The 03/11/2011 Mw9.0 Tohoku, Japan Earthquake

Educational Slides

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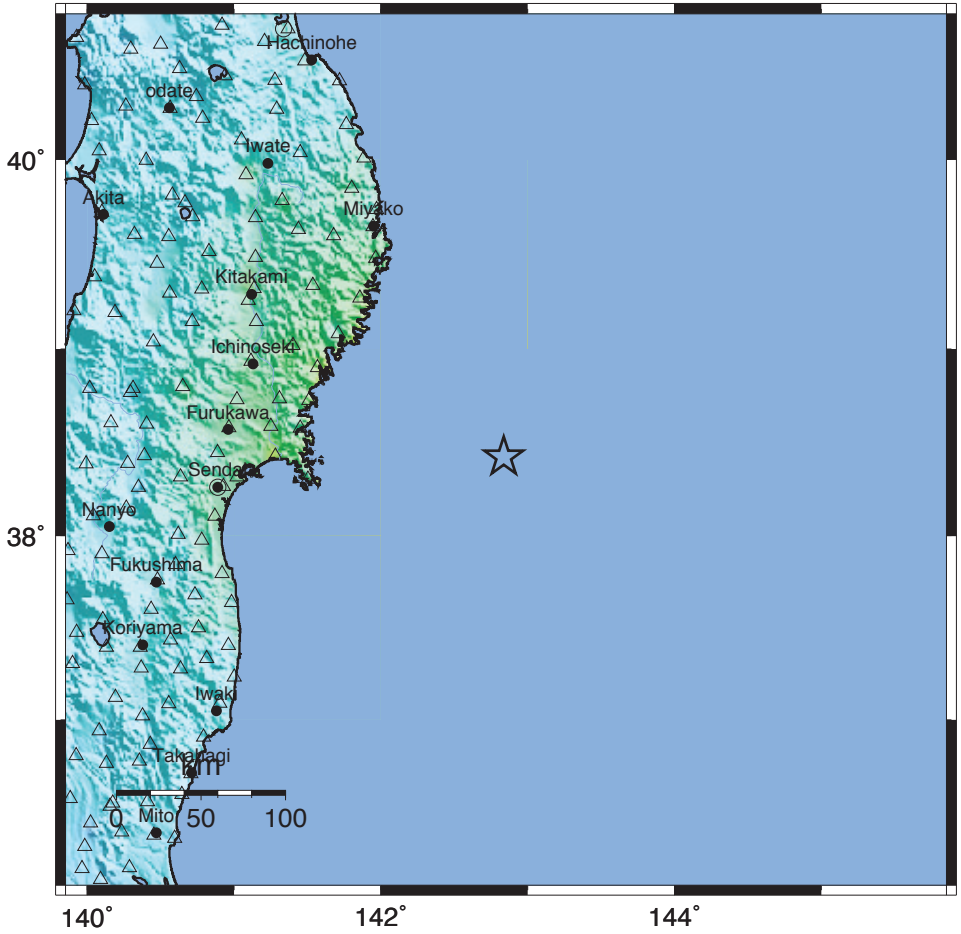
Gavin Hayes and Mike Hearne are contracted to work for the USGS NEIC by Synergetics Inc., Fort Collins, CO.

Offshore Honshu, Japan Earthquake, 03/09/2011, Mw 7.2

USGS ShakeMap : NEAR THE EAST COAST OF HONSHU, JAPAN

Wed Mar 9, 2011 02:45:20 GMT M 7.2 N38.42 E142.84 Depth: 32.0km ID:b0001r57



Map Version 4 Processed Wed Mar 9, 2011 05:27:14 PM MST -- NOT REVIEWED BY HUMAN

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+

USGS science for a changing world

Earthquake Shaking Green Alert

USAID FROM THE AMERICAN PEOPLE

GSN ANSS

M 7.2, NEAR THE EAST COAST OF HONSHU, JAPAN

Origin Time: Wed 2011-03-09 02:45:20 UTC (11:45:20 local)

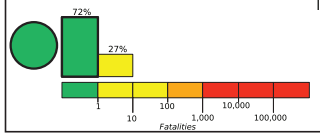
Location: 38.42°N 142.84°E Depth: 32 km

FOR TSUNAMI INFORMATION, SEE: tsunami.noaa.gov

PAGER Version 4

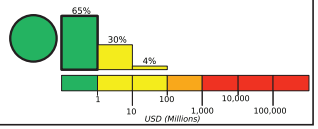
Created: 21 hours, 44 minutes after earthquake

Estimated Fatalities



Green alert for shaking-related fatalities and economic losses. There is a low likelihood of casualties and damage.

Estimated Economic Losses



Estimated Population Exposed to Earthquake Shaking

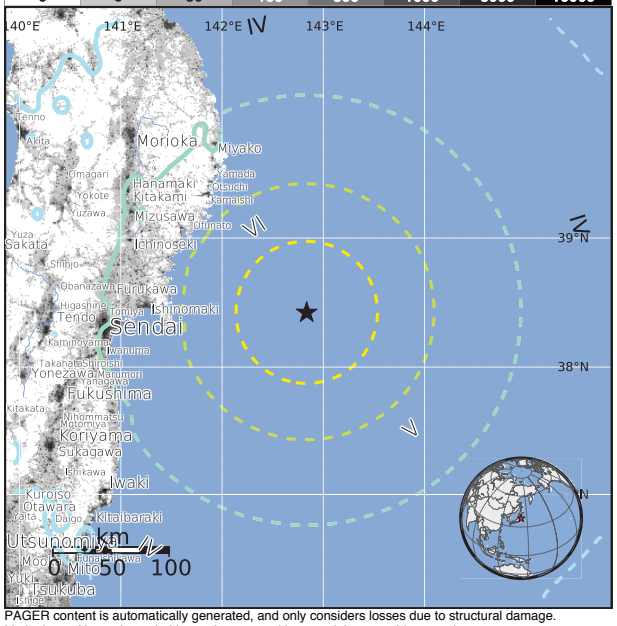
ESTIMATED POPULATION EXPOSURE (k = x1000)		- -*	2,462k*	5,120k*	2,708k	17	0	0	0	0
ESTIMATED MODIFIED MERCALLI INTENSITY		I	II-III	IV	V	VI	VII	VIII	IX	X+
PERCEIVED SHAKING		Not felt	Weak	Light	Moderate	Strong	Very Strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	Resistant Structures	none	none	none	V. Light	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

population per ~1 sq. km from Landscan

0	5	50	100	500	1000	5000	10000



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

Structures:
Overall, the population in this region resides in structures that are resistant to earthquake shaking, though some vulnerable structures exist.

Historical Earthquakes (with MMI levels):

Date (UTC)	Dist. (km)	Mag.	Max MMI(#)	Shaking Deaths
2003-10-31	73	7.0	V(7,236k)	0
1980-09-23	388	5.3	V(12,718k)	1
1983-05-26	385	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
V	**Ishinomaki**	**117k**
V	**Otsuchi**	**16k**
V	**Kamaishi**	**43k**
V	**Hanamaki**	**73k**
V	**Yamada**	**20k**
V	Yamoto	32k
V	**Sendai**	**1,038k**
IV	**Morioka**	**295k**
IV	**Fukushima**	**294k**
III	**Utsunomiya**	**450k**
III	Yamagata	255k

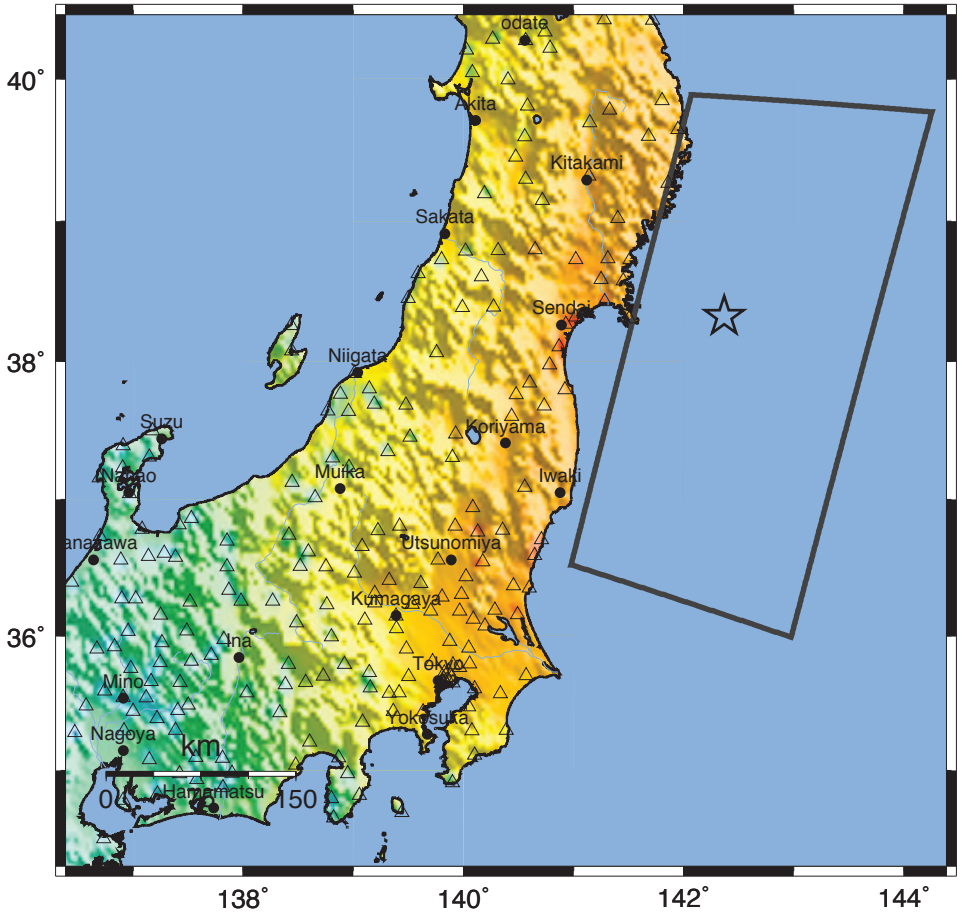
bold cities appear on map (k = x1000)

Event ID: usb0001r57

Tohoku, Japan Earthquake, 03/11/2011, Mw 9.0

USGS ShakeMap : NEAR THE EAST COAST OF HONSHU, JAPAN

Fri Mar 11, 2011 05:46:23 GMT M 9.0 N38.32 E142.37 Depth: 32.0km ID:c0001xgp



Map Version 6 Processed Tue Mar 15, 2011 08:39:58 AM MDT -- NOT REVIEWED BY HUMAN

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+

USGS science for a changing world

Earthquake Shaking — Red Alert

USAID FROM THE AMERICAN PEOPLE

M 9.0, NEAR THE EAST COAST OF HONSHU, JAPAN

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

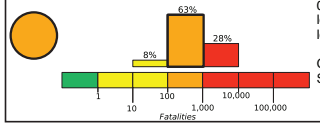
Location: 38.32°N 142.37°E Depth: 32 km

FOR TSUNAMI INFORMATION, SEE: tsunami.noaa.gov

PAGER Version 7

Created: 4 days, 9 hours after earthquake

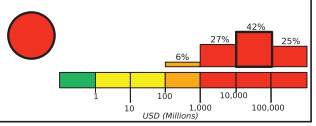
Estimated Fatalities



Red alert level for economic losses. Extensive damage is probable and the disaster is likely widespread. Estimated economic losses are 0-1% 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



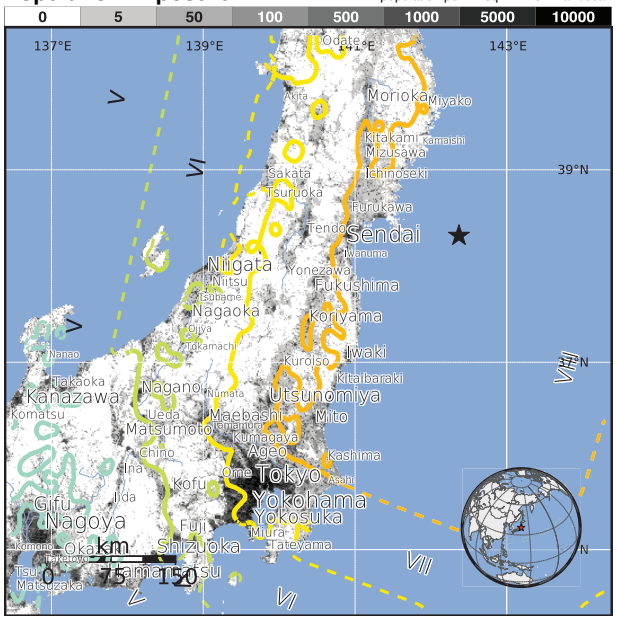
Estimated Population Exposed to Earthquake Shaking

ESTIMATED POPULATION EXPOSURE (k = x1000)		- -*	6k*	2,483k*	15,269k*	10,864k*	36,088k*	6,781k*	66k	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

population per ~1 sq. km from Landscan



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

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(428k)	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

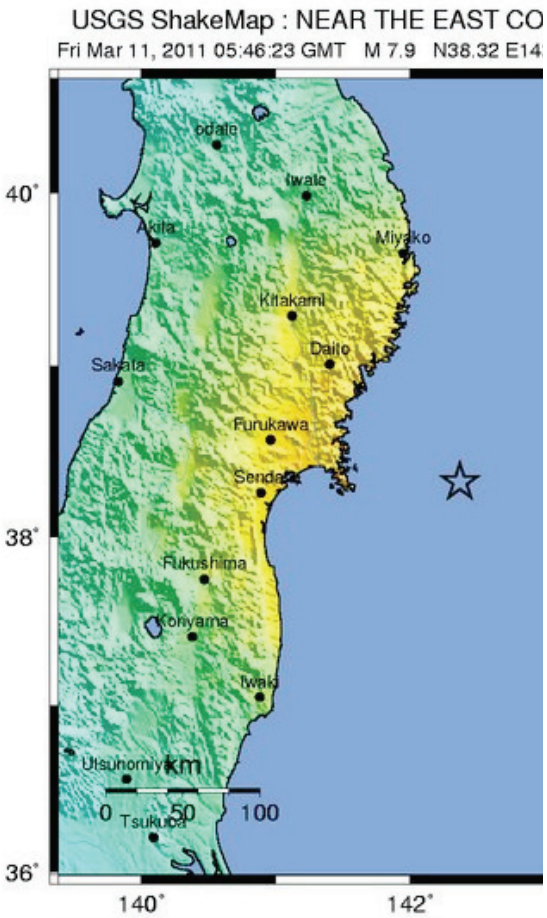
MMI	City	Population
IX	Iwanuma	42k
IX	Rifu	35k
IX	Shiogama	60k
IX	Hitachi	186k
VIII	Takahagi	34k
VIII	Ishinomaki	117k
VIII	Sendai	1,038k
VIII	Chiba	920k
VII	Yokohama	3,574k
VII	Tokyo	8,337k
V	Nagoya	2,191k

bold cities appear on map (k = x1000)

Event ID: usc0001xgp

Tohoku, Japan Earthquake: ShakeMap Evolution

V1: O.T. +21 min M7.9



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Ver
POTENTIAL DAMAGE	none	none	none	Very light	Light	M
PEAK ACC.(%g)	*<.17*	*.17-1.4*	*1.4-3.9*	*3.9-9.2*	*9.2-18*	
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	*8.1-16*	
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	

V2: O.T. +40 min M8.8

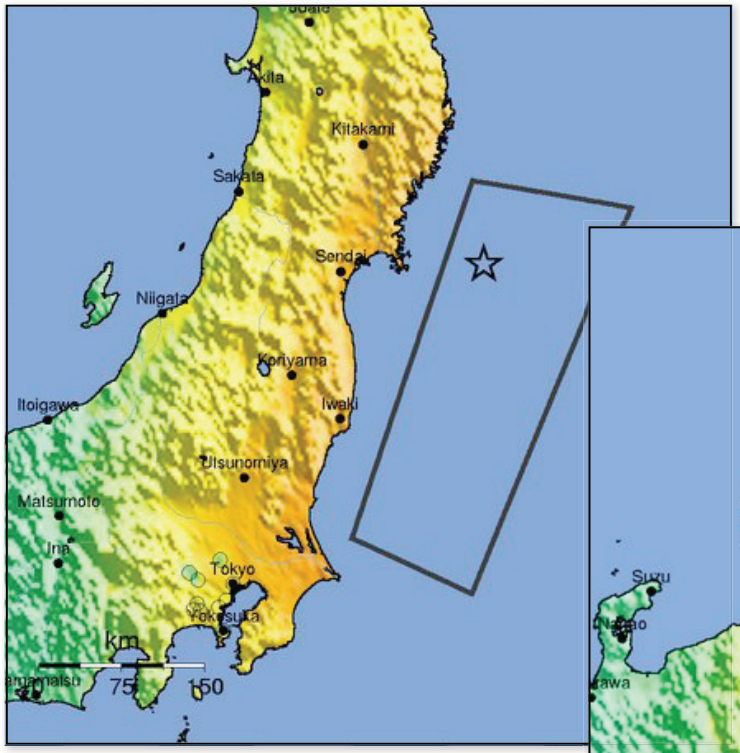
PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong
POTENTIAL DAMAGE	none	none	none	Very light	Light
PEAK ACC.(%g)	*<.17*	*.17-1.4*	*1.4-3.9*	*3.9-9.2*	*9.2-18*
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	*8.1-16*
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI

