

*International Civil Aviation Organization***ICAO****INFORMATION PAPER****Asia and Pacific (APAC)  
Thirteenth Meeting of the Meteorological Services  
Working Group (MET/S WG/13)**

Bangkok, Thailand, 29 to 31 March 2023

**Agenda Item 6: Guidance and education related to the provision of meteorological services****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 the three APAC Volcanic Ash Advisory Centre's (VAAC) Darwin, Tokyo, and Wellington, covering the period 1 January 2022 to 31 December 2022.

**1. INTRODUCTION**

1.1 This paper presents a summary of key operational items within the three APAC VAAC's and their area of responsibility between 1 January 2022 and 31 December 2022. Further information can be requested of the any of the VAACs separately.

1.2 The nine VAACs provided a Combined VAAC Management report to the METP Working Group – Meteorological Operations Group – International Airways Volcano Watch (WG-MOG-IAVW) in the recent face-to-face meeting on 7-9<sup>th</sup> February 2023 in Rotorua, New Zealand. The report showed the nine VAACs coordinating well to consolidate the required information to present to the meeting representatives to review and discuss.

1.3 The APAC VAACs are trialling a similar process to this with the combined APAC VAAC management report for the MET/S WG/13 with the potential to use the WG-MOG-IAVW Combined VAAC Management report to present to MET/S WG in the 2024 meeting.

**2. DISCUSSION**VAAC Darwin activity

2.1 VAAC Darwin issued 2006 advisories for the reporting period 1 January 2022 to 31 December 2022 (Appendix A table 1). Activity has been scattered amongst a number of volcanoes throughout this reporting period and there were 6 high impact eruptions. The activity per volcano is summarised in Figure 1.

2.2 There are 20 VAAC competent forecasters, these forecasters work within the Bureau of Meteorology's (the Bureau) Hazardous Weather Unit (HWU).

2.3 The VAAC is looking at new ways to train staff including a case study for the Hunga Tonga Hunga Ha'apai eruption which is almost ready as an exercise for new staff members and refresher for other staff. VAAC Darwin will look to do a full review of the VAAC competency after the work being started by WMO for a VAAC competency framework.

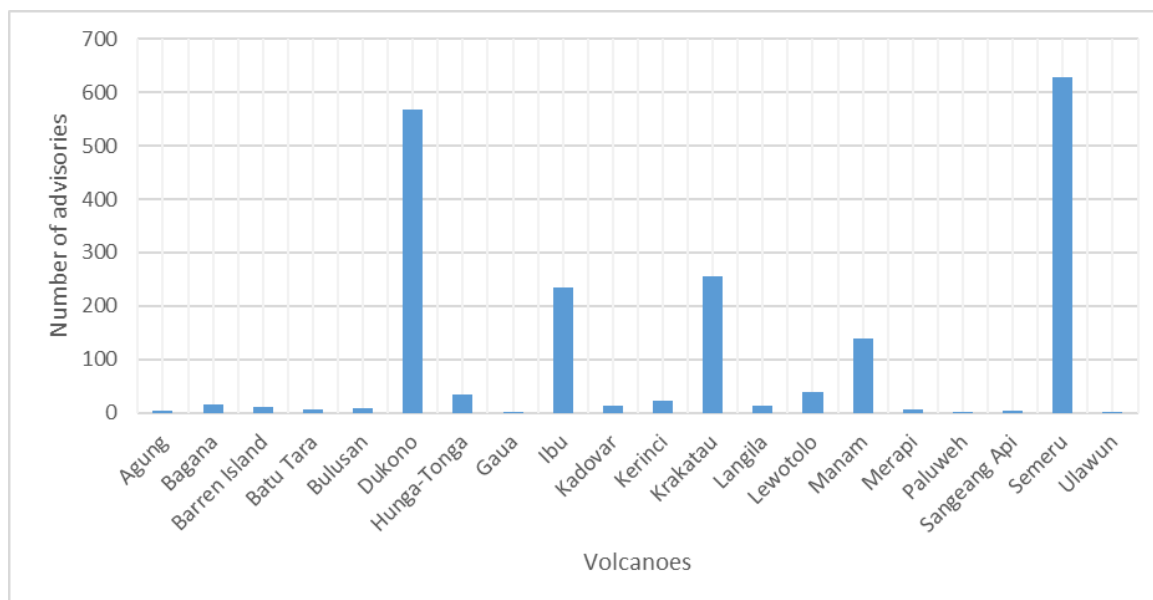
2.4 VAACs Darwin and Wellington have been supporting Solomon Islands with the removal of their air navigation deficiency with standalone volcanic ash exercises and data collection. The VAACs and Solomon Islands plan to continue to work together on a more day-to-day basis. A similar approach will now be used to support Papua New Guinea.

