JpGU-AGU Joint Meeting 2017
May 20 to 25, 2017, Makuhari, Chiba, Japan

[S-CG70] Analysis and Prediction of Near-Source Strong Ground Motions: Present Status and Future Perspective

Long-period strong ground motions near the source fault of the 2016 Kumamoto earthquake

*Kojiro Irikura, Susumu Kurahashi
(Aichi Institute of Technology)

Introduction 1

Surface ruptures:

- 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.
- Large slip with maximum dextral slip of 2.20 m 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 occurred on previously unrecognized fault traces in the alluvial lowland of the Kiyama plain and on the western rim of the Aso volcano caldera.

After Shirahama et al. (2016)

Introduction 2

Near-field ground motions

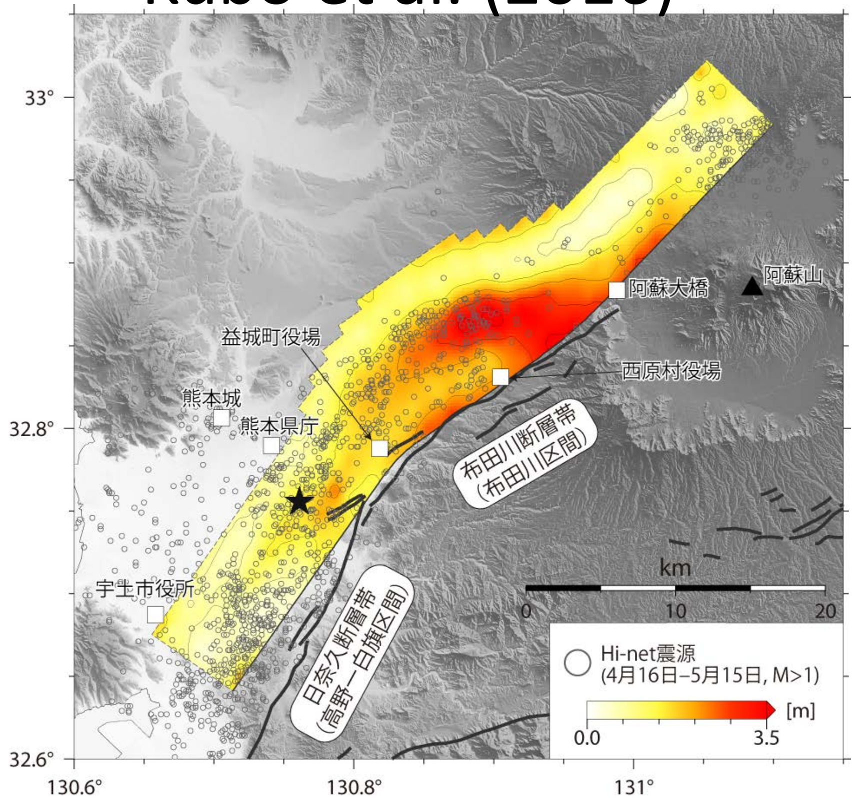
- Near-field strong ground motions with high accuracy were recorded by the NIED strong motion network (K-NET and KiK-net) and the JMA and local-government seismic-intensity network. In particular, two stations at Mashiki Town-Hall (93051) station and Nishihara Village-Hall (93048) were located within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

  The maximum displacement at 93048 is about 2.0 m in horizontal (N75E) and about 2.0 in vertical (down)

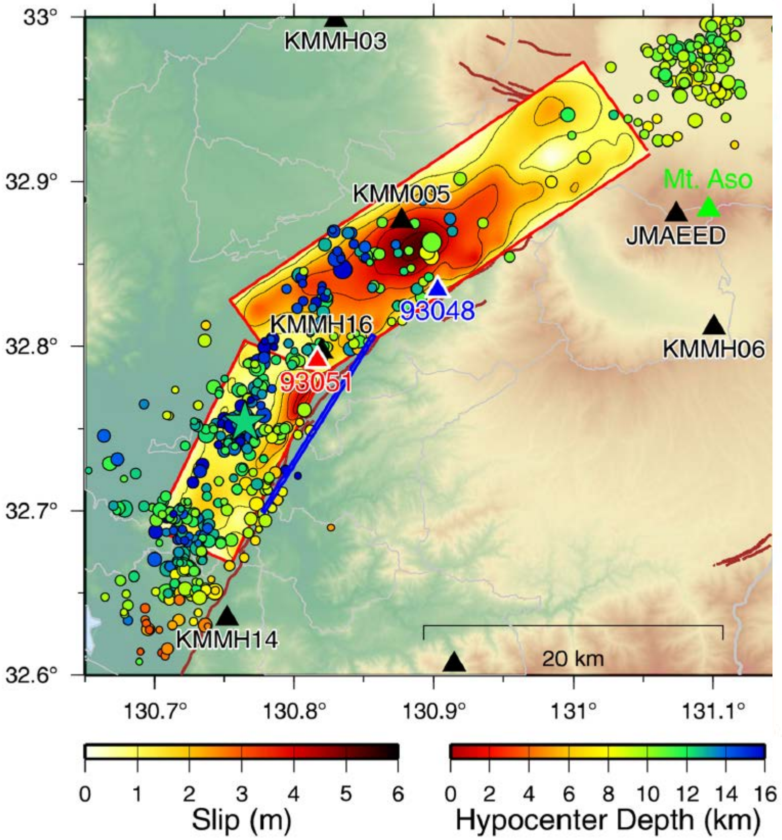
  (Iwata, 2016)

Examples of slip distributions from the waveform inversion of strong motion data

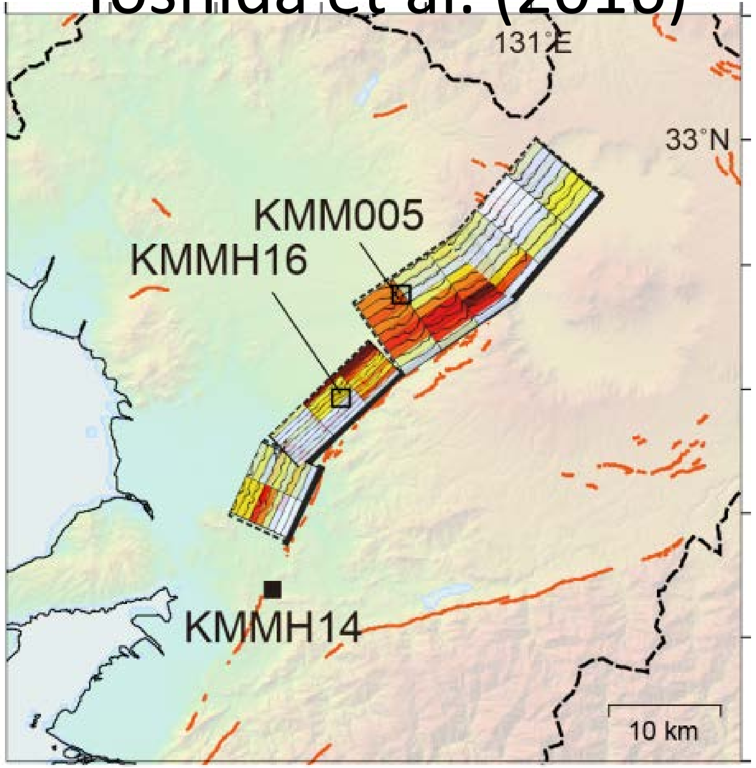
Kubo et al. (2016)



Asano and Iwata (2016)

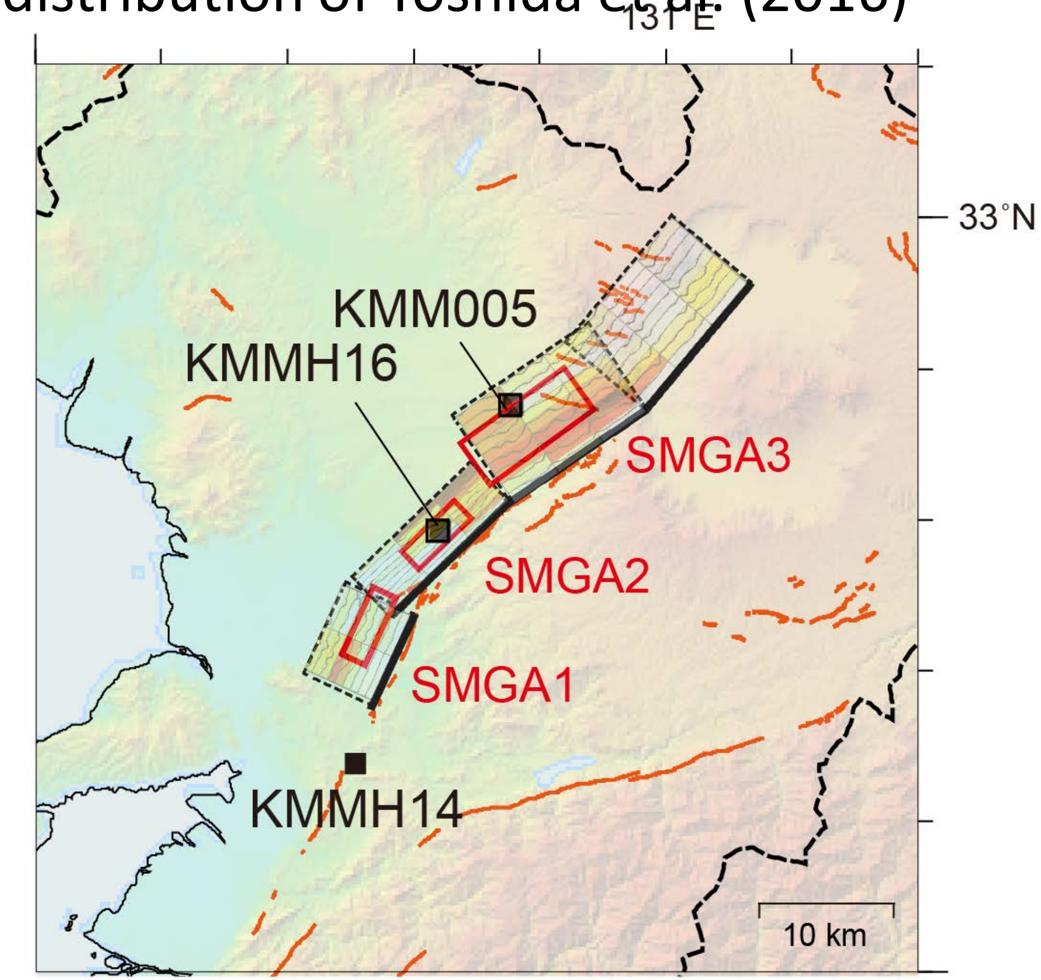


Yoshida et al. (2016)

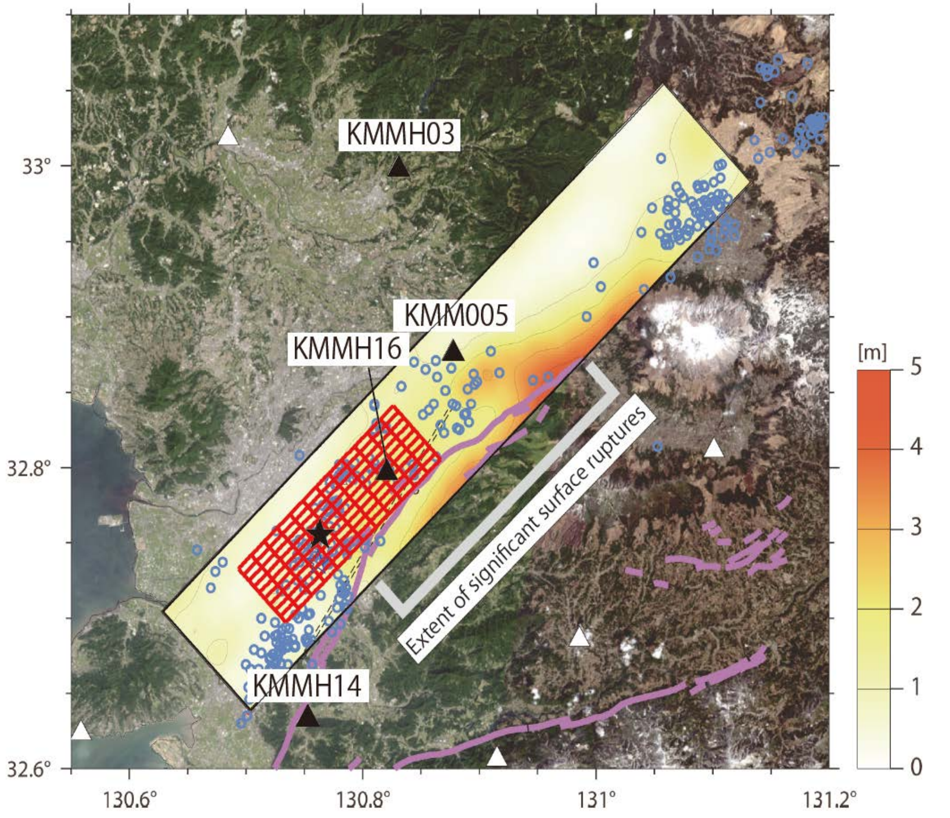


Characterized source models with SMGAs
(Irikura et al. 2017)

