Development of volcanic ash product for the next-generation Japanese Geostationary Meteorological Satellite Himawari-8

Hiroaki Tsuchiyama¹, Yukio Kurihara¹, Kazuhiko Masuda²
(1) Japan Meteorological Agency / Meteorological Satellite Center
(2) Japan Meteorological Agency / Meteorological Research Institute

Abstract
The Japan Meteorological Agency / the Meteorological Satellite Center (JMA/MSC) developed software for the volcanic ash product in collaboration with EUMETSAT. JMA/MSC has introduced volcanic ash retrieval algorithm and related software developed by EUMETSAT. The agency also examined the computation of atmospheric optical depth, effective particle radius and mass loading using MTSAT-1R imagery in the case of a significant eruption of Shinmoe-dake in January 2011. The preliminary results indicate that these parameters are computed appropriately over the volcanic ash area. Algorithm development is currently on-going at JMA/MSC to produce volcanic ash product, using MTSAT-2 data as input.

JMA is also planning to introduce another volcanic ash algorithm in collaboration with the National Ocean and Atmosphere Administration / the National Environmental Satellite, Data, and Information Service (NOAA/NESDIS) in the United State.

Introduction
Eyjafjallajökull eruption in Iceland caused serious damage to European air traffic control in 2011. Taking this opportunity, the development of volcanic ash product has drawn worldwide attention.

In terms of the Japan Meteorological Agency (JMA), Tokyo Volcanic Ash Advisory Center (JMA/Tokyo VAAC) issues the Volcanic Ash Advisory for aviation users, and the importance of the development of volcanic ash product has been increased in its operations. In response to this background, JMA/MSC has started a development of volcanic ash product. As a first step, we developed the prototype software for volcanic ash product for MTSAT series data.

Algorithm
We have developed the prototype software using a Look Up Table (LUT) provided from EUMETSAT [1]. Figure 1 shows the schematic diagram of the algorithm of this software. The algorithm is roughly classified into two parts of “Volcanic Ash Detection” and...
“Retrieval Processing of physical quantities”.
Bayesian method and grouping technique are used for volcanic ash cloud detection. Brightness Temperature of 10.8μm, 10.8μm minus 12.0μm Brightness Temperature Difference, Surface Temperature and ratio of reflectance in 0.68μm and reflectance in 3.7μm (RAT [2]) are main input data for the ash cloud detection processing. Pixels that have a robust ash probability are extracted as cloud objects using these methodologies. (This algorithm is similar to Pavolonis’ algorithm [3] and Mackie’s [4].)
The retrieval processing is performed at the ash cloud object pixels. The LUT is used for the retrieval processing. Brightness Temperature of 10.8μm, 12μm and Surface Temperature are main input data for this LUT. Brightness Temperature of 10.8μm and 6.8μm are used for calculation of cloud top temperature. Retrieved physical quantities are optical depth, effective particle radius and mass-loading. Also, the volcanic ash cloud height is derived from the cloud top temperature.

Result of the processing
Figure 2 shows the results of the case of Shinmoe-dake volcano that erupted in 2011. The red-color signal in the RGB composite image corresponds to ash cloud. Retrieved physical quantities, such as mass-loading, volcanic ash cloud top height, and effective
particle radius are also shown in Figure 2. Volcanic ash cloud is detected well and false alarms are almost all removed. Thus, the ash cloud detection process worked well in this software. However, the stripe pattern can be seen in the ash cloud area. It seems to be caused by the transmission of the radiance that was emitted from low layer meteorological cloud. It is understood that the retrieval process may not work well in the case of multilayer cloud structure.

Figure 2. Results of processing for Shinmoe-dake eruption, showing RGB composite image (top left), mass-loading (top right), volcanic ash cloud top height (bottom left), effective particle radius (bottom right).

Validation
A validation of the retrieved ash cloud height was performed. It can be seen that the volcanic ash height distribution from the software is roughly estimated as around 3,000m in Figure 3 (top). On the other hand, back scattering signal from CALIPSO indicated by downward arrow in Figure 3 (bottom) may correspond to the ash cloud. The ash cloud height from CALIPSO is also around 3,000m. These two results agreed with each other in this case. However, detailed validations are needed with more cases of volcanic ash.
Further Improvement
We have been also developing the volcanic ash cloud tracking algorithm. It is expected that the trace of ash cloud spread will be improved by this algorithm.

Figure 3. Ash cloud top height distribution (top), CALIPSO back scattering signal (bottom) (Cloud Aerosol Lider and Infrared Pathfinder Satellite Observations. http://www-calipso.larc.nasa.gov/)

Conclusions
JMA/MSC developed the software for volcanic ash product and has been tuning its algorithm. However, it is necessary to validate the physical quantities in detail for more cases of eruptions. The agency also plans to introduce the variational method-based volcanic ash retrieval algorithm developed by NOAA/NESDIS.
Acknowledgement
We had a collaboration with EUMETSAT \cite{5}\cite{6} and NOAA/NESDIS \cite{1}. We would like to take advantage of this opportunity to thank you all for their cooperation.

References
\cite{1} Fred Prata: Volcanic Information Derived from Satellite Data. Climate and Atmosphere Department. Norwegian Institute for Air Research, 2011.


\cite{3} Michael Pavolonis, Jastin Sieglaff: Development of a System for Quantitatively Monitoring Volcanic Clouds. Presentation at JMA/MSC, 2013.


\cite{5} Peter Francis, Roger Saunders, Sarah Millington, Michael Cooke: Satellite monitoring of volcanic emissions at the Met Office London VAAC. Presentation at JMA/MSC, 2013

\cite{6} Hans-Joachim Lutz: METEOSAT Volcanic Ash Products derived at EUMETSAT. Presentation at JMA/MSC, 2013