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[S07-8] Strong Motion and Seismic Sources 1
10:30-21:00 Wednesday 2 August, 2017

S07-8-05

Near-field long-period strong ground motions during the 2016 Kumamoto earthquake

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Introduction 1

Surface ruptures and :

- Surface rupture mostly occurred along fault traces mapped in previous active fault investigations. Approximately 34-km-long surface ruptures appeared along the eastern part of the Futagawa fault zone and the northernmost part of the Hinagu fault zone (Shirahama et al., 2016).
- Large slip with maximum dextral slip of 2.20 m (offset) was measured throughout the central section of the rupture zone along the Futagawa segment, and the slip gradually decreased bilaterally on the adjoining northeastern and southwestern sections. Slip exceeding 1 m (offset) occurred on previously unrecognized fault traces in the alluvial lowland of the Kiyama plain and on the western rim of the Aso volcano caldera (Shirahama, et al, 2016).

Introduction 2

Near-field ground motions

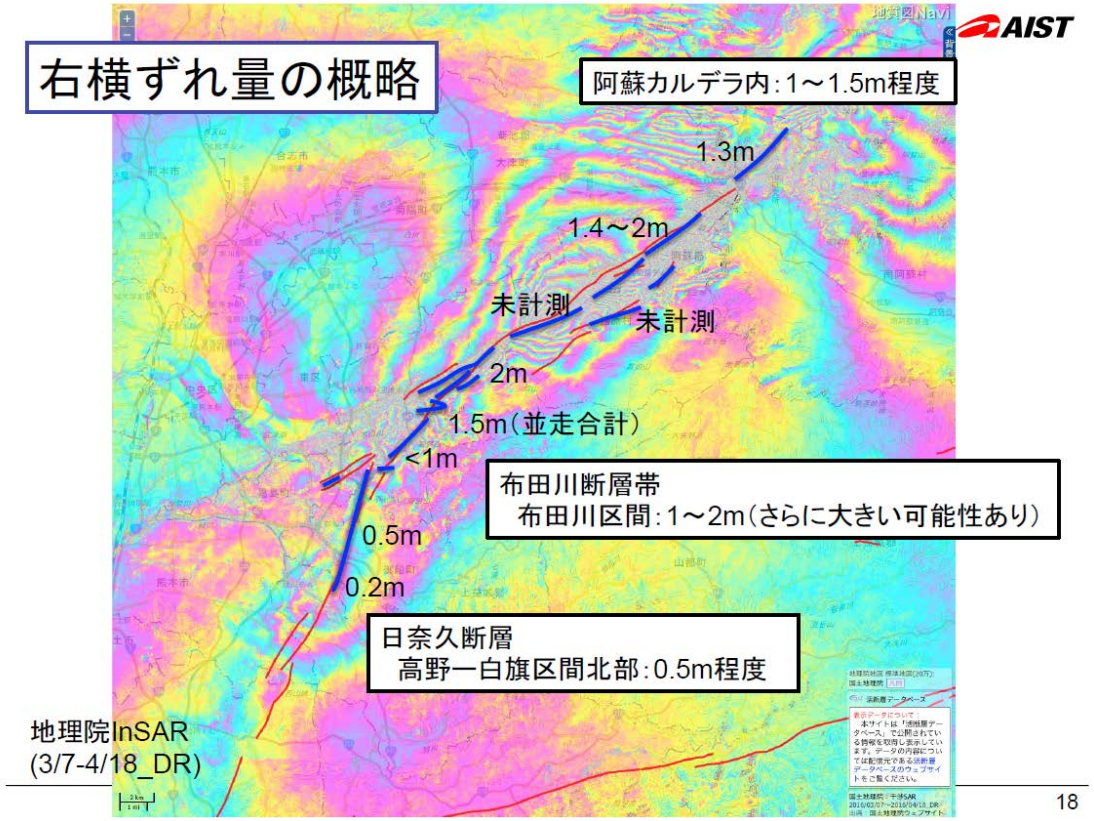
- Near-field strong ground motions with high accuracy were recorded by the NIED strong motion network (K-NET and KiK-net) and the JMA and local-government seismic-intensity network. In particular, two stations at Mashiki Town-Hall (93051) station and Nishihara Village-Hall (93048) were located within 2 km of the surface traces along the Futagawa fault.
- The maximum displacements are about 2.0 m in horizontal (N75E) and about 2.0 in vertical (down) at 93048 and about 1.1 m in horizontal (N65E) and about 0.7 m in vertical (down) at 93051 [Iwata, 2016].

Rupture models inverted from geodetic data and long-period motion data

- The fault length is more than 40 km and the maximum slip is 4 to 5 m from the source inversion due to geodetic data (e.g. Fukahata and Hashimoto, 2016; Yarai et al., 2016) and strong motion data (e.g. Kubo et al., 2016b, Asano and Iwata, 2016, Yoshida et al, 2017).

Displacement Data observed near Earthquake Faults during the 2016 Mw 7.0 Kumamoto earthquake

InSAR image



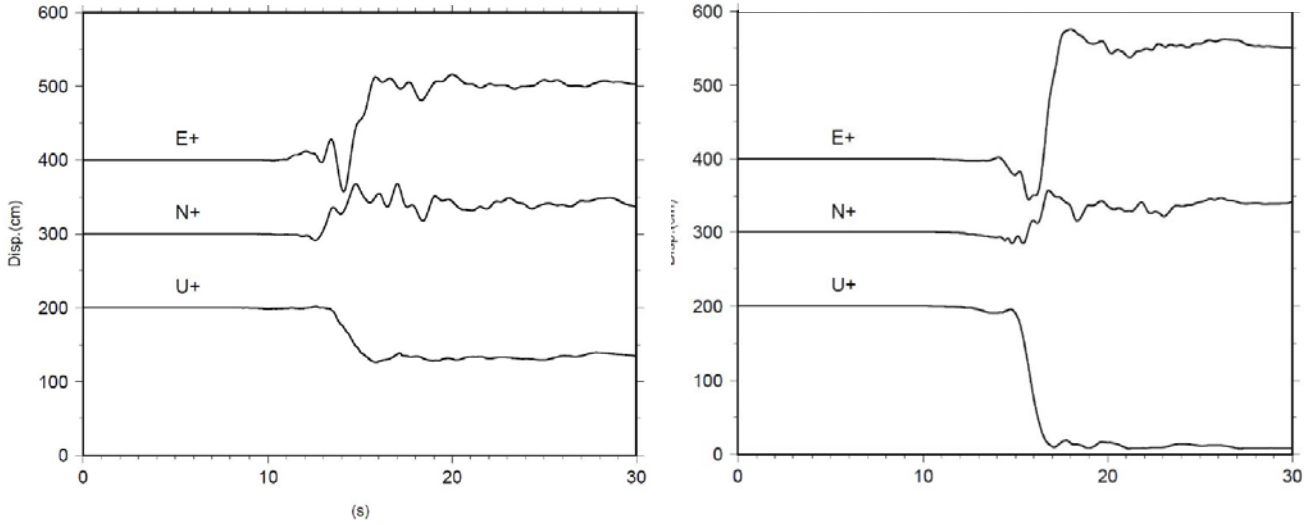
Yoshimi (2016)

Very-Near-Field Strong Motion Records

Displacement

98051 (Miyazono, Mashiki)

