High resolution GSMaP with Himawari 8

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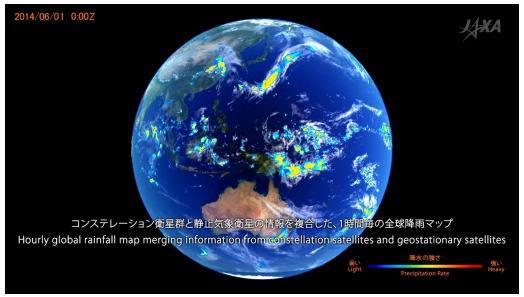
Global Satellite Mapping Precipitation

microwave

infrared radiometers



Global Satellite Mapping Precipitation (GSMaP)

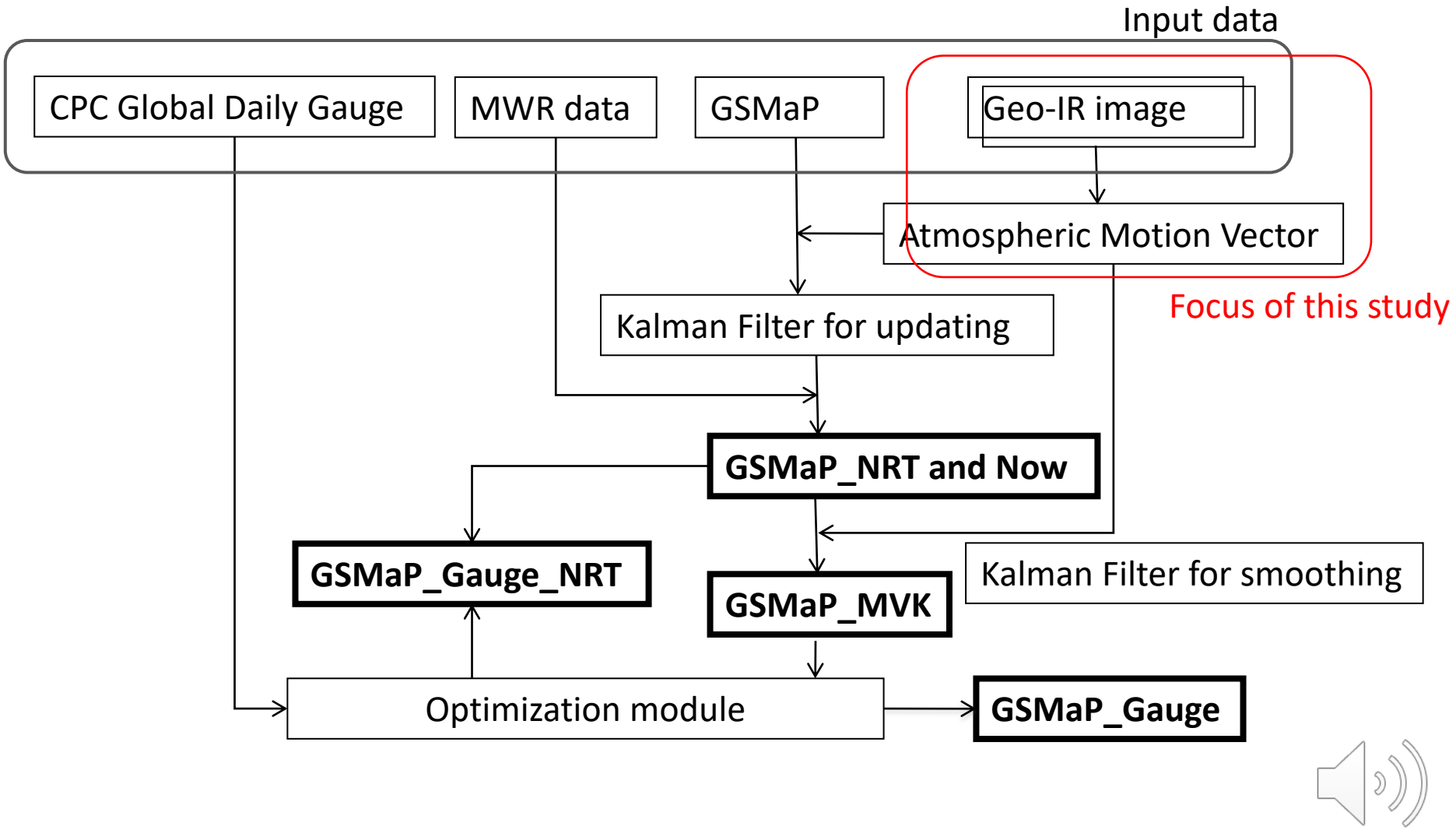
- Multi-satellite product for global precipitation map
- Use multiple microwave and infrared radiometers.
- Provides **hourly** data in the global domain ($60^\circ S$~$60^\circ N$) with latitude and longitude $\mathbf{0.1}^\circ$ grid resolution.
- Used in various fields such as weather forecasting,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

☐ 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 has been required.

