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Intergovernmental Oceanographic Commission

# 2a. Tsunamis generated by non-seismic and complex sources

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**Pre-IOWAVE25 Workshop on Standard Operating Procedures for NTWCs and DMOs**
**Hybrid – August 2025**

# Introduction

1. Atypical event types
2. Threat assessment techniques
3. Source Identification
4. Update IOTWMS Service Definition
5. TSP Product Examples
6. Case Study: Hunga Tonga-Hunga Ha'apai Volcano Jan 2022 Eruption

# Atypical event types (Non-Seismic and Complex Sources)

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## Volcanic Eruption

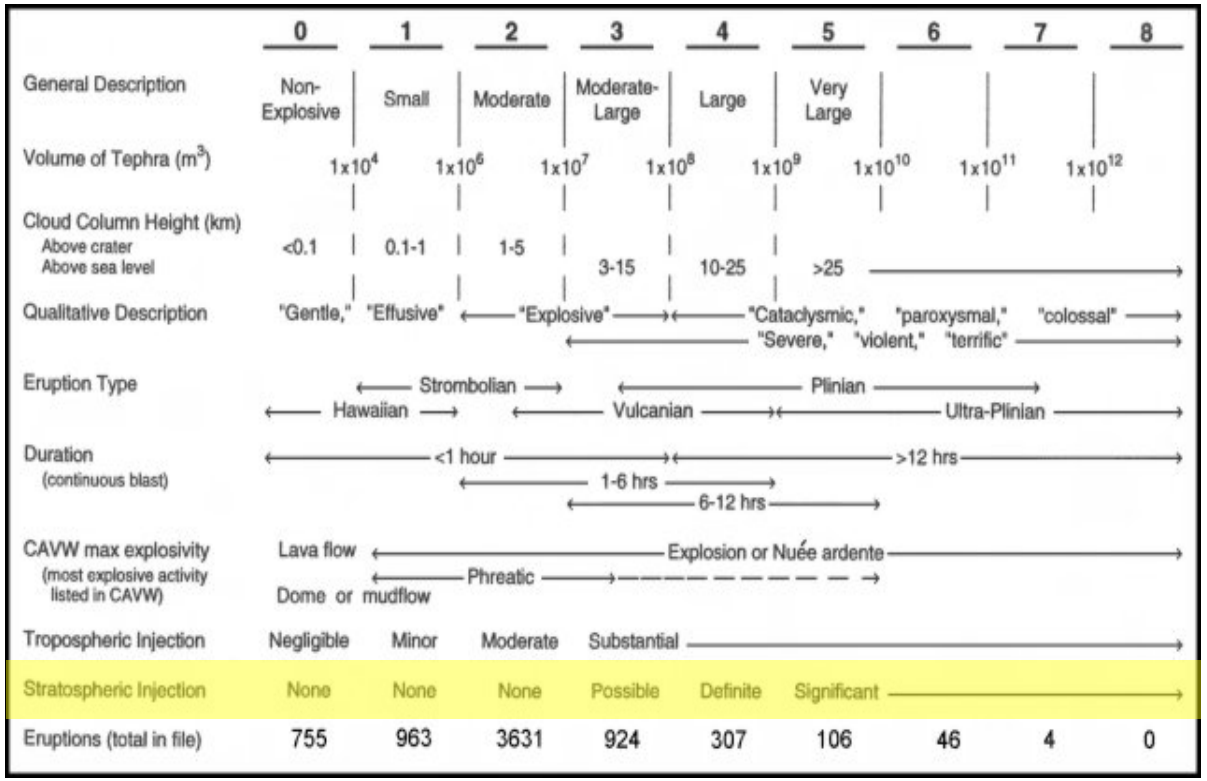
## Landslide

## Unknown

# JATWC Threat Assessment technique

| Severity | Action |
|---|---|
| Level 1 | The threat area is defined to be within the 1 hour travel time isochrone |
| Level 3 | The threat area is defined to be within the 3 hour travel time isochrone |
| Level 6 | The expanding threat area is defined by the elapsed time since event + 6 hour travel time isochrone |

# Volcanic Eruption




**Example Use Case: Hunga Tonga 2022**

- **A VEI 5–6 eruption created atmospheric pressure waves that circled the globe.**
- **Generated tsunamis not through traditional seafloor displacement but shock wave-induced uplift.**
- **Key takeaway: Traditional earthquake-based thresholds miss such events — volcano-aware systems are essential.**

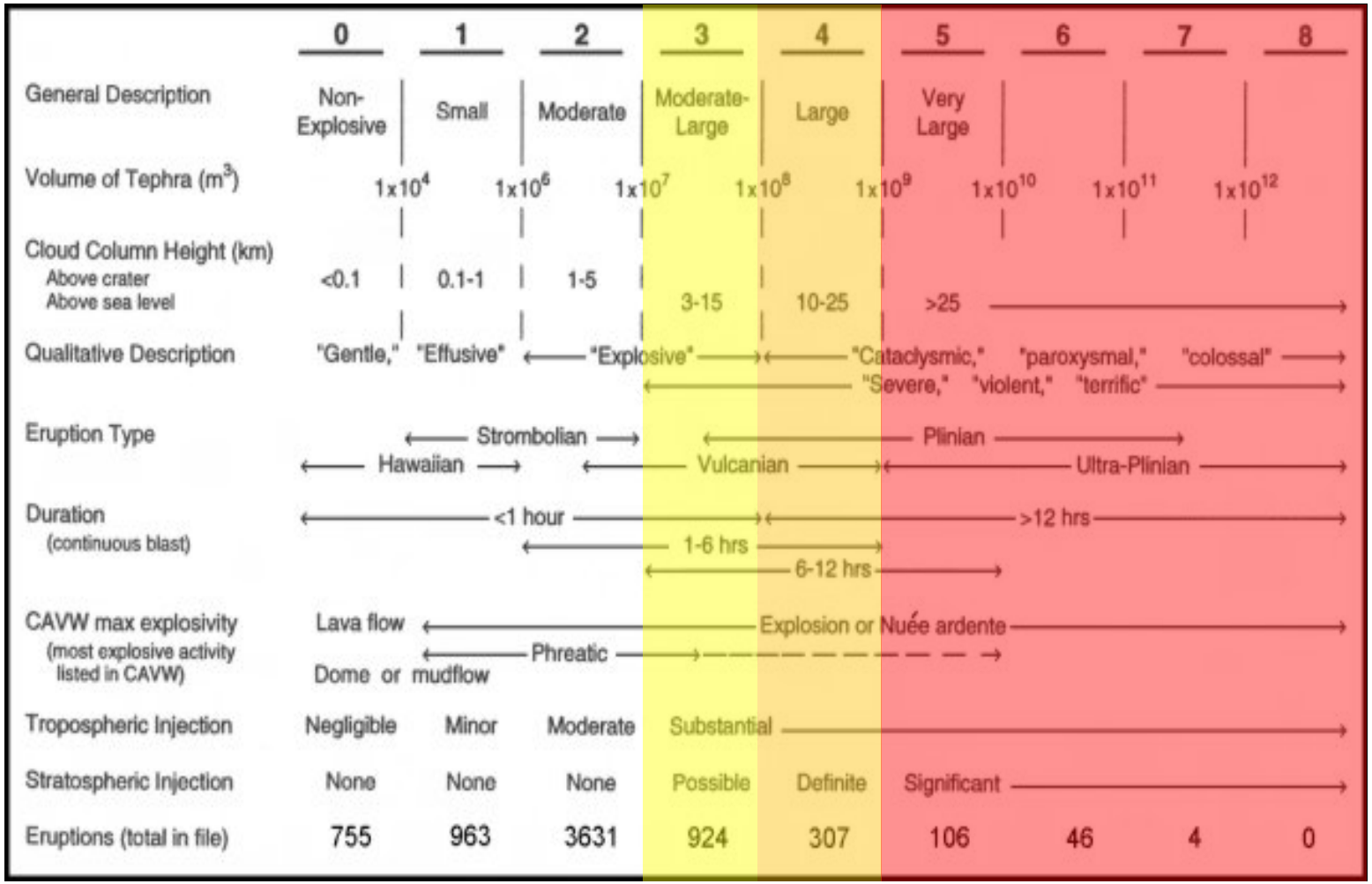
# Volcanic Eruption

**(1) Issue no products and monitor for any potential tsunami:** This action should be taken if there is little to no stratospheric injection and there is no evidence a tsunami has been generated.

**(2) Create the event with a Severity of 1 hour:** This action should be taken if there is little to no stratospheric injection and there is evidence that a small tsunami has been generated and the impacts are consistent with a low-level Marine Threat.

**(3) Create the event with a Severity of 3 hours:** This action should be taken if there is obvious stratospheric injection consistent with a VEI of 4 and/or there are reliable observations or reports that indicate a tsunami has been generated and the impacts are consistent with a high-level Marine Threat or low-level Land Threat.

**(4) Create the event with a Severity of 6 hours:** This action should be taken if there is significant stratospheric injection consistent with a VEI of 5+ and/or there are reliable observations or reports that indicate a catastrophic tsunami has been generated.



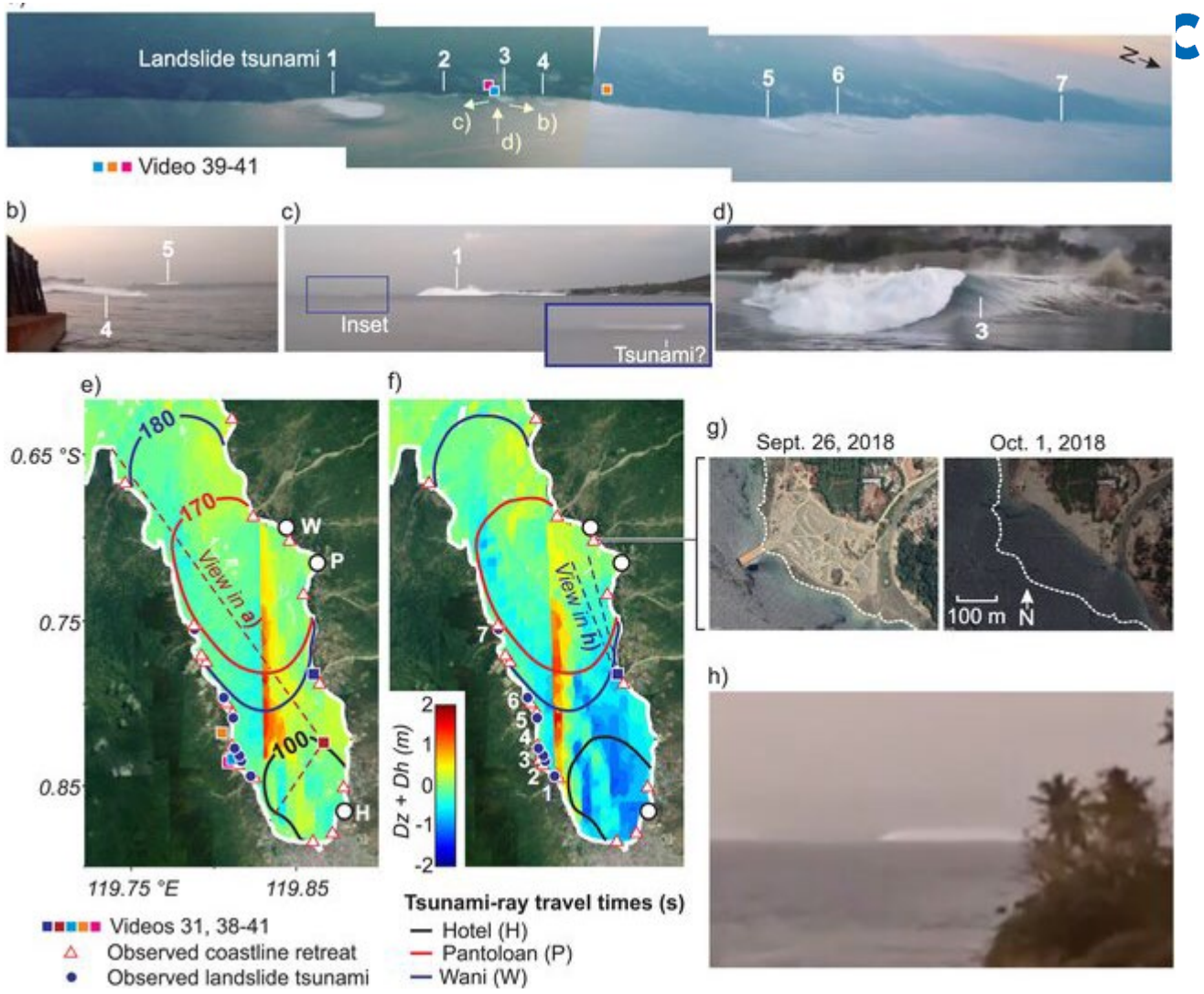
# Landslide

(1) Create the event with a Severity of 1 hour: This action should be taken if there are reliable observations or reports that indicate a small tsunami has been generated.

