EVALUATION AND IMPROVEMENT OF SURFACE REFERENCE TECHNIQUES FOR THE TRMM PR

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1. INTRODUCTION

The standard rain rate retrieval algorithm for Tropical Rainfall Measuring Mission (TRMM) Precipitation Radar (PR) employs surface reference technique (SRT, in short) for attenuation correction [1][2]. SRT regards the difference between observed surface backscattering cross section (denoted as σ^0_m(R)) and actual (attenuation corrected) surface backscattering cross section (denoted as σ^0_e(R)) as the path integrated attenuation (PIA) as in the equation; PIA= σ^0_e(R)- σ^0_m(R). Generally, SRT selects some no-rain pixels and calculates the average of the observed surface backscattering cross section of the no-rain pixels (denoted as σ^0_m(NR)). Seto et al. [3] pointed out that the change in σ^0_e between under rain and under no-rain conditions is significant and the ignorance of that change by SRT leads to the bias in rainfall estimates. This study reviewed the sensitivity test of SRT originally done in Seto et al. [3] and shows additional problems of SRT.

2. SENSITIVITY TEST

The standard rain rate retrieval algorithm is executed with different SRTs. Figure 1 shows the average monthly rain amount over all the land where TRMM can observe with the horizontal axis indicating the maximum instantaneous rain rate used for the calculation. To see the difference among SRTs, the horizontal axis ranges from 50 mm/hour to 300 mm/hour (the maximum limit of rain rate given by the standard algorithm.) The monthly rain amount of 61.88 mm/month is estimated by the standard algorithm, which employs temporal reference method (TR) and along-track spatial reference method (ATSR) as SRT. The monthly rain amount is 61.83 mm/month if the SRT is totally replaced by TR0 method, which is slightly modified method of TR. TR0 samples all the no-rain pixels in the same calendar month, in the same 1 by 1 degree lat./lon. grid, by the same incident angle, and with the same land/ocean flag as the target pixel. ATSR-W, which is the same as ATSR, gives the monthly rainfall amount of 62.31mm/month. ATSR-W samples eight no-rain pixels in the same angle bin, with the same land/ocean flag, and observed before the target pixel. As the TRMM satellite flies from west to east, ATSR-W usually samples no-rain pixels located west to rain area. There are largely two reasons why ATSR-W gives larger rain amount estimates than TR0. One reason is that TR0 can not reflect the soil moisture effect on the estimates of σ^0_e(R), while ATSR-W can partly do. As no-rain pixels sampled by ATSR-W are usually located near rain area, the possibility that such pixels were under rainfall shortly before the observation is relatively high compared with the case of unconditional no-rain pixels. Another reason is that ATSR-W gives very strong rainfall estimates more frequently than TR0. Accumulated rain amount with the instantaneous rain rate up to 50 mm/hour is larger in TR0 than in ATSR-W, while the total amount is larger in ATSR-W than in TR0. Figure 2 shows the comparison of instantaneous rain rate between ATSR-W and TR0. Over land, there are many cases that ATSR-W gives heavy rain rate larger than 100 mm/hour but TR0 does not. Such discrepancy between the two methods is not often seen over ocean. Heavy rainfall estimates by ATSR-W over land can be found mainly when the incident angle is smaller than 5 degrees. Over land, σ^0_e is highly variable particularly when the incident angle is small. If the target pixel is taken over mountainous region, but sampled pixels are taken from the plain region, as σ^0_e over plain is much larger than that over mountain at near nadir angle, PIA is badly overestimated, and it may lead to the extremely strong rainfall estimates. ATSR-E is same as ATSR-W, but it samples no-rain pixels after the target pixel. Here, “E” indicates east, as the sampled pixel by ATSR-E is generally located east to rain area. The rain amount estimates all over the land is 62.44 mm/month, and it is almost same as the estimates given by ATSR-W. However, in the Sahel region located in (10-15N, 0-30E), the rain amount estimates are 112.44 mm/month by ATSR-W and 119.69 mm/month by ATSR-E. In this region, as the rain system generally moves from east to west, no-rain pixels located east to rain area show relatively similar surface soil moisture compared with those located west to rain area. WRR (weak rainfall reference) is a newly proposed method. WRR averages σ^0_m at all the pixels under weak rainfall observed in the same calendar month, in the same 1 by 1 degree lat./lon. grid, by the same incident angle, and with the same land/ocean flag as the target pixel. The averaged σ^0_m(R) is attenuation corrected to be the estimates of σ^0_e(R) in a statistical way. As σ^0_m(R) under weak rainfall is used, this method can reflect the soil moisture effect. The rain amount estimates by WRR is 63.05 mm/month, is larger than the other methods, while the contribution of heavy rainfall on the total estimates is small.

