QVA verification with ash retrieval on Sheveluch 2023

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Abstract: For the Sheveluch eruption on April 2023, QVA, ash retrieval by satellite (OVAA), and forecaster observations were compared. The area sizes are in the order of forecast > observation > retrieval. The mass loading of QVA and retrieval have the same order of magnitude with the appropriate parameter settings. It should be noted that the order itself can change significantly depending on the setting of the particle size distribution. There are also many issues to consider in the validation method and satellite analysis.

Sheveluch eruption on April 2023

At 1310 UTC on 10th April 2023, the Sheveluch volcano in the Kamchatka Peninsula erupted. Tokyo VAAC detected the plume by Himawari-9 and issued the first advisory at 1349 UTC with the estimated cloud height of FL520. The volcanic ash cloud then spread so widely that eventually four VAACs issued advisories (Fig.1a). Air traffic was severely disrupted(Fig.1b).

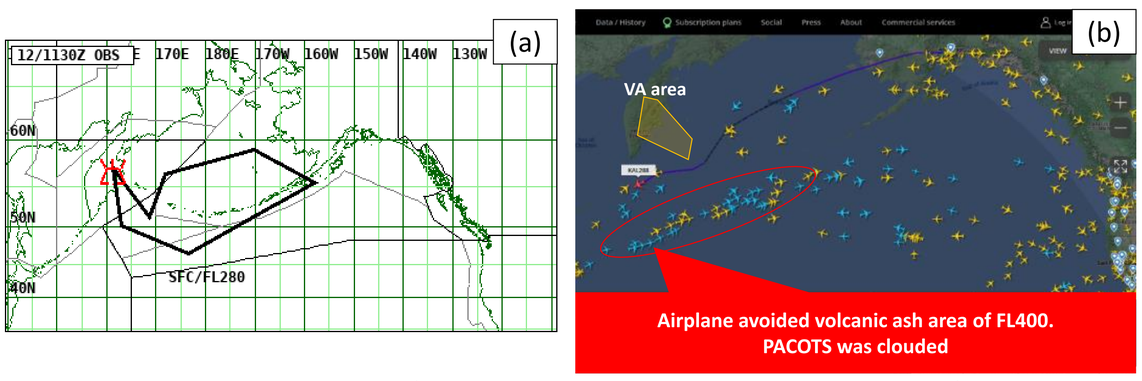

Figure 1. (a) VAG(OBS) at 1200UTC, 12th April 2023. (b)Airplane flight radar at 1200UTC,11th April 2023
Flightrader24, https://www.flightradar24.com/

In this presentation, we compare reproduced QVA, volcanic ash retrieval and forecaster observation, at about 7 hours after the eruption.

According to our posterior analysis, the ash cloud height we provided on advisories was overestimated. In this presentation, QVA is calculated with cloud height of FL330, which was considered to be more accurate.

Observation / Forecast / Retrieval

The observed polygon made by forecaster (Fig.2d), the ash retrieval by Optimal Volcanic Ash Algorithm (OVAA, Ishimoto et al. 2022), and the reproduced QVA forecast are compared (Fig.2a,b). Although the observed polygon may contain errors, it could represent a “true value”.

The locations of these three areas are roughly consistent. The area sizes are in the order of **forecast** > **observation** > **retrieval**. In general, forecast tends to be larger than observation because exact decrease of eruption rate is not described. Retrieval also tends to be underestimated because of the limitation of auto detection. The consistency of retrieval worsens over time, while that of forecast remains relatively stable (Fig.2c).

