High resolution GSMaP with New Himawari satellite

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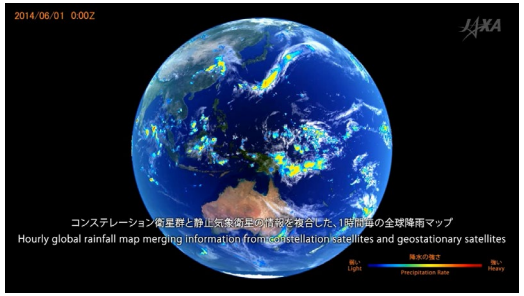
Global Satellite Mapping Precipitation

Global Satellite Mapping Precipitation (GSMaP)

- Multi-satellite product for global precipitation map
- Use multiple microwave and infrared radiometers.
- Provides **hourly** data in the global domain (60° S~60° N) with latitude and longitude $\mathbf{0.1}^{\circ}$ grid resolution.
- Used in various fields such as weather forecasting, precipitation prediction, agriculture, public health, education, etc.

microwave

infrared radiometers

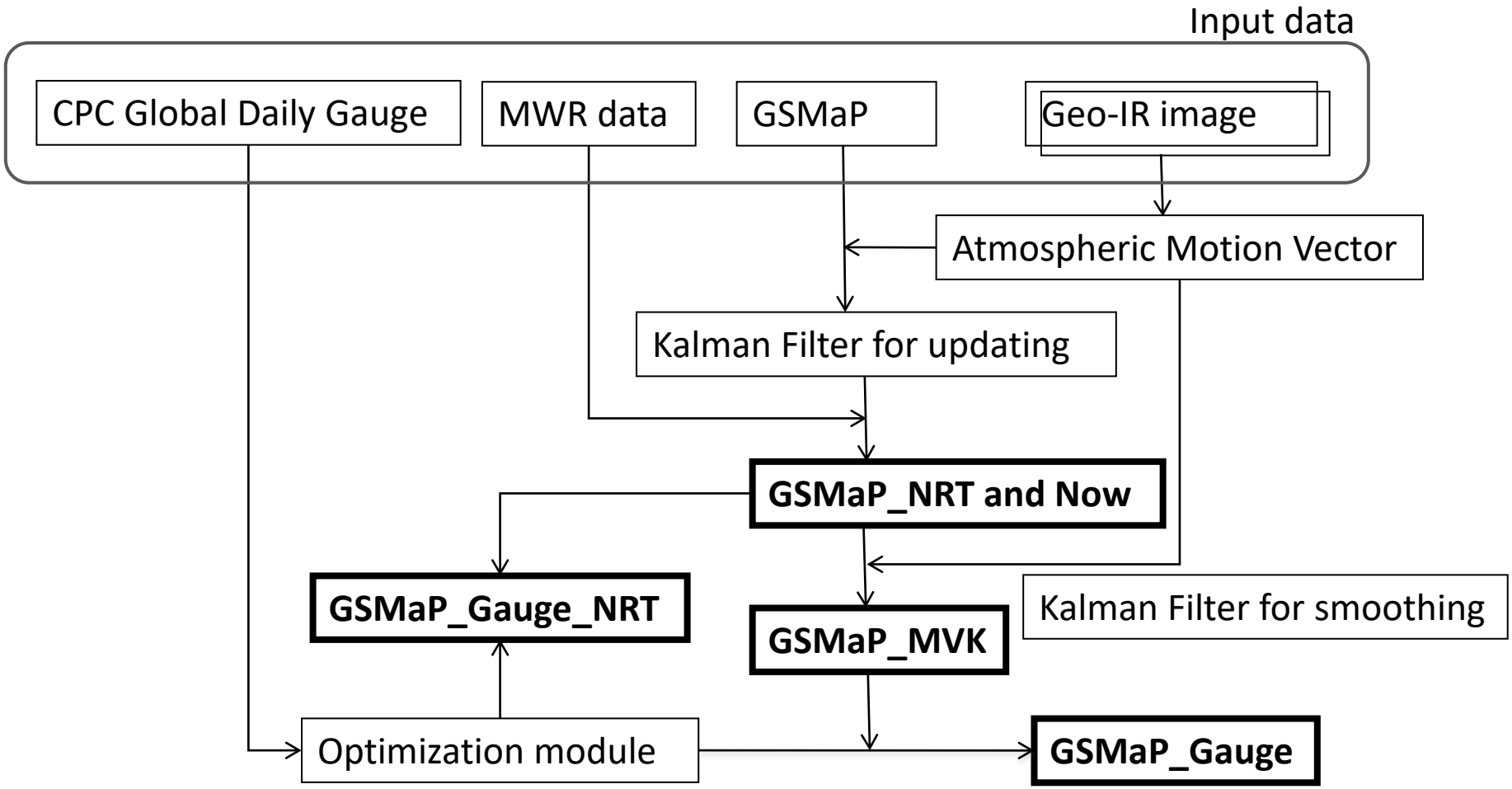


- In recent years, typhoons and torrential rains have caused many disasters
  ➡ Increasing need for GSMaP in disaster management

- Some weather events cause short-lived and localized disasters.
  ➡ **More accurate and higher res. have been required for GSMaP.**

Development of higher-resolution GSMaP is needed.

