PRECIPITATION TYPE AND PROFILE CLASSIFICATION Module FOR GPM-DPR

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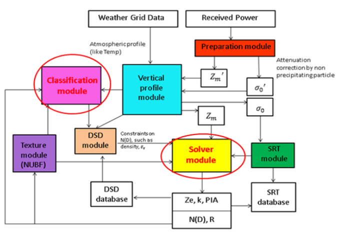
Framework for DPR-L2

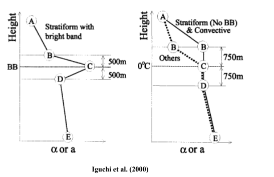
Classification module is a critical module in the microphysical retrieval system for space precipitation radar.

The nature of microphysical models and algorithms used in the retrieval are determined by the precipitation type for each profile.

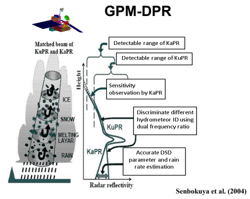
Flowchart of GPM-DPR L2 algorithm



TRMM-PR



GPM-DPR



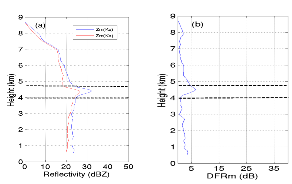
Measured dual-frequency ratio (*DFRm*)

$$DFR_m = Z_m(K_u) - Z_m(K_a) = \left(Z_e(K_u) - PIA_{K_u}\right) - \left(Z_e(K_a) - PIA_{K_a}\right)$$
$$= \left(Z_e(K_u) - Z_e(K_a)\right) + \left(PIA_{K_a} - PIA_{K_u}\right) = DFR + \delta PIA$$

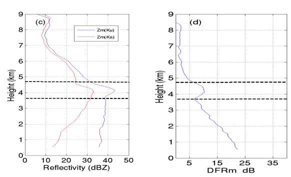
DFR **: Dual-frequency ratio. Caused by Non-Rayleigh scattering effect**

δPIA **: Attenuation difference (>0 dB)**

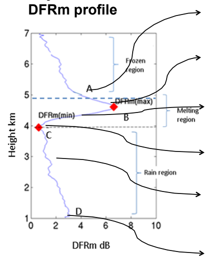
Stratiform rain



Convective rain



Key characteristics of DFRm profile



- DFRm slope maximum value at A
- DFRm maximum value at B
- DFRm slope between maximum and local minimum value (B,C slope)
- DFRm local minimum value at C
- DFRm slope between local minimum value and near surface value (C, D slope)
- DFRm value near surface at D

Dashed lines are melting layer boundaries using criteria in Le. et al (2011)

In order to quantify these features, a set of *DFRm* indices are defined. Let V1 be

$$V1 = \frac{DFR_m(max) - DFR_m(min)}{DFR_m(max) + DFR_m(min)} \qquad (1)$$

Let V2 be the absolute value of the mean slope of *DFRm* below the local min point.

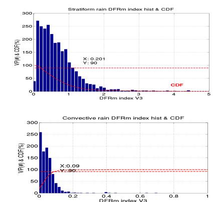
$$V2 = \mathrm{abs}(\mathrm{mean}(\mathrm{DFR_m\ slope})) \qquad (2)$$

Both V1 and V2 are normalized values and not dependent on the depth of melting region or the height of melting layer. In order to further enlarge the difference, a third *DFRm* index V3 is defined as

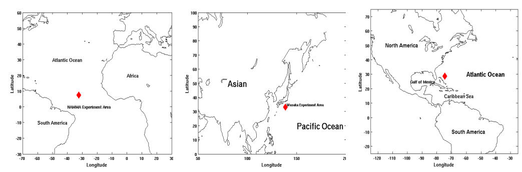
$$V3 = \frac{V1}{V2} \qquad (3)$$

The DFRm index V3 can be an effective parameter to perform profile classification.

