Study on characteristics of precipitation systems in Bangladesh

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Abstract

Characteristics and development mechanisms of precipitation systems that bring heavy rainfall in Bangladesh (88.05–92.74ºE, 20.67–26.63ºN) are very important for understanding the characteristics of monsoon precipitation systems associated with land-sea thermal contrast. A precise understanding of the characteristics and development mechanisms of precipitation systems is required for disaster prevention and water management in agriculture-dependent countries like as Bangladesh.

Characteristics of precipitation systems in Bangladesh are analyzed using 6 years of radar data from the Bangladesh Meteorological Department (BMD). Precipitation systems are classified as arc, line, or scattered types according to their shape; then as small, medium, or large according to their length; and as stationary, slow, or fast according to their propagation speed. Arc-, line-, and scattered-type systems are found 230 (29%), 117 (15%), and 442 (56%) times, respectively, from April to September during the analysis period (2000–2005). These arc-, line-, and scattered-type systems have average speeds of 11.0, 7.1, and 5.8 m/s, horizontal lengths of 185, 184, and 268 km, and approximate lifetimes of 4.3, 4.0, and 4.8 hours, respectively. Scattered-type systems dominate in the monsoon period (June, July, August, and September), while arc-type systems dominate in the pre-monsoon period (April and May). Line-type systems occur with nearly equal frequency in both periods. The monsoon systems are large and stationary or slow moving. In contrast, pre-monsoon systems are small and fast moving. Pre-monsoon systems propagate southeastward whereas monsoon systems propagate to the northeast, northwest, or southeast. A large number of systems occur in the southern, eastern, and northern

parts of Bangladesh. Of the 442 scattered-type systems, 244 are scattered-type systems having wide areal coverage (we named these systems as SWAC), which extends out of radar range.

SWACs, dominant during monsoon period, develop southern part of Bangladesh and then progress slowly northeastward or northwestward. Detailed analysis of radar data revealed that SWACs are composed of small individual cells with short lifetime. Cells propagation speed and direction are same as the low level (850 hPa) monsoonal wind. The lifetime of SWAC is 10 hours in average. SWAC has a low rain rate but covers a wide area, moves slowly and persists for a long time. Therefore, it is considered that SWAC contributes a large amount of the accumulated rain during monsoon period. On the other hand small arc-type systems, dominant during pre-monsoon, propagate southeastward relatively faster than SWAC.

Due to limitation of continuous radar plan position indicator data simulation has been done to understand the features and development processes of the arc-type pre-monsoon system. An arc-type system of 26 April 2002 is simulated using CReSS (Cloud Resolving Strom Simulator) with a horizontal grid increment of 2 km. The Pennsylvania State University/National Center for Atmospheric Research Mesoscale Model (PSU/NCAR MM5) is used for downscaling. Japanese 25-year Reanalysis (JRA-25) data and National Centers for Environmental Prediction (NCEP) Reynolds weekly mean sea surface temperature (SST) data are used to the model MM5 as initial and boundary conditions. Hourly outputs of the finest domain (grid increment of 5 km) of MM5 and NCEP Reynolds weekly mean SST data are used as initial and boundary conditions for CReSS. Younger and more intense cells are formed in the southwestern end of the system. These cells move northeastward, producing intense rainfalls and

becoming stratiform at the northeastern end. Simulation results indicate that low-level southwesterly or southerly wind brings warm moist air from the Bay of Bengal and helps to develop new cells. The propagation speed of the system is 8 m/s, and the northeastern end moves faster than the southwestern end, creating clockwise rotation of the system. The relatively small propagation speed and the rotation of the simulated system coincide well with radar observations. The clockwise rotation of the system can be explained by the stronger (weaker) outflow and weaker (stronger) inflow in the northeastern (southwestern) end. The relatively slow propagation of the system is attributable to the weak ($\leq$ 7 m/s, storm relative) rear-to-front flow in the moist environment. Thus, the arc-type system common to the pre-monsoon period in Bangladesh develops through a balance of strong southwesterly or southerly moist inflow at low altitude and relatively weak outflow at the rear of the system.

This study revealed that SWAC is a unique feature of the monsoon precipitation systems and contributing a large amount of the accumulated rain in Bangladesh and arc-type system with intense rainfall for a few hours over the small area is dominant during the pre-monsoon period.