Additional Release Notes for the DPR Version 06X Level 2 and Level 3 Experimental Products

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DPR-L2 algorithm development team

June 2020

KaPR scan pattern change

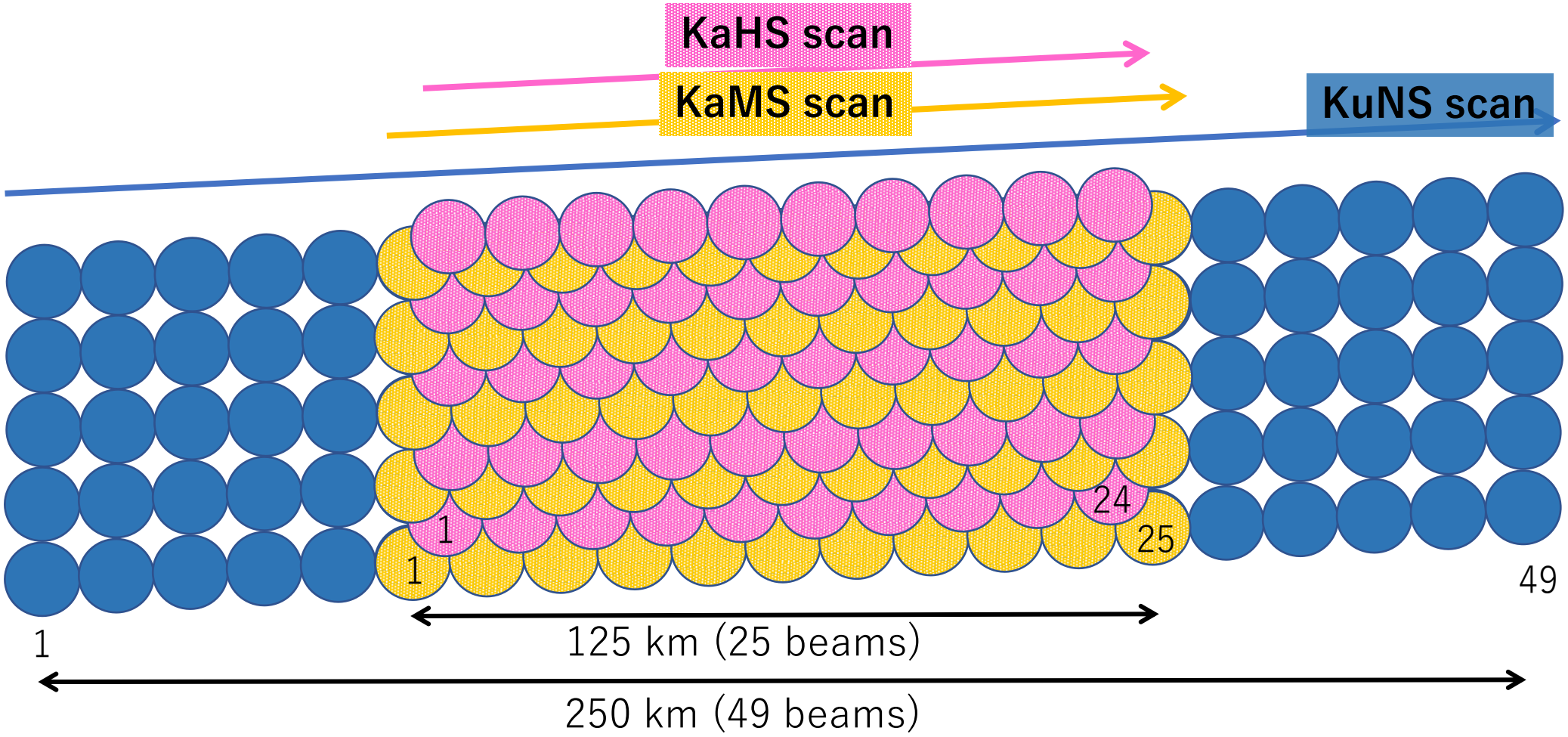
- On May 21, 2018, JAXA and NASA changed the scan pattern of the KaPR (see page 4-6).
- KaPR High-Sensitivity (KaHS) beams (shown as pink circles in the figures) scan in the inner swath before May 21 2018, but now they scan in the outer swath and match with KuPR's beams.
- The dual-frequency algorithm can be applied to the full swath of data after the change of the scan pattern.
- This is a big challenge to develop the DPR Version 06X Level 2 and Level 3 Experimental Products, which corresponded to the scan pattern change.

DPR scan pattern before 21 May 2018

Ku footprint (250km swath with 49 beams)

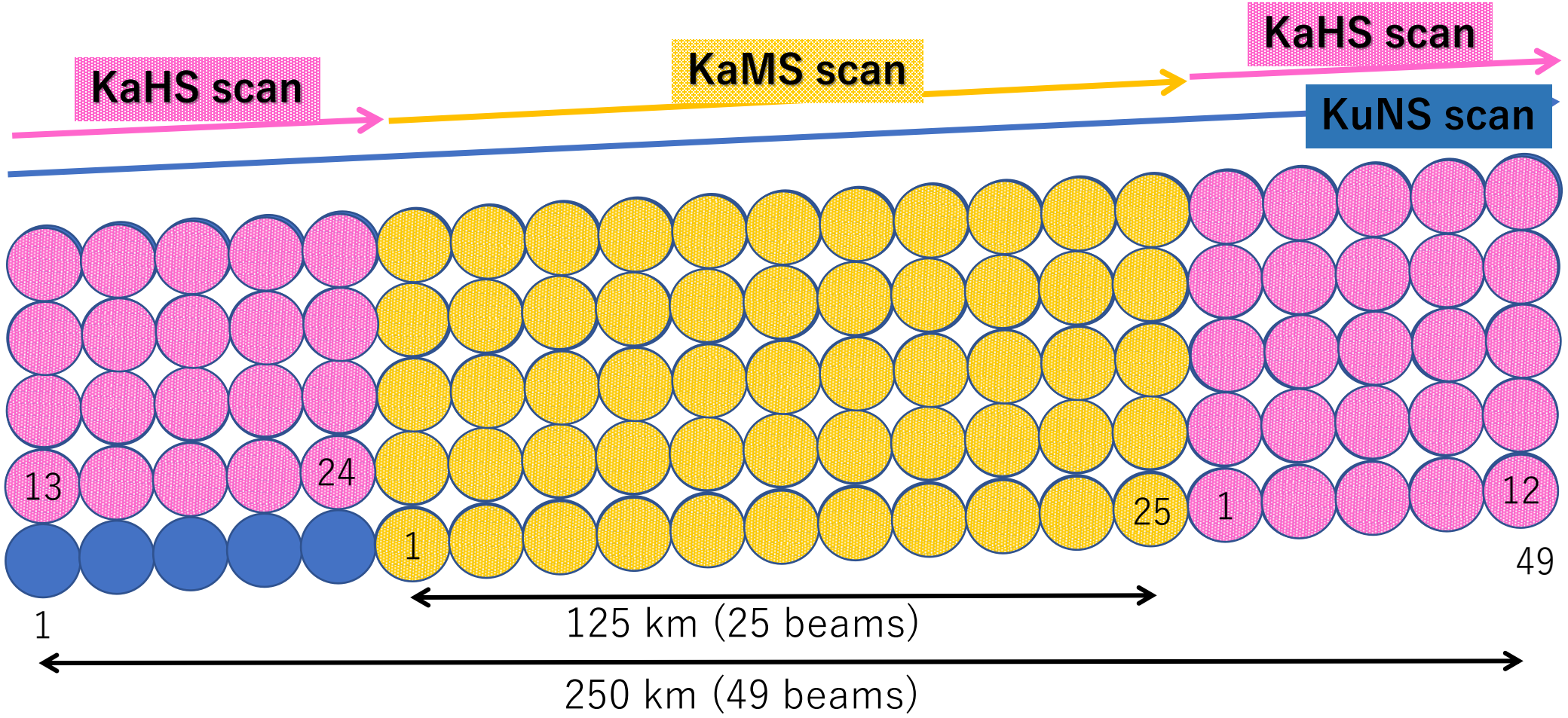
Ka footprint (125km swath, matched with Ku, 250m range res.)

Ka footprint (interlaced, 500m range res., high sensitivity)

