UN Ocean Decade - Safe Ocean Laboratory
SESSION A: Learnings from recent tsunamis generated by non-seismic and complex sources.
6 April 2022, 0000-0230 UTC

Pacific Tsunami Warning Center: The January 15, 2022 Tonga Volcanic Tsunami and Challenges with Non-Seismic Tsunamis

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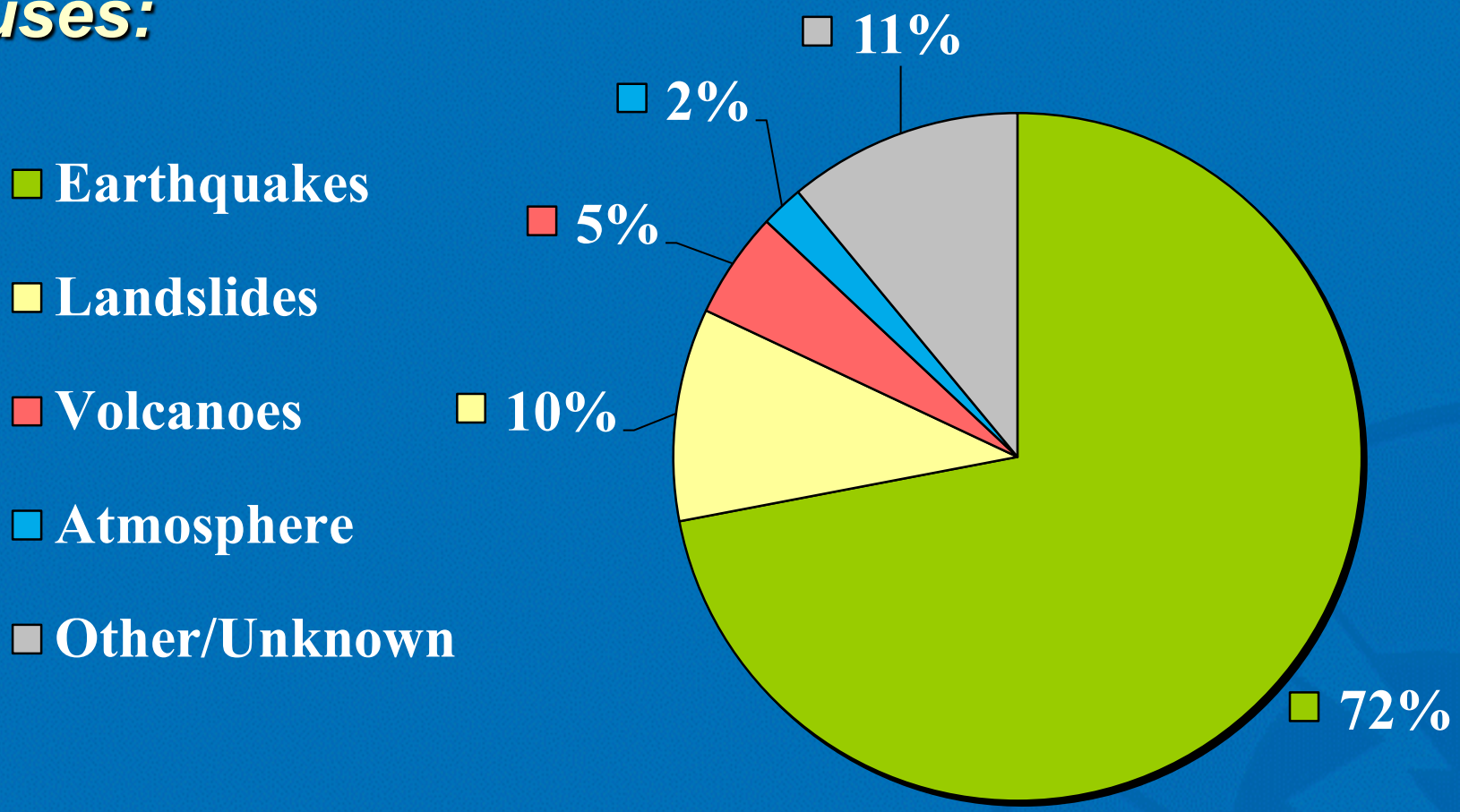
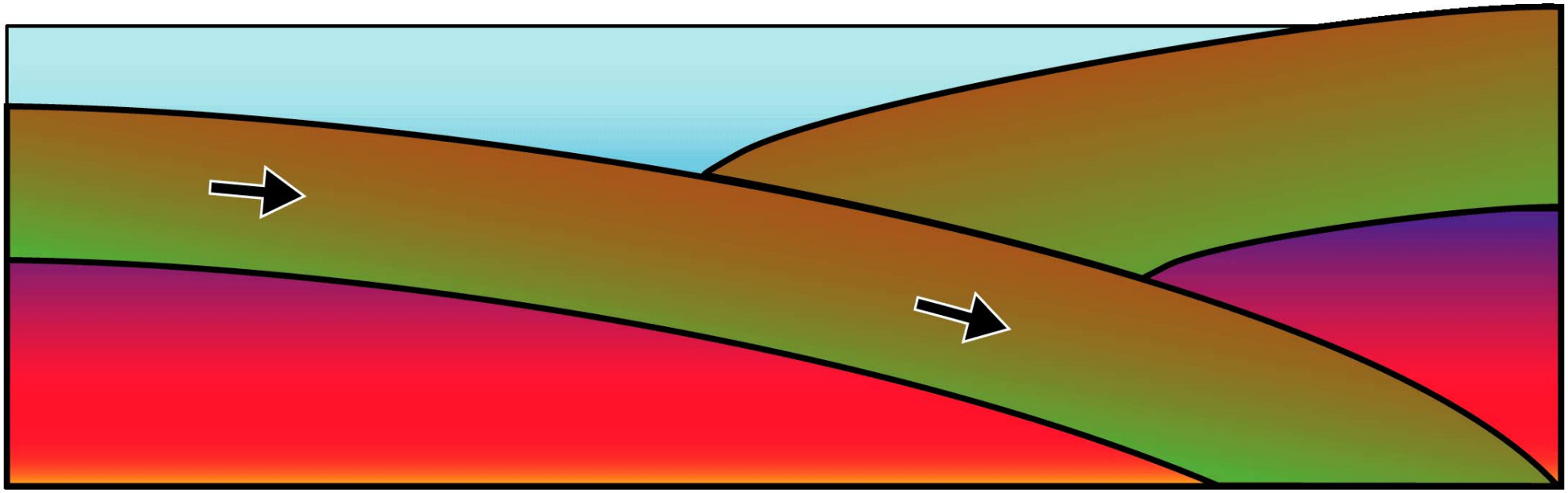
What is a tsunami?

