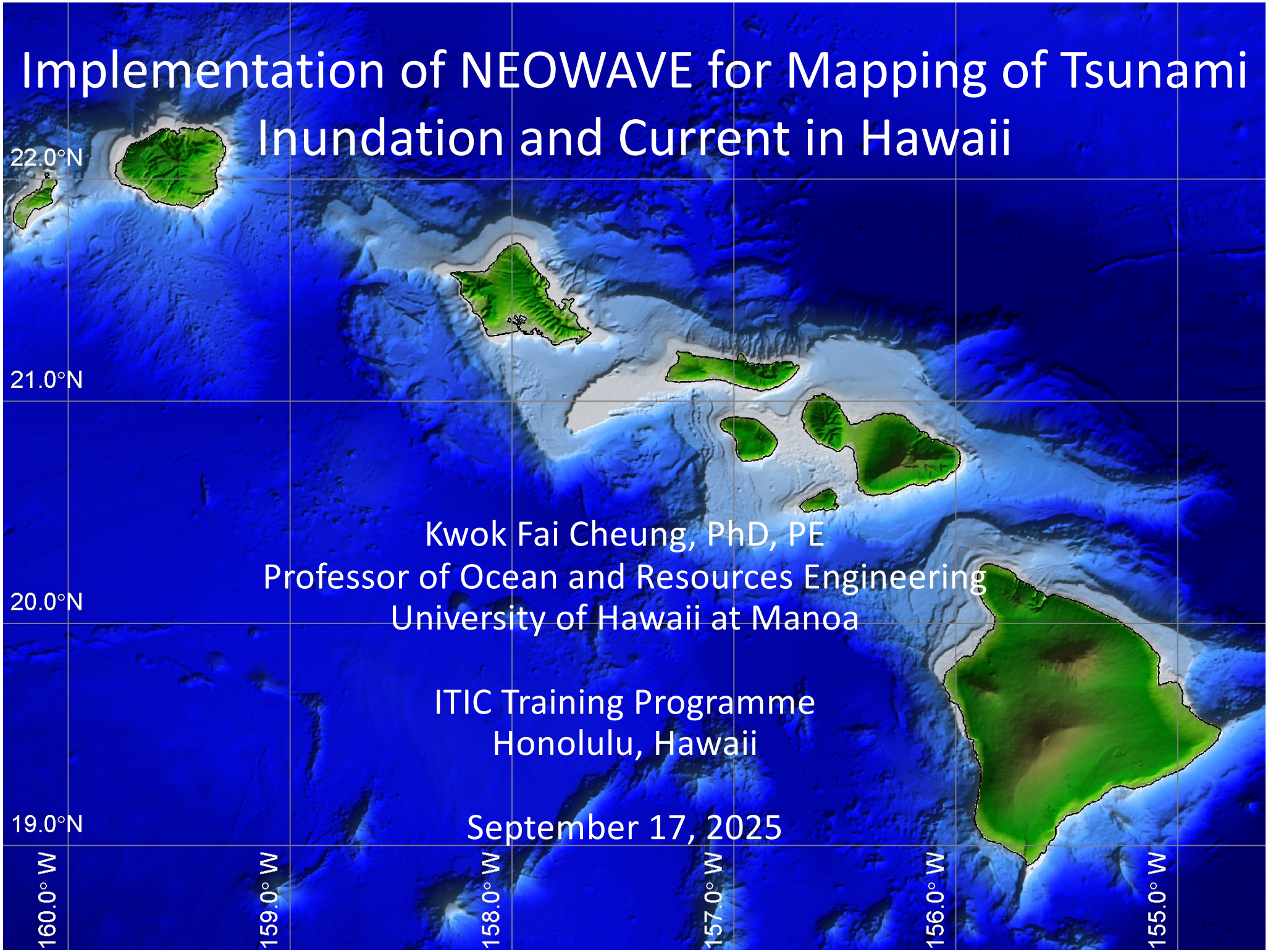
Implementation of NEOWAVE for Mapping of Tsunami Inundation and Current in Hawaii

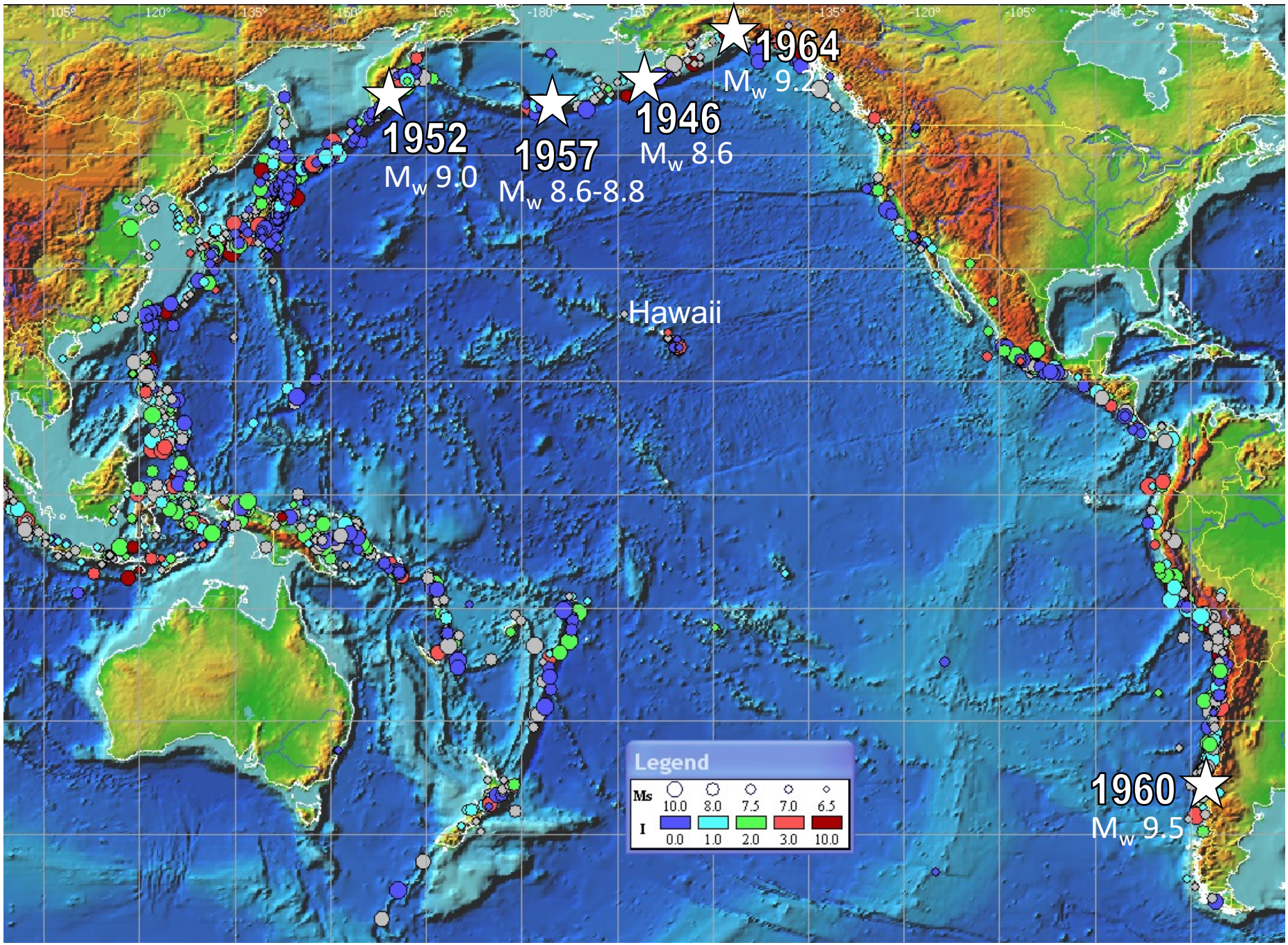


Kwok Fai Cheung, PhD, PE
Professor of Ocean and Resources Engineering
University of Hawaii at Manoa

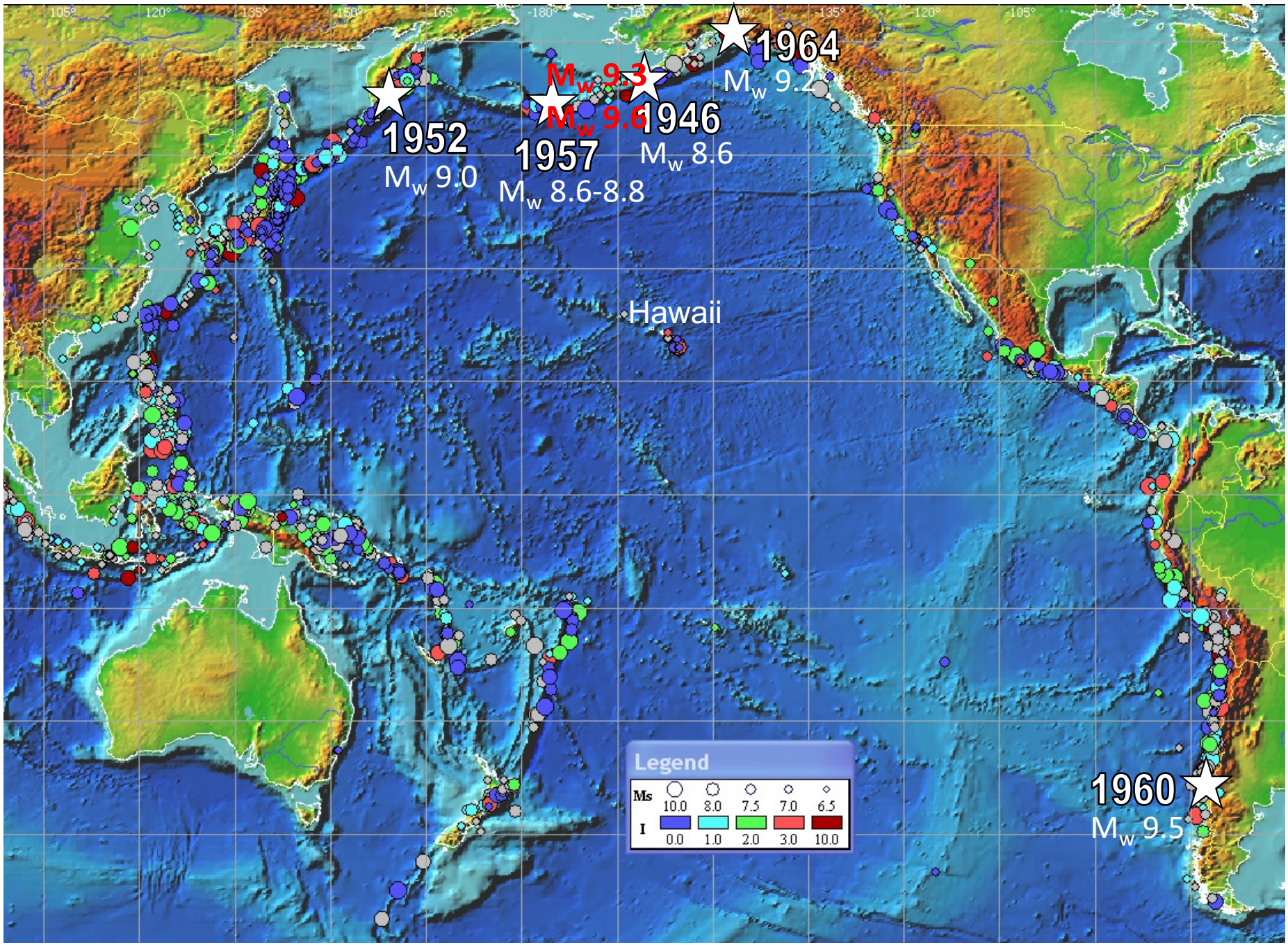
ITIC Training Programme
Honolulu, Hawaii