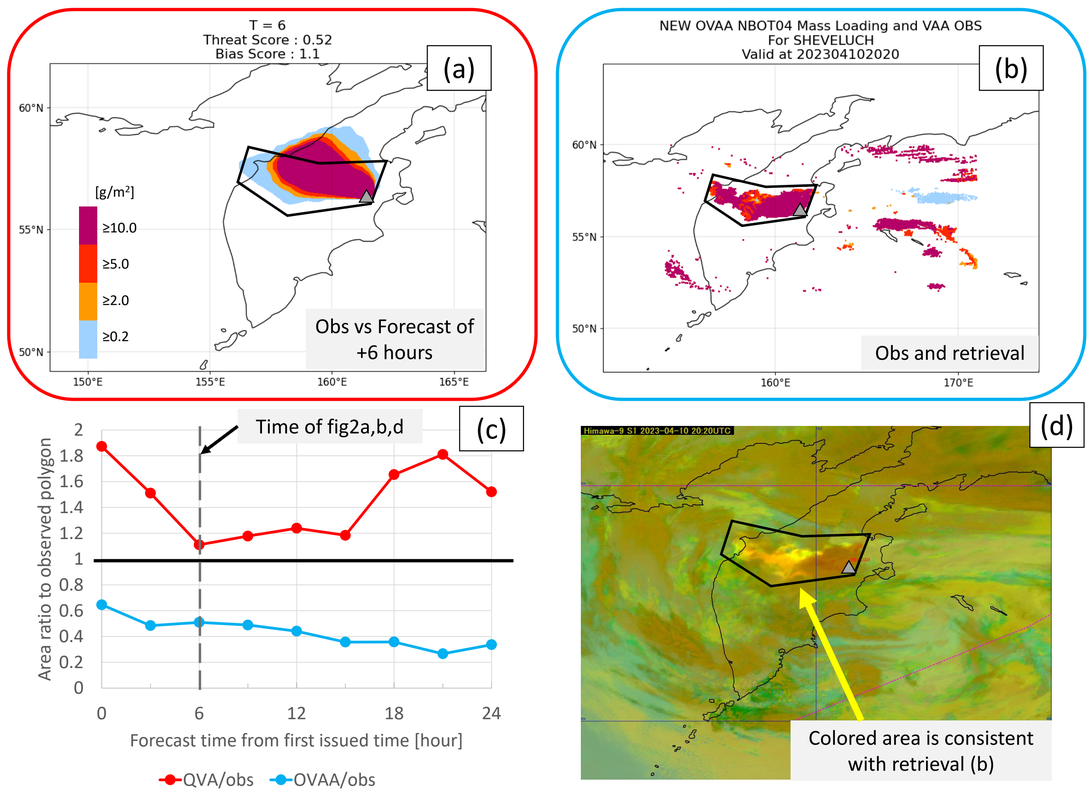

Figure 2. (a) QVA (colour) and observed polygon drawn by forecaster (thick black line). (b) OVAA retrieval and observed polygon. There are some noises outside of polygon. (c) Time evolution of area ratio of QVA or OVAA to observed polygon from first VAA issued time until T+24 . (d) Ash RGB imagery and observed polygon at 2100UTC, 10th April 2023.

Mass loading comparison

The retrieval of ash mass loading analyzed by OVAA is compared to QVA. The concentration of QVA is converted into mass loading with only fine particles (< 15 μm / 6Φ) which are dominant in this retrieval.

The ranges of mass loading values has the same order of magnitude (Fig.3a,b). The decrease of mass loading with time is seen in both QVA and OVAA retrieval. OVAA only detects ash grids above a certain mass loading, whereas QVA can describe even grids with very low concentration. Therefore, QVA has a smaller median mass loading value.

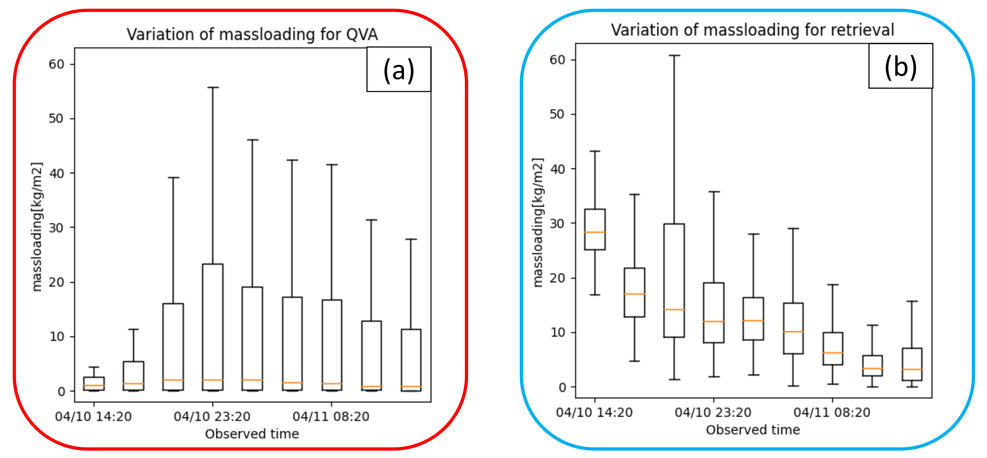

Figure 3. Box plot of mass loadings in all grid with time; (a) in QVA, (b) in OVAA retrieval. Orange bar shows the median of mass loadings.

Contribution of particle size

The physical model for QVA calculations make assumptions about the particle size distribution. The current setting has large number of coarse particles.

Experimentally, we increased the fraction of fine particles. As a result, it can increase the max mass loading value by a factor of 10-20 (Fig.4). This is because fine particles tend to remain in the atmosphere.

From a view point of volcanology, it is unrealistic to reduce the fine particles further than the current setting. At least in this case, it is considered to be appropriate.

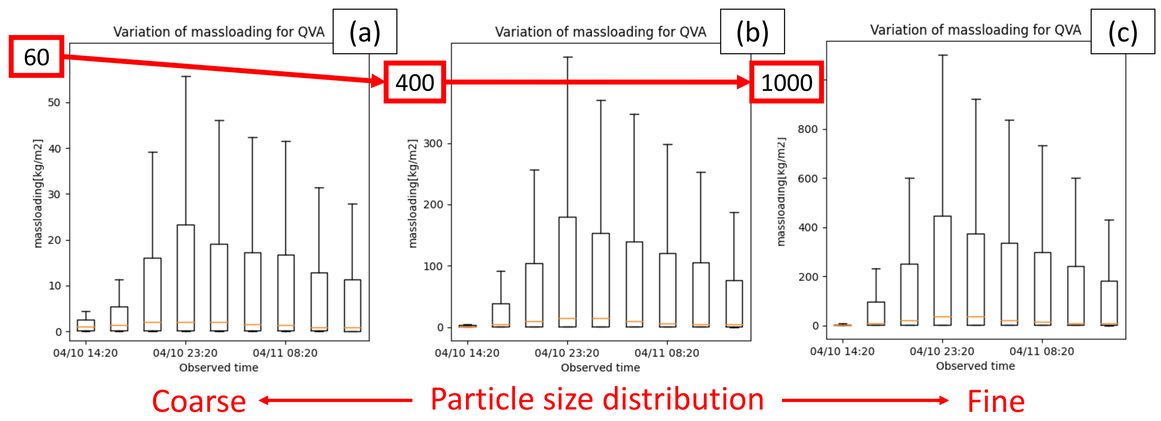

Figure 4. Box plot of mass loadings in QVA with time, changing particle size distribution; (a) coarse (current setting), (b) intermediate, (c) fine. Orange bar shows the median of mass loadings.

Conclusion

The order of the mass loading values for QVA and OVAA retrieval could be consistent with appropriate model parameter. However, this verification could have many other uncertainties such as settings and limitation of ash retrieval. While this case study has been successful in auto retrieval, we have also found patterns where it does not go well. It should also be noted this verification is just for the mass loading, not for the concentration itself.