Creation of Probabilistic Tsunami Design Zone

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Project Background

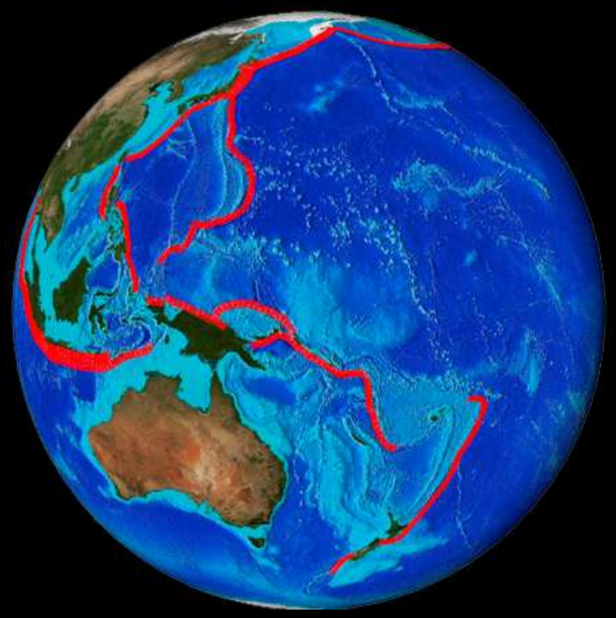
- The Tsunami Loads and Effects Subcommittee is developing a new Chapter 6 “Tsunami Loads and Effects” for the 2016 edition of the ASCE 7 standards

- Presently applicable only to the states of AK, WA, OR, CA and HI and later updates include Guam, American Samoa, and PR.

- PTHA maps of offshore wave amplitude are being developed. Structure member acceptability criteria will be based on performance objectives for a 2,500-year Maximum Considered Tsunami.

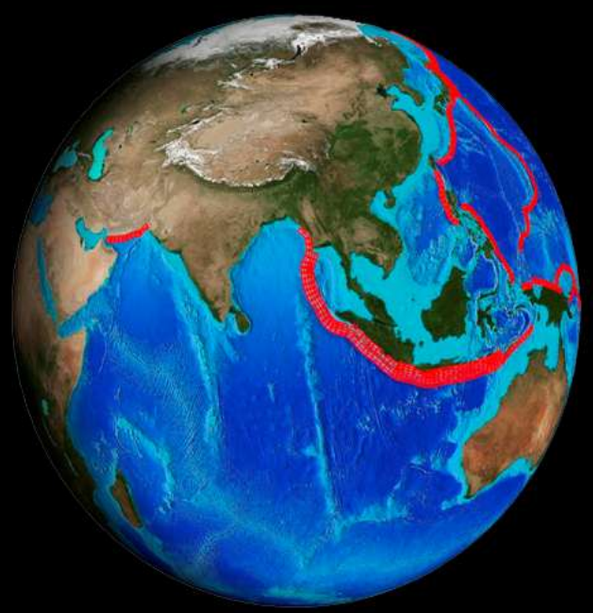
- Map of 2,500-year probabilistic Tsunami Design Zone for AK, WA, OR, CA and HI now need to be developed for use with the ASCE design provisions. These maps establish the basis of design and would most likely be emulated internationally.

PMEL's Tsunami Propagation Database



West Pacific

East Pacific



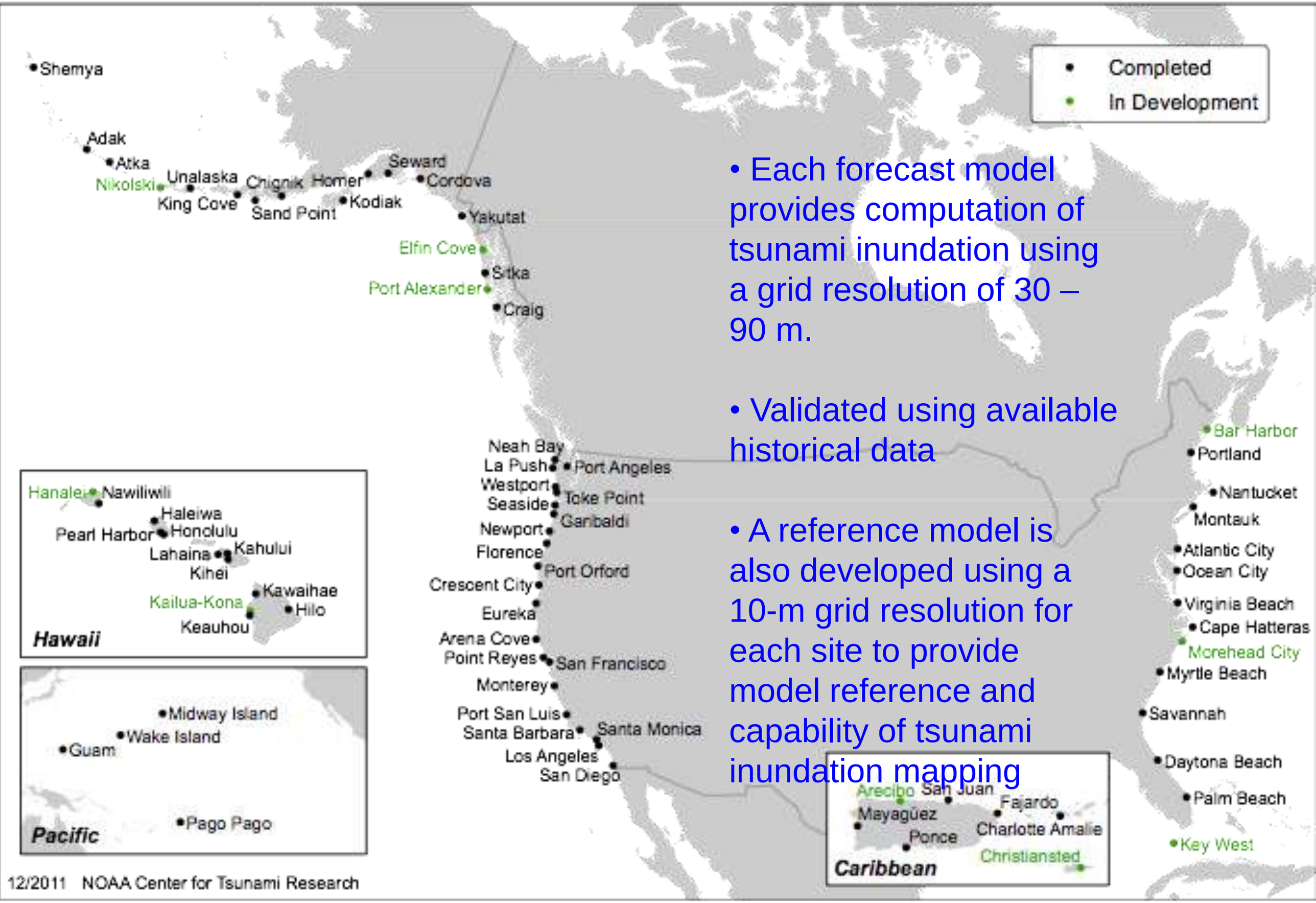
Indian Ocean

Atlantic

1725 Tsunami Unit Sources:

- 100 km × 50 km
- Placed along subduction zones and known tsunamigenic faults
- Aligned to fit known fault geometries
- Computed using shallow-water equations
- Can be linearly combined for source magnitude ≥ 7.5

NOAA Tsunami Forecast Models



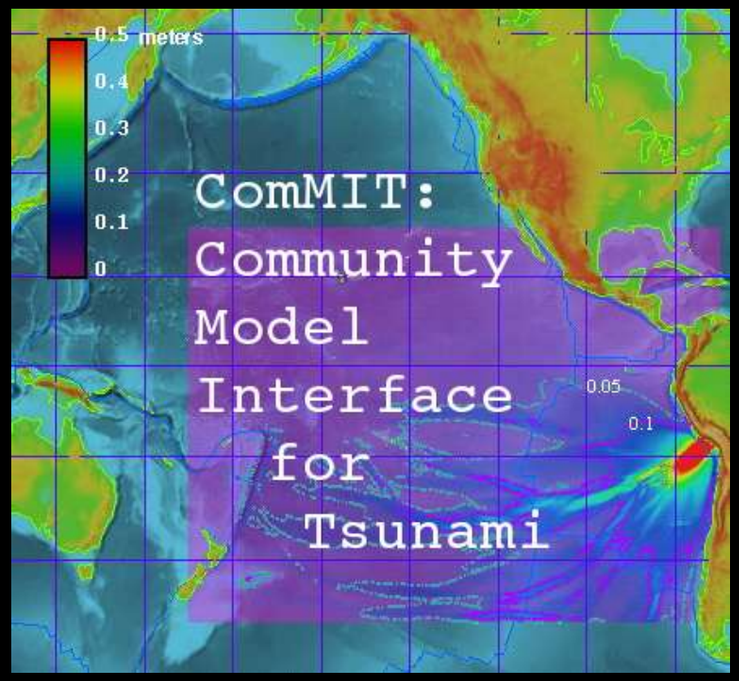
- Each forecast model provides computation of tsunami inundation using a grid resolution of 30 – 90 m.

