# Crescent City PTHA Project

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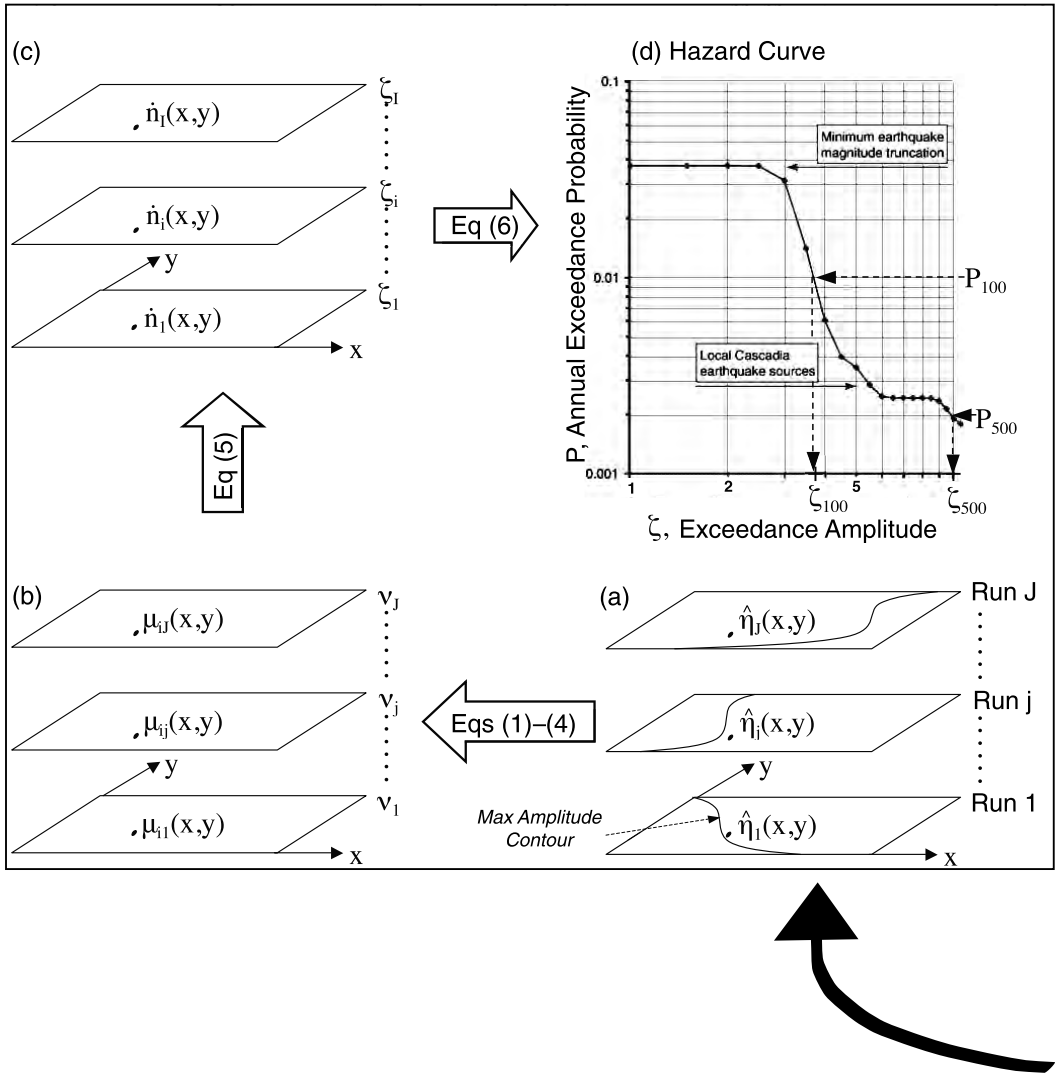
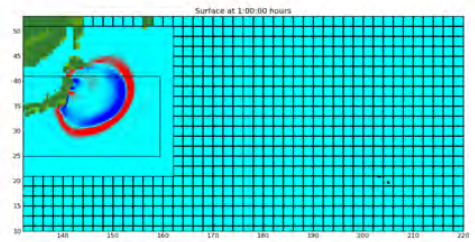
NTHMP MES & MMS Subcommittee Meetings
20-22 August 2013
Pacific Marine Environmental Laboratory
Seattle, WA

# Probabilistic Post-processing <==== GeoClaw Simulations

*González, et al., JGR, 2009*




## 11 March 2011 Tohoku event

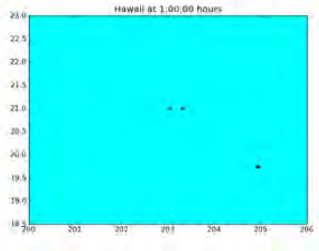


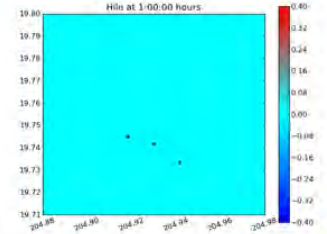

Time postquake: 1:00

CPU time: 0:01

(1 core of MacBook)

