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

December 2023

Highlights

Currently, strong El Niño conditions are prevailing over equatorial Pacific and the sea surface temperatures (SSTs) are above average over most of the equatorial Pacific Ocean. The latest MMCFS forecast indicates moderate to strong El Niño conditions are likely to continue during the upcoming season and weaken thereafter.

At present, positive IOD conditions are observed over the Indian Ocean and the latest MMCFS forecast indicates weakening of positive IOD conditions and then turn to neutral conditions during the upcoming season.

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

During November 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. As compared to the last month, warming of SST anomalies were observed over the central equatorial Pacific Ocean near the Date Line (Fig.1b) but cooling of SSTs were observed over the eastern and western equatorial Pacific Ocean. Cooling of SSTs were also observed over some region of the higher latitudes of North Pacific Ocean.

In November 2023, warmer than normal SST anomalies were observed over the north Arabian Sea, North Bay of Bengal and western equatorial Indian Ocean (Fig.1a). However, cold SST anomalies were observed over eastern equatorial Indian Ocean. Compared to the previous month, warm SSTs were observed over Bay of Bengal and western equatorial Indian Ocean. However, cold SSTs were observed over 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 December 2022 to November 2023 is shown in Fig.2a. The La Niña conditions were prevailing till early this year with maximum strength in December 2022. Thereafter ENSO neutral conditions were observed over the Pacific Ocean from February to May 2023 and Weak El Niño conditions developed during June and July 2023. However, moderate El Niño conditions developed during August 2023 to October 2023. At present strong El Niño conditions are prevailing over equatorial Pacific Ocean. The positive subsurface temperature anomalies are observed over most parts of the equatorial Pacific Ocean with maximum strength close to

surface along the eastern and Central Pacific Ocean (Fig.2 b). The negative subsurface temperature anomalies are observed over western equatorial Pacific Ocean both near and below the thermocline depth (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 December 2022 to November 2023 is shown in Fig.2c. The DMI has remained within the average and neutral IOD conditions were observed between December 2022 and July 2023. However, positive IOD conditions developed during August 2023 and continued till November 2023. The positive subsurface temperature anomalies (Fig. 2d) were seen over the western equatorial Indian Ocean with a strong magnitude in between 20^0 C isotherm and thermocline depth and negative subsurface anomalies were seen over the eastern equatorial Indian Ocean with a strong magnitude near and below the thermocline depth.
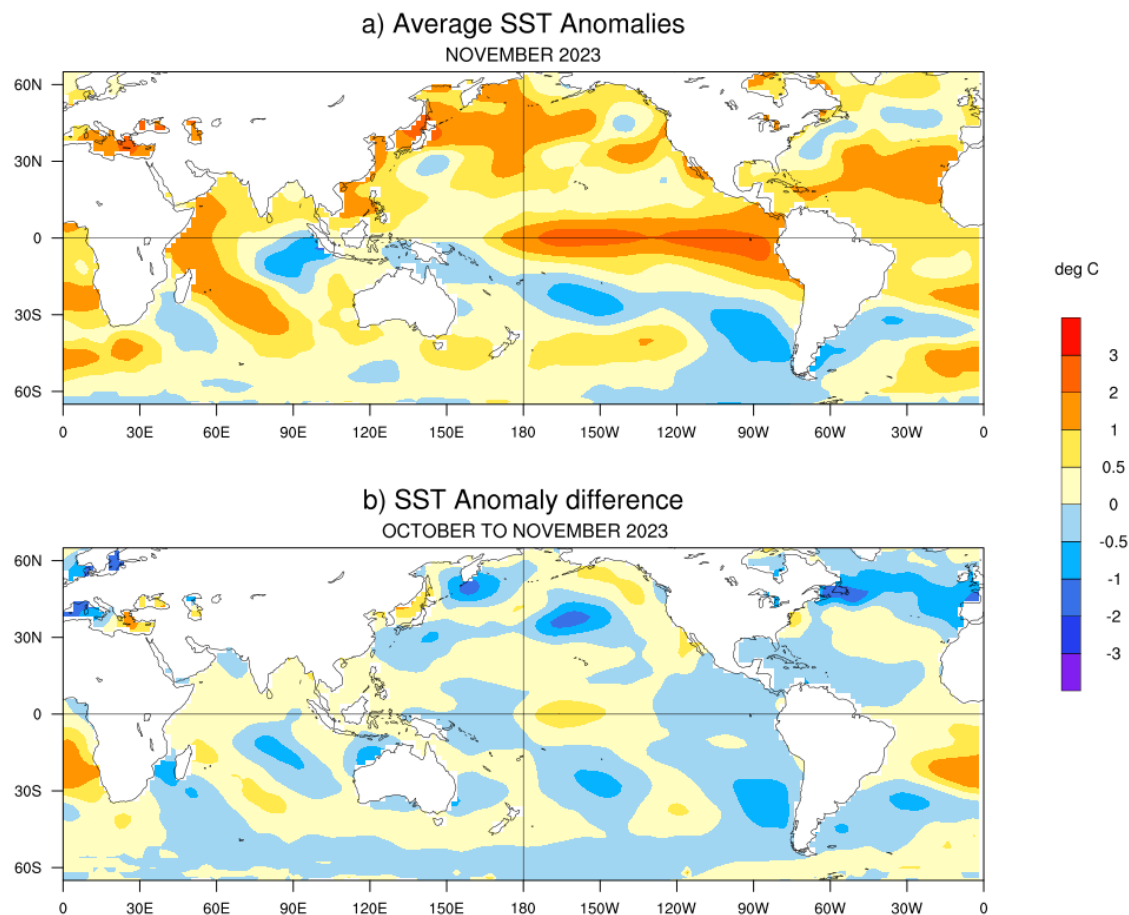

