Study on cloud climatology and its relationship with weather pattern in Bangladesh

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Abstract

Clouds have a relationship to all weather elements. It has two opposite seasonal patterns - winter monsoon and summer monsoon. As a result, the flow of cold-dry winds from the northwestern part of India during the winter season, the cloud cover is at a minimum. With the progression of the season, the clouds coverage increased. It has been seen whereas amount of cloud is more, there TS & Li days are also more like Sylhet division. It has been showed, cloud formation is more at Sylhet division, secondly Chattogram division. The yearly total cloud coverage is decreasing due to the post monsoon decreasing trend. Though all of the Bangladesh average cloud coverage is decreasing but increasing at Sylhet division decadal by decadal whereas rainfall and TS & Lightning days are also increasing. The calculated radiation data of Srimangal is consistent to cloudiness. The statistically co-relation between cloud & rainfall shows some month & place is strong and some month& place is weak.

Keywords: Cloud, Rain, Thunderstorm and Lightning.

1. Introduction

A cloud is an aerosol consisting of a visible mass of liquid droplets, frozen crystal or other particles suspended in the atmosphere of a planetary body or similar space [1]. Cloud have a little effect on the increase in Earth's temperature caused by anthropogenic greenhouse gases [2]. Upper-level cloud cover may have declined by 1.5% (of sky cover) over global land from 1971 to 1996 [3]. The past few decades indicate a strong linkage between the type, amount and diurnal variation of the cloud pattern and the rainfall derived from it [4]. A good estimate of the heating profile of the atmosphere can be obtained from the cloud cover over the area [5]. Cloud is formed when air is cooled below its dew point, and if the air is stable the cloud will be stratiform (i.e. layered). The cooling is usually brought about by uplift – rising air expands as the pressure decreases, and adiabatic expansion lower temperature. In the cases of layer cloud, there are three main ways in which air may be lifted to form cloud: (i) Mass ascent (2) Orographic uplift (3) Turbulent mixing [6]. The most significant layer clouds are those which form in the boundary layer – stratus and stratocumulus. These often form quickly with full coverage of the sky and very low cloud base, It cannot be separated of fog, dust, etc. from stratus/low cloud and their accurate forecasting is great importance, especially at aviation [6]. There are various types of low, medium & high cloud. They are - stratocumulus, cumulonimbus, altocumulus, altostratus, nimbostratus, cirrus, cirrocumulus, cirrostratus etc. But this research have considered total amount of cloud which is found more at Sylhet & Chattogram divisions.

Table-1: Approximate heights of cloud [11]

Category	Genera	Polar Region	Temperate Region	Tropical Region
High	Cirrus Cirrocumulus Cirrostratus	3-8km (10 000 – 25 000 ft.)	5-13 km (16 500 – 45 000)	6 -18 km (20 000-60 000 ft.)
Medium	Altocumulus Altostratus Nimbostratus	2 -4km (6 500-13 000ft)	2 -7 km (6 500-23 000 ft.)	2 – 8 km (6 500 – 25 000 ft.)
Low	Stratus Stratocumulus Cumulus Cumulonimbus	From the earth's surface to 2 km (0 - 6 500 ft.)	From the earth's surface to 2 km (0-6 500 ft.)	From the earth's surface to 2 km (0-6 500 ft.)

Clouds are classified by: Shape, Vertical extent and Altitude. Its terminology are given Latin names which describe their characteristics, e.g. Cirro- curl of hair/ High Level, Alto - Mid Level, Nimbo/Nimbus – rain/ High moisture

content, Cumulus – heaped or lumpy cloud, Stratus – layers of flat or low cloud, Cirrus – high wispy [7,8,9]. Clouds families are divided in 10 cloud genus [2]. They are – a) Low level (0-2km)- Sc,St b) Medium level (2-7km) c) High level (5-13km) d) Clouds with large vertical extends (0-13km)

And some special clouds are mamatus, fractus, lenticular, fog, contrails, shelf cloud, wall cloud, green cloud, hole punch cloud etc. [10,11]. Again the cloud levels overlap and their limits vary with latitude-which are showed

2. Objectives

Clouds play a major role in controlling the Earth's energy and water cycles at both global and regional scales. They have an enormous impact on the Earth's weather and climate, mainly through their interactions with radiation. But the genesis, size, cloud base heights and the amounts of clouds are different in different seasons and locations. Even they vary during day and nights also. To understand more on these aspects, the following objectives are taken into consideration:

i. To determine the cloud climatology over Bangladesh;

ii. To understand the variability of cloud coverage;

iii. To establish relationships of rainfall, Thunderstorm and amount of solar radiation with cloud coverage over Bangladesh.

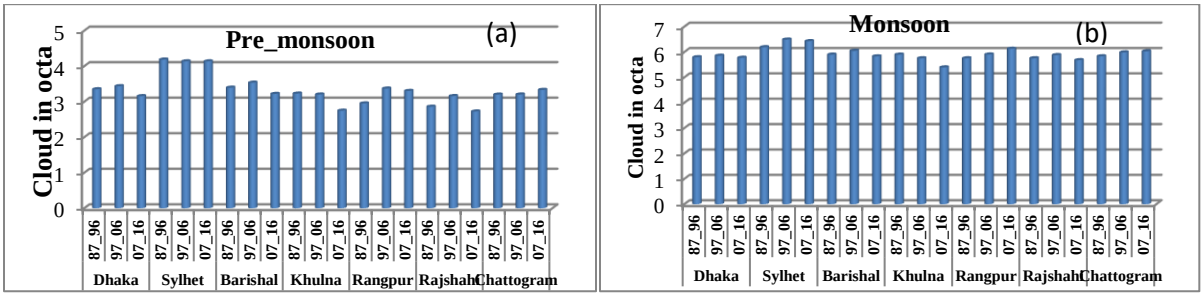
3. Data and Methodology

The monthly, seasonal and annual, decadal of cloud, Rainfall and TS & Li (days) data are constructed based on the 3 hourly observation data. But the daily calculate radiation data are taken from observation data. Most of the cases, some of the missing value are replaced by normal data. All of the data are selected from all weather stations of Bangladesh during the period 1987-2016 (30 years) for winter cases data have been taken from 1986 (December) to 2016 (January-February). And monthly data have been used from 3 hourly data that converted seasonal data which are collected from the Bangladesh Meteorological Department (BMD). These types of data are calculated by FORTRAN language, Excel and GIS have been used for spatial distribution. The location of the weather stations has been selected for this study of all meteorological stations in Bangladesh. There are some limitation to count of low cloud such as fog, haze, cumulus etc. It has no separation among them at cloud recording time.

