*International Civil Aviation Organization*

**INFORMATION PAPER**

**ICAO Asia and Pacific (APAC)**
Twenty-Seventh Meeting of the Meteorology Sub-Group (MET SG/27)

Bangkok, Thailand, 04 to 08 September 2023

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**Agenda Item 6 : Research, development and other initiatives**

# COMBINED APAC VAAC Management report

(Presented by Australia, Japan and New Zealand)

**SUMMARY**

This paper presents an International Airways Volcano Watch (IAVW) focused management report describing activities for three APAC Volcanic Ash Advisory Centre's (VAAC) Darwin, Tokyo, and Wellington, covering the period 1 July 2022 to 30 June 2023.

## 1. INTRODUCTION

1.1 This paper presents a summary of key operational items within three APAC VAAC's and their area of responsibility between 1 July 2022 to 30 June 2023. Further information can be requested of the any of the VAACs separately.

## 2. DISCUSSION

VAAC Darwin activity

2.1 VAAC Darwin issued 2009 advisories for the reporting period 1 July 2022 to 30 June 2023 (table in Appendix A). Activity has been scattered amongst a number of volcanoes throughout this reporting period and there were 3 high impact eruptions. The activity per volcano is summarised in Figure 1.

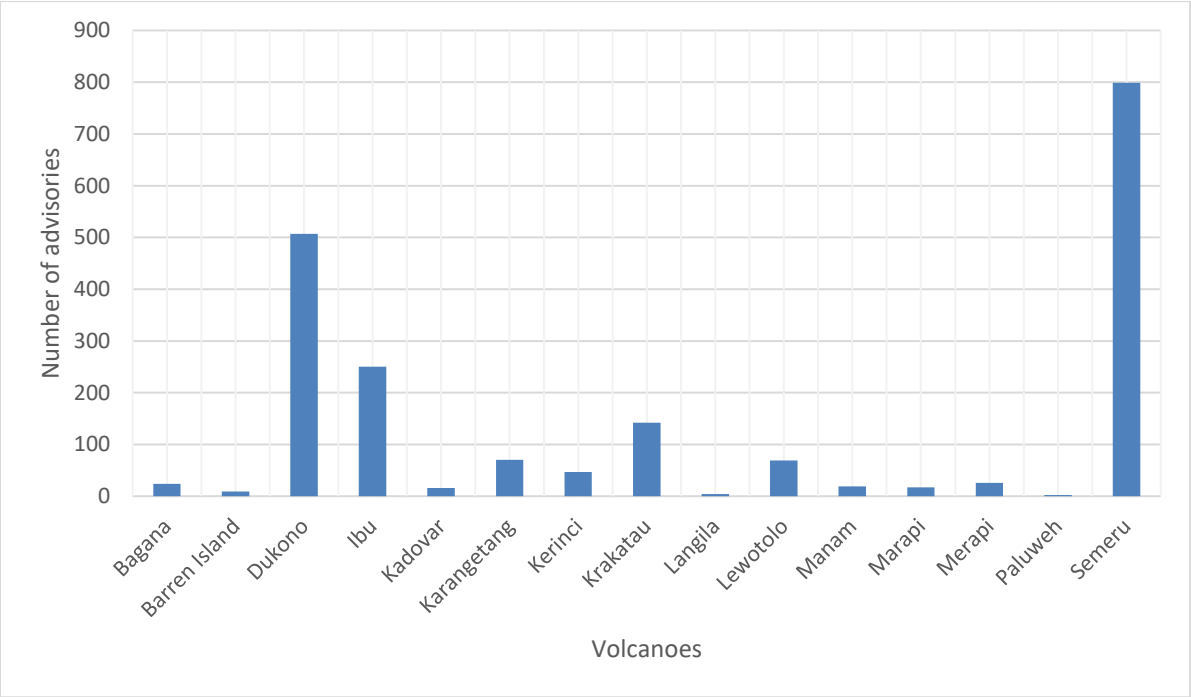


*Figure 1 - Advisories by volcano for the VAAC Darwin area of responsibility for 1 July 2022 to 30 June 2023.*

2.2 Mt Semeru on Java has been having intermittent discrete eruptions throughout the reporting period. This intermittent discrete behaviour at Mt Semeru can best be represented within an advisory as a short non-going emission with an observation and single forecast polygon in the T+6 field (Appendix A Figure 6, left). If the discrete eruptions continue to occur every few hours, then it is best to represent that eruption as a continuous event where the termination length of the advisory is the full extent of the ash cloud movement before it dissipates. Therefore, for multiple discrete eruptions the advisory may look like a continuous eruption with polygon covering the volcano to anticipate further eruptions and a full forecast out to T+18 (Appendix A Figure 6, right).

2.3 The VAAC Darwin webpage will now display back-up products issued by VAAC Darwin on behalf of other VAACs while under back-up mode. VAA/VAG products issued by VAAC Darwin for VAAC Tokyo, VAAC Wellington and VAAC Washington will be disseminated through AFTN and also appear on the VAAC Darwin webpage.

2.4 There are 18 VAAC competent forecasters in VAAC Darwin. We are looking at new ways to train staff which includes a case study for the 2022 Hunga Tonga-Hunga Ha'apai eruption which is almost ready for new and current staff members to work through as an exercise. VAAC Darwin will look to do a full review of its VAAC competency to align with the work being started by World Meteorological Organisation (WMO) for a VAAC competency framework.

2.5 VAACs Darwin and Wellington supported Solomon Islands with the removal of their Air Navigation Deficiency with standalone volcanic ash exercises, workshops, procedural reviews and data collections. The VAACs and Solomon Islands plan to continue to work together on a more day-to-day basis. A similar approach will now be used to support Papua New Guinea.

2.6 The Bureau has a new Dispersion Ensemble Prediction System (DEPS) which provides probabilistic forecasts for volcanic ash to help with more accurate advisories. This new tool helps move away from a deterministic approach, to better capture the uncertainties involved. The DEPS version 2 (DEPS2) upgrade was released in September 2022. This system supports improved VAAC operation forecasts and future quantitative volcanic ash information services coming from the ICAO METP WG-

MOG-IAVW (Met Panel Working Group - Meteorological Operations Group, International Airways Volcano Watch work stream).

2.7 VAAC Darwin participated in the Volcanic Ash Exercise (VOLCEX) 2022/01 which was run by BMKG Indonesia on 27 October 2022. The event was for an eruption at Sorikmarapi to FL400 moving to the west to impact domestic and international Air Traffic Service (ATS) routes, and test SIGMET coordination between Jakarta and Colombo FIR. There was good coordination between all parties involved.

2.8 WMO Advisory Group on Volcanic Science for Application (AG-VSA) held the 8th International Workshop on Volcanic Ash (IWVA) in Rotorua on 4 and 5 February 2023. There were 57 attendees from 22 countries. The full report can be found here: Proceedings of the Eighth International Workshop o... | E-Library (wmo.int). Further information on International WMO and ICAO engagement by the VAACs can be found in Appendix D.

VAAC Tokyo activity

2.9 A total of 2,716 Volcanic Ash Advisories (VAAs) and 1,114 accompanying Volcanic Ash Graphics (VAGs) were issued for the Tokyo area over the period of this report (Figure 2). In all, 99.9% of VAAs/VAGs issued were operational, relating to actual VA events or VAAC backup notices.

