

Ground-based Radar Validation Networks for GPM satellite products

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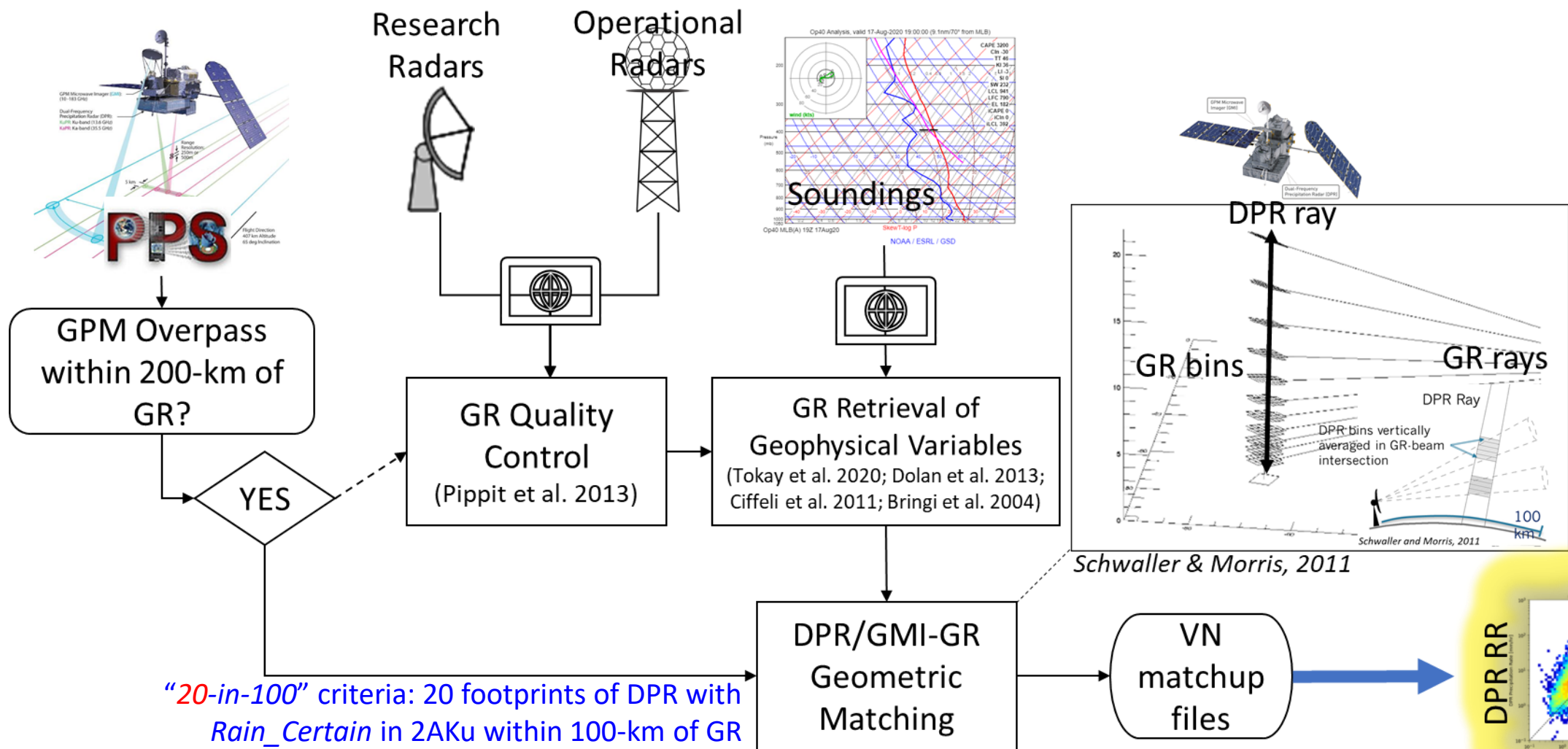
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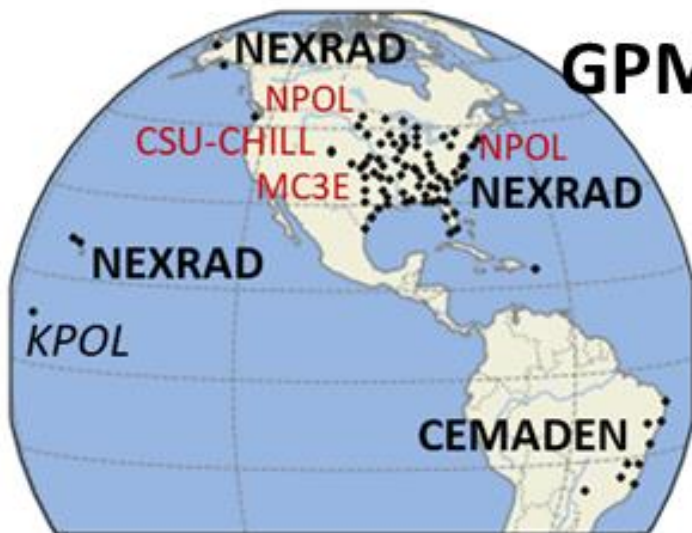
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Purpose: Validate GPM "Core" L1 Science Requirements



GPM Validation Network Radars



118 ground-based radars
(GR): March 2014-present

Polarimetric Radars

Operational Radars	Research Radars
WSR-88D (NEXRAD)	NPOL
CEMADEN (Brazil S-band)	CSU-CHILL
Meteo-France La Reunion (S-band pol.)	C-POL (Darwin)
KPOL (Kwajalein)	

