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**SEASONAL CLIMATE OUTLOOK FOR SOUTH ASIA**

**(March to June 2024)**

**Highlights**

- Strength of El Niño conditions weakened since beginning of the year and currently moderate El Niño conditions are prevailing over equatorial Pacific. The sea surface temperatures (SSTs) are warmer than normal over most of the equatorial Pacific Ocean. The latest MMCFS forecast indicates strength of El Niño conditions is likely to weaken during the upcoming season and turn to neutral thereafter. Model also indicate the development of La Niña conditions during the monsoon season.
- At present, neutral Indian Ocean Dipole (IOD) conditions are prevailing over the Indian Ocean and the latest MMCFS forecast indicates development of negative IOD conditions during the monsoon season.
- The probability forecast for precipitation for March – May (MAM) indicates that enhanced probability of above normal precipitation is likely in most parts of South Asia except in east coast of Indian Peninsula and southeast of South Asia where probability of below normal precipitation is likely. The same for April – June (AMJ) indicates that enhanced probability of above normal precipitation is likely in most parts of South Asia except in some parts of southeast and northwest regions where probability of below normal precipitation is likely.
- In March, the country averaged monthly precipitation is likely to be normal to above normal for all South Asian countries. In April, it is likely to be normal to above normal for all the countries except Maldives and Myanmar where it is likely to be below normal. In May, it is likely to be above normal for all the countries except Myanmar where it is likely to be below normal. In June, it is likely to be normal to above normal for all countries except Afghanistan where it is likely to be below normal.
- Temperature probability forecast for FMA and MAM seasons indicates that enhanced probability of above normal temperatures is likely over most parts of South Asia.
- The country averaged monthly temperatures during March, April, May and June are likely to be normal to above normal for all south Asian countries.

**DISCLAIMER:**

- (1) The long-range forecasts presented here are currently experimental and are produced using techniques that have not been validated.
- (2) The content is only for general information and its use is not intended to address particular requirements.
- (3) The geographical boundaries shown in this report do not necessarily correspond to the political boundaries.

# 1. Important Global Climate Factors

## 1.1 Sea Surface Temperatures over the Pacific Ocean

During the February 2024, warmer than normal SSTs were observed over most of the equatorial and the northern extra-tropical Pacific region (Fig.1a). Cooler than normal SSTs were observed over some parts of southern Pacific regions. As compared to January 2024, negative SST anomalies were observed across the equatorial Pacific Ocean (Fig.1b). Cool SST anomalies were also observed over many parts of the north Pacific. The latest MMCFS forecast indicates strength of El Niño conditions is likely to weaken during the upcoming season and turn to neutral thereafter. Model also indicates the development of La Niña conditions during the monsoon season (Fig. 2).

## 1.2 Sea Surface Temperatures over Indian Ocean

In February 2024, warmer than normal SSTs were observed over the Indian Ocean (Fig.1a). Compared to January 2024, warmer SSTs were observed over eastern equatorial Indian Ocean, north Bay of Bengal and north Arabian Sea (Fig.1b) and cooler SSTs were observed over the western Indian Ocean. The latest MMCFS forecast indicates development of negative IOD conditions during the monsoon season (Fig.3).

