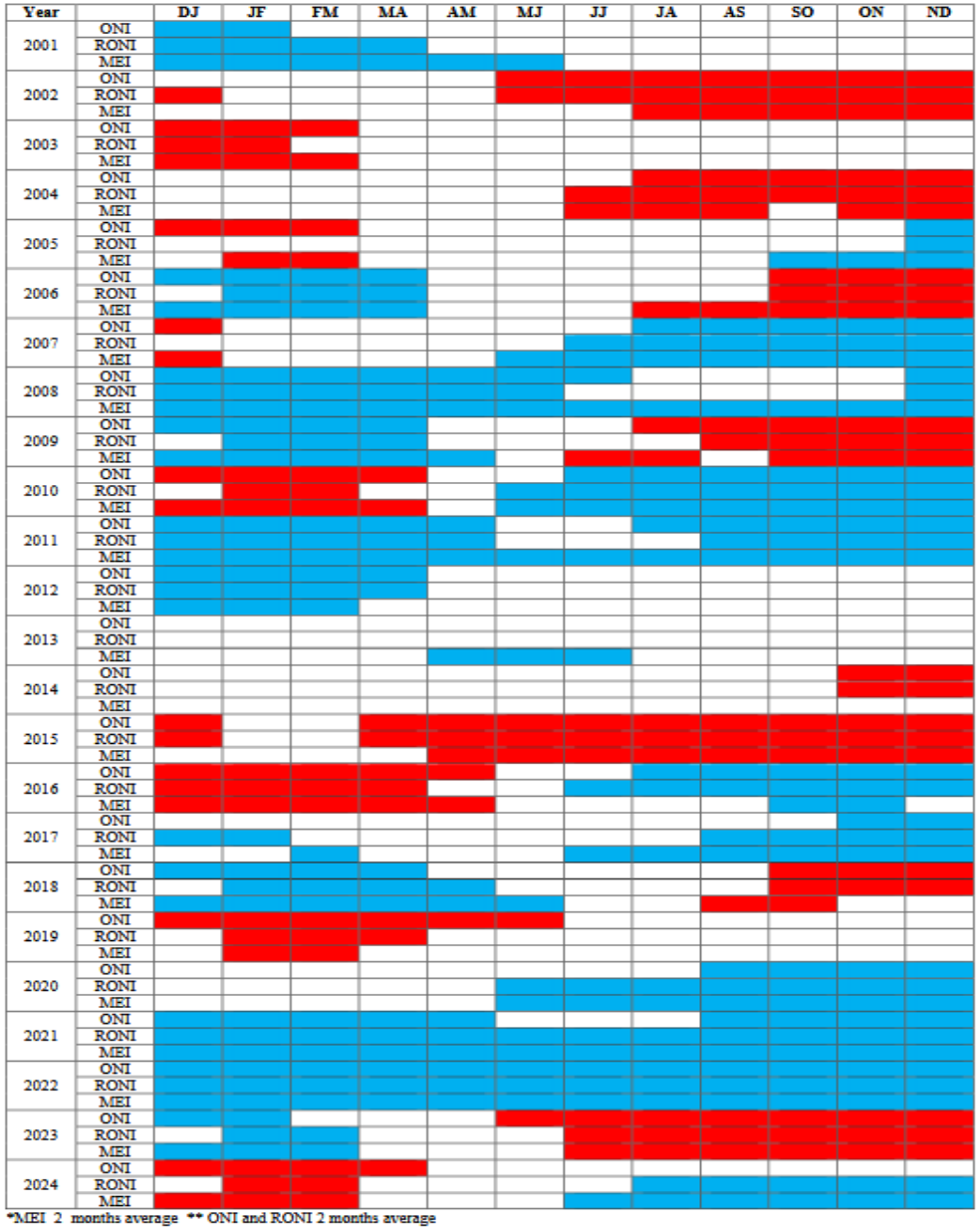
Historical El Niño and La Niña Episodes Based on the RONI computed using ERSST.v5

Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
2014	-0.5	-0.5	-0.3	0.0	0.1	0.0	-0.1	-0.1	0.1	0.4	0.5	0.6
2015	0.5	0.4	0.5	0.6	0.8	1.0	1.3	1.6	1.9	2.2	2.3	2.4
2016	2.2	1.8	1.3	0.5	-0.1	-0.6	-0.9	-1.0	-1.1	-1.1	-1.1	-1.0
2017	-0.7	-0.5	-0.3	-0.1	0.1	0.1	-0.2	-0.5	-0.7	-1.0	-1.1	-1.3
2018	-1.1	-1.0	-0.9	-0.7	-0.3	0.0	0.1	0.2	0.4	0.7	0.8	0.7
2019	0.6	0.6	0.6	0.5	0.3	0.2	0.0	-0.1	0.0	0.1	0.2	0.2
2020	0.1	0.1	0.0	-0.3	-0.6	-0.8	-0.8	-0.9	-1.2	-1.5	-1.5	-1.4
2021	-1.2	-1.0	-1.0	-0.8	-0.6	-0.5	-0.6	-0.7	-0.9	-1.1	-1.2	-1.2
2022	-1.2	-1.2	-1.3	-1.3	-1.2	-1.0	-0.9	-1.0	-1.1	-1.1	-1.0	-1.0
2023	-0.8	-0.6	-0.4	-0.2	0.1	0.4	0.6	0.9	1.1	1.4	1.5	1.5
2024	1.2	0.9	0.5	0.1	-0.3	-0.5	-0.5	-0.6	-0.8	-0.8	-0.9	-1.1
2025	-1.1	-0.9	-0.7	-0.5	-0.5	0.0	-0.5	-0.6	-0.8	-0.9	-0.9	-1.0
2026	-0.9	-0.7										

Monthly RONI indices are available in IMD Pune website

https://www.imdpune.gov.in/lrfindex.php

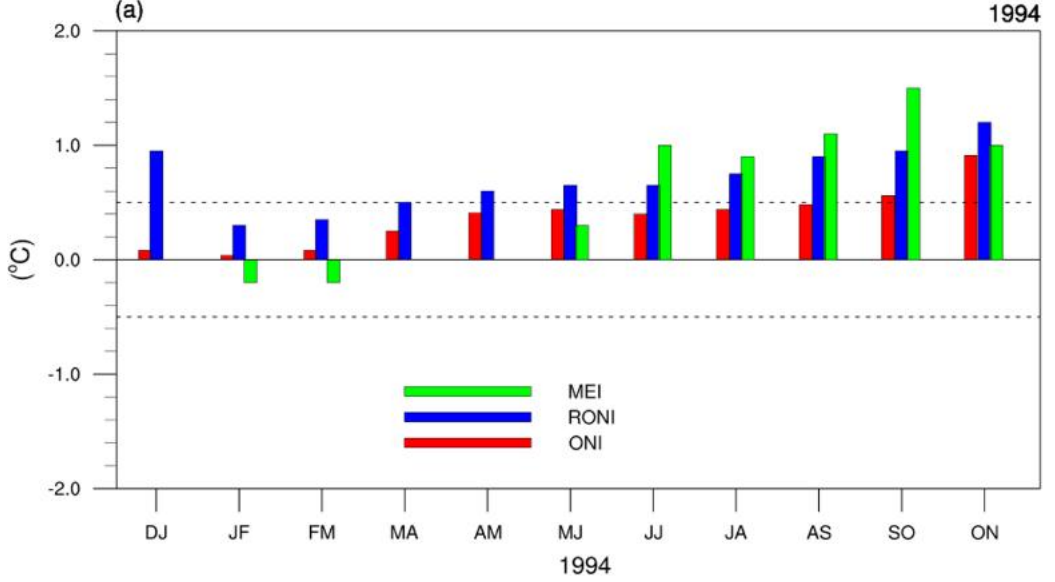


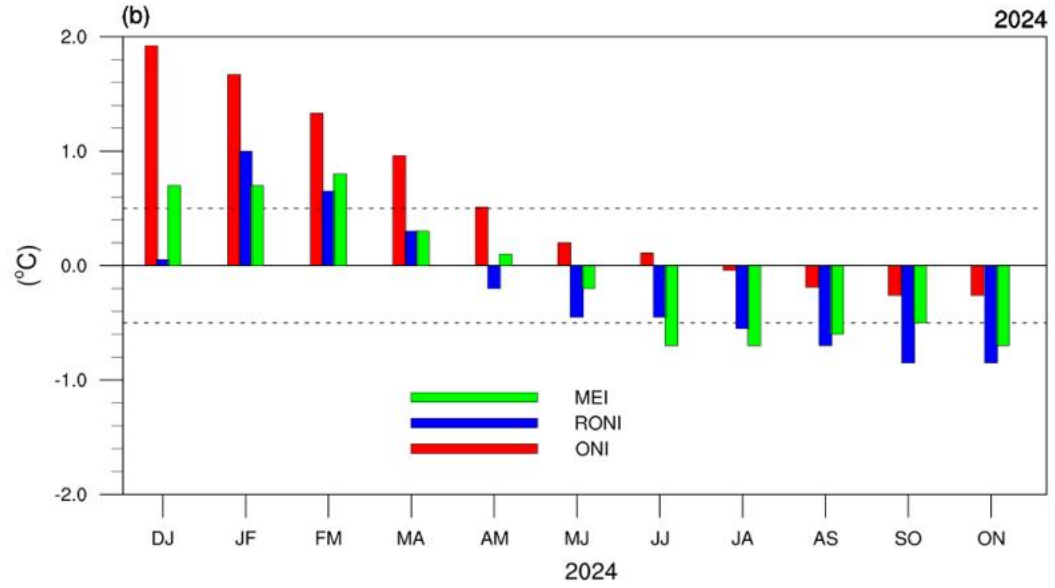


*MEI 2 months average ** ONI and RONI 2 months average

*MEI 2 months average ** ONI and RONI 2 months average

The historical El Niño and La Niña episodes from 1979 to 2024, as defined by NOAA's 0.5 °C threshold, using, the Oceanic Niño Index (ONI), the Relative Oceanic Niño Index (RONI) and Multivariate ENSO index (MEI). Major difference can be seen during 1994 and 2024





Evolution of the Oceanic Niño Index (ONI; red), Relative Oceanic Niño Index (RONI; blue), and Multivariate ENSO Index (MEI; green) for two years: 1994 (top panel) and 2024 (bottom panel)

1994 showed a gradual, sustained warming with El Niño thresholds reached earliest in RONI and latest in conventional ONI, which remained weaker throughout. In contrast, 2024 began with strong positive anomalies that rapidly transitioned to La Niña conditions in RONI and MEI by mid-year, while conventional ONI largely stayed neutral, indicating differing sensitivity during ENSO transitions.

