Nonhydrostatic Evolution of Ocean Waves

NEOWAVE for Tsunami Modeling

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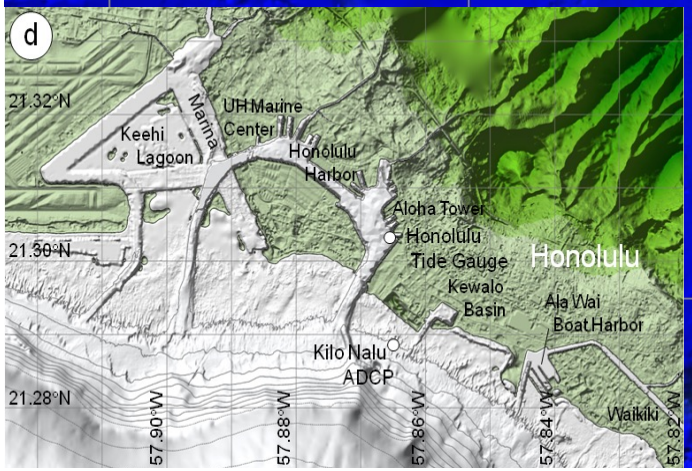


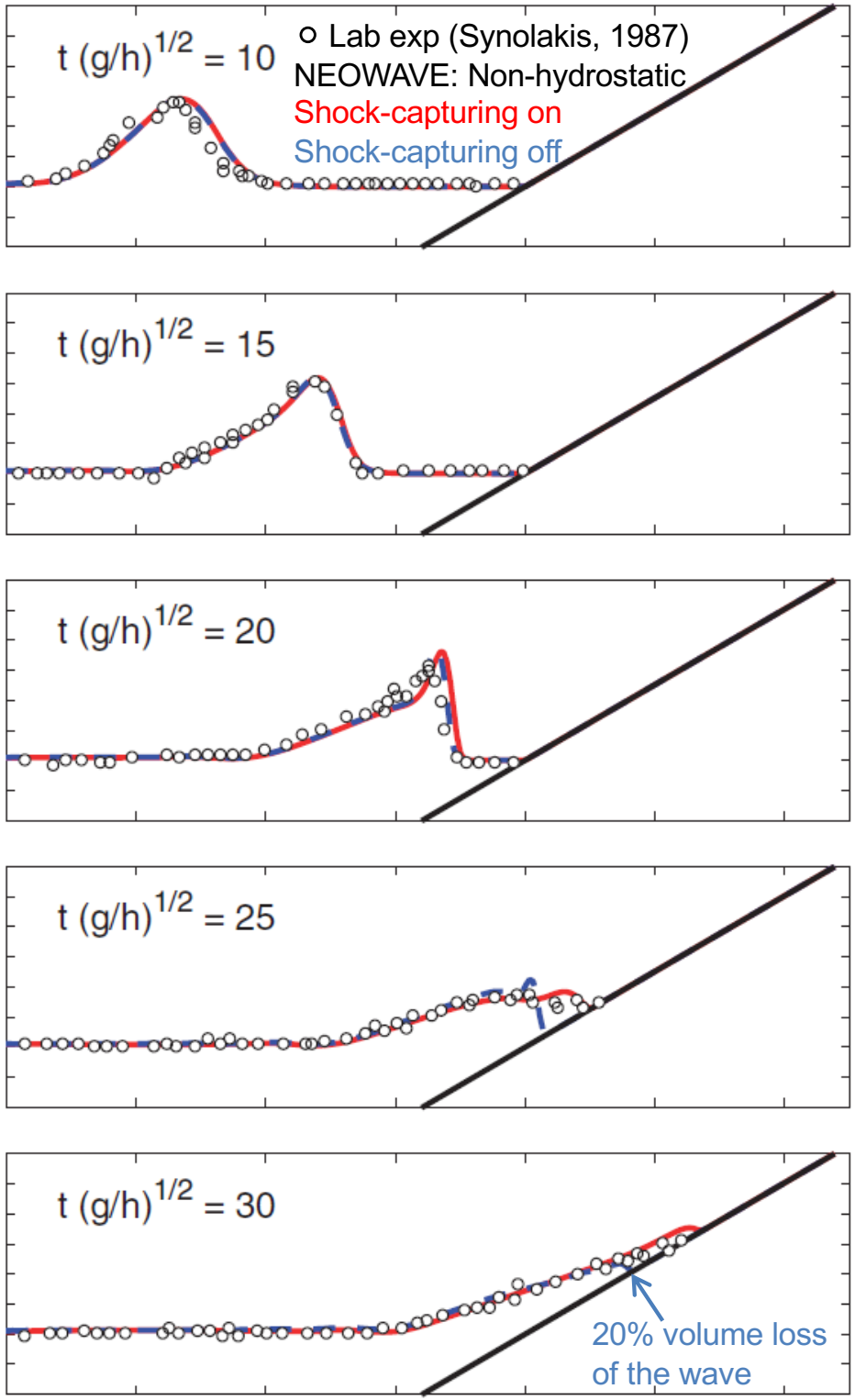
Tsunami Models

Shallow-water or hydrostatic models
- Zero vertical velocity
- TUNAMI, ALASKA, COMCOT, MOST, FVWAVE*, GeoCLAW*, …

Boussinesq-type models
- Vertical velocity profile expressed as horizontal velocity terms for dispersion
- pCOULWAVE*, FUNWAVE-TVD*, BOSZ*, …

Non-hydrostatic model - NEOWAVE*
- Developed by Yoshiki Yamazaki as part of his PhD dissertation in 2001
- Inclusion of depth-averaged Vertical velocity
- Tsunami generation, flow over steep slopes, and dispersion

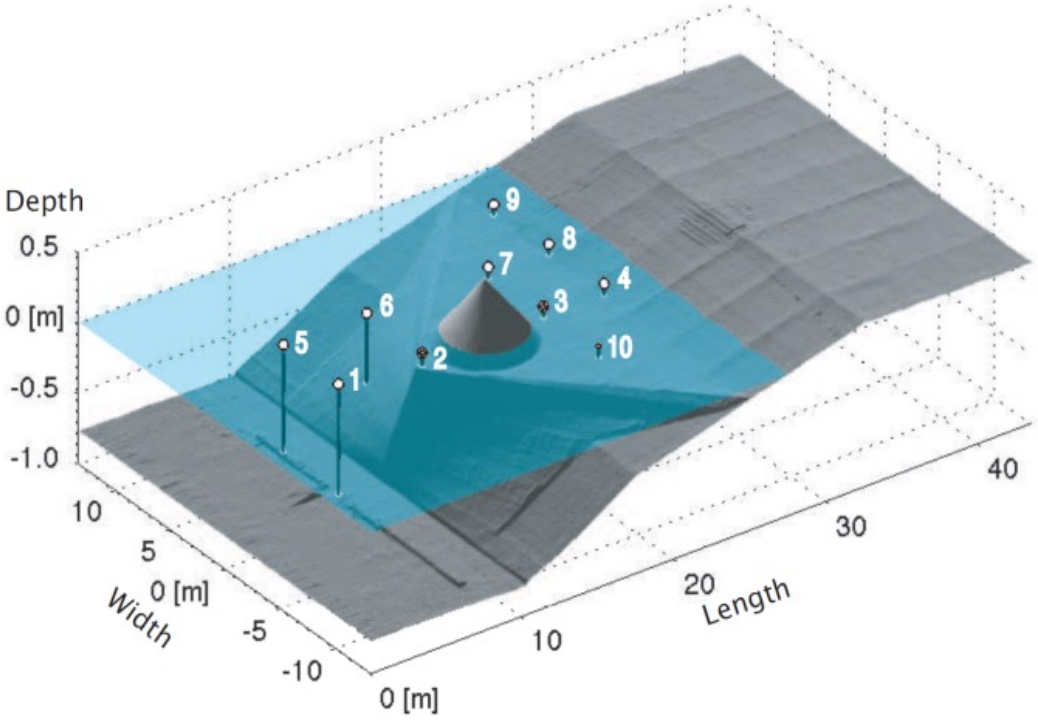
*Shock-capturing scheme for bore formation

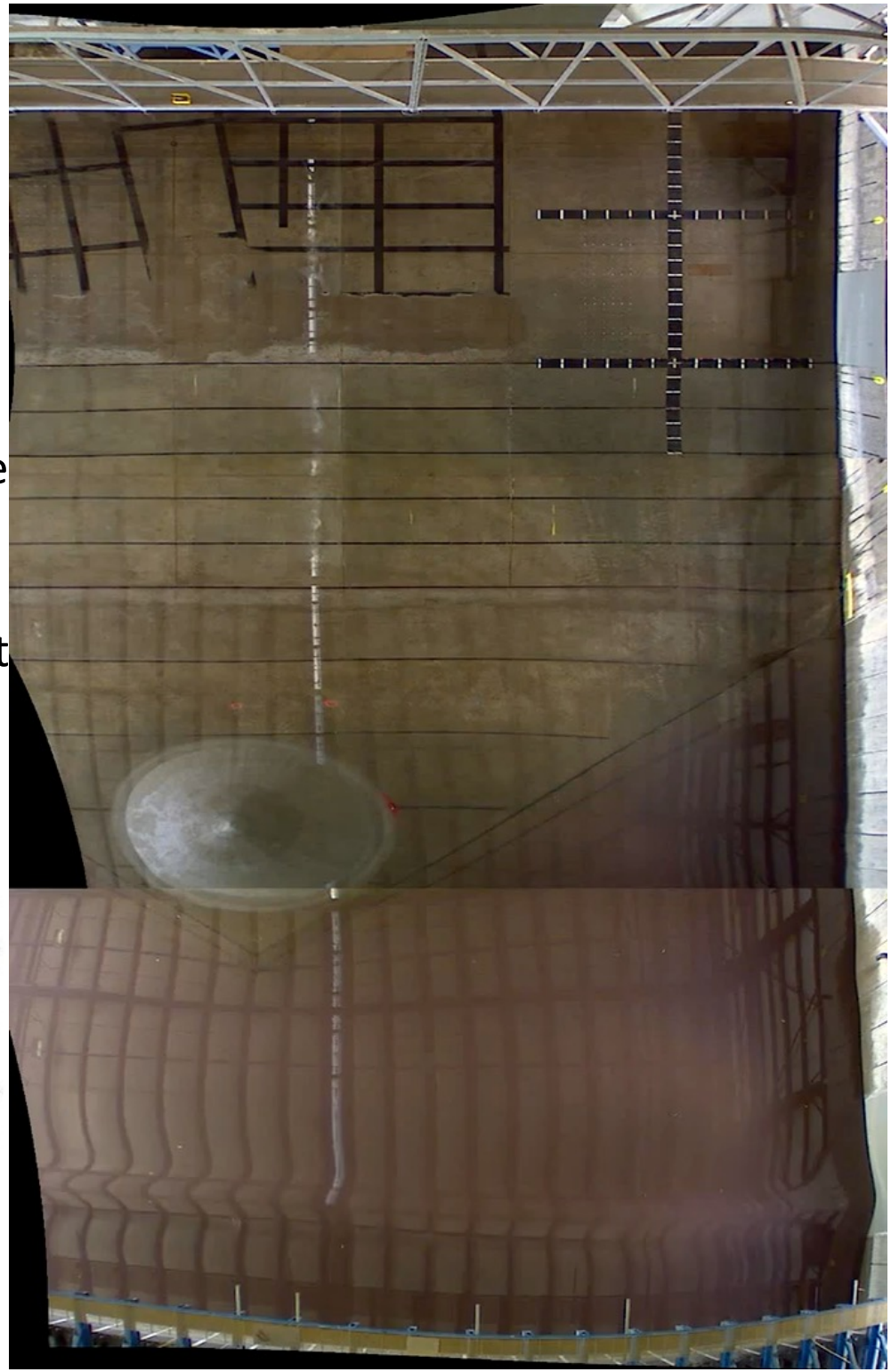


2009 Benchmark Challenge Sponsored by National Science Foundation

Basin tests at Oregon State University to evaluate validity of tsunami models

- Test configuration involving an island on a steep triangular shelf over gentle slopes
- Measurements of water surface at multiple locations
- Blinded tests for computer models with participants not knowing the measurement





