Brief report of the 2024 Noto Peninsula Earthquake in JAPAN

IAEG Japan National Group (Japan Society of Engineering Geology)

The 2024 Noto Peninsula Earthquake occurred on January 1st in 2024 with a maximum intensity of 7, in the northwestern part of Japan. The earthquake caused a magnitude 7.6 at the depth of about 15 km in the Noto region of Ishikawa Prefecture. The seismic mechanism of this earthquake was a reverse fault type with a pressure axis in the northwest-southeast direction, and the earthquake occurred within the earth's crust.

Figure 1 shows the general view of Japan. The Japanese Archipelago is comprised of five island arcs as shown in the figure. The Philippine Sea Plate has been moving to NW direction 4 cm/yr. on average and subducting in the Nankai Trough. On the other hand, the Pacific Plate has been moving to WNW direction 9 cm/yr. on average and subducting in the Japan Trench and the Izu-Ogasawara Trench. Moreover, the Izu-Ogasawara Island Arc have collided with Honshu Arcs and intruded to north direction. These continuing movements on the subduction zones at the boundary of the plates are the main causes of large earthquakes and tsunamis. And many active faults are distributed in the island arcs.

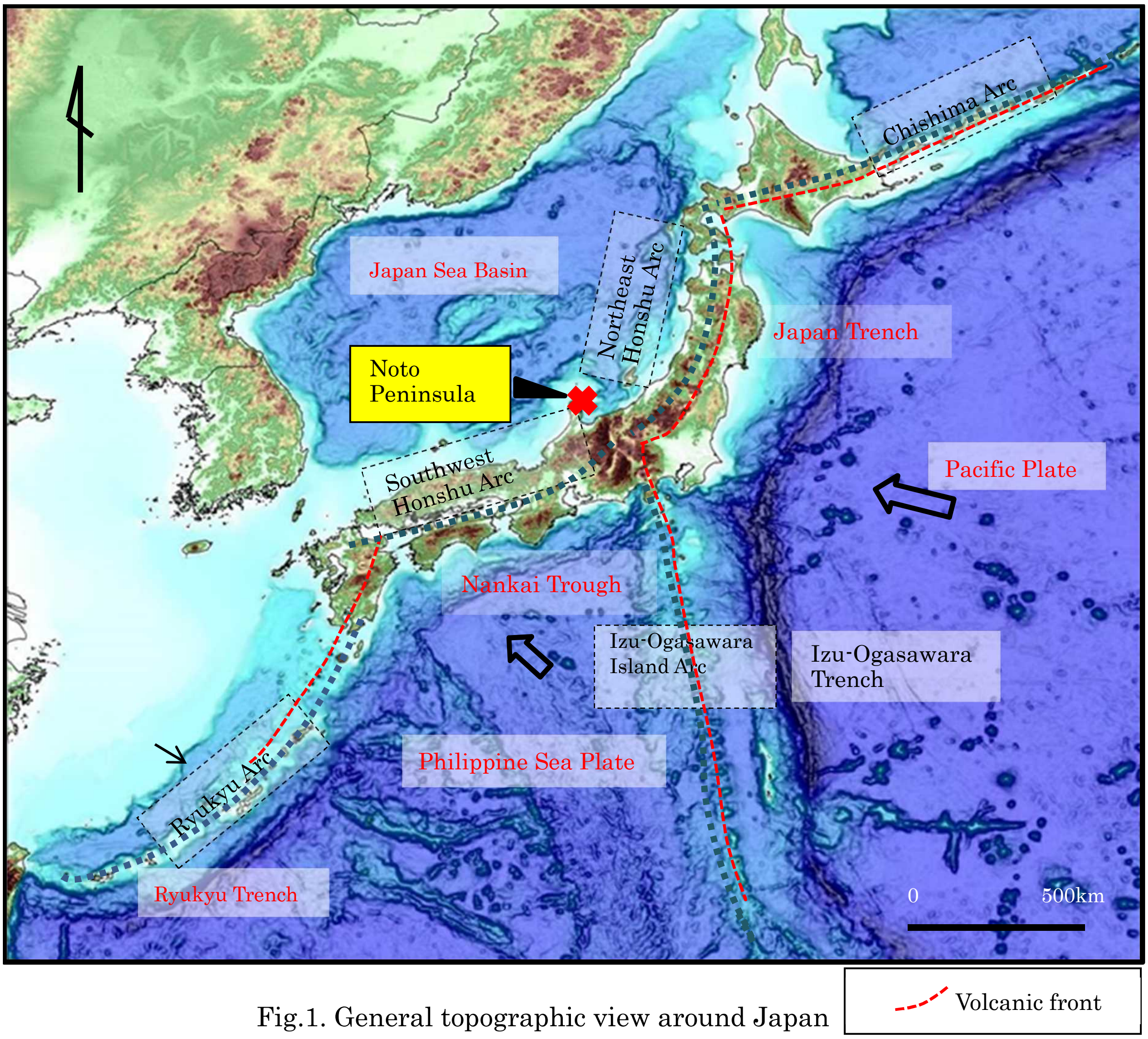


Fig.1. General topographic view around Japan

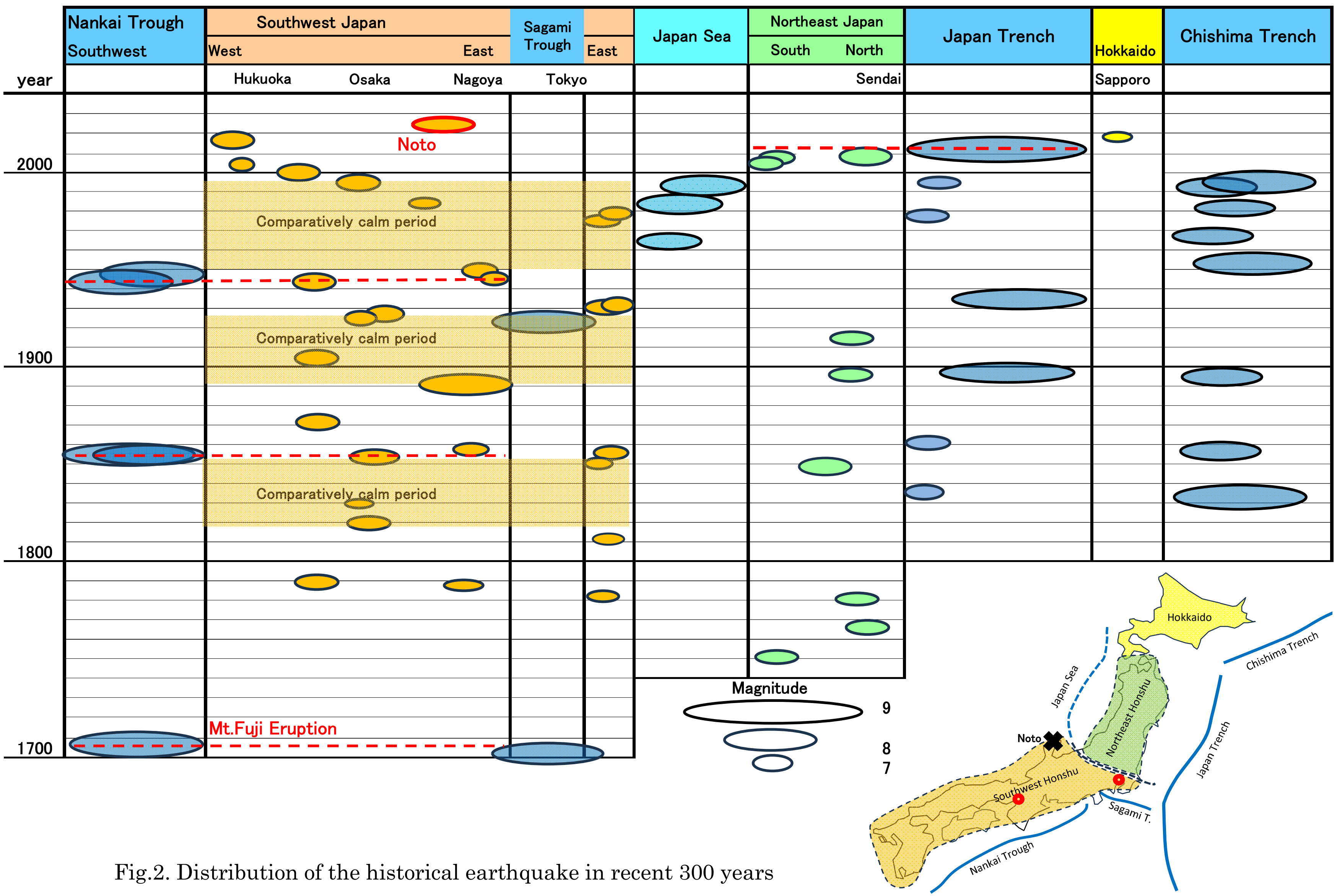


Fig.2. Distribution of the historical earthquake in recent 300 years

Figure 2 represents distribution of the historical earthquake in recent 300 years in Japan. Huge plate boundary earthquakes have sometimes occurred between Philippine Sea plate, Pacific Ocean plate, North American plate, and Eurasian plate respectively around Japan island Arc. Nankai trough is existed between Philippine Sea plate and Eurasian plate in the Pacific Ocean of west Japan island south. It is known that huge historical Nankai Earthquake in this trough have occurred in 100 years to 150 years interval and inland earthquake activity mainly in western Japan island have increased toward the occurrence of this plate boundary earthquake. After the Hanshin earthquake which occurred in 1995, activity of earthquakes looks like to increase gradually in all Japan island. It is not obvious that this time Noto Peninsula earthquake concerns with such increasing of activity and possibility of nearing Nankai Earthquake occurrence.