(2) Create the event with a Severity of 3 hours: This action should be taken if there are reliable observations or reports that indicate a tsunami has been generated and the impacts are consistent with a low-level Marine Threat.

(3) Create the event with a Severity of 6 hours: This action should be taken if there are reliable observations or reports that indicate a catastrophic tsunami has been generated and the impacts are consistent with a high-level Marine Threat or low-level Land Threat.

The 2018 Sulawesi tsunami in Palu city as a result of several landslides and co-seismic tsunamis



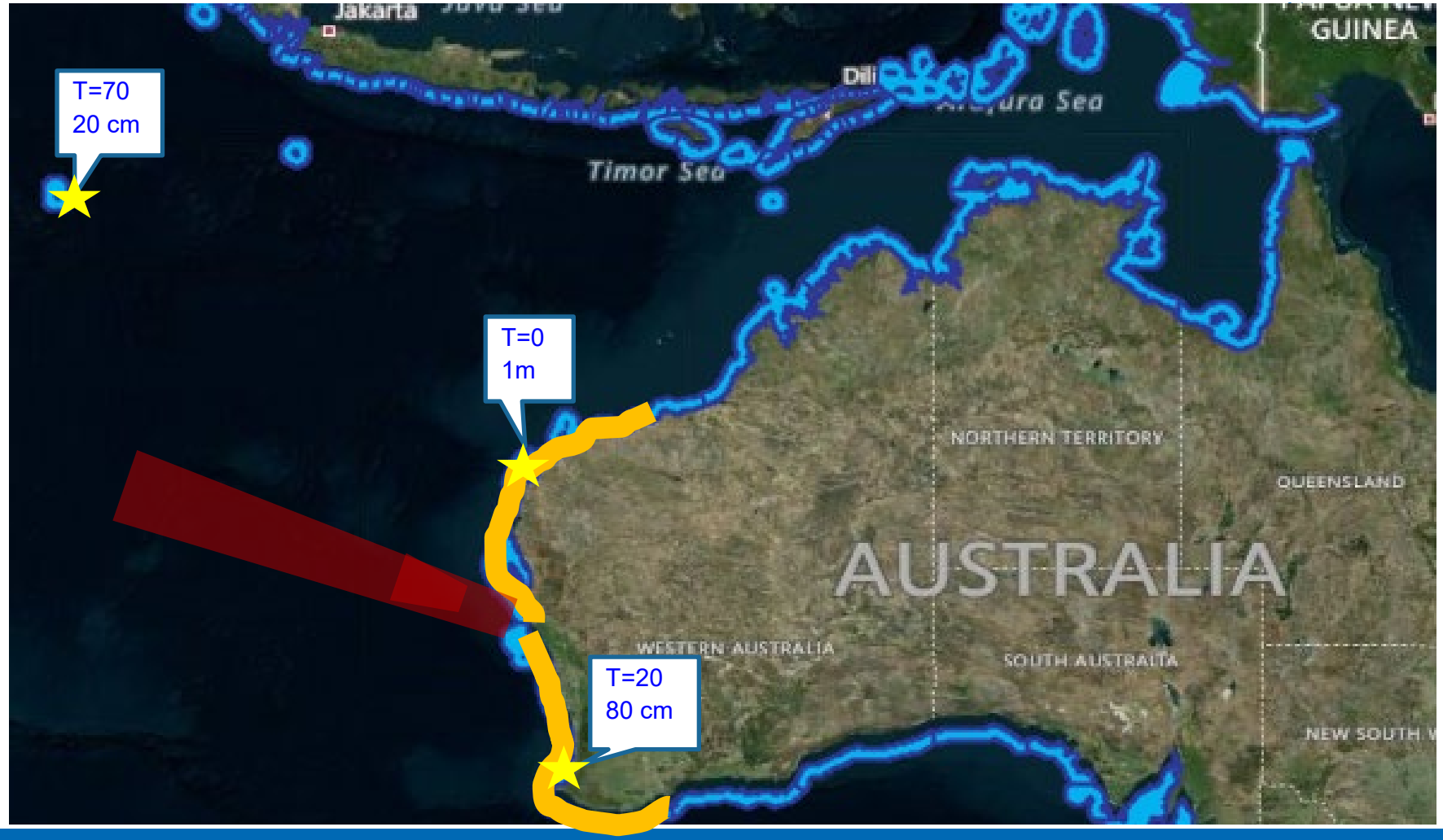

**Courtesy: DOI: [10.1029/2019GL082578](https://doi.org/10.1029/2019GL082578)**

# Unknown

**(1) Create the event with a Severity of 1 hour:** This action should be taken if there are reliable observations or reports that indicate a tsunami has been generated and the impacts are consistent with a low-level Marine Threat

**(2) Create the event with a Severity of 3 hours:** This action should be taken if there are reliable observations or reports that indicate a tsunami has been generated and the impacts are consistent with a high-level Marine Threat or low-level Land Threat.

**(3) Create the event with a Severity of 6 hours:** This action should be taken if there are reliable observations or reports that indicate a catastrophic tsunami has been generated.



# Update IOTWMS Service Definition to V5.0

11. Service Level 2 products may also be issued for non-seismic and complex source events if a regional or ocean wide scale tsunami has been generated or there is reason to believe one may have been generated. This is an area for future development and is not a current requirement. Due to the nature of non-seismic and complex source events and the limitations of current operational setups there it is high likelihood that many of them will not be detected in a timely manner. If a TSP chooses to respond to a non-seismic and complex source event, they should modify the standard templates as per Annexure-5.

# TSP Bulletin Types

## TSP Bulletin Type 1: Earthquake Bulletin

- Not Issued for atypical events

## TSP Bulletin Type 2: No Threat Bulletin

- Issued as soon as possible

## TSP Bulletin Type 2: Potential Tsunami Threat Bulletin

- Issued as soon as possible
- Only applicable to Volcanic Eruption and Celestial Impact events

## TSP Bulletin Type 3: Confirmed Tsunami Threat Bulletin

- Issued as soon as possible
- Could be the first bulletin issued for any atypical event

## TSP Bulletin Type 4: Final Tsunami Bulletin

- No Change to criteria compared to earthquake event

# TSP Australia Bulletin Examples: Notification Message

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TSUNAMI BULLETIN NOTIFICATION MESSAGE NUMBER 1 IOTWMS TSUNAMI SERVICE PROVIDER AUSTRALIA [JATWC] ISSUED AT 1046 UTC THURSDAY 13 FEBRUARY 2020

---

TO: INDIAN OCEAN NATIONAL TSUNAMI WARNING CENTRES [NTWCs]
FROM: IOTWMS-TSP AUSTRALIA

NOTIFICATION:
IOTWMS-TSP AUSTRALIA HAS JUST ISSUED TSUNAMI BULLETIN NUMBER 1 FOR THE INDIAN OCEAN, BASED ON THE FOLLOWING ~~EARTHQUAKE~~ EVENT:

~~MAGNITUDE: 6.9 MWP~~
~~DEPTH: 145KM~~
TYPE: LANDSLIDE
DATE: 13 FEB 2020
ORIGIN TIME: 1033 UTC
LATITUDE: 45.65N
LONGITUDE: 148.99E
LOCATION: KURIL ISLANDS

TO VIEW THE BULLETIN GO TO THE IOTWMS-TSP AUSTRALIA WEBSITE AT:

http://reg.bom.gov.au/tsunami/rtsp/index.shtml

NOTE: THIS IS A RESTRICTED-ACCESS WEBSITE CONTAINING TECHNICAL DATA FOR NATIONAL TSUNAMI WARNING CENTRES ONLY. IT IS NOT FOR GENERAL PUBLIC ACCESS.

GENERAL PUBLIC INFORMATION FOR THIS EVENT IS AVAILABLE FROM:

JOINT AUSTRALIAN TSUNAMI WARNING CENTRE [JATWC] BUREAU OF METEOROLOGY MELBOURNE, AUSTRALIA http://www.bom.gov.au/tsunami

END OF NOTIFICATION MESSAGE

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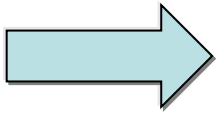

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TSUNAMI BULLETIN NOTIFICATION MESSAGE NUMBER 1 IOTWMS TSUNAMI SERVICE PROVIDER AUSTRALIA [JATWC] ISSUED AT 1046 UTC THURSDAY 13 FEBRUARY 2020

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TO: INDIAN OCEAN NATIONAL TSUNAMI WARNING CENTRES [NTWCs]
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NOTIFICATION:
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TYPE: LANDSLIDE
DATE: 13 FEB 2020
ORIGIN TIME: 1033 UTC
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JOINT AUSTRALIAN TSUNAMI WARNING CENTRE [JATWC] BUREAU OF METEOROLOGY MELBOURNE, AUSTRALIA http://www.bom.gov.au/tsunami

END OF NOTIFICATION MESSAGE

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# TSP Australia Bulletin Examples: Type 2 No Threat Bulletin

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-
TSUNAMI BULLETIN NUMBER 1 (TYPE-II THREAT ASSESSMENT BULLETIN)
IOTWMS TSUNAMI SERVICE PROVIDER AUSTRALIA (JATWC)
ISSUED AT 1214 UTC Friday 02 August 2019
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-

... NO TSUNAMI THREAT IN THE INDIAN OCEAN ...

This bulletin applies to areas within and bordering the Indian Ocean. It is
issued in support of the UNESCO/IOC Indian Ocean Tsunami Warning and Mitigation
System (IOTWMS).

1. ~~EARTHQUAKE~~ TSUNAMI SOURCE INFORMATION
IOTWMS-TSP AUSTRALIA has detected ~~an earthquake~~ a landslide with the following details:

~~Magnitude: 7.1 Mwp~~
~~Depth: 69km~~
Date: 02 Aug 2019
Origin Time: 1203 UTC
Latitude: 7.47S
Longitude: 104.58E
Location: Southwest of Sumatra, Indonesia

2. EVALUATION
Based on ~~pre-run model scenarios~~ a tsunami travel time threat assessment, there is NO THREAT to countries in the Indian Ocean.

