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Santiago - Chile

Session: General Session “Subduction Earthquakes” (ID 3019)
Date: Monday, January 9th
Time: 15:15 - 15:30
Room: Terraza Manquehue I Room (11)

Broadband ground motion simulations of mega-thrust subduction earthquakes based on multi-scale heterogeneous-source model

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Presentation content

1. Methodology of simulating ground motions from mega-thrust subduction earthquakes

   Segmentation

   Ground motion characteristics

   Period-dependent source model

2. Source dynamics of mega-thrust subduction earthquakes

   Source model with a multi-scale heterogeneity

   Ground motions from multi-scale heterogeneity sources

3. Simulation of strong ground motions from mega-thrust subduction earthquakes using kinematic source model

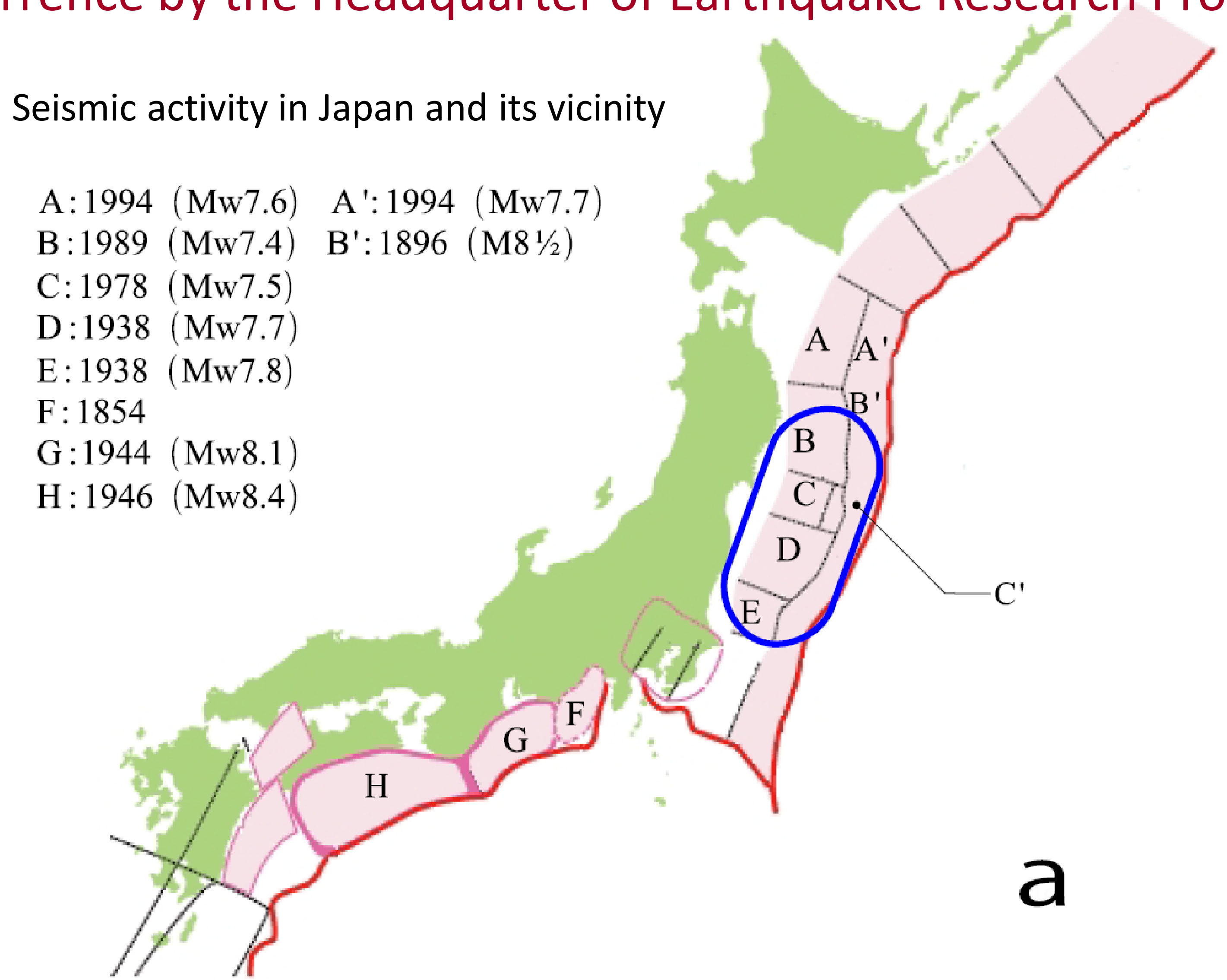
   Long-period ground motions

   Short-period ground motions

4. Conclusion

1. Methodology: Segmentation 1

Seismic Segmentation used in long-term evaluation of earthquake occurrence by the Headquarter of Earthquake Research Promotion

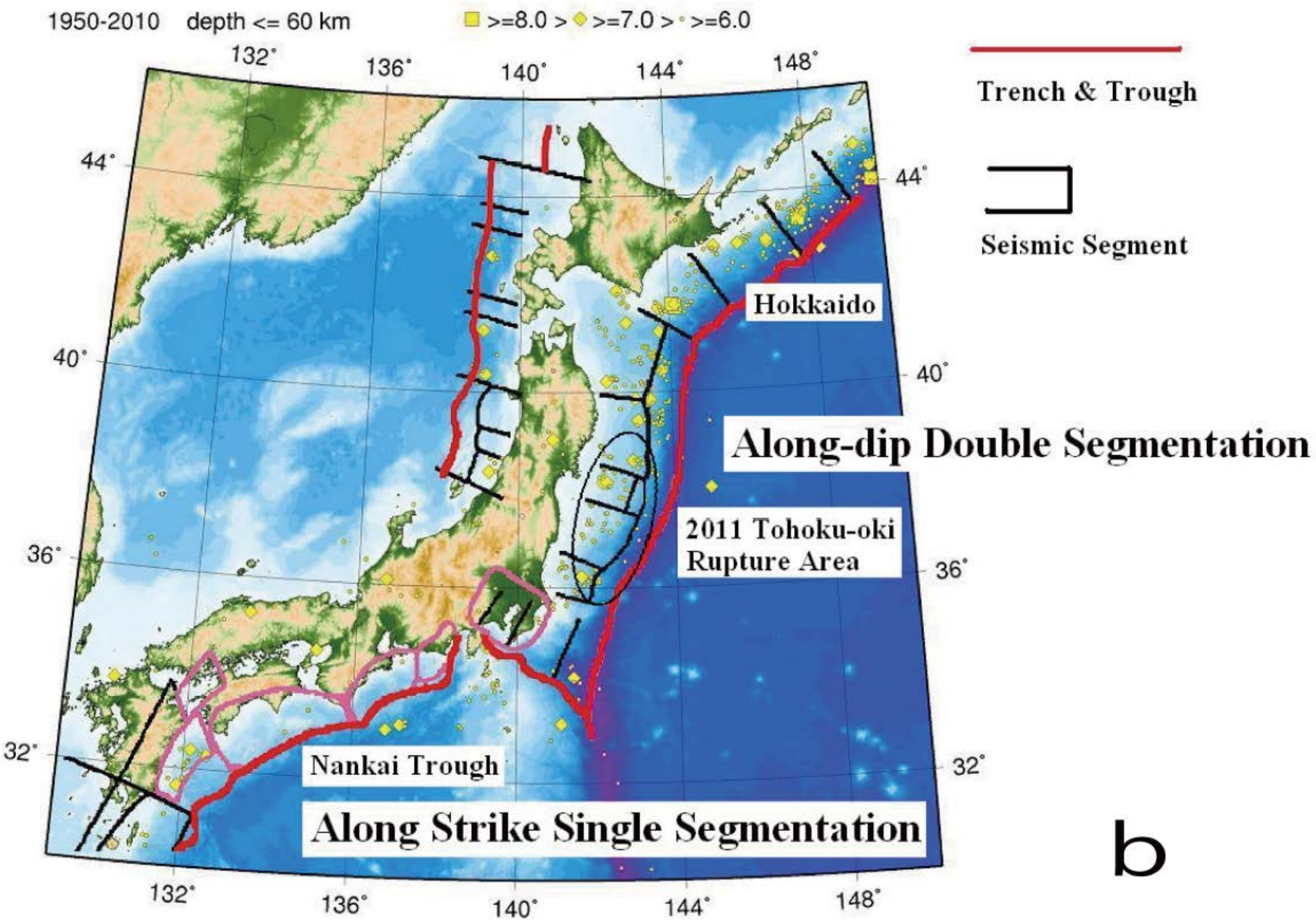


Koyama et al. (2012)