V3: O.T. +1 hr 9 min M8.9

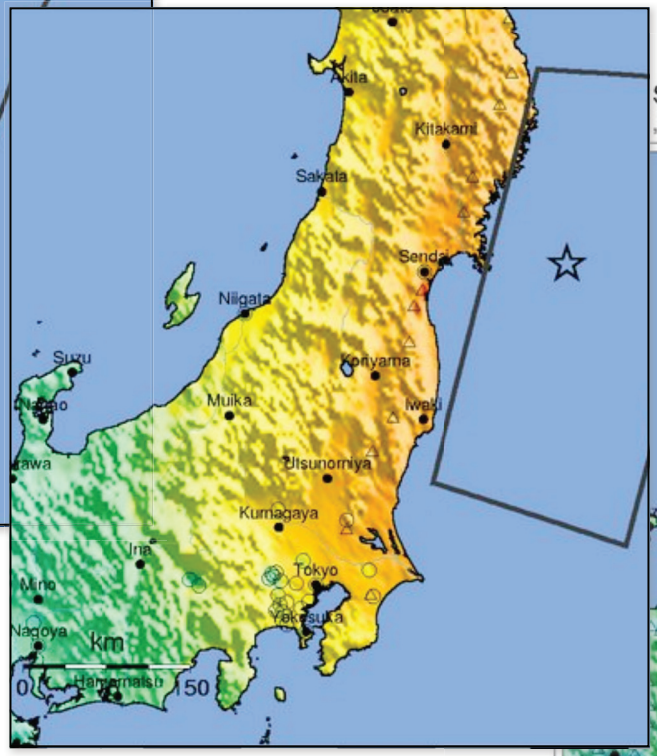
PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	*<.17*	*.17-1.4*	*1.4-3.9*	*3.9-9.2*	*9.2-18*	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1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

(Led to PAGER **RED** Alert
42.9 minutes after origin)

Tohoku, Japan Earthquake: ShakeMap Evolution

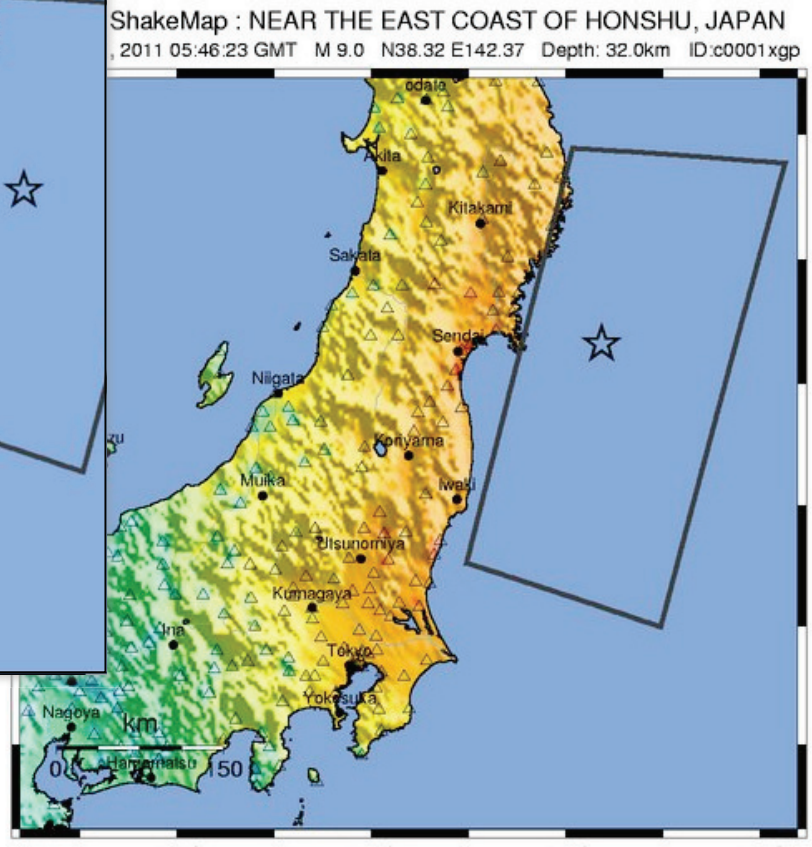


V4: O.T. +2 h 22 min
•M8.9
•**DYFI data**
•Finite fault inferred from aftershocks



V5: OT +2 d 11 hr
•M9.0
•DYFI Data
•**12 K-NET stations**
•Finite fault inferred from aftershocks

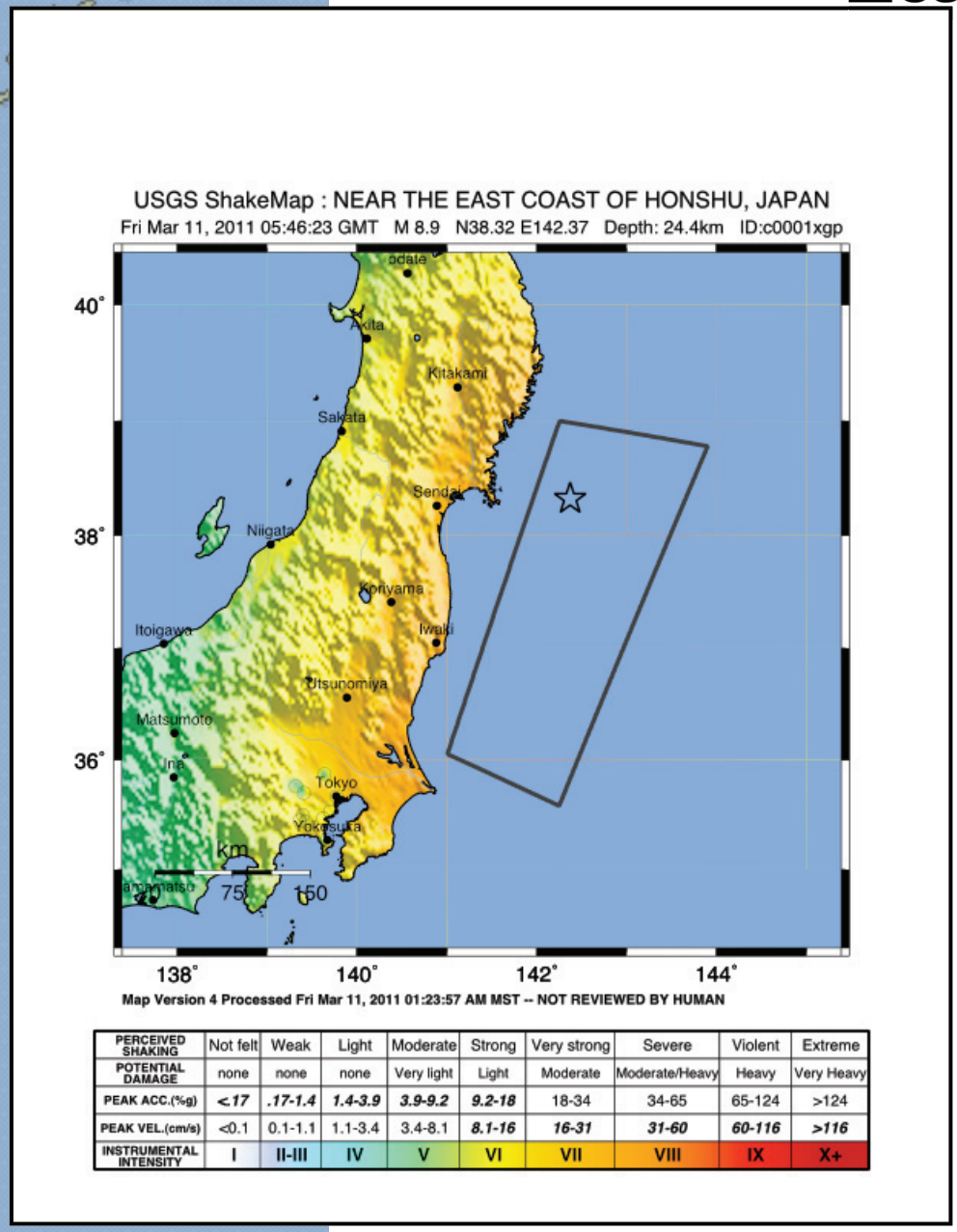
V6: OT +3 d 9 hr
•M9.0
•DYFI Data
•**273 K-NET stations**
•Finite fault from K-NET (NIED) inversion



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+

11 March 2011

Mainshock ShakeMap, assumed fault (rectangle), and JMA Intensity Map



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
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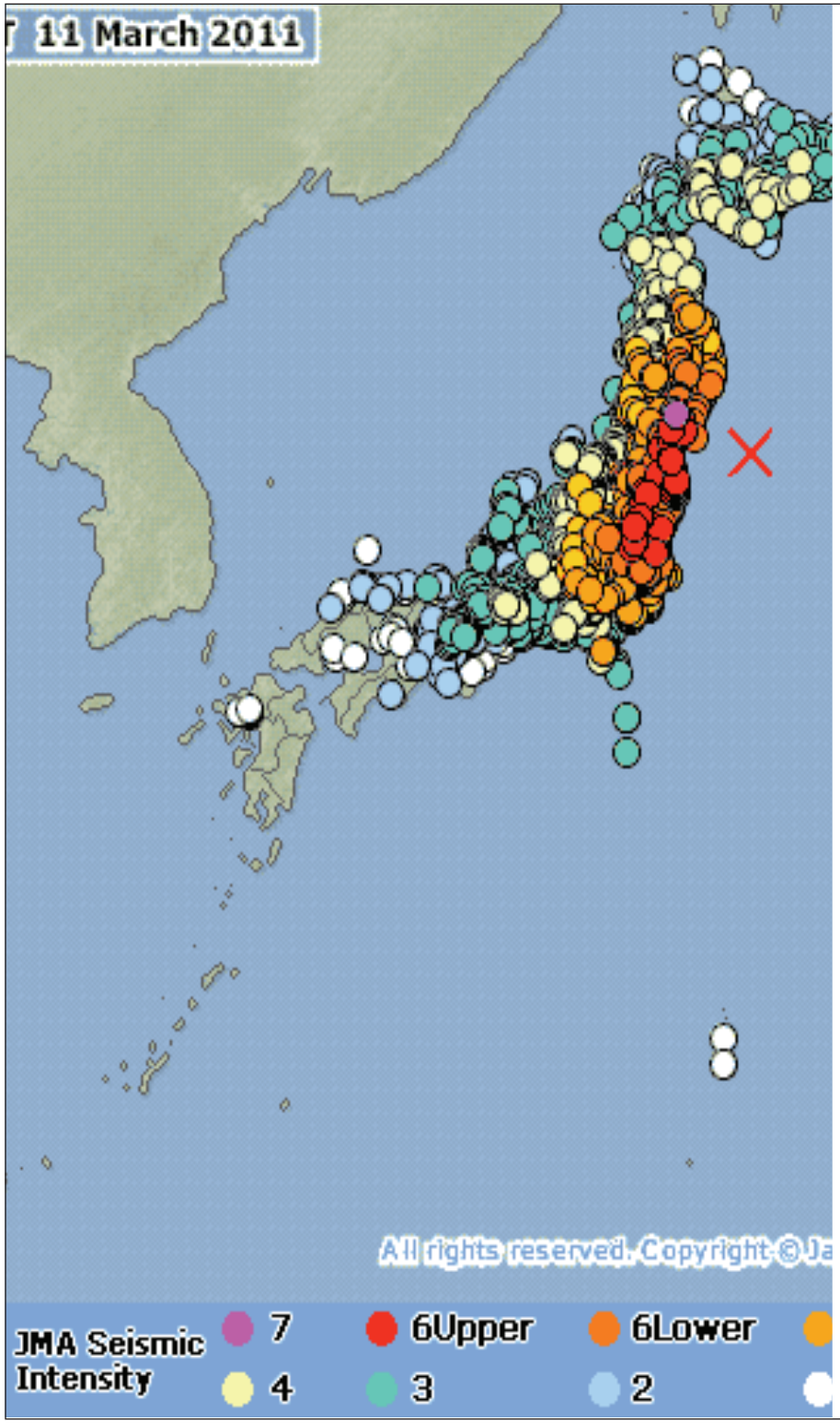
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

JMA Seismic Intensity: 7, 6Upper, 6Lower, 5Upper, 5Lower, 4, 3, 2, 1



USGS science for a changing world

Earthquake Shaking — Red Alert

USAID FROM THE AMERICAN PEOPLE

GSN ANSS

M 8.9, NEAR THE EAST COAST OF HONSHU, JAPAN

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

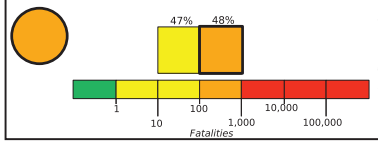
Location: 38.32°N 142.37°E Depth: 24 km

FOR TSUNAMI INFORMATION, SEE: tsunami.noaa.gov

PAGER
Version 5

Created: 2 hours, 44 minutes after earthquake

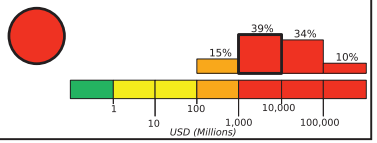
Estimated Fatalities



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



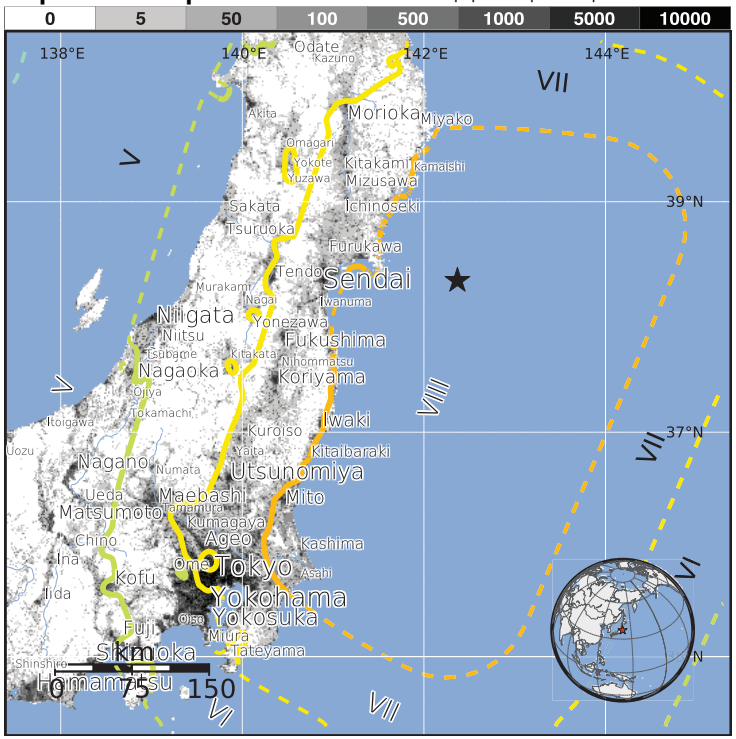
Estimated Population Exposed to Earthquake Shaking

ESTIMATED POPULATION EXPOSURE (k = x1000)		- -*	- -*	- -*	7,071k*	19,695k*	29,969k*	2,144k	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

population per ~1 sq. km from Landscan



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(428k)	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

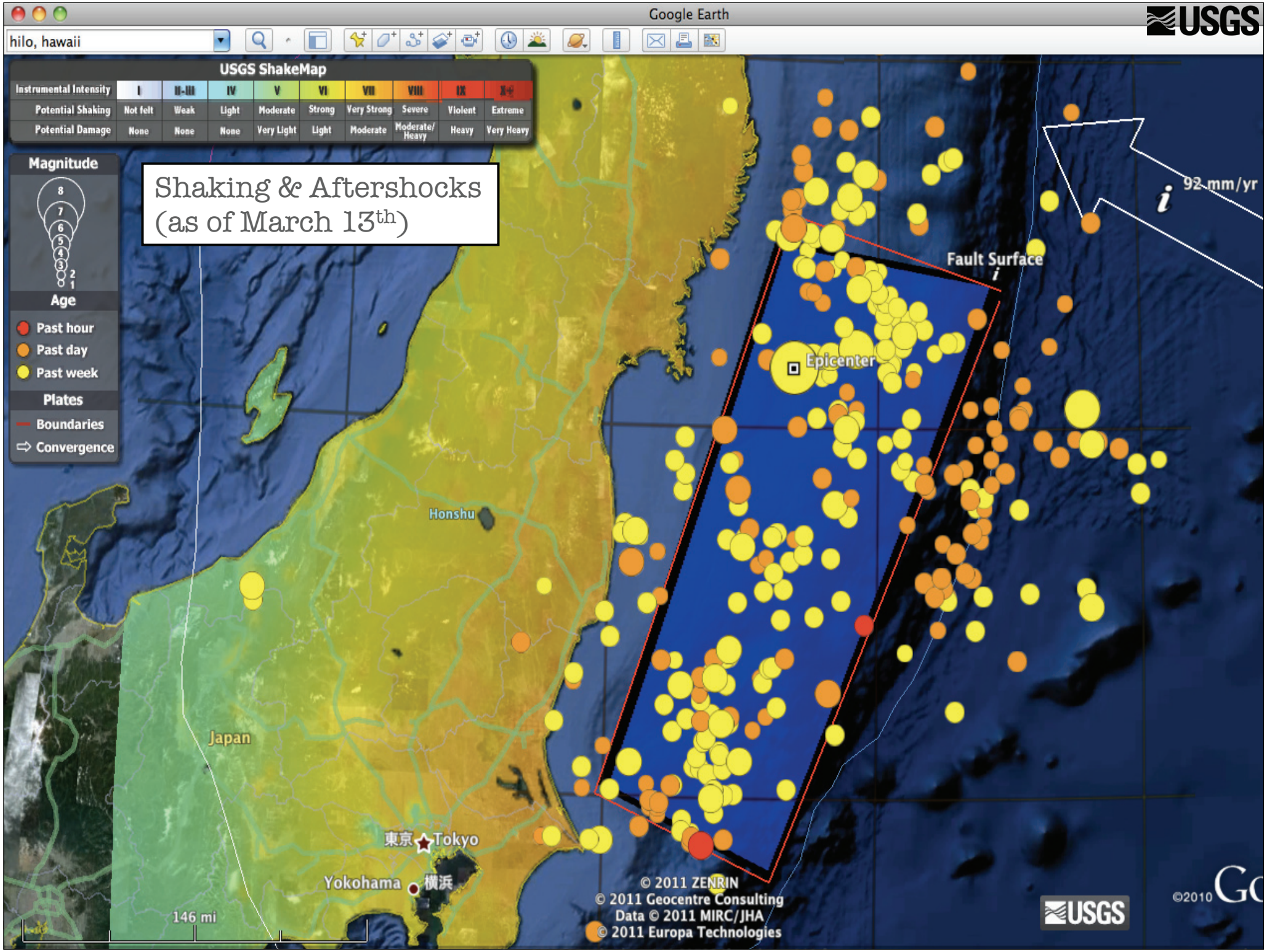
MMI	City	Population
VIII	Omigawa	26k
VIII	Oarai	19k
VIII	Hasaki	39k
VIII	Itako	26k
VIII	Ofunato	35k
VIII	Takahagi	34k
VII	**Sendai**	**1,038k**
VII	Chiba	920k
VII	**Tokyo**	**8,337k**
VI	**Yokohama**	**3,574k**
V	**Shizuoka**	**702k**

bold cities appear on map (k = x1000)

