ANALYSIS OF SCENE COMPATIBILITIES FOR MOSAIC OF LANDSAT 8 MULTI-TEMPORAL IMAGES BASED ON RADIOMETRIC PARAMETER

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Abstract. Cloud free mosaic simplified the remote sensing imagery. Multi-temporal image mosaic needed to make a cloud free mosaic i.e. in the area covered by cloud throughout year like Indonesia. One of the satellite imagery that was widely used for various purposes was Landsat 8 image due to the temporal, spatial and spectral resolution which was suitable for many utilization themes. Landsat 8 could be used for multi-temporal image mosaic of the entire region in Indonesia. Landsat 8 had 16 days temporal resolution which allowed a region (scene image) acquired in a several times one year. However, not all the acquired Landsat 8 scene was proper when used for multi-temporal mosaic. The purpose of this work was observing radiometric parameters for scene selection method so a good multi-temporal mosaic image could be generated and more efficient processing. This study analyzed the relationship between radiometric parameters from image i.e. histogram and *Scattergram* with scene selection for multi-temporal mosaic purposes. Histogram and *Scattergram* representing radiometric imagery context such as mean, standard deviation, median and mode which was displayed visually. The data used were Landsat 8 imagery with the Area of Interest (AOI) in Kalimantan and Lombok. Then the histogram and *Scattergram* of the image AOI was analyzed. From the histogram and *Scattergram* analysis could be obtained that less shift between the data's histogram and the more *Scattergram* forming 45 degree angle for distribution of the data then indicated more similar to radiometric of the image.

Keywords: *Landsat 8, mosaic, histogram, Scattergram*

1 INTRODUCTION

Remote sensing imagery could be used in regional, national and global scale for all kinds of application. The remote sensing satellite with the low to medium resolution could be used for National and global scale, i.e. MODIS and Landsat 8. The remote sensing program of *Indonesia National Carbon Accounting System* (INCAS) used Landsat 5, Landsat 7 and Landsat 8 imageries as primary data to count national carbon in Indonesia. Mosaic product from *Land Cover Change Analysis* (LCCA) from INCAS had wider application for land usage management and regional planning in Indonesia (LAPAN, 2014). Landsat was one of the most popular satellites to observe the earth's surface. Most of the researches used Landsat data on various applications, i.e. changing detection and land cover's classification because of medium special resolution and spectral variation from those data. (Zhu *et al.*, 2012). For lower resolution images, such as MODIS, it was very appropriate for the needs of global researches due to its global coverage were got mostly daily (Justice *et al.*, 1998).

The cloud free imagery was urgently needed for all necessities. The cloud free imagery could be got by one of multi temporal mosaic process. Landsat 8 data had temporal resolution that was 16 days, so on certain area (the imagery scene) was acquired about 22 times a year. For creating multi temporal mosaic of annual

Landsat 8 images could be done by choosing scene that would be mosaic from numerous scenes that were acquired on that year. Image mosaic was unification of the overlapping images so the unification images did not have barrier on transitional area and maintained the general appearance on the original image (Su *et al.*, 2004).

Ramage introduced the Indonesia name as maritime continent because of its area was as continental dimension, but it was dominated by water (sea) and flanked by two continents (Asia and Australia) and two oceans (Indian and Pacific). It caused the atmosphere in most of Indonesian areas was relatively wet throughout the year (Harijono, 2008). By this condition, the intensity of cloud formation was always high, so it caused harder getting cloud free imageries in image's acquisition. So it was needed unification of two images or more to get cloud free imageries in one scene. The image's choice aimed to get a set of image with the scope of maximum cloud free imagery but with the minimum number of image scene. The *cloud cover* statistic that was available on metadata was inadequate if it was used as reference of scene choosing. The best way to do was by directly valuating visual imagery. Image with the *cloud cover* usually 50% of all its images were influenced by atmosphere and shadow so it was hard to be used or closed. Another obstacle was *cloud cover* statistic did not give any information of special distribution. (LAPAN, 2014). However, direct visual calculation was too objective so became inconsistent.

In case of annual mosaic, it was better if the used data was data that was similar for it's radiometric to get seamless mosaic. Data that had radiometric similarities could be got by choosing the images based on the similar atmosphere condition and land cover. It was predicted could be done by comparing data to be mosaic, namely by observing the data histogram and *Scattergram*.