2.5 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).

2.6 There was a back-up test conducted between VAAC Darwin and VAAC Wellington on 16 June 2022 to test dissemination of VAAs. There were 7 responses from users. VAAC Darwin and VAAC Tokyo conducted a back-up test on 21 July 2022. A full test was carried out to test new procedures after the review of back-up documentation. There were multiple responses from operators for positive receipt.

2.7 VAAC Darwin, VAAC Montreal and VAAC Washington have been carrying out back-up tests every 3 months. The last back-up test was conducted on 11 November 2022. Instead of the regular back-up test, the VAAC Darwin staff issued a real advisory for one of the VAAC Washington volcanoes and the dissemination was tracked to a number of locations. A Corresponding WV SIGMET was issued for the advisory which indicated that the users had received the advisory issued under back-up.

2.8 Through the ICAO METP WG-MOG-IAVW, the VAACs have been supporting the development of key performance indicators, elevation of the Volcano Observatory Notice for Aviation (VONA) and aviation colour code discussions, delivery of the Initial Operating Capability (IOC) for Quantitative Volcanic Ash (QVA) information service, education and guidance materials for QVA, and best practices and consistency between the VAACs on the QVA information service. The other big task is the dissemination of this data in IWXXM and gridded datasets.



**Figure 1 - Advisories by volcano for the VAAC Darwin area of responsibility for 1 January 2022 to 31 December 2022.**

VAAC Tokyo activity

2.9 A total of 2336 Volcanic Ash Advisories (VAAs) and 986 accompanying Volcanic Ash Graphics (VAGs) were issued for the Tokyo area over the period of this report (Appendix A Table 1). 99.9% of VAA/VAG issued were operational, relating to actual VA events or VAAC backup notices (Figure 2.)

2.10 On 24th March 2022, VAAC Tokyo began issuing VAAs in IWXXM format.

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 The mutual backup agreement between VAAC Tokyo and VAAC Darwin was modified on 12th May 2022 to ensure smooth backup operations. In accordance with the modified procedures, the annual backup test was successfully conducted in July 2022. VAAC Tokyo issued no VAA on behalf of VAAC Darwin for its backup operations during the reporting period.

2.13 VAAC Tokyo continues to assist the Philippine Institute of Volcanology and Seismology (PHIVOLCS) in issuing VONA promptly. This helps VAAC Tokyo's smooth operations to issue VAAs triggered by VONAs.

2.14 Looking ahead to the elevation of recommended practice of Quantitative Volcanic Ash concentration information, VAAC Tokyo works to develop probabilistic forecasting methods. 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.

