



**Rainfall and Temperature Forecast of Bhutan
for
Winter Monsoon
(December 2021 – February 2022)**

**Weather and Climate Services Division
National Centre for Hydrology and Meteorology
Royal Government of Bhutan**

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. The SASCOF sessions are held in different member countries each year.

Seasonal forecasts generally consist of an outlook of precipitation and temperature for a particular region and the forecasts can be issued monthly throughout the year, or simply prioritizing to the rainy season (June to September) only. In most cases, the seasonal forecast is prepared as a 3-month average, and requires a monthly update for each subsequent 3-month period. Reliable seasonal forecast, particularly for the rainy season is of great benefit to Agricultural sectoral as most of the people in Bhutan depend on Agriculture for the livelihood. However, proper interpretation, reliability of information and efficient dissemination of seasonal forecast is required.

The seasonal forecast of Bhutan is prepared using a statistical model, the Climate Predictability Tool (CPT). The rainfall and temperature (maximum and minimum) forecasts for 2021/22 winter season (December 2021 – February 2022) are prepared using the Global Climate Models Sea Surface Temperature (SST), precipitation and temperature (maximum and minimum) data as the predictor and locally observed rainfall and temperature data of Bhutan as the predictand. The forecast of the respective National Meteorological and Hydrological Services (NMHSs) of South Asian countries is presented to the South Asian Climate Outlook Forum (SASCOF-21) and the consensus outlook is discussed with the scientists and experts of the forum.

Due to the COVID19 global pandemic, SASCOF-21 was held via video conferencing on 25th November, 2021. The session was attended by experts representing the National Meteorological and Hydrological Services (NMHSs) of South Asian countries as well as those representing several global and regional climate agencies including World Meteorological Organization (WMO), Regional Climate Centre (RCC), Pune, Indian Institute of Tropical Meteorology (IITM), Met Office (UKMO), International Research Institute for Climate and Society (IRI), Regional Integrated Multi-hazard Early-Warning System (RIMES), WMO Lead Centre for Long Range Forecasts Multi-Model Ensemble (LC-LRFMME), etc.

The outlook is derived as a consensus from the CPT output, outlook from other international centers, SASCOF outlook and discussion on the prevailing global climate phenomena such as El Niño Southern Oscillation (ENSO) and Indian Ocean Dipole (IOD) conditions affecting the monsoon.

2. ENSO Conditions over the Pacific Ocean

The El Niño Southern Oscillation (ENSO) is having a significant influence on the variability of the monsoon precipitation and surface temperatures over South Asia. The La Niña (colder than normal SSTs over the equatorial Pacific Ocean) conditions developed at the beginning of the year turned to weak La Niña conditions in April 2021. However, the strength of cooler SST anomalies started reducing in May, 2021 and favored to neutral (cool) ENSO conditions and continued in the subsequent months. During August and September, the cooling trend of Equatorial Pacific Ocean SSTs persisted and subsequently, weak La Niña conditions developed and prevailed over the Pacific. In addition, atmospheric patterns are reflecting La Niña conditions and the latest global model forecasts indicates a strong probability of La Niña conditions to prevail during winter season (DJF 2021/22).

3. Conditions over the Indian Ocean

The SSTs of Indian Ocean also influence the monsoon of the region. A positive (negative) IOD is associated with a stronger (weaker) than normal monsoon. Weak negative IOD over the Indian Ocean was observed during May, 2021 and the conditions favored in the subsequent month of June and July. However, the conditions weakened during August and September, 2021 and turned into neutral IOD conditions. Currently, neutral IOD conditions are prevailing over the equatorial Indian Ocean forecasts from global climate models suggest that neutral IOD conditions are likely to continue during the winter season (DJF).

4. SASCOF-21 outlook for DJF 2021/22

Climate outlook for the 2021/22 winter monsoon rainfall over South Asia was prepared based on assessment of 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 centers of the world. The regional climate is affected by the atmospheric variability and it is noted that there is uncertainty associated in the prediction of the precipitation of the winter season. In general, ENSO, IOD, tropical Atlantic Sea surface temperatures, Eurasian land heating etc. also determines the performance of monsoon. Therefore, all these factors are considered for the SASCOF outlook.