- **Profile type classification model (PCM)**
  - **----- To classify stratiform, convective , and other rain type.**
- **Hydrometeor Identification model (HIM)**
  - **----- To detect melting layer boundaries (where melting starts and ends)**



NAMMA / Wakasa Bay / GRIP

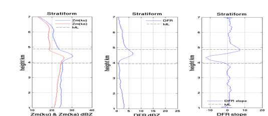


The CDF or (1-CDF)(cumulative density function) of V3 is calculated and the 90% confidence line gives:

Convective rain: V3< C1;
Stratiform rain: V3>C2;

90 % CDF	NAMMA	GRIP	Wakasa Bay
C1	0.09	0.120	0.101
C2	0.201	0.216	0.192

- In NAMMA, GRIP and Wakasa Bay cases, 90% CDF confidence line show that stratiform and convective rain can be separated by DFRm index V3.
- C2 value (90% CDF value for Stratiform rain) for NAMMA, GRIP and Wakasa Bay cases are very close. This a good sign that C2 value might be stable at different geometry locations.

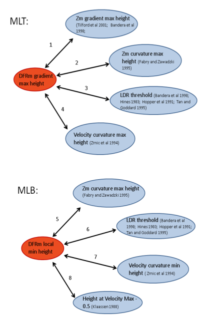


- Hydrometeor identification model *(HIM)* is the second model of the profile classification method.

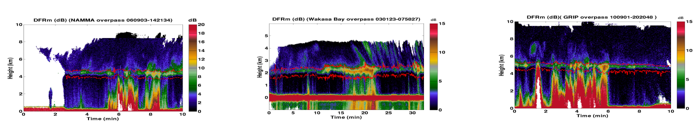
  The main parameter used in *HIM* is *DFRm* and its range variability.

  ---- Melting layer top is the height at which *DFRm* gradient has maximum value.

  ----Melting layer bottom is the height at which *DFRm* has a local minimum value.

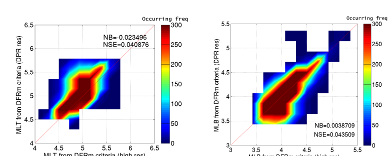


	Criteria	DFRm slope max (NAMMA)	DFRm slope max (GRIP)	DFRm slope max (Wakasa Bay)
Melting layer top comparisons	Zm slope max	NB= -0.026; NSE=0.036;	NB= -0.025; NSE=0.036;	NB= -0.049; NSE=0.066;
	Zm curvature max	NB= 0.016; NSE=0.033;	NB= 0.015; NSE=0.030;	NB= 0.028; NSE=0.052;
	LDR	NB= -0.028; NSE=0.045;	NB= -0.033; NSE=0.042;	NB= -0.06; NSE=0.072;
	* Velocity curvature max	NB= -0.013; NSE=0.036;	NB= -0.014; NSE=0.037;	NB= -0.019; NSE=0.056;
		DFRm local min (NAMMA)	DFRm local min (GRIP)	DFRm local min (Wakasa Bay)
Melting layer bottom comparisons	Zm curvature max	NB= 0.043; NSE= 0.055;	NB= 0.037; NSE=0.050;	NB= 0.043; NSE=0.069;
	LDR	NB= 0.045; NSE= 0.059;	NB= 0.040; NSE=0.054;	NB= 0.054; NSE=0.112;
	*Velocity curvature min	NB= 0.022; NSE= 0.049;	NB= 0.017; NSE=0.044;	NB= -0.0008; NSE=0.07;
	*Velocity max	NB= 0.016; NSE= 0.059;	NB= 0.019; NSE=0.043;	NB= -0.026; NSE=0.139;



Resample comparison

90% CDF	NAMMA (resample)	GRIP(resample)
C1	0.093	0.13
C2	0.210	0.20



The evaluation of the resampled APR2 data (DPR resolution) shows the method is applicable to GPM-DPR observations.

SUMMARY

- DFRm precipitation type and profile classification module is presented for GPM.
- A set of indices are defined and subsequently used to perform profile classification.
- Cross validation of the classification algorithm was performed using auxiliary information such as velocity and linear depolarization ratio.

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