



**Earth System Science Organization (ESSO)
Ministry of Earth Sciences (MoES)
India Meteorological Department (IMD)**

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

July 2024

Highlights

The sea surface temperatures are colder than normal in the eastern equatorial Pacific Ocean. Currently, El Niño-Southern Oscillation (ENSO) neutral conditions are observed over the equatorial Pacific. The latest Monsoon Mission Climate Forecast System (MMCFS) forecast indicates a higher likelihood of La Niña conditions during second half of monsoon season.

At present, neutral Indian Ocean Dipole (IOD) conditions are prevailing over the Indian Ocean. Most of the Climate models across the globe indicate the neutral IOD conditions likely to continue during the remaining part of the monsoon season. However, the latest MMCFS forecast indicates current neutral IOD conditions are likely to turn to negative IOD conditions by the end of the monsoon season.

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

In June 2024, below-average sea surface temperatures (SSTs) were observed over the parts of the eastern Pacific Ocean, while above-average SSTs were seen across the rest of the equatorial Pacific (Fig.1a). Warmer than average SSTs were observed over some parts of the northern and southern extra-tropical Pacific region. Cooler than average SSTs were observed over parts of the south of the extra-tropical Pacific region. Compared to May 2024, negative SST anomalies were seen over the eastern, central and western equatorial Pacific Ocean (Fig.1b).

In June 2024, warmer-than-average SSTs were observed over most parts of the Indian Ocean (Fig.1a), including the Bay of Bengal and the Arabian Sea. Compared to May 2024, cool SSTs were observed over the western equatorial Indian Ocean and Bay of Bengal, and warm SSTs were observed over the parts of the eastern equatorial Indian Ocean and north Arabian Sea (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 July 2023 to June 2024 is shown in Fig. 2(a). In July 2023, weak El Niño

conditions were observed over the Pacific Ocean. These conditions strengthened to moderate El Niño in August 2023 and intensified to strong El Niño during the latter part of 2023. After reaching its maximum intensity during November - December 2023, the El Niño conditions started to weaken. However, a gradual weakening of El Niño conditions was seen from January to April. By the end of May, El Niño conditions turned into ENSO neutral conditions and continued to be ENSO neutral in June 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 western, central and eastern equatorial Pacific Ocean with the highest magnitudes both near and below the thermocline depth (Fig.2 b).

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

The figure shows the monthly time series of the Dipole Mode Index (DMI) for the past 12 months from July 2023 to May 2024. After staying neutral for most of the first half of 2023, the Indian Ocean Dipole (IOD) conditions turned positive in August 2023, lasting until January 2024. In February, the IOD conditions weakened from positive to neutral and continued till June 2024. At present, neutral IOD conditions are prevailing over the Indian Ocean. Positive subsurface temperature anomalies (Fig. 2d) were observed in the western and eastern equatorial Indian Ocean, near or above the 20°C isotherm depth, and at some places extending to the thermocline depth. Conversely, certain regions in the western equatorial Indian Ocean displayed negative subsurface anomalies, particularly below the thermocline depth.

