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

May 2023

Highlights

Currently ENSO-neutral conditions are observed and equatorial sea surface temperatures (SSTs) are near-to-above average across most of the Pacific Ocean. The latest MMCFS forecast indicates the development of an El Niño in the coming season.

The neutral Indian Ocean Dipole (IOD) conditions are prevailing over the Indian Ocean. The latest MMCFS forecast indicates that neutral IOD conditions are likely to continue up to May-July season and Positive IOD conditions are likely to develop thereafter.

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

During April 2023, warmer than normal SSTs were observed across tropical 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 parts of the north Pacific Ocean.

Warm SST anomalies were observed over the Arabian Sea and western equatorial Indian Ocean (Fig.1a). However, cold SST anomalies were also observed over north Bay of Bengal and south equatorial Indian Ocean. As compared to the last month, warmer than normal SST anomalies were observed over the equatorial Indian Ocean and cool SST anomalies over some parts of 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 May 2022 to April 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 May 2022 to June-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 April 2023, the positive subsurface anomalies were observed over most parts of the equatorial Pacific Ocean (Fig.2 b) (at around thermocline depth) with highest magnitudes centred over 135°E to 180°E.

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 May 2022 to April 2023 is shown in Fig.2c. In the month of May 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 weakened from August 2022 to December 2022. The DMI has remained within the average and neutral IOD conditions were observed during January and March 2023. At present neutral IOD conditions are present over the Indian Ocean. In the month of April 2023, Negative subsurface temperature anomalies (Fig. 2d) were seen spread over the parts of eastern equatorial Indian Ocean and some pockets of positive subsurface temperature anomalies were seen over the western Indian Ocean at around thermocline depth.

