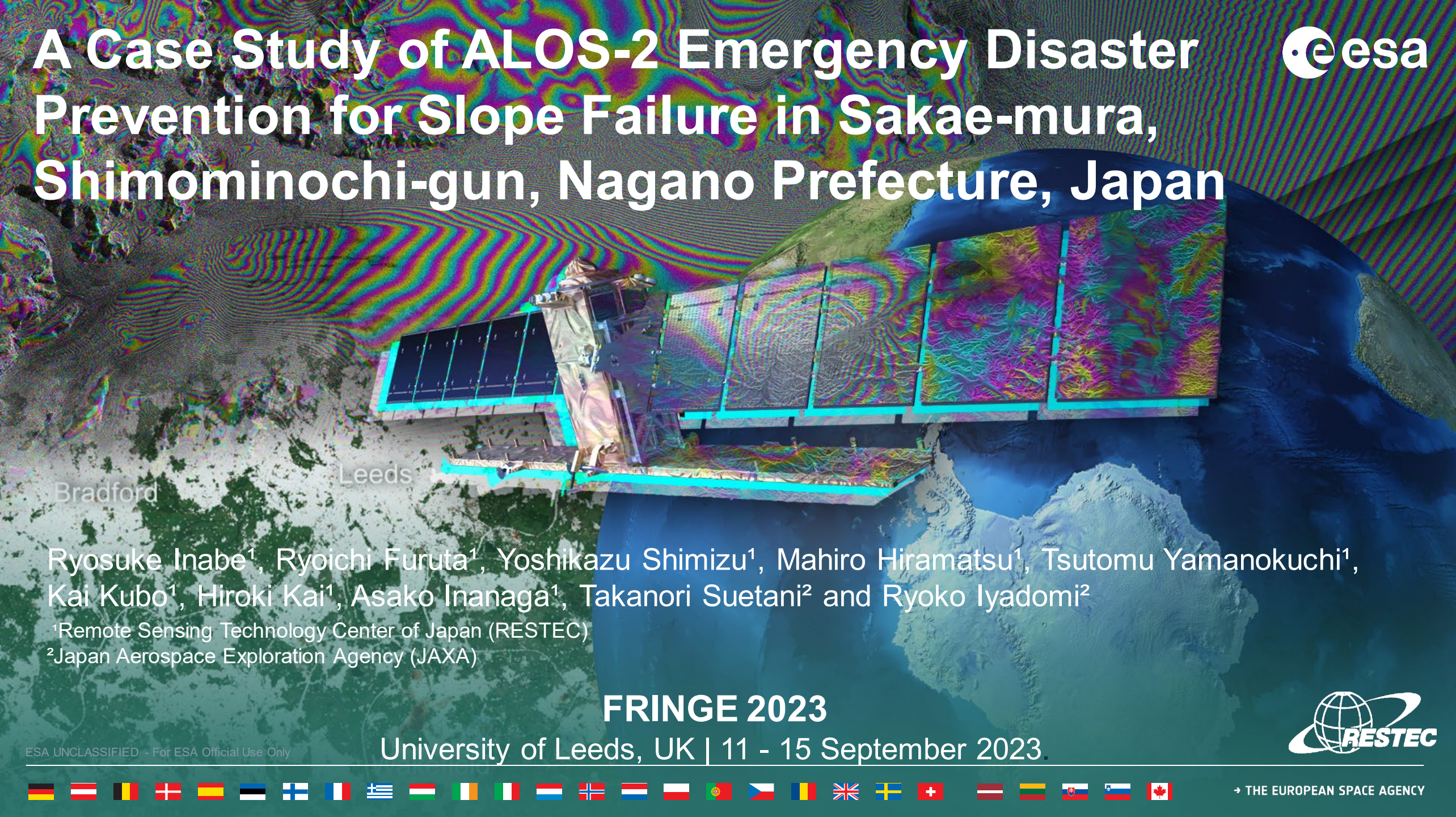
A Case Study of ALOS-2 Emergency Disaster Prevention for Slope Failure in Sakae-mura, Shimominochi-gun, Nagano Prefecture, Japan

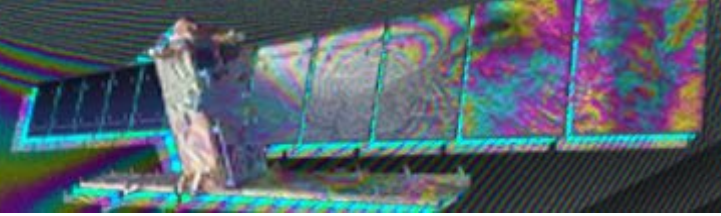


Ryosuke Inabe[1], Ryoichi Furuta[1], Yoshikazu Shimizu[1], Mahiro Hiramatsu[1], Tsutomu Yamanokuchi[1], Kai Kubo[1], Hiroki Kai[1], Asako Inanaga[1], Takanori Suetani[2] and Ryoko Iyadomi[2]

[1]Remote Sensing Technology Center of Japan (RESTEC)
[2]Japan Aerospace Exploration Agency (JAXA)

FRINGE 2023
University of Leeds, UK | 11 - 15 September 2023

Contents

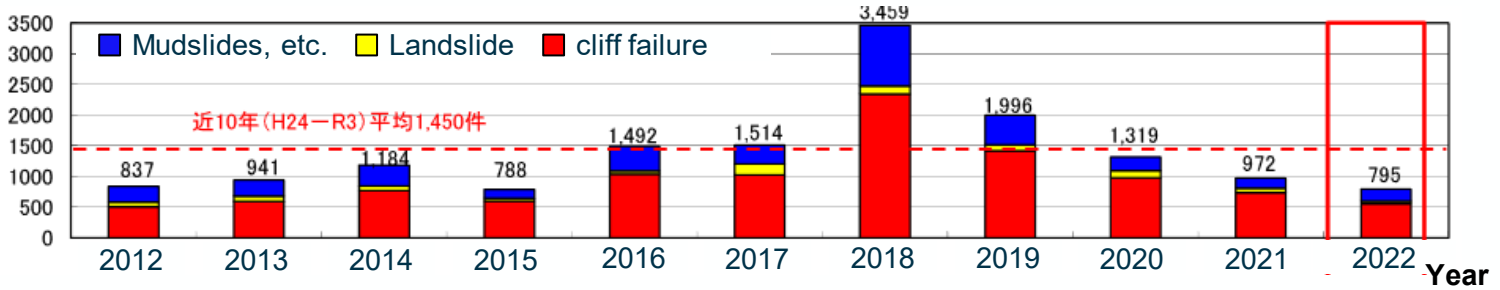


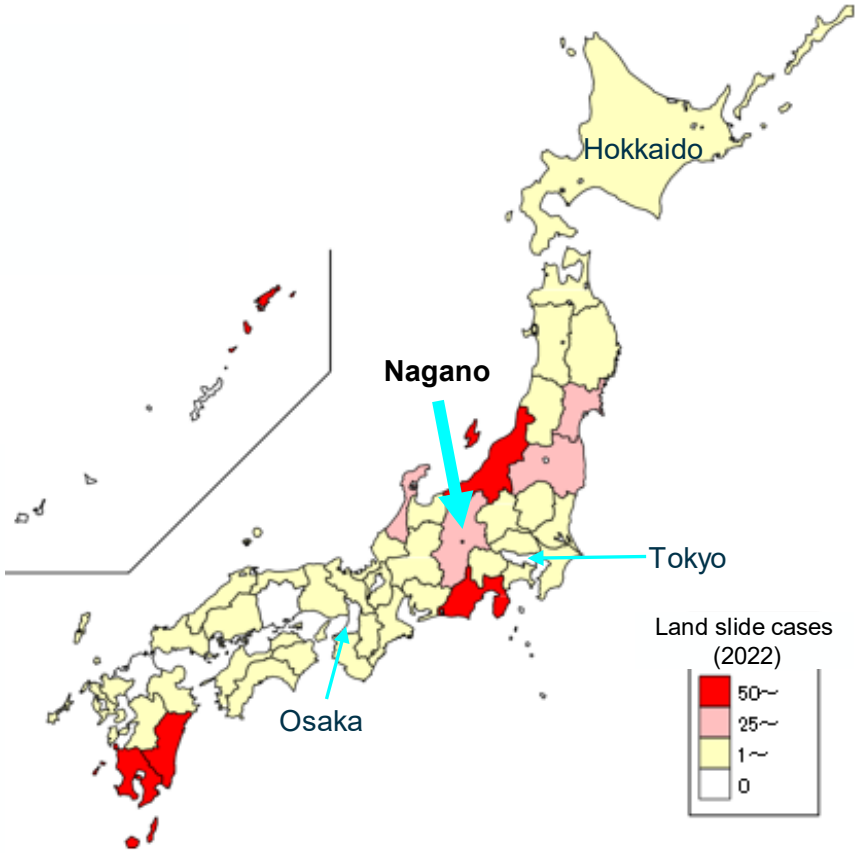
Introduction

Landslide Disasters in Japan 2022

➢ **795 cases***

- ✓ The average occurrence over the last 10 years is 1,450 cases.
- ✓ Many landslides have occurred every year in Japan.