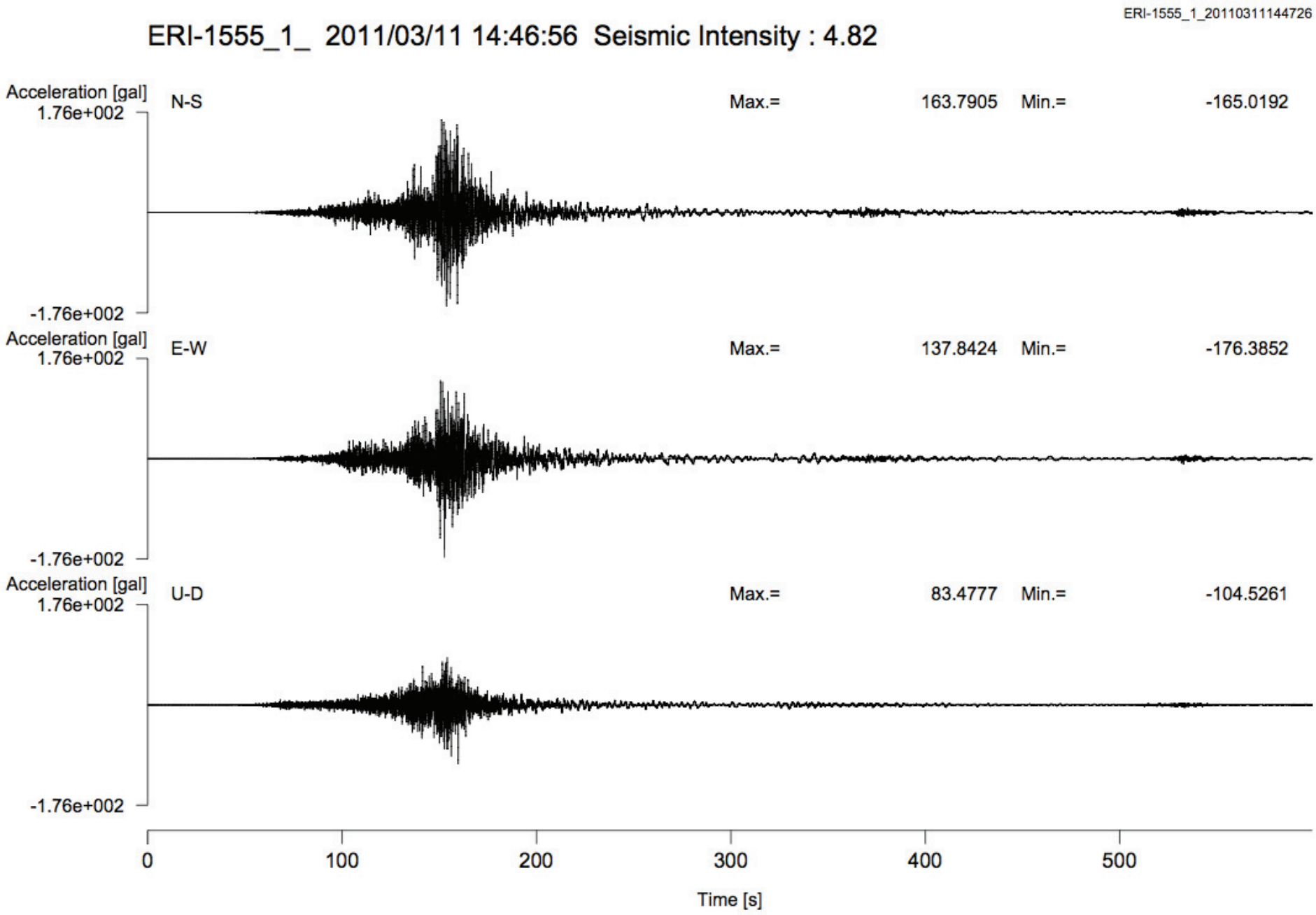
PAGER content is automatically generated, and only considers losses due to structural damage. Limitations of input data, shaking estimates, and loss models may add uncertainty.

http://earthquake.usgs.gov/pager

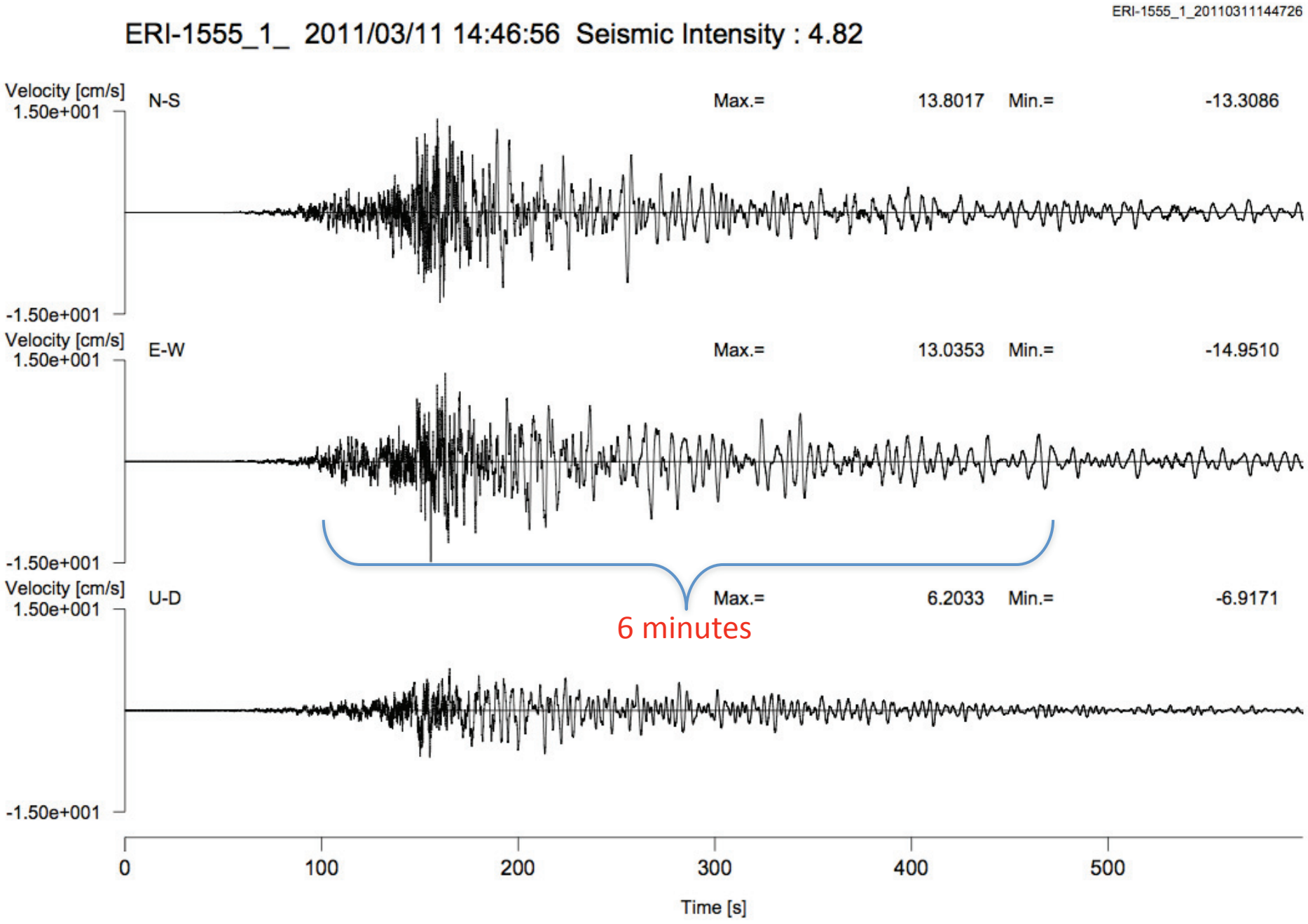
Event ID: usc0001xgp


Google Earth
USGS
hilo, hawaii
USGS ShakeMap
Instrumental Intensity
I
II-III
IV
V
VI
VII
VIII
IX
X+
Potential 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
Magnitude
8
7
6
5
4
3
2
1
Age
Past hour
Past day
Past week
Plates
Boundaries
Convergence
Shaking & Aftershocks
(as of March 13th)
92 mm/yr
Fault Surface
Epicenter
Honshu
Japan
東京 Tokyo
Yokohama 横浜
146 mi
© 2011 ZENRIN
© 2011 Geocentre Consulting
Data © 2011 MIRC/JHA
© 2011 Europa Technologies
USGS
©2010

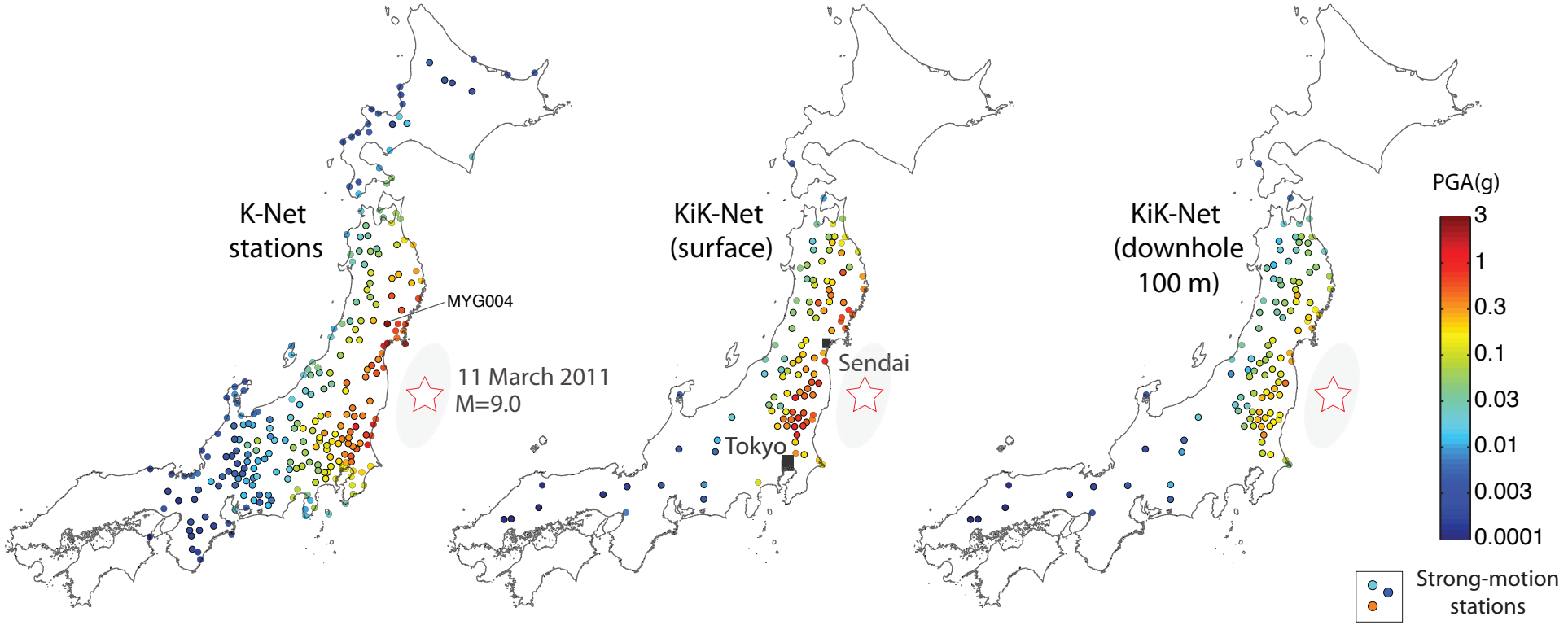
Tohoku, Japan Earthquake: Shaking Duration in Tokyo, Ground Acceleration



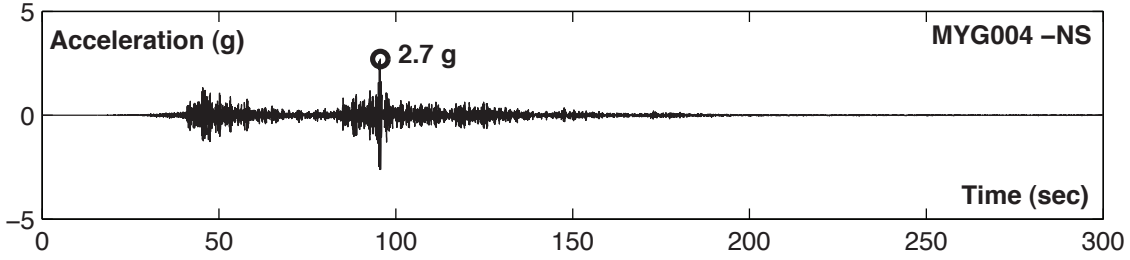
Tohoku, Japan Earthquake: Shaking Duration in Tokyo, Ground Velocity



Peak Ground Motion Acceleration (PGA) of the 11 March 2011 Tohoku M=9.0 earthquake

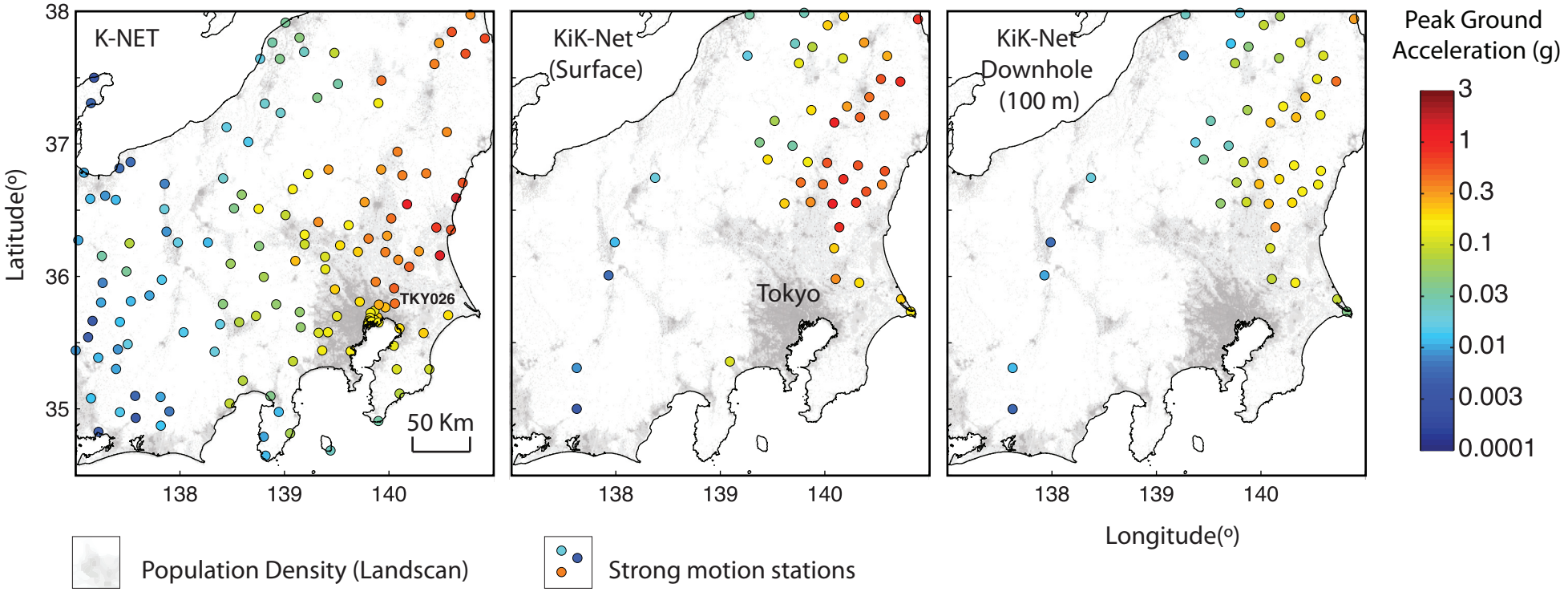


Maximum PGA of 2.7g was recorded at Miyagi Prefecture

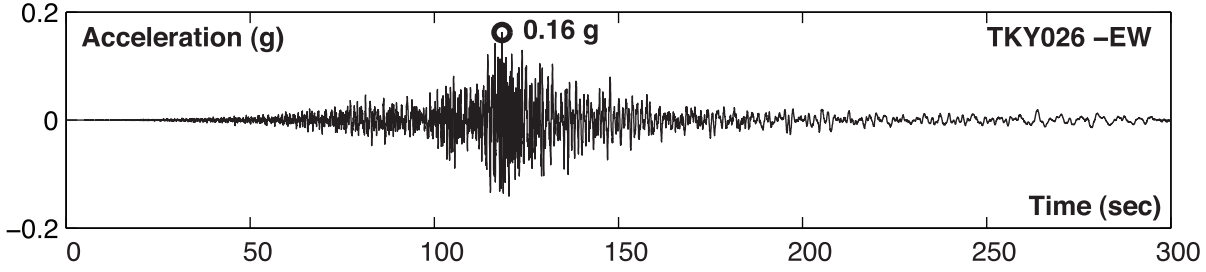


Erol Kalkan & Volkan Sevilgen (USGS)
March 17, 2011

Peak Ground Motion Acceleration (PGA) of the 11 March 2011 Tohoku M=9.0 earthquake
Tokyo Metropolitan and its surroundings

