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Single cell and multiple cell clouds analysed with satellite data in and around Bangladesh

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सार— बांग्लादेश और उसके समीपवर्ती क्षेत्रों के 6 और 13 अगस्त 1997 के तुल्यकाली मौसम विज्ञान उपग्रह (जी. एम. एस. — 5) आंकड़ों का उपयोग करते हुए बहु कोष्ठीय तथा एकल कोष्ठीय मेघों का विश्लेषण किया गया है। बहु कोष्ठीय मेघ 6 मीटर प्रति सेकण्ड की गति से उ. पू. की ओर चले और लगभग 21 घंटों तक रहे। एकल कोष्ठीय मेघ 13 मीटर प्रति सेकंड की गति से दक्षिण पूर्व की ओर चले और लगभग 12 घंटों तक रहे। स्थल की तुलना में महासागरों के ऊपर मेघ तेज गति से चले। मेघ के बरसने की स्थिति में, संवहनीय घटक 40 प्रतिशत था और शेष स्तरित था। मेघ की जलीय भाग 74 प्रतिशत था तथा शेष जलीय नहीं था जो सूचना पर आधारित मान से भिन्न था।

ABSTRACT. Multi-cell and single-cell clouds were analysed using Geostationary Meteorological Satellite (GMS-5) data on 6 and 13 August 1997 in and around Bangladesh. The multi-cell cloud moved NE with a speed of about 6 m/s and lasted approximately 21 hours. The single-cell cloud moved SE with a speed of about 13 m/s and lasted approximately 12 hours. Clouds move faster on oceans than on land. At the mature stage of the cloud, convective component was 40% and the rest was stratiform. The precipitable portion of the cloud was 74% and the rest was non-precipitable which differs from the reported value.

Key words — Cloud system, Single-cell, Multi cell, Convective, Stratiform, Cirrus shield, Precipitable, Non-precipitable, Sub-system, Mesoscale.

1. Introduction

Precipitation, which comes from the cloud system, controls our social, economical and daily life. In order to understand the organisation mechanism of the cloud system we need to analyse their detailed internal structure throughout their life time. It is very important to know the internal structure and the evolution of single and multiple cell clouds, because they play an important role in determining the precipitation structure. A single-cell cloud is an isolated cloud which does not take part to form a cloud system. It develops, matures, and dissipates individually. On the other hand, some single-cell clouds may merge to form a multi-cell cloud which forms a sub-system (Islam *et al.* 1994). Some early researchers report about the characteristics of cloud clusters over the Pacific, Atlantic and Tropics. The stages of a tropical cloud *viz.*; formative, mature and dissipating (Machado & Rossow, 1993), are well known. The daily variation of maximum cloud zone and the inter tropical convergence zone over the Indian latitudes during the southwest monsoon are investigated by Sikka and Gadgil *(1980)*. Goswami *et al.* (1990) describe the characteristics of cloud clusters of summer monsoon experiment (SMONEX) region (0° - 30°N, 70°E - 120°E) during June - August 1979. They categorise the cloud bands which have a longitudinal extent of at least 10° and ignore the remaining clouds smaller than 1°. The general characteristics of the clouds and cloud clusters over the western Pacific warm pool are analysed by Islam *et al.* (1997). The life cycle and internal structure of a mesoscale convective complexes over Texas are investigated by Leary and Rappaport (1987). However, there is no report about the analysis of internal structures of cloud and cloud system in this region of Bay of Bengal.

Now-a-days cumulus clouds are divided into two components *viz.*, convective and stratiform because the dynamics of their air motions and the physics of the precipitation growth in convective and stratiform regions are fundamentally different. Usually the convective region with active convection lies in the centre of the cloud cell and the

