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Application of LiDAR-derived high resolution topography to earthquake geology in Japan

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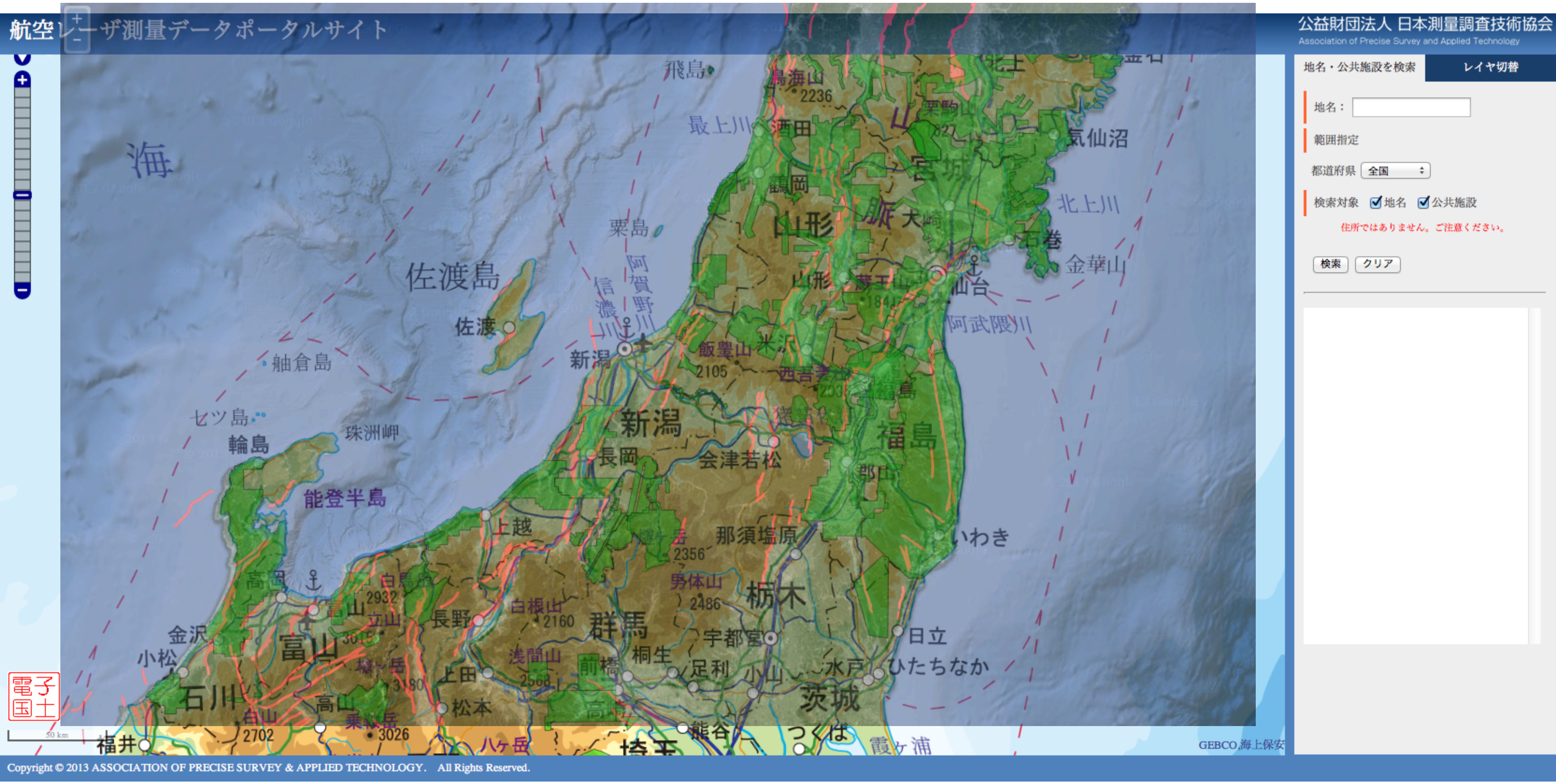
Collaborated with Shinji Toda, Masayuki Yoshimi, Hidetaka Saomoto and Eiji Saito

Wide areal coverage of high-resolution LiDAR data in Japan



http://www.sokugikyo.or.jp/laser/

Association of Precise Survey and Applied Technology

https://gbank.gsj.jp/geonavi/

Contents:

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- Detailed mapping earthquake surface rupture
- Detection of surface rupture in densely forested mountainous regions
- 3-D surface displacement field

Active fault/fold:

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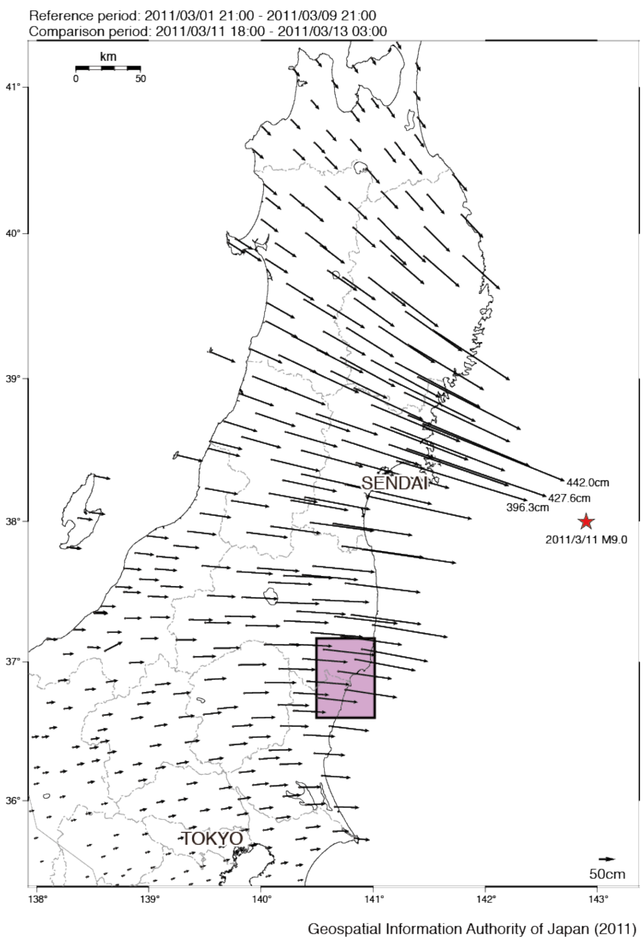
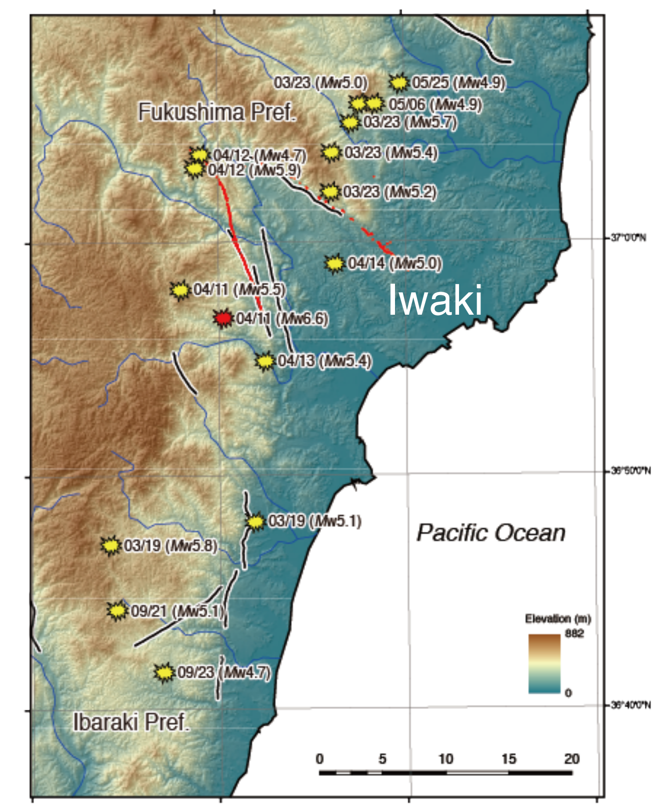
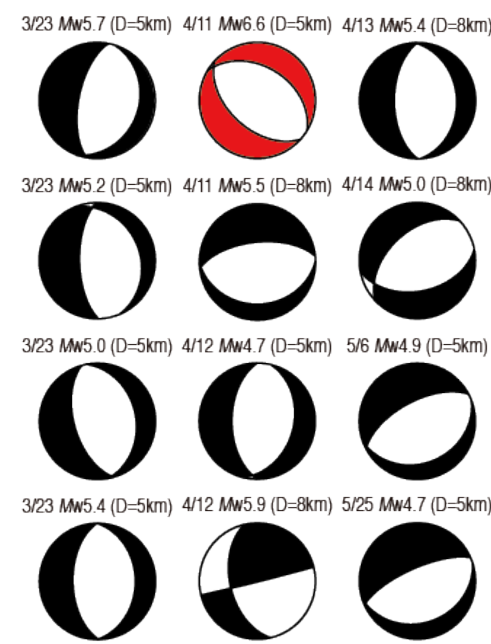
Detailed mapping earthquake surface rupture

- Surface rupture associated with the 2011 Fukushima-Iwaki earthquake







Focal mechanism solutions (lower hemisphere projection). F-net data provided by National Research Institute for Earth Science and Disaster Prevention


