Precipitation estimation over radar gap areas based on satellite and adjacent radar observations

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09. 17. 2015

37th Conference on Radar Meteorology

기상레이더센터
Weather Radar Center

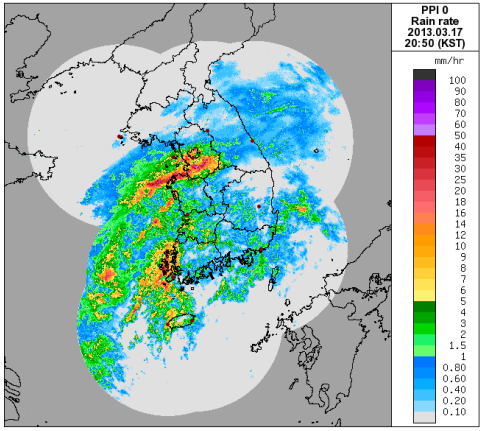
Background

- High temporal and spatial resolution
- Relatively accurate
- Limited observation area

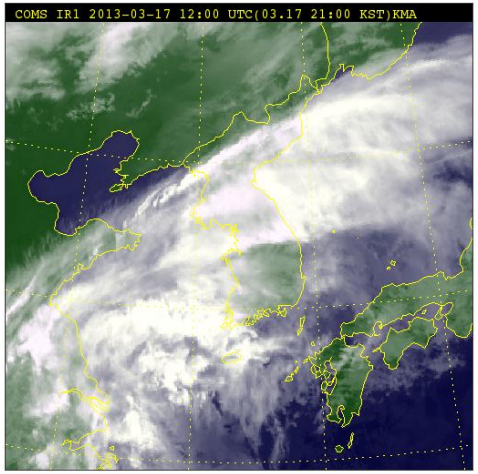
- Large observational coverage
- Including uncertainties

Development of techniques merging radar, satellite and model data utilizing the benefits of each dataset

- **Filling radar gap areas**
- **Monitoring the outside of radar observation areas**



Radars

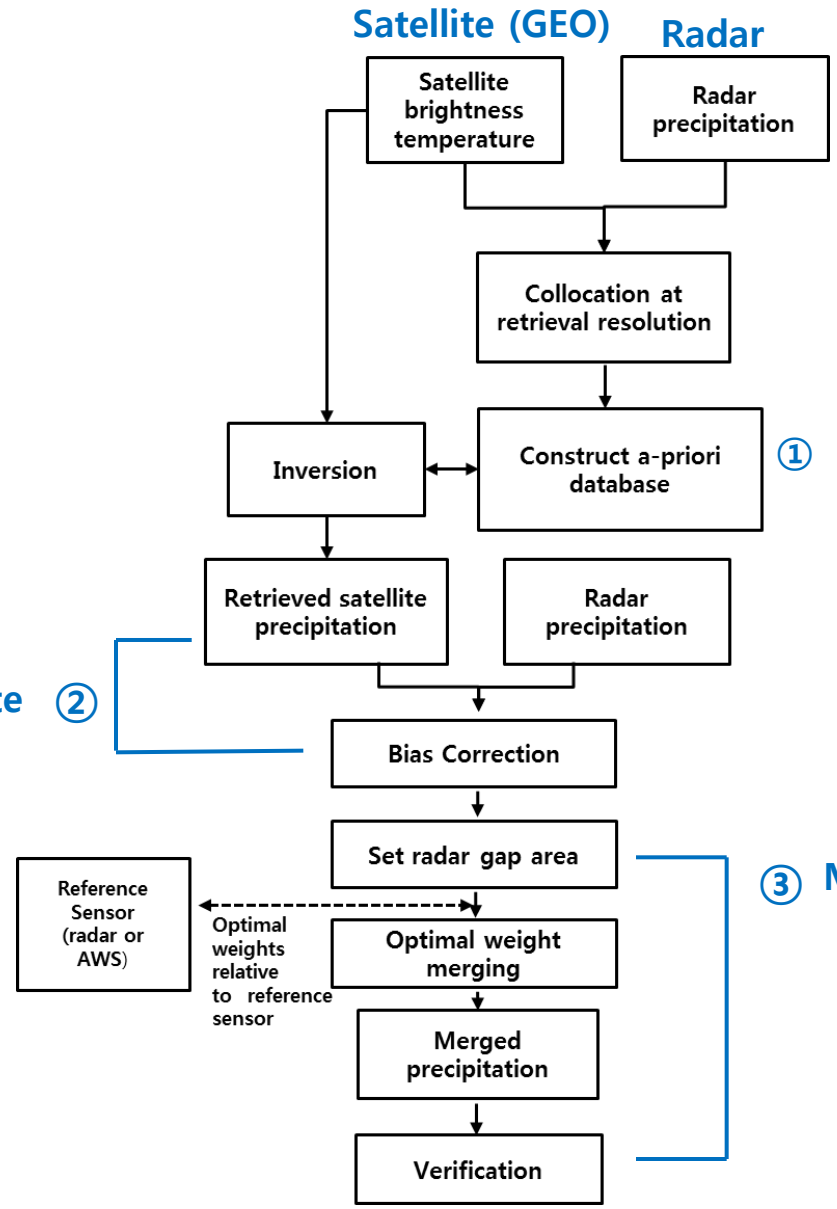


Satellites

Merging radar and satellite precipitation to fill radar gap areas

• Merging precipitations over the radar gap area

Flow chart

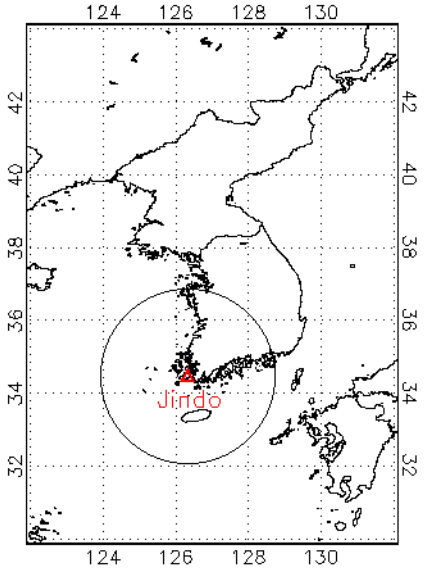


① Construct a-priori database for satellite precip. estimation

② Retrieve and correct satellite precipitation

③ Merging precipitation field

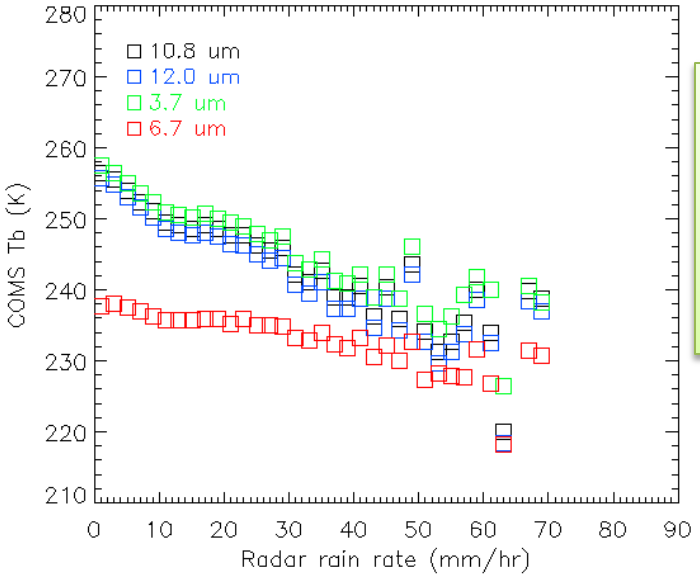
• Merging precipitations over the radar gap area



- **Radar**
  - Jindo S-band Doppler radar
  - Observes range of 240 km every 10 minutes
  - Spatial resolution: 1 km x 1 km
- **Satellite**
  - COMS (Communication, Ocean, and Meteorological Satellite)
  - Channels: **10.8 (IR1), 12.0 (IR2), 6.7 (WV), 3.7 (NIR)**, 0.67 (VIS) μm
  - Observes every 15 minutes with 4 km x 4 km spatial resolution

