Application of interferometric SAR using Sentinel-1A for flood monitoring in South of Sulawesi, Indonesia

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Abstract. An updated information of flood mapping that recently occurred in South Sulawesi is an important necessity for site policy makers. Mapping of flood area during or soon after the flooding event is tremendous hardwork. However using active-remote sensing namely InSAR (Interferometric Synthetic Aperture Radar) technique can overcome these limitations. To achieve it, at least two radar images have to be obtained which is 1 image before and 1 image during/after flood event. We selected 2 images Sentinel-1A GRD (Ground Range Detected) data for the same pass direction and the same time acquisition with polarization VH (Vertical-Horizontal), 12 days of temporal baseline. The images were then processed by SNAP (Sentinel Application Platform) Toolbox. The results show that Sentinel-1A succeeded in detecting and monitoring flood event, where inundated of water in Tallo River is clearly visible in VH polarization.

1. Introduction

Recently, the flood had occurred on 25 January 2019 in South Sulawesi, Indonesia. The issue is necessary since there is a little information available about the site area. Since the study area is located in a tropical region, passive remote sensing displays certain limitations mainly cloud cover over the study area and data can only be acquired during the day, while on the other hand, active remote sensing, Synthetic Aperture Radar (SAR) can overcome these restrictions due to the data that can be acquired potentially at any time even day or night and even penetrates cloud cover. However, using active remote sensing such as Sentinel-1A is value added since its low revisit time 12 days and it is value added for flood monitoring.

Some examples of successful application of radar for flood monitoring [1], [2]. Mapping disaster map, when flood is still occurring is another positive output of using remote sensing.

1.1. Study Area

The study area is along the Tallo River to the Bili-Bili Dam located in Southern of Ujung Pandang City, Makasar, South Sulawesi (Figure 1 and Figure 3.a). For the investigated flood area and damage analysis, the Sentinel-1A (C-Band) SAR data with Ground Range Detected (GRD) product format were used. The mode of satellite data is Interferometric Wide (IW) which has swath width area of 250
km² and has a dual polarization (VV & VH). The GRD range azimuth resolution is 20x22 m with pixel spacing 10x10 m [3].

1.2. Data

This research used Sentinel-1A GRD IW with the ESA (European Space Agency) SNAP (Sentinel Application Platform) software with 2 images acquisition which is, before and during the flooding event. In this case, there are 2 data available dated at 13th and 25th January 2019 images. The first image acquisition (13/01/2019) is before flood and the second (25/01/2019) is during the flood. The flood occurred on 25 January 2019. Because of the flooding event prolonged until subsequent days, Sentinel-1A is compatible for the site area since the time acquiring is at noon 15:34 – 15:35 local time. This means that Sentinel-1 captured the flood event and is suitable for this research. Table 1 shows the Sentinel-1A data.

**Table 1.** Satellite Sentinel-1A with dual polarization VV VH and azimuth range resolution 20x22 m.

| Satellite Data | Pass Direction | Time            | Track | Date (Jan 2019) | Orbit   |
|----------------|----------------|-----------------|-------|-----------------|---------|
| Sentinel-1A IW | Ascending      | 15:34:27 pm     | 10    | 13              | 25457   |
| GRDH           |                |                 |       | 25              | 25632   |

**Figure 1.** show the footprint of radar image in ascending orbit. Small square red is the study area, and purple line is the main road of the Ujung Pandang.

2. Methodology

InSAR technique utilizes two or more SAR images in the format of SLC (Single Look Complex) or GRD in order to extract information from a pair of SAR images at different acquisition times [4]. SAR emits its own energy of an electromagnetic wave to the earth surface with specific wavelength and
frequency. The lowest frequency sensor has high sensitivity [5], [6] to surface feature with an accuracy of the topography and displacement in meter and millimetre respectively [7].

Flood area monitoring can be analyzed by its pixel coefficient of backscatter (Sigma 0), which has low values than other pixels because the radar signal is reflected away from the sensor and this results in the area looking dark (black) in SAR images. The processing flow using SNAP Processing Tool [8] which is shown in Figure 2.

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START

Input 2 images of safe.file Sentinel-1A to ESA SNAP Processing Software

Subset or Clip to Study Area (Makasar)

Draw and overlaying to QGIS

END
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**Figure 2.** Flowchart of methodology with using ESA SNAP and QGIS.

For flood detection and monitoring, we used before and during flood images to compare water and land area. To decide the value threshold, statistical analysis was applied for selecting the water area.
3. Result

The results present a potential of detecting and monitoring flood event using 12 days of Sentinel-1A GRDH images with the intensity of the SAR images. Clear differences of VH polarisation between before and during flood are described in Fig.3b and Fig.3c. An observation of Center of the figure clearly shows inundated flood by over loading water of Tallo River dominated by dark areas. Moreover the river makes its own flow directly to the Billi-Billi Dam (see bottom left of red rectangle in Fig.3c). In addition, the width of the Tallo River looks wider when compared to before flooding image (Fig.3c). More than that, in the East-West of the Billi-Billi Dam, the land area disappears, which is perhaps due to high intensity and the pressure of water come in to the dam (see green circle in Fig. 3c)
Figure 3b. VH before flood.

Figure 3c. VH during flood.
4. Conclusion

This paper presents the potential of SAR classification technique to monitor flooding events in South Sulawesi with an active remote sensing Sentinel-1A GRDH IW using SNAP Processing Toolbox. The flooding features can be identified clearly and are highly visible in VH polarization.

4.1. Future Work

Since Sentinel-1A has another polarization VV, a comparison VV and VH is the next task beside Change Detection technique using SARPROZ by D. Perrisin which is to obtain the detail information of the differences in each pixels.

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6. References

[1] P. Razi, J. T. S. Sumantyo, F. Febriany, M. Nasucha, and J. Aminuddin, “Interferometry Synthetic Aperture Radar ( InSAR ) Application for Flood Area Detection Observed by Sentinel 1A,” in Progress in Electromagnetics Research Symposium PIERS, 2018, pp. 905–909.
[2] R. Kumar, “Flood Inundation and Hazard Mapping of 2017 Floods in the Rapti River Basin Using Sentinel-1A Synthetic Aperture Radar Images,” 2019, pp. 77–98.
[3] ESA User Guide, “Interferometric Wide Swath,” Online, 2019. [Online]. Available: https://sentinel.esa.int/web/sentinel/user-guides/sentinel-1-sar/acquisition-modes/interferometric-wide-swath.
[4] P. A. Rosen et al., “Synthetic Aperture Radar Interferometry,” Proceeding IEEE, vol. 88, no. 3, pp. 333–382, 2000.
[5] A. Refice et al., “SAR and InSAR for Flood Monitoring: Examples With COSMO-SkyMed Data,” vol. 7, no. 7, pp. 2711–2722, 2014.
[6] A. Refice et al., “Inundation monitoring through high-resolution SAR / InSAR data and 2D hydraulic simulations,” 2020.
[7] Y. Rauste, H. Lateh, Jefriza, M. W. I. Wan Mohd, A. Lönnqvist, and T. Häme, “TerraSAR-X data in cut slope soil stability monitoring in Malaysia,” IEEE Trans. Geosci. Remote Sens., vol. 50, no. 9, pp. 3354–3363, 2012.
[8] Sentinel-1 Tutorials, “SNAP Processsing and Tutorials,” 2016. [Online]. Available: http://step.esa.int/. [Accessed: 11-Dec-2016].