



**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**

April 2021

Highlights:

During March, weak La Niña conditions were prevailing over equatorial Pacific; and currently, strength of cooler SST anomalies has reduced significantly over the region. The latest MMCFS forecast showing further weakening of La Niña conditions over equatorial Pacific Ocean and it is likely to return of ENSO neutral conditions during upcoming seasons.

At present, neutral IOD conditions are observed over Indian Ocean and the latest MMCFS forecast indicates neutral IOD conditions are likely to continue up to AMJ season and negative IOD conditions likely to develop thereafter.

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

During March 2021 cooler than normal SSTs were observed over central and eastern parts of the equatorial Pacific and warmer than normal SSTs were observed over western equatorial Pacific Ocean (Fig.1a). Positive SST anomalies were observed over most parts of the north Pacific Ocean and central parts of south Pacific Ocean. As compared to the last month, warming of SSTs is observed over equatorial Pacific Ocean as well as some parts from southeast and northwest Pacific Ocean (Fig.1b). Cooling of SSTs is observed over some region of the higher latitudes of South and North Pacific Ocean.

In the north Indian Ocean, warmer than normal SSTs were observed over northern parts of Arabian Sea and cooler than normal SSTs were observed over head Bay of Bengal and normal SSTs over remaining areas. Warmer SSTs were observed over most parts of south Indian Ocean and the negative SST anomalies were observed over western parts of equatorial Indian Ocean (Fig.1a). As compared to the last month, warming of SSTs is observed over north Indian Ocean except a small region over south Bay of Bengal. Cooling of SSTs is also observed over east Indian Ocean off the northwest coast of Australia and south of the equatorial 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 April 2020 to March 2021 is shown in Fig.2a. Warm ENSO neutral conditions were observed over equatorial Pacific Ocean during April 2020, however SSTs over the region were started to get cool during the subsequent month of May and it was enhanced during June and July months of 2020. Since then cool ENSO neutral conditions were observed over the equatorial Pacific. In the month of August, SSTs have shown further cooling and Niño 3.4 SST anomaly crossed La Niña threshold. During September La Niña conditions were established which peaked by November. After December 2020 till February month of 2021, cool SST anomaly from Niño 3.4 region was kept decreasing and the weakening of La Niña conditions was observed continuously. During March, weak La Niña conditions were prevailing over equatorial Pacific; and currently, strength of cooler SST anomalies has reduced significantly. Atmospheric circulation also started reflecting weakening of La Niña pattern. Subsurface

warming is also showing warming trends over western Pacific Ocean with strongest magnitude spread around 130°E to 170°E (between isotherm and thermocline depth) (Fig.2b). The subsurface temperature anomalies were negative over the east central and eastern Pacific Ocean with strongest magnitude observed below the thermocline depth between 135°W to 105°W.

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

The DMI index for the last 12 months suggests that (Fig. 2c) neutral IOD conditions were observed during April 2020. During May 2020, weak positive IOD conditions were observed and started decreasing their strength during July 2020. The DMI has remained within the average and neutral IOD conditions were observed since August and continued in subsequent months from September 2020 till March. At present neutral IOD conditions are prevailing over Indian Ocean. Positive subsurface temperature anomalies (Fig. 2d) were seen over east equatorial Indian Ocean with stronger magnitude around 100°E in between 20°C isotherm and thermocline depth. Negative subsurface anomalies were seen over the west equatorial Indian Ocean at and around thermocline depth.

