



**Rainfall and Temperature Forecast of Bhutan
for
Winter Monsoon
(December 2024 – January 2025)**

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1. Background

Seasonal forecasting and climate predictions are important adaptation measures to climate variability and change. Regional Climate Outlook Forums (RCOFs) were created to bring

together countries having common climatological characteristics and to produce a joint assessment of the state of the regional climate. Thus, South Asian Climate Outlook Forum (SASCOF) came into existence in 2010 with specific focus on the information needs of countries affected by the monsoon climate in South Asia.

Seasonal forecasts generally consist of an outlook of precipitation and temperature for a particular region. The seasonal forecast of Bhutan is prepared with inputs from global and regional prediction centres, and national climate data. The final outlook is also based on the consensus outlook of the South Asian Climate Outlook Forum (SASCOF), products from World Meteorological Organization (WMO) Global Producing Centres (GPCs) of Long-Range Forecast, various other international sources, and the prevailing global climate conditions such as El Niño Southern Oscillation (ENSO) and Indian Ocean Dipole (IOD) affecting the monsoon. The summer monsoon outlook must be used and interpreted along with the extended, medium, daily weather forecasts and other advisories released by the Centre.

2. SASCOF-30 consensus on prevailing conditions

2.1 ENSO Conditions over the Pacific Ocean

The El Niño/Southern Oscillation (ENSO) is a global climate conditions having significant influence on the variability of the monsoon precipitation and the surface temperatures over South Asia. By the end of May 2024, El Niño conditions (warmer than normal SSTs over the equatorial Pacific) turned into ENSO Neutral condition and continued to be ENSO neutral till October, 2024. At present, ENSO neutral conditions are prevailing over the Pacific region. The latest global model forecasts indicate enhanced probability of development of La Nina conditions during the December to January (DJF) season.

2.2 Conditions over the Indian Ocean

The Sea Surface Temperature (SSTs) of the Indian Ocean also influence the monsoon of the region. A positive (negative) Indian Ocean Dipole (IOD) is associated with a stronger (weaker) than normal monsoon. In February 2024, the IOD conditions weakened from positive to neutral and continued neutral conditions till October 2024. At present, neutral IOD conditions are prevailing over the Indian Ocean. Forecasts from global climate models indicate neutral IOD conditions are likely to continue for the next several months.

3. SASCOF-30 Outlook for DJF 2024/25 Winter Monsoon over South Asia

A regional climate outlook for December, 2024 to February, 2025 season over South Asia was prepared based on assessment of the prevailing large-scale climate indicators, experimental models developed during capacity-building workshops of previous SASCOF sessions, statistical and dynamical long-range forecasts of NMHSs in the region and various other climate centres of the world. Factors such as ENSO and IOD are considered for the SASCOF outlook.

