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

June 2024

Highlights

Currently ENSO neutral conditions are observed over the equatorial Pacific. The sea surface temperatures (SSTs) are above average in the equatorial western and central Pacific Ocean, and below-average over the eastern equatorial Pacific Ocean. The latest MMCFS forecast indicates that the ENSO-neutral conditions are likely to continue with strong possibility of transition to La Niña conditions around August-October 2024 season.

At present, neutral Indian Ocean Dipole (IOD) conditions are prevailing over the Indian Ocean. The latest MMCFS forecast indicates enhanced probability for neutral IOD conditions to continue. At the same time, the possibility for the emergence of the positive IOD conditions during the monsoon season has reduced significantly. Up to last month, many global models including MMCFS were predicting the development of positive IOD conditions during the monsoon season.

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

During May 2024, below-average equatorial sea surface temperatures (SSTs) emerged in small regions of the eastern Pacific Ocean. However, above-average SSTs prevailed across the rest of the equatorial Pacific (Fig.1a). Warmer than normal SSTs were observed over some parts of northern and southern extra-tropical Pacific region. Cooler than normal SSTs were observed over some parts of the southern extra-tropical Pacific region. As compared to April 2024, negative SST anomalies were seen over central and eastern equatorial Pacific region and positive SST anomalies were seen over the western equatorial Pacific Ocean (Fig.1b).

In May 2024, warmer than normal SSTs were observed over most parts of the Indian Ocean (Fig.1a) including Bay of Bengal and Arabian Sea. As compared to April 2024, cool SSTs were observed over the equatorial Indian Ocean and warm SSTs were 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 2023 to May 2024 is shown in Fig.2a. A weak El Niño condition observed over the Pacific Ocean during June-July 2023. The El Niño conditions strengthened to moderate level during August 2023 and further to strong El Niño during the latter part of 2023. The El Niño conditions after peaking to its maximum intensity during November – December 2023, started to weaken thereafter. Currently, ENSO-neutral conditions are observed. The weak positive subsurface temperature anomalies are observed over some parts of the western Pacific Ocean between 20°C isotherm and thermocline depth (Fig.2 b). The negative subsurface temperature anomalies are observed over central and eastern equatorial Pacific Ocean with highest magnitudes 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 June 2023 to May 2024 is shown in Fig.2c. After remaining neutral for most part of the first half of 2023, the Indian Ocean Dipole (IOD) conditions switched to a positive phase in August 2023, and lasted until January 2024. In February, the IOD conditions weakened from positive to neutral, and currently neutral Indian Ocean Dipole (IOD) conditions are prevailing over the Indian Ocean. The positive subsurface temperature anomalies (Fig. 2d) were seen over the western equatorial Indian Ocean from surface to thermocline depth. Some negative subsurface anomalies were seen over the eastern equatorial Indian Ocean near and below the thermocline depth.

