

Non-Seismic tsunami and Complex Sources

Case Study: Hunga Tonga-Hunga Ha'apai Volcano Jan 2022 Eruption

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Hunga Tonga-Hunga Ha'apai Volcano

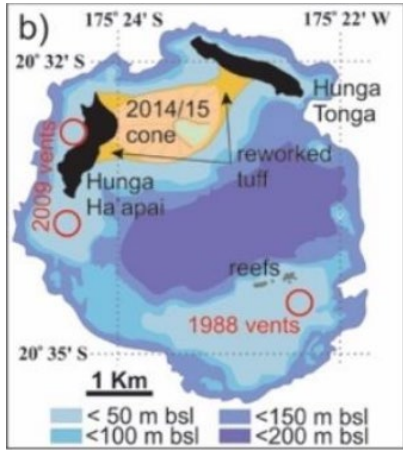
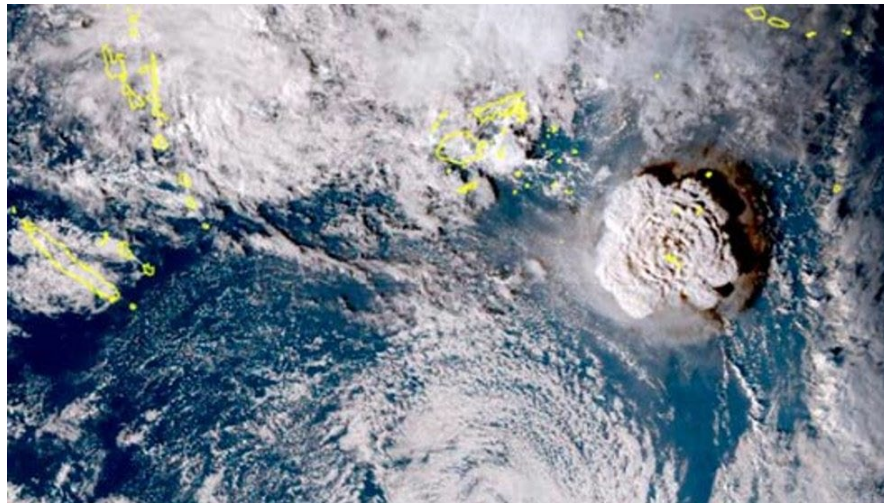
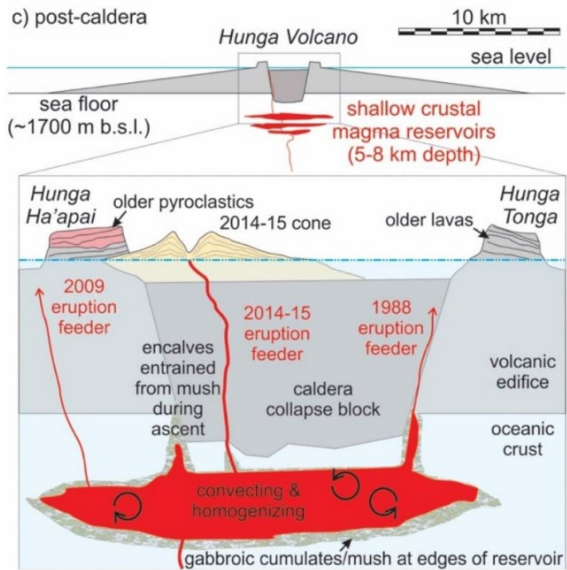


Image of volcanic eruption, the day before – January 14, 2022.

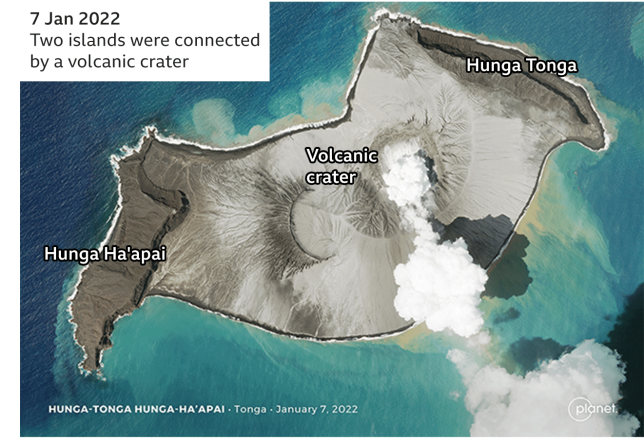


Satellite image of the volcanic eruption – January 15, 2022.