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

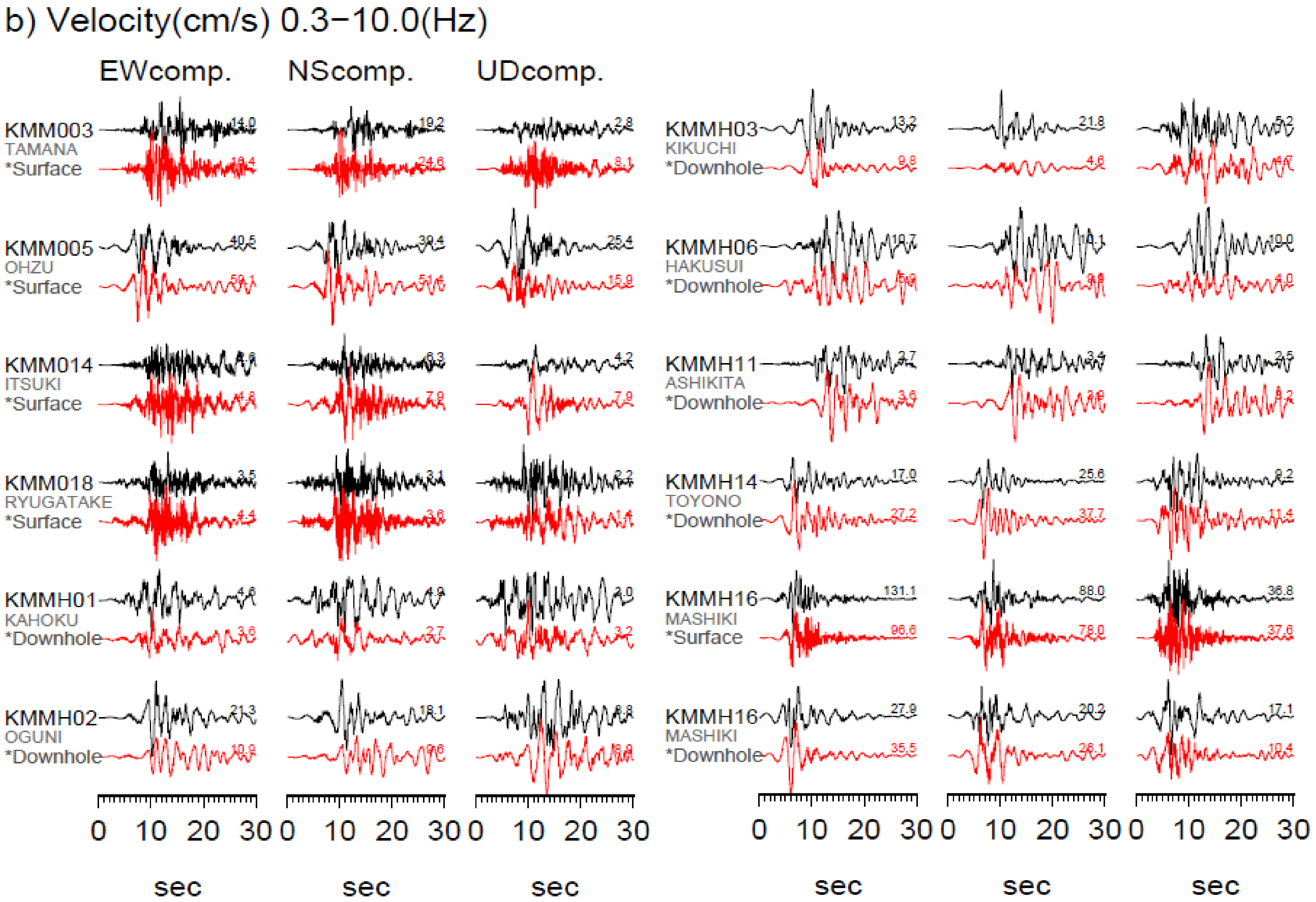


A single SMGA model based on the slip distribution of Kubo et al. (2016a)



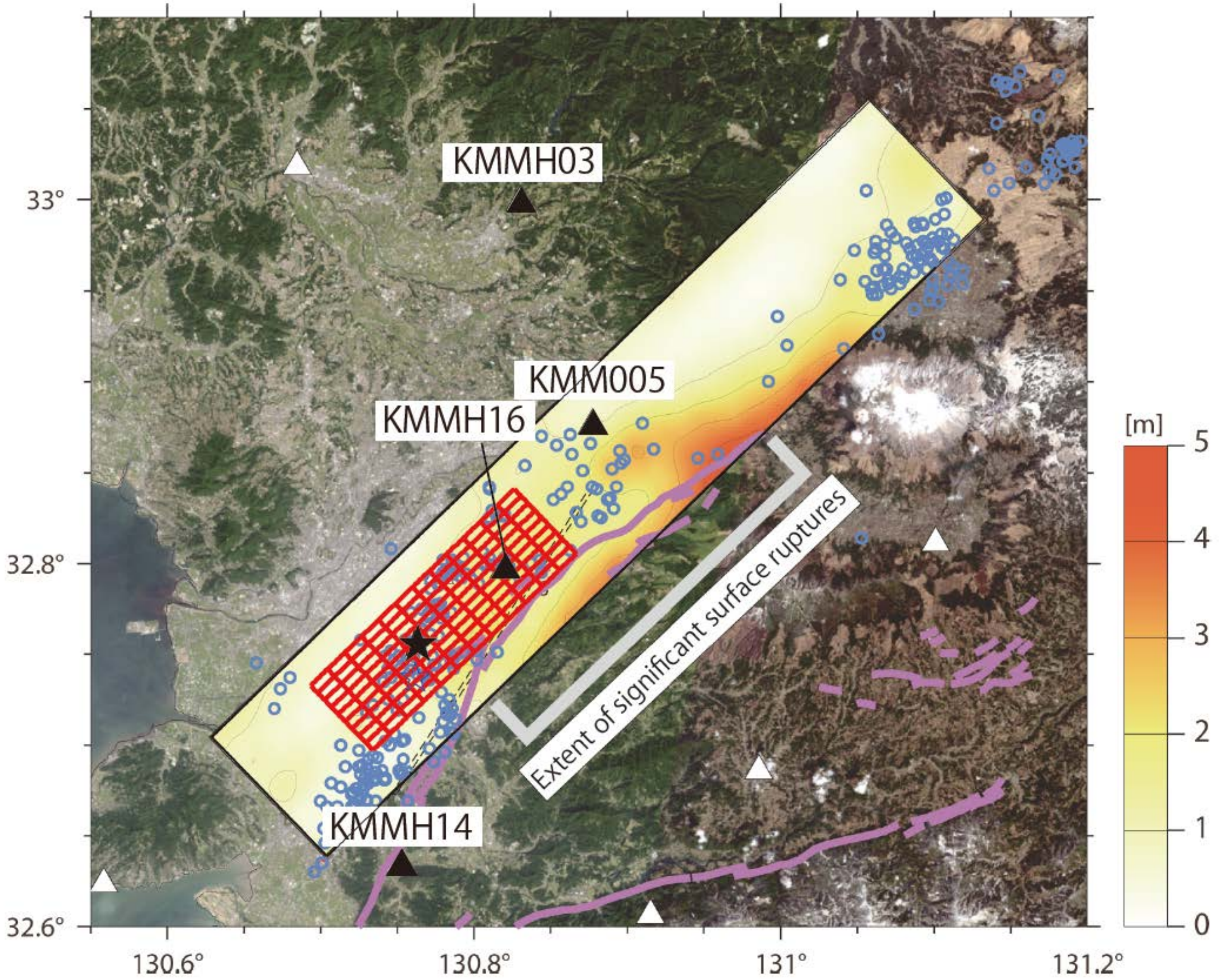
Comparison of the observed (*black*) and synthetic (*red*) ground motions of three components (east–west, north–south, and up–down)

A Single SMGA model
(Irikura et al., 2017)
Empirical Green's method



Model 1: A single flat fault plane model with a SMGA

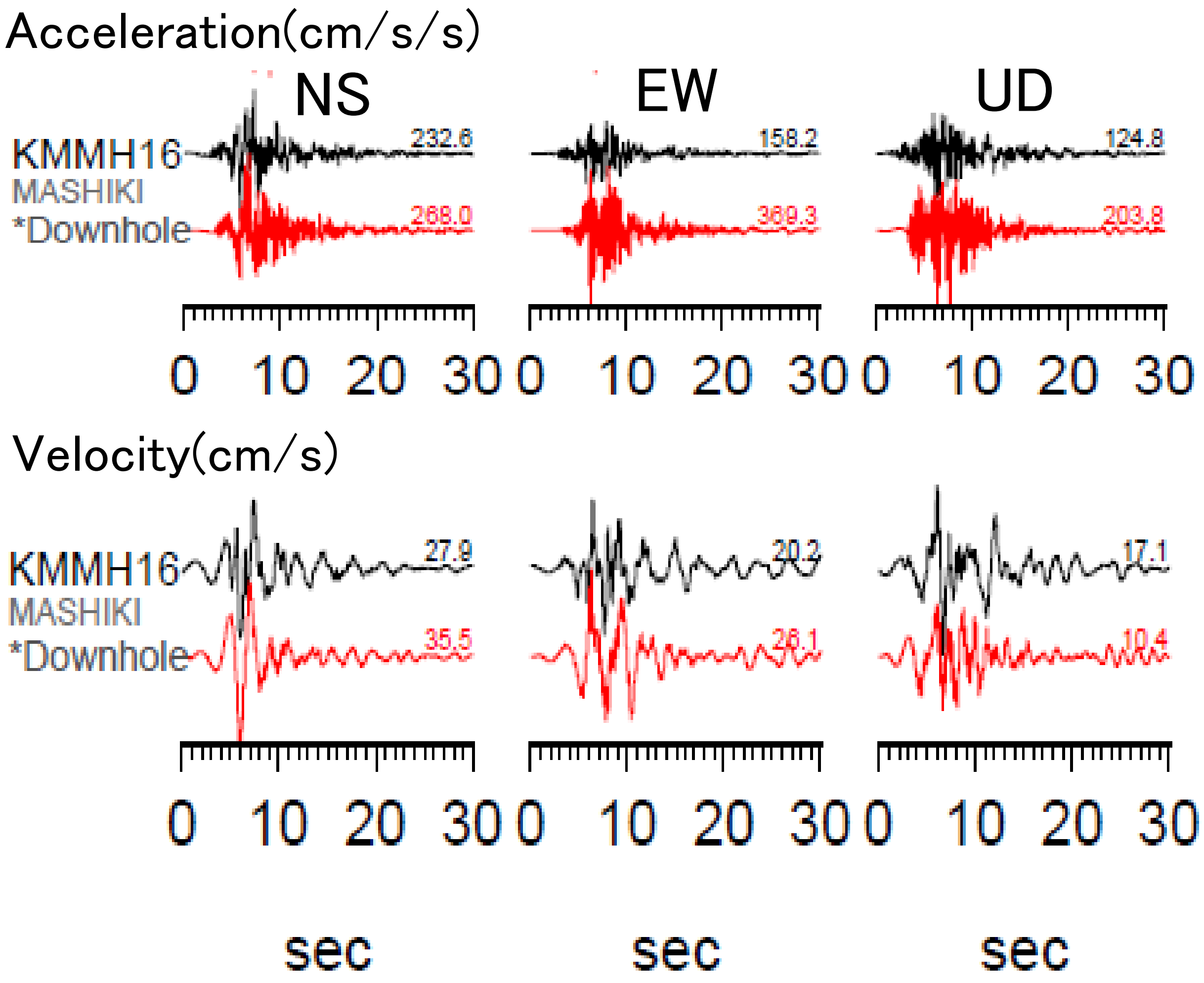
- Irikura et al. (2017) based on slip distribution of Kubo et al. (2016a)