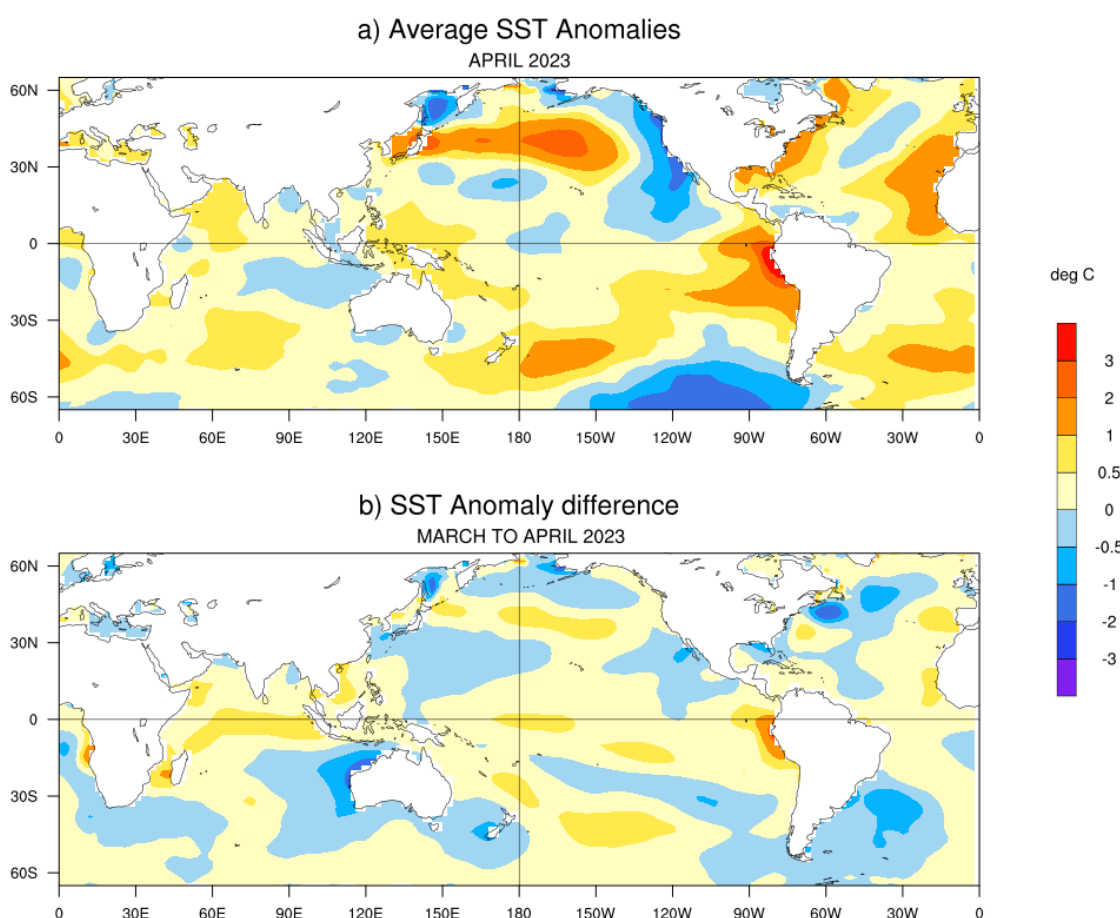


Fig.1: (a) Sea surface temperature (SST) anomalies ($^{\circ}\text{C}$) during April 2023 and **(b)** changes in the SST anomalies ($^{\circ}\text{C}$) from March 2023 to April 2023. SSTs were based on the ERSSTv5, NOAA, and anomalies were computed with respect to 30-year (1991-2020) long term mean.