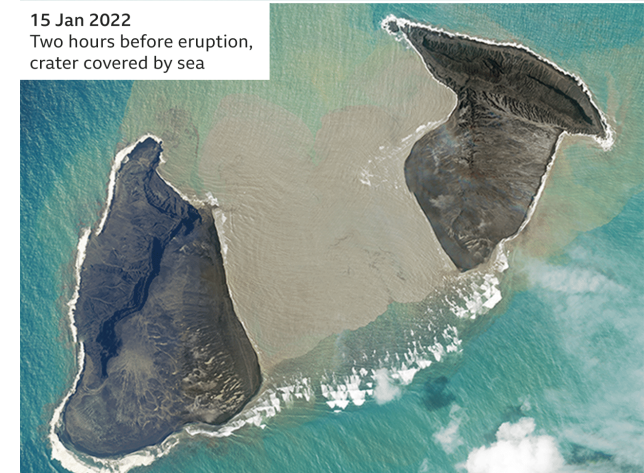


Eruption leaves little above water on Hunga-Tonga Hunga-Ha'apai

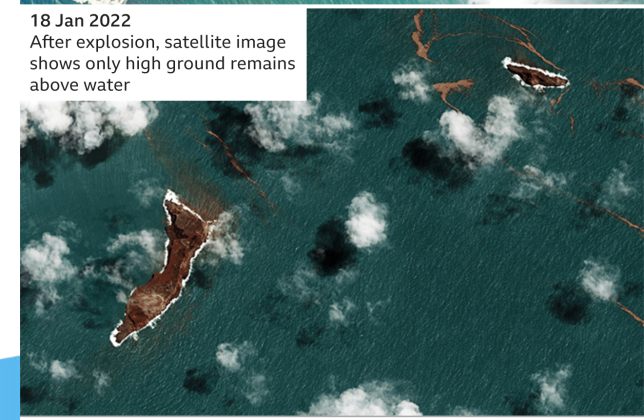
7 Jan 2022
Two islands were connected by a volcanic crater



15 Jan 2022
Two hours before eruption, crater covered by sea



18 Jan 2022
After explosion, satellite image shows only high ground remains above water



JATWC SOPs for Volcanic Events

	0	1	2	3	4	5	6	7	8
General Description	Non-Explosive	Small	Moderate	Moderate-Large	Large	Very Large			
Volume of Tephra (m ³)	1x10 ⁴	1x10 ⁶	1x10 ⁷	1x10 ⁸	1x10 ⁹	1x10 ¹⁰	1x10 ¹¹	1x10 ¹²	
Cloud Column Height (km) Above crater Above sea level	<0.1	0.1-1	1-5	3-15	10-25	>25			
Qualitative Description	"Gentle,"	"Effusive"	"Explosive"	"Cataclysmic," "Severe,"	"paroxysmal," "violent,"	"colossal"			
Eruption Type	Hawaiian	Strombolian	Vulcanian	Plinian	Ultra-Plinian				
Duration (continuous blast)	<1 hour	1-6 hrs	6-12 hrs	>12 hrs					
CAWW max explosivity (most explosive activity listed in CAVW)	Lava flow Dome or mudflow	Phreatic	Explosion or Nuée ardente						
Tropospheric Injection	Negligible	Minor	Moderate	Substantial					
Stratospheric Injection	None	None	None	Possible	Definite	Significant			
Eruptions (total in file)	755	963	3631	924	307	106	46	4	0

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.

