Earth System Science Organization (ESSO)
Ministry of Earth Sciences (MoES)
India Meteorological Department (IMD)
WMO Regional Climate Centre
Pune, India

El Niño Southern Oscillation (ENSO) and Indian Ocean Dipole (IOD) Bulletin

December 2024

Highlights

The sea surface temperatures are mostly below average in the central and eastern Pacific Ocean. Currently, neutral El Niño-Southern Oscillation (ENSO) conditions are observed over the equatorial Pacific. The probability forecast indicates a highest probability of La Niña conditions during the DJF and JFM seasons.

Above-average sea surface temperatures (SSTs) are currently seen across most of the Indian Ocean. Currently, neutral Indian Ocean Dipole (IOD) conditions are observed over the Indian Ocean. The latest MMCFS forecast indicates that the neutral IOD conditions are likely to continue for the next several months.

1. Current Sea Surface Temperature (SST) Conditions over the Pacific and Indian Oceans

In November 2024, sea surface temperatures (SSTs) were near-to-below average in most of the central and east-central Pacific Ocean. Equatorial SSTs were above average across the western Pacific Ocean and around the Maritime Continent (Fig.1a). Warmer than average SSTs were observed over some parts of the northern extra-tropical Pacific region. Cooler than average SSTs were observed over parts of the south of the extra-tropical Pacific region. Compared to October 2024, negative SST anomalies were seen over western equatorial Pacific Ocean and some region of the central equatorial Pacific Ocean. Positive SST anomalies were seen over east-central and eastern equatorial Pacific Ocean. Cool SST anomalies are observed over the higher latitudes of North Pacific Ocean (Fig.1b).

In November 2024, equatorial SSTs were above average across the most of the Indian Ocean, including Arabian Sea and Bay of Bengal (Fig. 1a). Compared to October 2024, warmer SSTs were observed in the Arabian Sea and north Bay of Bengal, as well as south eastern parts of Indian Ocean. In contrast, cooler SSTs were observed in the southern parts of central equatorial Indian Ocean (Fig. 1b).

1.1 El Niño Southern Oscillation (ENSO) conditions over the Pacific Ocean

The monthly time series of Niño3.4 SST anomalies for the last 12 months from December 2023 to November 2024 is shown in Fig. 2(a). In December 2023, strong El Niño conditions were observed over the Pacific Ocean. Thereafter El Niño conditions started to weaken. However, a gradual weakening of El Niño conditions was seen from January to April 2024. By the end of May 2024, El Niño conditions turned into ENSO neutral conditions and continued to be ENSO neutral till November 2024. Currently, ENSO-neutral conditions are observed. Weak positive subsurface temperature anomalies are observed over parts of the western Pacific Ocean, both near and above the 20°C isotherm depth (Fig. 2b). The negative subsurface temperature anomalies are observed over the eastern and central equatorial Pacific Ocean with the highest magnitudes both near and below the thermocline depth (Fig.2b).

1.2. Indian Ocean Dipole (IOD) conditions over the Indian Ocean

The figure 2 (c) shows the monthly time series of the Dipole Mode Index (DMI) for the past 12 months from December 2023 to November 2024. The positive Indian Ocean Dipole (IOD) conditions have continued in November 2023 and lasted up to January 2024. In February 2024, the IOD conditions weakened from positive to neutral and continued neutral conditions till November 2024. At present, neutral IOD conditions are prevailing over the Indian Ocean. Positive subsurface temperature anomalies (Fig. 2d) were observed in the eastern and central equatorial Indian Ocean, near and above the 20°C isotherm depth, and extending to the thermocline depth. Conversely, certain regions in the western equatorial Indian Ocean has shown negative subsurface anomalies, particularly near and below the thermocline depth.

