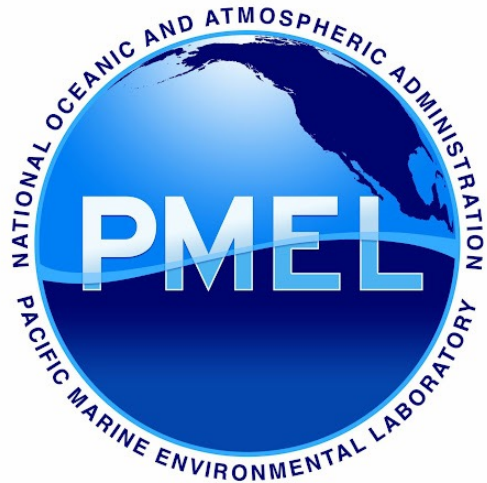


Tsunami Hazard Assessment Process

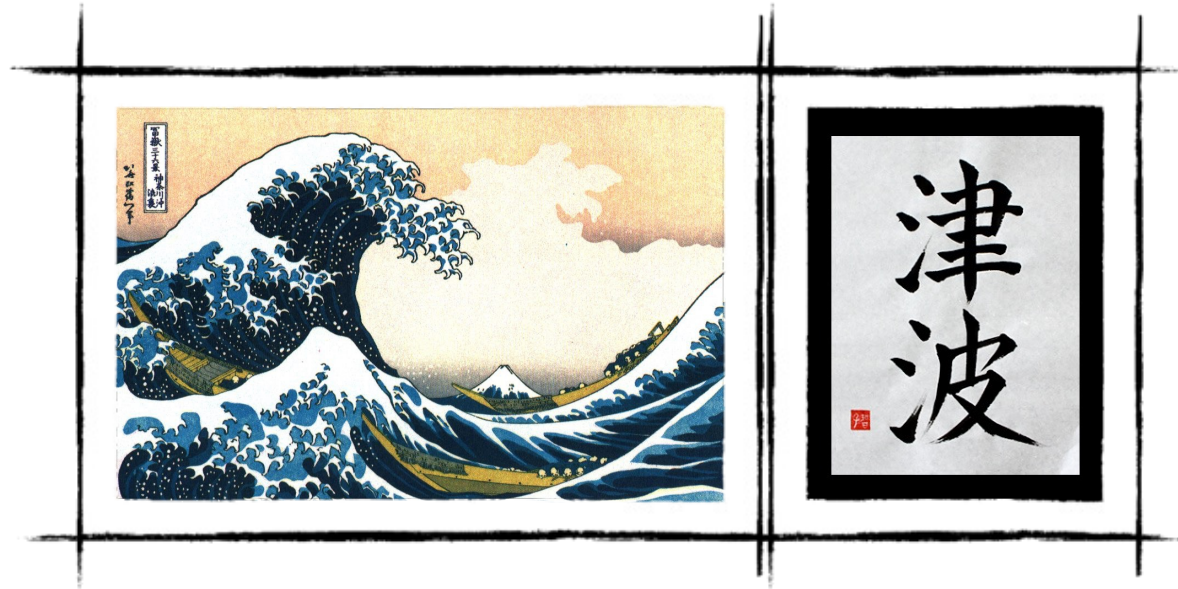
Natalia Sannikova^{1,2}

¹Pacific Marine Environmental Laboratory, NOAA, Seattle, WA,
<https://nctr.pmel.noaa.gov>

²Cooperative Institute for Marine and Atmospheric Research (CIMAR), Honolulu, HI



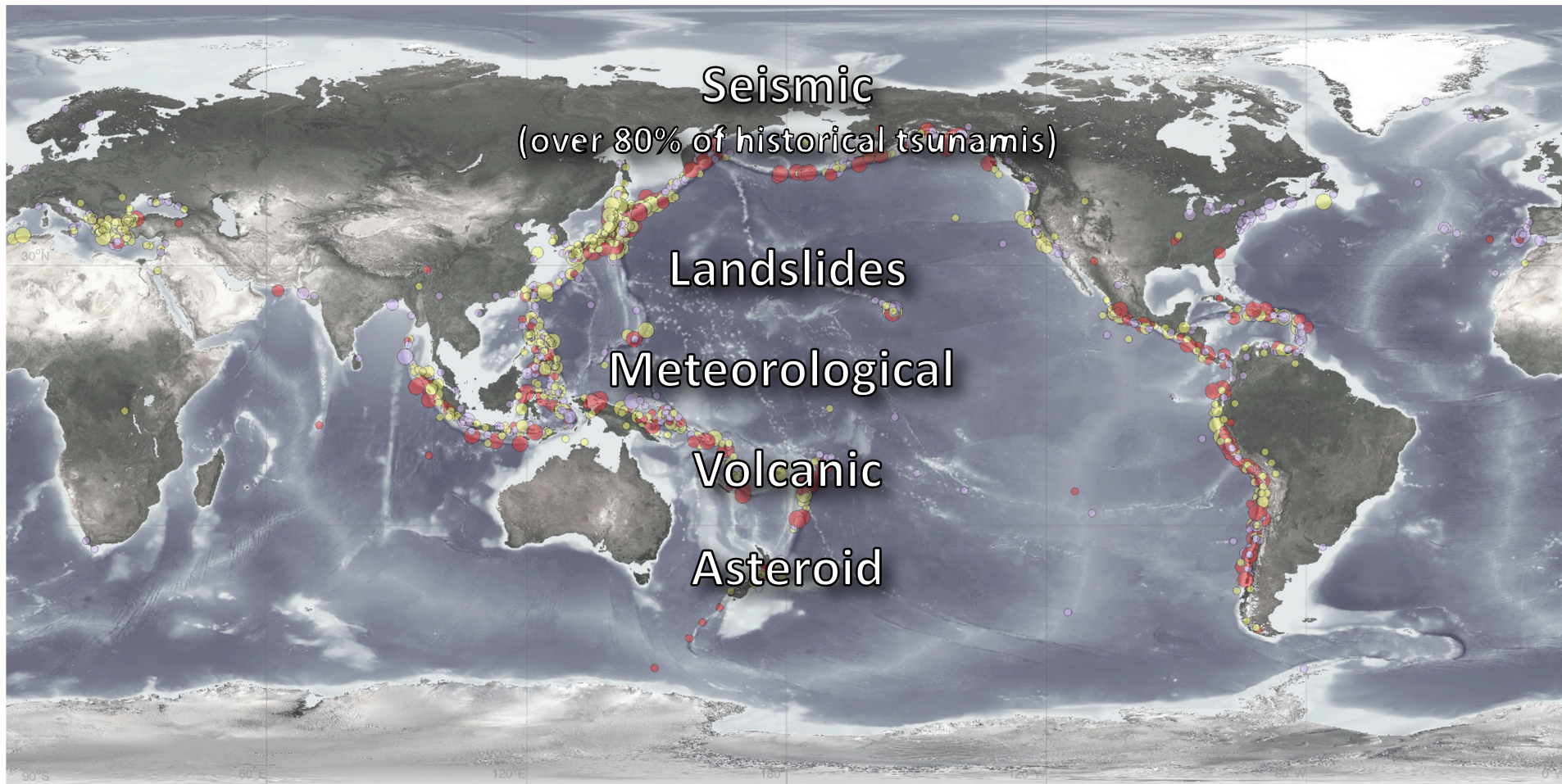
What is tsunami?



Japanese word: harbor wave

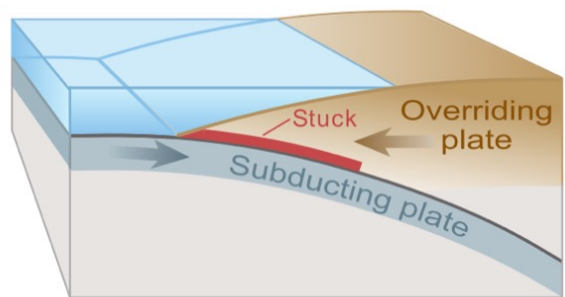
Tsunami is a series of waves in a water body caused by the displacement of a large volume of water.

