NASA Global Precipitation Measurement (GPM) Mission ground and satellite observations for ICE-POP: Status Update

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KMA ICE-POP Meeting

19-21 September 2017

Broader Framework for NASA Involvement in ICE-POP

Programmatic:

- NASA Weather Program, Short Term Prediction and Operational Research Transition Center (SPoRT)
- NASA's Global Precipitation Measurement (GPM) Mission Ground Validation and Precipitation Measurement Missions Science Program
- NASA Centers: MSFC and GSFC

Overarching Objective:

- Leverage international collaboration and synergistic observational (GPM), numerical modeling (SPoRT/GSFC), and research transition (SPoRT) opportunity to verify, test utility, improve satellite products and numerical prediction models in heavy orographic snow regime

NASA GPM Specific Objectives for ICE-POP

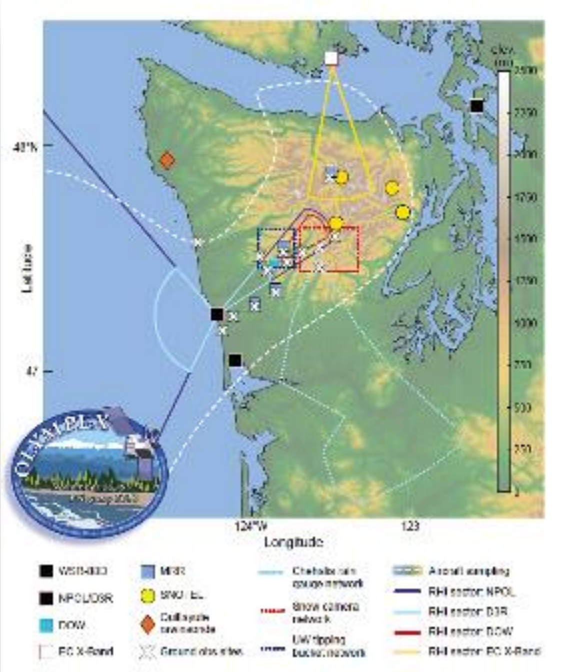
Support current NASA collaboration with KMA, provide real-time data in support of ICE-POP, participate in significant international science effort.

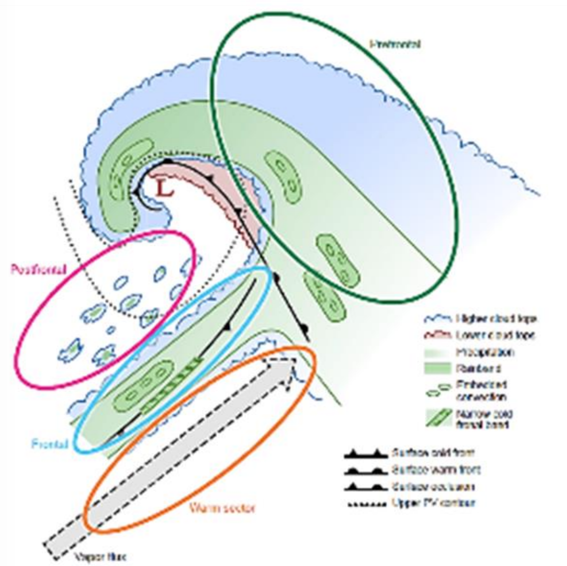
GPM Ground Validation (ICE-POP Field Campaign - RDP)

- Direct/physical validation of active/passive satellite-based snowfall retrieval algorithms over coastline and mountains; melting layer interaction with terrain
- Physics of snow, coupling to snow water equivalent rate and satellite remote sensor retrieval algorithm assumptions
  - Size distributions, types/habit, water equivalent, profiles
- NUWRF Model + Observational analyses: Movement toward "level IV products" leverage intensive and multi-faceted NWP component.
- Model precipitation processes (liquid, mixed phase and frozen); Build model testing database for further active/passive remote sensing algorithm development (e.g., satellite data simulators)
- "Integrated" validation of products in operational context

GPM OLYMPEX and ICE-POP

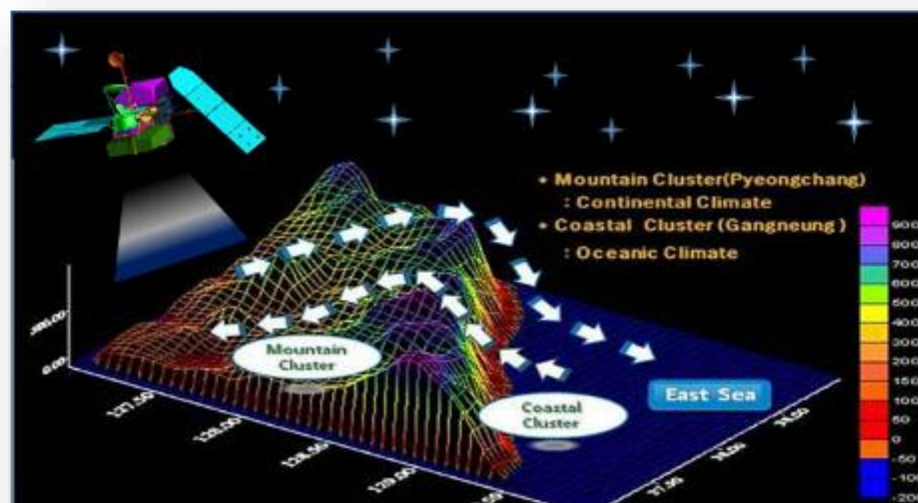
Multi-frequency radar networks, gauges, disdrometers, aircraft, soundings….