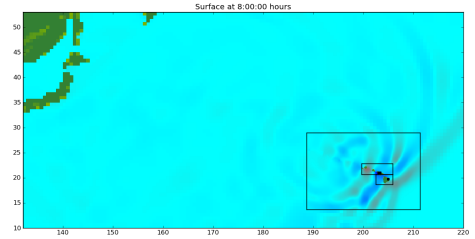
Level 1: $\Delta x = 2°$
Level 6: $\Delta x = 1/3$"
Ratios: 3,4,5,8,45.




R. J. LeVeque, University of Washington NTHMP workshop, PMEL, July, 2012

## 11 March 2011 Tohoku event

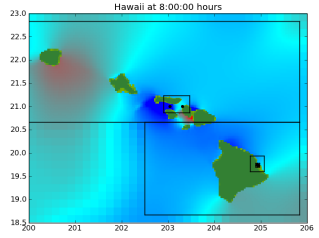


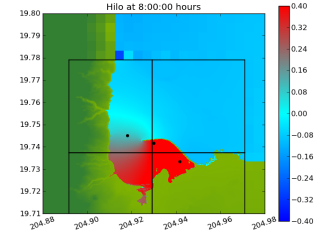

Time postquake: 8:00

CPU time: 4:49

(1 core of MacBook)

Level 1: $\Delta x = 2°$
Level 6: $\Delta x = 1/3$"
Ratios: 3,4,5,8,45.