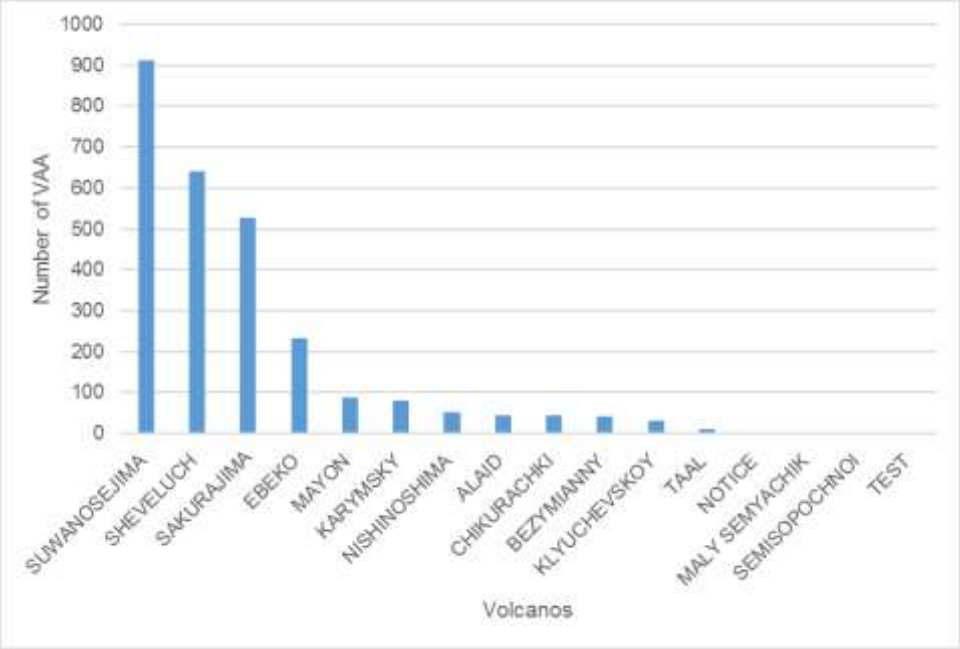


*Figure 2 - Advisories by volcano for the VAAC Tokyo area of responsibility for 1 July 2022 to 30 June 2023.*

2.10 A plume from the eruption of Mt. Sheveluch in Russia at 1300 UTC on 10th April 2023 reached a height of more than 15 km before crossing the Pacific Ocean at lower altitudes, with ash remaining in the atmosphere for a week. VAAC Tokyo detected the eruption and issued 20 advisories between 10 and 13 April.

2.11 On 13th December 2022, the Japan Meteorological Agency (JMA; the operator of VAAC Tokyo) began full-scale operation of its Himawari-9 satellite and moved its Himawari-8 predecessor into a backup role. Basic performance in monitoring of volcanic ash clouds remains unchanged.

2.12 VAAC Tokyo and VAAC Darwin conducted annual backup testing on 28th June 2023, issuing notification and test VAA information as per the backup agreement. VAAC Tokyo issued no operational VAA information on behalf of VAAC Darwin for backup operations during the reporting period.

2.13 VAAC Tokyo continues to assist the Philippine Institute of Volcanology and Seismology (PHIVOLCS) in prompt issuance of Volcano Observatory Notifications for Aviation (VONAs), which also support its own issuance of related VAAs.

2.14 All VAA forecasters meet the requirements of the Basic Instruction Package for Meteorologists (BIP-M). BIP-M-compliant Aeronautical Meteorological Forecaster (AMF) training has also been provided for 33 JMA staff toward development in the VAA forecasting field.

2.15 VAAC Tokyo works to develop probabilistic forecasting for QVA (Quantitative Volcanic Ash concentration information) and related work scheduling. As part of these efforts, work is underway on an ESP model incorporating ash-column physical dynamics (e.g., wind, density currents and particle settling) to support determination of initial parameters for transport modelling.

2.16 The 81st Amendment of Annex 3 will include recommendation of QVA implementation by all VAACs in November 2025 and VONA issuance by SVOs, as well as changes to the VAA template. VAAC Tokyo is currently informing users of these changes.

VAAC Wellington Activity

2.17 VAAC Wellington issued 30 advisories for the reporting period 1 July 2022 to 30 June 2023, including 2 test (TEST) advisories. All events were classified as low level, low impact events. The activity per volcano is summarised in Figure 3.

2.18 There are 29 Aeronautical Meteorological Forecaster (AMF) competent VAAC forecasters as per WMO and ICAO requirements, with 4 based out of the Auckland office and 1 in Christchurch for added resilience. We had 7 new forecasters joined the Aviation/VAAC team this year. Alongside our full AMF competent forecast team, we have an additional 3 VAAC specific forecasters.

2.19 VA scenario testing continues three times per week. This helps the team stay current and helps to quickly identify any technical issues that may have arisen in between operational VAA issues.

2.20 VAAC Wellington continues to utilise Microsoft Teams to connect with our neighbouring VAAC Darwin, MWO Nadi, and the NZ SVO GNS Science. We recently added a new Teams connection with the Tonga Meteorological Service which has proven useful for conferring on volcanic activity information.

2.21 VAAC Wellington was in close contact with the SVO USGS and the American Samoa meteorological office during the unrest at Ta'u Island in August 2022. This was a new relationship for the VAAC, and although there was no volcanic ash emitted in the end, the development of this connection will be useful for any future activity.

2.22 VAAC Wellington continues to assist the Tonga Meteorological Service and Solomon Islands Meteorological Service with addressing long-standing ICAO deficiencies. We are looking at further ways to support their progress with opportunity to practise using exercises, as well as setting up similar exercises with the Papua New Guinea meterological service, for the Nauru FIR.

2.23 VAAC Wellington is assisting with the planning of a New Zealand based volcanic ash exercise on 19 August 2023, simulating the eruption of Mt Taranaki. The exercise aim is to give local aviation industry the opportunity to practice their procedures, with a focus on ash fall at an aerodrome.

2.24 VAAC Wellington made no significant model upgrades during 2022 but is looking to update the VOLCAT system in 2023. In November 2022, VAAC Wellington switched over to using Himawari-9 satellite and expresses its gratitude to JMA for access to this data.

2.25 VAAC Wellington are in the early stages of developing the QVA concentration information service2, as included in the proposed Amendment 81 to ICAO Annex 3.

2.26 Representation from VAAC Wellington attended the WMO IWVA/8 and the ICAO METP/WG-MOG/20 IAVW, both held in Rotorua New Zealand between 4-9 February 2023.

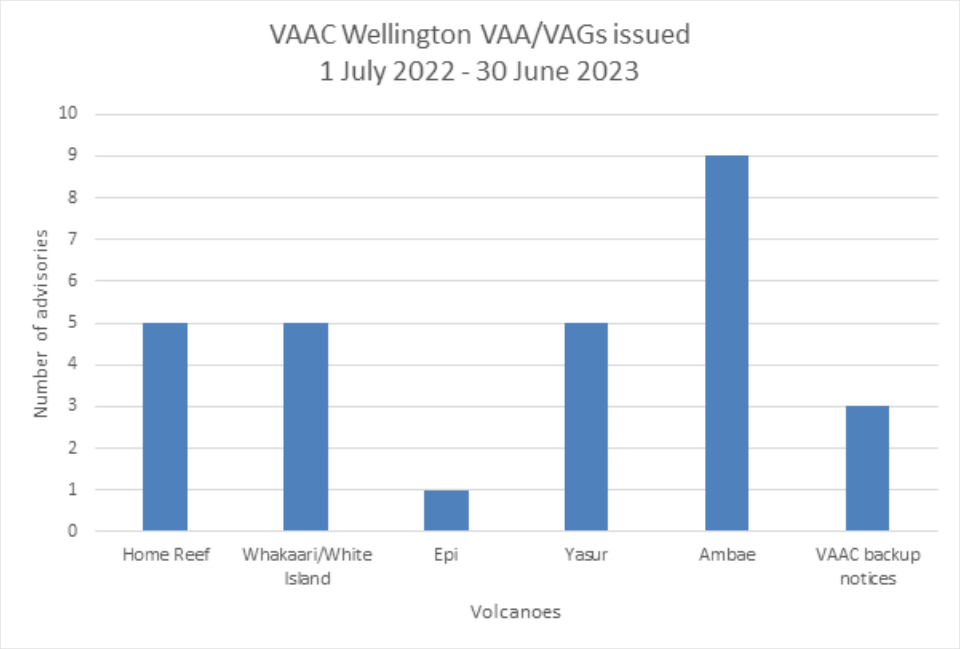


*Figure 3 - Operational VAA/VAG issued by VAAC Wellington for 1 July 2022 – 30 June 2023*

Summary of APAC VAACs Back-Up Tests

2.27 VAAC Darwin and VAAC Tokyo conducted a back-up test on 28 June 2023. A full test was carried out to test new procedures after the review of back-up documentation. There were over 10 responses from operators to each VAAC for positive receipt.