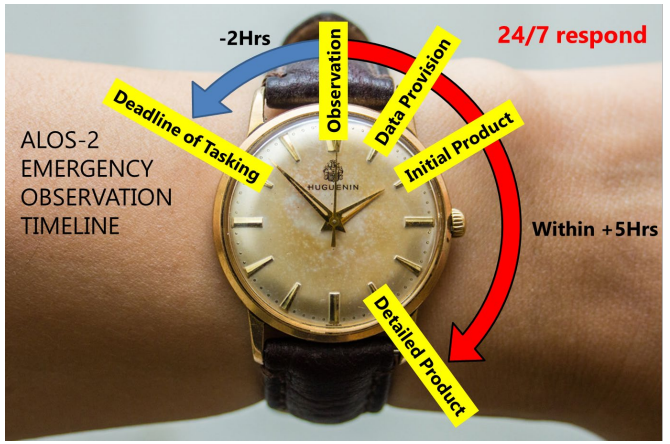
*Released by MLIT (Ministry of Land, Infrastructure, Transport and Tourism)
https://www.mlit.go.jp/river/sabo/jirei/r4dosha/r4doshasaigai.pdf

Overview of ALOS-2 Emergency Observation

JAXA conducts emergency observation by ALOS-2 when contacted by a ministry or other user to get information of the possibility of a disaster due to a typhoon or other heavy rainfall, earthquake, etc.

We support these emergency observations under contract with JAXA.

Domestic users
- Government
- Local government



- Initial report distribute within 2 hours after observation
- Final report distribute within 5 hours after observation

JAXA

RESTEC

Sentinel Asia

アジア防災センター
Asian Disaster Reduction Center (ADRC)

Asian countries
- Government
- Space agency

: Request

: Provision

Overview of Landslide (2022)

Slope failure occurred along Nakatsugawa River in Sakae-mura village on May 9, 2022

⇩

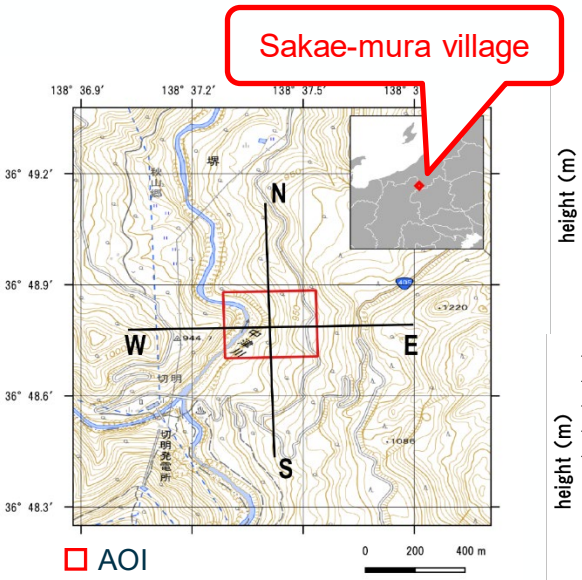
MLIT asked JAXA for emergency observation

⇩

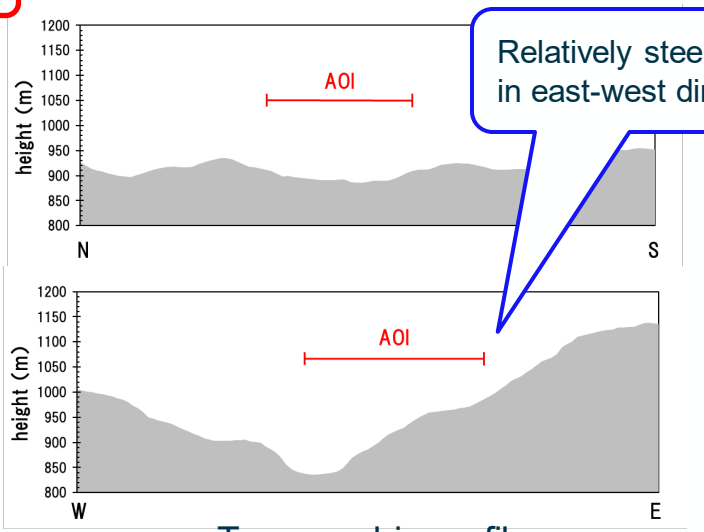
JAXA conducted emergency observation by ALOS-2 (observation date: 10, 18, 31 May and 1 Jun)

Photo by Sakae-mura village

https://www.hrr.mlit.go.jp/yuzawa/topics/r4/kishahappyo/20220510_kisyahappyo1.pdf



Study area

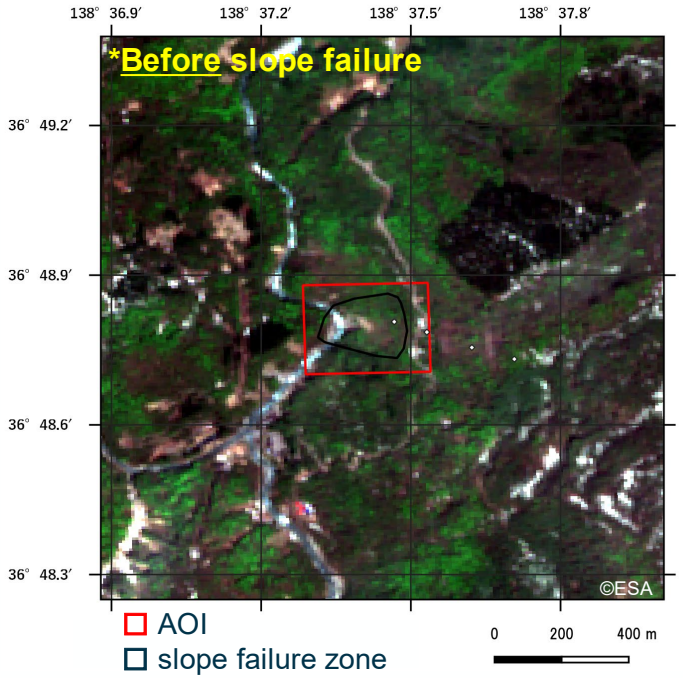


Topographic profile

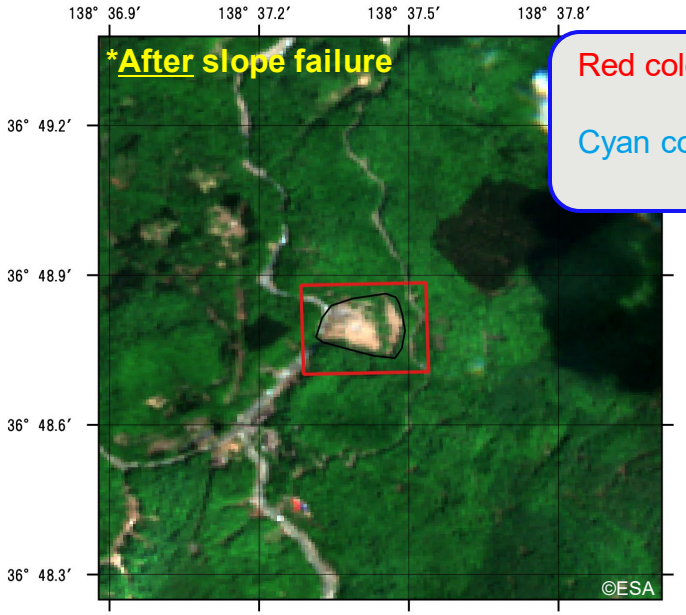
Overview of Landslide (2022)

The result of combining pre- and post-disaster PALSAR-2 intensity images (RGB color composite of the images observed before and after the failure) shows a slope failure.