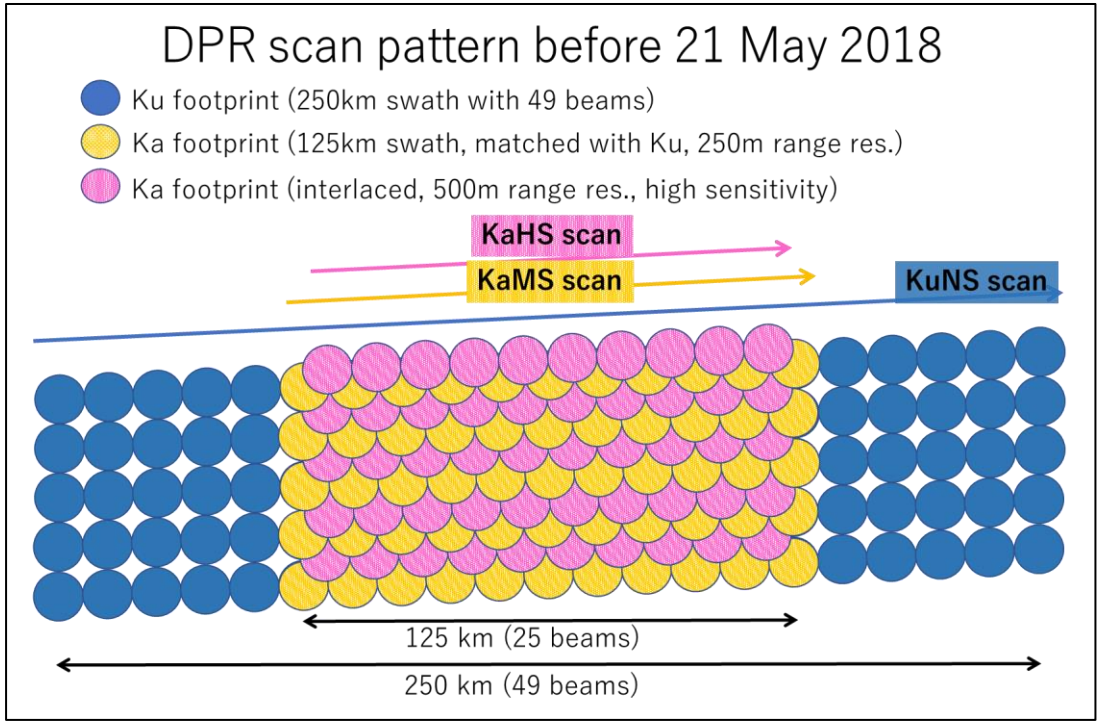


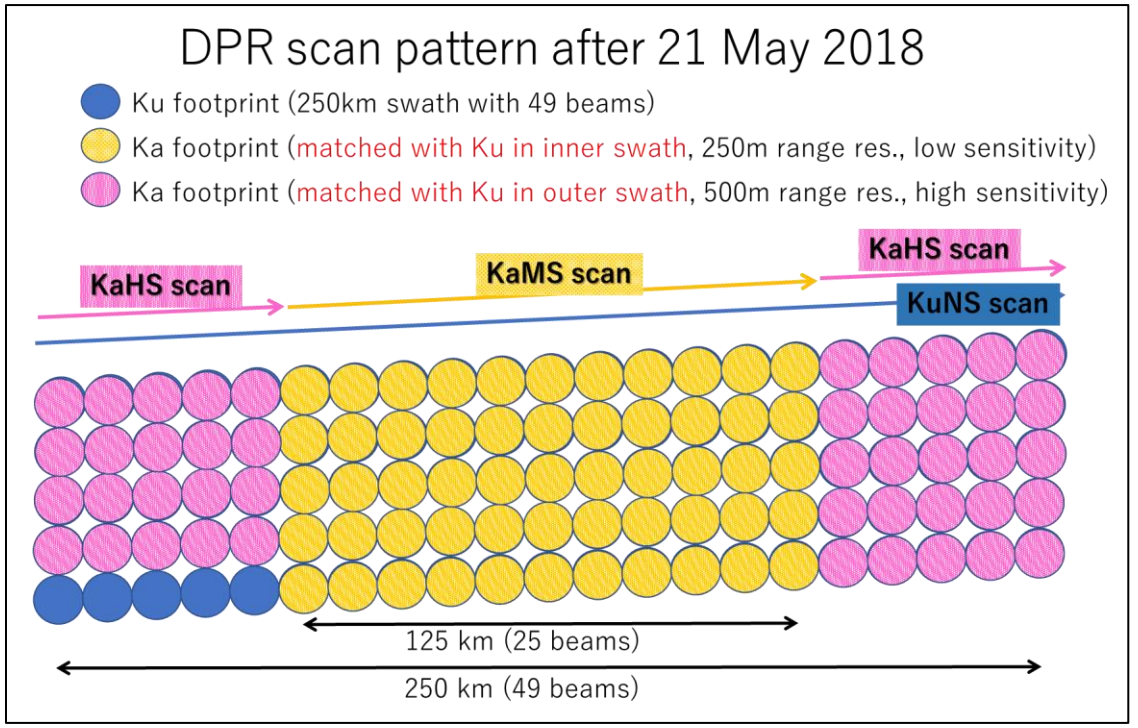
DPR scan pattern after 21 May 2018

- Ku footprint (250km swath with 49 beams)
- Ka footprint (matched with Ku in inner swath, 250m range res., low sensitivity)
- Ka footprint (matched with Ku in outer swath, 500m range res., high sensitivity)



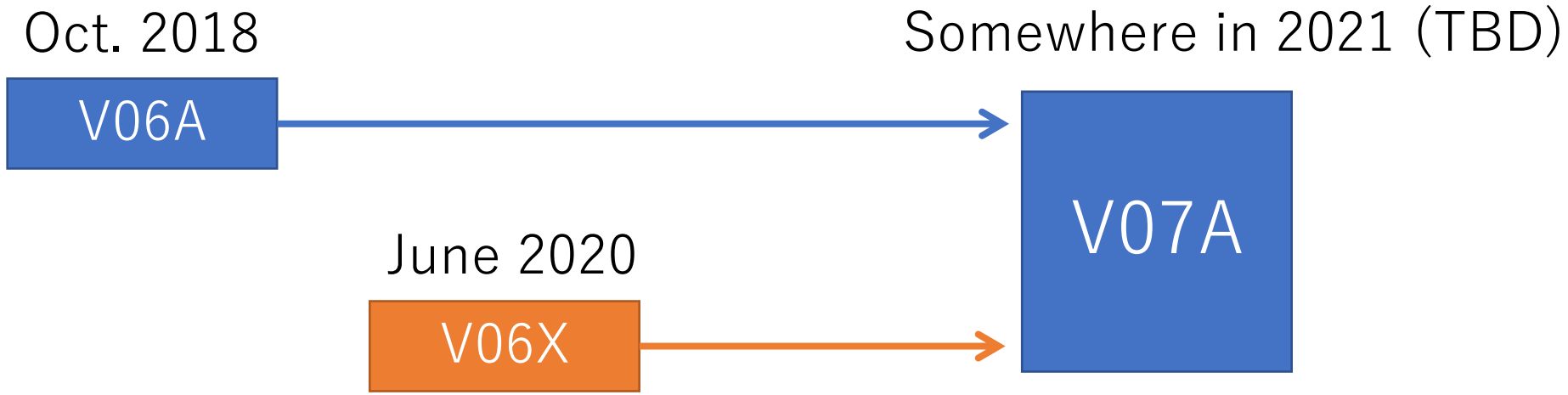
Needs to develop L2 algorithms to correspond to the new scan pattern





The full-swath coverage after the DPR scan pattern change provides consistent dual-frequency computations across the full swath. To realize it, we need to develop L2 algorithms to correspond to the new scan pattern.

Plan for DPR-L2 data distribution



- “Experimental product”=V06X
  - ➢V06X will be processed only data after May 2018
    - ✓V06X algorithm will not be applied data before May 2018.
  - ➢V06X and V06A will be processed parallelly.

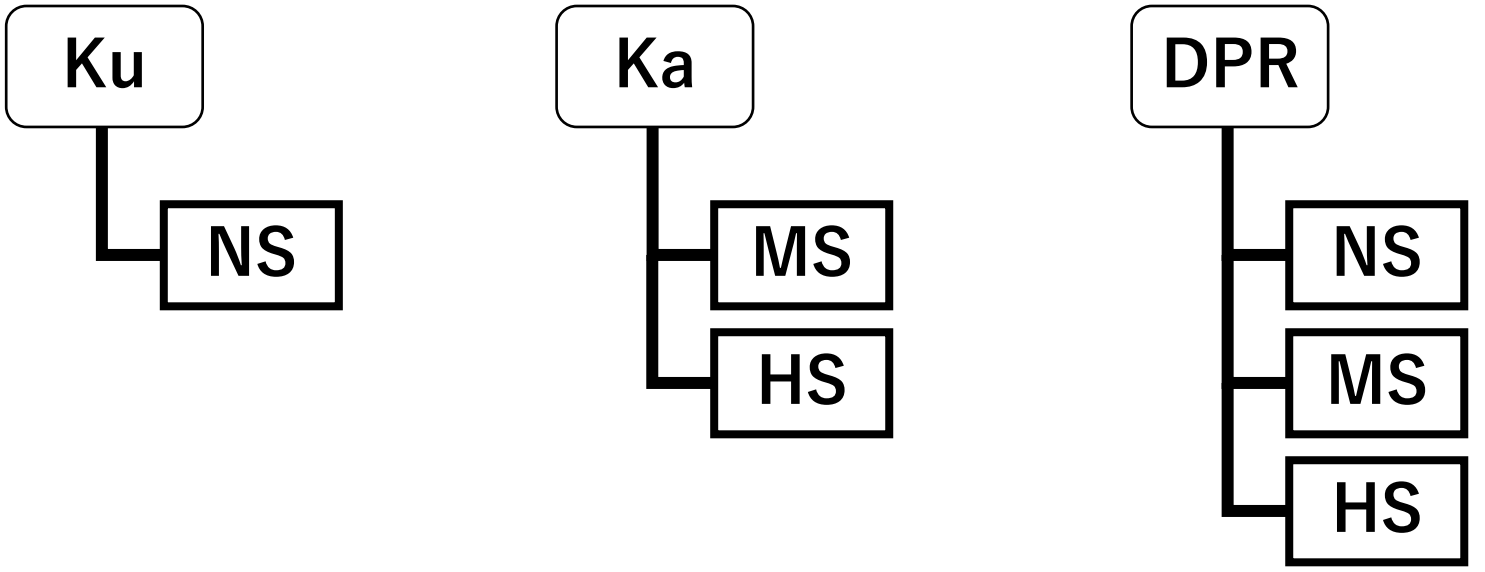
Tasks for the algorithm development and modifications to cope with the new KaPR scan pattern

Basic concept of V06X algorithm is the same as V06A.

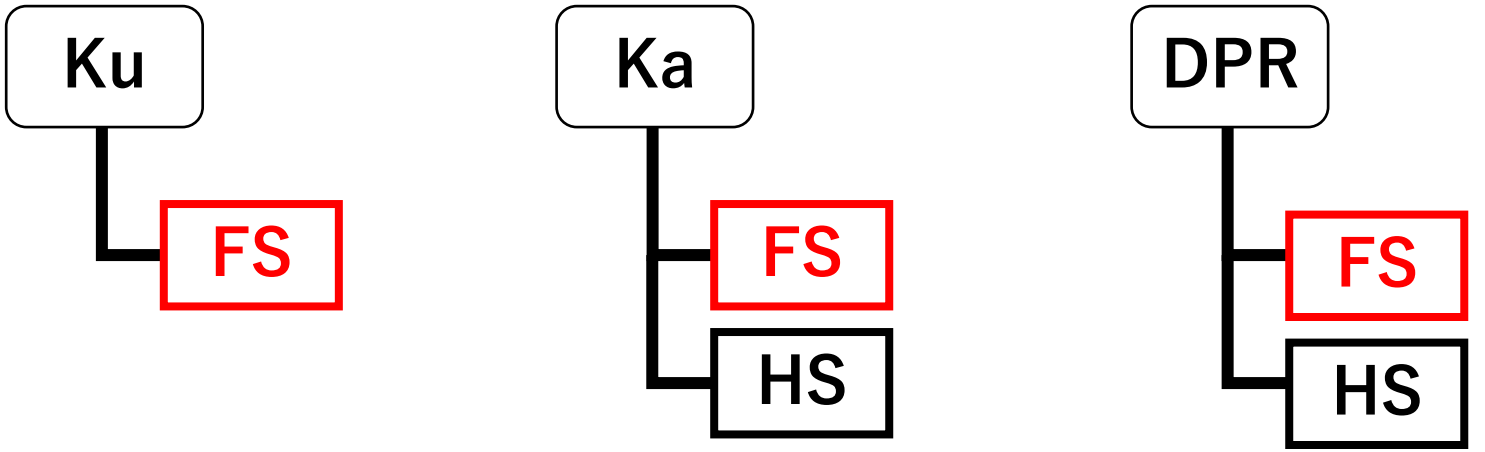
1. Implementation of a new format
   - ✓ The latest TKIO supports the new format including “FS”.
2. Algorithm updates
   - ✓Development of the DPR-L2 V06X which corresponds to the Ka scan pattern change after May 2018 was successful.
     - ➢There are several new features of the algorithm for the V06X
     - ➢Due to progresses by algorithm developments, precipitation retrievals in the inner swath of the V06X are not be the same as those in V06A.