1. Methodology: *Segmentation 2*

Epicenters of earthquakes from 1950 to 2010 by JMA

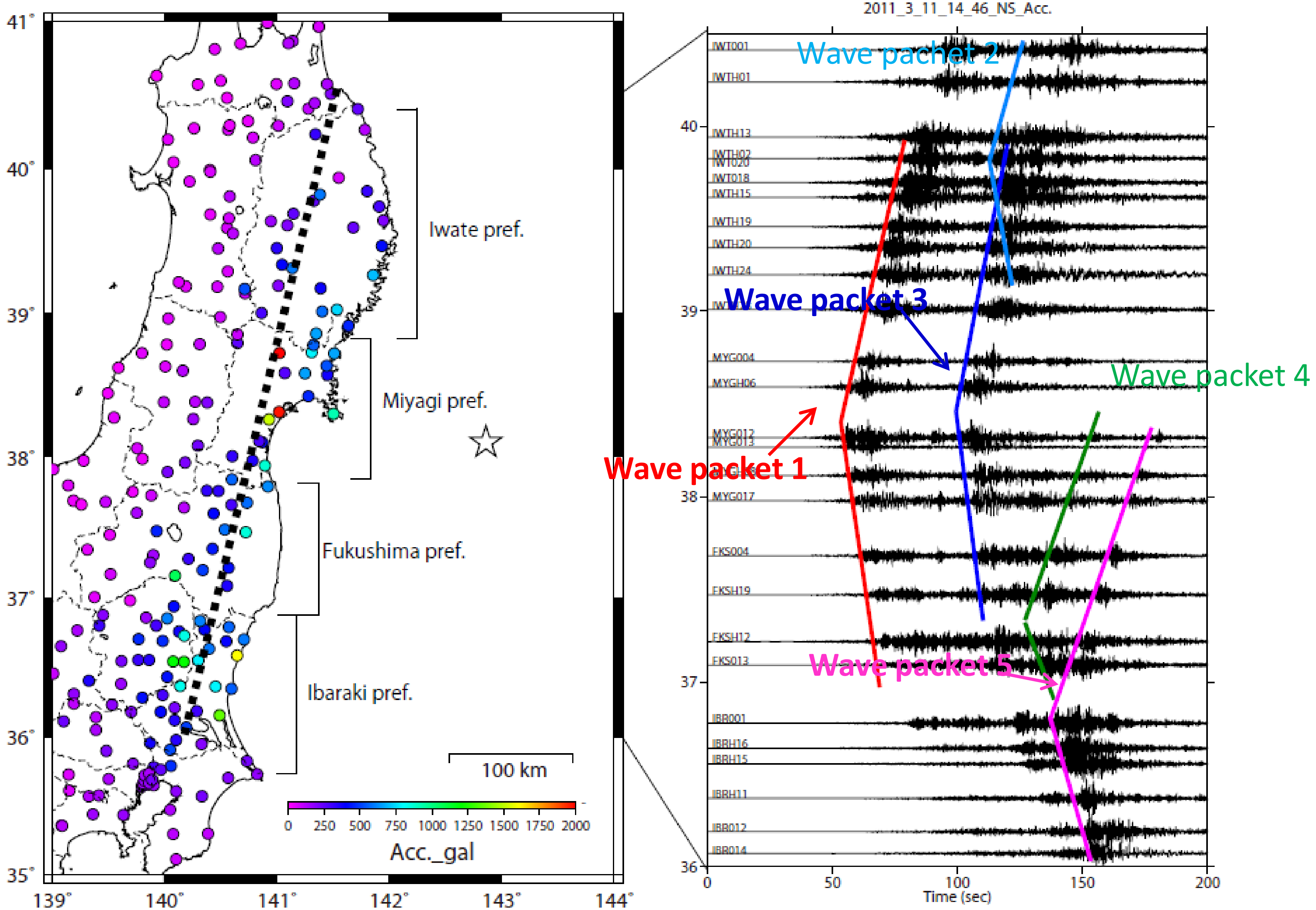
(Yellow symbols classified by magnitude)



Koyama st al.(2012)

1. Methodology: *Ground motion characteristics 1*

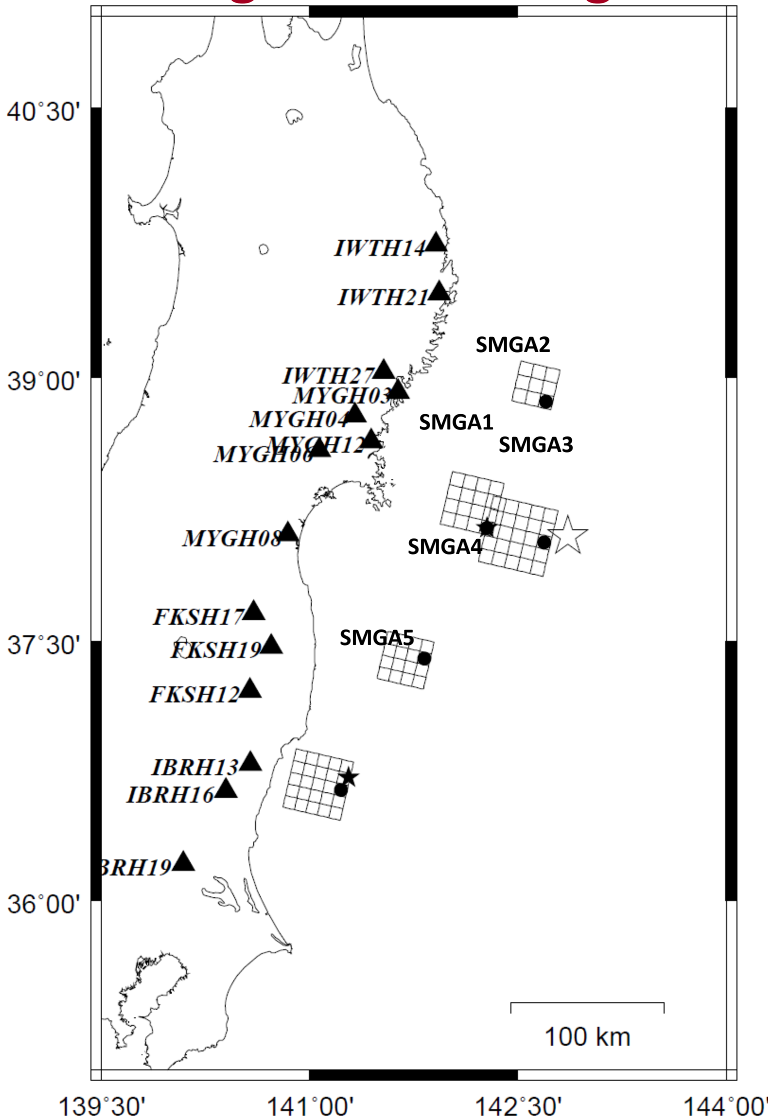
Strong ground motion records (acceleration) near the source area of the 2011 *Mw 9* Tohoku earthquake



After Irikura and Kurahashi (2011)

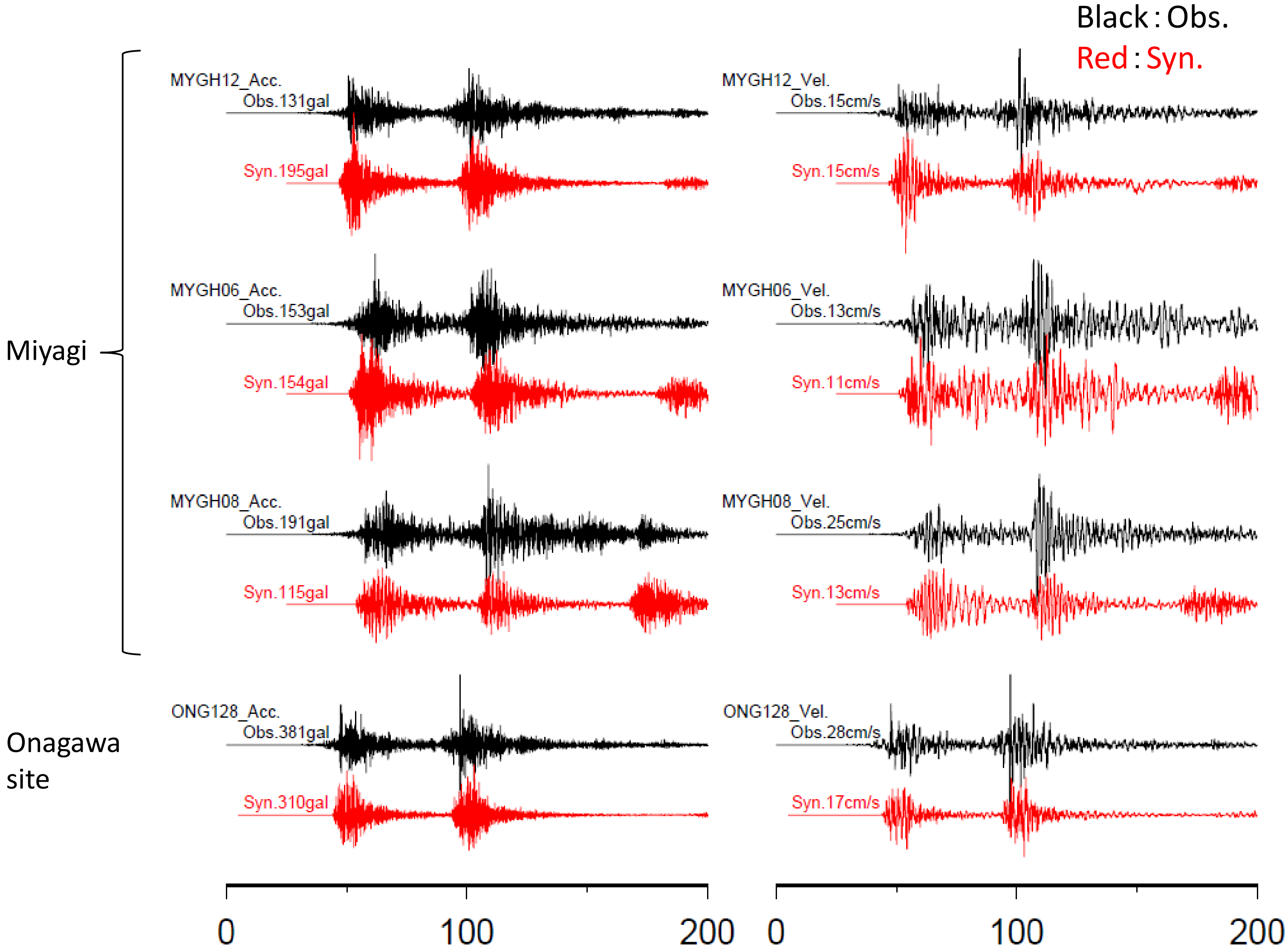
1. Methodology: *Ground motion characteristics 2*

