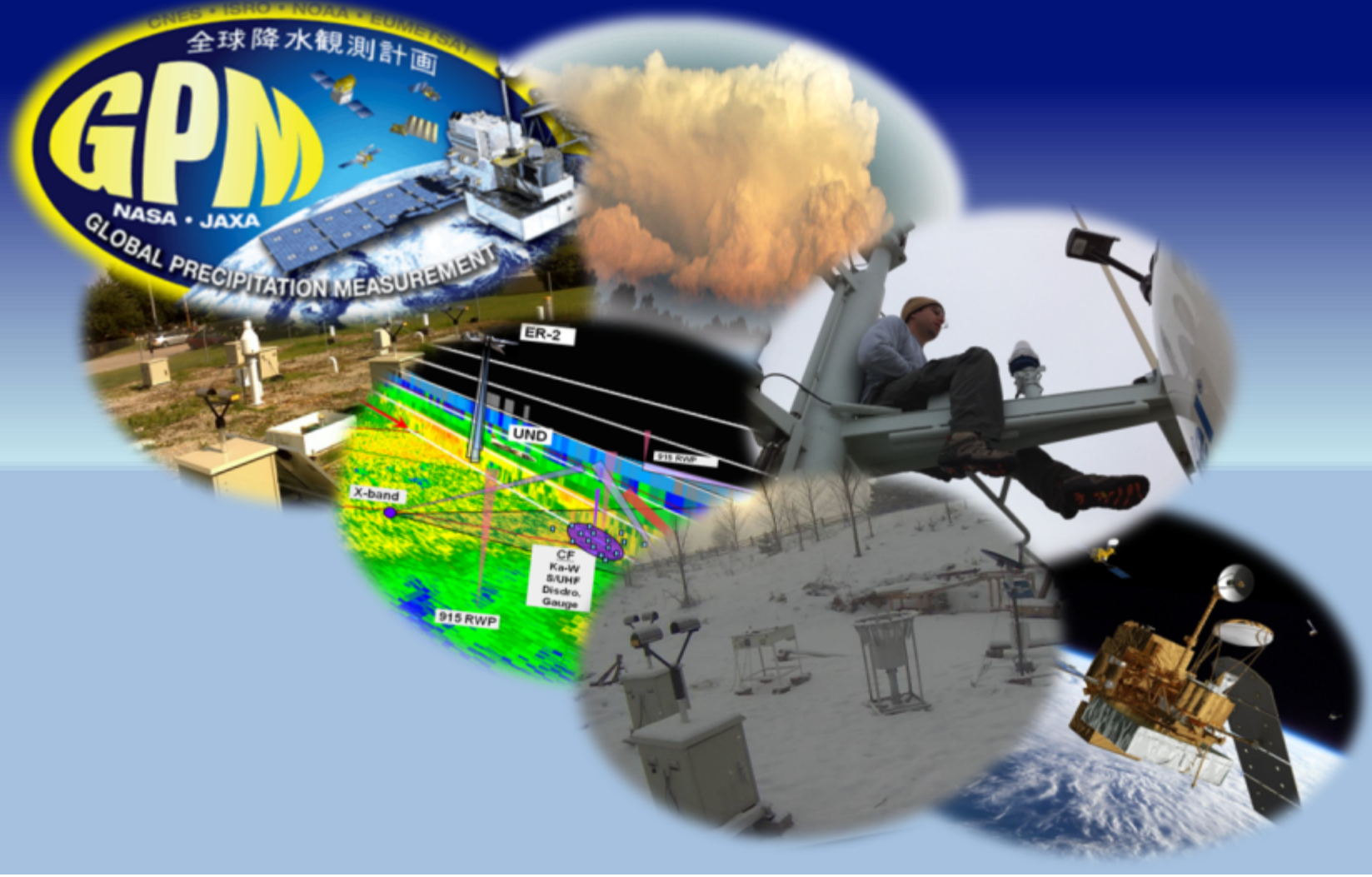
Core GV in the Post Launch Era

Walter A. Petersen, Deputy Project Scientist, GV
NASA GSFC/ Wallops Flight facility



Context

Specific Meeting Objectives

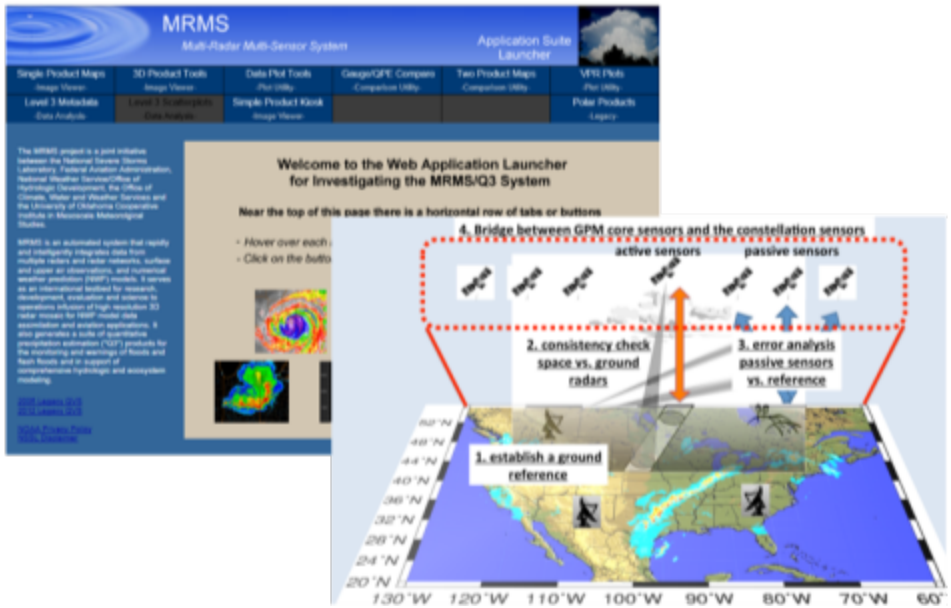
1. Direct GV Year-1 Post-Launch Results
   i. What are we seeing and how should we look at it? Near term priority needs/approaches?
   ii. Level 1 Requirements : What networks and approaches?

2. Physical GV Analysis and Assessment; value to algorithm development;
   i. What are we seeing; ***priorities for future physical validation*** *activities?*

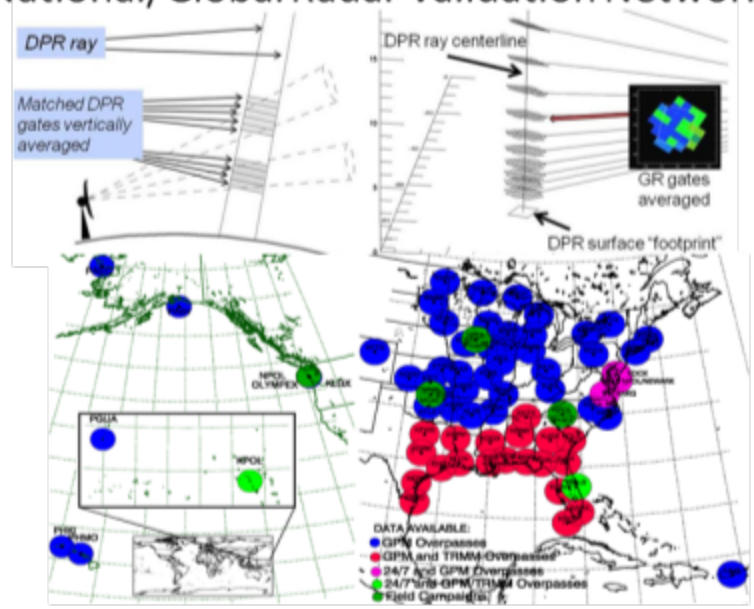
3. Integrated GV : Better understanding of methods to assess the uncertainty in and hydrologic utility of GPM satellite products

Tools, Data, Analysis

National Merged Radar and Gauge GV (MRMS)



National/Global Radar Validation Network



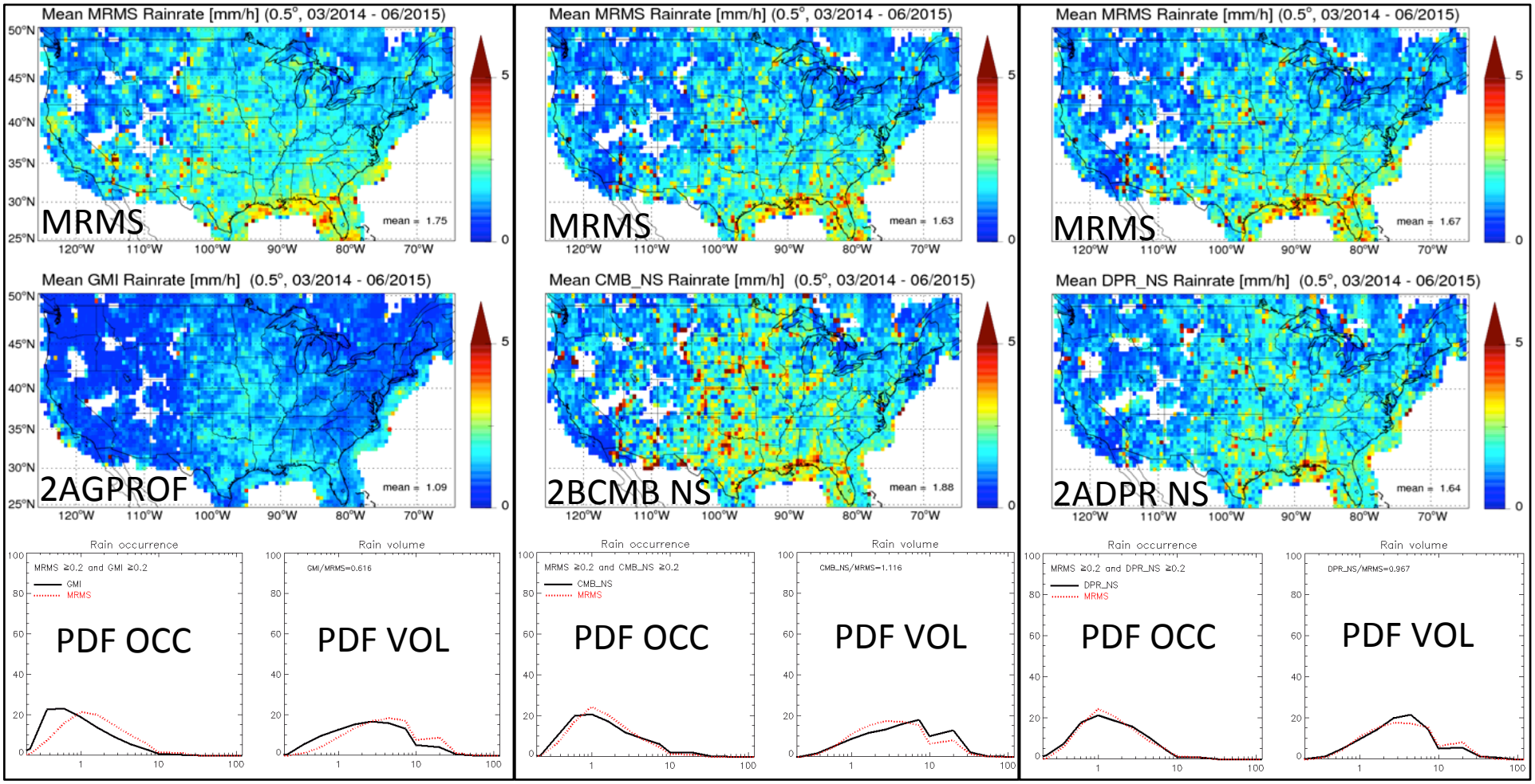
Regional Networks, Tier 1 Sites…….

