A Radar-Rain Gauge Data Merging Method using the Augmented Radial Basis Function Interpolation

11th Workshop of International Precipitation Working Group (IPWG-11)

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Outlines

1 Background

2 Study Region and Data

3 Methodology

4 Results

5 Summary and Conclusions

1. Backgrounds

Accurate spatiotemporal precipitation data

Rain Gauge data

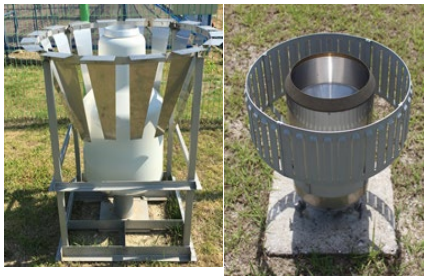
- Ground truth in the calibration and verification of precipitation sensors
- Low spatial resolution

Weather Radar data

- Higher spatial resolution than rain gauges.
- The accuracy of radar measurement is less accurate than that of rain gauge

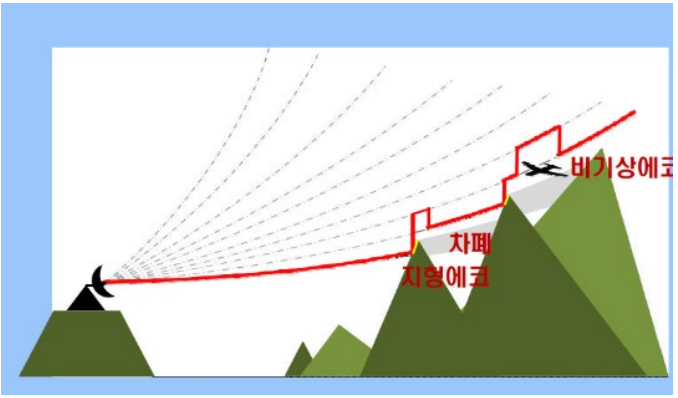
merge

High-resolution accurate precipitation field



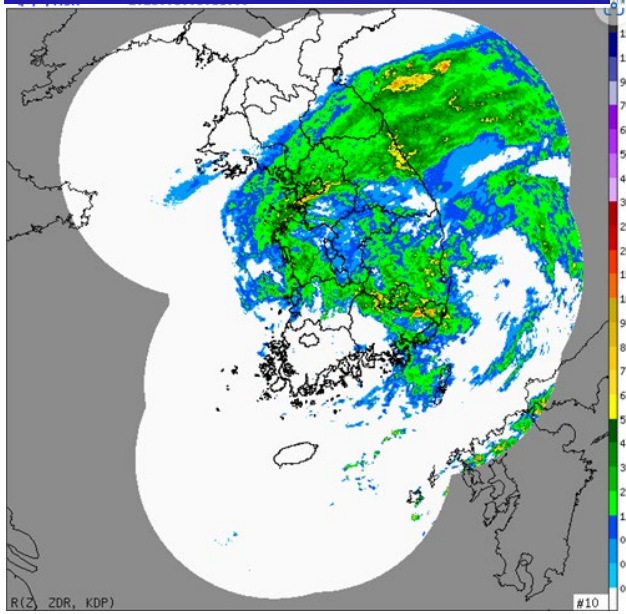
2. Study Region & Data : Radar

HSR(Hybrid Surface Rainfall)



11 radars

HSR Composite rainfall



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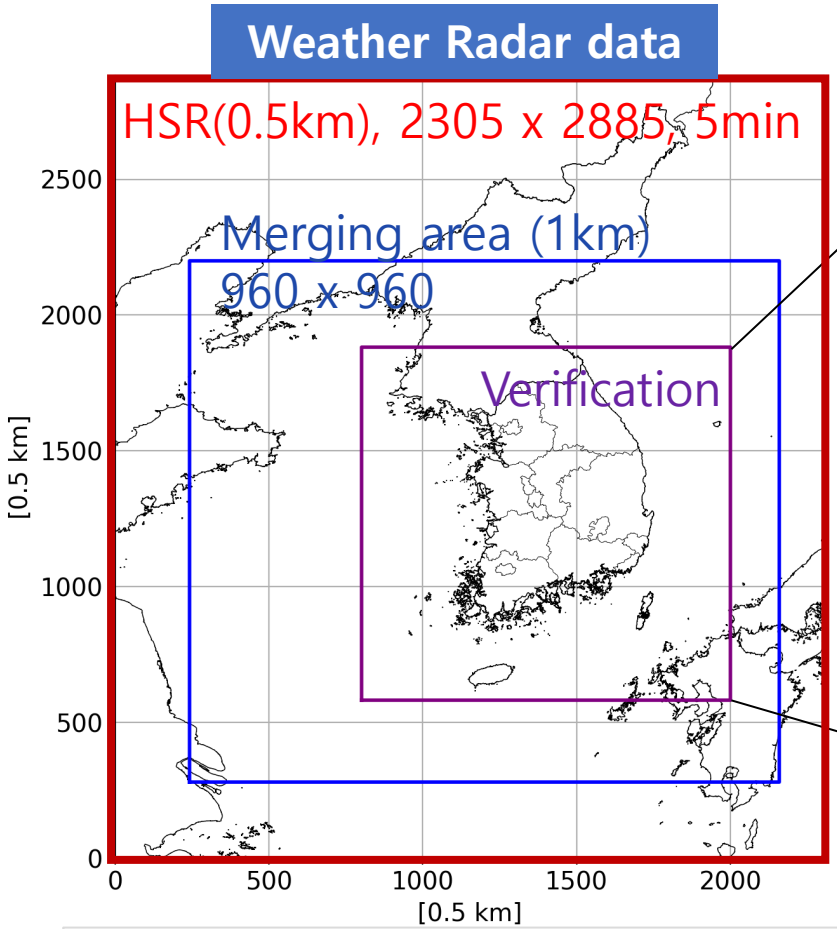
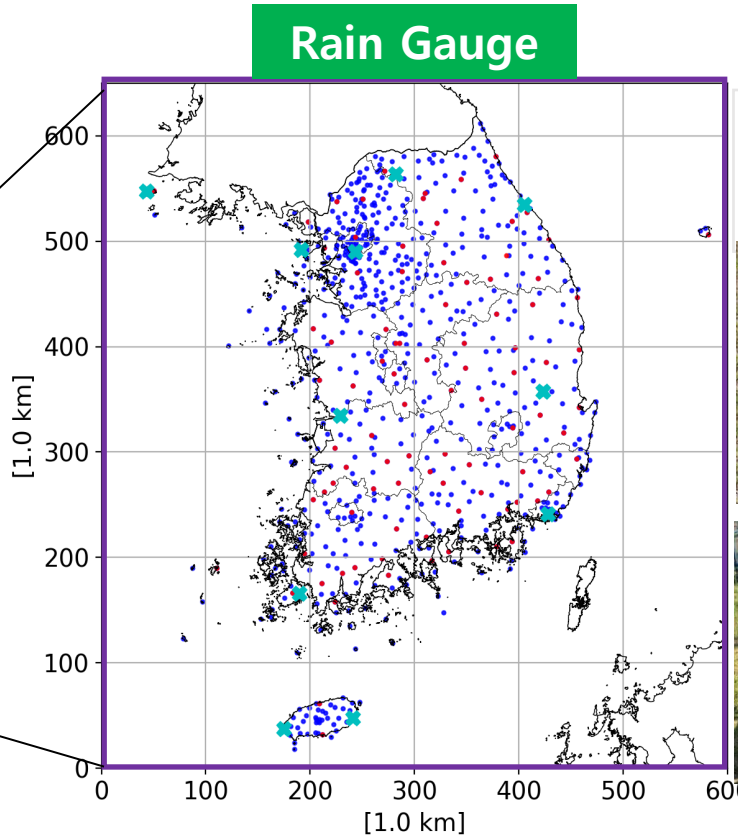
[Radar data]

