



Non-hydrostatic Modeling of Tsunamis in Support of Moore Foundation

SMART Cable Project

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Port Vila, Vanuatu

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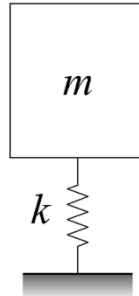
Nonhydrostatic Modeling of Tsunamis

Shallow-water models

- Two-dimensional horizontal flows
- Implemented for modeling of storm surge and astronomical tides
- 2D approximation for tsunami waves

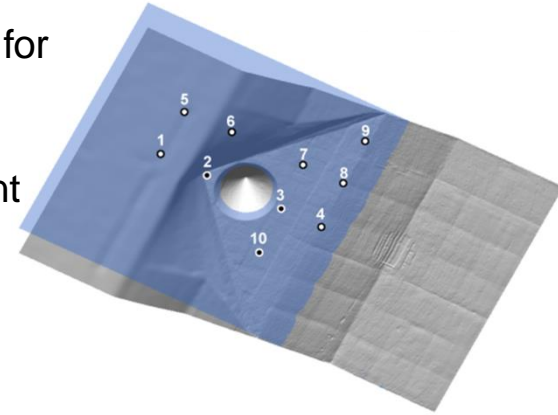
NEOWAVE

- Nonhydrostatic Evolution of Ocean Waves
- Depth-averaged vertical velocity for quasi-3D flow leading to
 - (1) Wave dispersion
 - (2) Wavenumber dependent shoaling
 - (3) Corrected flow on steep slopes
 - (4) Tsunami generation
 - (5) Vertical oscillations
- Shock-capturing for bore formation
- A community model developed and maintained at UH with users worldwide



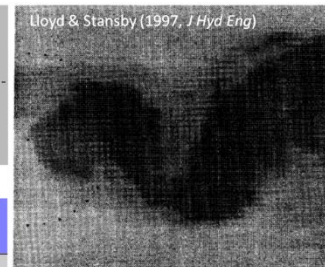
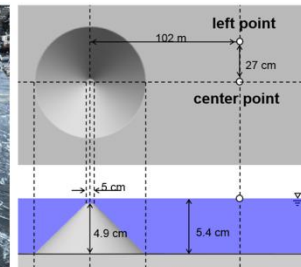
NSF Benchmark 2009

- Capability to account for shelves, and bore formation
- Laboratory experiment at Oregon State U
- Blind tests without knowledge of mode test results



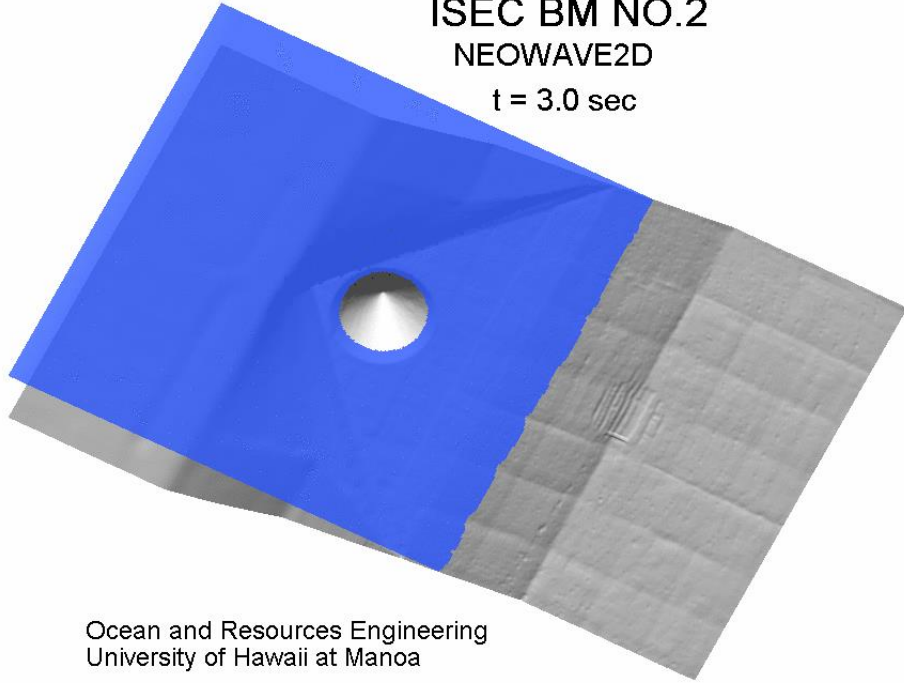
2015 NTHMP Benchmark

- Tsunami currents for maritime hazard mapping
- Vortex formation & shedding in published lab data

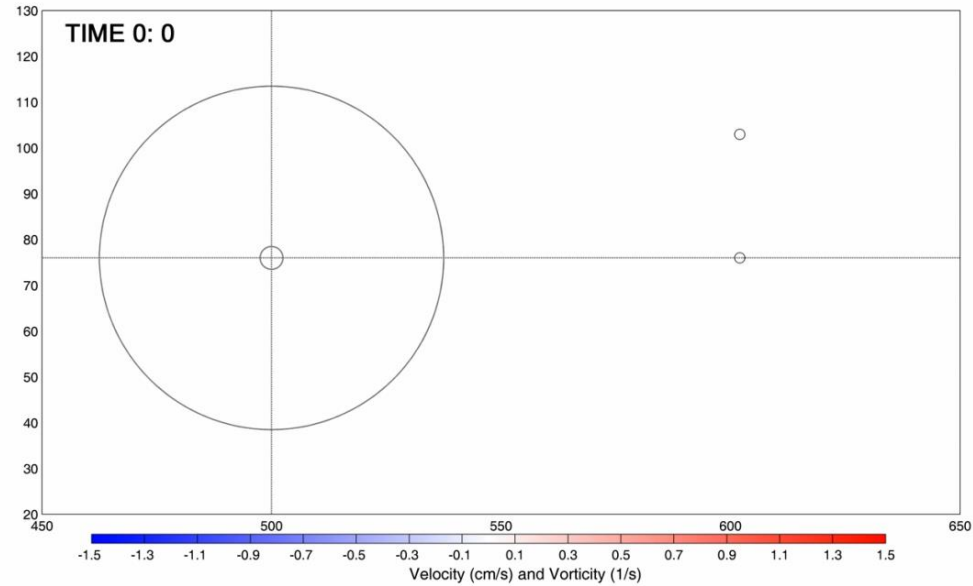
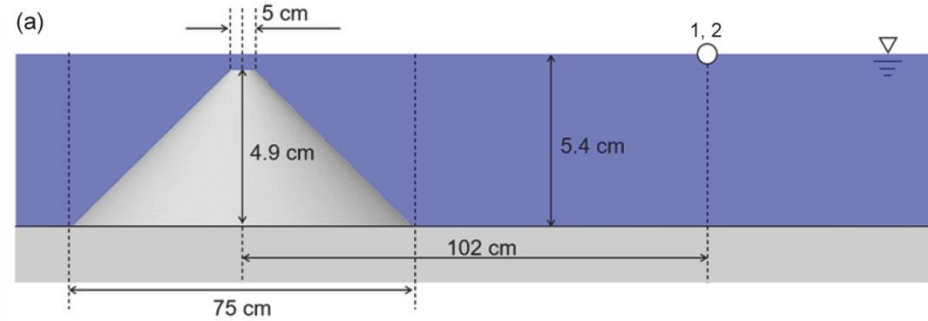