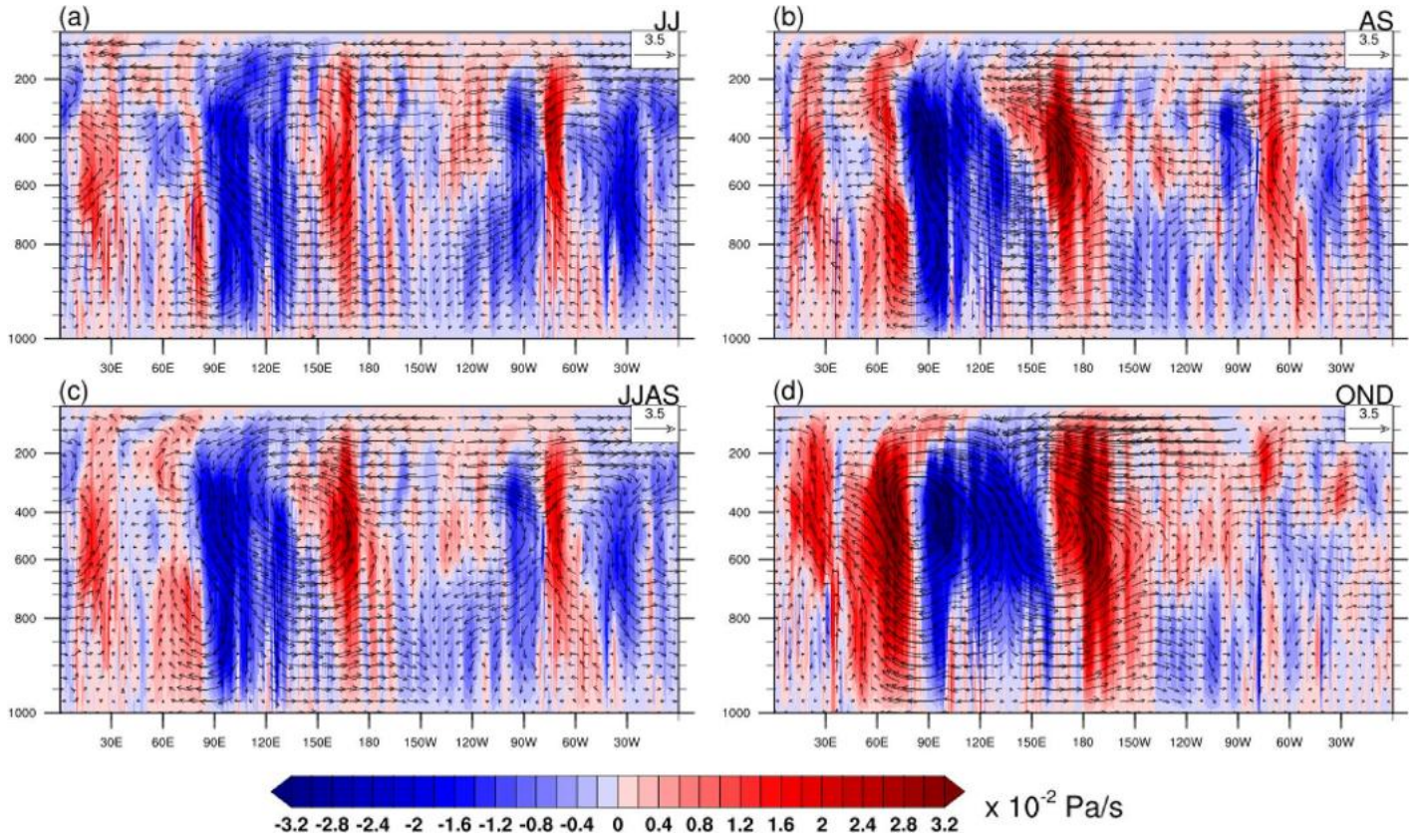
Walker Circulation anomaly 1994

JJ

AS

JJAS

OND



Walker circulation anomalies in 1994 showed enhanced ascent over the central, consistent with a central Pacific El Niño and supported by RONI and MEI. The JJAS mean indicates a persistent convective signal over the central Pacific, aligning with sustained El Niño conditions during the 1994 monsoon season.

