

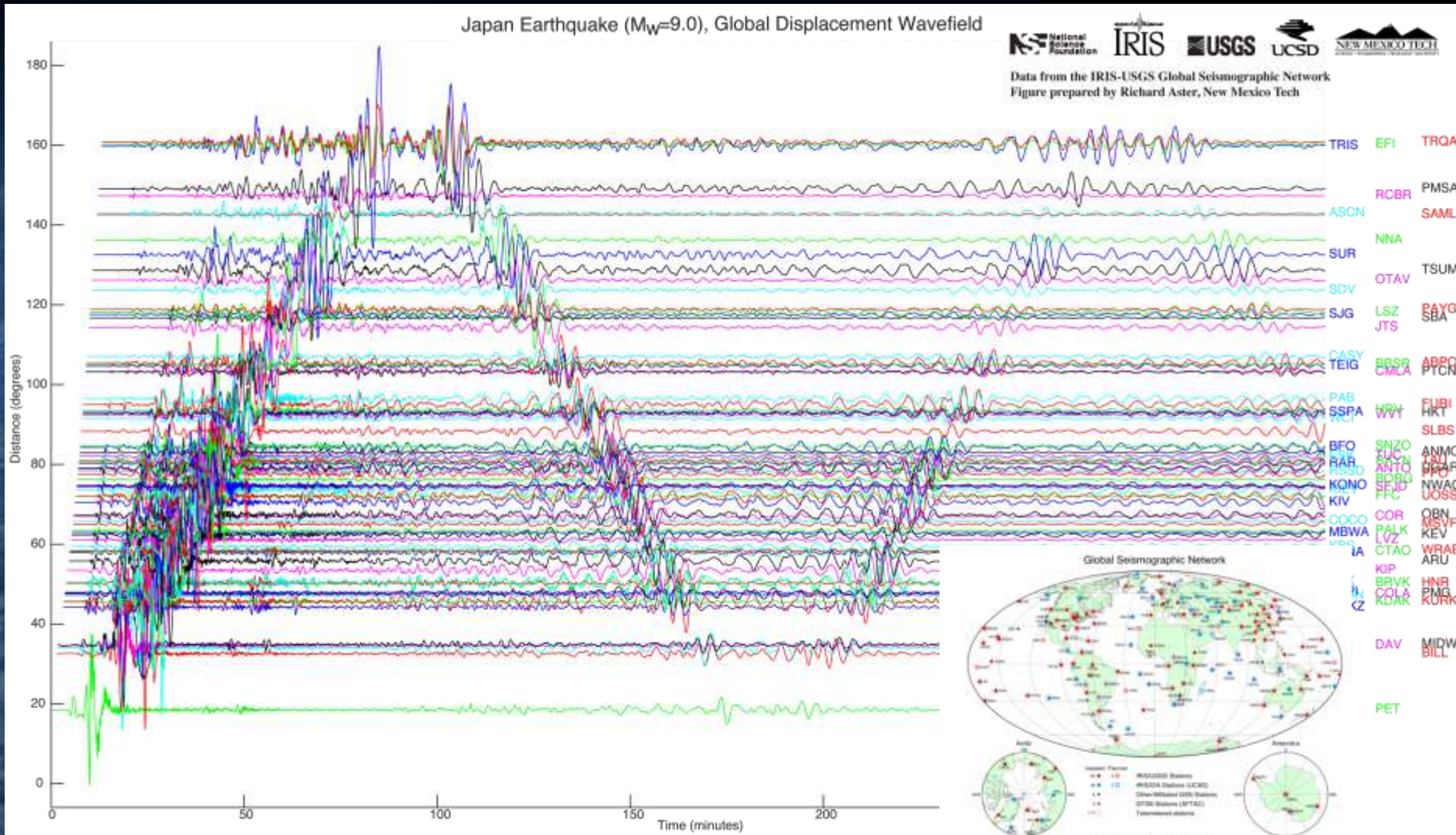
# Update on the Great Tohoku Earthquake

David Applegate

U.S. Geological Survey

April 7, 2011

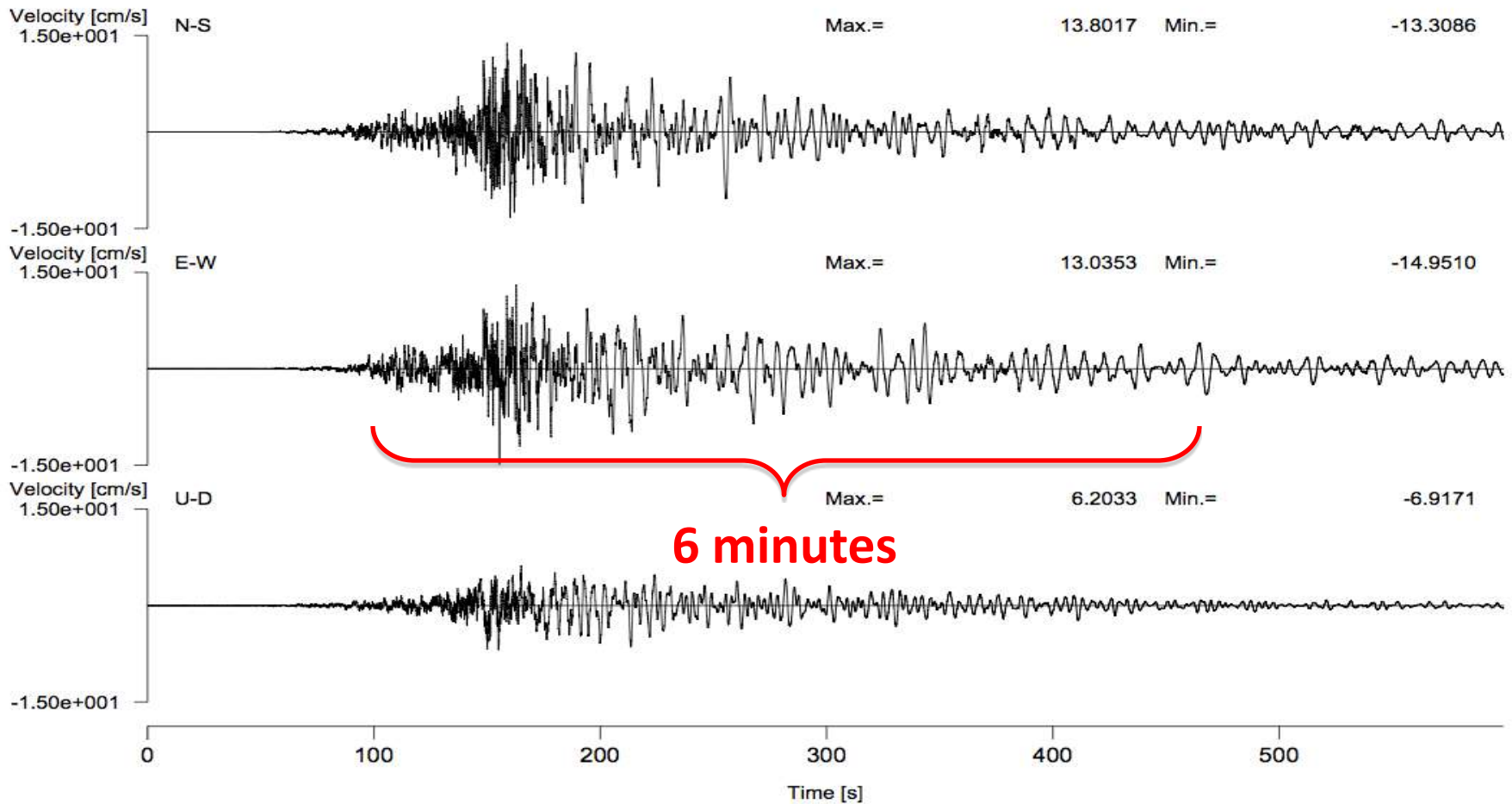
# Giant earthquakes ring the Earth like a bell