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

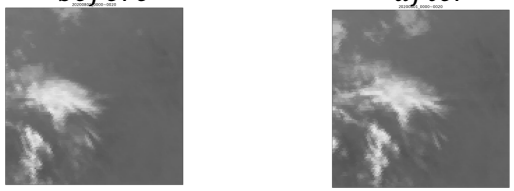
Temporal resolution:**6x**
Spatial resolution:**2x**

	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.

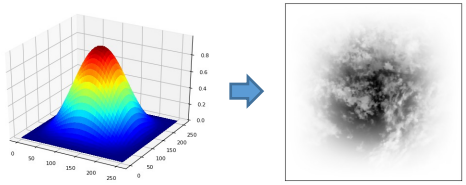
Module of Cloud Motion Vector

i_{before} i_{after}



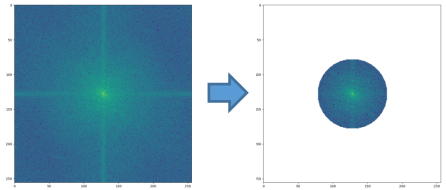
Applying Hamming Window

$$w(n) = \left(0.5 + 0.5\cos\left(\frac{2\pi n}{M-1}\right)\right),$$
$$0 \le n \le M-1$$
$$w(x,y) = w(x) \times w(y)$$



Fast Fourier Transformation (FFT)

Removing high frequency component by applying low pass filter



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

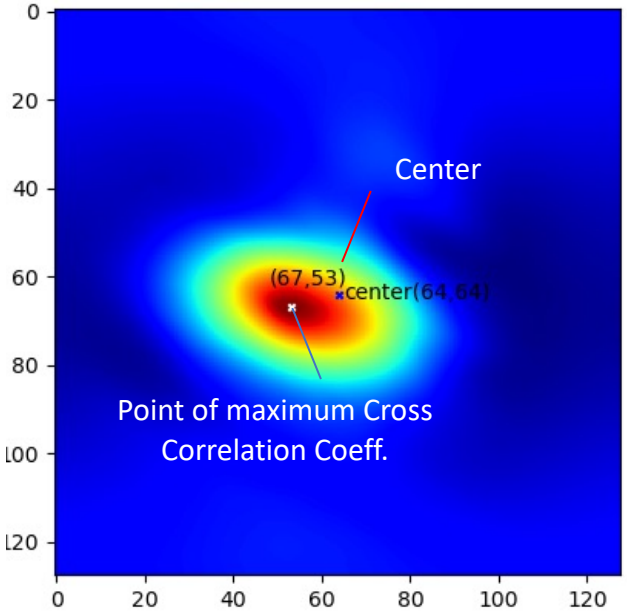
Cross Correlation Coefficient

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

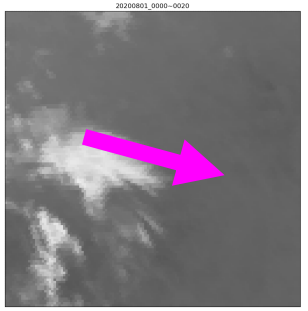
Template Matching Method

- 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.

