Tsunami Inundation Modeling & Mapping for Guam

Southern Shores: Umatac, Merizo, Inarajan, and Talofofo

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Background

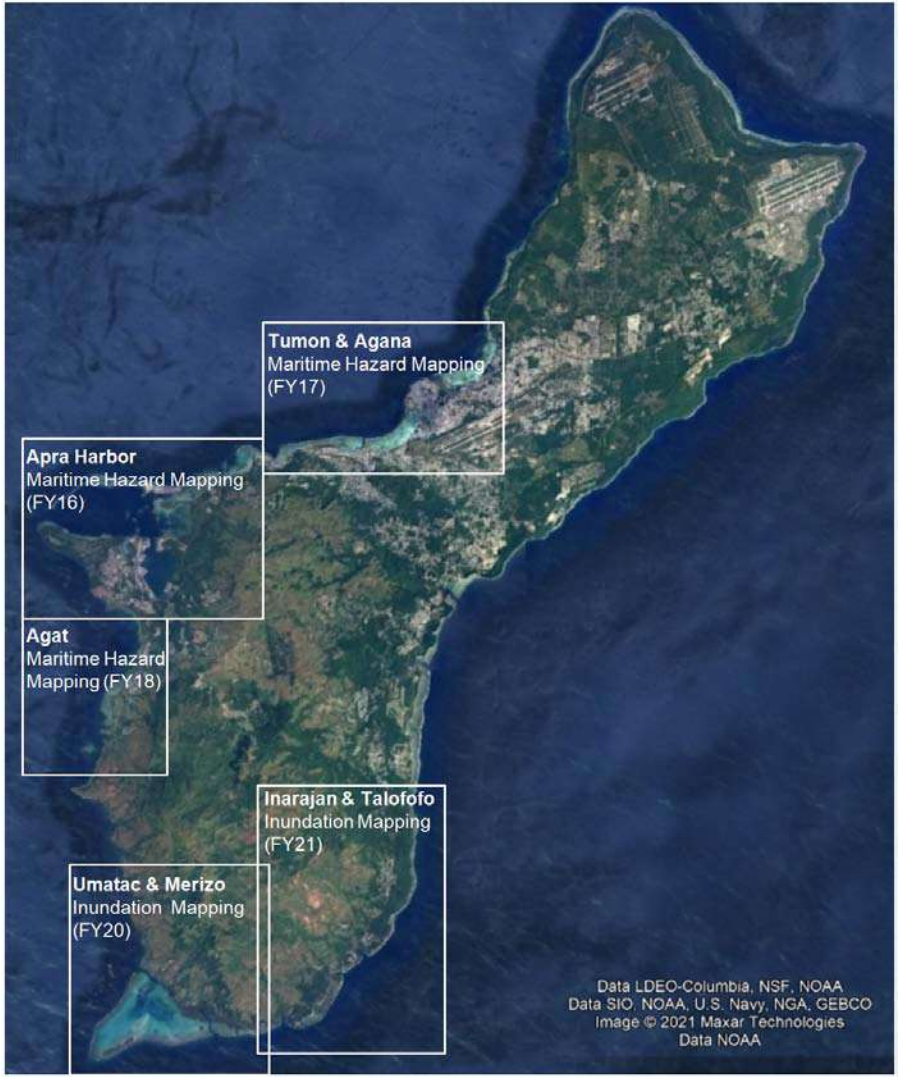
National Tsunami Hazard Mitigation Program
- NOAA, FEMA, USGS, and 28 US states and territories

Activities under Hazard Assessment
- Tsunami inundation mapping
- Maritime hazard mapping
- Sediment & debris modeling

Maritime Hazard Mapping
- Three-year project: FY16-18
- Apra Harbor, Agana Boat Basin, and Agat Marina and adjacent areas
- After similar effort with USCG Sector Honolulu
  - In-harbor hazard maps for advisory-level tsunamis
  - Offshore hazard maps for *probable* maximum tsunamis

Inundation Mapping (FY20-21)
- Southern shorelines including Umatac, Merizo, Inarajan, and Talofofo
- High-resolution modeling for probable maximum tsunamis from critical sources to Guam.

https://www.pacioos.hawaii.edu/data/search-results/?text=neowave&keyword=guam



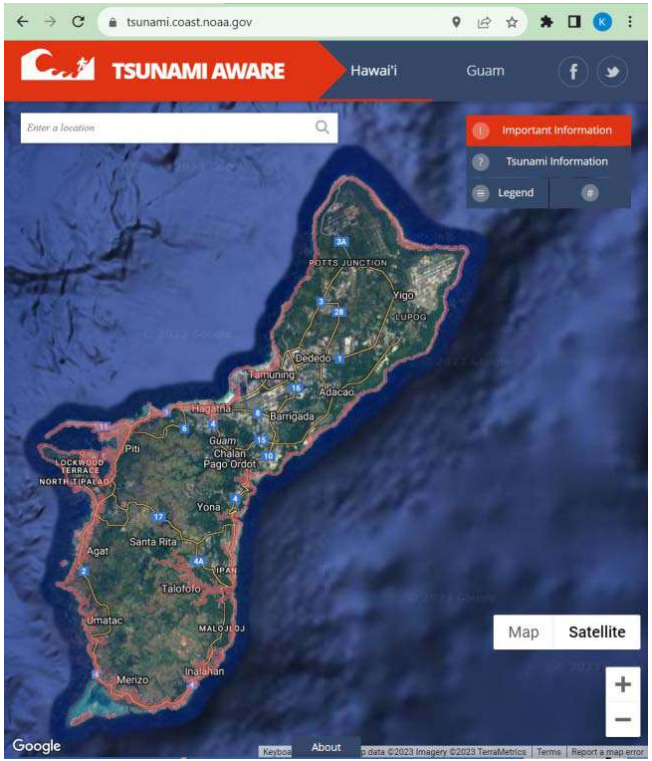
Prior Modeling Work

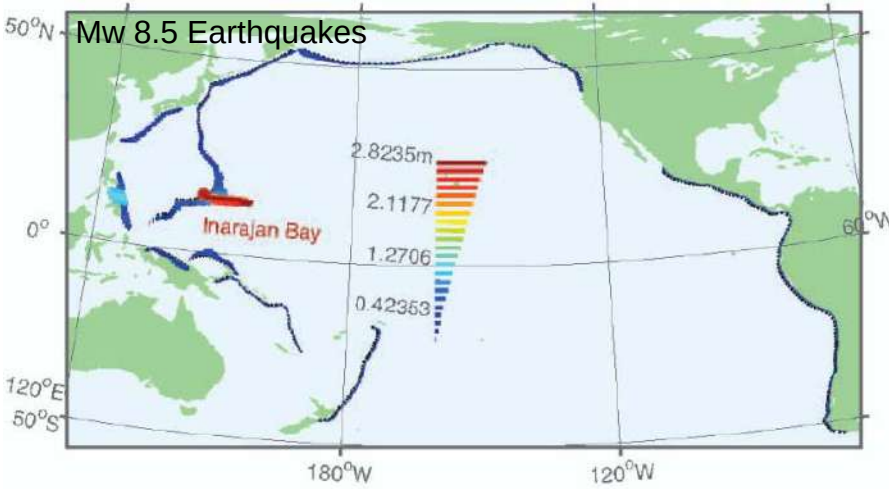
Tsunami Hazard Assessment for Guam

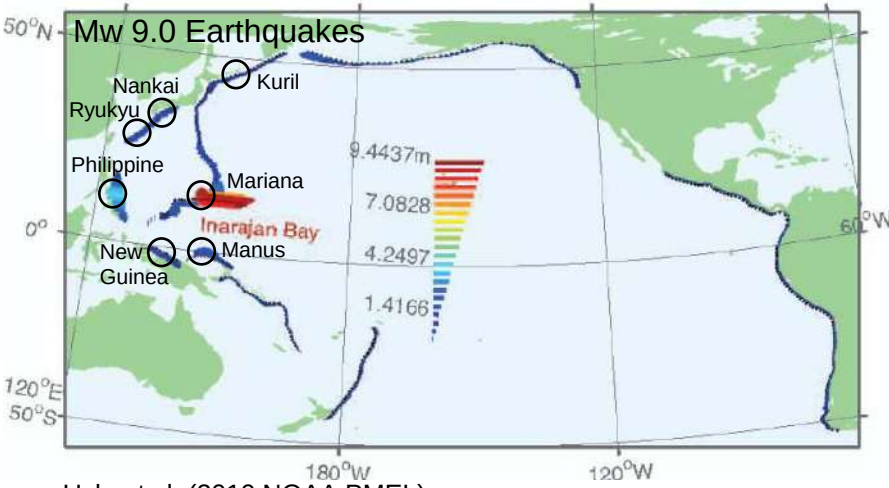
- NOAA Pacific Marine Environmental Lab in 2010
- Low-resolution tsunami modeling for hypothetical Mw 8.5 and 9.0 earthquakes to identify critical sources
- Mariana, Philippine, Nankai, Ryukyu, New Guinea, Manus, and Kuril Subduction zones
- High-res modeling for Apra Harbor, Pago, Agana, and Inarajan Bays