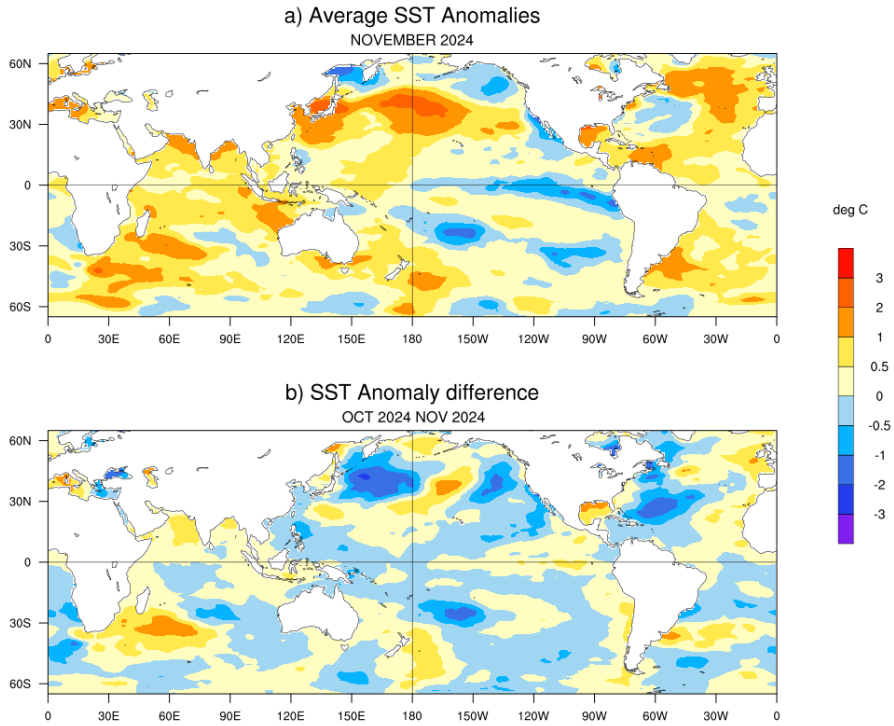

Fig.1: (a) Sea surface temperature (SST) anomalies (^{0}C) during November 2024 and (b) changes in the SST anomalies (^{0}C) from October 2024 to November 2024. SSTs are based on the COBE-SST 2, from JMA, and anomalies are computed with respect to 30-year (1991-2020) long term mean.

