Effect of Atmospheric River in Generating Extreme Precipitation in Meghalaya on June 2022

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Introduction

Atmospheric River (AR) is a long, narrow stream of water vapor that moves in the earth’s atmosphere and carries abound moisture from the mid-latitude, engendering extreme rainfall upon landfall (Ralph et al., 2006). According to Zhu & Newell, (1998), around 90% of the largest rainfall events in the world have been followed by ARs. Furthermore, recent research shows the relevance of AR in occurring extreme precipitation in South East Asia, especially in the Bay of Bengal Region (Yang et al., 2018). Hence, the role of AR in generating extreme rainfall in Meghalaya is necessary for a better understanding of flash floods in the North Eastern (NE) region of Bangladesh.

The NE region of Bangladesh is exposed to regular flash floods because of the rapid rainfall-runoff response from the extreme precipitation in Meghalaya. On June 2022, this region experienced one of the most devastating floods, more than 70% of the Sylhet and Sunamganj district went under water, as the aftermath of the heaviest rainfall in the last 102 years in Mawsynram, Meghalaya in conjunction with the existing water in the floodplain due to the flash flood in the previous month.

Therefore, this study illustrates the contribution of AR in generating the extreme precipitation in the Meghalaya region on June 2022 that created enormous flooding in the NE region of Bangladesh.

Methodology

To analyze the contribution of AR in the extreme rainfall event in Meghalaya on June 2022, the Vertically integrated Northward and Eastward Water Vapor Flux or Integrated Vapor Transport (IVT) in Meridian and Zonal direction data are collected from the European Center of Medium Range Weather Forecasts (ECMWF) ERA-5 Reanalysis data of June 2022 with an interval of 6 hours. Secondly, the extreme rainfall days have been identified from gauge station rainfall data from the Indian Meteorological Department (IMD). After that, the presence of AR will be detected by calculating the magnitude of IVT and identifying the geometric Criteria of AR (Length and area of AR, Length to Width ratio, and the direction of the IVT front)(Xu et al., 2020) from the collected data. Finally, the identified AR for June 2022 will be compared with the extreme rainfall timeline to determine the contribution of AR to this extreme rainfall. The conceptual framework of the study is provided in Figure 1.
Results and Discussions

Analysis of the Atmospheric River

The AR analysis indicates that an AR made landfall in the NE region of India on 15 June at 12 AM provided in Figure 2 where the moisture movement had been initiated from the Arabian Sea and the moisture front traveled across Northern India. Additionally, the IVT front persisted for 72 hours as a form of AR where the length of the front decreased. Later, the available moisture in the North Eastern India intensified by the supply of Moisture from Bay of Bengal during 16 to 18 June. Consequently, Indian Meteorological Department (IMD) recorded the extreme rainfall from 15 June in the North Indian region where Mawsynram and Cherapunjee received the heaviest rainfall on 17 June, around 1000 mm. Therefore, the presence of AR before the extreme rainfall from 14 to 17 June indicated the moisture from AR movement had a significant role in this extreme precipitation.
Figure 2: Magnitude and Direction of IVT for (a) 14 June (b) 15 June, (c) 16 June, and (d) 17 June, and Identification of AR
Climatic Drivers influencing the formation of AR

The initiation of the monsoon season in the Indian South Continent occurs in May, peaking in the region during the month of June. In order to distinguish between the monsoon onset and the formation of Atmospheric River, we evaluated the impact of the Low-Level Jet (LLJ) on the development of AR. Figure 3 displays the Wind Speed and Geopotential Height at a 500 hPa level for the time period of 15 June 12 AM in both 2021 and 2022. During the onset of the monsoon season, there is a movement of strong winds from the Indian Ocean into the Bay of Bengal in mid-June. This movement results in the provision of moisture in India and Bangladesh, as illustrated in Figure 3 (a) for the year 2021, when the AR was not formed. In contrast, Figure 3 (b) depicts the observation of a prominent high-velocity wind jet in 2022, which traverses the Northern area of India and extends towards the Pacific Ocean, encompassing Bangladesh and the neighboring nations. This jet facilitates the rapid movement of moisture in a narrow corridor, resulting in the formation of an Atmospheric River on 15 June 2022.
Conclusion

Extreme precipitation in Meghalaya region creates enormous and rapid flash floods in the downstream of the Meghna basin. The record breaking rainfall on 17 June engender massive flooding the downstream especially in Sylhet and Sunamganj district. Analysis results show that there had been a landfall of AR in the North Indian Region on 15 June indicating the significant contribution of AR in generating extreme rainfall in.
these regions. Further studies have become indispensable to understand the dynamics of AR linked with extreme precipitation in this region.

References


