International Civil Aviation Organization

WORKING PAPER

Twenty-fourth Meeting of the Meteorology Sub-group (MET SG/24) of the Asia and Pacific Air Navigation Planning and Implementation Regional Group (APANPIRG)

Web-conference, 16 – 20 November 2020

Agenda Item 5: Research, development and other initiatives

VOLCEX 20/02 EXERCISE OUTCOMES

(Presented by New Zealand)

SUMMARY

This paper presents an outline of the ICAO volcanic ash exercise VOLCEX 20/02 conducted in the south Pacific on 17 July 2020.

1. INTRODUCTION

1.1 The first[1] ICAO Asia Pacific (APAC) volcanic ash exercise to be conducted in 2020, named APAC VOLCEX 20/02, simulated the eruption of Tofua (19°45'S, 175°4'W) in the central part of the Tonga Islands group, in the South Pacific, with volcanic ash cloud contaminating the Auckland Oceanic (NZZO) and Nadi (NFFF) Flight Information Regions (FIRs), and forecasted to affect the Oakland Oceanic (KZAK) FIR within 12-18 hours. The exercise was held from 2100 UTC 16 July to 0300 UTC 17 July 2020, as a desk top exercise, with all exercise participants joining from their own office locations.

1.2 The selection of the volcano Tofua (Tonga) for APAC VOLCEX 20/02 was to meet two goals. The first was to give an opportunity for Tonga to demonstrate the sharing of volcanic activity information, to assist in the resolution of air navigation deficiency in the MET field for that activity. The second goal was to provide an exercise scenario that would allow collaboration and coordination across a wider section of the South Pacific, supporting the objectives of the Informal South Pacific ANSP Coordination Group (ISPACG).

1.3 VOLCEX 20/02 was led by the Civil Aviation Authority of New Zealand (CAA NZ), with Paula Acethorp as Exercise Leader. Exercise participants included Tonga Geological Services (volcano observatory); Wellington, Darwin, and Washington Volcanic Ash Advisory Centres (VAACs); the aviation meteorological service providers and air navigation service providers (ANSPs) of Tonga, New

[1] It was originally the second scheduled volcanic ash exercise for 2020, but due to the COVID-19 pandemic, VOLCEX 20/01 was postponed, meaning VOLCEX 20/02 became the first APAC VOLCEX to be run during 2020.

Zealand, Fiji, and the United States; the NOTAM offices of Tonga, New Zealand, and Fiji; and five airlines who routinely operate flights into wider Pacific.

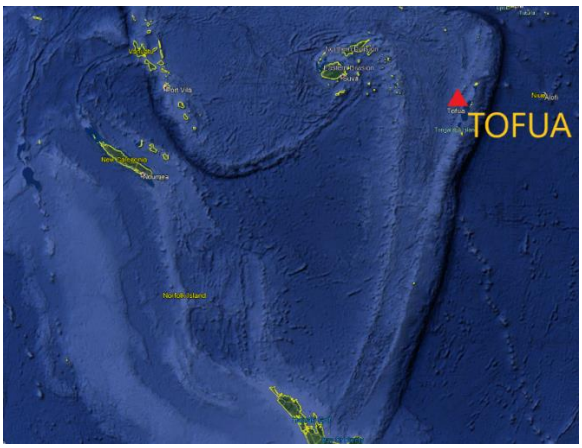

Figure 1. Red triangle indicates position of Tofua volcano.

2. DISCUSSION

2.1 The exercise was initiated by the provision of simulated satellite imagery, indicating the evolution of the volcanic cloud. A series of volcanological and meteorological messages were subsequently issued, prompting actions by the exercise participants who reacted to the simulated high-level volcanic ash emission. A detailed exercise timeline and summary of actions taken is provided in the full VOLCEX 20/02 report, and provided as an attachment to this paper. Some pertinent exercise actions have been highlighted in this information paper as follows:

2.1.1 The first ASHTAM issued by the Nadi NOTAM office was based on the exercise VAA, referring to the NZZO FIR. This was due to having noted there were not yet any NOTAMs issued for the NZZO FIR and having concern for flights that would be leaving the NFFF FIR and flights transiting the affected area. However, the responsibility for issuing NOTAMs on volcanic activity for NZZO FIR lies with Airways NZ (the New Zealand ANSP), with ASHTAMs not required within the NZZO FIR. This led to the formation of the exercise recommendation:

Recommendation 6: *Nadi, Christchurch and Tonga NOTAM offices to consider how to establish early communication and coordination during high level volcanic ash events that are expected to affect multiple FIRs, involving other NOTAM offices as appropriate (e.g. Tahiti, Brisbane, Honiara FIRs).*

2.1.2 A mid-exercise check-in was held at 0000 UTC through web conferencing for participants to outline messages issued and/or received and any actions taken, as well as any issues they may be encountering during the exercise. Participating airlines noted that if the eruption was real, they would have had to make significant re-routing decisions, which can be difficult in the south Pacific where alternate airport options are limited. This highlighted the importance of volcanic activity information reaching operators as quickly as possible, to allow timely decisions to be made.

2.1.3 VAAC Wellington and VAAC Darwin took the opportunity to conduct a VAAC back-up during the exercise, where participants in the exercise were able to give instant feedback on whether back-up VAAs were received. This was a useful test of the back-up procedures in place and highlighted that there was still work to be done to ensure backup VAAs were received by all necessary recipients.

2.2 Despite the low traffic volumes due to the COVID-19 pandemic, the simulated eruption still would have caused significant disruption across the south Pacific. This highlighted the critical importance of timely dissemination of volcanic activity information to airlines, to allow sufficient time for re-routing or diversion of flights as necessary.

2.3 Exercise participants found the process very worthwhile to not only test their own internal procedures, but also how well those procedures worked when interacting with other agencies. The exercise also offered an opportunity to build new relationships across the aviation industry and provided an opportunity for further engagement and improvements to be made to the volcanic ash system, long after the exercise was finished.

2.4 The exercise demonstrated how information on the location and expected evolution of volcanic ash in the atmosphere is issued by different sources, but not always necessarily well-aligned. At times the information available during the exercise was conflicting (for example, a Tonga Sector NOTAM was indicating the eruption was not producing volcanic ash, while the VA SIGMET and VAA valid at that time were describing continuous volcanic ash emission from Tofua volcano) and further thought maybe necessary to ensure a single source of information on volcanic ash observations and forecast movement across the region. To address this will take co-ordination across the ANSP and MET sectors, in close collaboration with operators. The full exercise report made the following recommendation:

> ***Recommendation 20****: ISPACG, in coordination with the ICAO APAC Meteorological Services Working Group, arrange a workshop to discuss proactive measures which could be used to minimise the likelihood of conflicting volcanic ash information and recommend strategies to the ICAO APAC VOLCEX SG Secretariat for further escalation within ICAO.*

3. RECOMMENDATION

3.1 To support ISPACG in conducting a workshop as outlined in 2.8, it is recommended that the MET SG/24 adopt the following Conclusion:

Conclusion MET SG/24-X: Volcanic Ash Information Conflict Reduction
What: That the MET/S WG support the Information South Pacific ATC Coordination Group in conducting a workshop to discuss proactive measures which could be used to minimise the likelihood of conflicting volcanic ash information.
Why: To support aviation safety during volcanic eruptions, by reducing the likelihood of conflicting volcanic ash information being supplied to aviation.
Expected impact: Ops/Technical **Follow-up:** N/A **When:** On request from ISPACG (likely 2021) **Status:** Adopted by MET SG **Who:** Sub groups (MET SG)

4. ACTION BY THE MEETING

4.1 The meeting is invited to:

a) Note the information contained in this paper; and
b) Adopt the Conclusion in paragraph 3.1

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ICAO ASIA/PACIFIC
VOLCANIC ASH EXERCISE
VOLCEX 20/02
REPORT

Finalised 21 September 2020

1. INTRODUCTION

1.1 The ICAO Asia Pacific (APAC) volcanic ash exercise 'APAC VOLCEX 20/02' simulated the eruption of Tofua (19°45'S, 175°4'W) in the central part of the Tonga Islands group, in the South Pacific. It was originally the second scheduled volcanic ash exercise for 2020, but due to the COVID-19 pandemic, VOLCEX 20/01 was delayed till later in the year, meaning VOLCEX 20/02 became the first APAC VOLCEX to be run during 2020.

1.2 The exercise was held from 2100 UTC 16 July to 0300 UTC 17 July 2020, as a desk-top exercise, with all exercise participants joining in from their own office locations. The exercise scenario featured a high-level eruption of Tofua, with volcanic ash cloud contaminating the Auckland Oceanic (NZZO) and Nadi (NFFF) Flight Information Regions (FIRs) and forecasted to affect the Oakland Oceanic (KZAK) FIR within 12-18 hours.

Figure 1. Red pin in Google map indicates position of Tofua.

1.3 VOLCEX 20/02 was led by the Civil Aviation Authority of New Zealand (CAA NZ), with Ms Paula Acethorp as Exercise Leader. Exercise participants included Tonga Geological Services (volcano observatory); Wellington, Darwin and Washington Volcanic Ash Advisory Centres (VAACs); the aviation meteorological service providers and air navigation service providers (ANSPs) of Tonga, New Zealand, Fiji and the United States; the NOTAM offices of Tonga, New Zealand and Fiji; and five airlines who routinely operate flights into the wider Pacific airspace. In addition, other aviation organisations or service providers observed the exercise and provided advice or observations as necessary to the participants. For a full list of participants and observers, please see Appendix A.

2. DISCUSSION

Preparation

2.1 The selection of the volcano Tofua for APAC VOLCEX 20/02 was to meet two goals. The first was to give an opportunity for Tonga to demonstrate the sharing of volcanic activity information, to assist in the resolution of air navigation deficiency in the MET field for that activity. The second goal was to provide an exercise scenario that would allow collaboration and coordination across a wider section of the South Pacific, supporting the objectives of the Informal South Pacific ANSP Coordination Group (ISPACG).

2.2 The exercise was originally scheduled for 2100 UTC 18 May 2020, however due to the COVID-19 pandemic and ensuing 'lockdown' in New Zealand and other States, it was subsequently delayed

until July, when organisations could be more confident that they would be able to make staff available for the exercise.

