Rainfall and Temperature Forecast of Bhutan
for
2021 Summer Monsoon
(June – September 2021)

Weather and Climate Services Division
National Center for Hydrology and Meteorology
Royal Government of Bhutan
2021

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Foreword

The National Center for Hydrology and Meteorology (NCHM) is the national focal agency responsible for studying, developing and providing services on meteorology, hydrology and cryosphere. The core mandates of the Center is to provide early warning information that helps the nation to protect lives and properties from the impacts of climate change and variability. Changes in climate and its variation presents both risks and opportunities and it affects all aspects of domain. NCHM strives to deepen the scientific understanding of weather and climate, deliver climate services from national to local scales extending from seasons to years and decades to improve public information about the impacts of a changing climate.

The climate information services include climate analysis and monitoring, assessment and attribution, prediction (monthly, seasonal, decadal) and projection as well as tailoring the associated products to meet the user needs and to better prepare for its associated disasters. Therefore, monitoring and studying the behavior of climate variability factors (especially rainfall and temperature) is significant in order to minimize the impact. Moreover, the planners, decision-makers and resource managers require information regarding future changes in climate and variability to better anticipate and to formulate adaptation policies/strategies in response to climate change impacts at various scales.

Seasonal forecasts generally consist of an outlook of precipitation and temperature for a particular region and 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 in Bhutan is prepared using a statistical model called the Climate Predictability Tool (CPT).The Global Observed Sea Surface Temperature (SST) and CFS (Climate Forecast System) model data are used as predictors and observed rainfall and temperature data of Bhutan and Chirps data as predictant. The forecast is also based on the output and information from WMO's Long Range Producing Centers. The forecast also considers the output from the South Asian Climate Outlook (SASCOF) and in addition, global scale climate phenomena such as ENSO and IODs were referred.

(Karma Dupchu)
Director

Acknowledgement

"**Rainfall and Temperature Forecast of Bhutan for 2021 Summer Monsoon**" report was prepared and made available to the user sectors after the completion of the 7th session of National Climate Outlook Forum which was held virtually on 21st May, 2021. 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).

The support of the GCF for the project is thankfully acknowledged. The Center acknowledge the contribution of the South Asian Climate Outlook Forum (SASCOF-19) and the National Meteorological and Hydrological Services (NMHSs) of eight South Asian countries. Contributions and references from several global and regional climate agencies including World Meteorological Organization (WMO), Indian Meteorological Department (IMD), WMO Regional Climate Centre (RCC) Pune, 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), Korea Meteorological Administration (KMA) among others are gratefully acknowledged. Lastly, all agencies and individuals who directly or indirectly contributed to the report are kindly acknowledged.

Contents

1. Background

Monsoon is defined as a seasonally reversing wind system accompanied by seasonal changes in atmospheric circulation. The monsoon occurs in countries like Bangladesh, Bhutan, India, Nepal, Pakistan, and Sri Lanka. Monsoon precipitation is likely to intensify due to climate change (IPCC, 2013). El Niño and the Southern Oscillation (ENSO) will be the dominant mode of climate variability at inter annual scale (IPCC, 2013; Stockdale et al., 2010). Predicting summer monsoon is of huge importance to society especially the agriculture and hydro power sectors. Proper interpretation, reliability of the information and efficient dissemination of seasonal forecasts is equally important. Bhutan receives rainfall from the southwest monsoon accounting for more than 70% of the total annual rainfall.

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. China coordinates the 'Forum on Regional Climate Monitoring, Assessment and Prediction for Regional Association II' (FOCRA II), covering the entire Asian continent. Since Asia is a large continent, World Meteorological Organization (WMO's) Regional Association II (Asia) recommended a sub-regional RCOFs devoted to the specific needs of the groups of countries having similar climatic characteristics. Thus South Asian Climate Outlook Forum (SASCOF) came into existence in 2010 with specific focus on the information needs of countries affected by the southwest monsoon climate. The SASCOF sessions are held in different member countries each year.

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 summer season (June - September) are prepared using the 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 predictant. The forecast is presented to the South Asian Climate Outlook Forum (SASCOF-19) and the outlook consensus is discussed with the scientists and experts of the forum. Due to the COVID 19 global pandemic, SASCOF-19 was held via video conferencing on 26-28th April, 2021. The session was attended by experts representing the National Meteorological and Hydrological Services (NMHSs) of eight South Asian countries as well as those representing several global and regional climate agencies including World Meteorological Organization (WMO), WMO Regional Climate Centre (RCC) Pune, Indian Institute of Tropical Meteorology (IITM), International CLIVAR Monsoon Project Office (ICMPO), Met Office (UKMO), International Research Institute for Climate and Society (IRI), Regional Integrated Multi-hazard Early-warning System (RIMES), Japan Meteorological Agency (JMA), WMO Lead Centre for Long Range Forecasts Multi-Model Ensemble (LC-LRFMME), Korea Meteorological Administration (KMA) etc.

The outlook is derived as a consensus from the CPT output, the outlook of the SASCOF and the discussion on the prevailing conditions in the region. In addition, output/products from the WMO Lead Center for Long Range Producing Centers are also used. ENSO conditions and the Indian Ocean Dipole (IOD) are the dominant boundary conditions affecting the summer monsoon.

2. SASCOF consensus on prevailing conditions

2.1 ENSO conditions over the Pacific Ocean

The El Niño/Southern Oscillation (ENSO) a significant influence on the variability of the monsoon precipitation and the surface temperatures over South Asia. La Niña conditions (colder than normal SSTs over the equatorial Pacific) were developed during the second part of 2020, which peaked in November. However, La Niña conditions over the equatorial Pacific started weakening in early 2021 and conditions are now favoring moving to ENSO neutral conditions. Equatorial Pacific subsurface temperatures have warmed substantially and atmospheric patterns reflect neutral ENSO conditions. The global model forecasts indicate further warming trends and ENSO neutral conditions are likely to prevail during this monsoon season. ENSO neutral conditions can be generally associated with normal southwest monsoon. Only in a few cases other factors like the Indian Ocean conditions may become more dominant in influencing monsoon.

