Developing Real-time Tsunami Forecast for US coasts.

(Challenges and Solutions)

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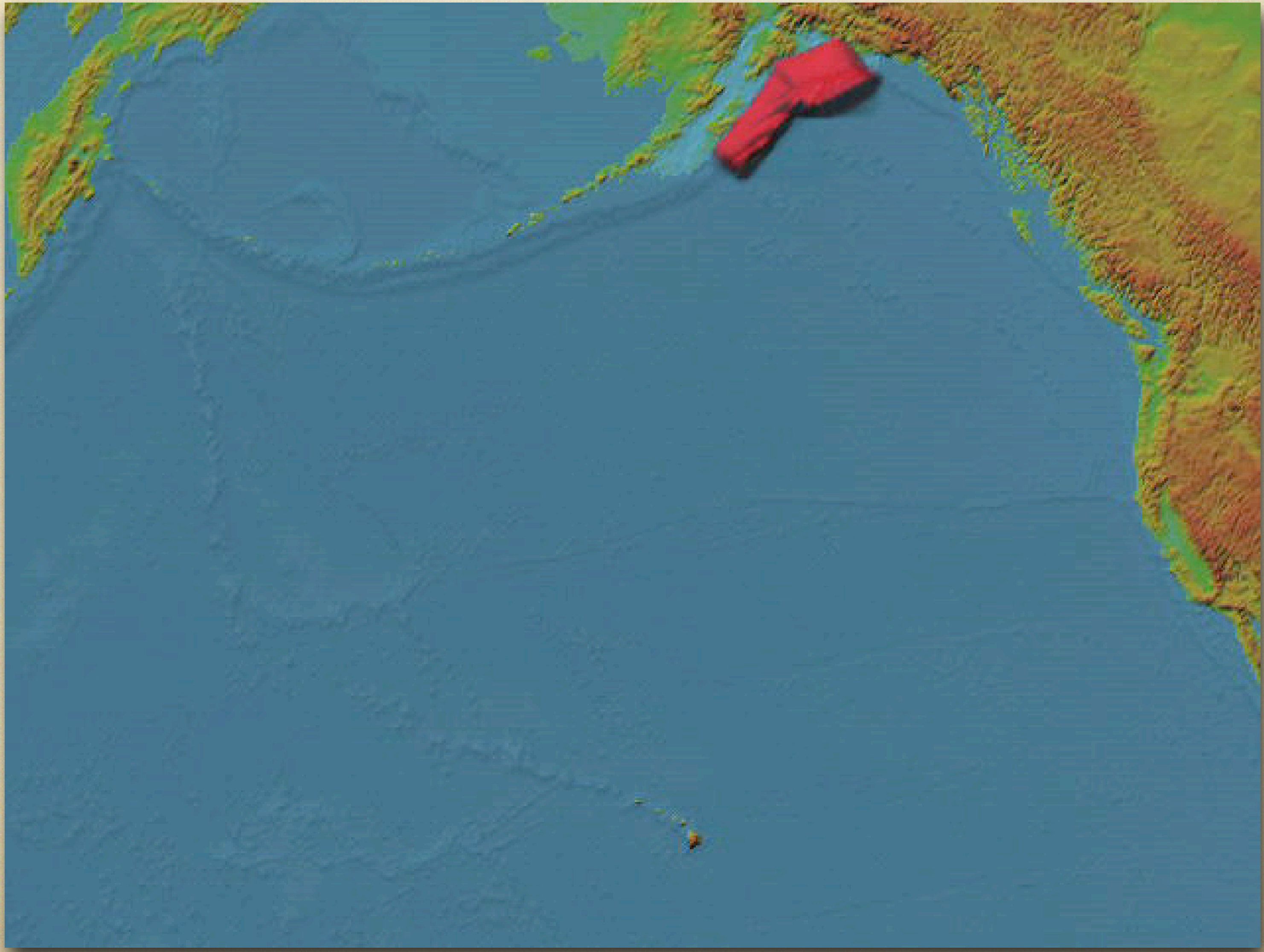
Tsunami Forecast:

use models to predict site-specific impact

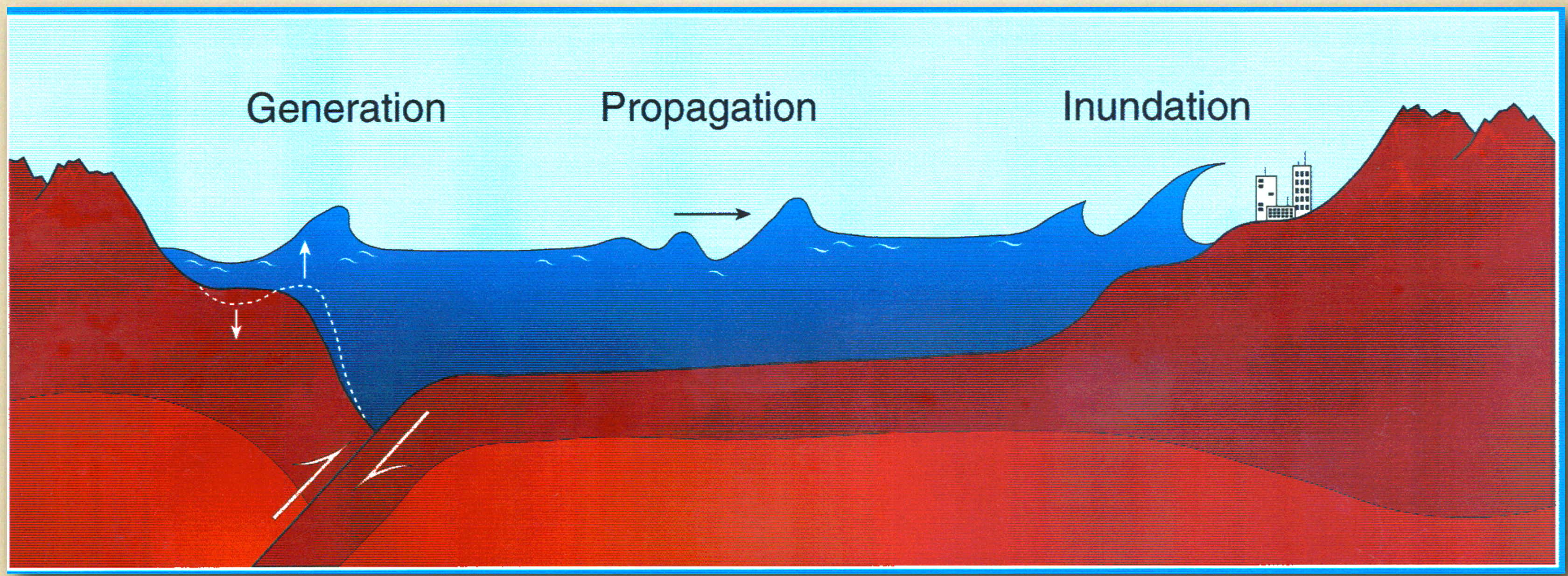


Forecast Challenge 1:

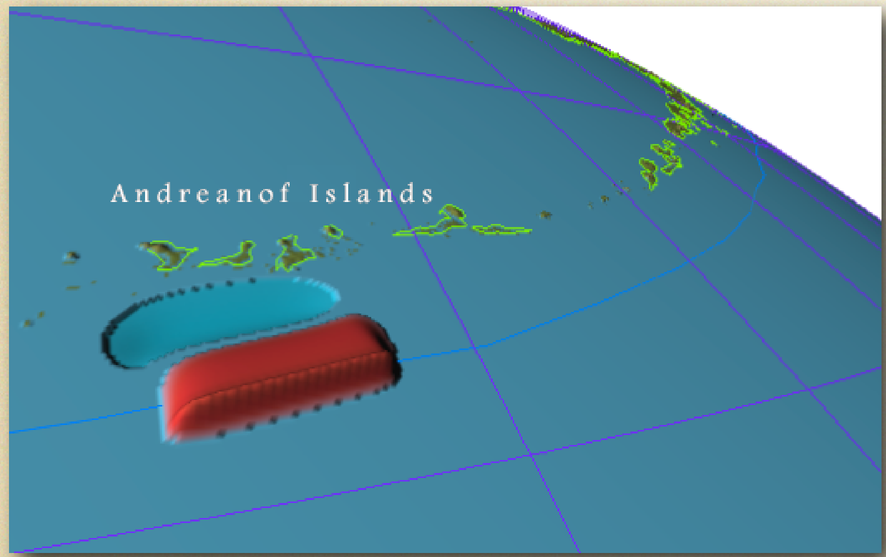
Can models reproduce details of tsunami impact?

Can models provide useful timely forecast?

Tsunami Modeling Stages



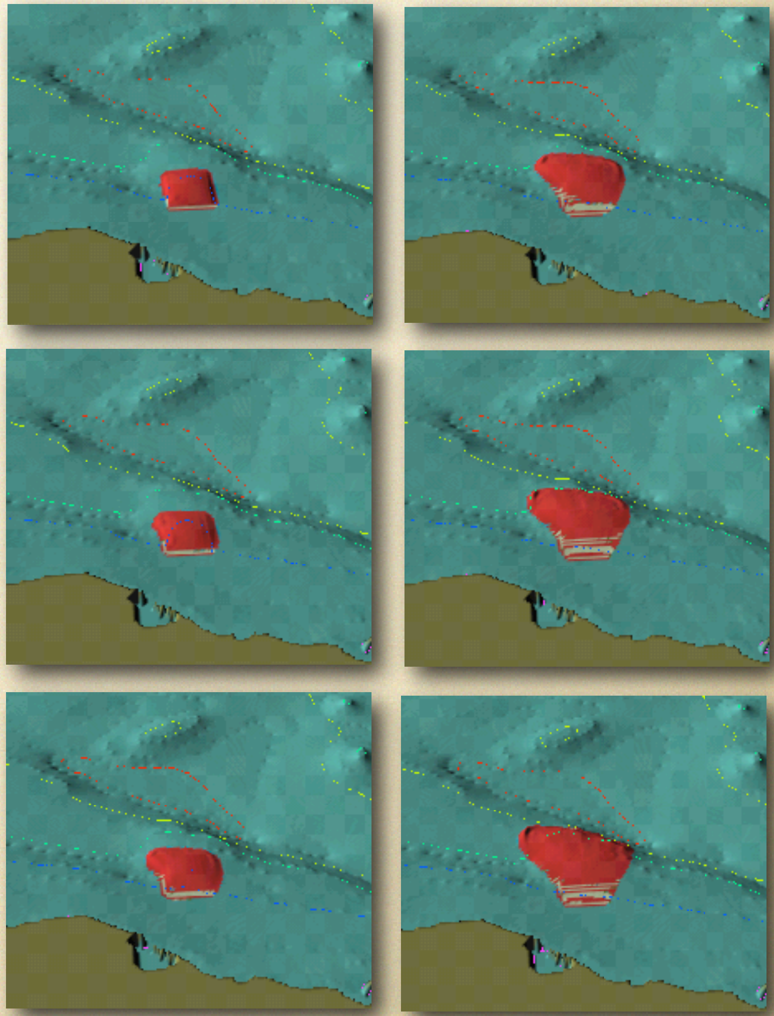
Model Sources



<u>Seismic source</u>

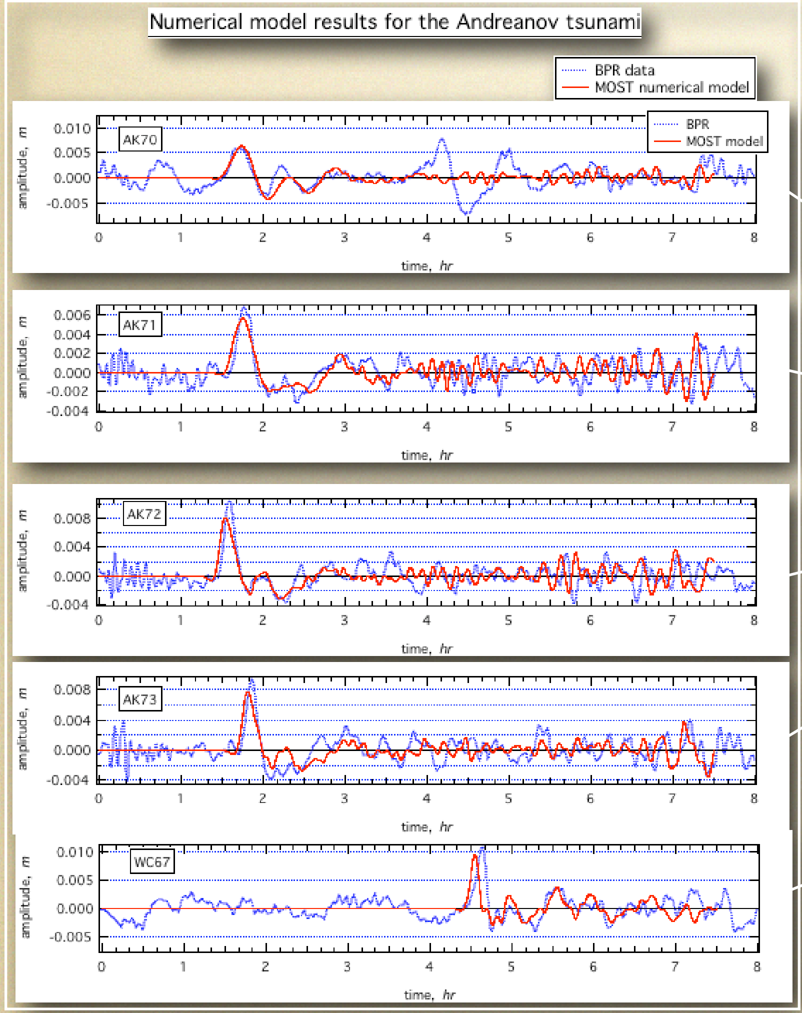
June10, 1996
Andreanov Island tsunami
Source Parameters:

Mw	7.9
Length	140km
Width	70km
Strike	260
Dip	20
Rake	108
Slip	2m

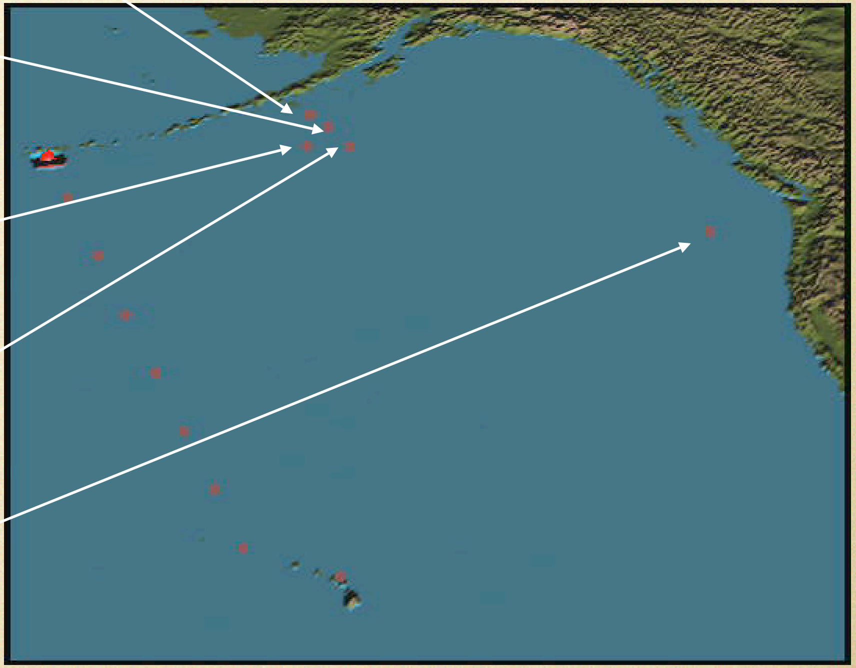


<u>Landslide source</u>
1998 Papua New Guinea tsunami

Propagation model testing



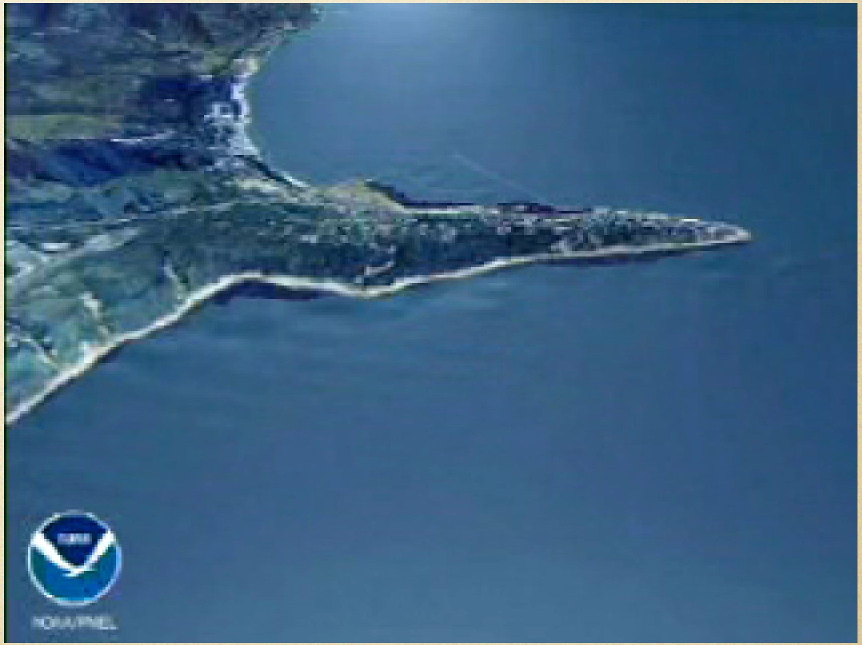
June 10, 1996 Andreanov tsunami
Simulation (MOST model)



