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Noise removal using thresholding and segmentation for random noise Sentinel-1 data

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Abstract. Sentinel-1 constellation will cover the entire world's land area continuously. Although Sentinel-1 data show consistency and stability, several noise have been observed in the data i.e. random noise on the right and left of the scene. The noise exists on the right and left of the scene of the SAR data that should be no data value. The noise is quite disturbing and interferes the data especially on mosaic product of some scene data sets. The mosaic product have a seam line that separate a scene and the neighbor that should be disappear after the mosaic process. This paper shows study on how to remove the random noise without losing the information contained. Some Sentinel-1 Level-1 GRD (Ground Range Detected) data in Kalimantan area were used in this study. Principally, the methods used for the noise removal were thresholding and segmentation. If the noise removal process using thresholding only, many noise still exist in the data. Region on the right and left of the scene filtered by a certain value of intensity and segmentation area. Generally, improvement of the data was evaluated both after each scene noise removal process and mosaic product. The noise in each scene Sentinel-1 data disappear and the mosaic product look seamless after applying the noise removal.

1. Introduction

Sentinel-1 satellite constellation operate day and night at C-band synthetic aperture radar make them possible to acquire imagery independent of the weather condition. The Sentinel-1 satellite constellation consist of two satellites in a near-polar and sun-synchronous orbit with a 12 day repeat cycle for a single satellite. The constellation of two satellites offers a 6 day repeat cycle. Sentinel-1 data acquisition data processing should be done consistently in order to receive a good observation or monitoring. All global landmasses are regularly covered in VV-VH polarization [1].

A processing step Sentinel-1 products leading to random noise on the right and left of the scene of the Sentinel-1 data [2]. These noise affect the target at the edges much more than those close to the center [3]. Combining the data of the individual sub-swath into consistent mosaic require a good performance [4].

Many methods have been proposed to remove various noise in various field application. Donoho [5] shown work on de-noising by soft-thresholding. The theorem has two components, one concerning about statistical decision theory and the other concerning about wavelet bases and their properties.

The work reported here was a study to applying a general de-noising theorem to remove the random noise in a Sentinel-1 SAR data above. The random noise affect the data both single scene data and more over the mosaic products.

2. Data and method

Almost all of the data Sentinel-1 in Level-1 Ground Range Detected (GRD) products affected by the noise. This paper used some data Sentinel-1 Level-1 GRD products in Kalimantan area to test the proposed methodology. The data were adjacent to another so the mosaic of the data could also evaluate.

The data used for this study were dual polarization i.e. VV and VH polarization Sentinel-1 data, acquired on December 13th and December 19th 2015 with Interferometric Wide (IW) swath mode and descending pass both of them. Each data have amplitude band and intensity virtual band (Figure 1).

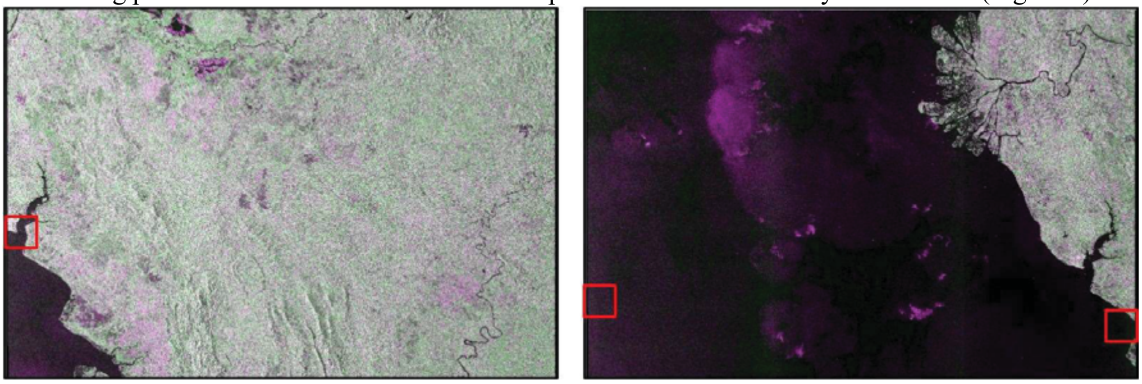

Figure 1. The Sentinel-1 Level-1 GRD data, with color composite combinations (Red=VV, Green=VV, and Blue=VH).

The noise could observed visually after saturate or enhance the data in the noise value. In the other hand, after make mosaic some adjacent data, the noise generate seam line that separate a scene and the neighbor that visible clearly.

The noise removal have two steps i.e. masking the noise then remove the masked noise. The noise masking algorithm perform some kind of classification using thresholding and segmentation principally. To masking the noise, some series of processing step performed i.e. masking the area that close to the left and right border, filter the masked area with the amplitude threshold to get the noise temporary, segmented the noise and filter the noise with the segmentation size.

