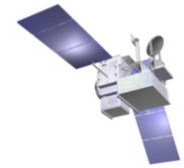

DPR Algorithm Status

Toshio Iguchi[1], Naofumi Yoshida[2], Tomohiko Higashiuwatoko[2], Takuji Kubota[3], Takeshi Masaki[3], Jun Awaka[4], V. Chandrasekar[5], Minda Le[5], Robert Meneghini[6], Hyokyung Kim[7], Liang Liao[7], Shinta Seto[8], Simone Tanelli[9], and John Kwiatkowski[10]

1. NICT, 2. RESTEC, 3. JAXA, 4. Tokai Univ., 5. Colorado State Univ., 6. NASA/GSFC, 7. Morgan State Univ., 8. Nagasaki Univ., 9. JPL, 10. George Mason Univ.

NASA 2016 PMM Science Team Meeting
24-28 October 2016, Houston, TX

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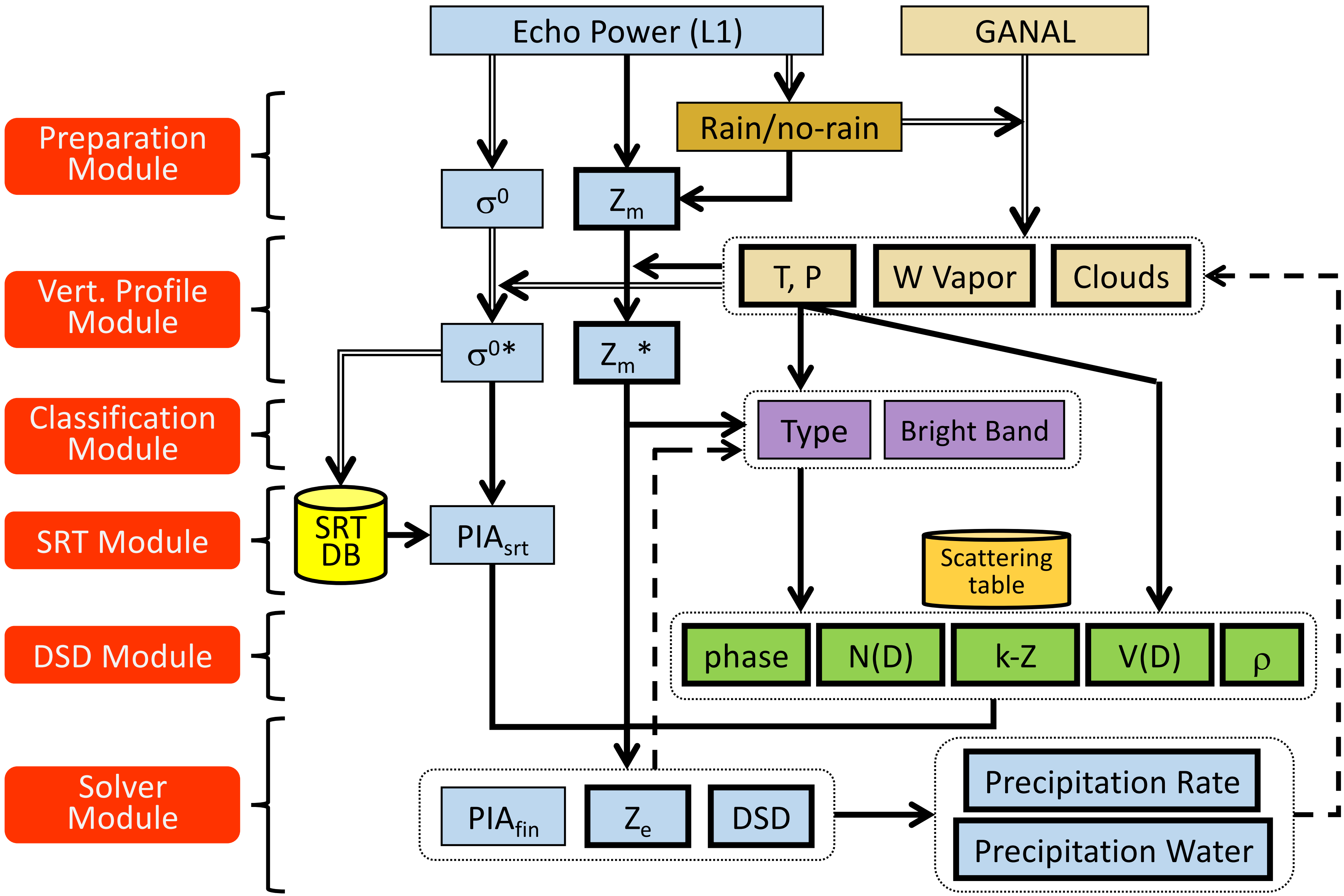
GPM/DPR rain profiling algorithm flow



V4 Summary

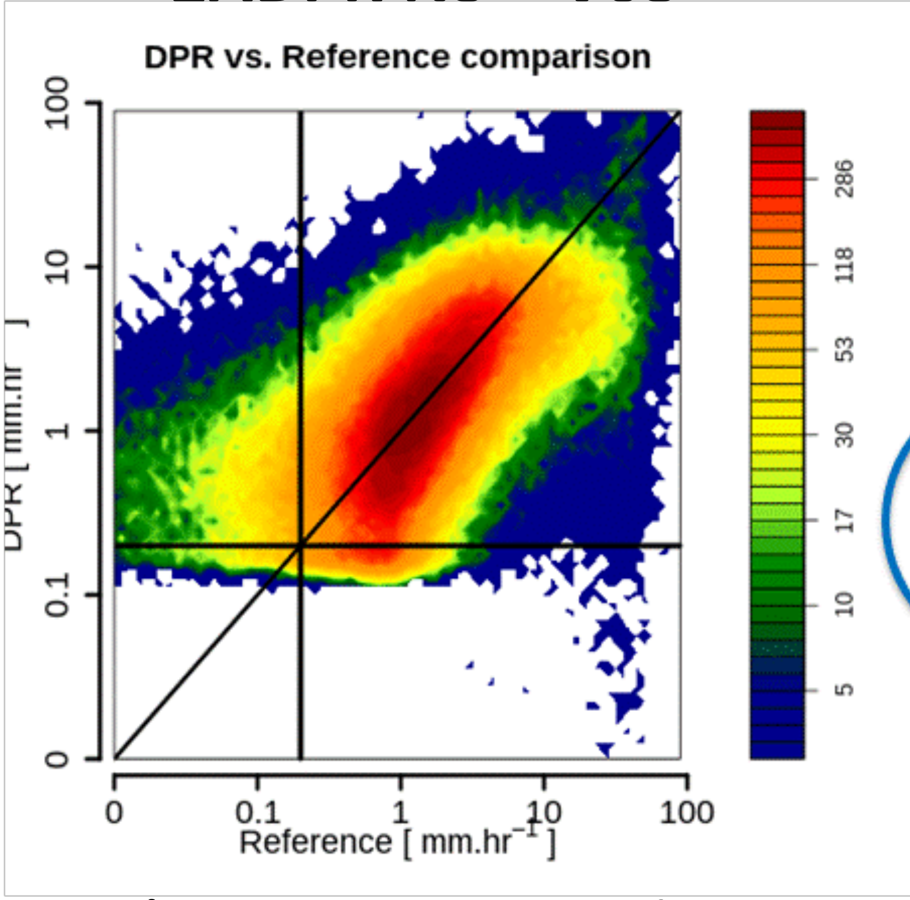
- Bugs in V3 were removed.
- Sidelobe clutter is reasonably well removed.
- New classification module with DFRm method works well.
- DF Solver module adopts conservative method in V04.
- Rain estimates from KaPR have been improved substantially.
- Rain estimates in V04 are generally larger than those in V03B and PR.

DPR Rain Rates, V3 and V4

Courtesy of W. Peterson

MRMS: 5 km footprint-match, liquid only, RQI=1 (summer months May – August, 2014)

