P12.9 OBSERVATIONAL STUDY ON THE PRE-MONSOON RAIN OVER BANGLADESH

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1. INTRODUCTION

The rainfall phenomena before the monsoon onset are known over Bangladesh and the northeastern part of India. Matsumoto (1997) calculated the onset of rainy season by the index of precipitation over the Asian summer monsoon region, and indicated that the Assam region of India is earliest region where the onset of rainy season starts. Also in Bangladesh where is located in the northeastern region of the Indian subcontinent, the severe local storms, sometimes associated with tornadoes, damaging hail and strong wind, frequency occurs during the pre-monsoon season during the period from March to May (e.g., Peterson and Mehta, 1981, 1995; Goldar et al., 2001; Yamane and Hayashi, 2006). Such kind of the disturbance during the pre-monsoon season cause severe damage almost each year. In last century, Bangladesh has many disasters and that damage was huge. In top 10 of loss of life caused by natural disasters in last century, we can find the 4 cases caused by the severe local storm during the pre-monsoon season (table 1). For instance, the tornado in May, 1996 in northern part of Bangladesh caused 540 deaths (Figure 1), and that in April, 2004 caused 66 deaths in the northern part of Bangladesh.

As climatological studies, the severe local storms in the Indian subcontinent were mainly treated. In Peterson and Mehta (1995) show the distribution and the frequency in month of tornadoes in the Indian subcontinent during the period from 1831 to 1993 (Figure 2). They show the high density of occurrence of tornadoes is located around Bangladesh and the West Bengal, India. They also indicated that high season of tornadoes is in April.

In the United States, many cases of the severe local storms were reported. Previous studies indicated that the important elements for the severe local storm are thermal instability and vertical wind shear (e.g., Brooks et al, 2003; Craven et al., 2002). Recently, Yamane and Hayashi (2006) shown the evaluation of environmental conditions for the formation of severe local storms across the Indian subcontinent using CAPE (Convective Available Potential Energy), which is one of index indicated

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the atmospheric instability, calculated by ECMWF (European Centre for Medium-Range Weather Forecasts) 40 years reanalysis data (ERA-40). High thermal instability and vertical wind shear occur in Bangladesh and the northeastern India during the pre-monsoon season (Figure 3). They showed that there is great potential for severe local storms during the pre-monsoon season in Bangladesh and northeastern India. Reason of high frequency of the severe local storm during the pre-monsoon season, however, is not clarified.

In this study, the rainfall phenomena during the pre-monsoon period over Bangladesh in 2007 are investigated using OLR and the NCEP/NCAR reanalysis data during the period from March to May in 2007. Moreover, for the purpose of clarifying the atmospheric condition and the structure of the disturbance during the pre-monsoon period, we carried out the upper air observation at Dhaka in Bangladesh during the period from 20 April to 15 May in 2007.

2. DATA AND METHODOLOGY

In Bangladesh, the observational data is not enough to clarify the rainfall phenomena during the pre-monsoon season. Until now, we strongly have rolled out the network of self-recording rain gauge. We also have carried out the intensive observation of the upper balloon observation. This upper balloon observation, however, was limited in summer monsoon season. We carried out the intensive observation using the upper balloon to clarify the atmospheric condition during the pre-monsoon season and structure of disturbance at Dhaka in Bangladesh during the period from 20 April to 15 May in 2007.

As of in April, 2007, the Bangladesh Meteorological Department (BMD) carry out the routine upper observation once 2 days. This observation site is in head office of BMD, Dhaka, and the observation time is 00UTC (06LT). The equipment of the upper observation is RS80 (VAISALA). We had carried out the upper observation 3 times (00, 06, 12UTC) in a day during the period from 20th April to 15th May in 2007 (Figure 4). When the BMD have a routine upper observation, we used their observational data to analyze. Our equipment of the upper observation is RS92-SGP (VAISALA) rented from the Hydrospheric Atmospheric Research Center (HyARC), Nagoya University, Japan.