Evacuation Maps by Guam DHS

- Aggregation of high-res results
- Extrapolation of low-res results







Uslu et al. (2010 NOAA PMEL)

Evacuation Map Updates

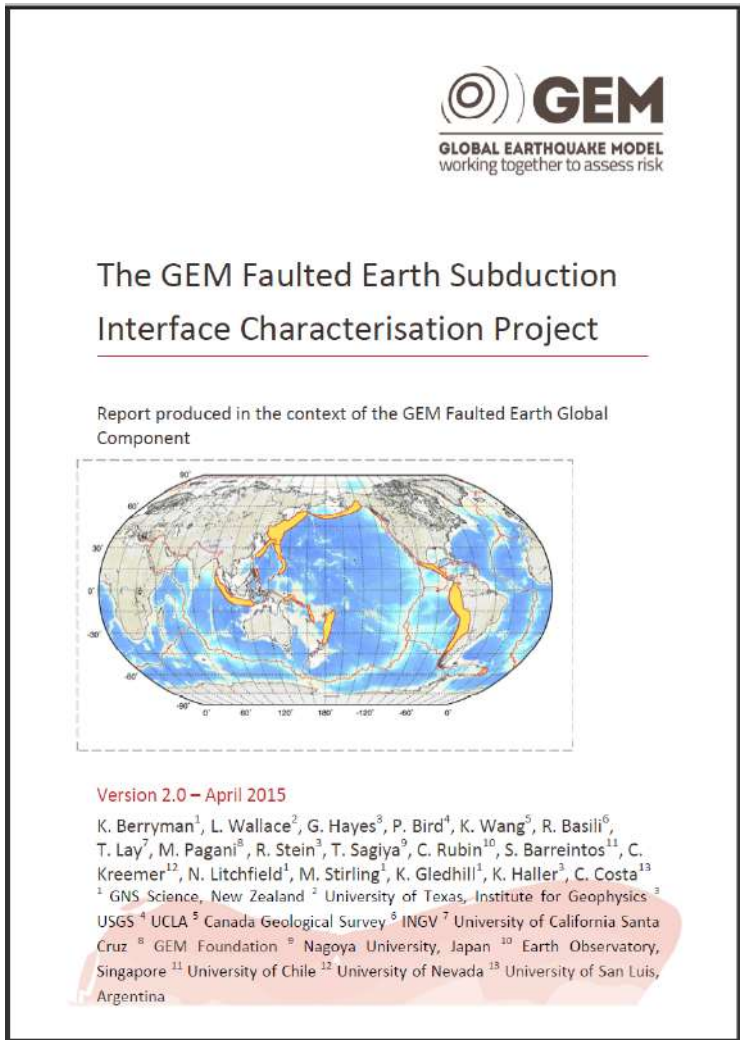
Why update?

- Arbitrarily selected earthquake magnitudes not representative of source seismicity
- Extrapolation of low-res model results lacking physical basis
- Newly developed digital elevation model by NOAA NCEI
- Recent advances in modeling for tropical island environment

Source Scenarios

- Global Earthquake Model (GEM) initiated by insurance industry after the 2011 Tohoku earthquake and tsunami
- Preferred maximum Mw agreed by notable seismologists
- Inundation maps based on preferred maximum earthquakes
- Refuge locations based on preferred max Mw + 0.2 (2 x energy)

Tsunami Source		Largest Recorded Earthquake (year)	GEM Preferred Max Mw	GEM Preferred Max Mw + 0.2
Local	Mariana	M 8.0 (1909)	8.3	8.5
North	Kuril	Mw 9.0 (1952)	9.3	9.5
Northwest	Nankai	Ms 8.6 (887)	8.7	8.9
West	Philippine	Ms 8.3 (1924)	8.5	8.7
South	New Guinea	Mw 8.2 (1996)	8.8	9.0

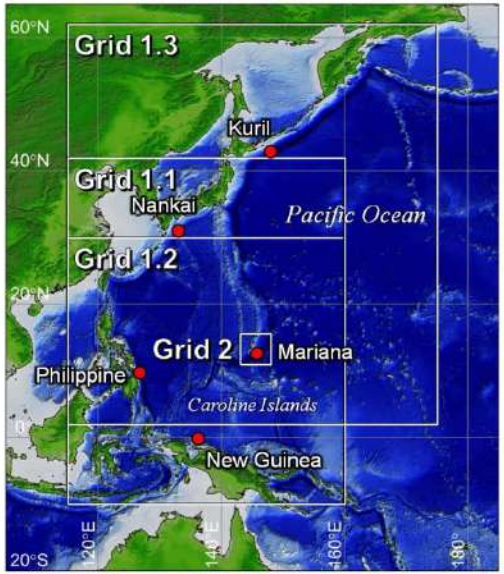


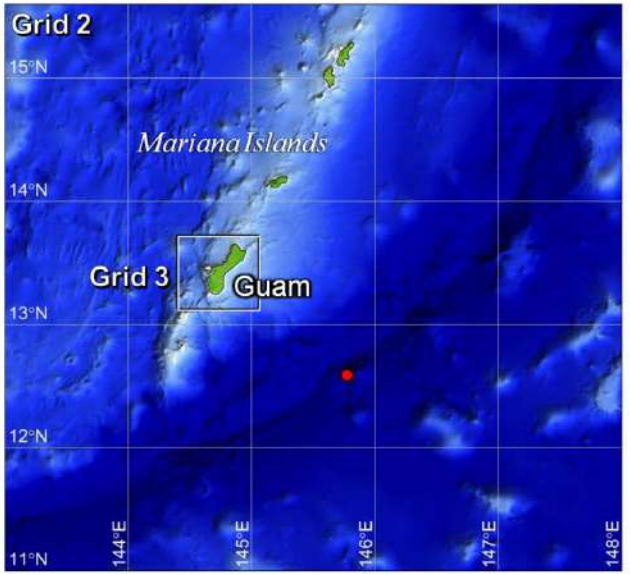
Tsunami Modeing

Nested grid systems
- Four levels of two-way nested grids
- Telescoping from western Pacific to Umatac-Merizo and Inarajan-Talofofo

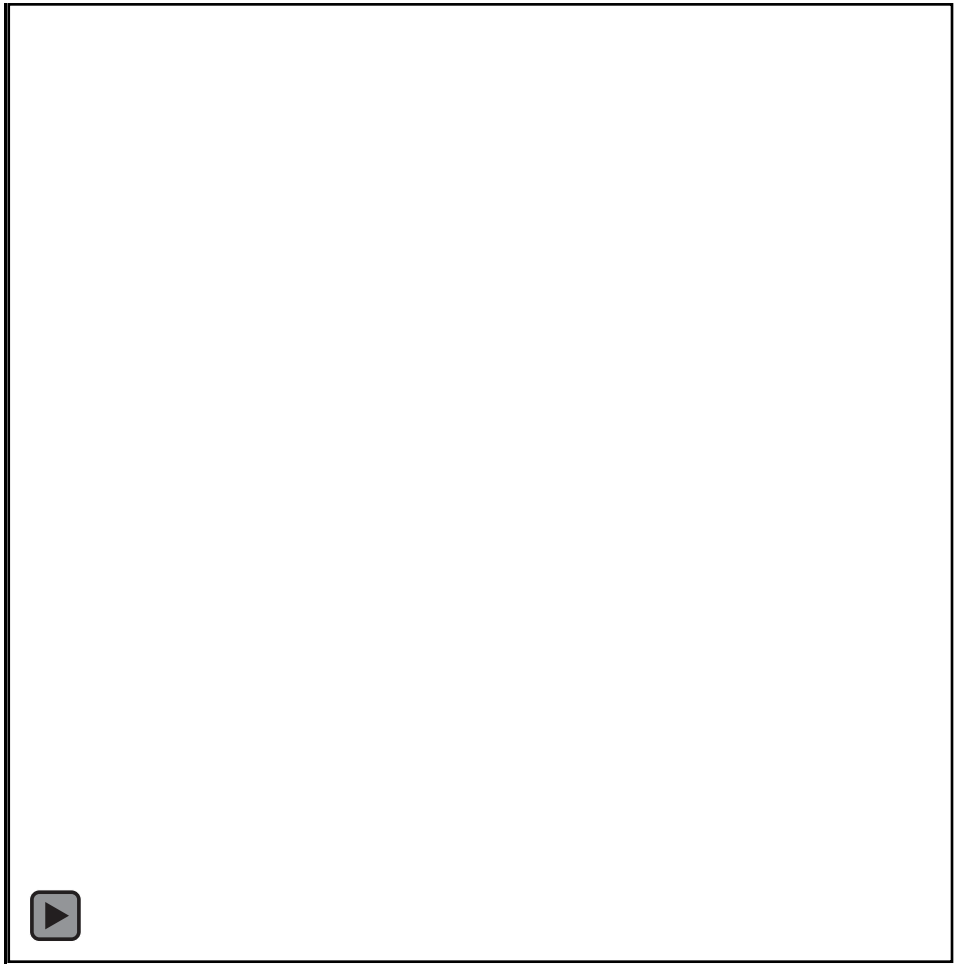
Digital Elevation Model
- Multibeam bathymetry at 5 and 60 m resolution down to 400 and 3500 m depth from U Hawaii
- Integrated LiDAR topography and bathymetry at 3 m resolution from U Colorado (NOAA CUDEM)

