



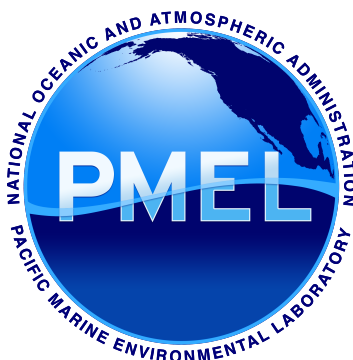
PMEL
Pacific Marine Environmental Laboratory

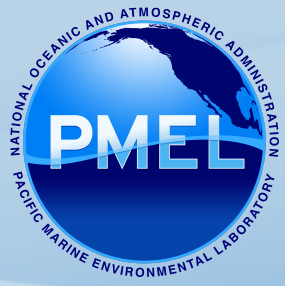
Tsunami Research

Tsunami Science after 2004 Sumatra Disaster

Vasily Titov

NOAA Center for Tsunami Research





NOAA Center for Tsunami Research

Develop methods and tools to reduce tsunami hazard and protect life.
 Testbed new tsunami forecast technologies for NOAA operations.



NCTR Personnel September 2009

Measurements:

Technology and the design of optimal tsunami monitoring networks

Projects:

- Support of DART research and operations
- Improve data assimilation into forecast modeling
- Explore new measurement technologies

Models:

Methods to predict tsunami impacts on the population and infrastructure of coastal communities

Projects:

- Enhancements to tsunami modeling capabilities
- Model application for tsunami hazard assessment
- Model studies to improve forecast capabilities
- Development of next generation operational model
- Testing new models for tsunami forecast applications

Forecast:

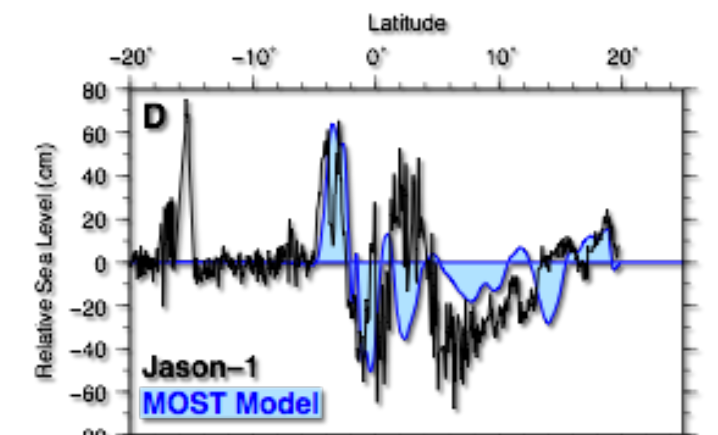
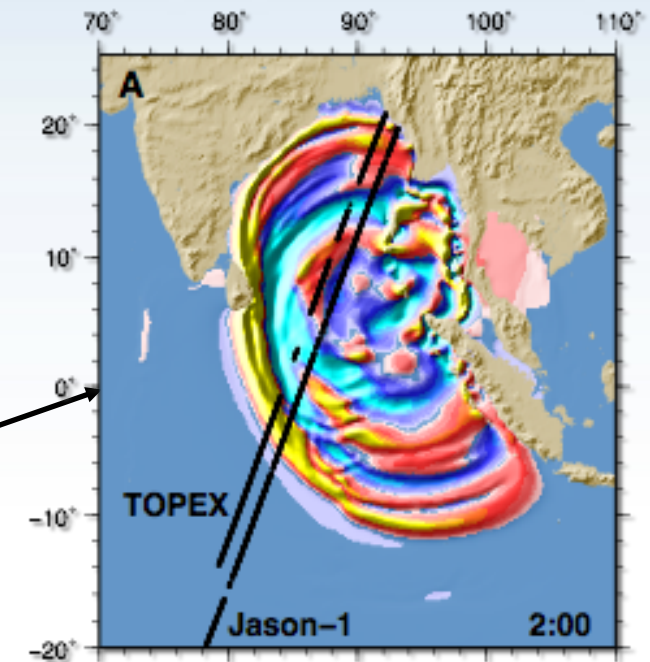
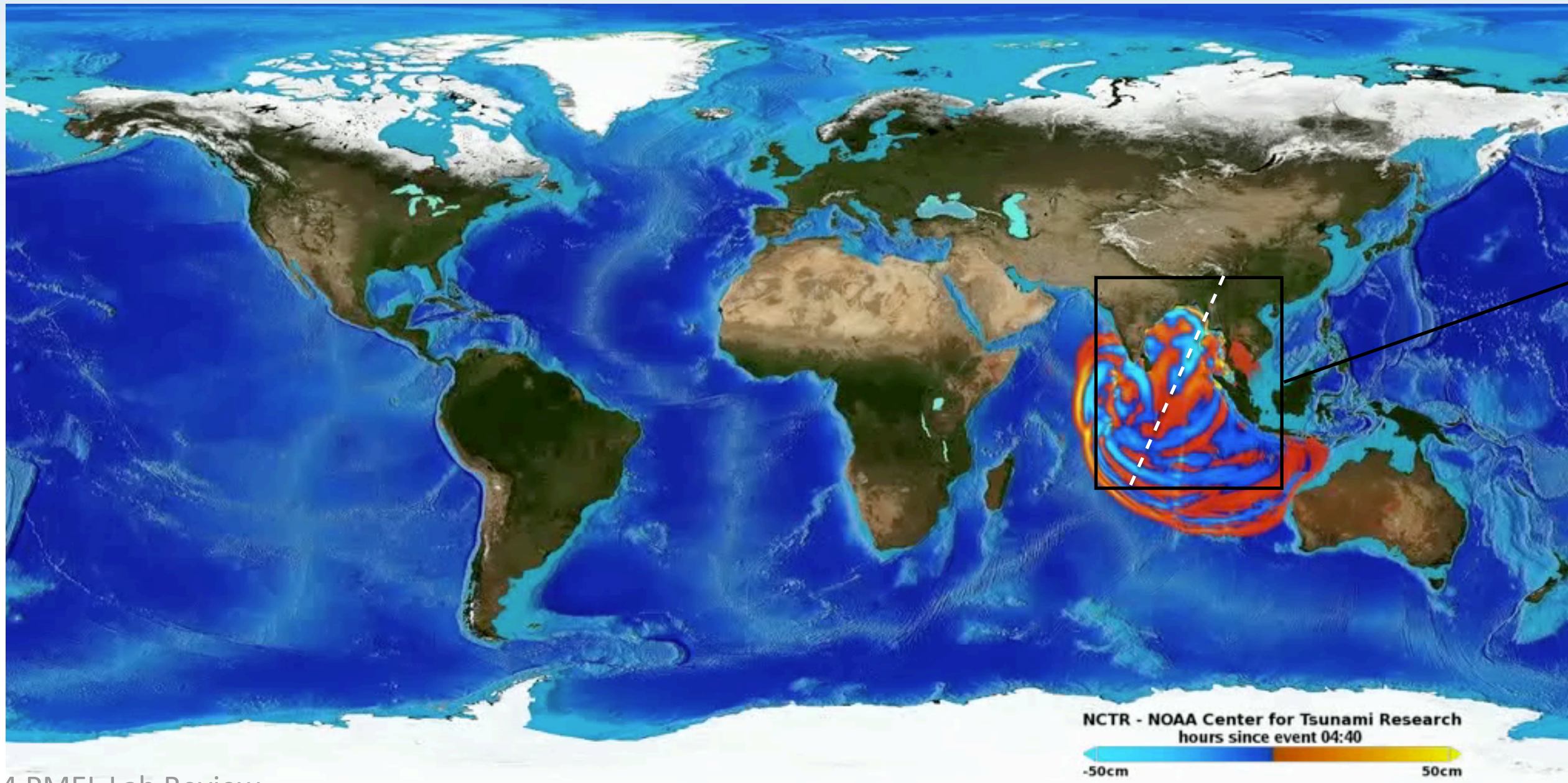
Improve operational tsunami forecast

Projects:

- Operational forecast maintenance
- Improve speed and accuracy of operational forecast capabilities
- Develop new applications for forecast dissemination using internet, cloud and mobile technologies
- Research, test and implement new measurements and modeling capabilities for forecast operations

Science Solution: Model Forecast

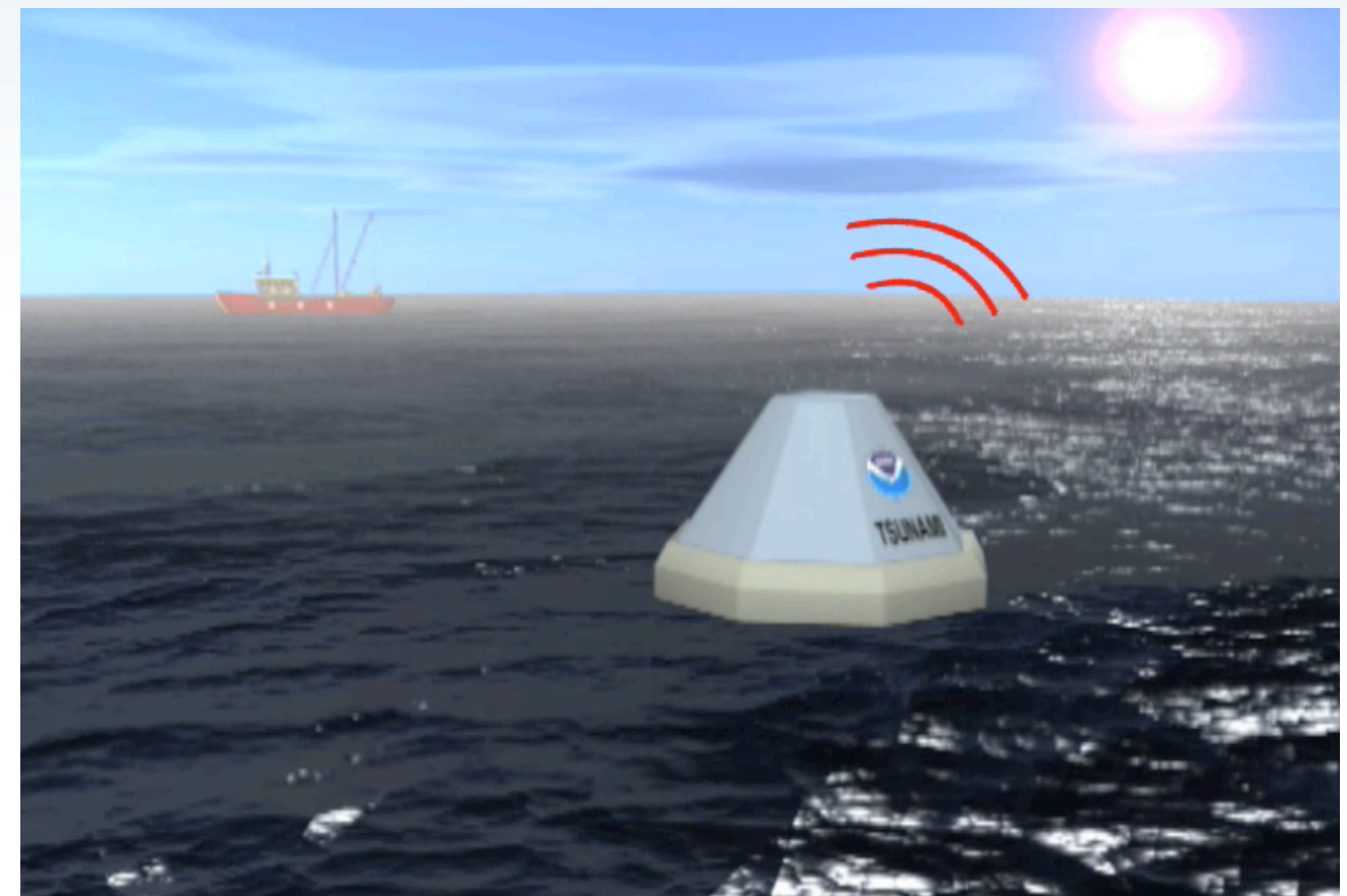
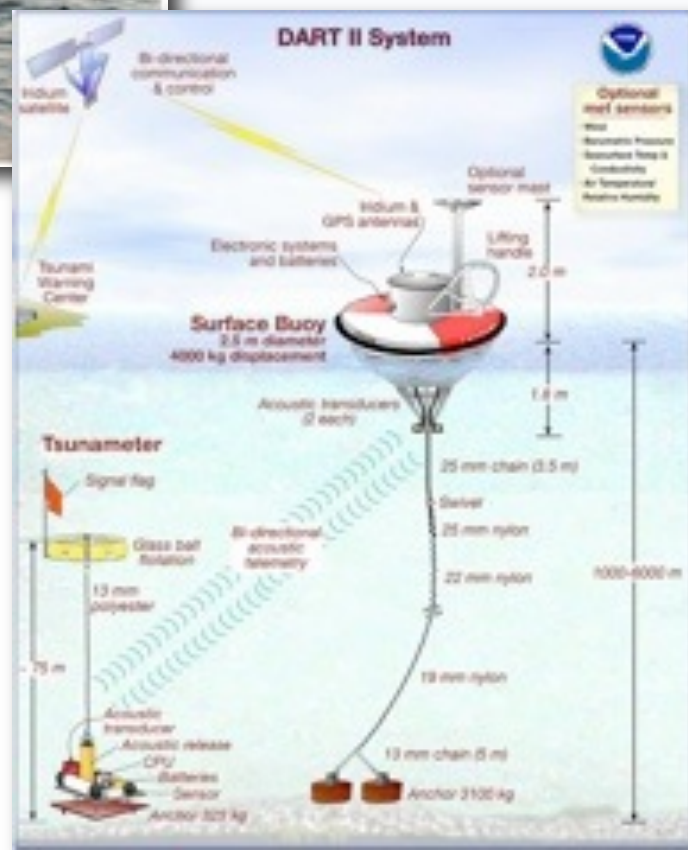
Milestone 1: Sumatra Tsunami 2004