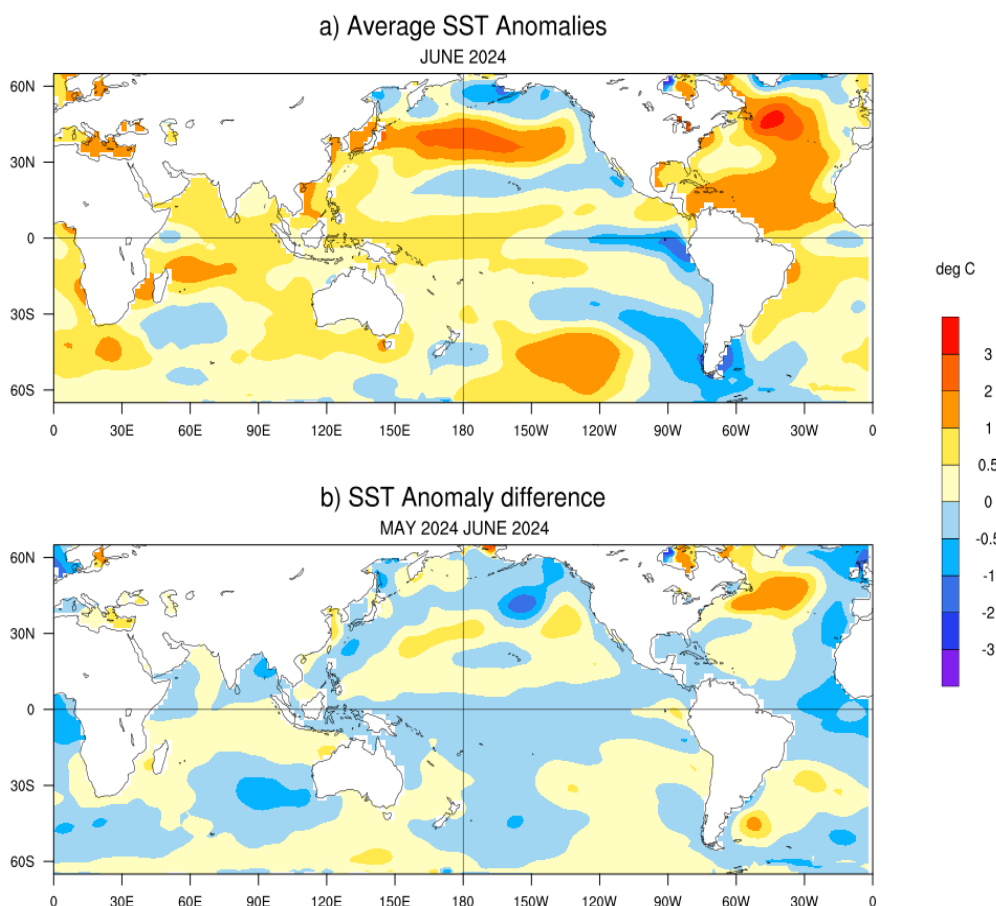


Fig.1: (a) Sea surface temperature (SST) anomalies ($^{\circ}\text{C}$) during June2024 and **(b)** changes in the SST anomalies ($^{\circ}\text{C}$) from May2024 to June2024. SSTs were based on the ERSSTv5, NOAA, and anomalies were computed with respect to 30-year (1991-2020) long term mean.