Short-period source model for the 2011 Tohoku earthquake consisting of five strong-mition-generation-areas (SMGAs)



	L x W (km^2)	Mo (Nm)	Stress Drop (MPa)
SMGA1	34 × 34	2.68E+20	16
SMGA2	23.1 × 23.1	1.41E+20	20
SMGA3	42.5 × 42.5	6.54E+20	20
SMGA4	25.5 × 25.5	1.24E+20	25.2
SMGA5	38.5 × 38.5	5.75E+20	25.2

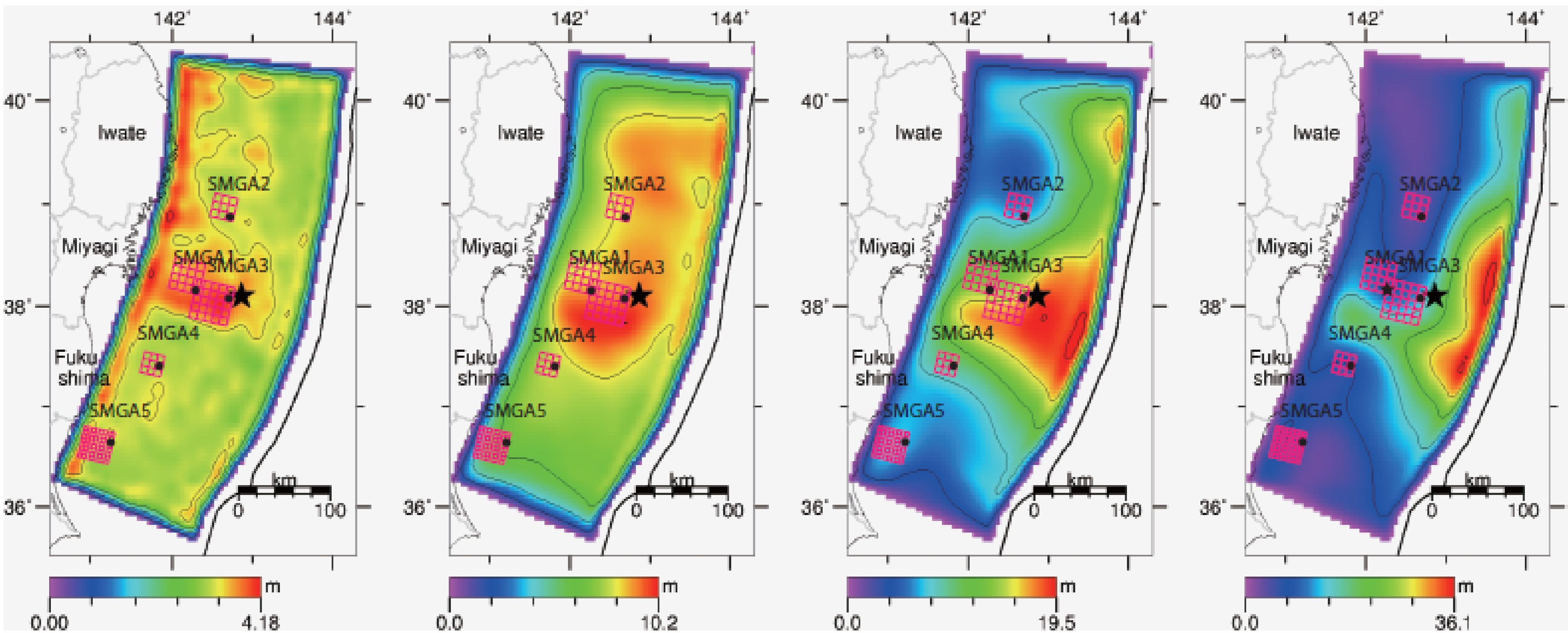
Comparison of observed motions and synthetic ones using five-SMGAs' model and the empirical Green's function method



Period-dependent source rupture behavior of 2011 Tohoku earthquake by Kubo, Asano and Iwata (2014)

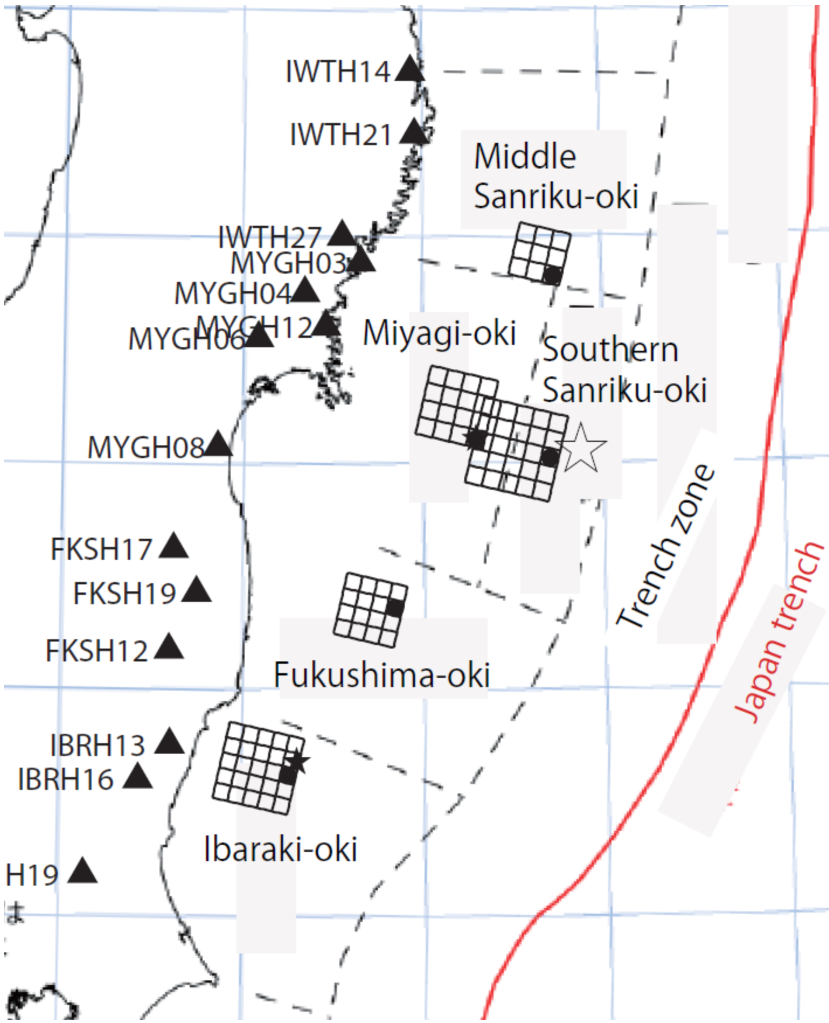
Final slip distributions for each period band