September 17, 2025

Historical (USGS M_w) and Hypothetical Tsunamis for Inundation and Evacuation Mapping in Hawaii



Historical (USGS M_w) and Hypothetical Tsunamis for Inundation and Evacuation Mapping in Hawaii



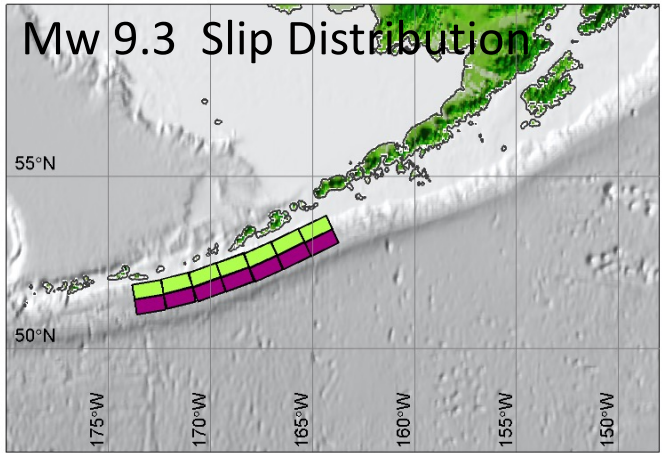
Tsunami Sources

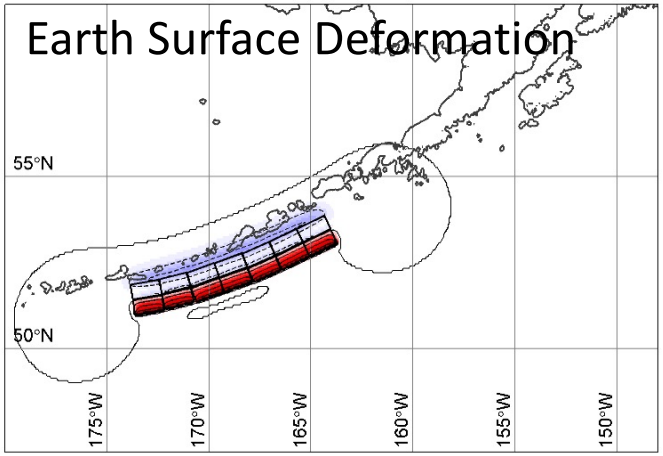
Two source models

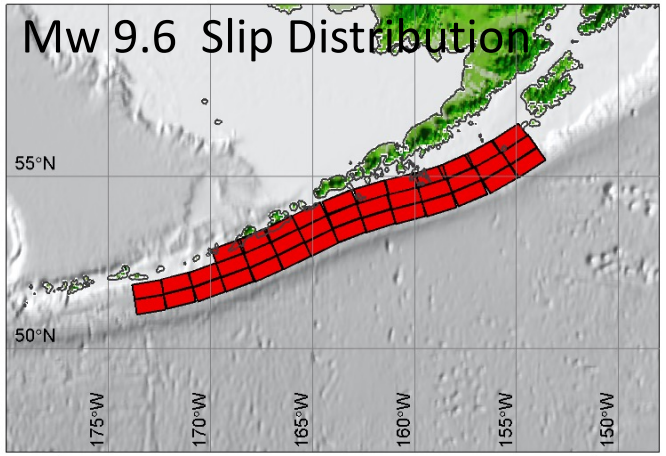
- Mw 9.3 and 9.6 with with 35 m average slip
- Based on NOAA PMEL fault discretization and parameters

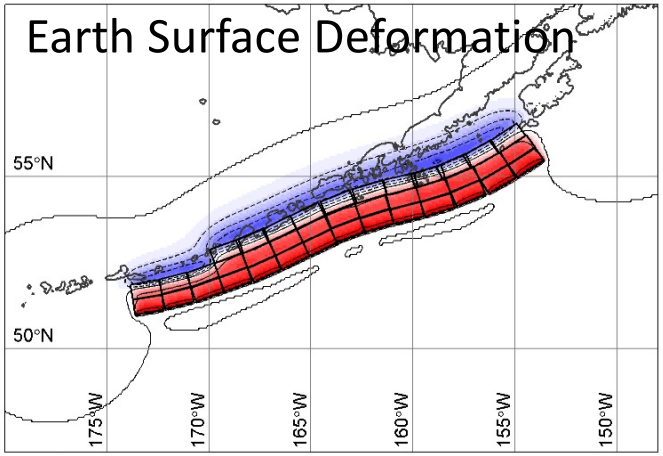
Earth surface deformation

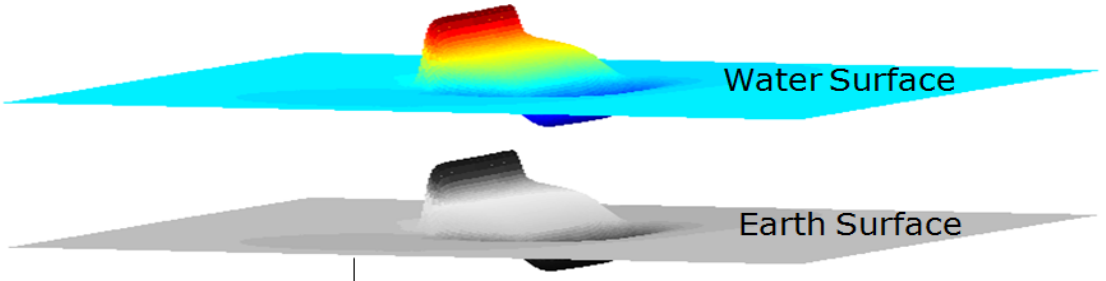
- Planar fault model of Okada (1984 BSSA)
- Superposition of subfault contributions for “static” earth surface deformation
- Mw 9.3: 21.8 m uplift and 4.6 m subsidence
- Mw 9.6: 15.7 m uplift and 8.2 m subsidence