Tsunami sources

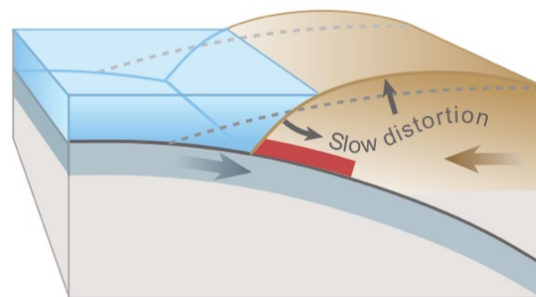




<https://www.youtube.com/watch?v=KB-TO5kq5Aw>



Drawing of **tectonic plate boundary** before **earthquake**



Over-riding plate bulges under strain, causing **tectonic uplift**.

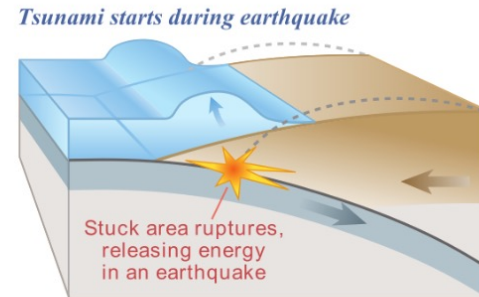
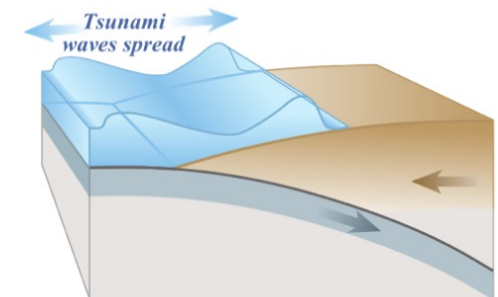


Plate slips, causing **subsidence** and releasing energy into water.



The energy released produces tsunami waves.



<https://www.youtube.com/watch?v=06huCv3cCaM>



Deep Ocean Speed 310 to 620 miles per hour
In Shallow Coastal Areas 19 to 31 miles per hour

Differences between tsunamis and wind-driven waves

Key differences between tsunamis and wind-driven waves.

	TSUNAMI	WIND WAVE
Source	Earthquakes, landslides, volcanic activity, meteorites, certain types of weather	Winds that blow across the near-surface layer of the ocean
Location of Energy	Entire water column, from the ocean surface to the ocean floor	Ocean surface
Wave-length	300-600 miles (500-1,000 kilometers)	300-600 feet (90-180 meters)
Wave Period	5 minutes-2 hours	5-20 seconds
Wave Speed	Deep water: 500-600 mph (800-1,000 km/h) Near shore: 20-30 mph (30-50 km/h)	5-60 mph (8-100 km/h)

Wind Waves



Tsunami

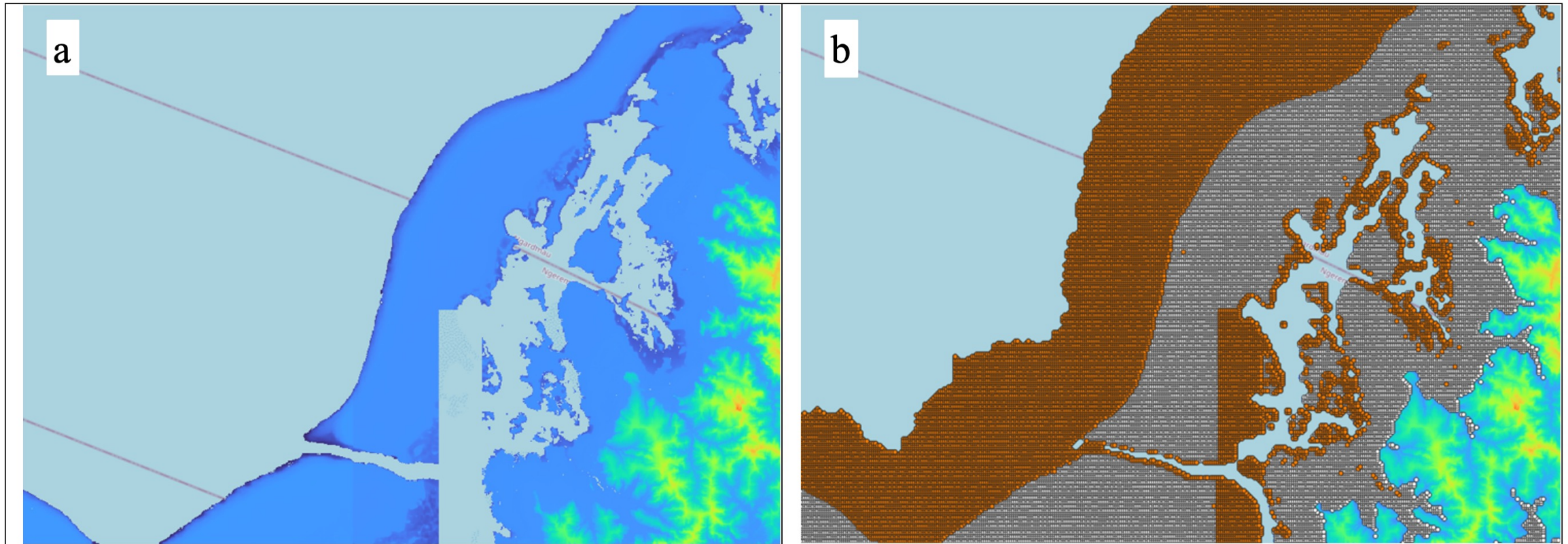


Modeling for Tsunami Hazard Assessment

Study Phases (Example: Palau)

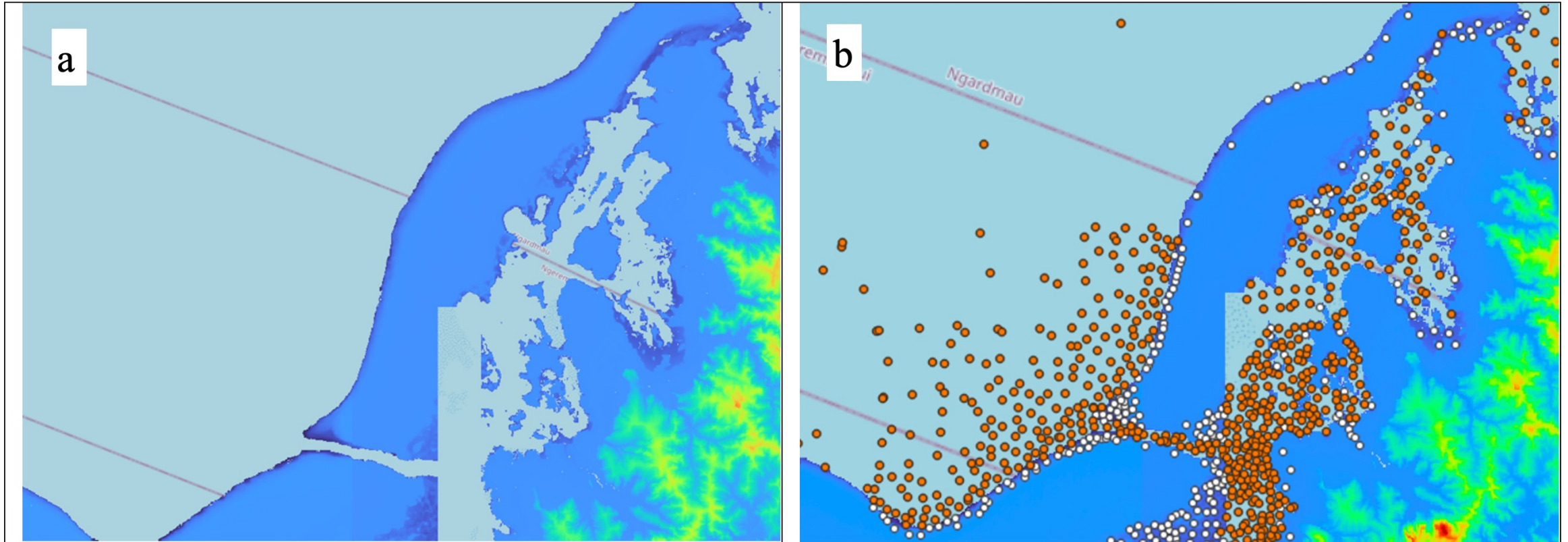
- 1. DEM Merging/Grid Generation**
- 2. Model Validation/Source Definition**
- 3. Modeling Results and Products**

Using CRRF data where there is no LiDAR data



The LiDAR (a) and the CRRF multi-beam data in Toachel Mlengui (West Passage) area (b). Orange points indicate the CRRF data that were used, white points – the CRRF data that were not used.