Retrieved variable	Technique	Description / Variable name in matchup file		
Hydrometeor Identification (HID)	Dolan & Rutledge (2009); Dolan et al. (2013)	1) NoPrecip/Unclassified	7) Vertical Ice	Counts of # of GR bins classified as each HID class (histogram)
		2) Drizzle	8) Low Density Graupel	
		3) Rain	9) High Density Graupel	
		4) Ice Crystals	10) Hail	
		5) Dry snow/aggregates	11) Big Drops	Stored as array in GR_HID variable
		6) Wet Snow	12) Mixed Rain/Hail	
Rainfall Rate	Bringi et al. (2004)	$Z_e = aR^{1.5}$, a=polarimetric-tuned parameter		RP
	Cifelli et al. (2011)	$R(Z_h, Z_{DR}, K_{DP})$		RC
	Chen et al. (2017)	Adaptive K_{DP} (Wang and Chandrasekar 2009) + HCA (Bechini and Chandrasekar, 2015) $\rightarrow R$		RR
DSD	Tokay et al. (2020)	$D_m = aZ_{DR}^3 + bZ_{DR}^2 + cZ_{DR} + d; N_w = \alpha Z_e D_m^\beta$		

DPR/GMI

- zFactorMeasured (DPR)
- zFactorCorrected (2ADPR/2BCMB)
- PrecipRate (2ADPR/2BCMB)
- PrecipRateSurface (2ADPR)
- SurfPrecipTotRate (2BCMB)
- Dm, Nw (2ADPR/2BCMB)
- clutterStatus (0-above DPR clutter bin; 1-one or more bin w/i clutter; 2- all within clutter)
- piaFinal (2ADPR/2BCMB)
- LandSurfaceType (2ADPR)
- heightStormTop (2ADPR)
- BBstatus and BBheight (2ADPR bright band; *m above MSL*)
- qualityData (2ADPR FLG group Quality Data)
- TypePrecip (2ADPR: 1-stratiform; 2-convective; 3-other)
- DPR scan number, ray number, time nearest approach

Attributes:

GPM Algorithm Version

DPR Scan Type

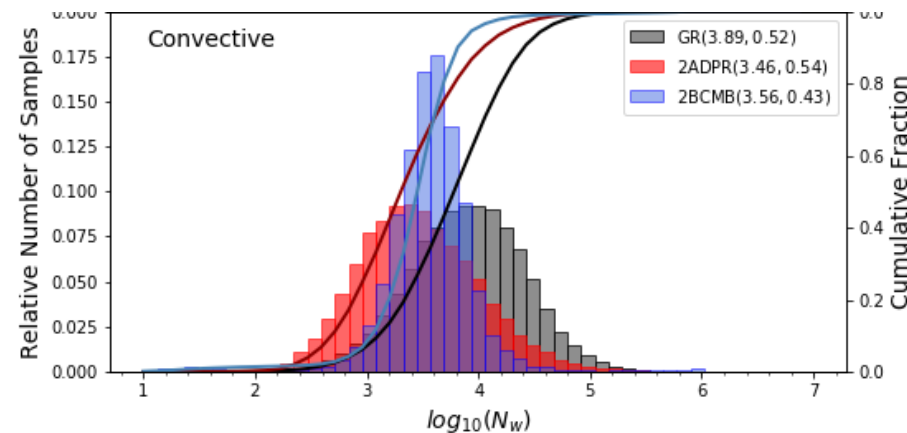
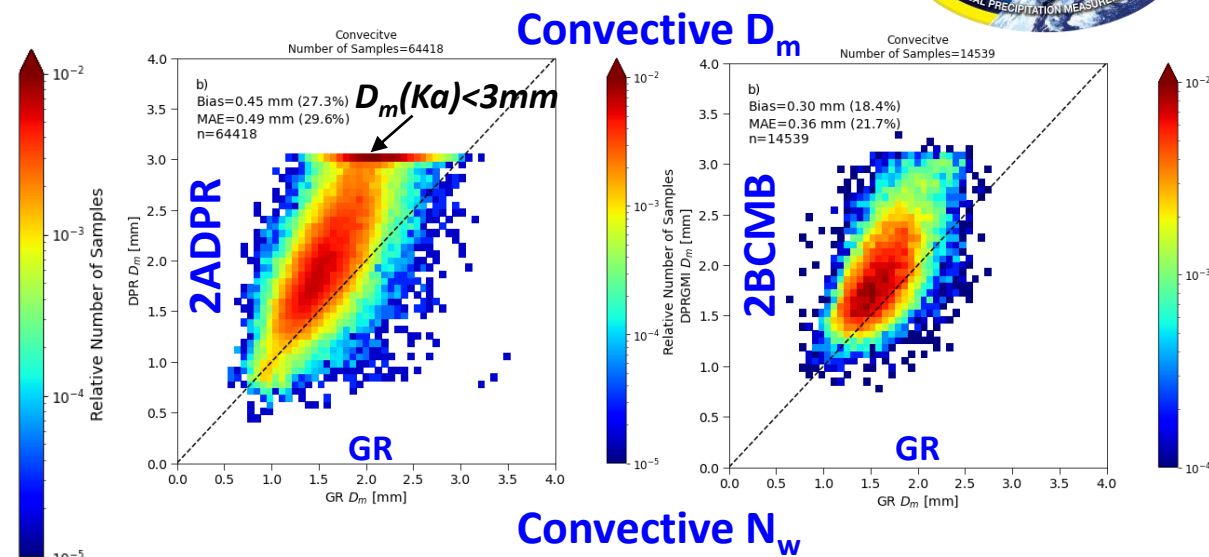
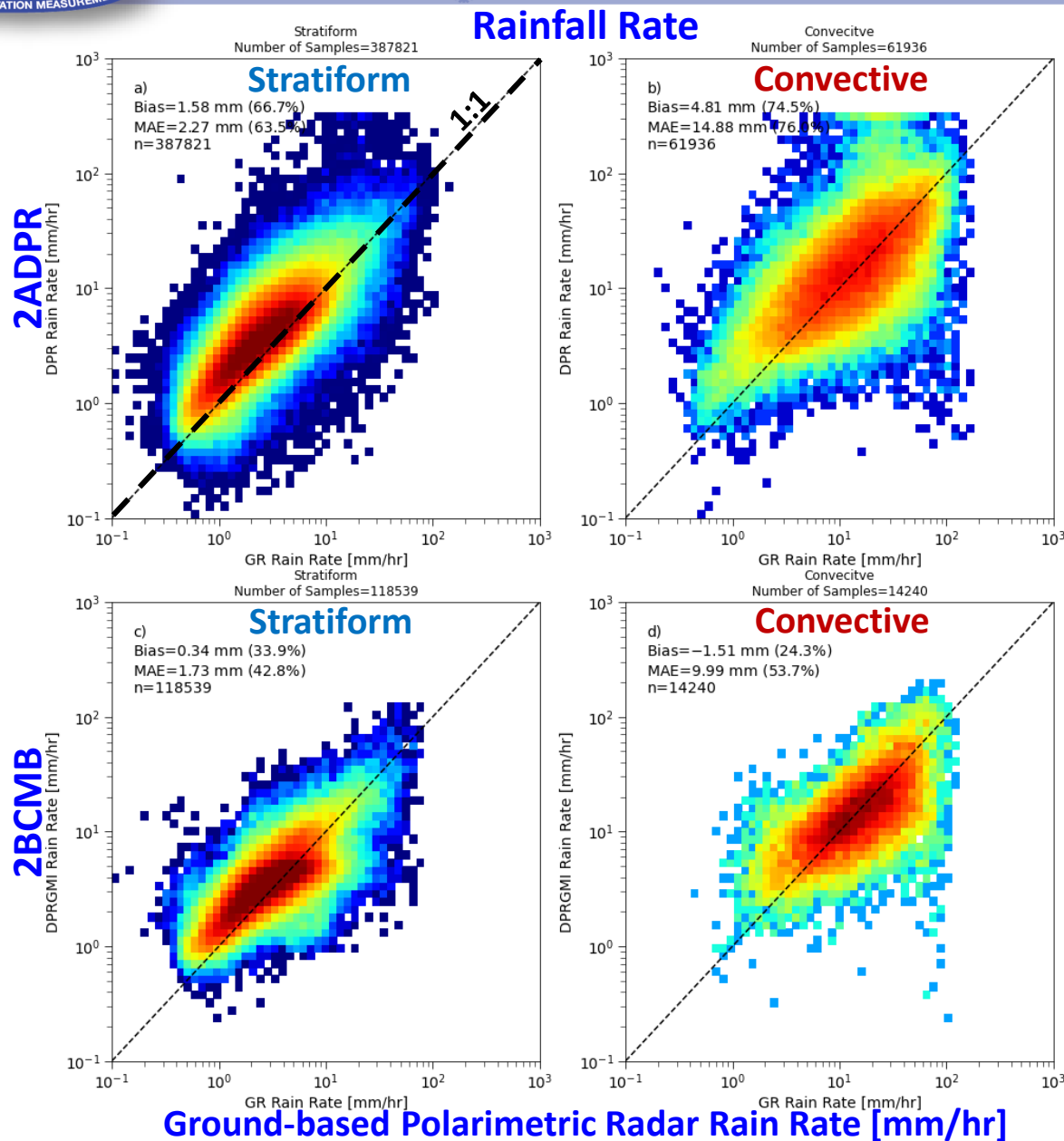
GR

