ABSTRACT

A STUDY OF HEAVY RAINFALL EVENTS DURING THE SOUTHWEST MONSOON SEASON IN THE PHILIPPINES

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Intense southwest monsoon (SWM) rainfall events causing massive landslides and flash floods along the western sections of the Philippines were studied through conduct of observational and numerical analysis. The heavy rainfall during the southwest monsoon season is hypothesized as caused by strong convective activity generated by monsoon westerlies and enhanced by the presence tropical cyclone (TC) in the vicinity of northeastern Luzon. The strong westerlies upon interaction with the mountain ranges along the west coast of Luzon produce strong vertical motion and consequently generate heavy rainfall. Scientific investigation of four of SWM rainfall cases were undertaken to prove this hypothesis. The heavy rainfall cases selected are of varying condition in terms of the presence and position of tropical cyclones. The first case involved two TCs within the Philippine area of responsibility (PAR), the second case has a TC crossing Luzon Island, the third case involves a strong typhoon that passed to the NE of Luzon and the fourth case has no tropical cyclone in the PAR. Five-year (2002 – 2006) time series of five-day moving average rainfall from eleven western Luzon stations was utilized in the selection of events. Observational analysis revealed that during the rainfall events, a trough is present over the northeastern portion of the Philippines between the islands of Luzon and Taiwan from the surface to 850 hPa level. Heavy rains in the amount of 20 mm/day and greater are recorded for duration of 5 days or longer over the western sections of Luzon from southern station (Sangley) to northern station (Laoag). Due to exposure and topography, the SWM rainfall distribution is maximum over the western part and decreases eastward except for the case of crossing tropical cyclone where maximum rainfall occurred along its path. It was also noted that heavier and longer duration rainfall occurred when tropical cyclones are embedded within the trough. In this situation, the weather condition is characterized by strong southwesterlies/westerlies of more than 20 meters/sec over the South China Sea and western sections of the Philippines from the surface to 850 hPa levels. The trough migrates northward from an initial NW-SE orientation with the axis rotating counterclockwise until it attains a SW-NE orientation with the upper end over southern Japan. As shown in the 850 hPa latitude-time cross section of zonal wind, the migration of the trough is modulated by the 30-60 day northward and 12-24 day westward oscillations. The position of the trough over Luzon Island up to Luzon Strait between Taiwan and Philippines and the strength of the westerlies of 20 meters/sec from the surface to 850 hPa level could serve as indicators of the occurrence of SWM heavy rainfall events. Through the aid of Fourier analysis, the hypothesis on the cause of heavy rainfall during the southwest monsoon has been presented and explained scientifically through the investigation of four selected cases of heavy rainfall events. With the use of Fourier transforms, the total streamflow is decomposed into monsoon basic flow (Wave Number 0 and 1) and tropical cyclone perturbation flow (Wave Numbers 2-23). The procedure was done to isolate the TC and study its effect or contribution to the monsoon rainfall activity. It was shown that the combined westerlies from the basic flow and westerlies generated by the tropical cyclone interact with the Cordillera Mountain ranges along the west coast of Luzon whose peaks are above 2,000 meters. The strong westerlies are forced to rise above the mountains resulting to strong vertical motion that brings about heavy rainfall. The rising motion is enhanced by the convergence of the northwesterlies from the tropical

cyclone and the southwesterlies from the basic monsoon flow over western Luzon. The numerical analysis involved simulation of the four cases of heavy rainfall events using the Fifth Generation Mesoscale Model (MM5) of the National Center for Atmospheric Research (NCAR)/Penn State University (PSU). In the simulation, four convective parameterization schemes (CPS) are tested to see which is best applicable to the local setting. The CPSs tested include Grell, Betts-Miller (BM), Anthes-Kuo (AK) and Kain Fritsch (KF). Generally, MM5 model did not perform well in the daily simulation of the SWM rainfall. The positions of the troughs and the vortices are displaced. However, the 5-day average of windfields and the total rainfall distribution are close to the observed analysis. In the skill test, the threat score and bias score at the heavy rain intensity threshold showed that the MM5 model fairly simulated the total volume of 5-day rainfall. But in terms of quantity of intense events, the rainfall amount is under-estimated. The skill of the model decreases as the rainfall intensity increases which means that the model performed better for less intense rainfall. The model had some difficulty in simulating the intense convection which is also the findings of other studies using MM5. On the most appropriate CPS, Grell was able to capture the major features of the rainfall distribution of the 5-day SWM rainfall events as well as the track of the tropical cyclone that crossed Luzon Island. It performed better than the other schemes as shown by the least mean error and the root-mean square error (RMSE). The diagnostic analysis of the model simulations did not yield encouraging results. The daily simulations of the model are not good enough. It is noted that the isolation of the cyclone waves is not completely accomplished because vortices are still present in the basic flow. The small model output domain could only preserve the cyclone wave vortices but not the large-scale long wave background flow unlike the NCEP analysis which covers the entire globe. Further studies on this regard shall be undertaken in the future.