RealPEP P1- Radar-based QPE

Status on the most recent QPE-products provided for RealPEP and Outlook

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Outline

Recent results

- QPE of the flooding event in West Germany on 14 July 2021
  - ✓ Rainfall algorithms based on the method of the 1st work package (Chen et al. 2021)

  ** large vertical variability of the precipitation flux below the ML during the **warm-rain process** → underestimation of rainfall

  - ✓ JUXPOL radar used as a gap filler
  - ✓ Vertical profile correction using RD-QVPs

What I am doing now and the near-future work…

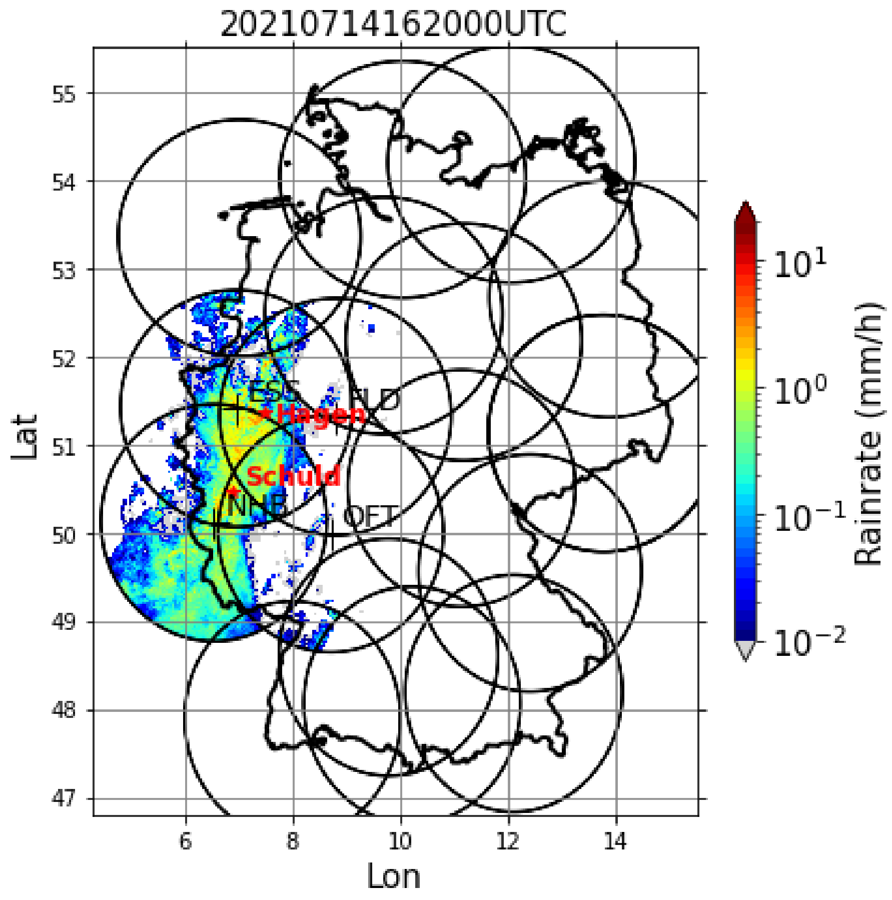
- Refinement of the ZPHI method
  - ✓ Ray-based alpha (in progress…)
  - ✓ Segment-wise applications along the radials (pure-rain segment)…

Recent results
QPE of the flooding event in West Germany on 14 July 2021

Before and after images from the Ahr and Eifel regions

https://www.dw.com/en/flooding-in-germany-before-and-after-images-from-the-ahr-and-eifel-regions/a-58299008

Rain map composite



DWD Radar-based QPE

Rain rate relations derived from DSD measurements

- ✓ 1 Parsivel from JOYCE
- ✓ 1 Thies from Bonn
- ✓ 29 Thies from DWD (within 4 radars' coverage)

→ Resulting in 2588 1min DSDs

QPE product list

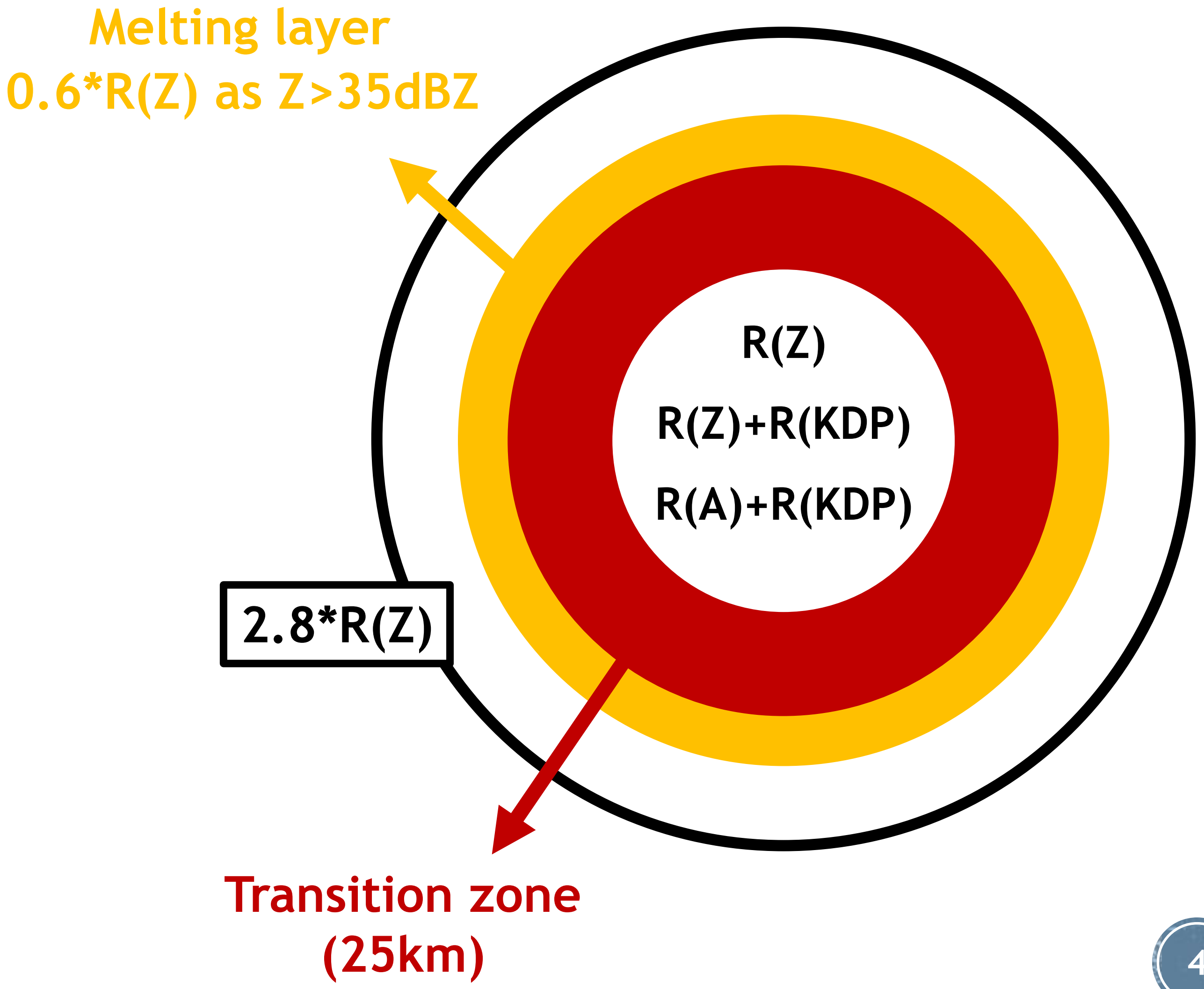
All radar coverage

- ✓ RW:DWD operational R(Z) QPE with gauge adjustment
- ✓ R(Z)

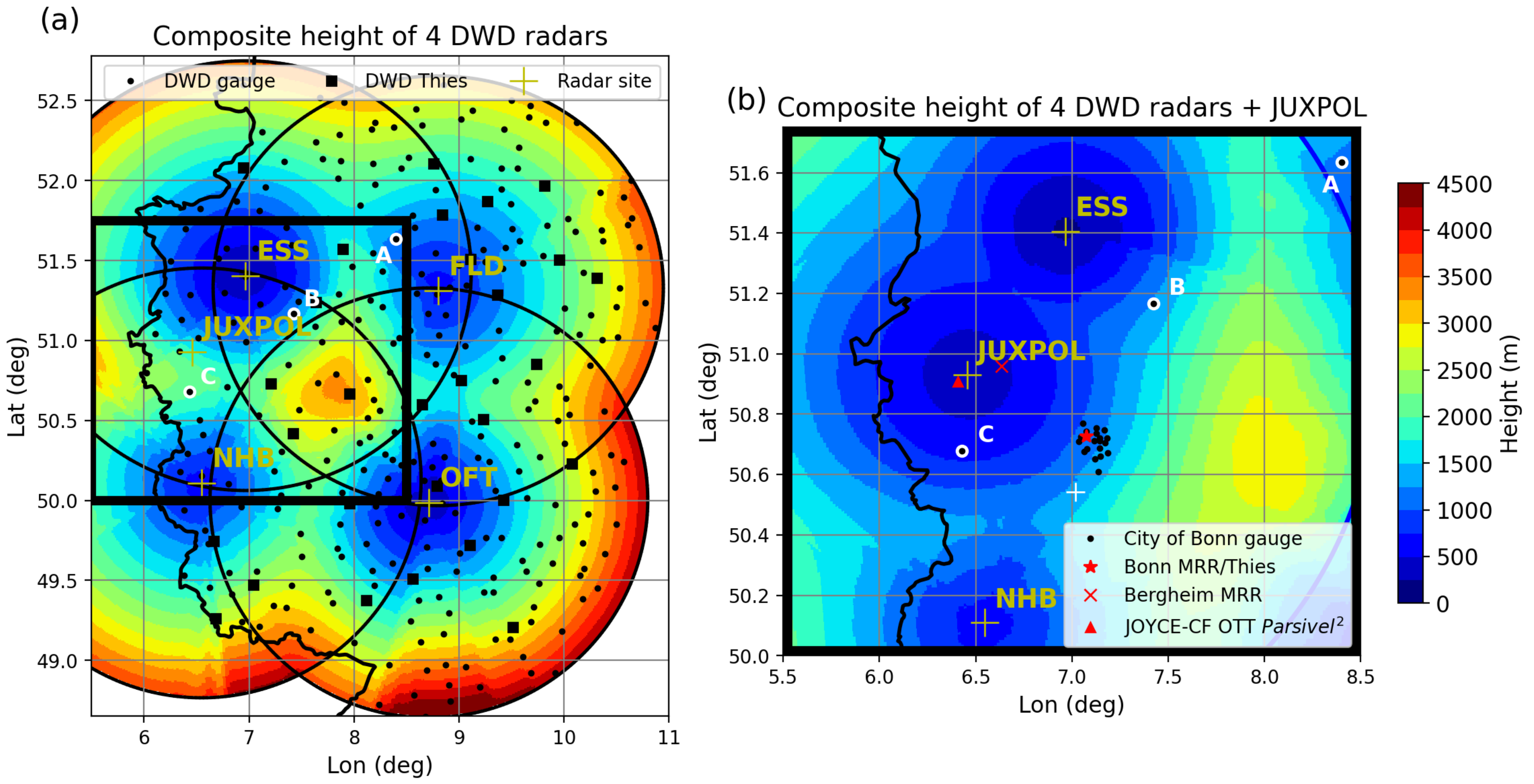
Below the ML

- ✓ R(Z)+R(KDP) as Z>40dBZ
- ✓ R(A)+R(KDP) as Z>40dBZ

Ryzhkov and Zrnic´ (2019)

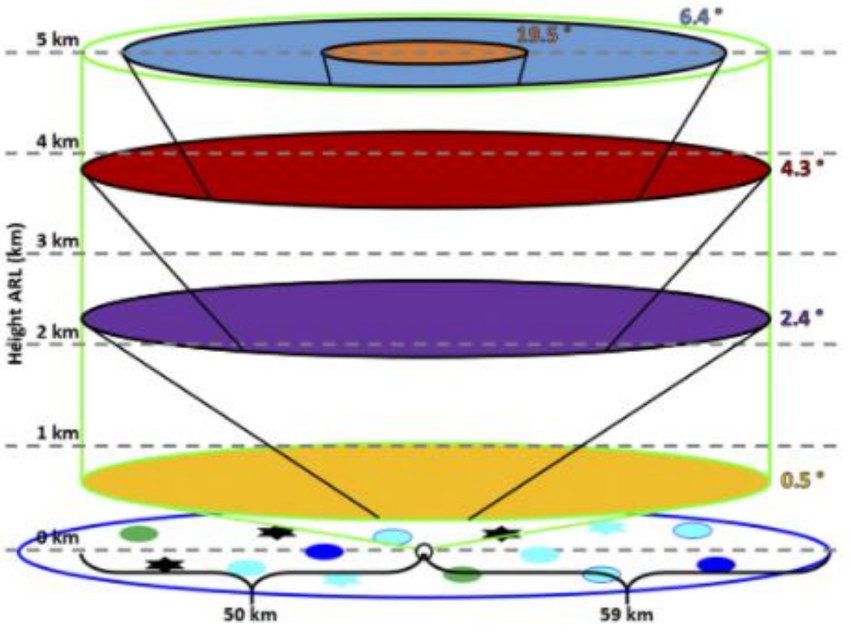


JUXPOL used as a gap filler



The value of the composed grid is the weighted average of data from all available heights (sampling volume of the radar beam).

