# Hybrid Estimates of Path Attenuation for the DPR


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## Hybrid Estimates- Motivation

- A hybrid formulation is motivated by the desire to obtain the most accurate estimate of path attenuation by combining existing methods
- Existing methods include
  - Hitschfeld-Bordan
  - Surface Reference Technique
  - Standard Dual-Wavelength
- We use the fact that if the hybrid estimate is written as a weighted sum of the above methods, then the weight of the jth estimate is proportional to the inverse error variance of that estimate
- As a consequence, the error variance of the hybrid is less than or equal to the smallest error variance among the methods used
- A difficulty in implementation is determining the error variance of each of the methods

## Hybrid Estimates– Summary

- At moderate to high PIA, DSRT tends to be weighted most strongly, esp over ocean, followed by DW and HB
- At low values of PIA, HB tends to dominate
- Reliability factor/flag indicates that hybrid estimate is often more accurate than SRT/DSRT
- Though dual-freq results tend to be more accurate than those from single-freq., the Ka-band signal is at times lost at high PIA
- A critical part of the procedure depends on the variances assigned to the SRT, HB and DW. More work is needed in quantifying these error variances

## Details

- If n independent estimates of a quantity A are available $\{A_1, \ldots, A_n\}$ and if the resultant estimate is written in the form

$$\hat{A} = \sum_{j=1}^{n} w_j A_j$$

- Then the minimum variance of the estimate A is obtained by taking (method of Lagrange multipliers)

$$w_j = \tau_j / \sum_{j=1}^{n} \tau_j$$

$$\tau_j = 1/\mathrm{var}(A_j)$$

- Explicitly, for the dual-frequency case

$$\delta A_{HY} = w_{SRT}\delta A_{SRT} + w_{HB}\delta A_{HB} + w_{DW}\delta A_{DW}$$

- For the single-frequency case

$$A_{HY} = w_{SRT}A_{SRT} + w_{HB}A_{HB}$$

- To characterize the errors, it is convenient to define a reliability flag (RF)

r = E(A)/std(A)

RF=1 if r>3 (blue)
RF=2 if 1<r<3 (green)
RF=3 of r<1 (yellow)
RF=4 if SNR<2 (red)

### Hitschfeld-Bordan

$$Z(r) = Z_m(r)/[1-\zeta(r)]^{1/\beta}$$

$$A_{HB}(r) = -(10/\beta)\log_{10}[1-\zeta(r)]$$

$$\delta A_{HB}(r) = 10\log_{10}[(1-\zeta(r,Ku))^{1/\beta(Ku)}/(1-\zeta(r,Ka))^{1/\beta(Ka)}]$$

$$\zeta(r) = 0.2\beta\ln 10\int_0^r \alpha(s)Z_m^{\beta}ds; \quad k = \alpha Z^{\beta}; \quad \delta A \equiv A(Ka) - A(Ku)$$

### Standard Dual-Wavelength

$$\delta A_{DW}(r_{ns}) = DFR_m(r_{ns}) - DFR(r_{ns})$$

$$\delta A_{DW}(r_{ns}) \approx [dBZ_m(Ku,r_{ns}) - dBZ_m(Ka,r_{ns})] - DFR(dBZ_m(Ku,r_{ns}))$$

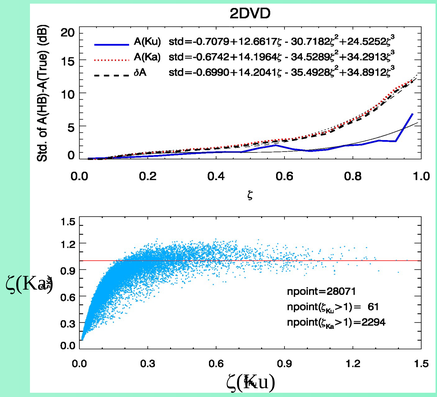
### Surface Reference Technique

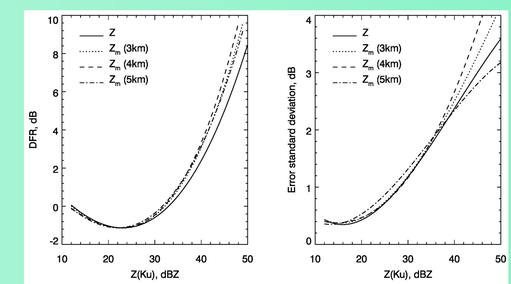
$$A_{SRT} = \sigma^0(no-rain) - \sigma^0(rain)$$

