GEOSTATIONARY SATELLITE BASED RAINFALL ESTIMATION AND VALIDATION AND ITS FUTURE DEVELOPMENT

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1. INTRODUCTION

Floods and landslides that triggered by severe storm are noticed as two of natural hazards that repeatedly occurred during rainy seasons in Indonesia. The hazards have very serious impact to the loss both infrastructures and lives. Those of impacts can be avoided if there is an early warning to the prone area due to the occurrence of successive high intensity of rainfall. The slow dissemination of measured rainfall information most likely is the obstacle in terms of the use of meteorological information for early warning purpose. Satellite based rainfall estimation has been considered to provide rainfall information because it can provide data in nearly real-time, covers wide area and depict spatial distribution of rainfall.

This research is addressed to perform rainfall estimation by blending Multi Transport Satellite (MTSAT) and Tropical Rainfall Measuring Mission (TRMM) 2A12 dataset in order to provide near real time rainfall information (hereafter referred to as MTSAT blended), especially for hazard study purposes. We combine the advantage of that has good temporal resolution in monitoring atmospheric condition and TRMM that has more direct rainfall estimation due to its capability to penetrate the cloud and interact with hydrometeor.

The MTSAT blended is mainly based on the algorithm developed by Maathuis et.al[1)]. The method has been chosen because it is relatively simple both in data need and process, affordable for non-meteorologist and low cost computing.

The objectives of this research are: (1) to apply and modify the rainfall algorithm developed by Maathuis et. al[1)]; (2) to validate both temporally and spatially with available rain gauge data (3) to evaluate the MTSAT blended performance to future improvement and development.

2. THE STUDY AREA AND DATASETS

The study area is Java Island located on 5°S to 10°S and 95°E to 105°E. For the validation purpose, we select only southern part of Central Java i.e. Yogyakarta city and its surrounding. The area of study and the validation area are presented in Figure 1.

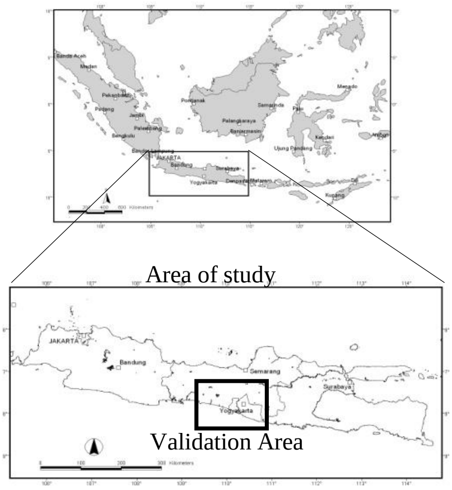

Fig.1 The study area of rainfall estimation and validation

The number of rainfall station situated in validation area is 22 automatic stations. The validation period is conducted during December 2007. The MTSAT images are acquired from WebGMS- MTSAT/GMS (HIMAWARI) data processing on WWW, Earthquake Research Institute & Institute of Industrial Science, University of Tokyo (http://webgms.iis.u-tokyo.ac.jp). TRMM 2A12 datasets are derived from http://mirador.gsfc.nasa.gov.

3. METHODOLOGY

The basic idea of MTSAT blended is how to develop statistical relationship between cloud top temperature depicted by MTSAT IR1 datasets and rain rate estimated by TRMM 2A12 datasets. For the convective cloud situation, the relationship between cloud top temperature and rain rate shows that the low cloud top temperature is associated with heavier rainfall[2)]. It can be represented by exponential curve that the rain rate is decreasing exponentially along the increasing of cloud top brightness temperature[3)]. The developed statistical regression will be used to generate rainfall estimation based on MTSAT datasets. Figure 2 shows the schematic diagram of MTSAT blended in the study[4)].

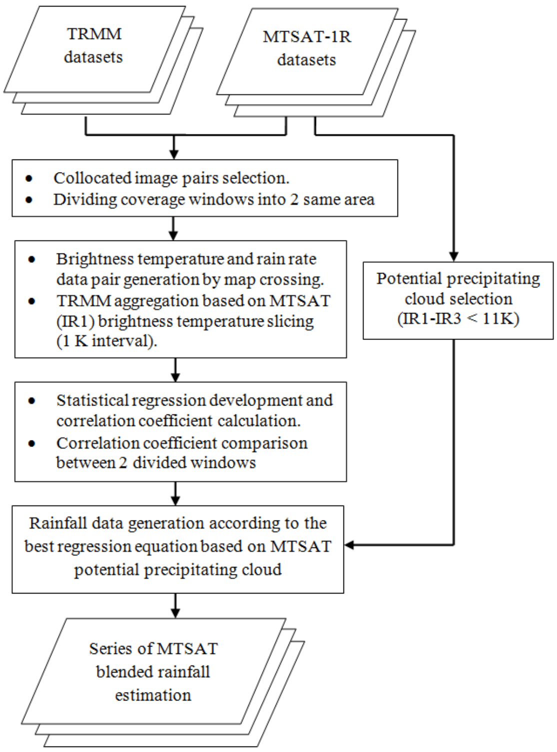

Fig.2 Blending method between MTSAT and TRMM data in the study[4)]

The most important step during performing this method is how to manage collocated image during spatial relationship development. The main problem of collocated image is there is a slightly discrepancy of cloud spatial distribution is depicted in collocated image because of the lag acquisition time. The discrepancy basically diminishes the statistical correlation of collocated image. In order to reduce the discrepancy of collocated image, two processes have been conducted i.e.: by averaging process and limiting the coverage of collocated image.