Inundation model

Simulation of the Aonae inundation

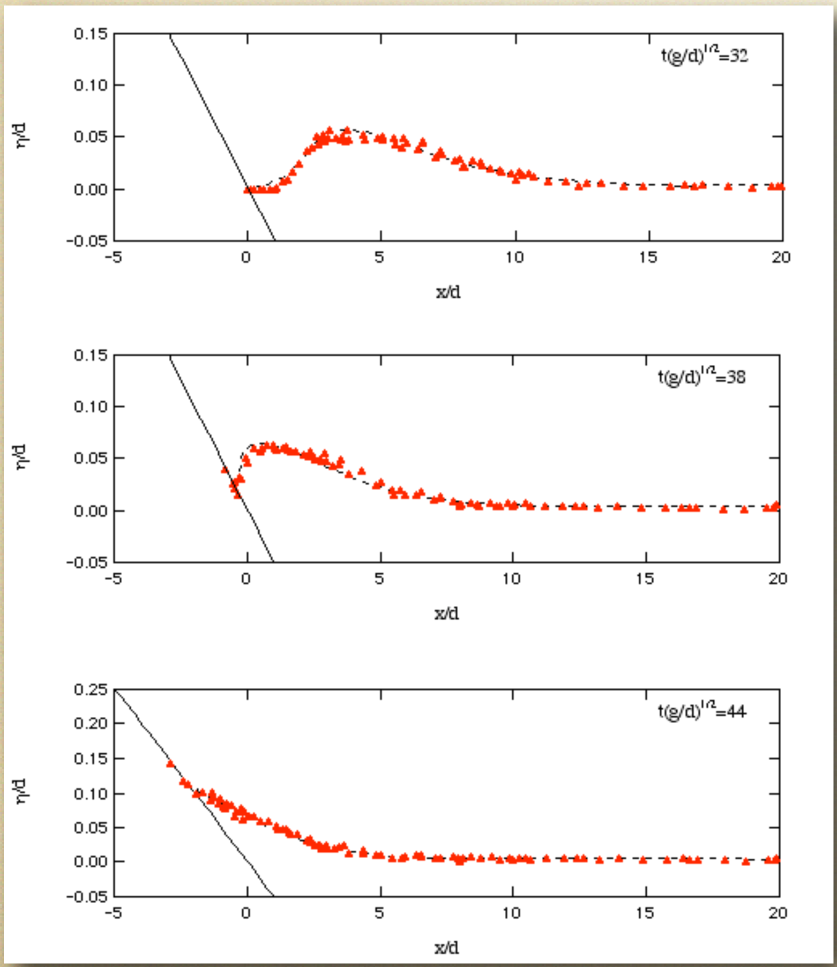
(1993 Okushiri tsunami)

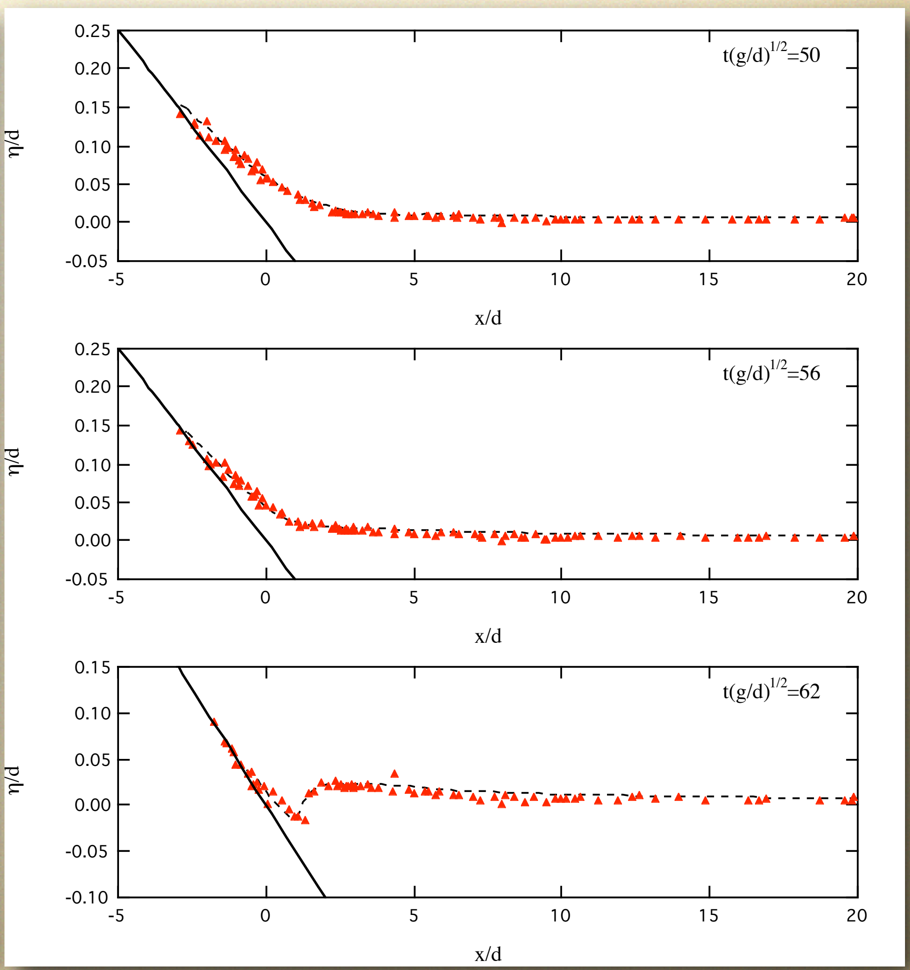


MOST Validation

Solitary wave runup on plain beach $H/d = 0.04$

Titov, V.V., and Synolakis, C.E. , 1998, Numerical modeling of tidal wave runup. Journal of Waterway, Port, Ocean and Coastal Engineering, 124 4), 157 – 171.

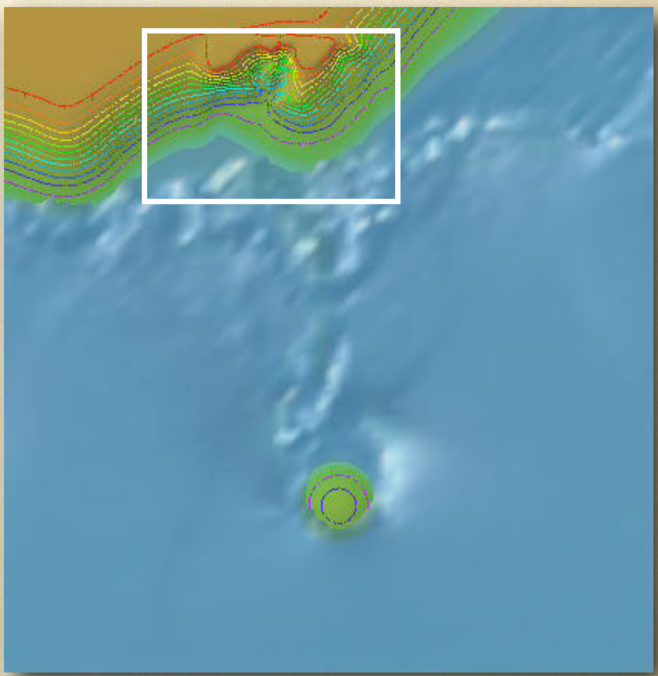




MOST validation

Catalina Workshop Benchmarks (Liu *et al.*, 2006)

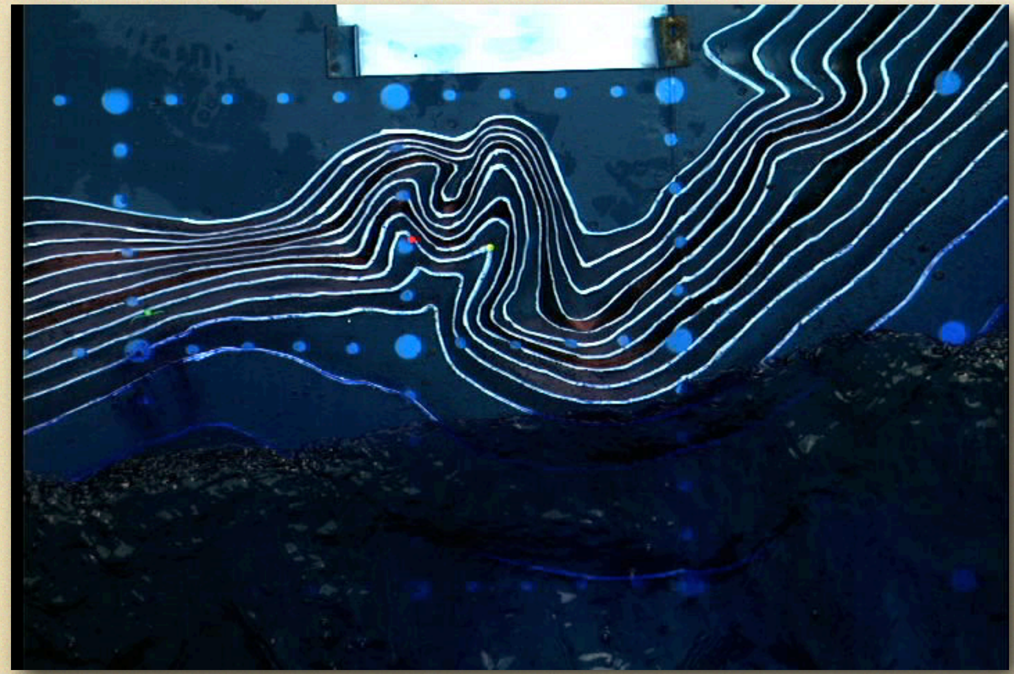
Wave tank experiment



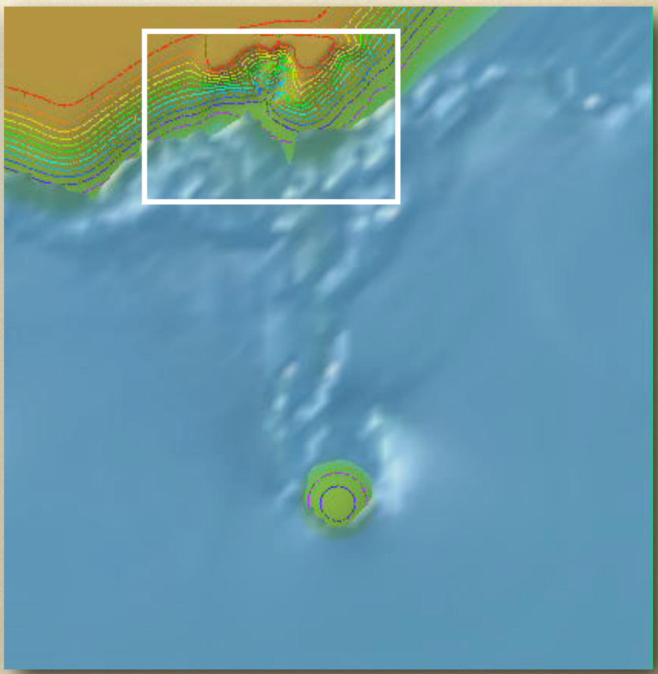
MOST model

MOST validation

Catalina Workshop Benchmarks (Liu *et al.*, 2006)



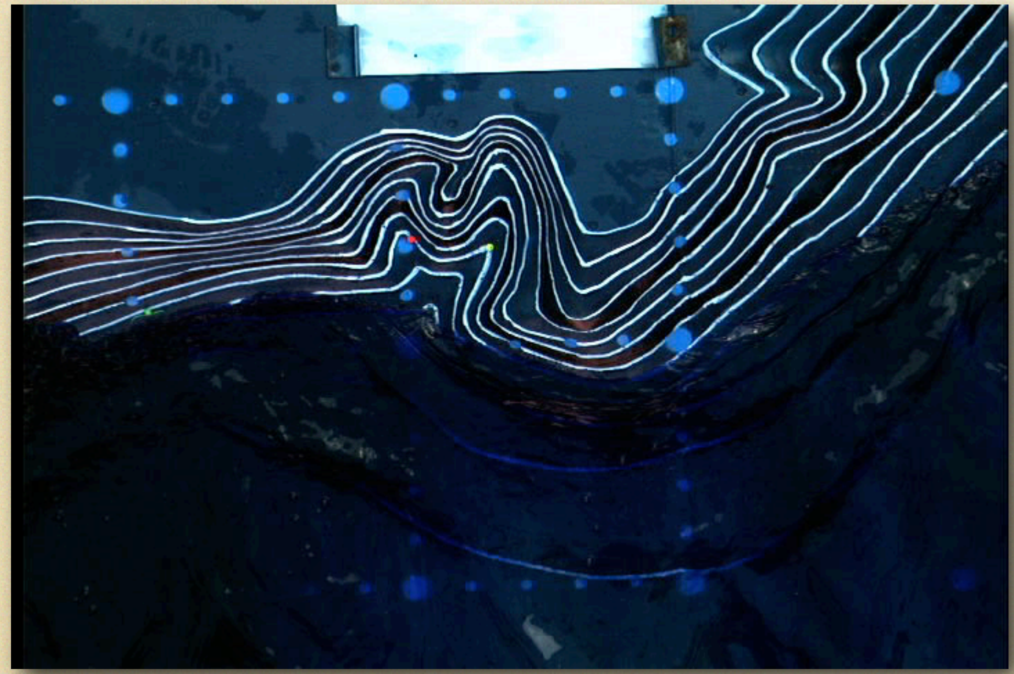
Wave tank experiment



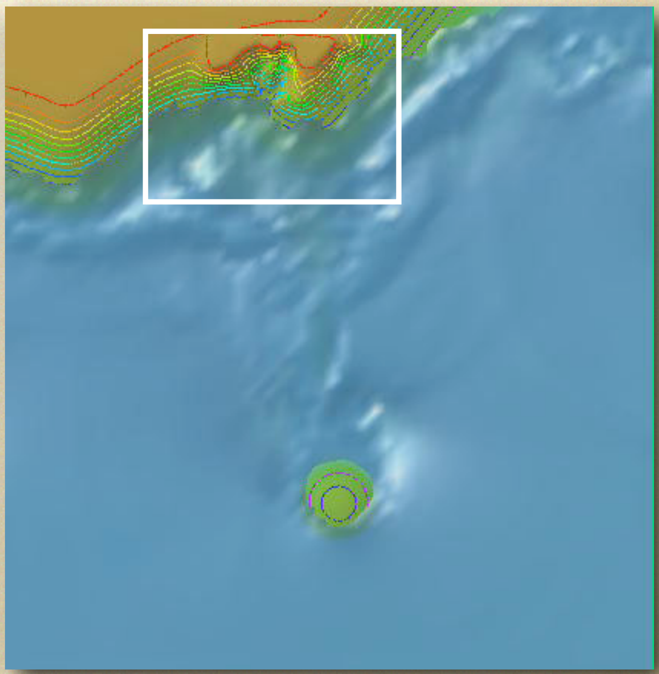
MOST model

MOST validation

Catalina Workshop Benchmarks (Liu *et al.*, 2006)



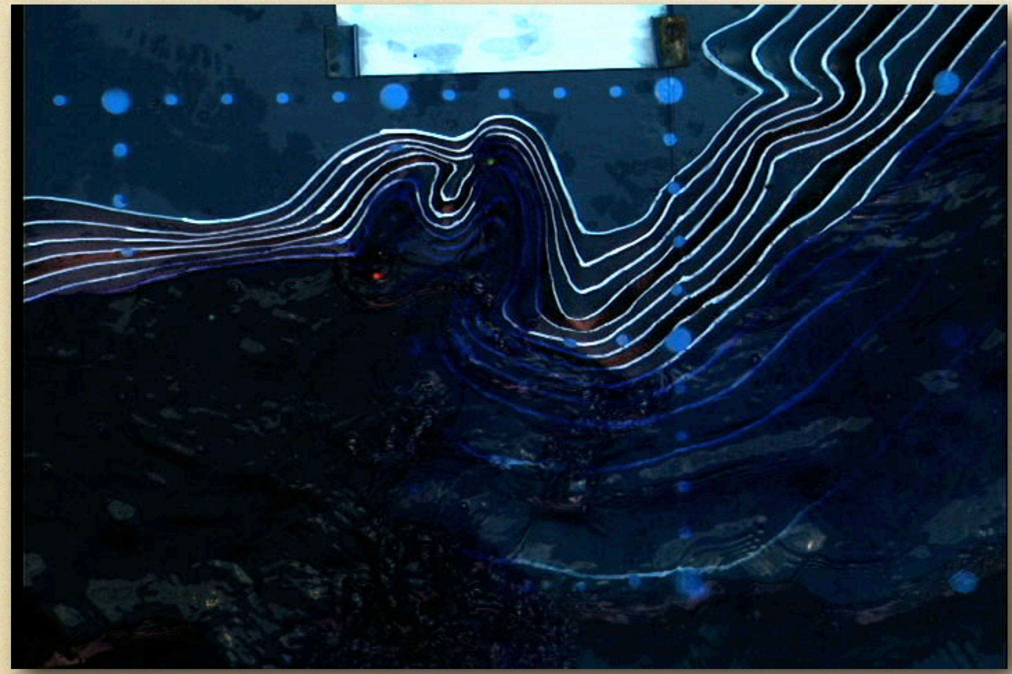
Wave tank experiment



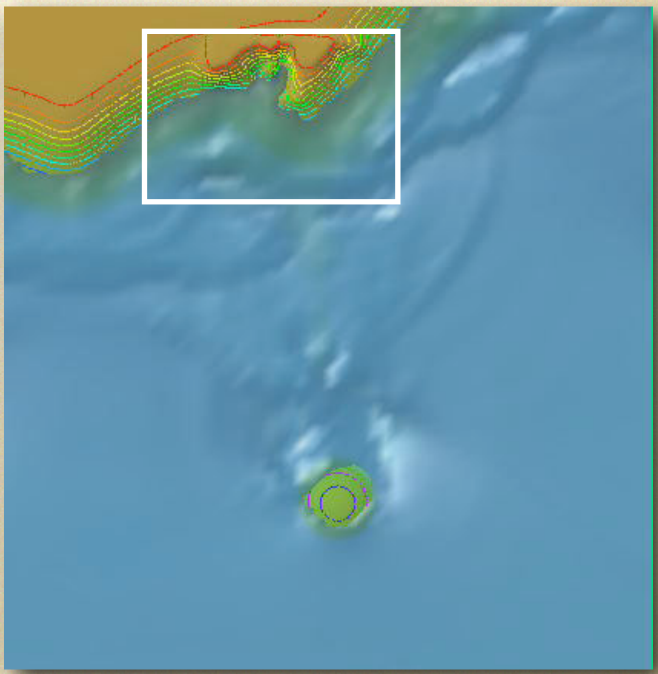
MOST model

MOST validation

Catalina Workshop Benchmarks (Liu *et al.*, 2006)