GSMaP algorithm flow



IR data used in study

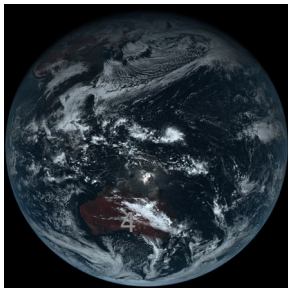
- Current GSMaP
  Globally-merged, full resolution IR data

- Data to be used in this study
  IR data from the Himawari-8

Temporal resolution:**6x**
Spatial resolution:**2x**

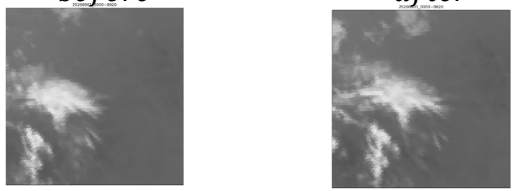
	Globally-merged, full-resolution IR Data	IR data from the Himawari-8
Provider	Climate Prediction Center, National Oceanic and Atmospheric Administration	Japanese Meteorological Agency
Temporal resolution	**1hour**	**10min**
Spatial resolution	**4km**	**2km**
area	60°N～60°S	85°E～155°W, 60°N～60°S

Development of high-resolution GSMaP algorithm by using Himawari-8 data with improved temporal and spatial resolution.



Module of Cloud Motion Vector

i_{before} i_{after}

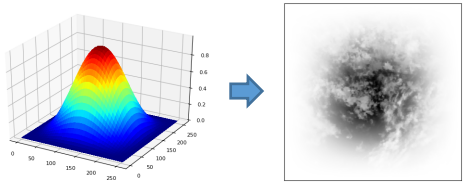


Applying Hamming Window

$$w(n) = \left(0.5 + 0.5\cos\left(\frac{2\pi n}{M-1}\right)\right),$$

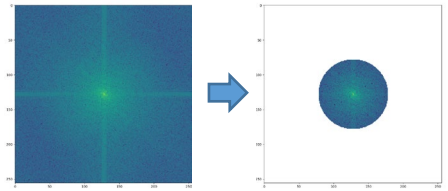
$0 \le n \le M-1$

$w(x,y) = w(x) \times w(y)$



Fast Fourier Transformation (FFT)

Removing high frequency component by applying low pass filter



$I_{before}(w), I_{after}(w)$

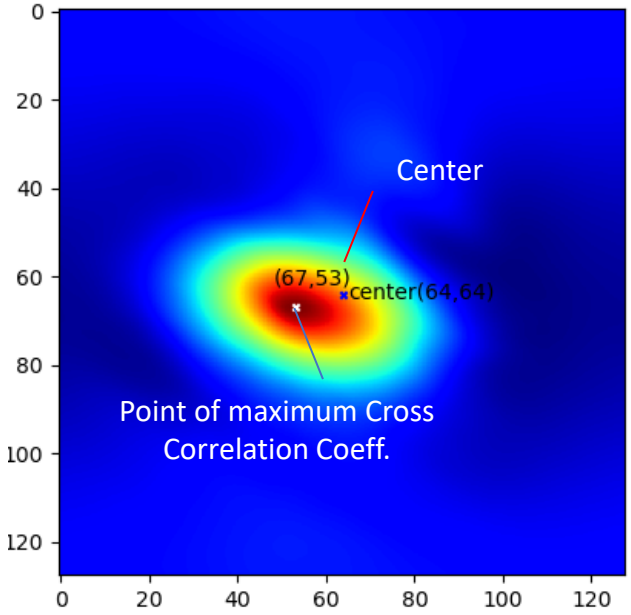
Cross Correlation Coefficient

$$R(r) = F^{-1}\left[I_{before}(w) * I_{after}(w)^*\right]$$

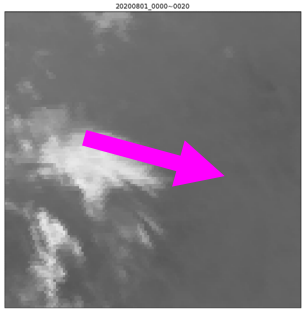
Template Matching Method

- Find where the template image is located in the reference image
- Calculate the normalized cross-correlation coefficient between the template image and the reference image that overlaps it

Distribution of Cross Correlation Coeff.

