



**Rainfall and Temperature Forecast of Bhutan
for
Summer Monsoon
(June – September 2023)**

**Meteorological Services Division
National Centre for Hydrology and Meteorology
Royal Government of Bhutan
2023**

Acknowledgement

“Rainfall and Temperature Forecast of Bhutan for Summer Monsoon (June – September 2023)” was prepared after the completion of the 9th session of National Climate Outlook Forum (NCOF-9) held on 31 May 2023. The event was carried as part of the **Project Title: Supporting Climate Resilience and Transformational Change in the Agriculture Sector in Bhutan** funded by Green Climate Fund (GCF).

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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-25 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. The La Niña conditions (colder than normal SSTs over the equatorial Pacific) has ended in March 2023 and currently, neutral La Nina conditions are prevailing over the Pacific region. The latest global model forecasts indicate El Nino conditions to develop during this monsoon 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. Currently, neutral IOD conditions are prevailing over the region and the latest global model indicate the development of a positive IOD during this monsoon season.

2.3 Snow Cover over the Northern Hemisphere

The Northern Hemisphere snow cover areas during February and March 2022 were below normal and the Eurasian snow cover area was 5th lowest during the March 2023 in the last 57 years. Generally, winter and spring snow cover extent has an inverse relationship with the summer monsoon rainfall of Asia.

3. SASCOF-25 Outlook for JJAS 2023 Southwest Monsoon over South Asia

A regional climate outlook for the 2023 Southwest monsoon 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, IOD, tropical Atlantic Sea surface temperatures, Eurasian land heating etc. are considered for the SASCOF outlook.

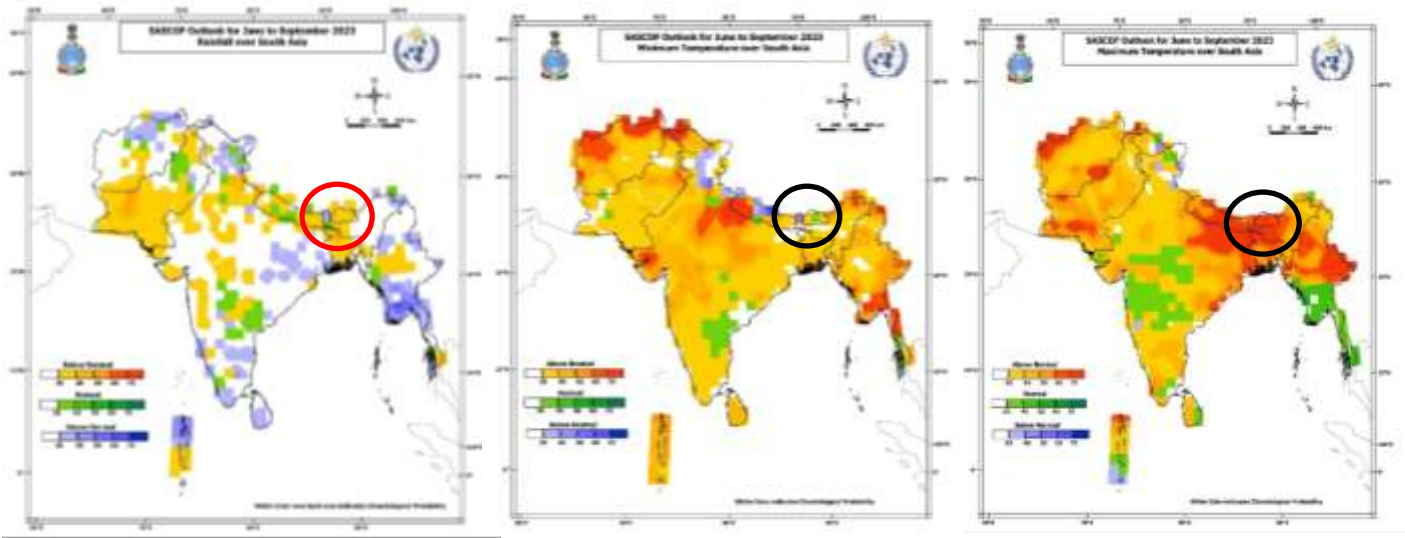


Figure 1: Outlook for JJAS 2023 rainfall over South Asia (left), minimum temperature (middle) and maximum temperature (right) over South Asia

