METEOROLOGY PANEL

Quantitative Volcanic Ash Concentration Information

Updated 30 March 2026

1 Introduction

This document describes the quantitative volcanic ash concentration information (QVA) service that is to be provided by Volcanic Ash Advisory Centres (VAACs) in support of the International Civil Aviation Organization's (ICAO) International Airways Volcano Watch (IAVW). This flyer is intended to give an overview of QVA for all users of this service and provide information that may be of interest to stakeholders such as regulators and State volcano observatories (SVO).

QVA offers operators the opportunity to move away from traditional discernible/visible ash criteria and instead use engine susceptibility information for flight route planning and in-flight replanning. Visible ash is what an observer or flight crew member sees with their eyes. The lower limit of visible ash ranges from approximately 0.01 mg/m^3 to 10 mg/m^3, depending on many factors such as time of day, sky background, position of the sun to the observer (pilot), as well as the angle at which the ash cloud is viewed (e.g., viewed from the side). Discernible ash is what a satellite or other remote sensing instrument detects. Discernible ash from satellites has been used by the VAACs to define the observed area in both the text-based volcanic ash advisories (VAA) and the volcanic ash graphic (VAG) since the late 1990s. The lower limit of discernible ash from satellites is approximately 0.1 mg/m^3 to 0.2 mg/m^3, depending on the satellite and other factors.

QVA provides users with forecast volcanic ash information at a higher spatial and temporal resolution than that which the traditional advisories and graphics offer. The traditional products are limited to a small number of vertices, with 6-hour resolution, sometimes leading to polygons of volcanic ash that overestimate the area of contaminated airspace. With QVA providing more detailed forecasts of the expected location of volcanic ash, this will support more efficient flight planning.

The traditional approach to weather forecasting is known as deterministic, with only one forecast outcome. While this can provide good advice, the addition of probabilistic QVA data sets, provided by combining information from multiple forecast scenarios, will provide users with a fuller understanding of the possible range of outcomes or indicate the risk of encountering specific phenomena.

2 QVA Data and Access

2.1 Data Sets

QVA forecasts are made up of three data sets:

- Gridded deterministic volcanic ash concentration information – these provide a **specific** forecast ash concentration value for each model grid point.
- Gridded probabilistic volcanic ash concentration information – which indicates the likelihood of the ash concentration **exceeding** four thresholds: 0.2 mg/m^3, 2.0 mg/m^3, 5 mg/m^3, and 10 mg/m^3 for each model grid point.
- Ash objects (polygons) in which the gridded deterministic forecast is turned into simple polygons by the VAACs for the very high, high, medium and low quantitative volcanic ash concentration ranges (as applicable) given in table 1. Each polygon will have attributes that indicate the vertical extent of that polygon (i.e., base and top). Examples are given in figures 1 to 7 (inclusive).

The gridded deterministic and probabilistic data sets will be provided in NetCDF format, and the ash objects will be provided in the ICAO Meteorological Information Exchange Model (IWXXM format).

While the gridded deterministic forecast will provide a specific expected ash concentration value (in mg/m^3) for each model grid point, these values could be assigned the categories as described in table 1. These ranges were formulated by

ICAO's Meteorology Panel in coordination with the International Coordinating Council of Aerospace Industries Associations (ICCAIA).

Table 1: Thresholds and ranges

Descriptor	*Concentration thresholds and ranges*
Very high	≥ 10 mg/m^3
High	≥ 5 and < 10 mg/m^3
Medium	≥ 2 and < 5 mg/m^3
Low	≥ 0.2 and < 2 mg/m^3
Very Low	<0.2 mg/m^3

2.2 Resolution

The gridded deterministic and probabilistic QVA data will initially have the following minimal horizontal, vertical, and temporal resolutions.

- Gridded QVA will be produced with a horizontal resolution of 0.25 degrees latitude and longitude.
- The vertical resolution of the gridded data will be in 5,000-foot flight levels (FL) from mean sea level to FL 600 (table 2).

Table 2: Vertical resolution

Mean sea level to FL 050	FL 150 to FL 200	FL 300 to FL 350	FL 450 to FL 500
FL 050 to FL 100	FL 200 to FL 250	FL 350 to FL 400	FL 500 to FL 550
FL 100 to FL 150	FL 250 to FL 300	FL 400 to FL 450	FL 550 to FL 600

The QVA objects, generated from the gridded deterministic data set, will be provided between mean sea level and FL600, as appropriate, in increments of 5000 feet.