2.28 VAAC Darwin and VAAC Wellington conducted their annual back-up test on 30 May 2023. Due to an increase in interest in receiving VAA from user groups (such as SVOs) who don't have access to the AFS, one specific objective of the test this year was to test the back-up email dissemination lists. There were minimal responses from users on the AFS and around 40% of users on the email distribution lists.

2.29 VAAC Darwin, VAAC Montreal and VAAC Washington have been carrying out back-up tests every 3 months of the VAAC Washington area of responsibility. The last back-up test was conducted on 31 March 2023. Instead of the usual back-up test format, the VAAC Darwin staff instead

issued a real advisory for one of the VAAC Washington volcanoes (Fuego, Guatemala) and the dissemination was tracked to a number of locations. A corresponding WV SIGMET was issued for the advisory which indicated that the MWO had received the advisory issued under back-up.

## 3. ACTION BY THE MEETING

3.1 Note the information contained in this paper.

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**APPENDIX A** – VAAC Darwin report

## 1. INTRODUCTION

1.1. The Volcanic Ash Advisory Centre (VAAC) Darwin is responsible for monitoring the area from the Andaman Islands (India) eastwards to the Solomon Islands, including the volcanically active Indonesian archipelago, Papua New Guinea and the southern Philippines. More than 150 active volcanoes lie within the area, some of which have given rise to the largest eruptions in human history. Areas within the region have poor communications and general infrastructure, incomplete volcanic monitoring and are characterised by moist tropical convection that makes remote sensing difficult for much of the year.

## 2. VAAC STATISTICS

| VAAC | Period of reporting | Total number of Advisories | High Impact Events* | |
|---|---|---|---|---|
| Darwin | 1 July 2022 – 30 June 2023 | 2009 | Dukono | 15 November 2022 |
| | | | Semeru | 4 December 2022 |
| | | | Merapi | 11 March 2023 |

* Discernible or visible ash that is impacting or expected to impact aircraft cruising levels, international aerodromes, is of high media interest, or is deemed to be significant to aviation operations by the VAAC

2.1. A total of 2009 Volcanic Ash Advisories (VAA) and accompanying Volcanic Ash Graphics (VAG) have been issued for the Darwin area of responsibility this reporting period. (Note: a financial year runs from 1 July to 30 June the following year).

2.2. Figure 4 shows the number of advisories issued by VAAC Darwin (reported by volcano name) during FY 22/23. Figure 5 shows the total number of advisories issued within a financial year. The peak in FY 15/16 was due to the operational release of Himawari-8 imagery at 10-minute intervals which highlighted smaller activity. The process for discernible volcanic ash was refined to match the new imagery resolution. FY 22/23 has continued with low impact volcanic activity. In the VAAC Darwin area of responsibility (AOR), Mt Dukono, in northern Halmahera, Indonesia had been continuously erupting for many years but over the recent months the emissions have stopped or become so minor that there has been no ash observed during clear days. Mt Semeru on Java has been having intermittent discrete eruptions throughout the year.

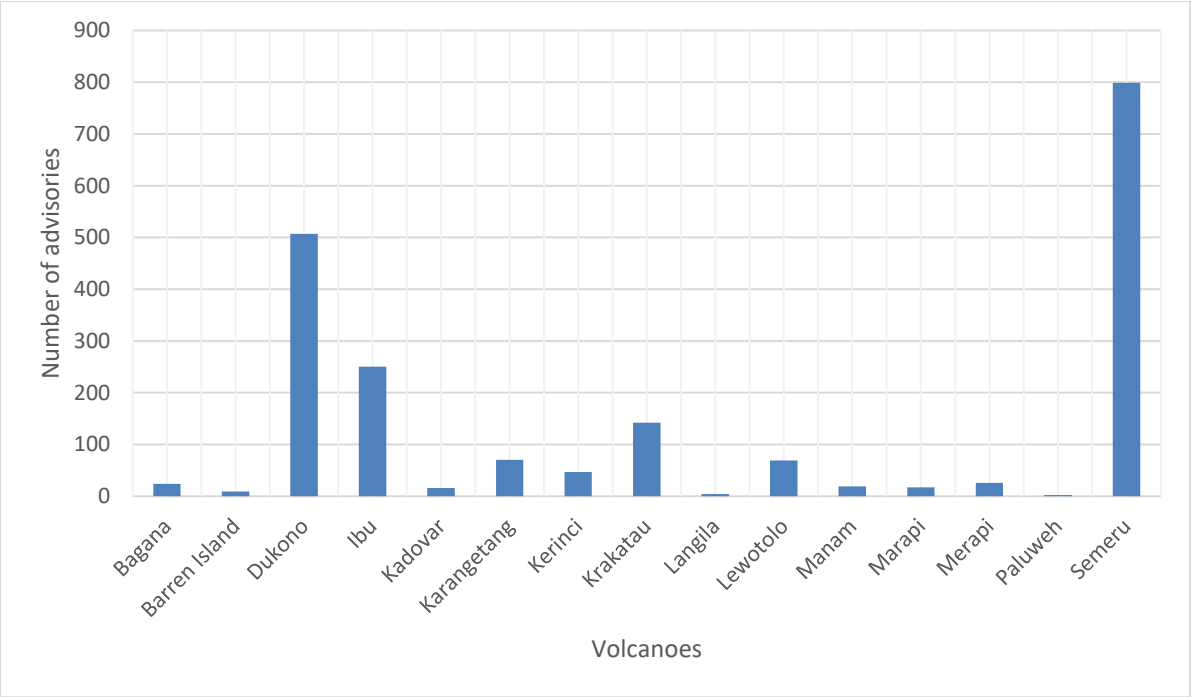


*Figure 4 - Advisories by volcano for the VAAC Darwin area of responsibility for 1 July 2022 to 30 June 2023.*