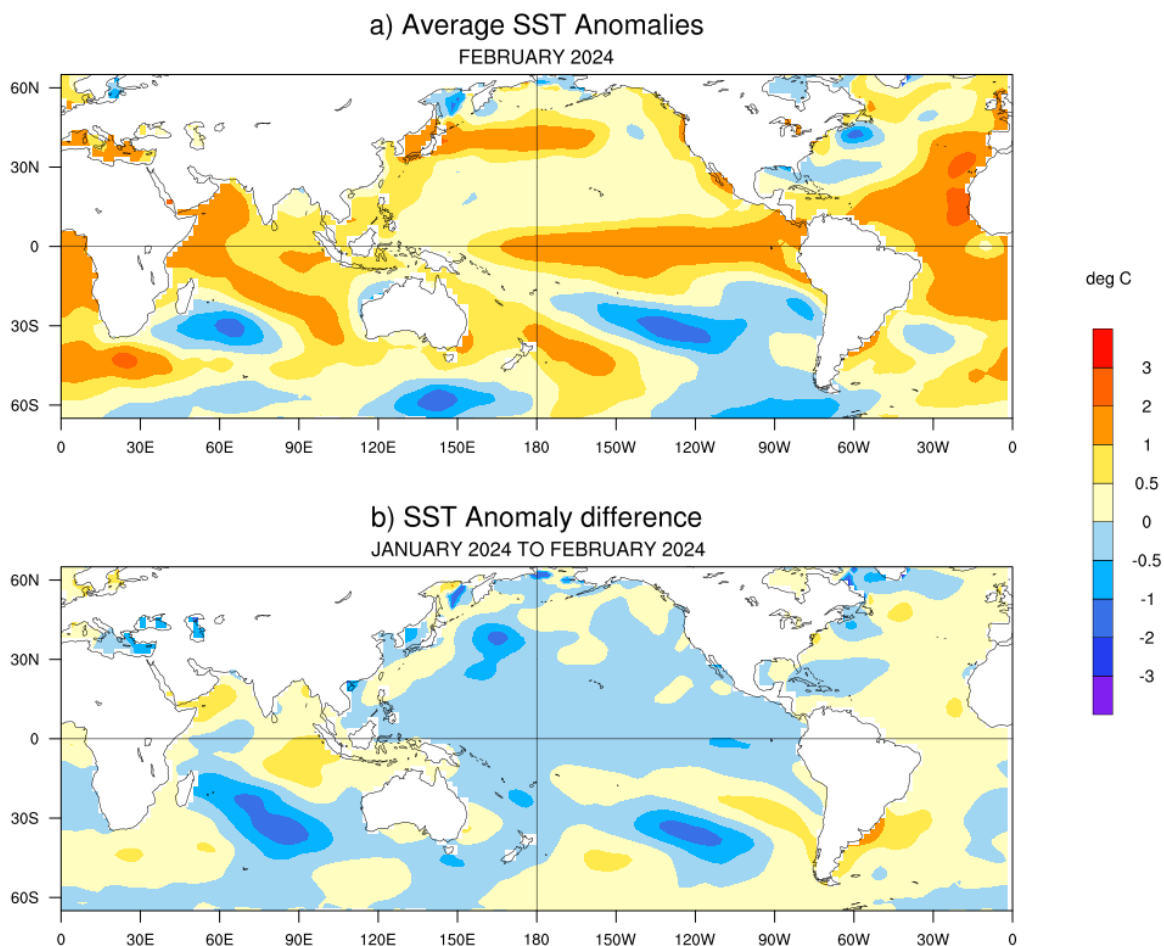
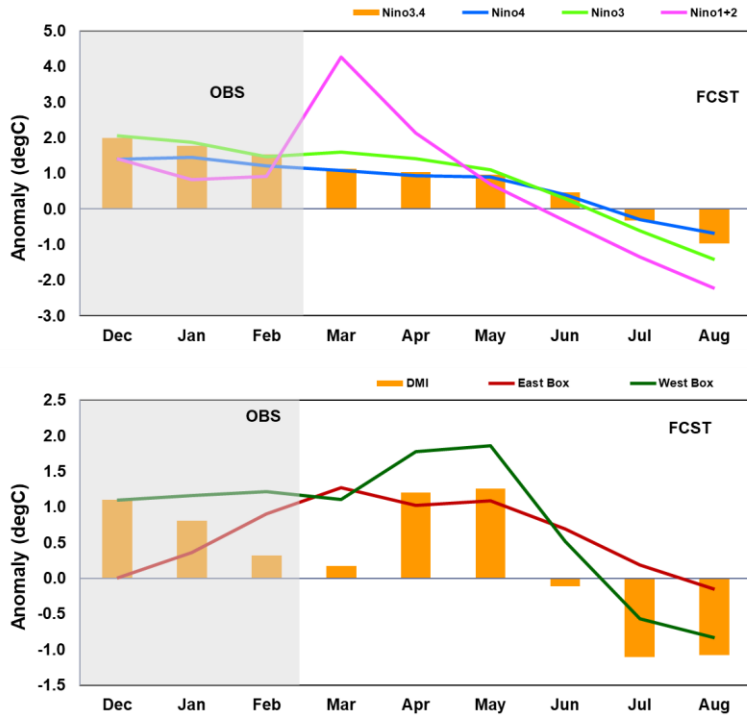


Fig.1(a) Sea surface temperature (SST) anomalies (°C) during February 2024 and (b) changes in the SST anomalies (°C) from January to February 2024. SSTs were based on the ERSSTv5, NOAA, and anomalies were computed with respect to 30-year (1991-2020) long term mean.