4. Result and Discussion

4.1 Cloud coverage area

The seasonal divisional amount of cloud coverage figure is showed in fig-2(a-d). The figure shows- the average cloud amount are formed more in Sylhet division but at post-monsoon season Chattogram and Sylhet is same about 2.9 octa clouds. During middle decadal period of all seasons cloud was more than others decadal but at the last decadal period cloud was relatively less than all seasons except Sylhet and Chattogram of pre-monsoon and monsoon and Rangpur of winter season. Actually, in winter season Rangpur cloud formation is increasing gradually (decadal by decadal).



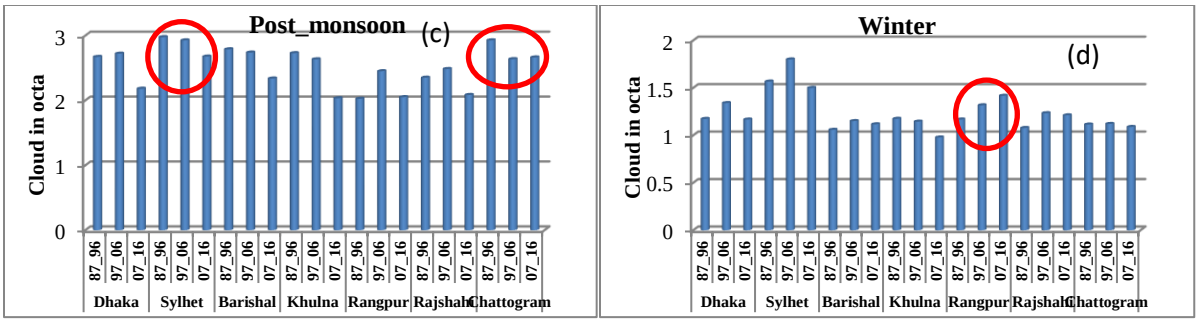


Fig-1 (a-d): Seasonal divisional amount of cloud coverage

4.2 Cloud variation and Trend analysis

The seasonal decadal cloud and yearly average cloud amount are showed in fig- 3(a-b). The fig-(a) shows cloud formation is decreasing year by year. The figure (b) shows the yearly decreasing cloud shows only for post monsoon decreasing cloud. It also shows the middle decadal cloud was more which is showed the previous figure-3

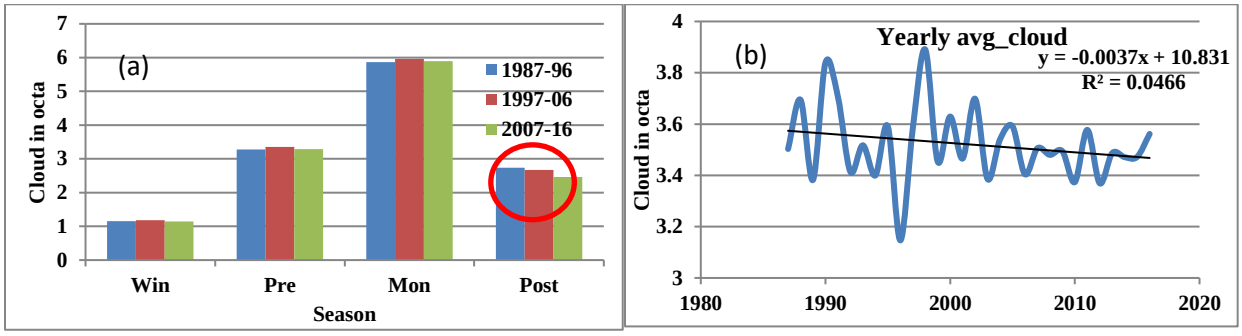


Fig-2 (a-b): Seasonal decadal cloud and yearly average cloud amount

4.3 Comparison of amount of Rainfall and incoming Radiation: Comparison between cloud and incoming radiation of Srimangal are showed in fig-4(a-b). Cloud is disproportional to radiation which is fully clear at 1997 to 2006. In winter, pre-monsoon, monsoon & post-monsoon, when cloud was more at Srimangal station region that time radiation shows less than 1987 to 1996 & 2007 to 2016 decadal periods.

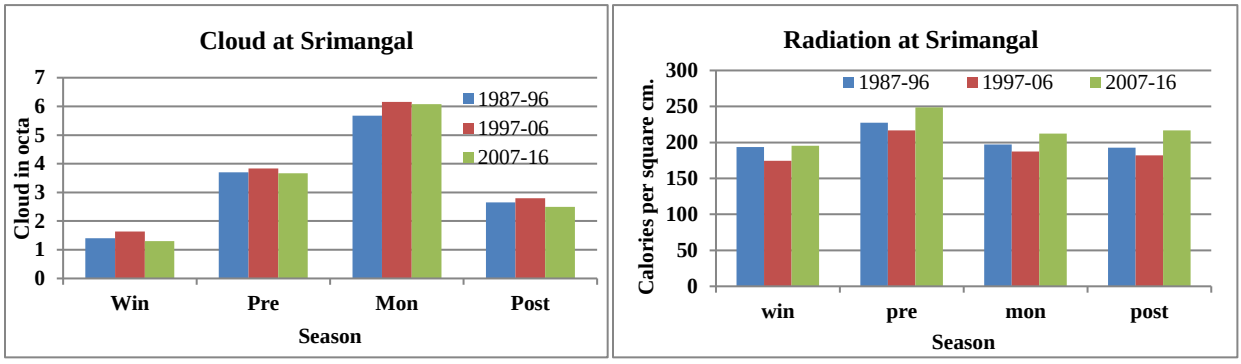


Fig-3 (a-b): Comparison between cloud and solar radiation of Srimangal

4.4 Spatial distribution of seasonal cloud at same scale

Spatial distribution of various seasonal cloud images (pre- monsoon, monsoon, post-monsoon and winter) are showed in fig-5(a-d). It shows less variation among the seasons because of same scale is drawn. But it is clear that in pre-monsoon season, western part of Bangladesh form very low cloud but Sylhet region form more cloud at pre-monsoon and monsoon seasons. In winter & post-monsoon seasons has no remarkable variation.