Irikura et al.(2017)

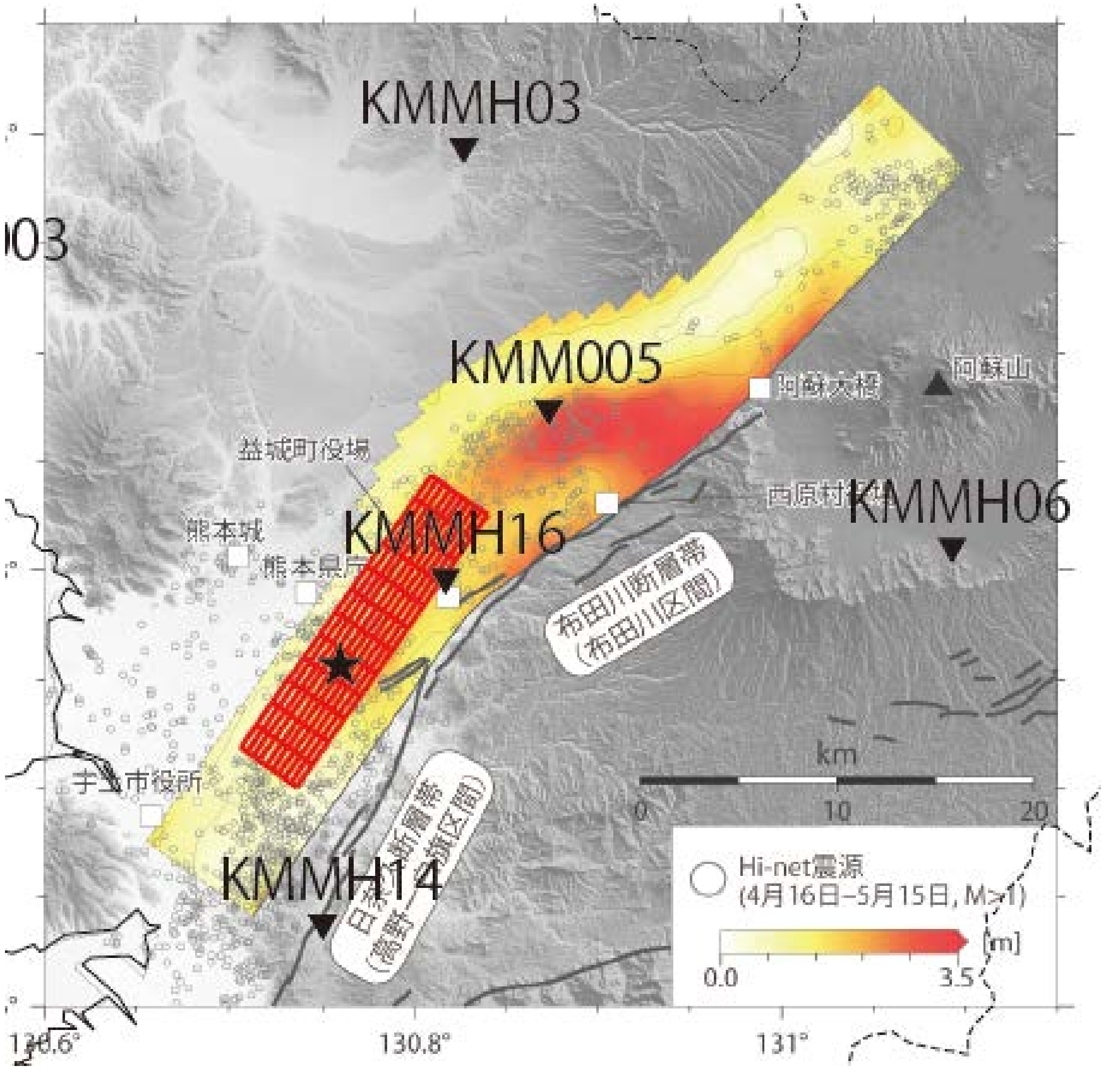
Empirical Green's function method

KMMH16（KiK-net Mashiki）



Model 2: A curved fault plane model with a SMGA

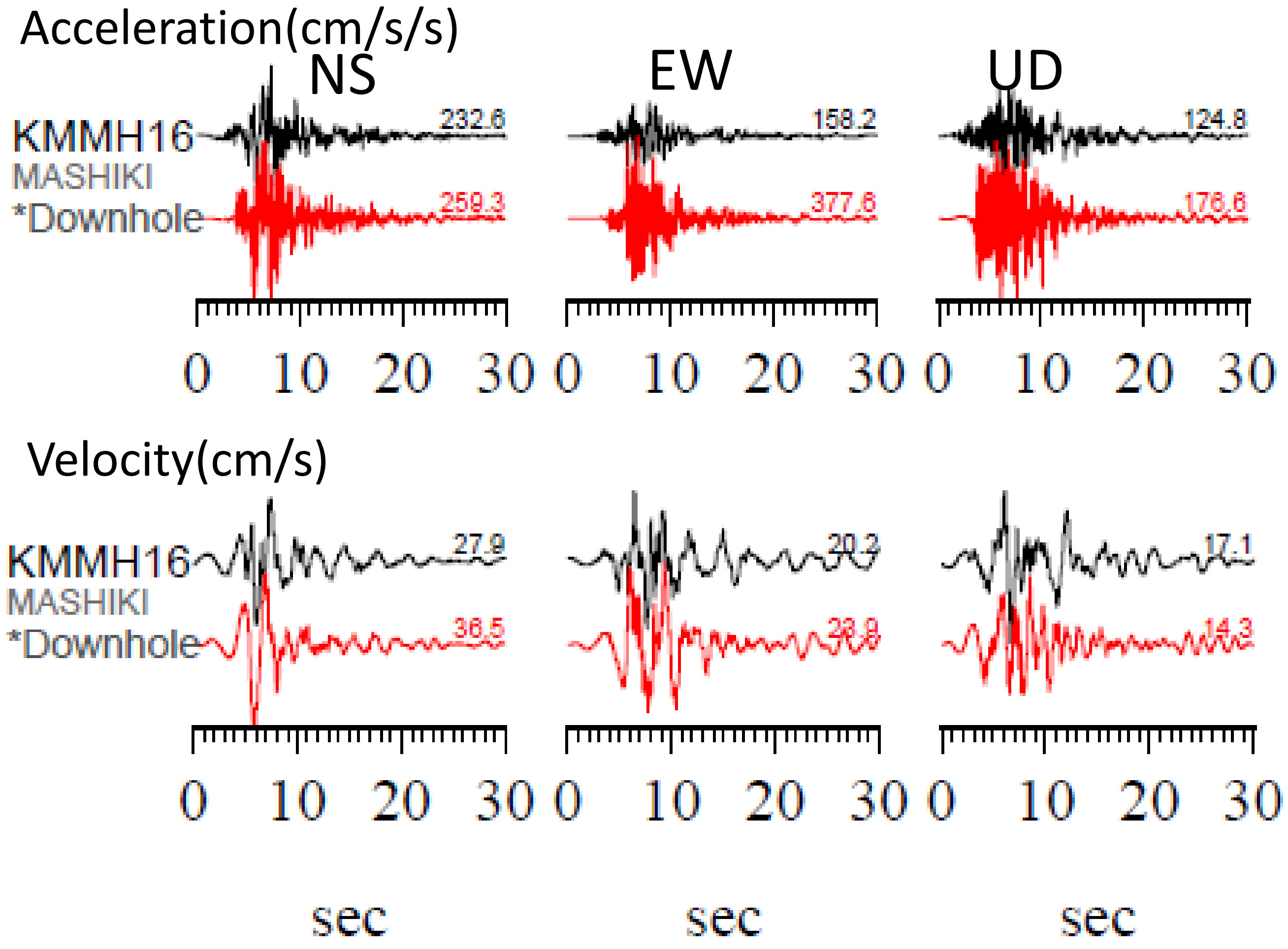
- Outer fault parameters are estimated based on Kubo et al.(2016b)



Kubo et al.(2016)

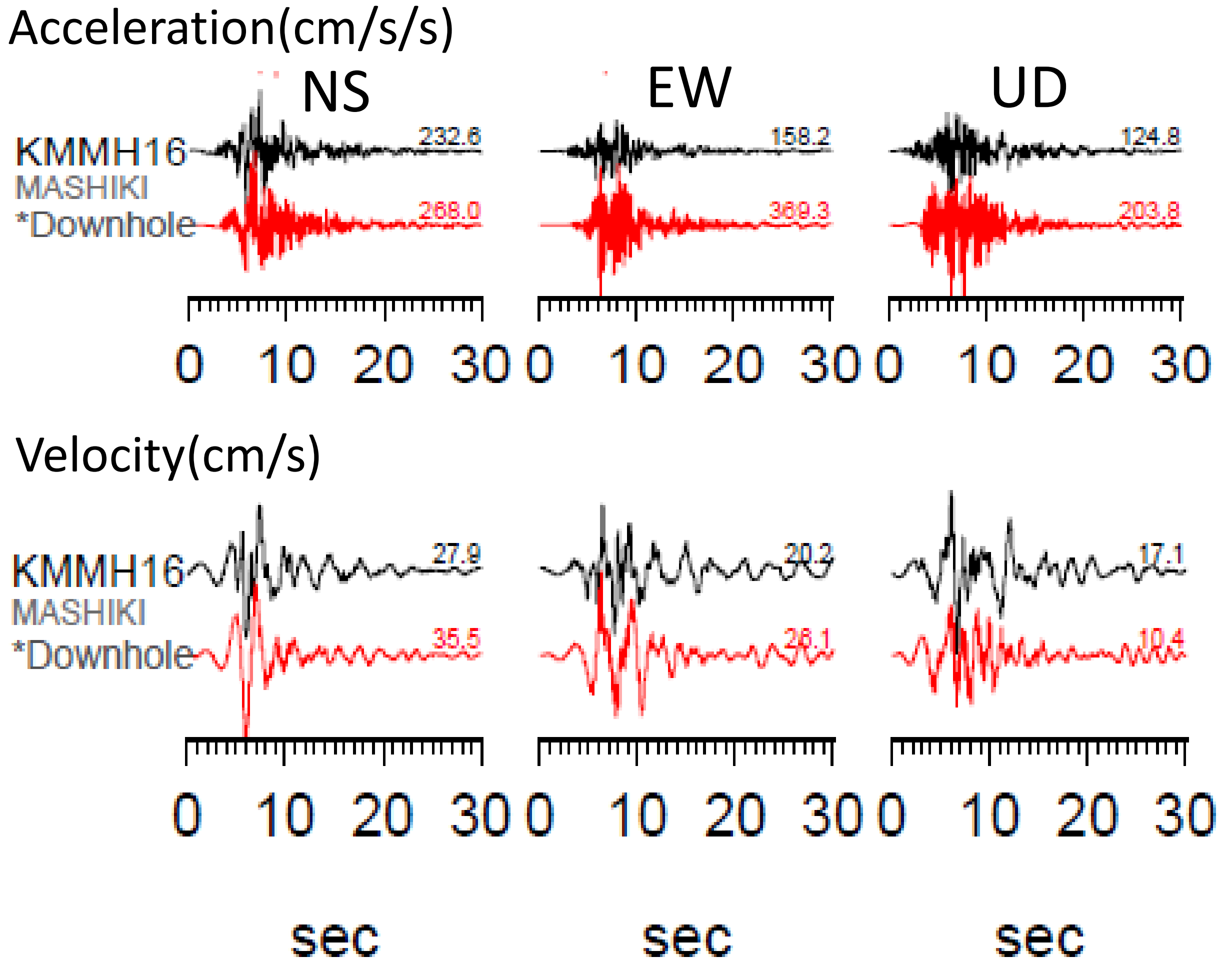
Empirical Green's function method

KMMH16 （KiK-net Mashiki)