- **Merging precipitations over the radar gap area**

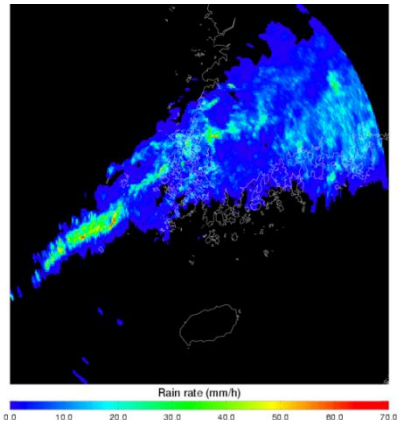
Construct a-priori database for satellite precipitation inversion



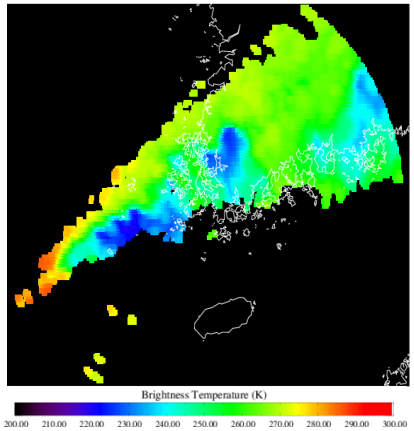
Precipitation estimation from satellite is based on the radar rain rate (R) - satellite brightness temperature (TB) relationships of a-priori databases

- **Datasets being updated continuously at in a timespan of approximately one hour prior to the designated retrieval time**

Collocation between radar and satellite



Radar rain rate (mm/hr)
1 km x 1 km resolution

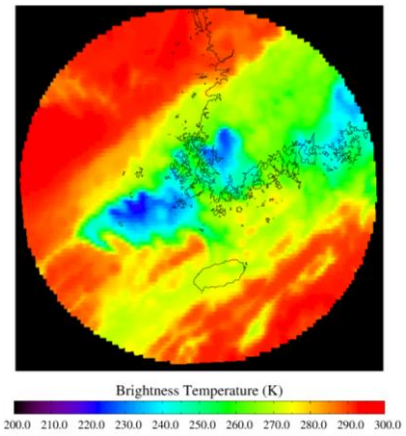


Collocated TB at COMS IR1
1 km x 1 km resolution

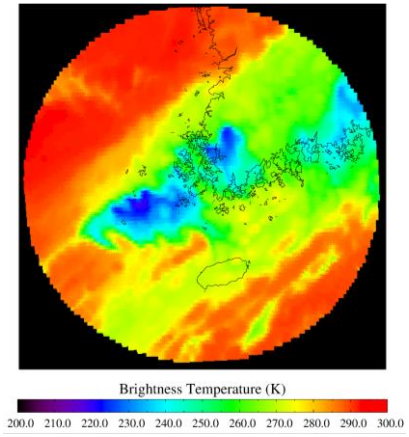
• Merging precipitations over the radar gap area

- **Precipitation estimation from satellite** based on the a-priori database
  - Case - 2011/07/09 21:00 LST

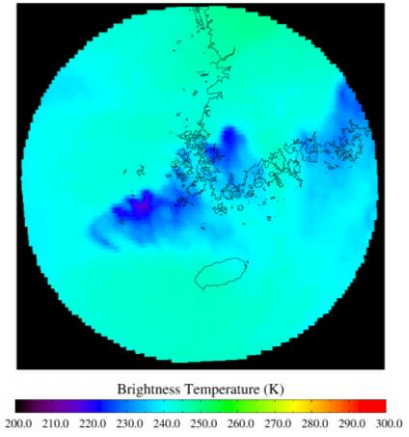
Input (collocated)



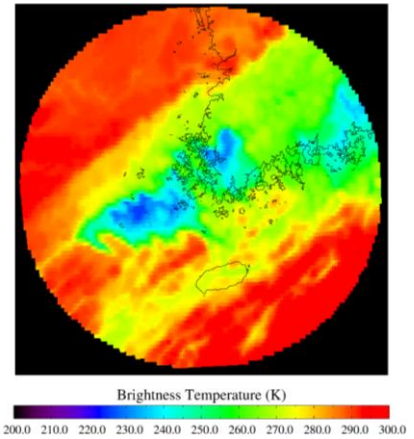
COMS IR1 (10.8 μm) Tb (K)



COMS IR2 (12 μm) Tb (K)



COMS WV (6.7 μm) Tb (K)



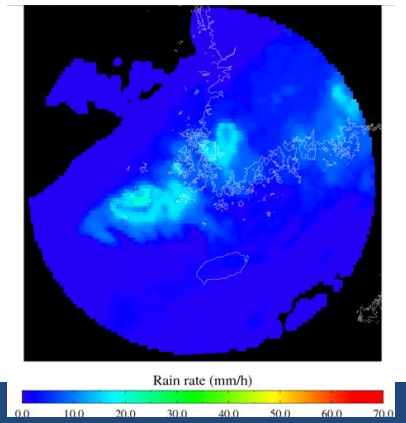
COMS NIR (3.7 μm) Tb (K)

Database (20:45, 20:00, 19:45, 19:30, 19:00 LST)