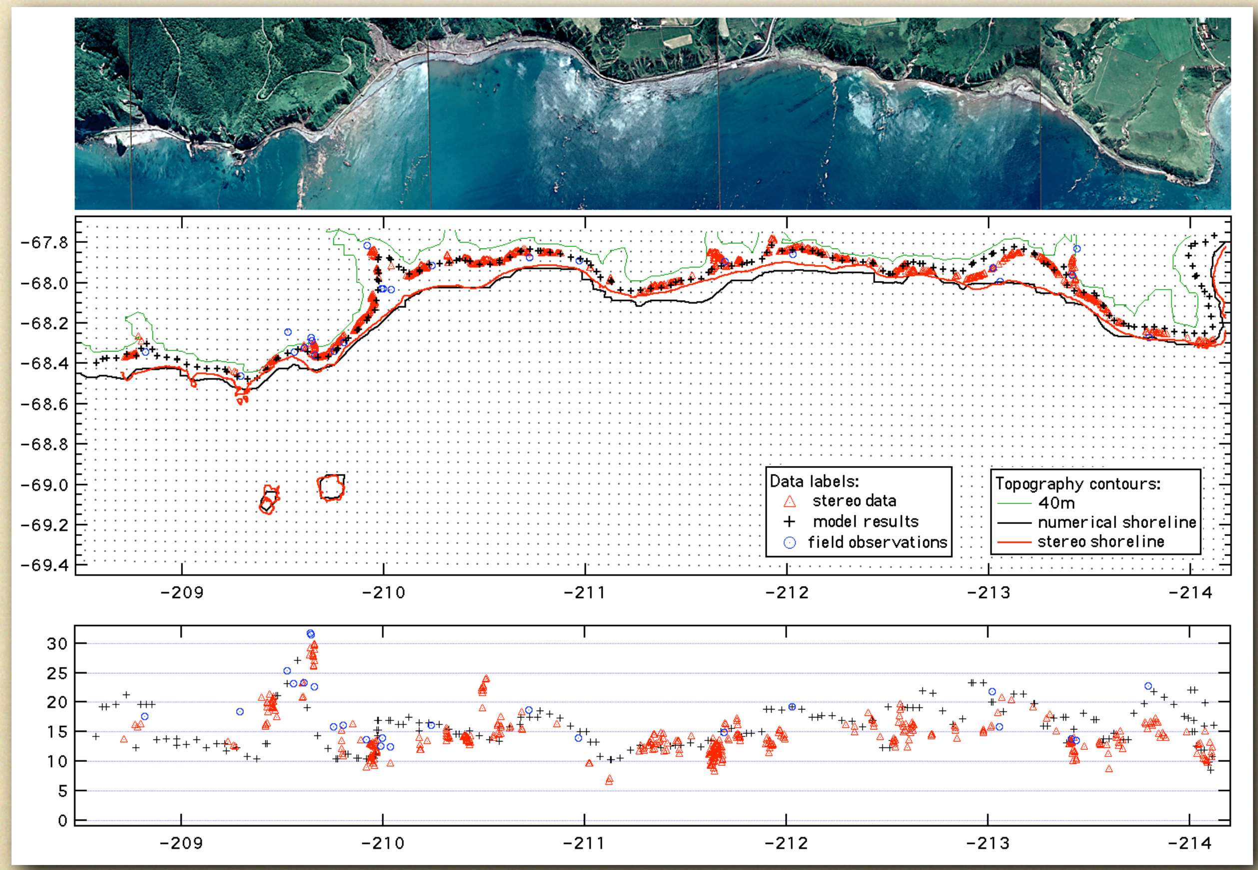
Wave tank experiment



MOST model

MOST validation

Okushiri simulation compared with field data

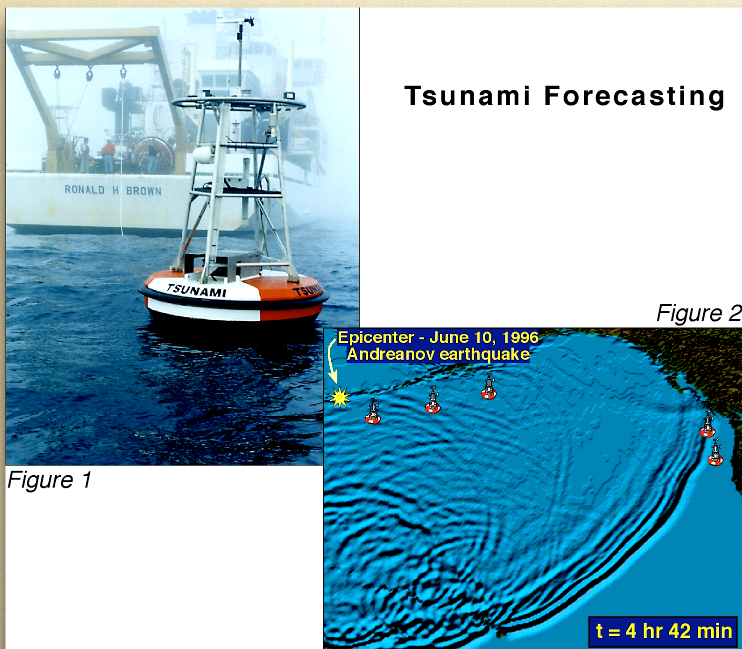


Forecast Challenge 2:

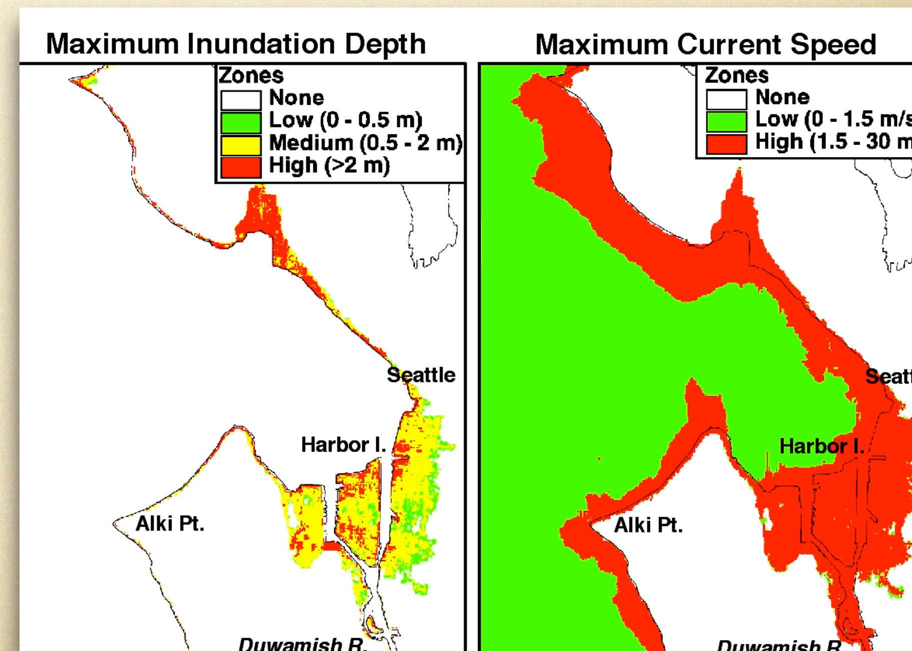
Can models provide useful timely forecast?

Tsunami Forecasting

Short-Term
(Real-time, during the event)



Long-Term
(Community inundation maps)



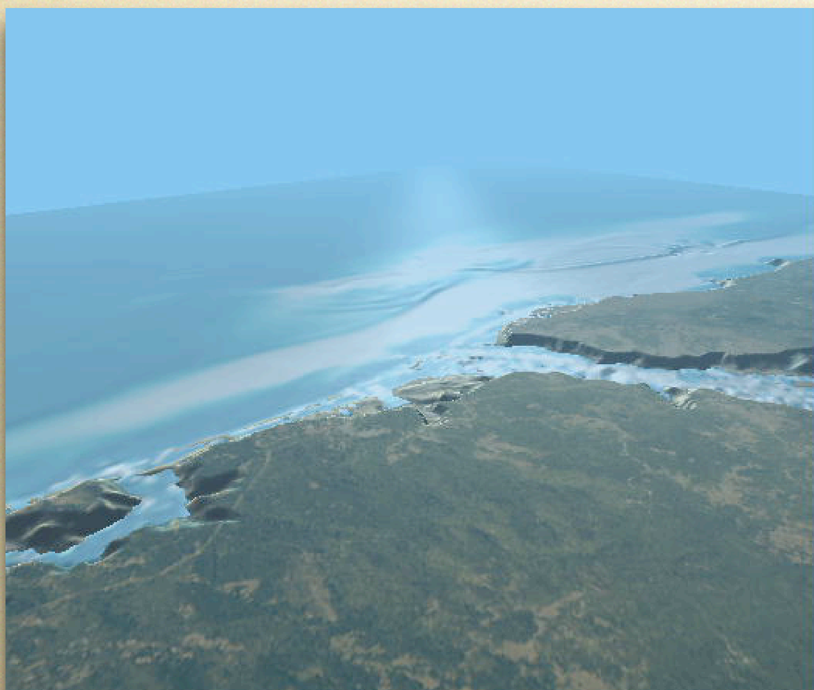
Tsunami Inundation Mapping

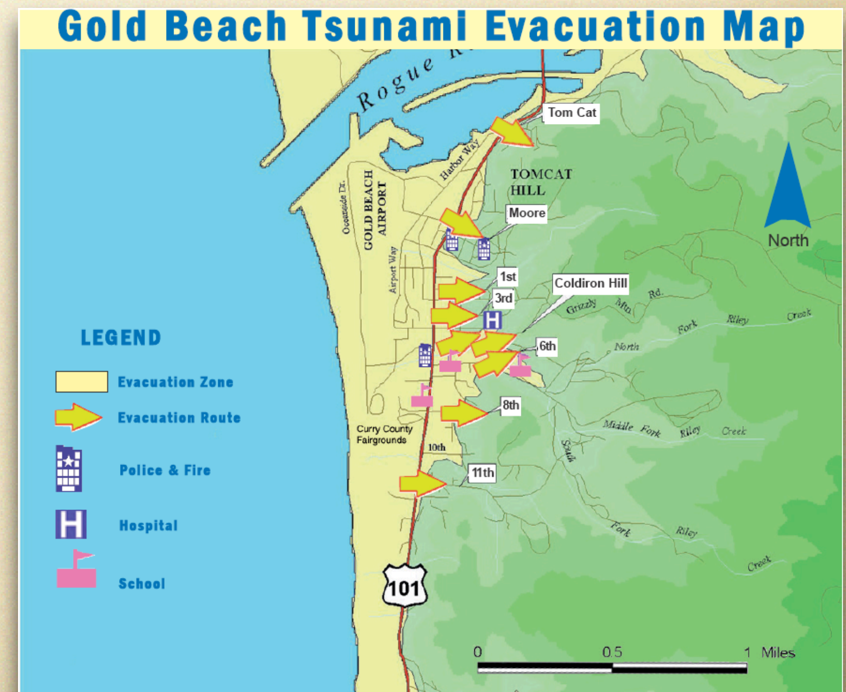
Apply:

- High-resolution model
- deterministic worst-case scenario

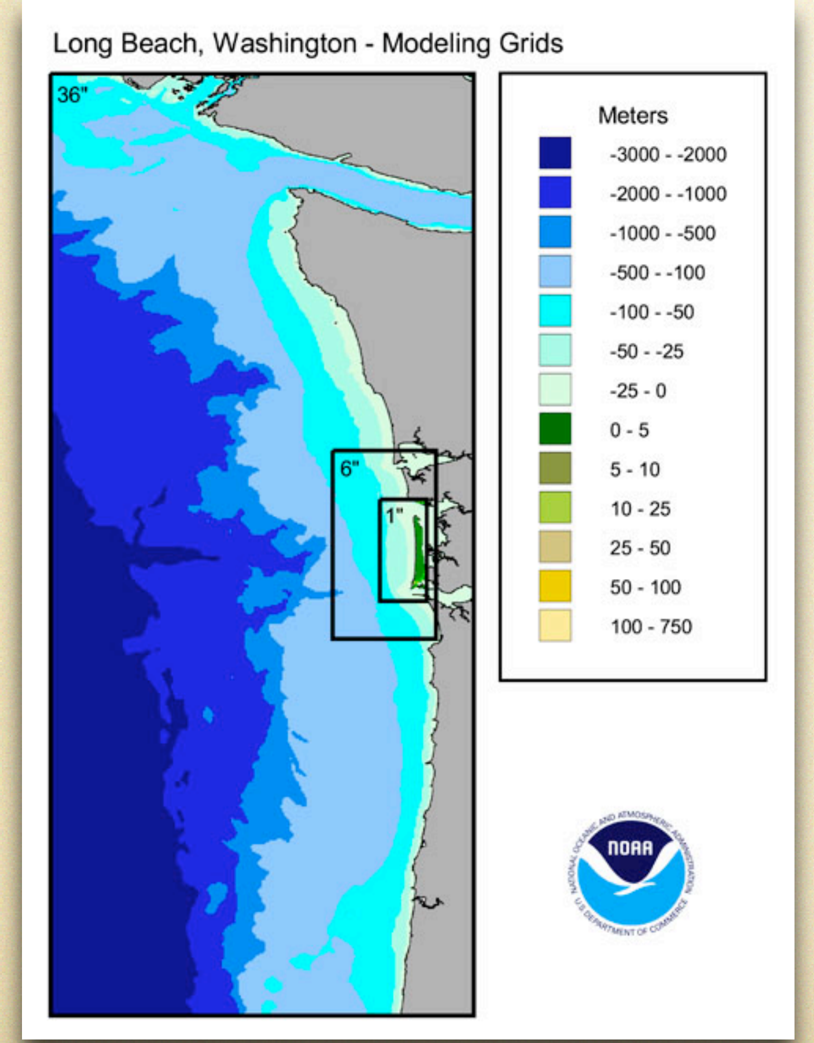
Produce:

- Tsunami inundation maps
- Evacuation maps

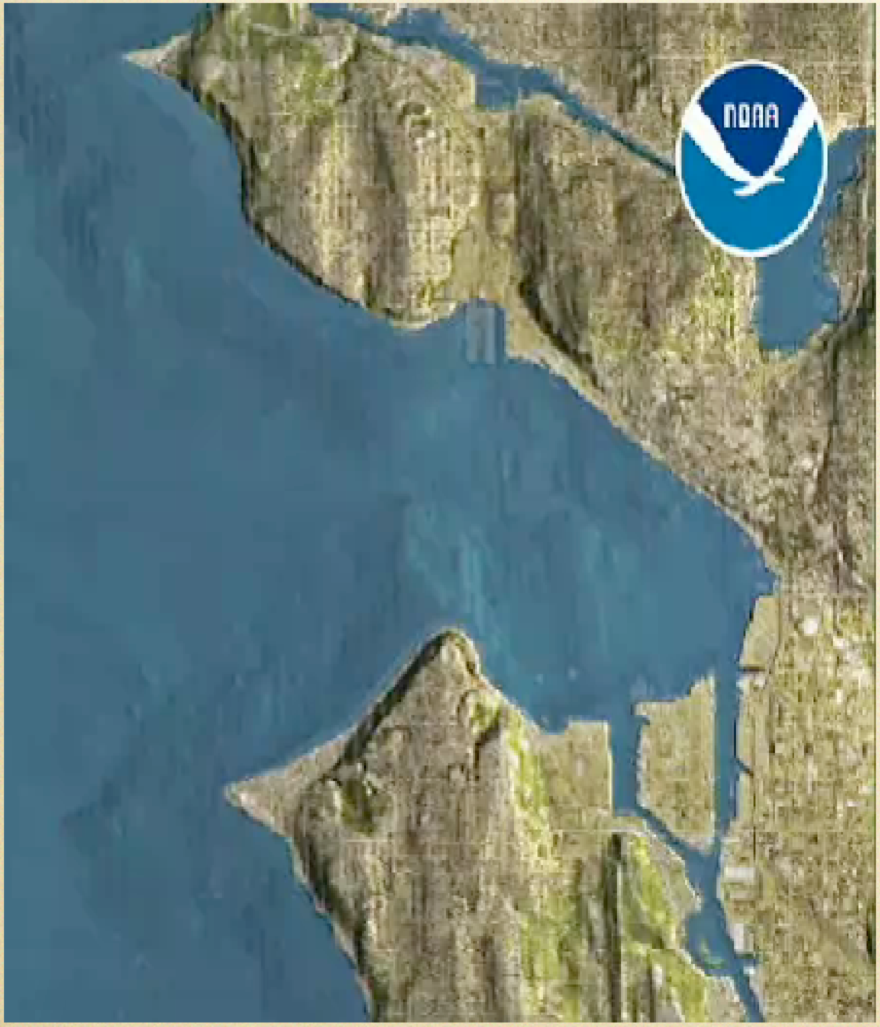


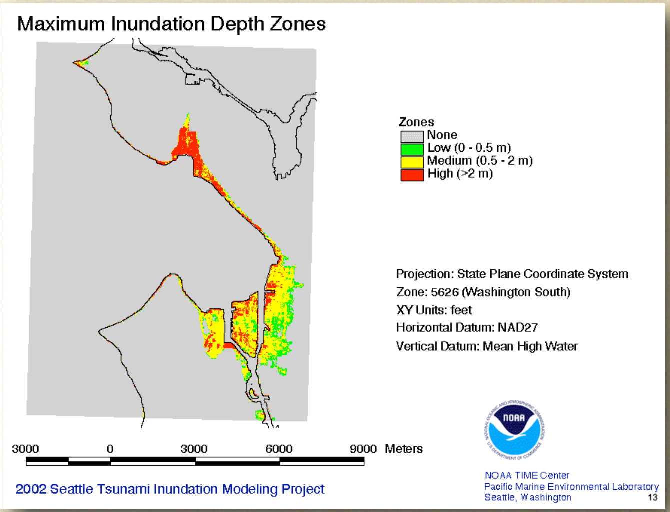


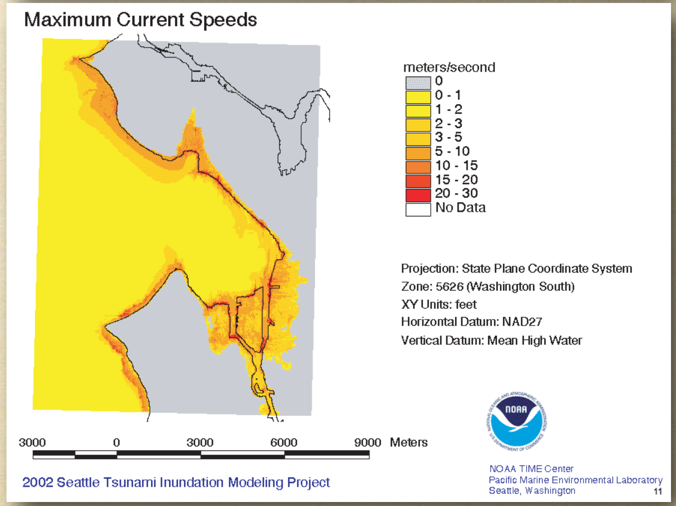
Modeling for Mapping



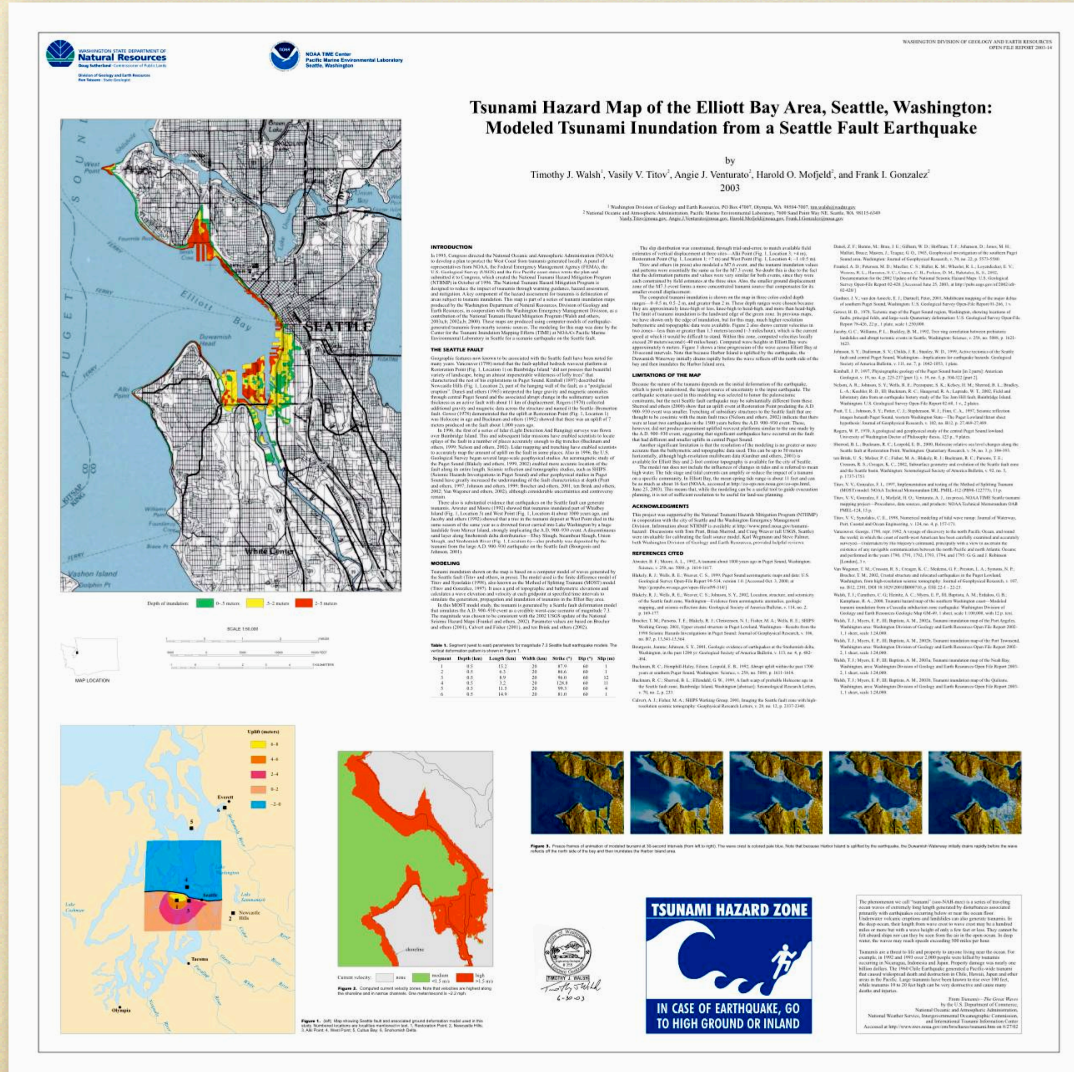
Scientific Products:



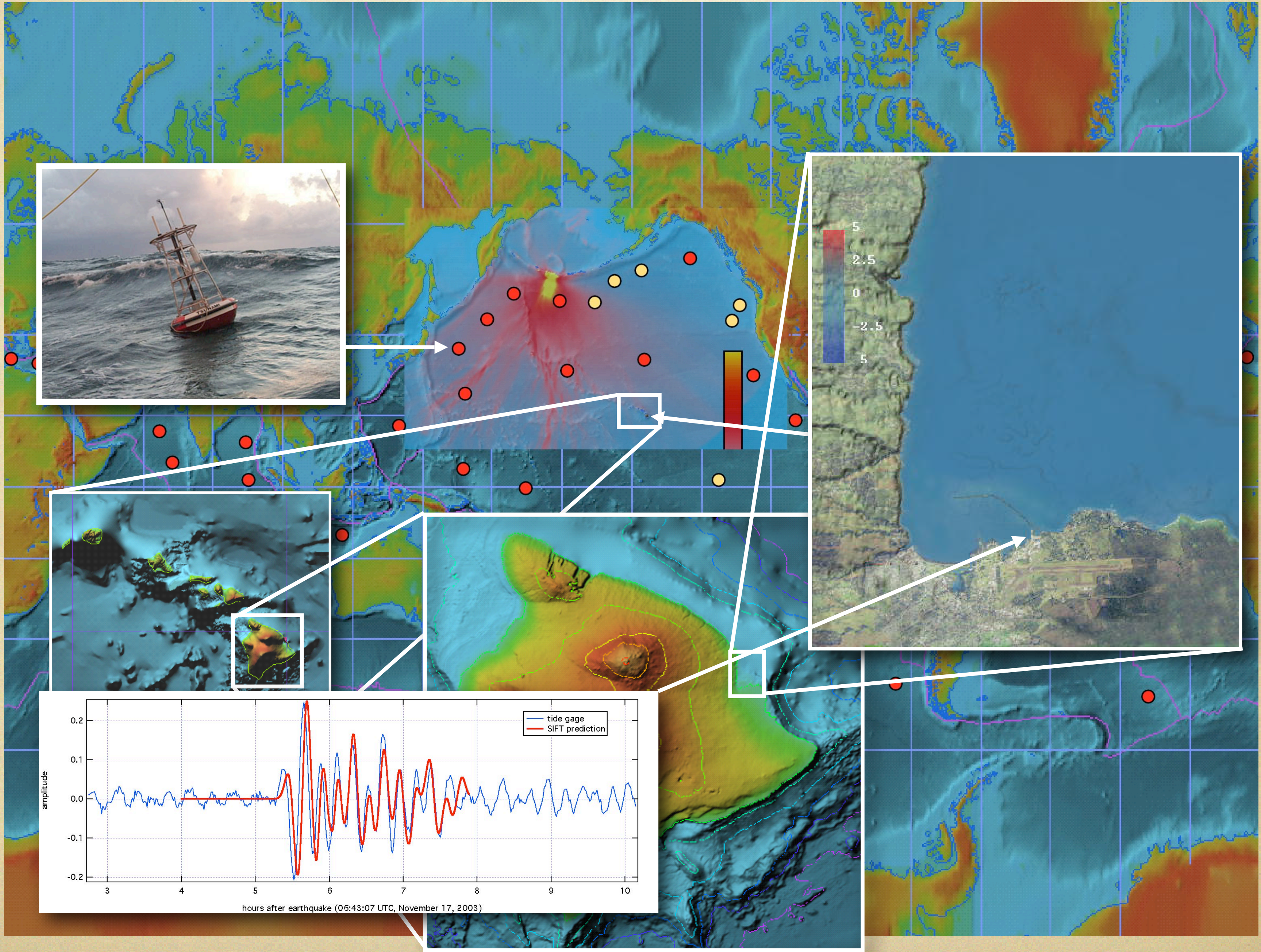




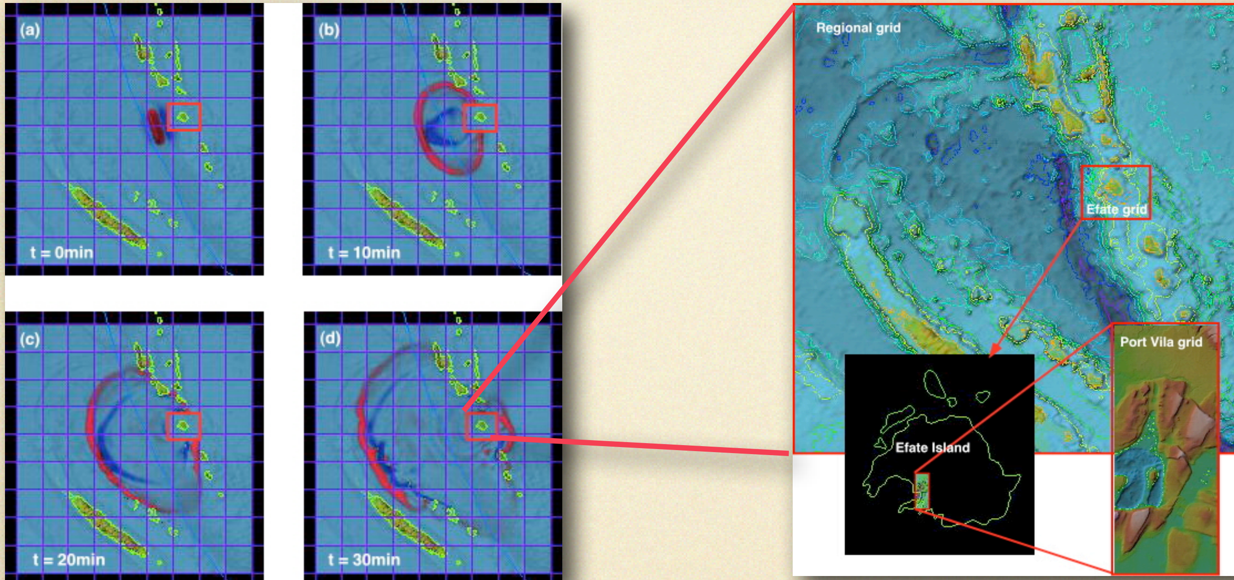
State Products: Inundation Map

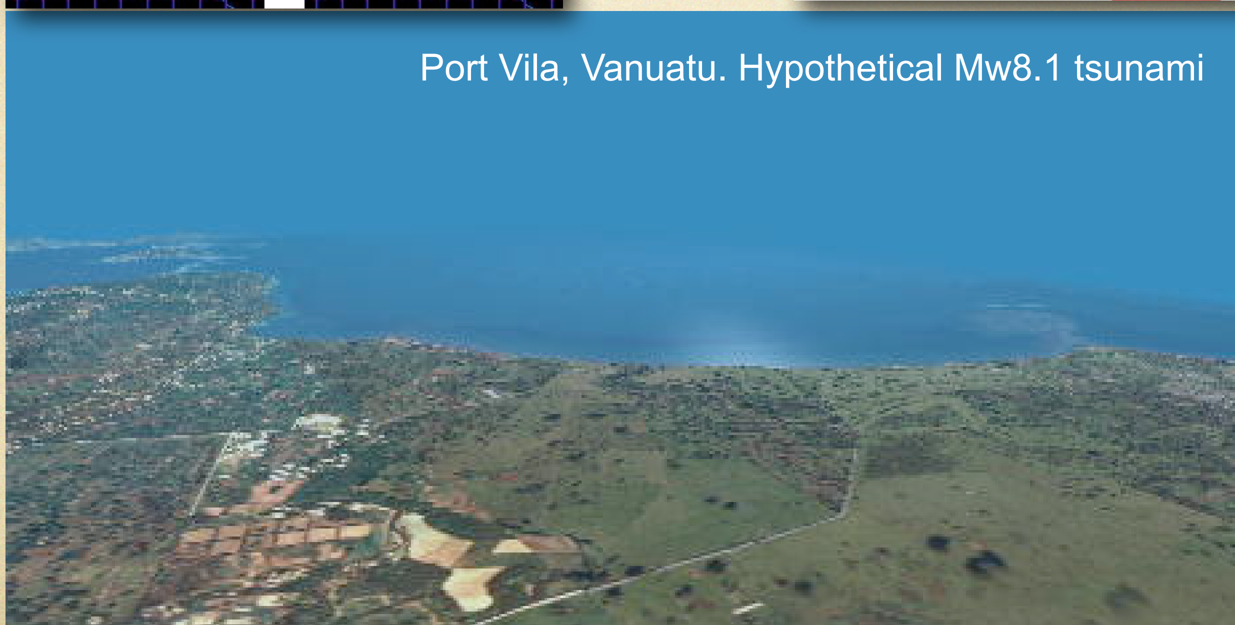


NOAA Tsunami Forecast

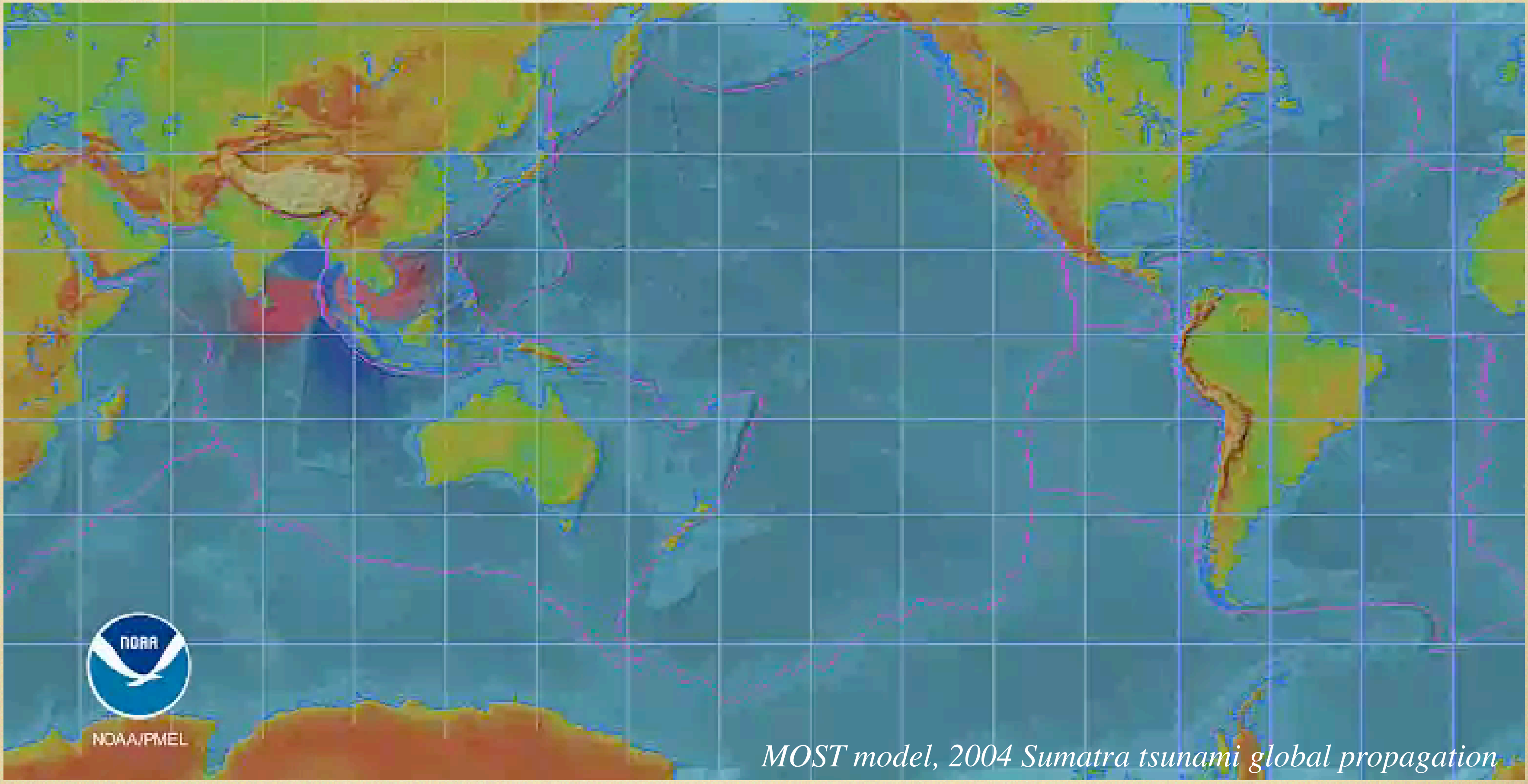


High-resolution model

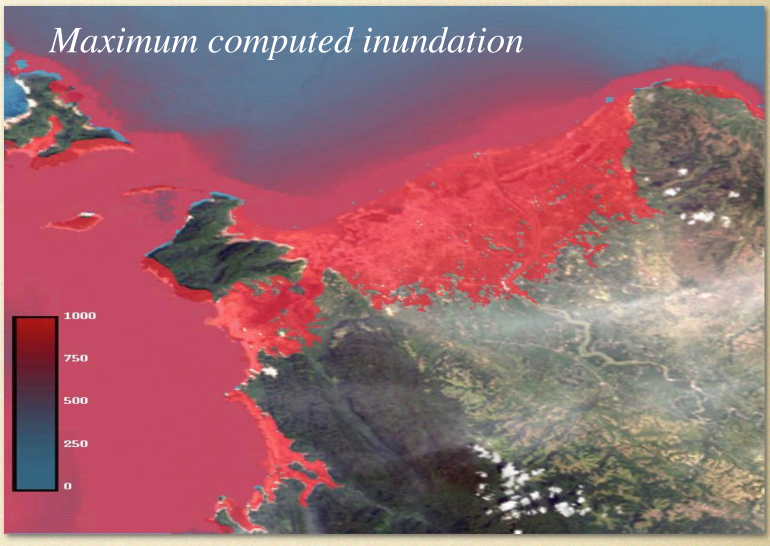


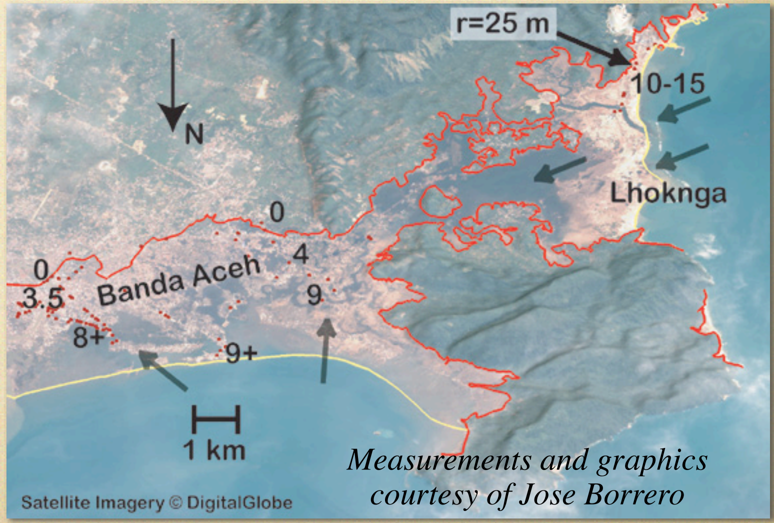


Sumatra 2004: Propagation model

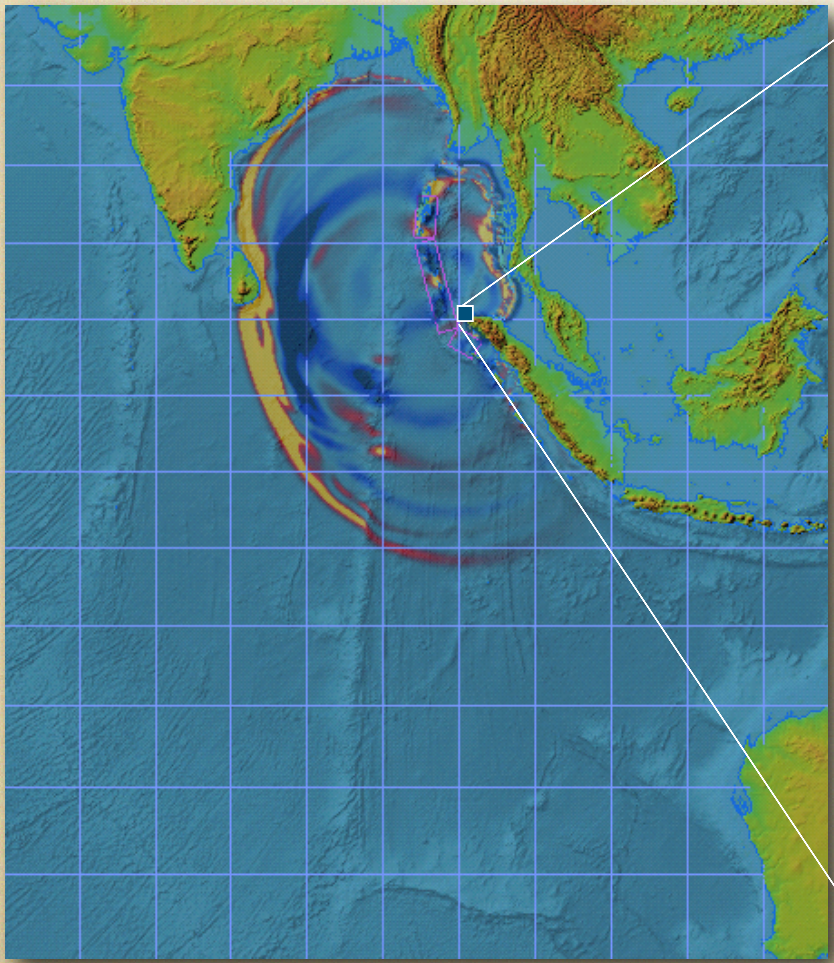


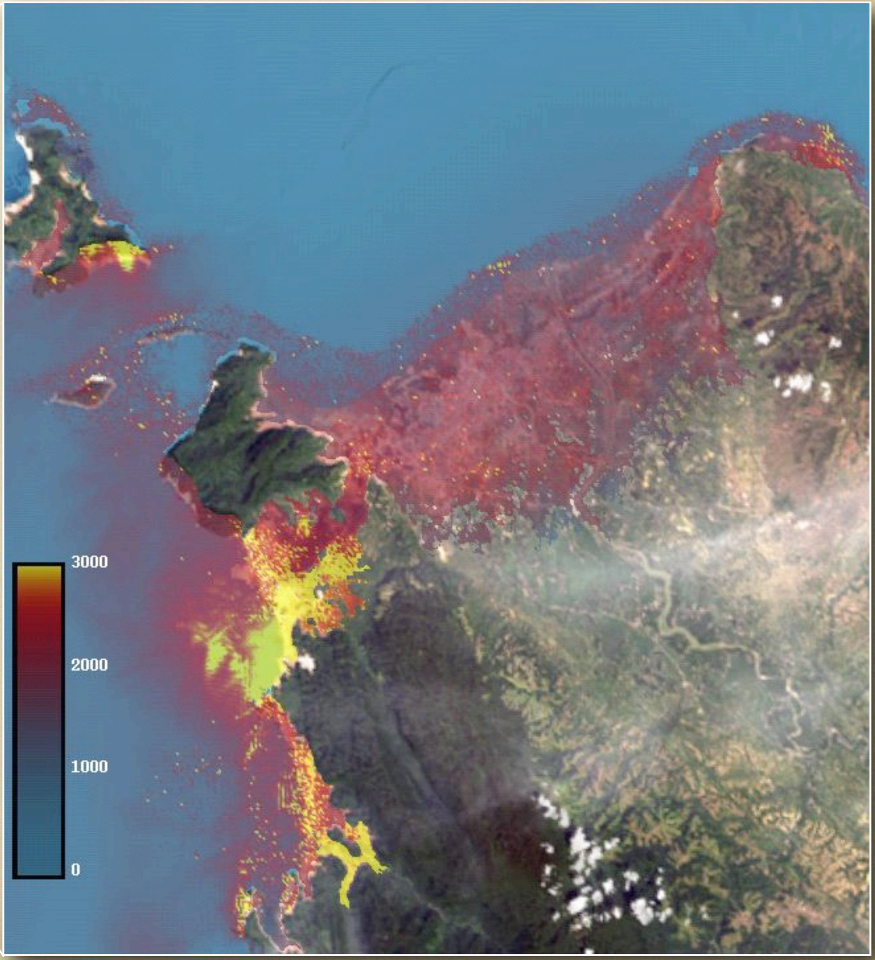
Sumatra 2004: Inundation Model





Test for Tsunami Forecast



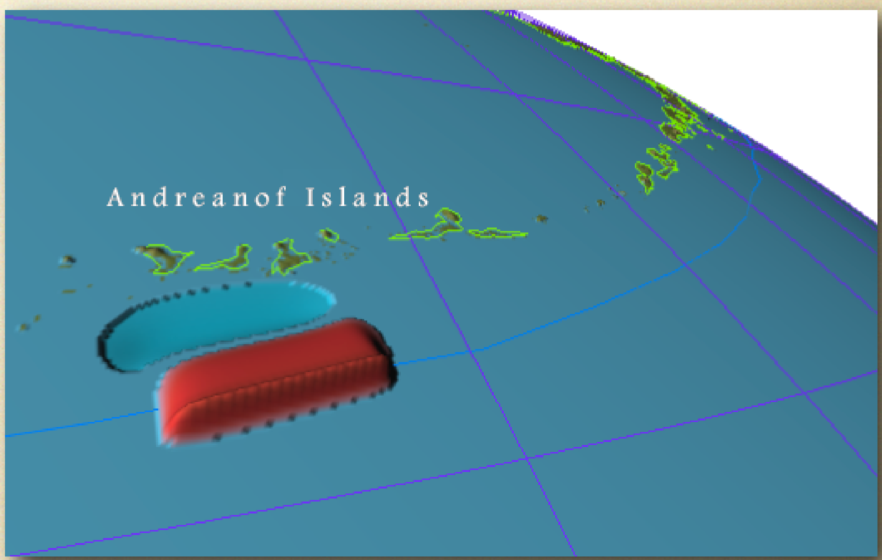


Challenge 3: Source definition

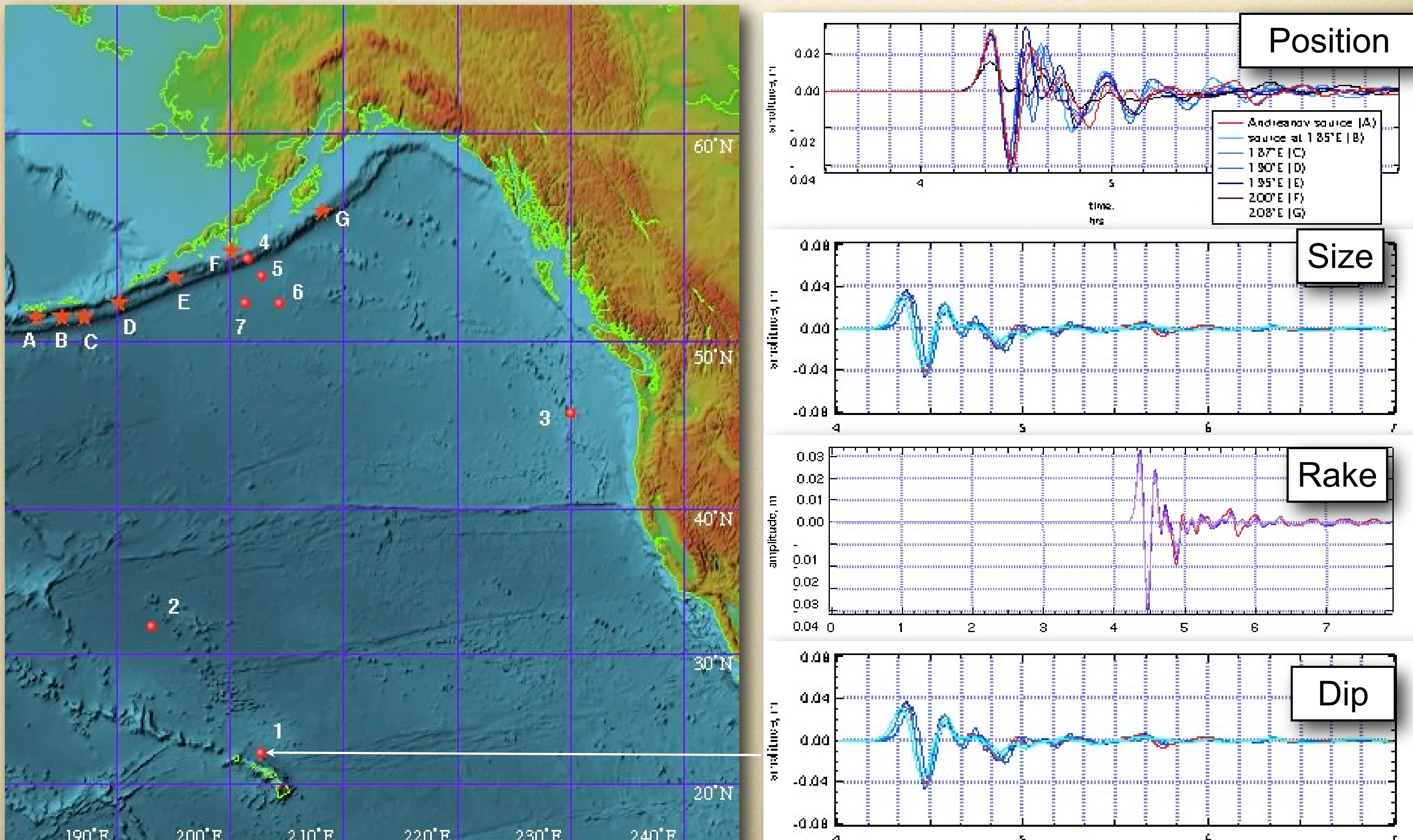
June10, 1996
Andreanov Island tsunami

Source Parameters:

Mw	7.9
Length	140km
Width	70km
Strike	260
Dip	20
Rake	108
Slip	2m



Source Sensitivity Study



Source Sensitivity Study

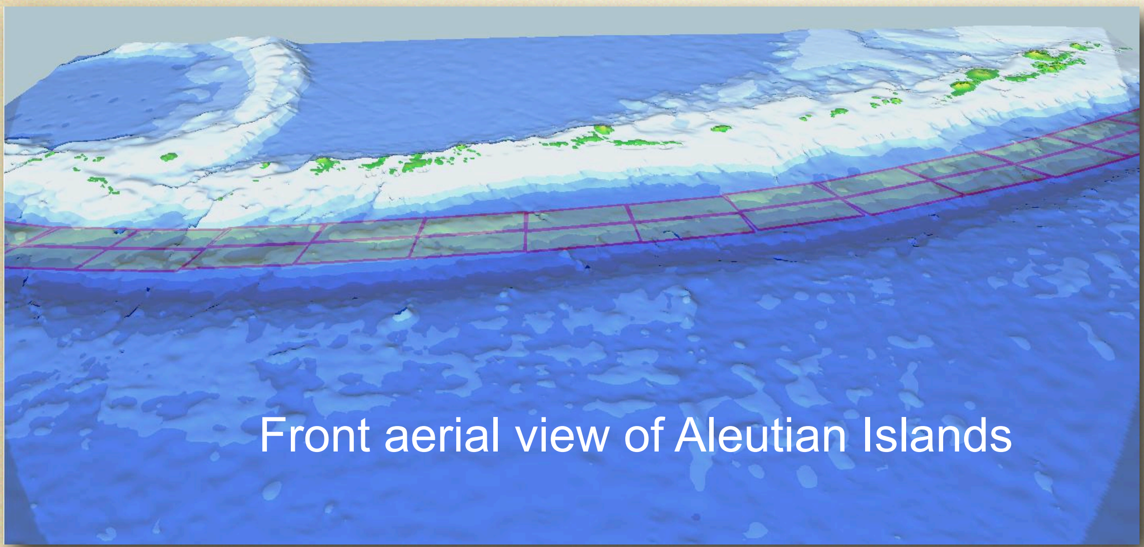
Titov, V. V., H.O. Mofjeld, F.I. González and J.C. Newman, 1999, Offshore forecasting of Alaska-Aleutian Subduction Zone tsunamis in Hawaii, NOAA Tech. Memo. ERL PMEL-114, 22pp.

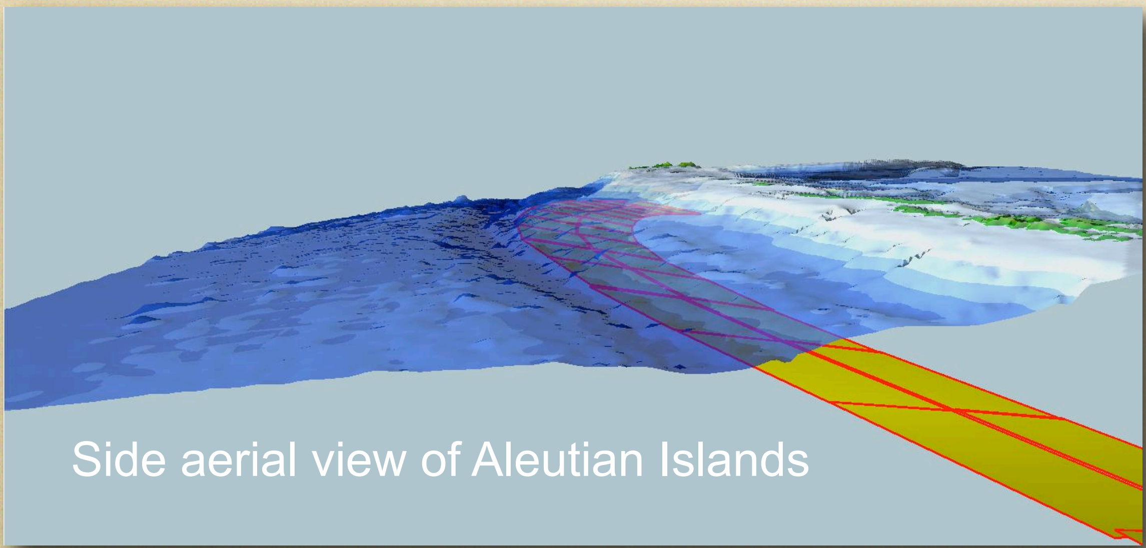
The sensitivity study for AASZ earthquake demonstrates that the offshore tsunami characteristics weakly depend on STRIKE, DIP, SLIP and SIZE (if the Moment kept constant by adjusting slip amount). Hence, the leading tsunami waves generated by AASZ earthquakes are characterized in the far field mainly by *earthquake magnitude and location*.

Forecast Methodology

- Linear propagation database
- Linear combinations model arbitrary source
- Source correction using DART
- Inundation estimates with non-linear model

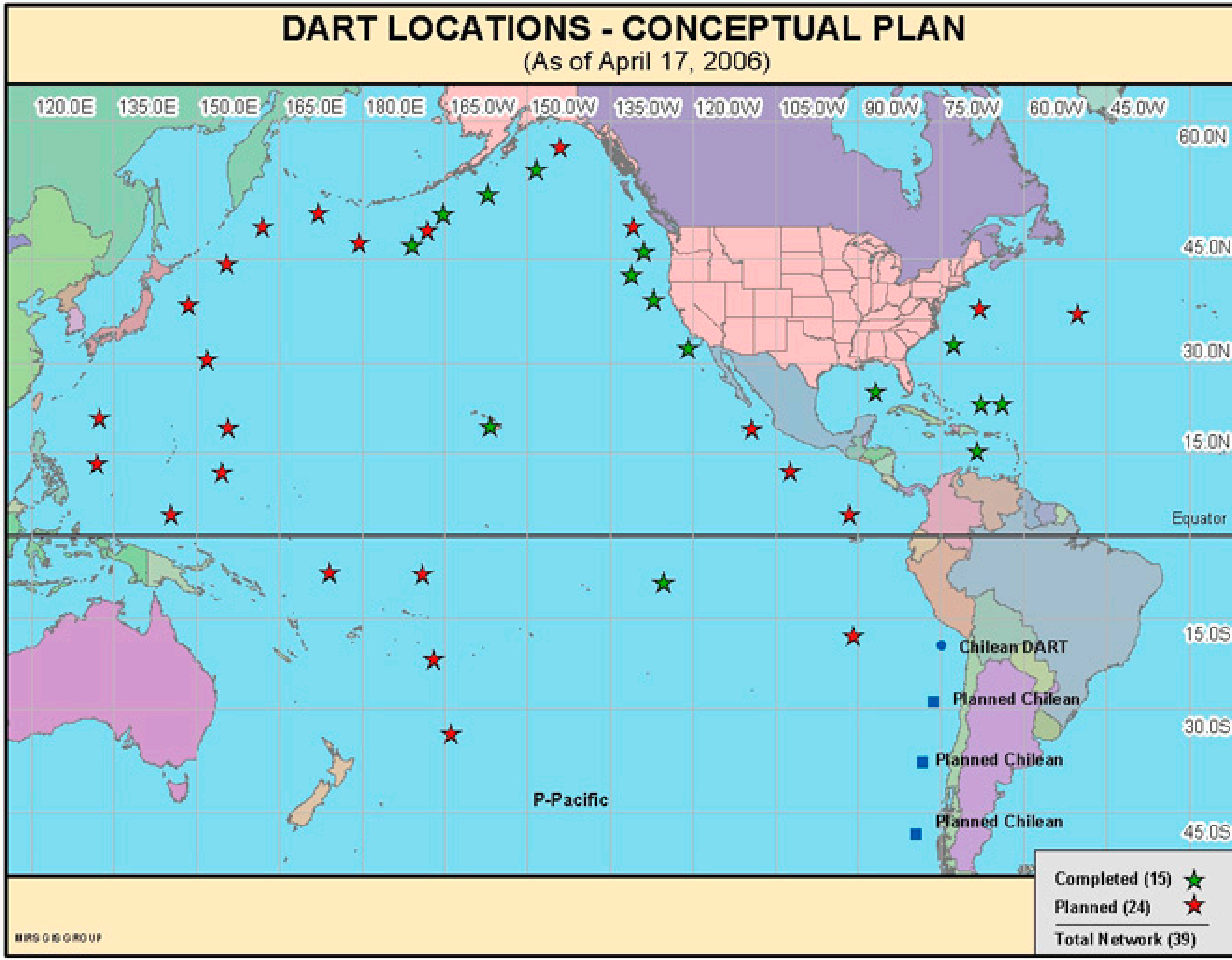
Propagation Model Database





Unit Sources:

- 100km × 50km faults
- Placed along subduction zones and known tsunamigenic faults
- Aligned to fit known fault geometries


