GPM Ground Validation Across the Precipitation Continuum

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1. Science

- **Field-data characterization of coupled precipitation properties and processes affecting GPM retrieval algorithms, including: Precipitation rate, type, size distribution, water content, and coupling of spatial variability in the column and horizontal plane.**

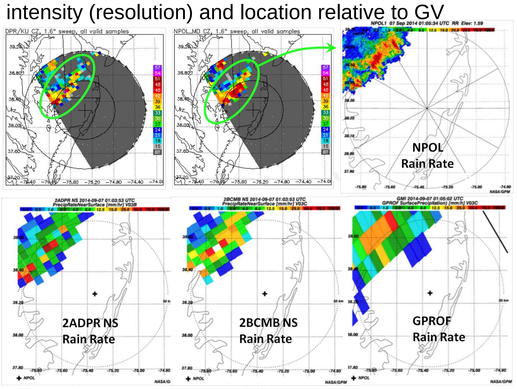
2. Data/Measurements

- **Work presented here is from three GPM GV Field Campaigns (LPVEX, MC3E, GCPEX), the NASA Wallops GPM GV Site, and the GPM GV partner site in Hyytiala, Finland.**
- **Primary measurement platforms: GPM Core Satellite, GV Polarimetric radars, 2D video disdrometers, Precipitation Imaging Package (PIP), snow gauges,**

3. Overpass Data Collections in Convection:

- **NUBF vs. PIA , DSD and 3-D structure (profile) impacts?**

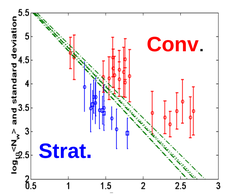
Products exhibit some differences in convective intensity (resolution) and location relative to GV

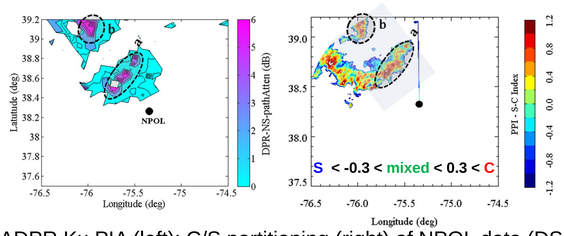


Top; Validation network (VN) matched geo-matched 2ADPR KU NS (left), NPOL PPI at 1.2º and NPOL rain rates (RR). Bottom: 2ADPR NS RR, 2BCMB RR and GPROF RR.

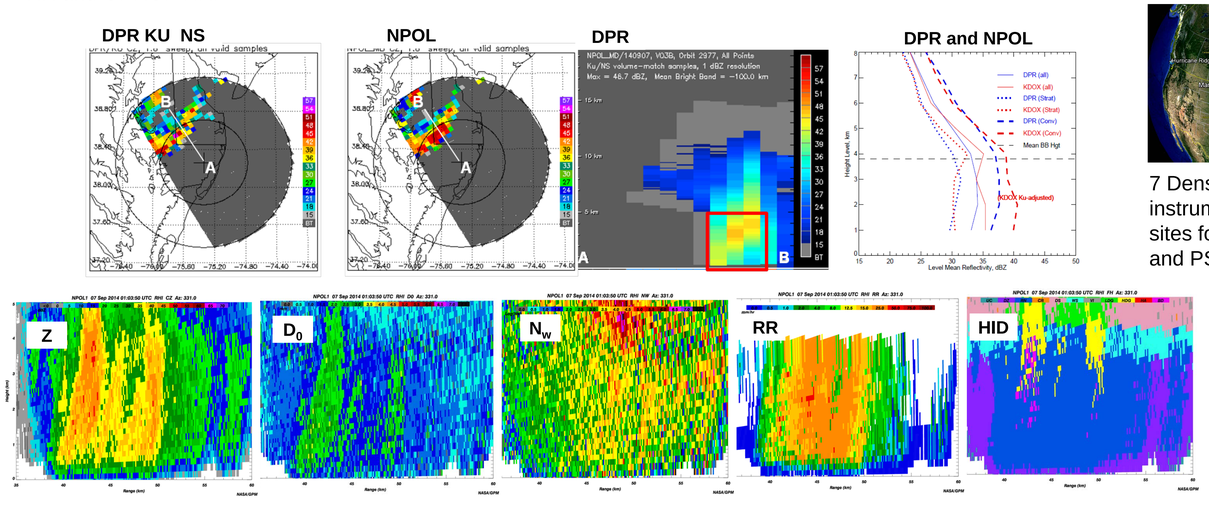
Given importance of DPR algorithm profile modules, consider linkage to C-S precip types.