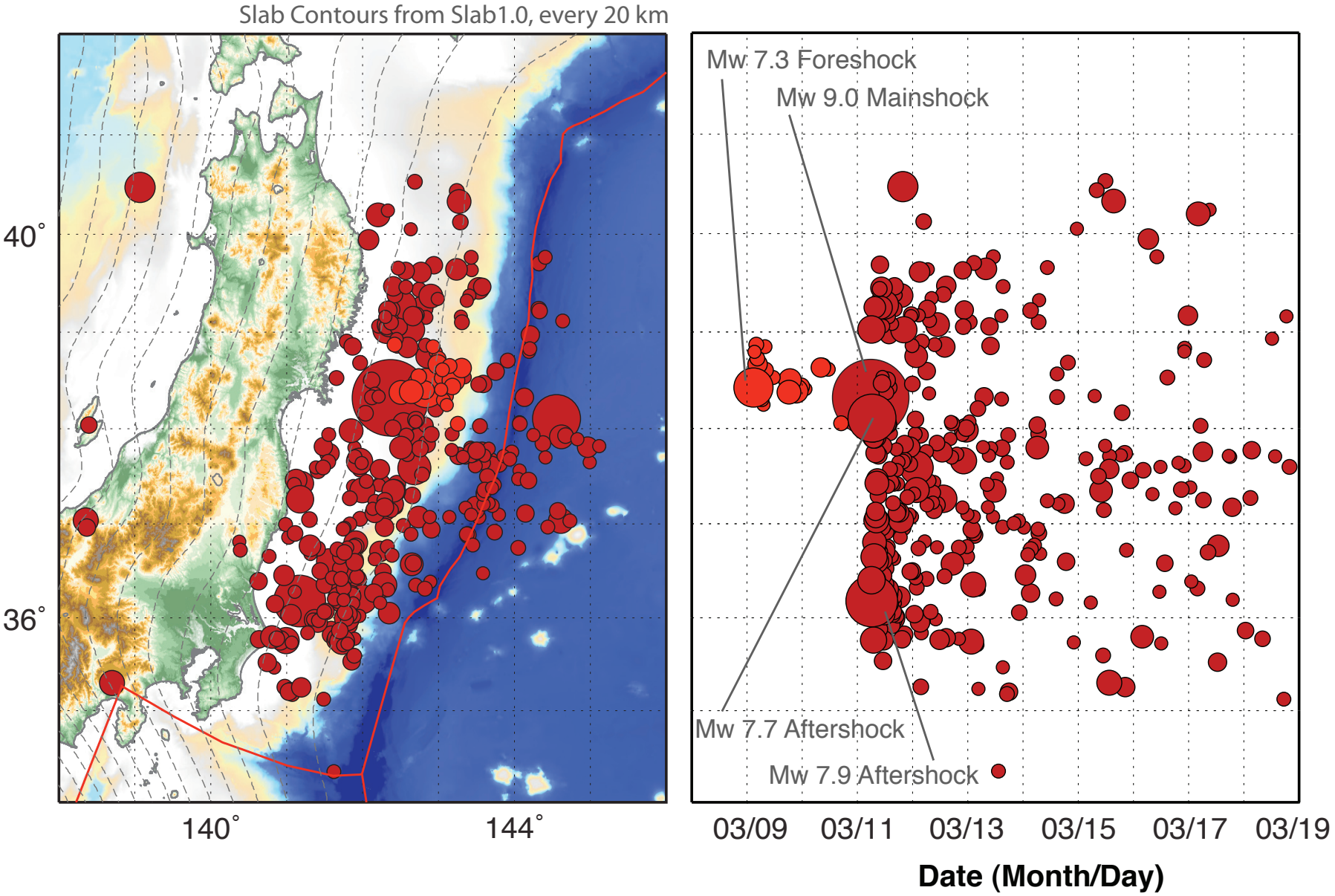


Maximum PGA of 0.16g was recorded at Tokyo Metropolitan



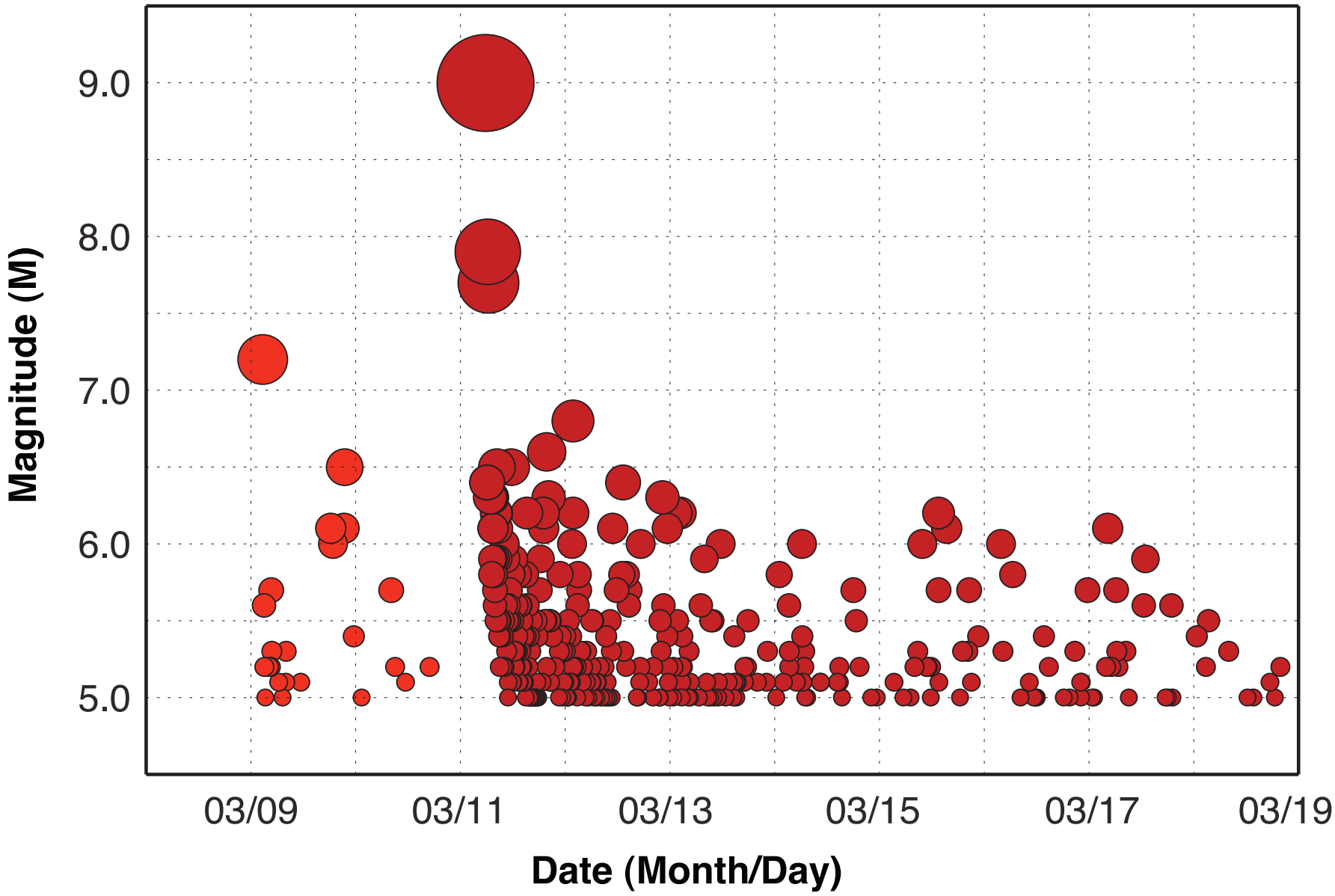
March 17, 2011
Erol Kalkan & Volkan Sevilgen (USGS)

Tohoku, Japan Earthquake: Aftershock (and Foreshock) Sequence, 03/08/11 - 03/16/11



Note that the magnitudes of the 2011/03/11 06:15 (Mw 7.9) and 2011/03/11 06:25 (Mw 7.7) aftershocks were updated from earlier, lower estimates. Updates occurred on 03/16 and 03/18, respectively.

Tohoku, Japan Earthquake: Aftershock (and Foreshock) Sequence, M:Time History

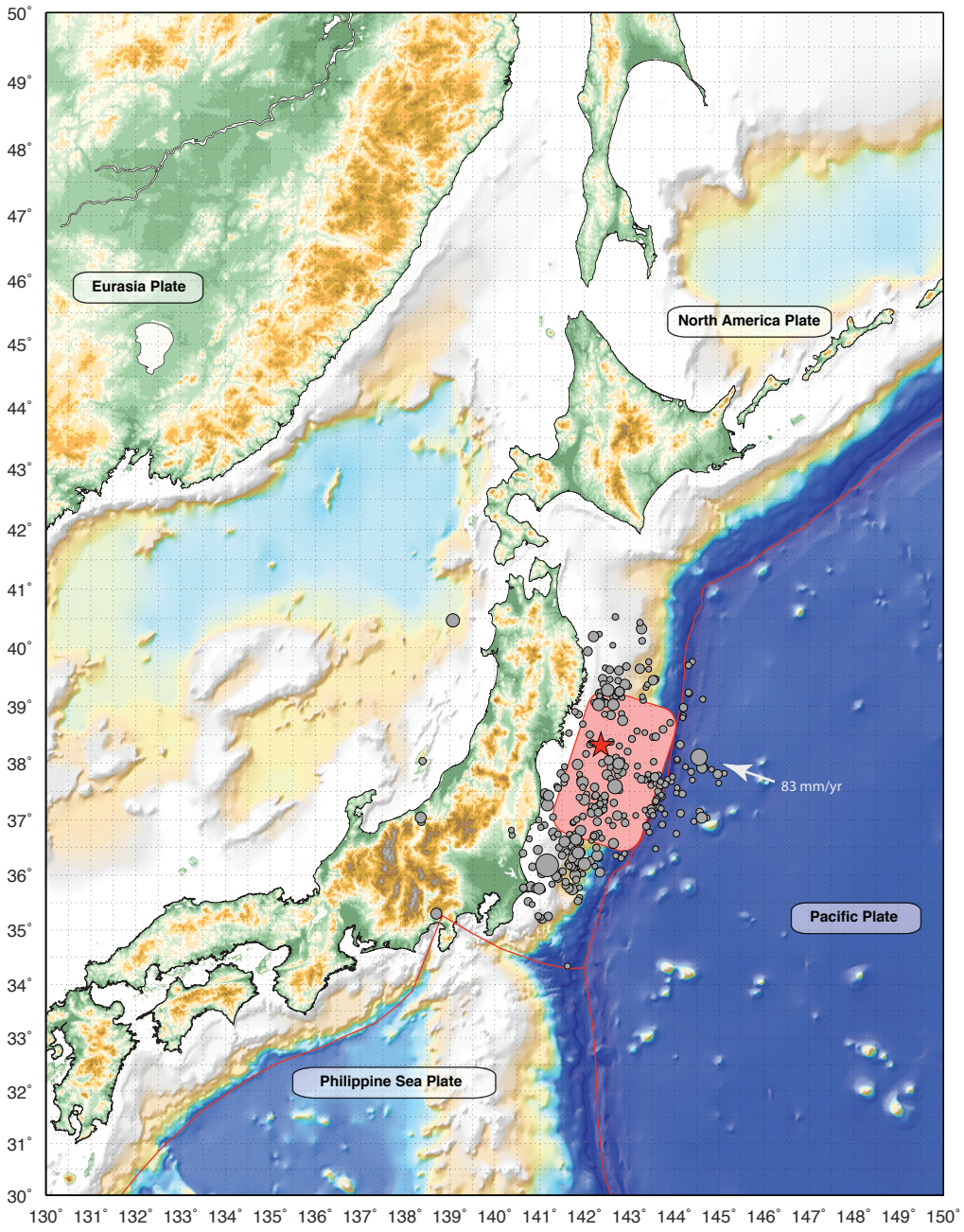


Tohoku, Japan Earthquake: Tectonic Summary

The magnitude 9.0 Tohoku earthquake on March 11, 2011, which occurred near the northeast coast of Honshu, Japan, resulted from thrust faulting on or near the subduction zone plate boundary between the Pacific and North America plates. At the latitude of this earthquake, the Pacific plate moves approximately westwards with respect to the North America plate at a rate of 83 mm/yr, and begins its westward descent beneath Japan at the Japan Trench.

The location, depth, and focal mechanism of the March 11 earthquake are consistent with the event having occurred on the subduction zone plate boundary.

Modeling of the rupture of this earthquake (red shading, approx.) indicate that the fault moved upwards of 30-40 m, and slipped over an area approximately 300 km long (along-strike) by 150 km wide (in the down-dip direction). The rupture zone is roughly centered on the earthquake epicenter along-strike, while peak slips were up-dip of the hypocenter, towards the Japan Trench axis. The March 11 earthquake was preceded by a series of large foreshocks over the previous two days, beginning on March 9th with a M 7.2 event approximately 40 km from the epicenter of the March 11 earthquake, and continuing with another three earthquakes greater than M 6 on the same day.



Japan Regional Seismicity, 1900-2007
USGS Poster/Open File Report 2010-1083-D

USGS
science for a changing world

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

OPEN-FILE REPORT 2010–1083-D
Version 1.0

Seismicity of the Earth 1900–2007
Japan and Vicinity

Compiled by Susan Rhea, Arthur C. Tarr, Gavin Hayes, Antonio Villaseñor', and Harley Benz

'Institute of Earth Sciences, CSIC, Lluis Solé i Sabaris s/n, 08028 Barcelona, Spain

TECTONIC SUMMARY

This map shows details of Japan and vicinity not visible in an earlier publication (Tarr and others, 2010). Japan and its island possessions lie across four major tectonic plates: Pacific plate; North America plate; Eurasia plate; and Philippine Sea plate. The Pacific plate is subducted into the mantle, beneath Hokkaido and northern Honshu, along the eastern margin of the Okhotsk microplate, a proposed subdivision of the North America plate (Bird, 2003). Farther south, the Pacific plate is subducted beneath volcanic islands along the eastern margin of the Philippine Sea plate. This 2,200 km-long zone of subduction of the Pacific plate is responsible for the creation of the deep offshore Ogasawara and Japan trenches as well as parallel chains of islands and volcanoes, typical of Circumpacific island arcs. Similarly, the Philippine Sea plate is itself subducting under the Eurasia plate along a zone, extending from Taiwan to southern Honshu, that comprises the Ryukyu Islands and the Nansei-Shoto trench.

Subduction zones at the Japanese island arcs are geologically complex and produce numerous earthquakes from multiple sources. Deformation of the overriding plates generates shallow crustal earthquakes, whereas slip at the interface of the plates generates interplate earthquakes that extend from near the base of the trench to depths of 40 to 60 km. At greater depths, Japanese arc earthquakes occur within the subducting Pacific and Philippine Sea plates and can reach depths of nearly 700 km. Since 1900, two great earthquakes occurred off Japan and three north of Hokkaido. They are the M8.4 1933 Sanriku-oki earthquake (Kawakatsu and Seno, 1983), the M8.3 2003 Tokachi-oki earthquake (Miyazaki and others, 2004), M8.4 1958 Etorofu earthquake (Fukao and Furamoto, 1979), the M8.5 1963 Kuril earthquake (Beck and Ruff, 1987), and the M8.3 1994 Shikotan earthquake (Kikuchi and Kanamori, 1995).

Several relevant tectonic elements, plate boundaries and active volcanoes, provide a context for the seismicity presented on the main map. The plate boundaries (Bird, 2003) are known most accurately along the axis of the trenches and are more diffuse or speculative in the Sea of Japan, China, and Russia. The active volcanic arcs (Siebert and Simkin, 2002) follow the Izu, Volcano, and Ryukyu island chains and the main Japanese islands parallel to the Japan trench.

DATA SOURCES

The earthquakes portrayed on the main map and the depth profiles are taken from two sources: (a) the Centennial earthquake catalog (Engdahl and Villaseñor, 2002) and annual supplements for the interval 1900-2007, where the magnitude floor is 5.5 globally, and (b) a catalog of earthquakes having high-quality depth determinations for the period 1964-2002 and a magnitude range of 5.0≤M≤5.4 (Engdahl, personal comm. 2003)

The nucleation points of great earthquakes (M≥8.3) are designated with a label showing the year of occurrence. Their rupture areas are shown as pale yellow polygons. Major earthquakes (7.5≤M≤8.2) are labeled with the year of occurrence. Slab contours are from Hayes and Wald (2010).

The Seismic Hazard and Relative Plate Motion panel displays the generalized seismic hazard of the region (Giardini and others, 1999) and representative relative plate motion vectors using the NUVEL-1A model (DeMets, et.al., 1994.)

Pre-instrumental seismicity was obtained from the NOAA National Geophysical Data Center (2010) database of significant earthquakes; locations are approximate, based on macro-seismic reports and field investigations. We selected for earthquakes with associated reports of moderate to major damage, deaths, an estimated magnitude of 7.5 or greater, or tsunami generation.

Base map data sources include GEBCO 2008, Volcanoes of the World dataset (Siebert and Simkin, 2002), plate boundaries (Bird, 2003), Digital Chart of the World, and ESRI (2002).

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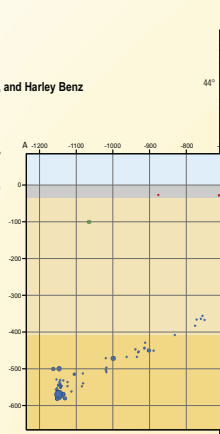
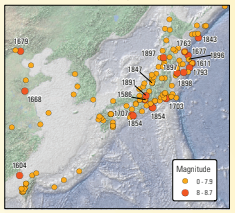
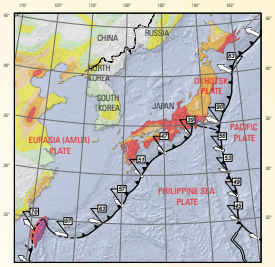
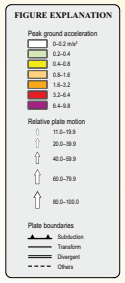
Tarr, A.C., Villaseñor, Antonio, Furlong, K.P., Rhea, Susan, and Benz, H.M, 2010, Seismicity of the Earth 1900–2007: U.S. Geological Survey Scientific Investigations Map 3064, scale 1:25,000,000.









