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

January 2024

Highlights

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

At present, positive Indian Ocean Dipole (IOD) conditions are continuing over the Indian Ocean and the latest MMCFS forecast indicates weakening of positive IOD conditions during the upcoming season.

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

During the December 2023, warmer than normal SSTs were observed over most of the equatorial and the northern extra-tropical Pacific region (Fig.1a). Cooler than normal SSTs were observed over some parts of southern extra-tropical Pacific regions. Compared to November 2023, cool SST anomalies were observed over the central equatorial Pacific Ocean near the Date Line, eastern and south eastern Pacific Ocean (Fig.1b) and some parts of western Pacific Ocean.

In December 2023, warmer than normal SSTs were observed over the western equatorial Indian Ocean (Fig.1a). However, cold than normal SSTs were observed over some parts of the eastern equatorial Indian Ocean. Compared to November 2023, warmer than normal SSTs were observed over equatorial Indian Ocean whereas colder than normal SSTs were observed over north Arabian Sea and north Bay of Bengal. (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 January 2023 to December 2023 is shown in Fig.2a. The La Niña conditions were prevailing till early this year. Thereafter, ENSO neutral conditions were observed over the Pacific Ocean from February to May 2023. Weak El Niño conditions developed during June-July 2023. Thereafter El Niño conditions strengthened to moderate level during August 2023 and turned to strong El Niño during last part of the year 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 central and eastern equatorial Pacific Ocean with maximum strength around $105\,^{0}W - 135\,^{0}W$. (Fig.2 b). The negative subsurface temperature anomalies are observed

over western and Central 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 January 2023 to December 2023 is shown in Fig.2c. The IOD conditions after remaining neutral during most part of the first half of 2023, turned to positive during August 2023 and continued till December 2023.The positive subsurface temperature anomalies (Fig. 2d) were seen over the western equatorial Indian Ocean with highest magnitudes between 20^0C isotherm and thermocline depth. Negative subsurface anomalies were seen over the eastern equatorial Indian Ocean with highest magnitude near and below the thermocline depth.
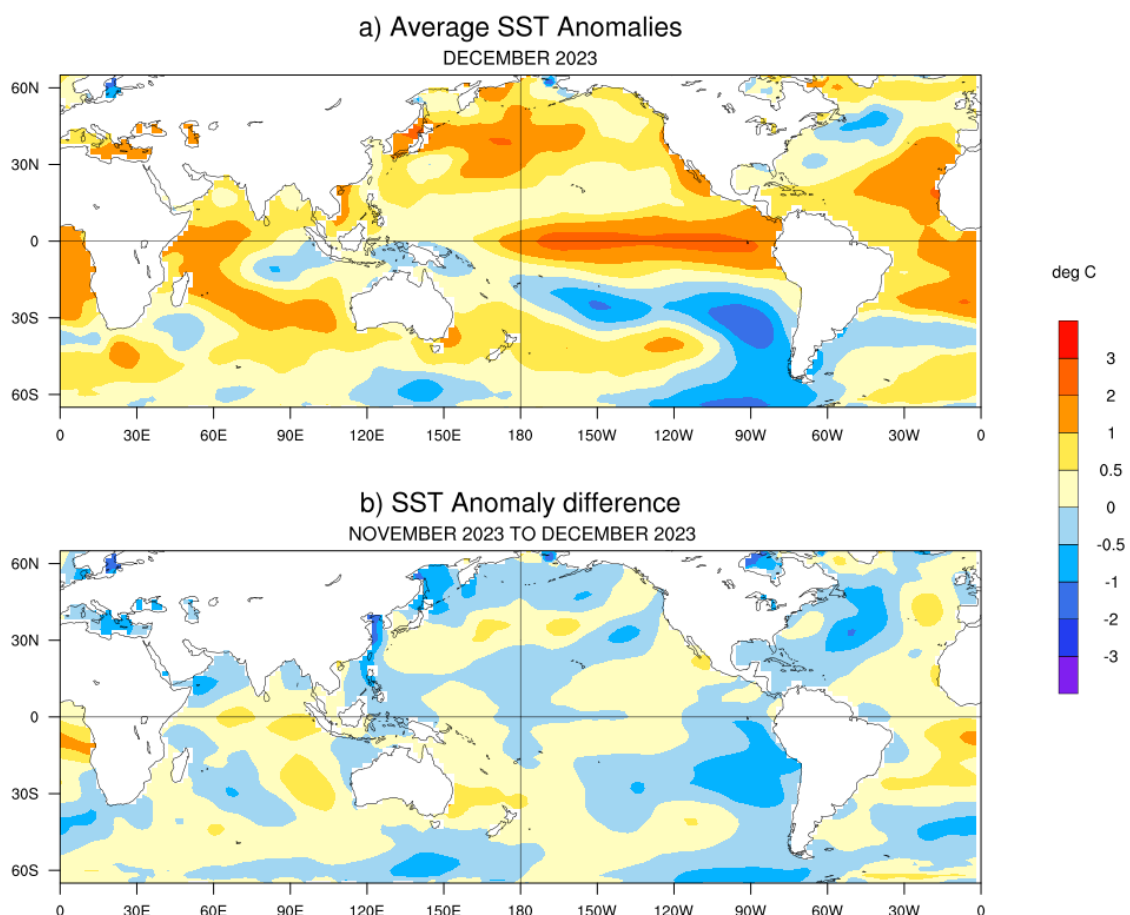