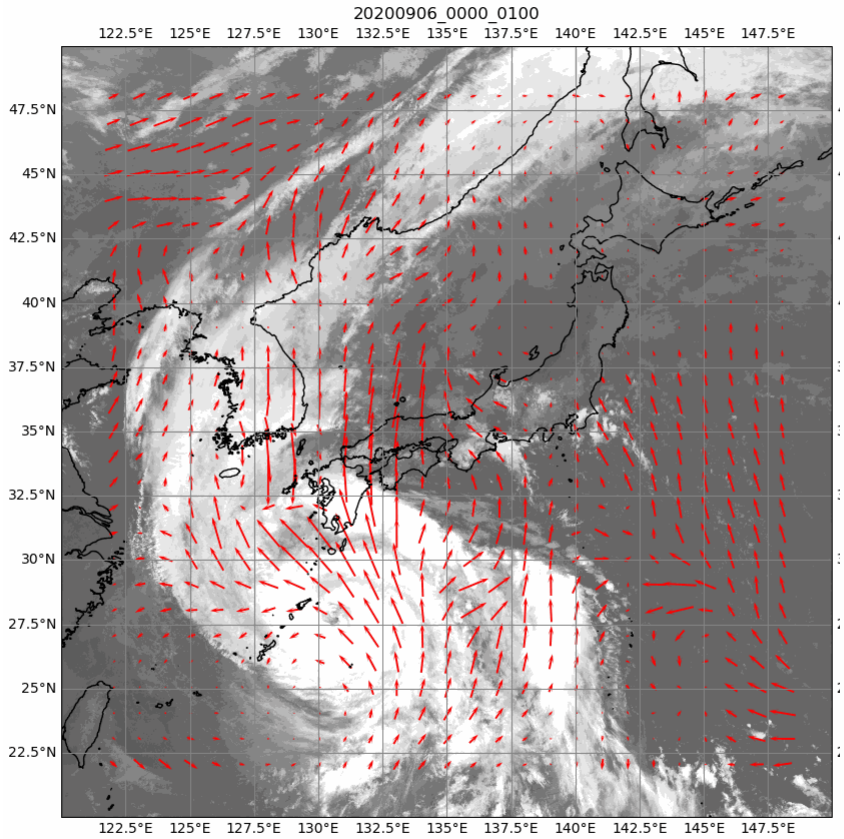


Cloud Motion Vector

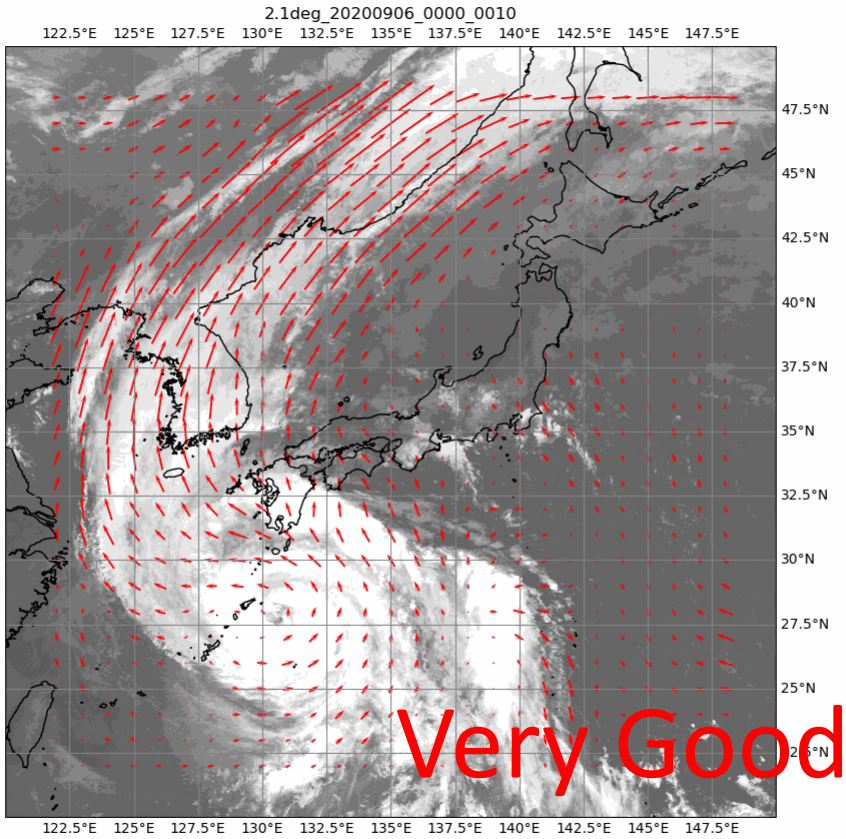


Cloud Motion Vector (2020.09.06 00:00~08:00)

GSMaP(2.5°, 1h)



This Study(2.1°, 10min)