NSF and NTHMP Benchmark Results

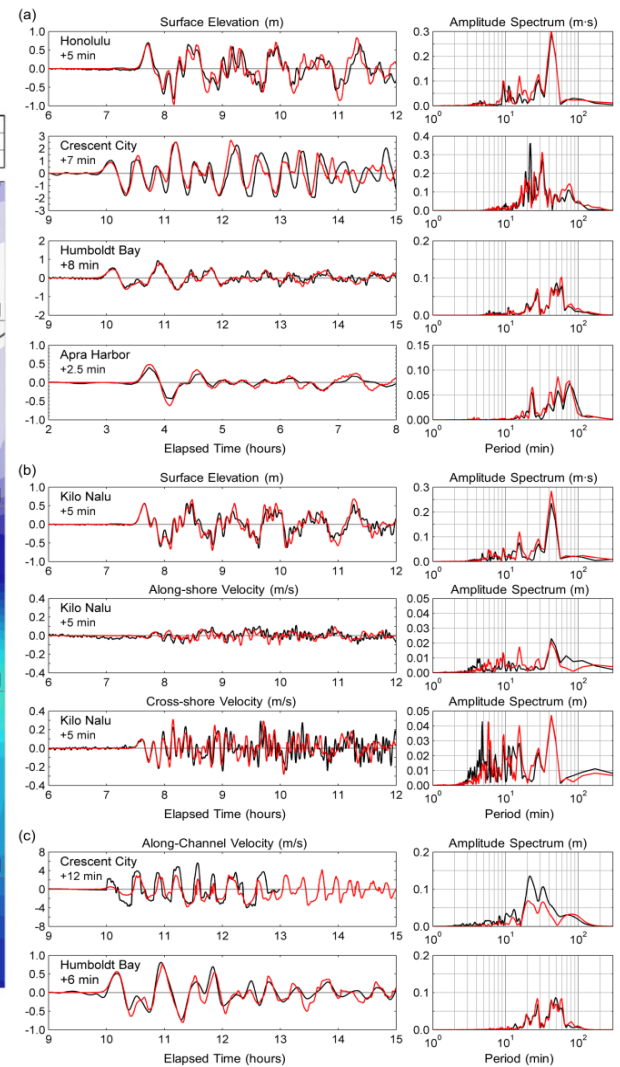
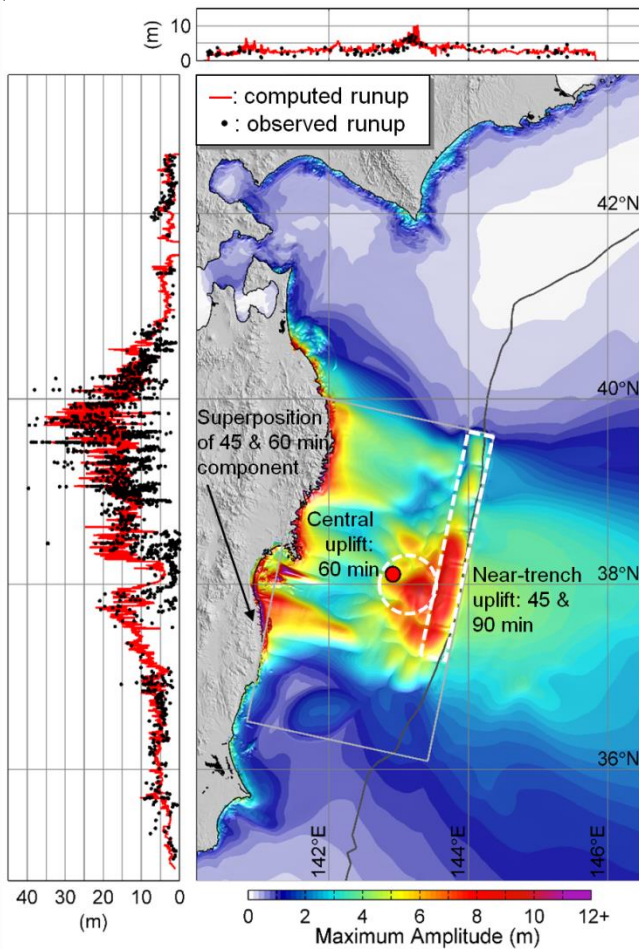
ISEC BM NO.2
NEOWAVE2D
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Ocean and Resources Engineering
University of Hawaii at Manoa