2.2 Conditions over the Indian Ocean

Other conditions such as SSTs of the Indian Ocean also influence the monsoon of the region. A positive (negative) IOD is associated with a stronger (weaker) than normal monsoon. Currently, neutral Indian Ocean Dipole (IOD) conditions are prevailing over the Indian Ocean. Forecasts from most of the coupled global models suggest that neutral IOD conditions are likely to continue, while a few models are indicative of the development of a weak negative IOD during this monsoon season.

2.3 Sow Cover over the Northern Hemisphere

The Northern Hemisphere and Eurasia snow-covered area was below normal during December 2020, January and March 2021. The Northern Hemisphere snow cover areas during February and March 2021 were 33rd and 11th lowest and the Eurasian snow cover area was 13th lowest ever in the last 55 years. Generally, winter and spring snow cover extent has an inverse relationship with the summer monsoon rainfall of Asia.

3. SASCOF-19 outlook for 2021

Climate outlook for the 2021 Southwest 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. Strong consensus on prevailing border line La Niña to ENSO neutral conditions over the equatorial Pacific and neutral ENSO conditions during the southwest monsoon season. In general neutral ENSO conditions are favorable for the normal southwest monsoon rainfall over most parts of South Asia. Other factors and conditions like IOD, tropical Atlantic sea surface temperatures, Eurasian land heating etc. also affects the monsoon. All these factors are considered by the dynamical climate models used for the SASCOF outlook.