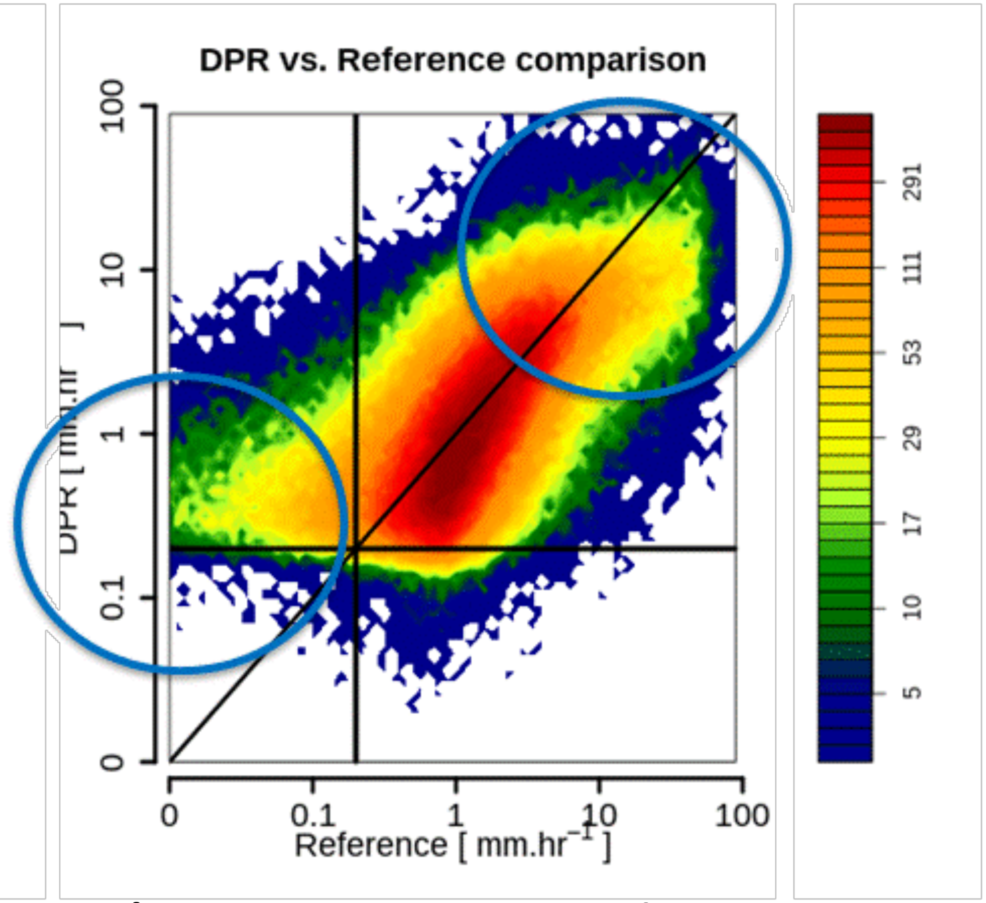
2ADPR NS – V03



Bias -12.2 %

Correlation 0.42

2ADPR NS – ITE057



Bias -11.5 %

Correlation 0.46

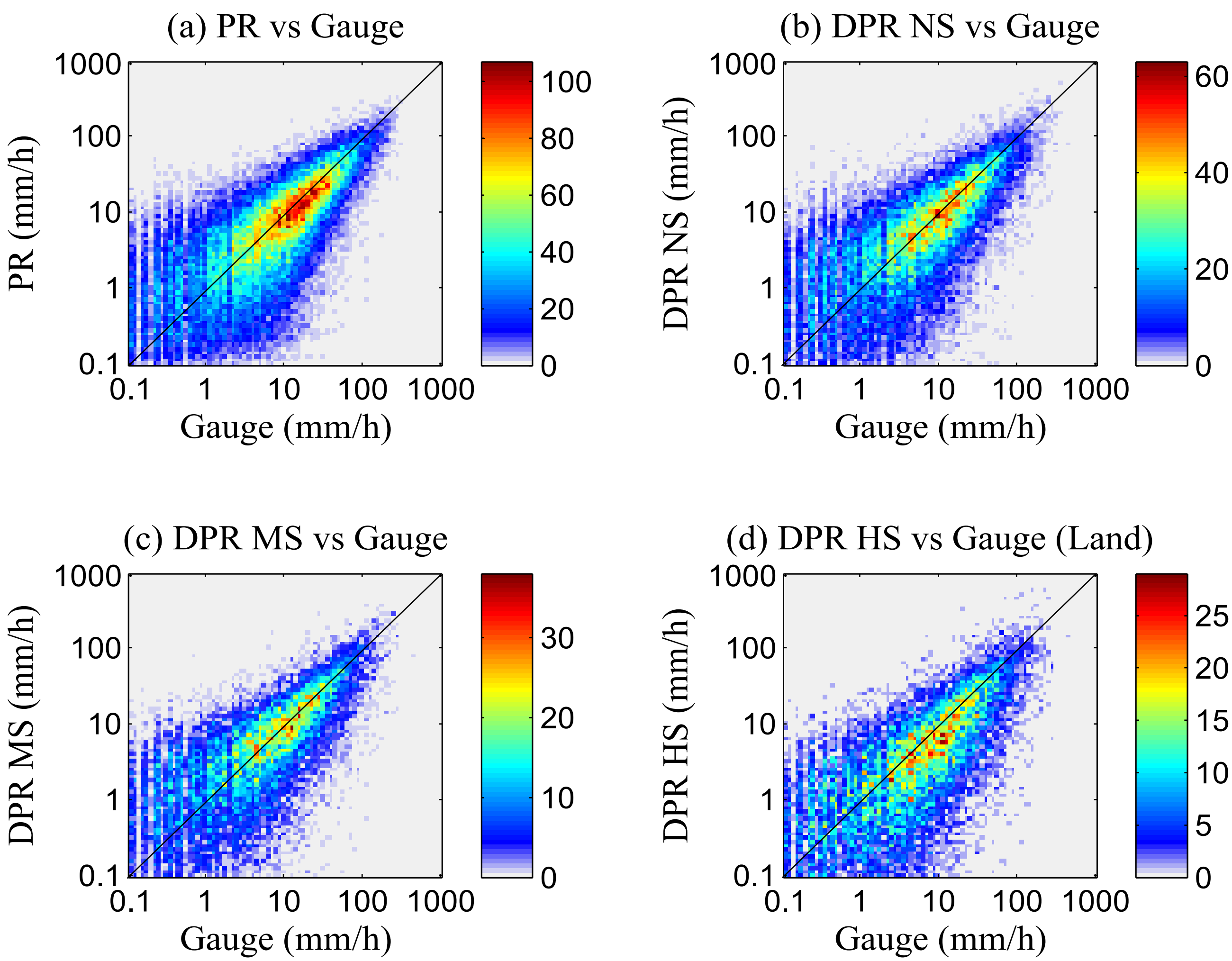
Improved correlation and reduced bias (still a little low)

ITE improvement on upper end of rain rates (>10 mm/hr).

Change in/extension of low rain rate floor (< 0.2 mm/hr)- relative overestimate of GV

PR & DPR vs Matched Hourly Rain Gauge Data in China

Courtesy of Yixin Wen

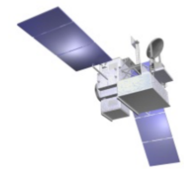


Matching:

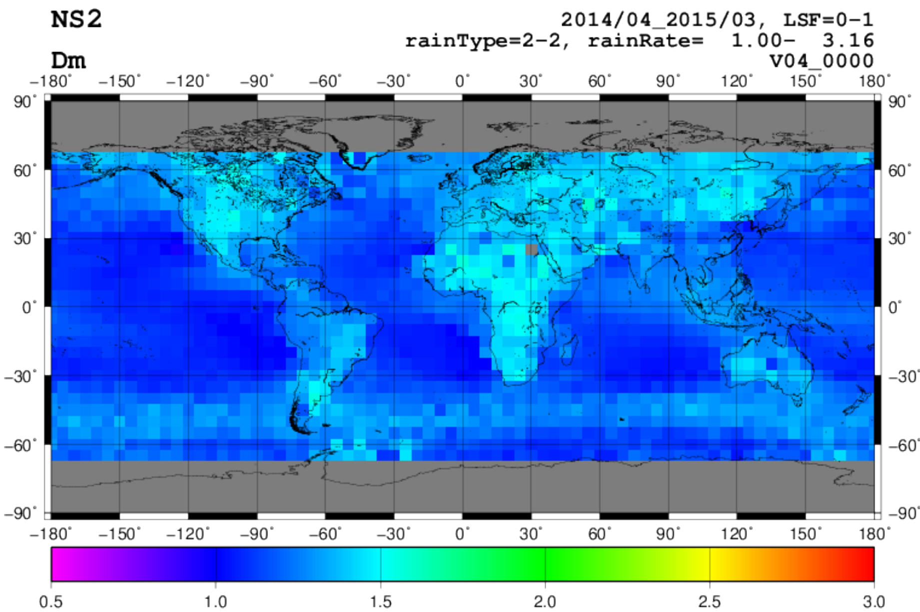
1. PR and DPR data resampled to 0.25° ×0.25° grid.
2. Grids containing less than ten radar pixels were excluded.
3. Grids with more than 2 gauges
4. Hourly accumulation of gauges.
5. Data are from Apr. 1, 2014 to Oct. 7, 2014.

Scatter density maps of matchup precipitation events between (a) PR and gauges, (b) DPR NS and gauges, (c) DPR MS and gauges, and (d) DPR HS and gauges in mainland China.

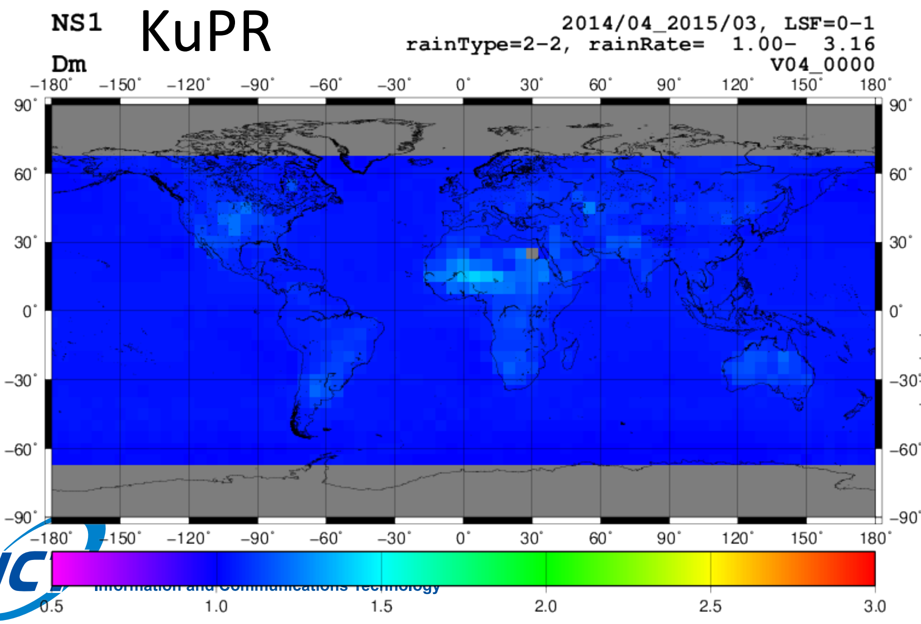
Convective, 1<R(mm/h)<3.2



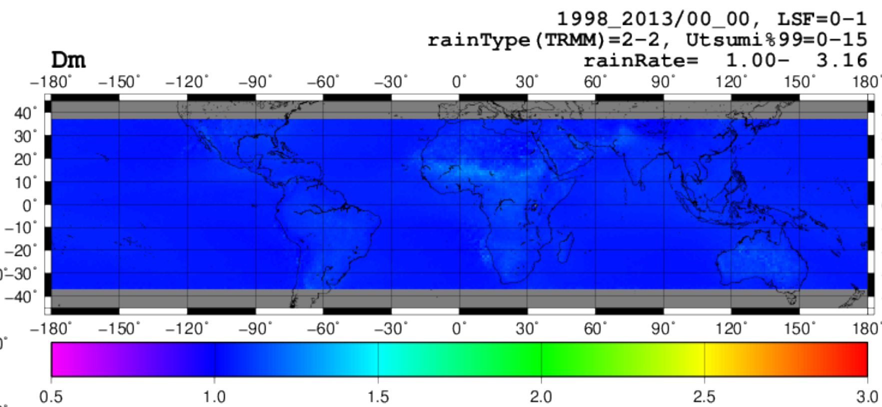
Dual-freq.



KuPR



PR



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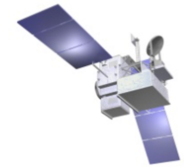
Changes in DPR L2 algorithm from V4 to V5



- Effect of changes in the DPR and PR L1 calibration
- Improvement in Zm and sigma0 calculations
  - Re-examination of pulse width
  - Removal of bias from DPR and small trend of calibration factor for PR.
    - constancy of σ^0 statistics is used.
  - New beam-mismatch correction in TRMM/PR data after orbit boost.
- Improvement of PIA estimation (R. Meneghini's presentation)
- Addition of new output parameters and flags
  - Anvil (Ku, DPR)
  - Hail (DFRm is used)
  - Snow near surface (flagSurfaceSnowfall, sufaceSnowfallIndex, DFRm is used)
  - Non-uniform beam filling (DFRm is used)
  - Multiple scattering (Not implemented yet, DFRm is used)
  - adjustFactor, snowIceCover, etc.
- Side-lobe echo cancellation parameters adjusted.
- Bug fixes.

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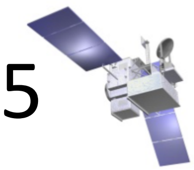
Changes of Z_m, σ^0, and rain rate from V4 to V5



- DPR: V4 -> ITE104, PR: V7 -> V8a9

Algorithm	Level 1		Level 2				
Variable / Sensor	Z_m	σ^0	Adjustment Factor (A) [*2]	Adjusted Z_m (=Z_m -A)	Adjusted σ^0 (=σ^0 -A)	Rain Rate [*3] (H=2 km)	
						Ocean	Land
KuPR	+1.7dB	+1.7dB	0.0 dB	+1.7dB	+1.7dB	+15.9%	+16.3%
KaPR(MS)	+1.4dB	+1.3dB	0.0 dB	+1.4dB	+1.3dB	+4.8%	+10.2%
KaPR(HS)	+1.3dB	+1.5dB	-0.3 dB	+1.6dB	+1.8dB	+2.7%	+10.6%
PR(A-side)	TBD [*1]	TBD [*1]	TBD	TBD	TBD	TBD	TBD
PR(B-Side)	+1.9dB [*1]	+1.9dB [*1]	+0.2dB	+1.7dB	+1.7dB	+19.0% [*5] +16.9% [*6]	+6.8% [*5] +15.7% [*6]

*1: DPR V5 calibration is fixed, but PR V8 calibration is still under final adjustment in L1 algorithm.

*2: Adjustment factors are introduced so that σ^0 of PR agrees with σ^0 of KuPR and that σ^0 of KaPR(HS) agrees with σ^0 of KaPR(MS).

*3: Numbers are preliminary results because V5 L2 algorithm is not final yet.
Data: June 2014, Area : TRMM/PR observation area (35S-35N)

*4: Inconsistency in the SRT database is under adjustment.

