Lightning in Bangladesh: Hydrometeors Assessment of Active and Inactive Lightning Days

M. Rafiuddin[1*], Nasreen Akter[1], Kazuhisa Tsuboki[2], Ronald L Holle[3] and Ashraf Dewan[4]

[1]*Department of Physics, Bangladesh University of Engineering & Technology, Dhaka-1000, Bangladesh*
[2]*Institute for Space-Earth Environmental Research (ISEE), Nagoya University, Japan*
[3]*Vaisala Inc., Louisville, CO 80027, USA*
[4]*Curtin University, Bentley, Australia*

[*]*Email: rafiuddin@phy.buet.ac.bd*

Bangladesh is one of the most vulnerable countries to severe weather events in the world due to the changing climate. It is well known that Bangladesh frequently faces different types of climatic extremes like lightning, cyclones, tornadoes, heavy rainfall, landslides, etc. During the pre-monsoon (March-May) season, the instability and vertical wind shear reaches its extreme values to nurture severe deep convective thunderstorms. These thunderstorms are associated with lightning, heavy rainfall, and strong wind gusts, which are responsible for hazardous situations in Bangladesh. In recent years, Bangladesh has been experiencing an increased number of lightning-related casualties and property loss, causing a significant threat to human civilization. Following the deaths of 81 people on 12 and 13 May 2016, the Bangladesh government has declared lightning as a natural disaster. In Bangladesh, the lightning stroke densities were counted very high (ranks 15th among 241 countries during 2016-2020), which resulted casualties of more than 286 per year, and an average of 1.73 deaths per day in the pre-monsoon season and 0.71 in the monsoon (*Ronald et al., Int. J. Disaster Risk Reduction, 41:101264, 2019*). More than half of the deaths were related to agricultural activities and April-June accounted for 70% of the year's agriculture-related fatalities.

The separation of charges for lightning strongly depends on the interaction among different hydrometeors within thunderclouds in the presence of suitable environmental conditions. In this study, the top-ranked available 50 active and inactive lightning days (using Vaisala GDL360 lightning data) were considered to evaluate the relationship between different hydrometeors of active and inactive lightning days from 01 March to 15 June during 2015-2020. For this purpose, ECMWF-ERA5 reanalysis data of 0.25°× 0.25° resolution has been studied for hydrometeors profiles. In addition, top-ranked active and inactive lightning days are simulated using the Cloud

Resolving Storm Simulator (CReSS) with a horizontal grid increment of 500 m. The University of Wyoming's atmospheric-sounding data at Dhaka station (ID: 41923, latitude: 23.76 N, longitude: 90.38 E) has also been used to calculate the thermodynamic parameters.

The cloud ice and snow were significantly large at 500-200 hPa levels on active lightning days compared to that on inactive lightning days. During active lightning days, the cloud liquid water (0.2 g/kg) was found to have a larger value in the low- to mid-levels. The equivalent potential temperature was 20 K higher with stronger westerlies at 850 hPa level in the active lightning days. Strong positive moisture and warm air advection are found at 850 hPa level on active days, which results an increasingly unstable low-level atmosphere. The simulation results from CReSS showed a relatively higher value of the mixing ratio of graupel at 500-700 hPa levels on active days. The larger value of the mixing ratio of snow is also noticed at 200 hPa level on active days. The mixing ratio of ice is found at 200 hPa level for active and inactive days of lightning.

The average value of the Showalter index indicates a moderately unstable condition prevails in the days during active lightning, whereas weak convection is possible on inactive days. The SWEAT index was found to be higher than 300 on the active days, which indicates the potential for the occurrence of severe thunderstorms. The averaged k index was larger on active days than inactive days, indicating an enhanced potential for the occurrence of thunderstorms with heavy rain. The average value of convective available potential energy was more than 1200 J/kg on the active days, indicating the air parcel has more potential to lift at a level of free convection than on the inactive days. Precipitable water is one of the most used parameters that determine the amount of rainfall and influences the dynamical evolution of convective storms for weather forecasting and is found much greater value during active days.

This study showed the co-existence of snow and ice more intensely on active days than on inactive days at 500-200 hPa levels and the significant differences in the thermodynamic parameters of the active and inactive days. This result will be helpful for better forecasting the most active days of lightning in Bangladesh. Better forecasting with significant lead time and building up public awareness will be helpful in reducing lightning-related casualties in Bangladesh.