Modeling for Tsunami Forecast

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Outline

- Tsunami Modeling Development Toward Real-time Tsunami Forecast
  - Challenges
  - Modeling development in 1990 -2000
- Short-term Inundation Forecast for Tsunamis
  - Forecast system description
  - Current status of the Forecast System
- Tests and Verification of the Forecast Performance

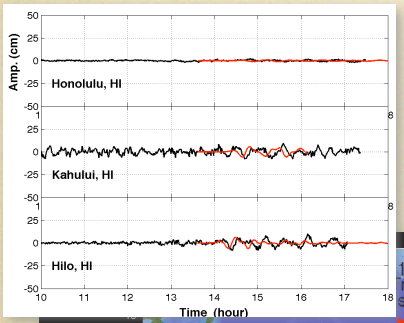
Tsunami Forecast

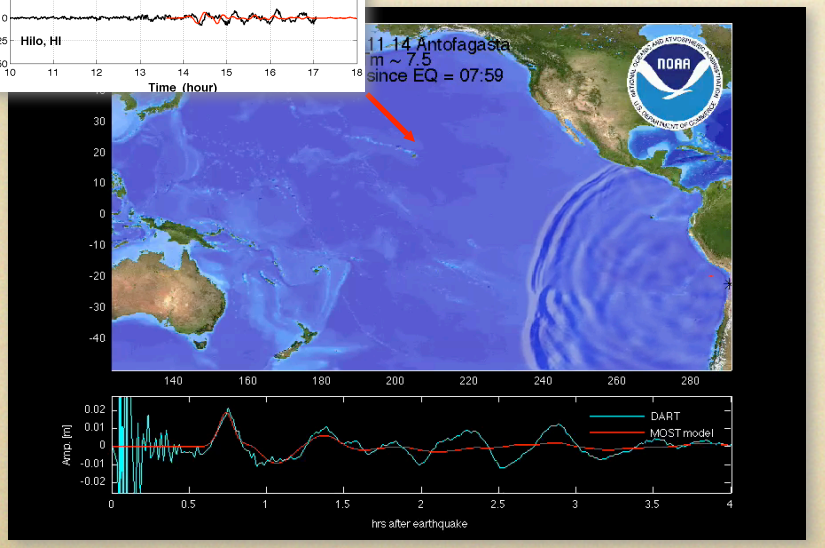
Short-term:

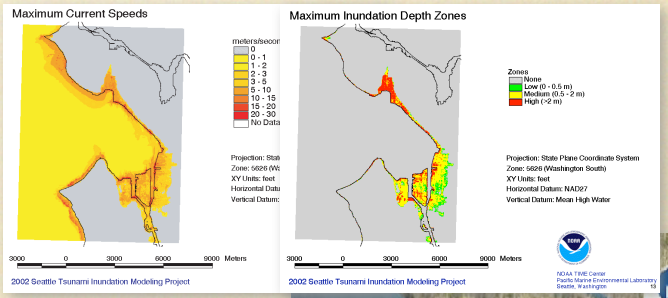
- Real-time assessment
- Real-time impact assessment before tsunami arrival

Long-term:

- Probable Maximum Tsunami
- Multiple scenarios for PTHA
- Comprehensive Hazard assessment







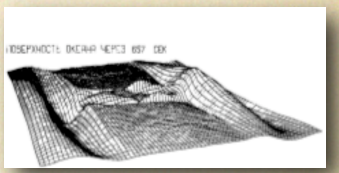
Challenges of Real-time Tsunami Forecast

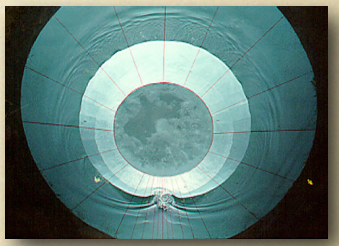
- Can models provide *accuracy* necessary for useful warning guidance?
- Can models provide useful *timely* forecast?
- Do we have real-time *measurement* to define input for real-time models?

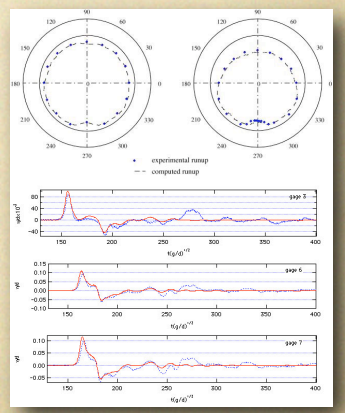
Brief history of tsunami modeling (1990-2000)

International Decade for Natural Disaster Reduction

- 1990 1st NSF workshop on tsunami models
  Modeling problems identified: little data for testing (MOST model first introduced)
- 1992-95 Conical Island experiments
- 1995 2nd NSF workshop on tsunami models
  First benchmark tests (MOST model first tests)
- 1997 NSF workshop on tsunami sources.
  Source problem identified: no real-time source parameters, value of deep-ocean tsunami measurements.







Brief history of tsunami modeling (1990-2000)

International Decade for Natural Disaster Reduction

Surveys of destructive tsunamis (1990 - 2000)

Over 4,000 people died

- 1992 Nicaragua (170)
- 1992 Flores Island, Indonesia (1000)
- 1993 Okushiri Island, Japan (239)
- 1994 E. Java, Indonesia (238)
- 1994 Kuril Islands, Russia (11)
- 1994 Mindoro Is, Philippines (49)
- 1996 Irian Jaya, Indonesia (161)
- 1998 Papua New Guinea (2182)

Brief history of tsunami modeling

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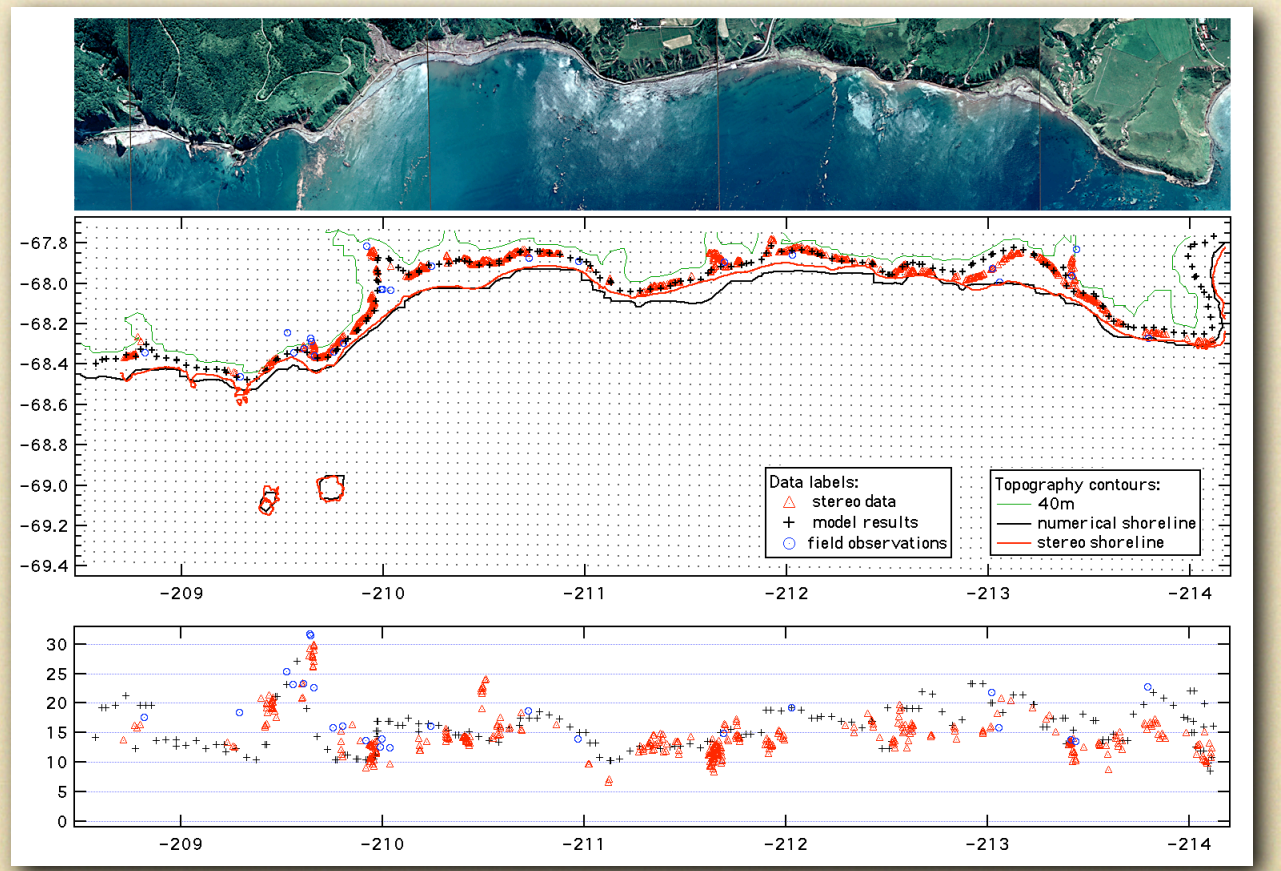

