METEOROLOGY PANEL

Quantitative Volcanic Ash (QVA) Concentration Information

First edition – 13 September 2022 (corrected 15 December 2022)

1 Introduction

This document describes the quantitative volcanic ash (QVA) concentration information (hereafter referred to as 'QVA information') that is planned to be provided by volcanic ash advisory centres (VAAC) as part of the International Civil Aviation Organization's (ICAO) International Airways Volcano Watch (IAVW). It is the first in a series of information "flyers" on QVA information.

Over the past two decades there were many requests by representatives of the IAVW, through various ICAO and World Meteorological Organization fora, for aircraft and engine manufacturers to provide information on the susceptibility of aircraft and their engines to volcanic ash. The specific desire was for ash concentration thresholds to be identified that did not pose a safety concern but could improve route efficiency. This need has led to the development of QVA information.

QVA information offers operators the opportunity to move away from traditional discernible/visible ash criteria and instead use certified engine susceptibility for flight route planning and inflight 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 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 the volcanic ash advisories (VAA) in both text and graphic form (VAG) over the past two decades. 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 information will begin with an initial operating capability (IOC) that is planned to be implemented in three phases in the mid-2020s.

2 Initial operating capability (IOC)

The IOC for QVA will provide forecasts of ash concentration in two data formats for significant eruptions.

2.1 Format

QVA information will be provided in two file formats. Objects will be provided in ICAO's Meteorological Information Exchange Model (IWXXM) format. Gridded data will be provided in a file format which has yet to be determined but will probably be a binary format. The IWXXM format contains a subset of the entire gridded data file set.

2.2 Concentration thresholds and ranges

QVA information will consist of the thresholds and ranges shown in Table 1, which were formulated by ICAO's Meteorology Panel in coordination with ICCAIA[1]. The units for the ash concentration thresholds and ranges are in milligrams per cubic meter (mg/m^3).

Table 1: Thresholds and ranges

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

The QVA information in IWXXM form will be provided as 'objects' for the very high, high, medium, and low concentration ranges. An illustrated example of QVA objects is shown in Figures 1 – 6 on page 5. Figure 7 is an illustrated example of QVA objects compared to a VAG.

2.3 Resolution

During the IOC, QVA information will have the following horizontal, vertical, and temporal resolutions.

2.3.1 Horizontal resolution

Gridded QVA information will be produced with a horizontal resolution of 0.25 degrees latitude and longitude.

2.3.2 Vertical resolution

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 50	FL 150 to FL 200	FL 300 to FL 350	FL 450 to FL 500
FL 50 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

2.3.3 Temporal resolution

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

2.4 Significant volcanic ash clouds

During the IOC, QVA information will 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. The VAACs will use the following guidance criteria for issuing QVA information:

- an ash cloud with a vertical extent to at least FL 300, and/or

[1] International Coordinating Council of Aerospace Industries Associations.

- an ash cloud within (or expected to move within) approximately 100 nm of a commercial aerodrome, or
- when requested by area control centre (ACC) or airline operator.

At their discretion, VAACs may deviate from this guidance for special circumstances and quality control assessment of the event.

2.5 Probabilistic forecasts

The traditional approach to weather forecasting is known as deterministic, with only one forecast outcome. While this can provide good advice, deterministic forecasting may not provide users with a full understanding of the possible range of outcomes, or indicate the risk of encountering specific phenomena. Probabilistic information will be provided by combining information from multiple forecasts.

QVA information in gridded code format will include ensemble relative frequency of exceedance for volcanic ash concentration thresholds of 10, 5, 2 and 0.2 mg/m^3. This is simply the number of ensemble members with concentration above a threshold divided by the total number of members at each grid point. Figure 8 shows some examples of QVA information in gridded format for relative frequency of exceedance of ash concentration thresholds 2.0 and 0.2 mg/m^3.

QVA objects in IWXXM form will not include probabilistic information.

2.6 Implementation of QVA

In the IOC, QVA information is planned to be implemented in three phases in accordance with the provisions in ICAO's Annex 3 – *Meteorological Service for International Air Navigation*.

2.6.1 Phase 1 – planned for late 2024

In Phase 1, QVA information will be issued by those VAACs that have developed the capability to issue QVA information for significant volcanic ash clouds. These VAACs will continue to issue VAAs and VAGs for all ash clouds.

2.6.2 Phase 2 – planned for late 2025

Phase 2 is noted by a Recommended Practice in ICAO Annex 3 that all VAACs should issue QVA information for significant volcanic ash clouds. VAACs will continue to issue VAAs and VAGs for all ash clouds.

2.6.3 Phase 3 – planned for late 2026

It is expected with Amendment 82 to Annex 3 that QVA information will be a Standard for all VAACs for significant volcanic ash clouds. With QVA as a Standard, it is expected that the VAA and VAG will only be issued for those volcanic ash clouds that don't meet the criteria for a significant volcanic ash cloud.

3 Full operating capability (FOC)

Details for the FOC have yet to be determined. It is anticipated that QVA will be provided in finer vertical and temporal resolutions. Probability information may be added to the IWXXM objects.