Fig.1: (a) Sea surface temperature (SST) anomalies (^{0}C) during November 2023 and **(b)** changes in the SST anomalies (^{0}C) from October 2023 to November 2023. SSTs were based on the ERSSTv5, NOAA, and anomalies were computed with respect to 30-year (1991-2020) long term mean.
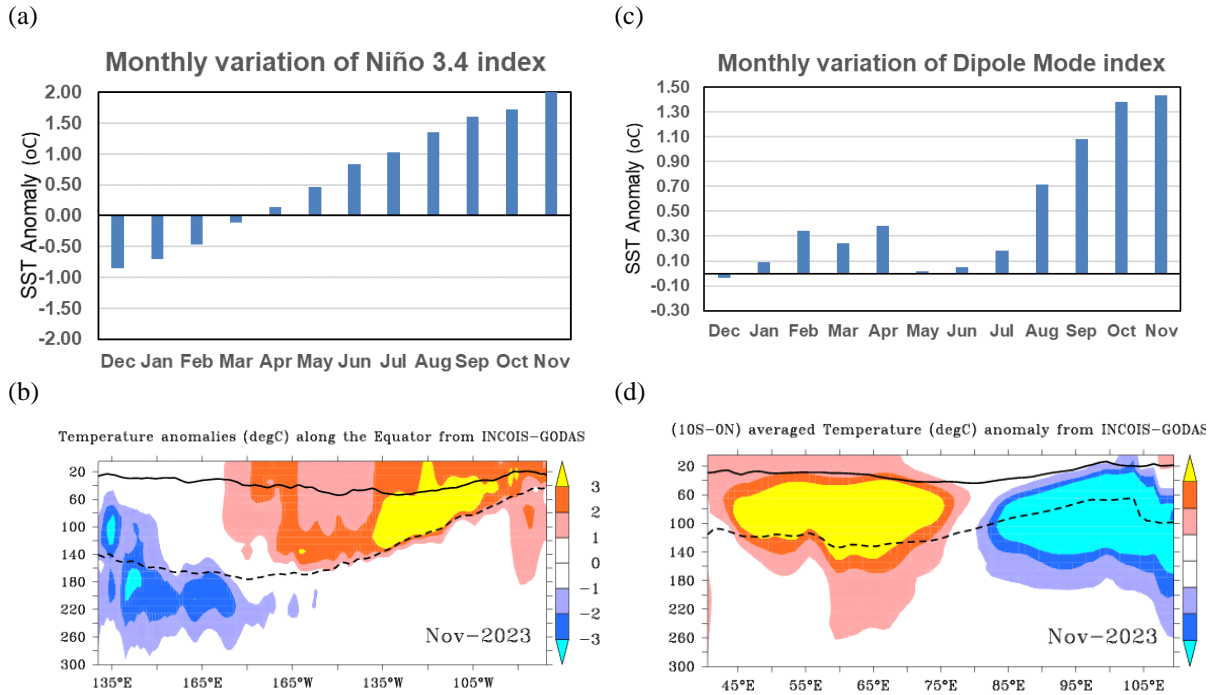
(a)