Field Campaign Instruments and Data

Post Launch Direct GV: What are we seeing? Product Consistency?

http://gpm-gv.gsfc.nasa.gov/

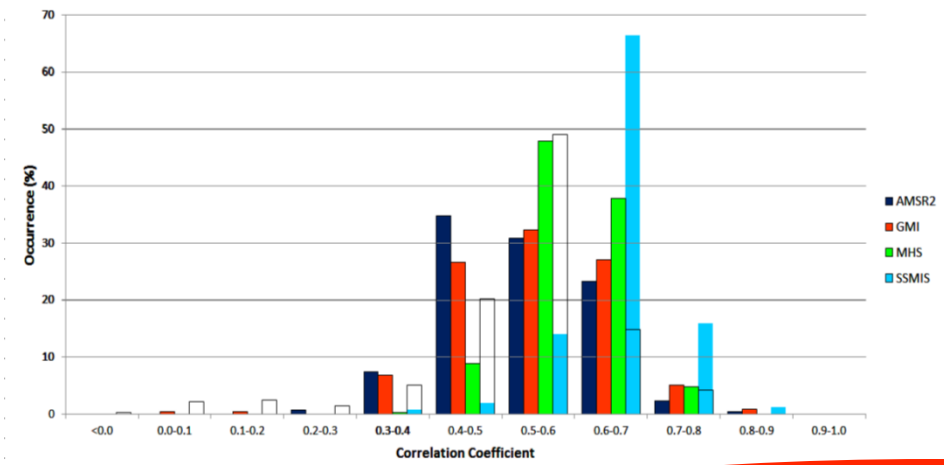
MRMS and GPM: 03/14 to 06/2015 : 0.5° grid; Liquid only; > 0.2 mm/hr; RQI >

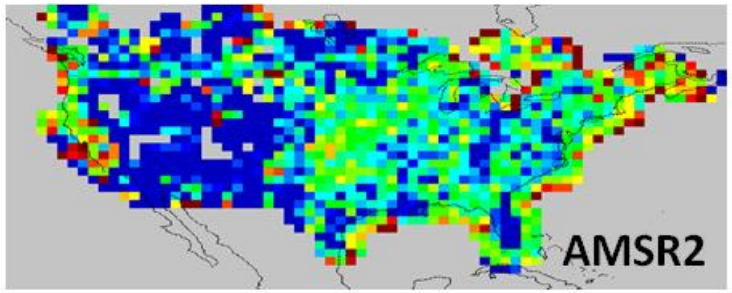


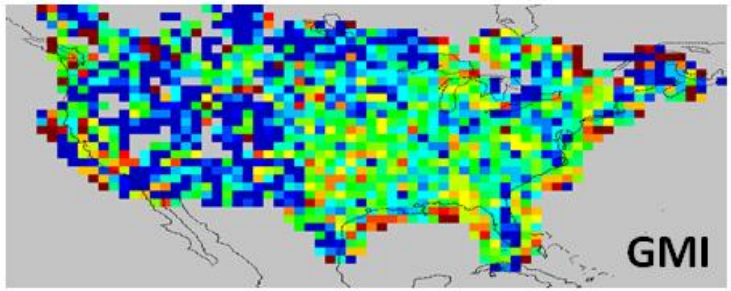
- Considering *liquid only* and *constraining GV* (MRMS)
  - GPROF low relative to DPR, CMB and MRMS Products. CMB, DPR, MRMS similar- CMB a bit higher in mean; ***How will things change with V4 of DPR/V2 of GPROF?***
- ***Level 1 Requirements:*** *Mean* relative error generally falls within requirements; RMSE……

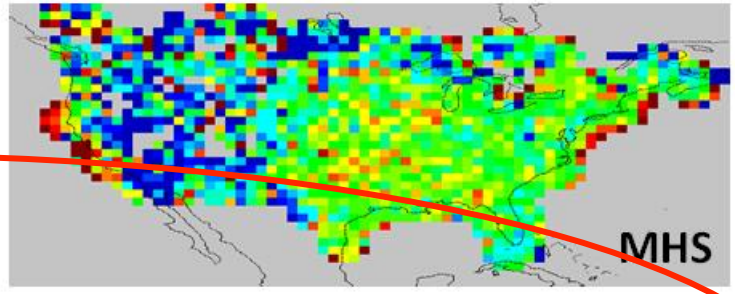
Correlation and impact of "resolution" (C. Kidd)

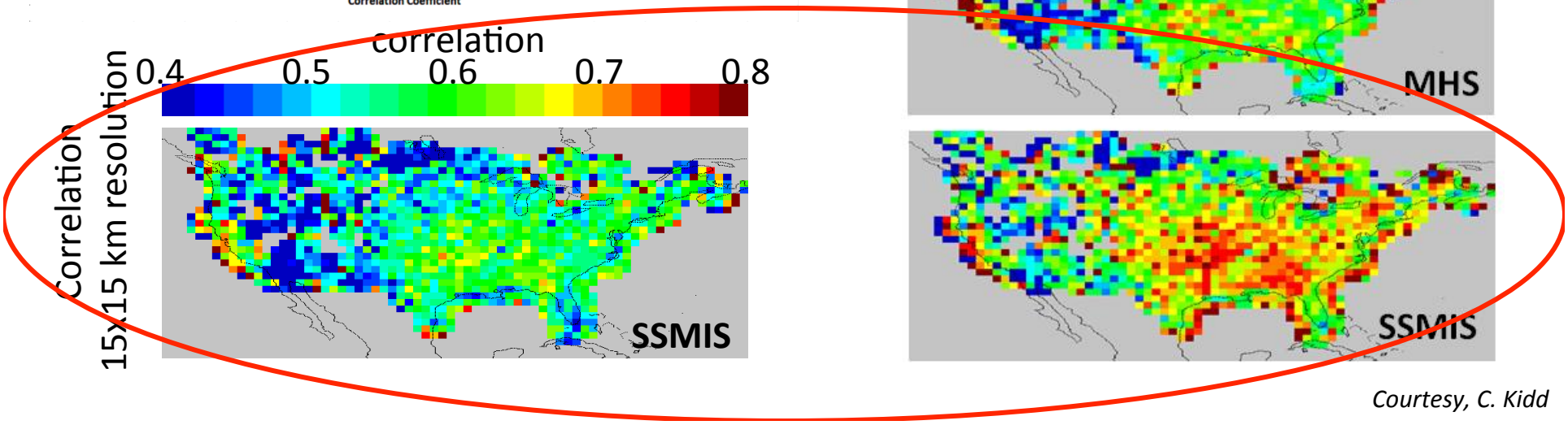
USA region: 1 year SSMIS = 150 M samples
0.01 x 0.01 degrees, 2 minute
Radar time = most recent data every 2 minutes
130°W-60°W, 20°N-55°N
FOV matches – oval, even-weighted footprints











Courtesy, C. Kidd

Direct GV: Directions

- Examine inter-product consistencies/inconsistencies and conditions under which they occur.

- Identify more global MRMS-like *gauge-adjusted radar* products for *maximum regime diversity*.
  - MRMS, KMA-RAR, NIMROD, MeteoSwiss?……..others?

- Investigate optimal temporal/spatial matching between ground and space-based products.
  - *Consider resolution for comparisons* : IFOV matching vs. Gridding?
  - "Near surface" products not really "at" the surface……..
    - Need to look at space/time lag correlate and accumulate?

- *Working Group* for approaches and datasets etc. (we have several volunteers; we need some more)
  - **best approach to Level 1 requirements evaluation**
    - Regional subsets of national products with best performance and known error
    - Common error definition of bias calculation and random error

GLOBAL PRECIPITATION MEASUREMENT

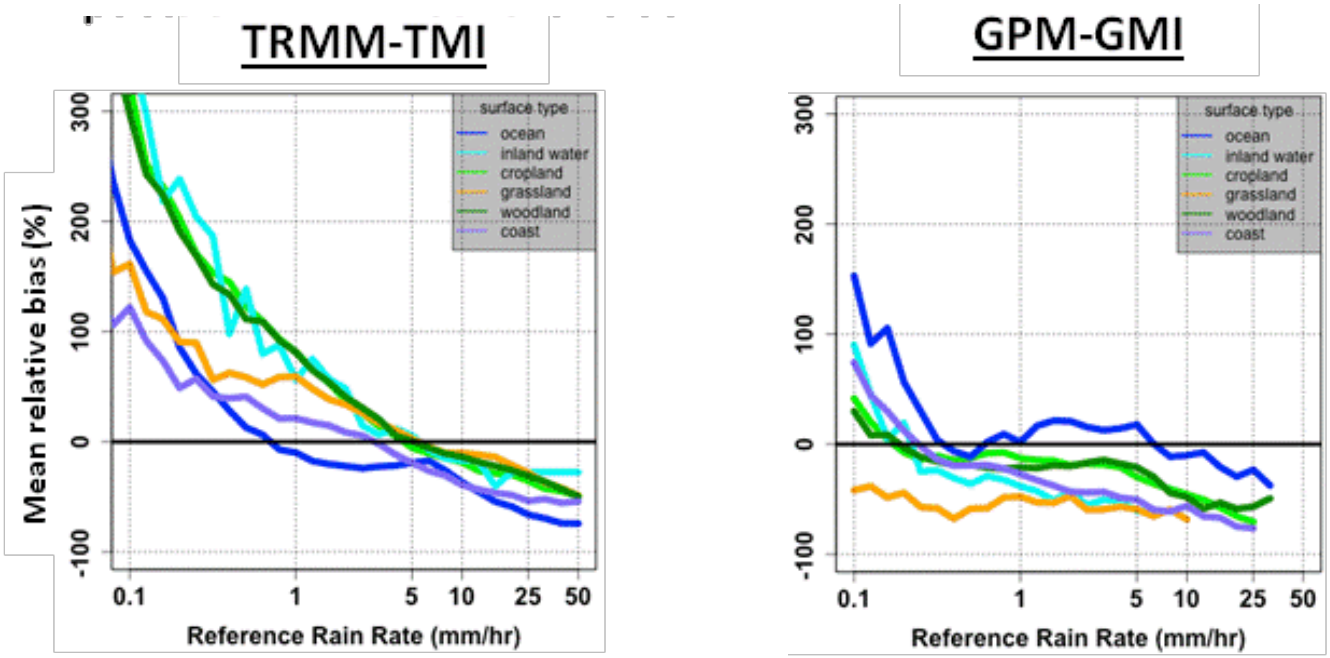
Directions Continued - Digging Deeper

- Need to *drill-down*; perform conditional analyses based on relevant algorithm parameters/observables

  E.g., radiometer: surface type, 2 m temperature, TPW

  E.g., DPR: Precipitation type (C/S), intensity/structure, variability, PIA, DSD profile……

