

Assessing Earthquake Disaster Using ALOS PALSAR and Aerial Photographs: A Case Study of the Iwate-Miyagi Nairiku Earthquake in 2008

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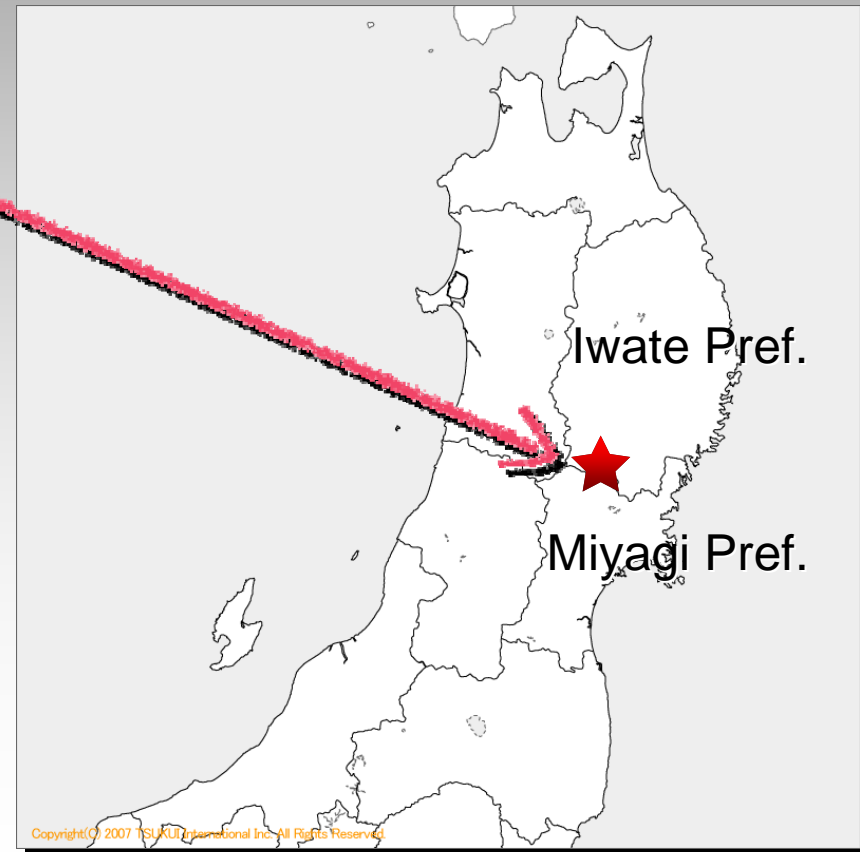
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Outline

- “Iwate-Miyagi Nairiku Earthquake in 2008”
- Aerial Survey
- ALOS/PALSAR Pixel-Offset
- Result & Summary

