Responses of Geographic Department to the 2016 Kumamoto Earthquake

Geographic Department Disaster Countermeasures Group

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Abstract

The Geographic Department Disaster Countermeasures Group, GSI published landslide distribution maps by interpreting aerial photographs to grasp the extent of damages caused by the 2016 Kumamoto earthquake. The Group also carried out aerial laser surveying in order to assess the ground surface fissures which occurred during the Kumamoto earthquake. This paper reports on such endeavors.

1. Preface

Just after the occurrence of the 2016 Kumamoto earthquake (hereinafter "the Kumamoto earthquake") on April 16, 2016, it was reported through the media and public sources that numerous landslides occurred mainly within the Kumamoto Prefecture, such as large-scale slope failures occurring around the Aso-ohasi Bridge, which are believed to have been most likely caused by seismic motion associated with the Kumamoto earthquake. Concerned with further potential landslides and damages by forecast subsequent rainfall, the Geographic Department Disaster Countermeasures Group, GIS (hereinafter "the Group") interpreted the aerial photos of the disaster-stricken areas to determine the location of the landslides and then made this information public in April, 2016.

The Group also conducted aerial laser scanning surveys in May, 2016 in order to assess the ground fissure distribution situation in the vicinity of Futagawa and Hinagu fault zones where discontinuous fissures occurred during the earthquake.

Reports on distribution map of surface fissures compiled by the Geographic Department in collaboration with Geography and Crustal Dynamics Research Center of GSI are available in the special feature collection "Mapping of Surface Cracks Derived from the Kumamoto Earthquake (Yoshida et al., 2016)."

2. Mapping of Landslide Distribution

2.1 Interpretation of Aerial Photos Taken on April 16, 2016

After the Kumamoto earthquake, the disaster-stricken areas experienced heavy rainfall which meant that there was concern for further damage, such as further expansion of the landslides originally caused by the Kumamoto earthquake. GSI recognized an urgent need of making landslide distribution information promptly available to affiliated organizations such as the Major Disaster Management Headquarters (hereinafter "MDMH").

In response to this urgent need, the Group interpreted the vertical photographs taken by the GSI on April 16 (Kumamoto, Uto, Aso, Koshi, Minami-aso, Nishihara and Beppu districts) and extracted the locations where landslides seemed to have occurred during the Kumamoto earthquake. The identified landslide locations were acquired as point data and this information was made available to the public.

This task was carried out by interpreting respective vertical photographs on PC screen using image viewer software, identifying landslides locations on the screen and assigning an icon onto the center location of each landslide by using mapmaking function of GSI Maps, a webmap service operated by GSI.

After coordinating with Water and Disaster Management Bureau, Ministry of Land, Infrastructure, Transport and Tourism (hereinafter "MLIT") which is responsible for landslide management, or Sabo administration, with respect to how to make this data public, Landslide Distribution Map based on aerial photo interpretation during the 2016 Kumamoto Earthquake (hereinafter referred to as “Landslide Distribution Map”) was published on April 18, on GSI Maps (in GeoJSON format) and GSI website on 2016 Kumamoto Earthquake (in PDF and KML format) (hereinafter referred to as “Kumamoto Earthquake website”).

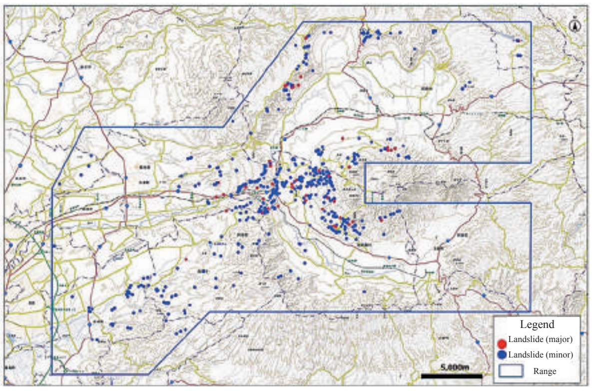

Fig. 1 Landslide Distribution Map during the 2016 Kumamoto earthquake (based on aerial photo interpretation) (initially published on April 18, 2016) (Red dots show major landslides, while blue dots show minor landslides)

2.2 Interpretation of Aerial Photos Taken on April 19 and 20

Unlike the technical flow of aerial photo interpretation employed for the vertical photos taken on April 16, the Group laid orthophoto images taken on April 19 and 20 over webmap interface. This method made it possible to get landslide icons with improved spatial accuracy, using the map-making function of GSI Maps.