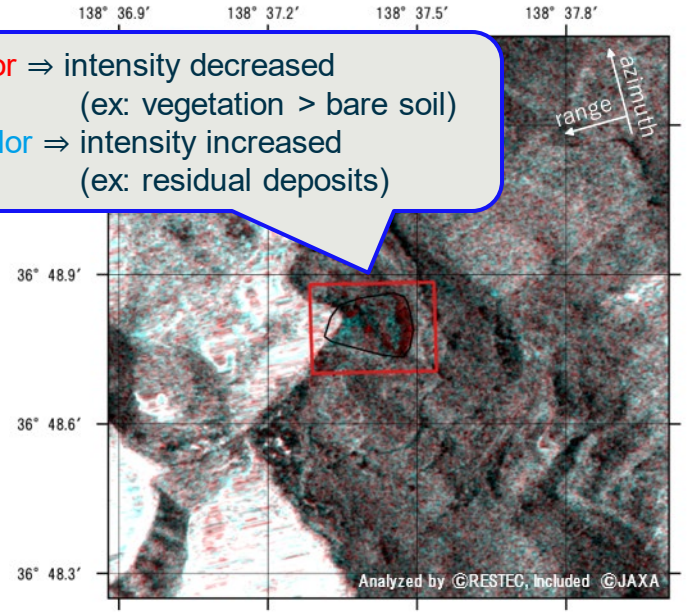
- Sentinel-2 also observed the same area before and after the slope failure. As you can see from the optical image, there is abundant vegetation and still snow in early May.
- DInSAR analysis was conducted in order to check conditions about ground deformation. → p.9-



Sentinel-2 True Color Image
(07/05/2022)

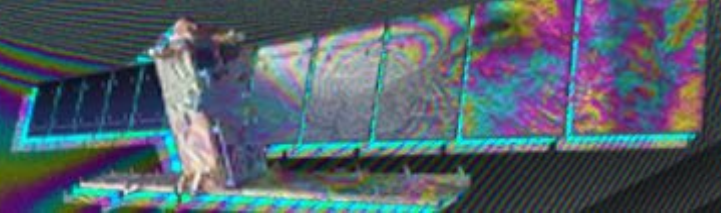


Sentinel-2 True Color Image
(25/05/2022)



ALOS-2/PALSAR-2
(R: 10/10/2018, G, B: 18/05/2022)

Satellite data



ALOS-2/PALSAR-2

Number of Scenes	Period	Orbit direction	Looking direction	Incidence angle (degree)	Notes
2	18/05/2022 - 01/06/2022	Ascending	Left	34.4	DInSAR analysis (just after slope failure)
2	11/08/2020 - 31/05/2022	Descending	Right	36.9	DInSAR analysis (most recent 2 years)
17	28/10/2014 - 27/06/2023	Descending	Right	36.9	SBAS analysis (about 10 years)

Sentinel-1A/C-SAR

Number of Scenes	Period	Orbit direction	Looking direction	Incidence angle (degree)	Notes
28	15/05/2020 - 25/10/2021	Descending	Right	34.8	DInSAR analysis in 2020 and 2021

*NOTE : This study area is well known for its heavy snowfall, so we used only data from the non-snow season.

Using methods and software

Methods

- DInSAR (Differential Interferometric SAR)

DInSAR analyzes the change in distance between the satellite and the ground from two SAR data and extracts the surface displacement component.

- SBAS (Small Baseline Subset)

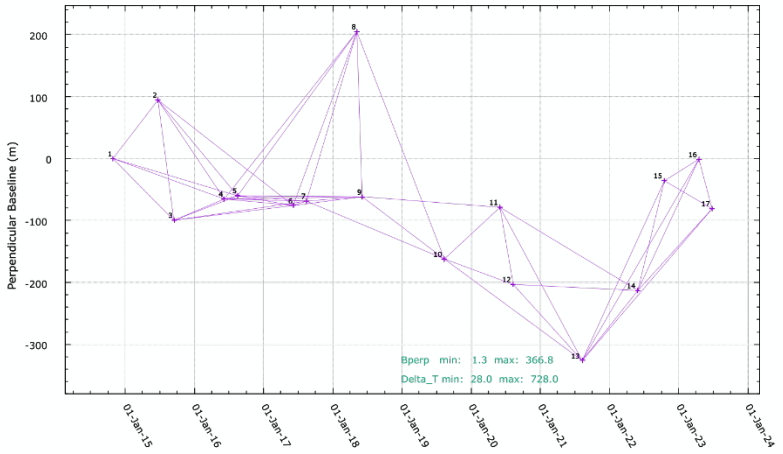
SBAS makes many pairs of SAR data with short term and short perpendicular baseline (Bperp) and calculate the displacement at each observation date by inversion.

⇒Threshold term and Bperp are 730 days and 1000 meter respectively in this research.

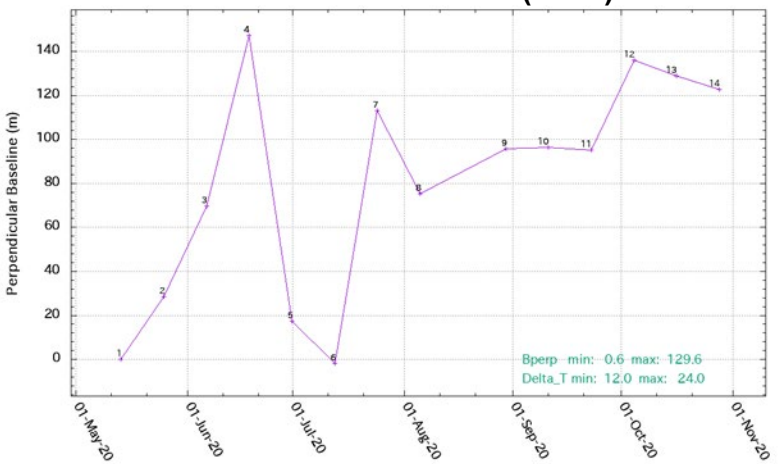
Using Software

GAMMA Software (https://www.gamma-rs.ch/)

