Advancement of the DPR-L2 precipitation retrieval algorithm

Joint PI Workshop of Global Environment Observation Mission 2013

Jan. 16th, 2014

Shinta SETO (Nagasaki University)

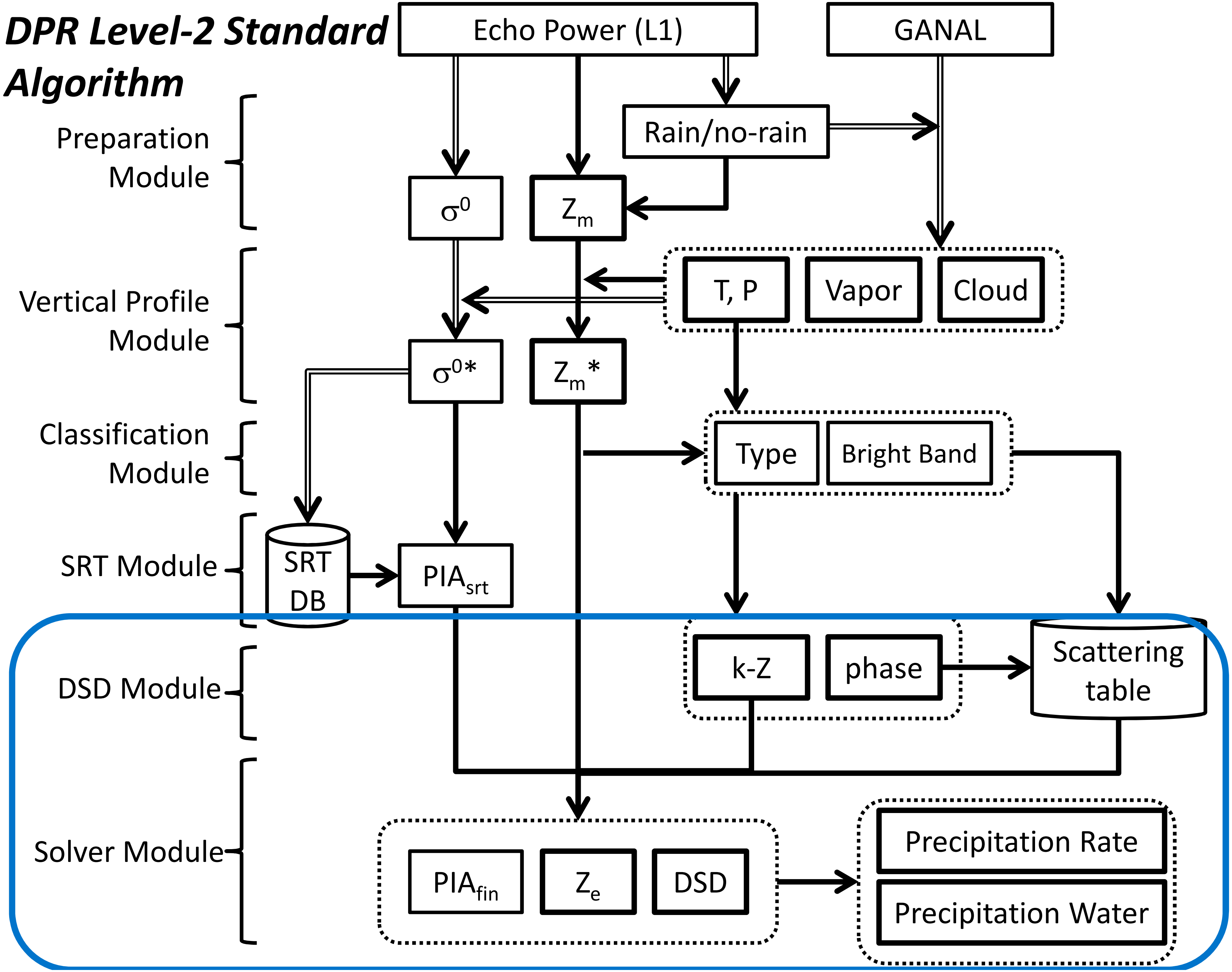
Contents

For *the At-launch code* of the DPR-L2 algorithm

- Use of SRT in the dual-frequency retrieval algorithm (HB-DFR-SRT method)

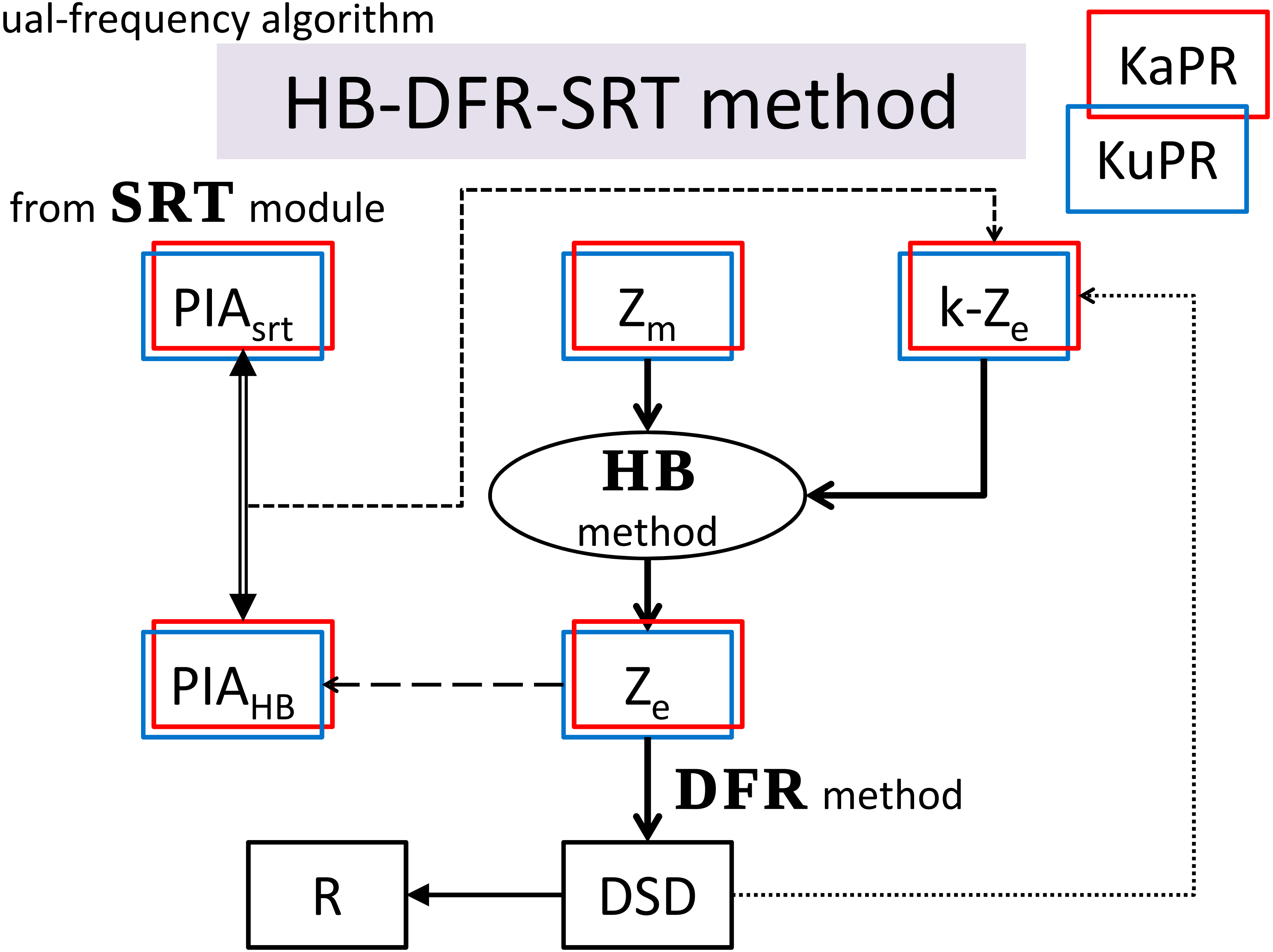
For *the post-launch code* of the DPR-L2 algorithm

- NUBF correction (for the edge of rain area)
- Extrapolation for clutter region


DPR Level-2 Standard Algorithm
Echo Power (L1)
GANAL
Preparation Module
Rain/no-rain
σ0
Zm
Vertical Profile Module
T, P
Vapor
Cloud
σ0*
Zm*
Classification Module
Type
Bright Band
SRT Module
SRT DB
PIAsrt
DSD Module
k-Z
phase
Scattering table
Solver Module
PIAfin
Ze
DSD
Precipitation Rate
Precipitation Water

