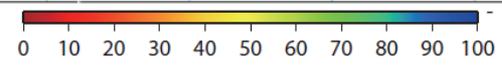
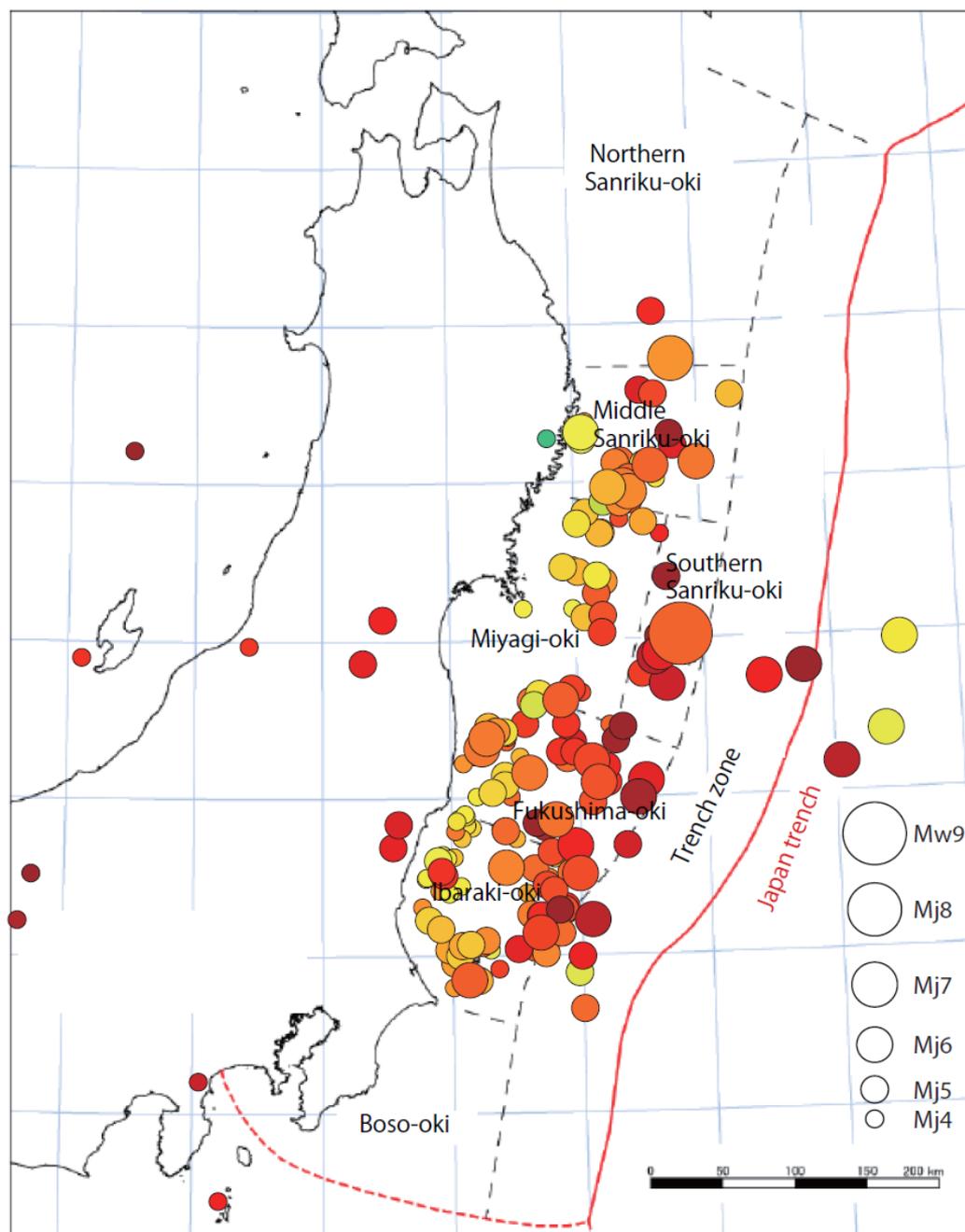


2011年東北地方太平洋沖地震の
強震動生成のための震源モデル
(2011年8月17日修正版)

Source Model for Generating Strong Ground Motions
during the 11 March 2011 off Tohoku, Japan Earthquake
(Revised on August 17, 2011)

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愛知工業大学地域防災研究センター

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Aichi Institute of Technology Disaster Prevention Research Center



- Mw9
- Mj8
- Mj7
- Mj6
- Mj5
- Mj4

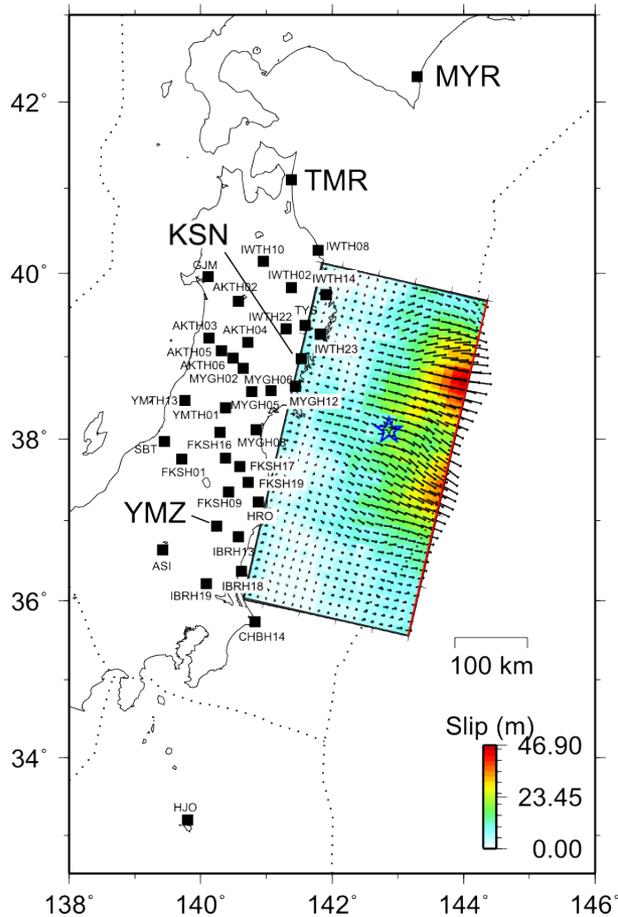
Rupture Process of the 11 March 2011 off Tohoku, Japan Earthquake

1. Slip and Moment-Rate Distribution inverted from Long Period Ground Motions
After Yoshida, Miyakoshi, Irikura and Petukhin (2011)
200 s to 20 s in period (0.005 Hz to 0.05 Hz in frequency)
Using F-net and K-net data by NIED
2. Tsunami Simulation for the 2011 Tohoku Earthquake Using Long-period Source Model
After Petukhin, Yoshida, Miyakoshi, and Irikura (2011)
Tsunami simulation using slip 200 s to 20 s in period
3. Strong Motion Generation Areas (SMGA) from Short Period Ground Motions
After Irikura and Kurahashi (2011)
Simulation of acceleration and velocity waveforms using the empirical Green's function method

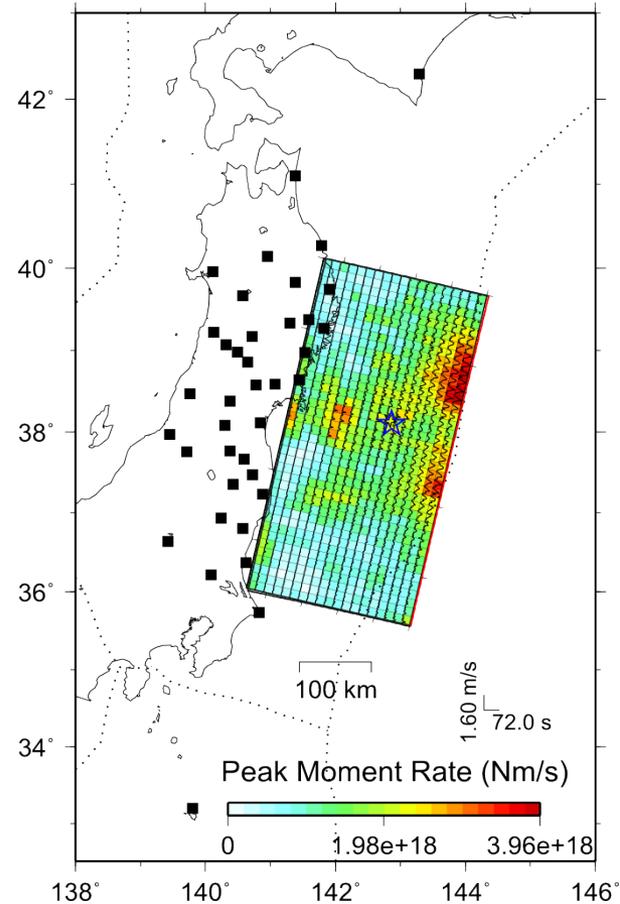
1. Slip and Moment-Rate Distribution inverted from Long Period Ground Motions

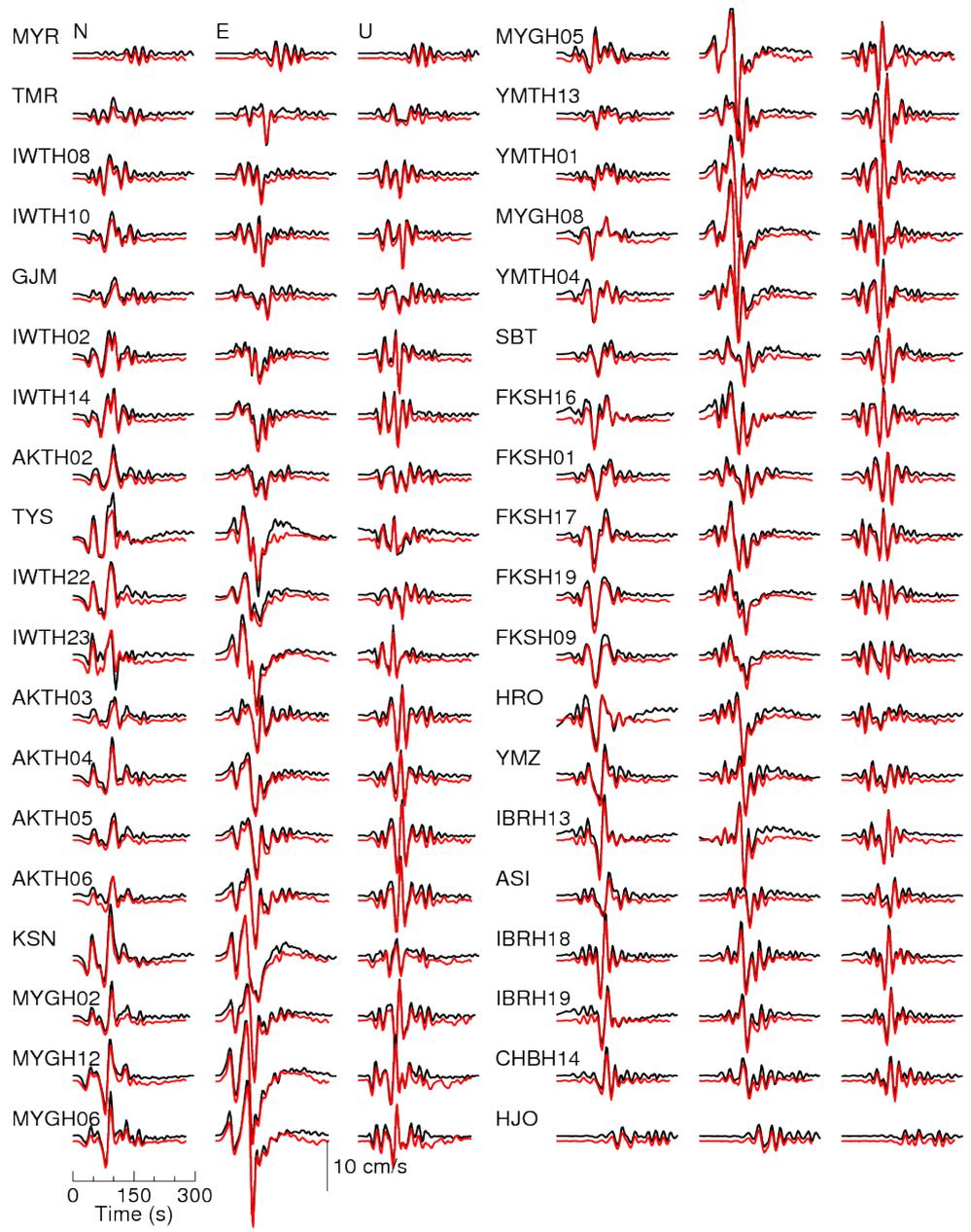
After Yoshida, Miyakoshi, Irikura and Petukhin (2011)