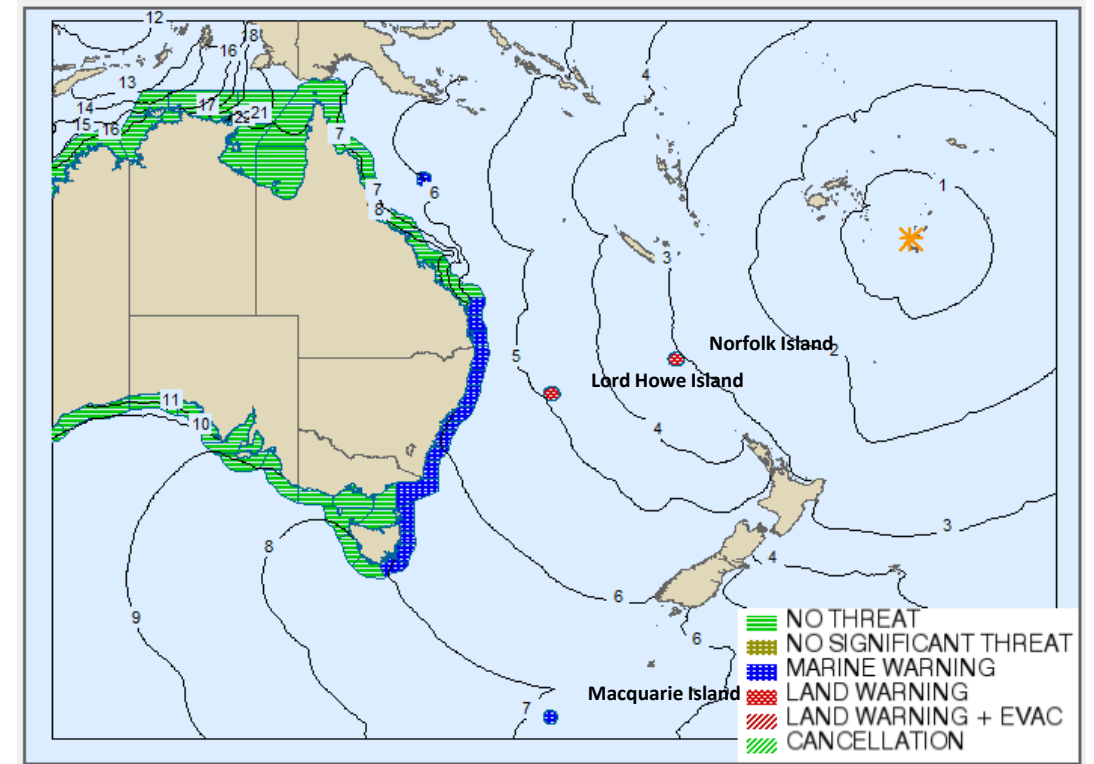
JATWC WARNING TIMELINE

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.