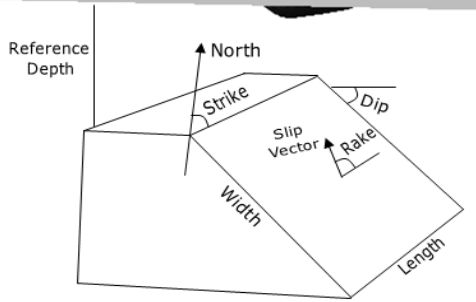




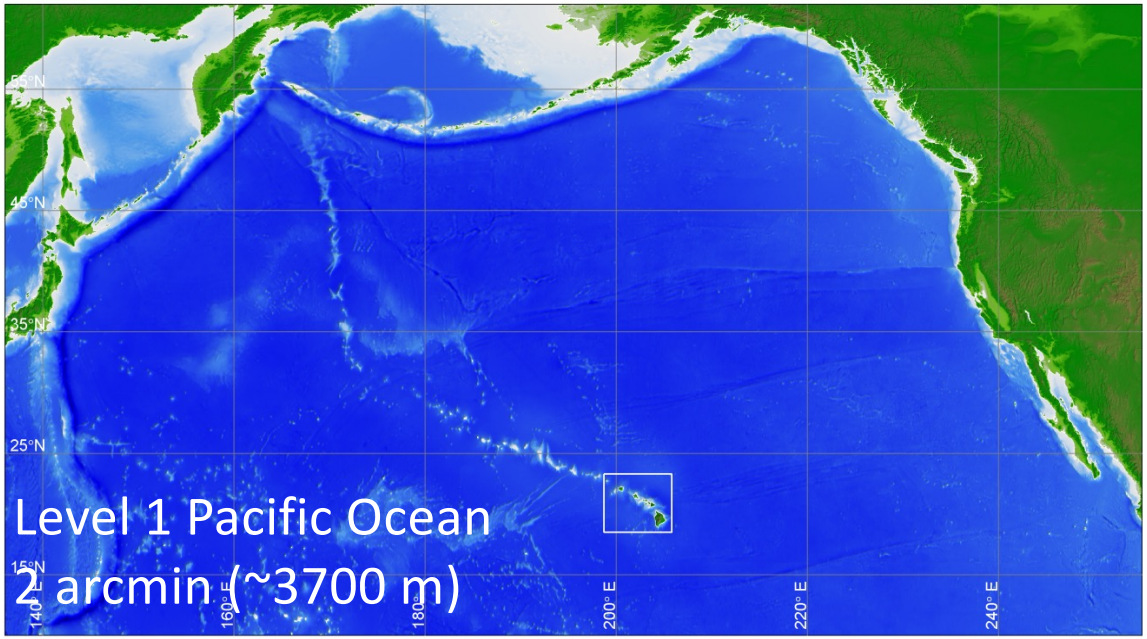


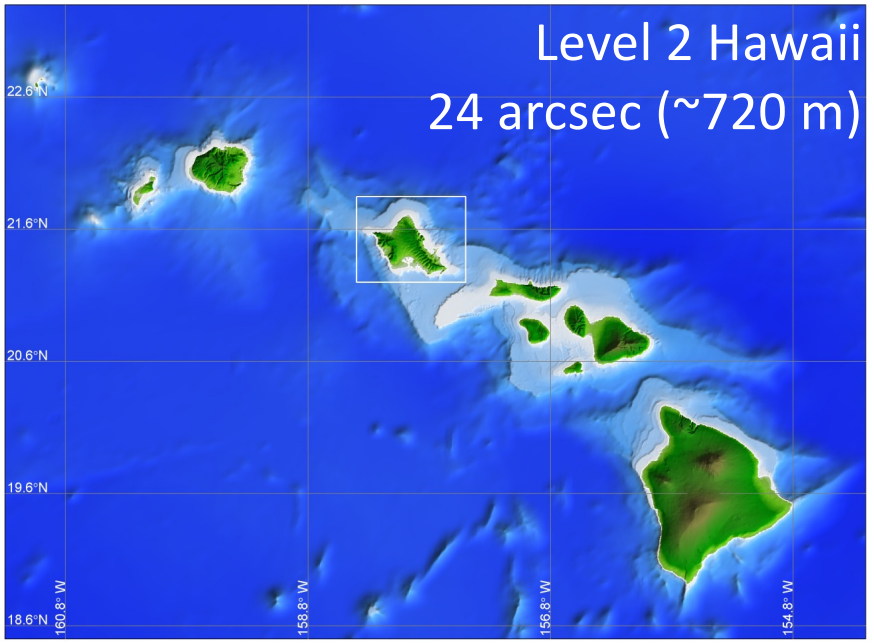


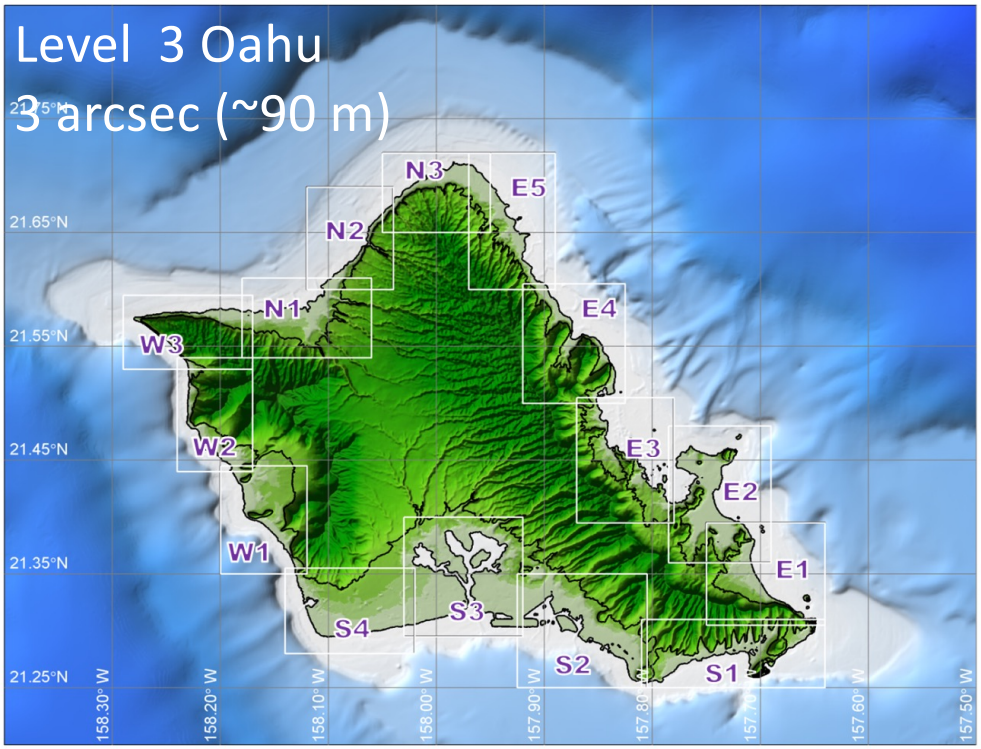


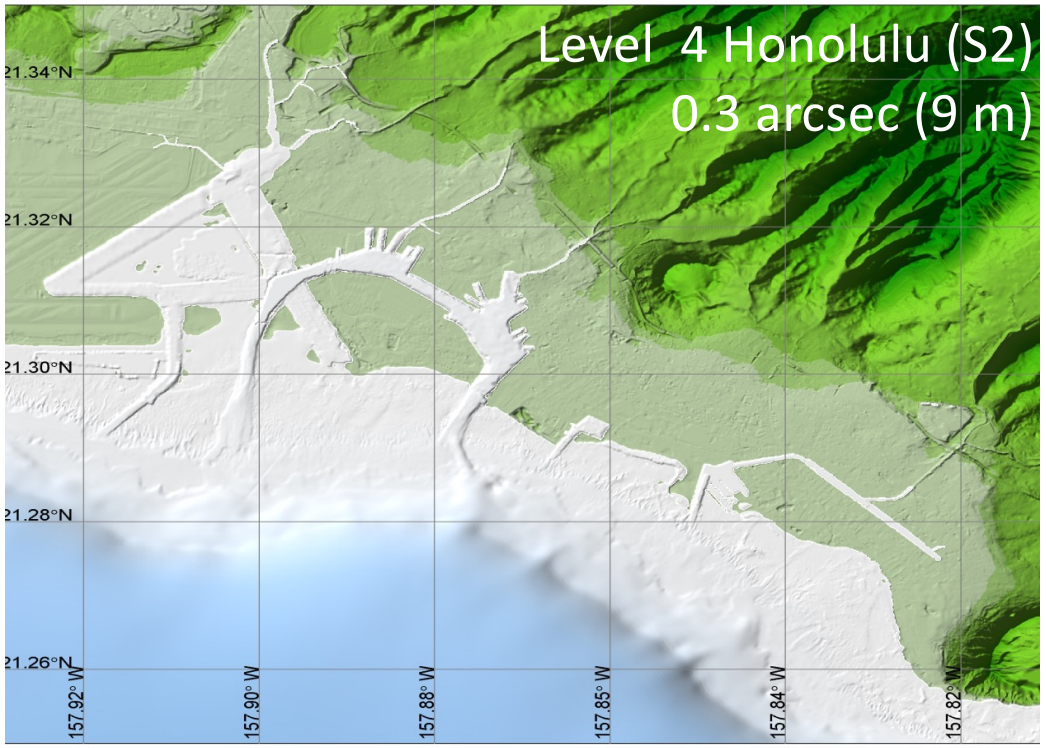


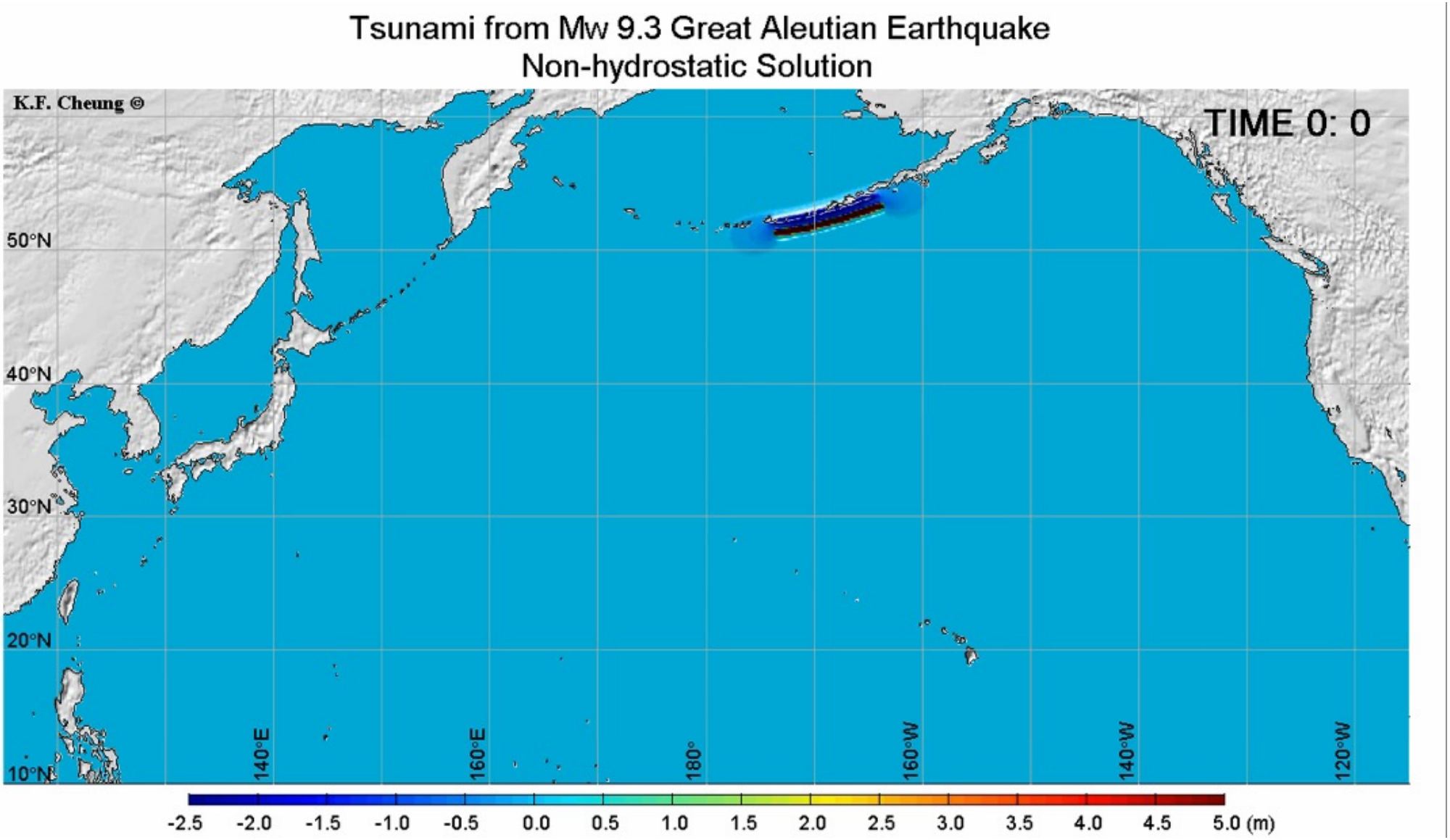
Systems of Two-way Nested Grids



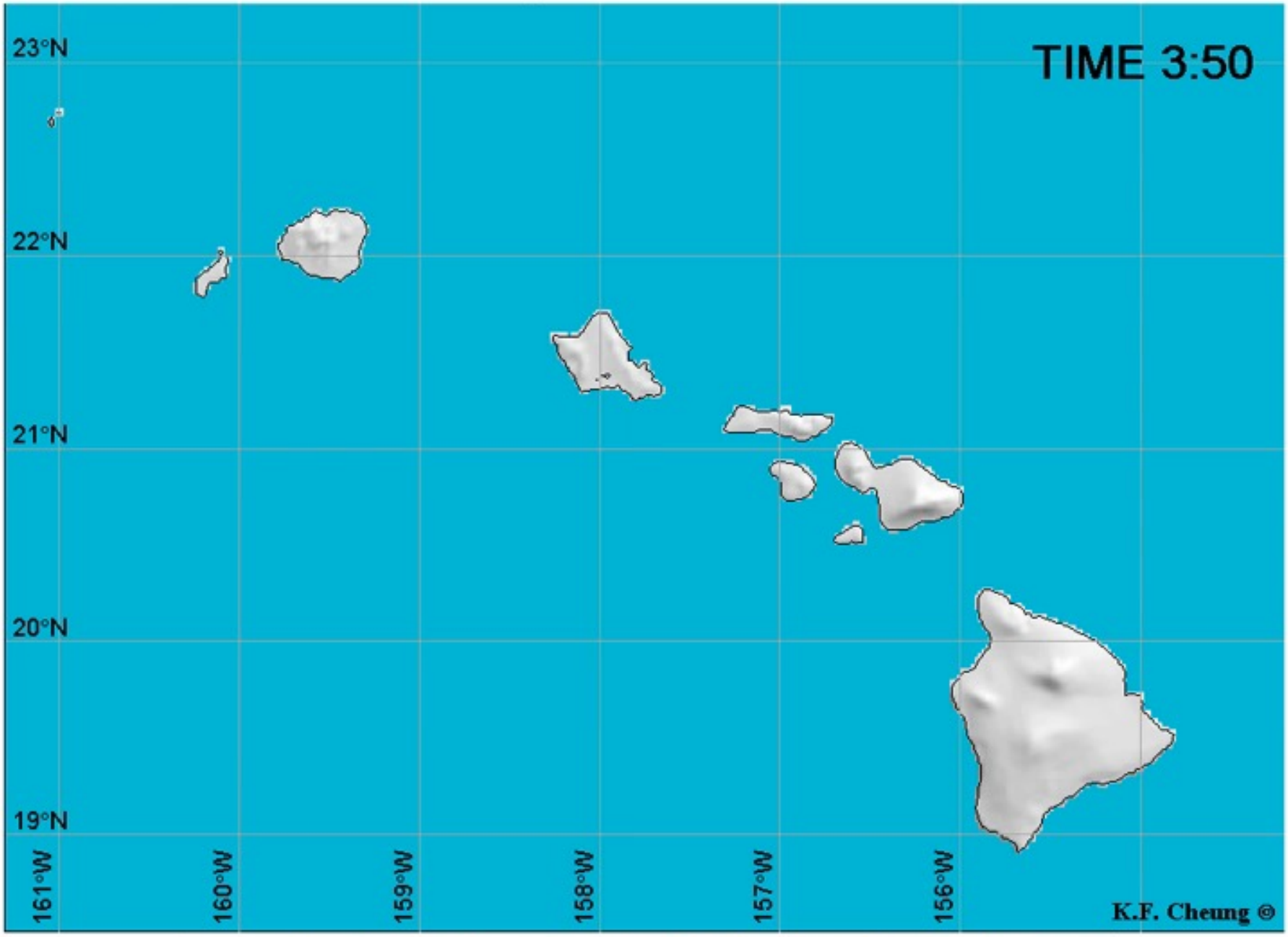




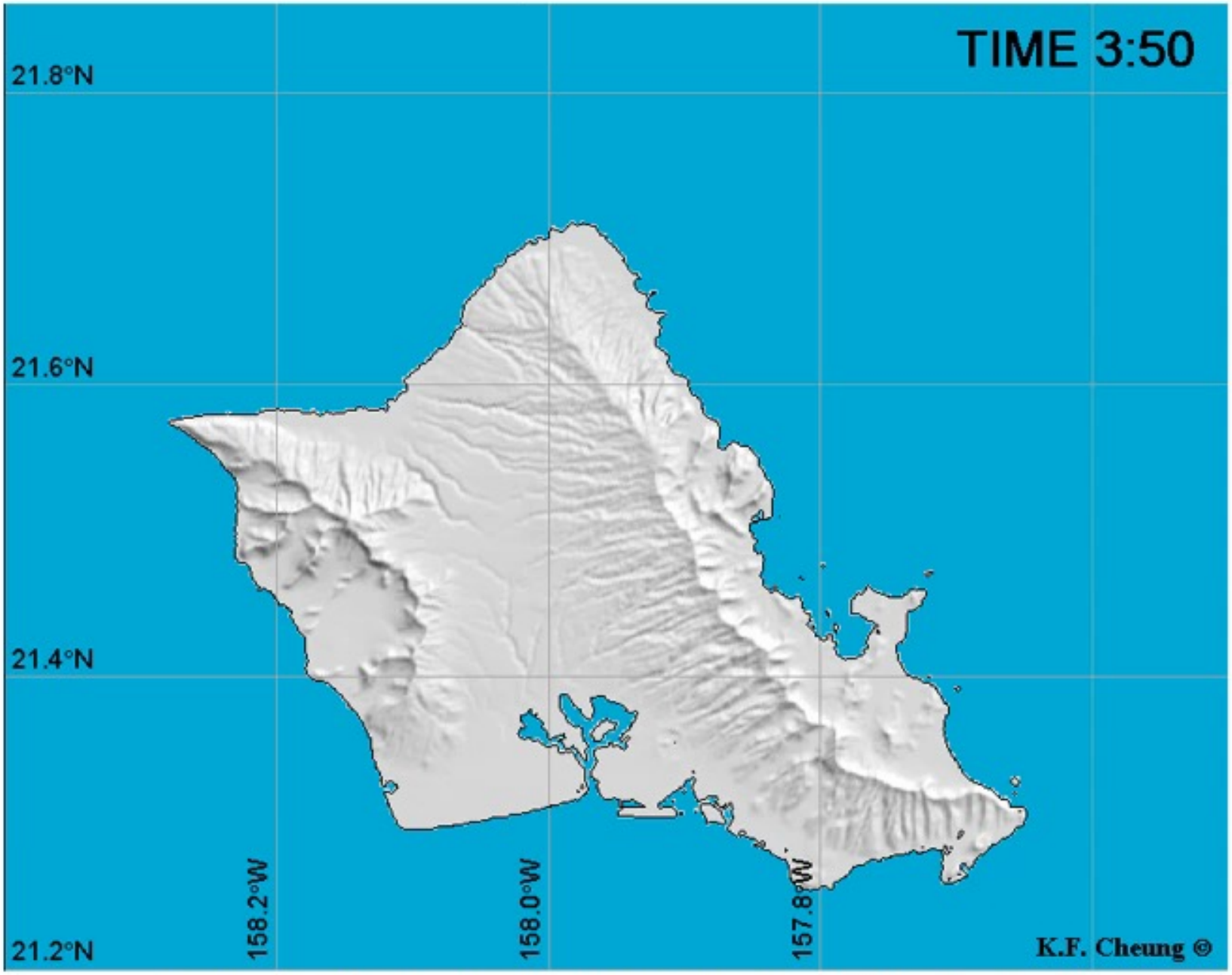