- **HSR :** uses the lowest elevation angle data that is not affected by ground clutter or beam blocking [*Kwon et al. 2015 (Journal of Hydrology)*]
- **HSR radar composite data:** (0.5km*0.5km, 2305 x 2885, 11 radars)

2. Study Region & Data: radar and gauge





[Radar data]

- **HSR radar composite** (0.5km, 2305 x 2885, 11 S-band radar), 5 min
- **1km (960x960), production area, M-P relation (Z= 200R^1.6)**

[Rain Gauge]

- AWS (Automatic Weather System) : 554 stations, 0.5 mm, 1 min
- ASOS (Automated Synoptic Observing System): 103 stations, 0.1 mm, 1 min

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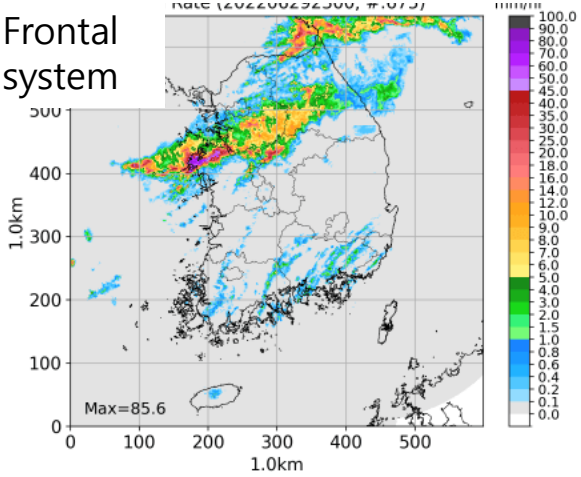
2. Study Region & Data

Test events: 6 events in 2022, South Korea

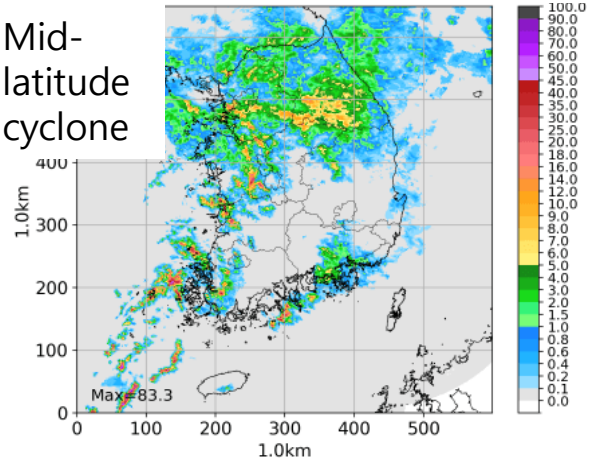
(1) 0629~0630 [29h]

Frontal system



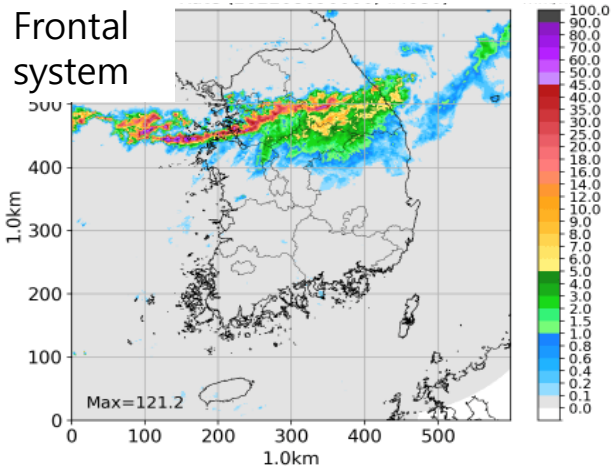
(2) 0723~0724 [18h]

Mid-latitude cyclone



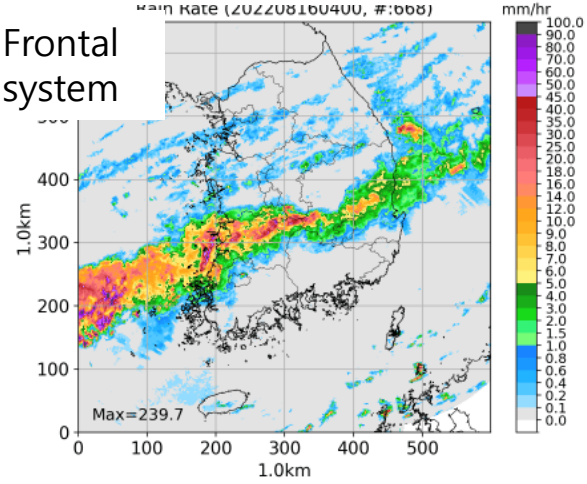
(3) 0808~0810 [48 h]