OLYMPEX: Validation of GPM precipitation (rain, snow) estimation and precipitation physics in mid-latitude frontal systems interacting with complex terrain

GPM in ICE-POP: Validation of snow (rain/mixed) detection, estimation, and precipitation physics in steep terrain gradients as a function of synoptic regime



NASA Instruments in ICE-POP: D3R, PIP, Pluvio, MRR

Dual Frequency Dual Polarimetric Doppler Radar (D3R)

Precipitation Imaging Package (PIP) x 2 (imager/disdrometer)

MRR x 2

$Pluvio_2$ x 3

Parsivel disdrometer (APU) x 3

GLOBAL PRECIPITATION MEASUREMENT

ICE-POP NASA Instrumentation Shipment and Status

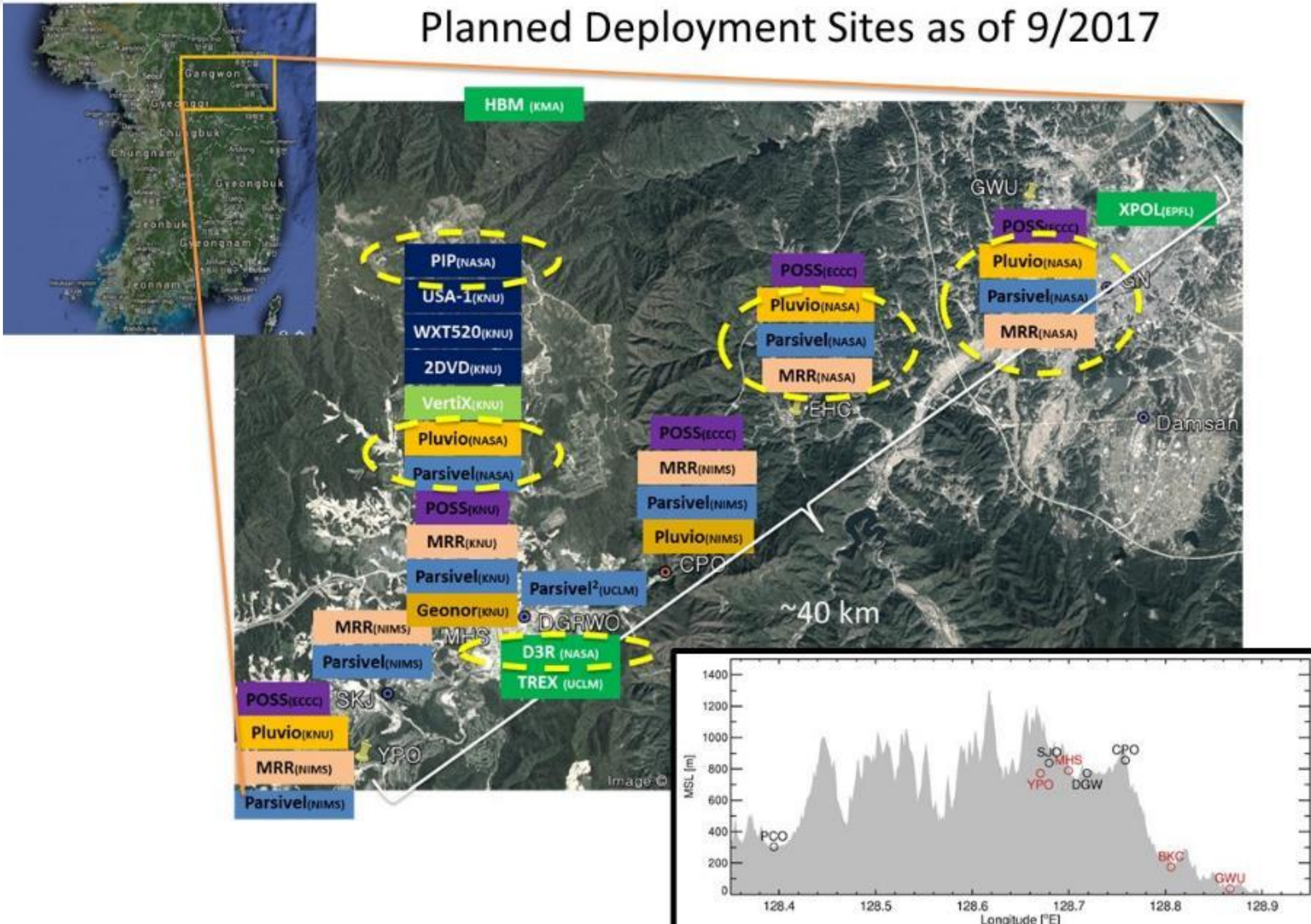
- Shipment 1:
  - 3 Autonomous Parsviel Units (APU)
  - 3 Pluvio^2 400 Weighting Precipitation Gauges with full Tretykov & alter wind fences
  - Arrived end of March 2017; Setup at DGW for testing in May
  - Data available from a KMA server via sftp

- Shipment 2:
  - 2 Precipitation Imaging Probes (PIP)
  - 2 Micro Rain Radars (MRR)
  - Arrived first week of July 2017
  - MRRs setup at DGW 14 July; Gate spacing?
  - Data not yet available on the KMA server
  - PIP status?

