

## Responses of GSI to the 2016 Kumamoto Earthquake

### Disaster Management Office, Planning Department

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#### Abstract

*Geospatial Information Authority of Japan (GSI) provides geospatial information to grasp the disaster situation to relevant organizations such as ministries and government offices, local public organizations and the like to help contribute in the lifesaving and rescue activities as well as recovery and reconstruction efforts when a large-scale natural disaster occurs. GSI provided geospatial information to concerned administrative authorities including the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), local government and related organ, in connection with the 2016 Kumamoto earthquake. This paper includes an overview of the disaster and reports on GSI's main responses.*

#### 1. Overview of the Kumamoto Earthquake

The 2016 Kumamoto earthquake (hereinafter referred to as “the Kumamoto earthquake”) included a magnitude 6.5 earthquake which occurred on April 14 at 21:26 JST, followed by a magnitude 7.3 earthquake which occurred on April 16 at 1:25 JST. Thus, these events produced a maximum seismic intensity 7 in Kumamoto.

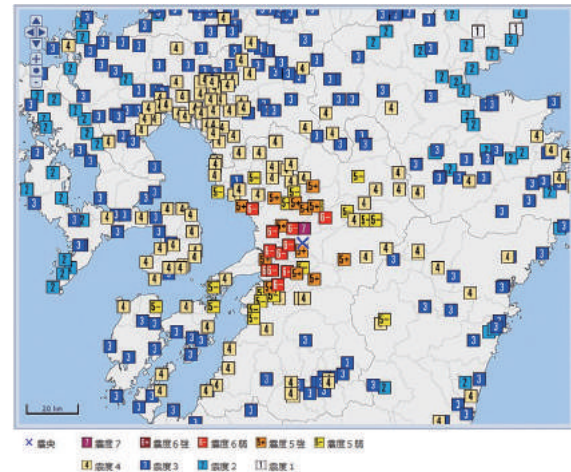
After April 14, 21:26 JST, 2 earthquakes with a maximum seismic intensity of a little over 6 and 3 earthquakes with a maximum seismic intensity of a little less than 6 occurred.

Damages caused by the Kumamoto earthquake include: 98 human casualties, 830 seriously injured, 1,491 people who suffered minor injuries, 8,198 buildings were completely destroyed, 29,761 were partially destroyed and 138,102 suffered minor damage. Other damages included: 190 landslides, 3 road closures, service on 2 railways was suspended (September 14, present time) (Cabinet Office, 2016, MLIT, 2016).

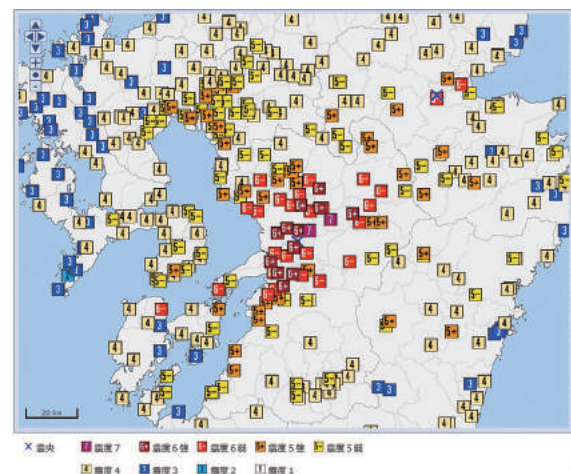
#### 2. GSI's Main Responses

As a response to the Kumamoto earthquake, the Geospatial Information Authority of Japan (hereinafter referred to as “GSI”) moved to the highest alert and established the Disaster Countermeasures Office on April 14 at 21:33 JST.