Vertical profile correction using RD-QVP (Range-defined QVP)



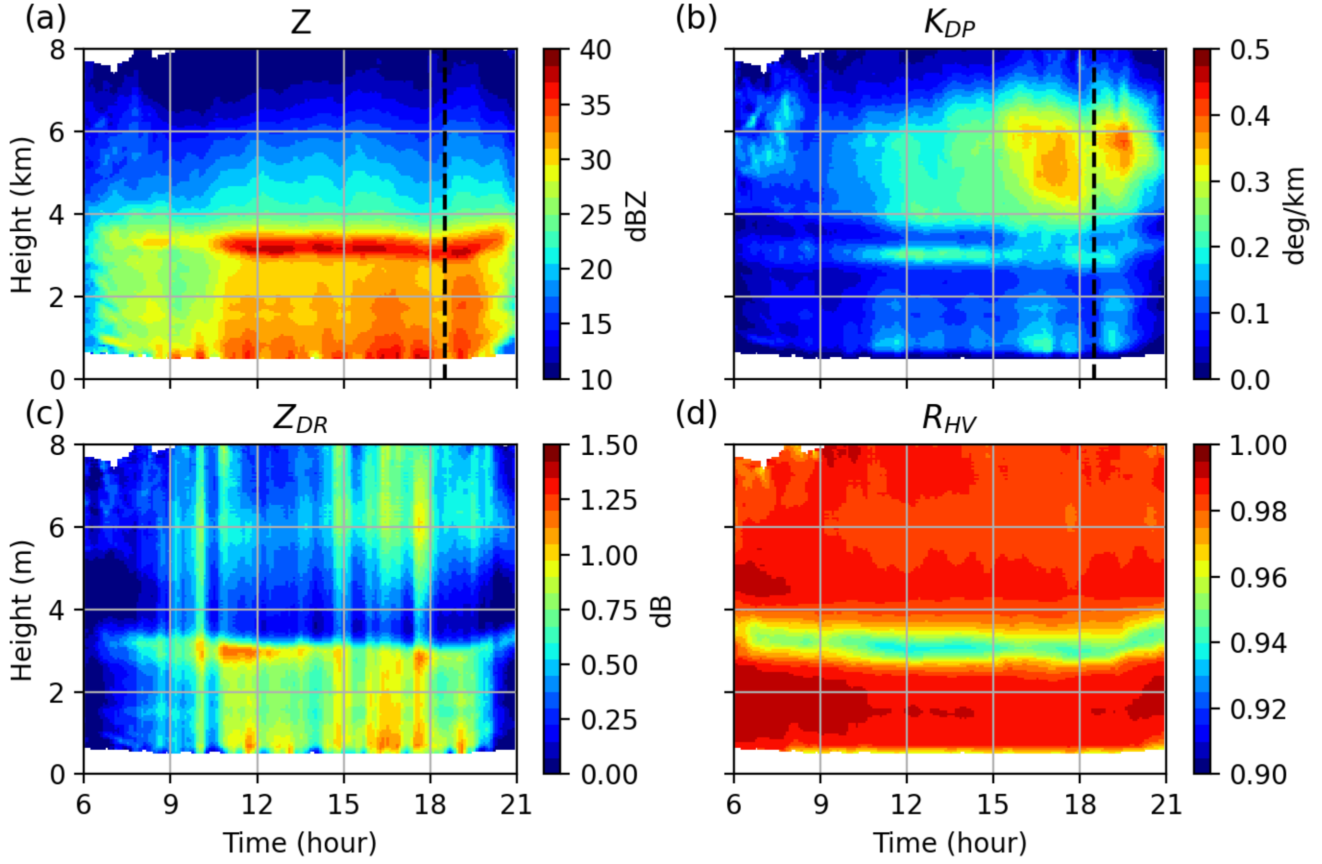
Tobin et al. (2017)

Data from **all elevation angles** are averaged according to the specified range using an inverse distance weighting:

✓ R < 75 km w = 1

✓ R > 75 km w = IDW

NHB radar



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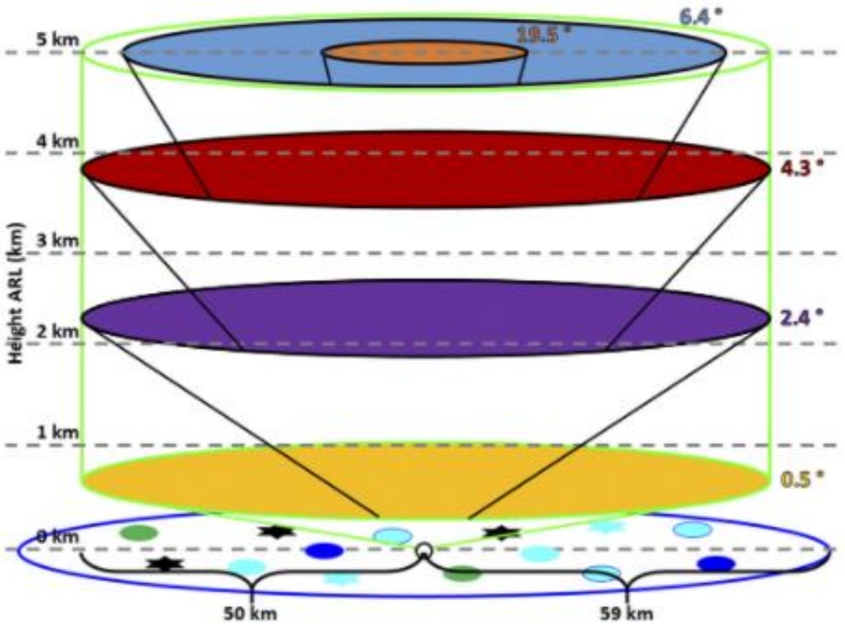

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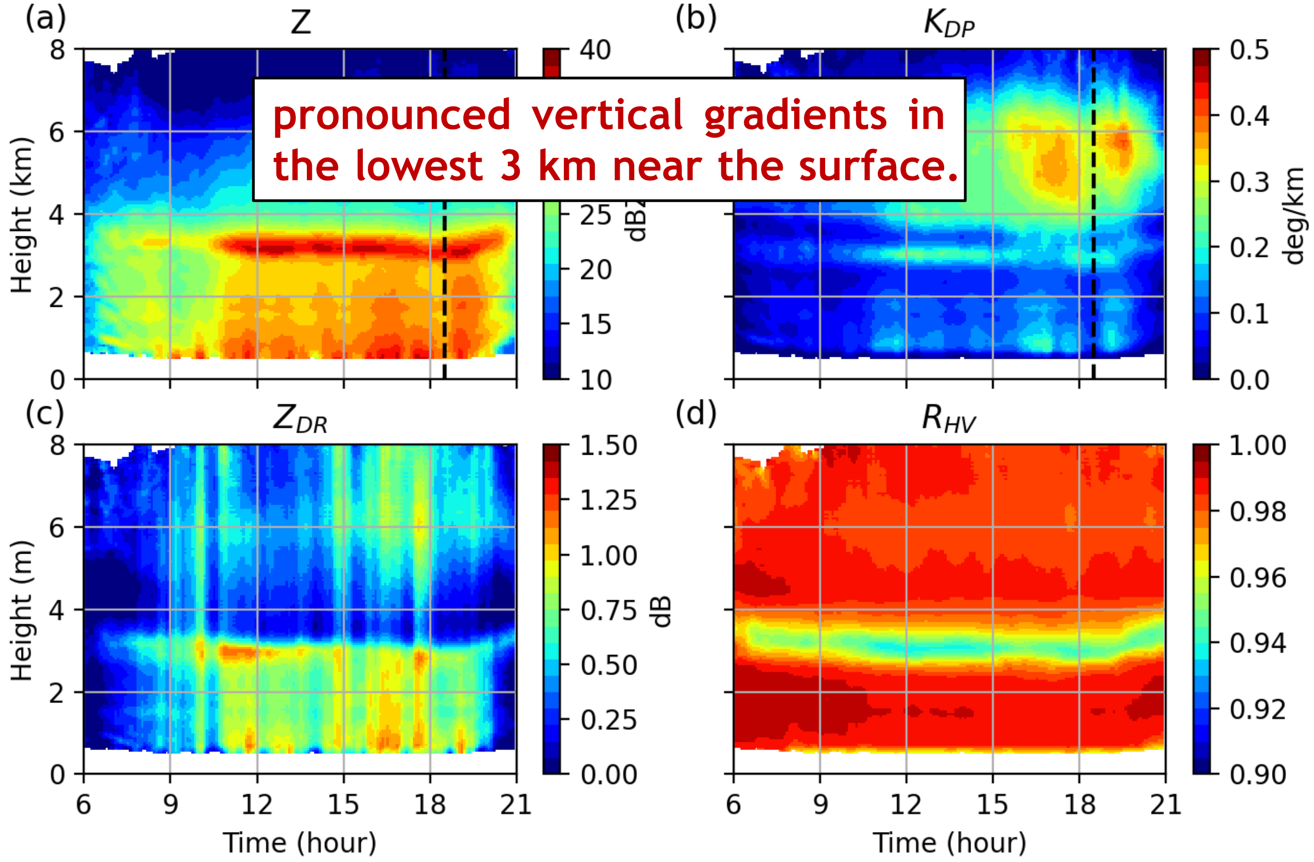
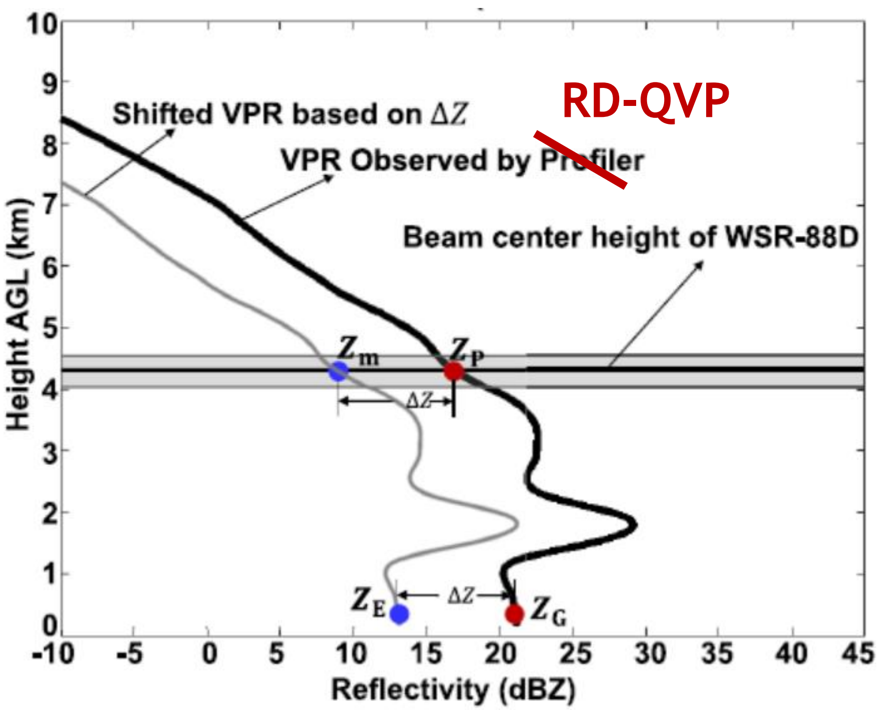