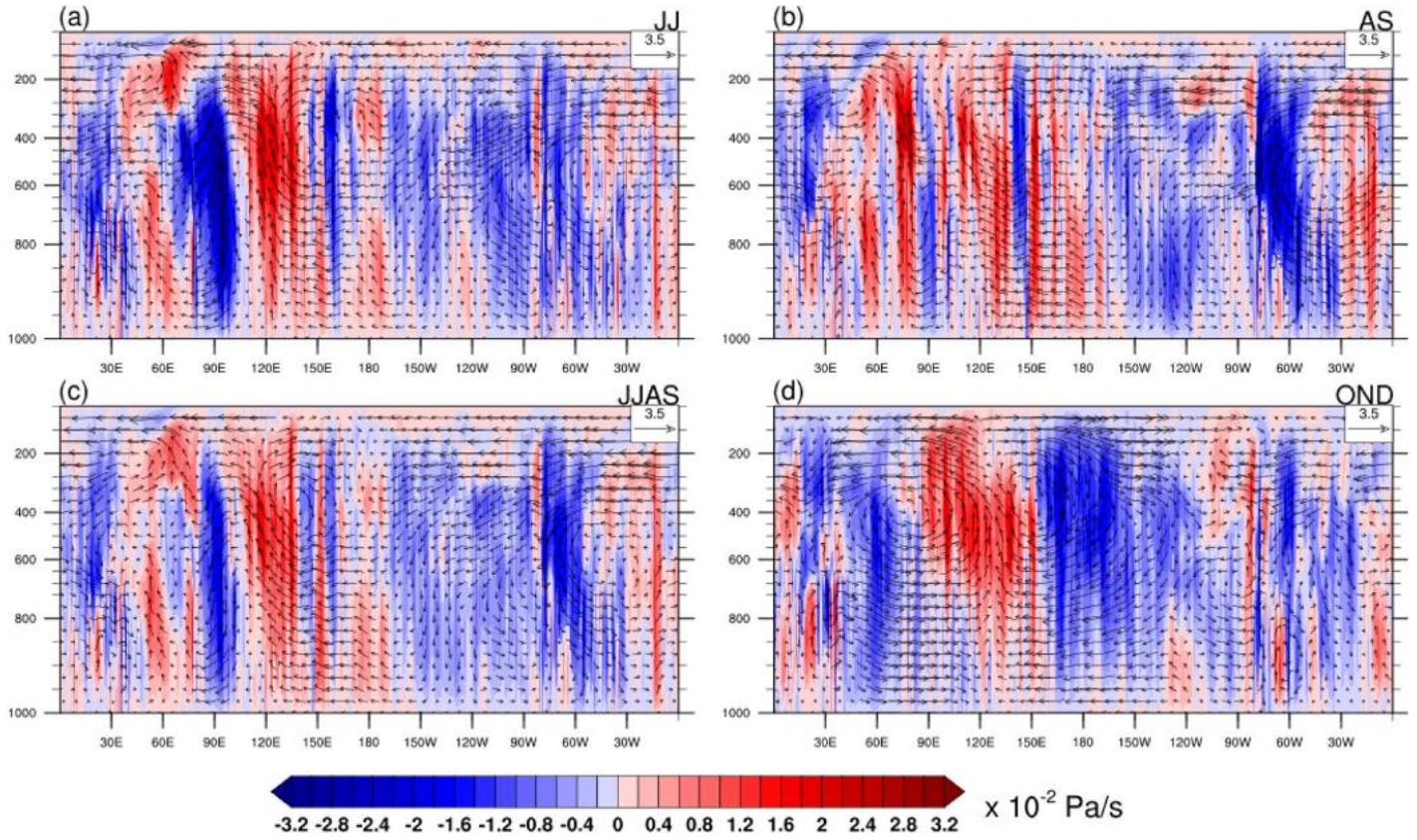
Walker Circulation anomaly 2024

JJ

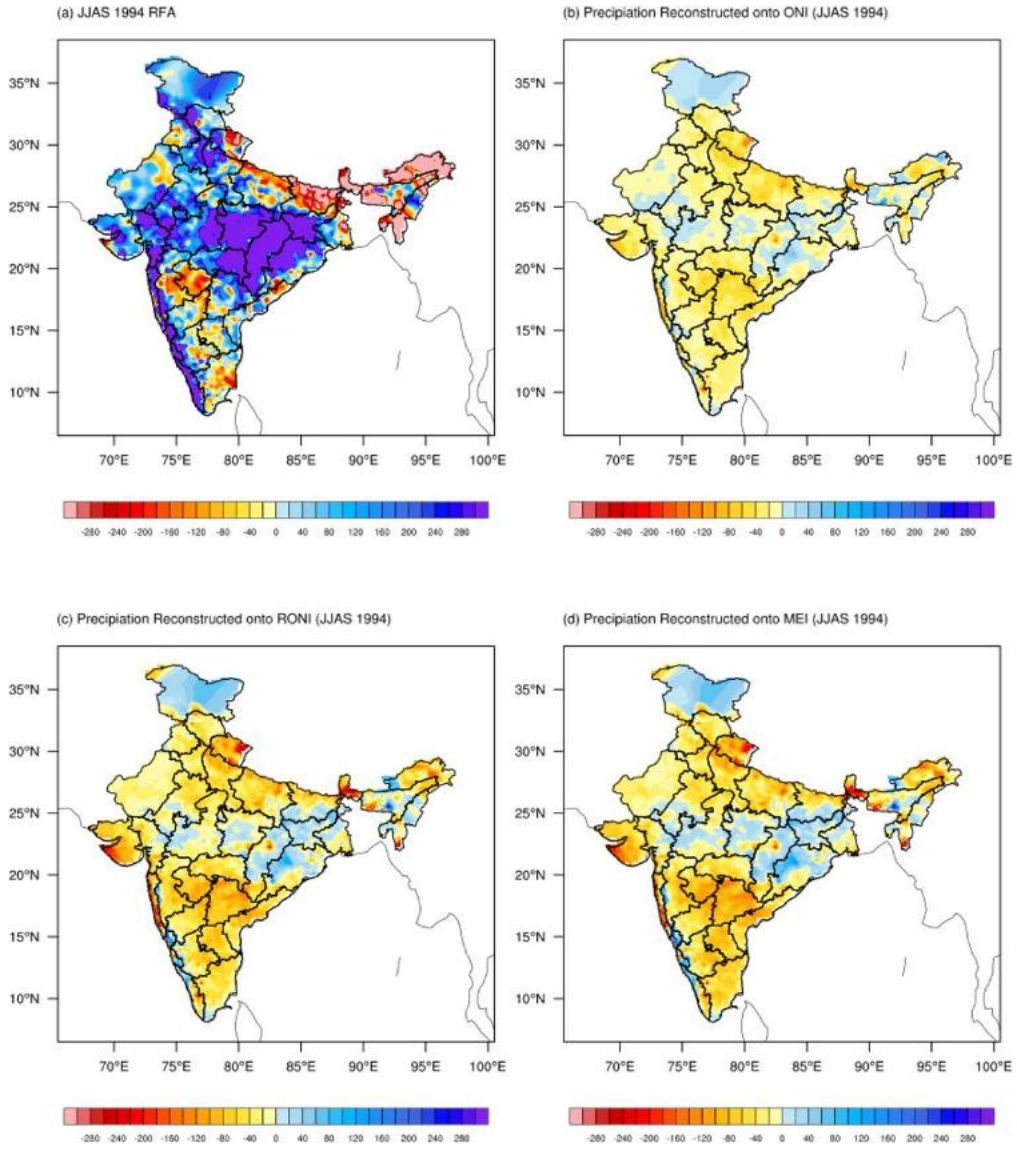
AS

JJAS

OND

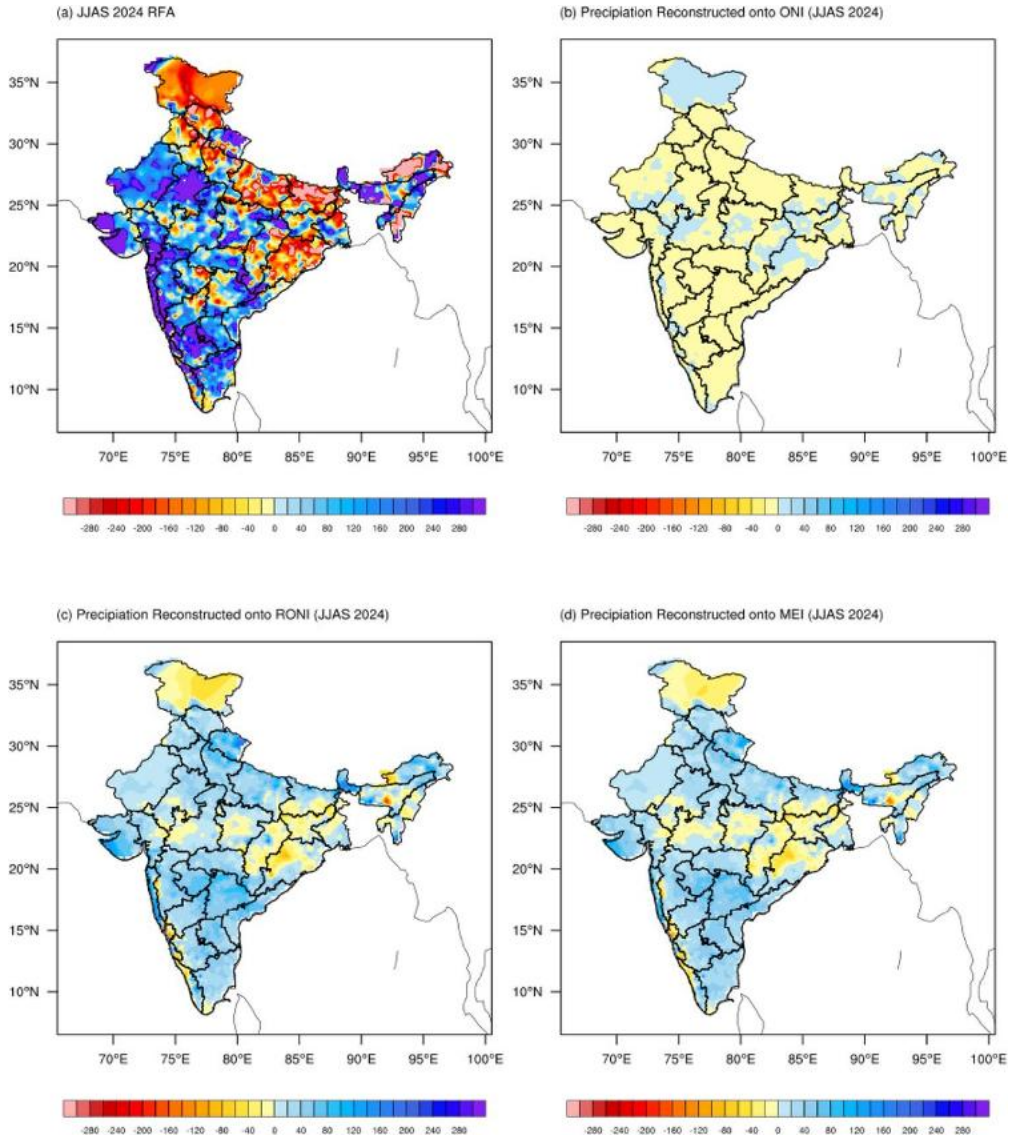


In 2024, Walker circulation anomalies showed strong ascent over the Indo-Pacific and enhanced subsidence over the central–eastern Pacific from June onward, intensifying into a mature La Niña pattern by October–December. This evolution aligns with RONI and MEI indicating La Niña conditions from mid-year, while conventional ONI remained mostly neutral.



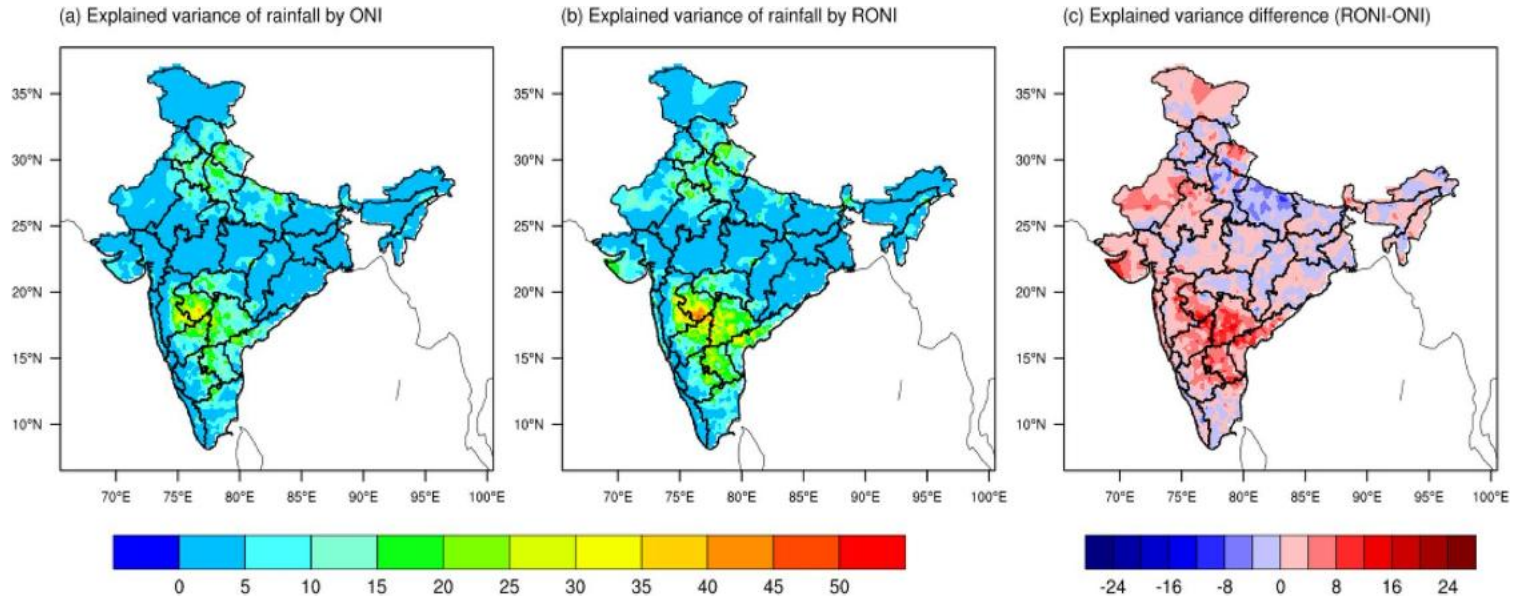
(a) Observed Rain anomaly for 1994
(b) 1994 precipitation reconstructed onto ONI index (c) 1994 precipitation reconstructed onto RONI index (d) 1994 precipitation reconstructed onto MEI index

In 1994, observed rainfall showed widespread above-normal conditions over India, contrasting with ENSO-based reconstructions (ONI, RONI, MEI) that indicated negative anomalies. This mismatch highlights the limitation of ENSO-only indices, as a concurrent positive IOD offset El Niño effects and enhanced monsoon rainfall.



(a) Observed Rain anomaly for 2024 (b) 2024 precipitation reconstructed onto ONI index (c) 2024 precipitation reconstructed onto RONI index (d) 2024 precipitation reconstructed onto MEI index

In 2024, observed rainfall showed widespread above-normal conditions, with RONI and MEI reconstructions capturing this pattern better than ONI, which remained largely neutral. This highlights the improved sensitivity of RONI and MEI in a warming climate, where conventional ONI may miss evolving ENSO–monsoon relationships.