QVA will be provided in the following three hourly valid time increments: 0, 3, 6, 9, 12, 15, 18, 21, and 24 hours. QVA will be updated as necessary, but at least every six hours until the volcanic ash cloud is no longer considered a hazard.

It is expected that the VAACs, taking full advantage of the evolving science and technology, will make available forecasts of QVA with enhanced spatial and/or temporal resolution over time. Incremental improvements are expected to be made to the QVA service with each new amendment to ICAO Annex 3 and/or as described in the *Handbook on the International Airways Volcano Watch* (Doc 9766).

2.3 Significant volcanic ash clouds

QVA will initially only be issued for significant volcanic ash clouds. Significant in this context means an ash cloud that poses a widespread impact to aircraft operations and air navigation. This is based on considerations[1] by the responsible VAAC of known or expected volcanic ash 'cloud'[2] spatial extent and persistence in the proximity of aerodromes and international airways.

There may be circumstances in which VAACs do not issue QVA. For example, if modelling is unable to reproduce the observed motion of volcanic ash, a VAAC may decide that the QVA is not reliable enough to publish. It should be noted that traditional VAAs and VAGs will continue to be issued, both when QVA is available and also in situations where QVA is not provided or is ended because an event is no longer considered significant.

[1] Informed by discussions and pre-agreement with relevant aviation users and, to ensure a consistency of approach, the other VAACs.

[2] Based on satellite-derived mass-loading detection threshold of 0.2 g m^{-2} which, although not directly comparable to ash concentration, provides a recognized quantitative constraint (lower threshold) for satellite-based remotely sensed discernible ash.

2.4 Accessing QVA information

QVA forecasts will be provided by each VAAC via their own Application Programming Interface (API). These APIs should adhere to the Open Geospatial Consortium Environmental Data Retrieval (OGC-EDR) API framework where possible and deliver data in accordance with ICAO System Wide Information Management (SWIM) requirements.

Each service will be listed in a SWIM registry which will provide technical information on the service as well as registration information.

While QVA is intended to be displayed by users in their own visualisation software or analysed for advanced use, VAACs plan to provide a limited set of supplementary charts via their websites to aid users in ensuring they are correctly visualising the data.

3 QVA Provision

3.1 Implementation of QVA

ICAO Annex 3 states that VAACs (who are in a position to do so) should provide QVA for significant volcanic ash clouds. As of 27 November 2025, VAAC London and VAAC Toulouse have made their QVA services operational. All other VAACs should provide QVA for significant volcanic ash clouds from 26 November 2026. VAACs who are providing QVA will be listed in ICAO Doc 9766, along with details regarding how to access the information. Provision of QVA for significant volcanic ash clouds is expected to become a Standard for all VAACs in Annex 3 beginning late 2030.

While QVA will initially only be provided for significant volcanic ash clouds, it is expected to eventually apply to all airborne volcanic ash (including resuspended ash).

3.2 VAAC coordination

As volcanic ash moves from the area of responsibility (AoR) of one VAAC to that of another, coordination between the affected VAACs will take place to ensure the continuity and consistency of QVA issuance. In some cases, a VAAC may continue to issue QVA after the volcanic ash moves into another VAAC's AoR. Coordination will also take place when backup operations are required.

3.3 State Volcano Observatory support for QVA

SVOs provide VAACs with information that supports accurate forecasts of airborne volcanic ash. By communicating ranges in their observations, such as in the volcanic ash cloud height estimate, the VAACs can incorporate this uncertainty when producing probabilistic QVA forecasts.

With the elevation of the volcano observatory notice for aviation (VONA) as a Recommended Practice for SVOs to use for communicating volcanic activity information, the VAACs will have more specific information on eruption details, including ash height, eruption style, and the start and end times of the eruption, which will be used within the dispersion modelling systems. The more accurate information from the SVOs will help VAACs provide more accurate QVA.

3.4 Verification of QVA

Where quantitative observations of volcanic ash are available, such information can be used to verify QVA forecasts. This will help VAACs and users to evaluate the accuracy of QVA for current and past events and improve forecasts in the future. The ability to do such verification is tied to improvements in detection of volcanic ash as well as modelling advances. Pilot reports have historically been helpful for knowing where volcanic ash is observed. This is expected to continue to be the case with QVA, even if only in a qualitative manner.