Dual-frequency algorithm

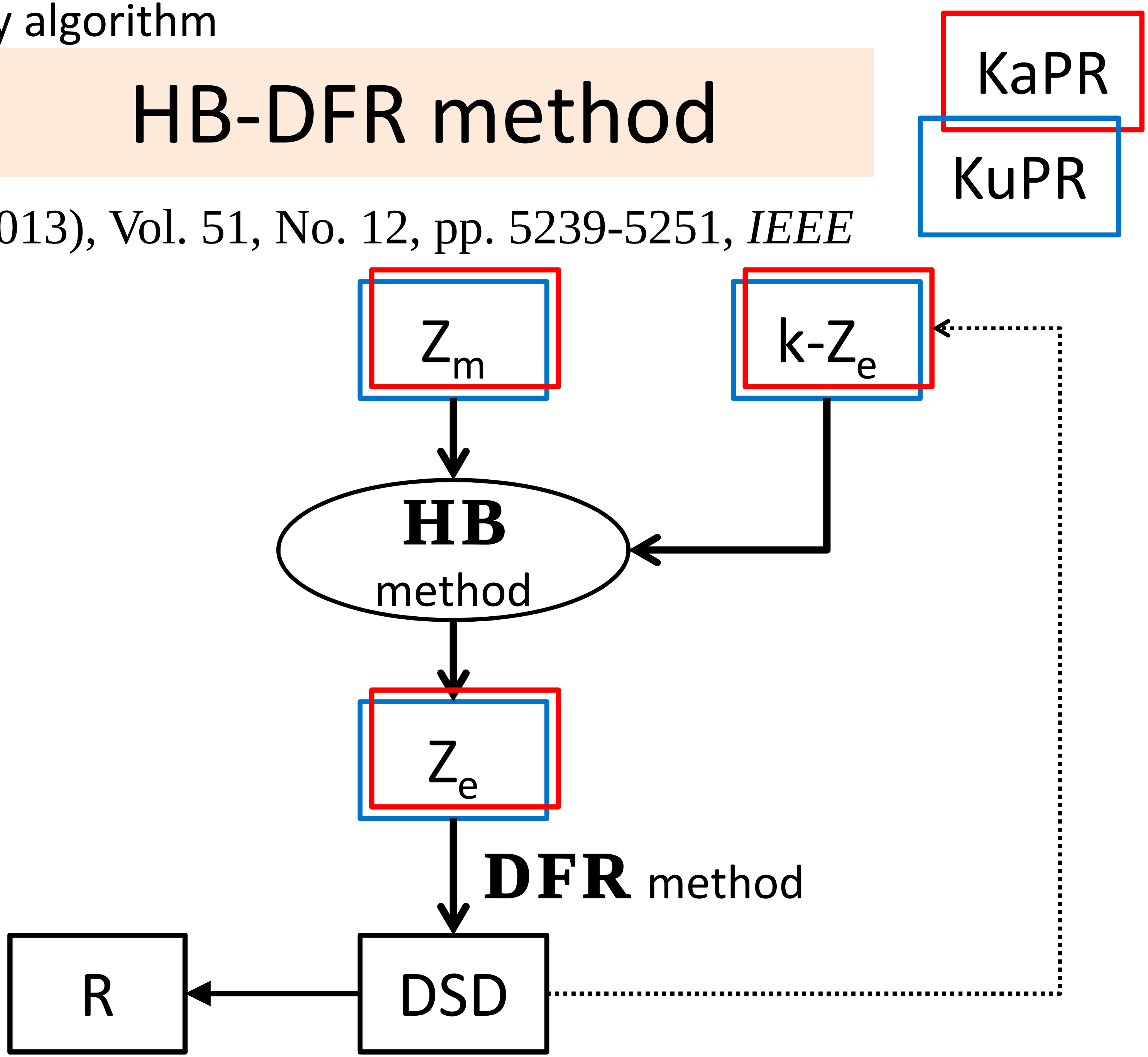
HB-DFR-SRT method



Dual-frequency algorithm

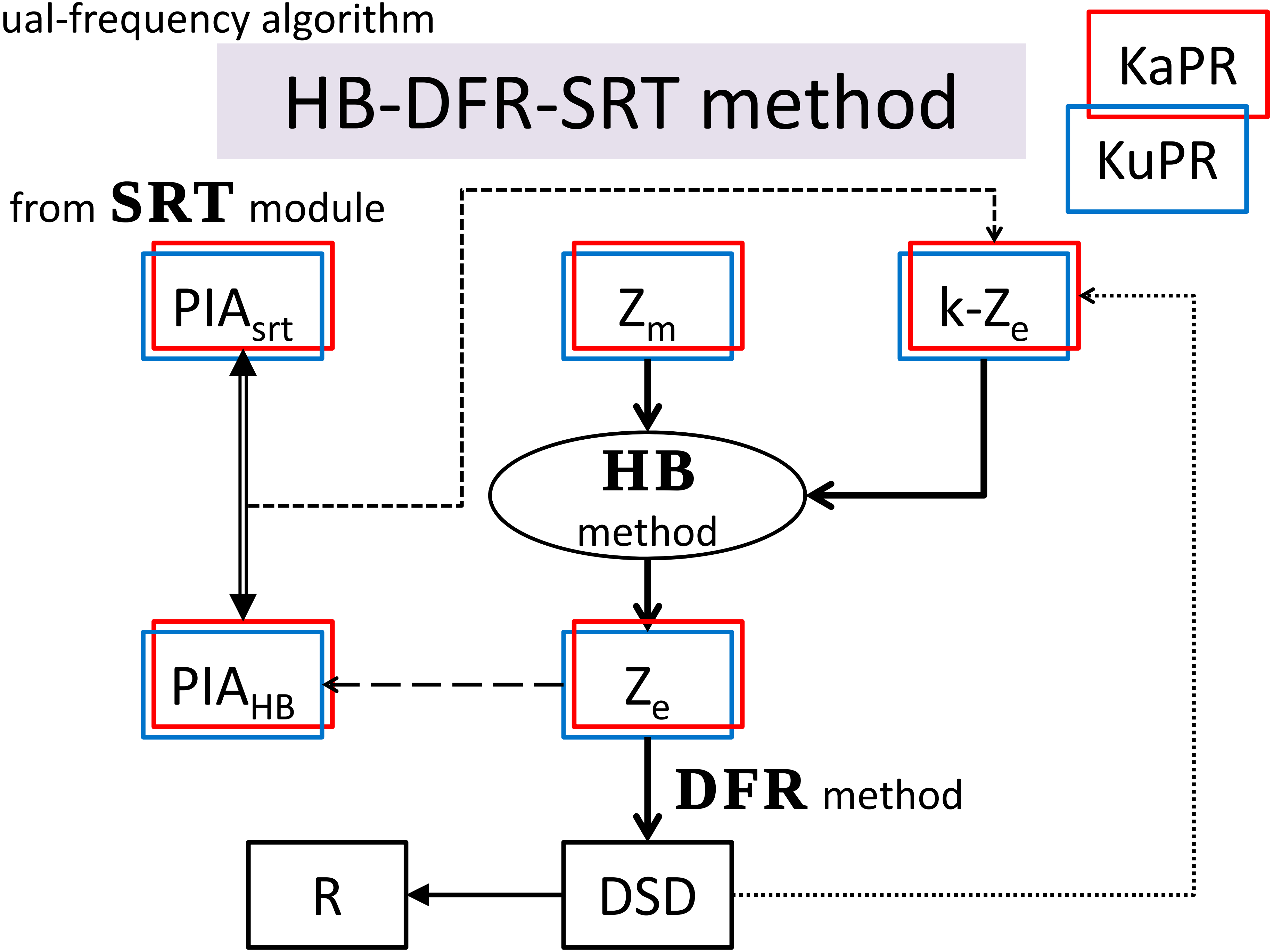
HB-DFR method

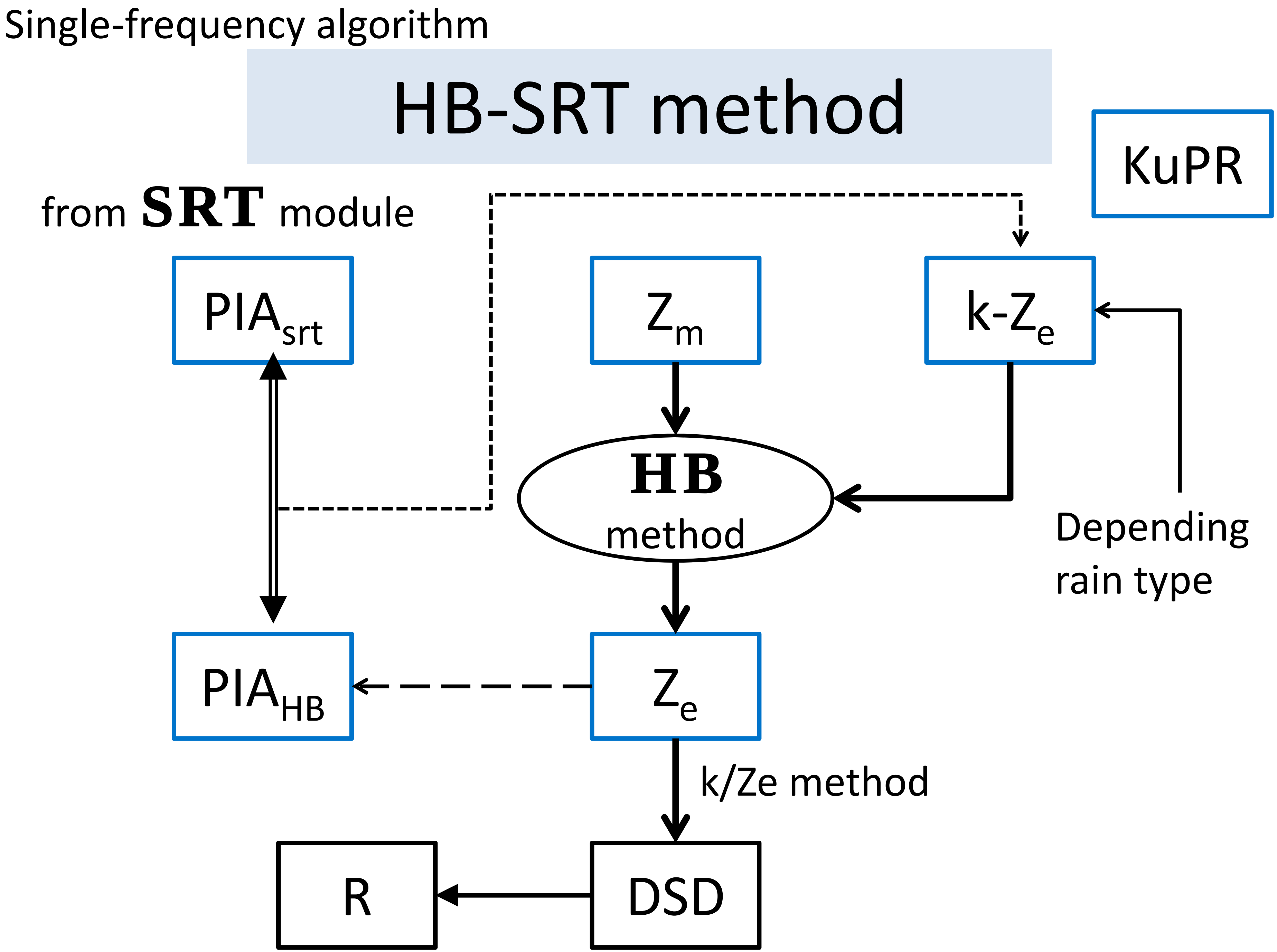
Seto et al. (2013), Vol. 51, No. 12, pp. 5239-5251, *IEEE TGRS*.



Dual-frequency algorithm

HB-DFR-SRT method

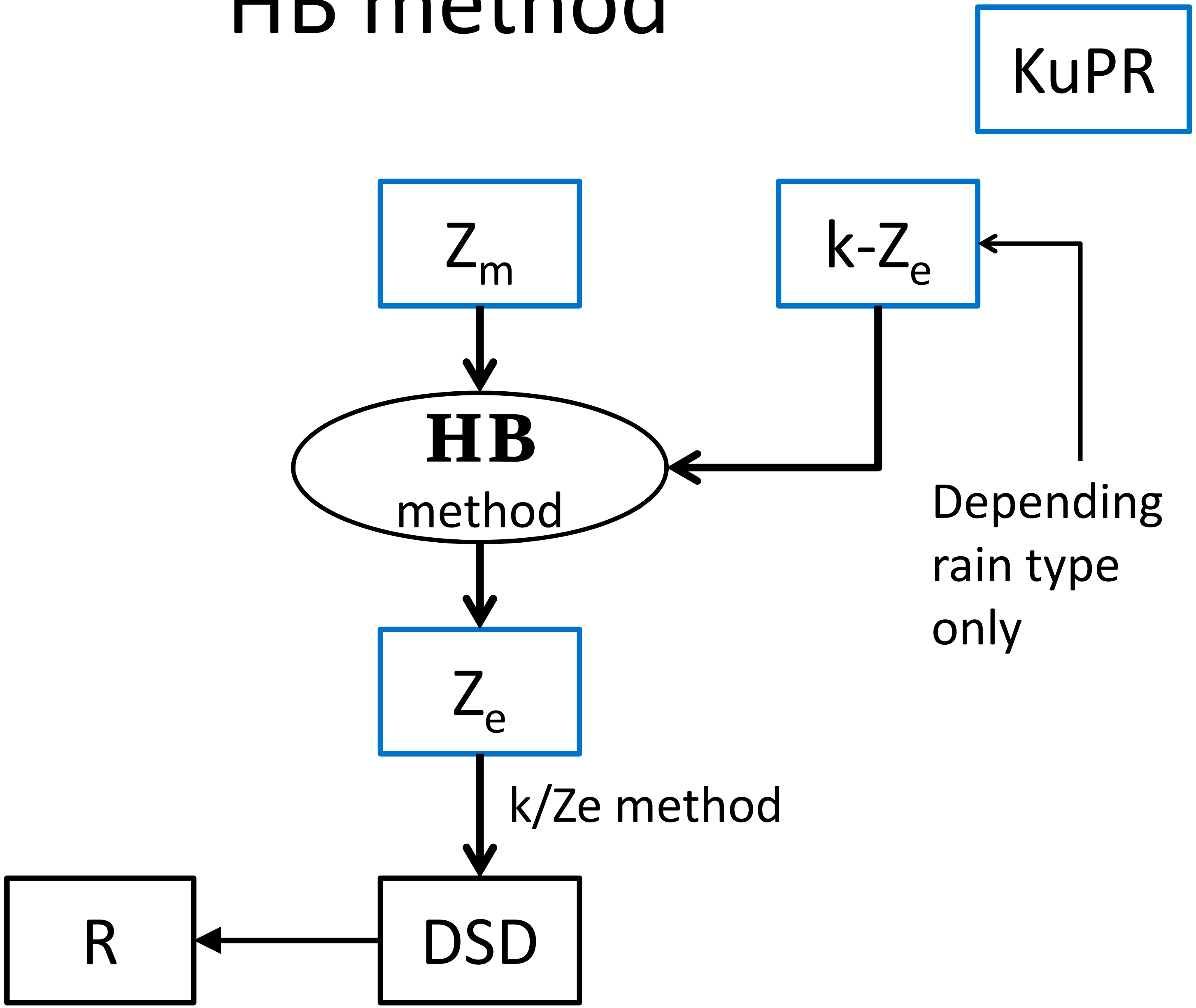