Final slip distribution



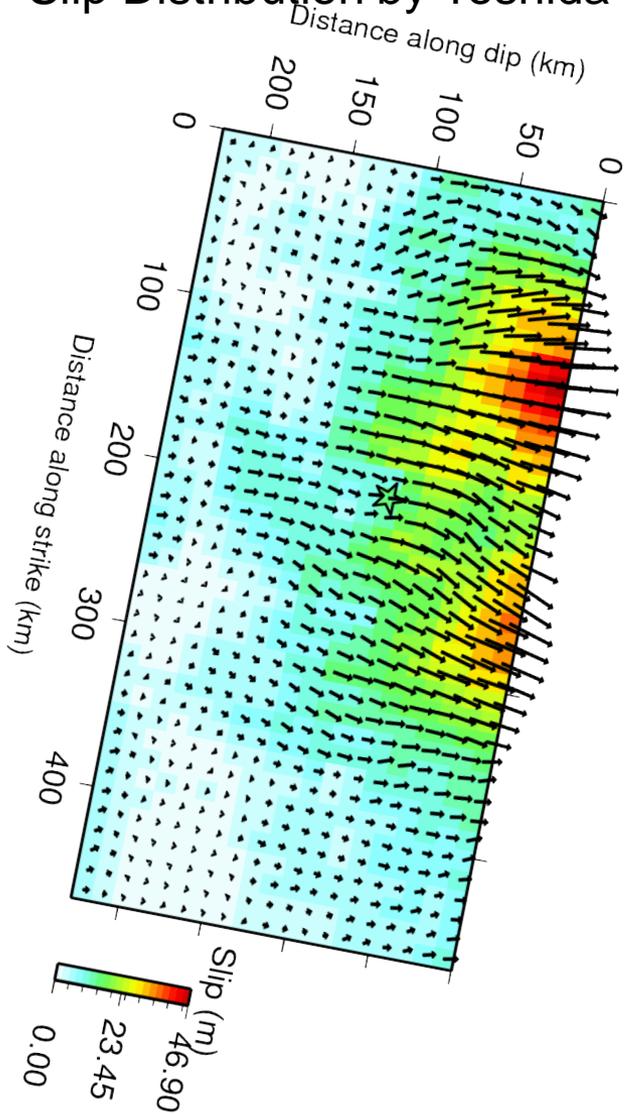
Moment rate function



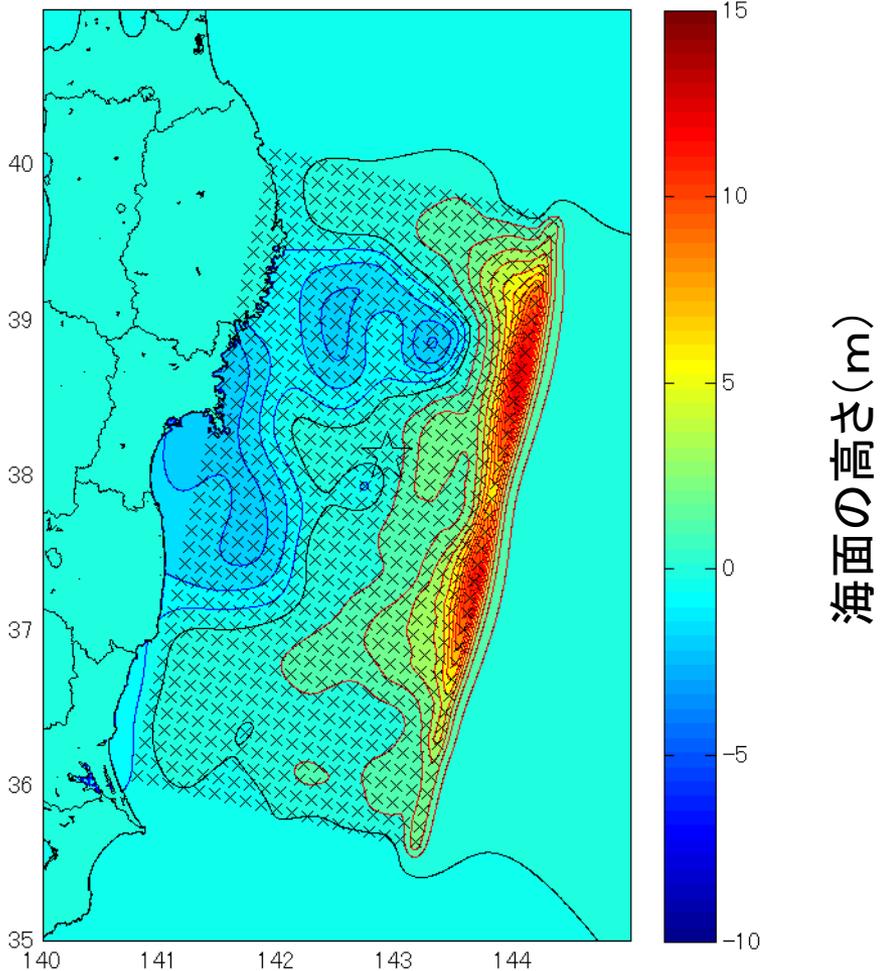


2. Tsunami Simulation Using Long-period Source Model from 20 to 200 sec. After Petukhin, Yoshida, Miyakoshi, and Irikura (2011)