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NEOWAVE2D

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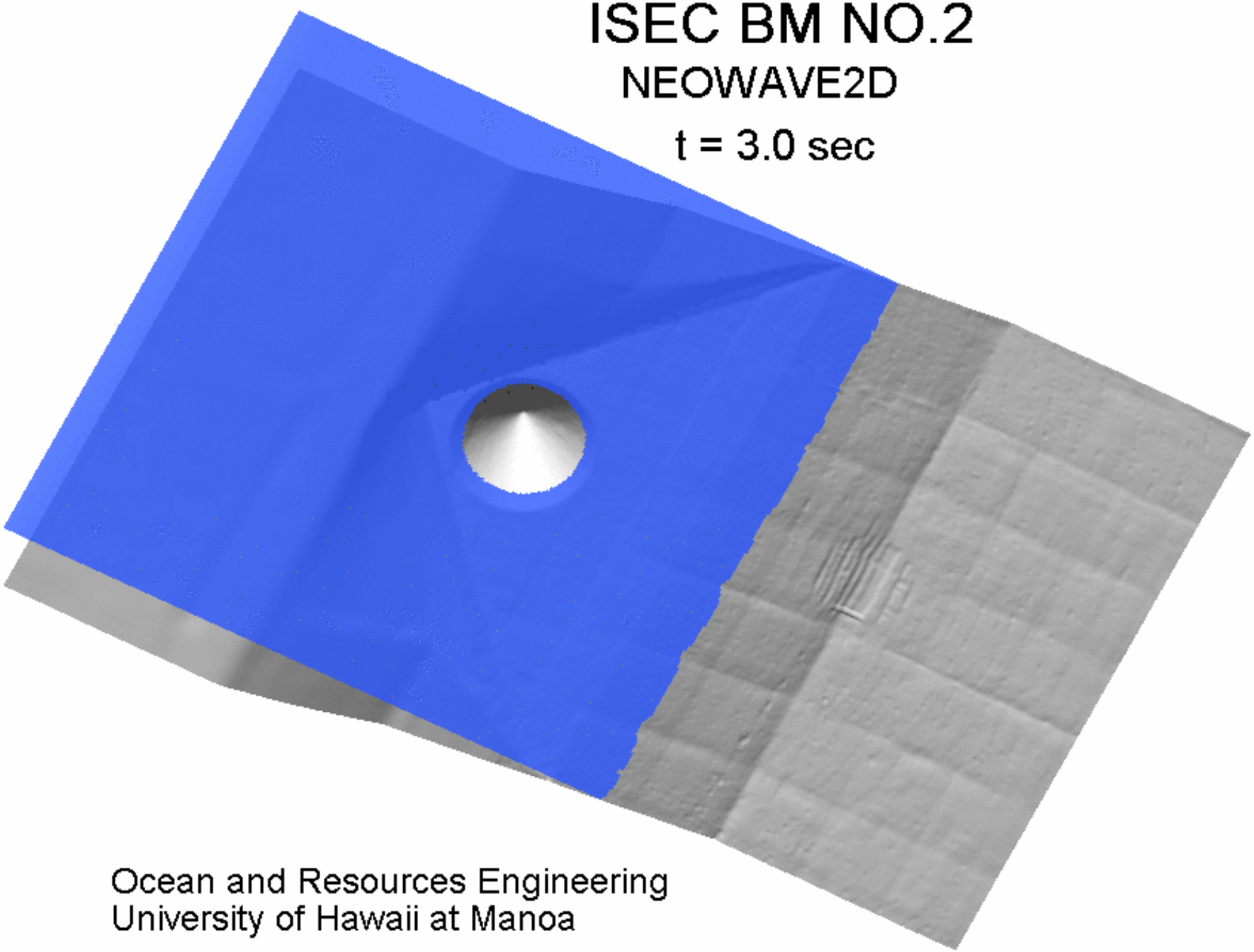

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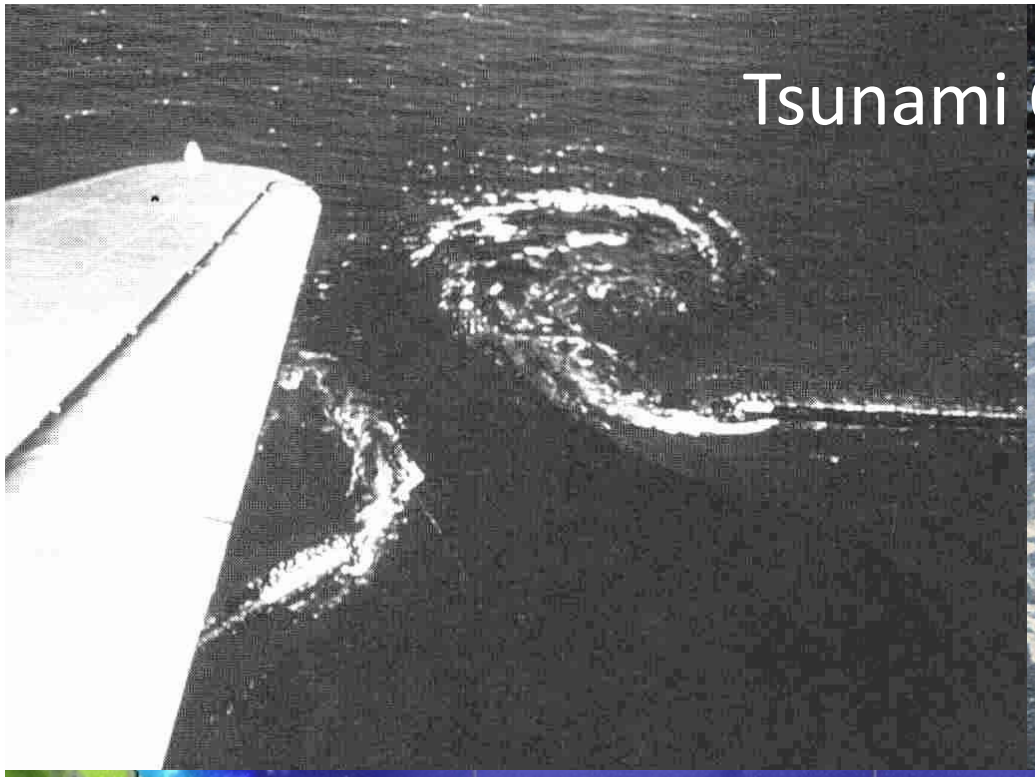
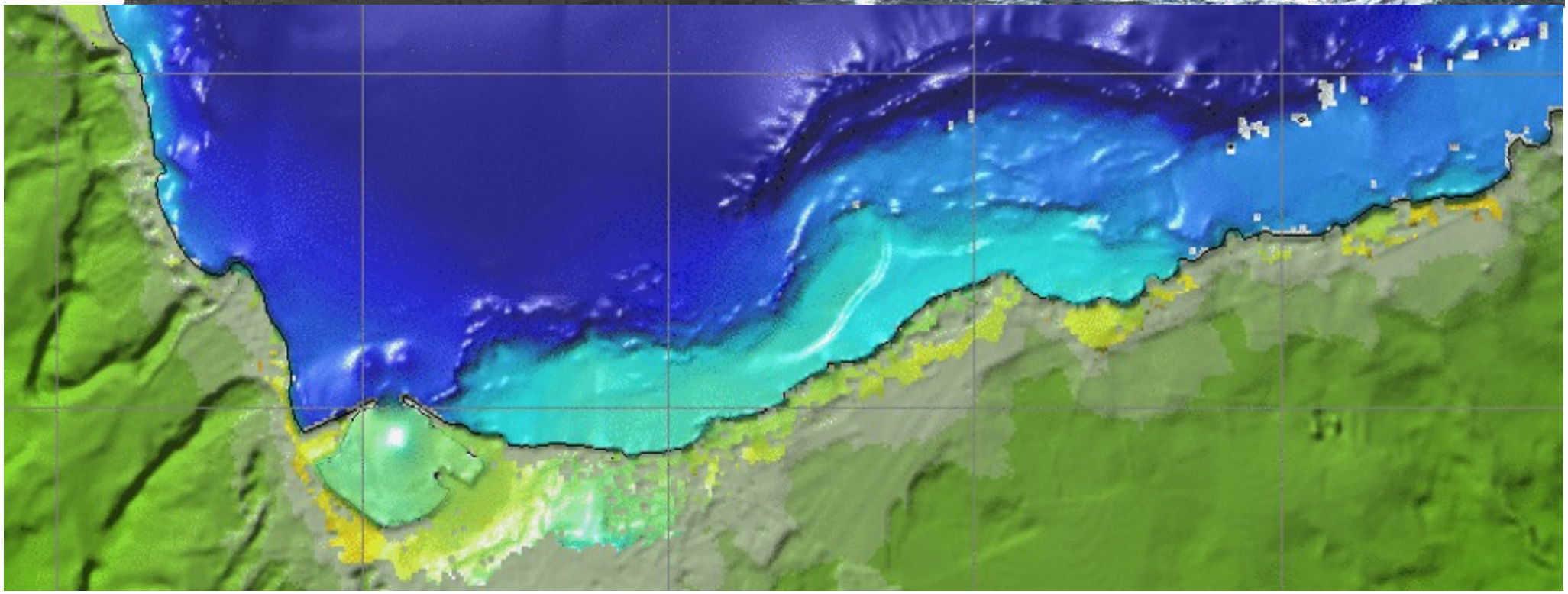
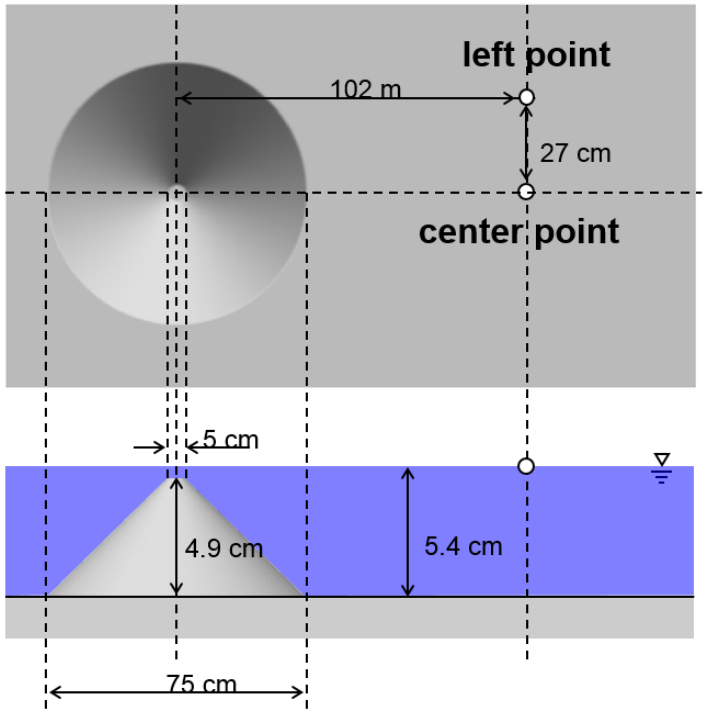
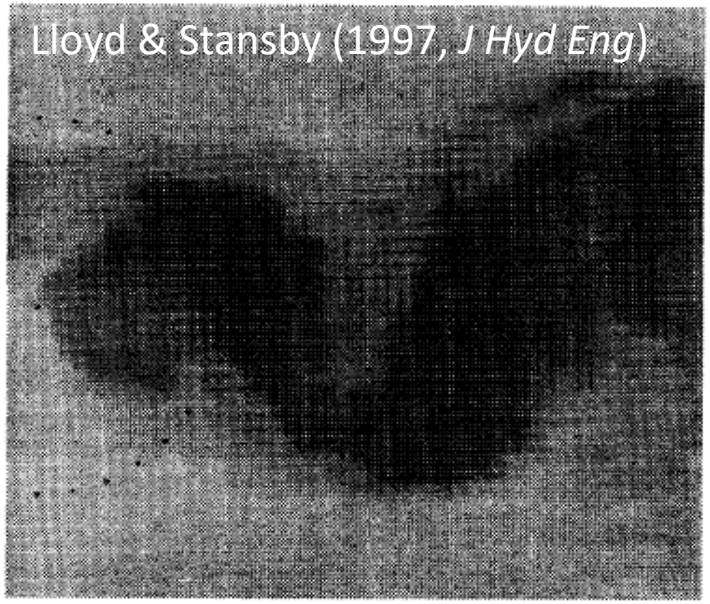
Tsunami Currents

