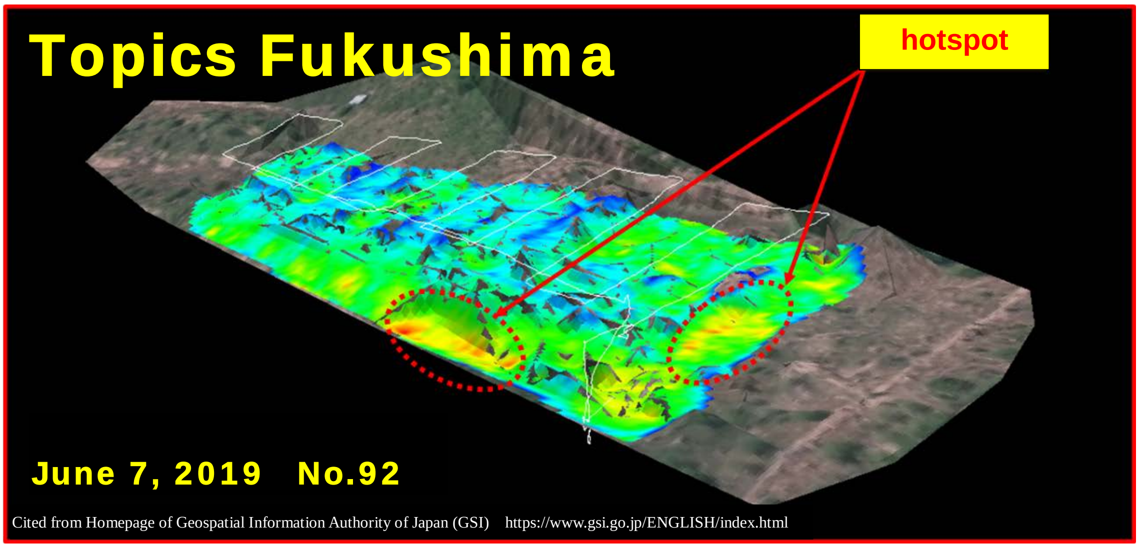

Three-dimensional distribution map of radioactive materials.
(Color contour map of radioactive materials measured in the area where the demonstration test was conducted[*1]. The map was first made by pasting the aerial photograph on the three-dimensional topographical model measured by LiDAR sensor. Then, the image of radioactive materials distribution taken by a Compton camera was overlapped on the map.)

Quickly visualizing three-dimensional distribution of radioactive materials in environment from the sky

Drone system equipped with camera visualizing radioactive materials was developed.

The Collaborative Laboratories for Advanced Decommissioning Science (CLADS), Japan Atomic Energy Agency (JAEA) in Tomioka Town, Fukushima Prefecture, has developed a remote-control radiation imaging system in collaboration with Chiyoda Technol Co. In this system, a drone can measure the distribution of radioactive materials even while moving, by loading the compact and lightweight Compton camera[*2)] that can specify the position of radiation source. In the demonstration test conducted in the difficult-to-return zone of Fukushima Prefecture, it was succeeded in visualizing three-dimensional distribution of radioactive materials in an area of about 7000 m^2. It was also demonstrated that the system could confirm scattered contamination (hotspot) in a short time (from more than half a day to less than 30 minutes).

Since the developed system can efficiently visualize the distribution of radioactive materials, it is expected to be applied to the wide area of difficult-to-return zone as well as the decommissioning works at the Fukushima Daiichi Nuclear Power Station (1F), Tokyo Electric Power Company Holdings. Inc.

■ Severe environment where workers cannot access, and invisible hotspot

In the outdoor environment including difficult-to-return zones in Fukushima Prefecture, it is important to clarify the distribution of radioactive materials scattered and deposited in the environment as a result of the 1F accident, as an indicator for providing information to decontamination workers and judging residents’ return. However, it took long time to measure radiation in a wide area using conventional survey meters. Also, there was a concern that the measurers would be at risk of injury in the place of bad scaffold. In particular, there are many places in difficult-to-return zones where farms have not been taken care of or managed after the 1F accident, resulting in the overgrowth of plants that have people's height. Also, many roads are exposed in a cracked condition. Furthermore, there is a concern that measurers would possibly approach an invisible hotspot. Therefore, it has been required to develop a remote measurement system to easily measure the distribution of radioactive materials in a wide area.