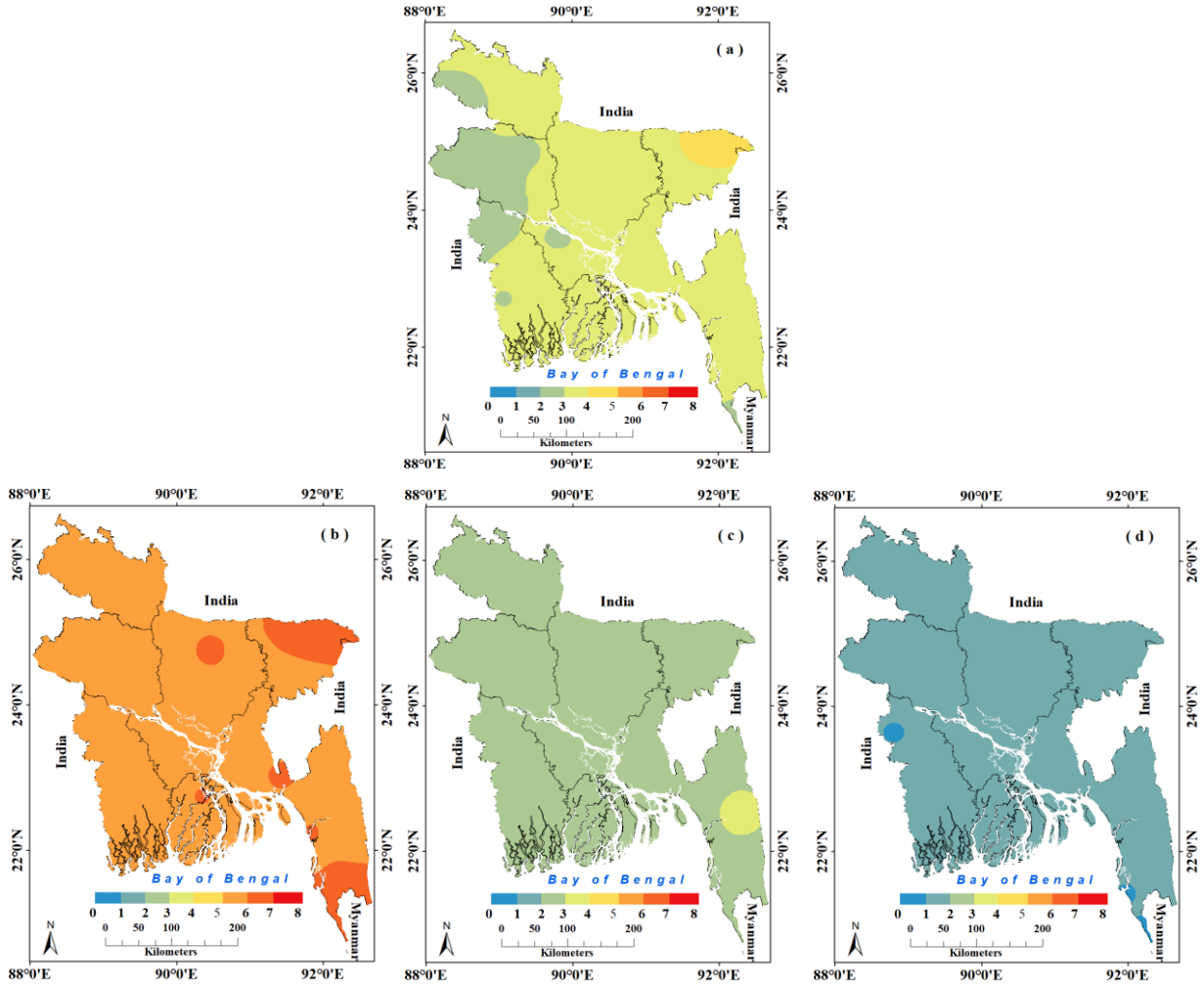


Fig-4 (a-d): Spatial distribution of various seasonal clouds at same scale

4.5 Spatial distribution of seasonal cloud at different scale:

Spatial distribution of various seasonal clouds at different scale image (pre-monsoon, monsoon, post-monsoon and winter) is showed in fig-6(a-d). It shows Sylhet division form more cloud of all seasons and northern and north-western part form less cloud in pre-monsoon and post-monsoon seasons. But in post-monsoon seasons recorded more cloud formation at Chattogram division than Sylhet division. In post-monsoon Chotogram recordeaverage 0.3octa cloud more than Sylhet at the same time at Rangpur division average cloud is significantly less (average 1 octa less than chatoogram division).