3. ADVICE
This bulletin is being issued as advice. Only national/state/local authorities and disaster management officers have the authority to make decisions regarding the official threat and warning status in their coastal areas and any action to be taken in response.

4. UPDATES
No further bulletins will be issued by IOTWMS-TSP AUSTRALIA for this event
unless other information becomes available.

Other IOTWMS-TSPs may issue additional information at:
IOTWMS-TSP INDIA:
http://www.incois.gov.in/Incois/tsunami/eqevents.jsp
IOTWMS-TSP INDONESIA: http://rtsp.bmkg.go.id

5. CONTACT INFORMATION
IOTWMS-TSP AUSTRALIA
Joint Australian Tsunami Warning Centre (JATWC)
Bureau of Meteorology
GPO BOX 1289 Melbourne, Victoria, Australia, 3001
http://reg.bom.gov.au/tsunami/rtsp

END OF BULLETIN

# TSP Australia Bulletin Examples: Type 2 Potential Threat Bulletin

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TSUNAMI BULLETIN NUMBER 1 (TYPE-II THREAT ASSESSMENT BULLETIN)
IOTWMS TSUNAMI SERVICE PROVIDER AUSTRALIA (JATWC)
ISSUED AT 1509 UTC Sunday 19 August 2018

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... POTENTIAL TSUNAMI THREAT IN THE INDIAN OCEAN ...

This bulletin applies to areas within and bordering the Indian Ocean. It is
issued in support of the UNESCO/IOC Indian Ocean Tsunami Warning and Mitigation
System (IOTWMS).

1. EARTHQUAKE TSUNAMI SOURCE INFORMATION
IOTWMS-TSP AUSTRALIA has detected an earthquake a volcanic eruption at Mt Rumble with the following details:

Magnitude: 7.0 Mwp
Depth: 12km
Date: 19 Aug 2018
Origin Time: 1456 UTC
Latitude: 8.47S
Longitude: 116.69E
Location: Sumbawa Region, Indonesia

2. EVALUATION
Earthquakes of this size are capable of generating tsunamis. However, so far there is no confirmation about the triggering of a tsunami.

An investigation is under way to determine if a tsunami has been triggered. This TSP will monitor sea level gauges and report if any tsunami wave activity has occurred.

Based on pre-run model scenarios a tsunami travel time threat assessment, the zones listed below are POTENTIALLY UNDER THREAT.

3. TSUNAMI THREAT FOR THE INDIAN OCEAN
For this event all locations within 3 hours are considered under Threat.

The list below shows the forecast arrival time of the first wave estimated to exceed 0.5m amplitude at the beach in each zone, and The amplitude of the maximum beach wave predicted for the zone. Zones where the estimated wave amplitudes are less than 0.5m at the Beach are not shown.

The list is grouped by country (alphabetic order) and ordered according to the earliest estimated times of arrival at the beach.

Please be aware that actual wave arrival times may differ from those below, and the initial wave may not be the largest. A tsunami is a series of waves and the time between successive waves can be five minutes to one hour.

The threat is deemed to have passed two hours after the forecast time for last exceedance of the 0.5m threat threshold for a zone.
Dangerous conditions should be expected to continue for a minimum of 5 hours after the predicted arrival time. As local conditions can cause a wide variation in tsunami wave action, CANCELLATION of national warnings and ALL CLEAR determination must be made by national/state/local authorities.

INDONESIA

| | | |
|---|---|---|
| NTB SUMBAWA B | 1512Z 19Aug2018 | 0.51m |
| NTB LOMBOK-TIMUR S | 1527Z 19Aug2018 | 0.51m |
| NTB LOMBOK-TENGAH | 1542Z 19Aug2018 | 0.51m |
| NTB SUMBAWA S | 1545Z 19Aug2018 | 0.51m |
| NTB LOMBOK-BARAT S | 1546Z 19Aug2018 | 0.51m |
| BALI KLUNGKUNG P.NUSAPENIDA | 1549Z 19Aug2018 | 0.51m |
| BALI DENPASAR PANTAI-SANUR | 1555Z 19Aug2018 | 0.51m |
| BALI BADUNG PANTAI-KUTA | 1555Z 19Aug2018 | 0.51m |

4. ADVICE
This bulletin is being issued as advice. Only national/state/local authorities and disaster management officers have the authority to make decisions regarding the official threat and warning status in their coastal areas and any action to be taken in response.

5. UPDATES
Additional bulletins will be issued by IOTWMS-TSP AUSTRALIA for this event
as more information becomes available.

Other IOTWMS-TSPs may issue additional information at:
TSP INDIA: http://www.incois.gov.in/Incois/tsunami/eqevents.jsp
TSP INDONESIA: http://rtsp.bmkg.go.id

6. CONTACT INFORMATION
IOTWMS-TSP AUSTRALIA
Joint Australian Tsunami Warning Centre (JATWC)
Bureau of Meteorology
GPO BOX 1289 Melbourne, Victoria, Australia, 3001
http://reg.bom.gov.au/tsunami/rtsp

END OF BULLETIN

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# TSP Australia Bulletin Examples: Type 3 Confirmed Threat Bulletin

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TSUNAMI BULLETIN NUMBER 2 (TYPE-III CONFIRMED THREAT BULLETIN)
IOTWMS TSUNAMI SERVICE PROVIDER AUSTRALIA (JATWC)
ISSUED AT 1345 UTC Sunday 05 August 2018

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... CONFIRMED TSUNAMI THREAT IN THE INDIAN OCEAN...

This bulletin applies to areas within and bordering the Indian Ocean. It is
issued in support of the UNESCO/IOC Indian Ocean Tsunami Warning and Mitigation
System (IOTWMS).

1. EARTHQUAKE TSUNAMI SOURCE INFORMATION
IOTWMS-TSP AUSTRALIA has detected an earthquake a volcanic eruption at Mt Rumble with the following details:

Magnitude: 7.0 Mwp
Depth: 25km
Date: 05 Aug 2018
Origin Time: 1146 UTC
Latitude: 8.56S
Longitude: 116.49E
Location: Sumbawa Region, Indonesia

2. EVALUATION
Sea level observations have confirmed that a TSUNAMI WAS GENERATED.
Maximum wave amplitudes observed so far:

| | | | | |
|---|---|---|---|---|
| Benoa | INDONESIA | 8.83S 115.33E | 0.01m | 05 Aug 12:45 UTC |
| Lembar | INDONESIA | 8.70S 116.07E | 0.13m | 05 Aug 13:08 UTC |

Based on pre-run model scenarios a tsunami travel time threat assessment, the zones listed below are POTENTIALLY UNDER THREAT.

3. TSUNAMI THREAT FOR THE INDIAN OCEAN
For this event all locations within 3 hours are considered under Threat.

The list below shows the forecast arrival time of the first wave estimated to exceed 0.5m amplitude at the beach in each zone, and the amplitude of the maximum beach wave predicted for the zone.
Zones where the estimated wave amplitudes are less than 0.5m at the beach are not shown.

The list is grouped by country (alphabetic order) and ordered according to the earliest estimated times of arrival at the beach.

Please be aware that actual wave arrival times may differ from those below, and the initial wave may not be the largest. A tsunami is a series of waves and the time between successive waves can be five minutes to one hour.

The threat is deemed to have passed two hours after the forecast time for last exceedance of the 0.5m threat threshold for a zone.
Dangerous conditions should be expected to continue for a minimum of 5 hours after the predicted arrival time. As local conditions can cause a wide variation in tsunami wave action, CANCELLATION of national warnings and ALL CLEAR determination must be made by national/state/local authorities.

INDONESIA

| | | |
|---|---|---|
| NTB SUMBAWA B | 1202Z 05Aug2018 | 0.51m |
| NTB LOMBOK-TIMUR S | 1217Z 05Aug2018 | 0.51m |
| NTB LOMBOK-TENGAH | 1232Z 05Aug2018 | 0.51m |
| NTB SUMBAWA S | 1235Z 05Aug2018 | 0.51m |
| NTB LOMBOK-BARAT S | 1236Z 05Aug2018 | 0.51m |
| BALI KLUNGKUNG P.NUSAPENIDA | 1239Z 05Aug2018 | 0.51m |
| BALI DENPASAR PANTAI-SANUR | 1245Z 05Aug2018 | 0.51m |
| BALI BADUNG PANTAI-KUTA | 1245Z 05Aug2018 | 0.51m |

4. ADVICE
This bulletin is being issued as advice. Only national/state/local authorities and disaster management officers have the authority to make decisions regarding the official threat and warning status in their coastal areas and any action to be taken in response.

5. UPDATES
Additional bulletins will be issued by IOTWMS-TSP AUSTRALIA for this event
as more information becomes available.

Other IOTWMS-TSPs may issue additional information at:
TSP INDIA: http://www.incois.gov.in/Incois/tsunami/eqevents.jsp
TSP INDONESIA: http://rtsp.bmkg.go.id

6. CONTACT INFORMATION
IOTWMS-TSP AUSTRALIA
Joint Australian Tsunami Warning Centre (JATWC)
Bureau of Meteorology
GPO BOX 1289 Melbourne, Victoria, Australia, 3001
http://reg.bom.gov.au/tsunami/rtsp

END OF BULLETIN

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# TSP Australia Bulletin Examples: Type 4 Final Bulletin

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TSUNAMI BULLETIN NUMBER 5 (TYPE-IV FINAL BULLETIN)
IOTWMS TSUNAMI SERVICE PROVIDER AUSTRALIA (JATWC)
ISSUED AT 1448 UTC Sunday 05 August 2018

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... FINAL TSUNAMI BULLETIN FOR THE INDIAN OCEAN ...

1. EARTHQUAKE TSUNAMI SOURCE INFORMATION
IOTWMS-TSP AUSTRALIA has detected an earthquake with the following details:

Magnitude: 7.0 Mwp
Depth: 25km
Date: 05 Aug 2018
Origin Time: 1146 UTC
Latitude: 8.56S
Longitude: 116.49E
Location: Sumbawa Region, Indonesia

2. EVALUATION
Data from sea-level gauges confirmed that a tsunami was generated.

The expected period of significant tsunami waves is now over for all threatened
Indian Ocean countries, based on IOTWMS-TSP AUSTRALIA modelling.

Because local conditions can cause a wide variation in tsunami wave action,
CANCELLATION of national warnings and ALL CLEAR determination must be made by
national/state/local authorities. Please be aware that dangerous currents can
continue for several hours after the main tsunami waves have passed.

3. TSUNAMI WAVE OBSERVATIONS
Listed below are maximum wave amplitudes recorded at the specified locations.
Note that wave amplitude is measured relative to normal sea level; it is NOT
the crest-to-trough wave height.

| | | | | |
|---|---|---|---|---|
| Benoa | INDONESIA | 8.83S 115.33E | 0.01m | 05 Aug 12:45 UTC |
| Lembar | INDONESIA | 8.70S 116.07E | 0.13m | 05 Aug 13:08 UTC |

4. ADVICE
This bulletin is being issued as advice. Only national/state/local authorities
and disaster management officers have the authority to make decisions regarding
the official threat and warning status in their coastal areas and any action to
be taken in response.

5. UPDATES
No further bulletins will be issued by IOTWMS-TSP AUSTRALIA for this event unless
additional information becomes available.

