Volcanic Ash Detection through COMS satellite

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INTRODUCTION

This study analyzes **volcanic ash (VA) products** derived from Communication, Ocean, and Meteorological Satellite (COMS) meteorological **data based on two algorithms of EUMETSAT and KMA/NMSC**. Hybrid method used in the algorithm of KMA/NMSC was developed based on brightness temperature difference (BTD) which uses split window channels (10.8 and 12.0 ㎛) combined with three band volcanic ash product (TVAP) method which adds shortwave infrared channel (3.9 ㎛), was just used in the comparison with EUMESAT algorithm in this study. EUMETSAT method of volcanic ash detection is based on BTD with water vapor correction. It can produce a detection area, aerosol optical depth, effective radius, mass loading and height of volcanic ash. To verify this algorithm, **two volcanic cases, Shinmoedake and Sakurajima Mt. Eruptions** were chosen which were occurred on 26 January 2011 and 18 August 2013. The results were validated with COMS/GOCI and MODIS data.

VOLCANIC ASH DETECTION

Data

- ✓ COMS Level-1B Brightness Temperature of 10.8 μm ($BT_{10.8\mu m}$)
- ✓ Brightness Temperature Difference (BTD) → $BT_{10.8\mu m}$ - $BT_{12.0\mu m}$, WVC
- ✓ Clear-Sky Surface Temperature (Ts) → The maximum value of $BT_{10.8\mu m}$ (15-day)
- ✓ Cloud Top Temperature (Tc) → CMDPS Level-2 CTTP product
- ✓ Satellite Zenith Angle (θ)

> ➢ **CMDPS:** COMS Meteorological Data Processing System
> ➢ **CTTP:** Cloud Top Temperature and Pressure
> ➢ **WVC:** Water vapor correction

Case Study

- ✓ Case 1) Mt. Shinmoedake (31.9 N, 130.9 E) in Japan
  : 26 January 2011, 07:30 KST (25 January 22:30 UTC)
- ✓ Case 2) Mt. Sakurajima (31.6 N, 130.7 E) in Japan
  : 18 August 2013, 16:31 KST (07:31 UTC)

Water vapor correction

- ✓ One of the main problems is the difficulty of identifying VA in clouds because VA exist as a form of mixture with water molecules or ice particles inside clouds.
- ✓ An empirical relation between the precipitable water in an atmospheric column and the brightness temperature difference is used to estimate the water vapor effect

$$\Delta T_{wv} = \exp(6T_* - b)$$

$T_* = T_1/T_{max}$, $T_{max} = 320\ K$

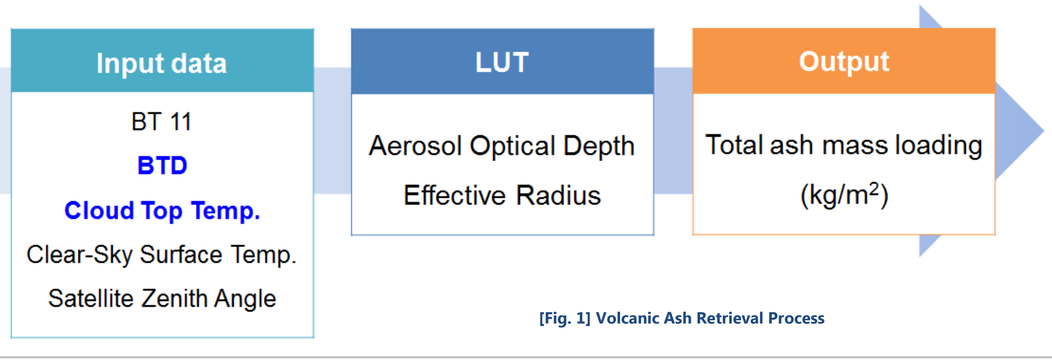
Mass loading calculation

- ✓ In order to estimate the mass concentration, the thickness of volcanic ash cloud is need.
- ✓ However, VA plume thickness and height cannot be estimated to better accuracy, because they are variously changed depending on moving VA clouds.
- ✓ Instead of using the thickness of VA cloud, the mass loading (M_l) is estimated.

$$M_l = \frac{4}{3}\rho\frac{r\tau}{Q_{ext}}$$

τ : Optical Depth Qext : Extinction efficiency
ρ : Density(kg m^{-3}) r : Effective Radius(μm)

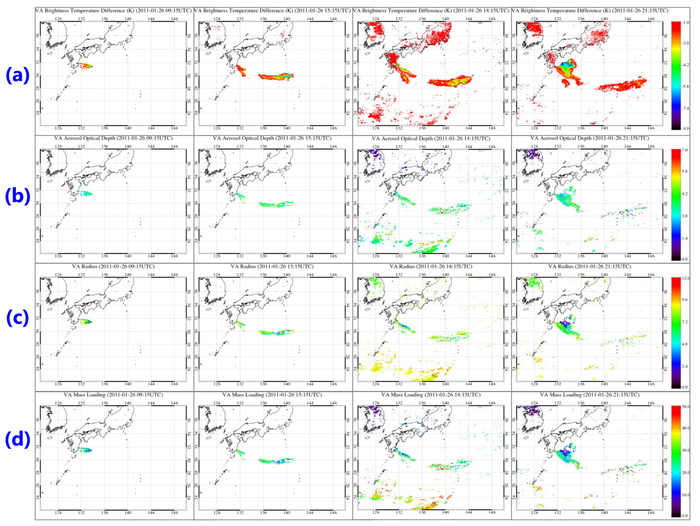
- ✓ The density(ρ) of the ash is taken to be 2,600 kg/m^3. and Aerosol optical depth (τ, AOD) and Effective radius (r, R_{eff}) are determined through the Look-up table (LUT) of EUMETSAT.



