DEVELOPMENT OF LANDSAT-8 IMAGE RADIOMETRIC QUALITY SCORE USING HAZE AND CLOUD DETECTION ALGORITHM

Kustiyo, Anis Kamila and Randy Prima Brahmantara
Remote Sensing Technology and Data Centre, LAPAN

kustiyo@lapan.go.id

Abstract. Image radiometric quality score is the score that shows how good the image from radiometric error, at least there are two parameters derived from Landsat-8 image that can be used to assess the radiometric quality, there are haze and cloud. This study used the Landsat-8 ortho rectified ready images, Top Of Atmospheric (TOA) and Bidirectional Reflectance Distribution Function (BRDF) algorithm were applied in radiometric correction. The haze identification technique was analyzed from the 2 dimensional (2D) histogram (scatterplot) between blue and red bands using supervised algorithm. The cloud identification was derived using the visible and cirrus band, visible band was used to detect the thick cloud, but the cirrus band to detect cirrus cloud. The identification result was transformed into 100 levels, score 1 shows pixel with lowest quality, and score 100 shows highest quality in radiometric. The minimum score was used in combining the haze and cloud images score to generate final radiometric score. The results shows that all the 5 scenes processed are no omission error, but some commission error, so that this algorithm is good enough for making the image mosaic.

1. Introduction

Satellite remote sensing identifies an object in specific coordinate locations of the earth's surface by measuring the value of radians, and then the value of radians can be converted into reflectance values. Reflectance value represents a certain object at a particular location, and the reflectance value of an object measure by satellite can be different from the actual reflectance, it depends on the atmospheric conditions at the acquisition time. The quality information of reflectance as part of image quality information is necessary and it is the key to the utilization of remote sensing image analysis (Y. Xia, 2015). There are at least two basic parameters used to determine the quality of remote sensing image, there are geometric accuracy, and radiometric accuracy. The geometric accuracy measures the geometric location error of the pixel in the image, and the radiometric accuracy measures the reflectance difference between the measured reflectance and actual reflectance (George, 2005). Several studies in the field of remote sensing image quality has been done, including the use of signal-to-noise ratio (Fiete, 2001), the use of universal reconstruction method (Shen, 2010), the use of visual information fidelity index (Shao, 2013), the use of a comprehensive evaluation factor (Wang, 2014), the use of statistical and visual analysis (Shahrokhy, 2004), the quality of the image for the high resolution image data (Mattia Crespi, 2009).

The radiometric quality was affected at least by three aspect, there are satellite sensor, earth topographic, and the atmospheric conditions. In this study, the radiometric quality is limited to the image quality caused by atmospheric conditions. The atmospheric radiometric quality of an image is influenced by clouds and haze conditions (Shahrokhy, 2004). The quality was indicated by the particular score, the higher the score the higher the image quality. The radiometric quality of the images was calculated by combining cloud and haze scores, and taking the lowest value from both scores.

Several methods for identifying haze had been developed, there are tasseled cap haze transformation, simplified tasseled cap haze transformation (Lavreau, 1991; Huang, 2002; Moro, 2007), the haze optimized transform (Zhang, 2003), and supervised algorithm (Kustiyo, 2016).

Kustiyo 2016, compared the four techniques above, the supervised algorithm was the best algorithm applied in Landsat-8 2015 in West Java region.

Cloud can be divided into two categoriesusing remote sensing data: thick and thin cloud, thick cloud is relatively easy to identify because the reflectance values were high on visible band, but thin cloud identification was more difficult because the effect of an object under a cloud (Gao and Kaufman, 1995; Gao et al 1998, 2002) . Cloud identification of Landsat data has been done (1) Automated Cloud Cover Assessment (ACCA) system (Irish et al, 2006), but the ACCA could not identify thin clouds (cirrus), (2) The cloud detection using the sensor Operational Land Imager (OLI) of Landsat-8, the algorithm use the cirrus, albedo, and the spatial relation between a shadow of the cloud (Kustiyo, 2016).

2. Data and Methods

2.1. Data and Research Sites

This study used the data from sensor Operational Land Imager (OLI) Landsat-8, scene number: 120-065, and acquisition date in 2016 which covers most of the southern part of Central Java. The L1T data were selected, so the geometric correction already done. One scene was used as data for developing the algorithm, and others were used as validation. Table 1 showed the data were used.

Table 1. Landsat-8 data were used in the study

No	Scene number	Acquisition Date	Level Data	Note
1	120-065	18-01-2016	L1T	modelling
2	120-065	25-02-2016	L1T	validation
3	120-065	28-03-2016	L1T	validation
4	120-065	15-05-2016	L1T	validation

2.2. Methodology

Image radiometric quality score was calculated from cloud and haze properties, these two properties combined together, and selected the minimum score or index. Figure 1 showed the general algorithm in producing the image radiometric quality score.

