GESTAR-MSU[1] / NASA-GSFC[2] / GMU[3]

Performance Evaluation of Path Attenuation Estimate

After Scan Pattern Change of the DPR Ka-band

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New Ka-band Scan Pattern

- The Dual Frequency Precipitation Radar (DPR-Ku and DPR-Ka) on board the GPM satellite has been providing reliable products related to estimates of global precipitation since it was launched 5 years ago.
- On May 21, 2018, the scan pattern of DPR-Ka radar was changed from near-nadir scanning (0 to 9 deg) to a scan pattern matched to that of the DPR-Ku radar (0 to 18 deg).
- The major advantage of this change is that the dual-frequency precipitation data are now available over the full swath so that, in principle, more accurate estimates of the precipitation amounts can be made over an area twice as large as the original area.

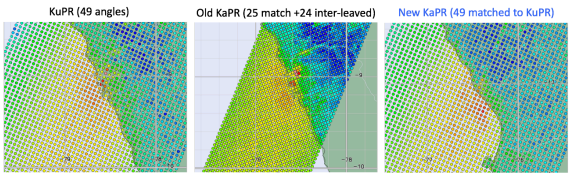

*Fig. 1 **Left)** 49 FOVs at DPR-Ku, **Middle)** 25 FOVs matched to DPR-Ku inner swath and 24 FOVs inner-leaved high sensitivity at old DPR-Ka scan mode, and **Right)** 49 FOVs matched to DPR-Ku full swath after new scan mode.*

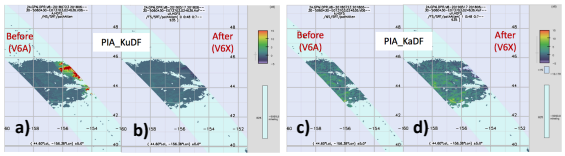

*Fig. 2 **a)** Before Ka scan pattern change (V6A), PIA_SRT by dual frequency methods are only available inner swath. Significant discontinuity of PIA between inner swath and outer swath. **b)** After scan pattern change (V6X), dual frequency PIA retrievals are available for full swath. **c)** and **d)** are those for Ka band.*

Path Attenuation Estimates in V6X

- One of methods to estimate path-integrated attenuation (PIA) for GPM-DPR is the Surface Reference Technique (SRT) that compares the difference of the radar normalized backscattering cross section (NRCS, σ^0) of the surface outside the rain to that measured within the rain.
- As the performance of the PIA estimate by the SRT is closely related to the behavior of the rain-free NRCS, this study focuses on the statistical features of the NRCS and an assessment of PIA estimates over the outer swath of the DPR-Ka using data measured from June 2018 to May 2019.

SRT look-up Tables for the past 5 years

- The SRT estimate of path attenuation is a weighted average of spatial and temporal reference estimates. The spatial reference is formed by an average of rain-free NRCS measured near the raining area at approximately the same time. For the temporal estimate, the attenuation is taken to be equal to the difference between the time-averaged rain-free NRCS and the NRCS measured in rain. The rain-free temporal statistics are computed and stored in the form of a look-up table
- One of the challenges with the new Ka-band data is to construct a look-up table that is applicable to the full swath and, in particular, includes statistics for the Ka-band and Ku-Ka-band difference in the outer swath.
- With regard to the use of statistics of temporal reference NRCS in the outer swath, the statistics at DPR-Ku are computed from datasets over the last five years, while those at DPR-Ka are derived from only a single year.