DART LOCATIONS - CONCEPTUAL PLAN
(As of April 17, 2006)
120.0E
135.0E
150.0E
165.0E
180.0E
165.0W
150.0W
135.0W
120.0W
105.0W
90.0W
75.0W
60.0W
45.0W
60.0N
45.0N
30.0N
15.0N
Equator
15.0S
30.0S
45.0S
Chilean DART
Planned Chilean
Planned Chilean
Planned Chilean
P-Pacific
Completed (15)
Planned (24)
Total Network (39)

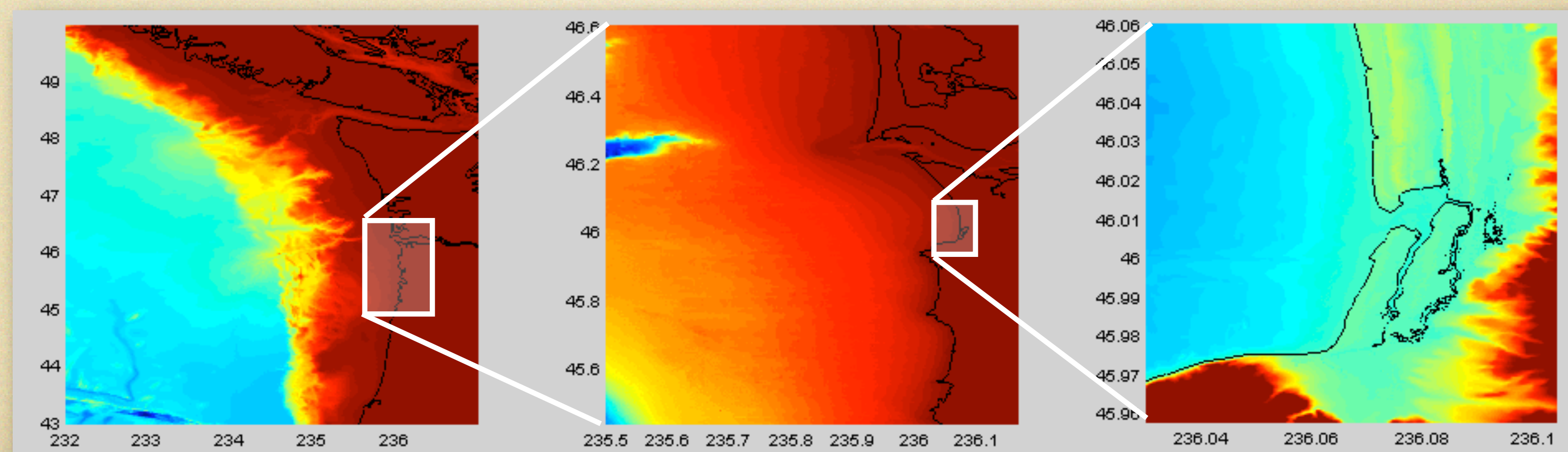
Stand-by Inundation Model

SIM development

Reference Model

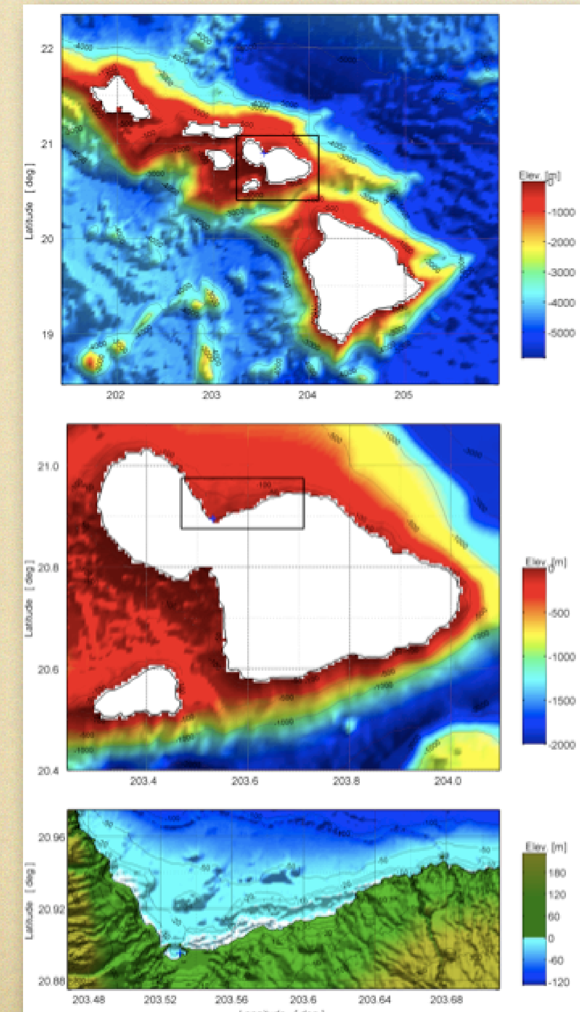
Use best available bathy-topo data. Identification of vital assets within the fine resolution inundation grid. Major population centers. Vital Infrastructure: Roads, Airports, Hospitals….

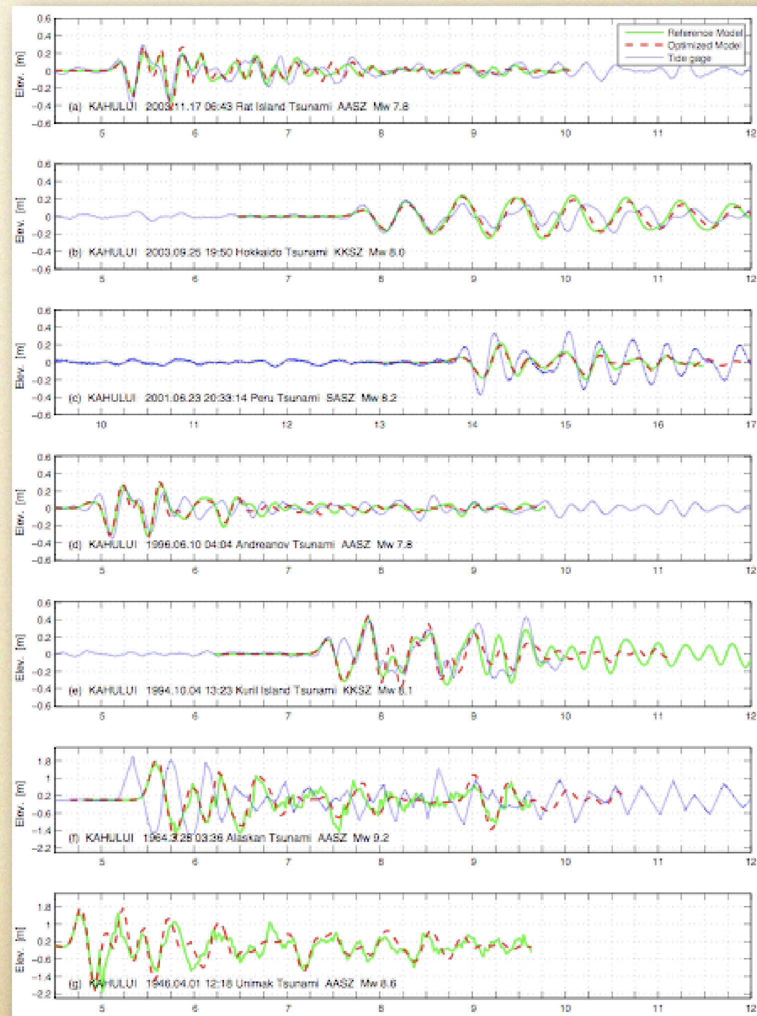
A. Resolution: 36'' x 36'' B. Resolution: 6'' x 6'' C. Resolution: 1/3'' x 1/3''



Optimize for speed

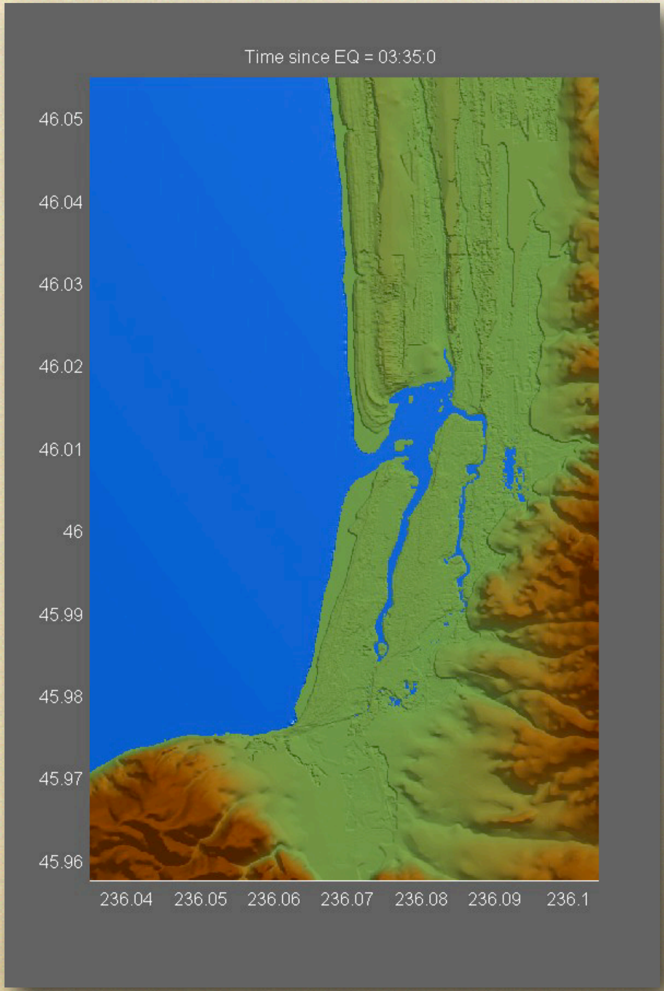
Monitor Speed vs. Accuracy by comparison with Reference Run.

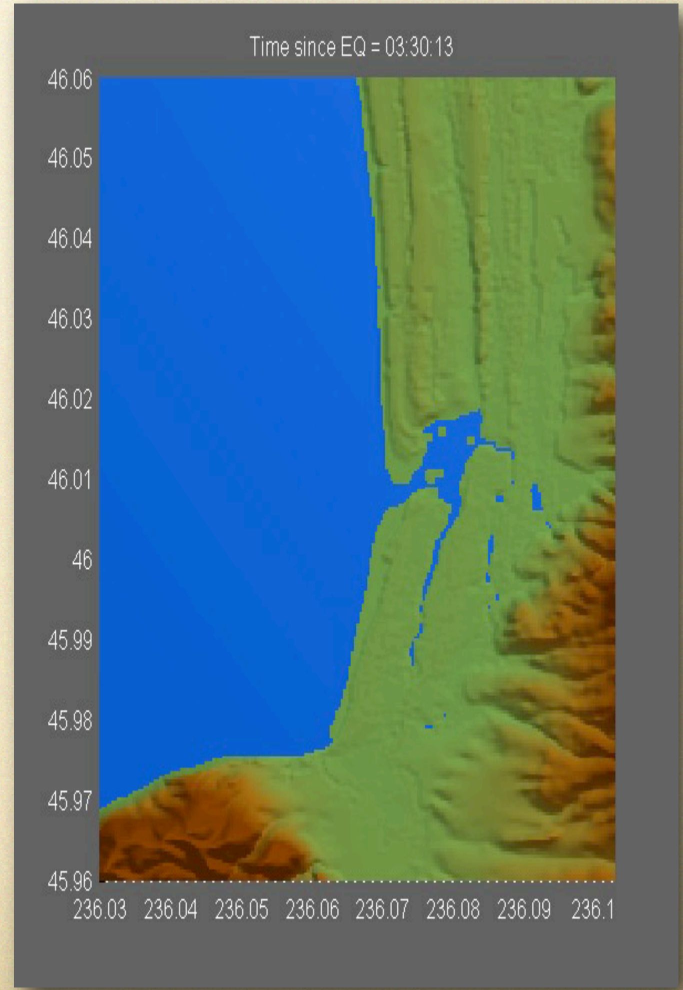




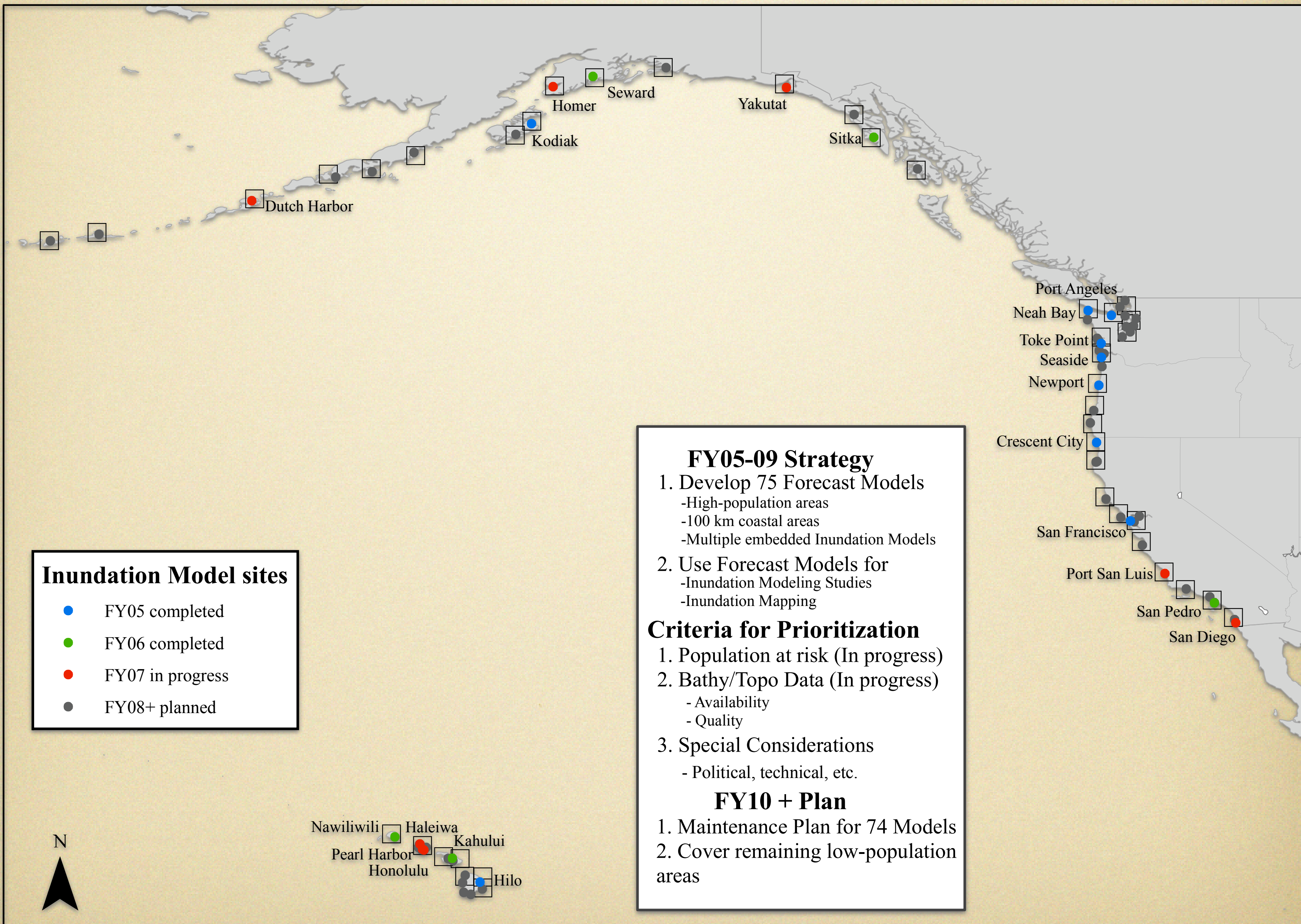
Reference vs Optimized

Comparison of the Reference Model (5.2 hours) and SIM (10 mins)





NOAA Tsunami Forecast Modeling and Mapping



FY05-09 Strategy

1. Develop 75 Forecast Models
   - -High-population areas
   - -100 km coastal areas
   - -Multiple embedded Inundation Models
2. Use Forecast Models for
   - -Inundation Modeling Studies
   - -Inundation Mapping

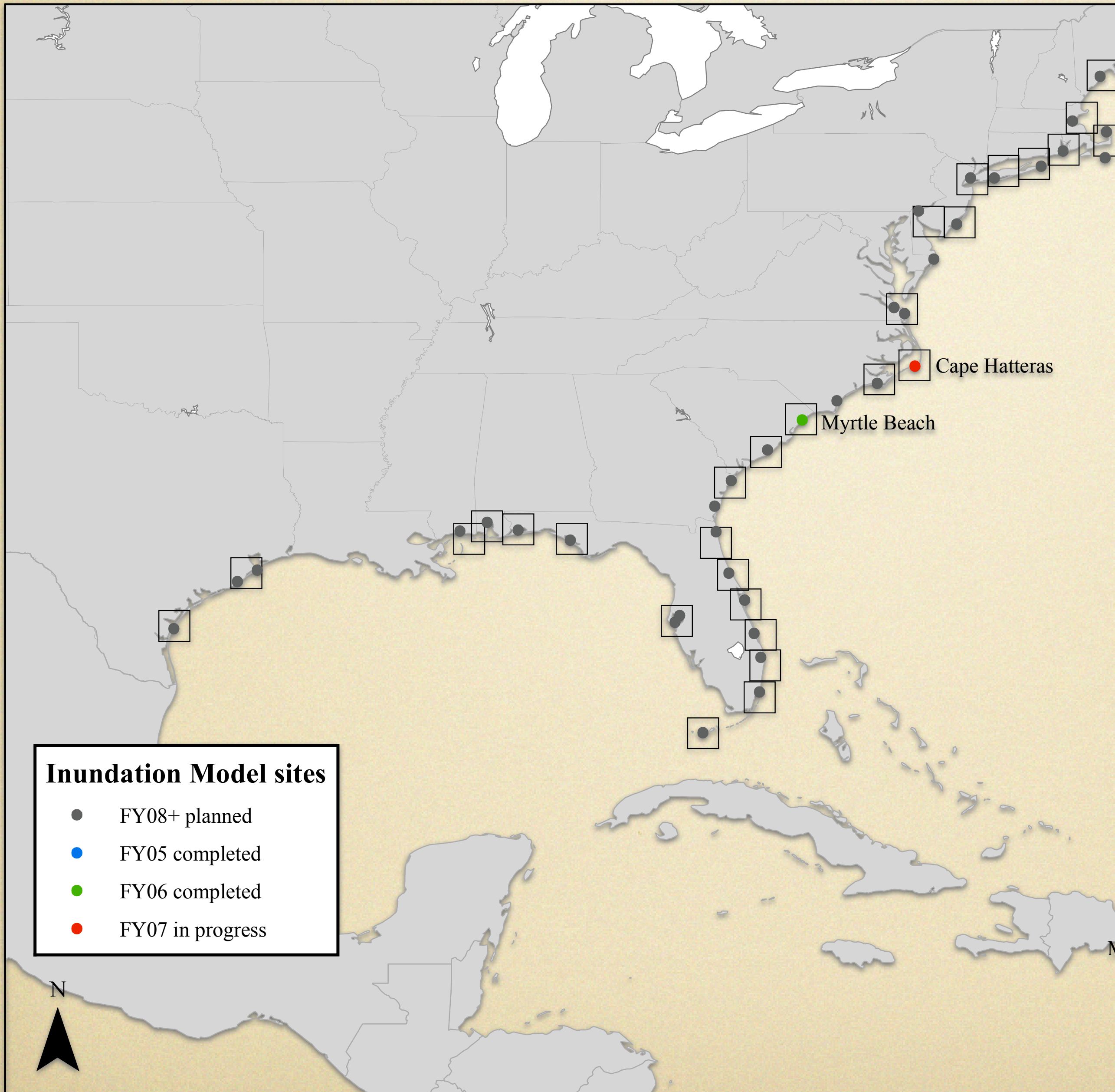
Criteria for Prioritization

1. Population at risk (In progress)
2. Bathy/Topo Data (In progress)
   - - Availability
   - - Quality
3. Special Considerations
   - - Political, technical, etc.