2.3 Amendment 78 to Annex 3 introduced the use of the "status indicator" for exercise and test SIGMETs and Volcanic Ash Advisories (VAA). The use of status indicator "EXER" in VOLCEX 20/02 messages would be the first time for an Asia-Pacific (and possibly for further afield) multi-organisation aviation volcanic ash exercise. Because of this, and due to the risk of users not noting the inclusion of word "EXER" particularly when reading the SIGMET messages (due to VAA having multiple free text fields within which to further highlight the exercise nature of the message), significant effort was made to ensure that; user systems could identify EXER messages and route them appropriately, and exercise NOTAMs highlighted the use of the status indicator in SIGMETs and VAA, along with notifying airspace users of the exercise being run, simulating the eruption of Tofua.

2.4 In line with the previous VOLCEX 19/01, affecting the southwest Pacific, it was agreed that only SIGMET and VAA would be disseminated via the usual official aviation channels (using the EXER status indicator, as note in 2.3). NOTAM issued *during* the exercise were agreed to be disseminated by email only, to a closed list of exercise participant email addresses. Volcano Observatory Notice Aviation (VONA) messages are normally issued via email, therefore this was also the case for VOLCEX 20/02, with information highlighting the exercise nature of the message being included.

2.5 While the exercise Directive did not *script* the exercise, the VAACs were provided with high level guidance on where the simulated volcanic ash should move to, to allow each Meteorological Watch Office (MWO) participating to issue any volcanic ash SIGMETs accordingly, as well as allow VAAC Washington to consider their processes for when volcanic ash is expected to move into its area of responsibility. Similarly, the volcano observatory for Tofua were provided with guidance on the required characteristics of the eruption to fit in with the wider exercise scenario.

2.6 Live NOTAM were issued for the NZZO and NFFF FIRs one week prior to the exercise, advising users of the upcoming exercise and ensuring they would not be unduly alarmed by any exercise messages referring to a Tofua eruption. Further, the United States National Weather Service issued a Public Information Statement outlining the VOLCEX 20/02 exercise and the extent of US participation. Examples of these messages can be seen in Appendix B.

2.7 The pre-exercise coordination meeting held via WebEx the day prior to the exercise was useful in that it gave participants an opportunity to familiarise themselves with the WebEx software, confirm that they were ready for the exercise and to ask any last minute clarification questions.

Exercise Timeline

2.8 The Exercise Leader started the exercise by sharing simulated satellite imagery (see Figure 2) with the Tongan volcano observatory Tonga Geological Services, and with the VAACs and MWOs, as organisations that monitor satellite imagery in their respective areas of responsibility. Further simulated satellite imagery was emailed 20 minutes later, indicating the evolution of the volcanic cloud.[1]

[1] The simulated satellite imagery was intended to show the volcanic cloud developing over Tofua. However, the cloud was unintentionally drawn by the Exercise Leader further north than the actual location of Tofua and appeared to be originating from the volcano Late. This was noted during the exercise, but it was agreed to continue referring to Tofua as the source of the eruption.

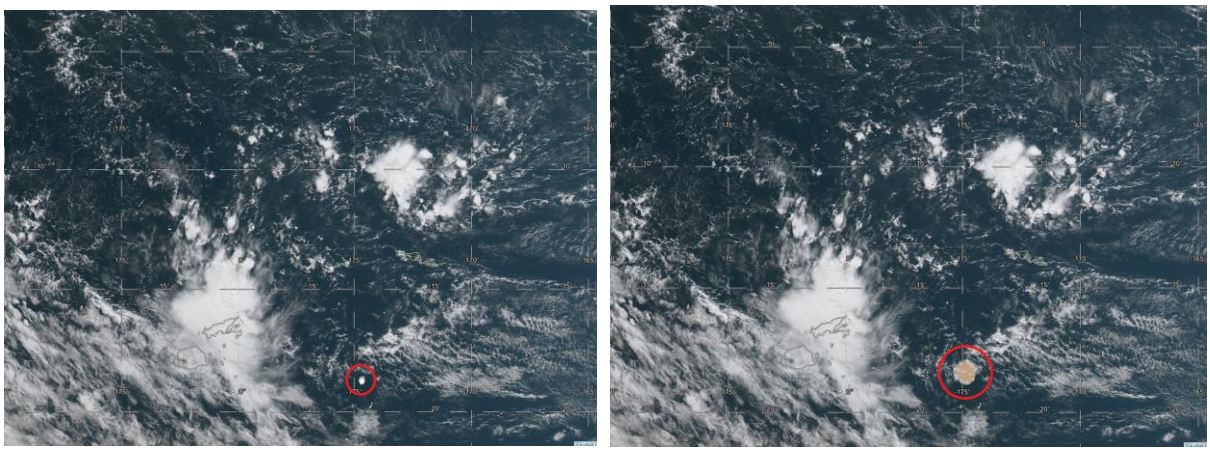


Figure 2. Red circle shows simulated suspicious cloud over the Tongan Island Group at 2100 UTC 16 July on left, and having grown significantly at 2120 UTC 16 July at the right.

2.9 Tonga Geological Services prepared and emailed an eruption report through to Tonga Meteorological Services at 2110 UTC, advising that Tofua had erupted. A VONA was then created and emailed by Tonga Meteorological Service to VAAC Wellington/MWO Wellington (both hosted by MetService NZ) and to Airports Tonga Ltd, as the local provider of Air Traffic Control (ATC) and Aeronautical Information Services (AIS). See Appendix B for this VONA and for all other exercise messages.

2.10 VAAC Wellington, on receiving the simulated suspicious satellite imagery at 2100 UTC, followed their internal processes and sent an email to Tonga Meteorological Services and Tonga Geological Services, asking if they had received any reports of a possible volcanic eruption. A draft 'initial' volcanic ash SIGMET was also created at this time in preparation for a positive response.

2.11 Confirmation of the eruption was received from Tonga Meteorological Services, with advice that a VONA would be issued shortly. The initial volcanic ash SIGMET was then issued at 2127 UTC, alerting airspace users that a volcanic ash cloud had been observed at Tofua.

2.12 Auckland Oceanic Control received the initial volcanic ash SIGMET but was unable to process it in their software due to the ash area and height not being described in the SIGMET. They were able to work around by manually entering a vertical extent of SFC to FL999 and a radius of 100nm.

2.13 The first VONA was issued at 2130 UTC described an eruption observed on satellite imagery at 16/2100 UTC and confirmed by residents of Pangai Ha'apai and by a local fisherman fishing between Kotu and Tofua at 16/2105 UTC. The plume was described as "large" and "dark coloured", reaching an estimated 8000-10000 metres in height and moving quickly north. The volcano location was provided in degrees/minutes but was presented in decimal format.

> **Recommendation 1**: Tonga Meteorological Service update VONA template to indicate the volcano location is in degrees/minutes.

2.14 Upon receipt of the VONA, Tonga Airports Limited in its capacity as ATC for the Tonga Sector, informed Talofa flight 408 en-route from Fua'amotu International Airport to Faleolo of the VONA contents, as well as the Chief Operations Officer at Fua'amotu International Airport.

2.15 An initial VAA was issued by VAAC Wellington at 2137 UTC, describing the height and movement of the cloud, but not the horizontal extent. It noted that forecast information on the cloud

evolution was not available at this time. From some participant comments, it was apparent that an 'initial VAA' was not a well-known concept.

> **Recommendation 2**: VAAC Wellington consider creating education material as part of outreach to users, volcano observatories and MWOs on how information on volcanic ash emission is shared.

> **Recommendation 3**: VAAC Wellington and CAA NZ to work together to determine whether initial basic SIGMET or initial VAA should be issued as the first indicator of an eruption.

2.16 At 2140 UTC, VAAC Wellington contacted the Christchurch NOTAM office to pass on information about the eruption. The VAAC Wellington procedure regarding NOTAM requests for eruptions only applies to New Zealand located volcanoes, so this was a courtesy call rather than contact required through any agreed procedure.

> **Recommendation 4**: VAAC Wellington to work with Airways to explore options to notify the Christchurch NOTAM office on any new eruption within the wider NZZO FIR.

2.17 Within the New Zealand FIR (and for Raoul Island), any significant volcanic activity would prompt a review and possible change to a volcanic hazard zone around that volcano. In the NZZO FIR, with embedded sectors below FL245, administered by States in those sectors whom have adopted the NZ Civil Aviation Ruleset, there is no clear approach to on how to handle a situation where a volcanic hazard may affect both the wider NZZO FIR and also an embedded sector.

> **Recommendation 5**: CAA NZ and Airways coordinate with other States within the NZZO FIR that have adopted the New Zealand ruleset to identify coordination of temporary volcanic hazard zone airspace that overlaps adjacent FIRs.

2.18 Fiji Airports issued (via email) their first ASHTAM at 2145 UTC based on the exercise VAA – indicating an ash height but no horizontal extent, in line with information provided by VAAC Wellington, and referring to the NZZO FIR in section a). This was due to having noted there were not yet any NOTAMs issued for the NZZO FIR and having concern for flights both leaving the NFFF FIR and flights transiting the affected area. However, the responsibility for issuing NOTAMs on volcanic activity for NZZO FIR lies with Airways NZ, with ASHTAMs not required.

> **Recommendation 6**: Nadi, Christchurch and Tonga NOTAM offices to consider how to establish early communication and coordination during high level volcanic ash events that are expected to affect multiple FIRs, involving other NOTAM offices as appropriate (eg Tahiti, Brisbane, Honiara FIRs).

2.19 VAAC Wellington then prepared and issued a full VAA at 2202 UTC, as well as issuing the accompanying full NZZO volcanic ash SIGMET (operating as MWO Wellington) at 2205 UTC. The NZZO SIGMET used the coordinates from the VAA, with the observed cloud coordinates matching, but mistakenly used the lower ash cloud coordinates for the forecast ash cloud position rather than issuing a second SIGMET.

> **Recommendation 7**: MetService review guidance on issuing VA SIGMETs for multiple volcanic ash clouds.

2.20 VAAC Wellington then phoned MWO Nadi to let them know that volcanic ash was expected to arrive within their FIR within 6 hours. The VAAC did not call MWO Honolulu at this point, as the volcanic ash was not expected to reach their FIR until T+18.

2.21 During this time a second VONA was issued by Tonga Meteorological Services, based on advice received by Tonga Geological Services. The VONA described the expanding ash cloud in the updated satellite imagery and that Kotu residents has reported a slight smell of sulphur and a visible "dark plume" over Tofua. The ash cloud height was estimated as 8000-10000 metres, based on satellite imagery.