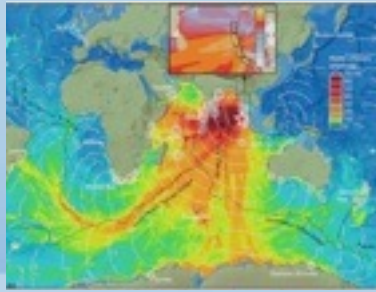


Science Solution: Tsunami Detection



Deep-ocean Assessment and Reporting for Tsunamis (DART)





2004.12.26

Indian Ocean tsunami killed over 230,000 people around the Indian Ocean basin



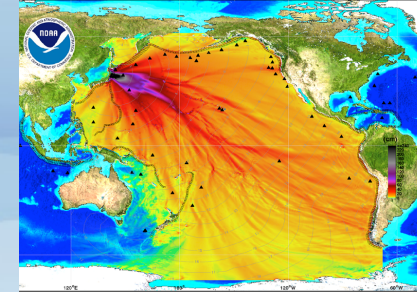
2006.12

Tsunami Warning and Education Act authorizing NOAA to strengthen its tsunami detection, forecast, warning and mitigation programs



2008.03

The United States tsunami detection array (DART) is complete, with 39 buoys positioned around the Pacific basin, western Atlantic and Caribbean Sea



2011.03

Japan Tsunami tsunami killed over 25,000 people in Japan, over \$1B



2013.09

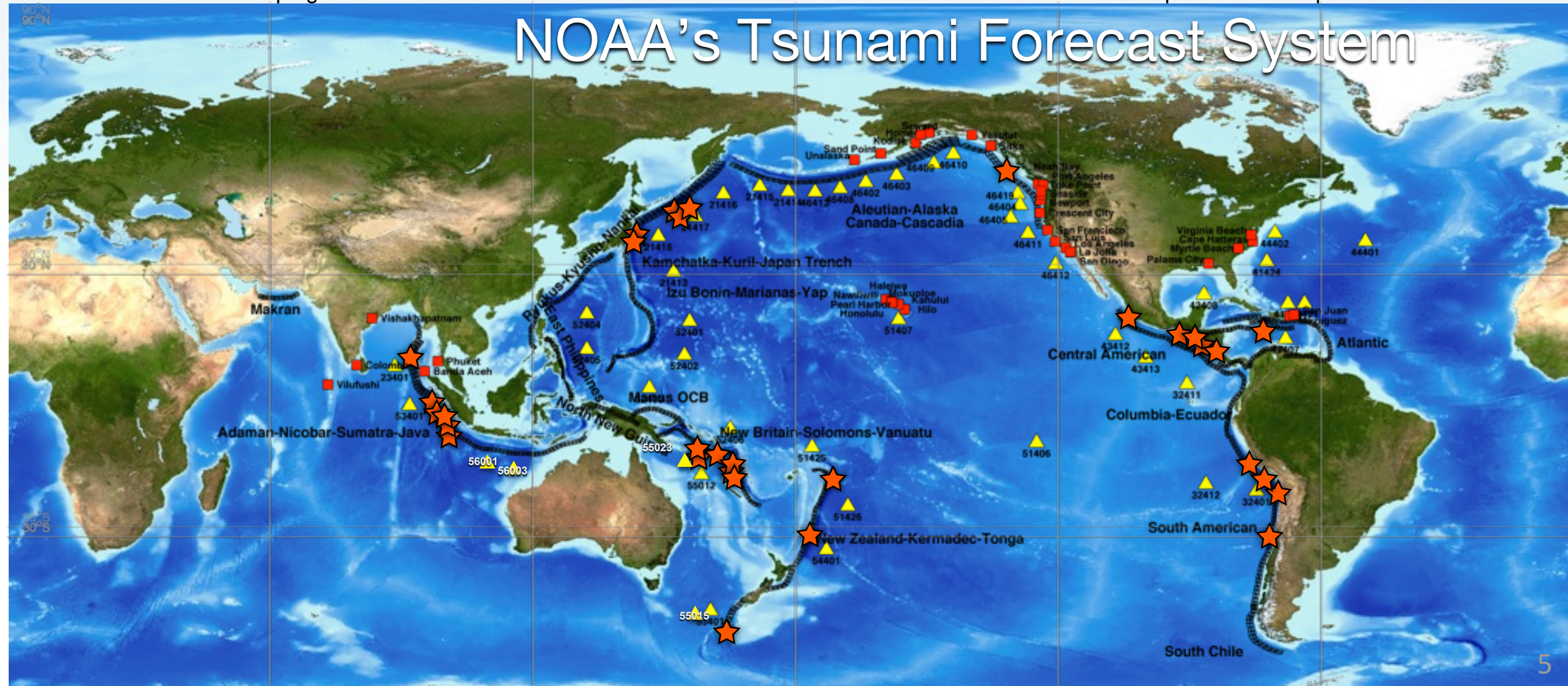
SIFT – NOAA Tsunami Forecast System that uses DARTs and models is tested and fully implemented into operations

Detection
▲ DART

Data ingest
▣ Model DB

Flooding forecast
■ Forecast Models

★ Tsunamis since 2004

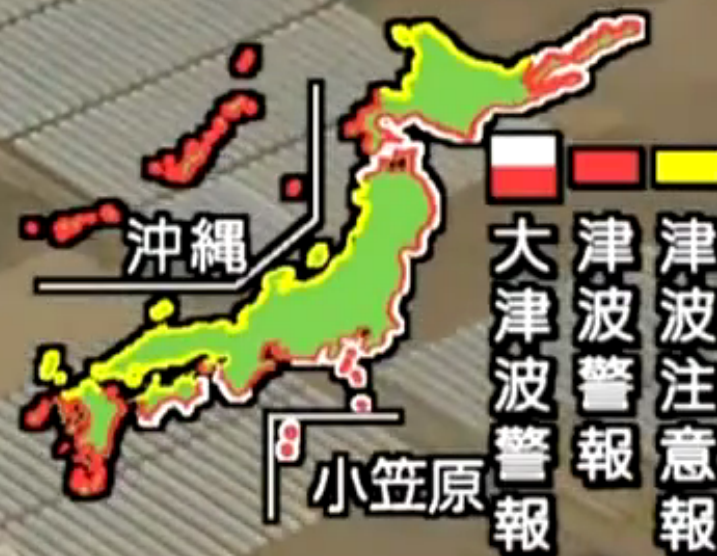


NOAA's Tsunami Forecast System

11 March, 2011 Japan Tsunami

大津波で385人死亡
長野県北部で震度6

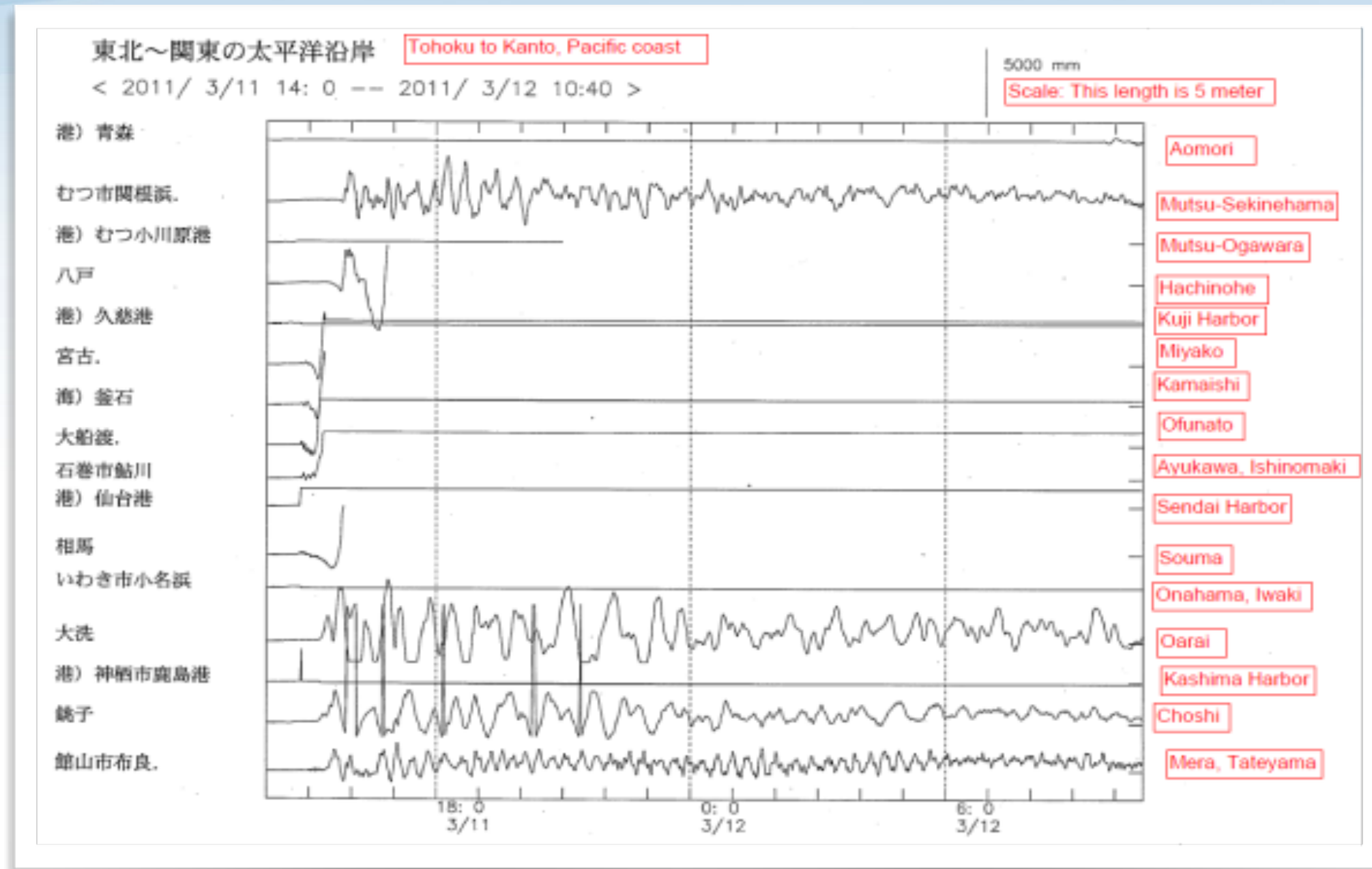
宮城 仙台・名取付近
きのう午後4時ごろ



Milestone and
New Challenges for
Forecast Development

- Costliest natural disaster of all time
- Virtually all damage and deaths from Tsunami
- >\$220B worth of damage
- over 15,000 killed