FY10 + Plan

1. Maintenance Plan for 74 Models
2. Cover remaining low-population areas

NOAA Tsunami Forecast Modeling and Mapping



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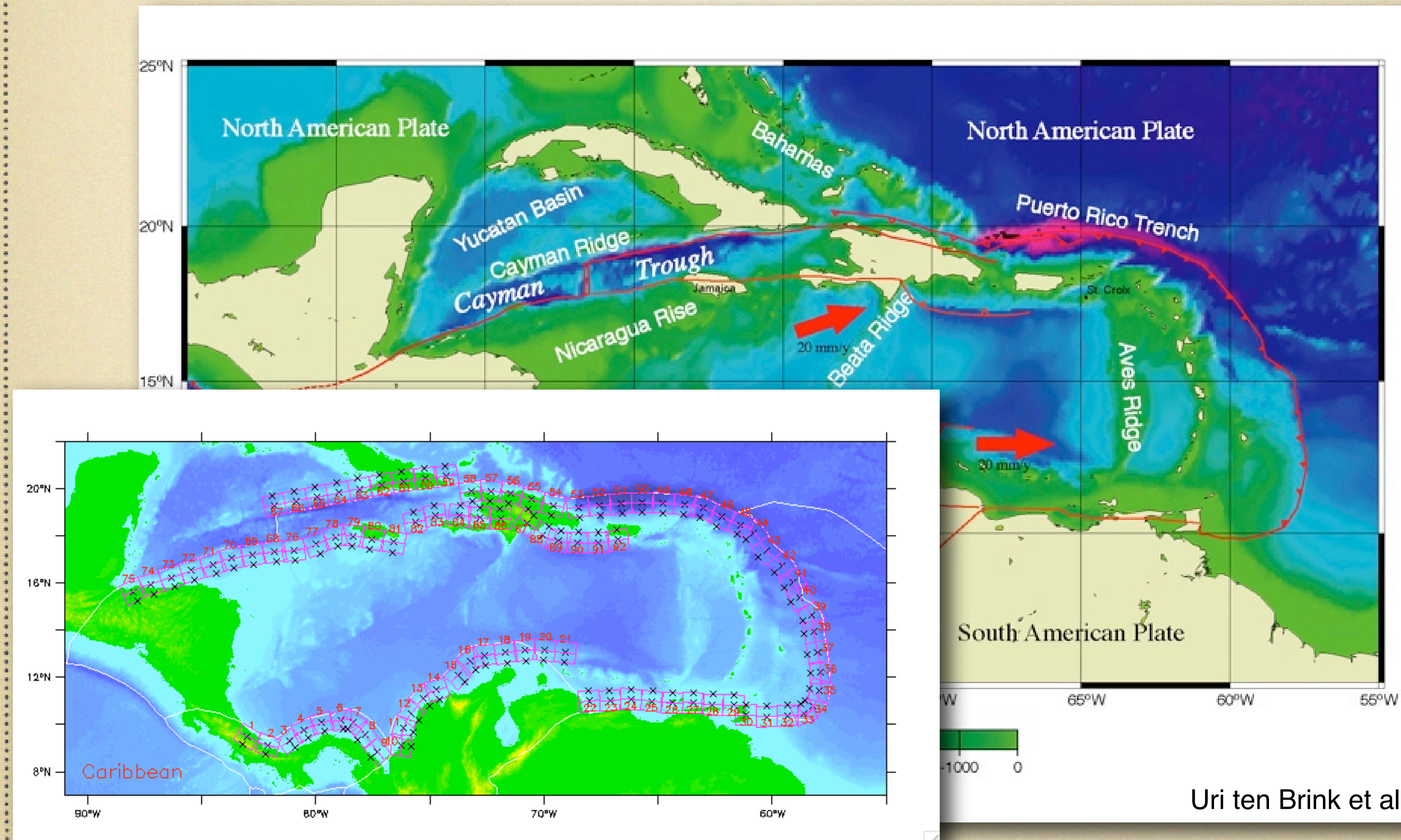
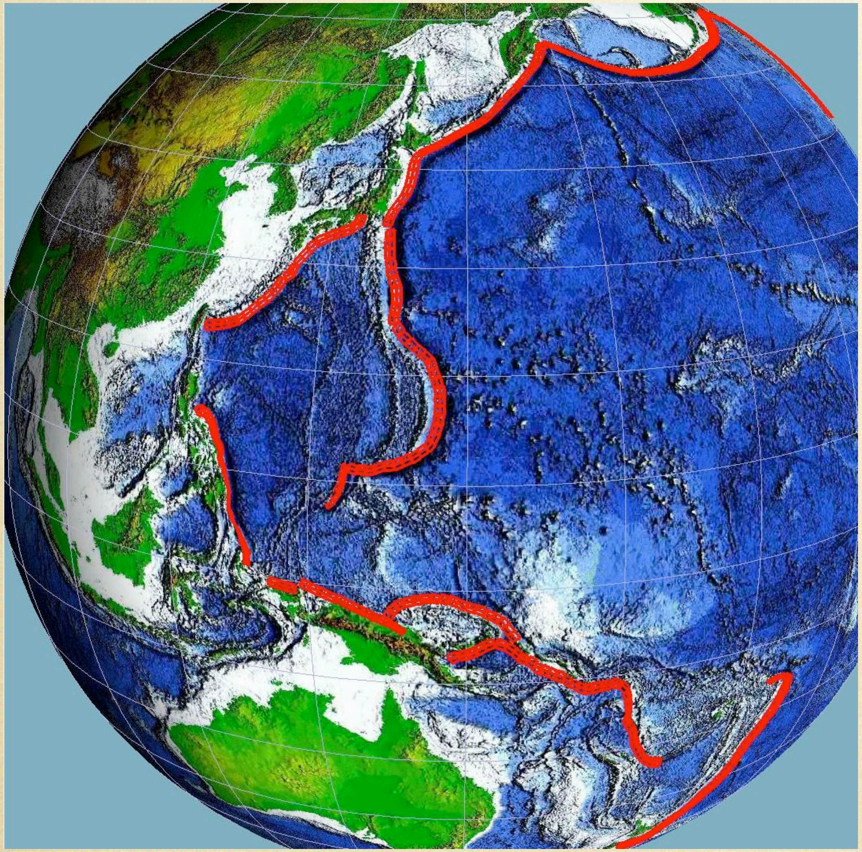
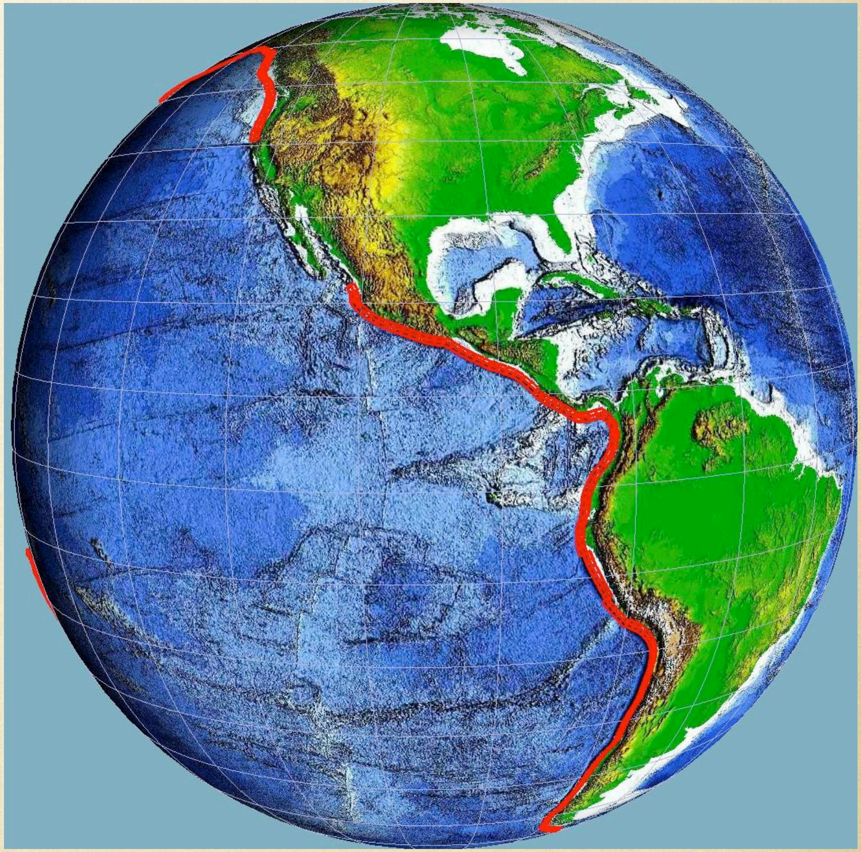
Propagation Model Database



Pre-computed tsunami propagation scenarios for 182 "Unit sources"

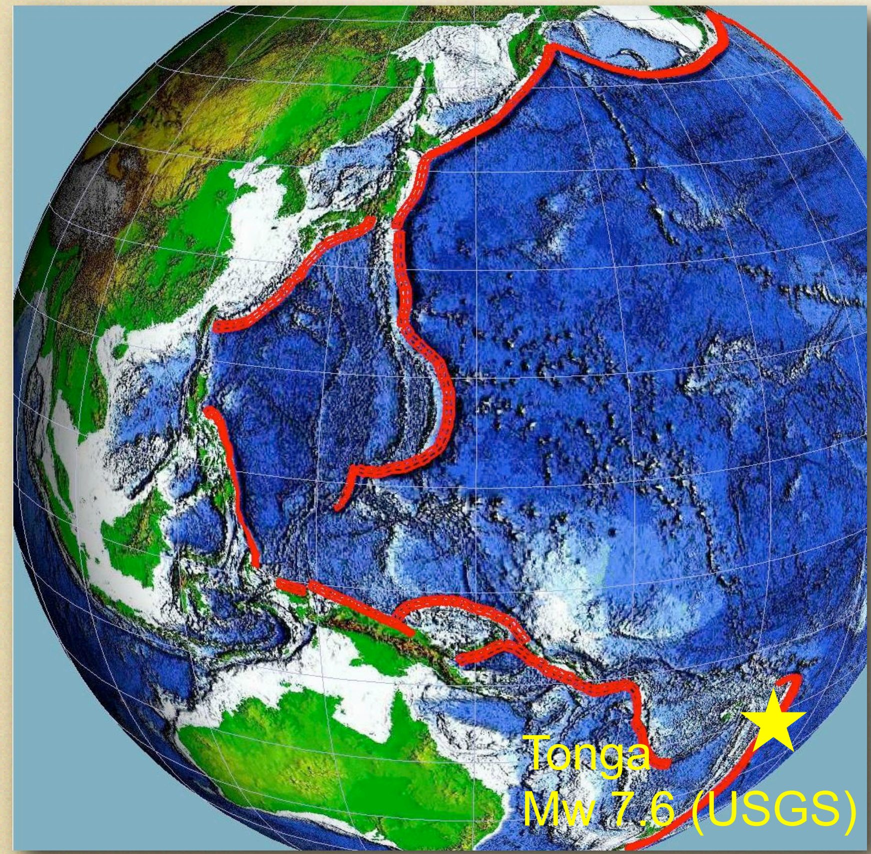
Propagation Model Database

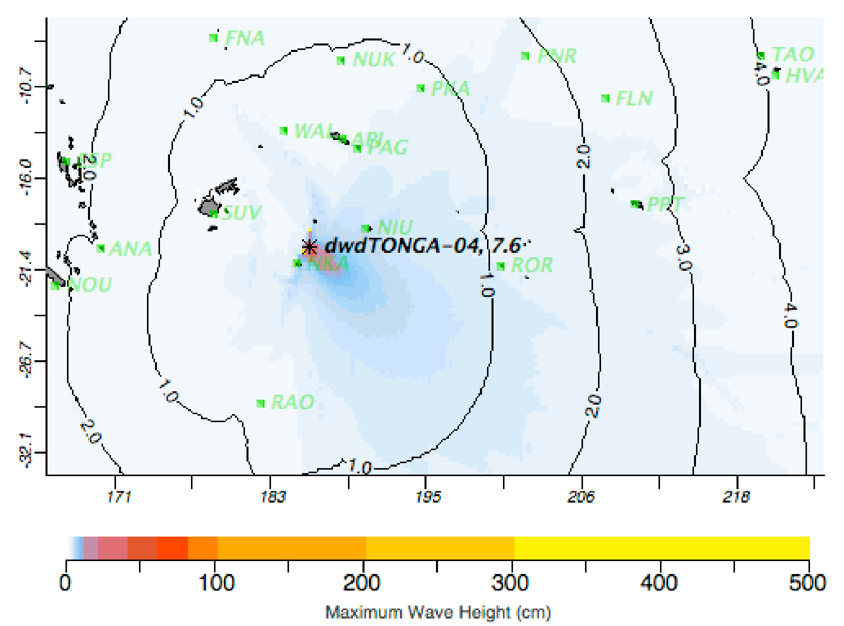




Pre-computed tsunami propagation scenarios for 1258 "Unit sources" for Pacific and Atlantic