NW
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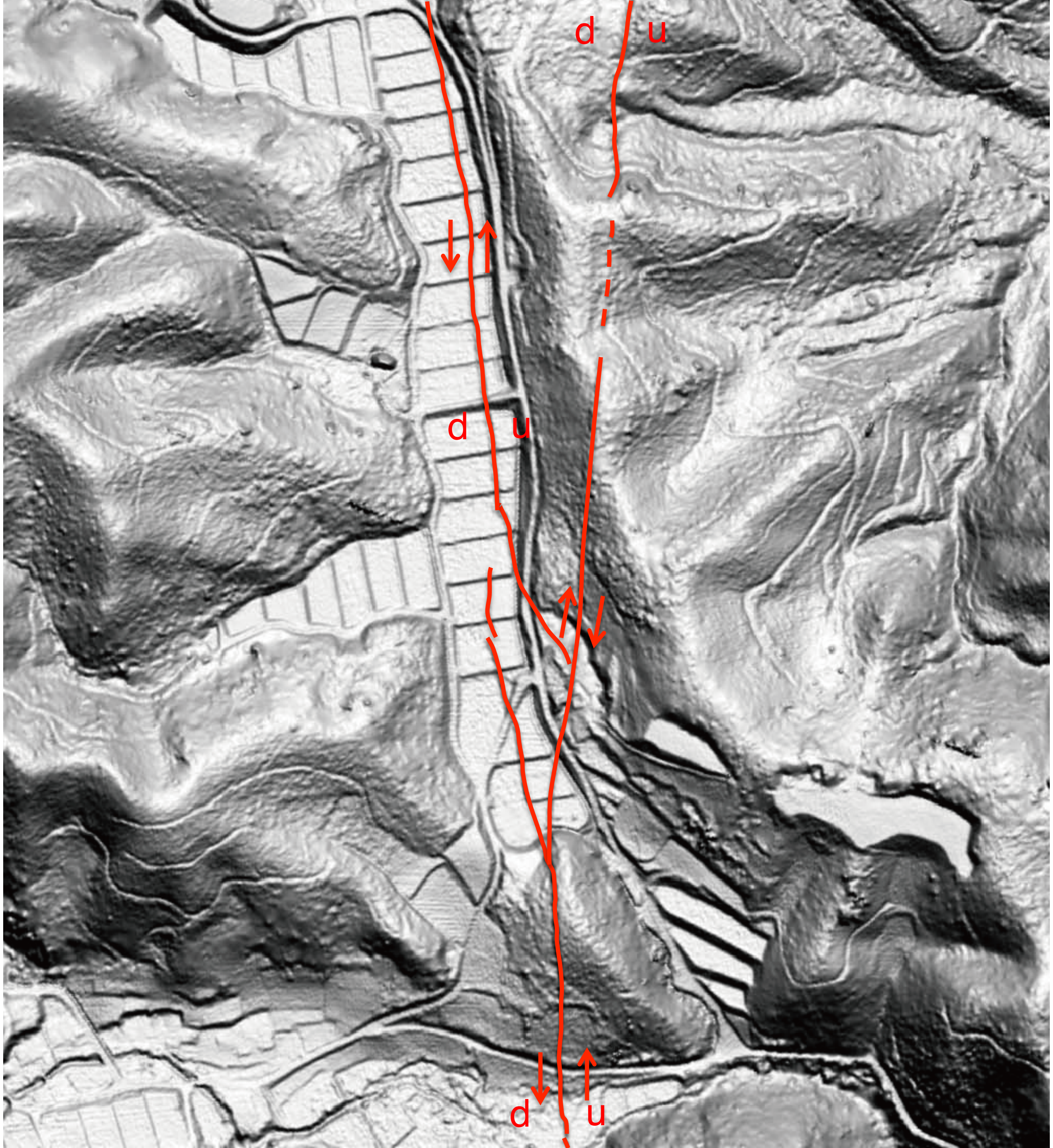

Post-Eq. LiDAR (data acquisition and filtering by Aero Asahi Corp.)

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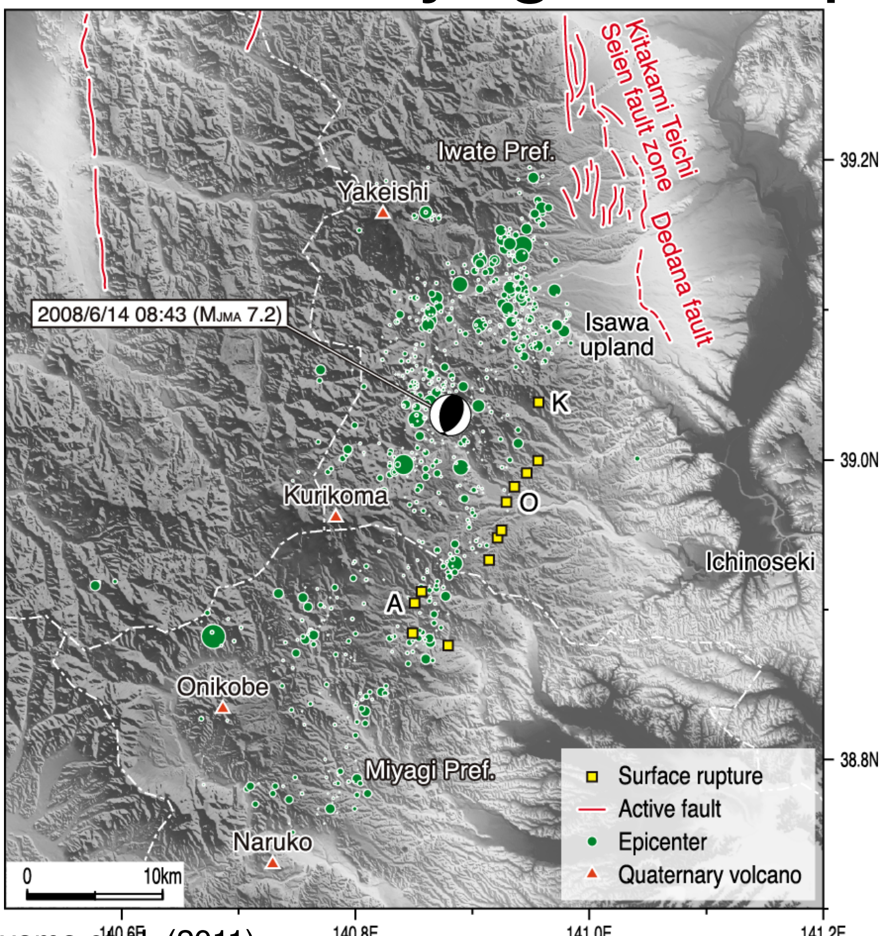
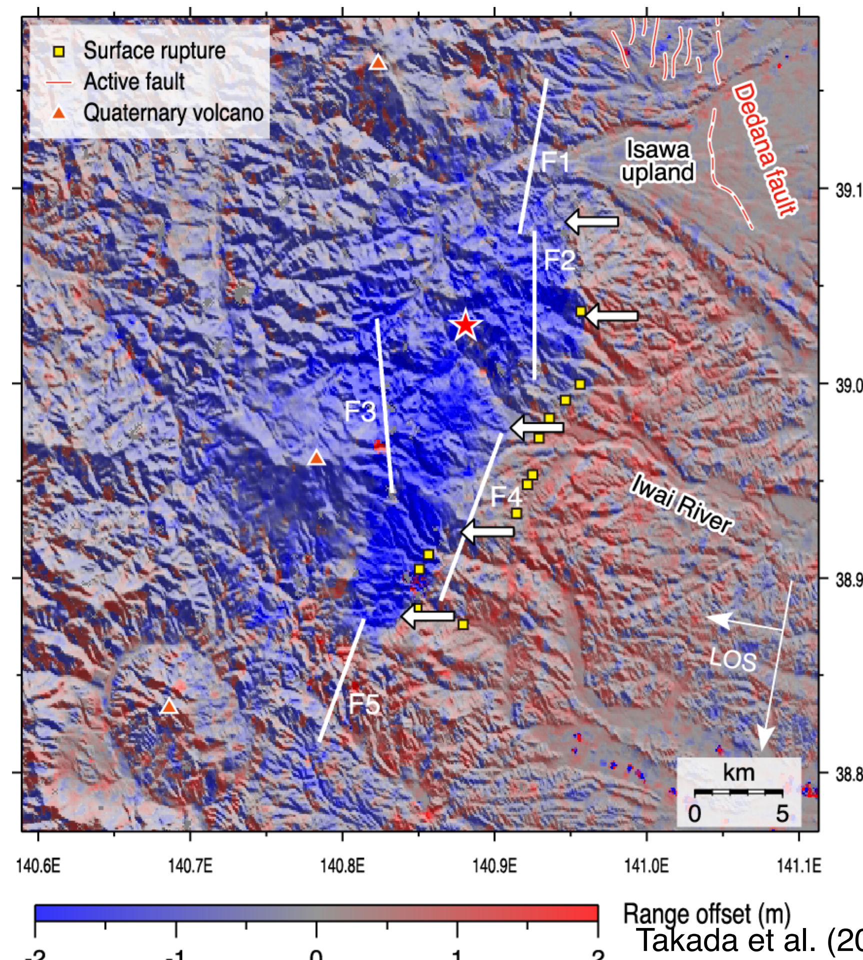
Mapping faults in densely forested mountainous regions

- Surface rupture associated with the 2008 Iwate-Miyagi earthquake

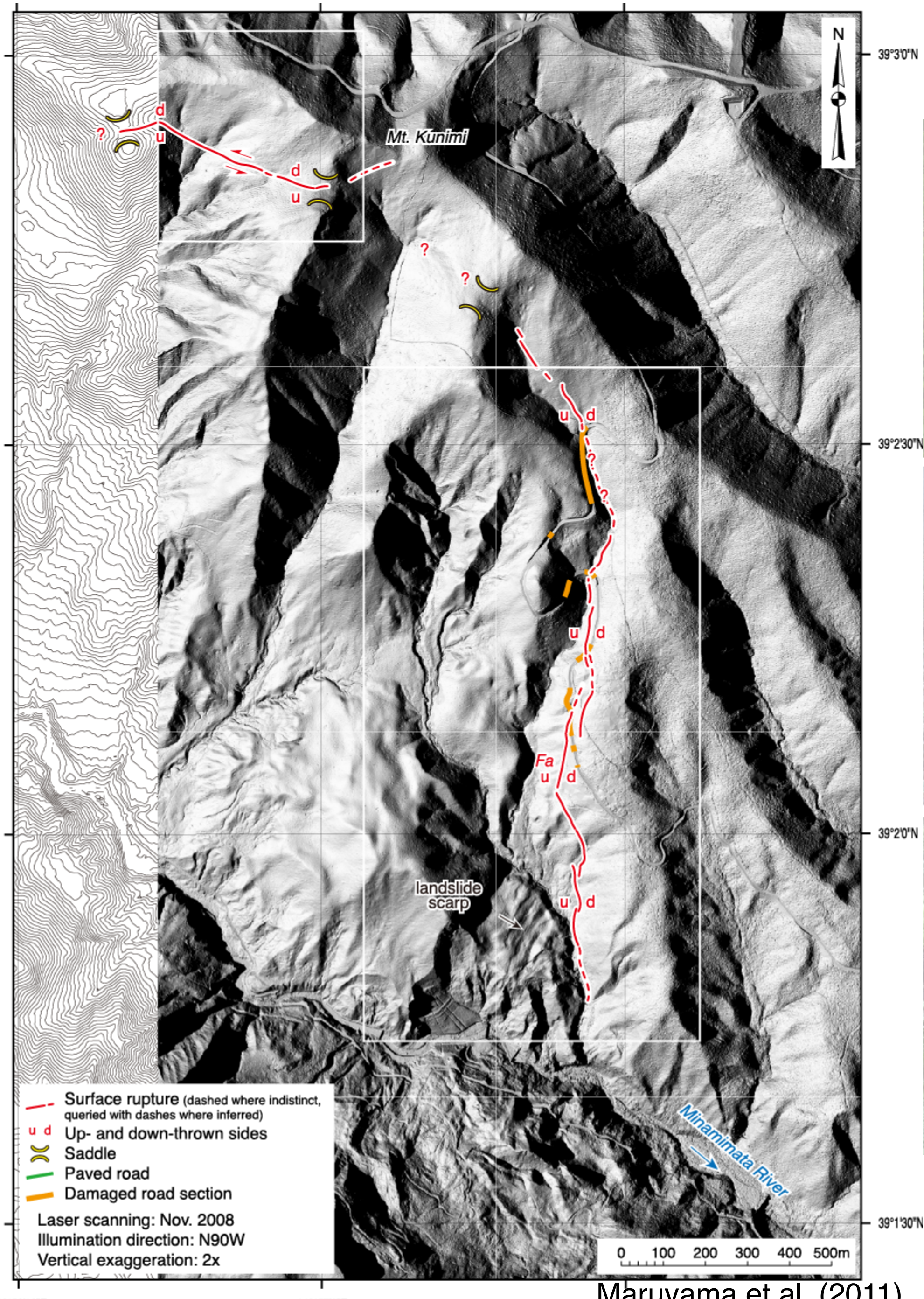


Maruyama et al. (2011)