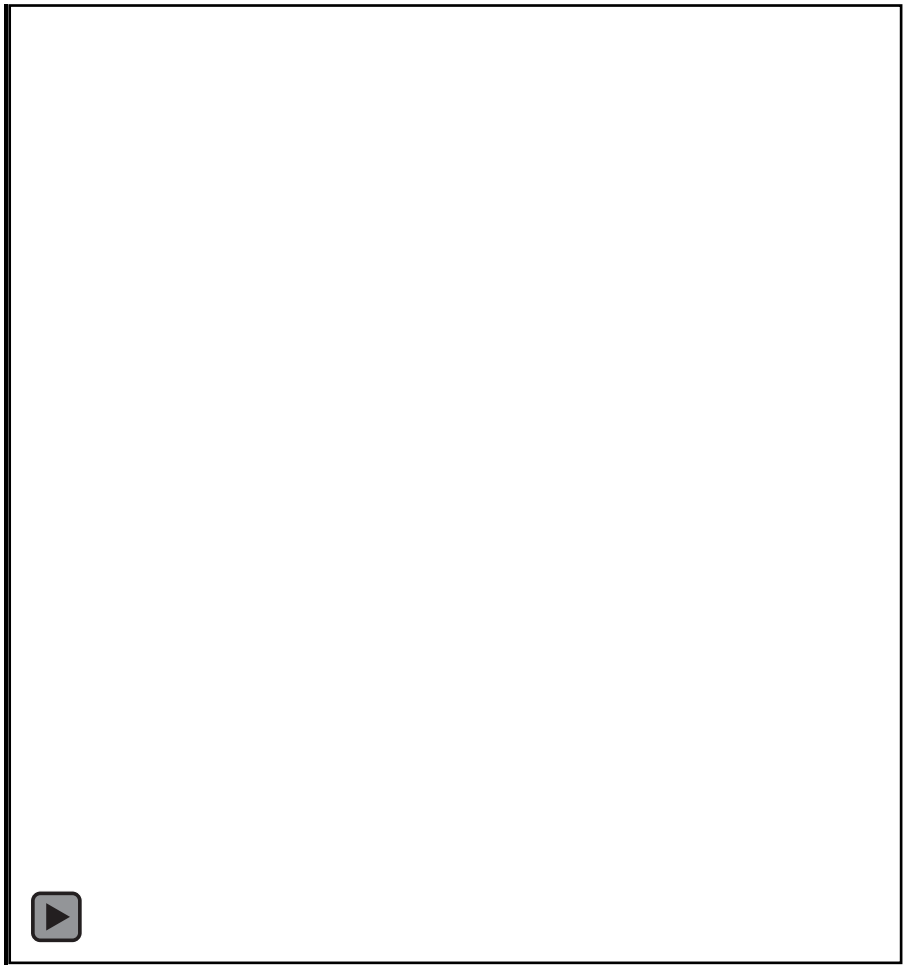
Tsunami Model: NEOWAVE
- Developed at the University of Hawaii for tropical island and reef environments
- Ranked #1 in 2009 National Science Foundation Benchmarking
- Ranked #1 in 2015 NTHMP Benchmarking (2D models)
- Validated with measurements from more than 10 major tsunamis since 2009





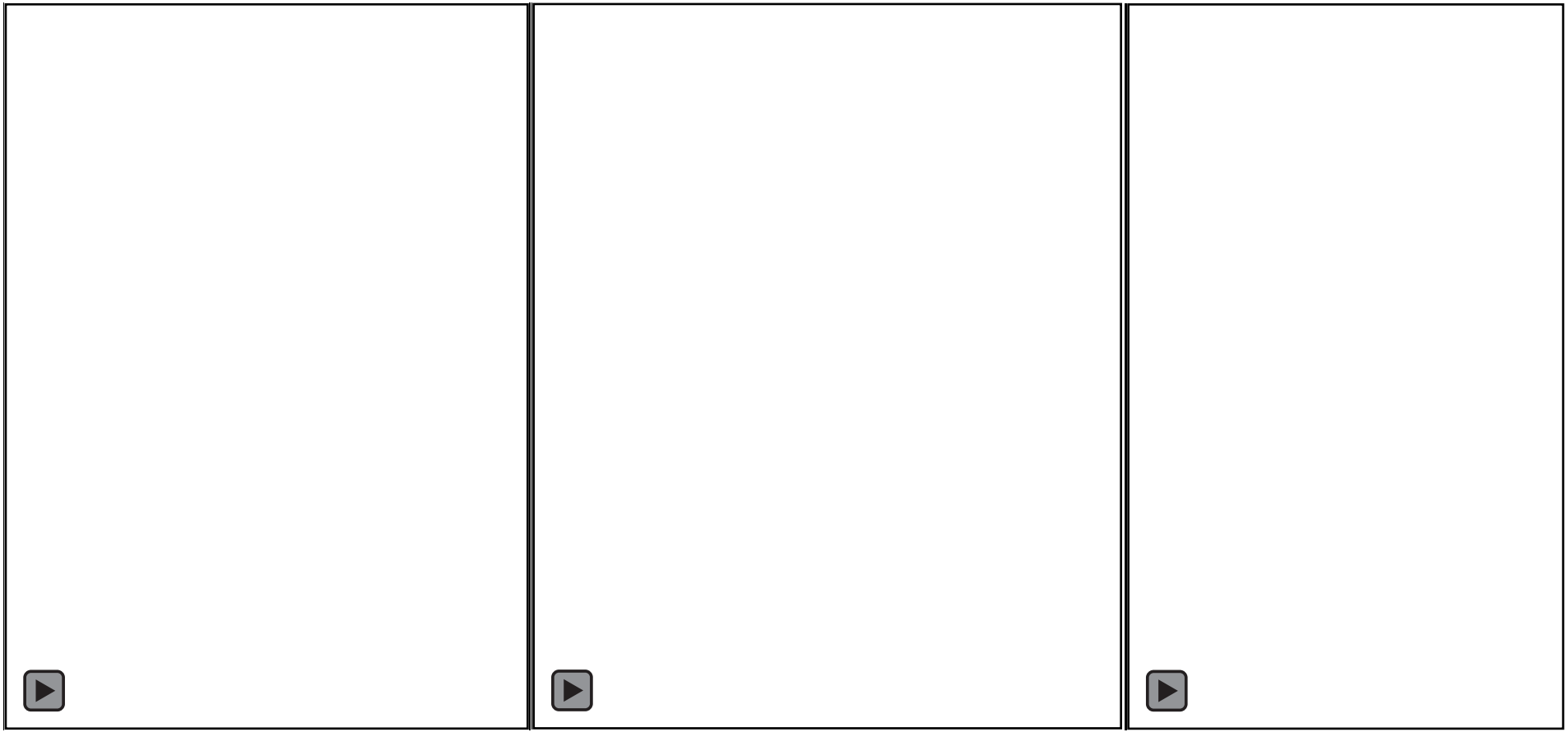
Tsunami Generated by Mariana Mw 8.3 Earthquake (GEM Preferred Maximum)