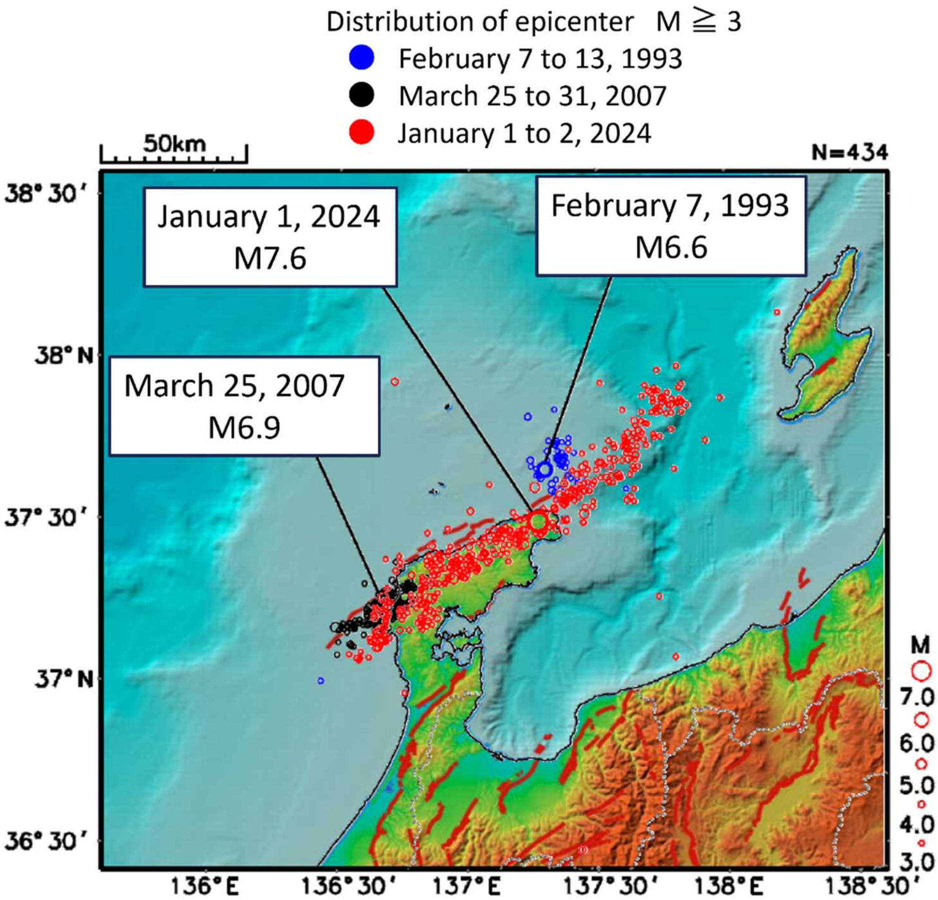


Fig. 3. Past seismic activity around Noto Peninsula. The size of circles indicates the magnitude of earthquakes.
.(https://www.static.jishin.go.jp/resource/monthly/2024/20240101_noto_2.pdf)

In the Noto Peninsula area, there have been earthquakes of magnitude > 6.0 in the past, including a magnitude 6.6 earthquake off the northeast coast on February 7, 1993, and a magnitude 6.9 earthquake off the southwest coast on March 25, 2007 as shown in Figure 3. In recent years, seismic activity had just increased from December 2020, increased from around May 2023, and then once seismic activity had returned to its post-December 2020 state. From December 1, 2020 to December 31, 2023, there were 506 earthquakes with intensity ≧ 1, of which 67 earthquakes with intensity > 3 occurred. The seismic activity was mainly centered in the northeastern and northern areas of the Noto Peninsula. The seismically active area since January 1, 2024 has traversed the northern part of the Noto Peninsula in a northeast-southwest direction.