We used the reanalysis dataset to investigate the atmospheric condition widely. Wind, uplift flow (omega), and specific humidity data are obtained by the daily mean values of the reanalysis of the National Centers for Environmental Prediction / National Center for Atmospheric Research (NCEP/NCAR) (Kalnay et al., 1996). As an indicator of the convective activity, the daily mean interpolated OLR (Outgoing Longwave Radiation) data provided by the National Oceanic and Atmospheric Administration (NOAA) are utilized (Liebmann and Smith, 1996).

3. RESULTS

The time series of OLR over Bangladesh (22.5 - 27.5N, 87.5 - 92.5E) from March to May in 2007 is calculated (Figure 5). It is well known that an average monsoon onset over Bangladesh occurs in early June (e.g., Ahmed and Karmakar, 1993; Wang and LinHo, 2002). In March, the convection activity becomes suppressed. During the IOP, we can divide it into 3 spells (A: 20 - 27 April, B: 28 April - 5 May, C: 6 - 14 May) by the OLR value indicated the convective activity. During spells A and C, there is comparatively convection activity. On the other hand, and the convection activity become suppressed during spell B. Actually, the meso-scale disturbance activity with a dead person is active in A. Although the convective activity during spell C is active, there was little rainfall by the ground observation. We carried out the composite analysis of OLR about each period in spell A, B, and C. It is shown that the lower OLR region goes southward from the middle latitude in spell A. In addition, the lower OLR region of the southern part of the Indochina Peninsula goes northwestward from spell A to C. It is suggested that the eastward moving and passage of the trough of the upper air along the south slope of the Tibetan plateau brought the rainfall phenomena during the pre-monsoon period. The northeastern part of Indian subcontinent during the pre-monsoon period is affected by the middle latitude.

We carried out the composite analysis of wind field on each period (Figures 6 and 7). During spell A, the southwesterly with a moist air in the lower troposphere (925 hPa layer) was dominated. On the other hand, the south (north) component was dominated during the spell A (B) in the upper troposphere (300 hPa layer). This thing means that Bangladesh was located in the front (rear) side of the upper trough during the spell A (B).

According to the radio sonde observation at Dhaka (Figure 8), the relative humidity decreased at about 4000 - 5000 m height during spell B. From the characteristic point of the equivalent potential temperature and the wind direction during spell A, the moisture was produced by the strengthening of southerly, so that, it became the air condition of the thermal instability with increase of equivalent potential temperature in the lower troposphere. Moreover it is suggested that the trough passage from west to east because of the decrease of equivalent potential temperature in the middle troposphere from spell A to B. When Bangladesh is located in the front side of the upper trough, it is suggested the strengthening of the uplift flow and southerly in the lower troposphere. From the time series of uplift flow produced by NCEP/NCAR reanalysis data (Figure 9), it is shown that the strengthening of uplift flow during spell A and the downward flow during spell B.

4. SUMMARY

For summary of this study, the one of the reasons of the convective activity during the pre-monsoon is the strengthening of the uplift flow and southwesterly in the lower troposphere in the front of the upper trough. The rainfall phenomena during the pre-monsoon season over the Indochina Peninsula were investigated using the reanalysis data (Kiguchi and Matsumoto, 2005). They also pointed out that the rainfall during the pre-monsoon season were effected the mid-latitude regime. It is suggested that the weather in this region are also effected the mid-latitude regime during the pre-monsoon season.

5. FUTURE WORK

In future, it is needed that the upper air radio observation at multiple stations to clarify the strengthening of uplift flow. Furthermore, it is necessary to investigate the effect from the low-latitude regime.

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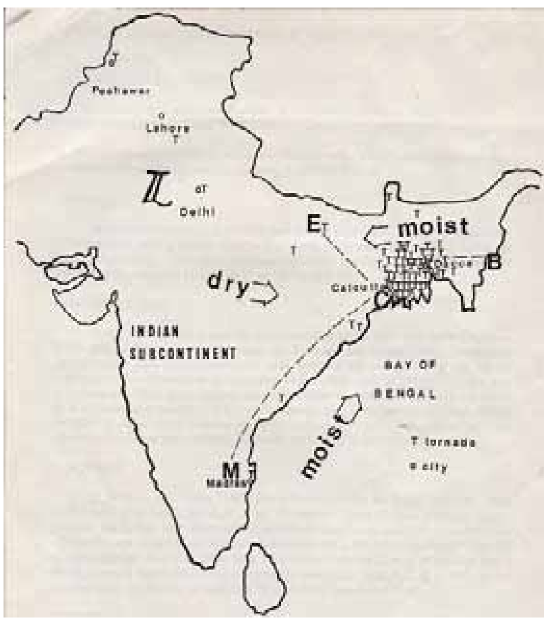
Table 1 Top 10 of loss of life caused by the natural disasters in Bangladesh. This table is listed from the database of EM-DAT.