This map was produced on request, directly from digital files, on an electronic plotter.

For sale by U.S. Geological Survey Information Services Box 25286, Federal Center, Denver, CO 80225 1-888-ASK-USGS

A PDF for this map is available at http://pubs.usgs.gov/of/2010/1083d/

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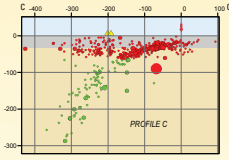


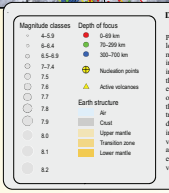
Albers Equal Area Conic Projection

Digital map database and cartography by Susan Rhea and Arthur Tarr

Manuscript approved for publication July 28, 2010

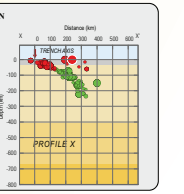
Albers Equal Area Conic Projection
SCALE 1:6 000 000

0 100 200 400 600 800 Kilometers

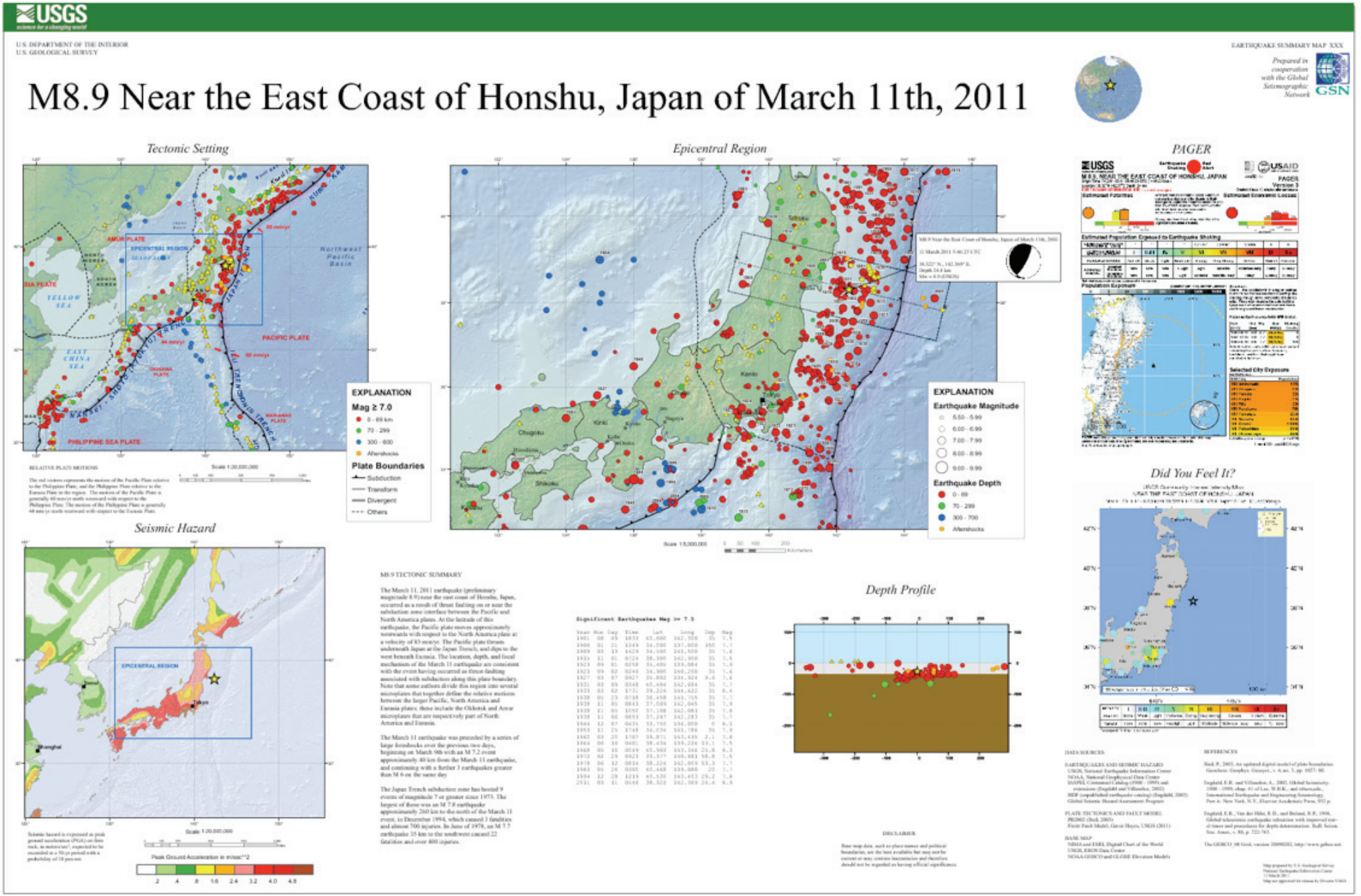


DEPTH PROFILE EXPLANATION

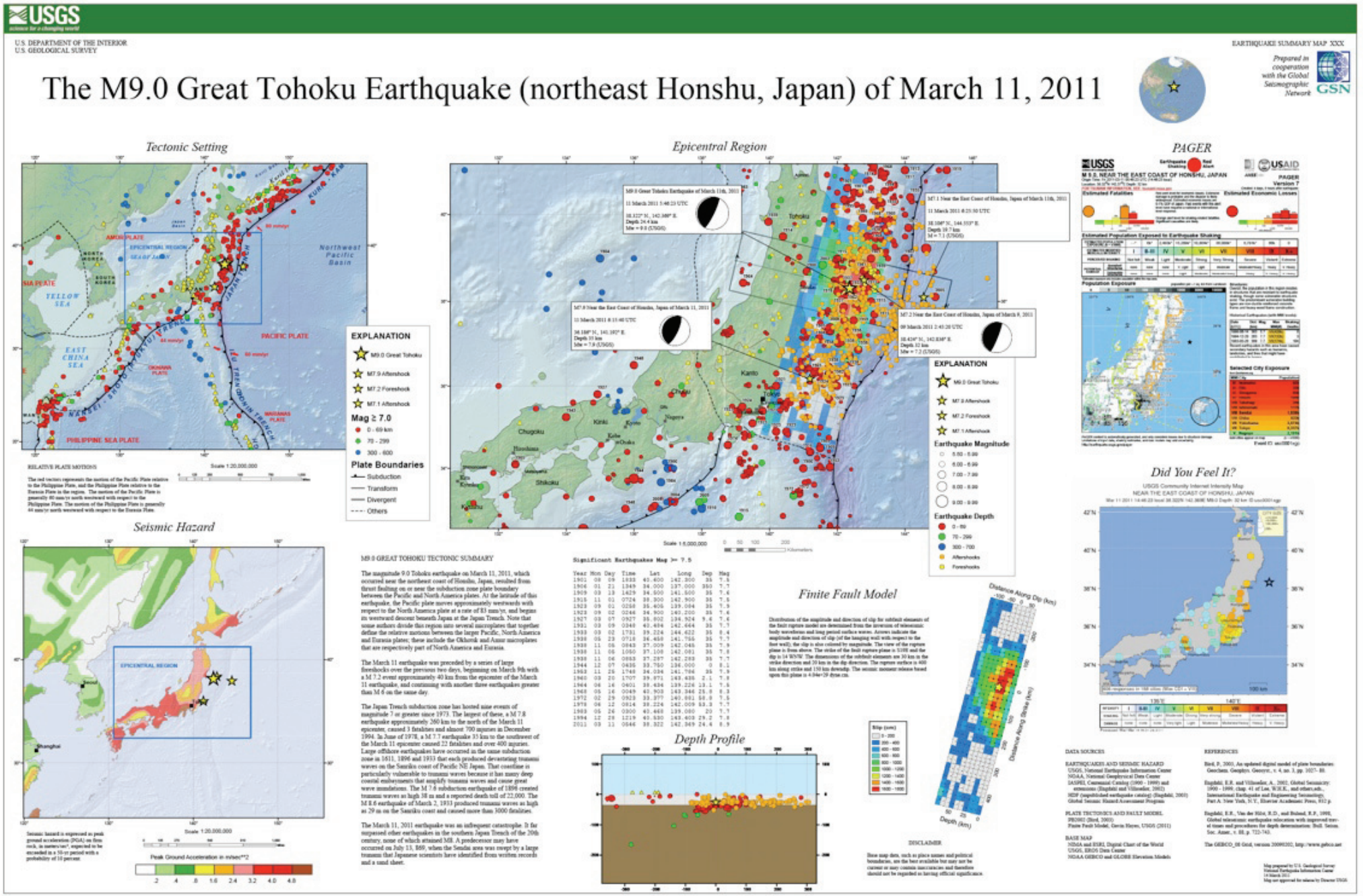
Profiles of earthquake and volcano locations are constructed from the mapped data. Locations of the profile intersection with the surface are drawn in the map and labeled to coincide with the profile label. Box defines extent of earthquakes included in profile. Length of the profile graphic is the same as in the map. Distance in kilometers from the trench axis is indicated in the X direction, depth in kilometers is indicated in the Y direction. There is no vertical exaggeration. See Explanation at side for color key. Not all earth layers, earthquake depths or magnitudes, are visible on every map.



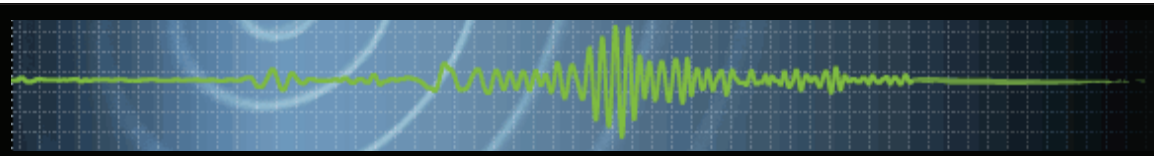
Tohoku, Japan Earthquake: Summary Poster
USGS V1 - 4.5 hrs after OT

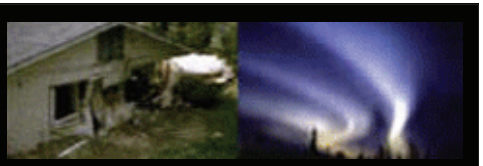


Tohoku, Japan Earthquake: Summary Poster
USGS Current Version



USGS science for a changing world





Web Traffic Statistics

Pageviews Visits

Graph by:

Graph Mode: One Metric | Compare Two Metrics | Compare to Site

- Visits
- Pageviews
- Pages/Visit
- Avg. Time on Site
- Bounce Rate
- % New Visits

Average – 400,000 visits/day & 1.5 million page views/day
Peak – 900,000 visits/day & 2.5 million page views/day