Instrumentation Challenges



Tsunami recorded at Japanese sea level stations

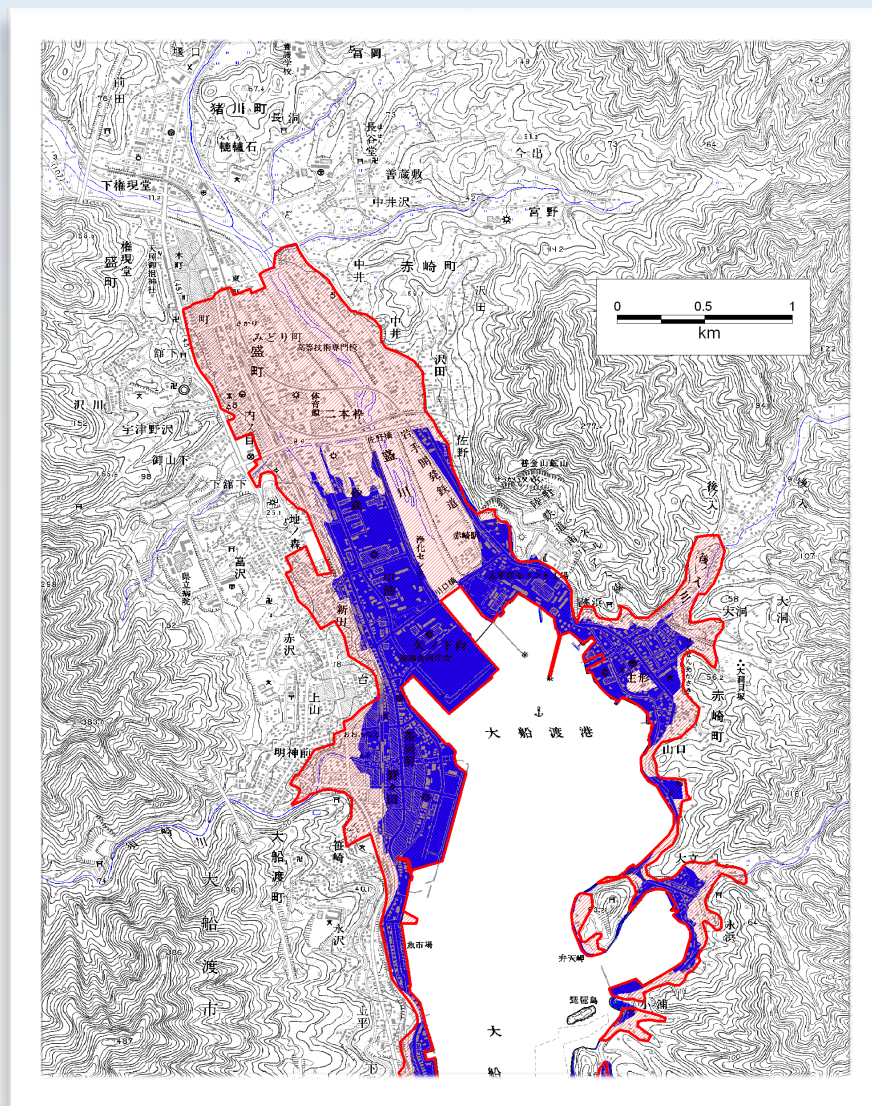
Engineering Challenges



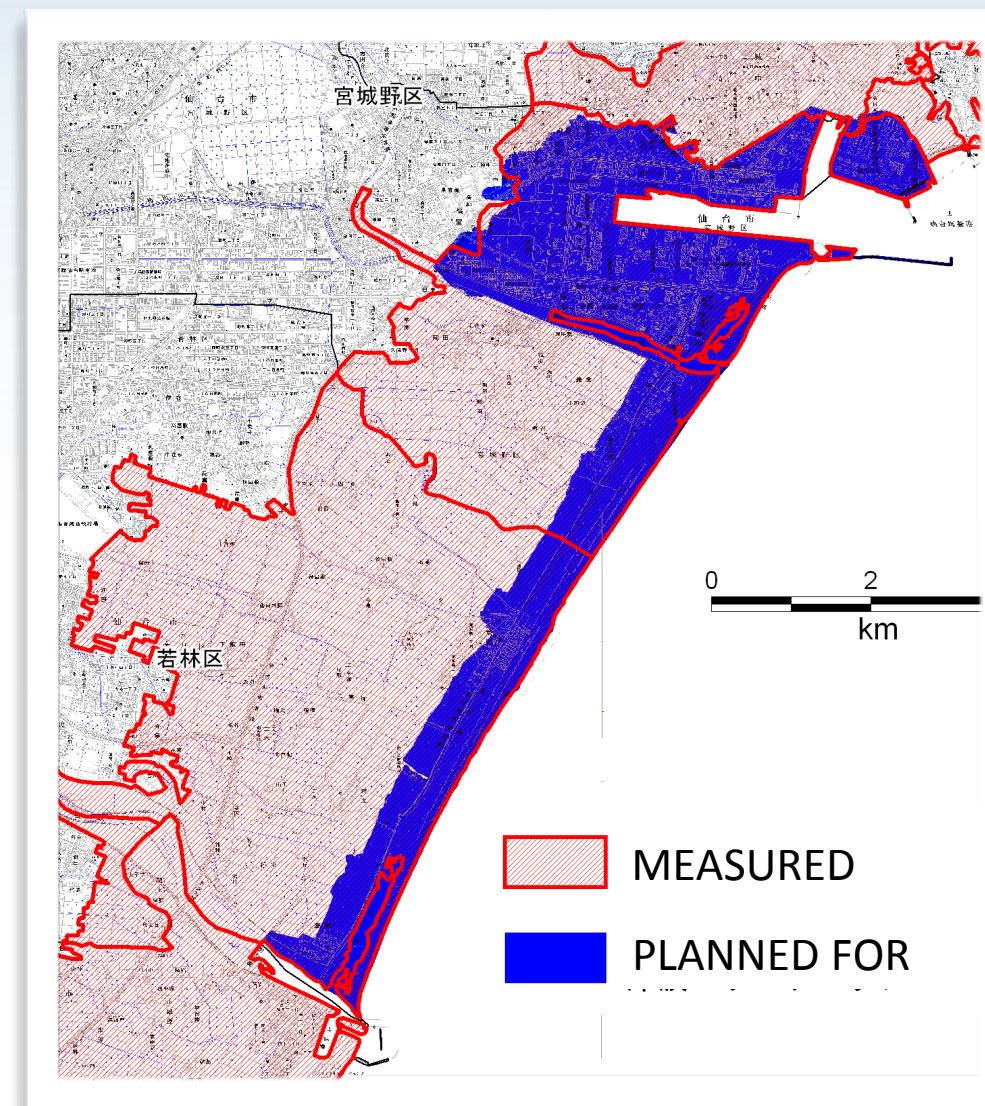
Minamisanriku City

Hazard Assessment Challenges

Ofunato City, Iwate Prefecture

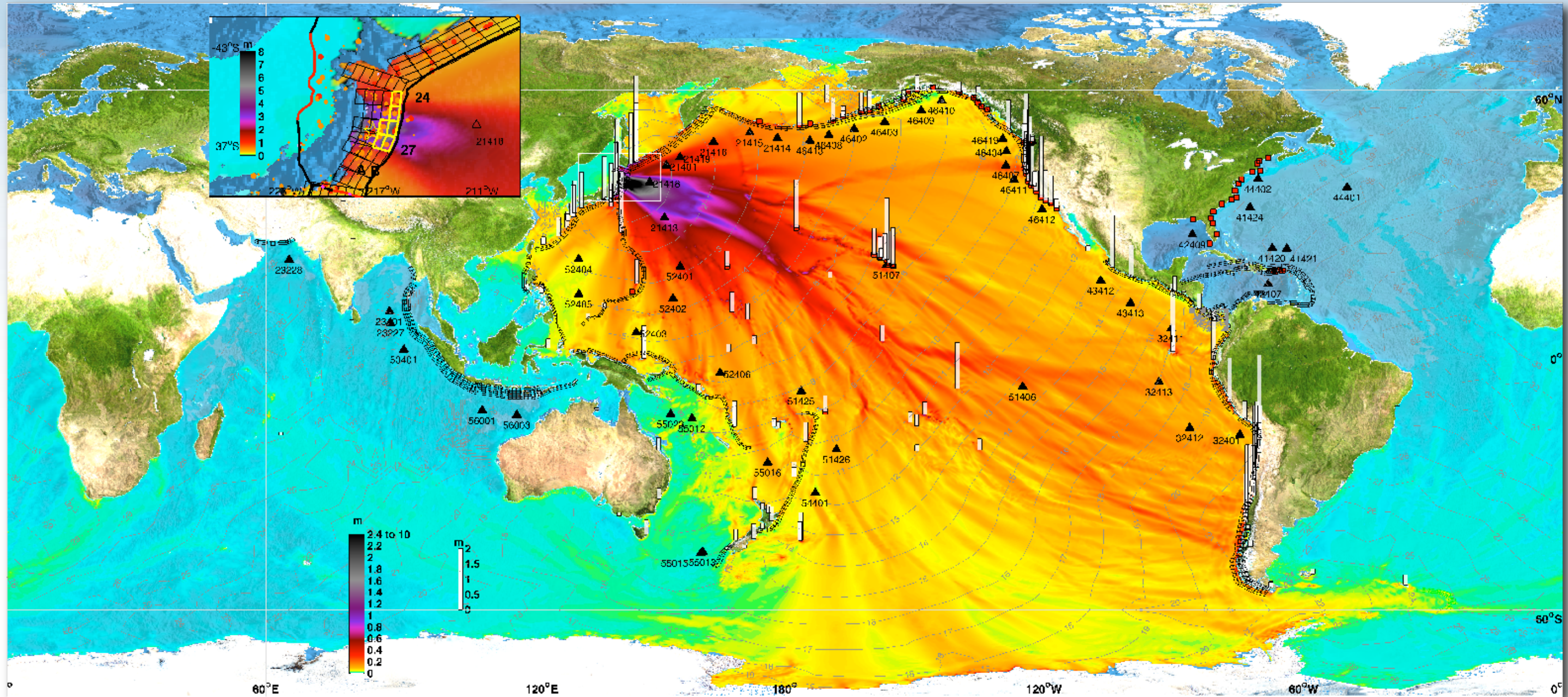


Sendai City, Miyagi Pref.