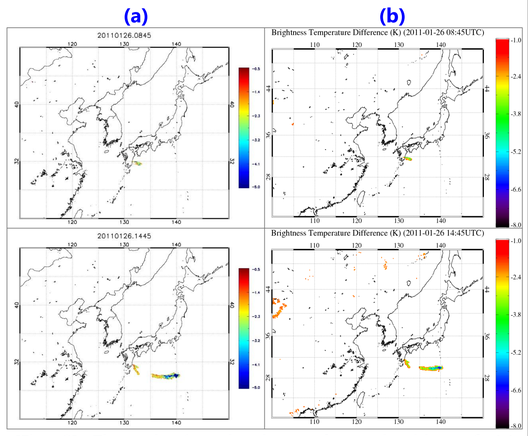
[Fig. 1] Volcanic Ash Retrieval Process

RESULTS

Case 1 : Mt. Shinmoedake



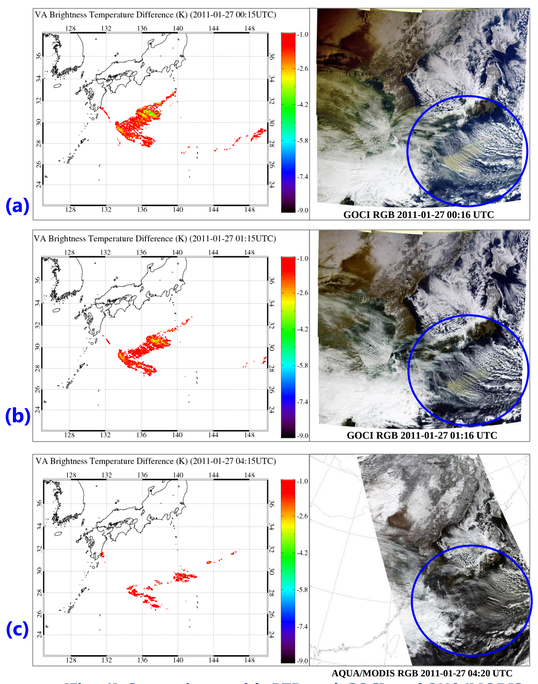
[Fig. 2] Results for (a) BTD, (b) AOD, (c) effective Radius (R_{eff}), and (d) Mass loading (M_l) at 09:15, 15:15, 18:15, and 21:15 UTC on 26 January 2011



[Fig. 3] The volcanic ash plumes from algorithm of (a) KMA/NMSC(Hybrid algorithm) and (b) EUMETSAT at 08:45 and 14:45 UTC on 26 January 2011

- ✓ VA products such as BTD, AOD, effective radius and mass loading(M_l) were retrieved by EUMETSAT algorithm and COMS data.
- ✓ When VA plume images of this algorithm are compared with Hybrid algorithm's, it produced more noise, but the detection areas of VA plume from both algorithms were in good agreement each other.
- ✓ BTD(00:15, 01:15, 04:15 UTC) images were validated with COMS/GOCI(00:16, 01:16 UTC) and AQUA/MODIS(04:20 UTC) RGB composite images on 27 January 2011, and the validation results showed the detection of VA plume was well.

> ➢ **GOCI:** Geostationary Ocean Color and Imager
> ➢ **RGB:** Red, Green, and Blue

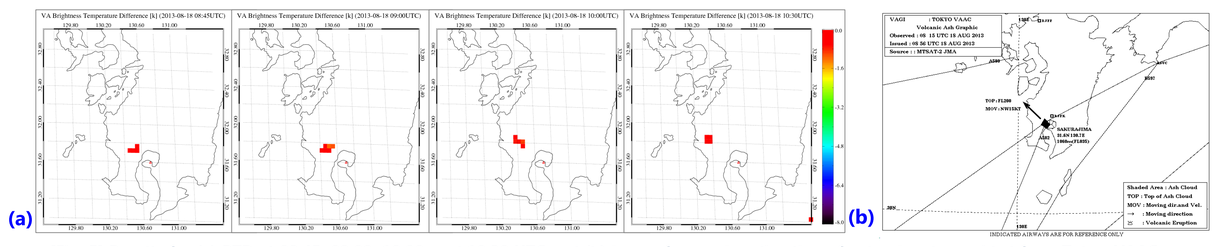


[Fig. 4] Comparisons with BTD and GOCI or AQUA/MODIS RGB images

Case 2 : Mt. Sakurajima

- ✓ The VA plume of Mt. Sakurajima eruption cannot be detected well, because it has low height and weak signals.
- ✓ Results for BTD and image for moving direction of VA provided from Tokyo VAAC showed VA plume moved toward northwest.

> ➢ **VAAC:** Volcanic Ash Advisory Center



[Fig. 5] Results for (a) BTD at 08:45, 09:00, 10:00, and 10:30 UTC and (b) image for moving direction of volcanic ash provided from Tokyo VAAC on 18 August, 2013

Summary & Future Plan

- The volcanic ash products for two cases were retreived using COMS IR data and EUMETSAT volcanic ash algorithm, and results showed VA plume is detected well.
- This study performed the qualitative validation for VA products because of the limited reference data.
- In order to generate more accurate VA products, we will continuously gather VA cases and verify quantitatively with other algorithm products.
- We will also continuously cooperate with EUMETSAT and other institutes to optimize VA algorithm.
- KMA will launch the 2nd geostationary meteorological satellite (Geo-KOMPSAT-2A) boarding AMI in 2017. So, KMA will develop meteorological data processing system which includes volcanic ash products for it.

> ➢ **AMI:** Advanced Meteorological Imager