Takada et al. (2009)

http://www.google.co.jp/intl/ja/earth/



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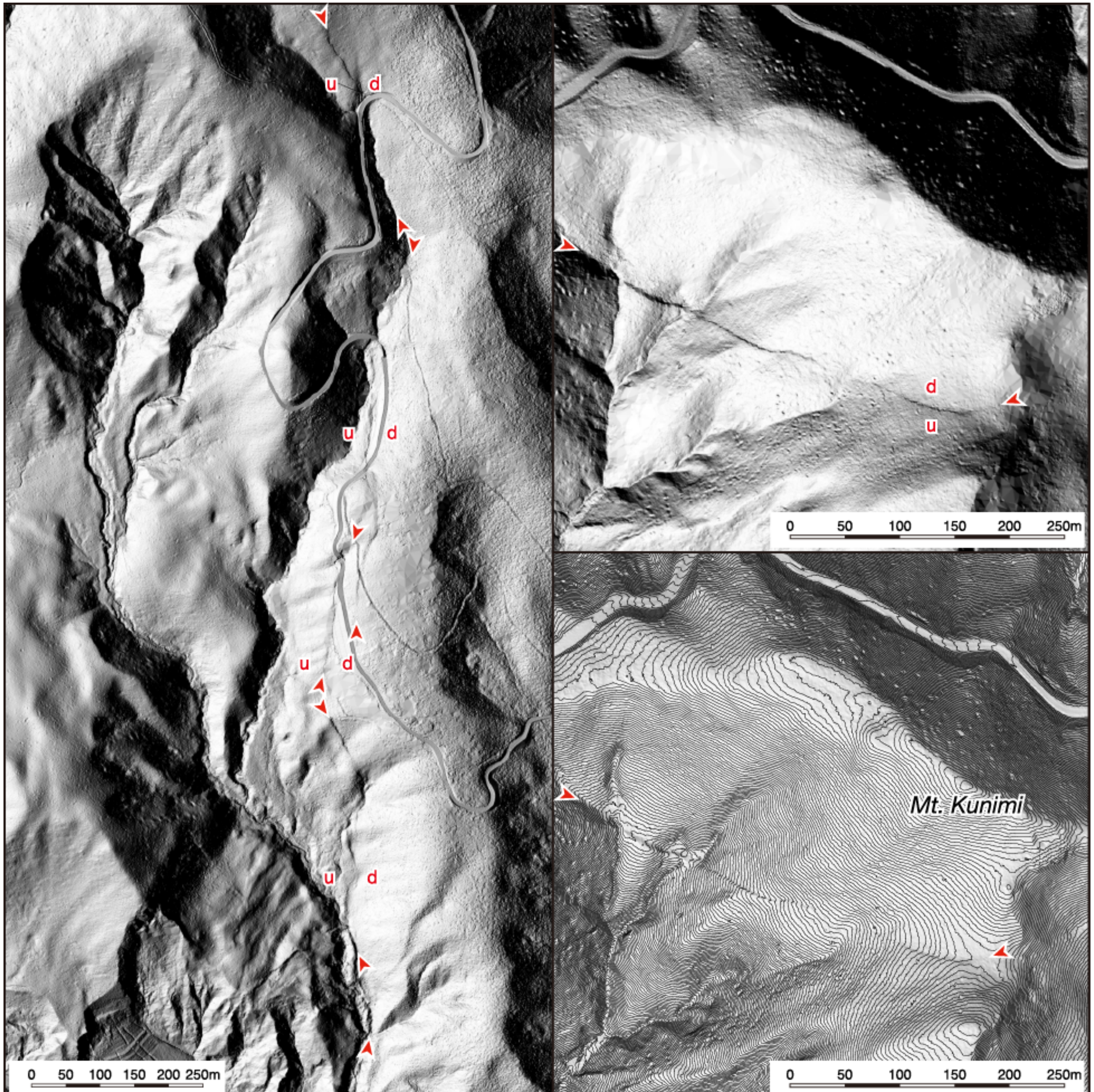

Maruyama et al. (2011)

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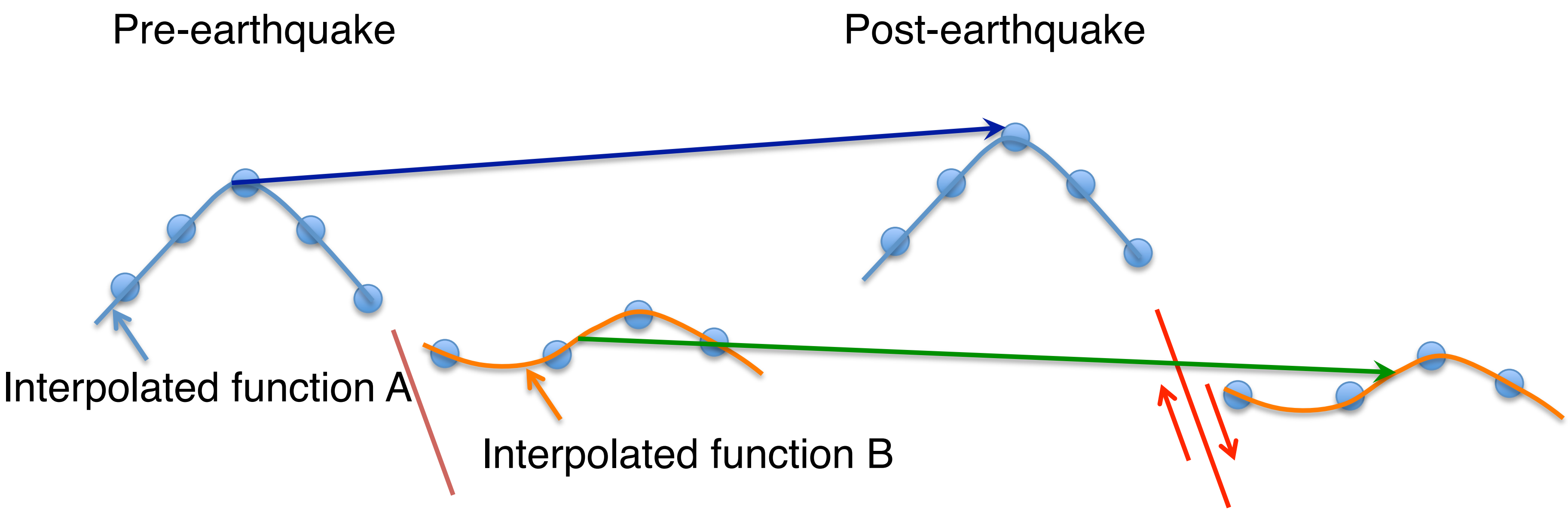
3-dimensional surface deformation

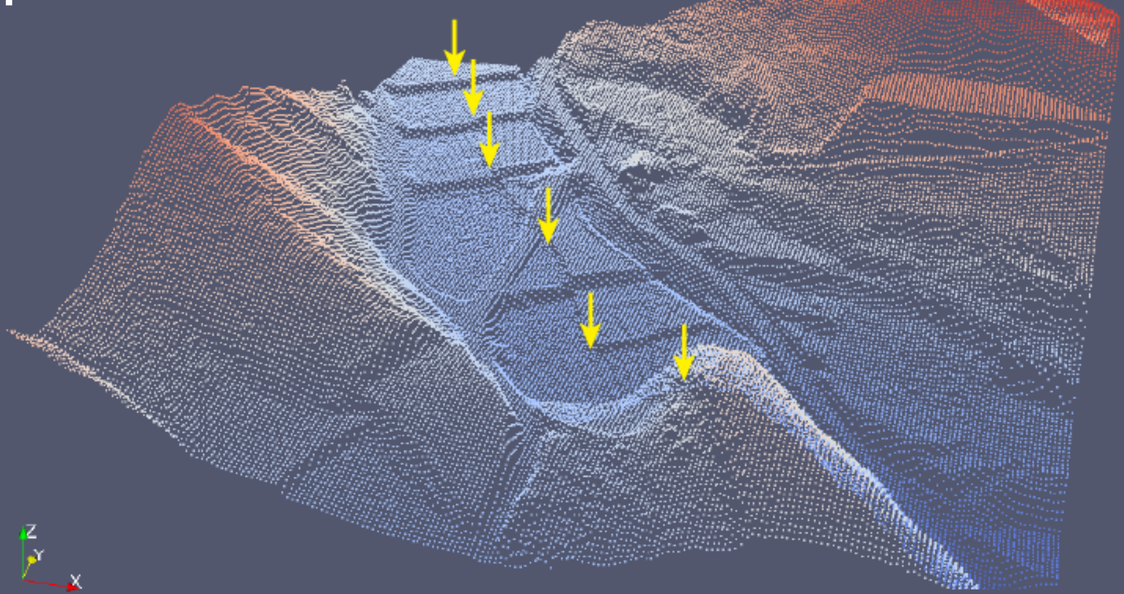
Differentiating pre- and post-earthquake LiDAR data