Single-frequency algorithm
HB-SRT method
KuPR
from SRT module
PIA_srt
Z_m
k-Z_e
HB
method
Depending
rain type
PIA_HB
Z_e
k/Ze method
R
DSD

Single-frequency algorithm

HB method



Comparison of the four methods

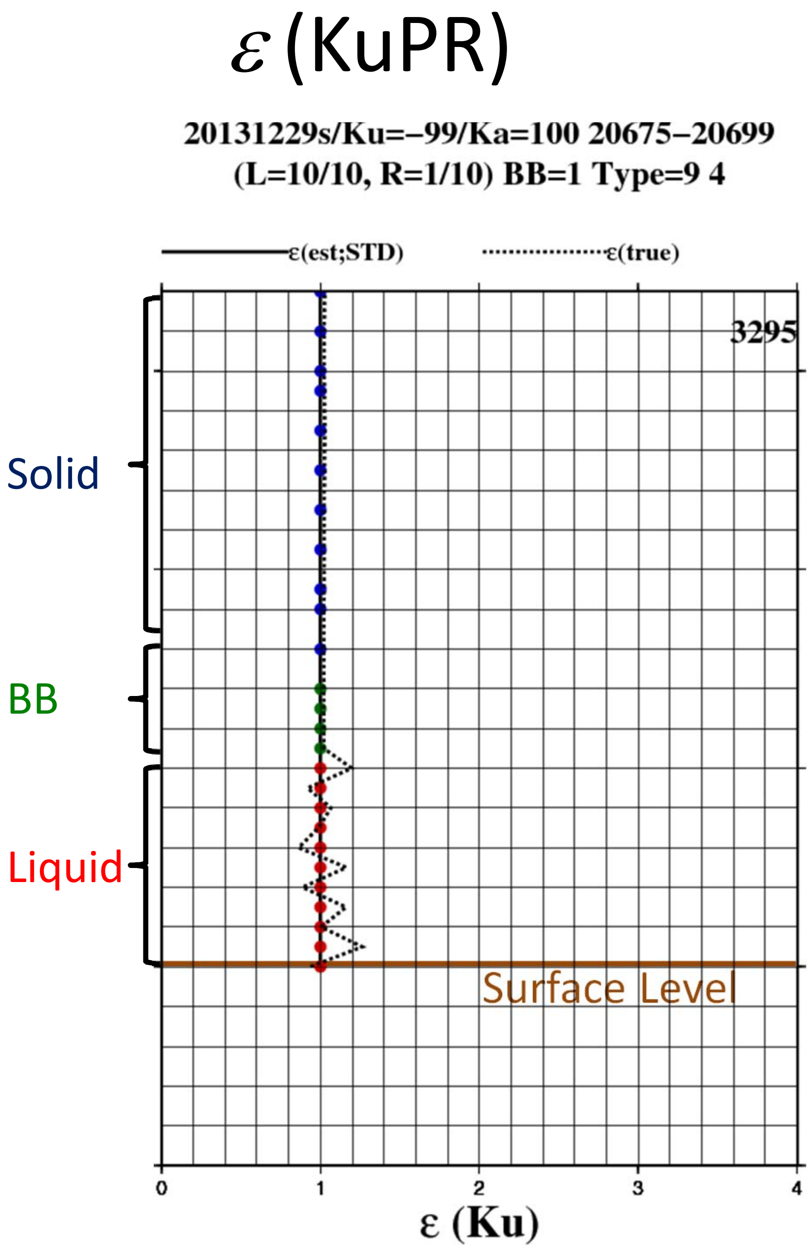
r is range from the radar, *f* is frequency, α and β are dependent on rain types.