Histogram generally was the digest chart from quantitative data (Kaplan *et al.*, 2014). The imagery histogram was described simply as a graphic bar from pixels intensity. The pixels intensity was plotted through the length of the x-axis and total appearance of each intensity was represented on y-axis (Murinto *et al.*, 2008). Histogram represented statistical value of a data set. One of the advantages using histogram was easier to read bigger data set. Histogram gave the information of mean, deviation standard, modus, median and distribution function of the data (Dean *et al.*, 2009). *Scattergram* helped searching the class, deviating data, trend and correlation. 3D *Scattergram* with animation, different symbols could give additional variable of dimension became three or more (Hoffman *et al.*, 2002). Elvidge *et al.*, (1995) developed the method of *Scattergram Controlled Regression* (SCR) automatically. This method applied the regression on pixel area that had no change. Those areas were chosen manually based on the *Scattergram* data of infra-red channel near the subject data with the references data. Using the infra-red channel was because of on the wave length, it could be seen the clear separation of land and water area; SO the data of pixel line that had no change could be decided. The subject data was rectification based on parameter of those *Scattergram*.

The research of scene's choice using histogram and *Scattergram* was ever done by Dyatmika *et al.*, (2015) that showed related imagery radiometric characteristic to histogram and *Scattergram* (Dyatmika, *et al.*, 2015). This research analyzed the compatibility of the imagery scene, which was by analyzing radiometric parameter between images for multi-temporal mosaic. By comparing the radiometric parameter between multi-temporal images, it could be understood the compatibility of radiometric for multi-temporal mosaic.

2 MATERIALS AND METHODOLOGY

The used data in this research was Landsat 8 imagery Level 1T. Data that was chosen from some area in Indonesia, i.e. in Kalimantan island with *path&row*117 062 and Lombok island with *path & row* 155 066. It was used three images on each chosen area. Data 1, 2, 3 in Kalimantan Island was recorded on May 15th, July 8th and July 24th 2014 whereas data 4, 5, 6 was data for Lombok island area that was recorded on May 7th, July 10th and August 27th 2014 (Figure 2-1).

The correction of TOA radiometric (Top of Atmosphere) was done on data based on manual guidance used Landsat 8 data (USGS, 2015). Data conversion Level-1 into spectral radiation using scale factor on metadata was done using the equation below:

$$L_\lambda = M_L \times Q_{cal} + A_L \qquad (2\text{-}1)$$

Where:

L_λ = Spectral radiation (W (m2*rs*µm))

M_L = Multiplier factor of channel radiance scale

A_L = Adder factor of channel radiance scale

Q_{cal} = Pixel value of Level-1 data on DN

Furthermore, those data were conversed to TOA reflectance before adding correction factor of sun angle through the equity:

$$\rho\lambda' = M_\rho \times Q_{cal} + A_\rho \qquad (2\text{-}2)$$

Where:

$\rho\lambda'$ = TOA reflectance without sun angle correction

M_ρ = Multiplier factor of channel reflectance scale

A_ρ = Adder factor of channel reflectance scale

Q_{cal} = Pixel value of Level-1 data on DN

The last TOA reflectance was got from this equity:

$$\rho\lambda = \frac{\rho\lambda'}{\cos(\theta_{SZ})} = \frac{\rho\lambda'}{\sin(\theta_{SE})} \qquad (2\text{-}3)$$

Where:

$\rho\lambda$ = TOA reflectance

θ_{SE} = Elevation angle of local sun

θ_{SZ} = Zenith angle of local sun

Data with cloud cover for Kalimantan area was data on July 24th 2014 (Data 3) with the cloud cover 6.61% whereas for Lombok area was data 3.75% (Data 6).

Each data was taken the AOI sample (*Area of Interest*) for about 160 x 160 pixel on the same area. This AOI was taken on area that had small intensity of land cover changes. The technique of histogram matching needed multi-temporal scene with consistent vegetation and humidity. Comparison between multi temporal recording on those areas would give more information about various radiometric spectral (Helmer et al, 2005). Taken from AOI, then it was created histogram and *Scattergram* data. To get the cloud free area, the value of digital number for histogram and *Scattergram* input might be taken on area of 60% - 100% from histogram height. It was assumed that histogram value on the area with height of 60% - 100% was the data with low variability. Figure 2-2 showed the area with low variability in area II, because of outside this area could be assumed as shadow area, water on area I (at the beginning of histogram value) and cloud on area III (at the end of histogram value). The value that was plotted on *Scattergram* was taken on area with the same reflectance value on the histogram creation (area II).

