

## Responses of Geospatial Information Department to the 2016 Kumamoto Earthquake

### Geospatial Information Department Disaster Countermeasures Group

(Published online: 28 December 2016)

#### Abstract

*The Geospatial Information Department has provided a variety of geospatial information in connection with the Kumamoto earthquake which occurred in 2016. This report briefly describes the disaster responses.*

#### 1. Introduction

The Disaster Countermeasures Group of the Geospatial Information Department (hereinafter referred to as “DCG”) provided a variety of geospatial information of the area affected by the 2016 Kumamoto earthquake (hereinafter referred to as “the Kumamoto earthquake”) on GSI Maps. In addition, DCG provided the web pages to compare aerial photographs before and after the Kumamoto earthquake. In short, DCG mainly provided the disaster-related information through the Internet.

DCG made three-dimensional models of Aso-ohashi Bridge and surrounding area where a massive landslide occurred during the Kumamoto earthquake. It provided a variety of geospatial information to the On-site Headquarters for Major Disaster Management (hereinafter referred to as “the Disaster Management Headquarters”) and the Kumamoto Prefectural Government. In addition, DCG also provided a variety of geospatial information to the Kumamoto Prefectural Government in accordance with its request in connection with the cooperation agreement to promote the use of geospatial information.

#### 2. Geospatial Information Provided on GSI Maps

DCG has been providing geospatial information, including aerial photographs, Synthetic Aperture Radar (SAR) analysis, Unmanned Aerial Vehicle (UAV) videos on GSI Maps since April 14.

GSI Maps are web-based maps provided by the Geospatial Information Authority of Japan (GSI). Various geospatial information from GSI such as topographic maps, aerial photographs, altitudes, land conditions and disaster information can be overlaid in the display. In

addition, GSI Maps has a function to display 3D maps. (<http://maps.gsi.go.jp/>)

After the occurrence of the Kumamoto earthquake, a new menu item named “the 2016 Kumamoto earthquake” was added under the “Disaster response”-“Earthquake” information list on GSI Maps. Since April 20, this new menu item has been relocated to the top of the information list for improving users’ convenience.

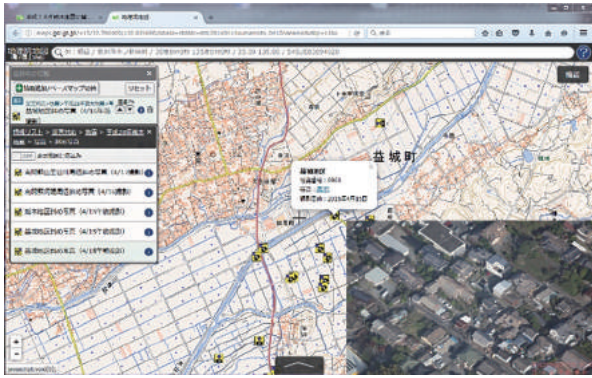
The type of information provided as well as disclosure dates are shown in Table 1.

**Table 1** GSI information as provided on GSI Maps

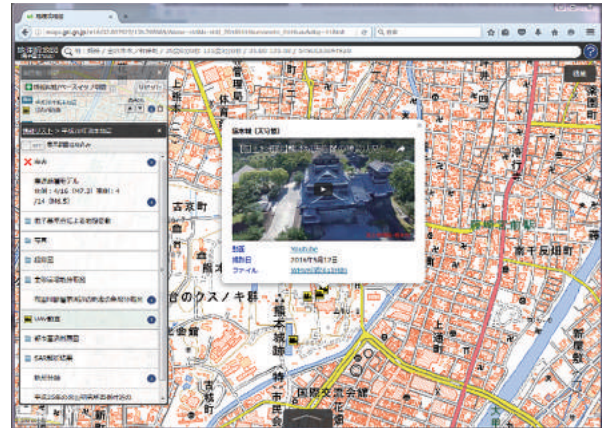
Disclosure date	Data type
Apr. 14	Active fault map in urban area and other related information
Apr. 15	Epicenter location
〃	Display method change in the active fault map in urban area (Display from zoom level 11)
〃	Oblique photo (Fig.1)
〃	Synthetic Aperture Radar analysis (SAR)
Apr. 16	Oblique photo (Mashiki district Apr. 15 afternoon)
〃	Oblique photo (Kumamoto district Apr. 15 afternoon)
〃	Vertical aerial photograph (Uki district and Mashiki district) (Fig.2)
〃	Vertical aerial photograph (Kumamoto South district)
〃	Orthophoto (Uki district) (Fig.3)
〃	Orthophoto (Mashiki district)
〃	Orthophoto (South Kumamoto district)
〃	Epicenter location (Main shock)
〃	Oblique photo (Minamiasokawayo district)