*5: Total effect = algorithm change (TRMM/2A25 -> DPR Ku) + calibration change

*6: Effect of calibration change only

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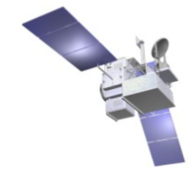
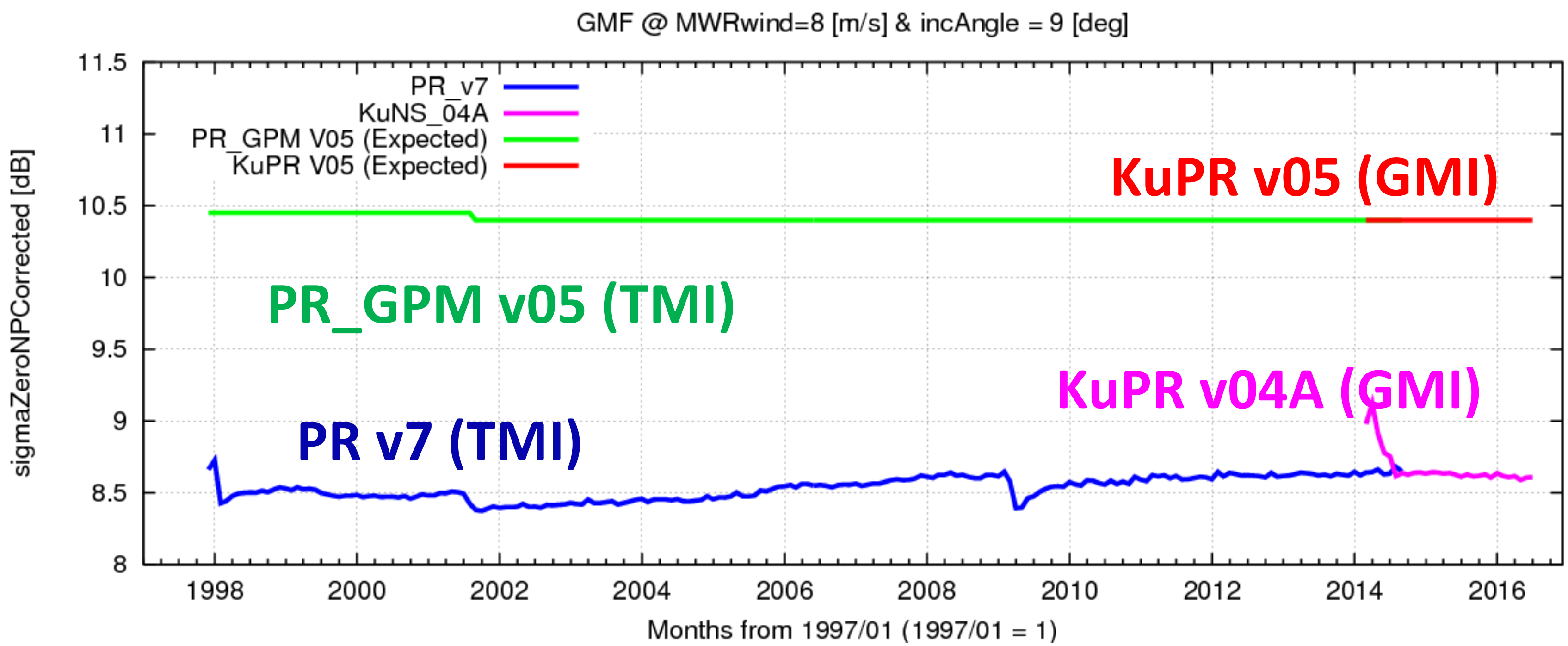
Trend of σ^0 with and without compensation



PR & DPR σ0* @ JAXA
MWRs SSW @RSS



Calibration drift of PR/DPR will be adjusted in L2PRE.

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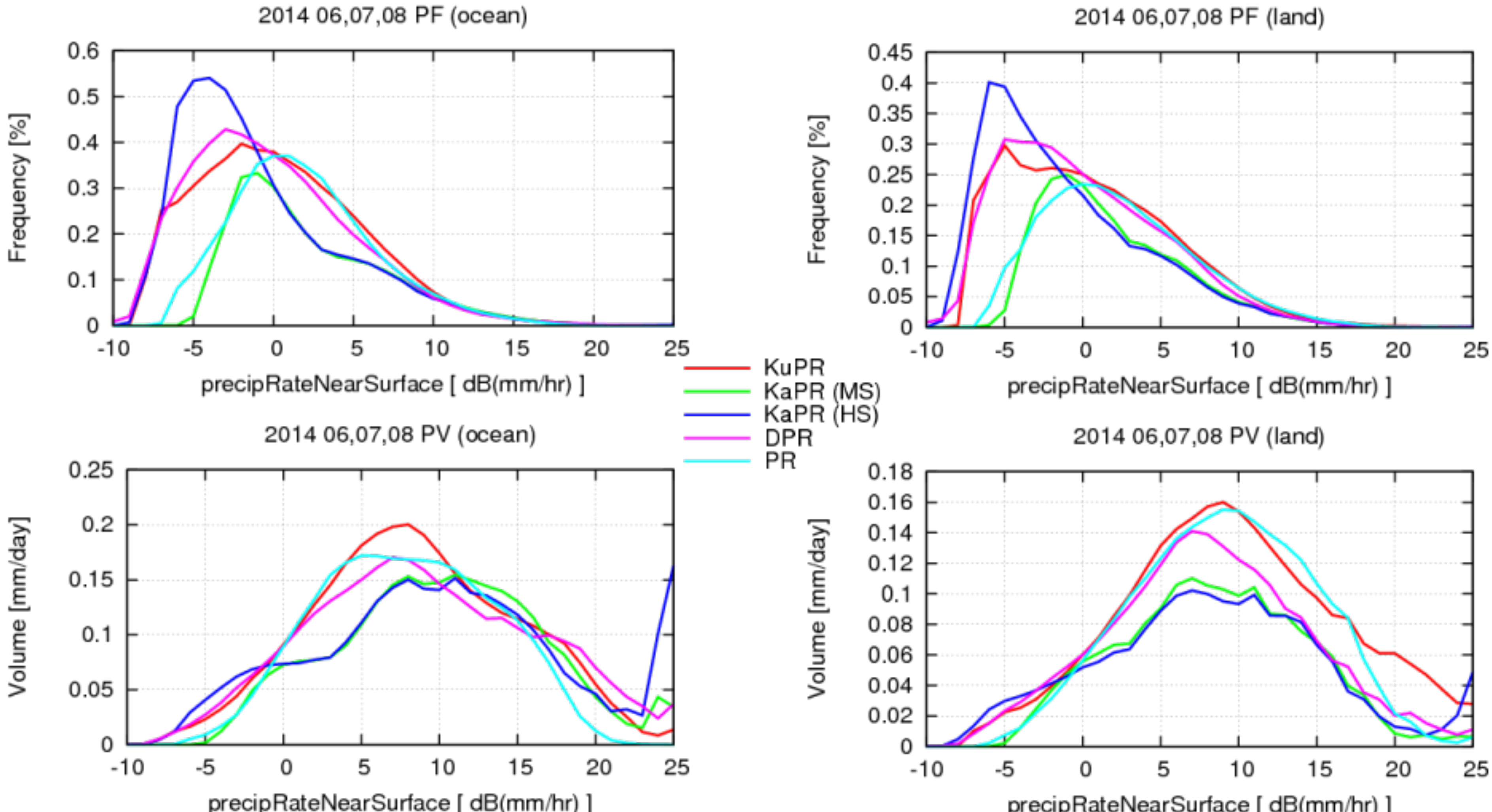
±6 angle bins excluding 3 bins near nadir

$$\mathrm{PF}(R_s) = \frac{N(R_s)}{N_{\mathrm{obs}}}$$

Ocean

DPR V04A & PR V7

Land



$$\mathrm{PV}(R_s) = \frac{\sum_{i=1}^{N(R_s)} R_{s,i}}{N_{\mathrm{obs}}}$$

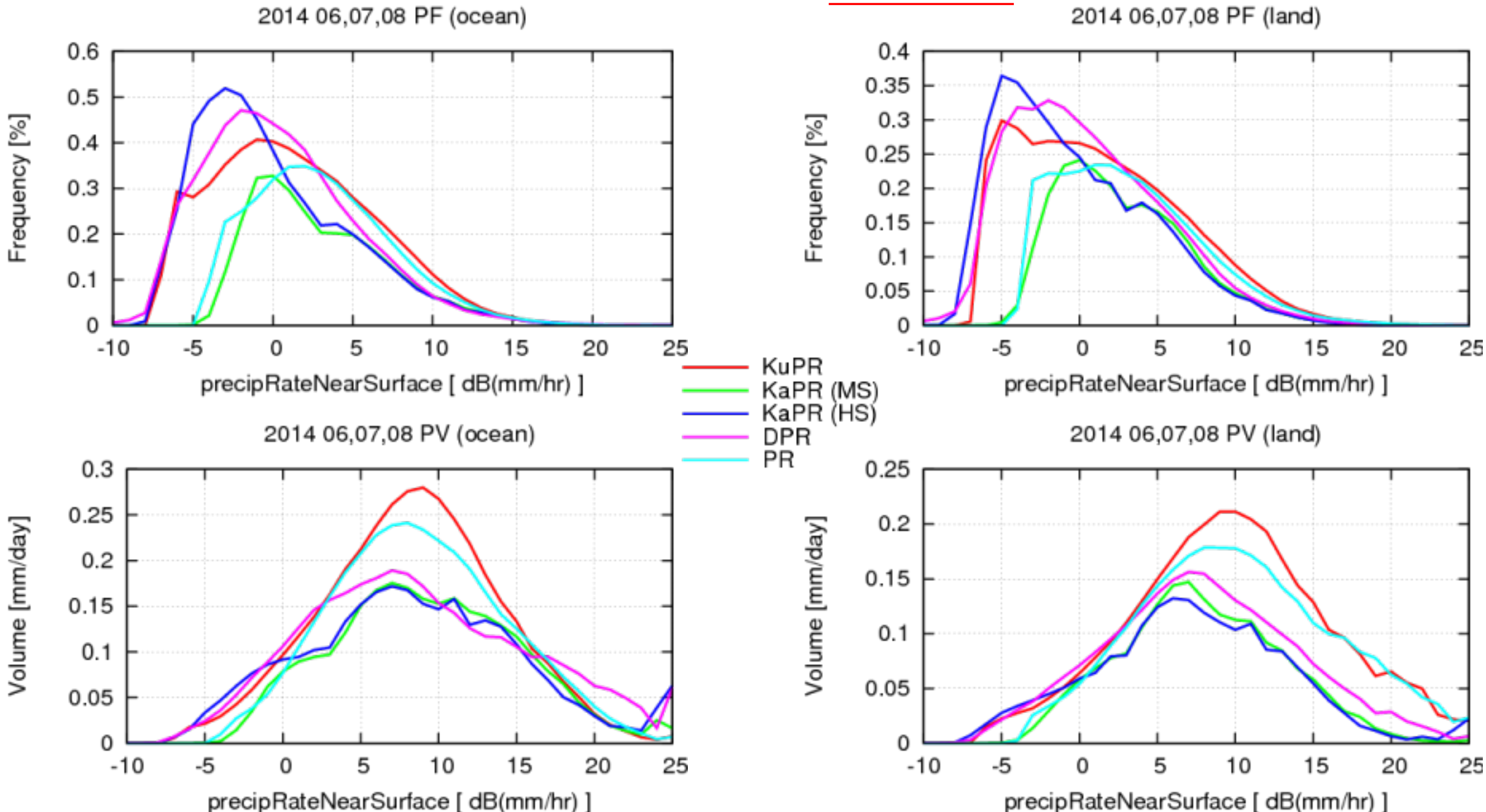
±6 angle bins excluding 3 bins near nadir