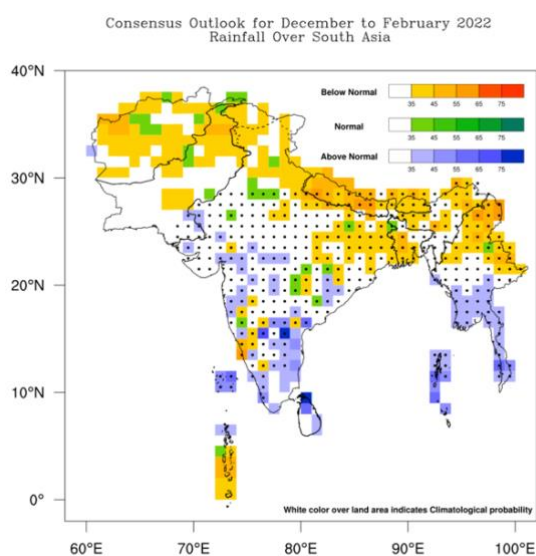


Figure 1: Outlook for DJF 2021/22 rainfall over South Asia

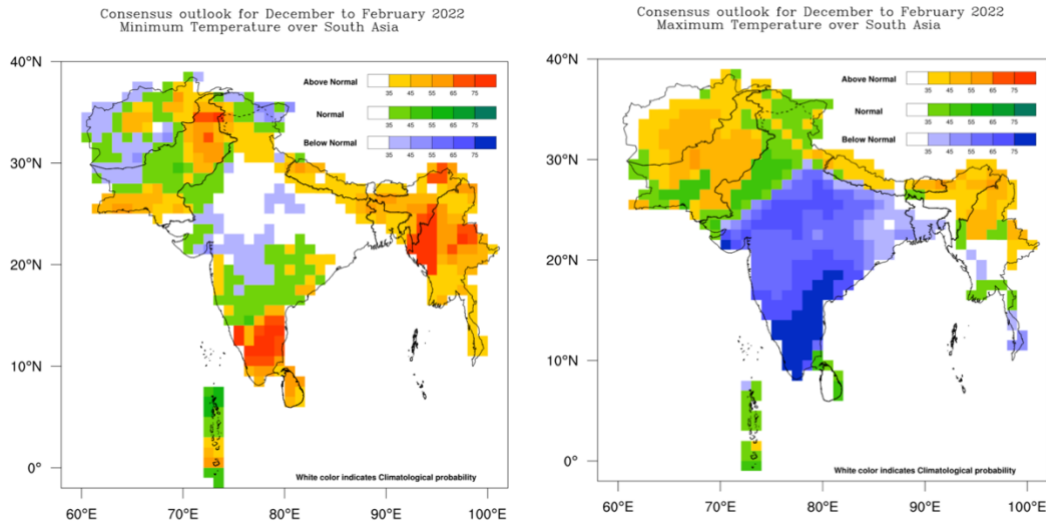


Figure 2: Outlook for DJF 2021/22 minimum (left) and maximum temperature (right) over South Asia

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 winter season DJF 2021/22, the rainfall is most likely to be above normal over most parts of South Asia, normal to below normal over the northwestern and northeastern parts of the South Asia and along the areas of the foothills of the Himalayas. The dotted area in Figure 1 illustrate that the area receives very low rainfall and had a dry winter season.

Outlook on minimum temperatures for December to February 2021/22 season are likely to be above normal overmost areas of north, northwest, northeast, southern parts of South Asia and along the Himalayas. While, the minimum temperatures are most likely to be below normal to normal over central and north western areas of the region and the remaining regions are expected to have climatological probabilities. The outlook on maximum temperatures for DJF 2021/22 is likely to be normal to above normal over most of the north,northwest, northeast and along the Himalayas areas. Below normal maximum temperature is expected over the rest of the remaining regions.

Since the rainfall and temperature during the winter season depicts strong intra- seasonal variability, it is recommended to follow the extended range forecast besides seasonal forecast for better planning. The extended range forecasts, cyclone etc. over the region can be obtained from RCC, Pune website (<http://rcc.imdpune.gov.in/exrange.html>) which are updated every week.

5. Winter Seasonal Outlook from International and Regional Climate Centers

5.1 WMO Lead Centers

Probabilistic multi-model ensemble forecast of all the GPCs of WMO forecast show below normal rainfall and above normal temperature during DJF 2021/22 over Bhutan.