The use of automated detection of volcanic ash clouds and the satellite retrieval information (where available) will be key to verification of volcanic ash events in real time and for past events. The satellite retrieval information will help with inputs into the VAACs dispersion modelling systems, which will provide continual opportunities to improve dispersion modelling output for QVA.

To assist in the verification of QVA, efforts are underway to update the Model Volcanic Activity Report found in Procedures for Air Navigation Services-Air Traffic Management (PANS-ATM, ICAO Doc. 4444) to allow for improved reporting on both expected and unexpected volcanic ash encounters.

4 Using QVA data

4.1 Visualisation of QVA forecasts

QVA data sets are not intended to be 'human readable' like legacy volcanic ash advisories. Users will need to procure or develop software to visualise the gridded and/or IWXXM QVA data sets.

Examples of gridded deterministic QVA data visualisation are given in figures 8 and 9. The data can be displayed using the severity categories given in table 1, or as the actual forecast ash concentration value. It may also be possible to create a horizontal section through the deterministic data to determine how the height and concentration of ash vary along a specified path.

Examples of gridded probabilistic QVA data visualisation are given in figures 10 to 13, for each of the exceedance thresholds.

QVA objects are designed to provide users with a basic format to view ash concentration levels and may be considered to be an enhanced version of the traditional volcanic ash advisory. Data is provided which shows where the ash is expected to exceed four different threshold concentrations described in table 1, which can be overlaid on top of each other to create a plot like the one shown in figure 7.

4.2 Operational use of QVA forecasts

QVA will likely have its greatest utility with ash cloud events that have a widely dispersed ash cloud with mostly lower values of ash concentration. Operators with appropriate regulatory approval will be able to use QVA to fly more efficient routes in accordance with their safety management program[3].

Probabilistic QVA is intended to further assist the operator's flight planning and decision support systems, allowing greater confidence in decisions being made when flying through volcanic ash clouds. By looking at the probabilities of reaching certain concentrations of volcanic ash, users can get a sense of how confident to be with respect to the deterministic forecasts of volcanic ash. A high (low) likelihood of attaining a certain concentration tells users that they can be more (less) confident in a deterministic forecast indicating that same concentration. Even if aircraft continue to avoid volcanic ash, QVA may give an operator the ability to reduce buffer zones around volcanic ash-contaminated airspace, if probabilistic information supports it.

There will not always be a perfect match between QVA data and traditional VAA/VAG products. Traditional products are generally created by a VAAC forecaster based on multiple information sources and therefore are likely to have some differences from the equivalent QVA due to the method of generation. The information provided by QVA will augment the VAA/VAG but should not be considered as the same data. The RMK section of the VAA may be used to comment on QVA availability and/or quality.

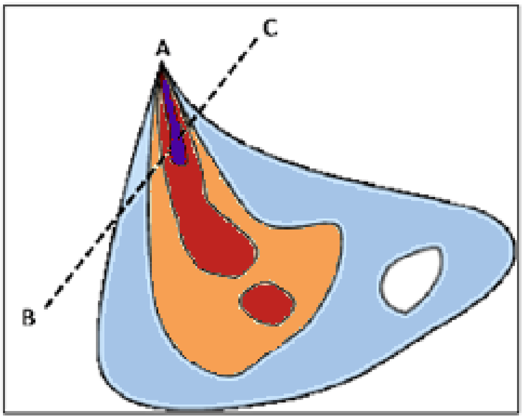
5 Further information

More information is available in Doc 9766 and in an upcoming amendment to the *Manual on Volcanic Ash, Radioactive Material and Toxic Chemical Clouds* (Doc 9691).

[3] Operators are encouraged to consult with their airplane and engine manufacturer flight and maintenance manuals for guidance regarding avoidance, mitigations, or maintenance when operating in or near volcanic ash.

Visual illustrations of QVA IWXXM objects

Colour legend: White = <0.2mg/m³, Blue = ≥ 0.2mg/m³, Orange = ≥ 2mg/m³, Red = ≥ 5mg/m³, Purple = ≥ 10mg/m³. Note that colours were chosen based on contrast and do not infer any visualization guidelines.