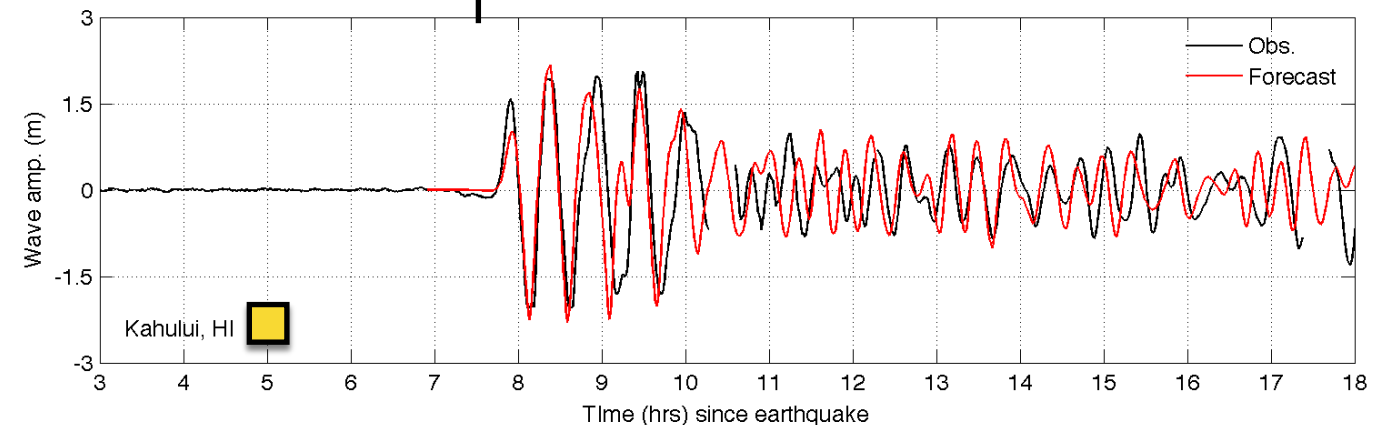
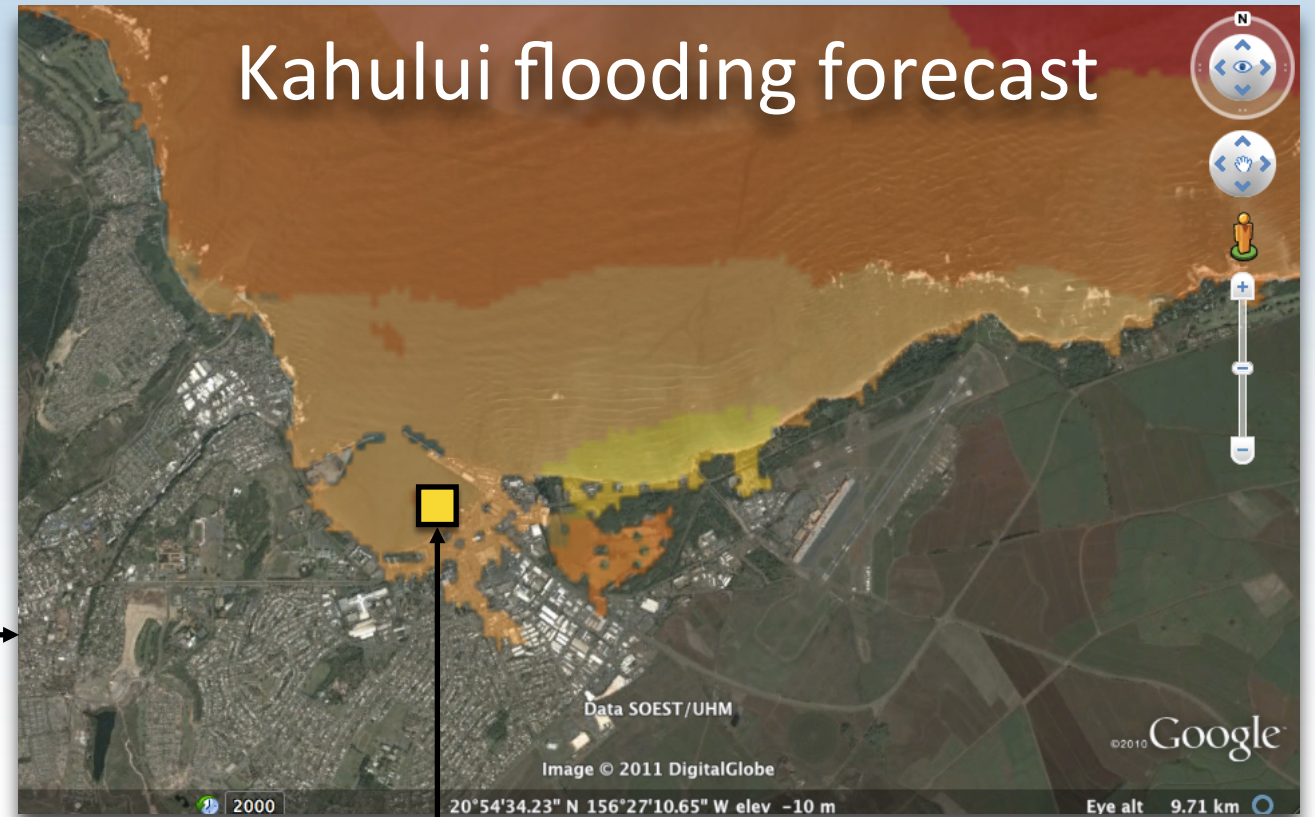
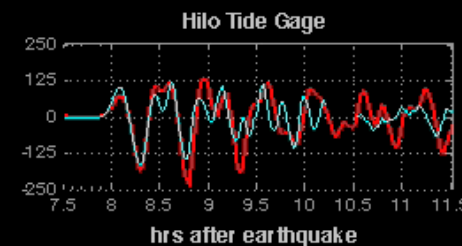
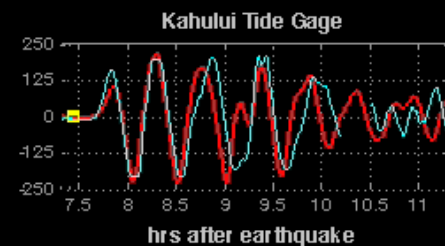
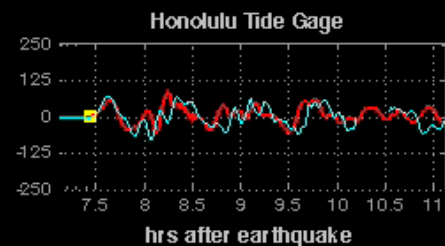
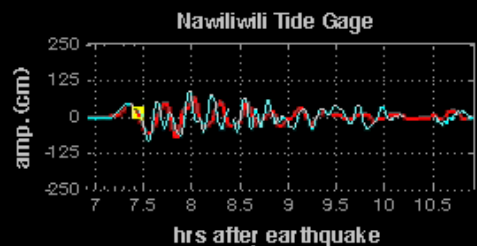
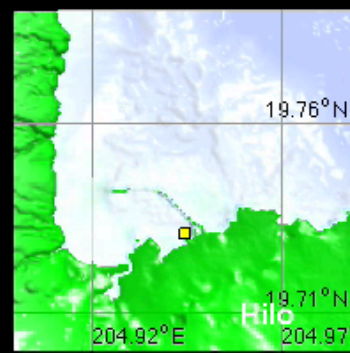
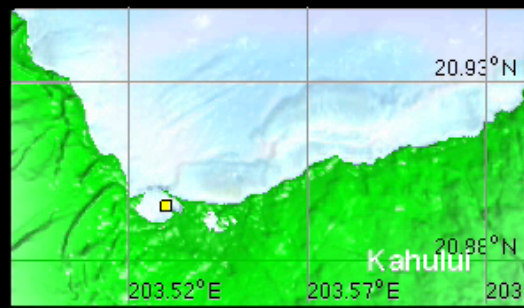
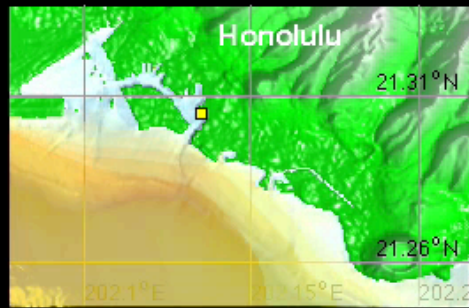
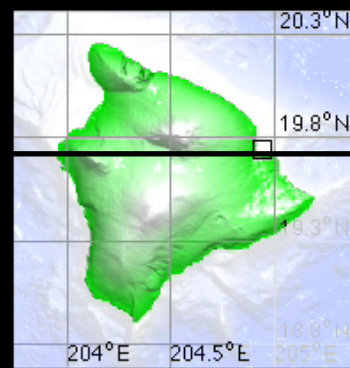
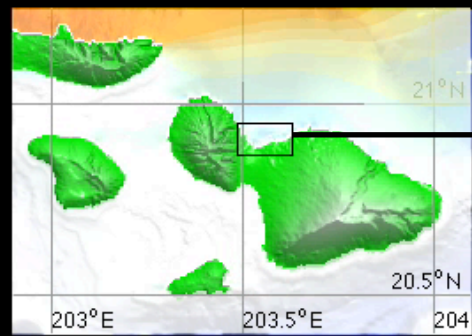
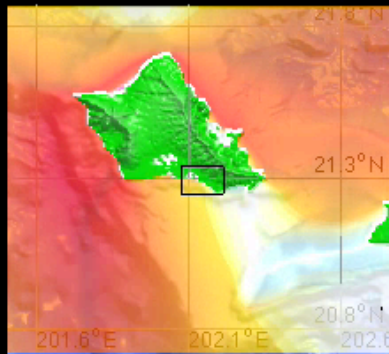
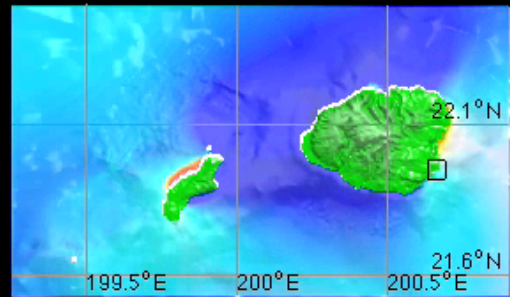
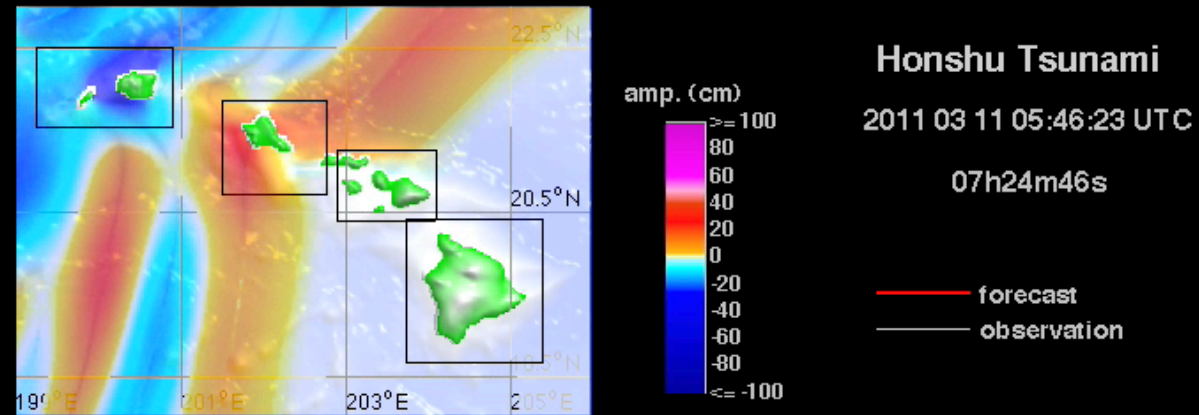
Hazard Maps vs Measured Inundation

