

*International Civil Aviation Organization*



ICAO

**INFORMATION PAPER**

**Twenty-fifth Meeting of the Meteorology Sub-group  
(MET SG/25)**

Online, 18 – 22 October 2021

**Agenda Item 5:** Research, development and other initiatives

**VAAC DARWIN MANAGEMENT REPORT**

(Presented by Australia)

**SUMMARY**

The paper presents a combined IAVW Management Report for the VAAC Darwin covering the period 1 July 2020 to 31 August 2021. It provides an update on current activities, significant operational changes, training and development, collaboration and stakeholder engagement.

**1. INTRODUCTION**

1.1 The full report is contained in Attachment A. The discussion points below contain a summarisation of the key topics.

**2. DISCUSSION**

Key topics from the report in Attachment A

2.1 VAAC Darwin issued 2580 advisories in this reporting period. The most advisories were issued for Dukono, Semeru and Sinabung in Indonesia.

2.2 The activity per volcano has been summarised in Figure 1 and 2 in Attachment A. (Note: a financial year runs from 1 July to 30 June the following year)

2.3 Mt Lewotolo, in the Lesser Sunda Islands in Indonesia, erupted to 50,000ft on 29<sup>th</sup> November 2020. Volcanic ash quickly moved southeast towards Australian airspace. The ash dissipated quickly, and satellite imagery showed no discernible ash; however, there was a strong lingering SO<sub>2</sub> signal that continued to move to the southeast and over central Australia.

2.4 Over the period 6<sup>th</sup> to the 15<sup>th</sup> of February there was an ongoing eruption at Mt Raung on Java, Indonesia with the eruption height varying from 13,000 to 23,000ft. The plume moved across the island of Bali, Indonesia with ash reaching over to Lombok Island at times.

2.5 The VAAC is creating new ways to train and assess forecasters' skills while they are gaining their competency. WMO will be looking at a review of the current VAAC competency framework with

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support from VAAC Darwin and VAAC Montreal to better align with Aeronautical Meteorological Forecaster (AMF). Work is progressing on creating a separate VAAC competency framework.

2.6 VAAC has transitioned to its new position in the Hazardous Weather Unit (HWU) under the new Melbourne Aviation Forecasting Centre (MAFC) in June 2020. It's been a year since the transition and the service continues to run smoothly as the team builds up knowledge and experience for the newest team members. The coordination is working well between desks with workloads. The MAFC and VAAC Darwin now have 20 VAAC competent staff who rotate around the HWU.

2.7 The VAAC and MAFC have been adapting to the ever-changing situation with COVID-19 affecting Australia. Commencing March 2020, the team has been looking for ways to continue the services and transition to work from home with no interruption to services. The current situation has the team split up into three different areas (Melbourne Office levels 5 and 11, and home-based work) but the communication and collaboration between the forecasters has been impressive and the response to high level eruptions has been as timely as ever.

2.8 VAAC Darwin has fixed an inconsistency with the Volcanic Ash Advisories (VAA) as our internal software now allows different DTG and OBS DTG. The product issue time (DTG) and the time of observation (OBS DTG) were always the same, now we can reflect that the observation time or the time of our observation polygon is based on imagery which is slightly older due to delay in receiving that imagery. This is consistent with the other VAACs.

2.9 VAAC Darwin and VAAC Montreal are still progressing with their back-up support for VAAC Washington. Dissemination testing has been in progress during the last 6 months. All VAACs will be aligning their back-up procedures due to previous issues with consistency and will now be notifying users with a message "*Issued by VAAC nnnnn on behalf of VAAC nnnnn*" in the VAA. The Bureau of Meteorology is also looking to add the VAAC back-up messages issued by VAAC Darwin on its external webpage.

2.10 VAAC Darwin is producing VAA in IWXXM format using schema version 3.0.

2.11 The Bureau operationalised Dispersion Ensemble Prediction System (DEPS) in 2020, 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 current major upgrade to the system is almost ready to be put into operations as DEPS2. DEPS2 will support the quantitative volcanic ash information such as ash concentration products or data as part of the international work from the ICAO Meteorology Panel (METP) Meteorological Information and Services Development (WG-MISD).

2.12 VAAC Collaboration has strengthened between VAACs Darwin and Wellington as they look to harmonise services. The two VAACs have been working on operational processes and procedures, comparison of ash dispersion models, comparison of advisory and forecast creation, daily check-ins, and back-up services and exercises. VAAC Darwin will look to expand collaboration efforts with VAAC Tokyo in a similar way in the near future.

2.13 VAACs Darwin and Wellington conducted a standalone volcanic ash exercise to support Solomon Islands with 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 exercise. Progress report was provided to the MET-SG24 and both VAACs will continue to support Solomon Islands to remove the deficiency. We are running through offline VA SIGMET checks with

Solomon Islands before conducting another standalone volcanic ash exercise on 30<sup>th</sup> September 2021 to evaluate their new understanding.

2.14 VAAC Darwin has contributed to other stakeholder engagement within the region as the international requirements will increase for training and coordination between VAACs and State Volcano Observatories.

2.15 The ICAO Meteorological Panel (METP) Working Group on Meteorological Operations Group (WG-MOG) International Airways Volcano Watch (IAVW) has been focusing on:

- key performance indicators to enhance consistency and accuracy of VAAC forecasts;
- elevation of the Volcano Observatory Notice for Aviation (VONA) to be an ICAO Annex 3 recommended practice and discussions around aviation colour codes; and
- progression of the Volcanic Ash Roadmap and Concept of Operations documentation.

2.16 The VONA elevation was recently approved by the METP to have the VONA as a recommended practice with a new VONA template as well as having the aviation colour code only appear in the VONA and removed from the VAA by November 2023.

2.17 The ICAO METP Working Group on Meteorological Information and Services Development (WG-MISD) Work Stream on Volcanic Ash and Sulphur Dioxide (VASD) is focusing on developing a potential operating capability for sulphur dioxide (SO<sub>2</sub>) services and having an initial operating capability (IOC) for the delivery of probabilistic quantitative volcanic ash information services. The IOC was recently approved by the METP to have quantitative volcanic ash information services included in Annex 3 and a timeline for this service to go from recommended practice to standard as follows:

- a. Recommended Practice: all VAACs in a position to do so by November 2023 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.

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

### **3. ACTION BY THE MEETING**

3.1 Note the information contained in this paper.

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**Appendix A****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.