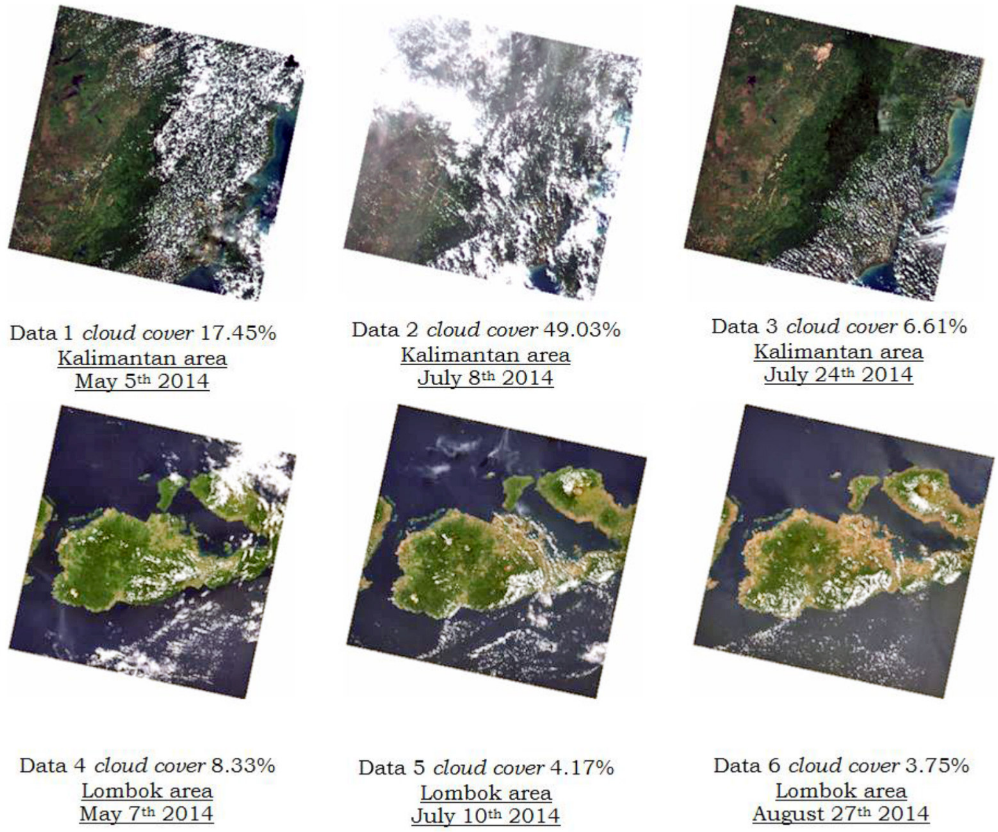


Figure 2-1: Landsat 8 data on Kalimantan Island

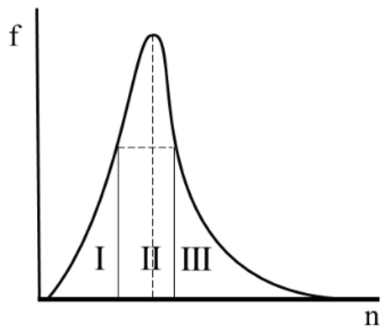


Figure 2-2: Histogram value making

It was created the histogram and *Scattergram* patch between reference data and tested data, then it was observed for the data distribution and compared the mean value between both of them. The simple way to get mean of some pixel of images could be got from this equity (Richards, 2013).

$$\bar{g} = \frac{1}{MN}\sum_{M=1}^{M}\sum_{N=1}^{N}\emptyset(m,n) \qquad (2\text{-}4)$$

Where,

$\bar{g}$ = Mean

M = The number of lines on the images

N = The number of rows on the images

$\emptyset(m,n)$ = Pixel value on lines and rows m,n

Figure 2-3 showed the steps that were done on this research.