V. Titov & Gonzalez, 1997

Brief history of tsunami modeling (1990-2000)

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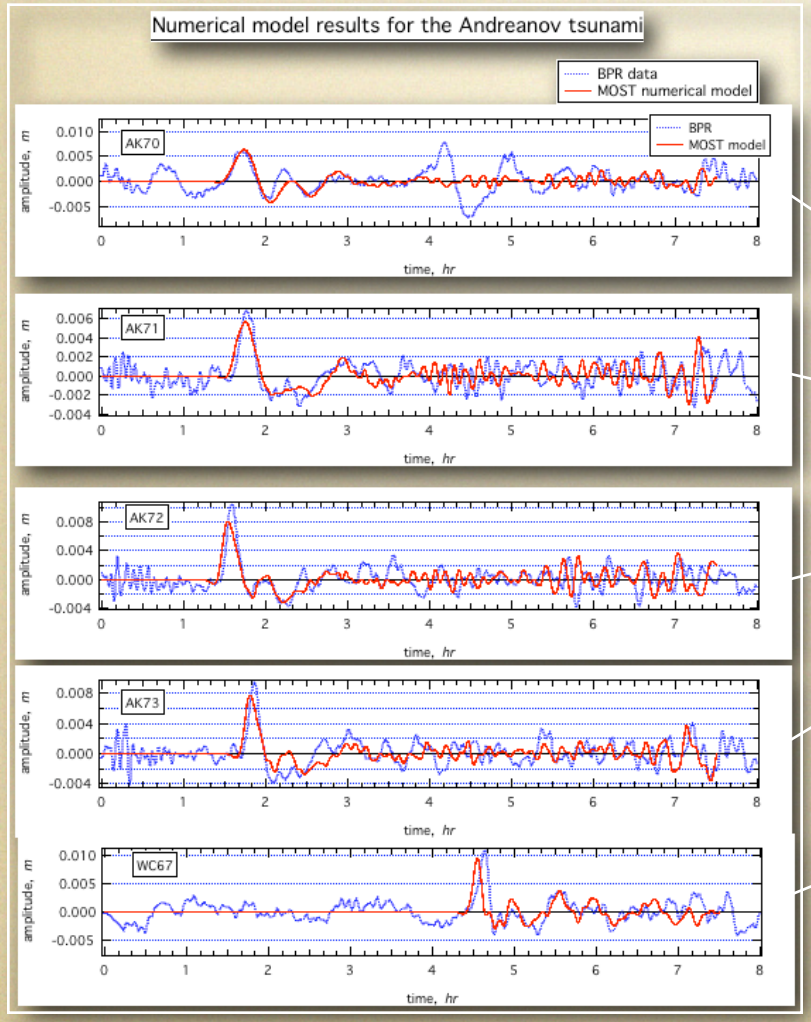
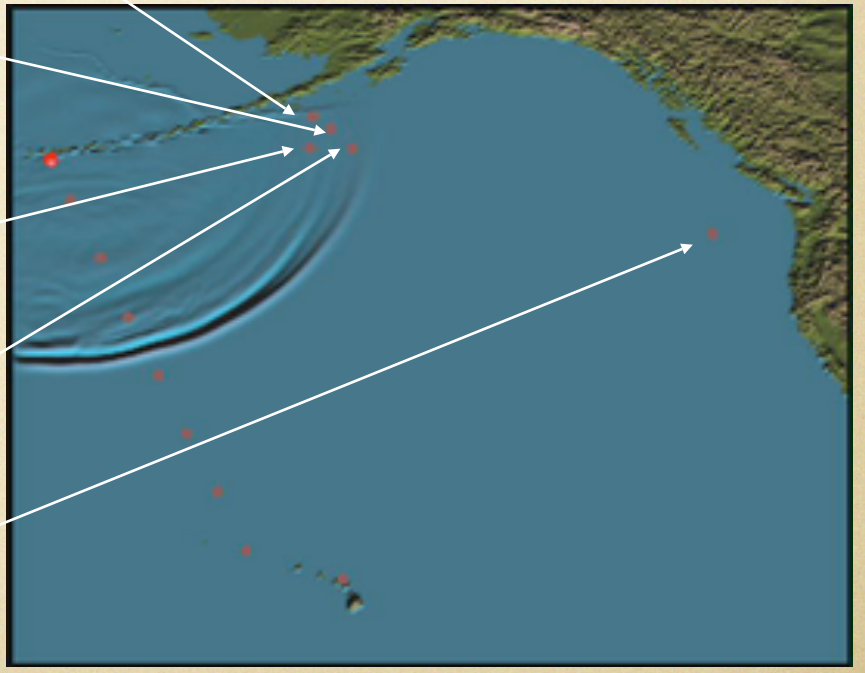
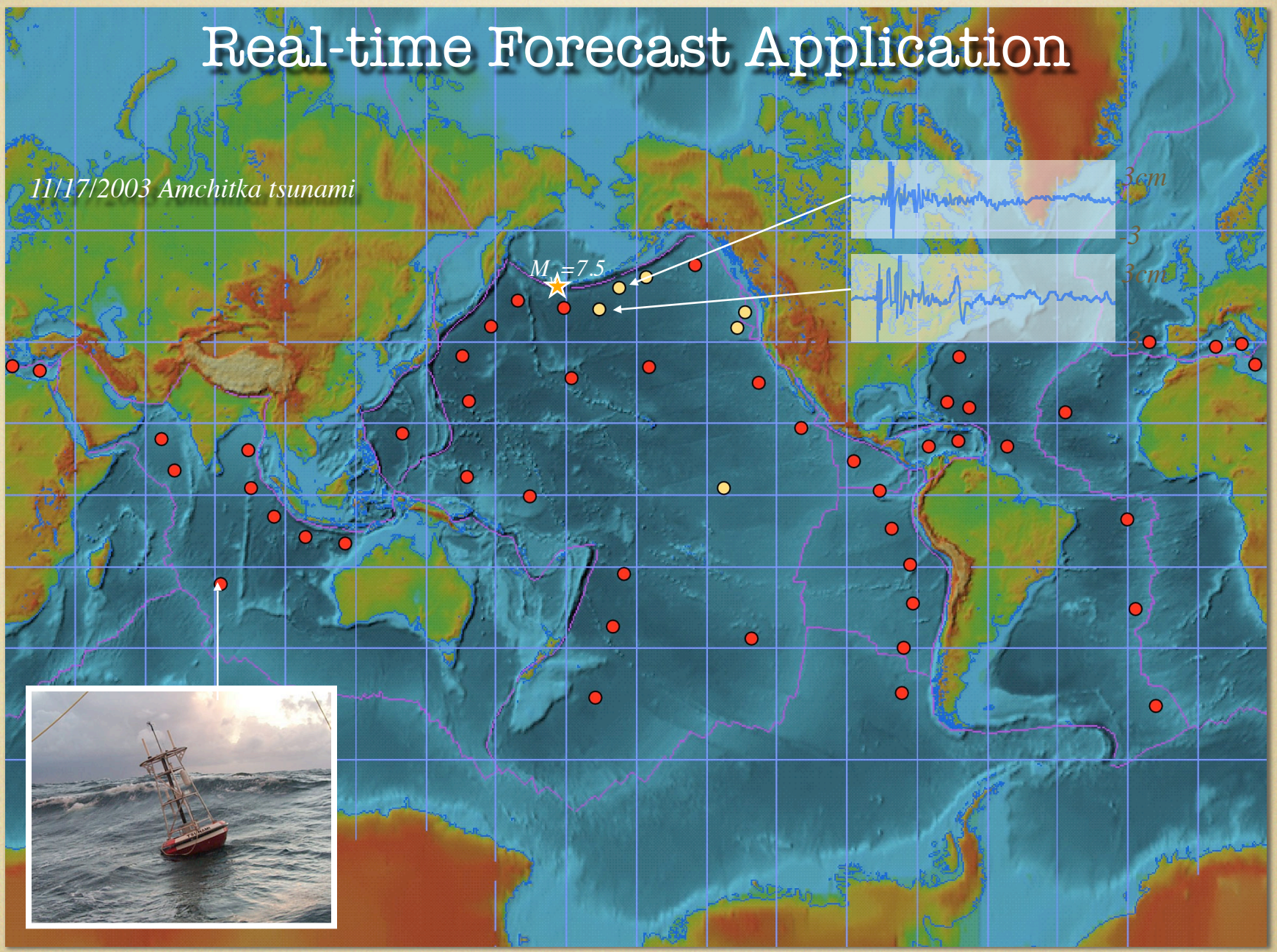


