Analysis and determination the correlation between thunderstorm occurrence and cloud coverage in Srimangal region of Bangladesh

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Abstract

A thunderstorm is a sudden electrical discharge that causes rapid flashes of light and a roar of sound waves, commonly known as thunder and lightning. It is a mesoscale weather phenomenon with space scale changes from a few kilometers to hundreds of kilometers. A severe thunderstorm is a natural phenomenon that causes extensive damage to life, property, animals and crops. The early warning system (EWS) can play a significant role to minimize the damage of lives and properties. In this study, thunderstorms occurrences are analyzed and corelated with a meteorological parameter i.e. cloud coverage. Thunderstorms occurrences and cloud data are collected from Bangladesh Meteorological Department. Linear regression technique is used to corelate thunderstorms events with cloud coverage. From the research, it is found that cloud coverage is directly related to thunderstorm events in Srimangal in Srimangal region of Bangladesh. This proportional relationship between thunderstorm and cloud coverage can provide the future thunderstorm occurrence information in this region.

Keywords: Thunderstorm, correlation, cloud coverage, linear regression, Srimangal

1. INTRODUCTION

Bangladesh has been facing many calamities such as tropical cyclones, thunderstorms, floods, river erosions, droughts, storm surge, tornadoes, heat waves, landslides etc. for a long period of time. But, lightning events associated with severe thunderstorms are becoming more frequent and more deadly in recent years than in the past. Nowadays, thunderstorms are more violent weather systems than others. Usually, maximum thunderstorm occurrences are occurred in small spatial region and lived in short time duration. But a few numbers of thunderstorms is defined as severe format and this type are more divesting thunderstorms.

Thunderstorms are meteorological phenomena which form in atmospheric favorable conditions of them. Usually, moist air and unstable atmosphere are two favorable conditions for the formation of thunderstorms. It is also essential a triggering force that can push the moist air to vertically. When the moist air is undrafted into the unstable atmosphere the cold air can mixes with it and it can condense & form thunder cloud. A thunderstorm is known as an electric storm or lightning storm. It is a storm that characterized in the presence of lightning [1] and the acoustic effect of the thunderstorm on Earth's atmosphere is called the thunder [2]. Sometimes, thunderstorms are called thundershowers when they are relatively weak nature [3]. Cumulonimbus is a special type of cloud that is responsible for thunderstorm formation [4]. Strong wind, hail, tornadoes, lightning and heavy rain are usually accompanied with a strong thunderstorm. But there are some thunderstorms that can produce snow, sleet but little precipitation or sometimes no precipitation at all. There are mainly three types of thunderstorms such as single cell, multi-cell and super-cell type. Some thunderstorms may have a series line up or rain band shape that is called a squall line thunderstorm.

Thunderstorms are formed the rapid upward movement of warm moist air in the atmosphere [5]. There is some triggering force which helps to accelerate the system to upward. Cumulonimbus clouds are formed by the upward movement of the warm & moist air into the unstable weather condition. It cools and condenses when the warm & moist air can reach 20 kilometers or 12 miles height from surface [5][6][7]. There are three ingredients that must be present for a thunderstorm to occur. They are moisture, instability and triggering force. Now, thunderstorms & associated lightning is a national disaster in the country. Scientists related to climate change have suggested [8] that the increase in CAPE (convective available potential energy) must have an impact on climate change and create a favorable situation for greenhouse gas forcing. As high value of CAPE is conducive for severe thunderstorms, we can expect to have more thunderstorms and lightening hazards in future in Bangladesh. With global warming expected to continue in future, thunderstorms will occur more frequently given conductive context for it to form [9].

2. EXPERIMENTAL SET UP & METHODOLOGY

In this study, the current thunderstorm situation of Bangladesh is analyzed. It is mostly used the observed available meteorological data such as thunderstorm and cloud coverage data for this research. In this study, it is analyzed that how the thunderstorms occurrences are correlated with cloud coverage. Below is the flowchart of the research procedure.