- Validated using available historical data

- A reference model is also developed using a 10-m grid resolution for each site to provide model reference and capability of tsunami inundation mapping

Related reference: PMEL tsunami forecast series on model development http://nctr.pmel.noaa.gov/most-pubs.html

Combining NOAA's inundation forecast models with products of ComMIT training workshops



- Provide mapping and forecast modeling capabilities
- Develop effective way to transfer modeling expertise and capabilities to and between the users
- Establish community efforts to develop model standards, improved tsunami models, and model applications
- Develop compatible model forecast capability

Model progress

Menu for grids and model results display

Model name

Define tsunami source from propagation database

hilo2: ComMIT: Community Model Interface for Tsunami 1.6.5

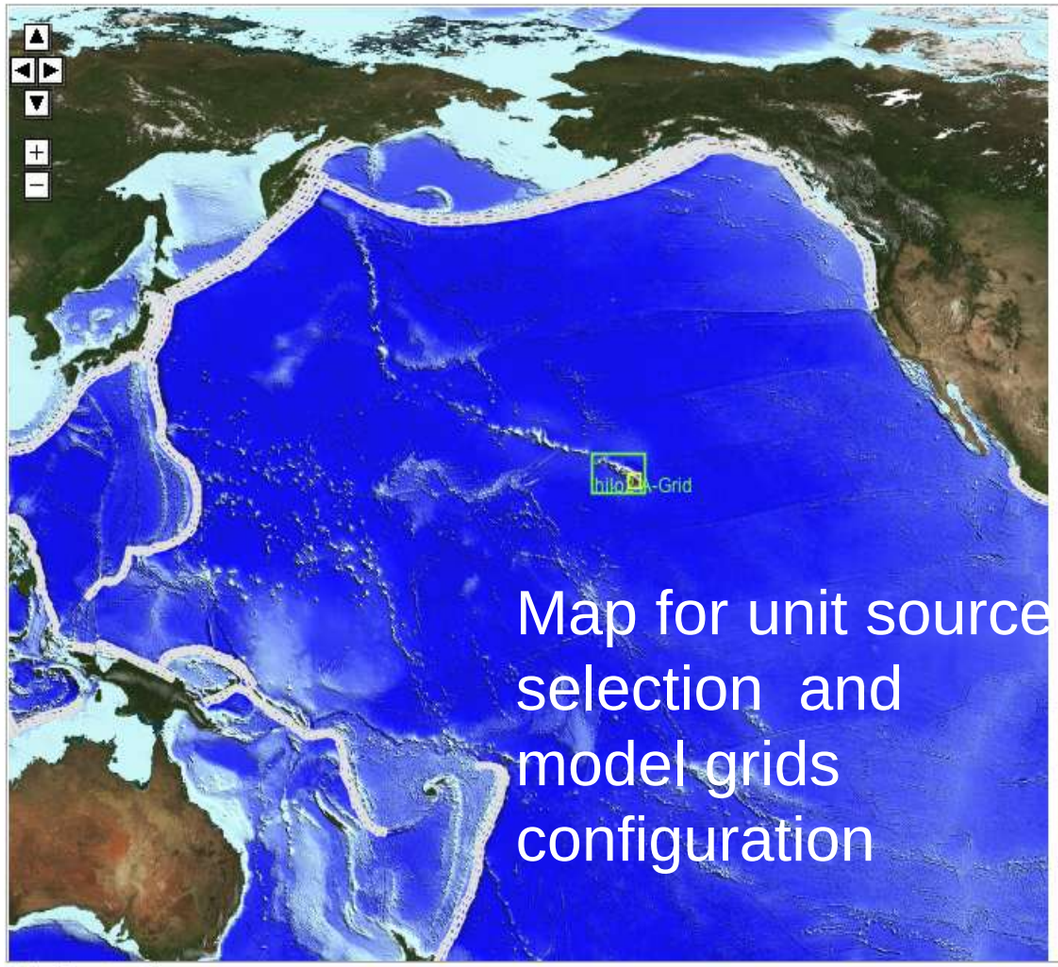
Start model

hilo2 stopped: step 0 of 2250

hilo2

Model Setup | Initial Condition | Grid Bathymetry | Results Animation | Results Extrememum

11 Mar 2011 05:46:23 (UTC) Mw: 8.9 Ep: 38.322° N, 142.369° E "Tohoku"



Map for unit source selection and model grids configuration

Total Magnitude: 8.8 Mw

Name	% Mag	Slip
ki24b	5.1	4.66
ki25b	13.3	12.23
ki26a	28.5	26.31
ki26b	23.1	21.27
ki27a	24.7	22.75
ki27b	5.4	4.98

Add/Del | to Site

0.0010	Minimum amp. of input offshore wave (m)
1.0	Minimum depth of offshore (m)
0.1	Dry land depth of inundation (m)
0.0009	Friction coefficient (n^2)
☑	Let A-Grid and B-Grid run up
300.0	Max eta before blow-up (m)
1.0000	Time step (sec)
72000	Total number of time steps in run
8	Time steps between A-Grid computations
2	Time steps between B-Grid computations
32	Time steps between output steps
32	Time steps before saving first output step
1	Save output every n-th grid point

Input parameters

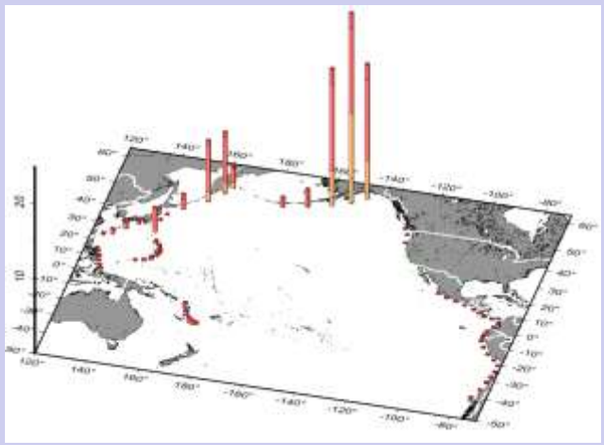
Model output log

Model output log

2,500-year Inundation Zone Using PTHA Maps & Forecast Tools

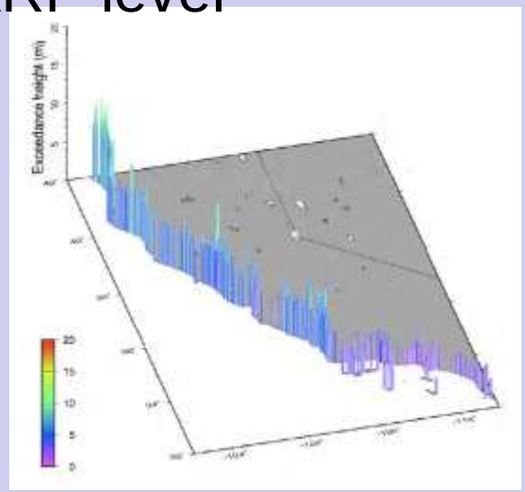
URS PTHA maps

- Source disaggregation and selection



Courtesy of Thio et al. (2010)

- ~~Offshore tsunami height~~ and wave period for an ARP level



Courtesy of Thio et al. (2010)

ComMIT

Reconstruct disaggregated scenarios using a combination of PMEL “unit tsunami sources”:

- source location
- magnitude
- rupture area
- slip

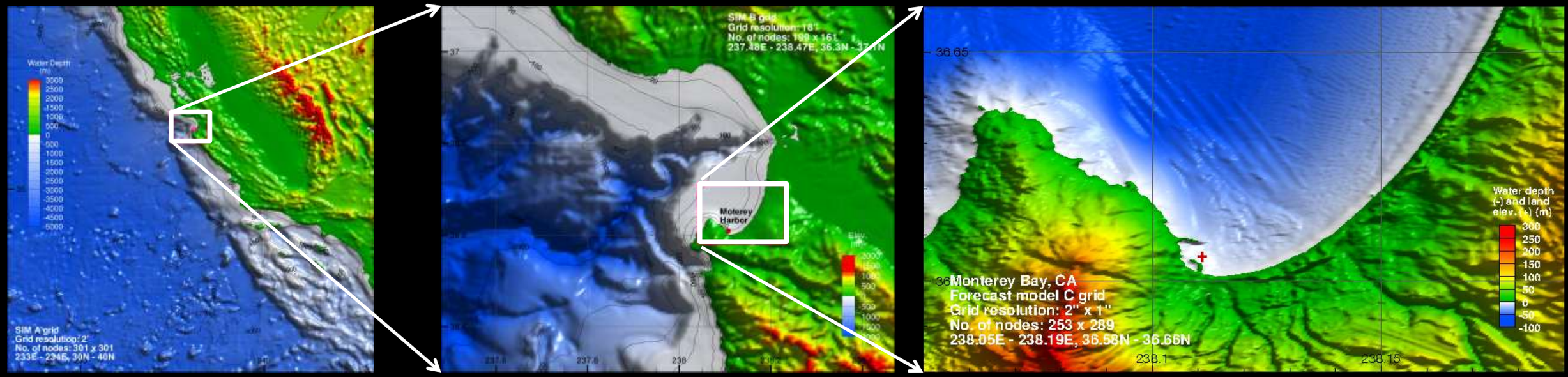
Tsunami inundation modeling for reconstructed sources