NOAA forecast performance



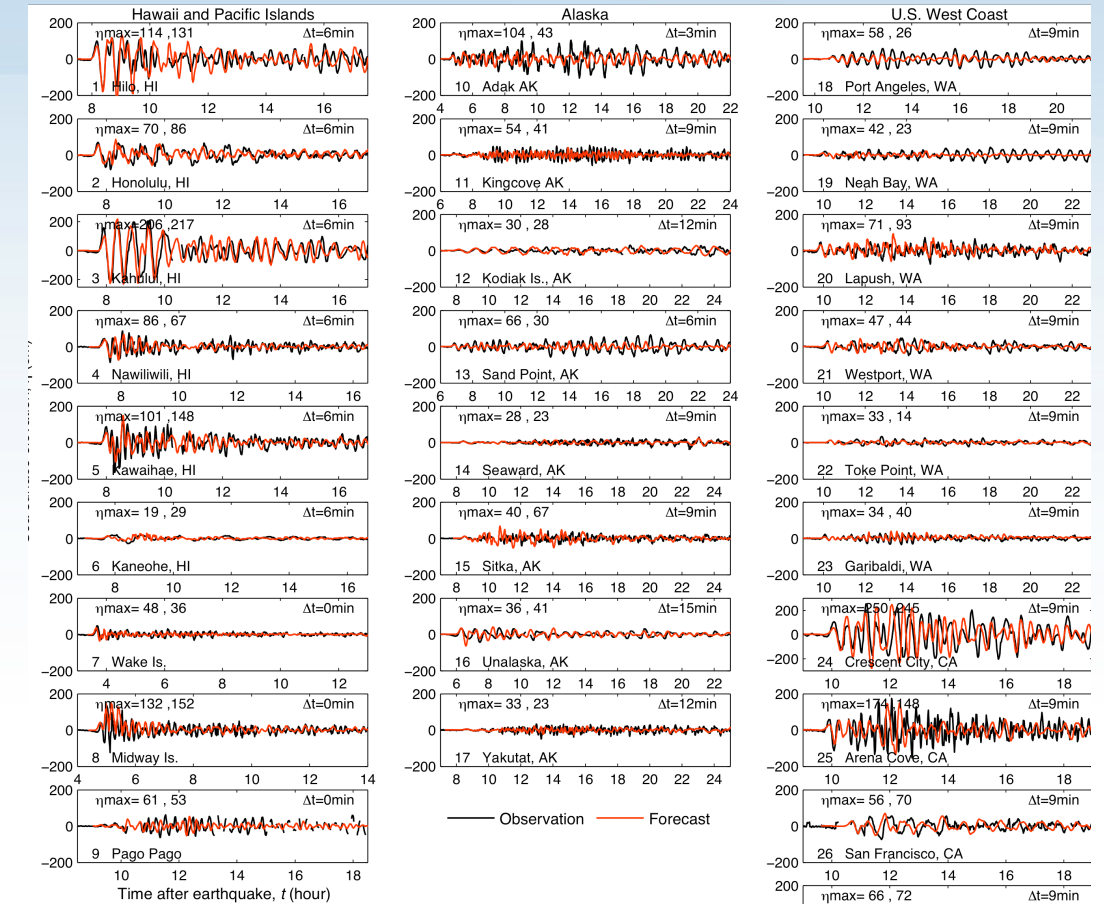
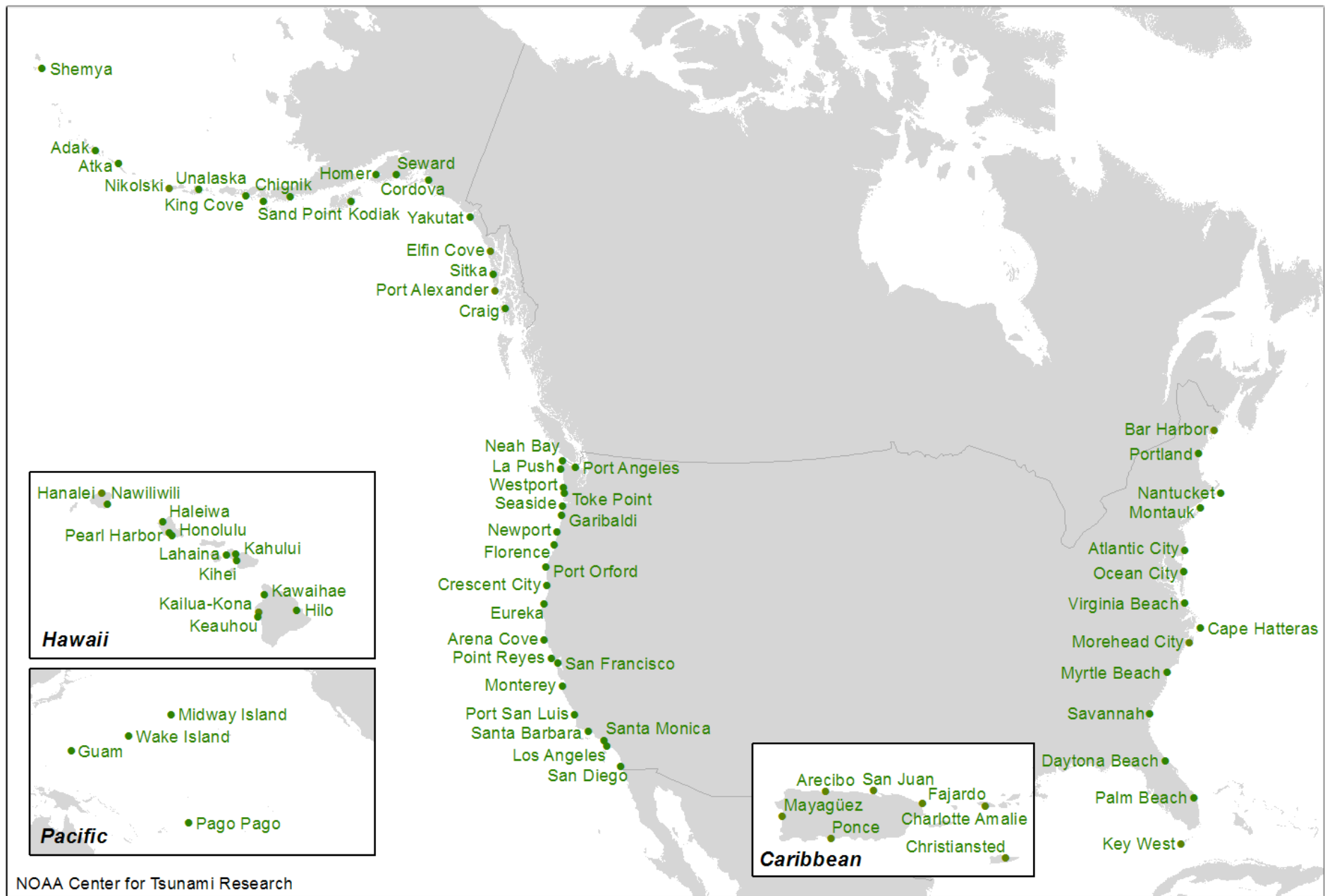
March 11, 2011 Japan Tsunami: Forecast based on 2 DART measurements

Tsunami Inundation Forecast



Honshu (northeastern Taiheiyou) tsunami, 11 March 2011

75 tsunami flooding forecast models



Coastal gages forecast accuracy (max amplitude)

All: 68% (0.2 m average error)

