Updates on Profile Classification Algorithm

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Abstract

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As part of the DPR algorithm development group, this poster is focused on maintenance, validation and enhancement for the profile classification module with algorithms developed for precipitation type classification and hydrometeor identification for DPR.

These studies are done, using space-borne observations from the GPM platform as well as ground dual polarization radar. The performance of the algorithms with the scan pattern change is discussed. Additional updates such as modification on melting layer detection, and graupel / hail identification are also presented.

Modification on melting layer detection of dual-frequency classification model

One function of the dual-frequency classification module is to detect melting layer on a profile basis. Currently, the detection of melting layer top and bottom is done simultaneously. If either the top or bottom is not detected, both melting layer top and bottom are not available. In order to increase the detectability, we modify the current version of algorithm to separate the melting layer top and bottom detection to make it independent.

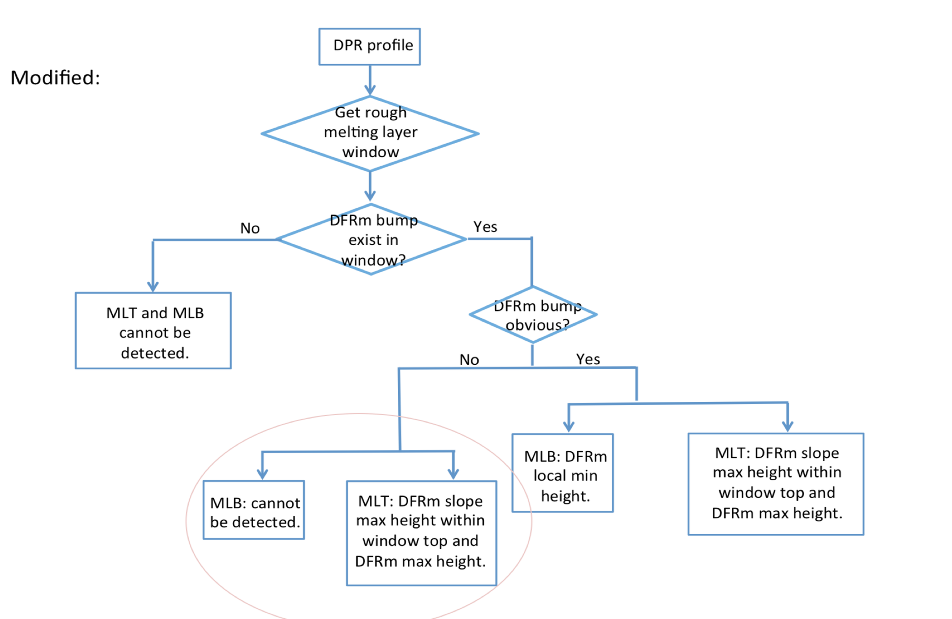
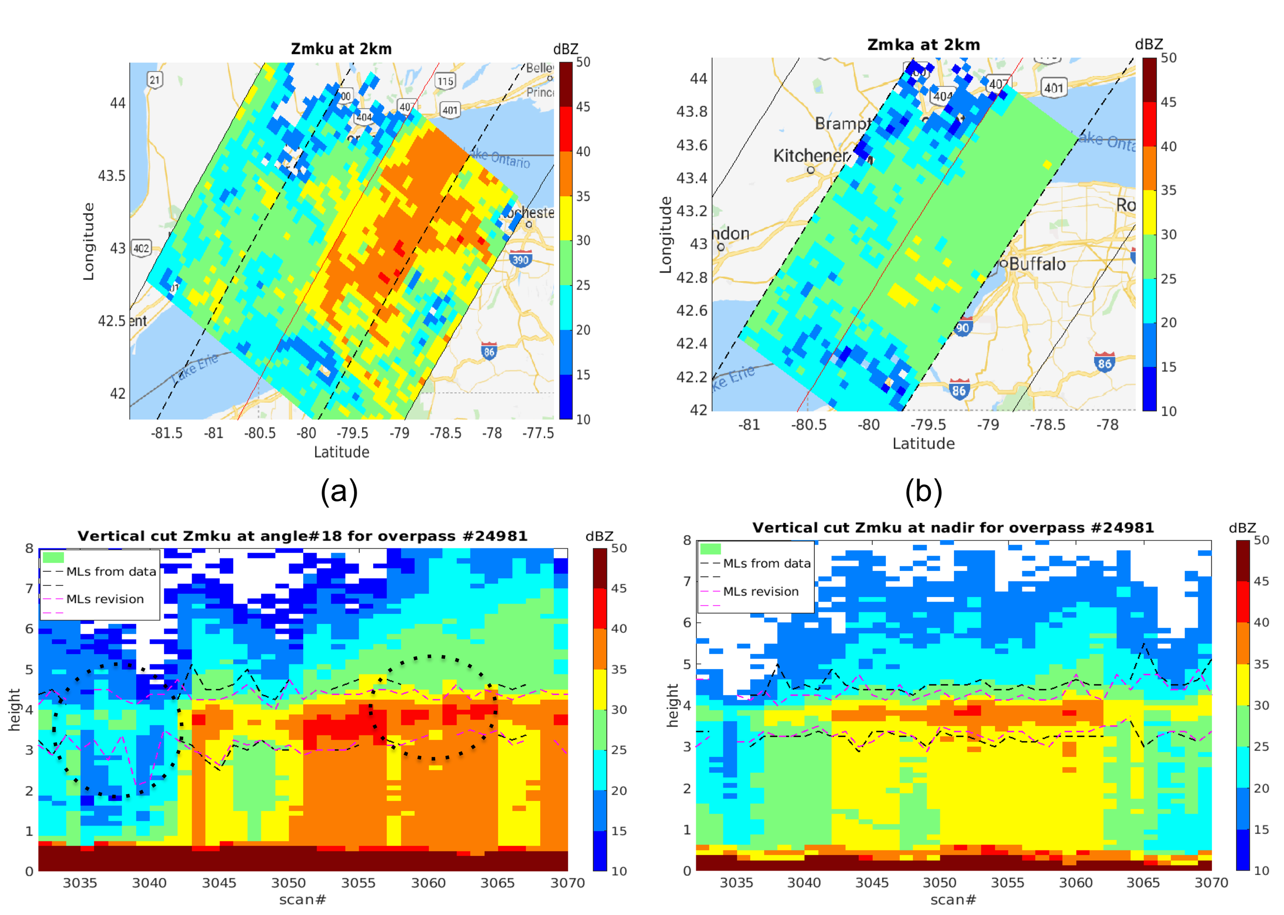