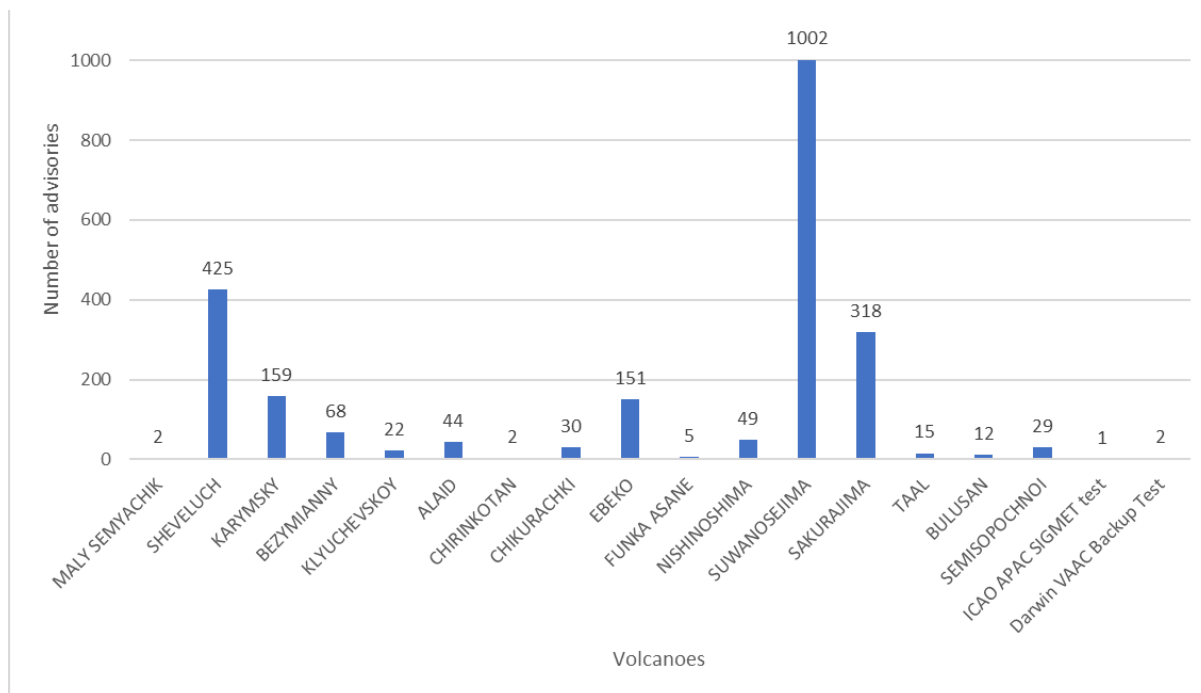


Figure 2 - Advisories by volcano for the VAAC Tokyo area of responsibility for 1 January 2022 to 31 December 2022.

### VAAC Wellington activity

2.15 VAAC Wellington issued 96 advisories for the reporting period 1 January 2022 to 31 December 2022, including 4 exercise (EXER) and 2 test (TEST) advisories (Appendix A Table 1). Most events were low level, low impact, except for Hunga Tonga – Hunga Ha’apai. The activity per volcano is summarised in Figure 3.

2.16 There are 28 Aeronautical Meteorological Forecaster (AMF) competent forecasters as per WMO and ICAO requirements, with 5 based out of the Auckland office and 1 in the Christchurch office for added resilience. We had 6 new forecasters joined the Aviation/VAAC team this year. Alongside our full AMF competency we have an additional 3 VAAC specific forecasters there.

2.17 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.

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

2.19 VAAC Wellington was in close contact with the SVO USGS and MWO American Samoa during the unrest at Ta’u Island in August 2022. This was a new connection for us, and although there was no volcanic ash activity in the end, the development of this connection will be useful for future activity.

2.20 VAAC Wellington continues to assist the Tonga Meteorological Service (TMS) and Solomon Islands Meteorological Service (SIMS) with addressing long-standing ICAO deficiencies. We are looking at further ways to support their progress with opportunity to practise using exercises.

2.21 A backup test was conducted with on 16 June 2022 to test a fix which allows VAAC Wellington to issue products on behalf of VAAC Darwin, mimicking the VAAC Darwin bulletin header. This fix eliminates the reliance on Airways NZ to disseminate the product on VAAC Wellington’s behalf and was successfully proven in this test.

2.22 VAAC Wellington made no significant model upgrades during 2022 but is looking to updated our VOLCAT system in 2023. In November 2022, VAAC Wellington switched over to using Himawari-9 satellite.