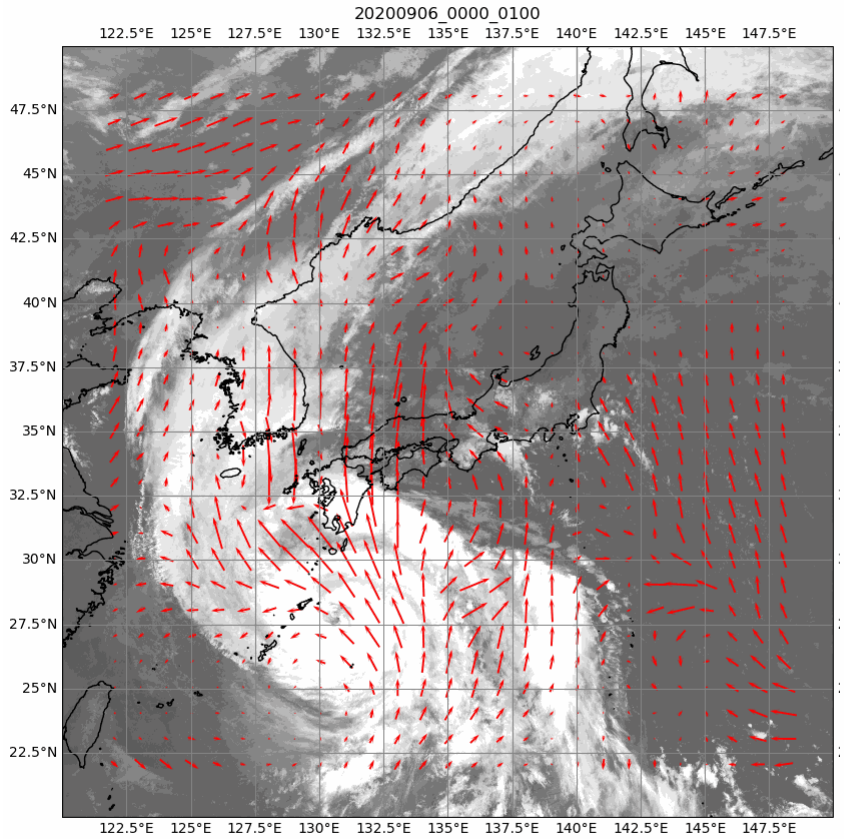


Cloud Motion Vector

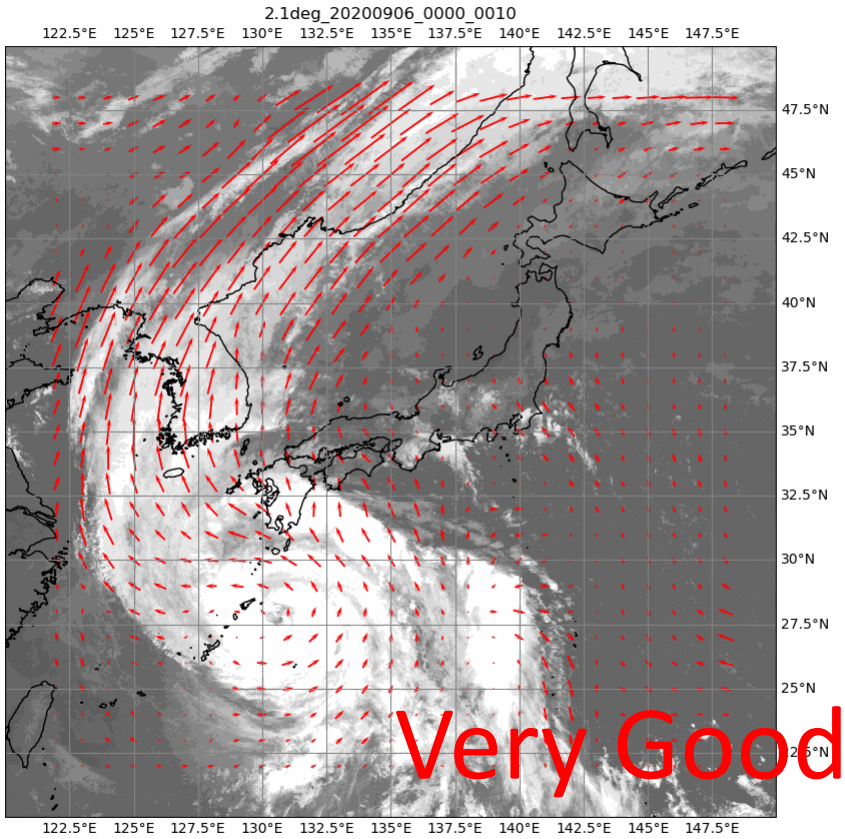


Cloud Motion Vector (2020.09.06 00:00~08:00)

GSMaP(2.5°, 1h)



This Study(2.1°, 10min)



Very Good!!

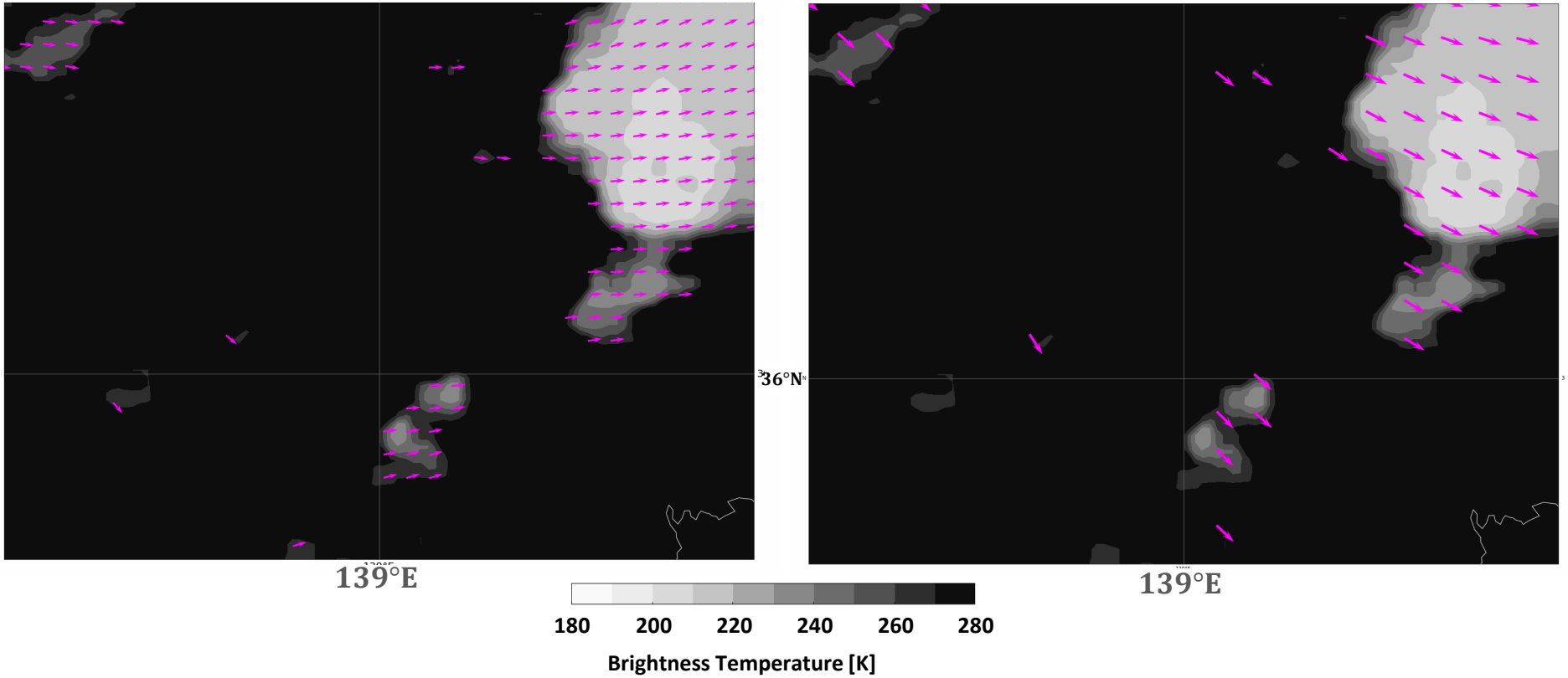
An example of high-resolution cloud moving vector