Tsunami from Mw 9.3 Great Aleutian Earthquake
Non-hydrostatic Solution
K.F. Cheung ©
TIME 0: 0
50°N
40°N
30°N
20°N
10°N
140°E
160°E
180°
160°W
140°W
120°W
-2.5 -2.0 -1.5 -1.0 -0.5 0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 (m)

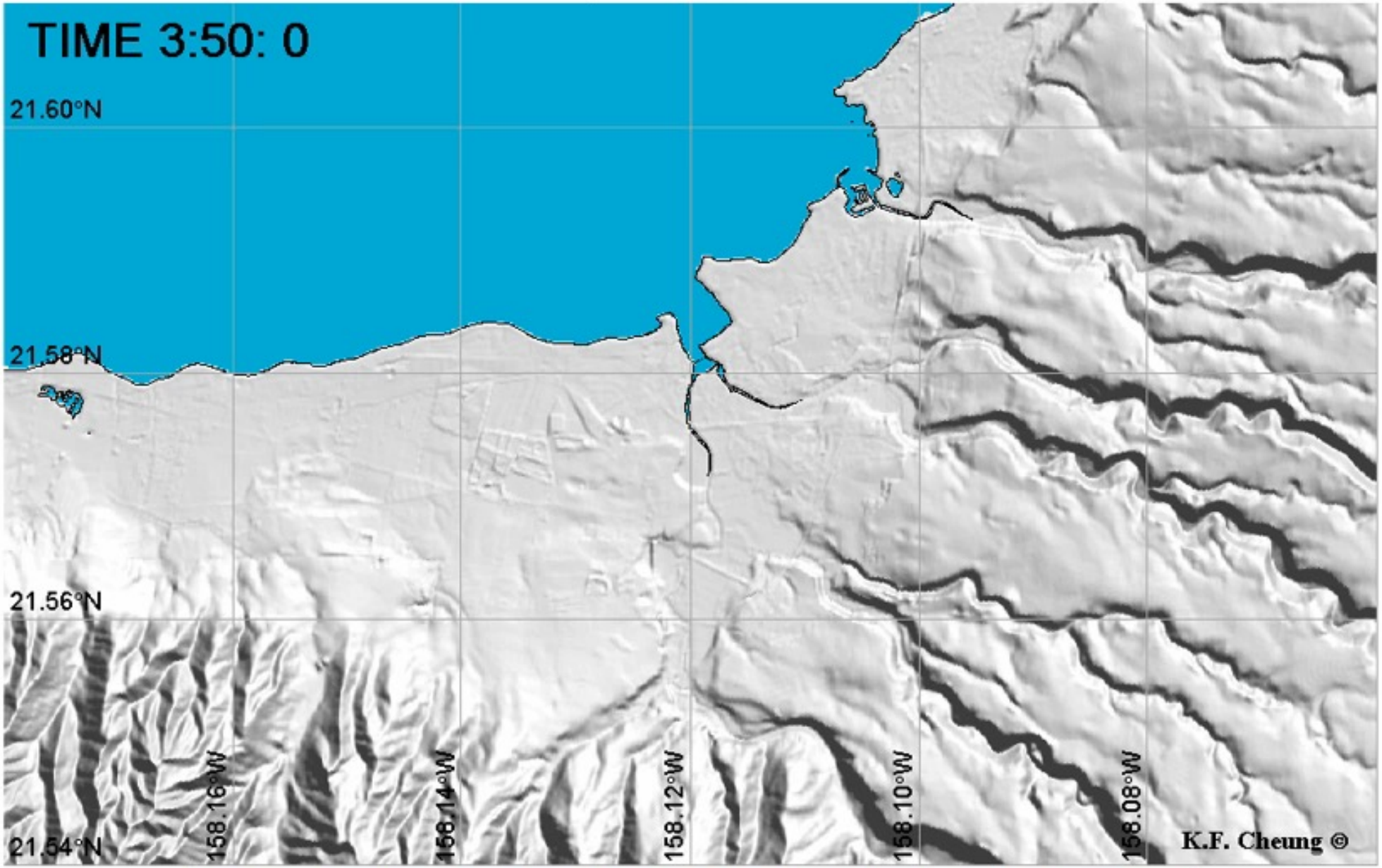
Tsunami from Mw 9.3 Great Aleutian Earthquake
Non-hydrostatic Solution



