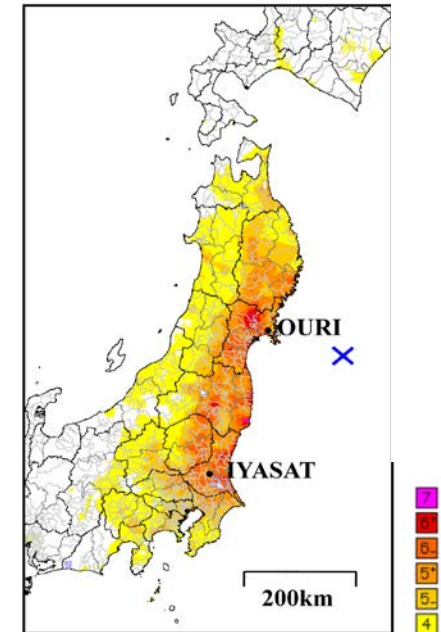
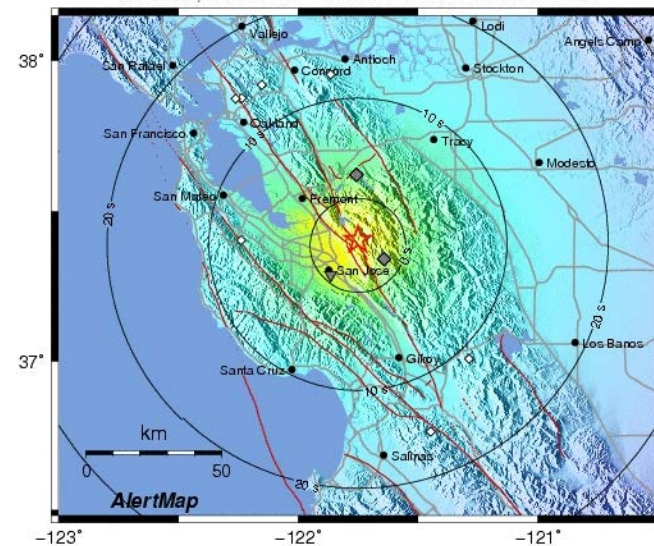


# Earthquake Early Warning and Cascadia

**Ingrid Johanson**  
Berkeley Seismological Lab

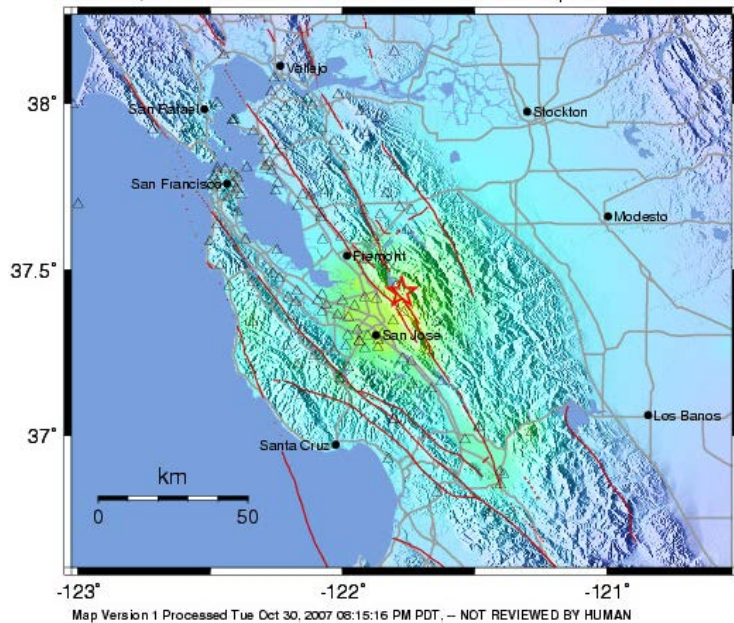


ElarmS Real-Time Hazard Map: Modified Mercalli Intensity  
2007/10/31, 03:05:00 UTC — Event detected: N37.40 W121.75 M 5.2