$$\mathrm{PF}(R_s) = \frac{N(R_s)}{N_{\mathrm{obs}}}$$

Ocean

DPR V05b_ITE104
& PR V8a8

Land



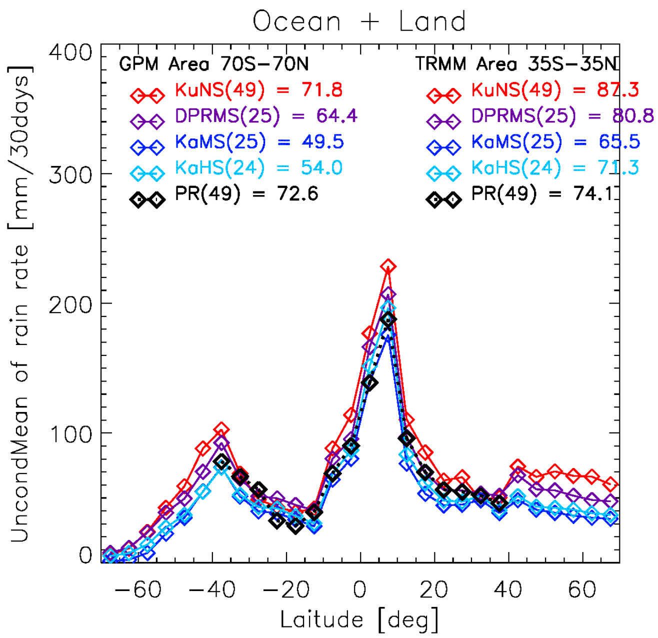
$$\mathrm{PV}(R_s) = \frac{\sum_{i=1}^{N(R_s)} R_{s,i}}{N_{\mathrm{obs}}}$$

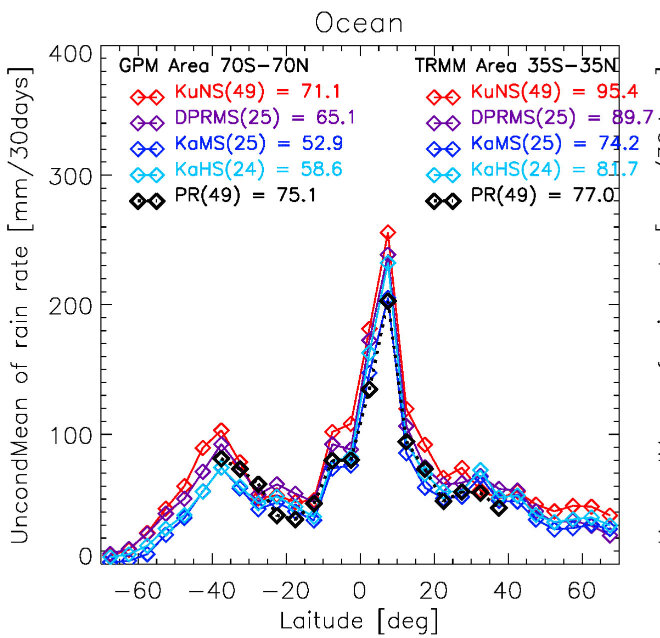
Zonal unconditional mean of eSurf

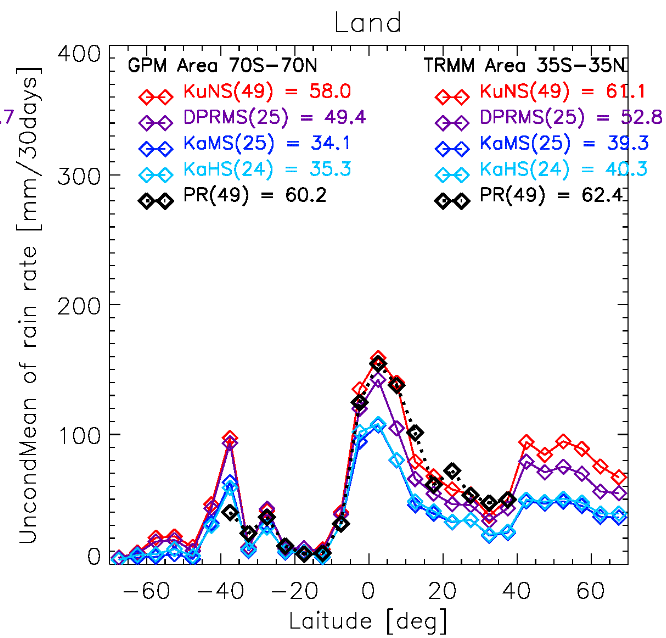
Period : June 2014

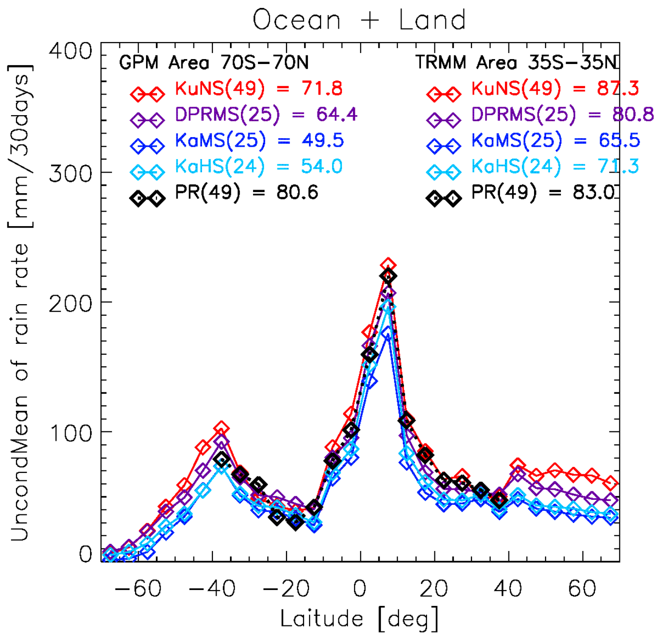
Product : PR V7 & DPR V4A

Input : Level2 product









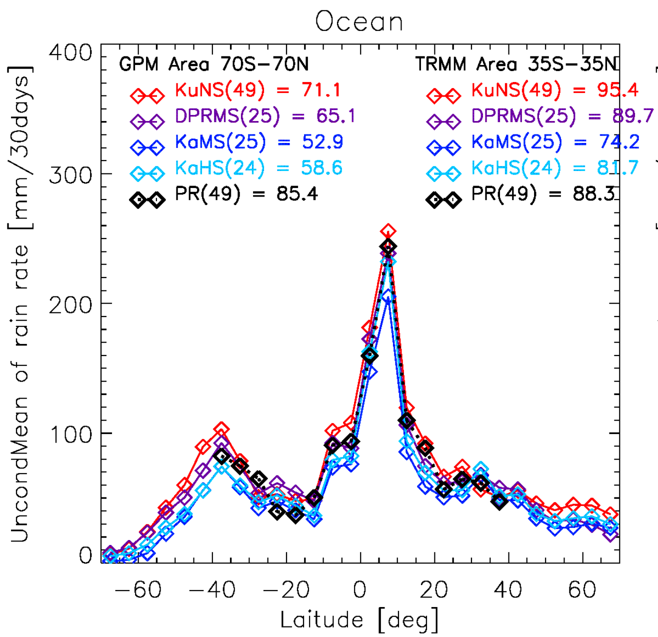
Zonal unconditional mean of eSurf

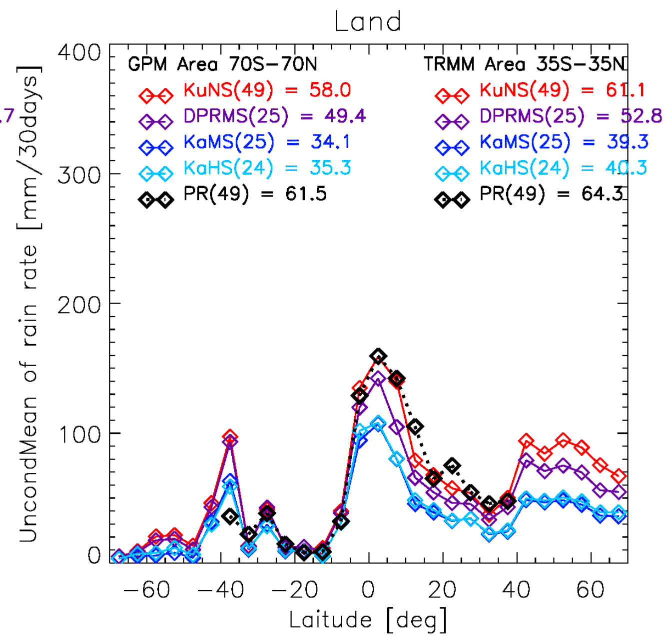
Period : June 2014

Product : PR V7exp & DPR V4A

Input : Level2 product

PR V7exp : PR PU2 + PR V7 1B21 cal coef
+ PR V7 2A21 sigmaZero
+ L2Ku V4A SRT DB
+ GANAL





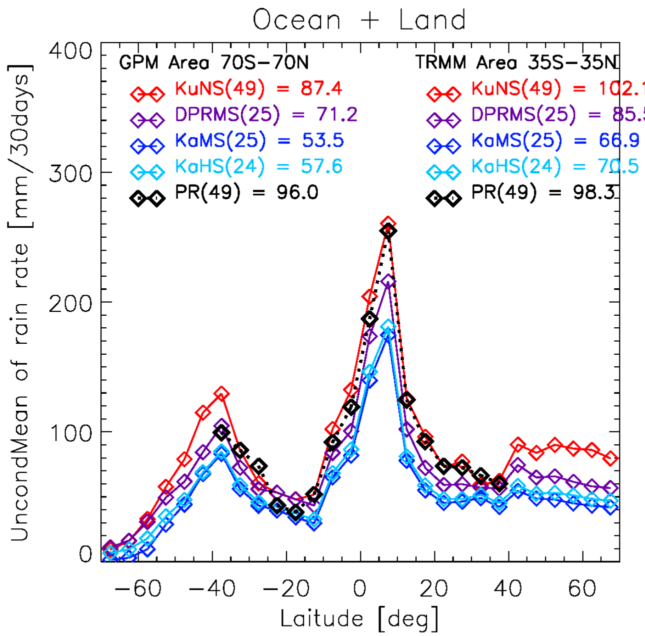
NEW
ITE104

Zonal unconditional mean of eSurf

Period : June 2014

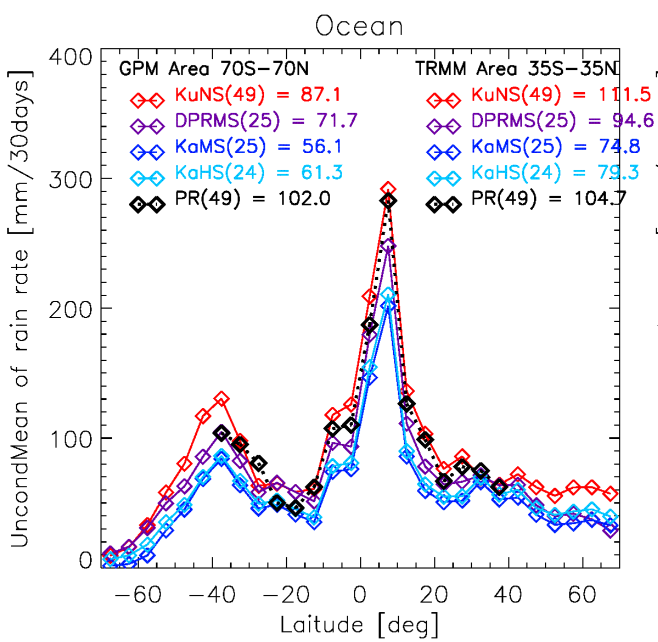
Product : PR V8a9 & DPR V5b

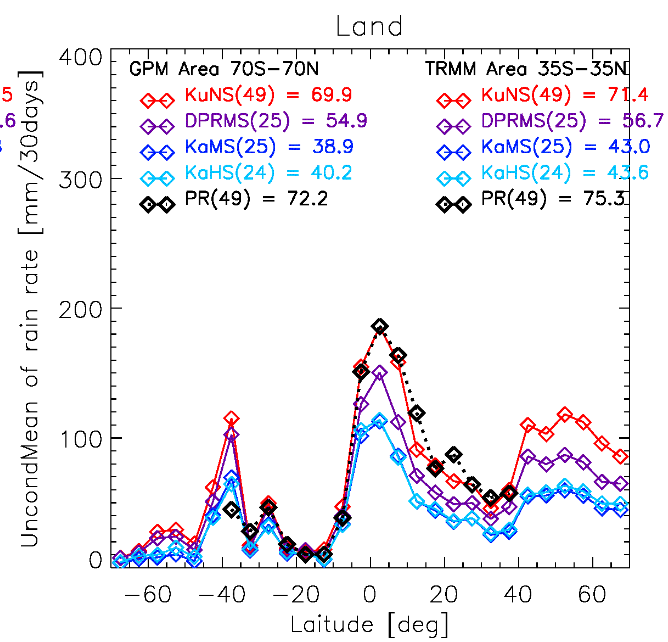
Input : Level2 product



PR V8 was adjusted to Ku V5.