Bayesian inversion

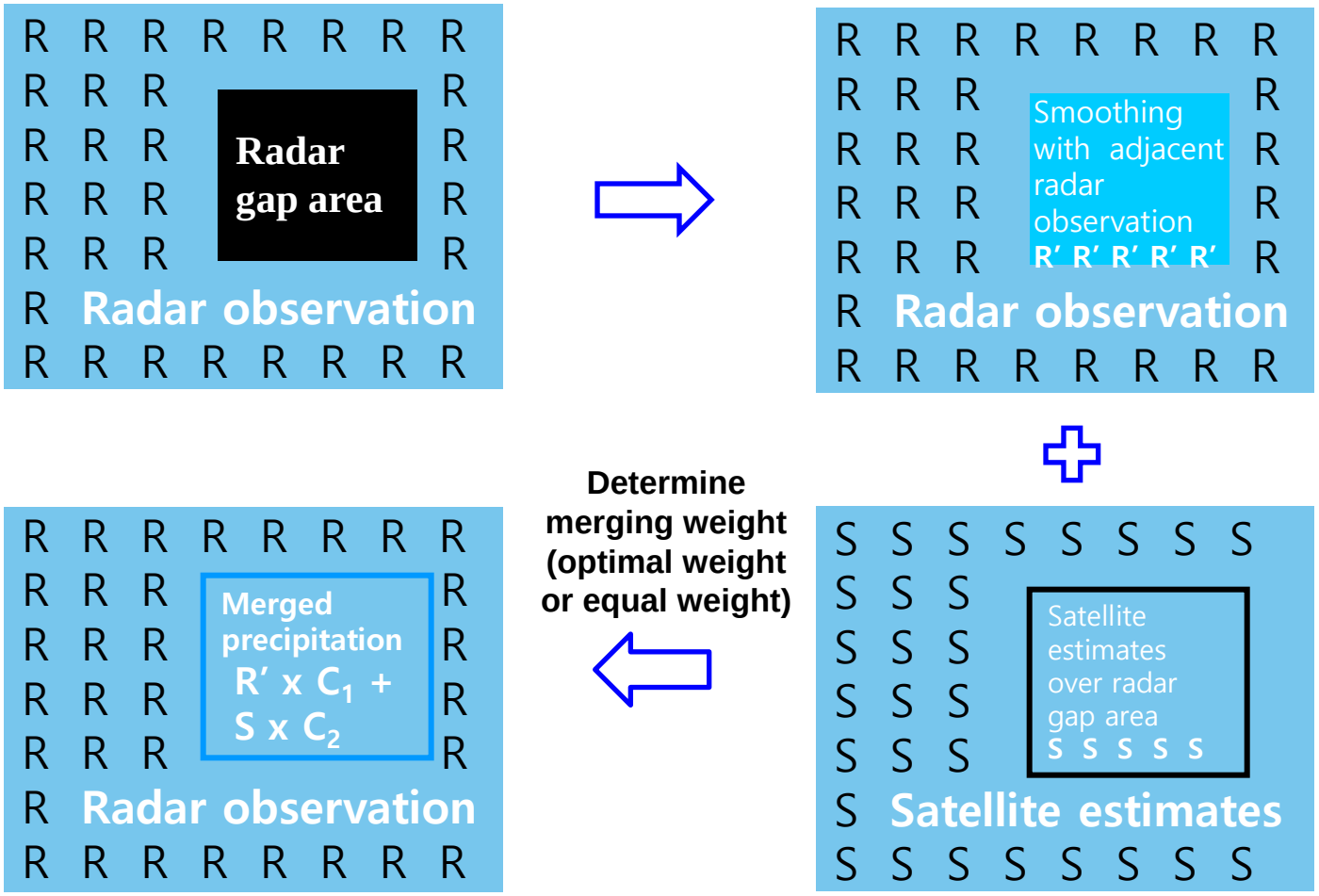
$$P(R|TB) = P(R)P(TB|R)$$

Retrievals of rain rates



Merging method

- Merging of radar - satellite precipitation
  - Diagram of merging method over artificially set radar gap area



• Merging precipitations over the radar gap area

- **Optimal weight merging method**
  - Using the reference data (original radar or AWS)
    1. **Optimal weight merging method using the original radar (to check the merging quality)**
    2. **Optimal weight merging method using AWS**
  - Determine merging weight from RMS with reference data

$$C_j = \frac{\frac{1}{\sigma_j^2}}{\sum_{i=1}^{2} \frac{1}{\sigma_i^2}} \longrightarrow \hat{R} = \sum_{i=1}^{2} C_i R_i$$

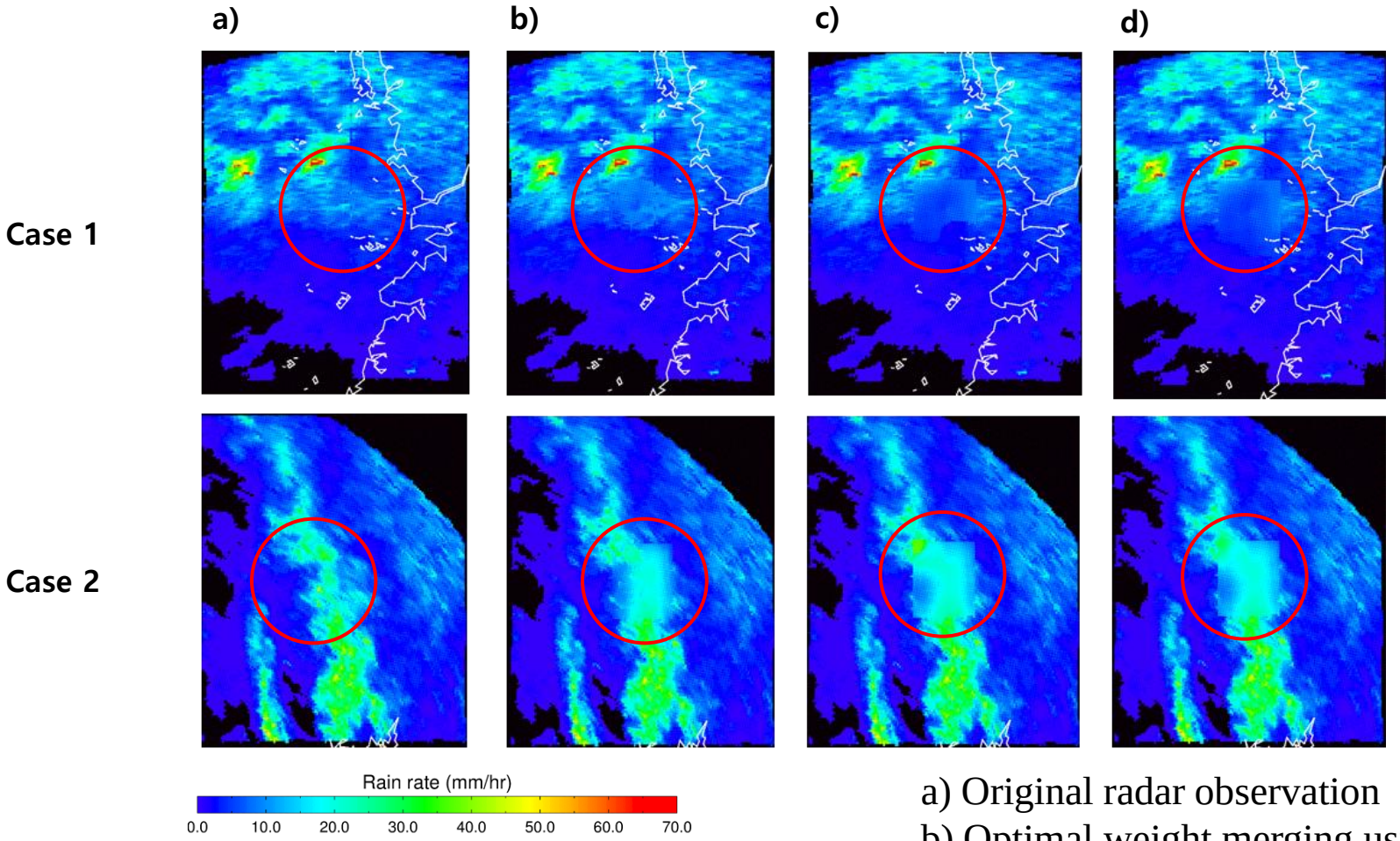
σ from comparisons with the reference data

Merged precipitation

- **3. Equal weight merging method**
  - Assign equal weights to the interpolated radar and satellite precipitation estimates
  - Not using the reference data