- Shipment 3:
  - D3R Radar shipped 9/12/17
  - Mid/late October setup/testing

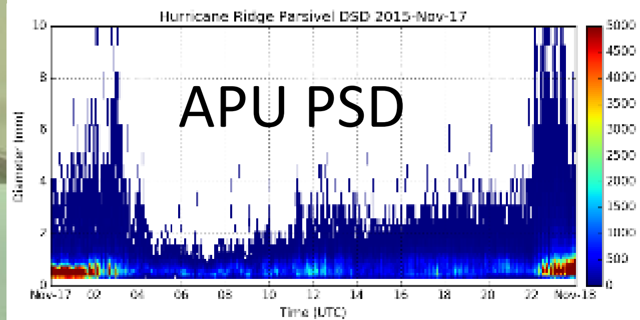
NASA GPM GV Instruments in ICE-POP Network

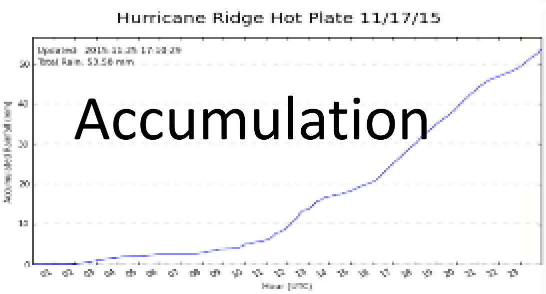
Planned Deployment Sites as of 9/2017

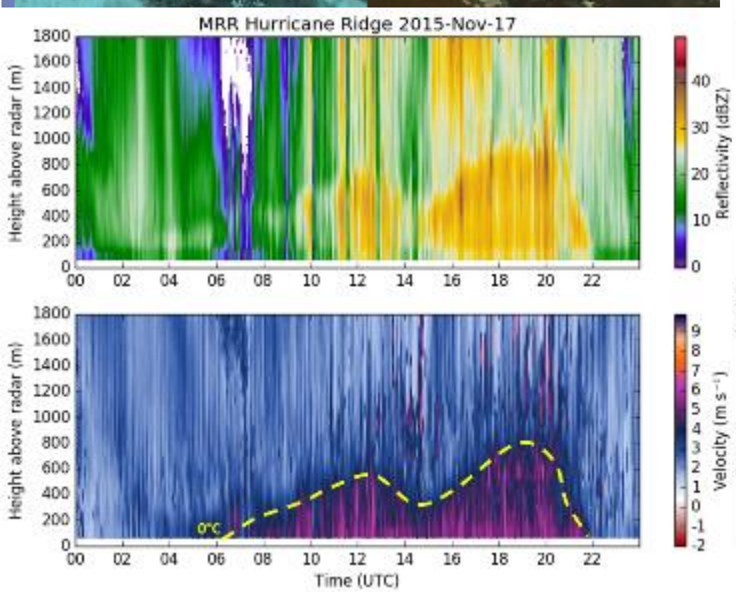


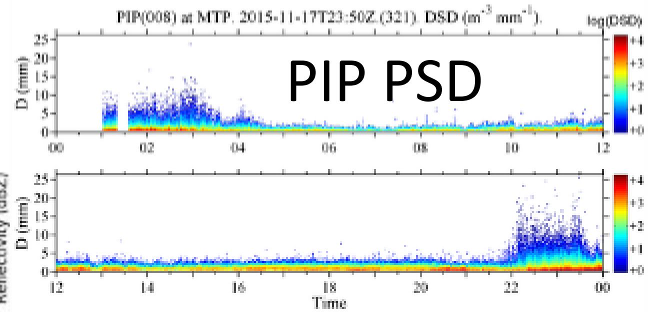
Instrument Data: MRR, APU, PIP, Accumulation