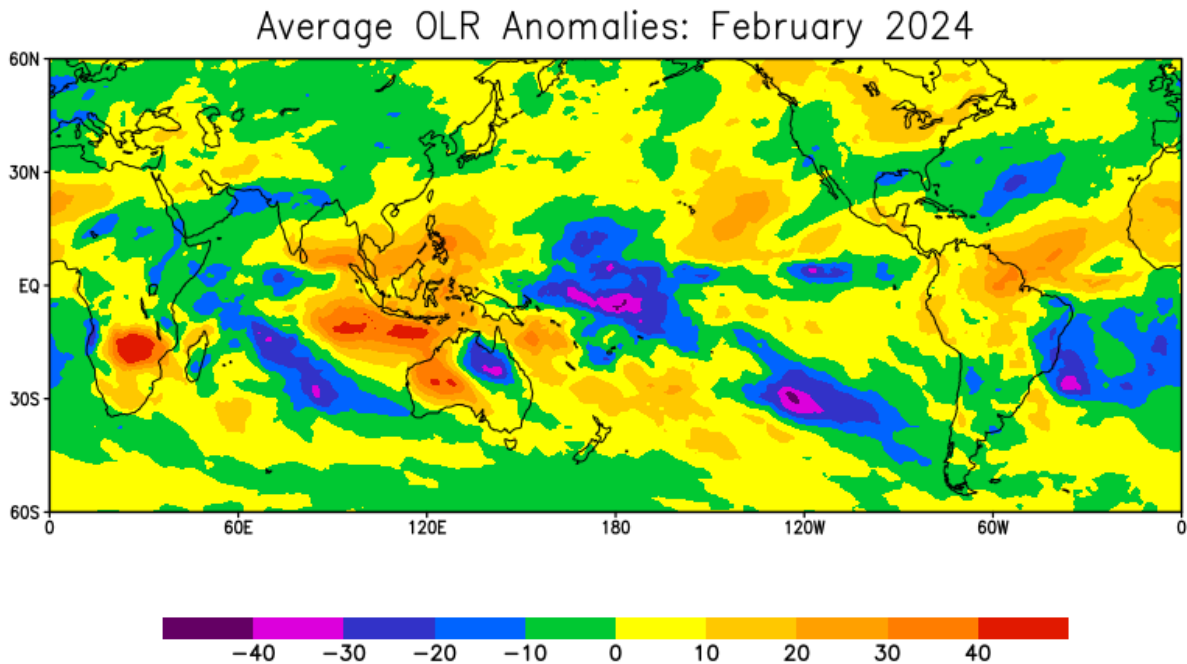


**Fig.2:** Time series of monthly area-averaged SST anomalies (°C) in the 4 Niño regions. ERSSTv5 observed anomaly for the last 3 months and MMCFS model PDF corrected anomaly forecast for the next 6 months.

**Fig.3:** The time series of the monthly area-averaged SST anomaly Indices (°C) over west equatorial Indian Ocean (WEI) & east equatorial Indian Ocean (EEI) along with Dipole Mode Index (DMI=WEI-EEI) representing Indian Ocean Dipole (IOD). ERSSTv5 observed anomaly for the last 3 months and MMCFS model PDF corrected anomaly forecast for the next 6 months.