On April 15, GSI dispatched GSI Land Bird



**Fig. 1** Seismic intensity map (April 14)  
(Japan Meteorological Agency, 2016)



**Fig. 2** Seismic intensity map (April 16)  
(Japan Meteorological Agency, 2016)

team (GSI-LB) to capture photos of the disaster areas using Unmanned Aerial Vehicle (UAV). Over the period from April 15 to April 20, survey aircraft “Kunikaze III” (hereinafter referred to as “Kunikaze III”) collected information such as emergency photographing (photo 1) of disaster areas from Kumamoto Prefecture to Oita Prefecture. GSI also promptly provided geospatial information to concerned administrative authorities, local government and related organ (hereinafter referred to as “Concerned Authorities”) to help grasp the damage situation in those areas.

## 2.1 TEC-FORCE (Technical Emergency Control Force)

After the earthquake which occurred on April 14 at 21:26 JST, GSI dispatched 170 man-days of its TEC-FORCE (Technical Emergency Control Force) from April 15 to May 27 (present day) to grasp the damage situation and provide geospatial information.

In surveying the damage situation using UAV, GSI-LB was used to collect information of disaster areas which were hard to access otherwise, identify landslides in the vicinity of Asohashi Bridge (Photo 2) and confirm the extent of ground faults which emerged in the vicinity of Kawayou, Shimojin, Minamiaso Village, Mashiki Town as well as identify the landslides which occurred in Sanoudani River. These activities were carried out on April 16 and 17 and the collected data was made public right away.

Also, at the request of the City of Kumamoto, the damage condition of the stone wall of Kumamoto Castle was also measured between May 11 and May 13 (Photo 3). The purpose of emergency photographing using aircrafts is to promptly identify the damage situation over



Photo 3 Castle tower of Kumamoto Castle (May 12)

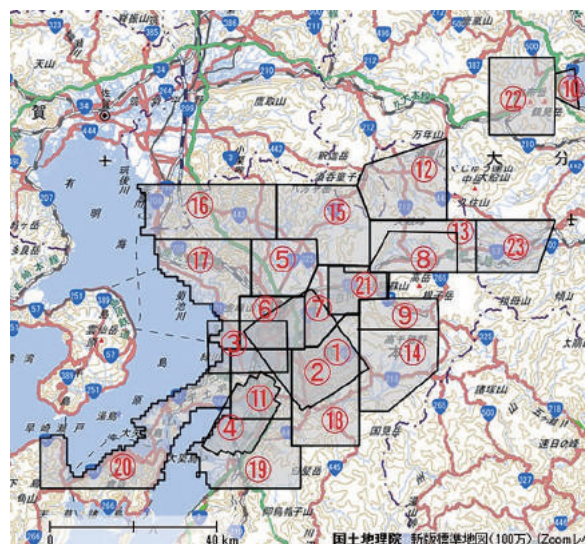


Fig. 3 Map of areas of vertical aerial photos for emergency response

a wide area and to that end, approximately 10,000 aerial photos were taken from April 15 to April 20 (Fig. 3, Table 1). They were promptly provided and made public and assisted during the first response for disaster as well as restoration period (National Mapping Department, 2016).

Observation of urgent crustal deformation was carried out from May 3 to May 5 through emergency GNSS surveying focusing on locations where SAR interferometry did not produce clear results in order to grasp the whole aspect of ground subsidence and uplift caused by the earthquake (Miyahara et al., 2016) (Photo 4).



