

*International Civil Aviation Organization*



**THE TWELFTH MEETING OF ASIA/PACIFIC ROBEX  
WORKING GROUP (ROBEX WG/12) and  
FOURTH MEETING OF METEOROLOGICAL HAZARDS TASK  
FORCE (MET/H TF/4)**

ICAO Regional Sub-Office, Beijing, China

19 March 2014

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**Agenda Item (conjoint session) 2:** SIGMET and advisory information

d) Advisory information

**VAAC DARWIN REPORT**

(Presented by Australia)

**SUMMARY**

This paper presents a concise management report highlighting recent developments and difficulties, advisory information and future planned events. The report is prepared by Australia for the group's review and consideration.

**1. EXECUTIVE SUMMARY**

1.1 The Volcanic Ash Advisory Centre (VAAC) Darwin issued 1096 Volcanic Ash Advisories (VAA) during the 11 month period January 2013 – November 2013. Significant eruptions during this period include a series of high level eruptions from the volcanoes Paluweh (Indonesia), Sinabung (Indonesia) and Manam (Papua New Guinea).

1.2 In addition to the existing Daily Activity Summary, two new volcanic activity situational awareness products have been introduced by VAAC Darwin during 2013.

1.3 The Australian Bureau of Meteorology and New Zealand MetService signed a Memorandum of Understanding formalising the backup arrangements between VAACs Darwin and Wellington.

1.4 The Australian Bureau of Meteorology and the Japan Meteorological Agency conducted an exchange of letters formalising backup arrangements between VAACs Darwin and Tokyo.

## 2. INTRODUCTION

2.1. VAAC Darwin covers the area from the Andaman Islands (India) eastwards to the Solomon Islands. This area includes the volcanically active Indonesian archipelago, Papua New Guinea and the southern Philippines. Overall, more than 150 volcanoes are active within the area. 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.

## 3. OPERATIONS OF THE VAAC

### 3.1 Issuance of Volcanic Ash Advisories (VAAs)

3.1.1 A total of 1096 VAA were issued by VAAC Darwin for the 11-month period from January to November 2013 (see Figure 1). Low level eruptive activity continued to dominate with the greatest number of VAA being issued for the volcanoes Batu Tara (333), Dukono (116) and Paluweh (230) in Indonesia and Bagana (124) in Papua New Guinea. Total advisory numbers by volcano are shown in Figure 2. A graph showing the trend in VAA issuance since 1993 is given in Figure 3.

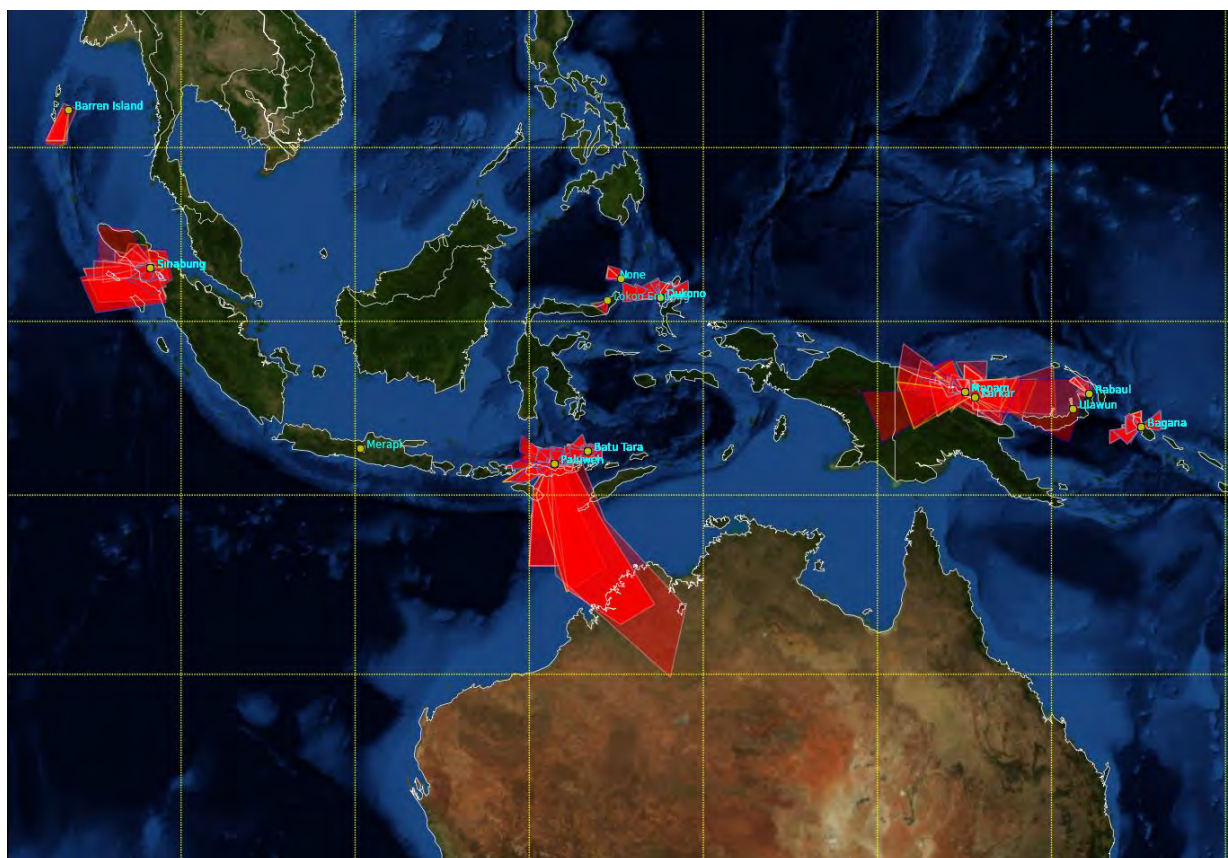


Figure 1. Volcanic Ash Advisories issued by VAAC Darwin (January to November 2013)