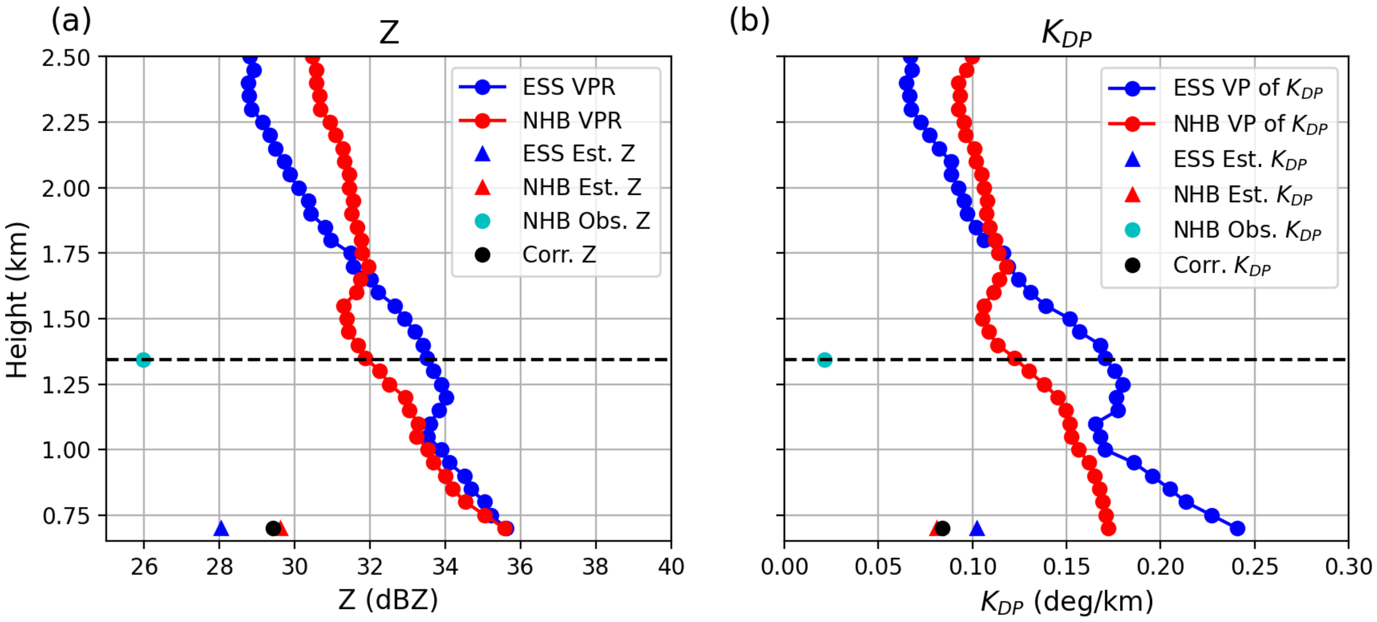
Warm rain processes (collision-coalescence) play the dominant role and lead to an underestimation of radar-based QPE.

Vertical profile correction using RD-QVP (Range-defined QVP)

VP correction for Z and KDP below the ML and 0.7km above the surface



Chen et al. (2020)



Corrected Z and KDP are the **weighted average** of estimated values based on **different radar RD-QVPs** for every timestep, as long as precipitation covers the radar domain more than a third of the area.

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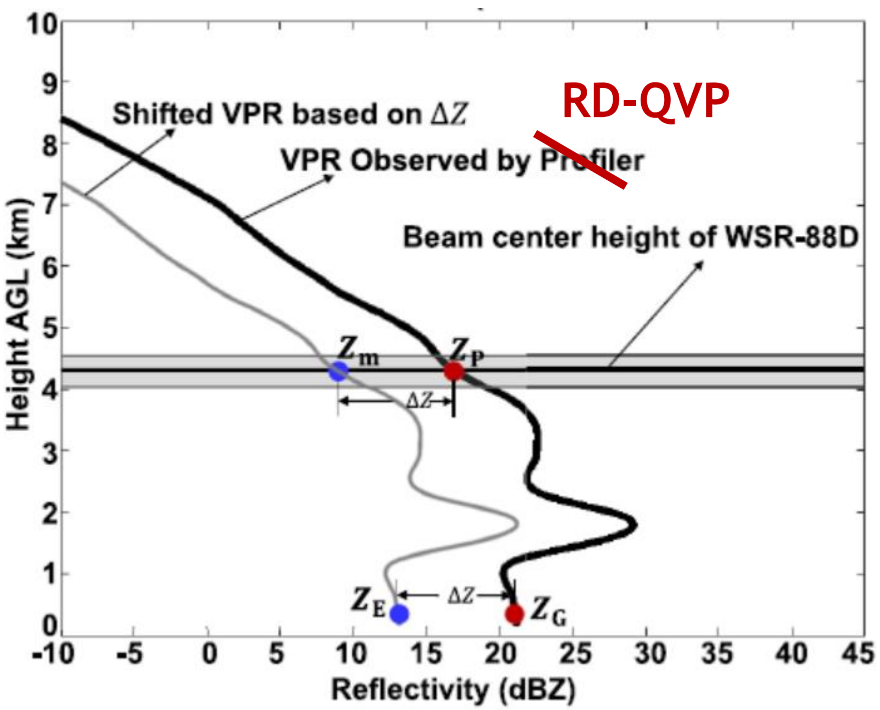
VP correction for Z and **KDP** below the ML and 0.7km above the surface



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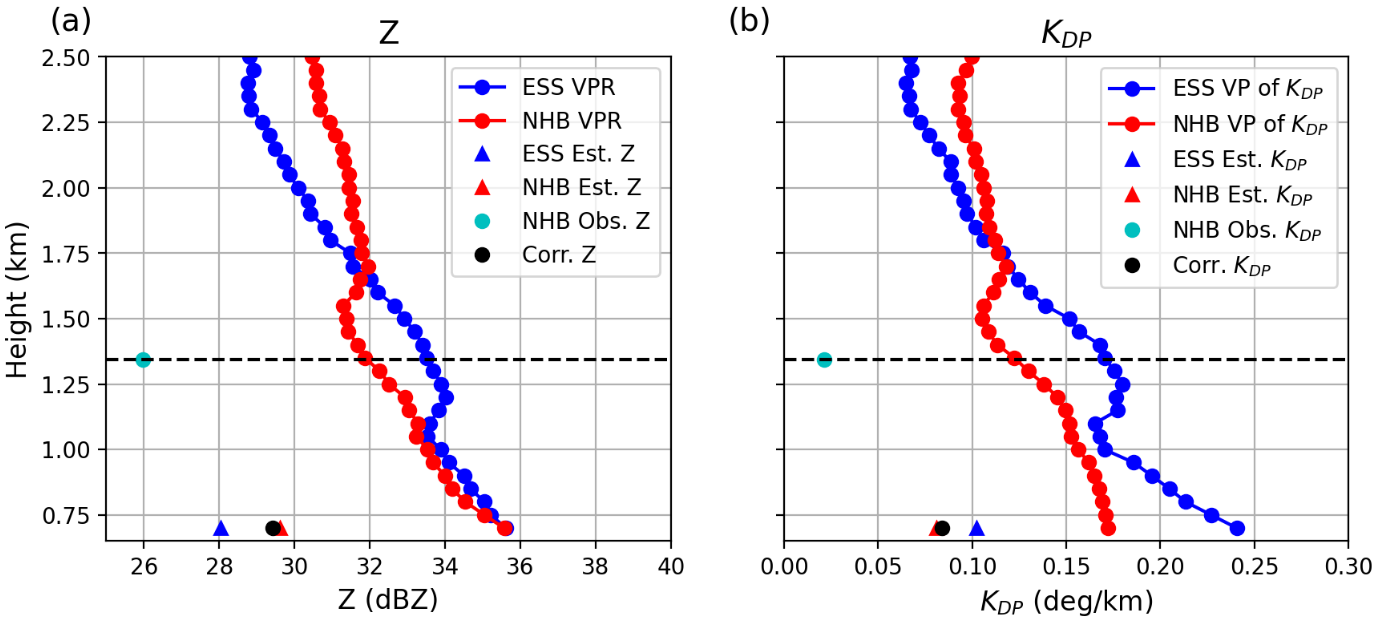

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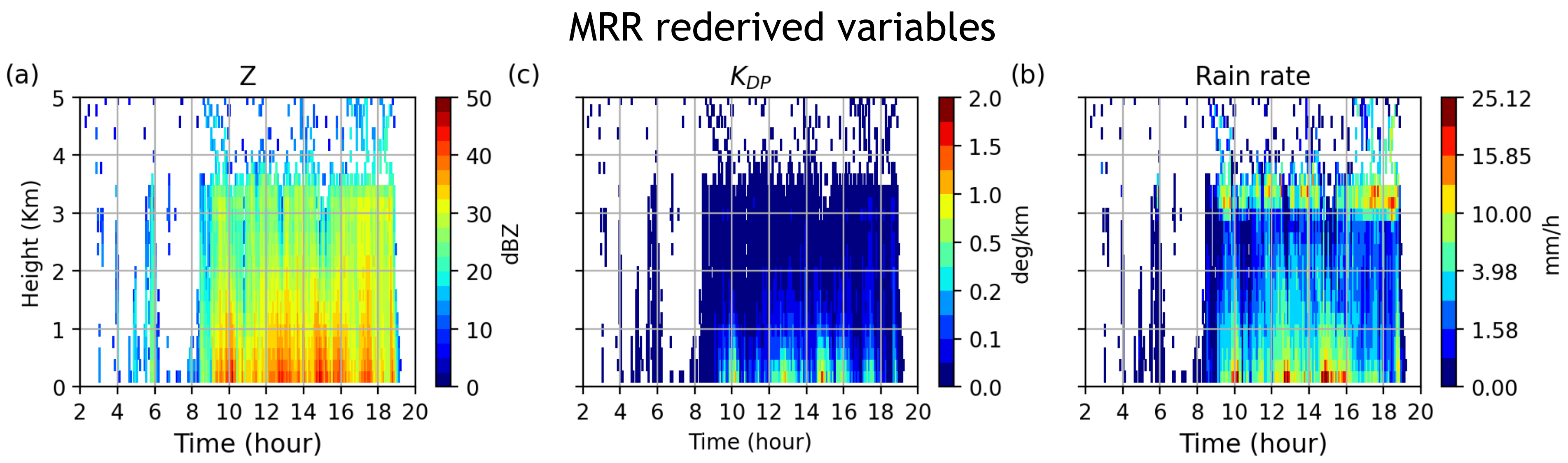
A is a strong function of temperature, therefore, the VP of A may characterize a temperature dependence of A rather than its dependence on rain rate.