1. A summary of the New format (V06A and V06X)

Current (V06A)



New (V06X or later)

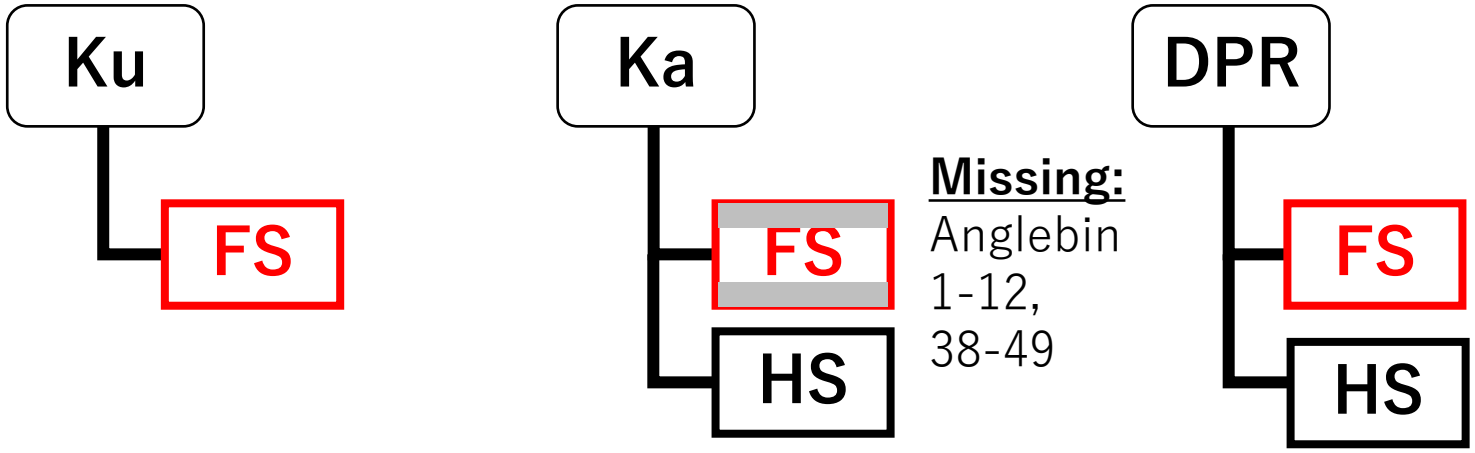


- Implementation of a new Group ‘FS’(Full Scan).
- ‘FS’ has 49 angle-bins and 176 range-bins for each scan.

V07

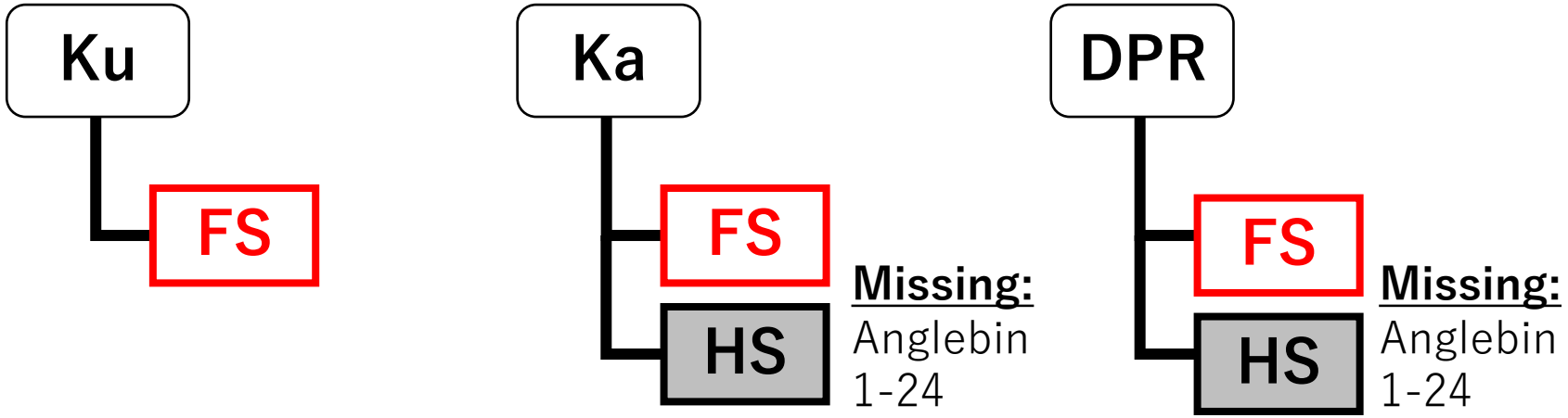
Before scan pattern change (21 May, 2018)

: Missing



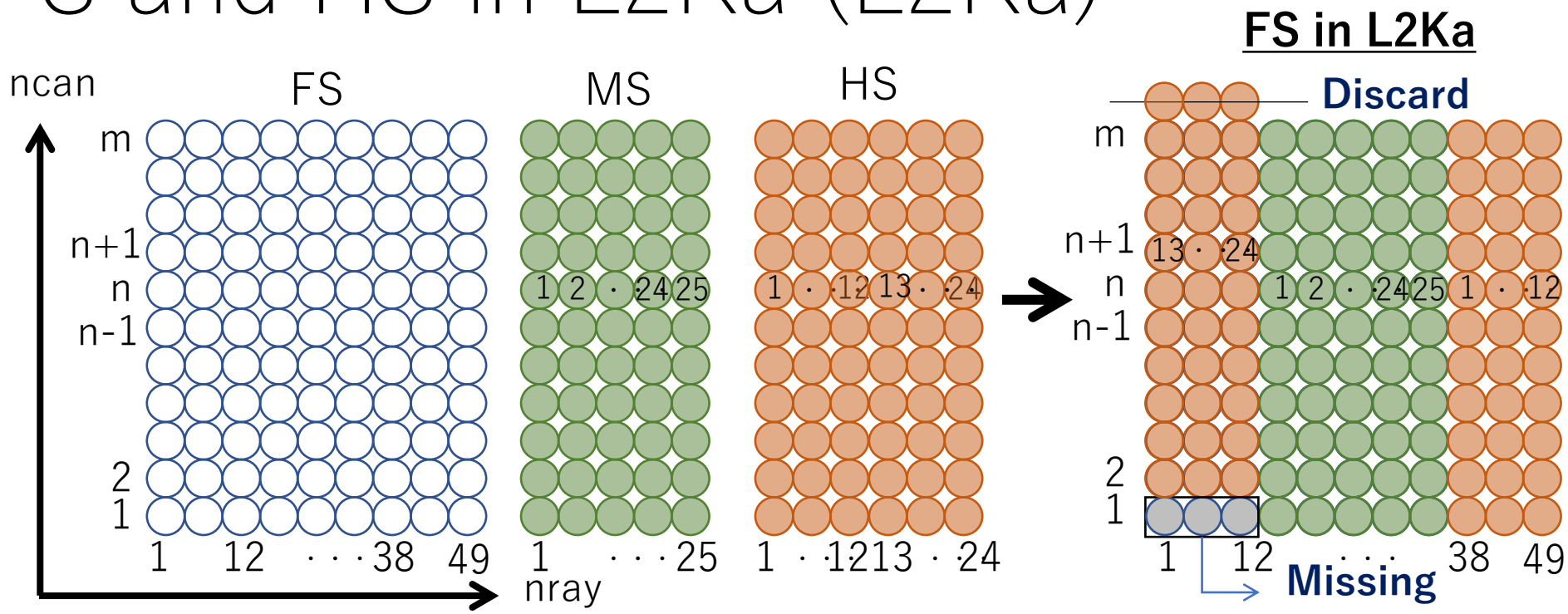
After scan pattern change (21 May, 2018)

Now we are developing



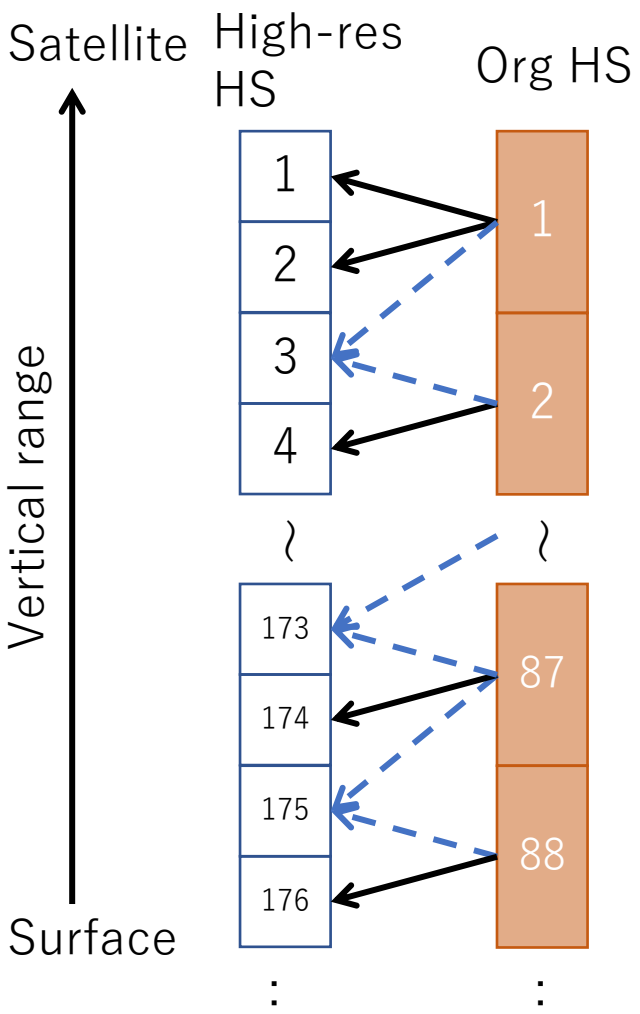
- We can keep the same format even if the KaPR scan pattern was changed.