- Average, Standard Deviation, Max:
 - Z_e (GR_Z, GR_Z_StdDev, GR_Z_Max)
 - Z_{DR} (GR_Zdr, ...)
 - ρ_{hv} (GR_RHO_{hv}, ...)
 - K_{DP} (GR_Kdp, ...)
 - ρ_{hv} (GR_RHO_{hv}, ...)
 - RainRates (GR_RP, GR_RC, GR_RR,...)
 - D_m (GR_Dm, ...); D_0 (GR_Dzero, ...)
 - N_w (GR_Nw, ...); $N_{w,2}$ (GR_N2, ...) ; $10 \cdot \log_{10} N_w$
- HID [additional dimension for hid category]
- Time of radar sweep start
- Lat, Lon, elev of radar site

Spatial variables:

- Latitude, longitude (GR: fpdim, elevAngle, xyCorners; DPR: fpdim)
- x,y corners of intersection (km from radar site)
- top, bottom height of intersection (*km AGL*)
- Height of freezing level (from model analysis or raob)

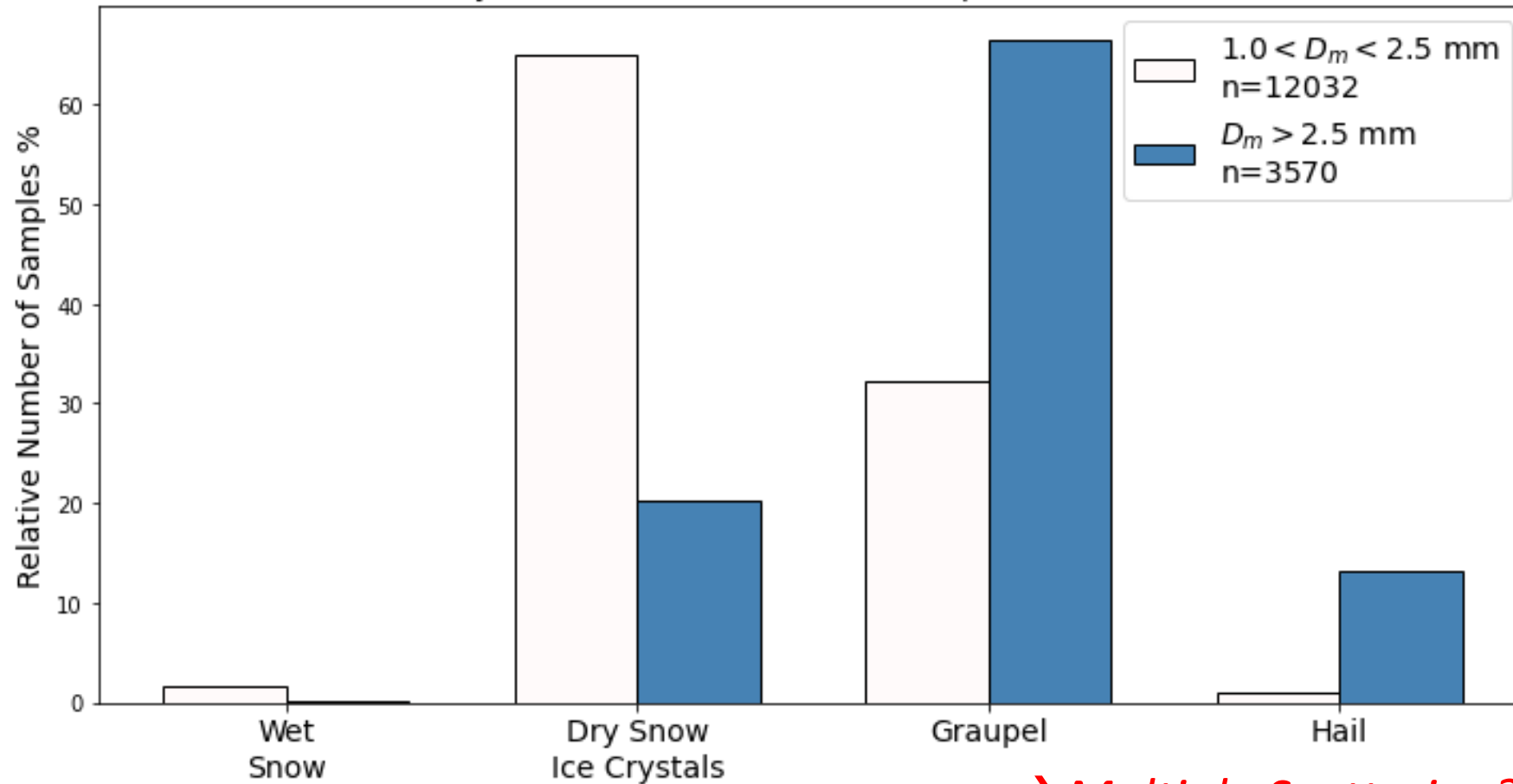
Using the VN to evaluate GPM algorithm retrievals