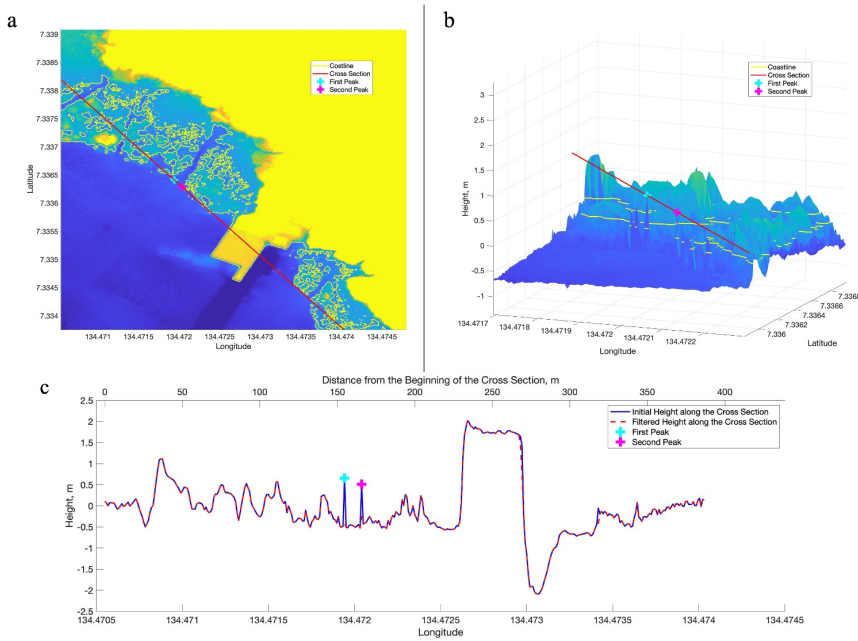
Using Nautical charts data where there is no LiDAR data



The LiDAR (a) and the nautical charts data in Toachel Mlengui (West Passage) area (b). Orange points indicate the nautical charts data that were used, white points – the nautical charts data that were not used.

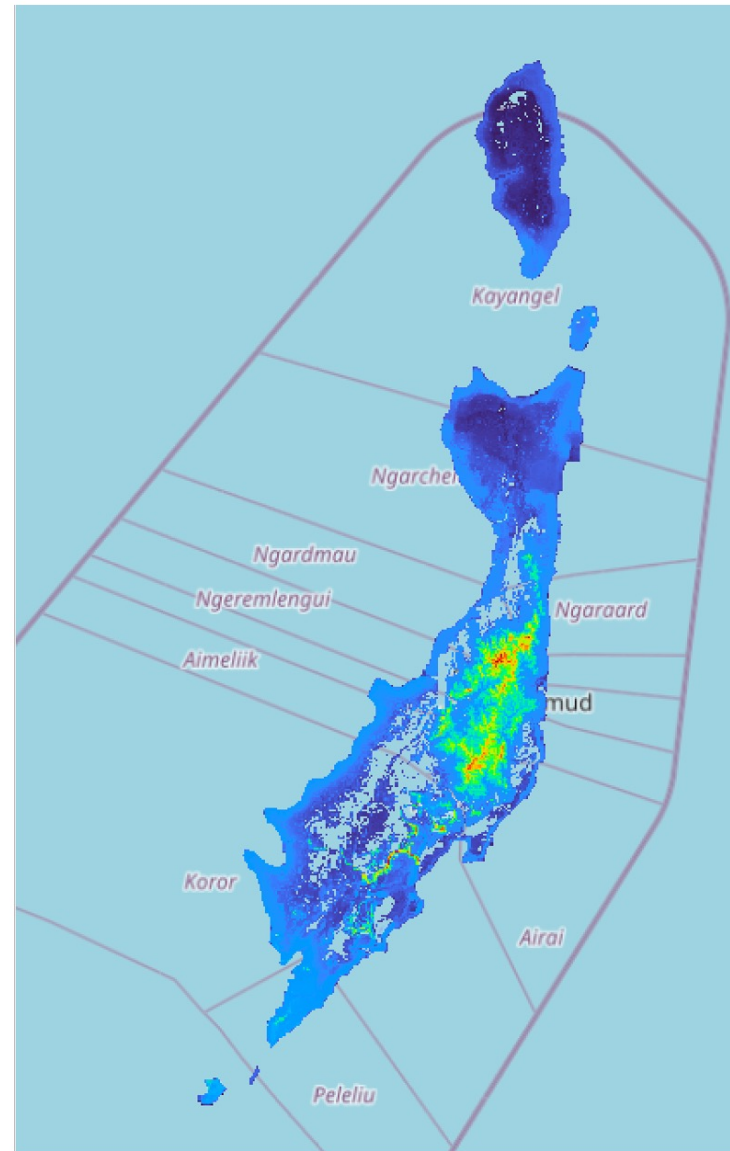
PALARIS LiDAR DEM (a) and final DEM (b)

Dataset Preprocessing & Filtering

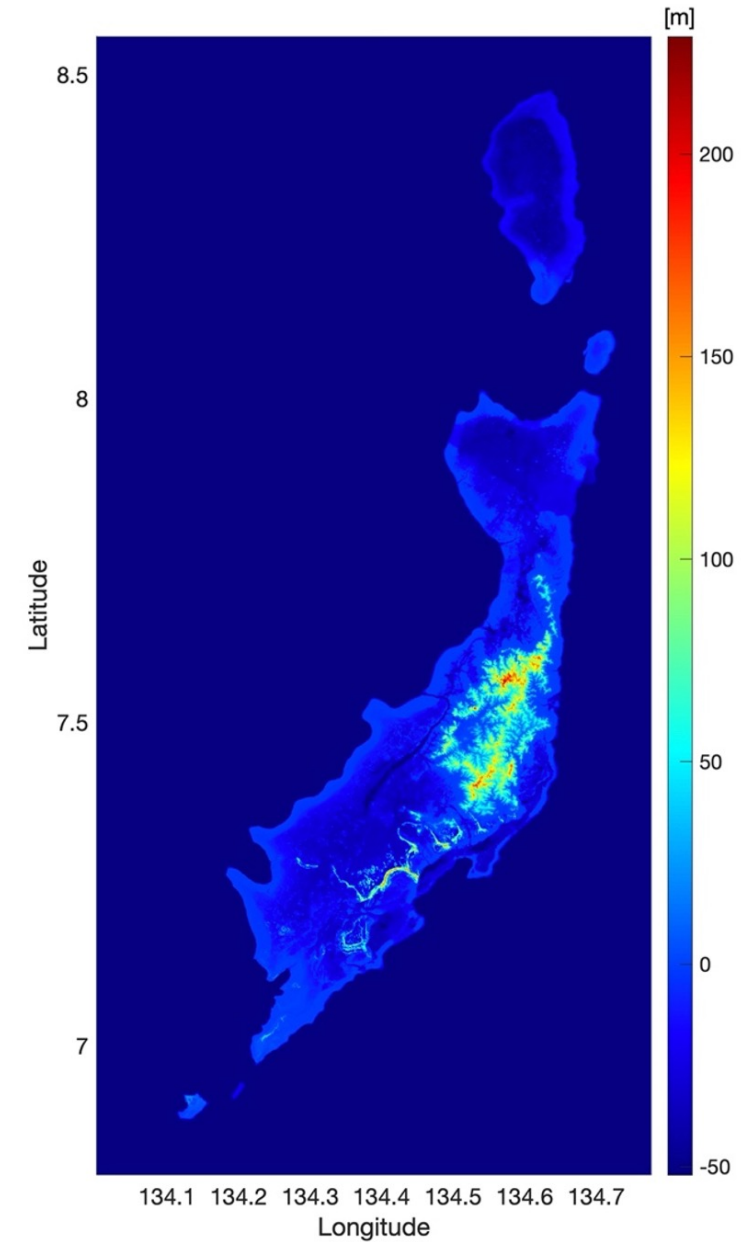


Number	Bathy/topo	Location	Name (Nickname)	Source	Type	Resolution
1)	Bathy and topo	Main Palau Group, where depth is up to 50 m	PALARIS LiDAR	PALARIS	LiDAR	1 m
2)	Bathy	Outer slope of Palau up to 500 m depth and deep lagoon	CRRF	CRRF	Multi-beam	50 m
3)	Bathy	Main Palau group	Nautical Charts	NOAA Charts (NOAA, 2024) and manual digitizing of NGA nautical charts (NGA, 2024)	Single beam, LiDAR, aerial, satellite	n/a
4)	Bathy	Deep ocean area outside main Palau group	GMRT	GMRT (Ryan et al., 2009) cleaned/curated NCEI data (NCEI, 2024)	Multi-beam and single beam	120 m
5)	Bathy	Deep ocean area outside main Palau group	GEBCO 2024	GEBCO 2024 (GEBCO, 2024)	Single beam, multi-beam, satellite	15 arcsec