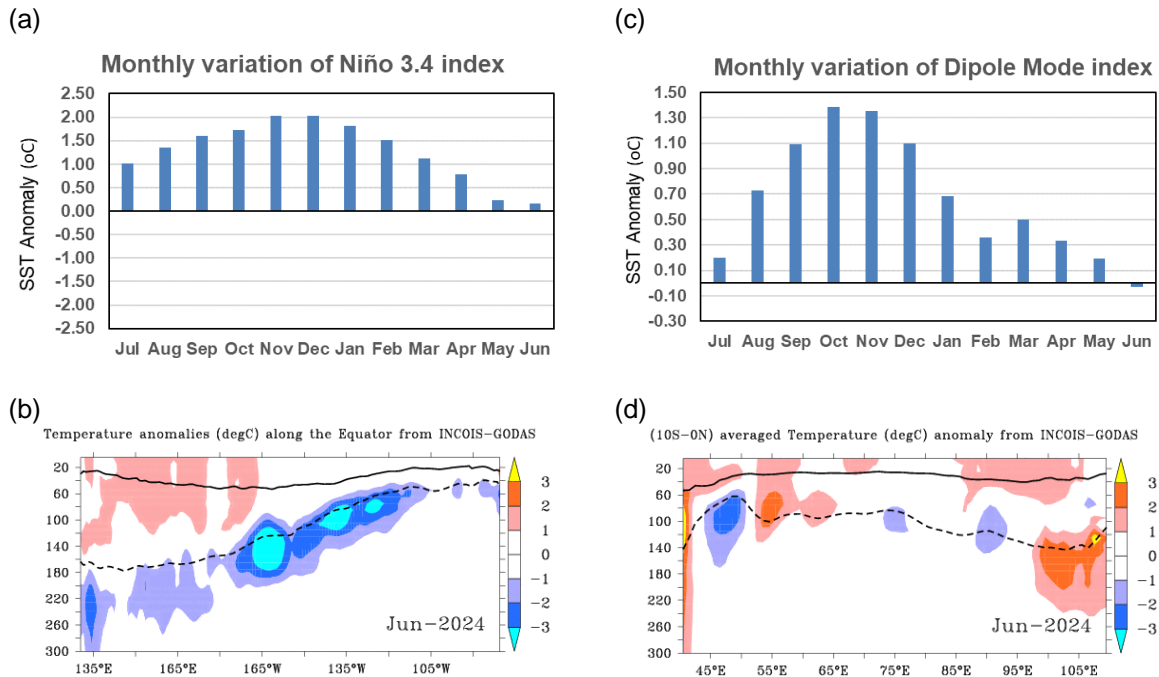


Fig.2: (a) Monthly variation of Niño 3.4 SST index for the last 12 months and (b) Depth-longitude section of sub surface temperature anomalies in the equatorial ($5^{\circ}\text{S}-5^{\circ}\text{N}$) Pacific Ocean for the month of June 2024. (c) Same as (a) but for the Dipole Mode Index (DMI). (d) Same as (b) but for the tropical Indian Ocean ($10^{\circ}\text{S}-\text{Eq}$). The anomalies in (a) and (c) were computed using the base period of 1991-2020 (Data Source: ERSSTv5, NOAA). The solid dark line in (b) and (d) is the 20°C 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 June 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.

The sea surface temperatures are currently cooler than average in the eastern equatorial Pacific Ocean, but warmer than average in most other areas of the equatorial Pacific. The 3-month season-averaged SST anomaly forecast (Fig. 3) indicates that negative SST anomalies over the eastern equatorial Pacific Ocean will strengthen in the upcoming season. The latest MMCFS plume forecast (Fig.4a) suggests a transition from ENSO neutral conditions to La Niña conditions by the end of the JAS season. The probability forecast (Fig.5a) also indicates an increased likelihood of La Niña conditions around the JAS 2024 season. IMD closely monitors El Niño conditions and provides monthly updates based on observed Pacific Ocean changes.

The 3-month season-averaged SST anomaly forecast (Fig. 3) indicates that near average SST anomalies are likely over most parts of the Indian Ocean. Most of the Climate models across the globe indicates the neutral IOD conditions likely to continue during the remaining part of the monsoon season. However, the latest MMCFS forecast indicates current neutral IOD conditions are likely to turn to negative IOD conditions by the end of the monsoon season (Fig. 4b and 5b).

MMCFS SST Anomaly Forecast :Jun 2024 IC

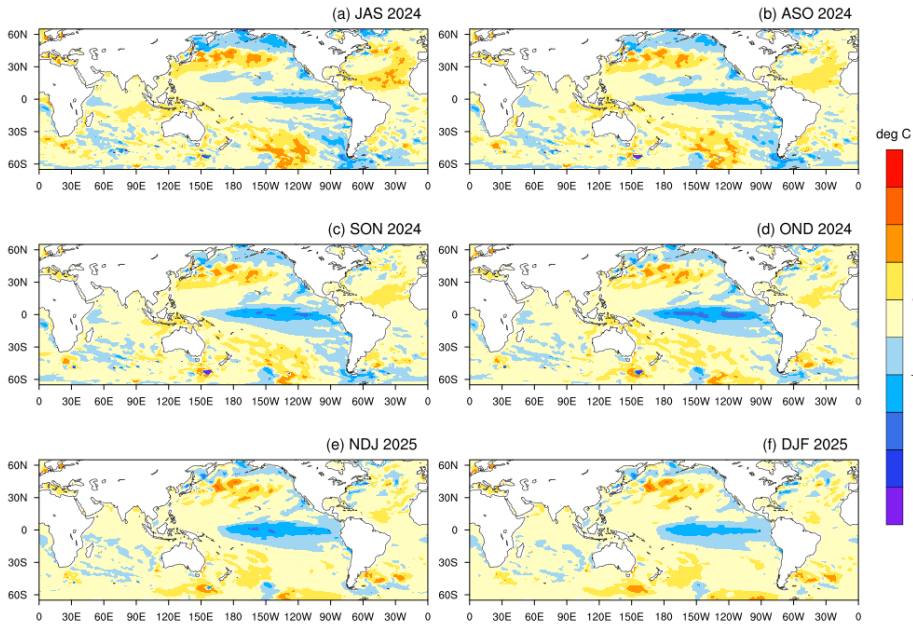


Fig.3: Forecasted Seasonal mean SST anomalies for three-monthly (a)July 2024 to September 2024 (JAS 2024) and (b) August 2024 to October 2024 (ASO 2024) (c) September 2024 to November 2024 (SON 2024), (d) October 2024 to December 2024 (OND 2024) (e) November 2024 to January 2025 (NDJ2025) and (f) December to February 2025 (DJF 2025) (Model bias correction base period: 1999-2008; Climatology base period:1991-2020).