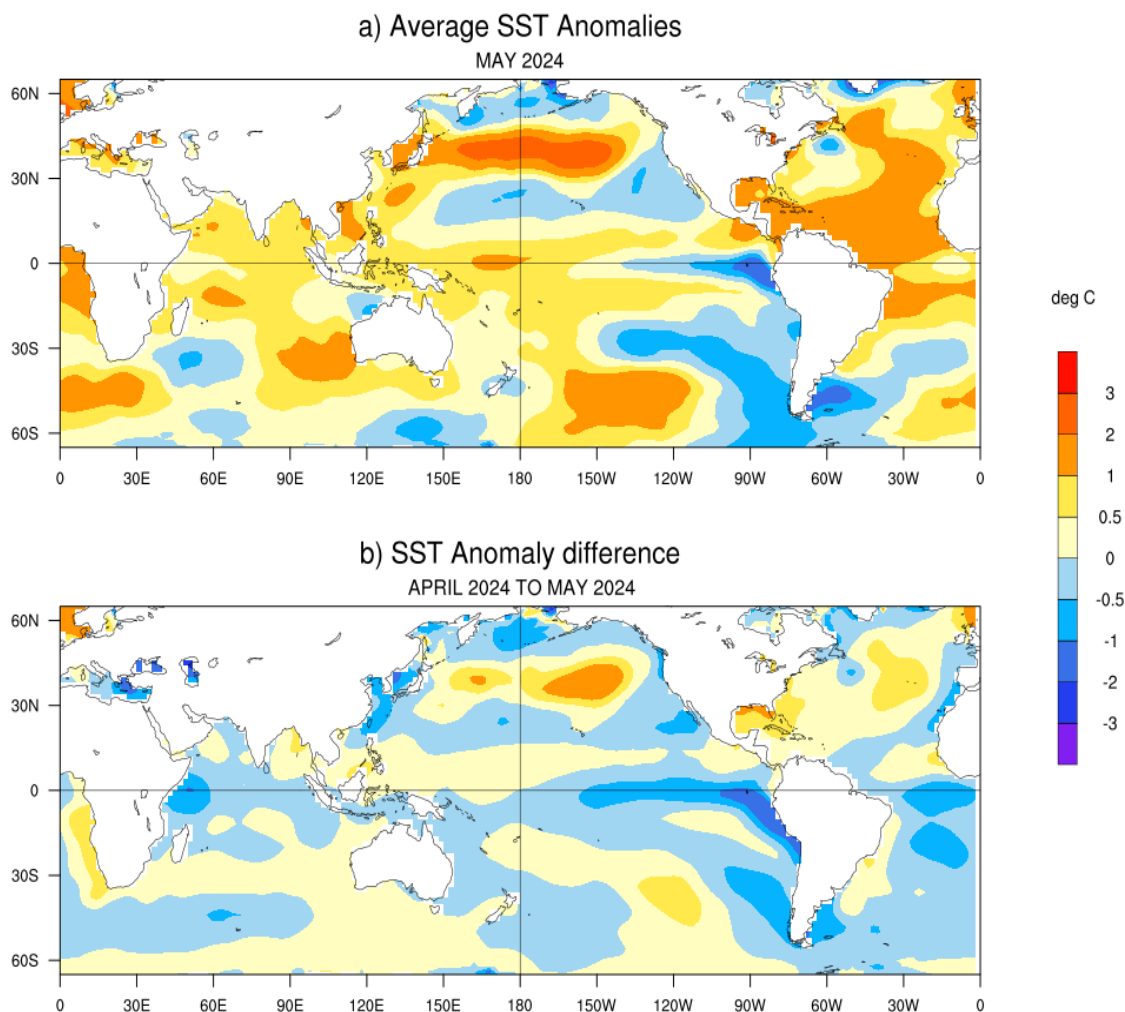


Fig.1: (a) Sea surface temperature (SST) anomalies ($^{\circ}\text{C}$) during May 2024 and **(b)** changes in the SST anomalies ($^{\circ}\text{C}$) from April 2024 to May 2024. SSTs were based on the ERSSTv5, NOAA, and anomalies were computed with respect to 30-year (1991-2020) long term mean.