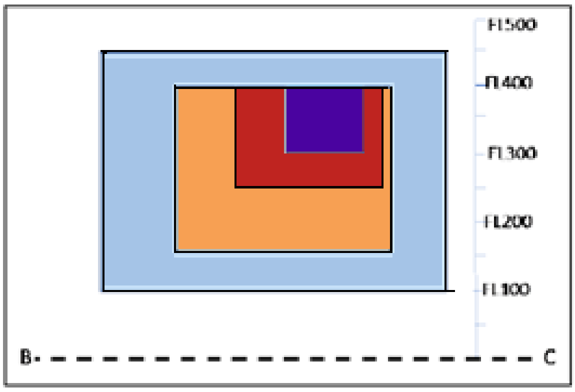
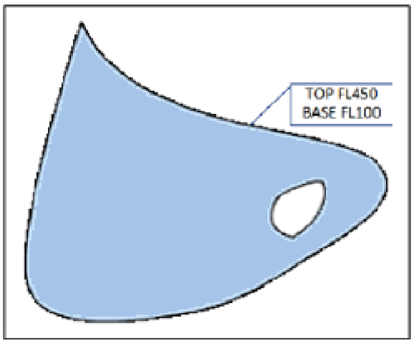
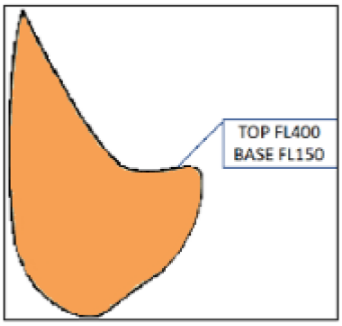
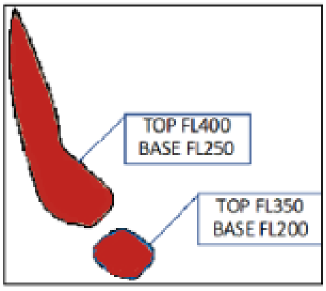


***Figure 1 (left)**. IWXXM objects showing all QVA thresholds depicted in the horizontal from a fictitious volcano located at A. The vertical depiction along line B-C is shown in **Figure 2 (right)**.*







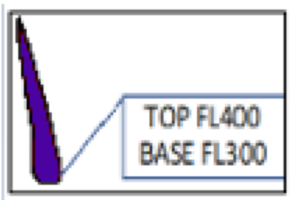


Figure 3. ***Figure 4.*** ***Figure 5.*** ***Figure 6.***

Figures 3 through 6 depict the individual IWXXM objects from Figure 1. Figure 3 is IWXXM object ≥ 0.2mg/m³ (the "hole" is ash <0.2mg/m³). Figure 4 is IWXXM object ≥ 2mg/m³. Figure 5 is IWXXM object ≥ 5mg/m³. Figure 6 is IWXXM object ≥ 10mg/m³.

Visual illustration of QVA IWXXM objects and volcanic ash advisory in graphic form (VAG)

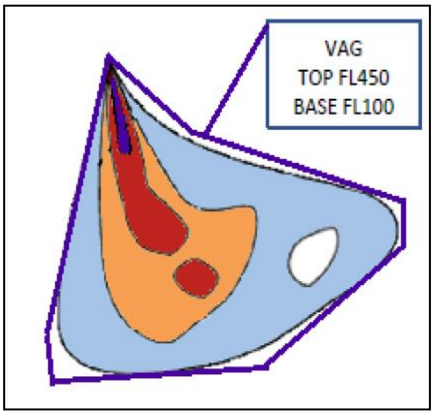
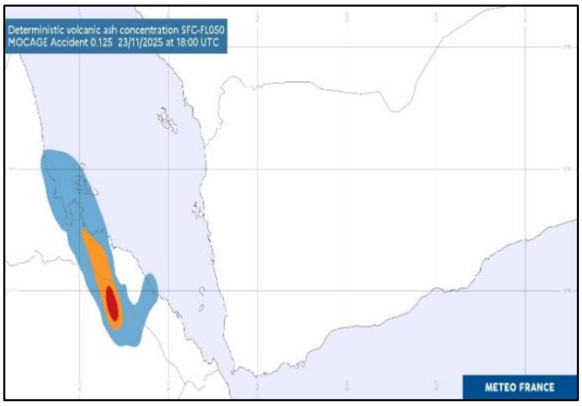


***Figure 7**. Same as Figure 1 but overlayed with the VAG (purple polygon).*

Example of deterministic QVA

Provided by VAAC Toulouse from the response to the eruption of Hayli Gubbi in November 2025