Frontal system



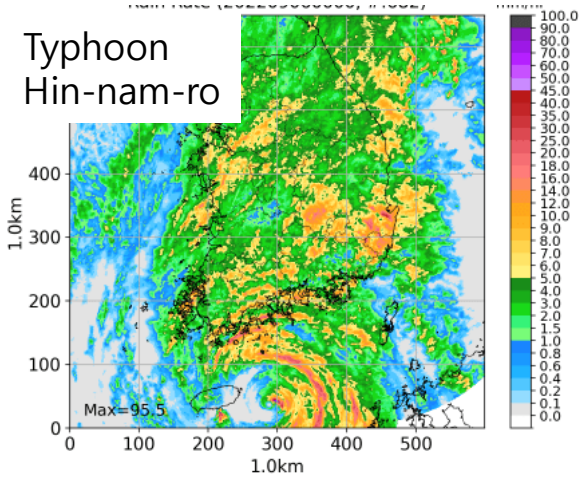
(4) 0815~0816 [16h]

Frontal system



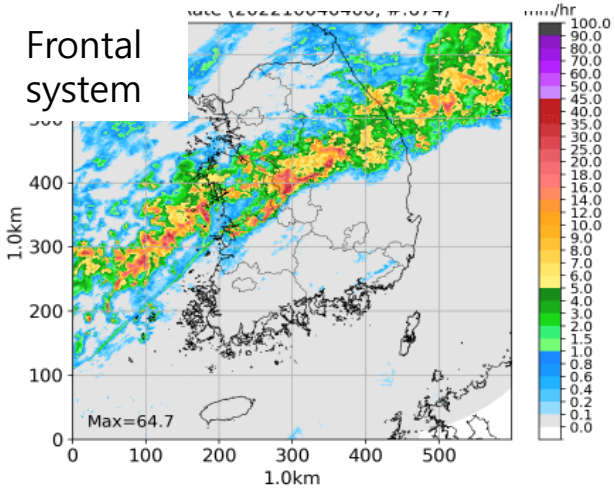
(5) 0905~0906 [29h]

Typhoon Hin-nam-ro



(6) 1003~1004 [17 h]

Frontal system



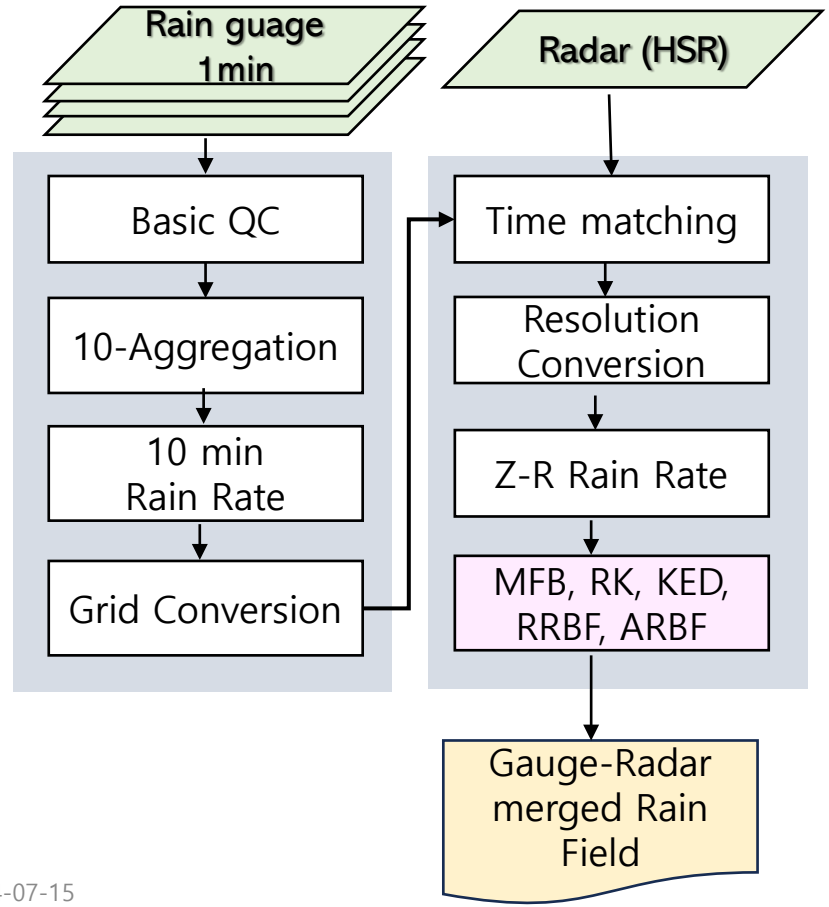
3. Methodology

#	Name	Short name	Gauge data	Radar data	Remark
1	Z-R relation	**ZR**	X	O	$Z = aR^b$ (a=200, b =1.6)
2	Mean field bias Adjustment	**MFB**	O	O	$P_{MFB}(s_0,t) = c(t)R(s_0,t)$ $c(t) = \frac{\sum G(s_i,t)}{\sum R(s_i,t)}$
3	Residual kriging	**RK**	O	O	Simple kriging on residuals
4	Kriging with external drift	**KED**	O	O	Kriging interpolation using radar data as an external variable
5	Residual radial basis function interpolation	**RRBF**	O	O	Simple RBF interpolation on residuals between radar and gauge
6	Augmented radial basis function interpolation	**ARBF**	O	O	RBF interpolation using radar data as an augmented variable

3. Methodology

Algorithm for the generation of precipitation field

- Rain gauge: basic quality control (removal of missing and physical limit value)
- Radar: HSR composite reflectivity field 0.5km ➔ Rain field(Z-R), 1km (960 x 960)