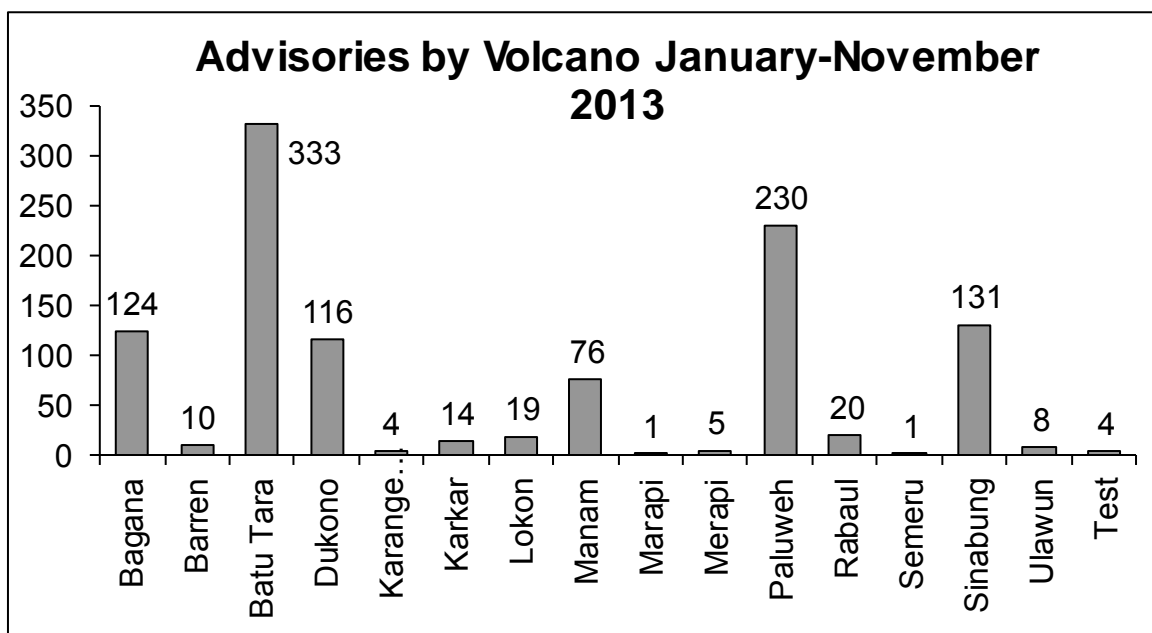


Figure 2. Number of Advisories issued per volcano (January - November 2013).

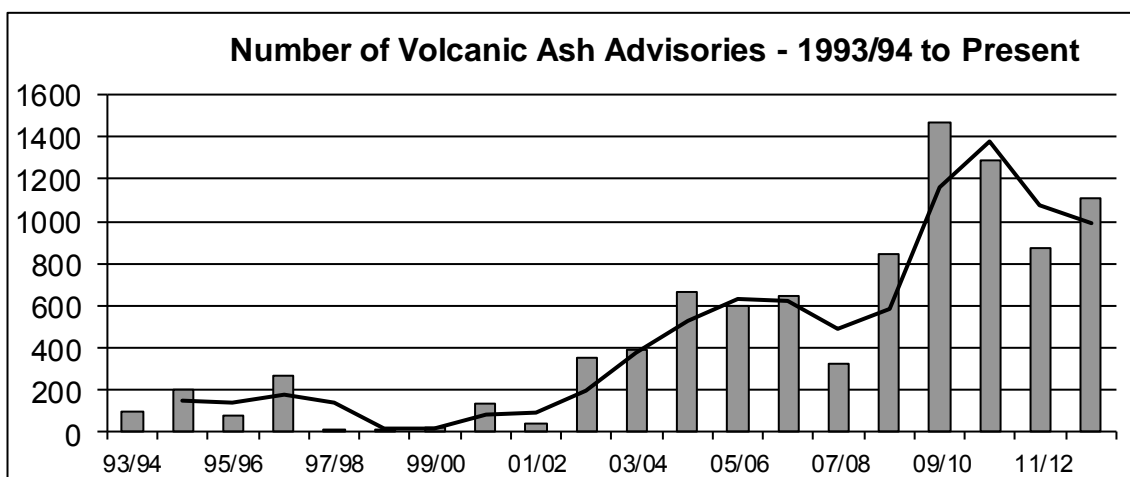


Figure 3. Number of VAA since 1 July 1993. Note Australian fiscal year runs from 1 July to 30 June.

### 3.2 Significant Eruptions

3.2.1 After nearly four months of low level eruptions, Paluweh erupted to above 40,000ft in early February. Ash from the Paluweh eruption caused significant impacts on the Australian aviation industry as it moved towards the Kimberley coast in Western Australia before dissipating.

3.2.2 Sinabung, which is located in close proximity to air routes servicing Singapore and Kuala Lumpur, began a new eruptive phase on September 2013. Frequent eruptions have been observed during November, with a maximum height of 30,000ft on the 19 November 2013 and the volcano remains a significant eruption risk. The installation of web cameras by Indonesia has proved very useful.

3.2.3 A series of three high level eruptions occurred at Manam from January until March 2013. The eruptions reached a maximum altitude of 45,000ft and were associated with significant SO<sub>2</sub> emissions.

### **3.3 Significant Operation or Technical Changes**

3.3.1 IBL Software has been commissioned to deliver a replacement to the Bureau's Volcanic Ash Warning System (VAWS) which has been in use at the VAAC since 2004. A prototype of the system is currently being trialed in the VAAC and is expected to be operationalized in mid-2014. The system is expected to deliver an integrated satellite monitoring – advisory generation system and enhanced collaborative decision making opportunities.

3.3.2 A Graphical Daily Activity Summary (GDAS) has been introduced into VAAC operations to encourage greater situational awareness amongst VAAC staff. The GDAS is being made available on a trial basis to registered aviation users via the Bureau of Meteorology website.

3.3.3 VAAC Darwin commenced the production of a Weekly Volcanic Activity Report with the aim of providing a more in-depth look at volcanic activity for the VAAC Darwin region and adjacent areas. New eruptions are covered in addition to reports received from observatories on the increase or decrease of volcanic activity.

3.3.4 VAAC Darwin was certified according to the AS/NZS ISO 9001:2008 Quality Management Standard in January 2008. An external audit of the VAAC Darwin quality management system, conducted by Lloyd's Register of Quality Assurance (LRQA) in April 2013. There were no areas of non-conformance.

### **3.4 Regional Engagement**

3.4.1 Liaison visits to Japan and Indonesia were undertaken in 2013. The focus of these visits has been to improve communications between VAACs, MWOs and volcano observatories within the region. Progress in this regard has been encouraging and the flow of information between regional organisations involved in the IAVW has been enhanced.

### **3.5 VAAC backup**

3.5.1 Darwin, Tokyo and Wellington VAACs are continuing to cooperate to enhance existing back-up arrangements. A Memorandum of Understanding formalising the backup relationship between Wellington and Darwin VAACs, was signed in 2013 between the Bureau of Meteorology and MetService New Zealand. In February 2014 an exchange of letters between Tokyo and Darwin VAACs took place to formalize the backup arrangements, with the date of effect being 1 March 2014.

## **4. IMPLEMENTATION ISSUES**

4.1 The risk of a significant eruption being undetected, or unreported to the VAAC, remains a significant concern. The paucity of the ground based monitoring and reporting networks within the region leads to a reliance on satellite monitoring for eruption detection; however meteorological activity associated with tropical areas of the region often compromises the detection of new eruptions.

## **5. FUTURE DEVELOPMENTS**

5.1 In response to user demand for improved forecast process transparency, a volcanic activity risk assessment support product will be trialed during 2014. The product is designed to provide flight planners with an indication of the strength of evidence upon which a volcanic ash forecast is based so as to better inform the collaborative decision making process.

