



**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**

June 2023

Highlights

Currently the sea surface temperatures (SSTs) are above average across most of the equatorial Pacific Ocean and the SST anomaly is very close to El Niño threshold. The latest MMCFS forecast indicates the development of an El Niño in the coming months.

The neutral Indian Ocean Dipole (IOD) conditions are prevailing over the Indian Ocean. The latest MMCFS forecast indicates that Positive IOD conditions are likely to develop during the upcoming season.

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

During May 2023, warmer than normal SSTs were observed across equatorial Pacific Ocean (Fig.1a). Warmer than normal SSTs were also observed over the extra-tropical regions of the north and the south Pacific Ocean. As compared to the last month, warming of SST anomalies were observed over equatorial Pacific Ocean (Fig.1b). Cooling of SST anomalies were observed over western equatorial Pacific Ocean as well as extra-tropical regions of north and south Pacific Ocean.

In the month of May 2023, warm SST anomalies were observed over the north Indian Ocean (Arabian Sea and Bay of Bengal) and over western equatorial Indian Ocean (Fig.1a). However, cold SST anomalies were also observed over the south of east-equatorial Indian Ocean. As compared to the last month, cooler than normal SST anomalies were observed over the Arabian Sea and equatorial Indian Ocean, and warm SST anomalies observed over the 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 June 2022 to May 2023 is shown in Fig.2a. The La Niña conditions were prevailing for most of the time during the last 12 months. The strength of La Niña conditions was decreased from June to July 2022 and then strengthened during August and subsequent month of September 2022. However, the strength of La Niña conditions was weakened from October 2022 to February 2023. From March 2023 onwards ENSO neutral conditions are prevailing over the Pacific Ocean. In the month of May 2023, the positive subsurface anomalies were observed over most parts of the equatorial Pacific Ocean, at around thermocline depth along the western Pacific Ocean and close to 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 June 2022 to May 2023 is shown in Fig.2c. In the month of June 2022, neutral IOD condition was observed over the Indian Ocean and the DMI was negative side of its normal. The negative DMI value strengthened from June to July 2022 and then weakened from August 2022 to December 2022. The DMI has remained within the average and neutral IOD conditions were observed during January and April 2023. At present neutral IOD conditions are present over the Indian Ocean. In the month of May 2023, Negative subsurface temperature anomalies (Fig. 2d) were seen spread over the parts of eastern equatorial Indian Ocean (near the thermocline depth) and some pockets of positive subsurface temperature anomalies were seen over the western Indian Ocean at around thermocline depth.

