The observation of pre-monsoon meso-scale cloudsystems developed over Bangladesh

*Toru Terao[(1)], Md. Nazrul Islam[(2)], Fumie Murata[(3)], Taiichi Hayashi[(4)]
(1: Osaka Gakuin University, 2: Bangladesh University of Engineering and Technology, 3: Research Institute for Humanity and Nature and 4: Kyoto University)
∗ Toru Terao, Faculty of Informatics, Osaka Gakuin University, Japan, 564-8511, Kishibe-Minami, Suita, Osaka, Japan. e-mail: terao@s.osaka-gu.ac.jp

Abstract

Using observations with relatively high temporal and spatial data resolutions such as AWS installed by our research group and radar of Bangladesh Meteorological Department (BMD), the meso-scale structure of pre-monsoon and monsoon cloud systems were investigated. In 2004, severe tornado attacked Mymensingh district on 14 April. On 23 May, strong meso-scale system developed over the country, causing two launches capsized by strong wind on the Meghna river somewhat downstream of Dhaka near Chandpur. The meso-scale system developed on 14 April had elliptical shape with size of several tens of kilometers. That developed on 23 May had rather larger size. It was composed of two parts; one was a strong convective rainband with size of several hundred kilometers and the other was trailing stratiform clouds. The data of AWS in Dhaka elucidated some characteristics of this convective system. The pressure increased around the convective rainband. Suddenly the temperature falled and the wind direction changed quickly to northwesterly.

Keyword: Bangladesh, pre-monsoon, tornado, meso-system, AWS.

1. Introduction

Many natural disasters due to various types of meteorological disturbances such as heavy rainfall in the monsoon season and the tropical cyclones in the pre- and post-monsoon seasons attack Bangladesh. Still more, in the pre-monsoon season (April to early June), damages due to developed tornadoes and strong gust winds frequently emerge over this country. In 2004 also, in the evening on 14 April, tornados attacked villages of Mymensingh and Netrokona districts, causing more than 70 deaths. In the early morning on 23 May, the strong gust wind due to a developed meso-scale cloud system passed the Meghna river basin, making two vessels sink. Local people are afraid of this type of pre-monsoon disturbances and call them "Kalbaishakhi" or "Nor'wester". Thus, the features of such meso-scale cloud systems should be addressed more. Needless to say, the cloud system developing in monsoon season brings severe flood disasters to this country. The mechanisms that are responsible for such cloud systems should be clarified more.

However, in this region, there was no observation with high spatial and temporal resolutions enough to resolve the meso-scale cloud systems. Although BMD (Bangladesh Meteorological Department) is maintaining more than 30 synoptic surface observation stations (**Fig. 1**, ×), the mean distance of these stations are several tens of kilometers. While the observations are conducted 24 hours for almost all stations, its frequency is only 3 hourly, because of the lack of the automatic instruments. Therefore, the meso-scale structures of such systems have not been investigated.

To enable the analysis of the meso-scale systems developing over this country, in spring 2004, we installed an automatic weather statioon (AWS) in Dhaka city, the capital of Bangladesh in the central part of this country (**Fig. 1**, rectangle). The data of this AWS system are accessible through the internet in quasi-real time by courtesy of ICDDR,B (Centre for Health and Population Research, Bangladesh), at which we settled the AWS. Furthermore, in 2000, the Dhaka radar of BMD was replaced and now we can get digital radar echo data.

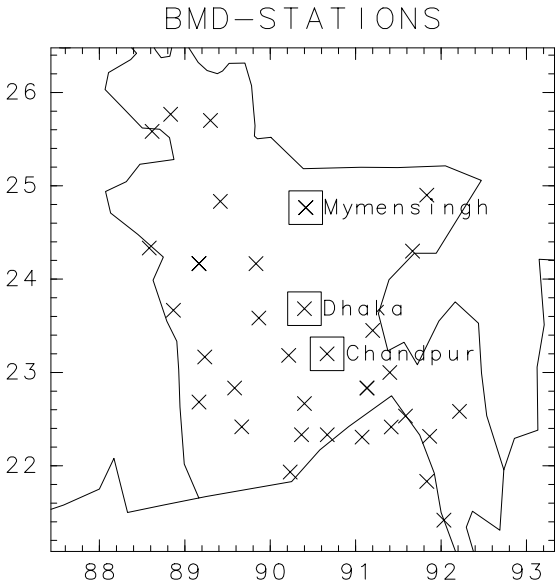

Fig. 1: BMD (Bangladesh Meteorological Department) observation sites for rainfall are indicated by ×. Three points, Dhaka, Mymensingh and Chandpur, are highlighted by big rectangles. The coast lines and border lines are shown. Horizontal and vertical axes indicate the longitude and latitude, respectively.