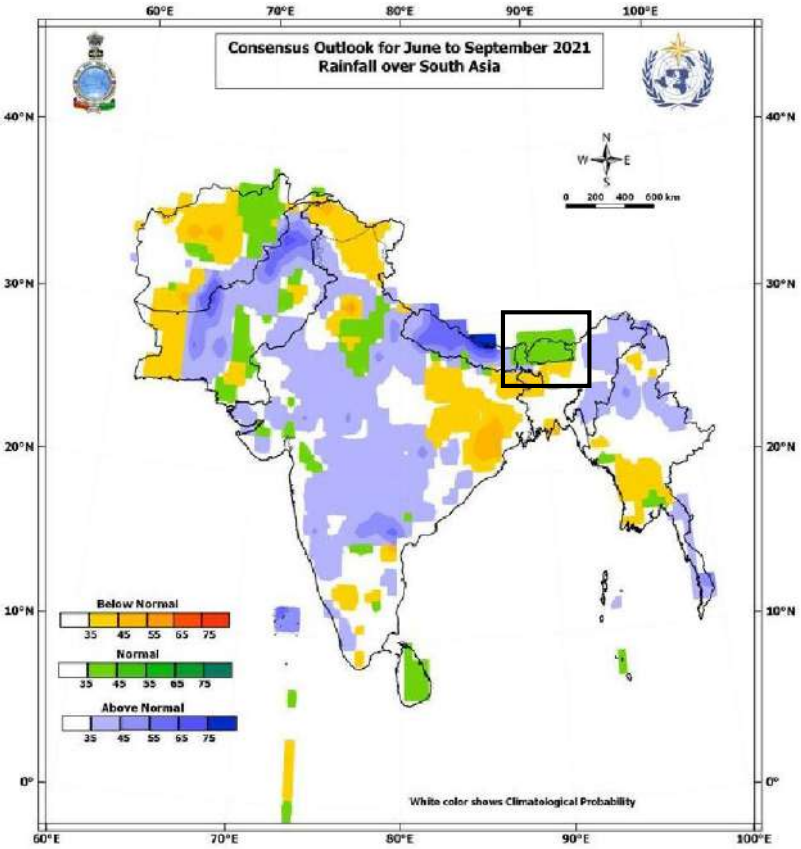


Figure 1: Outlook for 2021 Southwest Monsoon Rainfall over South Asia

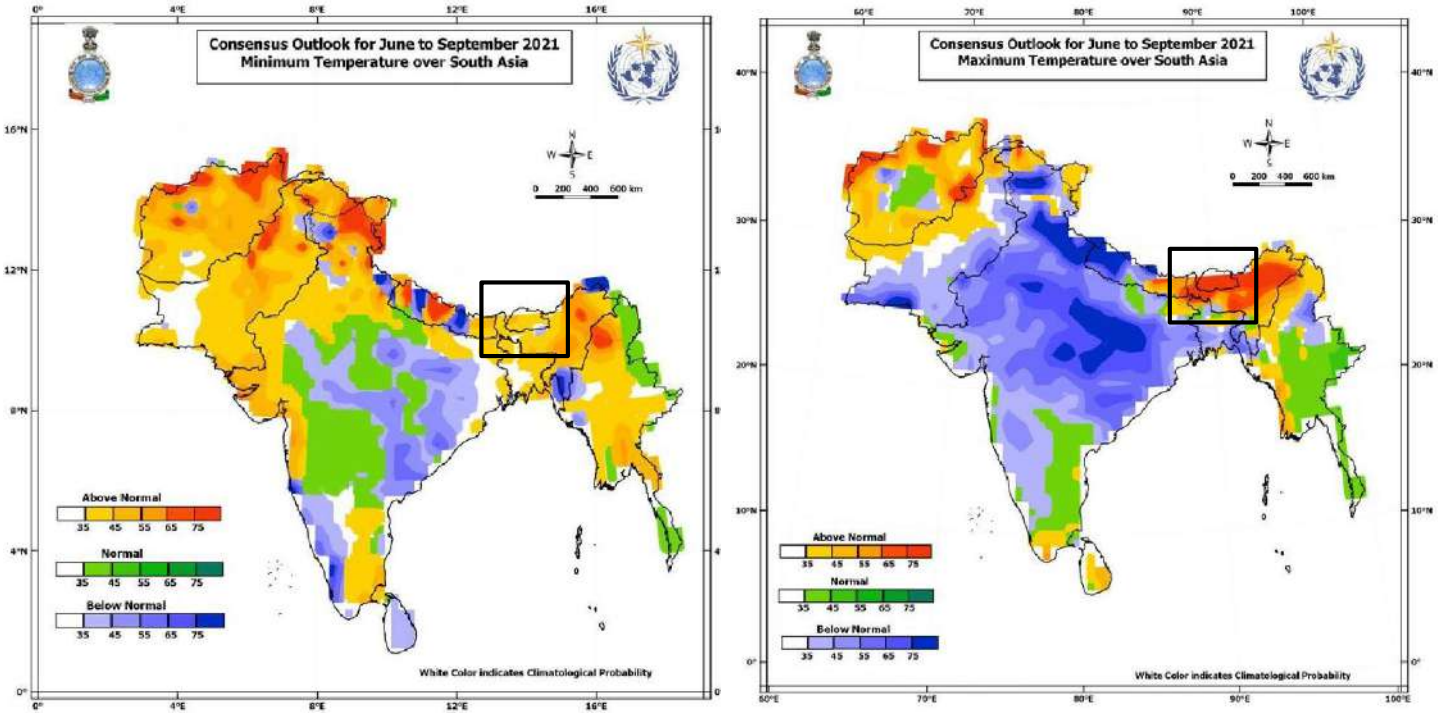


Figure 2: Outlook for 2021 Southwest Monsoon Minimum (left) and maximum (right) temperature over South Asia

The Figure shows grid wise most likely tercile category the probability for each 1x1 degree grids. The outlook suggests that the rainfall is most likely to be normal to above normal during the 2021 southwest monsoon season over most parts of South Asia (Figure 1). Outlook on minimum temperatures for June to September 2021 season are likely to be above normal over most areas of west, northwest, north and north eastern parts of South Asia. The minimum temperatures are most likely to be below normal over east-central and south western areas of the region. Outlook on maximum temperatures are likely to be below normal over most of the central parts of South Asia and above normal over northwest and northern areas of the northeast. Rainfall, minimum and maximum temperatures are likely to normal or of climatological probabilities over remaining parts of the region.

Since the rainfall and temperature during the southwest monsoon season depicts strong intra-seasonal variability, it is advised to watch the seasonal forecasts and extended range forecasts for better decision making. 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.

4. National Southwest Summer Monsoon Outlook

4.1 Precipitation

i. WMO Lead Centers

Probabilistic multi-model ensemble forecast of WMO GPCs climatological probability during June-September 2021. There are no skills over Bhutan.

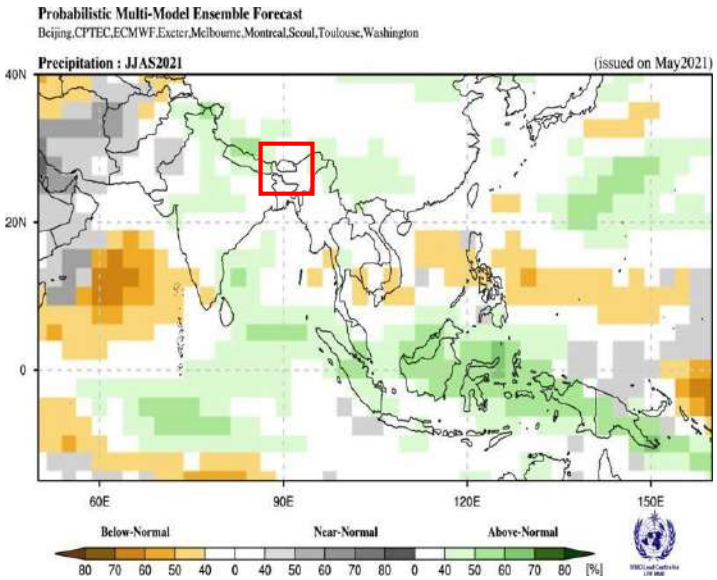


Figure 3: JJAS 2021 precipitation forecast from May initial conditions, 9 GPCs (WMO, 2021)

ii. International Research Institute for Climate and Society (IRI)

The IRI predicted below to slightly above normal rainfall during June-August and July-September 2021 over Bhutan respectively.