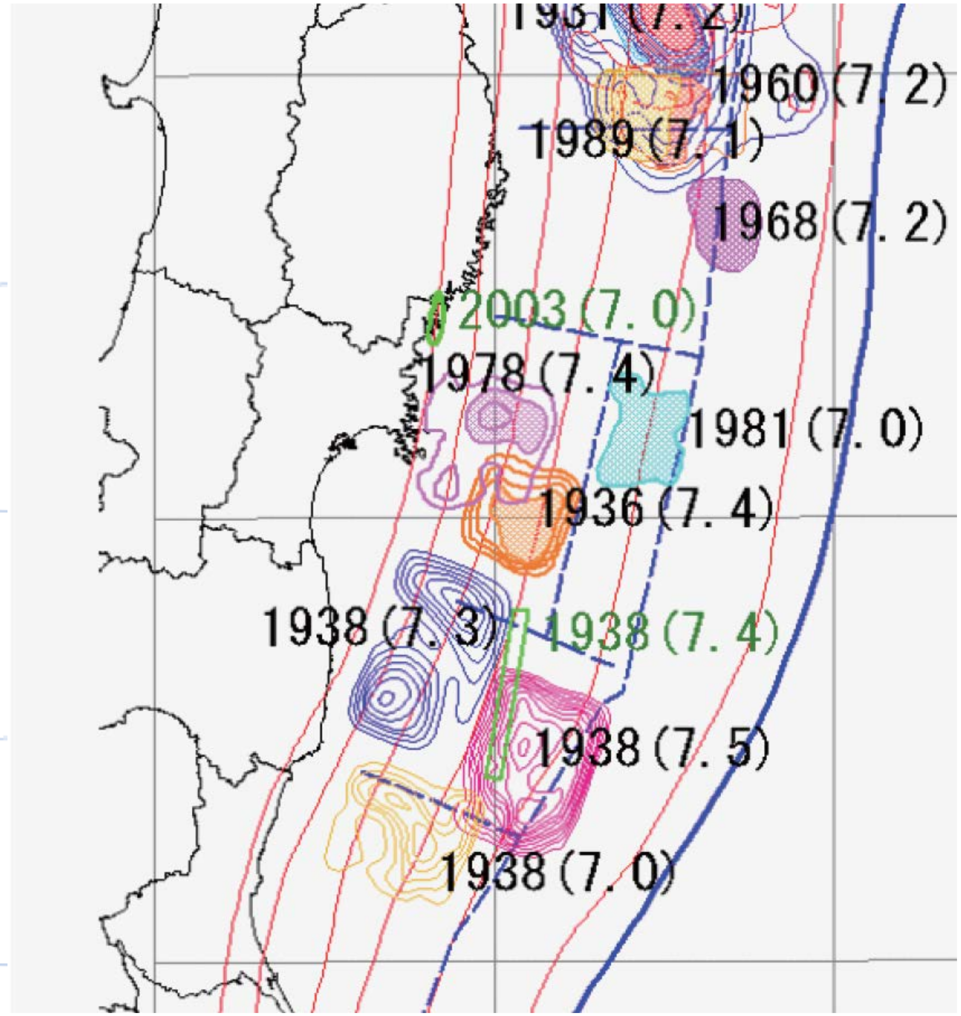
Period band 5-10 s	Period band 10-25 s	Period band 25-50 s	Period band 50-100 s
Mo: 1.3e+22(Nm) (Mw8.7)	Mo: 2.8e+22(Nm) (Mw8.9)	Mo: 3.9e+22(Nm) (Mw9.0)	Mo: 4.7e+22(Nm) (Mw9.1)
Max. Slip: 4.2(m)	Max. Slip: 10.2(m)	Max. Slip: 19.5(m)	Max. Slip: 36.1(m)



Rewrite Kubo et al. (2015)

Comparison between SMGAs in this study and source locations of past earthquakes off the Pacific coast of Tohoku