Disclosure date	Data type
Apr. 16	Vertical aerial photograph (Uto district)
Apr. 17	Orthophoto (Uto district)
〃	Vertical aerial photograph (Aso district)
〃	Unmanned aerial vehicle (UAV) video (Apr. 16) and links to video
〃	Orthophoto (Beppu district)
〃	Vertical aerial photograph (Beppu district)
〃	Orthophoto (Aso district)
〃	Vertical aerial photograph (Koshi district)
〃	Vertical aerial photograph (Minamiaso district)
〃	Vertical aerial photograph (Nishihara district)
〃	Quasi aerial photograph (Aso district)
〃	Orthophoto (Koshi district)
〃	Orthophoto (Minamiaso district)
〃	Orthophoto (Nishihara district)
Apr. 18	UAV video (Apr. 17) and link to video
〃	Orthophoto (Kumamoto Central district)
〃	Oblique photo (Sanoudani River district)
〃	Vertical aerial photograph (Kumamoto Central district)
〃	Landslide distribution map (Tateno in Minami Aso village and surroundings)
Apr. 19	UAV video (Apr. 18) and link to video
Apr. 20	Fault model
〃	Horizontal displacement vector
〃	Vertical aerial photograph (Oguni district)
〃	Orthophoto (Oguni district)
〃	Orthophoto (Minamiaso 2 district A)
〃	Vertical aerial photograph (Minamiaso 2 district A)
〃	Surface cracks derived map
Apr. 21	Vertical aerial photograph (Nishihara 2 district)
〃	Orthophoto (Nishihara 2 district)
〃	Orthophoto (Minamiaso 2 district B)
〃	Vertical aerial photograph (Takeda district)
〃	Vertical aerial photograph (Minamiaso 2 district B)
〃	Vertical & horizontal displacement vectors (revised)
〃	Orthophoto (Takeda district)
〃	Vertical aerial photograph (Yufuin district)
〃	Vertical aerial photograph (Yatsushiro district)

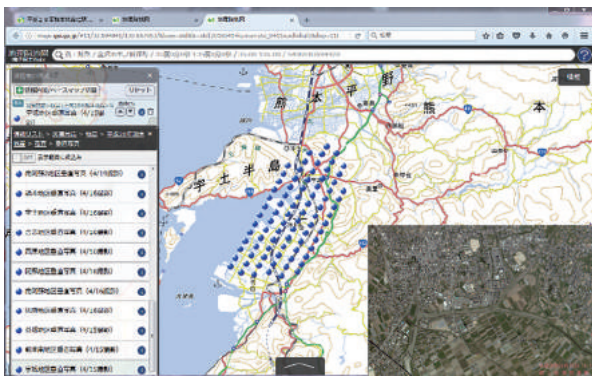
Disclosure date	Data type
Apr. 21	Vertical aerial photograph (Aso 2 district)
〃	Orthophoto (Yufuin district)
〃	Vertical aerial photograph (Kikuchi district)
〃	Vertical aerial photograph (Yamaga district)
〃	Overlay map
Apr. 22	Orthophoto (Yamaga district)
〃	Vertical aerial photograph (Tamana district)
〃	Orthophoto (Aso 2 district)
〃	Vertical aerial photograph (Amakusa district)
〃	Landslide distribution map update
〃	Orthophoto (Yatsushiro district)
Apr. 24	Orthophoto (Tamana district)
〃	Orthophoto (Mifune district)
〃	Orthophoto (Kikuchi district)
〃	Orthophoto (Amakusa district)
〃	Vertical aerial photograph (Mifune district)
Apr. 25	Landslide distribution map update
Apr. 28	Landslide distribution map update
May 2	Vertical aerial photograph (Kumamoto fault districts A and B)
May 12	Orthophoto (Kumamoto fault districts A and B)
May 13	Surface cracks derived map update
May 19	UAV video (Kumamoto castle) and link to video
Jun. 2	Vertical aerial photograph (Kumamoto districts A and B)
Jun. 3	Orthophoto (Kumamoto districts A and B)
Jun. 22	UAV video (Kumamoto castle tower parts 2 and 3) and link to video
Jul.1	Futagawa fault “color shaded map (before the earthquake), “color shaded map” (after the earthquake), Difference in elevation gradient tint maps
Jul.6	Vertical aerial photograph and orthophoto (Aso 3 district)
Jul.26	Vertical aerial photograph and orthophoto (Kumamoto 2 district)
Jul.27	Landslide distribution map (Jul.) Landslide distribution range map (Apr.)
Sep.12	Fluctuation correction parameters



