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Efficient Monte Carlo Algorithm to Retrieve Precipitation from Satellite Combined Radar and Radiometer Observations

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Precipitation estimation from satellite observations is an ill-posed problem that does not have a unique solution that is stable to small perturbations in the observations. To prevent the derivation of highly inaccurate estimates, it is customary to recast the problem in a statistical framework in which statistical distributions of solutions are derived instead of unique deterministic solutions. These distributions can be determined either parametrically through the minimization of parameterized likelihood functions or directly through the generation of random possible solutions and evaluation of their likelihoods. The latter approach (known as the Monte Carlo approach) although mathematically the most general is computationally intensive. In this study, we present an efficient Monte Carlo algorithm to generate the precipitation conditional distributions associated with GPM radar and radiometer observations. The algorithm is based on a dual-frequency radar retrieval procedure that derives precipitation profiles as a function of a set of assumed geophysical parameters and a radiometer observation simulation module. While radar-only retrievals can he readily handled using Monte Carlo procedures, combined retrievals are considerably more challenging because the number of solutions that need to be evaluated may increase exponentially without an efficient sampling methodology. Purely statistical Monte Carlo sampling strategies such at the Metropolis and Gibbs sampling techniques, although characterized by polynomial complexity, are still unfeasible for a real time algorithm. In this study we investigate a Hybrid Monte Carlo Technique (HMCT) that makes use of the gradient of an observation likelihood function to sample the space of possible solutions. The combined algorithm based on the HMCT is tested using actual TRMM observations and simulated GPM observations.