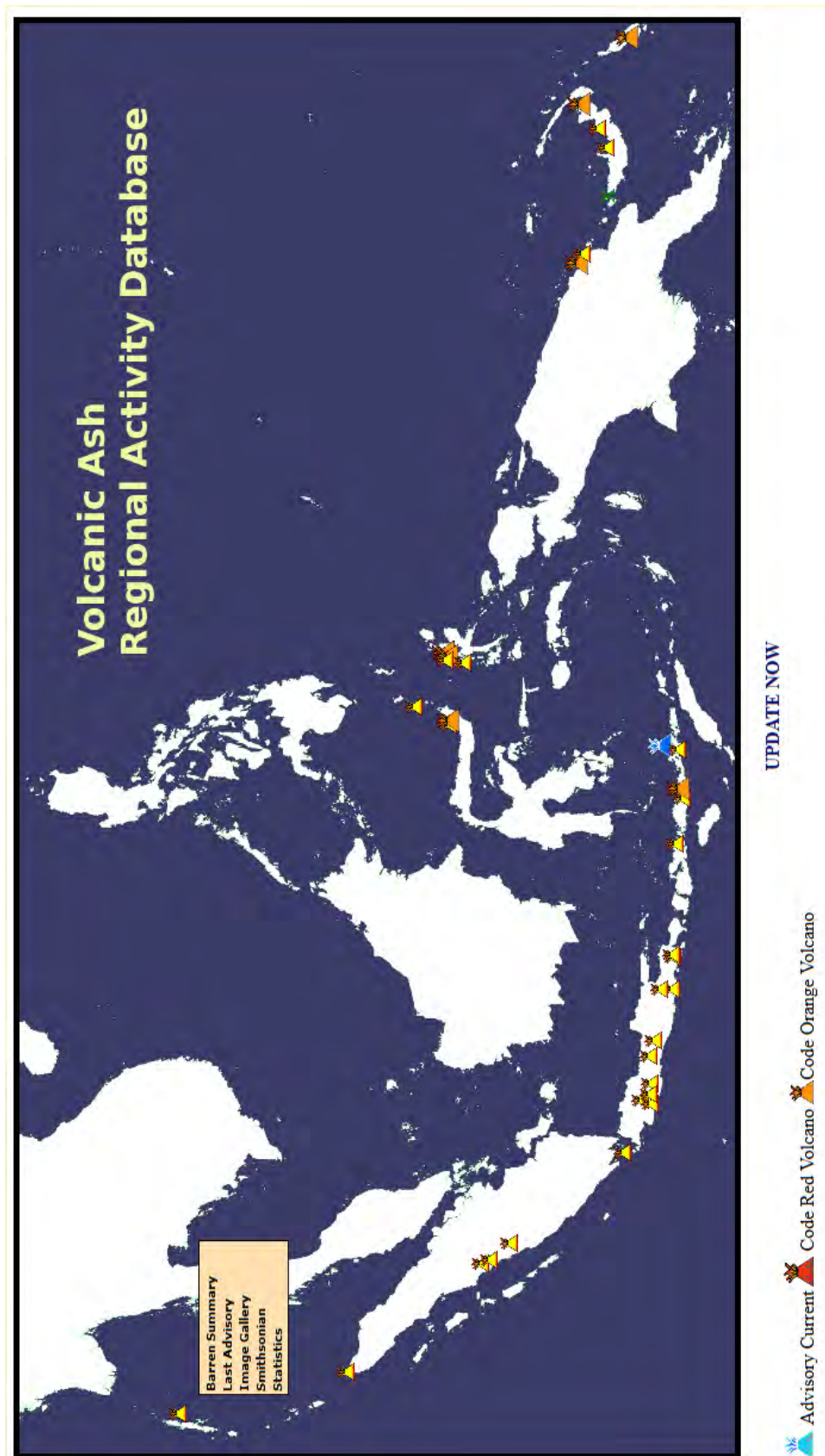
5.2 A major research project is currently being undertaken by the Centre for Australian Weather and Climate Research to support the operations of VAAC Darwin. Expected outcomes of the project include an automated ash loading retrieval system, improved dispersion modelling capabilities and more efficient product generation software.

## **6. ACTION BY THE MEETING**

6.1 The meeting is invited to note the information presented in this paper.

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**ATTACHMENT 1: EXAMPLE OF THE GRAPHICAL DAILY ACTIVITY SUMMARY**



**ATTACHMENT 2: EXAMPLE OF THE WEEKLY ACTIVITY REPORT**

**Australian Government**  
**Bureau of Meteorology**

Weekly Activity Report: 22-28 Jan 2014  
**VAAC Darwin**

Aviation Colour Codes**Red:**

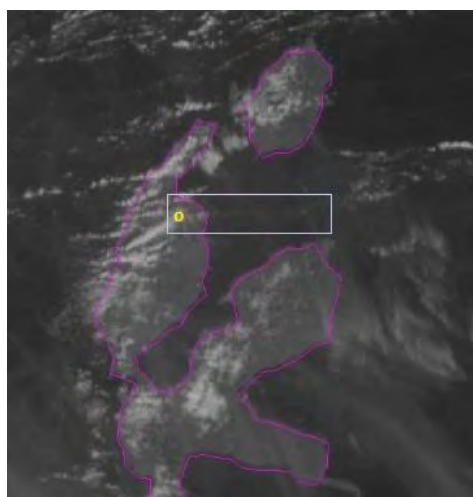
Sinabung

**Orange:**

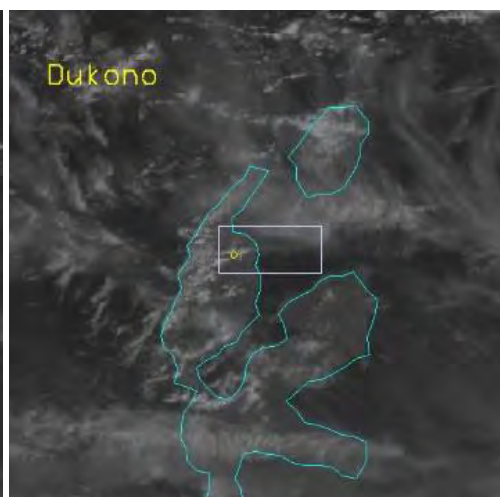
Bagana, Dukono, Lokon, Manam, Paluweh (Rokatenda), Rabaul

New eruptions /activity

**Dukono** – A VA plume was observed extending 60NM to the E at 0632Z on 22 January to FL100 (10 000ft). The VA forecaster maintained the advisory overnight when it was not identifiable on IR imagery due to the history of Dukono. Low level plumes are seen on visible satellite imagery during daylight hours. The VA plume was identified again on MTSAT-2 visible imagery at 22/2232Z and 23/0632Z to FL100 (10 000ft). After that ash was not identifiable on overnight IR satellite or on daylight images due to meteorological cloud. The VA Advisory was cancelled on 24 January at 0223Z when ash had not been identifiable for more than 15 hours and current data sources did not indicate an ongoing eruption.



**Figure 1** MTSAT-2 0032Z 20 Jan 2014



**Figure 2** MTSAT-2 2232Z 20 Jan 2014

A VA plume was observed to FL140 (14 000ft) extending 75NM to the east at 28/0832Z MTSAT-2. The plume was not identifiable due to meteorological cloud for the next two advisories, but was visible again on 29 January during the next weekly reporting period.

