

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

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

March 2024

Highlights

Strength of El Niño conditions weakened since beginning of the year and currently moderate El Niño conditions are prevailing over equatorial Pacific. The sea surface temperatures (SSTs) are warmer than normal over most of the equatorial Pacific Ocean. The latest MMCFS forecast indicates strength of El Niño conditions are likely to weaken during the upcoming season and turn to neutral thereafter. Model also indicate the development of La Niña conditions during the monsoon season.

At present, neutral Indian Ocean Dipole (IOD) conditions are prevailing over the Indian Ocean and the latest MMCFS forecast indicates development of negative IOD conditions during the monsoon season.

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

During the February 2024, 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 Pacific regions. As compared to January 2024, negative SST anomalies were observed across the equatorial Pacific Ocean (Fig.1b). Cool SST anomalies were observed over many parts of the north Pacific.

In February 2024, warmer than normal SSTs were observed over the Indian Ocean (Fig.1a). Compared to January 2024, warm SSTs were observed over eastern equatorial Indian Ocean, north Bay of Bengal and north Arabian Sea (Fig.1b) and cool SSTs were observed over the western Indian Ocean.

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 March 2023 to February 2024 is shown in Fig.2a. ENSO neutral conditions were observed over the Pacific Ocean from March 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 and January 2024. Strength of El Niño conditions weakened and at present moderate 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 near and above 20°C isotherm.

(Fig.2 b). The negative subsurface temperature anomalies are observed over central and eastern 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 March 2023 to February 2024 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 February 2024. The positive subsurface temperature anomalies (Fig. 2d) were seen over the western equatorial Indian Ocean with highest magnitudes between 20°C isotherm and thermocline depth. Negative subsurface anomalies were seen over the eastern equatorial Indian Ocean with highest magnitude near and below the thermocline depth.

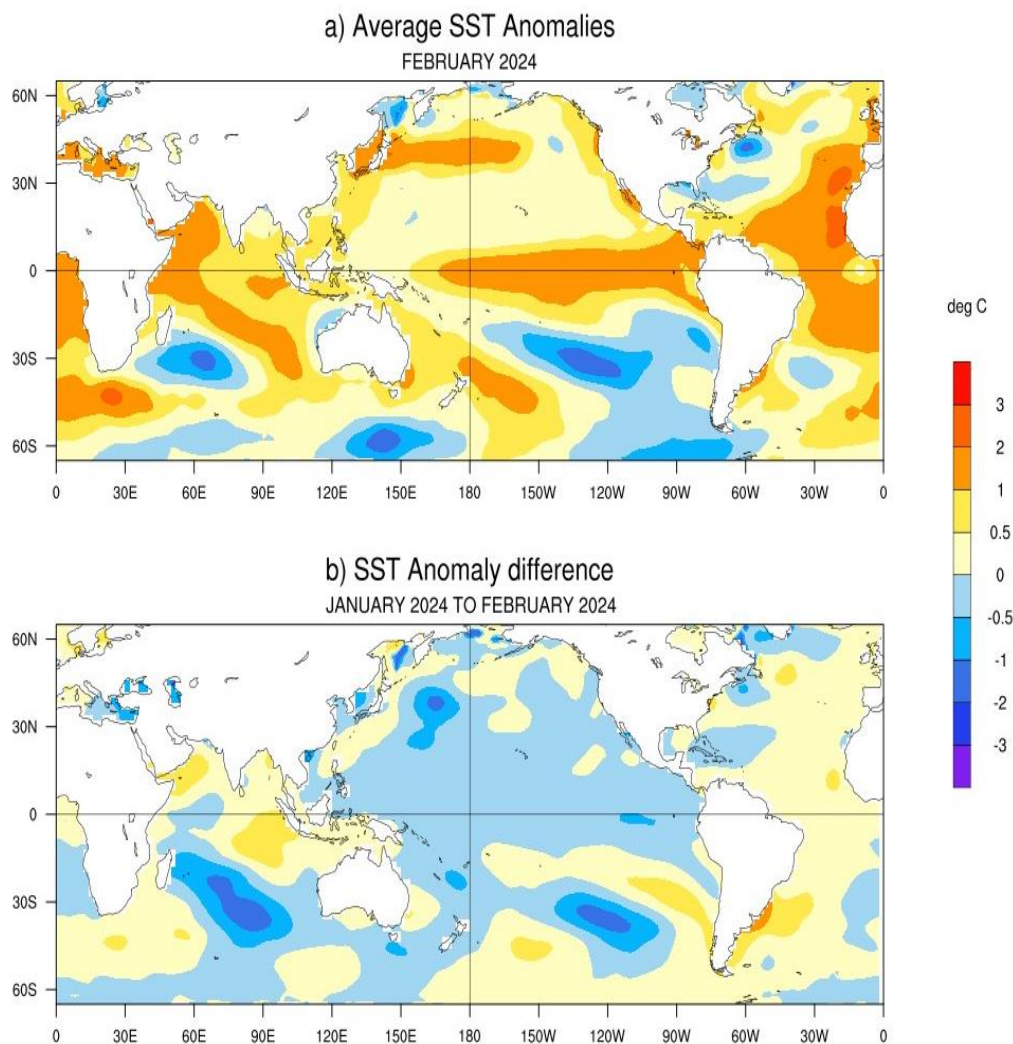


Fig.1: (a) Sea surface temperature (SST) anomalies ($^{\circ}\text{C}$) during February 2024 and **(b)** changes in the SST anomalies ($^{\circ}\text{C}$) from January 2024 to February 2024. SSTs were based on the ERSSTv5, NOAA, and anomalies were computed with respect to 30-year (1991-2020) long term mean.