Using these observations, in the present study, we will show the meso-scale structures of pre-monsoon and monsoon cloud systems that evolved over this country in this year. We have conducted some statistical analysis using Dhaka radar data (Terao et al, 2001, 2002, Islam et al, 2001, 2004). However, the case study has been conducted only for a few limited cases. This study is the first research of the meso-scale structure of disturbances developed over Bangladesh using our AWS observations.

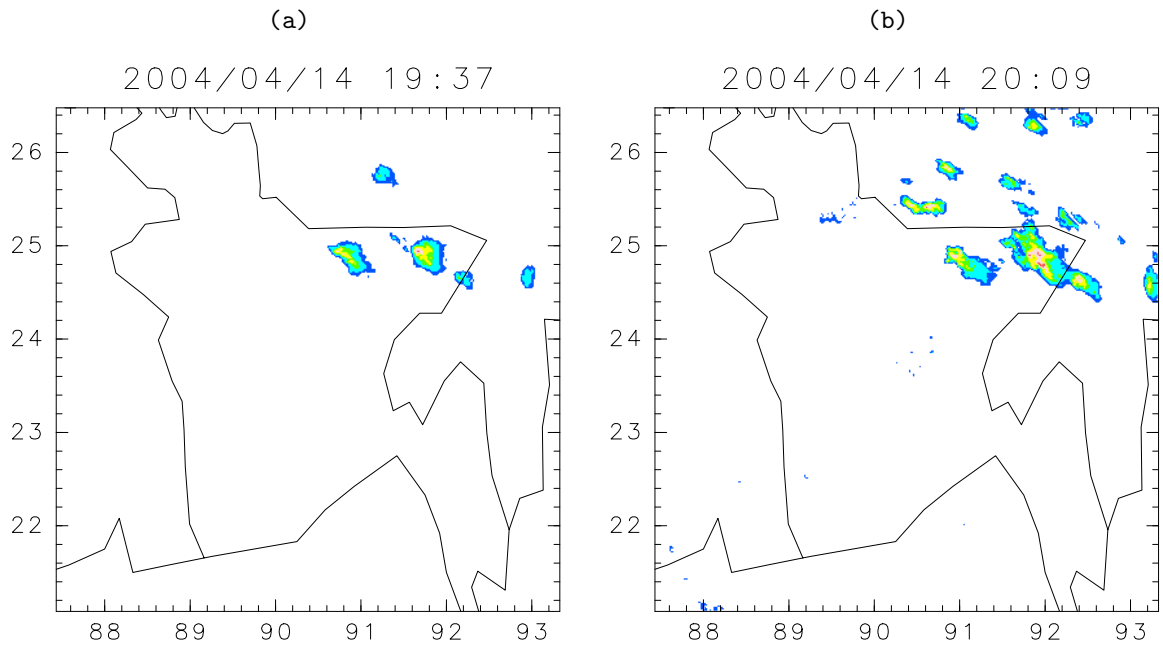

Fig. 2: The Dhaka radar images on 14 April 2004. The ovservation time (local time) is shown on the top of figures. The coast lines and border lines are shown. Horizontal and vertical axes indicate the longitude and latitude, respectively.

2. Meso-scale Structures of Cloud Systems

2.1. Tornado on 14 April

In the evening on 14 April 2004, strong meso-scale cloud systems with tornadoes attacked villages of Mymensingh (**Fig. 1**, rectangle) and Netrokona districts, which are in the northern part of the country. Following newspapers, these tornadoes occured in this area for 20 minutes from 19:45 LST. In Bangladesh, tornadoes commonly develop in the pre-monsoon season (Peterson and Mehta, 1981; Ono, 1997). The case on 14 April is one of the archetypal examples of such type of disturbances. The tornado occured far to the north of the AWS installed in Dhaka city. So, we could not find any signature of the system that caused the tornado in the AWS records. However, the Dhaka radar system caught the echoes associated with the system (**Fig. 2**).