1.1. FS and HS in L2Ka (L2Ka)



- FS has 176 range-bin arrays and 49 angle-bin arrays .
- To match the number of range-bin arrays of both MS(nbin=176) and HS(nbin=88), the vertical data in HS regions of FS structure are interpolated by original HS vertical data.
- Regarding horizontal arrays of FS structure in L2Ka,
  - ✓ FS [1:176, 1:12, n] = (interpolated) HS[1:176, 13:24, n-1]
  - ✓ FS [1:176, 38:49, n] = (interpolated) HS[1:176, 1:12, n]
  - ✓ Angle-bin 1 to 12 in the first scan of FS store missing values.
  - ✓ Angle-bin 13 to 24 in the last scan of HS are discarded.
- HS structure in L2Ka
  - ✓ Original HS values(nbin=88) is stored as it is.

1.2. Interpolation of KaHS vertical range



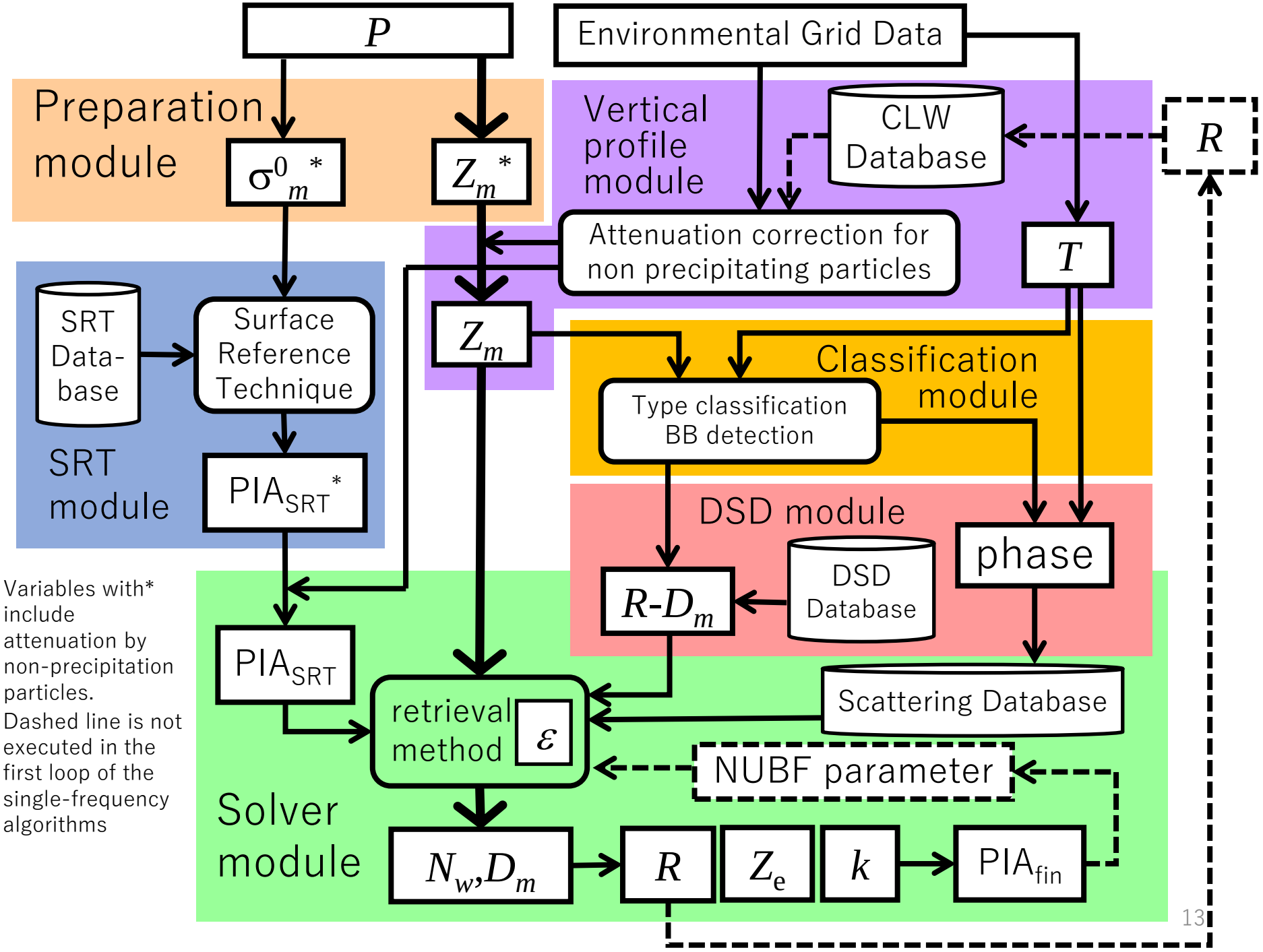
High resolution HS range bin number	corresponding range bin number for interpolation
1	1
2	1
3	1 and 2 (average)
4	2
5	2 and 3 (average)
～	～
173	86 and 87 (average)
174	87
175	87 and 88 (average)
176	88
:	:

- INP/PRE module implements the interpolation of HS data.

2. Algorithm updates

- All modules in the DPR-L2 algorithm were prepared for the V06X.
  - ✓The latest TKIO with the new format including “FS” was installed for the DPR-L2 algorithm.
- Status
  - ✓We keep the same method of the Solver (SLV) module between the V06A and the V06X.
    - ✓ We concluded that precipitation estimates in the Dual-frequency Product tended to estimate smaller in the outer swath than in the inner swath by the SLV in V06A/V06X.
    - ✓ This was regarded as one of future tasks and should be improved in V07.
  - ✓Several new features of the algorithm for the V06X will be presented later.

DPR-L2 Algorithm framework (GPM V06A/V06X)



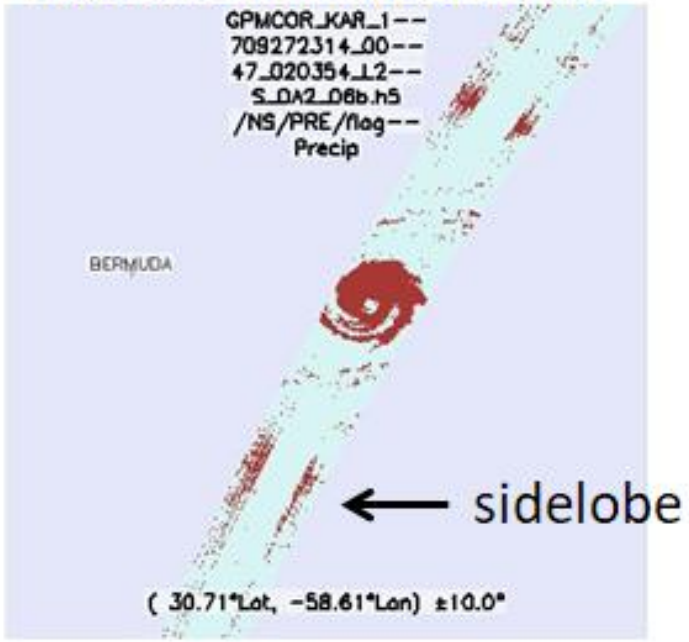
Variables with* include attenuation by non-precipitation particles.
Dashed line is not executed in the first loop of the single-frequency algorithms

2.1 Development of KaHS sidelobe reduction

- Sidelobe clutter contaminations of KaHS became more problematic in the new Ka scan pattern.
- A sidelobe clutter reduction method after the scan pattern will be installed in the V06X algorithm,

flagPrecip (Precipitation detection)

DA2.20180907KaOuter



DA2.20180913KaOuter

By Dr. Kubota (JAXA)

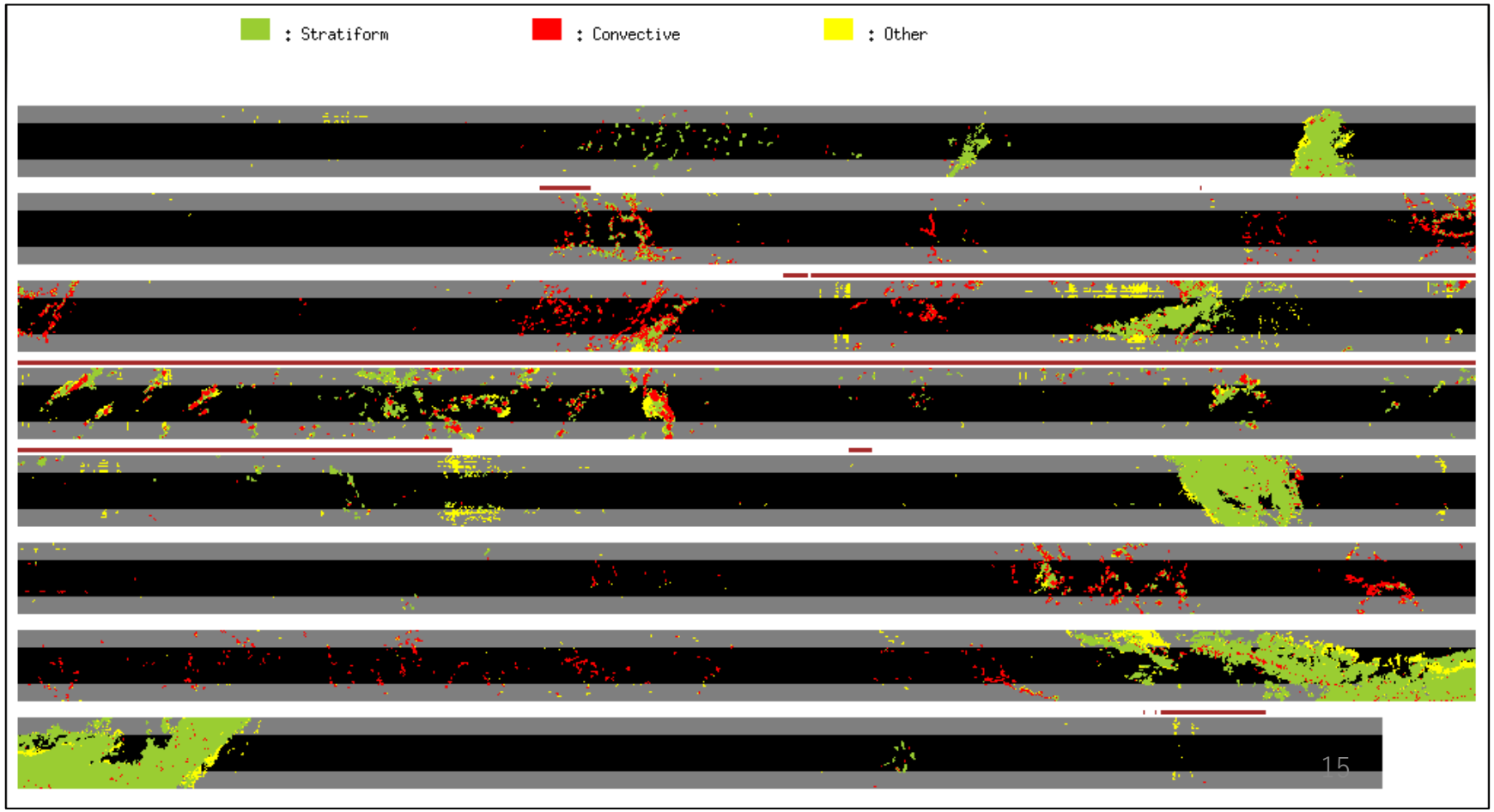
2.2 Classification module for FS

- Dual frequency technique of the classification module was improved to be applied in the FS.
  - ✓ Changed parameters will be used in the HS of the dual frequency technique .