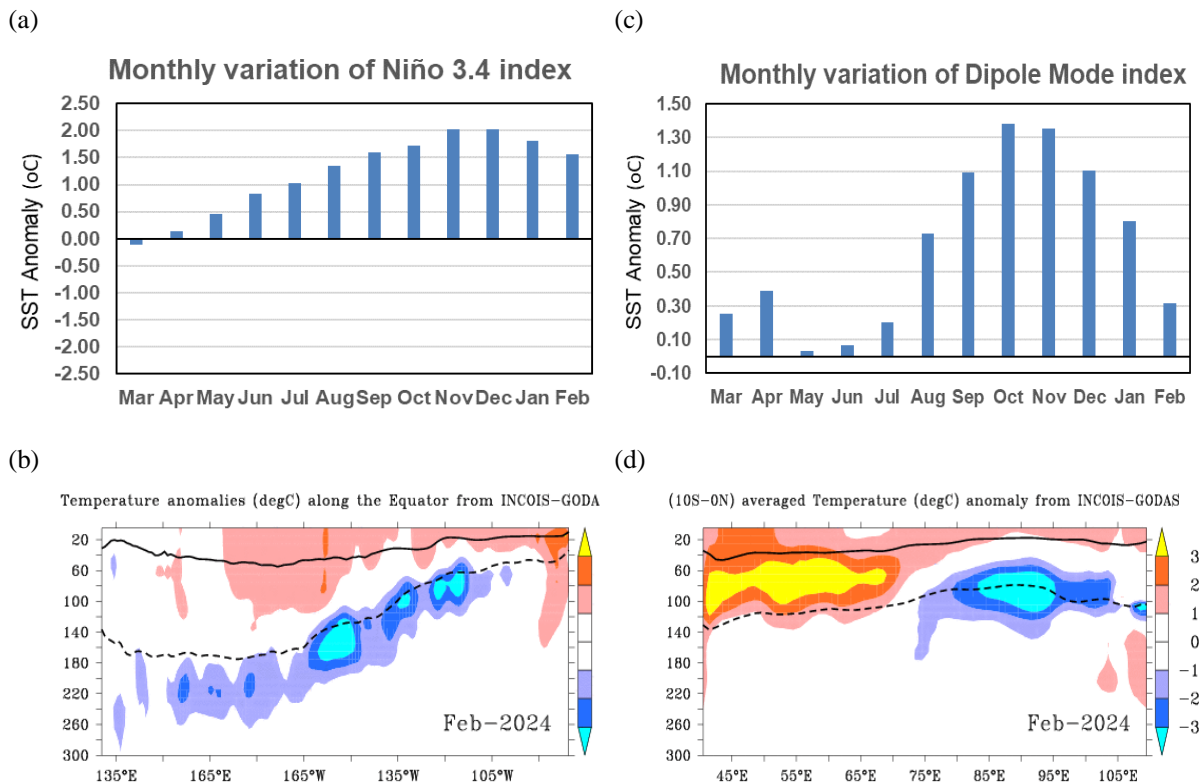


Fig.2: (a) Monthly variation of Niño 3.4 SST index for the last 12 months and **(b)** Depth-longitude section of sub surface temperature anomalies in the equatorial (50S-50N) Pacific Ocean for the month of February 2024. **(c)** Same as **(a)** but for Dipole Mode Index (DMI). **(d)** Same as **(b)** but for the tropical Indian Ocean (100S-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 200C 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 2024 February 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 moderate El Niño conditions are prevailing. The 3-month season-averaged SST anomaly forecast (Fig. 3) indicates that colder-than-normal SSTs are likely over most parts of the eastern equatorial Pacific Ocean during the next few seasons and are expected to strengthen thereafter. The latest MMCFS Plume forecast (Fig.4a) indicates that the El Niño conditions are likely turn to ENSO-neutral by MJJ season. The probability forecast also indicates enhanced probability of La Niña conditions (Fig.5a) around JAS 2024 season. IMD is closely monitoring the El Niño conditions and monthly updates are provided as per observed changes in the Pacific Ocean.

The neutral 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 neutral IOD conditions are likely to continue during the upcoming season (Fig.4b) and turn to negative IOD thereafter. The probability forecast for IOD (Fig.5b) also indicates the development of negative IOD conditions during the upcoming season.

