Comparison of DPR and GMI precipitation rate estimates

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Core satellite
Dual-frequency Precipitation Radar (DPR)
GPM Microwave Imager (GMI)

Constellation Satellites
Microwave Imagers and Sounders

GSMAp
KuPR: 13.6GHz
KaPR: 35.5GHz

KuPR(13.6GHz) similar to TRMM/PR(13.8GHz)
KaPR(35.5GHz) higher frequency for solid particles

Simultaneous measurement of KuPR and KaPR should give better precipitation estimates
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DPR (Level 2) algorithms

Section 2
DPR (Level 2) algorithms

• At level 2, physical variable or parameters related to precipitation are determined for each pixel.

• DPR (Level 2) algorithms are composed of three algorithms

Single-frequency algorithms

KuPR algorithm (for 13.6GHz)
KaPR algorithm (for 35.5GHz)

Dual-frequency algorithm (for 25)

(for 24 and 25, same or very similar results with single-frequency algorithm)
DPR (Level 2) algorithms

• At level 2, physical variable or parameters related to precipitation are determined for each pixel.

• DPR (Level 2) algorithms are composed of three algorithms

Single-frequency algorithms

KuPR algorithm (for $\lambda$ and $\lambda$)
DPR (Level 2) algorithms

- At level 2, physical variable or parameters related to precipitation are determined for each pixel.
- DPR (Level 2) algorithms are composed of three algorithms

Single-frequency algorithms

- KaPR algorithm (for 35.5GHz and 32GHz)

KaPR: 35.5GHz
DPR (Level 2) algorithms

• At level 2, physical variable or parameters related to precipitation are determined for each pixel.

• DPR (Level 2) algorithms are composed of three algorithms

- Single-frequency algorithms
  - KuPR algorithm (for $13.6\text{GHz}$)
  - KaPR algorithm (for $35.5\text{GHz}$)

- Dual-frequency algorithm (for $13.6\text{GHz}$ and $35.5\text{GHz}$, same or very similar results with single-frequency algorithm)
Single-frequency (KuPR) algorithm

Section 2.1.1
KuPR algorithm

PRE module (preparation)

VER module (vertical profile)

SRT module

SLV module (Solver)

CSF module (Classification)

DSD module

Level 1 Product (echo power)

\( \sigma^0_{m*} \)

\( Z_{m*} \)

Attenation correction for non precipitating particles

Attenation correction for precipitation

\( \sigma^0_m \)

\( Z_m \)

Surface Reference Technique

PIA

Type classification BB detection

k-\( Z_e \)

Scattering Table

Precipitation Rate, DSD

Rain or No-rain
KuPR algorithm

• Basically similar to TRMM/PR algorithm

• But, with minor differences
  • \( Z_e \neq \) DSD parameters \( \neq R \) (In TRMM/PR, \( R=aZ_e^b \))
  • Scattering tables and \( k-Z_e \) relations are from V6 not V7.
  • (currently) no temporal reference, no NUBF correction
  • Side lobe clutter, noise level…

• Comparison of PR and KuPR at their matchup cases
Matchup of PR and DPR(KuPR)

An example of one-day orbits of TRMM and GPM (March 27, 2014)

From JAXA Website
Matchup

Case 1

PR(V7)

- PR  Orbit#93121  13:59:56 March/22nd/2014
- DPR  Orbit#00356  13:56:13 March/22nd/2014

(223 sec. difference)
Matchup
Case 1

KuPR(01E)

- PR  Orbit#93121  13:59:56 March/22\textsuperscript{nd}/2014
- DPR  Orbit#00356  13:56:13 March/22\textsuperscript{nd}/2014
(223 sec. difference)
Matchup
Case 1

PR(V7)

- PR Orbit#93121 13:59:56 March/22nd/2014
- DPR Orbit#00356 13:56:13 March/22nd/2014
(223 sec. difference)
Matchup Case 1

KuPR(01E)

- **PR** Orbit#93121 13:59:56 March/22nd/2014
- **DPR** Orbit#00356 13:56:13 March/22nd/2014

(223 sec. difference)
Matchup Case 2

PR(V7)

• PR Orbit#93149 09:09:09 March/24th/2014
• DPR Orbit#00384 09:06:48 March/24th/2014
(141 sec. difference)
Matchup Case 2

KuPR(01E)

- PR Orbit#93149 09:09:09 March/24\textsuperscript{th}/2014
- DPR Orbit#00384 09:06:48 March/24\textsuperscript{th}/2014

(141 sec. difference)
Matchup Case 2

PR(V7)

- PR  Orbit#93149  09:09:09 March/24th/2014
- DPR  Orbit#00384  09:06:48 March/24th/2014

(141 sec. difference)
Matchup Case 2

KuPR(01E)

- PR Orbit#93149 09:09:09 March/24th/2014
- DPR Orbit#00384 09:06:48 March/24th/2014 (141 sec. difference)
Matchup Case 3

PR(V7)
Matchup Case 3

KuPR(01E)
Matchup Case 3

PR(V7)

- PR Orbit#93158 22:15:10 March/24th/2014
- DPR Orbit#00393 22:13:12 March/24th/2014 (118 sec. difference)
Matchup Case 3

KuPR(01E)