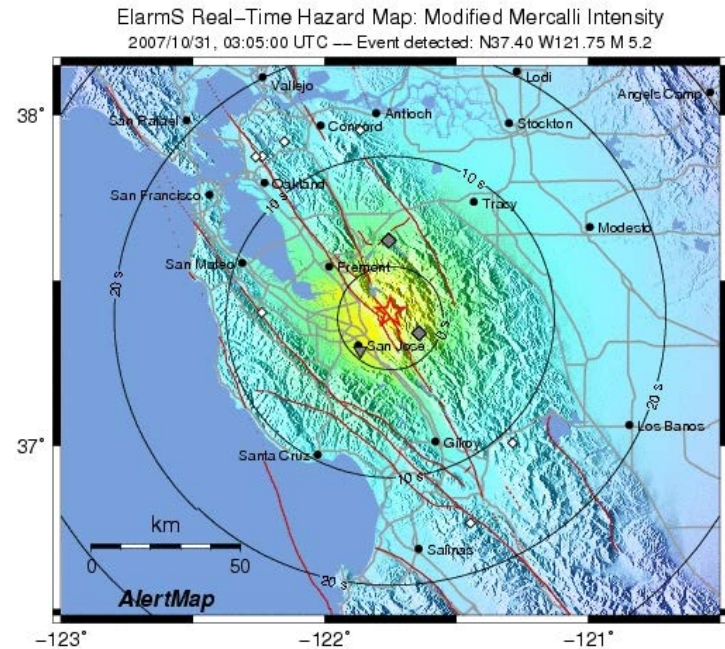


# What is Earthquake Early Warning?

Detect an earthquake very quickly and issue a warning before the strongest shaking starts



**Today: shakeMap**  
in 8-10 minutes



**Soon: AlertMap**  
seconds to tens of seconds  
before shaking

# Types of application

Using seconds to tens of seconds warning for...