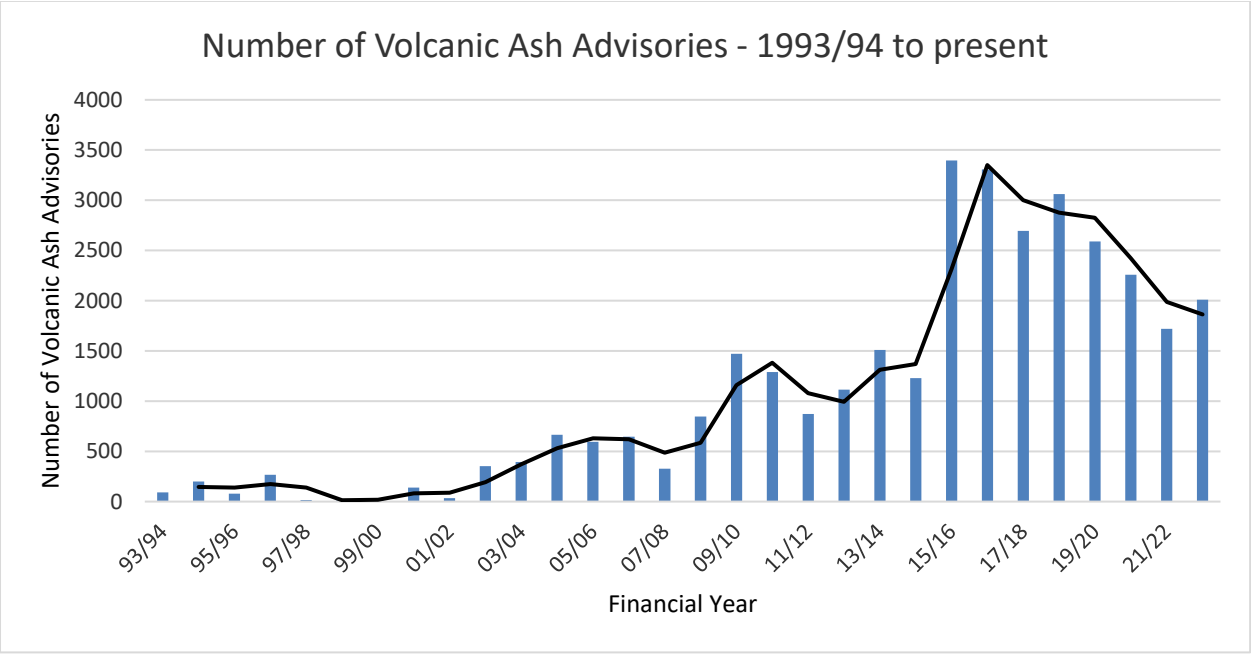


*Figure 5. VAAC Darwin advisories issued for Financial Years 1993/94 - 2022/23.*

2.3. This intermittent discrete behaviour at Mt Semeru can best be represented within an advisory as a short non-going emission with an observation and single forecast polygon in the T+6 field (Figure 6, left). If the discrete eruptions continue to occur every few hours, then it is best to represent that eruption as a continuous event where the termination length of the advisory is the full extent of the ash cloud movement before it dissipates. Therefore, for multiple discrete eruptions the advisory may look like a continuous eruption with polygon covering the volcano to anticipate further eruptions and a full forecast out to T+18 (Figure 6, right).

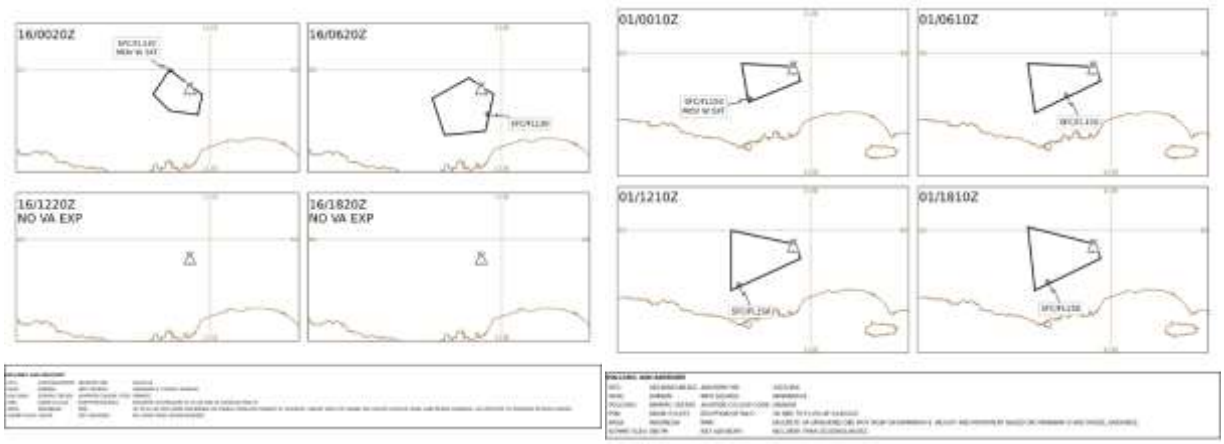


*Figure 6. Left: Volcanic ash advisory issued for Mt Semeru for a single discrete eruption. Right: Volcanic ash advisory issued for Mt Semeru for multiple discrete eruptions*

## 3. HIGH IMPACT ERUPTIONS

### 3.1. Merapi, Java – 11 March 2023

3.1.1. At 0512 UTC on 11 March 2023, an eruption occurred at Mount Merapi on Java in Indonesia. The eruption was initially reported through a photo sent, via WhatsApp, by Center for Volcanology and Geological Hazard Mitigation (CVGHM) at 11/0525 UTC, which showed a large amount of volcanic ash along the side of the volcano, indicating a possible high-level and high-impact eruption.

3.1.2. The photo showed that meteorological cloud was obscuring the vertical extent of the volcanic ash which made it difficult to determine the height of the eruption (Figure 7Figure 7). Other sources, such as YouTube webcam and Himawari-9 satellite imagery, were assessed to confirm the eruption, but a height could not be determined.

3.1.3. An Aviation Colour Code RED Urgent Initial advisory was issued at 11/0535 UTC, indicating that a significant eruption had occurred with an unknown height. Subsequent observations and measurements from satellite images revised the height to FL200 (20,000 feet), and the Aviation Colour Code was downgraded to Orange for the follow up advisory at 11/0557 UTC. Himawari-9 satellite imagery at 11/0600 UTC highlighted the bright ash signal appearing from the eruption at Mount Merapi (Figure 8). The forecast was provided by the Dispersion Ensemble Prediction System (DEPS) 2 (Figure 9). The eruption was tracked until the VA was no longer discernible on satellite imagery and finally cancelled at 11/2320 UTC.

*Figure 7. CVGHM's WhatsApp image at 11/0525Z.*

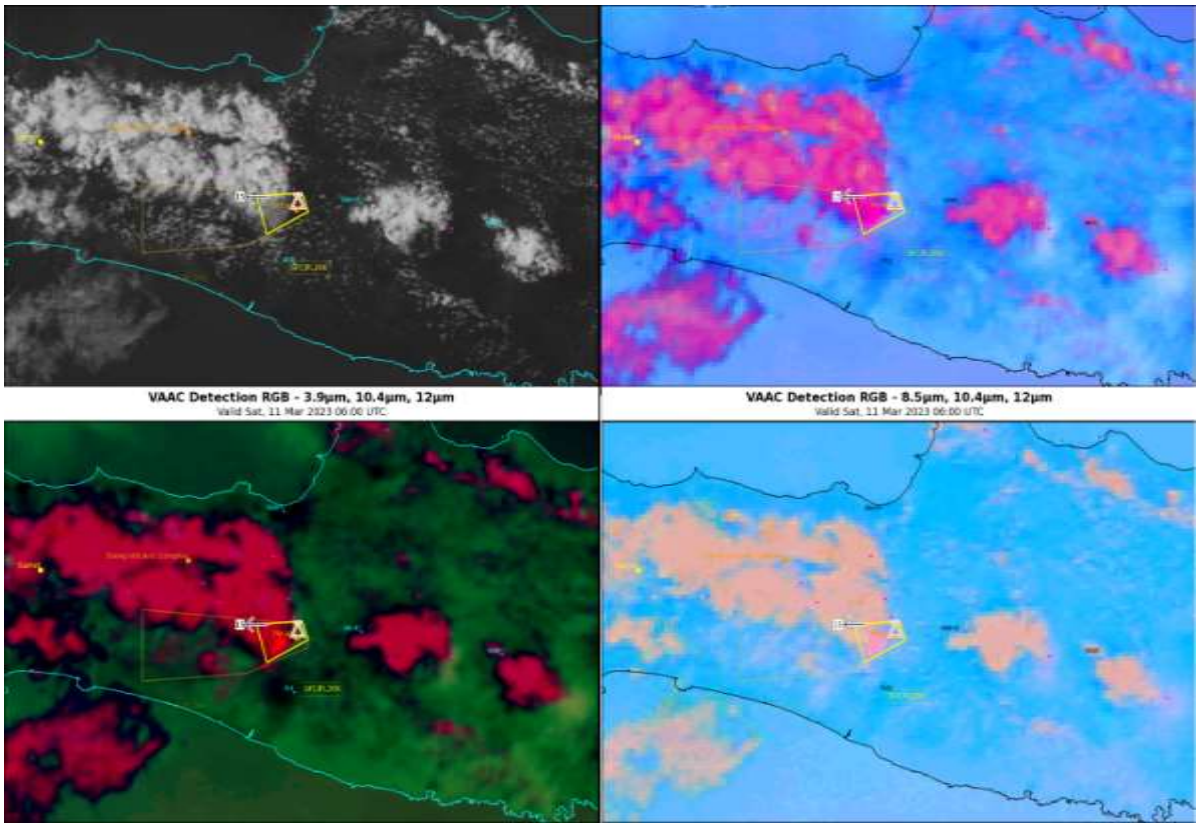


*Figure 8. Himawari-9 Satellite Imagery at 11/0600Z over Mount Merapi. Top left is visible imagery (pattern recognition used to identify volcanic ash), top right is RGB false colour image (3.9um) (bright pink is volcanic ash), bottom left is RGB false colour image (bright red is volcanic ash), and bottom right is RGB false colour image (8.5um) which highlights $SO_2$ as bright green.*


