



**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 2022**

**Highlights**

Currently, La Niña conditions are prevailing over the equatorial Pacific region. The latest MMCFS forecast indicates that La Niña conditions are likely to weaken starting from the February-March season and to reach cold ENSO neutral conditions during the second quarter of 2022.

At present, neutral IOD conditions are present over the Indian Ocean and the latest MMCFS forecast indicates that the neutral IOD conditions are likely to continue during the spring and summer seasons.

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

During December 2021 cooler than normal SSTs were observed over most parts of the central, eastern, and southeastern tropical Pacific, and warmer than normal SSTs were observed over extreme west 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, cooling of SSTs is observed over the parts of the eastern Pacific Ocean as well as parts of the Central-north Pacific Ocean (Fig.1b). Warming of SSTs is observed over the central-east region of the North Pacific.

In the north Indian Ocean, normal SSTs were observed with positive anomalies over most parts of the Arabian Sea and Bay of Bengal. However, the positive anomalies were stronger over the north Bay of Bengal and western part of the equatorial Indian Ocean. Positive SST anomalies were observed over north-central regions of the south Indian Ocean and along the coasts of northwest Australia (Fig. 1a). As compared to November month, warming SST anomalies were observed except in western parts of the Arabian Sea and eastern parts of the Bay of Bengal (Fig. 1b). Warming of SST anomalies was also observed over eastern parts of the south Indian Ocean whereas cooling of SST anomalies was observed over the western part of the mid-latitude south Indian Ocean (Fig.1b).

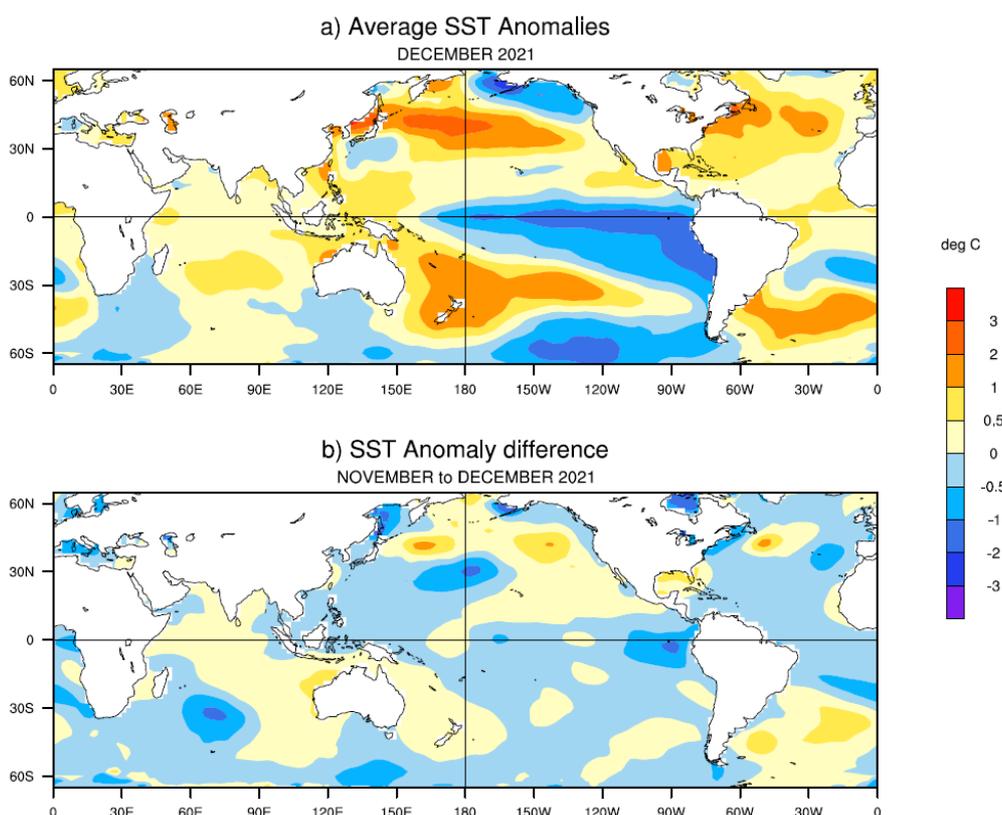
**1.1. El Niño Southern Oscillation (ENSO) conditions over the Pacific Ocean**