Gatlin, P.N.; Petersen, W.A.; Pippitt, J.L.; Berendes, T.A.; Wolff, D.B.; Tokay, A. The GPM Validation Network and Evaluation of Satellite-Based Retrievals of the Rain Drop Size Distribution. Atmosphere (Basel). **2020**, *11*, 1010, doi:10.3390/atmos11091010.

Larger D_m when rimed ice is more prevalent in DPR profile

Distribution of Hydrometeors in Convective Precipitation at 1.5 km above 0°C



→ Multiple Scattering?

CFADs of Reflectivity

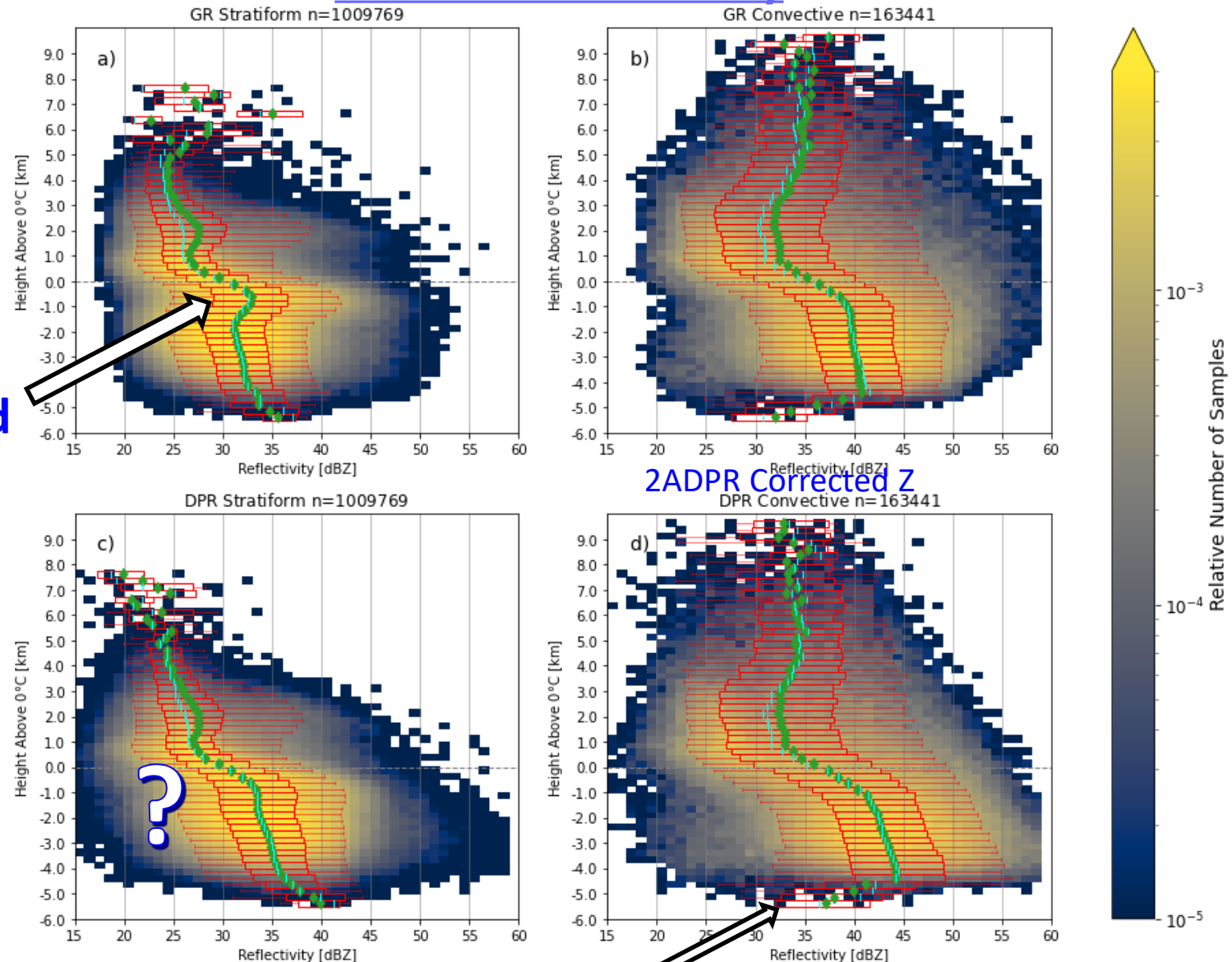
The VN retains the 3-D observations, thereby facilitating a look at GPM's profile-based retrievals

- Precipitation phase and type
- Distribution of hydrometeors
- Refine algorithm modules and assumptions

Some caveats with using the VN....