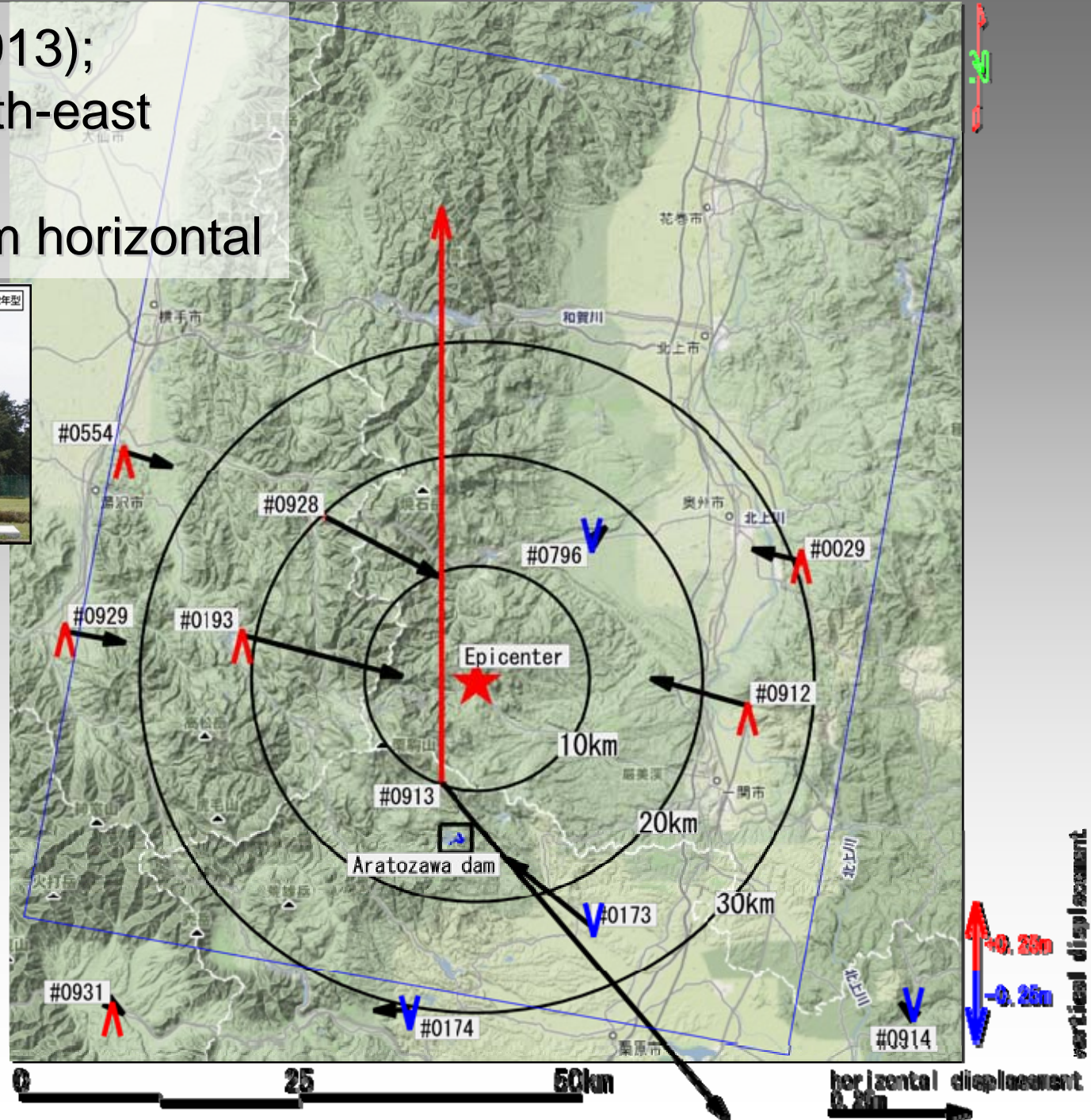
Iwate-Miyagi Nairiku Earthquake in 2008

- 14 June, 2008, $M_{JMA} = 7.2$, hypocenter depth= 8km
- 23 people death or missing
- 448 people injured
- Over 1,000 of buildings partially or completely collapsed



GPS network (GEONET)

- Near the epicenter (#0913);
2m uprising, 1.6m south-east
- Other places;
>0.1m vertical and 0.3m horizontal