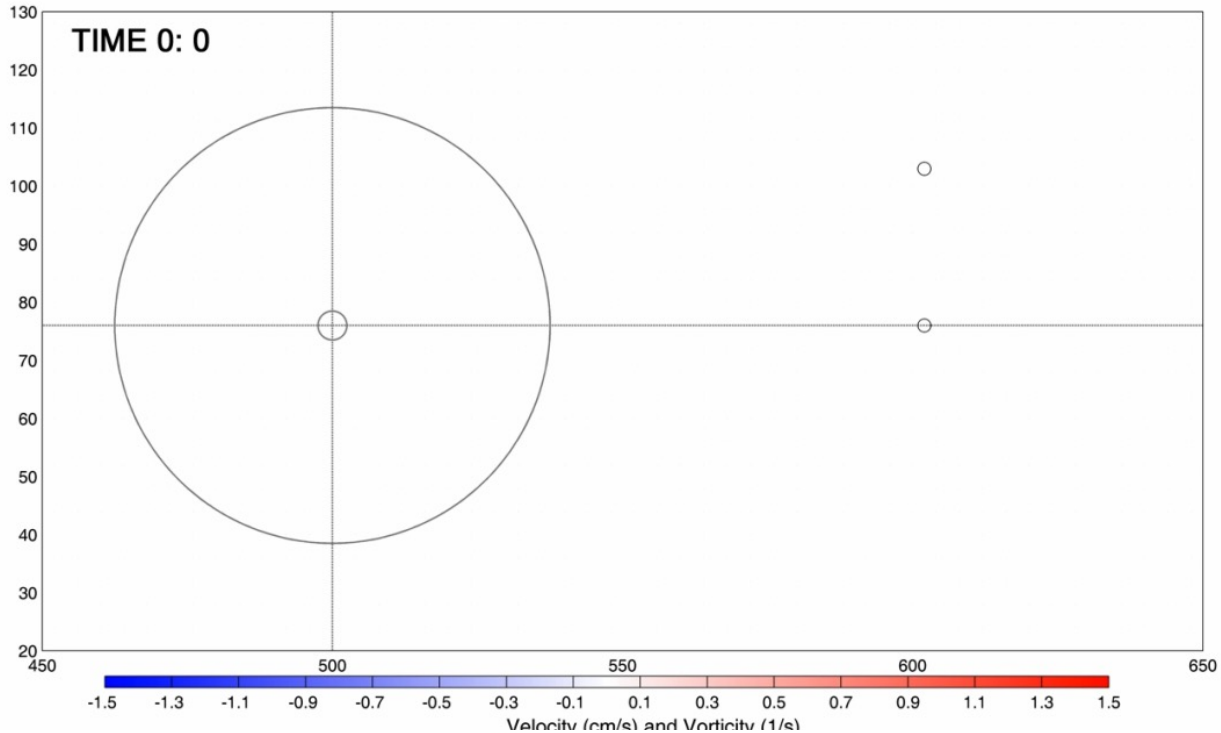


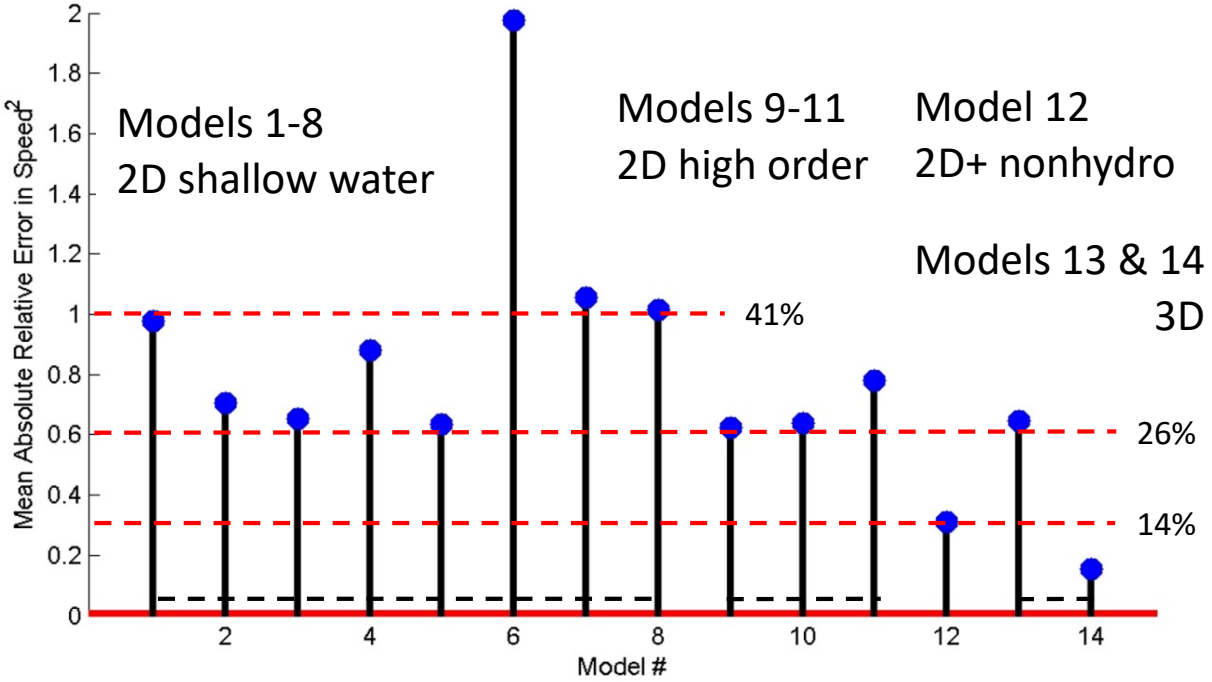


2015 NTHMP Benchmark Results





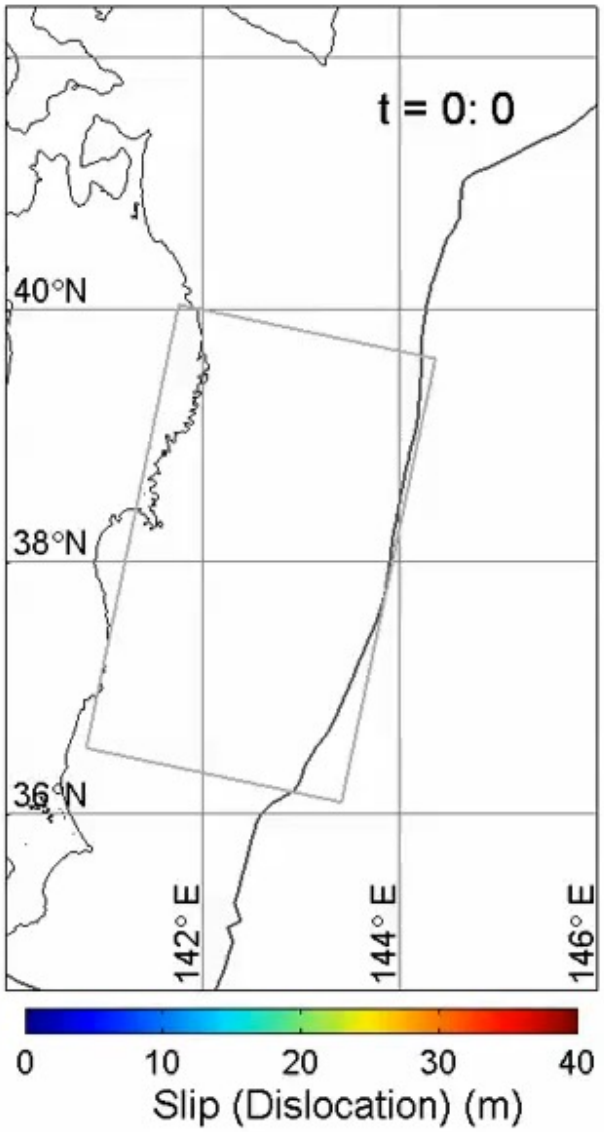


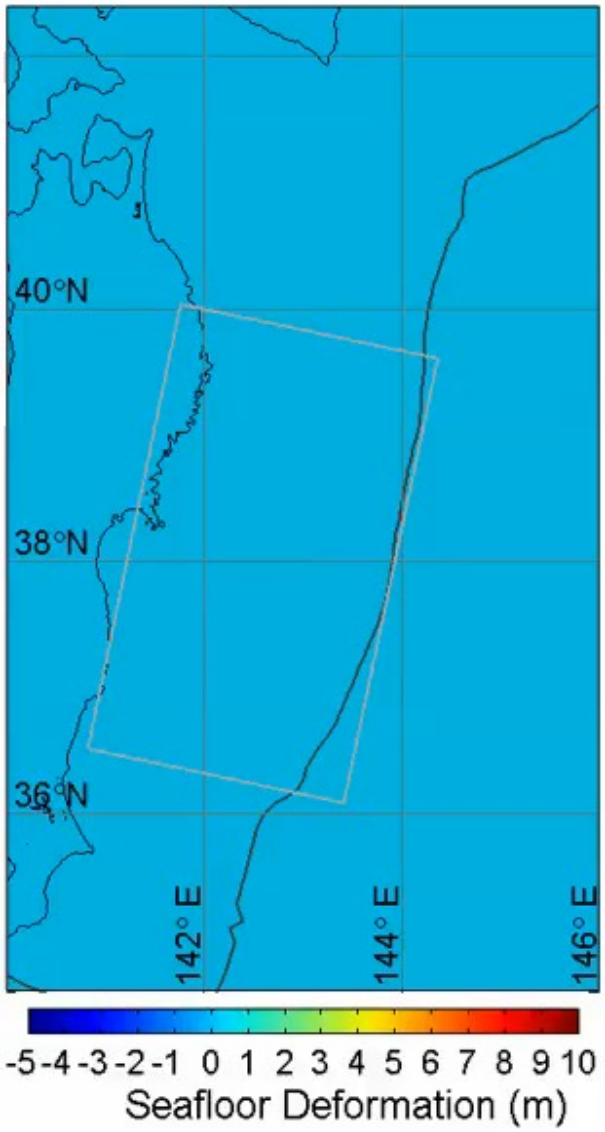


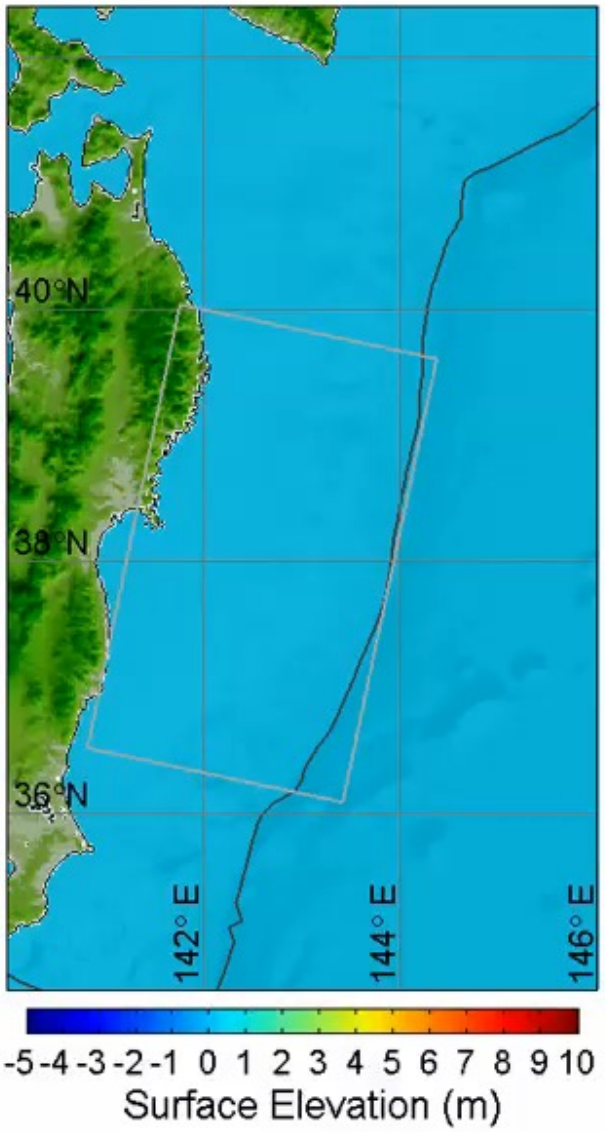
The 2011 Tohoku Earthquake and Tsunami

The 2011 Tohoku Earthquake and Tsunami Generation

Non-hydrostatic Modeling with Boundary Conditions from Kinematic Seafloor Deformation