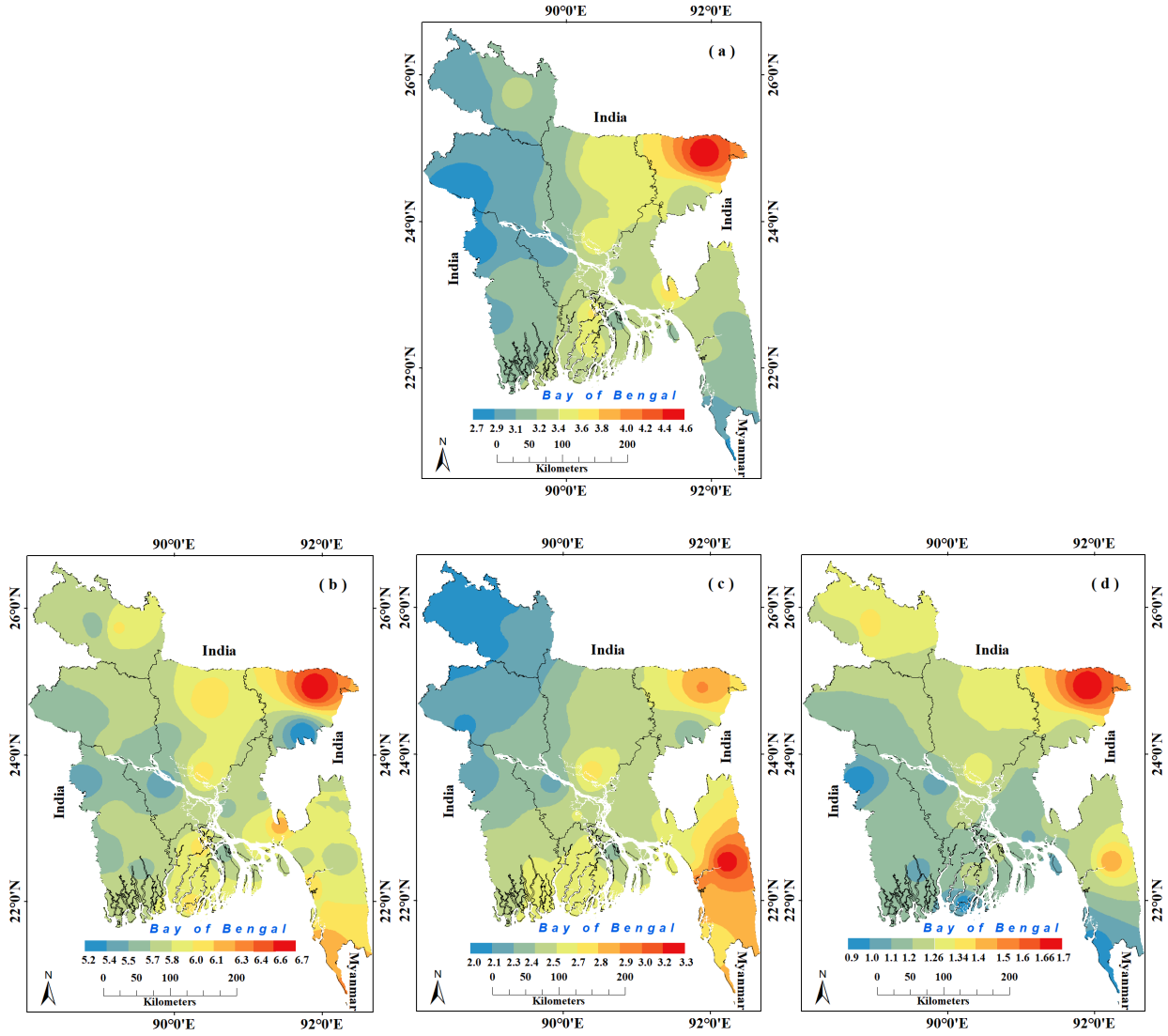


Fig-5 (a-d): Spatial distribution of various seasonal clouds at different scale

4.6 Spatial distribution of Seasonal comparison among Cloud/Rain/TS & Li (pre-monsoon to winter):

Comparison of spatial distribution among cloud, rain and TS & Li of various seasonal images (pre-monsoon, monsoon, post-monsoon and winter) are showed in fig-7. In Sylhet divisions form more cloud at pre-monsoon, monsoon and winters seasons but at post-monsoon season form more cloud at Chattogram division. For rainfall and TS & Lightning also about to same. In monsoon and winter seasons cloud formation more at Sylhet division but overall rainfall recorded at Chattogram, Sylhet and Khulna divisions respectively. Most of the time thunder storm and lightning (TS & Li) has been found at Sylhet division.

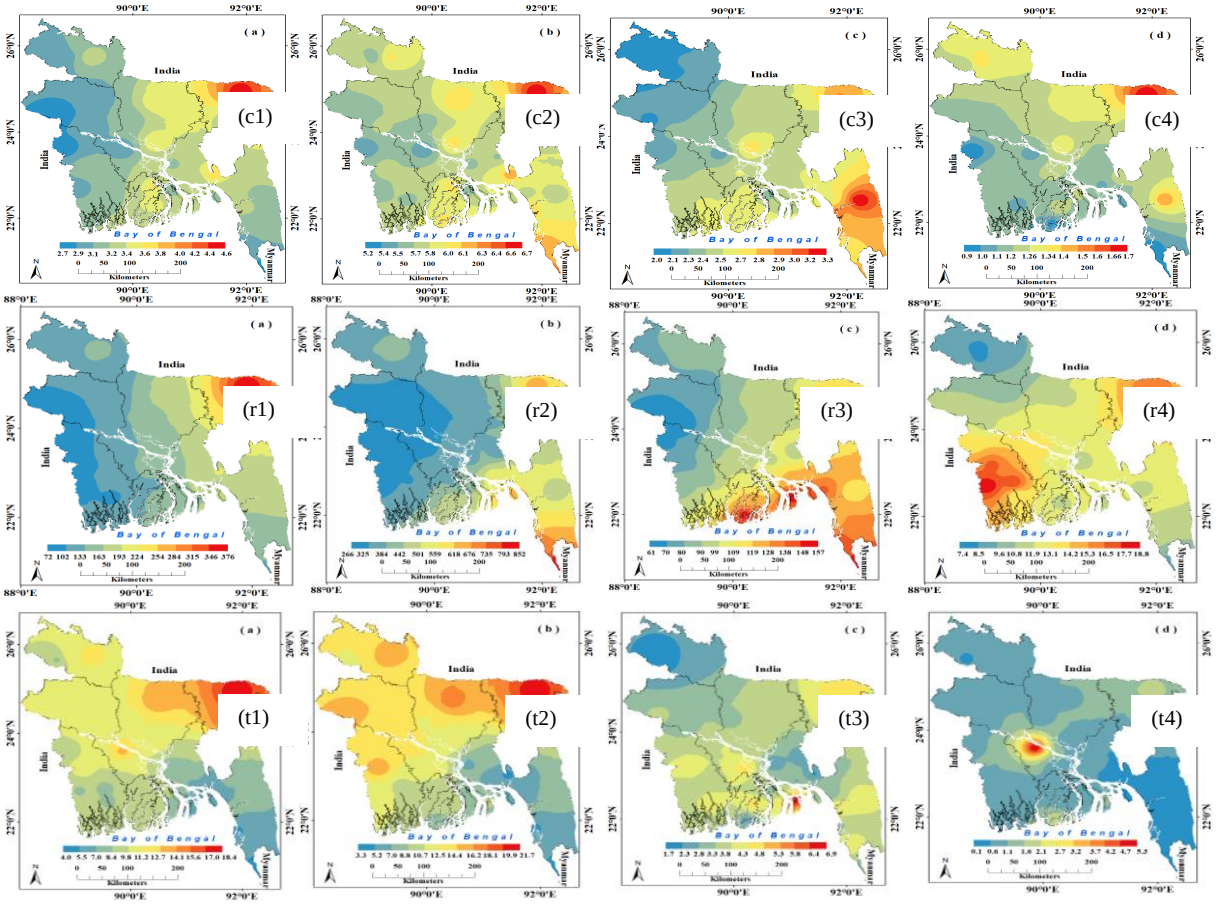


Fig.6(c1-c4, r1-r4 & t1-t4): Comparison of spatial distribution among cloud vs. rain and TS & Li of all seasons