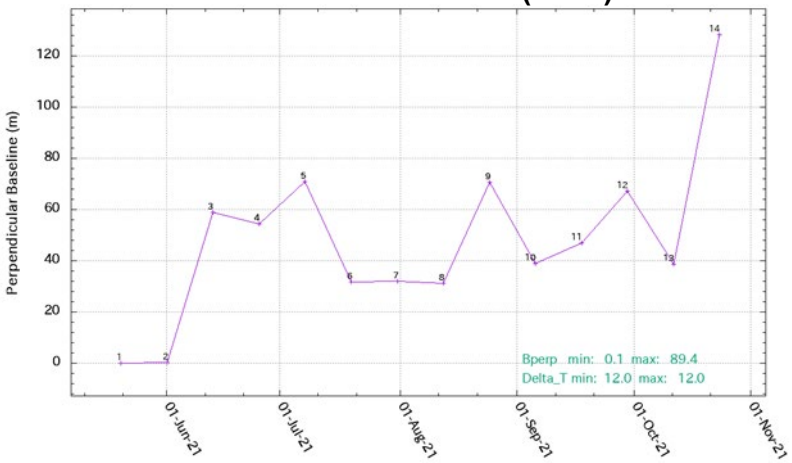
ALOS-2 SBAS network



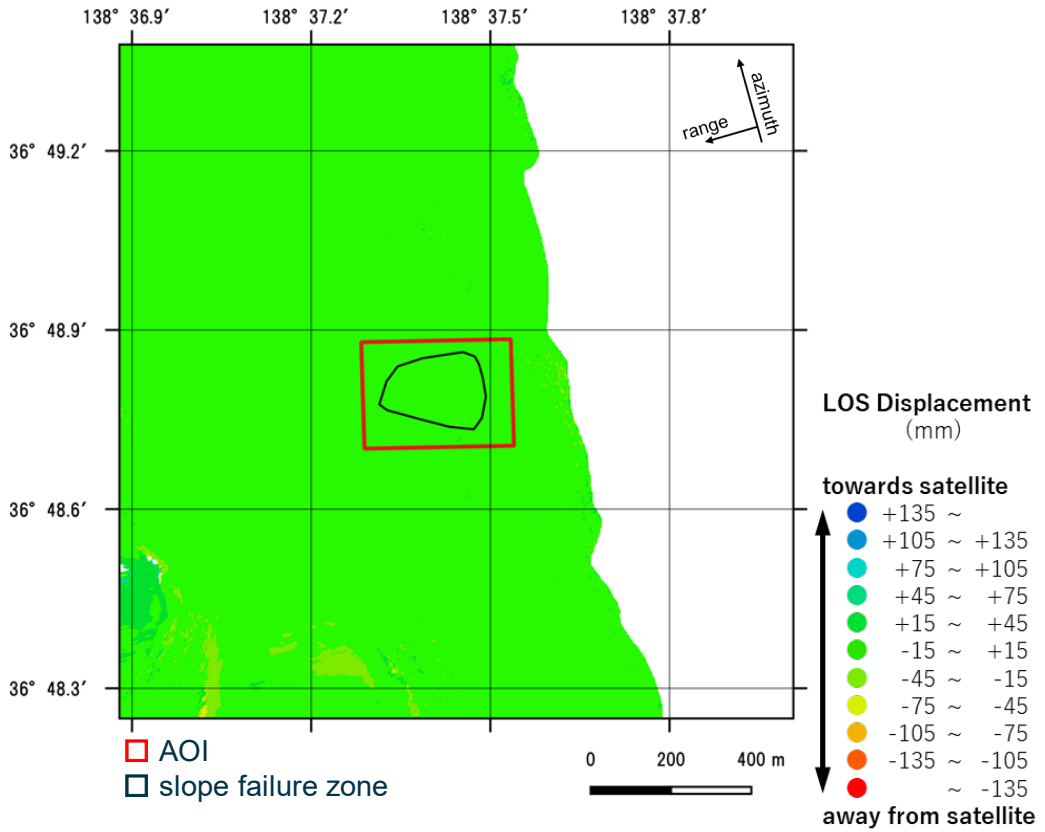
Sentinel-1A DInSAR network (2020)



Sentinel-1A DInSAR network (2021)

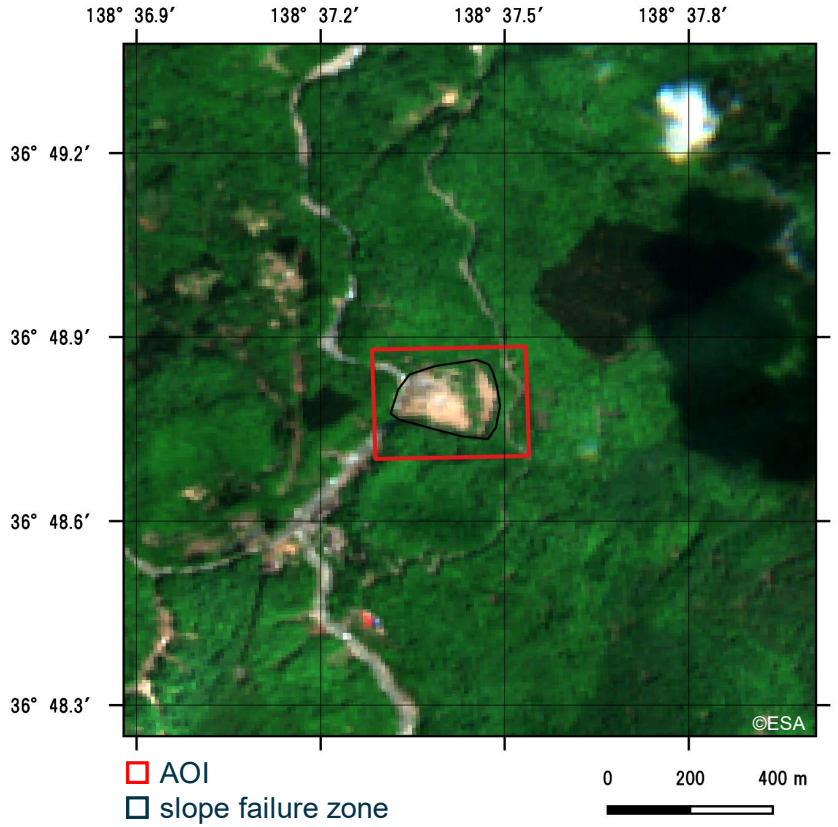


Result of DInSAR analysis in a short term after the slope failure



ALOS-2/PALSAR-2 DInSAR result

Primary: 18/05/2022
Secondary: 01/06/2022
(14 days)

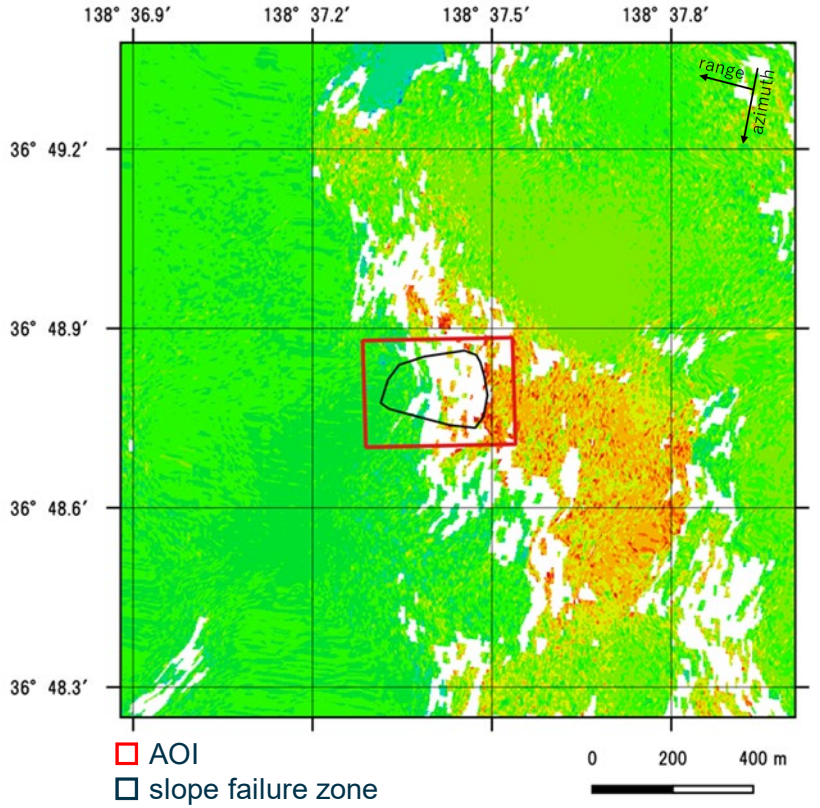


Sentinel-2 True Color Image (25/05/2022)

DInSAR results by ALOS-2 show no significant ground deformation.

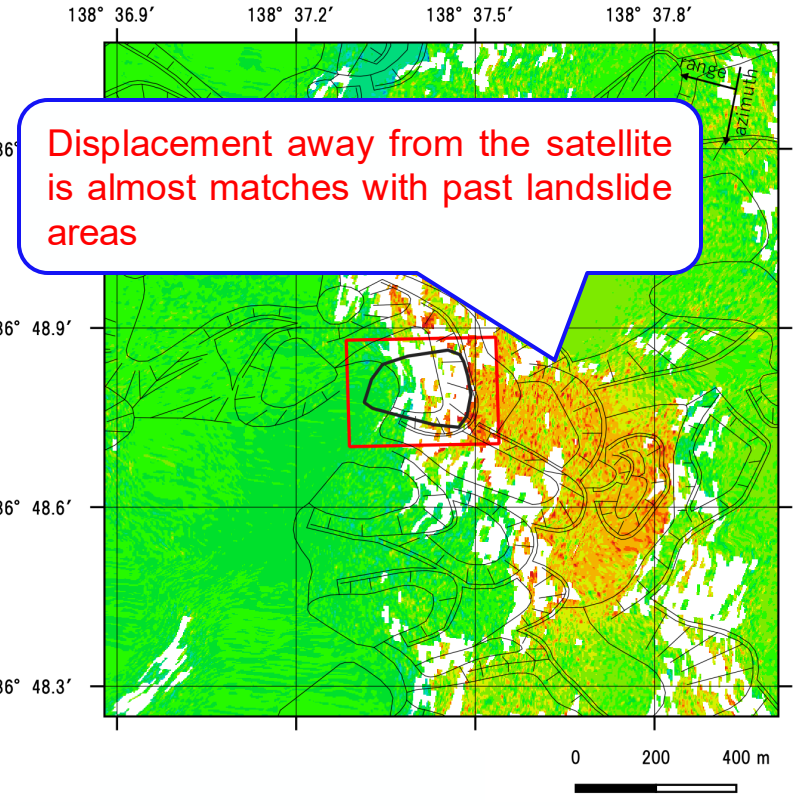
- Ground surface is stable just after the slope failure.