2.22 As part of the exercise activities, Air New Zealand was offered a re-route option by Auckland Oceanic Control for flight ANZ990 (see Figure 3 below) to avoid the volcanic ash cloud described by NZZO SIGMET 10.

Figure 3. Air New Zealand flight ANZ990 (circled) en-route from Auckland New Zealand to Faleolo International Airport Samoa, was initially on a route that would intersect with SIGMET 10 describing volcanic ash emitted from Tofua. A re-route option was offered by Auckland Oceanic Control, taking the route further east of the SIGMET area.

2.23 Tonga ATC, on receipt of the second VONA, coordinated with the local briefing office and adjacent ATS units, including those at Vava'u and Ha'apai Flight Service.

2.24 The first Tonga Sector NOTAM was issued at 2227 UTC, by the Christchurch NOTAM office on behalf of Tonga AIS. The NOTAM advised all NZZO FIR airspace users (not just those using the Tonga Sector) of the Tofua eruption, with the ash cloud to 28000ft in altitude and moving north, based on VONA information.

2.25 Nadi NOTAM office plotted the coordinates of the full VAA received to confirm which routes were affected. An updated ASHTAM was then issued at 2229 UTC outlining the observed and forecast ash areas, with a further ASHTAM issued at 2253 UTC indicating which routes were affected.

> **Recommendation 8**: Nadi NOTAM office consider just including observed ash cloud movement in section G of ASHTAM, rather than the full forecast volcanic ash polygons from the VAA, in order to mitigate pilot information overload.

2.26 NFFF SIGMET 01 was issued by MWO Nadi at 2226 UTC, describing the forecast ash area expected in the Nadi FIR at 0400 UTC. This SIGMET was then cancelled at 2234 UTC, before an updated NFFF SIGMET 03 was issued at 2241 UTC, meaning for a short time no SIGMET was in force.

Recommendation 9: MWO Nadi ensure that, when updating a SIGMET for a phenomenon that is continuing, any cancellation SIGMET is issued after the new SIGMET is issued, thereby ensuring there is always a SIGMET in force.

2.27 Tonga ATC, using flight data prior to the COVID-19 pandemic, simulated a Real Tonga flight 802 departing Fua'amotu International Airport at 2350 UTC, outbound for Vava'u. Tonga ATC simulated confirmation the flight had received the Tonga Sector NOTAM and requested both this flight and another simulated flight Talofa 407 to report back any volcanic activity visually sighted. Pilot reports received would be relayed to Tonga Meteorological Services.

Recommendation 10: Tonga ATC include the Wellington MWO / VAAC Wellington in any communications regarding volcanic activity reported by pilots. Tonga ATC work with Wellington MWO / VAAC Wellington to ensure receipt of relevant SIGMETs and VAA.

2.28 A mid-exercise check-in was held at 0000 UTC via WebEx for participants to outline messages issued and/or received and any actions taken, as well as any issues they may be encountering during the exercise. United Airlines noted that two of their flights were expected to come within 200nm and 400nm respectively of the forecast volcanic ash cloud. The planned route of a third flight departing Sydney for San Francisco was expected to intersect the forecast volcanic ash cloud and would have required re-planning. A fourth flight en-route from Los Angeles to Sydney was expected to encounter the volcanic ash cloud at around 1600 UTC and would therefore require a re-route. Given the flights are planned using ETOPS, aircraft must stay within a given time limit of being able to reach an alternative airport. As alternate airport options are limited across the South Pacific, having to re-route any flight could be very difficult and hence highlighted the importance of volcanic activity information reaching operators as quickly as possible, to allow timely decisions to be made.

2.29 The second phase of the exercise started with VAAC Wellington contacting VAAC Darwin at 0036 UTC via telephone, requesting backup services. VAAC Wellington outlined the current advisory in force for Tofua, including the current advisory and header numbers, along with details of the observed ash cloud.

2.30 At 0037 UTC an updated VONA was emailed through by Tonga Meteorological Services, informing that the volcanic activity was subsiding with the aviation colour code now yellow. This was based on satellite imagery and reports from nearby Kotu. Further, an estimated one-kilometre length pumice raft had been observed by local fisherman. This VONA was passed on to VAAC Darwin by VAAC Wellington, along with a copy of the latest VAA.

2.31 VAAC Darwin issued a 'notice VAA' on behalf of VAAC Wellington at 0051 UTC, informing users that they had taken responsibility for the VAAC Wellington area of responsibility. This was followed by a Tofua VAA at 0130 UTC, with the volcanic ash now expected to enter the VAAC Washington area of responsibility by T+12 hours. VAAC Washington then issued a 'near VAA' at 0142 UTC requesting users to see the VAA issued by VAAC Darwin on behalf of VAAC Wellington, which described conditions near the VAAC Washington area of responsibility. This VAA did not include the status indicator 'EXER' due to software limitations but did clearly indicate the exercise nature of the message in the free text fields. VAAC Darwin then sent an email to Tonga Meteorological Services, informing them of the enacted backup.

2.32 An updated Tonga Sector NOTAM was issued at 0124 UTC, advising all aircraft to avoid the area from SFC to 3000ft AMSL (based on the VONA), approximately 85 nm north of NFTF. The NOTAM also included the text "NO ASH CLOUD PRODUCED", despite the current SIGMET and VAA describing volcanic ash continuing to emit from Tofua. It is worth noting that the VONA is a description of the

current activity of a volcano, whereas the MWO and VAAC have a wider view of where volcanic ash may be present

> **Recommendation 11**: Tonga AIS to also consider contents of VA SIGMET or VAA affecting the Tonga Sector when drafting NOTAM on volcanic activity.

2.33 Updated SIGMETs were issued at 0155 UTC by Nadi MWO and at 0208 UTC by Wellington MWO – the latter having to be manually created from the VAAC Darwin VAA due to the message not being automatically ingested into the forecaster software. MWO Honolulu determined that there was no need to issue a SIGMET at that stage, due to the T+12 hour ash cloud being located just outside the KZAK FIR boundary.

> **Recommendation 12**: MetService continue working with VAAC Darwin to ensure backup VAAs issued on behalf by VAAC Darwin can be ingested into MetService internal systems.

2.34 Nadi NOTAM office issued further ASHTAMs at 0100 UTC and 0225 UTC advising affected routes.

2.35 VAAC Wellington resumed responsibility for their area of responsibility at 0216 UTC, issuing a 'notice' VAA to users advising of this.

2.36 The exercise messages sent via AFTN/AMHS were monitored by RODB Brisbane. After the initial Nadi FIR SIGMETs were issued, the Brisbane RODB quickly noted that the SIGMETs were not being received at the RODB and so contact was made with MWO Nadi to include Brisbane RODB in the dissemination list. The issue was quickly rectified, and later Nadi FIR SIGMETs were received. Brisbane RODB also noted that the VAAs issued by VAAC Darwin on behalf of VAAC Wellington were not received, along with the VAAC Washington 'near VAA'.

> **Recommendation 13**: VAAC Darwin review backup VAA dissemination list to ensure all APAC RODBs are included, alongside other usual recipients of VAAC Wellington VAAs, and conduct further backup tests to ensure receipt of backup VAAs.

> **Recommendation 14**: Brisbane RODB review requirement for VAAC Washington VAA receipt and if necessary, work with VAAC Washington on ensuring future VAA receipt.

2.37 The exercise concluded at 0300 UTC. All remaining SIGMETs were cancelled and a final VAA issued by VAAC Wellington indicated the end of the exercise. The live NOTAMs advising airspace users of the exercise being held were also cancelled.

2.38 The initial exercise debrief was held at 0315 UTC, where each participant outlined their thoughts on how the exercise went for them and highlighted any further issues encountered. A summary of the debrief discussion follows:

- The exercise was a useful training and relationship building experience for the volcanological and meteorological organisations. For Tonga Meteorological Services, the exercise prompted an improvement in the templates used to share volcanic activity information.

- For the VAACs, the backup component of the exercise was a useful test of the procedures in place and highlighted that there was still work to be done to ensure backup VAAs were received by all necessary recipients.

- VAAC Wellington appreciated the information included in the VONA, describing it as clear and helpful.

- Not all participants received the 'notice' and Tofua VAAs issued by VAAC Darwin on behalf of VAAC Wellington – either directly via AFTN nor via their flight watch tool. (To be addressed by Recommendation 12.)

- Auckland Oceanic Control noted that the (live) NOTAM issued a week prior to the exercise was good for situational awareness of operators in the region. They also reiterated the requirement to receive information on the radius and height of the eruption as soon as possible.

- Tonga Airports Ltd operate the ATC and AIS for the Tonga Sector of the NZZO FIR. They advised that in this exercise scenario that some domestic flights would have been diverted, while others cancelled.

- Christchurch NOTAM office also noted difficulties dealing with NOTAMs that cross FL245, the ceiling of the Tonga Sector.

- Airports Fiji Ltd participated in the exercise with the ATC and AIS functions co-located, sharing information seamlessly. Nadi NOTAM office issued ASHTAM for this exercise, using information in the VAA to describe the areas of volcanic ash.

- Oakland Oceanic ATC noted that in the future it would be useful to include their MET team in a VOLCEX exercise and that they would also look into issuing a NOTAM advising airspace users of the exercise.

- Air New Zealand found the exercise very useful for internal process review. During the exercise, a flight en-route from Auckland to Samoa was in the region of the simulated ash cloud, prompting internal conversations on how to deal with such a situation. It was noted that with the narrow body jets, there is not a lot of leeway with fuel – again highlighting the time-criticality of receiving high quality volcanic cloud information, supporting decision making on a potential diversion, turn-back or re-route around the ash cloud.

- Fiji Airports noted difficulties with plotting the VAA coordinates and asked how they might access the VAAC Wellington VAA and VAG.

Recommendation 15: VAAC Wellington discuss options for VAA/VAG provision for Fiji Airports, considering also access to VAA during VAAC Darwin backup events.

- The United States based airlines became aware of VOLCEX 20/02 shortly before the exercise date and this limited the extent of the participation they might otherwise have had, along with the requirements for some to work from home due to the COVID-19 pandemic. Despite this, those that were able to participate found it useful – noting that for some airlines, they did not receive the VAAs and SIGMETs in their various platforms, perhaps due to the use of the EXER status indicator. It was noted the inclusion of the affected routes in the ASHTAM was useful and that early notification of volcanic activity information is key due to limited leeway in fuel for diversions and re-routes. United Airlines recommended that volcanic ash exercises are carried out regularly, noting that during busy times the re-routes can be significant.

