Research on the Applicability of the Understanding Road Damage Status Utilizing SAR Satellite Images - Verification in the 2024 Noto Peninsula Earthquake -

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1. Introduction

The NILIM conducts research on the method of effective utilization of remote sensing technology that can be applied right after the occurrence of a disaster, for the purposes of early detection of the statuses of damaged road facilities due to an earthquake or torrential rain damage and of the prevention of the damage spreading as well as secondary disasters.

Satellites are expected to be utilized to help understand the breadth of road damage in recent years, with the expansion of satellite constellation projects in Japan and the higher resolution quality of small SAR satellites. On the other hand, there is a limit to the reading of the statuses of road damage utilizing SAR images, due to the principle and conditions of observation of Synthetic Aperture Radars (SARs) and restrictions on the resolution. However, specific studies are not being carried out regarding the extent and accuracy that can be grasped about the type of road structure and cause of damage.

Therefore, for the purpose of clarifying disaster events that can be read from small and high resolution X band SAR satellite images (hereinafter called the "small SAR satellite images") and the size of such events, verification was carried out concerning the statuses of road damage due to the 2024 Noto Peninsula Earthquake, and the results are reported below.

2. Understanding of the statuses of road damage utilizing the small SAR satellite images

Considering the road disaster events in the 2024 Noto Peninsula Earthquake, verification is carried out on the possibility of understanding such disasters from the small SAR satellite images. This paper presents the results of verification of slope failures in 6 locations that occurred in the following. Local roads which are the areas around the tip of the Noto Peninsula that is considered to take much time for road patrol during a large-scale disaster (No. 1 - No. 3 in Fig.-1); important urban trunk roads that connect cities (No. 4 and No. 5 in Fig.-1); and a trunk road expected to cause difficulty in recovery if a disaster occurs on a coast line (No. 6 in Fig.-1). Note that in this verification, the satellite images of the Institute for Q-shu Pioneers of Space, Inc. were used, which provide the highest resolution as a small SAR satellite in Japan.

Fig.-2 shows aerial photos and the small SAR

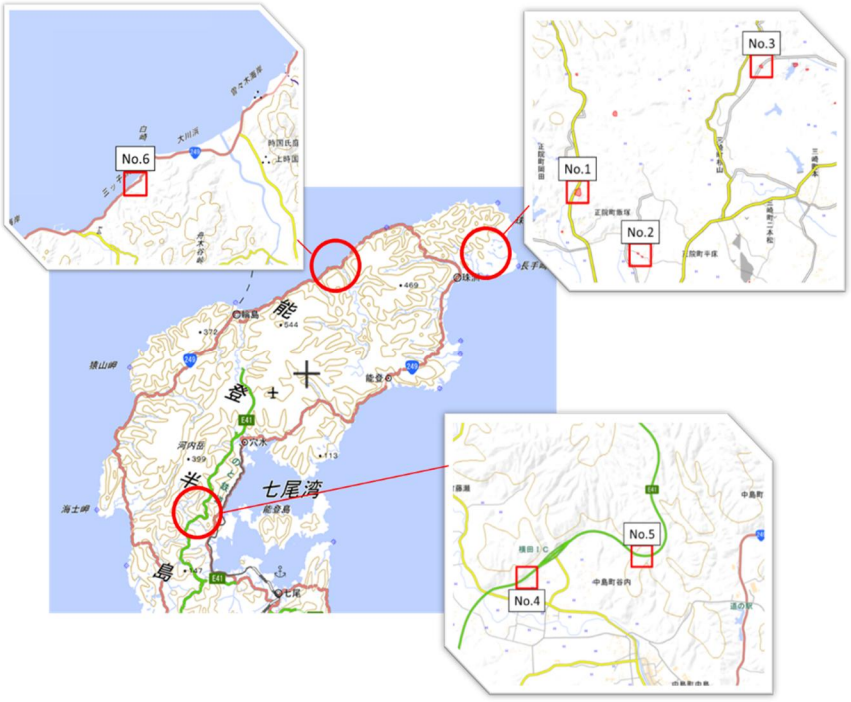

Fig.-1 Locations of slope failure in the 2024 Noto Peninsula Earthquake (partial excerpt)

satellite images of the locations of road damage due to slope failures that occurred in the 2024 Noto Peninsula Earthquake. Note that the examples of local roads are shown for comparison because observation was implemented before the occurrence of the earthquake as well.