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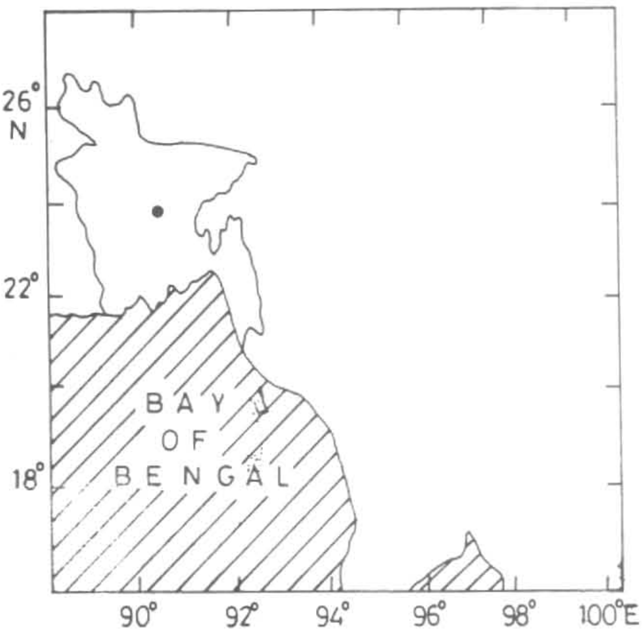

Fig.1. The study area (16°N - 28°N, 88°E - 102°E). Black dot represents the GMS data receiving station at IFCDR, BUET

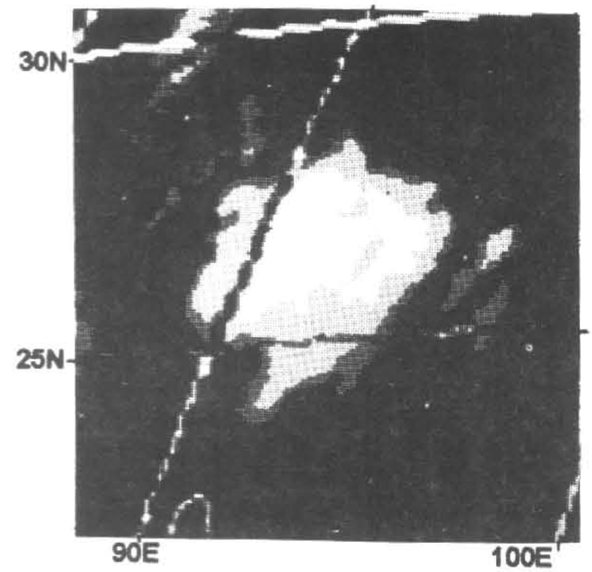

Fig.2. Satellite image at 0900 LST on 6 August, 1997. A target cloud is identified by solid line

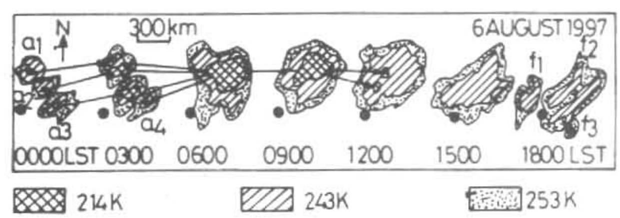

Fig.3. Cloud pattern and time evolution of a multi cell cloud (Case-I). The inner most line represents clouds below IR temperature 214K, the next line is that below 243K and the outer one is that below 253K. Dot represents the location 24°N, 90°E

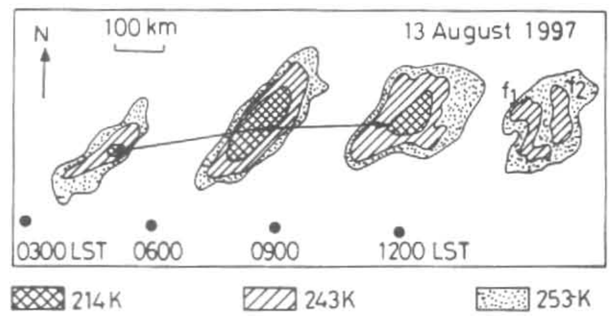

Fig. 4. Same as Fig. 3 except for Case-2. Dot represents the location 17°N, 90°E

stratiform region lies adjacent to the convection region, sometimes, it surrounds the convection (Houze, 1989). This paper discusses the internal structure and formation of three clouds which are single-cell or multiple cell clouds observed during August 1997.

2. Data and procedure

We used three hourly infrared (IR) data, provided by Institute of Flood Control and Drainage Research (IFCDR), Bangladesh University of Engineering and Technology (BUET), Dhaka, from the Japanese Geo-stationary Meteorological Satellite (GMS-5). The analysis area is shown in Fig. 1.