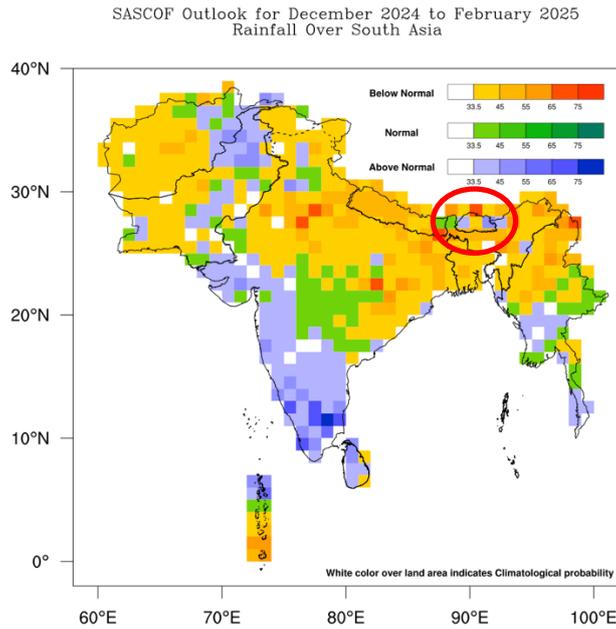


Figure 1: Outlook for DJF 2024/25 rainfall over South Asia,

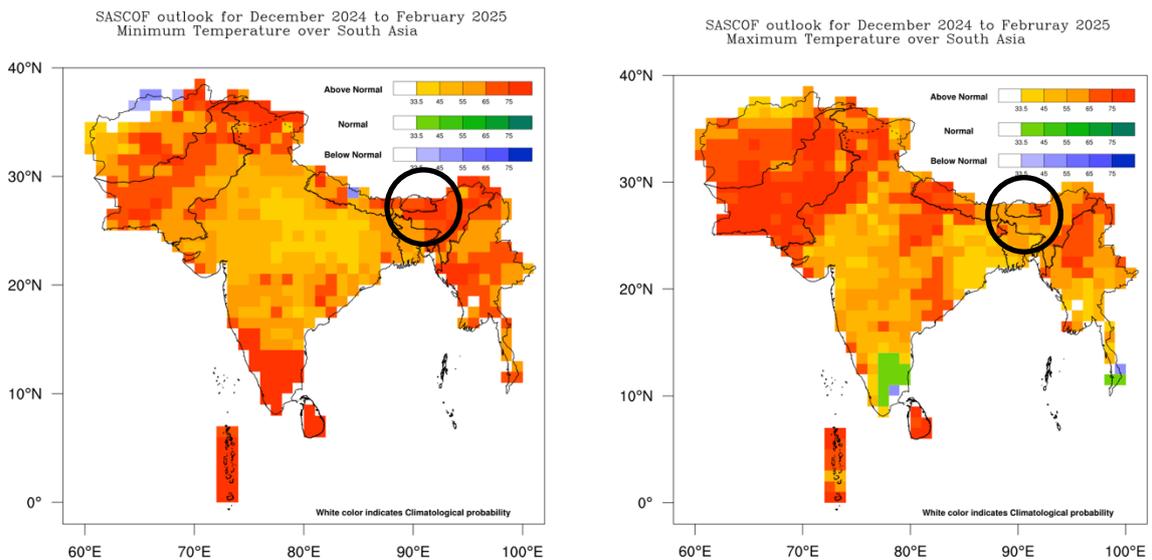


Figure 2: Outlook for DJF 2024/25 minimum temperature (left) and maximum temperature (right) over South Asia

The Figure 1 shows grid wise most likely tercile probability category for each 1x1 degree grids. As depicted in Figure 1, the outlook indicates that during the winter season DJF 2024/25, the rainfall is most likely to be below normal over most parts of South Asia. The below normal rainfall is expected over the north, northwestern, along the foothills of the Himalayas, and the northeastern region of South Asia. Above normal is likely over the parts of the western region and some regions of the northwest and some regions of northeast and southern part of South Asia. The remaining regions are likely to experience normal rainfall or climatological probabilities.

The outlook on minimum temperatures for DJF 2024/25 (Figure 2) is likely to be normal over most of the South Asia region except northern part of the Himalayan region. The outlook on maximum temperatures for DJF 2024/25 (Figure 2) is likely to be above normal over most of the region except north, northwest, south, northeast regions and along the Himalayas. Below normal maximum temperature is likely over parts of the central and foothills of Himalaya.

Since the rainfall and temperature during winter season depicts strong intra-seasonal variability, it is recommended to follow the extended range and medium range forecast besides the seasonal forecast for the better planning.

4. Winter Seasonal Outlook from International and Regional Climate Centres

4.1 WMO Lead Centres

Probabilistic multi-model ensemble forecast of all the GPCs of WMO forecast show above CP rainfall and above normal temperature during DJF 2024/25 over Bhutan.

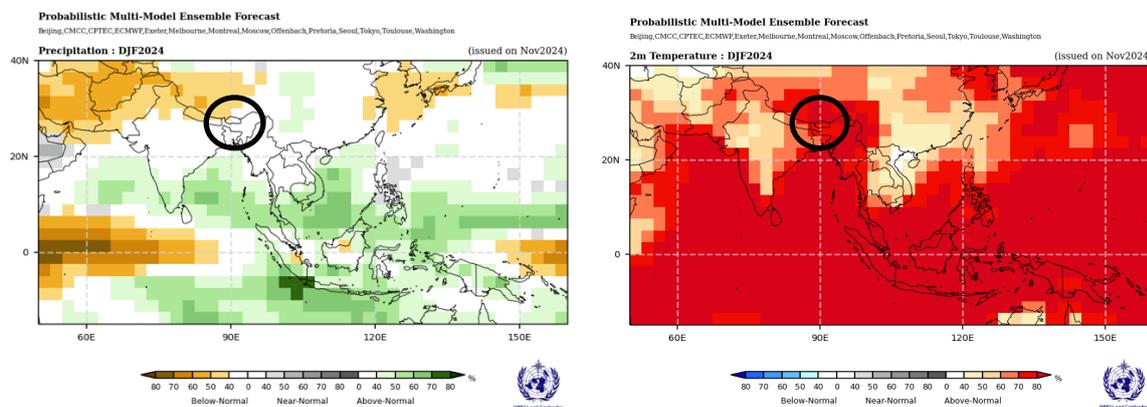


Figure 3: DJF 2024/25 precipitation (left) and temperature (right) forecast from WMO GPCs

4.2 International Research Institute for Climate and Society (IRI)

The IRI forecast indicates below normal rainfall and above normal temperature during DJF 2024/25 over Bhutan.