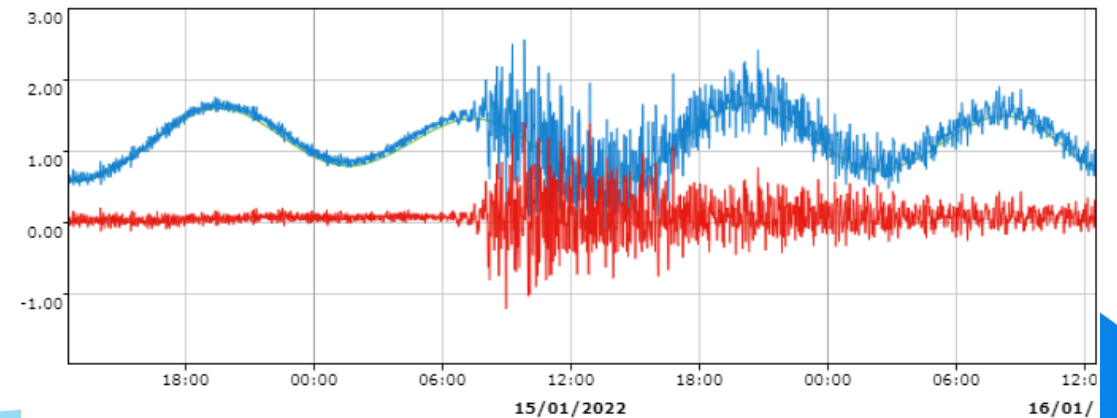
Key Challenges

- 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



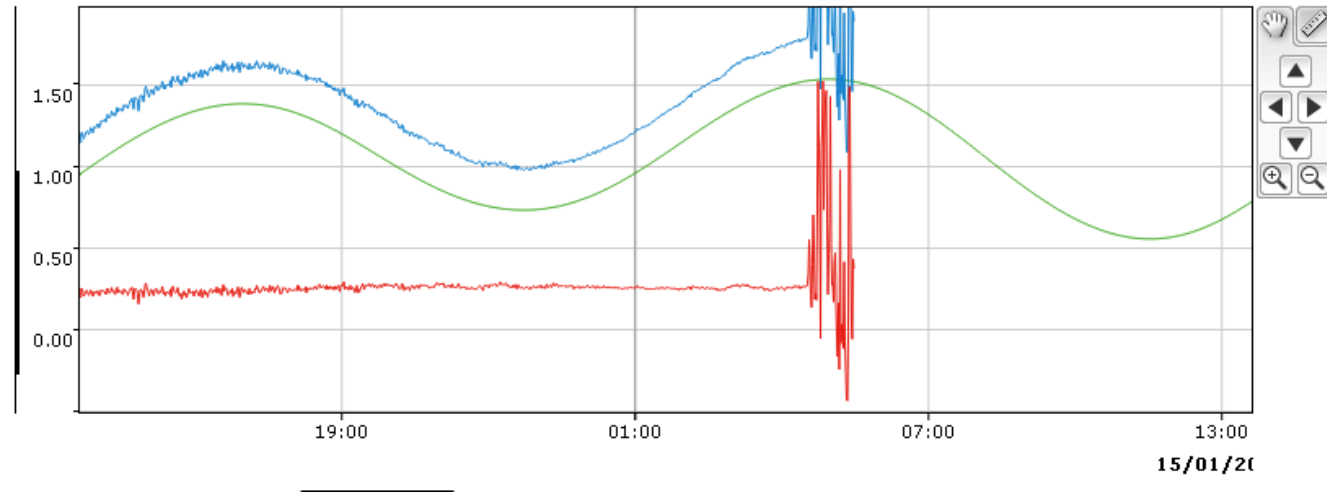
Norfolk Island – 1.27 m



Hunga Tonga-Hunga Ha'apai Volcano – Initial Assessment

Nuku Alofa (Tonga)(200861) [1 Day Static Plot](#) [7 Day Static Plot](#)

Loaded



- 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

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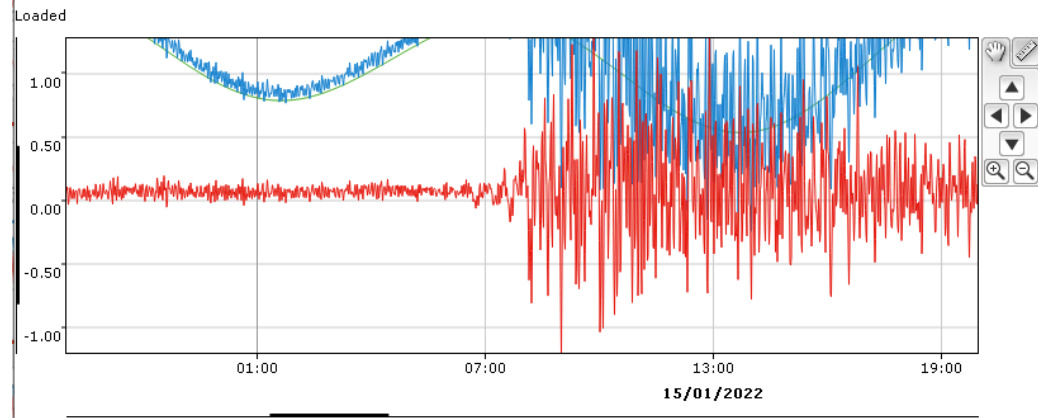
No [#tsunami](#) threat to Australia from volcanic eruption near TONGA ISLANDS. A 1.2 metre tsunami wave has been observed at Nuku Alofa in Tonga at 3:30 PM AEDT. We will continue to monitor the situation. Latest advice at bom.gov.au/tsunami.

