



**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**

September 2023

Highlights

Currently, moderate El Niño conditions are prevailing over the equatorial Pacific, and sea surface temperatures (SSTs) are above average across most of the equatorial Pacific Ocean. The latest MMCFS forecast indicates that El Niño conditions are likely to persist until the first quarter of next year.

Currently, positive IOD conditions are observed over the Indian Ocean, and the latest MMCFS forecast indicates that positive IOD conditions are likely to continue until the end of this year.

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

During August 2023, warmer than normal SSTs were observed over most of the equatorial Pacific Ocean (Fig.1a). Warmer than normal SSTs were also observed over most of the northern extra-tropical regions. Compared to the previous month, there is an increase in the warming of SSTs in the central and eastern equatorial Pacific Ocean (Fig.1b), along with cooler SST anomalies observed over the western equatorial Pacific Ocean.

In August 2023, warm SST anomalies were observed over most parts of the Indian Ocean, with a stronger magnitude in the western Indian Ocean (Fig.1a). In the north Indian Ocean, warm SST anomalies are observed over most parts of the Arabian Sea. Compared to the previous month, warmer SSTs are observed over western parts of the equatorial Indian Ocean and cooler SSTs are observed over north Arabian Sea and eastern 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 September 2022 to August 2023, is shown in Fig.2a. La Niña conditions prevailed until early this year, with maximum strength in September 2022, and then weakened. Thereafter, ENSO neutral conditions were observed over the Pacific Ocean from February to May 2023. However, El Niño conditions developed during June 2023. At present, moderate El Niño conditions are present over the equatorial Pacific Ocean. Positive subsurface anomalies are observed over most parts of the equatorial Pacific Ocean, with the maximum strength close to the surface along the eastern Pacific Ocean (Fig.2 b).

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

The monthly time series of Dipole Mode Index (DMI) for the last 12 months, from September 2022 to August 2023, is shown in Fig.2c. The negative DMI value weakened from September 2022 to December 2022. The DMI has remained within the average, and neutral IOD conditions were observed between January and July 2023. Positive IOD conditions developed in August 2023. Currently, positive IOD conditions are present over the Indian Ocean. Positive subsurface temperature anomalies (Fig. 2d) were observed over the western and central equatorial Indian Ocean with a strong magnitude in between 20°C isotherm and thermocline depth. Negative subsurface anomalies were observed over the western and eastern equatorial Indian Ocean, near and below the thermocline depth.