The IW swath mode acquires data with a 250 km swath at 5 m by 20 m spatial resolution (single look). In Level-1 GRD products, the resolution changed dependent upon of multi-looking performed [6]. One of the data used in this research was 10×10 m pixel spacing and 25326×16831 pixel dimension and the other was similar. In the other hand the noise mainly only fraction on the left and right border, so the first step would be restrict the working area. Processing whole area would be adding many computation load and processing time. The noise left and right fraction covered by only 200 pixels each of them from the edge.

After restrict the area, the noise masking continue with classified the noise by set the threshold to differ the noise and the data. It would be hard to set a perfect threshold to differ the noise and the data. If the threshold is too high, many pixels data contained information would be lost especially on the dark object like water and the opposite. The threshold would be different between each polarization i.e. 37 for VV and 25 for VH. The differences come from range of the backscatter each polarization. The thresholding would be only a process step and would be continue in the next step.

The latter step mainly about segmentation of the noise. The idea is fraction of noise usually only small segment of the data. So the process is set a threshold of area sized i.e. 20000 pixels square. A segment bigger than the threshold would be classified as a data. Finally the noise have been masked with the processing series above. And the last process remain is remove the masked noise.

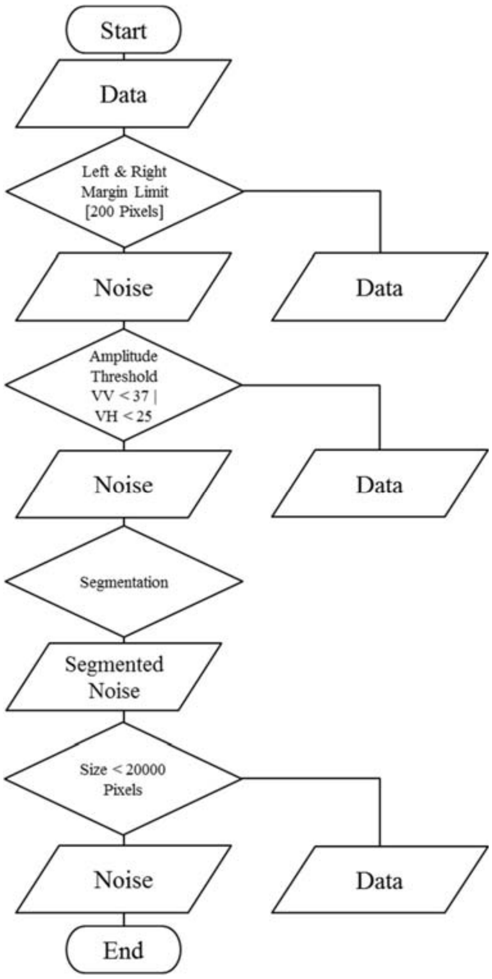

Figure 2. Noise masking algorithm flowchart.

Evaluation on single data could be directly observed but the mosaic products need to process a geometric correction before, because the Level-1 data were not yet geometric corrected. The single data evaluation only need to saturate or enhance the display into the noise value range.

3. Results and discussion

Figure 3 shows data subset with noisy image before enhance, noisy image after enhance and removed noise image after enhance. The subset were area in Figure 1 with red box marked. In the noisy image before enhance, the noise can't be seen because the value of the noise was very low and seen as a dark like 0 value. After enhance to the noise value, the noise is visible clearly. Finally the removed noise image show that the noisy fragment in the previous data were removed.

Also on the mosaic data (Figure 4) the noise on single data affect to the mosaic product. The mosaic product have two seam line that separate a scene and the neighbor that should be disappear after the mosaic process. The first line on the left affected by the noise in image shown on subset 3 and the second line on the right affected by the noise in image shown on subset 1 and 2 (Figure 3). The mosaic product look seamless after applying the noise removal (Figure 4). The mosaic product shown that this method could remove the noise significantly.