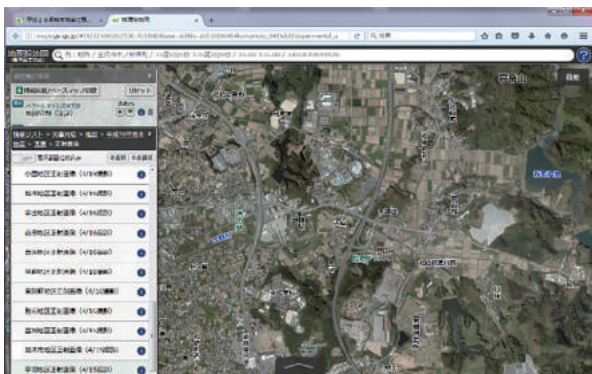
**Fig.1** Oblique aerial photographs (Mashiki district captured on Apr.15). Photo is fitting synthesis.



**Fig.4** Example of balloon display (after improvement)



**Fig.2** Vertical aerial photographs (Uki district captured on Apr.15). Photo is fitting synthesis.



**Fig.3** Orthophoto (Uki district)

As soon as new information was posted, DCG tweeted about it and also tweeted the technical information on GSI Maps required by technicians to use GSI tiles on external sites. GSI tiles are tile-based geospatial information for web maps provided by GSI. (<http://maps.gsi.go.jp/development/siyou.html>)

DCG improved display of all aerial photos and UAV videos to thumbnail images and UAV videos (Fig.4) on July 29.

### 3. Geospatial Information Provided from the Kumamoto Earthquake Website, etc.

#### 3.1 Web Pages for Comparison of Aerial Photographs Before and After the Disaster

On April 17, DCG published a web page (hereinafter referred to as “comparison web page”) for comparison of aerial photographs before and after the disaster.

The comparison web page displayed a photo before the disaster on the right side and a photo after the disaster on the left side. The two photos could be compared by moving the scroll bar at the bottom of the web page to the right or left.

DCG extracted affected areas by referring to the news and disaster-related information. DCG provided comparison web page of five areas: Aso-ohashi Bridge area (provided on April 17), Nagano area (provided on April 18), Aso Shrine area, Kumamoto Castle area (provided on April 18) and Mashiki town area (provided on April 22). A massive landslide occurred near Aso-ohashi Bridge (Fig.5). In Nagano area and Minami Aso Village, several houses were caught in landslides. Many buildings were damaged and collapsed in Aso Shrine area and Kumamoto Castle area. Central area of Mashiki town suffered serious damage (Fig.6).





Fig. 5 Comparison web page before and after the disaster (Aso-ohashi Bridge area)



Fig. 6 Comparison web page before and after the disaster in aerial photograph (Mashiki central district)

GSI did not have any aerial photographs of Aso-ohashi Bridge area earlier than 2007. So DCG had decided to make quasi aerial photograph in place of aerial photograph before the disaster. Quasi aerial photographs cannot be used for surveys because they are taken just for inspection of airborne laser scanning work. Also, in most cases, each area of airborne laser scanning work is small. But quasi aerial photographs can be utilized for disaster countermeasures in place of latest aerial photographs to compensate the area. Quasi aerial photographs in Aso-ohashi Bridge area were compiled from the airborne laser scanning work in 2013 (Fig.7), through processes of joining adjacent image files, projection transformation and tiling. As a result, quasi aerial photographs were used on the comparison web page created on April 16.