### 1.3 Convection (OLR Anomaly) Pattern over the Asia Pacific Region

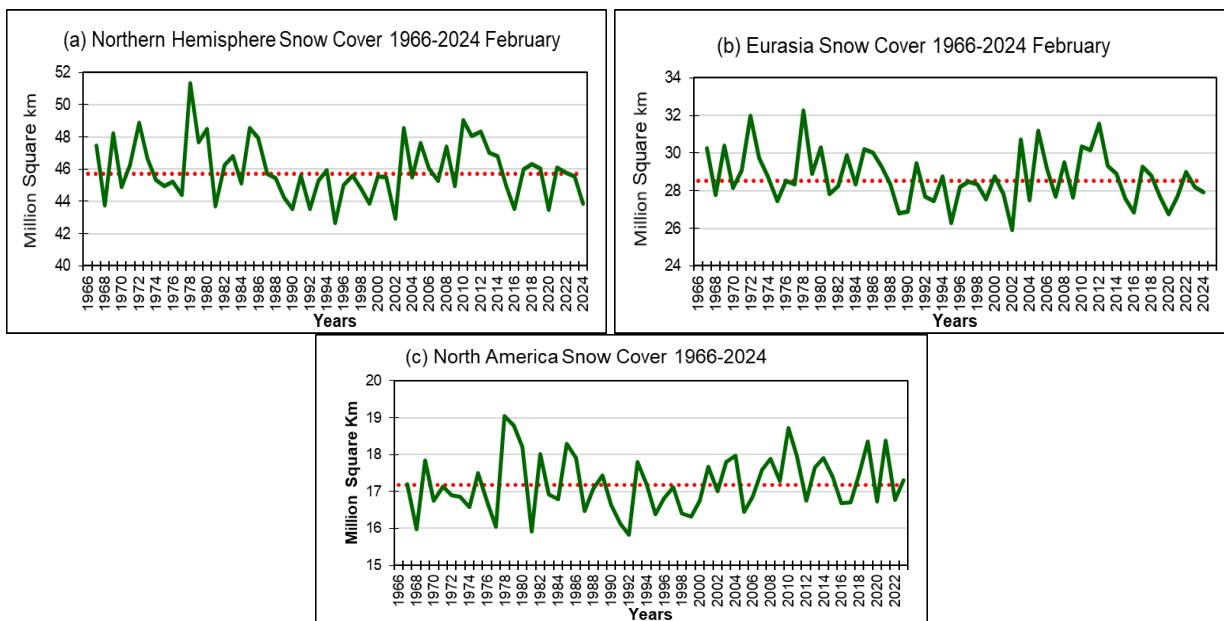
The Outgoing Longwave Radiation (OLR) anomaly during February 2024 is shown in (Fig.4). Negative OLR anomalies (enhanced convection, blue shading) were observed overhead Arabian sea, south Indian Ocean, central Pacific Ocean and some parts of south Pacific Ocean. Negative OLR anomalies were also observed over northern parts of Australia. Positive OLR anomalies (suppressed convection, orange/red shading) were observed over western tropical Pacific Ocean, south Bay of Bengal and eastern Indian Ocean. Positive OLR anomalies were also present in south Africa, maritime continent, southwest Australia and some parts of South America.



**Fig.4:** Outgoing Long Wave Radiation (OLR) Anomaly ( $W/m^2$ ) for February 2024 (Data source: NCEP-NOAA)

### 1.4 Snow Cover Area over the Northern Hemisphere (NH)

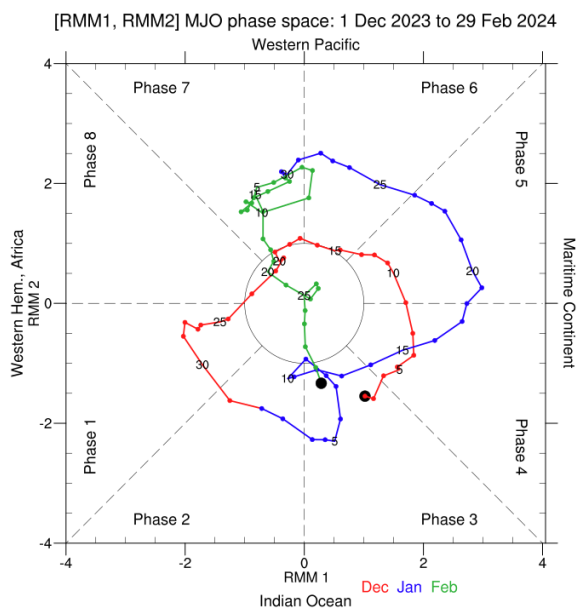
During February 2024, the NH snow cover area (43.84 million Sq. km) was less than the 1991-2020 normal by 1.86 million Sq. km (Fig. 5). Eurasian Snow cover area (27.92 million Sq. km) was 0.6 million Sq. km less than the 1991-2020 normal. North America snow cover area of 15.9 million sq. km was less by 1.3 million Sq. Km with respect to 1991-2020 normal.



**Fig.5.** Snow cover area (million Sq. km) for the month of February during the period 1966-2024 (green solid lines) and normal value (1991-2020) (red dotted line) for (a) Northern Hemisphere (b) Eurasia and (c) North America. (Data Source: Rutgers University Snow Lab).

### 1.5 Madden Julian Oscillation (MJO)

During the first fortnight of February 2024, MJO remained in phase 7(Western Pacific) with enhanced strength. During the second fortnight it directly moved to phase 3 (Indian Ocean) with reduced strength. The MJO phase diagram illustrates the progression of the MJO through different phases, which generally coincide with locations along the equator around the globe.