## 1. Personal safety

- moving to a safe zone



## 2. Automated control

- slowing/stopping/isolating sensitive systems

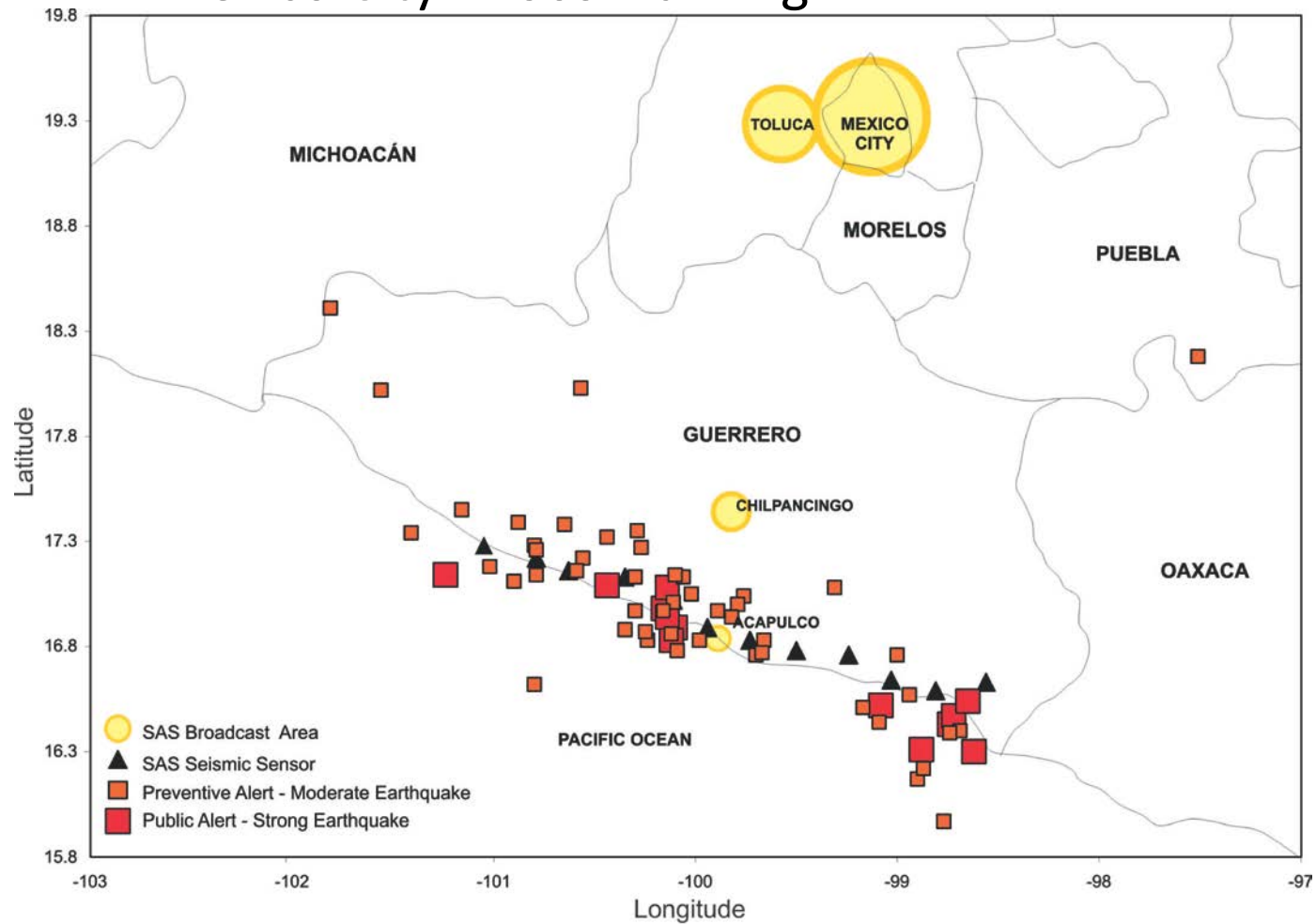


## 3. Situation awareness

- initiating response before shaking

# First EEW systems

In Mexico City - ~60s warning