• Merging precipitations over the radar gap area

Examples of merged precipitation

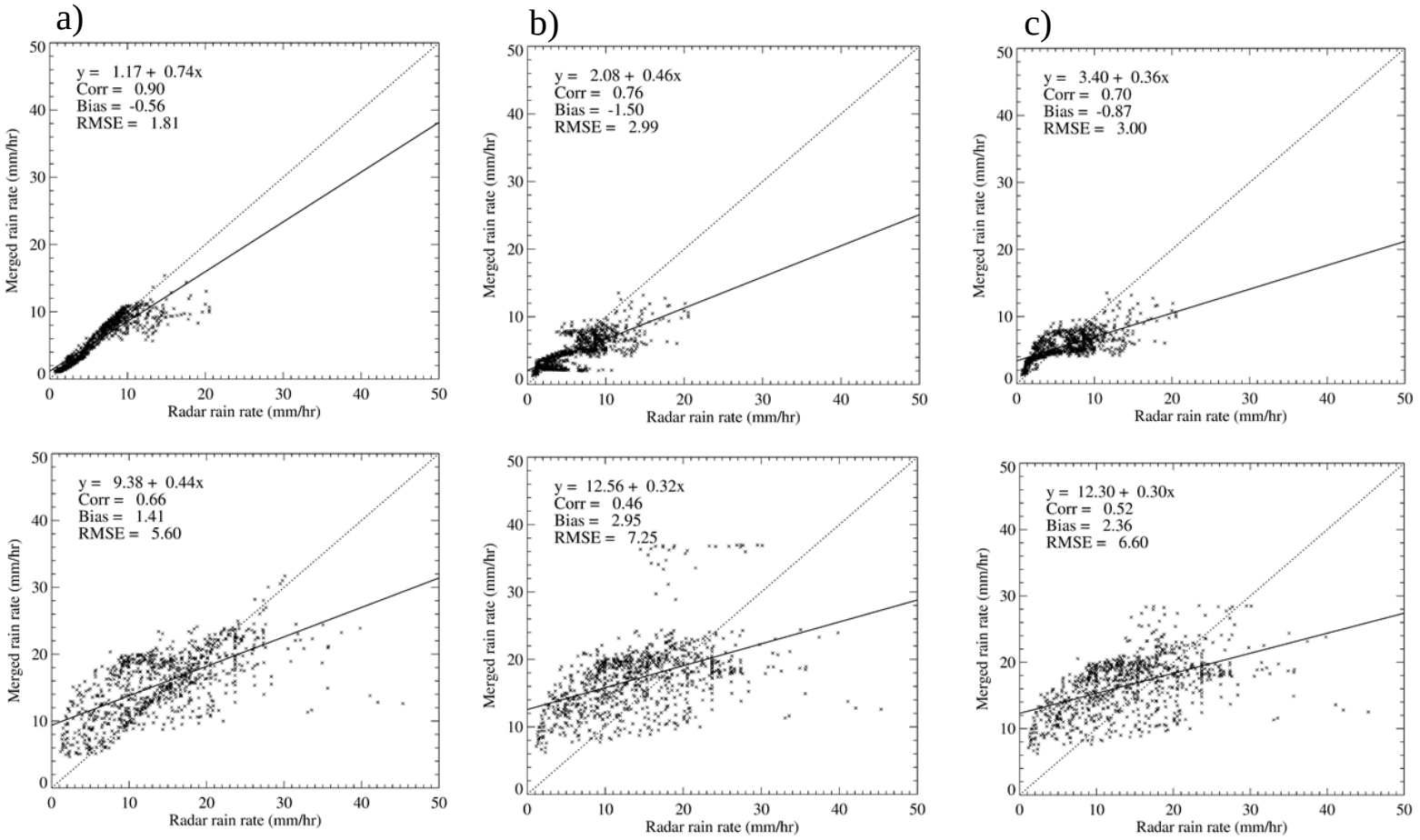


a) Original radar observation
b) Optimal weight merging using radar
c) Optimal weight merging using AWS
d) Equal weight merging

• Merging precipitations over the radar gap area

Case 1

Case 2

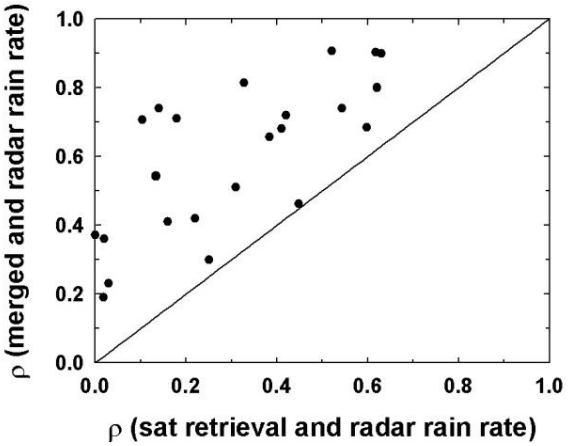


a) Optimal weight merging using radar
b) Optimal weight merging using AWS
c) Equal weight merging

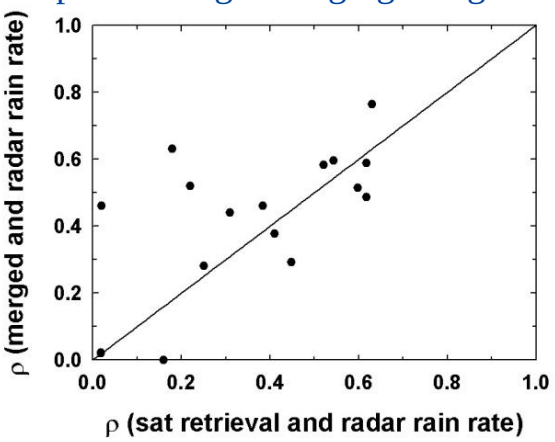
• Merging precipitations over the radar gap area

- Accuracy of merged precipitation field in terms of performance of satellite precipitation estimates

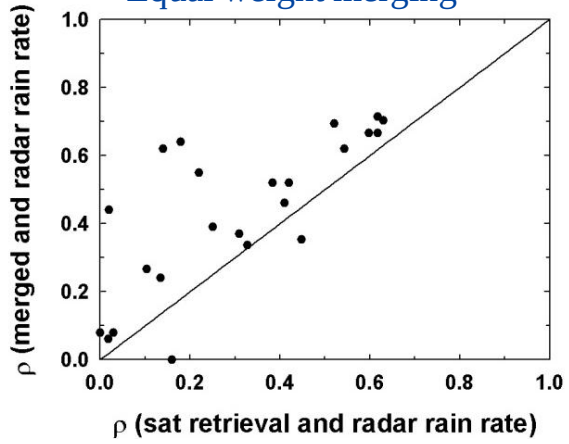
Optimal weight merging using radar



Optimal weight merging using AWS



Equal weight merging

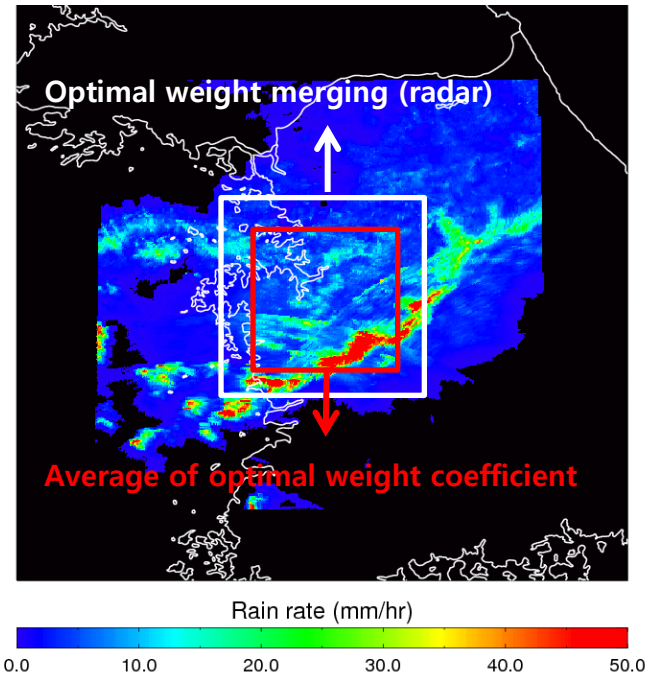


- Successful merging over the radar gap areas appears to be closely related to the quality of the satellite precipitation estimates

Lee et al. 2015, AMT

• Merging precipitations over the radar gap area

- Mitigate discontinuity around the merging precipitation field
  - The edge of radar observation was set to buffer zone
  - Merged precipitation at buffer zone was based on optimal weight merging method using radar observation

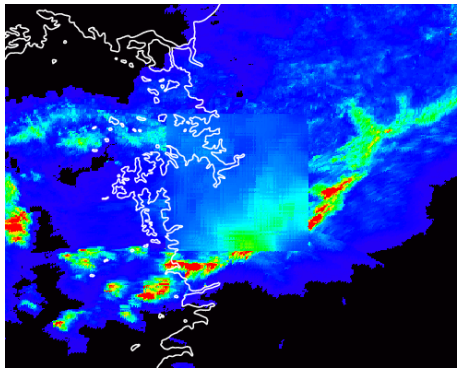
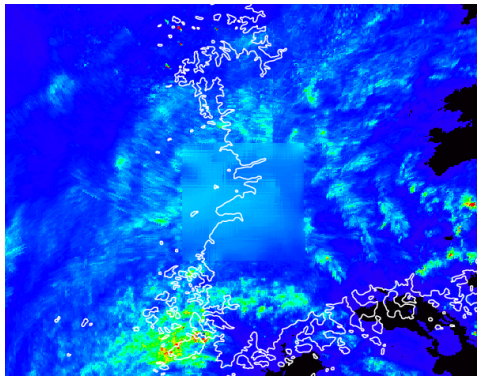
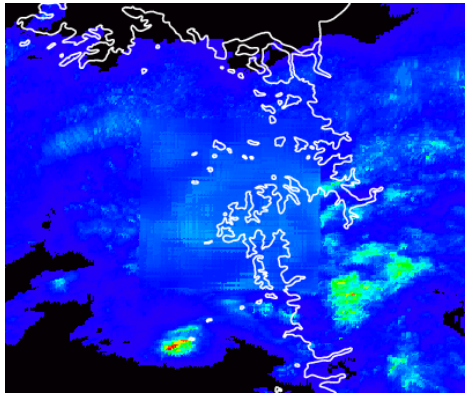