Disaster type	Date	Loss of life
Drought "Bengal drought"	1943	1,900,000 (1,500,00~3,000,000)
Epidemic "Spanish flu"	1918	393,000
Wind storm "Killer Cyclone"	12 Nov., 1970	300,000
Wind storm	29 Apr., 1991	138,866
Wind storm	Oct., 1942	61,000
Wind storm	11 May, 1965	36,000
Flood (include of starving)	July, 1974	28,700
Wind storm	June, 1968	12,047
Wind storm	28 May, 1963	11,500
Wind storm	9 May, 1961	11,000


Tornado batters Tangail-Jamalpur
Death toll may cross 500

Figure 1 The clipping (15th May, 1996) of the newspaper "THE BANGLADESH OBSERVER" published in Bangladesh.



←(a)

(b)

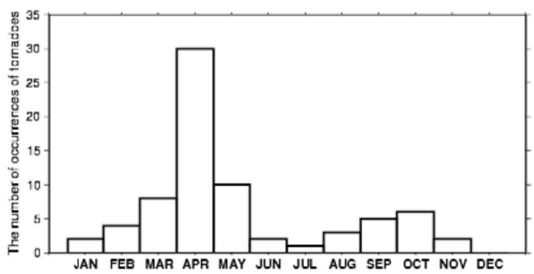


Figure 2 The distribution (a) and monthly frequency (b) of tornadoes in the Indian subcontinent (Peterson and Mehta, 1995). T indicates the location of tornado.

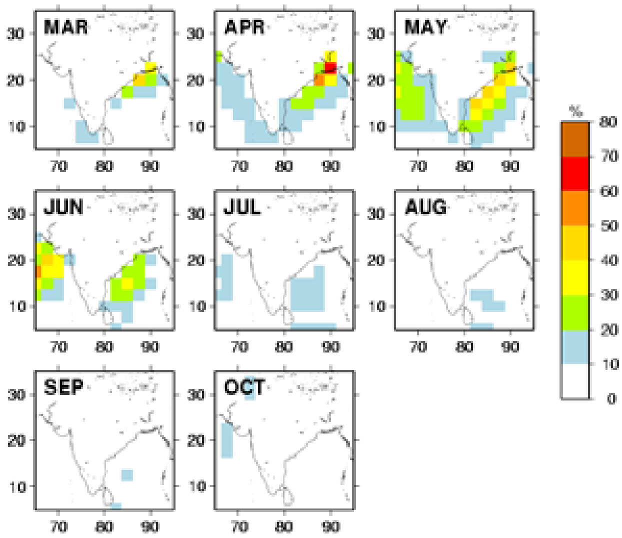


Figure 3 The distribution of the monthly frequency of data with CAPE exceeding 2000 Jkg^{-1} and SHEAR (the magnitude of the vector difference between the winds at 10m above ground level and 500 hPa) exceeding 10 ms^{-1} from March to October. (Yamane and Hayashi, 2006)

Figure 4 Upper observation scenery at Head office of BMD, Dhaka, Bangladesh.