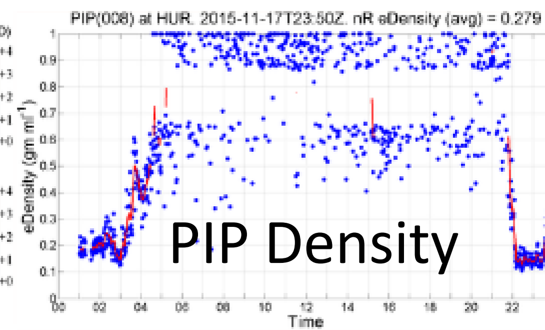
OLYMPEX: Mountain Rain-Snow Transition

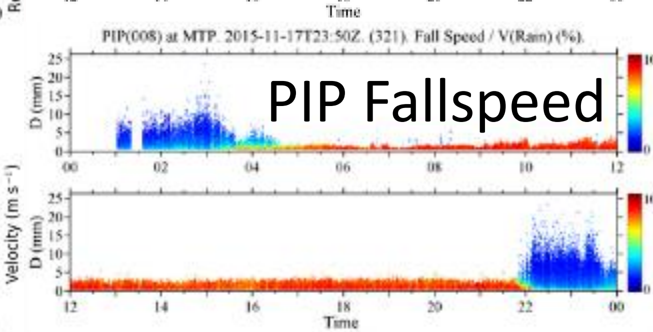


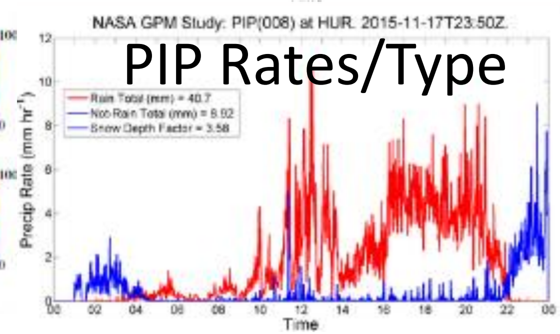








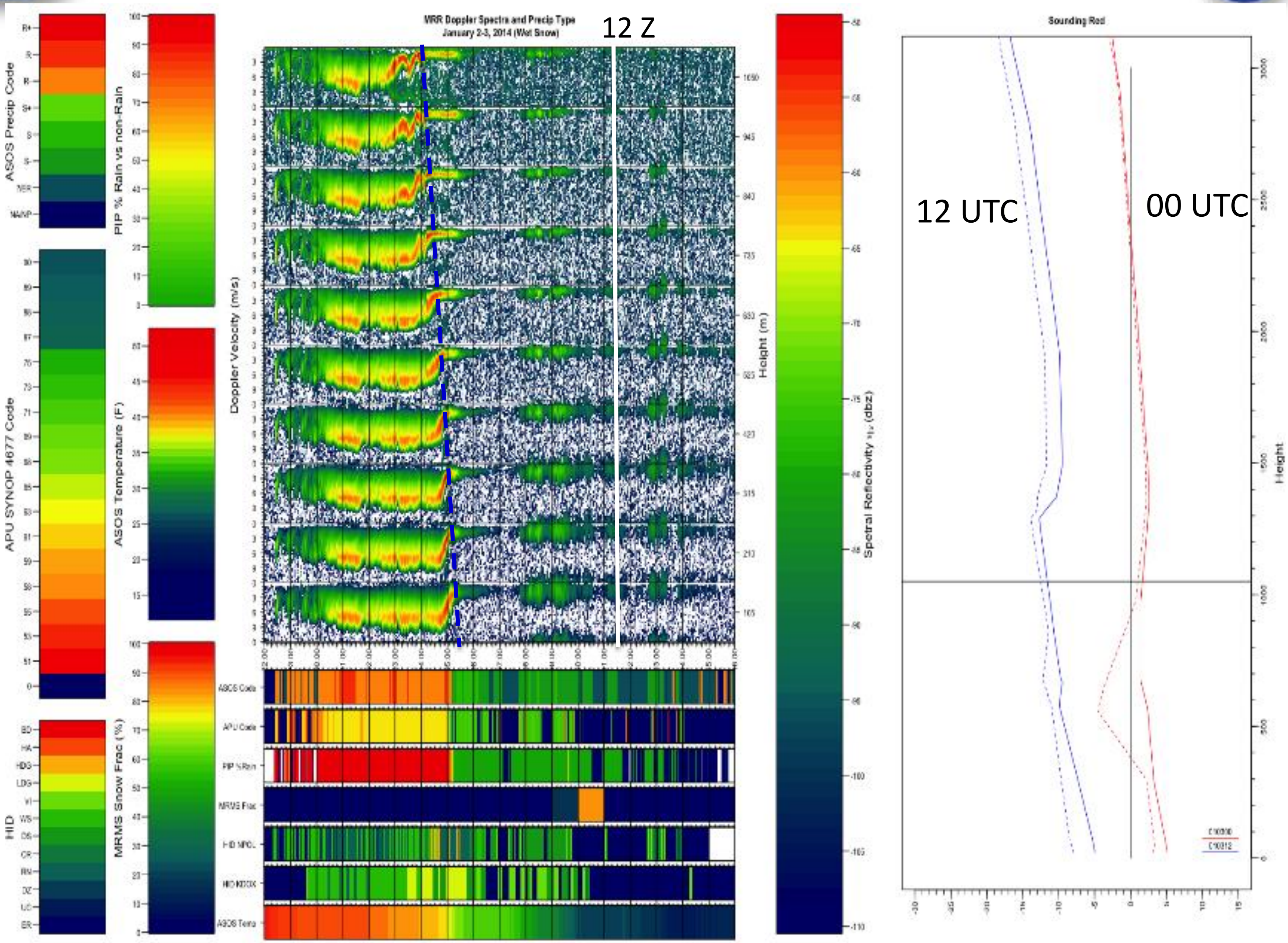




MRR Z, Velocity spectra capture phase transitions and low level structure

Parsivel (APU), PIP capture phase transition, precipitation type, size distribution, rates, while gauge captures reference water equivalent accumulation.