Deep-ocean measurements become available

June 10, 1996 Andreanov tsunami (Titov & Gonzalez, 1997)



Real-time Forecast Application



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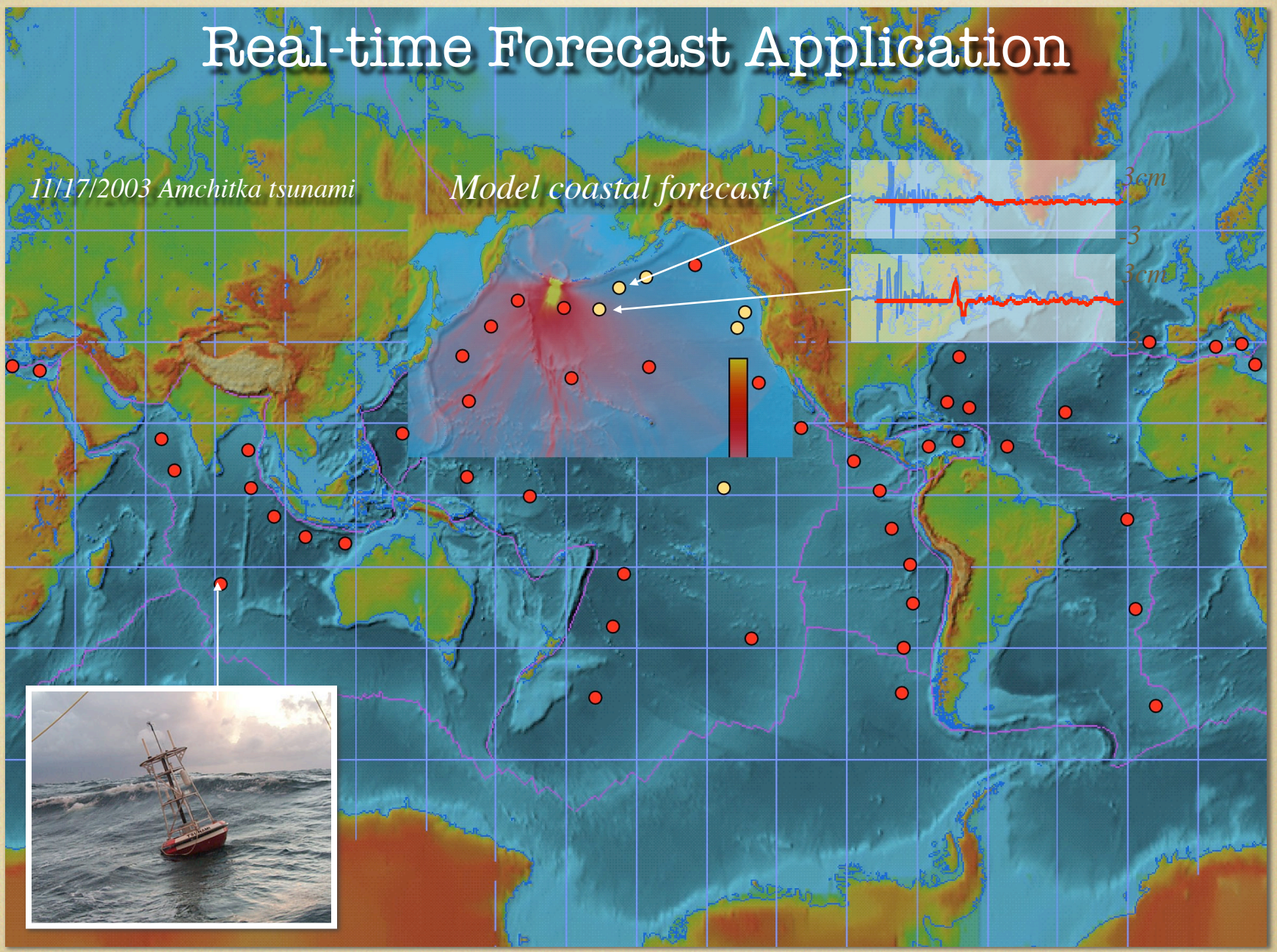
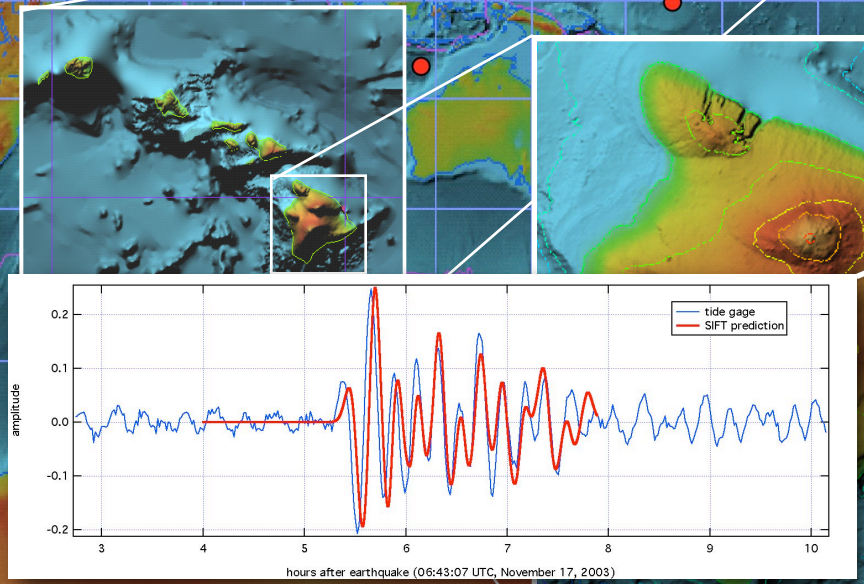


Real-time Forecast Application

11/17/2003 Amchitka tsunami

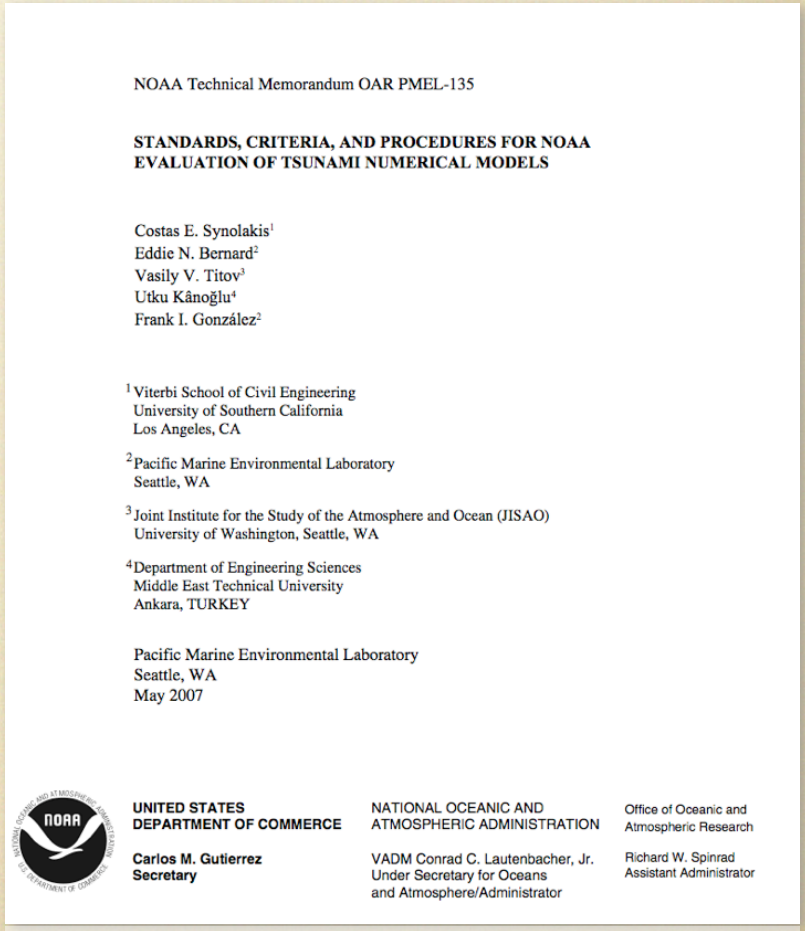
Model coastal forecast



Model Standards for Operational Forecast

NOAA Forecast Model Standards

- **Peer-reviewed publication**. An must be published in peer-reviewed scientific journals with impact factors greater than one
- **Benchmarking**. The model must be tested against other peer models in a benchmark workshop, and the results documented in a report
- **Operational Assessment**. Important factors to be assessed include the model speed, accuracy, special operating environment needs, ease-of-use, and documentation