Tuning for PTHA tsunami height using unit tsunami sources

Derive probabilistic flooding hazard maps using an envelop of inundation lines obtained from above steps

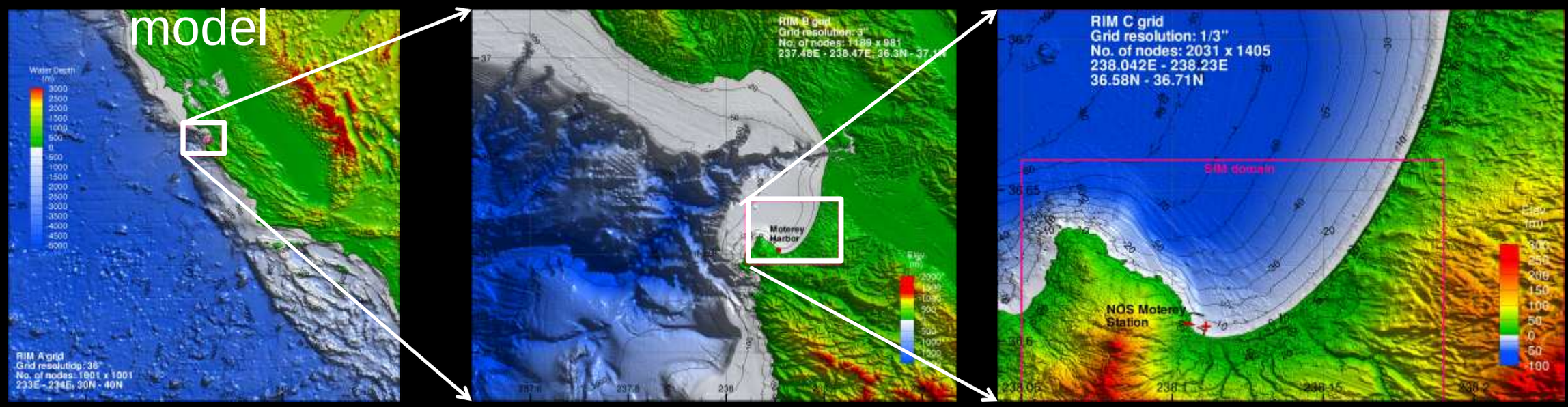
Example: Monterey Bay, CA

Forecast model



A grid (dx = 2’) B grid (dx = 18”) C grid (dx = 2” x 1”)

Reference model

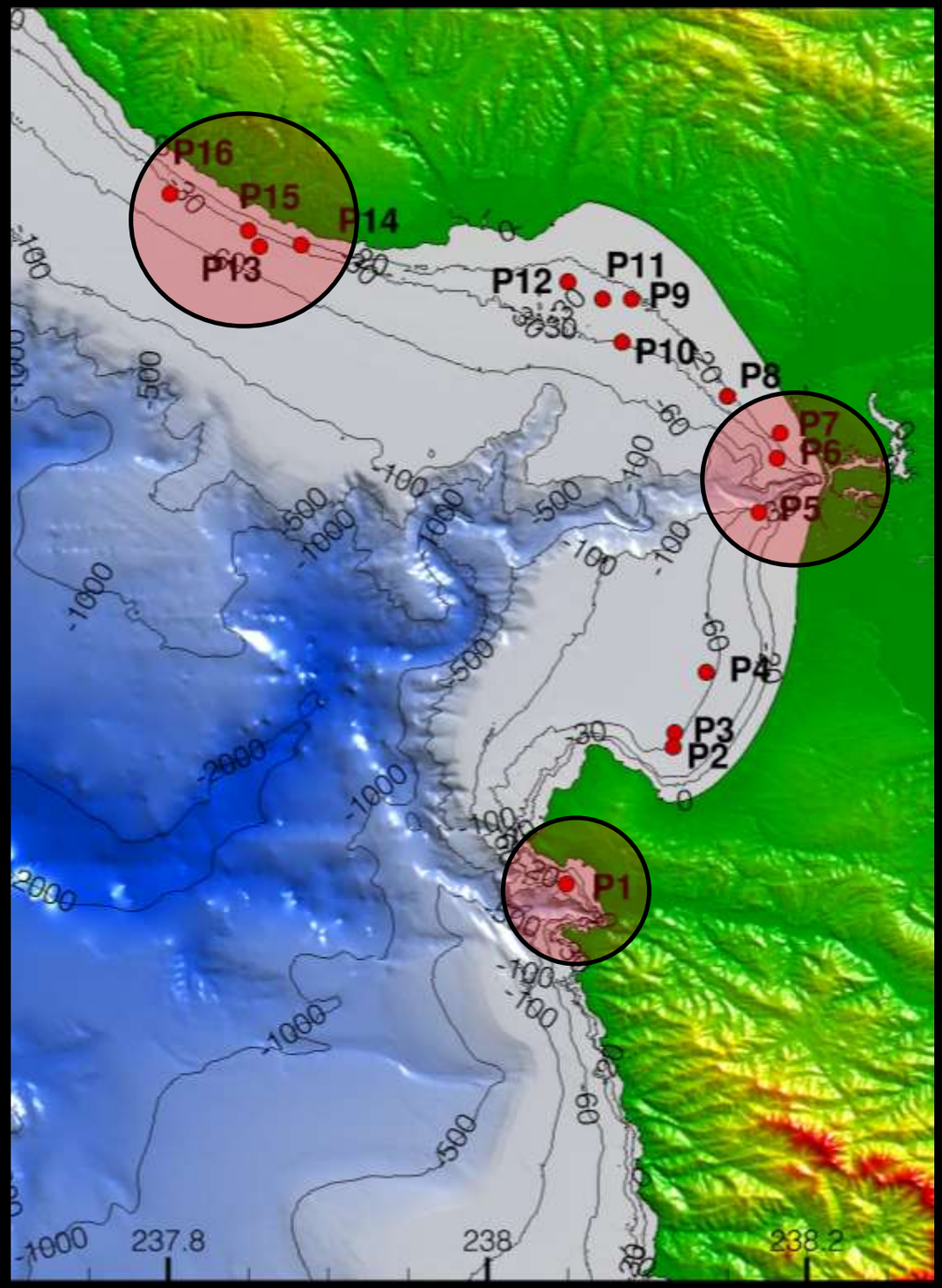


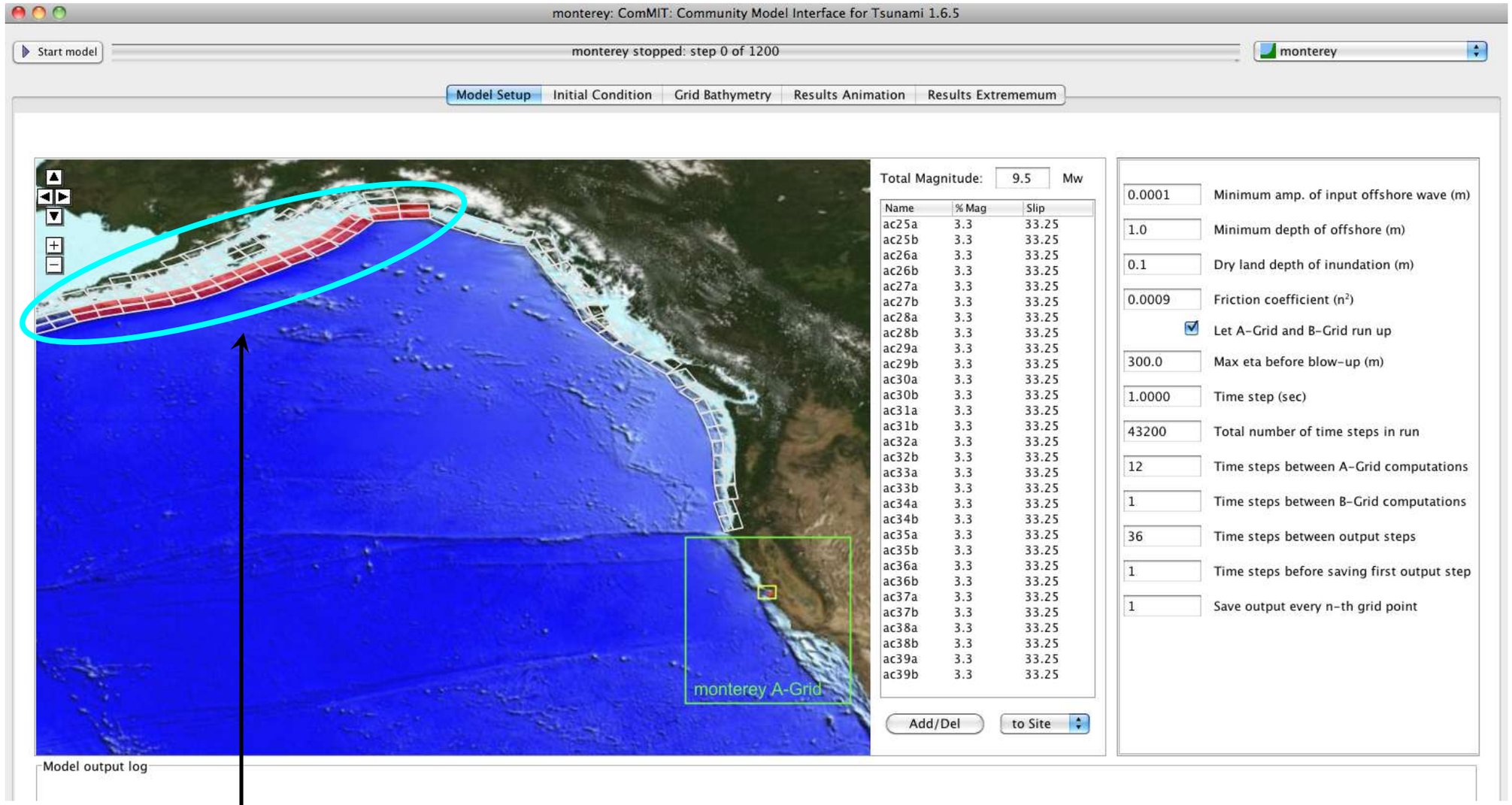
A grid (dx = 36”) B grid (dx = 3”) C grid (dx =1/3”)