■ Not missing the "localized contamination" in a wide area

The CLADS has been conducting the demonstration tests of a Compton camera that had been developed to specify the flying direction of gamma-rays and visualize the distribution of radioactive materials. This time, the CLADS has developed a remote-control radiation imaging system (Fig. 1) in collaboration with the Fukushima Office, Chiyoda Technol Co. in Naraha Town and Sakae Manufacturing Co. that is a local company in Minamisoma City, Hamadori District. In this system, a compact and lightweight Compton camera with a weight of 1.5 kg loaded on a drone can observe an image of radiation while moving by measuring the information of its location and position at real time using GPS sensor and inertial measurement unit (IMU).

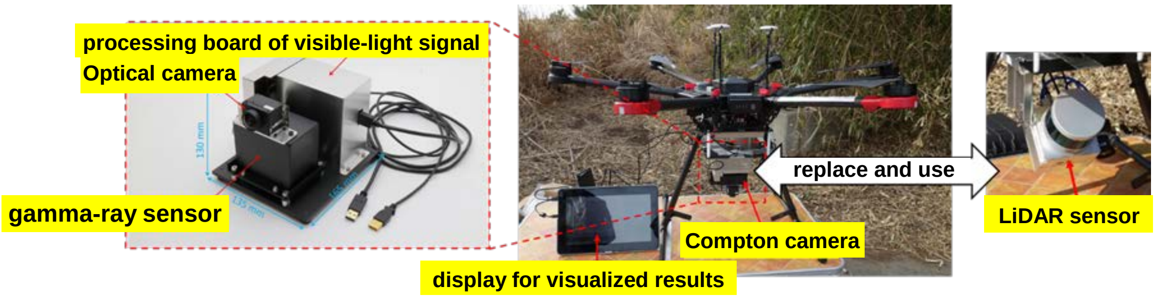

Fig. 1. Developed system for remote radiation imaging. Left photograph shows the compact and lightweight Compton camera loaded on the drone, and right photograph presents the LiDAR sensor.

The LiDAR sensor[*3)] shown in Fig. 1 can obtain three-dimensional topographical model. From these data, the distance between the drone and the observation spot can be measured. Herewith, it has become possible to visualize the distribution of radioactive materials deposited on the ground on a three-dimensional topographical model considering the attenuation of radiation due to the increase in the distance to the ground.

Fig. 2. Measurement in the demonstration test.

This time, a demonstration test of the developed system was conducted in a difficult-to-return zone (Fig. 2), and it was succeeded in drawing a three-dimensional distribution map of radioactive materials, as described at the beginning (in this figure, areas where large amount of radioactive materials is deposited are shown in red.). For comparison with the radiation distribution map shown at the beginning, the dose rates distribution map obtained by survey meters are also shown in Fig. 3.

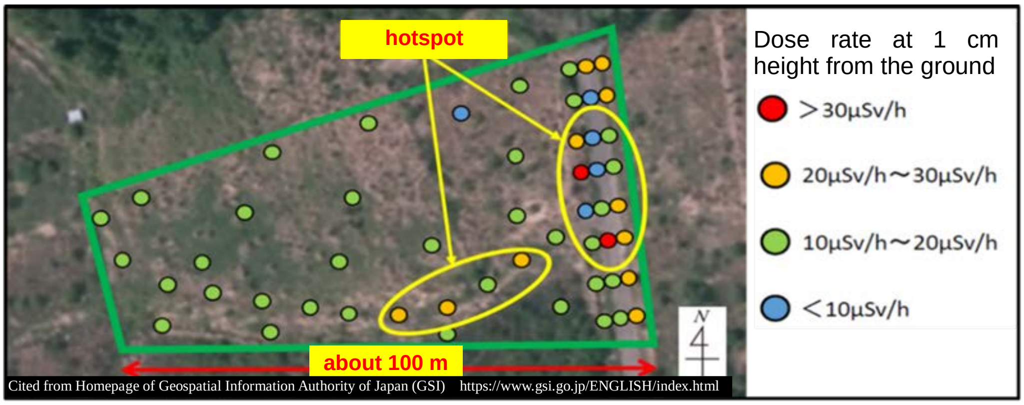

Fig. 3. Radiation distribution measured by survey meters in the same area (real measured values). Measurement area: about 7,000 m^2