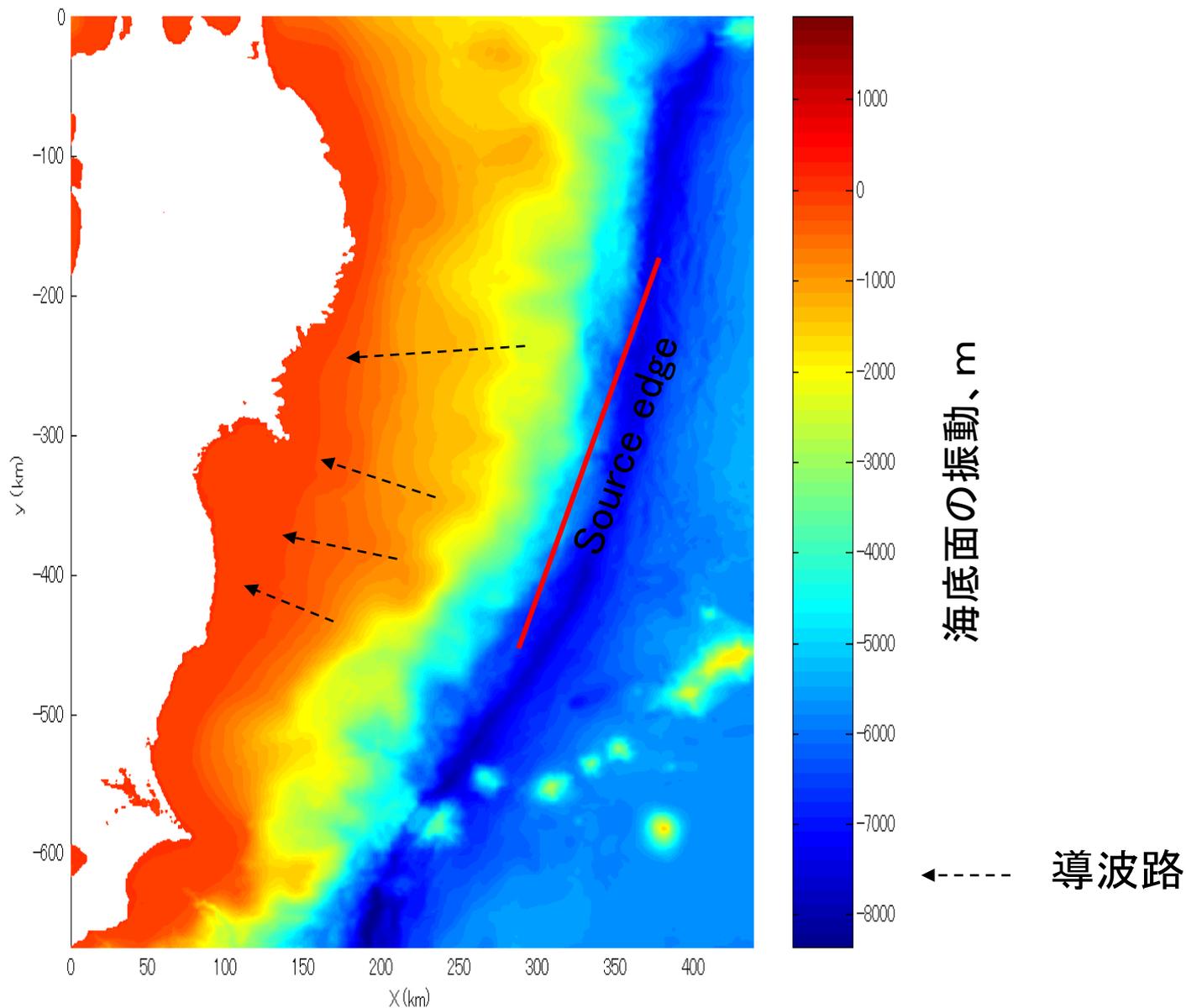
Slip Distribution by Yoshida



Height of Sea Surface

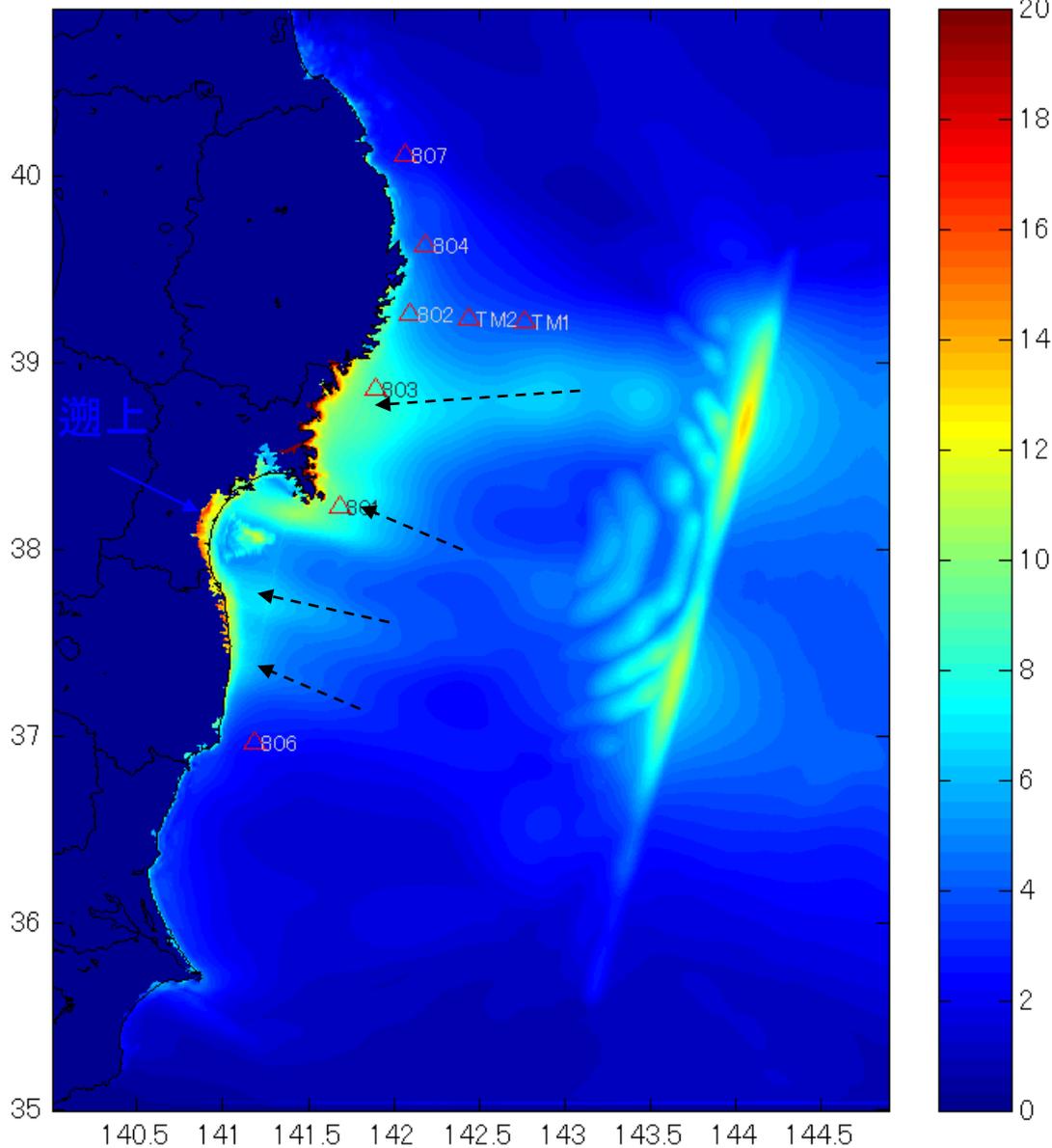


対象領域におけるJ-EGG500mのデータ



津波の波高分布

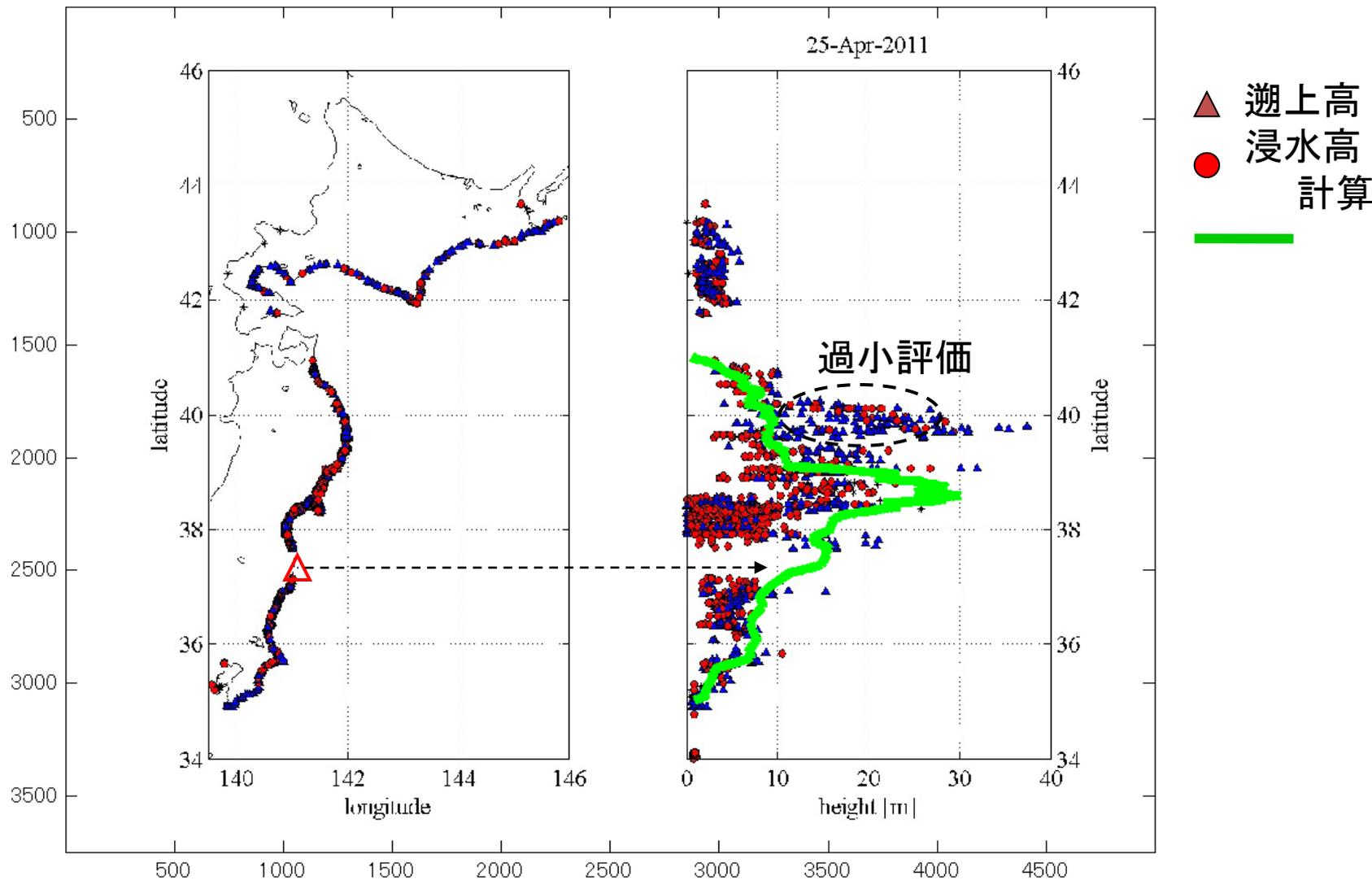
Tsunami peak amplitudes, m



津波最大高さ(m)

←----- 導波路による
波の増加

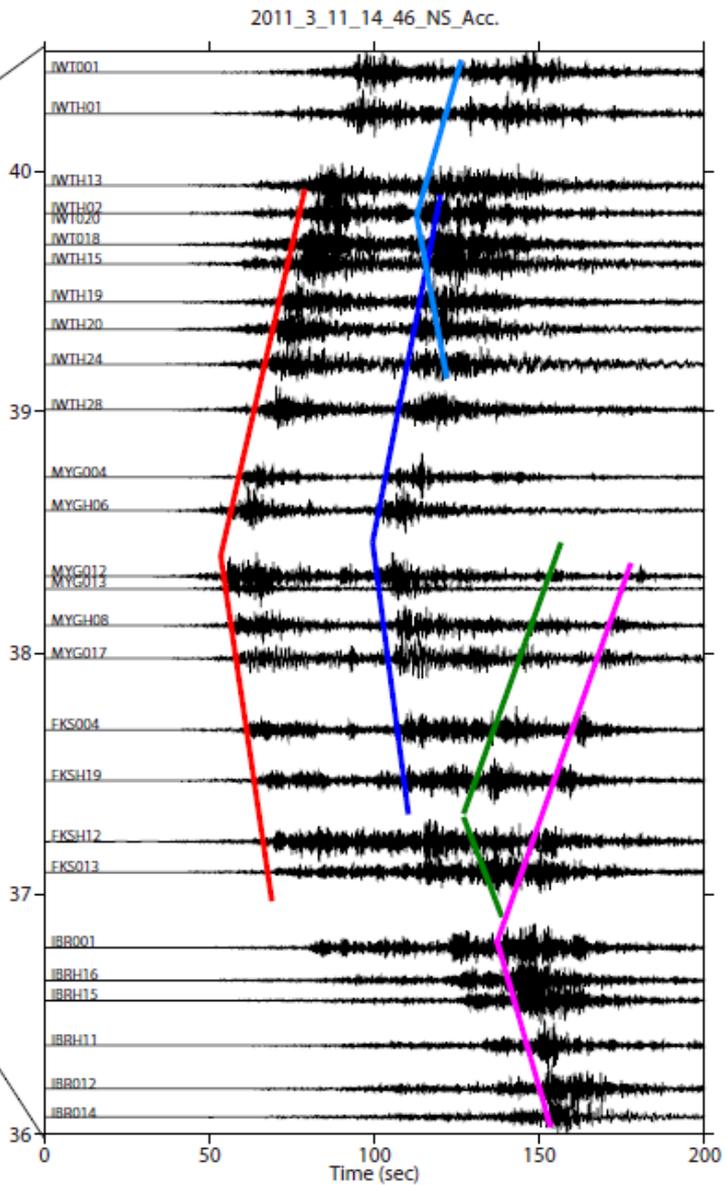
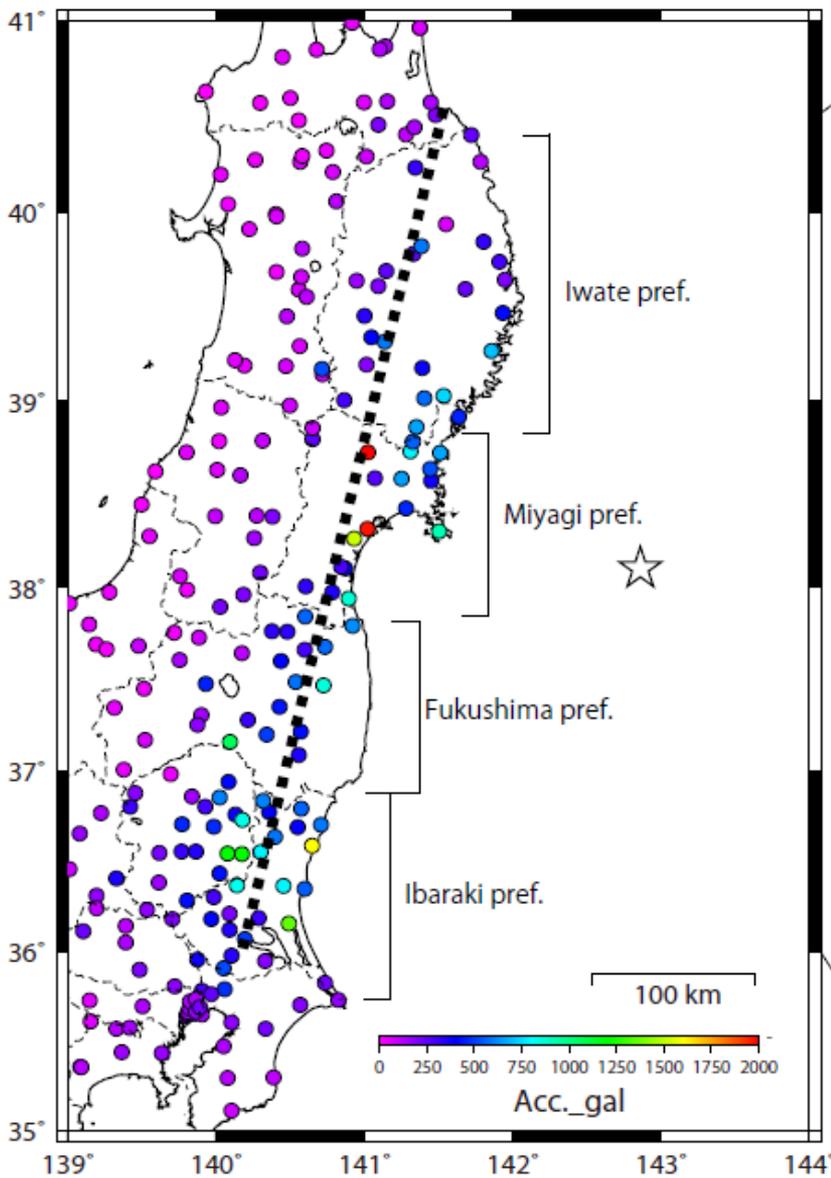
観測とシミュレーションによる 津波の波高分布比較