RRBF

$$c(t) = \frac{\sum G(s_i,t)}{\sum R(s_i,t)}$$

$$G(x,t) - c(t)R(x,t) = \sum_{i=1} w_i(t)\phi(|x - x_i|)$$

Find $w_i(t)$

$$\hat{R}(x_0,t) = \sum_{i=1} w_i\phi(|x_0 - x_i|) + c(t)R(x_0,t)$$

RBF: $\phi(r) = e^{-s/r}$

ARBF

$$G(x,t) = \sum w_i\phi(|x - x_i|) + c(t)R(x,t)$$

Find $w_i(t), c(t)$

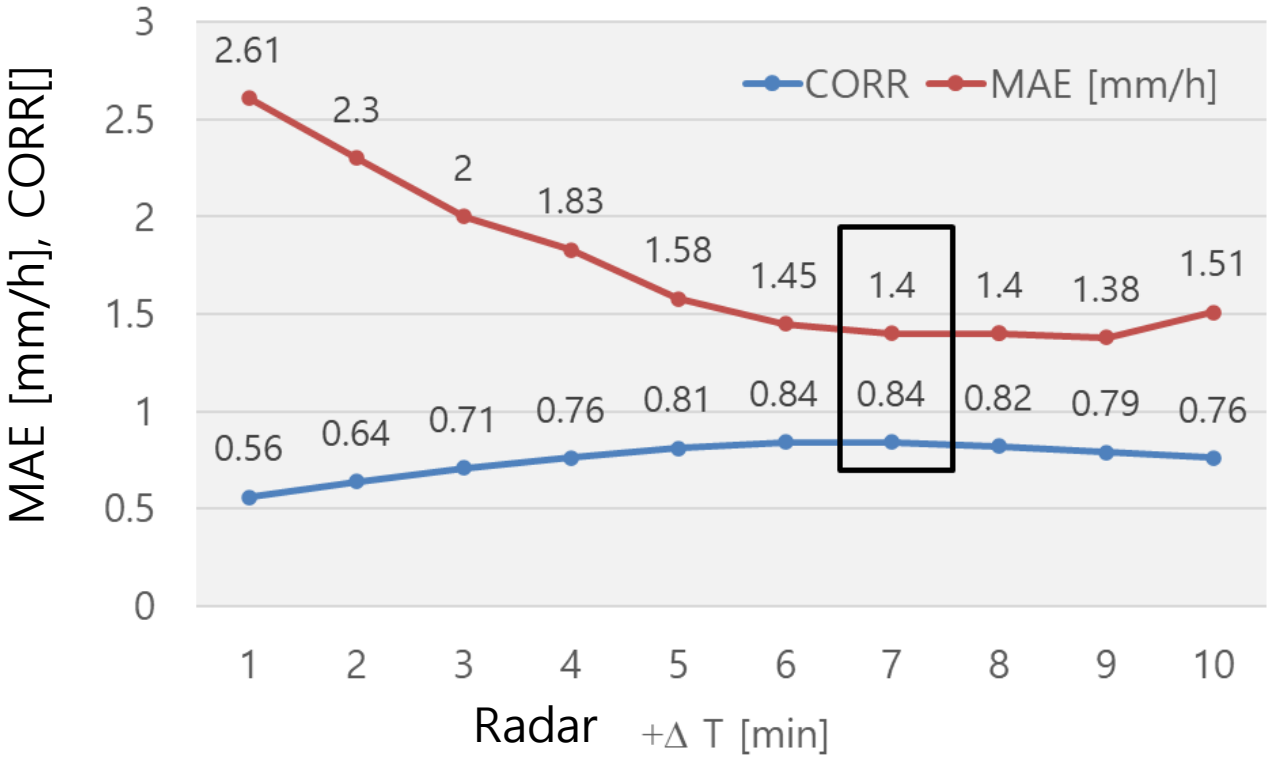
$$\hat{R}(x_0,t) = \sum_{i=1} w_i(t)\phi(|x_0 - x_i|) + c(t)R(x_0,t)$$

3. Methodology : Time calibration

Time matching with Gauge and Radar data

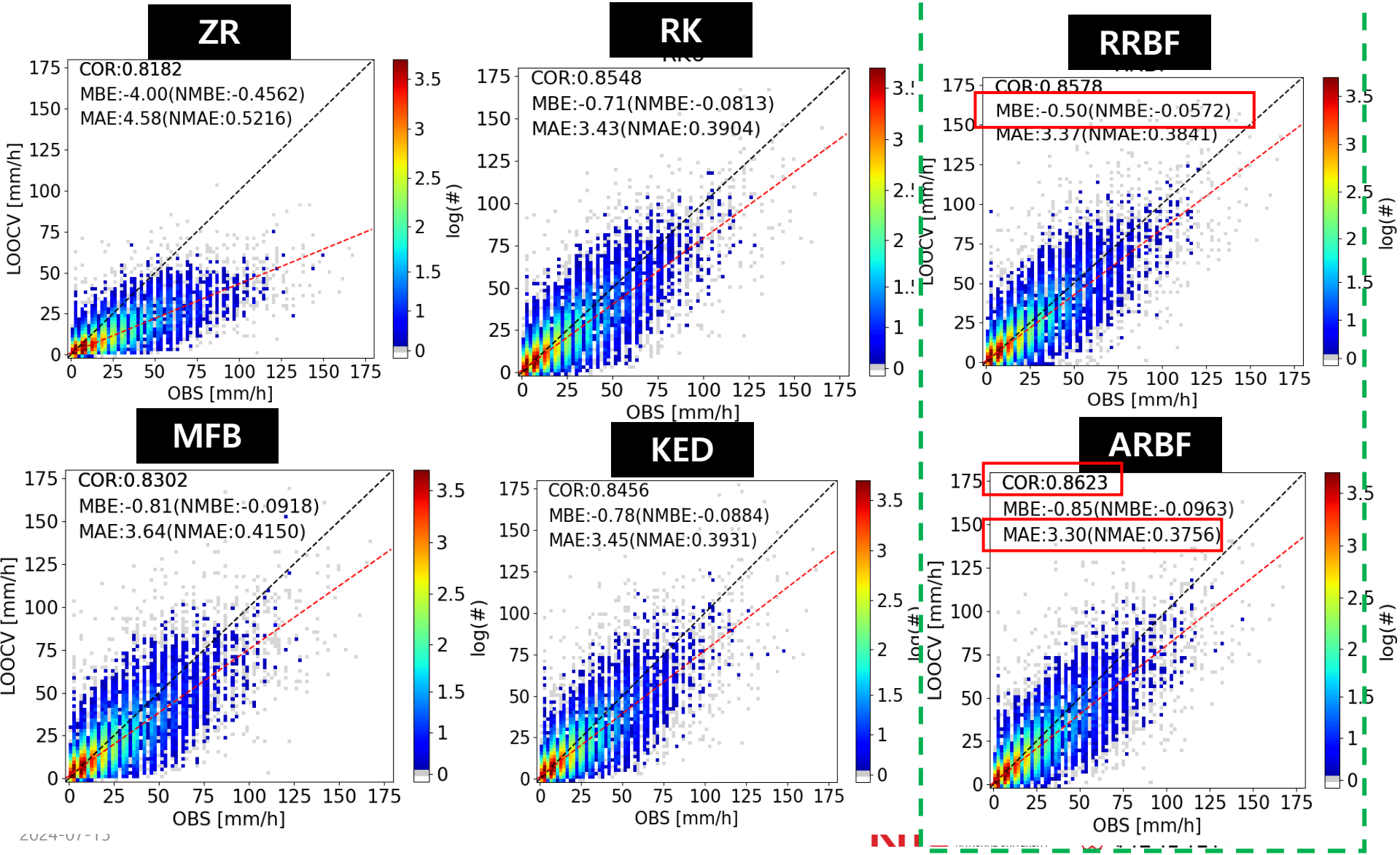
- Computation of Correlation coefficient and MAE between gauge and radar precipitation
- Best matching time of Gauge's 10-min (cumulative) average = radar time + 7 minutes