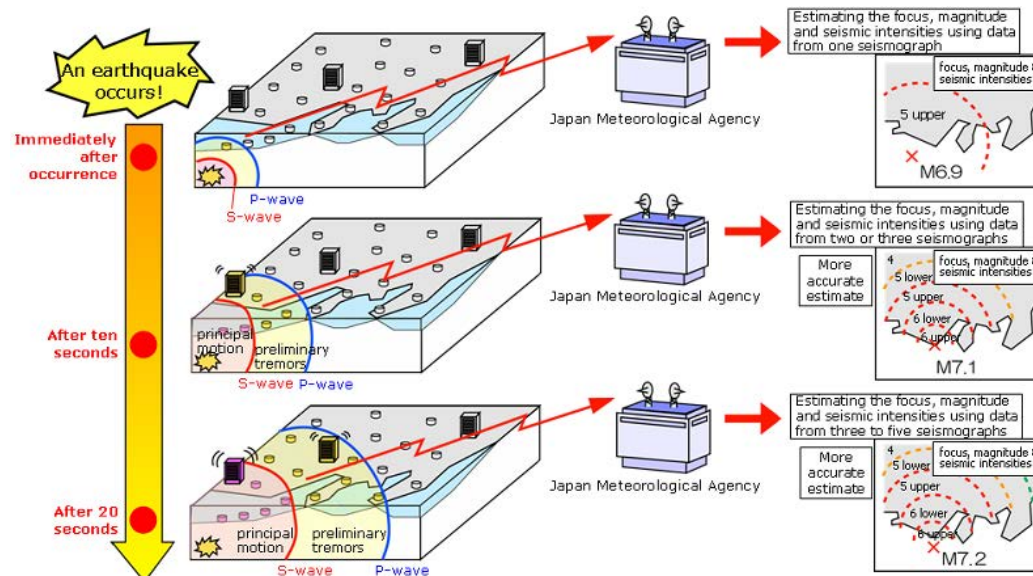
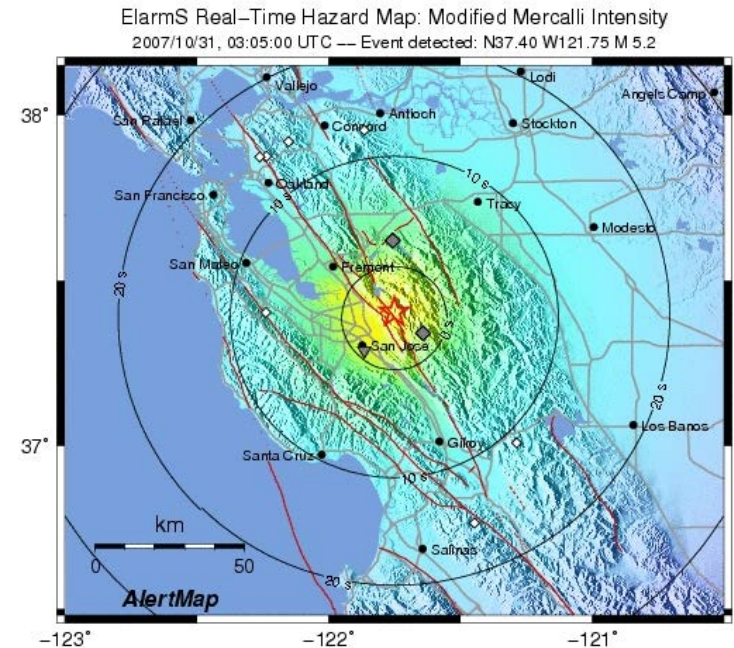


*Espinosa-Aranda et al., 2009*



# P-wave based methods

- Japan
- Taiwan
- USA
  - Elarms
  - VirtualSeismologist



Courtesy: JMA

# Saturation at Large Magnitudes

## 2011 Tohoku-oki Earthquake

March, 11, 2011

14:46:48.8 (JST)