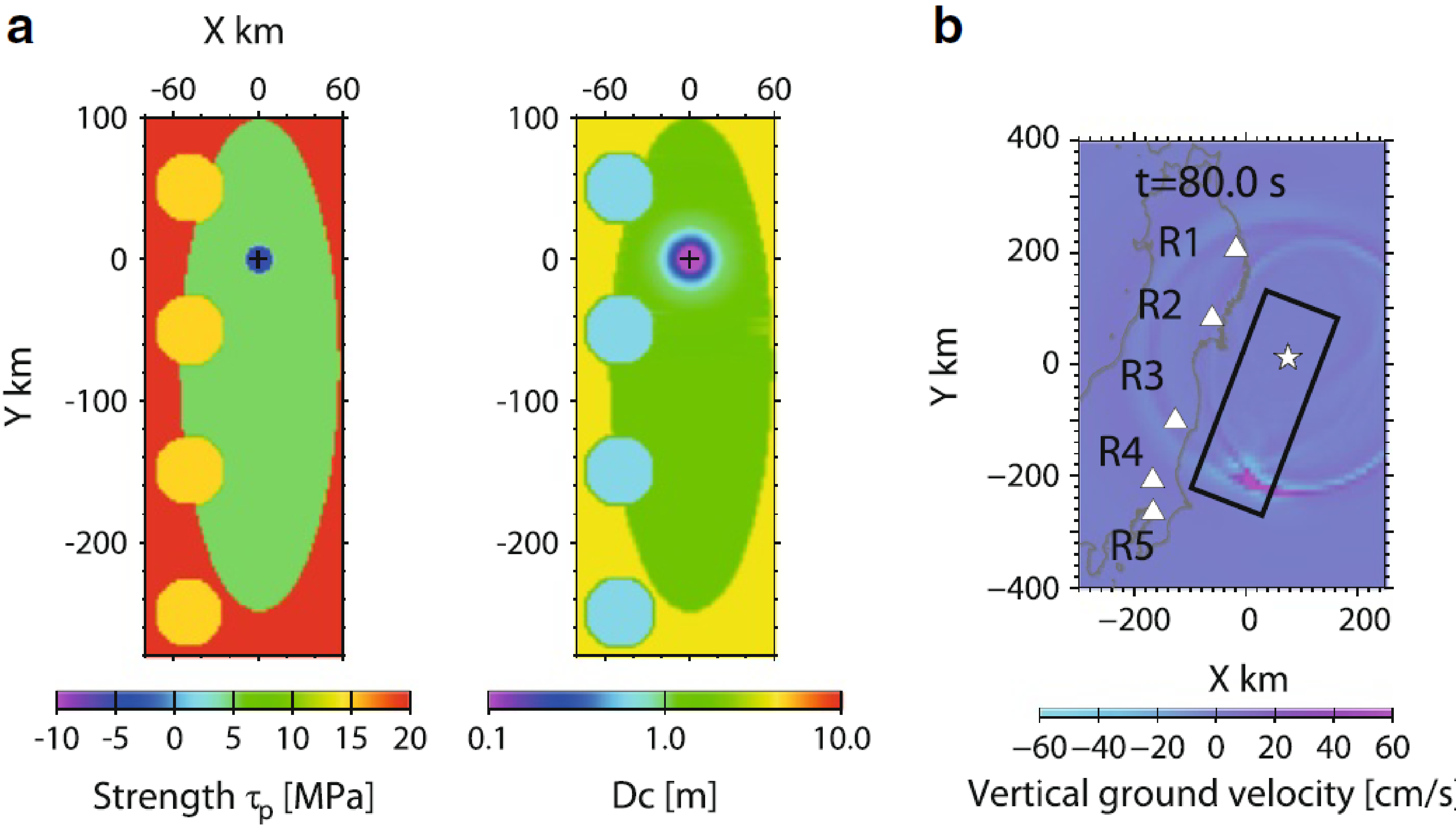




2. Source dynamics: *Multi-scale heterogeneous source model 1*

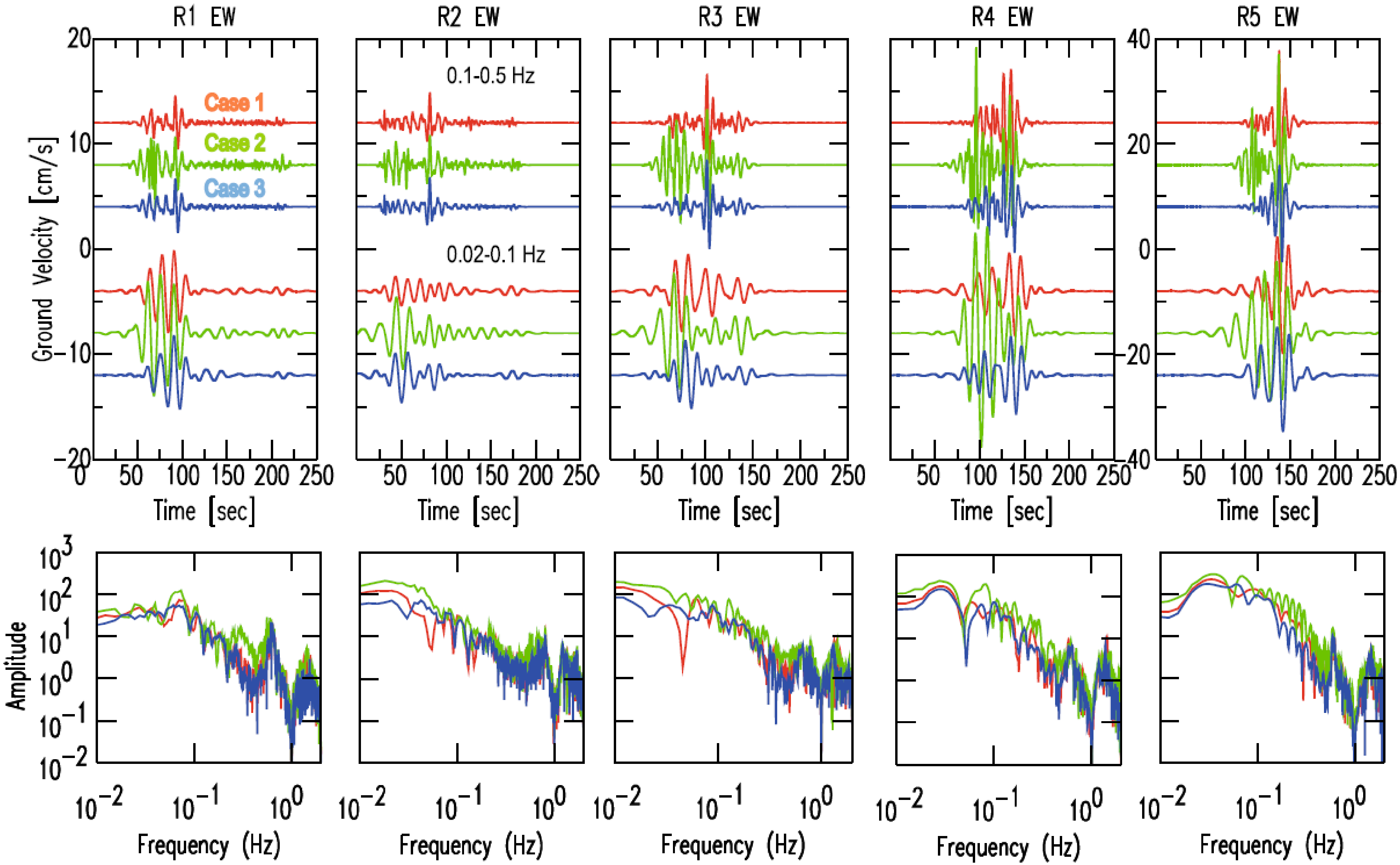
Multi-scale Heterogeneous Earthquake Model (Aochi and Ide2014)

Parametric Study of Multi-scale Heterogeneous Earthquake Model



2. Source dynamics: *Multi-scale heterogeneous source model 2*

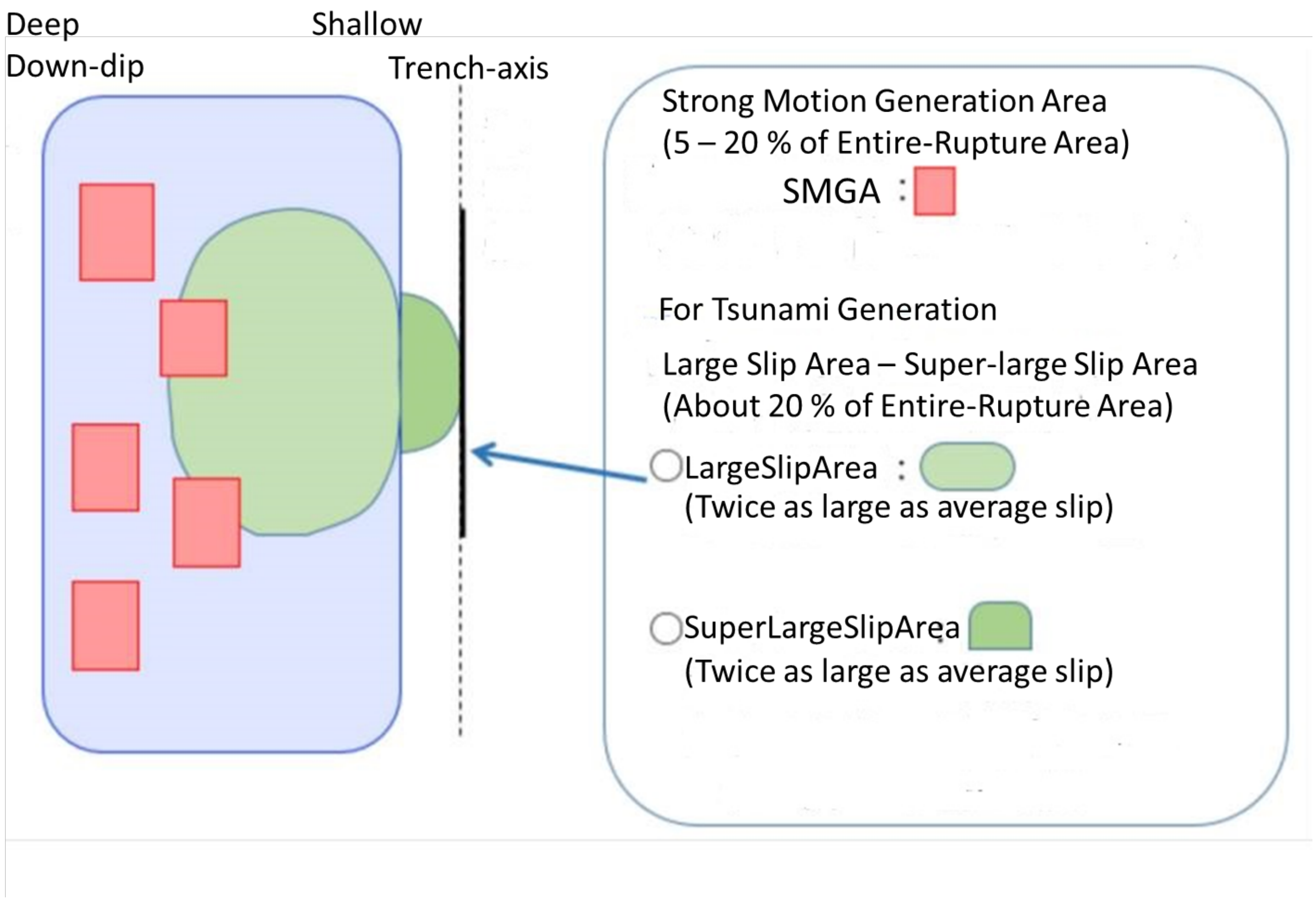
Ground motion comparison for three scenarios (Aochi and Ide, 2014)



Small patchesのパラメータ	case 1	case 2	case 3
Stress excess $\Delta\tau^{excess}$ [MPa]	15	5	10
Stress drop $\Delta\tau$ [MPa]	5	15	10

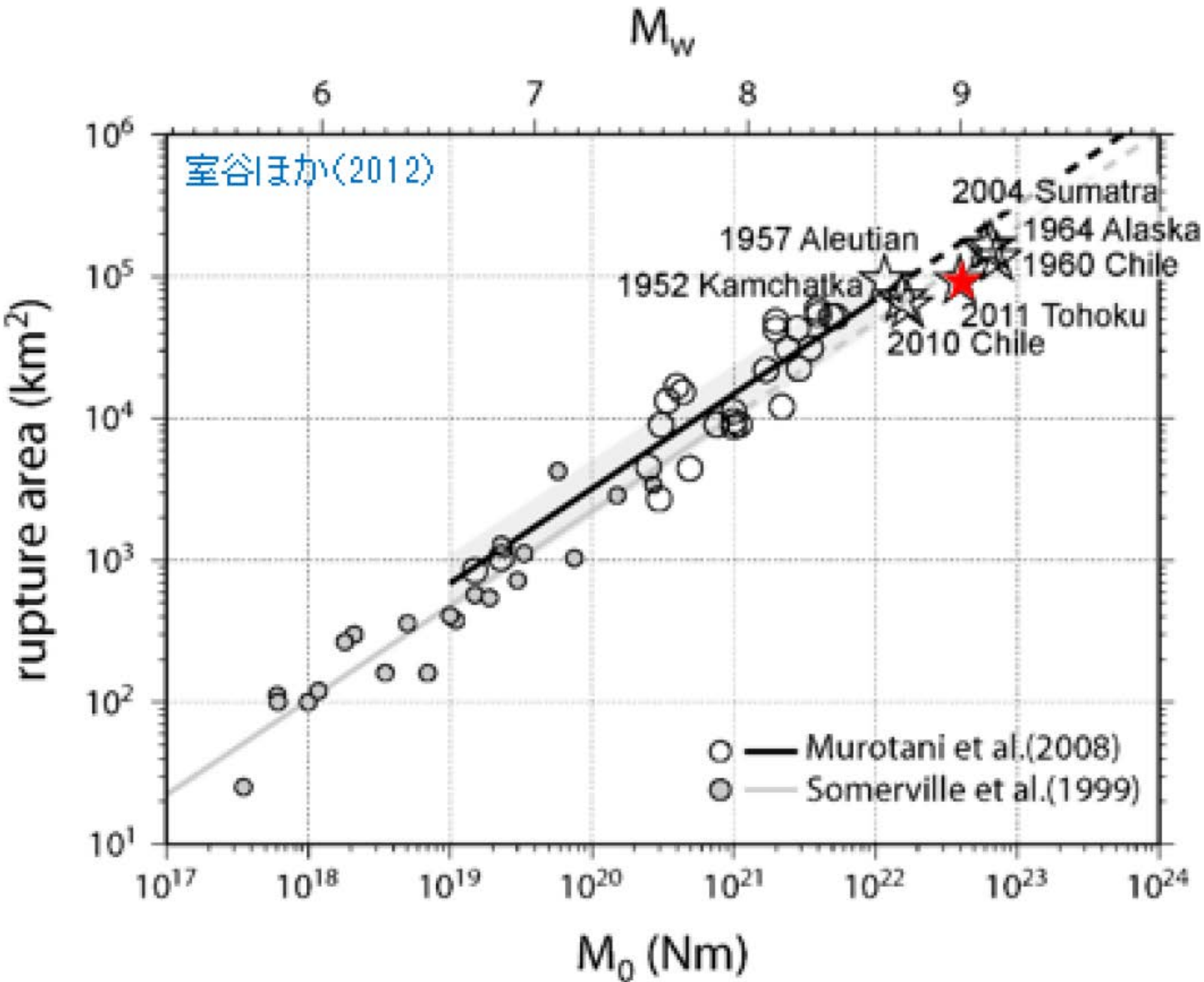
3. Simulation of ground motions: *Long-period source model 1*