The monthly time series of Niño3.4 SST anomalies for the last 12 months from January 2021 to December 2021 is shown in Fig.2a. La Niña conditions were observed during January-February 2021. However, the strength of La Niña started weakening from March 2021 to June 2021. The La Niña conditions turned into neutral (cool) ENSO conditions during May 2021-July 2021. The cool ENSO strengthened again to establish weak La Niña conditions in September 2021. Thereafter, the La Niña conditions kept strengthening to reach the maximum strength in December 2021. Currently, moderate La Niña conditions are prevailing over the Pacific. In the month of December 2021, positive subsurface temperatures were observed

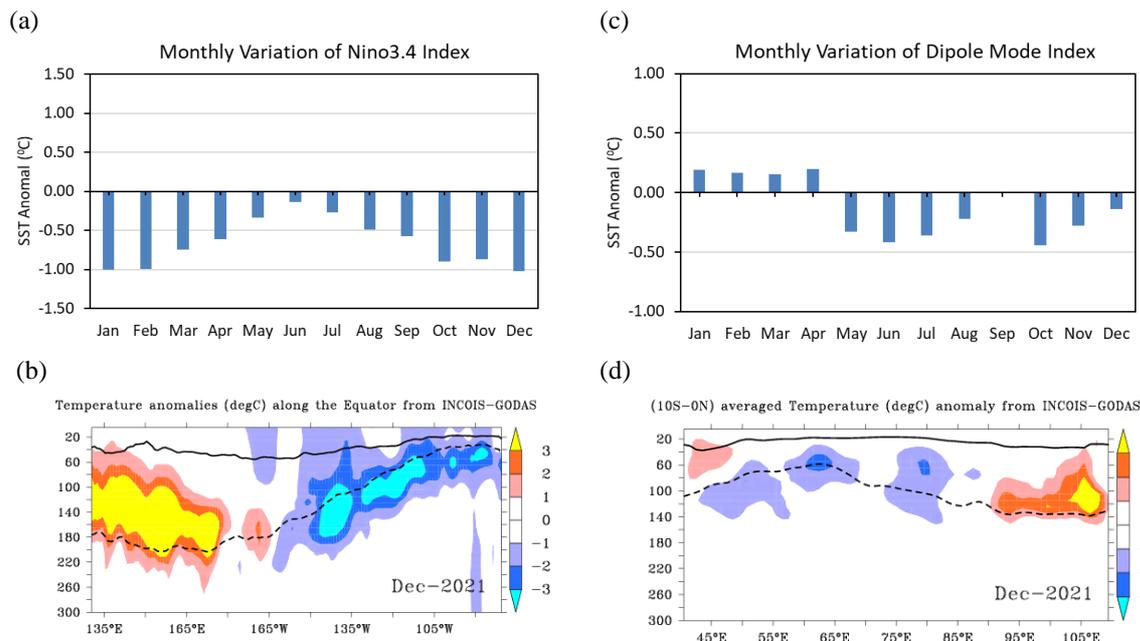
over the western Pacific Ocean (between 20° isotherm and thermocline depth) (Fig.2b). The subsurface temperature warm anomalies with stronger magnitude were observed nearby 135°E -175°E. The subsurface temperature anomalies were negative over the broad area across the central and eastern region of the Pacific Ocean below the thermocline depth between 160°W to 85°W.