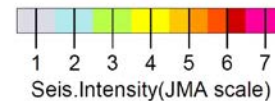
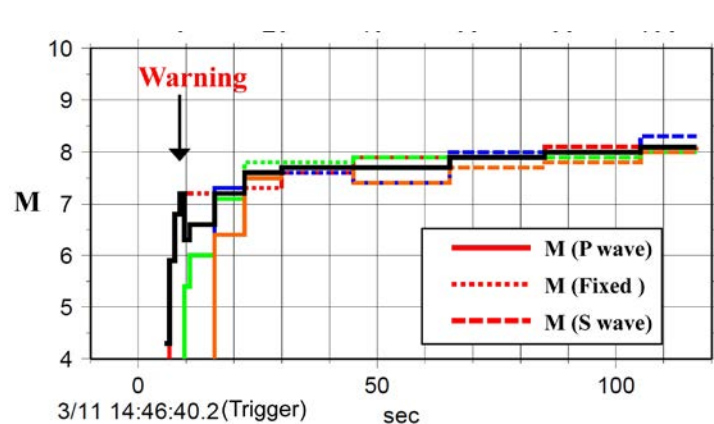
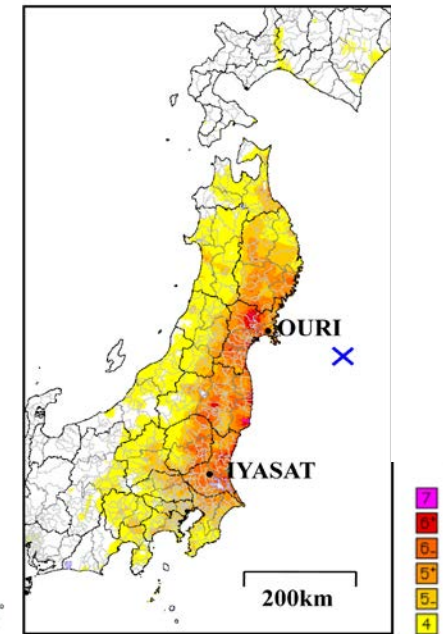
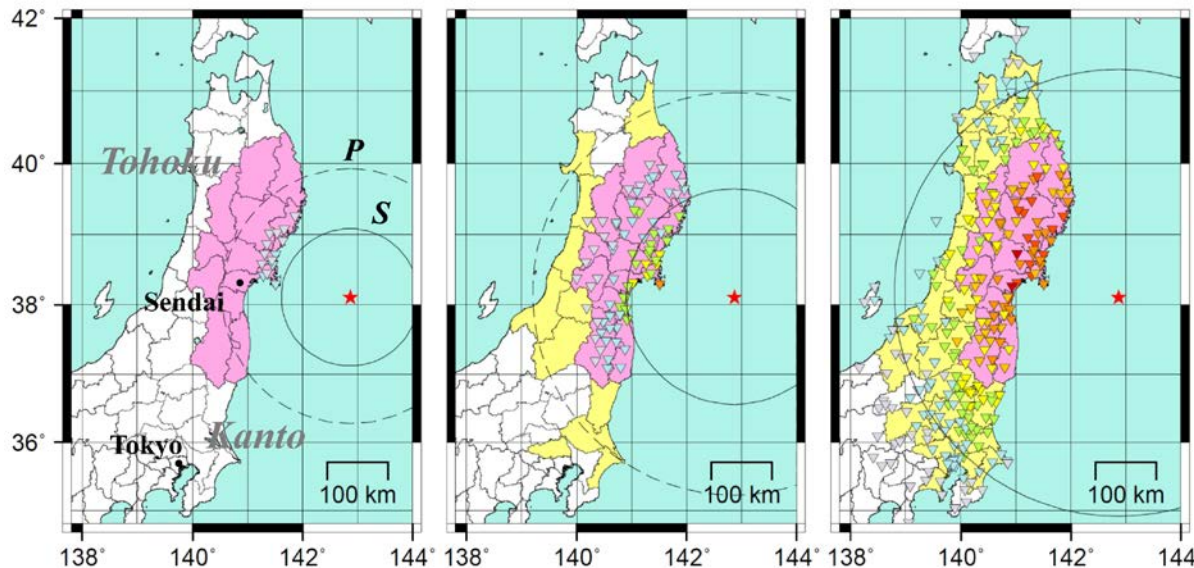
(at the time of “warning”)

14:47:04.0

(“warning” + 15s)

14:47:46.0

(“warning” + 57s)