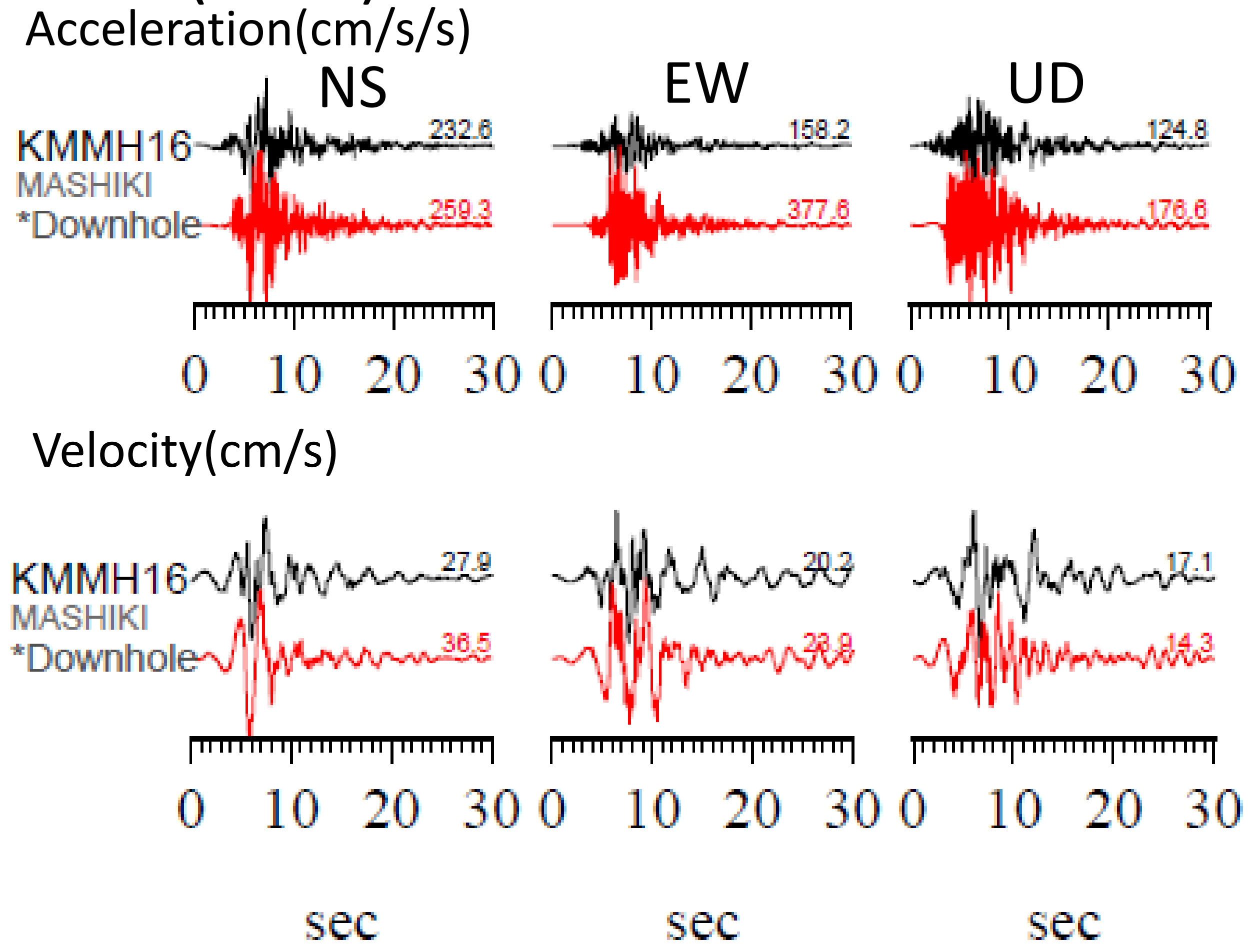


Comparison between synthetic motions by Model 1 and Model 2

Model 1 : Irikura et al.(2017)

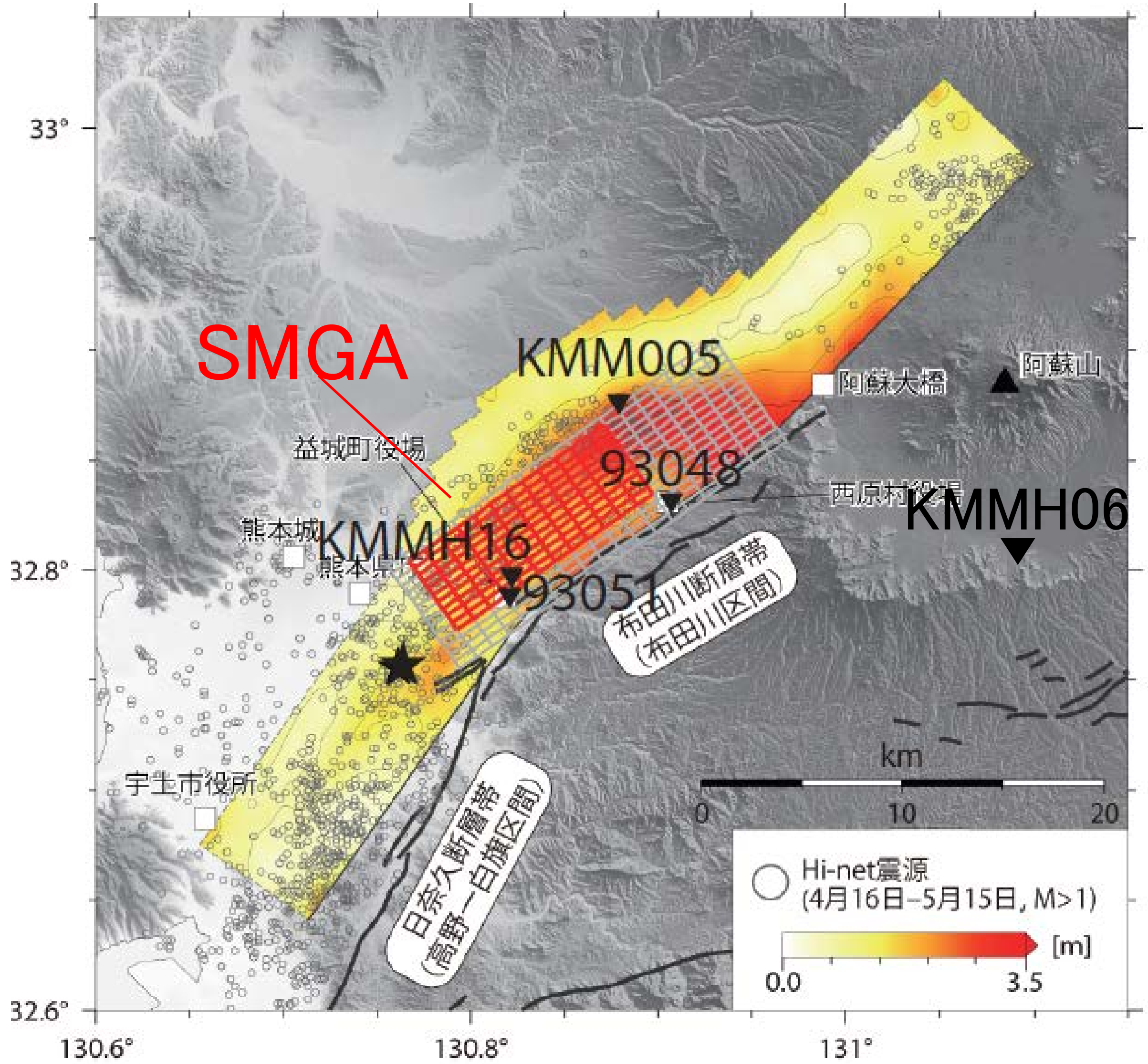


Model 2: SMGA model based on Kubo et al . (2016)



Long-period ground motion from SMGA

Assume a single SMGA in the seismogenic zone



Velocity structure

Very shallow: Borehole logging at KiK-net and K-NET sites

Shallow: J-SHIS model V2

Deeper: Fukuyama et al. (2000)

SMGA model

Computation method:

Discrete wavenumber method (Bouchon,1981)

Slip velocity time functions:

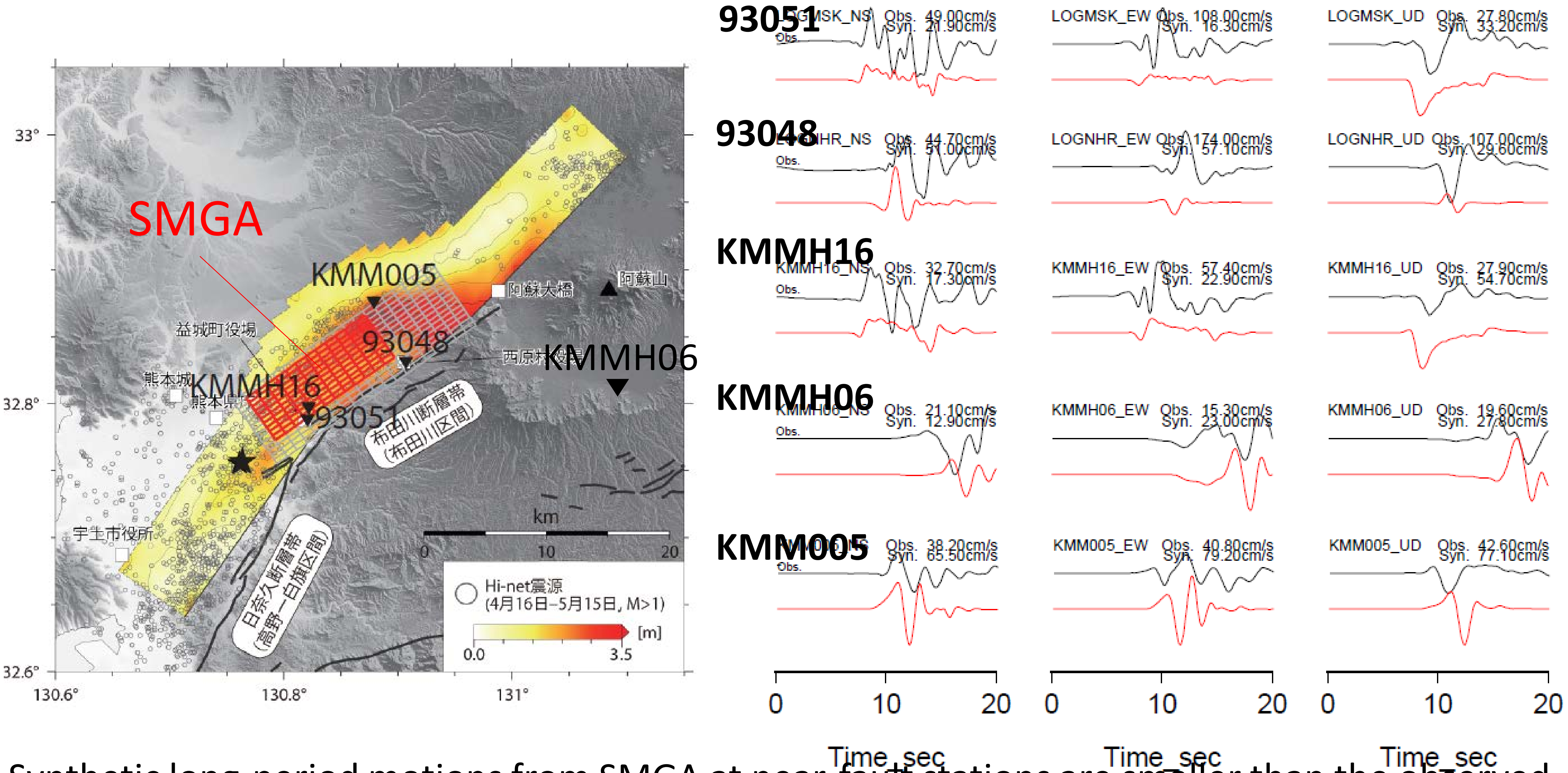
Nakamura and Miyatake function with rise time of 5.0 sec