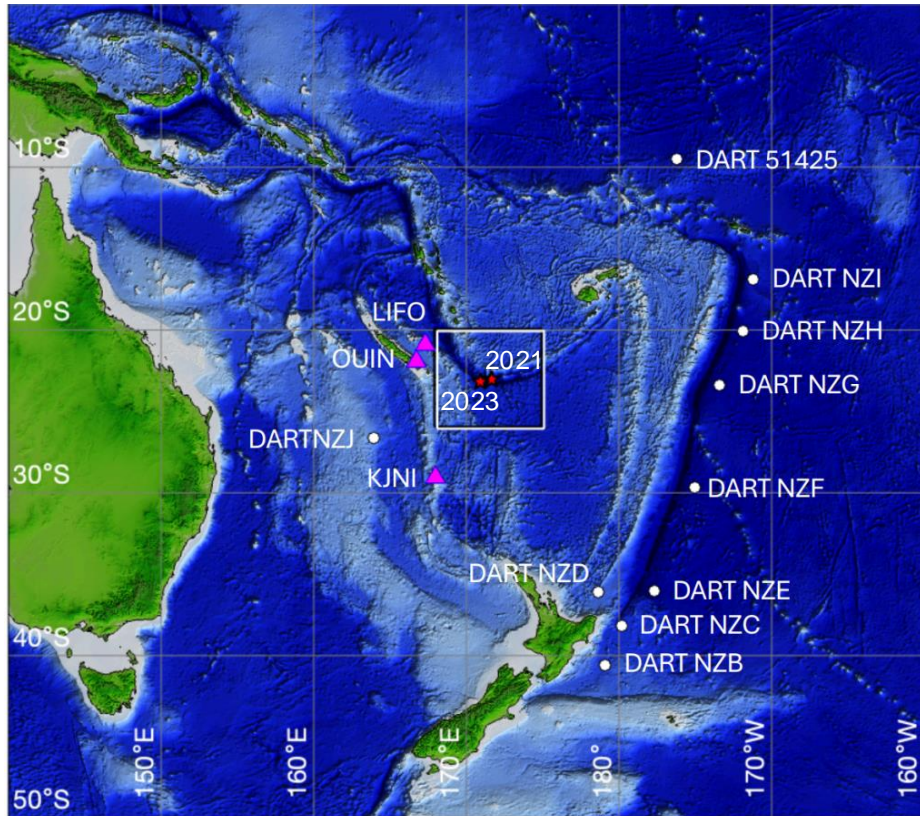


The 2011 Tohoku Tsunami

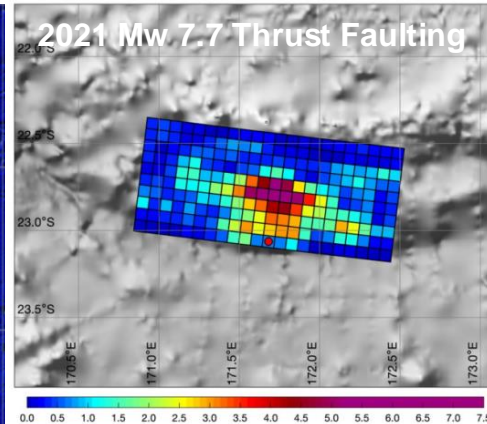


2021 and 2023 Mw 7.7 Loyalty Islands Earthquakes

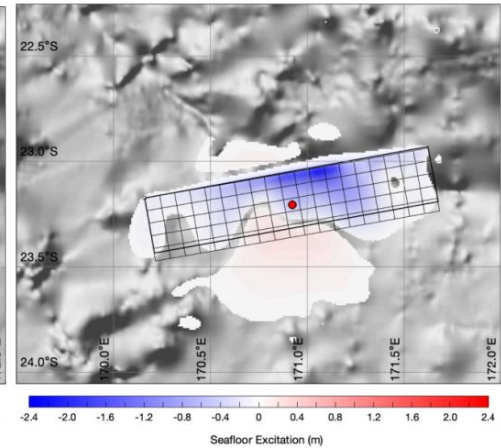
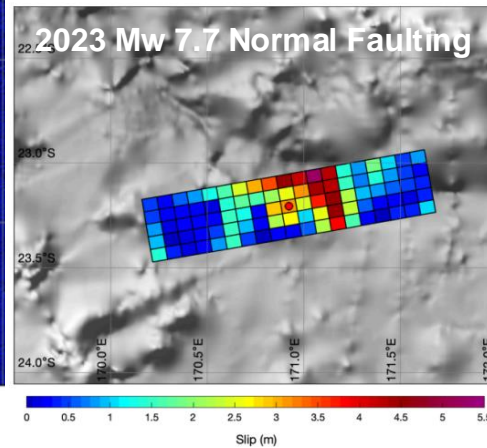
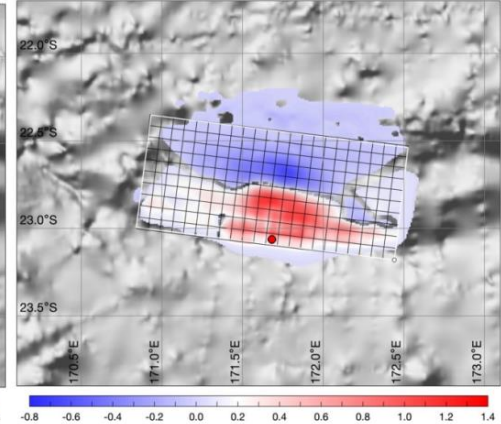
Earthquake Epicenters and Water-level Stations