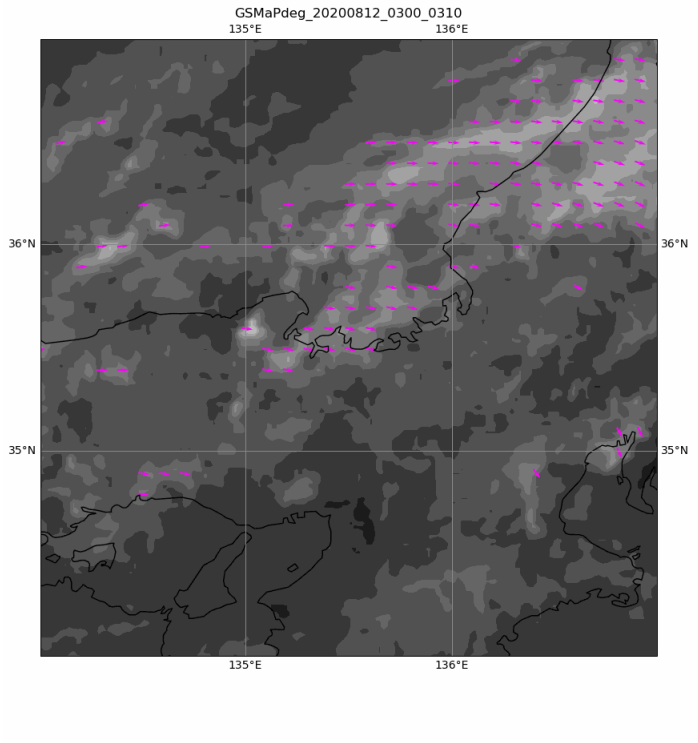


Very Good!!

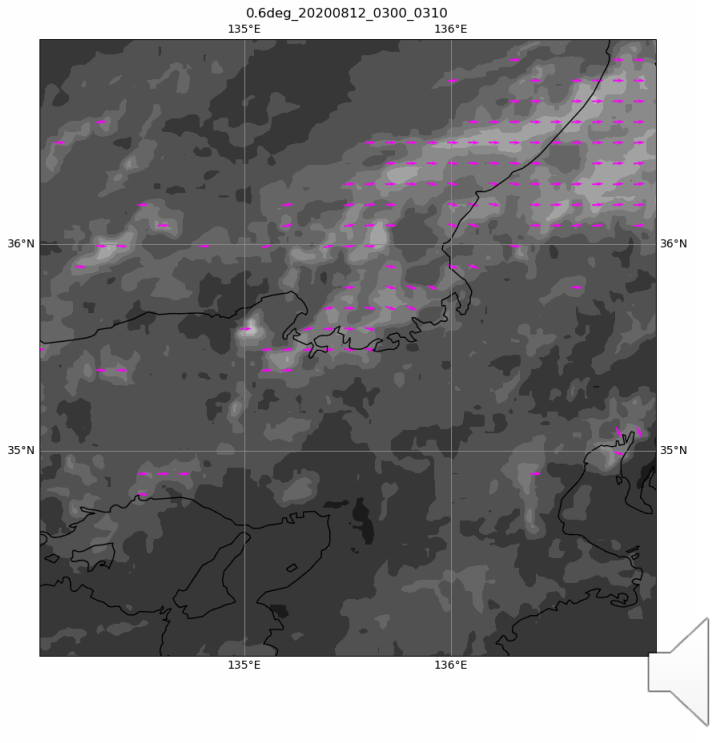
Derived Cloud Motion Vector with High Res.

- Left panel shows the cloud motion vector field of the current GSMaP, and right panel is from the new version.
- While the current GSMaP has 1 hour resolution, new version has 10 min. update, leading the more detailed and accurate precipitation map.
- In the current GSMaP algorithm, the vector fields tend to be monotonic (mostly east ward), but the new version shows the more complicated fields.

