Observing the Full Spectrum of the Rain Drop Size Distribution

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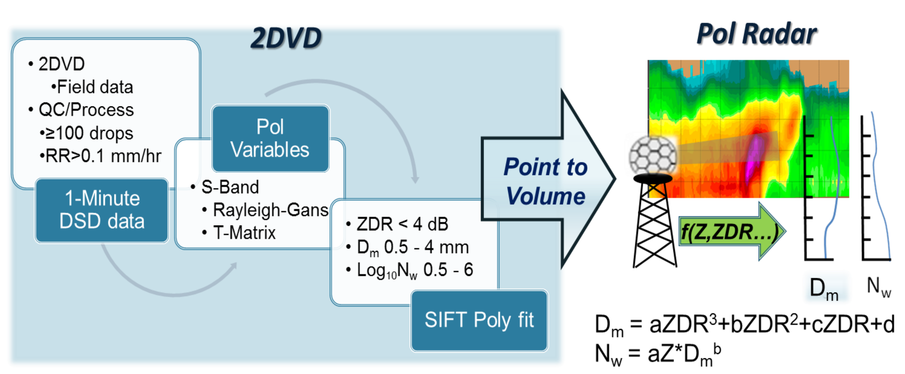
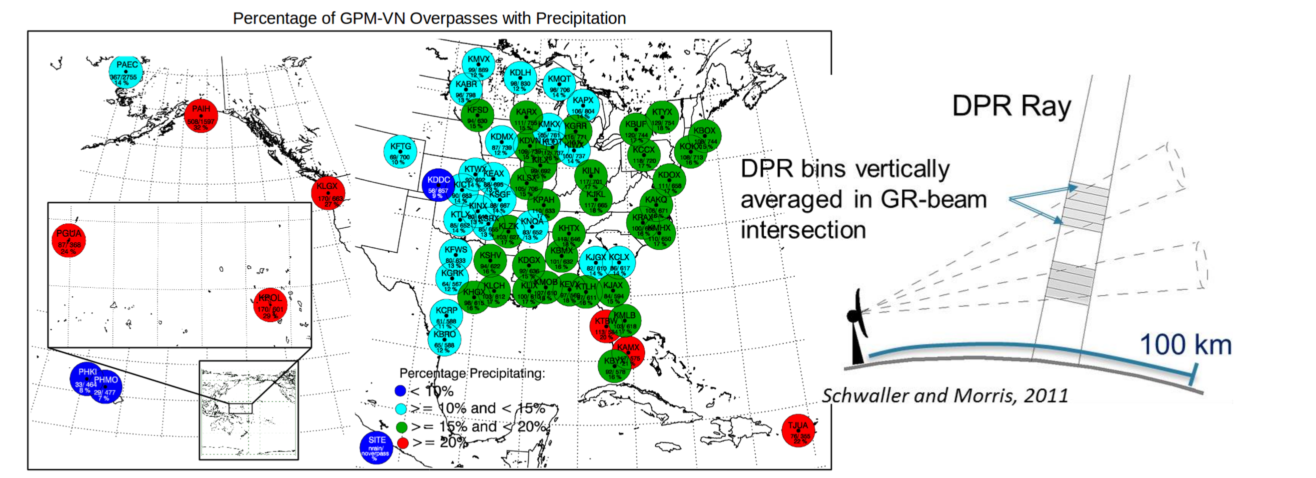
1. Objective: Verify and Improve GPM Drop Size Distribution Retrievals

- Drop size distributions (DSD; D_m, N_w) are critical to GPM DPR-based rainfall retrievals.
- Examine physical consistency between GV, algorithms, and within and between algorithms.
- Comparisons with GV suggest DPR D_m bias in convective rain is correlated to underestimation of rain rate. What is the source?
- Light rain/small DSDs are a challenge: Should a generalized gamma (GG) approach be used to model the full DSD spectrum?