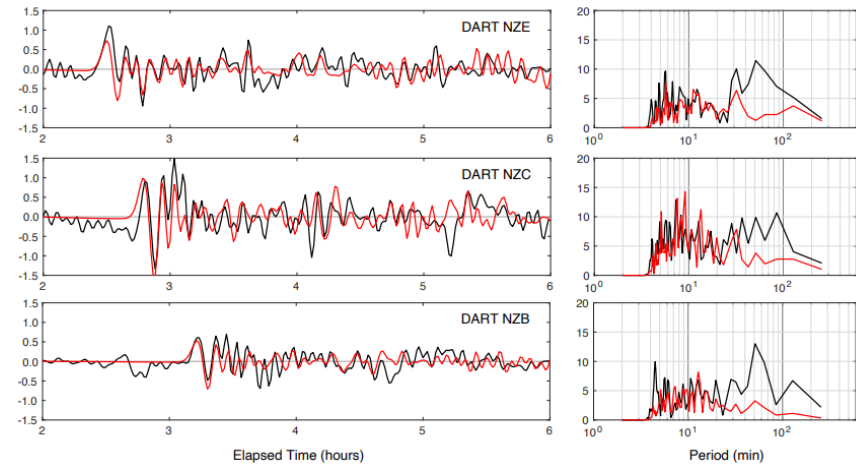
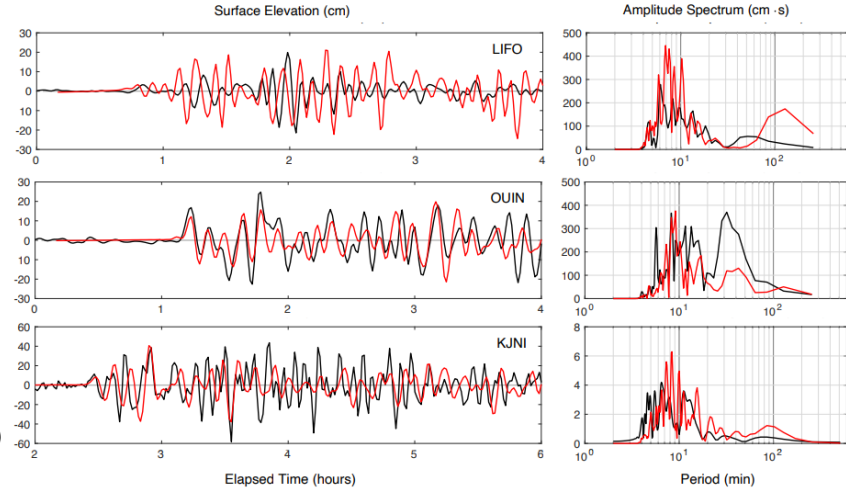
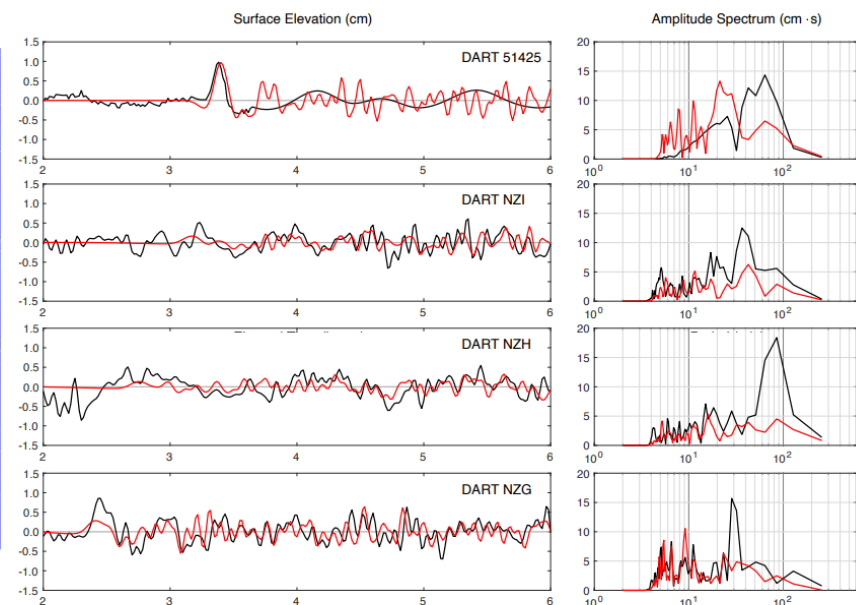
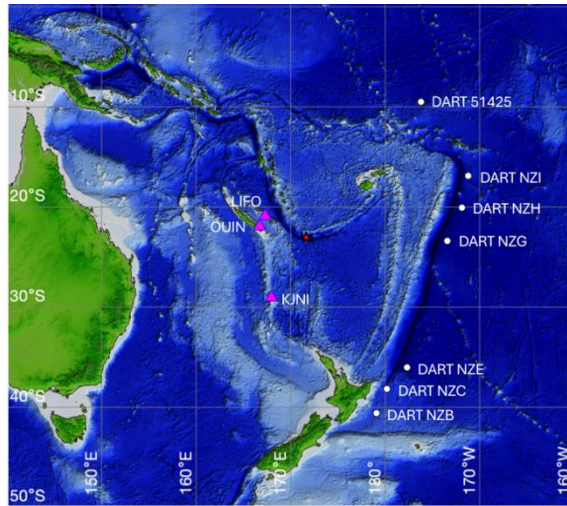
Finite Fault Models



Seafloor Deformation

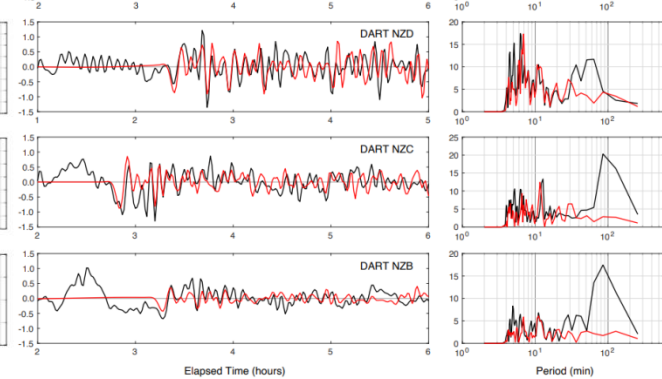
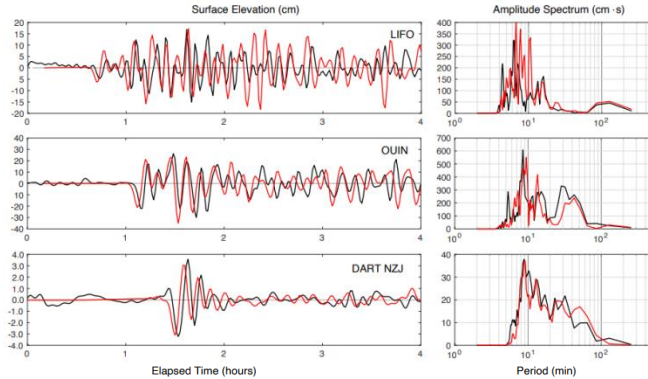
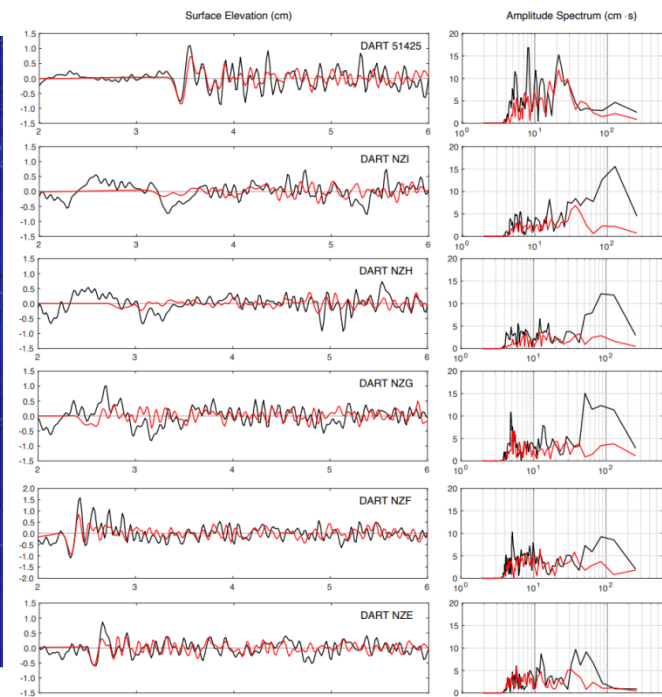
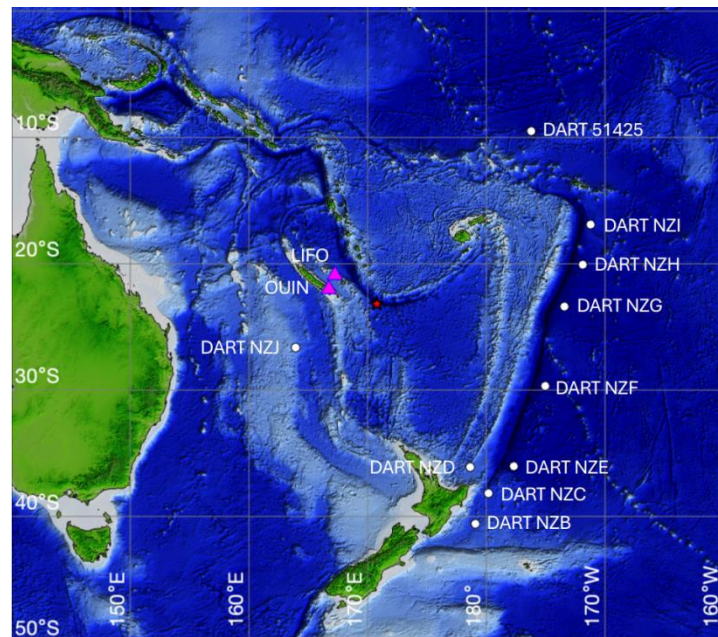