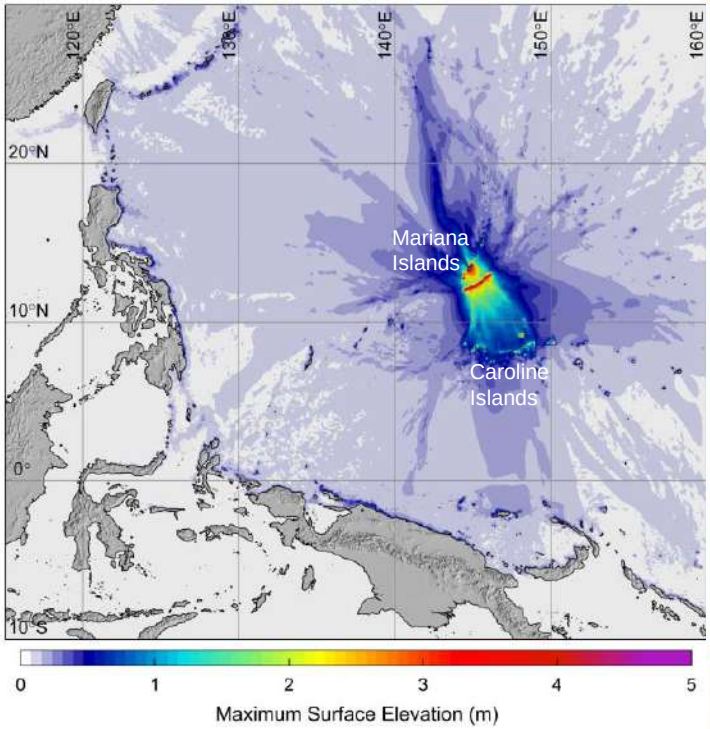
Tsunami Generated by Mariana Mw 8.3 Earthquake

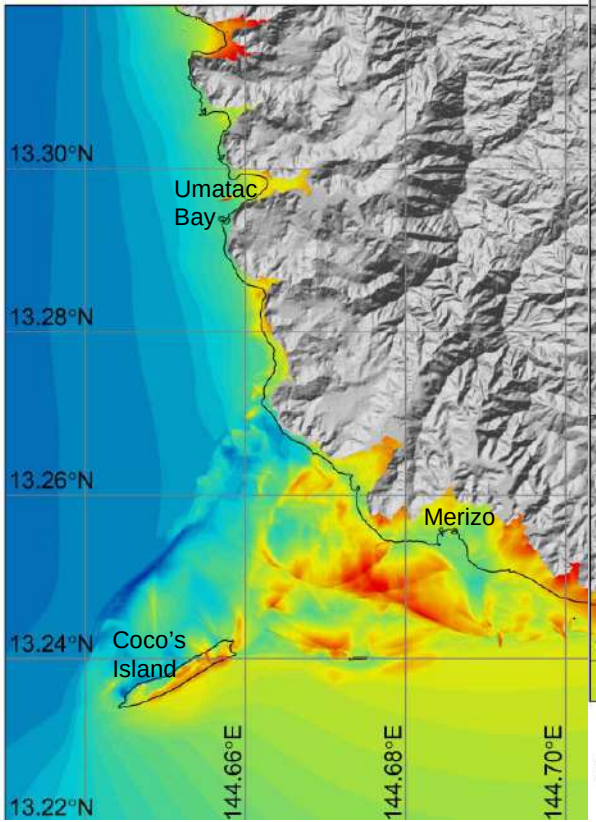
(GEM Preferred Maximum Computed at MHHW Level)

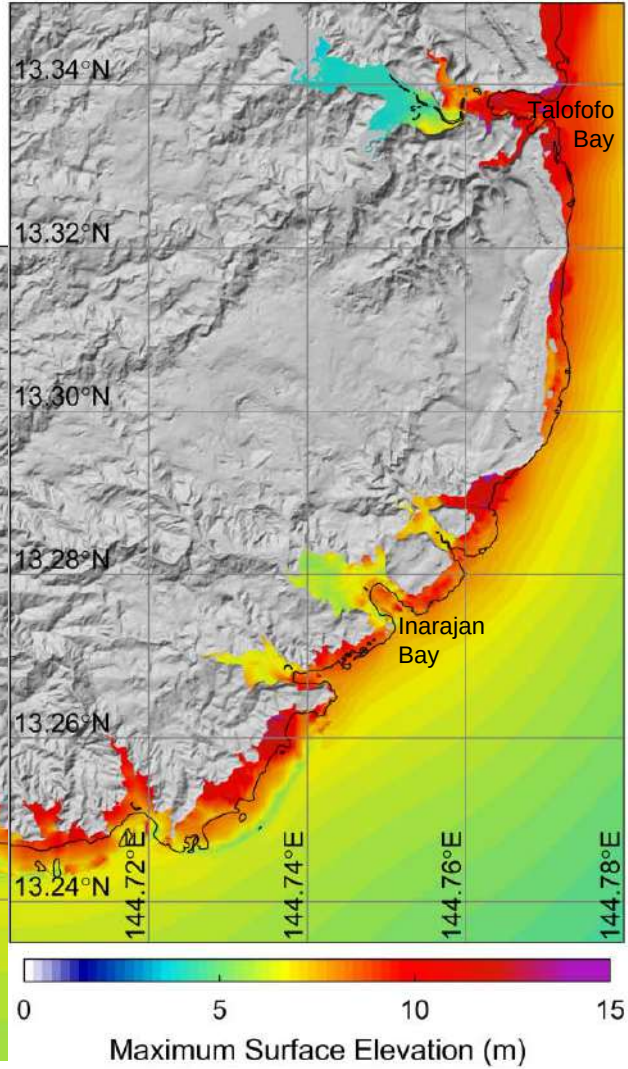


Tsunami Generated by Mariana Mw 8.3 Earthquake

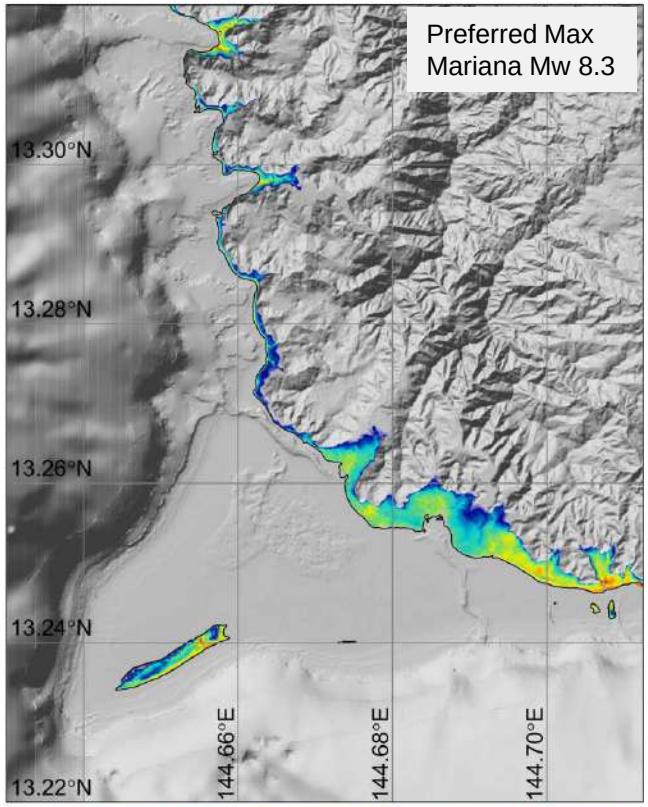
- GEM Preferred Maximum
- Computed at MHHW Level