2. Continental to Site Specific GV and DPR studies

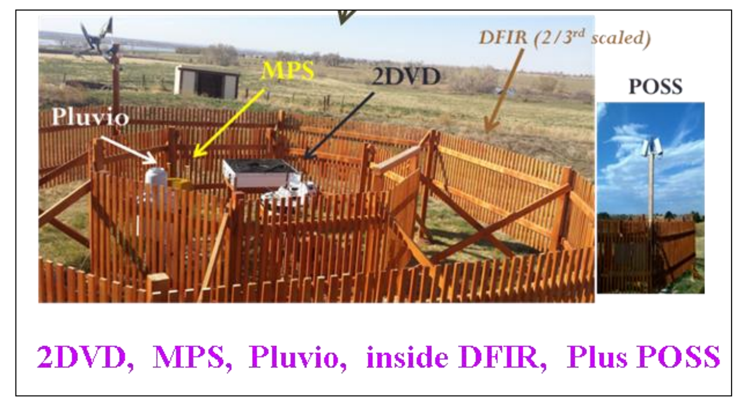


2D Video Disdrometer (2DVD) measurements in a multitude of regimes translated to dual-pol radar moments and DSD retrieval equations



Sample and collocate coincident GV radar and DPR DSDs for O[50-300] raining overpass volumes per radar site within VN radar network

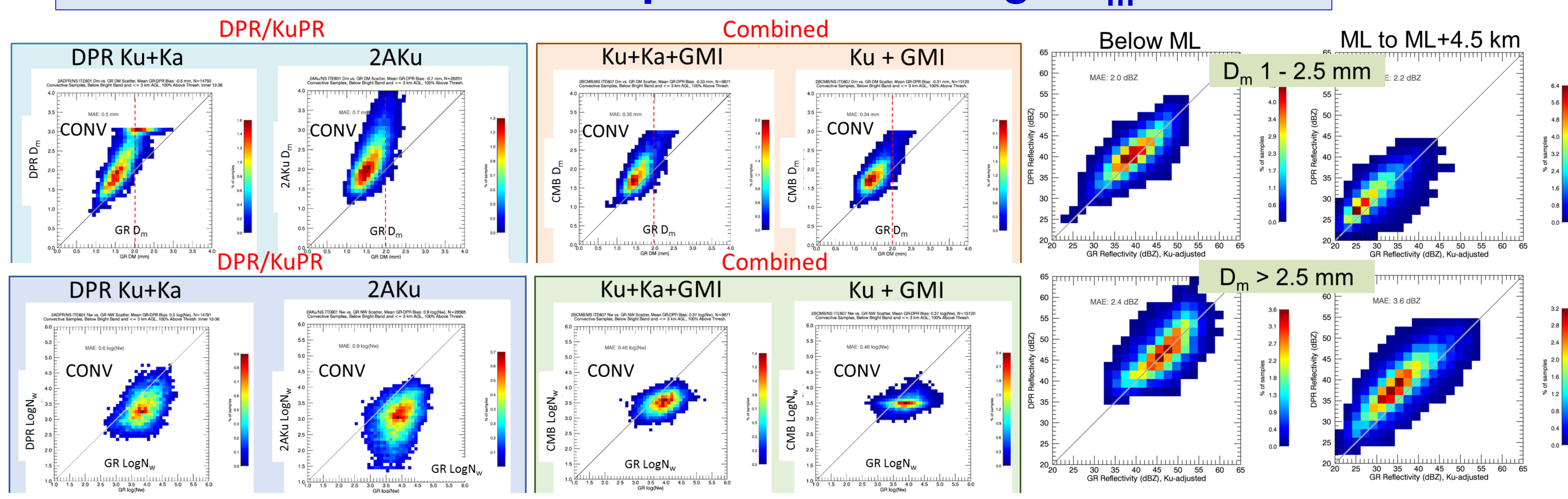
Greeley, CO



Huntsville, AL

Greeley CO (left) and Huntsville AL sites (right): 2DVD and Meteorological Particle Spectrometer (MPS) enable studies of the *full* DSD spectrum.