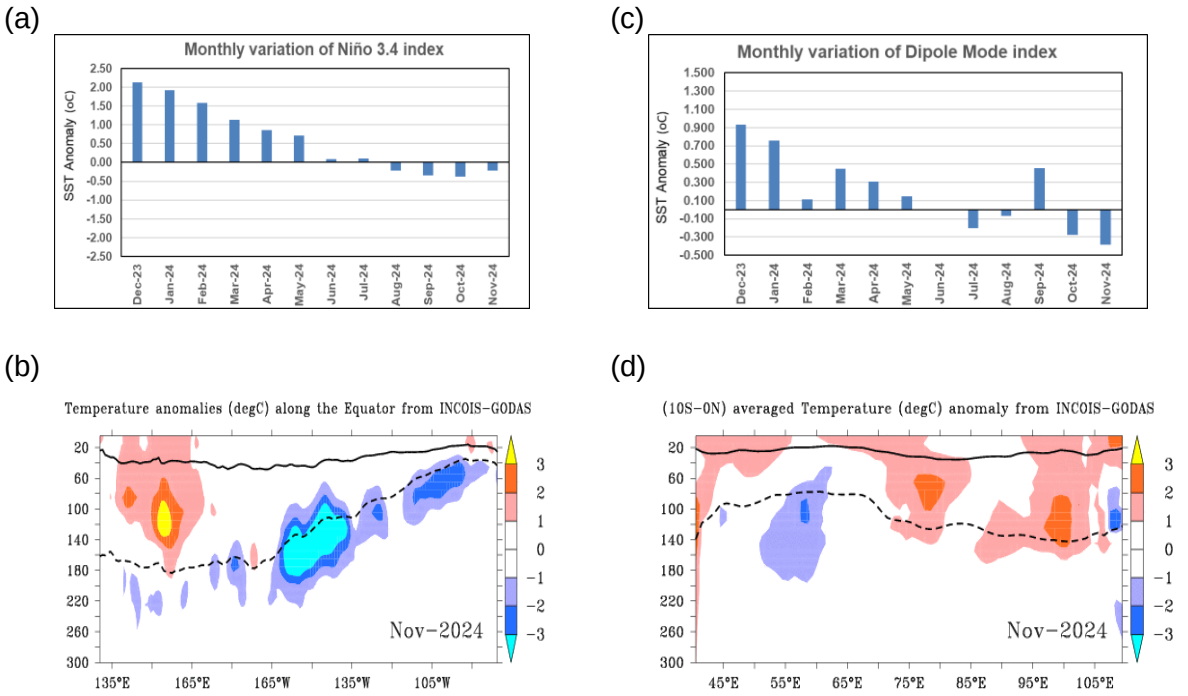

Fig.2: (a) Monthly variation of Niño 3.4 SST index for the last 12 months and (**b**) Depth-longitude section of sub-surface temperature anomalies in the equatorial (5^0S-5^0N) Pacific Ocean for the month of November 2024. (**c**) Same as (**a**) but for the Dipole Mode Index (DMI). (**d**) Same as **(b)** but for the tropical Indian Ocean (10^0S-Eq). The anomalies in (**a**) and (**c**) were computed using the base period of 1991-2020 (Data Source: COBE-SST 2, JMA) The solid dark line in (b) and (d) is the 20^0C isotherm and the dashed line is thermocline depth (Data Source: INCOIS-GODAS).

2. ENSO and IOD Forecast

The SST forecast was prepared using the high-resolution Monsoon Mission Coupled Forecast System (MMCFS) (AGCM T382L64; ~38 km and OGCM 25 km in tropics) based on the 2024 November initial conditions. The initial conditions for the model runs were obtained from ESSO-INCOIS and ESSO-NCMRWF analysis. Probability density function (PDF) bias correction was applied to the forecasts of Niño3.4 index (Fig.4a) and DMI (Fig.4b) based on hindcasts for the period 1999-2008 and anomalies were calculated based on 1991-2020 climatology.

In November 2024, sea surface temperatures (SSTs) were mostly below average in the central and east-central Pacific Ocean and equatorial SSTs were above average across the western Pacific Ocean.

The 3-month season-averaged SST anomaly forecast over the Pacific Ocean (Fig. 3) indicates the cooler than normal SSTs over the eastern equatorial Pacific Ocean during DJF 2024. The strength of the cool SSTs is seen to be decreased thereafter. The latest MMCFS plume forecast (Fig. 4a) indicate a SSTs in the tropical Pacific are likely to reach or surpass La Niña thresholds during the DJF season. The probability forecast (Fig. 5a) indicates a highest probability of La Niña conditions during the DJF and JFM seasons. IMD closely monitors El Niño conditions and provides monthly updates, reflecting the latest observations and changes in the Pacific Ocean.

The 3-month season-averaged SST anomaly forecast for the Indian Ocean (Fig. 3) suggests that near-average SST anomalies are expected across most parts of the Indian Ocean for the entire forecast period. The latest MMCFS forecast indicates that the current neutral IOD conditions are expected to continue for the next several months (see Fig. 4b and 5b).