URS 2,500-year Offshore wave amplitude

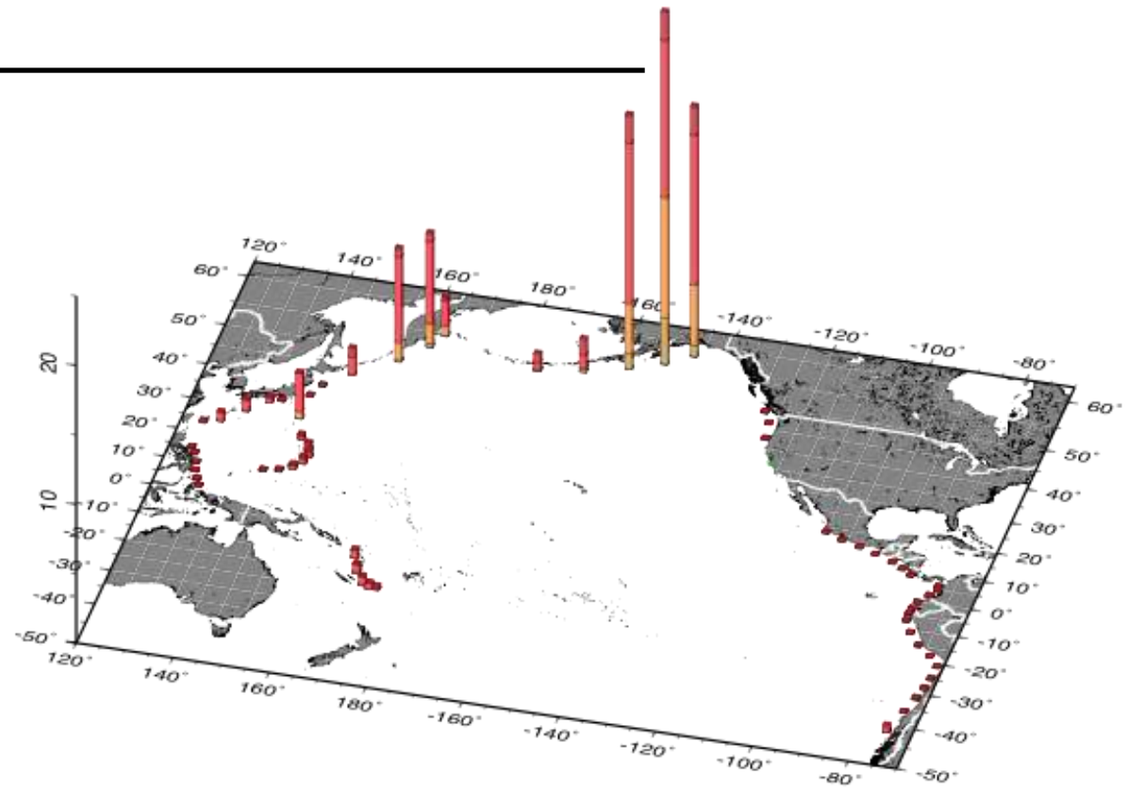
#	Lon	Lat	Water D. (m)	Exceedance amp. (m)	PMEL depth (m)
P1	238.049	36.55	35	5.68	60.7
P2	238.116	36.636	69	4.64	58.5
P3	238.117	36.645	69	4.64	63.5
P4	238.137	36.683	59	4.77	64.4
P5	238.17	36.783	21	5.92	78.2
P6	238.181	36.817	29	4.6	28.2
P7	238.183	36.833	29	4.6	13.7
P8	238.15	36.856	23	4.61	21.2
P9	238.09	36.917	23	7.39	22.6
P10	238.084	36.89	35	4.79	29.9
P11	238.072	36.917	23	7.39	24.2
P12	238.05	36.928	29	7.23	23.8
P13	237.857	36.95	53	4.41	42.5
P14	237.833	36.951	31	5.43	53.2
P15	237.85	36.96	53	4.41	32.1
P16	237.801	36.983	25	6.04	37.8