# Shaking duration in Tokyo

ERI-1555\_1\_20110311144726

ERI-1555\_1\_ 2011/03/11 14:46:56 Seismic Intensity : 4.82



# Japanese early warning systems

Issued at 14:49 JST, 11 March 2011



Automatic earthquake warning triggered by computer



Japan  
Meteorological  
Agency initial  
tsunami warning

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Tsunami Warning		Tsunami Advisory	
<b>Notes</b>	<b>Major Tsunami</b>	<b>Tsunami</b>	<b>Epicenter</b>
	Tsunami height is estimated to be 3 meters or more	Tsunami height is estimated to be up to 2 meters	Tsunami height is estimated to be about 0.5 meter

# Red Alert PAGER for the Tohoku earthquake issued in 42 minutes



science for a changing world

Earthquake Shaking **Red Alert**



## M 8.9, NEAR THE EAST COAST OF HONSHU, JAPAN

Origin Time: Fri 2011-03-11 05:46:23 UTC (14:46:23 local)

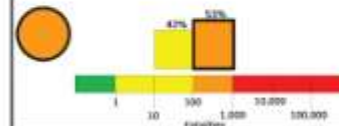
Location: 38.32°N 142.37°E Depth: 24 km

FOR TSUNAMI INFORMATION, SEE: [tsunami.noaa.gov](http://tsunami.noaa.gov)

Created: 2 hours, 6 minutes after earthquake

PAGER Version 4

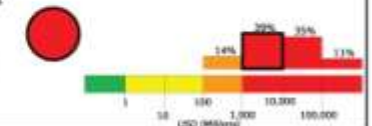
### Estimated Fatalities



Red alert level for economic losses. Extensive damage is probable and the disaster is likely widespread. Estimated economic losses are less than 1% of GDP of Japan. Past events with this alert level have required a national or international level response.

Orange alert level for shaking-related fatalities. Significant casualties are likely.

### Estimated Economic Losses

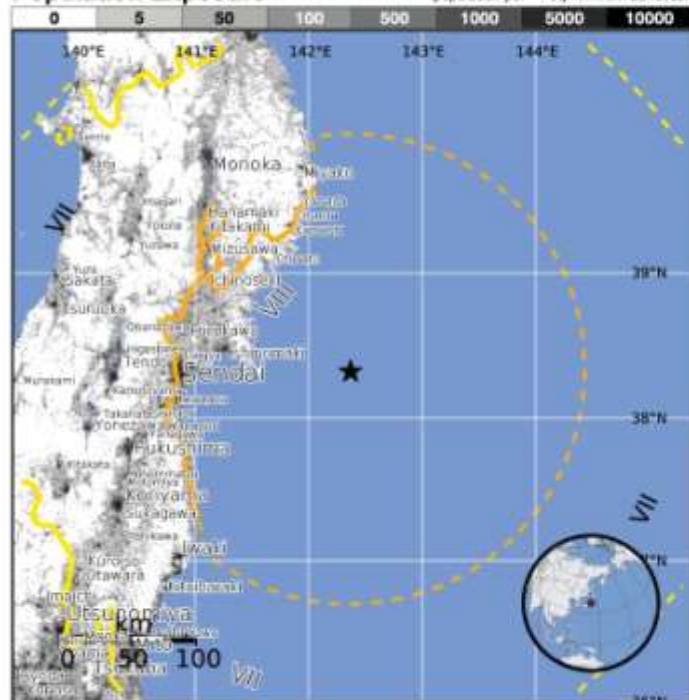


### Estimated Population Exposed to Earthquake Shaking

ESTIMATED POPULATION EXPOSURE (k = x1000)	--*	--*	--*	--*	2,472k*	7,986k*	2,598k	0	0	
ESTIMATED MODIFIED MERCALLI INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+	
PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very Strong	Severe	Violent	Extreme	
POTENTIAL DAMAGE	Resistant Structures	none	none	none	V. Light	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy
	Vulnerable Structures	none	none	none	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy	V. Heavy

\*Estimated exposure only includes population within the map area.

### Population Exposure



### Structures:

Overall, the population in this region resides in structures that are resistant to earthquake shaking, though some vulnerable structures exist. The predominant vulnerable building types are non-ductile reinforced concrete frame and heavy wood frame construction.

### Historical Earthquakes (with MMI levels):

Date (UTC)	Dist. (km)	Mag.	Max MMI(#)	Shaking Deaths
1998-06-14	363	5.7	VII(426k)	0
1994-12-28	263	7.7	VII(132k)	3
1983-05-26	369	7.7	VII(174k)	104

Recent earthquakes in this area have caused secondary hazards such as tsunamis, landslides, and fires that might have contributed to losses.

### Selected City Exposure

from GeoNames.org

MMI City	Population
VIII Ishinomaki	117k
VIII Shiogama	60k
VIII Yamoto	32k
VIII Kogota	20k
VIII Rifu	35k
VIII Furukawa	76k
VIII Yamagata	255k
VII Morioka	295k
VII Sendai	1,038k
VII Fukushima	294k
VII Utsunomiya	450k

bold cities appear on map (k = x1000)

Event ID: usc0001xgp

PAGER content is automatically generated, and only considers losses due to structural damage. Limitations of input data, shaking estimates, and loss models may add uncertainty. <http://earthquake.usgs.gov/pager>



# GoogleEarth feed from USGS showing fault rupture plane (blue rectangle), modeled shaking intensity and aftershocks

**USGS ShakeMap**

Instrumental Intensity	I	II-III	IV	V	VI	VII
Potential Shaking	Not felt	Weak	Light	Moderate	Strong	Very Strong
Potential Damage	None	None	None	Very Light	Light	Moderate