Other IOTWMS-TSPs may issue additional information at:
TSP INDIA: http://www.incois.gov.in/Incois/tsunami/eqevents.jsp
TSP INDONESIA: http://rtsp.bmkg.go.id

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http://reg.bom.gov.au/tsunami/rtsp

END OF BULLETIN

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# TSP Threat Table Example

**EARTHQUAKE: Sumbawa Region, Indonesia 11:46 UTC 05 August 2018 Mag 7.0**

**INFORMATION FOR BULLETIN 5.Final Bulletin 1448UTC 05 Aug 2018**

Exchange Bulletins | Threat Map | Threat Table | Deep Water Wave Amplitude Map | Travel Times Map | NTWC Status Reporting Form | Other Data

**SELECT COUNTRY:**

- AUSTRALIA
- BANGLADESH
- COMOROS
- DJIBOUTI
- FRANCE
- INDIA
- INDONESIA
- IRAN
- KENYA
- MADAGASCAR
- MALAYSIA
- MALDIVES
- MAURITIUS
- MOZAMBIQUE
- MYANMAR
- OMAN
- PAKISTAN
- SEYCHELLES
- SINGAPORE
- SOMALIA
- SOUTH AFRICA
- SRI LANKA
- TANZANIA
- THAILAND
- TIMOR-LESTE
- UNITED ARAB EMIRATES
- UNITED KINGDOM
- YEMEN

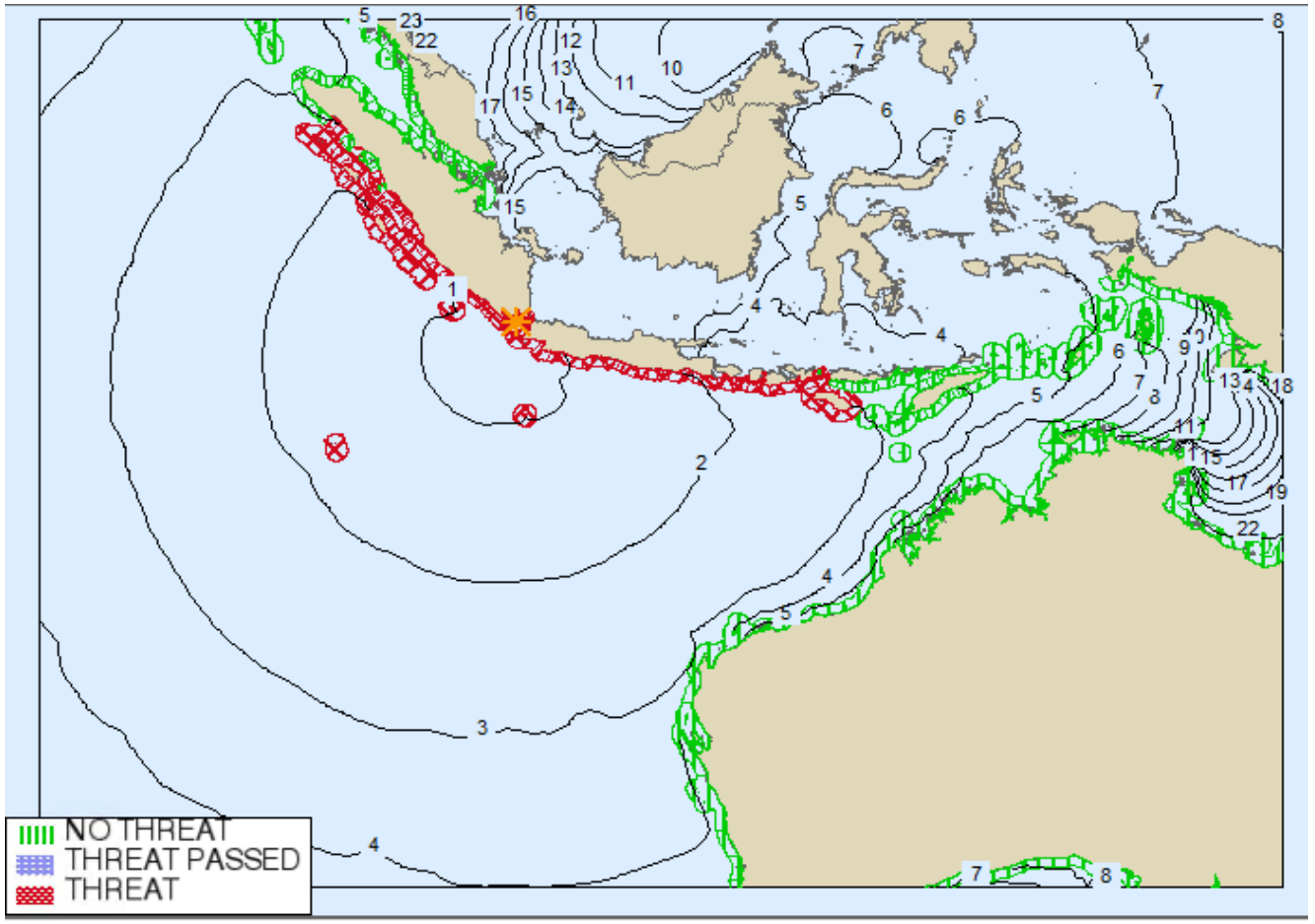
(Red = Threat, Blue = Threat Passed, Green = No Threat)

**ZONE PREDICTIONS FOR INDONESIA:**

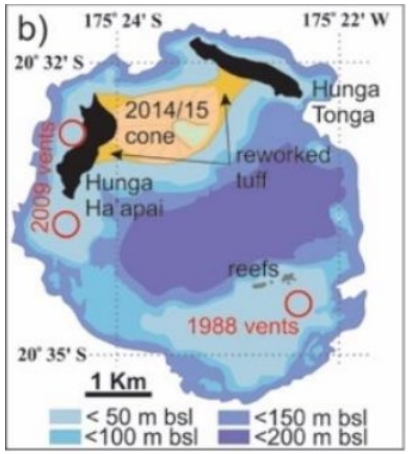
| COUNTRY ZONE | MAX BEACH (m) | MAX DEEP (m) | DEPTH AT MAX DEEP (m) | T1 (UTC) First Wave | T2 (UTC) First Above Threat Level | T3 (UTC) Max Wave | T4 (UTC) Last Above Threat Level | THREAT CATEGORY |
|---|---|---|---|---|---|---|---|---|
| NTB LOMBOK-TIMUR S | 0.51 | 0.24 | -20 | 05 Aug 1217Z | 05 Aug 1217Z | 05 Aug 1217Z | 05 Aug 1517Z | Threat |
| NTB SUMBAWA S | 0.51 | 0.24 | -20 | 05 Aug 1235Z | 05 Aug 1235Z | 05 Aug 1235Z | 05 Aug 1535Z | Threat |
| NTB LOMBOK-TENGAH | 0.51 | 0.24 | -20 | 05 Aug 1232Z | 05 Aug 1232Z | 05 Aug 1232Z | 05 Aug 1532Z | Threat |
| NTB LOMBOK-BARAT S | 0.51 | 0.24 | -20 | 05 Aug 1236Z | 05 Aug 1236Z | 05 Aug 1236Z | 05 Aug 1536Z | Threat |
| NTB SUMBAWA B | 0.51 | 0.24 | -20 | 05 Aug 1202Z | 05 Aug 1202Z | 05 Aug 1202Z | 05 Aug 1502Z | Threat |
| BALI DENPASAR PANTAI-SANUR | 0.51 | 0.24 | -20 | 05 Aug 1245Z | 05 Aug 1245Z | 05 Aug 1245Z | 05 Aug 1545Z | Threat |
| BALI KLUNGKUNG P.NUSAPENIDA | 0.51 | 0.24 | -20 | 05 Aug 1239Z | 05 Aug 1239Z | 05 Aug 1239Z | 05 Aug 1539Z | Threat |
| BALI BADUNG PANTAI-KUTA | 0.51 | 0.24 | -20 | 05 Aug 1245Z | 05 Aug 1245Z | 05 Aug 1245Z | 05 Aug 1545Z | Threat |
| NTT TIMOR-TENGAH-SELATAN | | | | | | | | No Threat |
| NTT ALOR S | | | | | | | | No Threat |

# Example of TSP Australia assessment for a non-seismic event

Assign threat area to all zones within 3 hours tsunami travel time.



# Hunga Tonga-Hunga Ha'apai Volcano



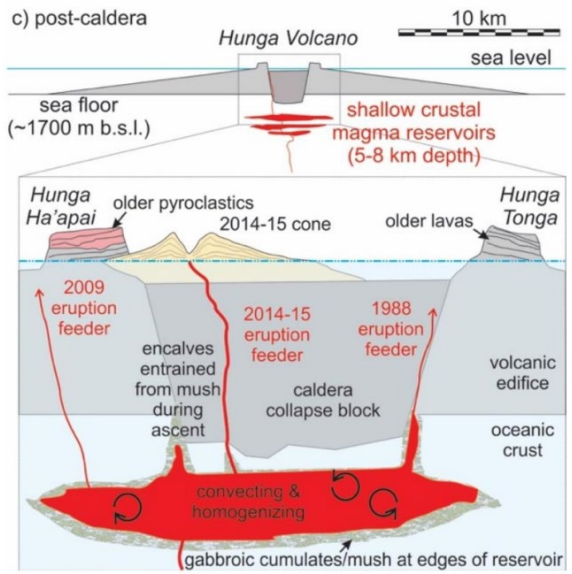
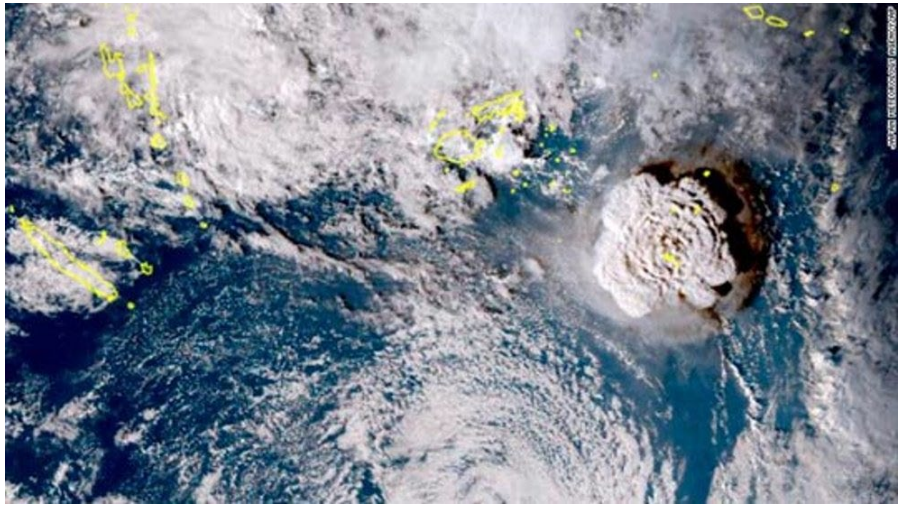
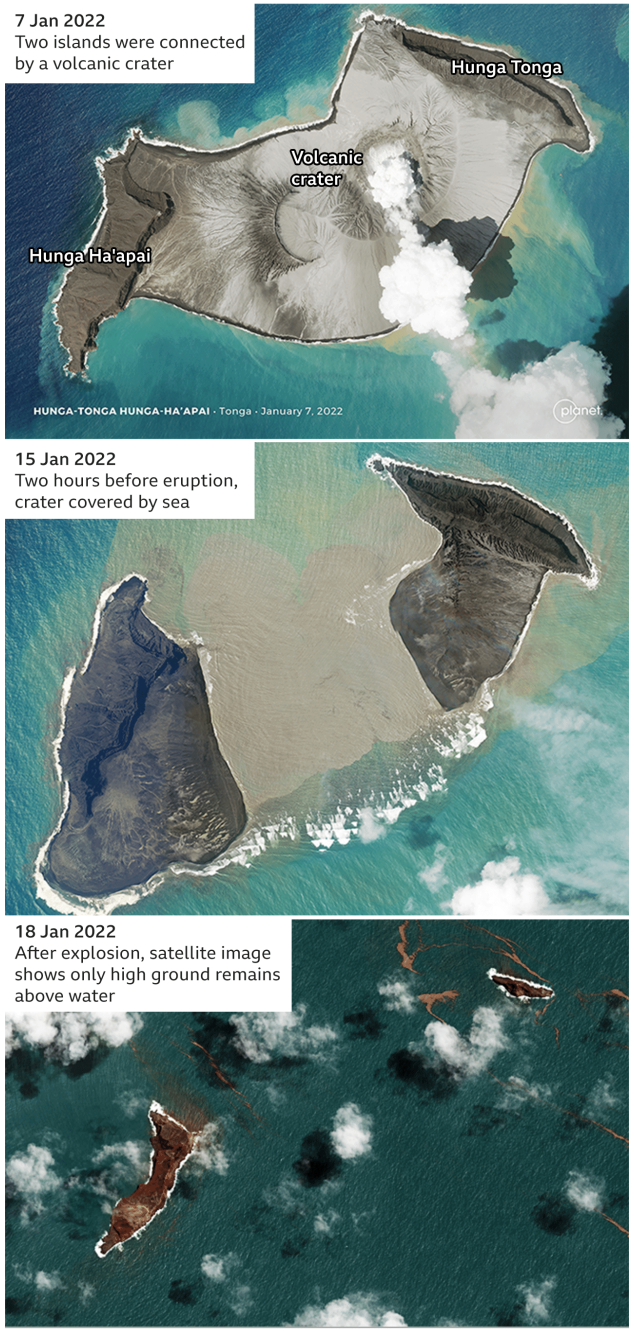