Vertical profile correction using RD-QVP (Range-defined QVP)

Rainfall relations applied to corrected Z and KDP

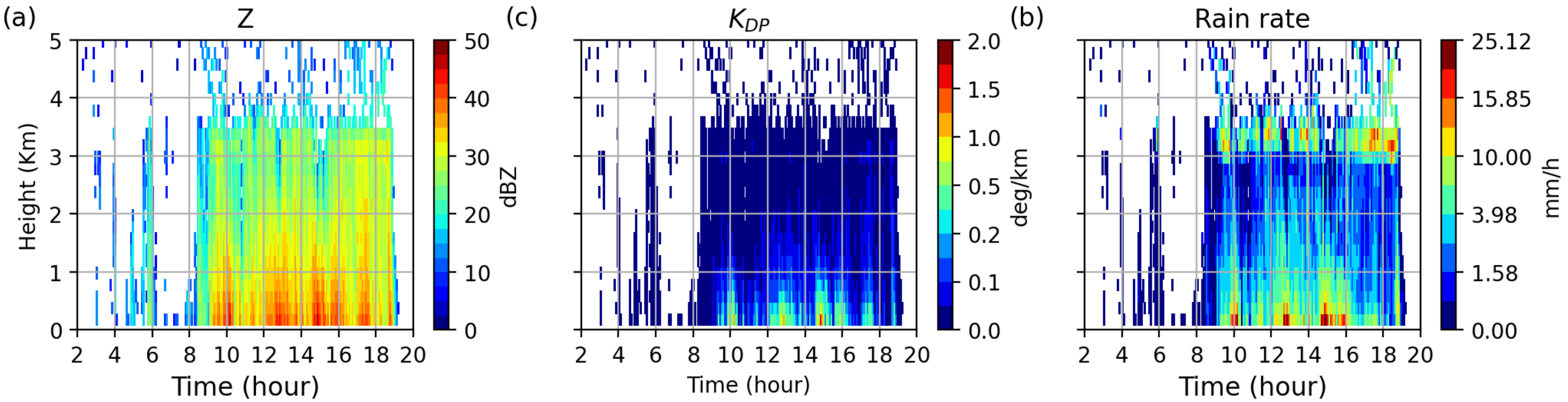


Rain rate relations between **MRR-retrieved** radar variables within certain heights (below 650 m here) and ground-level rainfalls.

Vertical profile correction using RD-QVP (Range-defined QVP)

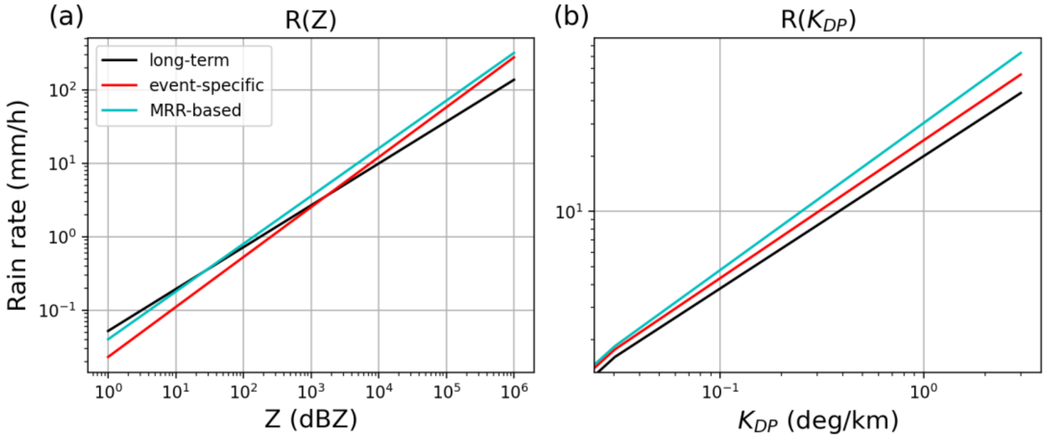
Rainfall relations applied to corrected Z and KDP

MRR rederived variables



Rain rate relations between **MRR-retrieved** radar variables within certain heights (below 650 m here) and ground-level rainfalls.

	R(Z)	R(KDP)	R(A)
Long-term	$R(Z) = 0.052Z^{0.57}$	$R(K_{DP}) = 20.7{K_{DP}}^{0.72}$	$R(A) = 307A^{0.92}$
Event-specific	$R(Z) = 0.023Z^{0.68}$	$R(K_{DP}) = 24.4{K_{DP}}^{0.75}$	$R(A) = 320A^{0.93}$
MRR-based	$R(Z) = 0.040Z^{0.65}$	$R(K_{DP}) = 30.3{K_{DP}}^{0.80}$	



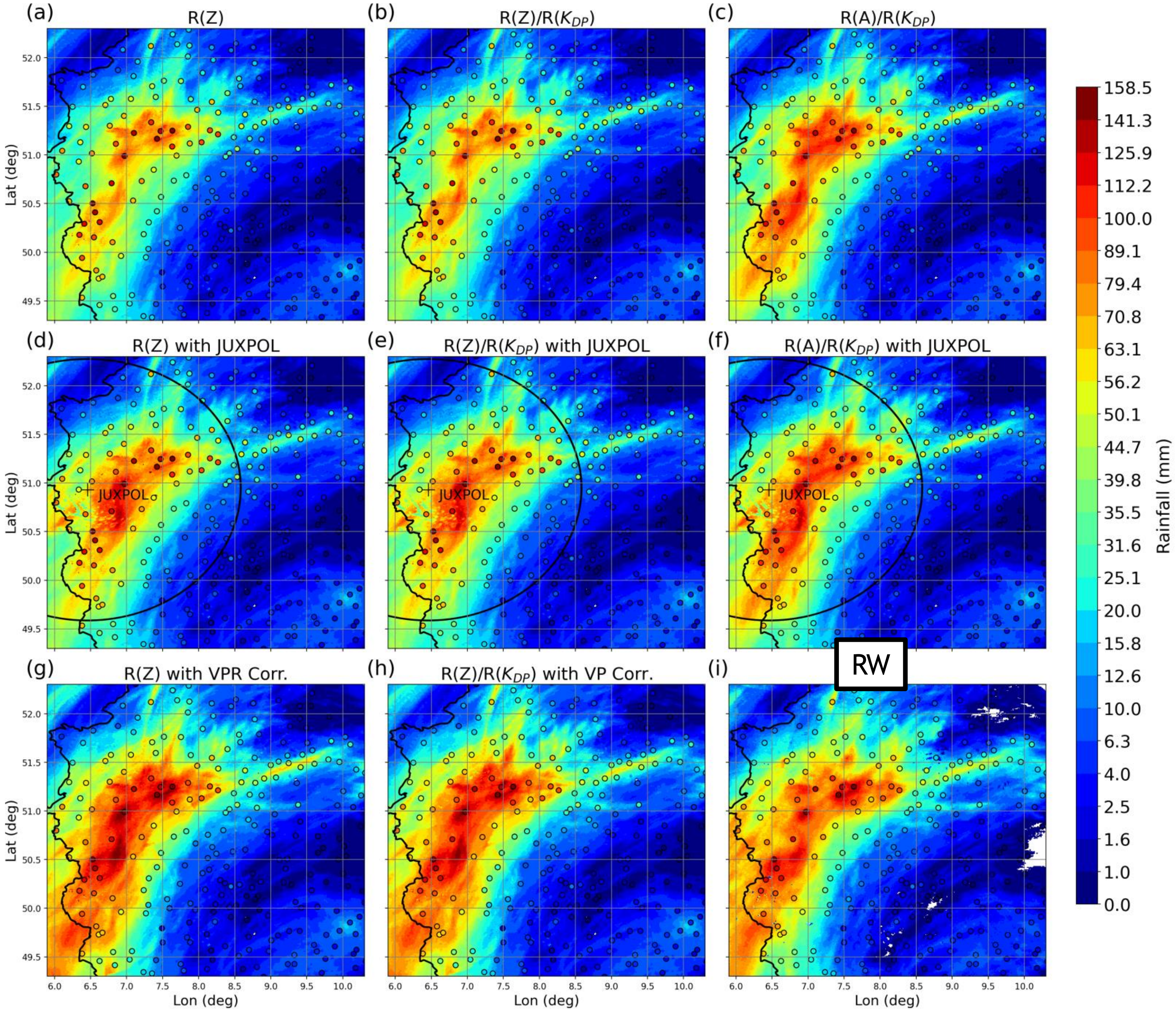
Results

R(Z) | R(Z)/R(KDP) | R(A)/R(KDP)

4 DWD radars

with JUXPOL

4 DWD radars with VP corr.



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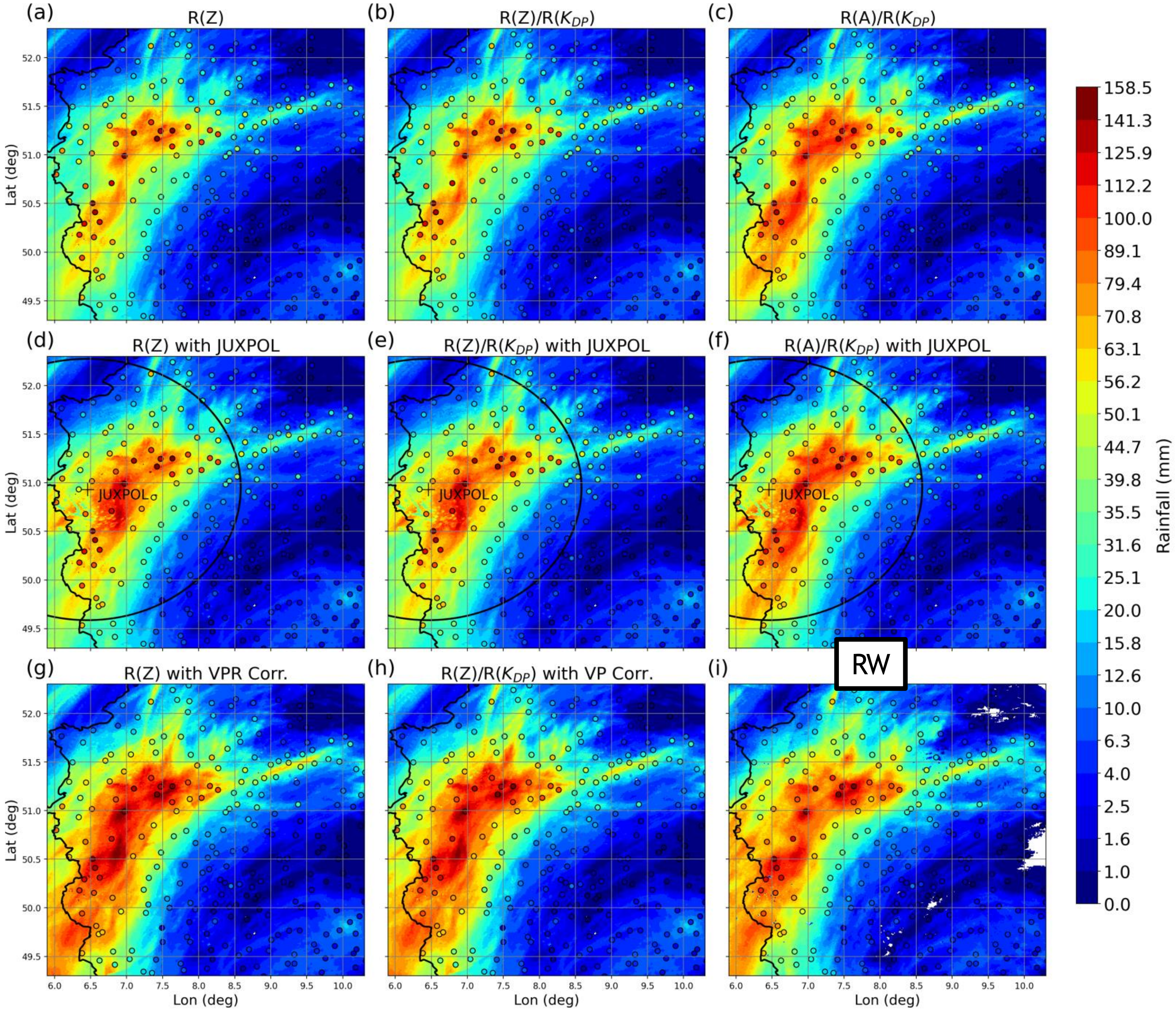

Spatial distribution analysis

- ✓ R(Z)/R(K_{DP}) produces slightly higher rainfall than R(Z).
- ✓ **R(A)/R(K_{DP})** has the highest rainfall and is more consistent with RW.