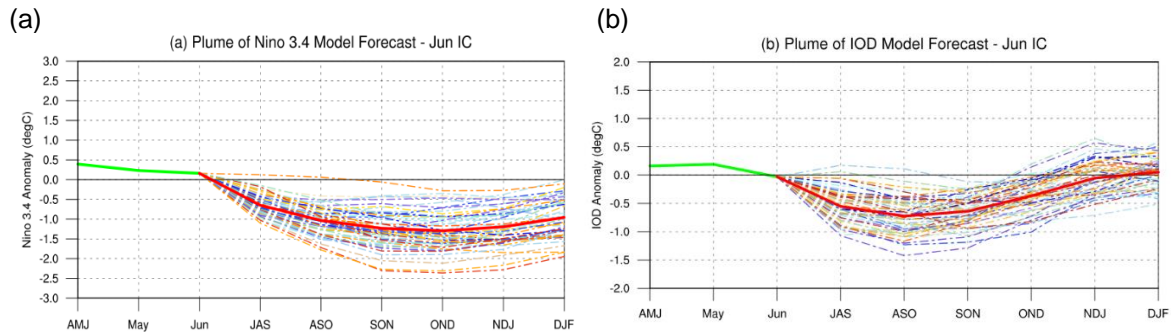


Fig.4: Plume of (a) Niño 3.4 SST index, (b) Indian Ocean Dipole (IOD) Mode Index forecasted by high-resolution MMCFS. The forecasts were PDF corrected for bias and variance. The solid green line is the observed SST anomaly (ERSSTv5, NOAA) and the solid red line is the ensemble mean SST anomaly forecast of 50 members (MMCFS). The individual ensemble member forecasts are shown in light dotted lines of different colours.

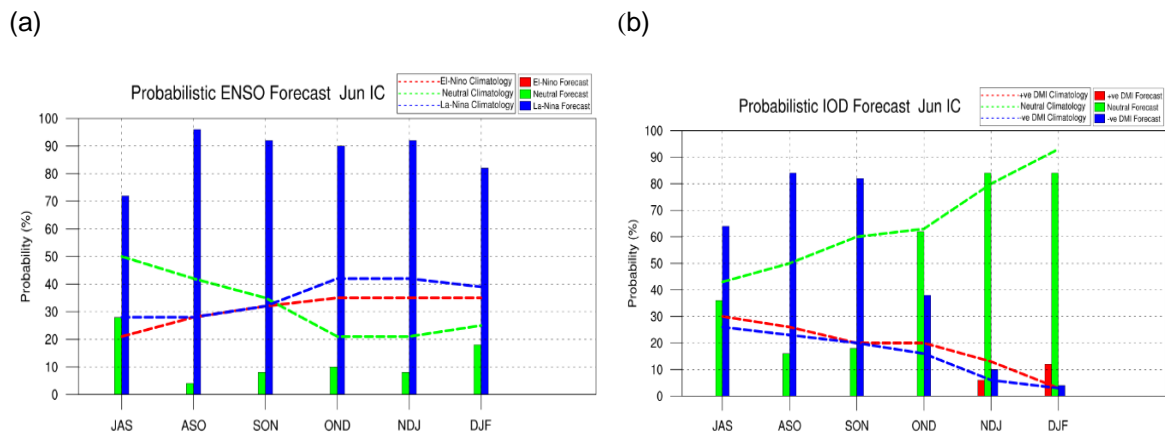


Fig.5: Probability forecast along with climatological probabilities of (a)Niño 3.4 and (b)Indian Ocean Dipole (IOD) Mode Index from high-resolution MMCFS. The data source for Climatology probabilities: NOAA Extended Reconstructed SST V5. Criteria used for Probabilistic ENSO Forecast: La Niña ≤ -0.5 ,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