• Merging precipitations over the radar gap area

- Mitigate discontinuity

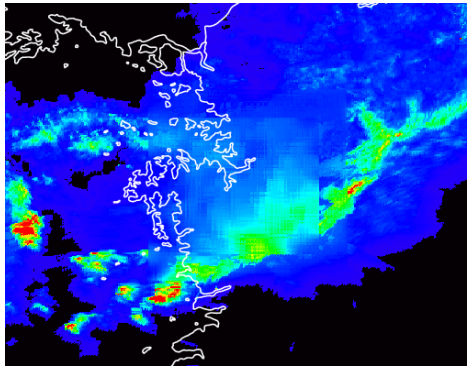
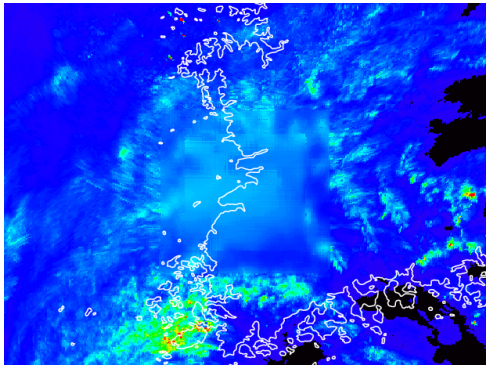
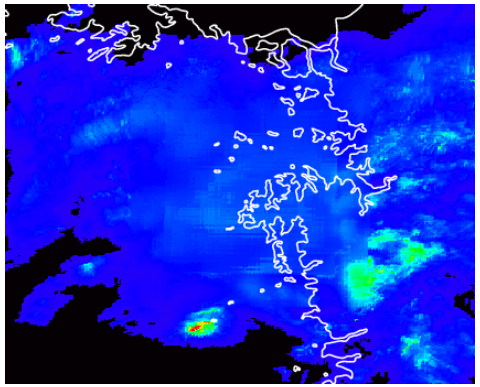
<Case 1> <Case 2> <Case 3>

<Merged precipitation>



<Applying mitigating technique>

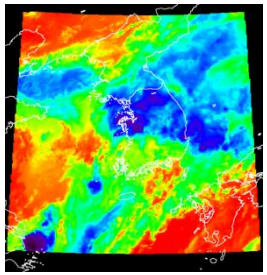
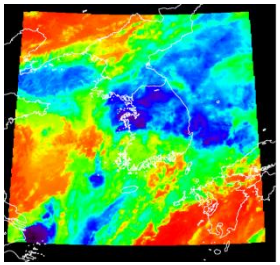
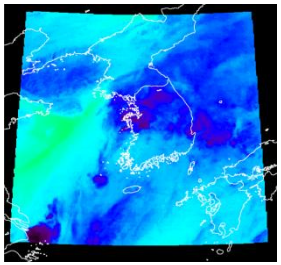
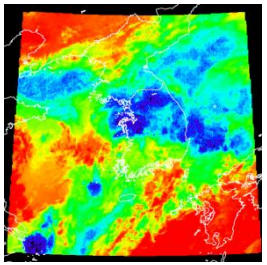




Enhancement of the merging method using three precipitation fields from radar, satellite and model

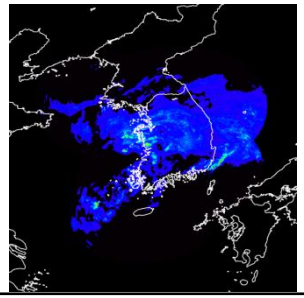
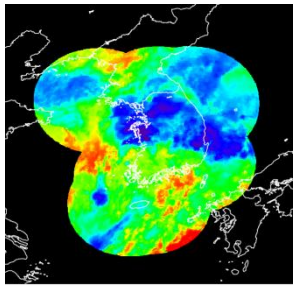
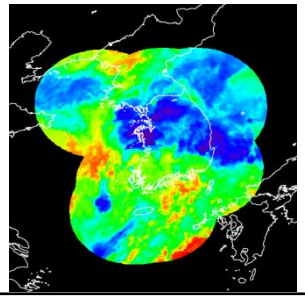
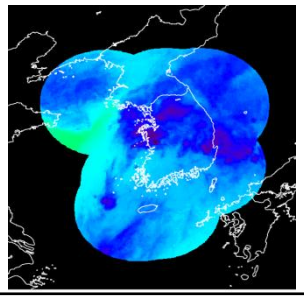
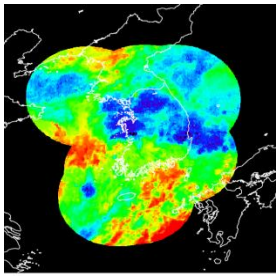
Applications to the yellow sea and east Asia regions

Rainfall retrieval from ground based radar rain rate – COMS TBs of a-priori DB

Input (2012.07.15. 03:00)

COMS IR1	COMS IR2	COMS WV	COMS NIR
			

Database (2012.07.15. 01:00 ~ 02:45)

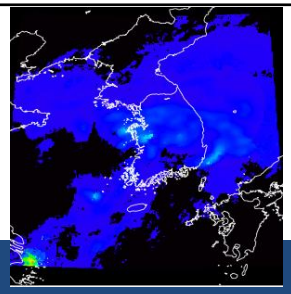
Radar	COMS IR1	COMS IR2	COMS WV	COMS NIR
				