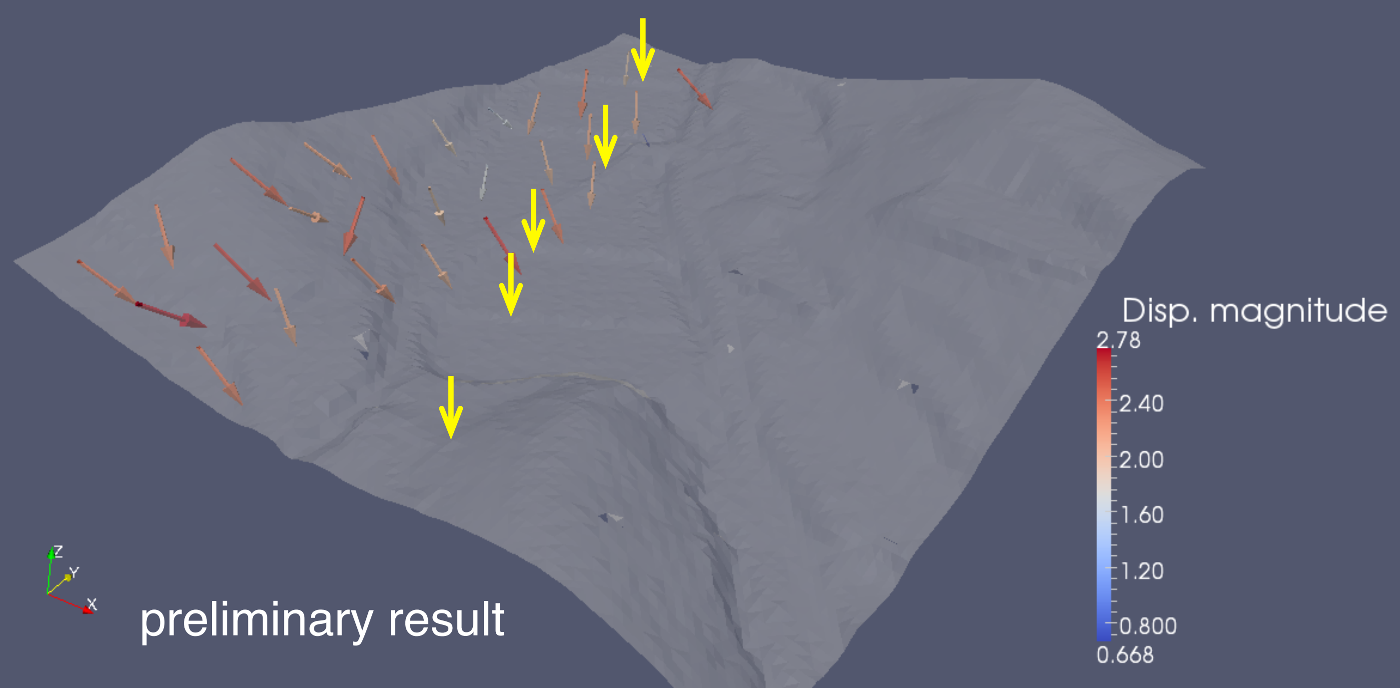
- Particle image velocimetry (PIV) algorithm: Mukoyama (2011)
- Iterative Closest Point (ICP) algorithm: Nissen et al. (2012)
- Genetic algorithm (GA) for matching functionized topography interpolated by Radial Basis Function (RBF): Saomoto (2013)



- Step 1: Landforms are divided into grids
- Step 2: Functionizing topography in each grid using Radial Basis Function (RBF) interpolation
  →minimize noise effects
- Step 3: Compute to minimize the distance between functions (each grid) by genetic algorithm
  →obtain optimal solution (avoid to obtain local solution)

3D displacement field along the central part of the Itozawa fault





preliminary result

Computed by Dr. Hidetaka Saomoto (AFERC, AIST)

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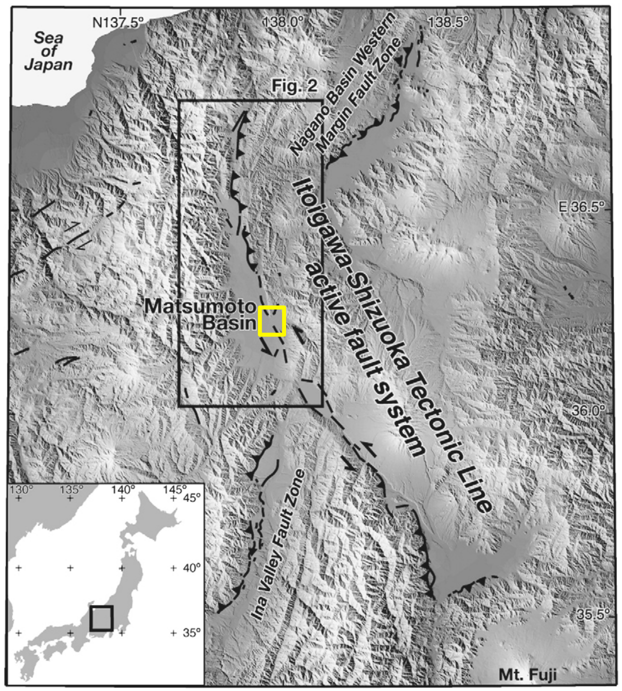
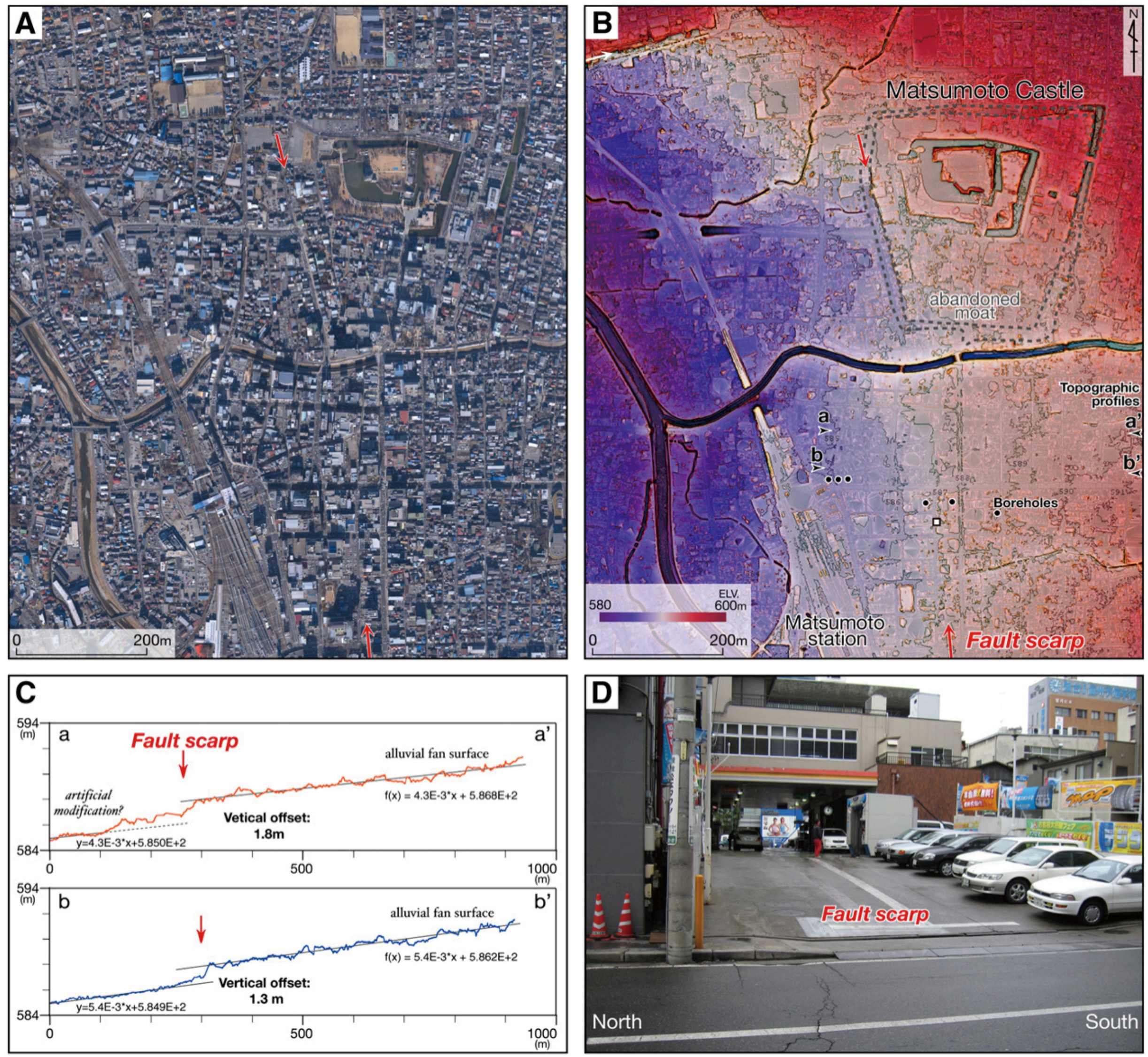
Mapping faults in urbanized areas

Itoigawa-Shizuoka Tectonic Line active fault system in Matsumoto, Nagano Prefecture