*Dukono is a complex volcano located in the northern part of Halmahera. It is a remote volcano with multiple summit peaks and overlapping craters. The summit reaches an elevation of 1335m ASL. Routine observations ended in the mid-1990s but from 1933 until then explosive eruptions with some lava flows occurred on a somewhat continuous basis. In 1550, a major eruption of Dukono led to the strait between Halmahera and the northern flank cone of Mamuya being filled in by lava.*



**Marapi** – There was an eruption of Marapi on 24 January at 0035Z according to Warseno, Post Officer PGA at West Sumatra. The duration of the eruption was 65 seconds with amplitude of 30 millimetres and an earthquake blast for 20 seconds. There was no height of the eruption given due to the thick fog covering Marapi. From 1-23 January, there have 48 eruptions, 25 Shallow Volcanic Earthquakes (VB) and 15 Deep Volcanic Earthquakes (VA) at Marapi along with tremors and tectonic events for a total of 170 seismic activity events. This is an increase from December 2013 when there were only 107 seismic activity events. No volcanic advisories were issued for Marapi, since the information on the low level eruption was not received within 12 hours. Marapi remains on a Level II advisory since 3 August 2011.

**Media Center @infobencana Jan 26**

(24/1/2014) sekitar pukul 07.35 WIB; Letusan Besar Gunung **Marapi** Sumbar Terekam di Seismograf <http://bit.ly/1f1ZSET>



**Sinabung** – The status of Sinabung remains at Level IV, the highest alert level by CVGHM. Seismic activity including hybrid earthquakes, avalanche earthquakes, pyroclastic flows and lava flows along with eruptive activity. Sinabung remains a serious threat. The webcam at has been an invaluable tool along with pilot reports from Jakarta WIII and ground reports from CVGHM detailing seismic and visual information. The webcam is not useful for observing eruptive activity when there are low clouds or ash from repeated pyroclastic flows.

A volcanic ash plume was seen to FL170 (17 000ft) extending 20NM to the east on the MTSAT-2 on 22 January 0232Z. Ongoing eruptions were expected to continue and that was included in the remarks of the 22/0527Z VA Advisory. A weak SO<sub>2</sub> signature was seen looking at the OMI-SO<sub>2</sub>



data later 22 Jan 0331Z. This was not available in real-time. The webcam showed that by late morning low level cloud and ash from pyroclastic flows made it difficult to see Sinabung.

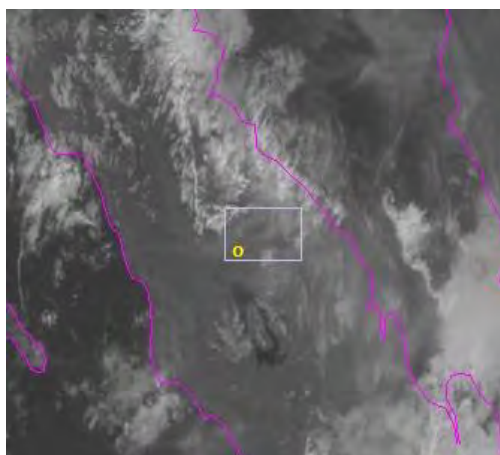


Figure 3 MTSAT-2 0232Z 22 Jan 2014



Figure 4 Sinabung Webcam, 22 Jan 2014- 0338Z +7hrs UTC.

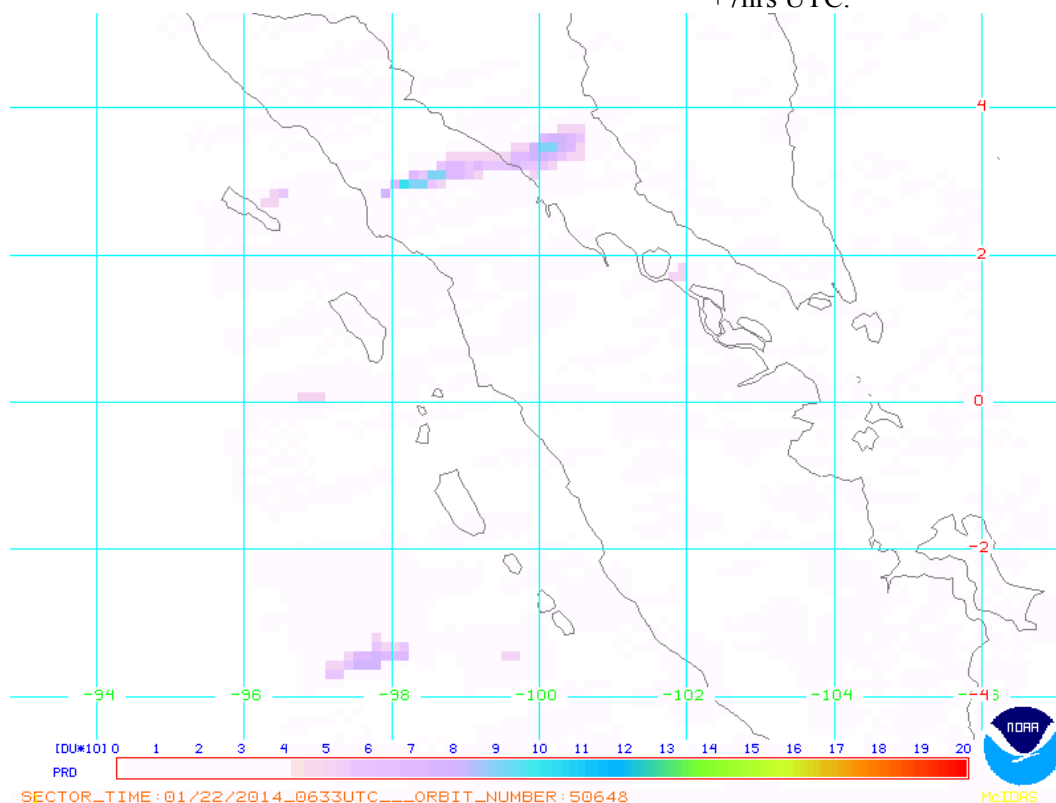


Figure 5 OMI-2 SO2 0633Z \_22 Jan

Eight eruptions were reported by @KAROGlobal on Twitter. According to the Dan Aktual Post Officer of PVMBG (CVGHM), the eruptions occurred from 21/1700Z until 22/1000Z. A pyroclastic flow at 0643Z reached 1.5KM to the southeast.

**Mt. SINABUNG @KAROGlobal Jan 22**

Jelang Kunjungan SBY, Sinabung Erupsi Delapan Kali. [http://m.aktual.co/nusantara/180413jelang-kunjungan-sby-sinabung-erupsi-delapan-kali ...](http://m.aktual.co/nusantara/180413jelang-kunjungan-sby-sinabung-erupsi-delapan-kali...) [pic.twitter.com/VGv1uu7I9v](http://pic.twitter.com/VGv1uu7I9v)

There was another plume seen on 23 January at 0432Z to FL170 (17 000ft). It stretched 20NM to the NE. Ongoing eruptions were expected to continue. It was noted on the 23/0545Z VA Advisory that further eruptions may change direction with the variable wind direction with height. Webcam photos showed the VA plume to the northeast through 23/0417Z.