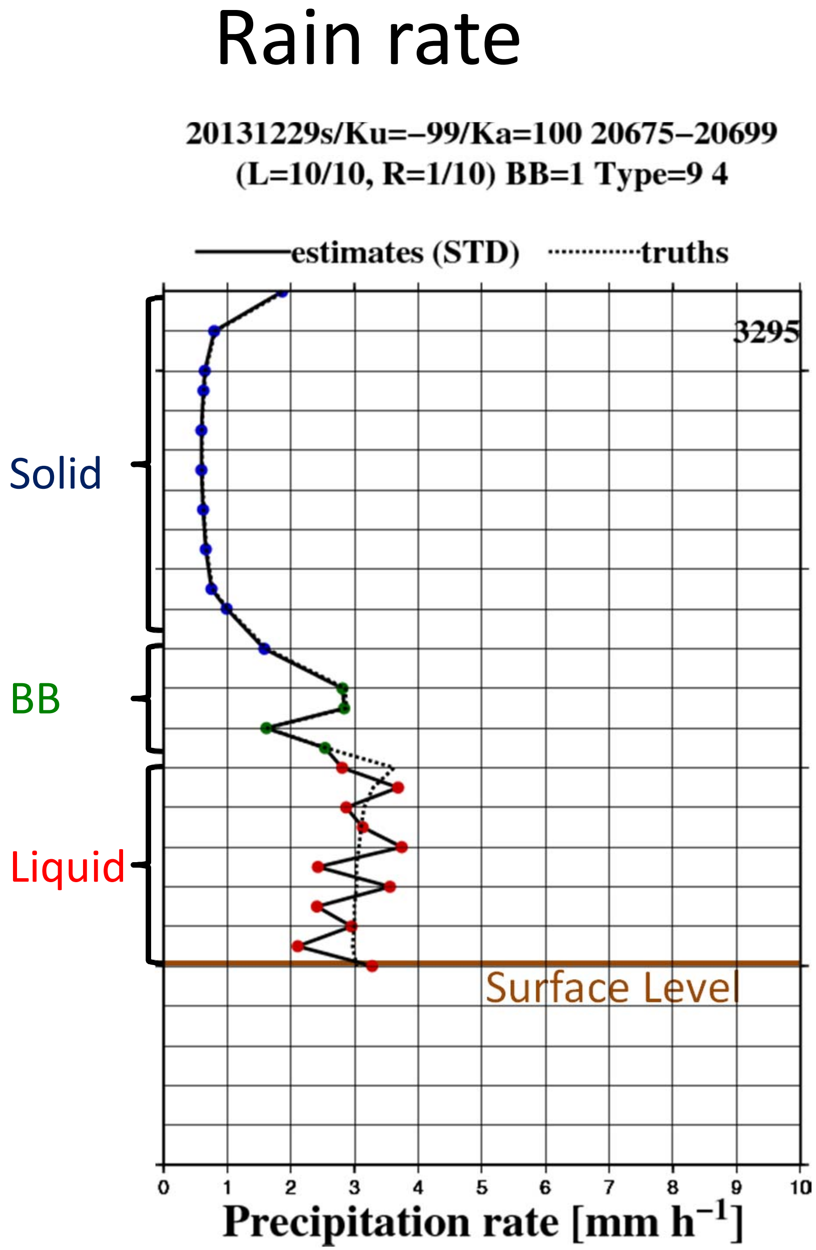
	Single-frequency	Dual-frequency
No SRT	HB method $k(r)=\alpha(r)Z_e(r)^{\beta}$ $\varepsilon = 1$	HB-DFR method $k(r;f)=\varepsilon_D(r;f)\alpha(r;f)Z_e(r;f)^{\beta(f)}$ $\varepsilon = \varepsilon_D$
With SRT	HB-SRT method $k(r)=\varepsilon_S\alpha(r)Z_e(r)^{\beta}$ $\varepsilon = \varepsilon_S$	HB-DFR-SRT method $k(r;f)=\varepsilon_S(f)\varepsilon_D(r;f)\alpha(r;f)Z_e(r;f)^{\beta(f)}$ $\varepsilon = \varepsilon_S\varepsilon_D$

Test under ideal conditions

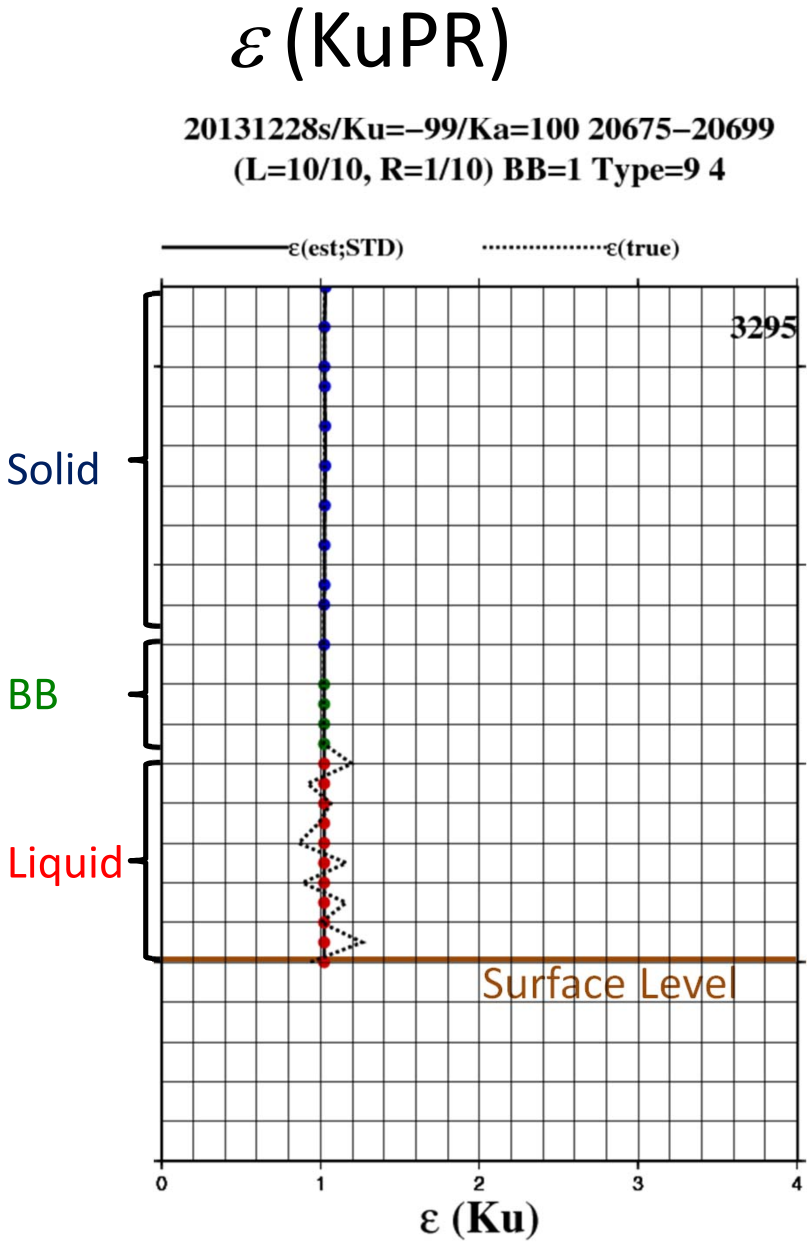
- The four methods are tested with simple synthetic dataset produced from TRMM/PR standard product 2A25 (orbit number 20675～20699)
  - No measurement errors in Z_m and No SRT errors
  - No noise (No lower limit of Z_m and no upper limit of PIA) and No clutter
  - When SRT is used, PIA by SRT is 100 % relied so that $PIA_{SRT} = PIA_{HB}$.
  - For liquid regions, different α is used for the retrieval from the synthetic data so that the true ε of KuPR is not vertically constant at each pixel.
  - Here, results are shown for the profiles with BB and 11 liquid-precipitation range bins.