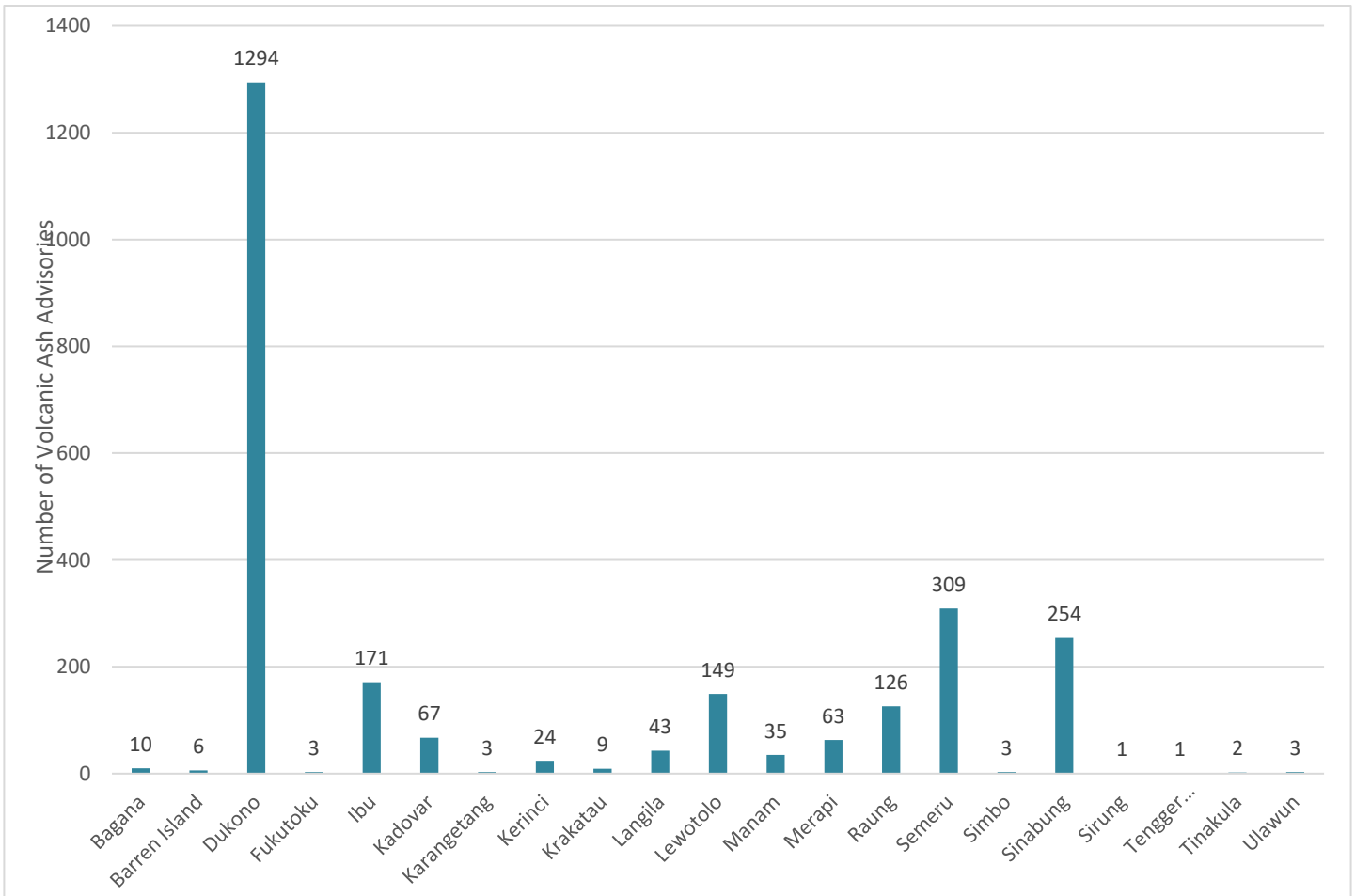
**2. VAAC STATISTICS**

VAAC	Period of reporting	Total number of Advisories	High Impact Events*
Darwin	1 July 2020 – 31 August 2021	2580	Lewotolo 29 November 2020 Semeru 21 August 2020 30 November 2020 Sinabung 10 August 2020 14 August 2020 06 June 2021 Merapi 27 January 2021 Raung 06 – 15 February 2021

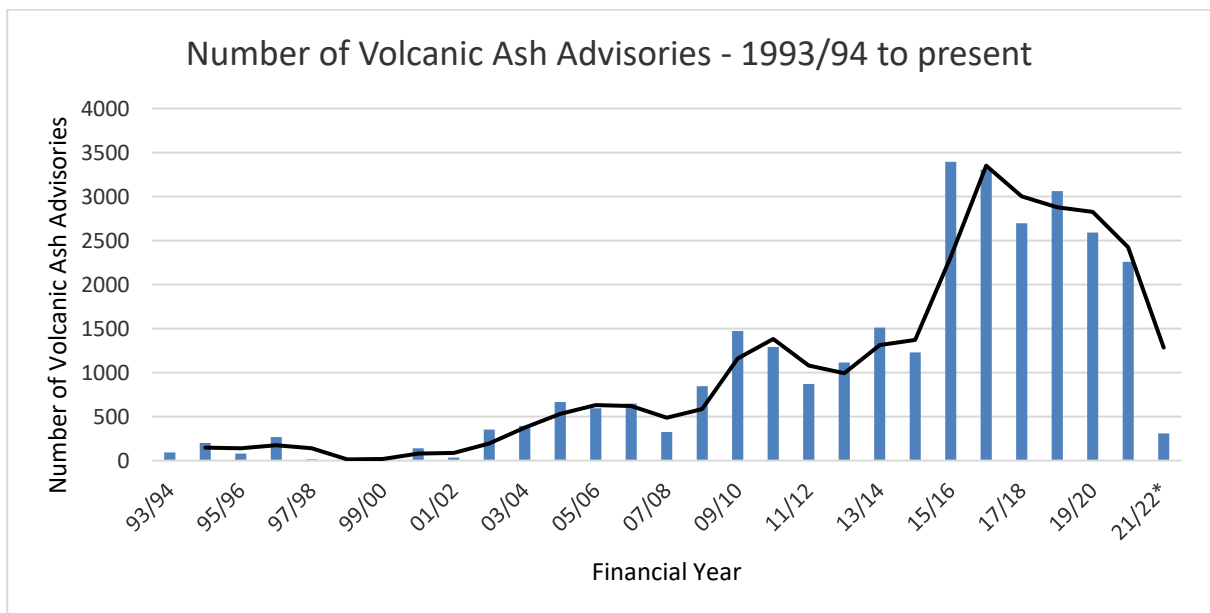
\* Discernible or visible ash that is impacting or expected to impact aircraft cruising levels, international aerodromes, is of high media interest, or is deemed to be significant to aviation operations by a VAAC

2.1. A total of 2580 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 1 shows the number of advisories issued by VAAC Darwin (reported by volcano) during FY 20/21. FY 20/21 has continued with low impact volcanic activity. In the VAAC Darwin area of responsibility (AOR), Mt Dukono, in northern Halmahera, Indonesia erupted almost continuously through this period with 1161 advisories. Other volcanoes with sustained volcanic activity include Mt Semeru in Java, Indonesia with 278 advisories and Mt Sinabung, on Sumatra, Indonesia, recording 254 advisories over the year. Collectively, these three volcanoes were responsible for 75% of all advisories issued by VAAC Darwin for this period. The volcanoes which have had high impact eruptions include Mt Lewotolo in the Lesser Sunda Islands in Indonesia, Mt Semeru and Mt Raung on Java in Indonesia and Mt Sinabung on Sumatra in Indonesia. In order to provide context, Figure 2 features the total number of advisories issued by VAAC Darwin (by FY) since 1993.



**Figure 1** - Advisories by volcano for the VAAC Darwin area of responsibility for 1 July 2020 to 31 August 2021.



**Figure 2** - VAAC Darwin: Number of advisories for Financial Years 1993/94 - 2020/21

### 3. HIGH IMPACT ERUPTIONS

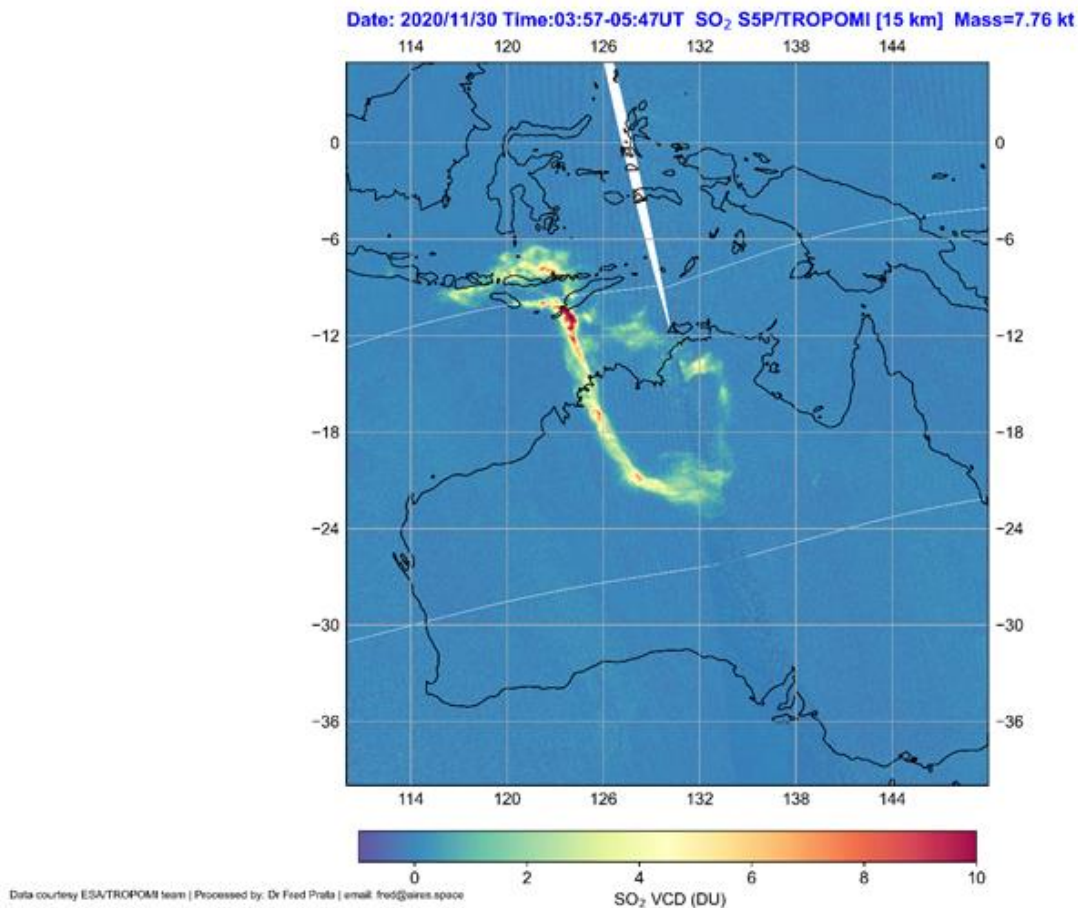
#### 3.1. Lewotolo, Lesser Sunda Islands Indonesia – 29 November 2020