The 2021 Mw 7.7 Loyalty Islands Earthquake and Tsunami



Recorded (—)
Computed (—)

The 2023 Mw 7.7 Loyalty Islands Earthquake and Tsunami



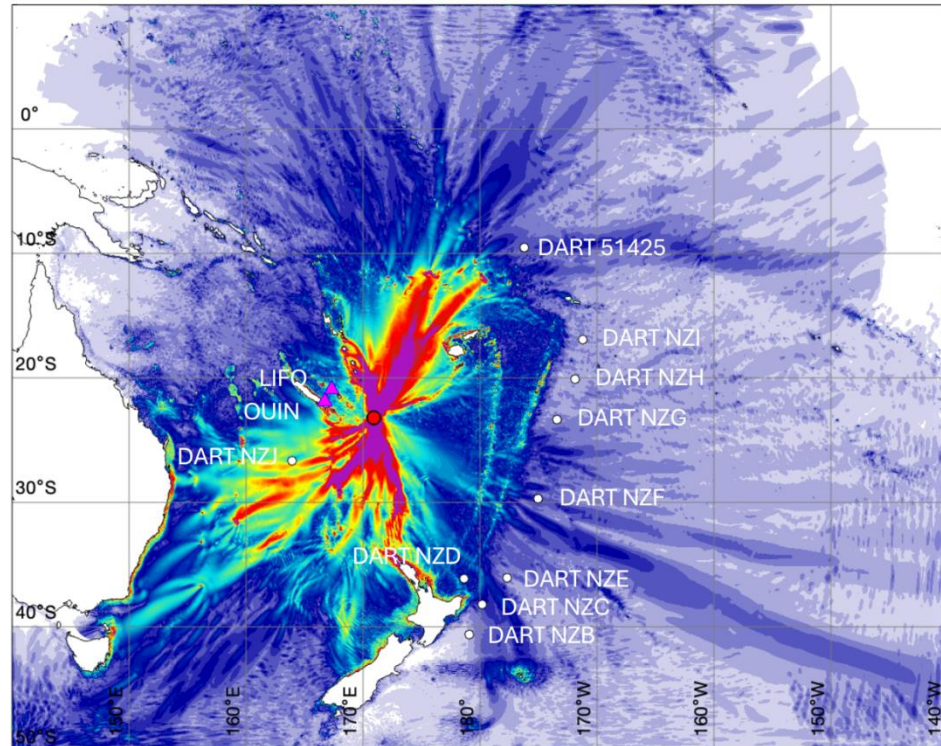
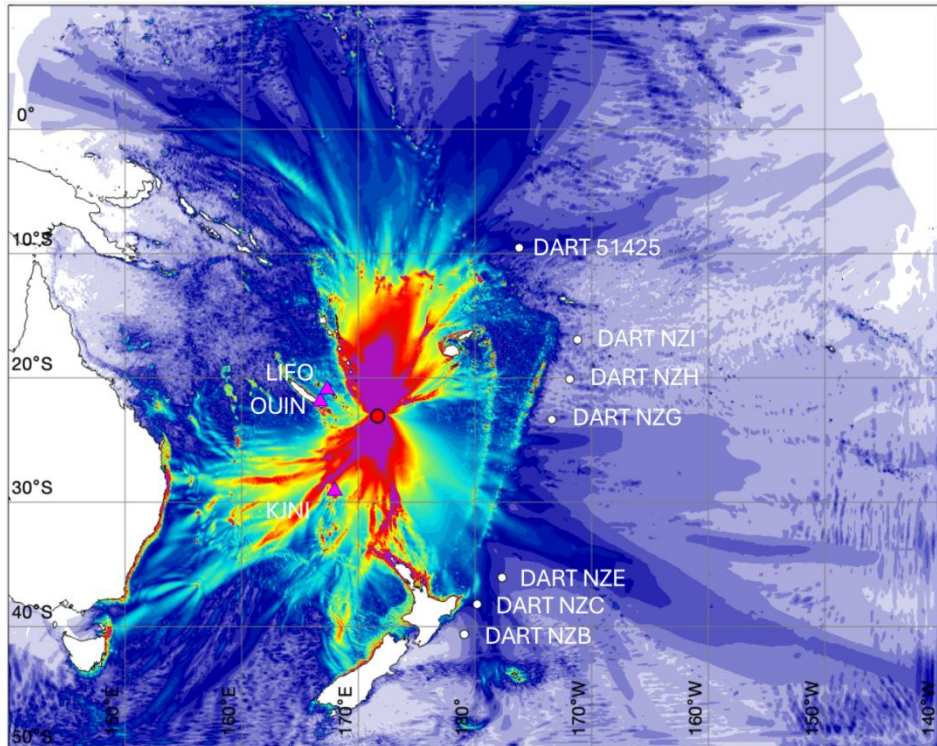
Recorded (—)
Computed (—)

Recorded (—)
Computed (—)

Comparison of Radiation Pattern

2021 Loyalty Island Tsunami

2023 Loyalty Island Tsunami



Max Surface Elevation (cm)



Max Surface Elevation (cm)