During this work, the Group found a few fissures that might cause new landslides on the upper part of slope failure sites within Aso City, Kumamoto Prefecture. The Group through GSI Disaster Response Headquarters sent a note of this potential hazard risk to MDMH, Kumamoto Prefecture and Aso City. As a result, Aso City issued an evacuation order to the concerned districts to avoid the risk.

With the partial completion of interpretation work covering Minami-aso-second, Oguni, Yufuin, Takeda, Yamaga, Aso-second and Nishihara-second districts, “Landslide Distribution Map” on GSI Maps and Kumamoto earthquake website was updated on April 22 (Fig. 2).

Immediately after the completion of interpretation work in remaining districts (i. e. Beppu, Kikuchi, Tamana, Amakusa, Yatsushiro and Mifune districts), “Landslide Distribution Map” was finally updated on April 25 (Fig. 3).

2.3 Interpretation of Aerial Photos Taken in July

GSI conducted a new aerial photo survey on July 5 for Aso-third district and a part of Kumamoto-second district. The purpose of this survey was to detect if further expansion of landslides had occurred during the torrential rain in the disaster-stricken area in late June. Referring to orthophoto images derived from aerial photos taken on July 5, the Group resumed its work to identify center locations of landslides by applying the method described in 2.2. The results were published as “Landslide Distribution Map” (Aso and Kumamoto Districts) on the Kumamoto earthquake website on July 8.

Thereafter, supplemental aerial photos were taken in Kumamoto-second district on July 18, 22 and 24 to complete the survey. Accordingly, the Group interpreted the imagery applying the same method. The integrated results were published as “Landslide Distribution Map” (general map) (Fig. 4) and “Landslide Distribution Map” (Aso and Kumamoto districts) (Fig. 5) and were also published on GSI Maps.

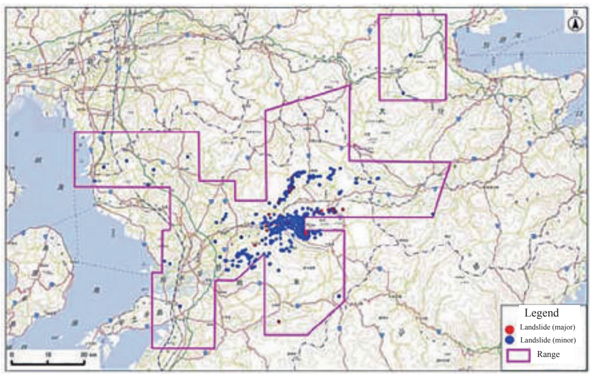

Fig. 2 Landslide Distribution Map during the 2016 Kumamoto earthquake (based on aerial photo interpretation) (released April 22, 2016)

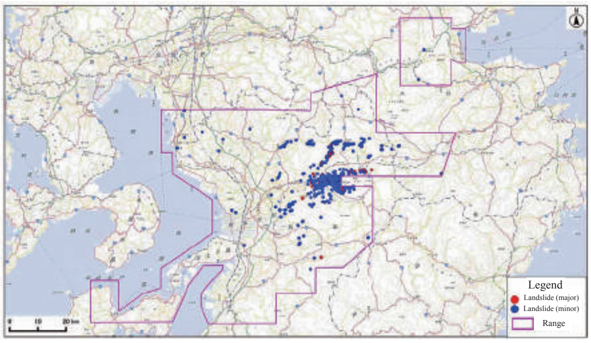

Fig. 3 Landslide Distribution Map during the 2016 Kumamoto earthquake (based on aerial photo interpretation) ((released April 25, 2016)