A tsunami is a series of long-period waves created by an abrupt displacement of the ocean.

Causes:



How an earthquake makes a tsunami

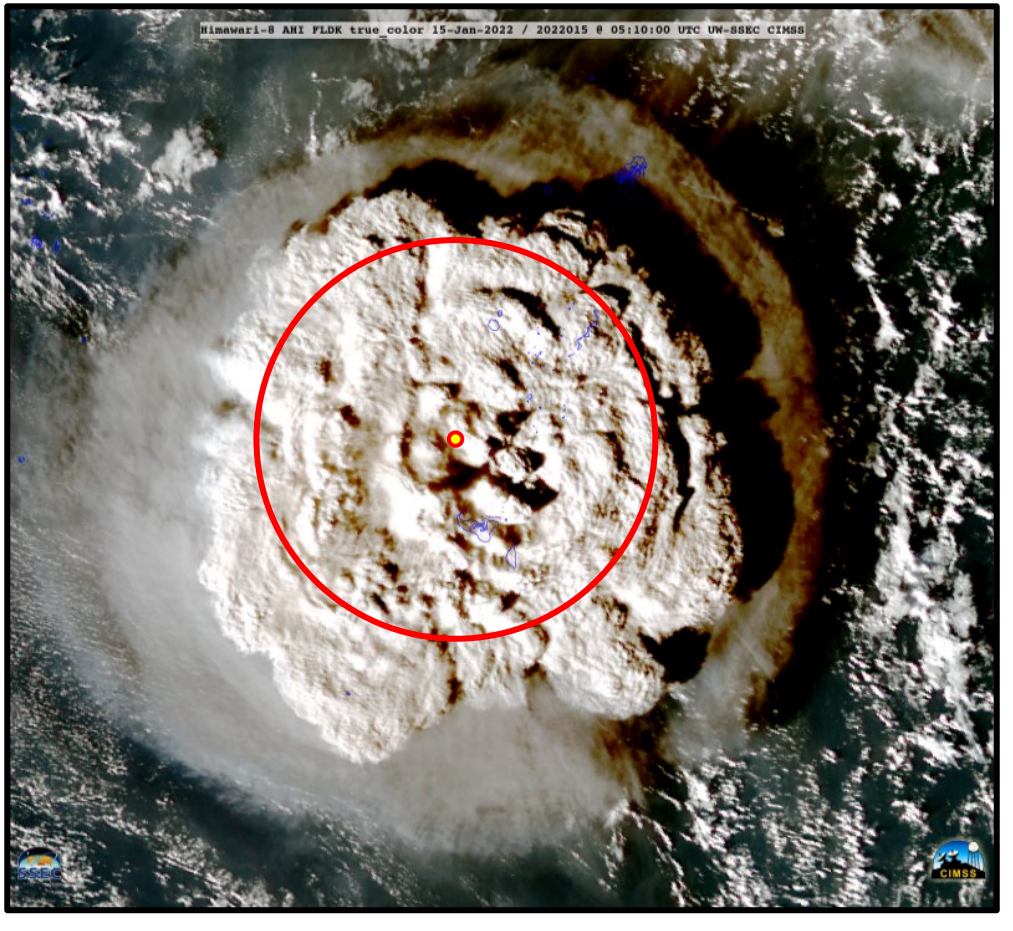


Ash Cloud from Hunga Tonga

Ash Cloud from the Hunga Tonga eruption.