- Apply DSD-based partitioning method to GV NPOL data (Bringi et al., 2003, Thurai et al., 2010, 2015) to develop a C-S likelihood index.





2ADPR Ku PIA (left); C/S partitioning (right) of NPOL data (DSD based). PIA consistent with C/S partition, but NPOL comparisons indicate PIA correction is not enough in convective echo (Below).



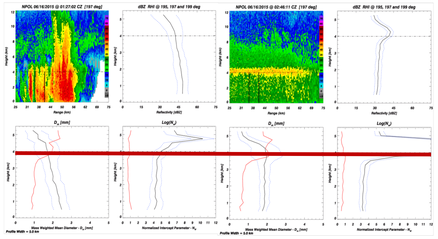
Top: As above but now with DPR cross-section along A-B, and VN profiles of DPR and NPOL averaged over combined coverage domain. Bottom: Coincident NPOL RHI of Z, D_0, N_w, RR, and Hydrometeor types (HID) along A-B and focused on red box in DPR cross-section. *DSD / rain rate variability are pronounced; ice influence on phasing of DSD, Z and Rain Rate (RR) profiles evident*

Robust agreement between DPR and NPOL in ice aloft and more generally in stratiform echo (more cases not shown); However profiles in Z sometimes diverge in convection at and below mixed phase (liquid layers). **Why?**

To what extent do observed 3-D gradients in water content, DSD and precipitation type impact NUBF algorithm(s) on inter and intra footprint scales? How dependent is this on precipitation type (e.g., C/S)?

4. Character of DPR IFOV Profile variability

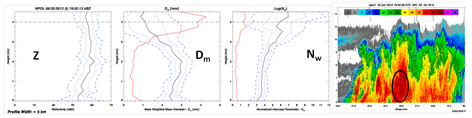
High resolution characterization of column hydrometeor properties and intra/inter IFOV correlation structure essential to validating DPR/Combined algorithms. ***Structure/magnitude of vertical profile variability is examined at intra IFOV scales in both convective and stratiform precipitation.***



Large-drop producing MCS 6/16/2015 WFF GV Site.

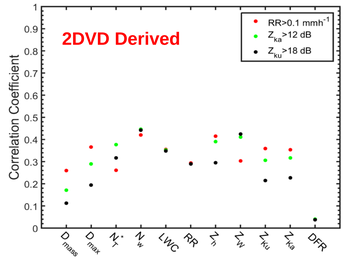
Top: NPOL RHIs of Z with profiles of Z-mean and σ for select 5 km IFOV over WFF GV 2DVD network (left shallow convective large-drop cores; right stratiform). Bottom: mean, σ, and coefficient of variation (σ/mean; red scaled by factor of 5) of D_m and N_w. Melting level indicated by bold red line.

Profile variability well-behaved but more pronounced in convection (as expected). See **Wofff et al. poster**.

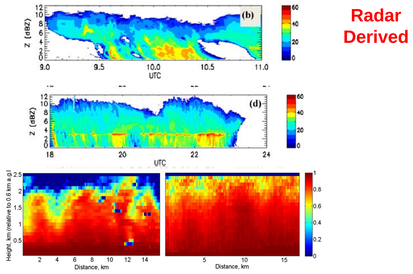


WFF GV Site: As in Fig. X but coastal ocean convection profiles with pronounced ice-process; far more vertical structure to profile variability. 2-σ variability also indicated.

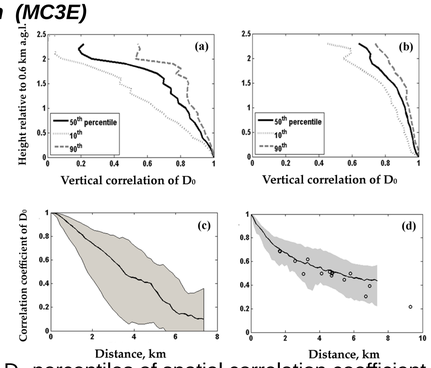
How does profile variability translate to 3-D correlation structure? Convective and Stratiform (MC3E)



MC3E campaign mean DPR IFOV scale (5 km) horizontal plane spatial correlation of DSD parameters, RR, Z_{ku}, Z_{ka}, and DFR. Correlations are computed for thresholds (colored dots as indicated) occurring at ***all seven 2DVDs*** in the network. ***Result is sensitive to the threshold selected, but virtually all parameters are decorrelated at the scale of DPR IFOV!*** (**cf. Pio D'Adderio et al. poster(s), this session**)

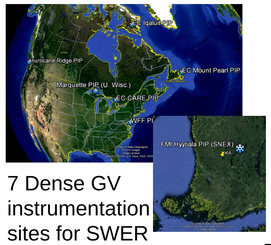


Top: MC3E S-band profiler time-height series of Z for 24 April convective, and middle, 11 May stratiform MCSs. Bottom: **NPOL RHI maps** of the D_0 correlation coefficients for left: April 24 (convective case,) and right: May 11 (stratiform casel). The vertical axis is height relative to 0.6 km (Bringi, Thurai, Tolstoy, Petersen, 2015, JAMC).