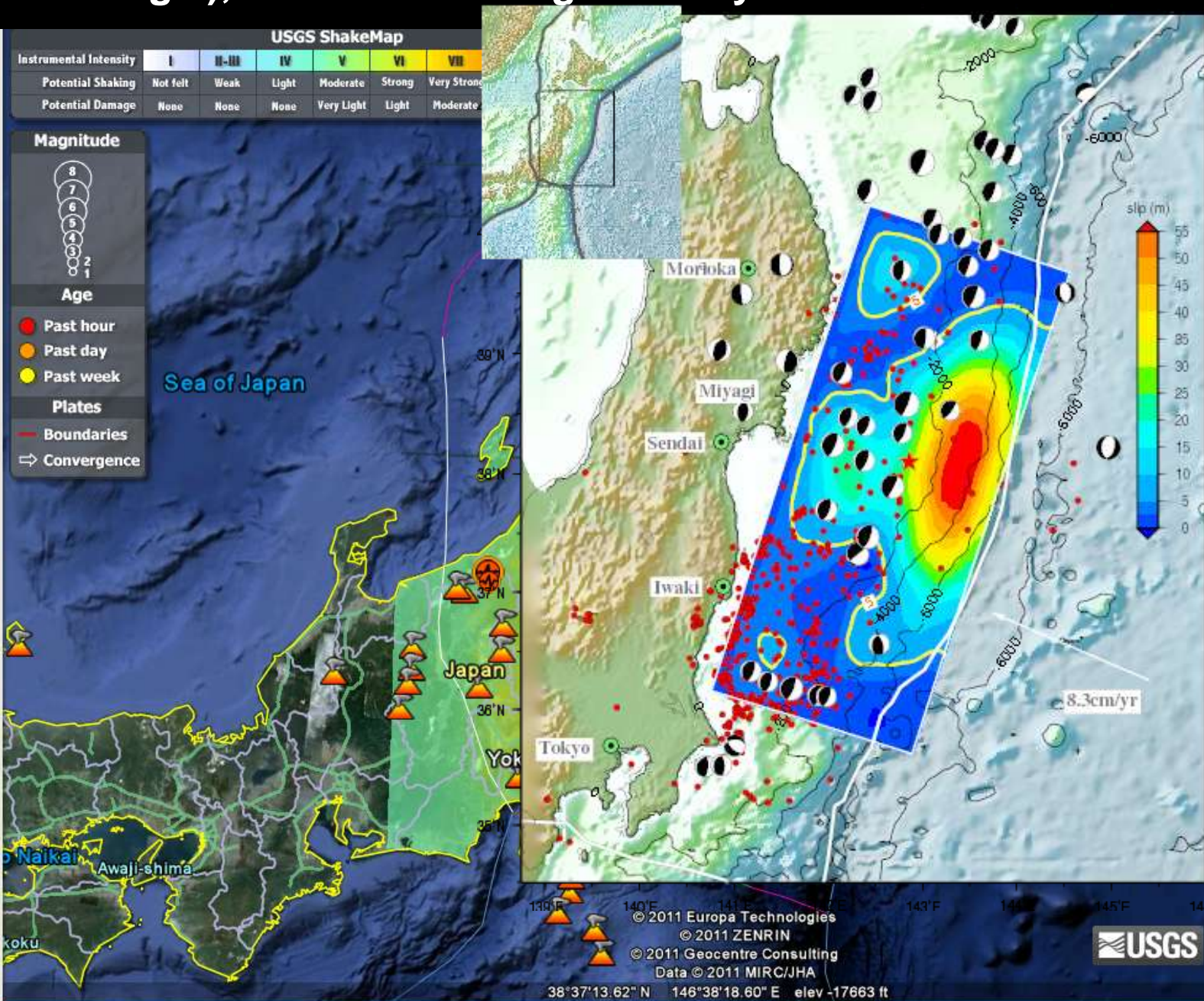
**Magnitude**

**Age**

- Past hour (Red dot)
- Past day (Orange dot)
- Past week (Yellow dot)

**Plates**

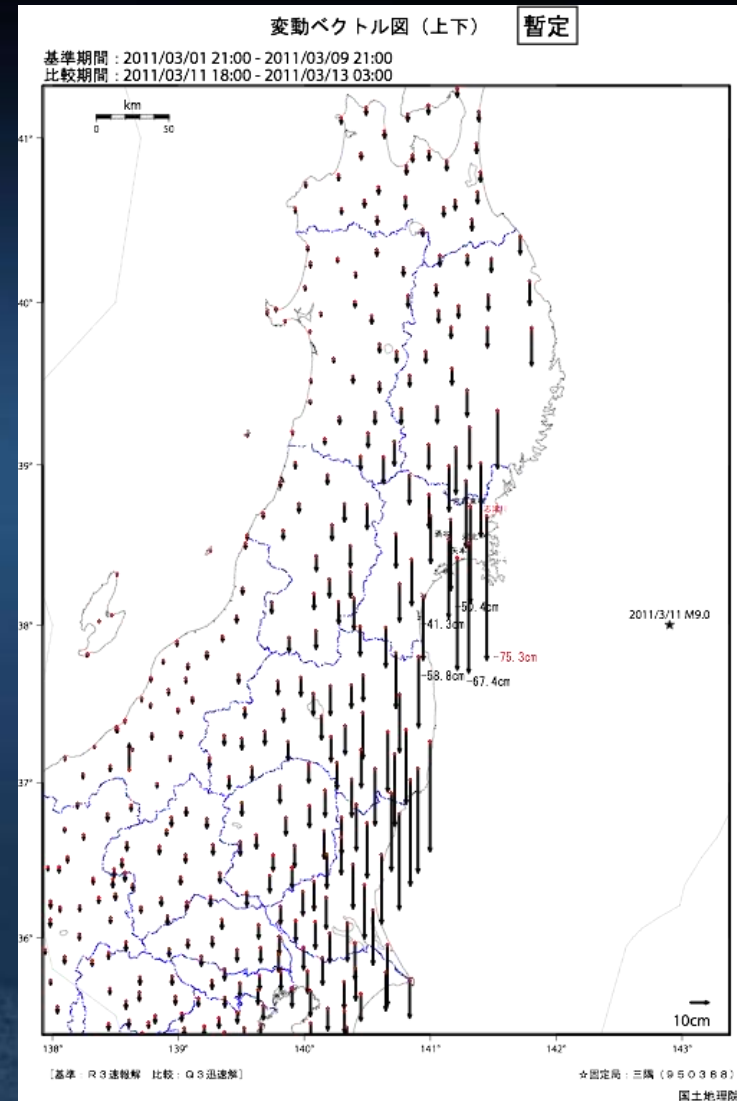
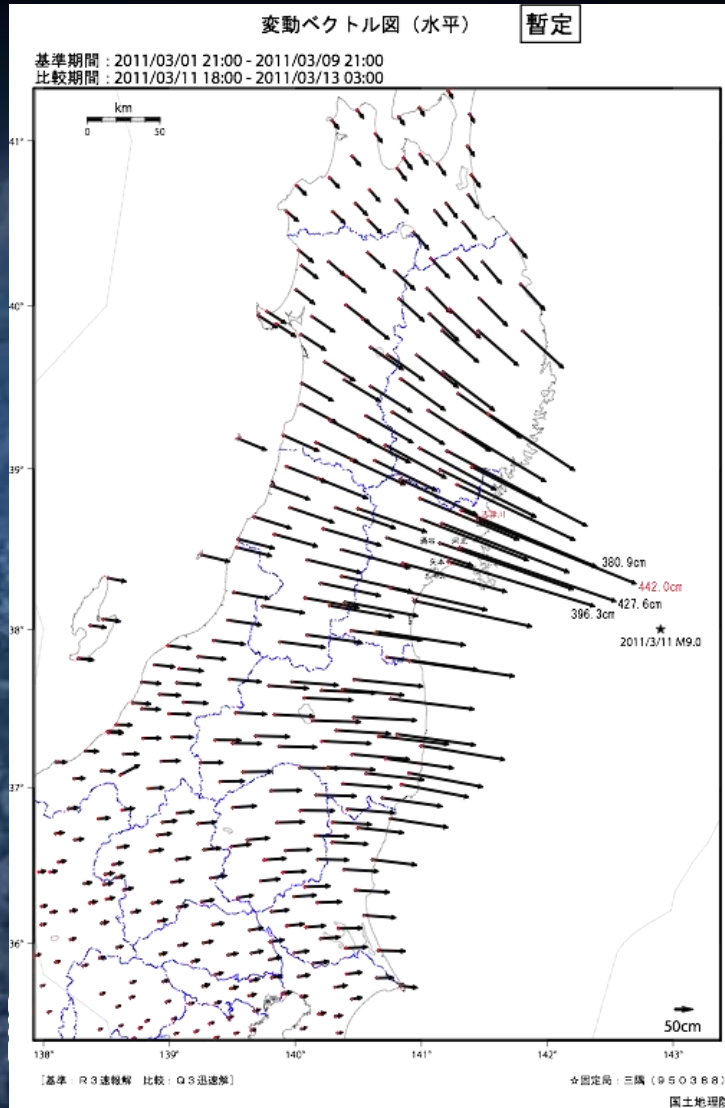
- Boundaries (Red line)
- Convergence (Arrow icon)