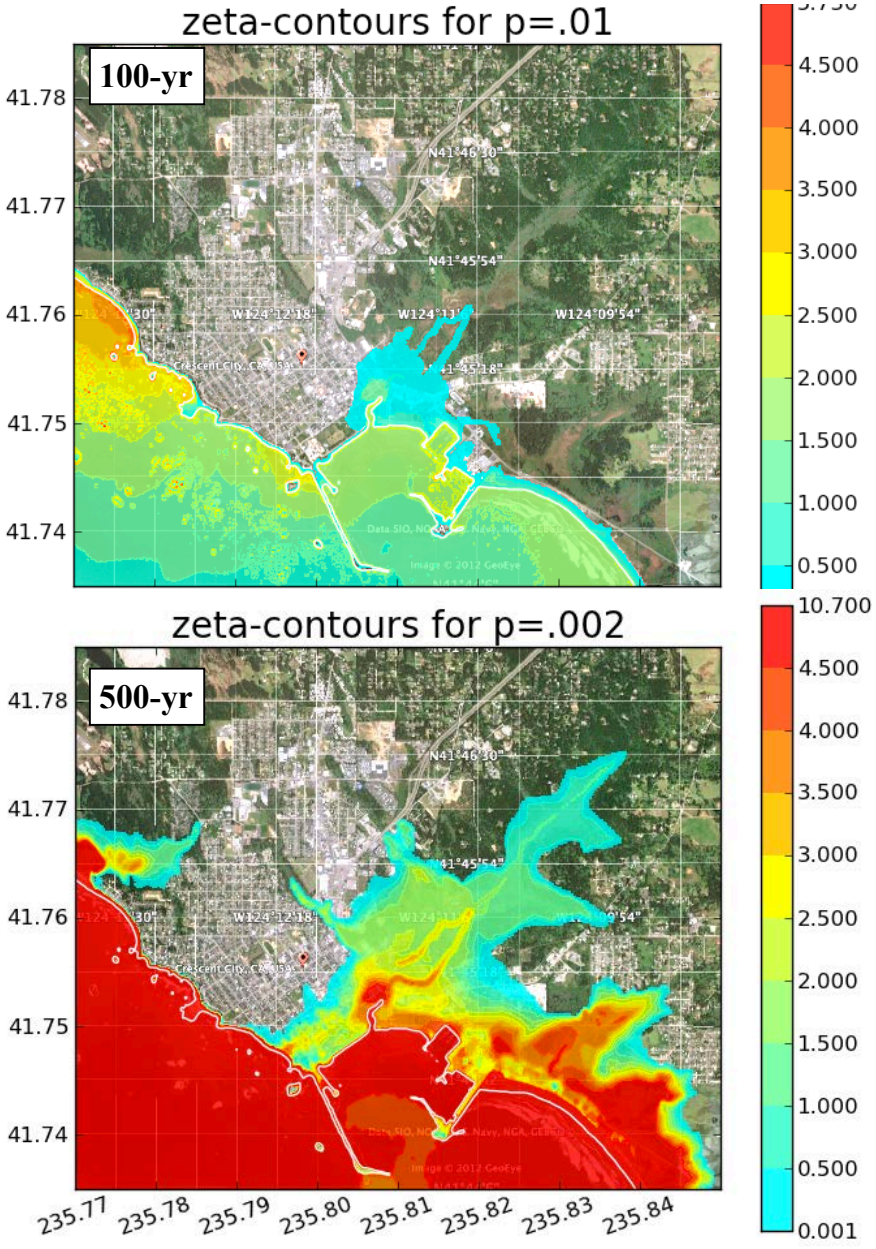



R. J. LeVeque, University of Washington NTHMP workshop, PMEL, July, 2012

# Phase I: Flooding Depth Annual Probabilities of Exceedance

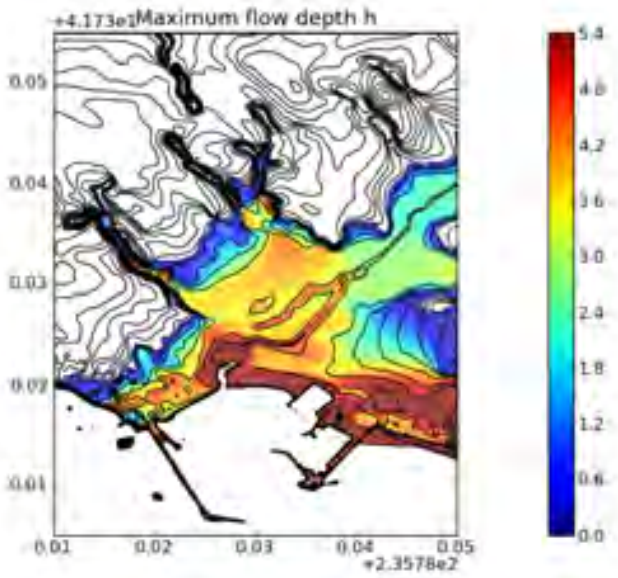
- **Sponsor**
  - BakerAECOM, as part of FEMA RiskMAP program.
- **Final Report completed on 31 January 2013**
  https://digital.lib.washington.edu/researchworks/handle/1773/22366
- **Primary Products:**
  - 0.01 and 0.002 Annual Probability of Flood Depth Exceedance
- **Sources:**
  - 2011 Bandon, OR Study: Witter, et al., Simulating Tsunami Inundation at Bandon, Coos County, Oregon, Using Hypothetical Cascadia and Alaska Earthquake Scenarios, DOGAMI SP 43.
  - 15 Sources viewed as stochastic realizations with conditional probabilities
- **Improvements to PTHA Tidal Methodology:**
  - Adams, et al. (2013), Incorporating Tidal Uncertainty Into Probabilistic Tsunami Hazard Assessment (PTHA) for Crescent City, CA (in preparation).



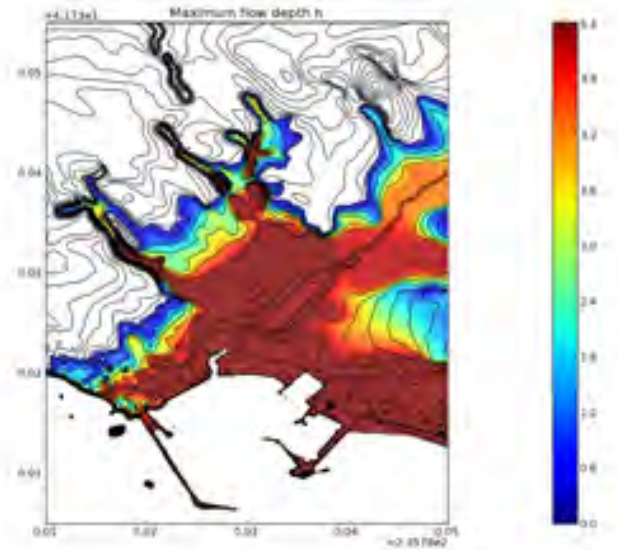
# Effect of tides on inundation at Crescent City

Source: One of 12 CSZ $M_w$ 9.1 realizations (worst case)

Maximum inundation at MLW:

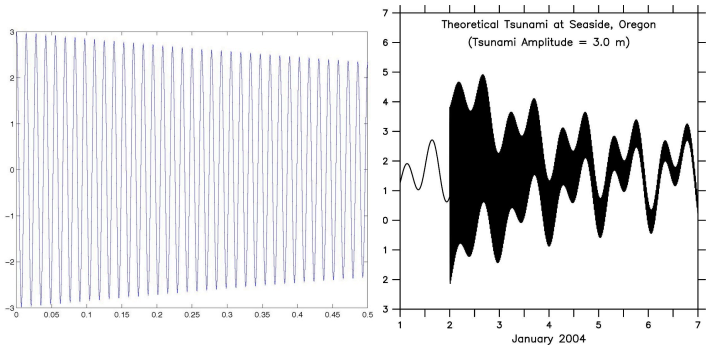


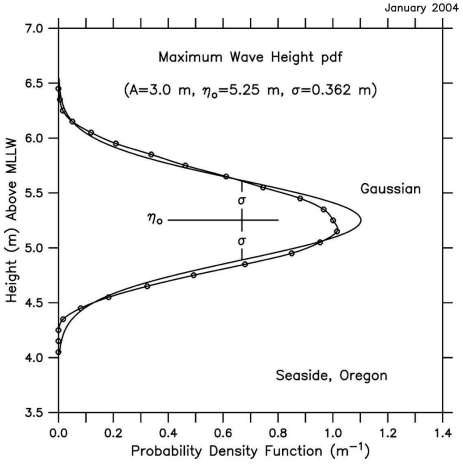

at MHW:

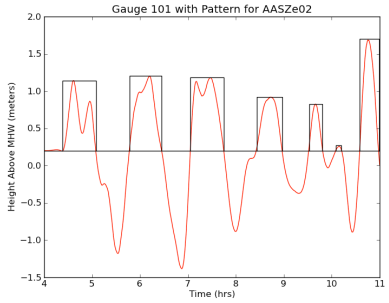


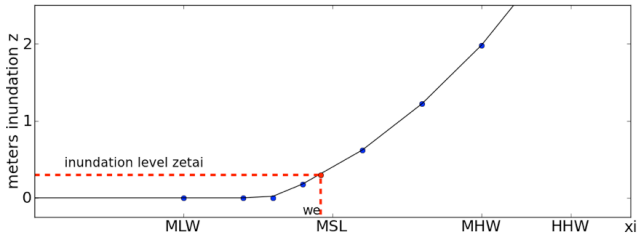
# Physics of Improved Tidal Uncertainty Methodology

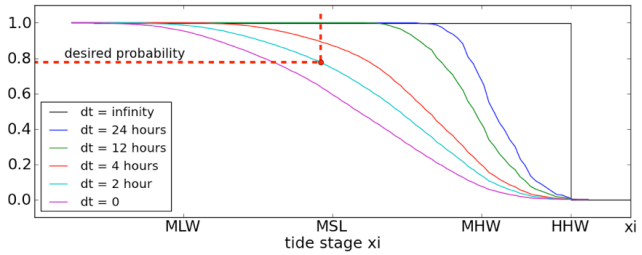
| Physics | Mofjeld, et al. (2007) | Adams, et al. (2013) |
|---|---|---|
| **Tide Effect on Inundation** | No nonlinear inundation effects. Estimated by Gaussian approximation to PDF for tide + tsunami, using station tide gage constants. | Direct nonlinear modeling at multiple levels: MLW, MSL, MHHW |
| **Tsunami Time Series** | Synthetic (based on Van Dorn, 1984):<br>• T=20 minutes<br>• 2-day decay time<br>• multiple amplitudes | GeoClaw output ***at each cell.*** |