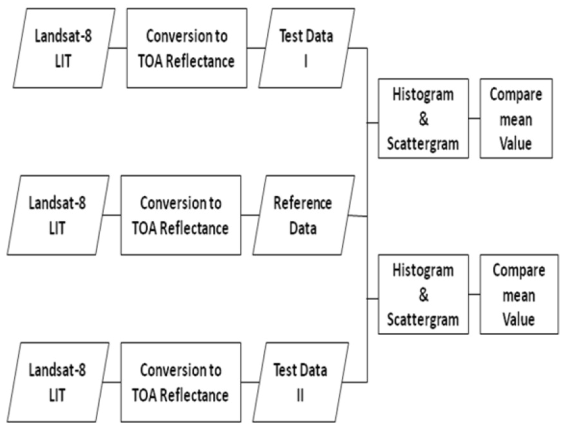


Figure 2-3: Work Step

3 RESULTS AND DISCUSSION

It had been done the comparison between Landsat 8 data and some ways visually, by observing histogram and *Scattergram* data. By data visualization that had been cut of (AOI) it's each data, as shown on Figure 3-1.

Radiometric imagery correction should have similar reflectance value on images if the objects were similar. But in fact, it was difficult to happen, because of numerous and various distortions on the imagery process on Remote sensing satellite imagery. It was assumed that images with the lowest cloud report had reflectance value which closed to the real object value.

Figure 3-2 showed the patch visualization of each image with the reference image. From the pictures could be seen that the patch of AOI data 1 with AOI Data 3 was the most seamless compared to other patches. It showed Data 1 with the cloud cover for almost 20% still contained of more proper data for multi-temporal mosaic although compared to Lombok data that had cloud cover lower than 10%. However, on the patch of AOI 2 and 3 showed the result that was not seamless so it was advised to the multi-temporal mosaic because of radiometric between inappropriate images.

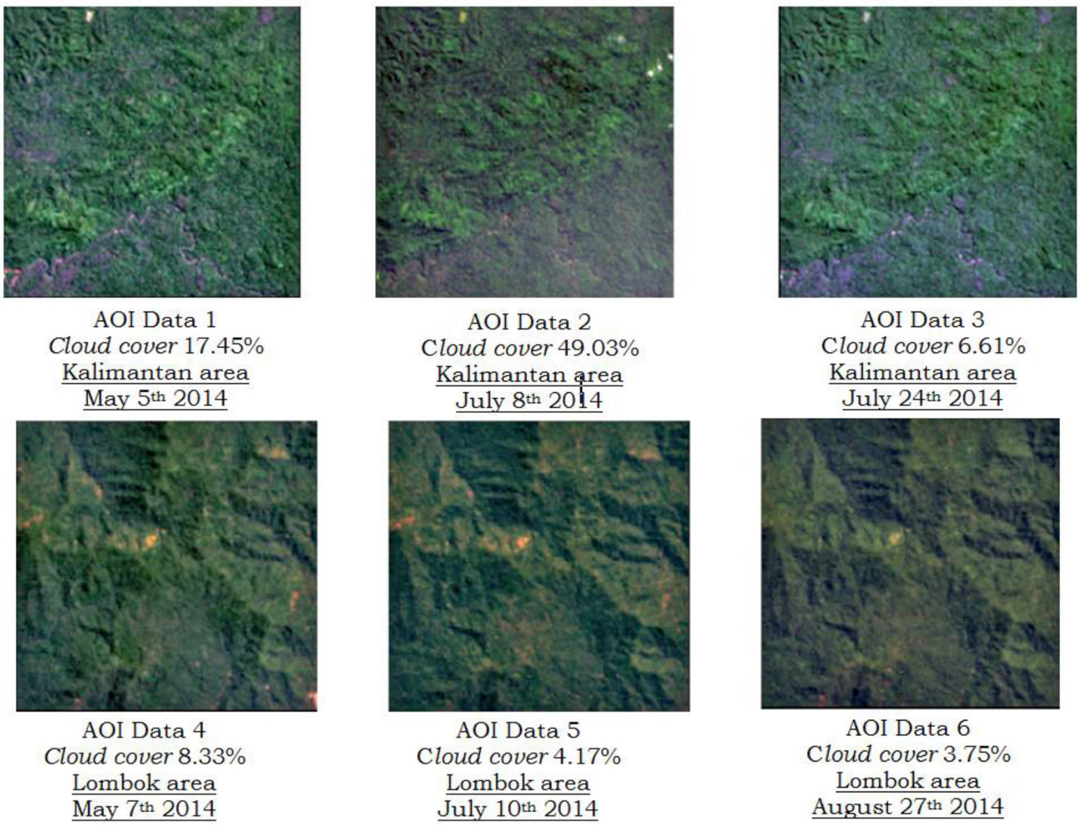
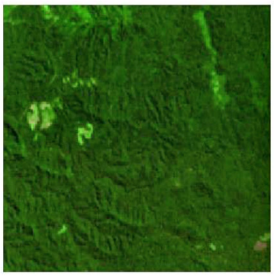
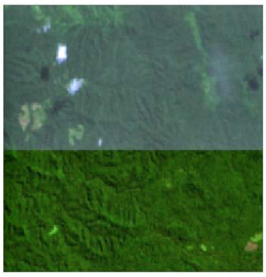