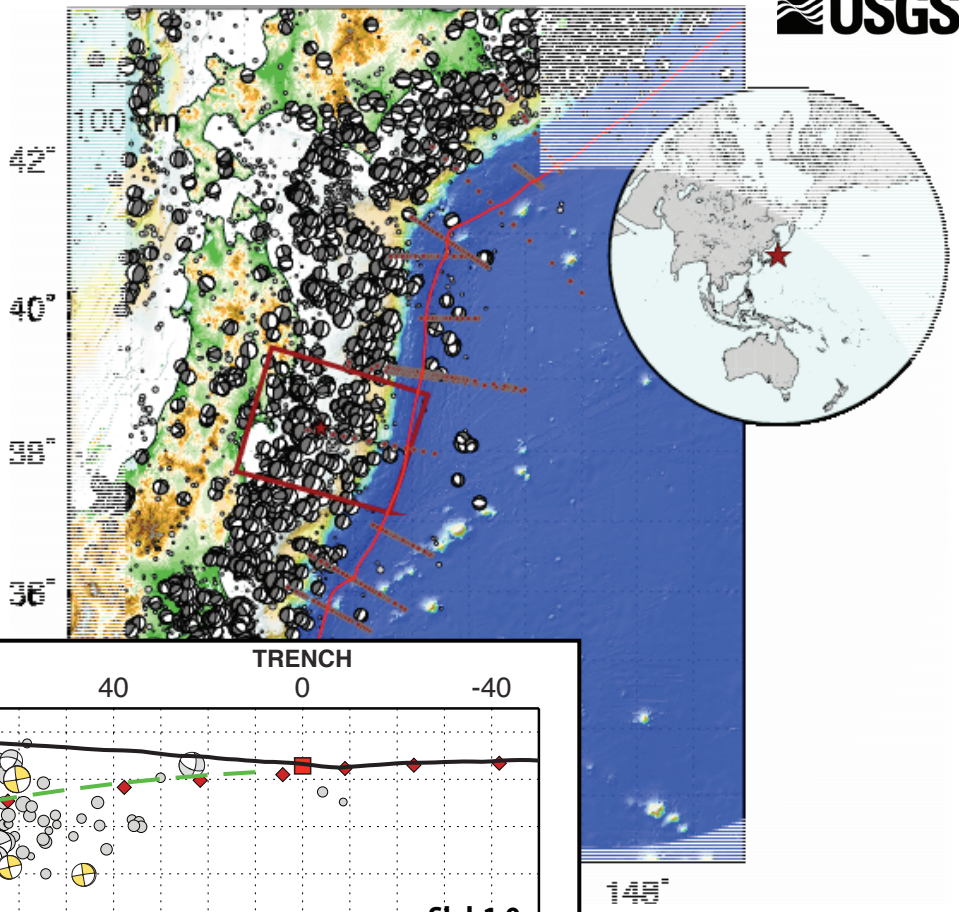
Christchurch (M6.1) NZ

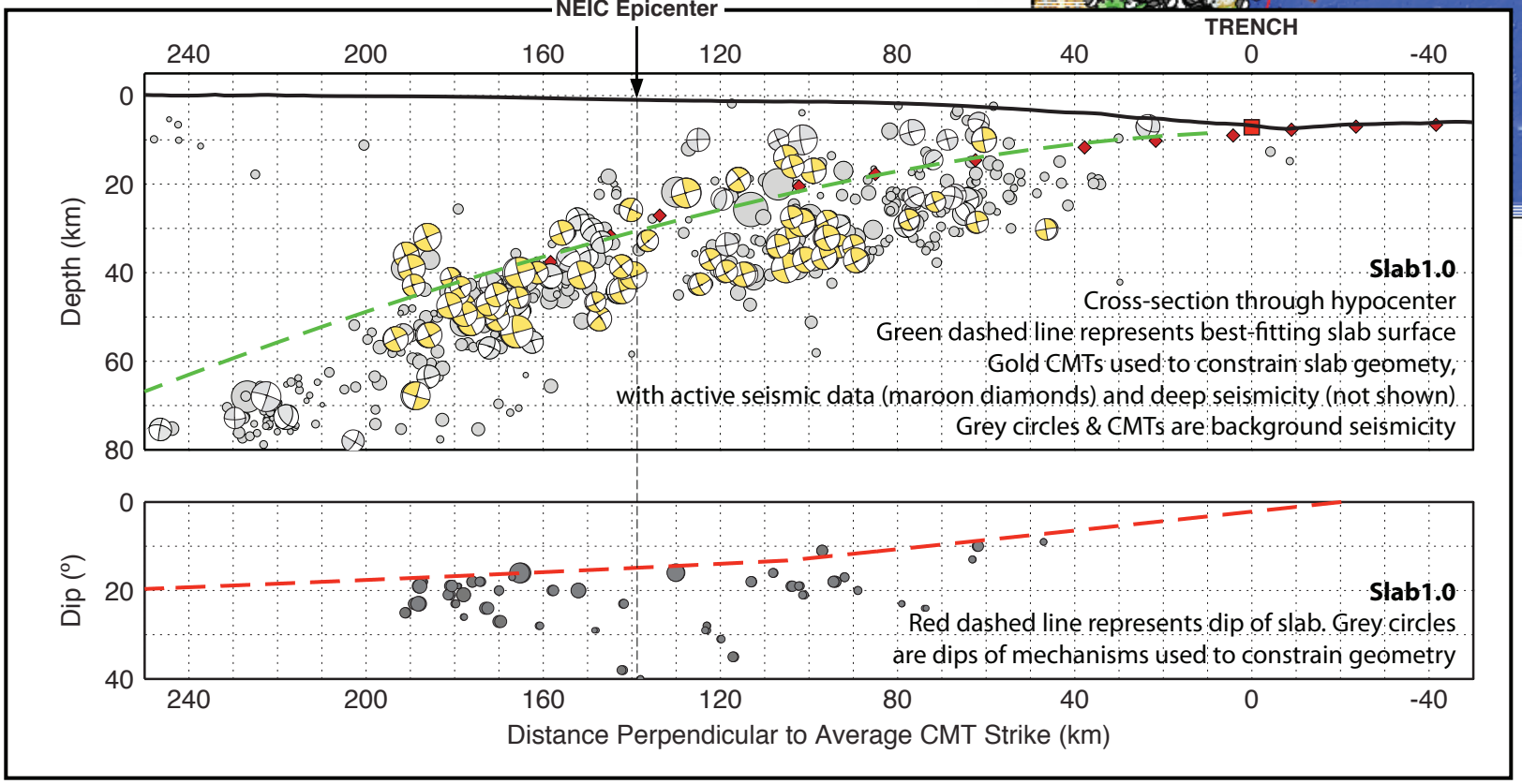
Tohoku (M9.0) JP

Site Usage

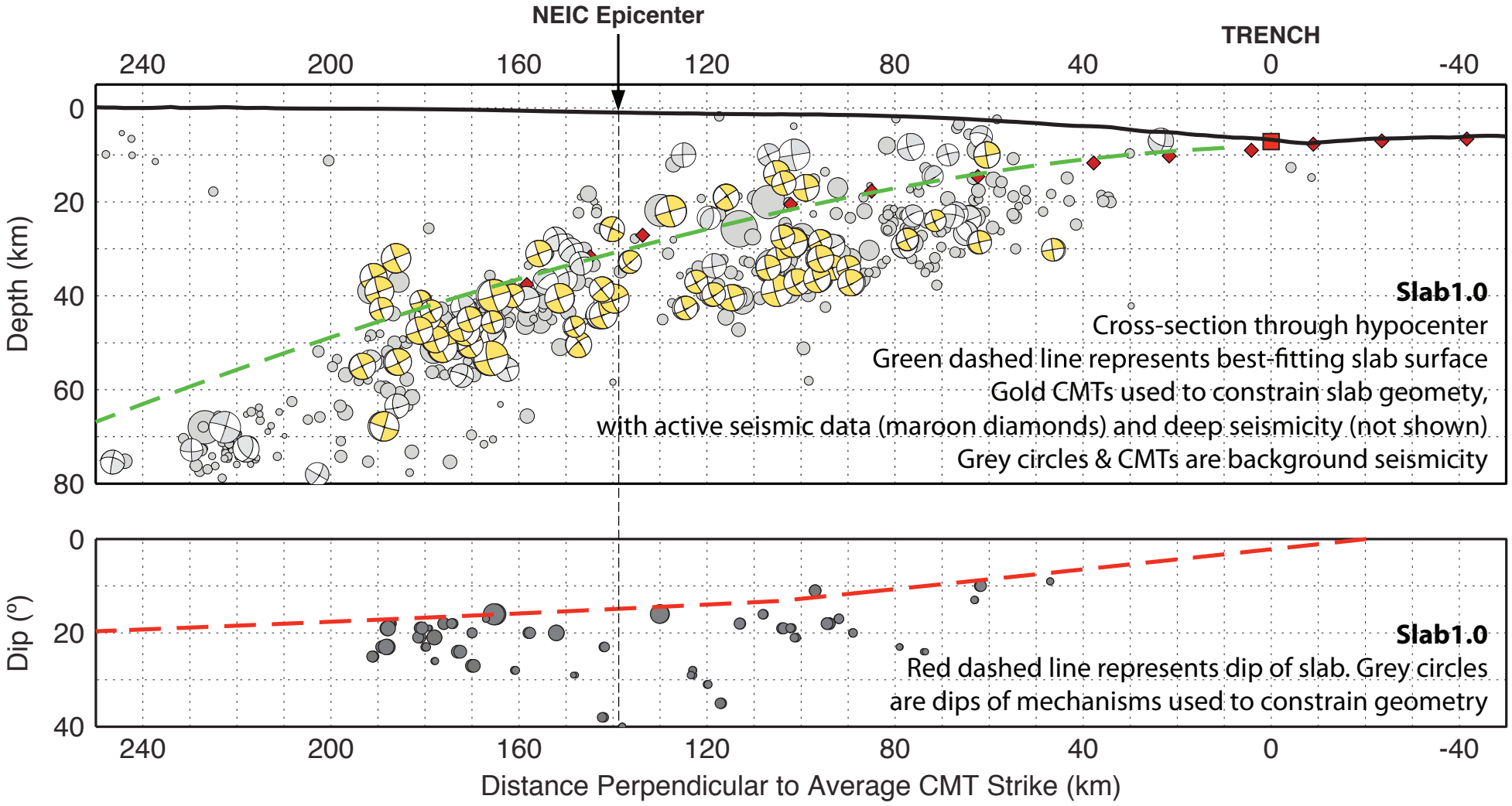
11,242,189 Visits	**51.33%** Bounce Rate
38,875,755 Pageviews	**00:02:46** Avg. Time on Site
3.46 Pages/Visit	**37.26%** % New Visits

Tohoku, Japan Earthquake: Source Region Slab Geometry

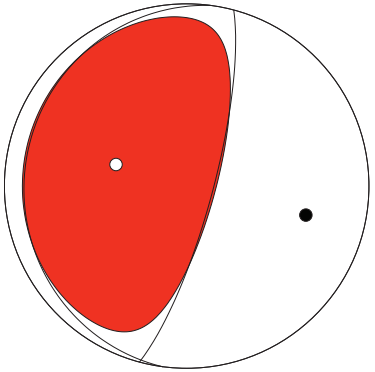




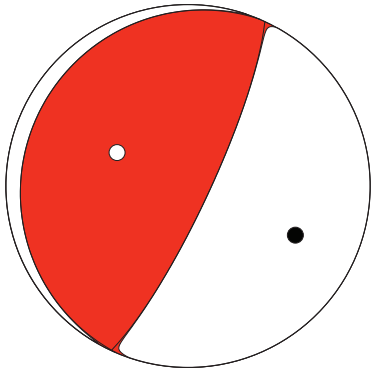
Tohoku, Japan Earthquake: Source Region Slab Geometry



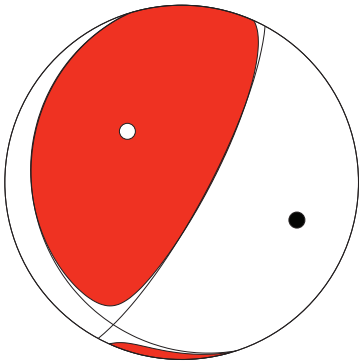
Tohoku, Japan Earthquake: Moment Tensor Solutions (Faulting Mechanisms)



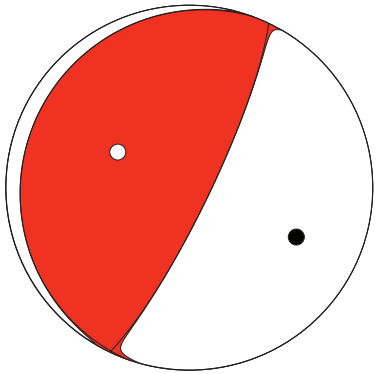
USGS Research Centroid Moment Tensor
Mw 8.9
Distributed ~34 minutes after OT
(Jascha Polet, Cal Poly Pomona)



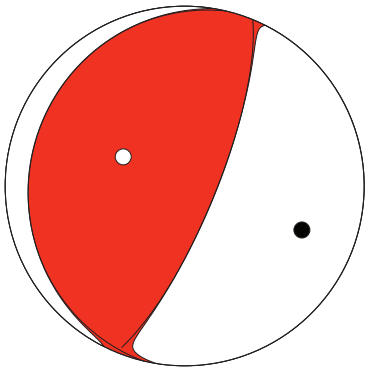
global Centroid Moment Tensor V1
Mw 9.1
Released 7 hrs after OT



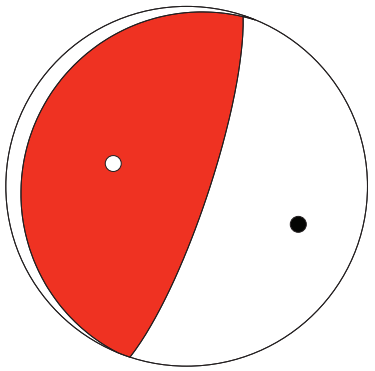
USGS W-Phase V1
Mw 8.9
Released 1 hr after OT



global Centroid Moment Tensor V2
Mw 9.1
Released ~ 3 days after OT

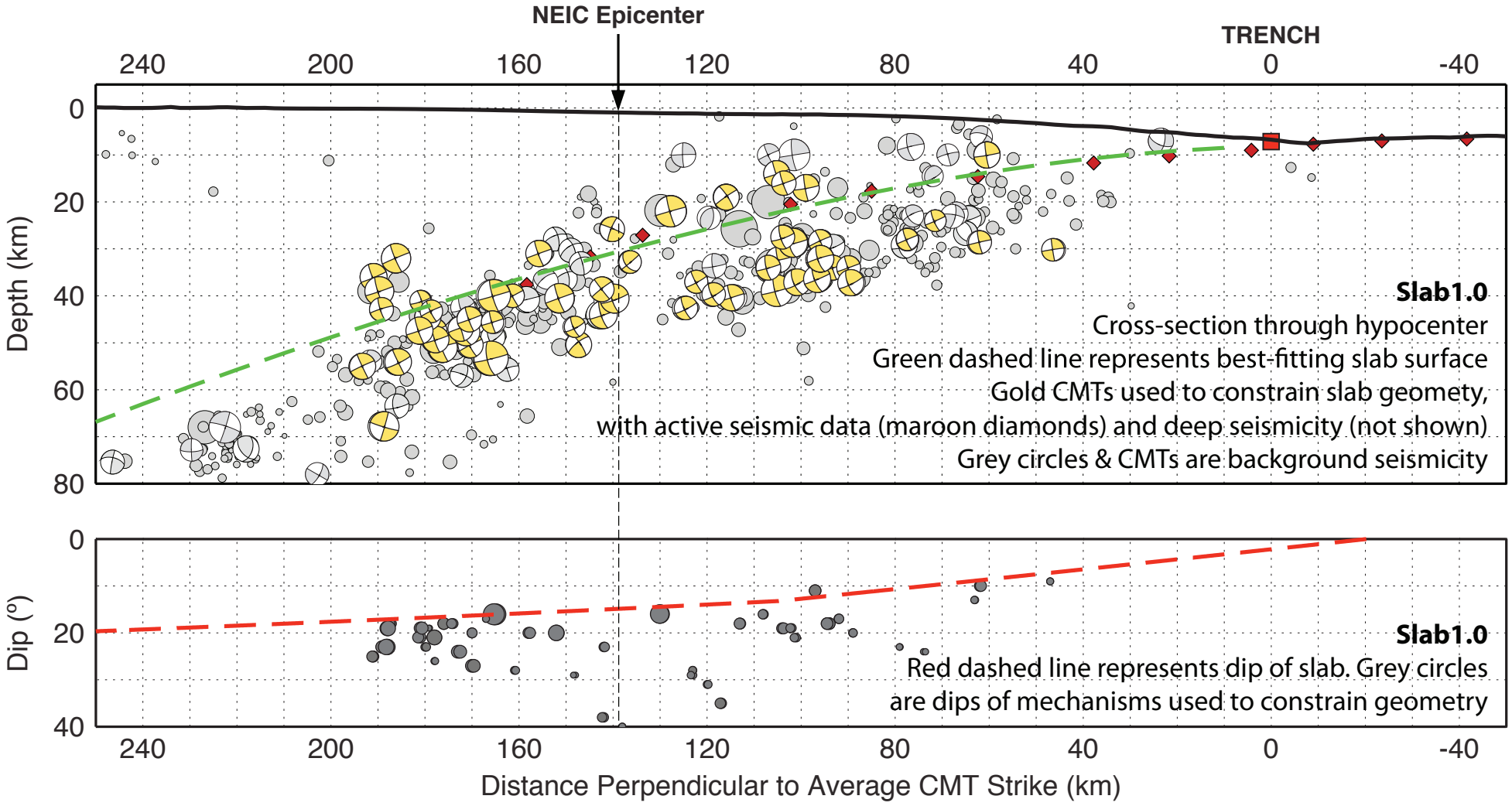


USGS W-Phase V2
Mw 9.0
Released 6 hrs after OT

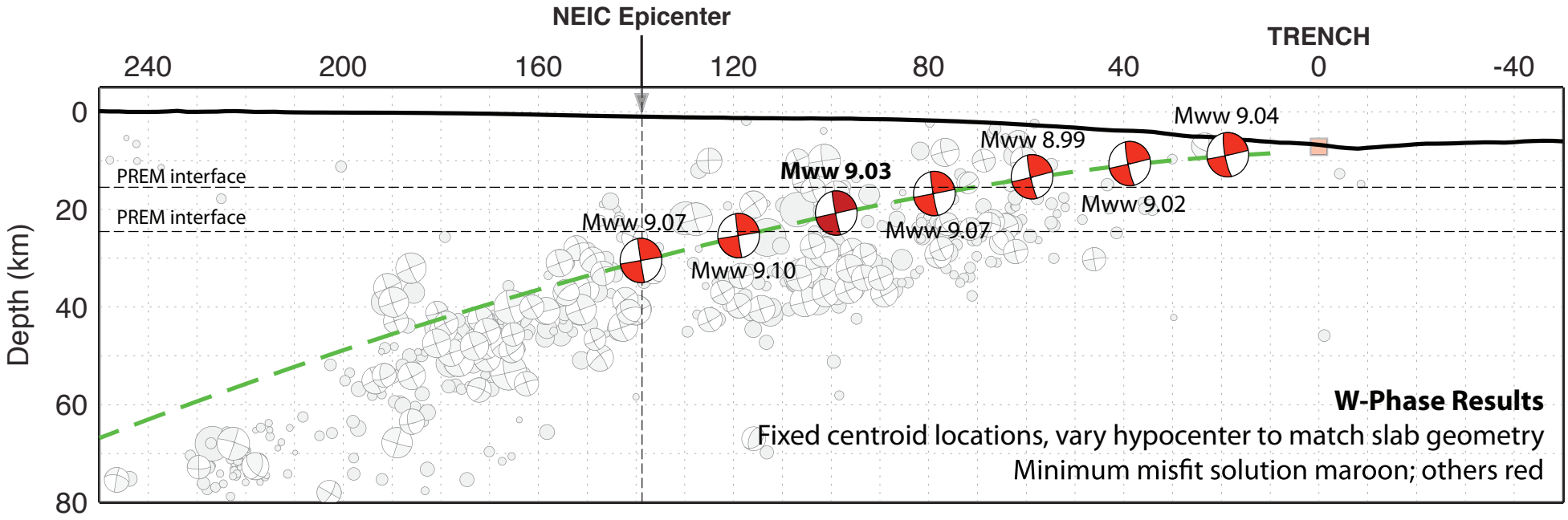


Earthquake Research Institute, Japan, CMT V1
Mw 9.0

Tohoku, Japan Earthquake: Source Region Slab Geometry



Tohoku, Japan Earthquake: Moment Tensor Analysis
Dip/Depth Sensitivity



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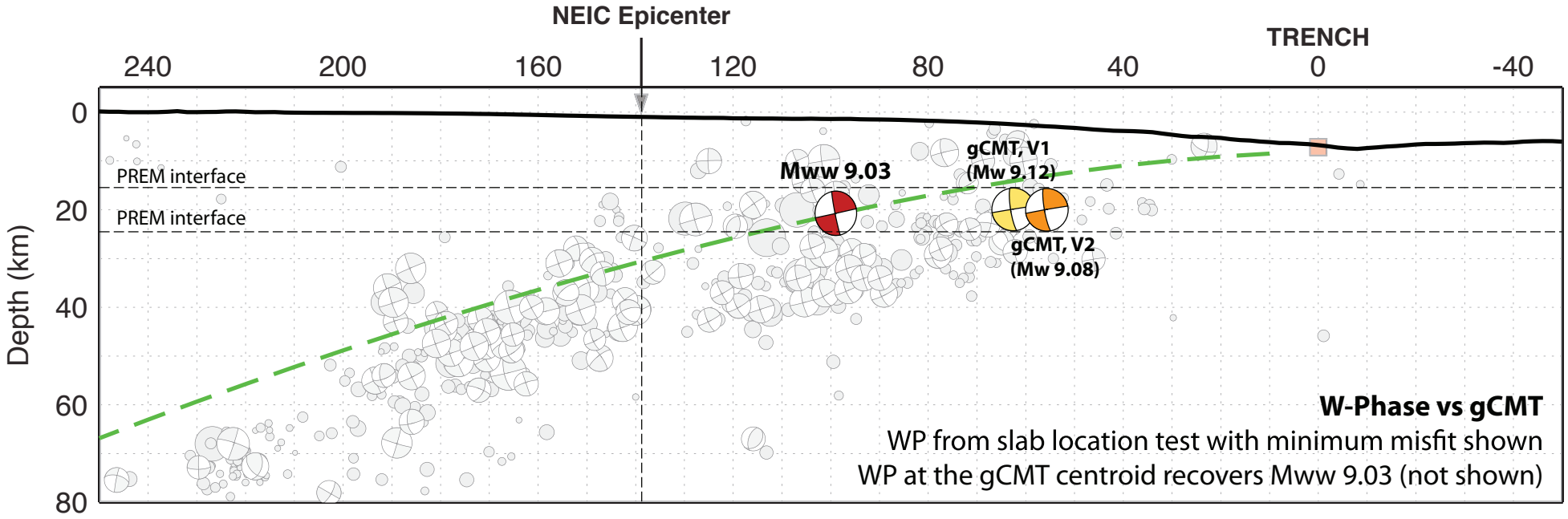