3.1.1. Mt Lewotolo is in the Lesser Sunda Islands in Indonesia. From early November there was an increase in seismic activity and thermal anomalies appearing at the volcano. On 27<sup>th</sup> November, there was a VONA for continuous emission which was observed on satellite imagery and an advisory issued to 6,000ft. On the November 29<sup>th</sup> at 0150 UTC, Mt Lewotolo erupted with ash reaching -60 degrees Celsius or 50,000ft. Figure 3 shows the ground report from Indonesia by Centre of Volcanology and GeoHazard Mitigation (CVGHM) and the satellite imagery at 0400 UTC. Satellite imagery indicated that the high-level ash was drifting to the southeast and a low-level component to 18,000ft moving to the northwest.

3.1.2. The ash continued to move to the southeast towards Australia. The signal appeared to have a significant Sulphur Dioxide (SO<sub>2</sub>) component as the volcanic ash started to dissipate. The ash moved into the Brisbane FIR and over Australia. The ash quickly separated from the SO<sub>2</sub> and dissipated leaving no trace of ash on satellite imagery. The SO<sub>2</sub> continued to move into central Australia and linger for a while longer. Figure 4 shows the strong SO<sub>2</sub> signature from the Mt Lewotolo eruption. The eruption appeared to have a large volcanic gas component compared to its ash component.



**Figure 3.** Mt Lewotolo eruption on 29 November 2020 in the Lesser Sunda Islands in Indonesia. The left image shows the ground report from CVGHM (courtesy of CVGHM) and the right image shows true colour visible Himawari-8 imagery at 0400 UTC.



**Figure 4.** The SO<sub>2</sub> from the Lewotolo eruption on 29 November 2020. Shows the spread and strength of the SO<sub>2</sub> signal.

### 3.2. Semeru, Java, Indonesia – 21 August and 30 November 2020

3.2.1. Mt Semeru on Java in Indonesia has had many eruptions throughout FY 20/21 with 278 advisories issued. Typically, the activity has been observed as low-level and discrete which can dissipate quickly.

3.2.2. On 21<sup>st</sup> August there was a VONA received for Mt Semeru via the VAAC Darwin e-mail account for an eruption to 25,000ft but the VONA didn't appear on the Indonesian Magma/VONA website. The forecaster issued an urgent initial while waiting for satellite imagery to arrive and confirm the activity. On satellite imagery the activity was observed to 12,000ft as small discreet puffs so the follow up advisory was downgraded.

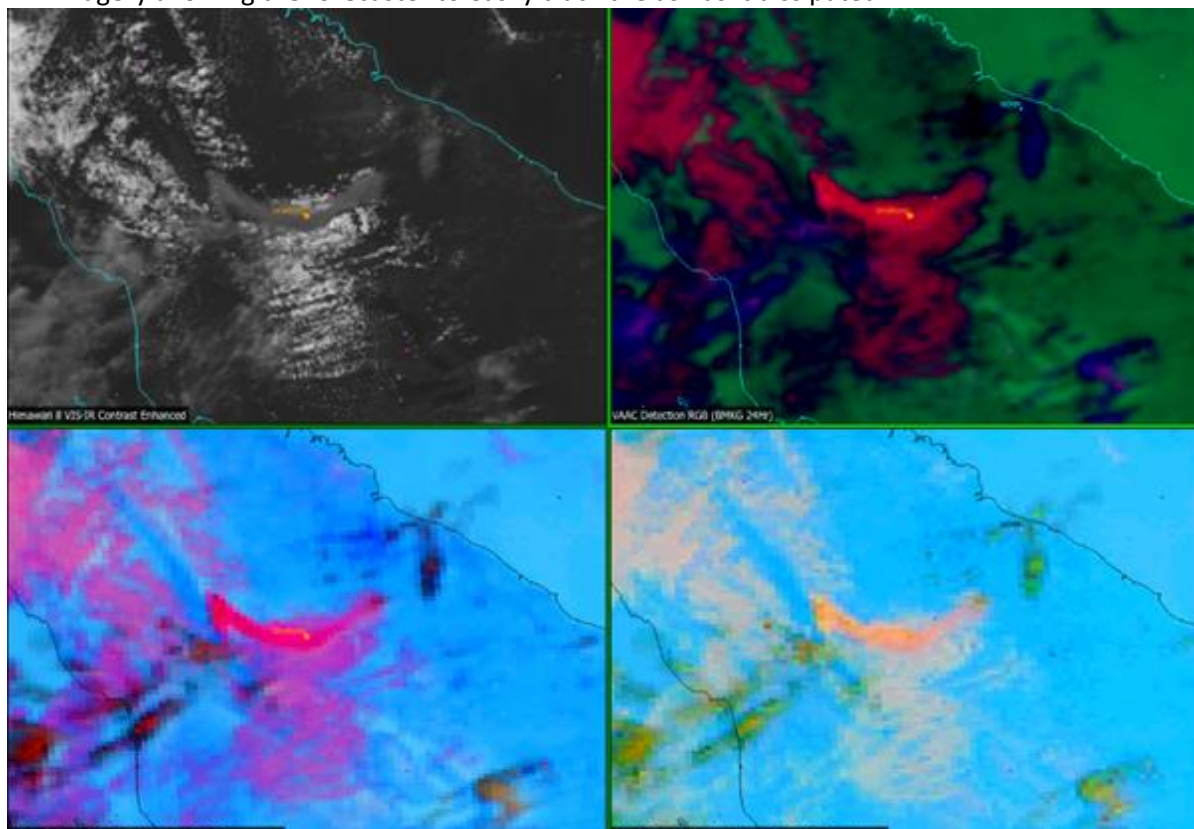
3.2.3. On 30<sup>th</sup> November there was reports of an eruption with landslides and possible ash rain. The webcam showed significant activity in the area. An urgent advisory was issued to 50,000ft which matched current observed activity on satellite imagery. The signature on satellite imagery was moving to the southwest. After one and a half hours, the high-level observation was reassessed as a thunderstorm which developed at the same time as the volcanic activity. An ash signal was observed on satellite imagery and an advisory was continued to 20,000ft to match the reassessment of activity.