M0 of SMGA : 2.16×10^{19}Nm

Area of SMGA : 12km × 10km

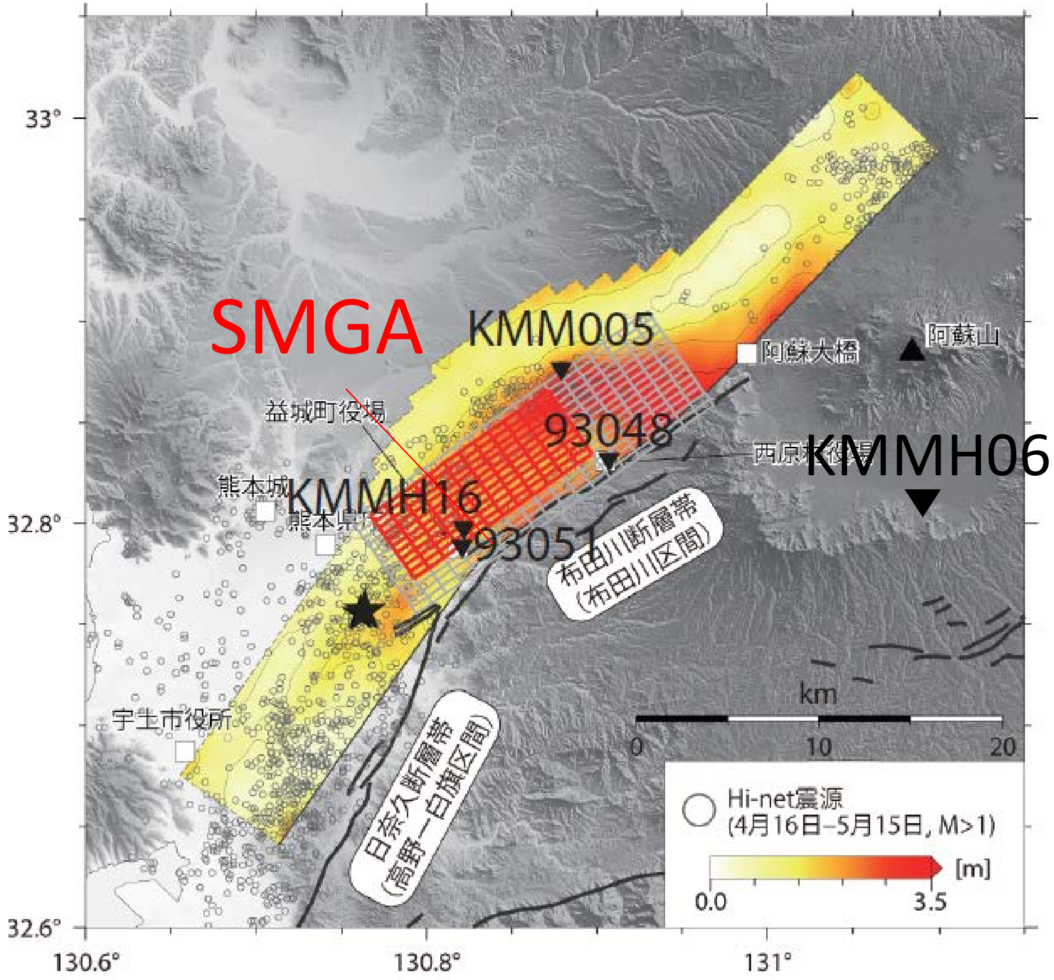
Stress drop: 13.9 MPa

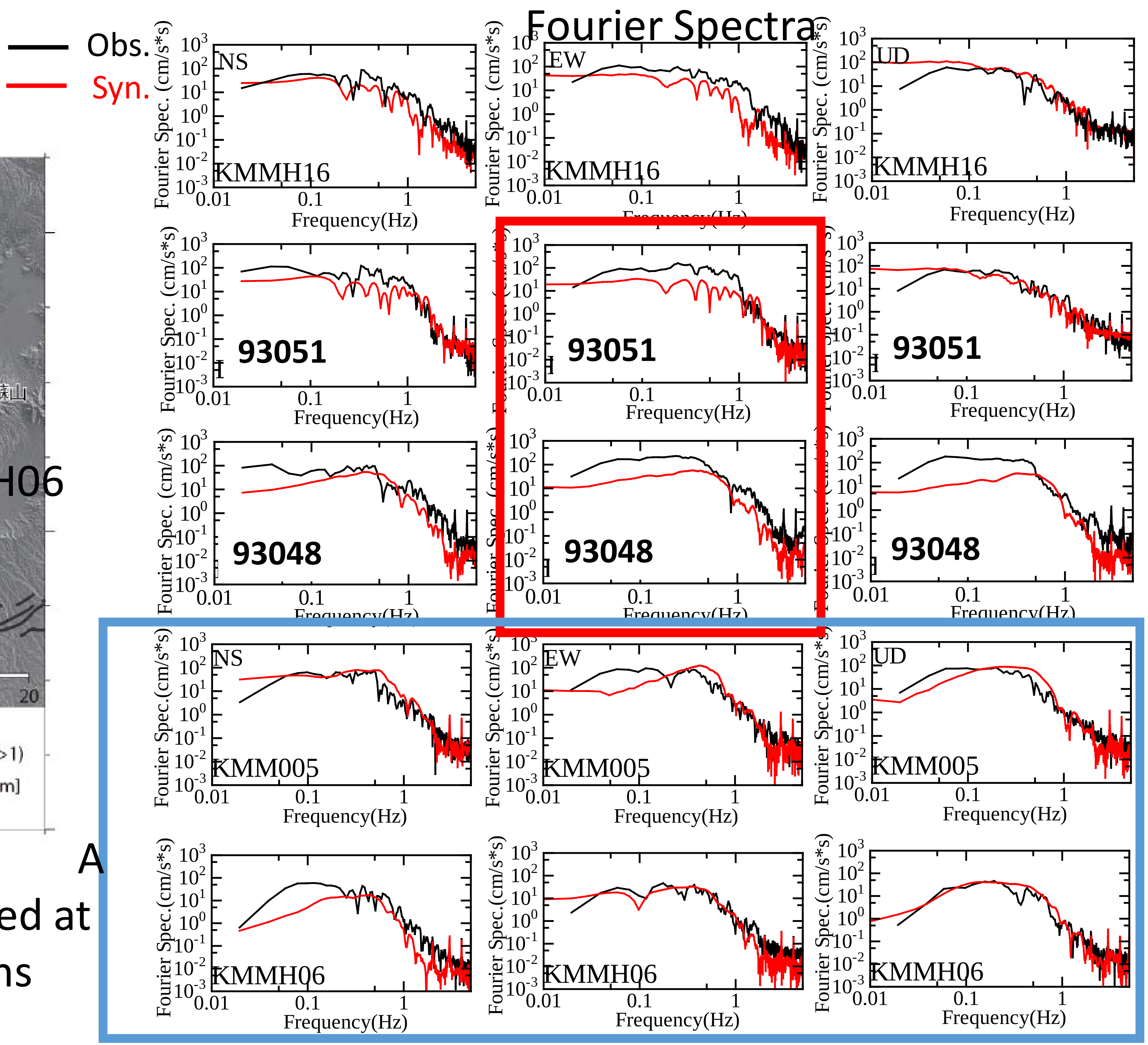
Long-period ground motions (velocity) from SMGA



Synthetic long-period motions from SMGA at near-fault stations are smaller than the observed.

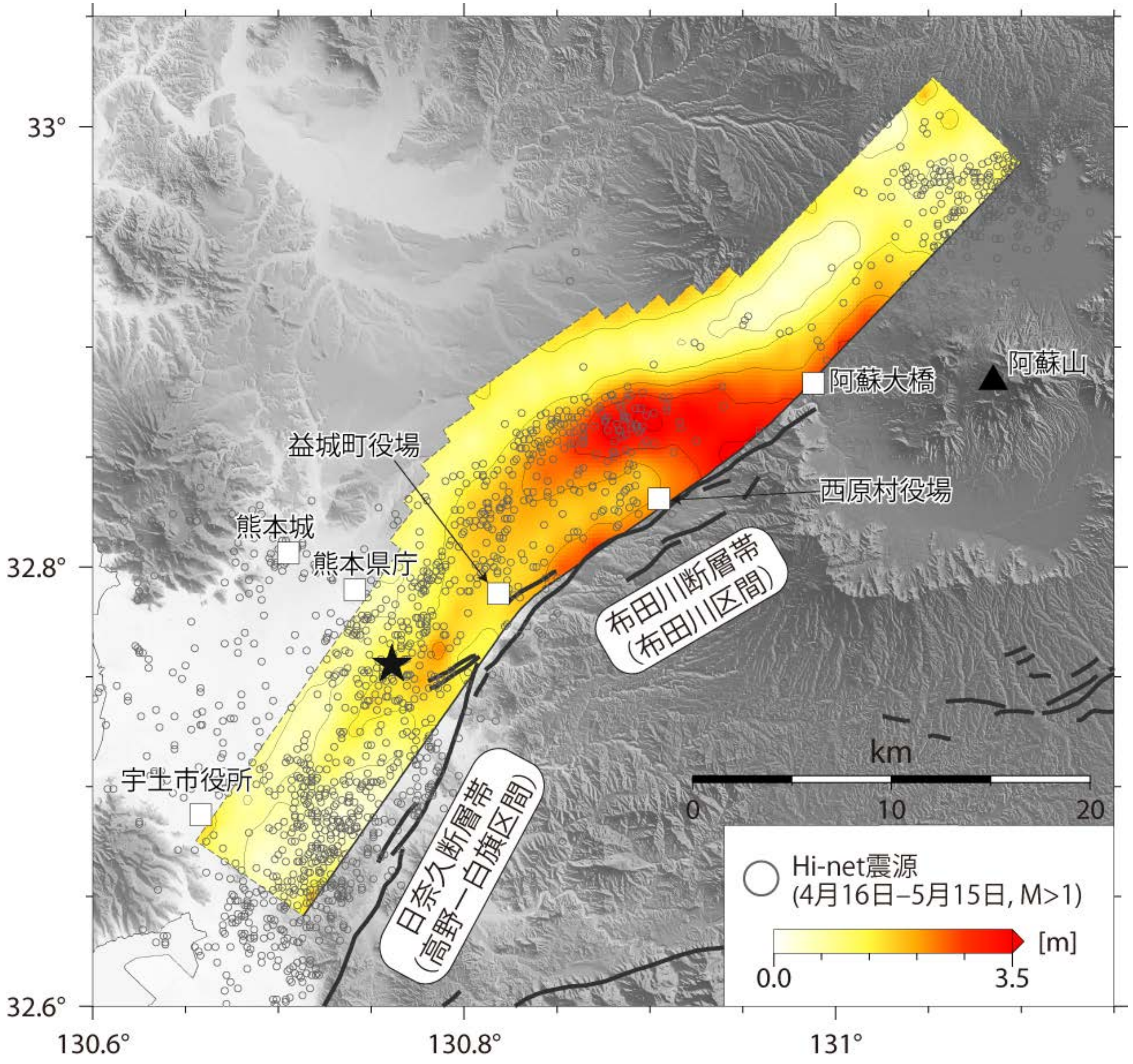
Long-period motions from SMGA



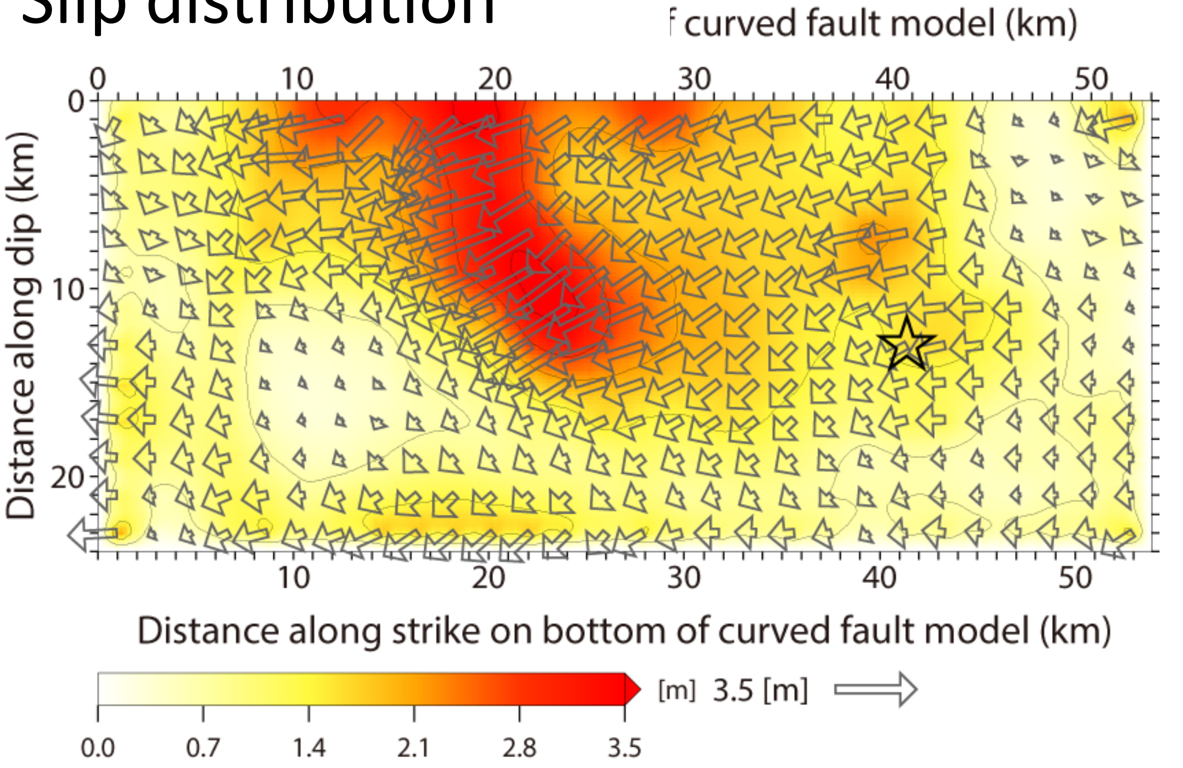


A have nearly the same level as observed at stations except very near-field stations 93048 and 93051.