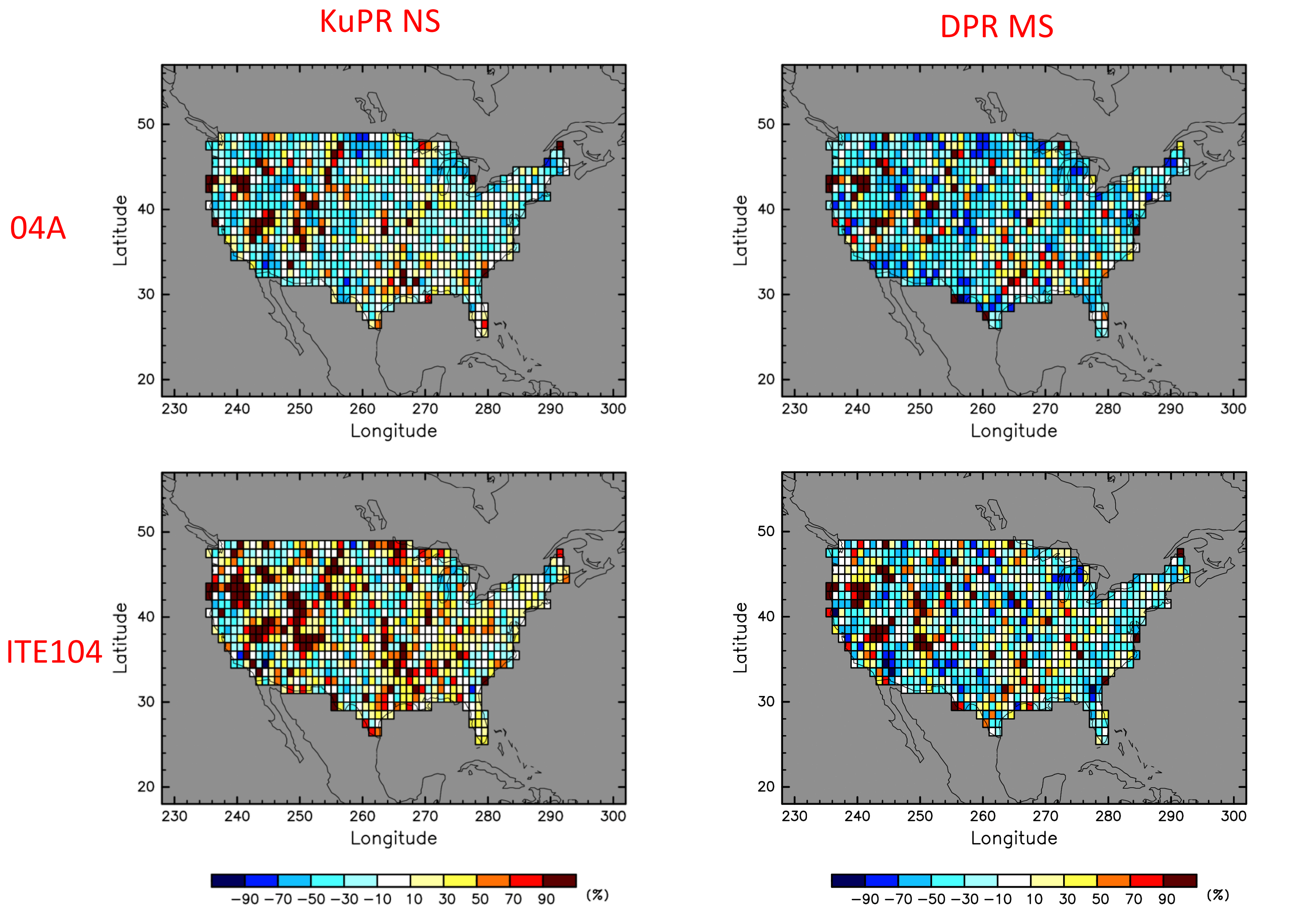
KaHS V5 was adjusted to KaMS V5.



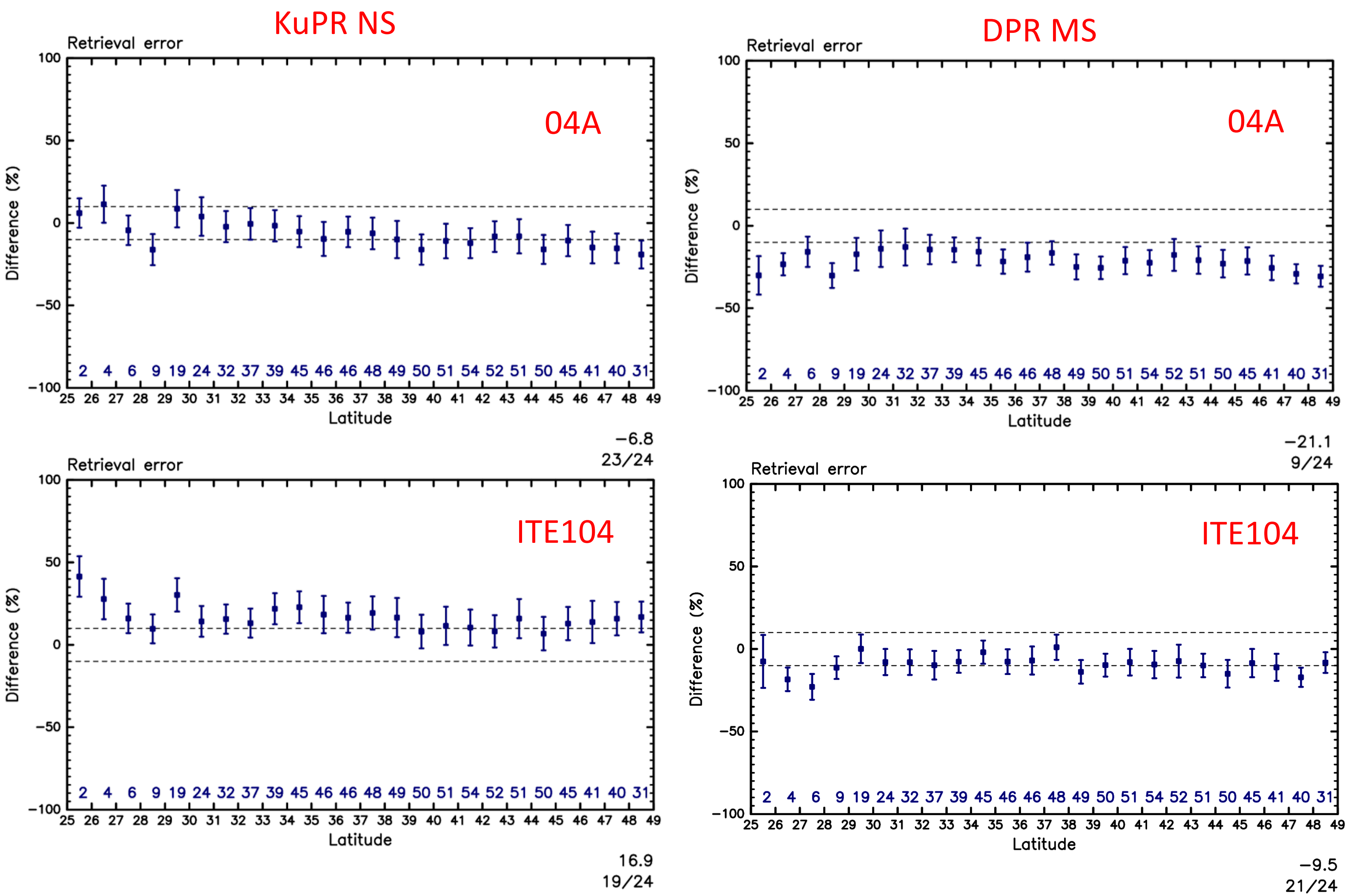


Comparison with MRMS/NMQ data (871 1 deg x 1 deg boxes)