As a result of the demonstration test using drone, it was confirmed that hotspots in roads and footpaths can be remotely visualized by the drone flight. Since the plants in the wide area of about 7,000 m^2 that was measured this time were not well maintained and the ground was bad, it took more than half a day to obtain the data related to the search for hotspots using survey meters. On the other hand, we needed only a short time (less than 30 minutes) to measure the data using the developed system.

In this way, unlike the measurements using conventional survey meters, the present system can measure the radiation in a wide area in a short time by combining a Compton camera that can specify the flying direction of gamma-ray (high-precision imaging) and drone (excellent mobility). In addition, we succeeded in constructing a system that does not miss the localized contamination. Herewith, it is expected that the radiation exposure of workers and the risk to safety such as injury will be reduced by the present development.

■ New radiation measurement was implemented by the system development.

Dr. Yuki Sato of CLADS who is conducting the present development said, “We have been developing a new radiation imaging technology by combining radiation measurement technology, remote-control technology and environment recognition technology. By this new technology, we have been succeeding in detecting hot spots in severe environment such as inside of the 1F reactor buildings.” Further, Dr. Sato continued, “We are happy if the developed technology will help not only the decommissioning site but also the radiation measurements in various environments such as the difficult-to-return zones in Fukushima Prefecture.”

The present system can be applied to the monitoring in wide area in a short time, and it is effective to detect localized contamination in houses and mountains. Therefore, it is expected that the present system will contribute to provide information to local governments in difficult-to-return zones and evacuees who want to return home. Furthermore, it is considered that the present system will contribute to the smooth promotion of the decommissioning in the 1F site where the decommissioning works are under way, because it can effectively detect and eliminate the hotspots and effectively shield radiation, by visualizing three-dimensional distribution of radiation.

This work was conducted under the project “Development of 3D Visualization Technology of Radiation Distribution with an Unmanned Aerial Vehicle” (Project Leaders: Yuki Sato of JAEA and Shingo Ozawa of Chiyoda Technol Co.) adopted by the Grant-in-aid under the Promotion of Practical Development for Local Revitalization in Fukushima Prefecture[*4)].

【Terminology】

1) Contour map

A line connecting points whose values are the same on a map. A map in which an isoline is drawn for each fixed value is called an isoline map, which is often used to represent topography. An isoline of height is called a “contour line”. In order to make it easy to see a contour map, each strap between the contour lines is sometimes stepwisely colored, which is called “color contour map”.

2) Compton camera

A Compton camera is a kind of gamma camera, which is well known as an apparatus to visualize radioactive materials. In a Compton camera, the flying direction of a gamma-ray is analytically specified from the position where the incident gamma ray (a kind of radiation) interacts with each of the scatterer/absorber and the energy received. Therefore, heavy weight shields are not necessary, and it is possible to miniaturize the camera that can be loaded on a drone.

3) LiDAR sensor (LiDAR: Light Detection and Ranging)

A sensor to measure the distance using a laser. The distance is obtained by measuring the time until the reflected scattered light comes back when a pulse laser is scanned on an object. When this sensor is loaded on a drone, three-dimensional topographical model for a working environment can be obtained.

4) Grant-in-aid under the Promotion of Practical Development for Local Revitalization in Fukushima Prefecture

Governmental fund supplied to fifteen municipalities of Hamadori District in order to promote the practical development for the local revitalization and realize the early industrial revival in Hamadori District in collaboration with the local enterprises. The purpose of the fund is to expand the base area of the priority fields of the Fukushima Innovation Coast Framework and accelerate the restoration of Fukushima Prefecture.

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Topics Fukushima No. 92

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