- Right panel shows the cloud motion vector field of the current GSMaP, and left panel is from the new version.
- While the current GSMaP has 1 hour resolution, high resolution version has 10 min. update, leading the more detailed and accurate precipitation map.
- In the current GSMaP algorithm, the vector fields tend to be uniform with storm scale, but the high resolution version shows the fields in more detail.

A case study near Japan from 03:00 to 13:00 UTC on 12 August 2020

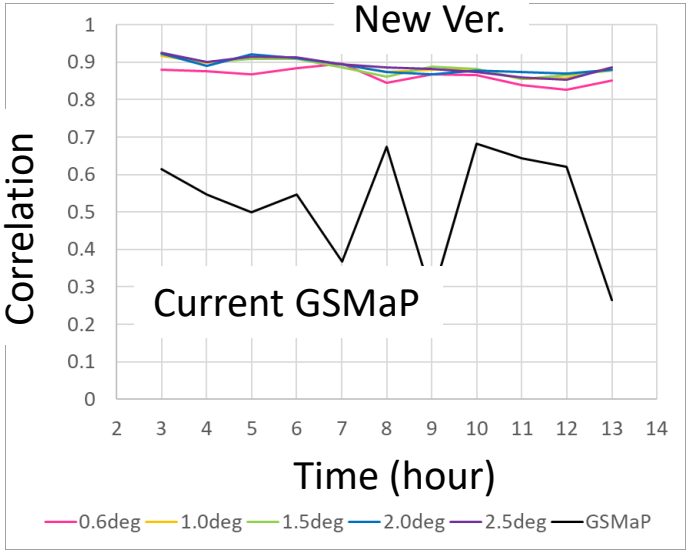
High-resolution CMV (every 10minutes, 0.02°)

Conventional CMV (every 1 hour, 0.1°)

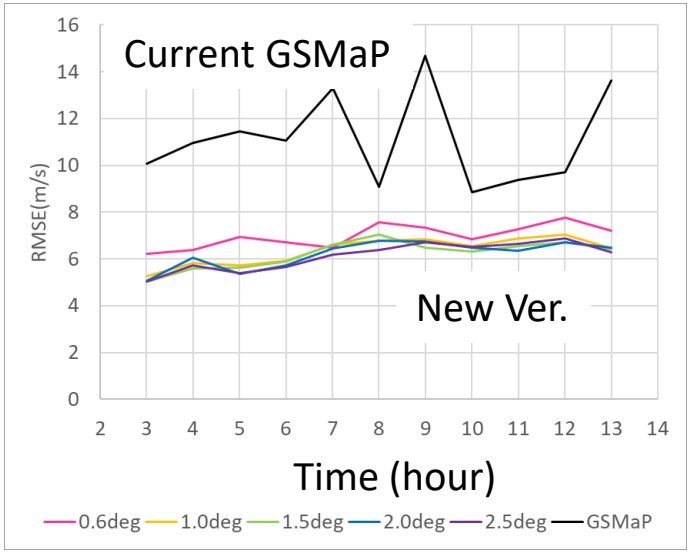


Assessment by the Local Forecast Model (LFM)

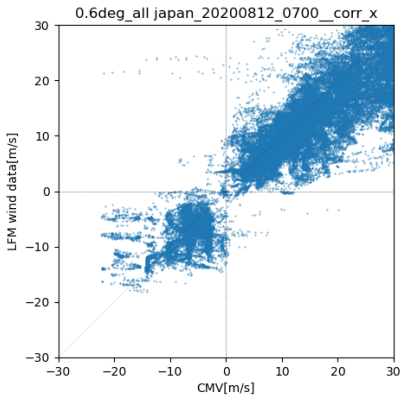
Correlation



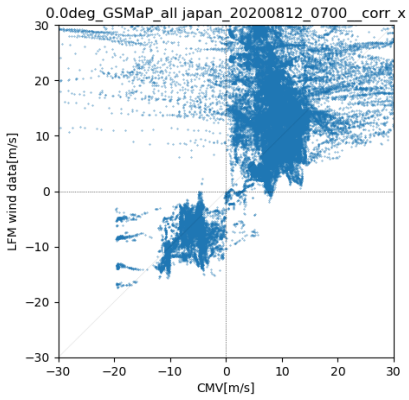
RMSE



New Ver.

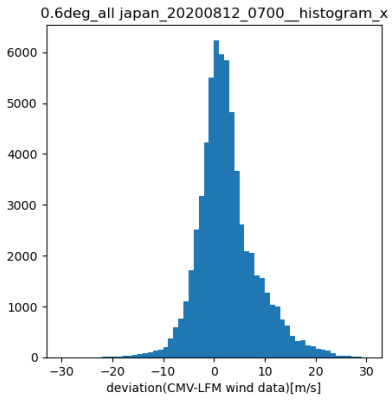


GSMaP, 07:00

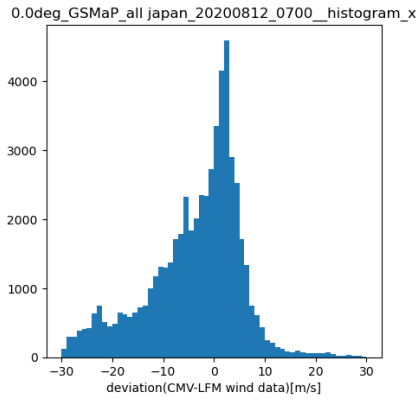


Scattergram

New Ver.