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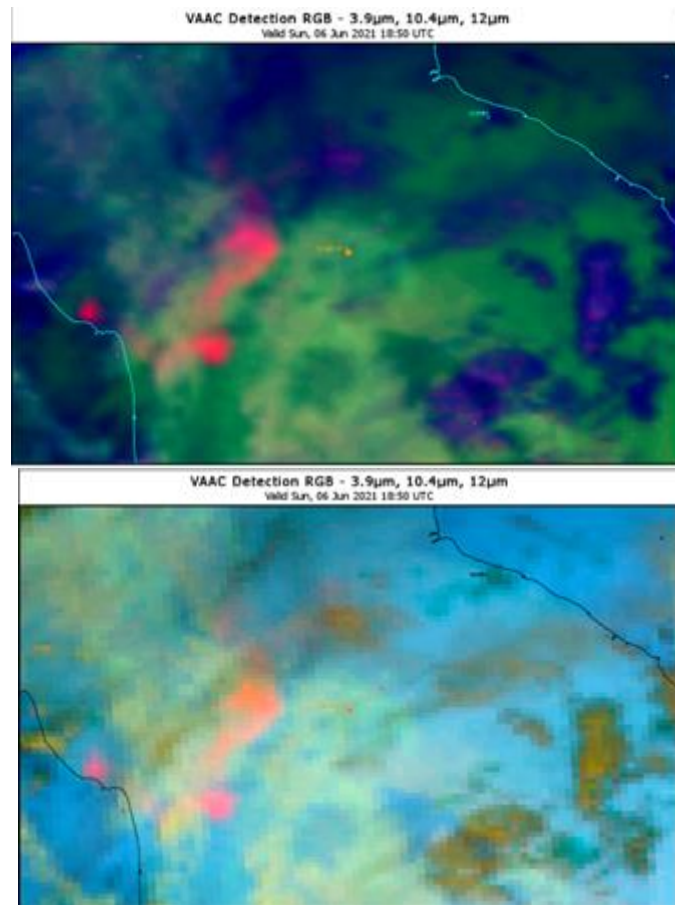
**3.3. Sinabung, Sumatra, Indonesia – 10 August 2020 and 6 June 2021**

3.3.1. On 10<sup>th</sup> August, there was an eruption observed on webcam and satellite imagery to 32,000ft. The ash quickly separated into two levels due to the wind profile above the volcano. The high-level component was moving to the west and the low-level component to 14,000ft was moving to the northeast (Figure 5). The eruption provided a clear and strong signal on satellite imagery allowing the forecaster to easily track the ash as it dissipated.



**Figure 5.** Himawair-8 imagery on 10 August for the eruption at Mt Sinabung. Top left is visible imagery, top right is RGB false colour image (bright red is volcanic ash), bottom left is RGB false colour image (bright pink is volcanic ash) and bottom right is RGB false colour image which highlights SO<sub>2</sub> as bright green.

3.3.2. A VONA reporting an eruption based on seismic data was issued at 1635 UTC on the 6<sup>th</sup> of June, however at the time the forecaster was not able to identify volcanic ash due to meteorological cloud near the summit. About half an hour later, the ash became visible on RGB false colour satellite imagery, and an urgent initial was issued. The height of the ash plume was estimated as 30,000ft and ash drifted both southwest and northwest of summit (Figure 6), due to shear in the wind profile. The ash from this discrete eruption dissipated after 10 to 12 hours.



*Figure 6. Himawair-8 imagery on 6 June for the eruption to 30,000ft at Mt Sinabung. Both images are false colour RGB: bright red is volcanic ash in the left image and bright pink is volcanic ash in the right image. The ash is identified to the north, west and southwest of the volcano, reaching as far as the coastline to the WSW of the summit.*

#### **3.4. Merapi, Java, Indonesia – Many discrete minor eruptions**

3.4.1. Mt Merapi on Java in Indonesia is one of the most highly monitored volcanoes in Indonesia. It is near Yogyakarta which is a densely populated area. The previous eruption in 2010 was devastating for the area and caused widespread evacuations as the eruptive activity continued for over a month.

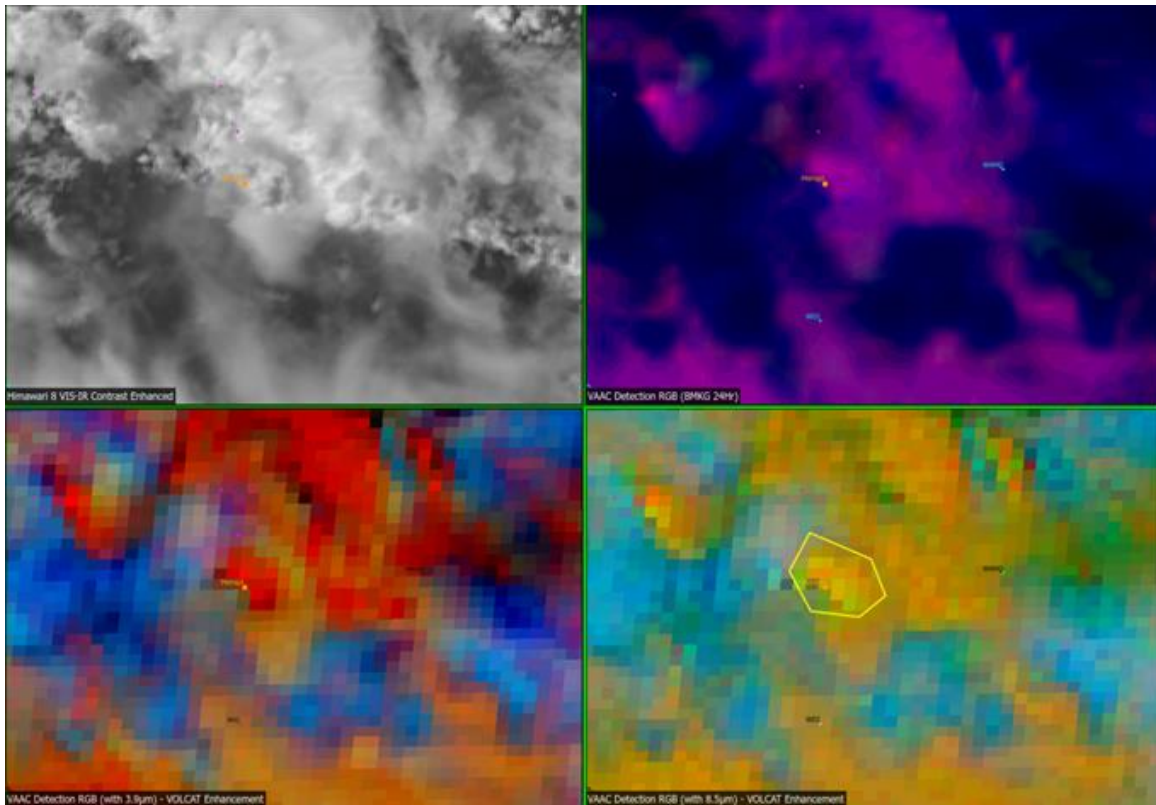
3.4.2. In 2020, the ground alert level at Mt Merapi was raised to Siaga or Level 3. There has been increased seismic activity at the volcano and many minor eruptions, pyroclastic flows and lava from the volcano which are still occurring in January 2021. The latest assessment from CVGHM is that the volcanic activity level is still quite high. Merapi is closely monitored by ground authorities and the VAAC.

3.4.3. On 27 January, an advisory for localised volcanic ash emissions near the summit was already valid, due to persistent pyroclastic flow activity. During the afternoon, a ground report was issued at 0650 UTC from Yogyakarta airport with information on a significant eruption underway. Social media sources also indicated that a large eruption had occurred. An urgent

initial advisory was issued and after 20 minutes a follow up advisory was able to identify volcanic ash to 40,000ft amongst a significant amount of thunderstorm activity on the island of Java. The high-altitude component of the ash was no longer discernible and overnight the advisory was lowered to 12,000ft after heavy rainfall was expected to have washed out the largest ash particles from the atmosphere.