Tohoku, Japan Earthquake: Moment Tensor Analysis
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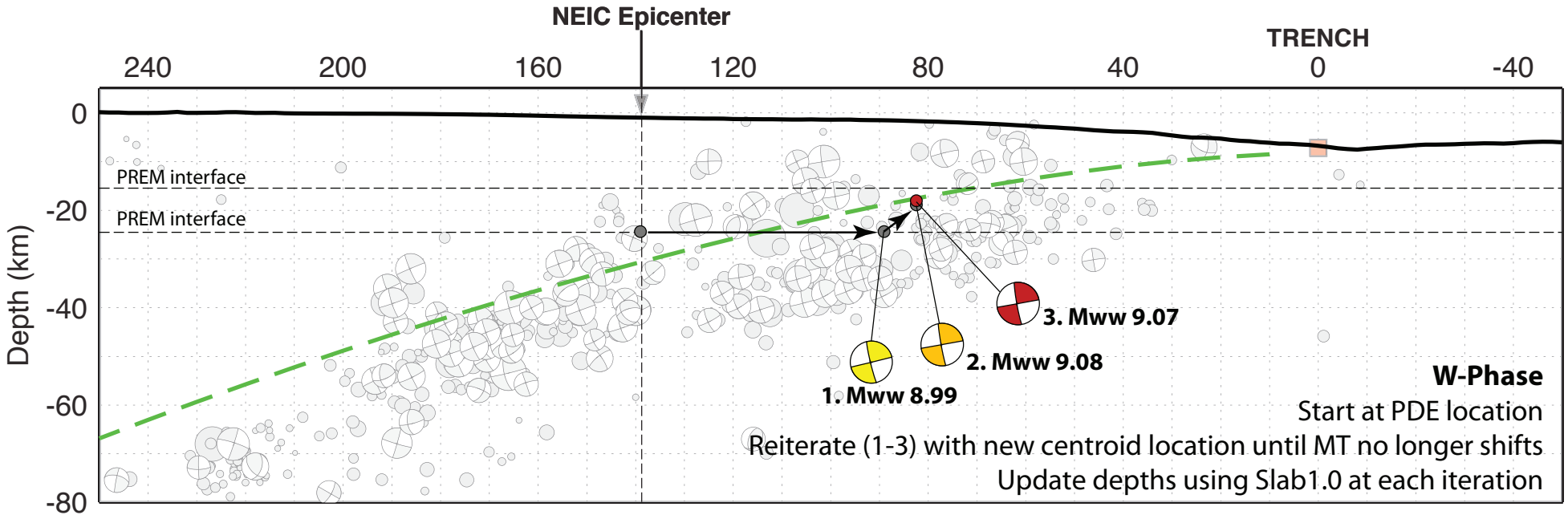
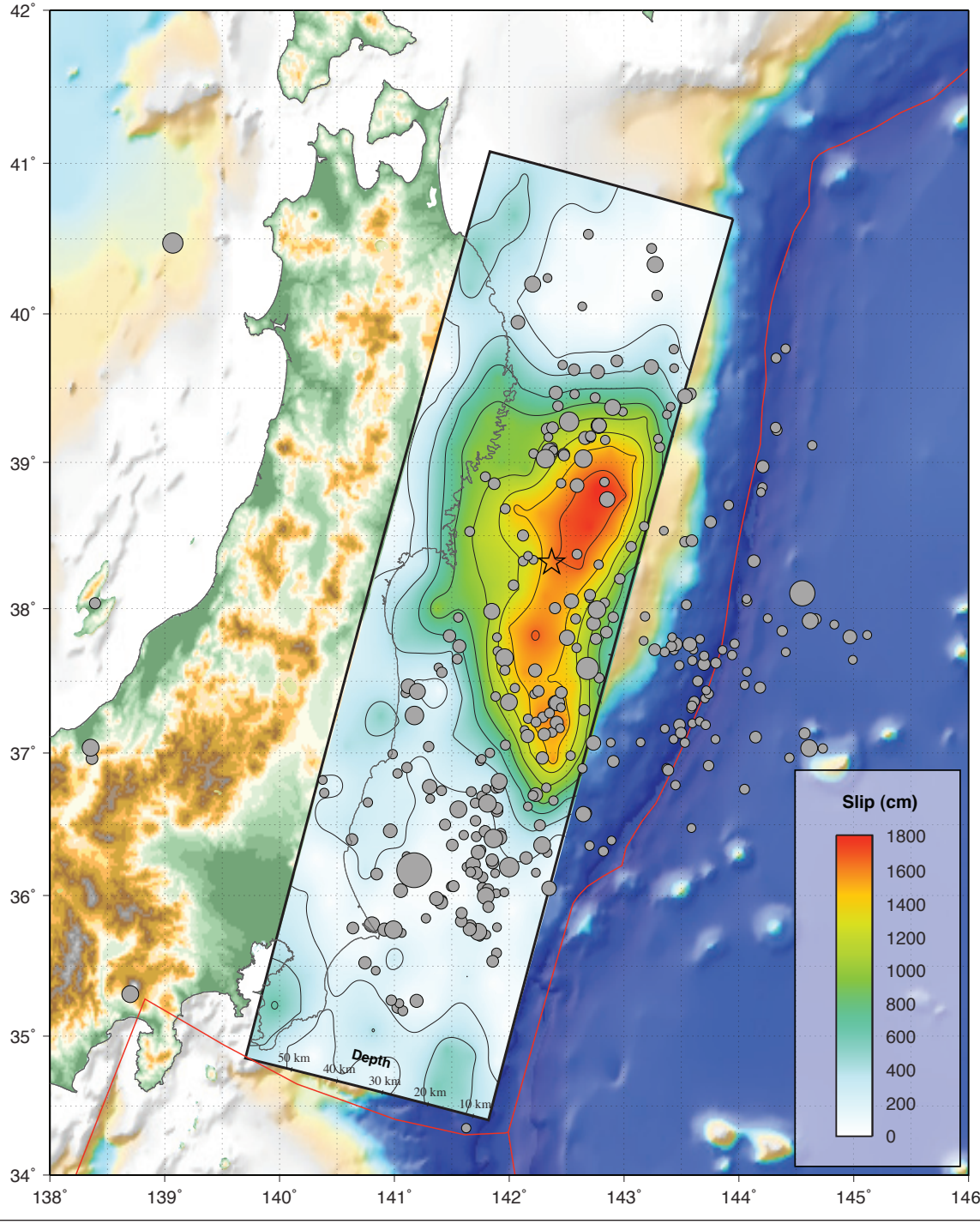


Tohoku, Japan Earthquake: Finite Fault Model
USGS V1 - 7 hrs after OT

Compact rupture, mostly bilateral about epicenter, peak slip up dip of hypocenter.

Rupture was likely restricted to the shallow trench, and GPS vectors suggest slip did not reach the plate boundary beneath the coastline.

Peak slips closer to 30+ m, inferred from updated modeling.



NATURE GEOSCIENCE DOI: 10.1038/NGEO421

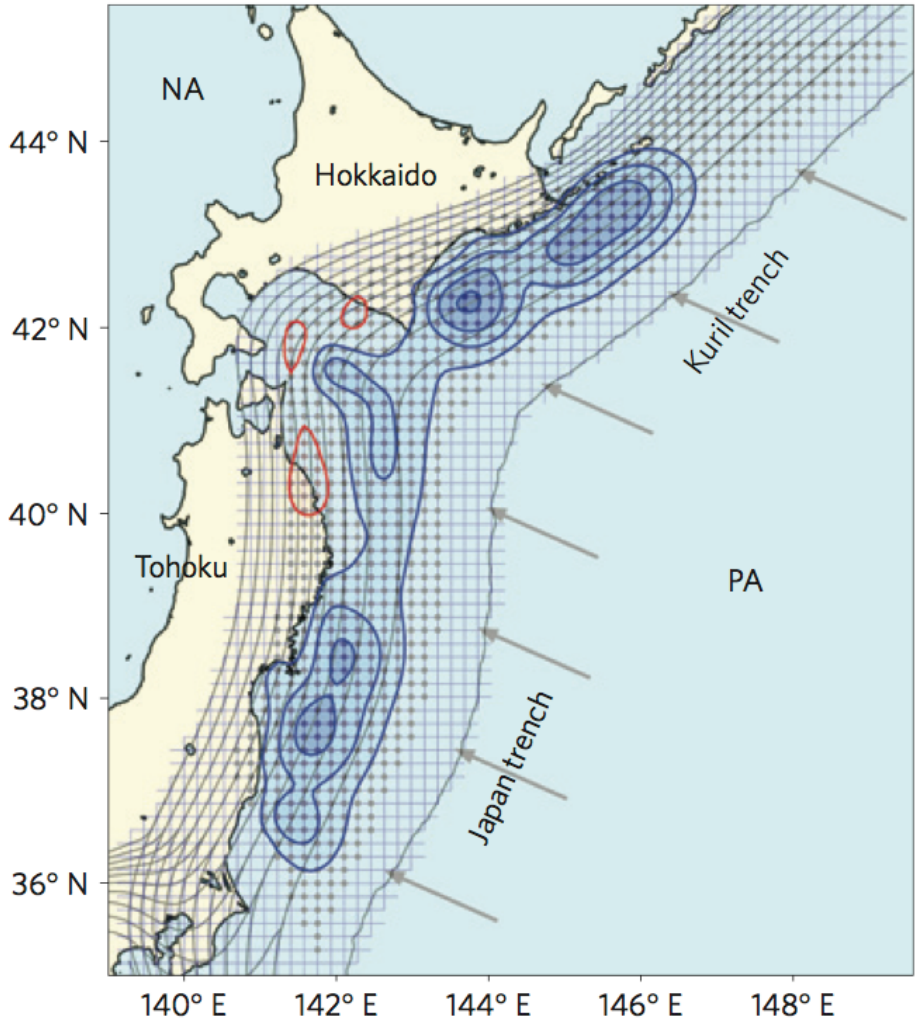
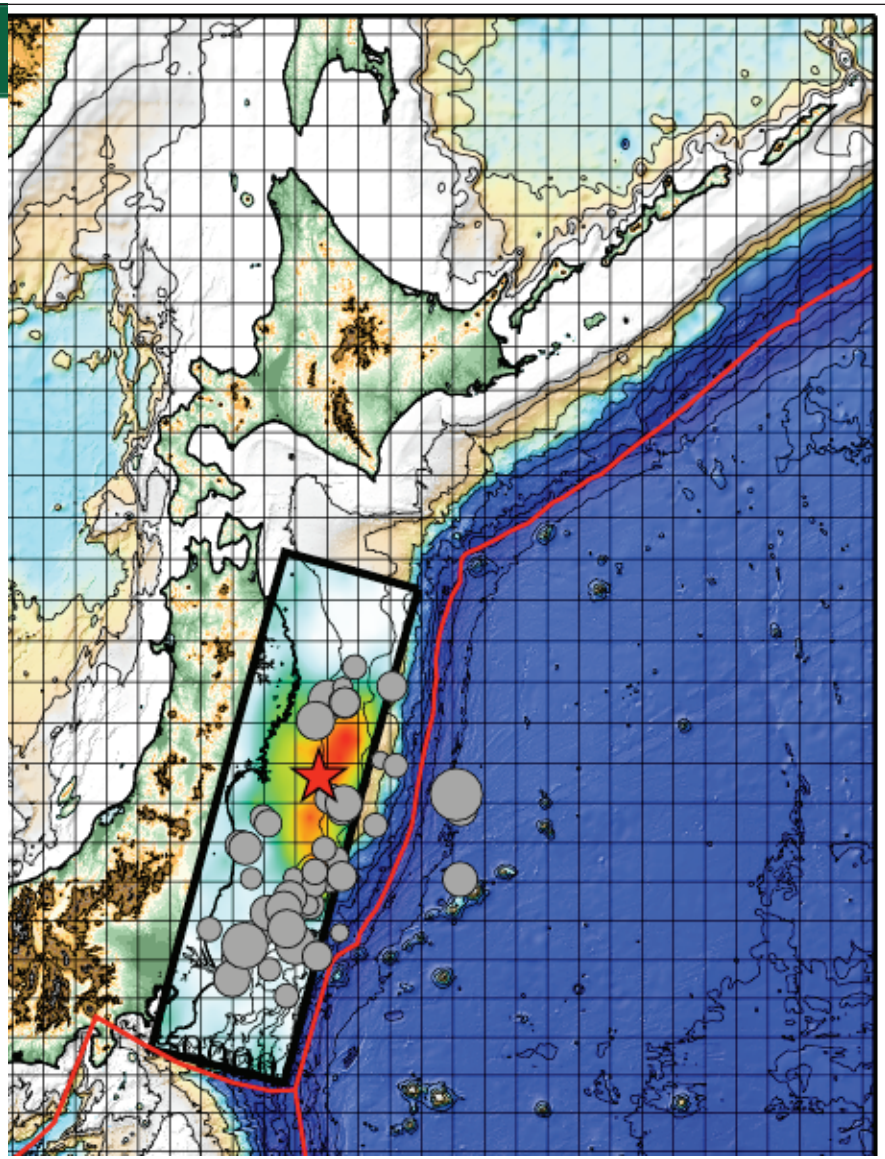


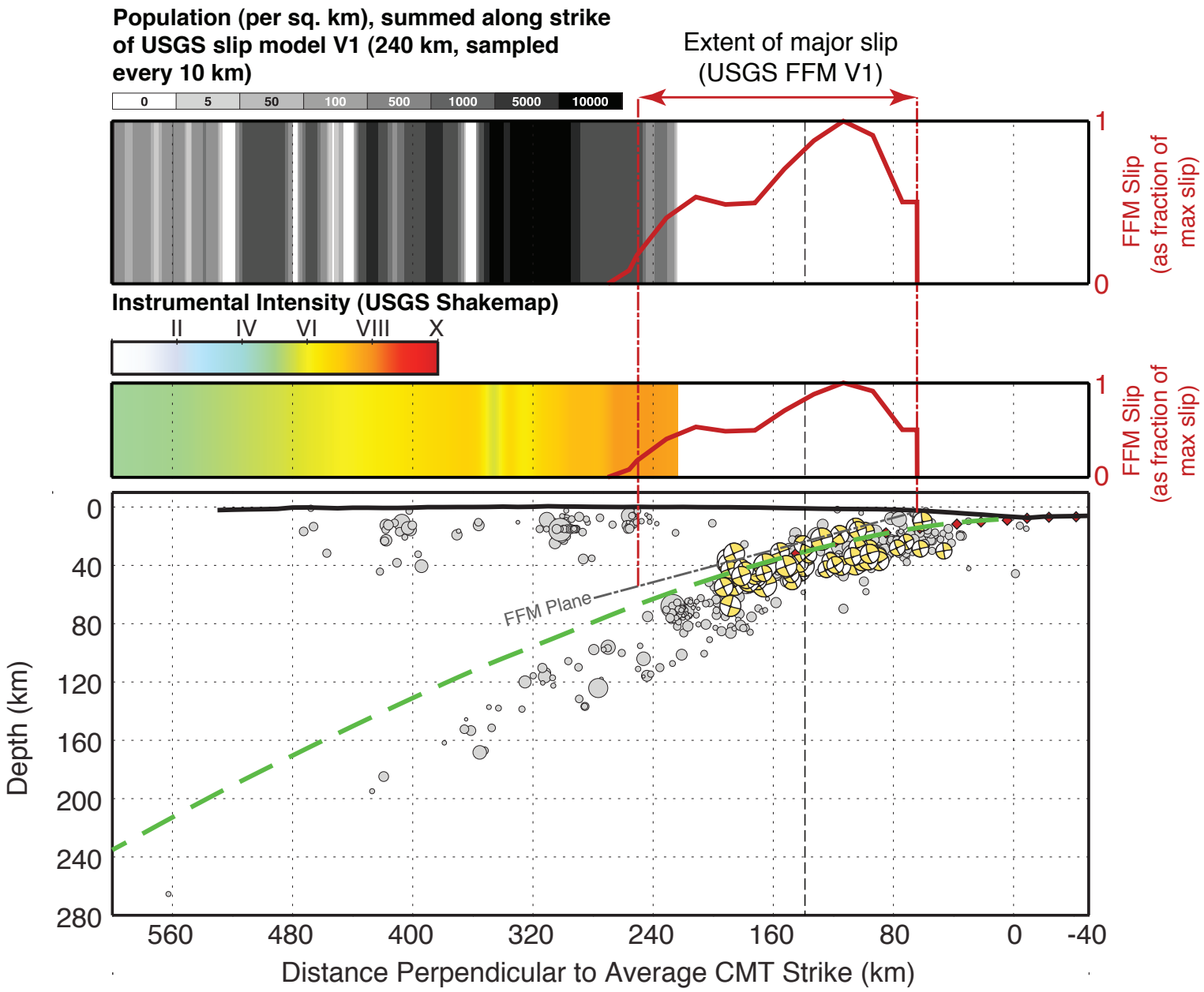
Figure 3 | Inverted slip-deficit rate distribution. The blue and red contours show, respectively, the inverted slip-deficit and slip-excess rates at intervals of 3 cm yr^{-1}. The grey dots indicate the central points of bi-cubic B-splines distributed on the North American/Pacific plate interface. The arrows indicate the relative plate motion calculated from NUVEL-1A (ref. 18).



Finite Fault Model USGS V1 - Comparison with locking estimates (Hashimoto et al. , 2009, Nat. Geo.)

USGS

Tohoku, Japan Earthquake: Population Exposure & Shaking Intensities vs Slab Geometry & Slip Extent



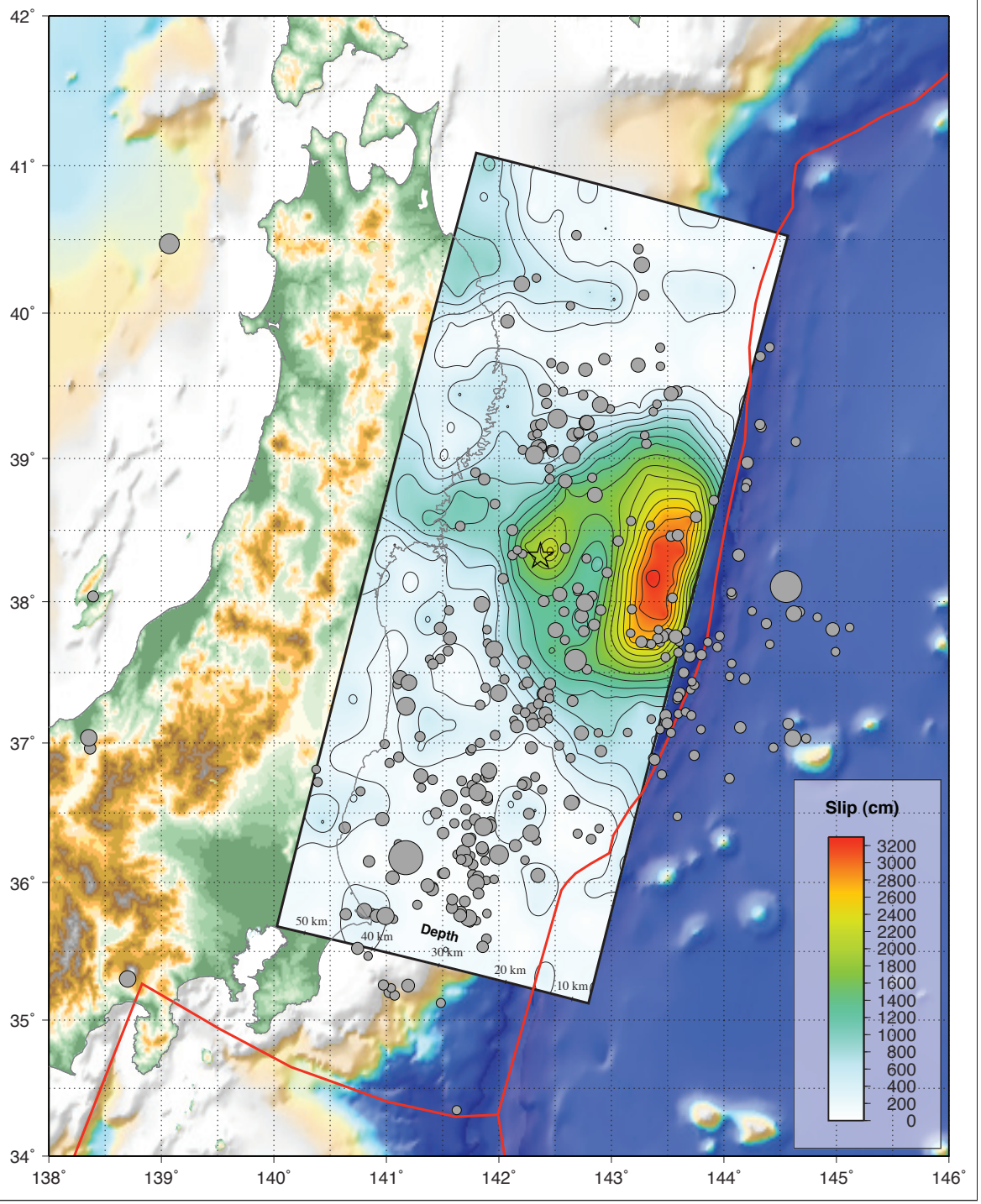
Note that slip during the earthquake likely did not extend to the depths of the plate boundary directly under the Japan coastline as shown here, because GPS data indicate that the coastline moved down coseismically.