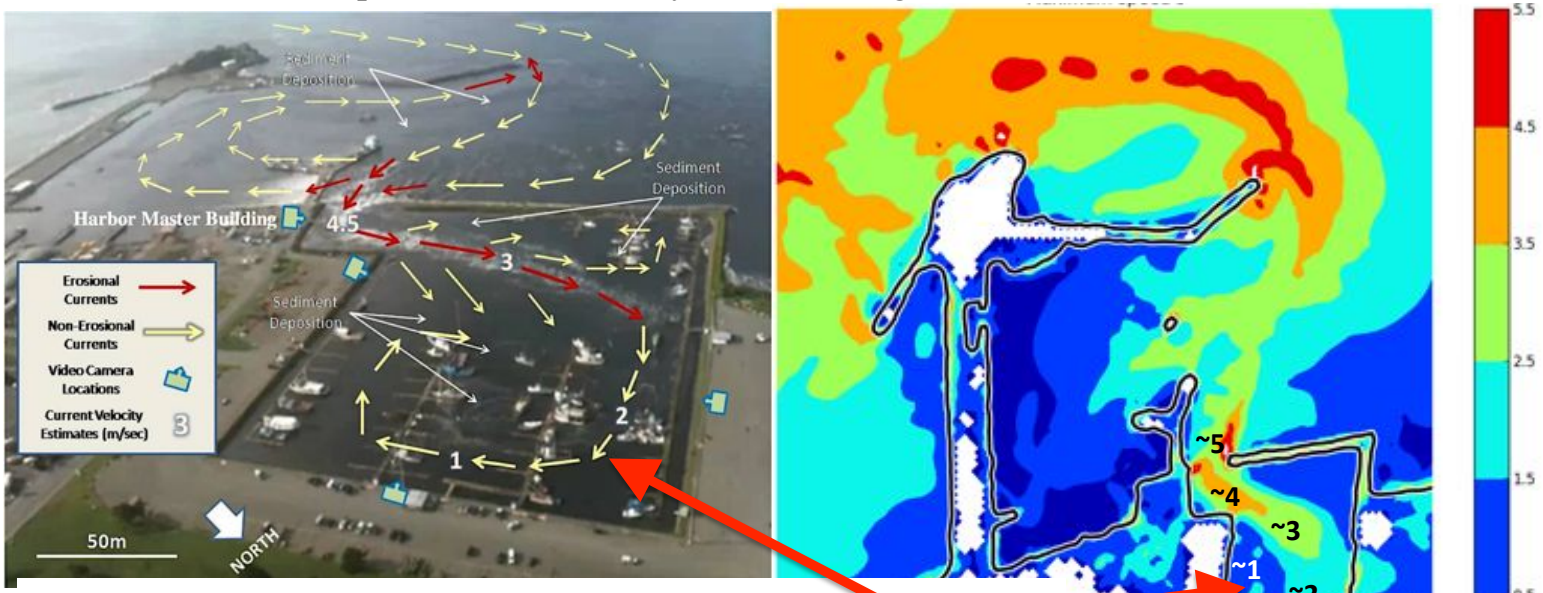



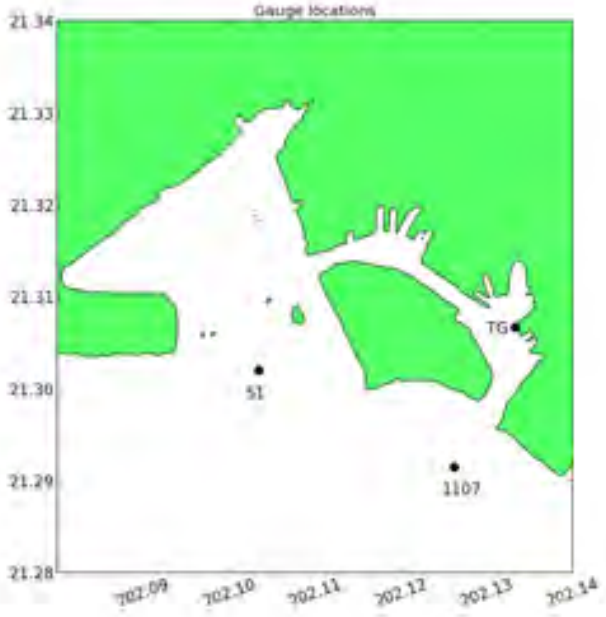
# Phase II: Current Speed and Momentum Flux Annual Probabilities of Exceedance

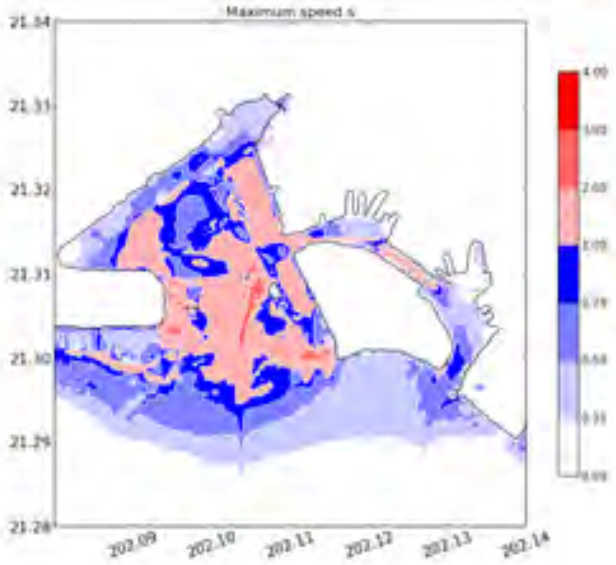
- **Primary Products:**
  - 0.01 and 0.002 Annual Probability of Exceedance for Flood Depth, Current Speed and Momentum Flux
  - Use sources consistent with USGS NSHM Program
- **GeoClaw Currents Compared to Field Data:**
  - Amanda R. Admire, 2013: Observed and modeled tsunami current velocities on California's north coast. Humboldt State University. (Available at http://humboldt-dspace.calstate.edu/handle/2148/1458.)