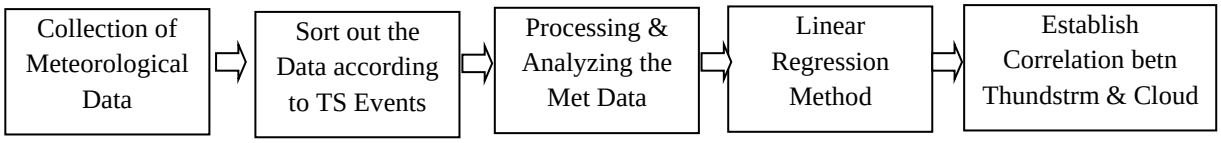

Fig.1. Flowchart of the Methodology

2.1. Study Area

Srimangal is the study area of current research. Srimangal is an upazila in Moulvibazar district of Bangladesh. It is situated in the south-west of the district. Srimangal is often called the 'Tea Capital' of Bangladesh. Srimangal is located at 24.3083°N and 91.7333°E. It has 43,952 households and a total area of 450.74 square kilometers. It is north of Moulvibazar Sadar, south of Tripura, east of Kamalganj and west of Chunarughat, Nabiganj and Bahubal.

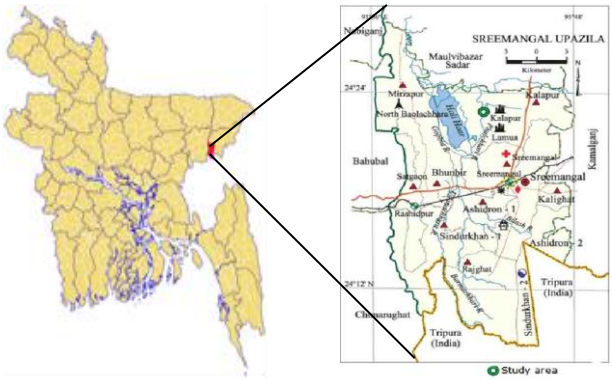

Fig. 2. Study Area: Srimangal region in Moulvibazar district of Bangladesh

2.2. Data Used

The observed thunderstorm and daily cloud coverage data is used to find the correlation between thunderstorms and meteorological parameter i.e. cloud coverage. Bangladesh meteorological department (BMD) is observed and measured these data at the standard time and 08 times per day.

2.3. Linear Regression Method

Linear regression is the method for establishing a relation between two scalar quantities. One is the independent and another is dependent quantity [10]. If the dependent variable depends on more than one independent variable, then the technique is generally called multiple regression method [11]. The linear regression establishes a relation between two parameters or variables; they are independent as well as dependent parameter. The mathematical connection of the two variables is shown by the formula below.

$$y = mx + c \qquad (1)$$

In here, y is the dependent parameter, x is the independent parameter, c is the line interception and m is the line slope.

3. RESULTS AND DISCUSSION

3.1. Analysis of Yearly Thunderstorms

The total number of thunderstorms occurred in the year is considered as yearly thunderstorms. Data is collected from BMD for the year 1990 to 2020. Yearly total thunderstorms are presented in Figure 3 and trend of yearly thunderstorms over Srimangal is shown in Figure 4. From the figure it is found that the trend of yearly thunderstorms is decreased with time in Srimangal.

