GLOBAL SATELLITE MAPPING OF PRECIPITATION (GSMAP) PROJECT

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ABSTRACT

Precipitation is one of the most important parameters on the earth system, and the global distribution of precipitation and its change are essential data for modeling the water cycle, maintaining the ecosystem environment, agricultural production, improvements of the weather forecast precision, flood warning and so on. In the GPM (Global Precipitation Measurement) project, the microwave radiometers observing microwave emission from rain will be placed on many low-orbit satellites, to reduce the interval to about 3 hours in observation time for each location on the earth. Although the GPM can provide the global precipitation fields with 3 hour resolution, the precipitation map with higher resolution (< 1 hour) is required for some operational users such as flash flood warning systems and also the monthly based precipitation map is required from the climatology studies. In this presentation, the GSMaP_MVK which is a product of surface rainfall rate with 0.1 degree and 1 hour resolution on a global basis and GSMaP_Gauge which is a gauge adjusted product to the GSMaP_MVK for climatological studies are introduced, focusing particularly on structure and performance of the algorithm and some initial evaluation tests.

Keywords: Precipitation, GPM, TRMM

1. INTRODUCTION

Precipitation is one of the most important parameters on the earth system, and the global distribution of precipitation and its change are essential data for modeling the water cycle, maintaining the ecosystem environment, agricultural production, improvements of the weather forecast precision, flood warning and so on. Because most of the rain gauges are distributed mainly in the Northern Hemisphere, and there are extremely few rain gauges on the sea, it is difficult to measure the temporal and spatial changes of the rain rate on a global scale.

One of the best approaches to capture the distribution and its changes of the global rain fall rate is to use the data from the space born platforms, and we have several satellites to observe the precipitation in passive or active ways. Among them, there are observations with the microwave radiometers in low earth orbit satellite. The observations are proved to be fairly good in terms of the estimation of the surface rainfall rate. However it is unavoidable as for the problem of the sampling error even if I used all the satellite aboard the microwave radiometer. Therefore it is necessary to perform the gap filling technique to the precipitation map only from the microwave radiometer data.

The GPM (Global Precipitation Measurement) project is led mainly by the United States and Japan, and is now being actively promoted in Europe, France, India, and China with international cooperation. In this project, the microwave radiometers observing microwave emission from rain will be placed on many low-orbit satellites, to reduce the interval to about 3 hours in observation time for each location on the earth. However, the problem of sampling error arises if the global precipitation estimates are less than three hours. Therefore, it is necessary to utilize a gap-filling technique to generate precipitation maps with high temporal resolution, which is quite important for operational uses such as flash flood warning systems.

As is well known, mapping of global precipitation using satellite data has already been performed by numerous researchers, and an increasing number of satellite-based rainfall products, for example TMPA-RT (Huffman et al. 2007), NRLgeo (Turk and Miller 2005), PERSIANN (Sorooshian et al. 2000), CMORPH (Joyce et al. 2004), PMR (Kidd et al. 2003), and so forth, are now available in near real time over the Internet. Among them, the WCRP (World Climate Research Program) GPCP (Global Precipitation Climatology Project) (Adler et al. 2003) and CMORPH (CPC Morphing technique) have succeeded in producing precipitation estimates at high resolution with good accuracies. So far, the CMORPH product has showed the best scores on a 1-day, 0.25-degree comparison in terms of correlation coefficient, RMS error, and several statistical parameters through the evaluation activities in PEHRPP (Pilot Evaluation of the High Resolution Precipitation Products).

On the other hand, the Global Satellite Mapping of Precipitation (GSMaP) project was established by the Japan Science and Technology Agency (JST) in 2002 to produce global precipitation products with high resolution and high precision from not only microwave radiometers but also geostationary infrared radiometers. Currently, the GSMaP_MVK has been successfully producing impressive pictures in near real time, and the products shows a comparable socre compared with other high-resolution precipitation systems (Ushio et al. 2009 and Kubota et al. 2009). In this paper, the algorithm, examples of the product, some validation results, and a new product which uses the global rain gauge data sets, are described.

2. GSMAP_MVK

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In this product, the precipitation estimates from microwave radiometer in LEO and infrared radiometer in GEO are used to produce the global precipitation map with 1 hour and 0.1 degree resolution. The primary data are given by the microwave radiometer, and its algorithm to convert the brightness temperature observed at the several microwave channels to surface rain rate is described in Aonashi et al. (1996) and Kubota et al. (2007). The surface rain rate is retrieved by finding the optimal rain intensity that matches the brightness temperature calculated from the radiative transfer model with the observed brightness temperature. On the other hand, the IR data sets used in the current version of the system are from the CPC (Climate Prediction Center) (Janowiak et al. 2001) through the Man–computer Interactive Data Access System (McIDAS; Lazzara et al. 1999), and the IR data is used to interpolate the precipitation estimates between the microwave overpasses. Its methodology is described below, and the algorithm flow is shown in figure 1.