An illustrative source model with multiscale heterogeneity combining tsunami and strong motion generation (Long-Period Motion Evaluation Committee of Cabinet Office, Japan)



3. Simulation of ground motions: *Long-period source model 2*

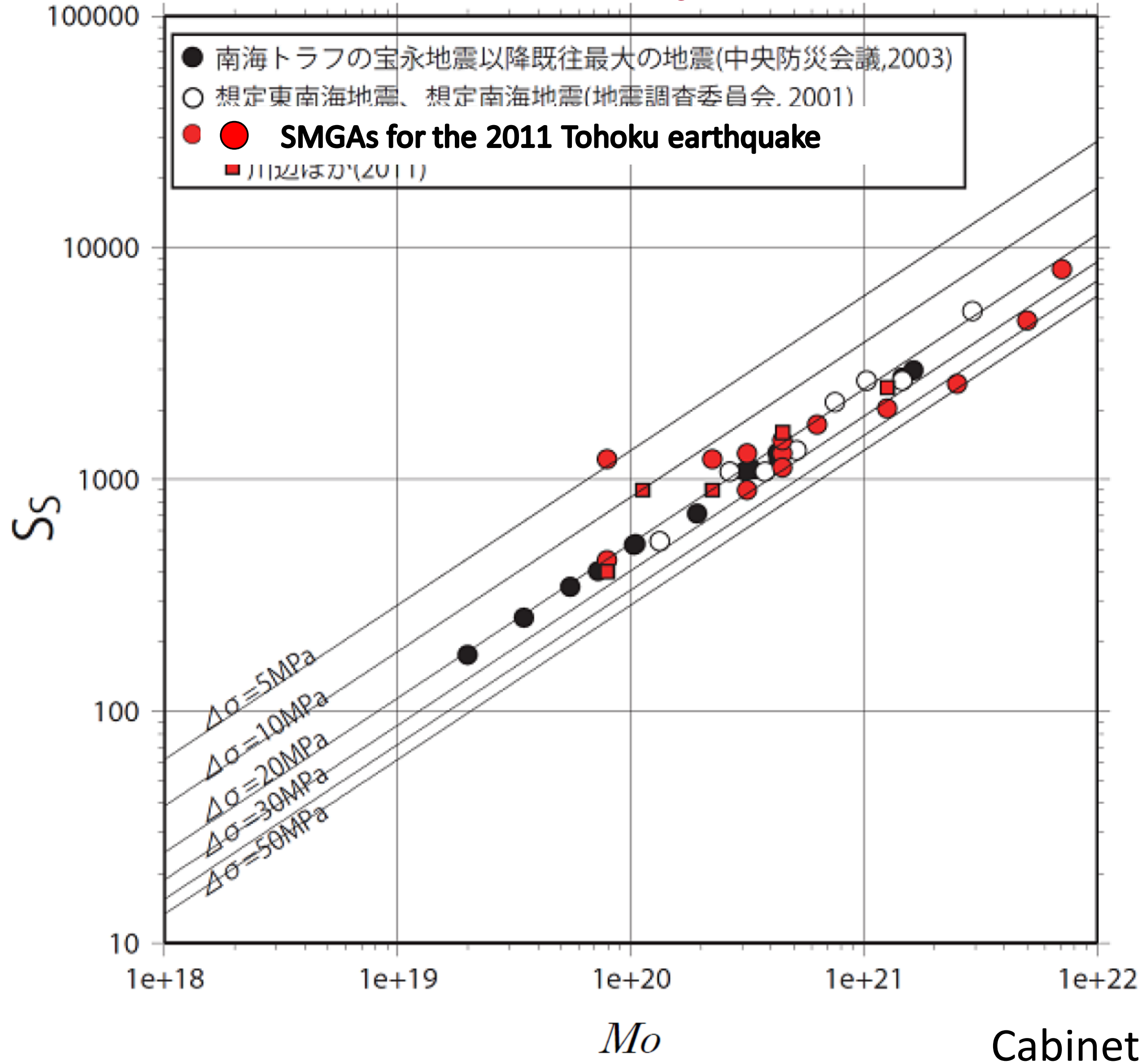
Empirical relationships between seismic moment M_o and rupture area S for subduction earthquakes



Cabinet Office (2015)

3. Simulation of ground motions: *Long-perios source model 3*

Empirical relationships between seismic moment M_o and combined area of asperities S_s for subduction earthquakes



Cabinet Office (2015)

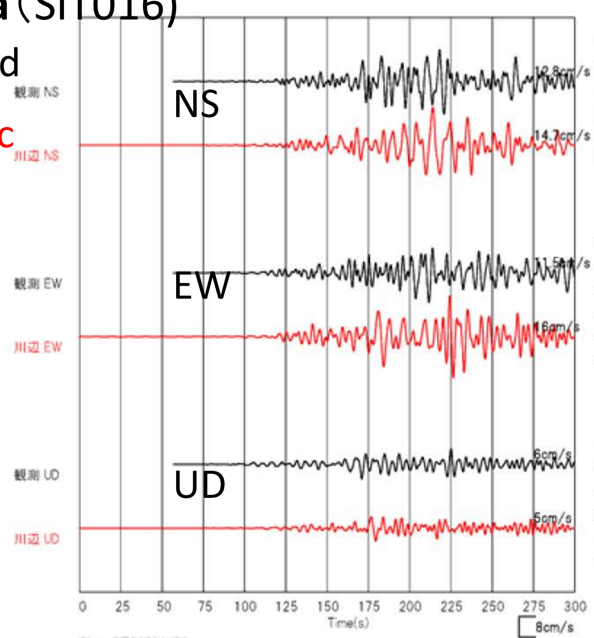
3. Simulation of ground motions: *Long-perios source model 4*

Comparison between observed and synthetic long-period motions

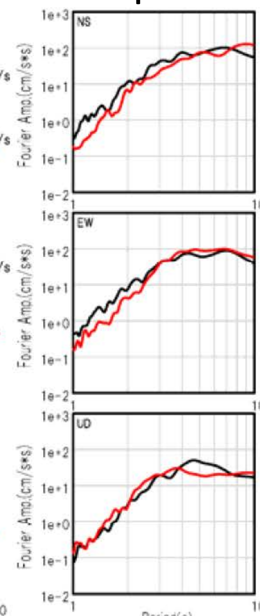
Ohmiya (SIT016)