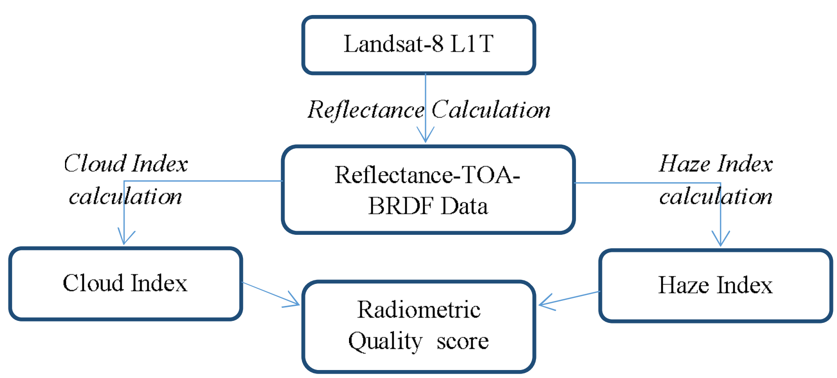

Figure 1. Image radiometric quality score general algorithm

2.2.1. Pre Processing. There are two pre-processing that usually used in remote sensing data processing, that are radiometric and geometric correction. The correction Top of Atmospheric (TOA) and Bidirectional Reflectance Distribution Function (BRDF) were applied in radiometric correction. Results of radiometric correction such as reflectance value to 0 -1, then multiplied by 60000 to be stored in a 16-bit integer. While the geometric correction is not performed because the data used is within the level of processing L1T.

2.2.2. Haze Detection. Before the detection of haze was calculated, the water masking using Short Wave Infra-Red-2 (SWIR-2) band was considered. The threshold value was applied, if the reflectance value of SWIR-2 < 0.167 then the pixel was classified into water. Haze detection algorithm used a supervised algorithm by taking a training sample on haze-free, a little haze, a more haze, and a lot of haze area for the objects of vegetation and open land. Furthermore, the observation of two-dimensional (2-D) between the blue and red bands, and created a straight line connecting the mean reflectance of open land and vegetationcloud free, then calculated slope angle, and calculate the haze index in below equation:

$$HI = \tan(\theta) \times Ref_{blue} - Ref_{red} \quad (1)$$

where:

HI	:	haze index;
θ	:	angle between the line from mean reflectance of open land to vegetation cloud-free with horizontal line
Ref_{blue}	:	reflectance value of blue band,
Ref_{red}	:	reflectance value of red band,

Based on the scene sample of 122-065, June-26th 2015 the angle θ is 73^{o}, and $\tan\theta = 3.27$.

2.2.3. Cloud detection. The cloud identification technique from Landsat-8 image detects the cloud and then calculated the cloud distance. It used the visible and cirrus band, visible band was used to identify the thick cloud,but the cirrus band to detect thin cloud. Water masking was applied before cloud detection. Cloud assigned with score 1 (lowestquality) using the certain threshold of albedo from visible band and from cirrus band, then cloud was assigned gradually with score 2 to 100 (the highest quality) using gradual threshold of albedo and cirrus band. All possible cloud must be considered as value 1 to 99, and certain clear assigned as 100. This technique was called as cloud spectral distance, value 1 was the certain cloud and value 2 is the closest spectral distance to certain cloud, value 100 was the longest spectral distance to certain cloud. The spatial distance to the certain cloud also applied, using this spatial distance, the cloud in surrounding cloud and cloudshadow are assigned as cloud, otherwise assigned as no-cloud (clear). More detail explanation could be found in Kustiyo 2016 *"Development of Landsat-8 Image Radiometric Quality Score (Phase I: Cloud Identification and Cloud DistanceCalculation)"*

3. Results and Discussion

3.1. Model development

The model was developed by using the Landsat-8, scene 120065, acquisition date of 18th Jan 2016. Cloud and haze identification and index was calculated, and combined to product radiometric image quality index. Cloudy and hazy image was indexed to lower radiometric quality, and clear image was indexed to the highest radiometric quality. Combined cloud and haze index using minimum index produced radiometric quality index. Figure 2 showed the natural color image, cloud index, haze index and radiometric quality index from the model development.