Figure 1, Modified block diagram for melting layer top and bottom detection for dual-frequency classification algorithm.

Figure 1 illustrates the modified flow chart of the melting layer detection algorithm in the dual-frequency classification module.



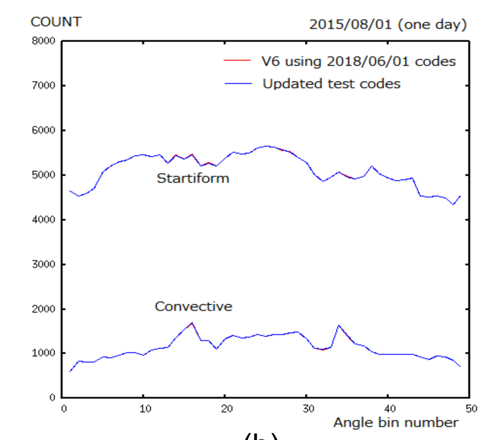
(a) (b) (c) (d)

Figure 2 shows a section (Scan range: 3032~3070) of the GPM DPR orbit #24981, where precipitation was captured over Buffalo, New York on 07/22/2018. (a) is Zmku at 2km, (b) is Zmka at 2 km. Sample vertical cut at angle bin # 18 & nadir is shown in (c) and (d). Black dashed lines are melting layer top and bottom before modification. Pink dashed lines are melting layer top and bottom after modification.

Figure 3 illustrates the count of rain types and melting layer top detection for one day of GPM orbits on 08/01/2018. Column of "V6" indicates the results before modification and column of "new" is for after modification. Changes of stratiform / convective counts occur in the inner swath only. Those small differences between V6 and updated codes occur due to the change of threshold1. However, melting layer top detection increases largely for both MS and HS condition. For MS, during one-day orbits, the count increases from 24,262 to 35,918, with increase percentage of 48%. For the HS condition, the increase percentage is around 63%. This is a big improvement on the melting layer detection part of the dual-frequency classification module. More extensive analysis will be performed in the near future.