Recommendation 16: Airlines that did not receive the exercise SIGMETs or VAA through their usual channels to determine why and, if necessary, request MWOs and VAACs to issue further 'status indicator EXER' messages to test receipt.

Recommendation 17: Future VOLCEX exercises to reach out to globally based airlines (including those in the United States) for participation, potentially via the ISPACG forum.

- CAA NZ noted that during the exercise a volcanic hazard zone was not designated, as it would be for NZ based volcanoes. This was due to not wanting to prescribe the airspace ahead of the exercise, but also as there was no contact with CAA NZ during the exercise to consider the need for this airspace designation. It was noted that there is currently no mechanism in place for such notification to occur.

Recommendation 18: CAA NZ to work with VAAC Wellington and/or Airways NZ to determine an appropriate mechanism to alert CAA NZ of any new volcanic activity in the NZZO, taking into account the existing NZZC volcanic activity process.

- Mr Ash McAlpine of CASA Australia represented the APAC VOLCEX Steering Group in observing the exercise and stressed that these exercises are an opportunity to learn. He encouraged participants to consider the subtle differences between the exercise and reality – think about what could be different. Mr McAlpine asked participants to share their experiences with their organisations, to make the most of any lessons learned. He said it was great to see there was no closure of airspace or routes during the exercise (in-line with established ICAO SARPS), instead excellent communication allowed airlines to risk assess their own operations.

3. ADDITIONAL EXERCISE OBSERVATIONS

3.1 Exercise participants found the exercise very worthwhile to not only test their own internal procedures but also how those procedures faired when interacting with other agencies. The exercise also offered an opportunity to build new relationships across the aviation industry and provided an opportunity for further engagement and improvements to be made to the volcanic ash system, long after the exercise was finished.

3.2 RODB Brisbane confirmed all exercise messages were visible on their message switch, however it was noted that some messages were not being sent to RODB Brisbane directly. Follow up on this is underway.

3.3 The VAAC Darwin backup VAAs for VAAC Wellington included in the VAA RMK field the statement 'PLEASE CONTACT VAAC DARWIN AS PER IAVW HANDBOOK TABLE 4-2 FOR VOLCANIC ASH ADVICE TO THE VAAC WELLINGTON AREA'. It was noted after the exercise that if an operator was to use Google Search to locate a copy of the IAVW Handbook (Doc 9766), they would find it only available via the 'Doc-Series Sharepoint library' – however this copy was significantly out of date. The Exercise Leader has since worked with the ICAO Secretariat to ensure all out of date copies of the IAVW Handbook are removed from the ICAO website, leaving the only the current copy available on the ICAO METP public documents site.

3.4 It was also noted that the time of compilation in the WMO header of some VAAs did not match the DTG group in the advisory itself, which was determined to be a function of the software used (header time reflected the time the VAA compilation process was initiated). Similarly, it was

noted that the WMO headers for MWO Nadi SIGMETs 1-3 were not unique, which may cause issues at some message switches[2].

Recommendation 19: Fiji Met Service to review the use of identical WMO headers for SIGMET bulletins issued within the same calendar month.

3.5 The exercise demonstrated how information on the location and expected evolution of volcanic ash in the atmosphere is issued by different sources, but not always necessarily well-aligned. At times the information available during the exercise was conflicting (for example, the Tonga Sector NOTAM at 0124Z, compared to the VA SIGMET or VAAs valid at that time) and further thought maybe necessary to ensure a single source of information on volcanic ash observations and forecast movement across the region. To address this will take coordination across the ANSP and MET sectors, in close collaboration with operators.

Recommendation 20: ISPACG, in coordination with the ICAO APAC Meteorological Services Working Group, arrange a workshop to discuss proactive measures which could be used to minimise the likelihood of conflicting volcanic ash information and recommend strategies to the ICAO APAC VOLCEX SG Secretariat for further escalation within ICAO.

3.6 For a full set of exercise messages issued, please refer to Appendix B.

3.7 For a full list of exercise recommendations, please refer to Appendix C.

4. CONCLUSIONS

4.1 The VOLCEX 20/02 exercise was an extremely useful opportunity for various organisations to come together to not only practice their own volcanic activity related processes and procedures, but to also practice those processes with each other and find opportunities for improvement in the system as a whole.

4.2 Despite the low traffic volumes due to the COVID-19 pandemic, the simulated eruption still would have caused significant disruption across the south Pacific. This highlighted the critical importance of timely dissemination of volcanic activity information to airlines, to allow sufficient time for re-routing or diversion of flights as necessary.

[2] WMO Manual on the GTS, Section 2.3.2.2: *An abbreviated heading defined by $T_1T_2A_1A_2$ ii CCCC YYGGgg shall be used only once.*

Appendix A – Participants and Observers

Participants

Area of Responsibility	Agency
Volcanic activity alerting (VONA)	Tonga Geological Service
	Tonga Meteorological Service
Volcanic ash advisory information (VAA/VAG)	VAAC Wellington
	VAAC Washington
	VAAC Darwin
SIGMET	MWO Wellington
	MWO Nadi
	MWO Honolulu
Air Traffic Control and Air Traffic Flow and Capacity Management	Airways NZ
	Airports Tonga Ltd
	Airports Fiji Ltd
	FAA
Aeronautical information service	Airways NZ
	Airports Tonga Ltd
	Airports Fiji Ltd
Airlines	Air New Zealand
	Fiji Airways
	United Airlines
	Southwest Airlines
	Hawaiian Airlines
Regulation	CAA New Zealand
	CAD Tonga
	CAA Fiji
	CASA Australia
	FAA
ICAO oversight	ICAO – APAC office

Observers

Area of Responsibility	Agency
Volcanic activity alerting (VONA)	GNS Science
Volcanic ash advisory information (VAA/VAG)	VAAC Tokyo
RODBs	Nadi RODB
	Brisbane RODB

Appendix B – Exercise Messages

Time (UTC)	Messages issued prior to VOLCEX 20/02	Notes
Issued 10 July 2020	(B3757/20 NOTAMN Q) NZZO/QWELW/IV/BO /W /000/999/1945S17504W999 A) NZZO B) 2007162100 C) 2007170300EST E) VA EXERCISE APAC VOLCEX 20/02. VOLCANIC ASH EXERCISE WILL TAKE PLACE FROM 2100 UTC 16 JULY TO 0300 UTC 17 JULY. EXERCISE NAME: APAC VOLCEX 20/02. VOLCANO: TOFUA 243060 - 19 45 S 175 04 W - TONGA ISLANDS GROUP. EXERCISE SIGMETS AND EXERCISE VOLCANIC ASH ADVISORIES USE STATUS INDICATOR EXER AS PER ANNEX 3. FREE TEXT OF PROMULGATED EXERCISE VOLCANIC ASH ADVISORIES START WITH: VA EXERCISE APAC VOLCEX 20/02 F) SFC G) UNL)	Live NOTAM for NZZO FIR notifying industry of exercise VOLCEX 20/02
Issued 10 July 2020	A1159/20 NOTAMN Q) NFFF/QWELW/IV/BO/W/000/999/1315S17507E999 A) NFFF B) 2007162100 C) 2007170300 EST E) EXERCISE (VA EXERCISE APAC VOLCEX 20/02 - VOLCANIC ASH EXERCISE) WILL TAKE PLACE FROM 2100Z 16 JULY TO 0300Z 17 JULY. EXERCISE NAME: APAC VOLCEX 20/02. VOLCANO: TOFUA 243060 S1945 W17504 TONGA ISLANDS GROUP. EXERCISE SIGMETS AND EXERCISE VOLCANIC ASH ADVISORIES USE STATUS INDICATOR EXERCISE AS PER ANNEX 3. FREE TEXT OF PROMULGATED EXERCISE VOLCANIC ASH ADVISORIES START WITH: VA EXERCISE APAC VOLCEX 20/02. F) SFC G) UNL	Live NOTAM for Nadi FIR notifying industry of exercise VOLCEX 20/02
Issued 10 July 2020	Public Information Statement 20-54 National Weather Service Headquarters Silver Spring MD 1020 AM EDT Fri Jul 10 2020 To: Subscribers: -NOAA Weather Wire Service -Emergency Managers Weather Information Network -NOAAPort -Other NWS partners and NWS employees FROM: Bruce Entwistle Chief, Aviation Space Weather Services Branch SUBJECT: The second ICAO APAC volcanic ash exercise, named APAC VOLCEX 20/02, is scheduled for July 16, 2020, and will include the Honolulu Meteorological Watch Office, the Washington Volcanic Ash Advisory Center, and Center Weather Service Unit Oakland.	Live "Public Information Statement" issued by the United States National Weather Service. Body of message outlined event information and extent of US participation.
	Messages issued during VOLCEX 20/02 from 16 July 2100 UTC to 17 July 0300 UTC.	
16/2127	WVPS21 NZKL 162124 NZZO SIGMET 9 VALID 162127/170327 NZKL- NZZO AUCKLAND OCEANIC FIR EXER VA ERUPTION MT TOFUA PSN S1945 W17504 VA CLD OBS AT 2100Z VA EXERCISE APAC VOLCEX 20/02=	"Initial basic SIGMET" issued by MWO Wellington, advising of eruption of Tofua.

<table>
<tr>
<td>16/2130</td>
<td>

VA EXERCISE APAC VOLCEX 20/02

VOLCANO OBSERVATORY NOTICE FOR AVIATION (VONA)

Item No	Element	Content
1	**Message title**	**VOLCANO OBSERVATORY NOTICE FOR AVIATION-VONA**
2	**Issued:**	20200716/2130Z
3	**Volcano:**	Tofua/243060
4	**Current Aviation Color Code:**	**RED**
5	**Previous Aviation Color Code:**	UNKNOWN
6	**Source:**	Tonga geological report including: 1. Satellite imagery shows eruption of Tofua at 162100Z (Figure 1) 2. Report of residents of Pangai Ha'apai 3. Report of local fisherman fishing between Kotu and Tofua reported sound at 162105Z.
7	**Notice Number:**	20/01
8	**Volcano Location:**	19.45°S , 175.04 °W
9	**Area:**	Ha'apai, Tonga
10	**Summit Elevation:**	515m
11	**Volcanic Activity Summary:**	Explosive volcanic eruption - Ongoing eruption with Ash emission and pyroclastic material, possibly from Lofia cone. Received report at 162105Z describing large "large plume" over Tofua visible from Pangai, Ha'apai. At 162105Z local fisherman fishing between Kotu and Tofua reported he heard explosive sound at 10:00am which was the initial eruption time.
12	**Volcanic Cloud Height:**	8000-10000 meters AMSL Source of height – Remote sensing (satellite).
13	**Other Volcanic Cloud information:**	Plume described as "large" and "dark coloured" (black and greyish) appearing to move North quickly.
14	**Remarks:**	Ash direction moving North. **VA EXERCISE APAC VOLCEX 20/02– TONGA METEOROLOGICAL SERVICE A EXERCISE VAAC WELLINGTON – TONGA METEOROLOGICAL SERVICE**
15	**Contacts:**	Tonga MET Services (+67635123/+67635355) E-mail: metstaff@met.gov.to
16	**Next Notice:**	A new VONA will be issued if any information receive from other boat vessels proceed near the area of eruption.