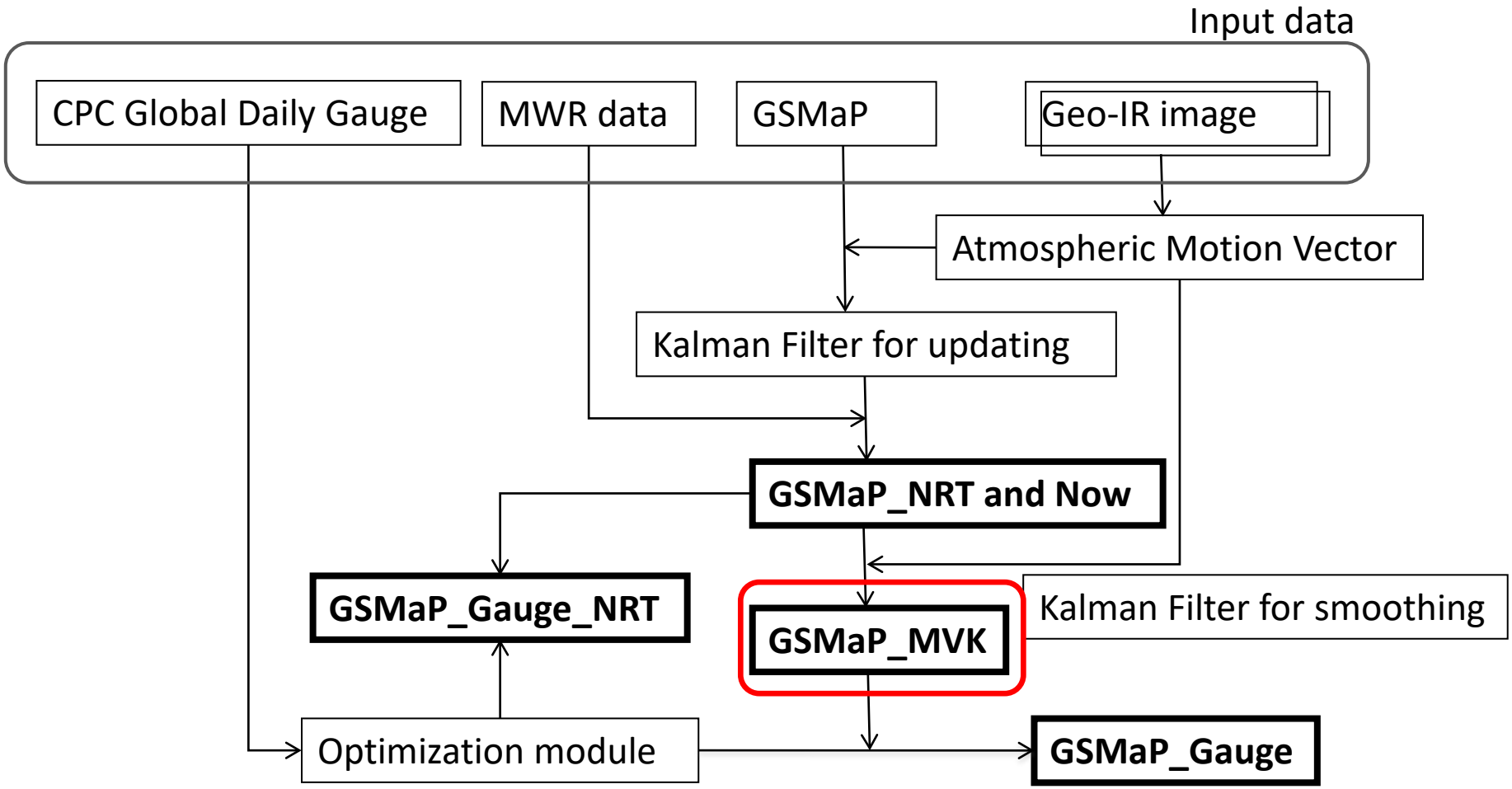


GSMaP, 07:00



Histogram (GSMaP – LFM)