Classification results of convective/stratiform in the DPR FS (Orbit: 024636)

The dual frequency technique was applied in the full swath.

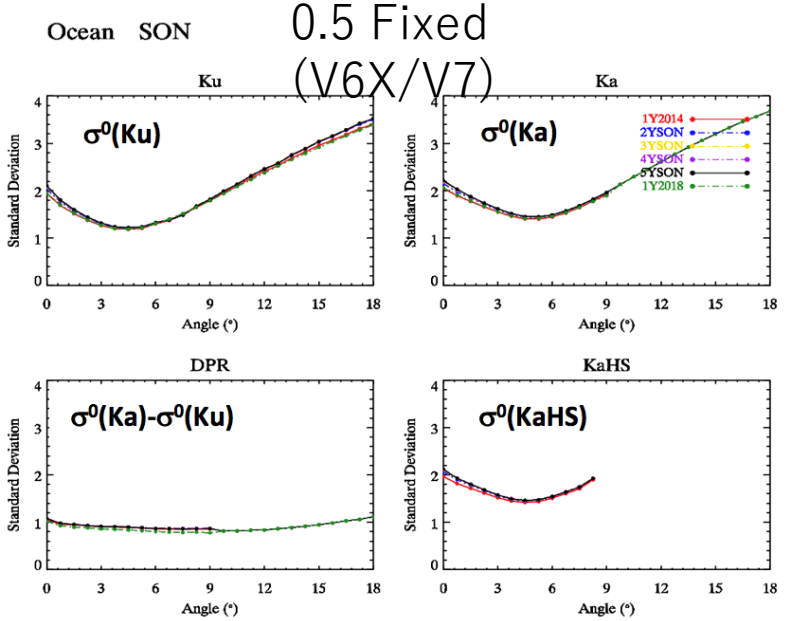
By Prof. Awaka (Tokyo Metropolitan University)

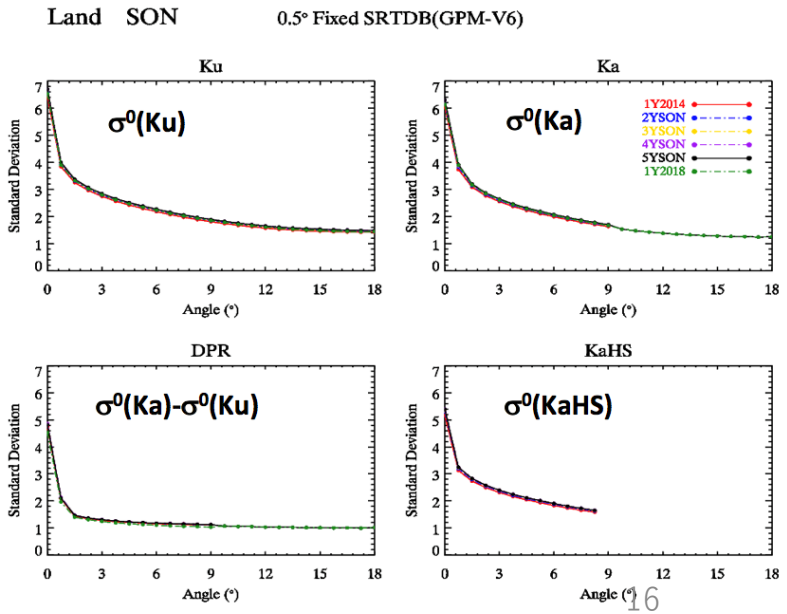


2.3 SRT for the new scan pattern

- Temporal Reference Files both for V6X and V7
  - Inner swath
    - Ku/Ka/DPR : 5 years observation from V06A
    - KaHS : 4 years from V06A
  - Outer swath
    - Ku : 5 years observation from V06A
    - Ka/DPR : 1 year (2018-2019) from ITE704
  - 4 Files are ready to use
    - Temporal_0.5F_5YJJA2018_6S_KaFull_UF.bin
    - Temporal_0.5F_5YSON2018_6S_KaFull_UF.bin
    - Temporal_0.5F_5YDJF2019_6S_KaFull_UF.bin
    - Temporal_0.5F_5YMAM2019_6S_KaFull_UF.bin
- SRT codes have been updated so that they now read temporal data over the full swath. Dual-frequency SRT and Hybrid estimates are now applicable to the full swath.

(by Dr. Meneghini, NASA/GSFC)





2.4 Additional improvements of algorithm

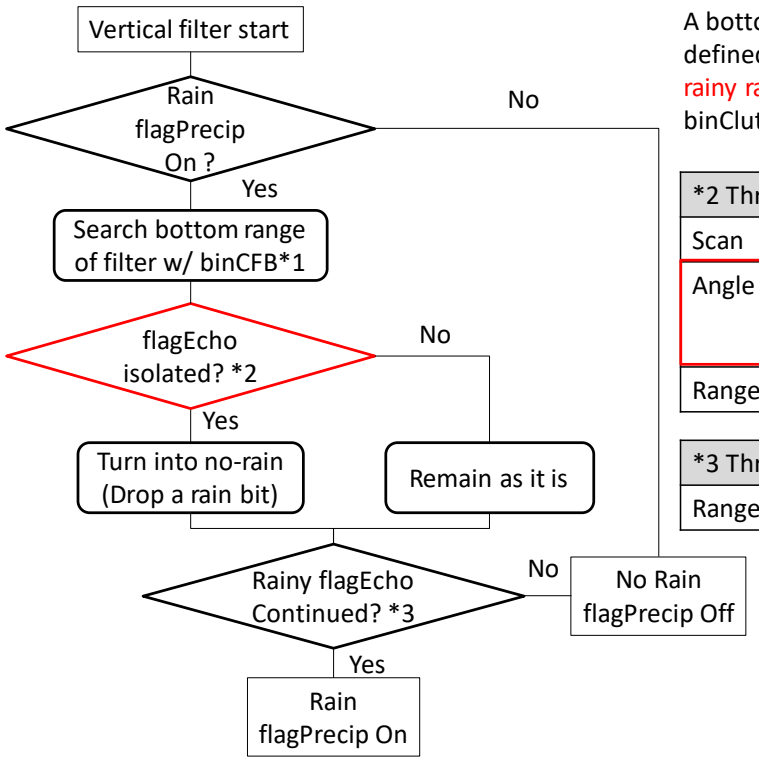
- Preparation (PRE) module
  - ✓Clutter free detection in the Ku is improved in cases when the brightband (BB) is found near the surface.
  - ✓A sidelobe clutter filter technique for the KaHS is applied also for the Ku.

- Classification (CSF) module
  - ✓New variables related to solid precipitation is implemented.
  - ✓Reclassification by the slope method is improved.

A sidelobe clutter filter technique for the KaHS is applied also for the Ku.

Flowchart of the vertical filter to reduce the sidelobe clutter contamination

Flow chart of the Vertical filter

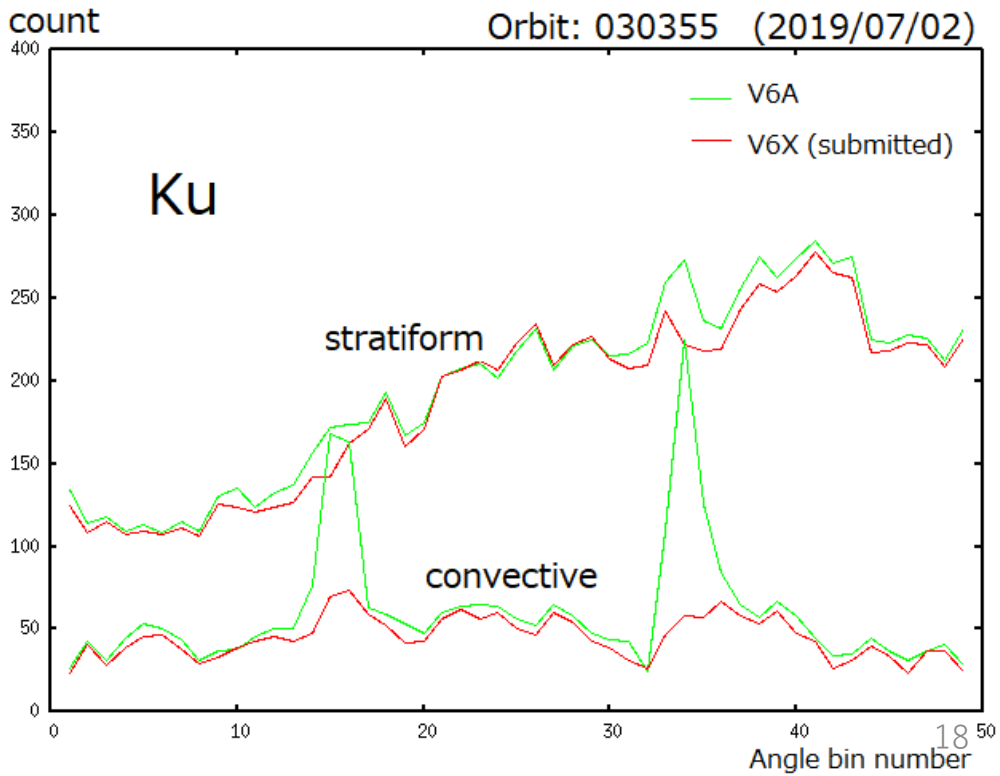


*1:
A bottom range of the filter is defined as a top of continuous rainy range bin above the binClutterFreeBottom.