This block contains the Google Earth interface elements. At the top right is a compass. Below it is a scale bar. At the bottom right, there is copyright information for Europa Technologies, ZENRIN, Geocentre Consulting, and MIRC/JHA. The USGS logo is also present. The Google logo is at the bottom right, along with the text "Eye alt 725.91 mi".

© 2011 Europa Technologies  
 © 2011 ZENRIN  
 © 2011 Geocentre Consulting  
 Data © 2011 MIRC/JHA  
 38°37'13.62" N 146°38'18.60" E elev -17663 ft

# GPS Displacements from Geospatial Information Authority of Japan



# All aftershocks of Tohoku earthquake



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EARTHQUAKES

HAZARDS

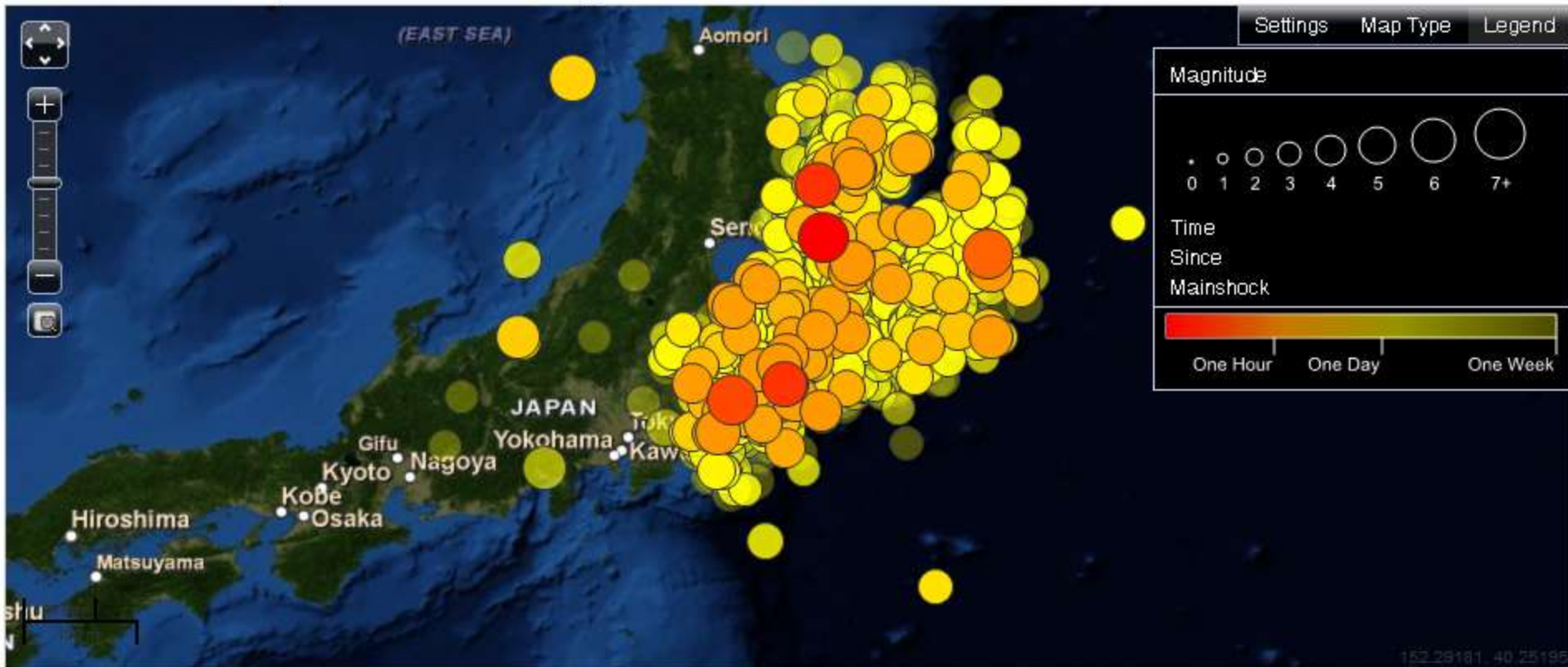
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## Aftershock Map Tohoku Earthquake