Result of DInSAR analysis before and after the slope failure (2020 - 2022)



ALOS-2/PALSAR-2 DInSAR result

Primary: 11/08/2020
Secondary: 31/05/2022
(658 days)



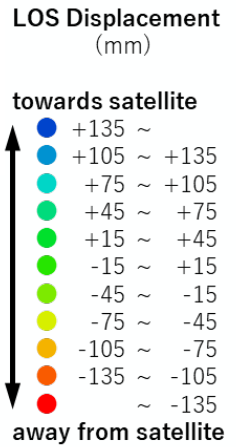
Superimposed with Landslide Distribution Map*

* Published by National Research Institute for Earth Science and Disaster Resilience (NIED)

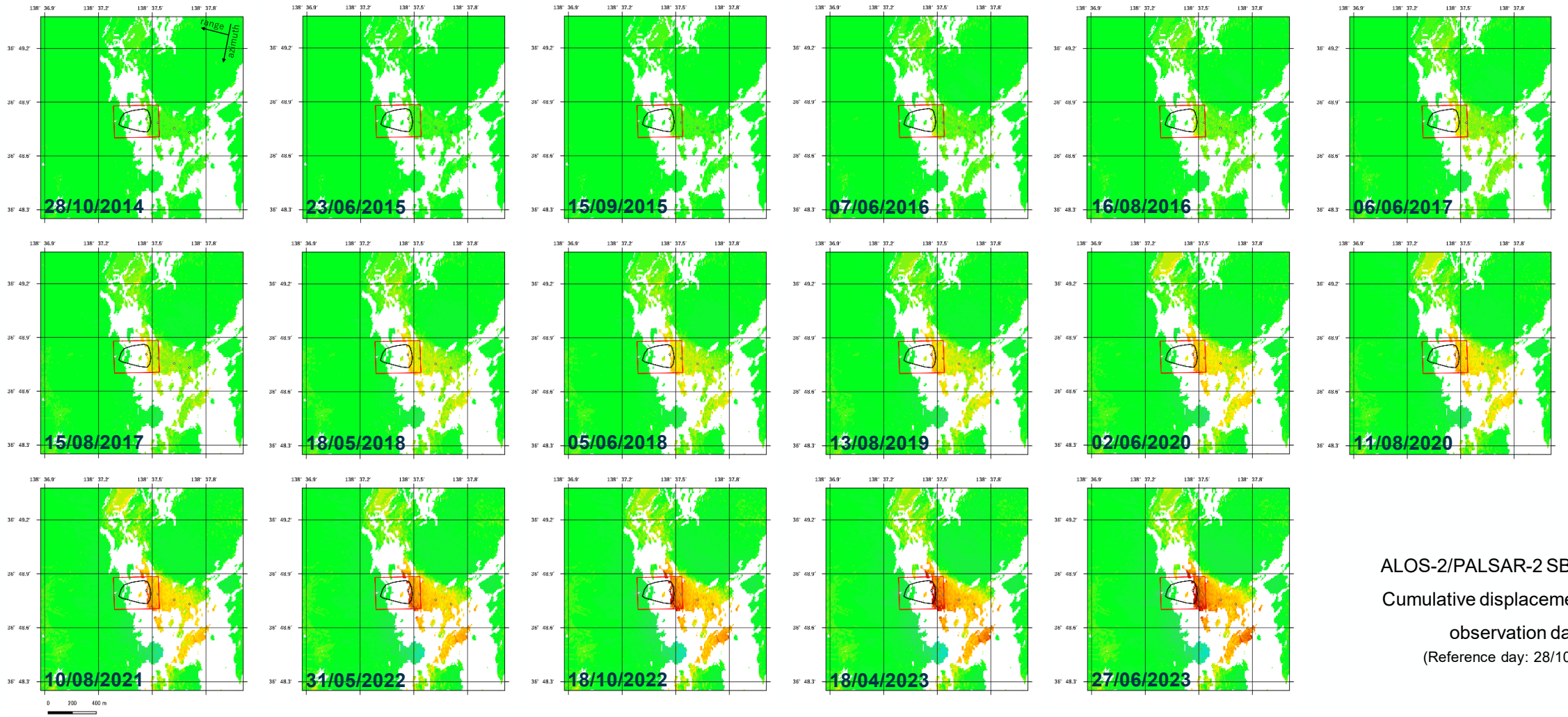
According to DInSAR analysis results from 2020 to just after the slope failure, a displacement away from the satellite was detected in the upper part of the slope failure.

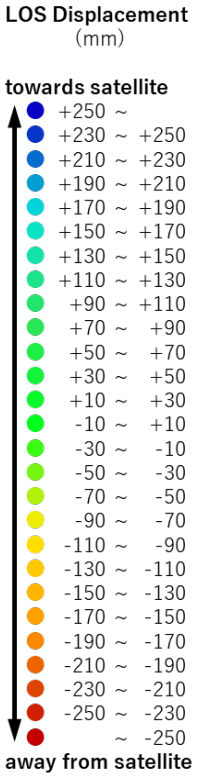
- Probably caused by a landslide.
- Longer term analysis is necessary.

  → SBAS analysis (p.11-)



Results of SBAS analysis before and after the slope failure (2014 - 2023)





ALOS-2/PALSAR-2 SBAS results

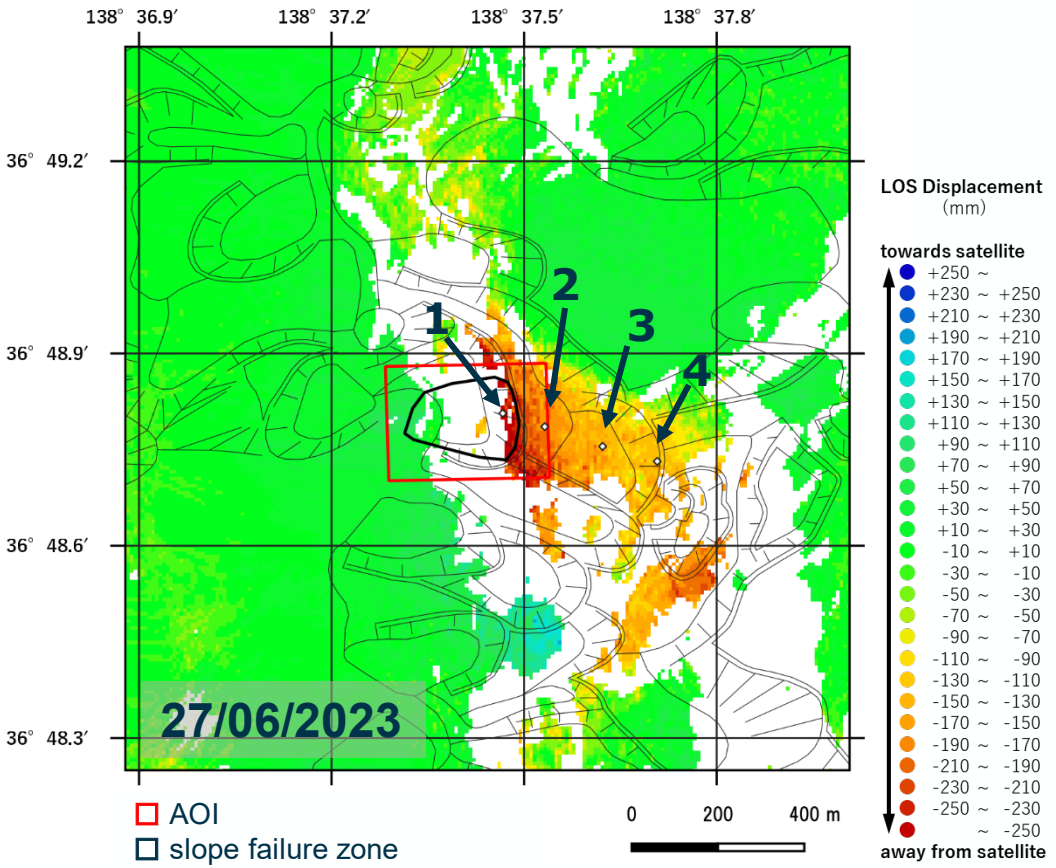
Cumulative displacement at each observation date

(Reference day: 28/10/2014)

Deformation away from the satellite was detected in the upper part of the slope failure throughout the period.