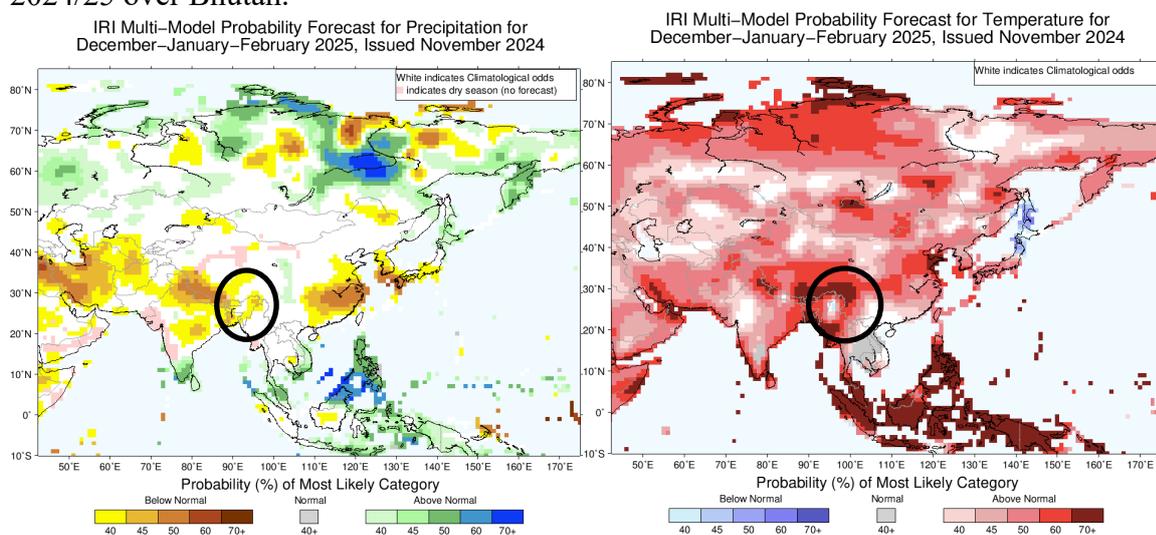


Figure 4: DJF 2024/25 precipitation (left) and temperature (right) forecast from IRI

4.3 Copernicus Climate Change Service (C3S)

According to C3S forecast, there is below normal rainfall and above normal temperature during DJF 2024/25 over Bhutan.

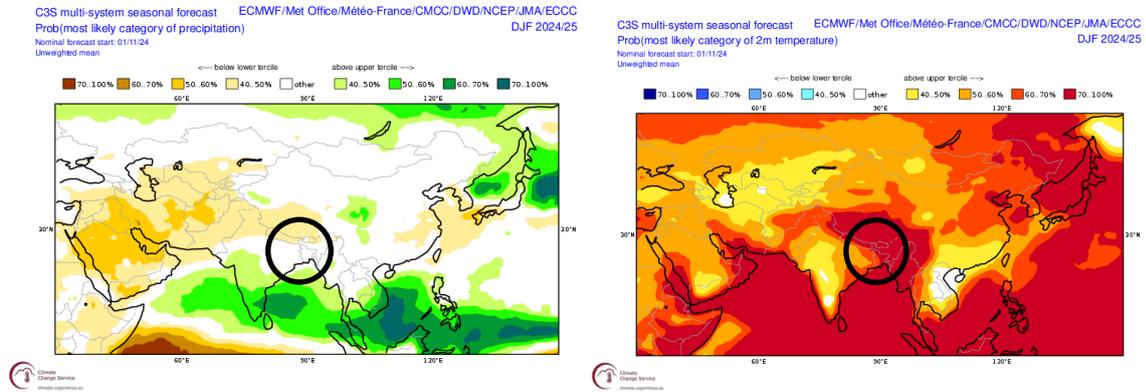


Figure 6: DJF 2024/25 precipitation (left) and temperature (right) forecast from C3S

4.4 Japan Meteorological Agency (JMA) forecast

The JMA forecast indicates below normal for rainfall and normal temperature during DJF 2024/25 over Bhutan.