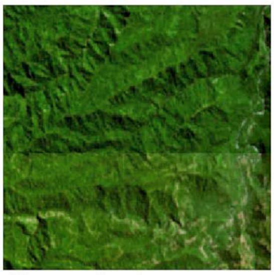
Figure 3-1: AOI data Landsat 8 on Kalimantan Island (above) and Lombok Island (below)



The patch of AOI Data 1 with AOI Data 3 (reference)



The patch of AOI Data 2 with AOI Data 3 (reference)



The patch of AOI Data 4 with AOI Data 6 (reference)

The patch of AOI Data 6 with AOI Data 6 (reference)

Figure 3-2: The Patch of AOI Data Test with reference

On histogram as shown on Table 3-1 and Table 3-2 below, the red color showed reference histogram, the green color showed the tested histogram data, and the yellow color was the patch area between reference histogram and tested histogram data. This yellow area showed the same reflectance value between reference imagery and tested imagery data. On *Scattergram*, it could be seen through the position of data distribution. The colors on *Scattergram* showed the appearance intensity of reflectance value. The red color indicated the most emerging value (modus), consecutively to the yellow one, green and blue (the intensity was getting lower). It was also created the help lines of 45° to ease the interpretation of data distribution position on *Scattergram*.

Next, it was done the statistic calculation to get the reflectance mean, looked on Table 3-3 below.

The calculation of mean value for each data would strengthen the interpretation of histogram and *Scattergram* that had been processed and was shown on Table 3-2 quantitatively. For example, on AOI 1 data of Kalimantan island, it was seen that histogram was coincided and *Scattergram* closed to 45° line strengthened this result, the ratio value of mean 2/mean 1 was also worth nearly 1, it mean the data that were compared were similar. On the contrary, on AOI data 2 Kalimantan island, it seem the histogram moved and deviating *Scattergram* from line of 45° strengthened this result, the ratio value of mean 2/mean 1 also was worth enough deviation from 1 to 1.53 on the red channel, which mean the data that were compared were different. Furthermore, when the ratio of Mean 2/Mean 1 was worth more than 1.00, it could be said that the images that had been tested tended to be brighter. On the contrary, if ratio of Mean 2 Mean 1 was worth less than 1.00, then the images that had been tested tend to be darker than the reference imagery.

The visual observation on imagery data, the result of histogram and *Scattergram* on Data 2 Kalimantan area that the cloud's report was almost 50% showed very different interpretation between the data.

It showed that the cloud free area on this scene was still influenced by atmosphere that made this data deviated, so this scene was inappropriate as multi-temporal mosaic imagery. Differed from above, the remaining data was similar visually, seem on histogram or *Scattergram*. Even on data 1 Kalimantan area although the cloud report was near 20% but the imagery radiometric was similar to the reference data. Same to the three data in Lombok island, which were data 4, 5, 6, visually could not be differentiated and radiometric parameter of those three images were similar each other.