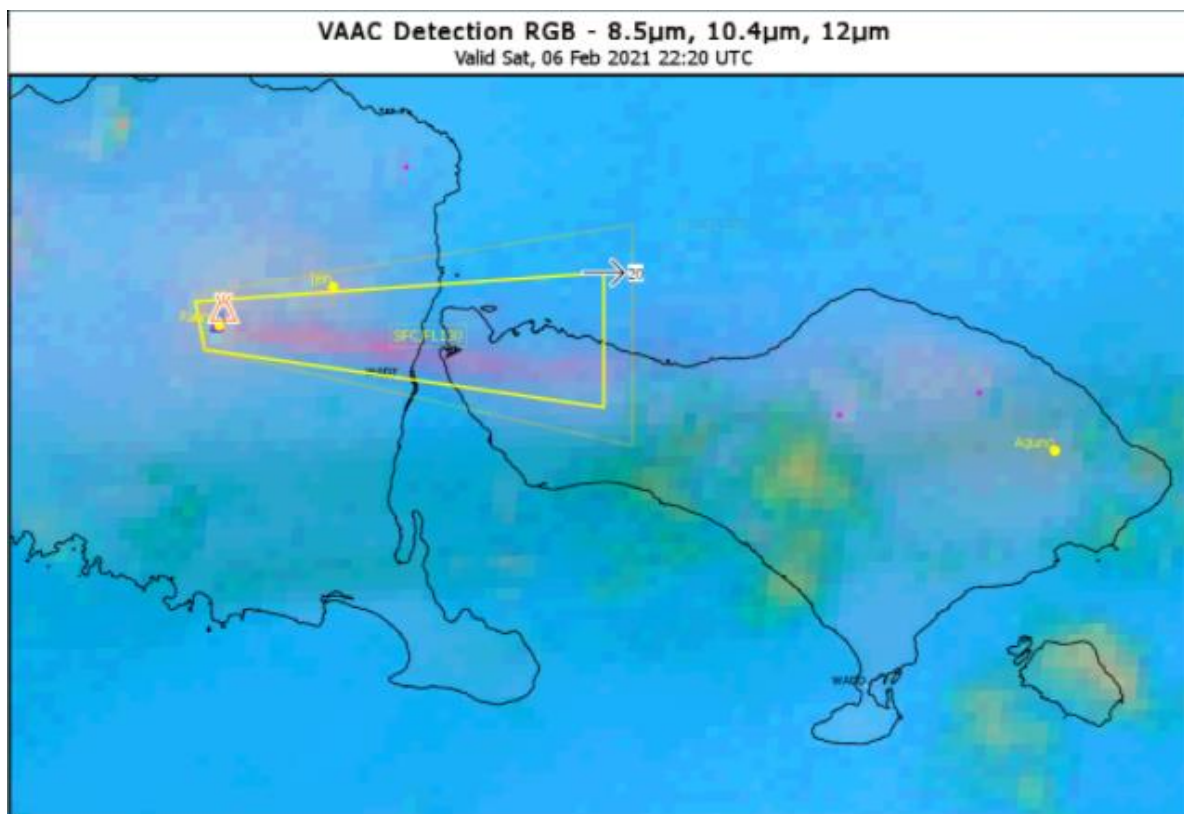
*Figure 7. Photograph from social media of the eruption at Merapi on 27 January, amongst significant amount of meteorological cloud (Courtesy of Twitter)*



**Figure 8.** Himawari-8 satellite imagery at 0630 UTC on 27 January. Volcanic ash is identified from animated satellite imagery but is difficult to discern on static images. RGB image at bottom right is annotated with plume extent, just to the northeast of the summit.

### 3.5. Raung, Java, Indonesia – 6 to 15 February, 2021


3.5.1. A VONA reported a volcanic ash plume from Mt Raung at 1246 UTC on the 6<sup>th</sup> of February, however the night forecaster was unable to observe volcanic ash. Volcanic ash emission became stronger and was observed to 13,000ft at 2025 UTC (Figure 9). During the day, this plume continued and extended across the island of Bali, which required further updates to the advisories.



**Figure 9.** False colour RGB satellite image from Himawari-8 at 2220 UTC on 6 February. Volcanic ash is identified by the thin streak of pink extending almost due east of Raung, with the observation ash advisory overlaid in yellow.

3.5.2. Multiple pilot reports were received by the VAAC between 2355 and 0200 UTC of volcanic ash as high as 23,000ft (Figure 10). This was not supported by satellite observations at the time, with the observed plume-top temperature of 6 degrees Celsius still equating to approximately 12,000ft. Forecast wind direction and speed was similar between 13,000ft and 23,000ft so this did not help verify the reports. It was concluded that the ash plume was diffuse and the IR temperature was not representative of the height of the ash cloud, so the advisory was updated based on the reports.

3.5.3. With the plume continuing to be emitted from Raung, another update was produced which analysed the ash across the coast of Lombok island, Indonesia. As the winds shifted from westerly to a north-westerly, Denpasar International Airport was thought to be at risk due to the volcanic plume. This forecast was issued with 12 to 18 hours notice; however multiple paper tests at the aerodrome reported nil volcanic ash.

 <b>PILOT REPORT OF MT. RAUNG ACTIVITY</b>								
NO	DATE	TIME (UTC)	CALLSIGN	LEVEL A/C	ROUTE	POSITION REPORT	ASH/SMOKE	REMARK
1	07/01/2021	23.55	BTK6506	FL230	WIII-WADD	10NML WEST OF RAUNG	ASH	FL150-FL200 MOV. NE 40 NML
		00.12	CTV822	FL220	WADD-WICC	35NML SE OF RAUNG	ASH	FL21 MOV.NE
		00.20	BTK6656	FL150	WIII-WADL	89NML NE OF RAUNG	ASH	ABEAM AGUNG FL150
		00.25	CTV702	FL200	WIII-WADY	20NML SW OF RAUNG	ASH	MOV. NORTH UP TO FL190
		01.29	BTK6412	FL210	WARR-WADD	25NML SE OF RAUNG	ASH	FL120-FL150,MOV TO EAST OF RAUNG
		01.35	LNH646	FL240	WARR-WADD	100NML NE OF RAUNG	ASH	FL230, THIN LAYER POINT AGUNG
		01.53	GIA438	FL230	WIII-WADD	100NML NE OF RAUNG	ASH	UP TO FL190 OVER AGUNG POINT
		01.59	GIA400	FL190	WIII-WADD	AGUNG POINT	ASH	ASH 20 NML MOVING S OF AGUNG POINT

**Figure 10.** Table of pilot reports received through WhatsApp from AirNav Indonesia. A number of reports indicated that the ash plume was as much as 10,000ft above the current advisory.

