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Influence of Meteorological Parameters on Lightning Flash in Bangladesh

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Abstract

The monthly distribution of lightning flash count (FC) using Tropical Rainfall Measuring Mission LIS lightning data from 2003 to 2012 are analyzed over Bangladesh and also examined the effect of meteorological parameters such as surface maximum temperature, boundary layer height (BLH), high cloud cover (HCC), mean sea level pressure (MSLP) and relative humidity (RH) on FC. It is found that the monthly variation of lightning activity over Bangladesh is strongly correlated with temperature and with BLH. The correlation coefficients (r) of monthly variation of FC with temperature and BLH are 0.70 and 0.83, respectively. The yearly variation of FC also shows strong correlation with HCC and MSLP, whereas it is moderately correlated with RH. The values of r for yearly variation of FC with HCC, with MSLP and with RH are 0.8, 0.64 and 0.55, respectively. Based on the analysis we expect that the above meteorological parameters influences to the lightning activity over Bangladesh.

Introduction

Lightning is a sudden high-voltage discharge of electricity that occurs within a cloud, between clouds, or between a cloud and the ground. Globally, there are about 40 to 50 flashes of lightning every second, or nearly 1.4 billion flashes per year. Recently, the fatalities in Bangladesh due to lightning has been increased devastatingly. Following the deaths of 89 people on 12 and 13 May 2016, Bangladesh government has declared lightning as a natural disaster. The annual average of 114 fatalities and 89 injuries were occurred in Bangladesh over the period of 1990 to 2016, and in the recent 6 years had 251 fatalities per year. The analysis of increasing lighting flash with atmospheric parameters can able to understand the climatic condition in Bangladesh. In order to manage the weather related hazard and to minimize risk associated with it, knowledge regarding environmental characteristics of lightning occurrence and its relation with atmospheric parameters is of great importance. In this study relation between monthly and annual lightning flash count (FC) with maximum surface temperature, boundary layer height (BLH), high cloud cover (HCC), mean sea level pressure (MSLP) and relative humidity (RH) are considered to be analyzed.

Methodology

Quality controlled Tropical Rainfall Measuring Mission (TRMM) lightning imaging sensors (LIS) lightning data from National Aeronautics and Space Administration (NASA) were used. Different types of meteorological variables such as BLH, HCC, MSLP and RH data with a spatial resolution of 0.5° × 0.5° were obtained from European Centre for Medium-Range Weather Forecasting (ECMWF) ERA-Interim database (MACC reanalysis) from 2003 to 2012. The value of maximum surface temperature was collected from 35 rain gauge station of Bangladesh Meteorological Department (BMD). Hierarchical Data Format (HDF) reading software from the NASA was used to access the lightning data. Custom Interactive Data Language (IDL) scripts are also used to extract lightning flash information including location coordinates and timestamp of occurrence for Bangladesh region (20°–27° N; 86°–93° E). Gridded flash count climatology datasets were converted into monthly and annual scale. Different meteorological parameters are processed and averaged according to month and annual scales using Grid Analysis and Display System (GrADS) software. To understand the influence of meteorological variables on lightning activity, the Pearson product moment correlation coefficient (r) is considered.

Results

The monthly variation of lightning flash count over the study area from 2003 to 2012 is shown in Fig 1(a). This figure showed two peaks of lightning activity. It is found that the lightning activity increases from January and reached at the primary maximum in the month of April, although the difference between lightning flash occurrence in April and May is small. The lightning activity after then decreases up to July and again increases and reached at the secondary maximum in September and then deceases. November to January, in these three months, i. e., during winter season, almost there is no lightning activities over Bangladesh. About 81% of annual lightning occurs from the month of March to June in Bangladesh. The monthly variation of FC and surface maximum temperature from 2013 to 2012 is shown in Fig 1(b). The correlation coefficient (r) between FC and maximum surface temperature is found 0.70. Higher temperature destabilizes the lower tropospheric layers, enhancing the convection and therefore increases lightning. Fig 1(c) shows the monthly variation of FC and BLH over Bangladesh from 2003 to 2012. Monthly variation of BLH is strongly correlated with the monthly variation of FC. The value of r between monthly variation of FC and BLH is found 0.83.