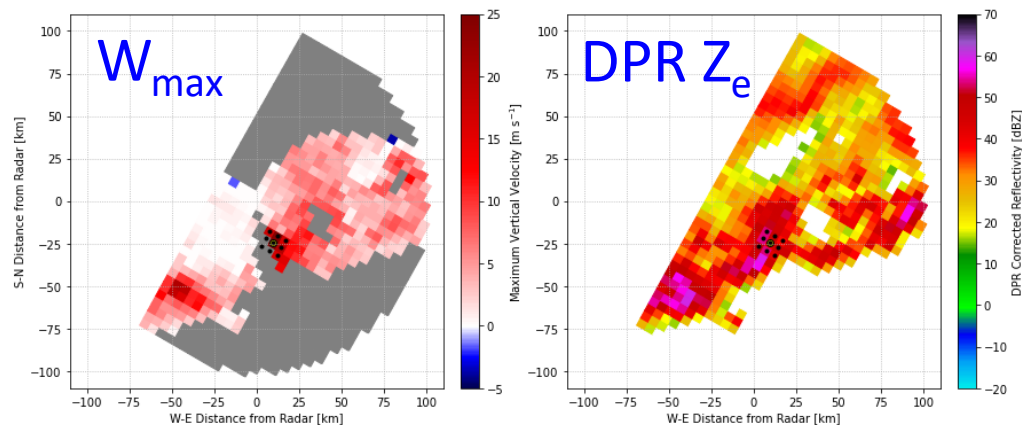
DPR range bins are averaged within GR beam

Bright Band



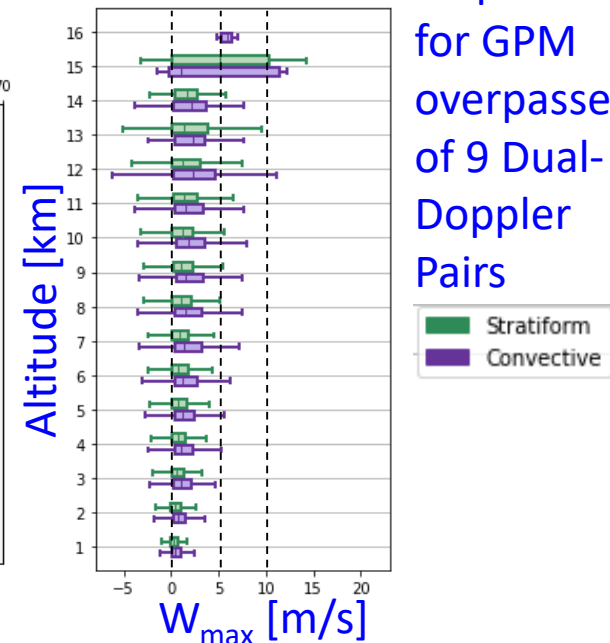
Vertical Motion

PyDDA retrievals: 14 July 2017 KDOX (NPOL) GPM Orbit #19187



Maximum W in DPR profiles

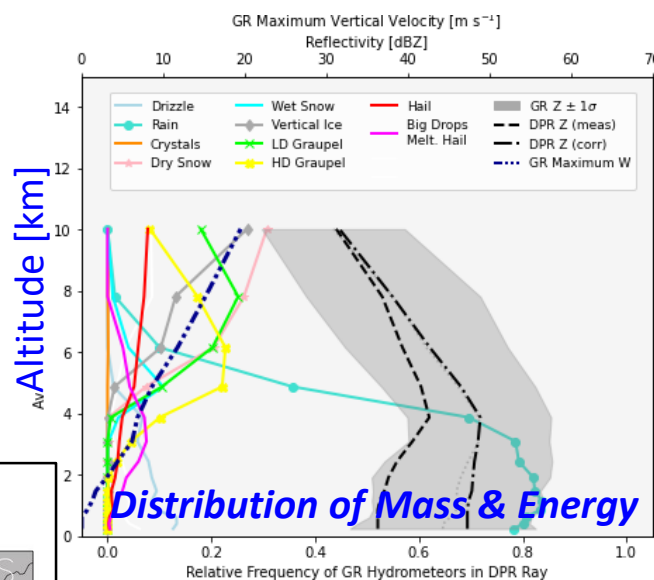
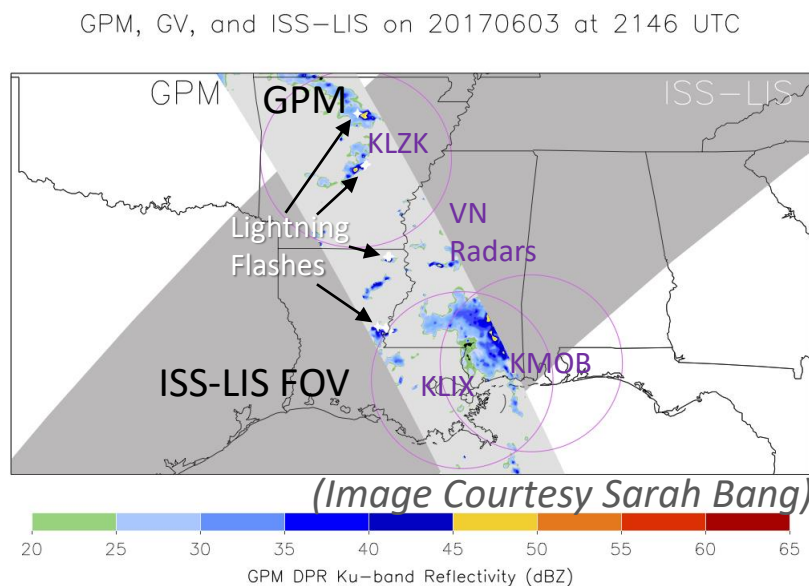
for GPM overpasses of 9 Dual-Doppler Pairs