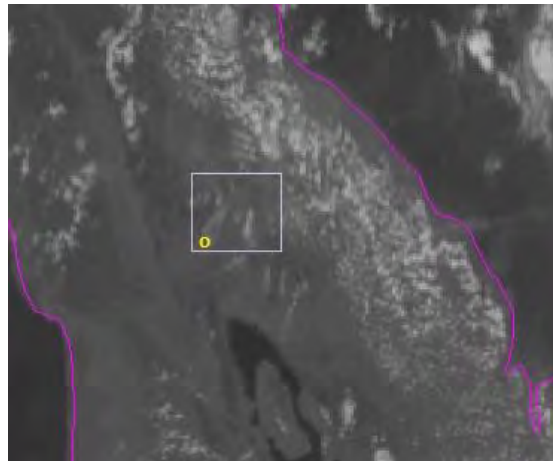


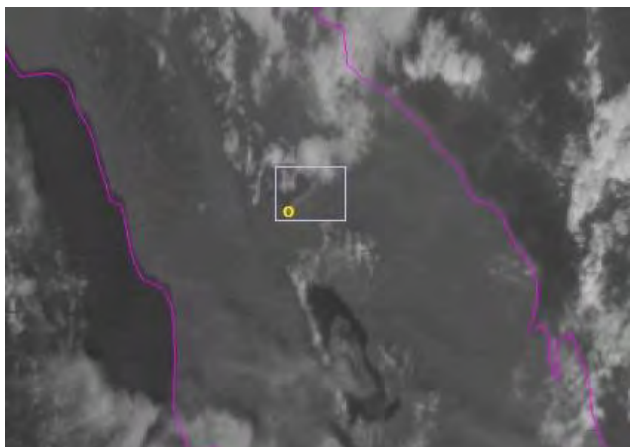
Figure 6 MTSAT-2 0432Z 23 Jan 2014



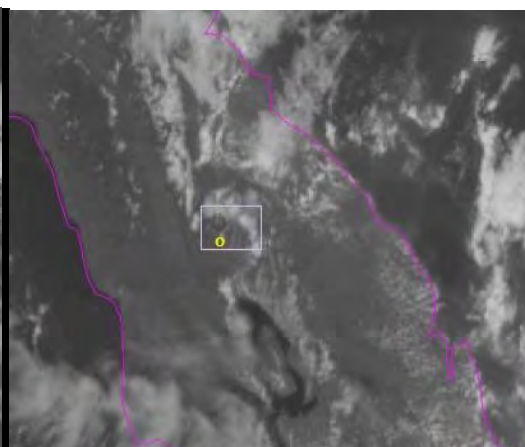
Figure 7 Sinabung Webcam, +7hrs UTC 23 Jan 2014 images: 0256Z, 0302Z, 0336Z and 0417Z.

Two advisories were sent out within a minute of each other at 22/1720Z and 22/1721Z Advisory NR: 92 and 93 for Sinabung. It appears that the submit button was accidentally hit twice as no information changed with the advisories except the issuance time and advisory number.

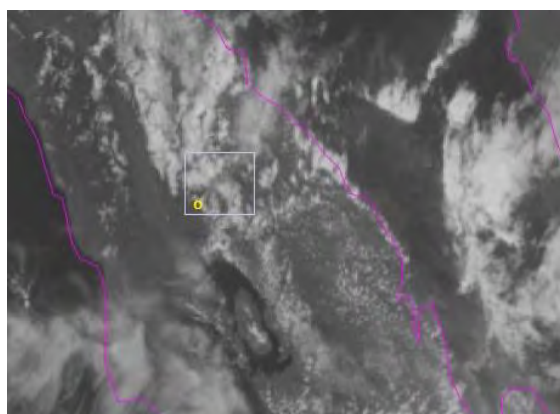
The next VA plume was observed on visible satellite from 24/0232Z until 24/0432Z to FL170 (17 000ft) stretching 20NM to the NE. Meteorological cloud obscured the view of the VA plume after 0432Z. The webcam photo from 24 January at 0557Z shows the ash and meteorological cloud limiting the view of Sinabung.



**Figure 8** MTSAT-2 0232Z 24 Jan 2014



**Figure 9** MTSAT-2 0332Z 24 Jan 2014

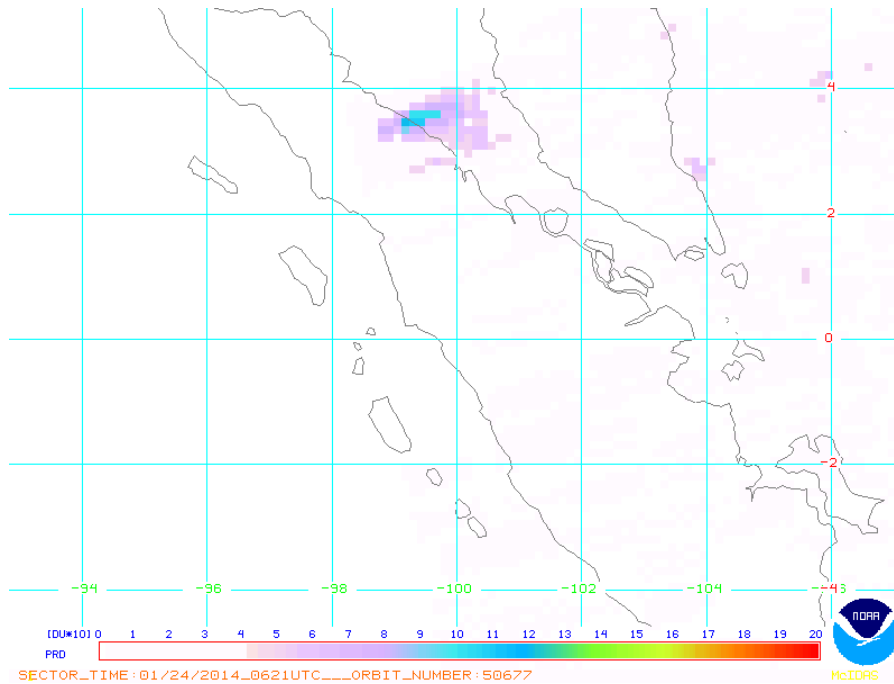


**Figure 10** MTSAT-2 0432Z 24 Jan 2014



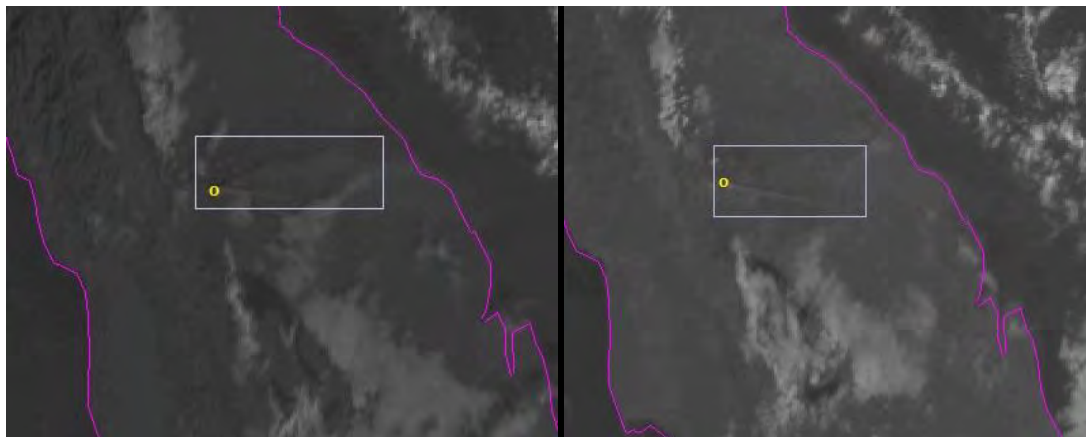
**Figure 11** Sinabung Webcam, +7hrs UTC  
24 Jan 2014 - 0557Z.