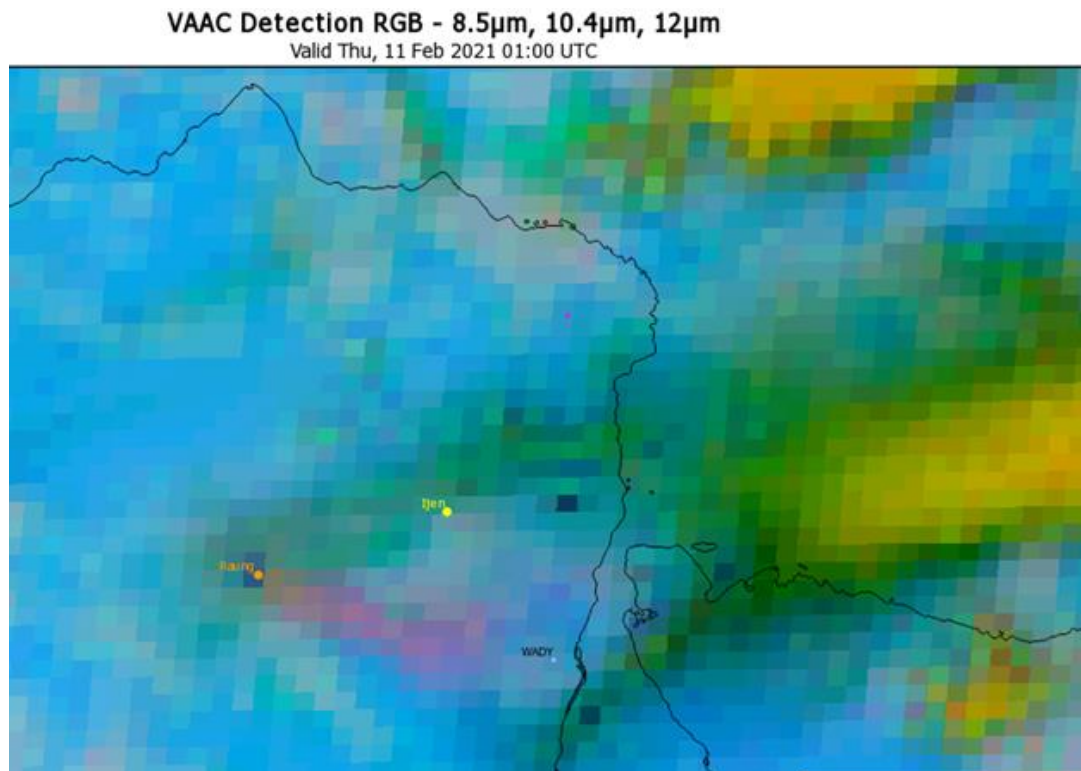


**Figure 11.** Webcam (courtesy CVGHM) indicating ongoing eruption of volcanic ash as at 0550WIB (2250 UTC 8/2/21).

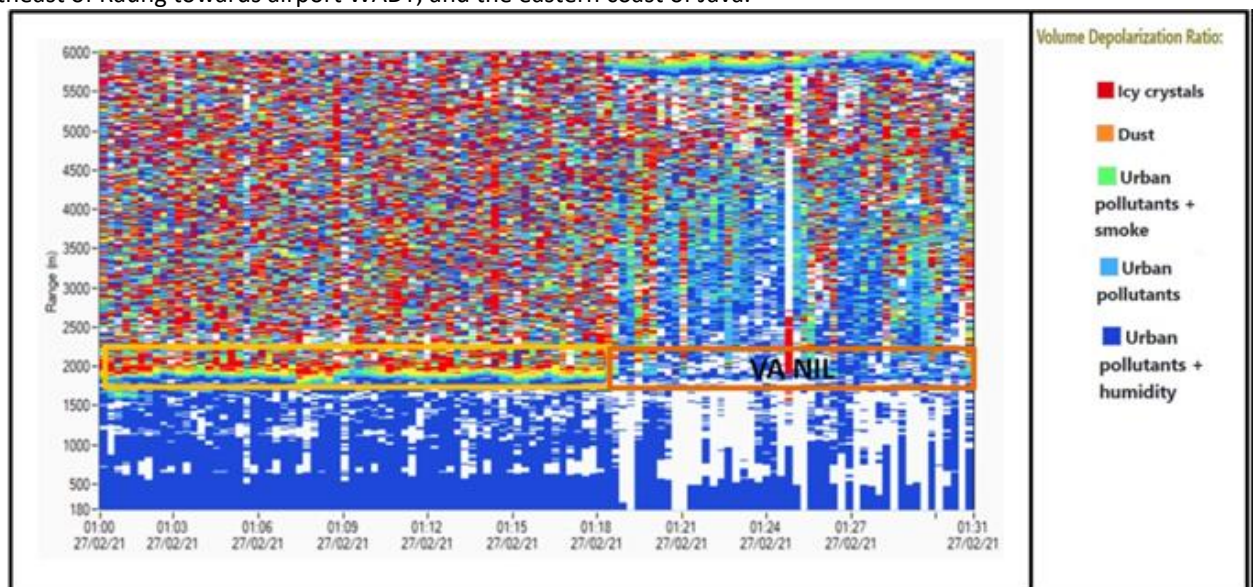
3.5.4. By the 11<sup>th</sup> of February, the ash emission had decreased in intensity and was no longer expected to impact the island of Bali (Figure 12). Observations were being received from the ground reporting positive to volcanic ash from WADY airport, despite the volcanic ash signal being weak at this location on satellite imagery.

3.5.5. The significant eruption had ceased by the 15<sup>th</sup> of February, with only minor localised ash emissions continuing for the rest of the month, reaching as high as 15,000ft.

3.5.6. This event saw the use of ground-based LIDAR measurement at several airport observing posts, and this data was provided to the VAAC (Figure 13). This technology shoots a laser vertically into the sky and the reflections are measured then plotted to determine the height of a volcanic cloud at a location.



**Figure 12.** Himawari-8 RGB satellite image, indicating volcanic ash (pink colour) extending to the east-southeast of Raung towards airport WADY, and the eastern coast of Java.



**Figure 13.** LIDAR measurements taken from the ground, indicating the presence of volcanic ash plume suspended above the surface (BMKG).

#### 4. SIGNIFICANT OPERATIONAL CHANGES

##### 4.1. VAAC Darwin transition to Hazardous Weather Unit

4.1.1. On 18<sup>th</sup> June 2020, VAAC Darwin moved from under the Bureau's National Operations Centre (BNOC) to its new home in the Hazardous Weather Unit (HWU) in the Melbourne Aviation Forecasting Centre (MAFC). All forecasters moving to HWU were required to have their VAAC competency (see section 4.3).

4.1.2. The VAAC transitioned smoothly into the HWU and the team of three forecasters working the three desks has worked quite well with coordination. The senior forecaster is able to manage the workload of the section and make sure that staff are able to issue all the necessary products. When a larger events occurs, the team work closely to inform the relevant sections and allow for timely dissemination of products. As the forecasters spend more time rotating through the different desks they are building up their knowledge and expertise which are being shared with the newest members of the team.

## **4.2. COVID-19 response**

4.2.1. Commencing March 2020, the Bureau of Meteorology has been adapting to the challenges associated with the COVID-19 pandemic. There was a great effort across the whole of the Bureau to make sure services provided to aviation users could continue uninterrupted. Forecasters were provided equipment to test working from home capabilities and internet connections.

4.2.2. Currently the forecasting team is split into three different areas: Operations Centre 1 in Melbourne Office level 11, Operations Centre 2 in Melbourne Office level 5, and work from home set-ups. With the use of MS Teams and other technologies, the three desks under HWU can keep in constant contact with each other to discuss activity and screen share as if they were both at the same desk. During high level events, the forecasters are working closely while (on occasion) in different locations to provide the same level of service as before COVID-19 – but with increased risk management around the threat of the pandemic itself.

4.2.3. There are many procedures around handover and coordination to make sure that the staff are kept safe during the current situation. This provides added comfort for the two teams still working from the office as well as knowing there is a lower risk to the service if any staff are exposed to COVID-19.

4.2.4. In 2021, the Bureau of Meteorology started a transition back to the office for staff who have been working at home due to minimal COVID numbers, however this has been placed on hold given the risks associated with the Delta variant.

## **4.3. VAAC Darwin Competency Program**

4.3.1. 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.

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4.3.2. VAAC Darwin currently has 20 VAAC competent staff members. This has significantly increased the number of competent technical staff available and able to respond to high impact volcanic ash events.

4.3.3. 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.

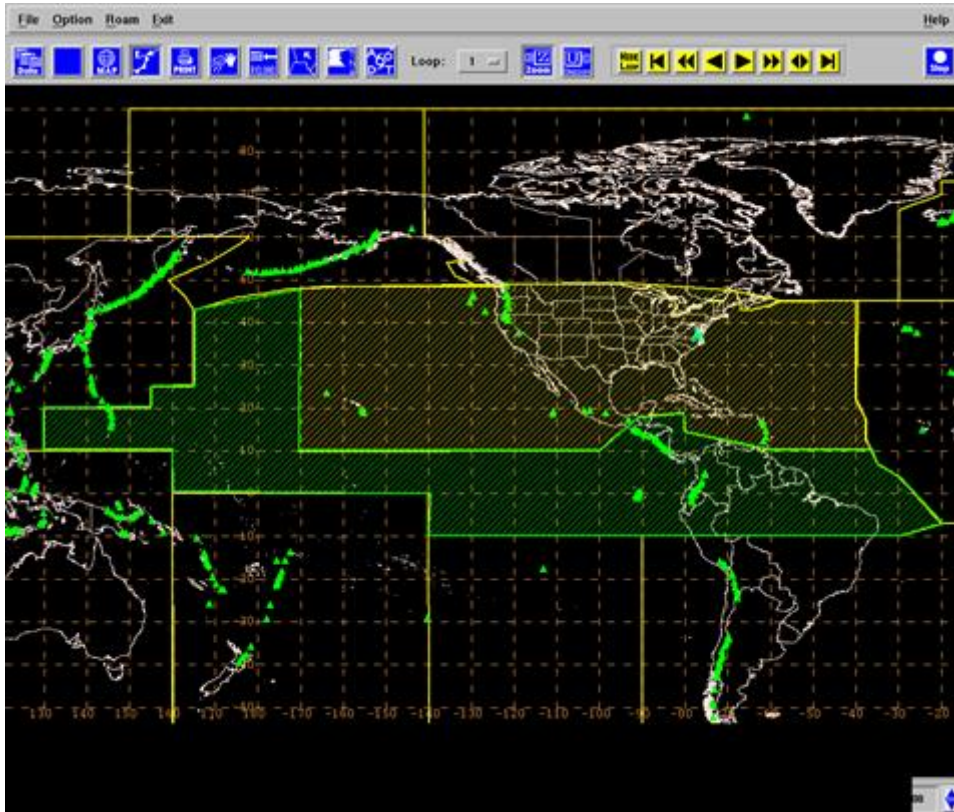
4.3.4. The World Meteorological Organization (WMO) Expert Team on Education, Training and Competency (ET-ETC) will be updating the top- and/or second-level competencies for aeronautical meteorological personnel to accommodate the role of VAAC forecasters and VAACs Darwin and Montreal will be assisting with the process. We are hoping that with VAAC Darwin 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.