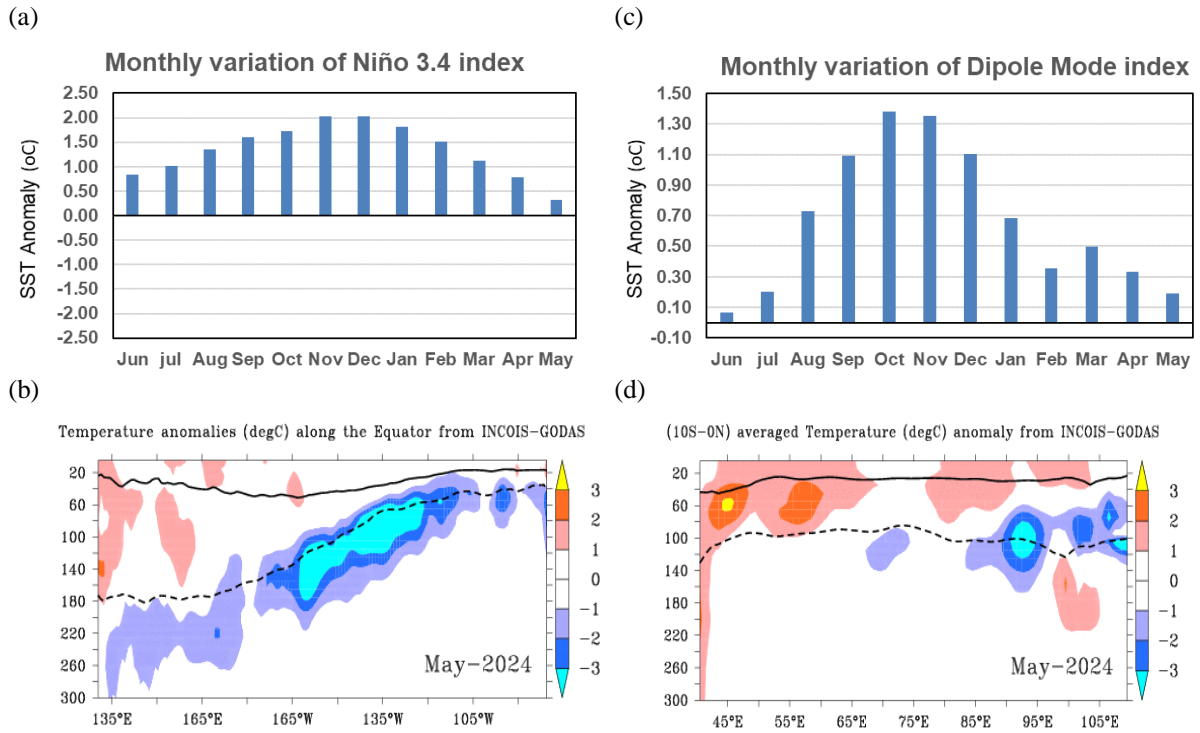


Fig.2: (a) Monthly variation of Niño 3.4 SST index for the last 12 months and (b) Depth-longitude section of sub surface temperature anomalies in the equatorial (5°S - 5°N) Pacific Ocean for the month of May 2024. (c) Same as (a) but for Dipole Mode Index (DMI). (d) Same as (b) but for the tropical Indian 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 and 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 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 1991-2020 climatology.

Currently, the sea surface temperatures are cooler than normal in the eastern equatorial Pacific Ocean, but in most other areas of the equatorial Pacific, the temperatures are warmer than normal. The 3-month season-averaged SST anomaly forecast (Fig. 3) indicates that strengthening of negative SST anomalies over eastern equatorial Pacific Ocean during the upcoming season. The latest MMCFS plume forecast (Fig.4a) indicates that the neutral ENSO conditions are likely to continue during the next few months and turn to La Niña conditions thereafter. The probability forecast 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 3-month season-averaged SST anomaly forecast (Fig. 3) indicates that positive SST anomalies are likely over most parts of the Indian Ocean. As per the latest MMCFS plume forecast (Fig.4b), the neutral IOD conditions most likely during the monsoon season and the probability for positive IOD has decreased substantially and the development of positive IOD during this monsoon season is unlikely as was expected so far. The probability forecast also indicates enhanced probability of neutral IOD conditions likely during the upcoming season.