In the radar image, many cloud systems moving east-southeastward had elliptical shapes with their major axes being parallel to the direction of the movement of systems. The strongest part of the disturbance seems to be in the center of the system. The size of echoes is 10 to 30 km. Many meso-scale disturbances developed over the northern slope of the Meghalaya mountains lying about 30 km to the north of 25°N from 90 to 93°E in the Indian teritory. They crossed the ridge and flew into northeastern Bangladesh.

The system at somewhat to the southwest of 91°E 25°N at 19:40 LST (**Fig. 2a**) induced the tornadoes. Although the "hook echo" is not clearly seen, the elliptic shape does not controvert the possibility that the system has the supercell structure. This system is the southwesternmost echo of the disturbances. This may imply that the system develops near the interface of two air masses with somewhat different characteristics.

2.2. Disturbance on 23 May

In the early morning (about 3:30 LST) on 23 May 2004, some launches (vessels) capsized during a storm on the Meghna river downstream Dhaka near Chandpur (**Fig. 1**, rectangle). The meso-scale system that causes this disaster was captured by both the AWS system installed at Dhaka city and the Dhaka radar system.

The radar image of this disturbance (**Fig. 3**) indicates that the system consists of strong linear shaped convective cloud band and trailing stratiform cloud area with relatively weak echo. The rainband oriented northeast-southwest with rather large size, and moved southeastward. It passed Dhaka at about 2:30 LST.

Figure 4 shows the result of AWS observations. This elucidates the meso-scale structure of this rainband. Strong rainfall with the rain rate of 3.5 mm/min is observed at 2:33 LST. After that, rain continues until 6 LST with relatively low rain rate. This result is consistent with the radar image. The record of pressure (**Fig. 4d**) indicates that this system accompanied a meso-high pressure system. Temperature falled and humidity rose rapidly, and wind direction changed to northwesterly with strong gust. These features are similar to the meso-scale rainbands described in Houze (1993).

2.3. Rainfall on 13 September

During monsoon season of 2004, severe flood occured over Bangladesh with two peaks in July and September. The former one is mainly due to the rainfall in the upper catchment of the Ganges, Brahmaputra (Padma, Jamna in Bangladesh) and Meghna rivers. However, the latter