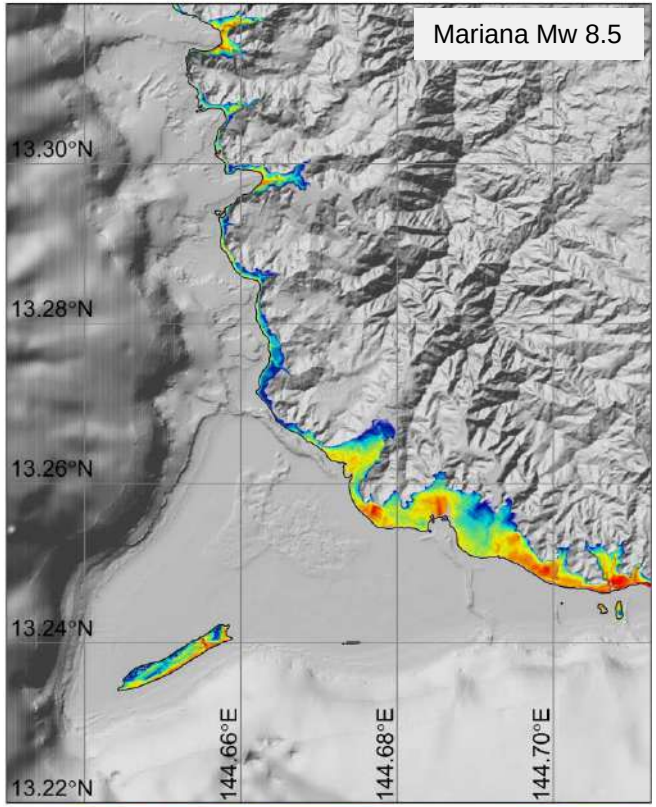


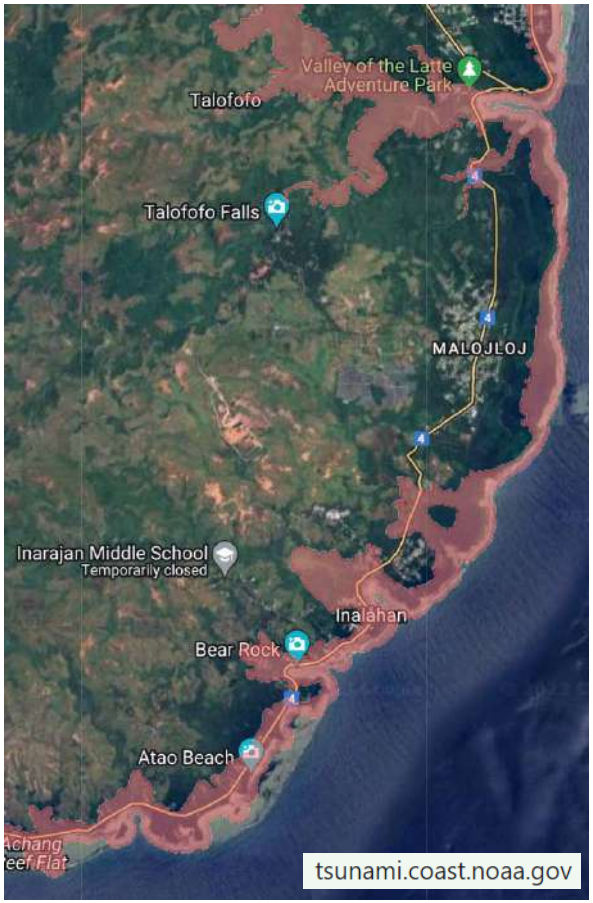




Existing Evacuation and Updated (Local Tsunami) Inundation Maps






Valley of the Latte
Adventure Park
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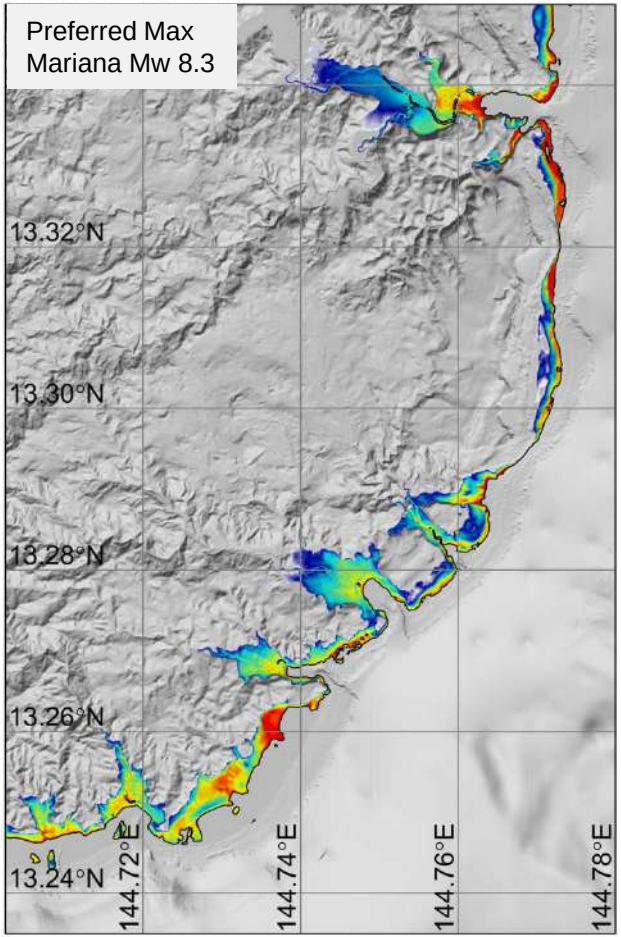
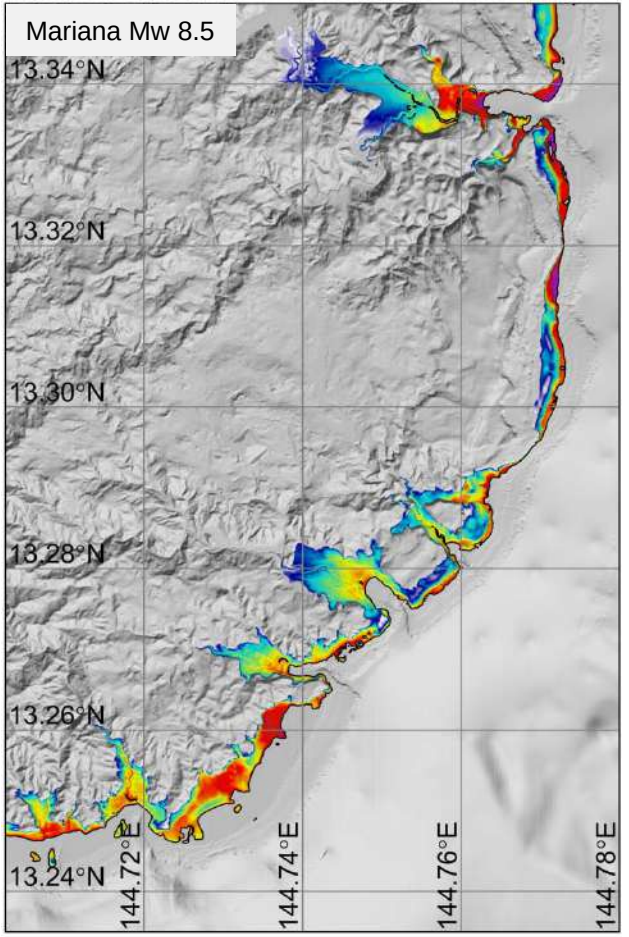
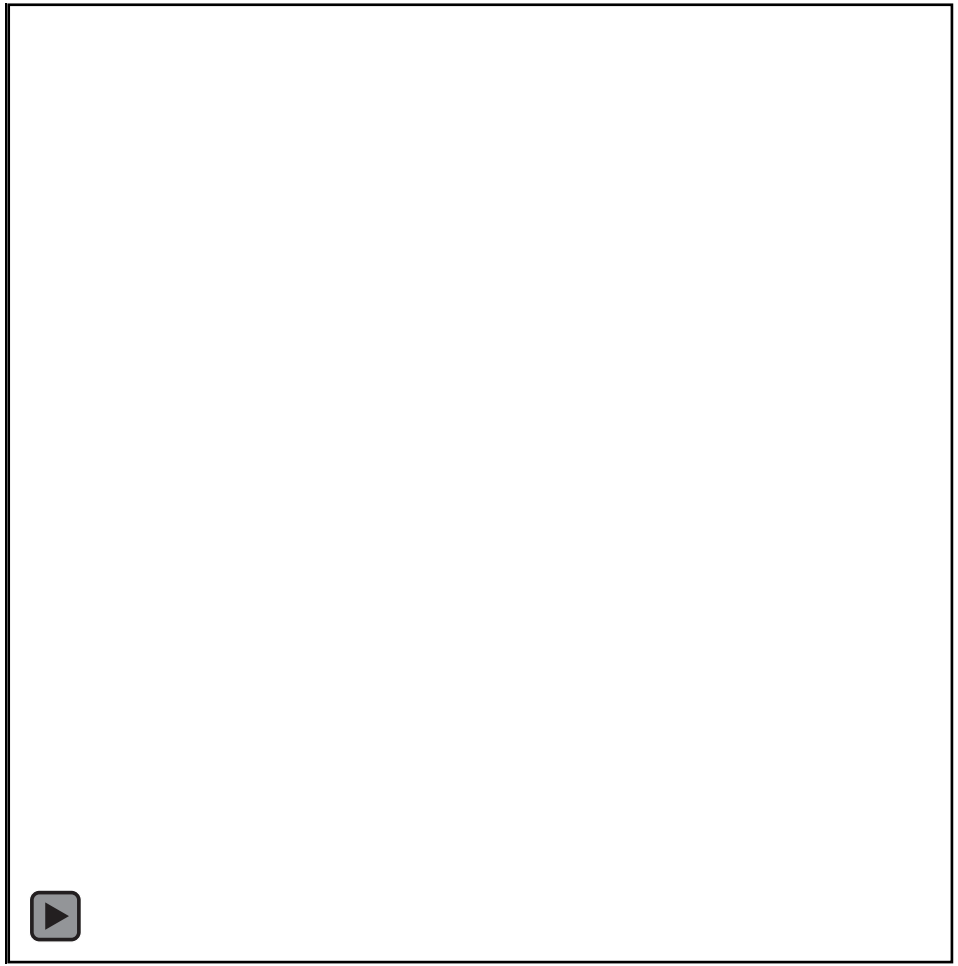
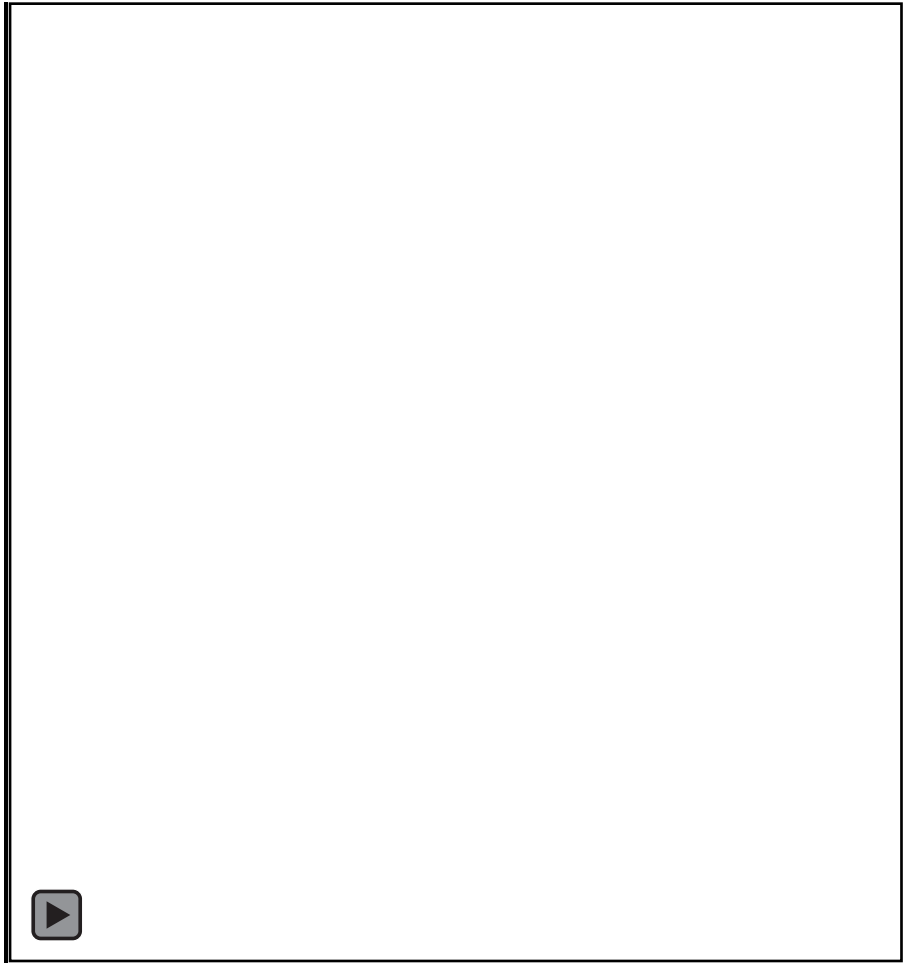
tsunami.coast.noaa.gov