Instrument Data: MRR, PIP phase transition

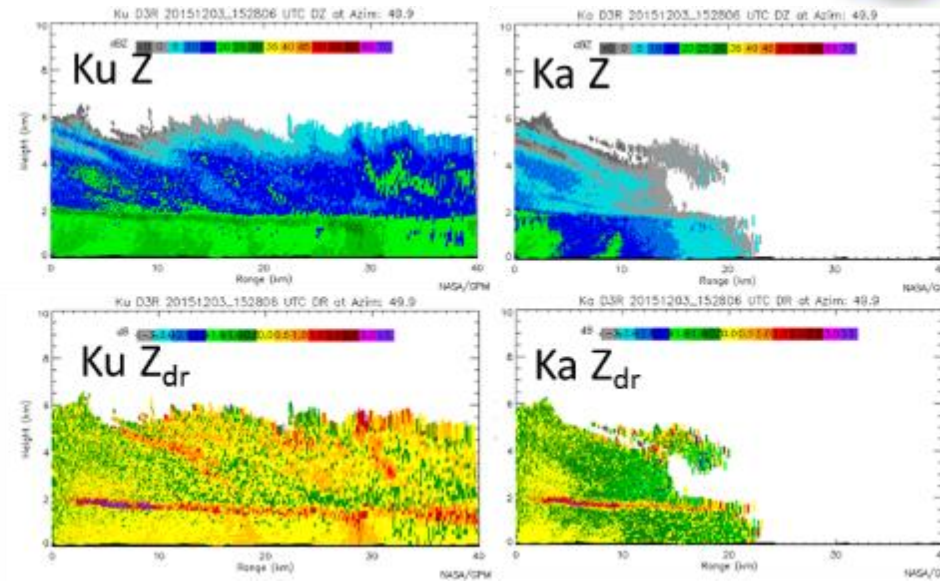


GLOBAL PRECIPITATION MEASUREMENT

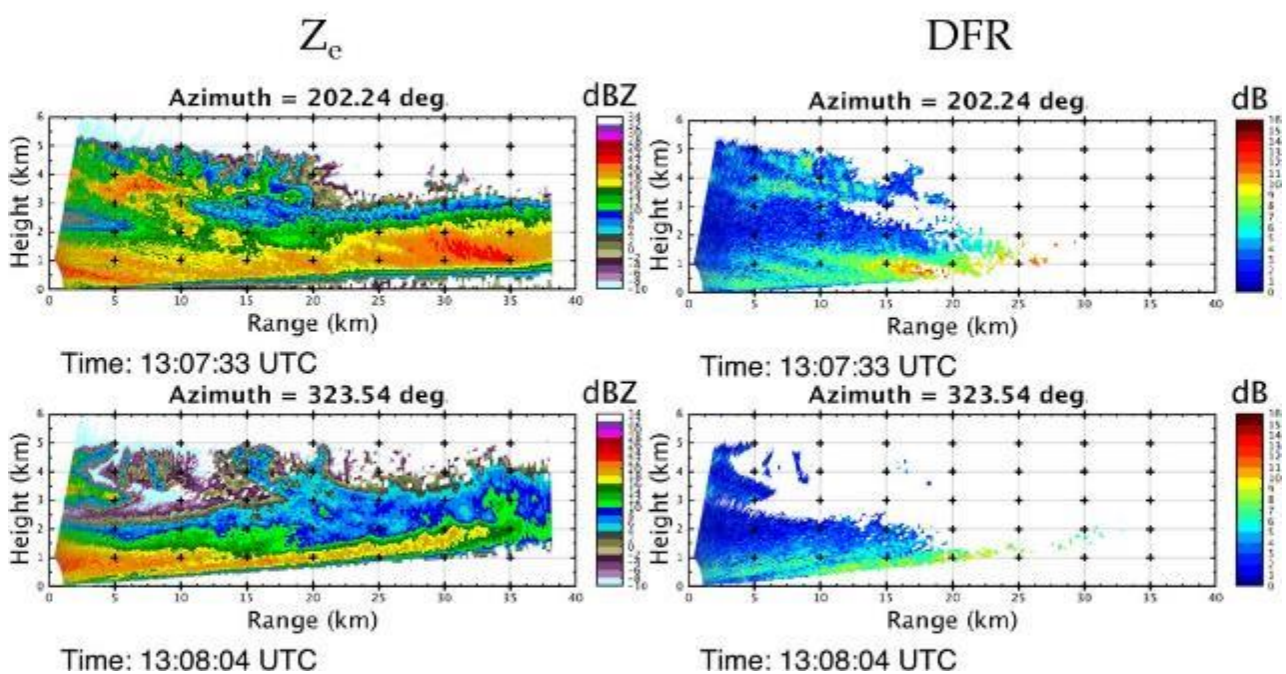
Data Examples: D3R

Polarimetric moments, DFR, I&Q recorded

Rain and ML



Complex mixed phase



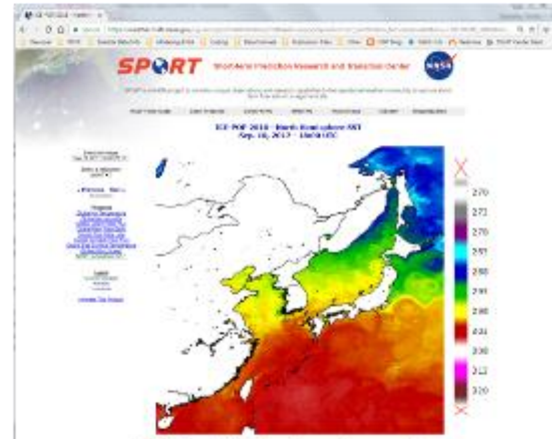
NASA SPoRT Website for Satellite Products