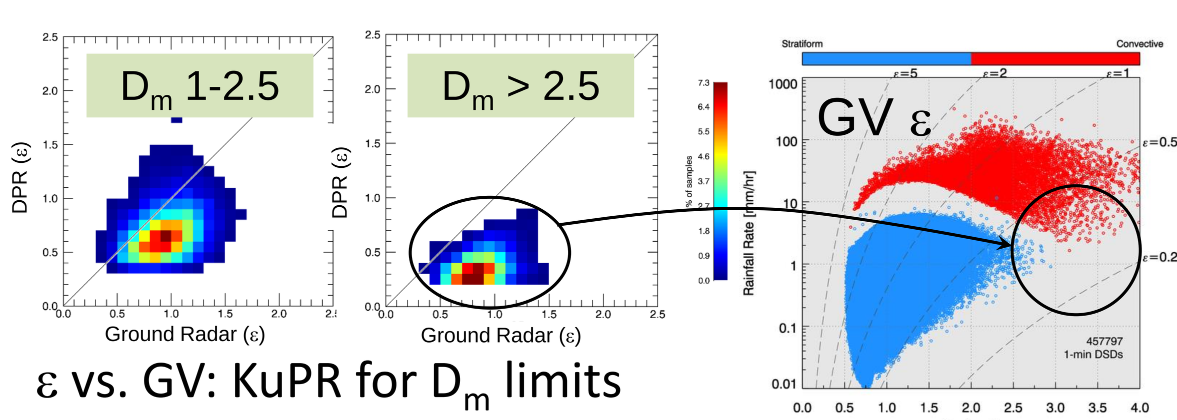
3. Focus on Convective spectrum and large D_m



KuPR Z-corrected for convection below and above melting layer (ML) common (left) and "big" D_m (right) regimes

Above: Positive bias in convective D_m (top) increases with D_m > 2 mm (red-dash line). N_w (bottom) inconsistent across algorithms, over-compensates negative bias in KuPR D_m.

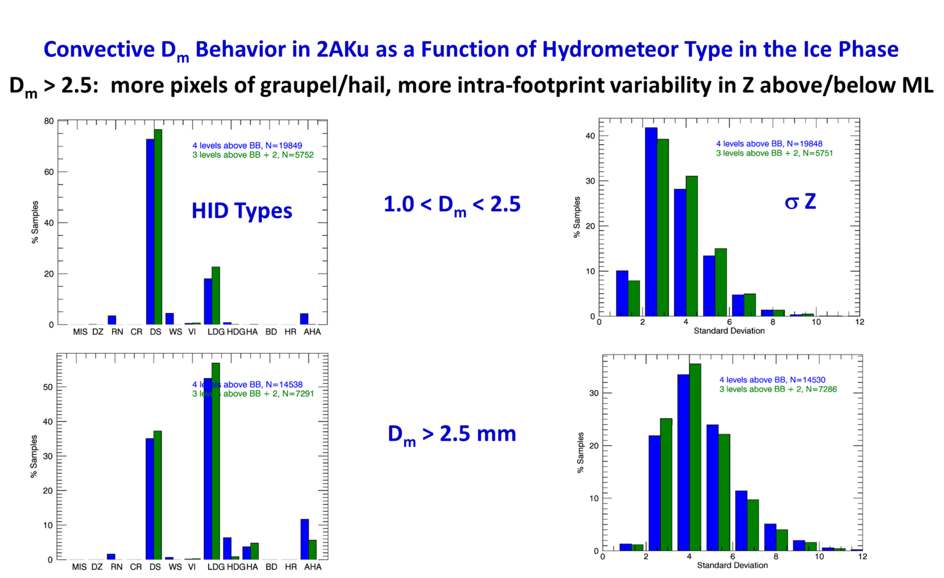
Convective Z below ML similar to GV regardless of D_m; Convective Z increases aloft with large D_m



ε vs. GV: KuPR for D_m limits

Recall: $R = a\varepsilon^{4.258} D_m^{5.42}$

Impact: ε is key to PIA correction and like an N_w; If too low, underestimation of convective rain rates when D_m is too large



HID has enhanced ice-phase in convection with large D_m- makes sense, but also more intra pixel variability in Z (above ML- shown, and below- not shown)

Large D_m issue a possible symptom of NUBF (PIA correction)?

4. Focus on Small D_m and GG model for complete DSD spectrum

The GG Model

For consistency with standard gamma, moments (M) I=3, J=4 used in this study; others have used 3, 6, respectively