Using the warm/cold DBs

Bayesian inversion

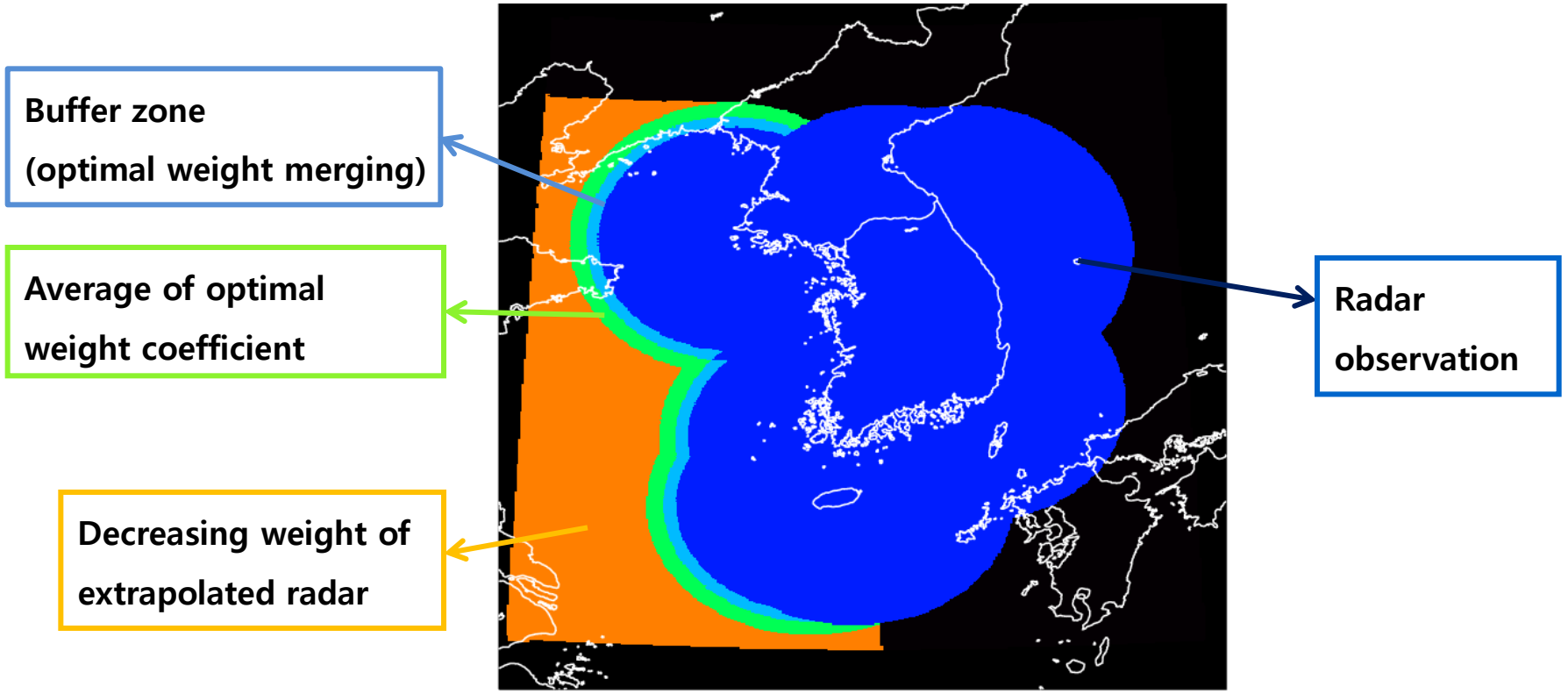
Rainfall retrieval

Bias correction



Introducing the model data to the merging procedure

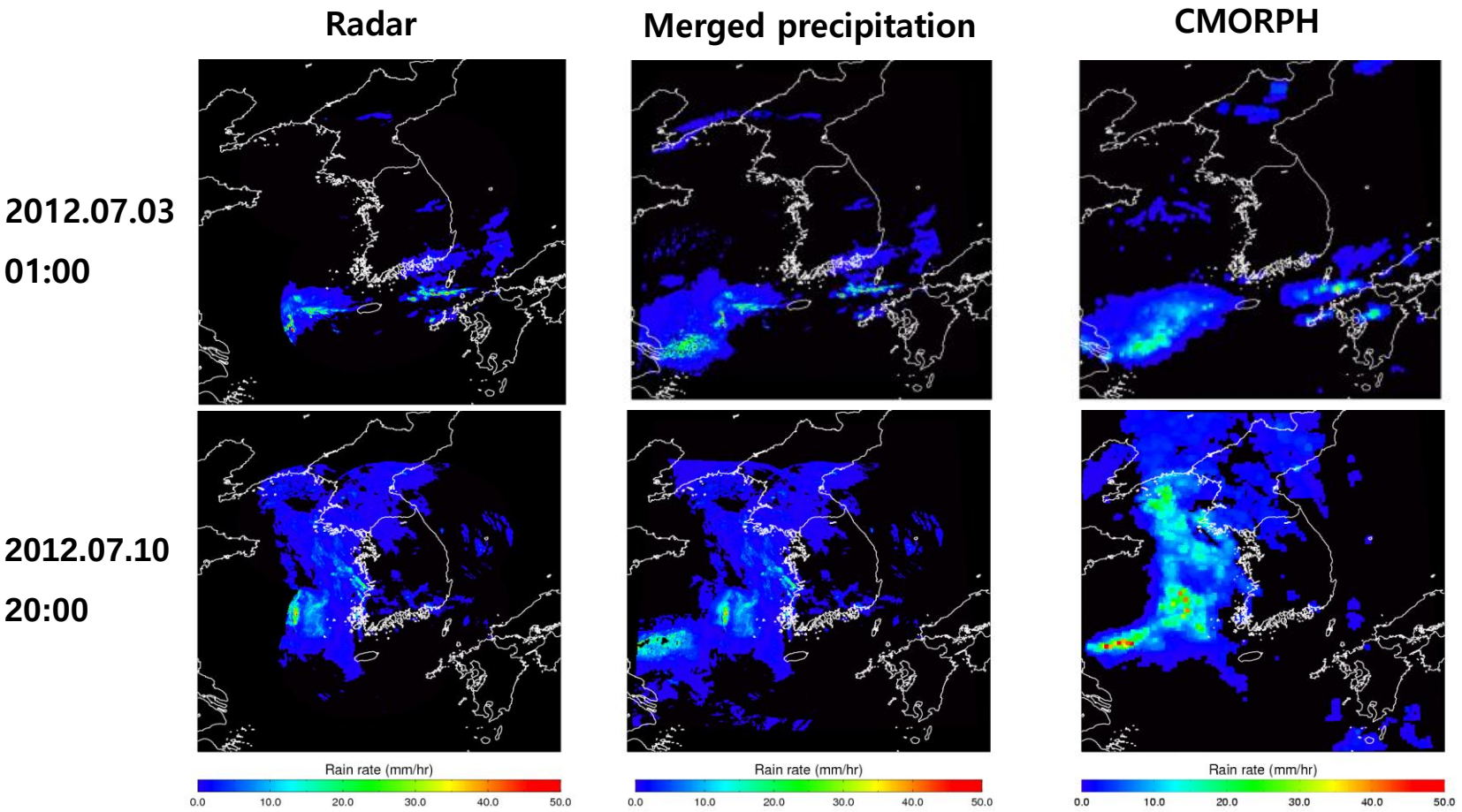
- Radar observation over Korean peninsula + satellite precipitation estimation over yellow sea + KLAPS (Korea Local Analysis and Prediction System) precipitation field



<Mask of merging method>

Merging radar, satellite and model precipitation fields

- Radar observation over Korean peninsula + satellite precipitation estimation over yellow sea + KLAPS precipitation field



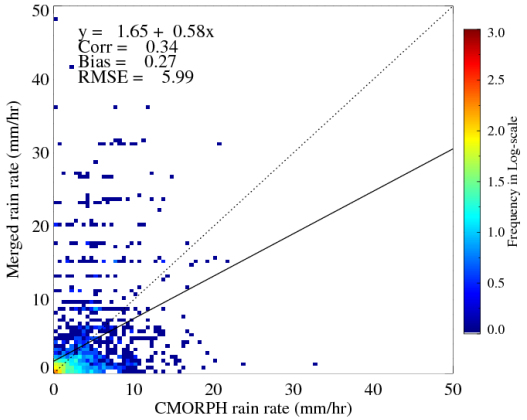
Comparison with other satellite estimates (CMORPH)

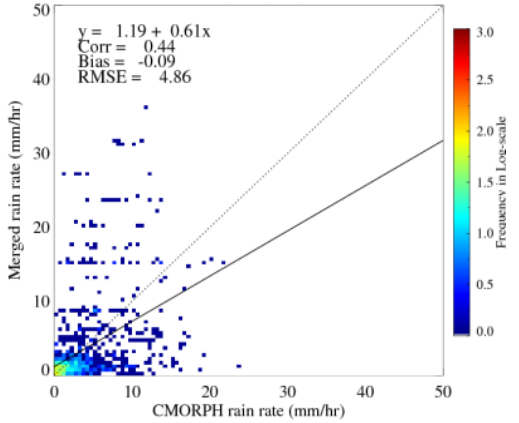
- **Merged precipitation is compared to independent satellite precipitation product (CMORPH)**

<Comparing merged precipitation and CMORPH >

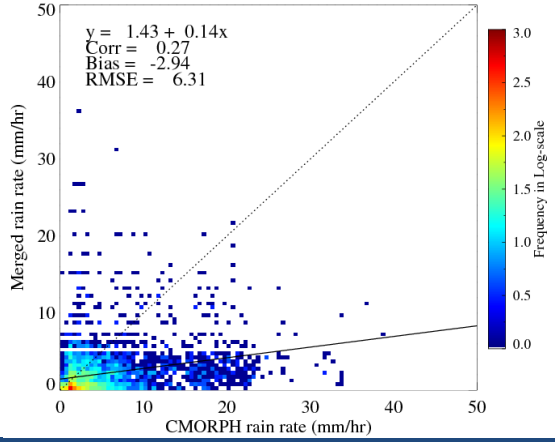
<Comparing over only yellow sea region where radar observations are not available>