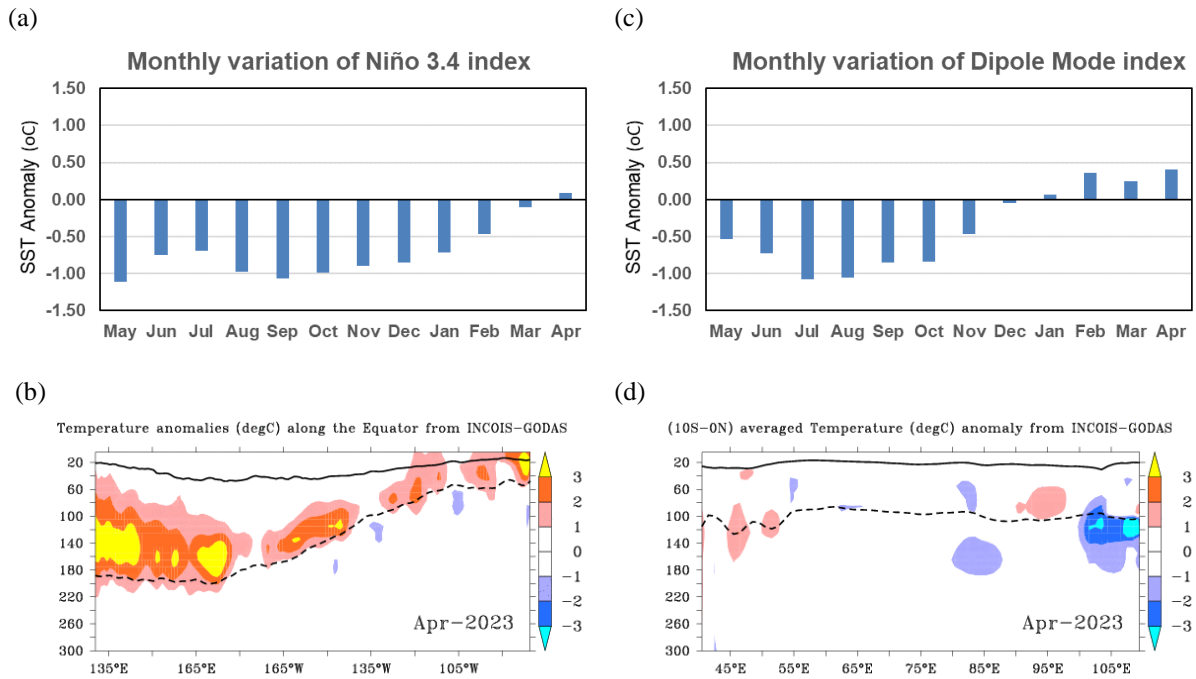


Fig.2: (a) Monthly variation of Niño 3.4 SST index for the last 12 months and **(b)** Depth-longitude section of ocean temperature anomalies in the equatorial (5°S-5°N) the Pacific Ocean for the month of April, 2023. **(c)** Same as (a) but for Dipole Mode Index (DMI). **(d)** Same as (b) but for the 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 April 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, neutral ENSO conditions are prevailing over the equatorial Pacific region. The latest MMCFS Plume forecast (Fig.4a) indicate the development of an El Niño in the coming season. The probability forecast for ENSO (Fig.5a) indicate a high probability of El Niño development during May-July 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 neutral IOD conditions are likely to continue during the upcoming seasons (Fig.4b). The probability forecast for IOD (Fig.5b) also indicates about 60% probability for neutral IOD conditions and 35 % (higher than the climatological probability) of development of a positive IOD towards May-July 2023 season. However, the probability of positive IOD increases during the second half of the monsoon season.

MMCFS SST Anomaly Forecast : Apr 2023 IC

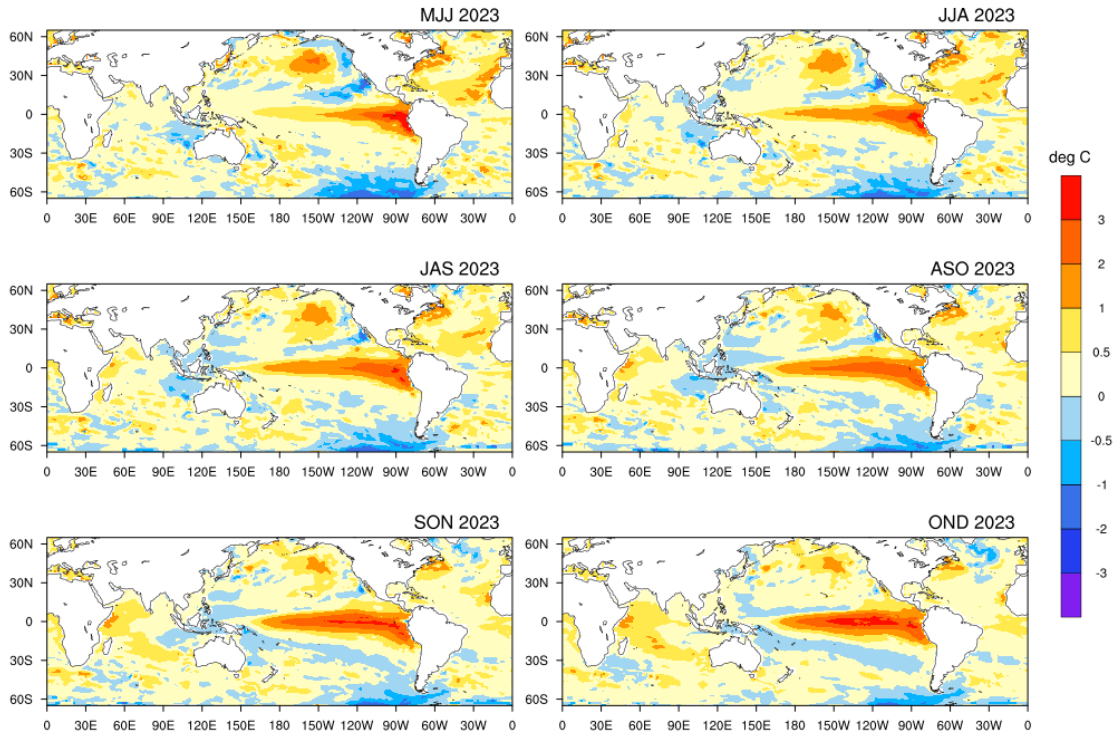


Fig.3: Forecasted Seasonal mean SST anomalies for three monthly seasons, (a) May to July (MJJ 2023), (b) June to August (JJA 2023), (c) July to September (JAS 2023), (d) August to October (ASO 2023) (e) September to November (SON 2023), and (f) October to December (OND 2023). (Model bias correction base period: 2011-2020; Climatology base period:1991-2020).