a

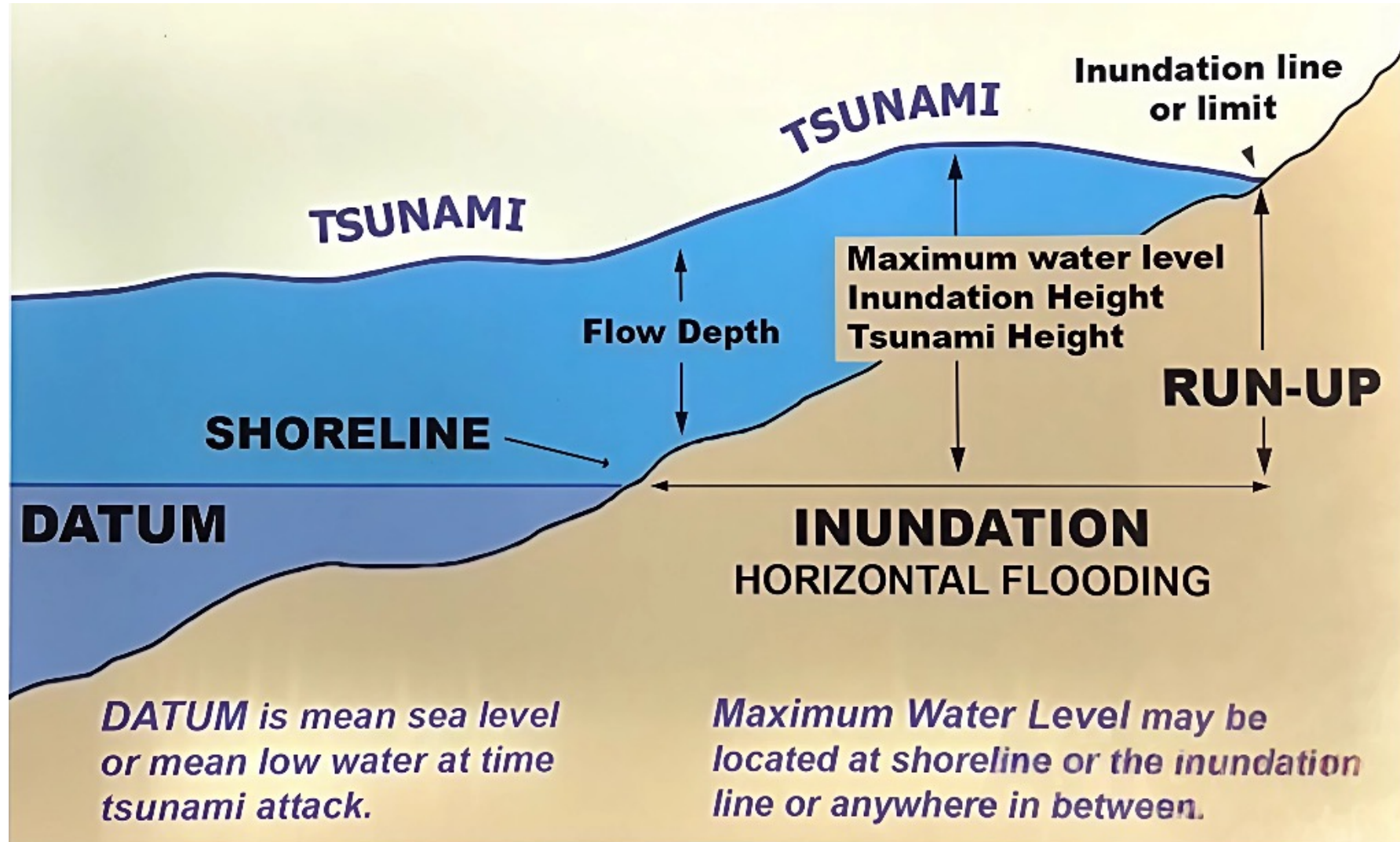


b

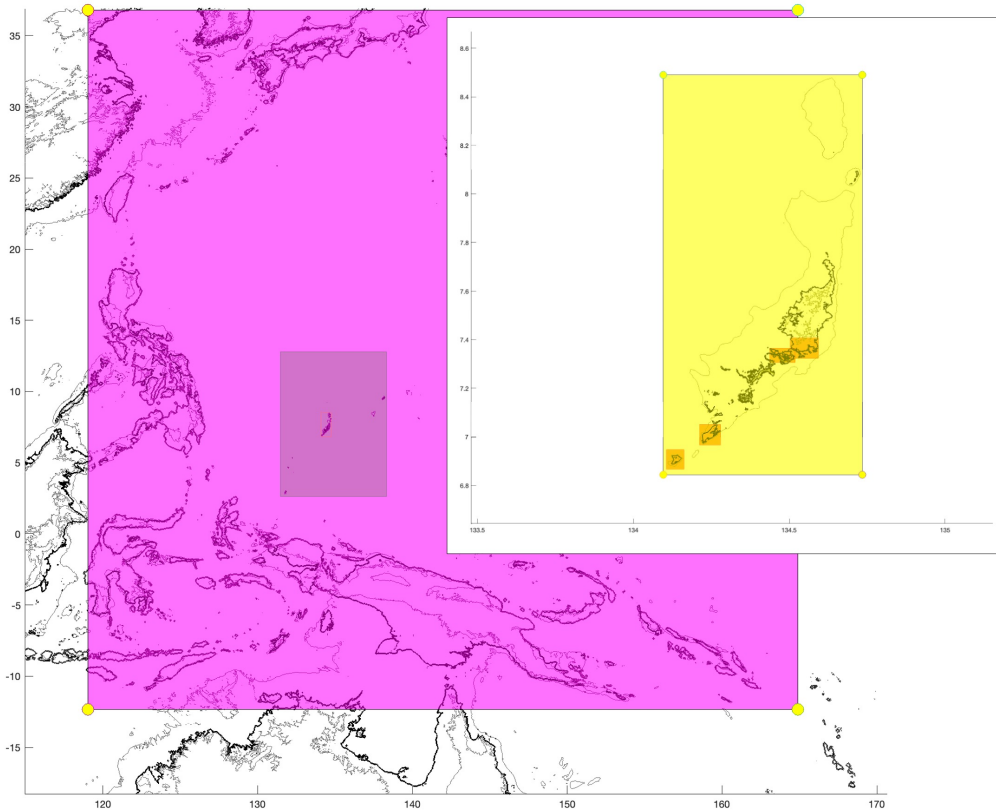


Tsunami Inundation Terms

(Intergovernmental Oceanographic Commission, 2019)