NOAA Technical Memorandum OAR PMEL-135

STANDARDS, CRITERIA, AND PROCEDURES FOR NOAA EVALUATION OF TSUNAMI NUMERICAL MODELS

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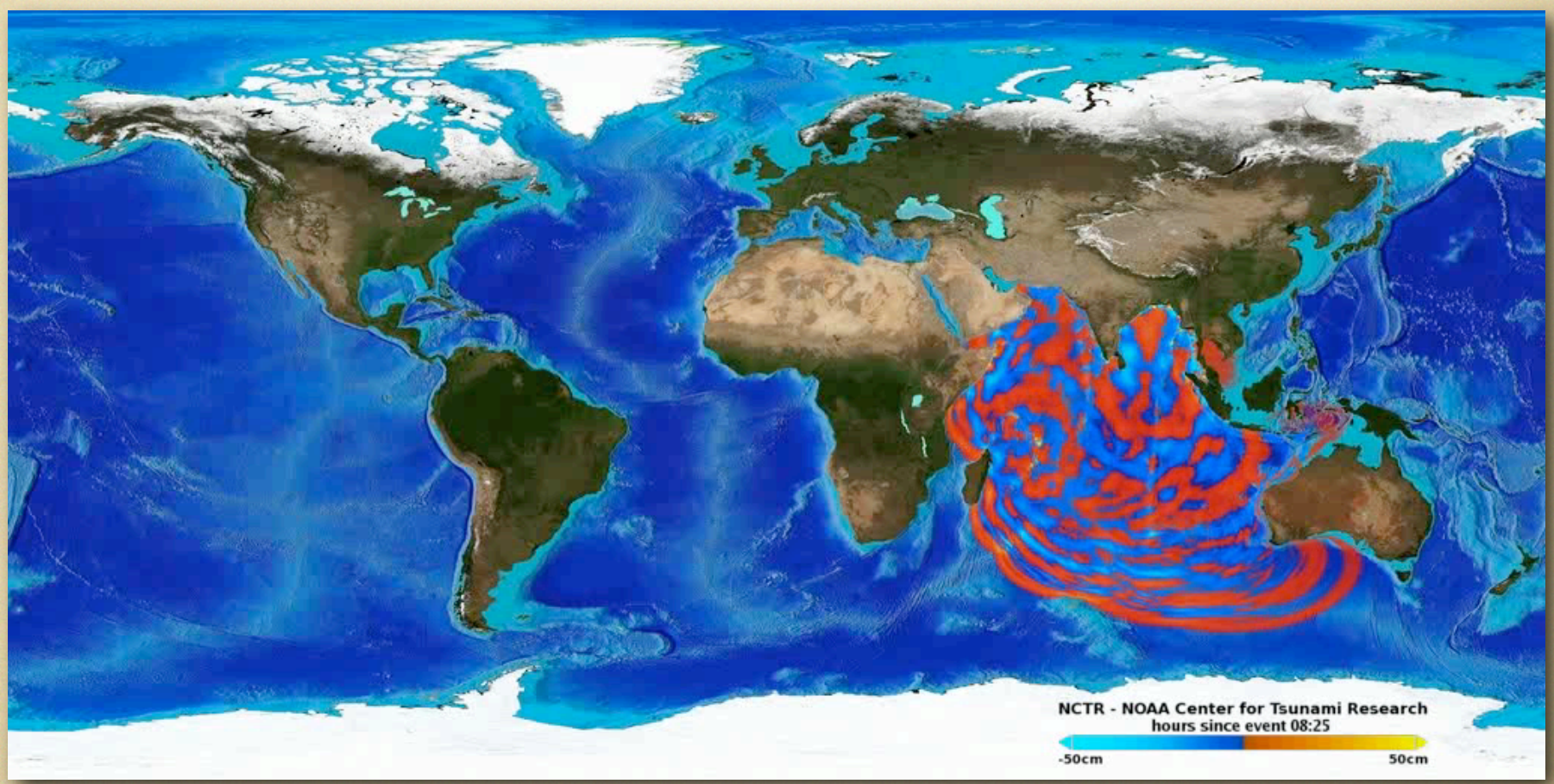
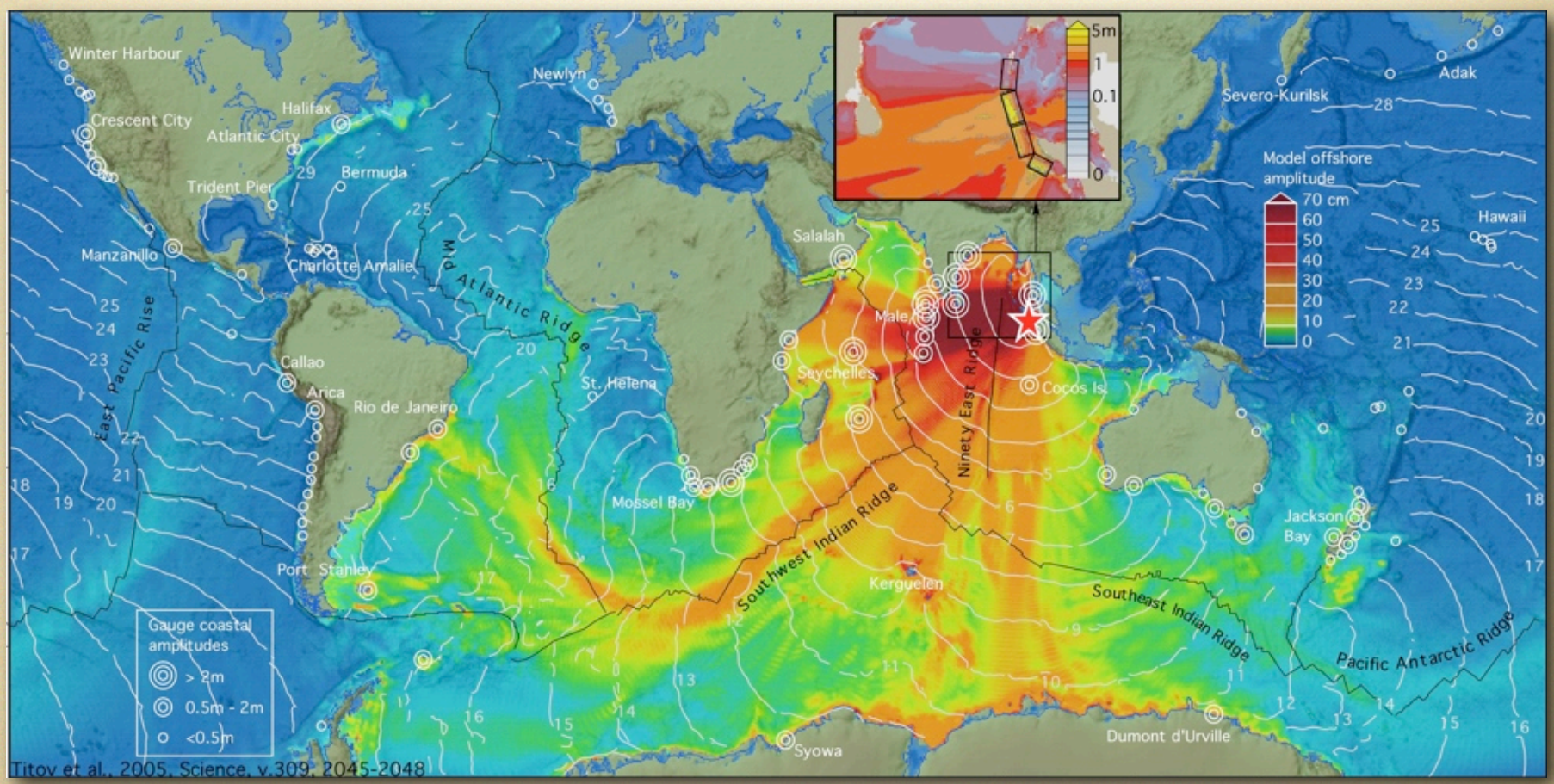
December 26, 2004