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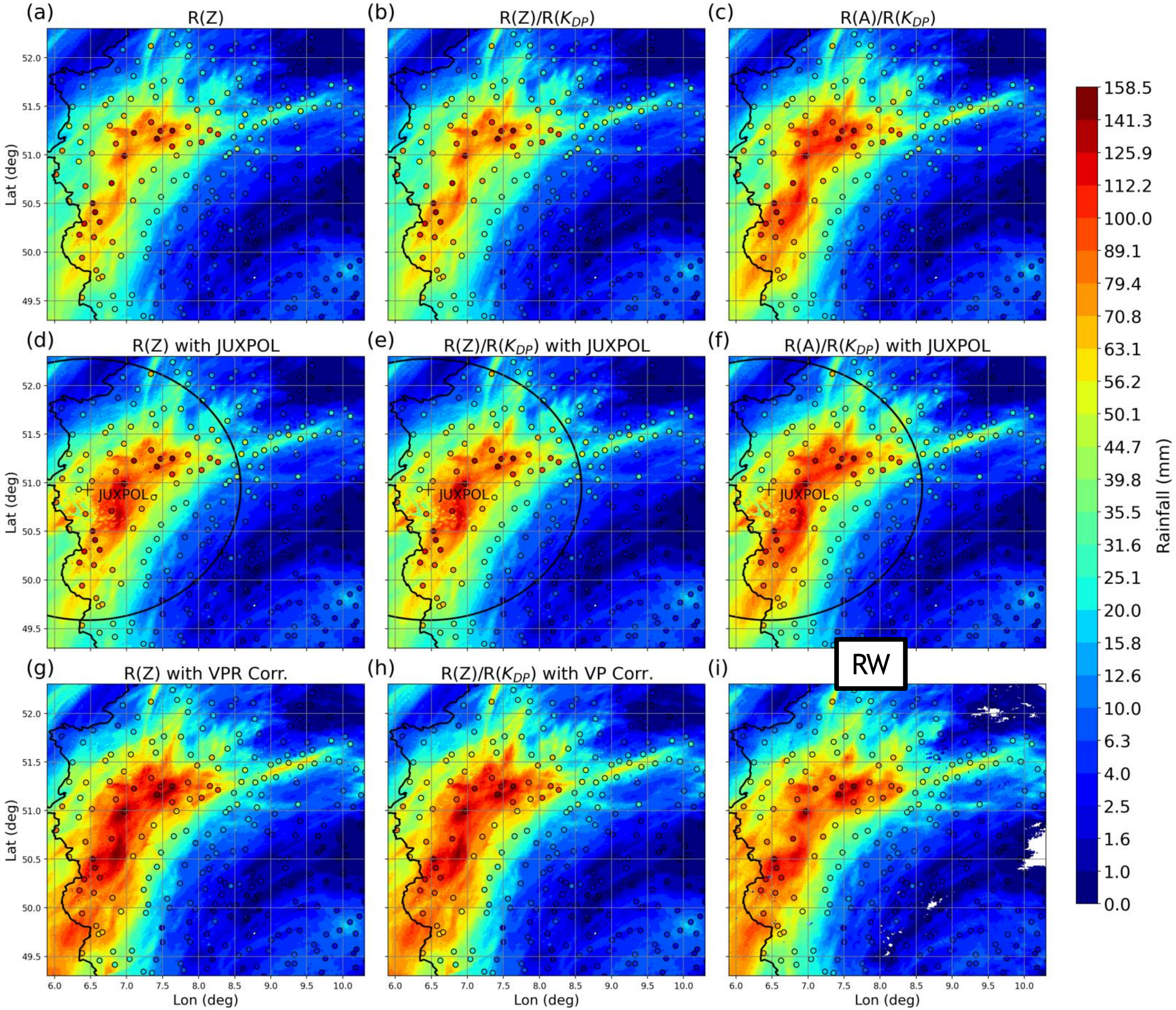

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- ✓ Areas in the south still show the largest differences of rainfall compared to RW.

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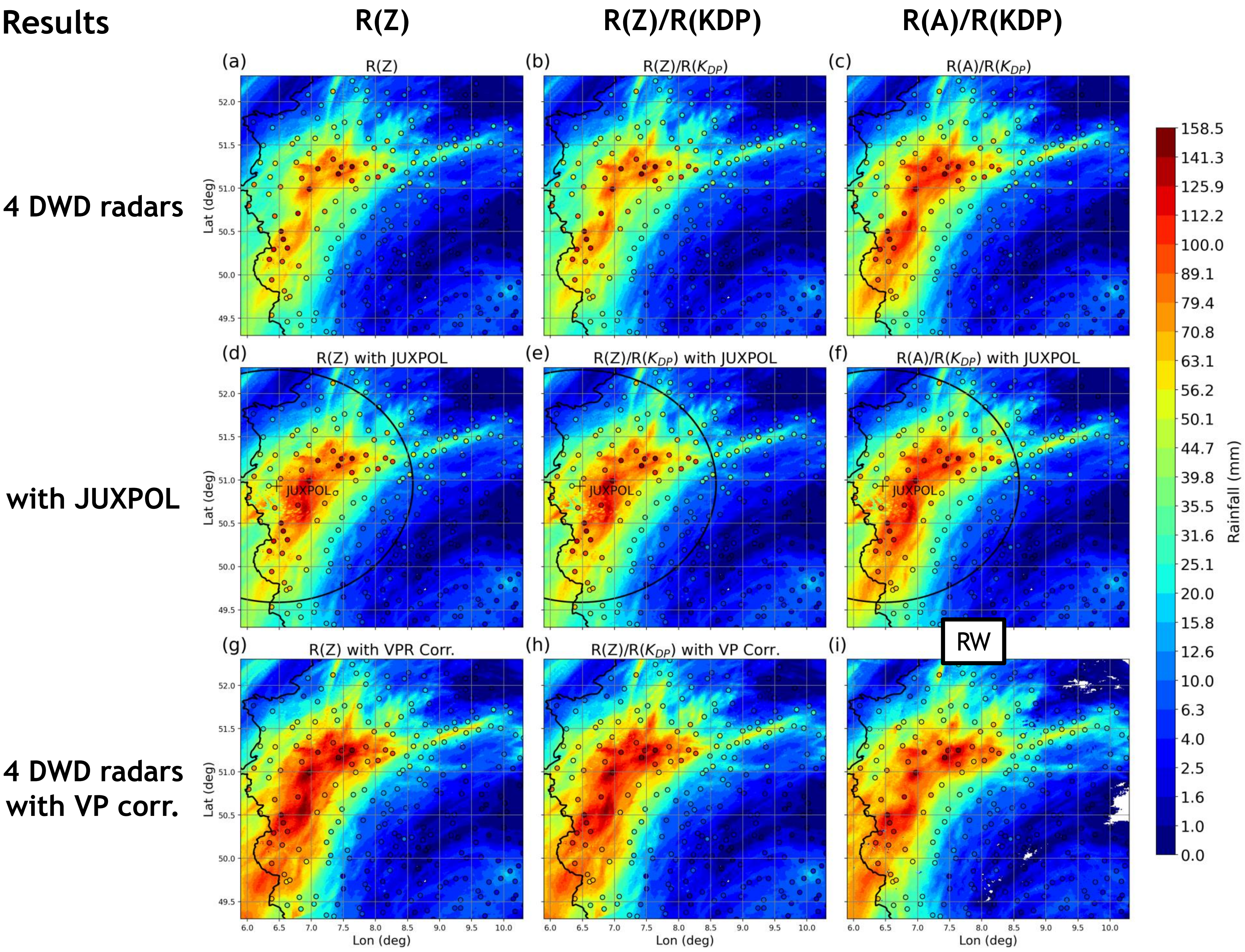

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- ✓ **Enhanced rainfall** can be observed for all three products.
- ✓ Areas in the south still show the largest differences of rainfall compared to RW.

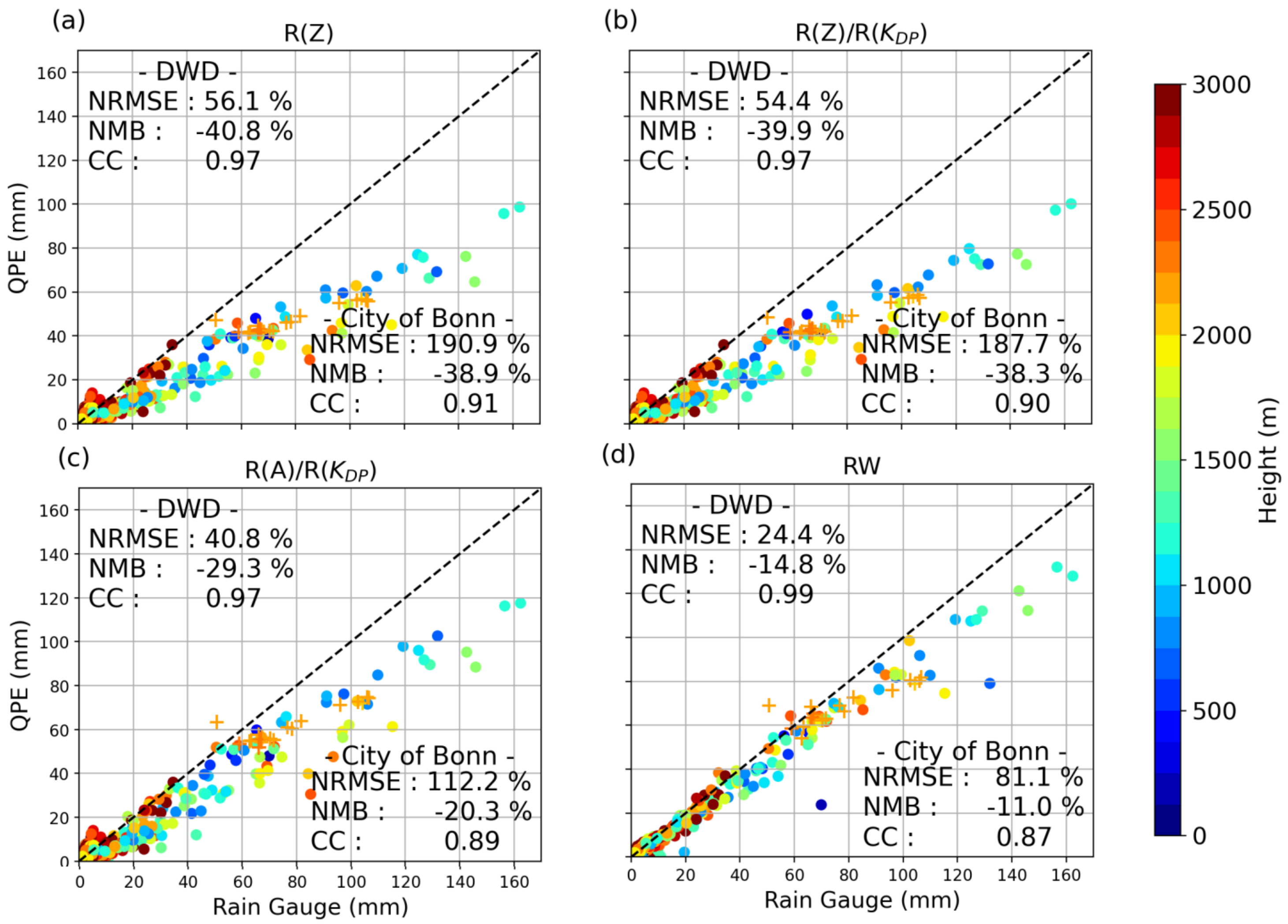
- ✓ QPEs with VP corr. reveal **similar** patterns and quantities as **RW**.