# Magnitude-6+ aftershocks



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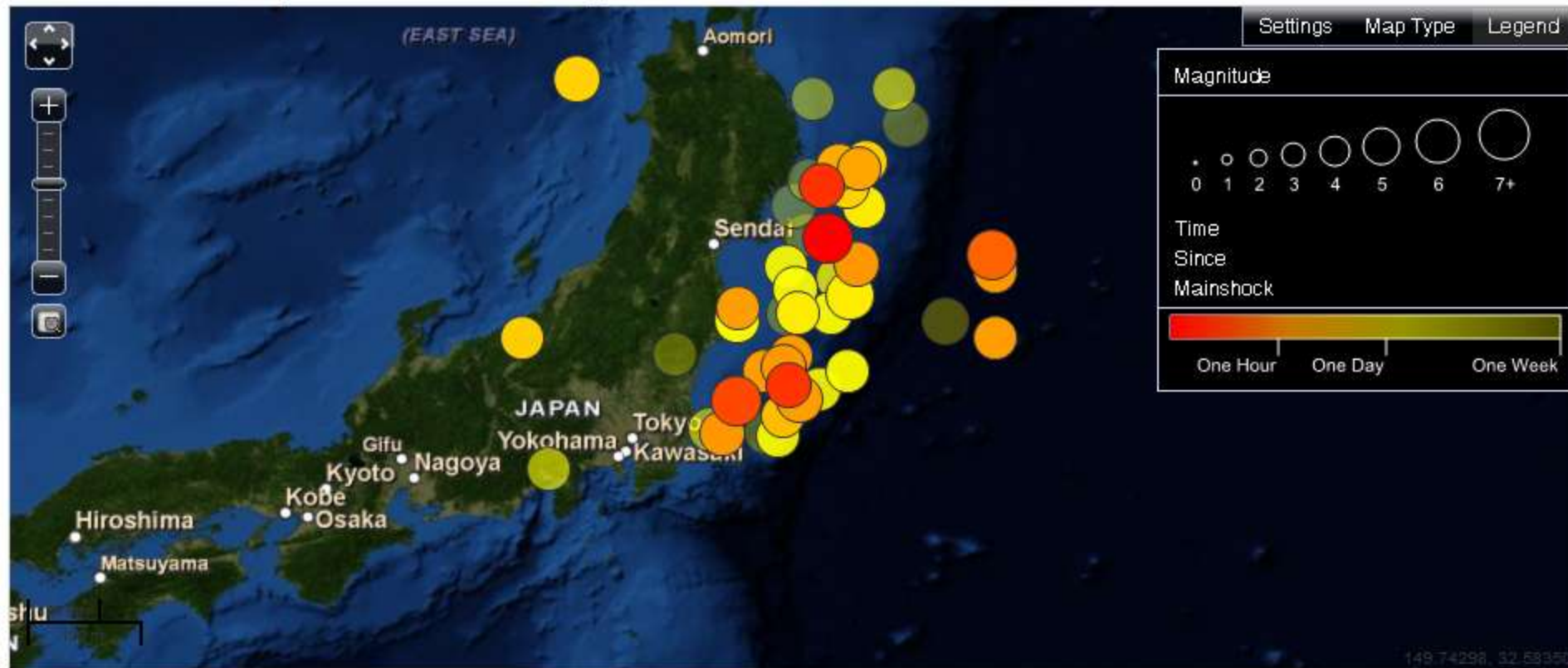
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## Aftershock Map Tohoku Earthquake



149.74298, 32.59350

Showing 46 earthquakes

# International Charter for disaster response

Volunteers from USGS, GISCorps, ImageCat, Rochester Institute of Technology, Penn State, Harvard, George Mason, and the USAID Office of Foreign Disaster Assistance responded to request from the Japan Aerospace Exploration Agency for imagery analysis.



<http://www.disasterscharter.org/>

Japan Tsunami Affected Areas: Onagawamachi, Miyagi Pref.



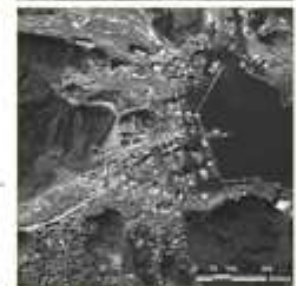
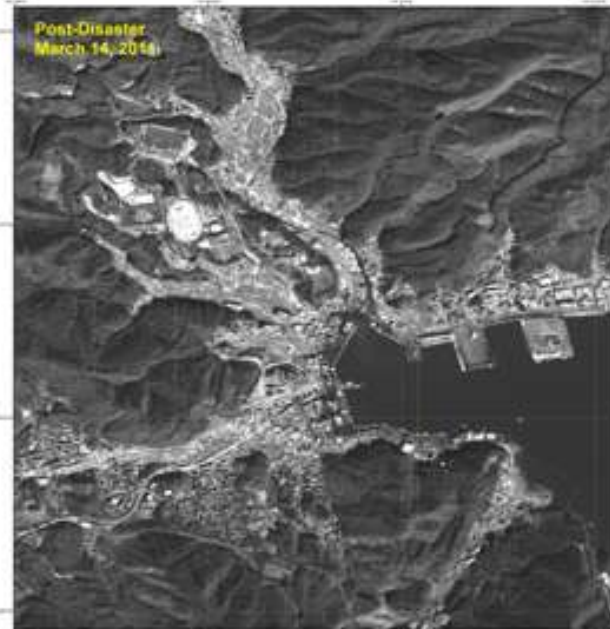
**Event Information**  
On March 11, 2011 a Tsunami destroyed several cities along the coast of Japan. These images show the city of Onagawamachi before and after the Tsunami.

**Data Sources**  
**Pre-Disaster:**  
Tsunami affected area extracted from WorldView-1, panchromatic imagery (30 cm at nadir). Acquisition date: March 11, 2011.

**Post-Disaster:**  
Tsunami affected area extracted from WorldView-1, panchromatic imagery (30 cm at nadir). Acquisition date: March 14, 2011.

Map Projection: Geographic, Datum: WGS 84.

Map produced on March 18, 2011  
by Clark Latta, Clark University  
[www.clarku.edu](http://www.clarku.edu)  
[clatlatta@clarku.edu](mailto:clatlatta@clarku.edu)



# Effect on Mines and Mineral Processing Facilities in Northern Honshu, Japan

- Up to one-quarter of the world's iodine and one-third of Japan's cement production may be affected.
- Effects may come from direct damage and the damage done to the surrounding infrastructure, including electricity and transportation.
- Japan is the world's second leading iodine producer, after Chile. The eight affected refineries alone have the capacity to produce 25 percent of the world's iodine. Iodine is used primarily in LCD's.
- In addition to iodine, Japan is a leading source of titanium metal, and its facilities in the affected area have the ability to produce 10 percent of the world's titanium metal.



# The mandate of the National Earthquake Hazard Reduction Program

- Develop effective measures for earthquake loss reduction;
- Promote their adoption;
- Improve the understanding of earthquakes and their effects on communities, buildings, structures, and lifelines.