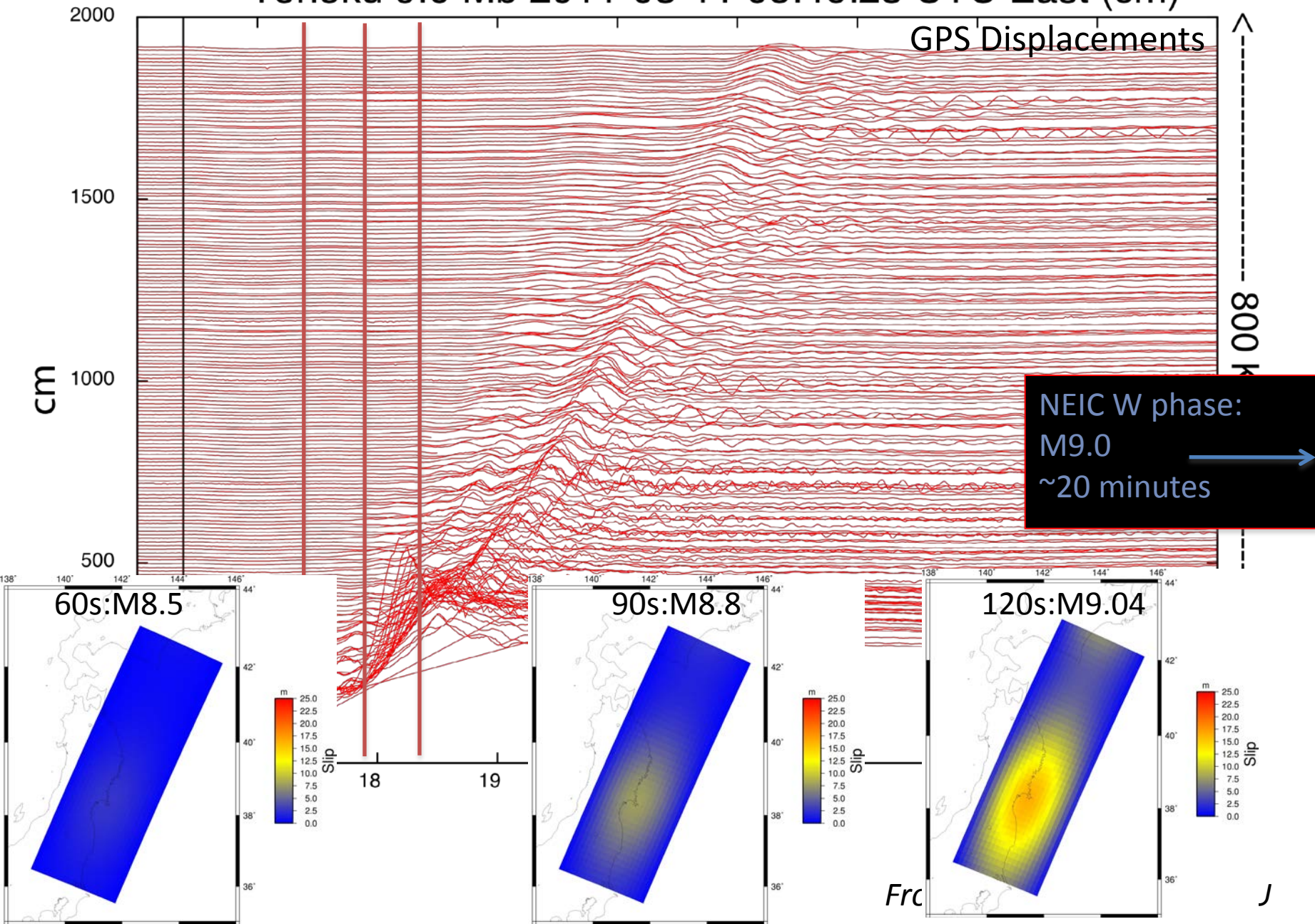


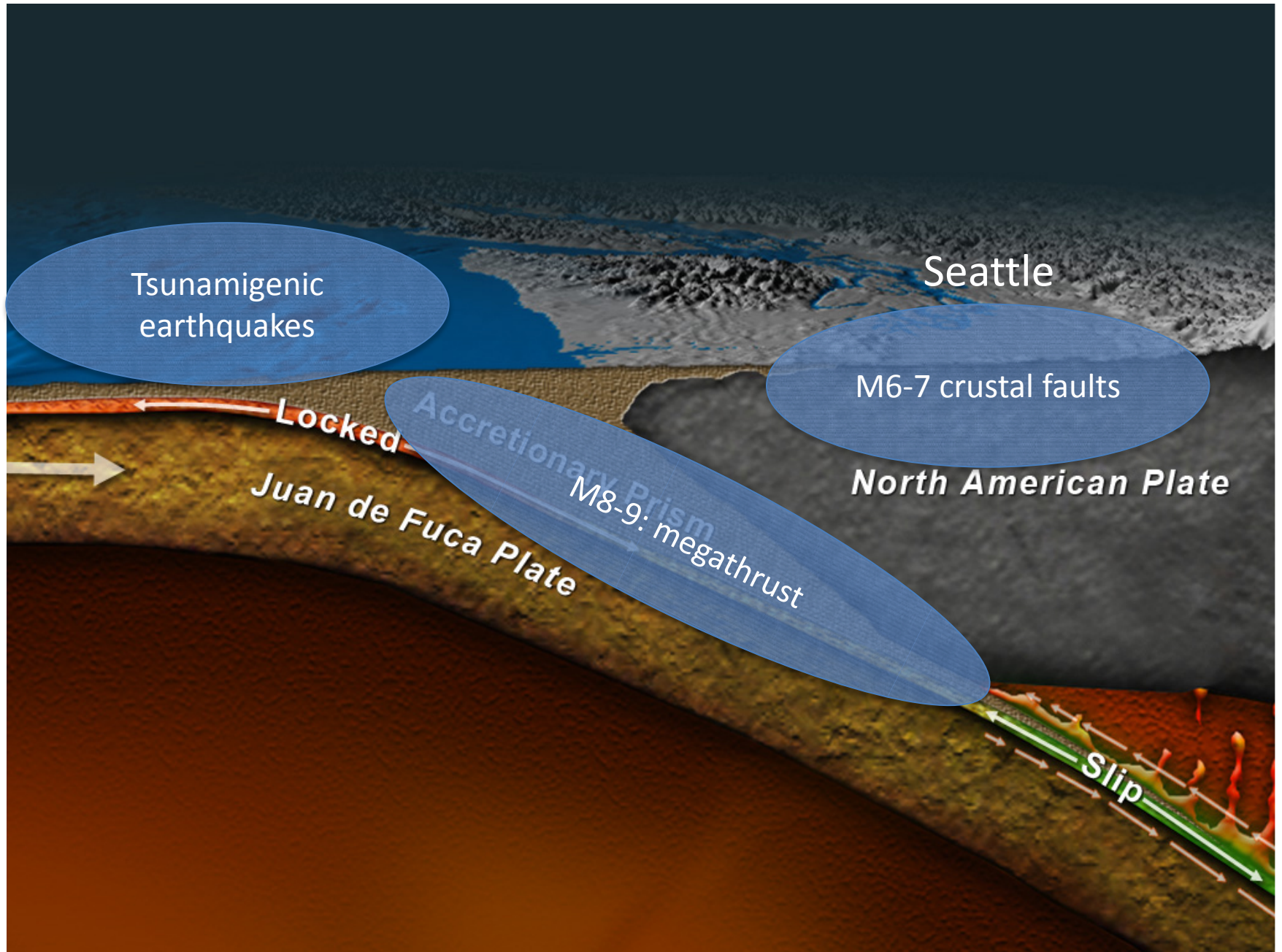
Magnitude  
estimates  
saturated at  
~M8