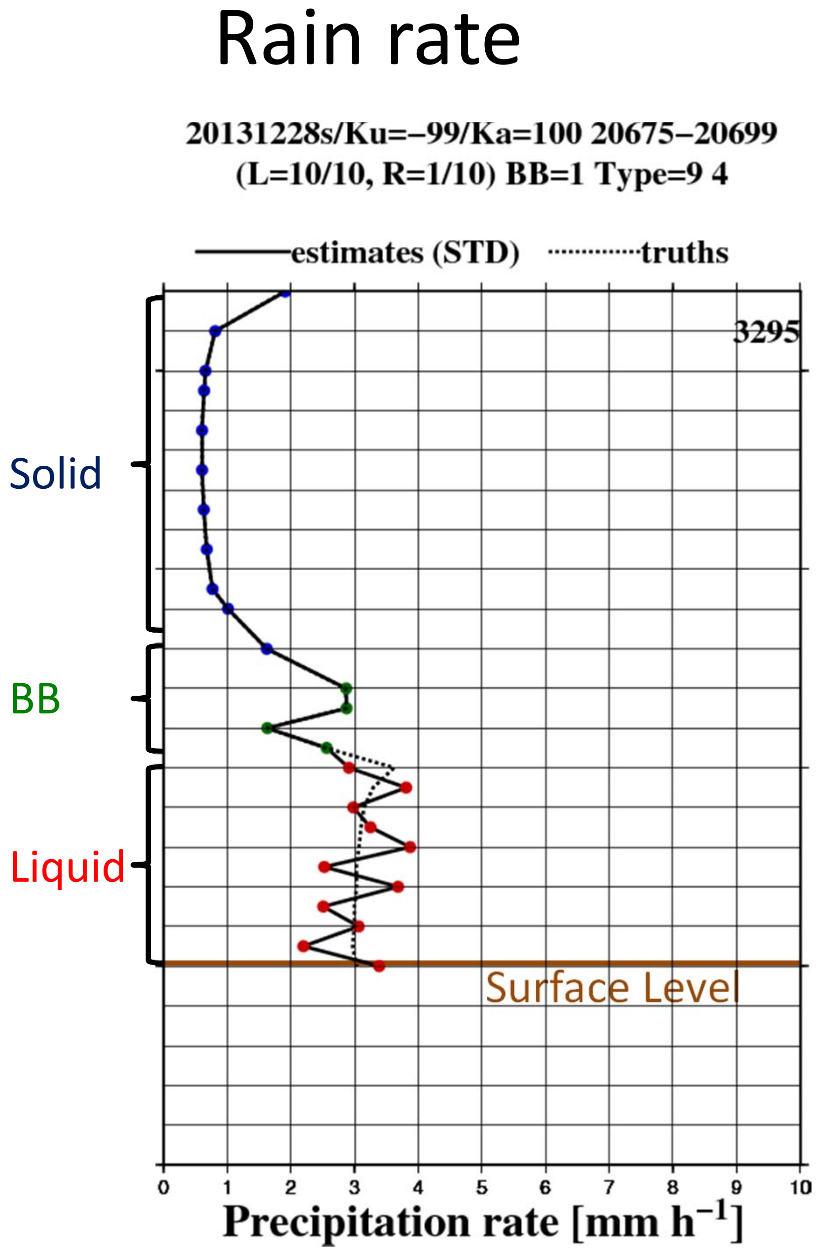
HB method


ε (KuPR)
20131229s/Ku=–99/Ka=100 20675–20699
(L=10/10, R=1/10) BB=1 Type=9 4
ε(est;STD)
ε(true)
3295
Solid
BB
Liquid
Surface Level
0
1
2
3
4
ε (Ku)

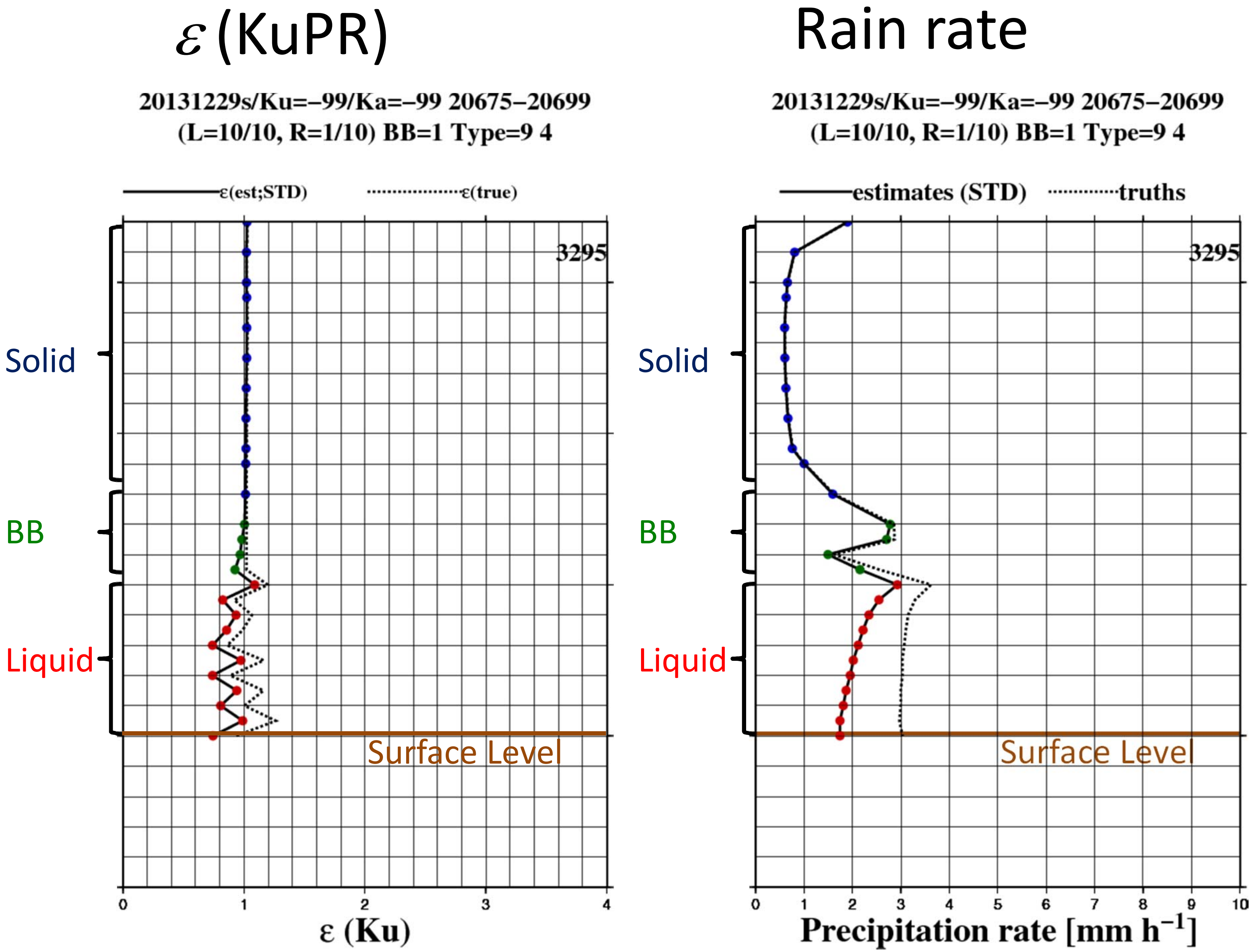

Rain rate
20131229s/Ku=–99/Ka=100 20675–20699
(L=10/10, R=1/10) BB=1 Type=9 4
estimates (STD)
truths
3295
Solid
BB
Liquid
Surface Level
0
1
2
3
4
5
6
7
8
9
10
Precipitation rate [mm h⁻¹]