Issued 04:58 PM AEDT 15/01/2022

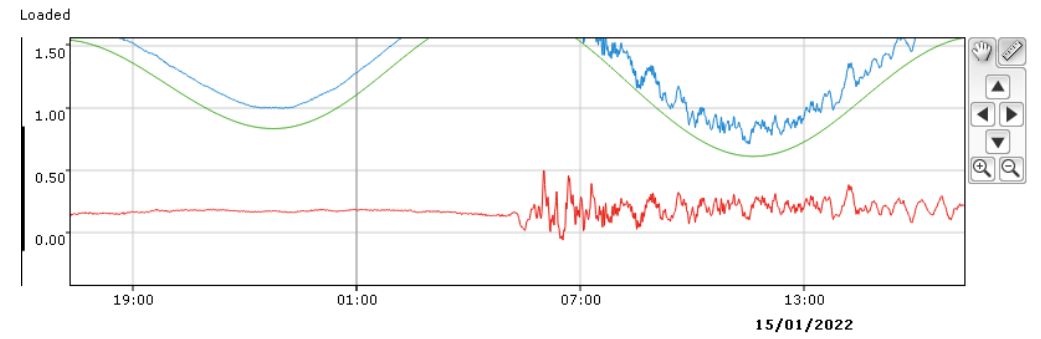
17 243 362

Hunga Tonga-Hunga Ha'apai Volcano – Early Observations

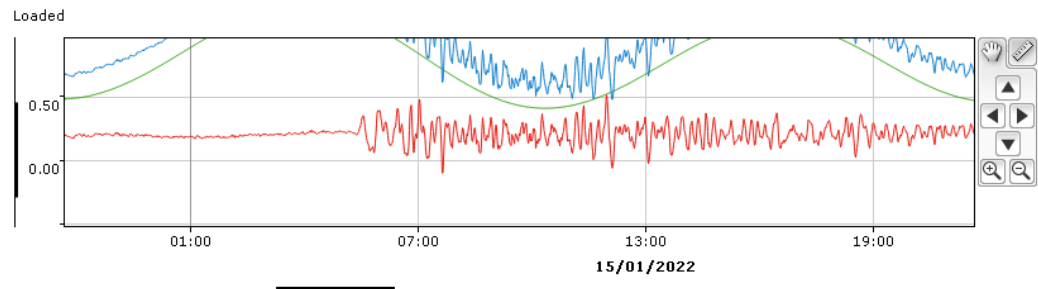
Norfolk Is (Australia)(200883) [1 Day Static Plot](#) [7 Day Static Plot](#)



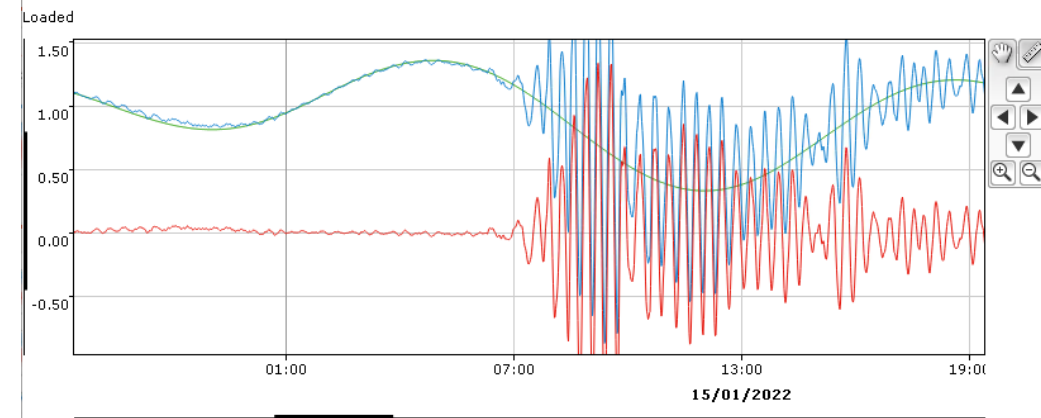
Suva (Fiji)(200863) [1 Day Static Plot](#) [7 Day Static Plot](#)



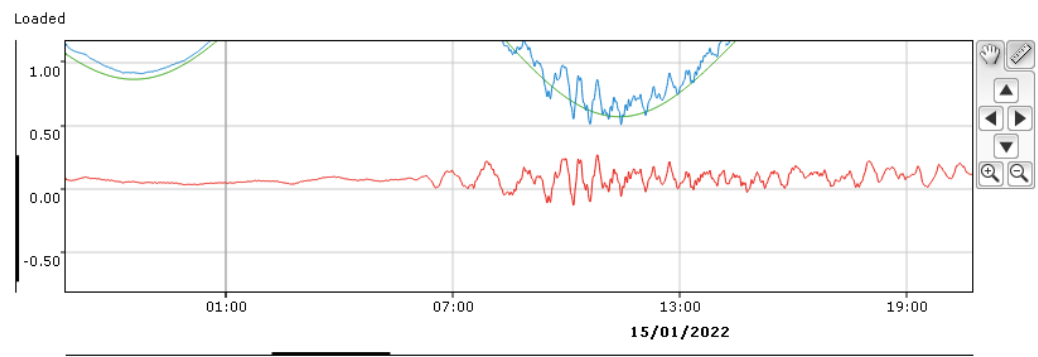
Apia (Samoa)(200814) [1 Day Static Plot](#) [7 Day Static Plot](#)



