Reduction of Non-visible Areas Using Plural SAR Satellites in Landslide Disaster Survey

(Research period: FY2024)

MURAKI Masahiro, Visiting Researcher
KANAZAWA Akito, (Ph. D.), Senior Researcher
TAKIGUCHI Shigetaka, Head
Sabo Department, Sabo Risk-Management Division

(keywords) SAR, landslide disaster survey, non-visible area

1. Introduction

It is very important to promptly and accurately identify areas that have landslides during the initial stage of disasters. As SAR (Synthetic Aperture Radar) can make observations for wide areas at night or under bad weather, it is utilized as soon as disasters occur.

If it is likely that a disaster will occur, currently we conduct a survey for areas that have landslides using one-time, Daiichi 2 (ALOS-2) emergency observation technology. However, SAR observation can detect non-visible areas using layover and radar shadow technology from the principle of observation. As non-visible areas tend to be in areas having steep land shapes, mountain areas which are the subject of surveys for landslides frequently have non-visible areas. If we do not detect the non-visible areas, we may overlook landslides. Therefore, in order to promptly and accurately identify areas that have landslides, it is necessary to expediate the reduction of non-visible areas. In recent years, as various SAR satellites have been launched in Japan and overseas, it is becoming possible to utilize them to reduce non-visible areas.

In this research, we studied to what extent we would have been able to reduce non-visible areas by using plural SAR satellites for past disaster cases to verify the effect using plural SAR satellites on non-visible areas.

2. Method

We selected the Northern Kyushu heavy rain in July 2017 (hereinafter referred to as “Disaster A”) that caused a lot of landslide disasters and the heavy rain in July 2018 (hereinafter referred to as “Disaster B”) as subject disasters and selected the range where many landslides occurred in both disasters as subject range for our research. For these two disasters, we prepared and estimated non-visible areas from actual observation results using plural satellites and verified to what extent the non-visible areas occurred within the range were reduced after the emergency observation. We used 3 satellites, ALOS-2 each having observation mode of resolution of 5m or less, COSMO-SkyMed (CSK) and TerraSAR-X (TSX). The time period we surveyed was 96 hours after the emergency observation (4 days). Also, we verified the proportion of the number of landslide polygons identifiable against the total number of polygons, using the polygon data of landslides identified through aerial photos and airborne laser scanning after the disasters. As for the polygon data of landslides, we used the identification results of Kyushu Regional Development Bureau for Disaster A, and of the study group of Hiroshima University (geography group) for the heavy rain disaster in July 2018 for Disaster B. In addition, for both disasters, as a lot of landslide polygons were distributed in the area where the inclination (θ) of slopes was 20 ~ 40°, we divided the subject range we surveyed into 3 sections as the slope inclination of less than 20°, of 20 ~ 40° and of 40° or more and verified the reduction of non-visible areas in each section.

3. Results and considerations

We have shown the observation history after the emergency observation for Disaster A and Disaster B in the Table. For Disaster A, there were 3 observations with ALOS-2 and one observation with TSX within the 96-hour time frame after the emergency observation. In the same manner, for Disaster B, there were 2 observations with CSK, and it was only around 275 hours after the emergency observation that the 2nd observation was conducted. We believe the reason would be that the observation requirements for ALOS-2 were widely distributed, as many landslides and flood disasters occurred in various areas in Western Japan, mainly in Chugoku and Shikoku regions. From this, we believe that it is possible to conduct multiple observations at the early stage by using plural satellites even if we cannot immediately use ALOS-2.

Table Observation history after emergency observation

Disaster	No.	Satellite name	Observation date	Time lapsed from emergency observation
Disaster A	1 (emergency observation)	ALOS-2	2017/7/7 12:52	0
	2	ALOS-2	2017/7/7 23:43	10 h 51 min
	3	TSX	2017/7/8 18:10	29 h 18 min
	4	ALOS-2	2017/7/9 11:57	47 h 05 min
	5	ALOS-2	2017/7/10 12:18	71 h 26 min
Disaster B	1 (emergency observation)	ALOS-2	2018/7/8 11:56	0
	2	CSK	2018/7/9 17:58	30 h 02 min
	3	CSK	2018/7/11 17:46	77 h 50 min