Yellow dot is Hunga Tonga

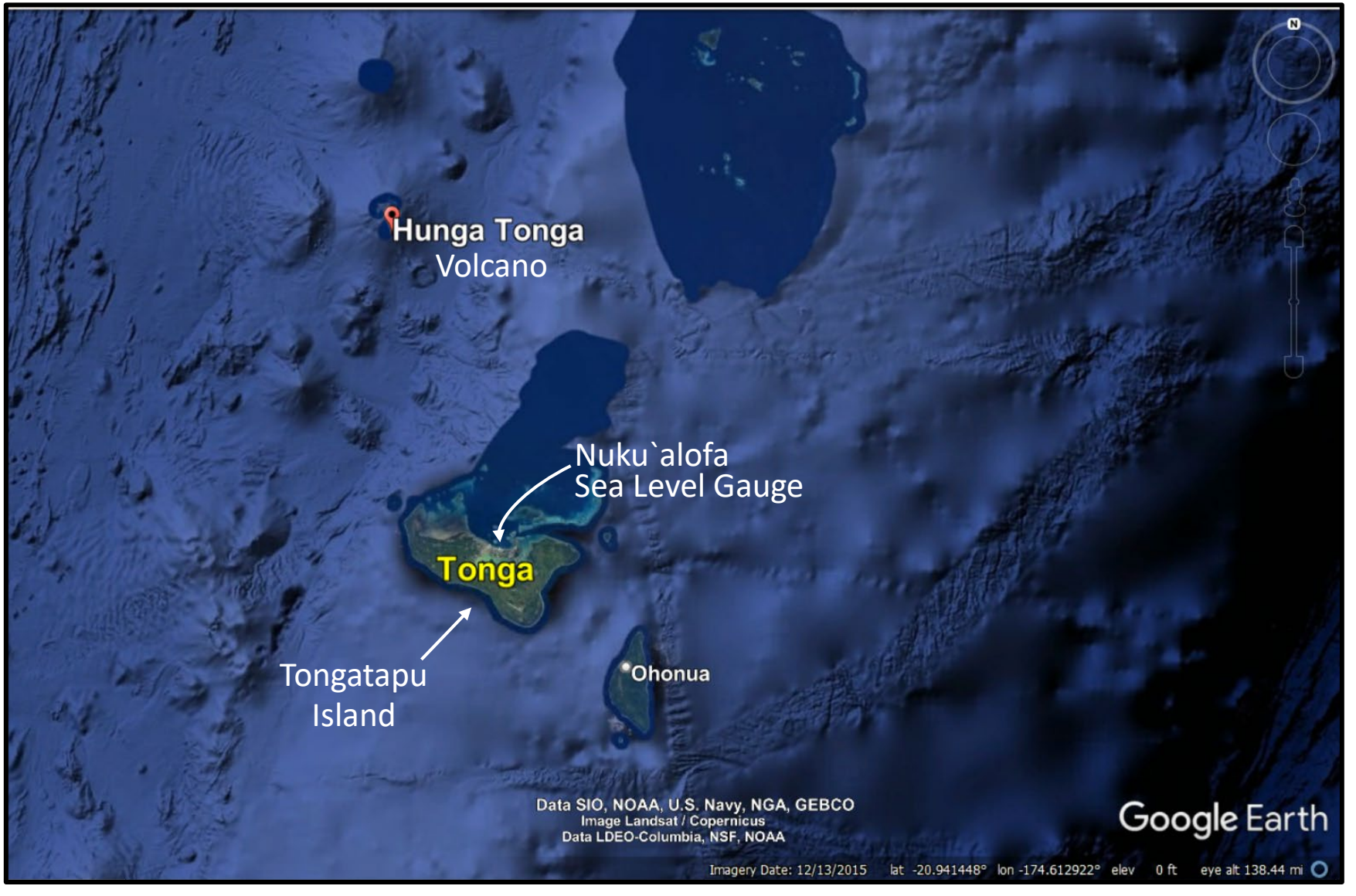
Circle has 150 km radius



Eruption occurred at 04:14:45 UTC (USGS)

Geographic Awareness

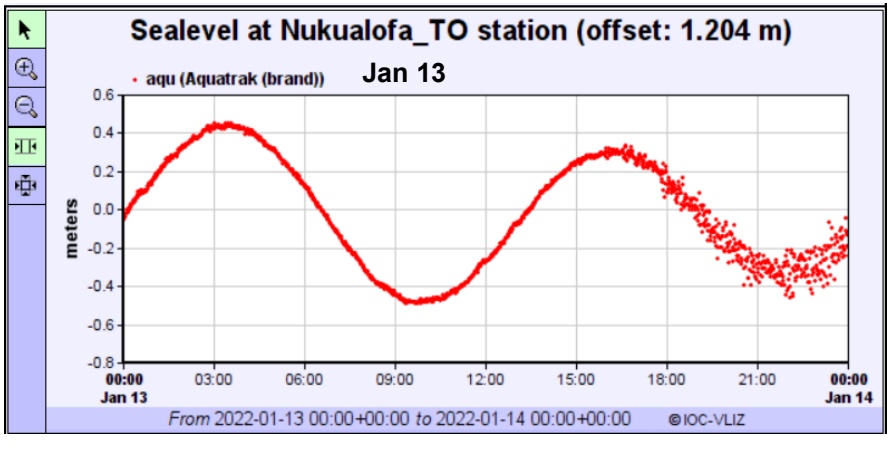
Hunga Tonga is about 70 km north of Tongatapu

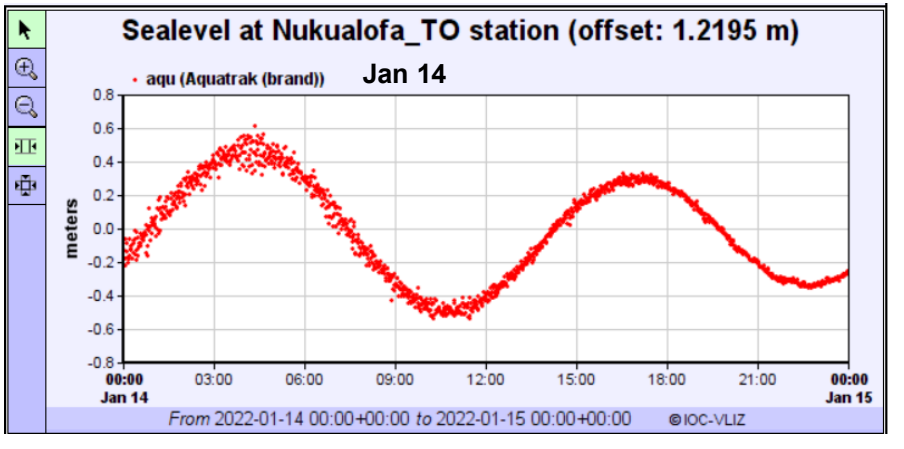


Pre-Event Activity

Volcanic activity at Hunga Tonga on January 13 and 14 caused small sea-level oscillations observed in Tonga and New Zealand.