ex) Radar time : 04:00 vs Gauge: 03:57~04:07



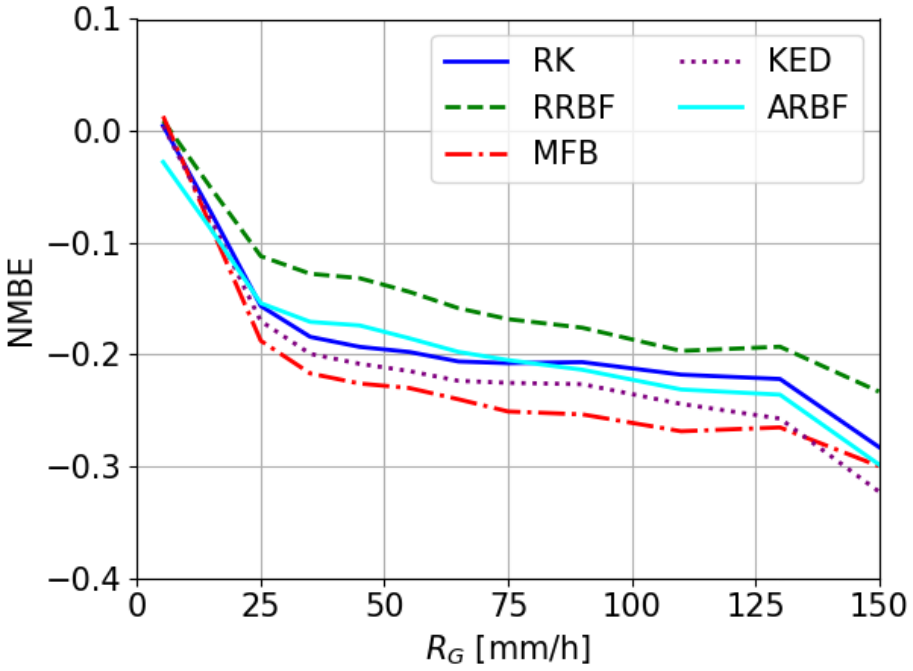
4. Results : verification (LOOCV)