Preferred Max
Mariana Mw 8.3
13.32°N
13.30°N
13.28°N
13.26°N
13.24°N
144.72°E
144.74°E
144.76°E
144.78°E
0
5
10
15+
Maximum Flow Depth (m)


Mariana Mw 8.5
13.34°N
13.32°N
13.30°N
13.28°N
13.26°N
13.24°N
144.72°E
144.74°E
144.76°E
144.78°E
0
5
10
15+
Maximum Flow Depth (m)

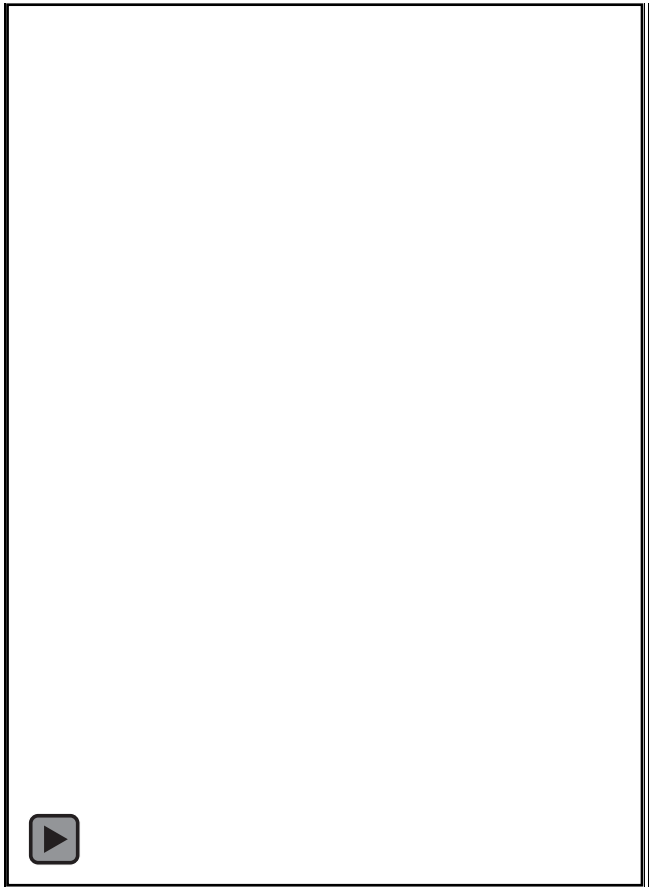
Tsunami Generated by Philippine Mw 8.5 Earthquake (GEM Preferred Maximum)

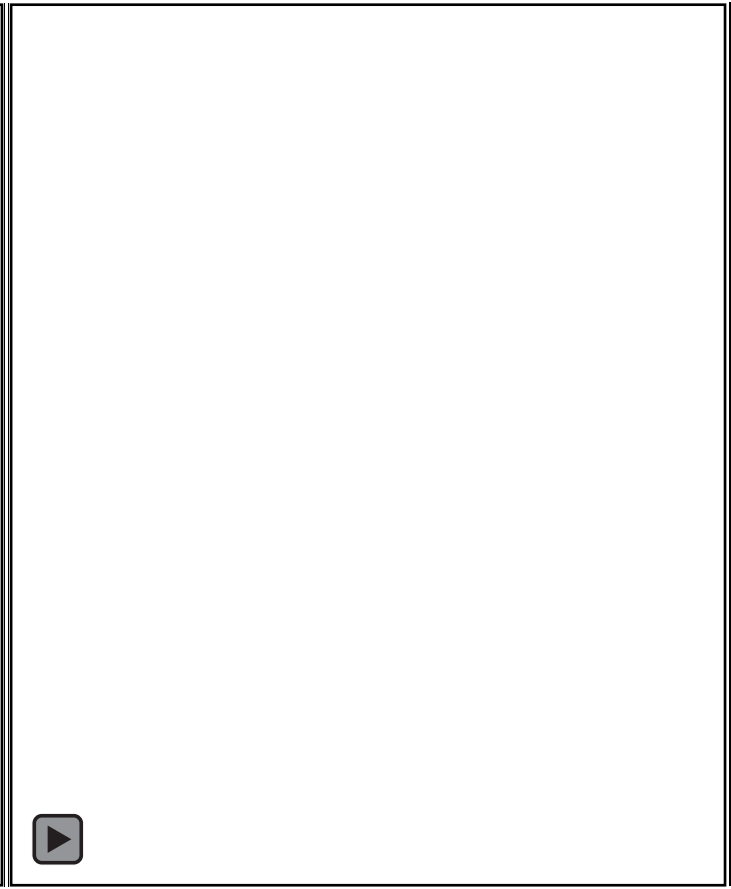


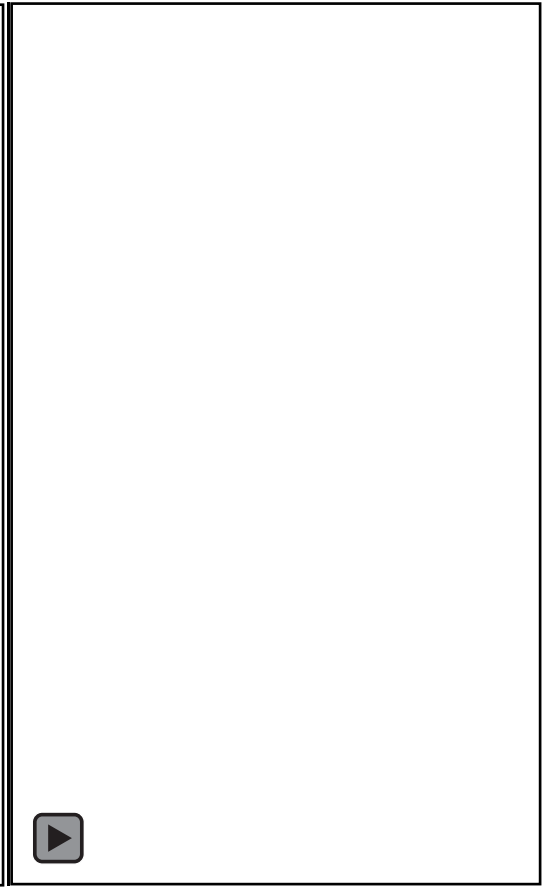


Tsunami Generated by Philippine Mw 8.5 Earthquake

(GEM Preferred Maximum Computed at MHHW Level)