	V6	new
stra (MS)	132,549	132,468
conv (MS)	33,688	33,771
MLtop (MS)	24,262	35,918
stra (HS)	120,313	120,408
conv (HS)	17,880	18,148
MLtop (HS)	14,020	22,938

(a)



(b)

Figure 3. (a) Count on rain type and melting layer top detection for GPM DPR orbits on 08/01/2018. (b) Rain type counts comparison before and after code change.

Extension of current dual-frequency classification algorithms from inner swath to full swath

The current dual-frequency classification algorithms including rain type classification, hydrometeor profile characterization, and surface snowfall identification are for GPM DPR matched inner swath. The performances of the current algorithms are summarized in Le et al, 2017, Awaka et al. 2016, Le and Chandrasekar, 2016. However, after scan pattern change, the dual-frequency profiles are available for outer swath also. There are some technical challenges merging the inner and outer swath, the most obvious being the resolution and sensitivity. It is essential that these dual-frequency algorithms are tested and validated on outer swath and makes any corresponding adjustments.

For the testing purposes, we have acquired 32 orbits data. These data are reformatted using beam-matching strategy in order to study the outer swath dual-frequency data. Interpolation on vertical resolution is also performed. Total of 59,559 vertical profiles are used for a preliminary study. The following shows initial results.

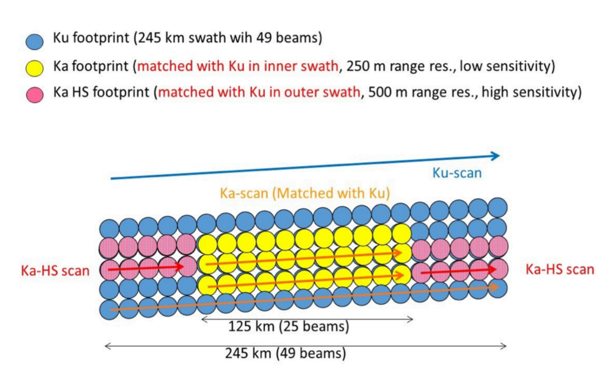
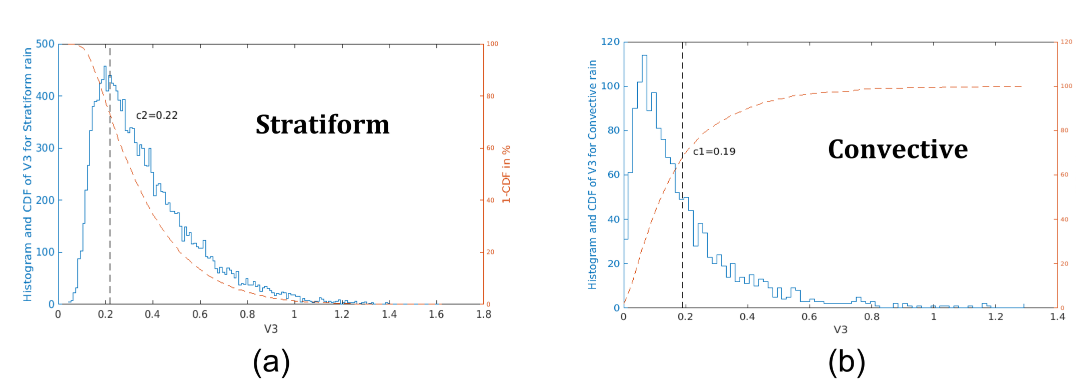


Figure 4. New DPR scan pattern.

a) Precipitation type classification

After the scan pattern change, V3 index is re-evaluated based on the test data of outer swath dual-frequency profiles. While we do not expect big changes in the threshold of V3 for inner versus outer swath, still extensive study needs to be done to make sure this is correct. Figures below illustrate the histogram of V3 for stratiform and convective rain based on matched outer swath profiles. Thresholds for stratiform rain is changed based on 70% CDF curve. Similarly, threshold for convective rain also is changed. Preliminary analysis of the 32-test orbit data sets show that there is less than 10% change in the thresholds of the algorithms for convective/ stratiform separation in V3 index.