Threshold = 0.1 mm/h

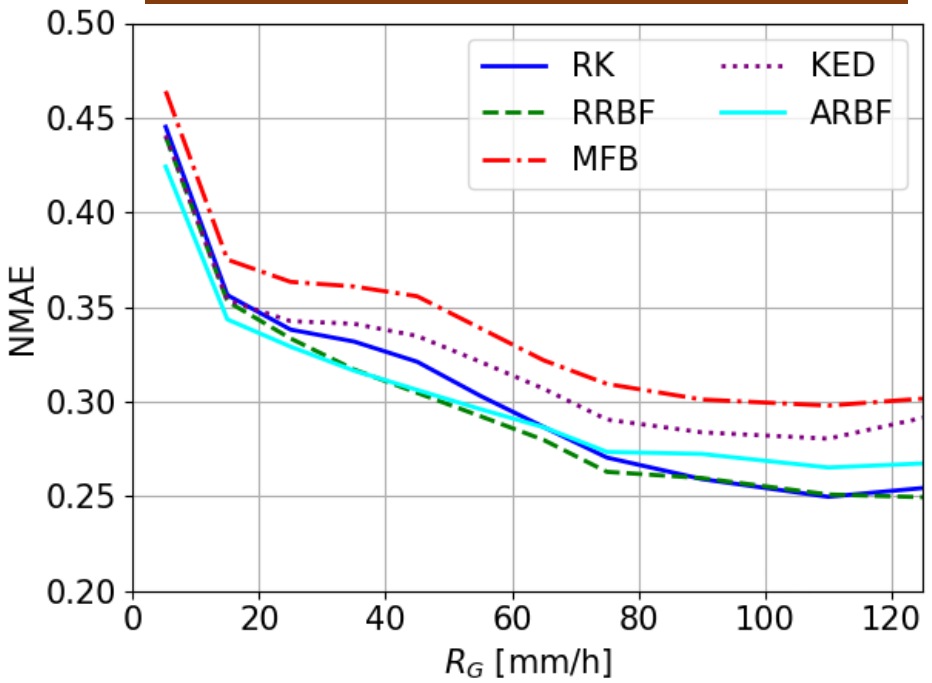


4. Results : R vs. normalized BIAS (LOOCV)

Normalized Mean Bias Error



Normalized Mean Absolute Error

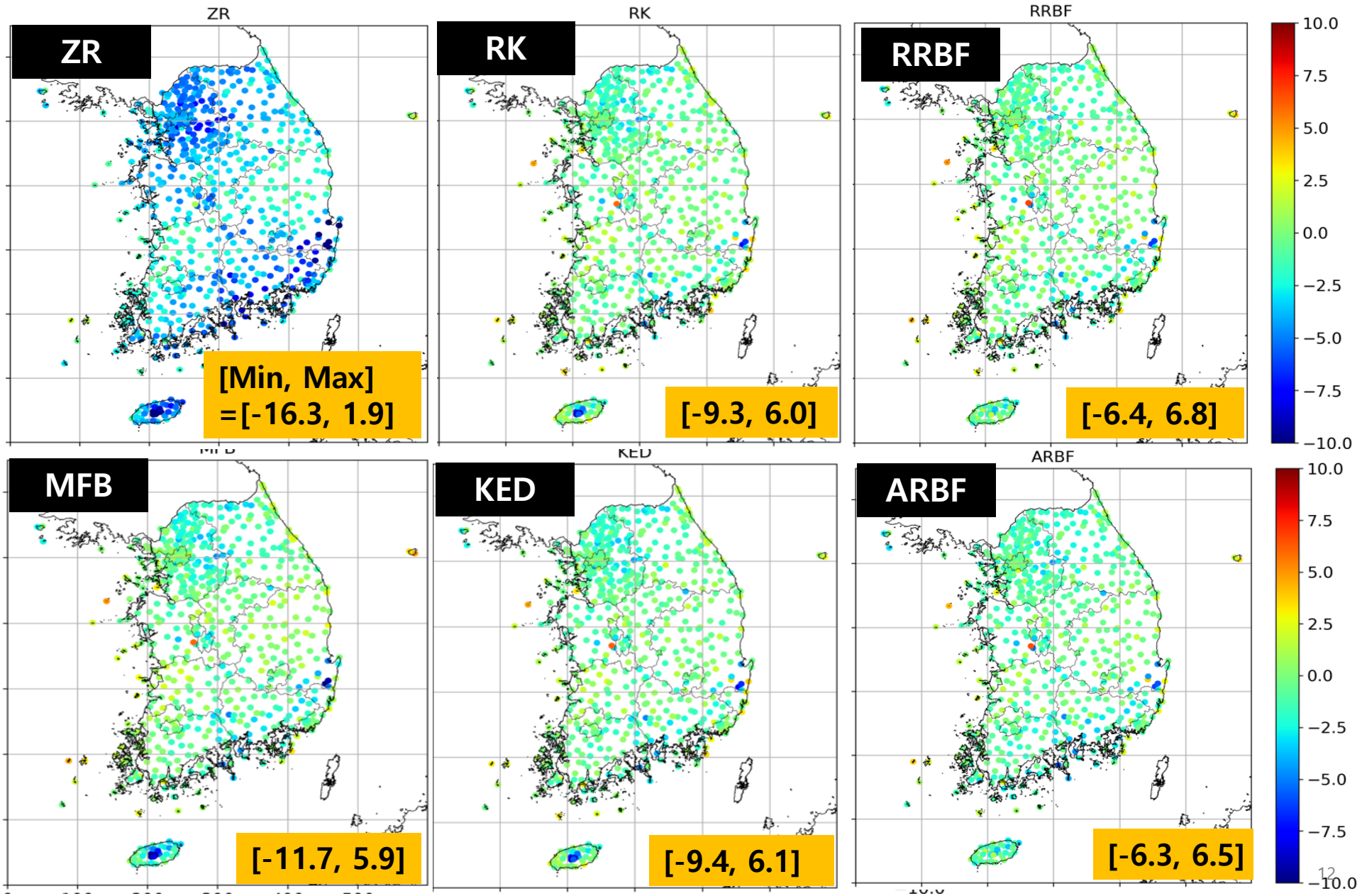


Good ⟵

NMBE RRBF < ARBF, RF < KED < MFB

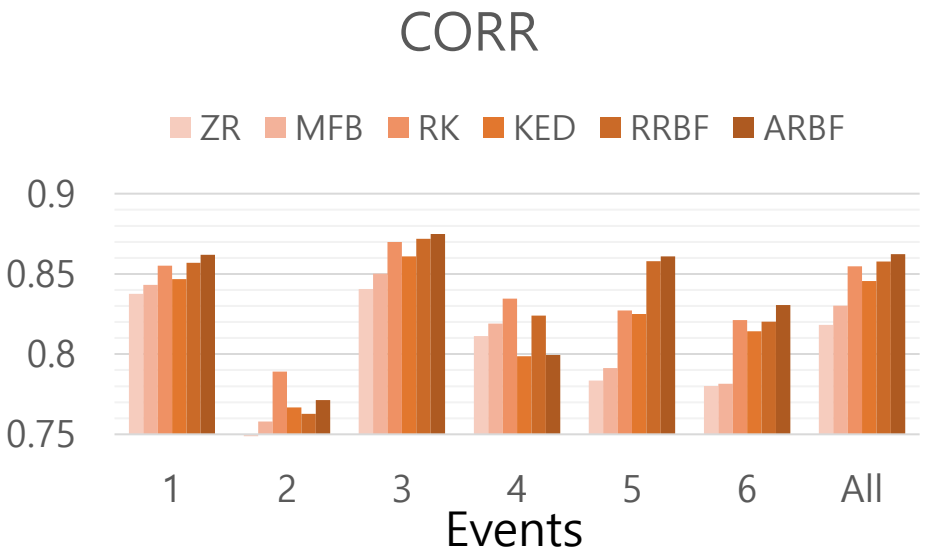
NMAE RRBF, ARBF < RK < LED < MFB

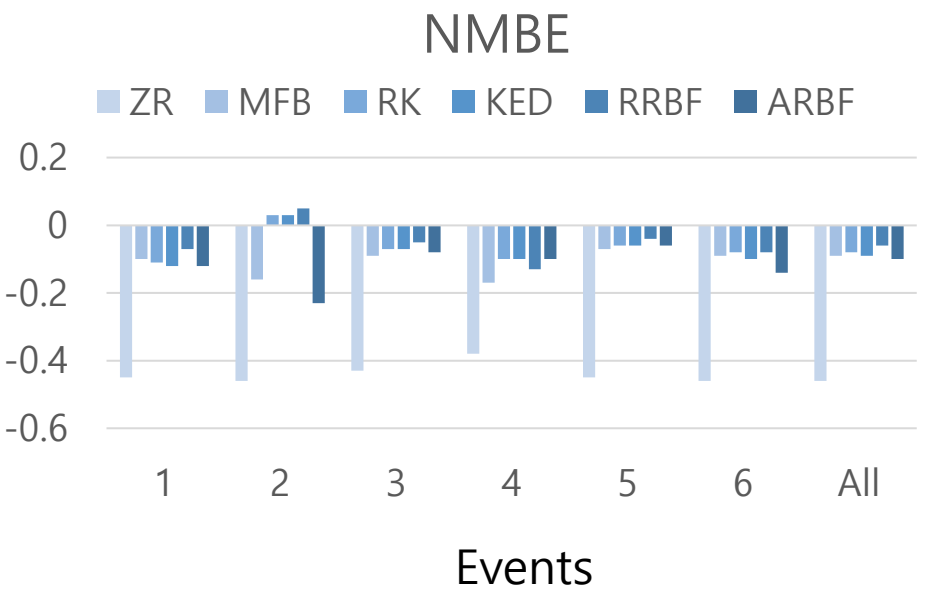
4. Results: MBE [mm/h] (LOOCV)