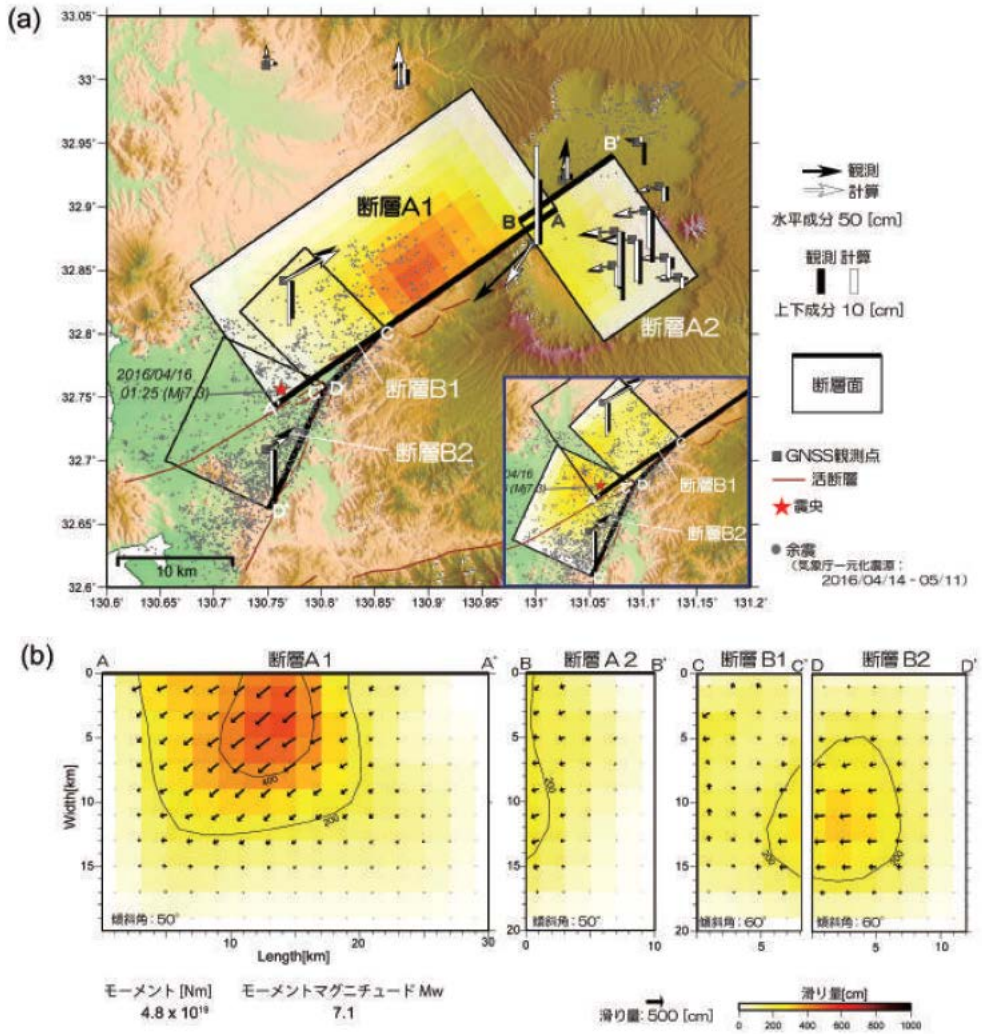
93048 (Komori, Nishihara)



Iwata (2016)

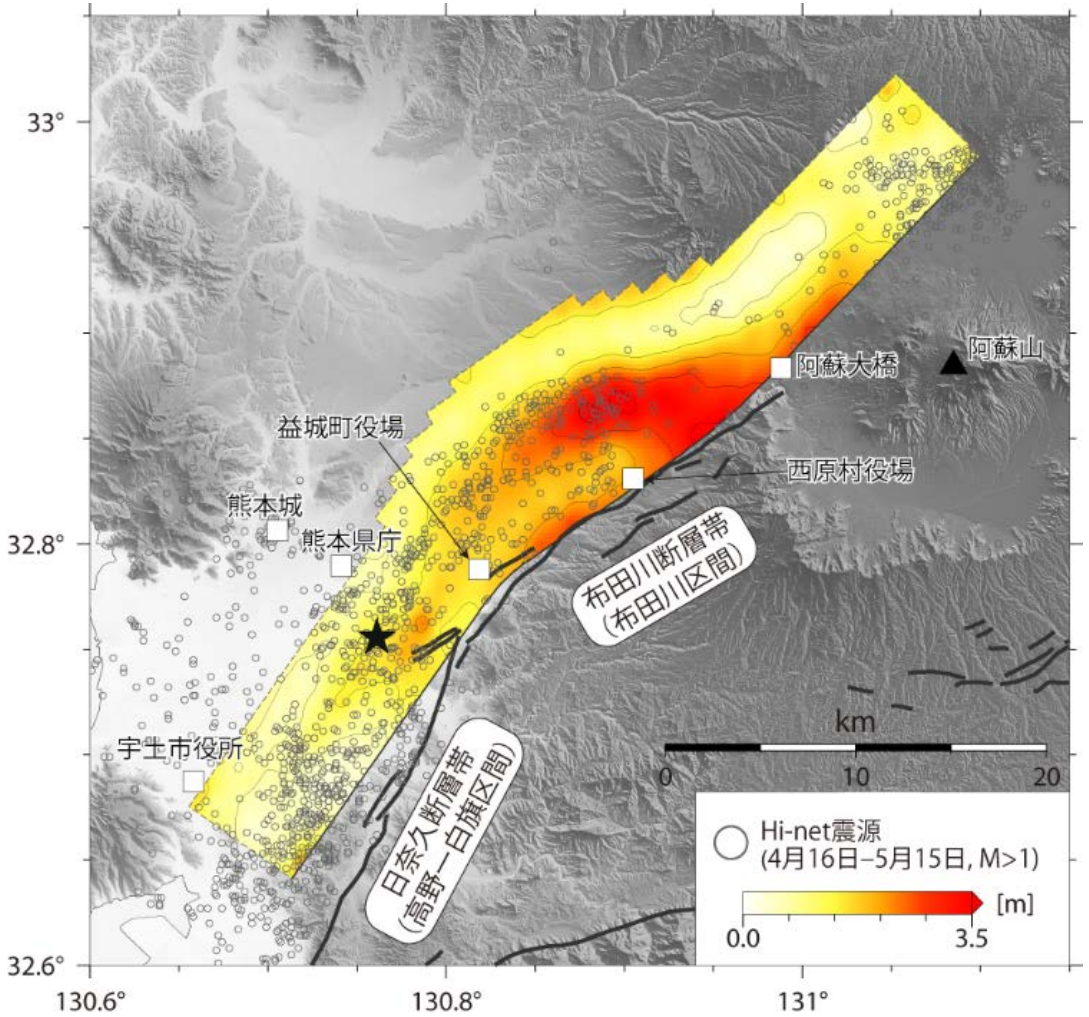
Slip Distribution from Inversion

Crustal deformation inversion



Yarai et al. (2016)

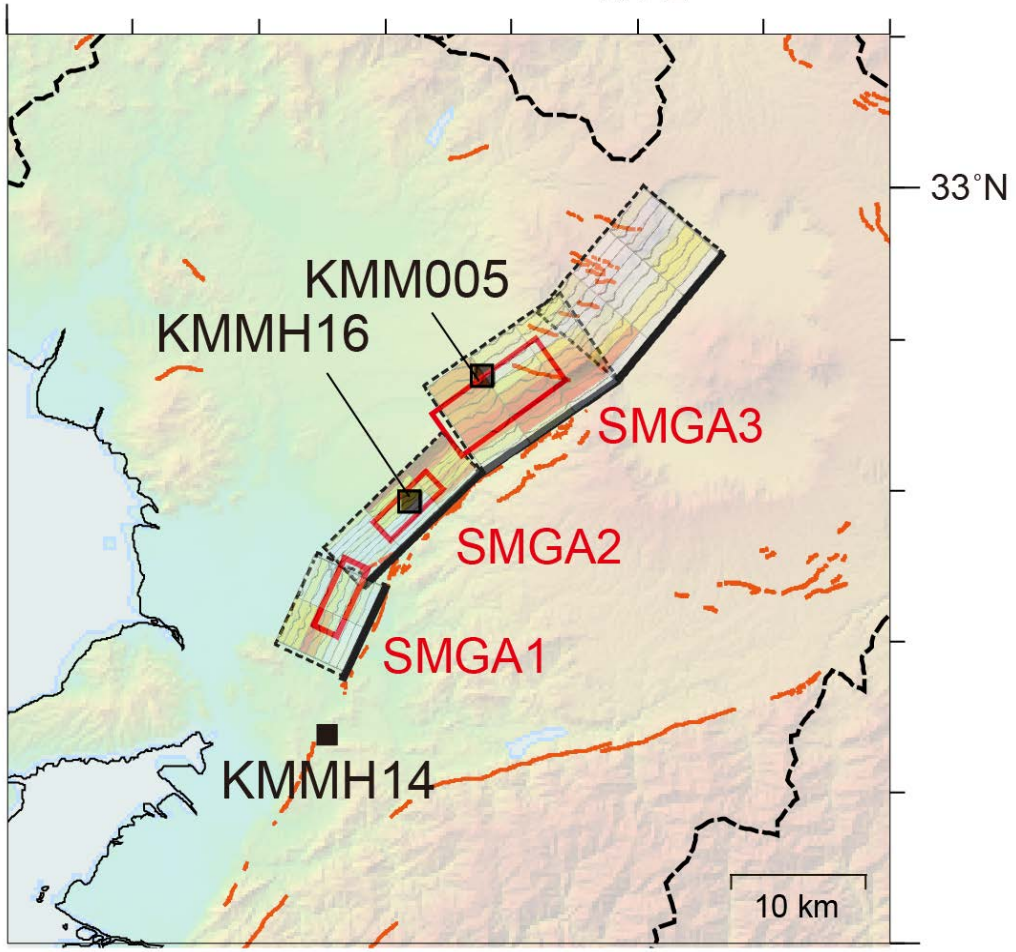
Waveform inversion of strong motion data