Tsunami Forecast:
use models to predict site-specific impact



Tsunami Forecast: use models to predict site-specific impact

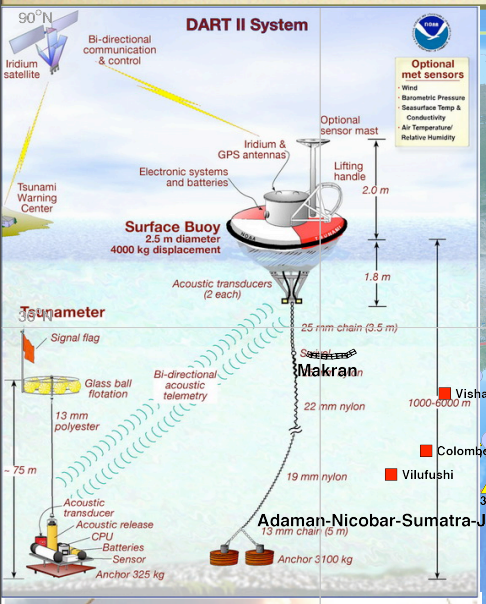


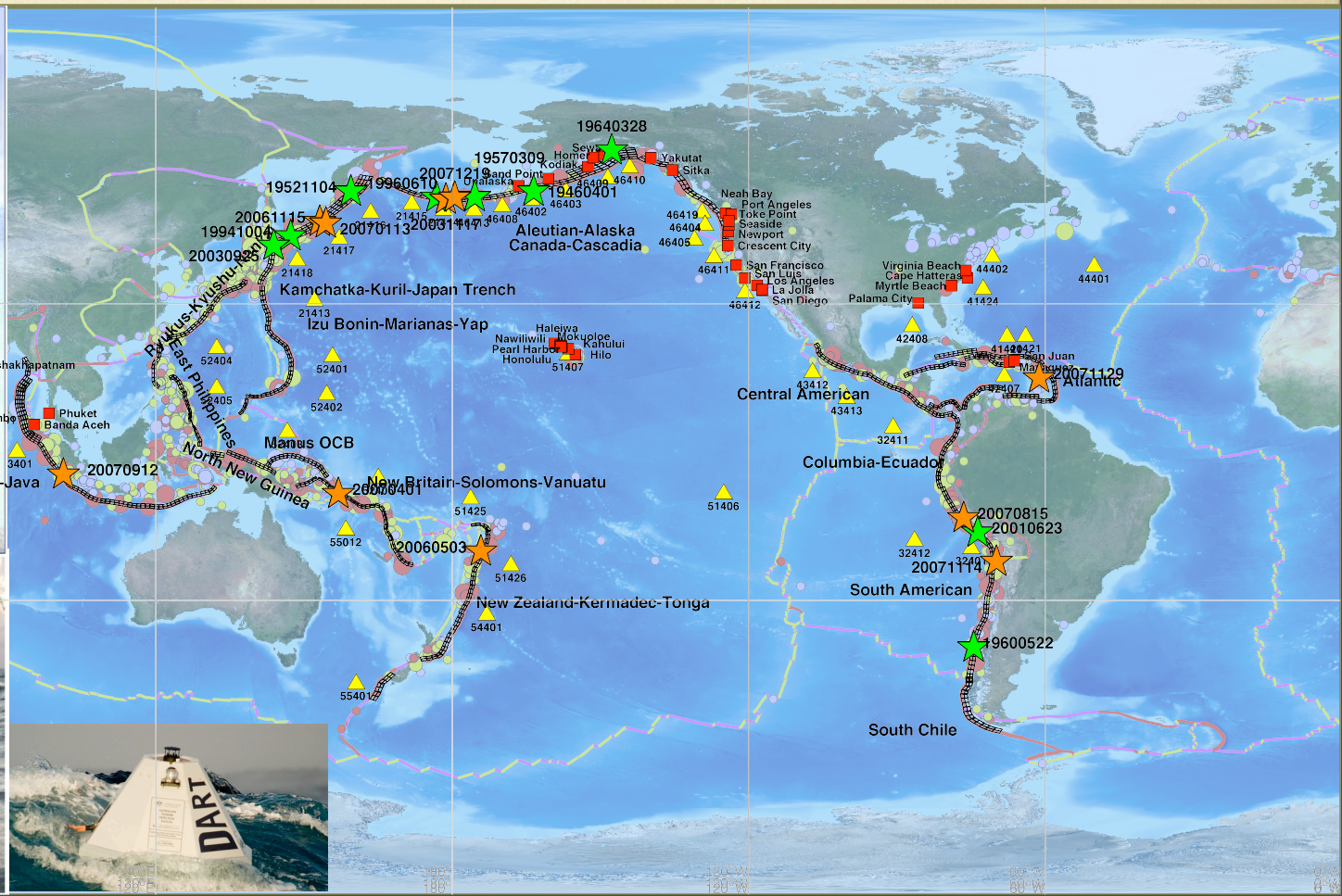
NOAA Tsunami Forecast

Detection
▲ Tsunameter

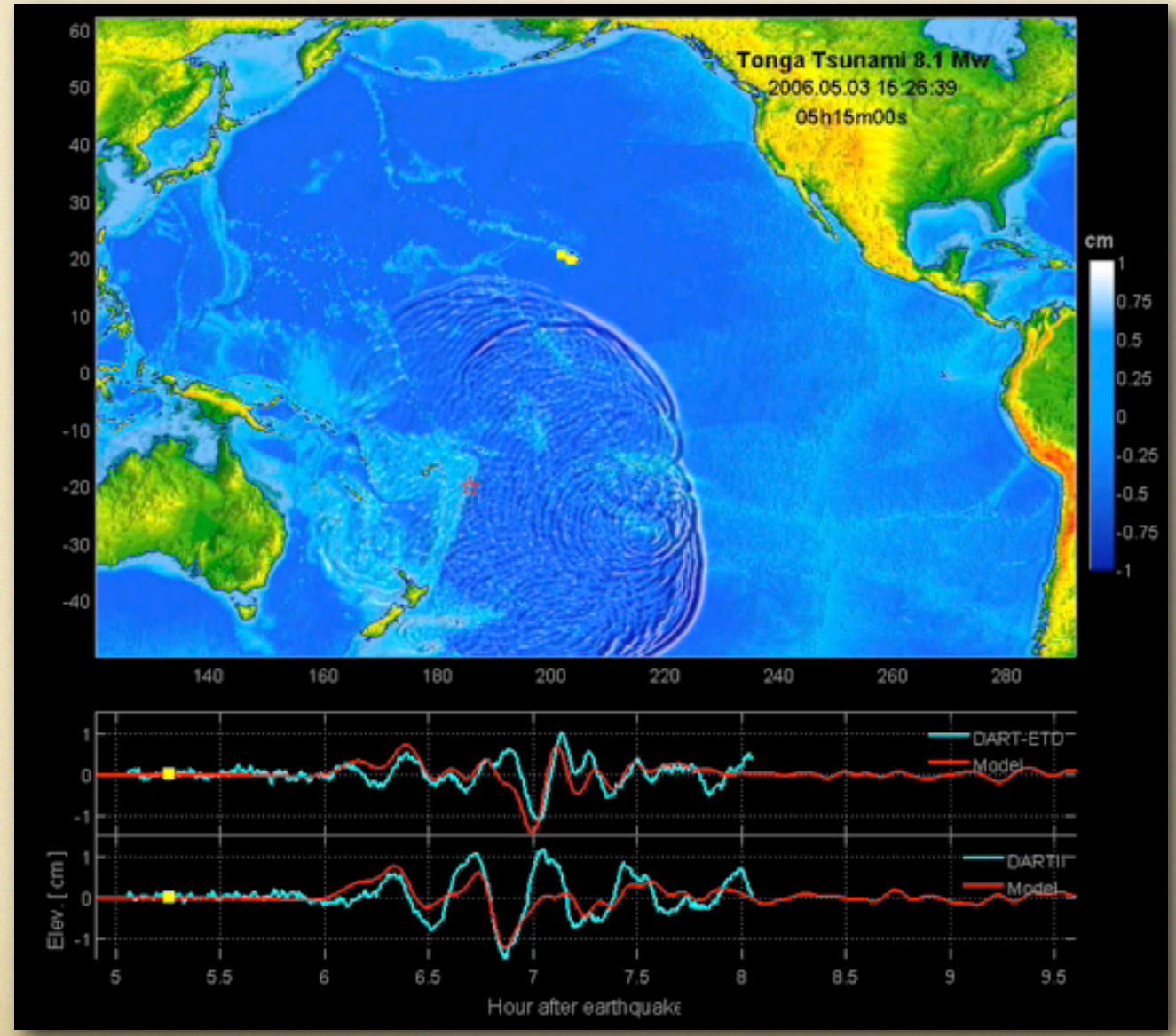
Inversion
▬ TSF (MOST)