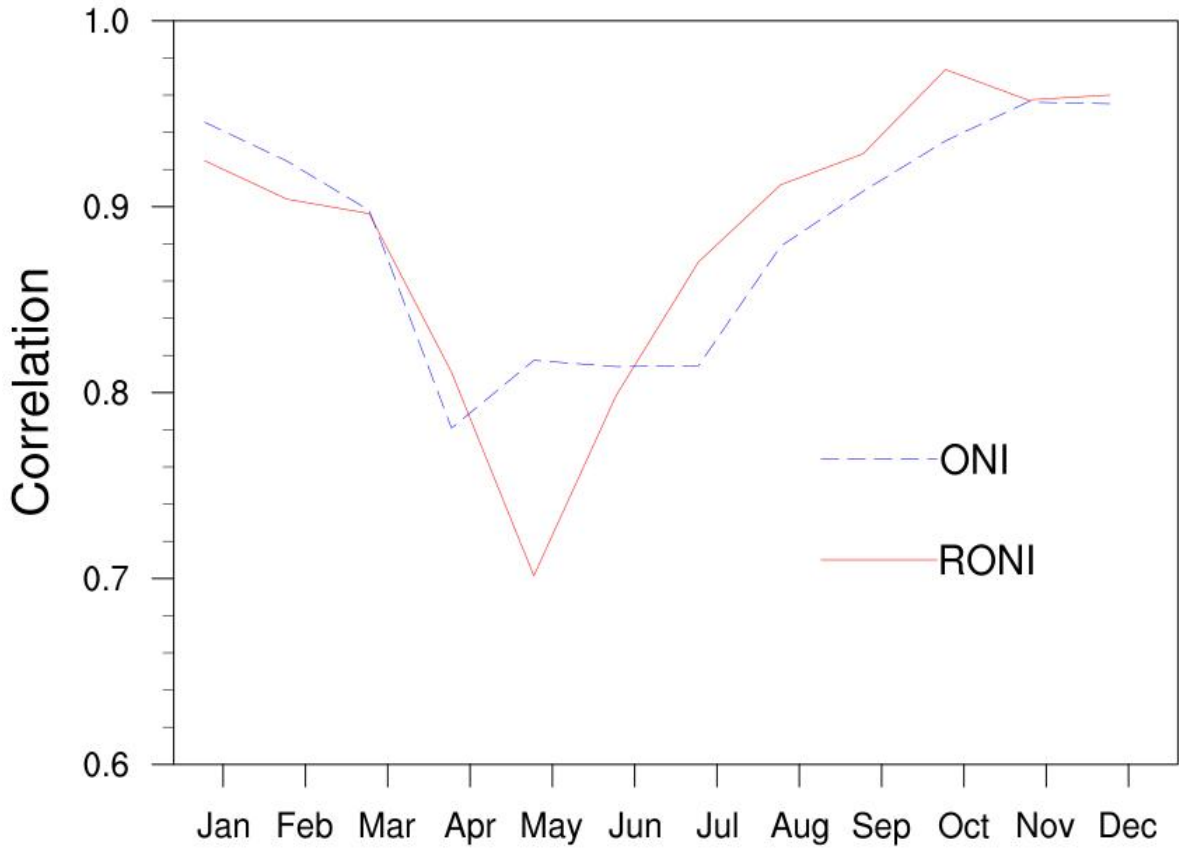


Spatial distribution of the explained variance ($r^2 \times 100$) of JJAS (June–September) mean precipitation over India associated with JJAS-averaged (**a**) ONI and (**b**) RONI, and (**c**) their difference (RONI – ONI)

Both ONI and RONI capture the ENSO–monsoon relationship, explaining significant rainfall variability over India, but RONI consistently explains a larger fraction, especially over west-central and southern regions. This indicates RONI provides a more robust representation of ENSO influence on monsoon rainfall under a warming climate.

MMCFS Skill in Predicting ONI vs. RONI

Anomaly correlation between predicted ONI and RONI from the MMCFS model at lead time 1 and their observed counterparts for each target month.



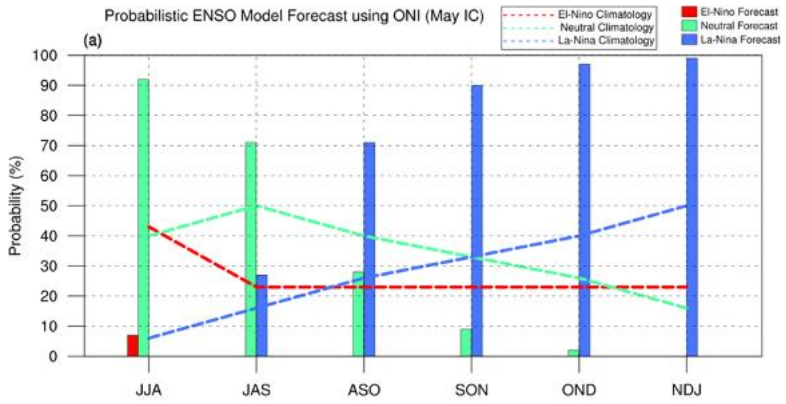
Forecast Skill Summary

✓ Both ONI and RONI show high predictive skill overall.

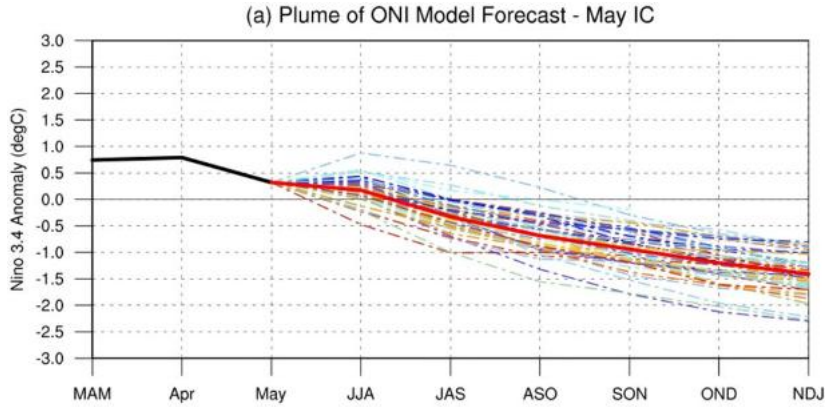
⚠ Both experience a skill drop during boreal spring (spring predictability barrier), with RONI showing a slightly sharper decline.

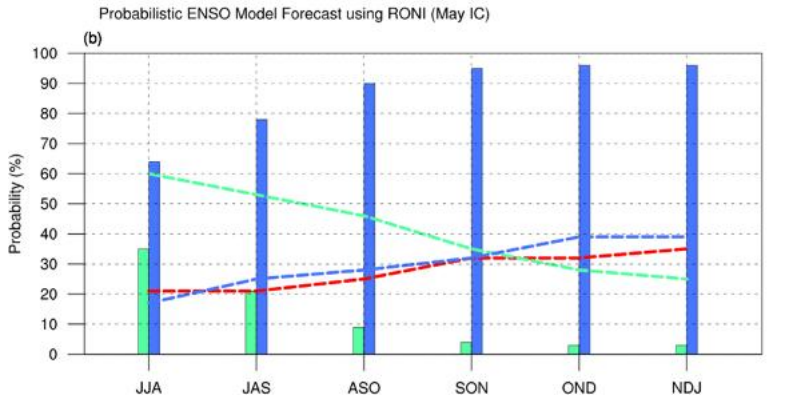
✓ RONI outperforms ONI in the latter half of the year, indicating better representation of ENSO dynamics for monsoon and post-monsoon predictions.

ENSO FORECAST : 2024

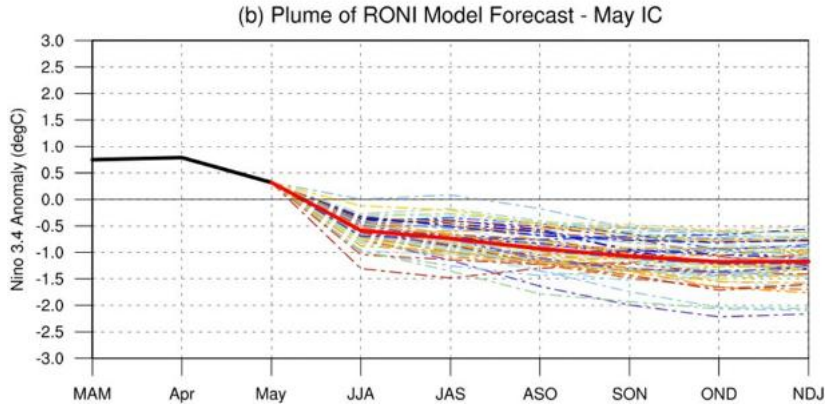


using ONI

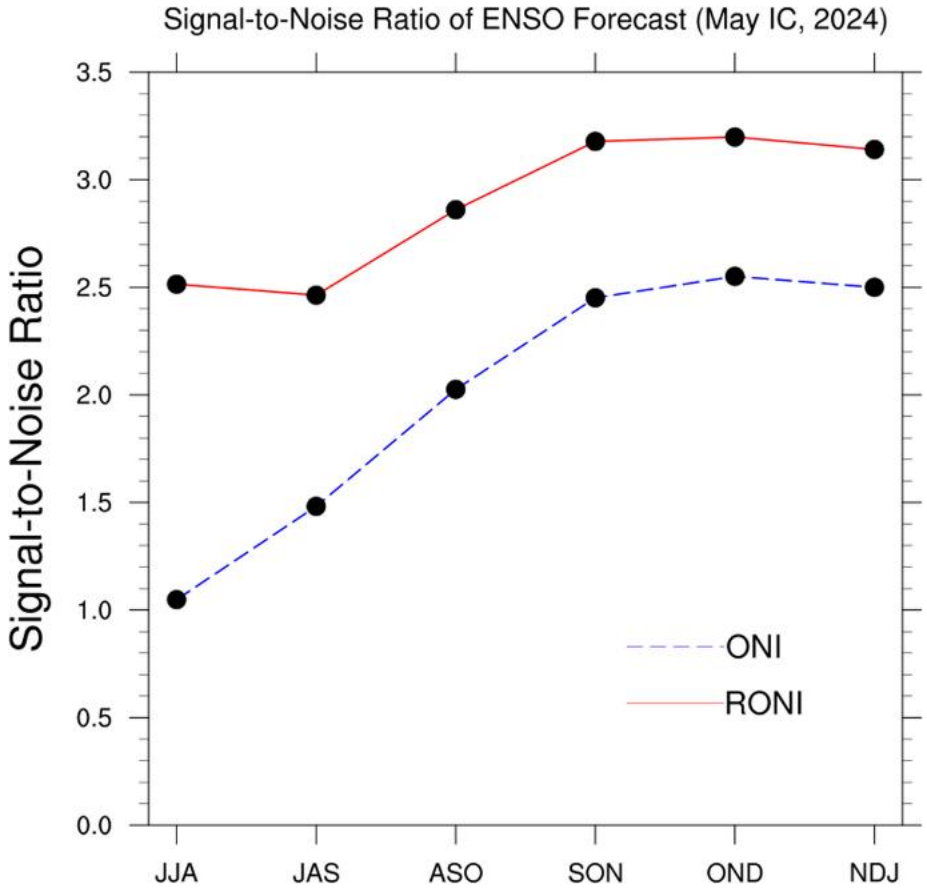




using RONI



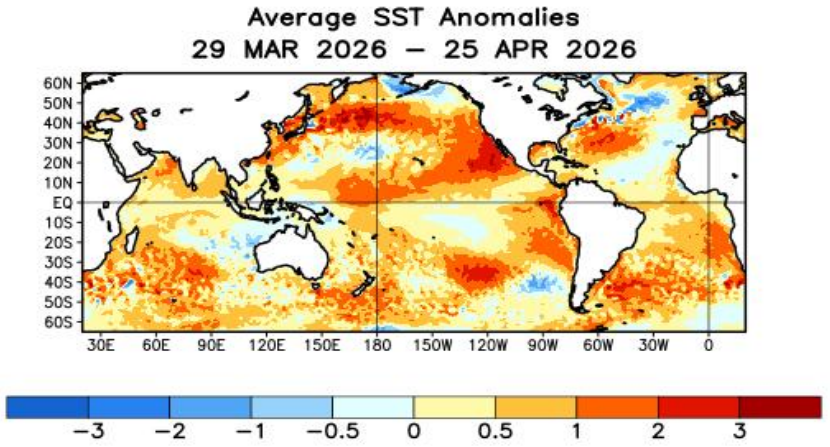
Both ONI and RONI predicted La Nina in model. But in observation ONI do not show La Nina while RONI align with prediction.