PMEL forecast model grids

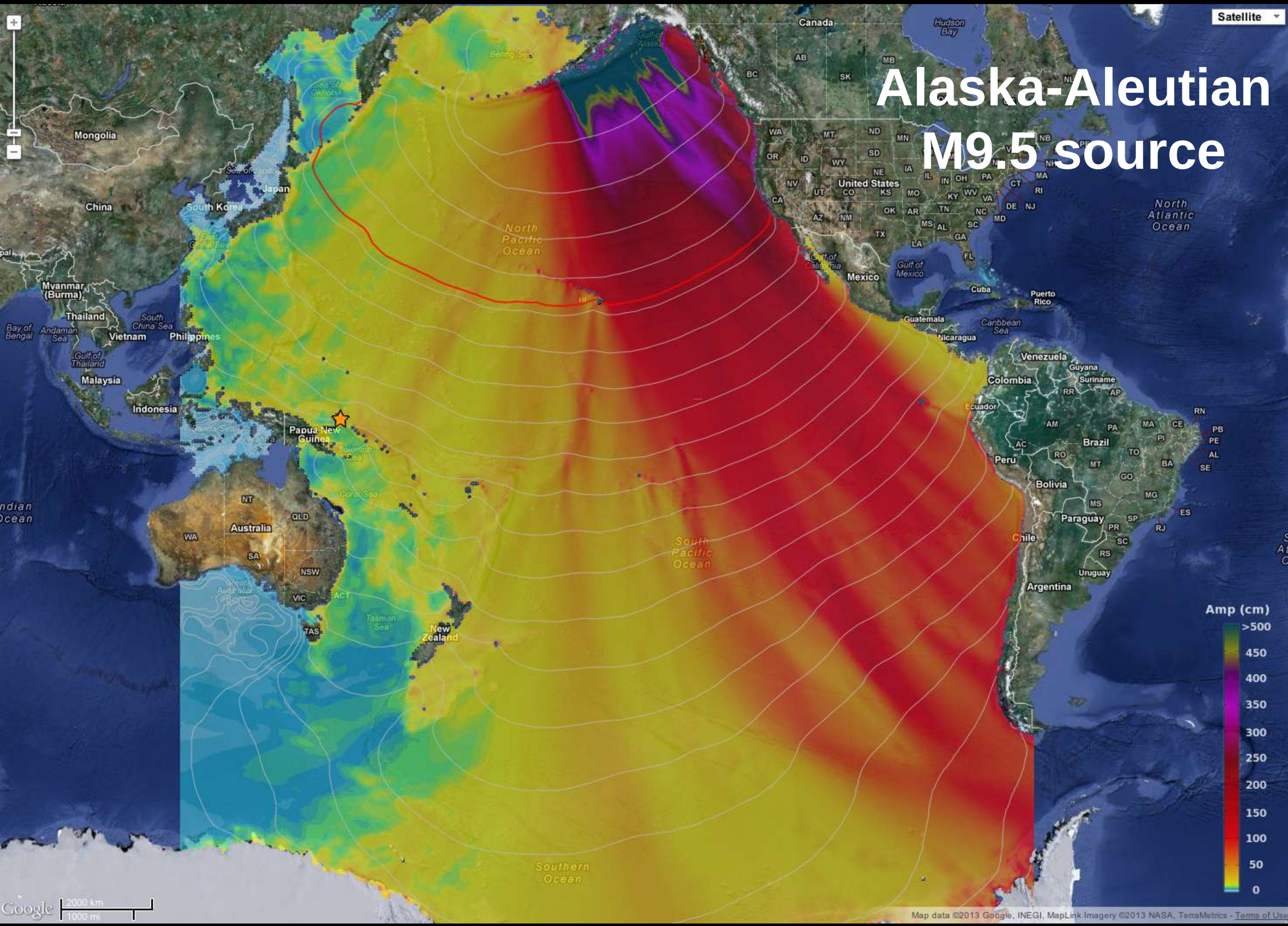


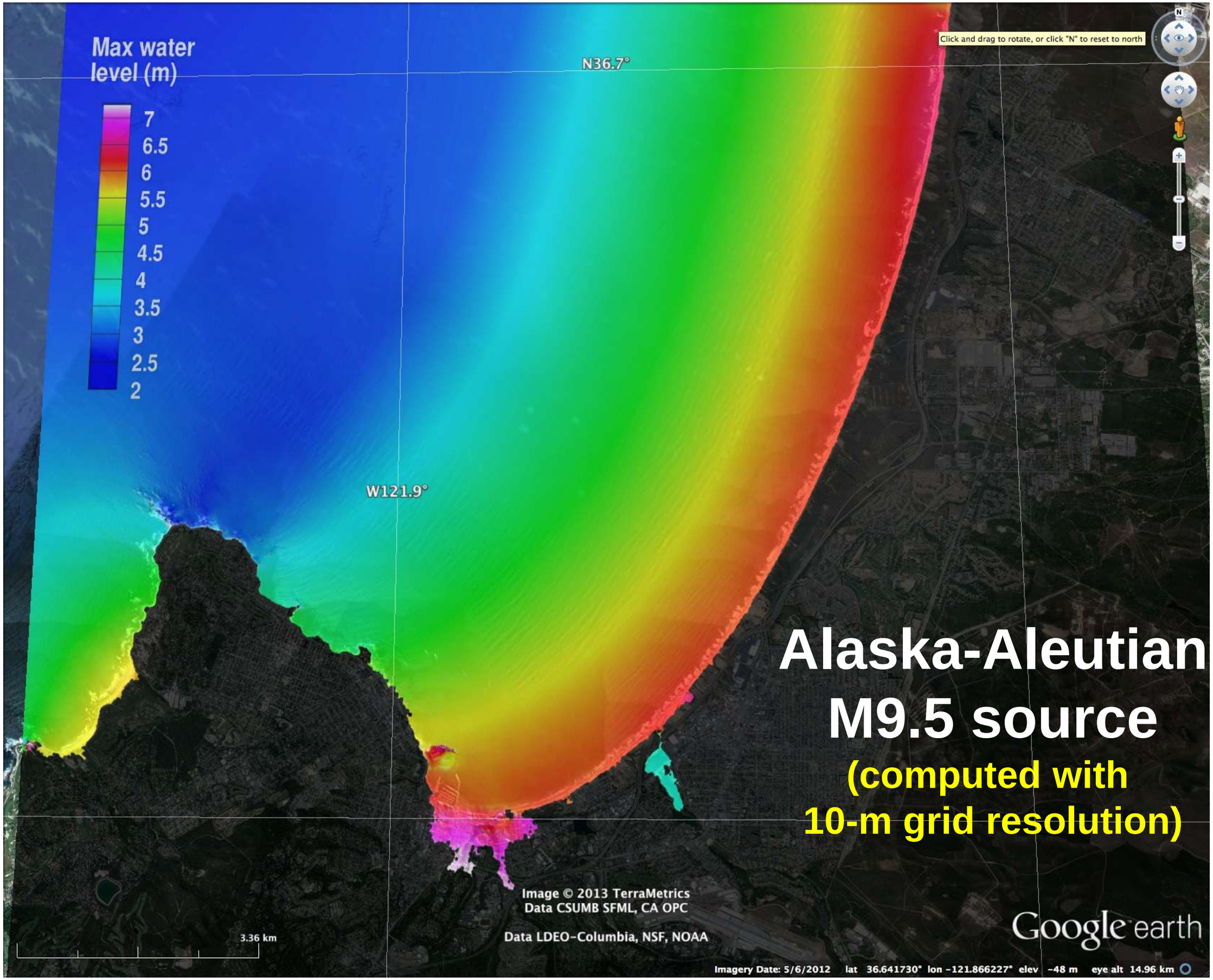


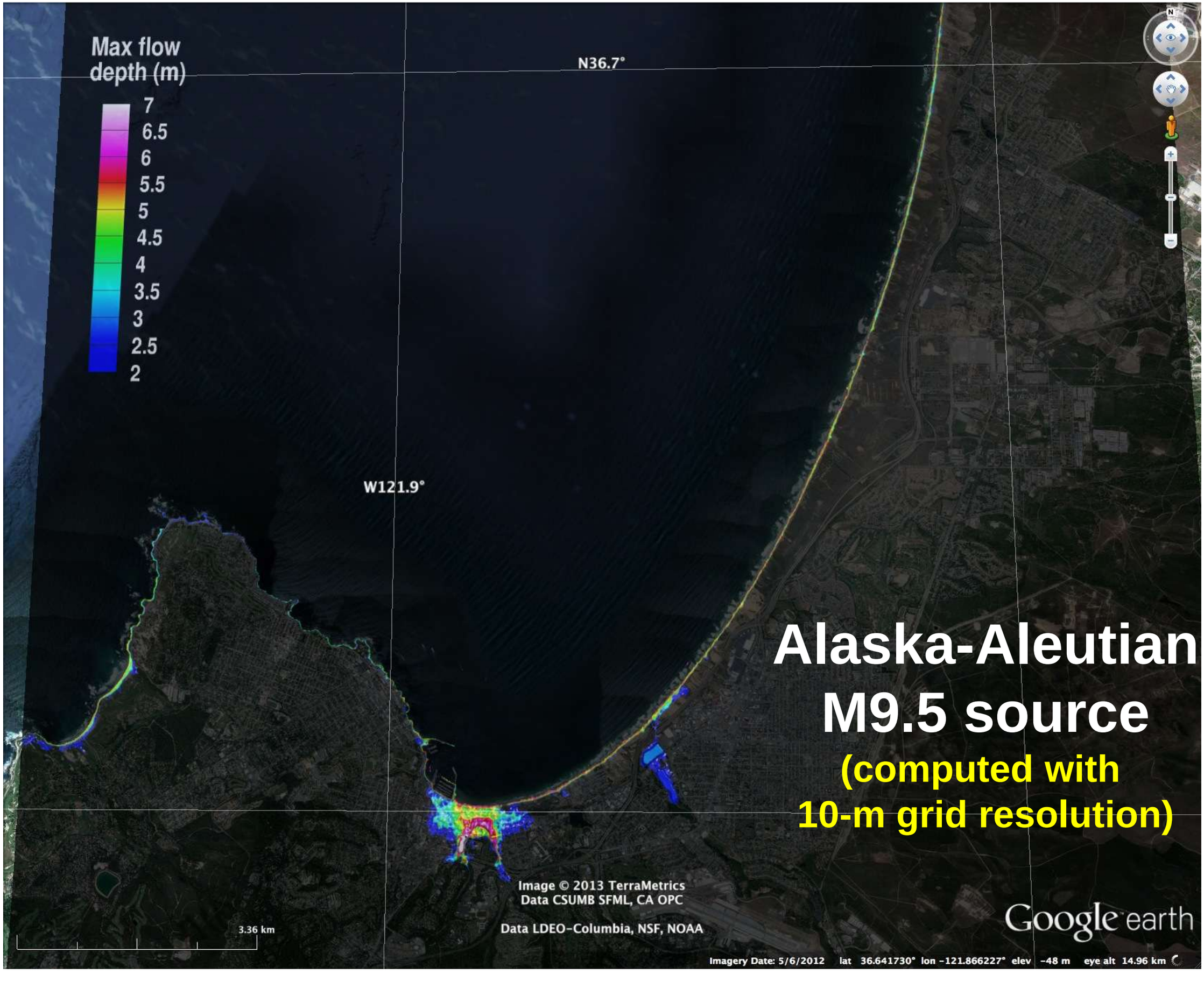
Source disaggregation using ComMIT: Alaska-Aleutian source