Inun. forecast
■ SIM (MOST)

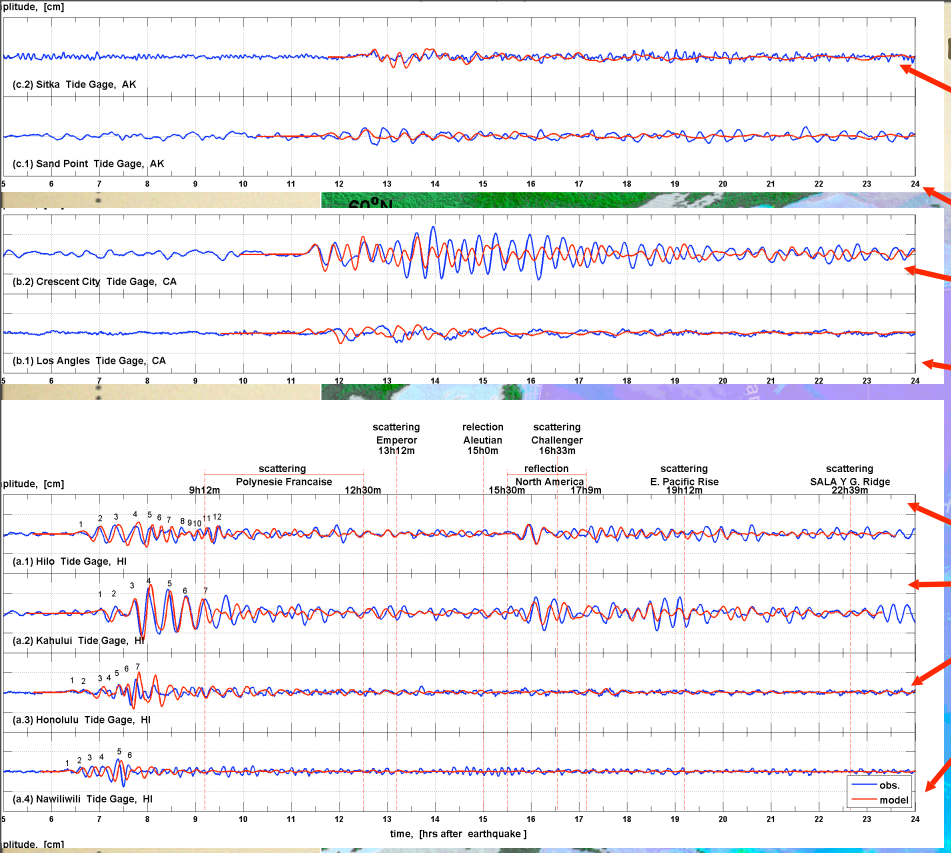




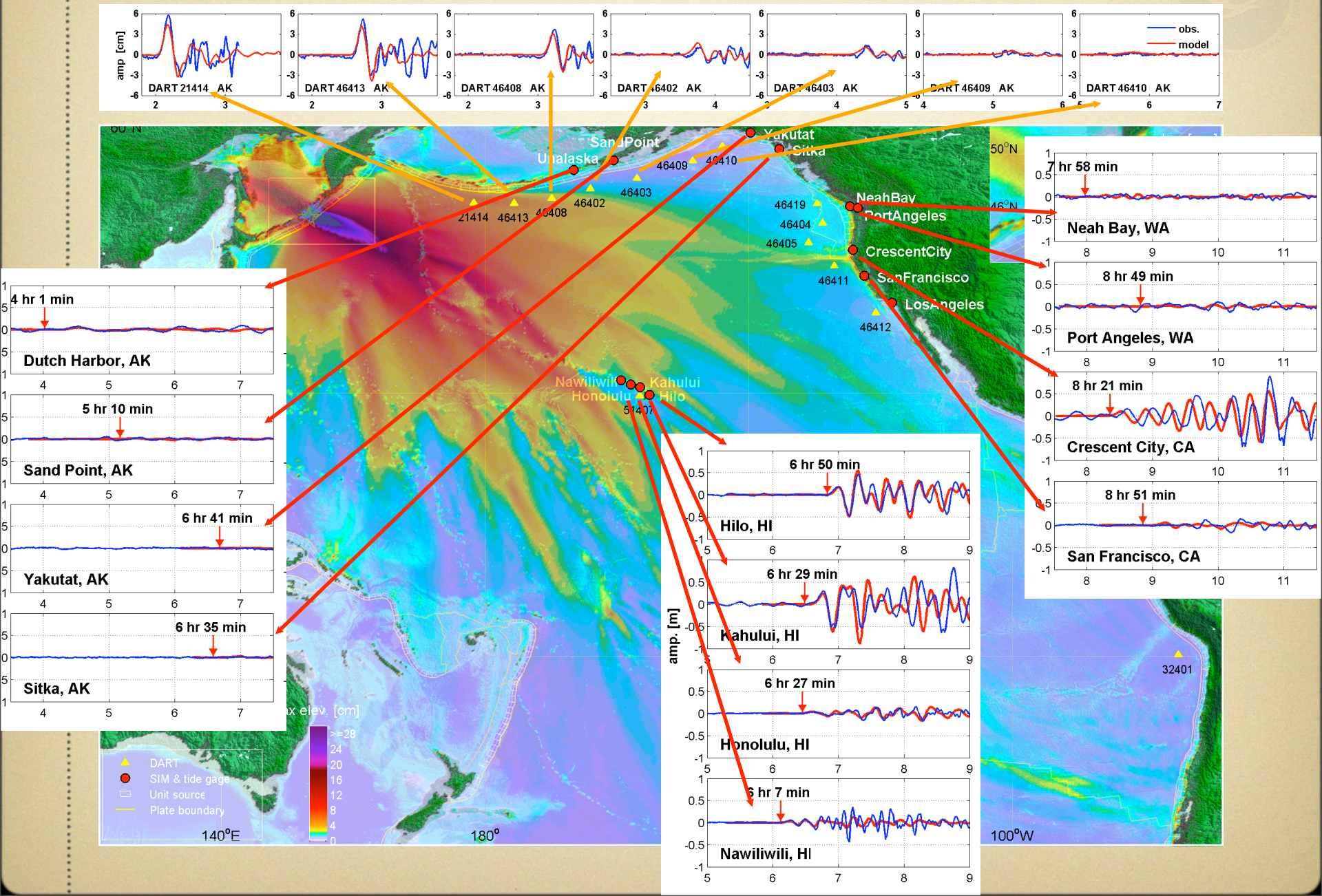
May 3, 2006 Tonga tsunami



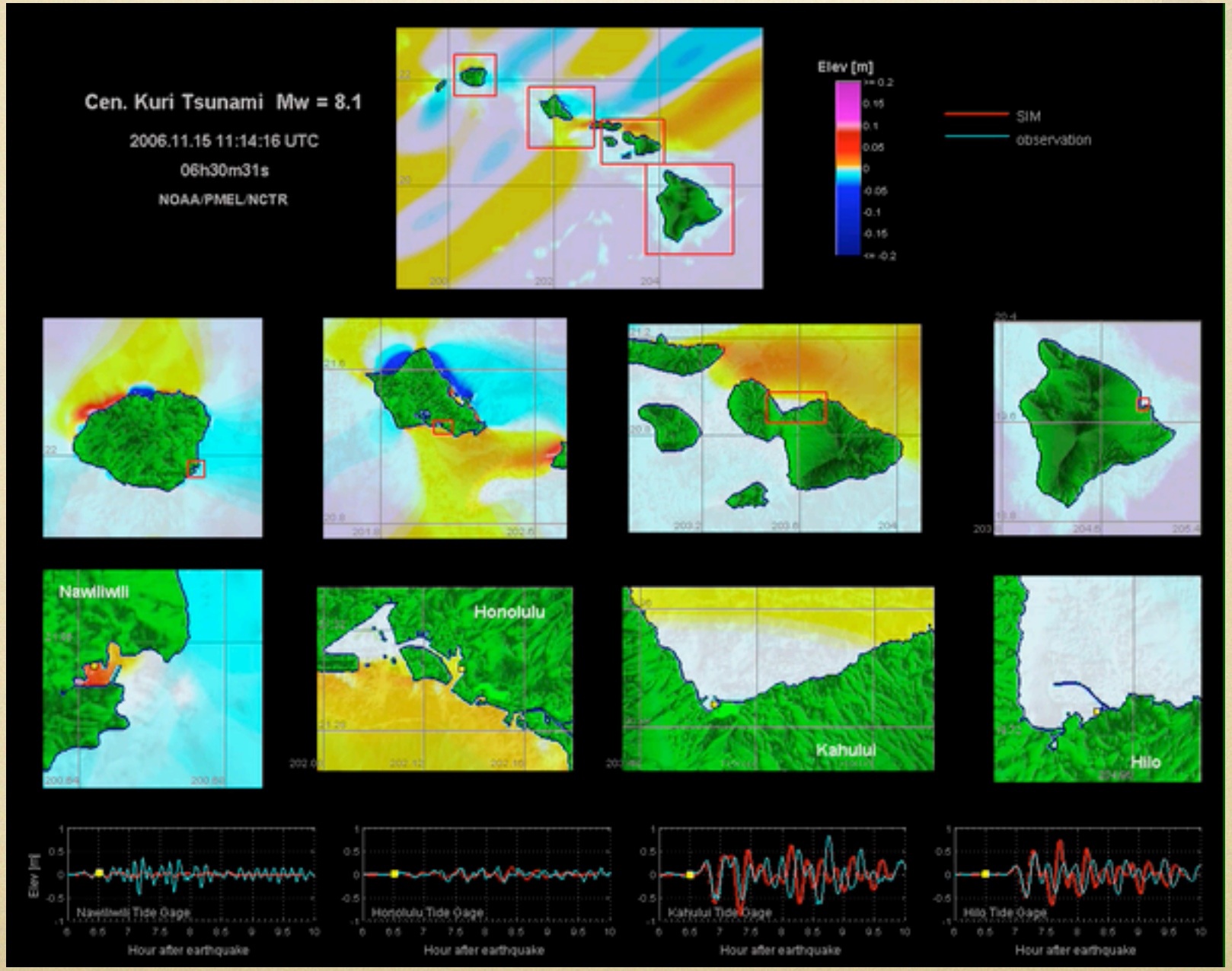
Tonga tsunami



The November 15, 2006 Central Kuril Tsunami



High-resolution forecast models



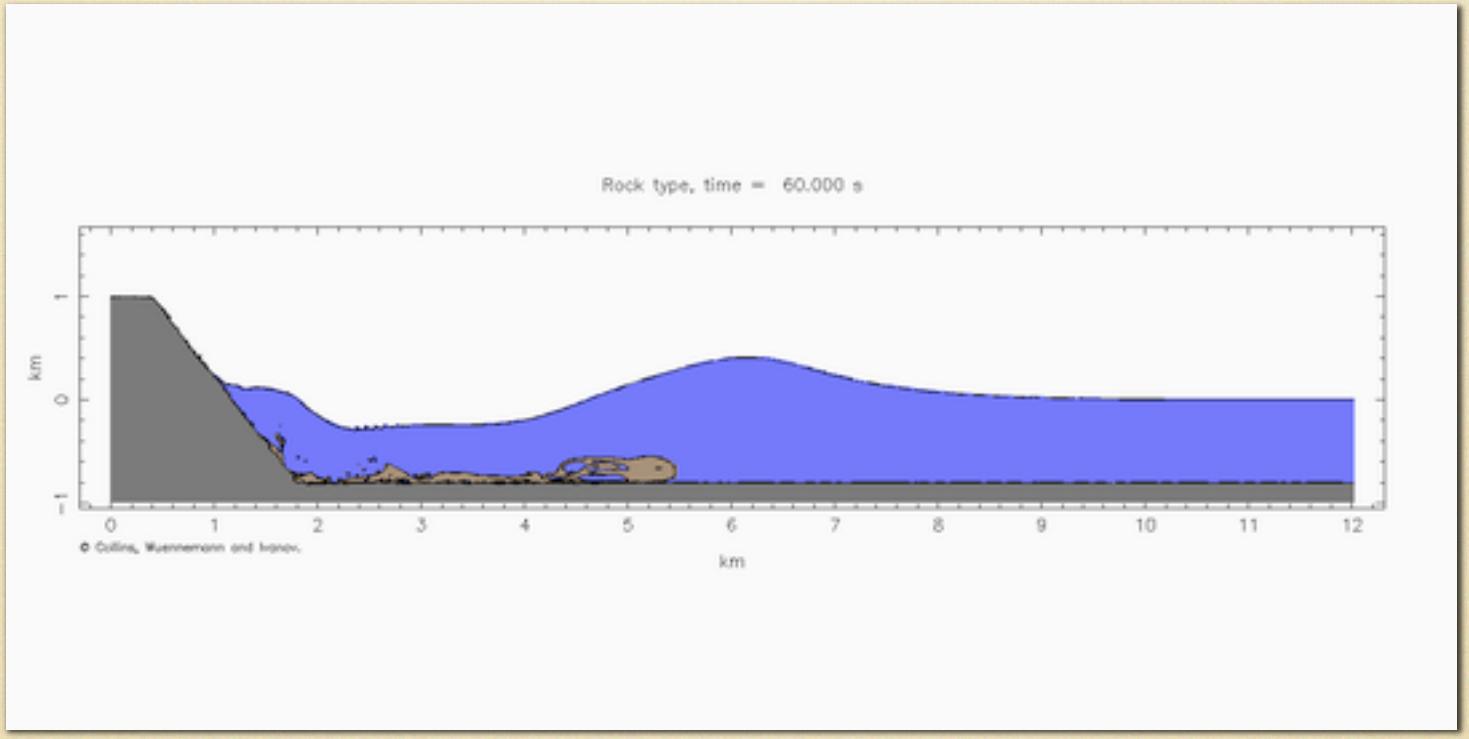
Impact of 8 Experimental Forecasts since November 2003

- 0 False Alarms
- 3 evacuations of Hawaii avoided saving approximately $210M in lost productivity
- 5 early cancellations of warnings reducing time of disruption

Future plans

- Further Tsunami Forecast System development (accuracy, speed, robustness)
  - Optimize DART network
  - New tsunami data inversion techniques
  - Local tsunami forecast
- Next generation models
  - Tsunami inundation impact
  - Landslide and other sources
- International coordination toward Global Forecast System (Australia, Indonesia, Chile, China, Russia)

