Reconstructing the 19 February 2018 of Sinabung Eruption Column by a 3D Numerical Model

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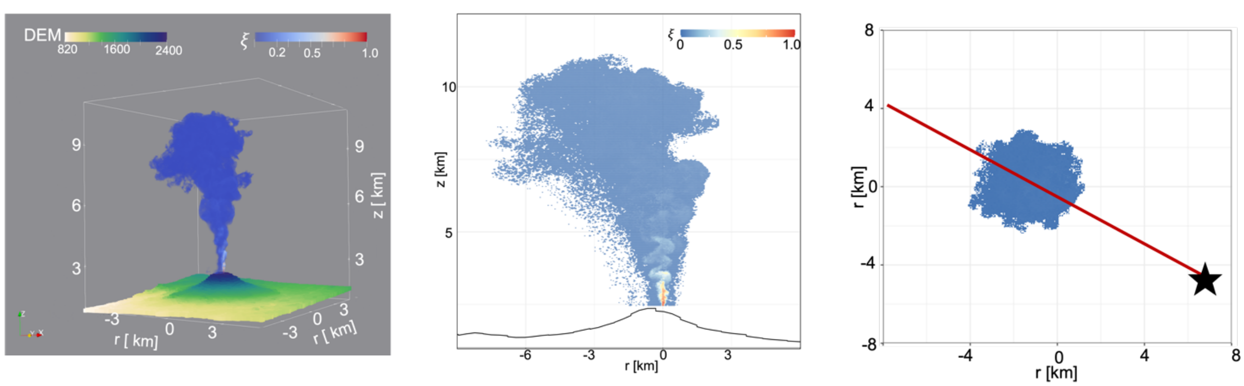
1. Introduction

My research aims to incorporate the velocity estimates from a weather radar observation into a three-dimensional (3D) numerical model to reconstruct the VEI-2 eruption of Sinabung Volcano, Indonesia, on 19 February 2018 at 08:53 local time. One collapsing column earthquake and 60 dome collapse earthquakes, including the disintegration of a lava dome were also reported. Although several studies have extensively discussed the eruptive plume dynamics and tephra characteristics using satellite- and ground-based observation, they still have several limitations, related to technical settings and spatio-temporal resolution. In this project, the temporal evolution of the plume is reconstructed using a 3D numerical model based on ranges values of exit velocity provided by radar observation. The results will be compared with radar and satellite imageries to understand the reliability of the 3D numerical model. At the same time, we expect to unravel the mechanisms of the partial collapsing plume reported during the event case.

2. 3D Numerical results of the eruption event

Fig. 1 presents the mass fraction of the ejecta at 360 s after the onset time based on a 3D numerical model. The values of the mass fraction range from 0 to 1, describing the ratio between the mass of ejecta (i.e., solid pyroclasts and volcanic gas) and total air. The eruption cloud is ejected from the vent with a large density (2.62 kg/m^3) comparing to the atmospheric density (0.91 kg/m^3). At the core of the plume, the ejected material is not mixed with ambient air ($\xi \cong 1$) and its density remains greater than the air. Then the ascending cloud is dispersed, and the mixture density becomes less than the ambient air, resulting in a buoyant plume. The simulation produces a stable column state, which cannot describe the partial collapsing plume.



(a) (b) (c)

Fig 1. (a) 3D visualization of the eruption column presenting the mass fraction of ejecta at 360 s after the onset, (b) Cross-sectional distribution of mass fraction at the same time stamp, extracted from the red line along the z-perspective (c). The star in (c) represents the location of the radar. The numerical model was run at exit velocity w= 100 m/s, Mass discharge rate m_0 = 5.15× 10^5 kg/s, and vent radius L_0 = 25 m. The meteorological data were provided by European Centre for Medium-Range Weather Forecasts (ECMWF) ERA5 at 02:00 UTC on 19 February 2018.

3. Comparison of vertical velocity of the 3D model and Radar Observation.

In general, the radar-retrieved updraft velocity fall behind the 3D numerical model (Fig. 2). It is reasonable due to the mechanisms of radar scanning, which samples a volume of the atmosphere according to the pulse width (100 m). On the other hand, the numerical model was performed on a 3-D domain of a non-uniform grid (5-25 m mesh), assuming the plume was an injected mixture of solid pyroclasts and volcanic gas into a stationary atmosphere.

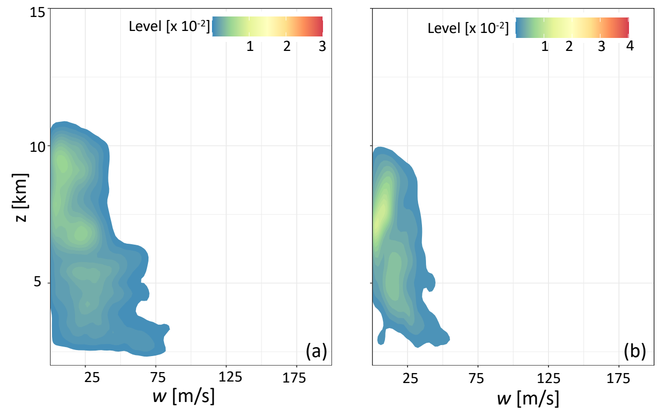


Fig 2. Density distribution of the updraft velocity relative to the height: (a) the result of the 3D model at 360 s after onset, and (b) radar-retrieved updraft velocity at approximately the same time: 08:58:7 local time. The 3D model was run using the same parameters described in Fig. 1.

4. Acknowledgement

I am grateful to the University of Tokyo, and Earthquake Research Institute, Professor Suzuki, and the staff at the International Office for the opportunity to study and research in Japan's finest institute. I enjoyed my productive and pleasant time in Japan.

Sincerely,
Magfira Syarifuddin.