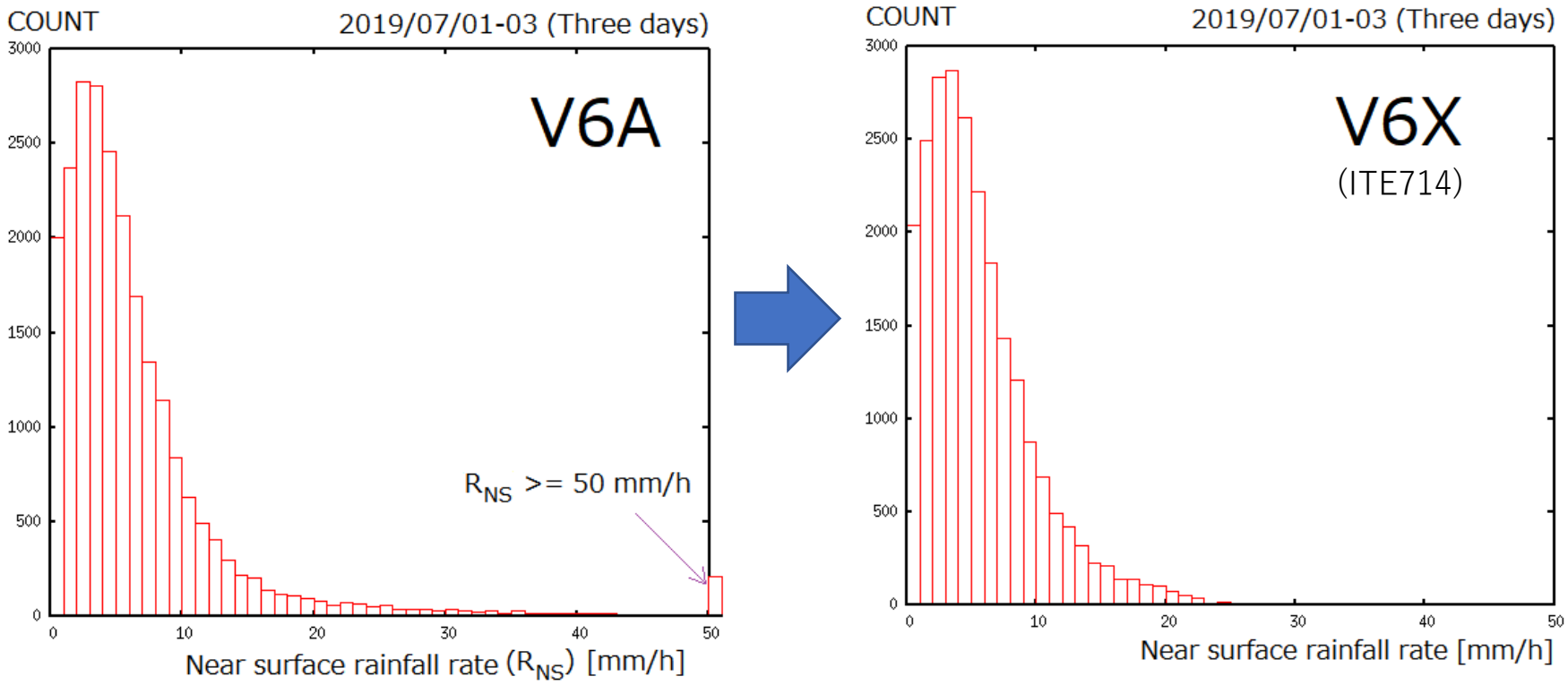
*2 Threshold	KuFS	KaFS
Scan	0	0
Angle	±1 iAng= 0-19 & 29-48	±1 (Only HS region)
Range bin	12	12

*3 Threshold	KuFS	KaFS
Range bin	6	6

Sidelobe clutter contamination iv V06A (green) was mitigated in V06X (red). They were clearly shown in statics of the convective precipitation.



Reclassification by the slope method is improved.



The V6A problem of large near surface rainfall rate (N_{RS}) for the re-classified stratiform type by the Slope method is solved by introducing an external filter in the CSF module. The threshold TH introduced in V6X is

TH = 20 mm/h.

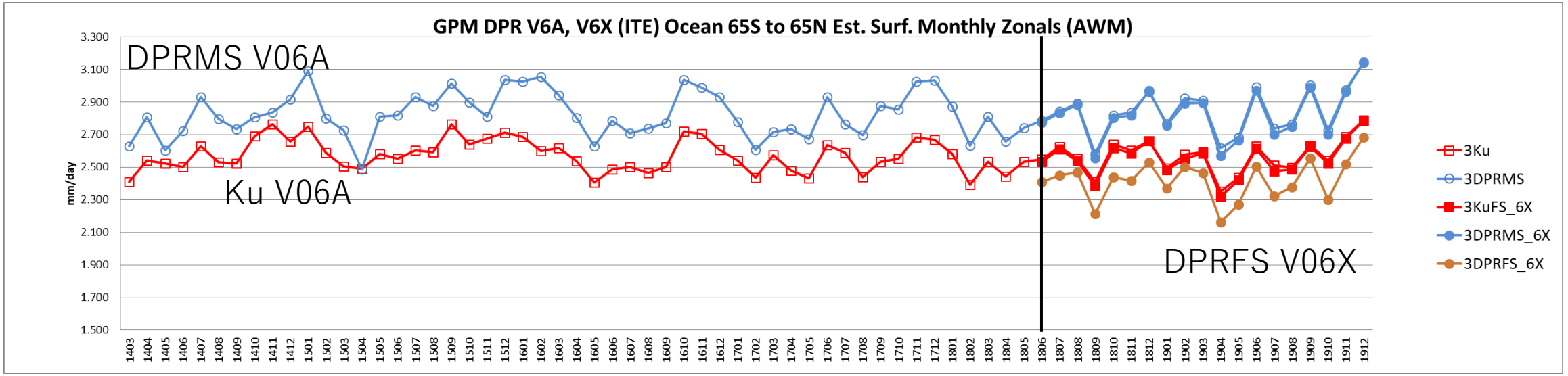
Even with the above filter, however, N_{RS} for the re-classified stratiform type in V6X sometime exceeds the above threshold because the SLV module in the downstream of the algorithm flow makes a NUBF attenuation correction to R_{NS}. (The CSF module which locates at the upstream can not access the downstream SLV output of NUBF attenuation corrected data.)

2.5 ITE & Evaluation

- NASA/PPS conducted several test runs and ITE729 was processed during a period from June 2018 to Dec. 2019.
- Here, we shows evaluation results using the ITE 729.

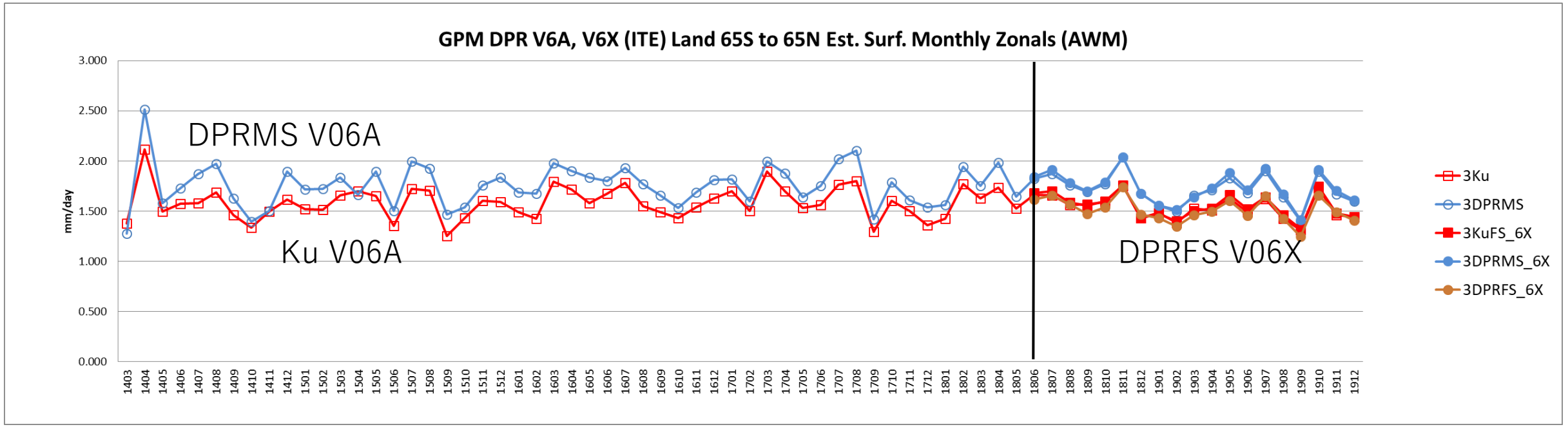
ITE #	Description	Dates
ITE729	**L2 2AKu/Ka/DPR (20191226 + SRT mods) and L3**	**6/2018-12/2019**

V06A/06X DPR Ocean (J. Stout)



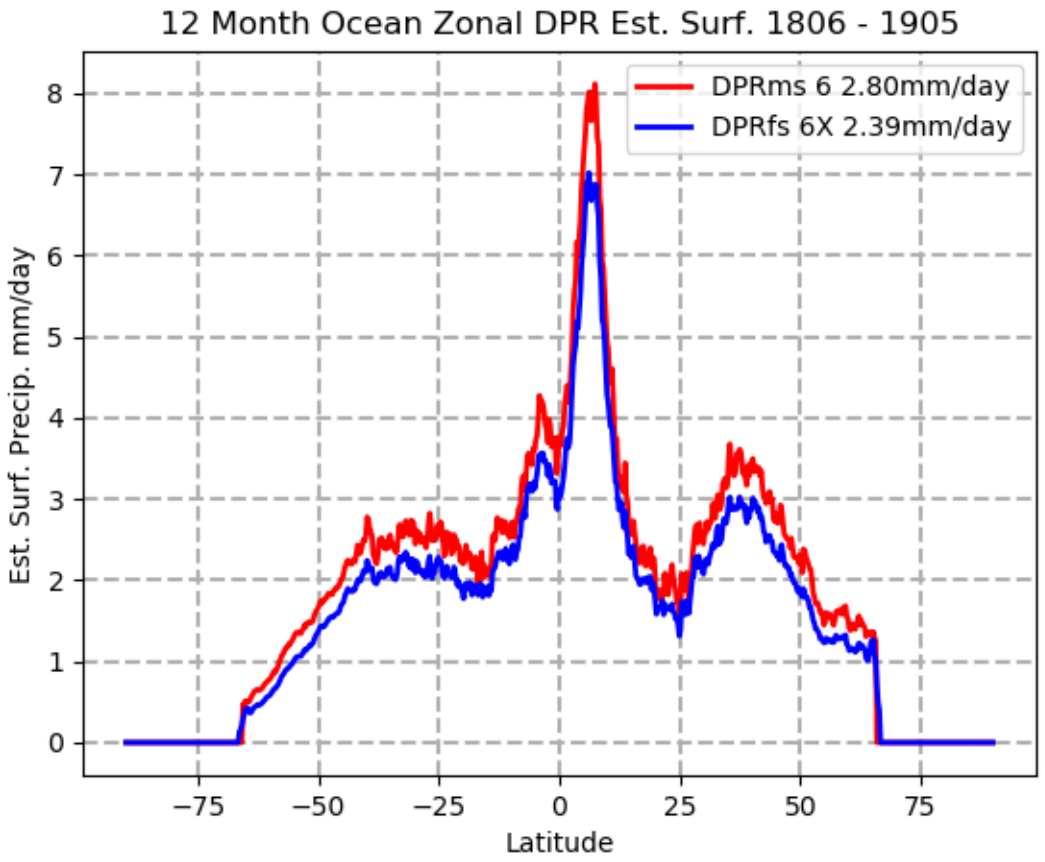
- Ku (49ifov) V06A – KuFS (49ifov) V06X little difference.
- DPRMS (25ifov) V06A – DPRMS (25ifov) V06X little difference.
- DPRFS V06X – Full 49ifov dual-freq. retrieval. showed smaller tendency.