Signal-to-noise ratio (SNR) of ENSO forecasts for 2024 based on the MMCFS model initialized in May, computed using the Relative Oceanic Niño Index (RONI; red) and the conventional Oceanic Niño Index (ONI; blue). The SNR is shown as a function of target season from JJA to NDJ

RONI shows higher signal-to-noise ratios than ONI throughout 2024, indicating a stronger and more reliable ENSO signal despite larger early spread. As the forecast progresses, increasing SNR and reduced spread highlight improved confidence and a more robust representation of La Niña development in RONI.

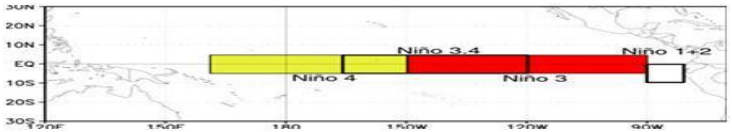
Latest Global SST Departures (°C) and ENSO Conditions over Pacific



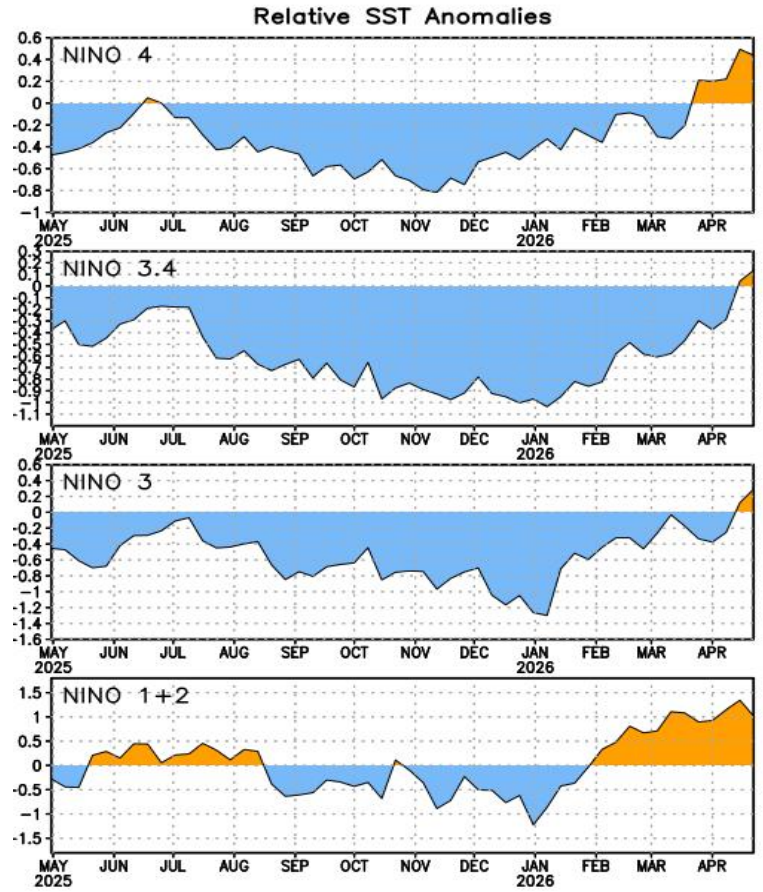
Data source
CPC, USA

The latest weekly SST departures are:

Niño 4	0.5°C
Niño 3.4	0.2°C
Niño 3	0.3°C
Niño 1+2	0.9°C



Recent evolution of NINO SSTs

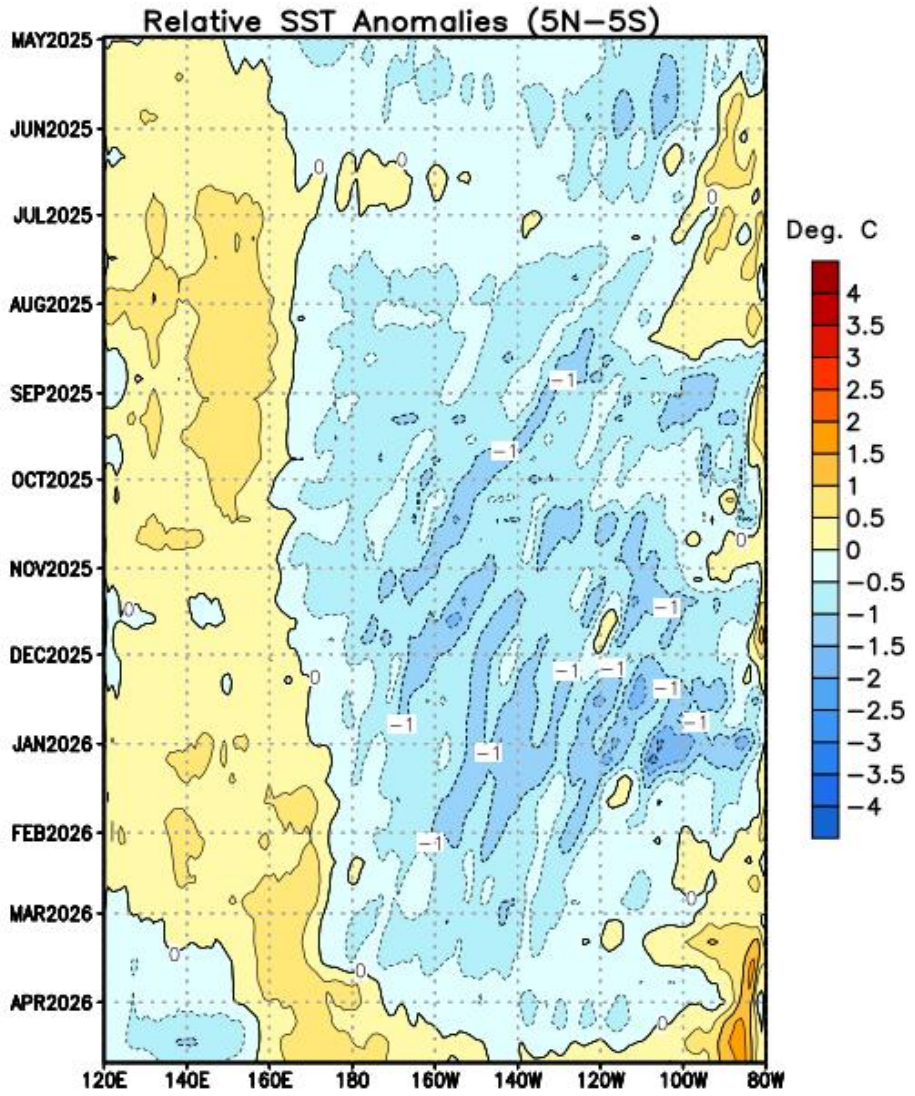


Data source
CPC, USA

During the last four weeks, above-average SSTs were prevalent over most of the global oceans. Equatorial SSTs were mostly above average in the Atlantic Ocean. SSTs were near-to-below average north of Australia. Equatorial SST anomalies were warmer near the Date Line and far eastern Pacific compared to the east-central Pacific.

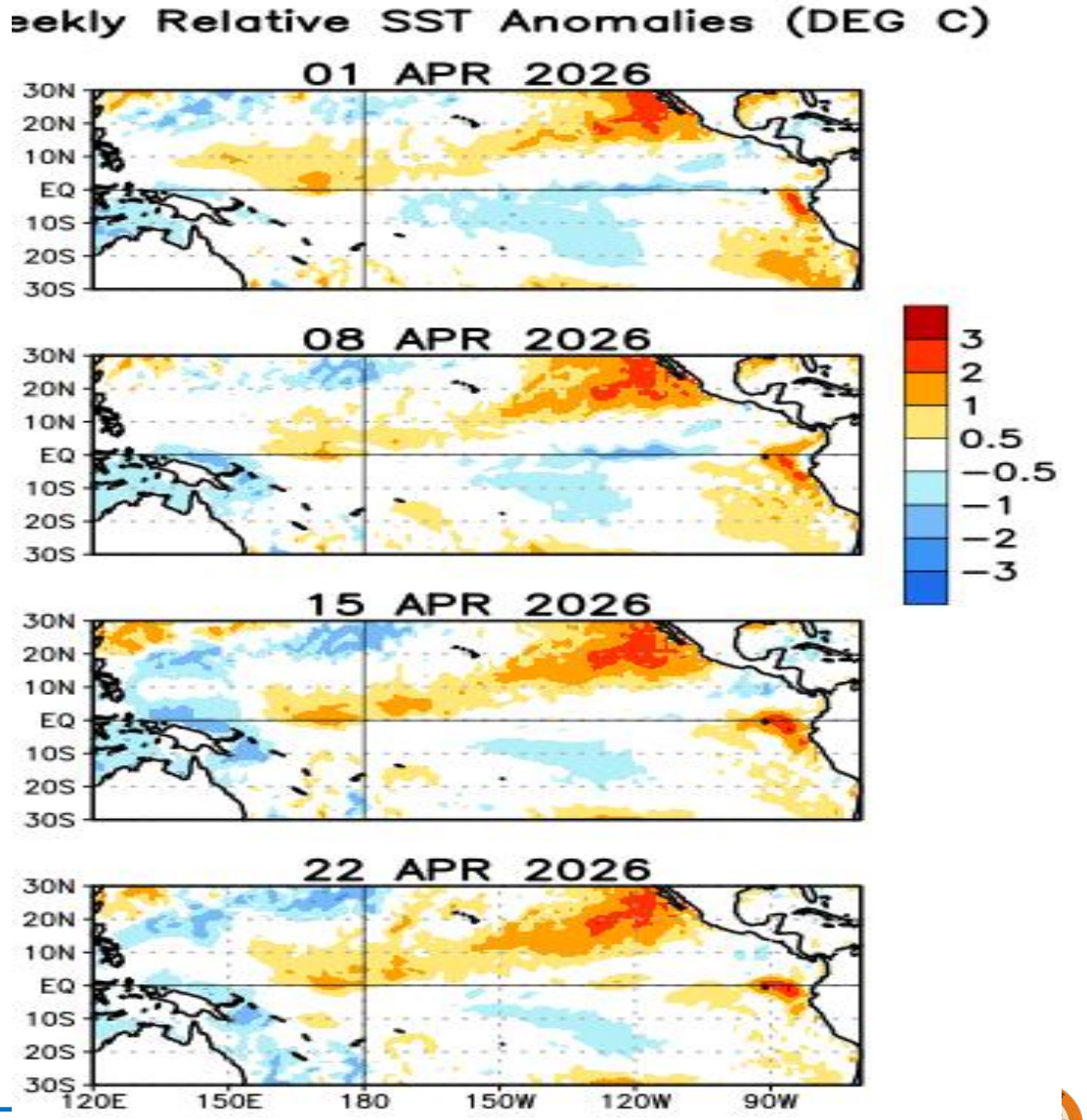
Recent Evolution of Equatorial Pacific SST Departures (ºC)

- Since early January 2026, below-average SSTs have gradually weakened across most of the equatorial Pacific.
- Beginning in early February 2026, above-average SSTs emerged in the far eastern equatorial Pacific.
- Since March 2026, above-average SSTs have shifted eastward to near the Date Line. In the last week, near-to-above-average SSTs have expanded into the east-central Pacific.