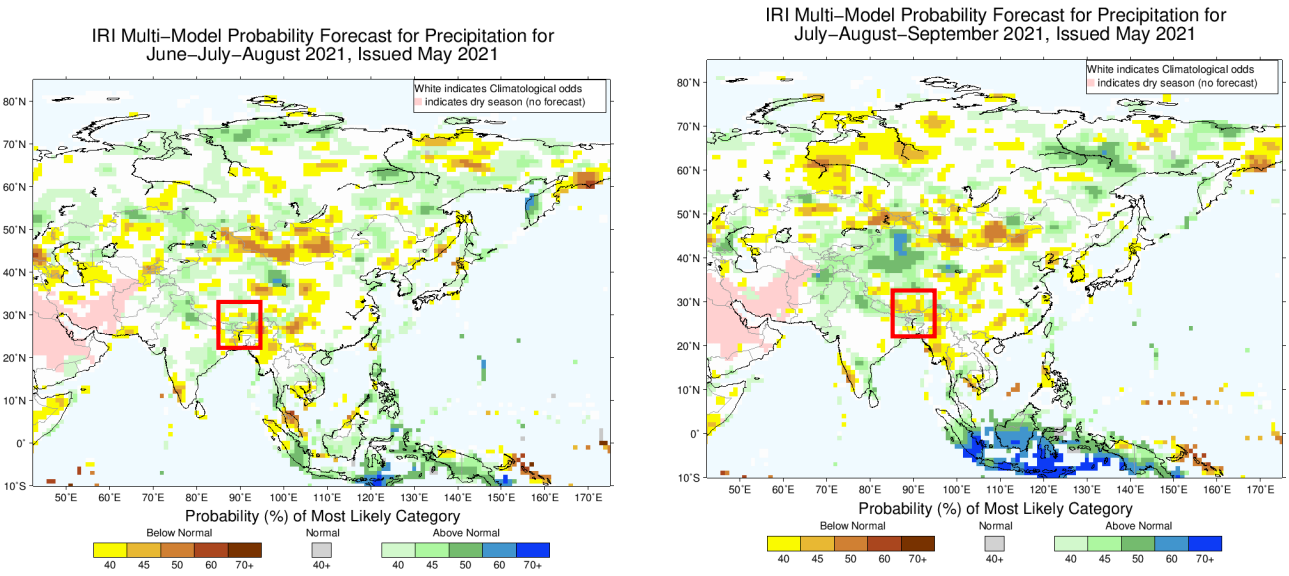


Figure 4: JJA (left) and JAS (right) 2021 precipitation forecast from May initial condition (IRI, 2021)

iii. UK Met Office

The UK Met office forecast indicates normal to slightly above normal rainfall during June-August and July-September 2021 over Bhutan respectively.

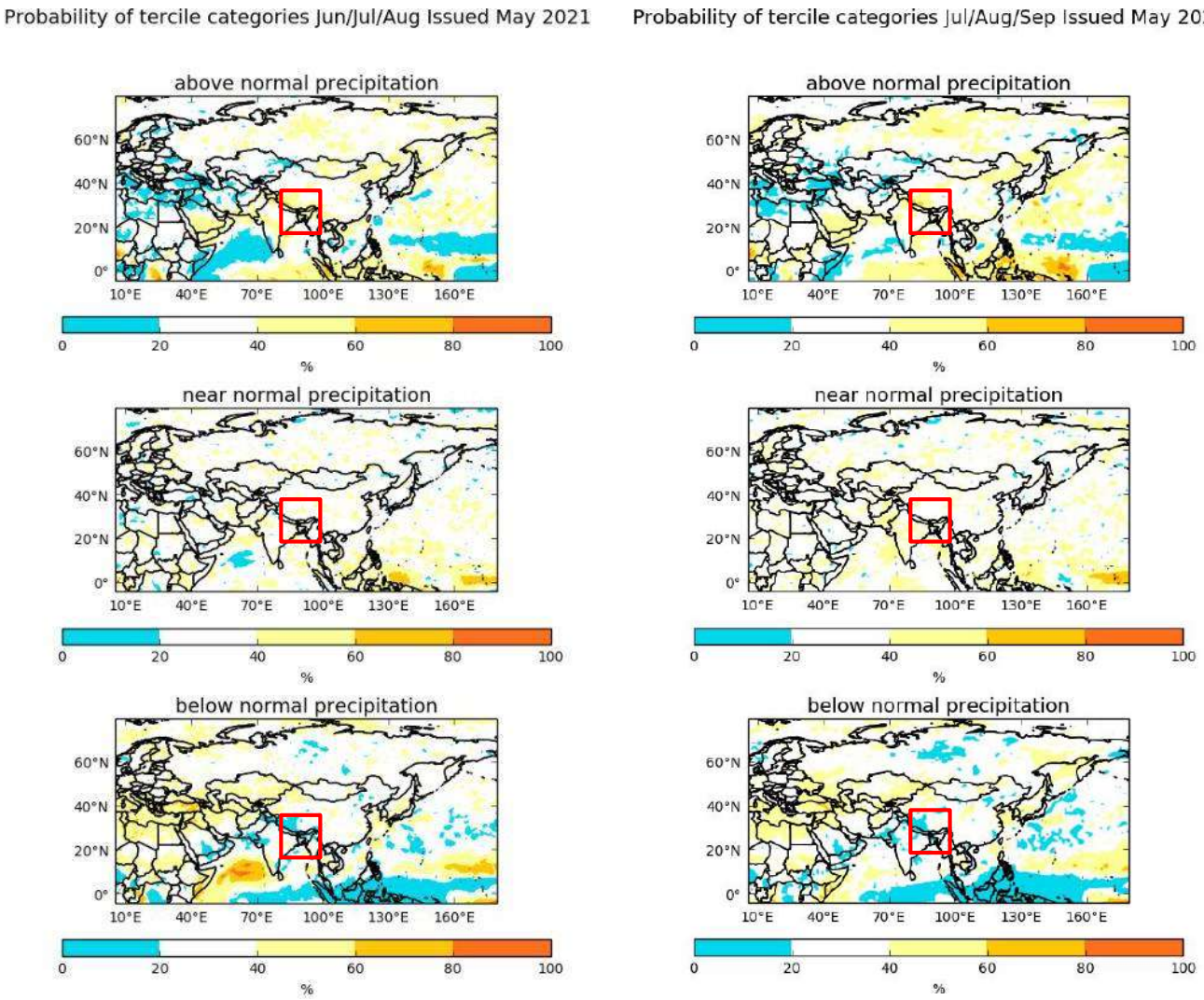


Figure 5: JJA (left) and JAS (right) 2021 precipitation forecast from May initial conditions (Met Office, 2021)

iv. APEC Climate Center

The APEC Climate Center forecast depicted the climatological probability of precipitation over Bhutan during June-August 2021.

