

# Research Trends and Results

## Urgent Determinant Investigation of Landslide Dams with SAR Satellite Images

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Keywords: SAR image, landslide dam, interpretation

### 1. Introduction

If abnormal phenomenon such as a large-scale collapse that may lead to the formation of a landslide dam is likely to occur in a wide area due to heavy rain, etc., it is necessary to prevent the occurrence of secondary disasters due to breaches or otherwise by quickly detecting the formation, position, and size of the landslide dam. This paper introduces a method of urgent determinant investigation of landslide dams using images obtained from synthetic aperture radar ("SAR"). Its aim is to investigate ways to detect landslide dams even at night or in bad weather where visual investigation using a helicopter is difficult.

### 2. Characteristics of SAR images

SAR is an active sensor usually installed in artificial satellites and airplanes. It observes backscattered microwaves that are originally irradiated obliquely to the earth's surface. SAR images have unidentifiable elements due to shadows, reversing, or tilting (Fig. 1) since microwaves are irradiated obliquely downward, But, SAR has an advantage that observations can be made without sunlight, i.e., observation at night or in bad weather, since microwaves penetrate clouds.

In addition, unidentifiable parts can be reduced using images observed from multiple directions, such as

manually in accordance with the below check list by enlarging images. They are otherwise read in consideration of geomorphic characteristics of landslide dams (Fig. 2) such as dammed lakes, collapsed areas, and colluvial sediment blocking a river channel, and in consideration of the aforementioned geometric characteristics of SAR images.

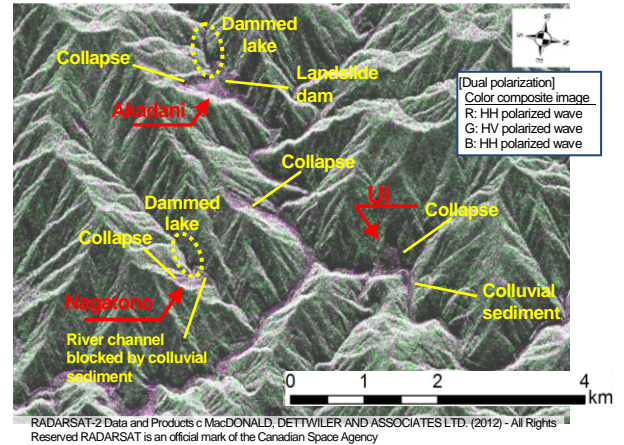


Figure 2: Example for SAR Image of Landslide Dam (Kii Peninsula in 2011)

Table: Check List for Dual-Polarization SAR Image Interpretation

Check areas	Check items	Decision criteria	Evaluation	
Collapsed land	Bare ground	- Is red-purple bare ground in the dual-polarization image? - Located on a slope? (Colony or river channel on flat land or gentle slope?) - Are any main scarps seen around dammed lakes?	Evaluation index ○: Shape can be identified △: Not clear but shape can be identified X: No shape can be identified -: Impossible to identify	
	Main scarp	- Are any shadows / layovers due to level difference seen around the main scarp? - Is the shape of the main scarp circular to the direction of the slope?		
	Inside the collapsed land	- Are any collapsed shapes seen under the main scarp? - Is the collapsed shape consistent with the direction of the slope?		
	Colluvial sediment (Blocked river channel)	- Are colluvial deposits seen from inside the collapsed land to the lower area? - Is the colluvial deposit tongue-shaped? - Is the extent of the colluvial deposit consistent with the topographic shape? - Is the blocked river channel shaped to aggrade the valley? - Has a dammed lake formed upstream of the blocked river channel? - Is the shape of fallen trees, etc. seen on the colluvial deposit?		
Scale of collapse	- Is the scale of collapse large enough to block the river channel?			
Scar of debris flow	Scar of flow down	- Is the transport area seen from the lower part of the collapsed land? - Is there scar of flow down of debris due to widening of the river channel, outflow of vegetation, etc.?		
	Debris flow deposit	- Is there debris flow deposition (debris flow terrace, alluvial cone) seen?		
Local terrain	Slope gradient	- Are there any slopes near the dammed lake? - Is the neighboring slope so steep it may collapse?		
Relative positional relation	Relation of upper and lower, etc.	- Are there any abnormalities in the positional relations of the main scarp, colluvial deposit, and dammed lake? - Is the extent of colluvial deposit consistent with the topographic shape?		
River channel	Dammed lake	- Is a dark area suspicious of a dammed lake seen? - Is the width abnormal compared with the water-route width upstream and downstream? - Is there flooding because of artificial structures, such as a dam or intake weir?		
Judgment	Collapse scar / Bare rock area	New collapse	Surface failure Large-scale collapse Deep-seated landslide River channel blockage	
		Scar of debris flow		

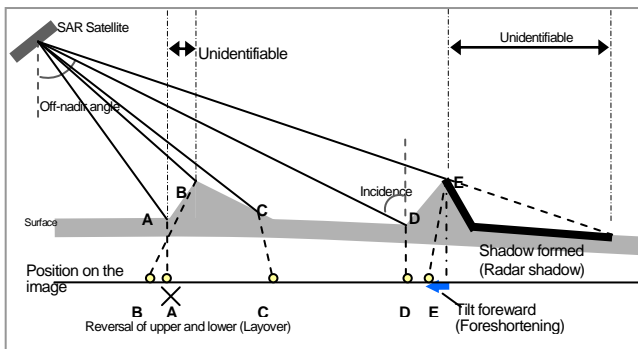


Figure 1: Geometric Characteristics of SAR Images (reversal of image, tilt)

observation from ascending (northward) / descending (southward) orbit.

### 3. Interpretation of SAR images

When using dual-polarization SAR images for interpretation, it is desirable to use wide-area images that have a resolution higher than HH + HV, i.e., 8 m (of the combinations of transmitted / received horizontally polarized wave H and vertically polarized wave V) and are observed at the incidence angle of approx. 35-50. Objects that can be identified with dual-polarization SAR images are mainly collapsed land with a plane projection area of about 1 ha or more. SAR images are read

### 4. Conclusions

Since engineers have started using SAR images in disaster response, as was the case following Typhoon No. 12 TALAS in 2011, we will continue to upgrade the investigation method into their practical use.