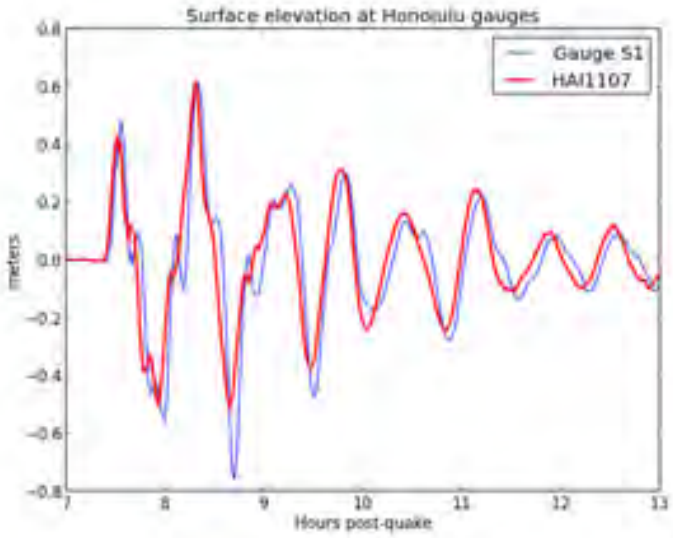
Preliminary Comparison of Geoclaw current computations with field estimates of maximum current speed in Crescent City harbor during the 2011 Tohoku Tsunami

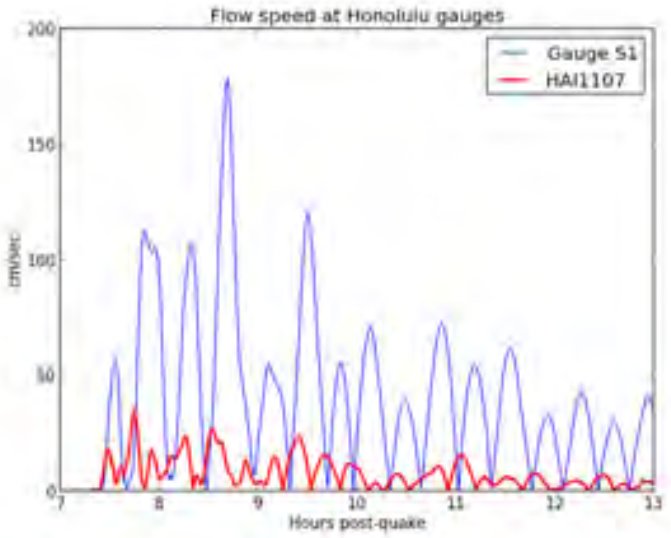


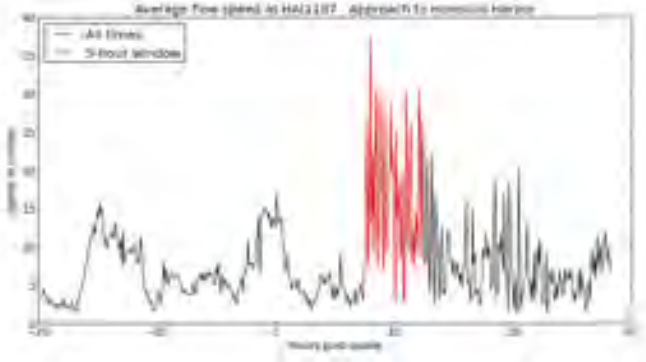

Figures are warped to ease comparison. Note that in the **eddy** of the small boat harbor, the Geoclaw estimates of maximum current speed are consistent with the field estimates of ~ 1 – 5 m/s .

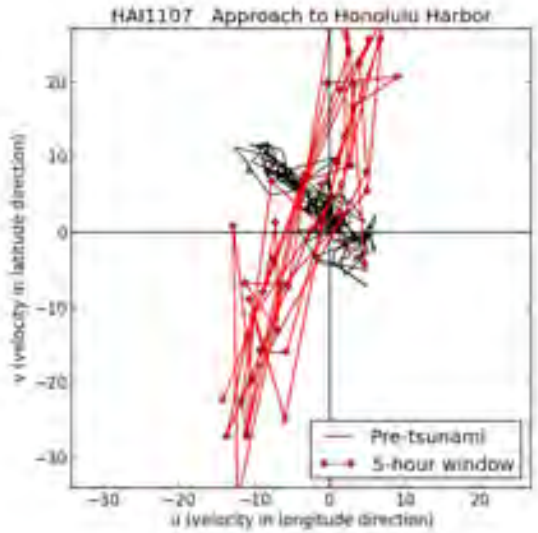

Gauge locations
21.34
21.33
21.32
21.31
21.30
21.29
21.28
TG
51
1107
202.09
202.10
202.11
202.12
202.13
202.14