HB-SRT method

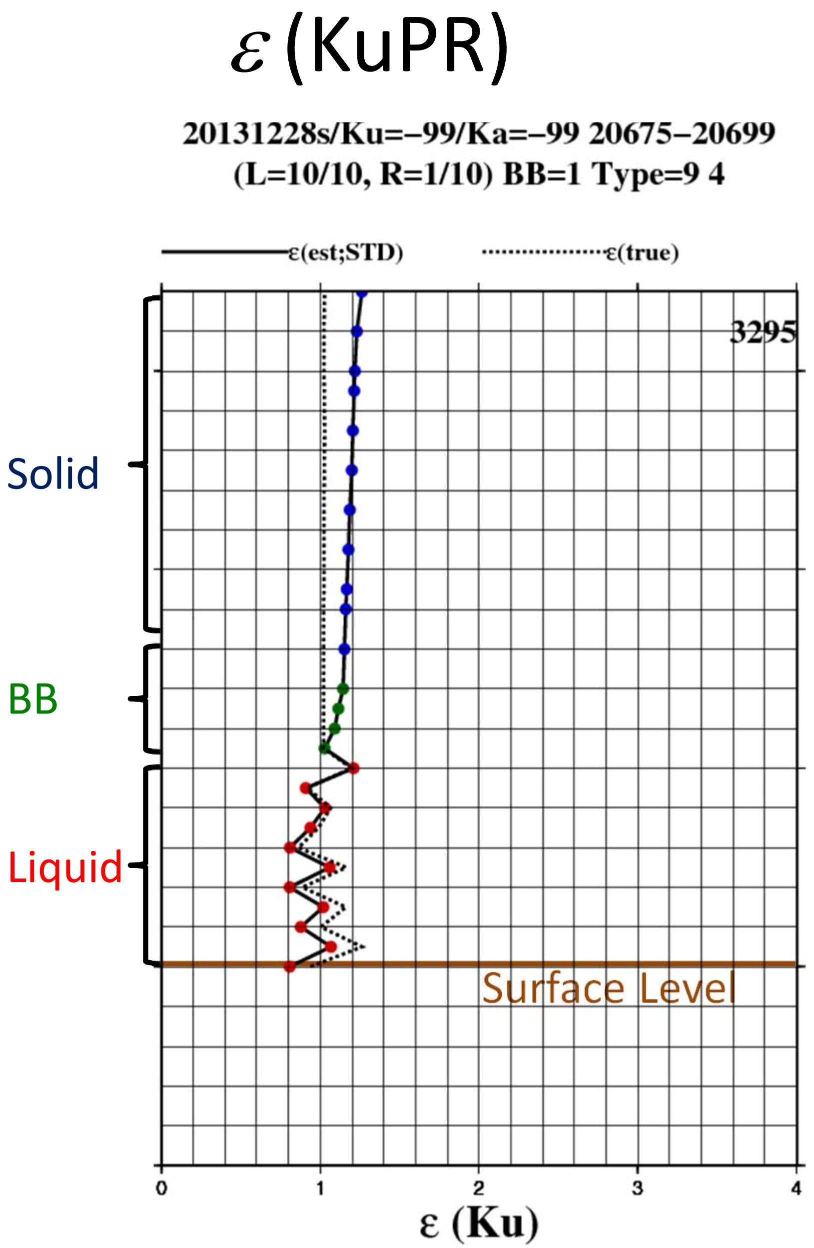


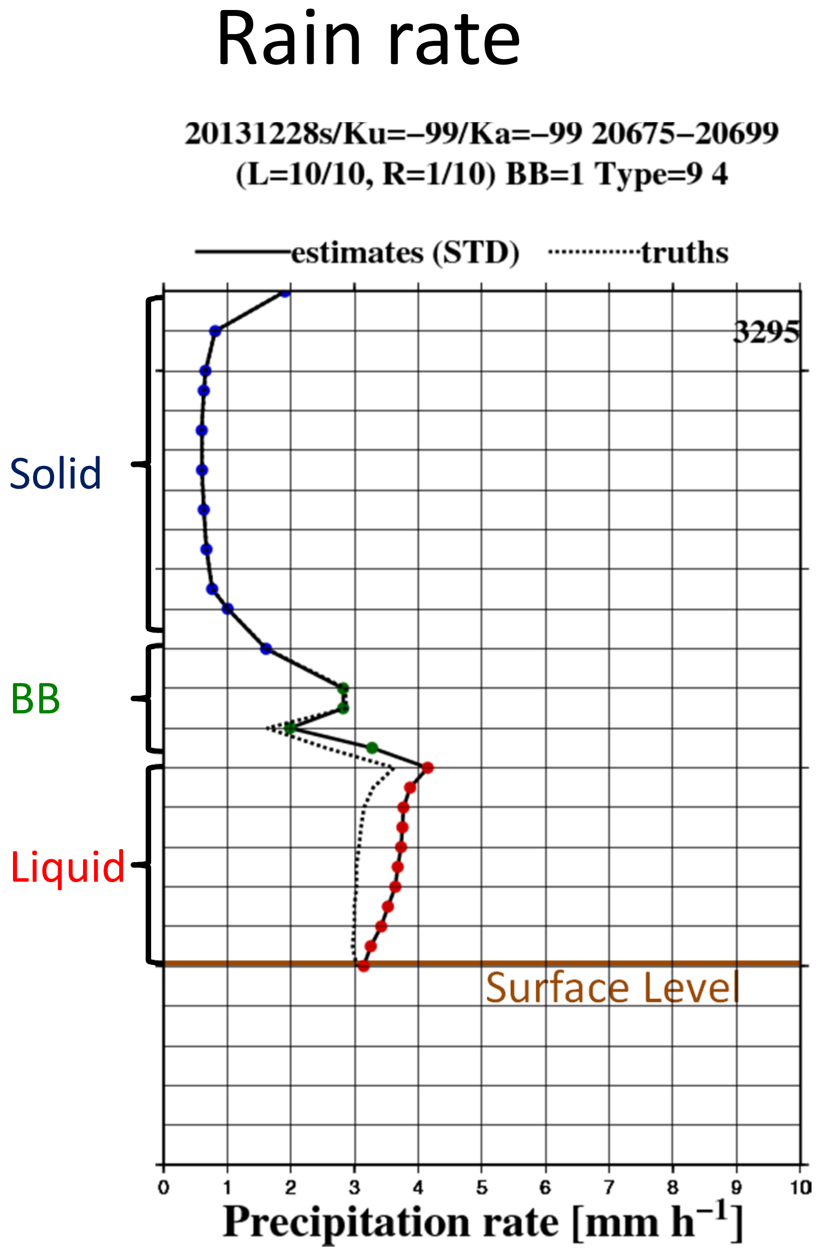


HB-DFR method



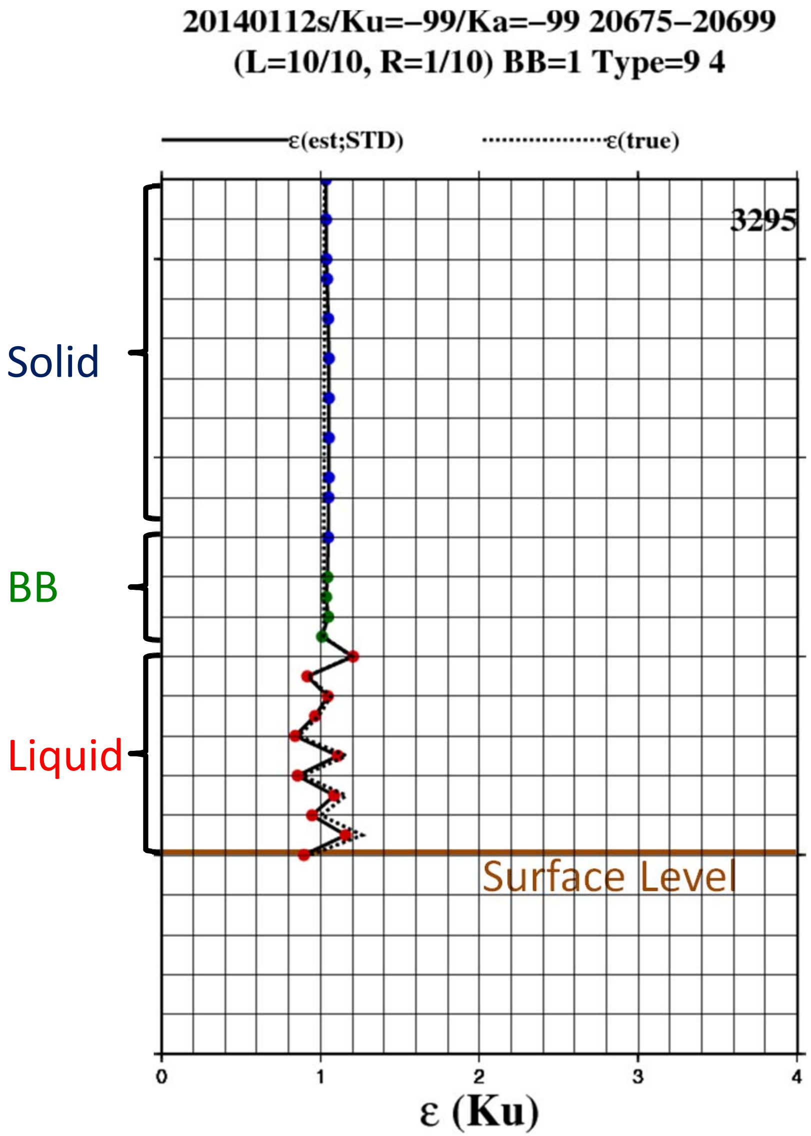
HB-DFR-SRT method



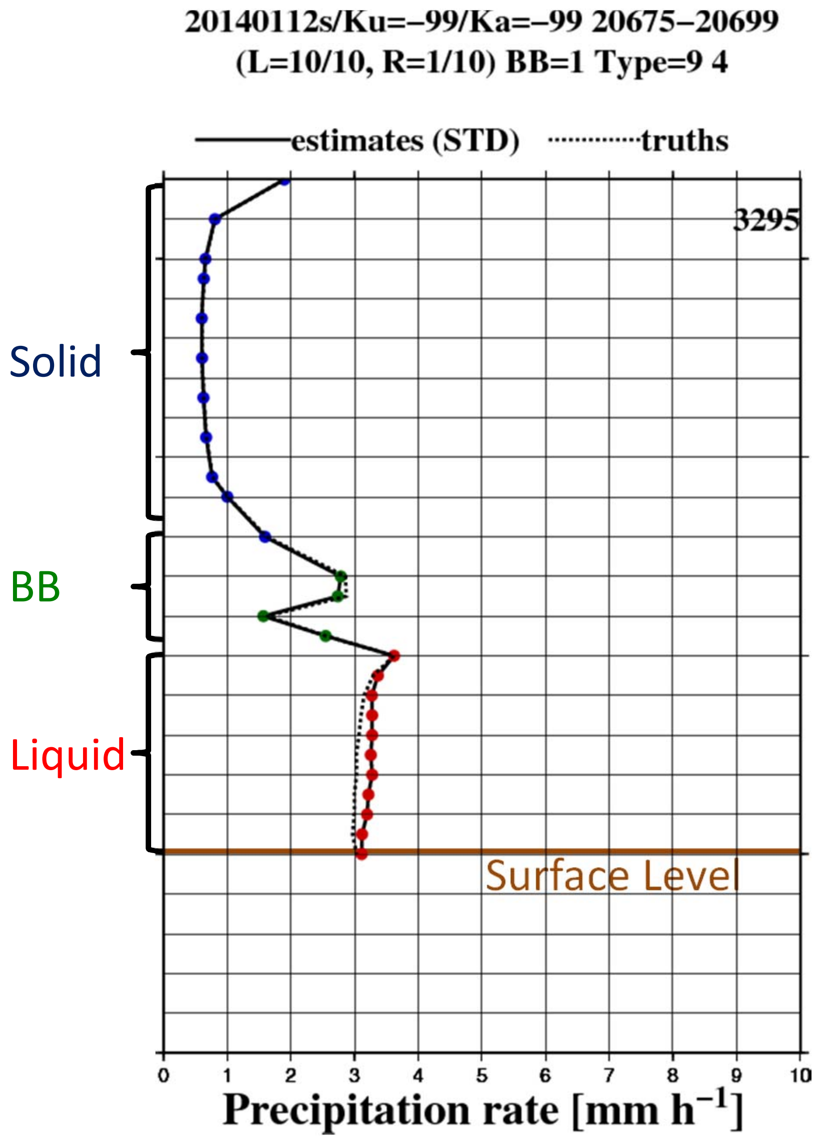


To be improved

ε (KuPR)

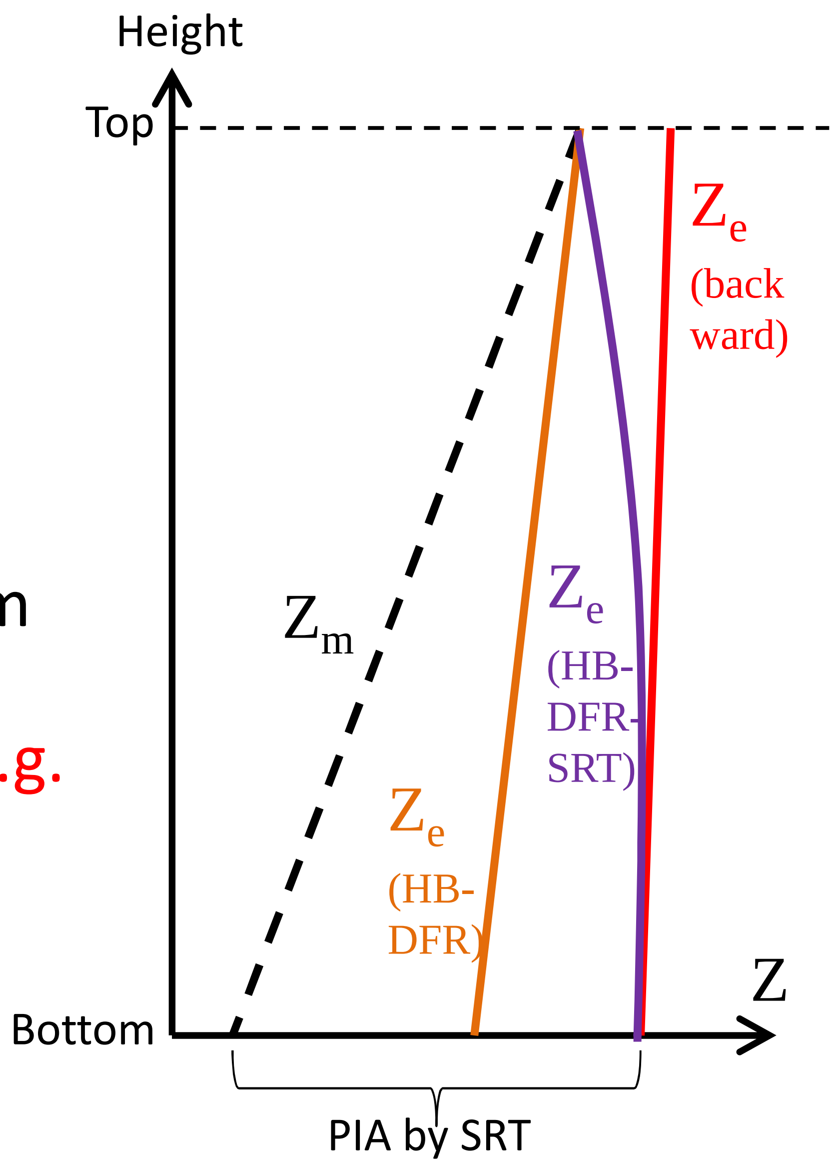


Rain rate



Advantage of HB-DFR-SRT method among dual-frequency algorithms

- HB-DFR-SRT method is, as far as I know, unique dual-frequency algorithm which can satisfy both the top and bottom boundary conditions.
- HB-DFR method (and Iterative backward retrieval method) generally do not satisfy the bottom boundary condition.
- The backward retrieval method (e.g. Meneghini et al. 1997) generally does not satisfy the top boundary condition.



Summary; HB-DFR-SRT method

- **satisfies the top and bottom boundary conditions.**