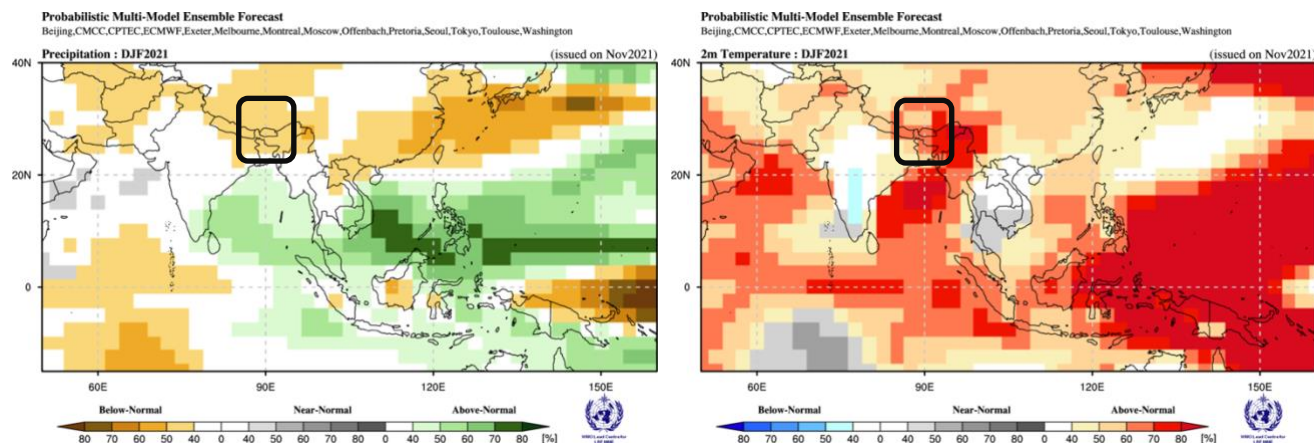


Figure 3: DJF 2021-22 precipitation (left) and temperature (right) forecast from WMO GPCs.

5.2 International Research Institute for Climate and Society (IRI)

The IRI forecast indicates below normal rainfall and above normal temperature during DJF 2021/22 over Bhutan.

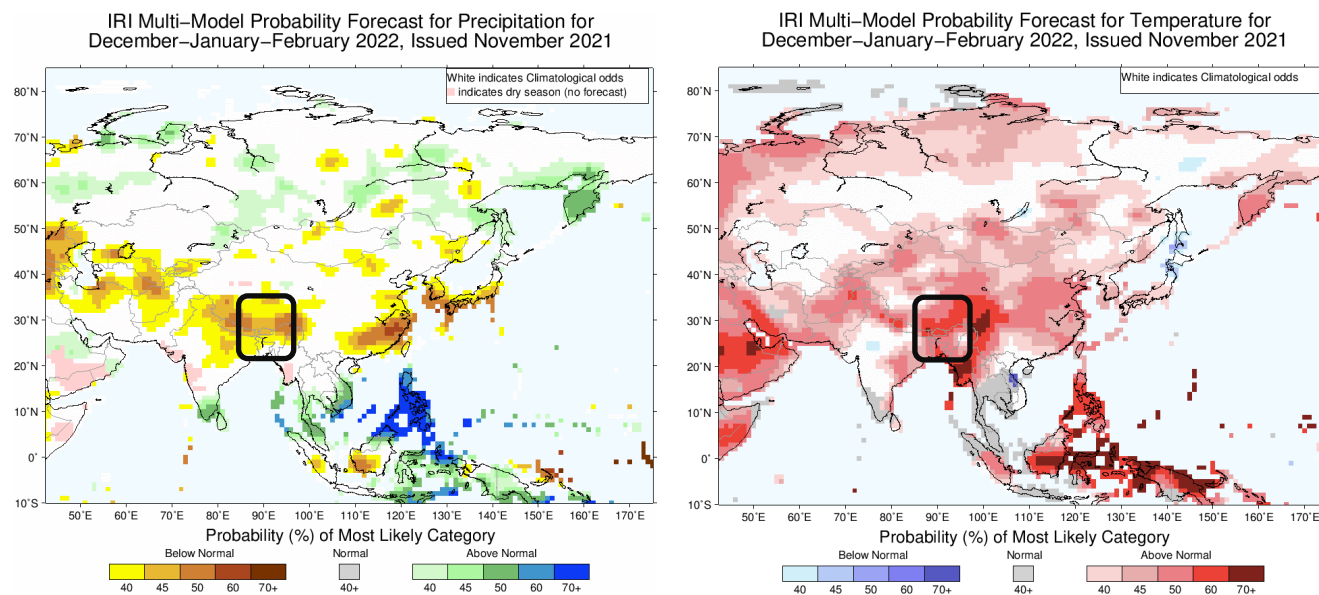


Figure 4: DJF 2021-22 precipitation (left) and temperature (right) forecast from IRI

5.3 APEC Climate Center (APCC)

The APCC forecast indicates climatological probability for rainfall and above normal temperature during DJF 2021/22 over Bhutan.