$$\delta A_{SRT} = \delta\sigma^0(no-rain) - \delta\sigma^0(rain)$$

$$\delta\sigma^0 = \sigma^0(Ka) - \sigma^0(Ku)$$

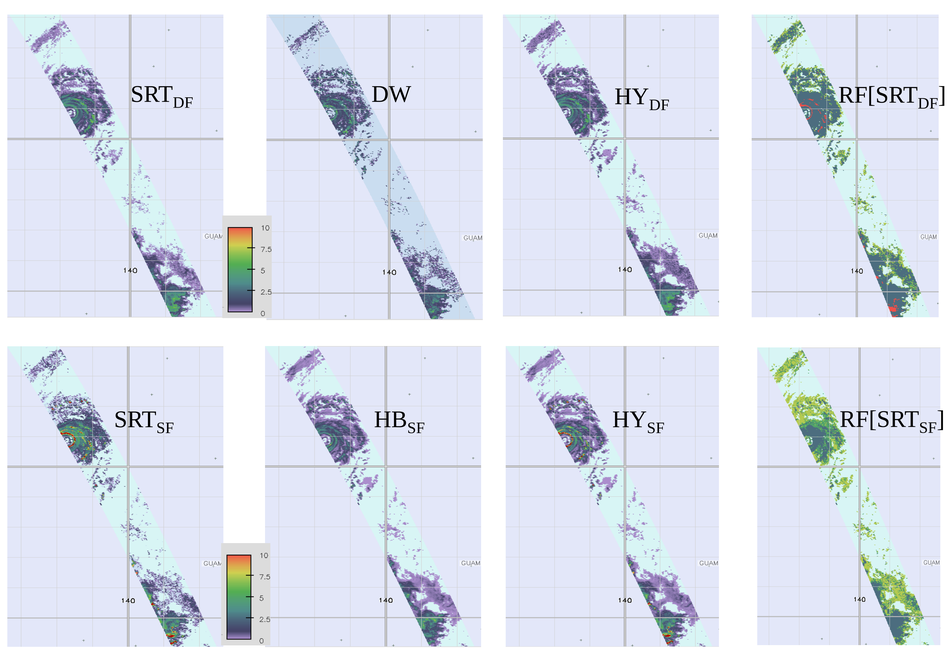
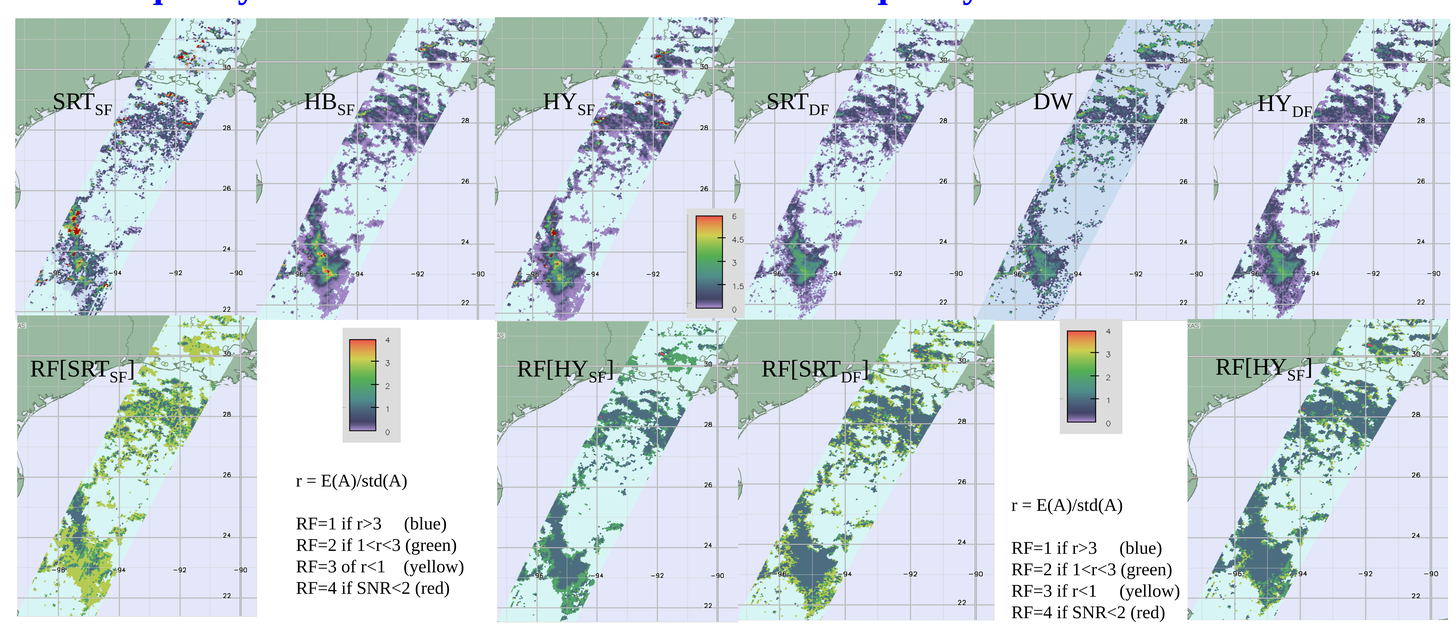
$$\delta A = A(Ka) - A(Ku)$$




## 1-Frequency Estimates of Ku-band PIA

## 2-Frequency Estimates of Ku-band PIA

**2-freq Ku PIA**

**1-freq Ku PIA**