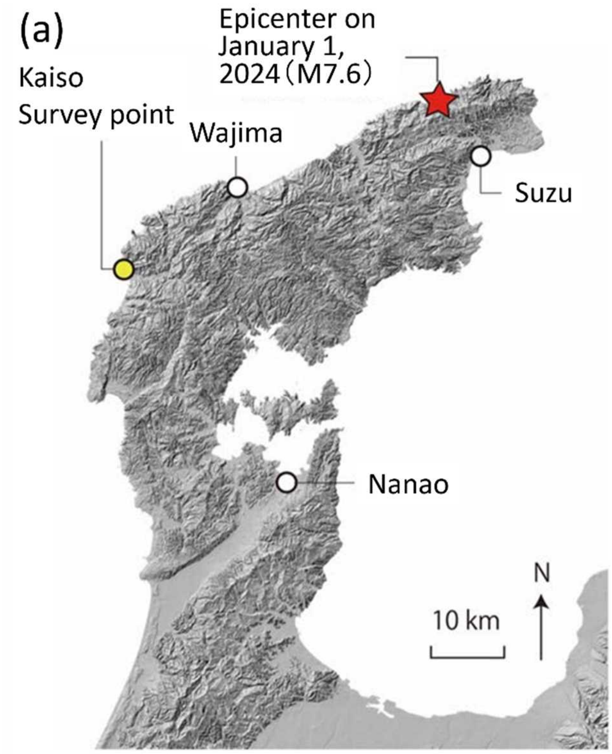
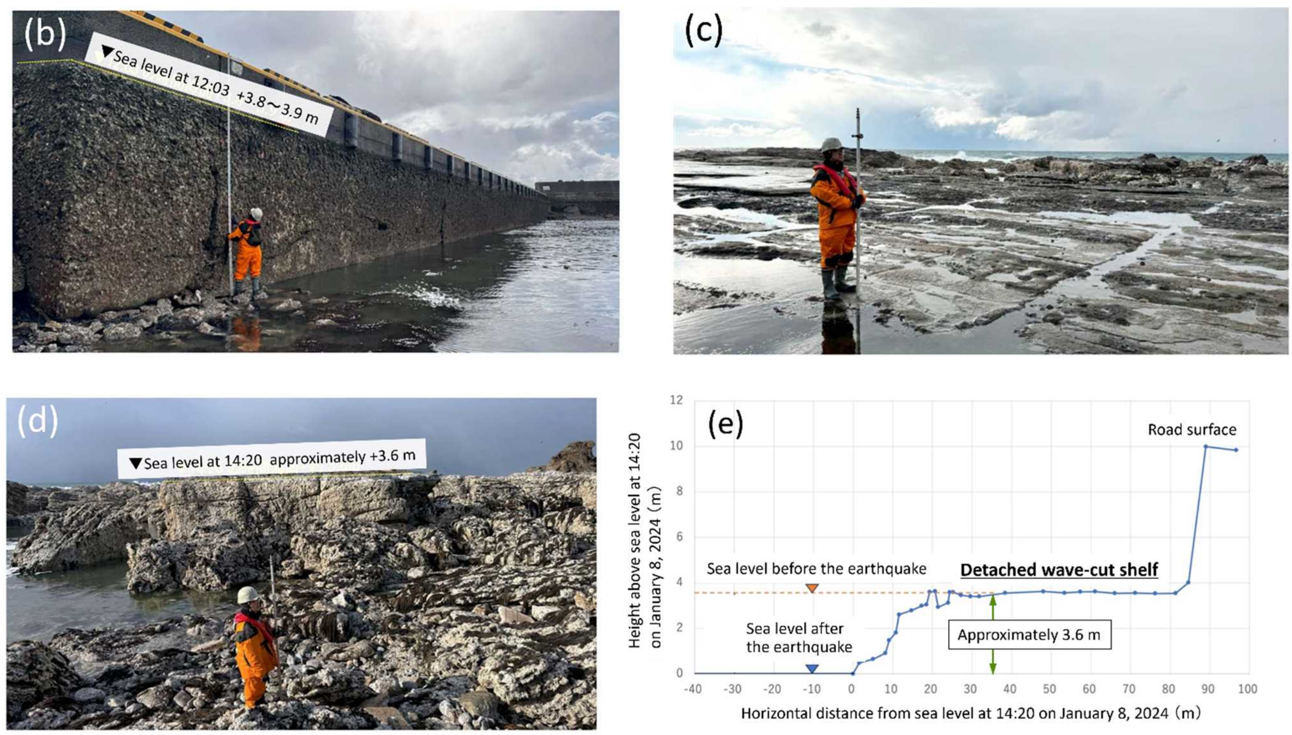