* 建築研究資料、2011

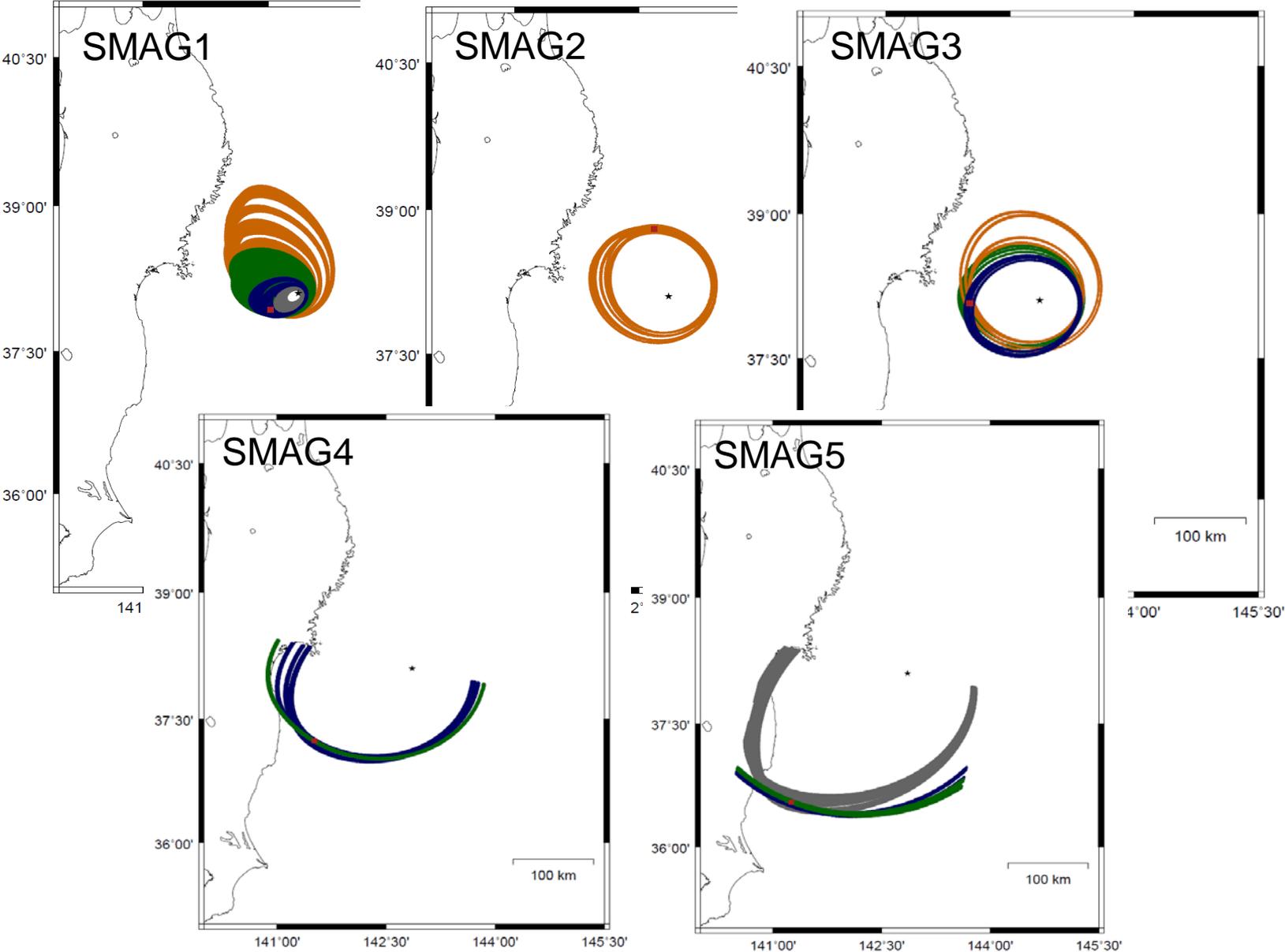
過小評価の原因: 不十分な海底地形精度

3. Strong Motion Generation Areas (SMGA) from Short-Period Ground Motions

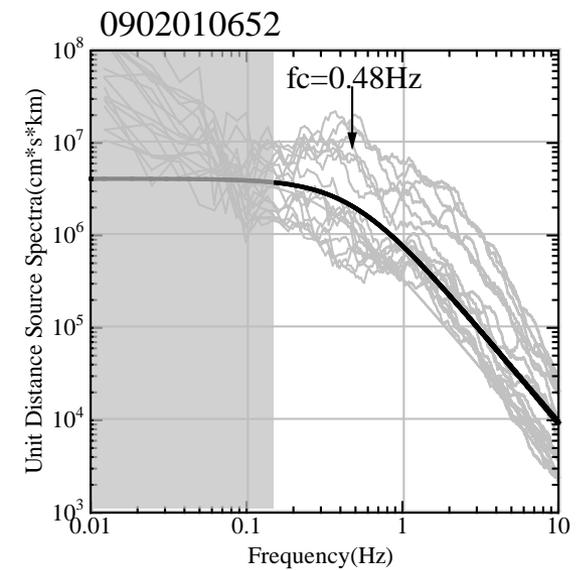
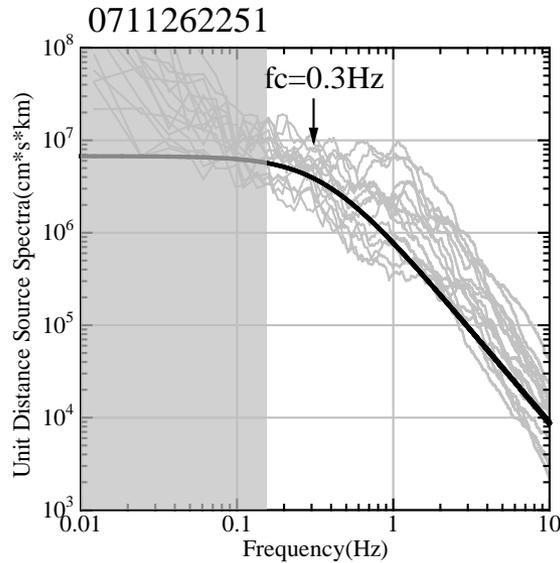
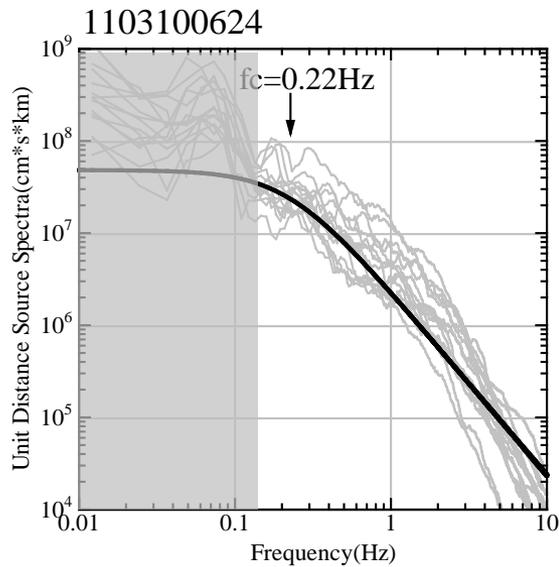


After Irikura and Kurahashi (2011)

Starting Points of SMGAs Estimated by Back-propagation Method



経験的グリーン関数として用いた小地震(Event 1, Event 2, Event 3, Event 4)の震源スペクトル



本震の震源情報

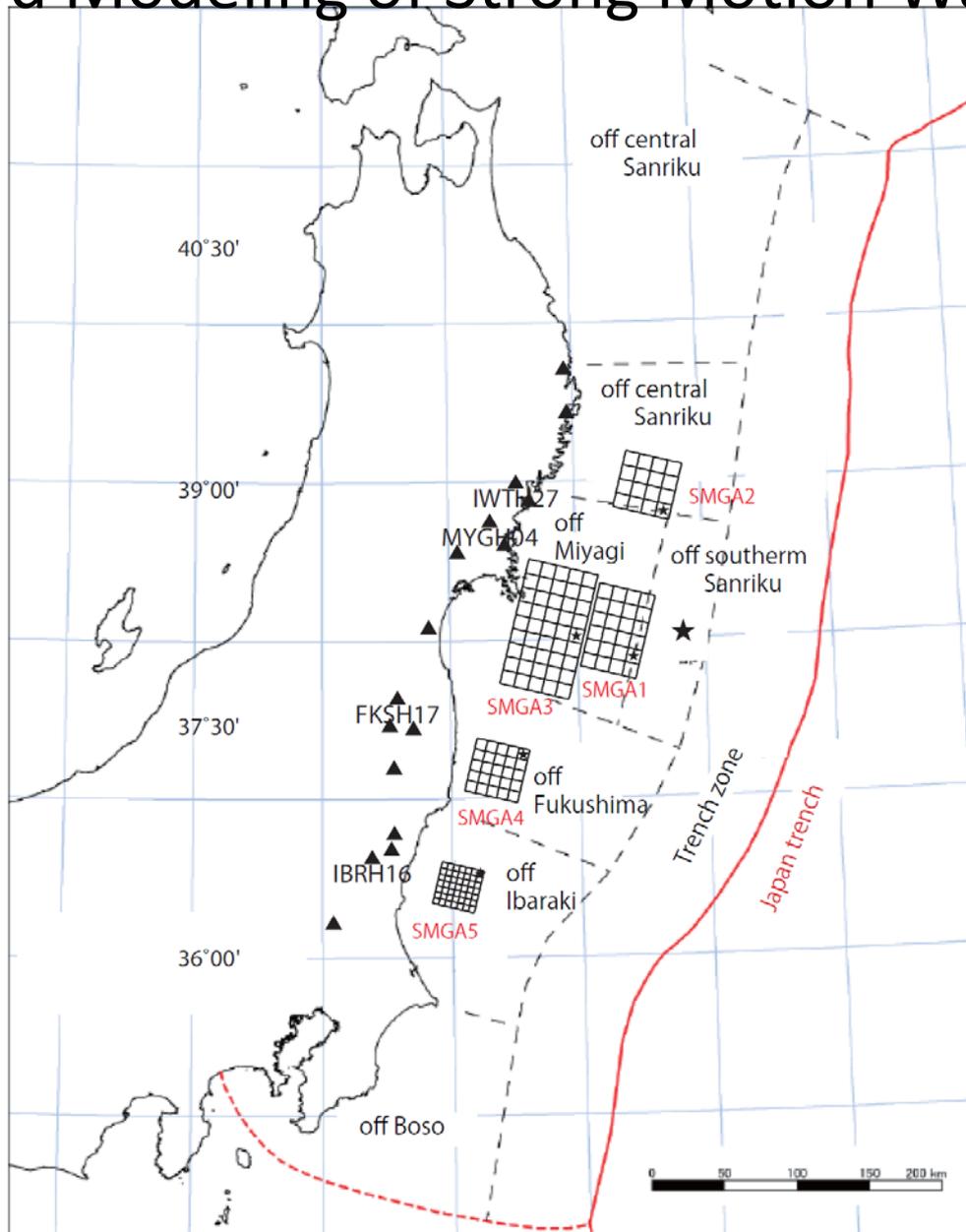
	Origin time	Latitude (deg)	Longitude (deg)	Mw	strike (deg)	dip (deg)	rake (deg)
Main shock	2011/3/11 14:46	38.103	142.86	9.0	24/193	81/10	92/79