https://weather.msfc.nasa.gov/sport/icepop/

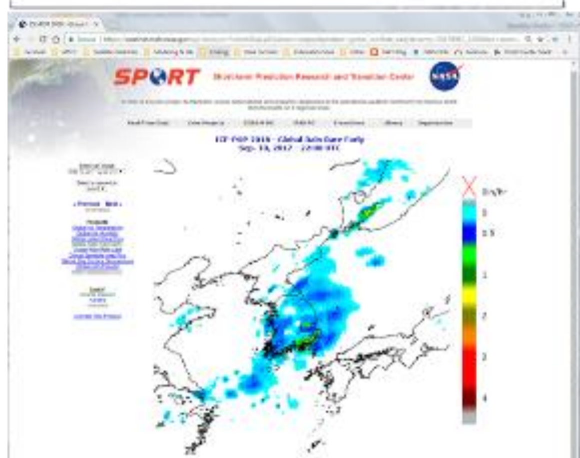
- Focused on forecast challenges in the Korean Peninsula
- Provides links to GPM (orbit, merged, diagnosed) and supporting satellite products and NUWRF NWP model output plots
- Display static images and animations to show evolution of weather situation
- Multiple zooms allow for look at big picture weather patterns and high-resolution features

Still under development- suggestions welcome.

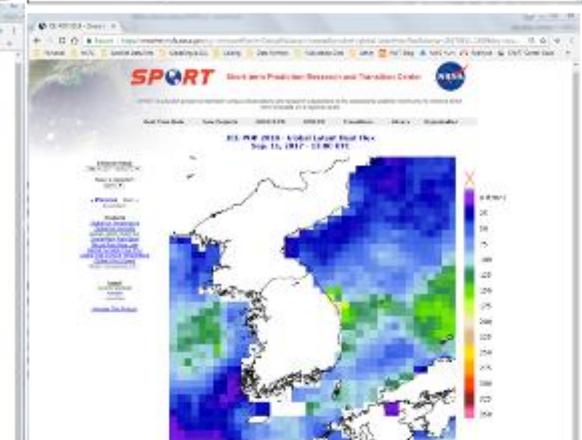
ICE-POP Home/Landing Page



High-Res SST Product; Lowest Zoom



IMERG Precipitation Analysis; Medium Zoom



Latent Heat Flux Product; Highest Zoom

For select IMERG Products also see: https://pmm.nasa.gov/data-access/global-viewer

Summary of Available Products**

Satellite Observations, Diagnosed, Model Products

Variable	Area Covered	Spatial Resolution	Temporal Refresh	Data Latency	Data Type; NASA Instrument(s)
Precipitation Rate and Phase	Land & Water	15-km	1-3 hours	30-60 minutes	Passive Microwave; GPM Constellation*
Merged Precipitation Analysis	Land & Water	10-km	30 minutes	4 hours (Early)	Passive Microwave, Infrared; GPM Constellation* + GEO
Surface Temperature	Water Only	25-km	1 hour	30-60 minutes	Passive Microwave; GPM Constellation*
Surface Relative Humidity	Water Only	25-km	1 hour	30-60 minutes	Passive Microwave; GPM Constellation*
Surface Wind Speed	Water Only	25-km	1 hour	30-60 minutes	Passive Microwave; GPM Constellation*
Sensible Heat Flux	Water Only	25-km	1 hour	30-60 minutes	Passive Microwave; GPM Constellation*
Latent Heat Flux	Water Only	25-km	1 hour	30-60 minutes	Passive Microwave; GPM Constellation*
H-Resolution Sea Surface Temperature	Water Only	2-km	12 hours	6 hours	Model, Infrared; MODIS, VIIRS
NUWRF Model Outputs (cf. Tao presentation)	3-Domain	9, 3, 1 km			Every 6-hours, 24-hour forecast for every 30 minutes; products FDP Defined

*GPM Constellation instruments: GMI, AMSR-2, AMSU/MHS, ATMS, SSMI/S

**Additions/modifications possible as requirements dictate

Summary

Weather Program

- SPoRT display/viewer for FDP/RDP operations in ICE-POP domain
- Satellite products, surface parameters (LH/SH fluxes), high resolution SST, NUWRF FDP model products
- Action(s) ongoing……..
  - Complete GPM observational and NUWRF model product access
  - Page navigation/product browse functionality

GPM GV: Validation for satellite products (databases, forward models etc.)