## 1.2. Indian Ocean Dipole (IOD) conditions over the Indian Ocean

The Dipole Mode Index (DMI) for the last 12 months suggests that (Fig. 2c) from January 2021 to April 2021, DMI was within the average values. During May 2021, weak negative IOD conditions were observed over the Indian Ocean which enhanced slightly in the subsequent month of June and July and weakened slightly in the month of August. During September, the negative IOD was weakened further and turned into neutral IOD conditions. In the months of October and November, the DMI is slightly negative side of its normal. At present neutral IOD conditions are prevailing over the Indian Ocean. In the month of November 2021, positive subsurface temperature anomalies (Fig. 2d) were seen over the eastern equatorial Indian Ocean with a stronger magnitude spread over 95°E and 110°E in between 20°C isotherm and thermocline depth. A small region of negative subsurface anomalies was seen over the central and western equatorial Indian Ocean around and the thermocline depth.



**Fig.1: (a)** Sea surface temperature (SST) anomalies (°C) during December 2021 and **(b)** changes in the SST anomalies (°C) from November 2021 to December 2021. SSTs were based on the ERSSTv5, NOAA, and anomalies were computed with respect to 30-year (1981-2010) 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 December, 2021. **(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 (b) were computed using the base period of 1981-2010 (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).

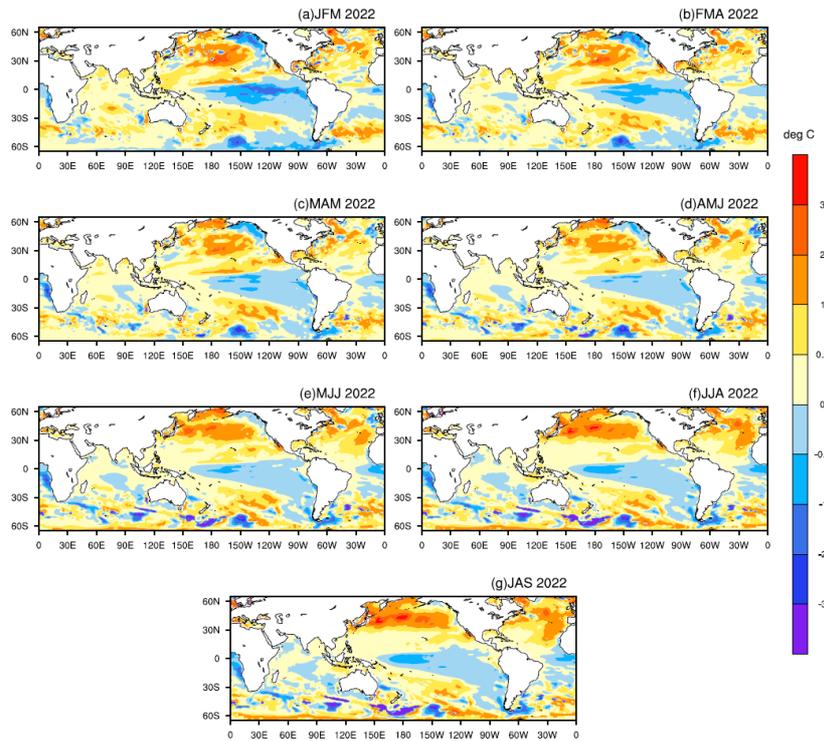
## 2. ENSO & IOD Forecast

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 2021 December 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 1982-2008 climatology.