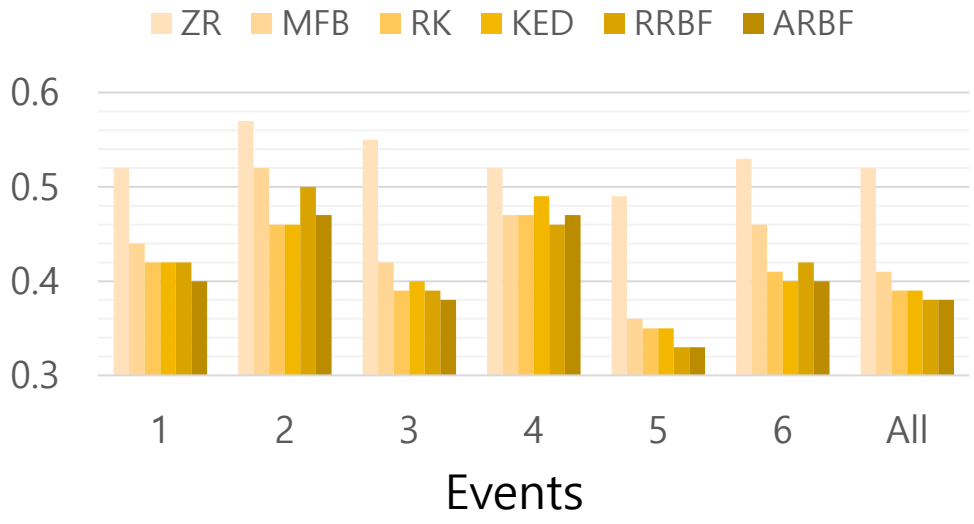


4. Results: (verification for all events, LOOCV)

Threshold = 0.1 mm/hr





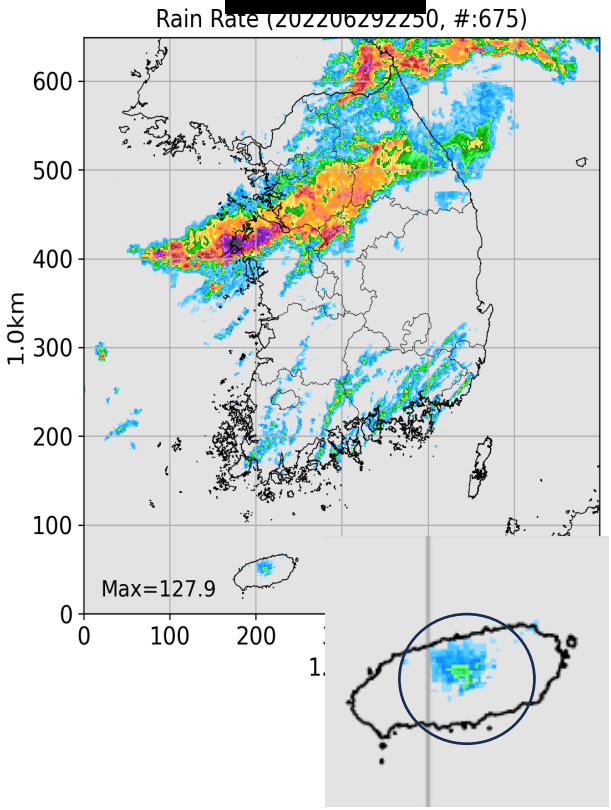


Score	Best (total)
CORR	ARBF
NMBE	RRBF
NMAE	ARBF, RRBF

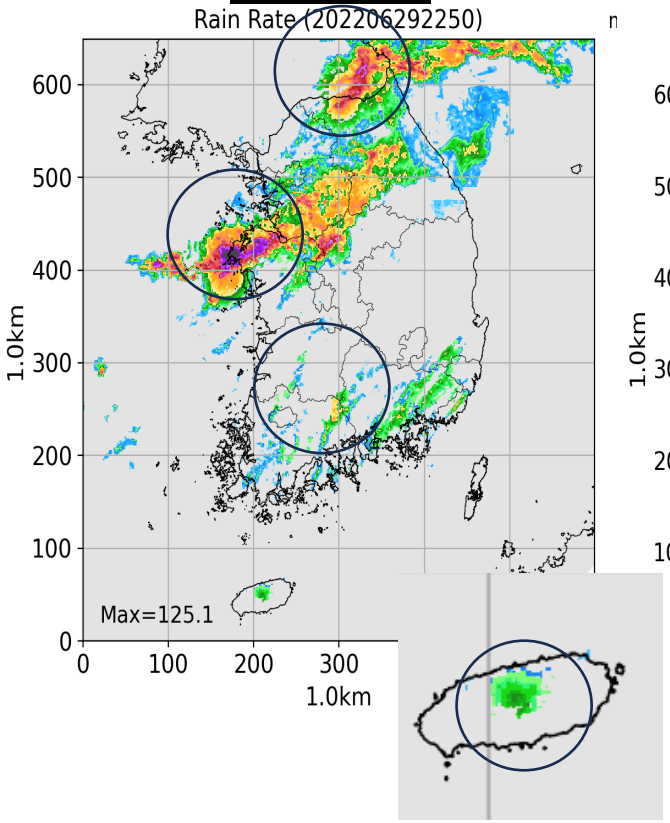
4. Results: examples

20220629 22:50(LST)