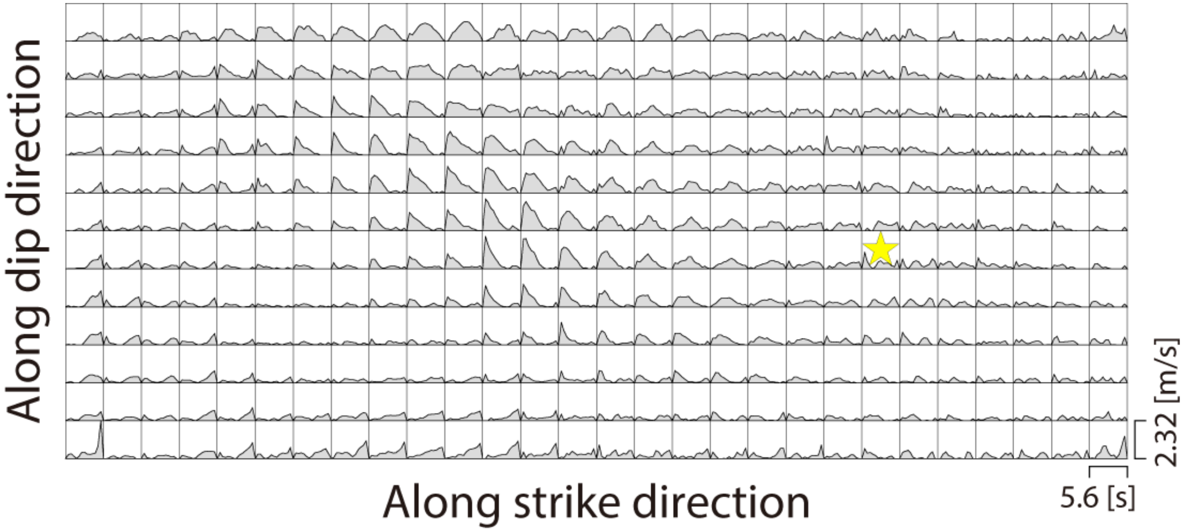
Source model by Kubo et al. (2016 b)



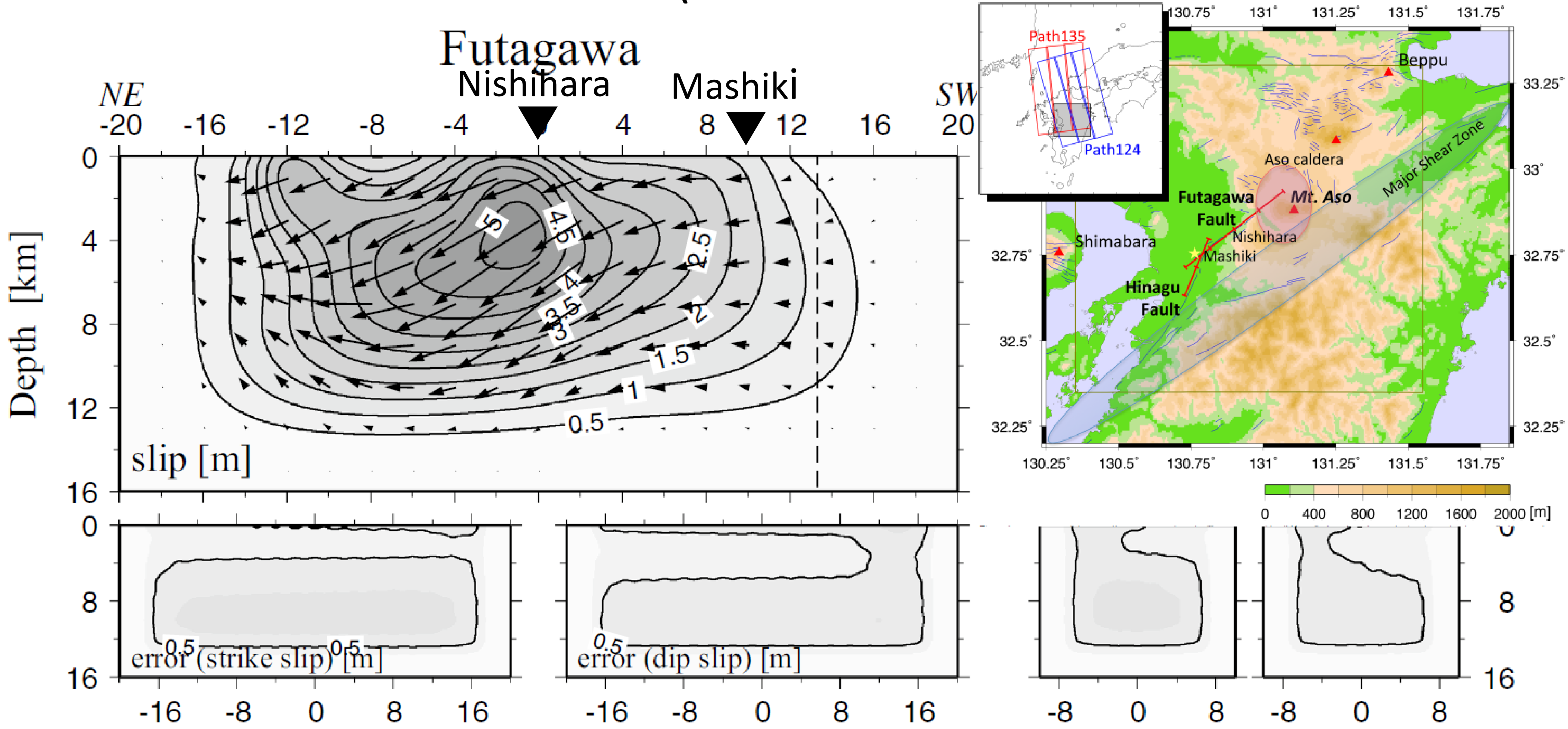
Slip distribution



Moment-rate distribution

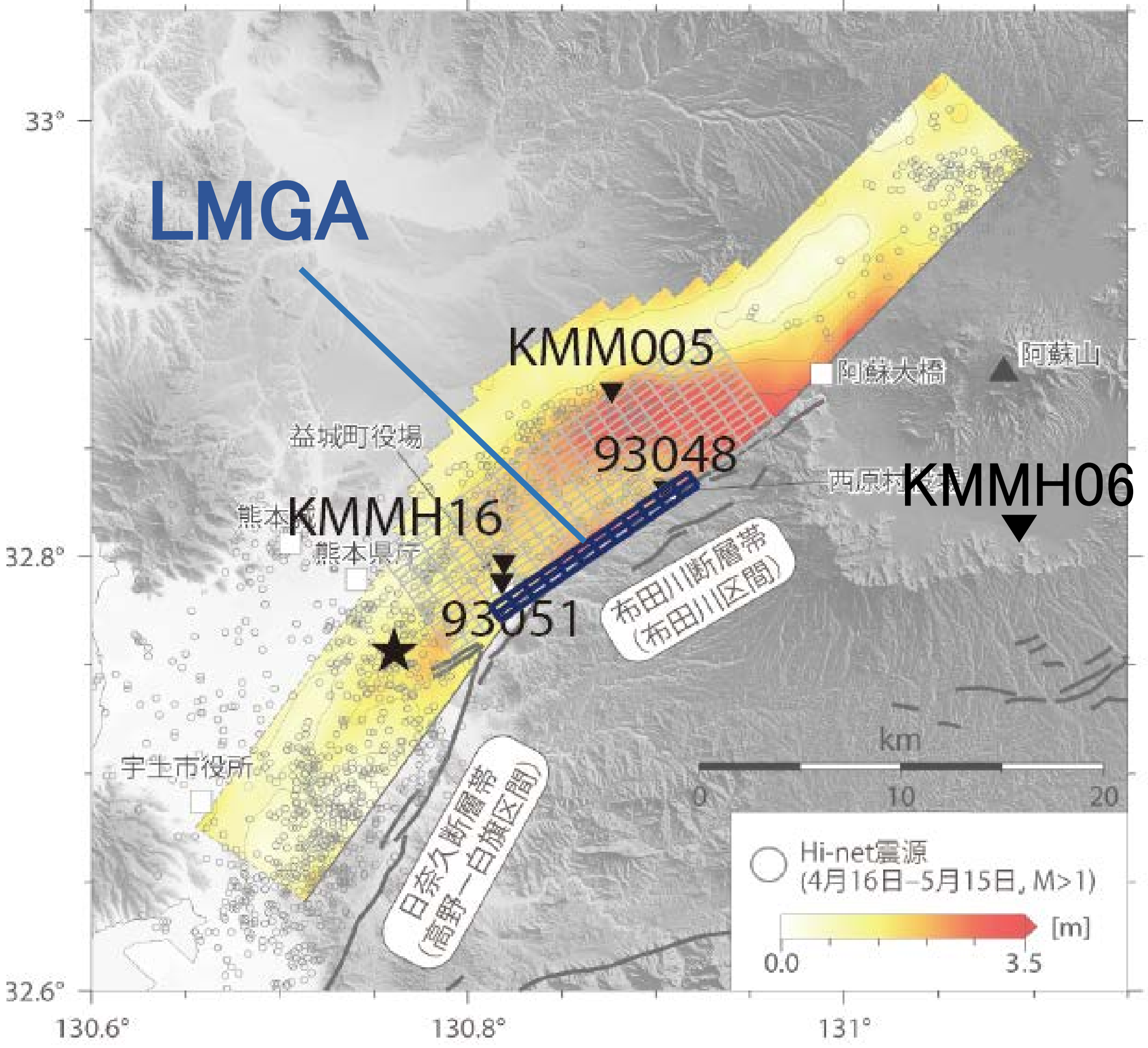


Slip distribution of the Kumamoto earthquake from a weak nonlinear inversion of InSAR data (Fukahata and Hashimoto, 2016)



Long-period ground motions from LMGA

Assume a LMGA in surface layers
above the seismogenic zone



Computation method:
Wavenumber integration method
(Hisada,2003)