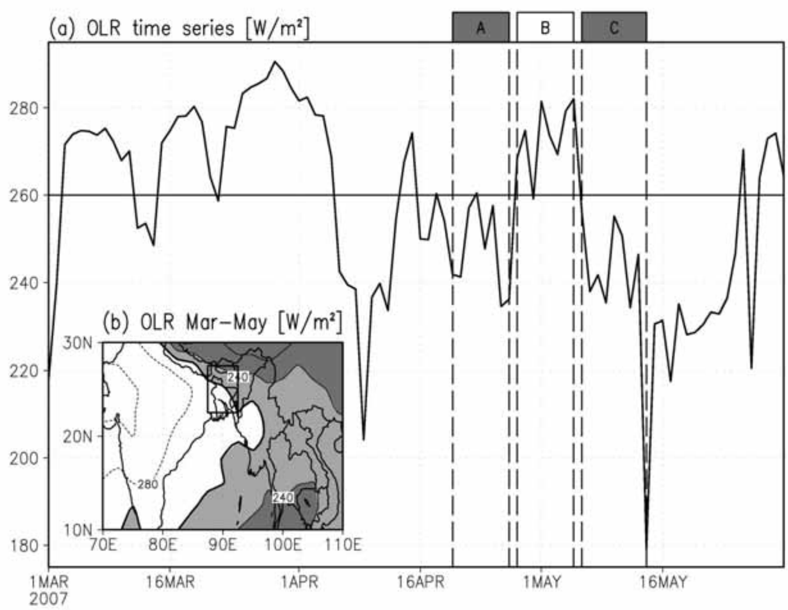


Figure 5 (a) Time series of area-averaged OLR from March to May in 2007. The area-averaged region is shown in (b). The distribution of the mean value OLR during the period from March to May. Unit is W/m^2. Contour of (b) is 20 W/m^2. Shading indicates the regions of less than 240 W/m^2.

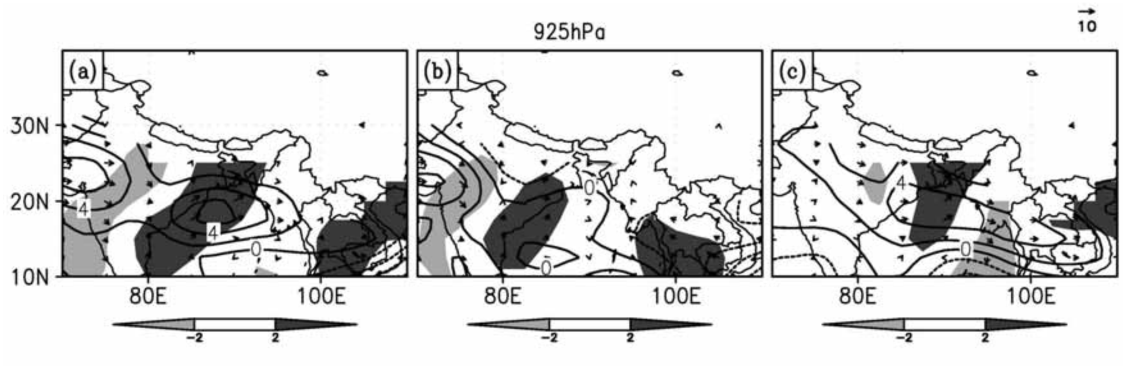


Figure 6 The composite map of wind speed and direction on 925 hPa. Zonal and meridional winds are illustrated using contoured and shaded, respectively. Shade and dark of shadings are less than -2 m/s and more than 2 m/s, respectively. Unit is m/s.

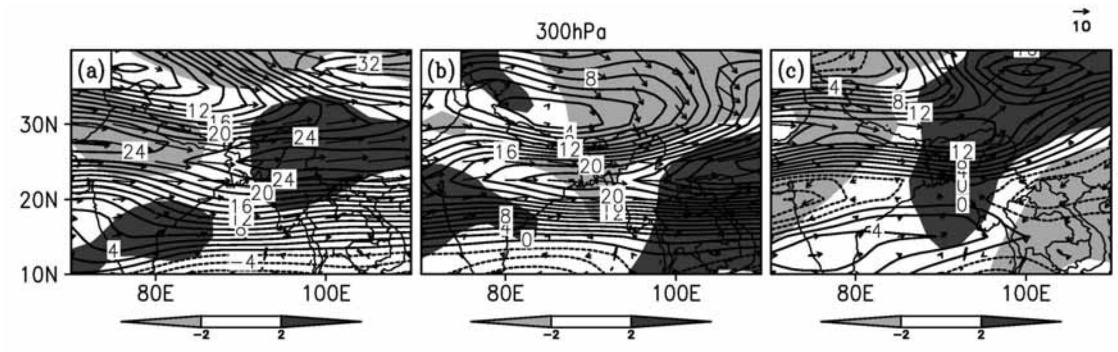


Figure 7 Same as Fig. 6, but for the 300 hPa wind vector.