Results

Quantitative analysis

QPEs derived from the DWD radar data

Evaluation with rain gauges from DWD (313) and the City of Bonn (20)



Data points with higher altitudes show lager negative bias.

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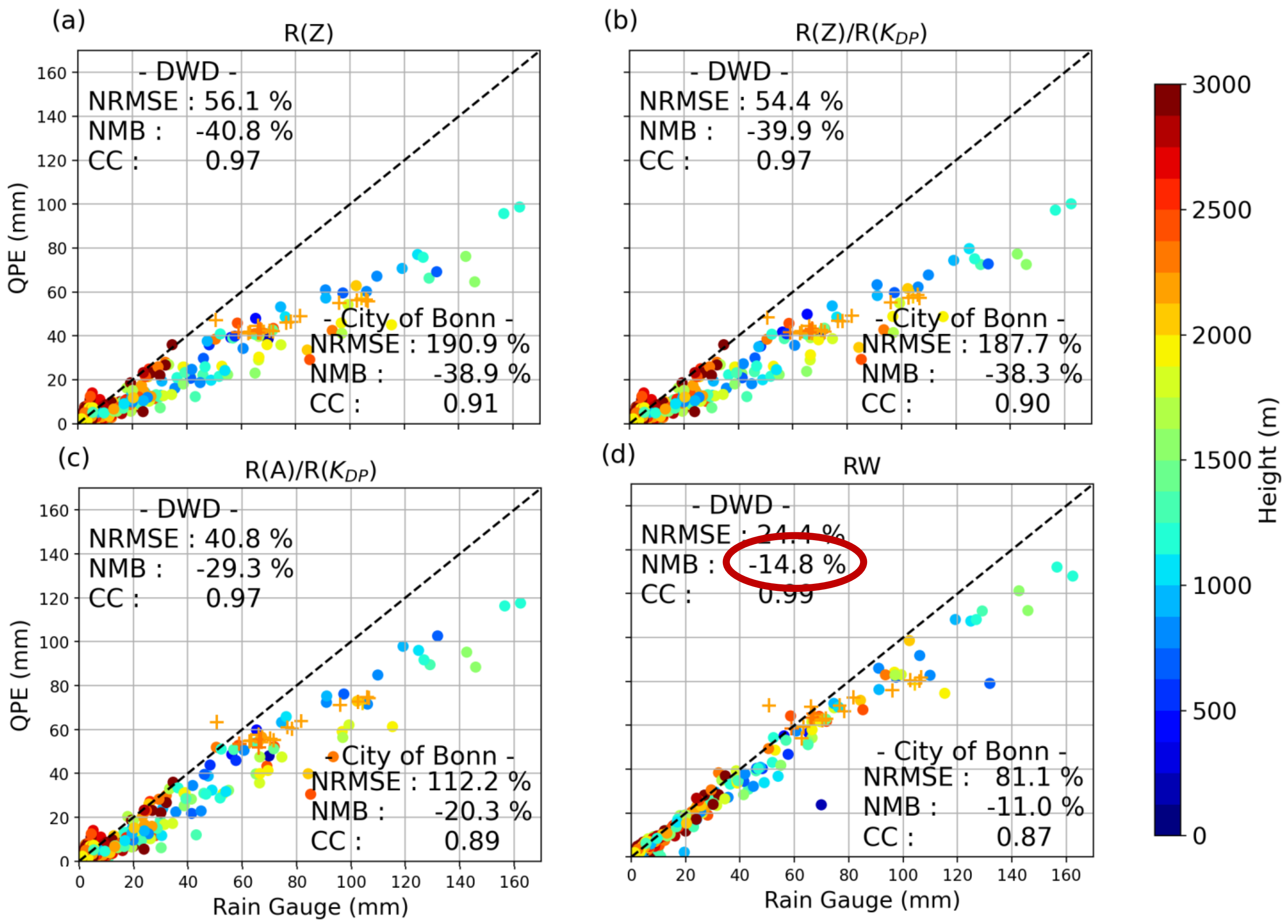

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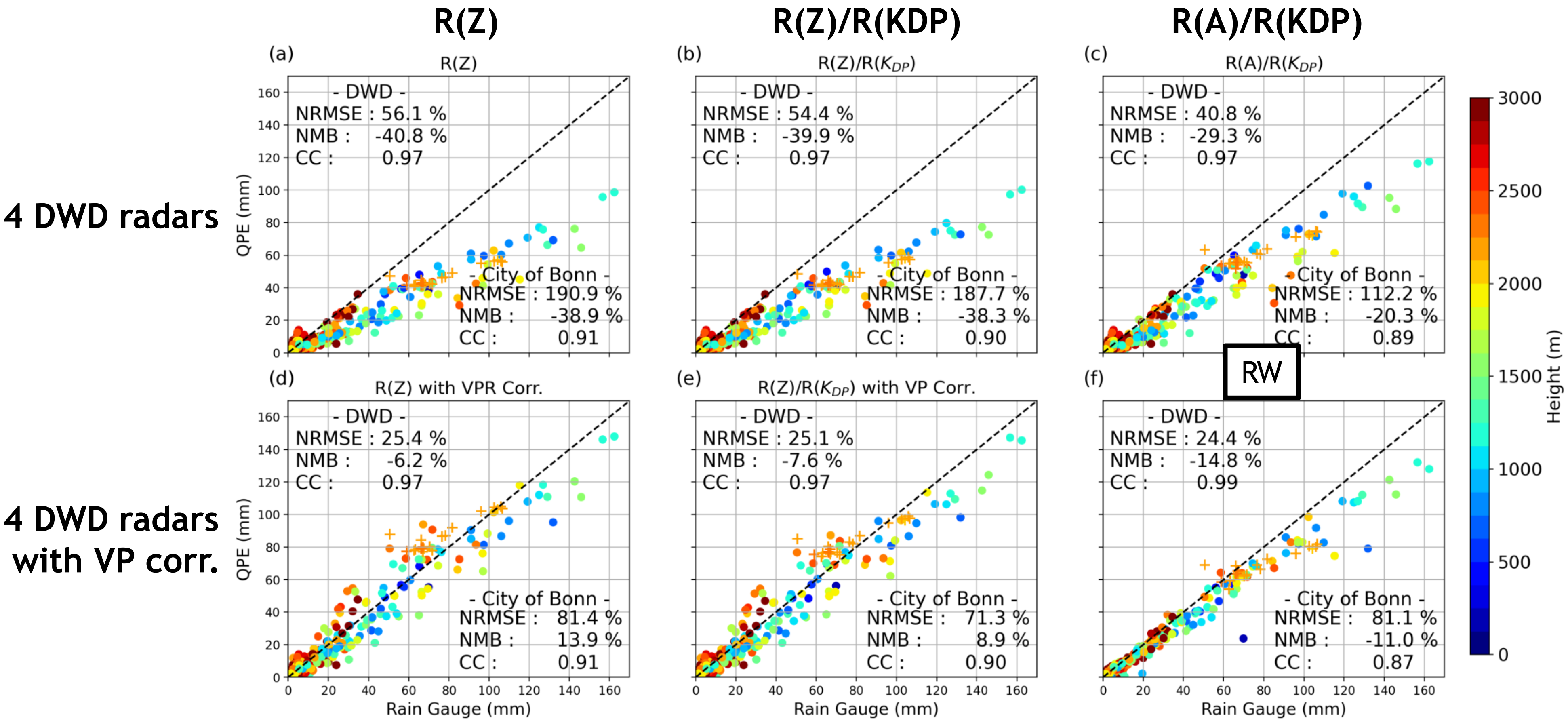


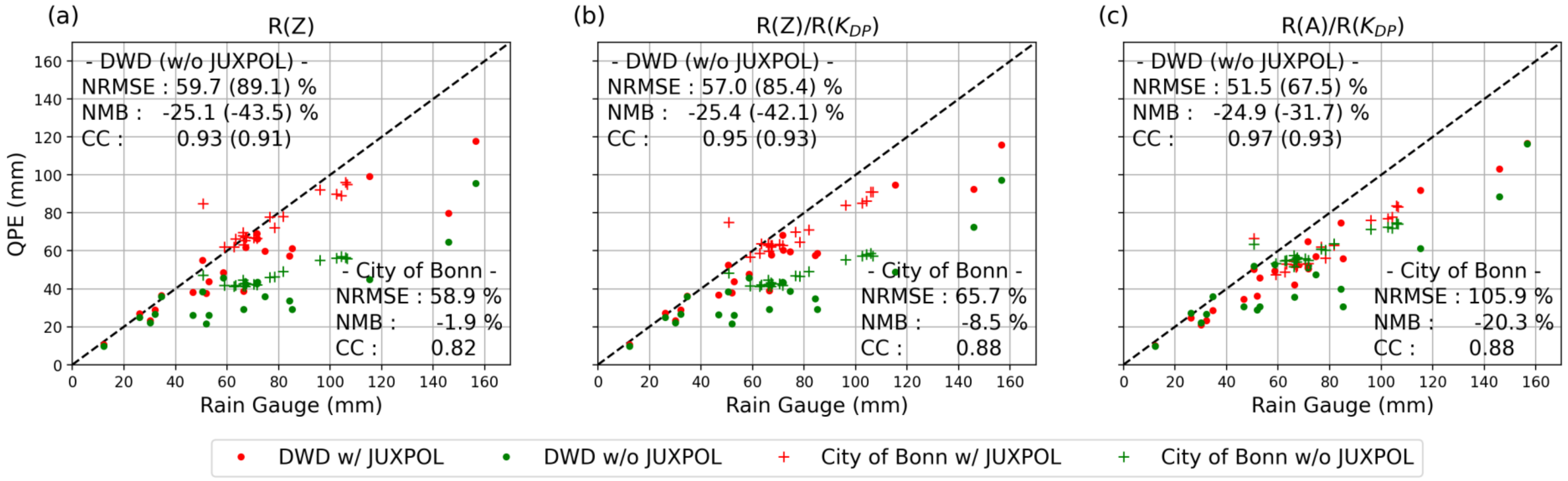
Quantitative analysis

- ✓ QPEs with VP corr. show close numbers to RW.
- ✓ The points with gauge-accumulated rain totals above 100 mm are **less underestimated and scattered than RW**.
- ✓ When evaluated by the gauges from the City of Bonn, the data are **overcorrected** and thus overestimated rainfall at that height.