Fig.1: (a) Sea surface temperature (SST) anomalies (^{0}C) during December 2023 and **(b)** changes in the SST anomalies (^{0}C) from November 2023 to December 2023. SSTs were based on the ERSSTv5, NOAA, and anomalies were computed with respect to 30-year (1991-2020) long term mean.
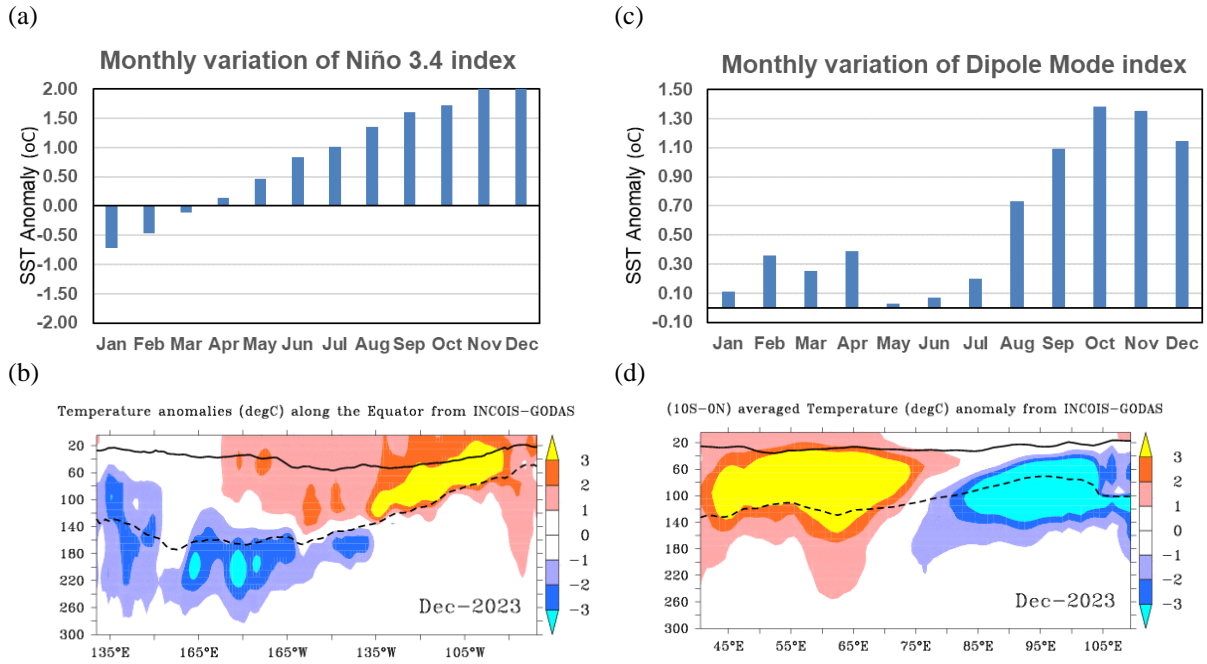
Fig.2: (a) Monthly variation of Niño 3.4 SST index for the last 12 months and (b) Depth-longitude section of sub surface temperature anomalies in the equatorial (5^{0}S-5^{0}N) Pacific Ocean for the month of December 2023. (c) Same as (a) but for Dipole Mode Index (DMI). (d) Same as (b) but for the tropical Indian Ocean (10^{0}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^{0}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 202 3December 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.

Currently, the sea surface temperatures (SSTs) are warmer than normal over most of the equatorial Pacific Ocean and strong El Niño conditions are prevailing. The 3-month season-averaged SST anomaly forecast (Fig. 3) indicates that warmer-than-normal SSTs are likely over most parts of the equatorial Pacific Ocean with maximum strength over equatorial Pacific Ocean during the next few seasons and are expected to weaken thereafter. The latest MMCFS Plume forecast (Fig.4a) indicates that the El Niño conditions are likely to continue through AMJ 2024 and then turn to ENSO-neutral. The probability forecast indicates enhanced probability of El Niño conditions (Fig.5a) from JFM to AMJ seasons and then transition to ENSO-neutral conditions in MJJ 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 conditions are prevailing over the Indian Ocean. The 3-month season-averaged SST anomaly forecast (Fig. 3) indicates that warmer-than-normal SSTs are likely over most parts of the Indian Ocean. As per the latest MMCFS Plume forecast, the prevailing positive IOD conditions are likely to weaken during the upcoming season (Fig.4b). The probability forecast for IOD (Fig.5b) indicates equal probability for the positive and neutral IOD during January to March 2024 season.