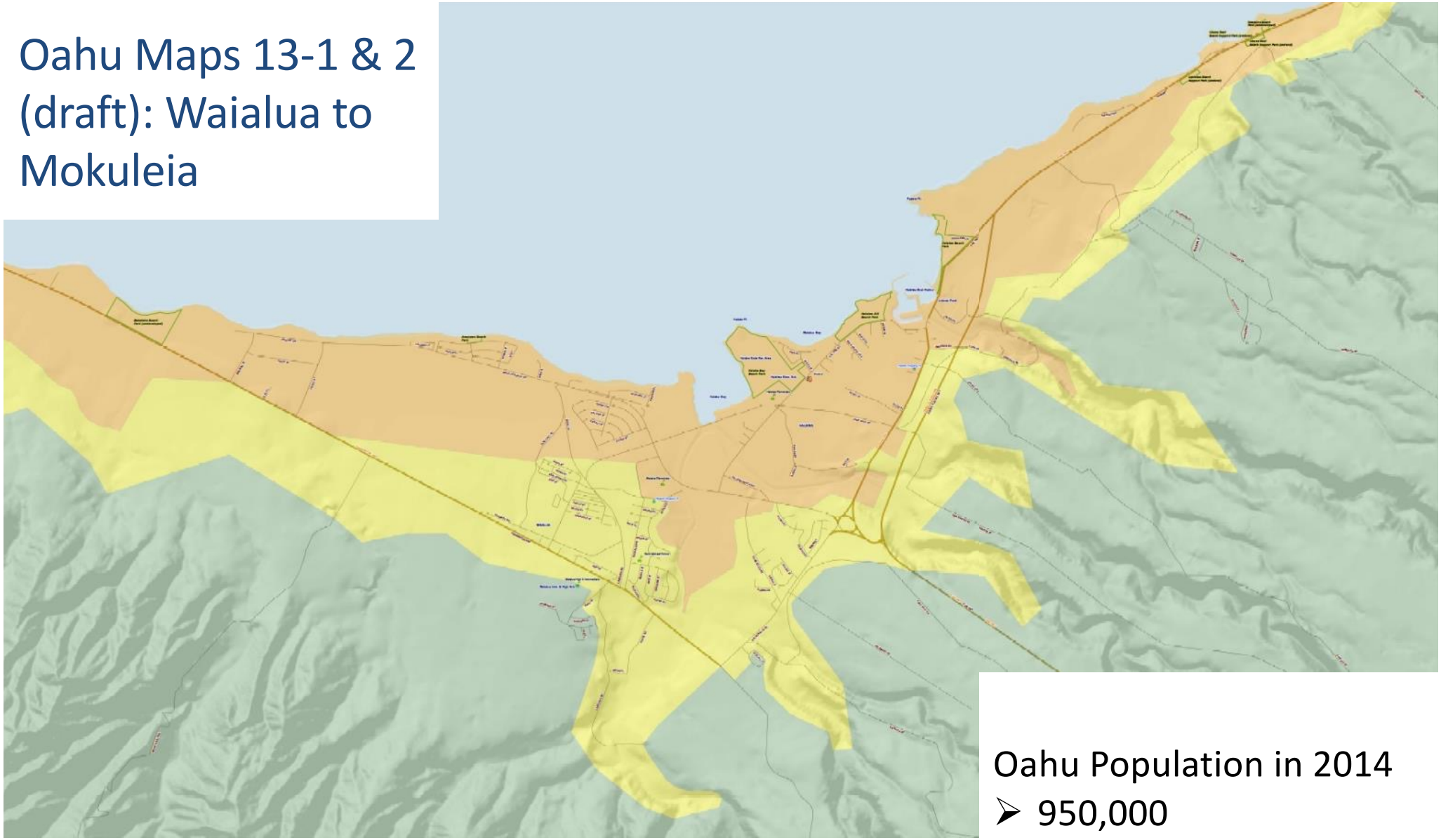
Tsunami from Mw 9.3 Great Aleutian Earthquake
Non-hydrostatic Solution

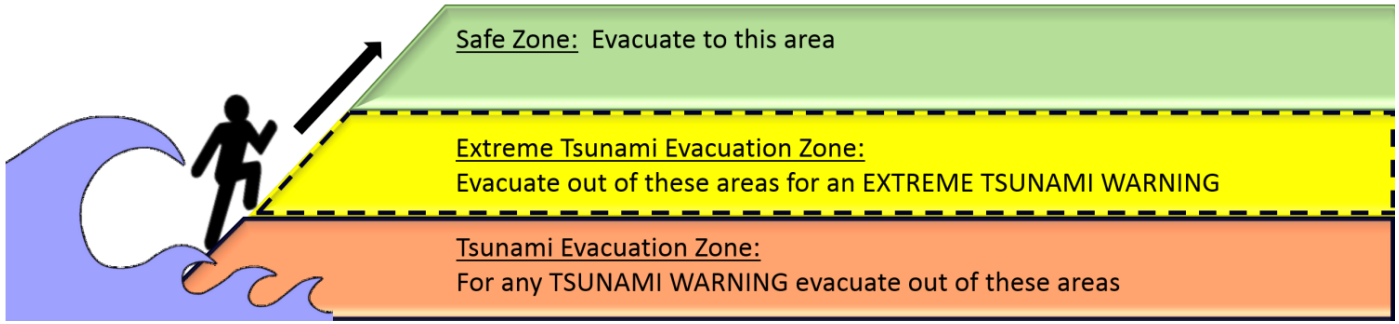


Tsunami from Mw 9.3 Great Aleutian Earthquake
Non-hydrostatic Solution



Oahu Maps 13-1 & 2 (draft): Waialua to Mokuleia





Oahu Population in 2014

- 950,000
- 530,000 (56%)
- 330,000 (35%)
- 90,000 (9%)

Maritime Hazard Mapping

USCG District-14 Responses to Tsunamis

- Integrated plan for Hawaii and American Samoa
- Warning (forecast water-level rise > 1 m): Evacua
  of ships and shore personnel
- Advisory (inundation not imminent, but expect
  strong currents): Severe Weather Plan

Data Products (with community input)

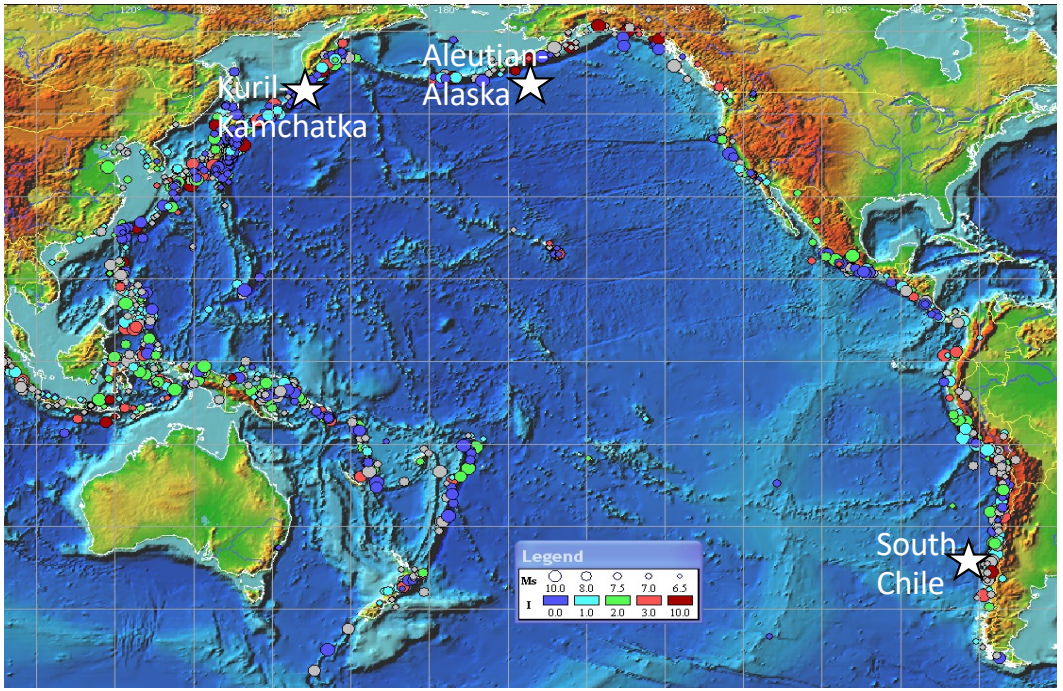
- Offshore currents from Mw 9.3 and 9.6 Aleutian tsunami scenarios for evaluation of safe zones, presently defined outside the 100-m depth contour
- In-harbor hazard maps of current, surge & drawdown for advisory-level tsunamis

Database of scenarios

- Three major subduction zones
- Earthquake at 0.1 Mw increments up to ~1 m nearshore wave amplitude
- Modeling at the present MSL

Operation modes:

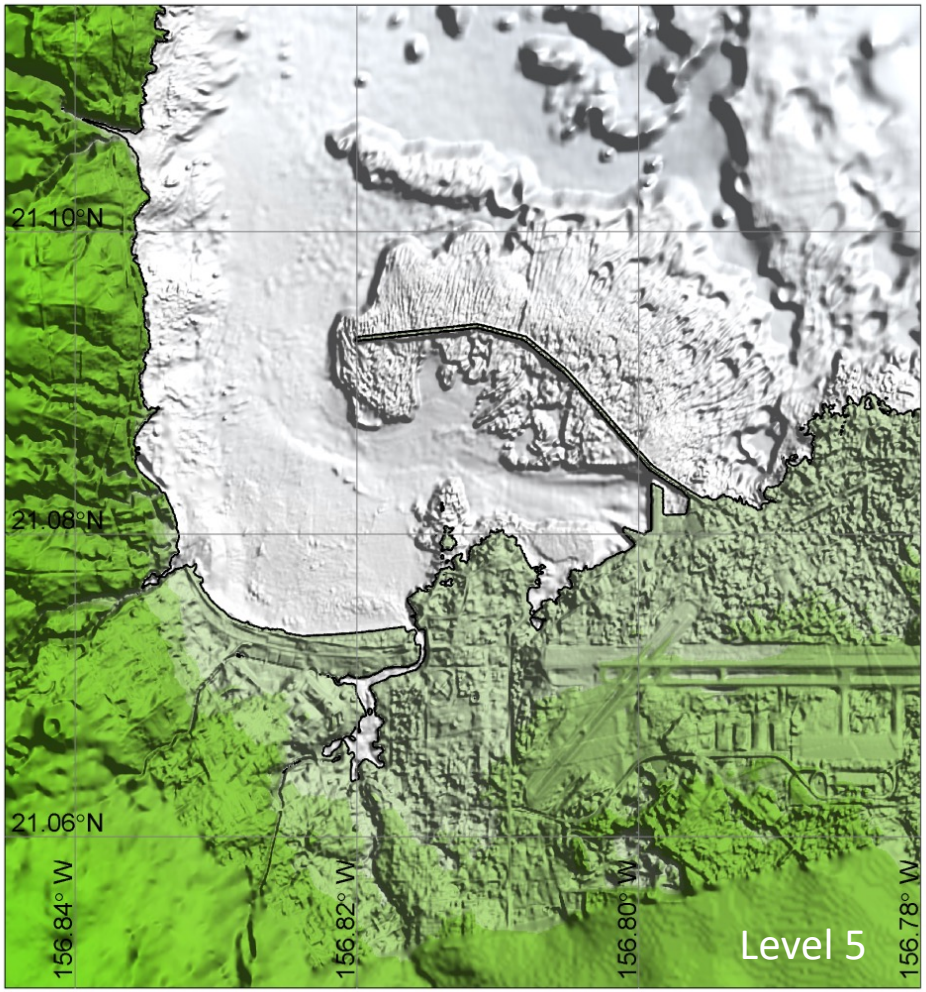
- Earthquake location and magnitude – surge, drawdown, and current