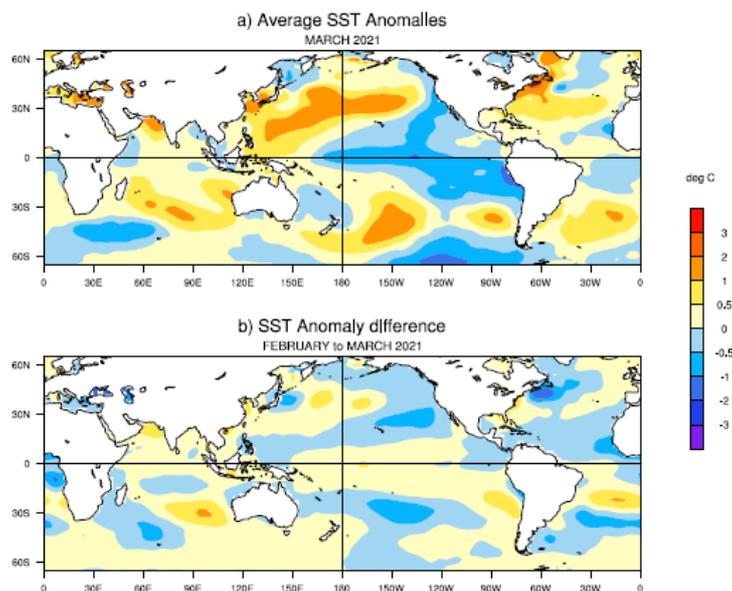


Fig.1: (a) Sea surface temperature (SST) anomalies (°C) during March, 2021 and (b) changes in the SST anomalies (°C) from February 2021 to March 2021. SSTs were based on the ERSSTv5, NOAA and anomalies were computed with respect to 30-year (1981-2010) long term mean ERSSTv5, NOAA.

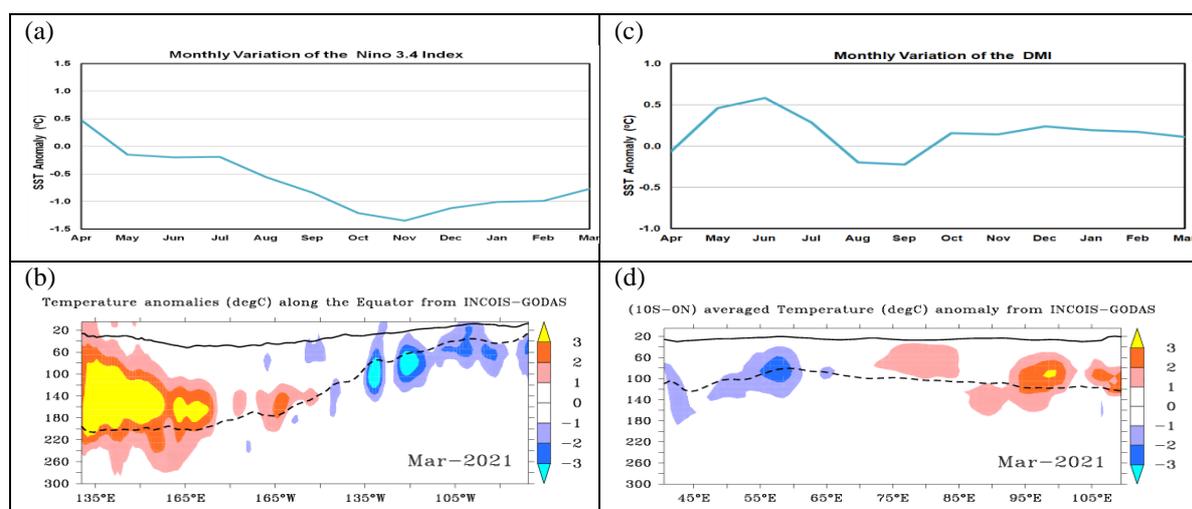


Fig.2: (a) Monthly variation of Niño 3.4 SST index anomaly for the last 12 months and (b) Depth-longitude section of ocean temperature anomalies in the equatorial (5°S-5°N) Pacific Ocean for the month of March, 2021. (c) Same as (a) but for Dipole Mode Index (DMI). (d) Same as (b) but for the tropical Indian Ocean (10°S-Eq). The anomalies were computed using 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 March 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 central and eastern equatorial Pacific Ocean for the entire forecast period. Normal to warmer than normal SSTs are likely over parts of north Pacific Ocean during most of the forecasted seasons. During March, weak La Niña conditions were prevailing over equatorial Pacific; and currently, strength of cooler SST anomalies has reduced significantly over the region. The latest MMCFS forecast showing further weakening of La Niña conditions over equatorial Pacific Ocean and it is likely to return of ENSO neutral conditions during upcoming seasons (Fig.4a).

In the Indian Ocean, normal to warmer than normal SSTs are likely over northern parts of Arabian Sea and Bay of Bengal during AMJ season (Fig.3). Thereafter, normal SSTs are likely over most parts of Indian Ocean (with negative SST anomalies over west Indian Ocean and positive SST anomalies in the east Indian Ocean). At present, neutral IOD conditions are observed over Indian Ocean and the latest MMCFS forecast indicates neutral IOD conditions are likely to continue up to AMJ season and negative IOD conditions likely to develop thereafter (Fig.4b).