*Figure 9. DEPS2 (20,000ft) showing maximum VA dispersal towards WNW at approximately T+6.*

## 4. SIGNIFICANT OPERATIONAL CHANGES

### 4.1. VAAC Darwin Competency Program

4.1.1. VAAC Darwin has implemented a competency and training program for VAAC forecasters in line with quality management obligations and recent advancements in volcanic ash detection, monitoring and forecasting (i.e. next generation geostationary satellites, automated alerts (VOLCAT)), as well as implementation of improved strategies for delivering aviation briefings which can be scaled up or down based on the impact of an event and to meet the evolving needs of industry.

4.1.2. VAAC Darwin currently has 18 VAAC competent staff members. This is a significant increase in the number of competent technical staff available and able to respond to high impact volcanic ash events.

4.1.3. VAAC Darwin is developing in-house simulations and case studies to provide forecasters with a well-rounded training program so they can gain first-hand experience with many high impact eruptions. We will be using Ulawun (2019) and Hunga Tonga-Hunga Ha'apai (2022) as training cases for staff.

4.1.4. The World Meteorological Organization (WMO) Expert Team on Education, Training and Competency (ET-ETC) will be updating the top- and/or second-level competencies for aeronautical meteorological personnel to accommodate the role of VAAC forecasters and VAACs Darwin and Montreal will be assisting with the process. We are hoping that with VAAC Darwin's involvement we can have a consistent competency framework between all the VAACs. A separate VAAC competency framework has been developed to align with the AMF under the top-level competencies but have a separate set of second-level competencies. The new separate VAAC competency framework has been passed to WMO groups for review and approval process.

### 4.2. VAAC Washington back-up

4.2.1. VAAC Darwin and VAAC Montreal have commenced back-up support service for VAAC Washington. The service became live on 1 November 2021, from which point VAAC Washington may request back-up support from VAAC Darwin and VAAC Montreal.

4.2.2. VAAC Darwin will back-up the area consisting of Central America, South America to 10°S, the Northwest Pacific which includes the Marianas Islands and sections west of Central and South America in the Eastern and Central Pacific (Figure 10, green area). VAAC Montreal will back-up the area consisting of the Continental US, Mexico, Caribbean, Eastern Atlantic and the Eastern and Central Pacific that includes Hawaii and west to 170°W. (Figure 10, yellow area).

4.2.3. There was a planned back-up test organised between the three VAACs on 31 March 2023 to test out the coordination and dissemination with both VAACs at the same time. VAAC Darwin issued an advisory for Fuego in Guatemala and VAAC Montreal issued the back-up notice only. There is another live back-up session later in 2023. Back-up information will be put into the APAC regional SIGMET guide of the new back-up service.

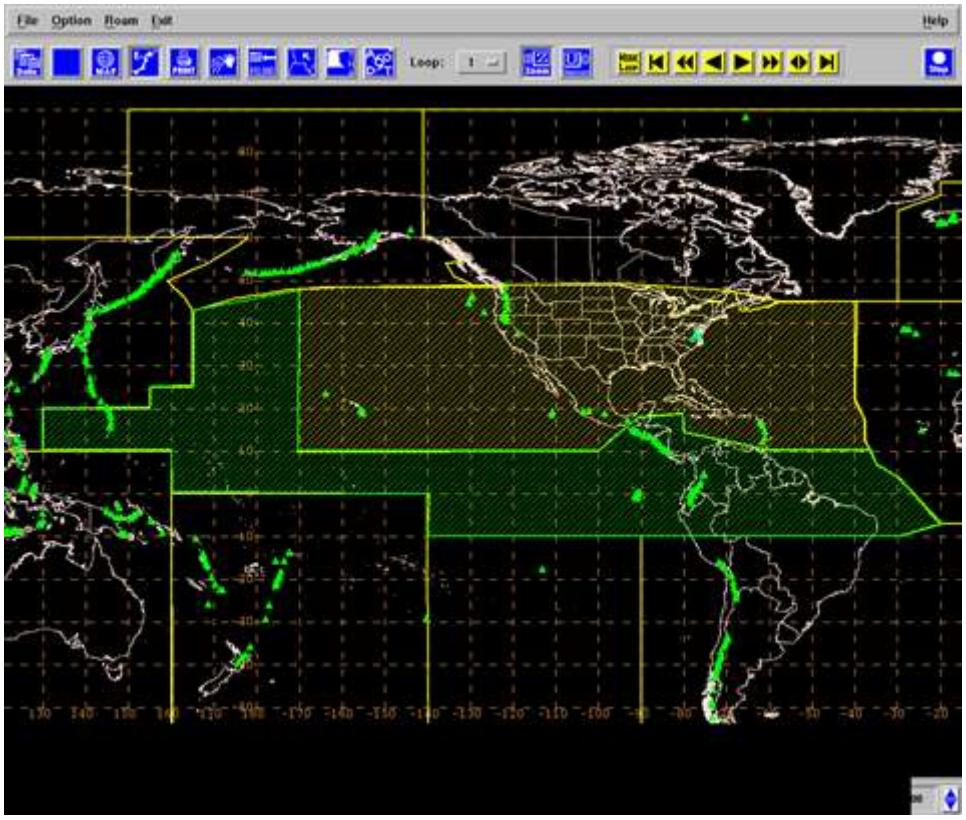


*Figure 10. The VAAC Washington area split between VAAC Montreal and VAAC Darwin for back-up support.*

### 4.3. VAAC Back-up testing

4.3.1. VAAC Darwin and VAAC Wellington conducted a back-up test on 30 May 2023 to test newly reviewed procedures for the VAAC staff. The back-up test was successfully carried out between the two VAACs. There was minimal receipt of VAAs from a number of the updated AFTN addresses. Further work is occurring to refine the back-up test process to ensure more user participation.

4.3.2. VAAC Darwin and VAAC Tokyo have renewed the back-up processes and put the scheme of cooperation Appendices into operations. To consolidate this, there was a back-up test conducted on 28 June 2023. Both VAACs received over 10 responses each from users including a good response from Indonesia.

### 4.4. VAAC Darwin webpage

4.4.1. The VAAC Darwin webpage will now display back-up products issued by VAAC Darwin on behalf of other VAACs while under back-up mode. VAA/VAG products issued by VAAC Darwin for VAAC Tokyo, VAAC Wellington and VAAC Washington will be disseminated through AFTN and also appear on the VAAC Darwin webpage.

### 4.5. VOLCEX 2022/01

4.5.1. BMKG Indonesia hosted the Volcanic Ash exercise (VOLCEX) 2022/01. VAAC Darwin participated in the exercise by issuing the initial advisory to FL400 for Sorikmarapi and continued the movement to the west and north-west so that it affected domestic and international Air Traffic Service (ATS) routes, closure of airports and re-routing, and SIGMET coordination between Jakarta and Colombo FIRs. The exercise was held on 27 October 2022. There were many participants and many actions that needed to be carried out during the exercise.