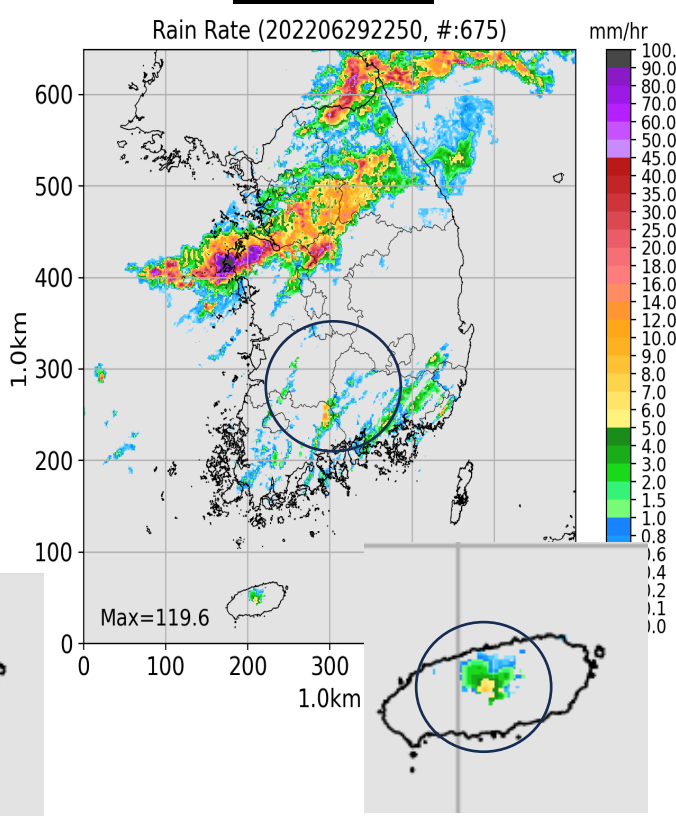
MFB



RK



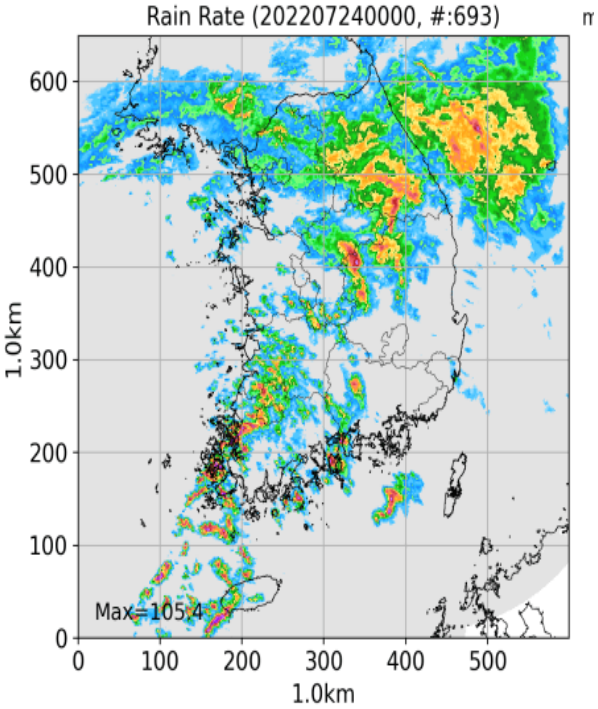
ARBF



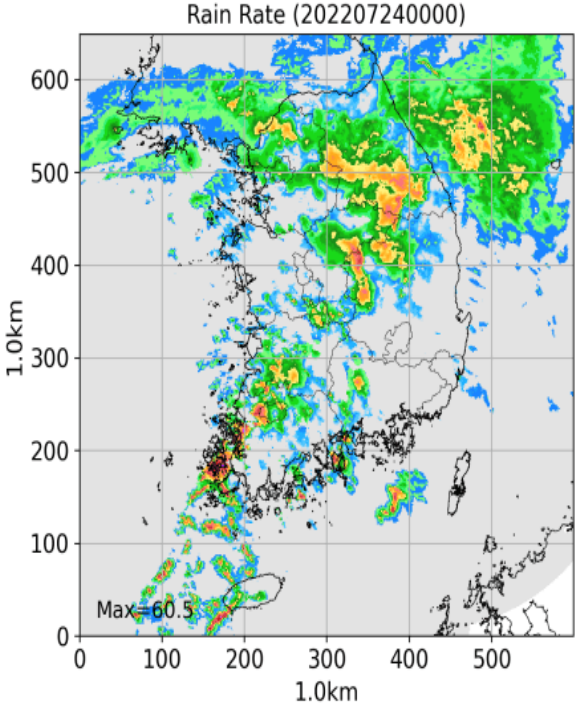
4. Results: examples

Event #2: 2022 0724 00:00 ~ 02:00 (LST)

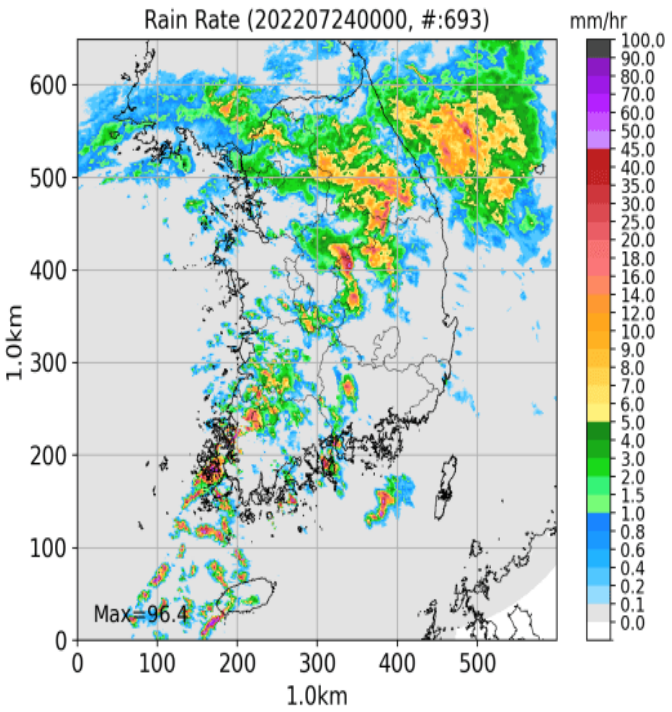
MFB



RK



RRBF



➔ RK: discontinuity over time

5. Summary and Conclusion

- Developed radar-rain gauge merging methods using the RBF based methods such as RRBF or ARBF, and compared the results with those of the kriging-based methods.

- Among the 6 methods, the RBF based methods showed the lowest (LOOCV) errors and highest correlation coefficients.

- For the kriging-based methods, smoothing was observed intermittently, and in some cases, discontinuities appeared over time.

➔ RBF-based merging methods were more stable and showed higher accuracy than the kriging-based methods.

➔ Merged precipitation data is available from 2018 to 2023 (6 years).