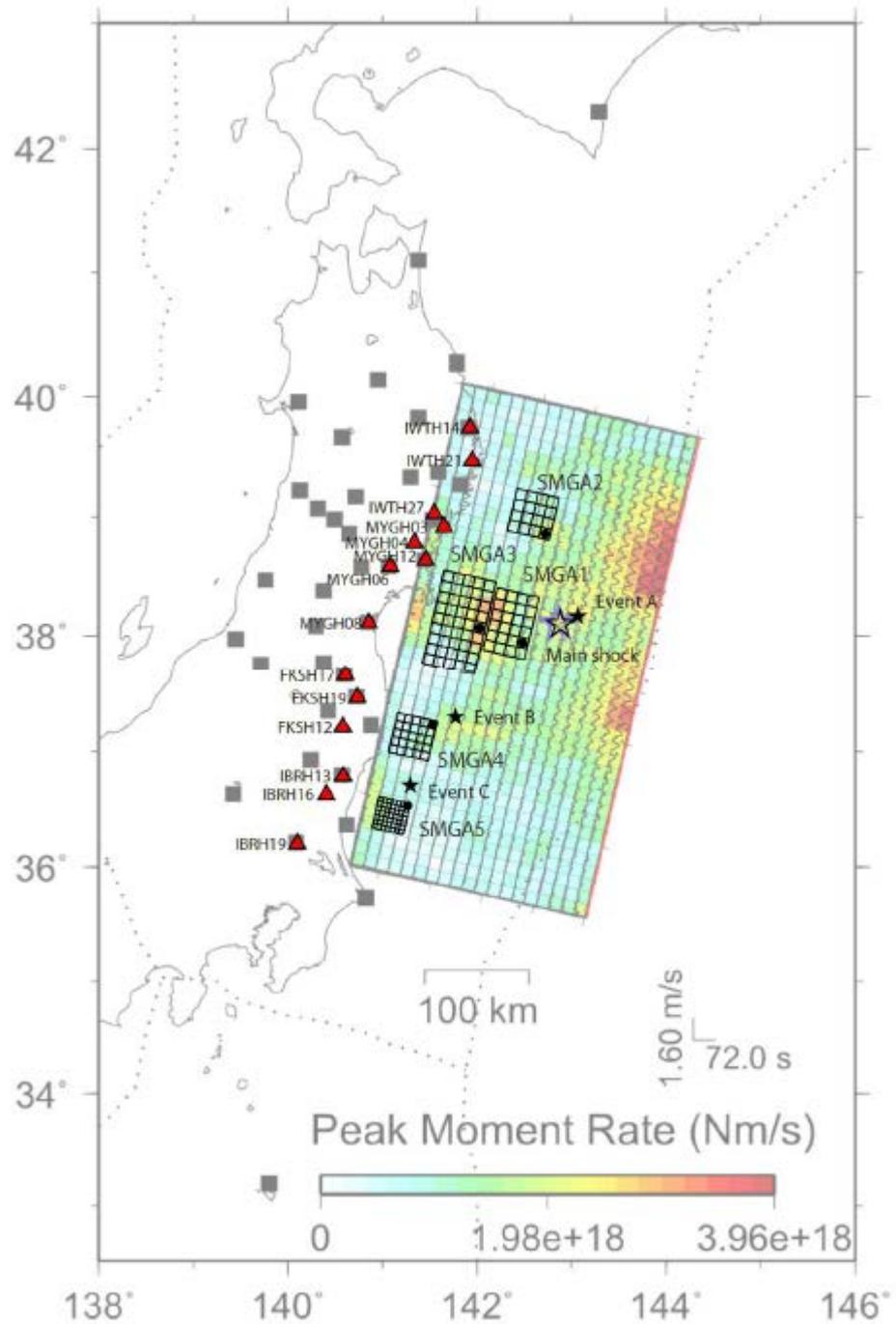
経験的グリーン関数に用いた小地震の震源情報

	Origin time	Latitude (deg)	Longitude (deg)	Mw	strike (deg)	dip (deg)	rake (deg)
Event A	2011/3/10 6:24	38.271	142.879	6.5	22/213	68/23	85/101
Event B	2007/11/26 22:51	37.304	141.757	5.9	24/217	71/20	86/102
Event C	2009/2/1 6:52	36.717	141.279	5.7	25/232	76/15	83/116

	Mo (Nm)	corner frequency (Hz)	Stress Drop (MPa)	Area (km ²)
Event A	5.51E+18	0.22	11.8	108.9
Event B	7.66E+17	0.3	4.1	58.5
Event C	4.65E+17	0.48	10.4	22.9

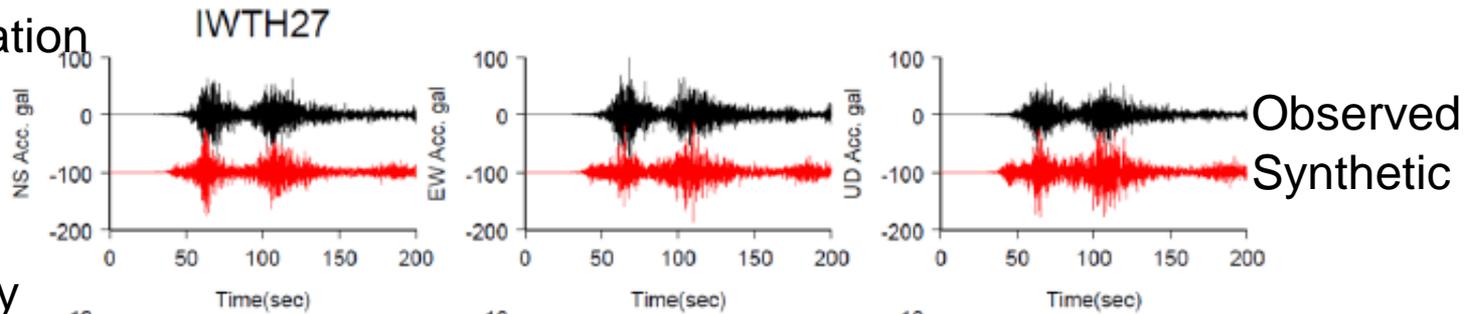
Strong Motion Generation Areas by Forward Modeling of Strong Motion Waveforms



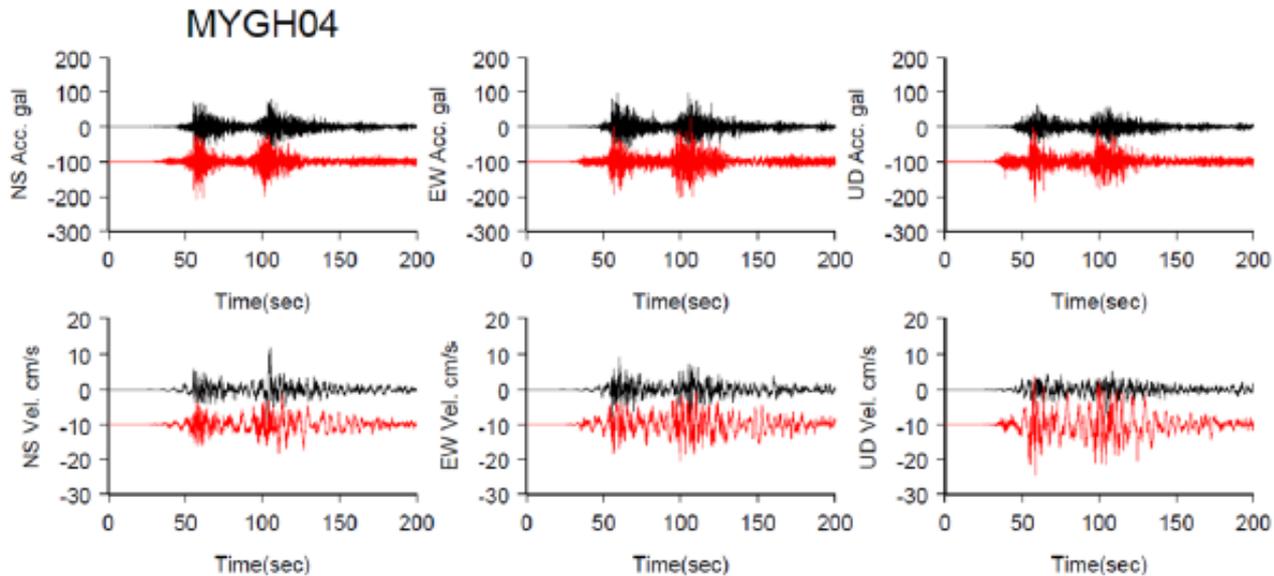
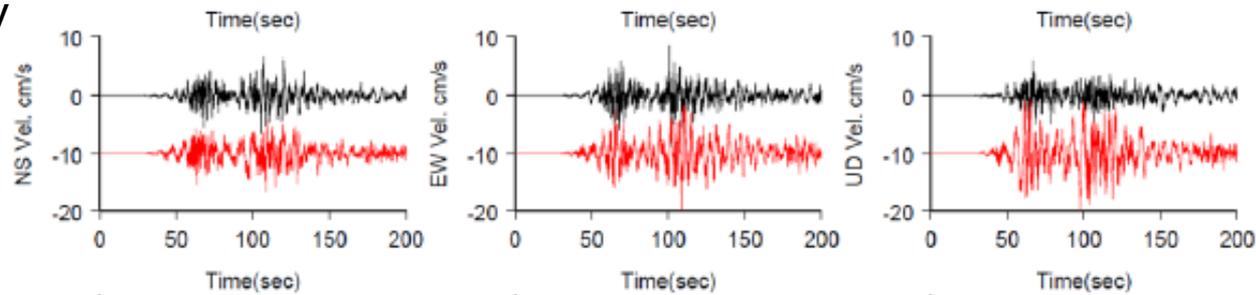