FEMA

NIST

National Institute of  
Standards and Technology



USGS  
science for a changing world

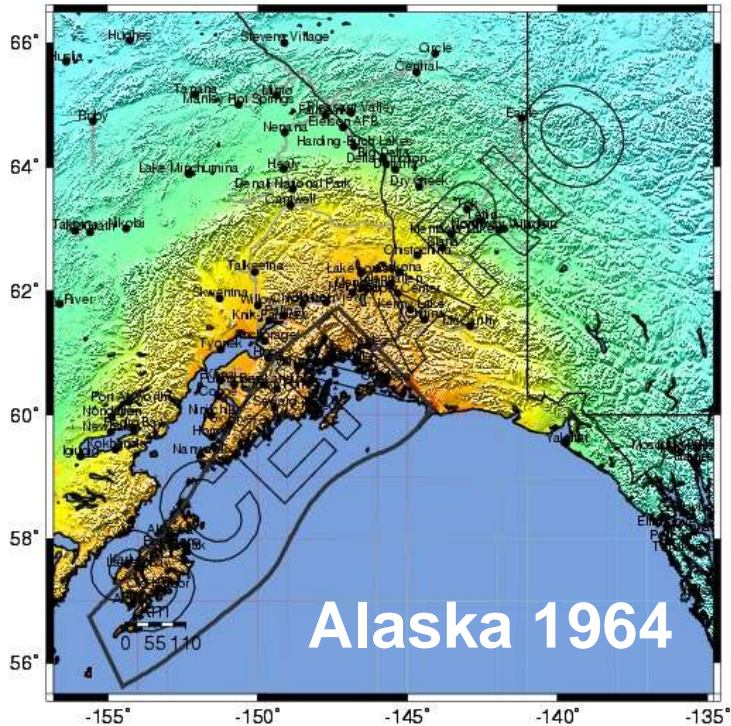
national **earthquake** hazards reduction program

# US subduction zones capable of magnitude-9 earthquakes

-- Earthquake Planning Scenario --

Rapid Instrumental Intensity Map for 1964 Scenario

Scenario Date: MAR 27 1964 05:36:14 PM AKDT M 9.2 N61.00 W147.80 Depth: 25.0km



**Alaska 1964**

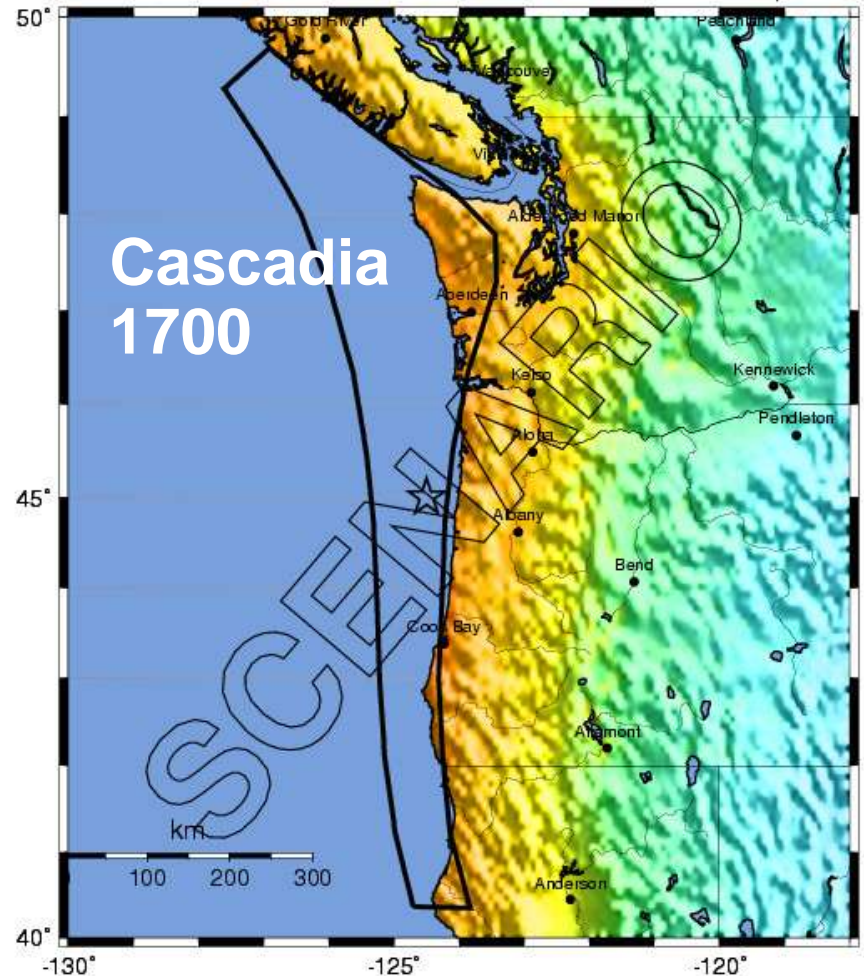
PLANNING SCENARIO ONLY -- Processed: Wed Jan 28, 2004 01:24:07 AM AKST

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC (%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL (cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

-- Earthquake Planning Scenario --

ShakeMap for Casc9.0 Scenario

Scenario Date: JUL 16 2009 09:00:00 PM PST PST M 9.0 N45.00 W124.50 Depth: 10.0km