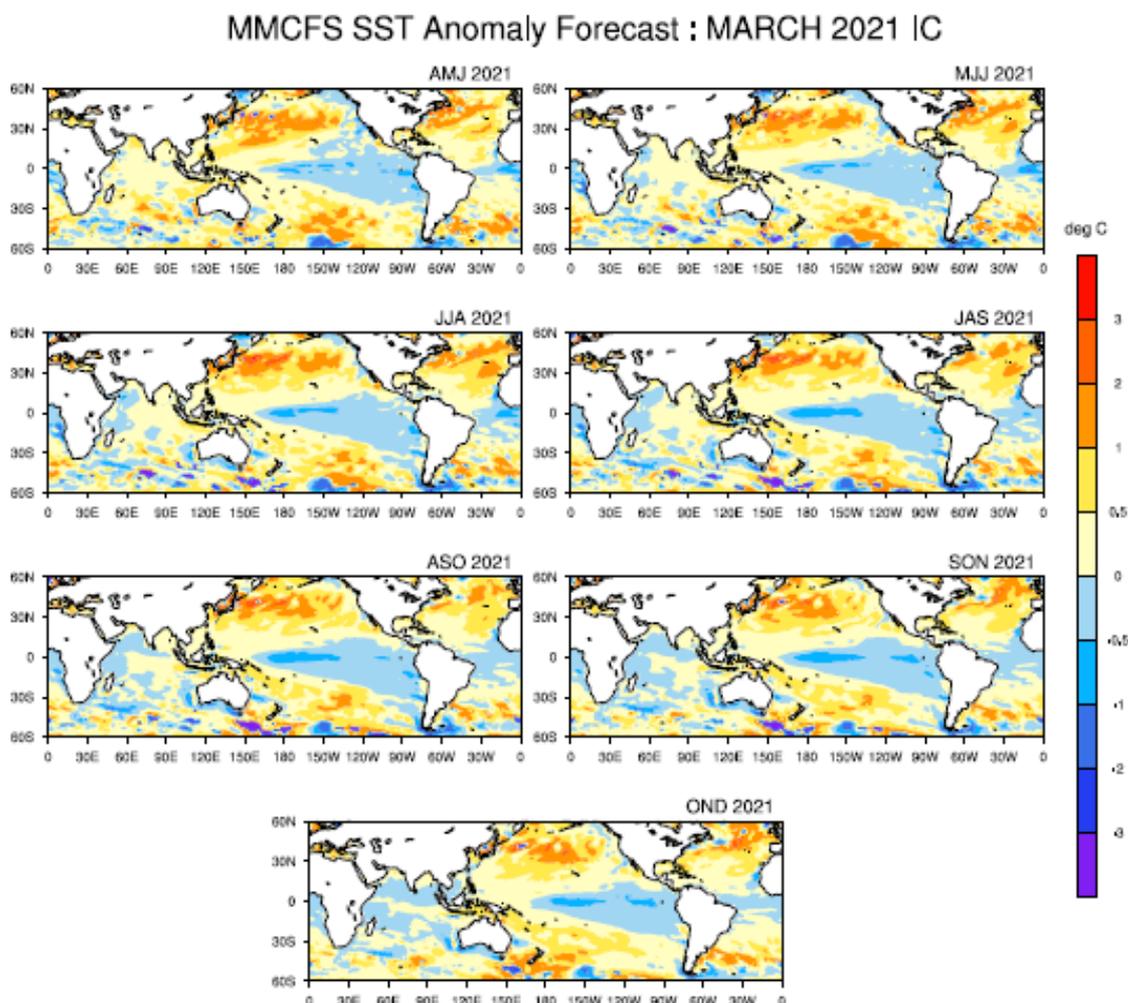


Fig.3: Forecasted Seasonal mean SST anomalies for 3 monthly seasons, (a) April to June (AMJ), (b) May to July (MJJ), (c) June to August (JJA), (d) July to September (JAS), (e) August to October (ASO), (f) September to November (SON) and (h) October to December (OND) (Model bias correction base period: 1999-2008; Climatology base period:1982-2008).