Comparison of Observed and Synthetic Seismograms 1

Acceleration



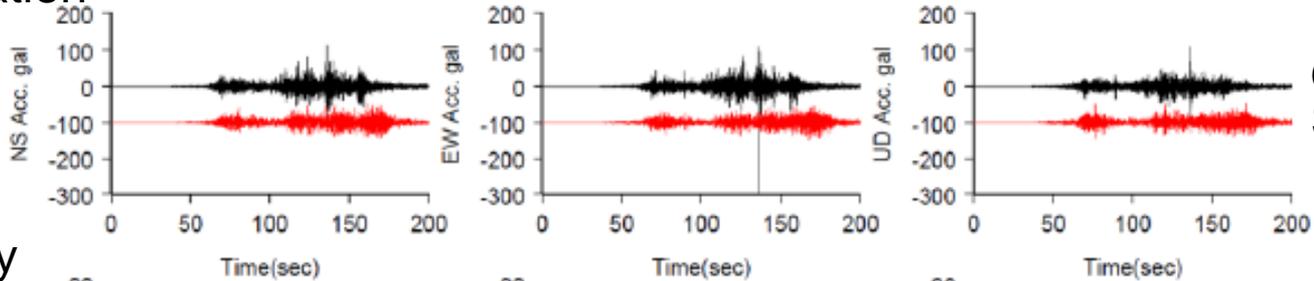
Velocity



Comparison of Observed and Synthetic Seismograms

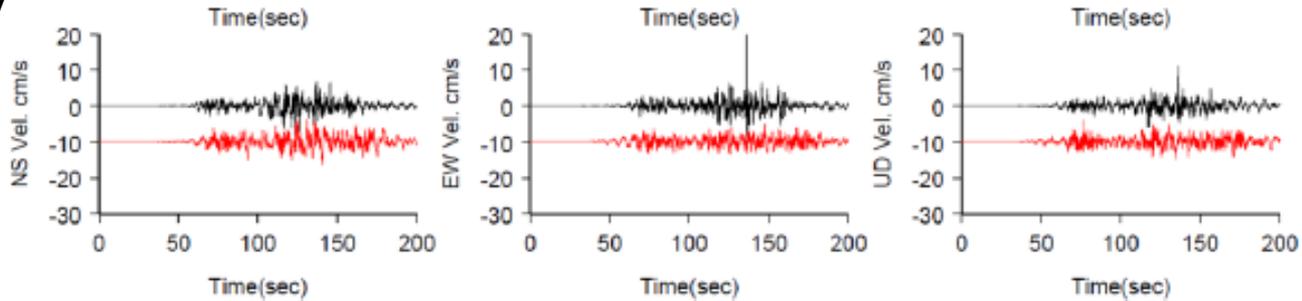
Acceleration

FKSH19

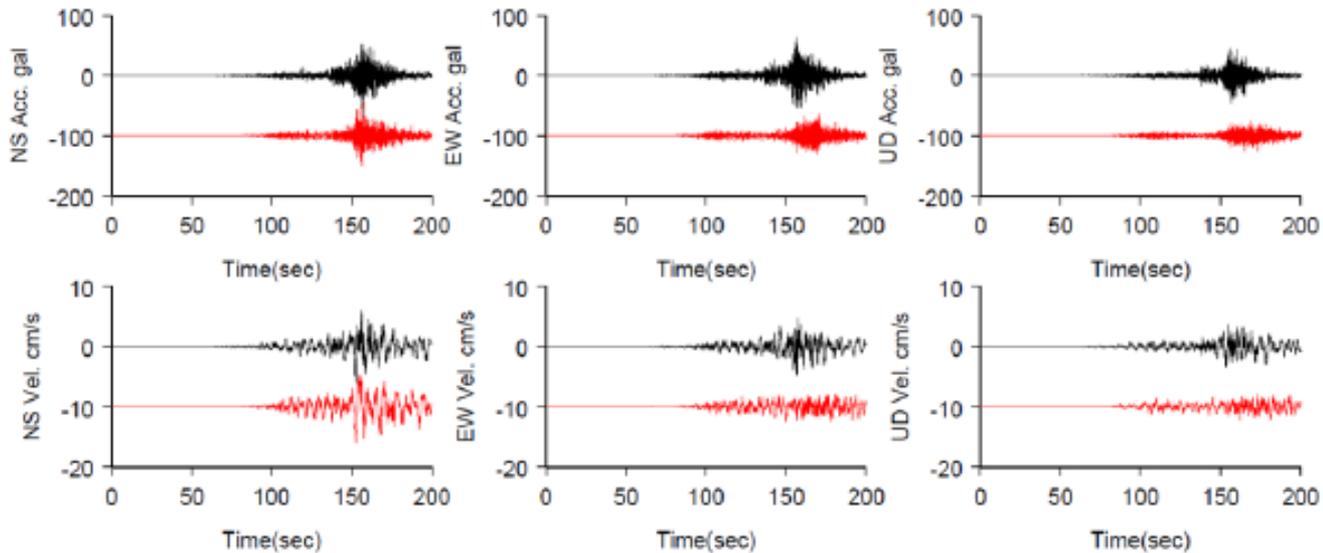


Observed
Synthetic

Velocity



IBRH19

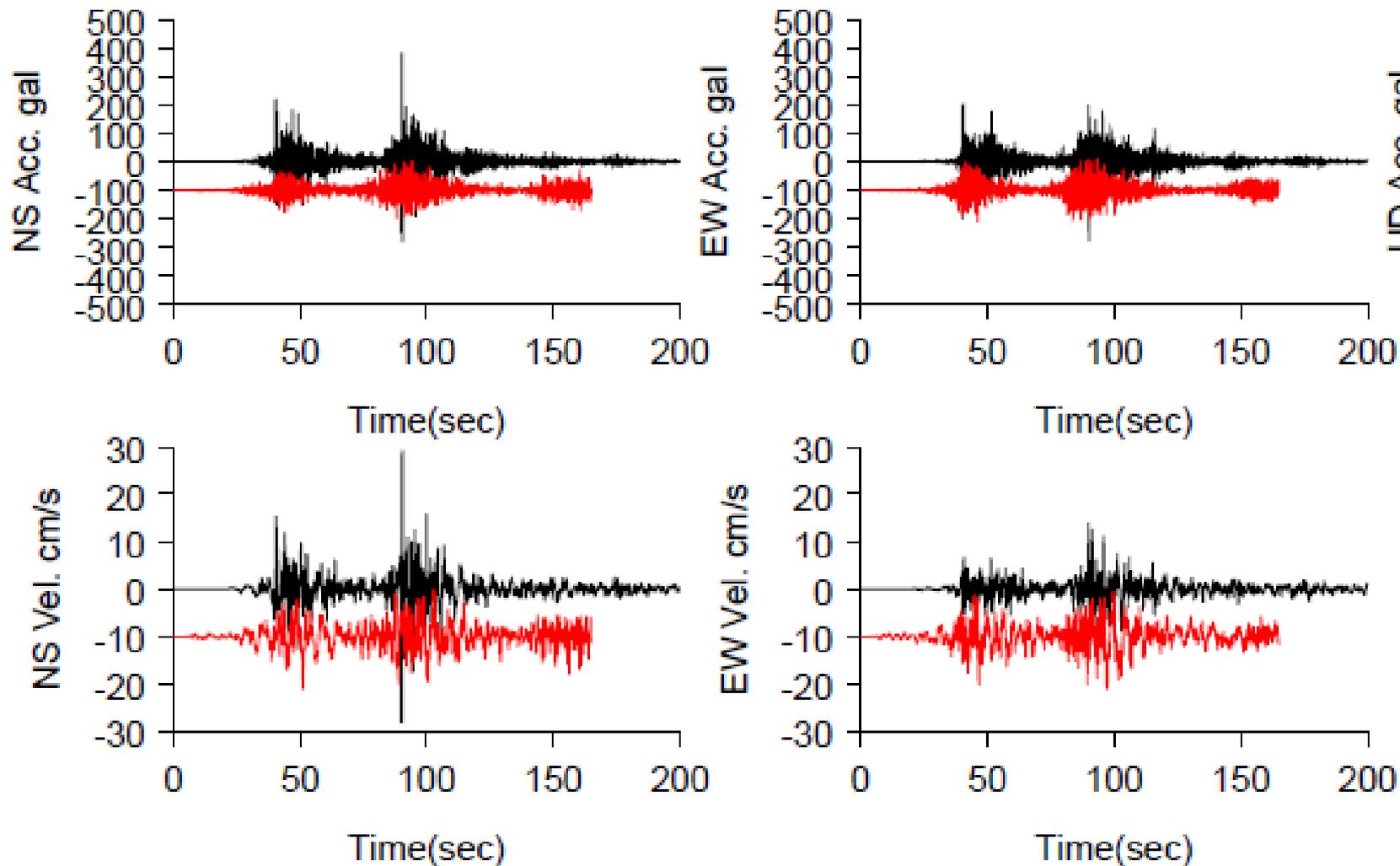


強震動生成域 (SMGA 1, 2, 3, 4 and 5) の震源パラメータ

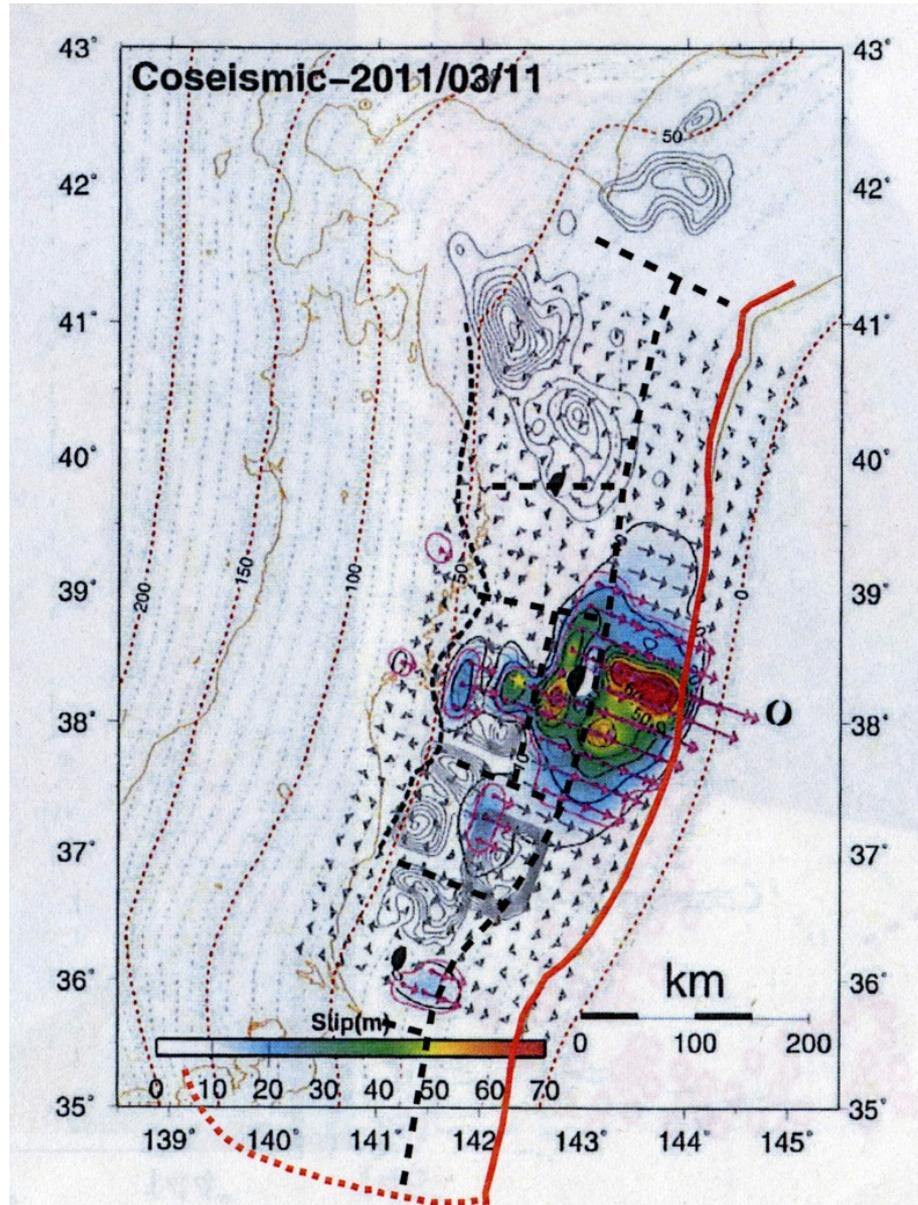
	L (km)	W (km)	Mo(Nm)	Stress Drop (Mpa)	Delay time from Origin time (sec)
SMGA 1	62.40	41.60	2.31E+21	41.3	15.64
SMGA 2	41.60	41.60	7.05E+20	23.6	66.42
SMGA 3	93.60	52.00	4.34E+21	29.5	68.41
SMGA 4	38.50	38.50	3.83E+20	16.4	109.71
SMGA 5	33.60	33.60	3.99E+20	26.0	118.17

女川原子力発電所 地中観測点(-128 m)

ONG128



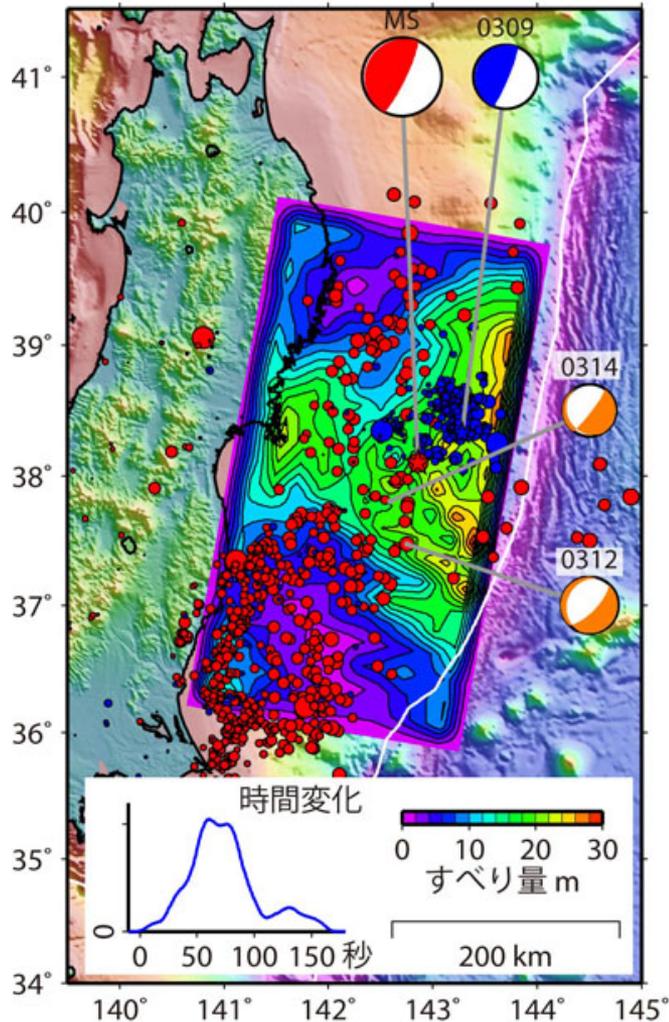
平成23年東北地方太平洋沖地震の すべり分布 (GPSと改訂地殻変動による)