Pattern matching technique is used to get idea about the movement of clouds. The selected events are so chosen that there exist at least a convective core or a number of individual clouds which combined to form a mesoscale system. We detected the clouds and followed until they merged with another cloud or disappeared. Cloud is delineated from clear sky by an IR temperature of 253K which is the same as used by Negri and Adler (1987). The detected clouds are separated into three components *viz;* convective, stratiform and cirrus shield using respective IR threshold temperature. We used 214K as threshold temperature to separate convective and stratiform portion of a cloud as it gives a better estimate. The clouds having temperature 214K or less are convective, those in between 214K and 243K are stratiform (Negri and Adler, 1987) and the rest are cirrus shield.

3. Results and discussion

We have analysed three events during the analysis period which are described below.

(a) *Case - 1 (0000-2100 LST, on 6 August 1997)*

Fig. 2 shows a satellite image of 0900 LST on 6 August 1997. The target cloud was detected by a solid line. For

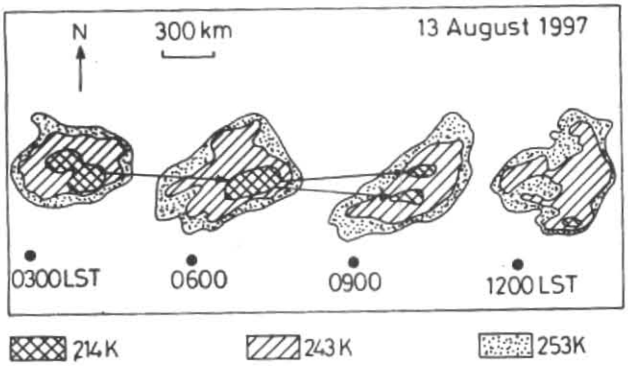

Fig. 5. Same as Fig. 3 except for Case-3. Dot represents the location 15°N, 105°E

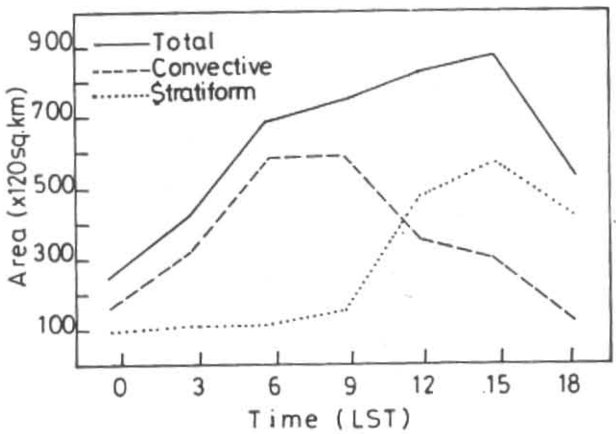

Fig. 6. Convective, stratiform and total rain area corresponding to Fig. 3

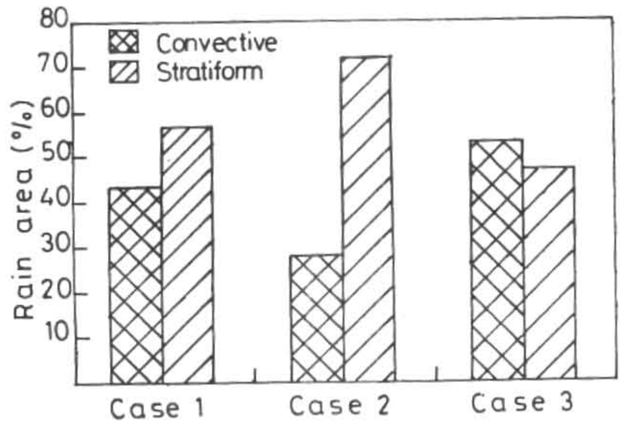

Fig. 7. The percentage of convective and stratiform rain area for three cases at their mature stages

TABLE 1

Characteristics of the clouds analyzed on August 1997

Events	Date	Detect time (hr LST)	Disappeared time (hr LST)	Life time (hr)	Speed (m/s)	Direction	Maximum length (km)
Case-1	06 Aug	0000	0021	21	~06	NE,SE	~640
Case-2	13 Aug	0003	0015	12	~13	NE,SE	~545
Case-3	13 Aug	0003	0015	12	~03	E,NE	~900

simplicity the time sequences of the event was drawn in Fig. 3.