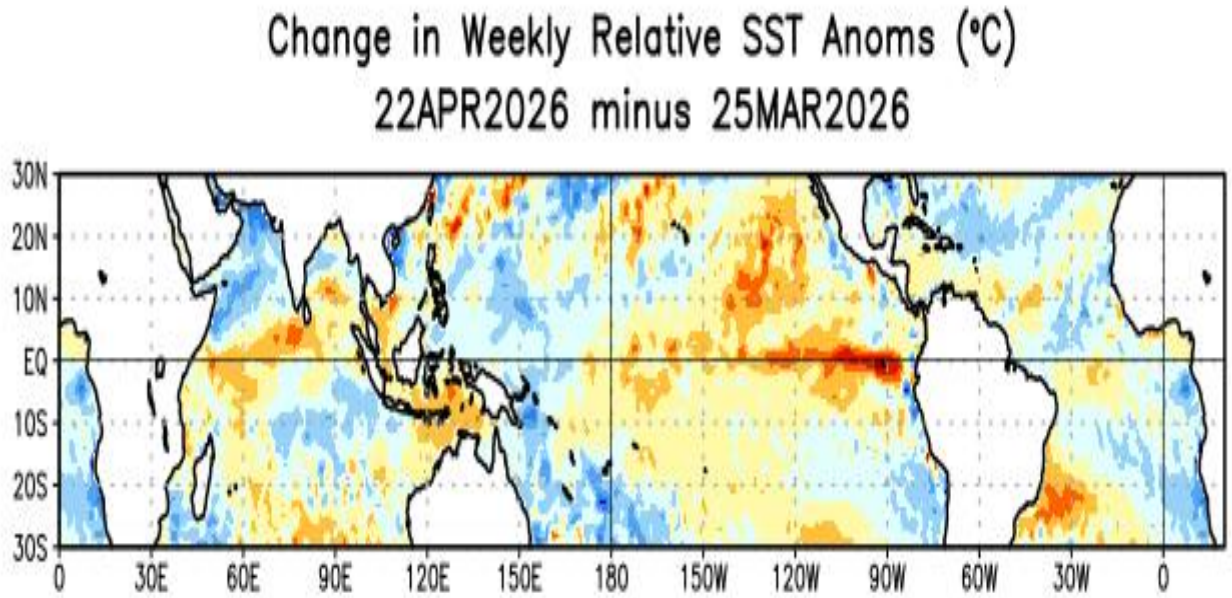
Weekly SST Departures during the Last Four Weeks

- During the last 4 weeks, below-average equatorial SSTs weakened in the east-central Pacific Ocean.
- Above-average SSTs stretched from Baja to near the Date Line in the tropical Pacific Ocean.
- Above-average SSTs persisted in the far eastern equatorial Pacific Ocean.

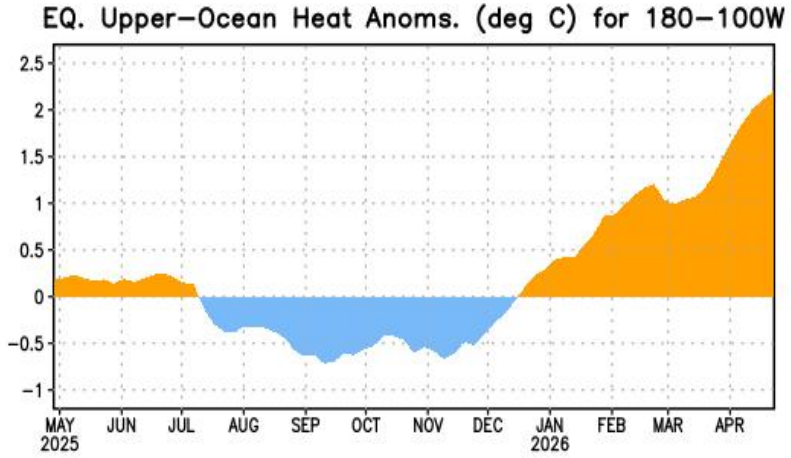


Change in Weekly SST Departures over the Last Four Weeks

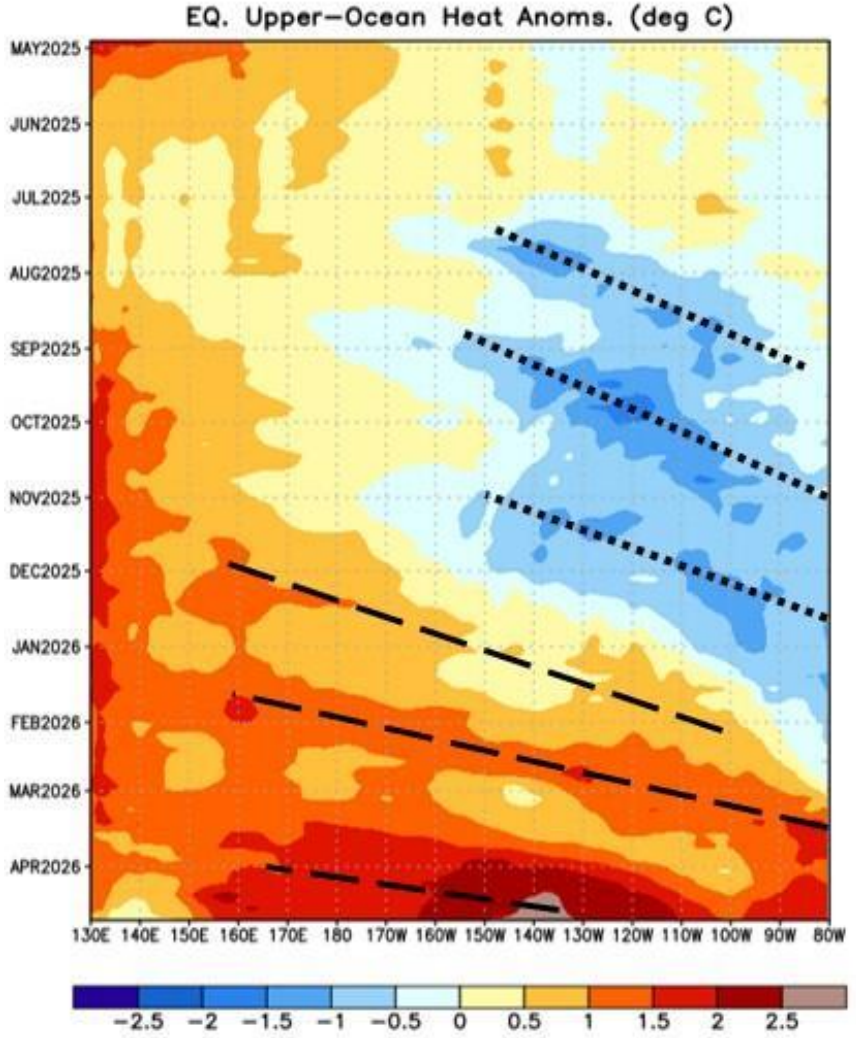
During the last four weeks, mostly positive SST anomaly changes were observed across the eastern and central equatorial Pacific Ocean and western Indian Ocean. Negative changes were evident in the far western Pacific Ocean.

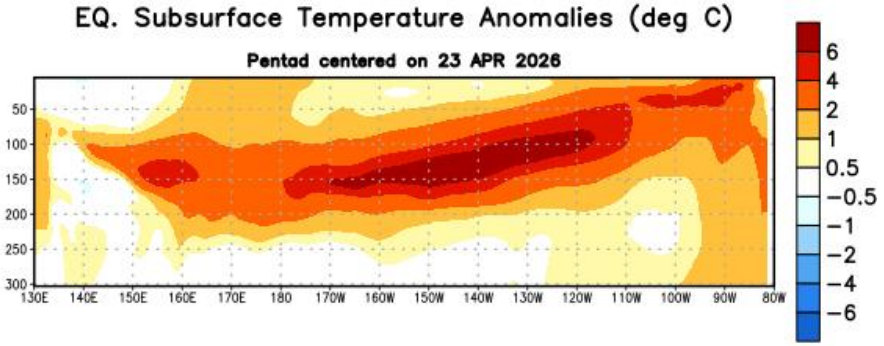


Pacific Subsurface Temperature & Heat Content



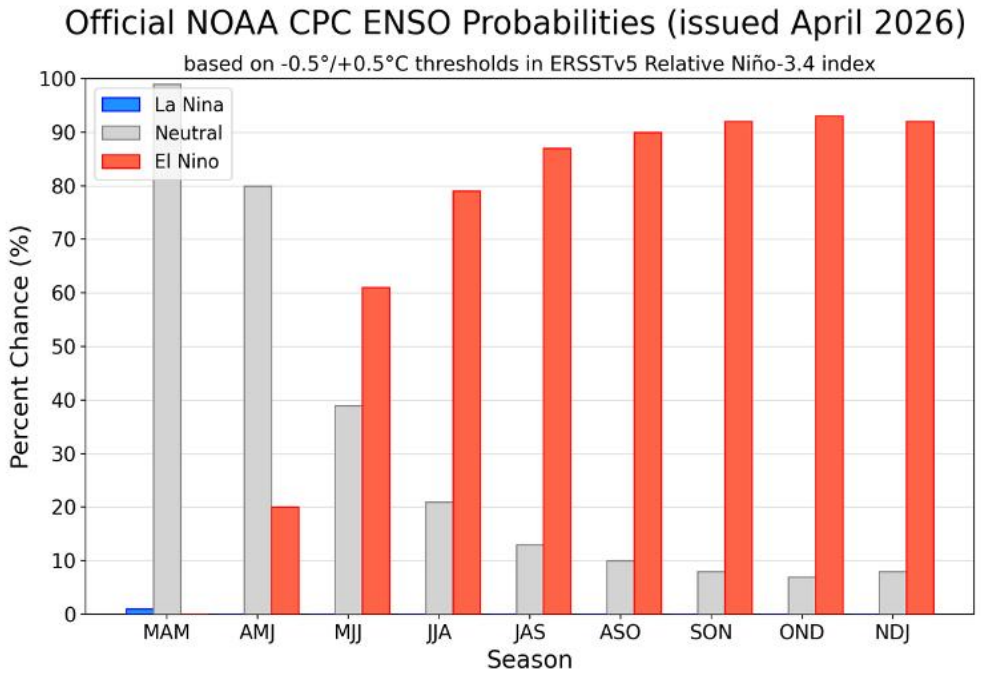
. From mid-December 2025 through late February 2026, positive anomalies developed and increased. After a slight decrease, positive anomalies have increased again since early March 2026.