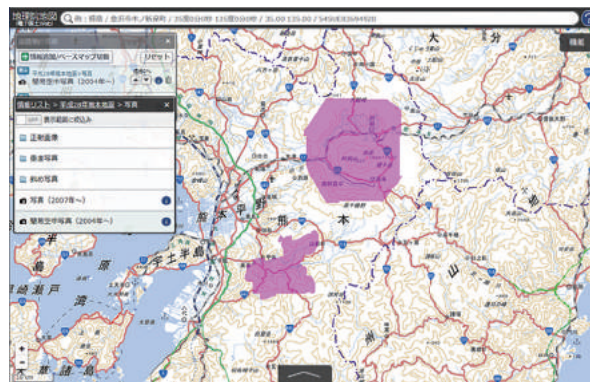


Fig. 7 Expanded area of quasi aerial photograph (pink)

### 3.2 Browsing Service for Survey Results of Control Points

DCG temporally stopped providing service of survey results of control points (GEONET stations (GNSS-based control stations), triangulation stations, bench marks) in the affected area where large crustal deformations were observed as a result of the earthquake on web browsing service and at rooms for browsing survey results in GSI Head Office and Regional Survey Department. DCG stopped providing survey results of 300 points at the center of Kumamoto City on April 15 and survey results in all municipalities in Kumamoto prefectural government excluding Amakusa City and Reihoku town in Amakusa district, and some areas of Fukuoka prefectural government, Oita prefectural government, Nagasaki prefectural government, Miyazaki prefectural government on April 16.

DCG provided revised survey results of 37 GEONET stations on May 19. Revision of data at “Sencho” GEONET station was postponed until June 16, when the status of data acquisition of the GEONET station was recovered.

The survey results from 285 triangulation stations, 155 bench mark points and the elevation of 9 GEONET stations were provided on August 31.

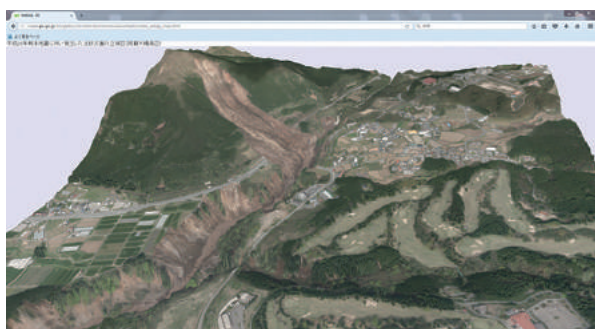
On September 12, the survey results obtained from 170 triangulation stations which were re-surveyed, 3,598 triangulation stations where data was calculated using correction parameters were provided. and a re-surveyed bench mark were provided. In addition, the survey results of the elevation of 29 GEONET stations and survey markers

of 38 GEONET stations with re-surveyed bench marks were provided. These survey results were re-calculated.

DCG also stopped the provision of public control points results on the web service for browsing control points on September 9, because correction parameters for coordinates (horizontal) and elevations had been revised and disclosed. The revised area was the region affected by the earthquake and its surrounding area (Kumamoto, Fukuoka, Oita, Nagasaki and Miyazaki prefectures).

### 3.3 3D Map Web Page

DCG created data for 3D maps that can be freely rotated on the browser, based on aerial photographs taken around the Aso-ohashi Bridge on April 16. The 3D map web page including a link to the Kumamoto earthquake website was published on April 18 (Fig.8). At first, the elevation information of this model was based on the ground elevation information before the earthquake. But, the elevation information was improved by using aerial photographs which were taken by Kunikaze III, the GSI's aircraft for survey, on April 16, the day of main shock. The revised version was provided on April 22 by using WebGL. The improved height was obtained by using digital surface model (DSM) which includes height of buildings and forests.



**Fig. 8** Example of 3D map at Aso-ohashi Bridge area built on WebGL

### 3.4 Geospatial Information Library

On April 18, DCG inserted a new banner about the Kumamoto earthquake as a “hot content” on the top page of the Geospatial Information Library run by the Geospatial Information Department.

The Geospatial Information Library is a “virtual library” for geospatial information providing information

to users using the Internet. Through the Internet, anyone can search, browse, and acquire basic survey results from GSI, such as maps and aerial photographs as well as public survey results such as maps created by national and local public organizations. (<http://geolib.gsi.go.jp/>).

### 3.5 GSI Maps on Globe (trial)

DCG uploaded the aerial photographs related to the Kumamoto earthquake on GSI Maps Globe (trial) on April 21.

GSI Maps on Globe (trial) is a web site used to display seamless 3D maps and aerial photographs provided from GSI Maps on the web browser. ([http://maps.gsi.go.jp/globe/index\\_globe.html](http://maps.gsi.go.jp/globe/index_globe.html))

This makes it possible to display seamless 3D aerial photographs taken after the disaster (Fig.9).