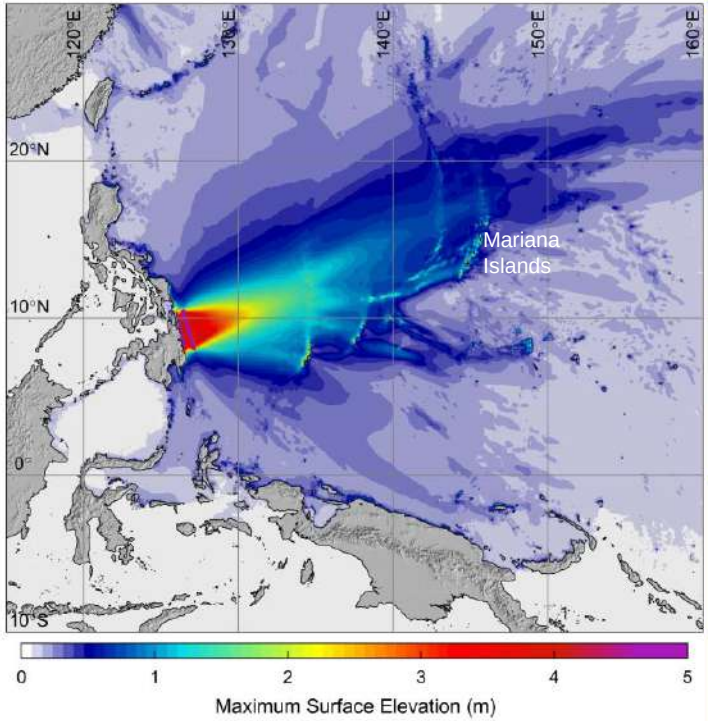


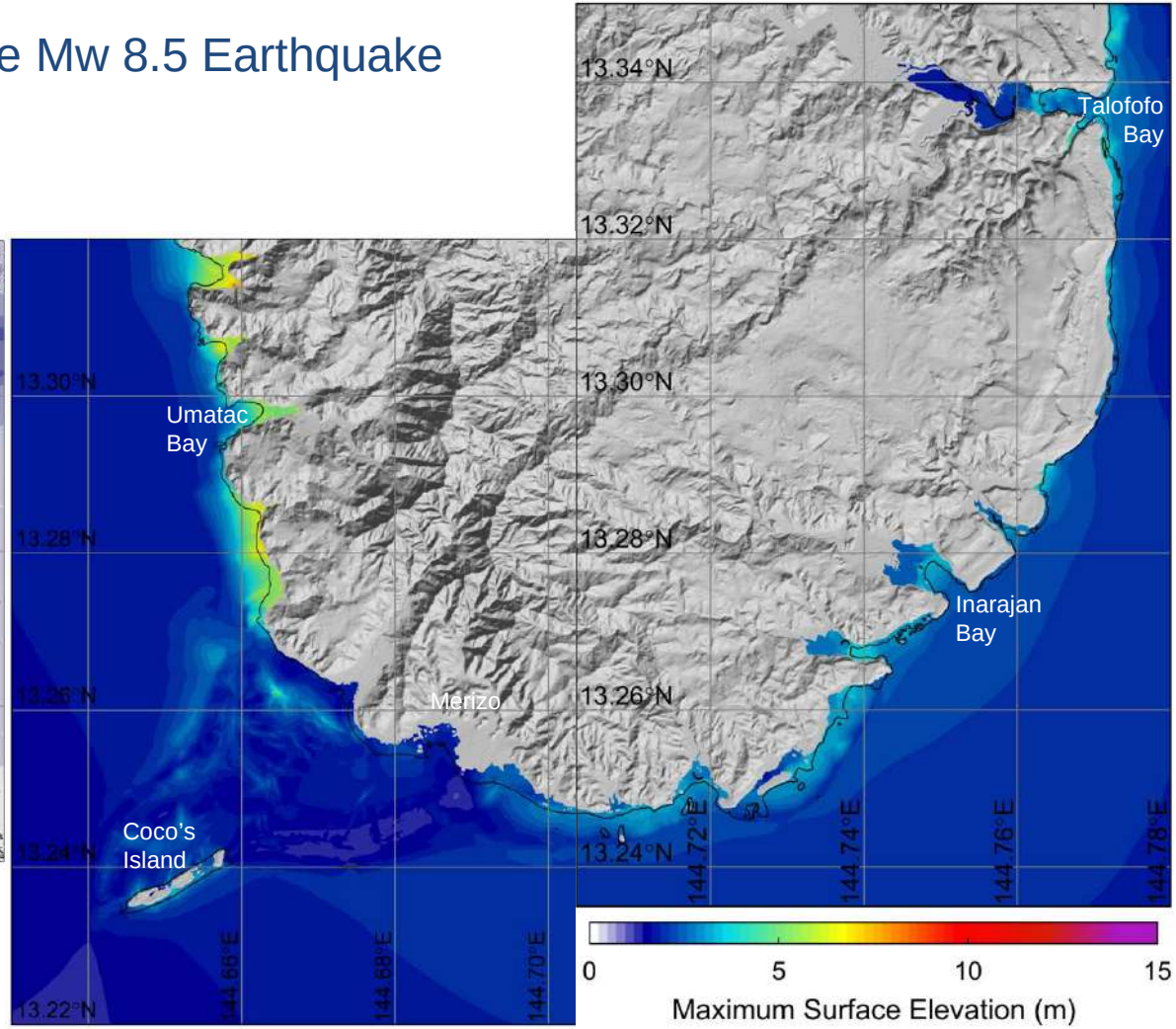




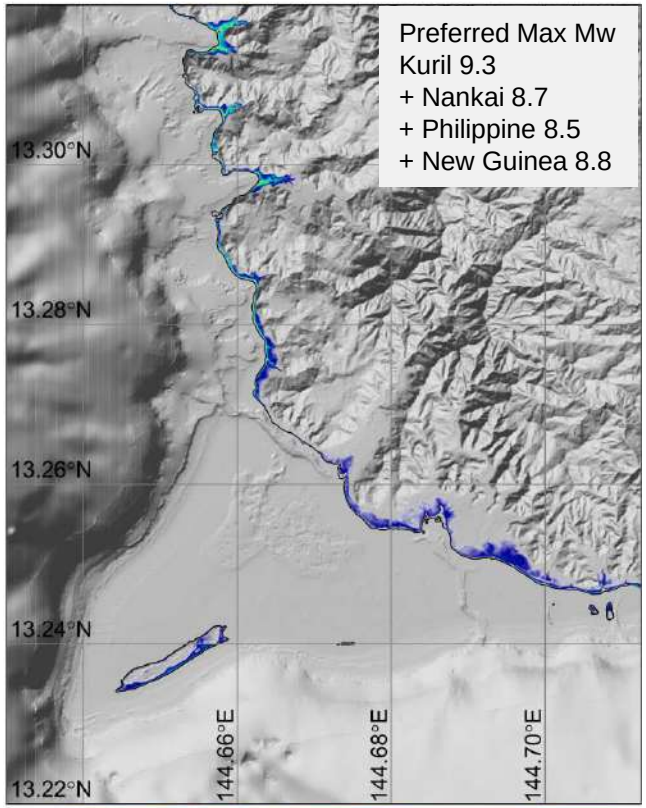
Tsunami Generated by Philippine Mw 8.5 Earthquake