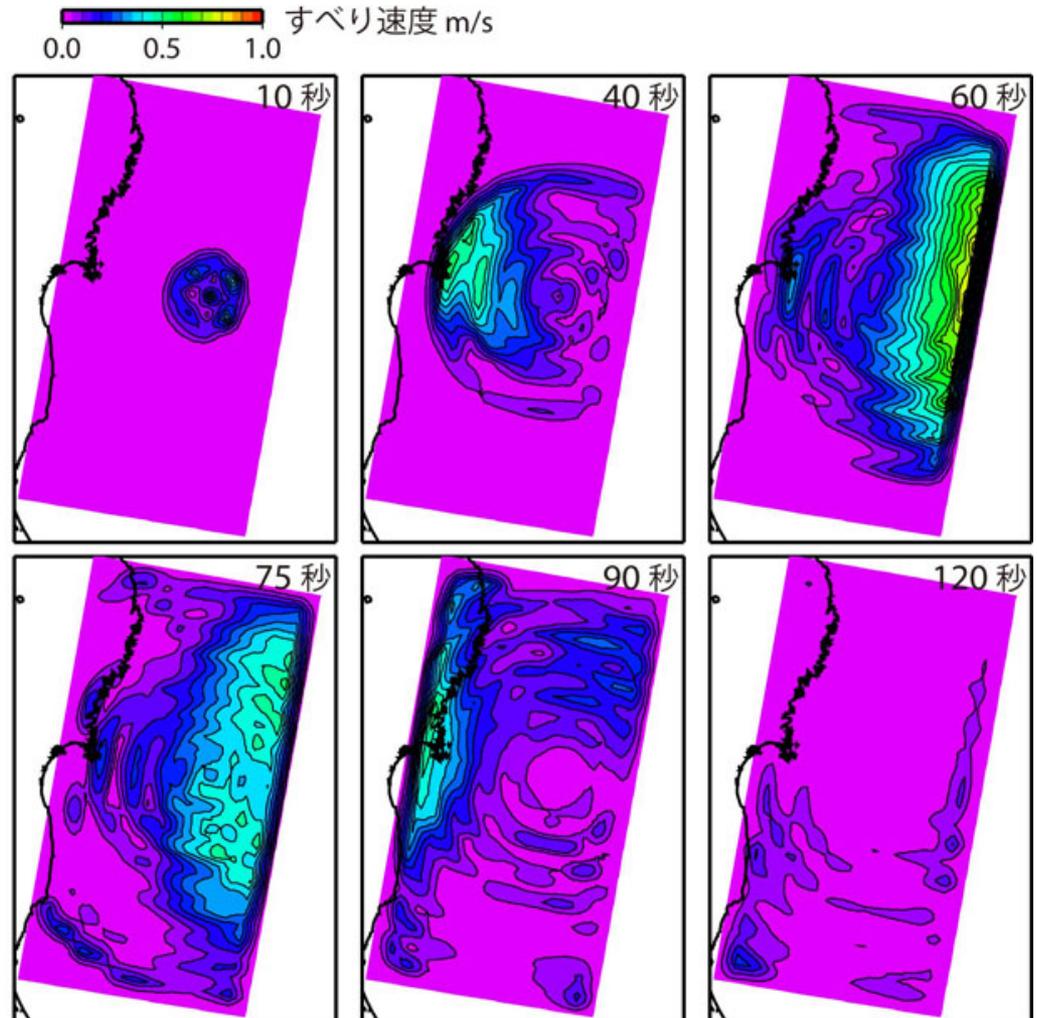
東北地方太平洋沖地震の破壊プロセス Ide(2011)

全世界のデジタル地震観測網で観測された地震波記録

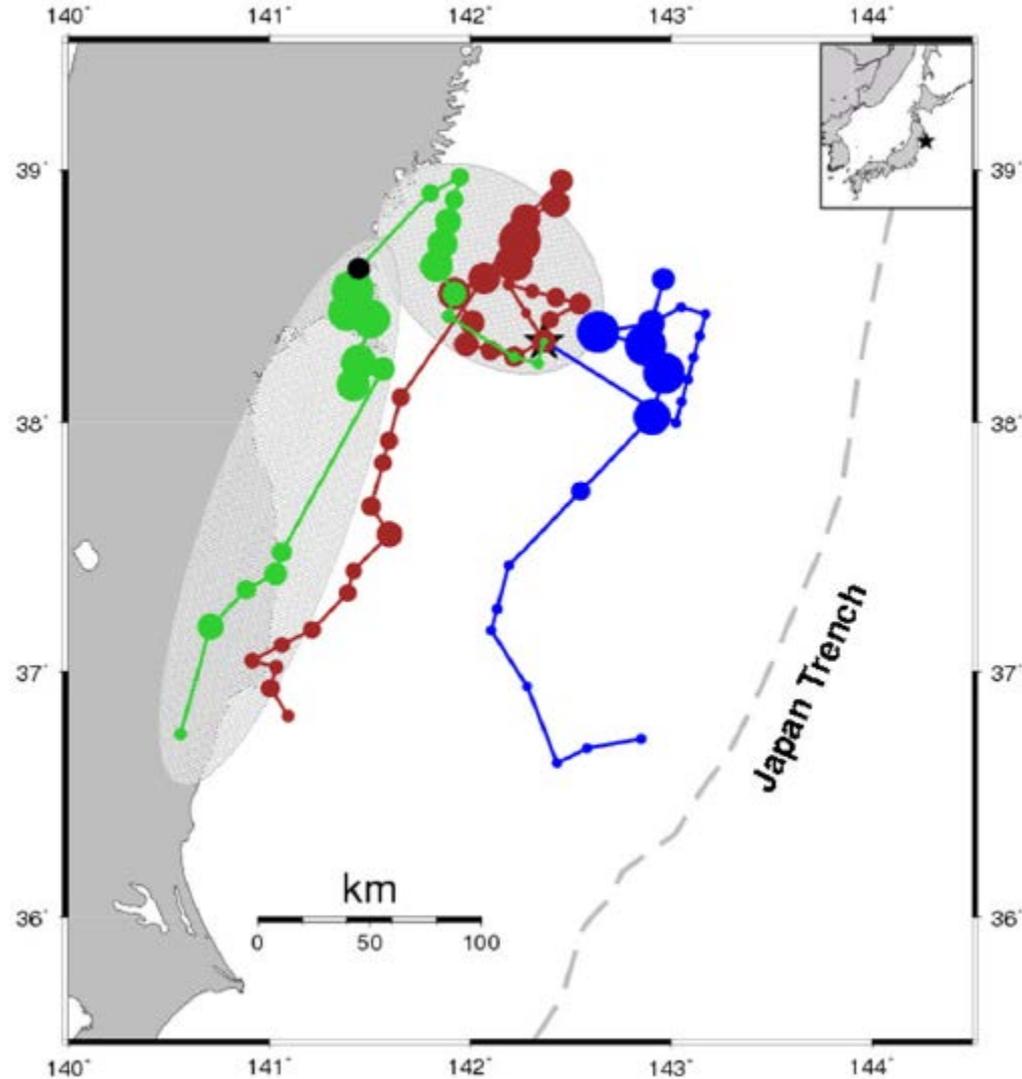
最終すべり量



すべり速度分布の時間的变化

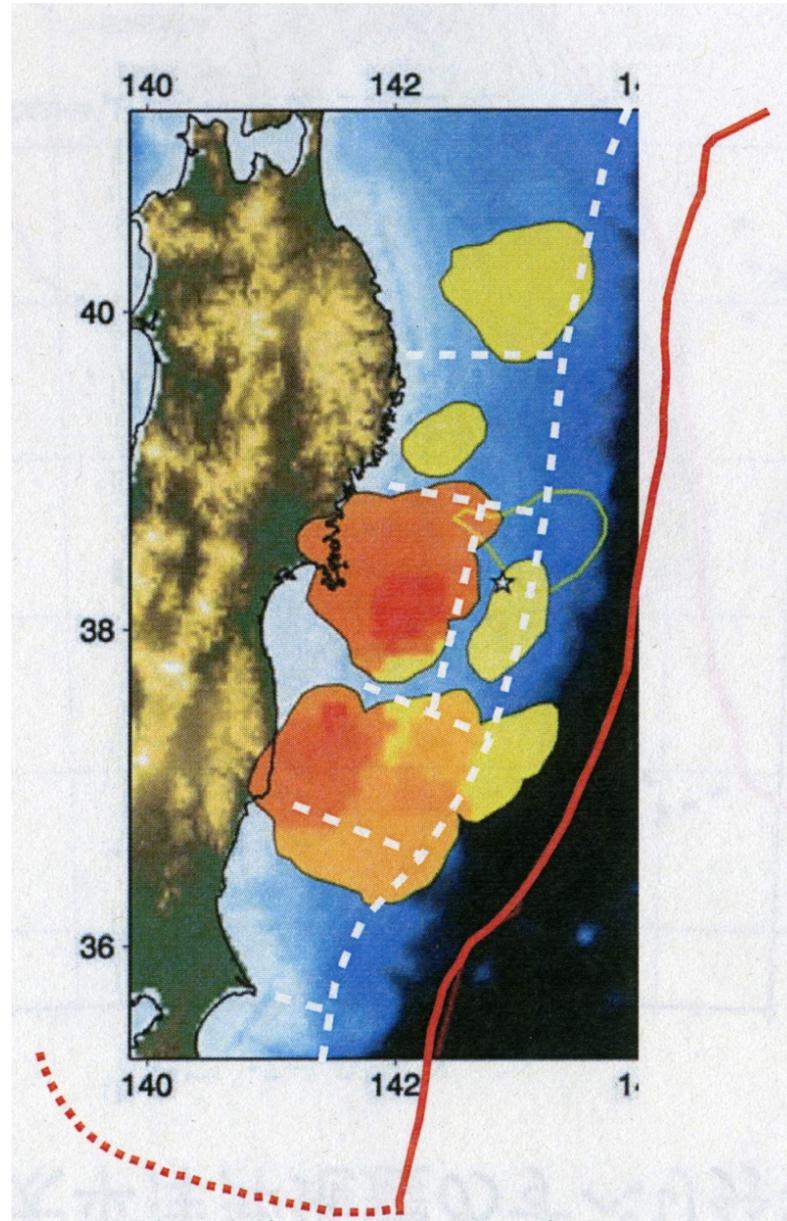


USAのArray Data (414 stations) を用いたBack-Projection Methodによる断層破壊過程 (Wang and Mori, 2011)

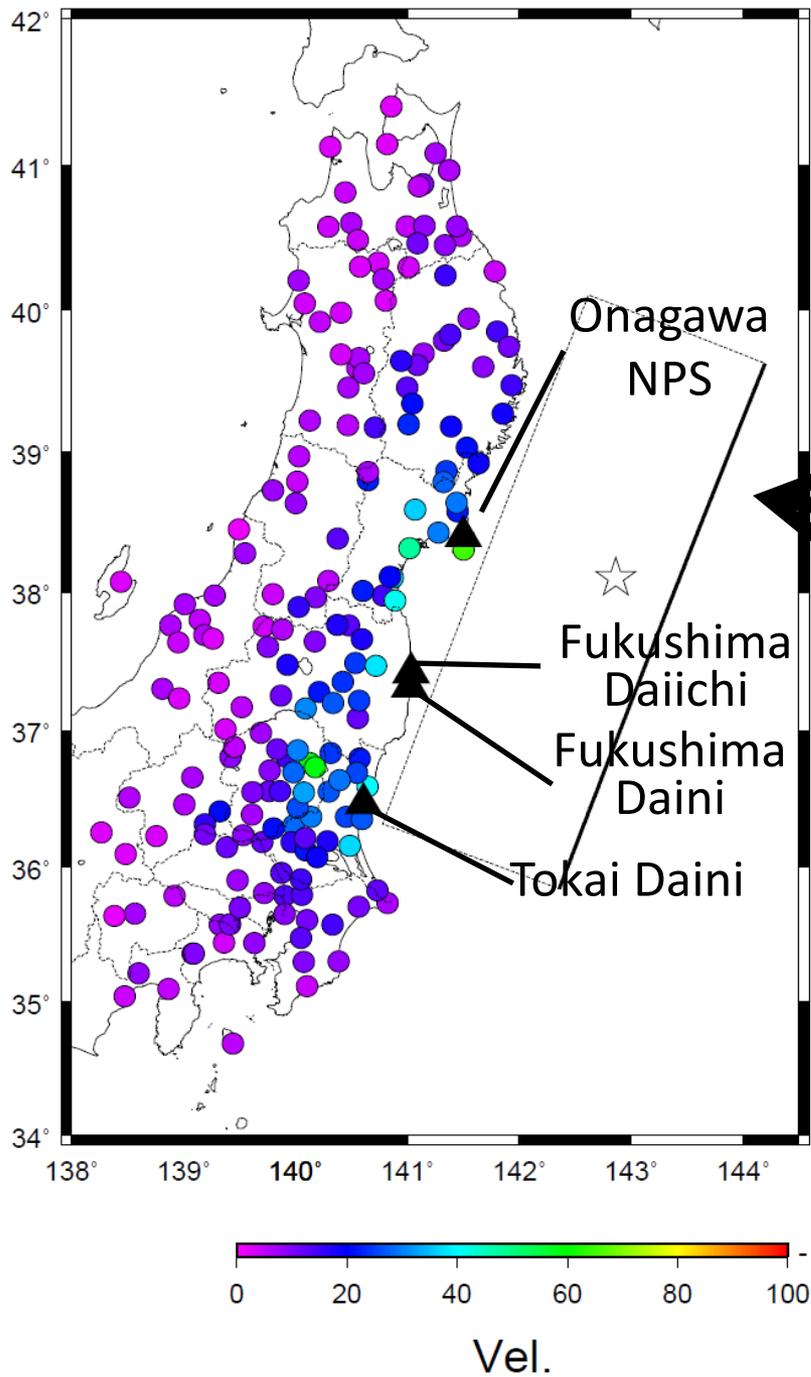


Sources of radiation for data high-passed filtered at 1 hz (green), band-passed filtered between 0.2 and 1.0 hz (brown) and low-passed filtered at 0.2 hz (blue).