Propagation Model Database

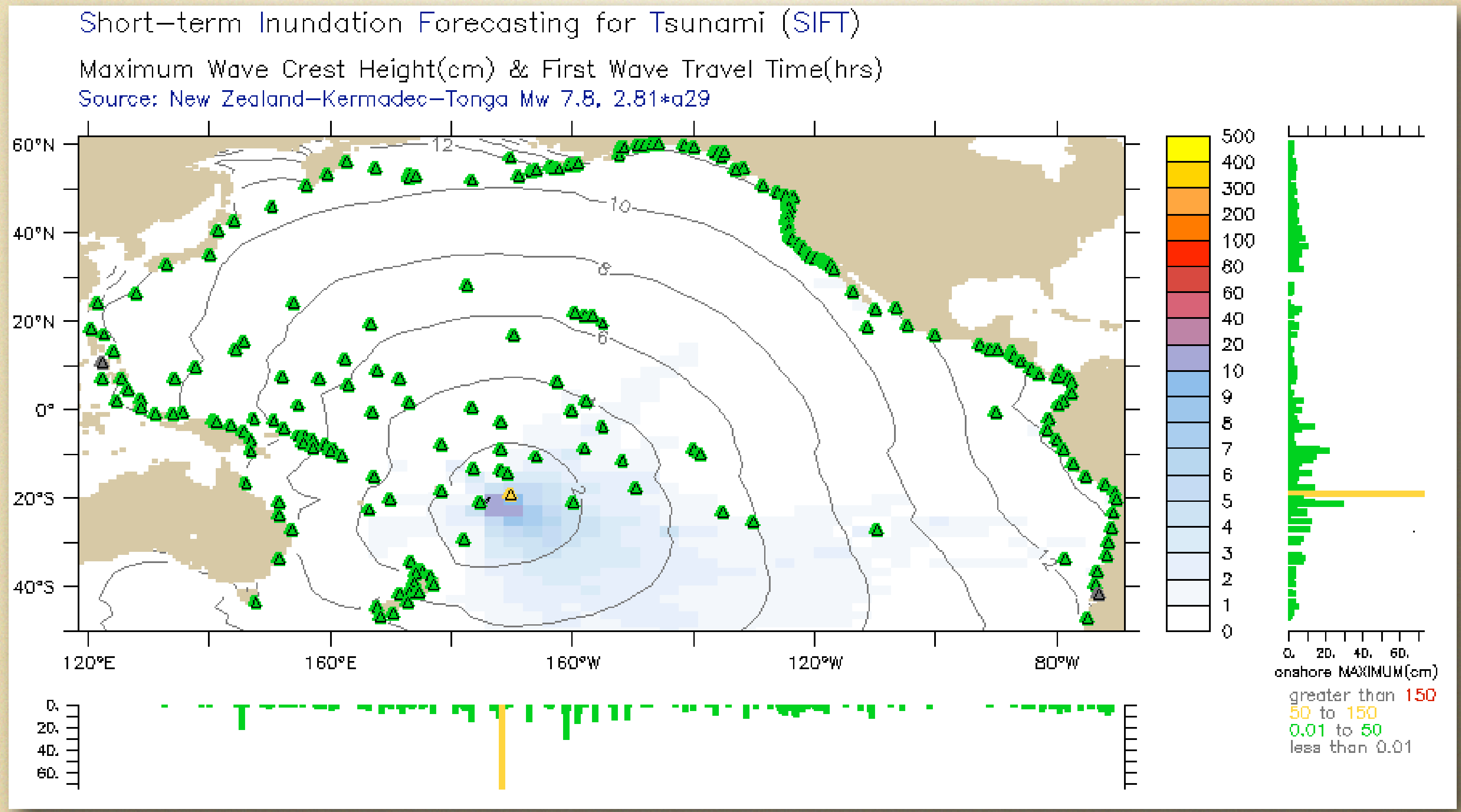




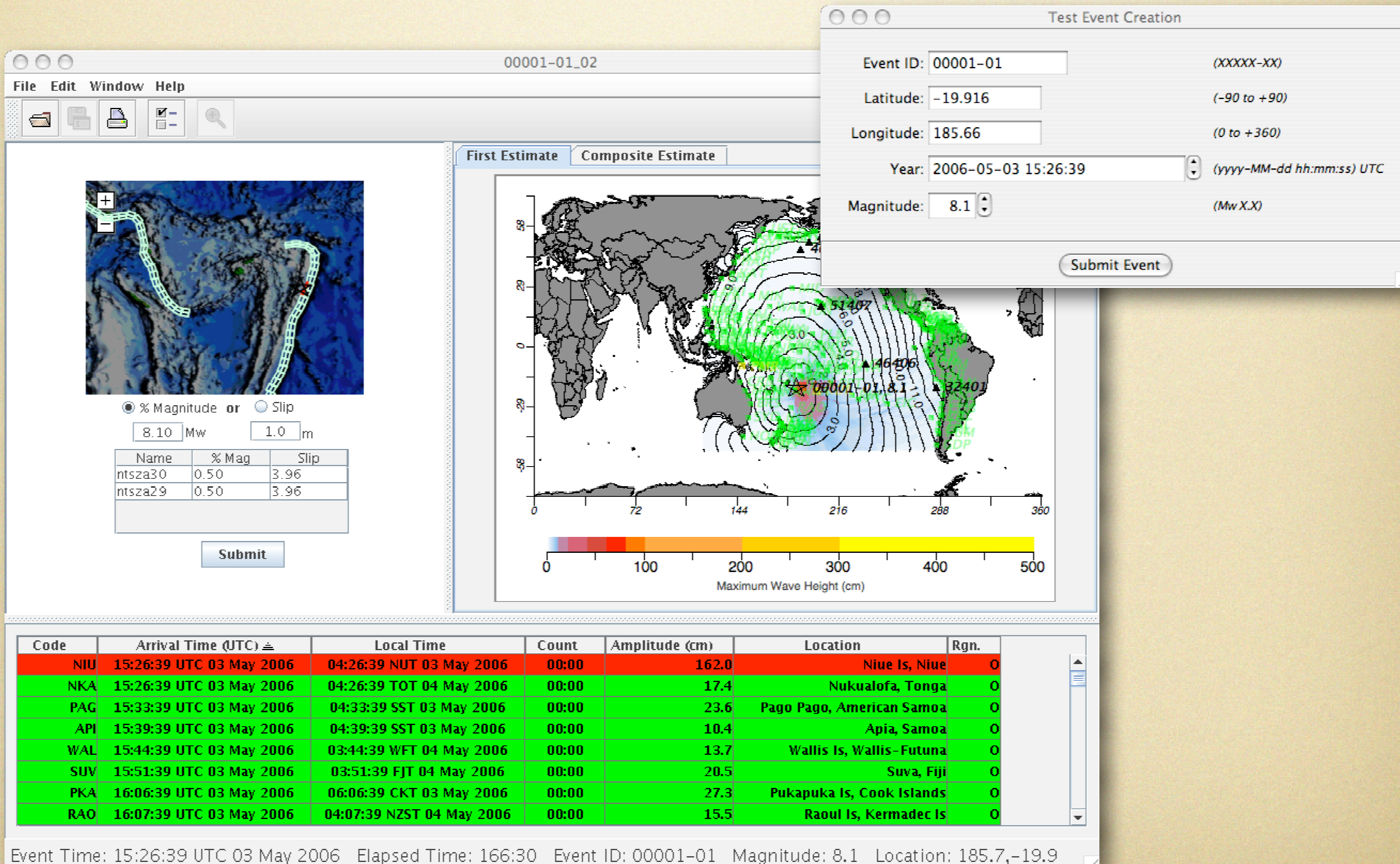
At Niue tide gage
Forecast: 36.6 cm
Observed: 42 cm.

May 3, 2006 Tonga tsunami test

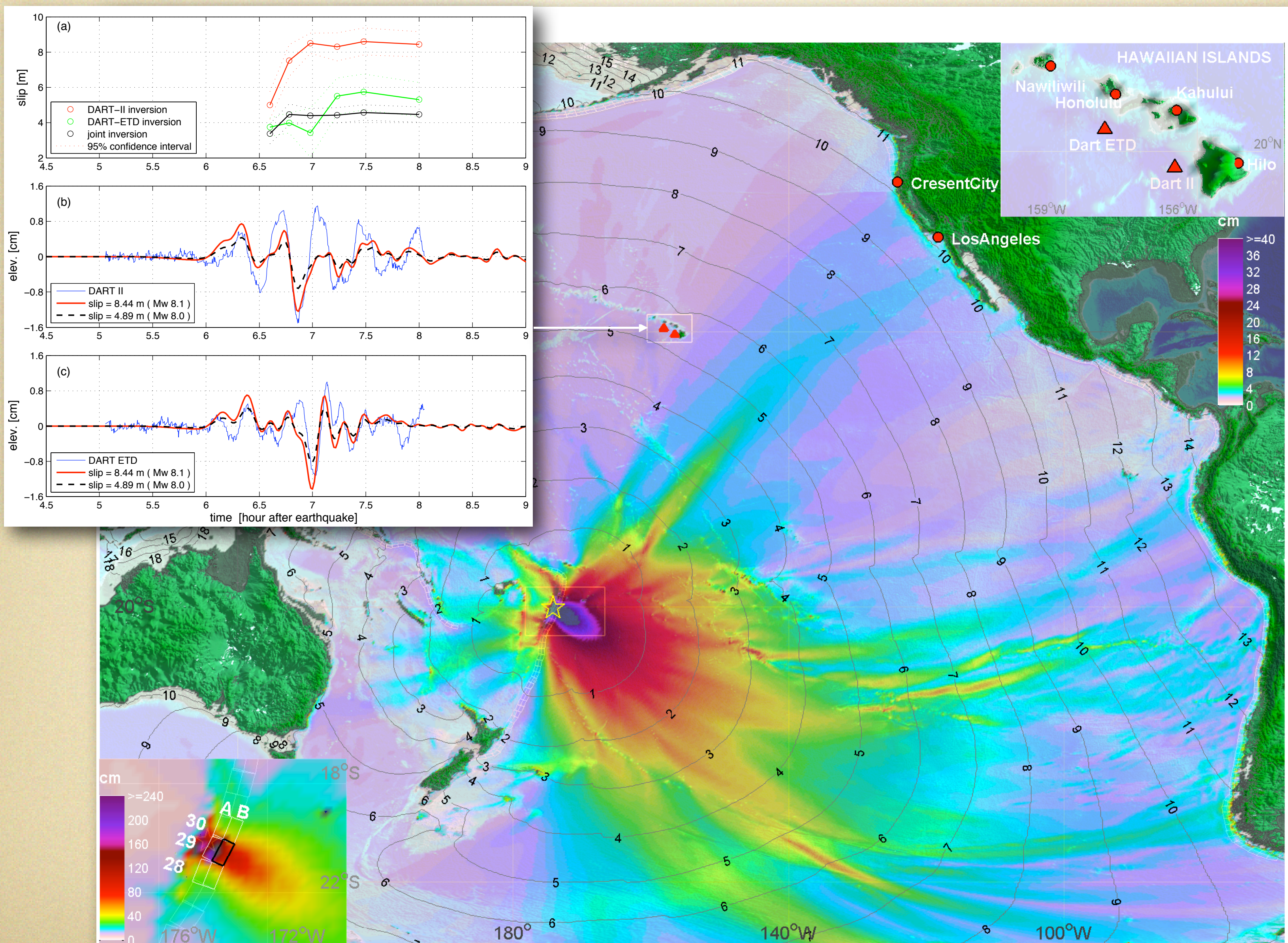
Tonga Tsunami Forecast

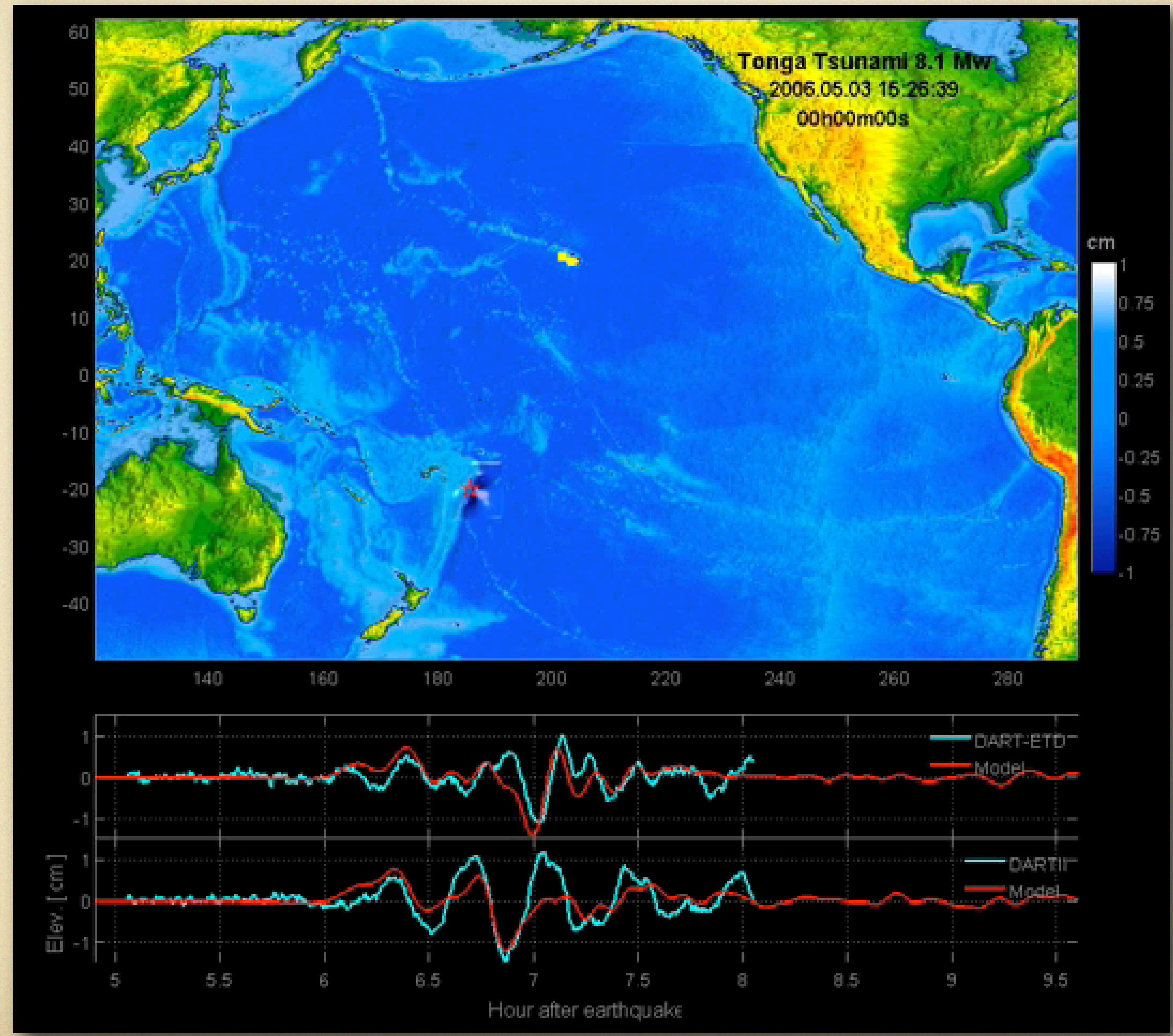


Tonga Tsunami Forecast



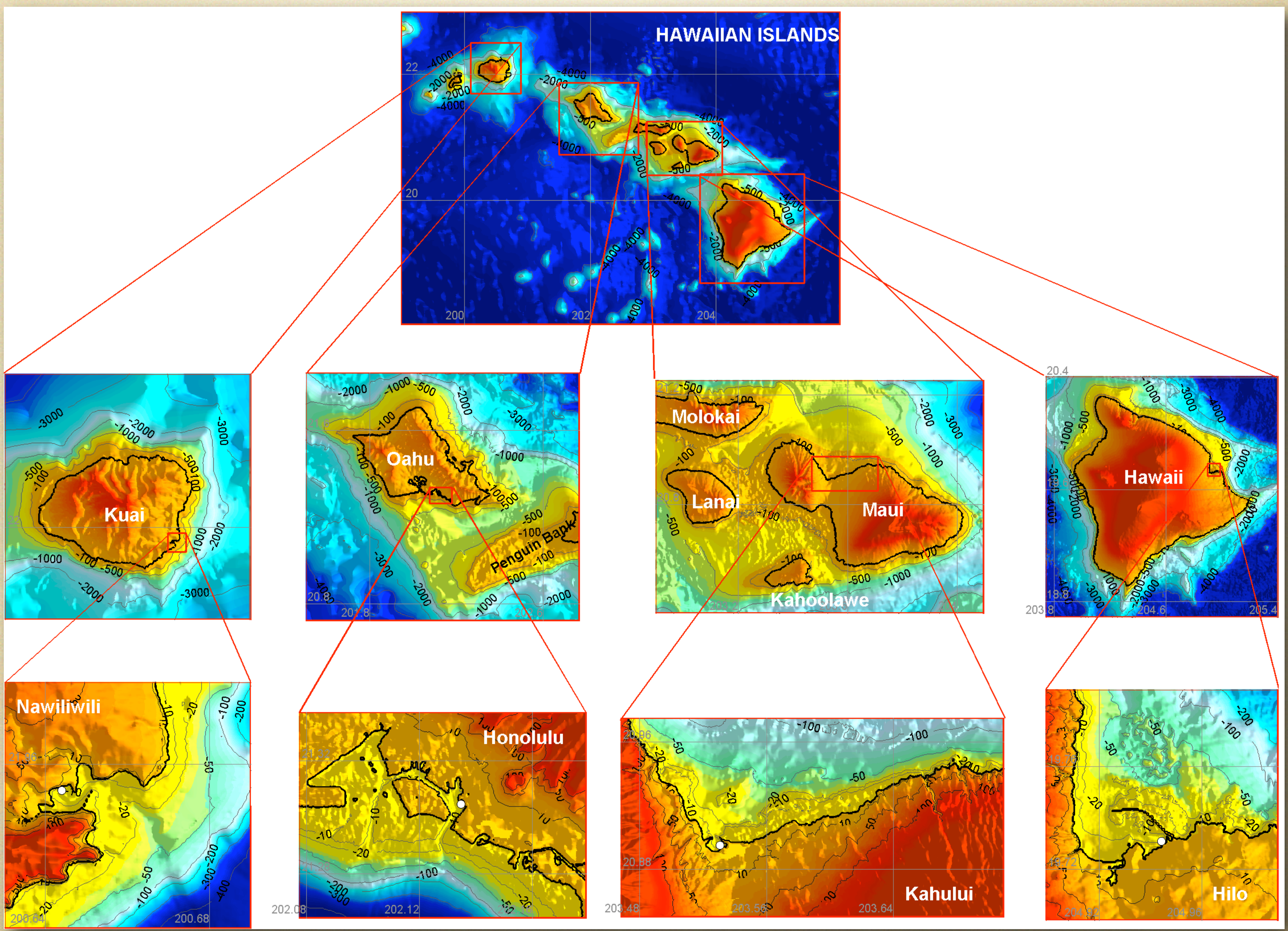
Data assimilation test



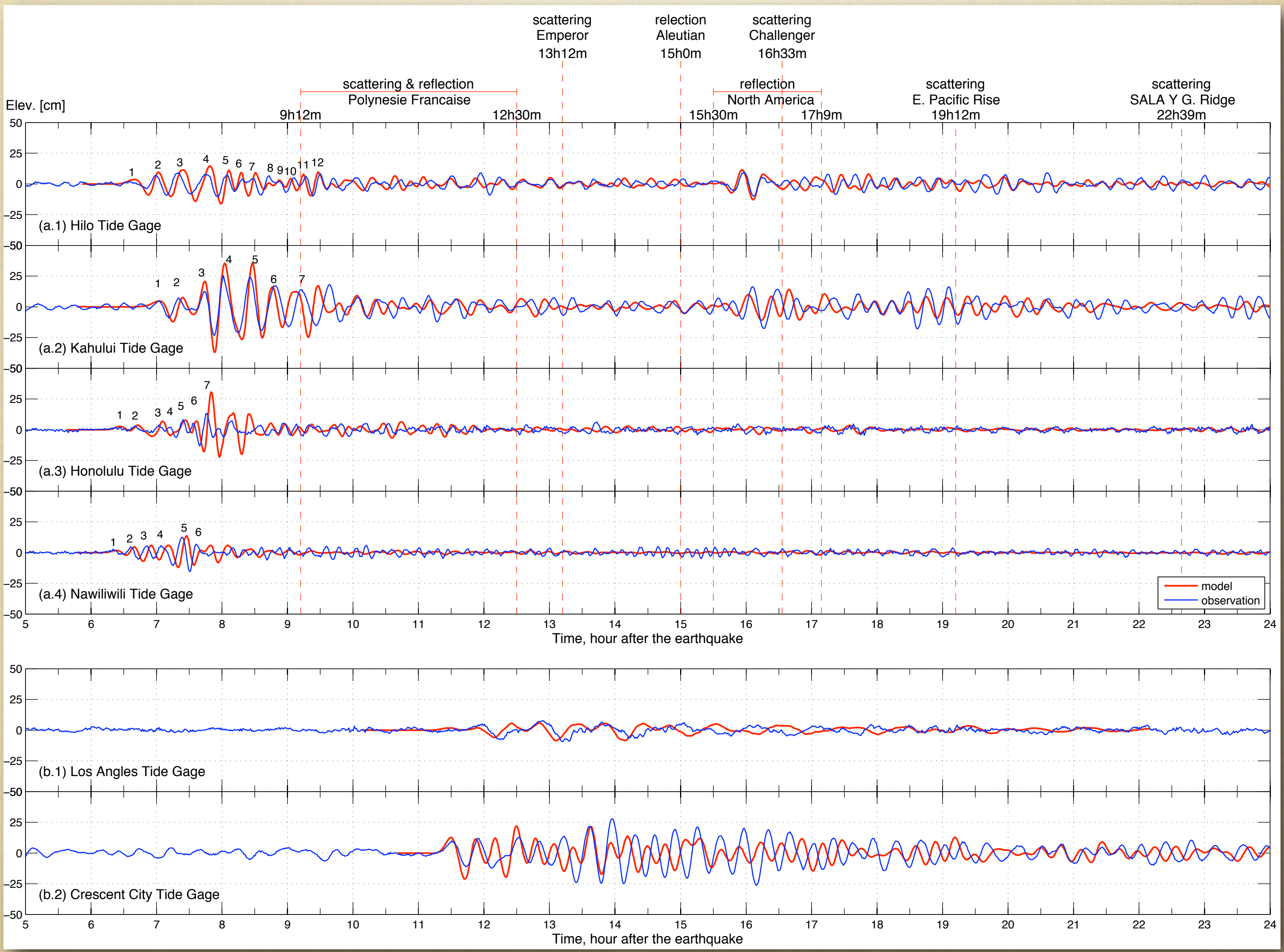


Tonga Tsunami 8.1 Mw
2006.05.03 15:26:39
00h00m00s
cm
1
0.75
0.5
0.25
0
-0.25
-0.5
-0.75
-1
60
50
40
30
20
10
0
-10
-20
-30
-40
140
160
180
200
220
240
260
280
DART-ETD
Model
DARTII
Model
Elev. [cm]
1
0
-1
5
5.5
6
6.5
7
7.5
8
8.5
9
9.5
Hour after earthquake

Forecast models test



Forecast models test



Thank You!

Questions?