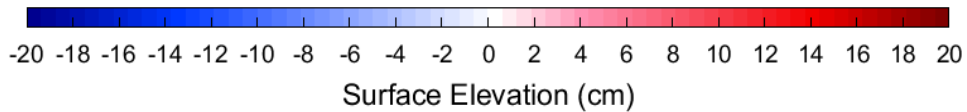
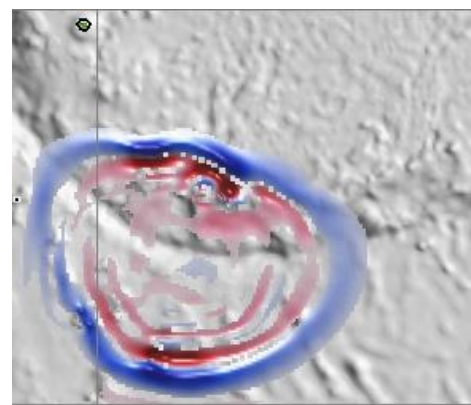
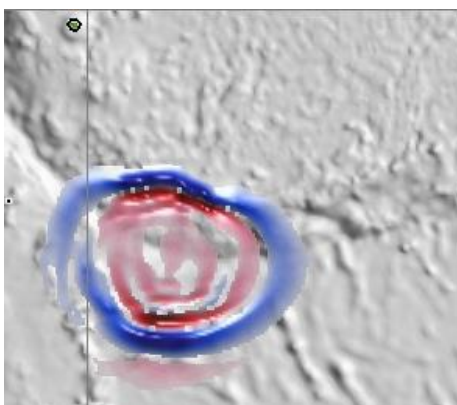
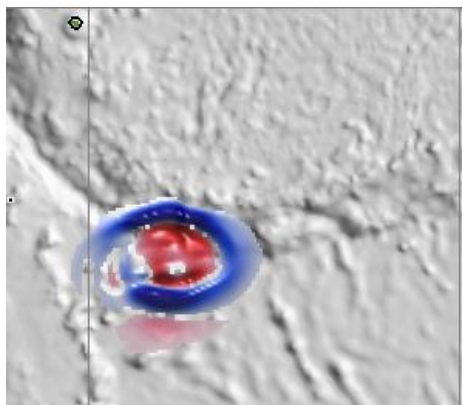
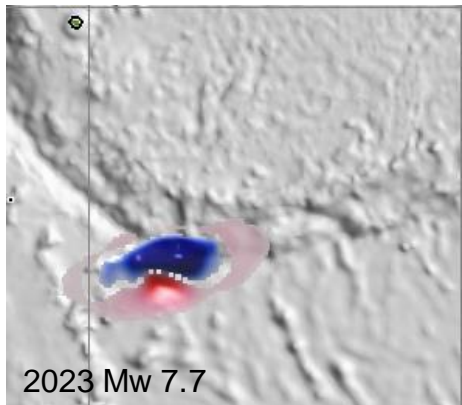
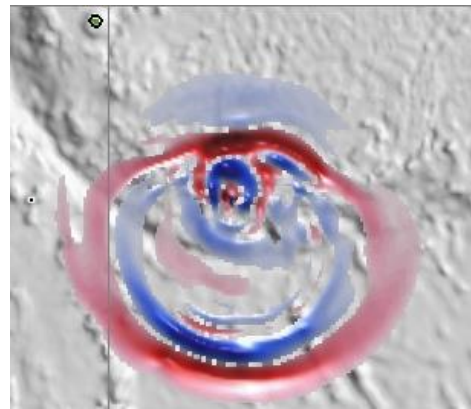
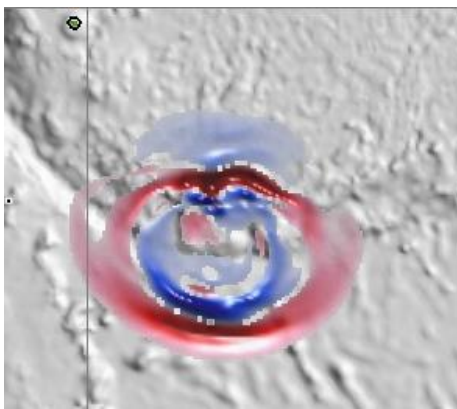
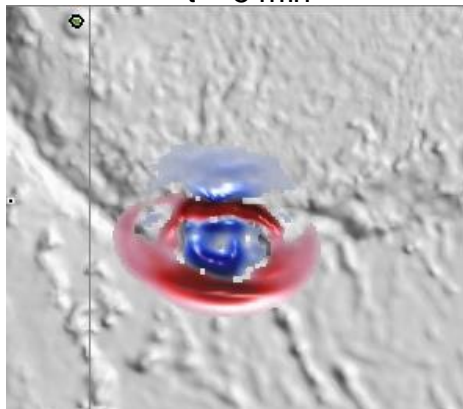
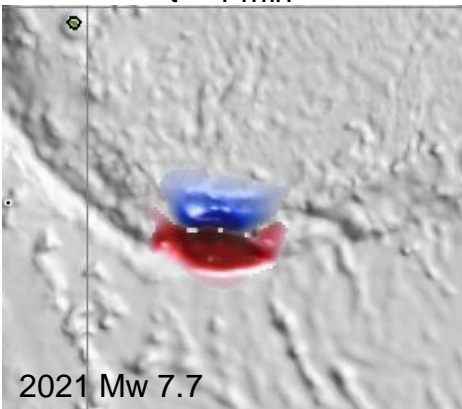
Tsunami Generation