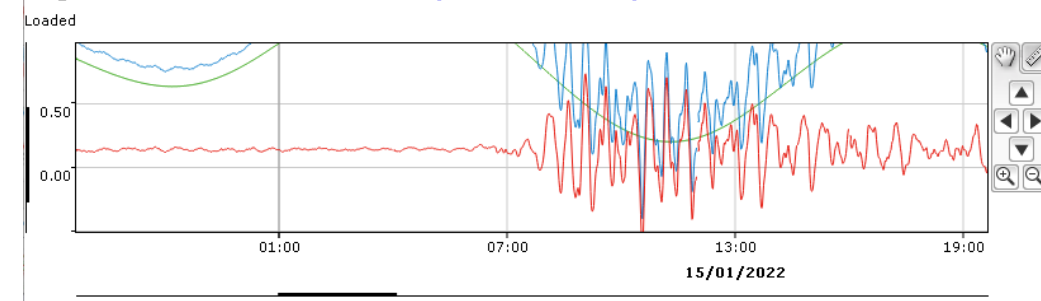
Port Vila (Vanuatu)(200857) [1 Day Static Plot](#) [7 Day Static Plot](#)



Lautoka (Fiji)(200856) [1 Day Static Plot](#) [7 Day Static Plot](#)

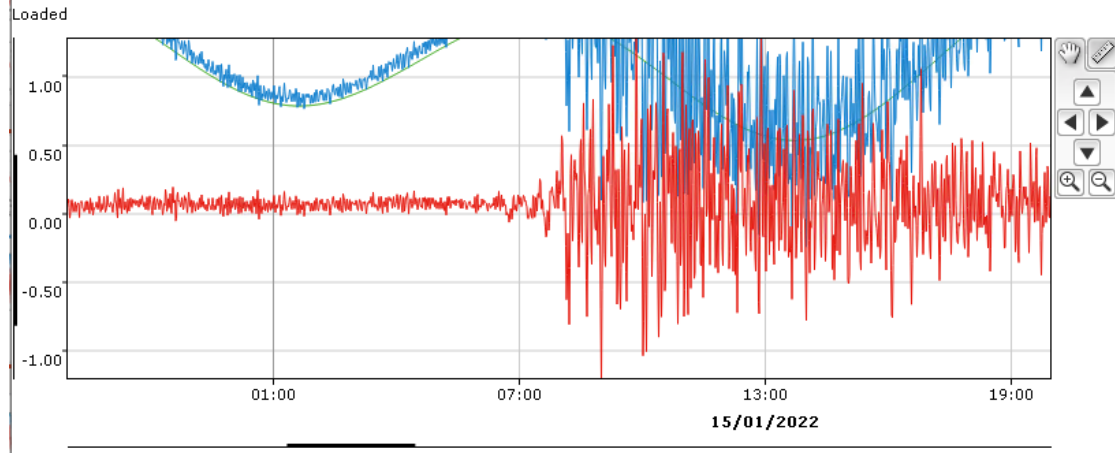


Luganville (Vanuatu)(200871) [1 Day Static Plot](#) [7 Day Static Plot](#)



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

Norfolk Is (Australia)(200883) [1 Day Static Plot](#) [7 Day Static Plot](#)



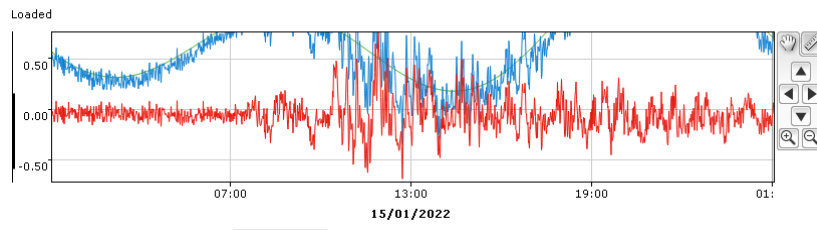
- Observed a 50cm tsunami at Norfolk Island
- Almost 3 hours after the No threat we issued a Marine Warning for Norfolk Island

Bureau of Meteorology, Australia @BOM_au · Jan 15
#NorfolkIsland under #Tsunami Warning after volcanic eruption near TONGA ISLANDS. Latest info here: bom.gov.au/tsunami.