The averaging process for TRMM data based on the grouped MTSAT-IR cloud temperature (e.g.: 0.5K or 1K equal range temperature) is performed. The limiting the coverage of collocated image process is conducted by dividing the coverage window into smaller window during statistical relationship development. We adopted the collocated window size that used by Heinemann et. al.[5)] i.e.: 5° x 5° latitude/longitude to divide the whole domain window size into two smaller windows.

Temporal validation is performed in point to pixel basis i.e.: point rainfall data from rain gauge measurement and pixel based rainfall estimation from satellite. Hourly average is used to validate MTSAT blended. We use some categorical statistics such as accuracy, bias score, Probability of Detection (POD), False Alarm Ratio (FAR) and Critical Success Index (CSI) to evaluate the performance of rainfall estimation from satellites. A dichotomous method is used to say 'yes' if rain≠0 and to say 'no' if rain=0.

Spatial validation is performed by calculating spatial correlation both in pixel to point and pixel to pixel basis. In this study we only investigate the spatial correlation of convective rainfall cases.

4. RESULTS

During the validation period, we have identified 36 collocated images. The effect of limiting the coverage of collocated image is explained below[4)].

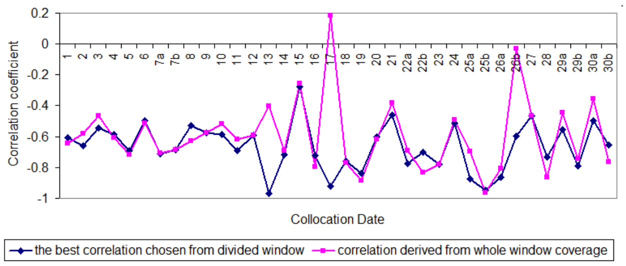

Fig.3 Comparison of correlation coefficient of the collocated images[4)].

We calculate correlation coefficient (r^2) of whole window coverage and those of two divided windows. We select the best r^2 between two divided windows and plot it against r^2 derived from whole window. For all collocation events the plotting result is shown in Figure 3. This result shows that the limiting window process is proven useful to reduce discrepancy by separating and rejecting it in one window and choose the other one that has less discrepancy.

The result of temporal validation is shown in Table 2. It can be examined that in term of overall accuracy, MTSAT blended is only 59% correct and it is likely related to the quality collocation images that may be occurred during rainfall estimation process. The bias score shows that MTSAT blended have a tendency to be overestimated. It indicates that potential precipitating cloud is more frequently detected in MTSAT blended. This situation is consistent with high POD value. The FAR value of MTSAT blended is also quite high and it is indicated that many potential precipitating cloud detected by MTSAT images which are not producing rain. The CSIs of MTSAT blended is quite low i.e. only 20% of 'rain' event both observed and/or estimated are correct. Based on those of statistical scores, it concludes MTSAT blended has quite low performance terms of temporal validation.

Table 2 Summary of categorical statistic for MTSAT blended.

Categorical statistic parameters	MTSAT blended
Accuracy	0.59
bias score	4.54
POD	0.83
FAR	0.79
CSI	0.20

Two convective storms have been chosen as the case study for spatial validation. The first case is 16 December 2007 storm and the second is 18 December 2007. Based on those two convective storm cases, spatial correlations of both pixel to point and pixel to pixel are conducted. The result is presented in Table 3.

Table 3 Comparison of spatial correlation between MTSAT and TMPA for two convective rainfall cases in pixel to point and pixel to pixel basis.

	Pixel to point	Pixel to pixel
MTSAT blended		
16 December 2007 case	0.36	0.50*
18 December 2007 case	0.33	0.61*

* = Correlation is significant at the 0.05 level (2-tailed).

The pixel to point spatial correlation of MTSAT blended for both 16 December 2007 and 18 December 2007 convective storms is quite low i.e.: 0.36 and 0.33 respectively. It can be readily explained due to spatial offset between cloud producing rain pixel and location of rainfall stations. However, positive correlation indicated that MTSAT blended can well represent the convective storms in both cases.

We compare pixel to pixel spatial correlation to the same convective storm cases, by performing the block kriging interpolation. The increasing spatial correlation i.e.: 0.50 and 0.61 for those respective cases is confirmed that after spatial interpolation, observed rainfall can be well represented by MTSAT blended. The average value of spatial correlation of MTSAT is 0.56, and it shows good agreement with the result of Ebert and Manton’s study[6] that for the instantaneous rainfall of mixed geostationary satellite and polar orbit satellite (IR-SSM/I) algorithms has correlation coefficient ranging from 0.49 to 0.55.

5. DISCUSSION AND CONCLUSIONS

MTSAT blended is demonstrated quite good performance to represent the spatial distribution of convective storms, though there are several limitations remain in term of temporal variation. The limitations are mainly due to the quality of collocated image and the quality of potential precipitating cloud detection.

In the future research some improvements will be conducted to overcome those of limitations i.e.:

a. We would like to accommodate not only TRMM image but also rainfall radar data as well as AMEDAS (Automated Meteorological Data Acquisition System). This process is considered to improve the quality of image collocation.
b. The limiting collocation window has been shown that it can reduce the discrepancy. However, by limiting window coverage is also reducing the significance of statistical relationship due to reduce sample. In order to overcome this problem we will apply robust non linier regression during development of statistical relationship.
c. In relation to potential rain cloud detection, we will try to use image segmentation process.

We will perform those of improvement by applying MTSAT blended over Japan.

The good representation of convective storm drives the possibility to enhance this natural hazard early warning purposes. In this case, we will try to develop convective storm severity due to rainfall triggered hazard, related to its return period. The presentation of return period of extreme storms event can be used as indicator of storm severity regarding rainfall triggered hazard early warning.

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