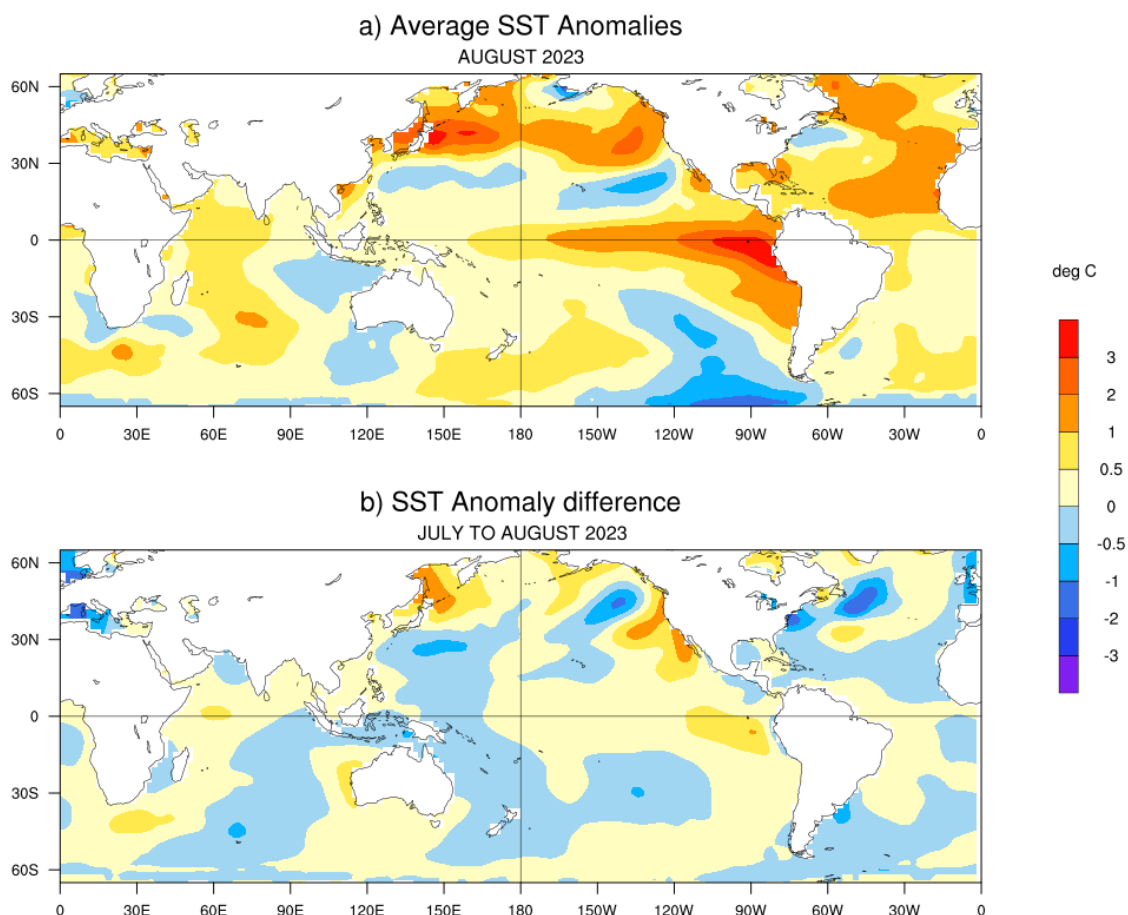


Fig.1: (a) Sea surface temperature (SST) anomalies ($^{\circ}\text{C}$) during August 2023 and **(b)** changes in the SST anomalies ($^{\circ}\text{C}$) from July 2023 to August 2023. SSTs were based on the ERSSTv5, NOAA, and anomalies were computed with respect to 30-year (1991-2020) long term mean.