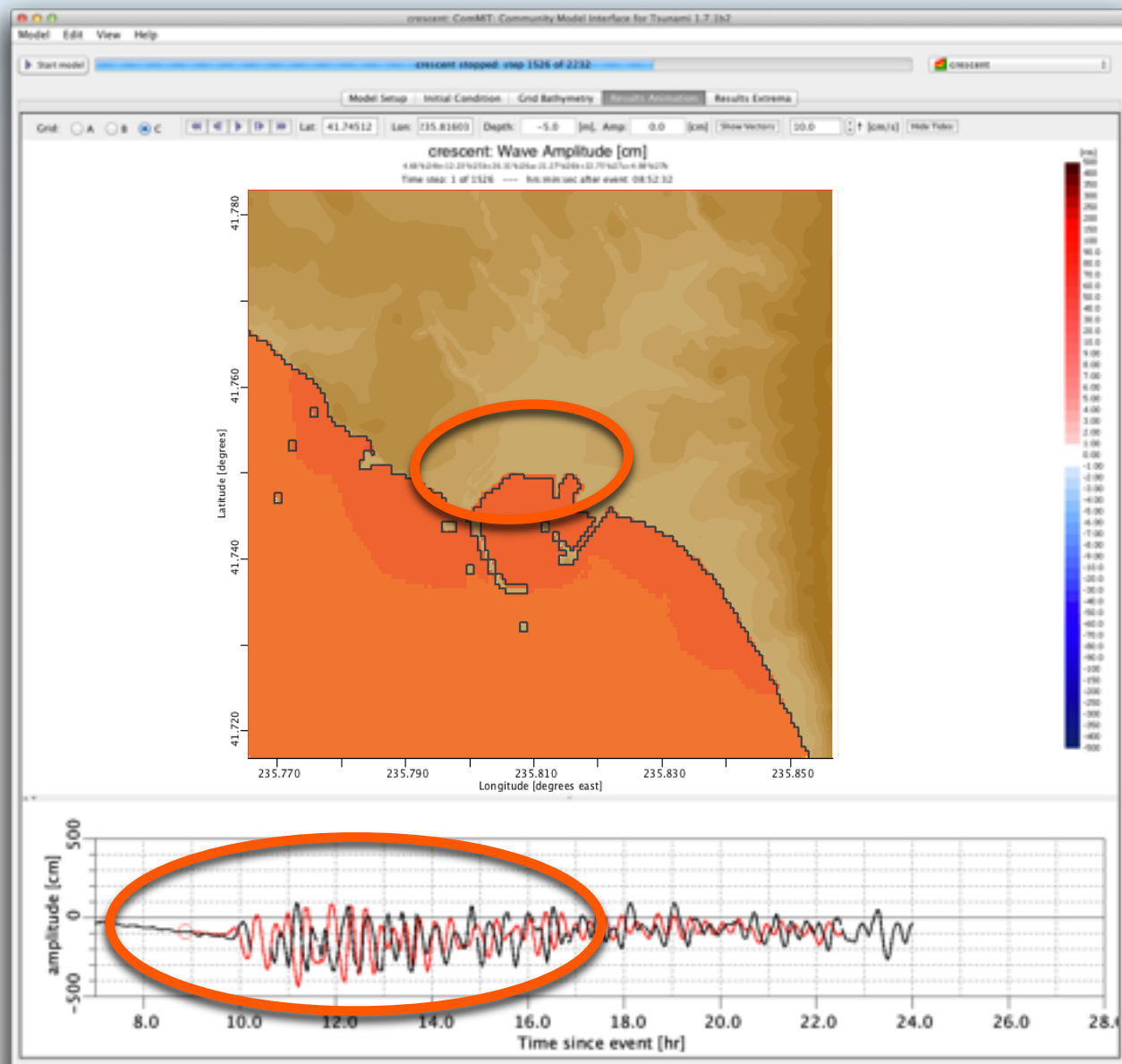
>1.0m: 74%

>1.5m : 87%

Kahului (2.1 m): 95%

Crescent City (2.5 m): 98%

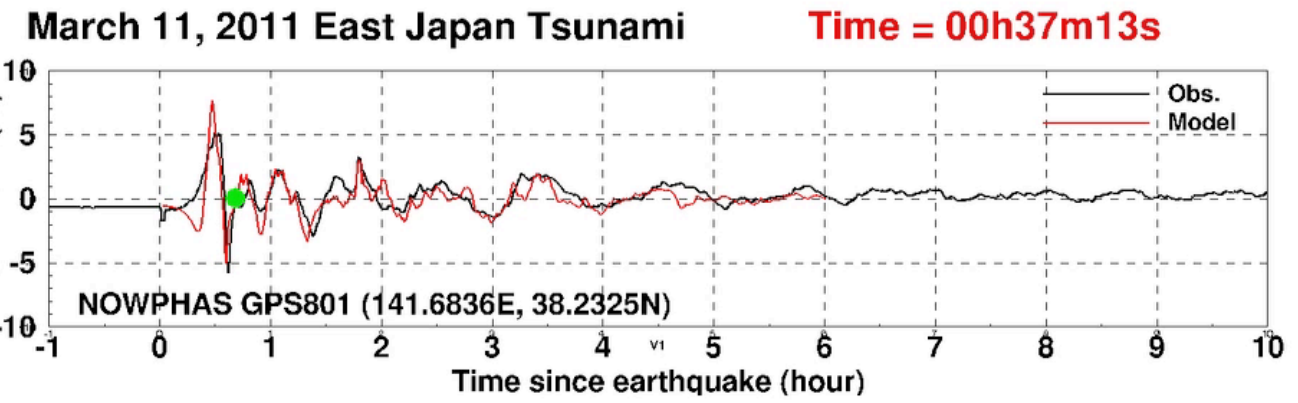
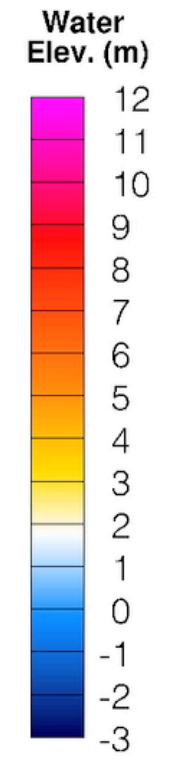
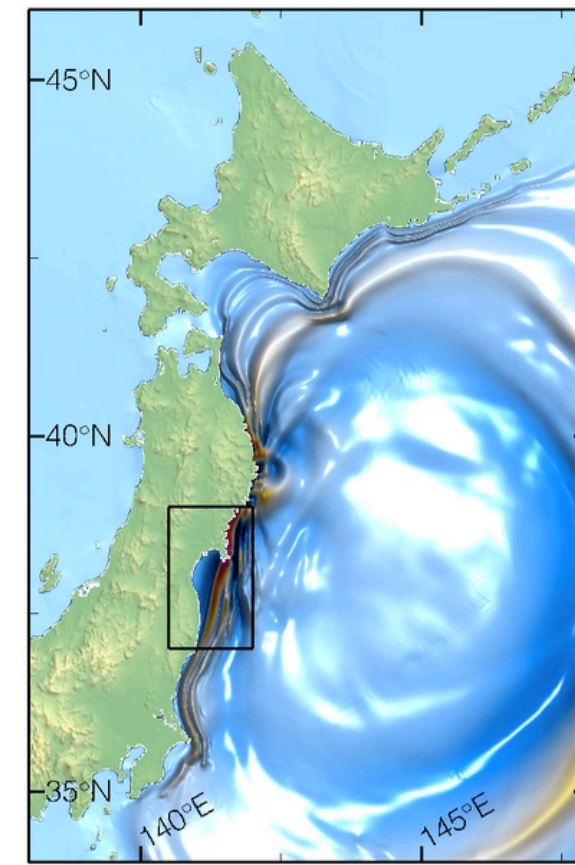
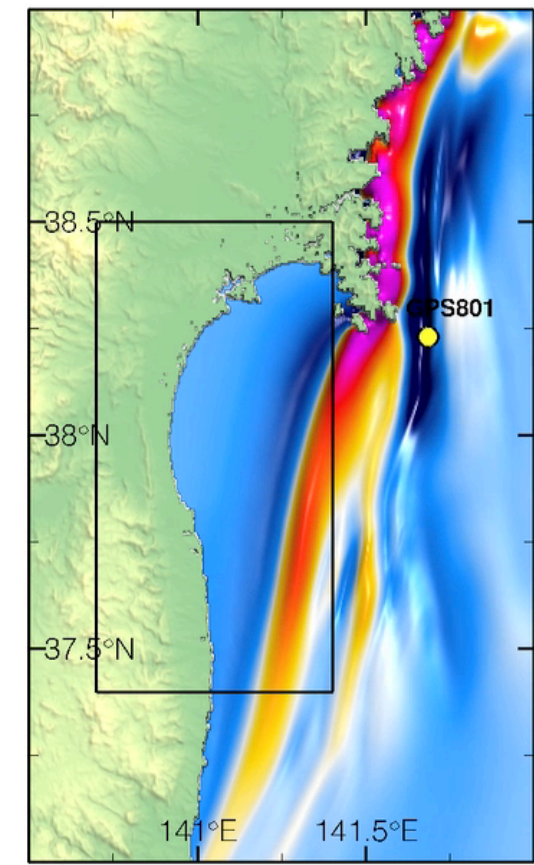
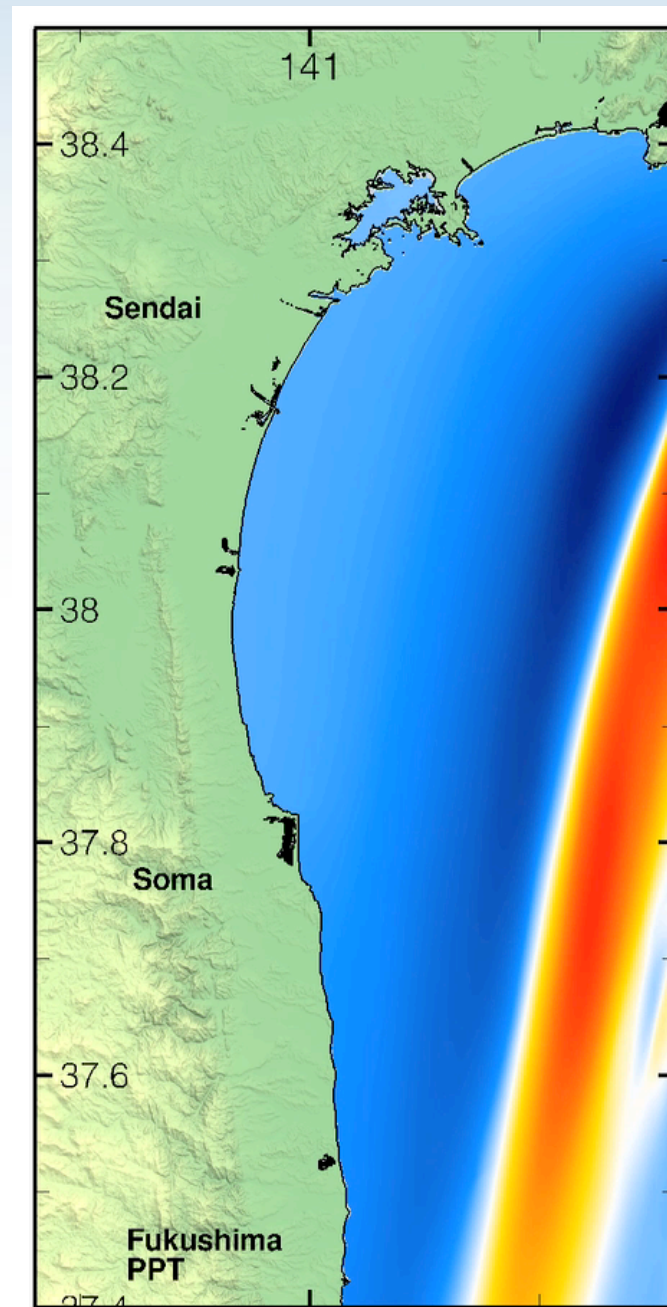
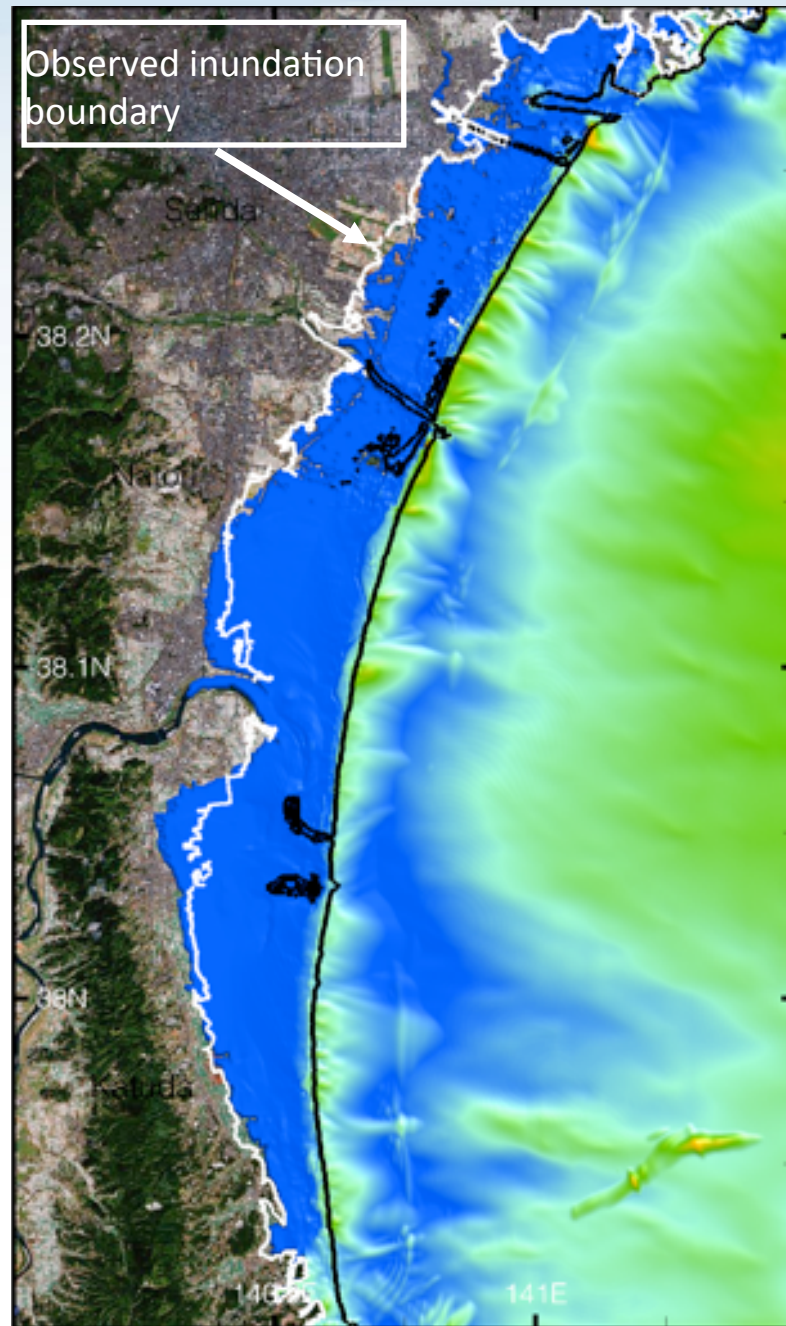
Future Challenges: Improve Tsunami Forecast Models



Include Predictions of Tides and
Other Sea Level Changes into
Tsunami Flooding Forecast

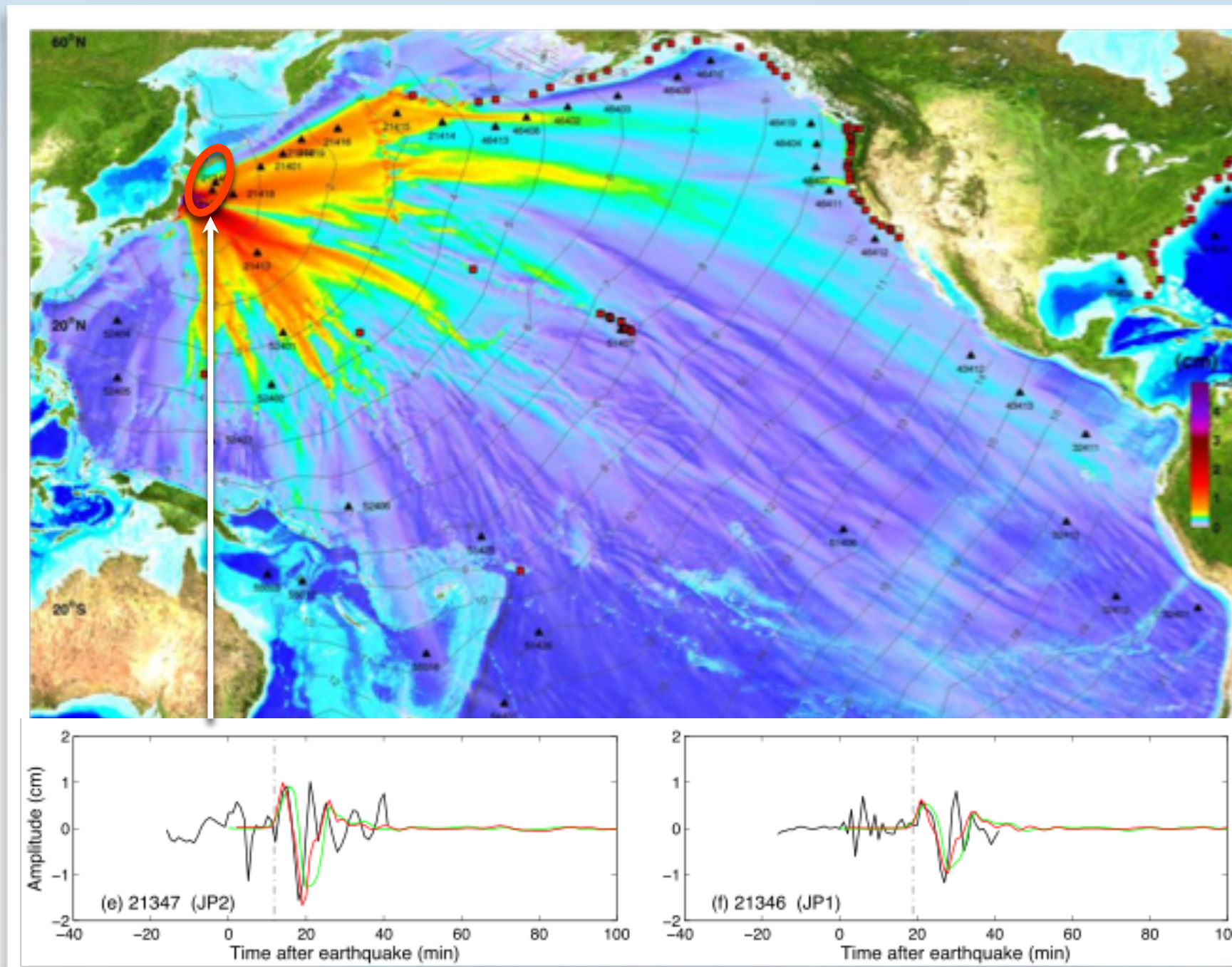
Example: 2011 Japan Tsunami
Forecast for Crescent City