- **adjusts k-Z_e relation at each range bin.**
- can be switched to HB-DFR method when SRT is unavailable.
- can be switched to HB-SRT method for single-frequency measurement.
- has been installed into the *At-launch code* of the DPR-L2 algorithm.
- *does not give the perfect vertical profile of rain rate even when Z_m and PIA are perfectly given.*

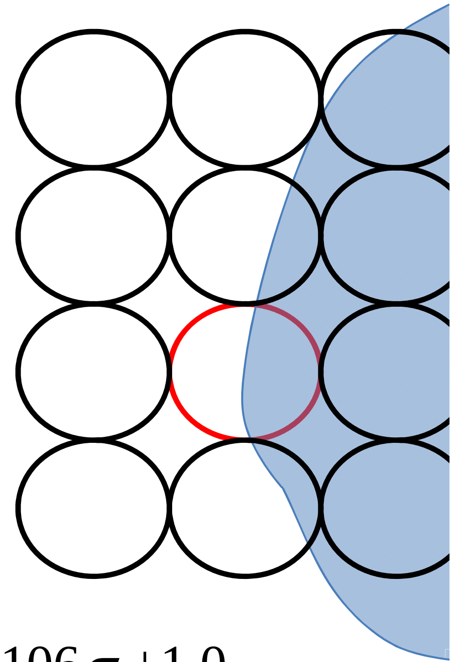
When HB-DFR-SRT algorithm is used in the DPR-L2

- SRT is not perfect. → Hybrid method between the original k-Z_e relation and PIA by SRT.
- KaPR suffers from attenuation → "Z_e-constant" assumption for heavy attenuation region as well as clutter region.
- HB-DFR method may not work so well → ε_D is between 0.8 and 2.0.
- Finally, rain rate is estimated not from DFR method but from k/Z_e method.