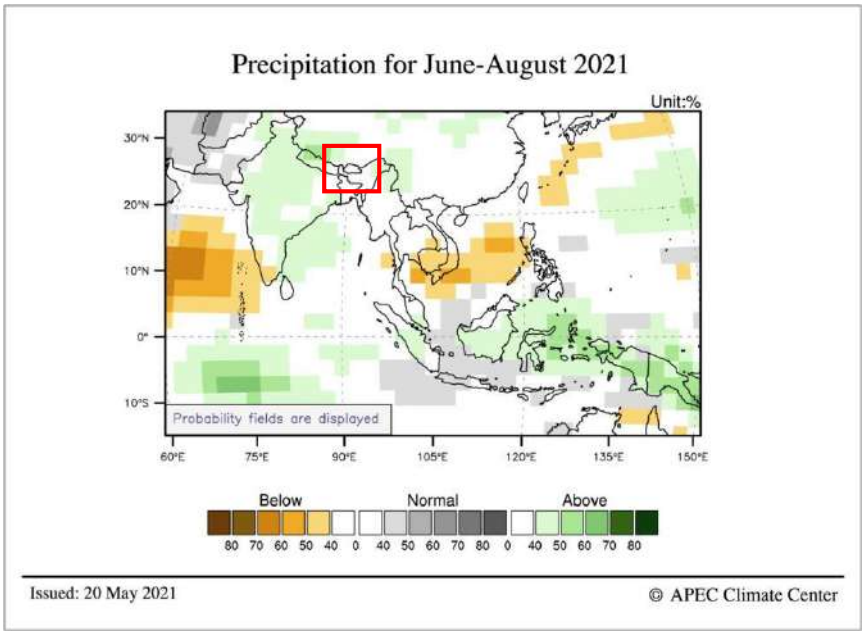


Figure 6: JJA 2021 precipitation forecast from May initial conditions (APCC, 2021)

v. MMCFs Probability forecast, Indian Meteorological Department

The IMD MMCFs illustrated the above normal precipitation during June-August 2021.

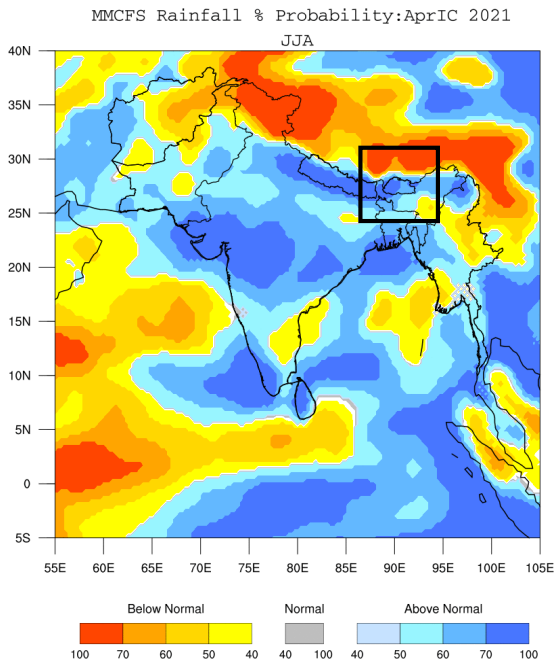
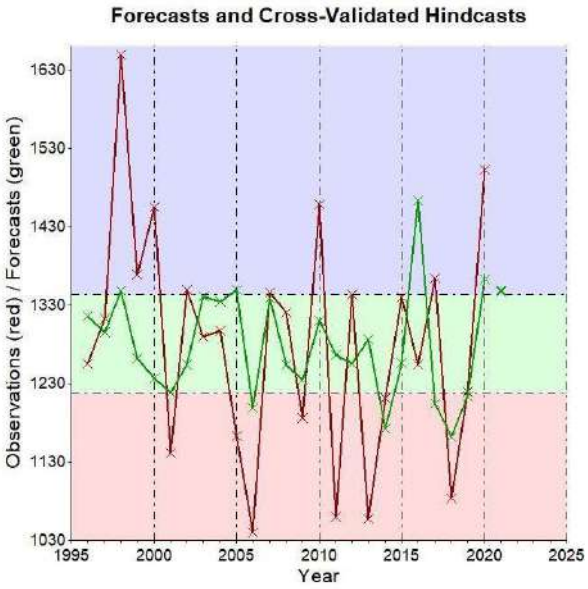


Figure 7: JJA 2021 precipitation forecast from MMCFs based on April initial conditions (IMD, 202

vi. Climate Predictability Tool forecast from NCHM station data

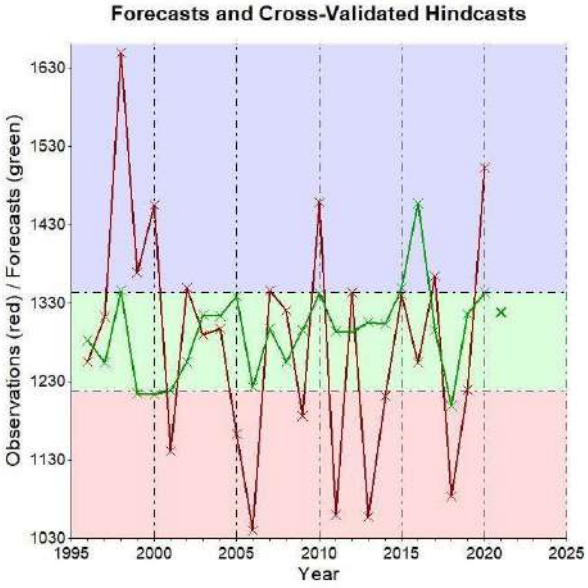
The CPT forecast indicates normal to slightly above normal precipitation during June-September 2021.



Probabilities:

Year	Probabilities		
	B	N	A
2021	15	29	56

Figure 8: JJAS 2021 precipitation forecast from May initial conditions based on GCMs precipitation data



Probabilities:

Year	Probabilities		
	B	N	A
2021	26	35	39

Figure 9: JJAS 2021 precipitation forecast from May initial conditions based on GCMs SST data

4.2 Temperature

i. WMO Lead Centers

Probabilistic multi-model ensemble forecast of WMO GPCs showed above normal temperature during JJAS 2021 over Bhutan.