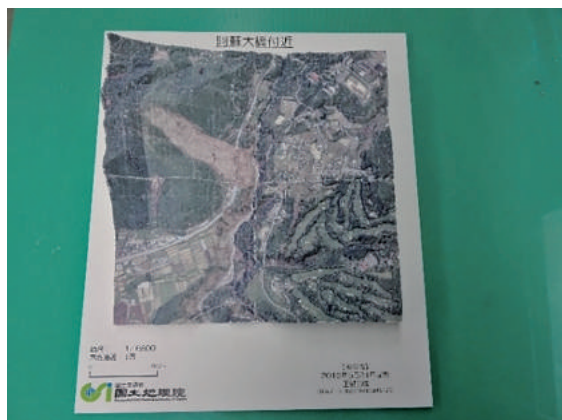
**Fig. 9** 3D display of GSI Maps on Globe (Minami Aso Village)

## 4. Creation and Provision of 3D Models

DCG has created 3D models of the Aso-ohashi Bridge area and provided them to the Disaster Management Headquarters and Kumamoto Prefectural Government. According to the request of the Kumamoto Prefectural Government, the 3D models (Photo 1) were provided on April 19, April 27, April 30 and June 24, through the Disaster Management Headquarters.

The height of the models was 5-meter mesh data of digital surface model (DSM) made from aerial photographs by National Mapping Department. These aerial photographs were taken by Kunikaze III on April 16, immediately after the main shock. The height data is created by stereo matching of overlapping pictures, which represents the surface after the Kumamoto earthquake.





**Photo 1** 3D models provided to Kumamoto Prefectural Government (DSM after the disaster)

The model was used as a reference material to discuss carry-in route of heavy equipment and to help senior ministry officials understand the situation at the Disaster Management Headquarters (Photo 2).



**Photo 2** Example of use of 3D models in the Disaster Management Headquarters

## 5. Provision of Geospatial Information to the Local Government Based on Cooperation Agreement

In March 2015, just one year prior to the

Kumamoto earthquake, GSI and Kumamoto Prefectural Government already signed a cooperation agreement. Thanks to this agreement, provision of geospatial information data to Kumamoto Prefectural Government was carried out smoothly. Details are shown in Table 2.

**Table 2** Geospatial information provided by GSI

Date	Data type	Recipient
May 24	Aerial photograph data 10 files (JPEG)	Kumamoto Prefectural Government
May 26	Aerial photograph data 17 files (JPEG)	〃
Jun. 14	Airborne laser survey data	〃
Jun. 17	Digital topographic map 1/200,000 and Digital topographic map 1/25,000	〃

The Geospatial Information Department dispatched personnel to the Disaster Management Headquarters as a liaison, and this provided an occasion to interview the engineering staff at the engineering management Section, Kumamoto Prefectural Government on how the geospatial information thus provided was utilized.

“In consideration of future city planning, it is important to identify the changes which occurred in the affected area”, commented staff of the Kumamoto Prefectural Government, “and aerial photographs taken before the event were very effective”. In addition, the staff acknowledged the quick response of GSI in providing the required data at no cost. Both parties reconfirmed the positive effects of this cooperation agreement..

## 6. Summary

The number of accesses to GSI Tiles over the month of April 2016 amounted to 1.8 billion GSI Tiles. This is about 1.5 times higher than in the case of the Kanto-Tohoku Heavy Rainfall Disaster of September 2015.

Some reasons for the increased number of accesses are as follows. First of all, DCG rapidly uploaded a large amount of information. Secondly, GSI Maps were often

introduced by mass media. Thirdly, GSI Tiles were also used by external sites, for example, “disaster response support map” by National Research Institute for Earth Science and Disaster Resilience and “road information providing system” by Kyushu Regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism and so on.

In the case of past disasters, server overload issues occurred due to increased accesses requests. However, the transition to the cloud server system in April 2016 addressed this problem, and server overload issues no longer occurred.

At first, a menu item “the 2016 Kumamoto earthquake” was added at a location not readily recognized in the information list of GSI Maps. However, the item was relocated at the top of the information list to improve the convenience for users. Important information items which attract user’s attention will be placed at the top of the information list of GSI Maps from the beginning of disaster responses.

While taking into account the above-mentioned improvements, we intend to provide geospatial information adequately as required to respond to any natural disasters which may occur in the future.