USAのArray Dataを用いた Back-Projection Methodによる短周期生成域

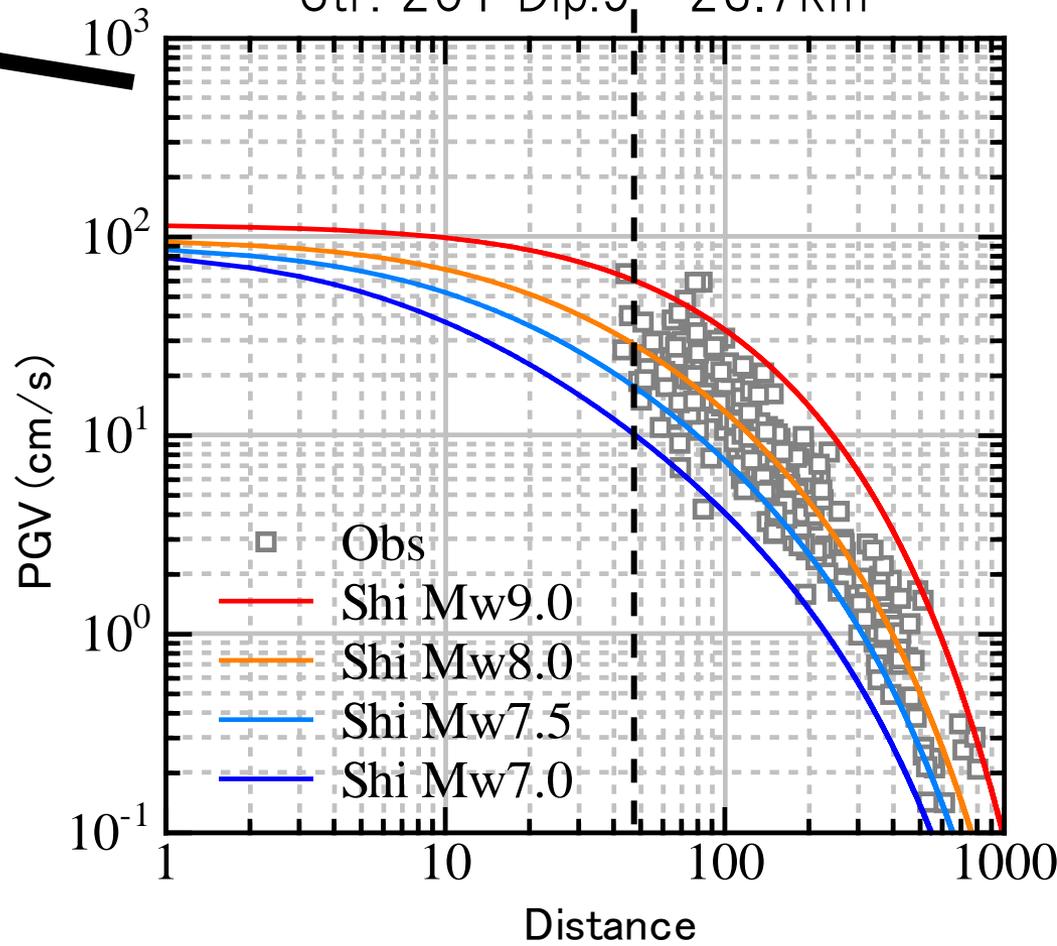


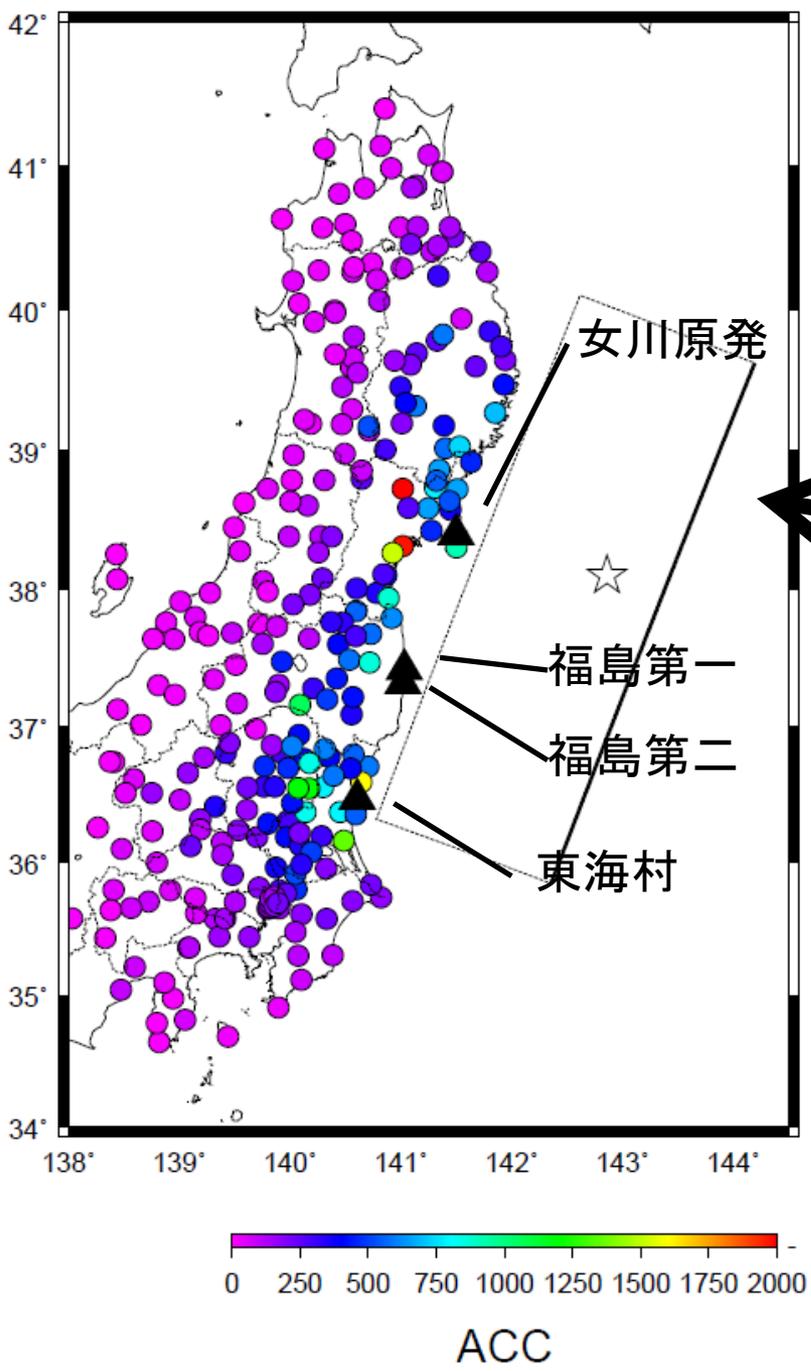
Kiser(Harvard Univ.)



Shortest Distance to Fault Plane
 Onagawa NPS: 46.3km
 Fukushima Daiichi: 46.1km
 Fukushima Daini: 44.5km
 Tokai Daini: 44.6km

2011/03/11 14:46 Mw9.0
 Str: 201 Dip:9° 23.7km

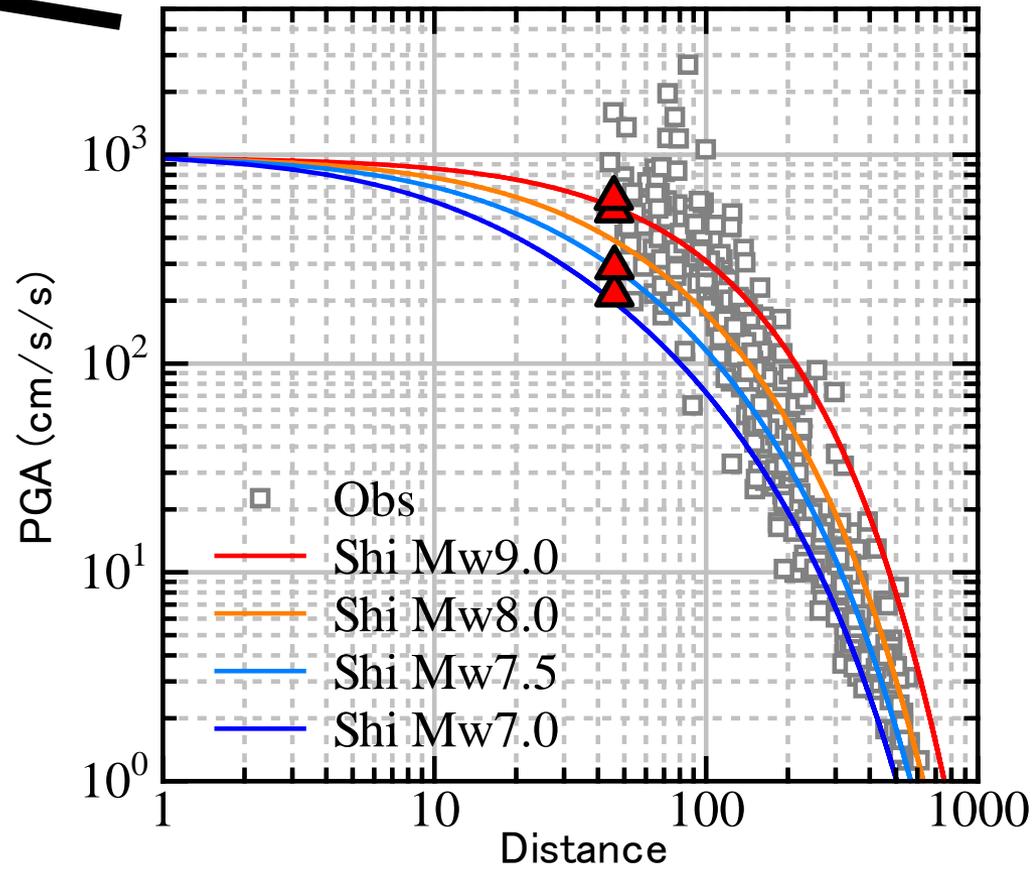




Shortest Distance to Fault Plane

Onagawa NPS	: 46.3km	: 607gal
Fukushima Daiichi	: 46.1km	: 550gal
Fukushima Daini	: 44.5km	: 288gal
Tokai Daini	: 44.6km	: 225.4gal

2011/03/11 14:46 Mw9.0
 Str: 201 Dip:9 23.7km



まとめー1

- 東北地方太平洋沖地震の強震動は5つの強震動生成域 (SMGAs 1, 2, 3, 4, 5) からなる特性化震源モデルで再現可能。
- SMGA 1は震源のすぐ東、SMGA 2は震源のやや北、SMGA 3, SMGA 4, SMGA 5は震源断層の深部西端に沿って分布。
- 本研究で得られた強震動生成域は、長周期の強震動記録(20秒–200秒)を用いた波形インバージョンによるPeak Moment Rate Functionの最大値の分布によく対応している。
- 強震動生成域は、地震調査委員会の長期評価のための領域区分に対応して、各領域にほぼ1つずつ分布している。

まとめー2

- 強震動記録から推定される震源モデルは、遠方でのARRAYデータを用いてBack-projection methodで推定された短周期生成の震源分布(Wang and Mori, 2011; Kiser and Ishii, 2011)によく一致している。