**Cascadia 1700**

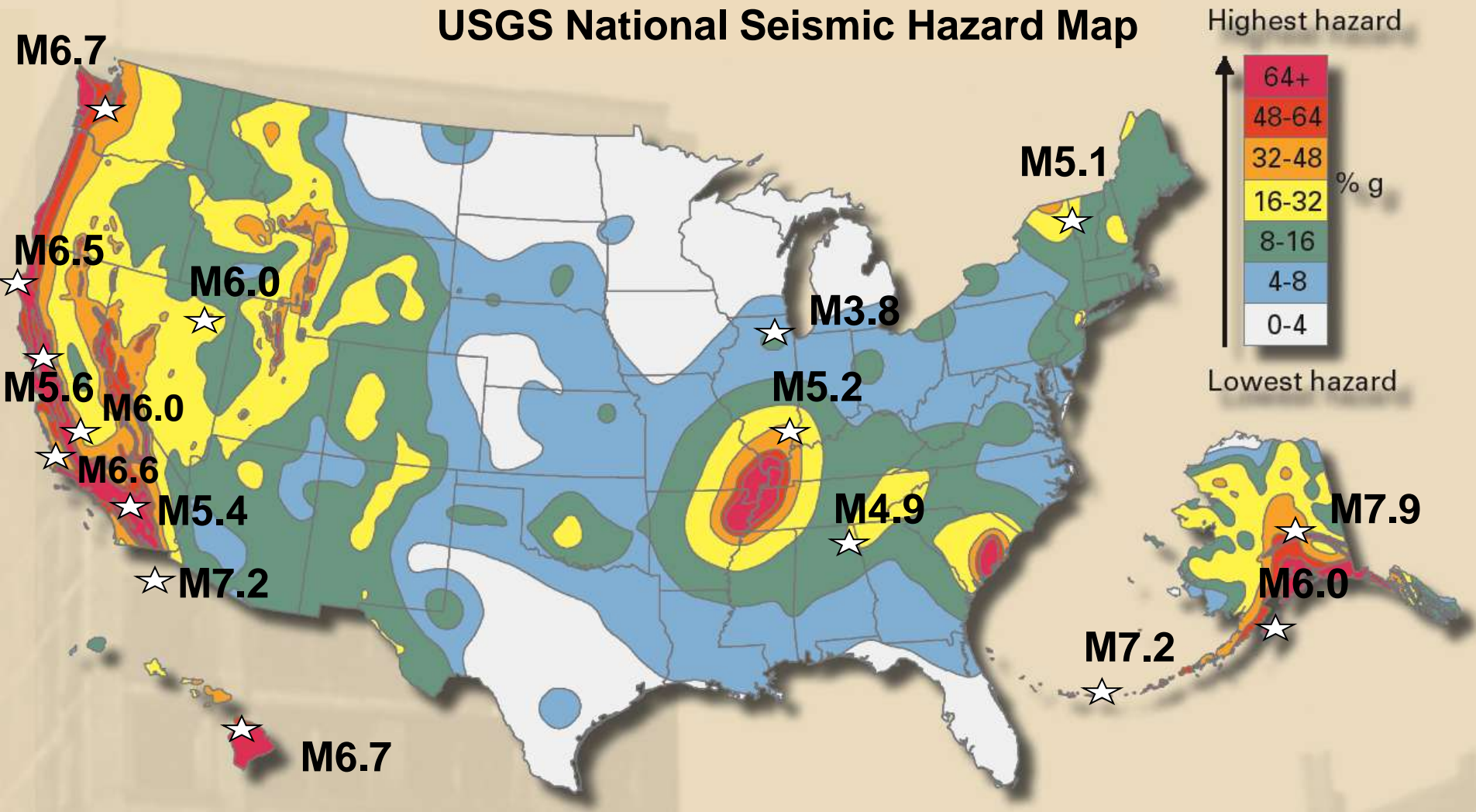
PLANNING SCENARIO ONLY -- Map Version 3 Processed Tue Sep 29, 2009 03:43:47 PM MDT

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC (%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL (cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+



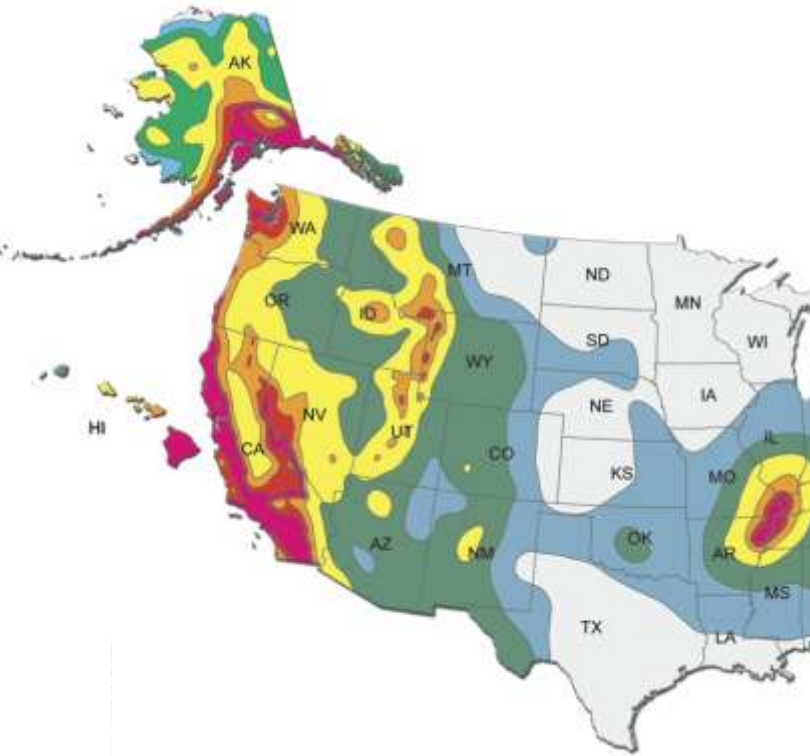
# Earthquakes are a national hazard

## USGS National Seismic Hazard Map



★ Notable earthquakes in past decade

# The heart of NEHRP: Translating USGS national hazard maps into model building codes



**NEHRP Recommended  
Seismic Provisions**  
for New Buildings and Other Structures  
FEMA P-750 / 2009 Edition



**Seismic element of NEHRP  
Provisions and Int'l Building  
Code based on the USGS  
national seismic hazard map**

# The Great Central U.S. ShakeOut™



Welcome to the Great Central U.S. ShakeOut!

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**Register Now!**  
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## GET READY TO SHAKEOUT!

[Register](#) now for the 2011 ShakeOut on April 28 at 10:15 a.m.!

[Participate](#) in the Great Central U.S. ShakeOut to practice [how to protect yourself](#) during earthquakes, and to get prepared.

Learn [how](#) to participate below.

*\*Indiana will ShakeOut on April 19. Also, you can hold your drill at another time or day if best for your schedule.*



Time to 2011 ShakeOut:  
3 months, 7 days 21:35:48

## ANNOUNCEMENTS

[The Great Central U.S. ShakeOut is a linked event to NLE 2011](#)

[Who is Participating?](#)

[ShakeOut Resources:](#) ShakeOut Drill Manuals, flyers, movies, and much more

[Why Drop, Cover, and Hold On?](#)

## QUICK LINKS

How to plan your drill and get prepared:

Select your category...

Earthquake hazards in your state:

Select your state...

[FAQ: Frequently Asked Questions](#)

## INTERACTIVE MAP

Over 1.7 million

Participants and Counting!

Click the map for details about each state



Other Areas

## LEARN & PLAY

PLAY BEAT THE QUAKE



QUAKE QUIZ

ARE YOU READY?