In the GSMaP_MVK algorithm, the technique of the Kalman filter and moving vector is used to interpolate the precipitation field. Moving vector is derived in a latitude and longitude of 6.5 degree domains of infrared radiometer data of every consecutive one hour. Along with this moving vector image, the rain pixels are propagated forward and backward in time, when the precipitation rate from the microwave radiometer is not available. This predicted rain rate is refined by the Kalman filter listed below.

$x_{k+1} = Fx_k + w$ (State equation)

$y_k = Hx_k + v$ (Observation equation)

xk: Current precipitation rate

w : A system noise

v: An observation noise

yk: The brightness temperature observed by an infrared radiometer

As one example of the system, figure 2 shows a comparison of precipitation observations by a single satellite with high horizontal resolution and accuracy (TRMM) and by combined multi-satellites with high temporal resolution and global coverage (GSMaP_NRT). The GSMaP_NRT is a product of the near real time version of the GSMaP_MVK product. The upper left panel is an observation of Cyclone Nargis just after its landfall on the coast of Myanmar at 00:43 UTC 3 May 2008. Nargis caused serious damage in the Irrawaddy Delta of Myanmar and became a wide-scale disaster. Color denotes rainfall observation by the Precipitation Radar (PR), and the grayscale denotes simultaneous observation of cloud images by the Visible Infrared Scanner (VIRS), both onboard the TRMM satellite. The footprint of PR is about 5 km, and detailed structures of strong rain bands are indicated in yellow and red. Although PR observes a three-dimensional structure, the observation swath is narrower (about 250 km) than that of VIRS (about 850 km). The upper right and lower panels are hourly global rainfall by the GSMaP_NRT systems and cloud image observed by geostationary satellites at 00:00-00:59 UTC 3 May 2008. The upper right panel is a zoomed image of the red rectangle area in lower panel. The well-organized rainfall area in the middle of the image is Cyclone Nargis at the coast of Myanmar. The horizontal resolution of the precipitation map (GSMaP_NRT) is a 0.1-degree latitude/longitude grid, coarser than that of PR (about 5 km), but it has major advantage in global coverage and temporal resolution.

Figure 3 shows a typical result consisting of a comparison near Japan of the 0.1 degree/1 hour resolution precipitation estimates for 24 hours in July 25 2005 as well as the RADAR-AMeDAS composites. In general, it is shown that the GSMaP_MVK can correctly catch the rainfall occurrences and adjust the rainfall rates in reference to the IR brightness temperature.

3. CONCLUSION

In this paper, the GSMaP_MVK product are introduced and demonstrated. The product has been shown to be effective for some applications such as flash flood warning system. Some validation results are also shown. In addition, the formulation of the GSMaP_Gauge product using the CPC global gauge data set is firstly described and the initial result shows that the multiple regression approach is effective to adjust the GSMaP_MVK estimates.