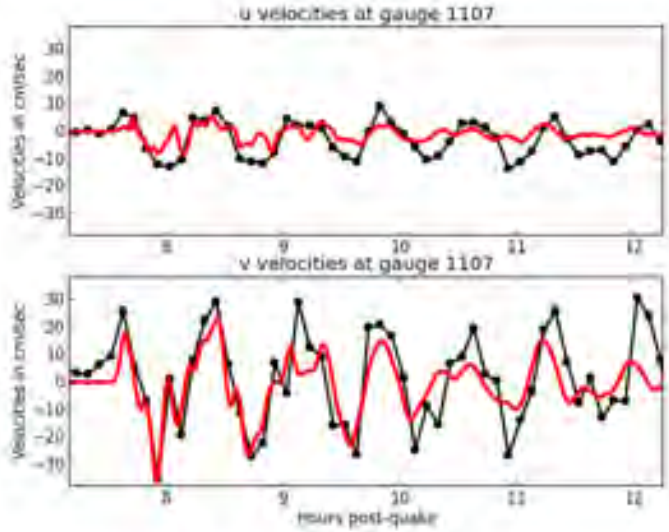

Maximum speed s
21.34
21.33
21.32
21.31
21.30
21.29
21.28
202.09
202.10
202.11
202.12
202.13
202.14

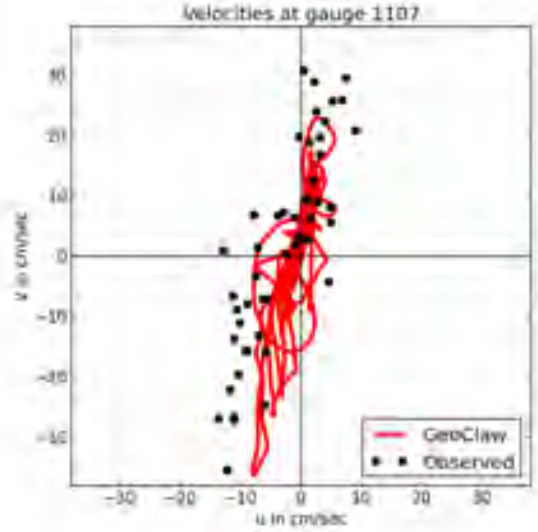

Surface elevation at Honolulu gauges
Gauge 51
HAI1107
meters
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
7
8
9
10
11
12
13
Hours post-quake


Flow speed at Honolulu gauges
Gauge 51
HAI1107
cm/sec
200
150
100
50
0
7
8
9
10
11
12
13
Hours post-quake



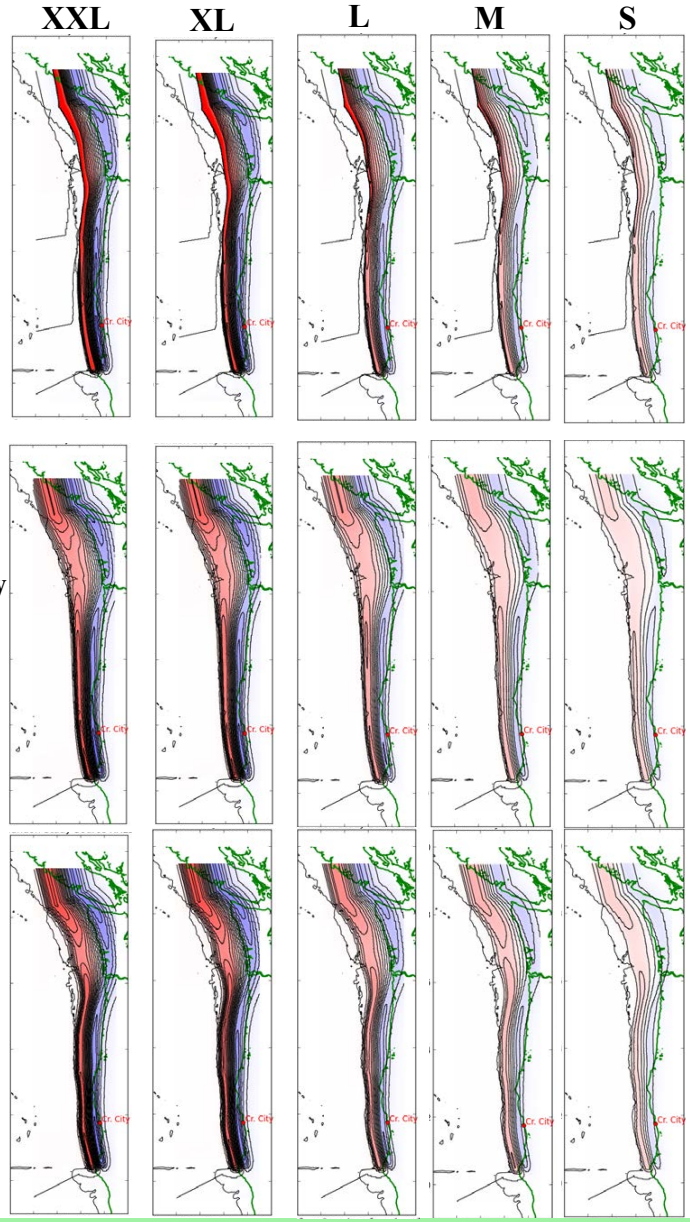

HAI1107 Approach to Honolulu Harbor
v (velocity in latitude direction)
u (velocity in longitude direction)
Pre-tsunami
5-hour window


u velocities at gauge 1107
Velocities in cm/sec
v velocities at gauge 1107
Velocities in cm/sec
hours post-quake