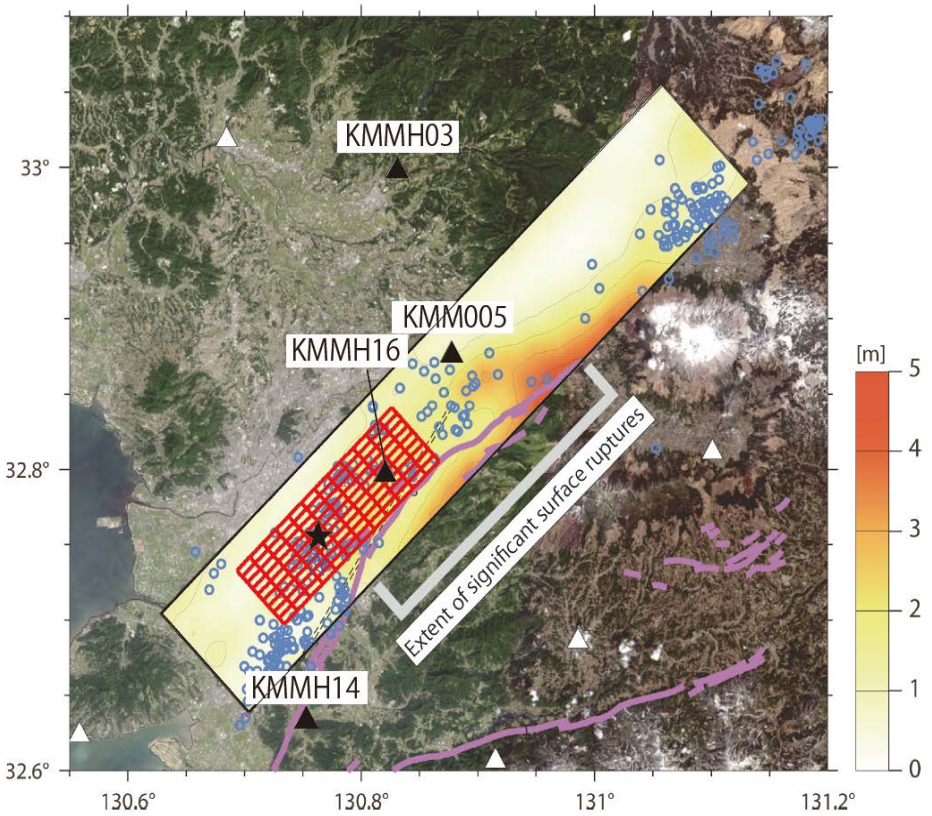
Kubo et al. (2016)

Characterized source models with SMGAs (Irikura et al. 2017)

Three SMGA model based on the slip distribution of Yoshida et al. (2016)



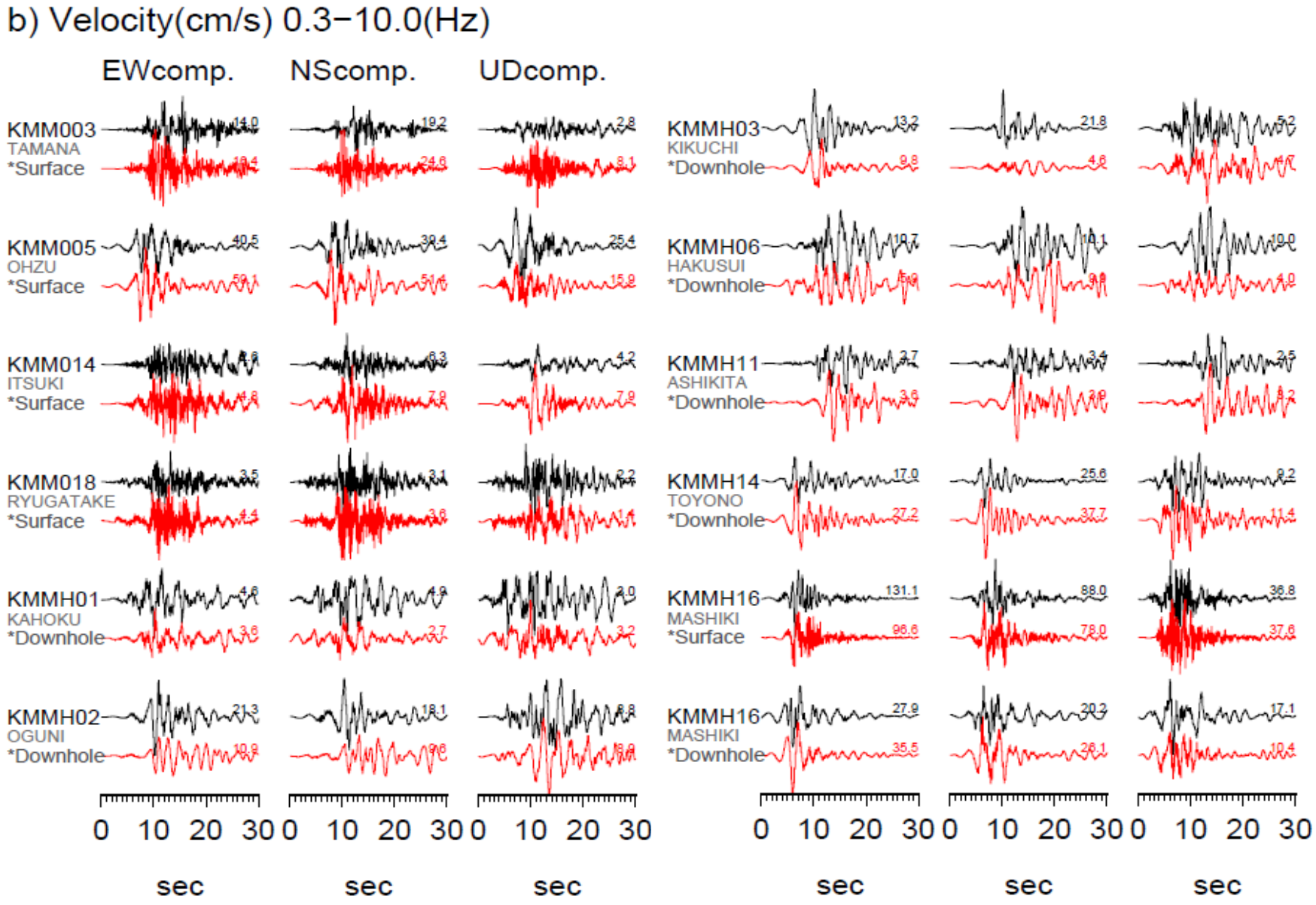
A single SMGA model based on the slip distribution of Kubo et al. (2016a)