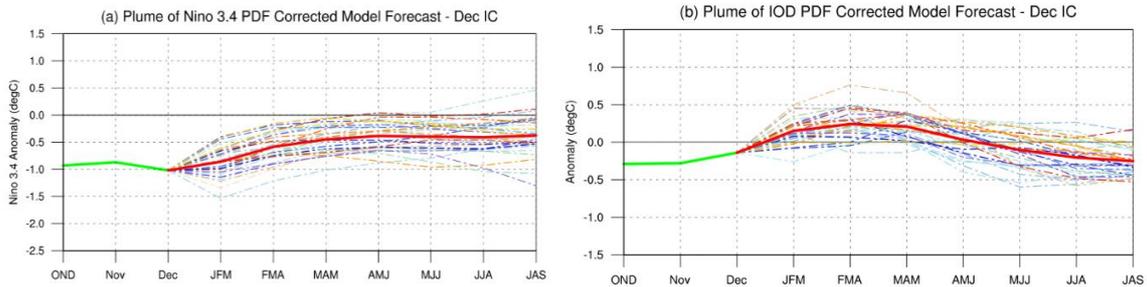
The 3-month season averaged SST anomaly forecast (Fig.3) indicates that negative SST anomalies are likely over most parts of the central and eastern equatorial Pacific Ocean for the entire forecast period. However, the magnitude of negative anomalies is stronger during JFM 2022 season. Warmer than normal SSTs are likely over most parts of the north and the south Pacific Ocean during most of the forecasted seasons. Currently, moderate La Niña conditions are prevailing over the equatorial Pacific region. The latest MMCFS forecast indicates that La Niña conditions are likely to weaken starting from the February-March season and to reach cold ENSO neutral conditions during the second quarter of 2022 (Fig.4a). The probability forecast for ENSO (Fig.5a) indicates the enhanced probability for La Niña conditions from JFM to FMA season. MAM season onwards enhanced probability for neutral ENSO conditions is predicted. IMD is closely monitoring ENSO conditions and monthly updates are provided as per observed changes in the Pacific Ocean SSTs.

Normal SSTs are likely over most parts of the Indian Ocean during the entire forecast period. However, SST anomalies in the northern parts of the Arabian Sea and Bay of Bengal are likely to remain warmer than normal for the next couple of seasons (Fig.3). Warmer than normal SSTs are likely over central parts of the south Indian Ocean for JFM to AMJ seasons. At present, neutral IOD conditions are present over the Indian Ocean and the latest MMCFS forecast indicates that the neutral IOD conditions are likely to continue during the forecast period. (Fig.4b). The probability forecast for IOD (Fig.5b) indicates the enhanced probability for neutral IOD conditions during most of the forecast period.

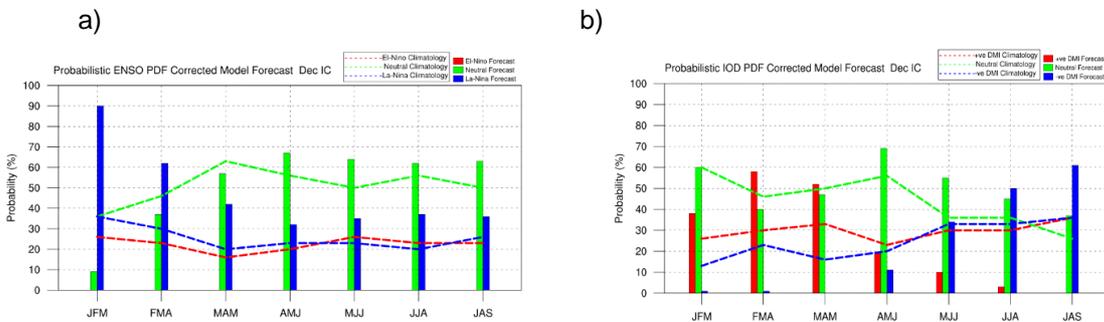
MMCFS SST Anomaly Forecast : DEC 2021 IC



**Fig.3:** Forecasted Seasonal mean SST anomalies for three monthly seasons, (a) January to March (JFM), (b) February to April (FMA), (c) March to May (MAM), (d) April to June (AMJ), (e) May to July (MJJ), (f) June to August (JJA), and (g) July to September (JAS), (Model bias correction base period: 1999-2008; Climatology base period:1982-2008).



**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 32 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  $\leq -0.5$ , Neutral  $<0.5$  to  $>-0.5$ , El Niño  $\geq 0.5$ . Criteria used for Probabilistic DMI Forecast: negative DMI  $\leq -0.2$ , Neutral  $<0.2$  to  $>-0.2$ , positive DMI  $\geq 0.2$ .