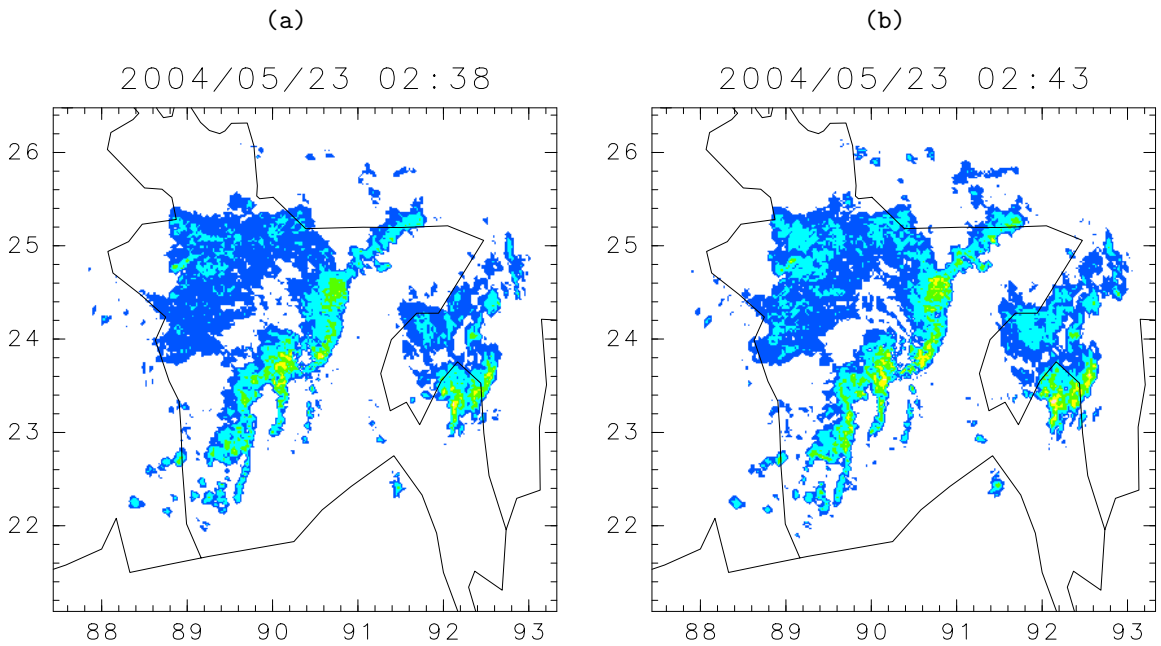

Fig. 3: Same as **Fig. 2** except for 23 May 2004.

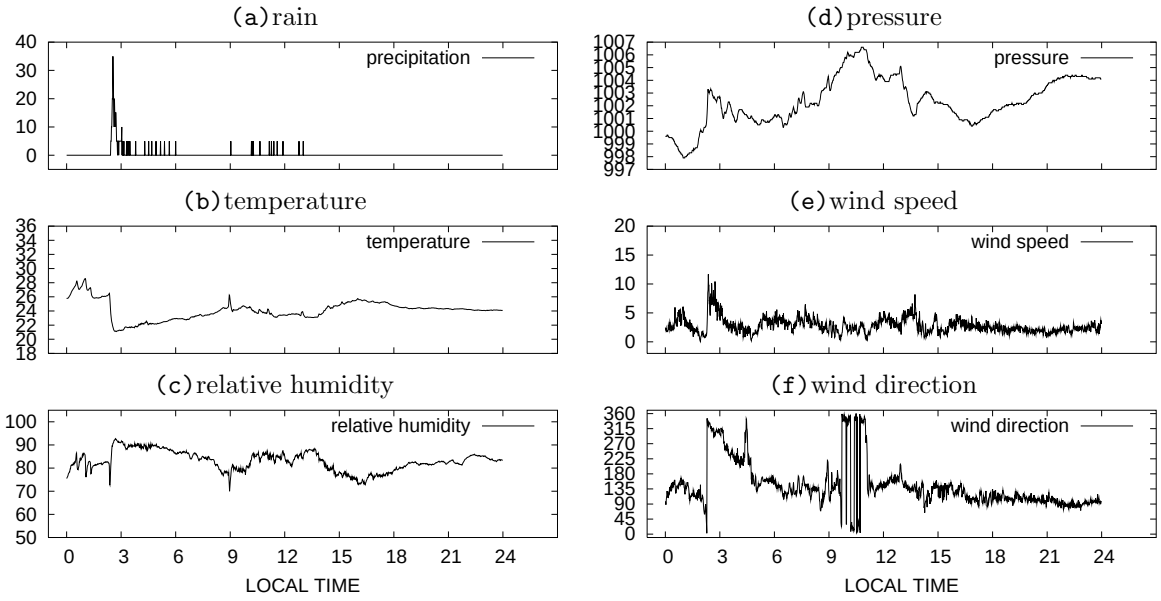

Fig. 4: The data of AWS installed at Dhaka city for 23 May 2004. (a)Rainfall (0.1mm/min), (b)temperature (°C), (c)relative humidity (%), (d)pressure (hPa), (e)wind speed (ms^{-1}), and (f)wind direction (degree). The horizontal axes are local time.

one occured at the same time as a heavy rainfall over Bangladesh.

The AWS shows the signature of the rainfall at Dhaka clearly (**Fig. 5**). The rainfall was so strong that the daily rainfall went up to 321.5 mm. Furthermore, the most significant feature of the rainfall is the nearly constant rainfall intensity during the day. The rain rate is moderately strong at about 15 mm/hour. However, the rain continues this intensity for more than one day.

3. Summary

In Bangladesh, remarkable meso-scale cloud systems develop in the pre-monsoon season as well as in the monsoon season. They cause severe disasters due to tornado, strong gust and rain. However, there was no observations that resolved meso-scale structures of disturbances. Therefore, we installed an automatic weather station at Dhaka city. Using this, in the present study, we analyzed meso-scale cloud systems developed over this country in 2004. Besides, we utilized the Dhaka radar system of Bangladesh Meteorological Department (BMD), which was replaced to digital system in 2000.