Lightning

Adding ISS LIS and GLM to VN matchup files

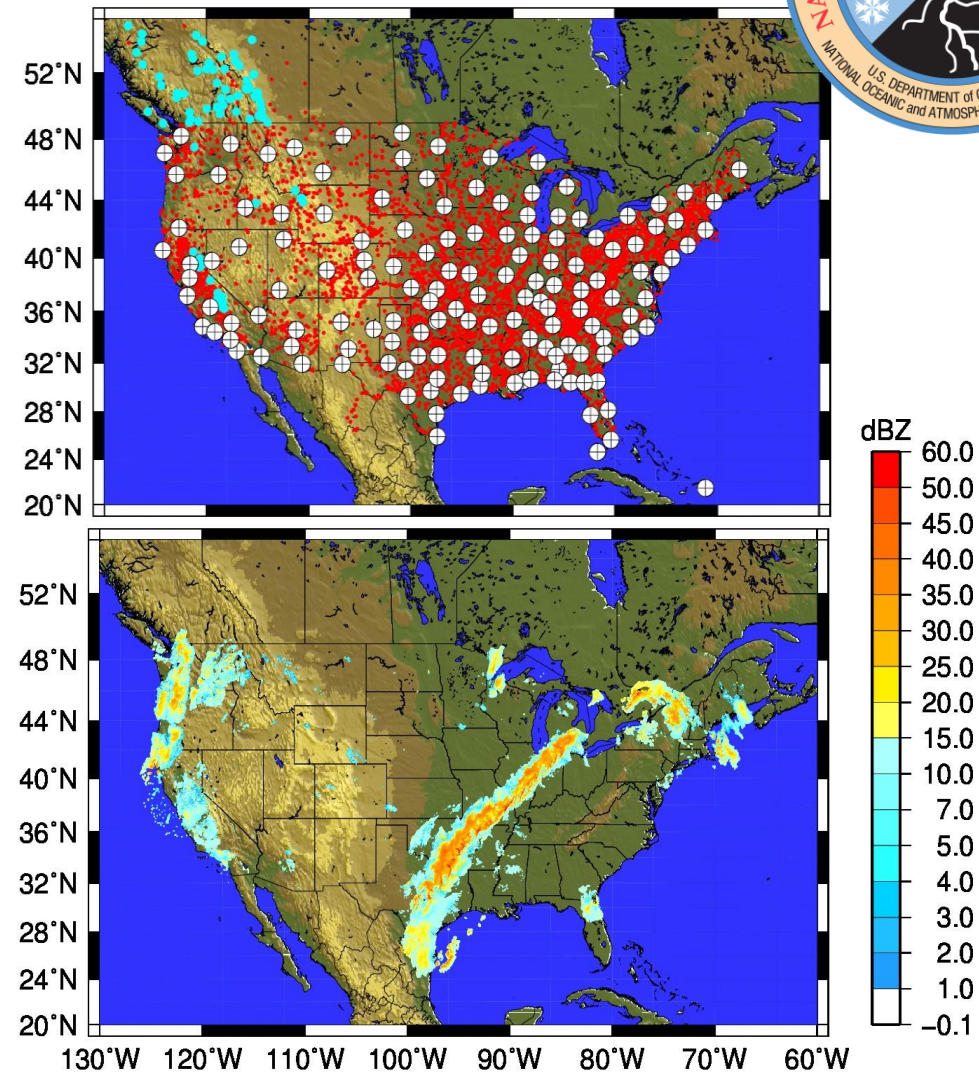
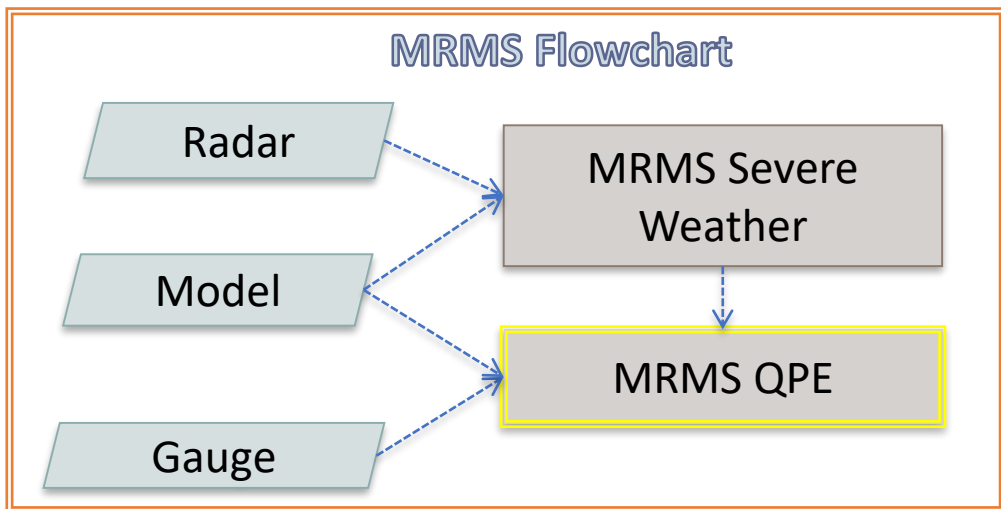
- Provide a multi-perspective tool for deep convection
- Precipitation effects on lightning emissions