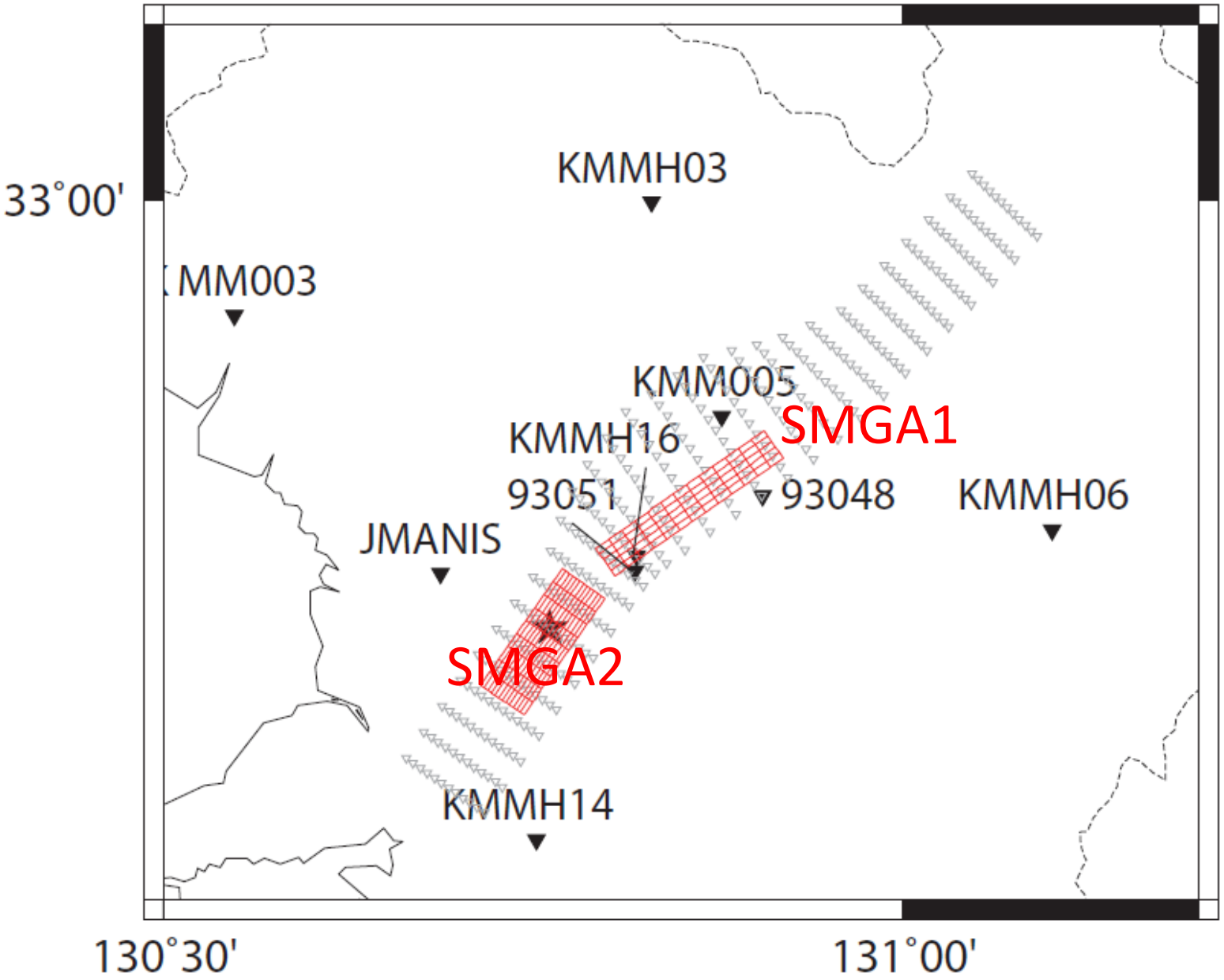
Comparison of the observed (*black*) and synthetic (*red*) ground motions of three components (east–west, north–south, and up–down)

A Single SMGA model (Irikura et al., 2017)

