TRMM PR, its possibility and limitation for the global mapping of precipitation

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Abstract

Data potential of eight-year data observed by the spaceborne radar, TRMM PR, was examined in view of the sufficiency of the sampling and the precipitation property. The degree of a biased climatology of monthly rainfall and the detection ratio of the significant diurnal signature were investigated. The eight-year data clarified a wide-range of the increasing possibilities and enhanced issues. Uncertainty of the precipitation structure adjacent to the surface was addressed as one of the cross-cutting issues.

1. Introduction

The Precipitation Radar (PR) on the Tropical Rainfall Measuring Mission (TRMM) satellite is the first and only spaceborne radar since the end of 1997. More than 12 TB of data had been stored. Given the growing number of data samples without any deterioration, we can apply the data to the climate research where long-term observations are essential to fundamental research needs. In this presentation, the increasing possibility and the performance limitations are introduced.

2. Unique strengths and the sampling issue of TRMM PR data

The primal uniqueness is the global 3-D observation of precipitation echo. It first observed accurate stratiform and convective rainfall over land and ocean. The regional diversity of precipitation profiles is recognized to be of great importance for any other conventional retrieval of precipitation. Main keywords of other unique points would be the attenuation correction by using the path-integrated attenuation, observation from the non-sun-synchronous orbit, and the combination with other sensors on the same platform. On the other hand, the biggest issue for most of possible users is the insufficient sampling. The bias of sampling for each local hour is a critical problem for one-month data analyses. The seasonal data also contain this problem since it consists of the insufficient intraseasonal dataset.

In order to mitigate this issue for the analyses of the seasonal and intraseasonal variation, the usefulness of the multiple-year data was examined. Figure 1 shows the variation of the sampling for each local time, and the change by the data accumulation. The minimum number of the sampling was significantly increased for 8 years. It is 1.4 times more than that of 7 years, and 8 times more than that of 3 years. The accumulated number of samples for the minimum-sampling hour, 3-4 LT, was about 875 samples over 0.5 degree box in August over Tibet. TRMM PR data are becoming climatologically significant and reliable dataset and enabled us to examine the precipitation variability in less time and in fine scale.

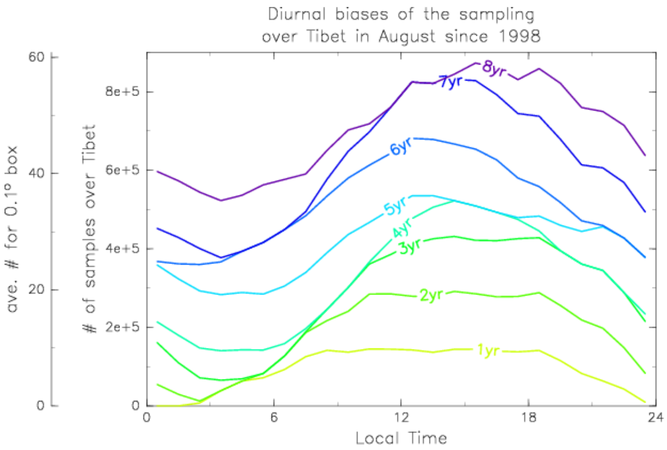

Fig. 1. The accumulated number of hourly samples over Tibet in August since 1998.

3. The temporal variation of rainfall depicted from the long-term data

The detection of the diurnal signature would be a good barometer for assessment of the impact of the long-term data accumulation since it needs sufficient hourly samples in fine spatial scale. We considered the significant diurnal peak based on sufficient samples as the time of maximum rainfall with consecutive positive anomalies for more than three hours. For one summer season, the diurnal signature was ambiguous in most places. The occurrence frequency of the diurnal signal has been increasing according to the increase of the sampling as shown in Fig. 2. For eight summer seasons, 20 % of regions could be detected as the region with the significant diurnal signature. For all season during 8 years, the number became doubled. Looking into Tibet, 80 % of the region was detected, implying the uniform mechanism therein. The TRMM satellite will be on orbit at least until 2009. There should be further examined the increasing possibilities in utilizing the dataset. Each regional characteristics of the diurnal signature prompt our speculation of possible research topics (not shown).

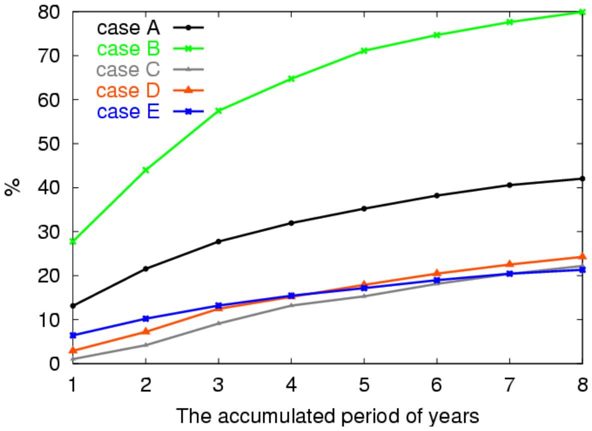

Figure 2. Year to year change of the percentage of significant features of time of maximum rainfall. Case A-E corresponds to the detection rate of the diurnal feature with temporal continuity (case A), over Tibet (case B), over the eastern part of the south Atlantic (case C), and over the globe but for JJA (case D), and that with spatial continuity in addition to the temporal continuity (case E).