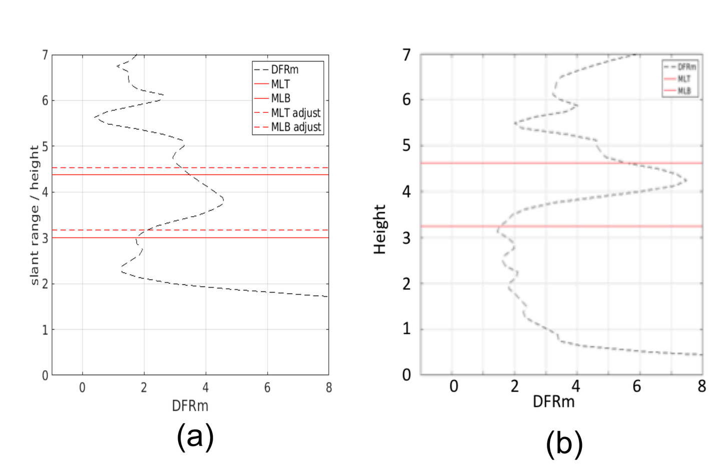


(a) (b)

Figure 5. Histogram on V3 index for (a) stratiform and (b) convective rain types using constructed DPR outer swath data.

b) Melting layer detection

The algorithm for melting layer bottom and top detection is applicable to both DPR inner and outer swath melting layer detection. However, for DPR outer swath, the radar scan angle is larger, which will affect (increase) the range bin number of melting layer top and bottom. The slant range is larger than the vertical range following a cosine relation. Total of 45,000 vertical profiles are used in melting layer testing. The test data was used to study the broadening of the profiles between inner swath and outer swath and the details are skipped for brevity.



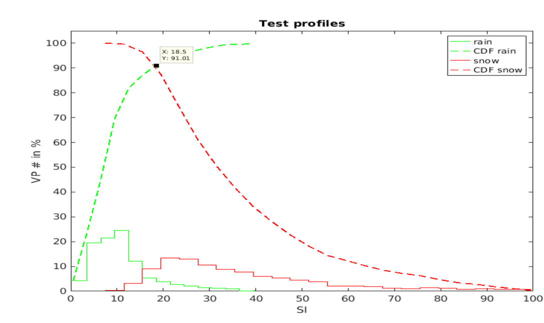
(a) (b)

Figure 6. Detected melting layer for DPR orbit # 22622, scan 1299 at (a) angle bin # 18 and (b) nadir.

For illustration, sample vertical profile is shown to demonstrate melting layer top and bottom detection at inner and outer swath. DPR orbit # 22622, scan 1299 is shown in the above figures. From (b) to (a) (from nadir to off-nadir), red solid lines move downward due to the slant range change. To correct this, cosine adjustment is applied to the profile. (a) shows the detection after angle correction. Dashed red lines are the melting layer boundaries after correction are applied. This type of adjustment/consistency check will be implemented to the dual-frequency classification module in the DPR outer swath.

c) Surface snowfall identification

A surface snowfall index is another product that is part of the suite of DPR algorithms (Le et al. 2017). It provides a "snow flag" at surface using dual-frequency profile information. The snow index is somewhat sensitive parameter and it was developed originally for best inner swath performance. For DPR outer swath, the snow index needs to be evaluated and fine-tuned with the outer swath data. However, in the test data there are not many profiles for snow case to be evaluated, we still collected total of 860 snow profiles and 79042 rain profiles within 46 GPM orbits for an initial evaluation. Snow profiles are chosen using 0 degree information and reflectivity values for this test purpose. Threshold of snow index for rain / snow separation is calculated for outer swath data as shown in the figure below.