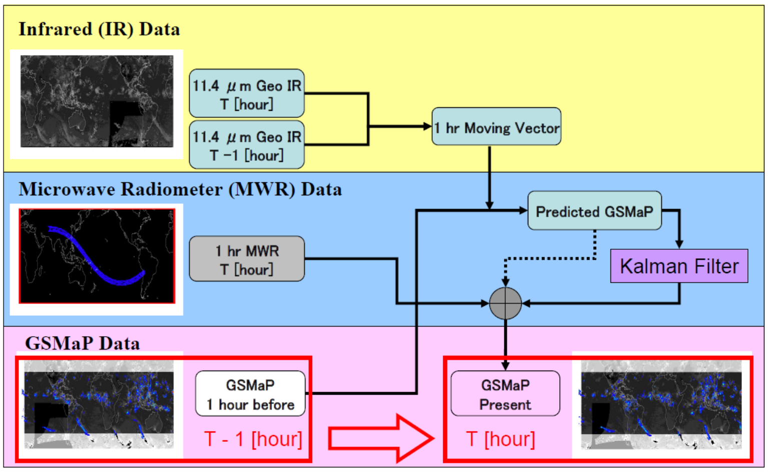

Fig. 1. An algorithm flow of the GSMaP_MVK system

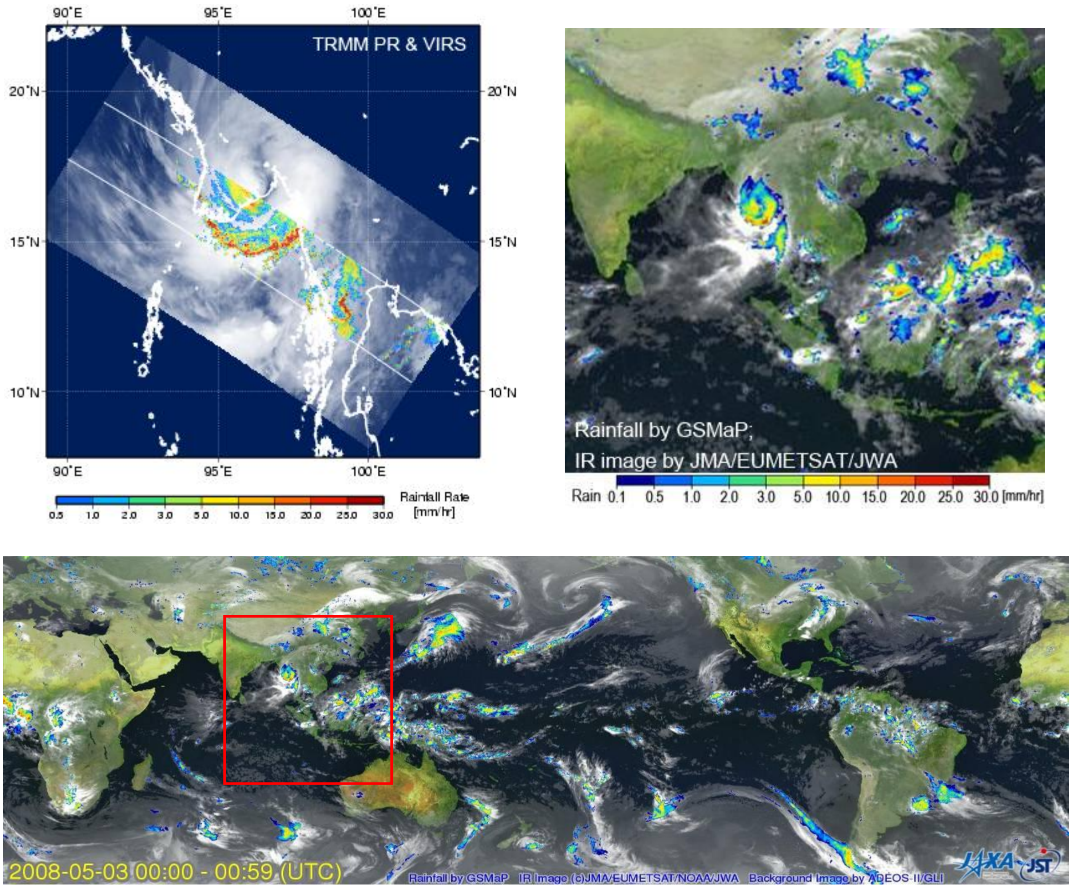

Fig 2. Rainfall observation of Cyclone Nargis. Upper left: Rainfall and cloud image observed by TRMM PR and Visible Infrared Scanner (VIRS) at 00:43 UTC 3 May 2008. Upper right: Zoomed image of red rectangle area in lower panel. Rainfall (color) estimated by GSMaP algorithm in near–real-time system, and cloud image (grayscale) observed by Geostationary satellites. Lower: Global rainfall at 00:00-00:59 UTC 3 May 2008.

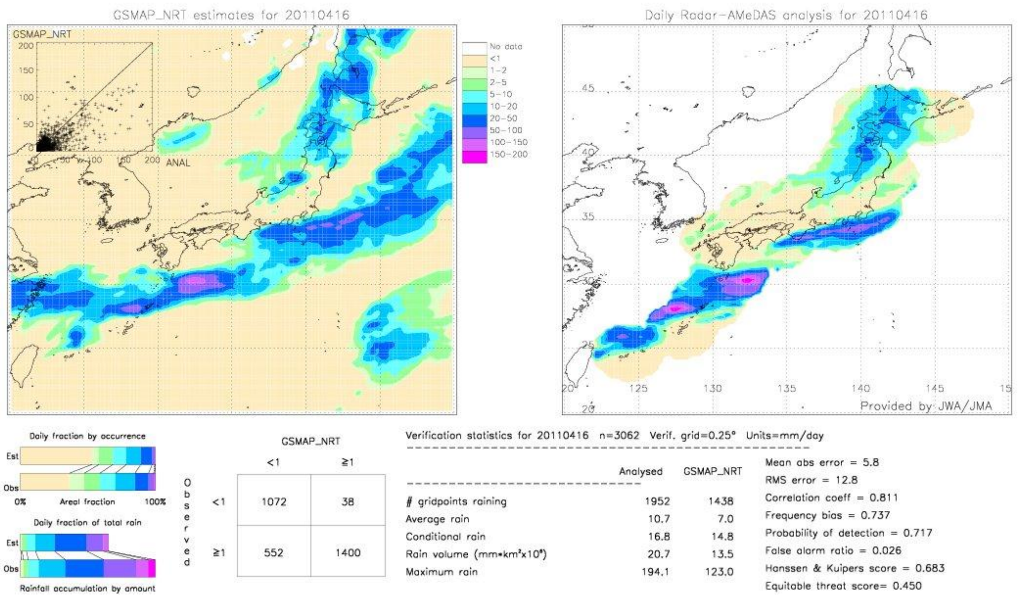

Fig. 3. Daily comparison between the GSMaP_NRT and radar rain gauge analysis in Japan

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