The Figure shows grid wise most likely tercile probability category for each 1x1 degree grids. As depicted in Figure 1, the outlook indicates that during the summer season JJAS 2023, the rainfall is most likely to be normal to below normal over most parts of South Asia. The above normal rainfall is expected over the extreme north, northwestern, parts of southern and eastern region of South Asia. Some areas of northwest, central and north-eastern parts of the region can expect below normal rainfall. The remaining regions are likely to experience climatological probabilities.

The outlook on minimum temperatures for JJAS 2023 is likely to be normal to above normal over most of the South Asia region except some parts of the Himalayas foothills region. The outlook on maximum temperatures for JJAS 2023 is likely to be above normal over most of the region except central and parts of the southern region of South Asia. Since the rainfall and temperature during the southwest monsoon season depicts strong intra- seasonal variability, it is recommended to follow the extended and medium range forecast besides seasonal forecast for better planning.

4. Summer Seasonal Outlook JJAS 2023 from International and Regional Climate Centres

4.1 WMO Lead Centres

Probabilistic multi-model ensemble forecast of all the GPCs of WMO forecast show climatological probability rainfall and above normal temperature during JJAS 2023 over Bhutan.

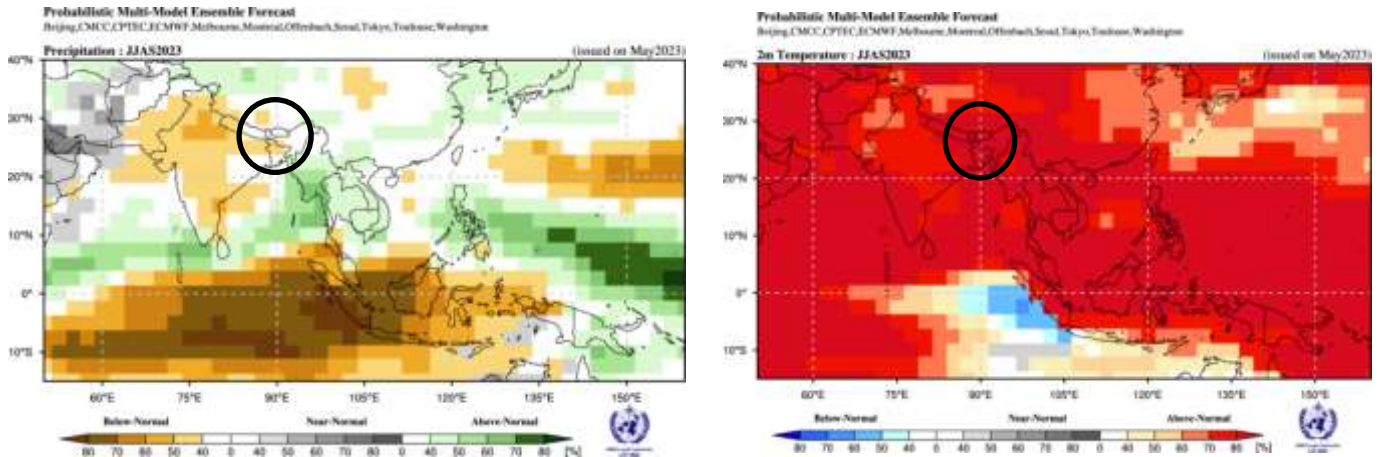


Figure 2: JJAS 2023 precipitation (left) and temperature (right) forecast from WMO GPCs

4.2 International Research Institute for Climate and Society (IRI)

The IRI forecast indicates below normal rainfall over western parts of the areas and climatological probability over the remaining regions. The temperature is likely to be above normal during JJA 2023 over Bhutan.