Nuku`alofa Sea Level Records

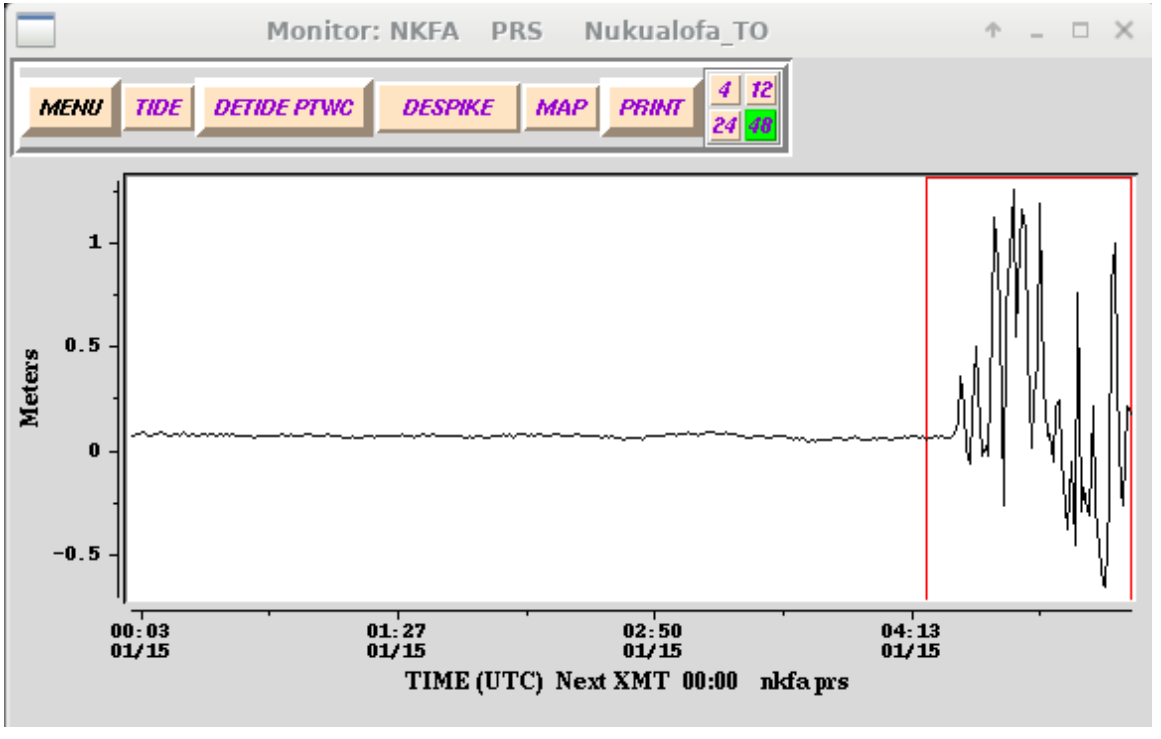




Consequently, PTWC implemented a tsunami detector on the sea level gauge at Nukualofa, Tonga. The detector rings PTWC alarms if a signal above a certain amplitude is detected on the gauge.