  Precipitation magnitude and surface impacts on PMW retrieval bias



Courtesy N. Carr, P. Kirstetter

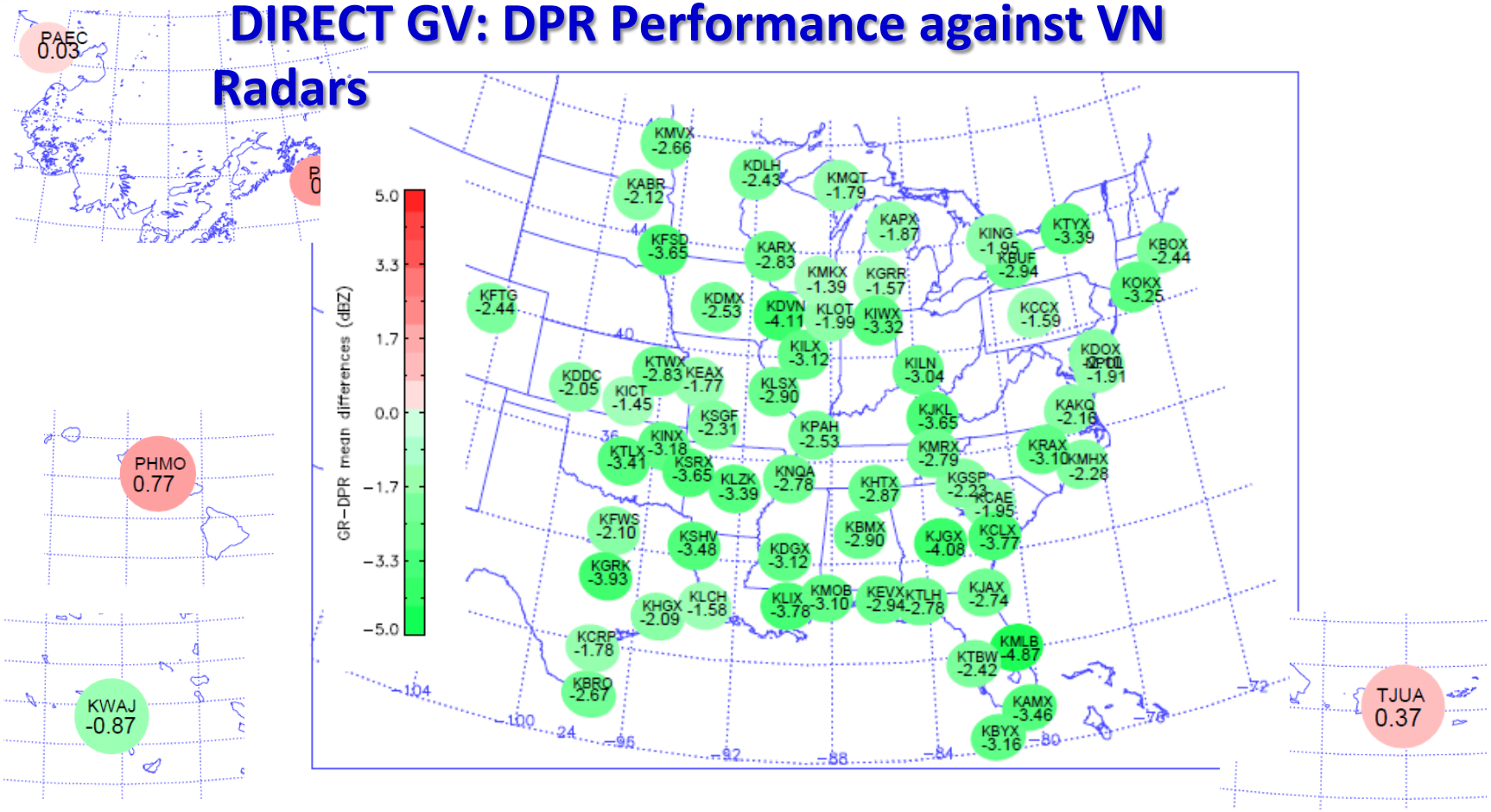
Surface type has an impact that varies with rain intensity

GMI improves(?) on TMI

Light rain rate intensity is problematic (may be for GV as well; need to examine how well we actually measure light rain- *work needed*)

DPR Ku calibration: 2 dB or not 2 dB?

DIRECT GV: DPR Performance against VN Radars



Geo-matched sampling in ice above ML.

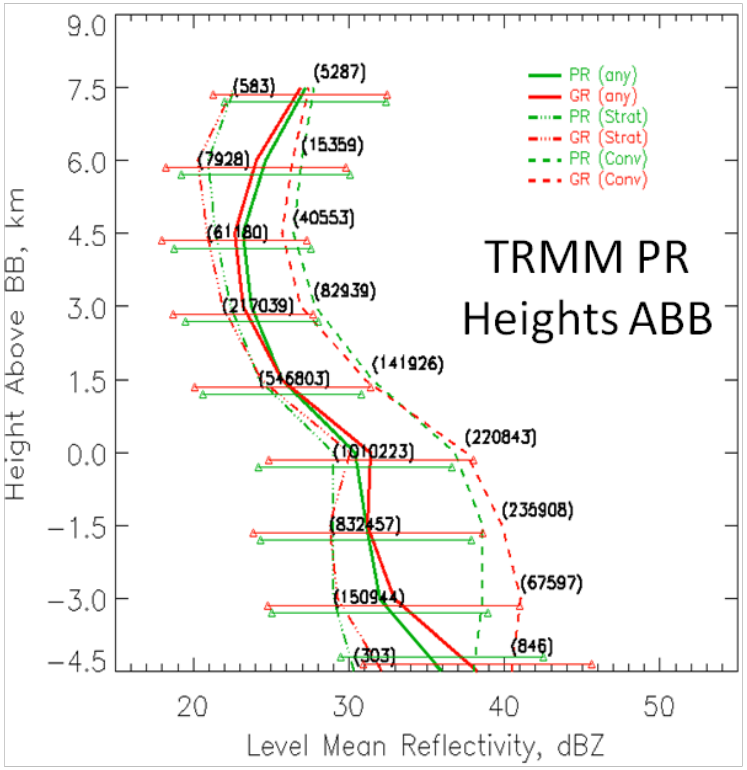
Most 88Ds well within 2 dB of DPR Ku (S-adjusted to Ku)

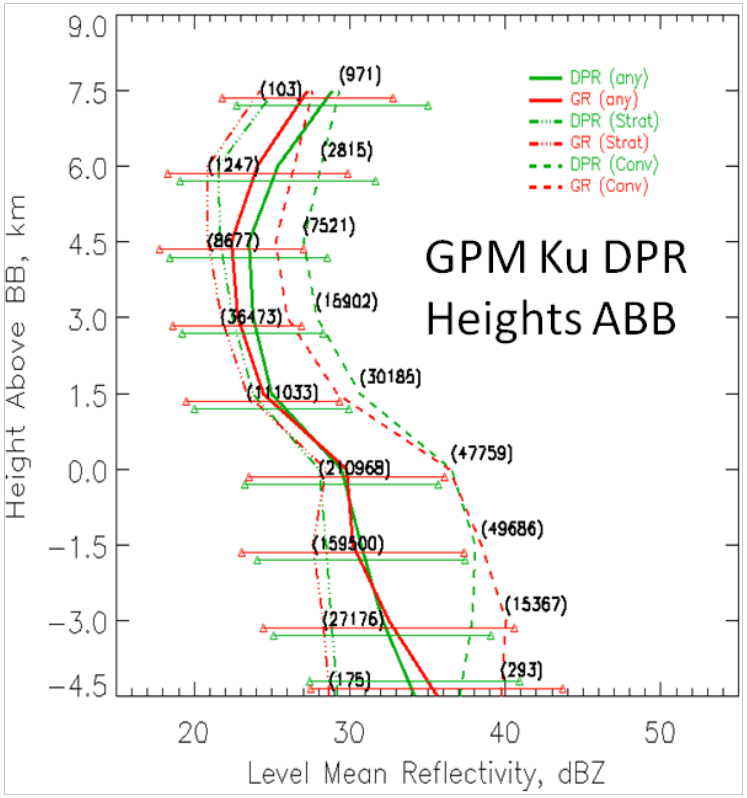
88D tendency to be a little on the "cool" side relative to DPR

GPM

Validation Network

Mean GR bias vs. PR and DPR, by height





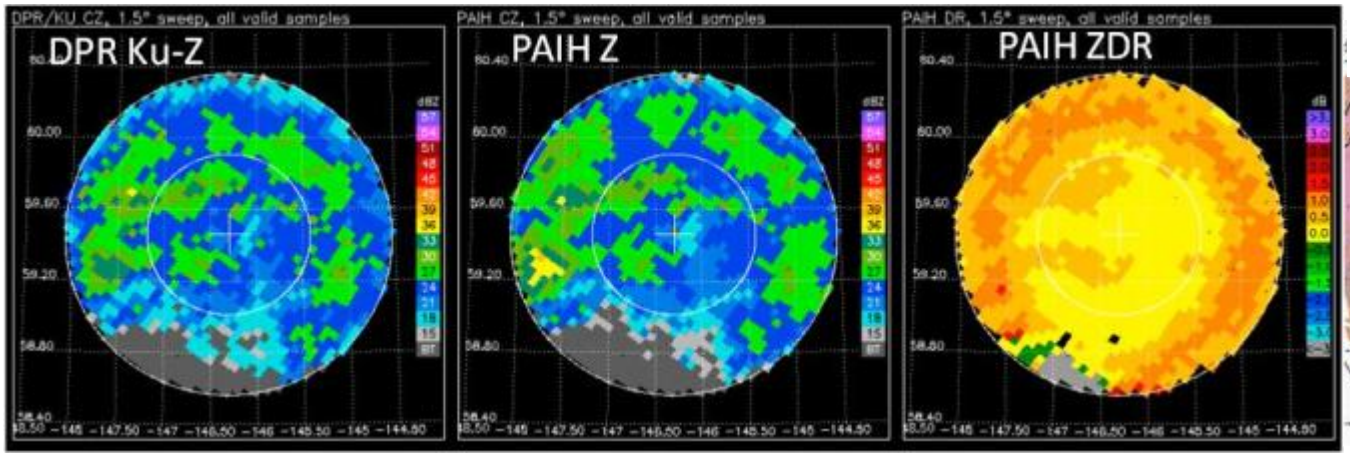
- PR, DPR and GR reflectivity profiles normalized by mean Bright Band height
- GR S-band frequency adjusted to Ku-band, mean bias in convection remains
- Southeastern VN sites, GPM-era dataset (March, 2014 – April, 2015)
- Constrained to 70% filled volume samples
- *VN database query results return bulk statistics over all or any part of the dataset*

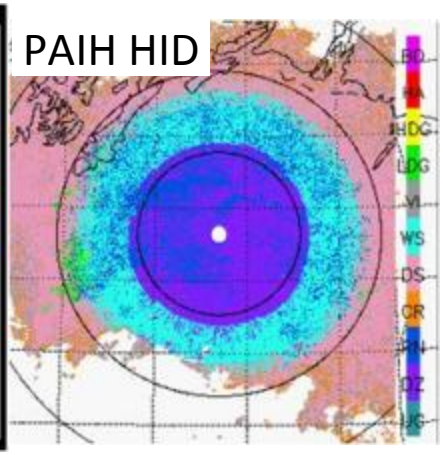
Courtesy K.R. Morris, 2015

Tools for Digging: DSD, precip types…..