- Direct/physical validation of satellite-based snowfall retrievals over complex terrain
- Physics of snow, cloud model ice process, simulated remote sensing
- Model + Observational analyses: Movement toward level IV products

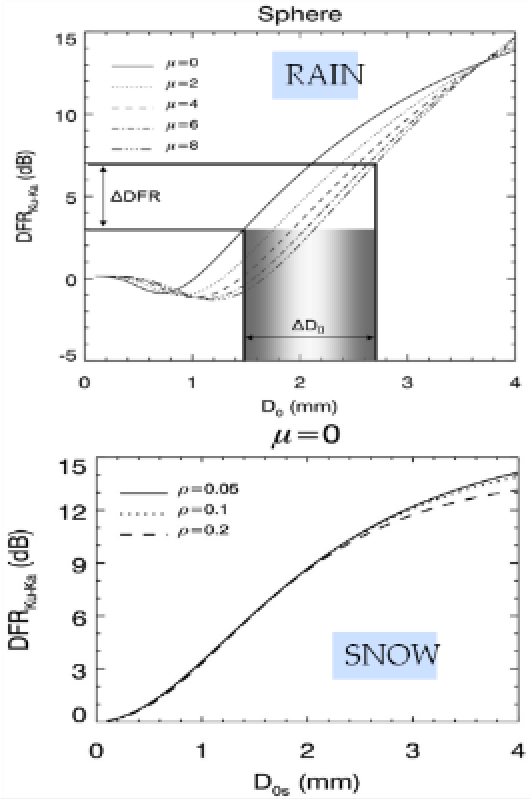
Instrument Deployment

- D3R Radar- in route 9/12/17 with install at DGRWO October 2017; IOP 2018
- PIP, MRR2, Parsivel, Pluvio in country; operating winter 2017/18
- *Action(s) ongoing………*
  - Complete radar deployment; ensure scanning strategy (system)
  - Complete instrument network deployments, ensure comms + operability
  - Ensure data QC, transfer, products, display, archive (temporary, permanent)

EXTRA

D3R: [Dual-Freq., Dual-Pol., Doppler Radar]

System	
Frequency	Ku- 13.91GHz ± 25MHz; Ka- 35.56GHz ± 25MHz
Minimum detectable signal (Ku, Ka)	-8 dBZ, -2 dBZ noise equivalent at 15 km, at 150m range resolution
Minimum operational range	450 m
Operational range resolution	150 m (nominal)
Maximum range	30 km
Angular coverage	0-360° Az, -0.5-90° El (full hemisphere)
Antenna	
Parabolic reflector –Diameter	6 ft (72 in.) (Ku), 28 in. (Ka)
Gain	45.6 dBi (Ku), 44.3 dBi (Ka)
HPBW	0.89° (Ku), 0.90 (Ka)
Polarization (Ku, Ka)	Dual linear simult. and alternate (H and V)
Maximum side-lobe level (Ku, Ka)	~ -25 dB
Cross-polarization isolation (on axis)	< -30 dB
Ka-Ku beam alignment	Within 0.1 degrees
Scan capability	0-24°/s Az, 0-12°/s El
Scan types	PPI sector, RHI, Surveillance, Vertical pointing
Transmitter / Receiver	
Transmitter Architecture	Solid State Power Amplifier Modules
Peak Power / Duty cycle	200 W (Ku), 40 W (Ka) per H and V channel, Max duty cycle 30%
Receiver Noise figure	4.8 (Ku), 6.3 (Ka)
Receiver dynamic range (Ku, Ka)	~ 90 dB
Clutter Suppression	GMAP
Data Products	
Standard products	- Equivalent reflectivity factor (Z_h) (Ku, Ka) - Doppler velocity (unambiguous: 26 m/s)
Dual-polarization products	- Differential reflectivity (Z_{dr}) (Ku, Ka) - Differential propagation phase (φ_{dp}) (Ku, Ka) - Copolar correlation coefficient (ρ_{hv}) (Ku, Ka) - Linear depolarization ratio (LDR_h, LDR_v) (Ku, Ka) *(in alternate mode of operation)*
Data format	NETCDF



Retrieving snowfall from Dual Frequency Precipitation Radar

Lookup tables of DFR to estimate D_o

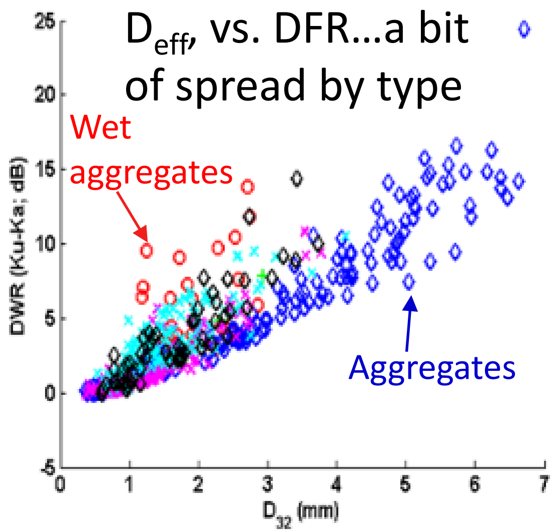
Use with Z_{Ku} to estimate N_w with μ = fixed (ambiguities in assumed ρ and μ).