2.23 VAAC Wellington are still in the early stages of developing the QVA concentration service.

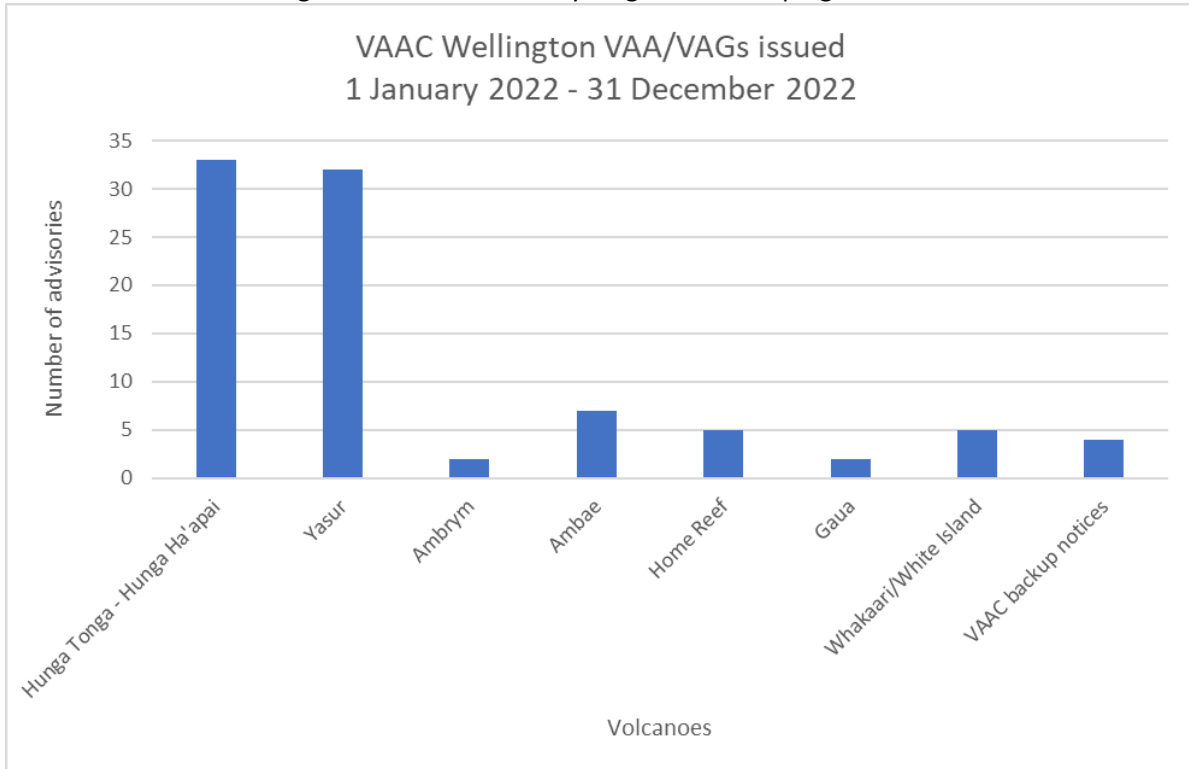


Figure 3 Operational VAA/VAG issued by VAAC Wellington for 1 January 2022 – 31 December 2022