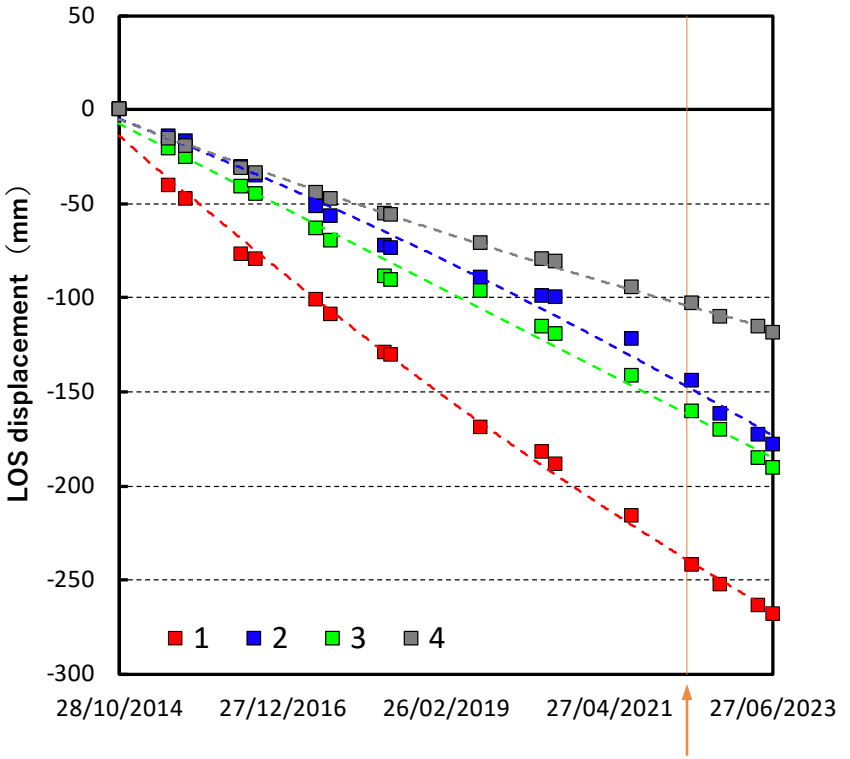
A time series graph for each observation date at points 1 to 4 is shown on the next slide.

Results of SBAS analysis before and after the slope failure (2014 - 2023)



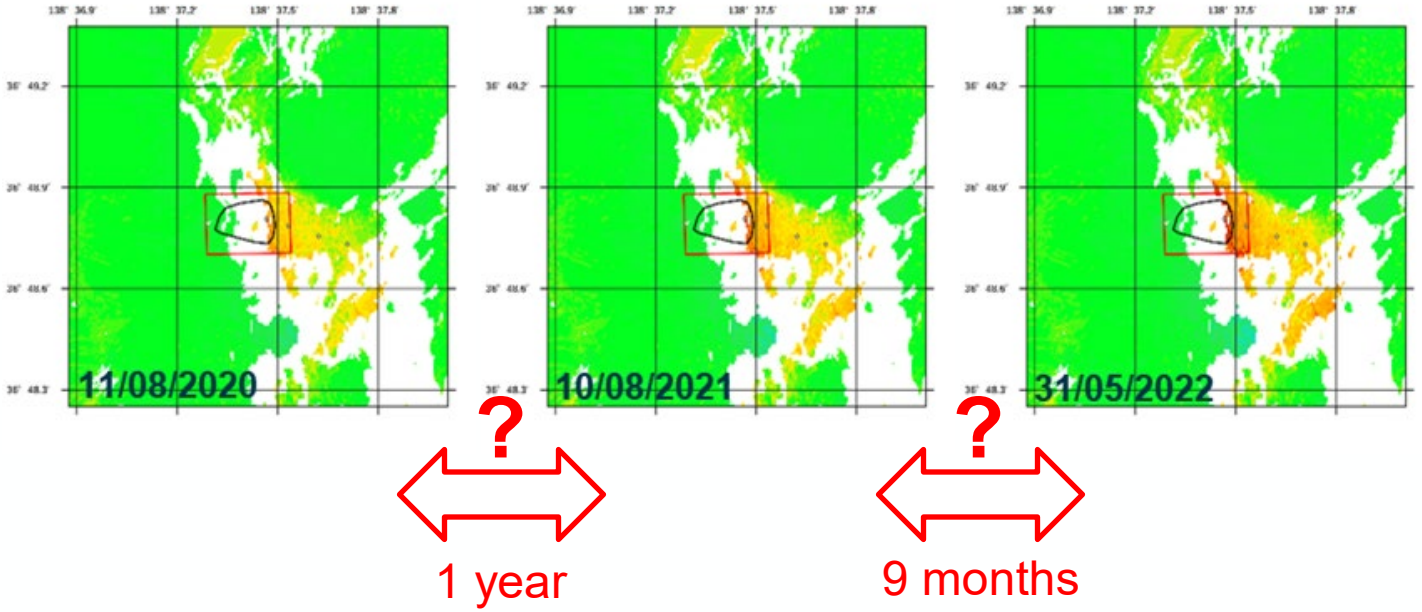
ALOS-2/PALSAR-2 SBAS result

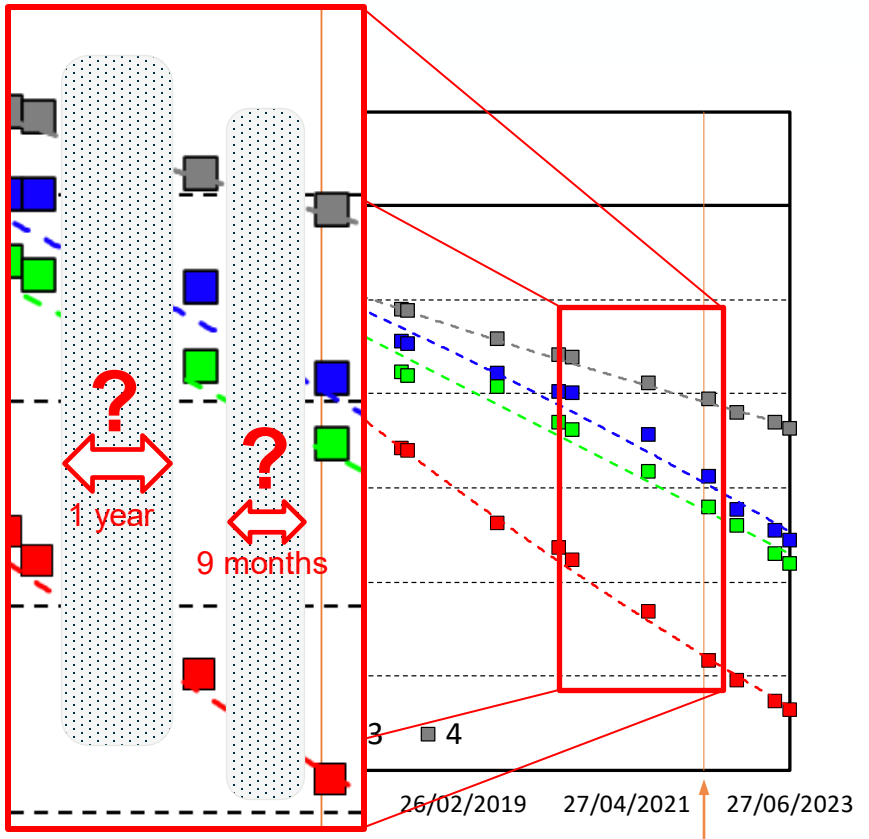
Cumulative displacement at 27/06/2023
(Reference day: 28/10/2014)
Superimposed with Landslide Distribution Map



- ✓ Deformation away from the satellite was detected in the upper part of the slope failure throughout the period.
- ✓ Detected deformation area almost matches with past landslide areas.

Discussion of applicability of Sentinel-1A data to ALOS-2 SBAS results





More detailed understanding of the variability is needed from a temporal perspective to investigate the factor of landslides.
Thus, detecting the presence or absence of an inflection point in the displacement velocity of a landslide could be useful for disaster prevention.