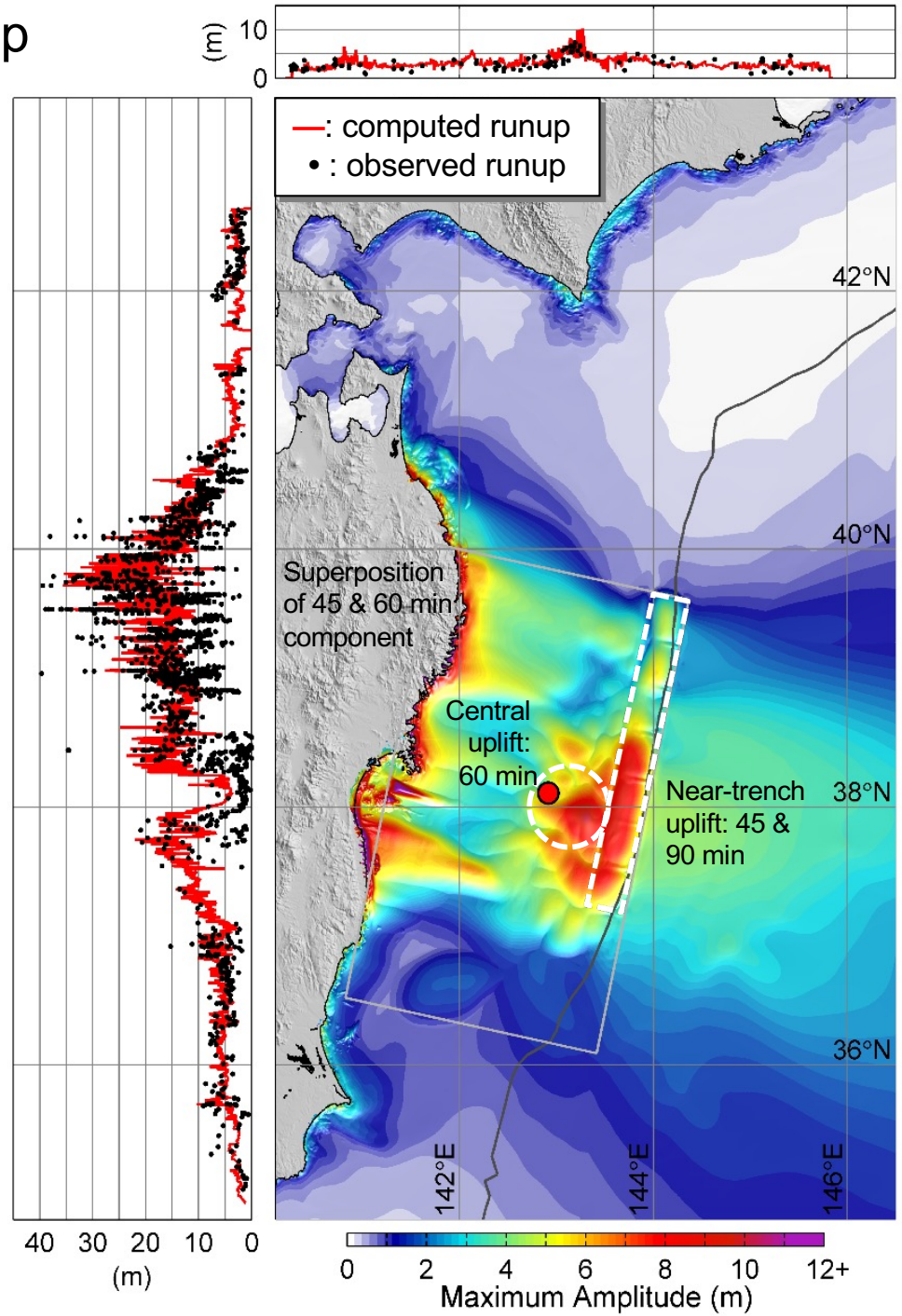




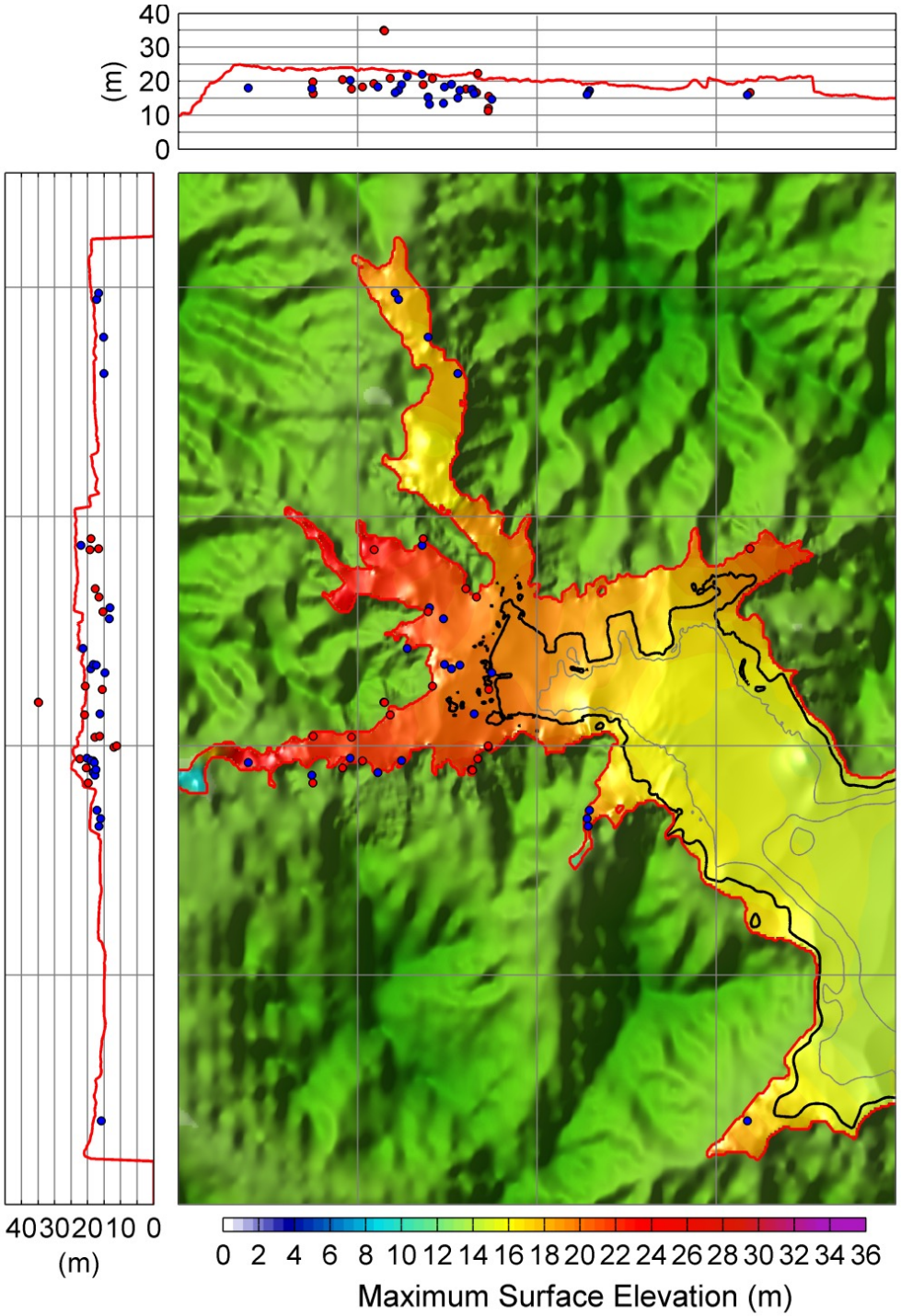


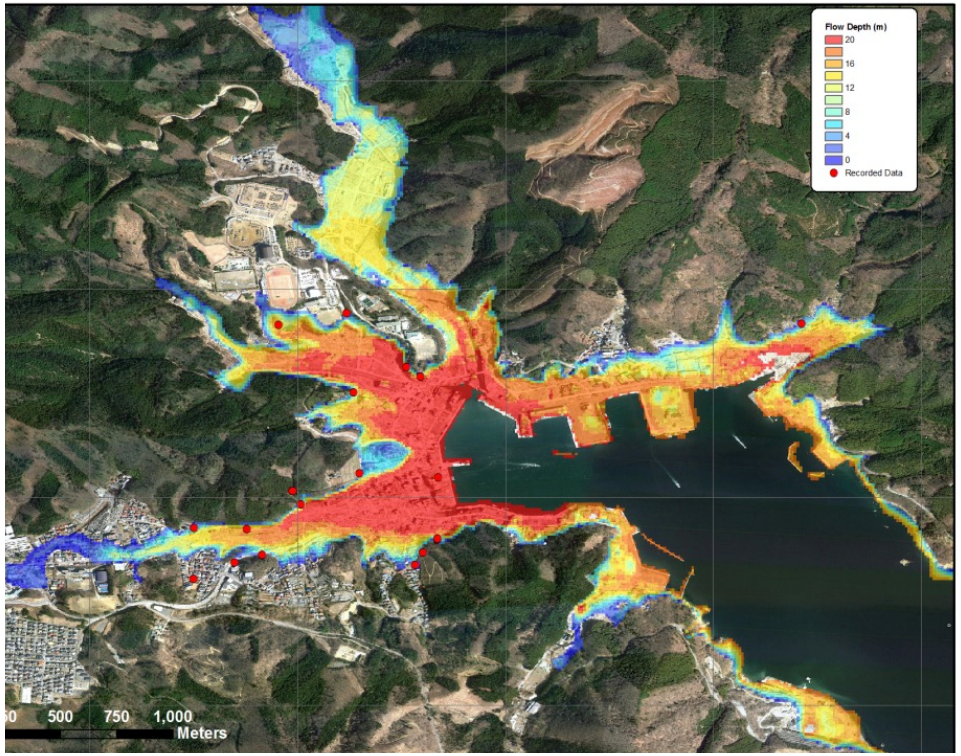
The 2011 Tohoku Tsunami

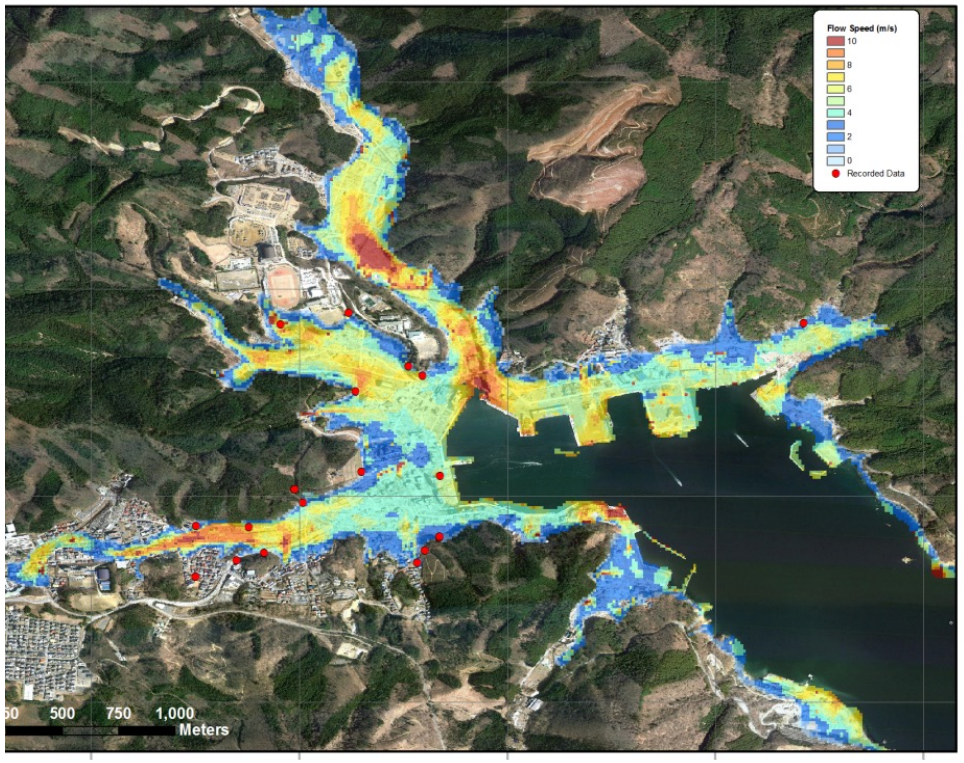
Near-field Waves and Coastal Runup



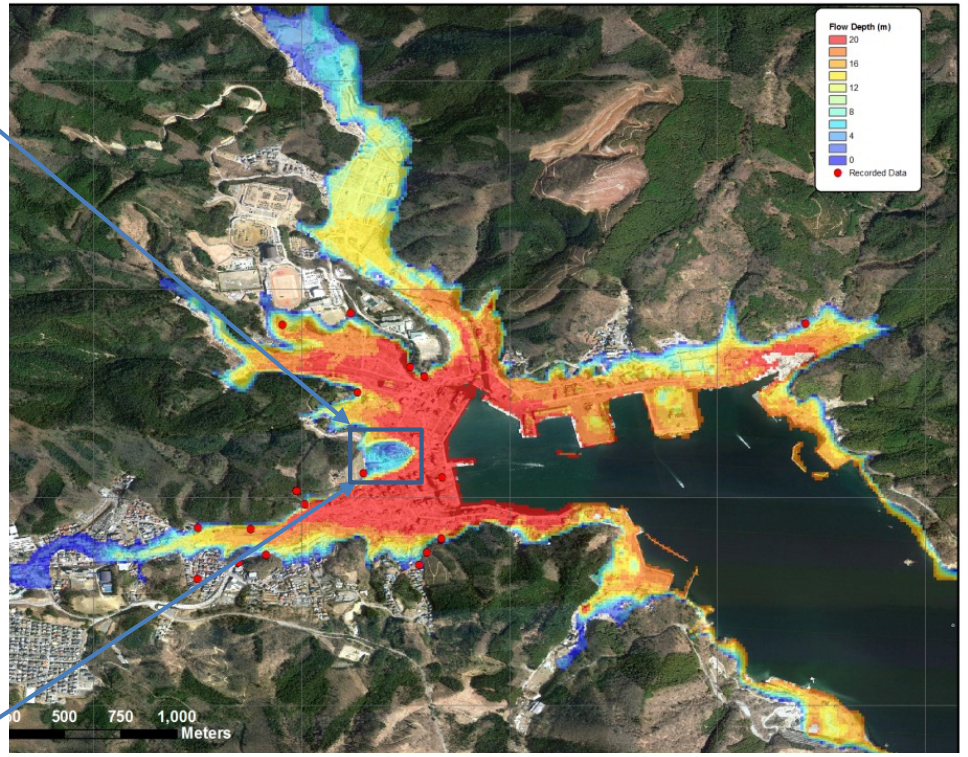
Inundation at Onagawa, Miyagi

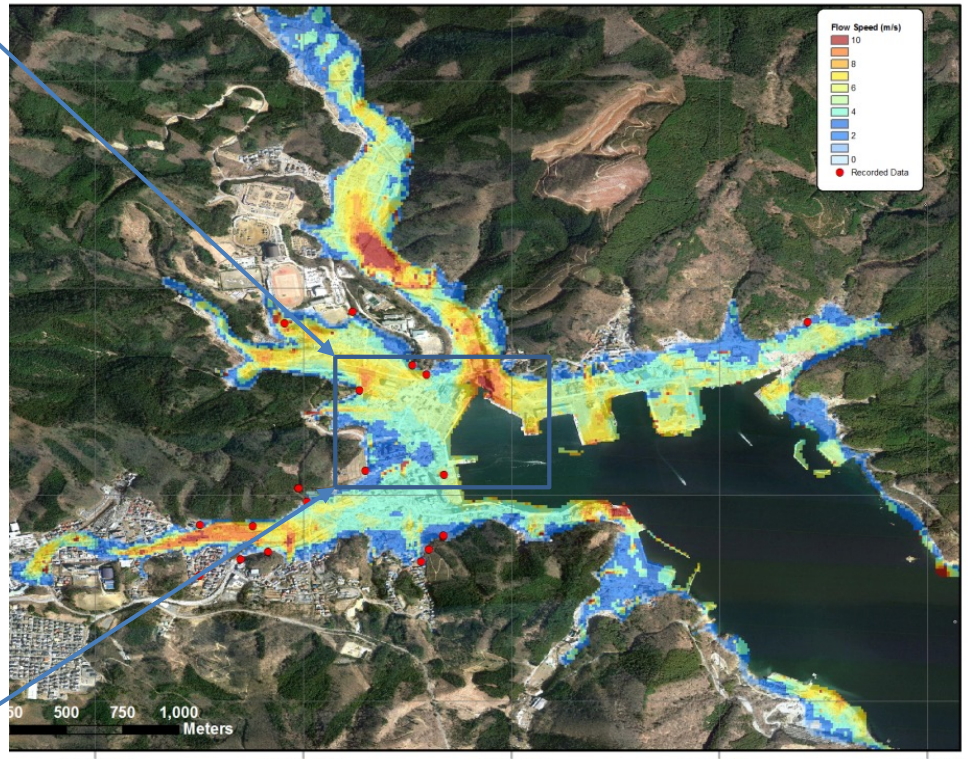






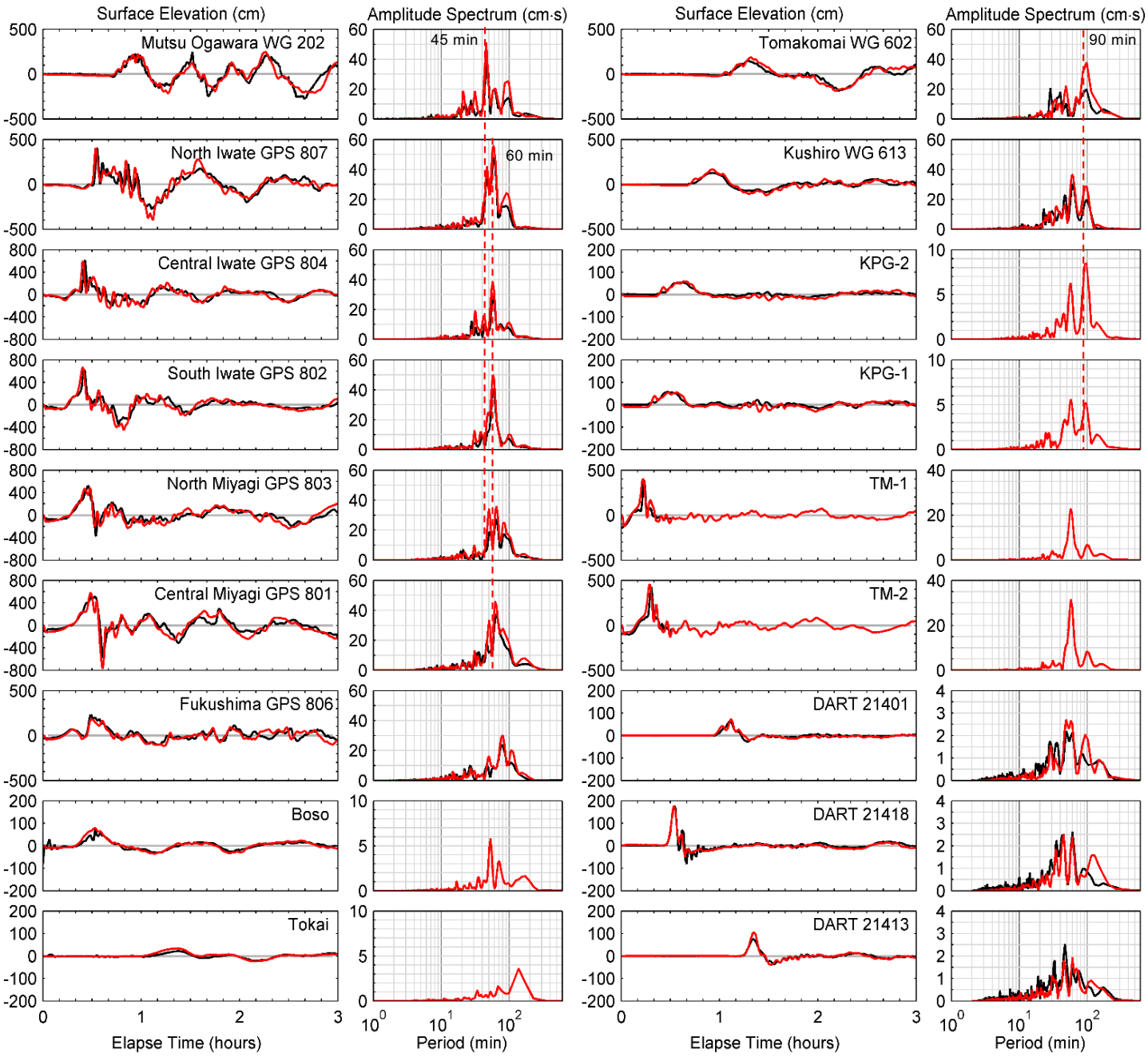
Inundation at Onagawa, Miyagi

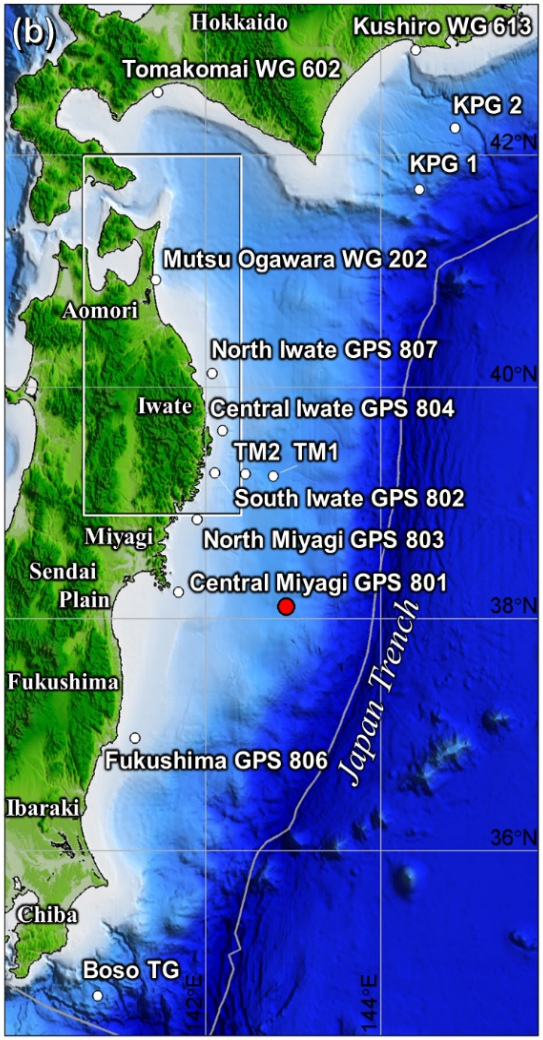