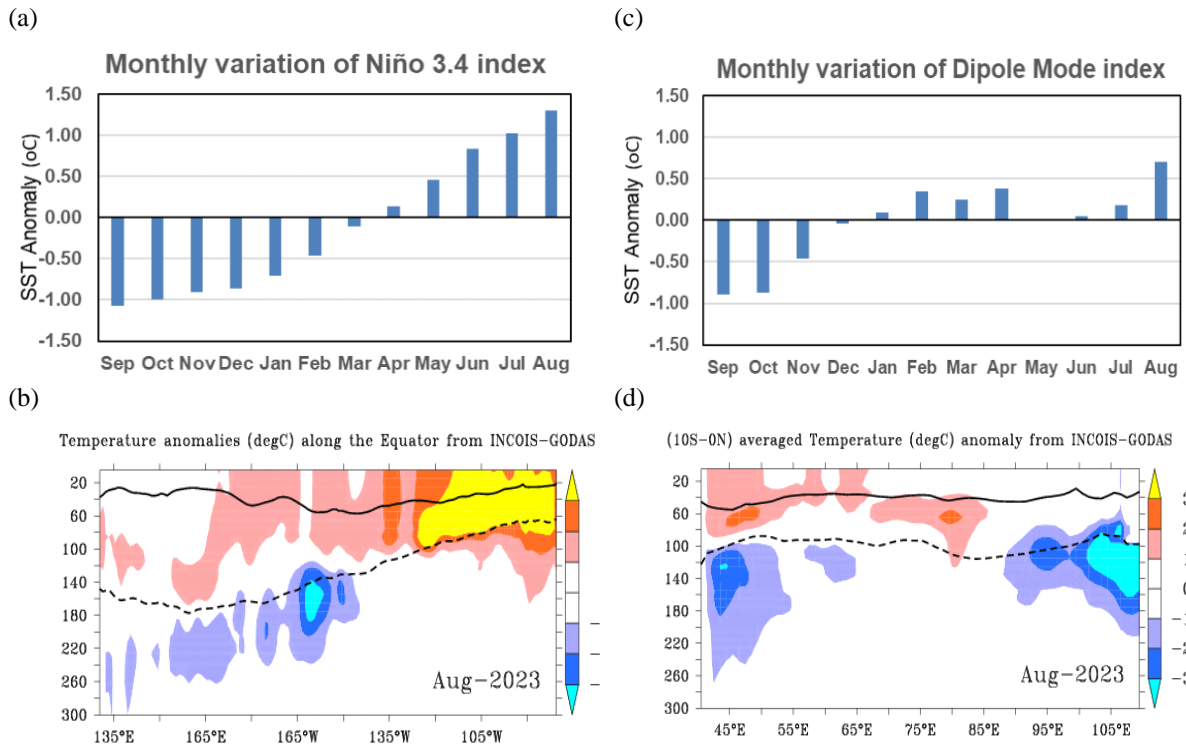


Fig.2: (a) Monthly variation of Niño 3.4 SST index for the last 12 months and (b) Depth-longitude section of ocean temperature anomalies in the equatorial (5°S-5°N) the Pacific Ocean for the month of August 2023. (c) Same as (a) but for Dipole Mode Index (DMI). (d) Same as (b) but for the tropical Indian Ocean (10°S-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 & 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 initial conditions from August 2023. The initial conditions for the model runs were obtained from ESSO-INCOIS and ESSO-NCMRWF analyses. 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 3-month season averaged SST anomaly forecast (Fig.3) indicates that positive SST anomalies are likely over most parts of the central and eastern equatorial Pacific Ocean for the entire forecast period. Currently, sea surface temperatures (SSTs) are above average over most of the equatorial Pacific Ocean, and El Niño conditions are prevailing. The latest MMCFS Plume forecast (Fig.4a) indicate that El Niño conditions are likely to continue until the first quarter of next year. The probability forecast for ENSO indicates an enhanced probability for El Niño conditions (Fig.5a) throughout the forecasted seasons. IMD is closely monitoring the El Niño conditions and providing monthly updates based on observed changes in the Pacific Ocean.

The positive IOD conditions are prevailing over the Indian Ocean. As per the latest MMCFS forecast a positive IOD conditions likely to continue up to the end of this year (Fig.4b). The probability forecast for IOD (Fig.5b) also indicates the high probability of the positive IOD during September-November and October-December 2023 season.