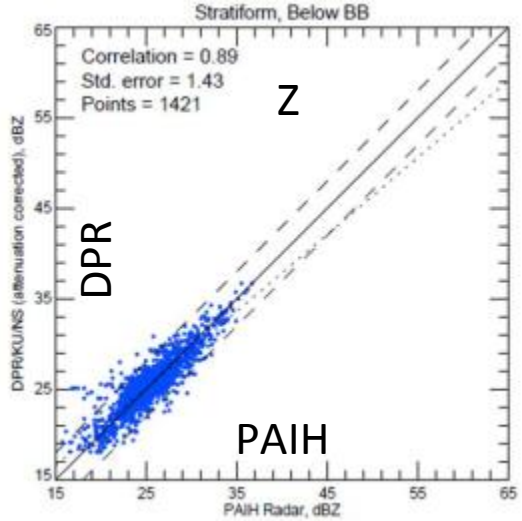
Middleton Island, Alaska PAIH (WSR-88D) August 14, 2014

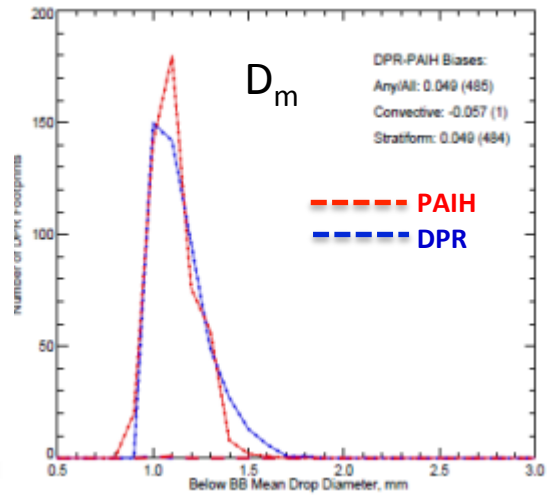
Light/moderate stratiform precip regime over NE Pacific (and stratiform more generally, elsewhere)- generally pretty good.

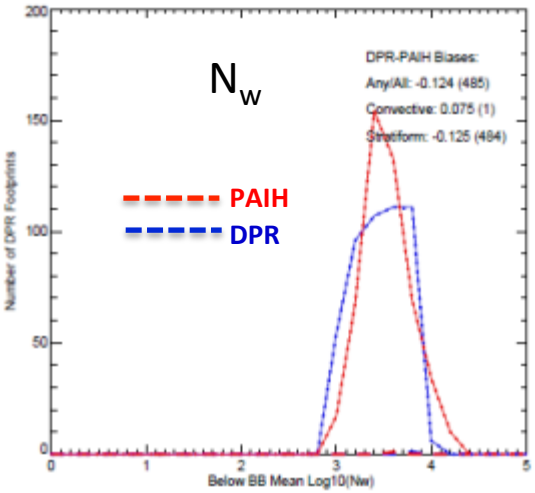




Robust comparison of 2ADPR Reflectivity (Z) and Drop size distribution Parameters (D_m, N_w)

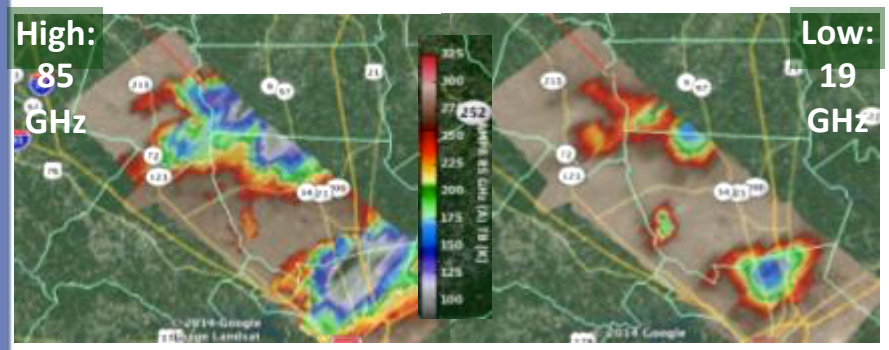




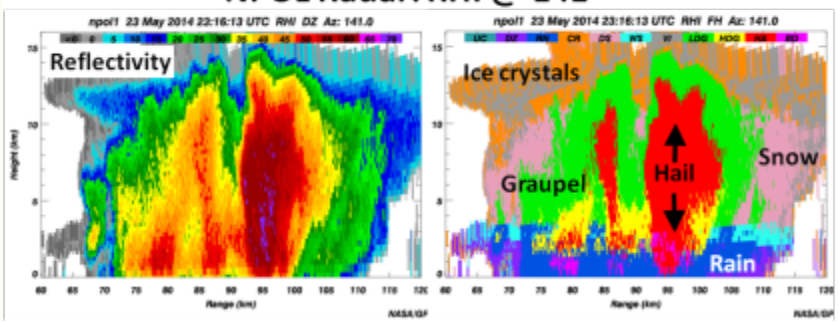


More "interesting" event: IPHEx 23 May 2014

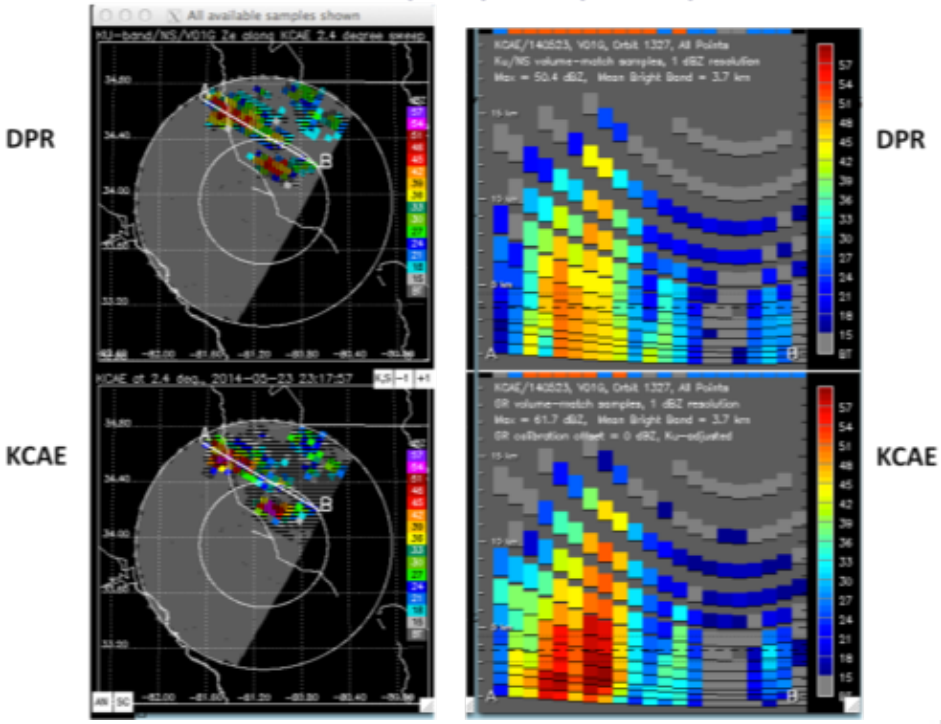
AMPR and NPOL

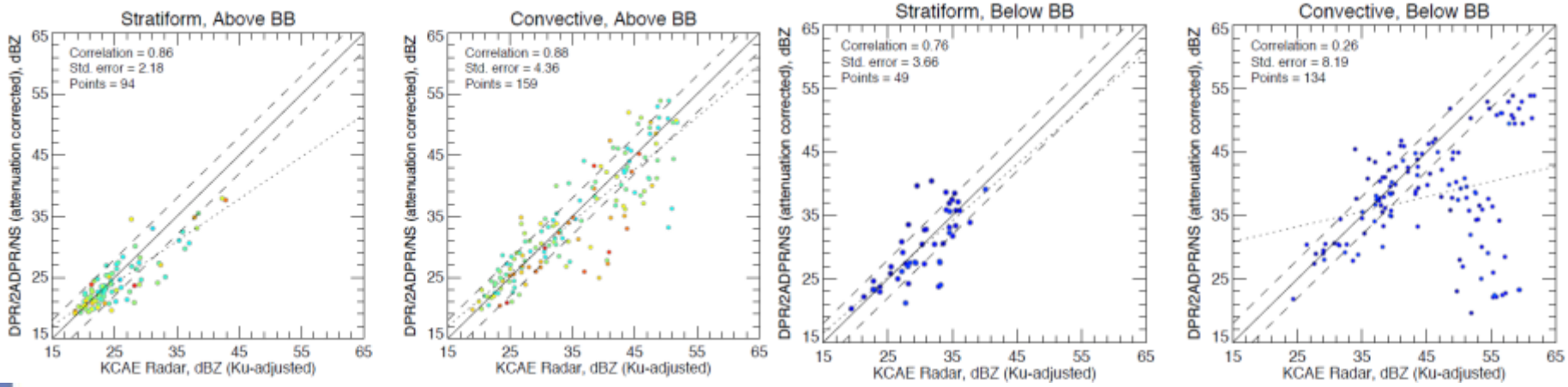


NPOL Radar: RHI @ 141°



VN match of Z (KCAE) and Z (DPR-KU)

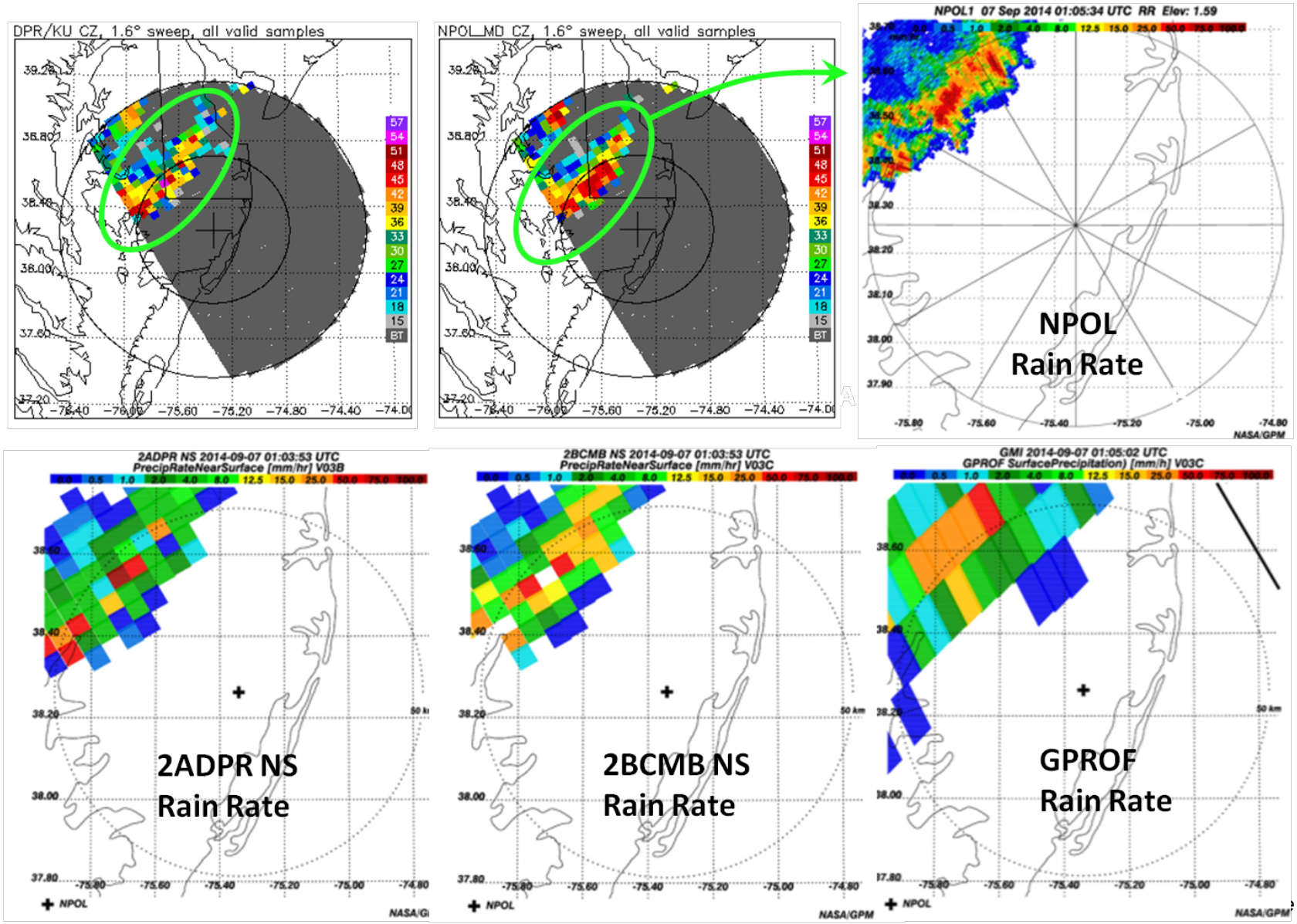




Special DPR dataset courtesy Toshio Oguchi

WFF: Moderate convection (spatial var.; NUBF vs. DSD and PIA)

GPM + VN + Field Data: Variability in convection- spatial and column impacts?