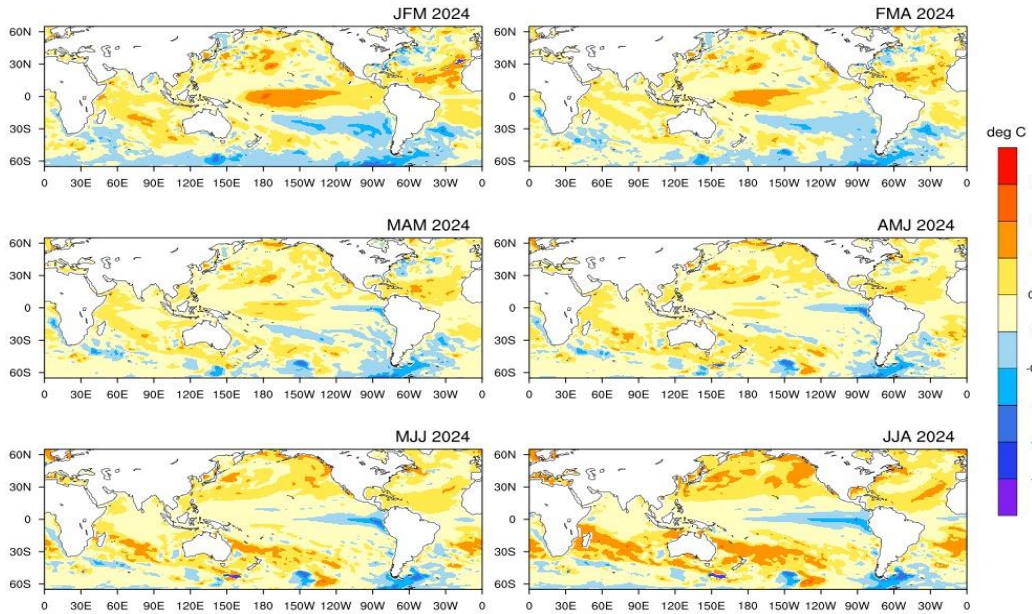**MMCFS SST Anomaly Forecast :Dec 2023 IC**

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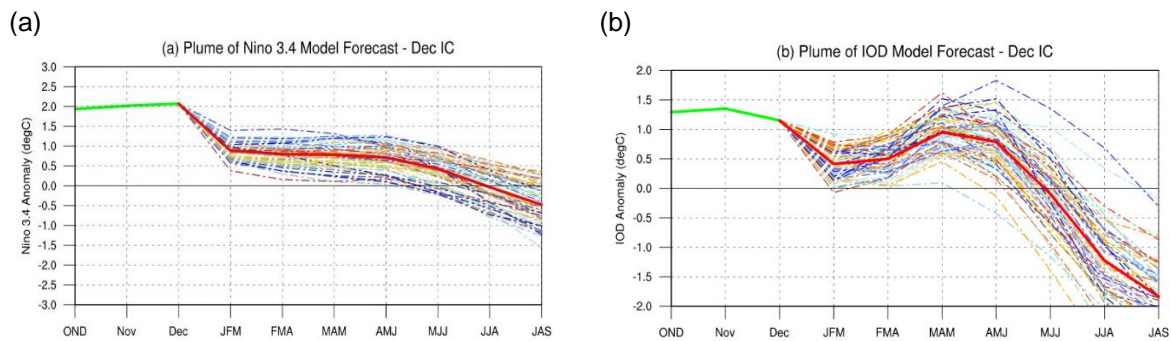
(a)   (b)

Fig.4: Plume of**(a)** Niño 3.4 SST index, **(b)** Indian Ocean Dipole (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 of60members (MMCFS). The individual ensemble member forecasts are shown in light dotted lines of different colours.
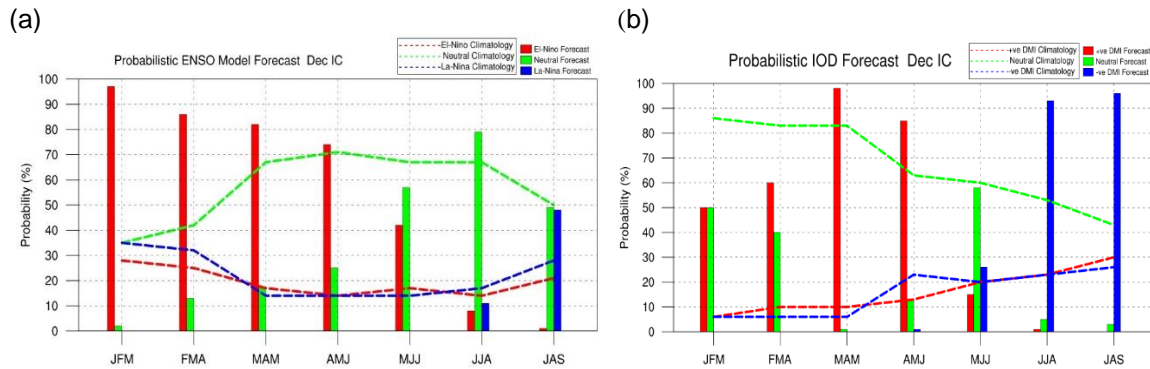
(a)   (b)

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.