VA EXERCISE VA EXERCISE VA EXERCISE

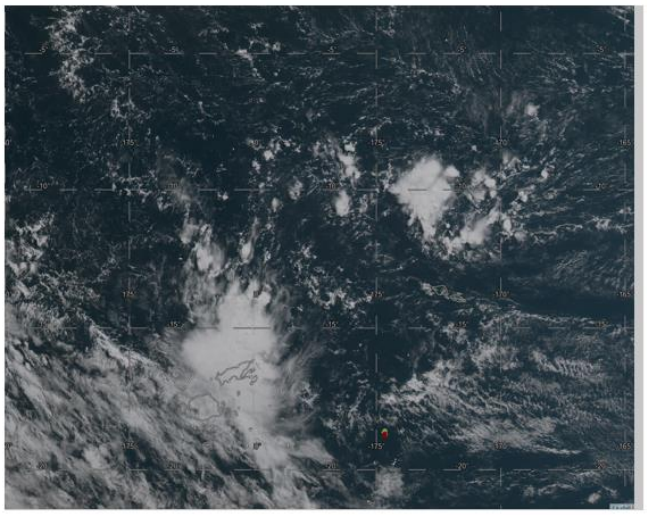
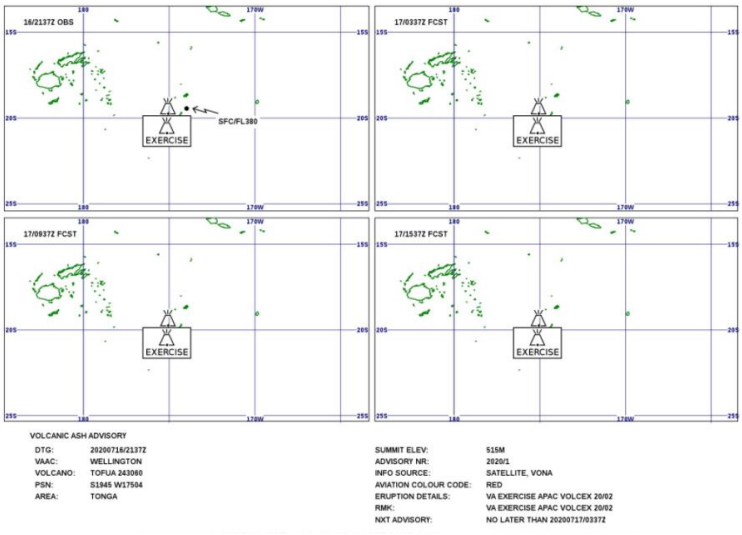


Figure 1: Himawari8 image

</td>
<td>VONA #1 issued by Tonga Meteorological Service, on behalf of Tonga Geological Service.</td>
</tr>
<tr>
<td>16/2137</td>
<td>FVPS01 NZKL 162137
VA ADVISORY
STATUS: EXER
DTG: 20200716/2137Z
VAAC: WELLINGTON
VOLCANO: TOFUA 243060
PSN: S1945 W17504
AREA: TONGA
SUMMIT ELEV: 515M
ADVISORY NR: 2020/1</td>
<td>Basic VAA issued upon advice of eruption – to be updated once dispersion model guidance available.</td>
</tr>
</table>

	INFO SOURCE: SATELLITE, VONA AVIATION COLOUR CODE: RED ERUPTION DETAILS: VA EXERCISE APAC VOLCEX 20/02 OBS VA DTG: 16/2137Z OBS VA CLD: SFC/FL380 MOV N 10KT FCST VA CLD +6 HR: 17/0337Z NOT AVBL FCST VA CLD +12 HR: 17/0937Z NOT AVBL FCST VA CLD +18 HR: 17/1537Z NOT AVBL RMK: VA EXERCISE APAC VOLCEX 20/02 NXT ADVISORY: NO LATER THAN 20200717/0337Z  	
16/2145	(ASHTAM 001/20 A) NZZO B) 2007162100 C) TOFUA 243060 D)1945S 17504W E) RED F) SFC-FL380 G) NORTHERLY AT 10KTS H) TONGA SECTOR I) NIL J) VAAC W K) NIL)	ASHTAM issued by Airports Fiji Ltd.

<table>
<tr>
<td>16/2152</td>
<td>
VA EXERCISE APAC VOLCEX 20/02

<u>VOLCANO OBSERVATORY NOTICE FOR AVIATION (VONA)</u>

<table>
<tr><th>Item No</th><th>Element</th><th>Content</th></tr>
<tr><td>1</td><td>Message title</td><td>VOLCANO OBSERVATORY NOTICE FOR AVIATION-VONA</td></tr>
<tr><td>2</td><td>Issued:</td><td>20200716/2150Z</td></tr>
<tr><td>3</td><td>Volcano:</td><td>Tofua/243060</td></tr>
<tr><td>4</td><td>Current Aviation Color Code:</td><td>RED</td></tr>
<tr><td>5</td><td>Previous Aviation Color Code:</td><td>red</td></tr>
<tr><td>6</td><td>Source:</td><td>Tonga geological report including:
1. Updated Satellite imagery (Himawari) at 162120Z
2. Received reports from Kotu residents.</td></tr>
<tr><td>7</td><td>Notice Number:</td><td>20/02</td></tr>
<tr><td>8</td><td>Volcano Location:</td><td>19.45°S , 175.04 °W</td></tr>
<tr><td>9</td><td>Area:</td><td>Ha'apai Group, Tonga</td></tr>
<tr><td>10</td><td>Summit Elevation:</td><td>515m</td></tr>
<tr><td>11</td><td>Volcanic Activity Summary:</td><td>• Release of sulphur gas – At 162110Z reports were received from residents of Kotu describing the slight smell of sulphur gas and visible "dark plume" over Tofua.
• Eruption continues – Ash Cloud expanding (Figure 1)</td></tr>
<tr><td>12</td><td>Volcanic Cloud Height:</td><td>8000-10000 meters AMSL
Source of height – Remote sensing (satellite).</td></tr>
<tr><td>13</td><td>Other Volcanic Cloud information:</td><td>Described by residents of Kotu as "dark plume" quickly drifting North of Tofua.</td></tr>
<tr><td>14</td><td>Remarks:</td><td>Ash direction moving North.

VA EXERCISE APAC VOLCEX 20/02– TONGA METEOROLOGICAL SERVICE A EXERCISE VAAC WELLINGTON – TONGA METEOROLOGICAL SERVICE</td></tr>
<tr><td>15</td><td>Contacts:</td><td>Tonga MET Services (+67635123/+67635355)
E-mail: metstaff@met.gov.to</td></tr>
<tr><td>16</td><td>Next Notice:</td><td>Immediately if conditions change significantly or if other reports are received.</td></tr>
</table>

VA EXERCISE VA EXERCISE VA EXERCISE

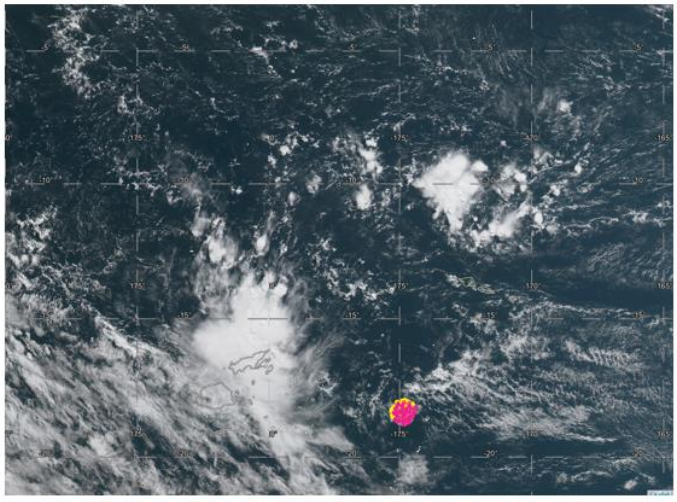
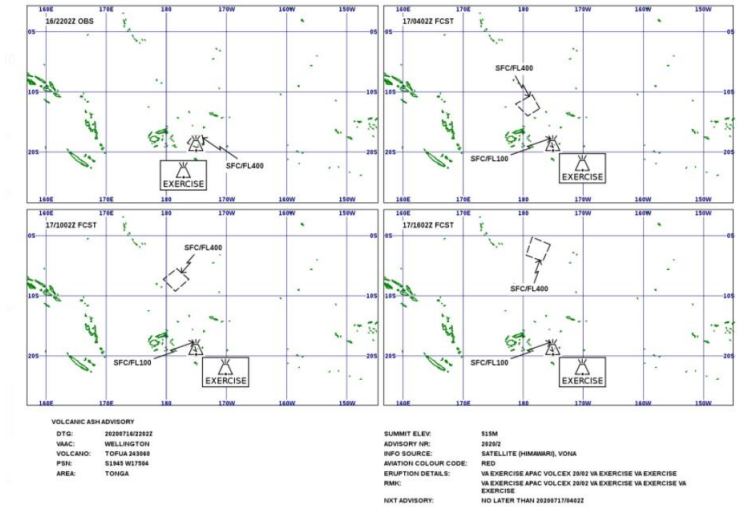