Kondo *et al*. (2008) Geomorphology

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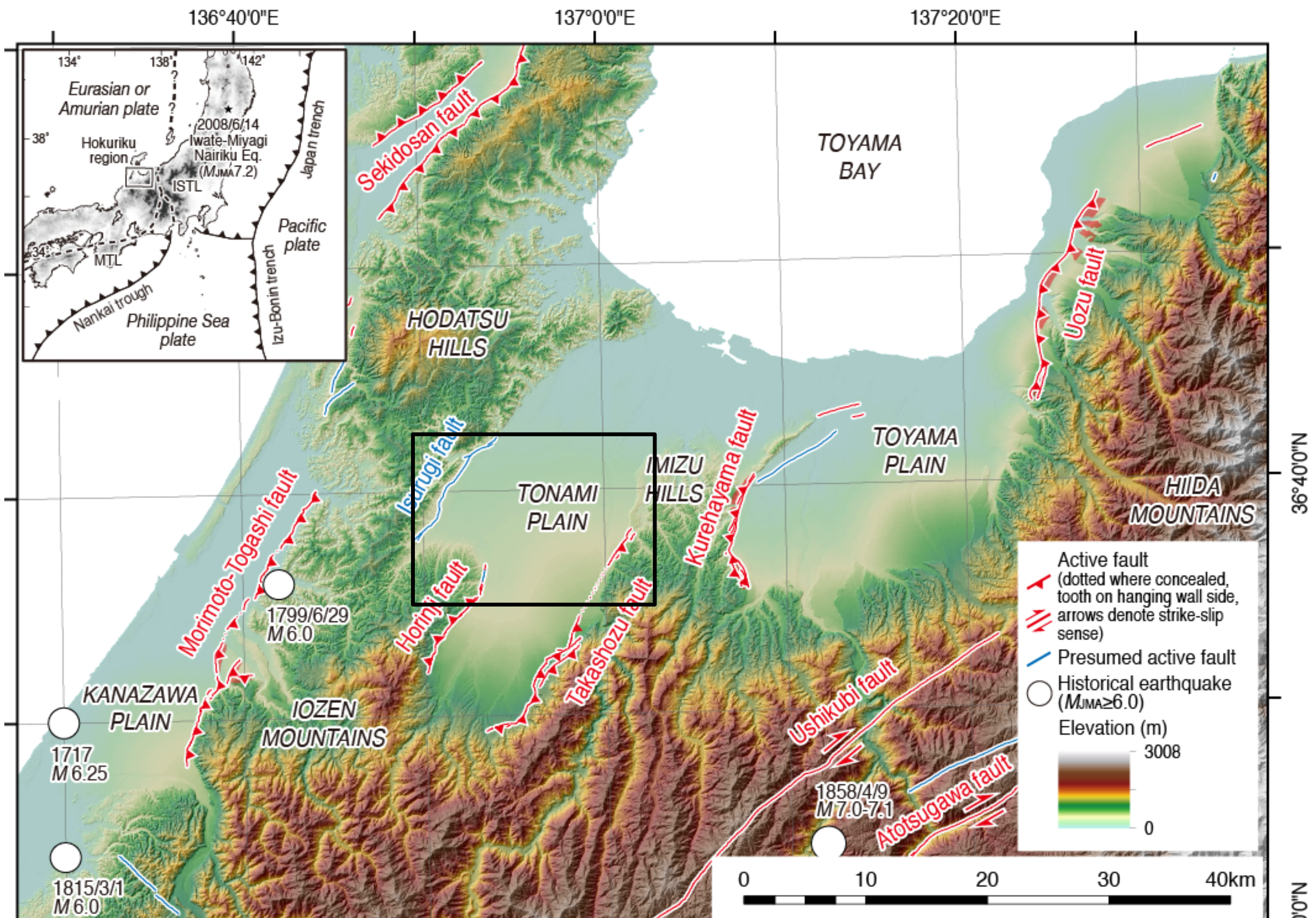
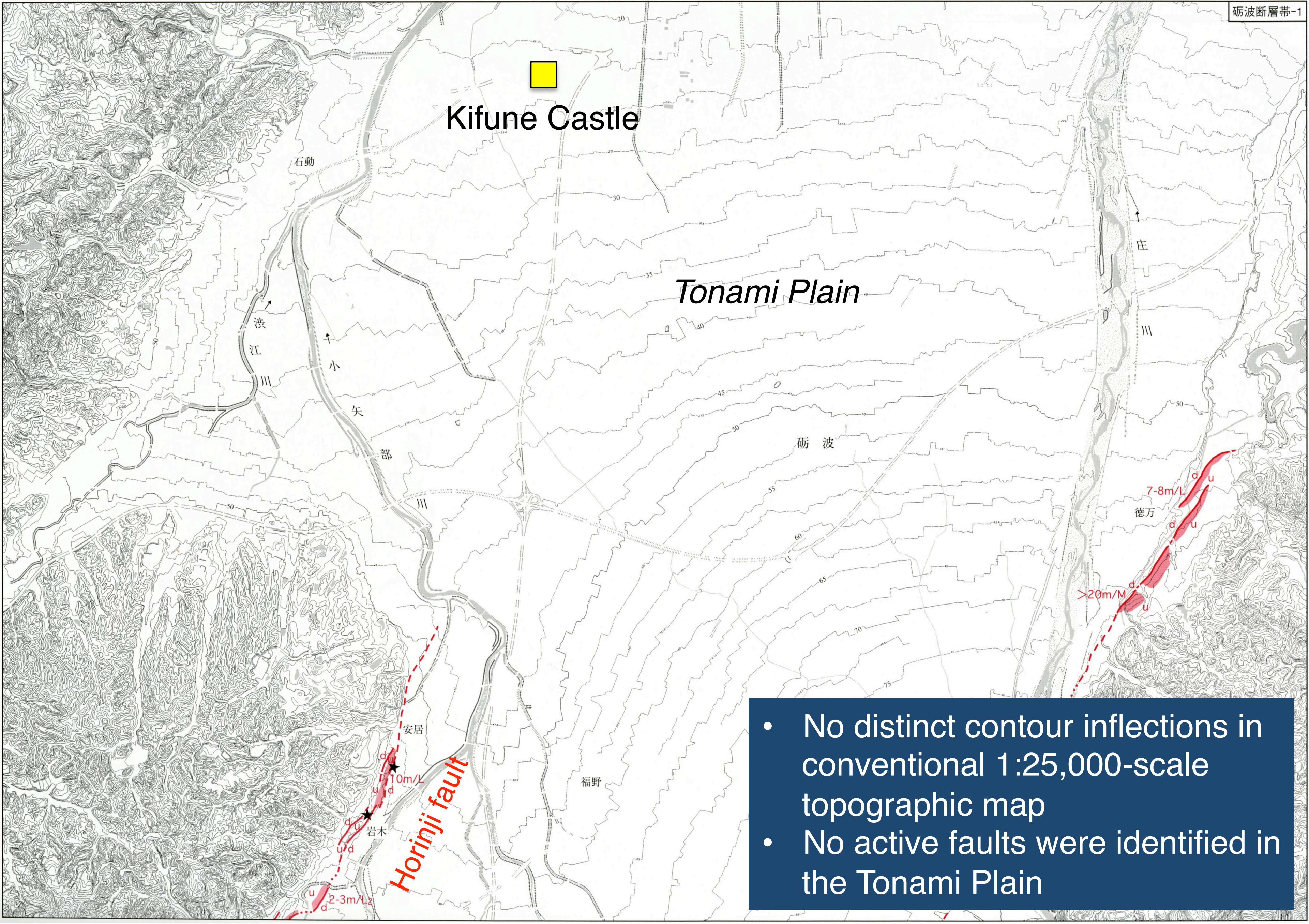
Identifying long wave-length gentle deformation in alluvial plain

- Horinji fault in Hokuriku region

- Destruction of castles and cities on the Tonami Plain by 1586 large earthquake
- Faults responsible for the quake are not found in the plain



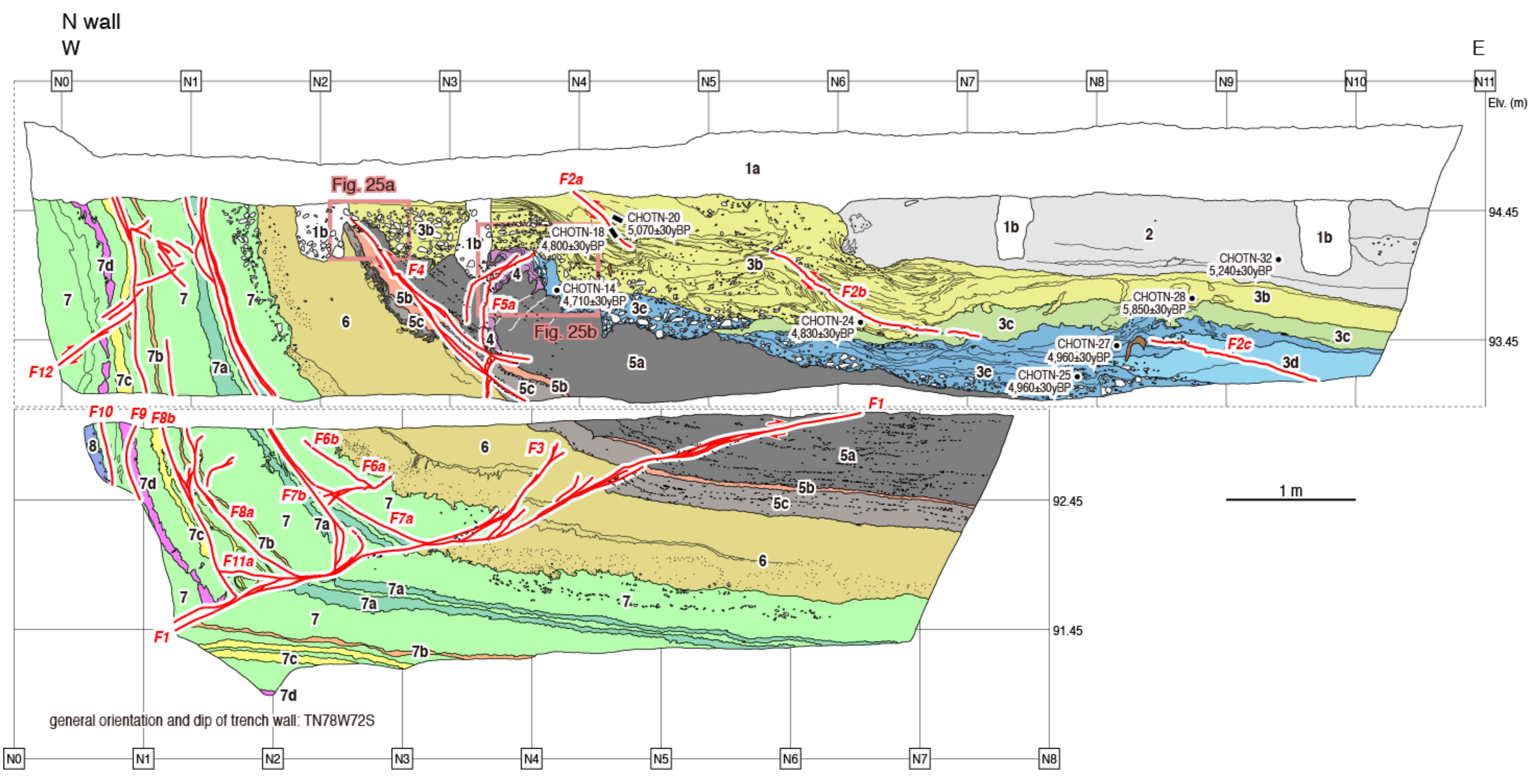
AIST (2012)



- No distinct contour inflections in conventional 1:25,000-scale topographic map
- No active faults were identified in the Tonami Plain