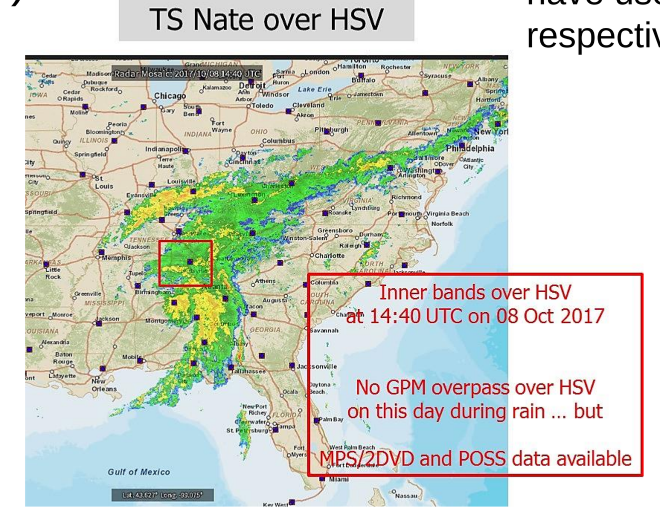
$$N(D) = N_0' \, h_{GG(i,j,\mu,c)}(x)$$

$$\text{where} \quad N_0' = M_i^{(j+1)/(j-i)} M_j^{(i+1)/(i-j)} \quad \text{and} \quad D_m' = (M_j/M_i)^{1/(j-i)}$$

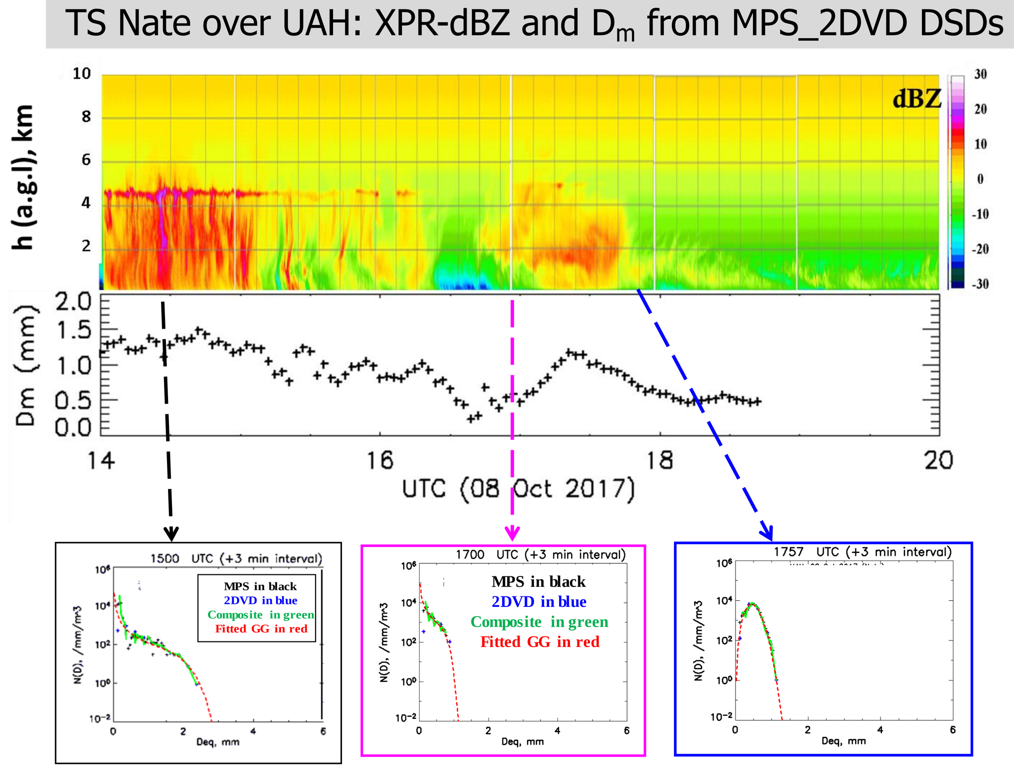
$$h_{GG(i,j,\mu,c)}(x) = c\,\Gamma_i^{\frac{(j+c\mu_{GG})}{(i-j)}}\,\Gamma_j^{\frac{(-i-c\mu_{GG})}{(i-j)}}\,x^{c\mu_{GG}-1}\exp\left[-\left(\frac{\Gamma_i}{\Gamma_j}\right)^{\frac{c}{(i-j)}} x^c\right]$$

$$\Gamma_i = \Gamma\left(\mu_{GG} + \tfrac{i}{c}\right) \quad \text{and} \quad \Gamma_j = \Gamma\left(\mu_{GG} + \tfrac{j}{c}\right) \quad \text{and} \quad x = \left(\tfrac{D}{D_m}\right)$$