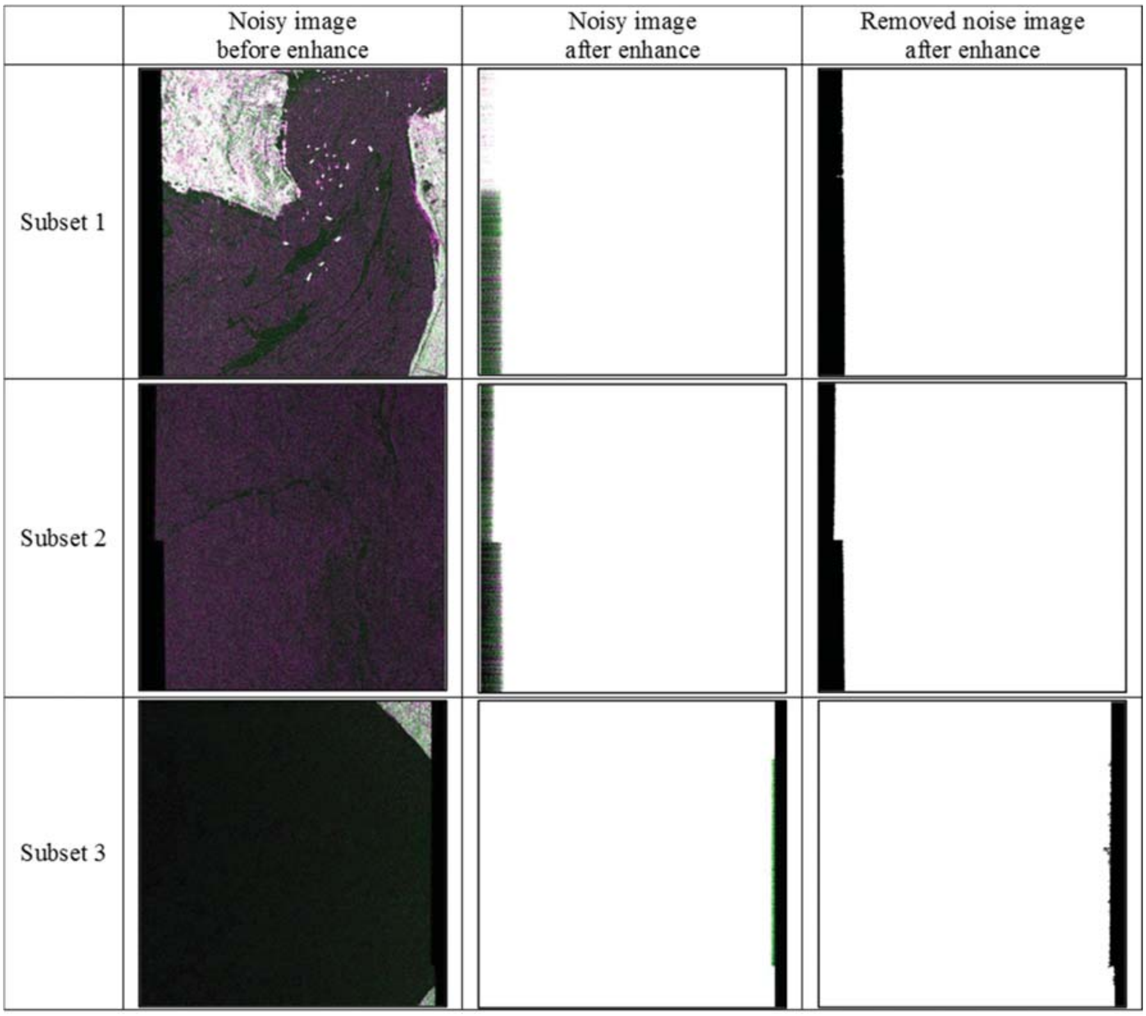

Figure 3. Data subset zoom in to the noise area by 1000×1000 pixels, selected in Figure 1.

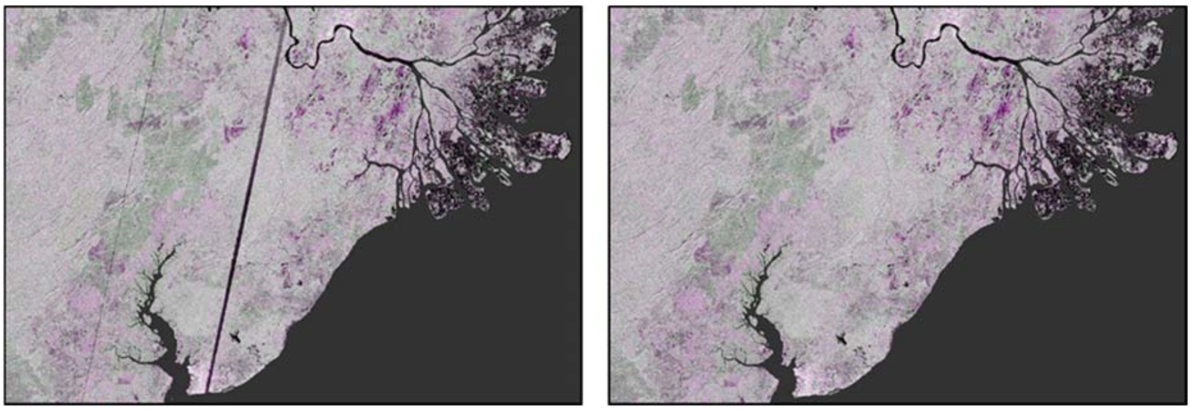

Figure 4. Sentinel-1 mosaic products subset. Left, noisy image and the right, removed noise image.

4. Conclusion

The single scene data Sentinel-1 noise could observed after enhance range value on the noise range value while the mosaic product could be directly observed. The noise removal using thresholding and segmentation could remove the noise on the right and left of the scene Sentinel-1 data significantly.

5. Acknowledgement

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