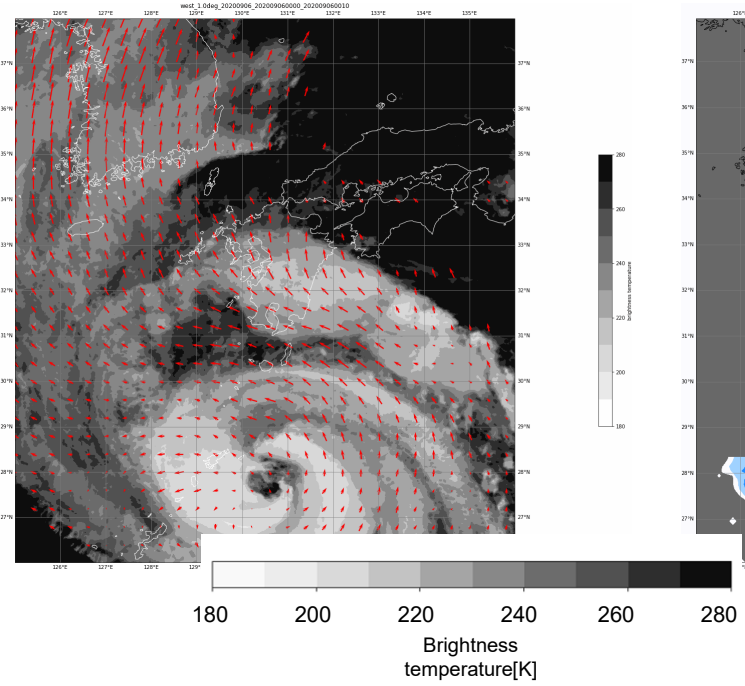
GSMaP algorithm flow



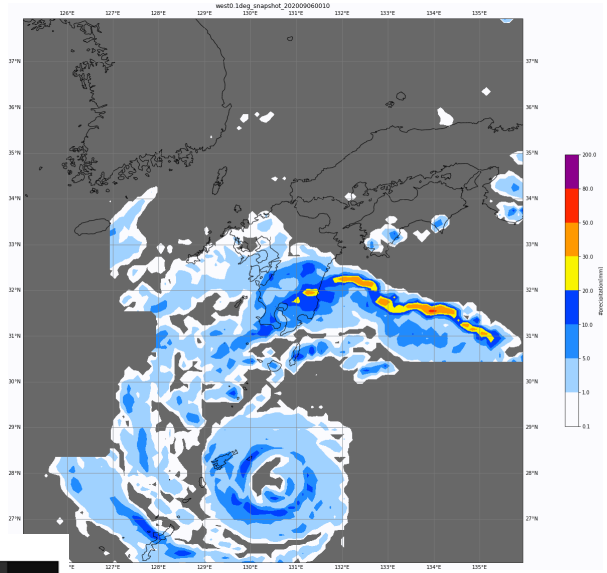
Initial images of the new high resolution GSMaP

- Typhoon case on September 6th in 2020
- Although different precipitation patterns are seen compared to ground observations, it can be seen that they are generally consistent.

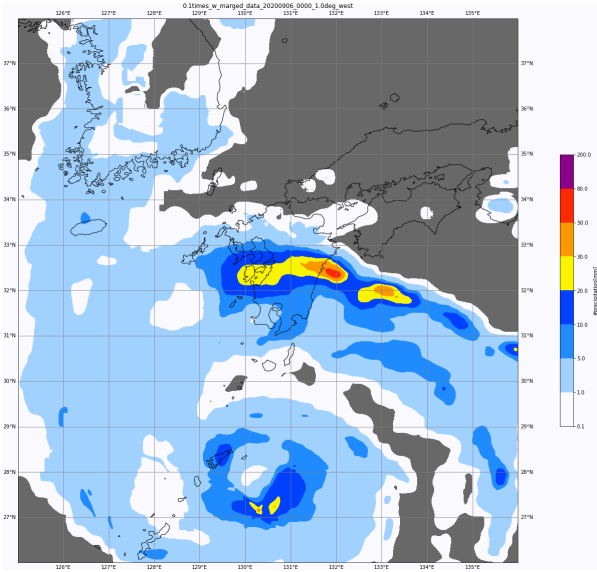
IR, CMV(1.0x)



5 min, 1km Radar GPV

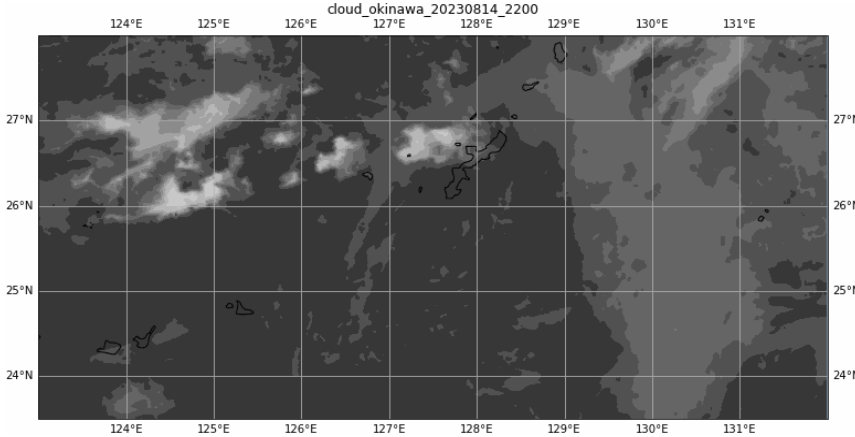


10 min, CMV(0.1x)

