Effects of Non-uniform Beam-filling on TRMM PR Rainfall Measurements

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The Tropical Rain Measuring Mission will carry a 14 GHz Precipitation Radar (PR) as one of its instruments. The surface horizontal resolution of the PR is approximately 4.3 km. Many of the most intense rainfall events in the tropics have horizontal scales less than the PR footprint. Consequently, the rainfall rate will not be uniform over the PR footprint when observing these events. Previous studies have shown that such non-uniform beam-filling (NUBF) can cause biases in the retrieved rainfall rate. In this work we investigate the effect of NUBF using data acquired by the Airborne Rain MApping Radar (ARMAR) during the TOGA COARE field experiment in 1993. ARMAR operates at the TRMM PR frequency but has much better spatial resolution because of its close proximity to the rainfall. We developed a technique to simulate the TRMM PR using the ARMAR data. This involves convolving a Gaussian shaped resolution volume with the ARMAR data. Because the operating frequency and geometry are essentially identical, the ARMAR attenuation is approximately the same as that expected for the PR, simplifying the simulation. The PR rainfall is retrieved from the simulated PR reflectivity data. The effect of NUBF is found by comparing the PR measurements with quantities computed by first retrieving the rainfall from the high resolution data. We find that the nonlinear dependence of the reflectivity on rain rate causes the rain rate at high altitudes to be overestimated. However, the exponential dependence of attenuation on rain rate cause the path attenuation and the near-surface reflectivity and rain rate to be underestimated. We present statistics on the expected errors in reflectivity, path attenuation, and rain rate due to NUBF, as a function of rainfall regime and rainfall spatial variability.