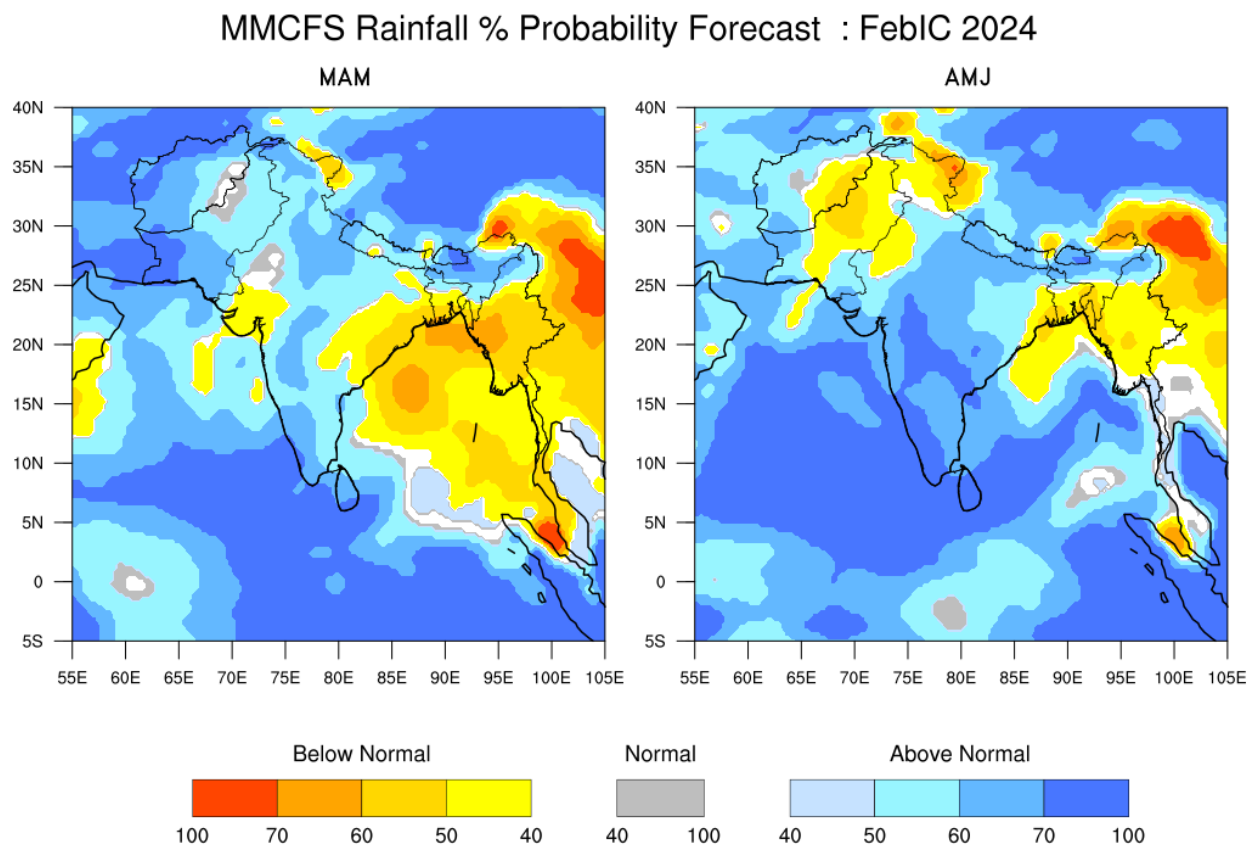
**Fig.6.** RMM phase diagram for Madden Julian Oscillation (MJO) for the period December 2023 to February 2024. (Data Source: <http://www.bom.gov.au/climate/mjo/>).

## 2. Seasonal Outlook for South Asia

The seasonal outlook was prepared based on the forecast from Monsoon Mission Coupled Forecasting System (MMCFS). The model is a fully coupled ocean-atmosphere-land model. The atmospheric component of CFSv2 is Global Forecast System (GFS) with spectral resolution of T382 (approximately 38 km) and 64 hybrid vertical levels and the ocean component is Geophysical Fluid Dynamics Laboratory (GFDL) Flexible Modelling System (FMS) Modular Ocean Model version.