GV Meeting Feedback: Column and variability

Ongoing interests for both TRMM/PR and GPM/DPR rain retrieval algorithms **DSD/profile and NUBF impacts** on retrievals**, mixed phase discrimination**.

Needs:

a) High resolution measurements of profiles (Z, RR, DSD…) ; associated spatial correlation (both horizontal and vertical) with the correlation length as a function of, for example, precip type, storm height, maximum Z value.

b) GV Radar sampling in coincident satellite overpasses….. important points, high spatial resolution, simultaneity, and absolute accuracy….Z, RR, and DSD for simulating Ku/Ka

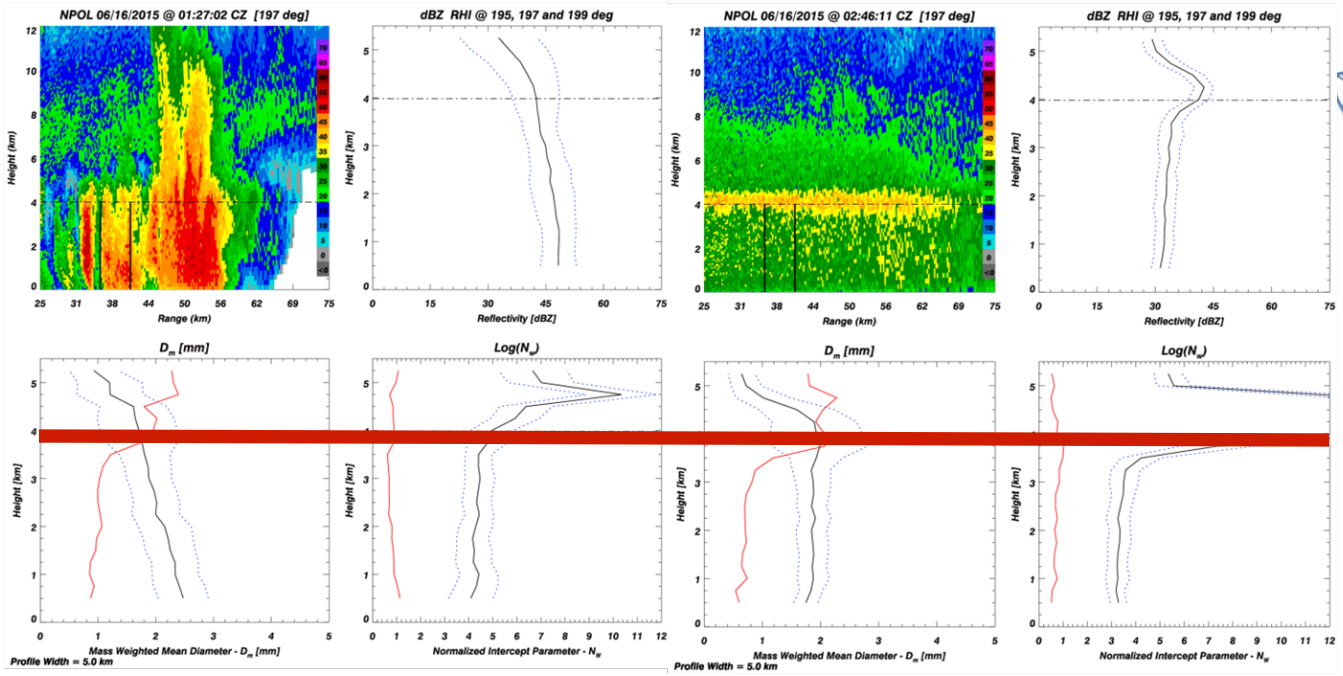
c) Develop vertical profiles of error as f(NUBF, PIA, regime, precip type etc.).

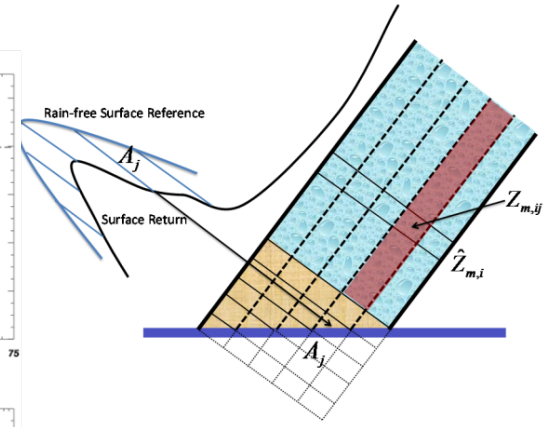
d) Use polarimetric GV radar to provide a precipitation profile model….identify ice and validate the mixed-phase detection accuracy in the DPR classification module

Examples to test NUBF, PIA and Profile Physics: High Res. correlation/profile structure

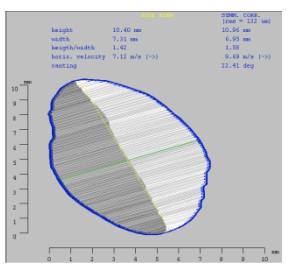
(MC3E, IFloods, IPHEx, WFF……Airborne and Ground-based……)

Rapid RHI/PPI Scanning to Capture Profile DSD/HID 3-D properties, correlation, coupling
51 sec. cycle, 3-RHI az + PPI sector rain scan; Vertical and Horizontal variability





NUBF testing needs high res information across (sub) IFOV and along ray (it is a 3-D problem)



Connect to surface properties

Giant drops observed by all 2DVDs across 2.5 km patch

Max D_m > 3 for 5+ minutes

Convective: CV ~ 20%

1 σ: D_m +/- 0.5 mm; N_w +/-8 dB

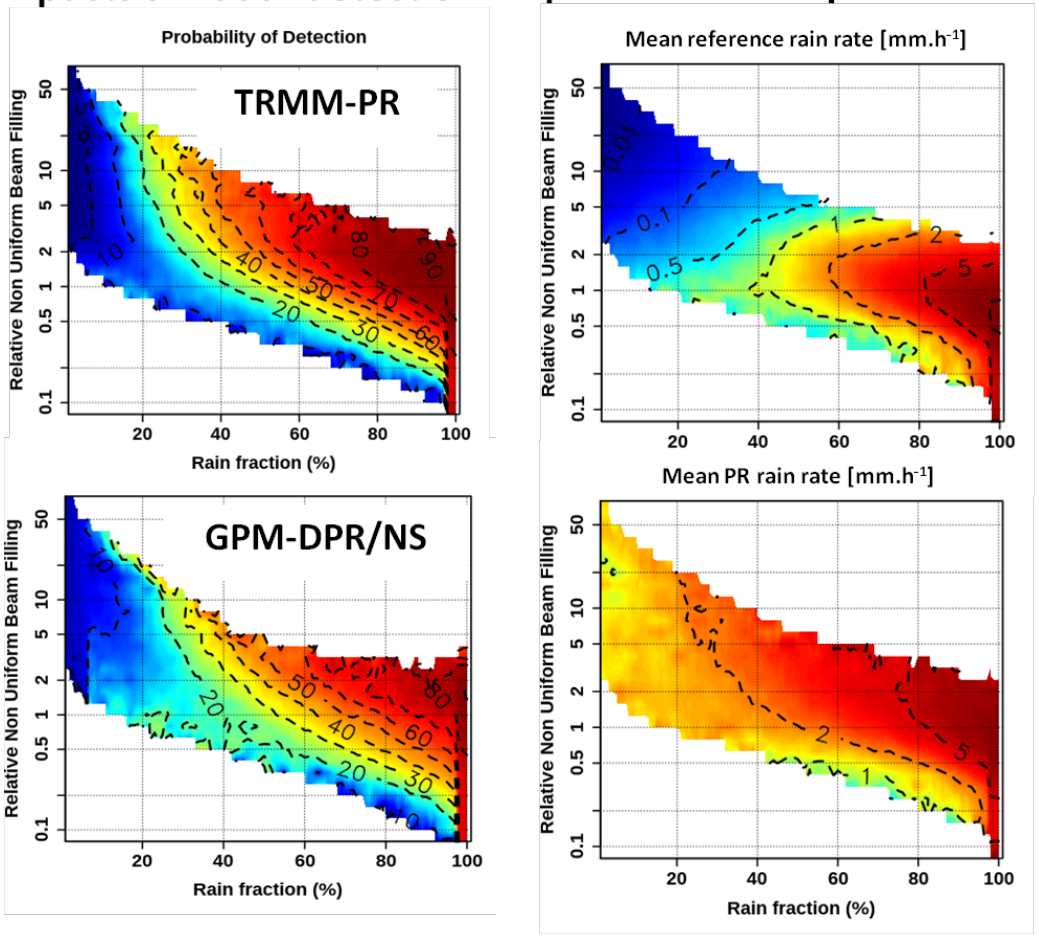
Stratiform: CV ~ 15%

1 σ: D_m +/- 0.25 mm; N_w +/-4 dB

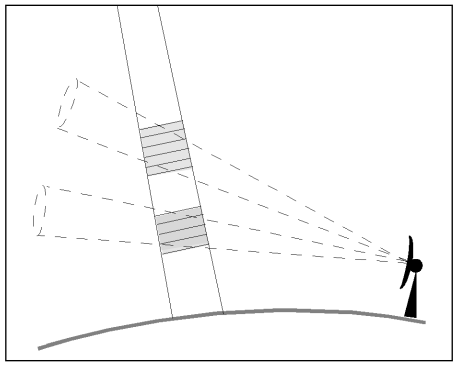
NUBF: Moving continental scale with MRMS and VN

Non-Uniform Beam Filling impacts on radar detection

Non-Uniform Beam Filling impacts on radar quantification



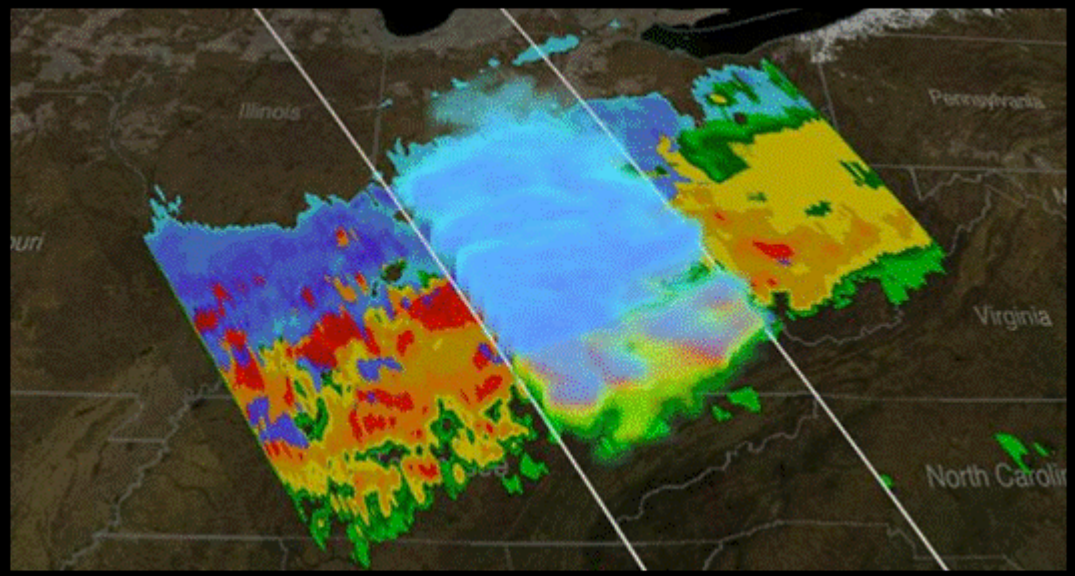
VN footprint σ up the column



In parallel work across scales

Field radars and data: surgical, adaptive; MRMS/VN- bulk continental, statistical

Snow- We CAN “detect” it!