Tsunami arrival at Nuku`alofa

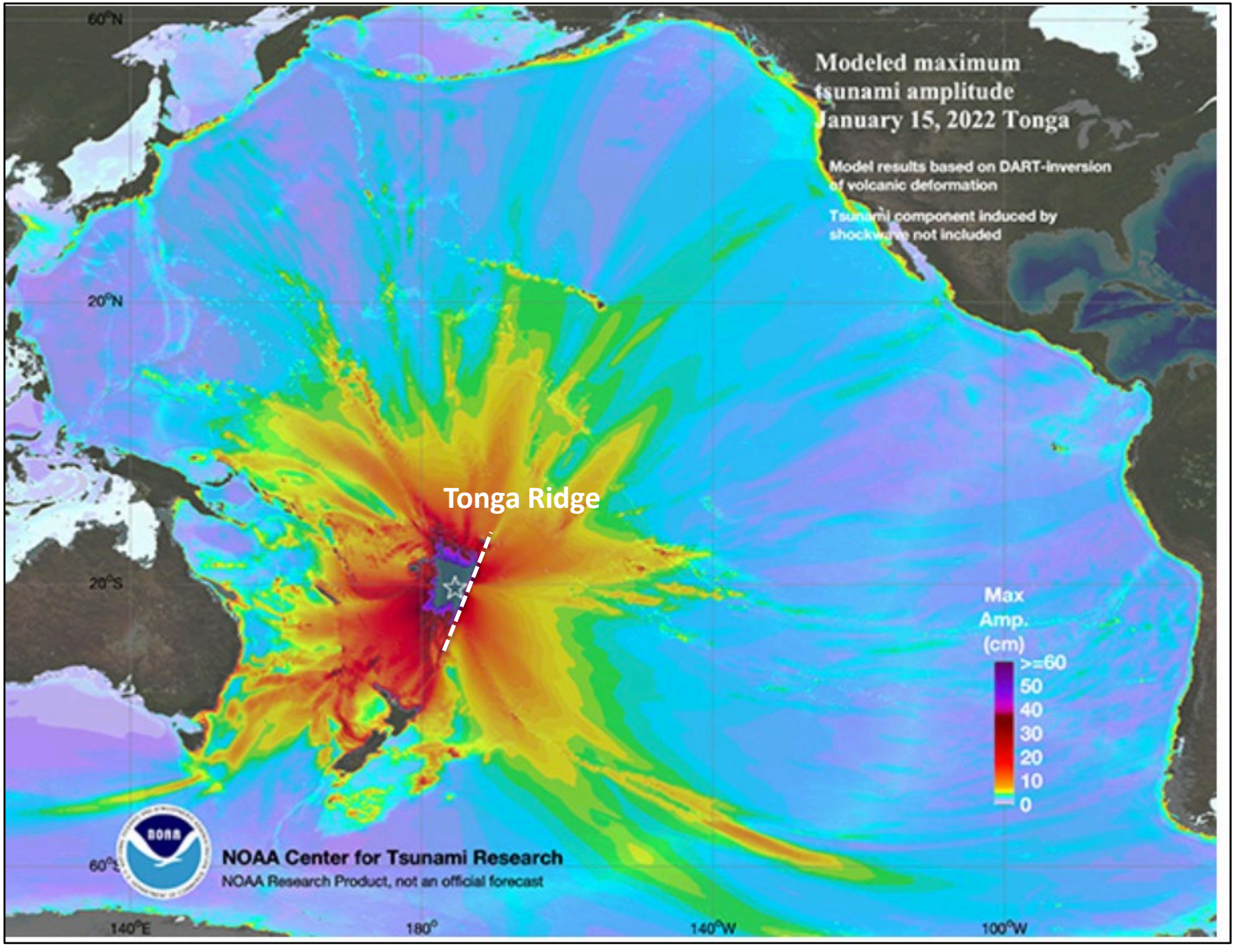
Tsunami signal at the Nuku`alofa Sea Level Gauge following the explosive eruption of the Hunga Tonga – Hunga Ha`apai Volcano



This signal triggered the PTWC alarms, alerting PTWC Duty Scientists to the tsunami that was underway.