Empirical Green's method



SMGA source model

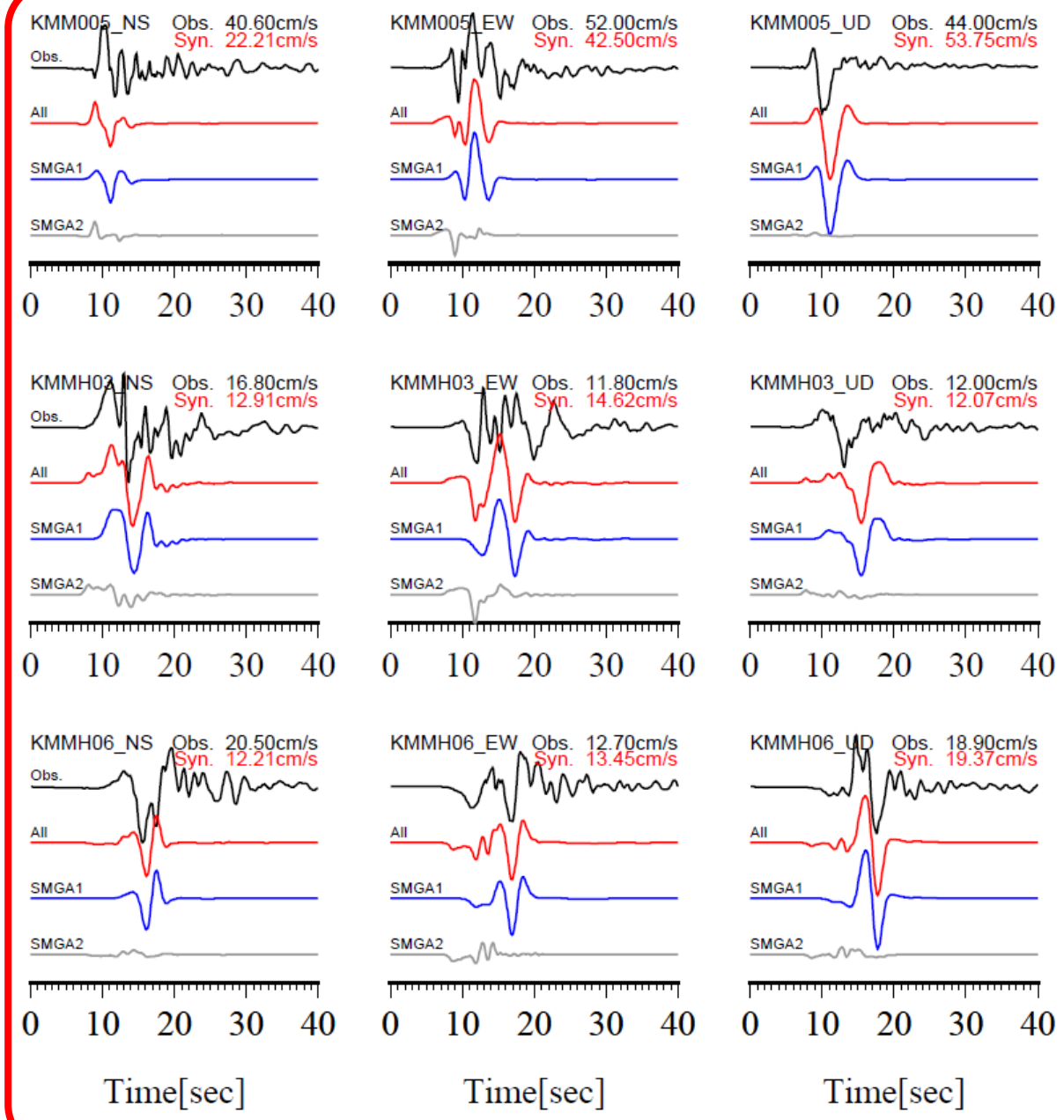


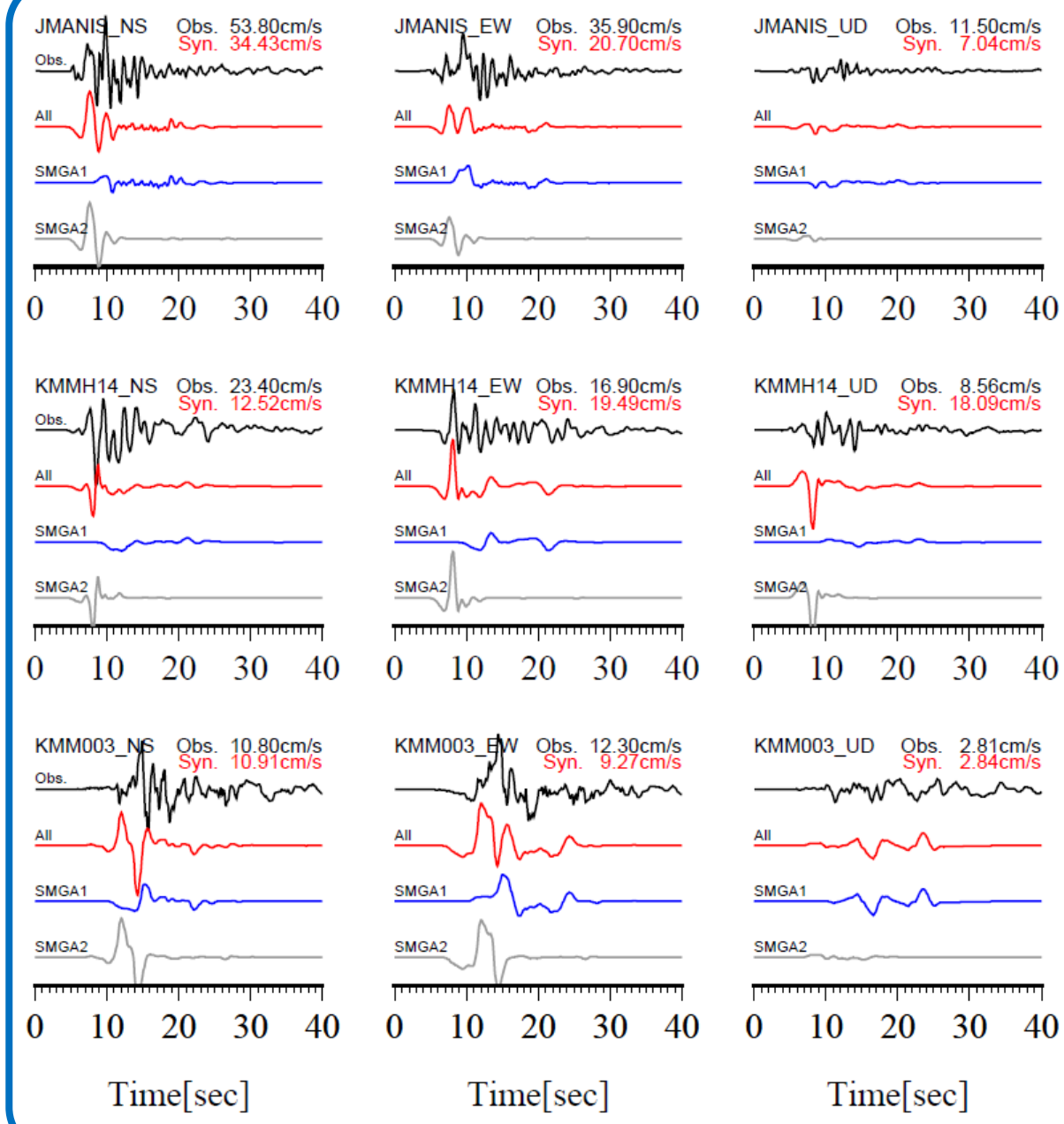
- Fault geometry (strike, dip) based on Kubo et al. (2016b)
- Observed data (KiK-net underground, Seismic-intensity accelerometer network)
- Two SMGA model (SMGA1 and SMGA2) best-bit to observed velocity waveform
- Frequency range 0.05 - 1 Hz

	SMGA1	SMGA2
Str,dip	235° ,65°	215° ,74°
rake	-145°	-180
M0	1.30×10^{19}Nm	7.49×10^{18}Nm
Dx × Dw	13 × 5km	9 × 13km
risetime	1.6sec	1.6sec
Lag time	0.0sec	3.0sec
Vr	2.8km/s	2.8km/s

North stations, large contribution from SMGA1

South stations, large contribution from SMGA2



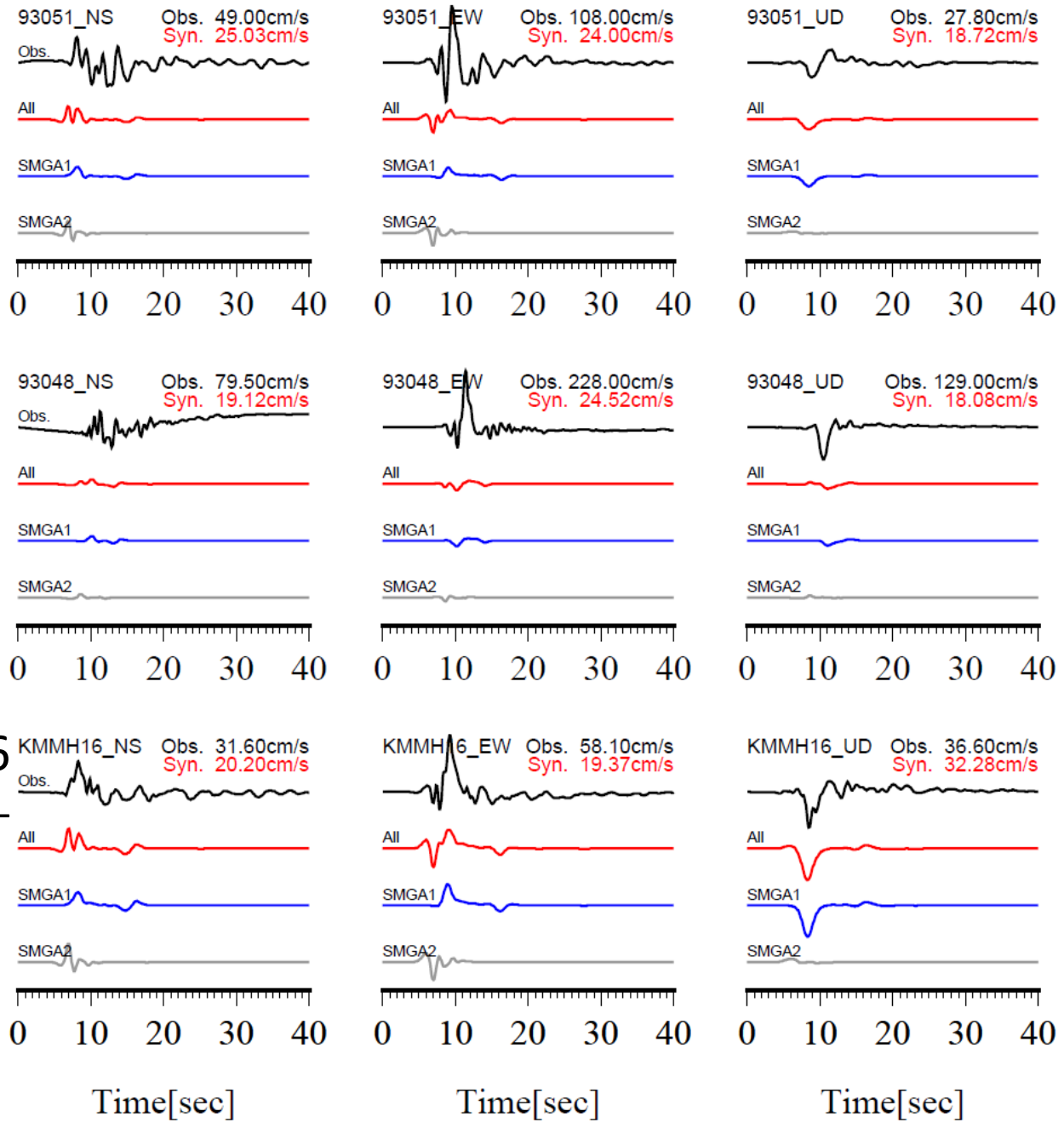


Comparison between observed and synthetic waveforms using the SMGA model

93051
(Miyazono)