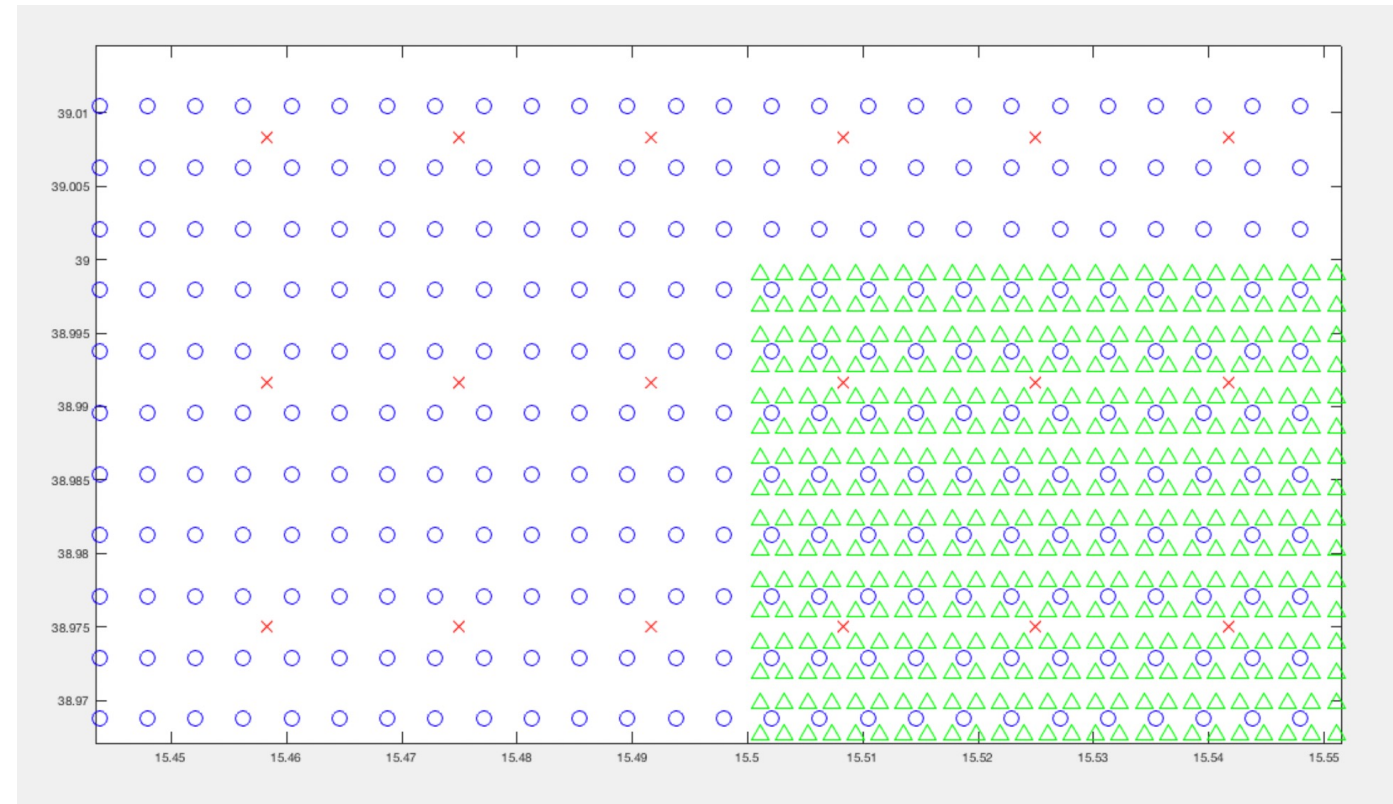


Using Numerical Models to Calculate Tsunami



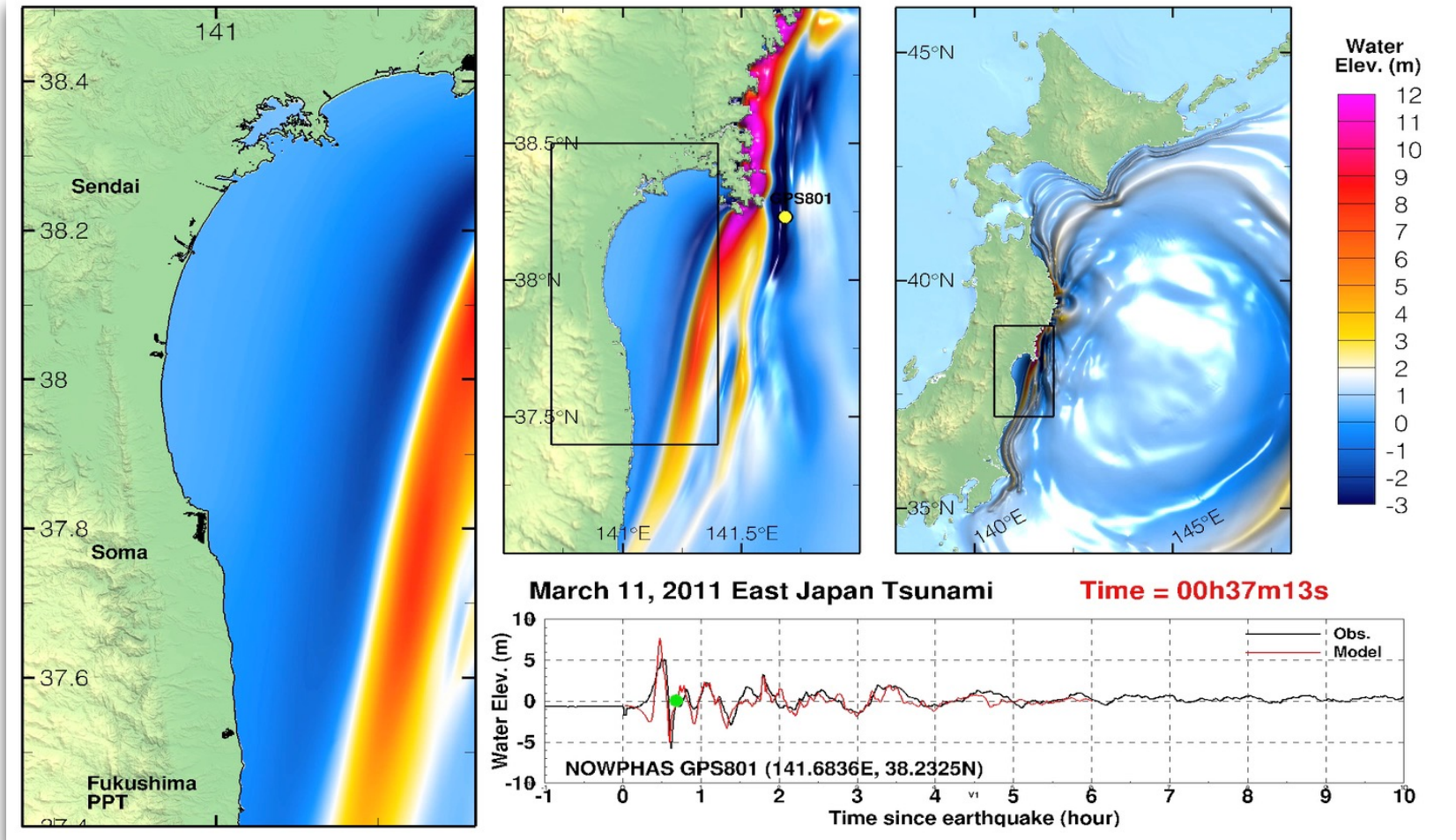
The HySea tsunami model numerically solves the non-linear shallow water equations and utilizes GPU graphics cards for parallelization, making it suitable for very large, very high-resolution grids.

The nested grids help to keep the accuracy-speed balance.