Table 3-1: The results of Histogram and Scattergram for Kalimantan

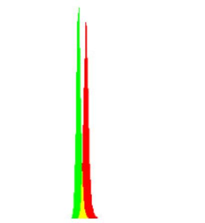
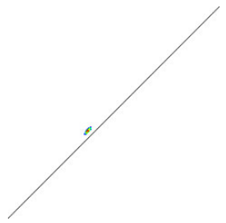
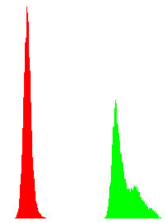
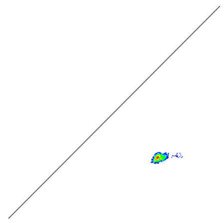
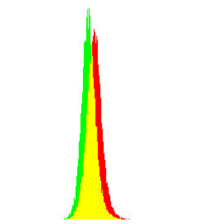
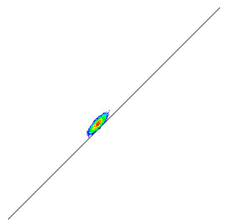
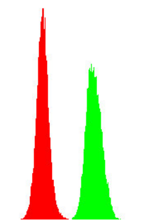
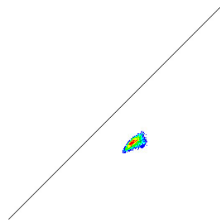
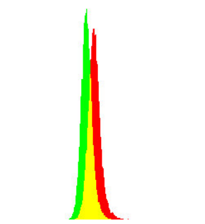
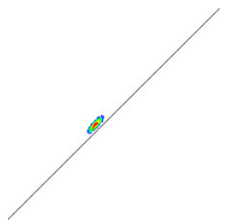
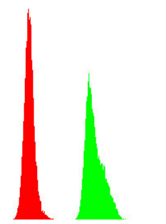
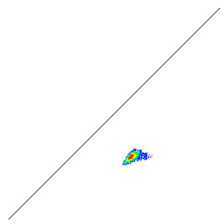
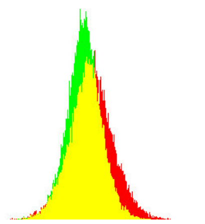
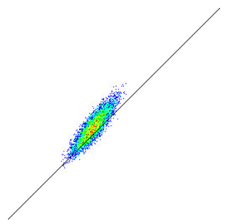
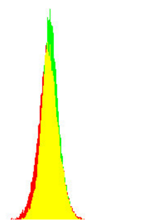
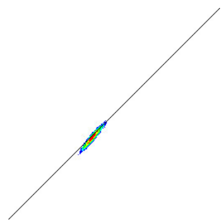
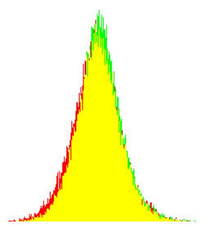
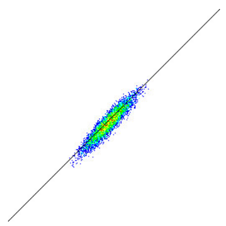
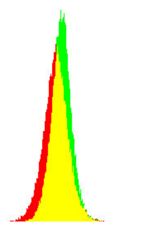
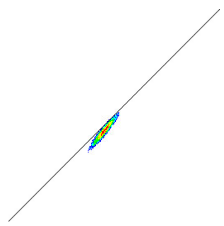
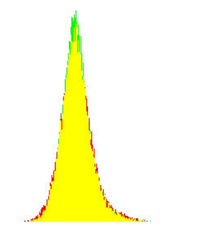
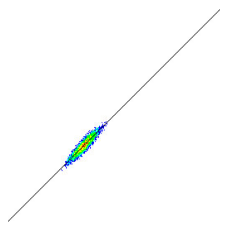
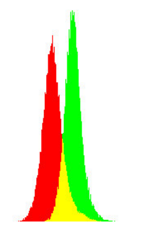
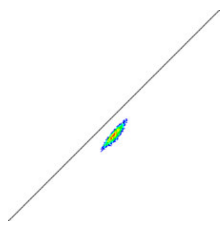
	Kalimantan Juli 24th vs Mei 5th 2014		Kalimantan Juli 24th vs Juli 8th 2014	
	Histogram	*Scattergram*	Histogram	*Scattergram*
Blue channel				
Green channel				
Red channel				
NIR channel				
SWIR1 channel				
SWIR2 channel				