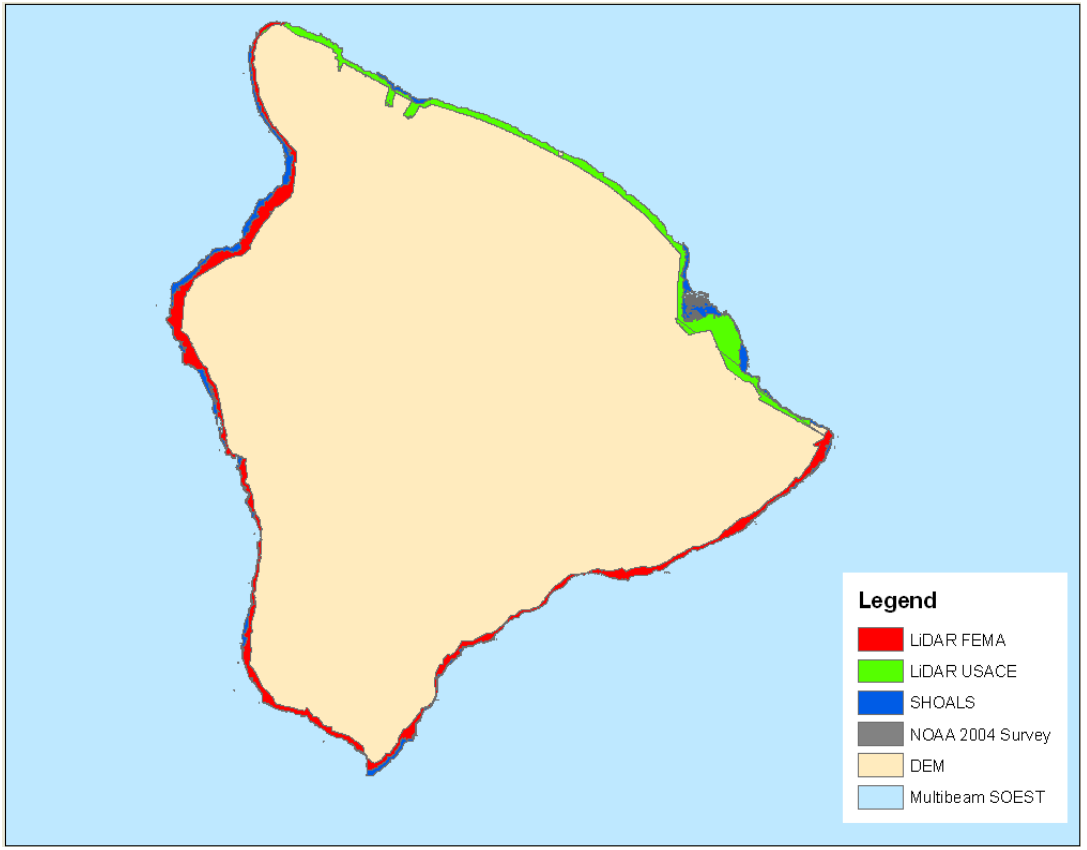


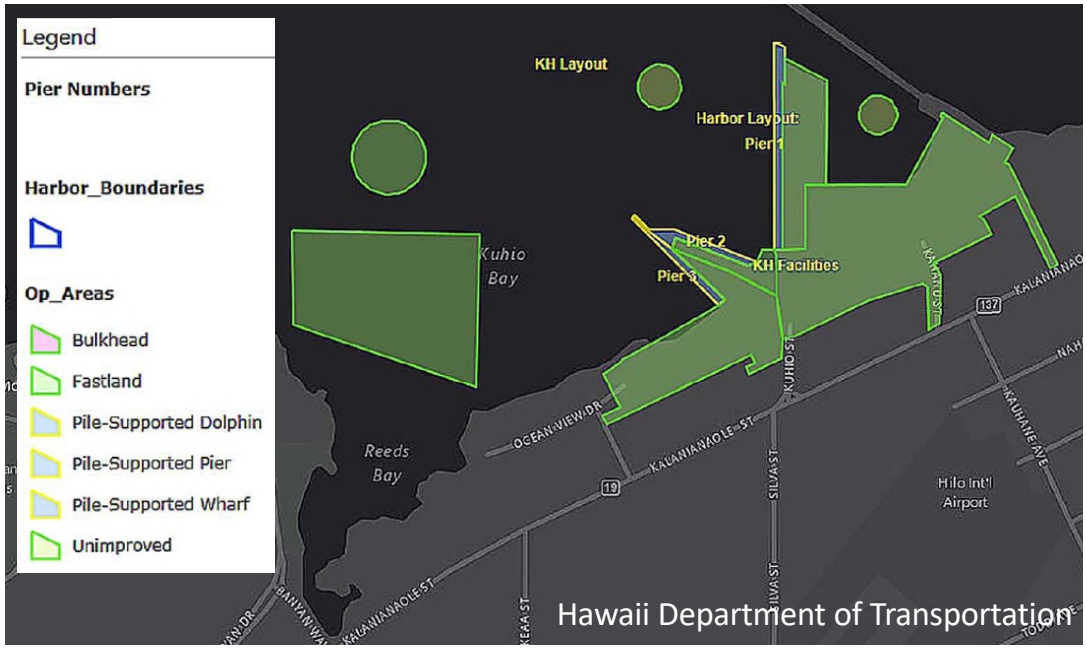
Digital Elevation Model

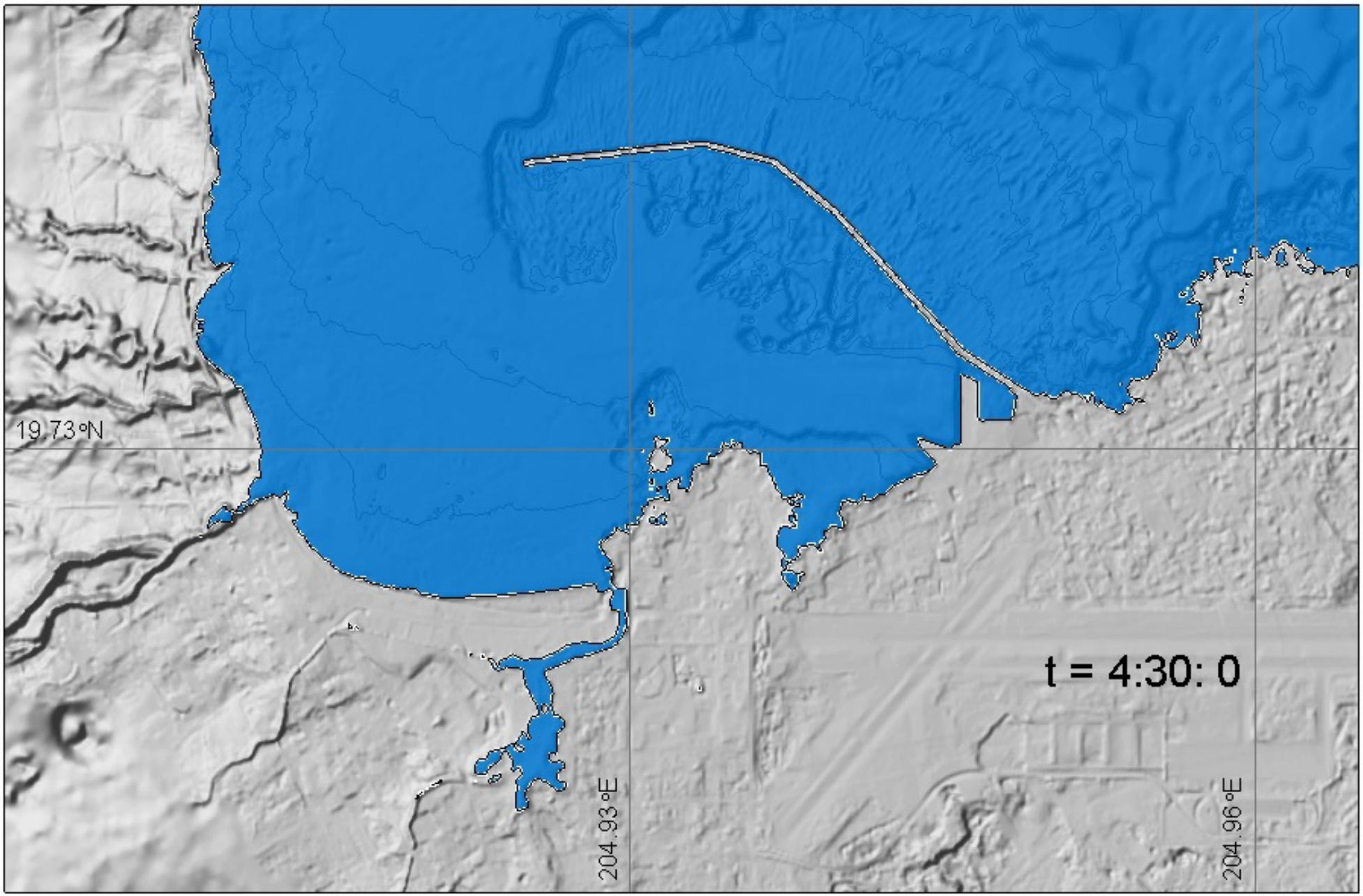
High Resolution Data

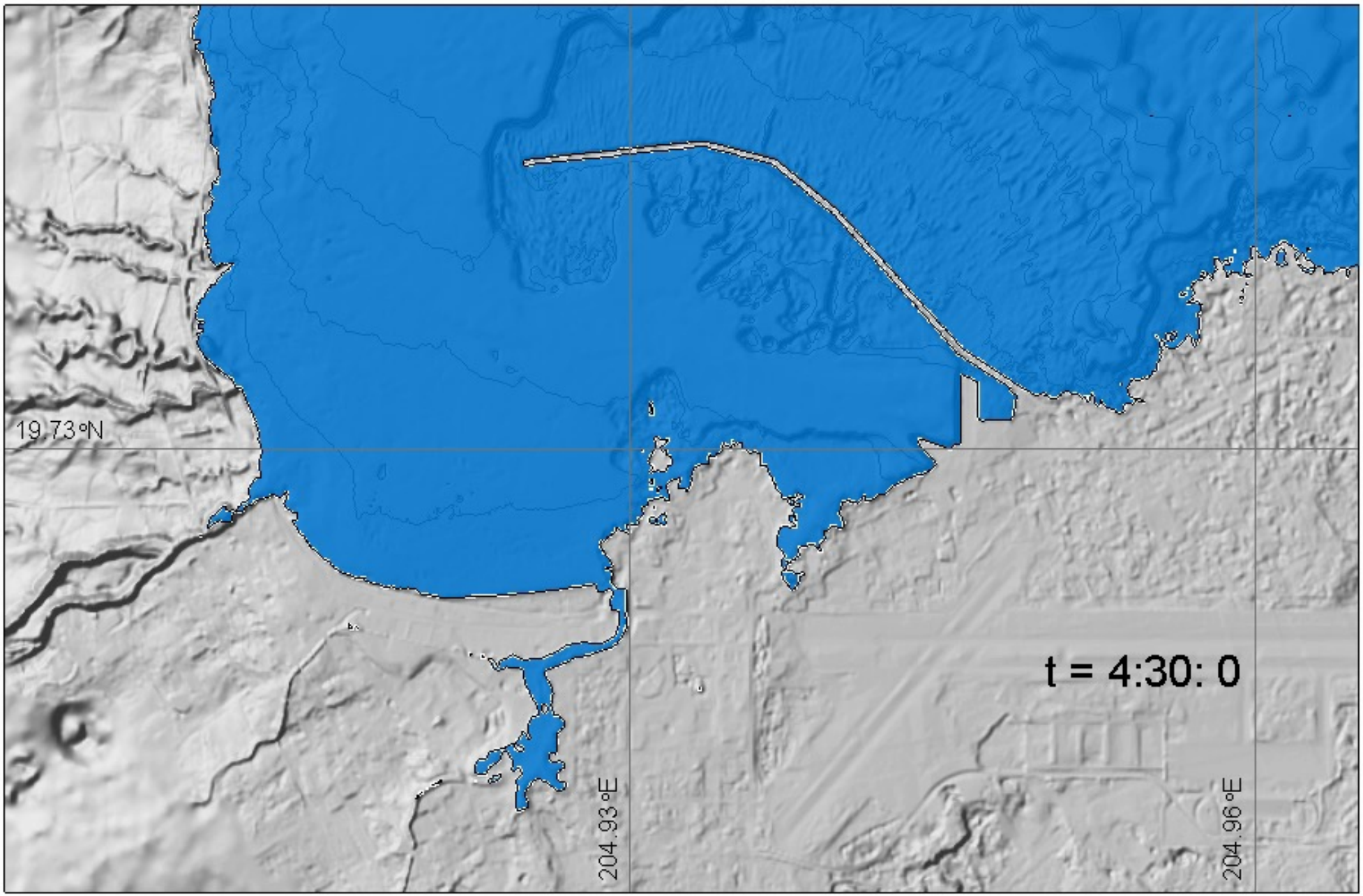
- FEMA and USACE LiDAR (1 ~ 3 m resolution)
- UH SOEST multibeam data (50 m)
- USACE hydrographic survey data
- Facility plans from HDOT