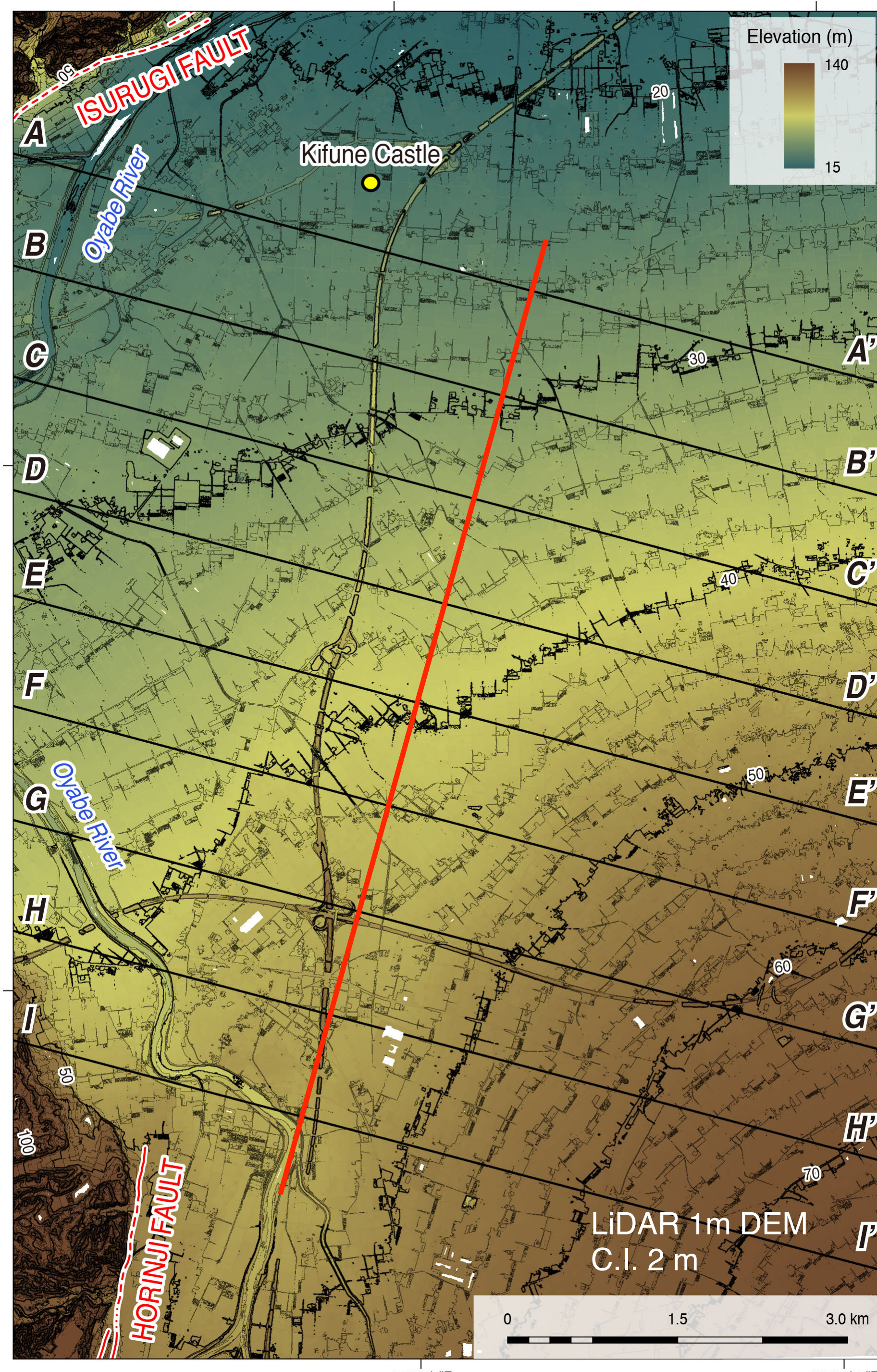
Ikeda *et al.* (2002) Atlas of Quaternary Thrust Faults in Japan, Univ. Tokyo Press
Base topographic map: 1:25,000, C.I.: 10 m (issued by Geospatial Information Authority of Japan)

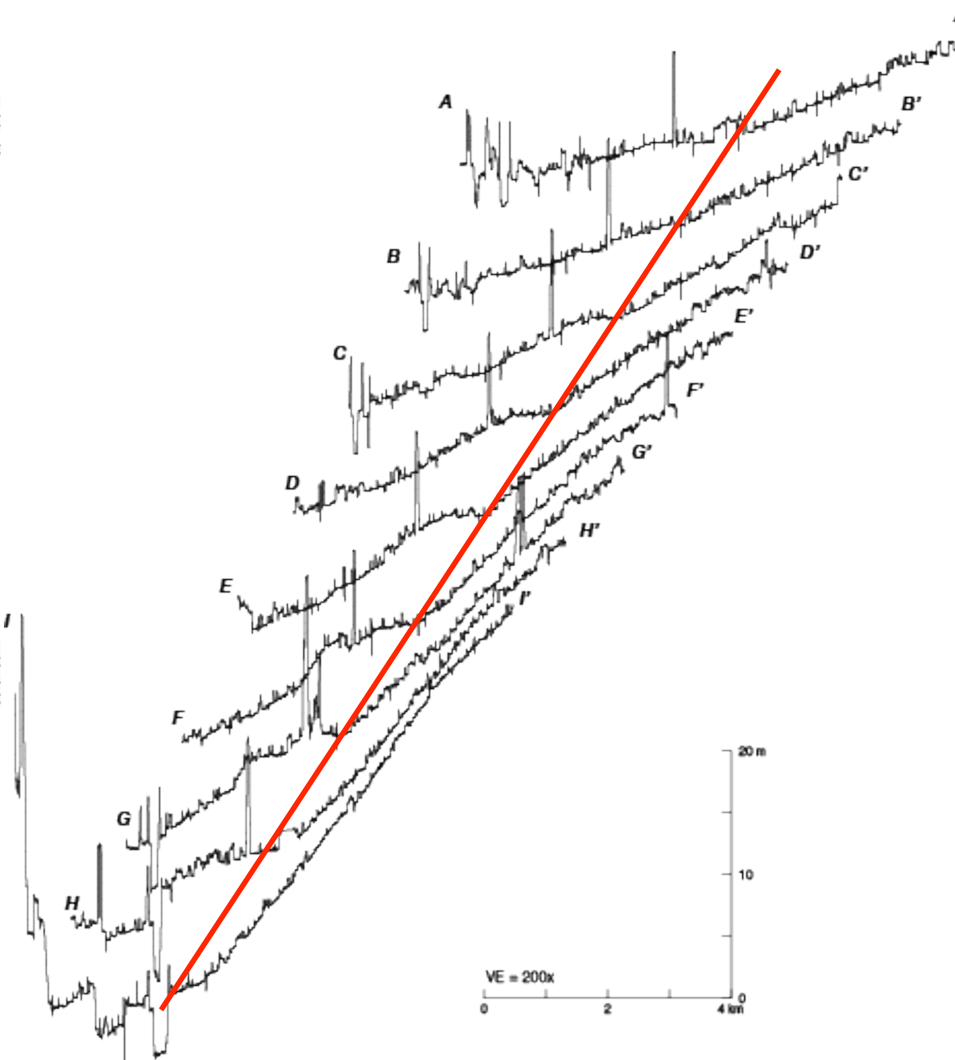
- The Horinji fault ruptured late Holocene repeatedly with two events in the last 5 ky ago
- The candidate fault responsible for the 1586 earthquake



AIST (2012)

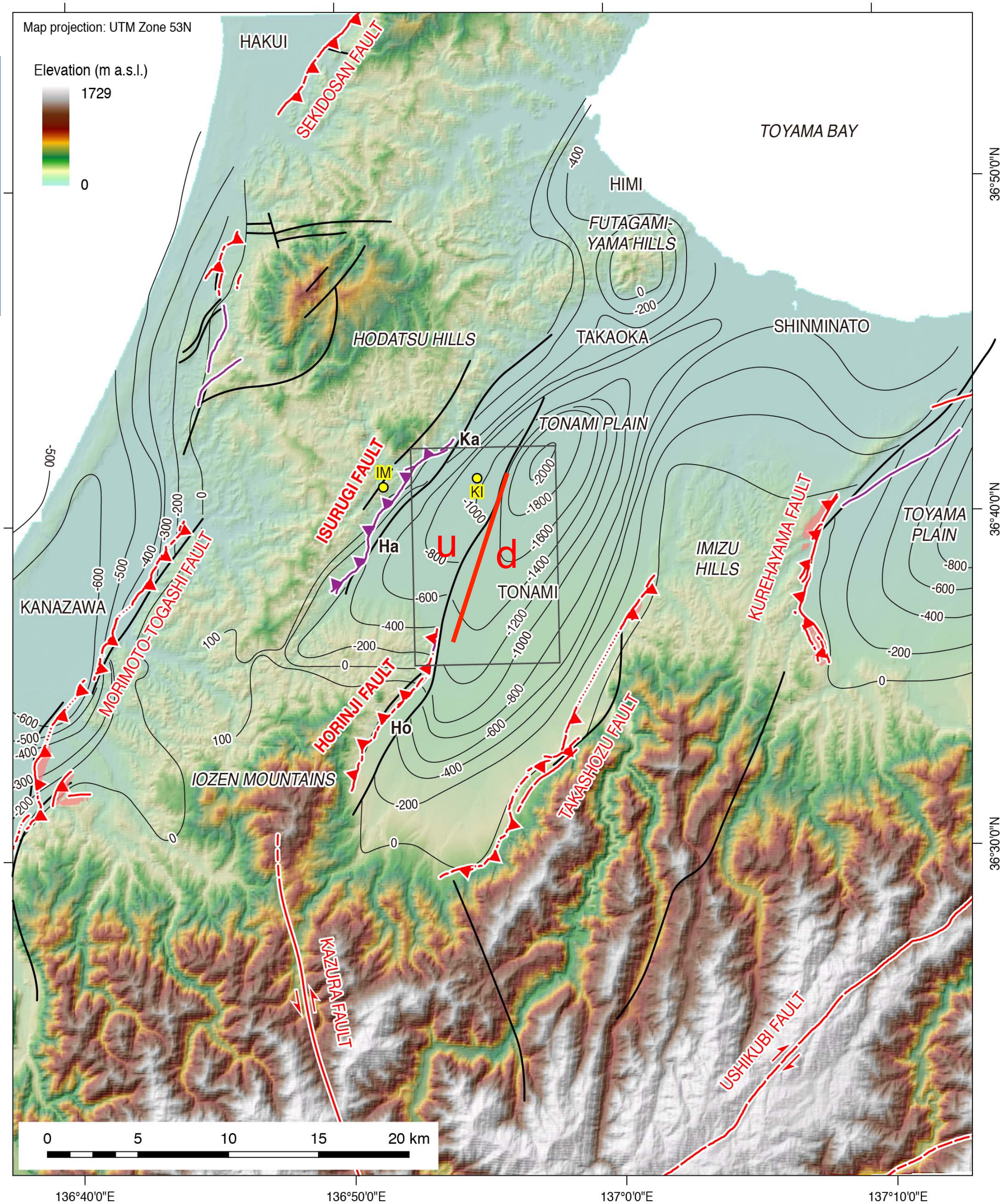
Virtual enhancing vertical exaggeration of LiDAR DEM delineates subdued gentle anticlinal warping in the plain, proximal to destructed castle and cities and extension of the Horinji fault





AIST (2012)

Position and slip sense of fault identified from warping correspond to geological fault as inferred from subsurface geology



Structural contour map (base of Quaternary strata) is after Fujiwara (2001) *in* Koike, K. and Machida, H. *eds.*, Atlas of Quaternary Marine Terraces in the Japanese Island, Univ. Tokyo Press.