Modeled Tsunami Maximum Amplitude In the Pacific

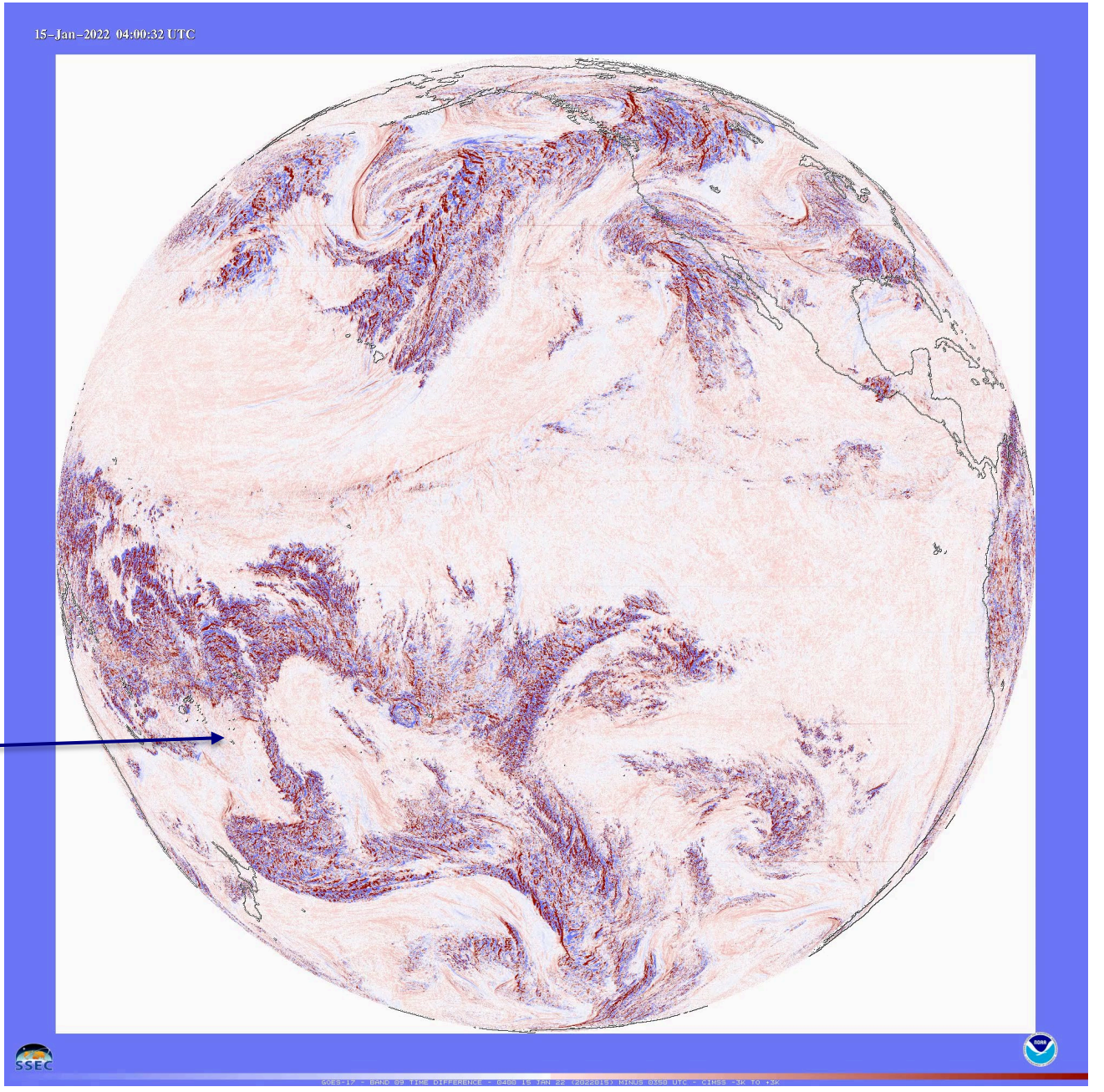
Based on Volcanic Deformation



Sample Maximum Tsunami Amplitudes

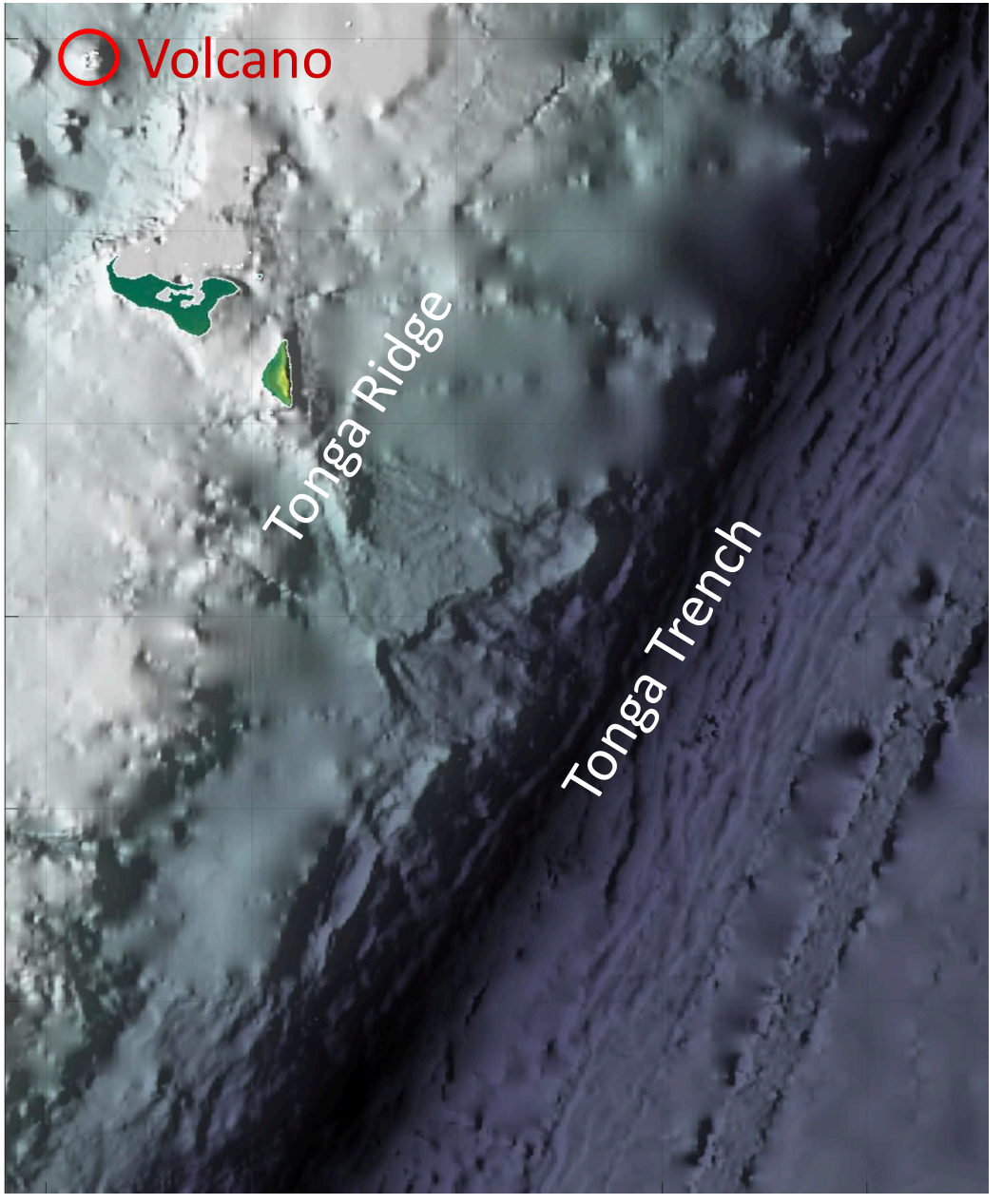
Gauge	Amplitude	
Nuku`alofa, Tonga	0.82 m	West of Tonga Ridge
Pago Pago, American Samoa	0.62 m	
Vanuatu	1.41 m	
Lifou, New Caledonia	0.89 m	
North Cape, New Zealand	0.69 m	
Kushimoto, Japan	0.96 m	
Rarotonga, Cook Islands	0.90 m	East of Tonga Ridge
Kahului, Hawaii	0.83 m	
Santa Cruz, Galapagos	0.75 m	
Coquimbo, Chile	1.08 m	
Arica, Chile	1.22 m	
Chanaral, Chile	1.74 m	

Atmospheric Pressure Wave Travels Around the World



GOES-17 Mid-level Water Vapor (6.9 µm) Time Difference images (credit: Tim Schmit, NOAA/NESDIS/ASPB)
https://cimss.ssec.wisc.edu/satellite-blog/archives/44252