Period: April 2014-March 2015, Gauge data: satellite overpass time

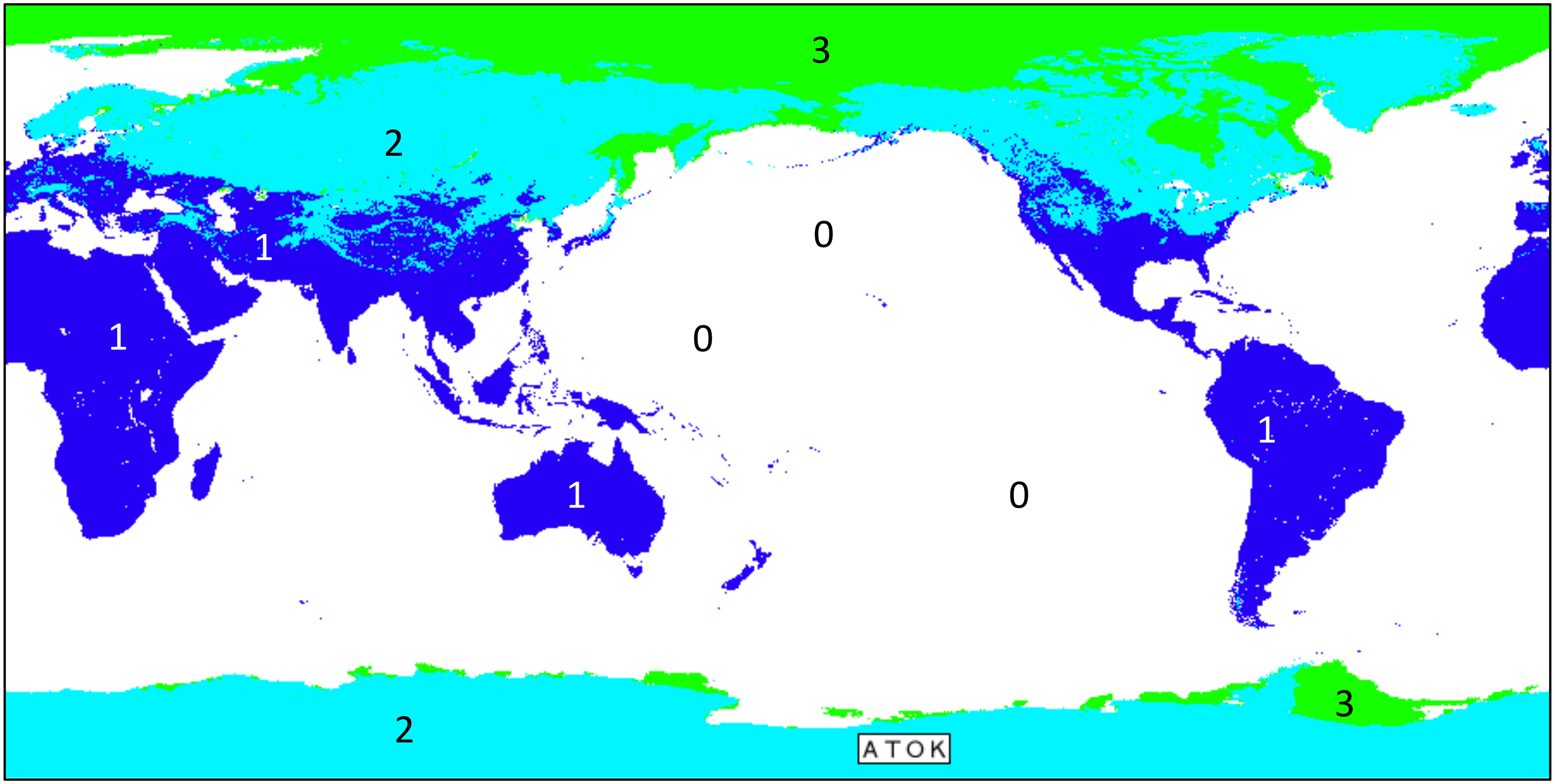


Relative biases from MRMS/NMQ in zonally averaged rainfall estimates



- ITE104 estimates are generally larger than 04A estimates.
- 16 out of 24 zonal data points from ITE104 are within +-10% difference band.

autosnow @ DPR L2

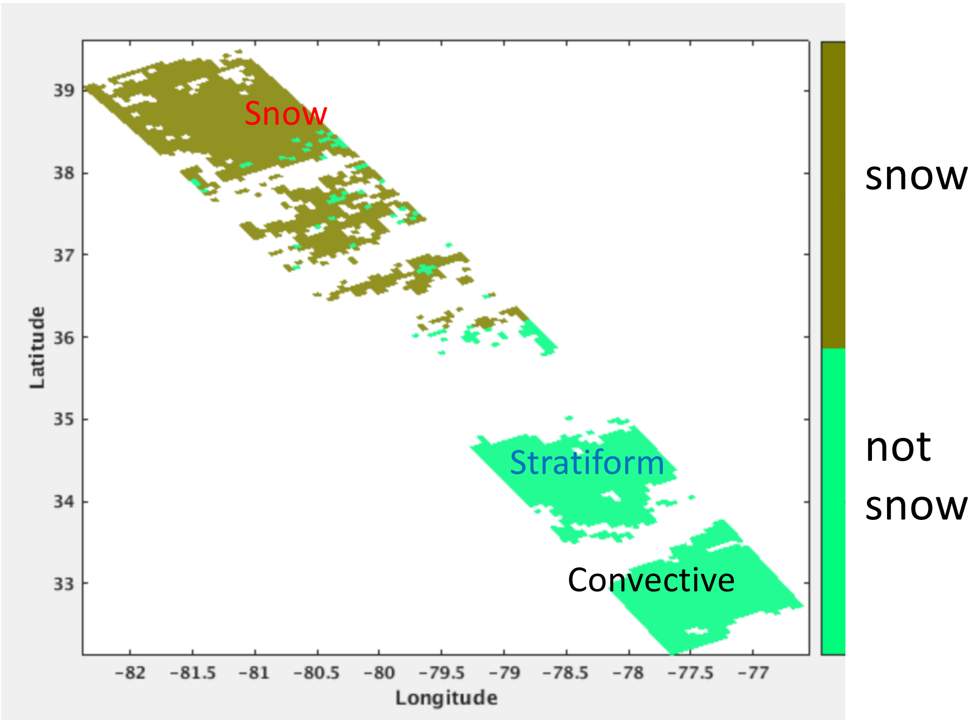


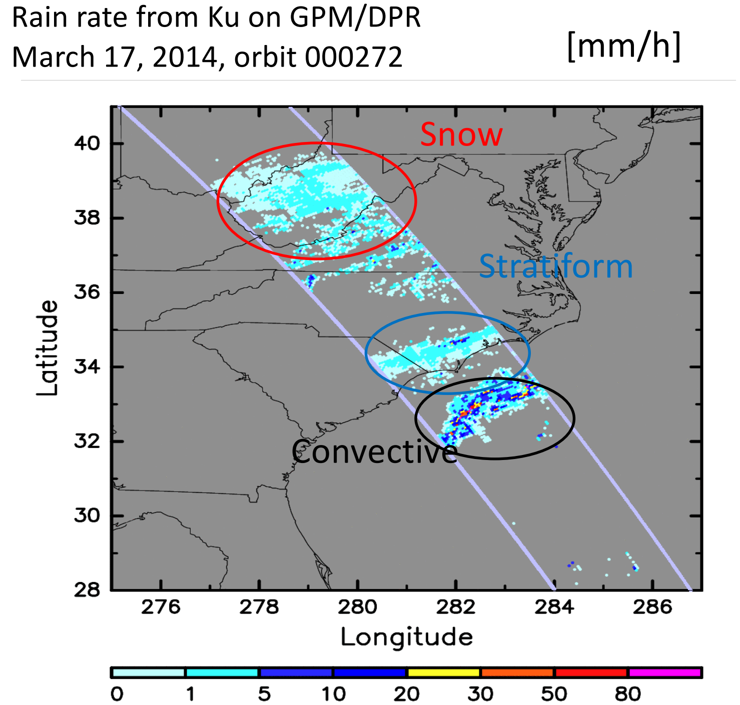
0: ice free water
1: snow free land
2: snow
3: ice

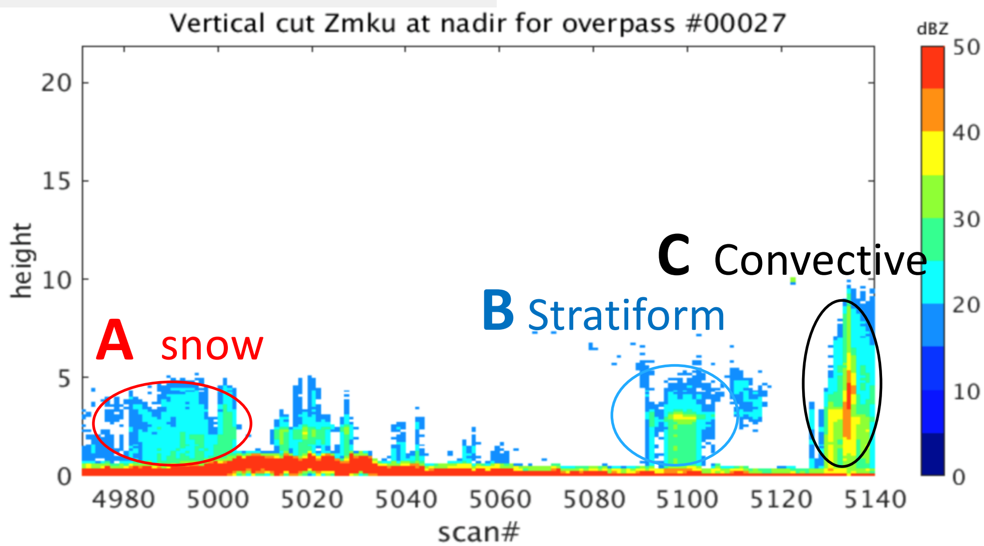
10: -> 0
20: -> 0
21: -> 1
(converting 10 & 20 into 0, 21 into 1)

200 and over: undetermined

Surface snowfall identification







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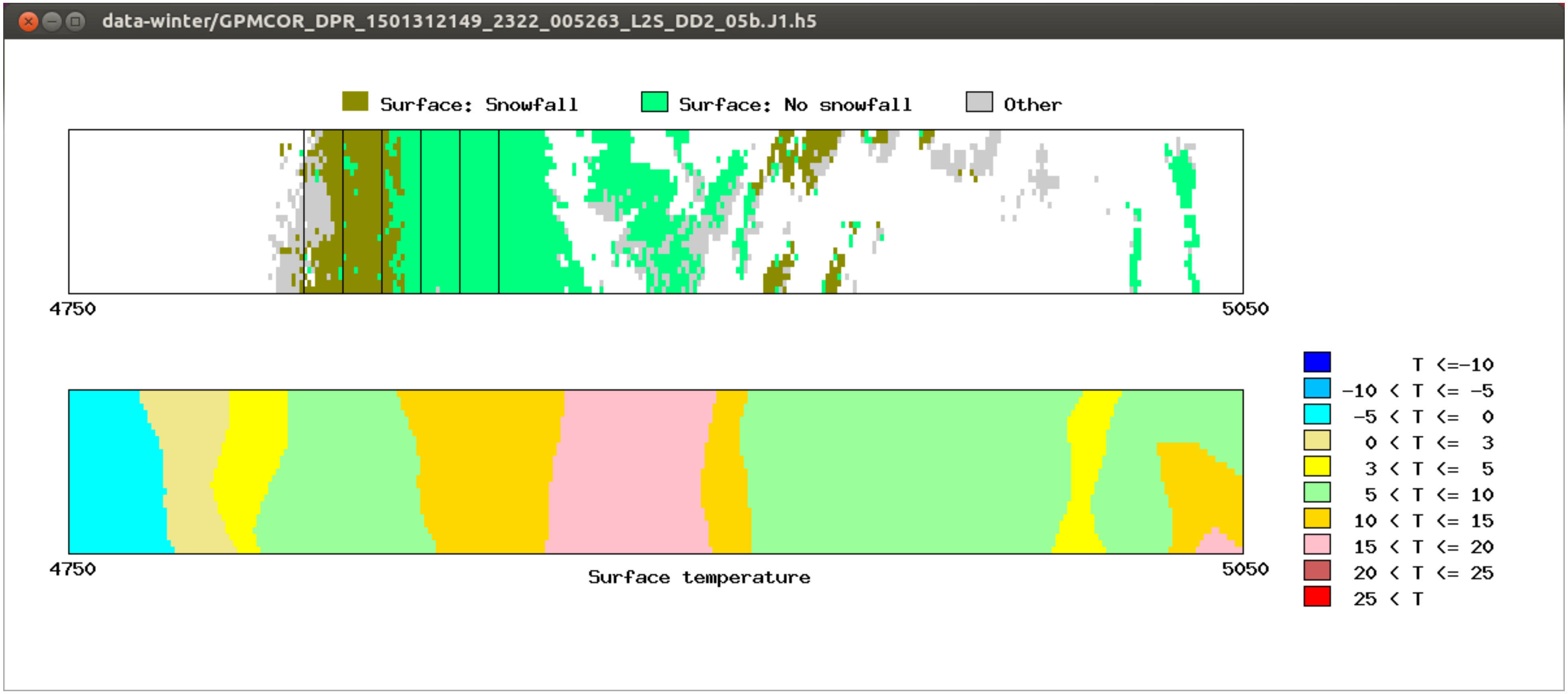
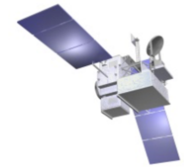
Introduction of surfaceSnowfall decision in Experimental output

(Details will be given by Dr. Le and Dr. Chandra.)