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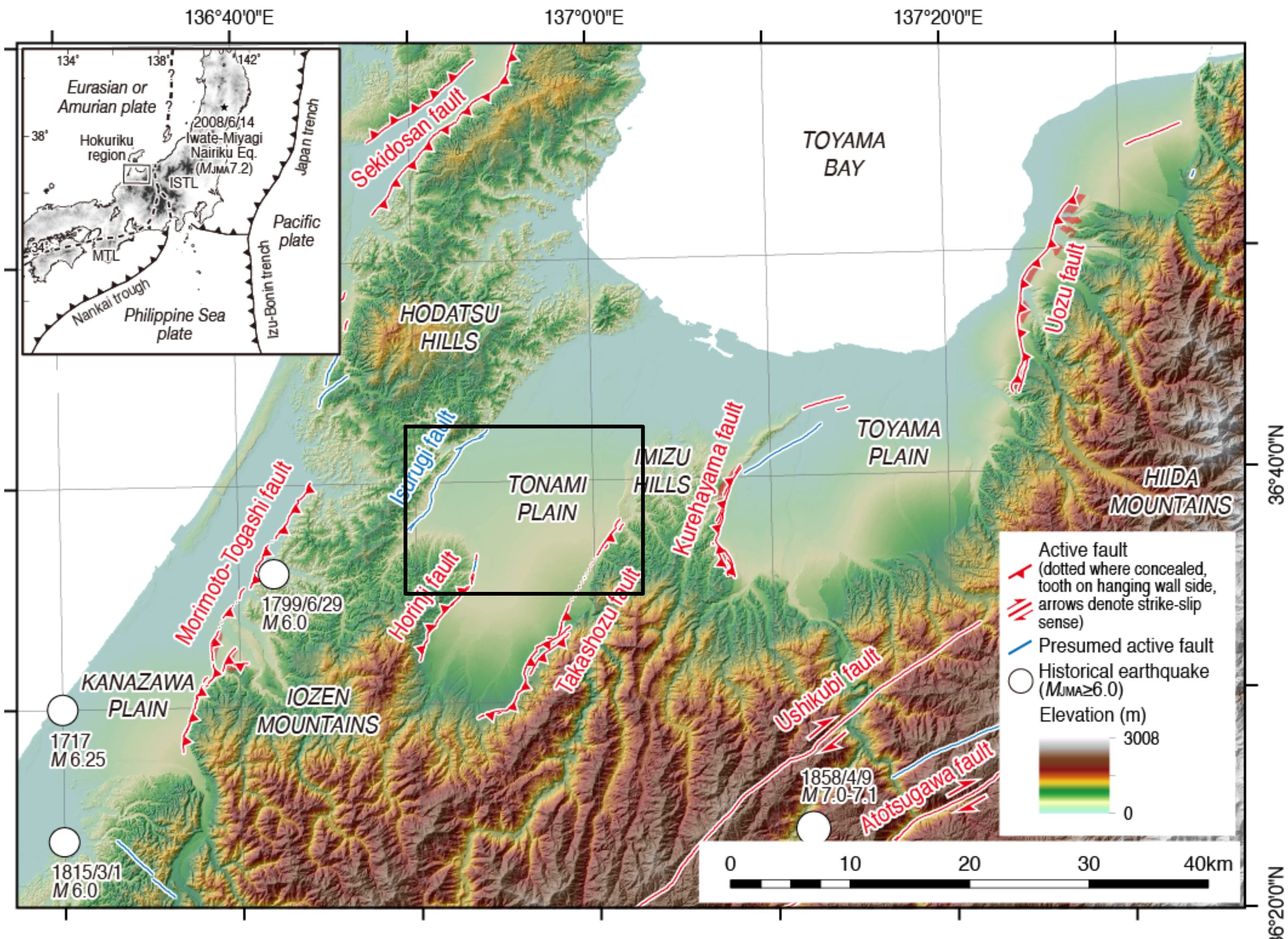
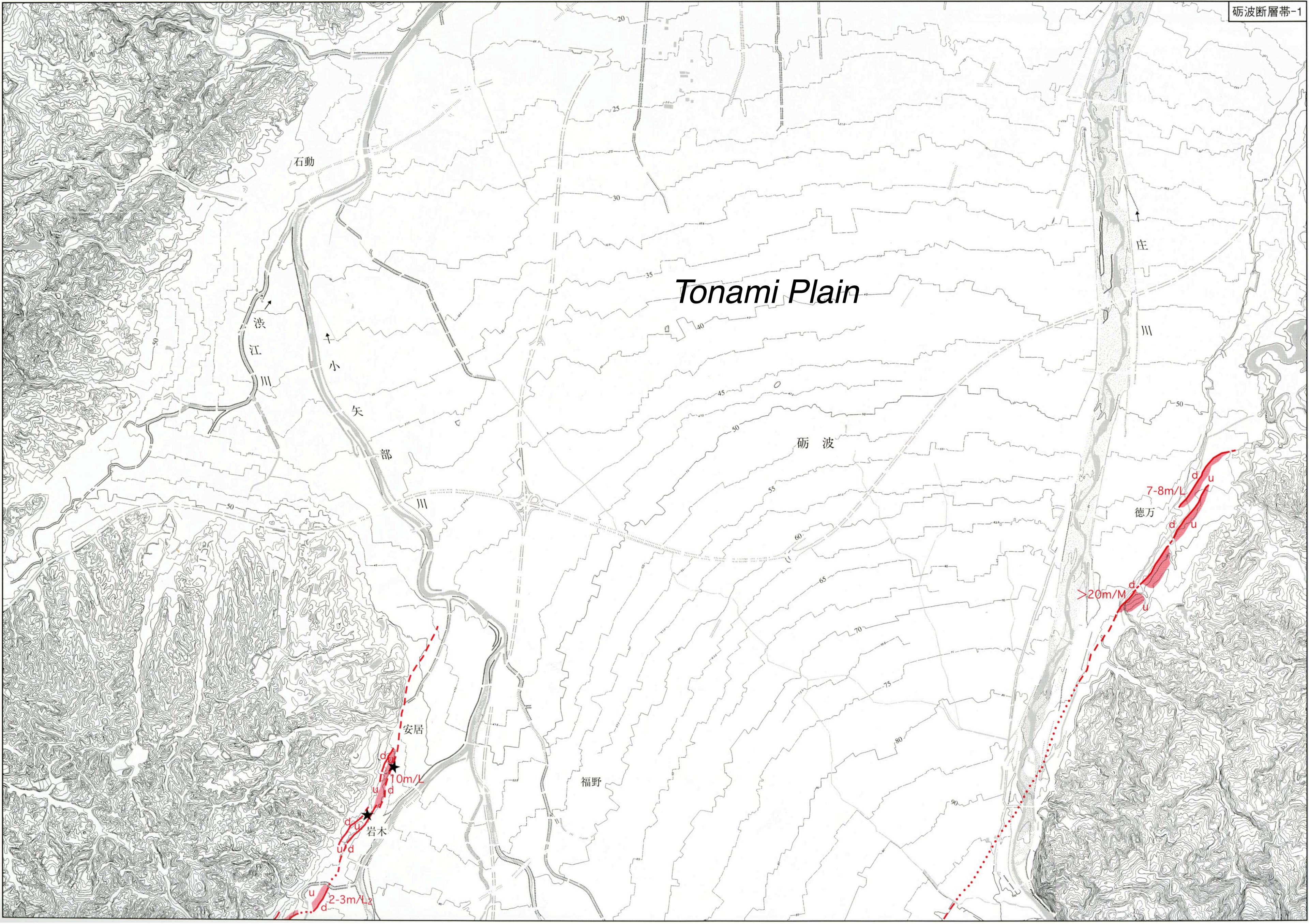
Detecting active faults with limited geomorphic evidence