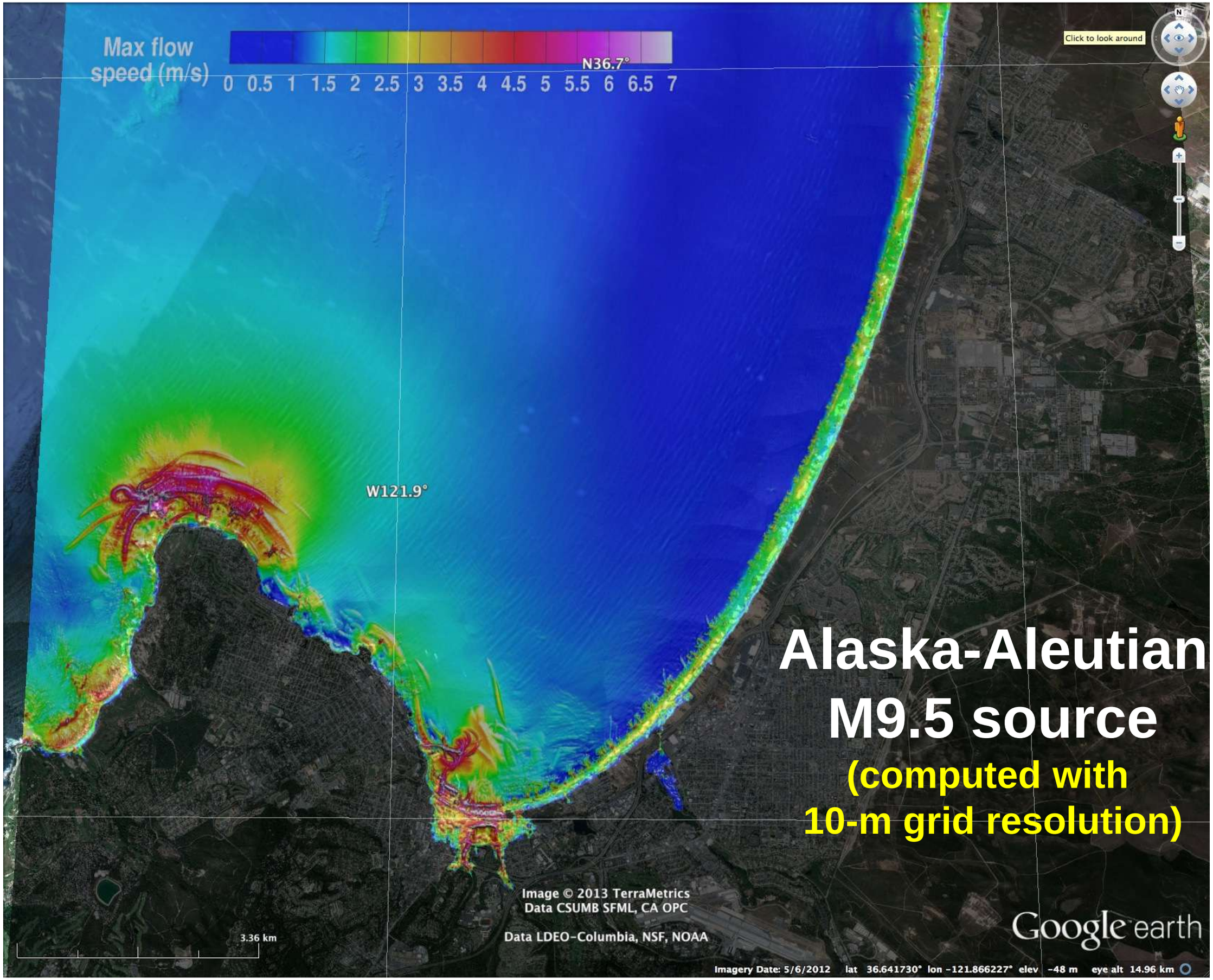


Alaska-Aleutian M9.5 source



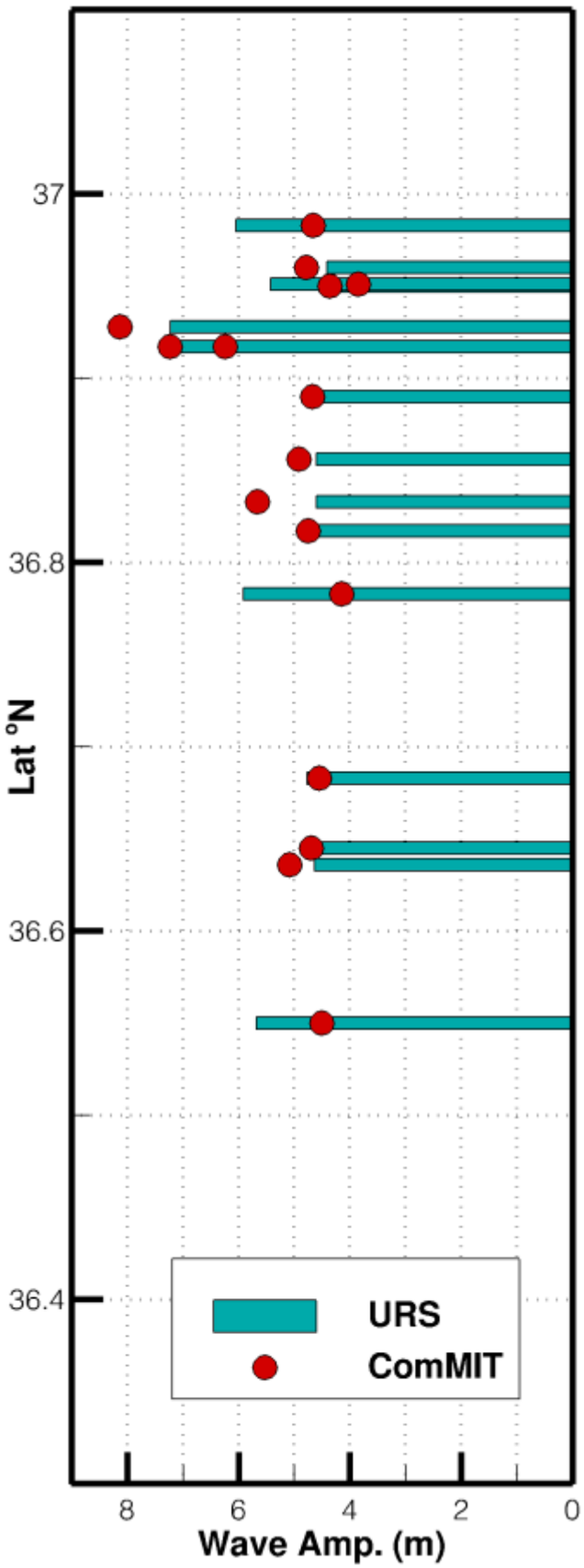

Max water level (m)
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
N36.7°
W121.9°
Click and drag to rotate, or click "N" to reset to north
Alaska-Aleutian
M9.5 source
(computed with
10-m grid resolution)
Image © 2013 TerraMetrics
Data CSUMB SFML, CA OPC
Data LDEO-Columbia, NSF, NOAA
3.36 km
Google earth
Imagery Date: 5/6/2012 lat 36.641730° lon -121.866227° elev -48 m eye alt 14.96 km

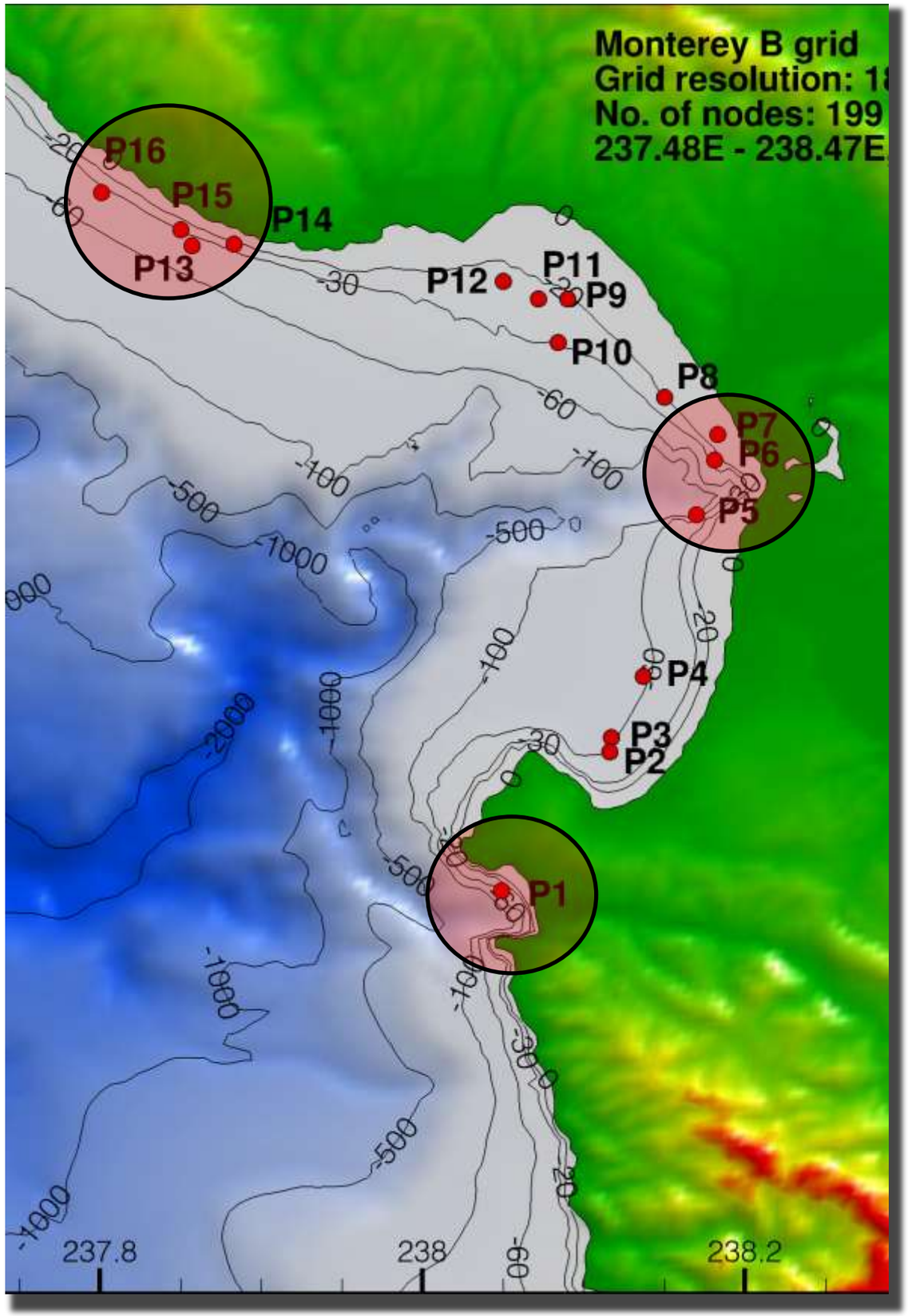

Max flow depth (m)
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
N36.7°
W121.9°
3.36 km
Image © 2013 TerraMetrics
Data CSUMB SFML, CA OPC
Data LDEO-Columbia, NSF, NOAA
Google earth
Imagery Date: 5/6/2012 lat 36.641730° lon -121.866227° elev -48 m eye alt 14.96 km
Alaska-Aleutian
M9.5 source
(computed with
10-m grid resolution)