Expanded plot of surfaceSnowfall (upper) and surface temperature (below). Profiles of Ku-band Z at six scans (indicated by six vertical lines in the upper figure) are shown in the separate figures (Not shown).

flag Hail (Hail, Graupel, Heavy snow)



Default value: flagHail=0

In the region higher than -10 deg. C,

L2Ku_STD

If KuPR's Zm > 35dB, then flagHail=4=0x04

If KuPR's Zm > 40dB, then flagHail=8=0x08

If KuPR's Zm > 45dB, then flagHail=12=0x0C

L2Ka_STD

If KaPR's Zm > 30dB, then flagHail=1=0x01

If KaPR's Zm > 35dB, then flagHail=2=0x02

If KaPR's Zm > 40dB, then flagHail=3=0x03

L2DPR_STD's outer swath, same as 2Ku_STD above.

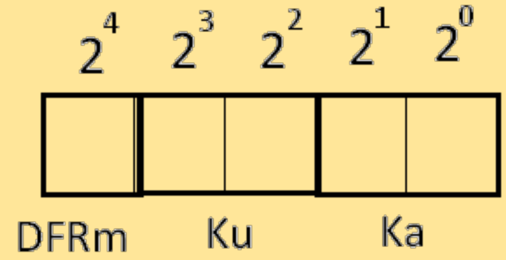
L2DPR_STD's inner swath

Take the OR of L2Ku_STD and L2Ka_STD above (sum of the two)

If KuPR's Zm > 27dBZ and DFRm > 7dB, then flagHail=16=0x10 is added.

flagHail

In binary expression



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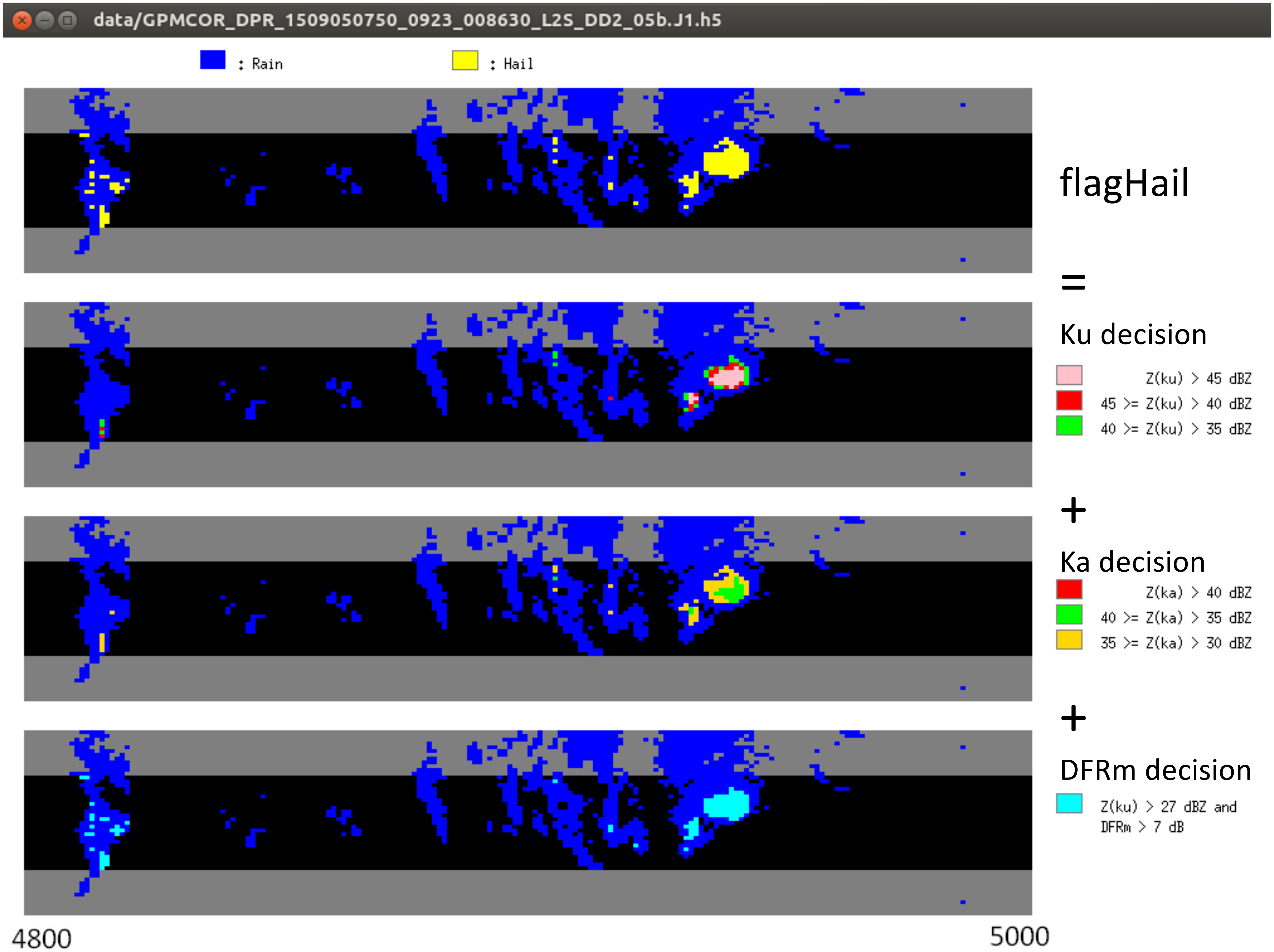
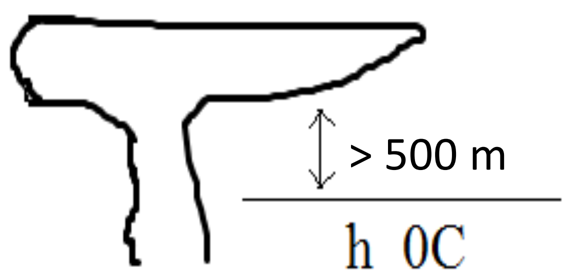

data/GPMCOR_DPR_1509050750_0923_008630_L2S_DD2_05b.J1.h5
: Rain
: Hail
flagHail
=
Ku decision
Z(ku) > 45 dBZ
45 >= Z(ku) > 40 dBZ
40 >= Z(ku) > 35 dBZ
+
Ka decision
Z(ka) > 40 dBZ
40 >= Z(ka) > 35 dBZ
35 >= Z(ka) > 30 dBZ
+
DFRm decision
Z(ku) > 27 dBZ and
DFRm > 7 dB
4800
5000

flag Anvil

flagAnvil is set when

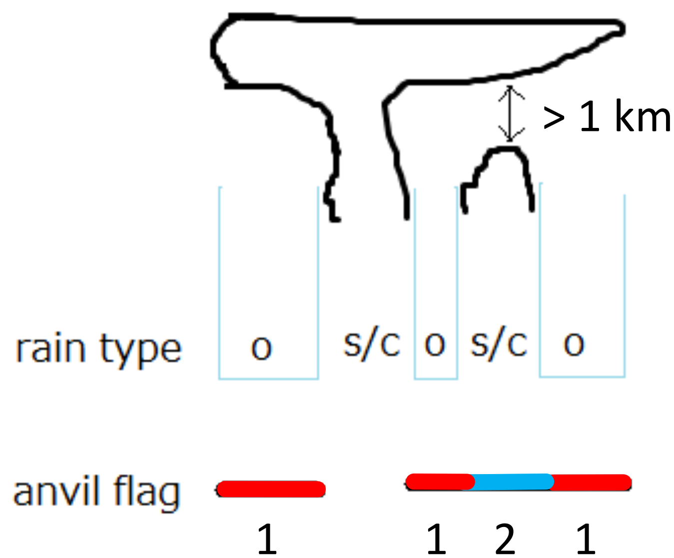
- Some echo above 0C + 500 m
- No echoes (Z < 15 dBZ) for more than 1 km below the bottom of the anvil echo
- Anvil1: No significant echo below anvil
- Anvil2: Some echo exists below anvil

Definition of anvil

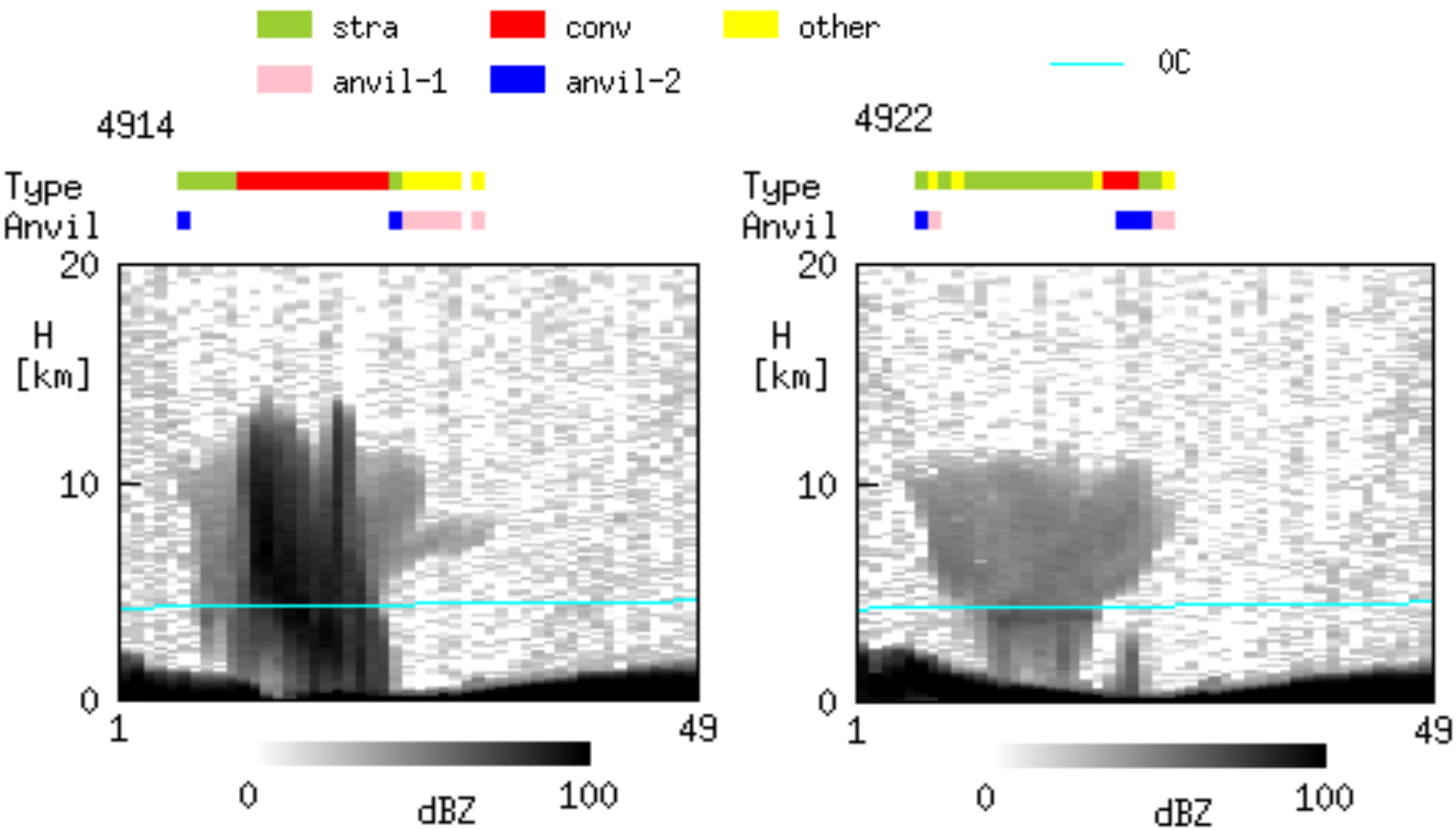


flagAnvil is unsigned char [angle bin]
(Ku-only, Ka-only, Dual-freq.)
Independent of rain type flag.