In the Figure, we show changes in the proportion of non-visible areas and the number of landslide polygons identifiable with the time lapsed from emergency observation. The proportion of non-visible areas at the time of emergency observation was 10.2% in the entire area for Disaster A and when we divided the data by slope inclination, it was 2.7% for less than 20°, 18.2% for 20 ~ 40°and 30.2% for 40°or more. In the same manner, for Disaster B, it was 3.7% for the entire area, and 0.7% for less than 20°, 6.7% for 20 ~ 40°and 16.7% for 40°or more. In this way, the non-visible areas may reach over 30% in the highly inclined areas where landslides occurred , so it may not be possible to make a conclusive survey based on only one emergency observation. On the other hand, the proportion of the non-visible areas at the 2nd observation after emergency observation for Disaster A was, 1.4% for the entire area, 0.3% for less than 20°of inclination, 2.3% for 20 ~ 40°and 5.9% for 40°or more. For Disaster B, it was 0.6% for the entire area, 0.2% for less than 20°, 1.0% for 20 ~ 40°and 3.4% for 40°or more. We found out that the proportion of non-visible areas for both disasters was gradually reduced from the 3rd observation onward. On the basis of these results, we recognized that we could substantially reduce the non-visible areas by making the 2nd observation and could gradually reduce such areas furthermore by making further observations. As the 2nd observation substantially contributed to reducing the non-visible areas, we believe it is important how quickly we make the 2nd observation. In addition, for such areas that have steep inclines and a propensity towards landslides that are likely to have non-visible areas, we acknowledged that it would be possible to sufficiently reduce the non-visible areas by continuing to make ongoing observations.

Also, though the proportion of the number of landslide polygons identifiable was 69.4% for Disaster A at the time of emergency observation, and 82.5% for Disaster B, it increased to 93.1% for Disaster A and 98.7% for Disaster B at the 2nd observation after emergency observation. From this, we recognize that it would be possible to conduct effective surveys for areas that have landslides by making observations more than twice to reduce non-visible areas.

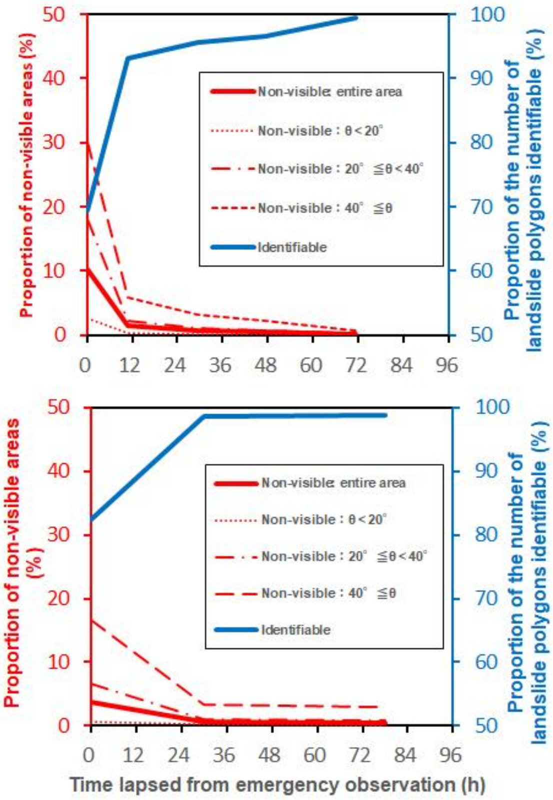

Figure Changes in the proportion of the non-visible areas and the number of landslide polygons identifiable
(upper figure: Disaster A, lower figure: Disaster B)

4. Conclusion

Based on the results of this research, we recognized that it would be possible to conduct an effective survey for areas that have landslides by making multiple observations after emergency observation utilizing multiple satellites, for areas that have steep inclines and a propensity for landslides and in so doing substantially reduce non-visible areas. In addition, we acknowledge that it is important how quickly we can make the 2nd observation to reduce non-visible areas. From these findings, we believe that it is important to effectively utilize various satellites to promptly and accurately identify areas that have landslides during the initial stage of disasters.

☞Detailed information is as follows.
1) Muraki and others: Reduction of non-visible areas using plural SAR satellites for landslide disaster survey, The Remote Sensing Society of Japan, collected papers of Academic Lecture, pp. 121-124, 2024