Recently, a precipitation system climatology has it going on [e.g., Nesbitt and Zipser, 2003]. Its concept is that climatic variability consists of individual factors and should be understood as conglomerates of precipitation systems. The total rainfall amount is the sum of the individual pixel rain intensities that are grouped into the precipitation systems. The eight-year observation captured millions of precipitation systems over the global tropics. For example, we can understand what kind of precipitation systems makes the regional characteristics of the diurnal variation [e.g., Hirose and Nakamura, 2005]. The global and regional understandings of precipitation properties will deepen from the further data accumulation and a diversity of researches.

4. Remaining issues of the precipitation retrieval

A number of the ground validation of TRMM PR showed that adequate “truth” of global map of rainfall is still in absence. Instead, the reduction of differences in rainfall estimates, about 5 % in average, between TRMM PR and TMI has been discussed by evaluating each data properties. Major possible error sources are listed: Regional variation of the drop size distribution, radar calibration, uncertainty of attenuation correction for water vapor/cloud/precipitation, non-uniform-beam-filling effect, rain profiles in the surface clutter, the temporal variation of the freezing level, the variation of the ice particles, and so on. Most of them are considered in the latest algorithm. However, they are still in controversy.

As an example of current activities, uncertainty in the surface rainfall estimates is focused on. Any radar cannot observe rainfall rate at the surface due to the surface clutter. Around nadir and at the edge of the swath, the most frequent near-surface level was 500 and 1750 m, and the ninety-fifth percentile was 750 and 2000 m, respectively (Fig. 3). Hence, in the latest algorithm, it has been estimated by assuming several constant slope of dBZe in the clutter region. The slope was obtained from the wind profiler and TRMM PR observation. It is generally decreasing considering on the slower terminal velocity near the surface. The height smearing effect of the near-surface levels on rainfall rate and the regional variation of the slope near the surface have not been clear yet.

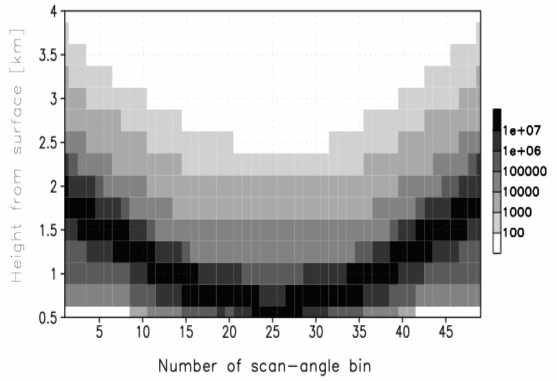

Fig. 3. The number of the lowest levels by altitude diagram for each angle bin in case of no-rain over ocean during 1998-2000.

As a comparative example, another surface rainfall was estimated by using the vertical gradient of rainfall rate near the surface at nadir. Compared with our estimates utilizing the profiling capability of TRMM PR, the difference between estimated surface rainfall and near-surface rainfall was almost same on the global average but becomes large over the tropical land and over the mid-latitudes in winter (Fig. 4). Rain at 2 km was 6.6 % smaller than that at 1 km. There is few statistics of the vertical gradient below the level of 1 km. With the collaboration of other ground-based observations, some kind of physical model is needed, considering on the regional variation of the precipitation type and the environment.

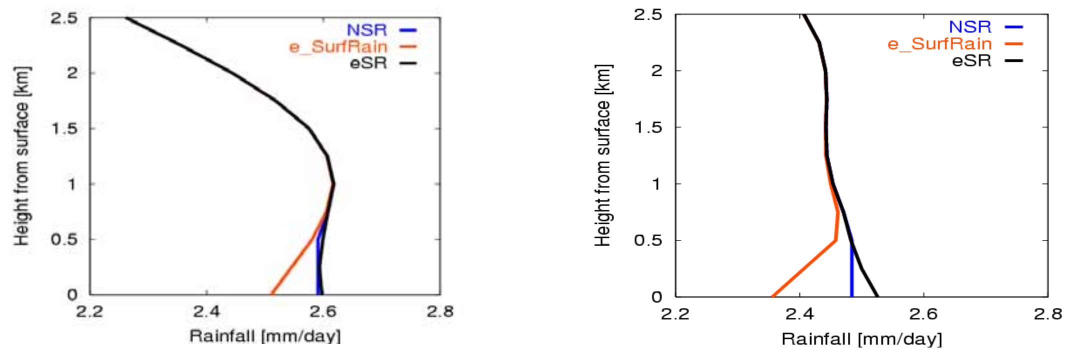

Fig. 4. Altitudinal differences of averaged rainfall over the global tropics (left) and over land (right). Dark colored lines indicate the observed and extrapolated vertical rain profiles. The other is estimated in the latest algorithm.

5. Conclusion

The long-term data accumulation enabled us to investigate more accurate rainfall at various temporal and spatial scales such as the intraseasonal and diurnal scales. Furthermore, it gives an opportunity to resolve the constituents of a particular climate regime as being congregations of various precipitation systems. The comprehensive and interdisciplinary discussions are needed for further scientific and algorithm benefits.

References

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