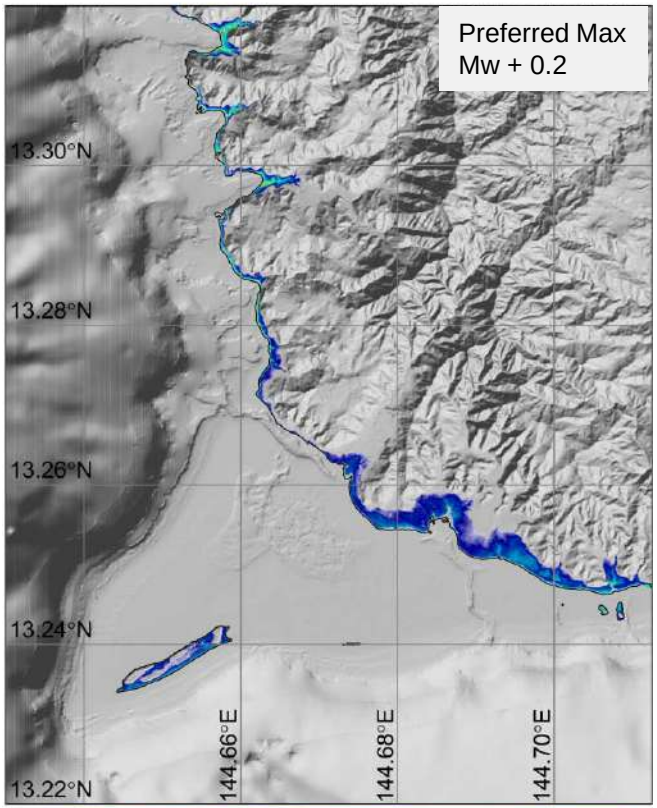
- GEM Preferred Maximum
- Computed at MHHW Level

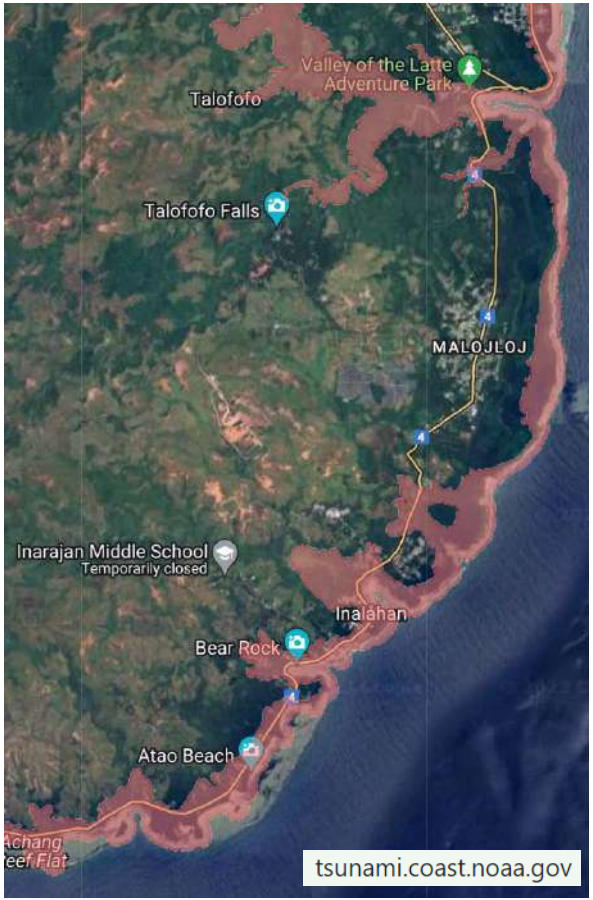




Existing Evacuation and Updated (Distant Tsunami) Inundation Maps



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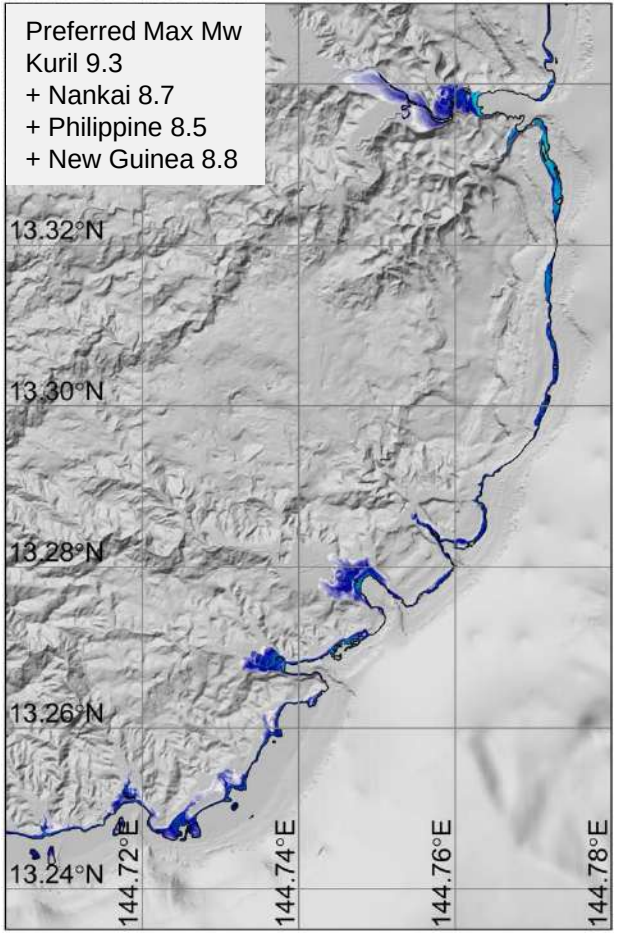
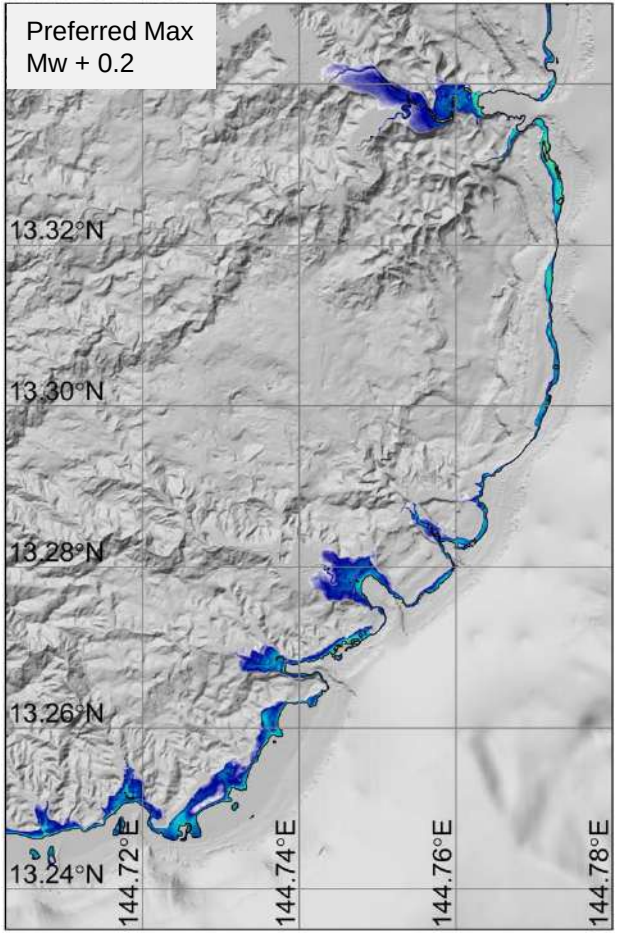

Preferred Max Mw
Kuril 9.3
+ Nankai 8.7
+ Philippine 8.5
+ New Guinea 8.8
13.32°N
13.30°N
13.28°N
13.26°N
13.24°N
144.72°E
144.74°E
144.76°E
144.78°E
0
5
10
15+
Maximum Flow Depth (m)


Preferred Max
Mw + 0.2
13.32°N
13.30°N
13.28°N
13.26°N
13.24°N
144.72°E
144.74°E
144.76°E
144.78°E
0
5
10
15+
Maximum Flow Depth (m)

Conclusions and Recommendations

Existing evaluation maps
- Too conservative for most locations due to arbitrarily selected Mw and extrapolation of low resolution results
- Underestimation of impacts on the south side especially Coco Island

Mariana tsunamis
- Arrival time of ~10 min at southeast shore with 8~16 m runup (preferred max) and insufficient time for warning
- Public education to ensure self-evacuation at nature's warning signs

Distant tsunamis
- Arrival time of ~2.5 hr from the nearest Philippine and New Guinea subduction zones with 4~7 m runup (preferred max)

Two-zone evacuation maps
- Hawaii for Aleutian Mw 9.0 or greater and all other subduction zone earthquakes
- Oregon for local and distant tsunami
- Option for Guam