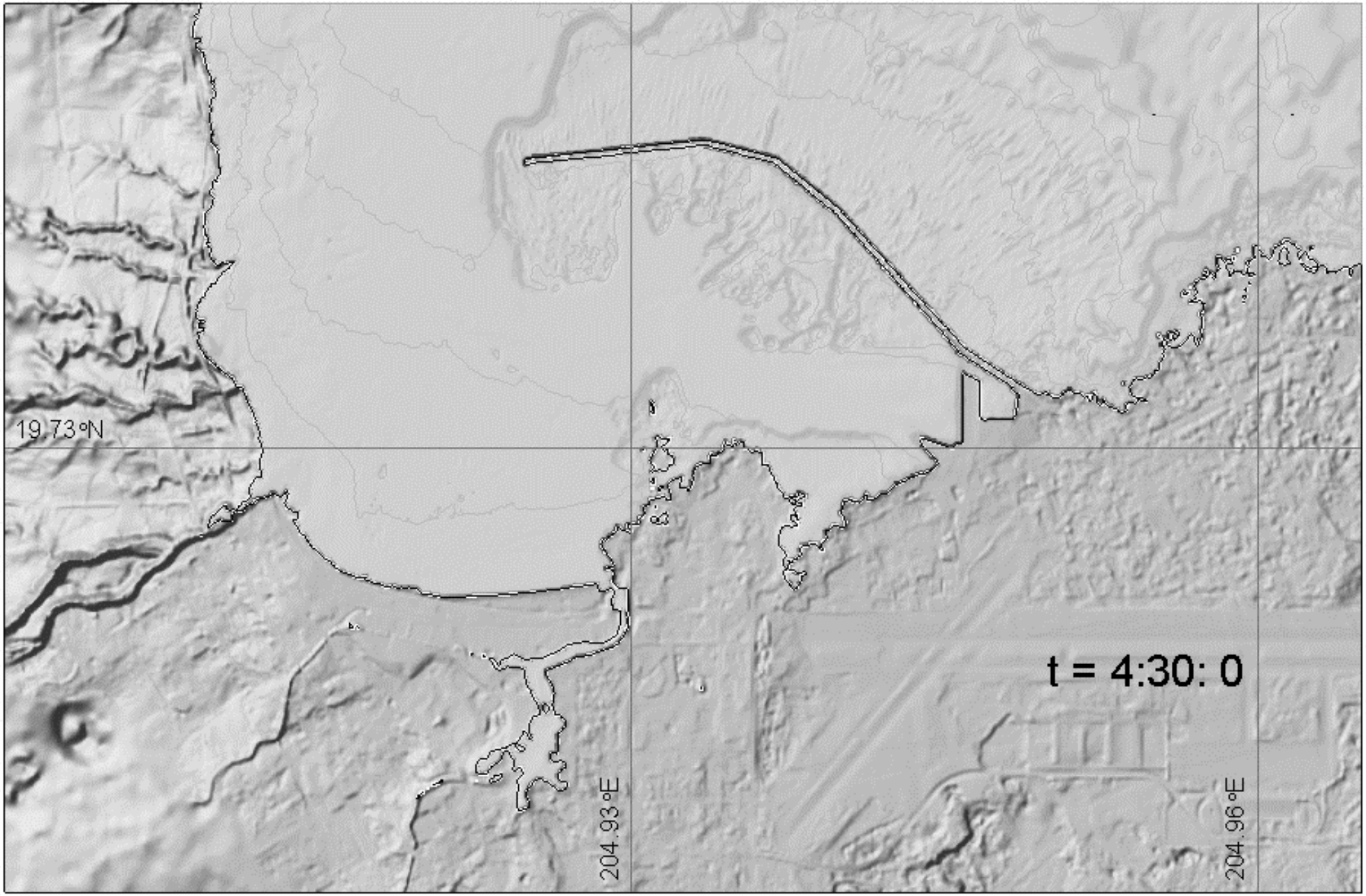


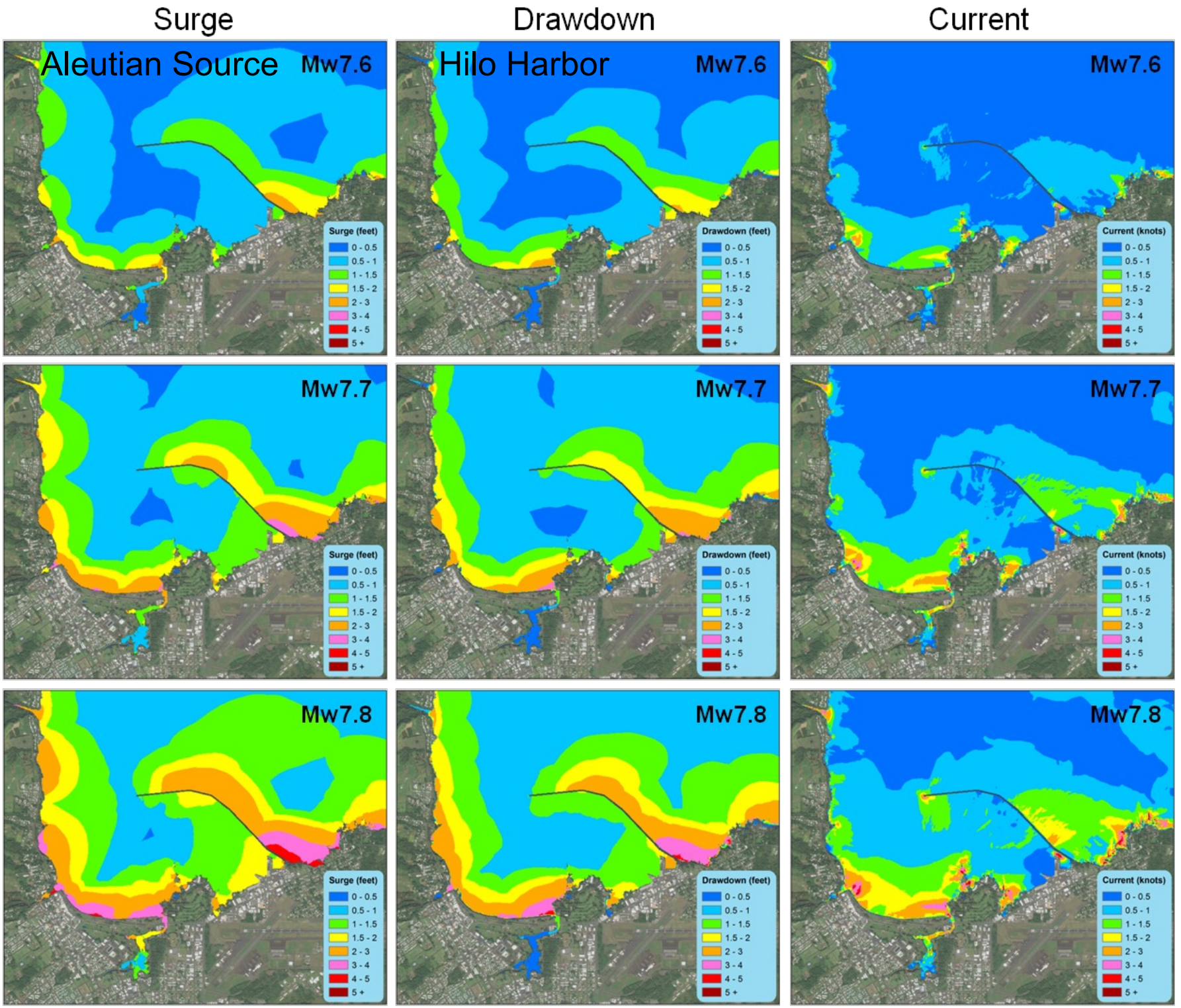





19.73°N
204.93°E
204.96°E
t = 4:30: 0
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
m


19.73°N
204.93°E
204.96°E
t = 4:30: 0
0
0.3
0.6
0.9
1.2
1.5 m/s


19.73°N
204.93°E
204.96°E
t = 4:30: 0


Surge
Drawdown
Current
Aleutian Source
Mw7.6
Hilo Harbor
Mw7.6
Mw7.6
Mw7.7
Mw7.7
Mw7.7
Mw7.8
Mw7.8
Mw7.8
Surge (feet)
Drawdown (feet)
Current (knots)
0 - 0.5
0.5 - 1
1 - 1.5
1.5 - 2
2 - 3
3 - 4
4 - 5
5 +

USCG Summary Tables

Aleutian Earthquake Magnitude	Hilo Harbor: Water Surface Rise/Fall			Water Current	
	Surge (feet)	Drawdown (feet)	Cycle Time Range (minutes)	Speed (knots)	Cycle Time Range (minutes)
7.6	2.6	2.6	8 - 13	3.5	13
7.7	3.6	3.9	8 - 13	4.5	13
7.8	4.6	4.3	8 - 13	5.2	13 - 20
7.9	6.2	5.2	8 - 13	6.0	13 - 20
8.0	8.2	6.6	8 - 13	7.4	13 - 20
8.1	9.2	8.2	8 - 13	9.3	13 - 20