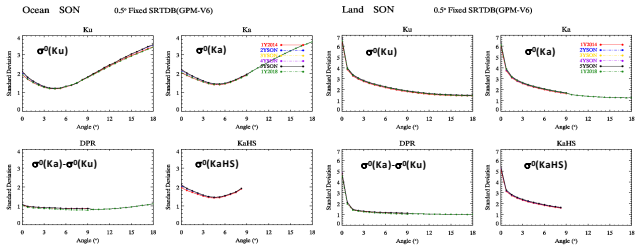

Fig. 3 Global averaged standard deviations (stdevs) of rain-free σ^0 at each frequencies over the ocean and land during Sep-Oct-Nov 3 months from 2014 to 2018. Black solid lines at each panels show the stdevs of σ^0 that are accumulated for the past 5 years (before Ka scan pattern change). The stdevs for the past one year after scan pattern change (Green dotted lines) show the smooth transition forward outer swath. For the outer swath at both Ka and Ku frequencies, the stdevs for ocean tend to increase monotonically as the incidence angle increases. On the other hand, on land, the stdevs are smaller toward the outer swath. As expected, the stdevs at difference of σ^0s between Ka and Ka are significantly lower than those at single frequencies, which will lead to the better performance of dual frequency PIA estimates.

PIA by Temporal SRT in V6A(Before) and V6X(After)

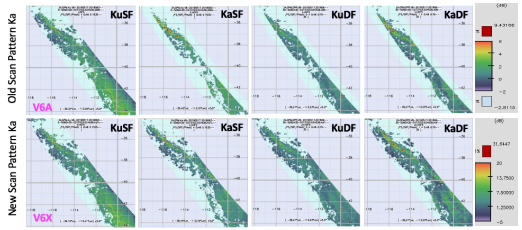

Fig. 4 Upper plots displayed PIA estimates in V6A and bottom plots are same, but for V6X. The dual frequency PIAs in transition areas from inner to outer swath showed slight discontinuity that caused by the different sensitivity and sampling at Ka.

Temporal Look-up Table for V6X

- One way to overcome this difference in sampling is to use a variable area sampling strategy so that the averaging area is expanded over statistically similar areas so as to include a larger number of samples.
- Another issue is the difference in sensitivity of the Ka-band in the outer and inner swaths. As a longer pulse length is used for the outer swath data, the sensitivity at Ka-band increases by about 5 dB relative to the inner swath data. Because of this, it is necessary to examine the statistical continuity of the NRCS between the outer and inner swaths and the statistical similarity of the differential surface cross sections, which is considered to be a key factor in determining the accuracy of the PIA estimates by dual frequency method.

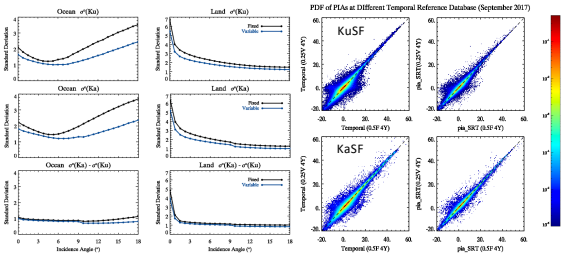

*Fig. 5 **Left panels** showed the stdevs of σ^0 in 0. 5 degree fixed grid and variable grid during Sep-Oct-Nov over 5 years. Variable grid approach significantly reduced the variance of σ^0 over ocean and land both. Scatter plots in **right panels** (up for Ku and down for Ka) shows the comparisons of path attenuation estimates(in temporal method and SRT) when 0.5 deg fixed grid (x-axis) and 0.25 deg variable grid (y-axis) look-up table are used, respectively. The difference of estimated PIA between the two approaches was noticeable in the case of weak precipitation, and For heavy rain region, the different look-up tables did not affect much the PIA estimation.*

Summary

- Since the DPR-Ka changed its scan pattern to expand the outer swath observation in May 2018, more than a year of GPM-DPR observations data have been accumulated and the dual frequency products are available for the full swath in V6X.
- Rain-free σ^0 look-up tables to estimate the temporal PIA estimate for the full swath was created and tested successfully and its statistical behaviors in outer swath were examined.
- By using more reliable look-up tables with lower variances, it is expected that the performance of PIA estimates will be further improved.

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