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Evaluation of heavy rainfall retrieval from TRMM/PR using a long-term C-band radar observation

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Over ten years of spaceborne precipitation radar (PR) measurements from Tropical Rainfall Measurement Mission (TRMM) satellite reveal a weak linkage between extreme rainfall and extreme convection: Even in regions where severe convective storms are representative extreme weather events, the heaviest rainfalls are mostly associated with less intense convections (Hamada et al. 2015, Nat. Commun.). Both the echo structures and environmental conditions suggest importance of warm-rain processes in producing extreme rainfall rates. However, there are still several questions to be addressed, such as uncertainty in the attenuation correction of the Ku-band PR especially for extreme convection. In this study, we make a statistical evaluation of TRMM/PR retrievals using a ground-based polarimetric radar, especially focusing on extreme rainfall and convection events.

We used 5-yr observation during Baiu season (May-June) by a C-band polarimetric radar at Okinawa Island, developed and operated by National Institute of Information and Communications Technology (NICT), named COBRA. The COBRA has polarization and Doppler observation functions and makes it possible to derive information about the characteristics of precipitation particles such as type and size distributions. In the analysis period, COBRA made almost continuous RHI observations with time interval of several minutes.

We make statistical comparison between the extreme events derived from TRMM/PR and COBRA, since direct comparison is quite difficult for such rare event because of very small number of simultaneous observations. Extreme rainfall and convection events are defined separately from TRMM/PR and COBRA. For TRMM/PR, extreme events are defined on a local basis with 2.5 x 2.5 degree grid cells around Okinawa, using the maximum values of near-surface rainfall rate (NSR) and 40-dBZ echo top height (ETH40) in “rainfall event” which is a set of contiguous rainy pixels of TRMM/PR measurements. Rainfall events of which the maximum NSR is within top 0.1% are defined as extreme rainfall events, while those of which the maximum ETH40 is within top 0.1% are defined as extreme convection events. For COBRA, extreme events are defined from vertical echo profiles in RHI observations. Extreme rainfall events are defined as the profiles in which rainfall rates at 1 km are within top 100, and extreme convection events are defined in similar way using 40-dBZ echo-top heights.

There are contrasting characteristics in the echo characteristics between the extreme rainfall events and extreme convection events derived from COBRA, as have been shown in our previous studies using TRMM/PR: Extreme rainfall events exhibit lower echo-top height than extreme convection events, and linear downward increase of radar reflectivity below freezing level, whereas extreme convection events exhibit slight downward decrease of Ze below freezing level. This demonstrates that the attenuation correction of TRMM/PR works, at least qualitatively, correctly, and that contaminations of surface and mainlobe clutter are of little concern for the echo profiles of extreme rainfall events. Temporal evolutions of both extreme events exhibit clear differences, indicating that extreme rainfall and convection events are associated with precipitation systems with different inherent characteristics.

Keywords: extreme precipitation, TRMM, precipitation radar