In 2004, severe tornado attacked the Mymensingh and Netrokona districts on 14 April. This system was one of cloud systems developing with elliptical shapes with size of several tens of kilometers, and moving southeastward. We could not analyze the meso-scale structure of this system extensively because this system did not pass the Dhaka AWS system. On 23 May, another strong meso-scale system developed over the country causing two launches capsized by strong wind on the Meghna river somewhat down-

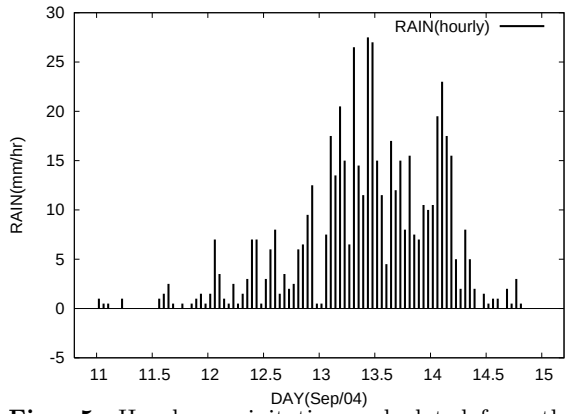

Fig. 5: Hourly precipitations calculated from the Dhaka AWS data during four days from 11 to 14 September 2004. The vertical axis shows rainfall intensity (mm/hour). The horizontal axis is the day of September 2004.

stream of Dhaka near Chandpur. This system had rather larger size. It is composed of two parts; one was a strong convective rainband with size of several hundred kilometers and the other was stratiform system. The data of AWS in Dhaka elucidated some characteristics of this convective system. The pressure increased around the convective rainband. Suddenly the temperature falled and the wind direction changed quickly to northwesterly.

While these cloud systems are pre-monsoon disturbances, the structure is different from each other. The meso-scale system on 14 April seemed to develop along the interface of two different air masses. Although the hook echo structure could not so clearly confirmed, the shape of the echo was similar to that of supercell. On the other hand, that developed on 23 May had a typical meso-scale structure with convective rainband and trailing stratiform clouds. While both cloud systems in the pre-monsoon season accompany instantaneous very strong rainfall, the rainfall in the monsoon season seems to have continuous moderately strong rainfall.

Aknowledgments

The authors would like offer special thanks to Dr. Wagatsuma at ICDDR,B for the cooperation with our research and the AWS operations. They express their gratitude to Mr. Md. Akram Hossain, the director of Bangladesh Meteorological Department, for his continuous support for our research. The GFD-DENNOU library was used to draw figures. This rsearch is supported by JSPS Grant-in-Aid for Scientific Research and Disaster Prevention Research Insitute, Kyoto University.

References

Houze, R. A. Jr., *Cloud Dynamics*. Academic Press, 573pp, 1993.

Islam, M. N., T. Hayashi, H. Uyeda, T. Terao and K. Kikuchi, Diurnal variations of cloud activity in Bangladesh and north of the Bay of Bengal in 2000. *Remote Sensing of Environment*, **93**, 378-388, 2004.

Islam, M. N., T. Terao, T. Hayashi, J. Matsumoto and T. Oka, Estimation of monsoon rain and the use of BMD radar data. *Proceedings of the Third International Symposium on Asian Monsoon System*, 10-12 Dec. 2001, Okinawa, Japan, 298-303, 2001.

Ono, Y., Climatology of tornadoes in Bangladesh. *J. Met.*, **22**, 325-340, 1997.

Peterson, R. E. and Mehta, K. C., Climatology of tornadoes of India and Bangladesh. *Arch. Meteor. Geophysik, Bioklim.*, **29B**, 345-356, 1981.

Terao, T., T. Hayashi, M. N. Islam, and J. Matsumoto, Diurnal variation of the atmospheric vertical structure over Bangladesh region ovserved by rawin sonde intensive observation. *Proceedings of the Third International Symposium on Asian Monsoon System*, 10-12 Dec. 2001, Okinawa, Japan, 174-179, 2001.

Terao, T., T. Hayashi, M. N. Islam, J. Matsumoto and T. Oka, Observational study on the diurnal variations of convective activity and circulations over Bangladesh in the summer monsoon season. *Annual Rept. DPRI Kyoto Univ.*, **45-B**, 223-244(in Japanese), 2002.