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An experimental study of small-scale variability of rainfall

Kurtulus Ozturk (1), Ali Tokay (2), and Paul G. Bashor (3)

(1) Turkish State Meteorological Service, Ankara, Turkey (kozturk@gmail.com), (2) JCET-UMBC/NASA-GSFC, Greenbelt, Maryland, United States (ali.tokay-1@nasa.gov), (3) CSC/NASA-WFF, Wallops Island, Virginia, United States (paul.g.bashor@nasa.gov)

Spatial and temporal variability of rainfall has been studied employing six dual rain gauge sites at NASA Wallops Flight Facility, Wallops Island, Virginia. The rain gauge sites were in a line where the separation distance ranged from 0.4 to 5 km. The maximum gauge separation distance coincides with the TRMM and GPM precipitation radar cross-section length. Considering areal average rainfall at 5-minute intervals, the site received 1960 mm rainfall in over 7,100 rainy samples during the two-year experiment period. This rich dataset allows studying the rainfall variability for a particular season, six-month, yearly periods as well for different weather systems and different uniformity of rainfall. A single gauge did not report as high as 67% of the time when at least one of the other gauges had rainfall in a given season. Since rainfall from one of the six rain gauges is sufficient for the rainy footprint from a satellite, this demonstrates the significance of the partial beam filling. For the periods where all gauges were reporting rainfall, a singe gauge had at most ±13% difference from the areal average rainfall. This suggests that the variability based on the rain gradient is relatively less important than the variability in a partially filled footprint at the spatial scale of 5 km. During the passage of frontal and tropical cyclone rainfall, the cross-sectional beam was mostly filled by rain most of the time and therefore, the correlation distances were 53 and 44 km in these weather systems when a three-parameter exponential model was fitted to the correlations. The correlation distance was 42 km for uniform rainfall, while it was only 3 km when the rainfall was highly variable. The uniformity of rainfall is determined through the coefficient of variation within the sampling cross-section. The correlation distances ranged from 5 km to 35 km between the seasons and longer observation periods. This wide range in correlation distances suggests the need for a long-term field campaign for this type of studies. These correlation distances were quite sensitive to the shape parameter of the exponential fit and relatively less sensitive to the nugget parameter of the fit. The nugget parameter is the correlation from collocated gauges, while the exponential fit estimates the correlation distance and shape parameter. While the collocated gauges were available throughout the study period, this study recommends that the nugget parameter rather than shape parameter should be predetermined if the collocated gauges are not present. Considering temporal sampling, polar orbiting satellites like TRMM pass through at a given point within its coverage twice a day, while its multi-satellite product provides a three-hourly sample. The monthly rainfall error in sampling cross-section was 73% and 35% for three-hourly and twice-daily passages, respectively.