A LONG-TERM TREND OBSERVED IN TRMM/PR MONTHLY RAINFALL PRODUCTS AND AN EVALUATION OF SAMPLING ERROR BY A BOOTSTRAP METHOD

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In this study, monthly rainfall amounts from September 2001 to December 2007 observed by the Precipitation Radar (PR) aboard the Tropical Rainfall Measuring Mission (TRMM) satellite are analyzed. It is shown that the monthly rainfall amounts averaged in the range of 35N to 35S tend to increase slightly over this period. Since the quality of data has changed after the TRMM satellite altitude was raised from 350km to 402.5 km in August 2001, we focus our analysis on the PR dataset only after the altitude change. For more than 10 years, all components of the PR including the 128 elements of the T/R system have shown no sign of trouble. The long term hardware stability of the PR is verified from the small monthly variation (less than 0.05 dB) of sea surface scattering cross sections in no rain conditions (Okamoto et al. 2002, Oki et al. 2008). Therefore, it is considered that this tendency is mainly due to natural variability and sampling error in the rainfall amount data. Natural variations such as El Niño and La Niña can affect the tendency. In fact, an El Niño event was observed during 2002-2003 and La Niña events were observed during 2005-2008. In addition, the monthly rainfall products include large sampling errors due to narrow observation swath of the PR. Here, we evaluate the sampling error in PR-observed monthly rainfall amounts by a bootstrap method using PR 2A25 Version 6 data, and detect a long-term trend in the time series of monthly rainfall amount considering the simulated sampling error by the bootstrap method.

We simulate 1000 monthly rainfall amounts over 5-degree boxes of 35N-35S using a bootstrap method. The PR-observed monthly average rainfall amount can be obtained by averaging the mean rainfall rates (R_{obs}s) at the PR visits, weighted by the number of footprints (N_{obs}). Here, the R_{obs} is a rain rate averaged over the 5-deg. x 5-deg. area at each visit and N_{obs} is the number of PR pixels over the 5-deg. x 5-deg. area at the visit. We make the probability distribution function (PDF) of the mean rainfall rate R_{obs} and the number of footprints N_{obs} calculated from the 2A25 data, respectively, and resample the mean rainfall rate R_{ran} and the number of footprints N_{ran} using the PDF by generating the random number. Thus, we can simulate a PR-observed monthly rainfall amount over a 5-degree x 5-degree area. The sampling error can be calculated as the standard deviation of the 1000 simulated monthly rainfall amounts. By averaging the simulated rainfall amounts on all the 5-degree areas, we calculate 1000 monthly rainfall amounts averaged in the range of 35N-35S and evaluate the sampling error. In the trend detection, assuming zero-order and first-order linear regression models, we fit two lines to the time series of monthly rainfall amount weighted by the simulated sampling error, and calculate AIC (Akaike's Information Criterion) of the models. From comparison with AIC values of the two models, the first-order linear regression model, which indicates increases of monthly rainfall amount, is more suitable than the zero-order model showing no-trend.

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