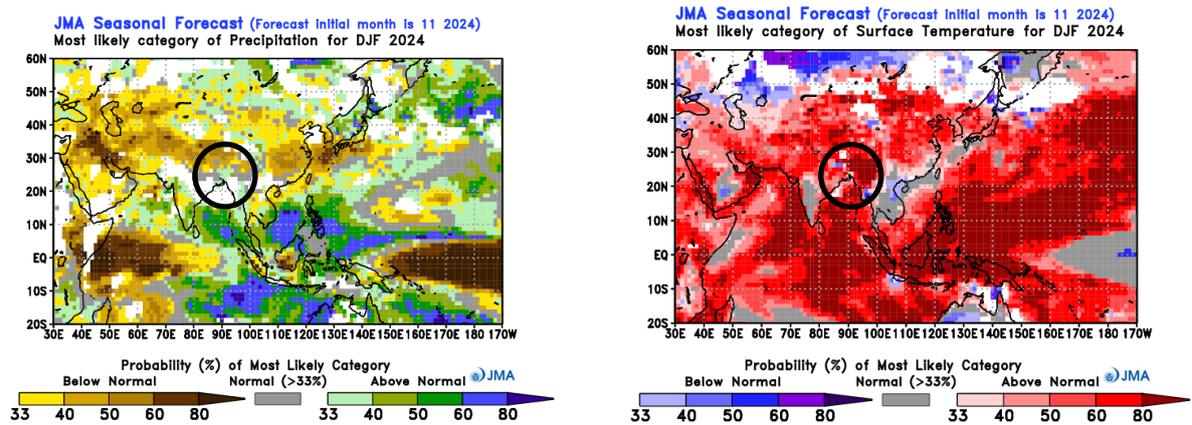


Figure 7: DJF 2024/25 precipitation (left) and temperature (right) forecast from JMA

4.5 North American Multi Model Ensemble (NMME) forecast

The NMME forecast indicates CP rainfall in regions during DJF 2024/25 over Bhutan.

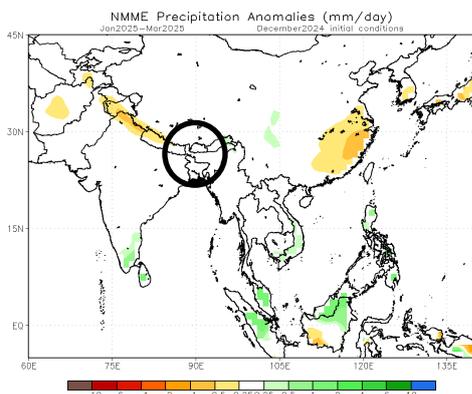


Figure 8: DJF 2023/24 precipitation (left) and temperature (right) forecast from NMME

4.6 Forecast from NCHM using Climate Predictability Tool (CPT)

The CPT forecast indicate normal rainfall, above normal maximum temperature and normal minimum temperature during DJF 2024/25.