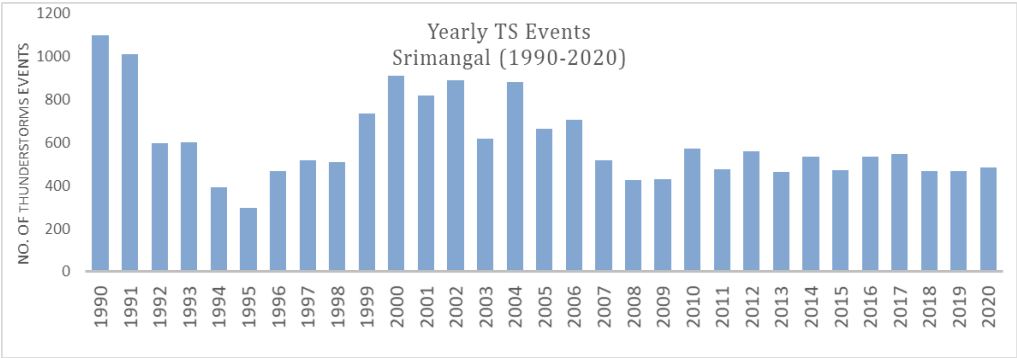

Fig. 3. Yearly thunderstorms events in Srimangal from 1990 to 2020

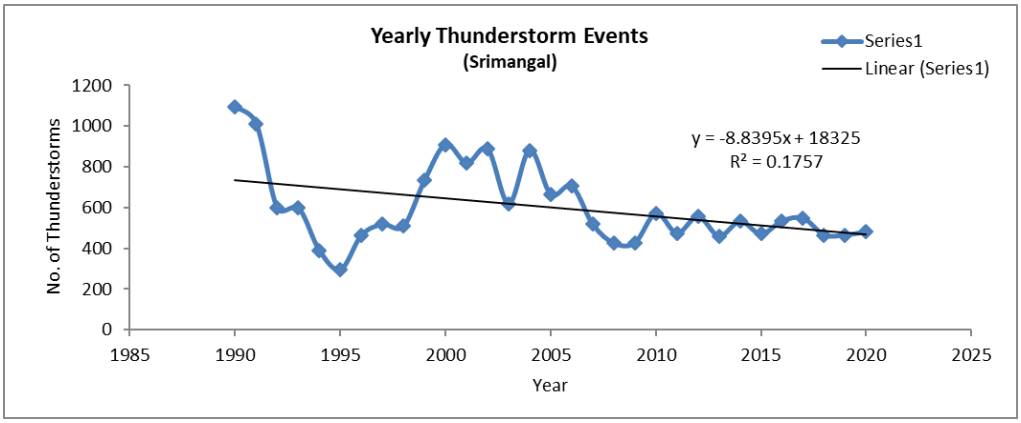

Fig. 4. Trend of Yearly thunderstorm events in Srimangal from 1990 to 2020

3.2. Analysis of Seasonal Thunderstorms

The seasonal thunderstorms distribution from 2015 to 2020 is showed in figure 5 & figure 6. In Figure 7, the trend of seasonal thunderstorms intensity is presented. From figure, it is found that pre-monsoon (March to May) has highest intensity of thunderstorms over Srimangal and lowest in winter (December to February). There are many events of thunderstorm in monsoon (June to September) also.

Fig. 5. Seasonal thunderstorms occurrences in Srimangal from 2015 to 2020

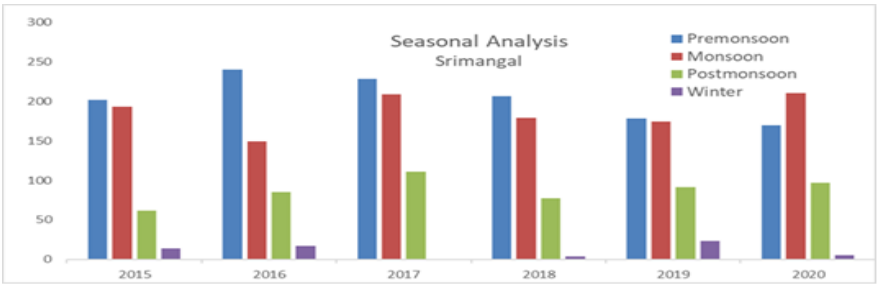

Fig 6. Combined result of seasonal thunderstorms occurrences in Srimangal from 2015 to 2020

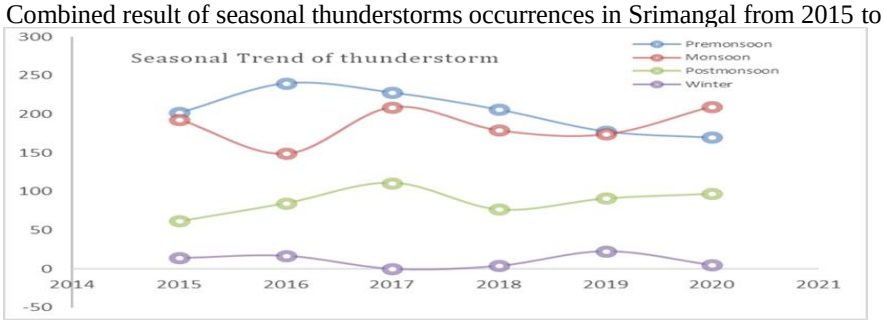

Fig. 7. Trend of seasonal thunderstorms occurrences in Srimangal from 2015 to 2020

3.3. Analysis of Monthly Thunderstorms

Monthly total thunderstorms from January to December are shown in Figure 7 for the year 2015 to 2020. Combined results of monthly total thunderstorms occurrences from 2015 to 2020 in Srimangal region is shown in Figure 9. From the result, it is found that April, May & June are thunderstorms suitable months and many events of thunderstorms are occurred in these three months. Thunderstorm occurrences are moderately occurred in the months of March, July, August, September & October and there are very less number of occurrences from November to February.