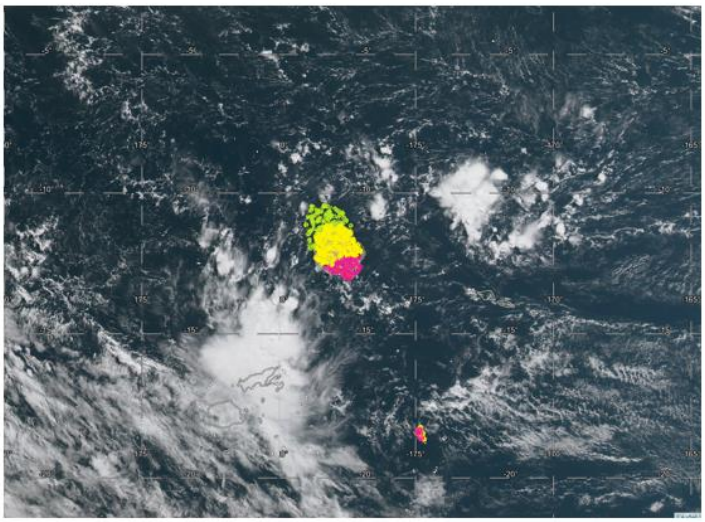
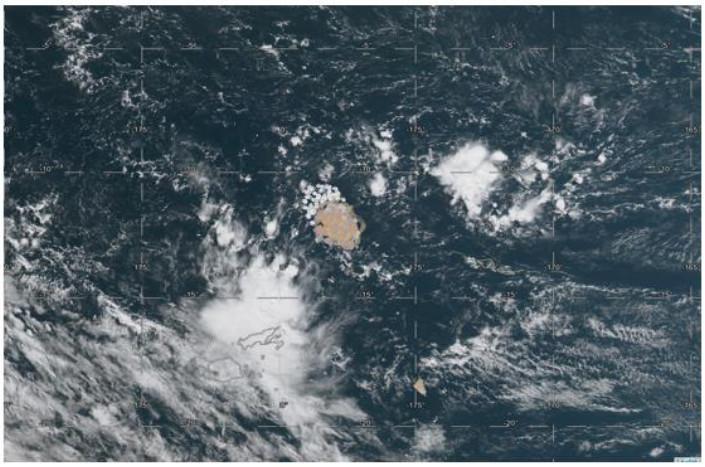
Figure 1: Himawari 8 image. Pink – Ash , Yellow – Mix of Ash and Sulphur gas.
</td>
<td>VONA #2 issued by Tonga Meteorological Service, on behalf of Tonga Geological Service, updating information on Tofua eruption.</td>
</tr>
<tr>
<td>16/2202</td>
<td>FVPS01 NZKL 162202~
VA ADVISORY
STATUS: EXER
DTG: 20200716/2202Z
VAAC: WELLINGTON
VOLCANO: TOFUA 243060
PSN: S1945 W17504
AREA: TONGA
SUMMIT ELEV: 515M
ADVISORY NR: 2020/2
INFO SOURCE: SATELLITE (HIMAWARI), VONA
AVIATION COLOUR CODE: RED
ERUPTION DETAILS: VA EXERCISE APAC VOLCEX 20/02 VA EXERCISE VA EXERCISE</td>
<td>Updated VAAC Wellington VAA and VAG.</td>
</tr>
</table>

	OBS VA DTG: 16/2202Z OBS VA CLD: SFC/FL400 S1915 W17500 - S1830 W17630 - S1715 W17530 - S1715 W17400 - S1845 W17345 MOV NW 15KT FCST VA CLD +6 HR: 17/0402Z SFC/FL100 S1915 W17500 - S1845 W17600 - S1745 W17530 SFC/FL400 S1400 W17915 - S1200 E17845 - S1030 W17830 - S1245 W17715 FCST VA CLD +12 HR: 17/1002Z SFC/FL100 S1915 W17500 - S1845 W17600 - S1745 W17530 SFC/FL400 S0915 W17830 - S0715 E17930 - S0530 W17815 - S0715 W17615 FCST VA CLD +18 HR: 17/1602Z SFC/FL100 S1915 W17500 - S1845 W17600 - S1745 W17530 SFC/FL400 S0415 W17645 - S0315 W17930 - S0015 W17830 - S0130 W17530 RMK: VA EXERCISE APAC VOLCEX 20/02 VA EXERCISE VA EXERCISE VA EXERCISE NXT ADVISORY: NO LATER THAN 20200717/0402Z  	
16/2210	WVPS21 NZKL 162205 NZZO SIGMET 10 VALID 162210/170410 NZKL-NZZO AUCKLAND OCEANIC FIR EXER MT TOFUA PSN S1945 W17504 VA CLD OBS AT 2202Z WI S1845 W17345 - S1715 W17400 - S1715 W17530 - S1830 W17630 - S1915 W17500 - S1845 W17345 SFC/FL400 FCST AT 0402Z WI S1745 W17530 - S1845 W17600 - S1915 W17500 - S1745 W17530= WVPS21 NZKL 162211 NZZO SIGMET 11 VALID 162211/170327 NZKL- NZZO AUCKLAND OCEANIC FIR EXER CNL SIGMET 9 162127/170327=	Full VA SIGMET issued by MWO Wellington, followed by cancellation of initial basic SIGMET. SIGMET used the VAA coordinates, without truncating at FIR boundary. Forecast ash cloud used coordinates for FL100 cloud, but labelled it FL400.
16/2226	NFFF SIGMET 01 VALID 170400/171000 NFFN- NFFF NADI FIR EXER MT TOFUA PSN S1945 W17504 VA CLD FCST AT 0402Z WI S1400 W17915 - S1200 E17845 - S1030 W17830 - S1245 W17715 SFC/FL400=	VA SIGMET issued by MWO Nadi.
16/2227	(P9000/20 NOTAMN A) NFTF B) 2007162220 C) 2007170220 EST E) VA EXERCISE APAC VOLCEX 20/20 VOLCANIC ERUPTION ALERT POSITION 19 45 S 175 04 W TOFUA. APRX 85NM N NFTF. ASH CLOUD MOVING NORTH. ALL ACFT TO AVOID AREA FROM SEA LEVEL UP TO 28000 FT AMSL F) SFC G) 28000FT AMSL	NOTAM for the Tonga Sector of the NZZO FIR, issued by Christchurch NOTAM office on behalf of Tonga AIS.
16/2229	(ASHTAM 002/20 A) NZZO B) 2007162228 C) TOFUA 243060 D)1945S 17504W E) RED F) SFC/FL400 S1915 W17500 - S1830 W17630 - S1715 W17530 - S1715 W17400 - S1845 W17345 MOV NW 15KT G) FCST VA CLD +6 HR: 17/0402Z SFC/FL100 S1915 W17500 - S1845	Updated ASHTAM issued by Nadi NOTAM office.

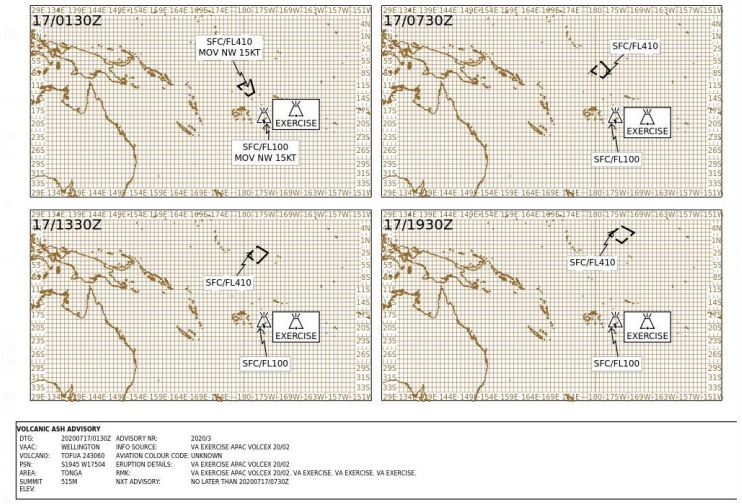
	W17600 - S1745 W17530 SFC/FL400 S1400 W17915 - S1200 E17845 - S1030 W17830 - S1245 W17715 FCST VA CLD +12 HR: 17/1002Z SFC/FL100 S1915 W17500 - S1845 W17600 - S1745 W17530 SFC/FL400 S0915 W17830 - S0715 E17930 - S0530 W17815 - S0715 W17615 FCST VA CLD +18 HR: 17/1602Z SFC/FL100 S1915 W17500 - S1845 W17600 - S1745 W17530 SFC/FL400 S0415 W17645 - S0315 W17930 - S0015 W17830 - S0130 W17530 H) TONGA SECTOR/NFFF FIR I) NIL J) VAAC WELLINGTON K) NIL)	
16/2234	NFFF SIGMET 02 VALID 170400/171000 NFFN- NFFF NADI OCEANIC FIR EXER CNL SIGMET 1 170400/171000=	Cancellation of VA SIGMET by MWO Nadi
16/2241	NFFF SIGMET 03 VALID 170400/171000 NFFN- NFFF NADI FIR EXER MT TOFUA PSN S1945 W17504 VA CLD FCST AT 0402Z WI S1400 W17915 - S1200 E17845 - S1030 W17830 - S1245 W17715 SFC/FL400=	Updated VA FIR SIGMET, issued by MWO Nadi.
16/2253	(ASHTAM 003/20 A) NZZO B) 2007162253 C) TOFUA 243060 D)1945S 17504W E) RED F) SFC/FL400 S1915 W17500 - S1830 W17630 - S1715 W17530 - S1715 W17400 - S1845 W17345 MOV NW 15KT G) FCST VA CLD +6 HR: 17/0402Z SFC/FL100 S1915 W17500 - S1845 W17600 - S1745 W17530 SFC/FL400 S1400 W17915 - S1200 E17845 - S1030 W17830 - S1245 W17715 FCST VA CLD +12 HR: 17/1002Z SFC/FL100 S1915 W17500 - S1845 W17600 - S1745 W17530 SFC/FL400 S0915 W17830 - S0715 E17930 - S0530 W17815 - S0715 W17615 FCST VA CLD +18 HR: 17/1602Z SFC/FL100 S1915 W17500 - S1845 W17600 - S1745 W17530 SFC/FL400 S0415 W17645 - S0315 W17930 - S0015 W17830 - S0130 W17530 H) TONGA SECTOR/NFFF FIR I) NFFF FIR ATS ROUTE SEGMENTS AFFECTED AT 6HR FORECAST: G593- WPT ATOPO TO FU NDB A578- WPT TOLUS TO WPT TESAR A579- WPT KAMAP TO WPT IDEMU B581- WPT BONLO TO WPT BAXIL A584- WPT KETOT-FU NDB J) VAAC WELLINGTON K) FLIGHTS ON ABOVE AFFECTED ROUTES EXPECT TO BE RE-ROUTED BY NADI ATC)	Updated ASHTAM issued by Nadi NOTAM office, outlining affected routes.