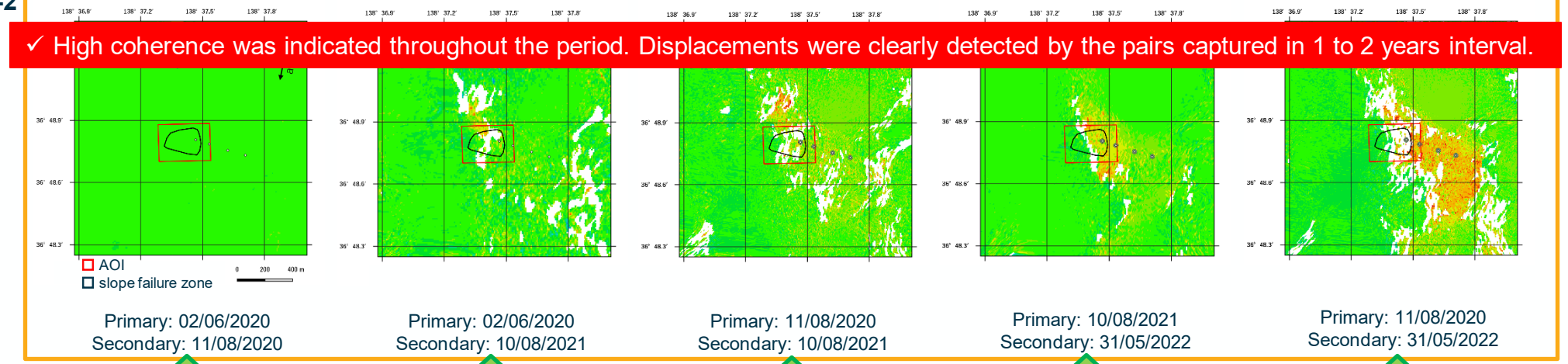
- It is necessary to keep observations for this purpose at least once every few months.
- This task will be overcome when ALOS-4 is launched in the future.
- Sentinel-1A was selected as the most appropriate data to overcome this task in the current situation.

Comparison of ALOS-2 and Sentinel-1A DInSAR results

We review the results of ALOS-2 and Sentinel-1A over almost the same DInSAR pair period.

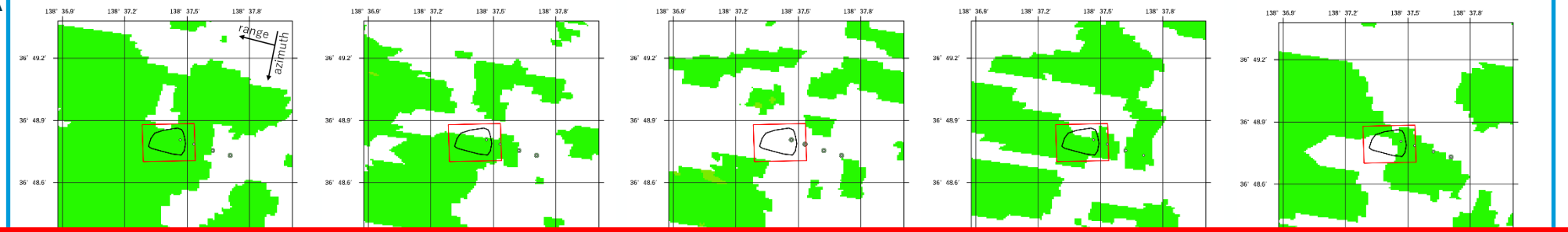
ALOS-2

✓ High coherence was indicated throughout the period. Displacements were clearly detected by the pairs captured in 1 to 2 years interval.



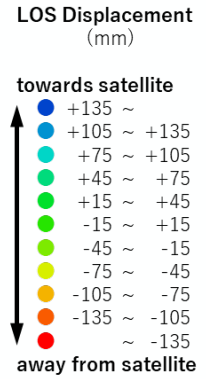
Primary: 02/06/2020 Secondary: 11/08/2020	Primary: 02/06/2020 Secondary: 10/08/2021	Primary: 11/08/2020 Secondary: 10/08/2021	Primary: 10/08/2021 Secondary: 31/05/2022	Primary: 11/08/2020 Secondary: 31/05/2022

Sentinel-1A



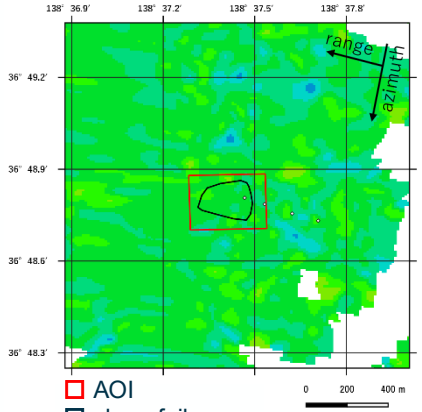
✓ Only about a half area of the images were coherent. No displacement was detected in the pairs that have interval of one year or more.
⇒ Next, we attempted DInSAR using pairs of one return, that is, 12 days interval.

Primary: 08/06/2020 Secondary: 07/08/2020	Primary: 08/06/2020 Secondary: 14/08/2021	Primary: 07/08/2020 Secondary: 14/08/2021	Primary: 14/08/2021 Secondary: 29/05/2022	Primary: 07/08/2020 Secondary: 29/05/2022

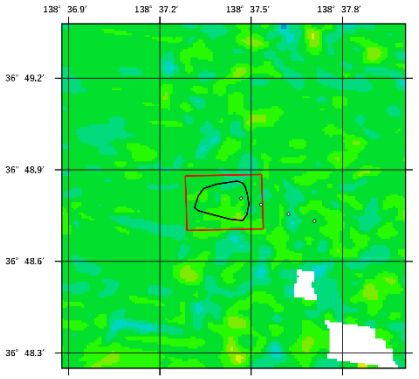


DInSAR results by Sentinel-1A every 12 days (2020 – 2021)

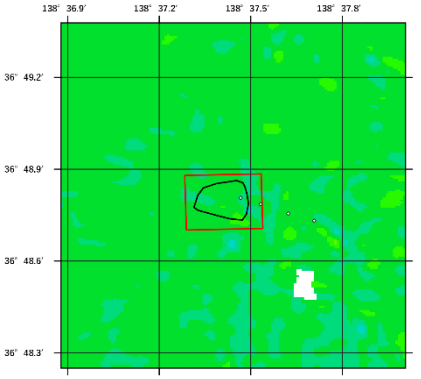
Year : 2020



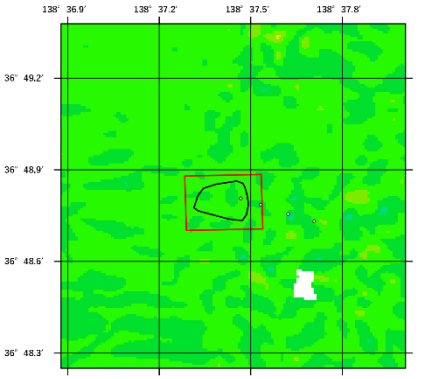
Primary: 12/09/2020
Secondary: 24/09/2020



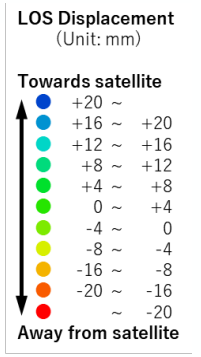
Primary: 24/09/2020
Secondary: 06/10/2020



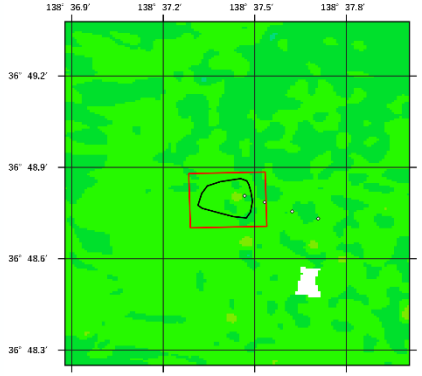
Primary: 06/10/2020
Secondary: 18/10/2020



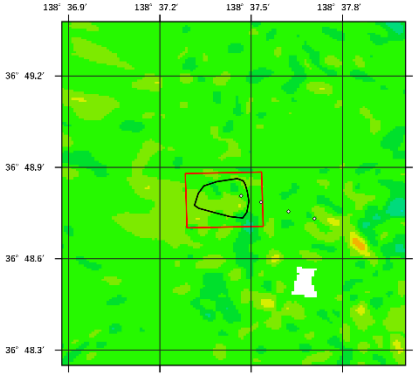
Primary: 18/10/2020
Secondary: 30/10/2020