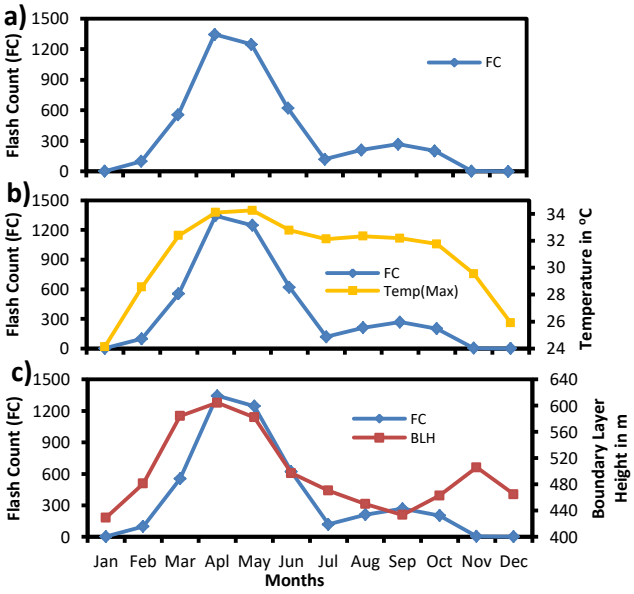

Fig. 1. Monthly variation of (a) FC, (b) FC and temperature and (c) FC and BLH.

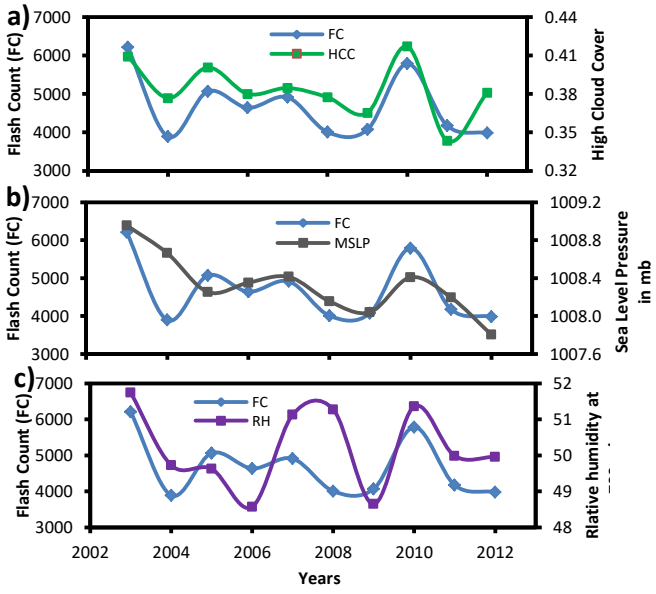

Fig. 2. Yearly variation of (a) FC and HCC, (b) FC and MSLP and (c) FC and relative humidity at 700mb.

The yearly variation of FC and HCC from 2003 to 2012 is shown in Fig 2(a). It is found that the annual variation of FC and HCC is very much similar over Bangladesh during the study period. The value of r between FC and HCC is 0.80. Fig 2(b) shows the yearly variation of flash count and MSLP. Yearly variation of FC shows positive correlation with the yearly variation of MSLP. The correlation between annual variation of FC and MSLP is found 0.64. Fig 2(c) shows the yearly variation of FC and RH at 700mb pressure level and The CC between FC and RH is found 0.55.

Summary

Nowadays there are many economic losses and casualties in Bangladesh due to increase in lightning activities. Therefore, study on the characteristics of lightning activities over Bangladesh and related atmospheric parameters are very much essential to minimize fatalities, injuries and hazardous situations. Using satellite and ground based data we found that the monthly variations of lightning are strongly correlated with surface temperature and with boundary layer height. We also observed that the yearly variations of lightning activity are strongly correlated with high cloud cover and mean sea level pressure but moderately correlated with relative humidity. We may conclude that these meteorological parameters may be some of them by which the lightning phenomenon over Bangladesh is controlled.