**3. ACTION BY THE MEETING**

3.1 Note the information contained in this paper.

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**APPENDIX A**

# VAAC Managers combined report

## INTRODUCTION

### Introduction of World Volcanic Ash Advisory Centres

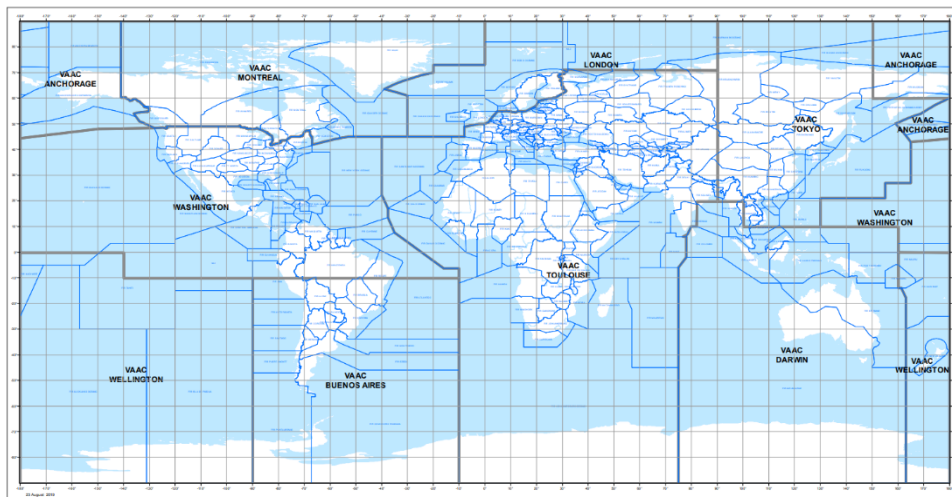


Figure 1: Area of Responsibility (AoR) for each VAAC (updated to 2019 map)

## DISCUSSION ON OPERATIONS

### Issuance of VAA and VAG for the period 1 January 2022 to 31 December 2022

2.1. The table below is a breakdown of the number of advisories issued by each VAAC, as well as a total. Note, the column “Volcanic Ash Advisory” includes nearly all advisories issued by the VAAC, including those for re-suspended ash as well as re-broadcast advisories. Note that advisories for re-suspended ash are also tallied in the column entitled “Re-suspended ash”. Only test and exercise advisories are not included in this column: they are accounted for in the “Test and exercise advisory” column.

Volcanic Ash Advisory Centre	Volcanic Ash Advisory	Volcanic Ash Graphic	Re-suspended ash	Test and exercise advisory	“False alarm” VAA
Darwin	2006	2006	4	11	0
Tokyo	2336	986	53	3	0
Wellington	90	90	5	6	1
<b>Total</b>	<b>4432</b>	<b>90</b>	<b>62</b>	<b>20</b>	<b>1</b>

Table 1 The total number of advisories issued by each VAAC including the number of test/exercise or back-up advisories for each VAAC between the period of 1 January 2022 to 31 December 2022 (inclusive).

### 2.2 Significant satellite imagery, modelling or technical changes

This section describes significant satellite, model or technical changes that influenced the performance of operations. The aim is to summarize how technology has been used to enhance the operational capability of the VAACs. Any new tools can be mentioned in this section.

#### VAAC Darwin

VAAC Darwin recently upgraded its Dispersion Ensemble Prediction System (DEPS) software to version 2 which has included new features to help improve the dispersion modelling output.

VAAC Darwin has transitioned to using the new Himawari-9 imagery from JMA.

#### VAAC Tokyo

On 24th March 2022, VAAC Tokyo began issuing VAAs in IWXXM format.

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.

### VAAC Wellington

A backup test was conducted with on 16 June 2022 to test a fix which allows VAAC Wellington to issue products on behalf of VAAC Darwin, mimicking the VAAC Darwin bulletin header. This fix eliminates the reliance on Airways NZ to disseminate the product on VAAC Wellington's behalf and was successfully proven in this test.

An improved Volcano Monitoring Tool for internal use was released in November 2021. The tool provides a central location to access monitoring tools, including webcams, NOAA/CIMSS observations, satellite imagery, lightning data and links to internal procedures. Further updates are being investigated to include VOLCAT alert emails to the tool.

## 2.3 Competency, Training and Education

This section highlights any noteworthy competency, training or education work undertaken at the VAACs during the reporting period.

### VAAC Darwin

VAAC Darwin has 20 VAAC competent staff members. These staff members work as part of the Hazardous Weather Unit (HWU) where they rotate through VAAC/Aviation desks so there is always 2 to 3 VAAC competent staff working a shift which gives greater support during high impact eruption events.

The Hunga Tonga-Hunga Ha'apai eruption in January 2022 tested a number of different operational procedures (stratospheric eruption, ash cloud approaching boundary, ash cloud handover etc). VAAC Darwin is developing a training exercise using the data from the eruption to train new staff and refresh existing staff.

VAAC Darwin and VAAC Montreal continued to support WMO Expert Team on Education, Training and Competency (ET-ETC) on top-and second-level competencies for aeronautical meteorological personnel to accommodate the role of VAAC forecasters. Looking at what is required for VAAC competency framework.