With the FOC, it is anticipated that QVA information will be issued for all volcanic ash clouds (rather than for significant), which would lead to the retirement of the current versions of the VAAs and VAGs.

Implementation date of the FOC has yet to be determined but is not likely until the next decade.

4 Using QVA information

User education material is expected to be developed that will provide flight crew and other users with information on the subtleties, uses and limitations of the QVA information.

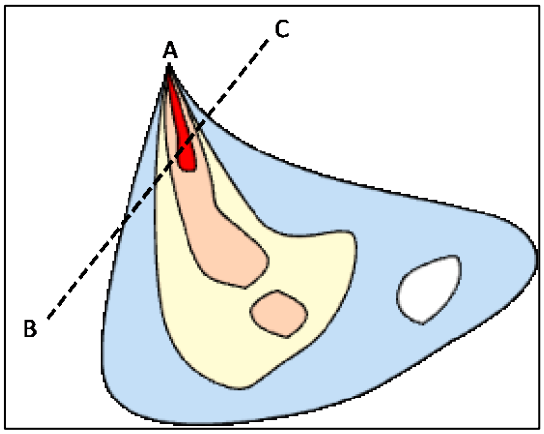
QVA information provides users with a high-resolution four-dimensional representation of a volcanic ash cloud, providing a more realistic depiction of the ash cloud. The 3-hourly timesteps of QVA information provides users with more accurate forecast positions of the ash cloud, compared to the 6-hourly timesteps of the VAA/VAG.

QVA information will likely have its greatest utility with ash cloud events that have a widely dispersed ash cloud with mostly lower levels of ash concentration. Operators with approval and procedures/practices, e.g., maintenance for planned flight into select thresholds of ash concentration, will be able to use QVA information to fly more efficient routes in accordance with their safety management program.

Probabilistic QVA information is intended for use in operator's flight planning and decision support systems. Operators will use probabilistic QVA information in conjunction with their safety management program to optimise airspace and plan more efficient routes during significant volcanic ash cloud events.

Visual illustrations of QVA information IWXXM objects

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



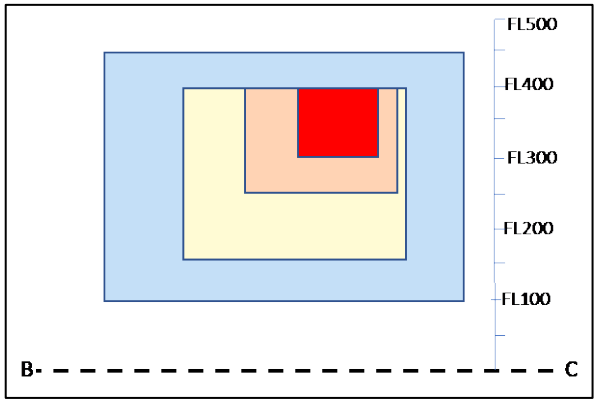


***Figure 1 (left)**. IWXXM objects showing all QVA thresholds depicted in the horizontal from a fictitious volcano located at A. The vertical depiction along line B-C is shown in **Figure 2 (right)**.*

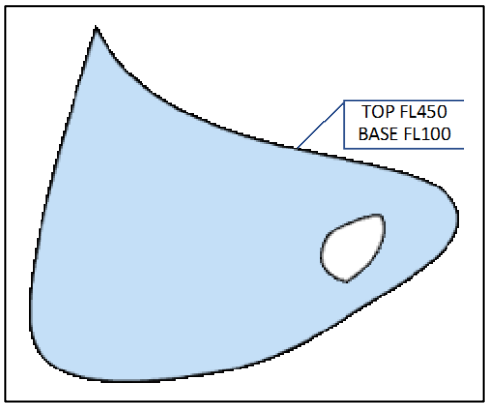


Figure 3.

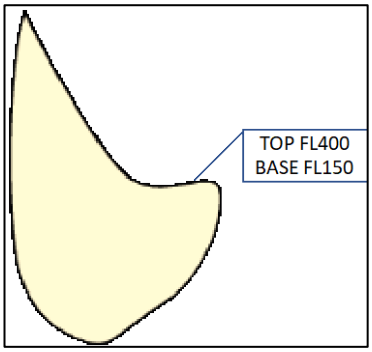


Figure 4.

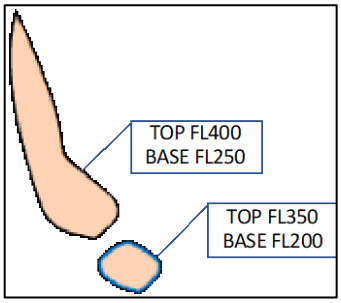


Figure 5.

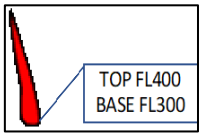


Figure 6.