## 5. Dispersion Ensemble Prediction System (DEPS)

5.1.1. The Bureau has deployed the Dispersion Ensemble Prediction System (DEPS) in 2020 which is a computer-derived model that provides probabilistic forecasts for volcanic ash to help with more accurate advisories. This new tool helps uses a probabilistic output which takes 18 current Numerical Weather Prediction (NWP) members and the previous 18 NWP members to create a lagged ensemble of 36 members to accommodate for a number of uncertainties. DEPS2 upgrade was released during September 2022 which has brought improved sciences and inverse modelling to support improved parameterisation, the use of satellite retrievals and forecaster observations to improve forecast output. This system will support improved VAAC operation forecasts and future QVA information services. The next steps involve using DEPS2 against as many different eruptions and verify/validate the results.

## 6. VAAC COLLARBORATION

### 6.1. VAAC Wellington

6.1.1. VAAC Darwin and VAAC Wellington collaboration has been a major focus for the two VAACs to look at consistency and harmonisation of services. The VAACs have been considering coordination, quality, consistency, flexibility, and resilience. There are forecasters organising many activities which include looking into current capabilities and comparing ash dispersion models, looking into ways to incorporate daily collaboration activities, comparison of advisory and forecast creation, and sharing current activity or gaining insight into potential volcanic activity. With the increase in use of Microsoft Teams software due to the pandemic, a new Wellington-Darwin chat has been established which is allowing closer and more frequent collaboration.

6.1.2. We are having forecasters take on these responsibilities to further build up relationships between the two VAACs and to provide professional development for staff. We continue to work closely to organise, participate and review volcanic ash exercises to test out procedures and

coordination. The coordination between the two VAACs was demonstrated during the Hunga Tonga-Hunga Ha'apai eruption where there was ongoing discussion, information sharing, video calls, and product coordination to make sure there was a seamless service across both VAAC's AORs. Looking to build upon this in a more day-to-day operational sense.

6.1.3. VAAC Darwin and VAAC Wellington supported Solomon Islands with the removal of their Air Navigation Deficiency (AP-MET-23). The Solomon Islands FIR 'Honiara' is split between both VAACs so a volcano from each VAAC area of responsibility was used for the exercises (Figure 11). There were volcanic ash exercises, data collection periods, offline exercises, workshops and documentation reviews to support the removal of the deficiency.

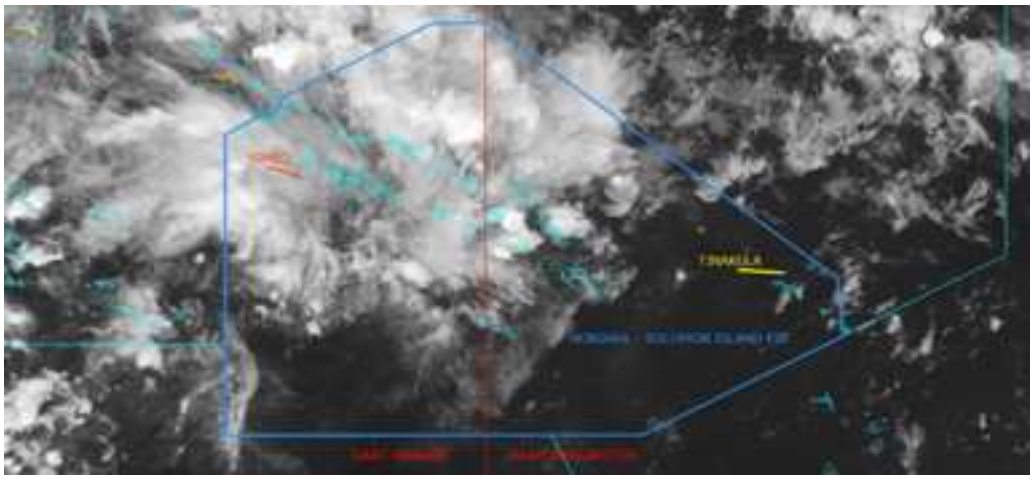

*Figure 11. Map of the Honiara FIR, VAAC Darwin and VAAC Wellington Area of responsibility boundaries and Simbo and Tinakula volcanoes used in exercises.*

### 6.2. VAAC Tokyo Collaboration

6.2.1. VAAC Darwin and VAAC Tokyo are collaborating on a number of tasks to improve operational services and consistency between both centres. VAAC Tokyo have developed the JMA SIGMET Collaboration tool which will be expanded to include VAAC collaboration. The VAACs are looking to revise their back-up arrangements and conduct a back-up test.

6.2.2. Both VAACs are looking to incorporate the collaboration tool into back-up procedures as an easier way to communicate. VAAC Tokyo is also looking to join the MS Teams group to see if it is appropriate for operational use.

## 7. INTERNATIONAL STAKEHOLDER ENGAGEMENT

### 7.1. State Volcano Observatory engagement

7.1.1. Due to COVID, the State Volcano Observatory (SVO) engagement has slowed down since States have been responding to the pandemic. There has been outreach to States that have APAC Met deficiencies to see where the VAAC can provide support especially to deficiencies around volcanic ash services. VAAC Darwin will be supporting RVO with its current work to provide volcanic

activity information and remove its deficiency. VAAC Darwin has also supported MWO Solomon Islands to remove some air navigation deficiencies and continues to support them for issuing volcanic ash SIGMETs.

7.1.2. With the elevation of the VONA by the ICAO in Annex 3 Amendment 81, there will be follow on education for SVOs and customers. The VAACs will need to help with education around the changes and continue the discussion with SVOs now that METP has approved the changes to VONA and that is will be in the Amendment 81 of Annex 3.

**APPENDIX B** – VAAC Tokyo report

## 1. INTRODUCTION

The Volcanic Ash Advisory Center (VAAC) Tokyo operated by the Japan Meteorological Agency (JMA) is responsible for monitoring East Asia, the Northwest Pacific region and part of the Arctic Circle. Although its area of responsibility is smaller than those of other VAACs, the work burden is high due to the presence of many active volcanoes along the northwestern part of the Pacific Ring of Fire from Russia's Kamchatka Peninsula to the northern Philippines.

As some regions in the vicinity of active volcanoes are densely populated, VAAs are essential for safety in local air transportation. VAAC Tokyo (together with VAAC Anchorage) monitors the North Pacific airspace, which is characterized by heavy air traffic between Asia and North America.

VAAC Tokyo is committed to maintaining the safety of local and international air transportation in close coordination with ground observatories and civil aviation authorities based on information from its Himawari geostationary satellites and forecasting for rapid detection of eruptions.

## 2. Major Eruptions

### 2.1 General information

A total of 2,716 Volcanic Ash Advisories (VAAs) and 1,114 accompanying Volcanic Ash Graphics (VAGs) were issued for the Tokyo area over the period of this report.