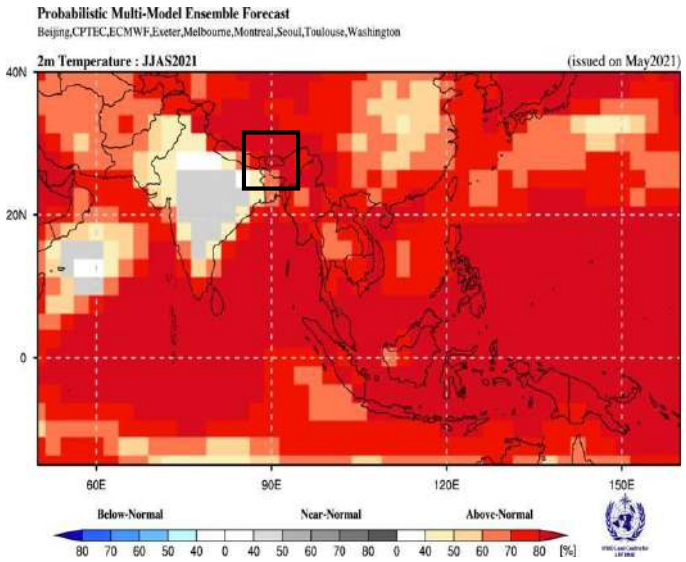


Figure 10: JJAS 2021 temperature forecast from May initial conditions, 9 GPCs (WMO, 2021)

ii. International Research Institute for Climate and Society (IRI)

The IRI forecast indicates climatological probability over most of the regions. The southern regions showed below normal temperature during JJA and JAS 2021 over Bhutan.

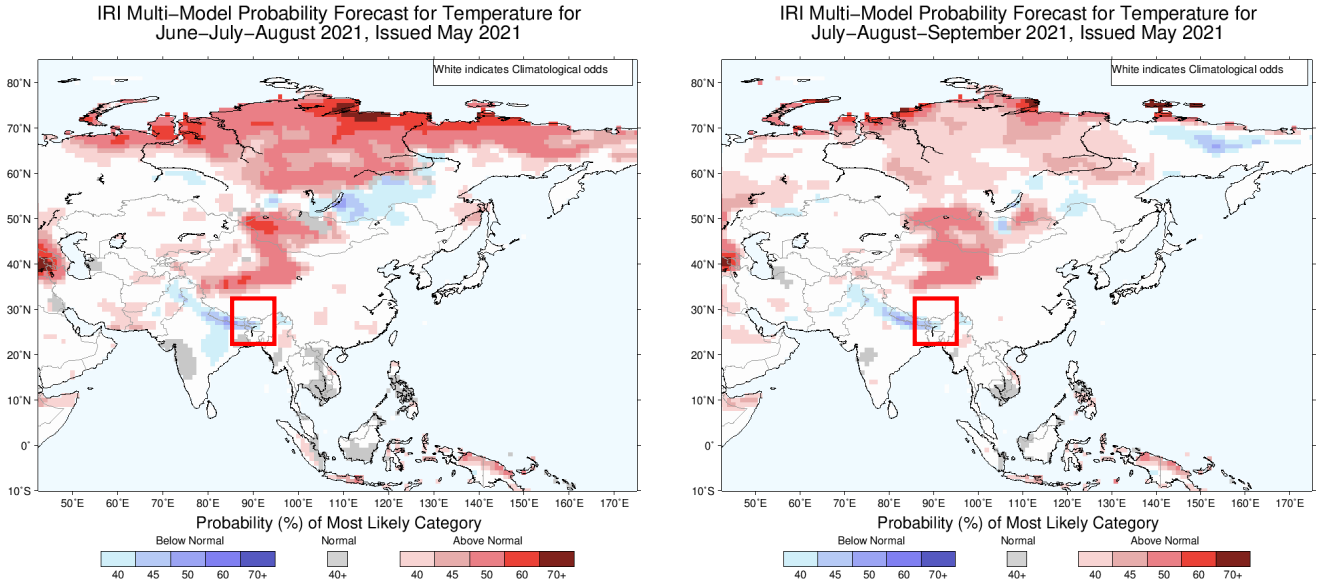


Figure 11: JJA (left) and JAS (right) 2021 temperature forecast from May initial conditions (IRI, 2021)

iii. UK Met Office

The UK Met office forecast indicates normal to slightly above normal temperature during JJA and JAS 2021 over Bhutan.