TS Nate over HSV

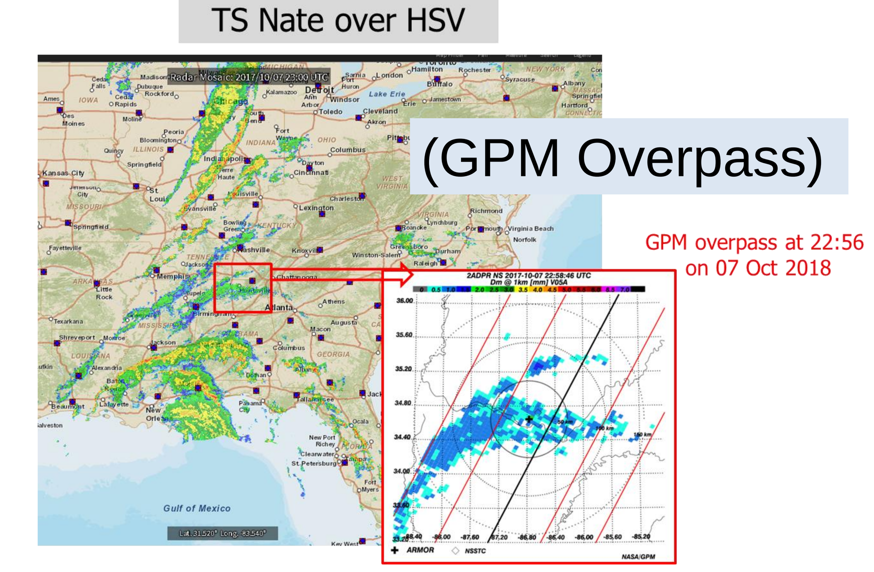


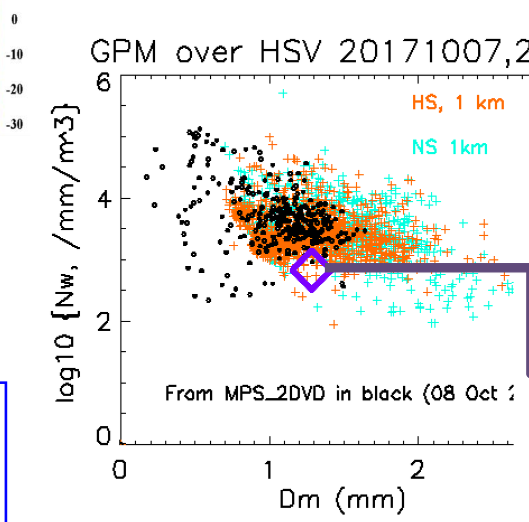
TS Nate over UAH: XPR-dBZ and D_m from MPS_2DVD DSDs

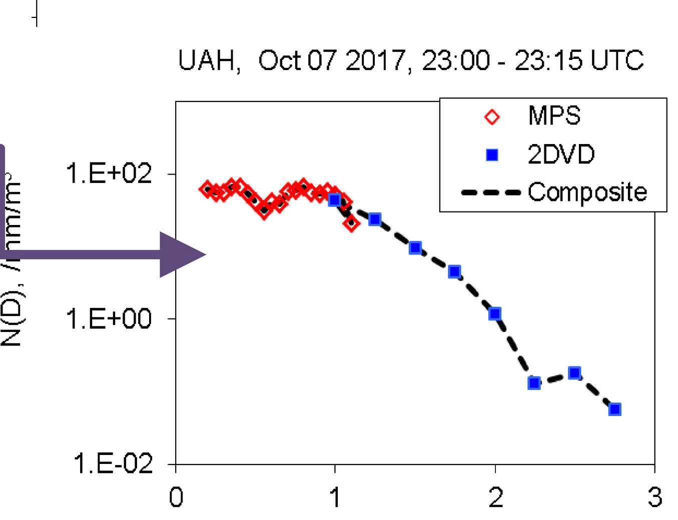


Top: XPR Observations of TS Nate during weak bright band period and shallow warm rain. Bottom: DSDs as indicated. GG approach represents varying spectra in light rain very well.