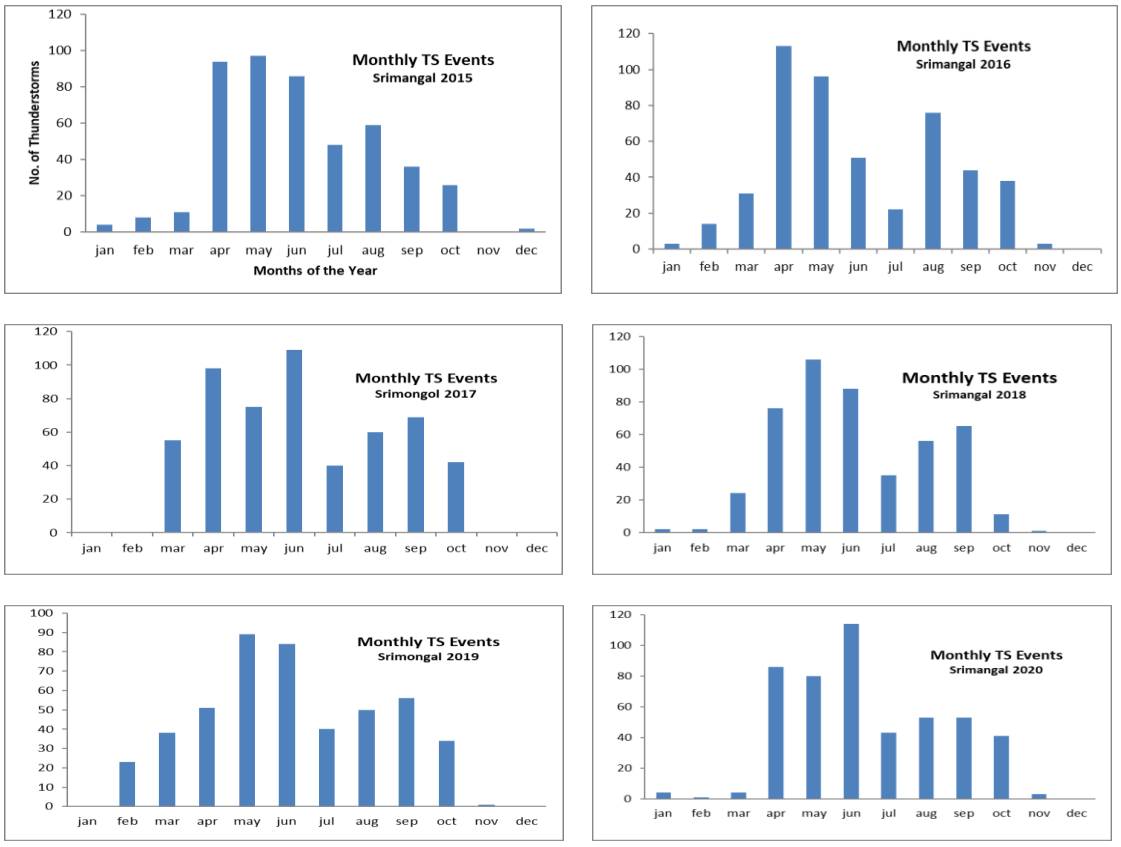

Fig. 8. Monthly total thunderstorms occurrences from 2015 to 2020 in Srimangal region

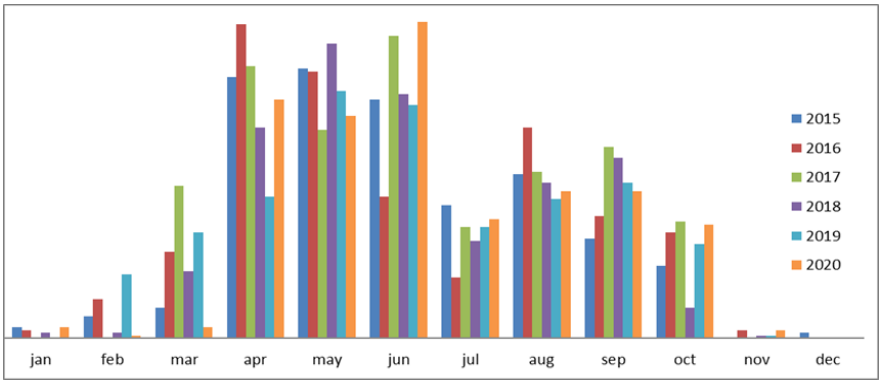

Fig. 9. Combined results of monthly total thunderstorms occurrences from 2015 to 2020 in Srimangal region

3.4. Analysis of Yearly Cloud Coverage

The yearly average cloud coverage on Srimangal region for the year 1990 to 2020 is shown in figure 10 and the trend of average cloud coverage is shown in figure 11. From the figure 11, it is found that the trend of yearly average cloud coverage is slightly increased with time over the study area.