### 2.2 Mt. Sheveluch, Kamchatka – 10th April 2023

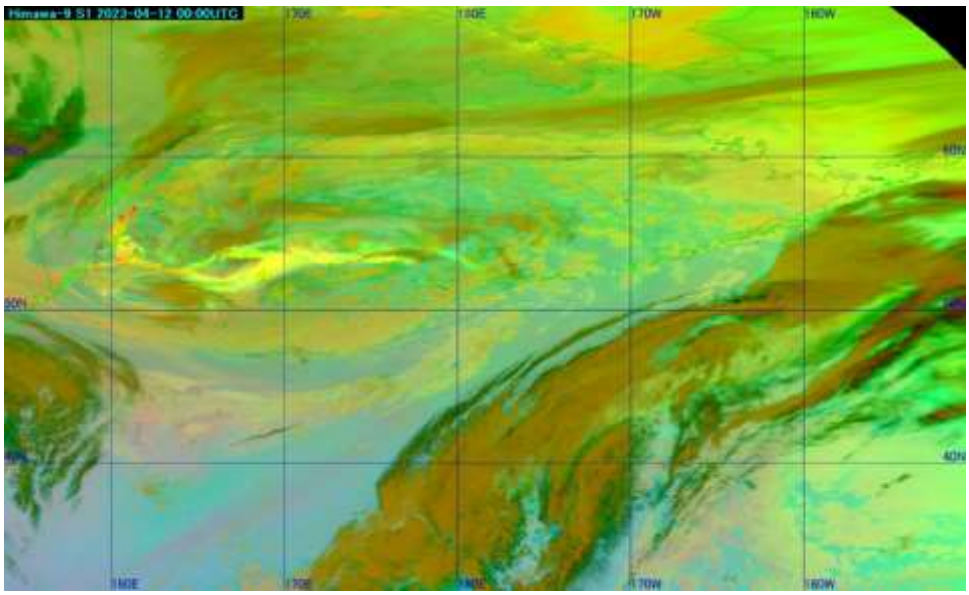

*Figure 12 - Himawari-9 composite RGB image for Mt. Sheveluch eruption at 00 UTC on 12 April 2023*

2.2.1 Mt. Sheveluch on Russia's Kamchatka Peninsula erupted at 1310 UTC on 10th April 2023, producing a plume that reached a height of FL520. The resulting ash cloud remained over the northern

Pacific and parts of North America (Figure 12) for a week, seriously effecting air traffic control in the region.

2.2.2 VAAC Tokyo detected the eruption from Himawari-9 satellite imagery and issued the first VAA at 1349 UTC. A total of 20 advisories had been issued by 1750 UTC on 13 April, when ash cloud was no longer identifiable in Tokyo's area of responsibility.

2.2.3 VAAC Tokyo handed over monitoring for part of the volcanic ash cloud to VAAC Anchorage as it moved out of Tokyo's area of responsibility. VAAC Anchorage raised the cloud height from FL280 to FL380 in its second VAA based on information provided by airline operators. As the ash cloud spread, VAAC Montreal and VAAC Washington also issued advisories for their own regions.

2.2.4 VAAC Tokyo responded to phone/e-mail inquiries from airlines regarding VA forecasts and height changes before and after the handover.

2.2.5 ICAO METP WG-MOG-IAVW (Met Panel Working Group, Meteorological Operations Group, International Airways Volcano Watch) analyzed coverage of the event, with discussion of VAAC work, feedback from airlines and general IAVW tasks. The results indicated room for coordination improvement for such major events.

### 2.3 Hunga Tonga-Hunga Ha'apai, Tonga – 15th January 2022

In relation to the eruption of the Hunga Tonga-Hunga Ha'apai submarine volcano in Tonga on 15th January 2022, massive atmospheric pressure waves and tsunami-like sea level changes (known as meteo-tsunami) caused damage to Japan. Accordingly, JMA determined to engage in assessment of the potential for meteo-tsunami generation with large eruptions causing plumes of FL500 or higher from July 2022 onward. For this operation, VAA data are also utilized to detect major eruptions.

## 3. Significant operational changes

JMA aspires to engage in stable and continuous satellite observation with redundancy based on twin-satellite operation (Himawari-8 and -9). On 13th December 2022, the Agency began full-scale operation of its Himawari-9 satellite and moved its Himawari-8 predecessor into a backup role. Basic performance in monitoring of volcanic ash clouds remains unchanged.

## 4. Recent development

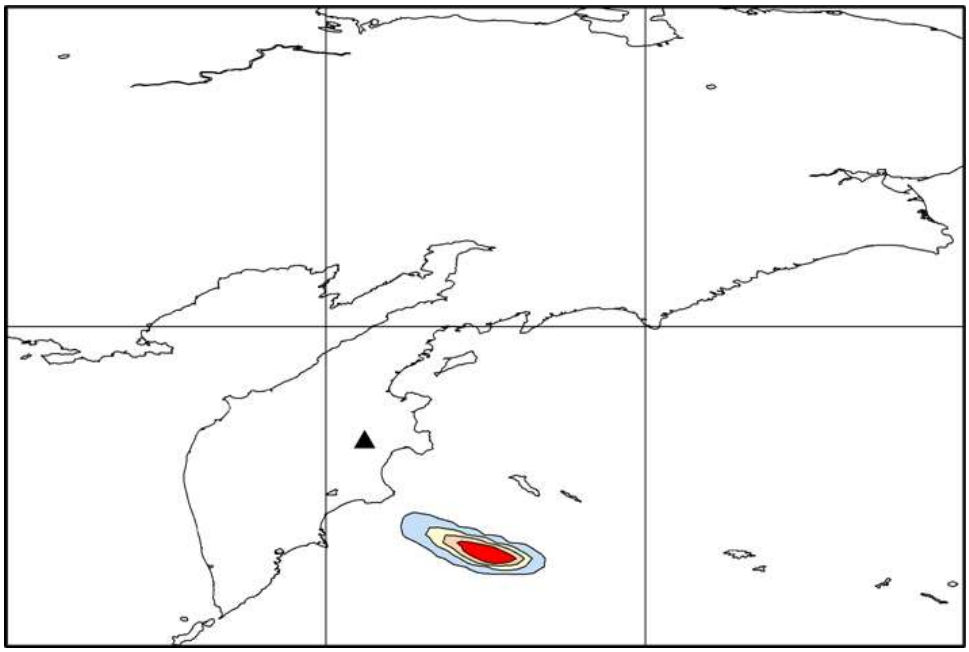

*Figure 13 - QVA forecast for Mt. Sheveluch, FL200-250*

VAAC Tokyo works to develop probabilistic forecasting for QVA (Quantitative Volcanic Ash concentration information) and related scheduling. As part of these efforts, work is underway on an ESP model incorporating ash-column physical dynamics (e.g., wind, density currents and particle settling) to support the determination of initial parameters for transport modelling. Figure 13 shows QVA forecast calculation.

## 5. Forecasting competency

5.1 All VAA forecasters meet the requirements of the Basic Instruction Package for Meteorologists (BIP-M). BIP-M-compliant Aeronautical Meteorological Forecaster (AMF) training has also been provided for 33 JMA staff toward development in the VAA forecasting field.

5.2 VAAC Tokyo holds meetings every month at which forecasters share opinions, including reviews of past volcanic ash events. These events are intended to improve related operations and VAA products.

5.3 VAAC Tokyo develops forecaster capacity-building tools for analysis of volcanic ash clouds in actual events. Forecaster analysis results are compared to encourage enhancement of related skills as a whole.

## 6. User survey

6.1 In October 2022, VAAC Tokyo carried out a survey of domestic users to identify the most commonly referenced VAA elements and gain feedback for improvement of its services in accordance with ICAO Annex 3 and related documentation.

6.2 JMA holds conferences with domestic and overseas airlines twice a year, with content including recent developments in its services and information relevant to the airline industry. The Agency also holds additional meetings to gauge subjective opinions on outlooks for the usage of new information and other areas.

## 7. Collaboration with VAACs/stakeholders

7.1 VAAC Tokyo holds regular online meetings with VAAC Darwin and VAAC Wellington to discuss operational tasks. Meetings involving all VAACs were also started in 2023 for enhanced collaboration.

7.2 VAAC Tokyo utilizes JMA's VAAC Collaboration Website to interact with VAAC Darwin regarding handover and back-up operation.

7.3 VAAC Tokyo and VAAC Darwin have an arrangement for mutual back-up to ensure ongoing services in the event of an emergency. In line with ICAO regulations, annual back-up testing is conducted between the two organizations to check the back-up procedure and appropriate provision of information.

7.4 VAAC Tokyo runs monthly VONA issuance drills with PHIVOLCS (the Philippine Institute of Volcanology and Seismology) to support prompt issuance in actual events.

7.5 On 14th September 2022, VAAC Tokyo presented a management report at a Vulcan Working Group Meeting held by Australia's Bureau of Meteorology.