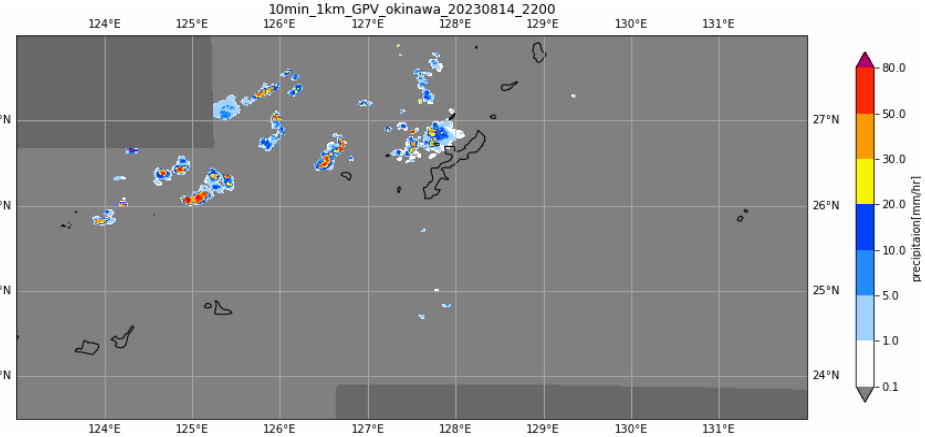


2023/8/14 22:00 ~ 2023/8/15 9:50 Okinawa

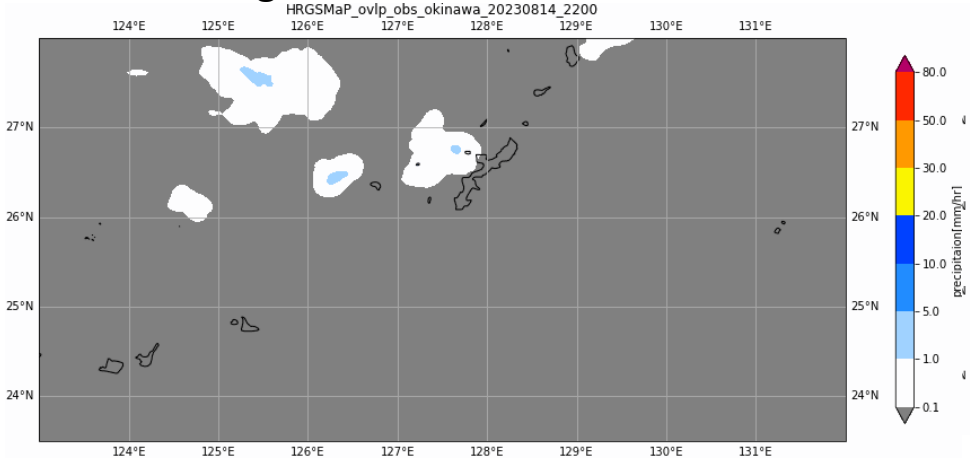
IR



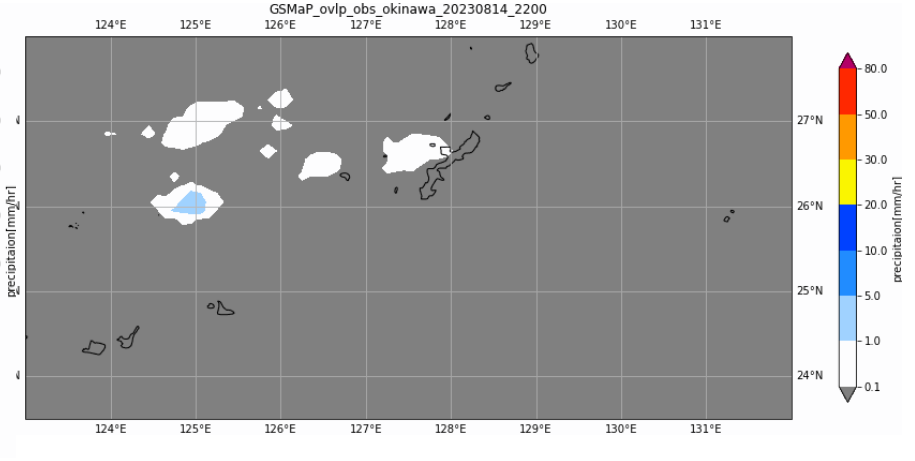
Ground Radar



High resolution GSMaP

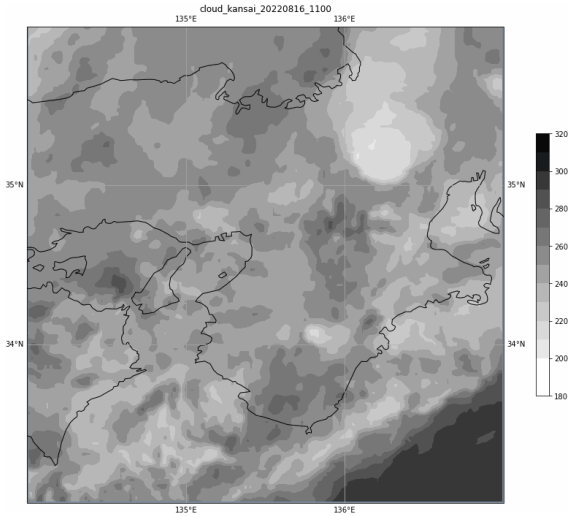


GSMaP

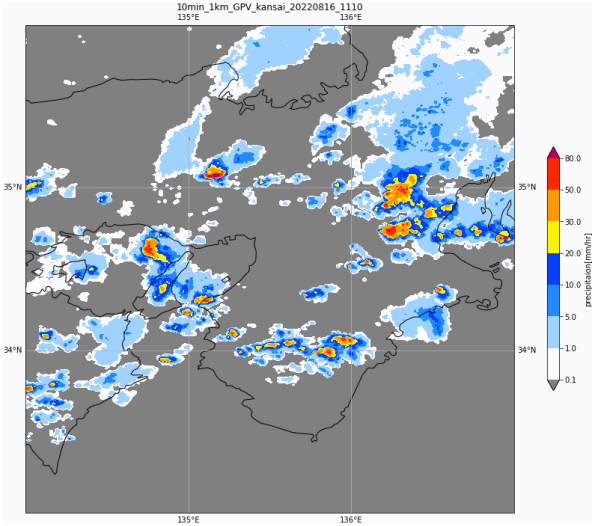


2022/8/16 11:00 ~ 2022/8/16 20:50 Osaka

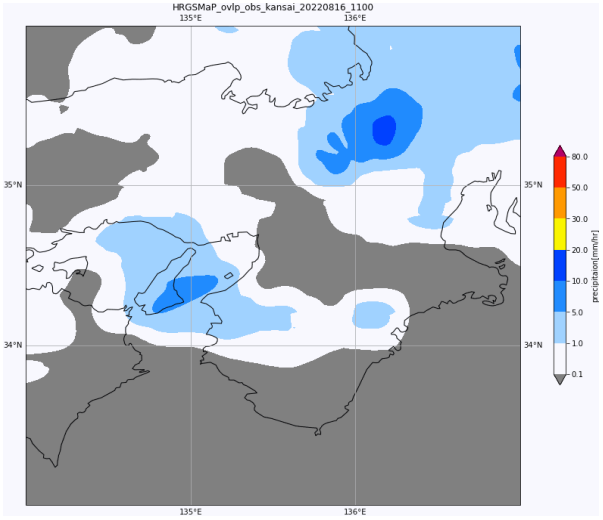
IR



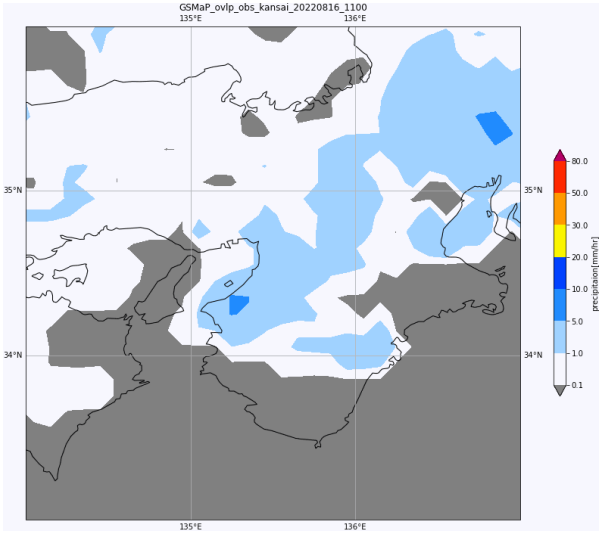
Ground Radar



High Resolution GSMaP



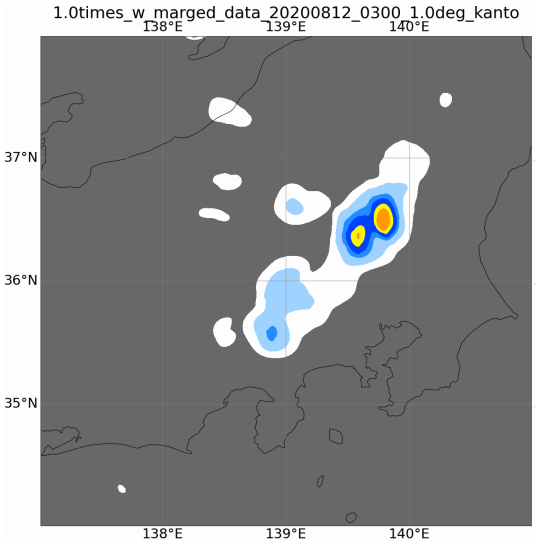
GSMaP



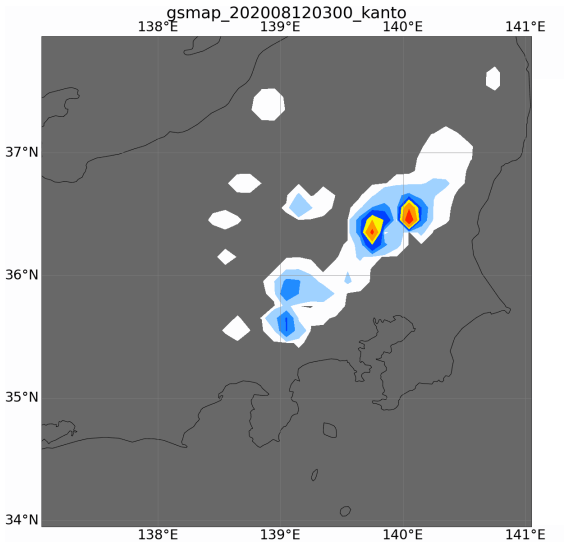
An example of high-resolution GSMaP

- A case study near Japan from 03:00 to 12:50 UTC on 12 August 2020
- With improved spatio-temporal resolution, the development and decay of precipitation systems are captured in more detail. Note that high res. GSMaP shows relatively similar precipitation patterns to the current GSMaP product.