*Hoshiba et al., 2011*



# Tohoku 9.0 Mb 2011-03-11 05:46:23 UTC East (cm)





From: Tim Melbourne, CWU



# Real-time GPS in Cascadia

## 230+ PBO GPS sites

- High sample rate (1 Hz)
- Realtime to UNAVCO
- Raw realtime data available

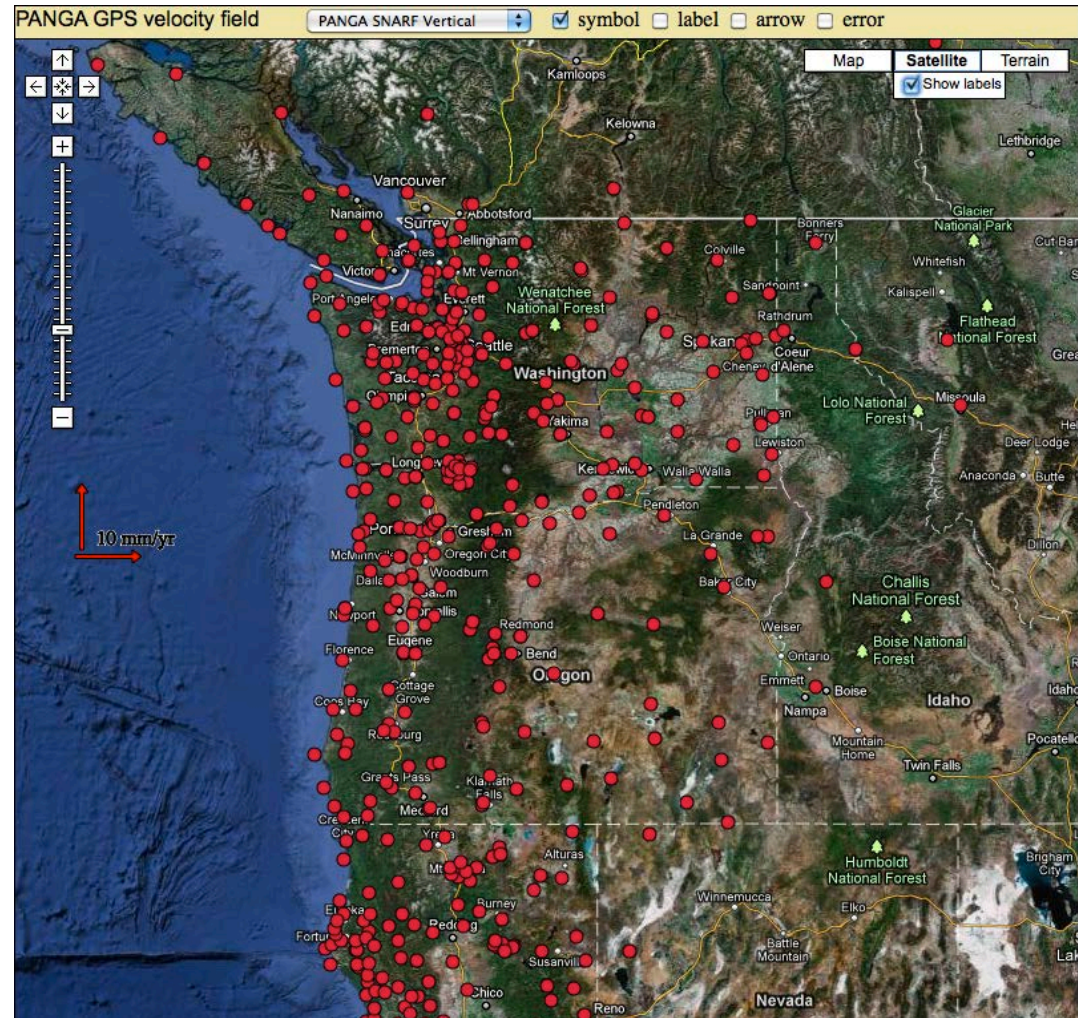
## 220+ PANGA

- Includes WSRN and OGRN stations
- Displacement timeseries available from

*CWU (Tim Melbourne)*

And viewable on

[www.geodesy.cwu.edu](http://www.geodesy.cwu.edu)



*From: Tim Melbourne, CWU*

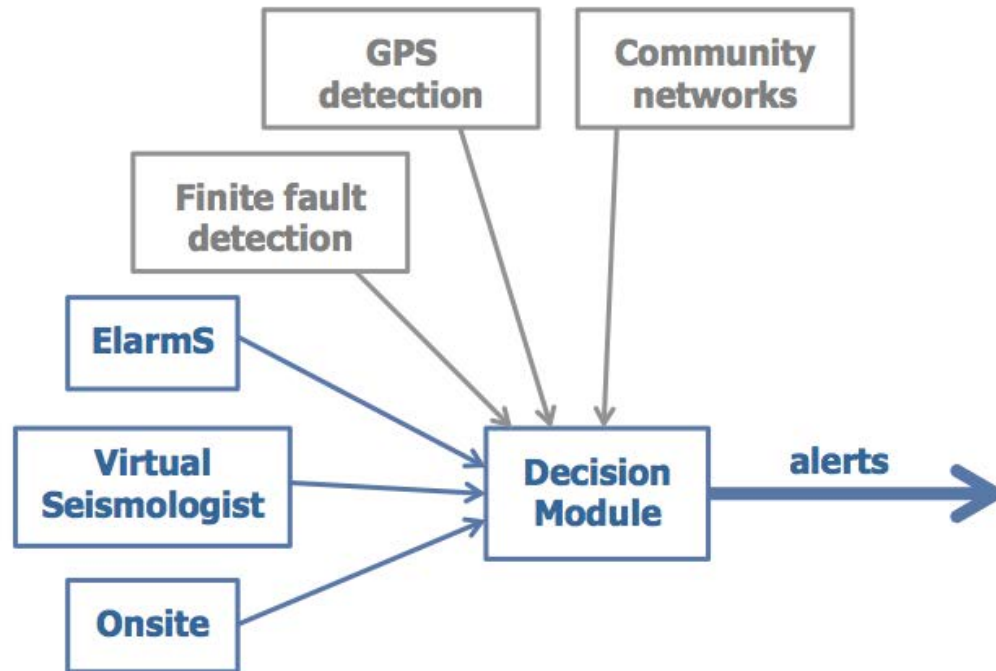
# Shake/Alert

Progress toward California's

Aug 2006 – Aug 2009: USGS funds...

## Phase I: Development and testing of realtime algorithms

Parallel statewide testing of multiple methodologies



# Shake/Alert

Progress toward California's

Aug 2006 – Aug 2009: USGS funds...