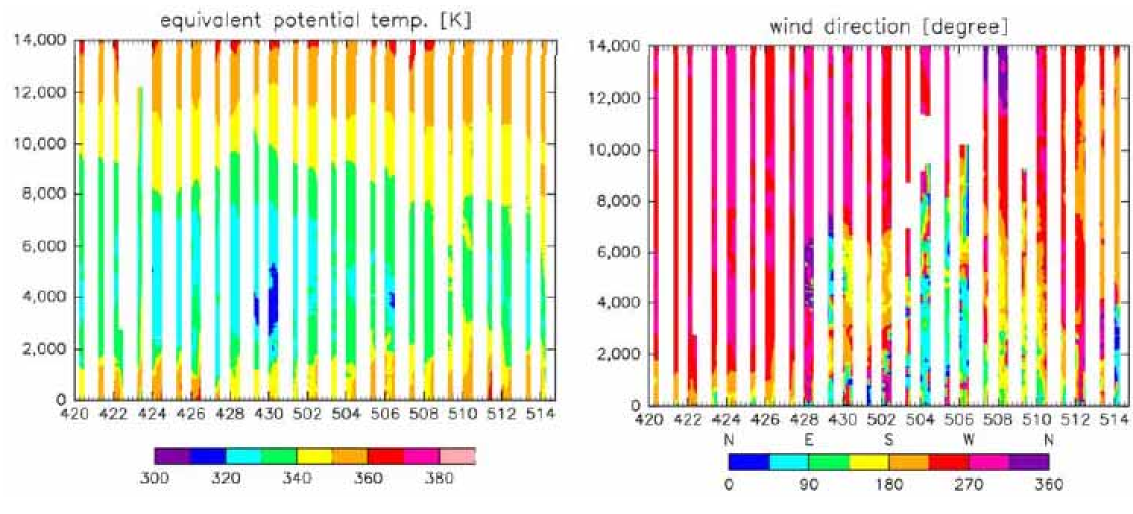


Figure 8 The time-height cross section obtained by the upper observation of the equivalent potential temperature (left) and wind direction (right). Units of panels are Kelvin and degree, respectively. Unit of the vertical axis is m.

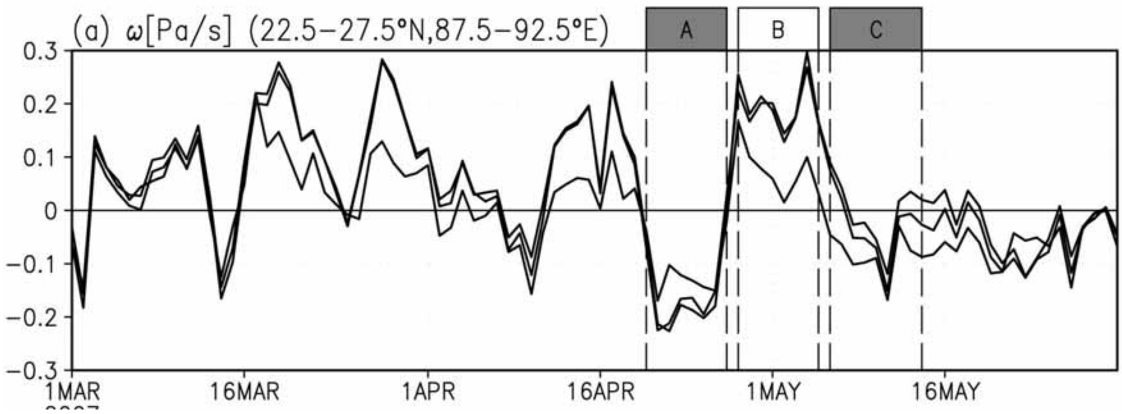


Figure 9 The time series of the area-averaged omega obtained by the reanalysis data from March to May in 2007. Unit is Pa/s. Each line mean the omega on 925, 850, 700 hPa layers.