Fig. 4. Coastal Uplift Survey for the 2024 Noto Peninsula Earthquake (https://www.gsj.jp/hazards/earthquake/noto2024/noto2024-04.html)



According to an analysis of geodetic observation data by the Geospatial Information Authority of Japan (GSI) (2024), an uplift of up to 4 m was reported in the Kaiso area, Monzen-machi, Wajima City, Ishikawa Prefecture. At Kaiso Fishing Port (Fig. 4. (a) yellow point), oysters, serpulidae, and other organisms adhering to the seawall surface were observed to have been displaced by the uplift (Fig. 4. (b)). The upper altitude of the sessile organisms, which indicates the approximate pre-earthquake location of the sea surface, was measured at several points after the earthquake ranged from 3.8 to 3.9 m. Figure 4 (c) shows a wave-cut shelf has dried up due to upheaval caused by the earthquake, as seen in the area north of the Kaiso fishing port. Wave-cut shelves, which are formed by weathering of the bedrock and erosion by waves, are originally spread out at approximately the height of the mean sea level. The front of the wave-cut shelf is a cliff (Fig. 4. (d)), and the difference in height from the sea level after the earthquake is approximately 3.6 m. Cross-sectional topographic survey using a lightwave rangefinder revealed the terraced topography shown in Figure 4 (e), indicating the formation of marine terraces.