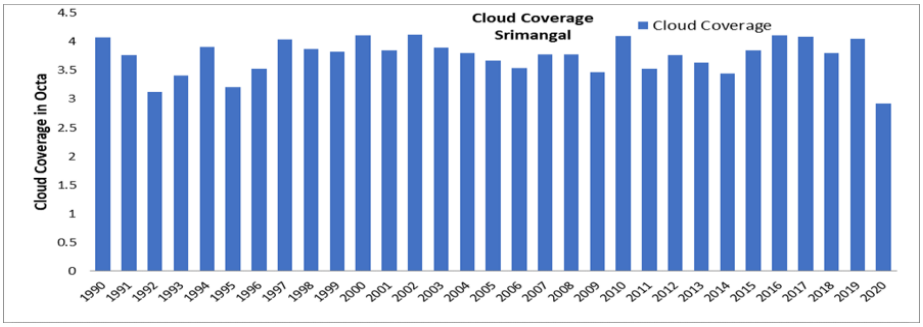

Fig. 10. Yearly average cloud coverage over Srimangal region for the year 1990 to 2020

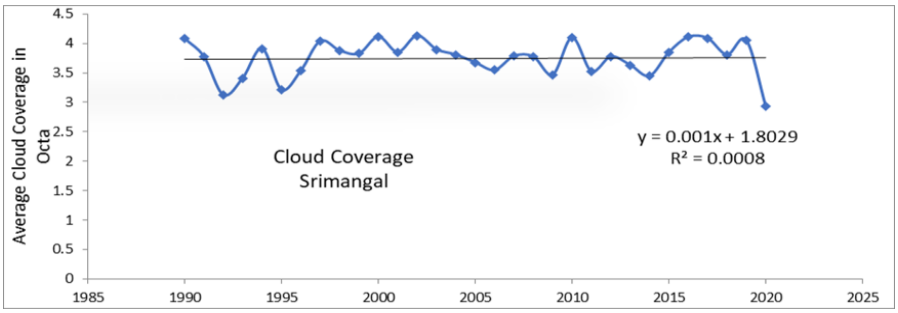

Fig. 11. Trend of yearly average cloud coverage over Srimangal region for the year 1990 to 2020

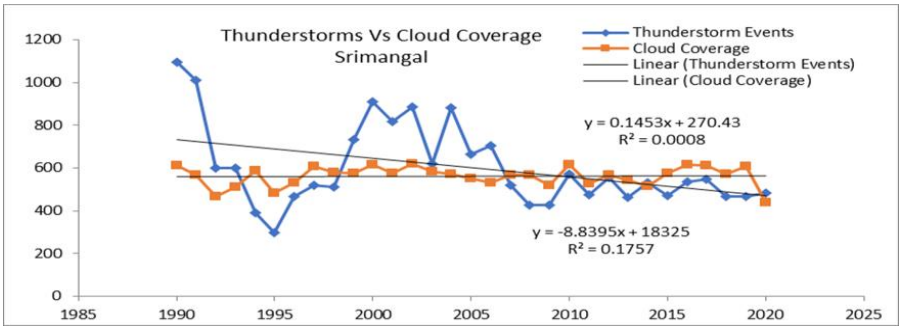

Fig. 12. Thunderstorms versus average cloud coverage over Srimangal region

The predicted cloud coverage is estimated by linear regression method. It is found that predicted cloud is slightly increased with time. Thunderstorms versus average cloud is shown in figure 12. It is found that though average cloud trend is increasing but intensity of thunderstorms is decreasing with time in Srimangal region.

3.5. Analysis of Monthly Cloud Coverage

Monthly average cloud coverage and monthly thunderstorm occurrences are presented in the same figure so that it can be compared and correlated between thunderstorm and cloud coverage in Srimangal region. Figure 13 is showed the correlation from 2015 to 2020.