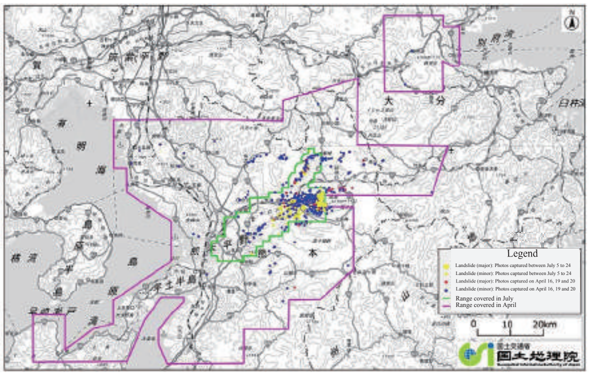

Fig. 4 Landslide Distribution Map during the 2016 Kumamoto earthquake (based on aerial photo interpretation) (general map) (Yellow dots show new landslides which occurred during heavy rain in late June. The yellow green polygon indicates the subject areas for photo interpretation carried out on July 20.)

3. Implementation of Aerial Laser Surveying

On May 1, a data request came from the Mashiki-town, which sustained heavy damages during the Kumamoto earthquake and experienced ground subsidence caused by the earthquake, for post-earthquake elevation data covering the entire town in preparation for the rainy season from June to July. An agreement between GSI and a private company was signed on May 6 to carry out terrestrial laser survey work over an area of approximately 132km^2 centered around Mashiki-town, to be implemented as “Disaster Emergency Terrestrial Laser Surveying” (commissioned work) based on the agreement with the Association of Precise Survey and Applied Technology (publicly financed).

The actual aerial laser survey was carried out on May 8, with a measurement data acquisition density of one point or higher per one square meter.

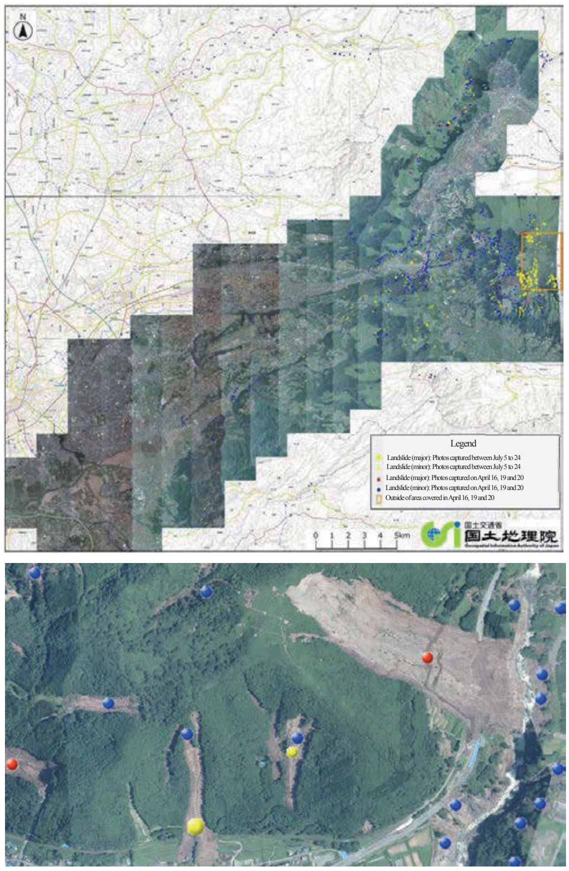

Fig. 5 Landslide Distribution Map during the 2016 Kumamoto earthquake (based on aerial photo interpretation) (Upper : overview, lower : partial view)

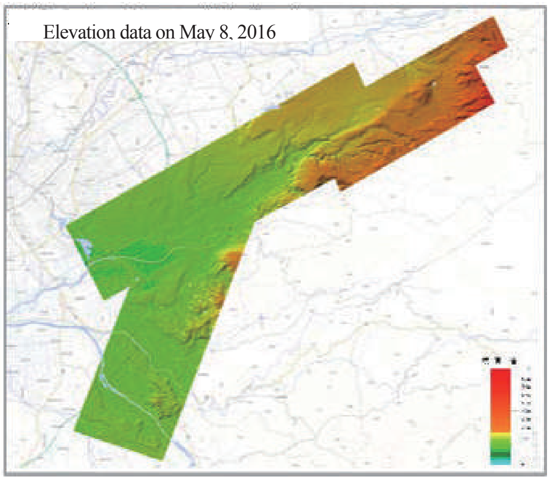

Fig. 6 Color shaded maps in the vicinity of Futagawa Fault – Hinagu Fault zone (after the earthquake)