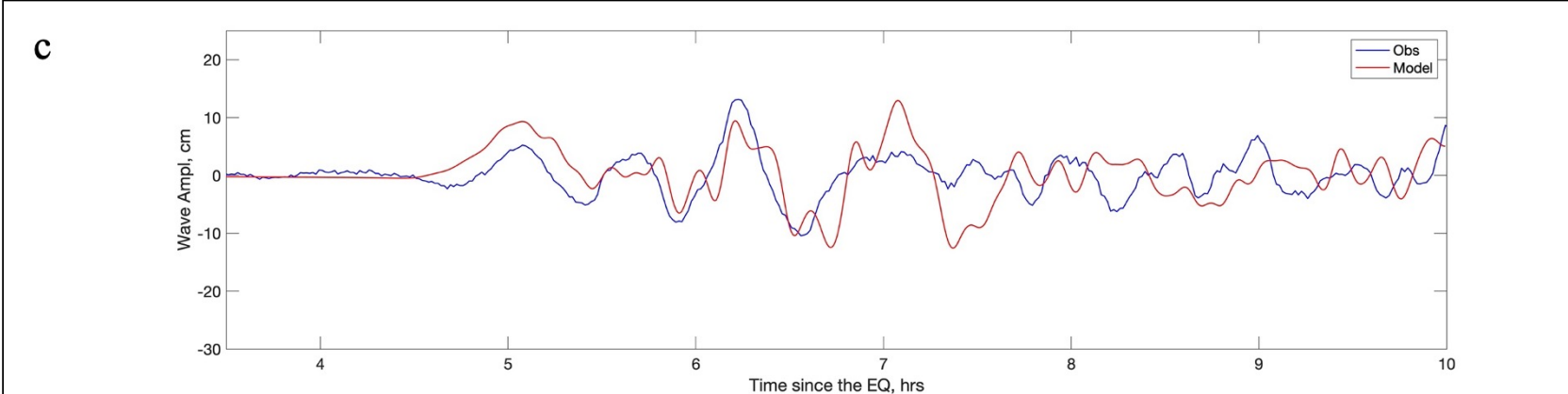
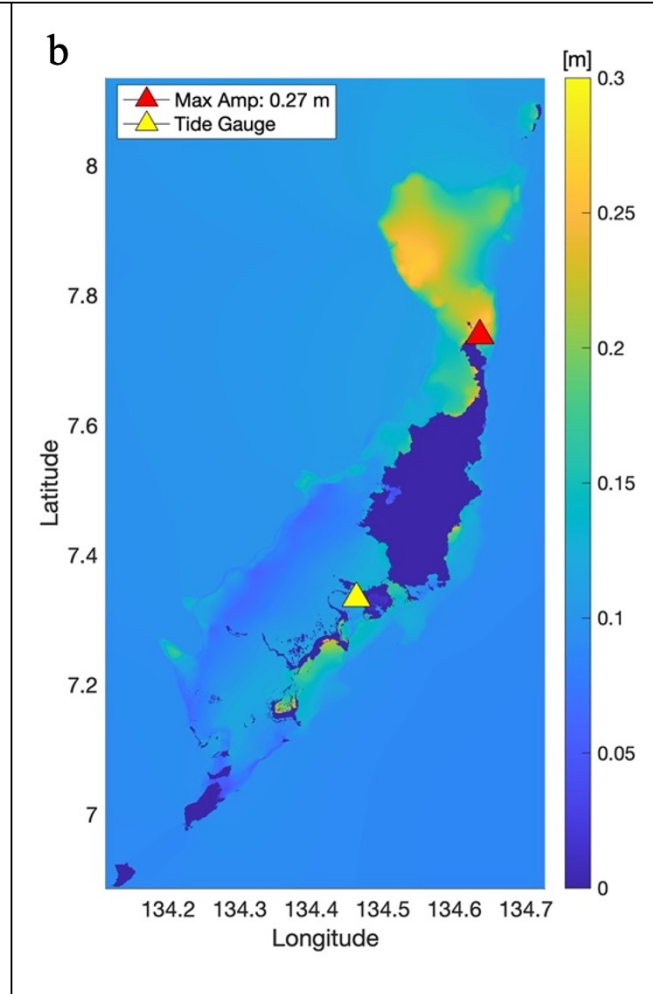
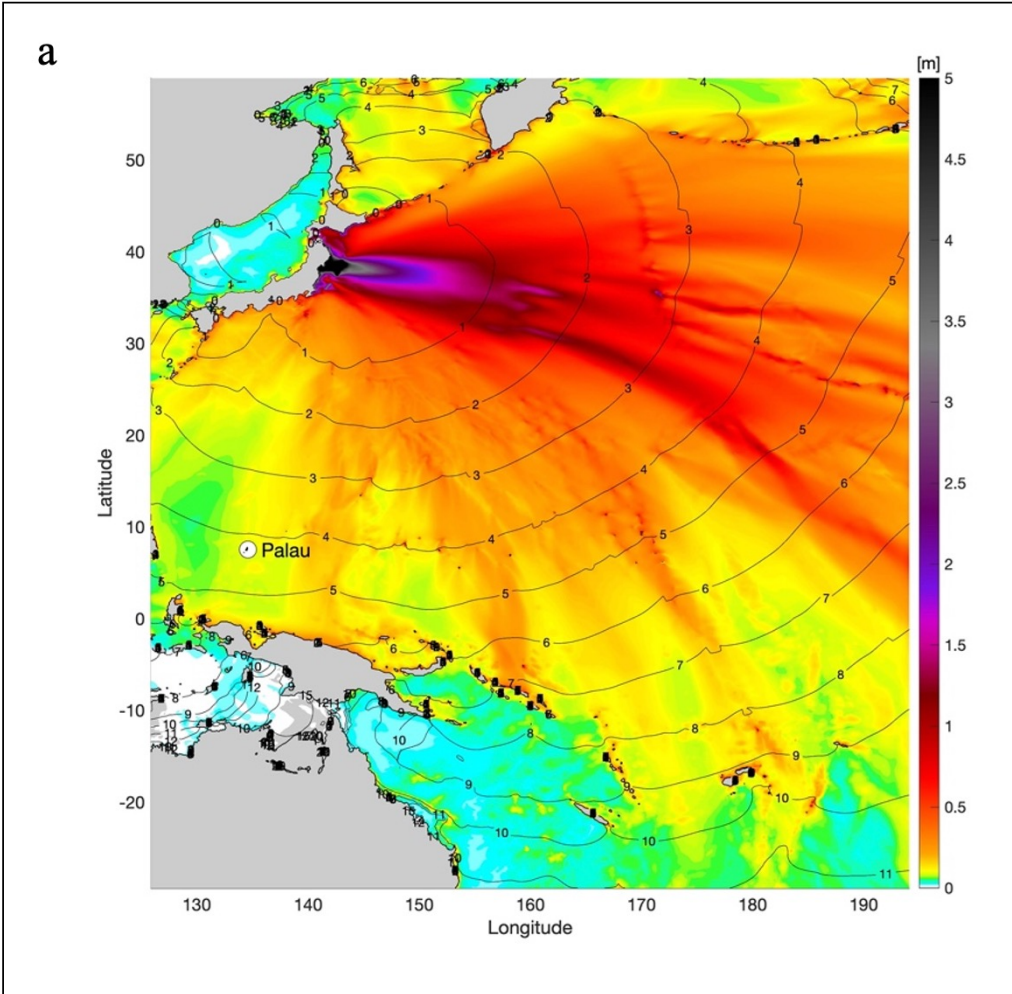
Forecast of local impact?

Local flooding forecast test: Model vs Observations for Japan Coast



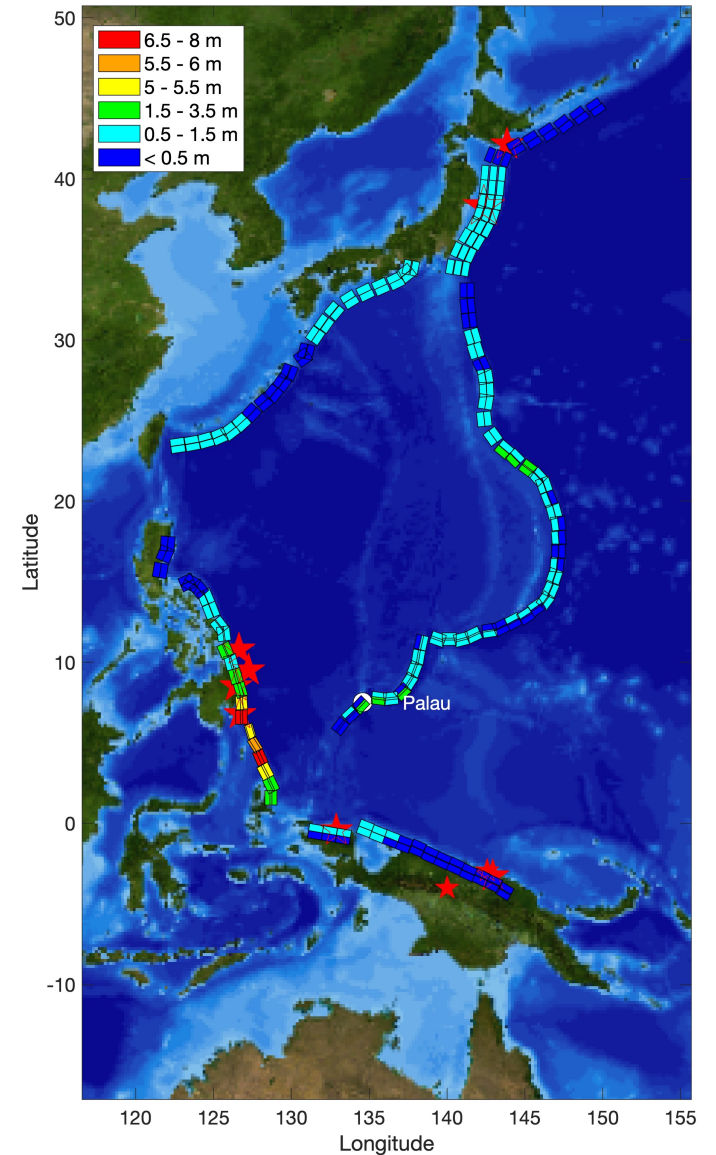
The animation was created by Dr. Yong Wei (NCTR, PMEL, NOAA/CICOES, UW)