Slip velocity time function:
triangle function with
rise time of 5.0 sec

M0 of LMGA: 2.88×10^{18} Nm

Area of LMGA: 12 km x 2 km

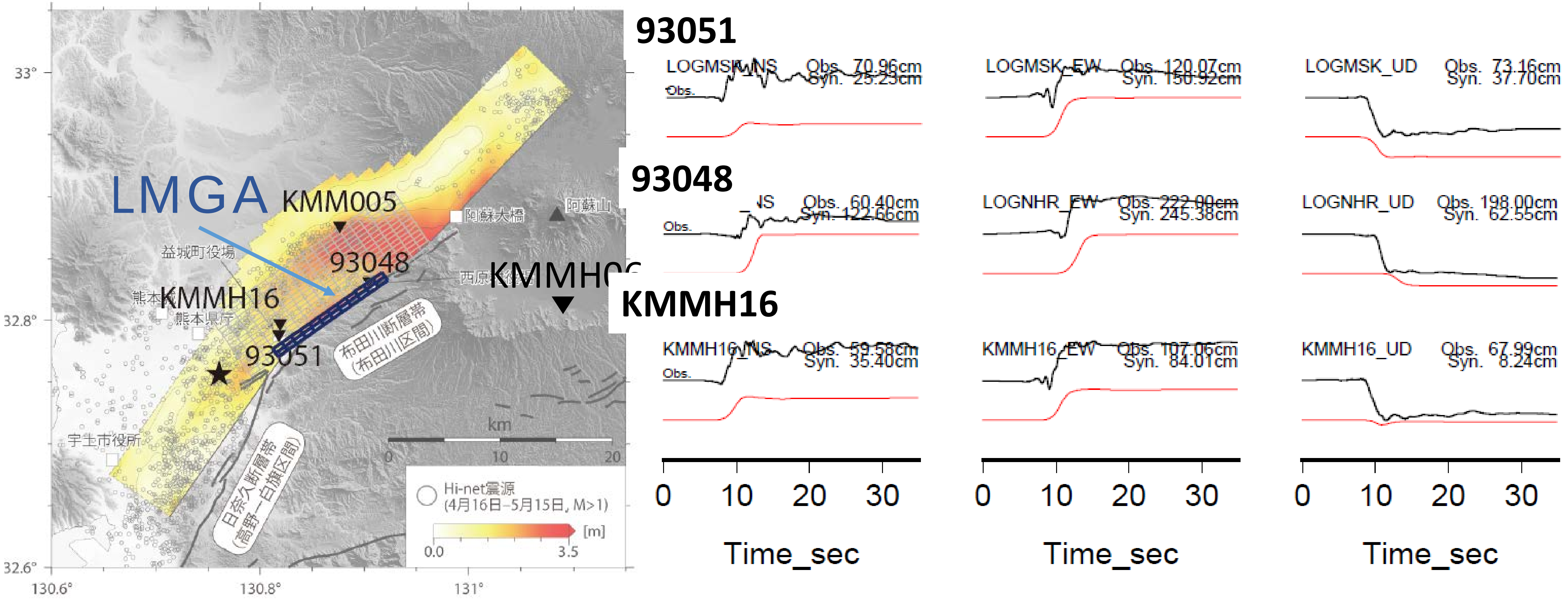
Slip: 4.0 m

Depth of top of LMGA: 0 km

Long-period ground motions (displacement) from LMGA

LMGA-Model **a**: Length 12 km, Width 2 km

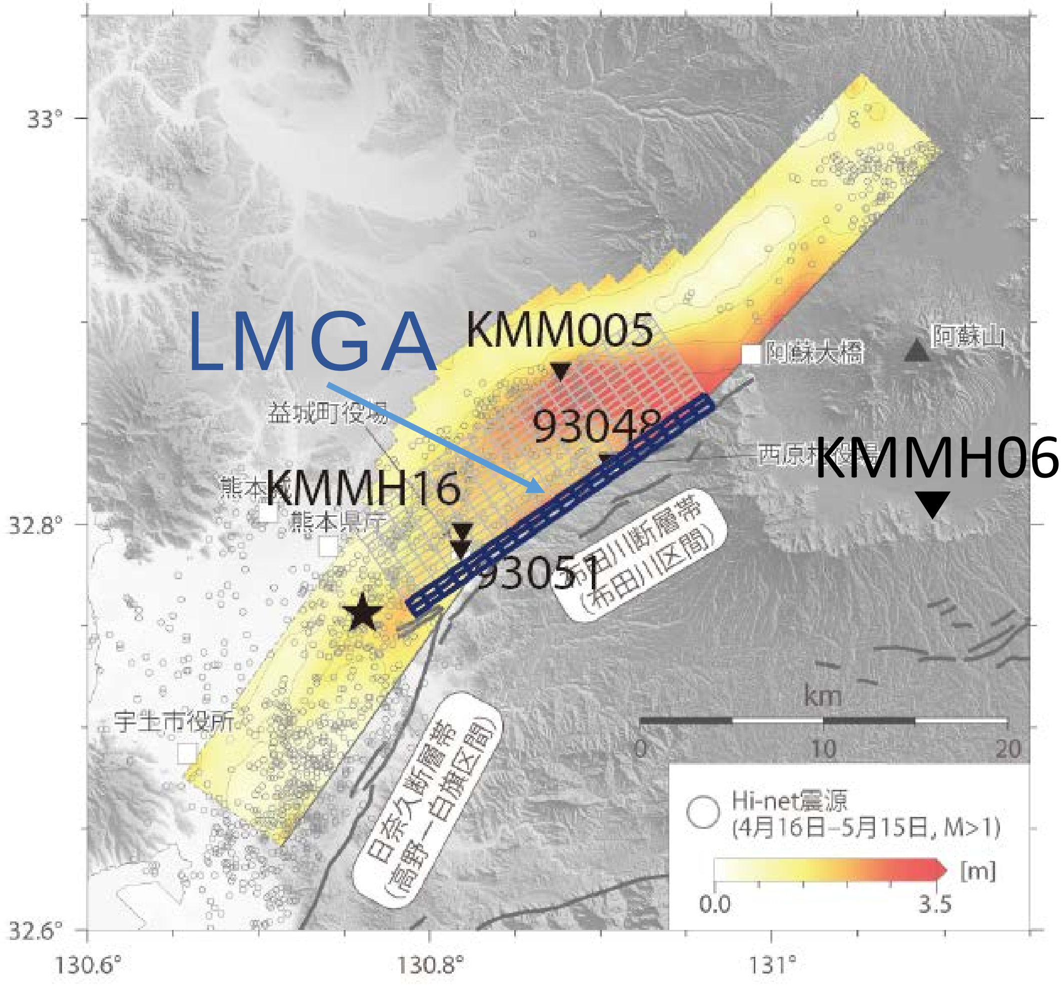
Black: observed
Red: Synthetic

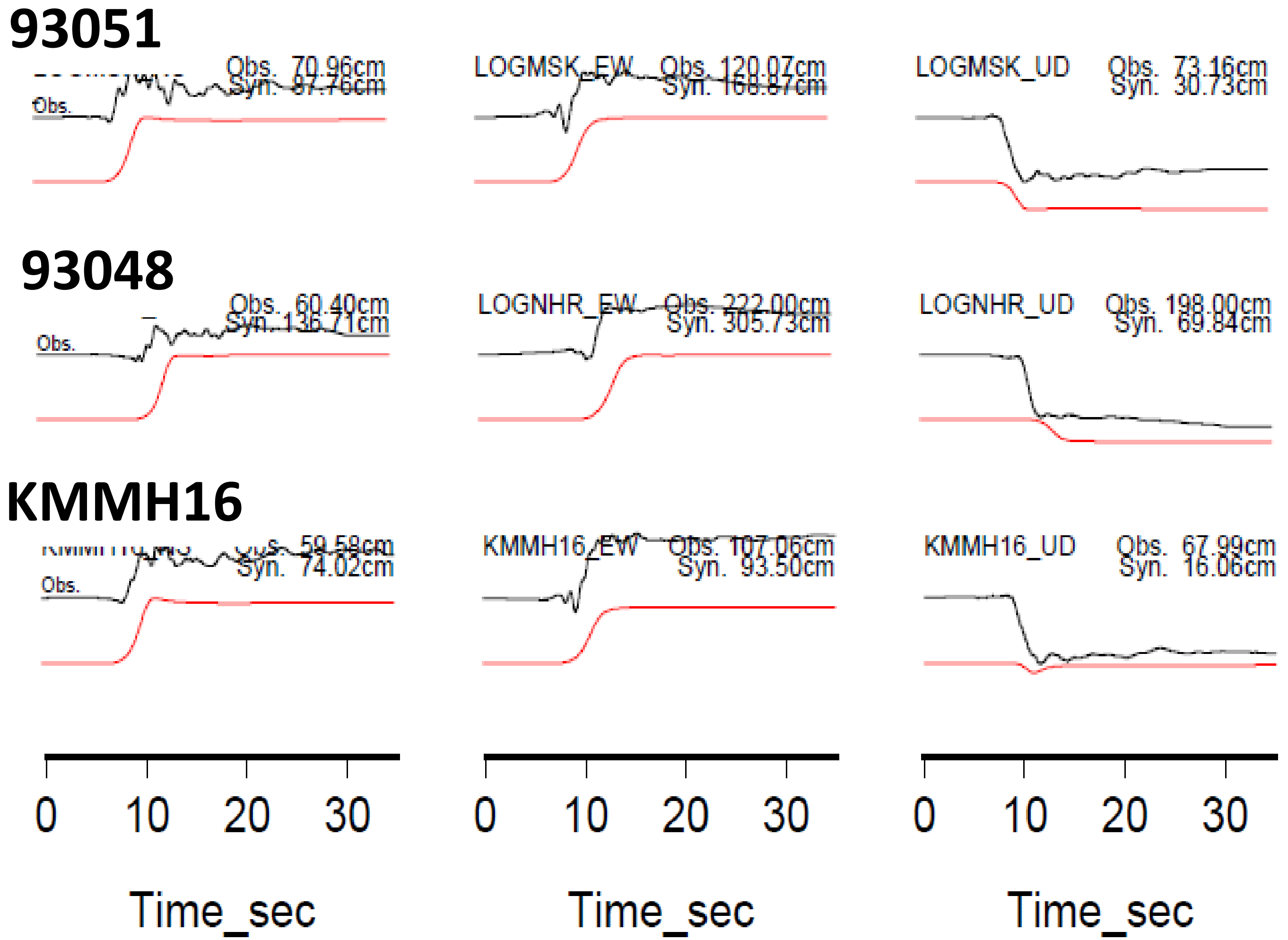


Long-period ground motions (displacement) from LMGA

LMGA-Model **b**: Length 20 km, Width 2 km

Black: observed
Red: Synthetic

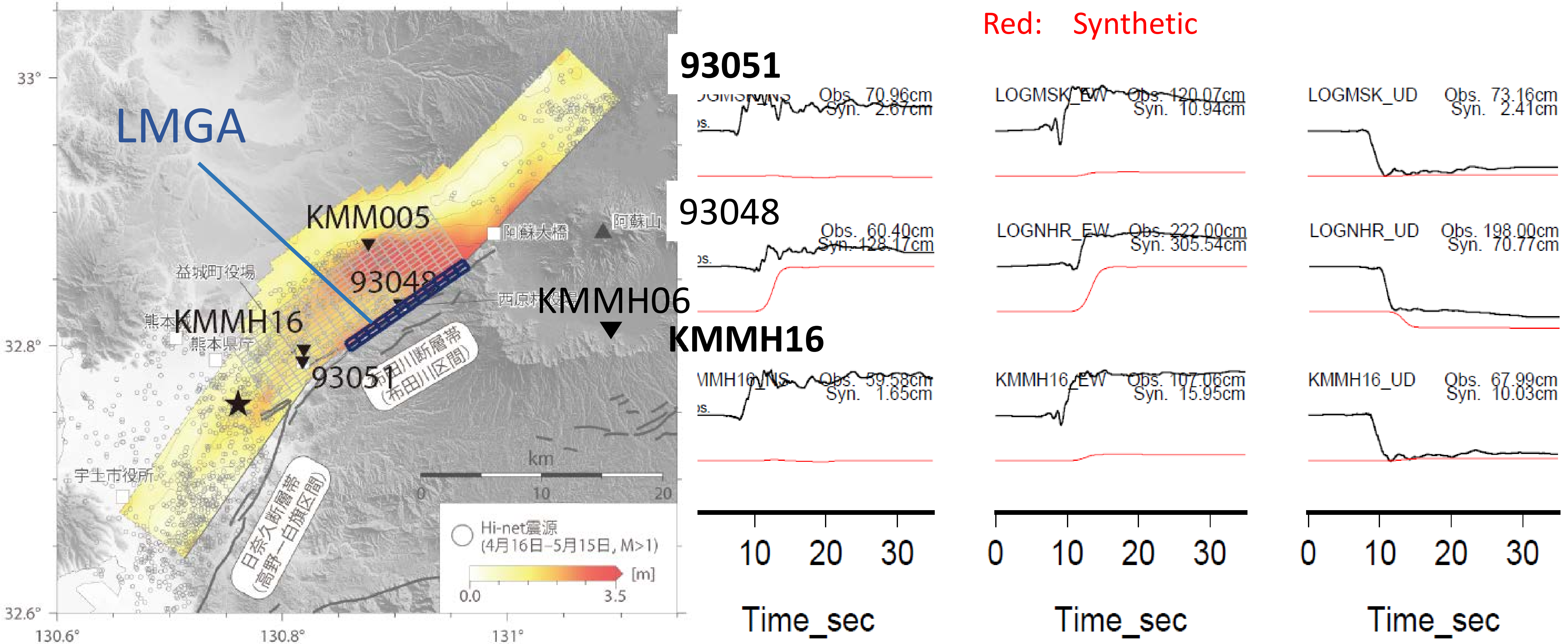




Long-period ground motions (displacement) from LMGA

LMGA-Model **c**: Length 12 km, Width 2 km

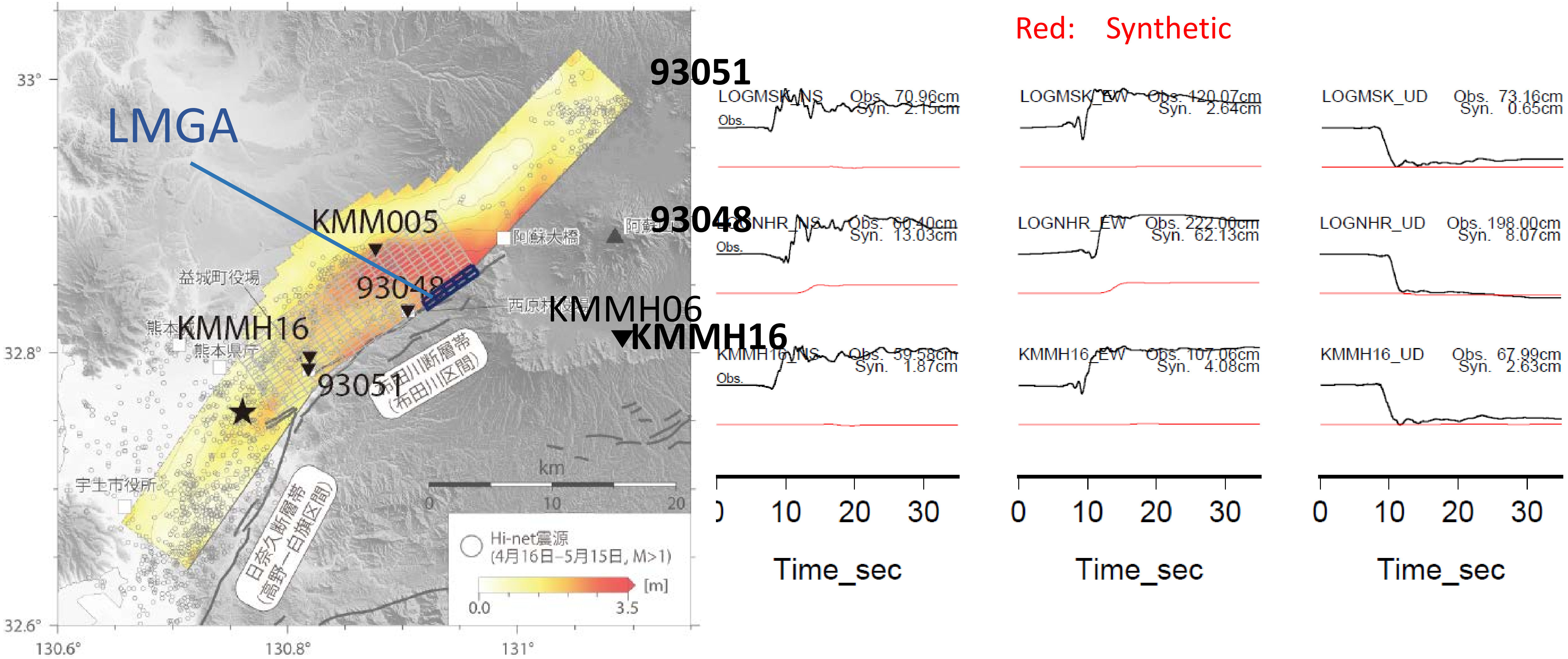
Black: observed
Red: Synthetic



Long-period ground motions (displacement) from LMGA

LMGA-Model **d**: Length 5 km, Width 2 km

Black: observed
Red: Synthetic