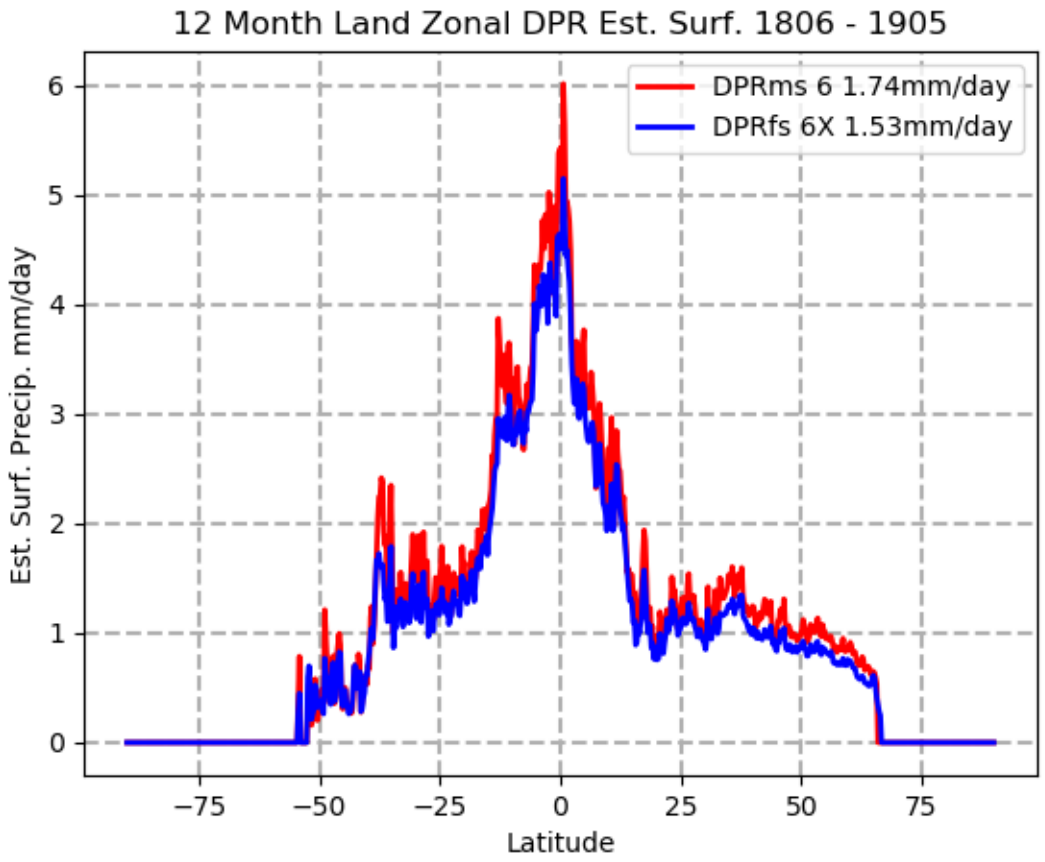
V6/V6X DPR Land (J. Stout)



- Ku (49ifov) V06A – KuFS (49ifov) V06X little difference.
- DPRMS (25ifov) V06 – DPRMS (25ifov) V06X little difference.
- DPRFS V06X - Full 49ifov dual-freq. retrieval. showed slightly smaller tendency.

12 Month V06A/V06X Zonals DPR (J. Stout)

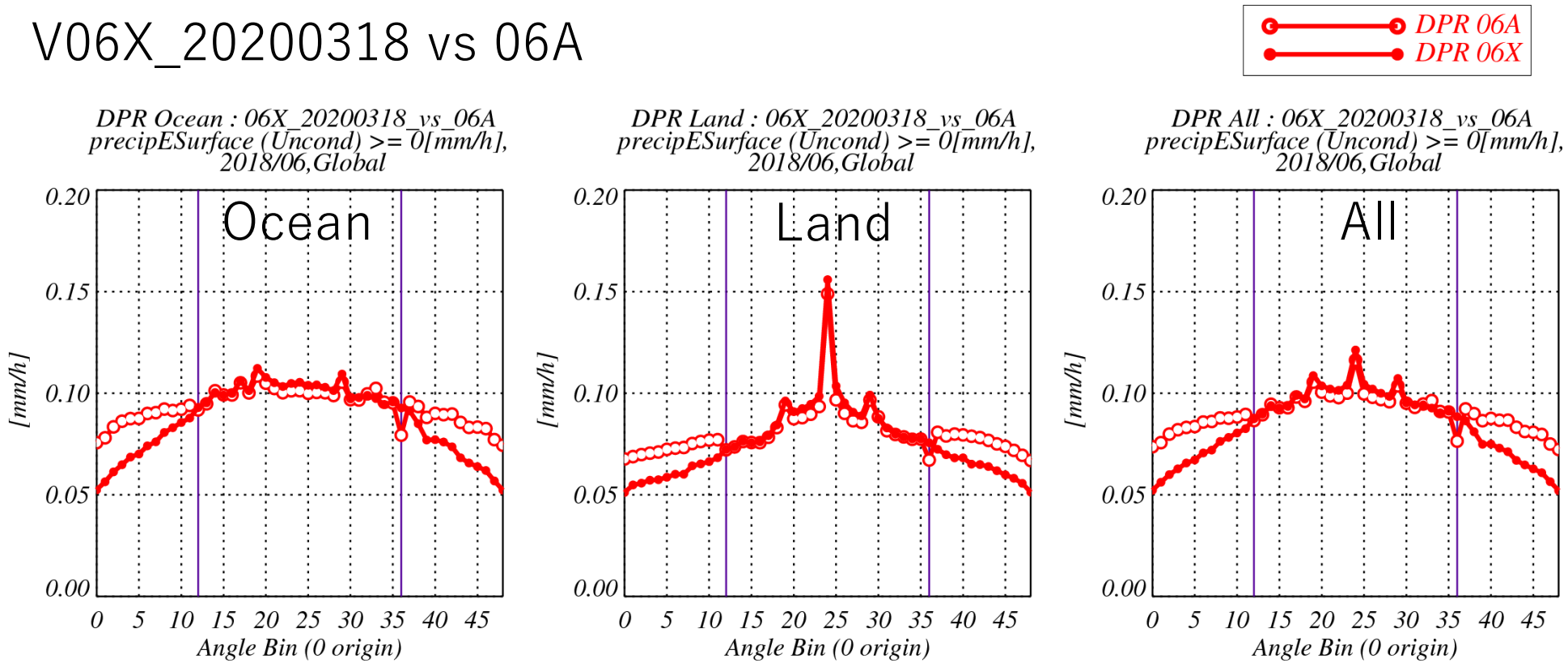




Dependency upon angle-bins (scan angles)

Unconditional, Global mean, precipESurf (June 2018) in the Dual-frequency product

V06X_20200318 vs 06A



Differences between V06A and V06X in the Dual-frequency product were found in the outer swath.

Why the strong angle-bin dependency found in the Dual-frequency product? (Seto)

- KuPR and KaPR (including KaHS) are available at all pixels, but it is not always true that the two radars detect precipitation and “dual-frequency method” is applied even in the dual-frequency algorithm.
- In this study, pixels are classified into three types. Only for type-1, dual-frequency method is applied.

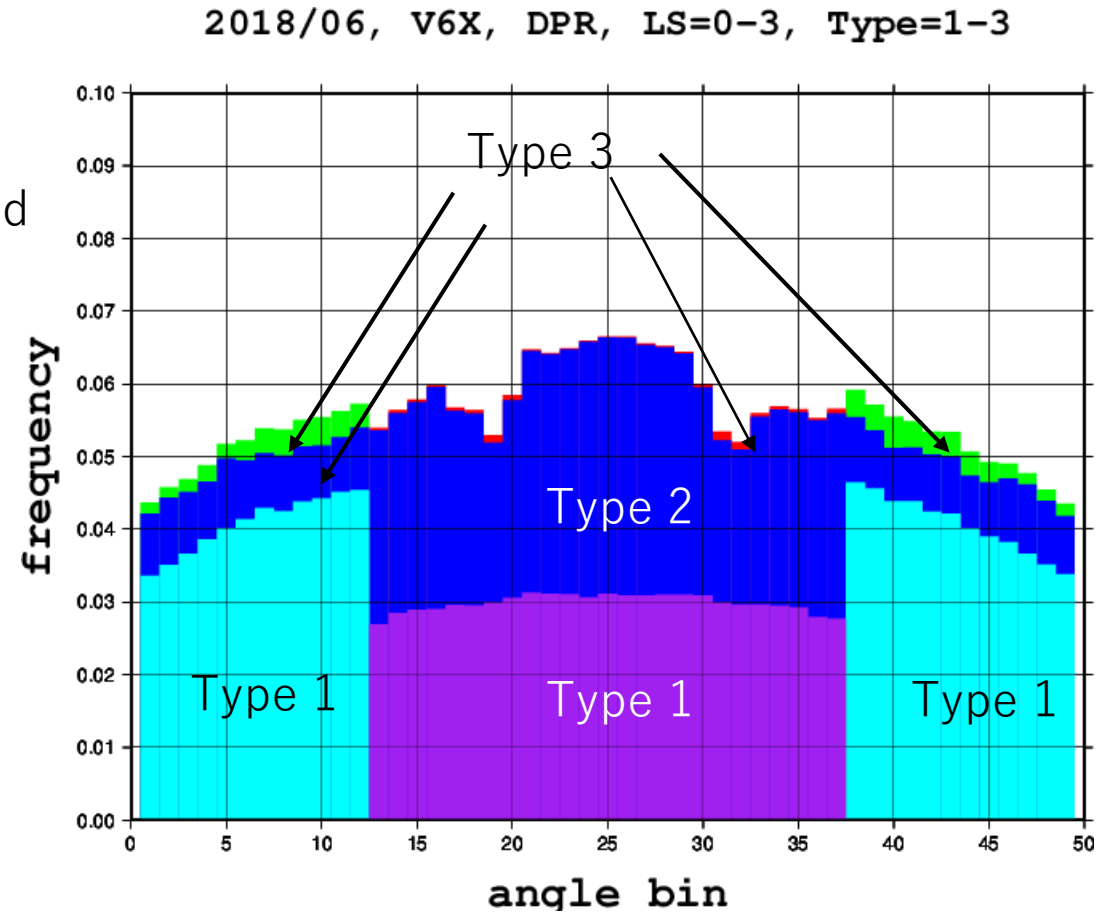
	Inner swath	Outer swath
Type-1 (both KuPR and KaPR detects precipitation → dual-frequency method)	■ = ■ + ■	■ = ■ + ■
Type-2 (only KuPR detects precipitation)	■	■
Type-3 (only KaPR detects precipitation)	■	■