Photo 4 Emergency surveying of crustal deformations

**Table 1** Emergency photographing areas

			Photo disclosure	Orthophotos disclosure
4/14	21:26 JST earthquake (magnitude 6.5, max 7)			
4/15	1) Kumamoto Pref., Mashiki District	Kumamoto City, Yatsushiro City, Uto City, Uki City, Misato Town, Kikuyo Town, Nishihara Village, Mifune Town, Kashima Town, Mashiki Town, Kosa Town, Yamato Town, Hikawa Town	4/15	-
	2) Kumamoto Pref., Mashiki District		4/16	4/16
	3) Kumamoto City, South District		4/16	4/16
	4) Kumamoto Pref., Uki District		4/16	4/16
4/16	01:25 JST earthquake (magnitude M7.3, max 7)			
	5) Koushi District	Kumamoto City, Yatsushiro City, Yamaga City, Kikuchi City, Uto City, Uki City, Aso City, Koushi City, Misato Town, Ozu Town, Kikuyo Town, Takamori Town, Nishihara Village, Minamiaso Village, Mifune Town, Kashima Town, Mashiki Town, Kousa Town, Yamato Town, Hikawa Town, Beppu City, Hiji Town	4/17	4/17
	6) Kumamoto Central District		4/18	4/18
	7) Nishihara District		4/17	4/17
	8) Aso District		4/17	4/17
	9) Minamiaso District		4/17	4/17
	10) Beppu District		4/17	4/17
	11) Uto District		4/16	4/17
4/17~ 19	17 Heavy rainfall 18, 19 magnitude over 5 earthquake			
4/19	12) Oguni District	Omuta City, Yanagawa City, Miyama City, Kumamoto City, Yatsushiro City, Arao City, Tamana City, Yamaga City, Kikuchi City, Uto City, Kamiamakusa City, Uki City, Aso City, Amakusa City, Misato Town, Gyokuto Town, Nankan Town, Nagasu Town, Nagomi Town, Ozu Town, Kikuyo Town, Minamioguni Town, Ubuyama Village, Takamori Town, Nishihara Village, Minamiaso Village, Mifune Town, Kashima Town, Mashiki Town, Kousa Town, Yamato Town, Hikawa Town, Itsuki Village, Beppu City, Hita City, Takeda City, Kitsuki City, Usa City, Bungoono City, Yufu City, Hiji Town, Kokonoe Town, Kusu Town	4/20	4/20
4/20	13) Aso2 district		4/21	4/22
	14) Minamiaso2 district		4/20, 21	4/20, 4/21
	15) Kikuchi District		4/21	4/24
	16) Yamaga District		4/21	4/22
	17) Tamana District		4/22	4/24
	18) Mifune District		4/24	4/24
	19) Yatsushiro District		4/21	4/22
	20) Amakusa District		4/22	4/24
	21) Nishihara2 district		4/21	4/21
	22) Yufuin District		4/21	4/21
	23) Takeda District		4/21	4/21



Field investigation on ground surface displacements was carried out from May 10 to May 12 to confirm the actual situation at phase discontinuous locations as detected by SAR interferometry as well as ground surface displacements such as cracks, focusing on surface earthquake faults as extracted from aerial photointerpretation (Yoshida et al., 2016, Fujiwara et al., 2016) (Photo 5).



**Photo 5** Field Investigation on Ground Surface Displacements

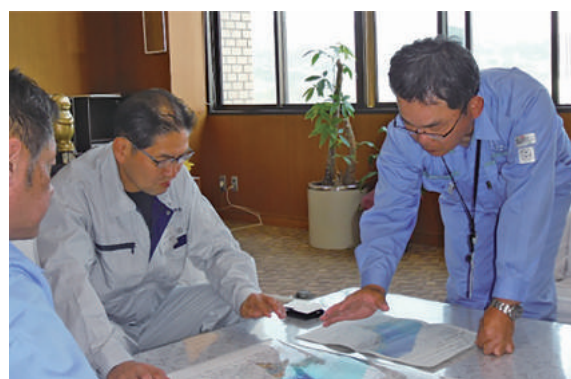
At the request of the City of Kumamoto, ground laser survey was carried out between May 18 and May 22 to measure the damage condition around Kumamoto Castle, with focus on the stone wall and the acquired data was provided to the City of Kumamoto.



**Photo 6** Ground laser survey around Kumamoto Castle

With respect to restoration of the stone wall at Kumamoto Castle, vertical and horizontal section drawings of stone wall were drafted based on the acquired data. These, together with the information on which stone material collapsed up to what point, were helpful in studying the collapse mechanism as well as restoration planning and were also used as the grounds for setting a stone wall incline (Photo 6).

As part of geospatial information support, Kyushu Regional Survey Department promptly provided geospatial information to the affected local public organizations and needs assessment was conducted (Kyushu Regional Survey Department, 2016) (Photo 7).



