A24

The Volcanic Ash Parameters Estimation and Visualization Based on a Small X-band Dual-polarization Doppler Weather Radar Data

〇Magfira SYARIFUDDIN ・Masayuki MAKI ・Satoru OISHI
・Ahmad LUKMAN・Haruhisa NAKAMICHI・Masato IGUCHI

In recent years, several works have investigated the potential of ground-based weather radar to monitor the volcanic ash clouds [1]-[3]. The goal of this study is to show the usefulness of a small compact X-band dual-polarization weather radar (X-Band) measurements to monitor the volcanic eruptions in Sinabung Volcano in 2018.

Descriptive analysis and visualization are applied to the multi-parameter of radar to give valuable information on how the sensor reads the echo caused by the eruption. The study also discusses the volcanic ash parameter estimation based on a two-stepwise approach of ash class identification and ash class calculation.

Case Study

The case study is the volcanic eruptions occurred in February 2018 and May 2018, at Sinabung Volcano (3.17°N, 98.39°E), located in Karo Regency, North Sumatera of Indonesia. This Volcano has shown increasing activity since 2010 after more than 400 years dormant period. An eruption happened on 19 February 2018 which caused the closing of Kualanamu Airport in Medan, North Sumatera. Volcanic ash plume was said to exceed 6 km height. The volcanic activity of Sinabung Volcano kept increasing and another series of eruptions happened on 20 May 2018.

Data Descriptions and Visualization

Since May 2017, a small X-band radar has been deployed at 8 km from the Sinabung Volcano. This radar is small with radome size diameter of 1085 mm and 65 kg weight. The first case in February 2018 was monitored by sectoral range height indicator (SRHI) scan mode at elevation angle 7 to 40 angular degrees. The second case in May 2018 was monitored by Plan Position Indicator (PPI) scan mode at 9 different elevation angles ranging from 3-21 degrees. The X-band radar data that we analyzed are the multi parameter of radar, consists of horizontal polarized and differential reflectivity, the correlation coefficient and the specific differential phase shift, respectively indicated by Z_H [dBZ], Z_{DR} [dB], ρ_{HV} [-], and K_{DP} [°/km]. The mesh size of SRHI scan mode is 100 m with 50 seconds time interval, while the PPI scan mode has 100 m mesh resolution and 2-min time interval.

Figure 1 (left panel) shows an example of the SRHI scan mode of radar variables on 19 February 2018 at 08:56 local time, 3 minutes after the eruption, at the azimuth angle 290°. The right panel shows the temporal values of each parameter at four different points indicated in **Figure 1**.

Volcanic Ash Retrieval model and Visualization

The volcanic ash retrieval model in this study adopted the Volcanic Ash Radar Retrieval (VARR) model constructed by Marzano et al [1][2]. Where, the distribution of volcanic ash particles following the scaled Gamma distribution. The radar reflectivity Z_H is derived from the 6-th moment of scaled Gamma distribution, and the ash concentration is derived from the third moment of scaled Gamma distribution. The first step was the ash classification based on a set of training data of synthetic ash and their estimated reflectivity factor. Using a Naïve-Bayesian classification, the measured reflectivity factor from the eruption were classified into the classification model. The second step was volcanic ash concentration and fall-out rate estimation by power-law function. The radar reflectivity measured can be classified into 6 different ash classes, which consist of two different ash particle classes and three different intensities. The particles are lapilli (mean diameter *Dm* = 1 mm) and coarse ash (*Dm* = 0.1 mm). The three different concentrations *Ca* are light (*Ca*= 0.1 g/cm^3), moderate (*Ca*= 1 g/cm^3), and intense (*Ca*= 5g/cm^3). **Figure 2** shows the ash classes and estimated concentration for both cases. The model shows an indication that the higher reflectivity during the eruptions belong to the coarse ash with higher intensity or lapilli classes. The SRHI scan mode gives clearer result comparing to the PPI scan mode of the second case. Although this study can give an insight of the volcanic ash clouds based on radar measurement, future verification based on real particle size distribution from field measurement, such as by parsivel is required to improve the model reliability.