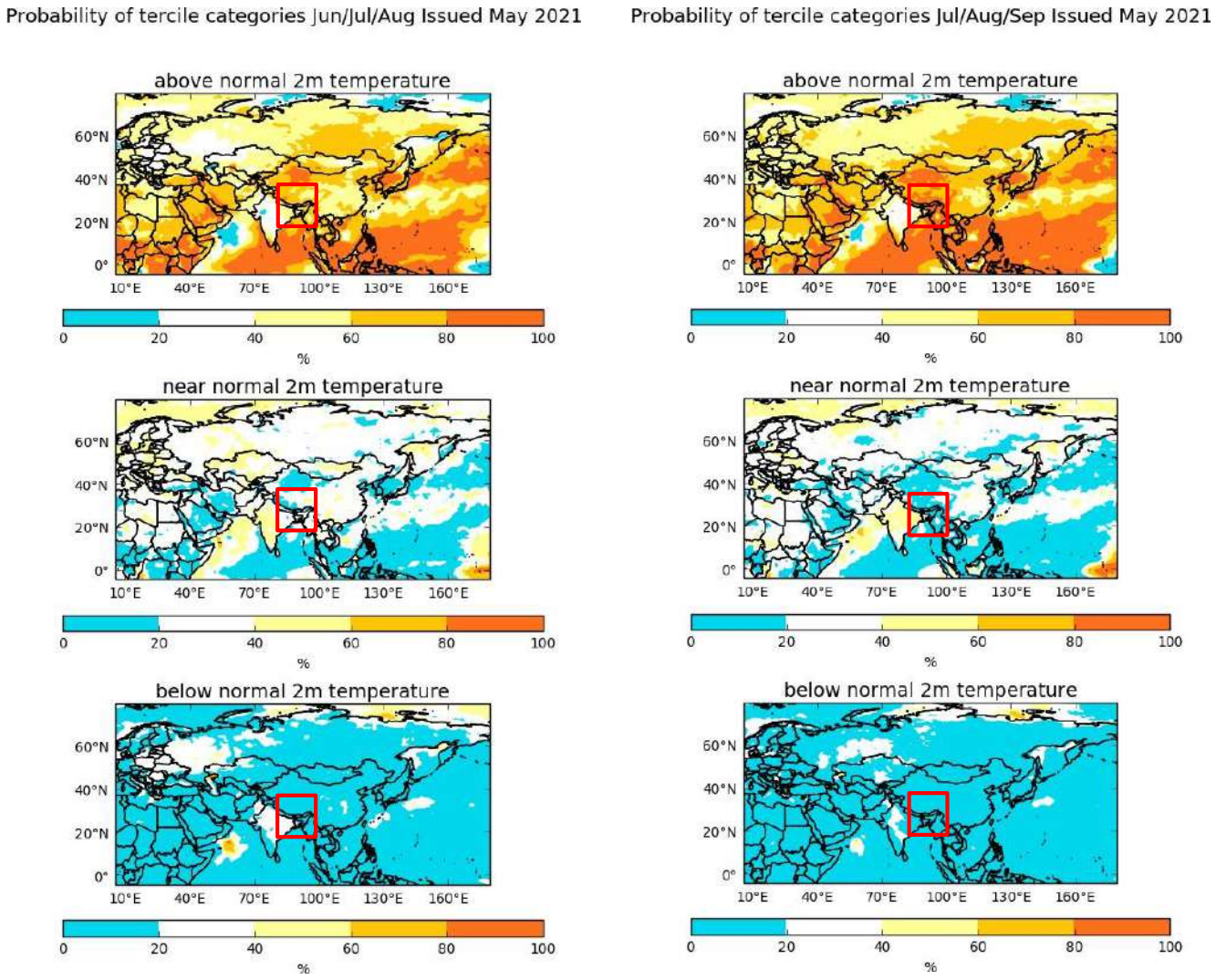


Figure 12: JJA (left) and JAS (right) 2021 temperature forecast from May initial conditions (Met Office, 2021)

iv. APEC Climate Center

The APEC Climate Center forecasted above normal temperature during JJA 2021 over Bhutan.

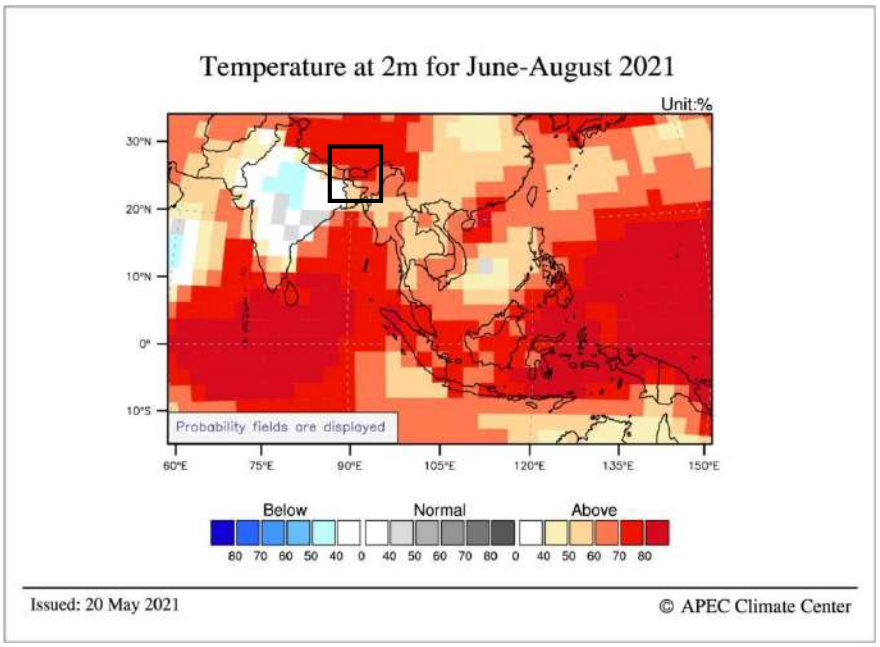


Figure 13: MJJ (left) and ASO (right) 2021 precipitation forecast from May initial conditions (APCC, 2021)

v. MMCFs Probability forecast, Indian Meteorological Department

The MMCFs, IMD forecast illustrated the above normal temperature during JJA 2021 over Bhutan.