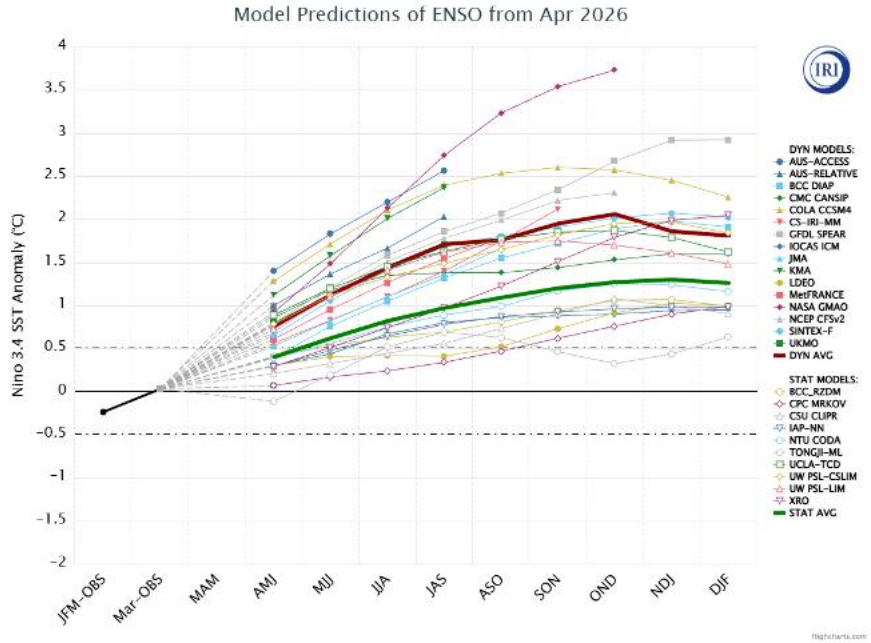




In the last two months, above-average subsurface temperatures have strengthened in the east-central and eastern equatorial Pacific Ocean.

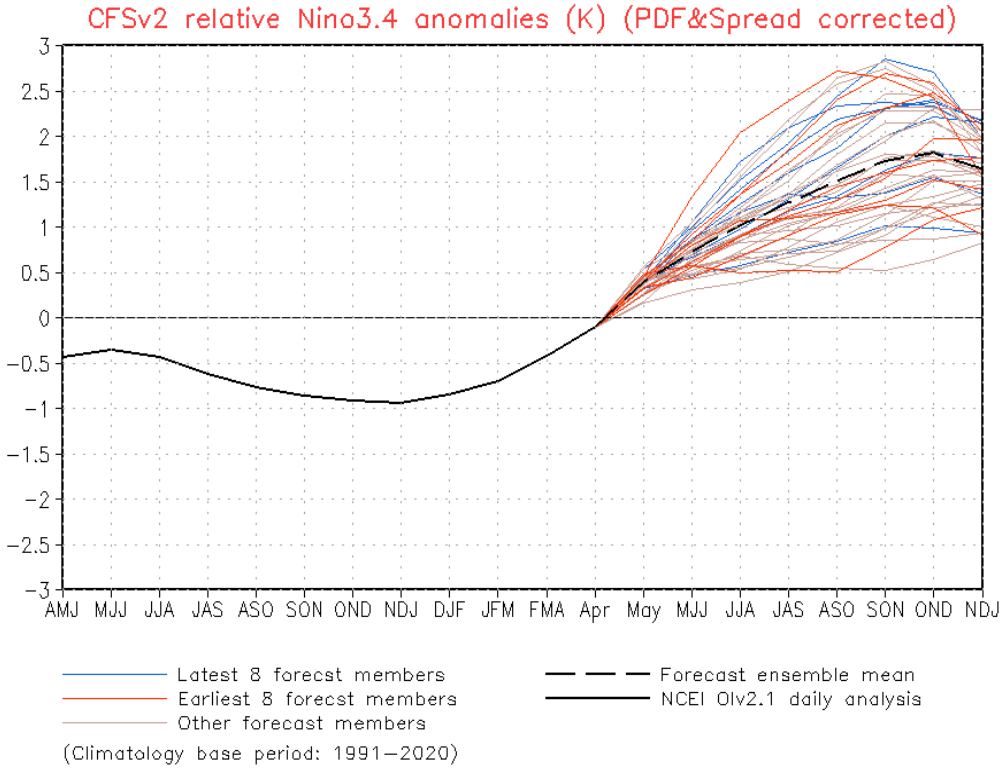
Latest ENSO & IOD Forecast : April 2026

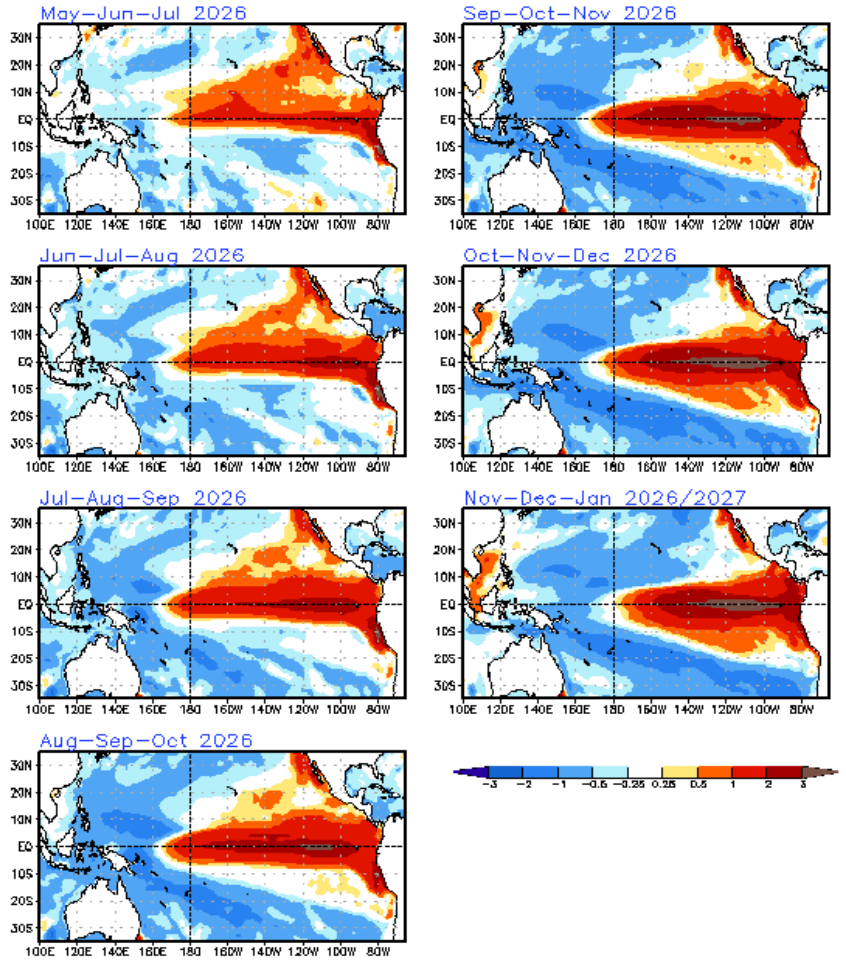




A transition from La Niña to ENSO-neutral is expected in the next month, with ENSO-neutral favored through May-July 2026 (55% chance). In June-August 2026, El Niño is likely to emerge (62% chance) and persist through at least the end of 2026.

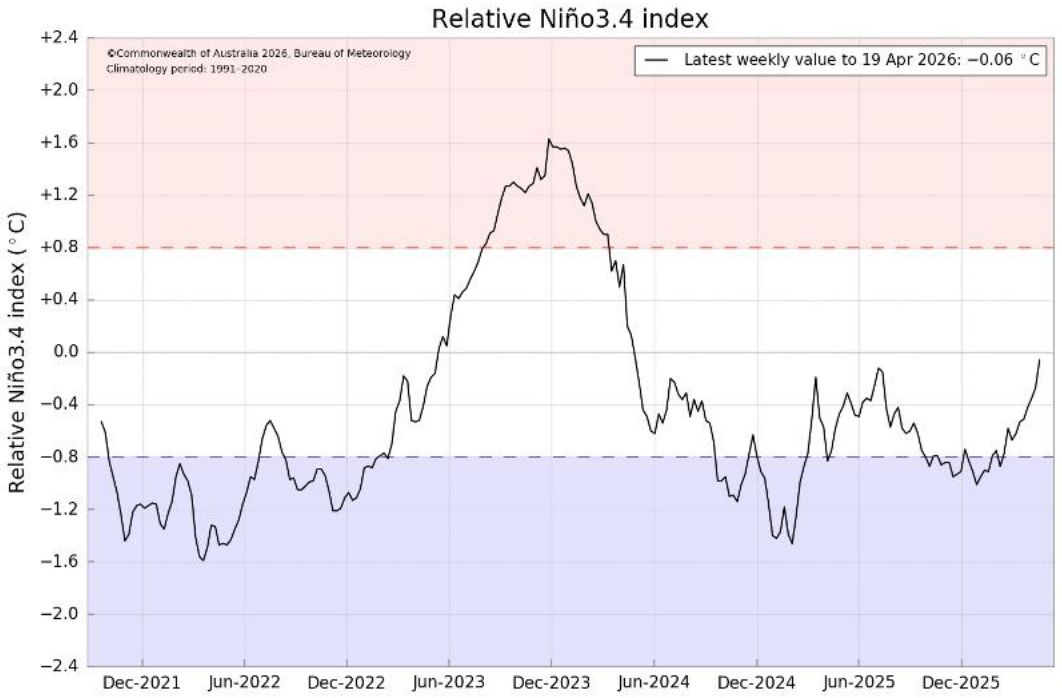
NCEP CFSv2 forecast





The CFS.v2 ensemble mean (black dashed line) favors the continuation of ENSO-neutral for the next month or two, with a transition to El Niño during May-July 2026.