Velocities at gauge 1107
v in cm/sec
u in cm/sec
GeoClaw
Observed

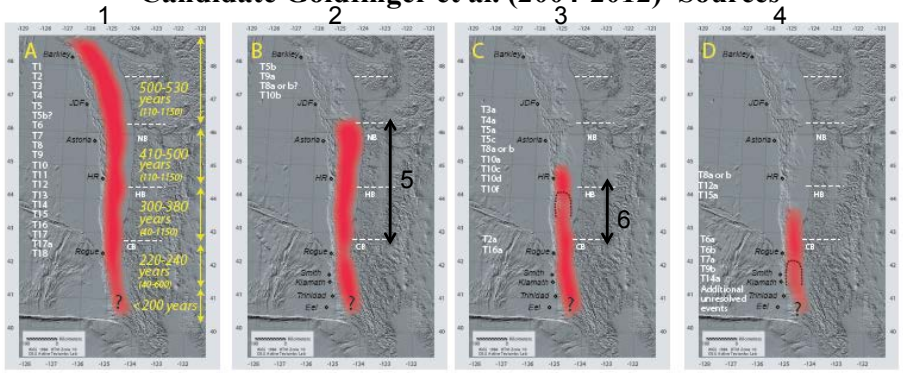
# Menlo Park Workshop (3-4 June 2013): "Sources should be consistent with USGS NSHM Program."

## Bandon sources

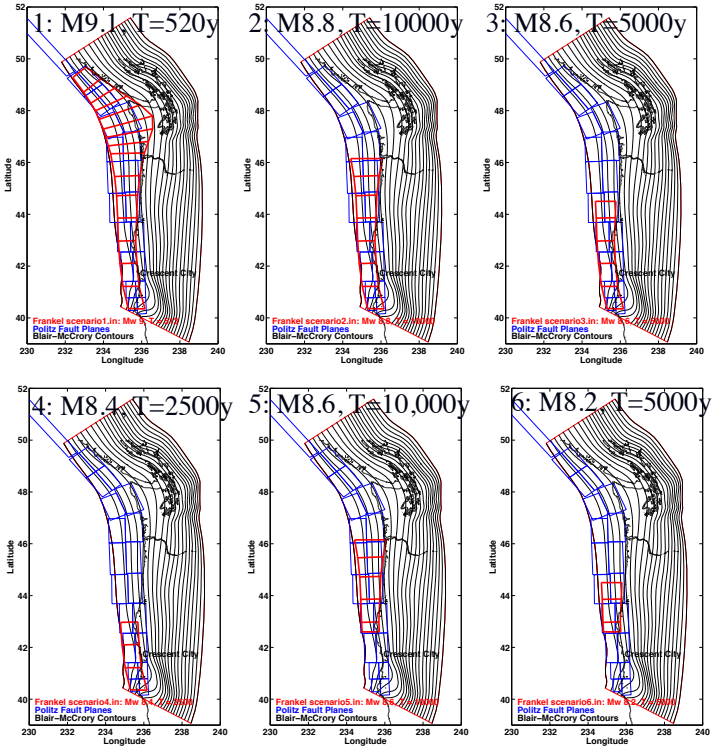



## Basis for sources consistent with NSHM

### Candidate Goldfinger et al. (2004-2012) Sources




### Candidate USGS NSHM Sources



# Summary

- **Phase I**
  - PTHA of Flood Depth
  - 0.01 and 0.002 annual probabilities of exceedance (100- and 500-yr events)
  - Developed improved tidal uncertainty methodology
  - Completed 31 January 2013 (https://digital.lib.washington.edu/researchworks/handle/1773/22366 )
  - But ... used Bandon Sources, which are not entirely consistent with USGS National Seismic Hazard Mapping Program

- **Phase II**
  - PTHA of Flood Depth, Currents and Momentum Flux
  - 0.01, 0.002 and 0.0004 annual probabilities of exceedance (100-, 500- and 2500-yr events)
  - URS developing sources consistent with USGS National Seismic Hazard Mapping Program
  - Completion by 3 December 2013