Tohoku, Japan Earthquake: Finite Fault Model
USGS V2 - 2011/03/18

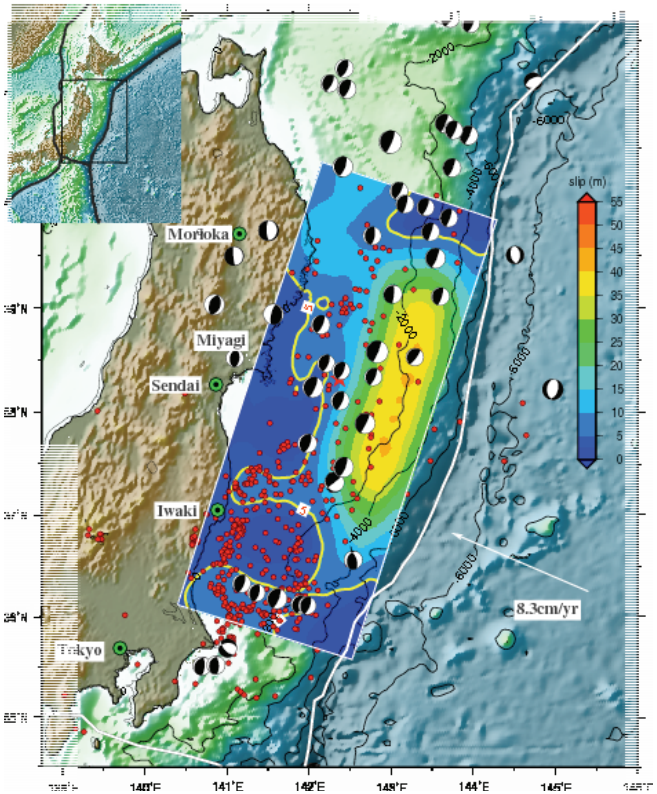
Updated modeling shows peak slips of 30+ m, depending on the parameterization of rupture velocity. This updated model shows peak slip of ~32 m, using a range of rupture velocity from 1.25 - 3 km/s.

Models with constant rupture velocity show slips of 40-50 m, all at shallow depths. This may imply that the up-dip nature of rupture is well resolved, but peak slips are not.

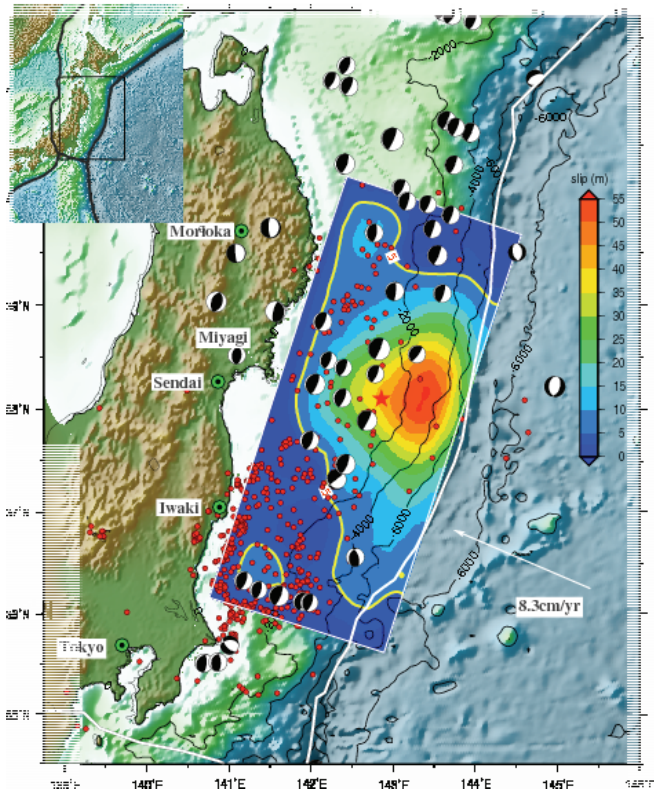
'Low' slip regions near the fault edges, and fault base, are also poorly resolved.



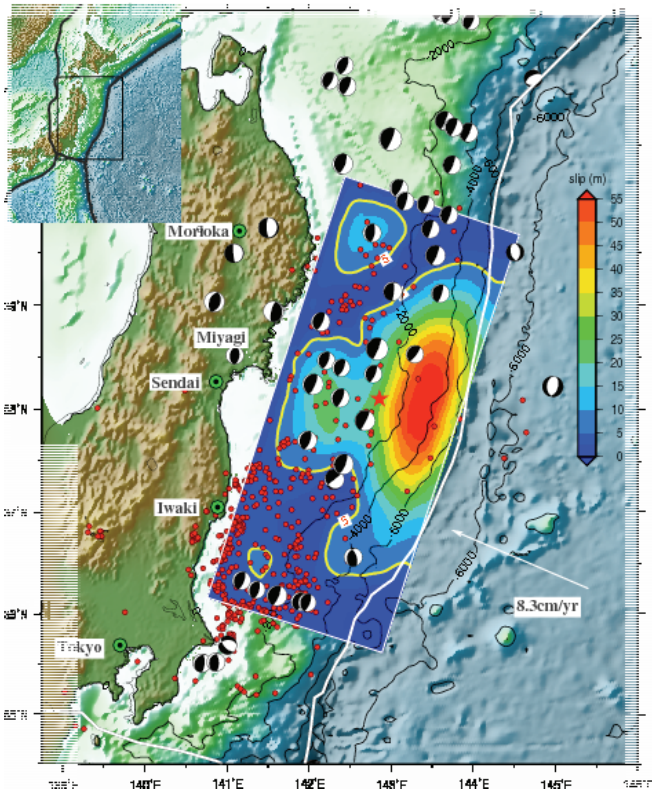
Tohoku, Japan Earthquake: Finite Fault Model
U. California, Santa Barbara



Version 1
NEIC Hypocenter



Version 2
JMA Hypocenter
(50 km ESE)



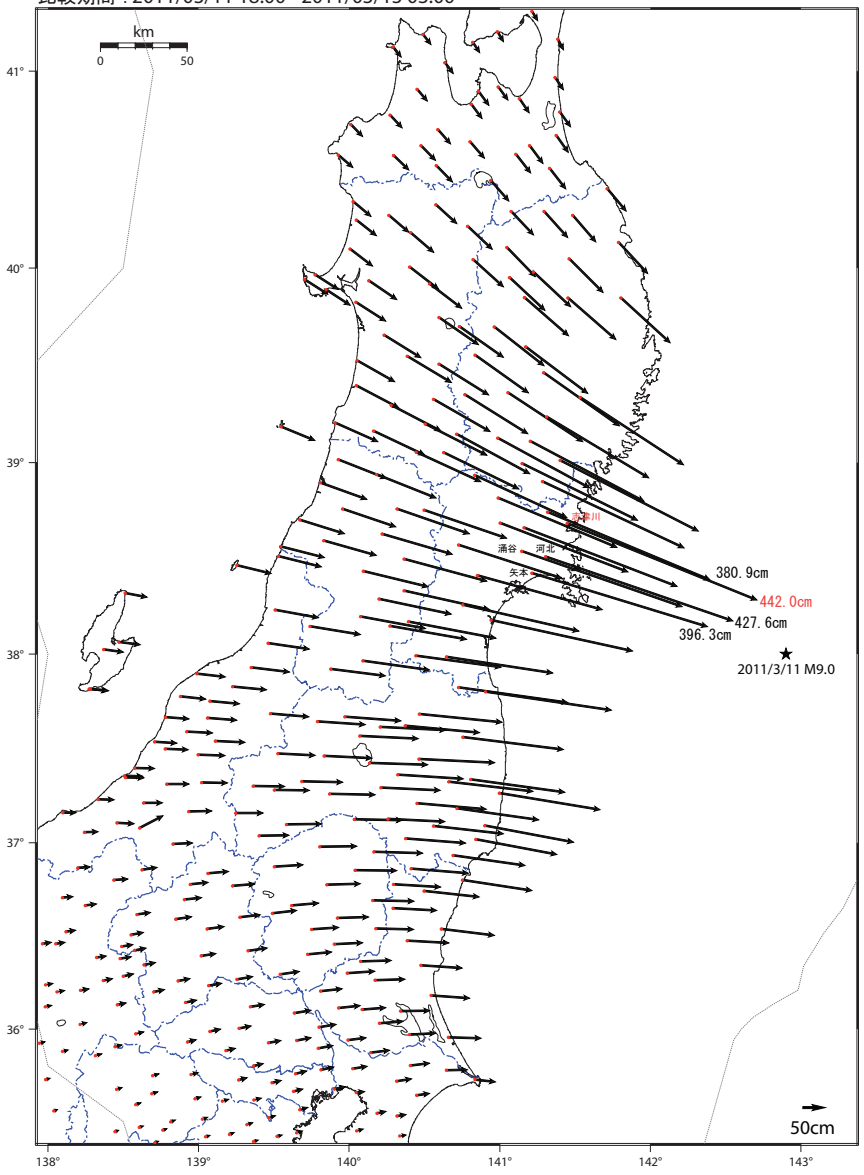
Version 3
Body & Surface Waves
realigned using the
03/09/2011 Mw 7.3
foreshock.

Figures courtesy of Guangfu Shao, U. California, Santa Barbara

Tohoku, Japan Earthquake: GPS Displacements
Geospatial Information Authority of Japan

変動ベクトル図（水平） 暫定

基準期間：2011/03/01 21:00 - 2011/03/09 21:00
比較期間：2011/03/11 18:00 - 2011/03/13 03:00



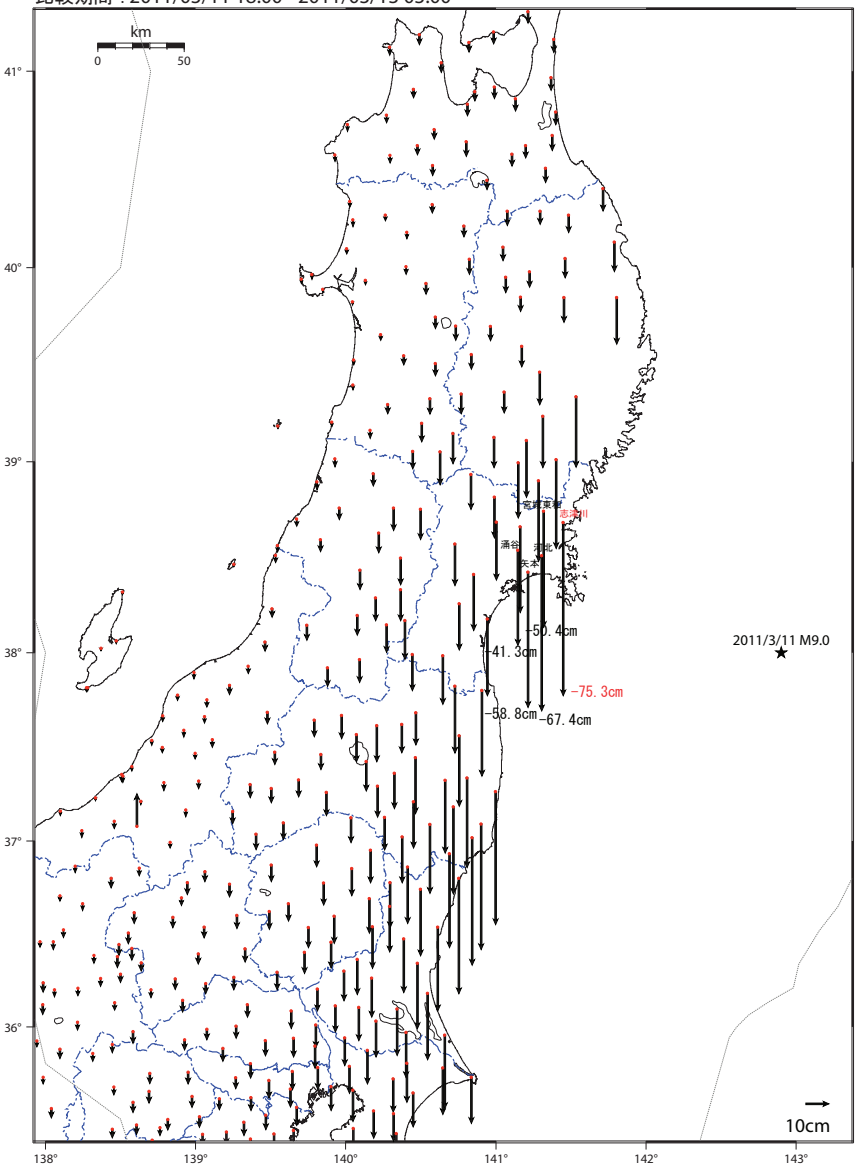
［基準：Ｒ３速報解　比較：Ｑ３迅速解］

☆固定局：三隅（９５０３８８）

国土地理院

変動ベクトル図（上下） 暫定

基準期間：2011/03/01 21:00 - 2011/03/09 21:00
比較期間：2011/03/11 18:00 - 2011/03/13 03:00



［基準：Ｒ３速報解　比較：Ｑ３迅速解］

☆固定局：三隅（９５０３８８）

国土地理院

Tohoku, Japan Earthquake: Other Groups

Many groups have published (online) slip models for this earthquake; below is a list of some of these (note this is not complete):

Geospatial Information Authority, Japan (using regional GPS data):
http://www.gsi.go.jp/cais/topic110315-index-e.html

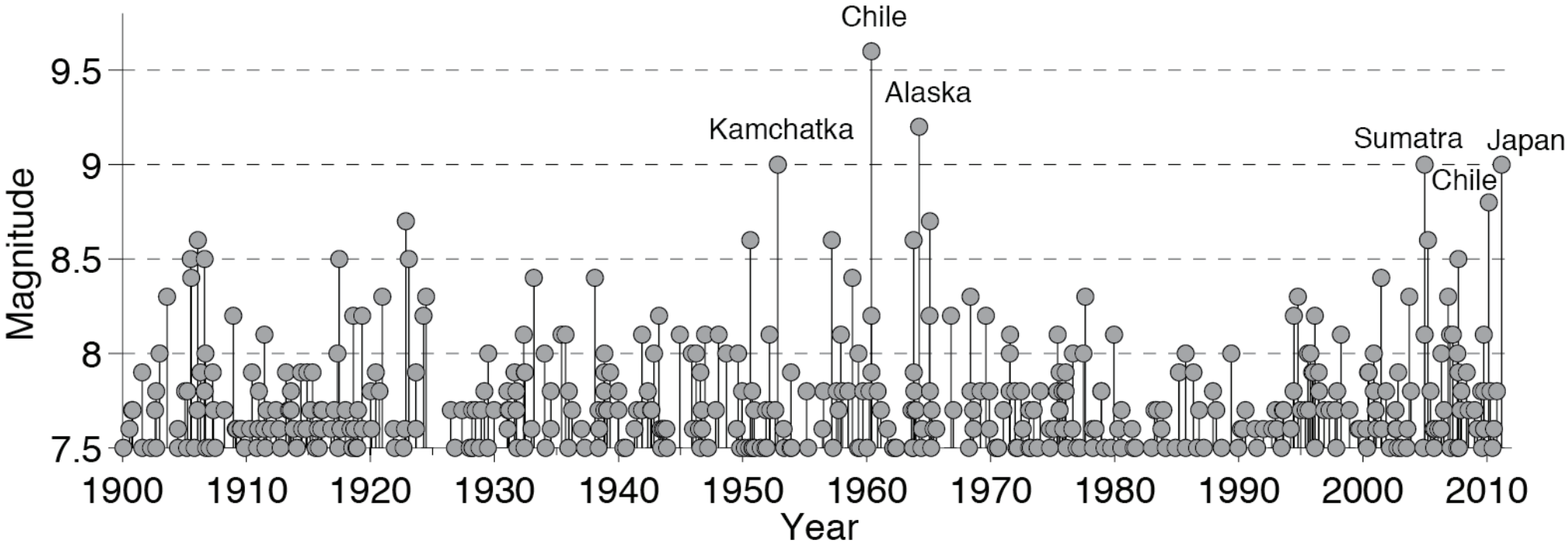
Charles Ammon, Penn State; Thorne Lay, UCSC; Hiroo Kanamori, Caltech:
http://eqseis.geosc.psu.edu/~cammon/Japan2011EQ/

Caltech Tectonics Observatory:
http://tectonics.caltech.edu/slip_history/

Yuji Yagi, Naoki Nishimura, University of Tsukuba:
http://www.geol.tsukuba.ac.jp/~yagi-y/EQ/Tohoku/

For a more comprehensive list of models, and results from other analyses, see the special IRIS website:
http://www.iris.edu/news/events/japan2011/

A History Of Large Earthquakes



Data: USGS PAGERCAT 1900-2008, USGS-NEIC & gCMT 2008-present

Figure courtesy of Charles Ammon, after Ammon et al., SRL, 2010