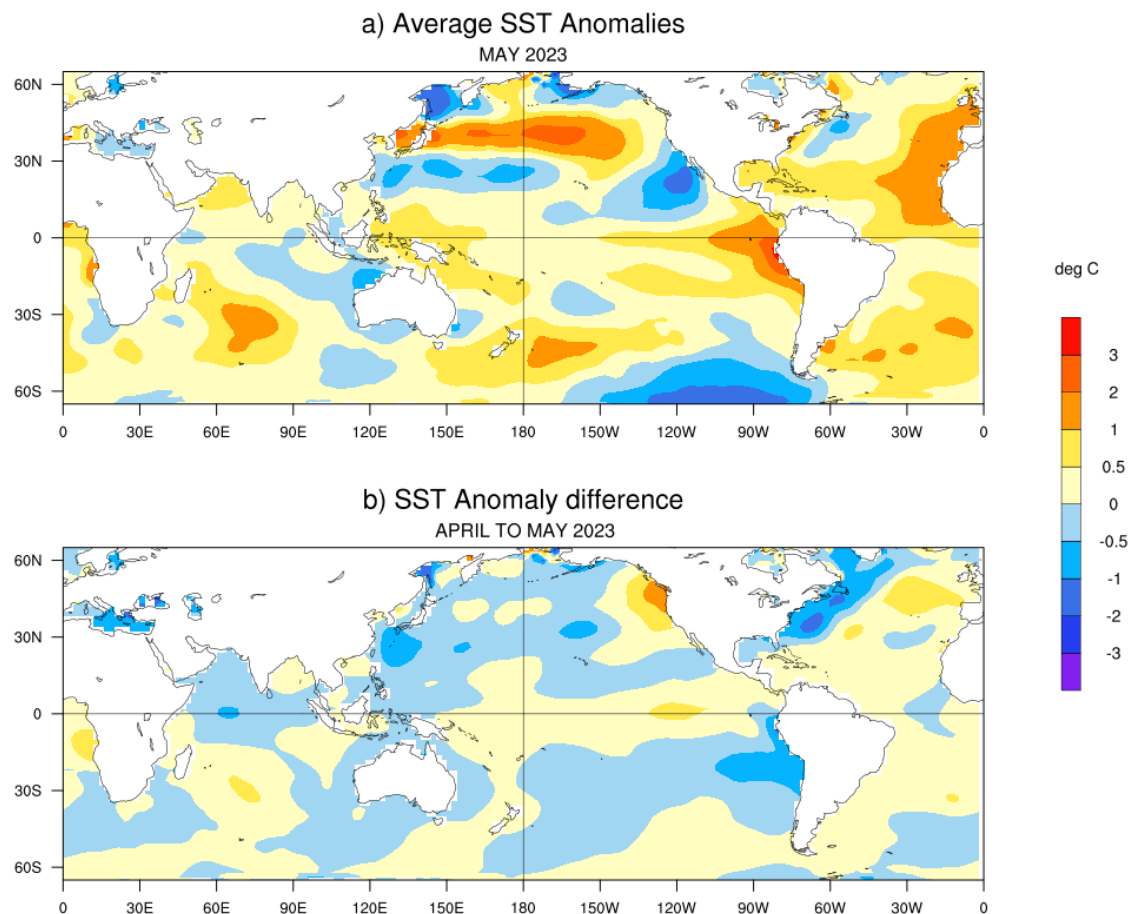


Fig.1: (a) Sea surface temperature (SST) anomalies ($^{\circ}\text{C}$) during May 2023 and **(b)** changes in the SST anomalies ($^{\circ}\text{C}$) from April 2023 to May 2023. SSTs were based on the ERSSTv5, NOAA, and anomalies were computed with respect to 30-year (1991-2020) long term mean.