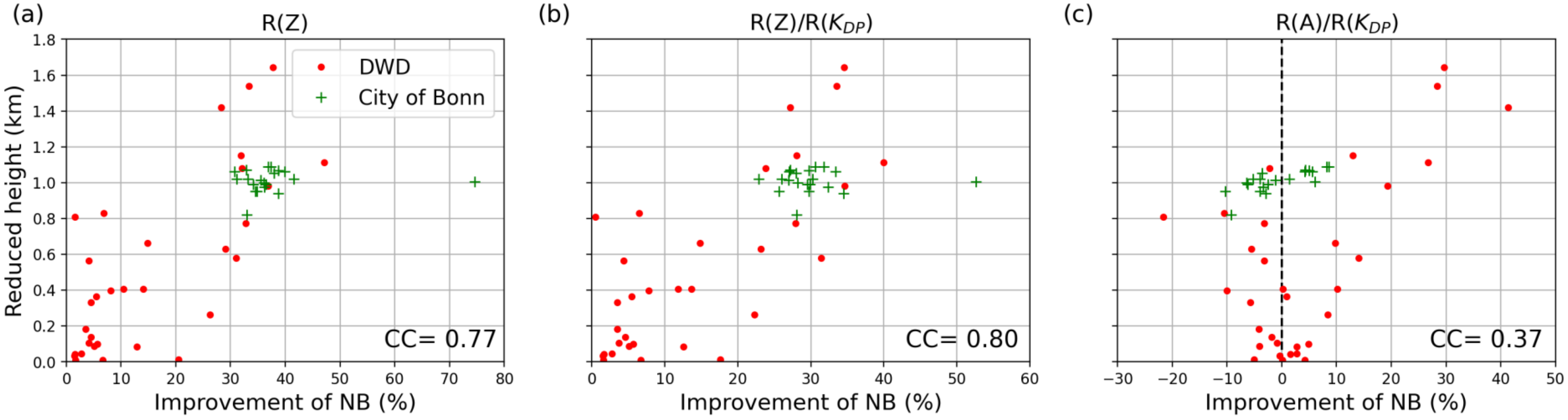
Results

Quantitative analysis

QPEs with JUXPOL



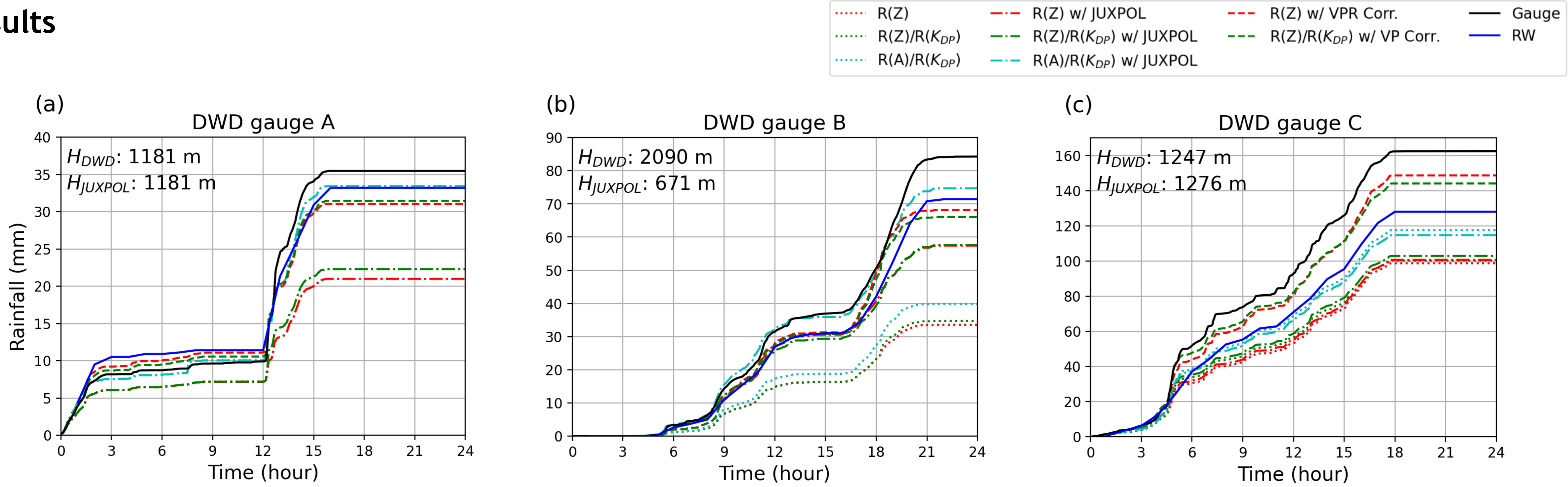
Improvement of NB vs. reduced height by JUXPOL



Quantitative analysis

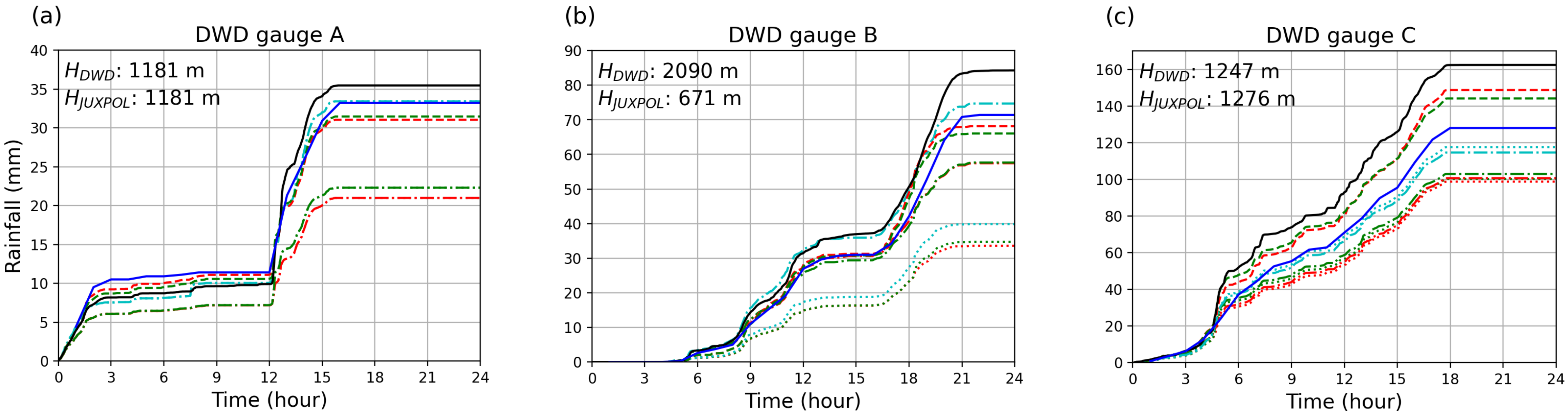
- ✓ The errors are reduced especially for the **R(Z)-based retrievals (lower than VP-corr QPEs)**.
- ✓ The improvement is more pronounced in the areas where JUXPOL provides much lower-attitude observations.
- ✓ Although QPE based on **R(A)/R(K_{DP})** is also improved, it shows the **largest errors** when evaluated with the City of Bonn gauges, and little correlation between the improvements and reduced heights.

Results



Time series analysis

Results



Time series analysis

- ✓ R(A) which is less sensitive to the DSD variability shows the best performance followed by QPEs with VP corr.

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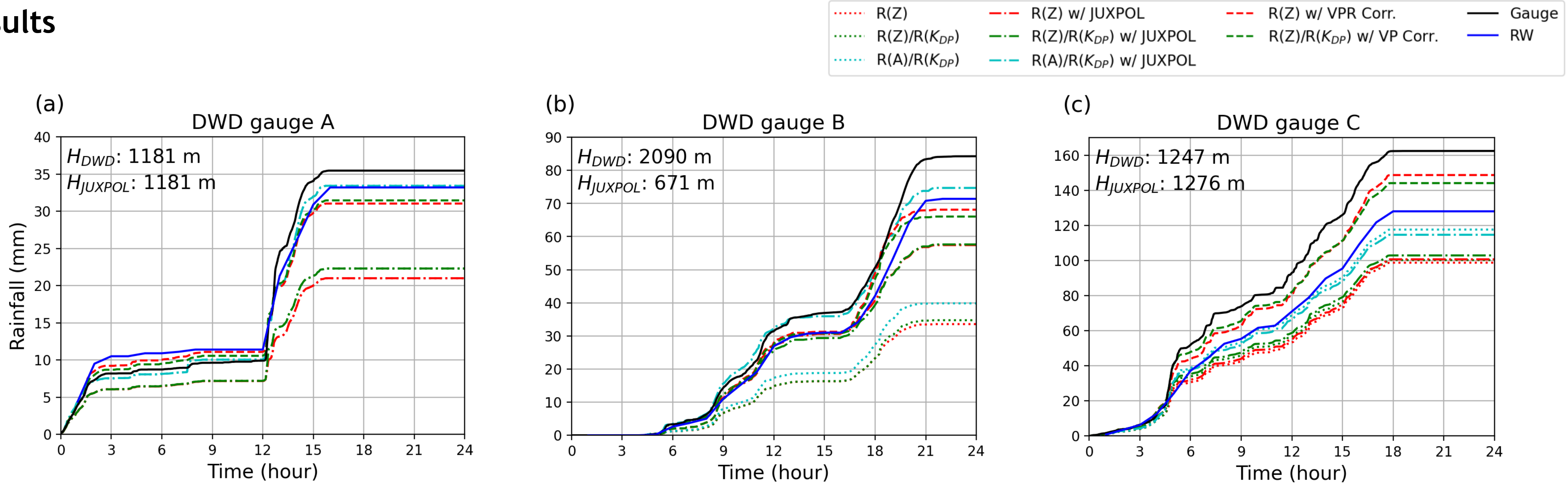
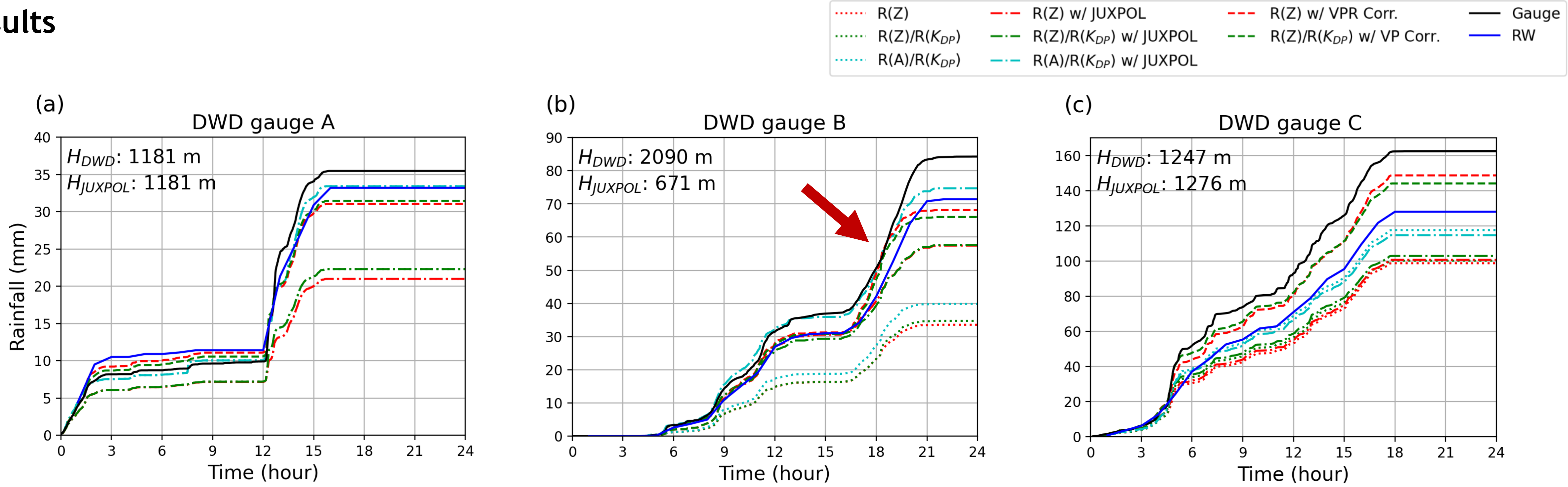


Time series analysis

- ✓ R(A) which is less sensitive to the DSD variability shows the best performance followed by QPEs with VP corr.
- ✓ Rainfall sum estimated by JUXPOL grows closely with the gauge or RW, and $R(A)/R(K_{DP})$ has even better agreement with the gauge than RW.
- ✓ VP-corr. QPEs follow well RW and result in rain totals almost two times more than the original version of QPE.

