Improved Combined Radar/Radiometer Instantaneous Rain Retrievals

Z. S. Haddad
Jet Propulsion Laboratory – California Institute of Technology
300-227 JPL
4800 Oak Grove Drive
Pasadena, CA 91109-8099

In spite of the generally satisfactory performance of the current TRMM combined radar/radiometer instantaneous rain profiling algorithm, validation efforts have revealed three significant weaknesses. The first is the current "naive" least-squares measure of the difference between expected and measured radiances, which the algorithm uses to weigh prospective radar-derived rain profiles according to how well they match the measured radiances. The second is the current simplified relations between rain profiles and microwave radiances, which the algorithm uses to calculate expected radiances given a prospective radar-derived rain profile. The third is the absence of any ice profiling, which effectively precludes any estimation of latent heating profiles.

The (Bayesian) approach implemented in the algorithm tries to compensate for the known shortcomings of each instrument by exploiting the strengths of the other, and it does so while avoiding unjustified ad-hoc shortcuts — it calculates the probability of rainrate given the measurements, conditioned on the observations from the radar and the radiometer. It turns out that the strengths and weaknesses of the radiometer's measurements are not quite as they were though to be before TRMM date started to become available. Specifically, the current algorithm presumes that the radiances at the various frequencies are approximately independent, and computes the corresponding probability weights accordingly. However, an analysis of the joint behavior of the radiances in the TRMM cloud simulations database has revealed strong correlations between the channels. The new estimates of the conditional covariance of the radiances given the rain are currently being incorporated into the algorithm to make the probability weighting more realistic.

The second weakness of the combined algorithm stems from the representativity of the passive microwave database. Indeed, the calculation of the mean radiances to be expected from a given rain profile, using the TRMM cloud simulations database, assumes that the database is representative of tropical rain. It turns out that while the database is passable representative at 10.7 GHz, its values and those of the TRMM measurements are significantly mismatched at higher frequencics. To reduce the rain over-estimation produced by this discrepancy, we have re-sampled the database and re-derived mean rain-radiances relations which are currently being incorporated into the algorithm.

The third weakness is the lack of any ice estimates. The main problem with trying to estimate graupel, ice and snow profiles, along with a rain profile, is the large number of unknown variables involved: given one radar reflectivity profile and a few colocated radiances, one would think that one can only estimate the rain profile and a few additional variables. However, a principal component analysis has revealed that the frozen hydrometeor profiles can be approximately estimated by calculating a single variable for the ice, one for the snow, and two for the graupel. A straightforward Bayesian method is currently being implemented to estimate these additional variables, and to include them in the output structure of the combined algorithm. Simple linear formulas will enable users to reconstruct the corresponding graupel/snow/ice profiles, and will make possible the estimation of latent heating profiles based on the radar and radiometer data.