Observed

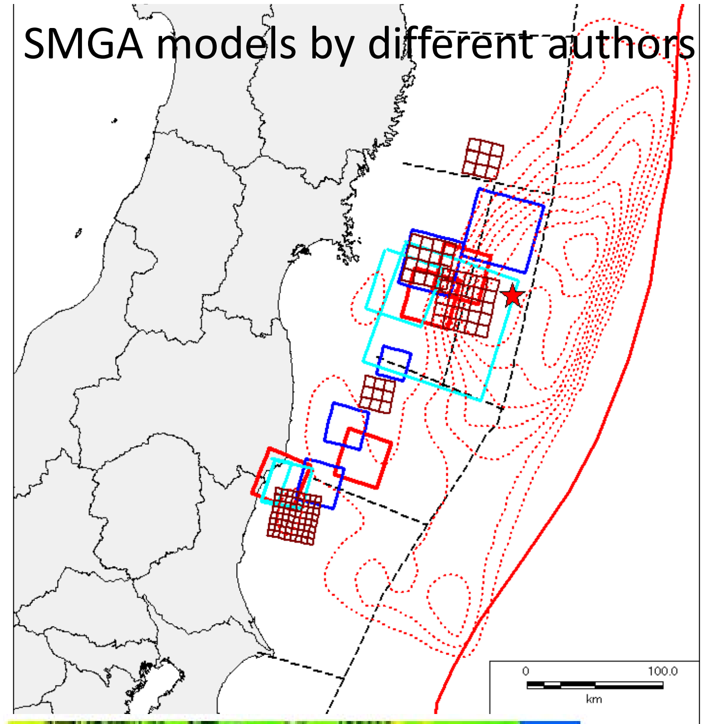
Synthetic



F. Spectra



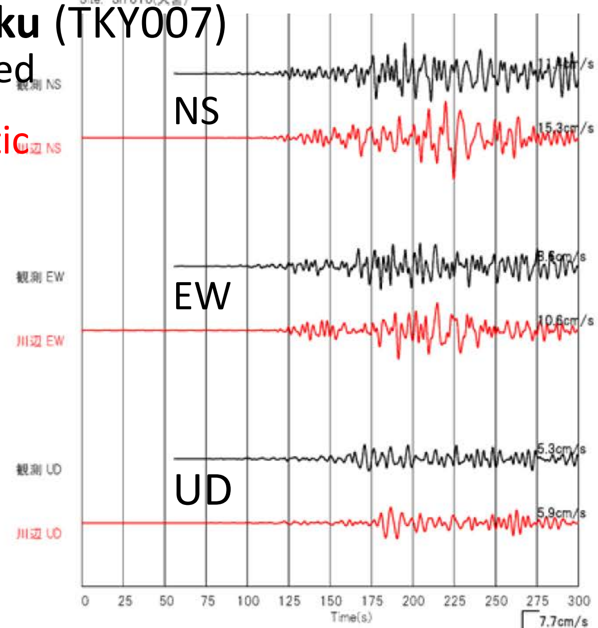
SMGA models by different authors



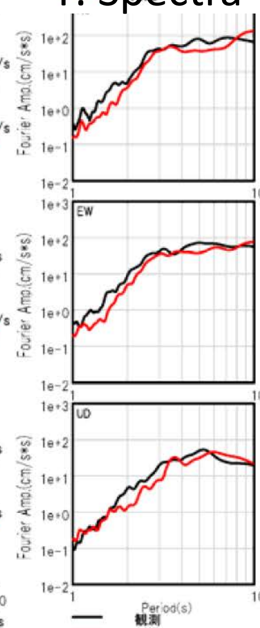
Shinjuku (TKY007)

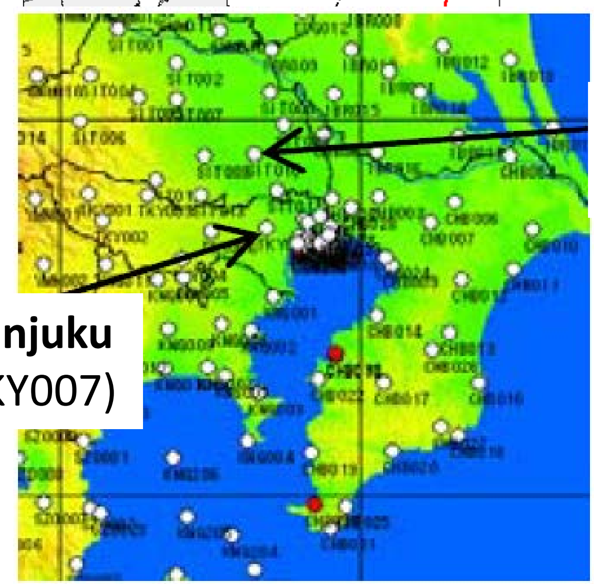
Observed

Synthetic



F. Spectra



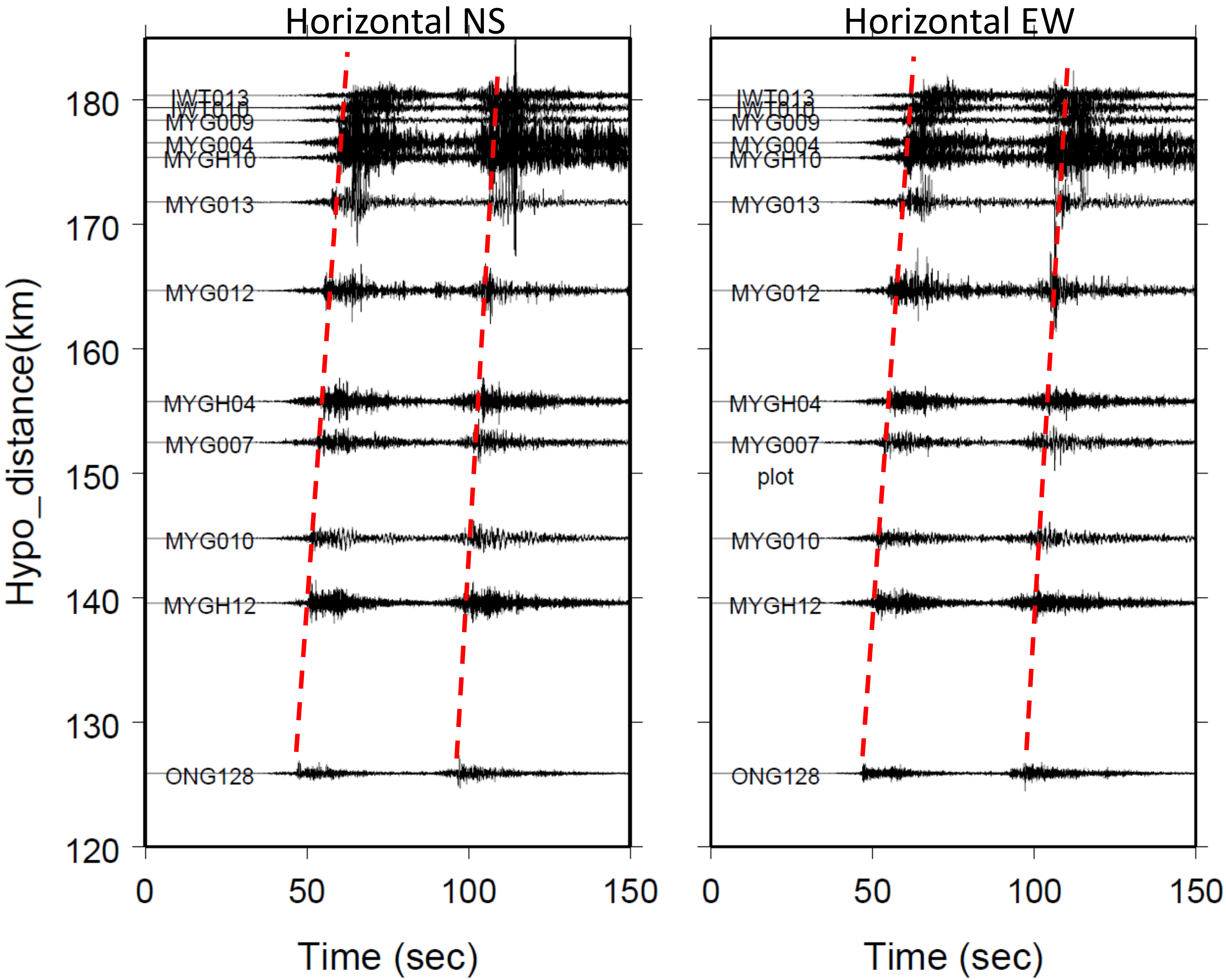


Ohmiya (SIT016)

Shinjuku (TKY007)