- Isurugi fault in Hokuriku region





Ikeda *et al.* (2002) Atlas of Quaternary Thrust Faults in Japan, Univ. Tokyo Press
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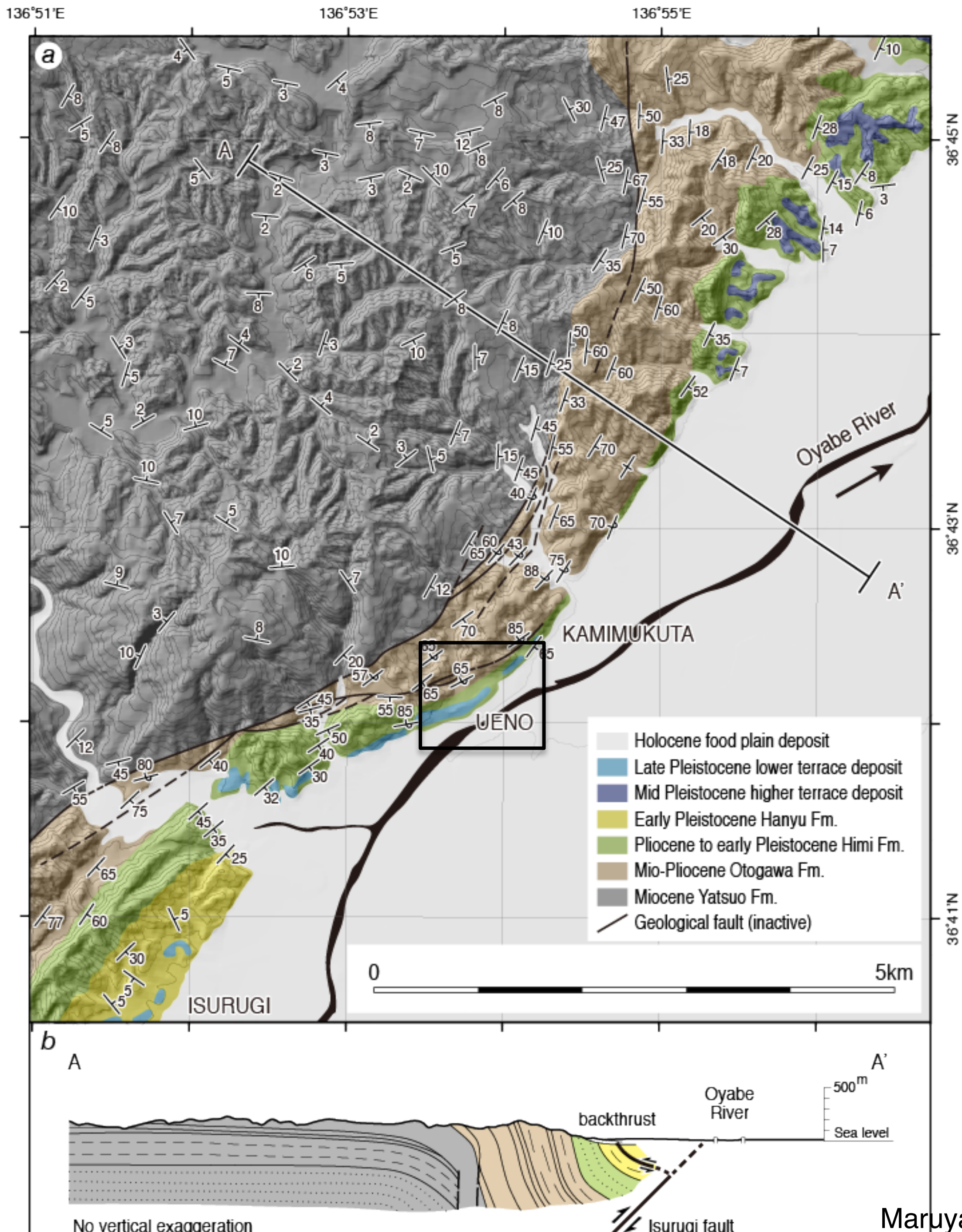
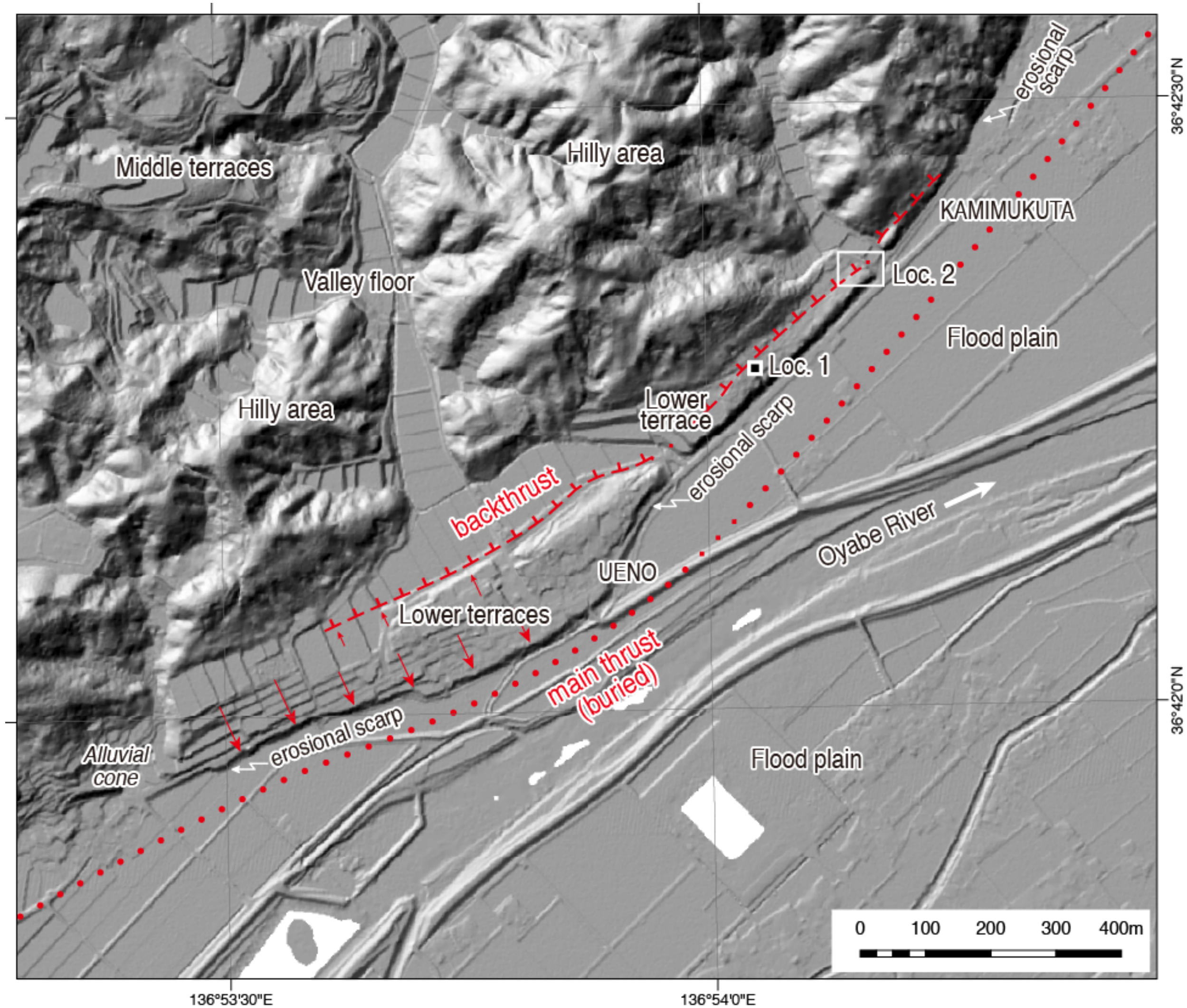


Maruyama et al. (unpublished data)



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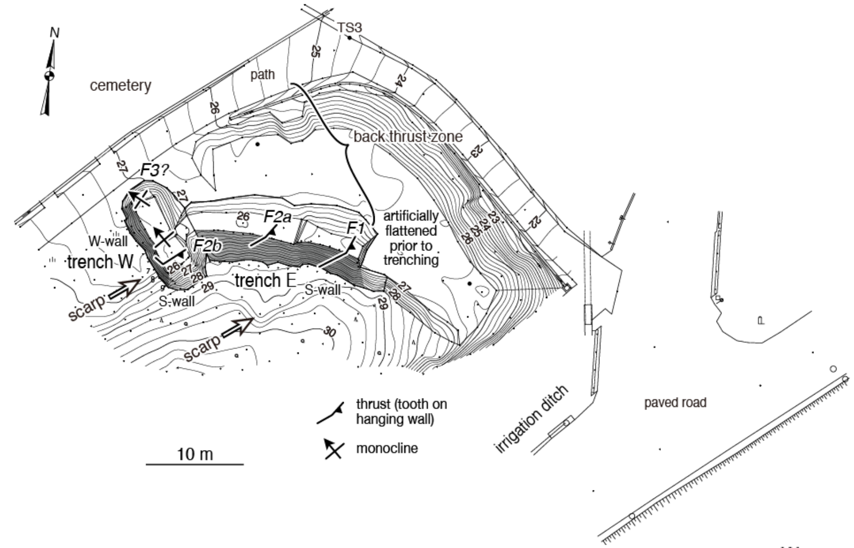

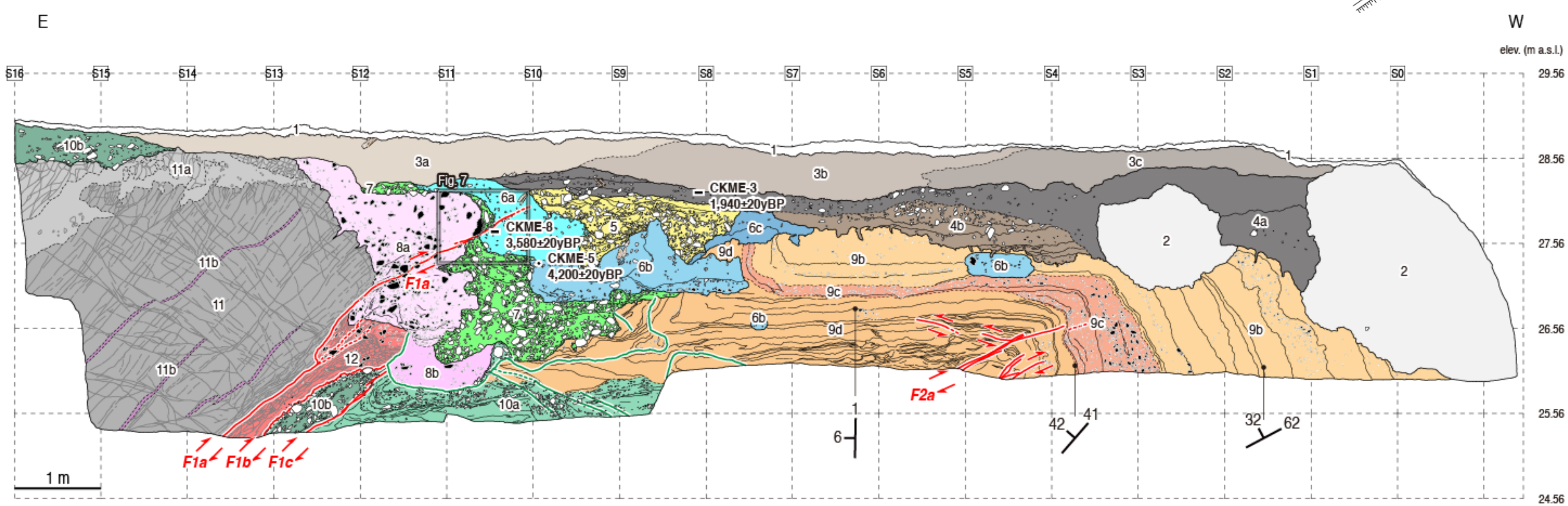

Evidence of recent faulting is only preserved for limited section of the fault (1 km of ca. 20 km) by destroy of faulted landforms due to intense erosion of large river

AIST (2012)

Summary:

- High-resolution airborne LiDAR topographic data covers most of major active faults in Japan
- LiDAR topography provides important clues for detecting and characterizing active faults in forested mountain and urban areas
- LiDAR topography is unrivaled data for detecting active structures with long wavelength gentle warping in alluvial plain