7.6 The 81st Amendment of Annex 3 will include recommendation of QVA implementation by all VAACs in November 2025 and VONA issuance by SVOs, as well as changes to the VAA template. VAAC Tokyo is currently informing users of these changes.

**APPENDIX C** – VAAC Wellington report

## 1. INTRODUCTION

1.1. Volcanic Ash Advisory Centre (VAAC) Wellington, operated by the Meteorological Service of New Zealand Limited (MetService) covers the region southward from the Equator and from E160 to W140, except for the Melbourne and Brisbane FIRs, and southward from S10 and from W140 to W90.

1.2. This report covers the period 1 July 2022 – 30 June 2023.

## 2. STATISTICS

2.1. The number of advisories issued by VAAC Wellington (reported by volcano) during the period 1 July 2022 – 30 June 2023 are shown in Table 1.

| Volcano | Date | VAAs/VAGs issued |
|---|---|---|
| **Home Reef** | 20 and 21 September 2023 | 5 |
| **Whakaari/White Island** | 7-8 October 2022 | 5 |
| **Epi (East Epi)** | 1 February 2023 | 1 |
| **Yasur** | 4 April 2023 | 5 |
| **Ambae** | 5 and 6 April 2023 | 9 |
| **VAAC backup notices** | 15 November, 3 and 12 December 2022 | 3 |
| **ICAO APAC SIGMET test** | 15 December 2022 | 1 |
| **Darwin VAAC Backup Test** | 30 May 2023 | 1 |

*Table 1 Breakdown of dates/VAA issued per volcano for 1 July 2022 – 30 June 2023*

## 3. ERUPTIONS OF INTEREST

3.1. The were no eruptions considered 'high impact' during this reporting period.

3.2. Whakaari/White Island – 7-8 October 2022

3.2.1. The addition of the '/' in the volcano name continues to cause some issues with consistency between VAA and SIGMET. We are working with our software provider to enable our

Graphical Sigmet Monitoring product to allow the '/' in the volcano name.

3.3. Epi – 1 February 2023

3.3.1. The Duty VAAC Forecaster was made aware of a small eruption at East Epi, Vanuatu, via a social media page several hours after the eruption occurred. We continue to work with the local VO to received timely reports.

## 4. SIGNIFICANT OPERATIONAL CHANGES

4.1. There were no significant operational changes during this period.

## 5. QVA UPDATE

5.1. VAAC Wellington is committed to the implementation of QVA. A project team has been established to work through the requirements. VAAC Wellington has also started engaging with our biggest customers to share the QVA flyer.

## 6. COLLABORATION WITH VAACS/STAKEHOLDERS

6.1. VAAC Wellington continues to work closely with our local SVO, GNS. Alongside our thrice weekly meetings, we have also conducted site visits to each other premises and presented overviews of how each organisation's operations are undertaken. We have had an information sharing session, where both organisations presented on various topics that are being worked on.

6.2. VAAC Wellington is assisting with options to help with implementation of VONA as a recommended practice.

6.3. VAAC Wellington continues to collaborate closely with VAAC Darwin. Recently forecasters from the two VAAC trialled 'shadow shifts' where they worked together to share procedures and information. This was considered successful, and we are looking at ways to roll this out to the broader group of VAAC forecasters.

**APPENDIX D** – International WMO and ICAO engagement

### 1.1. The Advisory Group on Volcanic Science for Applications (AG-VSA) replacing VAAC BP/VASAG

1.1.1. WMO has started up a new volcanic ash science group called the Advisory Group on Volcanic Science for Application. This group will be taking over the work conducted by the VASAG and support the METP WG-MOG-IAVW which will take on work of the VAAC Best Practice. The AG-VSA is currently working on the future operating plan and terms of reference which should be finalized by the end of 2023.

1.1.2. There are a number of tasks being undertaken by the AG-VSA including VAAC science are volcanic ash detection and identification through satellite imagery, event reviews, dispersion modelling and forecasting capabilities, and support with WMO VAAC forecaster and SVO competency frameworks.

1.1.3. The AG-VSA held the 8th International Workshop on Volcanic Ash (IWVA) in Rotorua on 4 and 5 February 2023. There were 57 attendees from 22 countries. The full report can be found here: Proceedings of the Eighth International Workshop o... | E-Library (wmo.int)

1.1.4. Some of the key recommendations or discussions include:

- The amount of data that aviation will be receiving could be information overload for users. Need to ensure that they get the key information or if it can be filtered, otherwise it could be unusable for many operators.
- Education and guidance on future services and the data that is provided will be required by many users.
- The support State Volcano Observatories (SVOs) need to continue providing a service. This includes data sharing with MWOs or VAACs for monitoring remote volcanoes, cost recovery, guidance for Volcano Observatory Notice for Aviation (VONA) and aviation colour code and potentially a review of service, the demand on staff for information, training and staffing, and the issue if VONA and aviation colour code are not issued.
- Verification of dispersion modelling output for the concentration of volcanic ash as verification comes from flying though volcanic ash clouds or satellite retrievals on clear days and how the forecaster will fit into the workflow for the new Quantitative Volcanic Ash (QVA0 concentration information service. Improvements in science to support the global effort.
- A volcano catalogue database to capture appropriate information for the VAACs, SVOs and Aviation industry to support dispersion modelling and historic knowledge.

### 1.2. ICAO Meteorological Panel Working Groups

1.2.1. The WG-MOG-IAVW is responsible for operational oversight in the global system for volcanic ash, namely the International Airways Volcano Watch (IAVW) and developing future services for volcanic ash and sulphur dioxide. The IAVW work stream is working on the Concept of Operations to identify user needs, determining shortfalls, refining concept of operations, and defining functional and performance requirements for new information related to volcanic ash. The MOG-IAVW is also looking at the requirements of $SO_2$ reporting and the future of volcanic ash products including concentration charts and graphics. The key action items for the new WG-MOG IAVW include:

- Timeliness and accuracy of key performance indicators to look at VAAC consistency, compliance and forecasts.

- Looking towards the future with the roadmap for the Concept of Operations and IAVW.
- Annex 3 Amendment 81 will contain the elevation of Volcano Observatory Notice for Aviation (VONA) to recommended practice in 2024 in TAC and IWXXM formats and the removal of the aviation colour code from the Volcanic Ash Advisory (VAA) so it only appears in the VONA for consistency purposes. The group is actioning several tasks which are directly related to the above endorsement which includes:
    - IAVW updates,
    - regional engagement activities, and
    - guidance and educational materials.
- Annex 3 Amendment 81 will contain the provision of new quantitative volcanic ash (QVA) services from Volcanic Ash Advisory Centres (VAACs). The group is actioning several tasks which are directly related to the above endorsement which includes:
    - defining 'significant volcanic ash cloud',
    - QVA IWXXM schemas,
    - QVA data delivery, and
    - guidance and educational material.
- Looking at the $SO_2$ requirements for the provision of a new service has been put on pause until QVA is operational and a new user requirement has been defined.

1.2.2. The timeframe for QVA in Annex 3 Amendment 81 will be:

a. Recommended Practice: all VAACs in a position to do so by November 2024 should issue forecasts of quantitative volcanic ash concentration information for significant volcanic ash clouds;

b. Recommended Practice: all VAACs by November 2025 should issue forecasts of quantitative volcanic ash concentration information for significant volcanic ash clouds; and,

c. Above becomes a Standard in November 2026. (looking to be in Annex 3 Amendment 82)

Note: Significant volcanic ash cloud in this context means an ash cloud that poses widespread impact to aircraft operations and air navigation.

1.2.3. All nine VAACs are heavily involved in developing these capabilities. The next steps will involve looking at the service and consistency as well as education and guidance for users of the quantitative volcanic ash concentration information. Thresholds and forecast conditions will be placed in PANS-MET. Any delays to the Annex 3 update schedule could delay this work.