17/0034	**VA EXERCISE APAC VOLCEX 20/02** **VOLCANO OBSERVATORY NOTICE FOR AVIATION (VONA)** (see table below) **VA EXERCISE VA EXERCISE VA EXERCISE**	VONA #3 issued by Tonga Meteorological Service, on behalf of Tonga Geological Service, updating information on Tofua eruption.

Item No	Element	Content
1	**Message title**	**VOLCANO OBSERVATORY NOTICE FOR AVIATION-VONA**
2	**Issued**:	20200717/0030Z
3	**Volcano:**	Tofua/243060
4	**Current Aviation Color Code**:	**YELLOW**
5	**Previous Aviation Color Code**:	red
6	**Source**:	Tonga geological report including: 1. Updated Satellite imagery (Himawari) 2. Received reports from Kotu residents. 3. Received reports from local fisherman.
7	**Notice Number**:	20/03
8	**Volcano Location**:	19.45°S , 175.04 °W
9	**Area**:	Ha'apai Group, Tonga
10	**Summit Elevation**:	515m
11	**Volcanic Activity Summary**:	• Volcanic Activity is subsiding. The Ash and gas emission has significantly decreased based on satellite imagery and reports received from Kotu. • Large Ash Cloud is drifting quickly to the NNW of Tofua and has passed Niuafo'ou (Figure 1 & 2). • Local fisherman reports an estimated 1km length pumice raft drifting North from Tofua.
12	**Volcanic Cloud Height**:	About 1000 meters AMSL Source of height – Remote sensing (satellite), Ground observer
13	**Other Volcanic Cloud information:**	UNKNOWN
14	**Remarks**:	Ash direction moving NNW ACC changed from RED to YELLOW. **VA EXERCISE APAC VOLCEX 20/02– TONGA METEOROLOGICAL SERVICE A EXERCISE VAAC WELLINGTON – TONGA METEOROLOGICAL SERVICE**
15	**Contacts**:	Tonga MET Services (+67635123/+67635355) E-mail: metstaff@met.gov.to
16	**Next Notice**:	Ideally in real situation VONA will ceased in GREEN colour. For the purpose of this exercise this will be the last VONA report issued from Tonga Met Services.

	 *Figure 1: Himawari 8 image (12:30PM) . Pink – Ash, Yellow – Mix of Ash and Sulphur gas and Green – Sulphur Gas*  *Figure 2: Himawari 8 image (12:30PM) . True Colour Image.*	
17/0110	(ASHTAM 004/20 A) NZZO B) 2007170110 C) TOFUA 243060 D)1945S 17504W E) RED F) SFC/FL400 S1915 W17500 - S1830 W17630 - S1715 W17530 - S1715 W17400 - S1845 W17345 MOV NW 15KT G) FCST VA CLD +6 HR: 17/0402Z SFC/FL100 S1915 W17500 - S1845 W17600 - S1745 W17530 SFC/FL400 S1400 W17915 - S1200 E17845 - S1030 W17830 - S1245 W17715 FCST VA CLD +12 HR: 17/1002Z SFC/FL100 S1915 W17500 - S1845 W17600 - S1745 W17530 SFC/FL400 S0915 W17830 - S0715 E17930 - S0530 W17815 - S0715 W17615 FCST VA CLD +18 HR: 17/1602Z SFC/FL100 S1915 W17500 - S1845 W17600 - S1745 W17530 SFC/FL400 S0415 W17645 - S0315 W17930 - S0015 W17830 - S0130 W17530 H) TONGA SECTOR/NFFF FIR I) NFFF FIR ATS ROUTE SEGMENTS AFFECTED: G593- WPT ATOPO TO FU NDB A578- WPT TOLUS TO WPT TESAR A579- WPT KAMAP TO WPT IDEMU B581- WPT BONLO TO WPT BAXIL A584- WPT KETOT-FU NDB B578- WPT NILAX- GURDI	Updated ASHTAM issued by Nadi NOTAM office, outlining affected routes.

	B450- WPT DUNAK-SOVRA B598- WPT SUGNI-TAXIS G223-WPT PAGRA-ESDOX B599- WPT ELDOG-VIMEK G224- WPT LAPUM-BODER A580- WPT ANBAT-DOMAX R453- WPT GOKIT- IDNIP B577- WPT PUKET-HOI VOR J) VAAC WELLINGTON K) FLIGHTS ON ABOVE AFFECTED ROUTES EXPECT TO BE RE-ROUTED BY NADI ATC)	
17/0124	(P9001/20 NOTAMR P9000/20 A) NFTF B) 2007170120 C) 2007170300 E) VA EXERCISE APAC VOLCEX 20/20, VA EXERCISE APAC VOLCEX 20/20 VOLCANIC ERUPTION ALERT POSITION 19 45 S 175 04 W TOFUA. APRX 85NM N NFTF. NO ASH CLOUD PRODUCED. ALL ACFT TO AVOID AREA FROM SEA LEVEL UP TO 3000FT AMSL F) SFC G) 3000FT AMSL	NOTAM for Tonga Sector of NZZO FIR, issued by Christchurch NOTAM office on behalf of Tonga AIS.
17/0050	FVPS01 NZKL 162230 VA ADVISORY STATUS: EXER DTG: 20200717/0051Z VAAC: WELLINGTON VOLCANO: UNKNOWN PSN: UNKNOWN AREA: WELLINGTON SUMMIT ELEV: UNKNOWN ADVISORY NR: 2020/2 INFO SOURCE: VA EXERCISE APAC VOLCEX 20/02 AVIATION COLOUR CODE: UNKNOWN ERUPTION DETAILS: VA EXERCISE APAC VOLCEX 20/02 OBS VA DTG: 17/0050Z OBS VA CLD: FCST VA CLD +6 HR: 17/0650Z FCST VA CLD +12 HR: 17/1250Z FCST VA CLD +18 HR: 17/1850Z RMK: VA EXERCISE APAC VOLCEX 20/02. VAAC DARWIN HAS ASSUMED RESPONSIBILITY FOR ISSUING VAA TO VAAC WELLINGTON AREA OF RESPONSIBILITY. PLEASE CONTACT VAAC DARWIN AS PER IAVW HANDBOOK TABLE 4-2 FOR VOLCANIC ASH ADVICE TO THE VAAC WELLINGTON AREA. VA EXERCISE. NXT ADVISORY: NO FURTHER ADVISORIES	“Notice VAA” issued by VAAC Darwin announcing initiation of backup services for VAAC Wellington area of responsibility.
17/0130	FVPS01 NZKL 170100 VA ADVISORY STATUS: EXER DTG: 20200717/0130Z VAAC: WELLINGTON VOLCANO: TOFUA 243060 PSN: S1945 W17504 AREA: TONGA SUMMIT ELEV: 515M ADVISORY NR: 2020/3 INFO SOURCE: VA EXERCISE APAC VOLCEX 20/02 AVIATION COLOUR CODE: UNKNOWN ERUPTION DETAILS: VA EXERCISE APAC VOLCEX 20/02 OBS VA DTG: 17/0130Z OBS VA CLD: SFC/FL100 S1948 W17505 - S1930 W17528 - S1915 W17507 - S1944 W17458 MOV NW 15KT SFC/FL410 S1333 W17857 - S1111 E17829 - S0941 W17821 - S1241 W17728 MOV NW 15KT FCST VA CLD +6 HR: 17/0730Z SFC/FL100 S1948 W17504 - S1930 W17531 - S1914 W17509 - S1944 W17458 SFC/FL410 S0914 W17806 - S0735 E17856 - S0516 W17833 - S0729 W17625	VAA and VAG issued by VAAC Darwin, on behalf of VAAC Wellington.

	FCST VA CLD +12 HR: 17/1330Z SFC/FL100 S1948 W17505 - S1930 W17532 - S1916 W17509 - S1943 W17459 SFC/FL410 S0435 W17637 - S0245 W17905 - S0027 W17641 - S0203 W17405 FCST VA CLD +18 HR: 17/1930Z SFC/FL100 S1948 W17506 - S1930 W17534 - S1913 W17509 - S1943 W17459 SFC/FL410 N0021 W17329 - N0220 W17635 - N0432 W17335 - N0256 W17030 RMK: VA EXERCISE APAC VOLCEX 20/02. VA EXERCISE. VA EXERCISE. VA EXERCISE. NXT ADVISORY: NO LATER THAN 20200717/0730Z 	
17/0145	FVXX26 KNES 170145 VA ADVISORY DTG: 20200717/0145Z VAAC: WASHINGTON VOLCANO: TOFUA PSN: S1944 W17504 AREA: TONGA-SW.PACIFIC SUMMIT ELEV: 1690 FT (515 M) ADVISORY NR: 2020/001 INFO SOURCE: VA EXERCISE APAC VOLCEX 20-02. WELLINGTON VAAC ERUPTION DETAILS: VA EXERCISE APAC VOLCEX 20-02 OBS VA DTG: NOT PROVIDED OBS VA CLD: NOT PROVIDED FCST VA CLD +6HR: NOT PROVIDED FCST VA CLD +12HR: NOT PROVIDED FCST VA CLD +18HR: NOT PROVIDED RMK: VA EXERCISE APAC VOLCEX 20-02. PLEASE SEE FVPS01 NZKL 170130 ISSUED BY THE DARWIN VAAC FOR THE WELLINGTON VAAC THAT DESCRIBES CONDITIONS NEAR THE WASHINGTON VAAC AOR. VA EXERCISE VA EXERCISE VA EXERCISE ...KIBLER NXT ADVISORY: NO FURTHER ADVISORIES	"Near VAA" issued by VAAC Washington referring users to VAAC Wellington VAA issued by VAAC Darwin, describing VA near the VAAC Washington area of responsibility. Note – due to software limitations, the status indicator EXER could not be used in this VAA.
17/0155	NFFF SIGMET 04 VALID 170200/170800 NFFN- NFFF NADI FIR EXER MT TOFUA PSN S1945 W17504 VA CLD OBS AT 0130Z WI S1333 W17857 - S1111 E17829 - S0941 W17821 - S1241 W17728 SFC/FL410 FCST AT 0730Z WI S0914 W17806 - S0735 E17856 - S0516 W17833 - S0729 W17625=	Updated VA SIGMET, issued by MWO Nadi.
17/0208	WVPS21 NZKL 170153 NZZO SIGMET 1 VALID 170208/170808 NZKL- NZZO AUCKLAND OCEANIC FIR EXER MT TOFUA PSN S1945 W17504 VA CLD OBS AT 0130Z WI S1948 W17505 - S1930 W17528 - S1915 W17507 - S1948 W17505 SFC/FL100 FCST AT 0730Z WI S1948 W17504 - S1930 W17531 - S1914 W17509 - S1948 W17504= WVPS21 NZKL 170154	Updated VA SIGMET, issued by MWO Wellington, plus cancellation of previous SIGMET.