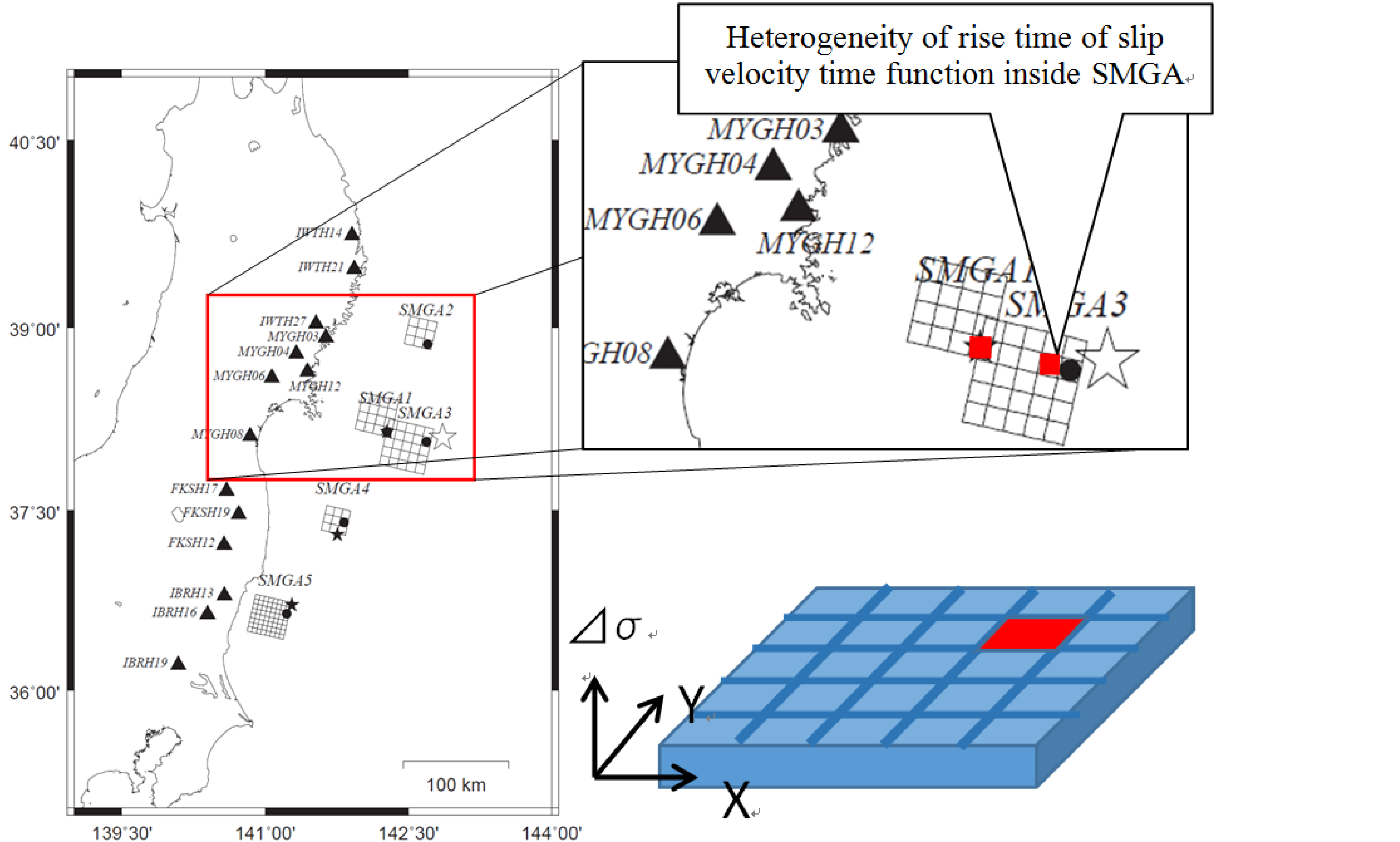
3. Simulation of ground motions: *Short-period source model 1*

Impulsive acceleration motions in near-source areas



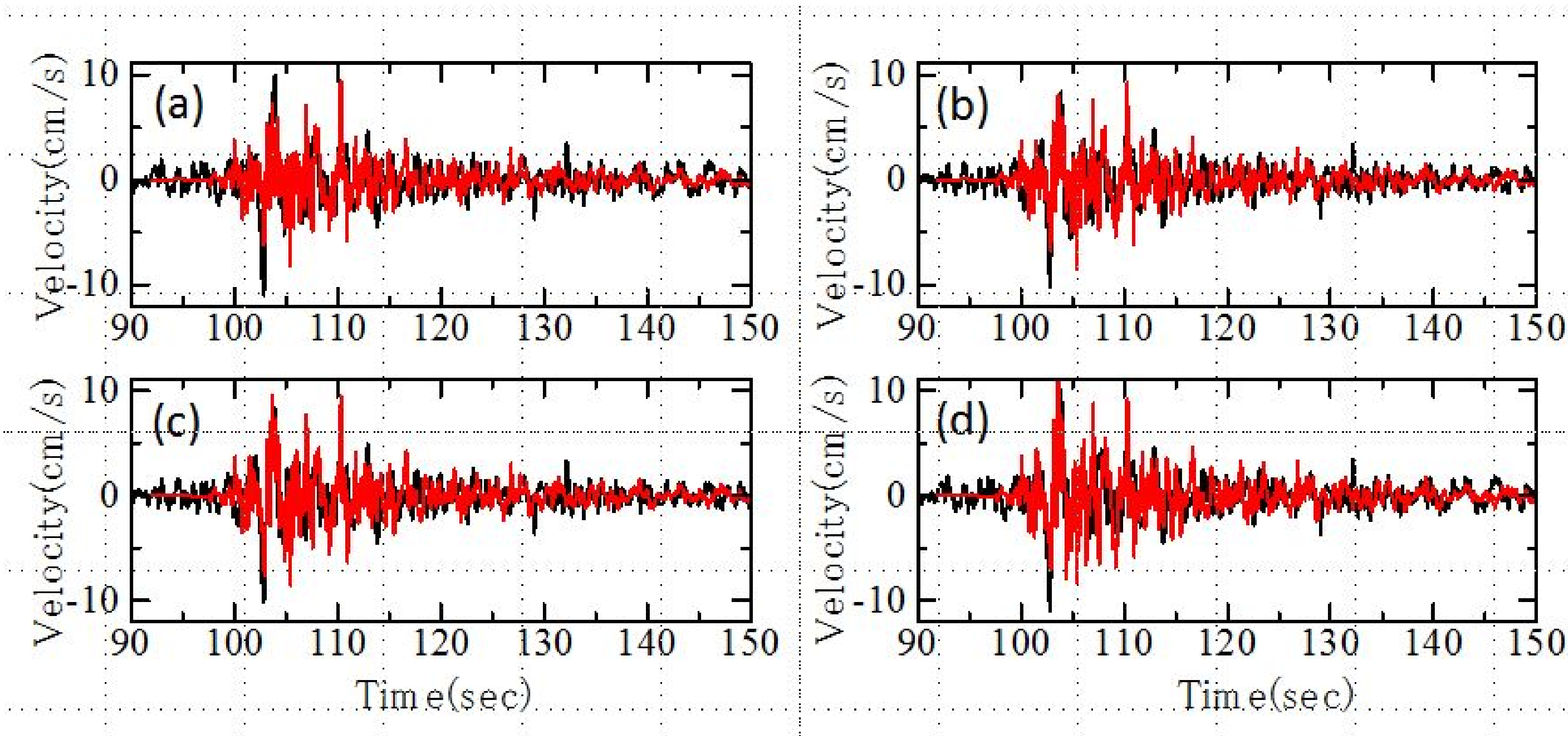
3. Simulation of ground motions: *Short-period source model 2*

Heterogeneity inside 'strong motion generation areas' (SMGAs)



3. Simulation of ground motions: *Short-period source model 3*

Simulated motions from a heterogeneous model, varying rise-times of slip velocity time functions at subfaults inside the SMGAs.



(a) Uniform model with uniform rise time of 3.7 s in all subfaults.
(b) Heterogeneous model with rise time of 2.5 s in one of the subfaults
(c) Heterogeneous model with rise time of 1.0 s in one of the subfaults
(d) Heterogeneous model with rise time of 0.25 s in one of the subfaults.

Conclusion 1

1. Six segments in the Pacific coast region off Tohoku from Middle Sanriku-Oki to Ibaragi-Oki were related to the 2011 Mw 9 Tohoku Earthquake, which are characterized by along-dip double segmentation (ADDS). The segmentation tends to control the characteristics of ground motions judging from the rupture process inversion results of near-field strong motion data as well as of this event.

2. Short-period motions radiated from five strong-motion-generation-areas (SMGAs) in the down-dip areas closer to the Pacific coast inside the source fault of this earthquake, while extremely long-period motion data such as tsunamis and geodetic variations were generated in the shallow segment closer to the trench based on the slip distributions inverted from long-period (more than 20 s) strong-motions data.

Conclusion 2

3. Long-period motions in the range of 2 – 10 s of engineering interest have successfully been simulated taking radiation mainly from the same SMGAs as the short-period motions less than 2 s into account. Impulsive motions with high accelerations whose amplitudes are large at onsets of the wave-packets were simulated taking heterogeneity of slip durations inside the SMGAs into account.
4. We propose a multi-scale heterogeneous model as a recipe of predicting strong ground motions for mega-thrust subduction earthquakes. This model provides broadband ground motions from 0.1 s to 10 s that are engineering interest for aseismic design and base-isolation.