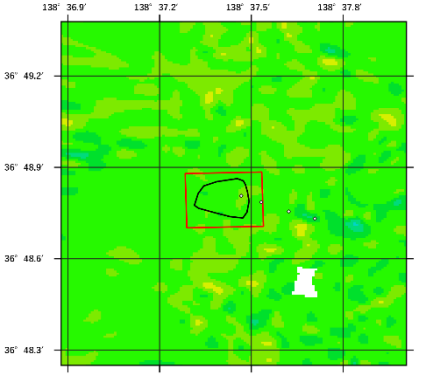
Year : 2021



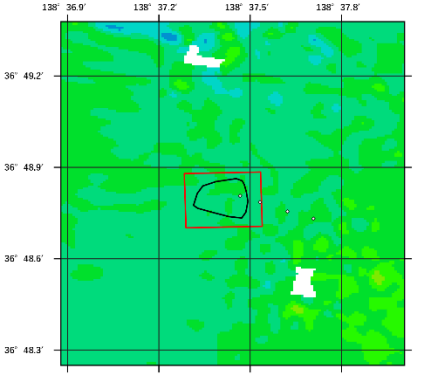
Primary: 15/06/2021
Secondary: 27/06/2021



Primary: 27/06/2021
Secondary: 09/07/2021



Primary: 09/07/2021
Secondary: 21/07/2021



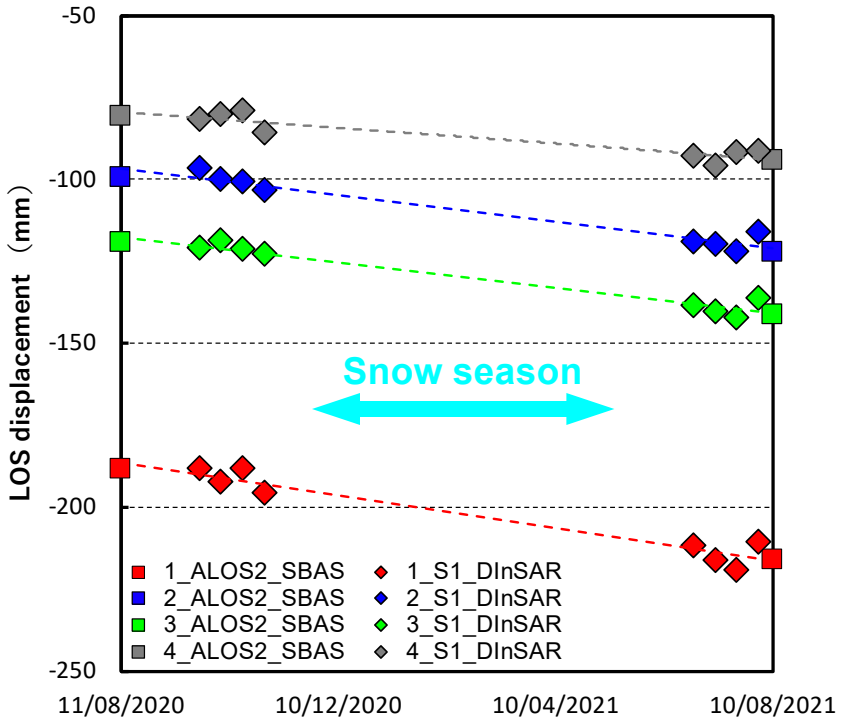
Primary: 21/07/2021
Secondary: 02/08/2021

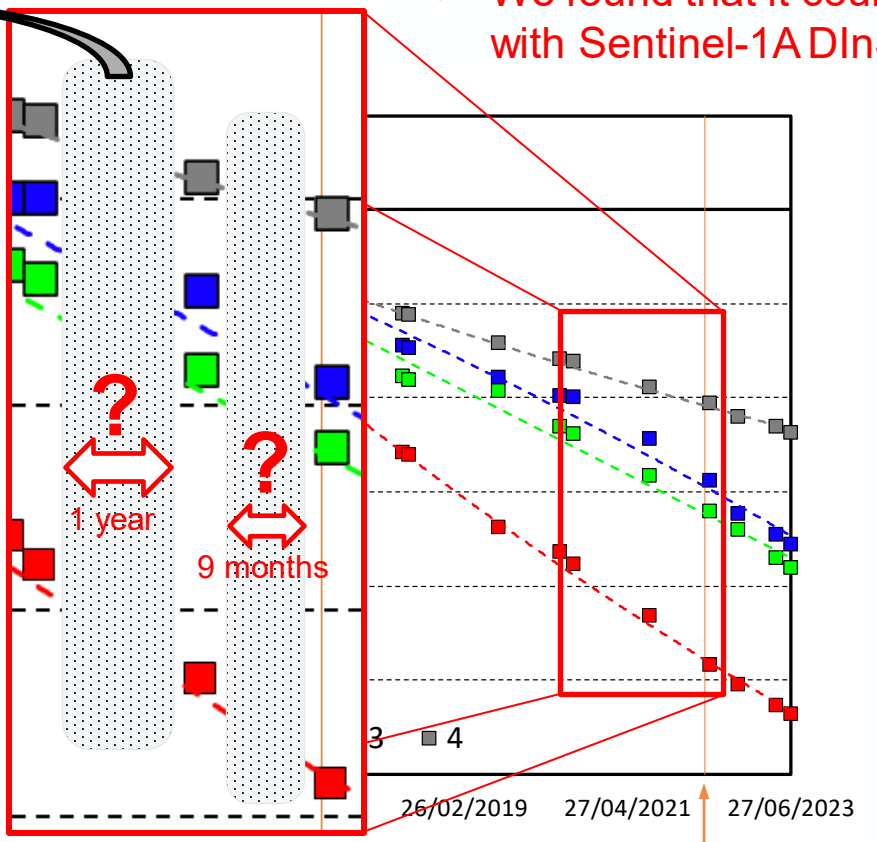
We performed a DInSAR every 1 return (12 days) of Sentinel-1A in 2020 and 2021.
*This area is well known for its heavy snowfall, so we used only data from the non-snow season (May through October).

- The images shown on the left are averaged coherence values greater than 0.5 for the pairs (only 8 of the 28 pairs).

Applying Sentinel-1A data to ALOS-2 SBAS results

Attempt to supplement this period with 8 pairs of Sentinel-1A, which had relatively high coherence.

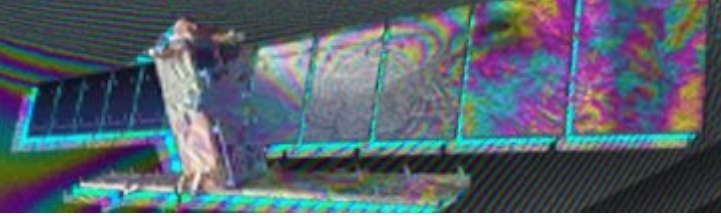




✓ We found that it could be partially supplemented with Sentinel-1A DInSAR analysis.

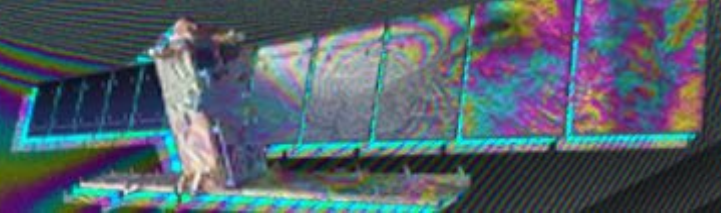
It can be considered that the displacement may have occurred at approximately the same rate during this period.

Conclusion



- A short-term ALOS-2 DInSAR analysis was conducted to investigate the ground deformation caused by slope failure of the Nakatsugawa river that occurred on 9 May 2022. As a result, no trend of displacement was observed after the failure.
- The result of the ALOS-2 DInSAR analysis for August 2020 through May 2022, including the time of slope failure showed displacement in the upper part of the failure area, which could have been caused by landslide.
- A long-term SBAS analysis by ALOS-2 data (October 2014 through June 2023) showed displacement around the disaster area throughout the period. In addition, these results were making for disaster warning by local government.
- In order to detect displacements with high temporal resolution for landslides that occurred in the study area, we examined the possibility of applying Sentinel-1A data to cover the period of time when ALOS-2 did not observe. As a result, we found that interferometric coherence was kept in a part of the pair for one observation cycle and it was possible to use the data for this task, but it was not sufficient, so we plan to continue the study.
- We can use the satellite data for disaster prevention and monitoring as important information. We would like to continue to work on disaster management using satellite data by taking advantage of the benefits of its use.
- We look forward to the upcoming launches of Sentinel-1C/-1D and ALOS-4 for expecting the synergy of C-band and L-band SAR data.

Acknowledgements



We would like to thank Ministry of Land, Infrastructure, Transport and Tourism (especially Dr. Yusuke Takeshima) for supporting our work.

RESTEC

Sense your Earth

Thank you for your attention