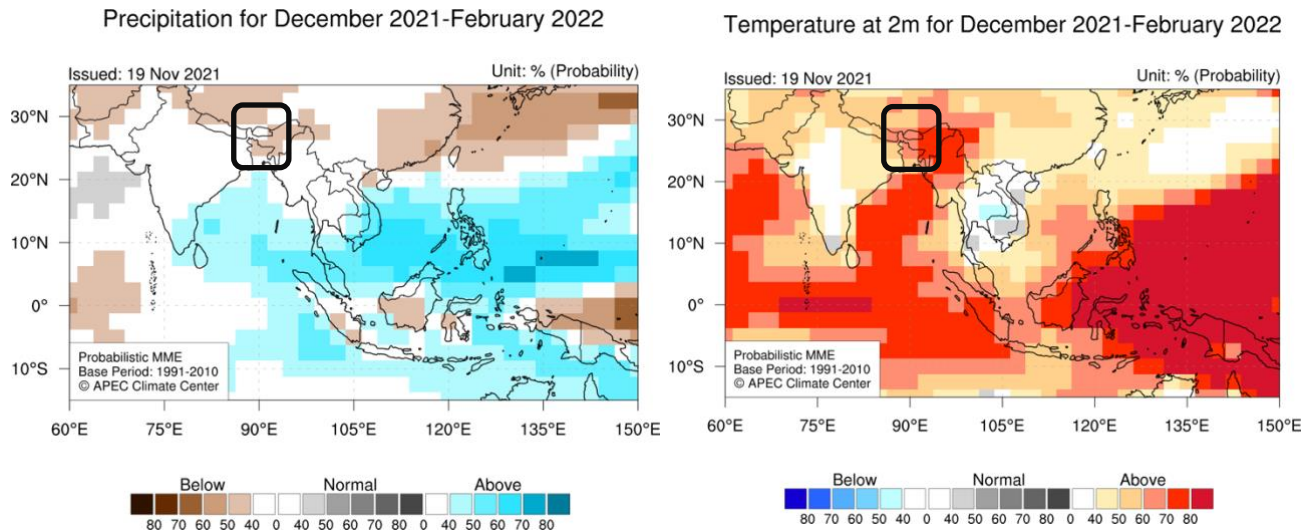


Figure 5: DJF 2021-22 precipitation (left) and temperature (right) forecast from APCC

5.4 UK Met office

According to UK Met office forecast, there is high probability of below normal rainfall and above normal temperature during DJF 2021/22 over Bhutan.

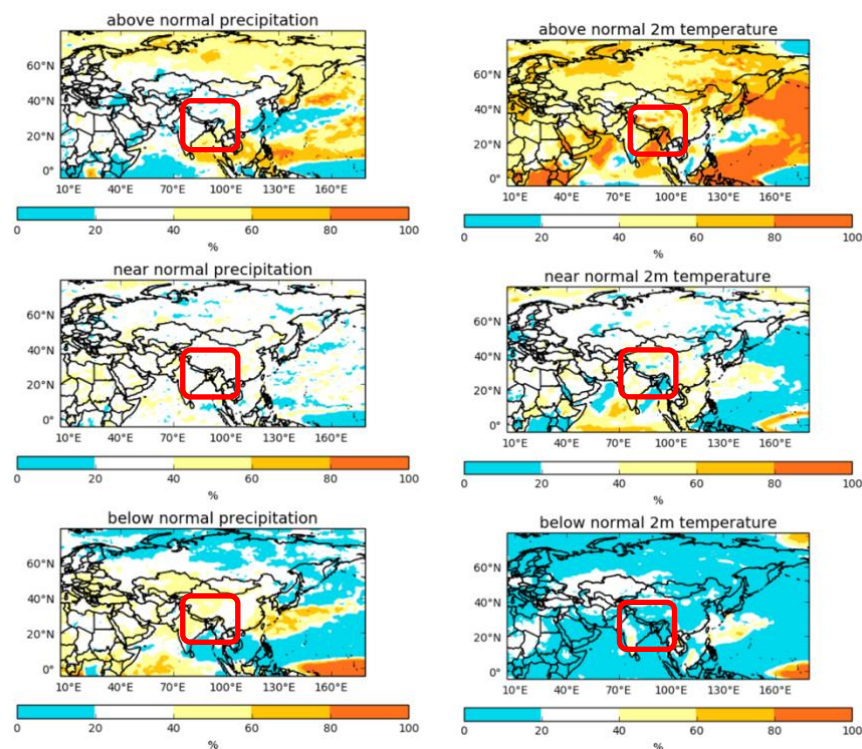


Figure 6: DJF 2021-22 precipitation (left) and temperature (right) forecast from UK Met office