Table 3-2: The results of Histogram and Scattergram for Lombok

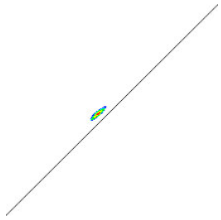
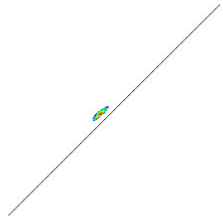
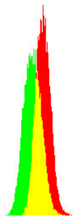
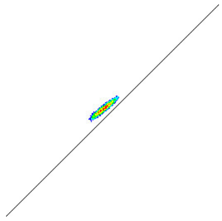
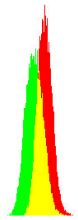
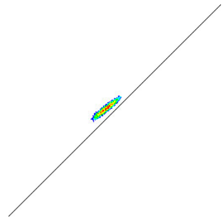
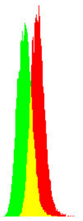
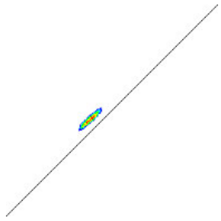
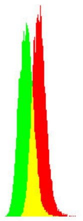
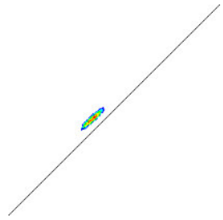
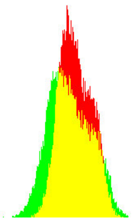
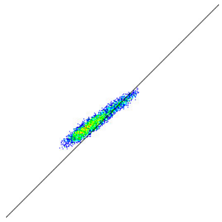
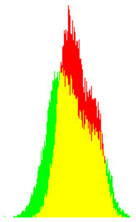
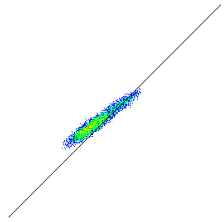
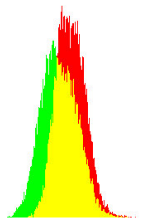
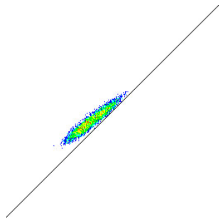
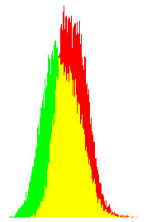
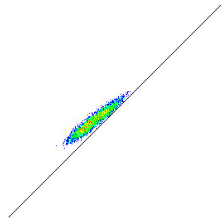
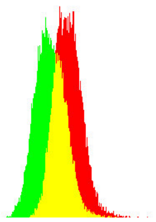
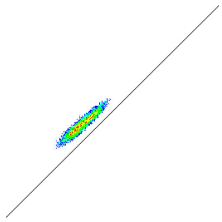
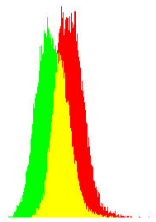
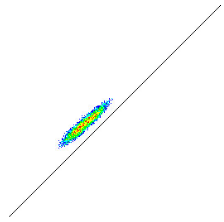
	Lombok August 27th vs May 7th 2014		Lombok August 27th vs July 10th 2014	
	Histogram	*Scattergram*	Histogram	*Scattergram*
Blue channel				
Green channel				
Red channel				
NIR channel				
SWIR1 channel				
SWIR2 channel				

Table 3-3: The result of mean calculation on each AOI

	Blue channel	Green channel	Red channel	NIR channel	SWIR 1 channel	SWIR 2 channel
Kalimantan 1						
Mean1 (July 24th)	0.081	0.064	0.036	0.310	0.121	0.041
Mean2 (May 5th)	0.078	0.061	0.034	0.299	0.122	0.040
Mean 2/ Mean 1	0.97	0.97	0.95	0.97	1.01	1
Kalimantan 2						
Mean1 (July 24th)	0.081	0.064	0.036	0.310	0.121	0.041
Mean2 (July 8th)	0.102	0.082	0.055	0.317	0.127	0.050
Mean 2/ Mean 1	1.26	1.3	1.53	1.02	1.05	1.23
Lombok 1						
Mean1 (August 27th)	0.082	0.066	0.040	0.296	0.114	0.043
Mean2 (May 7th)	0.076	0.059	0.033	0.286	0.107	0.037
Mean 2/ Mean1	0.93	0.91	0.83	0.97	0.94	0.85
Lombok 2						
Mean1 (August 27th)	0.082	0.066	0.040	0.296	0.114	0.043
Mean2 (July 10th)	0.079	0.061	0.035	0.278	0.102	0.036
Mean 2/ Mean 1	0.96	0.92	0.88	0.93	0.88	0.81

4 CONCLUSION

Histogram and *Scattergram* could be used for choosing the imagery scenes as an alternative besides using the cloud report on the metadata or visually. Histogram and *Scattergram* gave more detail information compared to use cloud report, which was the radiometric similarity from some images, and the cloud cover just gave information of cloud cover percentage from one image. Histogram and *Scattergram* gave consistent information of radiometric and more quantitative compared to visual appraisal. Even a slight histogram shift between data and closer to 45 degree line of *Scattergram* data distribution, it mean more similar to its radiometric imagery.

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