**4.4. VAAC Washington back-up**

4.4.1. VAAC Darwin and VAAC Montreal are in consultation with VAAC Washington to continue working towards back-up support. VAAC Darwin are creating products for issuing VAAC Washington advisories, compiling important operational information such as contacts and AFTN addresses, working towards live dissemination tests once products and software are ready and preparing a Implementation Agreement (IA) for VAAC services between the two organisations. The IA is in the final stages of review before it will be passed to upper management for signatures.

4.4.2. 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 14, 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 14, yellow area). The service is expected to commence in second half of 2021.

4.4.3. Work is progressing towards these new back-up capabilities for VAAC Washington. VAACs Darwin and Washington have issued test VAAs, and information exchange between forecasters to facilitate background knowledge is ongoing. Many tests have been conducted and VAAC Darwin has issued live advisories for active volcanoes in the VAAC Washington AOR.



**Figure 14.** The VAAC Washington area split between VAAC Montreal and VAAC Darwin for back-up support.

#### **4.5. VAAC Back-up testing**

4.5.1. After recent changes at the ICAO METP WG-MOG, there will be a minor update to the VAAC back-up headers. The meeting decided:

*That VAACS, when acting in a back-up capacity to another VAAC:*

*Shall use the same product and location ID in the bulletin header as used by the VAAC they are backing up (with header number ii as appropriate), and*

*Shall add a comment in the remarks section of the VAA when providing back-up to notify users in the form of “Issued by VAAC nnnnn on behalf of VAAC nnnnn”*

4.5.2. These changes will make sure the back-up procedures are consistent between all VAACs and that end users know which VAAC has issued the product. VAAC Darwin has implemented this change and is looking to put all back-up products issued by VAAC Darwin on behalf of another VAAC on our webpage for ease of access.

4.5.3. VAAC Darwin and VAAC Tokyo are reviewing and updating their operational back-up procedures before the next back-up test.

#### **4.6. DTG vs OBS DTG**

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4.6.1. VAAC Darwin always issued its volcanic ash advisories using the same Date Time Group (DTG) for the product issue time and the observed volcanic ash polygon OBS DTG. This is inconsistent with other VAACs and the internal software Visual Weather now allowed these times to be set different.

4.6.2. VAAC Darwin made the transition on 1<sup>st</sup> June 2021 so that the DTG for when the product was issued is the current time and the OBS/EST DTG now reflects the time of the image used to draw the observation polygon or the time of the VONA report volcanic ash. This now shows the latest information that the VAAC has access too.

VA ADVISORY

DTG: 20210512/0120Z

VAAC: DARWIN

VOLCANO: DUKONO 268010

PSN: N0141 E12753

AREA: INDONESIA

SUMMIT ELEV: 1335M

ADVISORY NR: 2021/368

INFO SOURCE: HIMAWARI-8

AVIATION COLOUR CODE: ORANGE

ERUPTION DETAILS: CONTINUOUS VA EMISSION TO FL070 EXT NE

OBS VA DTG: 12/0100Z

OBS VA CLD: SFC/FL070 N0140 E12751 - N0154 E12738 - N0218  
E12732 - N0233 E12803 - N0226 E12812 - N0155 E12824 - N0139  
E12810 MOV NE 05KT

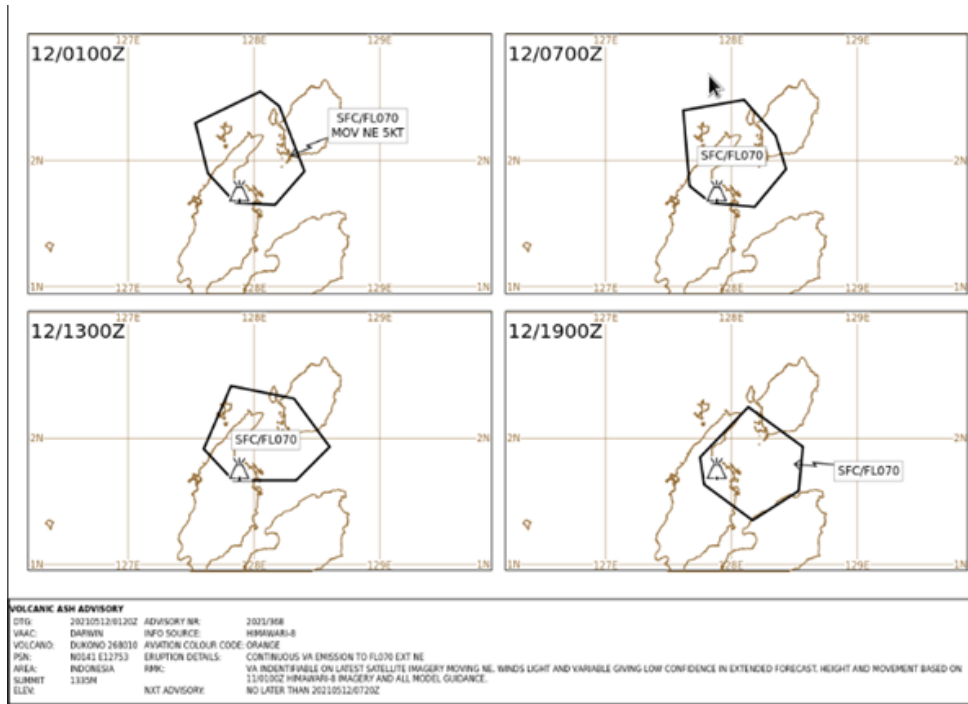
FCST VA CLD +6 HR: 12/0700Z SFC/FL070 N0140 E12750 - N0148  
E12740 - N0224 E12737 - N0229 E12806 - N0212 E12821 - N0156  
E12826 - N0138 E12811

FCST VA CLD +12 HR: 12/1300Z SFC/FL070 N0140 E12750 - N0155  
E12736 - N0225 E12749 - N0219 E12819 - N0156 E12836 - N0140  
E12820

FCST VA CLD +18 HR: 12/1900Z SFC/FL070 N0138 E12747 - N0151  
E12745 - N0215 E12808 - N0156 E12834 - N0135 E12832 - N0121  
E12810

RMK: VA INDENTIFIABLE ON LATEST SATELLITE IMAGERY MOVING NE.  
WINDS LIGHT AND VARIABLE GIVING LOW CONFIDENCE IN EXTENDED  
FORECAST. HEIGHT AND MOVEMENT BASED ON 11/0100Z HIMAWARI-8  
IMAGERY AND ALL MODEL GUIDANCE.

NXT ADVISORY: NO LATER THAN 20210512/0720Z=



#### 4.7. IWXXM

4.7.1. VAAC Darwin is producing Volcanic Ash Advisories (VAA) in IWXXM format using schema version 3.0.

### 5. Dispersion Ensemble Prediction System (DEPS)

5.1.1. The Australian Bureau of Meteorology transitioned its new dispersion model software to operations in 2020, which will give VAAC Darwin access to probabilistic forecasts and data for volcanic ash to help with more accurate forecasts in its advisories. The previous dispersion model capability was deterministic which provided a single output forecast for a volcanic eruption. The model could be run multiple times but didn't take into account the atmospheric uncertainties as well as the eruption uncertainties.

5.1.2. The new system DEPS provides a probabilistic output which takes 18 current Numerical Weather Prediction (NWP) models and the previous 18 NWP models to create a lagged ensemble of 36 members. The output shows a probabilistic view of how many of the ensemble members suggest there is in any volcanic ash in a section of air space. Having an ensemble approach accounts for more of the uncertainties associated with the dispersion model process so it highlights that uncertainty in the output. This allows the VAAC forecaster to process the data and incorporate it into their advisories. It also puts VAAC Darwin in a good position to provide input into the international work by METP WG-MISD that is happening around quantitative volcanic ash and the future of volcanic ash services.