5.5 FOCUS probability forecast, RIMES

The forecast from the FOCUS tool is calculated on three probability forecast methods viz; simple mean, skilled weighted average and principal component regression. According to FOCUS, there is high probability of below normal rainfall during DJF 2021/22 over Bhutan for both ECMWF Re-analysis (ERA) and Climate Hazards Group Infrared Precipitation with Station data (CHIRPS) observation.

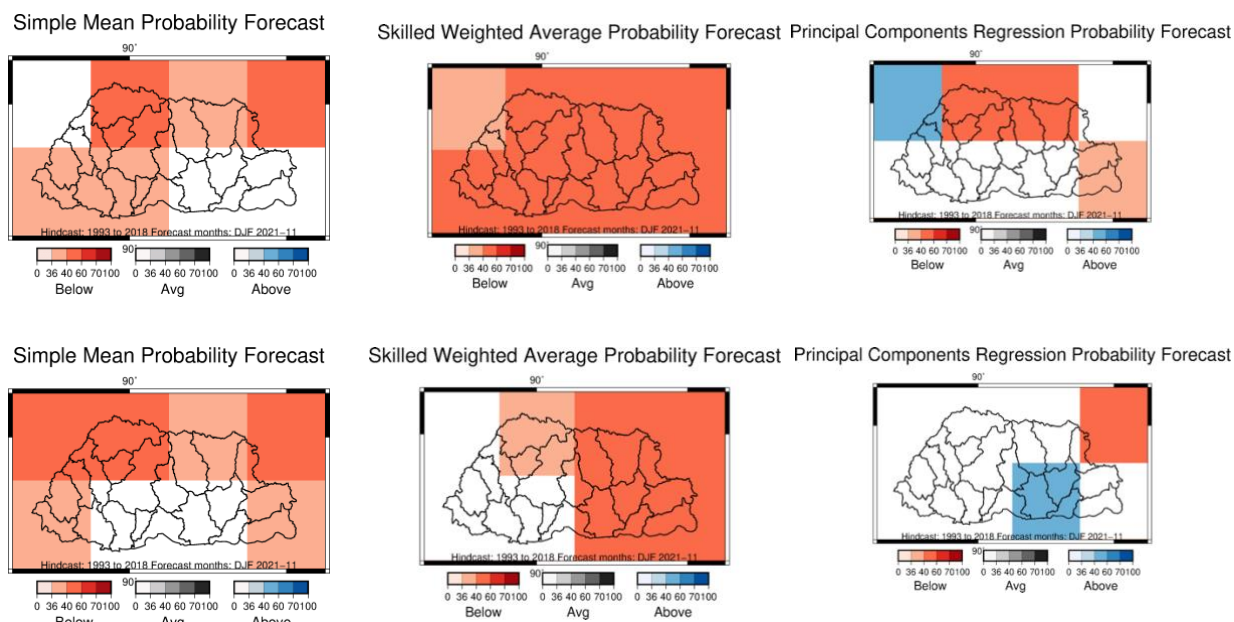


Figure 7: DJF 2021-22 precipitation forecast based on ERA (top) and chirps (bottom)

5.6 Precipitation forecast from NCHM using CPT

The CPT forecast indicated below is based on Global Climate Models SST and Precipitation (PPN) data with the local station data of Bhutan. As per the CPT, slightly below normal to near normal rainfall is indicated during DJF 2021/22.