Results



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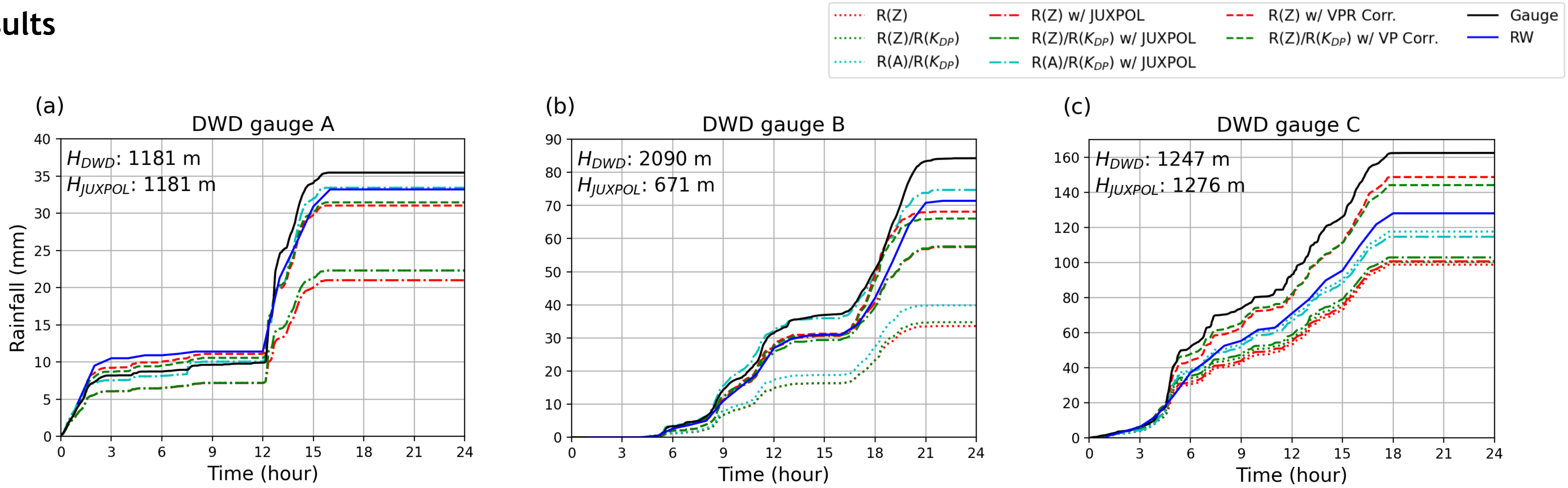

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- ✓ VP-corr. QPEs follow well RW and result in rain totals almost two times more than the original version of QPE.

- ✓ The improvement by JUXPOL is limited.
- ✓ It shows better matched lines between the gauge and QPE products with VP corr. than those between the gauge and RW.

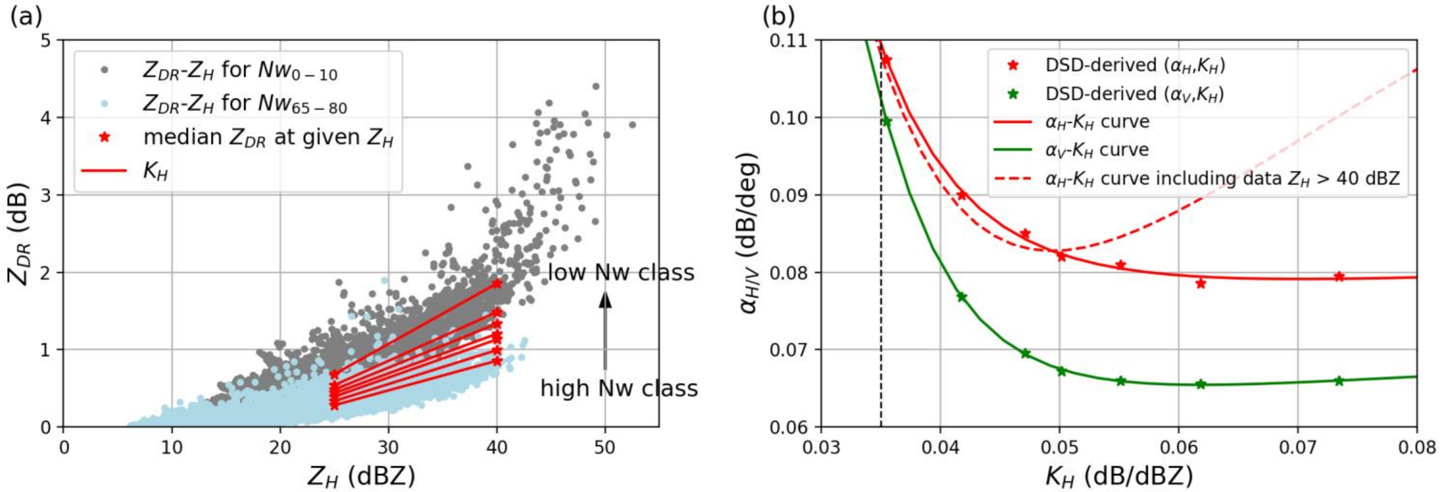
Conclusions

- QPE based on DWD radar network
  - ✓ R(Z)-based retrievals show large underestimated rainfall compared to the R(A)-based estimate.
  - ✓ Also RW shows -15% of NMB.
  - ✓ Data points derived from **higher altitudes show lager negative bias**.
- QPE with X-band radar served as gap filler
  - ✓ More pronounced improvements were obtained for R(Z)-based retrievals especially evaluated with gauges from City of Bonn.
- QPE with VPR and K_{DP} correction
  - ✓ It resulted in larger improvements, showing **close numbers to RW** (DWD gauges).
  - ✓ Errors increase with respect to JUXPOL but the performances are still better than RW when evaluated with gauges from the City of Bonn.
  - ✓ **Larger uncertainties** are shown with the points from **higher altitudes**.

What I am doing now and the near-future work…

Review:

✓ The DSD sensitivity of the key attenuation parameter α used to estimate A needs to be accounted for in the ZPHI method.



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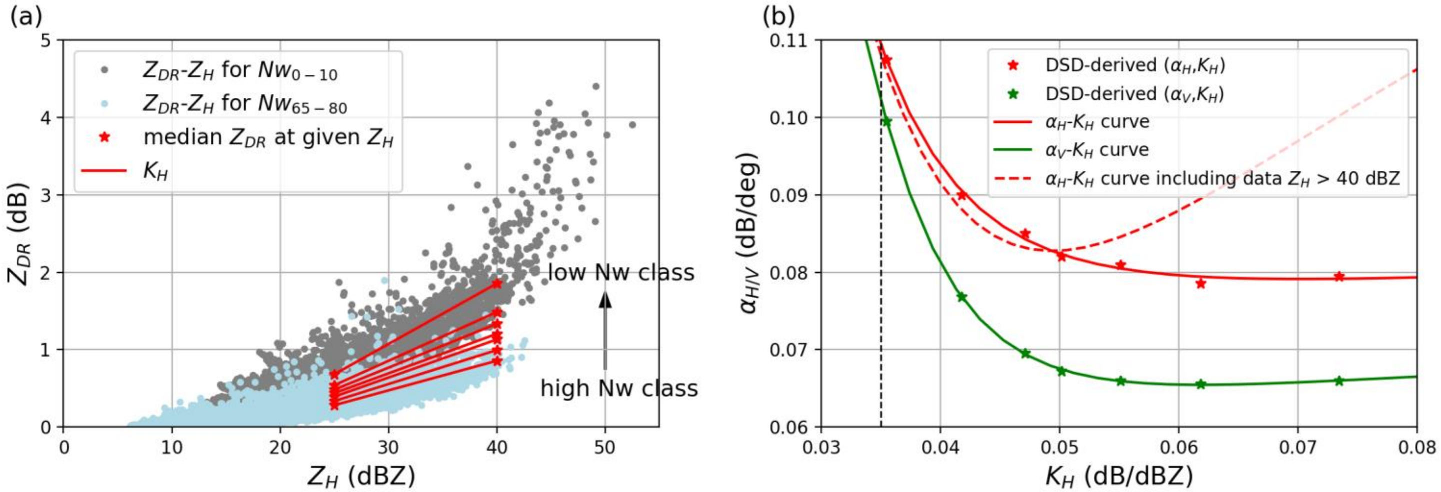
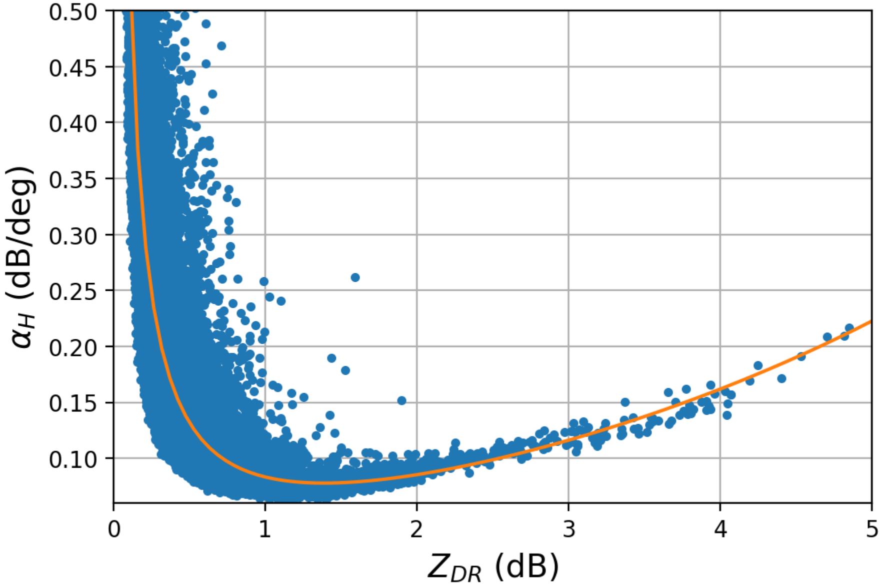


✓ Although this method is not affected by **radar miscalibration**, scan-wise α adjustment may not be ideal enough because of the **inhomogeneity** of the precipitation regimes within the scan.

example: significant rainfall underestimation for stratiform events with ever-occurring embedded convection.

As a result, an optimization of α(Z_{DR}) along the ray is needed



$$< \alpha > = \frac{\int Z^b(r)dr}{\int \frac{Z^b(r)}{\alpha[Z_{DR}(r)]}dr}$$

At C band, the differential **attenuation** and resonance effects are much stronger compared to S band....

Attenuation correction for ZDR with hail core in the radial

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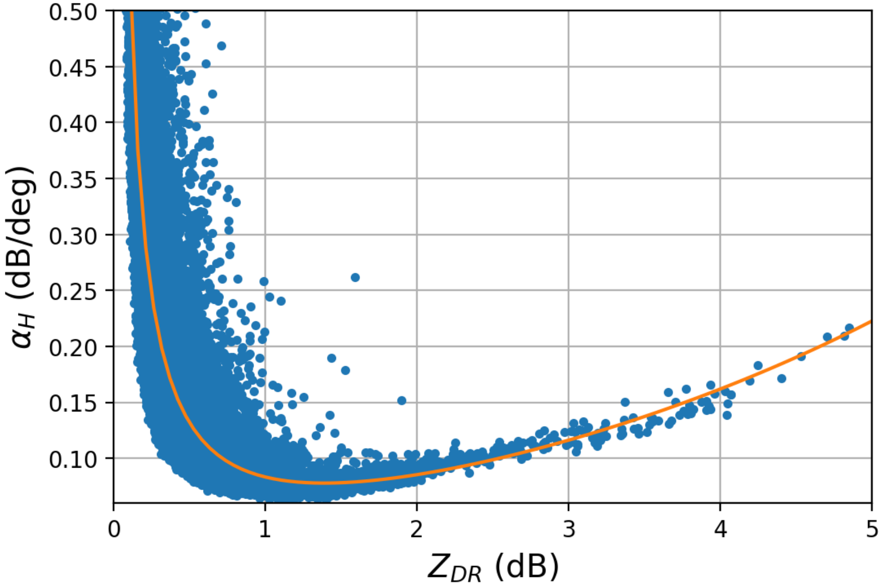

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-- Thanks for your listening --