Monthly variation of Niño 3.4 index

(c)

Monthly variation of Dipole Mode index

(b)

Temperature anomalies (degC) along the Equator from INCOIS-GODAS

Nov-2023

(d)

(10S-0N) averaged Temperature (degC) anomaly from INCOIS-GODAS

Nov-2023

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 (5^0S-5^0N) Pacific Ocean for the month of November 2023. **(c)** Same as (a) but for 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: ERSSTv5, NOAA). 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 & 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 2023 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 on 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 warmer-than-normal SST anomalies are likely over most parts of the eastern and central equatorial Pacific Ocean during the DJF to MAM seasons and are expected to weaken thereafter. During the AMJ and MJJ seasons, it is likely to transition to normal SST anomalies over most parts of the equatorial Pacific Ocean. Currently, the sea surface temperatures (SSTs) are above average over most of the equatorial Pacific Ocean and strong El Niño conditions are prevailing. The latest MMCFS Plume forecast (Fig.4a) indicate that El Niño conditions are likely to continue through AMJ 2024 and then transition to ENSO-neutral. The probability forecast indicates the enhanced probability for El Niño conditions (Fig.5a) during DJF to MJJ season and then transition to ENSO-neutral in JJA 2024. IMD is closely monitoring the El Nino conditions and monthly updates are provided as per observed changes in the Pacific Ocean.

The positive IOD threshold are prevailing over the Indian Ocean. The 3-month season-averaged SST anomaly forecast (Fig. 3) indicates that warmer-than-normal SST anomalies are likely over most parts of the Indian Ocean. As per the latest MMCFS Plume forecast a neutral IOD conditions likely to develop during the upcoming season (Fig.4b). The probability forecast for IOD (Fig.5b) indicates the probability of the neutral IOD during December to January 2024 season.

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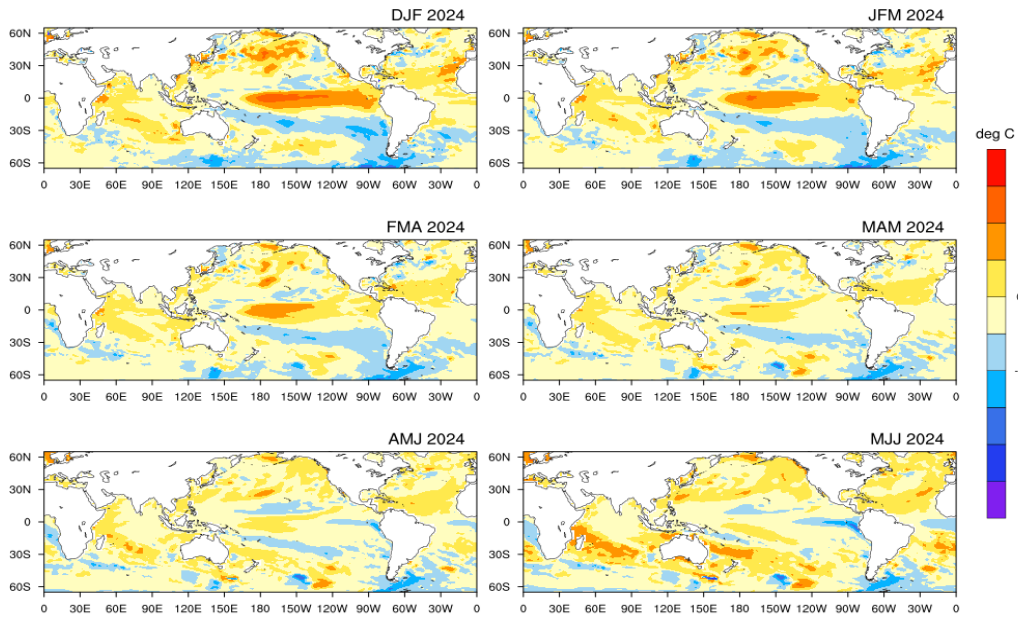**MMCFS SST Anomaly Forecast :Nov 2023 IC**