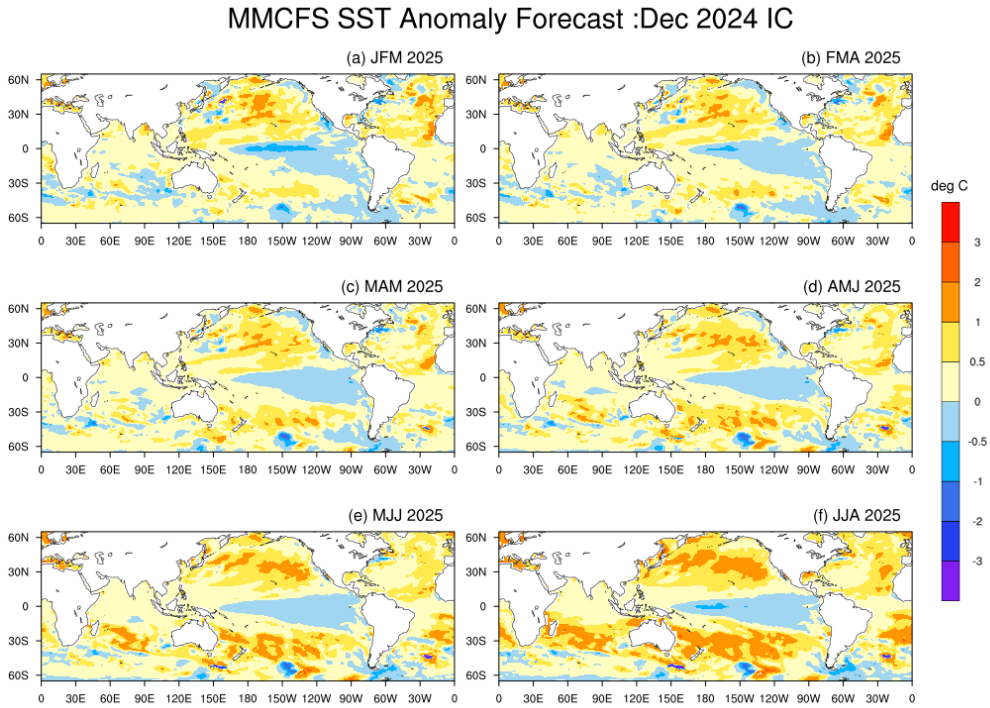

Fig.3: Forecasted Seasonal mean SST anomalies for three-monthly (a) December to February 2025 (DJF 2025) (b) January to March 2025 (JFM 2025), (c) February to April (FMA 2025) (d) March to May (MAM 2025), (e) April to June (AMJ 2025) and (f) May to July (MJJ 2025) (Model bias correction base period: 1999-2008; Climatology base period:1991-2020).

(a) (b)

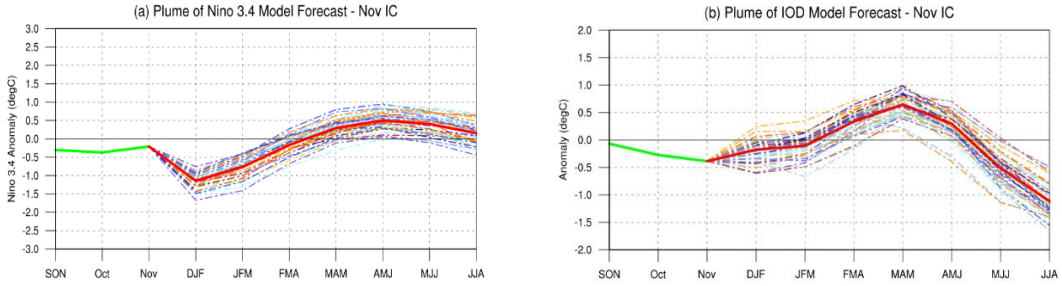

Fig.4: Plume of **(a)** Niño 3.4 SST index, **(b)** Indian Ocean Dipole (IOD) Mode Index forecasted by high-resolution MMCFS. The forecasts were PDF corrected for bias and variance. The solid green line is the observed SST anomaly (ERSSTv5, NOAA) and the solid red line is the ensemble mean SST anomaly forecast of 44 members (MMCFS). The individual ensemble member forecasts are shown in light dotted lines of different colours.

(a) (b)

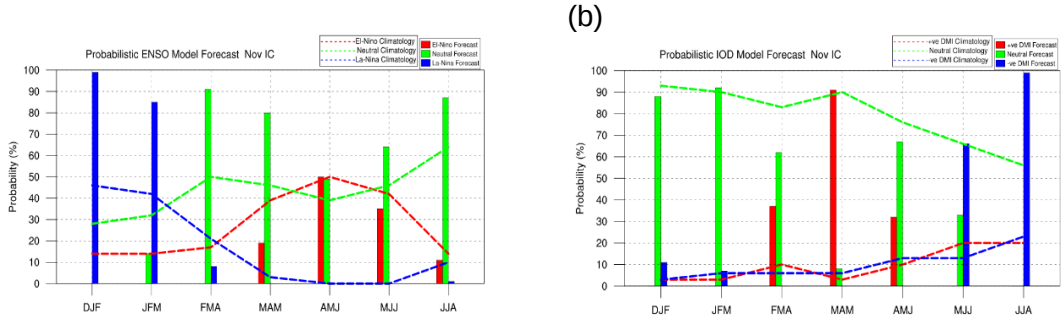

Fig.5: Probability forecast along with climatological probabilities of **(a)** Niño 3.4 and **(b)** Indian Ocean Dipole (IOD) Mode Index from high-resolution MMCFS. The data source for Climatology probabilities: NOAA Extended Reconstructed SST V5. Criteria used for Probabilistic ENSO Forecast: La Niña ≤ -0.5, Neutral <0.5 to >-0.5, El Niño ≥ 0.5. Criteria used for Probabilistic DMI Forecast: negative DMI ≤ -0.4, Neutral <0.4 to >-0.4, positive DMI ≥ 0.4.