A GOME-SO2 image from 24/0621Z shows a concentration of SO2 to the east of Sinabung.



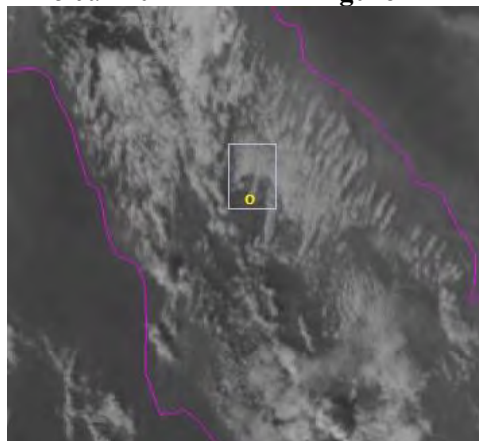
**Figure 12 GOME-2 SO2 0621Z \_24 Jan**

On 25 January, the VA plume was observed to FL170 (17 000ft) at 0032Z. It extended 100NM to the east. The plume was seen at 25/0132Z and then again at 25/0832Z before meteorological cloud made VA not identifiable on satellite.



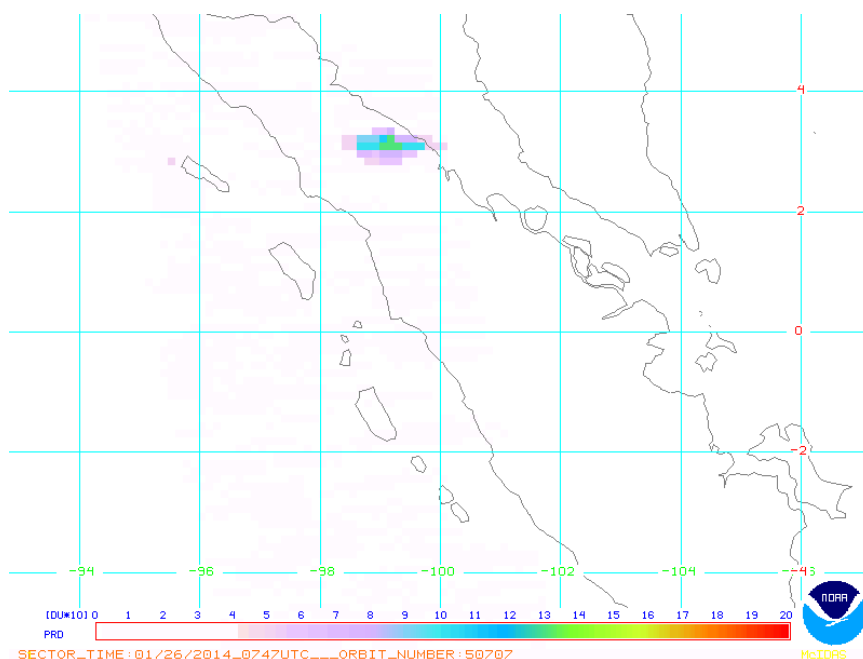
**Figure 13 MTSAT-2 0032Z 25 Jan 2014**

**Figure 14 MTSAT-2 0132Z 25 Jan 2014**



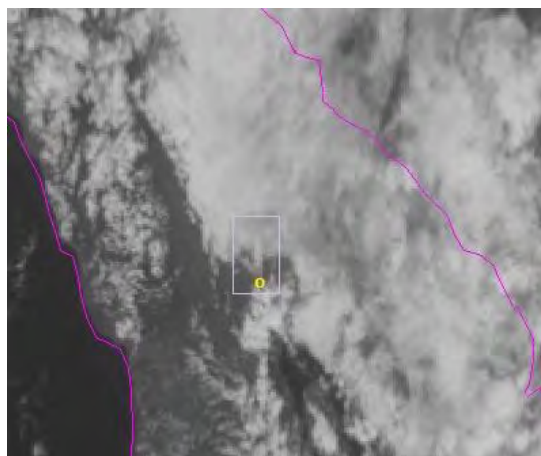
**Figure 15** MTSAT-2 0832Z 25 Jan 2014

A concentration of SO2 was seen on the OMI-SO2 at 26/0746Z. It stretched to the east of Sinabung towards Medan. This data was not available in real-time.

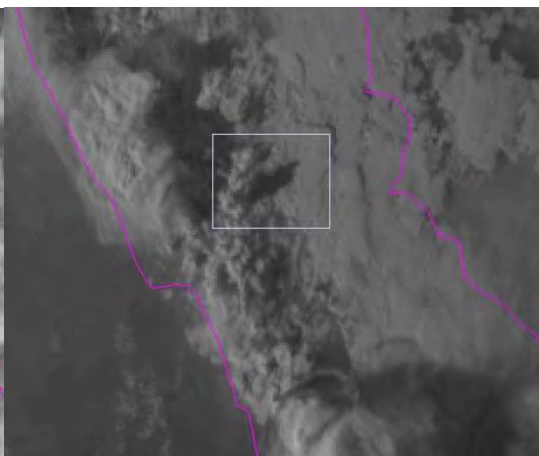


**Figure 16** OMI-2 SO2 0747Z \_26 Jan

On the 27/0532Z MTSAT-2 image, a VA plume was seen 40NM to the north of Sinabung. The height was reported to FL170 (17 000ft). One of the last images of the day from the MTSAT-2 visible satellite showed the VA plume at 27/1032Z. The plume was not seen again on satellite through the end of the reporting 28 January. Ongoing eruptions were seen on webcam and the VA Advisories mentioned this in the remarks for 28 January.



**Figure 17** MTSAT-2 0532Z 27 Jan 2014



**Figure 18** MTSAT-2 1032Z 27 Jan 2014

A SACS multi-sensor notification of exceptional SO2 concentration was received on 27 January at 0652Z. A strong concentration of SO2 was picked up in the vicinity of Sinabung and to east/northeast. This information was available to forecasters within 85 minutes at 0814Z when it was received by email. The link supplied by sacs is broken, but the image was saved in Figure.

SACS multi-sensor notification of exceptional SO2 concentration

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Process date : 2014/01/27  
Process time : 08:11 UTC  
Instrument : OMI  
Notification region: 309

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[http://sacs.aeronomie.be/OMIalert/2014/01/alertsOMI\\_20140127\\_06h06\\_309.php?alert=20140127\\_081122\\_309](http://sacs.aeronomie.be/OMIalert/2014/01/alertsOMI_20140127_06h06_309.php?alert=20140127_081122_309)

Date : 2014/01/27  
Time : 06:52 UTC  
Longitude : 98.4 deg.  
Latitude : 3.3 deg.  
SZA : 28.3 deg.  
Max. SO2 vcd : 7.4 DU  
Cloud data : used for VCD  
< Super Region 2 >