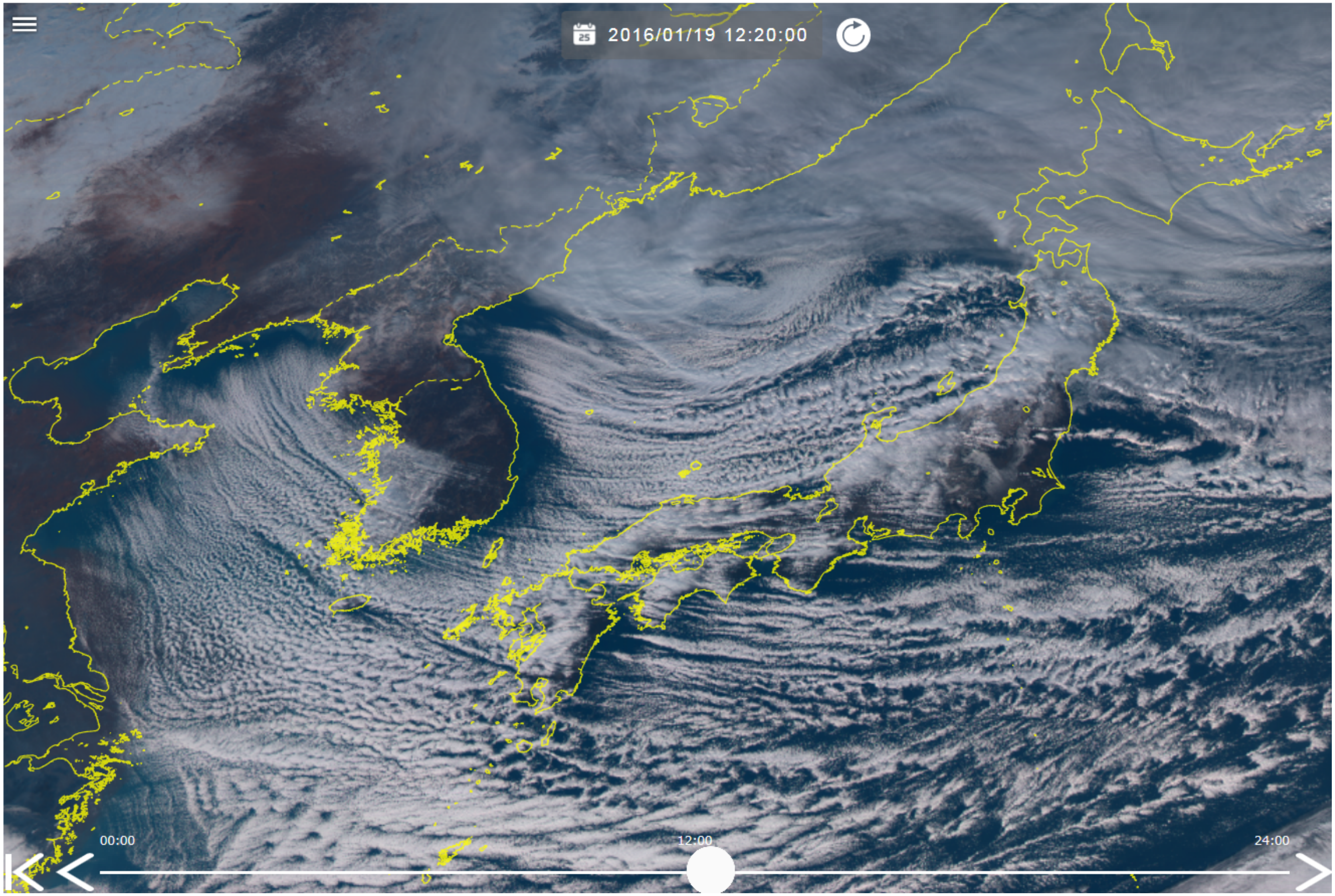
Anvil flag should be independent of rain type flag (see below)



Examples of flagAnvil



Ocean(Lake)-effect snow



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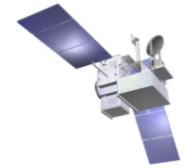
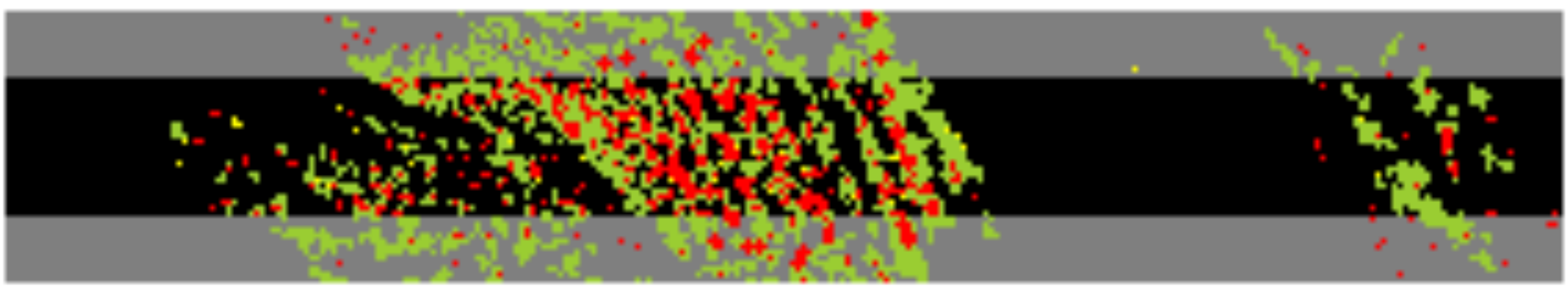


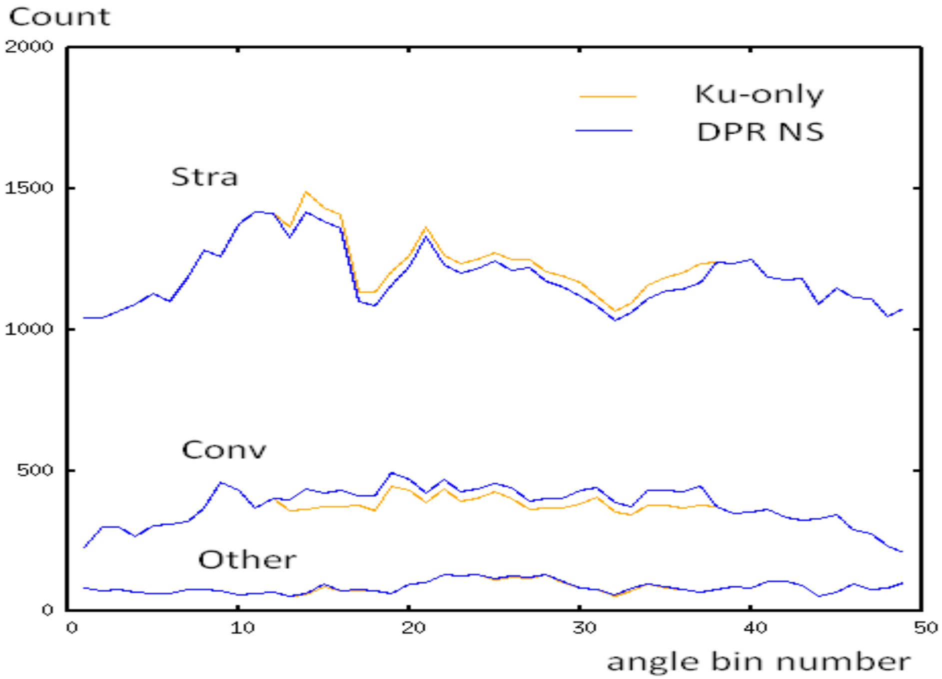
New type in convective category

- Conditions that make a lake-effect snow system convective
  - Estimated 0 deg C lower than 1 km (Winter)
  - At 4 or more bins in the 5 range bins from storm top, DFRm is larger than
    (2.5 – 0.8)/5.0*x + 0.8
    where x is the bin number from storm top.
  - If Z>35dBZ at these 5 bins, then the profile may be BB, and not categorized as convective.
  - These conditions are not perfect. There may be side effect. (e.g., BB may exist underneath.) Needs improvement.

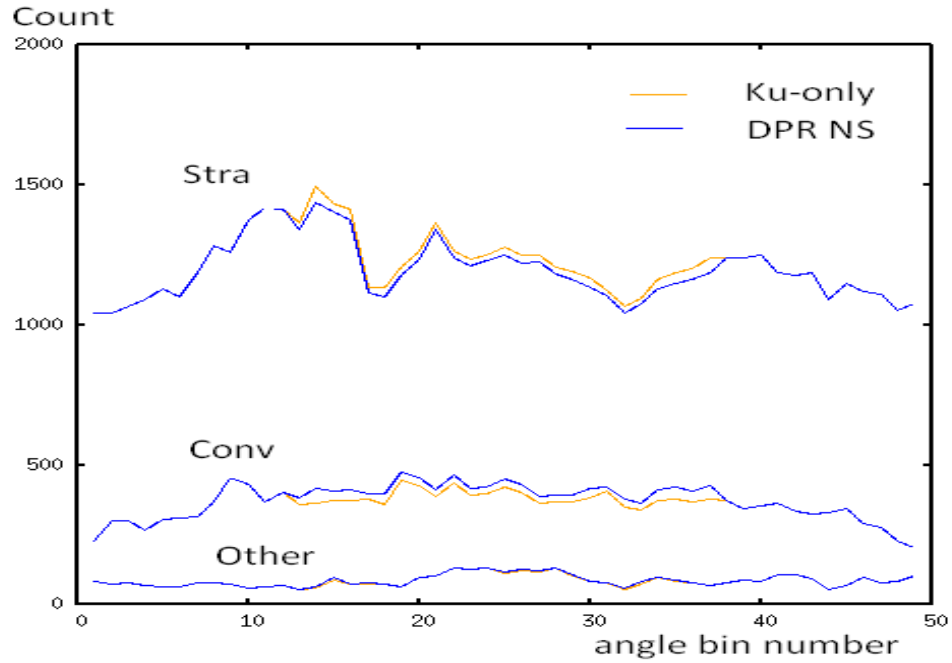
Combined with flagHail (detection of Hail, graupel, and heavy snow)
Red: convective



Statistics of rain types



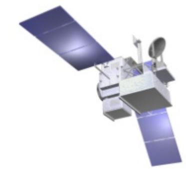
(a) 5 orbit data
DPR NS: Hail + DFRm extension



(b) 5 orbit data
DPR NS: DFRm extension only

- In V4, statistics of rain types judged by the single frequency Ku-only and dual frequency methods agreed well. After introducing the new convective type in winter snow storm by using Hail detection and DFRm extension method in V5, however, there are some differences.
- This new type in convective rain category is available by taking advantage of dual-frequency information (DFRm). In other words, new knowledge is gained with dual-frequency radar echoes.

Summary of DPR L2 Status



- V4 removed many defects in V3.
  - Sidelobe clutter, significant underestimation by KaPR, New classification with DFRm, etc.
- V4's rain estimates are more reliable than V3.
- Significant changes will be implemented in V5
  - Changes in radar parameters with new calibration
    - Removal of bias from DPR and small trend of calibration factor for PR.
    - New beam-mismatch correction in TRMM/PR data after orbit boost.
  - Improvement of PIA estimation (R. Meneghini's presentation)
  - Addition of new output parameters and flags
    - Snow near surface, Anvil, Hail (Graupel), NUBF, MS, snowIceCover, etc.
  - Rain estimates of V5 will be 10 – 20 % larger than those of V4.