The 2011 Tohoku Tsunami

Near-field Waveforms and Spectra

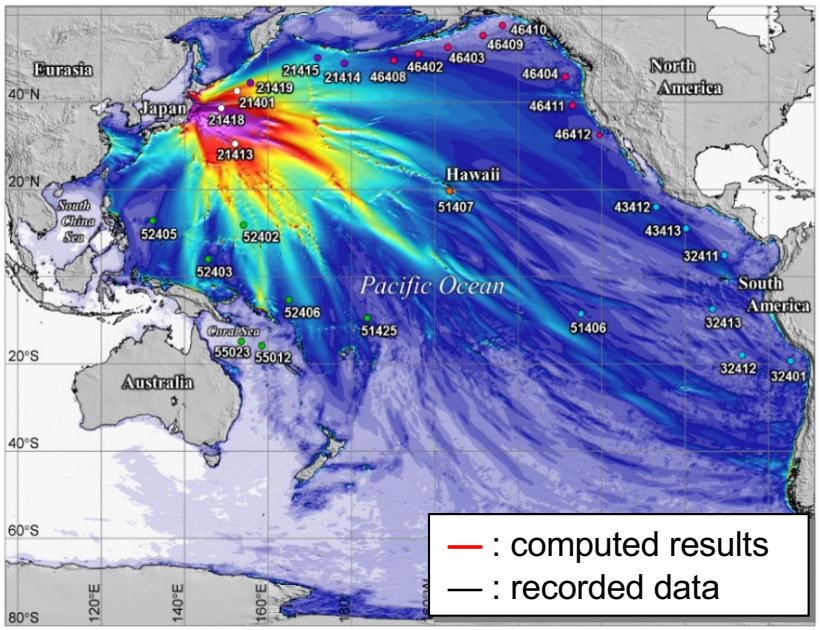


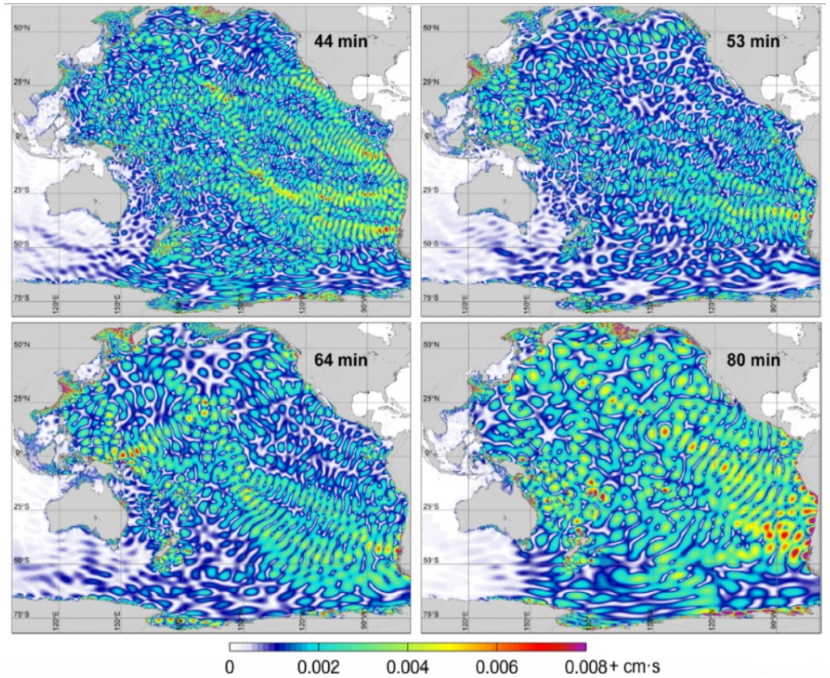


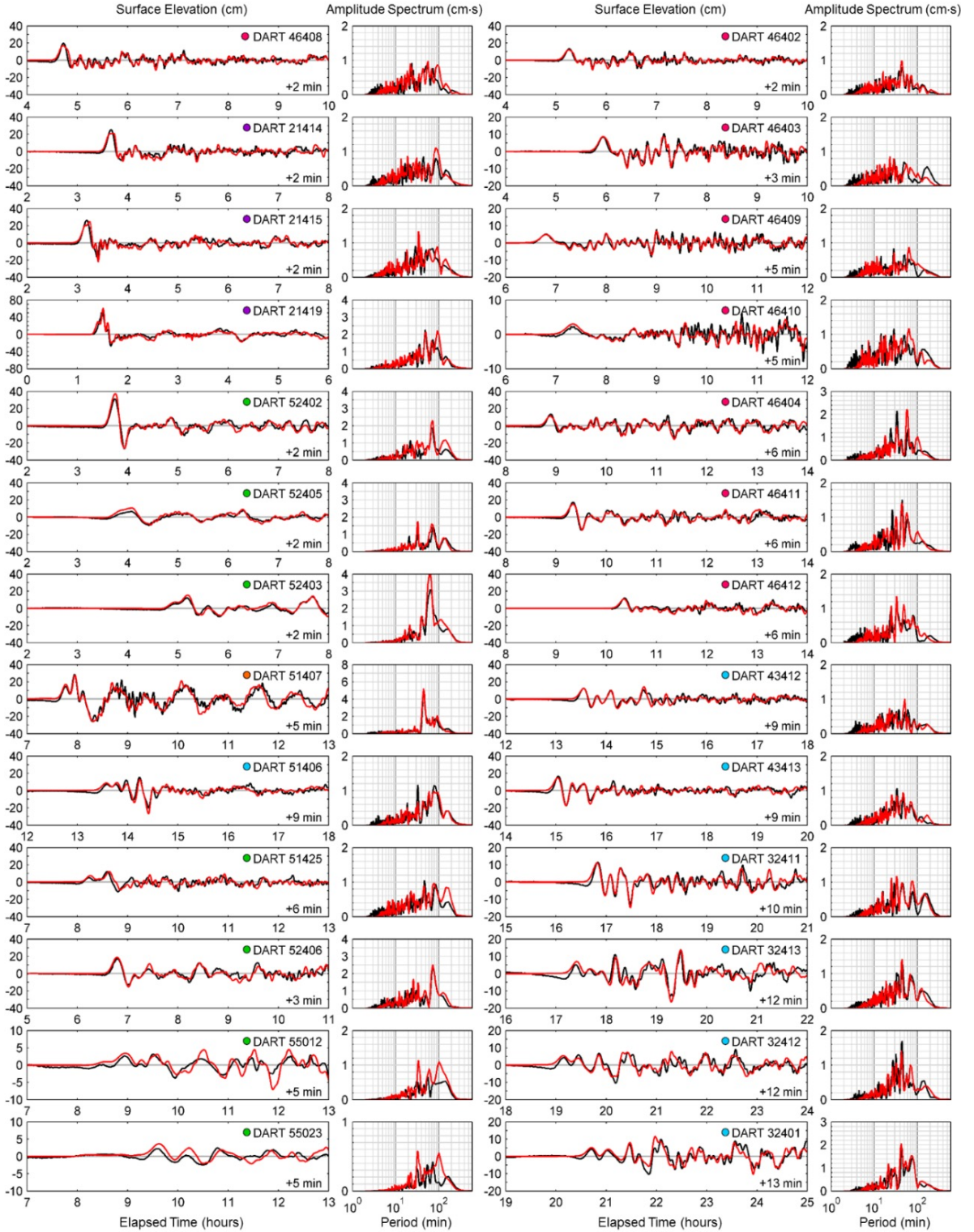
— : computed results
— : recorded data

Model Validation

Far-field Waveforms & Spectra

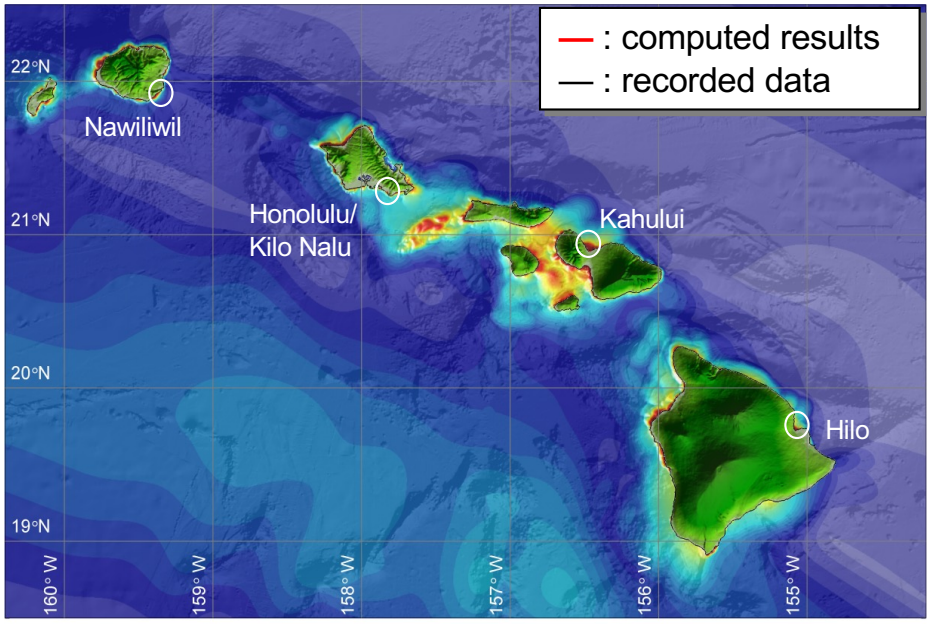


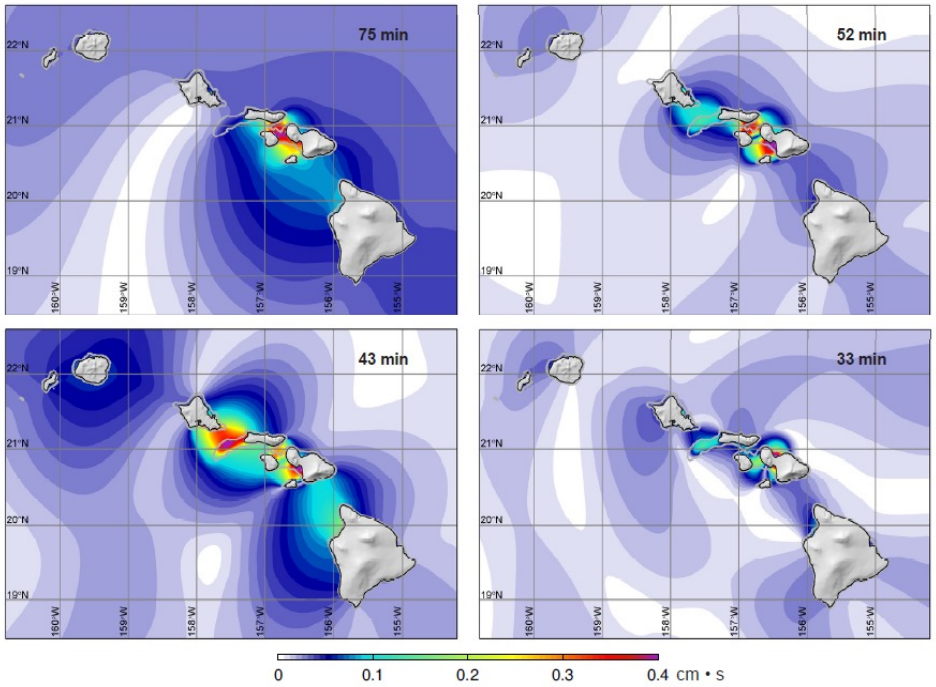


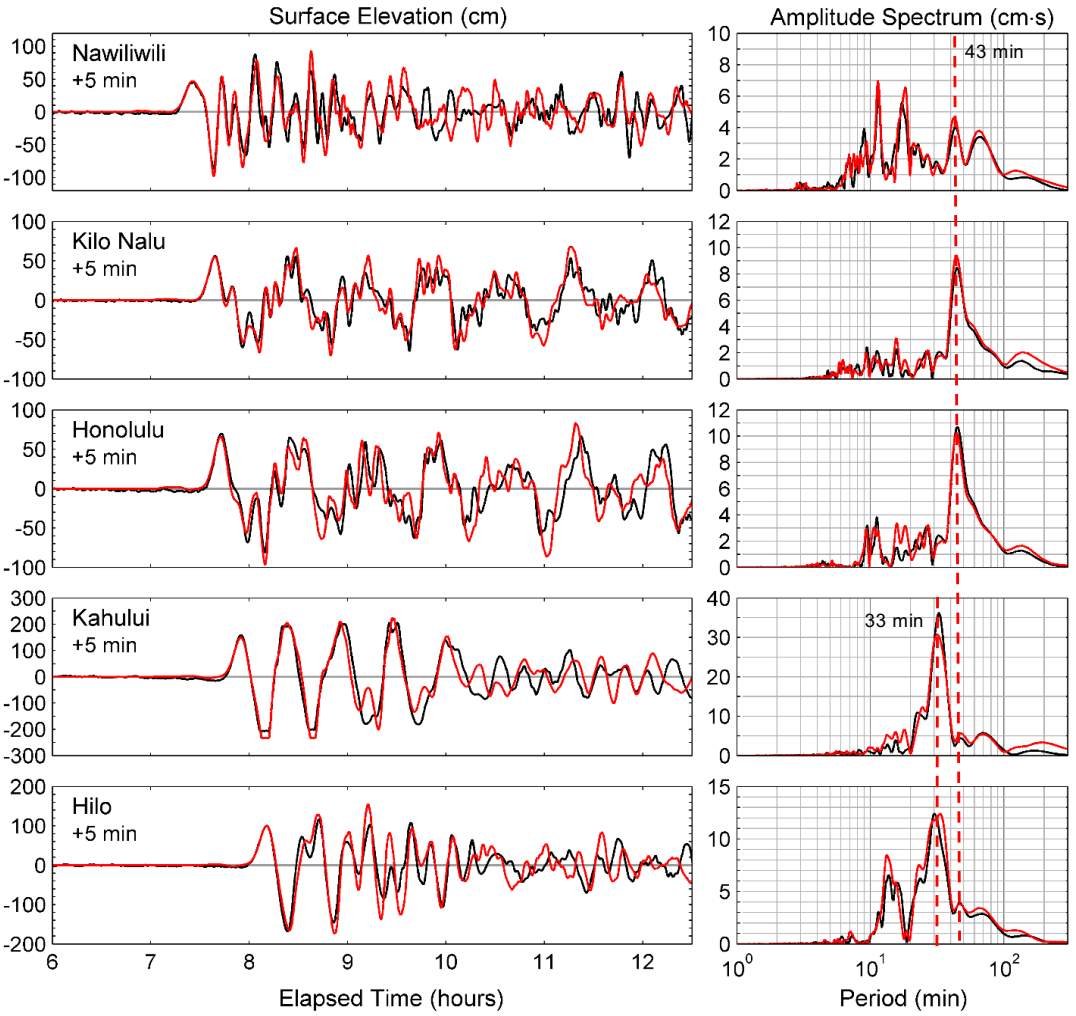


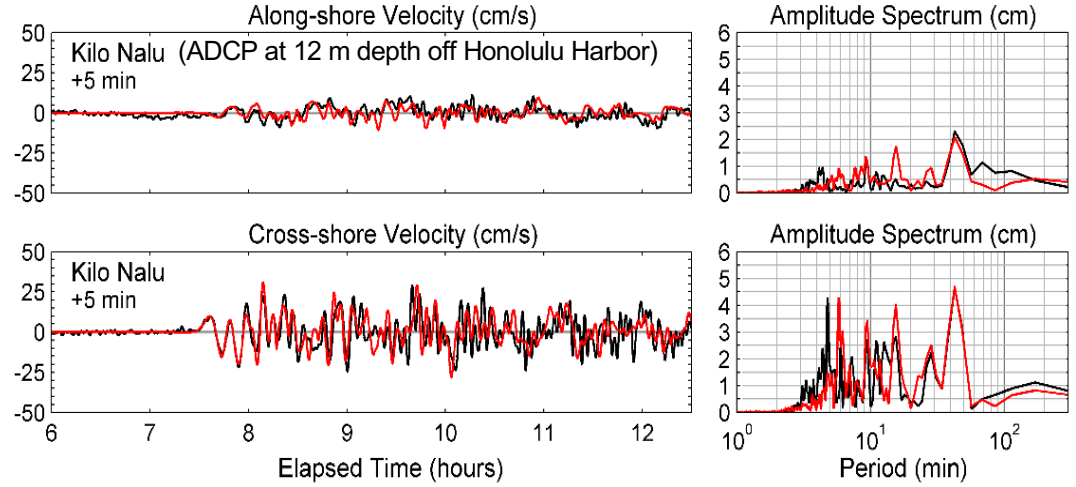
Model Validation

Hawaii Tide Gauges & ADCPs