3. SUMMARY

The rain rate estimates over land by the standard algorithm is considered to be underestimated. Ignoring the soil moisture effect by the surface reference technique may be one reason of the underestimation, while the quantitative contribution is not so large. Spatial reference method can explain the soil moisture effect partly, but it causes some false heavy rainfall. The newly proposed WRR method can overcome the shortcomings of both the temporal reference method and the spatial reference method. The rain rate retrieval for Global Precipitation Mission (GPM) Dual-frequency Precipitation Radar (DPR) also requires surface reference technique for medium to strong rainfall [4], so further improvement of surface reference technique by using more than 10-year TRMM dataset are very important.

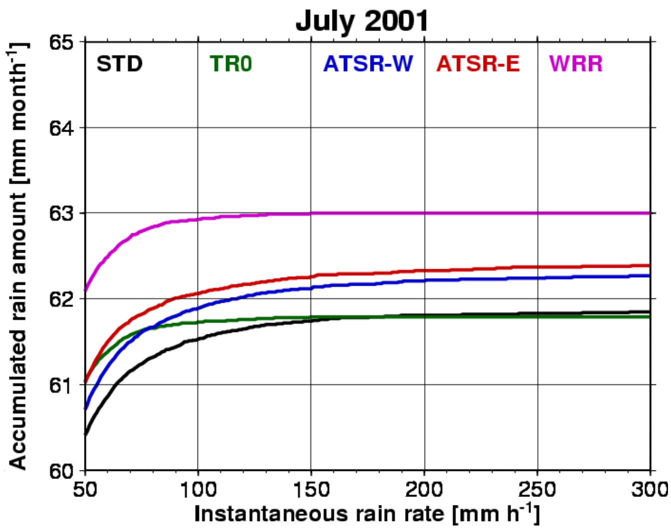

Fig. 1. The average monthly rain amount by different SRTs for all over the TRMM observable land and in July 2001. Horizontal axis shows the maximum rain intensity used for the calculation.

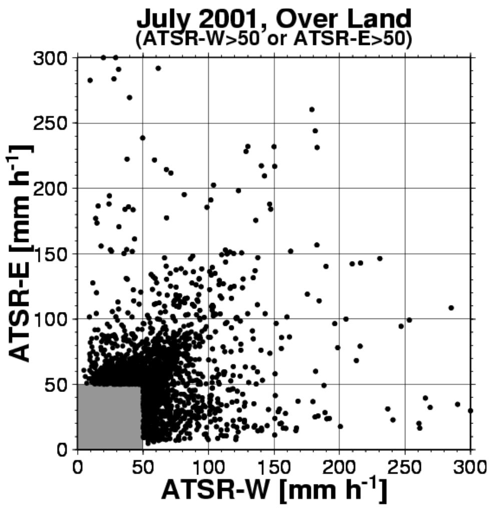

Fig. 2. Comparison of instantaneous rain rate estimates by ATSR-W and ATSR-E over land for July 2001. The case when both estimates are less than 50mm/h is not shown.

[1] Iguchi, T., T. Kozu, R. Meneghini, J. Awaka, and K. Okamoto, “Rain-profiling algorithm for the TRMM Precipitation Radar,” *Journal of Applied Meteorology*, pp. 2038-2052, 2000.

[2] Meneghini, R., J. A. Jones, T. Iguchi, K. Okamoto, and J. Kwiatkowski, “A hybrid surface reference technique and its application to the TRMM Precipitation Radar”, *Journal of Atmospheric and Oceanic Technology*, pp. 1645-1658, 2004.

[3] Seto, S., T. Iguchi, “Rainfall-induced changes in actual surface backscattering cross sections and effects on rain-rate estimates by spaceborne precipitation radar”, *Journal of Atmospheric and Oceanic Technology*, pp. 1693-1709, 2007.

[4] Rose, C. R., V. Chandarasekar, “A GPM dual-frequency retrieval algorithm: DSD profile-optimization method”, *Journal of Atmospheric and Oceanic Technology*, pp. 1372-1383, 2006.