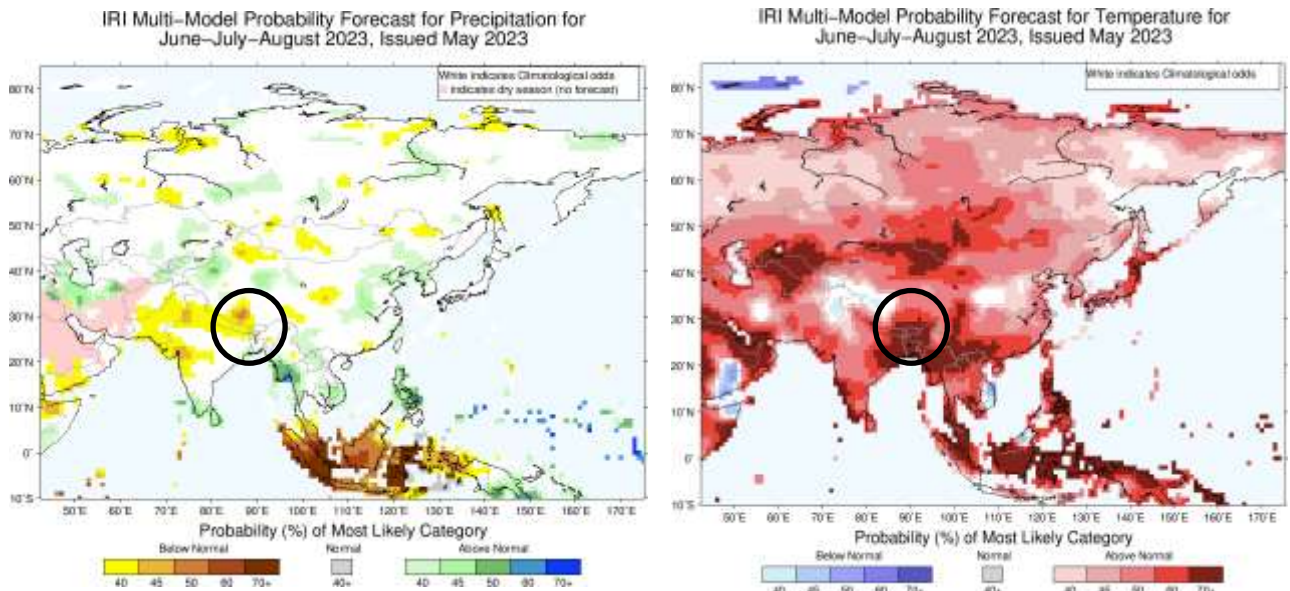


Figure 3: JJA 2023 precipitation (left) and temperature (right) forecast from IRI

4.3 APEC Climate Center (APCC)

The APCC forecast indicates above normal for rainfall and above normal temperature during JJA 2023 over Bhutan.