Current GSMaP

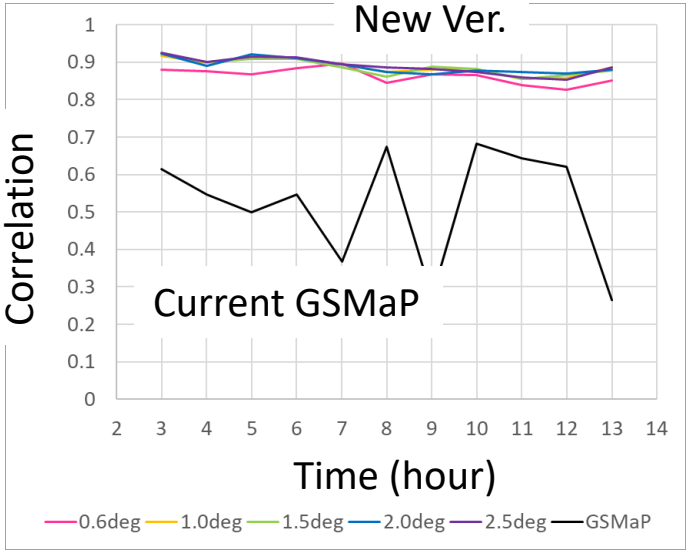


New Version

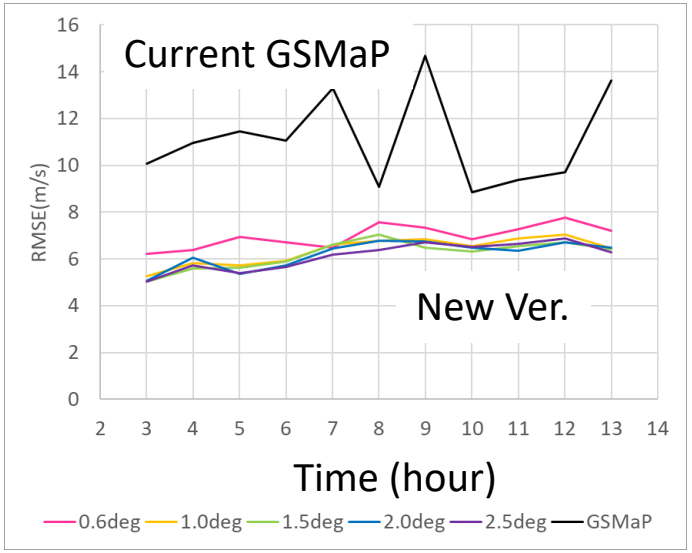


Assessment by the Local Forecast Model (LFM)

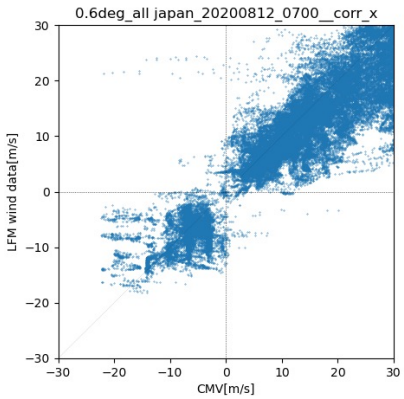
Correlation



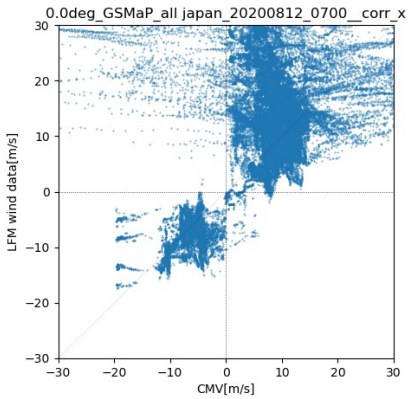
RMSE



New Ver.

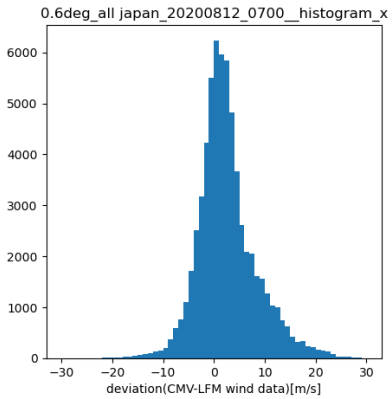


GSMaP, 07:00

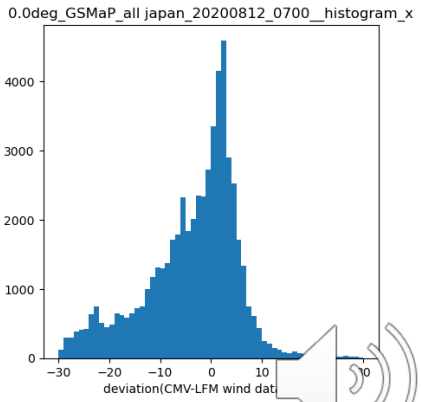


Scattergram

New Ver.