Model Validation (03/11/2011 Mw 9.0 Tohoku Tsunami)



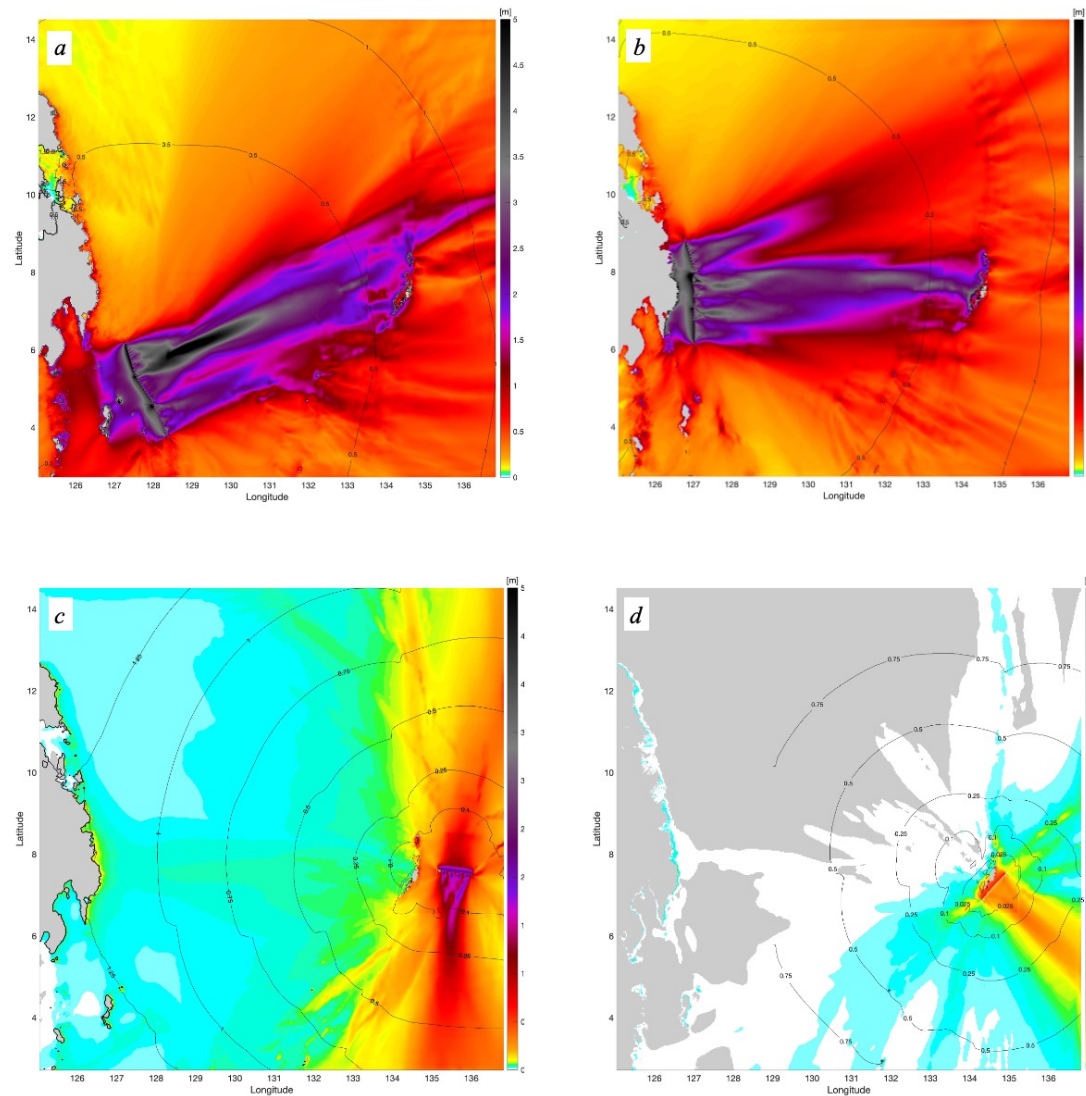
Identification of the Most Dangerous Tsunami Sources

- Tsunami databases
- Historical events
- Expert elicitation



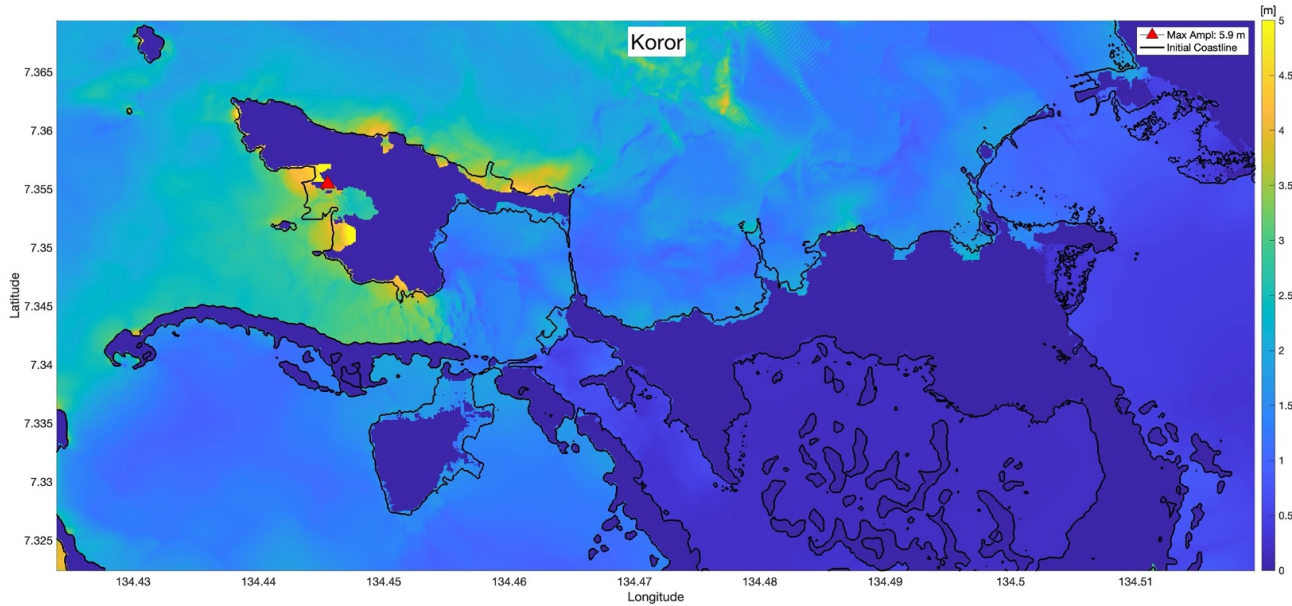
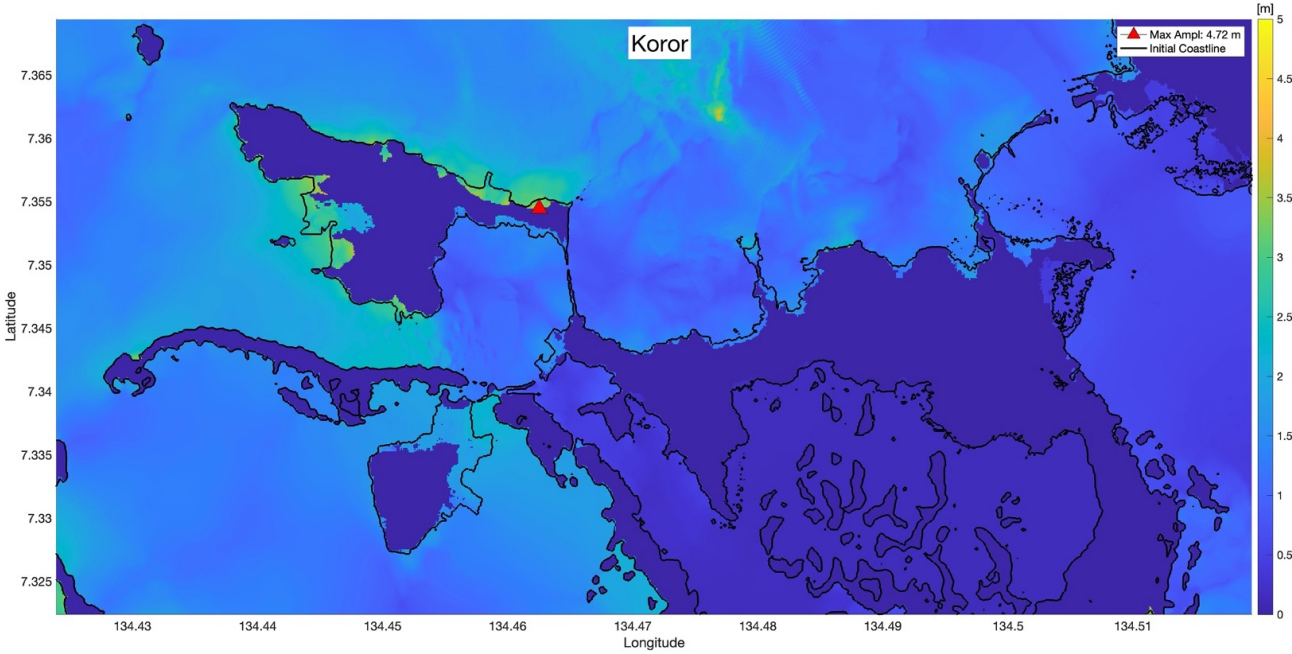
Stars mark the origins of historic tsunamis that have affected Palau