### VAAC Tokyo

5 VAA forecasters from the Volcanic Observation and Warning Center (VOWC) at JMA's Tokyo headquarters (responsible for mitigating ground-based eruption hazards) support VAAC Tokyo's services. For around-the-clock monitoring of volcanic activity, VOWC runs five operation units, each employing three forecasters tasked with issuing VAAs, volcanic warnings/forecasts and ash fall forecasts.

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.

VAAC Tokyo holds meetings every two months at which forecasters review past volcanic ash events to improve related operations and VAA products.

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.

### VAAC Wellington

VAAC Wellington has 28 AMF (Aeronautical Meteorological Forecaster) competent forecasters as per WMO and ICAO requirements, with 5 based out of the Auckland office and 1 in the Christchurch office. 6 new forecasters joined the Aviation/VAAC team this year. We also have an additional 3 VAAC specific forecasters.

VAAC Wellington has two separate competencies that forecasters have the full AMF and VAAC specific competencies, however we haven't run anyone through the VAAC specific competency during 2022 due to staffing pressures across the full forecasting team.

Three-times/week testing of VA scenarios continues to benefit the team in staying current.

## 2.6 Outreach for stakeholders and SVOs

This section discusses any outreach events, meetings, triumphs, issues, concerns, new ideas, etc.

### VAAC Darwin

VAAC Darwin is expanding its connection with key stakeholders using MS Teams:

- The channel with VAAC Wellington and MWO Nadi are continually used to collaborate and share information. The channel was highlighted through the Hunga Tonga-Hunga Ha'apai eruption in January 2022.
- VAAC Darwin and VAAC Wellington are looking to start a channel with MWO Honiara and a separate one for MWO Port Moresby.

VAAC Darwin along with VAAC Wellington have supported Solomon Islands Meteorological Service (SIMS) with their long-standing ICAO Air Navigation Deficiencies for lack of SIGMETs. With the success of the work with SIMS, VAAC Darwin will be using a similar approach to support Papua New Guinea in the near future.

VAAC Darwin supported Indonesia with their recent ICAO APAC VOLCEX 20/01 exercise.

### VAAC Tokyo

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 documents.

In December 2022, JMA began providing Himawari-9 products in conjunction with SVOs and other stakeholders.

### VAAC Wellington

VAAC Wellington has expanded our connection with key stakeholders using Microsoft Teams:

- Our Teams Chat groups with VAAC Darwin and MWO Nadi continue to be well used and valuable.
- Our three weekly chats with the New Zealand SVO (GNS) have been expanded to include NEMA (National Emergency Management Agency) 24hr Operations Centre.
- We have set up a new Teams Channel with Tonga Meteorological Services.
- We connected with American Samoa when there was increased activity reported in their area.

VAAC Wellington continues to assist the Tonga Meteorological Service (TMS) and Solomon Islands Meteorological Service (SIMS) with addressing long-standing ICAO deficiencies.

A post event review of the Hunga Tonga – Hunga Ha’apai eruption was held in March and attended by representatives from New Zealand aviation agencies.

### 2.7 Volcanic events of interest

This section highlights events of interest that VAACs wish to share. This can include summaries, analyses, insights, lessons learned, etc. This section can also point readers to more in-depth work.

### VAAC Darwin

Mt Hunga Tonga-Hunga Ha’apai is a volcano in Tonga that is activity monitored by VAAC Wellington. On 15 January at 0400 UTC, there was an eruption from the volcano which was initially issued to FL500 in the VAAC Wellington AOR. VAAC Wellington and VAAC Darwin were collaborating closely at the start of the stratospheric eruption confirming the height assessment and movement between forecasters. The VAACs were sharing PIREPs received from multiple airlines confirming hazy volcanic cloud high above cruising altitude.