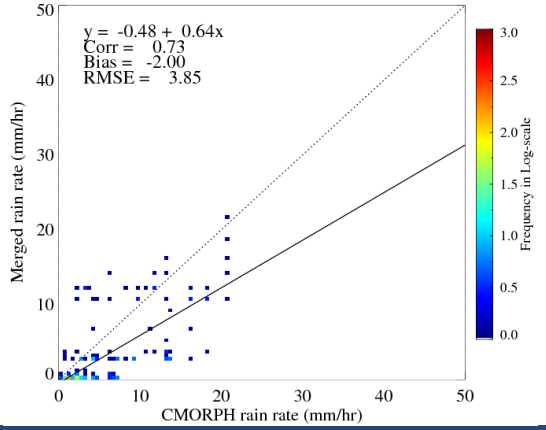
2012.07.03 01:00





2012.07.15 03:00



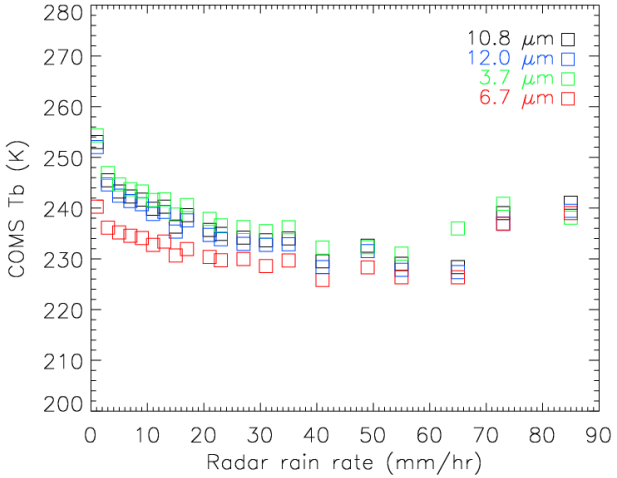


Improving the accuracy of the satellite precipitation estimates

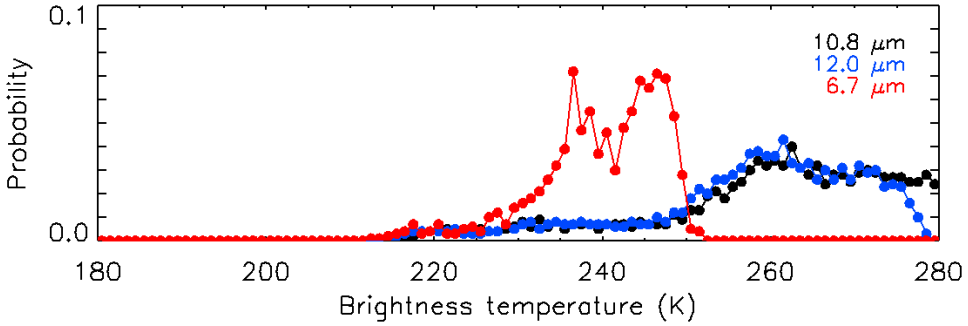
- Warm/Cold rain discrimination based on Probability Density Function (PDF) of the satellite TBs

