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A study of the dependence of heavy precipitation on air temperature with the space-borne precipitation radar

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How does global warming affect the characteristics of heavy precipitation? Not only numerical simulations on future climate, but data analyses on current climate may hint to us about this big problem. Recently, many studies drew relations between heavy precipitation rates and surface air temperature. Some of them suggested that the relations are governed by the Clausius-Clapeyron (C-C) relation; if precipitation rates are proportional to the saturated water vapor content, the former is expected to increase by nearly 7% with an increase in air temperature of 1 K as the latter is. However, according to our analysis with Global Historical Climatological Network (GHCN) dataset, the 99th percentile daily precipitation amount and daily average surface air temperature can be fitted in a line with the slope of 7%/K only in limited area and temperature range. It is clearly shown that heavy precipitation rates decrease with increase in temperature beyond a peak value (generally around 25 degree C) on daily time scale. We also analyzed 10-minute precipitation dataset around Japan. On a shorter time scale, no decrease in heavy precipitation rates with higher temperature are found and the slope is closer to 7%/K on 10-minute scale than on daily scale. Further analyses on a shorter-time scale precipitation dataset in other regions are required, but the data availability of short-time scale in-situ data is not as satisfactory as that of daily dataset, particularly in Tropics. To overcome the shortage of in-situ data, precipitation estimates by the space-borne precipitation radar (TRMM/PR) are employed. Precipitation rates are derived from the TRMM/PR with a vertical resolution of 250 m and a horizontal resolution of 5 km. As the falling velocity of rain drops is generally several meters per second, the temporal resolution (not the sampling interval) of the TRMM/PR estimates can be regarded as about one minute (horizontal inhomogeneity of precipitation in a footprint of TRMM/PR is ignored here). The latest version of TRMM/PR estimates (V7) is used because it is expected that V7 presents heavy precipitation better than previous versions. TRMM/PR estimates do not show a clear decrease even when temperature is beyond 25 degree C, but the slope is not as steep as 7%/K.