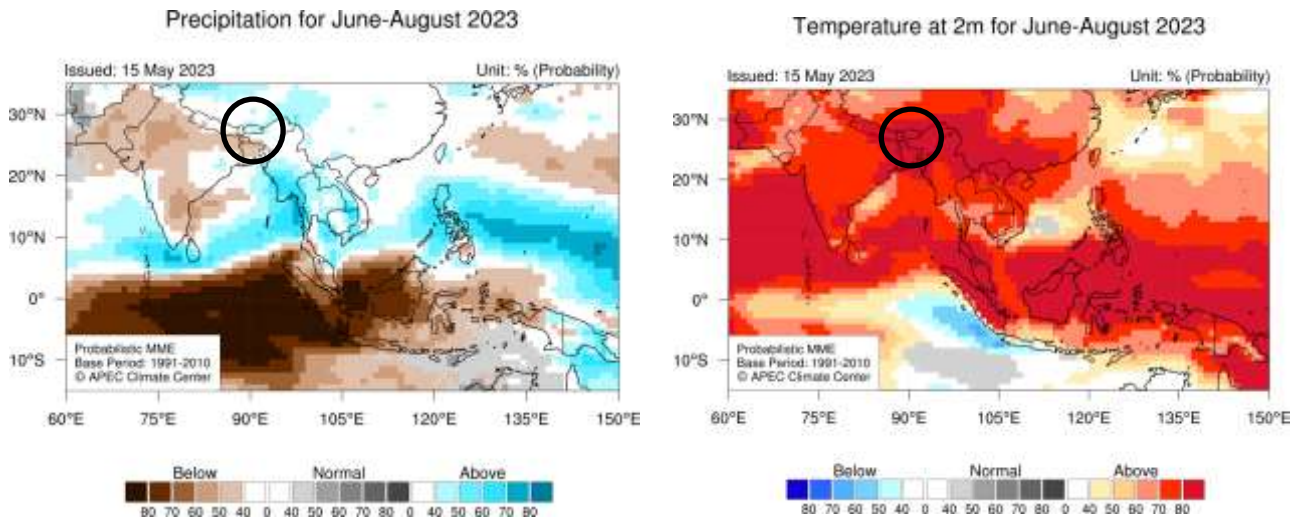


Figure 4: JJA 2023 precipitation (left) and temperature (right) forecast from APCC

4.4 Copernicus Climate Change Service (C3S)

According to C3S forecast, there is climatological probability for rainfall and above normal temperature during JJA 2023 over Bhutan.

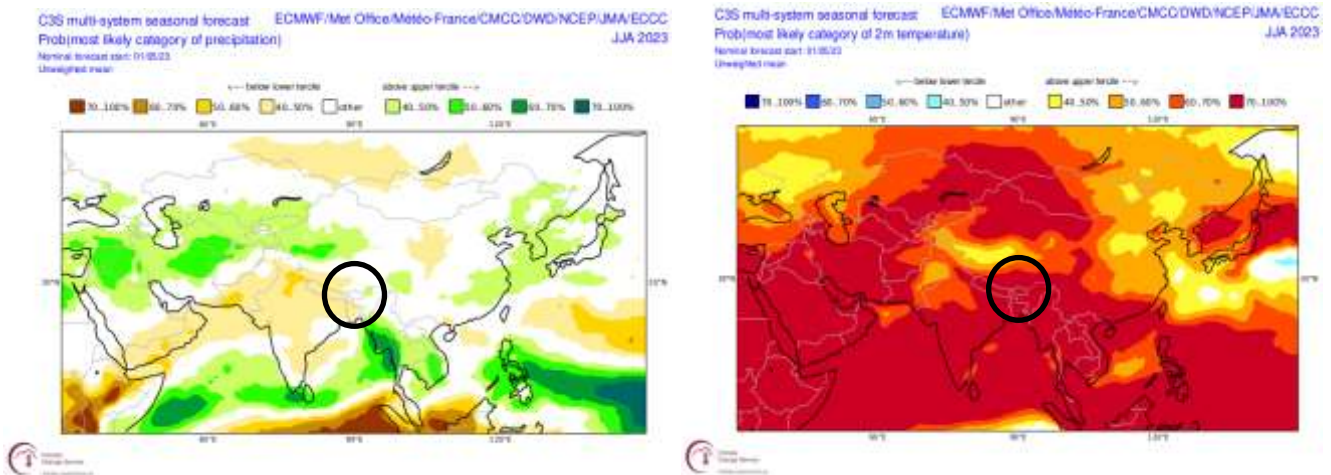


Figure 5: JJA 2023 precipitation (left) and temperature (right) forecast from C3S

4.5 Japan Meteorological Agency (JMA) forecast

The JMA forecast indicates below normal for rainfall and above normal temperature during JJA 2023 over Bhutan.