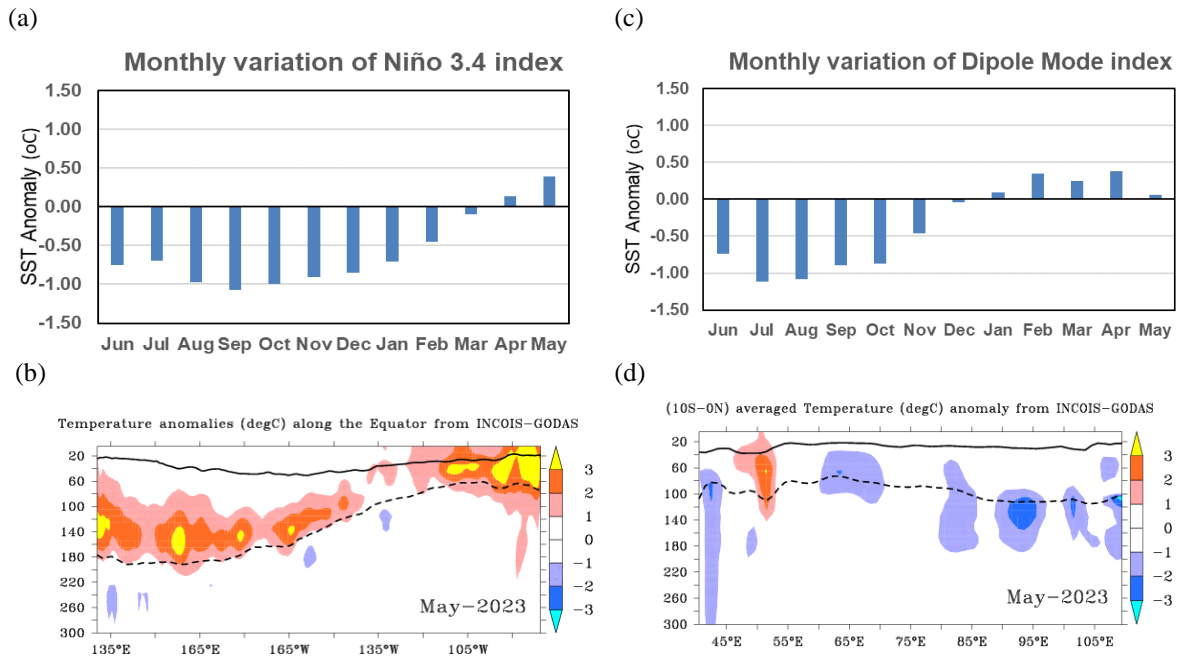


Fig.2: (a) Monthly variation of Niño 3.4 SST index for the last 12 months and (b) Depth-longitude section of ocean temperature anomalies in the equatorial (5°S-5°N) the Pacific Ocean for the month of May 2023. (c) Same as (a) but for Dipole Mode Index (DMI). (d) Same as (b) but for the tropical Indian 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 2023 May 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 1991-2017 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, the sea surface temperatures (SSTs) are above average across most of the equatorial Pacific Ocean and the SST anomaly is very close to El Niño threshold. The latest MMCFS Plume forecast (Fig.4a) indicate the development of an El Niño in the coming months. The probability forecast for ENSO (Fig.5a) indicate a high probability of El Niño development during June-August 2023. IMD is closely monitoring the ENSO conditions and monthly updates are provided as per observed changes in the Pacific Ocean.

At present the neutral IOD conditions are prevailing over the Indian Ocean and the latest MMCFS forecast indicates that the positive IOD conditions are likely to develop during the upcoming seasons (Fig.4b). The probability forecast for IOD (Fig.5b) also indicates about 80% probability for positive IOD conditions and 15 % of probability for the development of a neutral IOD during June-August 2023 season.

MMCFs SST Anomaly Forecast :May 2023 IC

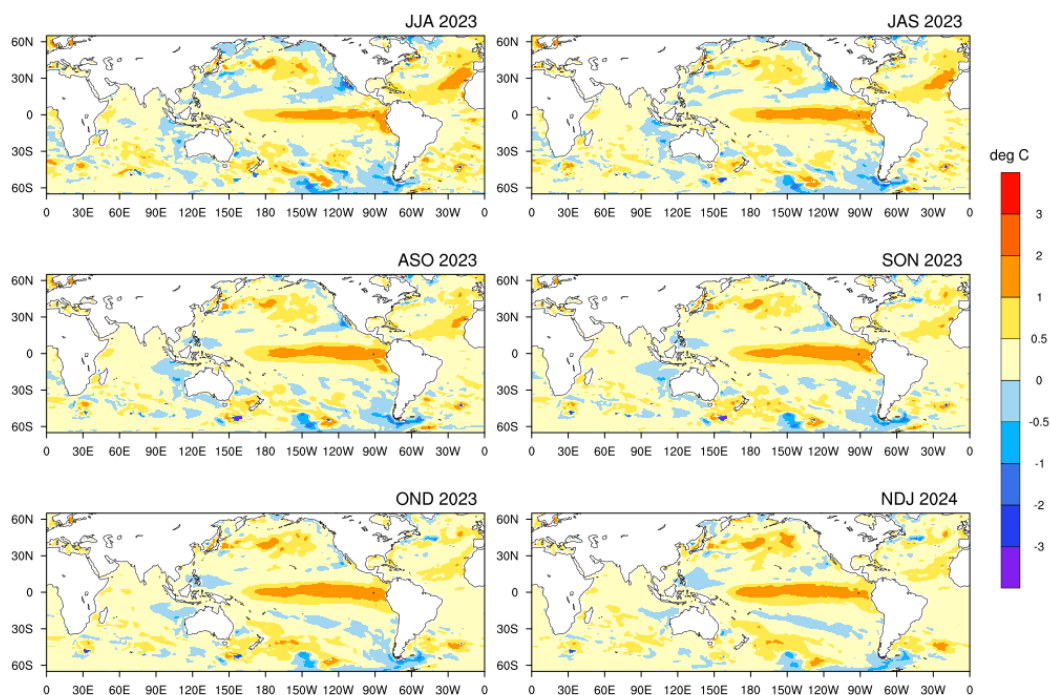


Fig.3: Forecasted Seasonal mean SST anomalies for three monthly a) June to August (JJA 2023), (b) July to September (JAS 2023), (c) August to October (ASO 2023) (d) September to November (SON 2023), (e) October to December (OND 2023) and (f) November to January (NDJ 2024). (Model bias correction base period: 1999-2008; Climatology base period:1991-2017).

