# Improved parameterizations in the GPM combined algorithm

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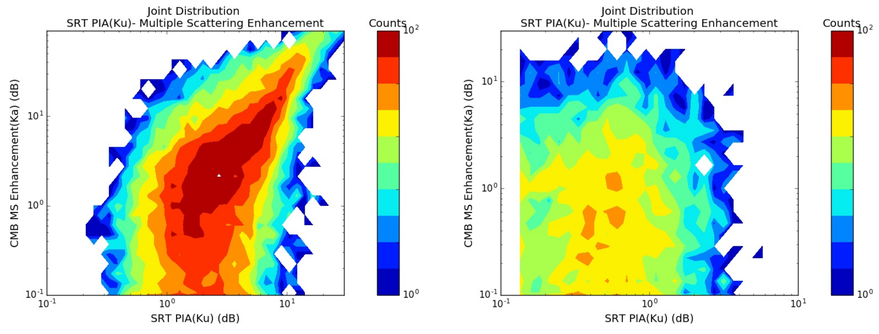
## 1. Background

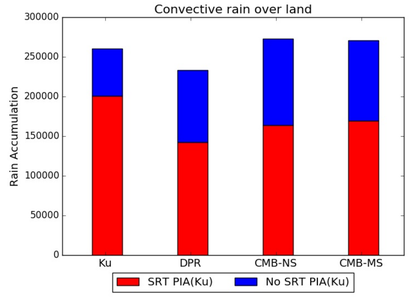
- Dual (and single) frequency radar retrievals may be affected by multiple scattering and non-uniform beam filling (NUBF).
- To mitigate multiple scattering and NUBF appropriate parameterizations have been introduced in the combined algorithm (CMB).
- While these parameterizations are performing satisfactorily, comparisons between CMB rain estimates and GV estimates suggest either defficiencies in the parameterization of the state variables or the quantification of uncertainties in the forwad models.

## 2. Methodology

- To investigate these issues, the convective precipitation retrievals over land are separated in two classes as a function of the reliability of the Surface Reference Technique (SRT) estimate of the PIA.
- Reliable SRT PIA estimates are expected to be generally large and associated with reflectivity observations that exhibit multiple scattering in the Ka-band observations. For such profiles dual frequency retrievals are not expected to be more reliable than Ku-only retrievals.



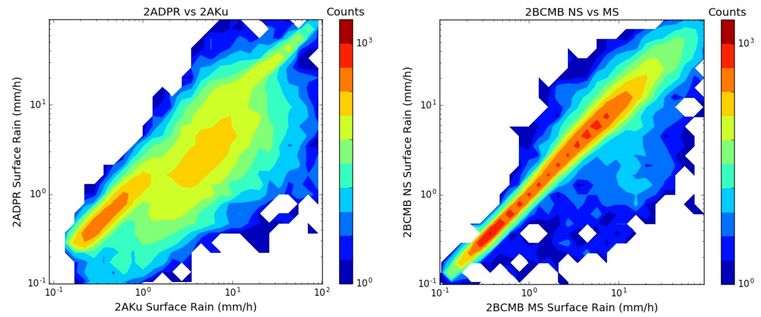

## 3. Results



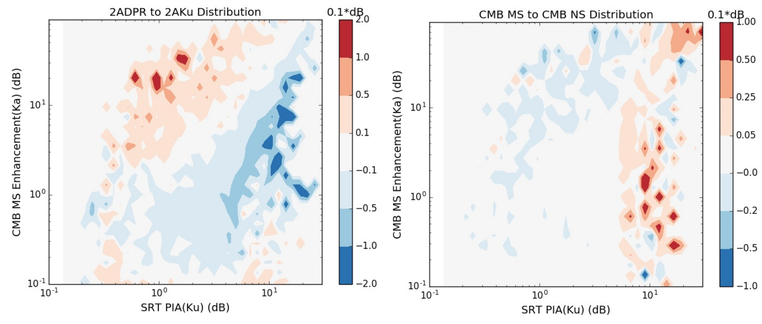

- Estimates of the total convective rain over land are consistent among algorithms.
- However, an inversion, is apparent in 2AKu estimates.
- Significantly more intense rain is estimated by the 2AKu algorithm when SRT PIA(Ku) is reliable, while the opposite holds when SRT PIA(Ku) is small and unreliable.

## *Convective precipitation with reliable Ku SRT estimates*

- The joint distribution of 2AKu and 2ADPR surface rain rates show large differences and two discontinuities (at about 1.0 and 10. mm/h)
- Combined MS and NS estimates are in better agreement with each other than the DPR products.



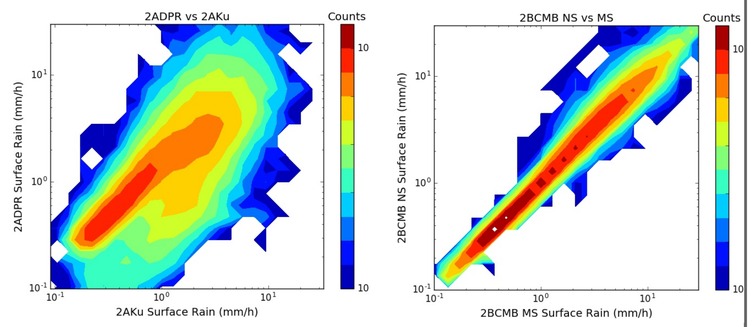

- Similar trends are apparent for convective rain with no reliable SRT PIA(Ku) estimates.
- The ratio of dual frequency to single frequency estimates show

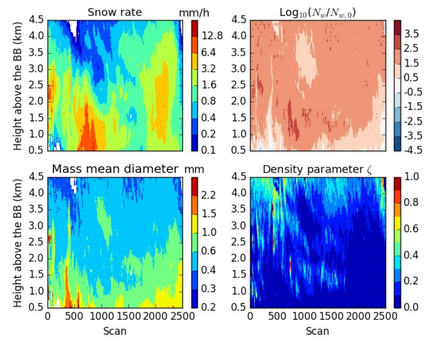



that DPR estimates are larger than 2AKu estimates for strong multiple scattering and moderate SRT PIA, while for the combined estimates the trend is opposite.

## *Convective precipitation without reliable Ku SRT estimates*

- Exhibit similar behaviour as estimates in the previous category
- Since both multiple scattering and NUBF effects are small, it is the optimal category to investigate and refine dual frequency retrievals.




Combined retrievals exhibit very small differences for rain rates smaller than 1.0 mm/h. The covariances in the ensemble filter need to be re-assessed.

- Snow density parameterizations derived from airborne observations collected during OLYMPEX/RADEX will be incorporated into the combined to reduce the degrees of variability in light/moderate rain retrievals.

## Summary

- Multiple scattering and NUBF parameterizations have been introduced in the combined algorithm to improve the consistency between single and dual frequency retrievals and reduce biases.
- The consistency between single and dual frequency retrievals have been investigated for both DPR and the CMB algorithm.
- While discrepancies and uncertainties are difficult to explain and quantify when attenuation and MS are strong, the consistency and optimality of the algorithms can be established for low intensity convective rain.

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