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 information IWXXM objects and volcanic ash advisory in graphic form (VAG)

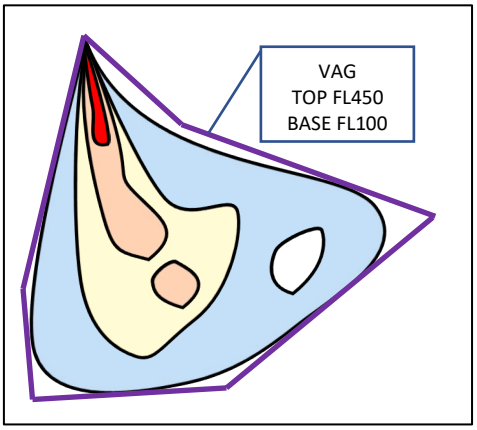


Figure 7. *Same as Figure 1 but overlayed with the VAG (purple polygon).*

Visualized examples of QVA grid point probability information

(Provided by VAAC Buenos Aires using FALL3D model and correspond to the exercise of 10 December 2021)

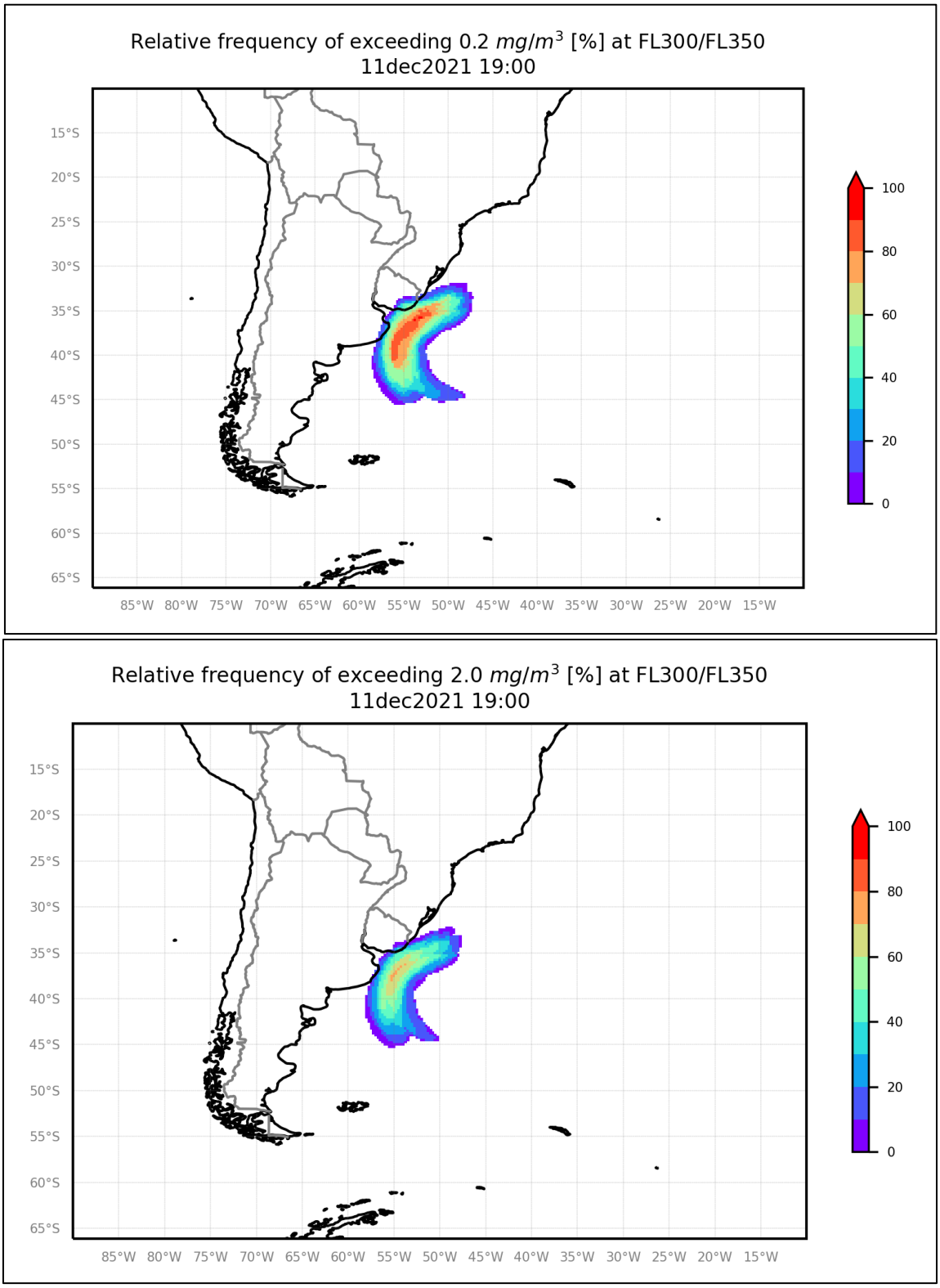


Figure 8. *Visualized examples of QVA grid point probability information from FL 300 to FL 350. Upper frame is the probability of exceeding 0.2 mg/m³. Lower frame is the probability of exceeding 2 mg/m³.*

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