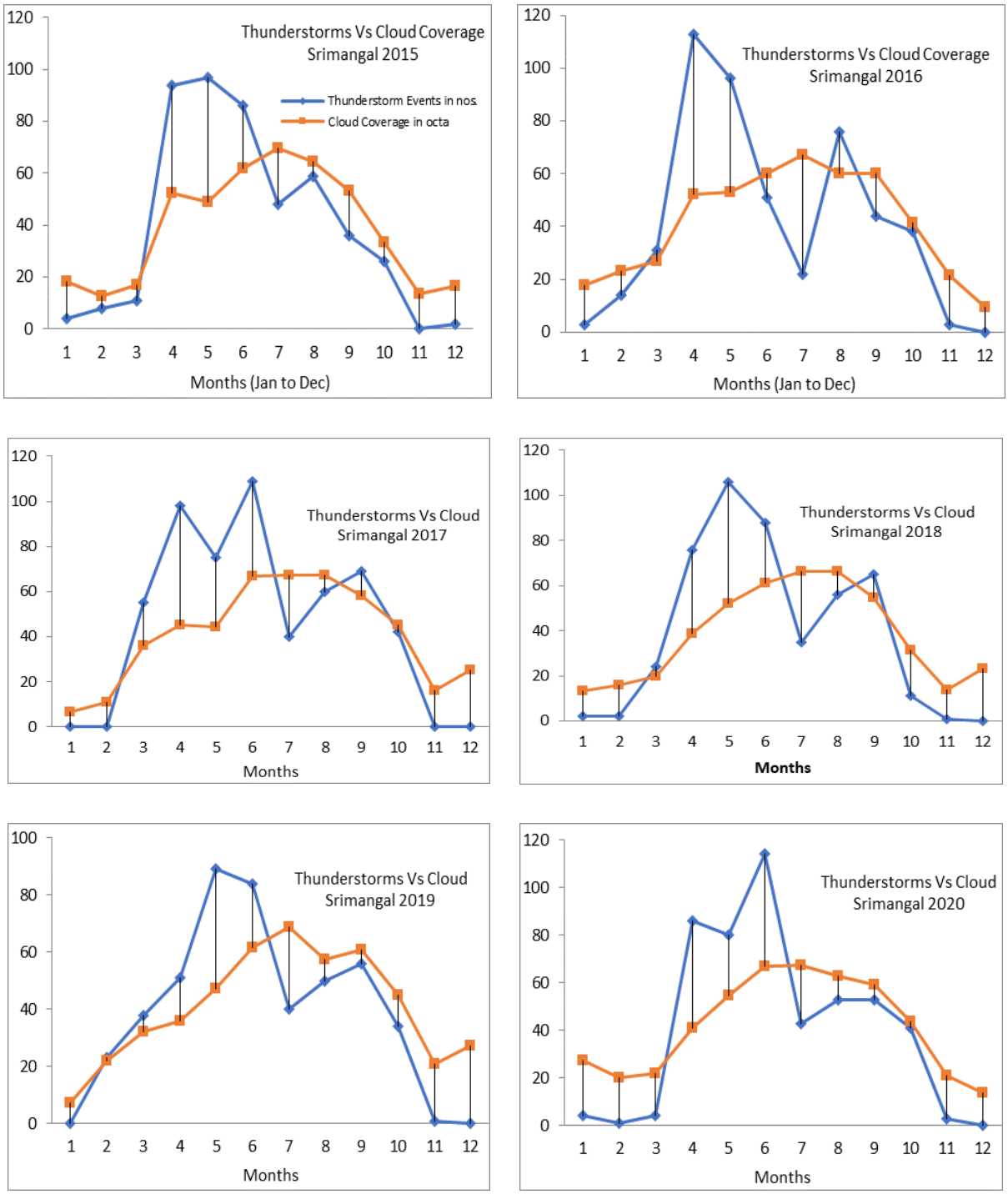

Fig. 13. Monthly thunderstorms versus cloud coverage in Srimangal (2015-2020)

Monthly cloud coverage is measured in octas and is considered ten times of its overage value in this analysis. From the analysis, it is found that thunderstorm intensity is higher than cloud coverage in March, April, May and June and the intensity is decreased from July. Usually, from July to February the thunderstorm intensity is less than cloud coverage over the study area.

4. CONCLUSION

A total of 2968 thunderstorms and associated lightning events occurred in Srimangal region during the last five years from 2015 to 2020. The most favorable months of the year for thunderstorms and associated lightning are April and May. Pre-monsoon (March–May) and monsoon (June–September) are the most vulnerable periods for thunderstorms, and winter (December–February) is the least likely to occur. The risk of thunderstorms and associated lightning has increased in Srimangal over the past few years. But it is true that the number of casualties in the study area has increased sharply in the last five years despite the decrease in lightning incidents. Thunderstorm occurrences depend on many meteorological factors or parameters. But, in the present study, it is considered only cloud coverage which is one parameter. But, there are many meteorological parameters such as temperature, dew point temperature, relative humidity, pressure, LI, CAPE, TTI, K index etc can influences the thunderstorm occurrences.

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