Future Challenges: Forecast of Local Impact



New Development since 2011

Mw 7.3 December 7, 2012 tsunami



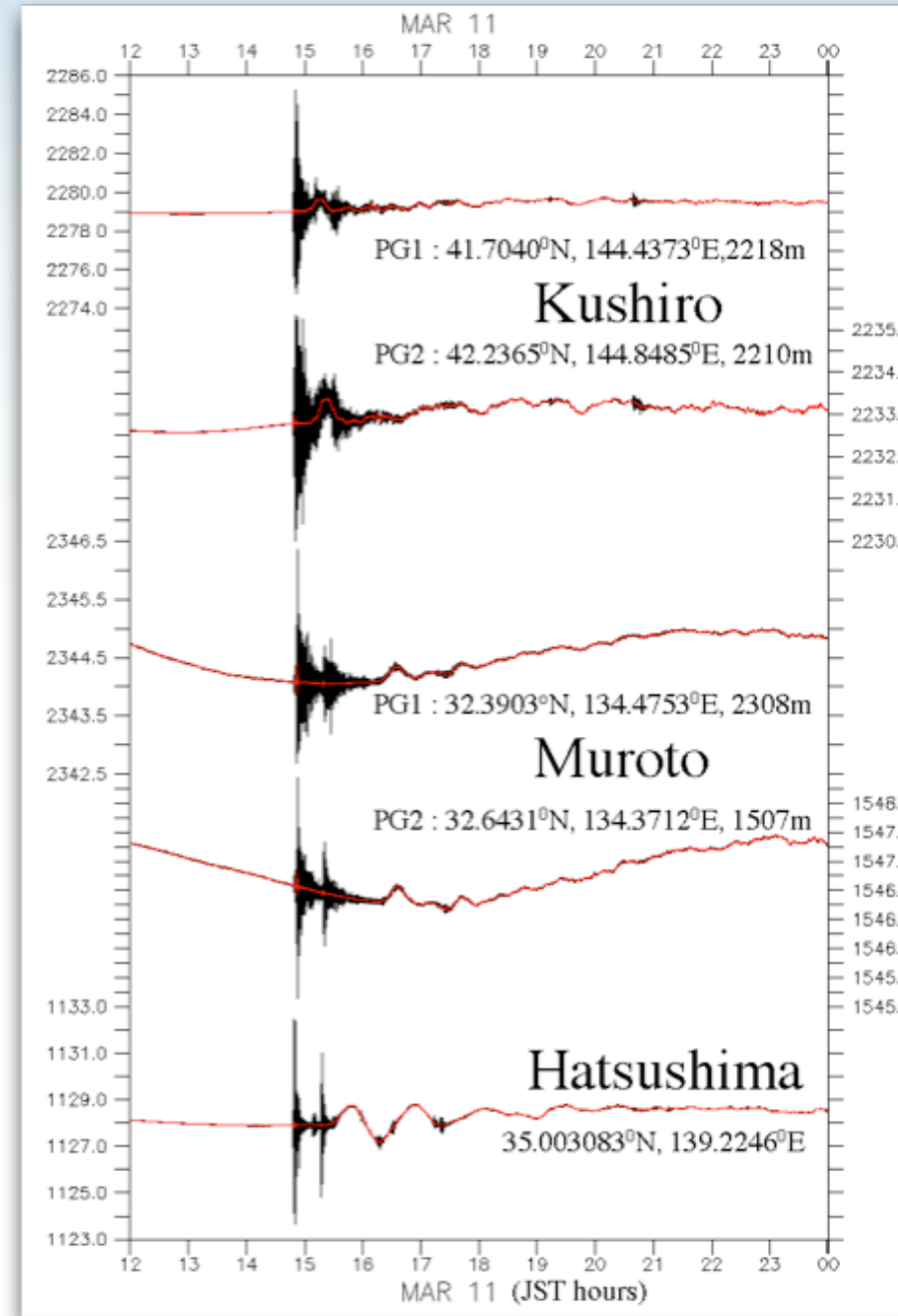
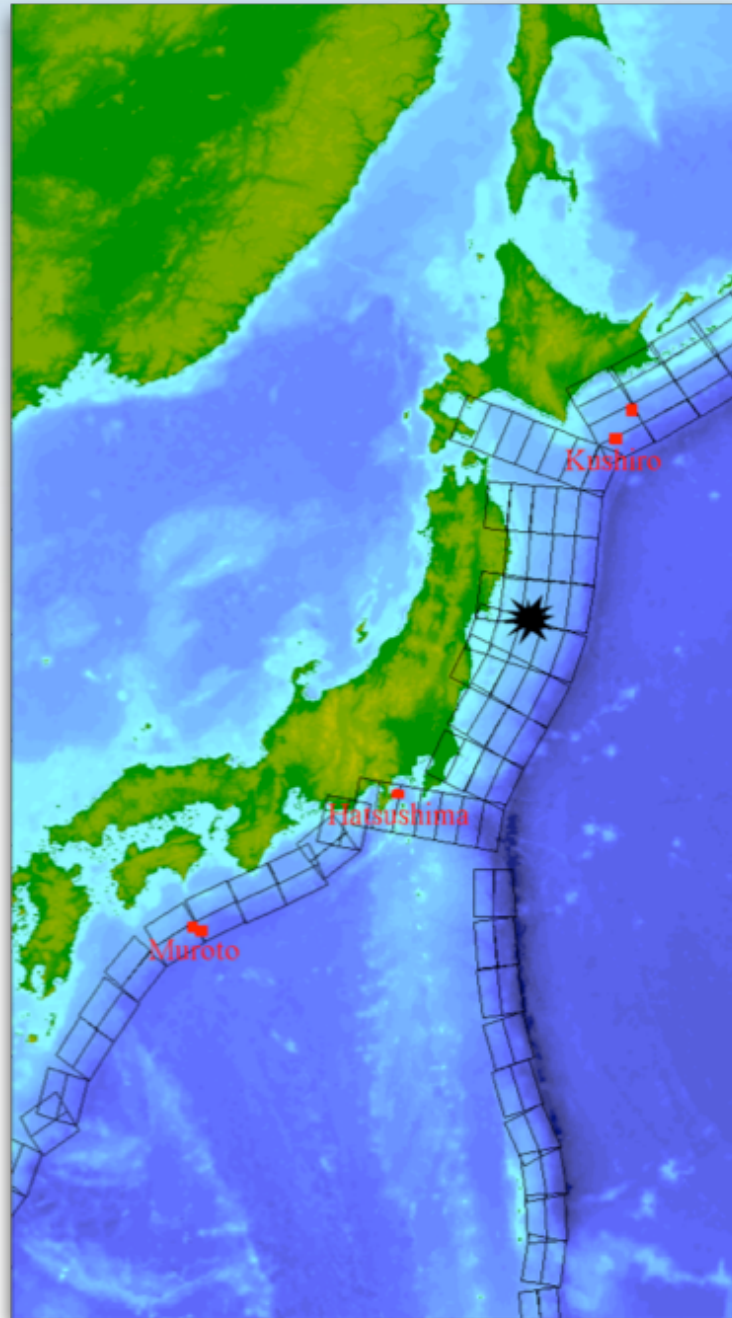
Japan bought US made tsunami detections system

