Estimation of Distribution of Tephra Fall Deposit Using the Interpolation Method Based on Multi-observation Data

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INTRODUCTION

In watersheds where volcanic ash has been deposited by volcanic eruption, it is known that subsequent rainfall has a high risk of triggering debris flows. Therefore, it is very important to provide the debris flow disaster warning information for the local residents living in areas affected by the volcanic ash. To detect the susceptible areas, it is crucial to estimate the distribution of tephra fall deposits.

Several studies have been attempted to apply models to produce the isopach maps (Johnston et al. 2012; Tajima et al. 2013; Klawonn et al. 2014). Tajima et al. (2013) used a simple method-ellipse-approximated isopach (EAI) to assess the volcano tephra based on the few observation data. However, it is hard to decide the direction of the tephra transportation. The most straightforward tool for producing the isopach map is still hand-drawn visualizing method, yet it lacks a consistent standard and may cause subjectivity (Klawonn et al. 2014). The data-driven interpolation method is more objective option for producing the isopach maps (Engwell et al. 2015).This method needs the sample data to estimate the distribution in the study area, though it lacks the thickness data nearby source volcanic vent owing to the danger to access vent. The objectives of this study are to: 1) examine the interpolation method based on the automatic multi-observation and briefly estimated source volcanic vent data for objectively producing the tephra isopach map through the geographic information system (GIS) platform; 2) verify the accuracy of a new method to estimate the isopach map.

DATA AND METHODS

One of the large eruptive events on June 1, 2015 at the Sakurajima Island was selected to produce the isopach maps. The thickness of tephra-fall data were measured by the automatic measuring systems at hourly time intervals. The raw observation data were randomly divided into two parts: a training and a testing part, using the 1:1 split ratio.

In this study, the tephra-fall around the source volcanic vent are estimated by three point data via the linearly approximated algorithm. The point P(x,y,z) nearby source volcanic vent and the three observation points data $P_1(x_1,y_1,z_1)$,$P_2(x_2,y_2,z_2)$,$P_3(x_3,y_3,z_3)$ are shown in **Figure 1**. Here, x and y are planar coordinates, z stands for the thickness of volcanic ash. The vector at the source volcanic vent is assumed to pass the three points of the vectors. The deposit thickness in the vicinity of the source volcanic vent can be estimated by giving the coordinate on the horizontal plane. Next, the estimated data combined with the observation data were used to produce the isopach map by the interpolation method. After comparison, the spline interpolation approach was selected. This model can reduce the difference between estimated data and observation data because this model uses a mathematical function to minimize overall surface curvature, resulting in a smooth surface which passes precisely through the input points. The details can be referred to Franke (1982).

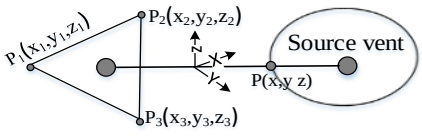

Figure 1 Schematic illustration showing how to estimate the thickness nearby the source volcanic vent.

RESULTS

Figure 2a is ash isopach map produced by the spline interpolation model. According to this figure, the deposited area almost distributed at the northeast direction.

To validate the accuracy of the model, the relationship between estimated data and observation data was plotted as shown in **Figure 2 b**. Here, the value of root mean square error (RMSE-frequently measured the difference between estimated value and observed value) is 0.16. The result showed that the estimated values were a bit larger than observation data, yet they were almost close to the ground-based Observation data.

These results show the method based on spatial interpolation allows an objective estimation of isopach with good agreement between observed data and estimated data.

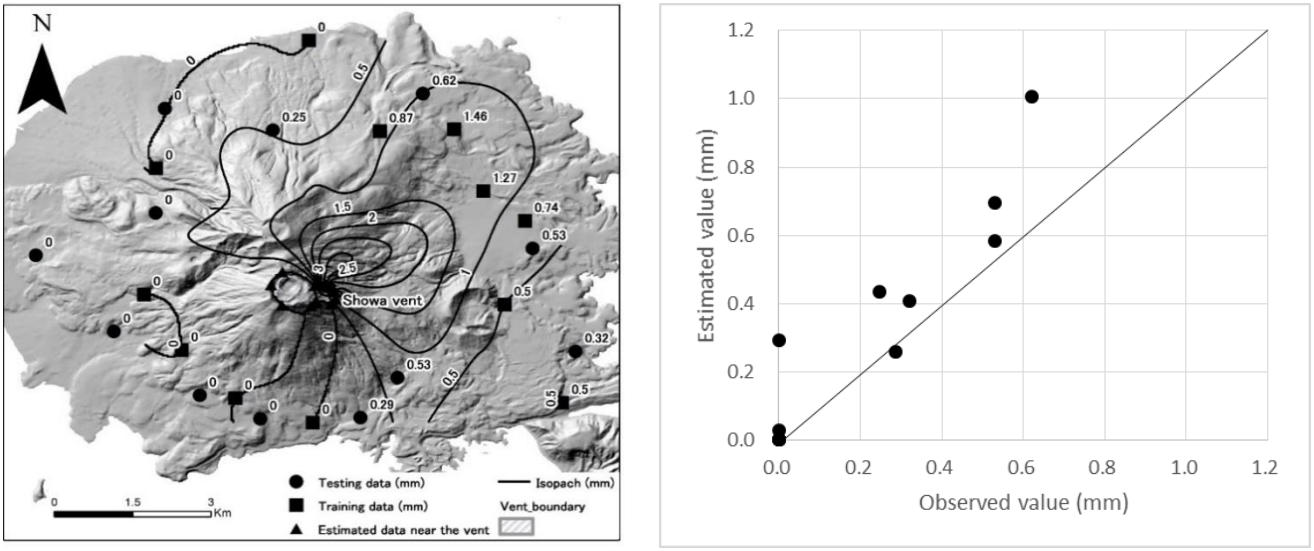

Figure 2 a) tephra fall deposit maps in Sakurajima Island by interpolation model using 50% of total data; b) validation.

CONCLUSIONS

In this study, the isopach map was objectively produced based on the multi-observation data combined with estimated source volcanic vent data by the data-driven interpolation model through the GIS platform. In the future work, we will investigate the method to estimate ash thickness nearby the source volcanic vent.

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