(Shota Hayashi, Nagasaki University)

A study on NUBF correction

- In TRMM/PR 2A25, *k* follows gamma distribution.
  → The same method can be applied in the DPR-L2.
- Here, considering the edge of rain area, rain rate takes two discrete values. (e.g. 0 mm/h or 10 mm/h)
  → Correction factors are derived empirically.

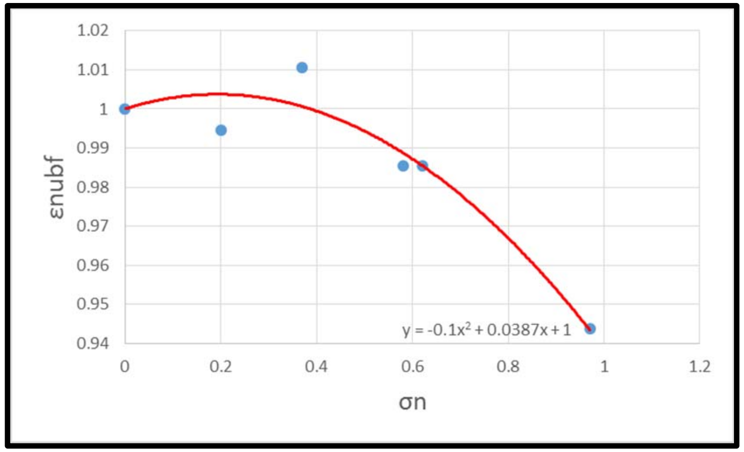


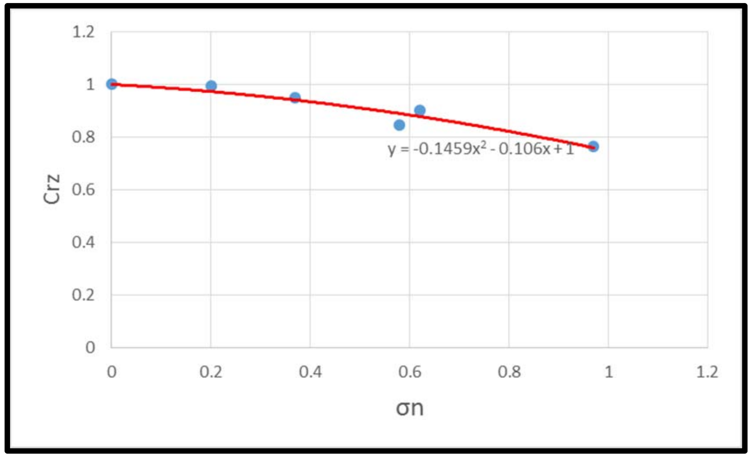
$$k(r)=\varepsilon_{nubf}\alpha(r)Z_e(r)^{\beta}$$

$$\varepsilon_{nubf}=-0.1\sigma_n^2+0.0387\sigma_n+1.0$$

$$R(r)=C_{RZ}a(r)Z_e(r)^{b}$$

$$C_{RZ}=-0.1459\sigma_n^2+-0.106\sigma_n+1.0$$





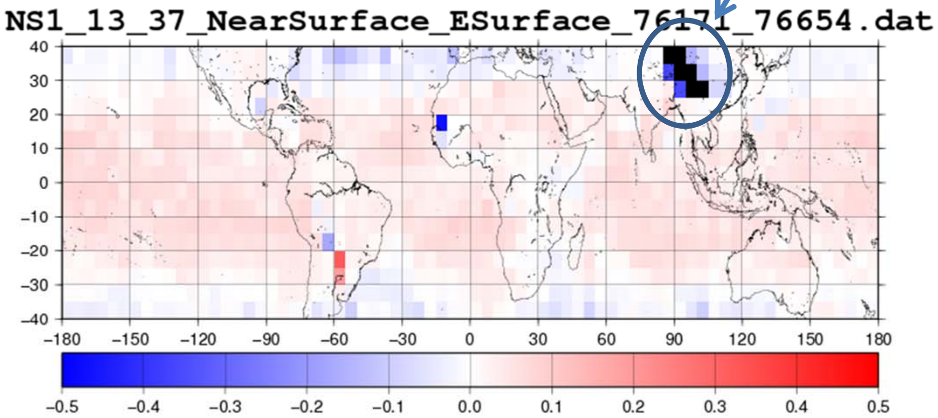
(Yuya Momosaki, Nagasaki University)

Extrapolation for the clutter region

- In the DPR-L2 algorithm, Z_e is assumed to be constant in the clutter region. But, the vertical change in Z_e may be dependent on environmental conditions.
  - Judging from precipRateESurface2, rain rate should increase in going downward over high mountains (orographic rainfall?)
  - precipRateESurface is severely smaller than precipRateNearSurface → Ze-constant assumption is inappropriate for non-liquid precipitation.

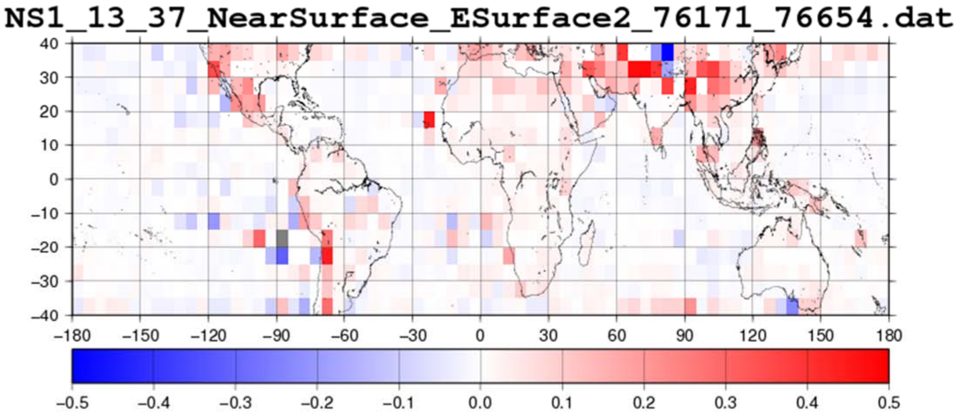
precipRateESurface

(change from precipRateNearSurface)



precipRateESurface2

(change from precipRateNearSurface)



Items to be installed in the DPR-L2

As soon as possible after the launch

- Improvement of HB-DFR-SRT
- NUBF correction
- Improved extrapolation for the clutter region
- The direct use of delta-PIA estimated from DSRT
- More realistic k-Z_e relation for KaPR
- Improvement of scattering databases

After the observation data is accumulated to some extent

- Weak rain reference method
- "Texture method"
- Angle bin dependence correction

Future Issue

- Multiple scattering

Summary

- HB-DFR-SRT method has been developed and implemented in *the At-launch code* of the DPR-L2 standard algorithm. We would like to improve the vertical profile.
- NUBF correction has not been installed in *the At-launch code*, but we are preparing the code.
- In the clutter region, Z_e is assumed to be constant in *the At-launch code*. We are trying to improve the extrapolation method considering the environmental conditions.
- Though many improvements should be done after the launch, basically the retrieval algorithm (DSD & SLV modules) is ready for the launch, I believe.

Published in 2013

- **Seto, S.**, T. Iguchi, T. Oki, 2013: The basic performance of a precipitation retrieval algorithm for the Global Precipitation Measurement mission's single/dual-frequency radar measurements. *IEEE Transactions on Geoscience and Remote Sensing*, Vol. 51, No. 12, pp.5239-5251.
- **Seto, S.**, T. Iguchi, N. Utsumi, M. Kiguchi, T. Oki, 2013: Evaluation of extreme rain estimates in the TRMM/PR standard product version 7 using high-temporal rain gauge datasets over Japan. *SOLA*, Vol. 9, pp. 98-101.

Members

- PI: Shinta Seto (Nagasaki University)
- CI: Toshio Iguchi (NICT)
- CI: Tosiaki Kozu (Shimane University)
- CI: Taikan Oki (University of Tokyo)
- CI: Hyungjun Kim (University of Tokyo)
- CI: Tanvir Islam (NOAA)
- CI: Susumu Ogawa (Nagasaki University)

We also would like to acknowledge

- Other DPR-L2 members (Awaka, Kubota, Meneghini, Liao, Hanado, Higashiuwatoko, Yoshida, Urita, …)
- Other JAXA people
- Students of Nagasaki University (Hayashi, Momosaki)