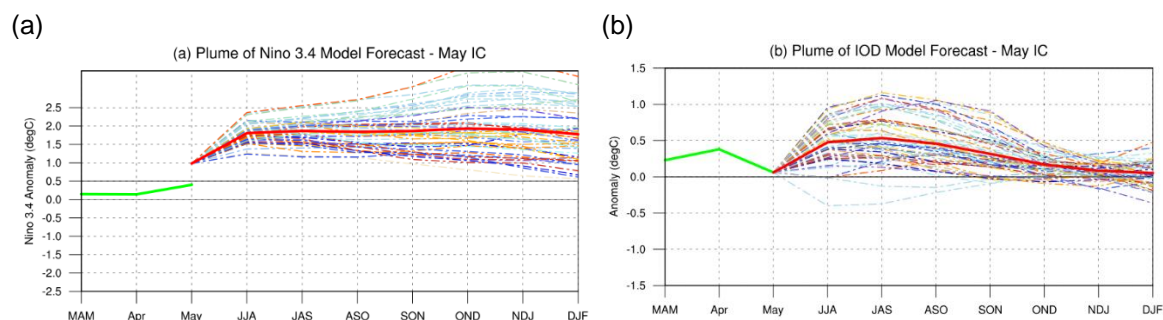


Fig.4: Plume of (a) Niño 3.4 SST index, (b) Indian Ocean Dipole Mode Index forecasted by high-resolution MMCFs. The forecasts were PDF corrected for bias and variance. The solid green line is the observed SST anomaly (ERSSTv5, NOAA) and the solid red line is the ensemble mean SST anomaly forecast of 53 members (MMCFs). The individual ensemble member forecasts are shown in light dotted lines of different colours.

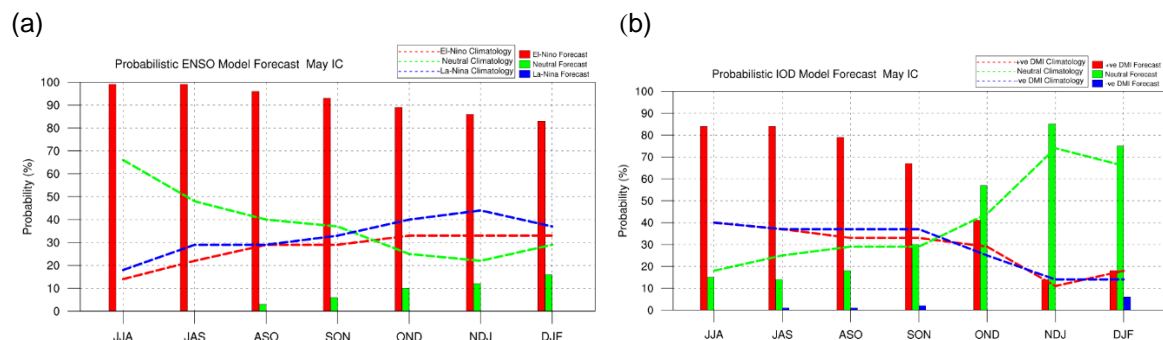


Fig.5: Probability forecast along with climatological probabilities of (a) Niño 3.4 and (b) Indian Ocean Dipole Mode Index from high-resolution MMCFs. The data source for Climatology probabilities: NOAA Extended Reconstructed SST V5. Criteria used for Probabilistic ENSO Forecast: La Niña ≤ -0.5 , Neutral <0.5 to >-0.5 , El Niño ≥ 0.5 . Criteria used for Probabilistic DMI Forecast: negative DMI ≤ -0.2 , Neutral <0.2 to >-0.2 , positive DMI ≥ 0.2 .