PREPARE



PROTECT



RECOVER



FEMA



Prepare. Plan. Stay Informed.®



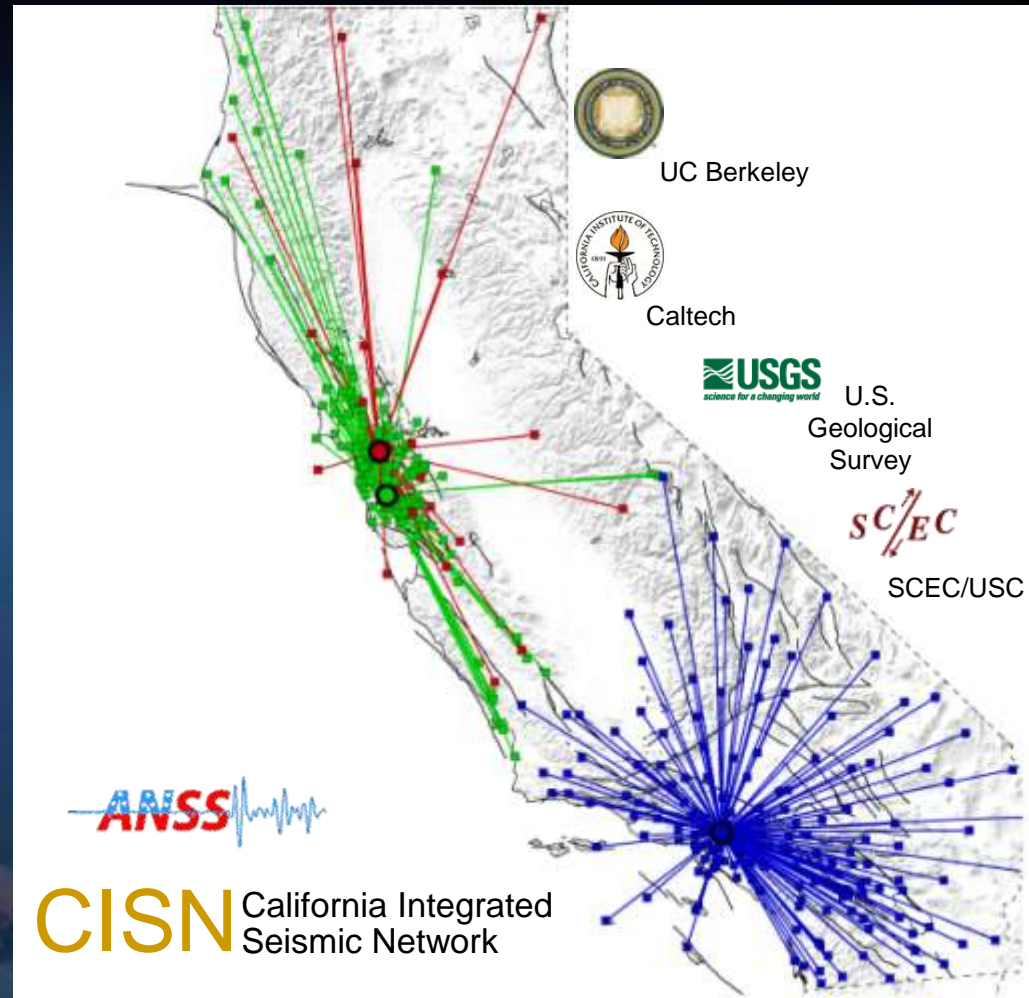
science for a changing world

<http://www.shakeout.org/centralus/>



# Earthquake early warning – getting ahead of strong ground shaking

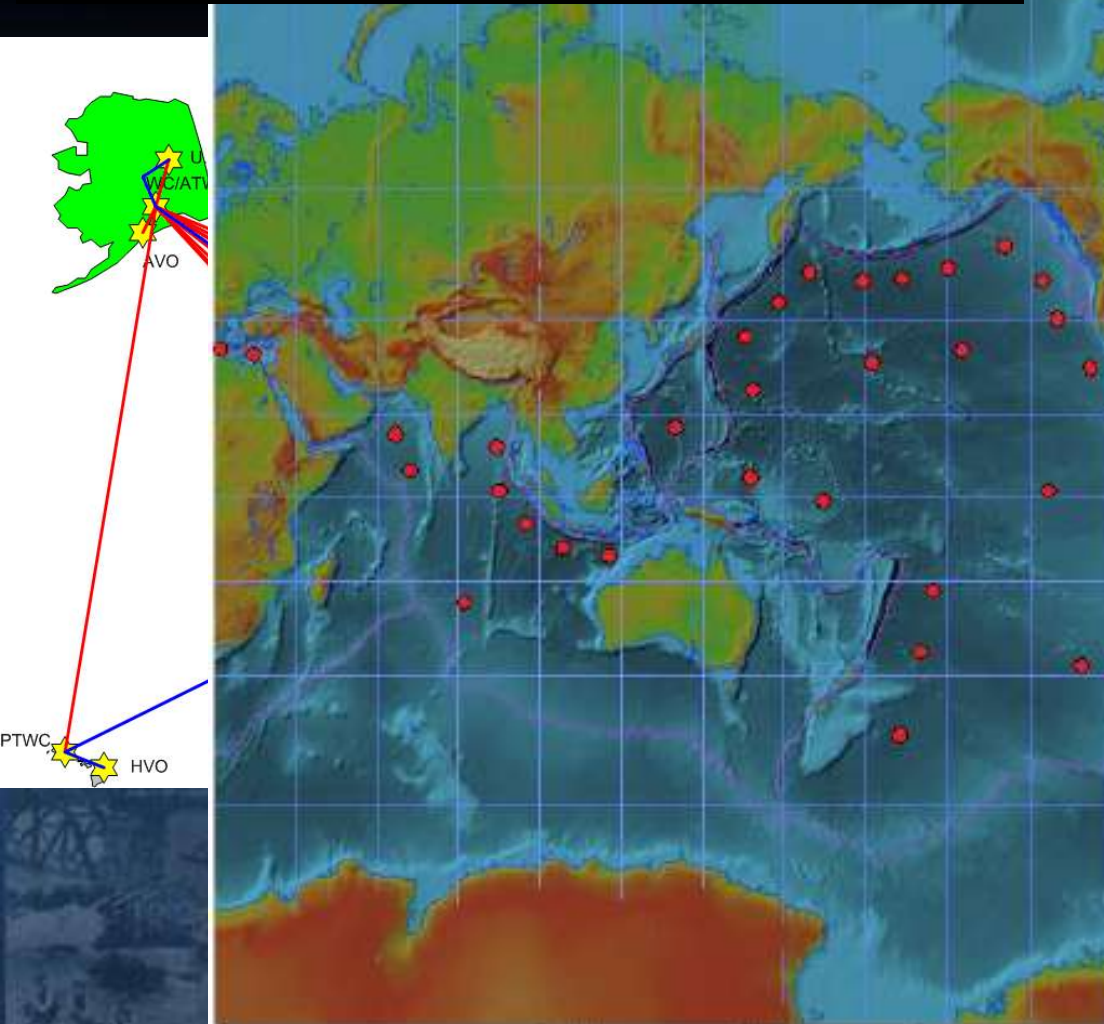
- USGS/CISN Phase I (2007-2009) cooperative agreement supported algorithm testing
- Phase II (2010-2012) supports prototype development and identifies test users
- ARRA funding used to reduce datalogger delays
- EEW requirements:
  - rapid earthquake detection
  - early magnitude estimation
  - ground shaking prediction
  - robust monitoring networks
  - well-defined user community



**For tsunamis, seismic is the start**



**All Hazard Alert Broadcast system installed at Ocean Shores, Washington.**



**The beach is the finish**

Credit: Washington Emergency Management