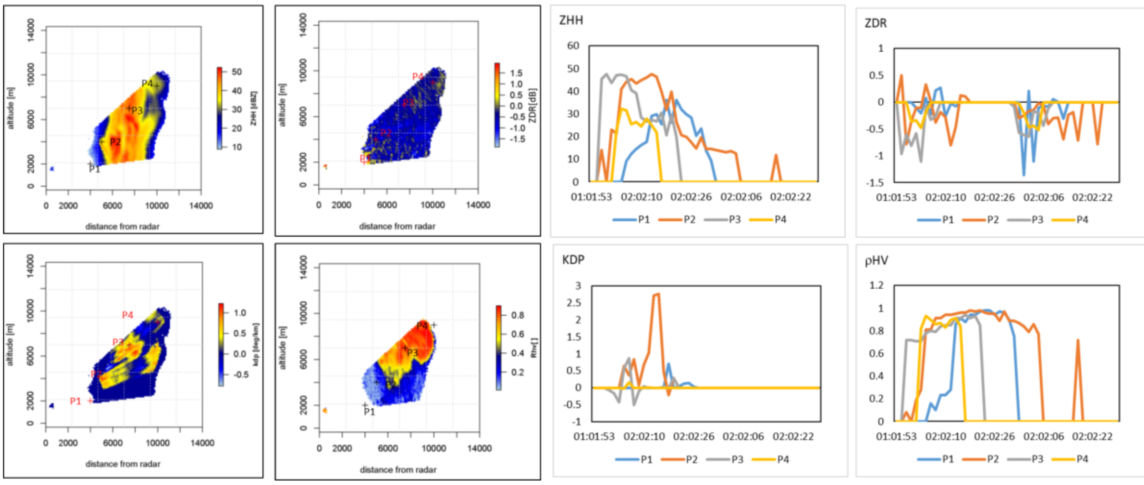

Figure 1. Left, RHI of radar variables listed in the top panel for the case study of 19 February 2018 eruption, 01:56 UTC (3-min after eruption). Right panels shows the temporal evolution of each radar variables on the left for the four crosses on the line.

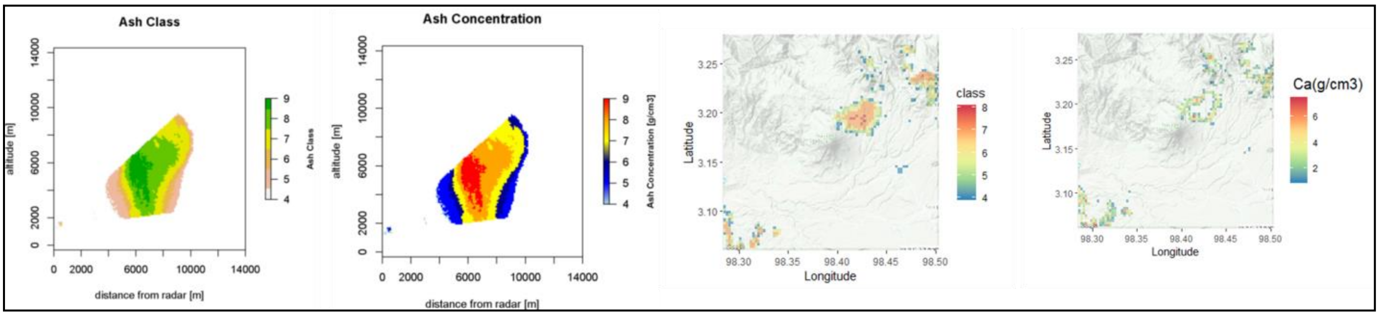

Figure 2. Left, ash class and its retrieval ash concentration for the 19 February 2018 case (SRHI scan mode). Right is the ash class and its retrieved concentration for the second case by PPI scan at 5° elevation angle.

References:

[1] F.S Marzano, G. Vulpiani, and W. I. Rose, “Microphysical characterization of microwave radar reflectivity due to volcanic ash clouds,” IEEE Trans. Geosci. Remote Sen., vol. 44, no. 2, pp. 313-327, Feb. 2006

[2] F.S Marzano and G. Vulpiani, “Volcanic ash cloud retrieval by ground-based microwave weather radar,” IEEE Trans. Geosci. Remote Sen., vol. 44, no. 11, pp. 3235-3246, Nov. 2006

[3] F. S. Marzano, E. Picciotti, M. Montopolli, and G. Vulpiani, “Inside volcanic clouds – Remote sensing of ash plumes using microwave weather radars,” Bull. Am. Met. Soc., vol. 94, pp. 1567–1586, Oct. 2013