Table-2: Summary of comparison

	Season	Cloud	Rain	TS & Li day
More	Pre	Sylhet	Sylhet	Sylhet
	Mon	Sylhet	Ctg & sylhet	Sylhet
	Post	Ctg	Ctg	Barishal,Ctg
	Win	Sylhet	Khulna & sylhet	Jamuna bridge, NE
Less	Pre	Rajshahi	Western side	Ctg
	Mon	Jssr,Rajshahi	Jssr,Rajshahi	Ctg
	Post	Northern side	Jssr,Rajshahi	Northern side
	Win	Jssr,Cox'sbazar	Northern side	Southern, secondly Northern side

4.7 Cloud verses rain and TS_Lightning

4.7.1Pre-monsoon

The similarity of cloud verses rain and TS & lightning days of pre-monsoon season are showed in fig-8(a-c). At pre-monsoon season, when cloud is more at Sylhet division, rain and TS & Li days are also more at same division secondly Chattogram but TS & Li days is not so much at Chattogram division. The figure also shows, though rainfall is about decreasing all of the division but increasing at Sylhet division decadal by decadal (1987-2016). Among three decadal

average cloud, rainfall and TS & Li days is more at middle (19997-2006) period than another two 1987-1996 and 2007-2016 period.

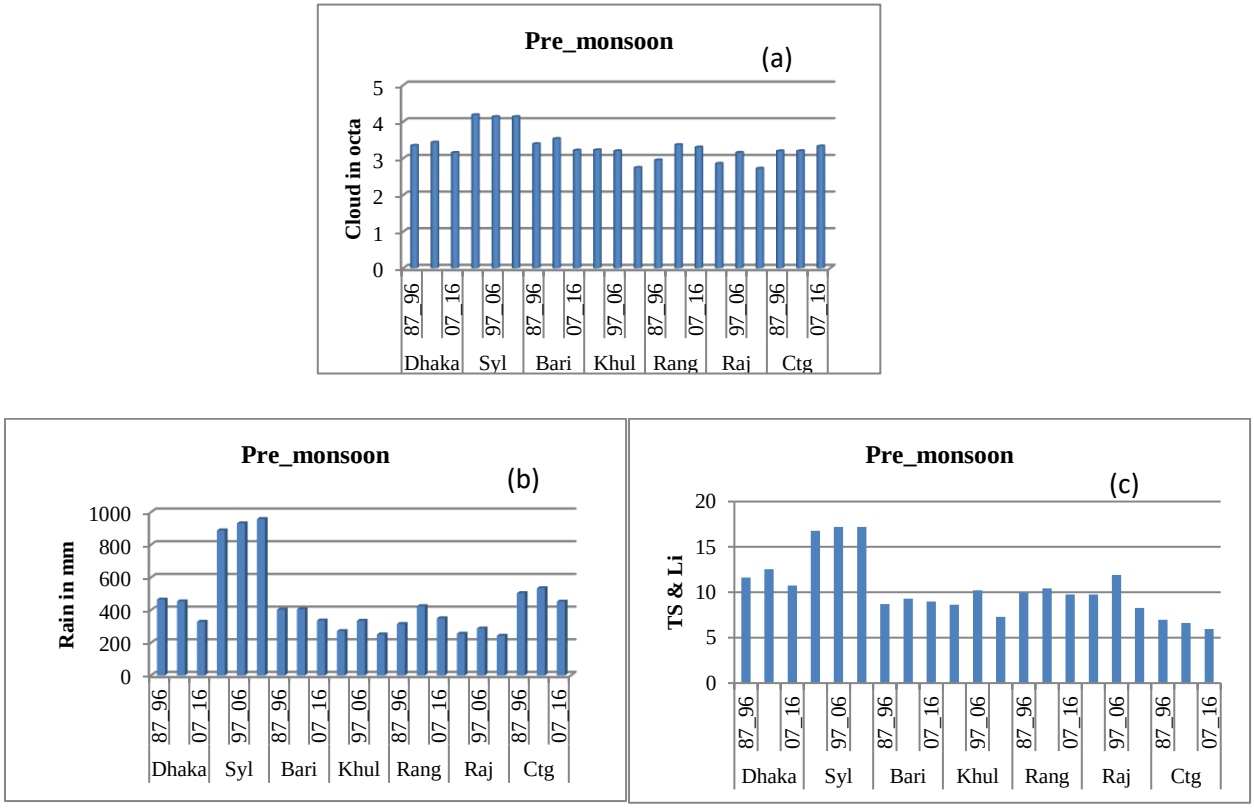


Fig-7 (a-c): Similarity of cloud verses rain and TS & lightning at pre-monsoon

4.7.2 Monsoon

The similarity of cloud verses rain and TS & Li days of monsoon season are showed in fig-9. Though cloud is increased of all division but decreased at Khulna division. Average rainfall is about decreased but increased at chattogram division gradually. This division rainfall recorded more (at last decadal period about 2381mm) than rainfall region division of Sylhet (about 1920mm). And this monsoon season, TS & Li days is recorded more at Sylhet division like pre-monsoon season.