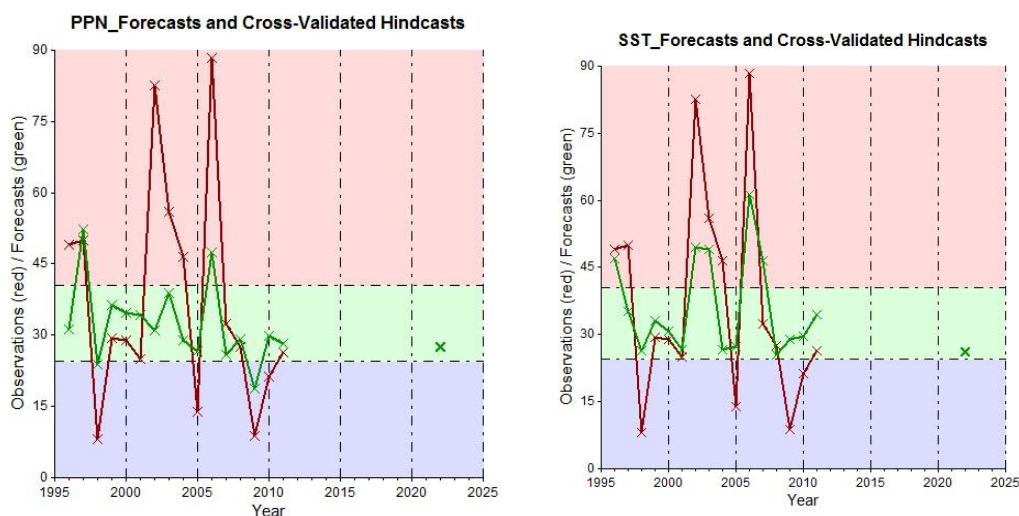


Figure 8: DJF 2020-21 Precipitation forecast from CPT

6. Winter Seasonal Monsoon outlook for Bhutan

ENSO La Nina and neutral IOD conditions are likely to prevail during this winter season. The final outlook of winter season over Bhutan is based on the forecast of the climate predictability tool, considering the consensus outlook of the SASCOF, and outlook from various other sources. The rainfall forecast during the DJF 2021/22 will most likely be below normal. The maximum and minimum temperature will most likely be normal to slightly above normal. It is to be noted that the forecast provided is an average across the country therefore, slight deviations in the forecast are expected from the point or stations wise forecast.

References:

APCC. (2021). Outlook | APEC Climate Center.
<https://www.apcc21.org/ser/outlook.do?lang=en>

IMD. (2021). Climate Prediction and Monitoring Group.
https://imdpune.gov.in/Clim_Pred_LRF_New/lrf_Index.html

IPCC. (2013). Climate Change 2013 - The Physical Science Basis. In Ipcc.
<https://doi.org/10.1017/CBO9781107415324>

IRI. (2021). Seasonal Climate Forecasts. <https://iri.columbia.edu/our-expertise/climate/forecasts/seasonal-climate-forecasts/>

Met Office. (2021). Global long-range model probability maps.
<https://www.metoffice.gov.uk/research/climate/seasonal-to-decadal/gpc-outlooks/glob-seas-prob>

Stockdale, T. N., Alves, O., Boer, G., Deque, M., Ding, Y., Kumar, a., Kumar, K., Landman, W., Mason, S., Nobre, P., Scaife, a., Tomoaki, O., & Yun, W. T. (2010). Understanding and predicting seasonal-to-interannual climate variability - The producer perspective. *Procedia Environmental Sciences*, 1(1), 55–80. <https://doi.org/10.1016/j.proenv.2010.09.006>

WMO. (2021). WMO LRF MME. https://www.wmolc.org/seasonPmmeUI/plot_PMME#



༄༅། རྒྱལ་ཡོངས་ཁྱུ་དབྱུང་དང་གནམ་གཤིས་རིག་པའི་རྩེ་བ།

NATIONAL CENTER FOR HYDROLOGY AND METEOROLOGY
THIMPHU: BHUTAN

"Center of Excellence in Hydrology, Meteorology and Cryosphere Science and Services"



Precipitation and Temperature Outlook for Winter Season (December 2021 – February 2022)

The National Center for Hydrology and Meteorology releases the outlook for precipitation and temperature for the 2021/22 winter season, for the months of December 2021 to February 2022. The forecast was prepared using a statistical model (Climate Predictability Tool) with inputs of Global Climate Models data. The final outlook is based on the consensus outlook of the South Asian Climate Outlook Forum (SASCOF-21) held virtually from 25th November, 2021 and outlook from various sources. The seasonal outlook has to be used along with the extended range, medium, daily weather forecast and other advisories and remarks released by the Center. The stakeholders and users are advised to follow the NCHM website and social media page for any relevant updates.

Rainfall Forecast for 2021-22 Winter Season

Normal is the average rainfall for winter (DJF) of Bhutan from 1996 to 2020. The winter rainfall for Bhutan during DJF 2021-22 will most likely be below normal.

Temperature Forecast for 2021-22 Winter Season

Normal is the average temperature for winter (DJF) of Bhutan from 1996 to 2020. The maximum and minimum temperature forecast for Bhutan during DJF 2021-22 winter season is most likely to be normal to slightly above normal.