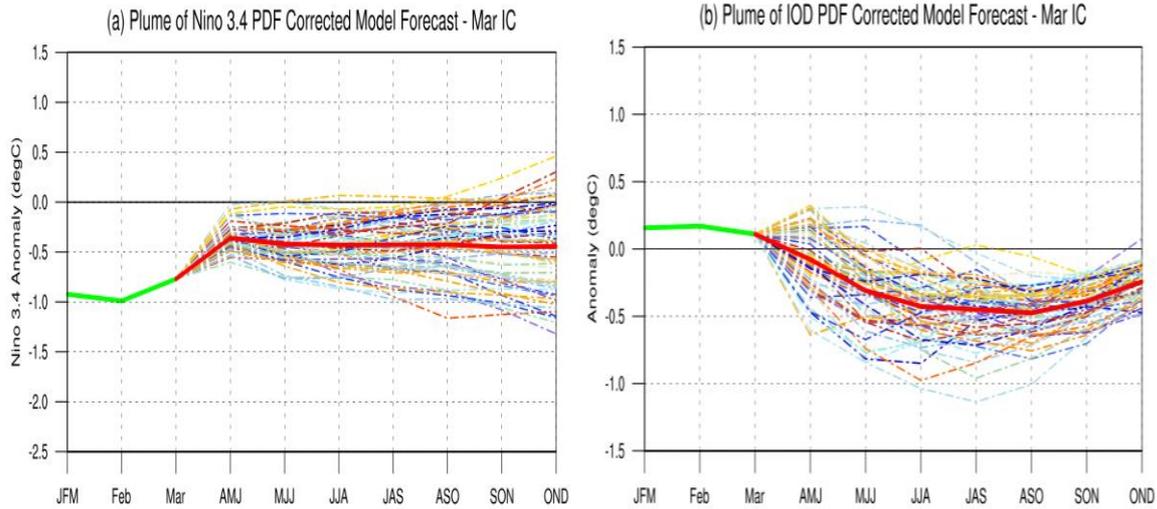


Fig.4: Plume of (a) Niño 3.4 SST anomalies, (b) Indian Ocean Dipole Mode Index forecasted by high resolution MMCFS. The forecasts were PDF corrected for bias and variance. The solid green line is the observed SST anomaly (ERSSTv5, NOAA) and solid red line is the ensemble mean SST anomaly forecast of 58 members (MMCFS). The individual ensemble member forecasts are shown in light dotted lines of different colours.

Probability Forecast for Niño 3.4 and India Ocean Dipole Mode Index

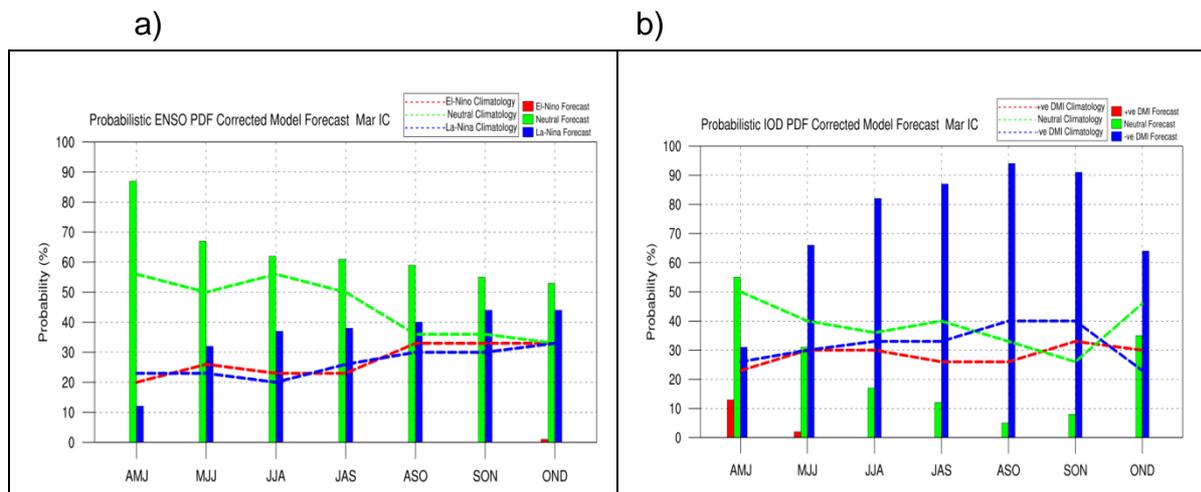


Fig.5: Probability forecast along with climatological probabilities of (a) Niño 3.4 and (b) Indian Ocean Dipole Mode Index from high resolution MMCFS. Data source for Climatology probabilities: NOAA Extended Reconstructed SST V5. Criteria used for Probabilistic ENSO Forecast: ≤ -0.5 La Niña, >0.5 to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

The probability forecast for ENSO (Fig.5a) indicates enhanced probability for neutral ENSO conditions during entire forecast period. IMD is closely monitoring ENSO conditions and monthly updates are provided as per observed changes in the Pacific Ocean SSTs.

The probability forecast for IOD (Fig.5b) indicates enhanced probability for neutral IOD conditions for AMJ season and from MJJ onwards enhanced probability for negative IOD conditions is predicted.