VAAC Wellington handed over the responsibility of the volcanic ash cloud to VAAC Darwin but continued to provide support by passing on all information related to the event. As the volcanic ash was in the stratosphere, the particles were expected to remain in the stratosphere and not fallout as it is above the cloud forming layer. The base of the ash cloud used varied from FL400 to FL450, which represented the height of the tropopause. The ash cloud passed from VAAC Wellington to VAAC Darwin AOR for which rebroadcast products were issued and ash cloud handover was conducted. The cloud continued to move over Australian FIRs in a layer from FL400/FL630, trapped in the stratosphere above the tropopause. As the ash cloud moved over the Indian Ocean, the collaboration and coordination started with VAAC Toulouse before the ash became too difficult to discern, at which point the advisory was finalised on 22/2340 UTC.

The Hunga Tonga-Hunga Ha’apai eruption tested many IAVW operational procedures between VAAC Wellington, VAAC Darwin and VAAC Toulouse.

### VAAC Tokyo

In relation to the eruption of the submarine volcano Hunga Tonga-Hunga Ha’apai 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 engaged in assessment of the potential for meteo-tsunami generation with large eruptions causing plumes of FL500 or higher. For this operation, VAA data are also utilized to detect major eruptions.

### VAAC Wellington

The eruptions at Hunga Tonga-Hunga Ha’apai from 20th December 2021 through to the very large eruption on 15 January 2022 was a new experience for our VAAC. It was at first for dealing with an eruption that entered the stratosphere, and for issuing multi-polygon VAA. The stratospheric ash cloud was moving to the west, while an ongoing eruption continued above the volcano. The winds in the stratosphere were easterlies which matched the westward-moving activity seen on satellite imagery and confirmed the intrusion into the stratosphere was higher than the initial assessment. The advisory was updated to FL630 which is the limit in the software used to produce VAA/VAGs, even though the eruption was reported to approximately 31 km (101,000 ft) at the time. VAACs Wellington and Darwin closely collaborated during this event.

The eruptions also provided Tonga Meteorological Service the opportunity to show their progress in producing VONA.

## 2.8 VAAC collaboration

This section mentions work done by VAACs on common tasks, visits, information exchanges, etc. Collaboration or efforts to develop working relationships with State Volcano Observatories can be included in this section.

### VAAC Darwin

VAAC Darwin is working closely with VAAC Wellington on a number of collaboration tasks to work closely as neighbouring VAACs. Both VAACs have also been finetuning procedures to share ground reports for volcanoes with the potential to affect both VAAC area of responsibilities.

VAAC Darwin has worked with VAAC Washington and VAAC Montreal to conduct multiple back-up test session. The idea is to conduct these tests every 3 or so months to allow VAAC Darwin and VAAC Montreal time to get accustomed to the activity seen by VAAC Washington.

### VAAC Tokyo

Since May 2022, VAAC Tokyo has run monthly VONA issuance drills with PHIVOLCS (the Philippine Institute of Volcanology and Seismology) to support prompt issuance in actual events.

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

### VAAC Wellington

VAAC Wellington continues to work closely with VAAC Darwin, attending and presenting at various Australian Aviation Industry Meeting.

We are working on a plan to upgrade our VOLCAT system during 2023.

A planned presentation to the National Geohazards Monitoring Centre team (NGMC) on what we do as a VAAC was postponed due to illness but will be picked up again in 2023. We are also planning a bigger Info Share session between the New Zealand SVO (GNS) and the VAAC in March/April 2023, where both agencies present to each other.

### Future developments, steps towards Roadmap or ConOps for IAVW

This section describes work that has been done towards progressing the future of IAVW such as Quantitative Volcanic Ash (QVA) forecasts, probabilistic forecast and concentration plot capabilities, information sharing capabilities (collaboration tool), etc. Both the IAVW [Roadmap](#) and [ConOps](#) are guiding documents for the work described in this section.

### VAAC Darwin

The Bureau has deployed the Dispersion Ensemble Prediction System (DEPS) 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.

### VAAC Tokyo

VAAC Tokyo works to develop probabilistic forecasting methods 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 the determination of initial parameters for transport modelling.

### VAAC Wellington

VAAC Wellington has started scoping out requirements for QVA Concentration Service, including working in with user groups.