Modified Characterized Source Model

Strong Motion Generation Areas (SMGAs)

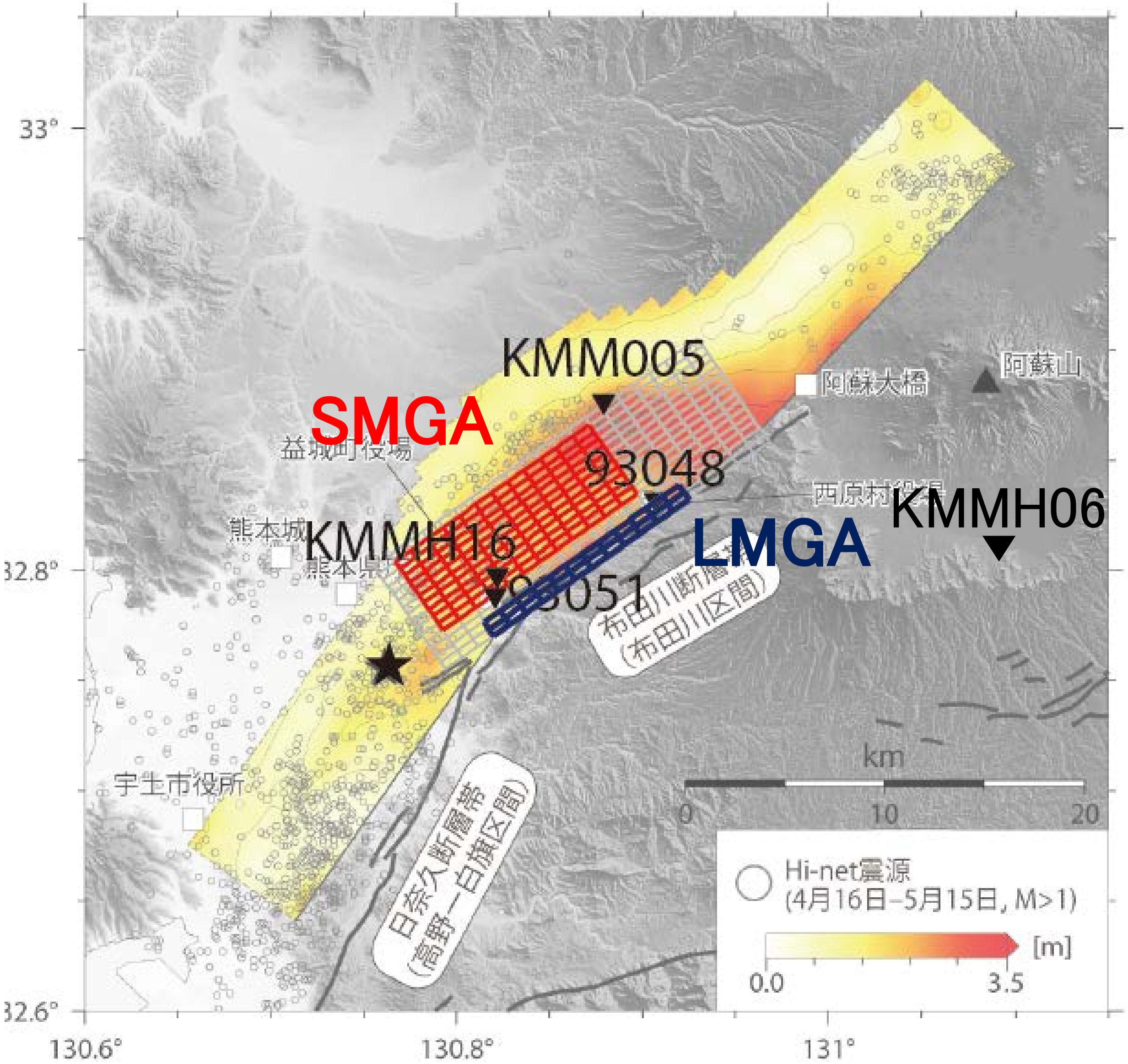
+

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.

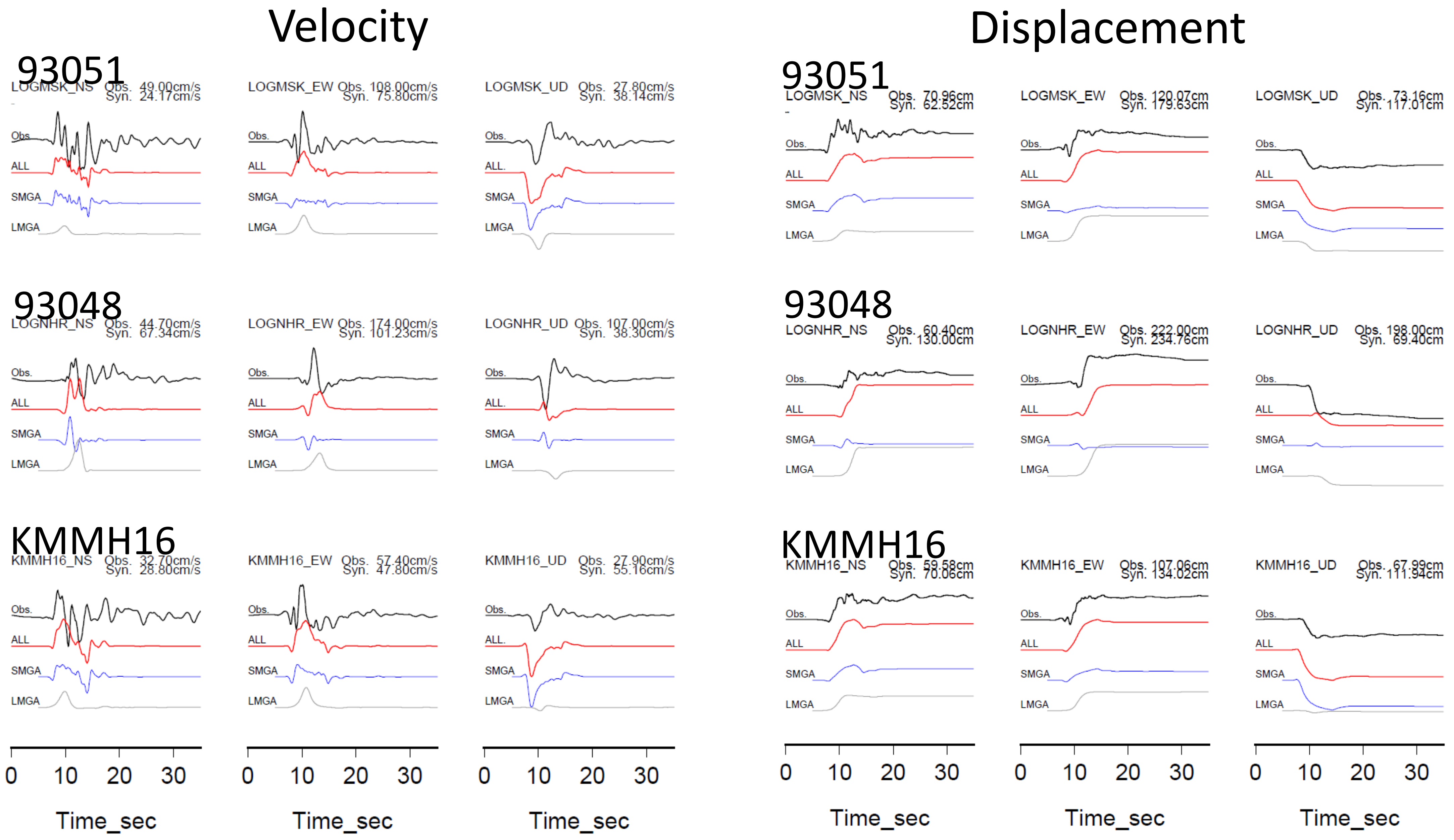
Long-period ground motions from SMGA + LMGA



- SMGA
  - M0 : 2.16 × 10^{19} Nm
  - Area : 12km × 10km
  - Slip velocity time function:
    - Nakamura-Miyatake function with rise time of 5.0 sec
  - Stress drop: 13.9 MPa

- LMGA
  - M0 : 2.88 × 10^{18} Nm
  - Area: 12 km × 2 km
  - Slip velocity time function
    - Triangle function with rise time of 5.0 sec
  - Slip: 4.0 m

Long-period ground motions from SMGA + LMGA



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).
2. However, long-period ground motions (more than 3 sec) at very near-fault stations from SMGA are underestimated compared with observed motions.
3. The 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.