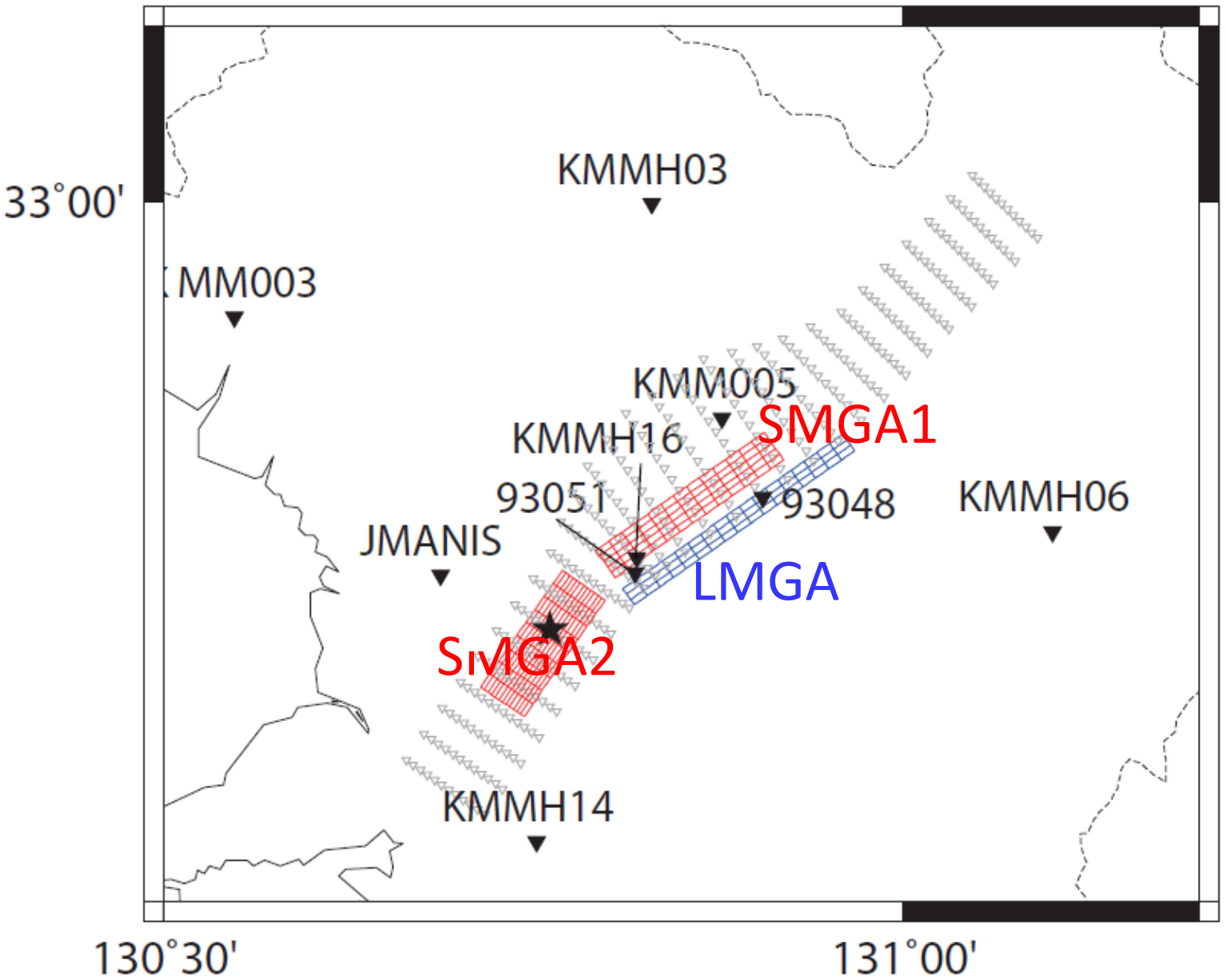
93048
(Komori)

KMMH016
(Mashiki KiK-net)



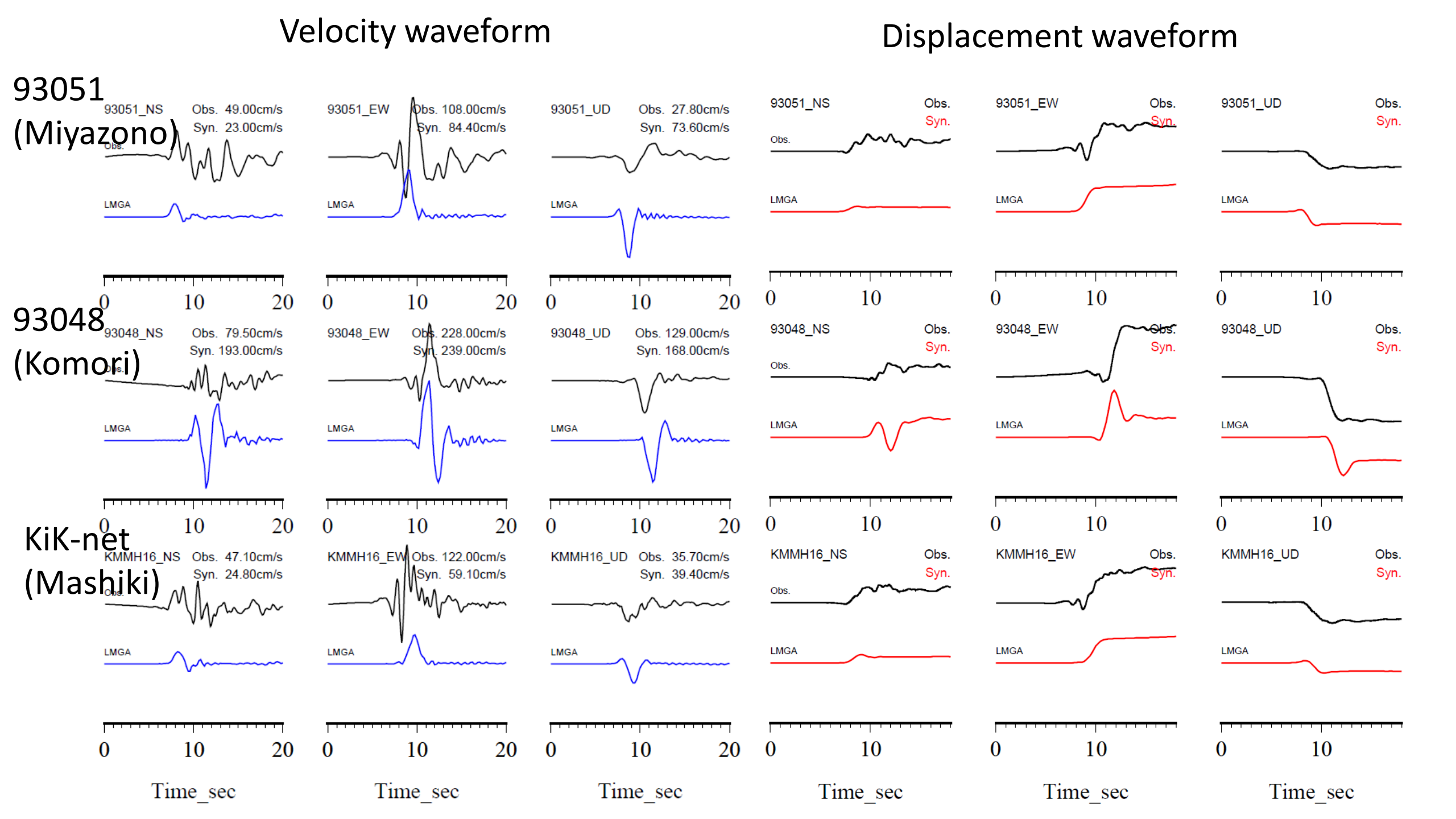
- Ground motions at very near-field stations from the fault traces
- 93051 (Mashiki-Miyazono) about 1.6 km from the fault.
- 93048 (Nishihara-Komori) about 1 km from the fault.
- KMMH016 (Mashiki-KiK-net) about 2.4 km from the fault.