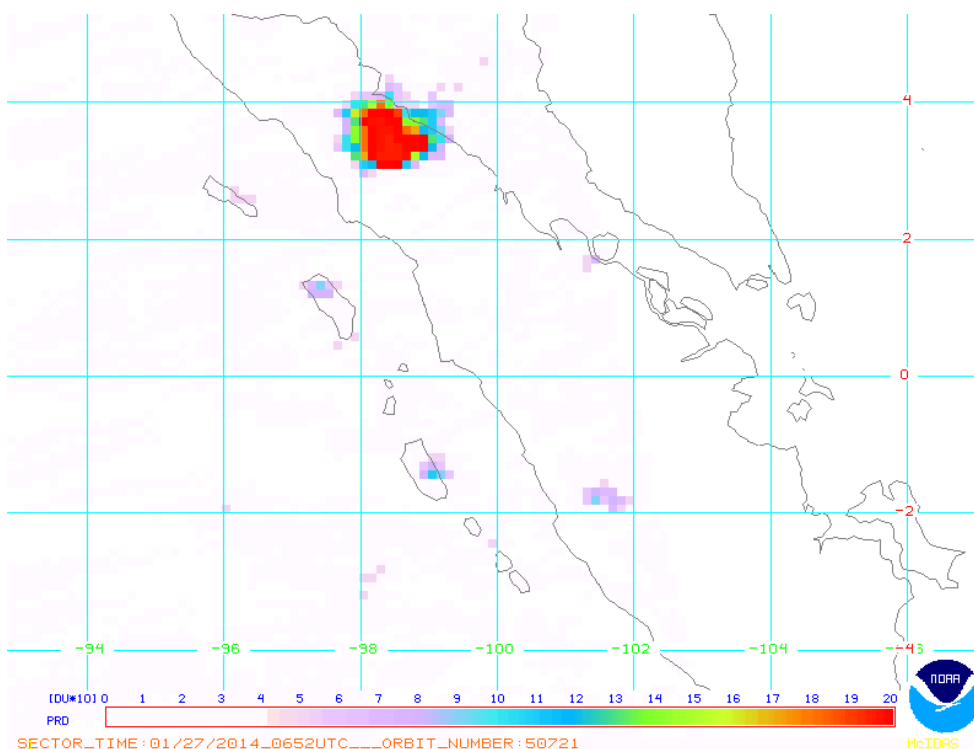


Figure 19 OMI-2 SO2 0652Z \_27 Jan

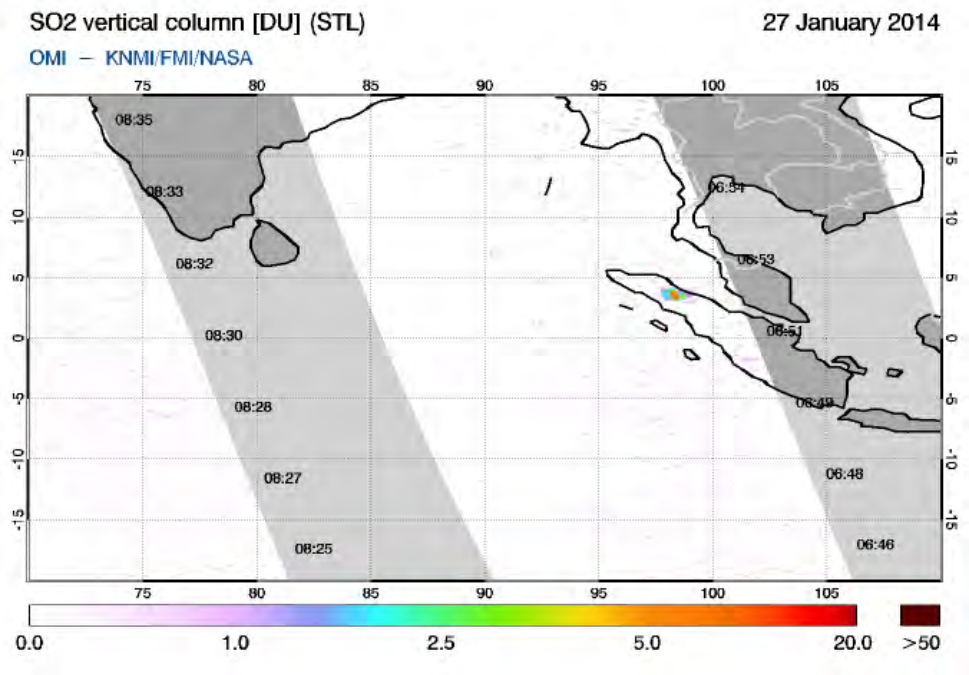


Figure 20 OMI-2 SO2 0652Z \_27 Jan

Another strong concentration of SO2 was picked up in the vicinity of Sinabung and to the east/northeast on 28 January at 0735Z. This information was not real-time and was not available to the VA forecaster for a few hours.

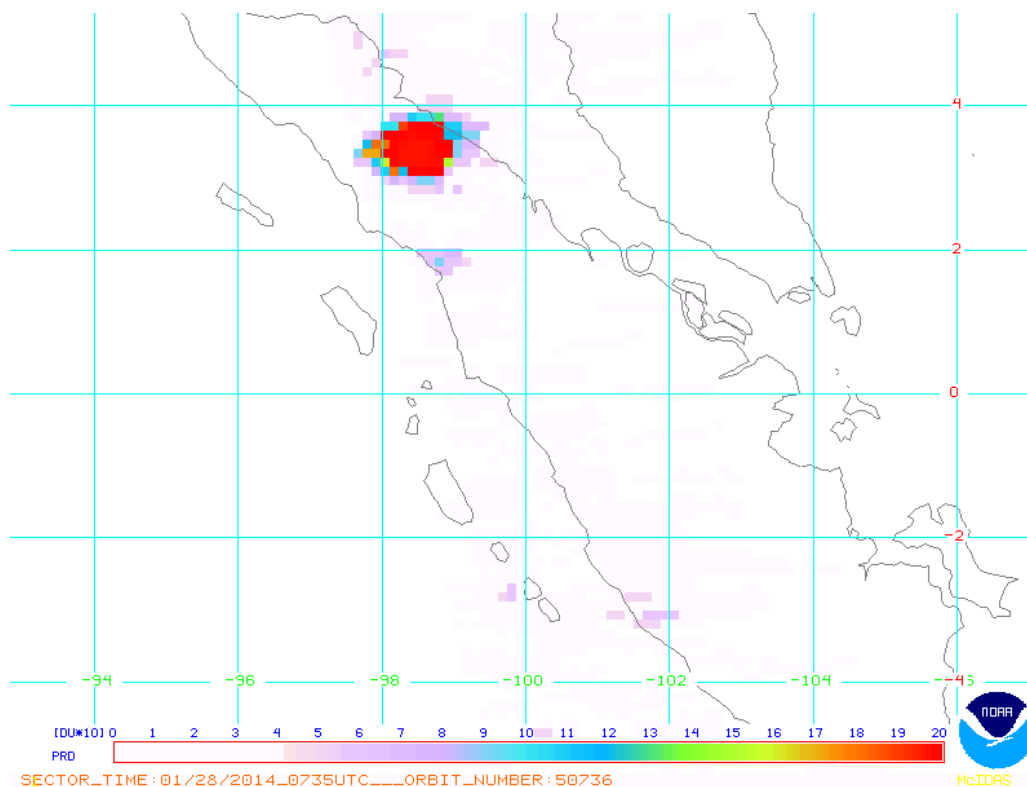


Figure 21 OMI-2 SO2 0735Z \_28 Jan

The MODVOLC shows the high level of thermal hot spots from Sinabung for the period of 4-27 January. Incandescent lava was seen flowing as far as 1000 metres to the southeast on 25 January.