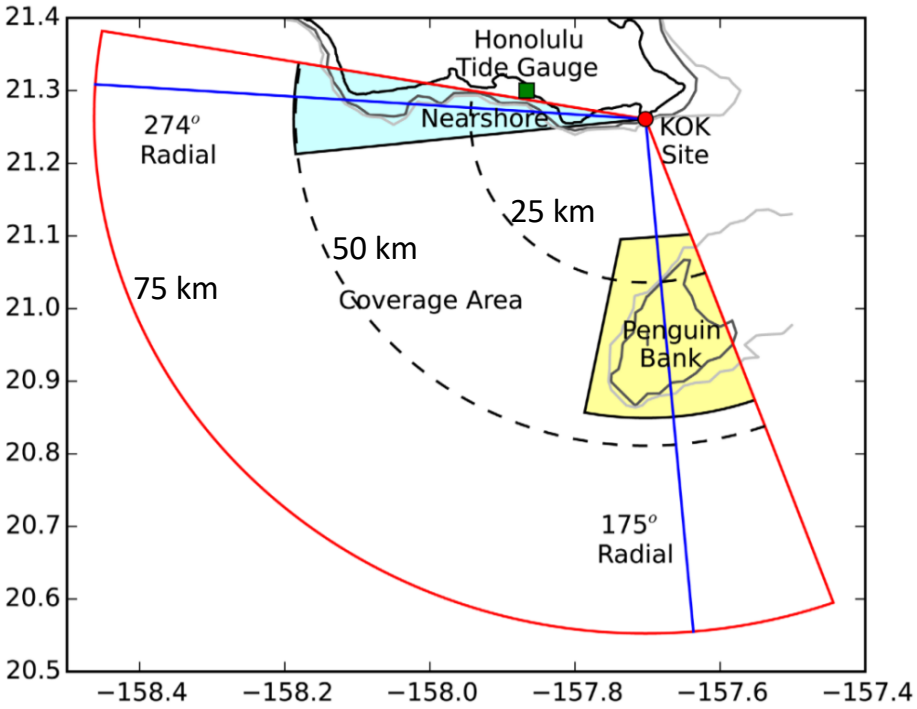




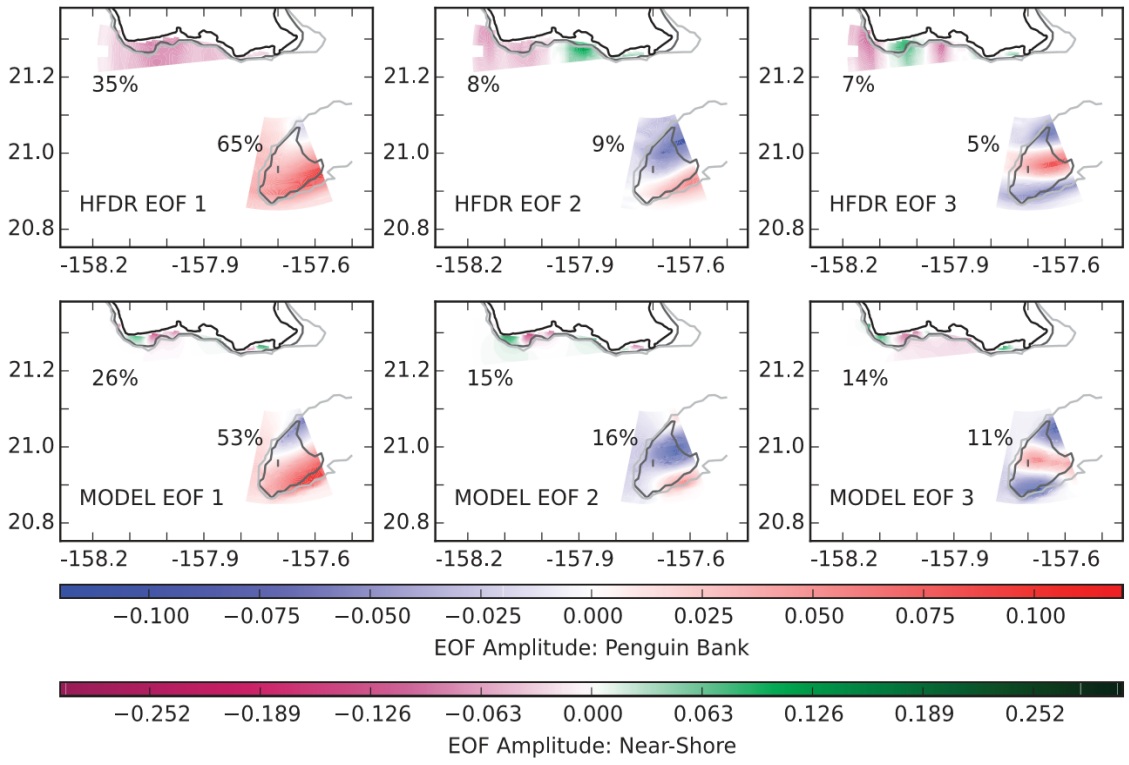


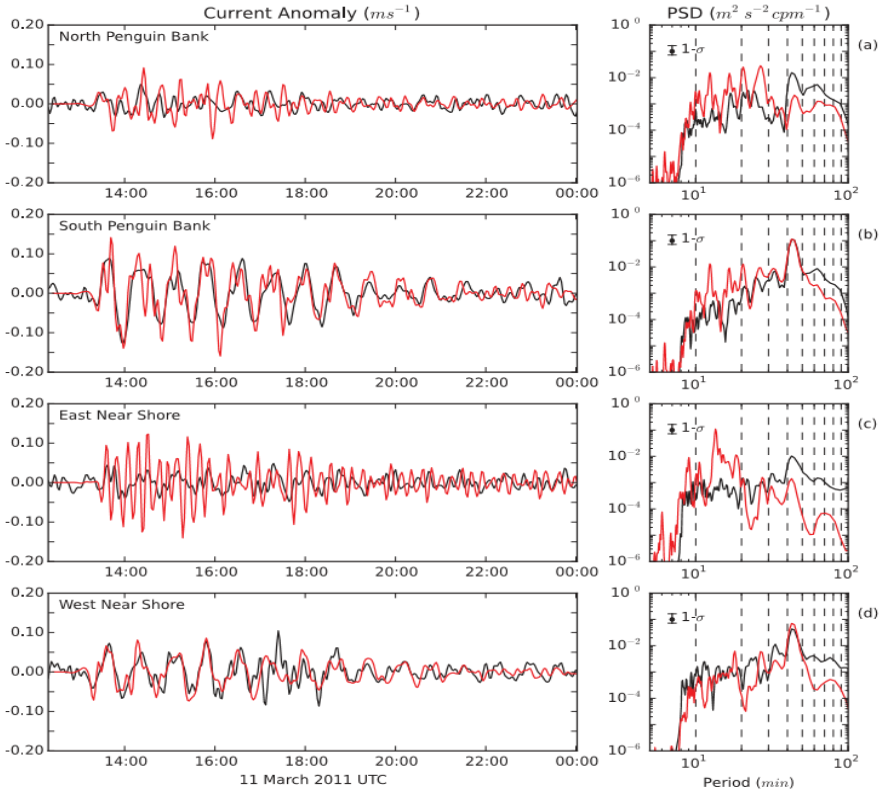
Validation with 2011 Tohoku Tsunami

- High Frequency Doppler Radar (HFDR) detection of currents south of Oahu
- Confirmation of resonance oscillations over Penguin Bank
- Discrepancies between model and recorded data due to side-lobe contamination of HFDR
- Benjamin, Flament, Cheung & Luther (2016, *Journal of Geophysical Research*)