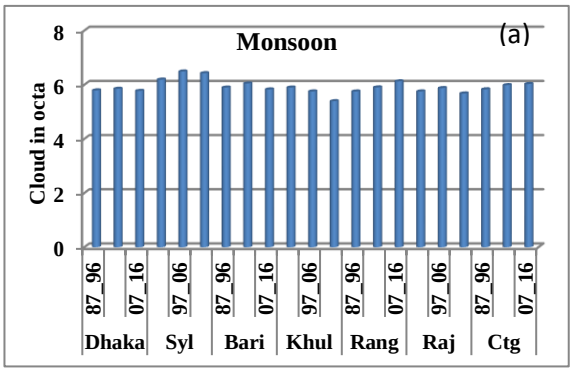


Fig-8 (a): Similarity for monsoon

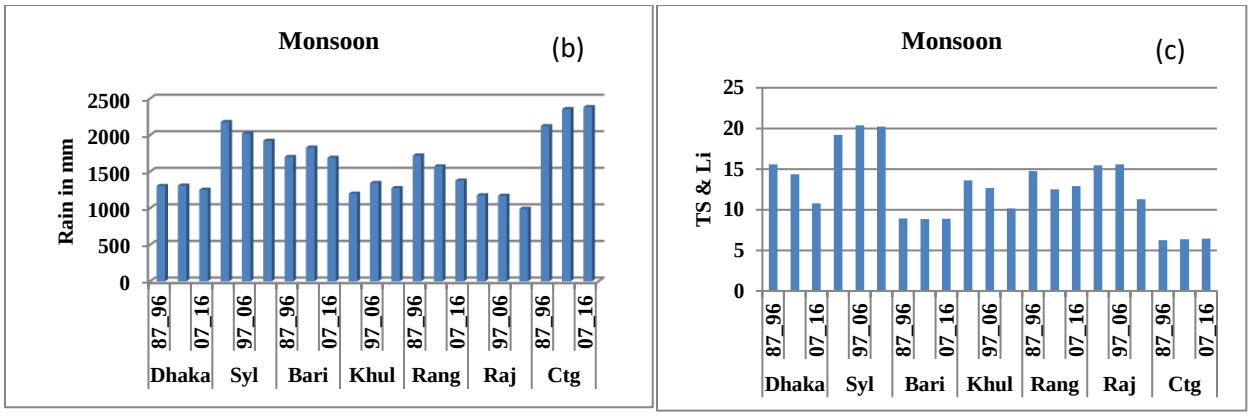


Fig-8 (b-c): Similarity of cloud verses rain and TS & lightning at monsoon

4.7.3 Post-monsoon

The similarity of cloud verses rain and TS & Li days of post-monsoon season are showed in fig-10(a-c). The cloud is more gradually at sylhet, Chattogram, Barishal & Khulna. Though cloud is more at Sylhet division (about3 octa) but rainfall recorded more at chattogram (299mm) and then Barishal (281mm) division. TS & Li days are more at Sylhet division (about 5days) at post-monsoon season.

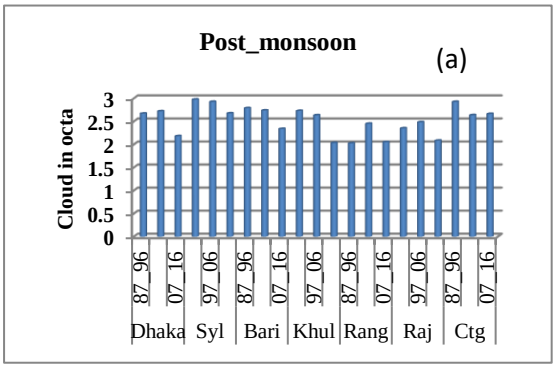


Fig-9 (a): Similarity for post- monsoon

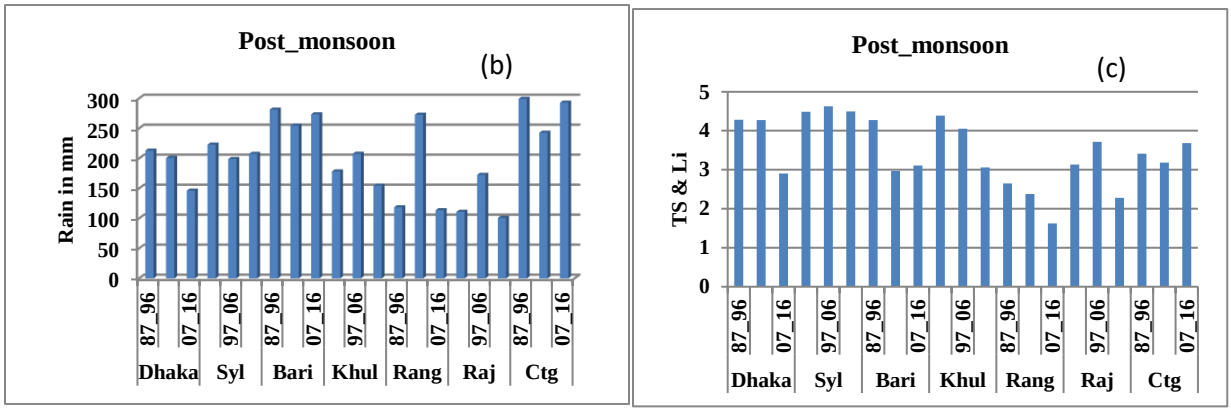


Fig-9 (b-c): Similarity of cloud verses rain and TS & lightning at post- monsoon

4.7.4 Winter

The similarity of cloud verses rain and TS & lightning days of winter season are showed in fig-11(a-c). It shows Khulna, Barishal & chattogram regions recording less cloud amount but all division rainfall condition about to same. Here Sylhet division recorded more cloud (average 1.8 octa), average rainfall 71mm and TS & Li about 2 days. It also shows that rainfall of 1987-1996 all divisions recorded more rainfall than others two decadal periods (1997 - 2006 & 2007 - 2016).