	NZZO SIGMET 2 VALID 170208/170410 NZKL- NZZO AUCKLAND OCEANIC FIR EXER CNL SIGMET 10 162210/170410=	
17/0216	FVPS04 NZKL 170216~ VA ADVISORY STATUS: EXER DTG: 20200717/0216Z VAAC: WELLINGTON VOLCANO: UNKNOWN PSN: UNKNOWN AREA: SUMMIT ELEV: UNKNOWN ADVISORY NR: 2020/5 INFO SOURCE: VA EXERCISE APAC VOLCEX 20/02 AVIATION COLOUR CODE: UNKNOWN ERUPTION DETAILS: VA EXERCISE APAC VOLCEX 20/02 OBS VA DTG: 17/0216Z OBS VA CLD: VA NOT IDENTIFIABLE FM SATELLITE DATA WIND FL010/020 VRB00KT FCST VA CLD +6 HR: 17/0816Z NO VA EXP FCST VA CLD +12 HR: 17/1416Z NO VA EXP FCST VA CLD +18 HR: 17/2016Z NO VA EXP RMK: VA EXERCISE APAC VOLCEX 20/02. VAAC WELLINGTON HAS RESUMED RESPONSIBILITY FOR ISSUING VAA TO THE VAAC WELLINGTON AREA OF RESPONSIBILITY. NXT ADVISORY: NO FURTHER ADVISORIES	"Notice VAA" issued by VAAC Wellington advising of resumption of responsibility for issuing VAA to the VAA Wellington area of responsibility.
17/0225	(ASHTAM 005/20 A) NZZO/NFFF B) 20071702 C) TOFUA 243060 D)1945S 17504W E) RED F) SFC/FL100 S1948 W17505 - S1930 W17528 - S1915 W17507 - S1944 W17458 MOV NW 15KT SFC/FL410 S1333 W17857 - S1111 E17829 - S0941 W17821 - S1241 W17728 MOV NW 15KT G) FCST VA CLD +6 HR: 17/0730Z SFC/FL100 S1948 W17504 - S1930 W17531 - S1914 W17509 - S1944 W17458 SFC/FL410 S0914 W17806 - S0735 E17856 - S0516 W17833 - S0729 W17625 FCST VA CLD +12 HR: 17/1330Z SFC/FL100 S1948 W17505 - S1930 W17532 - S1916 W17509 - S1943 W17459 SFC/FL410 S0435 W17637 - S0245 W17905 - S0027 W17641 - S0203 W17405 FCST VA CLD +18 HR: 17/1930Z SFC/FL100 S1948 W17506 - S1930 W17534 - S1913 W17509 - S1943 W17459 SFC/FL410 N0021 W17329 - N0220 W17635 - N0432 W17335 - N0256 W17030 H) NFFF FIR G593 A578 A579 B581 A584 B578 B450 B598 G223 B599 G224 A580 R453 B577 I) ROUTES SEGMENT CLOSED B580-WPT GITON TO WPT BOILS G593- WPT ATOPO TO FU NDB A578- WPT TOLUS TO WPT TESAR A579- WPT KAMAP TO WPT CUFFY B581- WPT BONLO TO WPT BAXIL A584- WPT KETOT-AKUMO B578- WPT NILAX- WPT GURDI B450- WPT DUNAK- WPT SOVRA B598- WPT SUGNI- WPT TAXIS G223-WPT PAGRA- WPT ESDOX B599- WPT ELDOG- WPT VIMEK G224- WPT LAPUM- WPT BODER A580- WPT ANBAT- WPT DOMAX R453- WPT GOKIT- WPT IDNIP B577- WPT PUKET- HOI VOR J) VAAC DARWIN	Updated ASHTAM issued by Nadi NOTAM office, outlining affected routes.

	K) FLIGHTS ON ABOVE AFFECTED ROUTES EXPECT TO BE RE-ROUTED BY NADI ATC)	
17/0234	(P9002/20 NOTAMC P9001/20 A) NFTF B) 2007170232 E) VA EXERCISE APAC VOLCEX 20/20, VA EXERCISE APAC VOLCEX 20/20 VOLCANIC ERUPTION ALERT CANCELLED	Final NOTAM for the Tonga Sector emailed by Christchurch NOTAM office on behalf of Tonga AIS during exercise.
17/0254	WVPS21 NZKL 170254 NZZO SIGMET 3 VALID 170254/170808 NZKL- NZZO AUCKLAND OCEANIC FIR EXER CNL SIGMET 1 170208/170808=	Cancellation SIGMET issued by MWO Wellington at conclusion of exercise.
17/0300	FVPS01 NZKL 170300~ VA ADVISORY STATUS: EXER DTG: 20200717/0300Z VAAC: WELLINGTON VOLCANO: TOFUA 243060 PSN: S1945 W17504 AREA: TONGA SUMMIT ELEV: 515M ADVISORY NR: 2020/3 INFO SOURCE: VA EXERCISE APAC VOLCEX 20/02 AVIATION COLOUR CODE: UNKNOWN ERUPTION DETAILS: VA EXERCISE APAC VOLCEX 20/02 CONCLUDED OBS VA DTG: 17/0300Z OBS VA CLD: VA NOT IDENTIFIABLE FM SATELLITE DATA WIND FL010/020 VRB00KT FCST VA CLD +6 HR: 17/0900Z NO VA EXP FCST VA CLD +12 HR: 17/1500Z NO VA EXP FCST VA CLD +18 HR: 17/2100Z NO VA EXP RMK: VA EXERCISE APAC VOLCEX 20/02 CONCLUDED NXT ADVISORY: NO FURTHER ADVISORIES	Final VAA issued by VAAC Wellington.
17/0300	170300 NZCHYNYX (B3899/20 NOTAMC B3757/20 Q) NZZO/QWECN/IV/BO /W /000/999/1945S17504W999 A) NZZO B) 2007170300 E) VA EXERCISE APAC VOLCEX 20/02. VOLCANIC ASH EXERCISE COMPLETE)	Final NOTAM issued through normal channels by Christchurch NOTAM office announcing completion of VOLCEX 20/02 exercise.
17/0303	(VOLCEX 20/02 ENDED…ALL ASHTAMS TO BE NOW DISREGARDED)	Email sent to participants from Nadi NOTAM office.
17/0307	01 NFFN 170300 NFFF SIGMET 01 VALID 170310/170800 NFFN- NFFF NADI FIR CNL SIGMET 04 150200/150800=	Cancellation SIGMET issued by MWO Nadi at conclusion of exercise.

Appendix C – List of Recommendations

1	Tonga Meteorological Service update VONA template to indicate the volcano location is in degrees/minutes.
2	VAAC Wellington consider creating education material as part of outreach to users, volcano observatories and MWOs on how information on volcanic ash emission is shared.
3	VAAC Wellington and CAA NZ to work together to determine whether initial basic SIGMET or initial VAA should be issued as the first indicator of an eruption.
4	VAAC Wellington to work with Airways to explore options to notify the Christchurch NOTAM office on any new eruption within the wider NZZO FIR.
5	CAA NZ and Airways coordinate with other States within the NZZO FIR that have adopted the New Zealand ruleset to identify coordination of temporary volcanic hazard zone airspace that overlaps adjacent FIRs.
6	Nadi, Christchurch and Tonga NOTAM offices to consider how to establish early communication and coordination during high level volcanic ash events that are expected to affect multiple FIRs, involving other NOTAM offices as appropriate (eg Tahiti, Brisbane, Honiara FIRs).
7	MetService review guidance on issuing VA SIGMETs for multiple volcanic ash clouds.
8	Nadi NOTAM office consider just including observed ash cloud movement in section G of ASHTAM, rather than the full forecast volcanic ash polygons from the VAA, in order to mitigate pilot information overload.
9	MWO Nadi ensure that, when updating a SIGMET for a phenomenon that is continuing, any cancellation SIGMET is issued after the new SIGMET is issued, thereby ensuring there is always a SIGMET in force.
10	Tonga ATC include the Wellington MWO / VAAC Wellington in any communications regarding volcanic activity reported by pilots. Tonga ATC work with Wellington MWO / VAAC Wellington to ensure receipt of relevant SIGMETs and VAA.
11	Tonga AIS to consider contents of VA SIGMET or VAA affecting the Tonga Sector when drafting NOTAM on volcanic activity.
12	MetService continue working with VAAC Darwin to ensure backup VAAs issued on behalf by VAAC Darwin can be ingested into MetService internal systems
13	VAAC Darwin review backup VAA dissemination list to ensure all APAC RODBs are included, alongside other usual recipients of VAAC Wellington VAAs, and conduct further backup tests to ensure receipt of backup VAAs.
14	Brisbane RODB review requirement for VAAC Washington VAA receipt and if necessary, work with VAAC Washington on ensuring future VAA receipt.
15	VAAC Wellington discuss options for VAA/VAG provision for Fiji Airports, considering also access to VAA during VAAC Darwin backup events.
16	Airlines that did not receive the exercise SIGMETs or VAA through their usual channels to determine why and, if necessary, request MWOs and VAACs to issue further 'status indicator EXER' messages to test receipt.
17	Future VOLCEX exercises to reach out to globally based airlines (including those in the United States) for participation, potentially via the ISPACG forum.
18	CAA NZ to work with VAAC Wellington and/or Airways NZ to determine an appropriate mechanism to alert CAA NZ of any new volcanic activity in the NZZO, taking into account the existing NZZC volcanic activity process.
19	Fiji Met Service to review the use of identical WMO headers for SIGMET bulletins issued within the same calendar month.
20	ISPACG, in coordination with the ICAO APAC MET Services working group, arrange a workshop to discuss proactive measures that could be used to minimise the likelihood of conflicting volcanic ash information and recommend strategies to the ICAO APAC VOLCEX SG Secretariat for further escalation within ICAO.