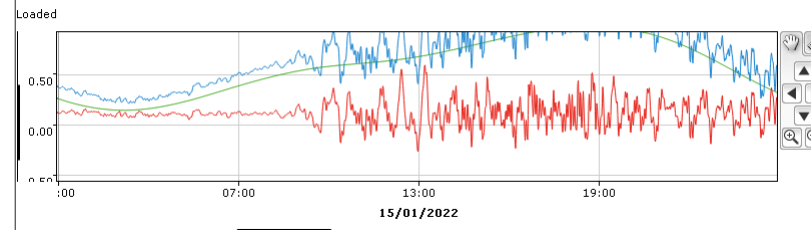
12 135 255

Hunga Tonga-Hunga Ha'apai Volcano – Updated Warnings

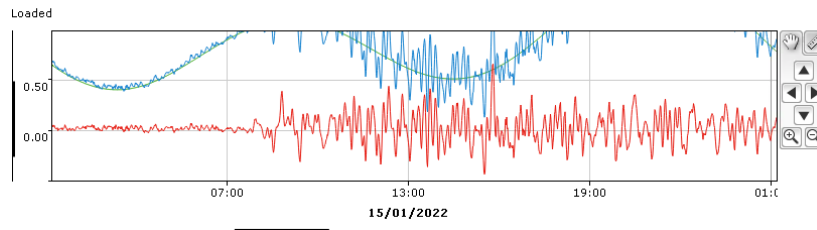
Gold Coast (QLD,Australia)(40987) [1 Day Static Plot](#) [7 Day Static Plot](#)



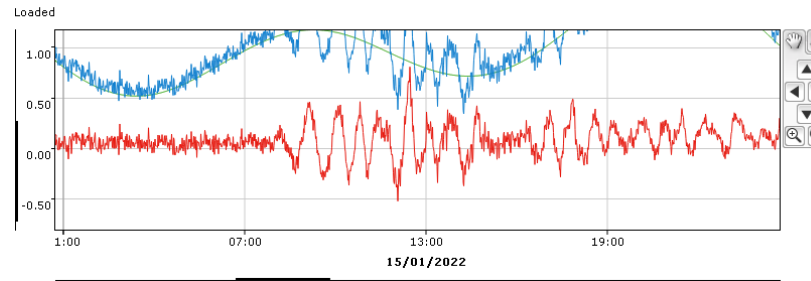
Southport (TAS,Australia)(94243) [1 Day Static Plot](#) [7 Day Static Plot](#)



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](#)



BOM AUS Bureau of Meteorology, Australia [@BOM_au](#) · Jan 15
 #NSW, #QLD, #LordHowelsland, #NorfolkIsland under #Tsunami Warning after volcanic eruption near TONGA ISLANDS. Latest info here: bom.gov.au/tsunami.



23 564 648

BOM AUS Bureau of Meteorology, Australia [@BOM_au](#) · Jan 15
 #NSW, #QLD, #TAS, #VIC, #LordHowelsland, #MacquarieIsland, #NorfolkIsland under #Tsunami Warning after volcanic eruption near TONGA ISLANDS. Latest info here: bom.gov.au/tsunami.




15 252 256

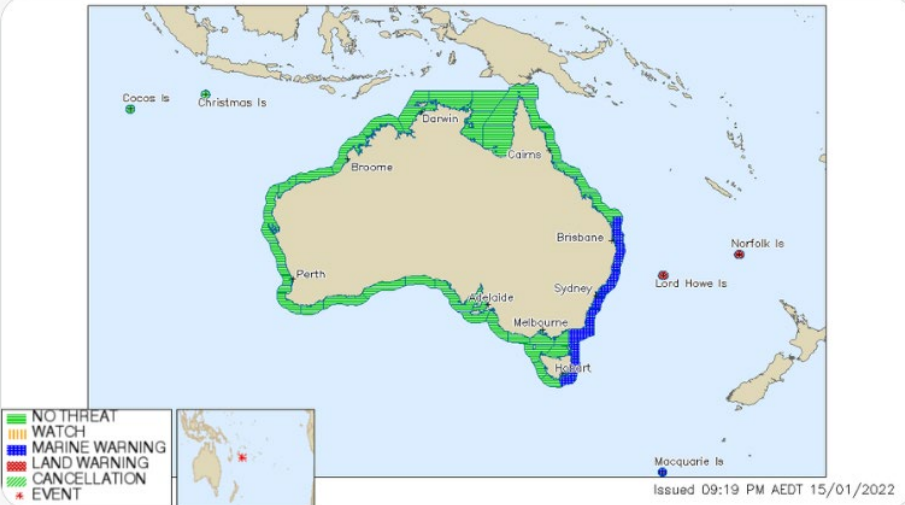
- Rapid escalation of the situation resulted in Marine Threat issued for the SE coast of Australia and Land threat upgrade for Norfolk Island
- Based off tsunami tide gauge observations and travel time method
- Recognised a pattern of low observations that increase at closer locations
- Tsunami observed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

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


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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.