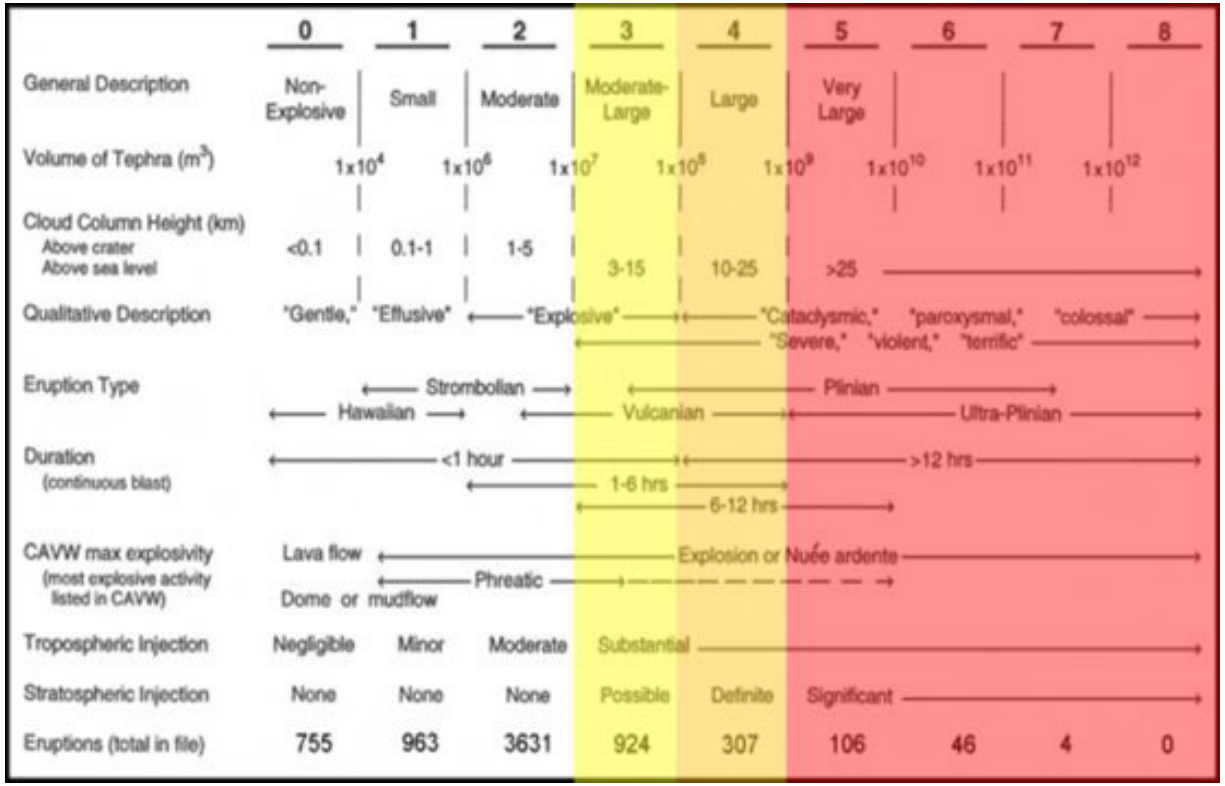

Image of volcanic eruption, the day before – January 14, 2022.



Satellite image of the volcanic eruption – January 15, 2022.



# JATWC SOPs for Volcanic Events




| Severity | Action |
|---|---|
| Level 1 | The threat area is defined to be within the 1 hour travel time isochrone |
| Level 3 | The threat area is defined to be within the 3 hour travel time isochrone |
| Level 6 | The expanding threat area is defined by the elapsed time since event + 6 hour travel time isochrone |

(1) *Issue no products and monitor for any potential tsunami*: This action should be taken if there is little to no stratospheric injection and there is no evidence a tsunami has been generated.

(2) *Create the event with a Severity of 1 hour*: This action should be taken if there is little to no stratospheric injection and there is evidence that a small tsunami has been generated and the impacts are consistent with a low-level Marine Threat.

(3) *Create the event with a Severity of 3 hours*: This action should be taken if there is obvious stratospheric injection consistent with a VEI of 4 and/or there are reliable observations or reports that indicate a tsunami has been generated and the impacts are consistent with a high-level Marine Threat or low-level Land Threat.

(4) *Create the event with a Severity of 6 hours*: This action should be taken if there is significant stratospheric injection consistent with a VEI of 5+ and/or there are reliable observations or reports that indicate a catastrophic tsunami has been generated.

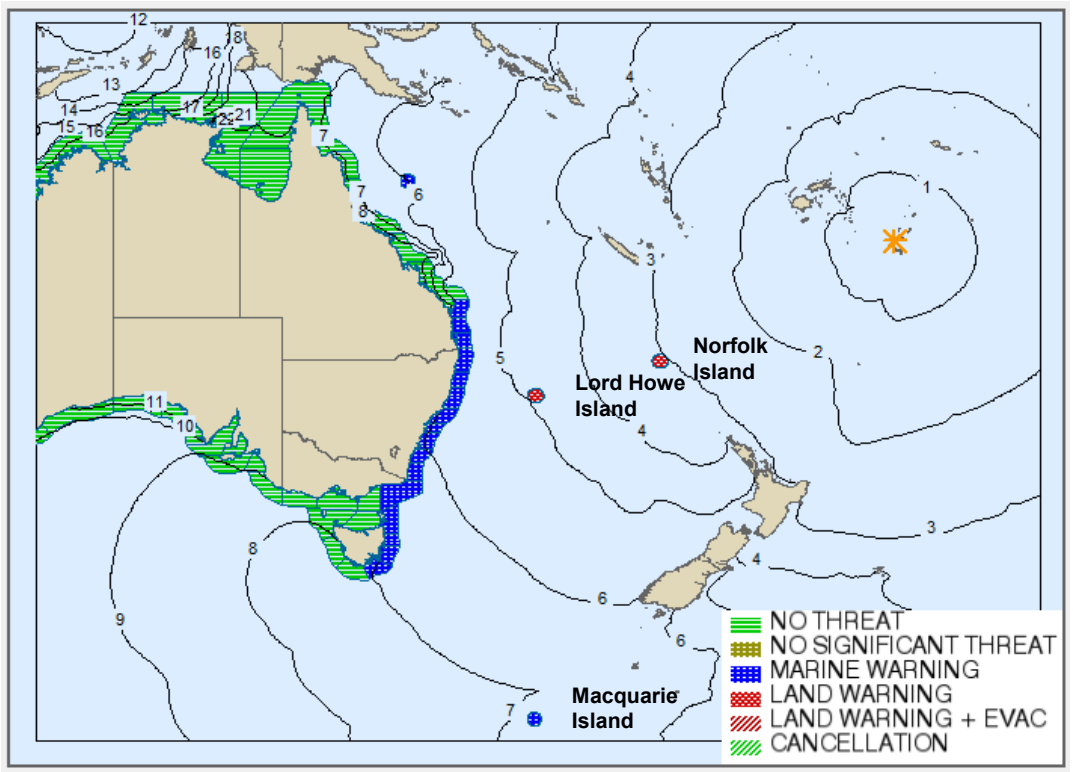
# JATWC WARNING TIMELINE

| Time (AEDT) | Elapsed Time (hh:mm) | Key Event: 15 January 2022 |
|---|---|---|
| 15:10 | 00:00 | Explosive volcanic eruption of the Hunga Tonga-Hunga Ha'apai volcano (Tonga) |
| 15:30 | 00:20 | Observations confirm a tsunami was generated at 3:30 PM AEDT at Nuku Alofa. |
| 16:58 | 01:48 | No Threat Bulletin issued with additional text to advise that a tsunami had been generated and that the JATWC would continue to monitor observations. Initial assessment based on 3 hours travel time. |
| 19:36 | 04:26 | Marine Warning for Norfolk Island issued after 50 cm wave observed at the tide gauge. |
| 20:00 | 04:50 | Marine Warning issued for Lord Howe Island based on tide gauge measurements increasing at Norfolk Island. |
| 20:37 | 05:27 | Significant observations in NSW and QLD: (40cm at Twofold Bay at 8:10 PM AEDT; 25 cm at Gold Coast at 7:40 PM AEDT) prompts the issuing of Marine Warnings. |
| 20:58 | 05:48 | Norfolk Island Warning upgraded to Land Threat after wave observations exceed 1.0 m at the tide gauge. |
| 21:00 | 05:50 | Marine Warnings extended to Victoria, Tasmania and Macquarie Island using a 7 hours travel time threat assessment. |
| 21:18 | 06:08 | Lord Howe Island Warning upgraded to Land Threat with evacuation order issued at 10:12 PM AEDT. |
| 10:09 +1 | 18:59 | Land warnings for Norfolk Island and Lord Howe Island downgraded to marine. |
| 10:30 to 11:50 +1 | 19:20 to 20:40 | QLD, Macquarie Island, Victoria and Tasmanian marine warnings cancelled. |
| 19:56 to 21:59 +1 | 28:46 to 30:49 | Lord Howe Island, Norfolk Island and NSW warnings cancelled. |

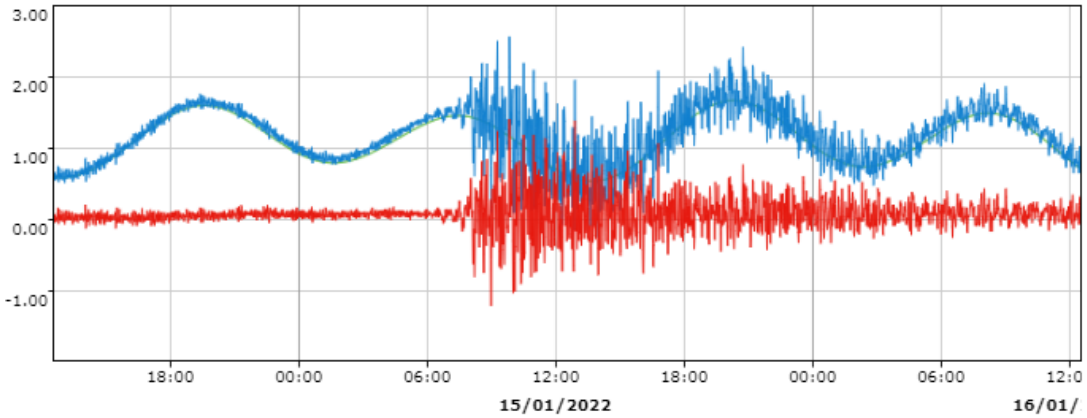
## Key Challenges

- Initial detection of the volcanic eruption / tsunami and scale of eruption.
- Lack of event-specific tsunami modelling.
- Lack of a unified sea-level observing tool.