LMGA source model



- Fault geometry (strike, dip) based on Kubo et al. (2016b)
- LMGA is put to fit the long-period motions with fling steps and surface breaks.
- Simulated displacement and velocity waveforms are compared with observed ones at very-near-field stations
- Slip velocity time functions are a triangle.
- Max slip is given to be 4.0 m.
- Frequency range 0.05 – 1 Hz

	LMGA
Str,dip	235° ,65°
rake	-150°
M0	2.84×10^{18}Nm
Dx × Dw	17 × 3km
risetime	2.5sec
Lag time	5.0sec
Vr	2.8km/s


Velocity waveform
Displacement waveform
93051 (Miyazono)
93048 (Komori)
KiK-net (Mashiki)
93051_NS Obs. 49.00cm/s Syn. 23.00cm/s
93051_EW Obs. 108.00cm/s Syn. 84.40cm/s
93051_UD Obs. 27.80cm/s Syn. 73.60cm/s
93048_NS Obs. 79.50cm/s Syn. 193.00cm/s
93048_EW Obs. 228.00cm/s Syn. 239.00cm/s
93048_UD Obs. 129.00cm/s Syn. 168.00cm/s
KMMH16_NS Obs. 47.10cm/s Syn. 24.80cm/s
KMMH16_EW Obs. 122.00cm/s Syn. 59.10cm/s
KMMH16_UD Obs. 35.70cm/s Syn. 39.40cm/s
Obs.
Syn.
LMGA
0
10
20
Time_sec

Modified Characterized Source Model

Strong Motion Generation Areas (SMGAs)

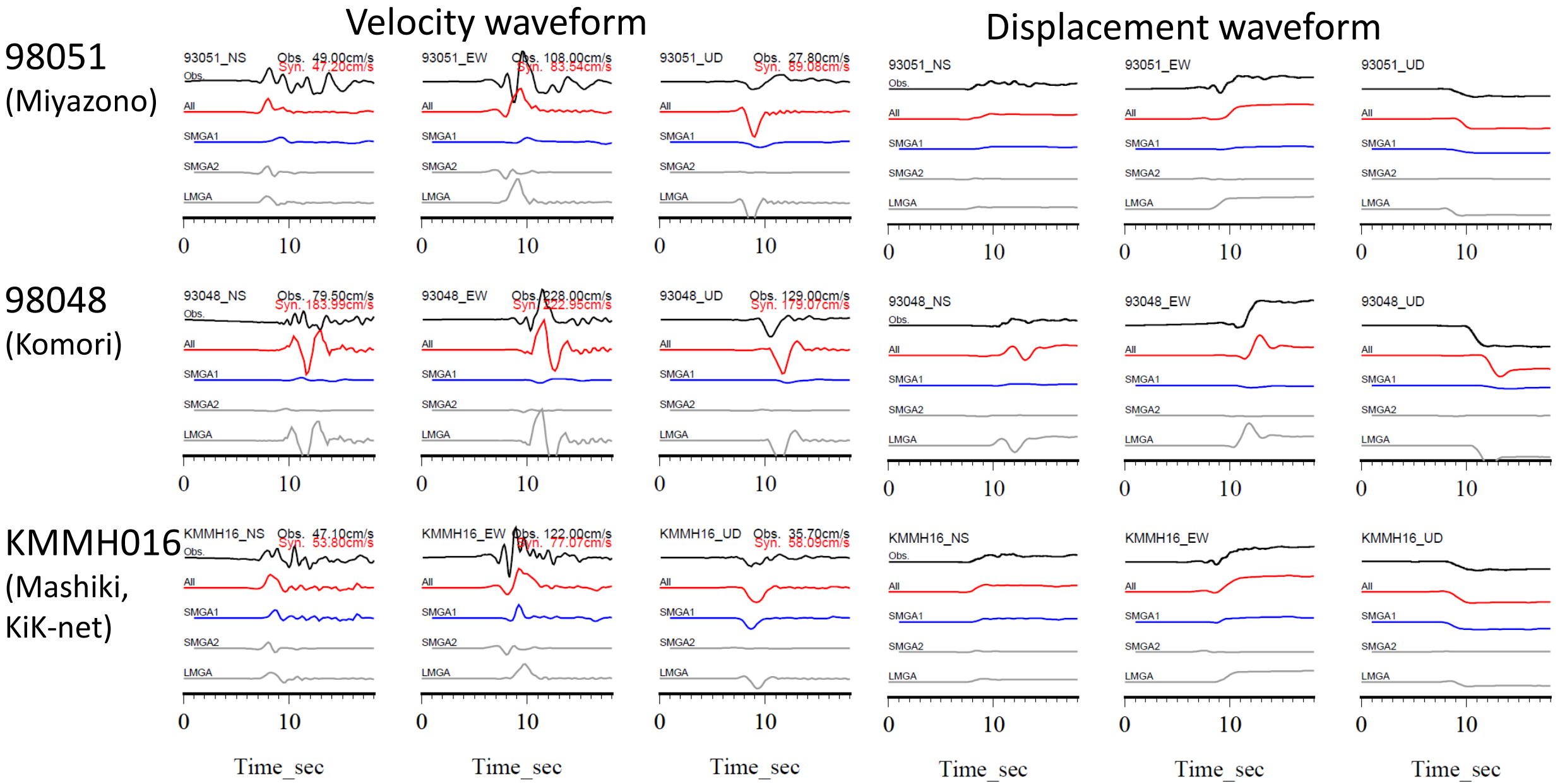
+

Long-period Motion Generation Areas (LMGAs)

SMGAs are located inside the seismogenic zone on the source fault plane having slip time functions such as Kostrov-type (e.g. Nakamura-Miyatake , regularized Yoffe functions)

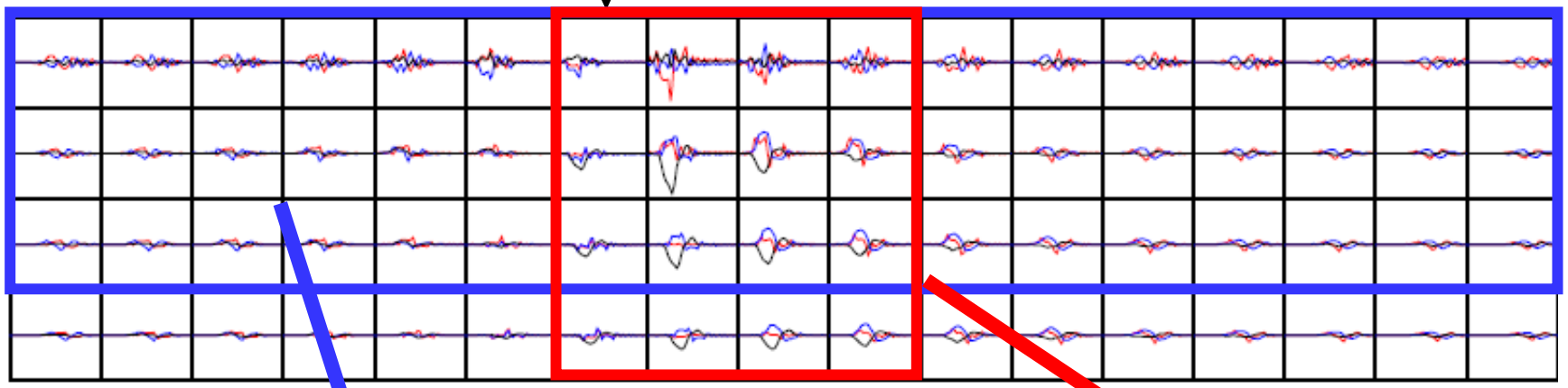
LMGAs are placed is inside near-surface layers above the seismogenic zone on the source fault plane having slip time functions such as smoothed ramp functions.