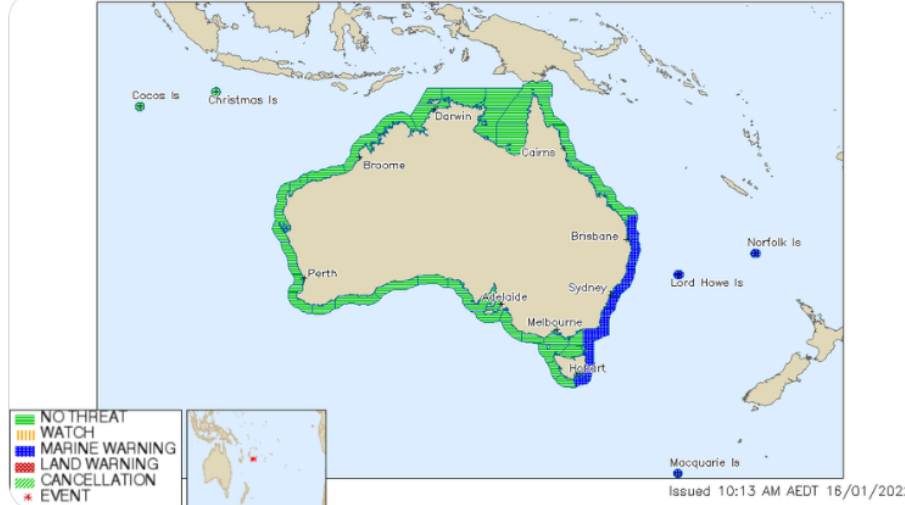


Issued 09:19 PM AEDT 15/01/2022

33 665 827

BOM AUS 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.




Issued 10:13 AM AEDT 16/01/2022

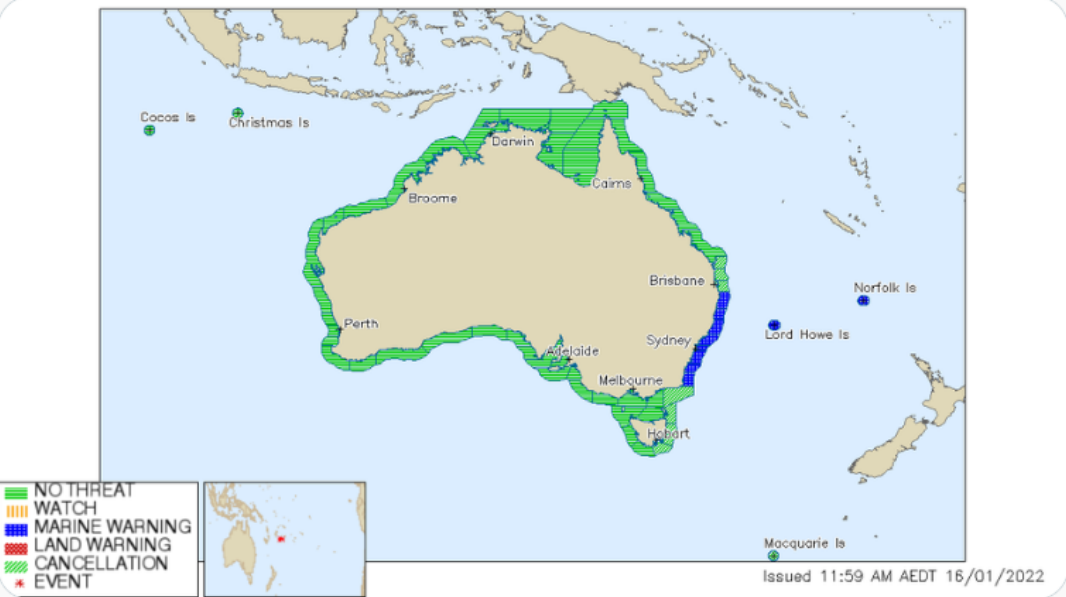
5 71 137



Hunga Tonga-Hunga Ha'apai Volcano – Cancellations

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[#NSW](#), [#LordHoweIsland](#), [#NorfolkIsland](#) [#Tsunami](#) Warnings for the marine environment continue after volcanic eruption near the TONGA ISLANDS yesterday. [#TAS](#), [#VIC](#) and [#QLD](#) [#Tsunami](#) Warnings have been cancelled. Latest info here: bom.gov.au/tsunami.



Issued 11:59 AM AEDT 16/01/2022

4 107 157

- 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

Thank you

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