### 2.1. Precipitation Probability Forecast:

The probability forecasts for precipitation for the seasons March to May 2024 (MAM) and April to June 2024 (AMJ) are given in the Figures 7a and 7b respectively. The forecast is prepared based on the February initial conditions. The probability forecast for precipitation for MAM and AMJ seasons indicates enhanced probability of above normal precipitation is likely in most parts of South Asia except in east coast of Indian Peninsula and southeast of South Asia where probability of below normal precipitation is likely. The same for AMJ season indicates that enhanced probability of above normal precipitation is likely in most parts of South Asia except in some parts of southeast and northwest regions where probability of below normal precipitation is likely.

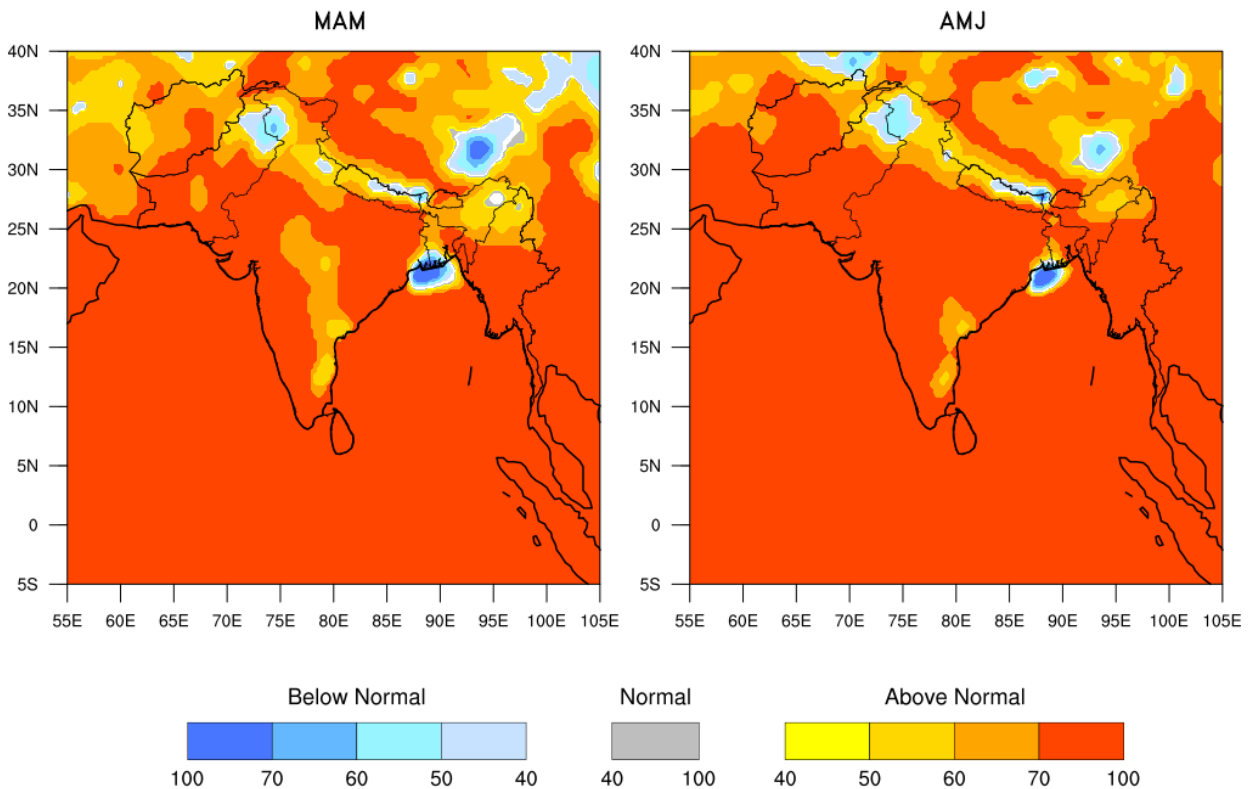


**Fig.7:** Seasonal probability (%) forecasts of precipitation for (a) MAM 2024 (left) and (b) AMJ 2024 (right) based on initial conditions of February 2024. The white colour indicates climatological probability.

### 2.2. Temperature Probability Forecast:

The probability forecasts for temperature for the season March to May 2024 (MAM) and April to June 2024 (AMJ) are given in the Figures 8a and 8b respectively. The forecast is prepared based on the February initial conditions. Temperature probability forecast for MAM season and AMJ season indicates that enhanced probability of above normal temperatures is likely over most parts of South Asia.