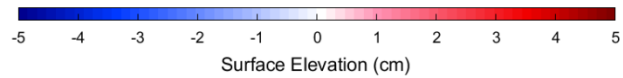
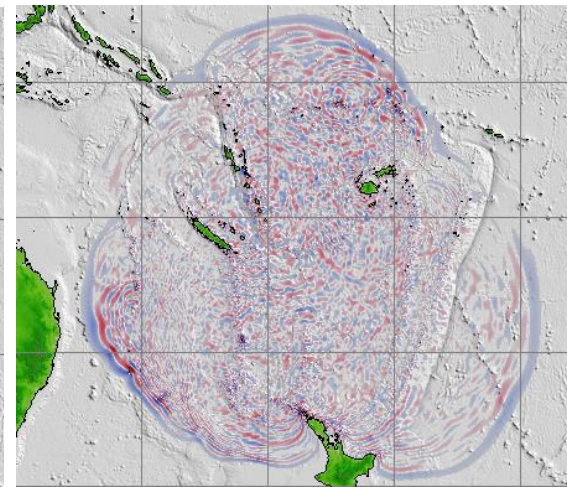
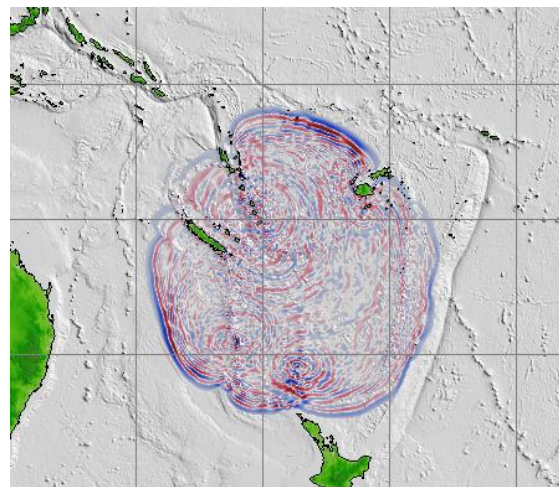
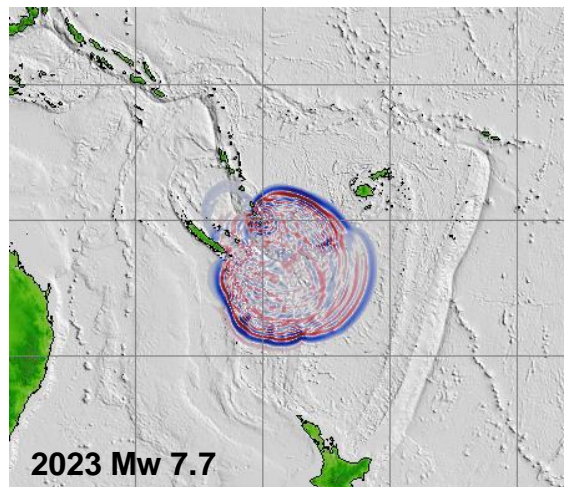
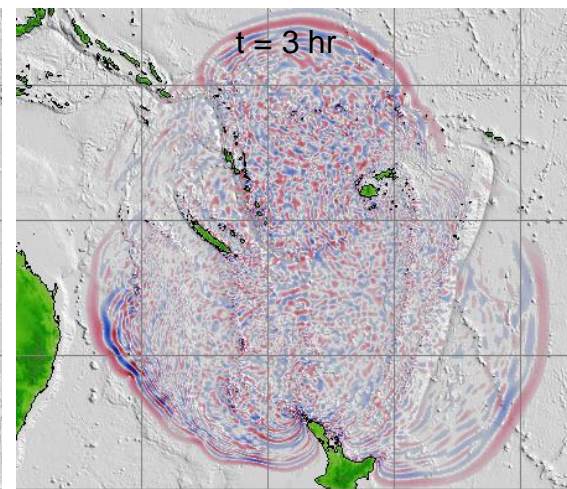
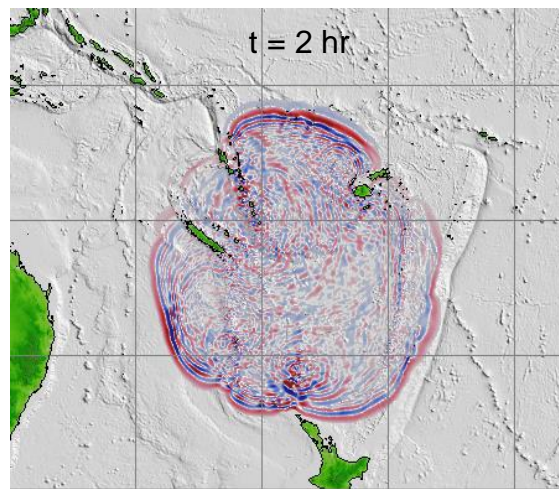
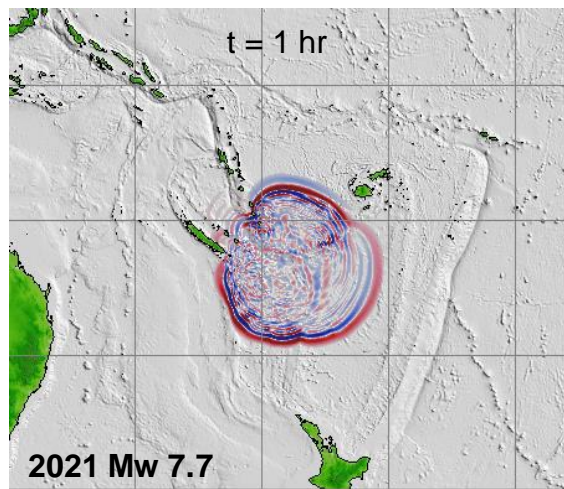
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t = 5 min

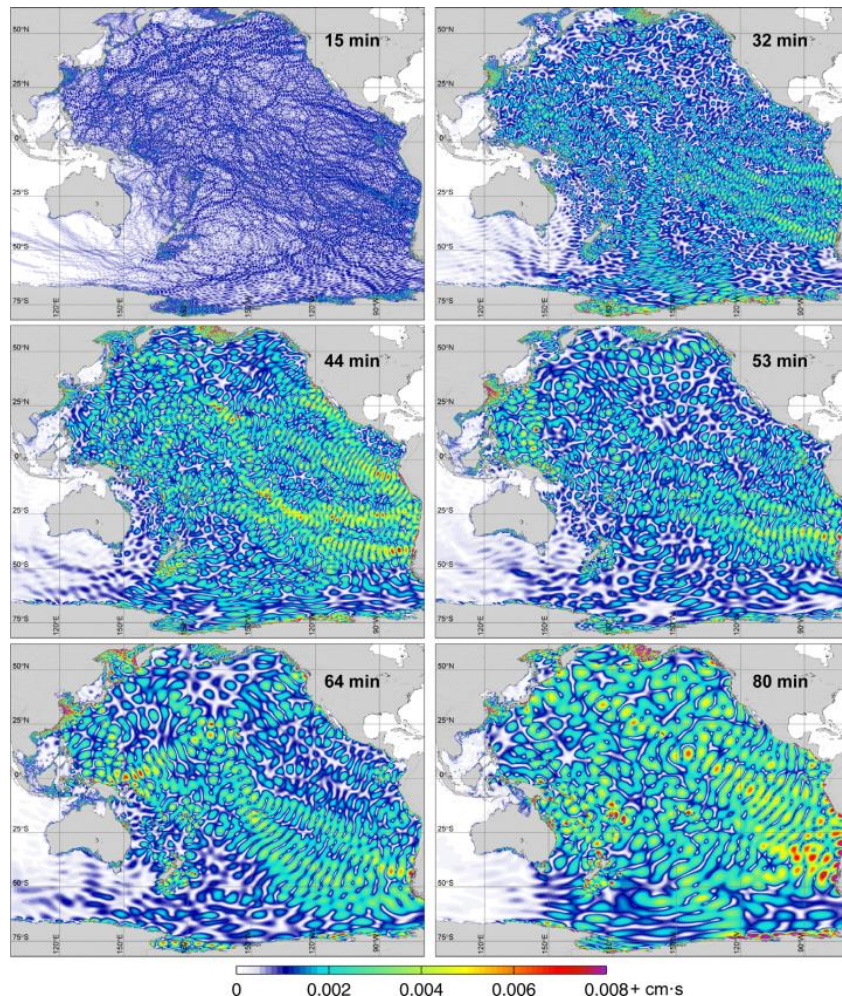
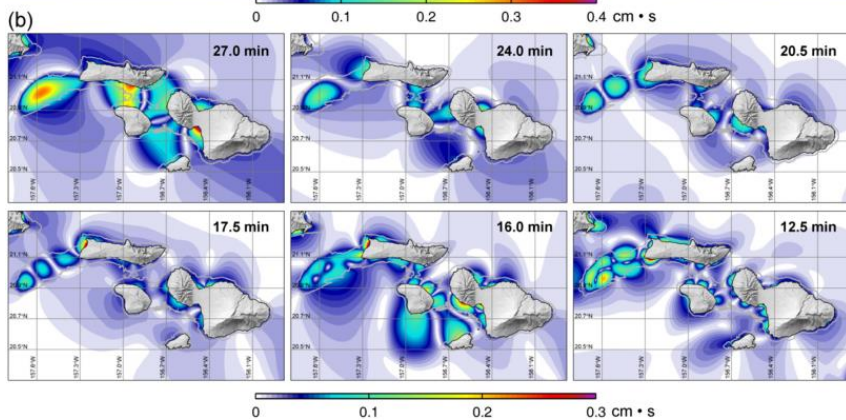
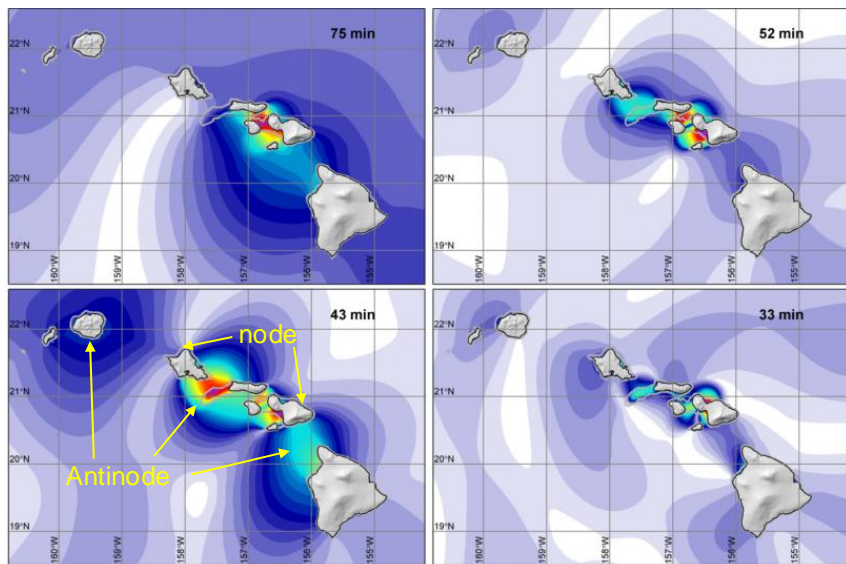
t = 10 min