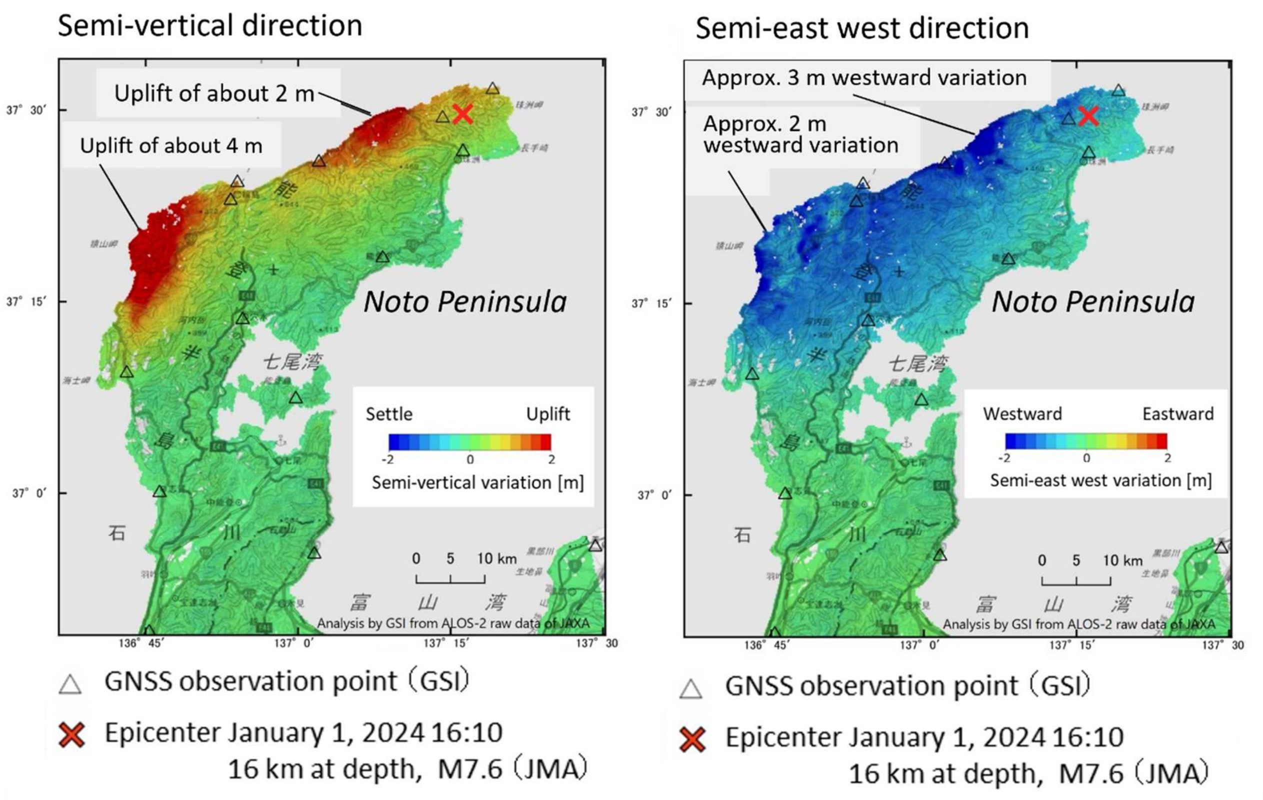


Fig. 5. Amount of crustal deformation based on 2.5D analysis from Geospatial Information Authority of Japan updated January 19, 2024
(https://www.gsi.go.jp/uchusokuchi/20240101noto_insar.html)

Figure 5 shows crustal deformation over the entire Noto Peninsula based on 2.5D analysis, using observation data from ALOS-2 (DAICHI-2). These results show a maximum uplift of approximately

4 m and a maximum westward movement of approximately 2 m in the western part of Wajima City. A maximum uplift of approximately 2 m and a maximum westward variation of approximately 3 m can be seen in the northern part of Suzu City.