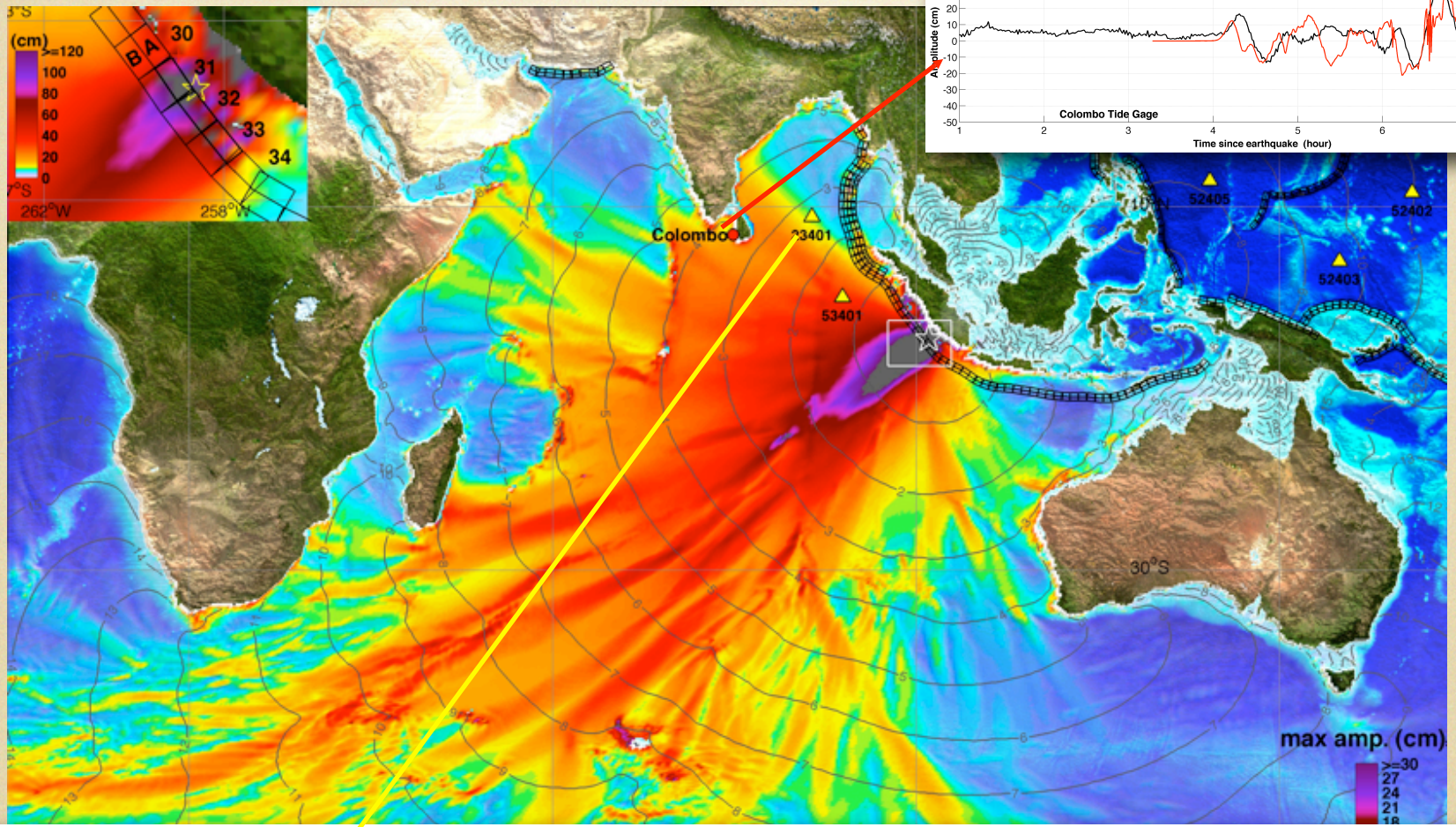
Next-generation models

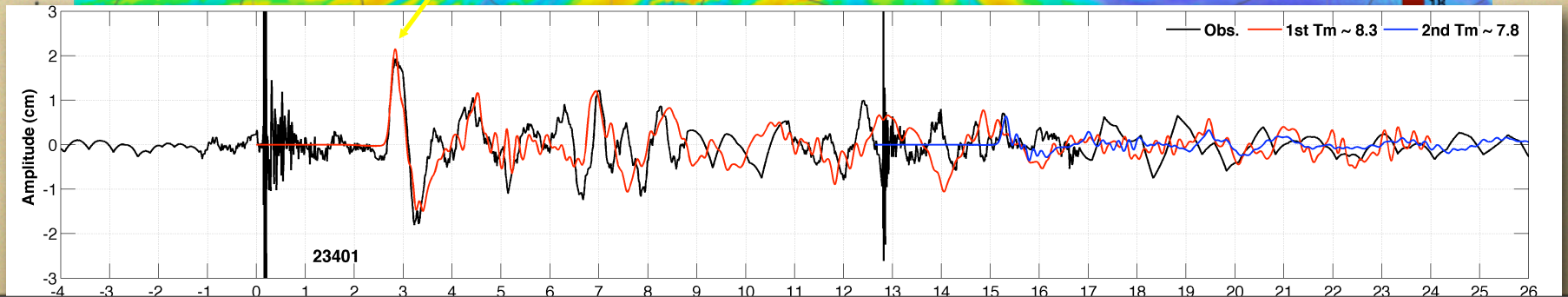


Large-scale landslide-generated tsunami model

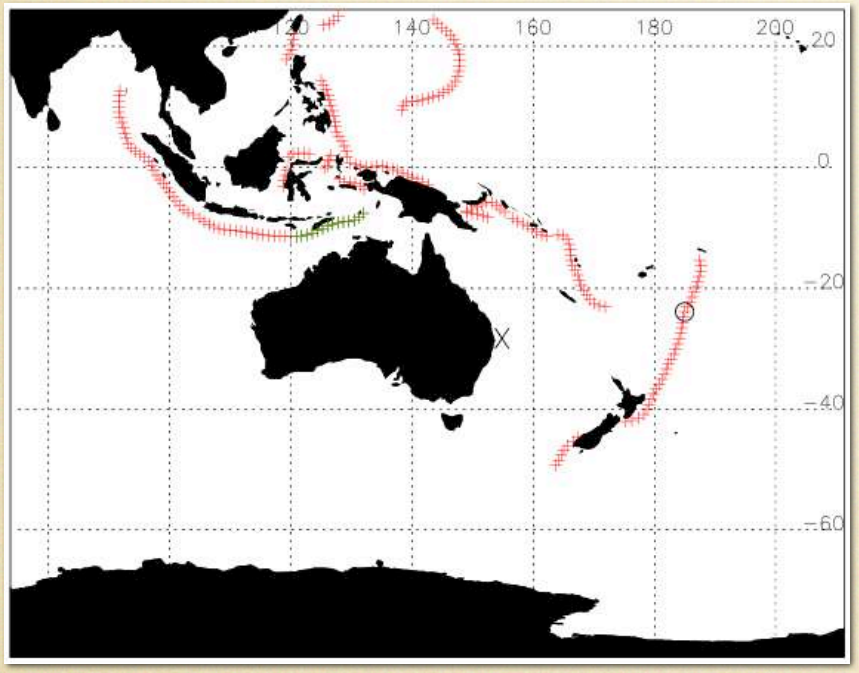
(studies for Nuclear Regulatory Commission)

The 12 September 2007 Sumatra Tsunami (Mw 8.3)



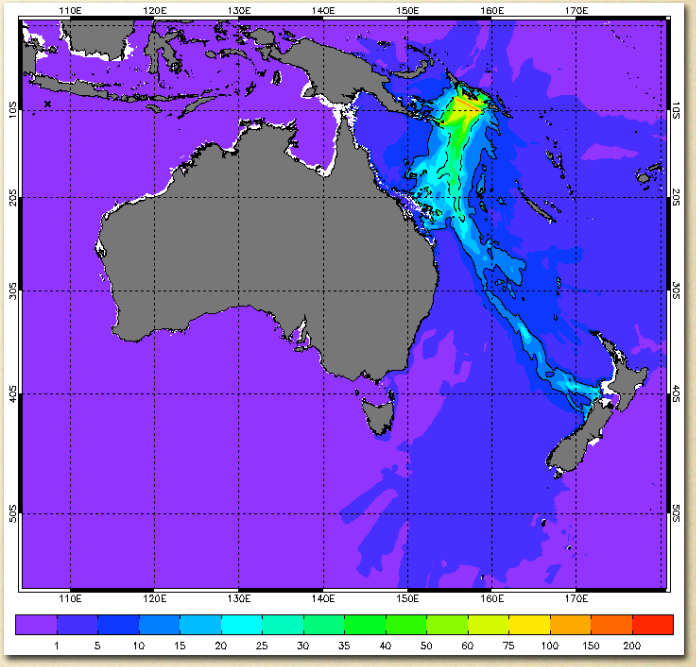


Australian tsunami forecast



MOST model propagation scenario database

DART measurements



April 1, 2007 Solomon Island Tsunami

Summary

- Short-term tsunami forecast method has been developed that combines tsunami measurement and modeling into real-time capability to forecast tsunami dynamics at specific coastal locations
- Real-time experimental forecasts show up to 90% amplitude accuracy and high efficiency of the method
- Tsunami Forecast System is being transfered into operations of the U.S. Tsunami Warning System

Thank You

Questions?