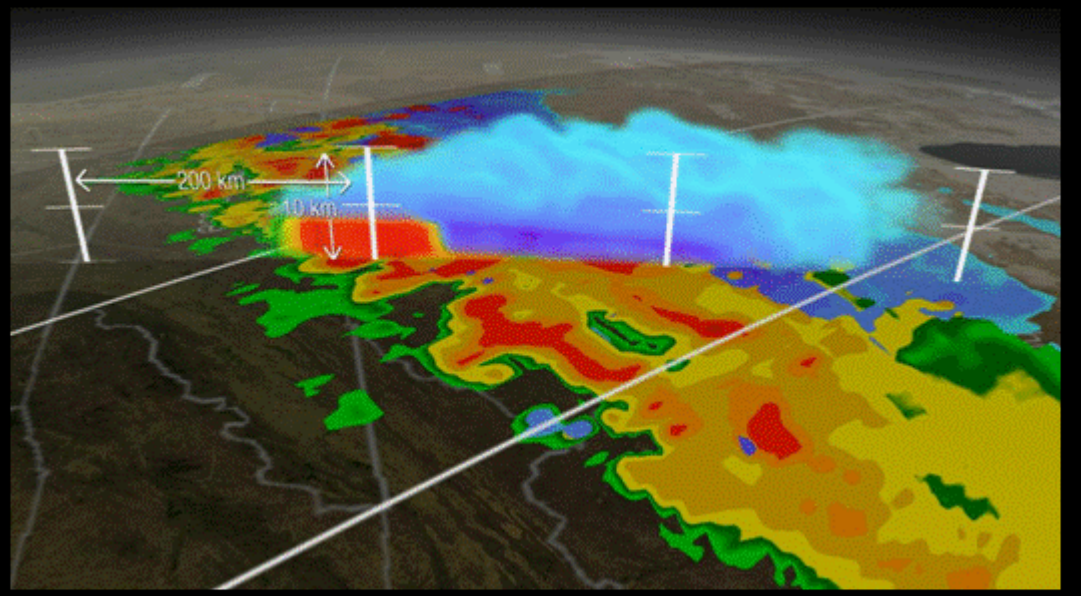
Winter storm with mix of liquid, freezing, frozen precipitation

GPROF and D3R delineate snow and rain……

But not always uniformly-

Can we adequately and routinely capture physical variability?

How well can we estimate SWER (threshold?)



Snowfall Validation

Using areas where *reliable snow measurements* exist, provide "MRMS-type" estimates of both snowfall rate (SWER) and snow accumulations for areal snow

Consider optimal time delays between in situ observations, ground based radar, and radiometer snow observations as f(temperature, column water vapor…..*column T and precip profile*)

Focus on random and systematic biases in the GPROF retrieval over areas of at least 0.25 degrees

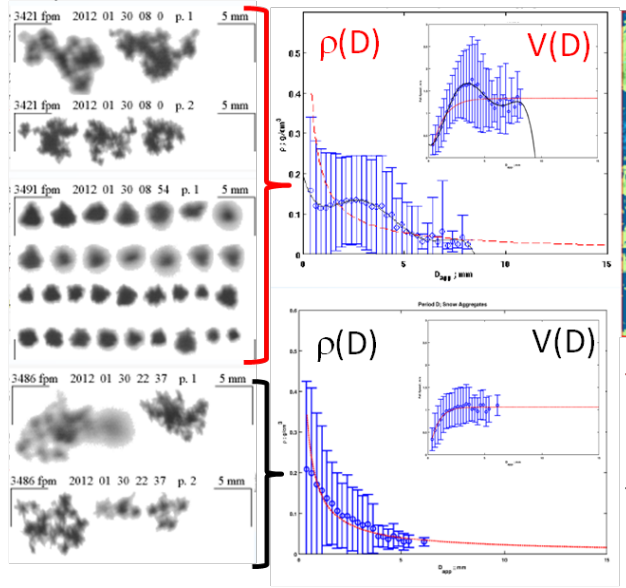
Inter compare accumulated precipitation and SWE measurements over 0.25 to 0.5^{o} scales.

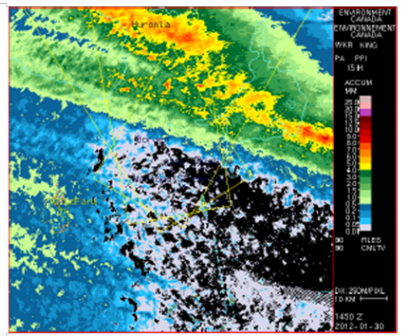
Diagnose differences as a function of mean temperature regimes

GLOBAL PRECIPITATION MEASUREMENT

Accurate SWER a Case to Case Proposition.....

Approach: ρ-D adjustment and Z-S model (LPVEX) .....GCPEX: Intra-event Z-S variability - good SWER

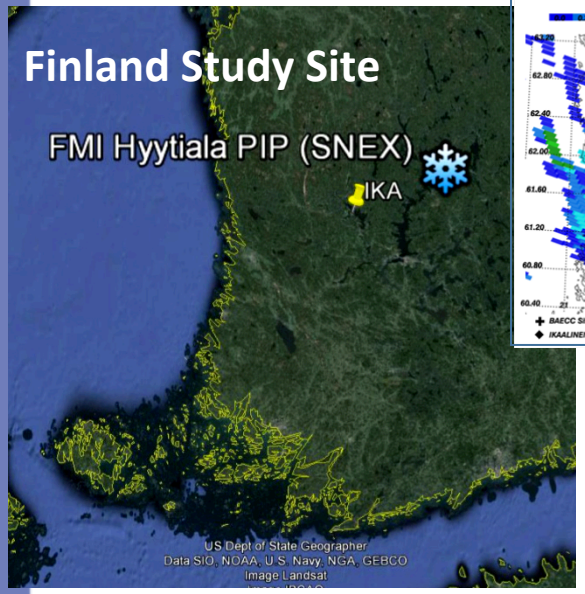


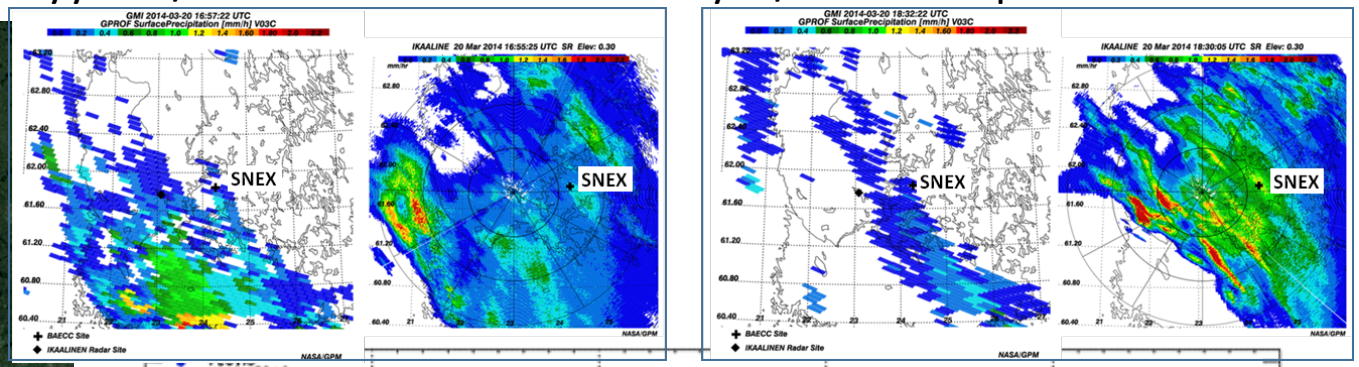


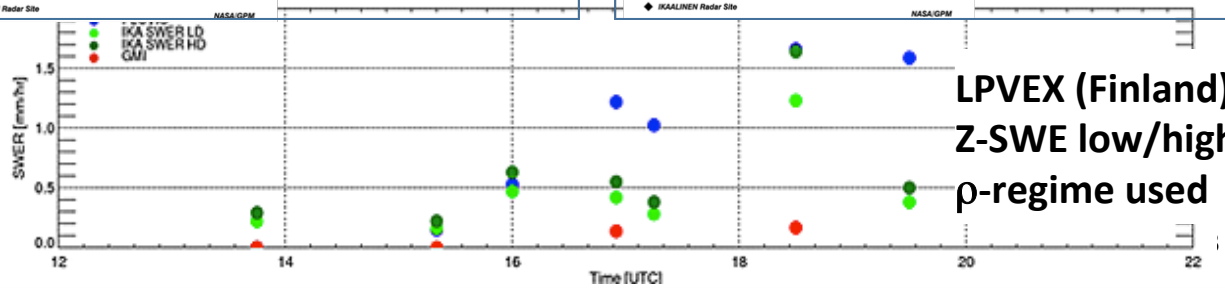
Period 1:
N(D)= 4473 exp(-1.19D)
Z = 178 $SWER^{1.35}$