**Photo 7** Geospatial information support  
(status report of ground subsidence to mayor of Mashiki Town)

## 2.2 On-site Headquarters for Major Disaster Management

On-site Headquarters for Major Disaster Management (hereinafter referred to as “Disaster Management Headquarters”) were established in Kumamoto prefectural office on May 15 and a total of 46 staff were dispatched by GSI from May 15 to August 1. They carried out tasks such as: provision of newly developed aerial photographs and maps, response to requests of compiling various types of map data, updates on shelter distribution map from updated data in shelters as provided by the bureau and provision of such to Concerned Authorities.

## 2.3 Establishment of Groups by the Disaster Countermeasures Office and Their Responses

In accordance with GSI disaster countermeasures

requirements, Records Group, Public Relations Group, Geospatial Information Provision Support Group and Emergency Mapping Group were established.

### 2.3.1 Public Relations Group

Public relations activities such as press briefing with respect to, for example, “Crustal Deformation in Connection with the 2016 Kumamoto Earthquake” on April 16 and “Crustal Deformation in Connection with the Kumamoto Earthquake as Captured by ALOS-2” on April 22 and subsequent information gathering on the publishing and broadcasting status in main publications and television.

### 2.3.2 Geospatial Information Provision Support Group

Geospatial Information which was newly acquired from emergency photographing as well as a variety of analytical results was provided to the respective Concerned Authorities simultaneously with publishing on the “Information concerning the 2016 Kumamoto earthquake” website (49 cases, as of July 15).

Other information provision requests were handled as they happened.

### 2.3.3 Emergency Mapping Group

At the request of Disaster Management Headquarters, Kumamoto prefectural government and respective concerned authorities, the group promptly mapped geospatial information (40 requests as of July 15, present day).

## 2.4 Responses of Respective GSI Departments

The main responses of the respective departments in GSI in connection with the Kumamoto earthquake are as follows.

#### 1) Geodetic Department

- Revise survey results of GNSS-based control stations, triangulation points and benchmarks.
- Detect ground surface deformation caused by the Kumamoto earthquake by InSAR using ALOS-2 data.

#### 2) Geospatial Information Department

- Provide geospatial information to public through GSI

Maps.

- Build a website that allows for comparison of aerial photos before and after the disaster.
- Build and provide 3D models.
- Provide geospatial information to local governments based on cooperative agreement.

#### 3) National Mapping Department

- Capture aerial photographs using “Kunikaze III” etc.
- Draft disaster restoration base maps etc.

#### 4) Geographic Department

- Identify landslides and ground collapse using aerial photos.
- Develop highly precise elevation data base by airborne laser survey around the Futagawa fault zone and Hinagu fault zone.
- Create color shaded maps and elevation variation maps.
- Create surface cracks derived maps.

#### 5) Geodetic Observation Center

- Detect crustal deformation in connection with the Kumamoto earthquake using GEONET.

#### 6) Geography and Crustal Dynamics Research Center

- Extract small-displacement linear surface ruptures of the Kumamoto Earthquake detected by ALOS-2 SAR interferometry.
- Estimate source fault models of the Kumamoto Earthquake inverted from crustal deformation.

#### 7) Kyushu Regional Survey Department

- Provide and survey the needs for various kinds of geospatial information to concerned municipalities, Kumamoto prefectural government and Disaster Management Headquarters.

## 3. Summary

In order to fulfill duties as a designated administrative organization and designated local administration organization as per the Disaster Countermeasures Basic Act, GSI promptly acted in response to the Kumamoto earthquake to allow for maximum support and manage to collect and provide information in a very timely manner. GSI will strive to take all possible measures for future storms or floods disasters as well as volcanic activity and earthquakes,

including Nankai Trough earthquake and Tokyo Inland earthquake which are expected to occur in the future.

We would like to pray and offer our sincerest condolences for victims and their families of the Kumamoto earthquake. Our thoughts are with everyone who has been affected by this disaster.

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