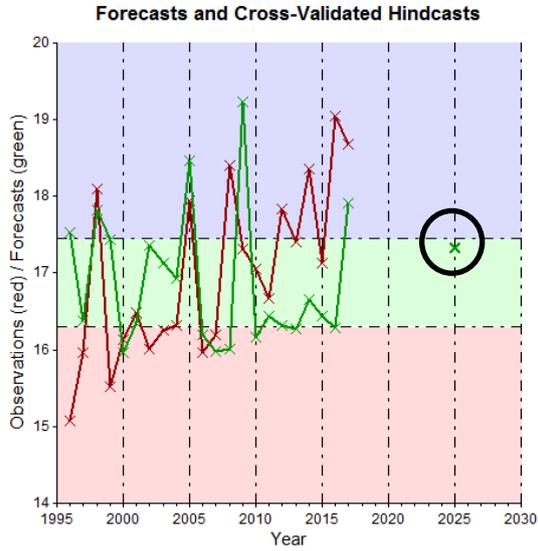


Figure 9: DJF 2024/25 Precipitation forecast from CPT

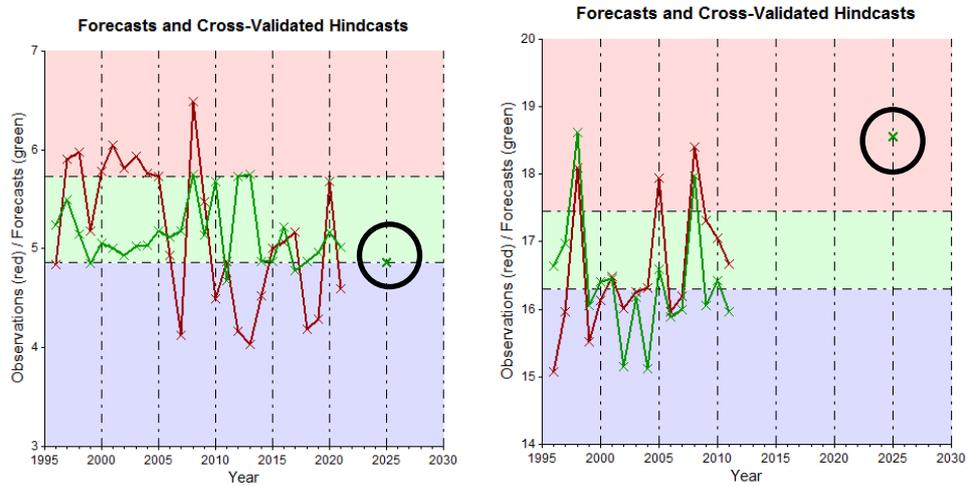


Figure 10: DJF 2024/25 minimum (left) and maximum temperature (right) forecast from CPT

5. ENSO and IOD outlook DJF 2024/25

ENSO Neutral and neutral IOD conditions are likely to prevail during this season.

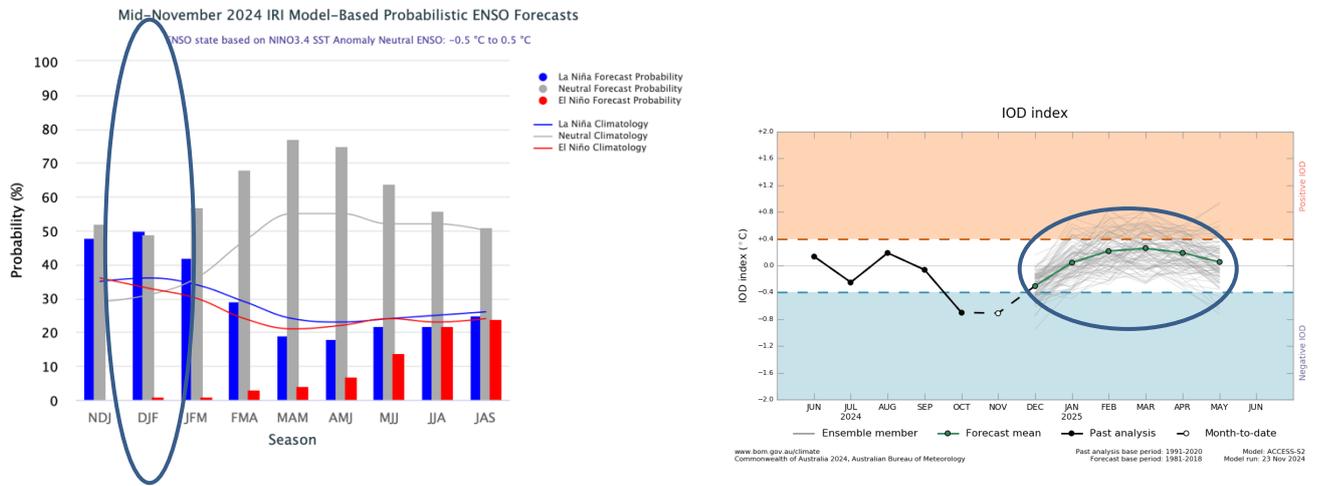


Figure 11: El Niño condition (left) and IOD condition (right)

The final outlook of winter season DJF 2024/25 over Bhutan is based on the forecast products from various sources.

SI No.	Indicators	Precipitation	Maximum Temperature	Minimum Temperature
1	CPT	Normal	Above normal	Normal
2	GPCs	CP	Above normal	
3	IRI	Below Normal	Above normal	
4	C3S	Below normal	Above normal	
5	JMA	Below normal	Above normal	
6	NMME	CP		
7	SASCOF	Below normal	Above normal	Above normal
8	ENSO	Neutral		
9	IOD	Neutral		

Table 1: Summary of results from various sources