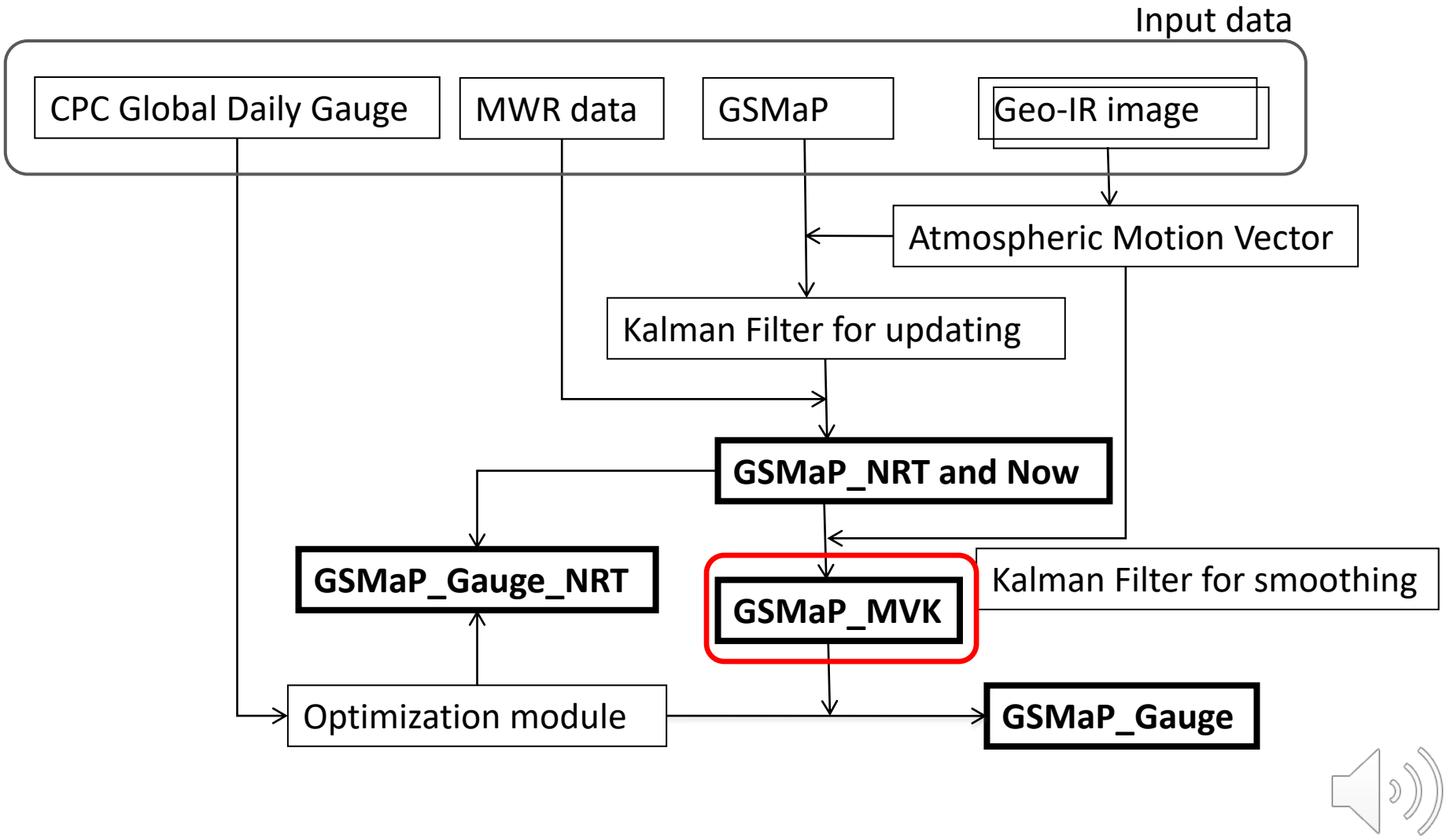


GSMaP, 07:00



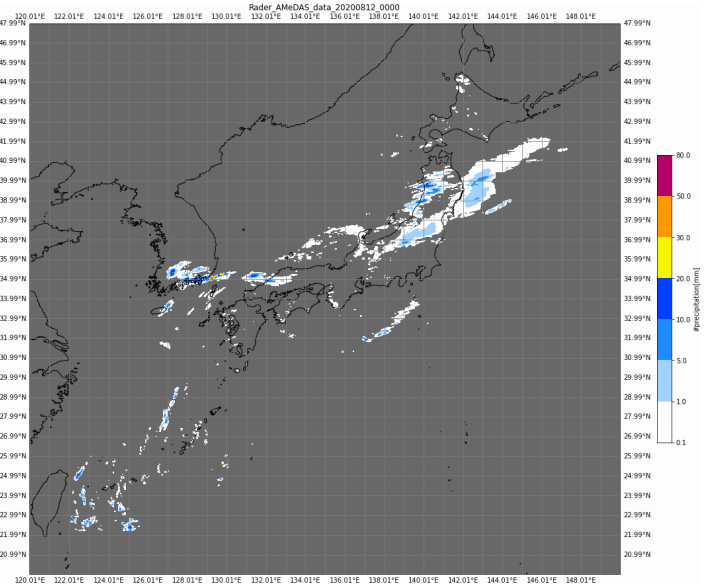
Histogram (GSMaP – LFM)