- Dual-frequency method” uses a combination of DSRT and ZfKa method to modify an adjustment factor, ε, while “single-frequency method” uses SRT and DSD database.

Histogram (normalized by total number of pixels)

- V06X, Dual-frequency product, Jun 2018, ITE718

At Nearly 2/3 of the precipitation pixels, dual-frequency method is applied.



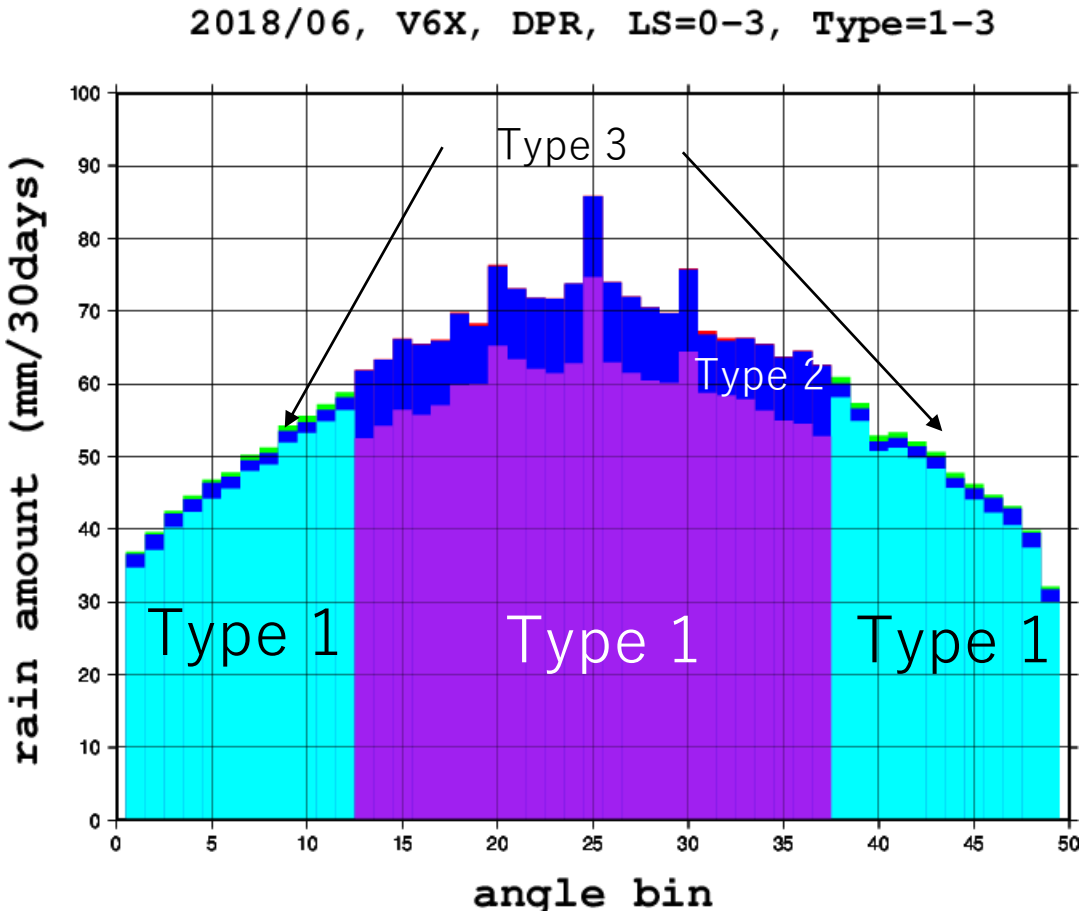
	Inner swath	Outer swath	All swath
Type-1 (both)	50.2%	78.8%	63.2%
Type-2 (KuPR)	49.1%	15.7%	33.9%
Type-3 (KaPR)	0.7%	5.5%	2.9%

Contribution to precipitation amount
(unconditional average of precipRateESurface)

- V06X, Dual-frequency product, Jun 2018, ITE718

"Dual-frequency method" contributes to about 90% of total precipitation amount.

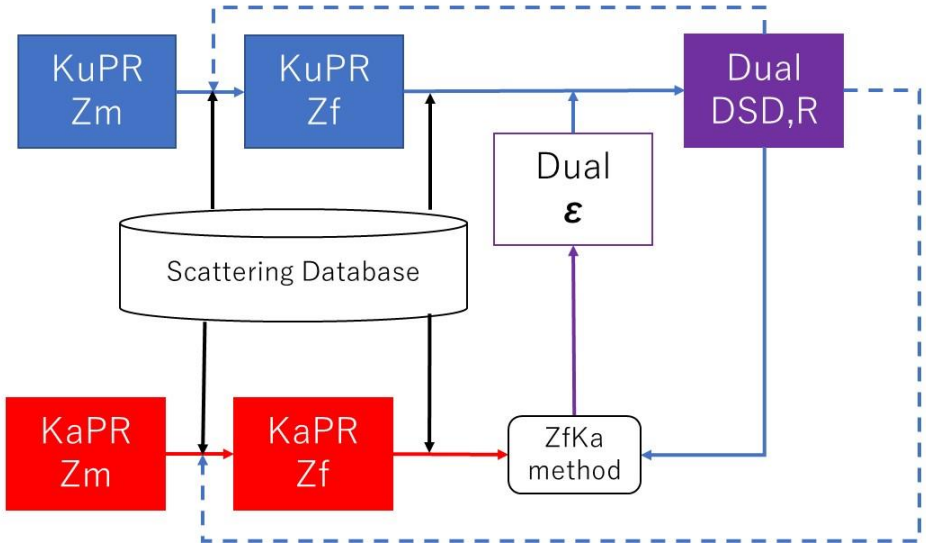
Precipitation amount shows strong angle bin dependence



	Inner swath	Outer swath	All swath
Type-1	85.9%	95.2%	89.6%
Type-2	13.9%	3.6%	9.8%
Type-3	0.2%	1.3%	0.6%

Angle bin dependence of ε

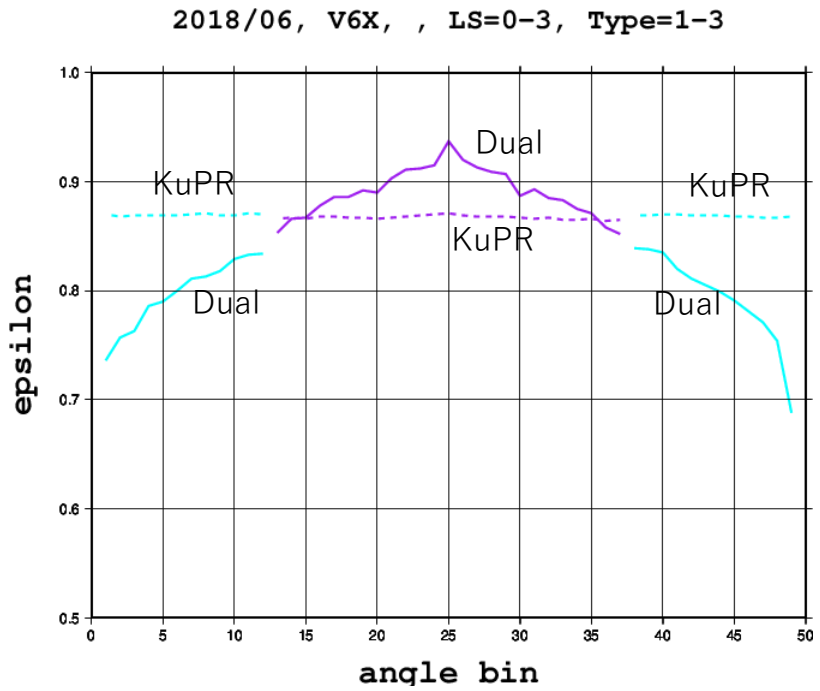
Dual-frequency Algorithm



"ε" is an adjustment factor in the relationship between precipitation rate R and volume-weighted mean drop size D_m (so-called, R-D_m relationship).

- **For type-1,**
- Soild line: V06X, Dual-frequency product, Jun 2018, ITE718
- Dotted line: V06X, KuPR product, Jun 2018, ITE718

ε



While ε is almost constant in KuPR algorithm, ε decreases at larger incident angle in Dual-frequency algorithm.

→ This leads to angle bin dependence in surface precipitation. Need to improve the SLV in V07.

Summary

- Development of the DPR-L2 V06X which corresponds to the Ka scan pattern change after May 2018 was completed.
  - ✓ The latest TKIO with the new format including "FS" was installed for the DPR-L2 algorithm.
  - ✓ We applied the same dual-frequency precipitation estimation in Solver (SLV) module of V06A for V06X.
    - ➢ We found that estimated precipitation of outer swath from the dual-frequency method tended to be under estimation in V06X. It is characterized as angle bin dependency of epsilon (ε) both in V06A and V06X.
    - ➢ This was regarded as one of future tasks and should be improved in V07.
  - ✓ There are several new features of the algorithm for the V06X, due to progresses by algorithm developments.
- Several issues in V06X will be solved by the major revisions of the algorithms in V07 scheduled in 2021.