Subsequent to the sensitivity study, we selected four earthquake scenarios to be modeled at the highest resolution of 10 m: two the most hazardous to Palau sources along the Philippine Trench and two closest to Palau sources with the significant impact (one source from Palau and one from Yap Trenches).

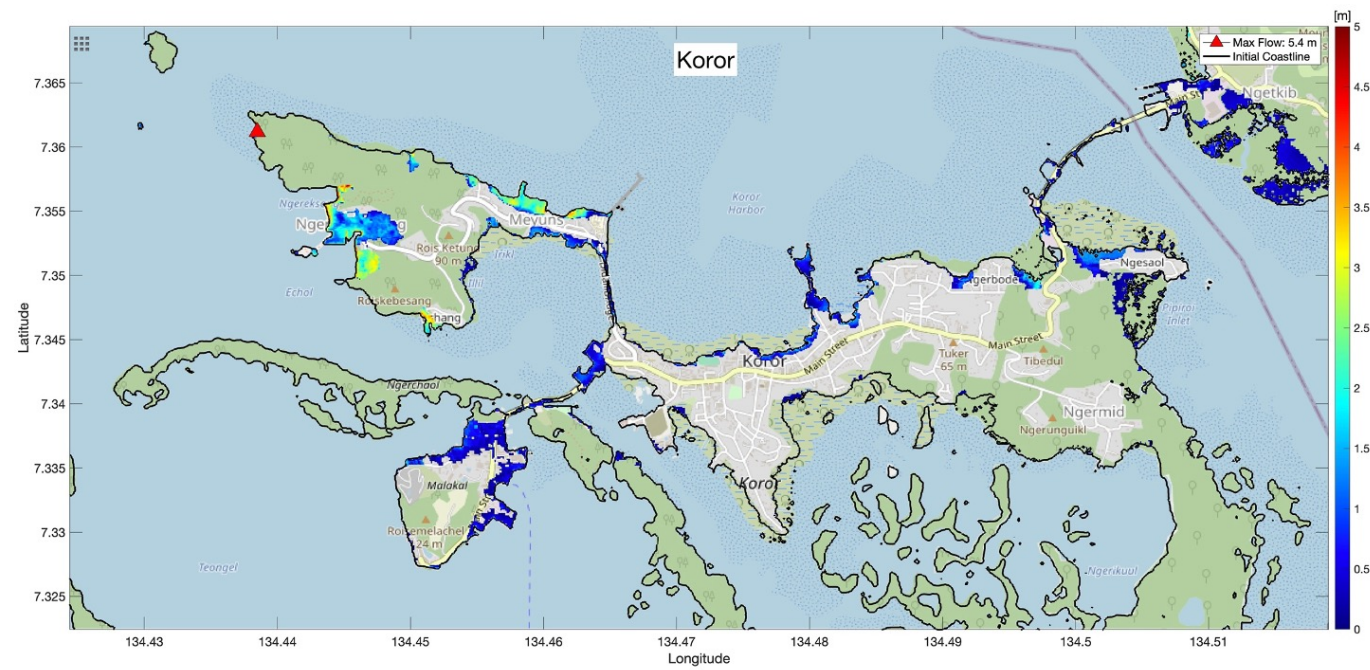
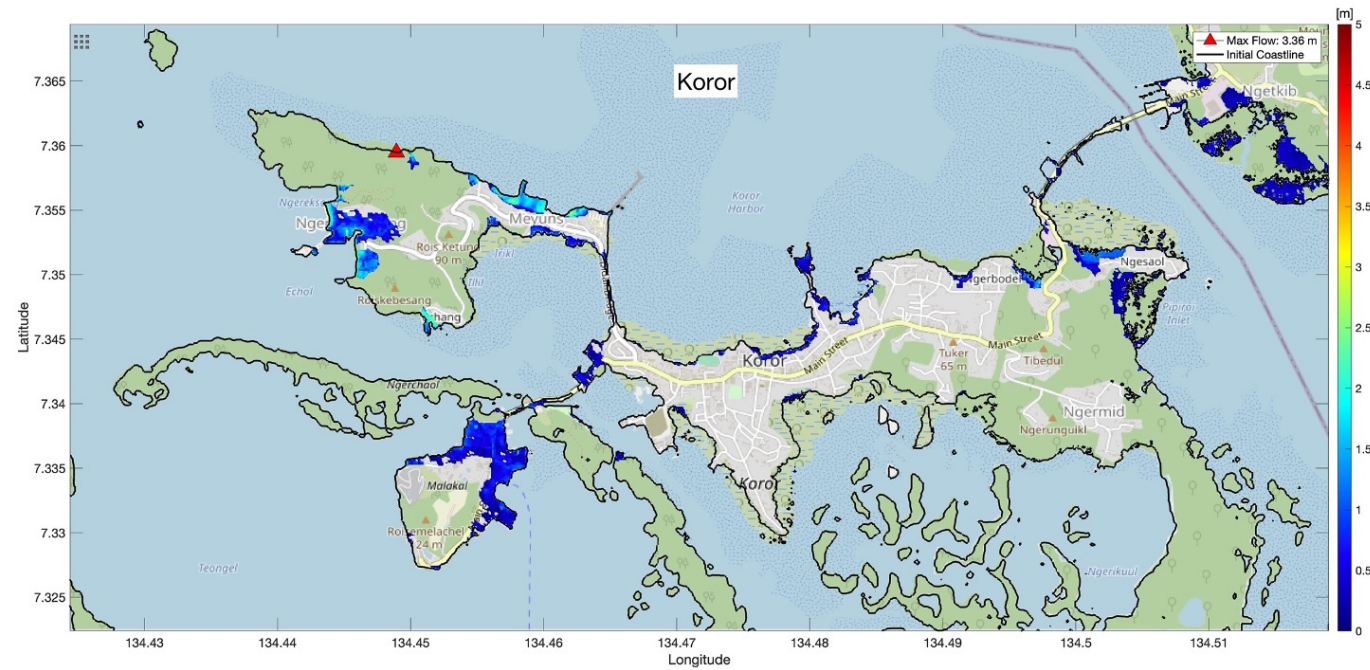


Source location, arrival times, and maximum wave amplitudes in deep ocean for the most hazardous sources Phillipine1 (*a*), Phillipine2 (*b*) and the closest to Palau significant impact sources Yap (*c*) and Palau (*d*).

The maximum tsunami height and inundation from the two most hazardous. Red triangle marks the position of the overall grid maximum (Koror State)



The maximum tsunami flow depth and inundation from the two most hazardous sources originated from the Philippine Trench. Red triangle marks the position of the overall grid maximum (Koror State)



Thank you!