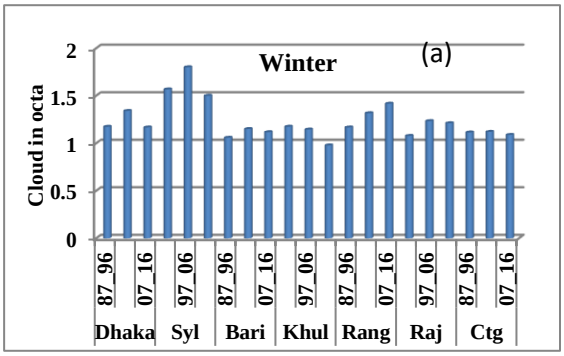
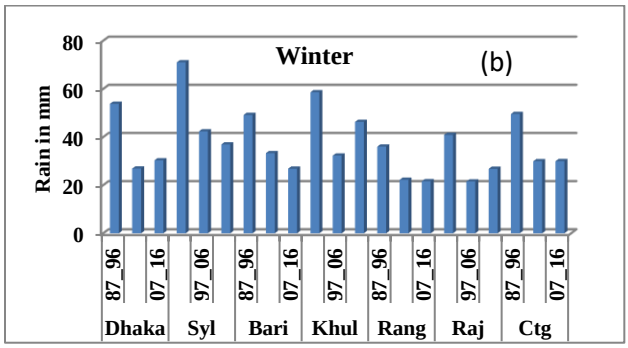


Fig-10 (a): Similarity for winter



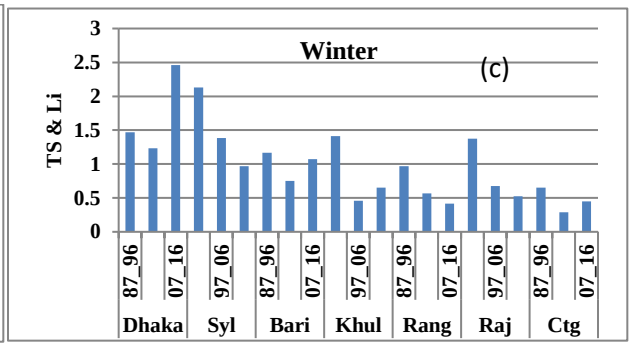


Fig-10 (b-c): Similarity of cloud verses rain and TS & lightning of winter

4.8 Correlation

Rainfall & cloud correlation:

Spatial distribution of the correlation coefficient (CC) between monthly cloud coverage and rainfall during January to December are showed in Fig. 11 (a-l) respectively. The CC's are higher over southwestern and central parts of Bangladesh with its highest magnitude over 0.64, but it is lower over northern part with the lowest at 0.06 in January. On an average CC's are found to decrease from south to north over the country. In Febaruary, the situation is slightly different and the higher CC's are found over northwestern part of the country with its maximum magnitude of 0.7 at Ishurdi. But the gradient of the CC's are low in this month.

In March highest magnitude is Sylhet division of 0.84 and about to 0.2 magnitude at Sandwip & Hatiya. Aong all of the month more gradient at April month where higher and lower magnitude is 0.85 and 0.07 respectively. In May, Cloud and rainfall relation of eastern part is less than others area. The opposite condition of October month where CC of Northern and Northwestern part is less than eastern part. In June, all over the country of CC is about to medium where CC showed slightly low at northern part. In July, August and September, their CC values of highest (about 0.6) , lowest (0.03) are about to same. The magnitude of November is like February and December is also like January.

The The figure shows all relation between (0-1) values. In January Northern part relation is very low than Southern part and the opposite condition of November month. Feruary & July about to medium relation (0.3-0.7). In March & April Chattogram & eastern part of barishal division correlation is very less than others part of Bangladesh. In May, Cloud & rainfall relation is less of eastern part than others. In June,September & December relationship about to same which are medium correlation. In August, southwestern part correlation shows relatively more. Among all of the month, October month corelationship is actually more than others month. This month correlation value is (0.4-0.7). Actually the co-relation between cloud & rainfall is strong of October, May, March, April and weak co-relation is January, December & September respectively.