- Although the high-resolution GSMaP image showed precipitation distribution with higher spatial and temporal resolution, comparison with ground-based observations revealed that there is still room for improvement, especially observations by microwave radiometers with higher spatial resolution are needed.

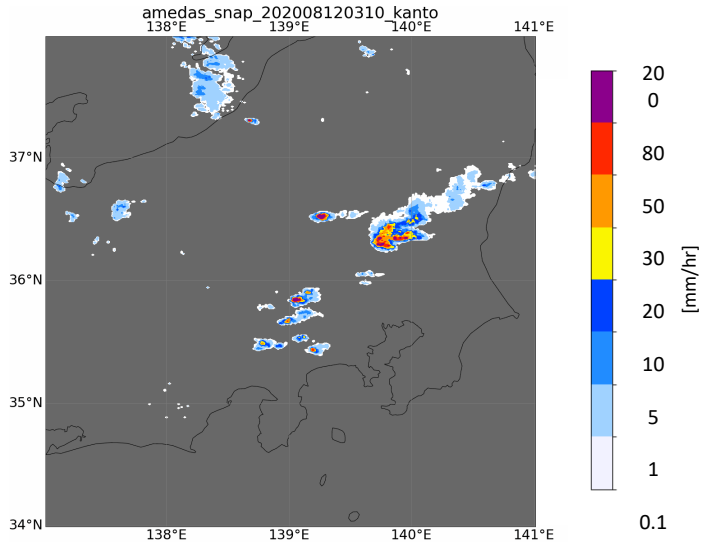
High-resolution GSMaP



Conventional GSMaP



Radar-AMeDAS



Summary

- A new cloud motion vector algorithm for the higher resolution GSMaP has been developed.
- 10 min./2 km motion vector fields show smoother images, suggesting that the new GSMaP will have the more accurate and higher res. estimation of rain rate.
- Initial results of the new high res. GSMaP have been reported, showing the highest resolution images of precipitation from satellite.