Fig. 3 shows a multi-cell cloud detected on 6 August at 0000 LST. At first there were three individual clouds named a1, a2, a3 identified by IR temperature. They moved almost NE with a speed of about 4.5 m/s. At 0300 LST, a1 and a2 merged together and a new cloud a4 grown in the SE flank of the merged one. It was observed that at 0600 LST all the clouds merged to form a semicircular cloud cluster of area ~ 8.9×10^4 km^2. The cluster with a vigorous convective core at the centre moved NE with a speed of about 6.5 m/s and reached in its mature stage at 0900 LST. At this stage the area was ~9.5×10^4 km^2. After the mature stage it was observed that the convective area decreased while the stratiform area increased which implies that the cloud is going to its dissipating stage. At 1800LST upon dissipation the cloud was divided into three fragments *f*1, *f*2, and *f*3. After 1800 LST two new convective core started growing at the north-eastern and south eastern flank of the cloud (not analysed) and at about 2100 LST this event disappeared.

(b) *Case-2 (0300 - 1500 LST on 13 August 1997)*

A growing squall line-like single-cell cloud was identified at 18°N and 91°E over the Bay of Bengal at 0300 LST (Fig. 4) on 13 August 1997. The horizontal length of the system was about 250 km with a growing convective core at the centre. The system moved NE with a speed of about 13 m/s. After 3 hours it increased in area and became mature. At 0900 LST the cloud moved E and after dissipation the convective area shrinks while the total area increased. At 1200 LST the cloud seems to be in two fragments named *f*1 and *f*2. All the fragments moved SE and a new convective core grew on the south-eastern portion (not analysed) of the system and the event disappeared at about 1500 LST.

(c) *Case- 3 (0300 - 1500 LST on 13 August 1997)*

A semicircular single cloud having horizontal length of about 350 km was identified 17°N at 0300 LST on 13 August 1997 (Fig. 5). At 0600 LST this cloud was at its mature stage. It moved E with a speed of about 3 m/s. The convective core intensified and the cloud area slightly increased. At 0900 LST the cloud moved NE. At 1200 LST the cloud seems to be in two fragments and a new convective core grew at the south-eastern flank (not analysed). The system disappeared at about 1500 LST.

The comparative study of the characteristics of three events are shown in Table 1. As was found the resultant direction of the three clouds were E. They moved with an average speed of about 7 m/s. The Case-1 and Case-3 developed over land and Case-2 developed on ocean. Comparing the speeds of Case-1 (or Case-3) and Case-2 we see that clouds move faster on oceans then on lands. The speeds of the cloud system were found to be high during their formative stages than their mature or dissipating stages.

The average life times of the three events were 15 hours which is consistent with the life time of tropical cloud analysed by Islam *et al.* (1997). The life time of Case-1 was 21 hours while the other two events had life time of 12 hours each. So non-isolated multi cell (Case - 1) was more stable than isolated single-cell cloud (Case-2) and (Case-3).

Fig. 6 shows the change of cloud area with time for Case-1. In the formative stage of a cloud or cloud system there was a small convective core which increased gradually and was maximum in the mature stage. Then the convective area decreased. On the other hand the stratiform rain area were small in the early developing stage of a cloud, but it increased further until the dissipating stage.

Fig. 7 describes the percentage of the convective and stratiform rain area at their mature stages. The simple calculation shows that the convective portion (≤214K) is 40% and the rest was stratiform (≤243K and ≥214K). The separation of convective and stratiform component is essential in determining the exact rainfall amount from cumulus cloud. The precipitable portion (≤243K) of the cloud was 74% while the rest was non precipitable (≤253 and ≥243K). This percentage differs from the clouds of other region as reported by Islam *et al.* (1998) that 56% of the tropical cloud is precipitable.

4. Conclusions

As was found the non-isolated multi-cell cloud lasted 21 hours while the isolated single-cell cloud lasted 12 hours. At the end of each event a new convection started to develop that depended on the environment conditions. Multi cell cloud moved NE up to its mature stage and then SE and single-cell clouds moved NE. It was also found that the clouds move faster on ocean than on land. The area embedded by stratiform cloud component was larger than that of convective cloud component. Cloud components are essential in estimating precipitation from satellite data which we will described in a separate paper. The percentage of the precipitable cloud of this region was subjectively calculated large (74%) demands the objective calculation of the percentage.

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