MMCFS SST Anomaly Forecast :Aug 2023 IC

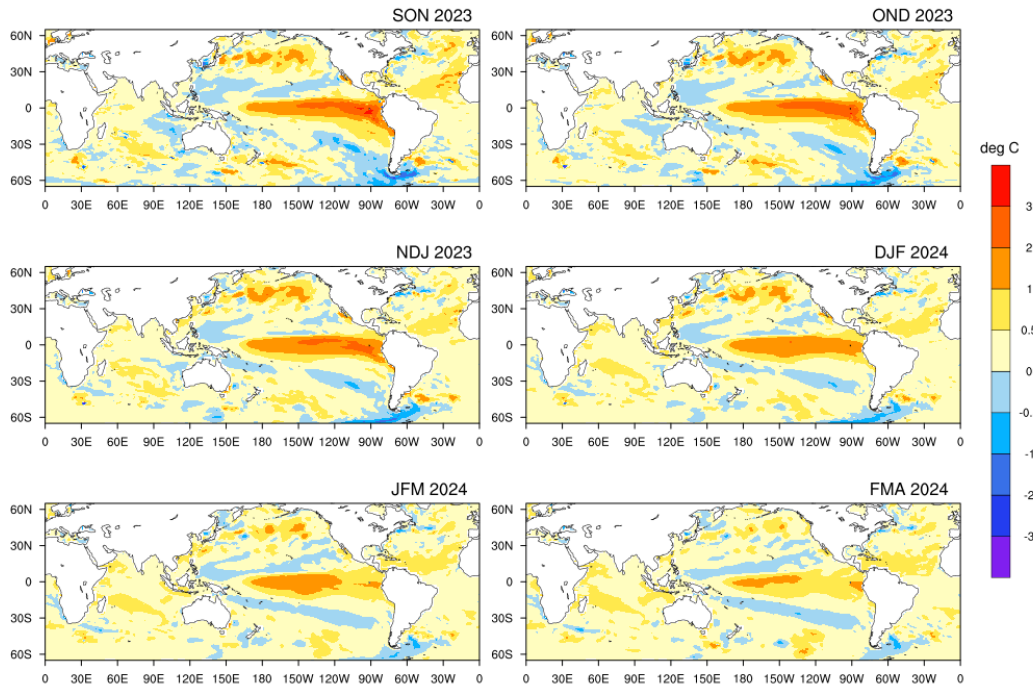


Fig.3: Forecasted Seasonal mean SST anomalies for three monthly (a) September to November (SON 2023), (b) October to December (OND 2023), (c) November 2023 to January 2024 (NDJ 2024), (d) December 2023 to February 2024 (DJF 2024), (e) January 2024 to March 2024 (JFM 2024) and February 2024 to April 2024. (Model bias correction base period: 1999-2008; Climatology base period:1991-2020).

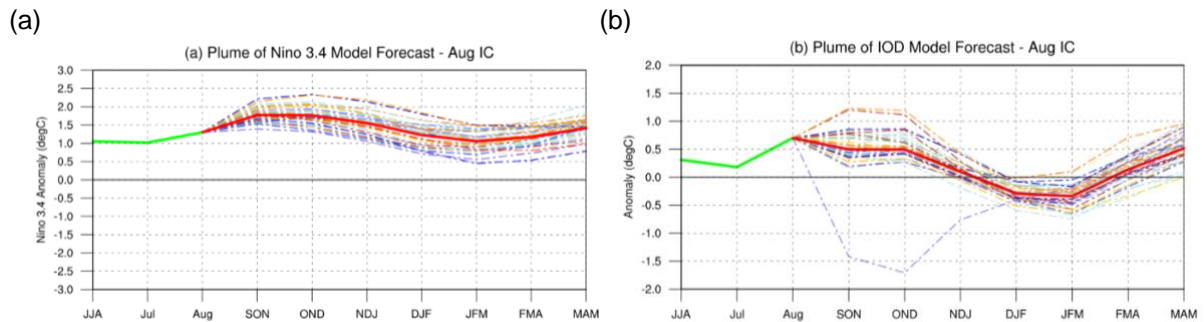


Fig.4: Plume of (a) Niño 3.4 SST index, (b) Indian Ocean Dipole Mode Index forecasted by high-resolution MMCFS. The forecasts were PDF corrected for bias and variance. The solid green line is the observed SST anomaly (ERSSTv5, NOAA) and the solid red line is the ensemble mean SST anomaly forecast of 34 members (MMCFS). The individual ensemble member forecasts are shown in light dotted lines of different colours.

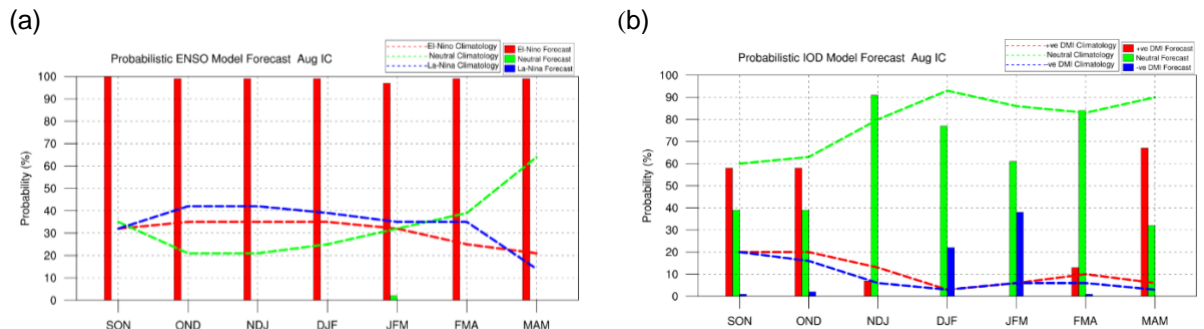


Fig.5: Probability forecast along with climatological probabilities of (a) Niño 3.4 and (b) Indian Ocean Dipole Mode Index from high-resolution MMCFS. The data source for Climatology probabilities: NOAA Extended Reconstructed SST V5. Criteria used for Probabilistic ENSO Forecast: La Niña ≤ -0.5 , Neutral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