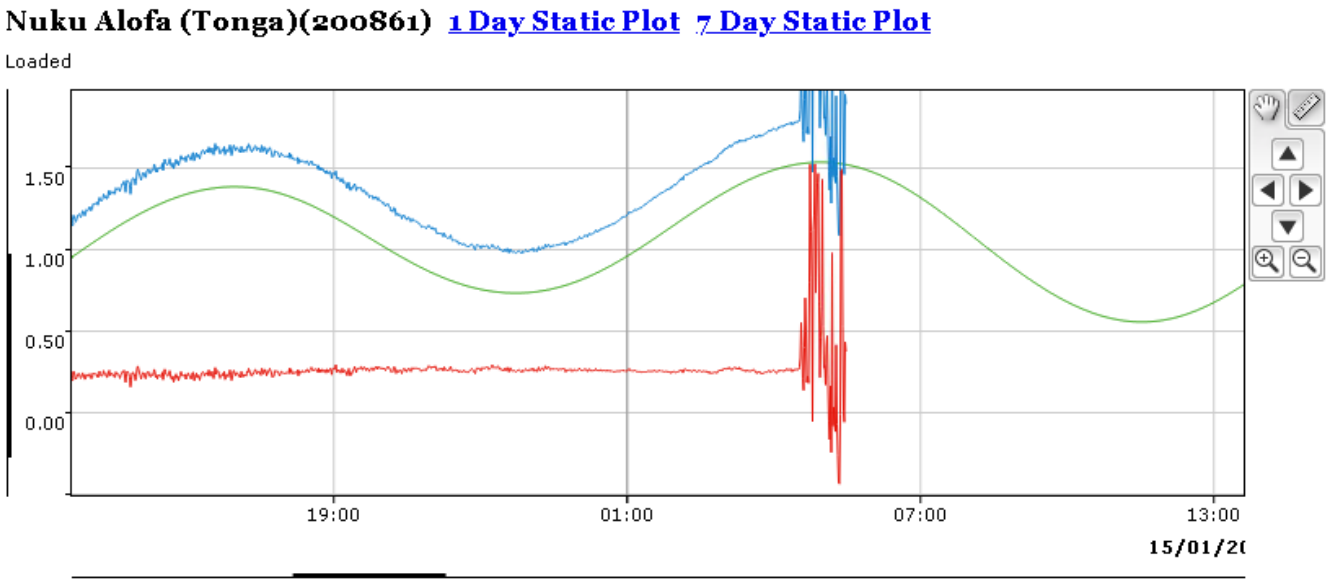
JATWC Tsunami Threat Assessment – Within 7 Hours Travel Time



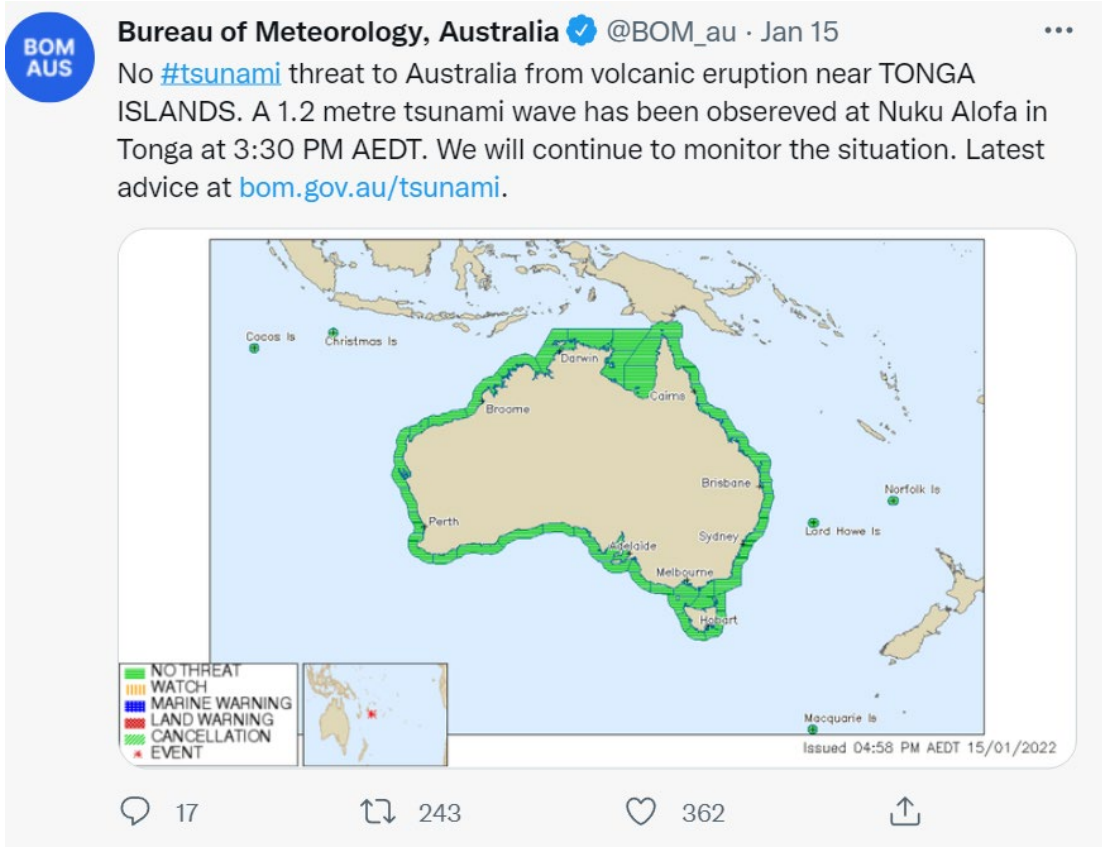

Norfolk Island – 1.27



# Hunga Tonga-Hunga Ha'apai Volcano – Initial Assessment




- Identified a 1.25 m Tsunami at Nuku Alofa
- Told by Darwin VAAC that there was stratospheric injection
- Opted for severity level 3 but continued to monitor observations



# Hunga Tonga-Hunga Ha'apai Volcano – Early Observations

**Norfolk Is (Australia)(200883)** 1 Day Static Plot 7 Day Static Plot

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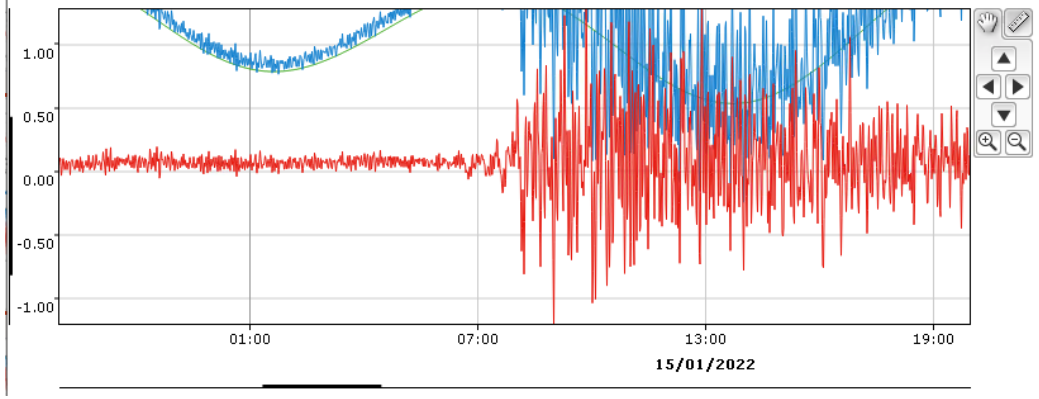


**Apia (Samoa)(200814)** 1 Day Static Plot 7 Day Static Plot

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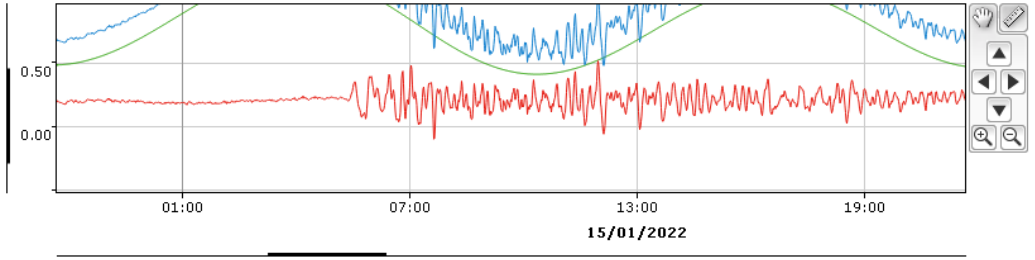


**Lautoka (Fiji)(200856)** 1 Day Static Plot 7 Day Static Plot

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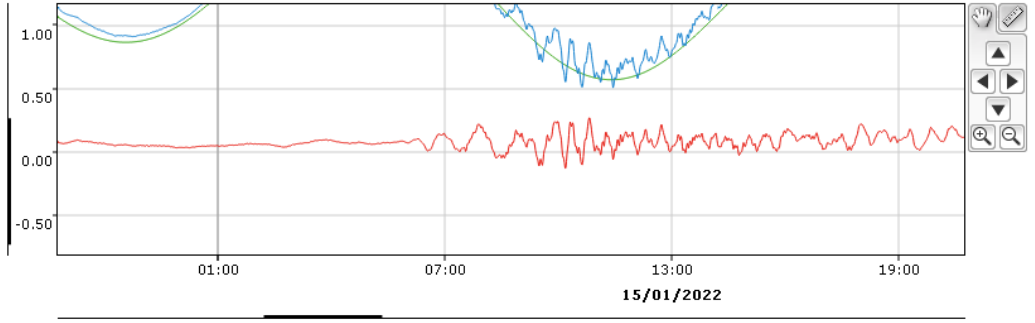


**Suva (Fiji)(200863)** 1 Day Static Plot 7 Day Static Plot

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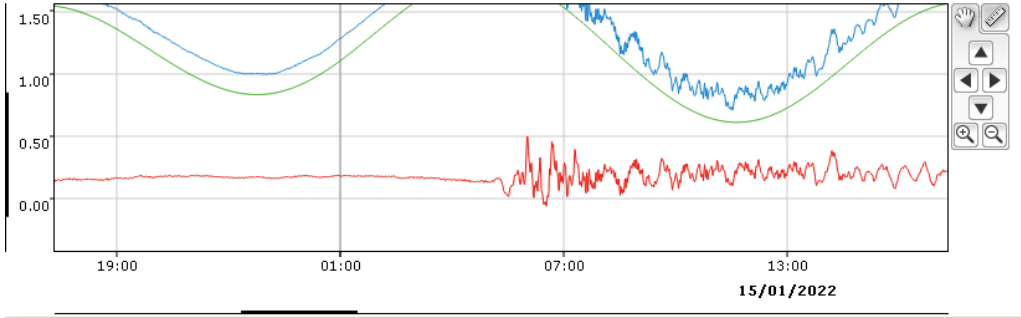