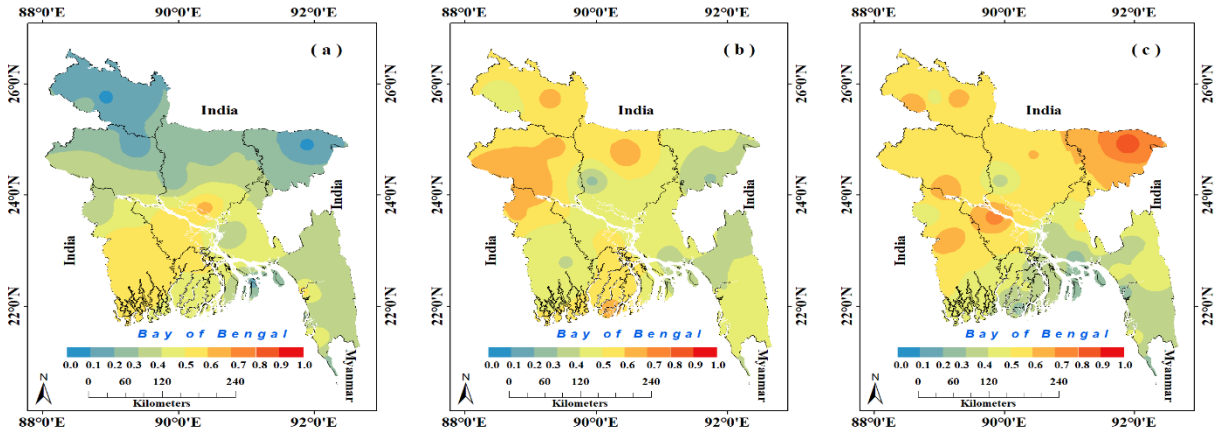


Fig. 11(a-c): Spatial distribution of of CC between cloud coverage and rainfall

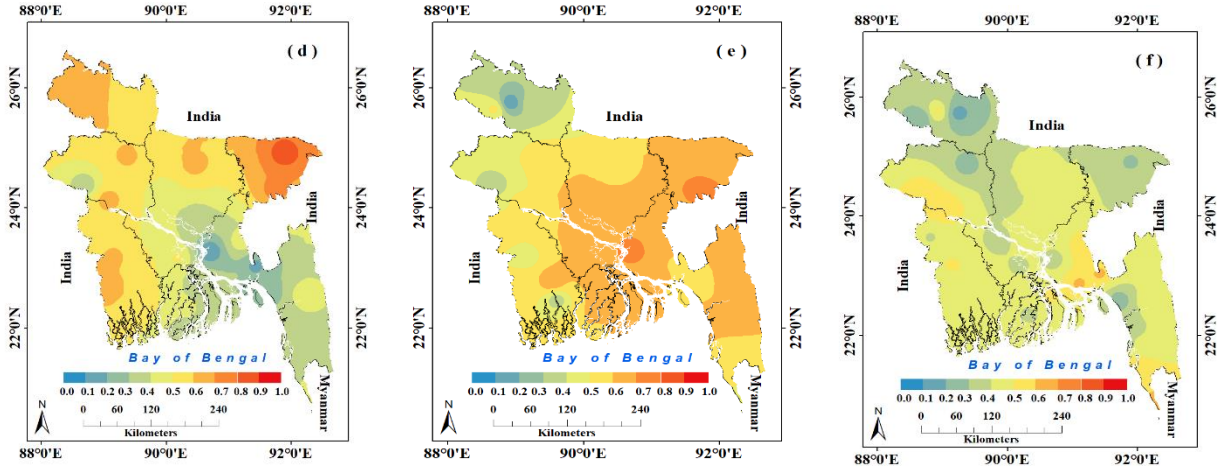


Fig. 11(d-f): Spatial distribution of of CC between cloud coverage and rainfall

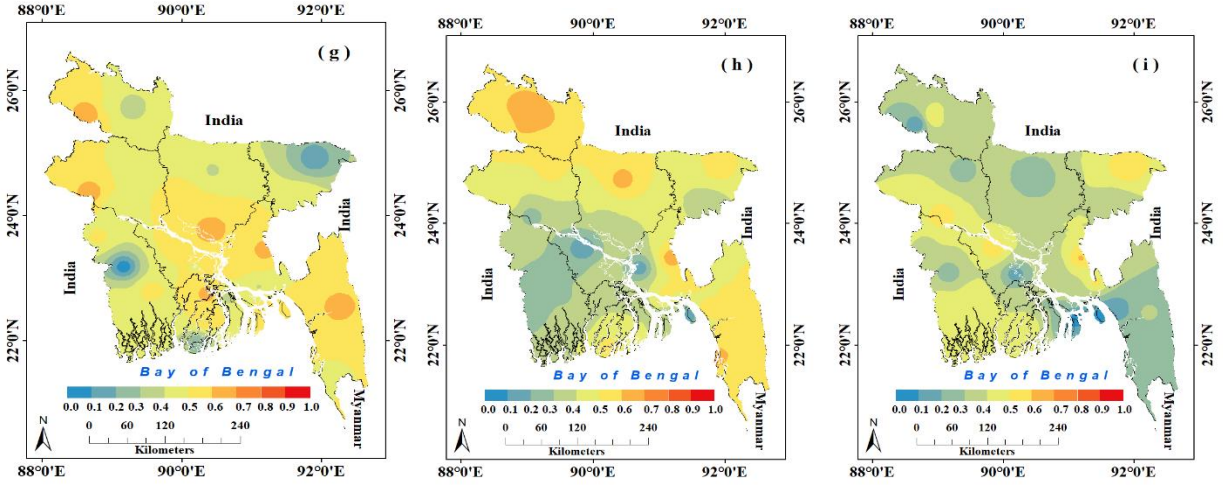


Fig. 11(g-i): Spatial distribution of of CC between cloud coverage and rainfall

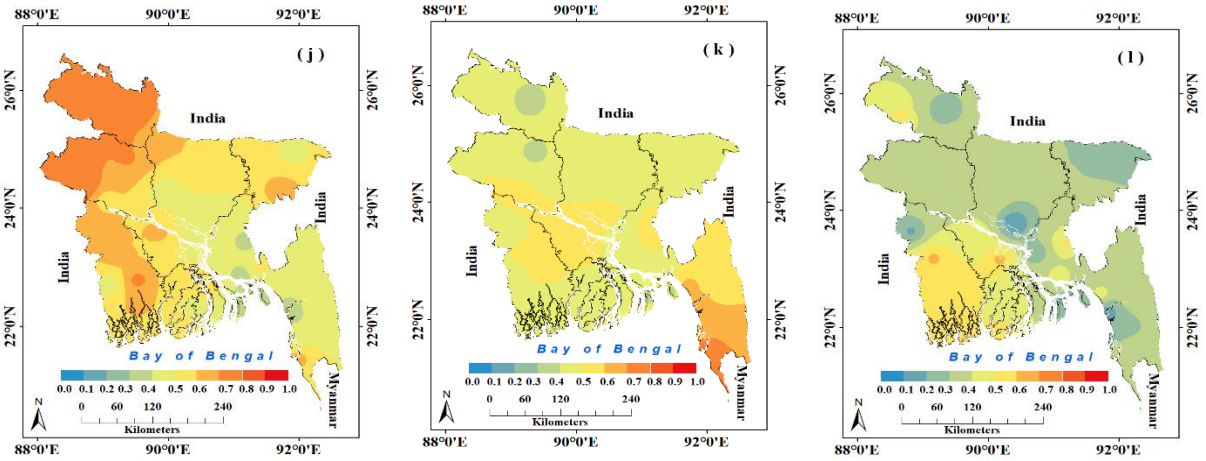


Fig. 11(j-l): Spatial distribution of of CC between cloud coverage and rainfall

But Correlation coefficient between normalized pixels count values of convective, statiform cloud amount,total cloud amount and rainfall for the Core Monsoon Region(CMR) of India [5] :

Table-3:

Phase/Type	Convective vs Stratiform	Convective vs Rainfall	Stratiform vs Rainfall	Total cloud vs Rainfall
active	0.928	0.900	0.981	0.978
Break	0.869	0.819	0.755	0.781

5. Conclusion

By reflecting sunlight, blocking outgoing longwave radiation, and producing rainfall, clouds have an enormous impact on Earth's weather and climate [2]. Actually clouds have a relationship among all of the weather elements. Whereas amount of cloud is more, there TS & Li days are also more like Sylhet division. It also says that rainfall occurred more from convective cloud (91%) than statiform cloud (77%) [5]. It has been showed, cloud formation is more at Sylhet division, secondly Chattogram division. The yearly total cloud coverage is decreasing due to the post monsoon decreasing trend. Among three decadal period of Bangladesh average cloud was more at 2nd decadal period (1997-2006) than others period. Though all of the Bangladesh average cloud is decreasing but increasing at Sylhet division decadal by decadal whereas rainfall and TS & Lightning days are also increasing. The TS & Lightning days of Dhaka division at winter season is increasing except 2007 to 2016. The calculated radiation data of Srimangal is consistent to cloudiness. The findings of this study are a great role of cloud with rainfall, TS & Lightning_days & radiation.

Acknowledgement

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