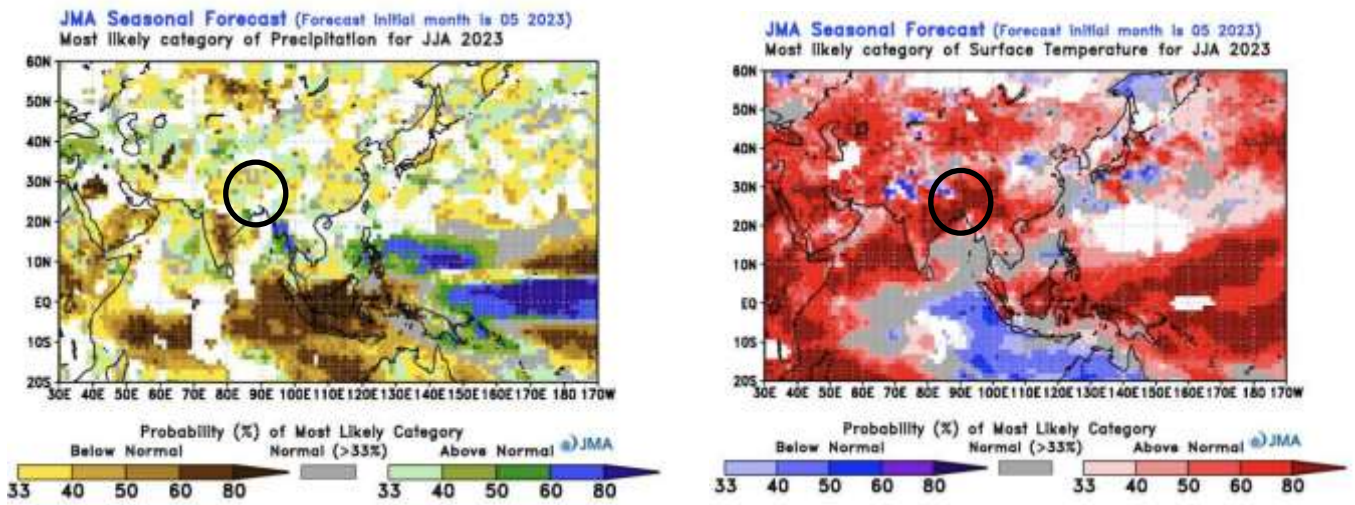


Figure 6: JJA 2023 precipitation (left) and temperature (right) forecast from JMA

4.6 North American Multi Model Ensemble (NMME) forecast

The NMME forecast indicates below normal rainfall towards northern areas and climatological probability over the remaining regions and above normal temperature during JJAS 2023 over Bhutan.

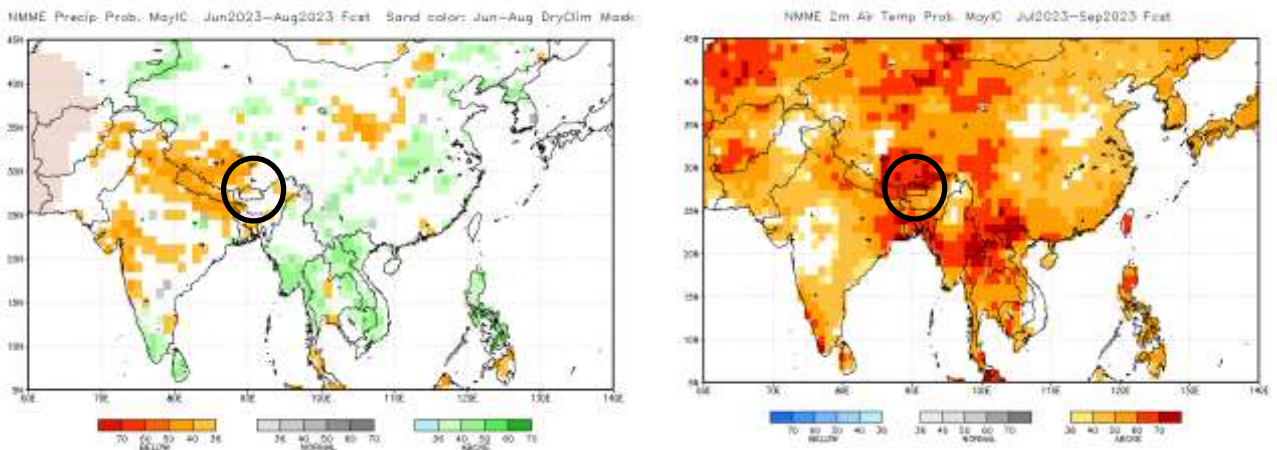


Figure 7: JJAS 2023 precipitation (left) and temperature (right) forecast from NMME