From Fig.-2, it can be seen by checking the satellite images of Examples No. 1 and No. 3 that the locations of failure are photographed in white (areas in red circle in the figure). It is considered from these that clear reflections could be confirmed because they were the locations of failure that occurred on slopes roughly placed face-to-face with the direction of irradiation of satellite radio waves. On the other hand, in Example No. 2, the reading was difficult because the location of failure was localized, the slope was a location placed not face-to-face with the direction of irradiation of satellite radio waves, and it is also considered that there was an influence of the foreshortening of vegetation in the surrounding area (a phenomenon in which, if the target of observation has a height, the target is projected toward the side of the observer, corresponding to the shortening of the transmission and receiving time of radio waves). Example No. 4 was a slope failure on the side opposite to the direction of irradiation of radio waves, and it was a location under the conditions close to those of radar shadow, the reading was difficult. Lastly, Examples No. 5 and No. 6 were locations where the slope before the disaster was not located face-to-face with the direction of irradiation of radio waves, but as a result of occurrence of a surface located face-to-face due to the influence of the slope failure, the location of the slope failure was photographed in white, and the reading was possible.

3. Conclusion

As a result of trying whether a reading of the statuses of road damage was possible by using the small SAR satellite images, it has been clarified that thorough understanding of the statuses is possible if the location of failure is around 25 m x 25 m in size and occurred on a slope and was roughly face-to-face with the direction of irradiation of satellite radio waves. On the other hand, as a precaution when utilizing SAR satellite images, since the images are greatly affected by the surrounding trees and houses on actual roads, it is necessary to factor in certain principles of observation, such as prior verification of areas where the reading will be impossible, and the organization of documents for the improvement of reading accuracy so that the road line data can be put onto the SAR satellite images during analysis.

In future, we will verify whether it is possible to grasp the actual disaster events as well, such as slope failures and road surface failures, level differences that are smaller in size, and at the same time will summarize utilization guides (draft) that make the utilization at site possible.

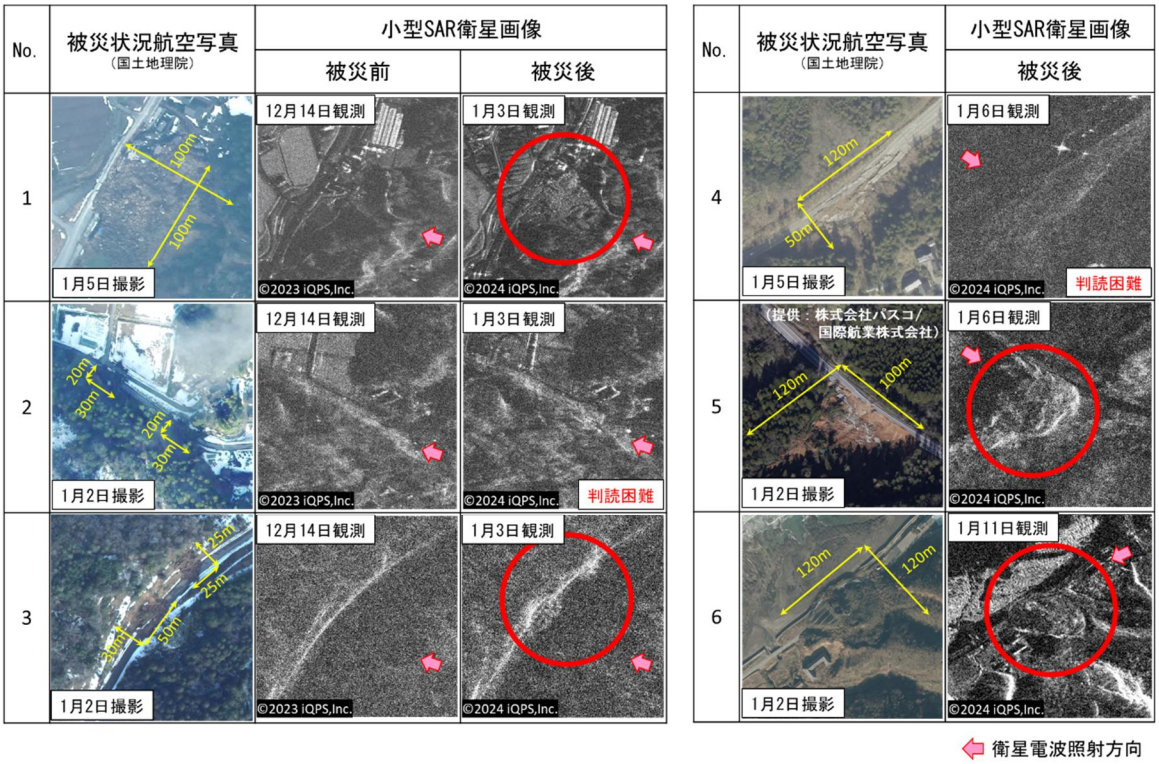

Fig.-2 Example of reading in the 2024 Noto Peninsula Earthquake (locations of slope failure)