Fig.3: Forecasted Seasonal mean SST anomalies for three monthly (a) December 2023 to February 2024 (DJF 2024), (b) January 2024 to March 2024 (JFM 2024), (c) February 2024 to April 2024 (FMA 2024), (d) March 2024 to May 2024 (MAM 2024), (e) April 2024 to June 2024 (AMJ 2024) and May 2024 to July 2024 (MJJ 2024). (Model bias correction base period: 1999-2008; Climatology base period:1991-2020).
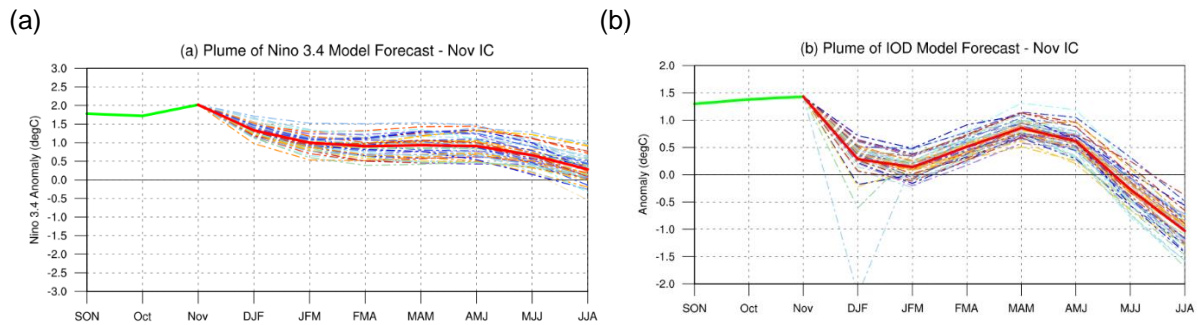
(a)   (b)

Fig.4: Plume of **(a)** Niño 3.4 SST index, **(b)** Indian Ocean Dipole 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 51 members (MMCFS). The individual ensemble member forecasts are shown in light dotted lines of different colours.
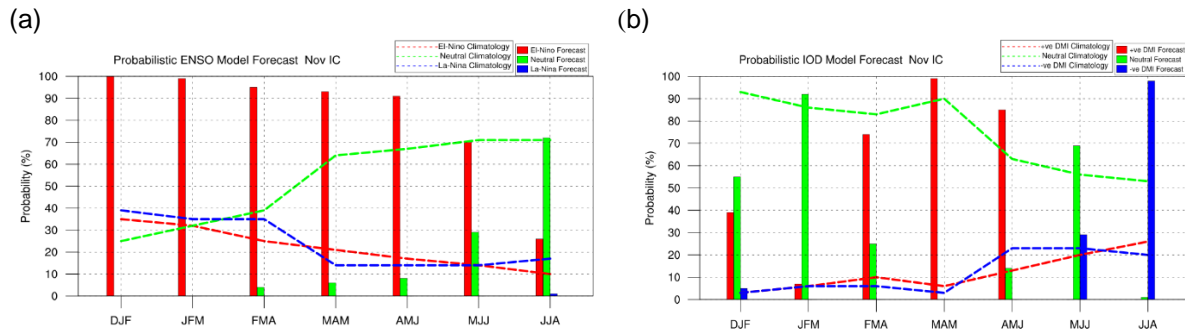
(a)   (b)

Fig.5: Probability forecast along with climatological probabilities of **(a)** Niño 3.4 and **(b)** Indian Ocean Dipole 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.