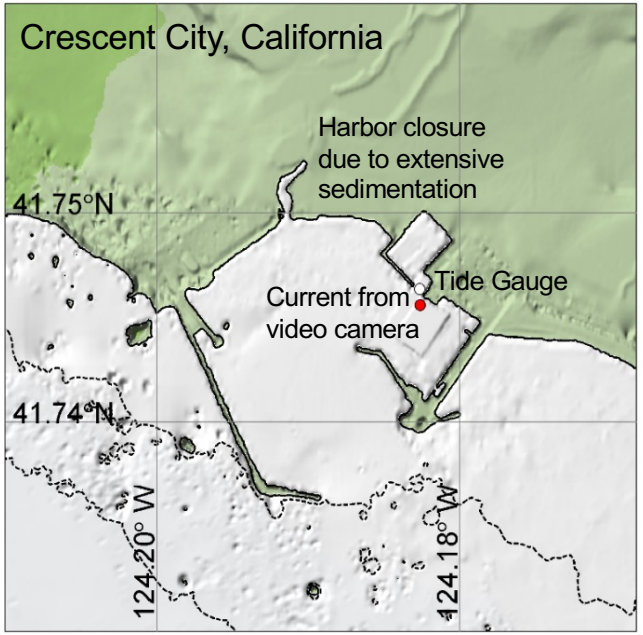
Processed Oscillation Models from HFDR and Model Data

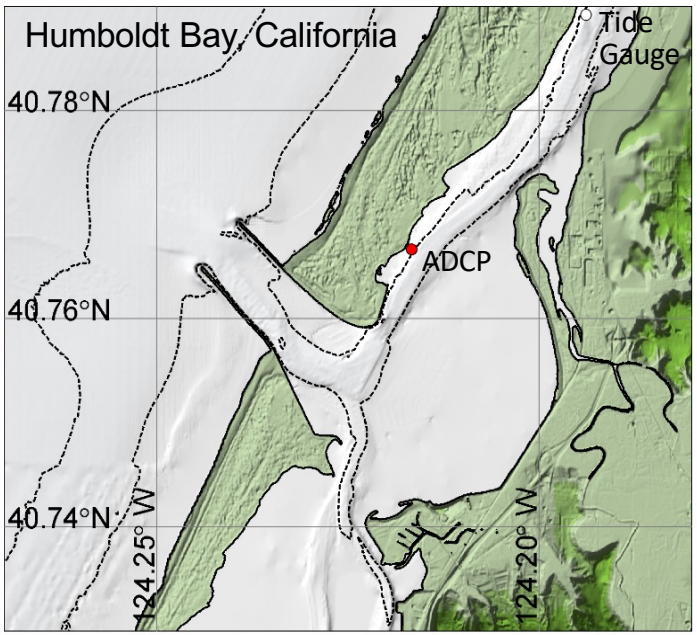


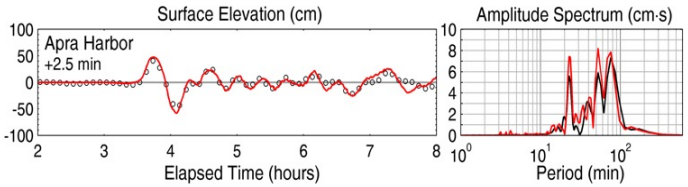


Model Validation

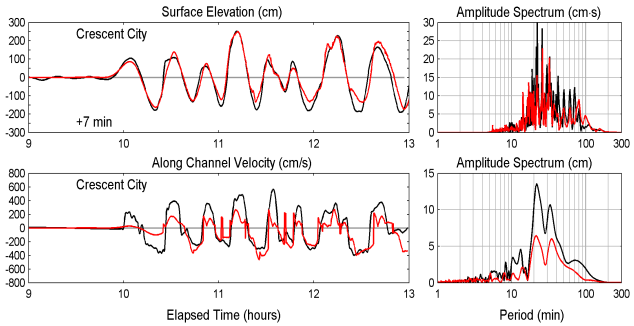
Mariana Islands and US West Coast

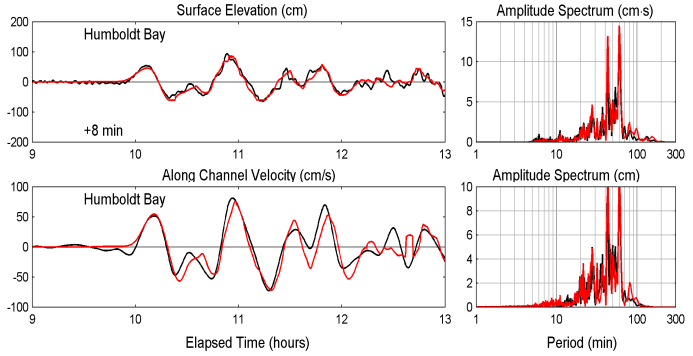






Records at 6 min intervals





Concluding Remarks and Continuing Work

NEOWAVE is a proven tool for tsunami modeling and inundation mapping as evident in the validation with laboratory experiments and the 2011 Tohoku earthquake and tsunami.

Modeling of over 20 earthquake and tsunami events in collaboration with Prof. Thorne Lay (seismologist) UCSC.

Implementation of NEOWAVE for mapping of tsunami inundation and maritime hazards in support of emergency management agencies in Hawaii, American Samoa, Guam, and CNMI.

Implementation of NEOWAVE for design and assessment of infrastructure, harbors, and land reclamations.