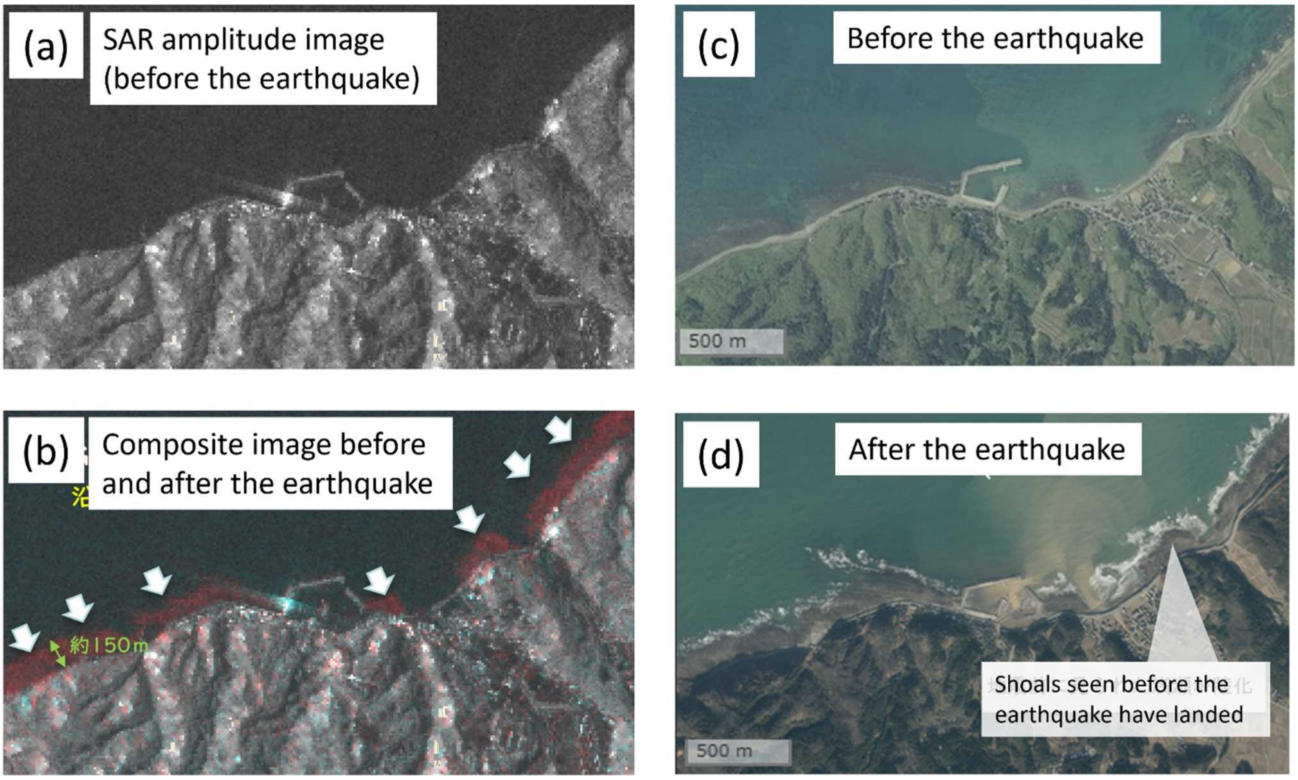


Fig.6. ALOS-2 SAR intensity composite images acquired (a) before and (b) after the earthquake, aerial photographs (c) before and (d) after the earthquake around Nafune-machi in Wajima City. Red zones indicate the zones where the uplift associated with the earthquake was detected (https://www.gsi.go.jp/uchusokuchi/20240101noto_pwr.html).

In the coastal area in Wajima City, an uplift of approximately 4 m was detected and the coastline has changed by approximately 150 - 200 m along the coastal line (Fig.6).

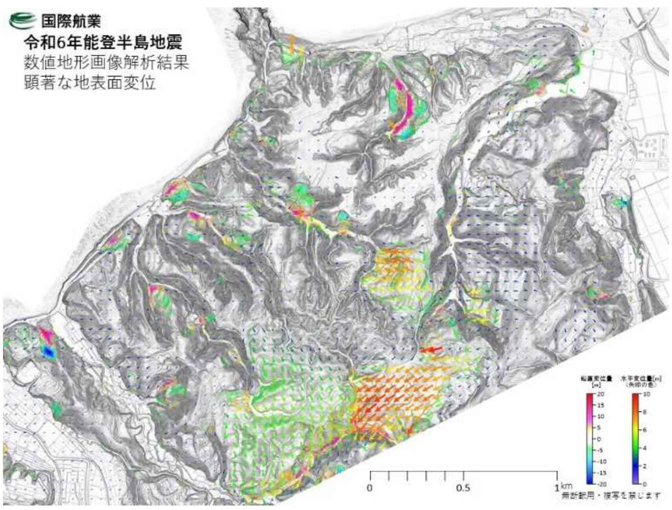


Fig. 7. Slope Variation by Numerical Topographic Image Analysis

Numerical topographic image analysis (Patent No. 4545219) using detailed topographic data before and after the earthquake was conducted in the area from northeast to southwest of the Noto Peninsula. In the northeastern part of the survey area, a 1500 x 1000 m area of land surface displacement was observed on a mountain slope near Machino-machi, Wajima City (Fig. 7). The ground surface displacement was divided into several blocks, and the maximum displacement of the slope, calculated by correcting the amount of displacement due to crustal deformation, was approximately 8 m.

Fig. 8. Linear steps seen in Wakayama-machi of Suzu City

Fig.7. and Fig.8. are offered by KOKUSAI KOGYO CO., LTD Geospatial Information Authority of Japan (GSI) (https://www.kkc.co.jp/disaster/2024/01/%e4%bb%a4%e5%92%8c%ef%bc%96%e5%b9%b4%e8%83%bd%e7%99%bb%e5%8d%8a%e5%b3%b6%e5%9c%b0%e9%9c%87/)

In the Wakayama-machi of Suzu City, linear deformations were found in the GSI survey. It has confirmed a rise in the ground approximately 4 km long and 100 to 200 meters wide from east to west. A maximum of 2.2 m high steps across fields and rivers were also observed. Aerial laser measurements show steps as indicated by the white arrows in Figure 8. It is believed that the ground was uplifted by strong compression in the north-south direction.

Fig. 9. Damage to buildings in Tagamishin-machi, Kanazawa City, Ishikawa Prefecture

Fig. 10. Damage to the Noto Satoyama Kaido Road, that directly connects Kanazawa City to the Noto Peninsula, Ishikawa Prefecture

Fig. 11. Collapse of slope along Route 249, Matsunagi-machi, Suzu City, Ishikawa Prefecture

Fig. 9., Fig. 10. And Fig. 11. are offered by
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(https://www.kkc.co.jp/disaster/2024/01/%e4%bb%a4%e5%92%8c%ef%bc%96%e5%b9%b4%e8%83%bd%e7%99%bb%e5%8d%8a%e5%b3%b6%e5%9c%b0%e9%9c%87/)