4.7 FOCUS forecast, RIMES

The forecast from the FOCUS tool is calculated on the probability forecast methods viz; simple mean and skilled weighted average. According to FOCUS, there is high probability of above normal rainfall during JJAS 2023 over Bhutan for both ECMWF Re-analysis (ERA) and Climate Hazards Group Infrared Precipitation with Station data (CHIRPS) observation.

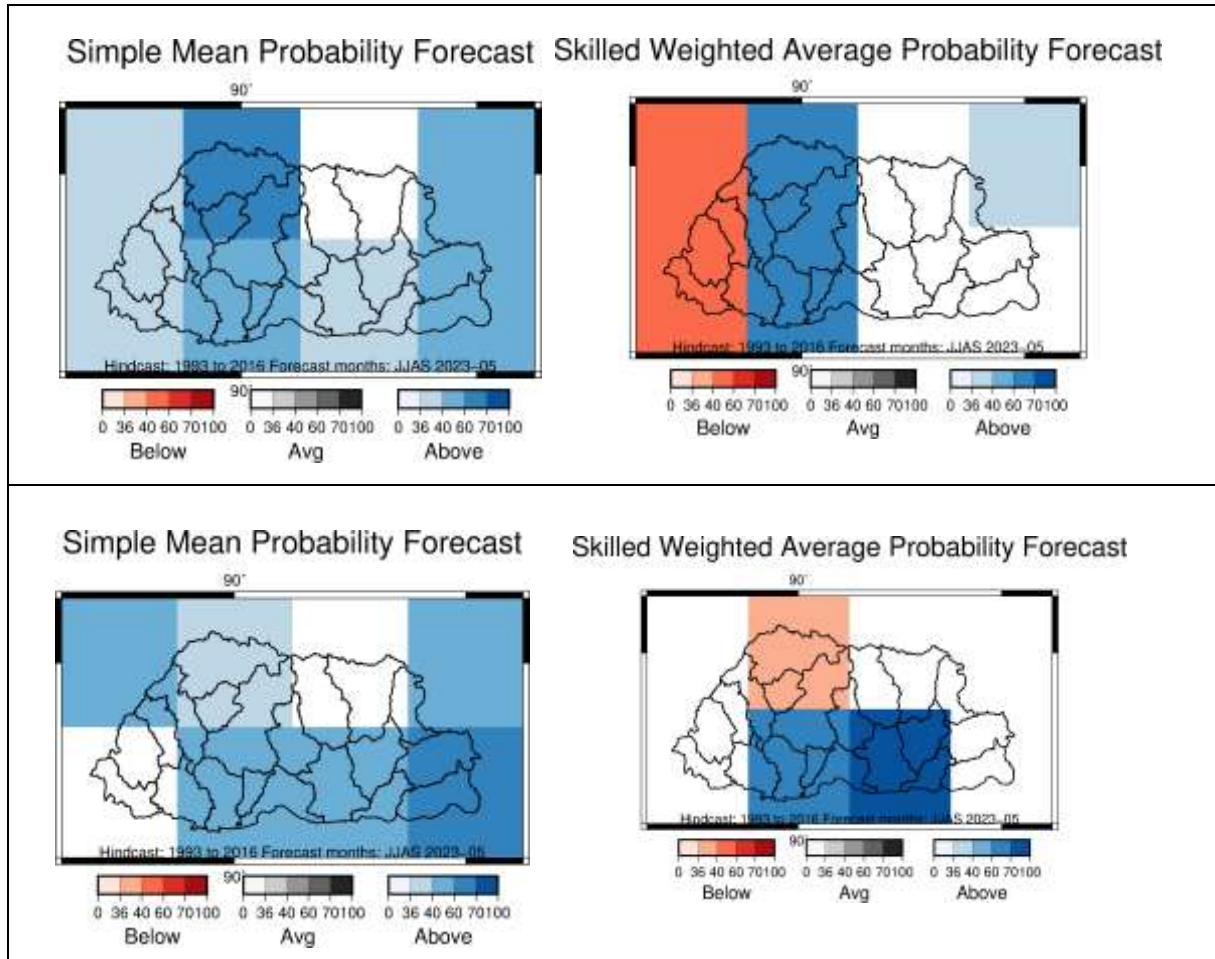


Figure 8: JJAS 2023 precipitation forecast based on ERA (top) and CHIRPS (bottom)