CaPRI: Cloud-based VN Data Storage/Access

- Interactive plotting (e.g., 2-D histograms, Cesium KML)
- >40x faster access to results (no more downloading and reading in individual matchup files)
- Amazon Athena Database → Amazon S3
- Python API and notebook examples
- Being funded as part of NASA ESTO AIST project

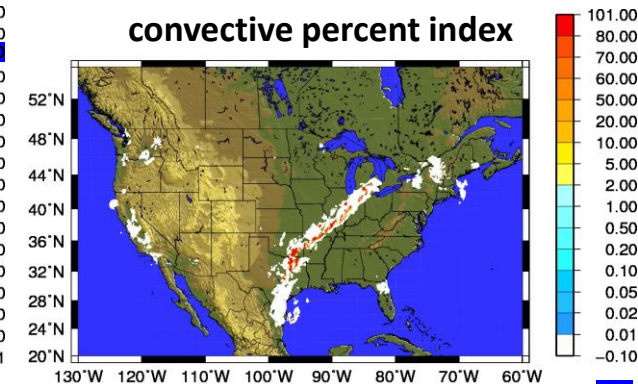
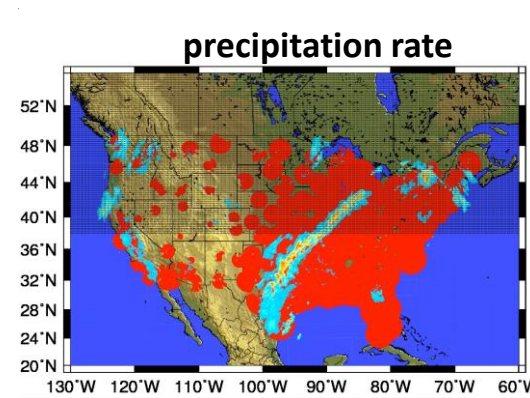
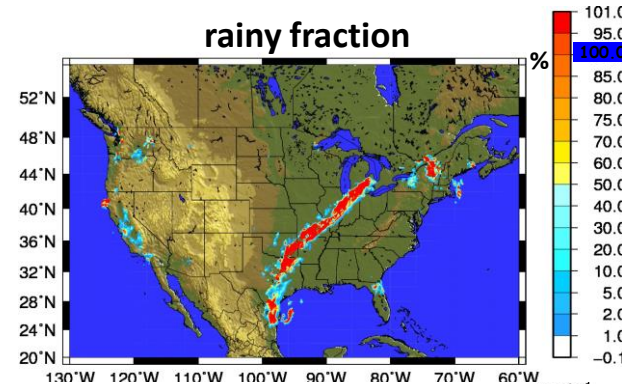
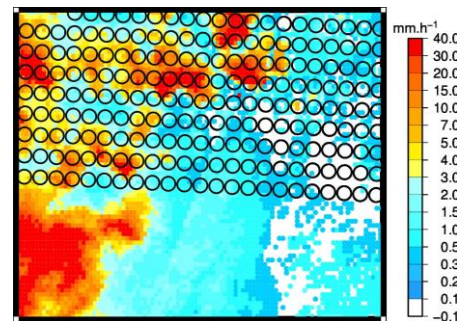
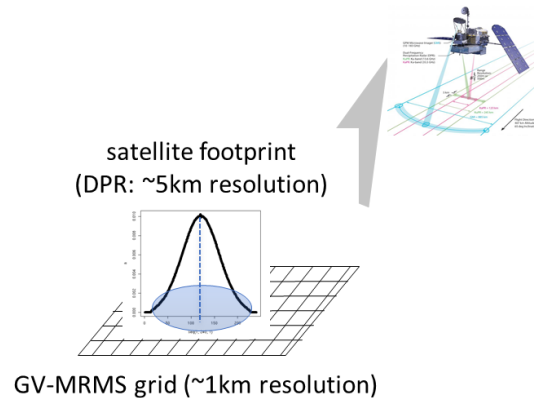
- **Domain:** 20-55°N, 130-60°W
- **Resolution:** 0.01°, 2 min update cycle
- **Data Sources:**
 - ~180 **polarimetric** radars every 4-5min
 - ~18,000 gauges every hour
 - - RAP model hourly 3D analyses



frontal system at 0800 UTC on 11 April 2011

PURPOSE:

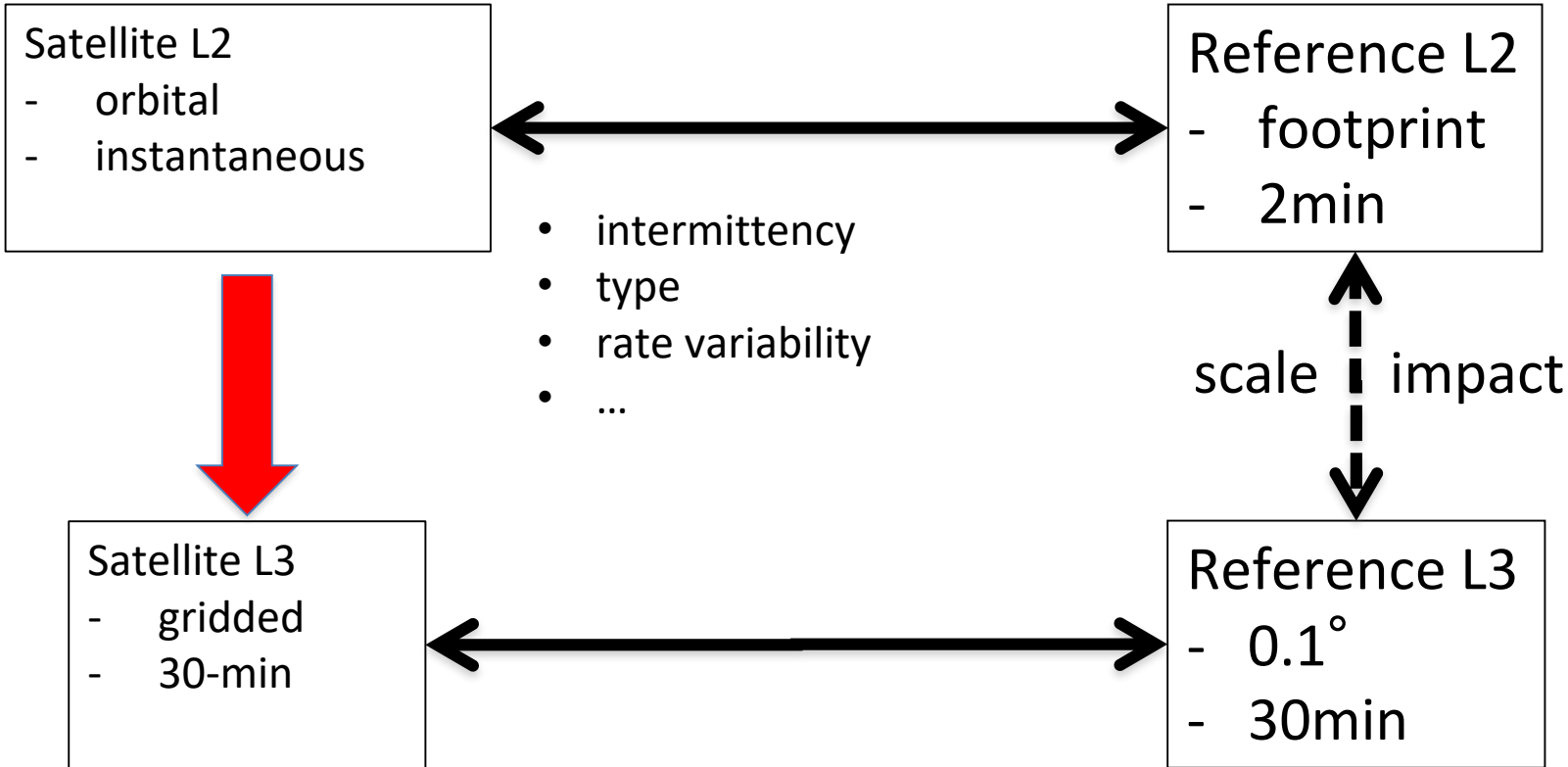
- refine reference precipitation as much as possible
 - quality controls (e.g. RQI)
 - gauge-based bias adjustment
- upscale to the satellite resolution



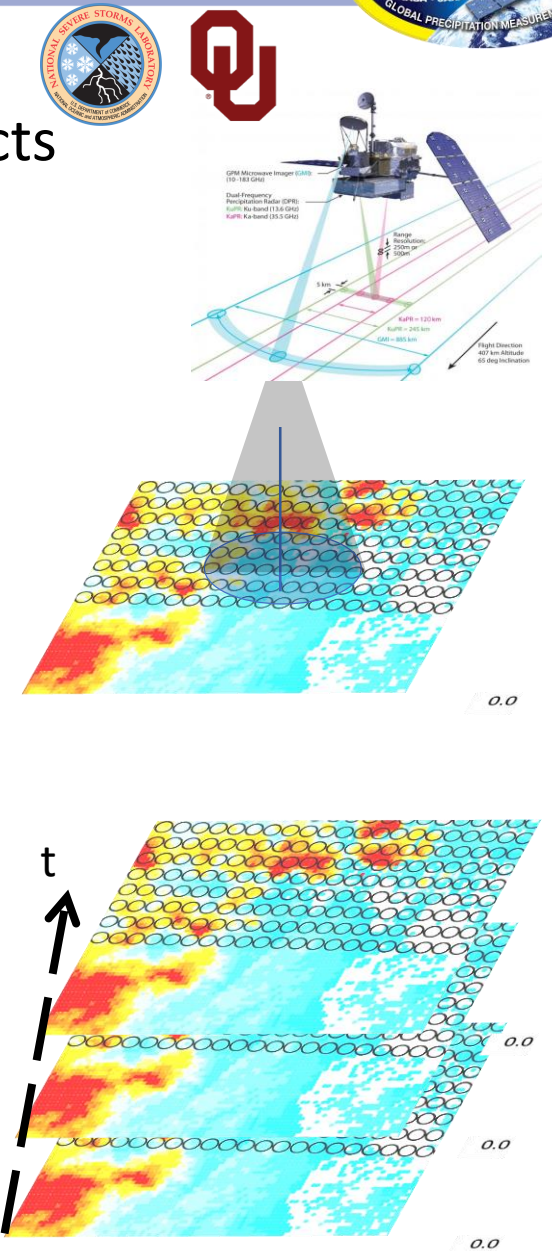
Consistent analysis: detection, classification, quantification ⇔ sub-pixel **intermittency**, **typology**, **variability**, rate

- **Detection** abilities of active / passive sensors
- Precipitation **typing**, **Z-R relationships**, **convective rainfall** (passive)
- First and second order **quantitative discrepancies**, **conditioned** on factors
- **Non-Uniform Beam Filling** for active and passive sensors

Objective: improve precipitation across Level 2 and Level 3 products



- Identify conditions of agreement / disagreement
- Provide guidance to improve the retrievals



- VN matchup files on GHRC Archive:

<http://dx.doi.org/10.5067/GPMGV/WFF/MULTIPLE/DATA101>

- GV-MRMS: <https://ghrc.nsstc.nasa.gov/hydro/details/gpmmrms>

- VN Manual:
https://gpm.nasa.gov/sites/default/files/document_files/Val_Network_Users_Guide_Vol_2_Nov2015.pdf

- VN Ground & Space Radar Volume Matching code:
<https://opensource.gsfc.nasa.gov/projects/GSRadar/index.php#software>

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Measurement and Modeling of the Precipitation Particle Size Distribution

Guest Editors

Dr. Patrick Gatlin, Dr. Merhala Thurai, Dr. Christopher Williams, Dr. Elisa Adirosi

Special Issue of Atmosphere (published October 2020)

https://www.mdpi.com/journal/atmosphere/special_issues/Precipitation_Particle