MMCFS SST Anomaly Forecast :May 2024 IC

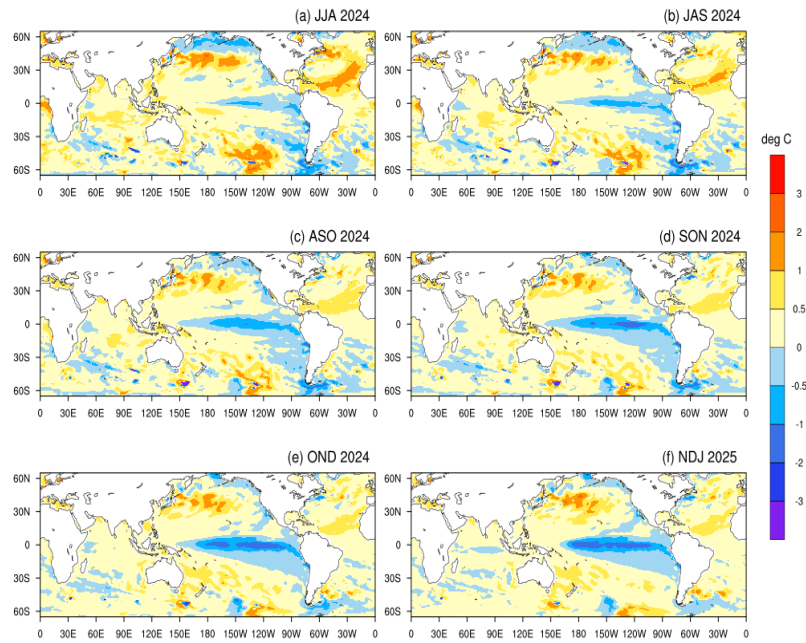


Fig.3: Forecasted Seasonal mean SST anomalies for three monthly (a) June 2024 to August 2024 (JJA 2024), (b) July 2024 to September 2024 (JAS 2024) and (c) August 2024 to October 2024 (ASO 2024) (d) September 2024 to November 2024 (SON 2024), (e) October 2024 to December 2024 and (f) November 2024 to January 2025 (NDJ2025) (Model bias correction base period: 1999-2008; Climatology base period:1991-2020).

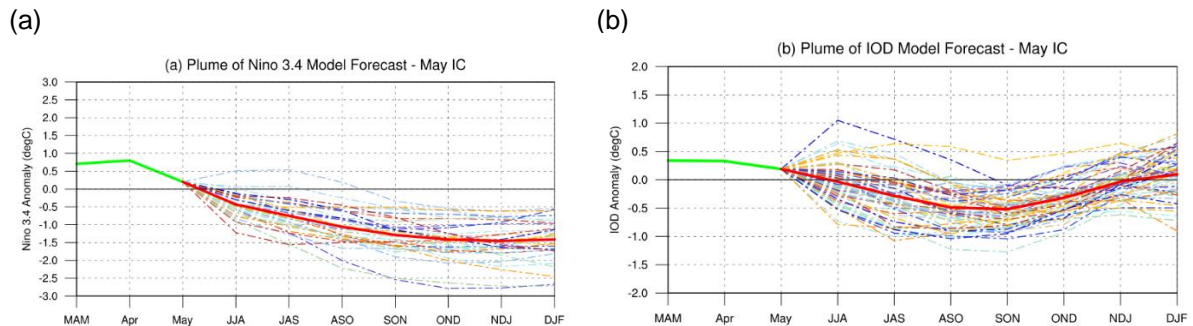


Fig.4: Plume of (a) Niño 3.4 SST index, (b) Indian Ocean Dipole (IOD) Mode Index forecasted by high-resolution MMCFS. The forecasts were PDF corrected for bias and variance. The solid green line is the observed SST anomaly (ERSSTv5, NOAA) and the solid red line is the ensemble mean SST anomaly forecast of 59 members (MMCFS). The individual ensemble member forecasts are shown in light dotted lines of different colours.

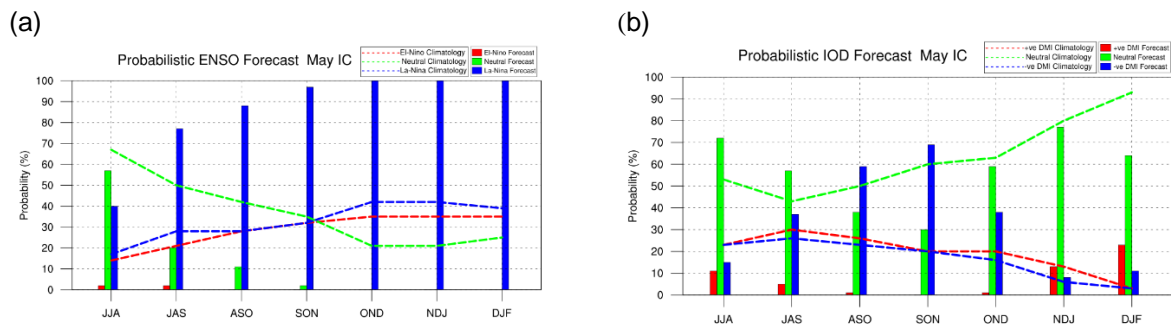


Fig.5: Probability forecast along with climatological probabilities of (a)Niño 3.4 and (b) Indian Ocean Dipole (IOD) Mode Index from high-resolution MMCFS. The data source for Climatology probabilities: NOAA Extended Reconstructed SST V5. Criteria used for Probabilistic ENSO Forecast: La Niña ≤ -0.5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