- PR Orbit#93158  22:15:10 March/24th/2014

(118 sec. difference)
Single-frequency (KaPR) algorithm

Section 2.1.2
KaPR algorithm

**PRE** module (preparation)
- $\sigma^0_m$ (Echo Power)
- $Z_m$ (Attenuation correction for non-precipitating particles)

**VER** module (vertical profile)
- $\sigma^0_m$ (Echo Power)
- $Z_m$ (Type classification, BB detection)

**SRT** module
- SRT DB
- Surface Reference Technique
- PIA
- Attenuation correction for precipitation

**SLV** module (Solver)
- $Z_e$ (Precipitation Rate, DSD)

**CSF** module (Classification)
- Type classification
- BB detection

**DSD** module
- k-Z$_e$
- Scattering Table

**GANAL**
- Rain or No-rain
KaPR algorithm

• Basically same as KuPR algorithm

• But, adjustments are needed.
  • Attenuation is heavy, sometimes echoes are disappeared
  • $k-Z_e$ relations for KaPR are under development
  • Bright band is not clearly seen
Comparison of precipitation rates between KuPR and KaPR algorithms

- Because of heavy attenuation, KaPR underestimates precipitation rates when KuPR estimates are higher than 10 mm/h.

- Because of lower sensitivity, KaPR underestimates precipitation rates or detects no precipitation when KuPR estimates are lower than 1 mm/h.
Dual-frequency algorithm

Section 2.2
Attenuation correction for non-precipitating particles.

Type classification and BB detection.

Attenuation correction for precipitation.

Precipitation Rate, DSD.
Dual-frequency algorithm

- **Main stream** is same as KuPR algorithm,
  
  **KuPR**’s $Z_m \mp \quad \text{KuPR’s } Z_e \mp \quad \text{DSD & precipitation rate}$

- But, several dual-frequency methods are applied
  - PIA(\text{KuPR}) is estimated by Dual-frequency SRT (DSRT)
    - $\delta\text{PIA} \equiv \text{PIA(KaPR)} - \text{PIA(KuPR)}$ is estimated by DSRT
    - $\text{PIA(KuPR)} = \delta\text{PIA}/(p+1)$ where $p = \text{PIA(KaPR)}/\text{PIA(KuPR)}$
      
      \hspace{1cm} \text{(Meneghini et al. 2012, IEEE TGRS)}

  - $k-Z_e$ relation is initially set according to Dual-frequency type classification (DFRm method)
    - $\text{DFR}_m = \text{dB}Z_m(\text{KuPR}) - \text{dB}Z_m(\text{KaPR})$
      \hspace{1cm} \text{(Le and Chandra 2013, IEEE TGRS)}

  - $k-Z_e$ relation is modified by HB-DFR method by means of
    - KaPR’s $Z_m$
      \hspace{1cm} \text{(Seto et al. 2013, IEEE TGRS)}
Comparison of precipitation rates between **KuPR** and **Dual-frequency** algorithms

- Dual-frequency algorithm’s estimates are not very different from those by **KuPR** algorithm.
- If dual-frequency methods are fully used, estimates are changed drastically, but currently dual-frequency methods are used cautiously.
- Further validation are necessary to use dual-frequency methods aggressively.

Dual-frequency

![Graph comparing KuPR and Dual-frequency algorithms](image)

Statistics if KuPR or DF has non-zero precipRateNearSurface

- Number: 17708
- BIAS: -0.184
- CORR: 0.799
- RMSE: 1.909

Red lines are average of DF’s pRNS
Solid line including zero estimates
Dotted line excluding zero estimates
Summary of section 2

• **KuPR** algorithm is basically similar to TRMM/PR algorithm, and they showed similar precipitation estimates in matched up cases, but **KuPR** can detect weaker precipitation.

• **KaPR** algorithm has similar structure with **KuPR** algorithm, but due to heavy attenuation and lower sensitivity, applicable range maybe from 1 to 10 mm/h.

• **Dual-frequency** algorithm implement three dual-frequency methods (classification, SRT, attenuation correction), but they are not fully used until their performance are well validated. Currently, Dual-frequency algorithm gives similar precipitation rate estimates with **KuPR** algorithm.
Comparison with GMI

Section 3
KuPR monthly rain estimates (May 2014)
GM I monthly rain estimates
(May 2014)
GMI - KuPR
(May 2014)
Zonal mean (May 2014)

Solid red is KuPR for KuPR swath
Solid blue is GMI for KuPR swath
Dotted blue is GMI for GMI swath
Zonal mean (May 2014)

Solid red is KuPR for KuPR swath
Solid blue is GMI for KuPR swath
(probability of precipitation)
Zonal mean (May 2014)

Solid red is KuPR for KuPR swath
Solid blue is GMI for KuPR swath
(pop is always set to 100%)

GMI (RNC=none)
KuPR (RNC=KuPR)

precipitation Rate [mm/month]

Latitude
Zonal mean (May 2014)

Solid red is KuPR for KuPR swath
Solid blue is GMI for KuPR swath
(precipitation judgement by KuPR)
Summary of Section 3

• Difference between KuPR and GMI
  • Caused by sampling
    • 1 x 1 deg., monthly large
    • Zonal mean, monthly small
  • Caused by retrieval and detection
    • TRMM region small
    • Higher latitude large (KuPR > GMI)
  • Caused by retrieval itself
    • TRMM region large (KuPR > GMI)
    • Higher latitude large (KuPR > GMI)