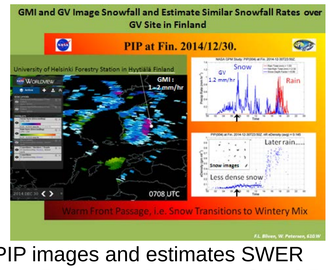


D_0 percentiles of spatial correlation coefficient (SCC) (a) in the *vertical column* for the 24th April and (b) 11th May cases. c) *horizontal plane* D_0 percentiles of SCC for 24 April and (d) 11th May cases- 2DVD estimates of correlation as f(distance) are indicated by circles in 11 May case. (Bringi, Thurai, Tolstoy, Petersen, 2015, JAMC)

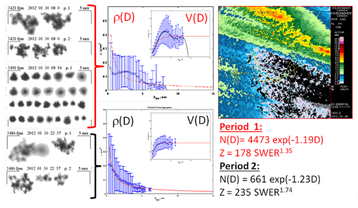
5. Distributed measurement and validation of snow water equivalent rate



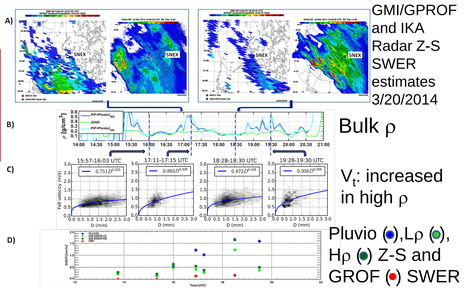
7 Dense GV instrumentation sites for SWER and PSD Obs.



PIP images and estimates SWER (**see Bliven et al. poster**); GPROF estimate agrees



But we need a distributed measurement using radar- depends on SWER regime- case by case!



GMI/GPROF and IKA Radar Z-S SWER estimates 3/20/2014

Bulk ρ

V_t: increased in high ρ

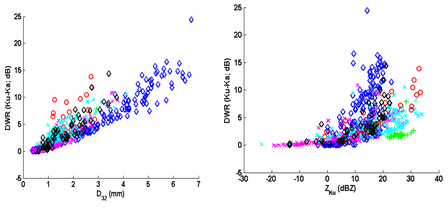
Pluvio (●),Lρ (●), Hρ (●) Z-S and GROF (●) SWER

LPVEX Z-S used with observed/inferred snow density (B and C; above; provided by D. Moisseev) - not successful for overpass case in Hyytiala, Finland. GMI/GPROF low biased.

Snow regime variability complicates GV measurement of SWER – but should be manifest in DWR; Use field obs to model DWR as f(observed snow type)

Field Campaign	Site	File name	Time (UTC)	Qualitative Inference of Dominant Precipitation Type	Marker type & color	Reference
GCPEx	CARE	V12049	12:00-13:30	Sleet†	+ Green	
Target of opportunity	Huntsville	V11010	00:00-03:30	Large wet snow aggregates†† *"Thunder" snow event*	Circle Red	Huang et al. 2011
LPVEx	Jävenpää	V10354	15:00-23:59	Fluffy snow aggregates†††	Diamond Blue	Huang et al. 2014
LPVEx	Jävenpää	V11006	00:00-08:24	Compact graupel†††	x-mark Magenta	Huang et al. 2014
GCPEx	Huronia	V12030	06:15-14:30	Alternating periods of aggregates and graupel†††	x-mark Cyan	2014 PMM Science Meeting
GCPEx	Huronia	V12030	14:30-23:59	Fluffy snow aggregates†††	Diamond Black	2014 PMM Science Meeting

† : observer reports ††: reported by Petersen; †††: visual exam of SVI images



Some separation of snow types in DWR, but not clean. Mixture of particle types complicates result.

Simulations of DWR=10log10(Z_ku/Z_ka) versus D32 (ratio of 3rd to 2nd moment of the PSD). Each data point is 3-min averaged PSD from 2DVD. The marker/color are from different events as listed in the Table 3.2.1. The shape is assumed oblate with fixed axis ratio at 0.8 and Gaussian canting angle distribution at vertical incidence.

Summary: Continued work toward quantifying column hydrometeor profile variability ***warm/cold season, convective/stratiform, and liquid and frozen phases is required*** ***but the process is highly dependent on precipitation regime/types***

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