Max flow speed (m/s)
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6 6.5 7
N36.7°
W121.9°
Click to look around
Alaska-Aleutian M9.5 source
(computed with 10-m grid resolution)
Image © 2013 TerraMetrics
Data CSUMB SFML, CA OPC
Data LDEO-Columbia, NSF, NOAA
3.36 km
Google earth
Imagery Date: 5/6/2012 lat 36.641730° lon -121.866227° elev -48 m eye alt 14.96 km

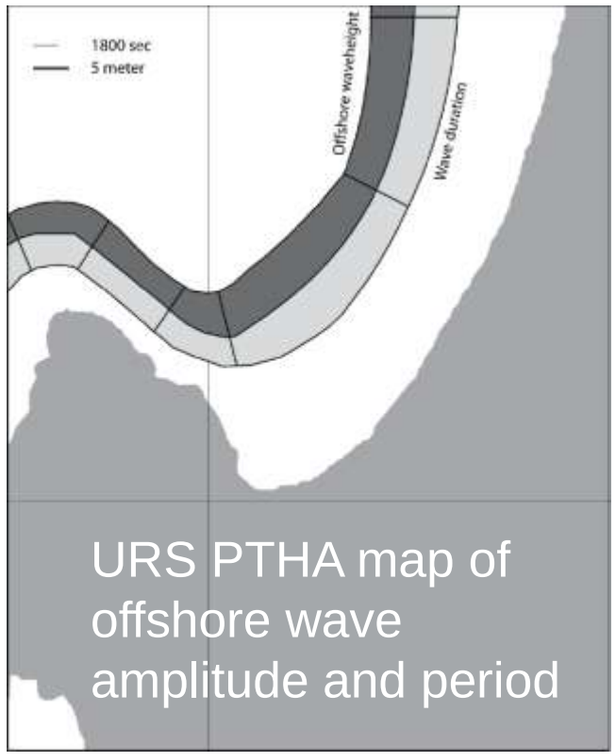
Preliminary Test Results for Alaska Source – M9.5 (33-m slip)

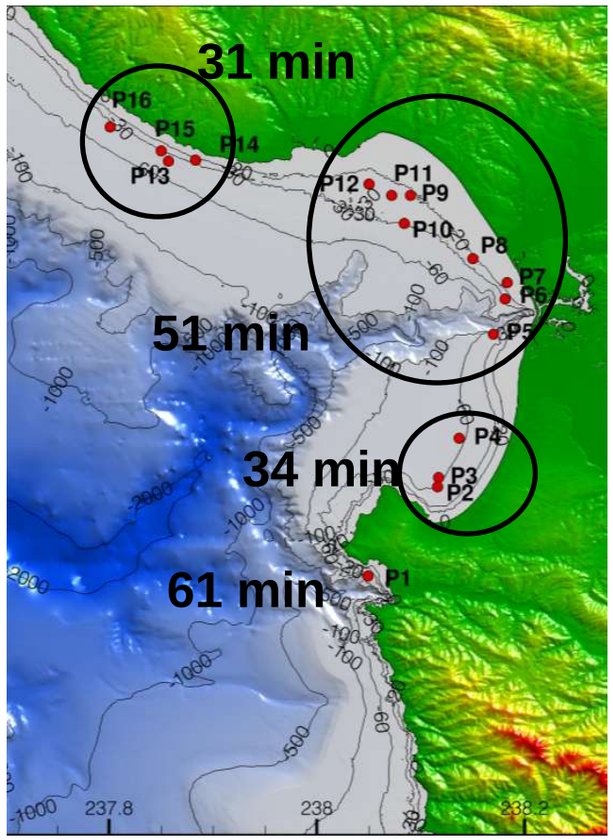
#	URS (m)	ComMIT (m)	Difference
P1	5.68	4.51	-20.7%
P2	4.64	5.01	9.6%
P3	4.64	4.70	1.3%
P4	4.77	4.55	4.6%
P5	5.92	4.15	-30.0%
P6	4.6	4.75	3.2%
P7	4.6	5.66	23.0%
P8	4.61	4.91	6.6%
P9	7.39	6.25	-15.5%
P10	4.79	4.67	-2.5%
P11	7.39	7.24	-2.1%
P12	7.23	8.13	12.4%
P13	4.41	4.36	-1.1%
P14	5.43	3.85	-29.2%
P15	4.41	4.78	8.5%
P16	6.04	4.66	-22.9%
Ave. Error = 12.1%			
RMS = 0.89 m			