Period 2:
N(D) = 661 exp(-1.23D)
Z = 235 $SWER^{1.74}$

Post-Launch: Finland, Hyytiala/SNEX Intra-event Variability w/GPM Overpass

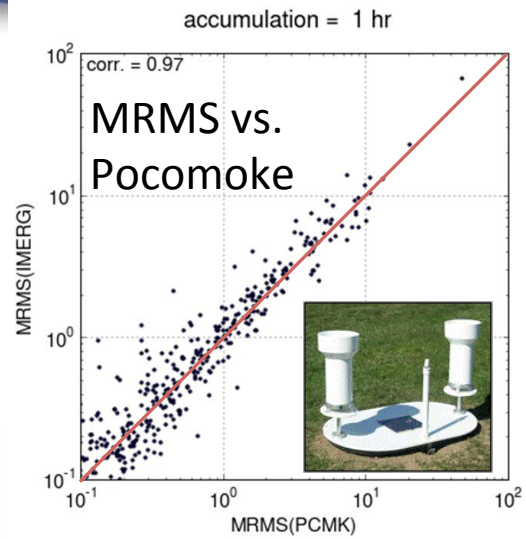


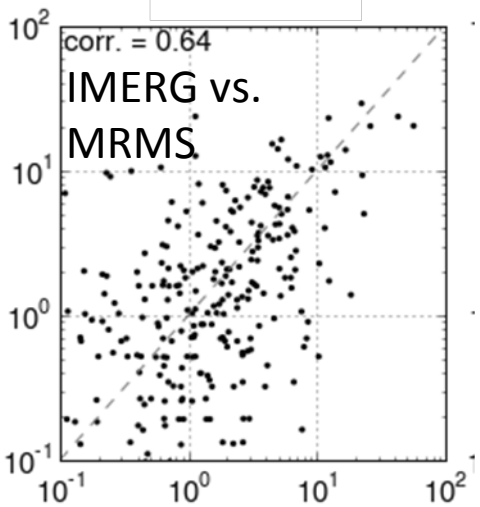


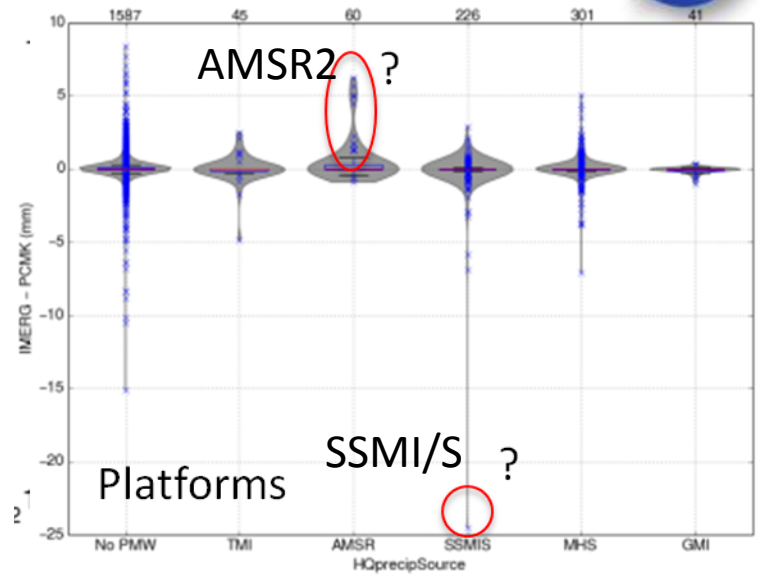


LPVEX (Finland)
Z-SWE low/high
ρ-regime used

Bridging L2-L3: GV, MRMS, IMERG & Level II

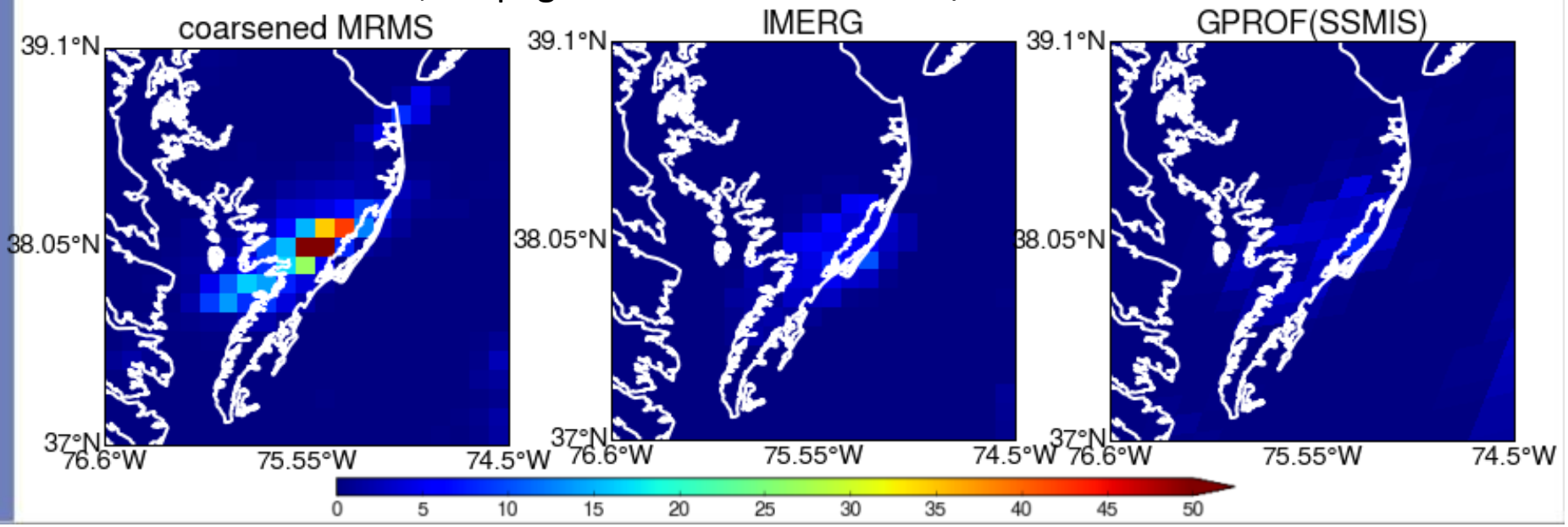






7/16/2015 Convective System:

~ 60 mm in one hour; Propagation of 2AGPROF SSMI/S estimation error into IMERG Final

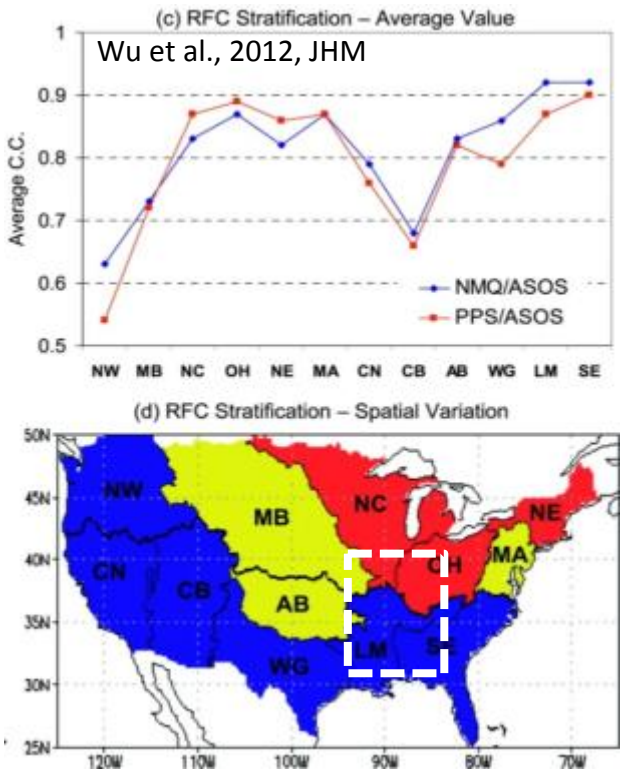


Integrated Validation: IMERGE Improves on 3B42

IMERG and 3B42 "Final" Products

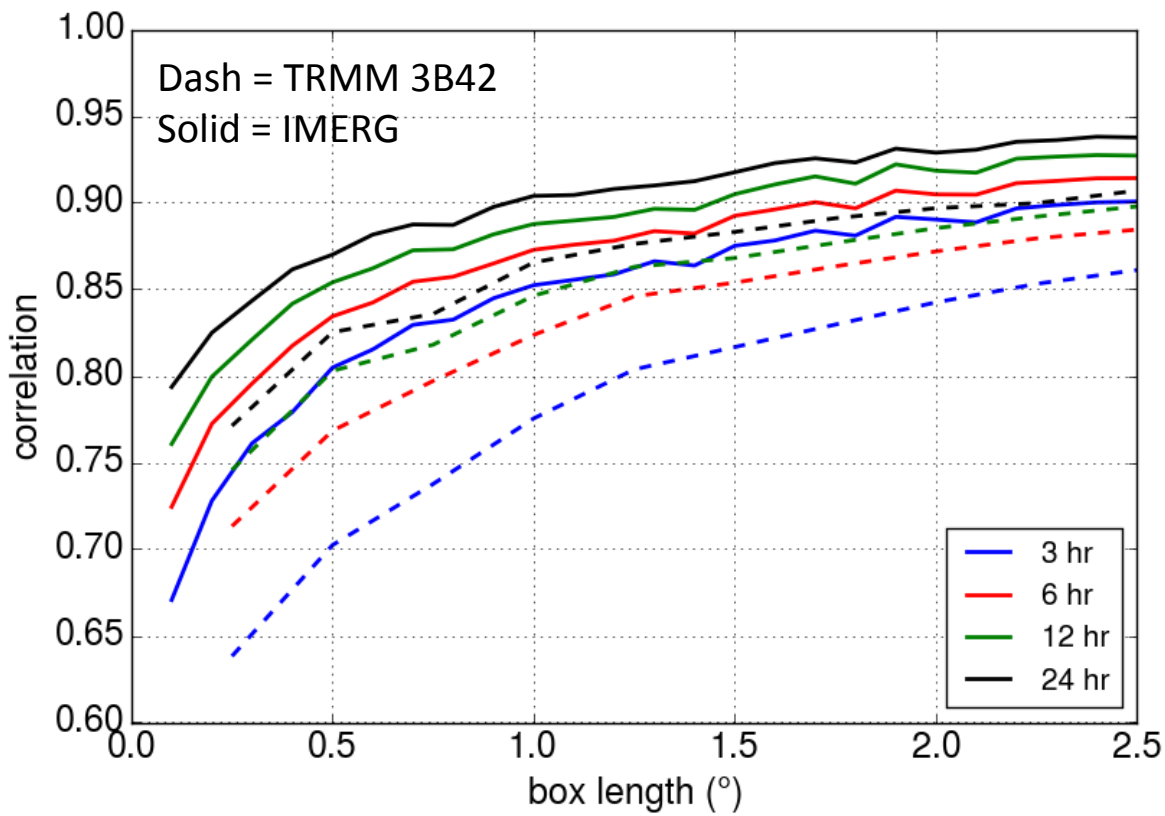
Space-time correlation trends demonstrate improved GPM Product

Use "optimal" regions for GV (MRMS)



April – Nov. 2014

IMERGE (calibrated), 3B42 vs. (MRMS RQI = 1)



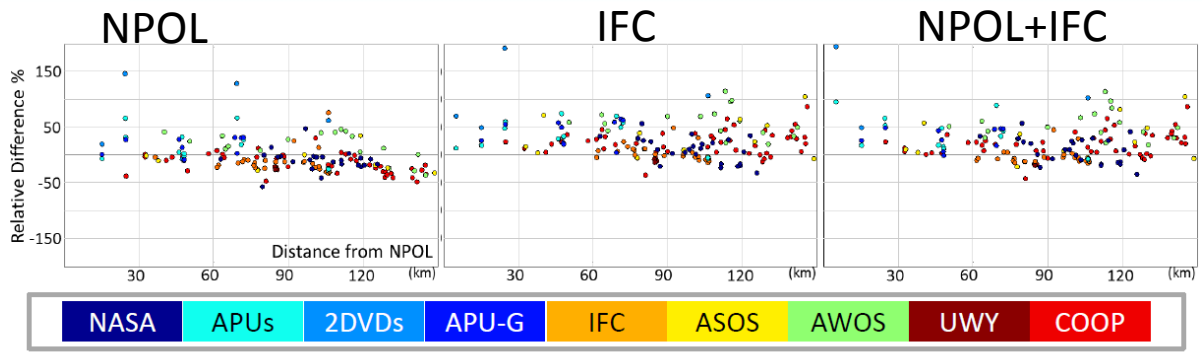
Performance trends as f(scale); How does this correlate to application impact?