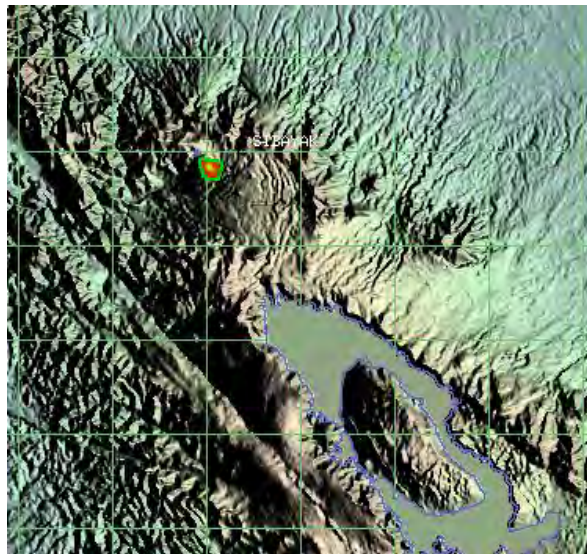


Figure 22 MODVOLC Sinabung, 4-27 January 2014

[Sinabung webcam](#)

On Twitter @KAROGlobal reported that PVMBG also known as CVGHM said that lava domes and a lava tongue have formed with a volume of 4 million cubic meters.

[Mt. SiNABUNG @KAROGlobal Jan 28](#)

PVMBG: Saat ini telah terbentuk kubah lava dan lidah lava dengan volume mencapai 4 juta meter kubik. [#Sinabung pic.twitter.com/AgKeIsBqSW](#)



*Sinabung is a stratovolcano located in North Sumatra. The volcano has a summit of 2460m. Sinabung is from the Pleistocene-Holocene period around 11,700 years ago. There was an unconfirmed eruption in 1881 and then in 1912 hot rich sulphur gases were seen at the summit and upper flanks of Sinabung. Sinabung was not considered active until an eruption in August-September 2010. It had been quiet for more than 400 years, but in September 2013, a new eruptive phase began. Activity began on 14 September with an eruption to 50 metres. On 17 September, there was a pilot report of ash to FL200. By mid-October the volcano was degassing almost daily with small phreatic eruptions. Seismic and visual activity continued to build into November with ash reaching 7 km (FL210) on 2 November, 8 km (FL240) on 18 November and to the highest level to date 10 km*



*(FL330) on 19 November. The status of Sinabung was raised on 24 November by the Centre for Volcanology and Geological Hazard Mitigation (CVGHM) from Level III to Level IV, the highest volcano rating after nine powerful explosions in a 24 hour period.*

### Observatory Reports

### **Indonesia – Center for Volcanology and Geological Hazard Mitigation (CVGM)**

#### **Volcano –Sinabung *Level IV***

Monitoring of Sinabung is conducted in the village of Ndokum Siroga located 8.5km from the summit of Sinabung. Vibration Tremors have varied between 0.5-20mm. SO<sub>2</sub> flux measured between 500-1500 tons/day between 19-26 January. The SO<sub>2</sub> flux measured 4457 tons/day on 27 January when it was measured during an eruption. Hybrid Earthquakes continue to dominate and are associated with the growth of the lava dome, while Avalanche Earthquakes are correlated with the instability of the lava dome. The alert status of Level IV is maintained for Sinabung.

#### **24 January 2014:** [Report 24-31 January 2014](#)

There were 358 Hybrid Earthquakes, 353 Avalanche Earthquakes and 24 Deep Volcanic Earthquake. Thick white smoke was observed in a column 100-1000 metres above the summit. Glowing material was seen as far as 700-1000 metres to the southeast. A continuous tremor vibration was recorded with the amplitude from 0.5-12 mm.

#### **25 January 2014:**

There were 9 Earthquake eruptions, 254 Hybrid Earthquakes, 15 Deep Volcanic Earthquakes (VA), and 433 Avalanche Earthquakes. An eruption column of thick greyish white smoke was seen from 500-1000 metres above the summit. The pyroclastic flow pushed 500-1500 metres to the southeast. Incandescent lava was seen flowing 200-1000 metres to the southeast. A continuous tremor vibration was measured with maximum amplitude of 0.5-15 mm.

#### **26 January 2014:**

There were 3 Earthquake eruptions, 168 Hybrid Earthquakes, 8 Deep Volcanic Earthquakes (VA) and 420 Avalanche Earthquakes. Thick greyish white smoke was observed in an eruption column 300-1500 metres above the summit. Avalanches of pyroclastic flows were seen as far as 700-1500 metres. There was a rumble heard in the PGA G. Post Sinabung. A continuous tremor vibration was recorded with maximum amplitude of 0.5-8 mm.

#### **27 January 2014:**

There were 3 Earthquake eruptions, 178 Hybrid Earthquakes, 11 Deep Volcanic Earthquakes (VA) and 459 Avalanche Earthquakes. Thick greyish white smoke was observed in an eruption column 1000-4000 metres above Sinabung. Pyroclastic flows pushed 1500-4500 metres to the southeast. A continuous tremor vibration was recorded with maximum amplitude of 0.5-20 mm.

#### **28 January 2014:**

There was 1 Earthquake eruption, 118 Hybrid Earthquakes, 11 Deep Volcanic Earthquakes (VA) and 413 Avalanche Earthquakes. Thick greyish white smoke was observed in an eruption column 500-1000 metres above the summit. Pyroclastic flows pushed 500-1500 metres to the southeast. A continuous tremor vibration was recorded with maximum amplitude of 0.5-9 mm.

## Papua New Guinea – Rabaul Volcano Observatory (RVO)

### Volcano –Rabaul

Rabaul was quiet for the reporting period of 20-26 January. There has been no ash since 13 January with only white vapour being reported. No audible noises were heard and there has not been a glow at night. Seismic activity has also been low with only low frequency earthquakes being recorded. There has been some slow uplift in the central part of the caldera and significant browning of the vegetation on Turanguna. Activity is expected to remain quiet, but with the slow inflationary trend, vegetation browning and small low frequency earthquakes RVO said, “the system may return to more sustained activity.”

### Changes to Volcanic Activity Summary (VAS)

Update to Dukono, Marapi, Rabaul and Sinabung.

Maps of volcano locations and close-up views created from <http://gis.icao.int/flexviewer/>.

MODIS Thermal Alerts – <http://modis.higp.hawaii.edu/cgi-bin/modis/modisnew.cgi>

Centre for Volcanology and Geological Hazard Mitigation (CVGHM) <http://www.vsi.esdm.go.id/>

Rabaul Volcano Observatory

Department of Mineral Policy and Geohazards Management (PNG)

Global Volcanism Program <http://www.volcano.si.edu/index.cfm> background

Volcano Discovery <http://www.volcanodiscovery.com/volcanoes.html> background

Badan Meteorologi Klimatologi dan Geofisika – radar data

Cyndee O’Quinn Seals – Weekly Activity Report Editor

[c.seals@bom.gov.au](mailto:c.seals@bom.gov.au)