TS Nate over HSV

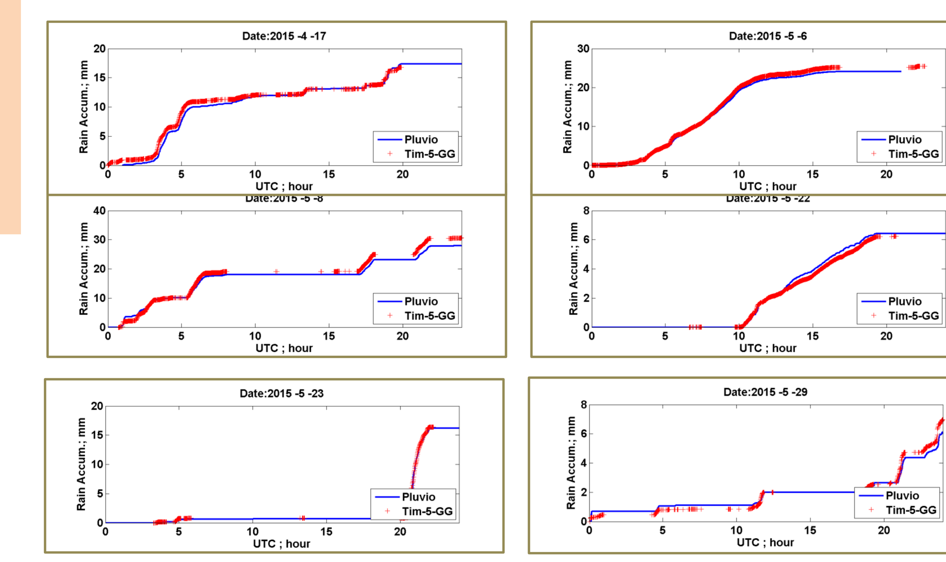






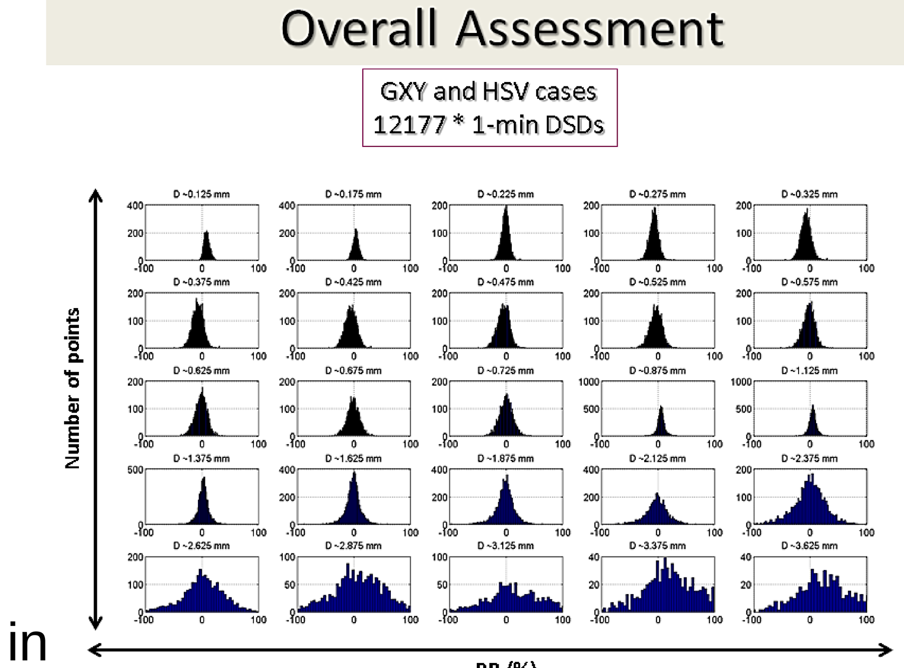
MPS and GPM Observations of TS Nate DSD in full bands on 8 Oct. (left). Diamond represents DSD sampled in HSV during overpass (right)

GXY cases: R and Accum vs. Pluvio



<u>Above</u>: Greely (GXY) CO site. MPS-2DVD DSD fits result in robust accumulation performance for a variety of event types.
<u>Below</u>- Little bias in MPS-2DVD GG data-fits until large diameters (sampling impact)

Overall Assessment



Collectively, the GG approach seems robust; how might we might implement the approach in future GPM algorithms?

4. Summary

GPM DSD retrievals exhibit inconsistencies between GV, DPR and Combined algorithm retrievals. Development of positive bias in convective D_m rain DSD noted, and strongest in KuPR retrieval. Associated epsilons are too low and result in markedly reduced convective rain rates (a current issue in the retrievals). Source may be NUBF. Issues with the large end of the DSD not withstanding, on the small end of the DSD, combined MPS and 2DVD measurements fit with generalized gamma functions exhibit strong potential for representing the entire spectrum of the DSD and subsequently the whole rain rate spectrum.

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