Aleutian Earthquake Magnitude	Honolulu Harbor: Water Surface Rise/Fall			Water Current	
	Surge (feet)	Drawdown (feet)	Cycle Time Range (minutes)	Speed (knots)	Cycle Time Range (minutes)
7.6	0.6	0.7	9 – 20	0.6	9 – 20
7.7	0.8	0.9	9 – 20	0.7	9 – 20
7.8	1.0	1.2	10 – 20	0.9	9 – 20
7.9	1.3	1.5	10 – 20	1.2	9 – 20
8.0	1.8	2.0	10 – 20	1.6	9 – 20
8.1	2.2	2.4	10 – 20	2.1	10 – 20
8.2	3.0	3.3	10 – 20	2.7	10 – 20
8.3	3.6	4.3	10 – 21	3.5	10 – 21
8.4	4.7	4.7	11 – 21	4.8	11 – 21

Modeling and Mapping: Maritime Hazard Maps II

Hawaii Harbor 2050 Master Plans

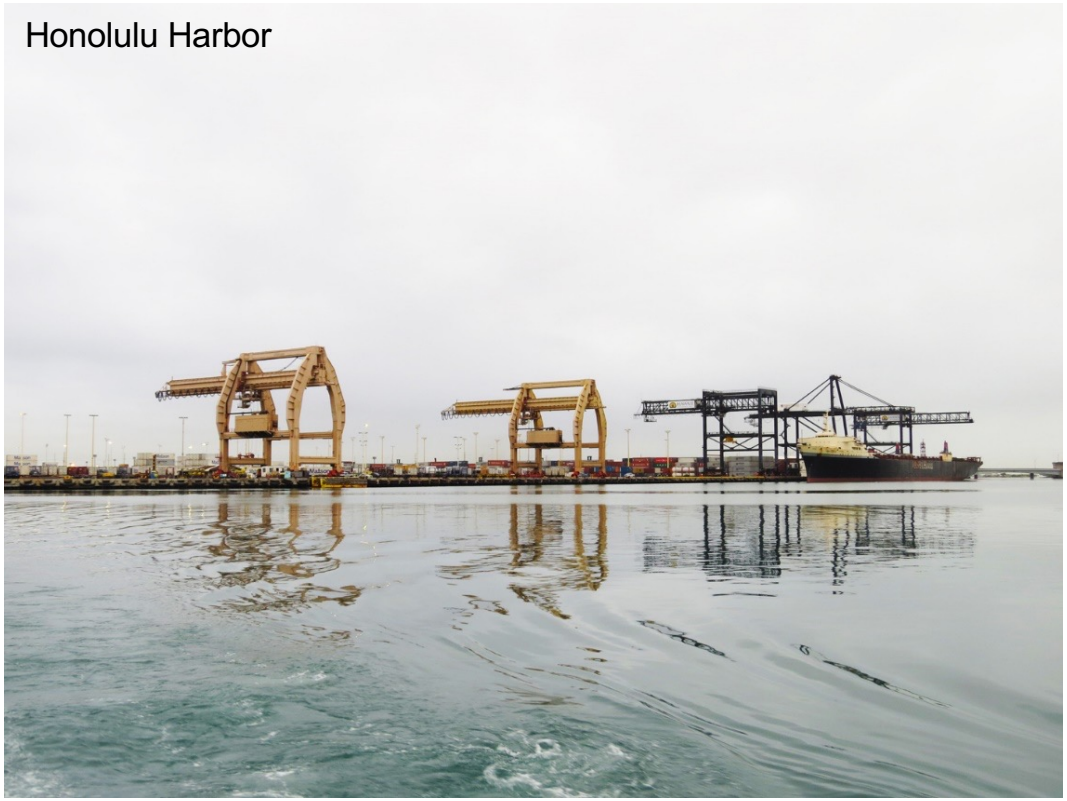
- Hawaii Department of Transportation – Harbor Division
- Infrastructure development and retrofit for nine commercial harbors
- Inclusion of sea-level rise, hurricanes, and tsunamis

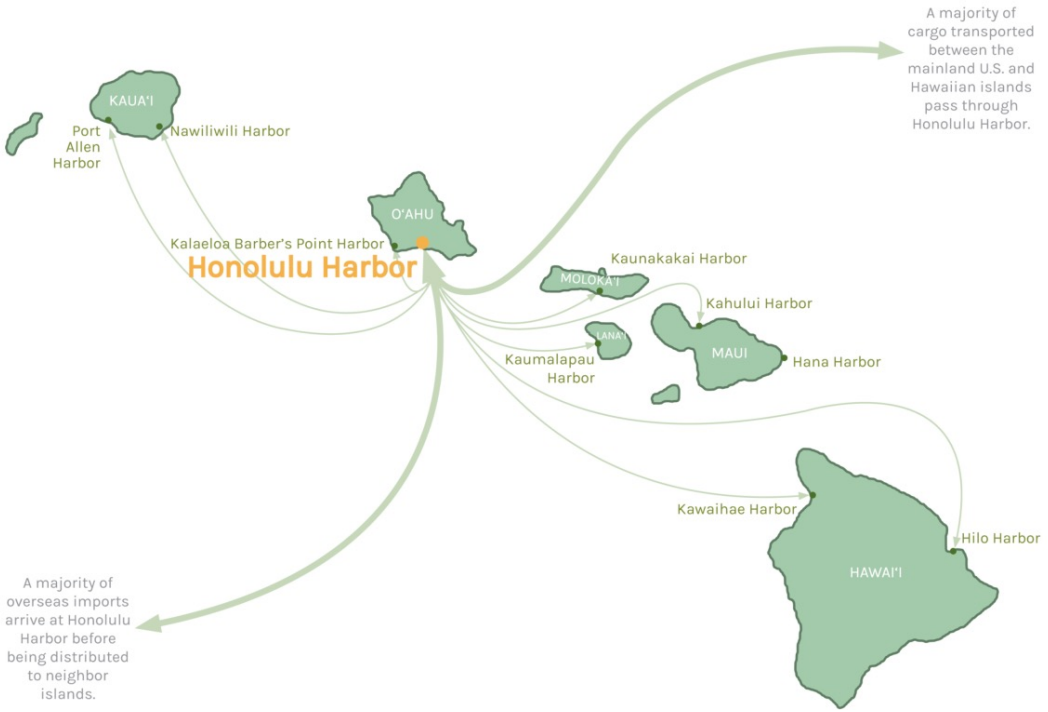
Maritime Hazard Maps

- Surge, drawdown, and current for 200 and 500-year events
- Reassessment of tsunami hazards with 700 years of paleodeposit data in the Aleutian and Hawaiian Islands
- Existing elevations with sea-level rise

Hawaii DOT & Harbor Users Group

- Subsequent vulnerability assessment
- Prioritization of redevelopment and retrofit of port facilities
- Planning and design of harbor facilities to increased resiliency


Honolulu Harbor



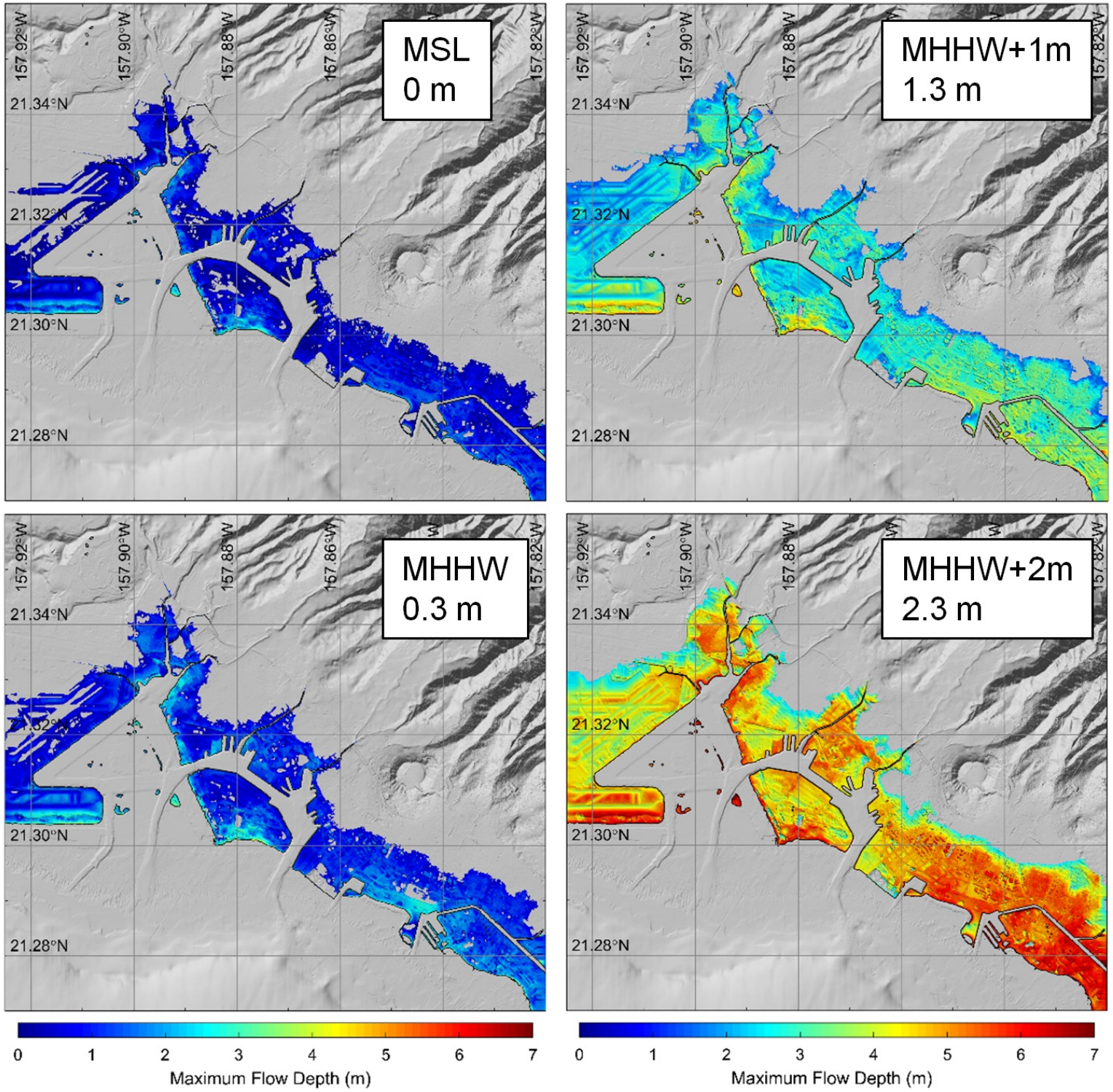
500-Year Tsunami

Scenario

- Mw 9.0 earthquake Inferred from tsunami deposits dating back 1300s
- Probable maximum earthquake based on 700 years of inferred Aleutian earthquakes
- Tsunami impacts exceeding historical records

Present and project sea-levels

- Disproportionate increase of impact with sea level rise



Concluding Remarks and Continuing Work

Two-tier inundation maps cater to a range of hazard levels for mitigation and response planning in Hawaii.

Mapping of hazardous currents from advisory-level tsunamis in support of harbor operations in Hawaii, American Samoa, and Guam (CNMI pending).

Continuing project to support development of the 2050 Harbor Master Plan for Hawaii.

Continuing project to investigate local tsunami hazards.