**Port Vila (Vanuatu)(200857)** 1 Day Static Plot 7 Day Static Plot

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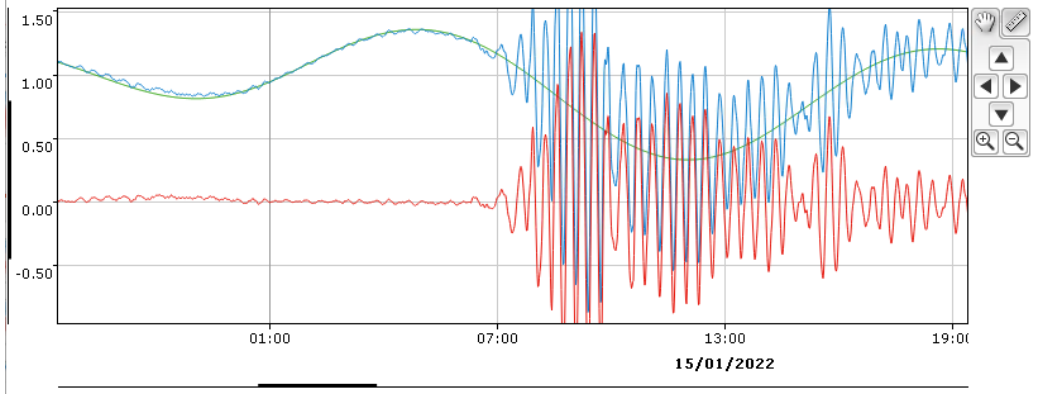


**Luganville (Vanuatu)(200871)** 1 Day Static Plot 7 Day Static Plot

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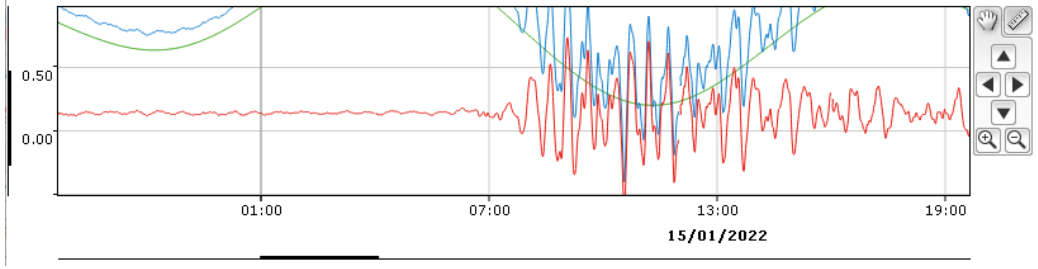
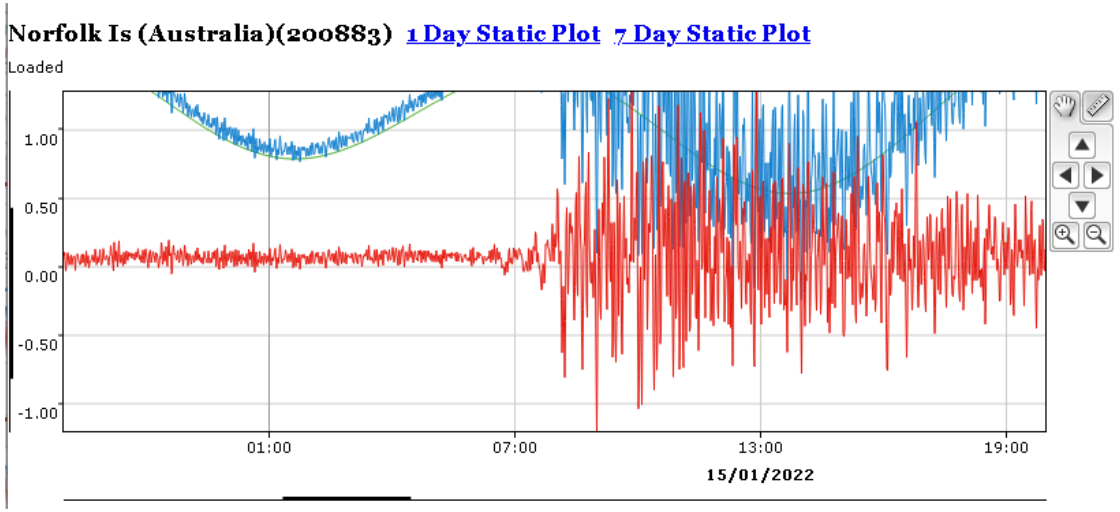
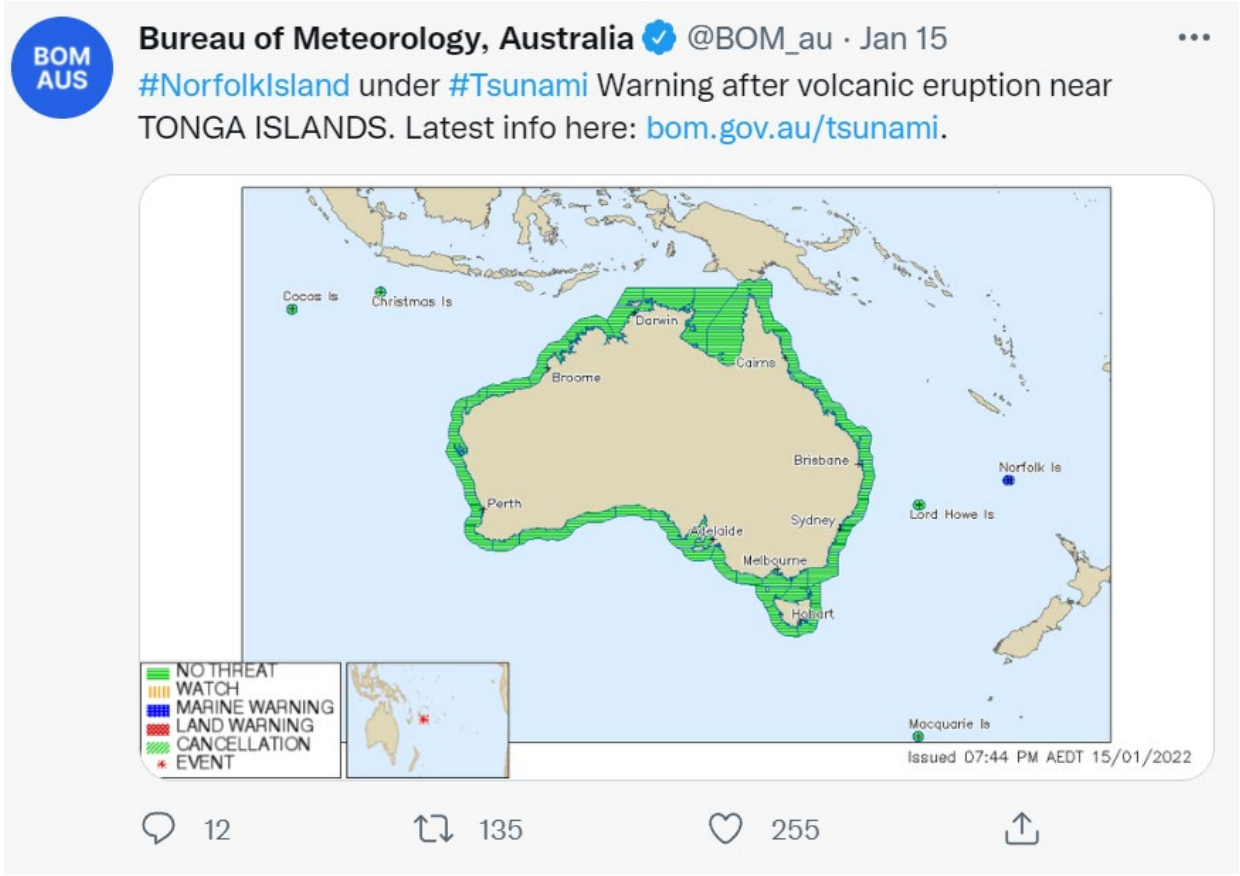


# Hunga Tonga-Hunga Ha'apai Volcano – Norfolk Island Warning

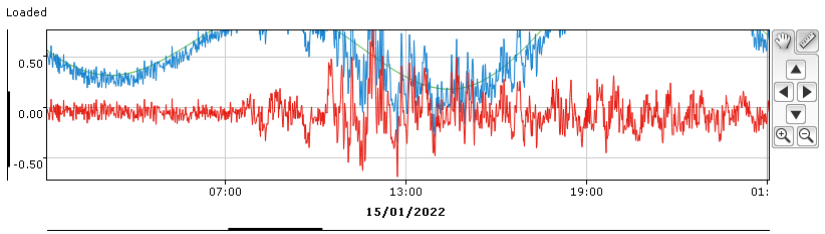



- Observed a 50cm tsunami at Norfolk Island
- Almost 3 hours after the No threat we issued a Marine Warning for Norfolk Island

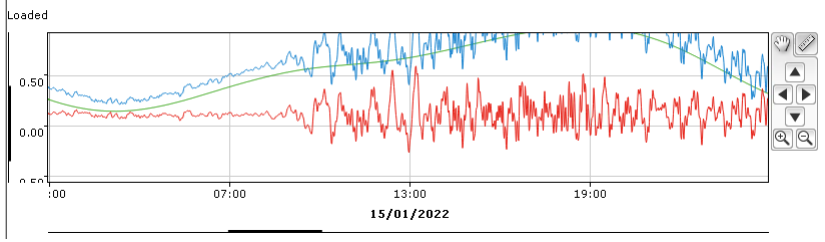


# Hunga Tonga-Hunga Ha'apai Volcano – Updated Warnings

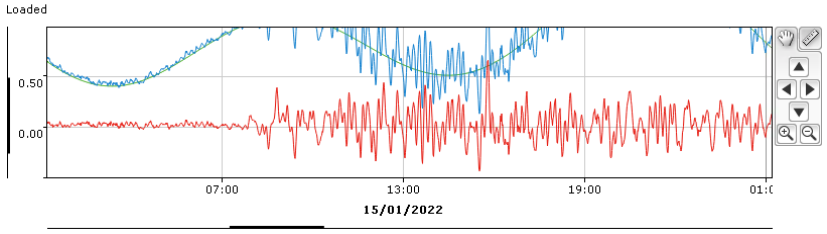
**Gold Coast (QLD,Australia)(40987)** 1 Day Static Plot 7 Day Static Plot



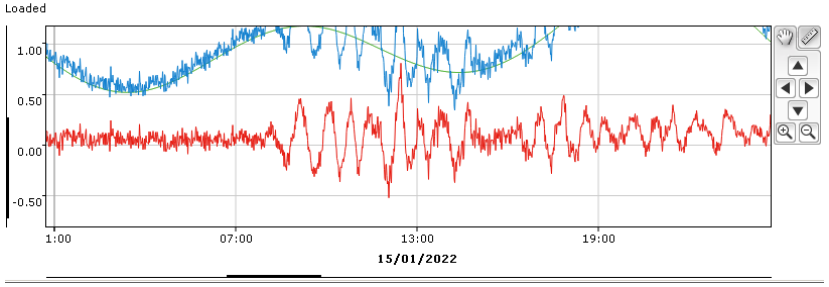

**Southport (TAS,Australia)(94243)** 1 Day Static Plot 7 Day Static Plot




**Port Kembla (NSW,Australia)(68253)** 1 Day Static Plot 7 Day Static Plot



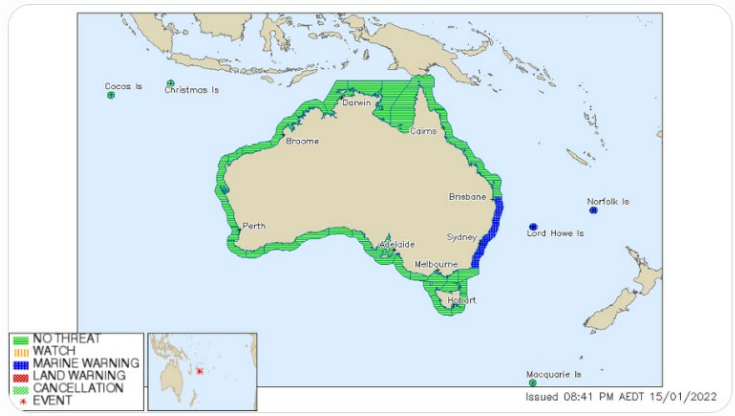

**Twofold Bay (NSW,Australia)(69129)** 1 Day Static Plot 7 Day Static Plot




- Rapid escalation of the situation resulted in Marine Threat issued for the SE coast of Australia and Land threat upgrade for Norfolk Island
- Based off tsunami tide gauge observations and travel time method
- Recognised a pattern of low observations that increase at closer locations
- Tsunami observed earlier than expected at Australian locations.