MMCFS SST Anomaly Forecast :Feb 2024 IC

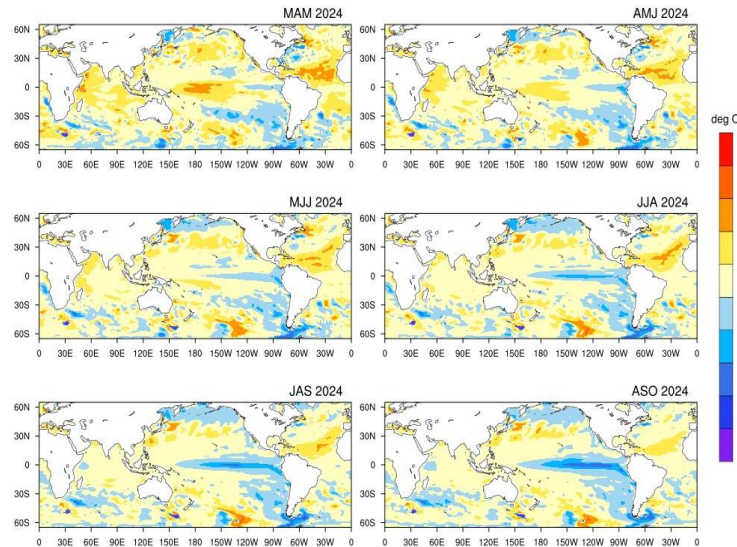


Fig.3: Forecasted Seasonal mean SST anomalies for three monthly (a) March 2024 to May 2024 (MAM 2024), (b) April 2024 to June 2024 (AMJ 2024) (c) May 2024 to July 2024 (MJJ 2024) (d) June 2024 to August 2024 (JJA 2024), (e) July 2024 to August 2024 (JAS 2024) and (f) August 2024 to October 2024 (ASO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

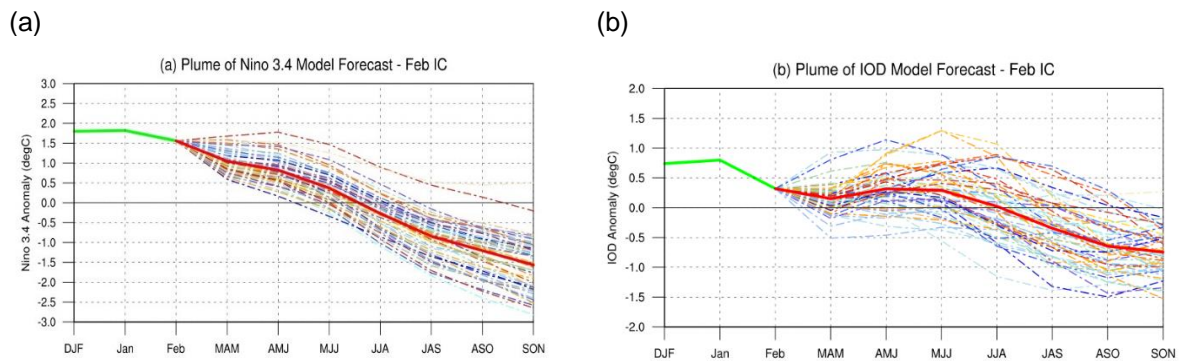


Fig.4: Plume of (a) Niño 3.4 SST index, (b) Indian Ocean Dipole (IOD) Mode Index forecasted by high-resolution MMCFS. The forecasts were PDF corrected for bias and variance. The solid green line is the observed SST anomaly (ERSSTv5, NOAA) and the solid red line is the ensemble mean SST anomaly forecast of 51 members (MMCFS). The individual ensemble member forecasts are shown in light dotted lines of different colours.

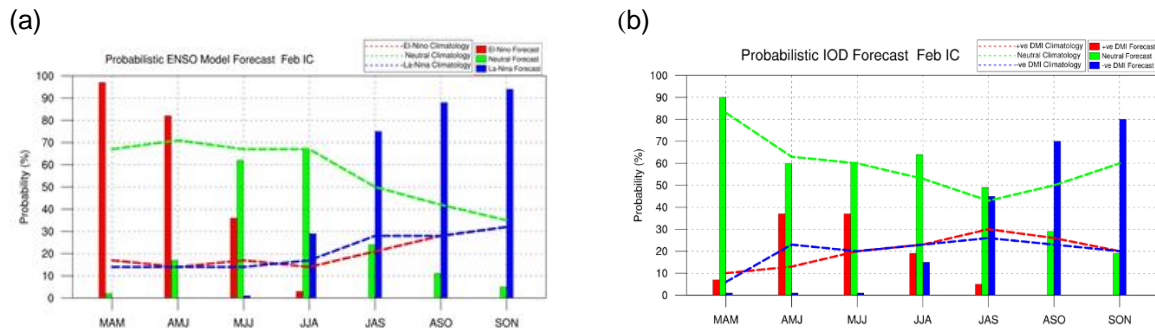


Fig.5: Probability forecast along with climatological probabilities of (a) Niño 3.4 and (b) Indian Ocean Dipole (IOD) Mode Index from high-resolution MMCFS. The data source for Climatology probabilities: NOAA Extended Reconstructed SST V5. Criteria used for Probabilistic ENSO Forecast: La Niña ≤ -0.5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