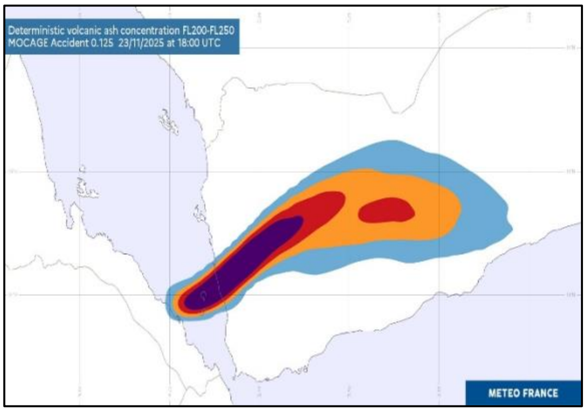


Figure 8 *Forecast of volcanic ash concentration Valid 1800 UTC 23 Nov 2025 for SFC-FL050*

Figure 9 *Forecast of volcanic ash concentration Valid 1800 UTC 23 Nov 2025 for FL200-250*

Example of gridded probabilistic data

Provided by VAAC Toulouse from its response to the eruption of Hayli Gubbi in November 2025

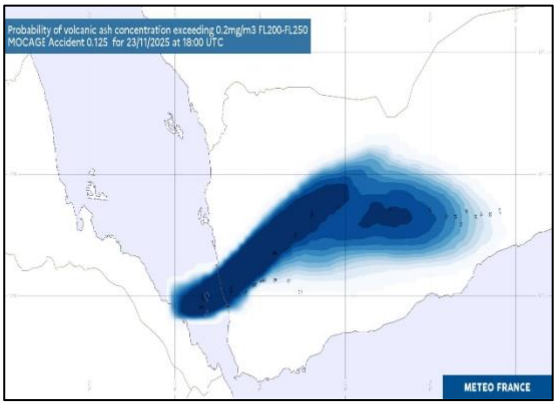


Figure 10 *Probability of volcanic ash concentration exceeding 0.2 mg/m^3 FL200-250*

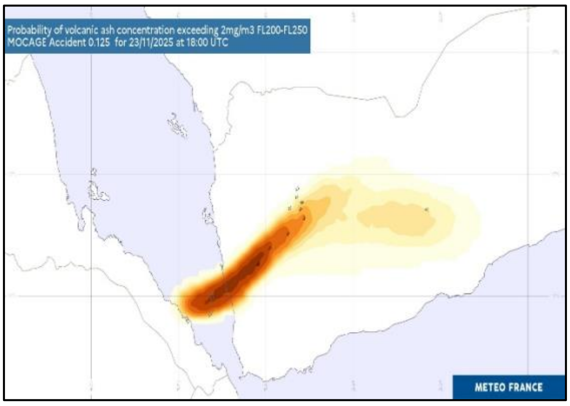


Figure 11 *Probability of volcanic concentration exceeding 2.0 mg/m^3 FL200-250*

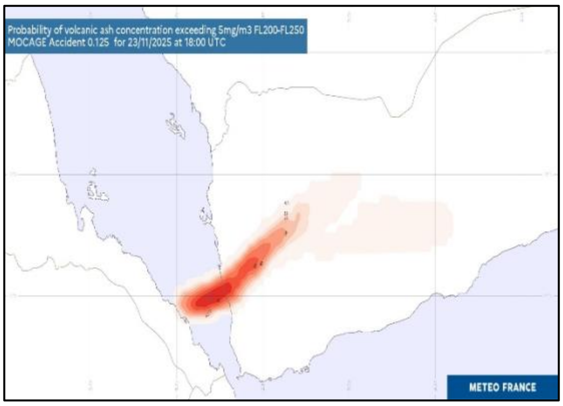


Figure 12 *Probability of volcanic ash concentration exceeding 5 mg/m^3 FL200-250*

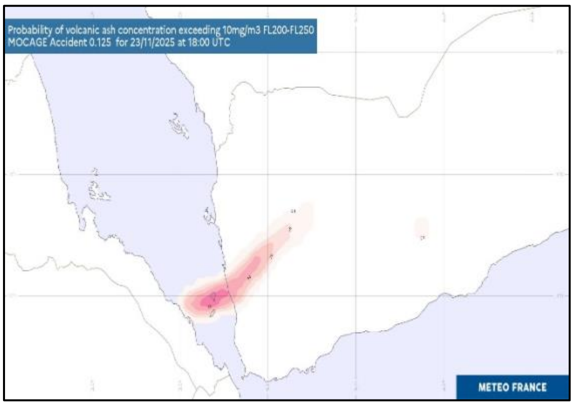


Figure 13 *Probability of volcanic ash concentration exceeding 10 mg/m^3 FL200-250*