t = 15 min





Resonance Modes (Standing Waves) Derived for the 2011 Tohoku Tsunami



Summary and Continuing Work

Consistent source models from seismic and tsunami data

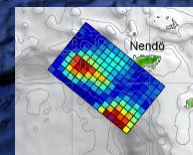
- 2021 Mw 7.7 Loyalty Islands earthquake
- 2023 Mw 7.7 Loyalty Islands earthquake
- 2013 Mw 8.0 Santa Cruz earthquake (Lay et al., 2013)

Spectral analysis of computed sea-surface time series

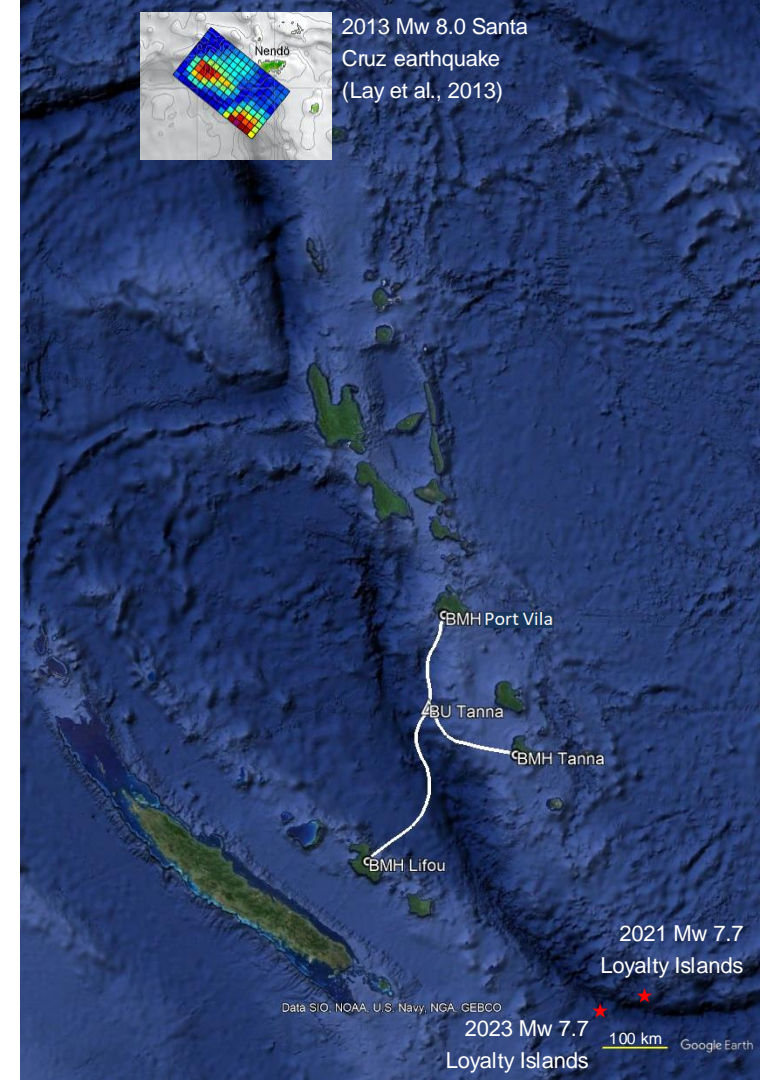
- Resonance modes in the Vanuatu-New Caledonia region
- Identification of energetic modes and high-hazard locations
- Locations with strong tsunami signals by period

SMART Cable Application

- Identify optimal sensor locations from resonance modes
- Verify optimal sensor locations through modeling of recent events and/or hypothetical scenarios
- Synthesize SMART data samples from recent events and hypothetical scenarios to aid integration with existing warning systems
- And suggestions provided by the expert panel



2013 Mw 8.0 Santa Cruz earthquake (Lay et al., 2013)



Data SIO, NOAA, U.S. Navy, NGA, GEBCO

2023 Mw 7.7 Loyalty Islands

2021 Mw 7.7 Loyalty Islands

100 km Google Earth