## **Phase I: Development and testing of realtime algorithms**

Parallel statewide testing of multiple methodologies

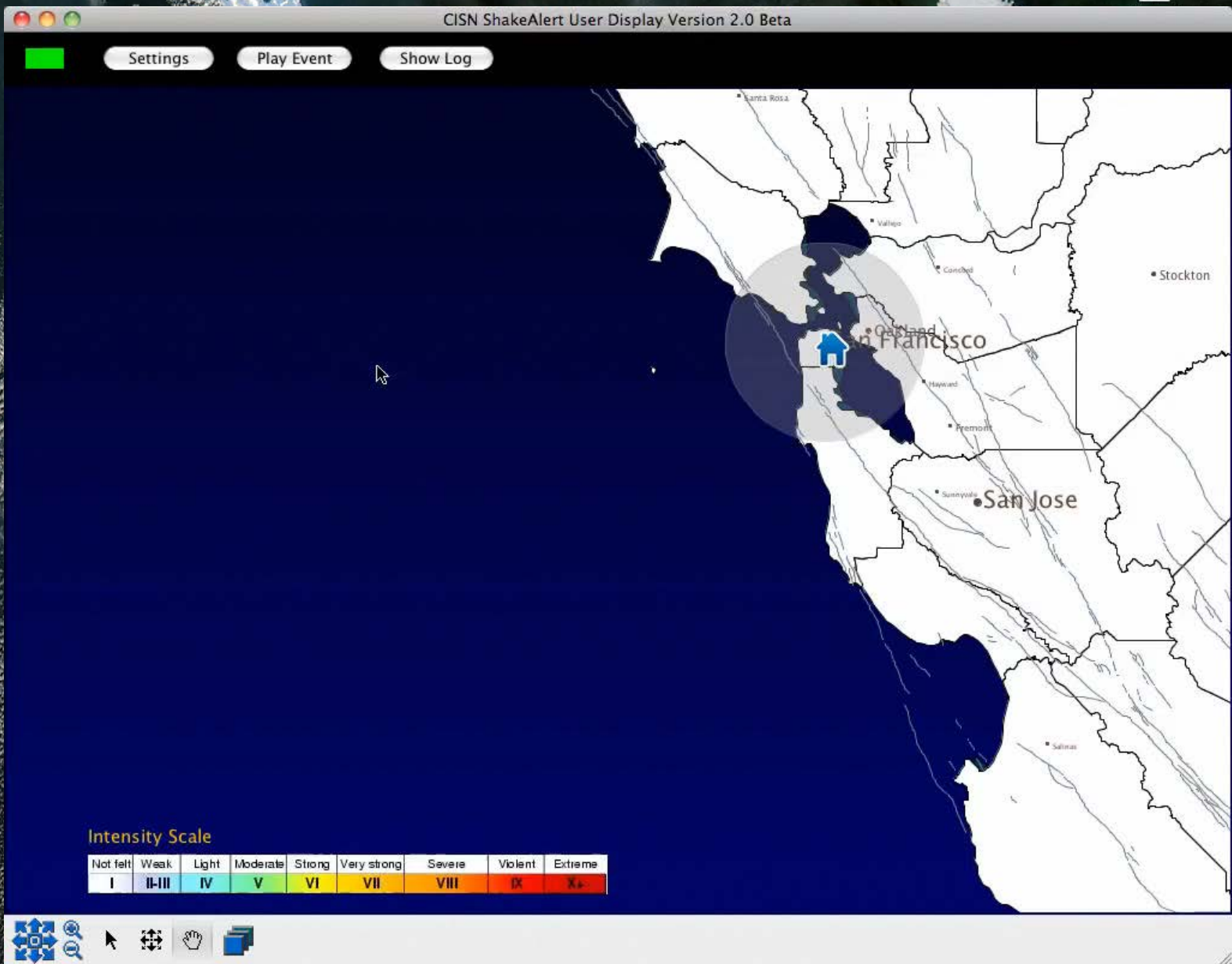
Aug 2009 – Aug 2012: USGS funds...

## **Phase II: Implementation of an end-to-end test system**

A single CISON early warning output to a group of test users

Upgrade of station hardware for faster delivery





# Shake/Alert

Progress toward ~~California's~~  
West Coast

Aug 2006 – Aug 2009: USGS funds...

## Phase I: Development and testing of realtime algorithms

Parallel statewide testing of multiple methodologies

Aug 2009 – Aug 2012: USGS funds...

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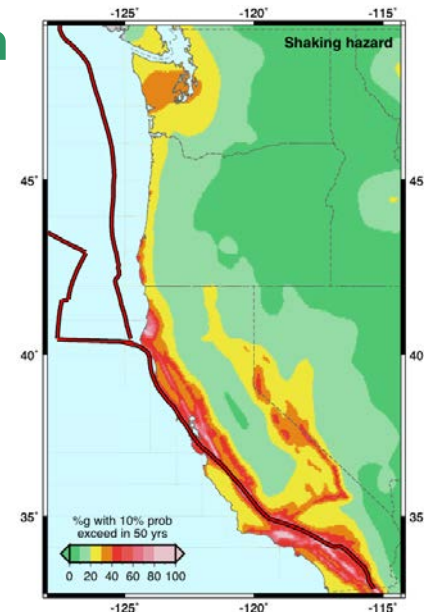
Jan 2012 – Dec 2014: Moore Foundation funds...

## Phase III: West coast prototype warning system

Extend testing region to the entire west coast

Develop robust methodologies for large earthquakes

Deliver warnings to public-private partners



## Future Directions

- Extend the testing region into Cascadia
- Integrate seismic data with real-time GPS
  - Data ingestion and handling
- Study large earthquake rupture and develop warning algorithms for them
- Deliver alerts to a test group of public/private partners for evaluation