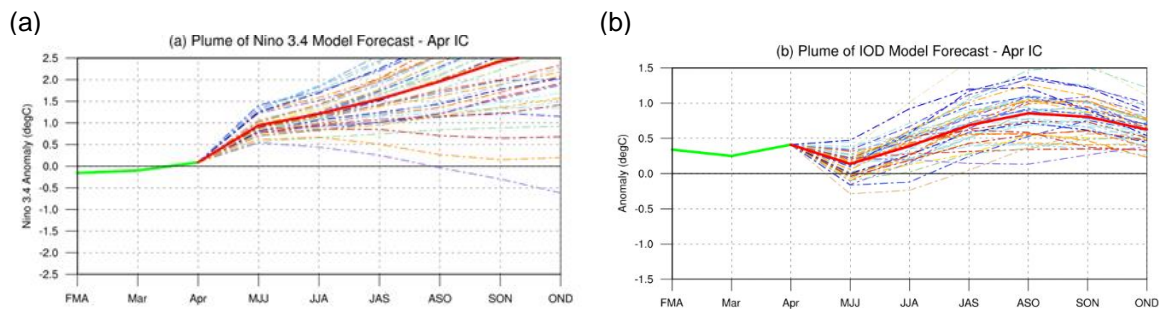


Fig.4: Plume of (a) Niño 3.4 SST index, (b) Indian Ocean Dipole Mode Index forecasted by high-resolution MMCFS. The forecasts were PDF corrected for bias and variance. The solid green line is the observed SST anomaly (ERSSTv5, NOAA) and the solid red line is the ensemble mean SST anomaly forecast of 44 members (MMCFS). The individual ensemble member forecasts are shown in light dotted lines of different colours.

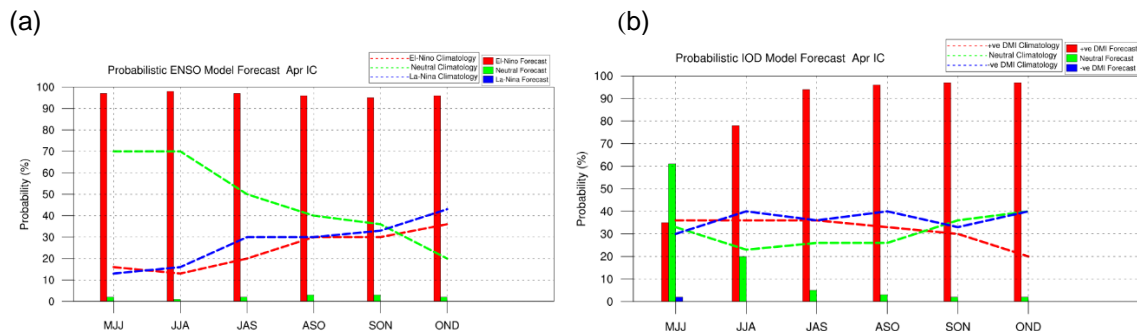


Fig.5: Probability forecast along with climatological probabilities of (a) Niño 3.4 and (b) Indian Ocean Dipole Mode Index from high-resolution MMCFS. The data source for Climatology probabilities: NOAA Extended Reconstructed SST V5. Criteria used for Probabilistic ENSO Forecast: La Niña ≤ -0.5 , Neutral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