GSMaP algorithm flow

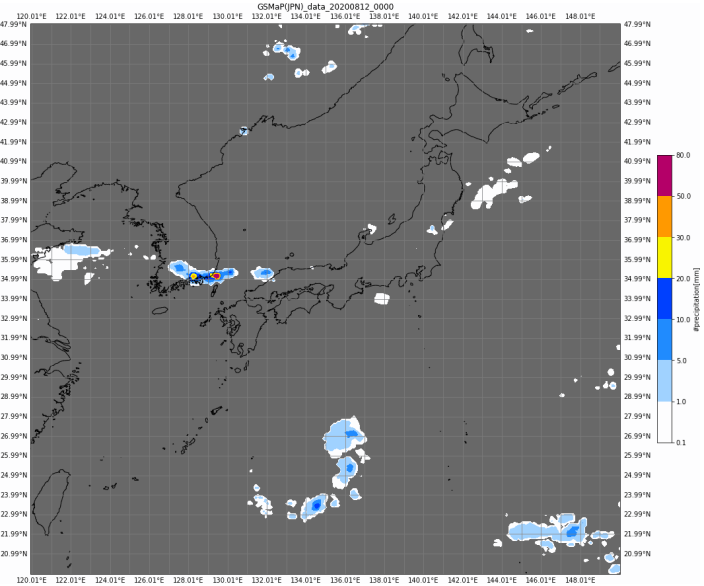


Initial results for the event 2020.08.12 00:00 – 23:50 (UTC)

Radar AMeDAS data(30 min)

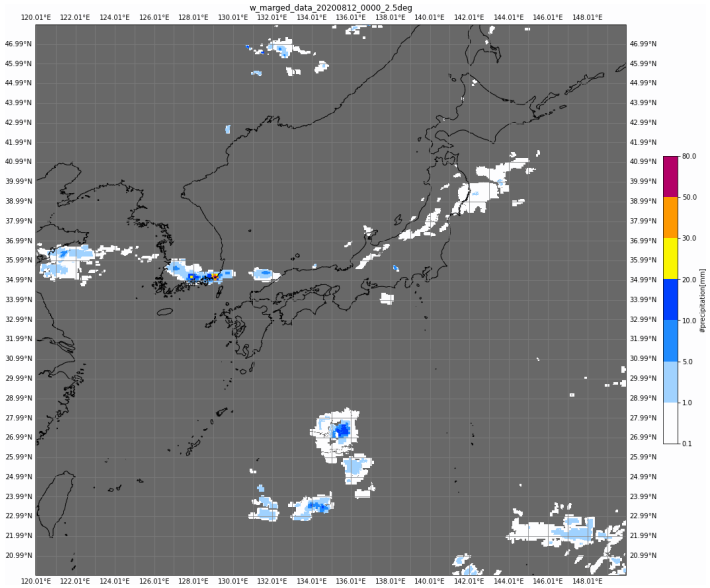


GSMaP data (1h)



- Basically the current and new GSMaP have similar results, because both use the same passive microwave radiometer data. However, if you look at in more detail, you can see some differences.
- For example, some rainy areas which do not appear in the current version are seen in the new version.
- Apparently more updates are needed in the algorithm. (ex. Kalman filter)

Overwrite, weighted average,
2.5 deg-CMV (10 min)