Bureau's of Meteorology ENSO & IOD Monitoring

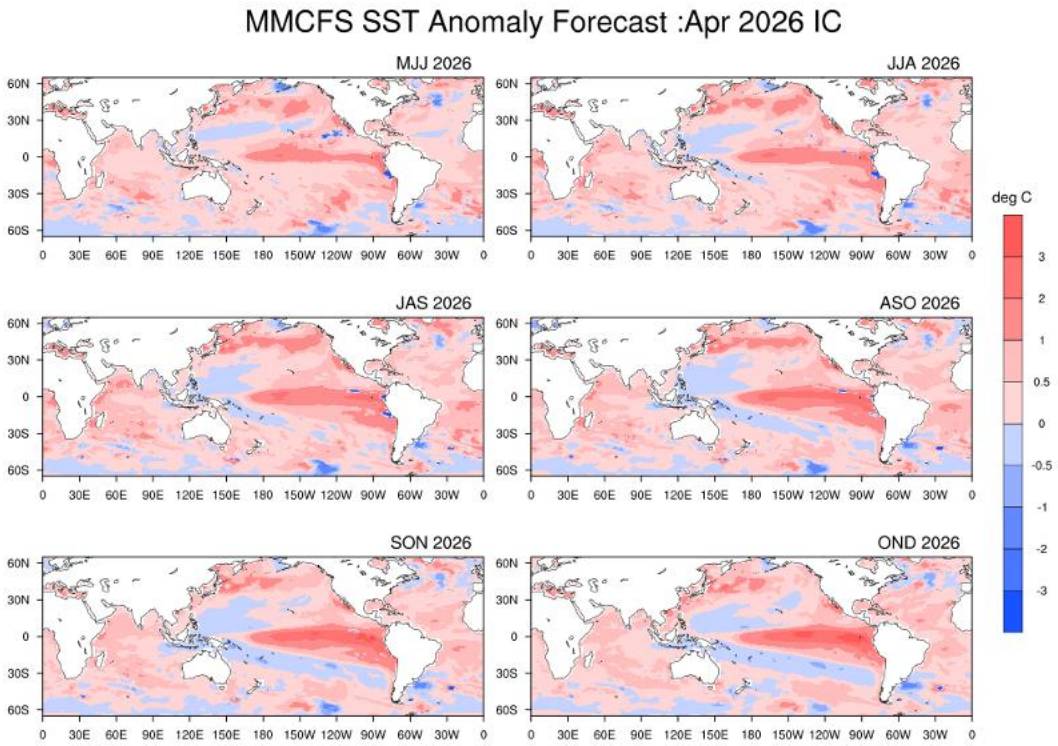


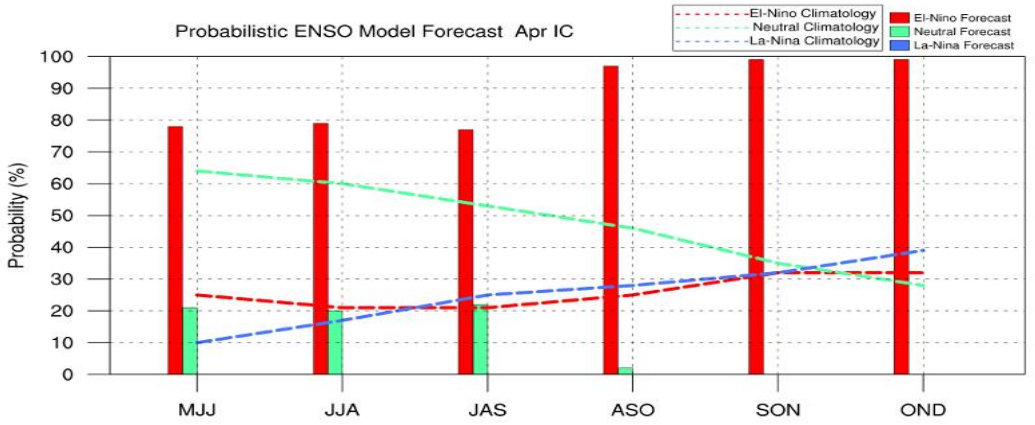
ENSO

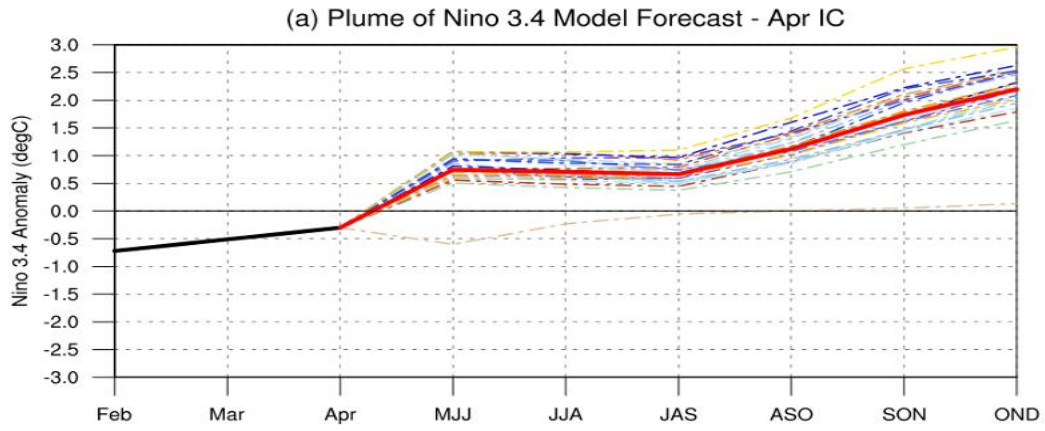
IOD

MMCFS ENSO Forecast: 2026

MMCFS Forecast: April IC



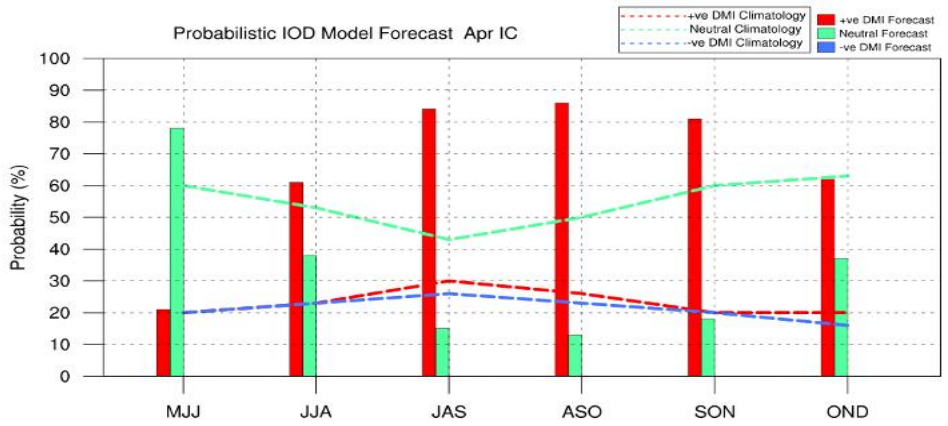


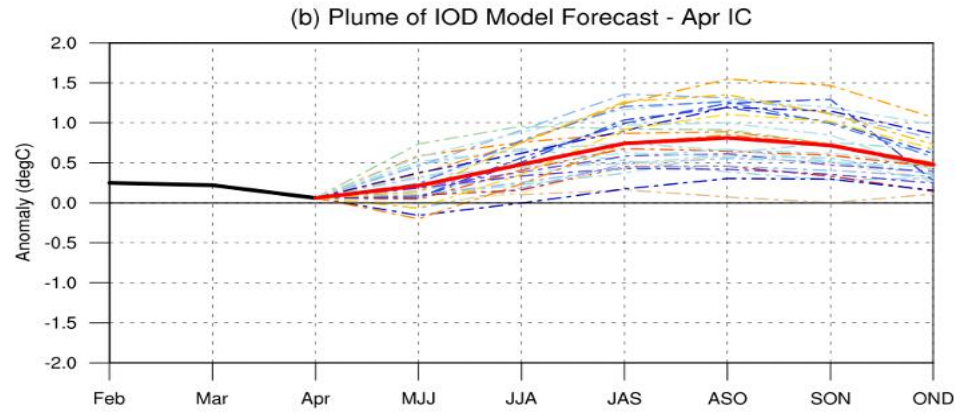


The latest MMCFS forecast indicates enhance chance for El Nino conditions to develop during monsoon season.

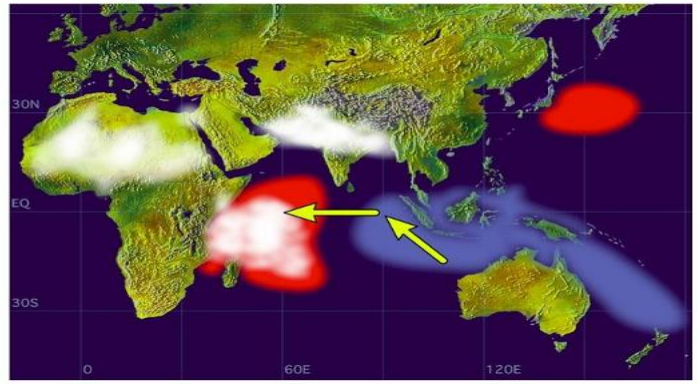
Indian Ocean Dipole: April 2026

MMCFS Forecast: Apr IC

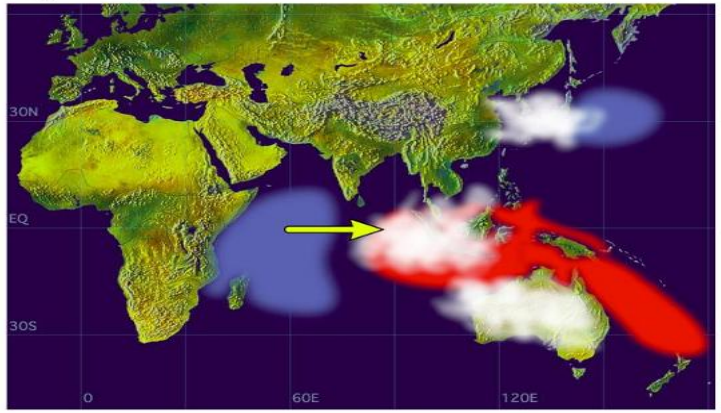




Positive Dipole Mode



Negative Dipole Mode



The latest MMCFS forecast indicate a positive IOD conditions during JJAS season.

Summary

ENSO-neutral conditions are present.

Equatorial sea surface temperatures (SSTs) are near-to-above-average in the east-central Pacific Ocean.

ENSO-neutral conditions favored through April-June 2026 (80% chance). In May-July 2026, El Niño is likely to emerge (61% chance) and persist through at least the end of 2026.

Thank you