4.8 Forecast from NCHM using Climate Predictability Tool (CPT)

The CPT forecast indicate below normal rainfall, above normal maximum temperature and normal to slightly below normal minimum temperature during JJAS 2023.

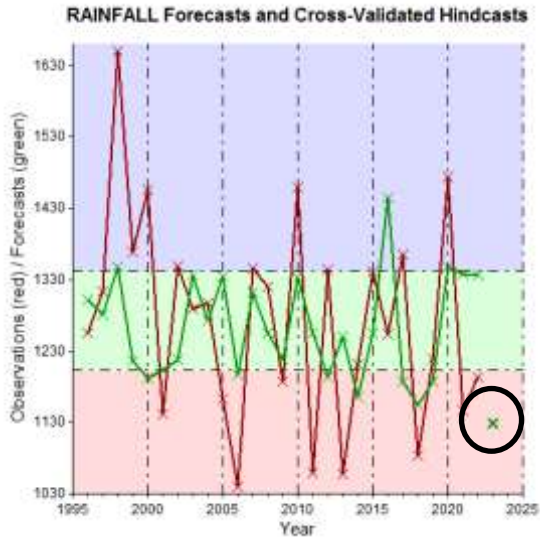


Figure 9: JJAS 2023 Precipitation forecast from CPT

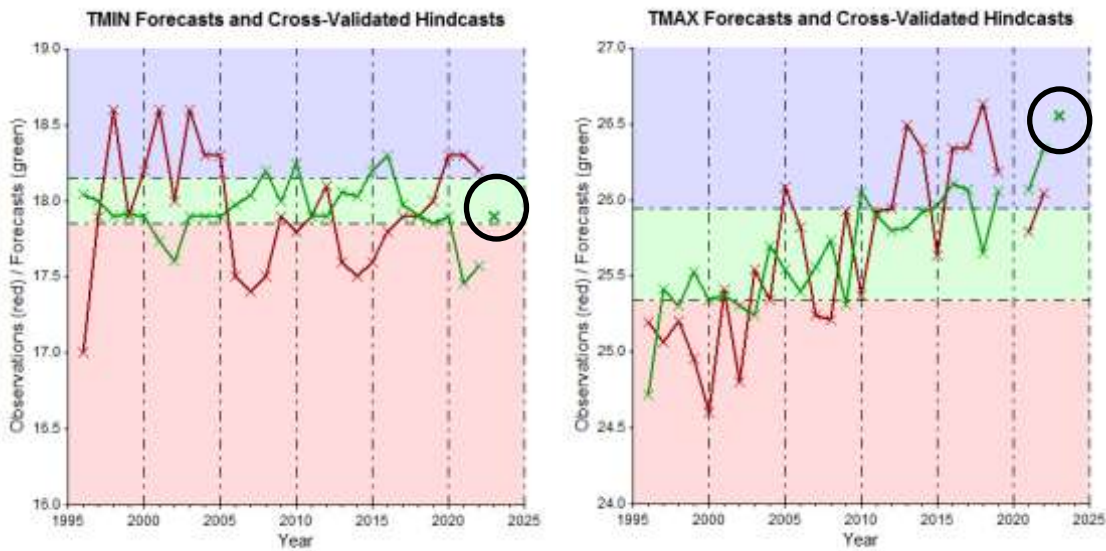


Figure 10: JJAS 2023 minimum (left) and maximum temperature (right) forecast from CPT

5. ENSO and IOD outlook JJAS 2023

ENSO El Nino and positive IOD conditions are likely to prevail during this season.