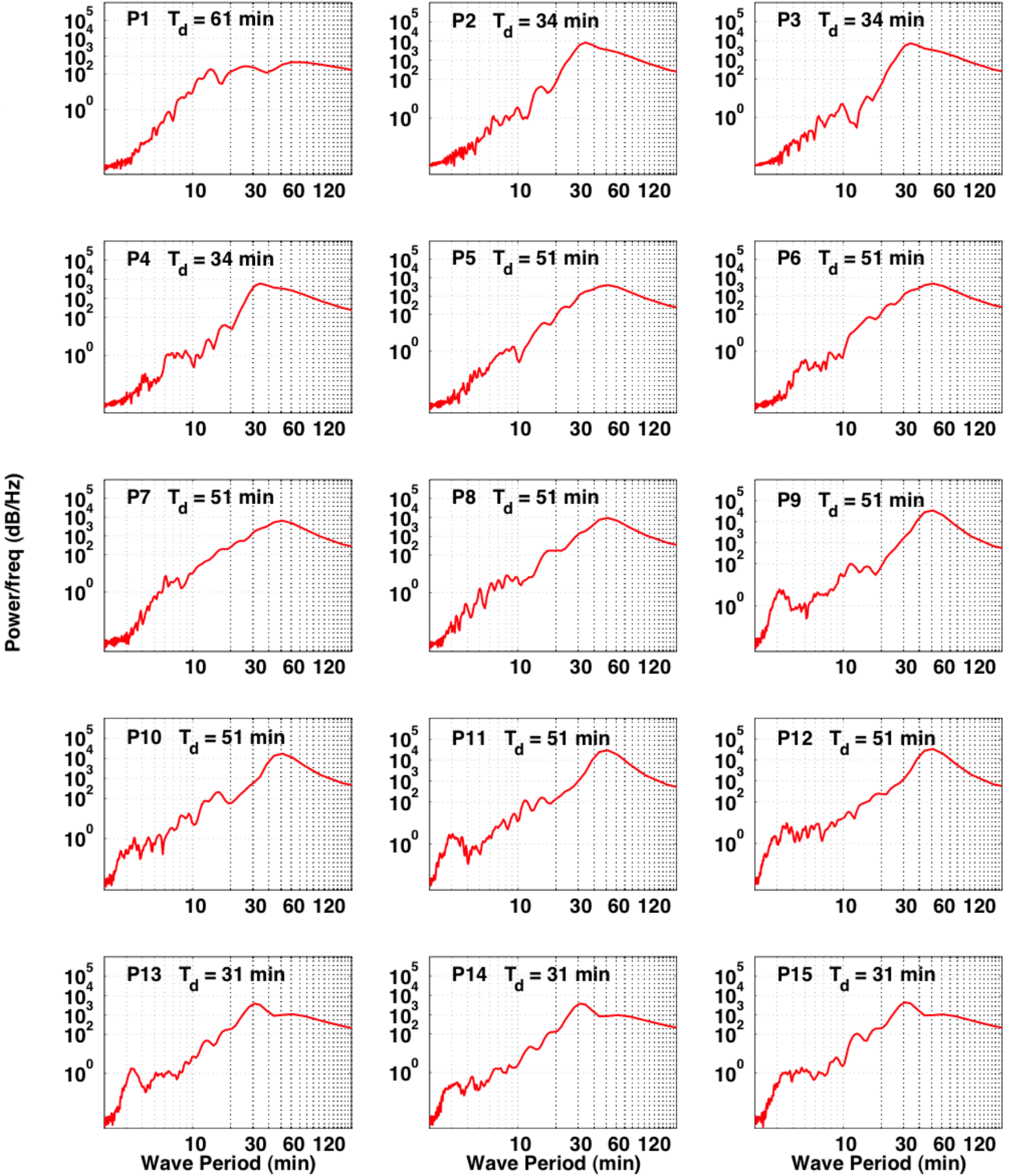




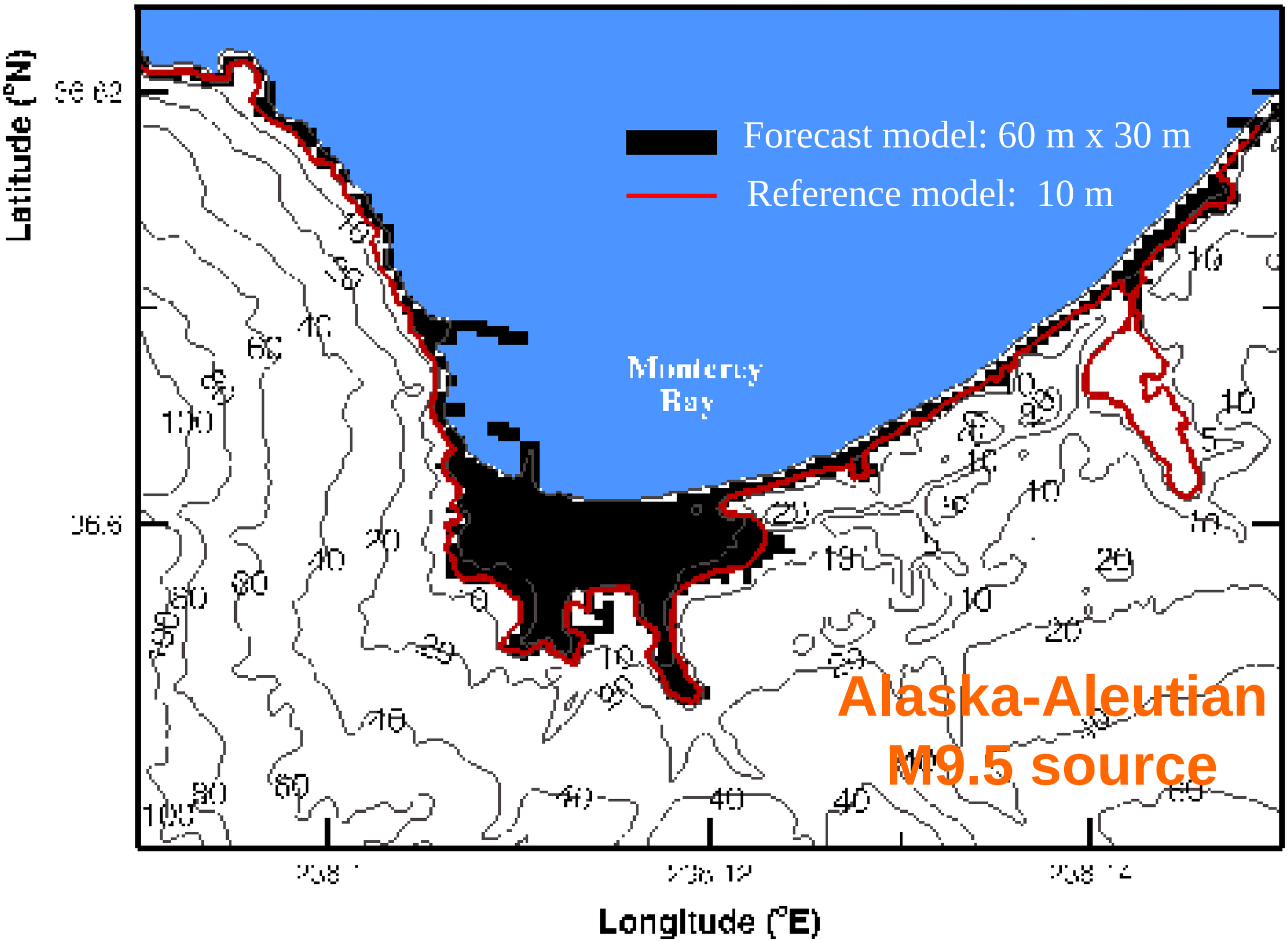
Model Results of Dominant Wave Period

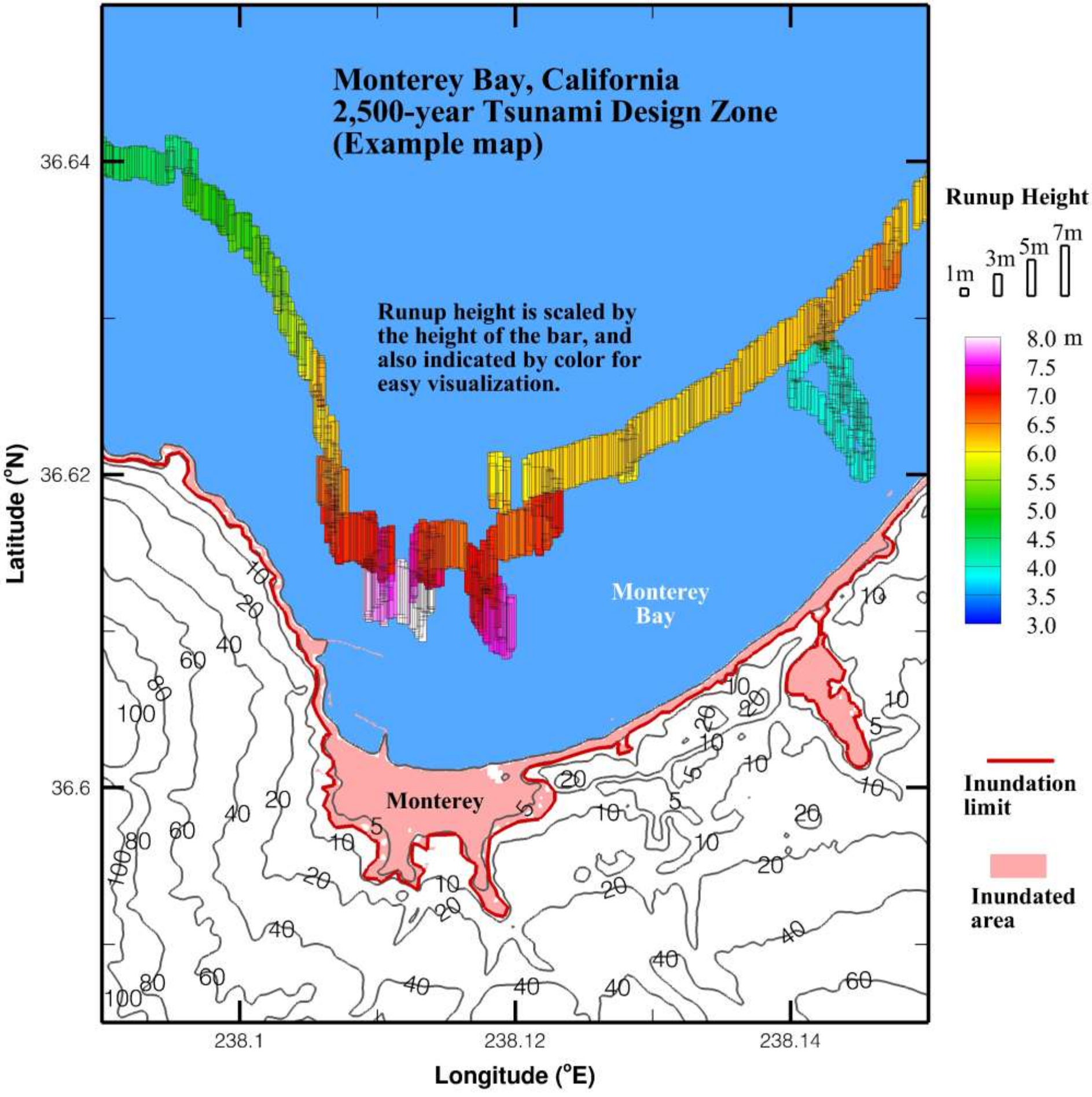






Inundation Limit vs. Grid Resolution




Monterey Bay, California
2,500-year Tsunami Design Zone
(Example map)
Runup height is scaled by the height of the bar, and also indicated by color for easy visualization.
Monterey Bay
Monterey
Runup Height
1m
3m
5m
7m
8.0 m
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
Inundation limit
Inundated area
Latitude (°N)
Longitude (°E)
36.64
36.62
36.6
238.1
238.12
238.14

ASCE Tsunami Design Zone Project

Phase I

PTHA of offshore wave amplitude and disaggregated governing scenarios for input to the inundation model

Probabilistic tsunami design zone maps for the major regions of 5 western states (WA, OR, CA, AK, HI)

Phase II

Development of higher resolution probabilistic inundation hazard maps of reference sites, constituting benchmarks for the validation of risk-consistent local probabilistic inundation maps covering greater geographical extent to the produced by the five western states under separate funding of NTHMP.