J. Tan (NPP, WFF)

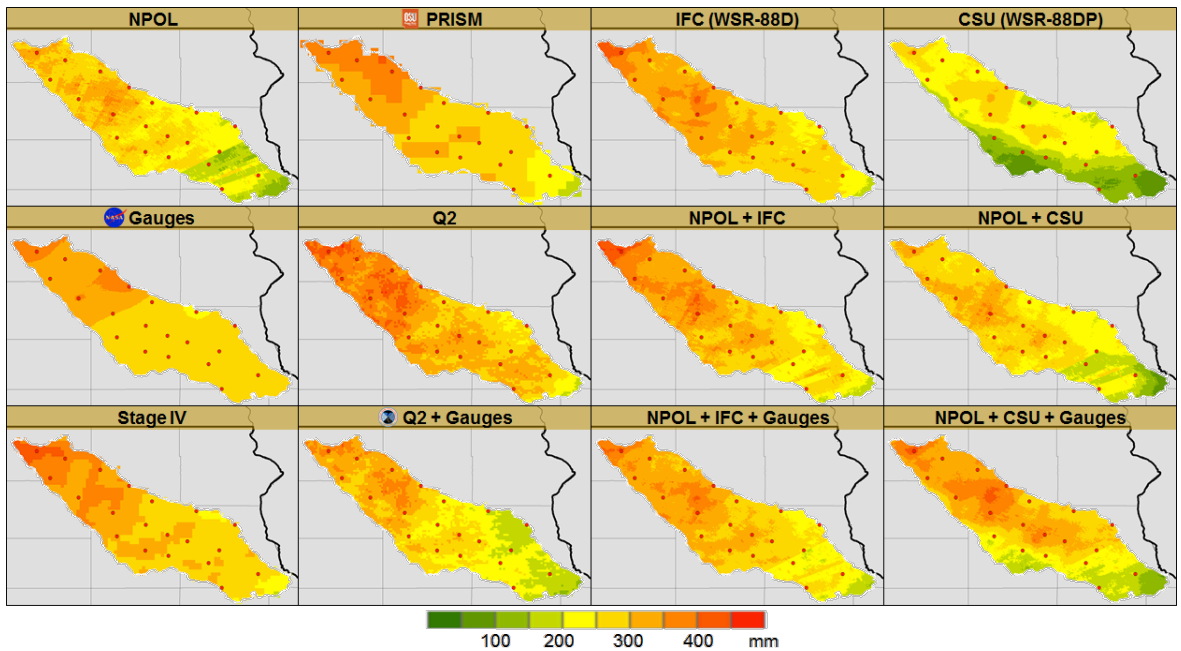
GLOBAL PRECIPITATION MEASUREMENT

Integrated Val.: IFloodS Rainmaps of Turkey River Basin (4000 km^2)

Creating/ evaluating a reference….



Products for testing over the Turkey River Basin



Final throws of "reference"……..Remaining post processing to remove outliers

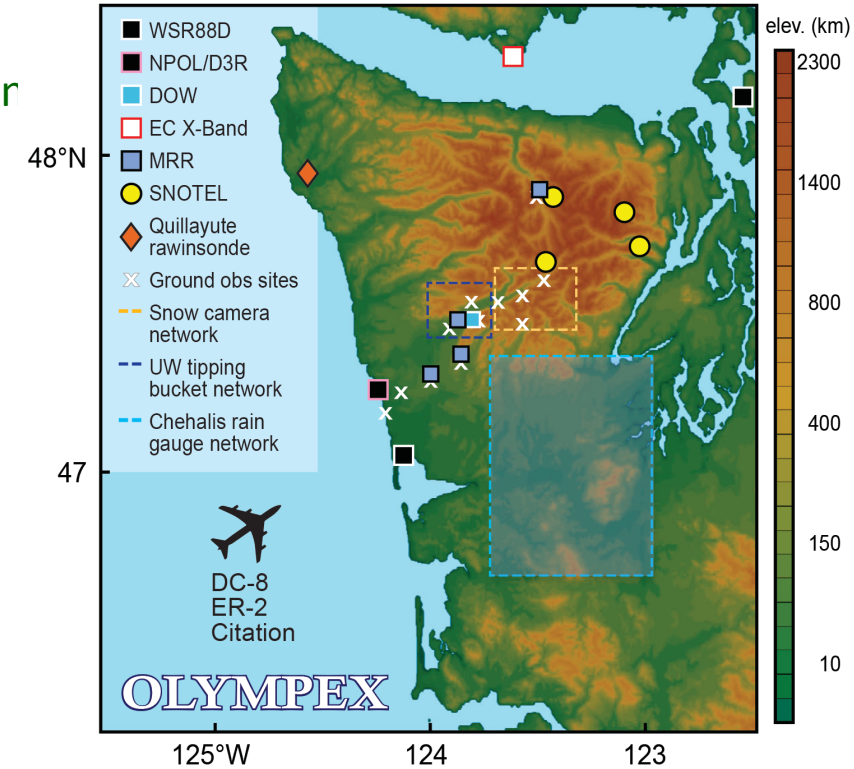
L2 orbit products processed for imagers and sounders; GPROF 2010, 2014, 2015 (late) + Multi-Satellite.

Impacts of range of uncertainty for both GV and satellite products? Scale of utility, unique applications of satellite estimates relative to ground products.

Next (final) Post-Launch NASA GPM GV Field Campaign
OLYMPEX: *Olympic Mountains Experiment in the Pacific NW*
Nov 2015 – Jan 2016

Science Goals:

- Physical Val. (rain, mixed, snow) for GMI and DPR in cold-season; ocean, coast, orographic gradient
- Precipitation mechanisms in midlatitude frontal systems and modification by terrain.
- Level IV product experimentation
- Testing of hydrologic applications
- ACE/RADEX Radar instrument and cloud physics



Instrumentation:

- Surface: Rain gauge networks on Quinault and Chehalis, SNOTEL, Snow cameras, Disdrometers, Pluvios, PIPs
- Soundings: AVAPS (DC-8) and Ground-based
- Radars: NPOL, D3R, EC-X, DOW, KLGX(88D)
- Aircraft: DC-8, Citation, ER-2 (ACE/RADEX): CoSMIR, AMPR , W, Ka, Ku , X-band radars, CPL, AirMSPI
- ASO flights (planned)

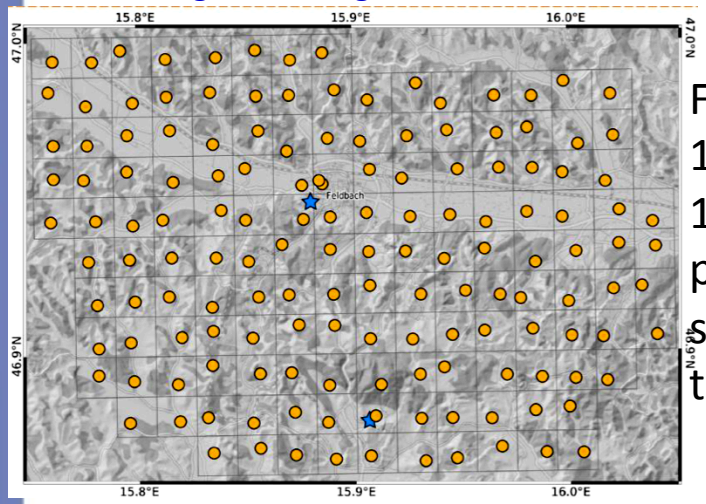
Status:

- Intensive planning, pre-IOP instrument deployments and testing (Wed. 7-8:30 PM meeting)

New International Efforts Joining GV/PMM

WegnerNet (Austria): U. Foelsche, G. Kirchengast, J. Fuchsberger, Sungmin O

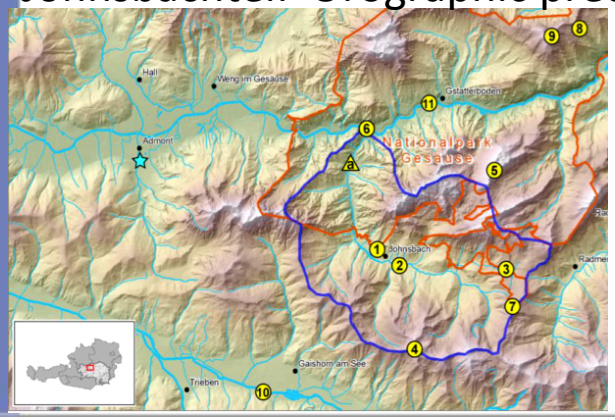
www.wegcenter.at/wegenernet
www.wegnernet.org



Feldbach:
151 stations,
15x20 km^2;
precip, weather,
soil moisture/
temp

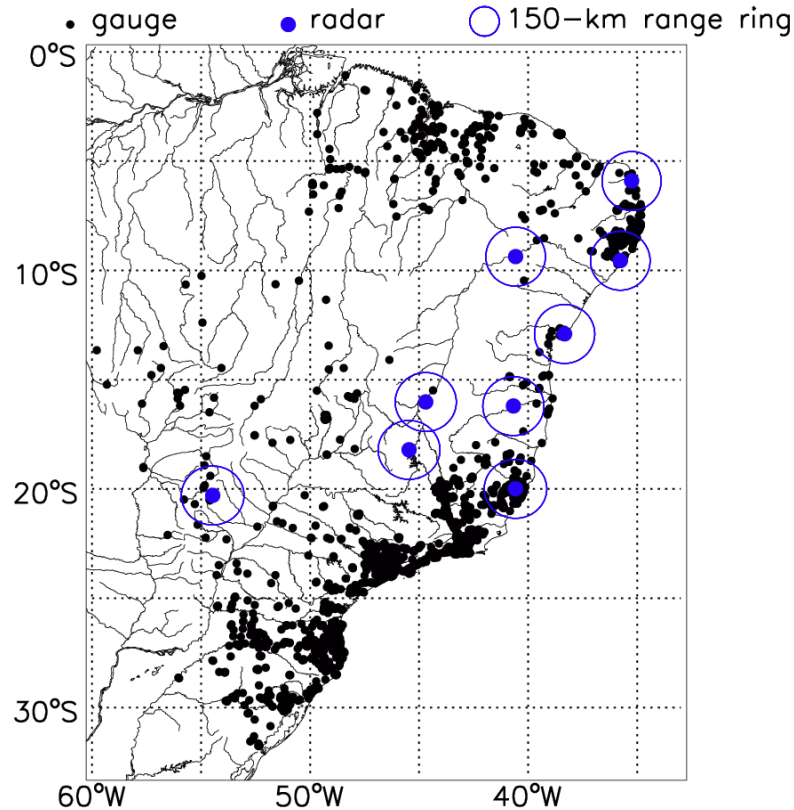
2+ IMERG Pixels covered by
km-scale dense network

Johnsbachtel: Orographic precip/snow



11 stations
10 x 10 km^2
700-2100 m
7 precip, 4 snow
depth, 2 SWE

CEMADEN Brazil: Centro Nacional de Monitoramento e Alertas de Desastres Naturais [Dr. Carlos Angelis]



9 S-band SELEX Dual-Pol Radars
~2750 rain/stream gauges
Data processed/archived by GPM GV
(available to PMM Science Team only)

Summary Points

- ***Level I Requirements -*** common approach, optimal data, metrics- Working Group
- Expand GC-Radar Datasets (international)
- 2 dB or not 2dB….maybe not, for now.....
- Direct GV Working Group

- ***"Drill down"*** in Direct GV
  - Product to product consistency, comparisons conditioned on algorithm parameters and observables
  - Investigate and optimize temporal-spatial correlation between GV and products
- ***Snow (SWER) challenge-*** quality distributed spatial products- careful estimation approaches
- ***Column*** behavior, e.g., profiles, correlation structure, NUBF, mixed phase identification,
  - Field campaign analysis….8 or more campaigns airborne and ground based data……
  - GV assets can be tasked (overpass or not); Tier-1 Radars and Networks

- ***Integrated GV:***
  - Bridge Level 2 and Level 3 (IMERG);
  - Optimize Hydrologic analysis/application- evaluate what can be done and what unique applications GPM offers
- ***OLYMPEX*** campaign 2015/16