## MMCFS Temperature % Probability Forecast : FebIC 2024



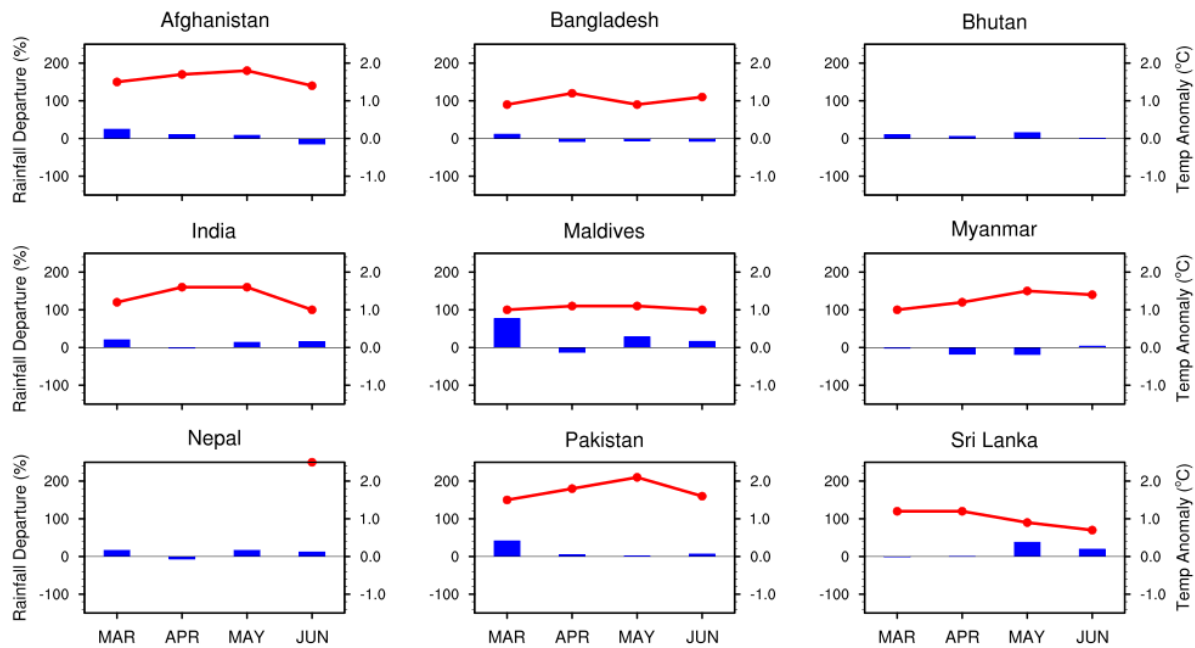
**Fig. 8:** Probability (%) forecast for the seasonal mean temperature for (a) MAM 2024 (left) and (b) AMJ 2024 (right) based on initial conditions of February 2024. The white colour indicates climatological probability.

### 3. Forecast Outlook for the Country Averaged Monthly Precipitation and Temperature

The MMCFS model forecast for monthly precipitation and temperature for the next four months (from March to June 2024) averaged over the 9 south Asian countries viz., Afghanistan, Bangladesh, Bhutan, India, Maldives, Myanmar, Nepal, Pakistan and Sri Lanka were shown in the Figures 9. The monthly rainfall anomaly is expressed as percentage departure from Long Period Model Average (LPMA) and monthly temperature anomaly is expressed in degree Celsius.

In March, the country averaged monthly precipitation is likely to be normal to above normal for all South Asian countries. In April, it is likely to be normal to above normal for all the countries except Maldives and Myanmar where it is likely to be below normal. In May, it is likely to be above normal for all the countries except Myanmar where it is likely to be below normal. In June, it is likely to be normal to above normal for all countries except Afghanistan where it is likely to be below normal.

The country averaged monthly temperatures during March, April, May and June are likely to be normal to above normal for all south Asian countries.



**Fig. 9:** Monthly country averaged rainfall forecast expressed as percentage departures (%) and Monthly country averaged temperature anomaly (°C) forecast during March to June 2024. Here, the normal range for country averaged monthly precipitation is taken as -10% to +10% (Left Vertical Axis Scale for Precipitation indicated in blue shaded bars) and the normal range for country averaged monthly temperature is taken -0.25°C to +0.25°C (Right Vertical Axis Scale for Temperature indicated in red coloured lines).