SMGA + LMGA


Velocity waveform
Displacement waveform
98051
(Miyazono)
98048
(Komori)
KMMH016
(Mashiki,
KiK-net)
93051_NS Obs. 49.00cm/s Syn. 47.20cm/s
93051_EW Obs. 108.00cm/s Syn. 83.54cm/s
93051_UD Obs. 27.80cm/s Syn. 89.08cm/s
93048_NS Obs. 79.50cm/s Syn. 183.99cm/s
93048_EW Obs. 228.00cm/s Syn. 222.95cm/s
93048_UD Obs. 129.00cm/s Syn. 179.07cm/s
KMMH16_NS Obs. 47.10cm/s Syn. 53.80cm/s
KMMH16_EW Obs. 122.00cm/s Syn. 77.07cm/s
KMMH16_UD Obs. 35.70cm/s Syn. 58.09cm/s
Obs.
All
SMGA1
SMGA2
LMGA
0
10
Time_sec

Distribution of Green's functions (displacement) from individual subfaults to the nearest station

93048 (Nishihara)



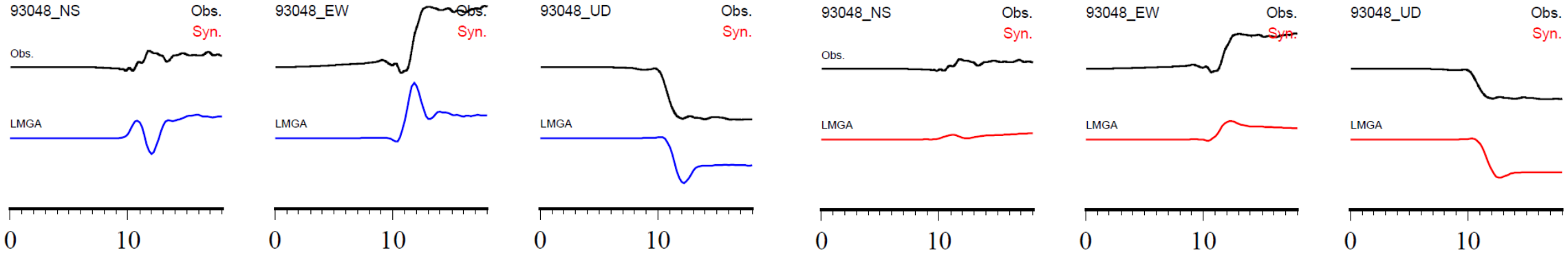
NS
EW
UD

Contribution from the blue area to the station

Contribution from the red area to the station

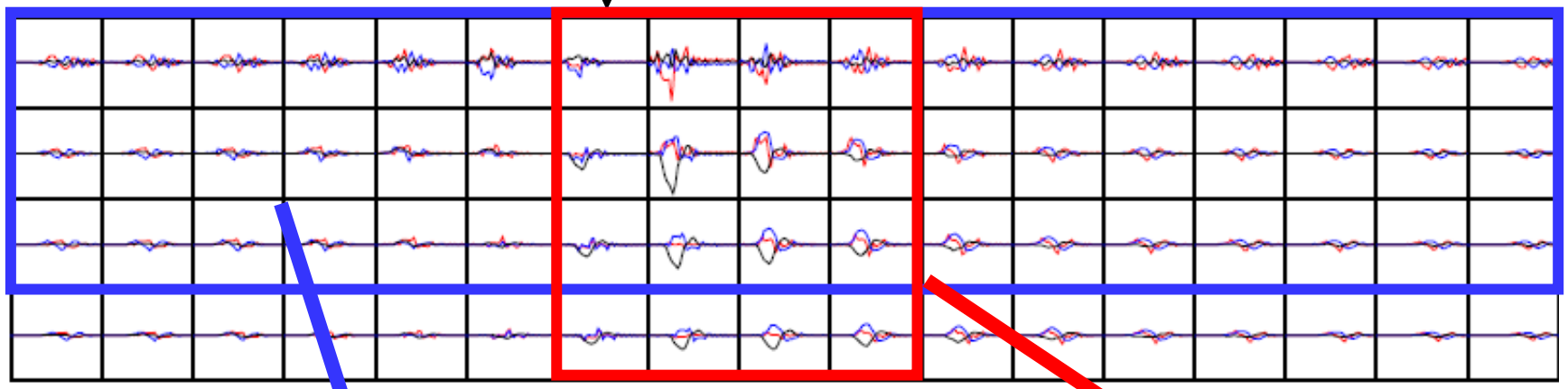
観測

合成



Distribution of Green's functions (velocity) from individual subfaults to the nearest station

93048 (Nishihara)



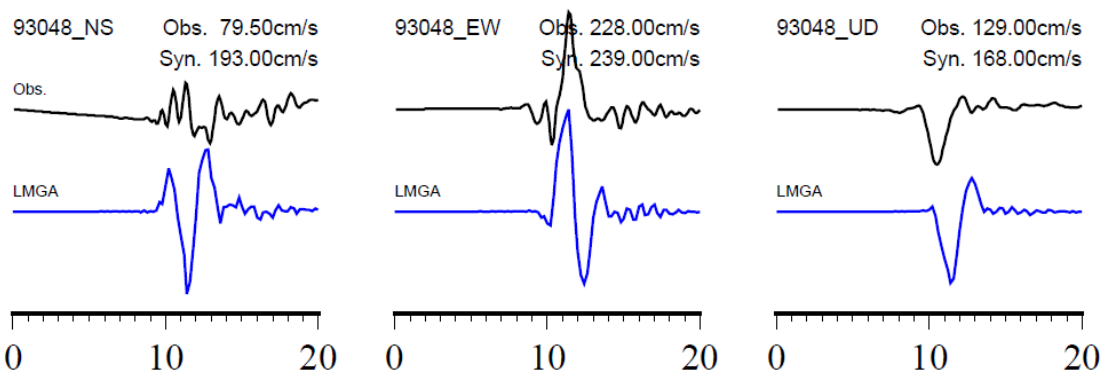
NS
EW
UD

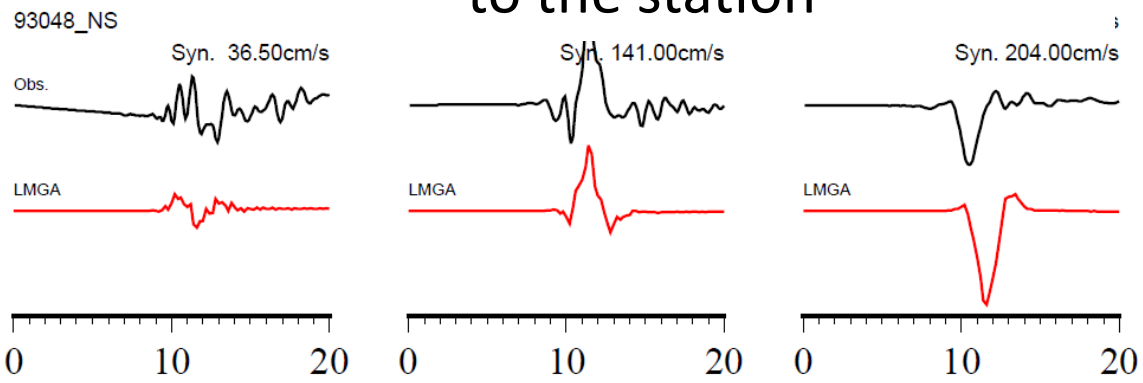
Contribution from the blue area to the station

Contribution from the red area to the station

観測

合成





Summary

1. The ground motions of the 2016 Kumamoto earthquake (Mw 7.0) are well simulated using a characterized source model consisting of strong motion generation areas (SMGAs) except those at very-near-field stations less then 2 km.
2. Long-period ground motions (more than 2 sec) with fling-steps at very near-fault stations are observed.
3. Such long-period ground motions including fling steps at very near-fault stations are well simulated when the long-period generation areas (LMGA) in near-surface areas of earthquake fault are taken into account in addition to the SMGAs.