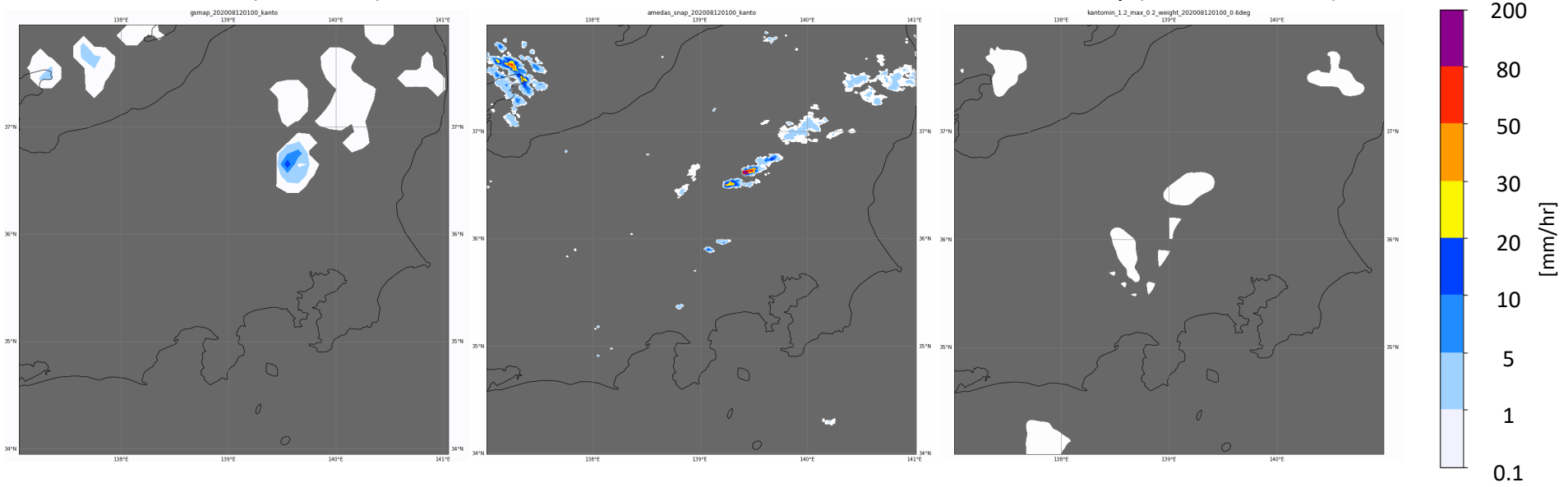


Zoomed images of the 10 min. GSMaP (01:00~12:50 UTC)

GSMaP data (1h, 0.1°)

5 min, 1km radar GPV

This study (10 min, 0.02°)



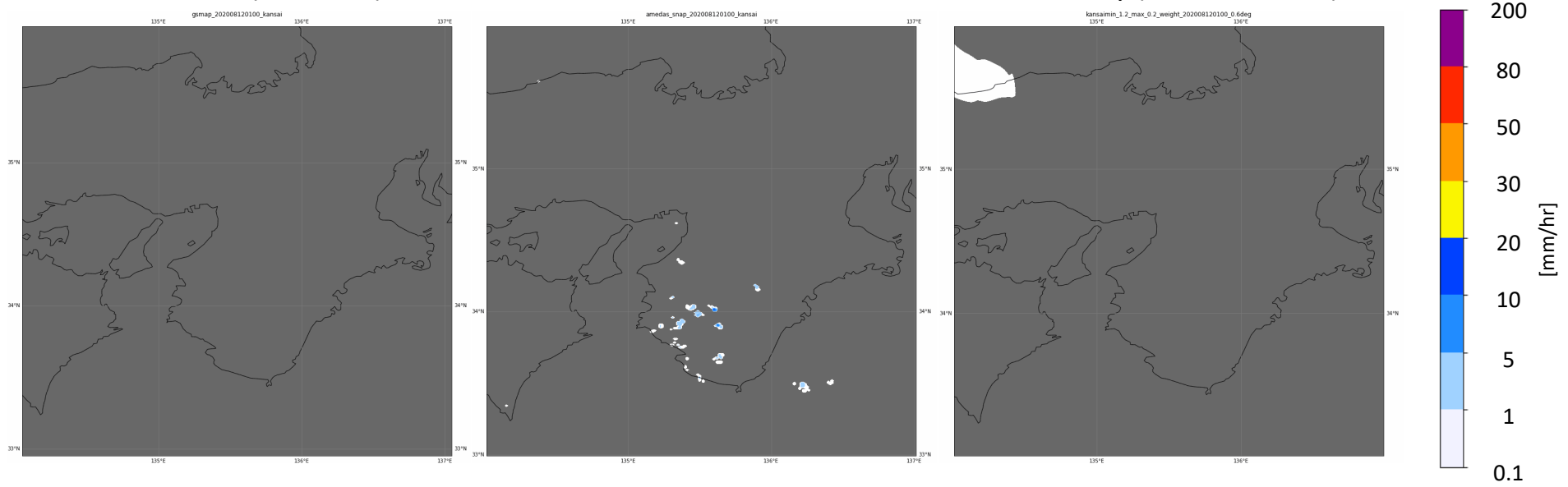
- It is clear that the new version shows how the precipitation system changes with time in more detail than the current GSMaP does.
- However, there still are some discrepancies between ground based radar obs. and the high res. GSMaP.
- More comparisons and validations are needed. And based on these we will improve this algorithm for the next few years.

Zoomed images of the 10 min. GSMaP (01:00~12:50 UTC)

GSMaP data (1h, 0.1°)

5 min, 1km radar GPV

This study (10 min, 0.02°)



- Also here, life cycle and advection process of isolated thunderstorms are better captured in the new high res. GSMaP.
- We are expecting that the high res. GSMaP can contribute to better warning of extreme weather events in global scale.

Future work

- Implementation of the Kalman filter module.
  - Kalman filter improves the estimation of rainfall rate.
  - Some AI techniques may work for this.

- Validation of the product
  - Ground based radar and rain gauge measurements should be used to validate the products in some temporal and spatial scales for various types of precipitation system.

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 for the first time, showing the more detailed images of precipitation systems.