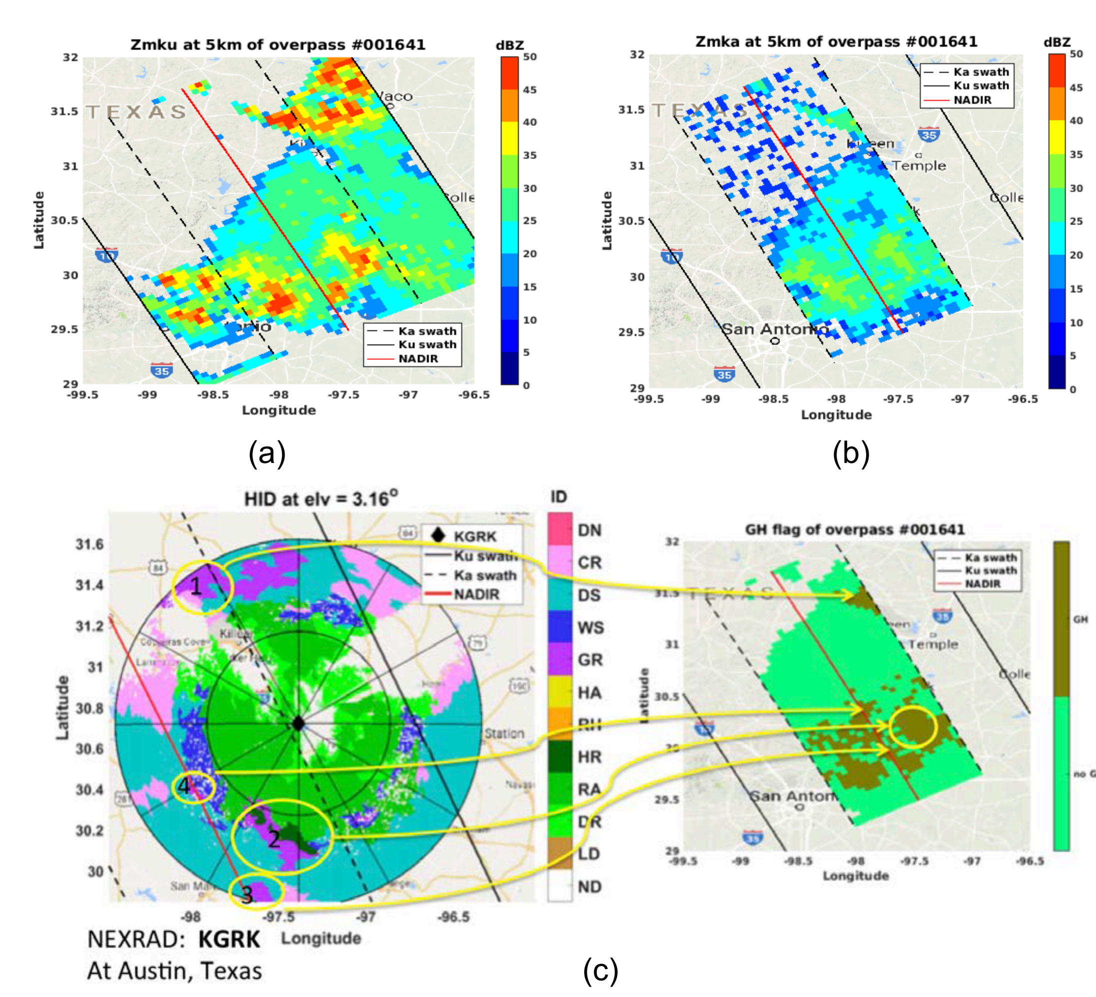


More than 90% rain and snow profiles can be separated with the snow index. This value is slightly different (<10%) from inner swath test. This result is expected because snow index is a "value based" parameter, not the "location based" parameter.

Figure 7. Histogram of snow index for snow and rain using constructed DPR outer swath data.

Application to graupel and Hail identification

Similar to the approach that was used in the surface snowfall identification, we study DPR vertical profiles for graupel and hail. We identify profiles with graupel and hail that has the value of the "Precipitation type index" value below a certain threshold for most of the case and this threshold can effectively separate these profiles. Preliminary comparison with ground based dual-polarization radar observations show excellent agreement and we plan to extensively evaluate this precipitation type index for graupel and hail and release the new product in the next version release. Figure below provides a preliminary example of the validation of the graupel/Hail identification using coordinated data with NEXRAD radar observations near Austin, Texas. Hydrometeor identification from NEXRAD is applied to KGRK radar. Magenta color represents graupel in the plot. Four locations with magenta color have a good one to one match of "GH flag" as illustrated by yellow arrows. We plan to further validate the product with observations over many locations and in-situ validation. More details are in Le and Chandrasekar, 2018.



(a) (b) (c)

Figure 8. GPM DPR overpass # 1641. (a) Zmku at 5km. (b) Zmka at 5 km. (c) Hydrometeor of KGRK radar which captured the same precipitation in (a) and (b) and its correspond match of GH flag results.

Summary

The algorithm to perform melting layer detection has been updated. Melting layer top detection is largely improved. Algorithms currently implemented in the dual-frequency classification module are adjusted for full DPR swath. Parameter tuning and testing are undergoing. Preliminary results show that algorithms are affected less than 10%.

Reference

M. Le and V. Chandrasekar, Evaluation and Validation of GPM Dual-frequency Classification Module after Launch, J. Atmos. Oceanic Technol., Special Collection: Precipitation retrieval algorithms for GPM. December, 2016.

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