R-TB relationship

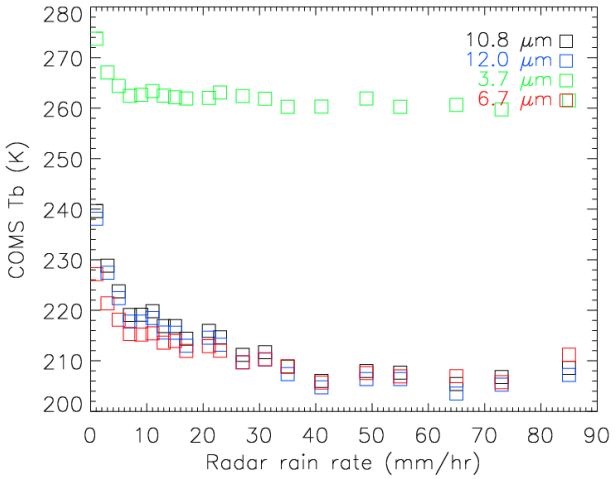
database 1

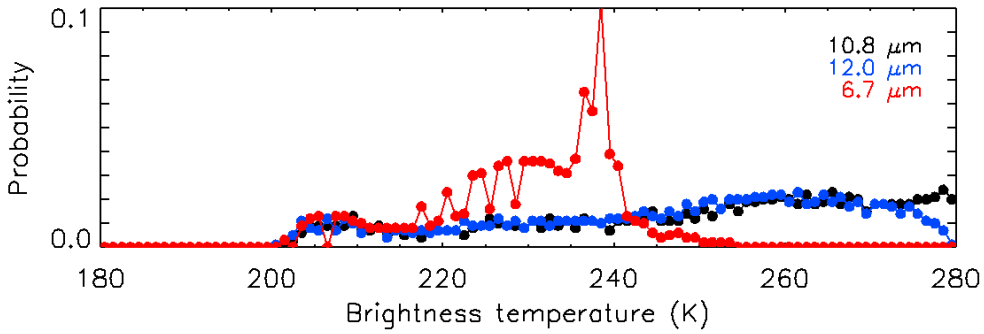


PDFs of TB

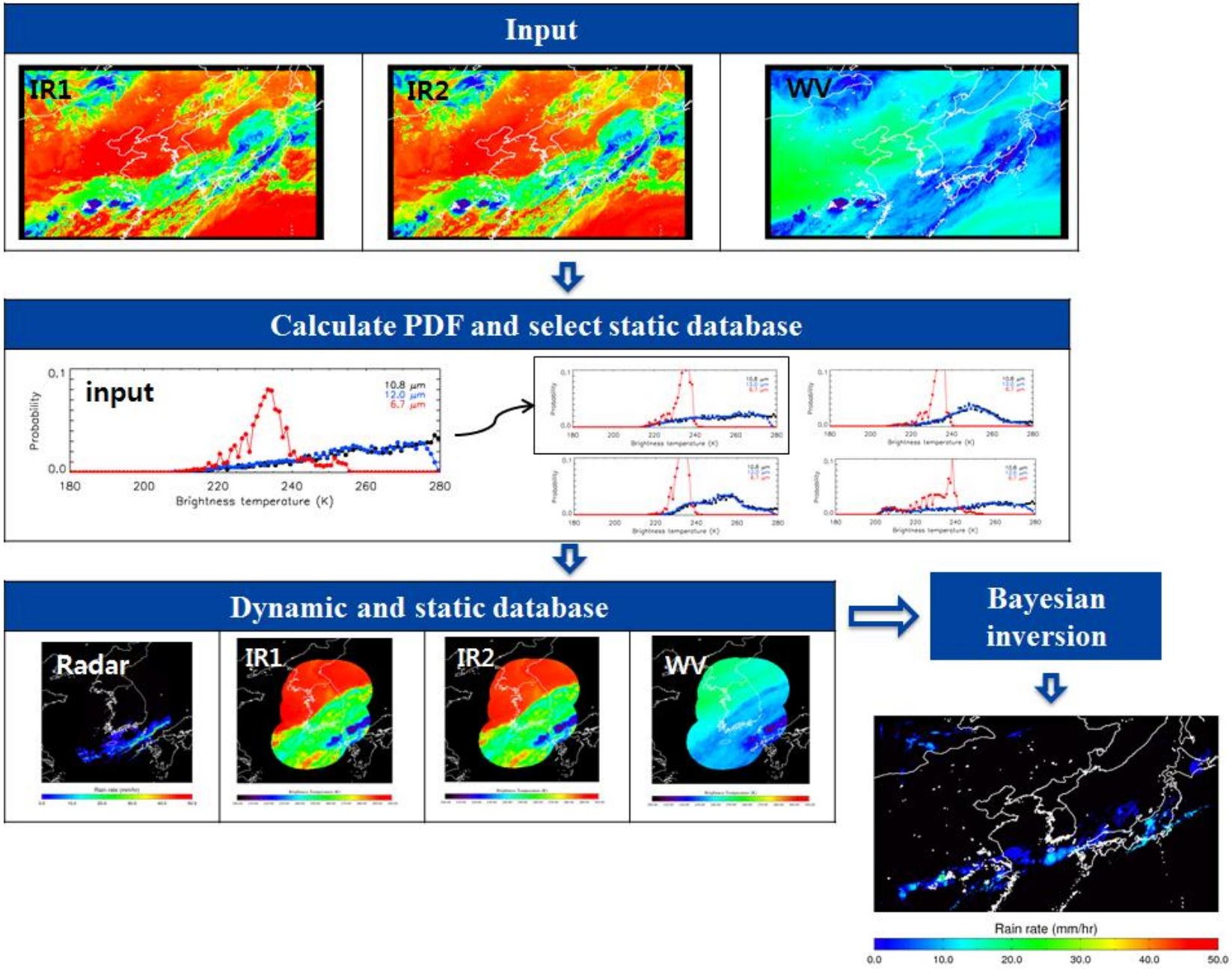


database 2





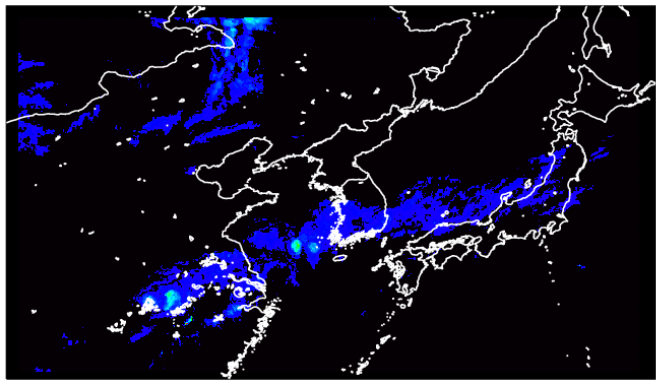
- **Another application of the enhanced merging method (Preliminary results over East Asia region)**

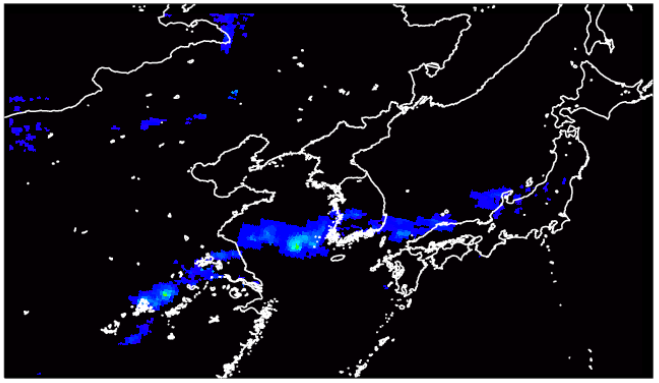


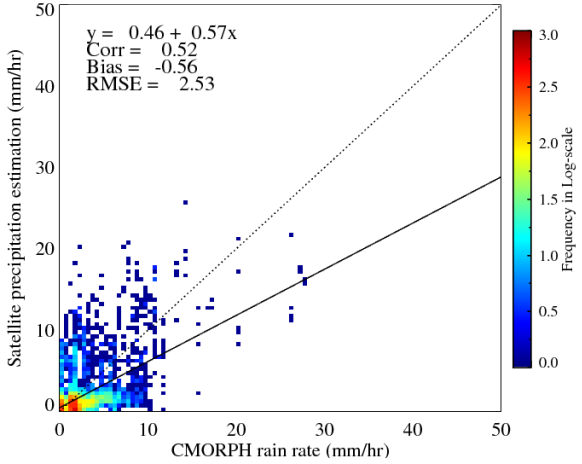
- **Another application of the enhanced merging method (Preliminary results over East Asia region)**

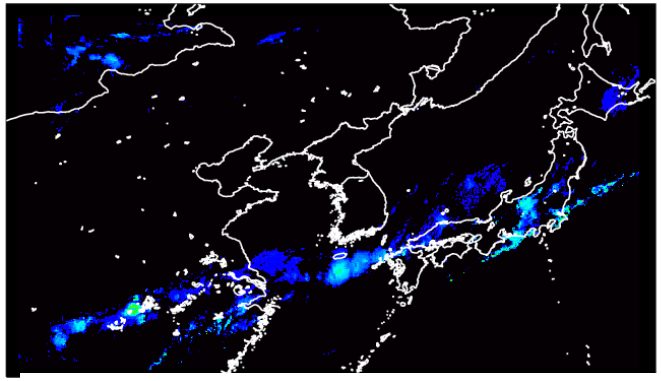
Retrieved precipitation

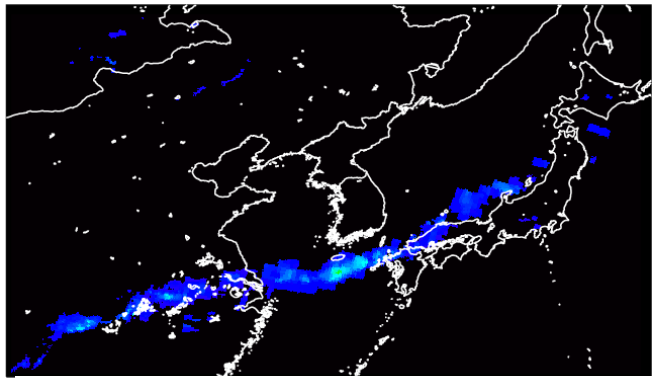
CMORPH

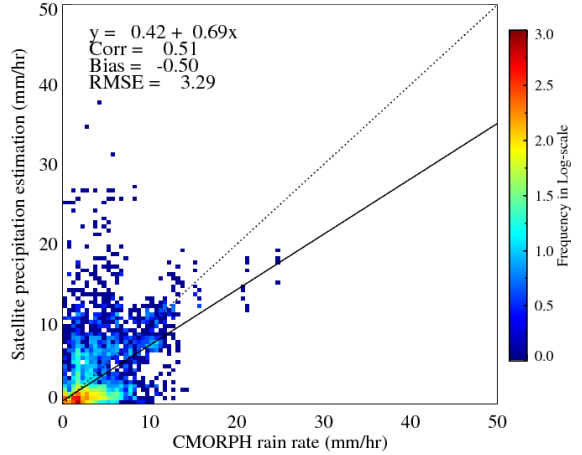


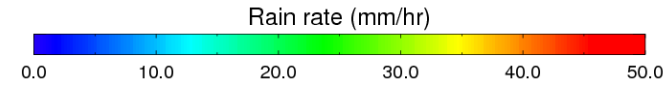


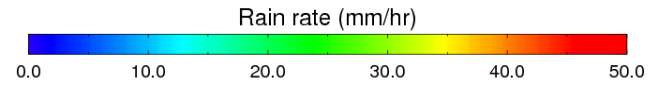












Summary

- A method is developed to fill the radar gap using surrounding radar-estimated precipitation and observations from the COMS satellite.
- Satellite precipitation is estimated based on radar rain rate – satellite brightness temperature relationships of a-priori databases.
- Methods of optimal weight and equal weight merging are applied to merge radar and satellite precipitation estimates over the radar gap areas
- The enhanced merging method is also developed by introducing a numerical model forecast data and improving the satellite estimates
- Applications of the enhance merging method to produce precipitation outside the radar observation areas are experimentally examined

Thank you!