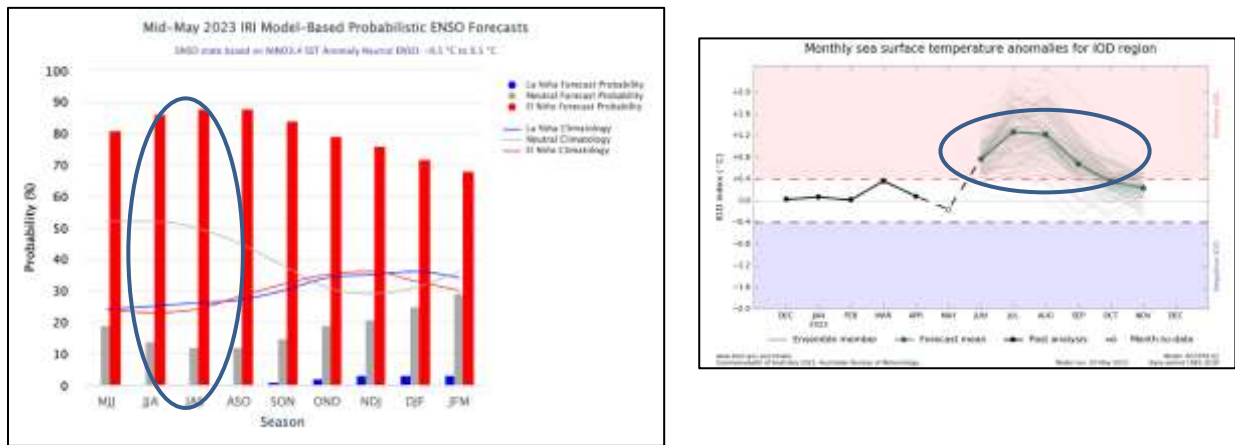


Figure 11: El Nino condition (left) and IOD condition (right)

The final outlook of summer season JJAS 2023 over Bhutan is based on the forecast products from various sources.

Table 1: Summary of results from various sources

Sl No.	Indicators	Precipitation	Maximum Temperature	Minimum Temperature
1	CPT	Below normal	Above normal	Normal to slightly above normal
2	FOCUS	Below to above normal		
3	GPCs	Climatology Probability	Above normal	
4	IRI	Climatology Probability	Above normal	
5	APEC	Above normal	Above normal	
6	C3S	Climatology Probability	Above normal	
7	JMA	Below normal	Above normal	
8	NMME	Below normal to CP	Above normal	
9	SASCOF	Below normal	Above normal	Above normal
10	ENSO	El Nino		
11	IOD	Positive		

6. Consensus Monsoon outlook JJAS 2023 for Bhutan

The National Centre for Hydrology and Meteorology release the outlook for precipitation and temperature for the 2023 summer season, for the months of June to September 2023. The consensus forecast was 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-25) held from 27 – 29 April 2023, outlook from WMO GPCs and various other international sources. The summer monsoon outlook must be used and interpreted along with the extended, medium, daily weather forecasts and other advisories released by the Centre.

a. Rainfall Forecast for 2023 Summer Season

The summer rainfall for Bhutan during the 2023 JJAS monsoon season is most likely to be slightly below normal. Normal is the average rainfall for the summer season (JJAS) of Bhutan from 1996 to 2022.

b. Temperature Forecast for 2023 Summer Season

The maximum and minimum temperature in Bhutan during the 2023 JJAS monsoon season is likely to be slightly above normal. Normal is the average temperature (maximum and minimum) for the summer season (JJAS) of Bhutan from 1996 to 2022.



Figure 12: Press release issued by Centre for JJAS 2023 Outlook