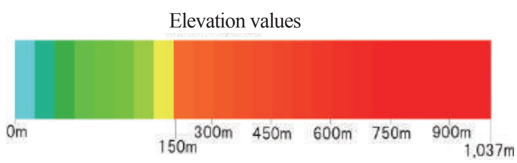

Fig. 7 Assignment of colors for color shaded maps (general example)

3.1 Creation of Color Shaded Maps

The 2m mesh elevation data acquired from the aerial laser survey was processed to create color shaded maps (Fig. 6) by shading some areas to highlight three-dimensional effect of topographical features and assigning a reddish color to high elevation features (elevation of approximately 1,000m) and a blue-ish color to low elevation features (Fig. 7). These maps were published on GSI Maps on July 1.

Since pre-earthquake 2m mesh elevation data in 2005 (partially in 2012) acquired by aerial laser survey by Kyushu Regional Development Bureau, MLIT mostly covered the subject area, the Group produced color shaded maps before the earthquake (Fig. 8) from the 2m mesh elevation data and published them on GSI Maps on July 1.

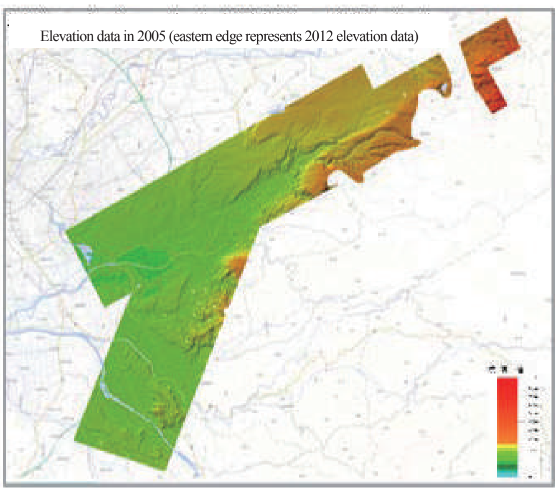

Fig. 8 Color shaded map of Futagawa Fault – Hinagu Fault (before the earthquake)

3.2 Compilation of Elevation Variation Map between pre- and post- Kumamoto Earthquake

In order to prepare materials which clearly show the degree of elevation changes due to the earthquake, it was necessary to calculate the variation between the 2m mesh elevation data acquired through aerial laser surveying in 2005 and those acquired this time.

Elevation variation maps in the vicinity of Futagawa fault and Hinagu fault zones (Fig. 10) were compiled using this elevation difference data and cold colors (blue) were assigned to locations where elevation decreased as compared to before the earthquake and warm colors (yellow to red) were assigned to locations where elevation increased as compared to before the earthquake (Fig. 9). As a result, the maximum decrease in elevation was found to be in Nishihara-village where a point sank 2.5m. These maps were published on the GSI Maps and Kumamoto earthquake website on July 1.

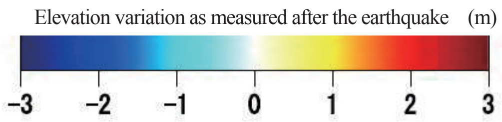

Fig. 9 Color assignment for Elevation Variation Map (general example)

Fig. 10 Elevation Variation Map in the Vicinity of Futagawa Fault and Hinagu Fault Zone

4. Summary

The compiled data described in this report were published both on GSI Maps and Kumamoto earthquake website and also provided to the MDMH, Kyushu Regional Development Bureau and Kumamoto Prefecture and other relevant organizations. The data were provided as electronic files and large format print-outs to assist with their disaster response efforts. The Group will continue to provide required information in a timely manner through photo interpretation work in case of disaster occurrence.

References

Yoshida, K., T. Sekiguchi and T. Nakano (2016) : Mapping of surface cracks derived from the 2016 Kumamoto Earthquake, Journal of the Geospatial Information Authority of Japan, 128, 201-206. (in Japanese).