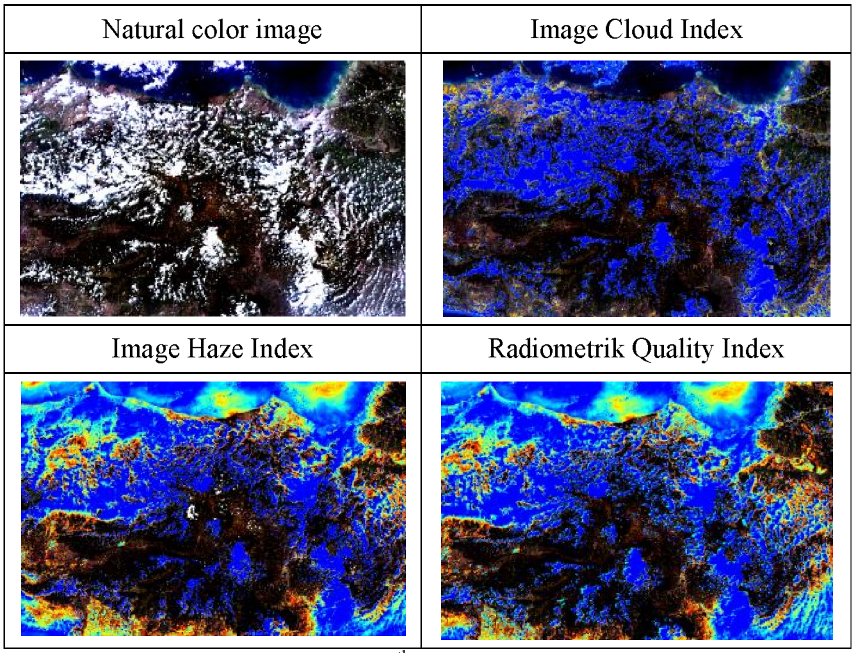

Figure 2. Landsat-8 data, 120065 18th Jan 2016 and the result of developing model

3.2. Testing model

Base on threshold for generating cloud and haze index in the model development, the threshold was applied to others Landsat-8 data with same area but difference acquisition date. The result of model testing could be seen in the figure 2.

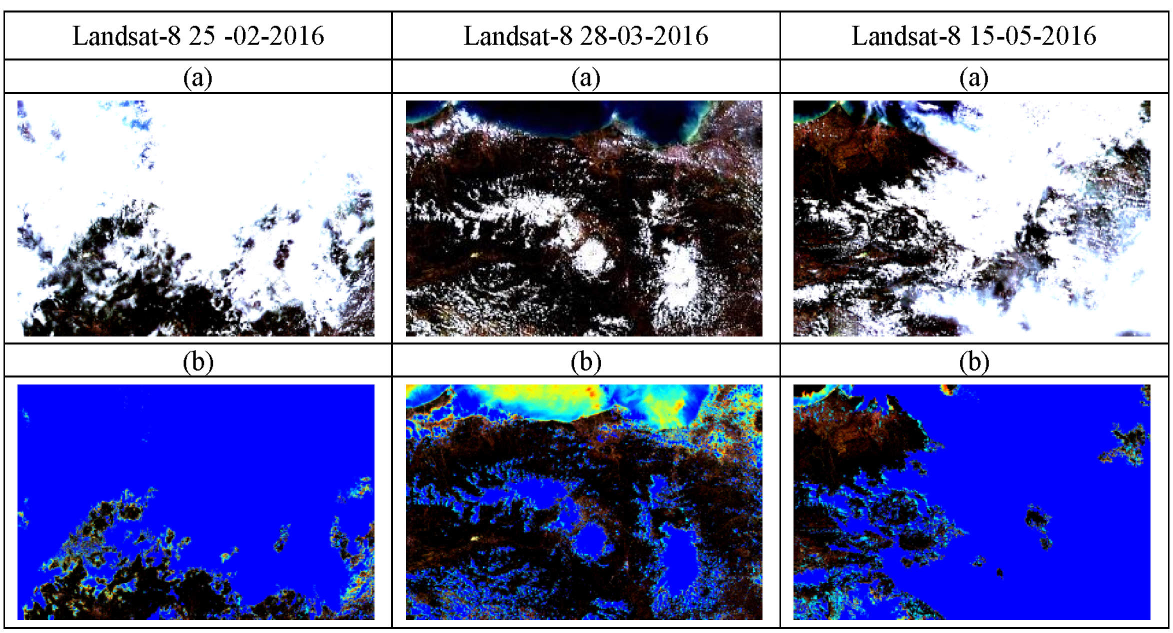

Figure 3. Image radiometric quality index for others scene for testing model (a) natural color composite, and (b) image radiometric score.

3.3. Discussion

In developing radiometric quality, cloud and haze identification must be combined. In the model development, same area was detected by cloud identification but not detected by haze identification; otherwise also same area was detected by haze identification but not detected by cloud identification. Detail analysis about the difference results between cloud and haze identification was explained in Table 2. From analysis in table 2, there no omission error but some commission error. This is a good result, the algorithm must be detect all the cloud, haze and potentially haze or cloud. If some clear area was detected as cloud or haze, it does not matter, because it can be substitute by others data. But if there are still cloud and haze, it will be problem in the mosaic image later.

Table 2. Difference result between cloud and haze identification from model development

		Cloud identification	
		Cloud	Non-Cloud
Haze identification	Haze	most of cloud was detected as haze	• in the button right and button left, much haze but not detected as cloud • in the top right, there are some haze detected by haze identification, but not detected y cloud identification • in the city area some clear area detected as haze
	Non-Haze	• in central area, detected as cloud but not detected as haze; • in the water area, clear area was detected as haze	all area with non haze and non cloud was the clear area

In the validation data, the same with the data in model development, there are some commission error, but no omission error. In next process for mosaic image, this algorithm can be applied before mosaic process to generate the cloud and haze free mosaic image. More validation image must be taken in other location or other scene before applying it for operational mosaic of Indonesia cloud free image using Landsat-8 data.

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