5.1.3. We are currently working towards a major upgrade to the DEPS system to include new features and be put into operations as DEPS2 in a number of months. The new features will

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include inverse modelling of the eruption to support improved parameterization, an ingest of satellite retrievals to support more accurate eruption details including mass eruption rate, and the user defined polygon to tailor the eruption to start with specific area of coverage. These improvements will allow VAAC Darwin to work towards the new quantitative volcanic ash information services developed by the WG-MISD.

**6. VAAC COLLABORATION****6.1. Volcanic ash evidence checklist**

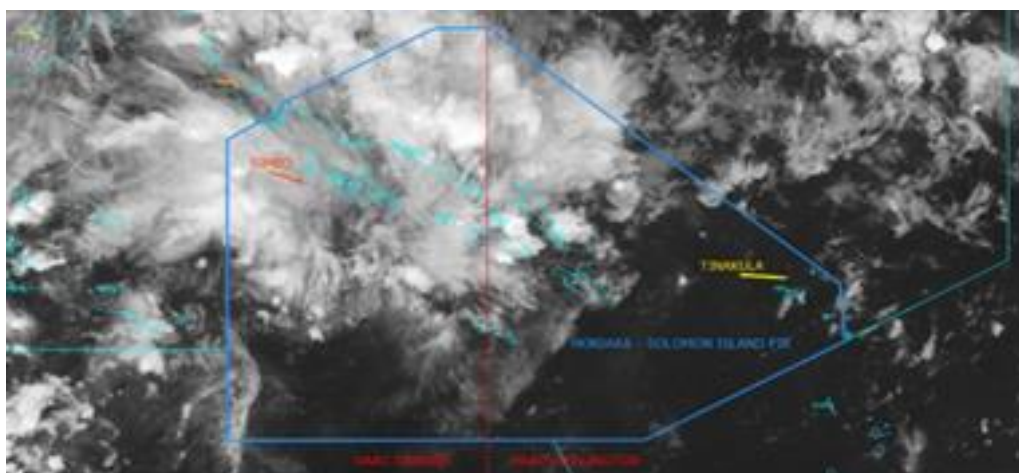
6.1.1. VAAC Darwin has been working on a volcanic ash evidence checklist to support VAAC operations for when to issue an advisory. Each VAAC issues a volcanic ash advisory when they have sufficient evidence that an eruption is imminent or underway. The evidence checklist is a way to visualise the information which will provide faster decisions and more timely advisories.

**6.2. VAAC Wellington**

6.2.1. 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.

6.2.2. 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.

6.2.3. VAAC Darwin and VAAC Wellington conducted a volcanic ash exercise to support Solomon Islands with 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 exercise (Figure 15). Both VAACs have continued to support Solomon Islands with follow up training and discussions about volcanic ash advisories and volcanic ash SIGMETs, offline tests for creating ICAO compliant SIGMETs and other standalone volcanic ash exercise.



*Figure 15. Map of the Honiara FIR, VAAC Darwin and VAAC Wellington Area of responsibility boundaries and Simbo and Tinakula volcanoes*

### **6.3. VAAC Tokyo Collaboration**

6.3.1. 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 in the next few months.

6.3.2. 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. VAAC BP/VASAG**

7.1.1. The combined VAAC Best Practice and VASAG was not held in 2020. The group is looking at the information exchange for operational volcanic ash practices, which includes monitoring and forecasting, technology, back-up services, new developments and ICAO compliance. There are a number of key actions that came out of the 2019 meeting which involve all VAACs or specifically VAAC Darwin and have been worked on over the last 12 months:

- WMO are reviewing top- and/or second level competencies for VAAC forecasters and VAAC Darwin will be heavily involved in the updates for consistent VAAC competencies.
- All VAACs are contributing to the International Volcanic Ash Workshop being organised by the VASAG and committee.
- The VASAG is preparing for the eighth International Workshop on Volcanic Ash (IWVA) that was scheduled to be held in October in Reykjavik, Iceland 2020. The last workshop was held in 2015. The workshop is a chance for operational and scientific groups to talk about volcanic ash and the future. Next steps – to prepare agenda and finalise the concept note for the workshop. Due to COVID and restriction on international travel by

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many countries, the group has decided to postpone the workshop to a tentative date of October 2022.

- Further VOLCAT development and dashboard for all automated alerts.
- All VAACs use evidence from different sources, but when do forecasters have enough information to issue a volcanic ash advisory? The group is looking at graphical representation of this information as a flow chart or pyramid of information to help forecasters make decisions. This will improve consistency between operations for each VAA.
- The VASAG finalised the SO<sub>2</sub> recommendations based on guidance from World Health Organization on the level of exposure to SO<sub>2</sub> for different scenarios to pass back to the WG-MISD-VASD.
- The group is looking at quantitatively based volcanic ash information services.
- WMO is looking at merging the VAAC BP and VASAG into one group. But there has been no progress on that.

**7.2. ICAO Meteorological Panel Working Groups**

7.2.1. The WG-MOG and WG-MISD meetings are being held virtually in November 2021 after the last meeting in 2019.

7.2.2. The WG-MOG is responsible for operational oversight in the global system for volcanic ash, namely the International Airways Volcano Watch (IAVW). The IAVW work stream is working on the Concept of Operations (ConOps) to identify user needs, determining shortfalls, refining the ConOps, and defining functional and performance requirements for new information related to volcanic ash. The key action items for the WG-MOG include:

- Timeliness and accuracy key performance indicators;
- Improve VAAC consistency, compliance and forecasts;
- Status of Volcano Observatory Notice for Aviation (VONA) and aviation colour codes; and
- Looking towards the future with the roadmap for the Concept of Operations and IAVW.

7.2.3. The WG-MOG has been looking into the status of the VONA and the proposed elevation to recommended practice. The group developed a new VONA template to accommodate the change of status and provided draft provisions to Annex 3 to the METP meeting in June 2021. The changes to VONA and its elevation to recommended practice from November 2023 were approved by METP. WG-MOG will now look at guidance and education materials for this change and the support required within each VAAC region.

7.2.4. The Volcanic Ash and Sulphur Dioxide (VASD) work stream of the WG-MISD is looking at the requirements of SO<sub>2</sub> reporting and the future of volcanic ash products including concentration charts and graphics. The MISD is also looking at a new SO<sub>2</sub> service based on user requirements and input from World Health Organisation with an ad-hoc group tasked with developing a provisional first look at a potential capability. The potential capability will be presented at the next WG-MOG meeting in 2021.

7.2.5. The VASD has gathered requirements and developing the Initial Operating Capability (IOC) for a probabilistic quantitative volcanic ash service as well as updates for Annex 3 to incorporate the new service. The group provided draft provisions to Annex 3 and the new *Procedures for Air Navigation Services - Meteorology* (PANS-MET) to the METP meeting. The proposal was approved and the work with quantitative volcanic ash will go ahead and be put into Annex 3. The timeframe for QVA in Annex 3 will be:

- d. Recommended Practice: all VAACs in a position to do so by November 2023 should issue forecasts of quantitative volcanic ash concentration information for significant volcanic ash clouds;
- e. Recommended Practice: all VAACs by November 2025 should issue forecasts of quantitative volcanic ash concentration information for significant volcanic ash clouds: and,
- f. Above becomes a Standard in November 2026.

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

7.2.6. All nine VAACs are heavily involved in developing these capabilities. The next steps will involve looking at these new services, particularly service 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.

### **7.3. State Volcano Observatory engagement**

7.3.1. Due to COVID, the State Volcano Observatory (SVO) engagement has slowed down since States have been responding to the pandemic. There have been some outreach activities to States that have APAC Met Deficiencies to see where the VAAC can provide support to address deficiencies associated with volcanic ash services. VAAC Darwin will be supporting Rabaul Volcano Observatory 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.

7.3.2. With the elevation of the VONA to a recommended practice, there will be follow on education for SVOs and customers. The SVOs in each region were consulted prior to the decision to elevate the VONA.