Proudman Resonance at the Tonga Trench



Atmospheric Pressure Wave Speed = $310\ \mathrm{m/s}$

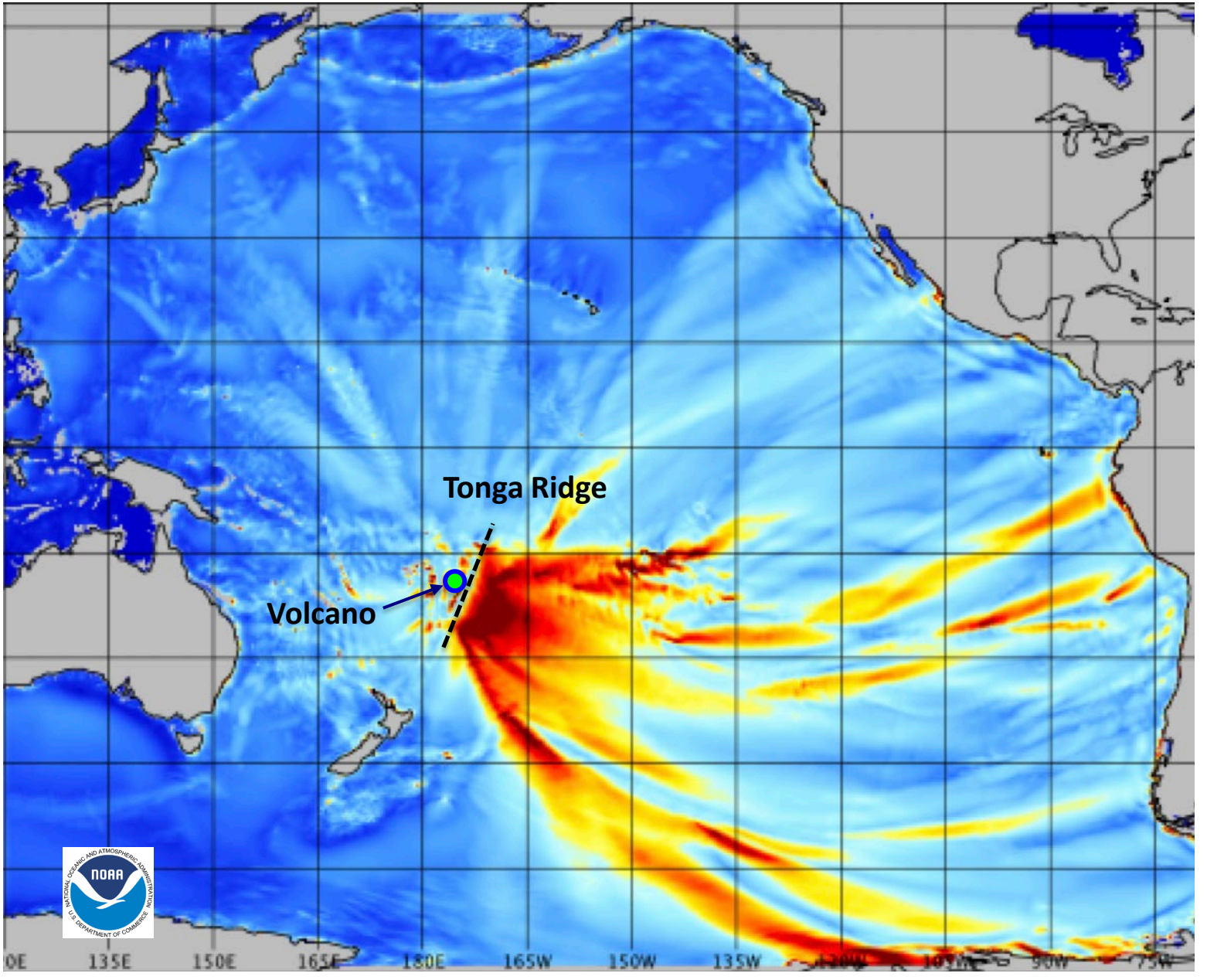
Tsunami Propagation Speed= $\sqrt{gd}$

Maximum Depth of the Tonga Trench = $11000\ \mathrm{m}$

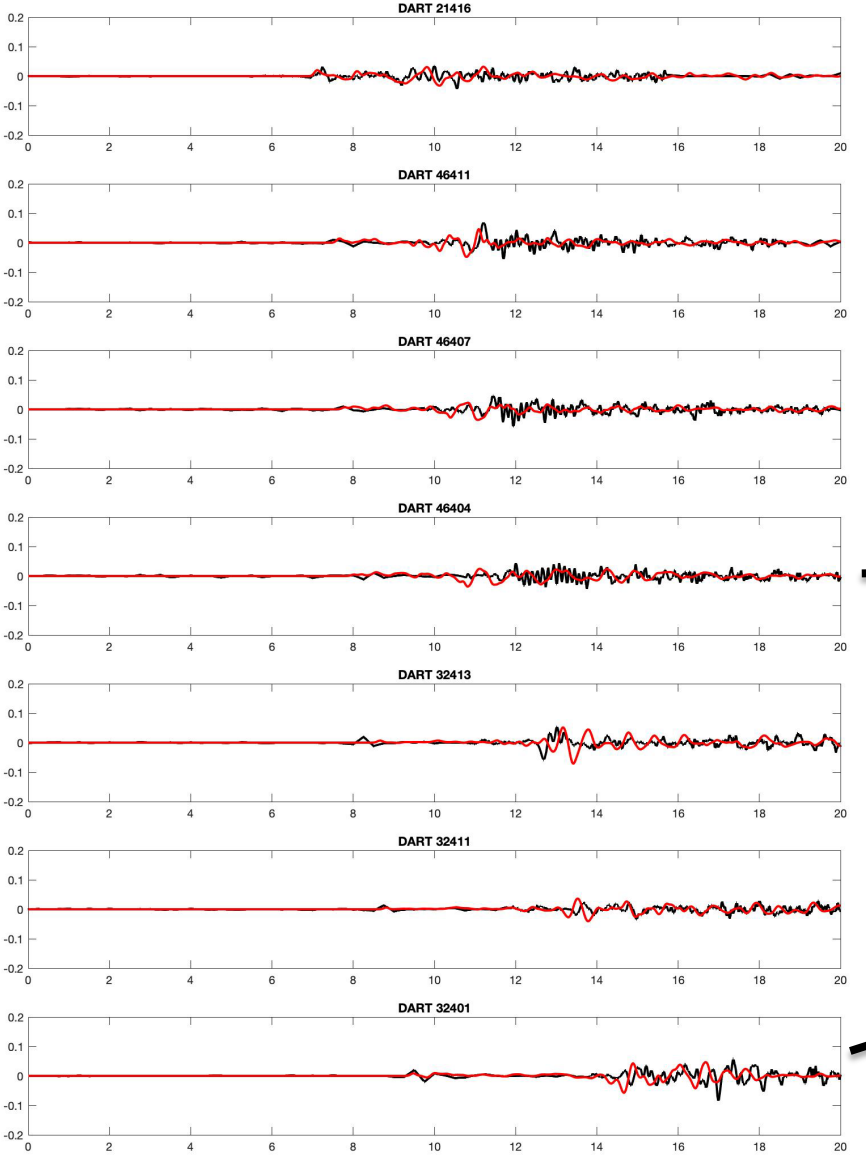
Tsunami Speed= $\sqrt{9.8 * 11000}$ $= 328\ \mathrm{m/s}$

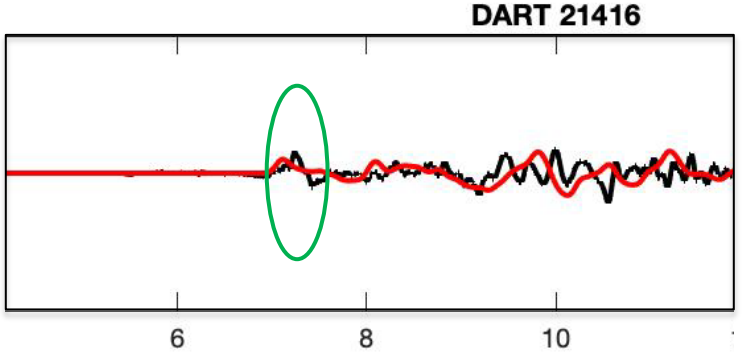
Modeled Tsunami Maximum Amplitude In the Pacific

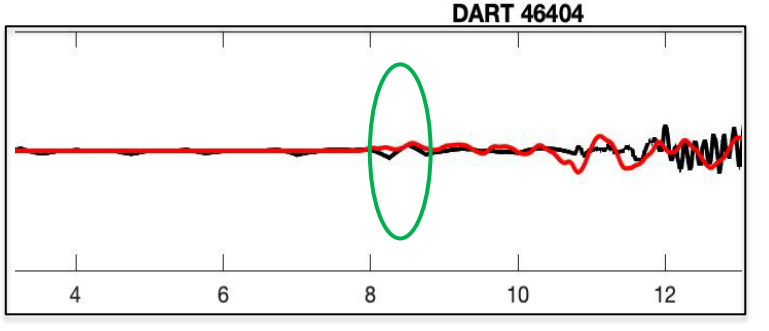
Based on Atmospheric Pressure Wave Forcing

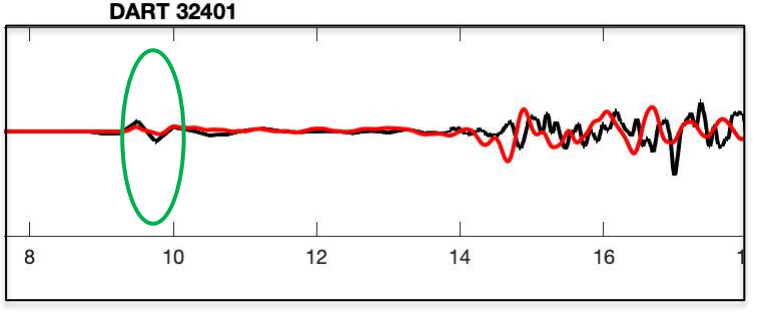


DART Observations vs. Atmospheric Tsunami Model Results









Tsunami Warning Center Challenges with Non-Seismic Tsunamis

No rapid alert

- Seismic waves give an alert within minutes of any large earthquake
- But no such alert for a landslide, volcano, or meteo-tsunami
- Alert is only on later detection of tsunami waves

No source location

- Earthquake hypocenter and origin time quickly determined
- Landslide, volcano, meteo-tsunami source location only estimated later from tsunami arrival times on different gauges

No source mechanism

- Earthquake parameters and tsunami source mechanism can be determined quickly to estimate tsunami impacts and drive forecast models
- Landslide, volcano, and meteo-tsunami source mechanisms are only determined later – after event is over

No Forecast

- Earthquake-driven tsunami impacts can be numerically forecast
- Non-seismic tsunamis can only be observed and reported

No Pre-Scripted Standard Products

- Appropriate products may need to be constructed on-the-fly to fit the situation
- Recipients may not respond appropriately to these products

Thank You

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