Integrate to get contents.

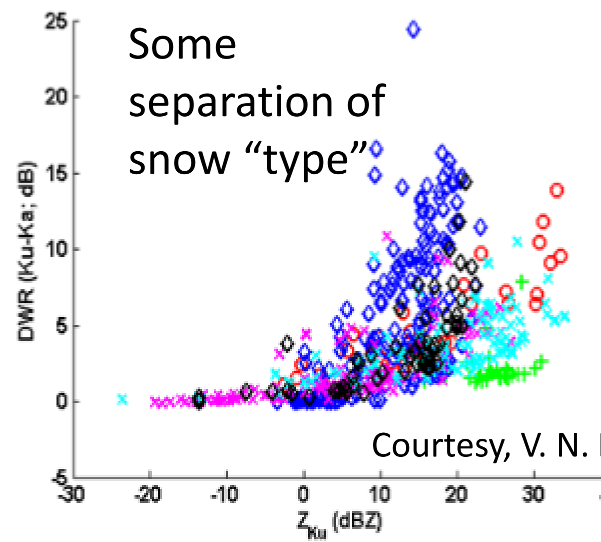
CMB additionally uses the GMI scattering to constrain total column IWP (at say, 166 GHz).

Dual-Frequency Approach tested with GV data

D_{eff}, vs. DFR…a bit of spread by type

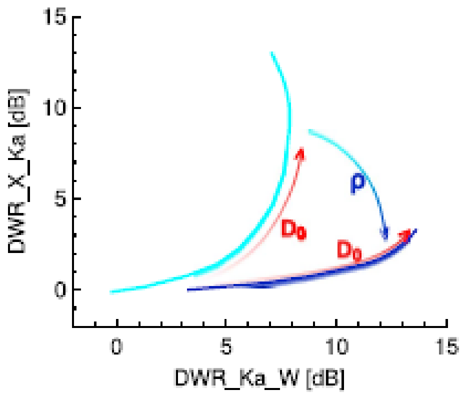


Some separation of snow "type"

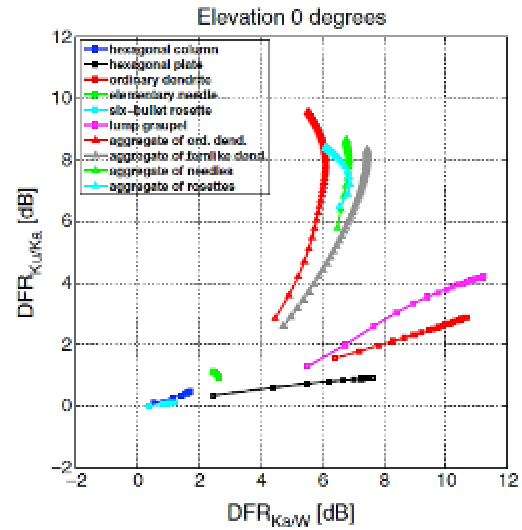


Courtesy, V. N. Bringi

Snow Physics with Triple-Frequency Polarimetric Radar



DFR (X/Ka, Ka/W)



DFR (Ku/Ka, Ka,W)

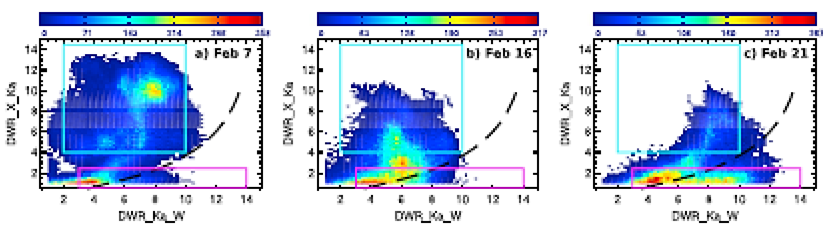
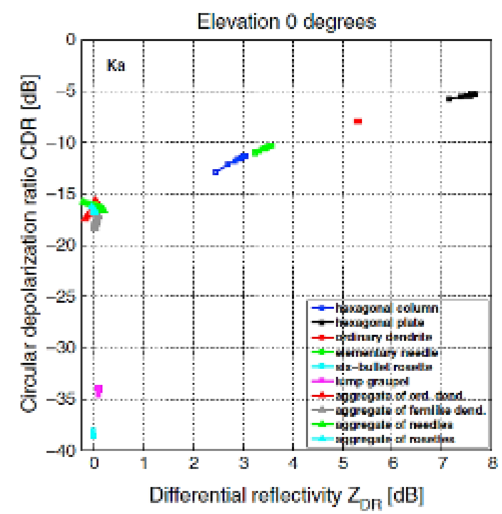


Figure 16. Two-dimensional histograms of triple-frequency signatures from all three cases including all heights below 4 km AGL. The color represents the absolute number of observations per pixel. The colored frames represent approximate areas in the triple-frequency space that were found to be related to the presence of large aggregates (light blue) or rimed particles (purple) in the surface in situ observations.

Pol (CDR, ZDR)



Kniefel et al., 2015 JGR

Tynella and Chandrasekar (2014, JGR)