**Bureau of Meteorology, Australia** @BOM_au · Jan 15

#NSW, #QLD, #LordHoweIsland, #NorfolkIsland under #Tsunami Warning after volcanic eruption near TONGA ISLANDS. Latest info here: bom.gov.au/tsunami.

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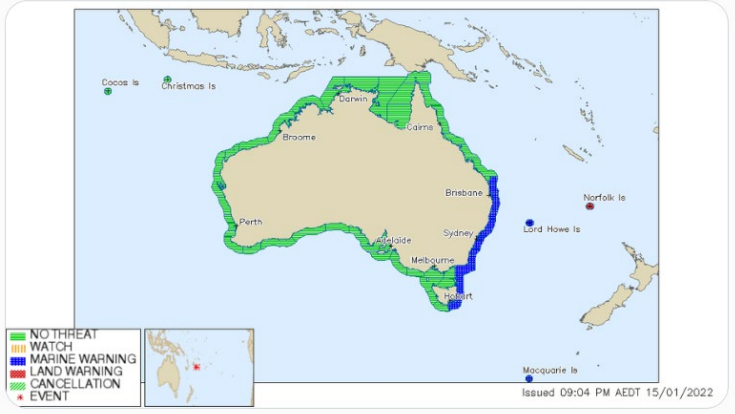
**Bureau of Meteorology, Australia** @BOM_au · Jan 15

#NSW, #QLD, #TAS, #VIC, #LordHoweIsland, #MacquarieIsland, #NorfolkIsland under #Tsunami Warning after volcanic eruption near TONGA ISLANDS. Latest info here: bom.gov.au/tsunami.

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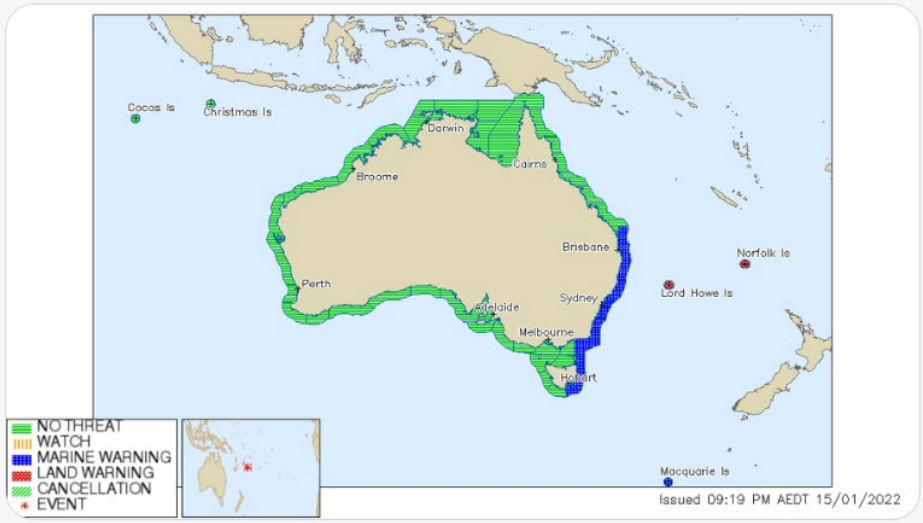
# Hunga Tonga-Hunga Ha'apai Volcano – Evacuation Order for Lord Howe Island

- Land Threat based on Norfolk Island Observations and Bureau Observer reports at Lord Howe Island
- Evacuation Order lasted for ~ 13 hours
- Impacts at Lord Howe Island extended past the immediate foreshore but did not impact any structures

**Bureau of Meteorology, Australia** @BOM_au · Jan 15

Marine Threat to #NSW, #QLD, #TAS, #VIC, #MacquarieIsland. Land threat to #LordHoweIsland, #NorfolkIsland. #Tsunami Warning after volcanic eruption near TONGA ISLANDS. Latest info here: bom.gov.au/tsunami.

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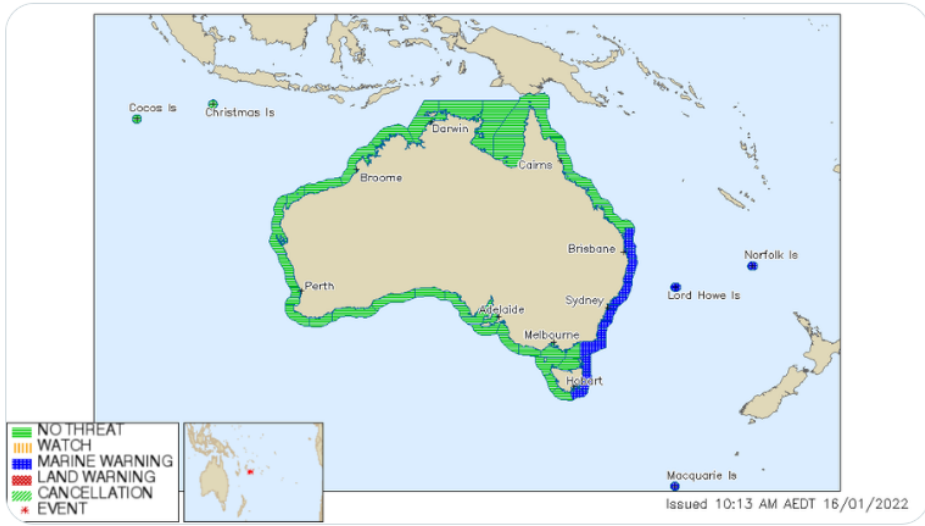
**Bureau of Meteorology, Australia** @BOM_au · Jan 16

#LordHoweIsland, #NorfolkIsland #Tsunami Warnings downgraded to Marine Threat. #NSW, #QLD, #TAS, #VIC, #MacquarieIsland #Tsunami Warnings unchanged at Marine Threat after volcanic eruption near the TONGA ISLANDS. Latest info here: bom.gov.au/tsunami.

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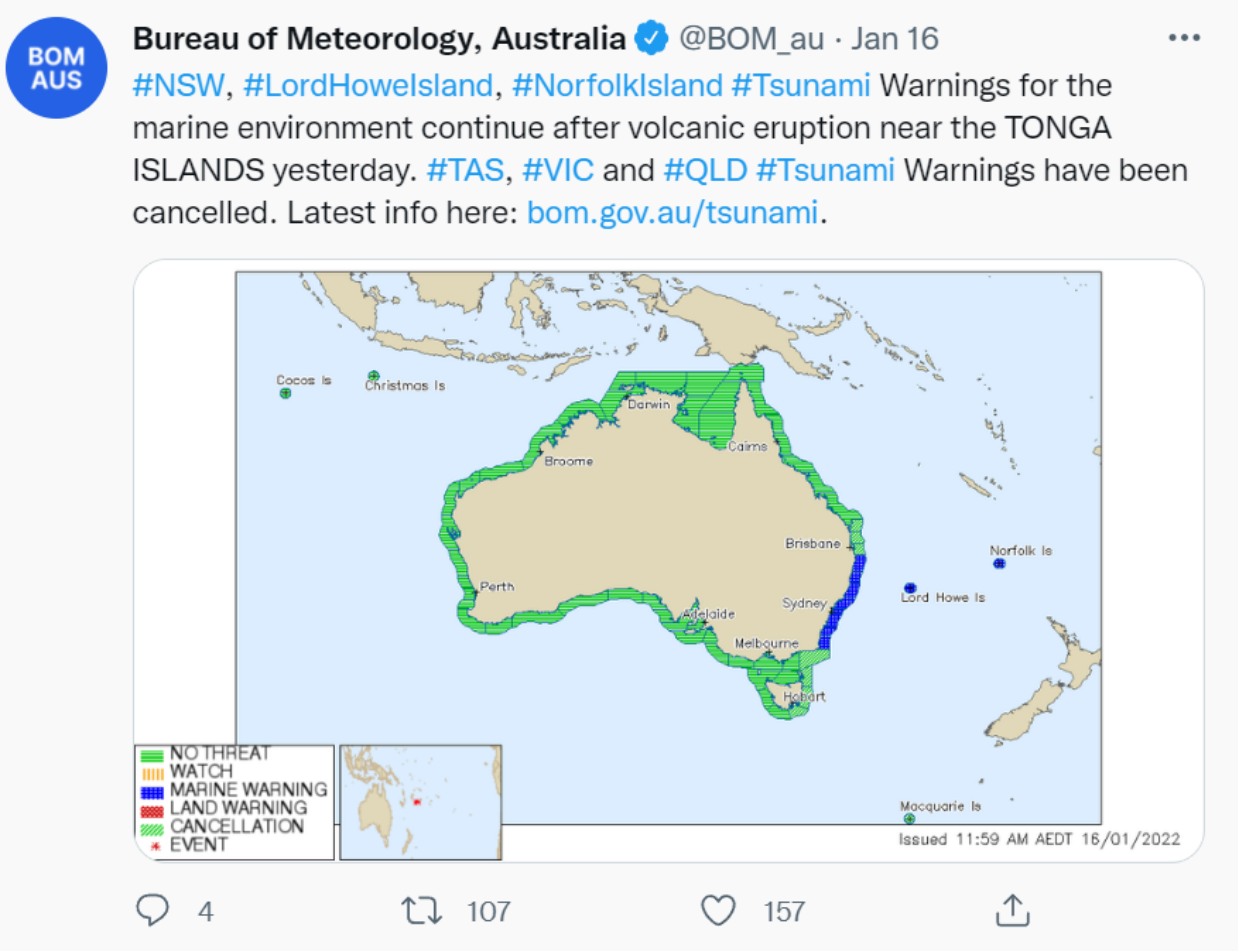
# Hunga Tonga-Hunga Ha'apai Volcano – Cancelations




- Cancelled in consultation with emergency services.
- QLD, Macquarie Island, Victoria and Tasmanian marine warnings were cancelled ~19-20 hours after the eruption
- Lord Howe Island, Norfolk Island and NSW warnings were cancelled ~28-30 hours after the eruption.
- Tide gauge observations are useful but sparse
- In the case of NSW – observations at tide gauges had met the cancellation criteria but reports from NSW SES and Lifesaving NSW extended the warning period

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Intergovernmental
Oceanographic
Commission

# THANK YOU

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