3 new DARTs near Japan coast

15 minutes detection time

Improved forecast

Future Challenges: Faster Tsunami Detection



Design new detection system to extract tsunami data out of earthquake shaking



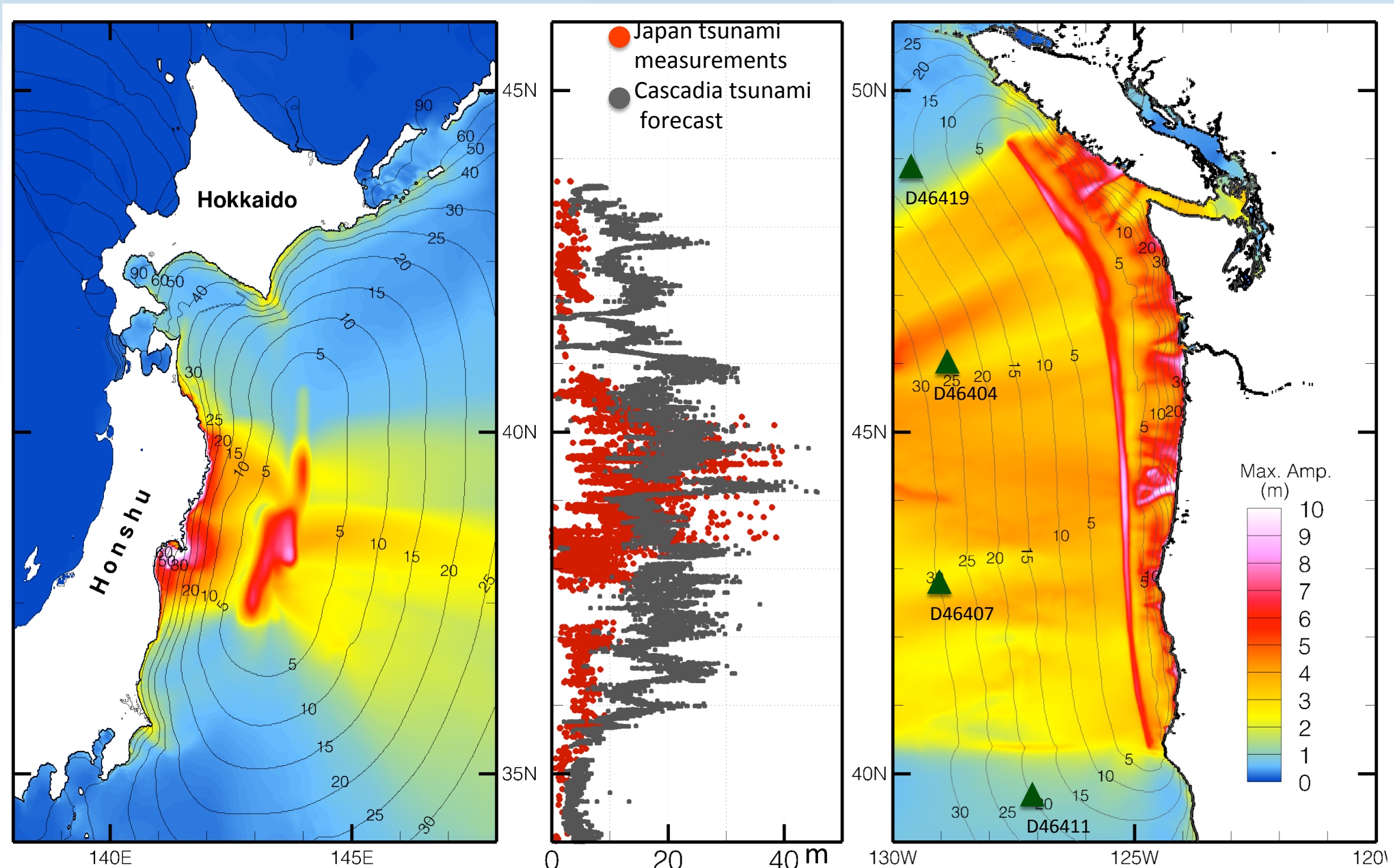


Relevance to U.S. and NOAA

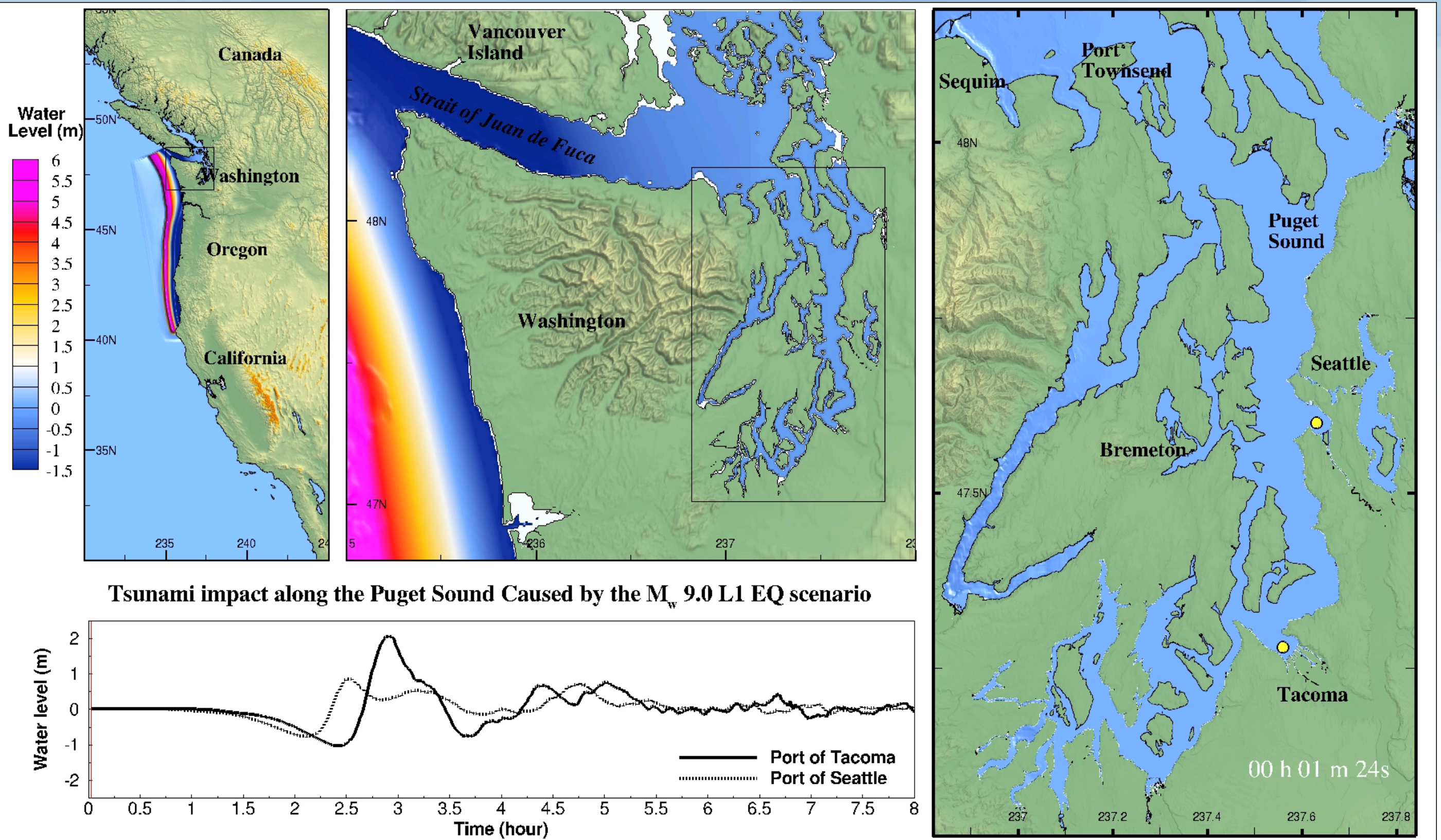
Japan: M9.0 03/11/2011
Exposed population: 300,000
Killed: 20,000

20-60 minutes
before tsunami
impact

Cascadia: M9.1
Exposed population: 200,000
Killed: ?

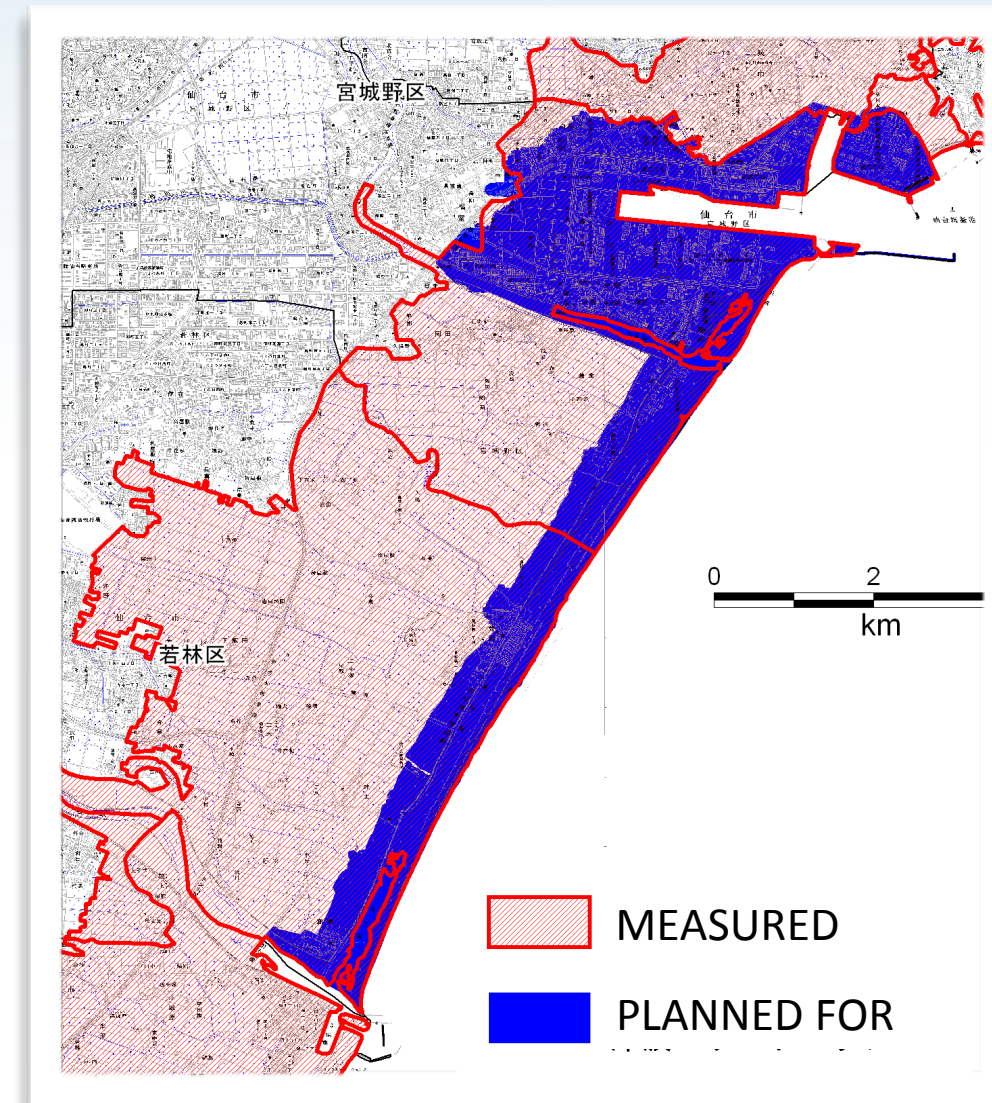
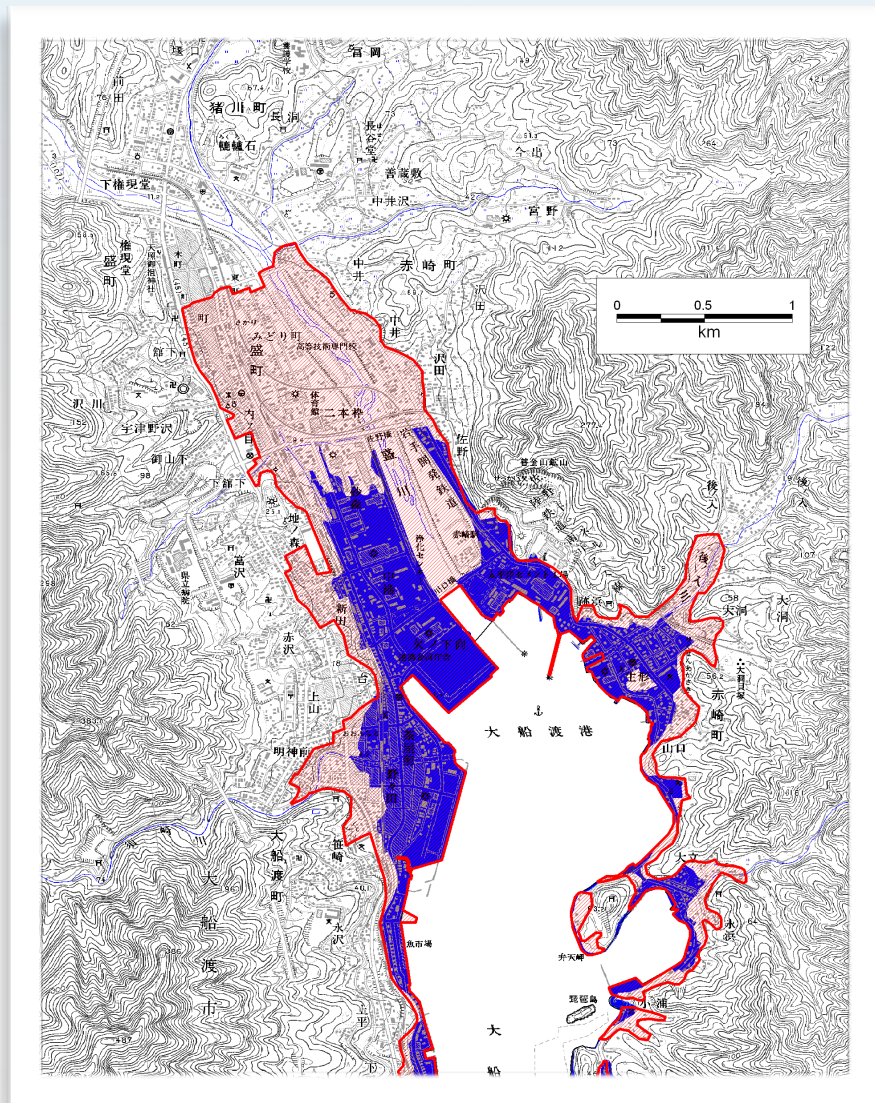


Relevance to U.S. and NOAA



Tsunami Forecast Quality

Past:



Tsunami Forecast Quality

Future: Research-proven solutions

Research to fill gaps in Tsunami Forecast:

- Fast near-field tsunami detection
- Near-field tsunami forecast
- Easy-to-understand graphical products
- Non-seismic tsunamis
- Inclusion of other flooding hazards into forecast