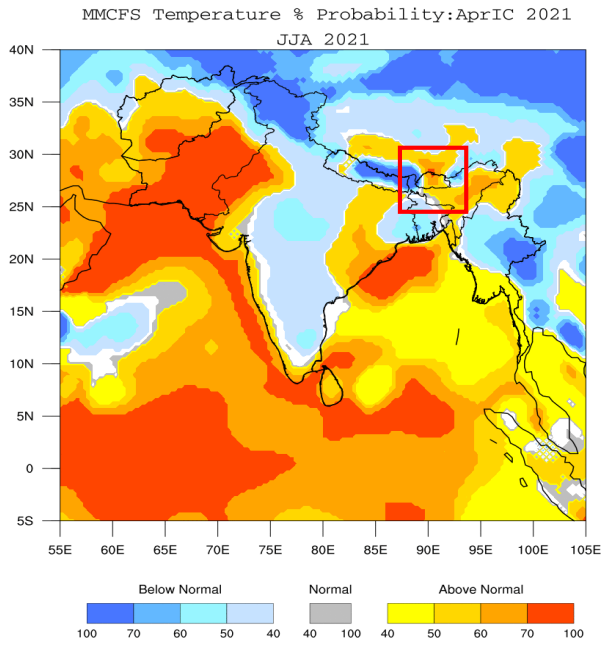
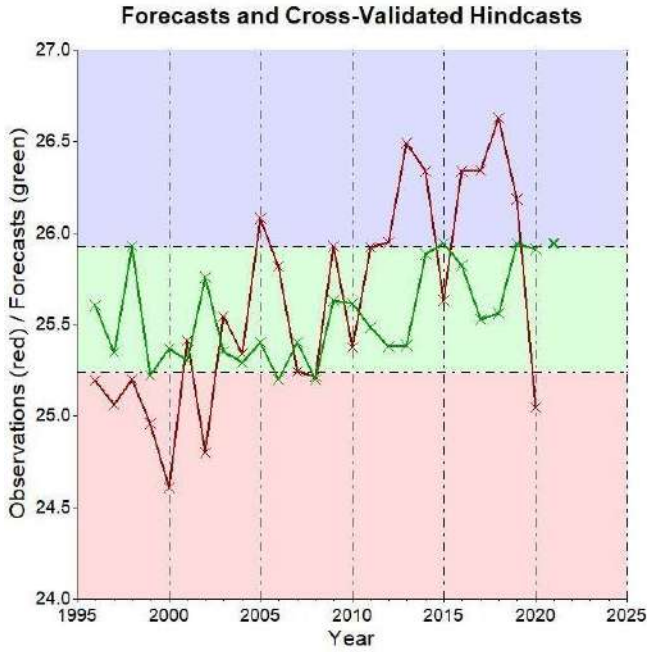


Figure 14: JJA 2021 precipitation forecast from April initial conditions (IMD, 2021)

vi. Climate Predictability Tool forecast from NCHM station data

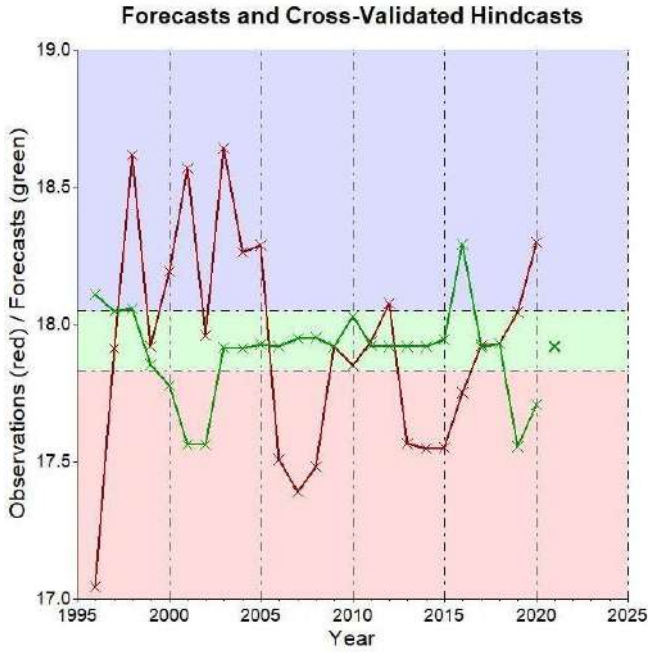
The CPT forecast indicates normal to slightly above normal temperature during JJAS 2021.



Probabilities:

Year	Probabilities		
	B	N	A
2021	15	31	54

Figure 15: JJAS 2021 precipitation forecast from May initial conditions based on GCMs maximum temperature data



Probabilities:

Year	Probabilities		
	B	N	A
2021	38	28	34

Figure 16: JJAS 2021 precipitation forecast from May initial conditions based on GCMs minimum temperature data

4.3 Monsoon outlook for Bhutan

ENSO neutral conditions are likely to prevail during this monsoon season which are generally associated with normal southwest monsoon. The final outlook of summer monsoon 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 summer JJAS 2021 will most likely be normal to slightly above 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.

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NATIONAL CENTER FOR HYDROLOGY AND METEOROLOGY
THIMPHU: BHUTAN
"Center of Excellence in Hydrology, Meteorology and Cryosphere Science and Services"

21 May, 2021

Press Release
Precipitation and Temperature Outlook for Southwest Summer Monsoon
(June – September, 2021)

The National Center for Hydrology and Meteorology releases the outlook for precipitation and temperature for the 2021 summer season, for the months of June to September 2021. This year due to the pandemic, the 7th session of National Climate Outlook Forum (NCOF-7) was held virtually on 21 May 2021. The presentation of the outlook was made to all the stakeholders and media. The forecast was prepared using a statistical model (Climate Predictability Tool) with inputs of the GCMs data. The final outlook is also based on the consensus outlook of the South Asian Climate Outlook Forum (SASCOF-19) held virtually from 26 – 28th April, 2021, and outlook from WMO GPCs and various other sources. Similar to best practices in other countries, the summer monsoon outlook has to be used along with the extended range forecasts, daily weather forecasts and other advisories released by the Center. Stakeholders and users are advised to follow the NCHM website and Facebook pages for advisories and updates.

Rainfall Forecast for 2021 Summer Season

Normal is the average rainfall for the summer season (JJAS) of Bhutan from 1996 to 2020. The summer rainfall for Bhutan during 2021 JJAS monsoon season is most likely to be normal to slightly above normal. Rainfall is likely to be similar to last year.

Temperature Forecast for 2021 Summer Season

Normal is the average temperature (maximum and minimum) for the summer season (JJAS) of Bhutan from 1996-2020. The maximum and minimum temperature in Bhutan during the 2021 JJAS monsoon season is likely to be normal to slightly above normal. Summer temperature is also expected to be similar or slightly warmer than last year.

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