Aerial Survey ~ Aircrafts~

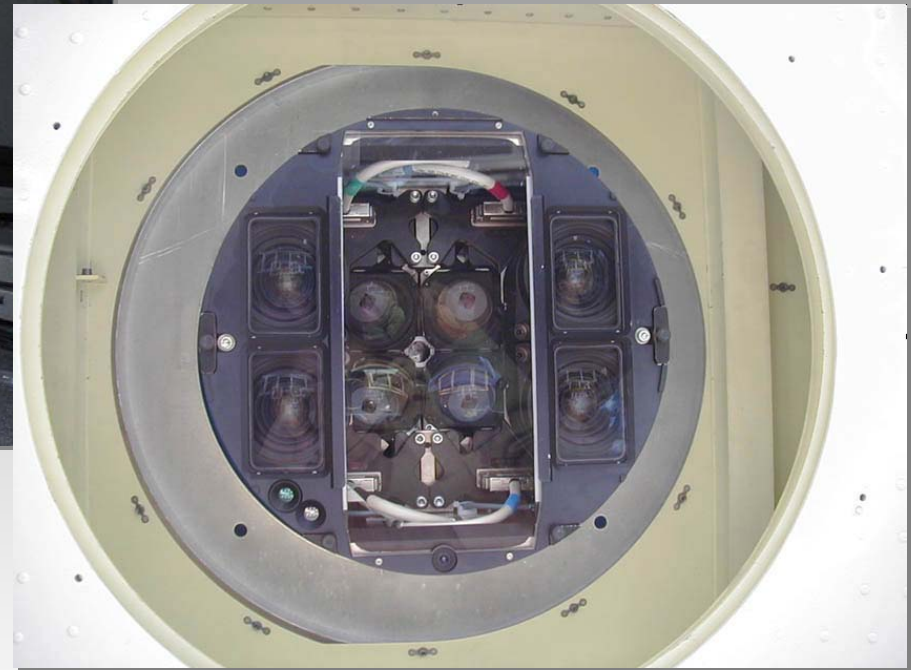


Gulfstream Commander 695



Cessna 208

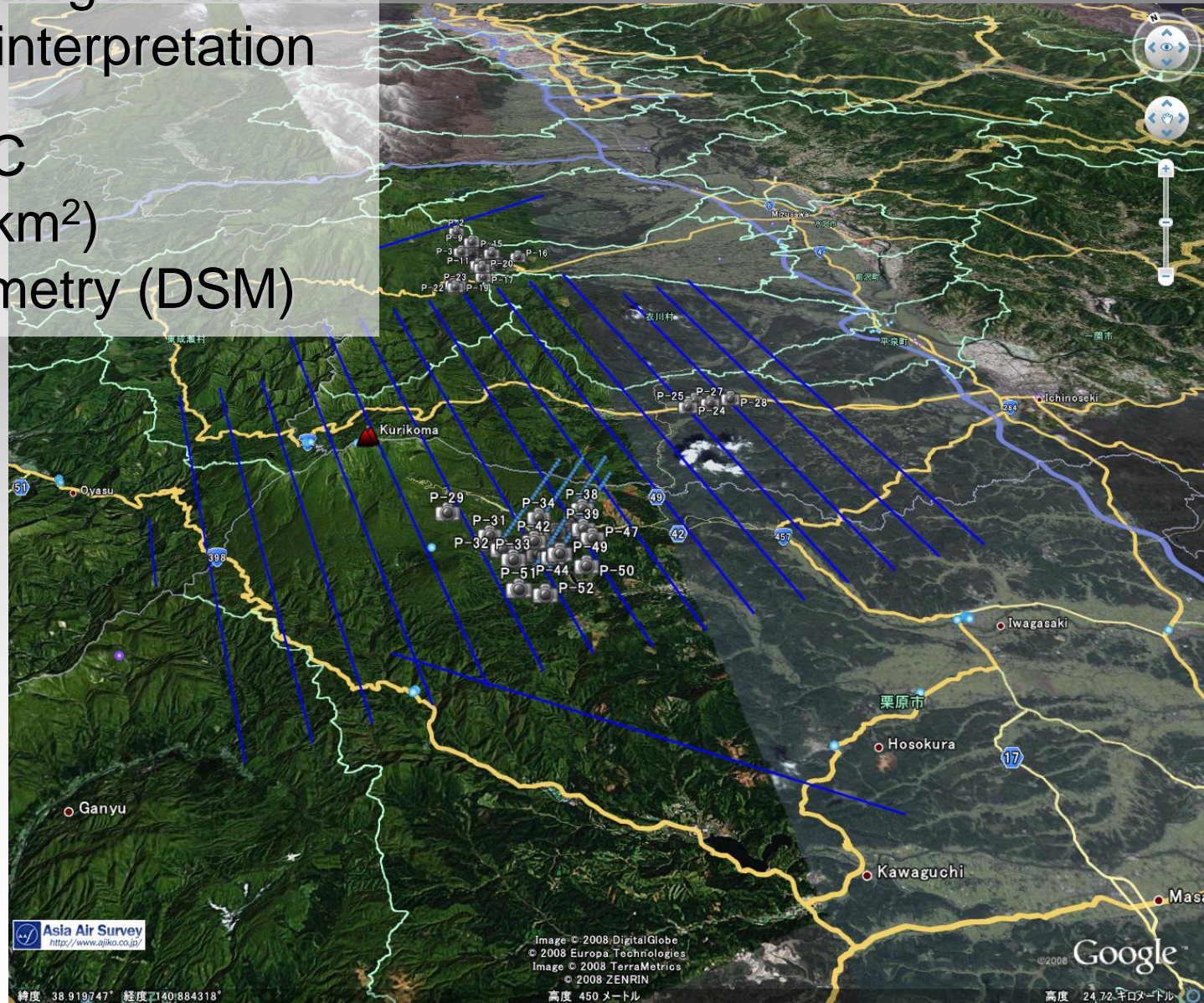
Aerial Survey ~Digital Mapping Camera (DMC)~



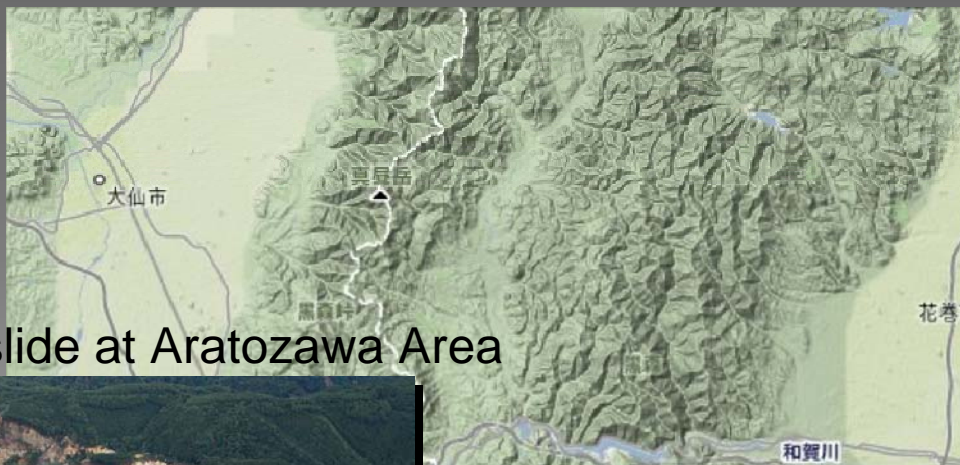
- Panchromatic image; 106 million pixels (13,824 x 7,680)
- Visible and NIR image: 6million pixels (3,072 x 2,048)
- Dynamic range: 12bit

Survey Area

- June 15 ~ 16, 2008
- 18 flight lines for analogue camera
683.4km² -> Photo interpretation
- 4 flight lines for DMC
Aratozawa area (10km²)
-> Aerial Photogrammetry (DSM)

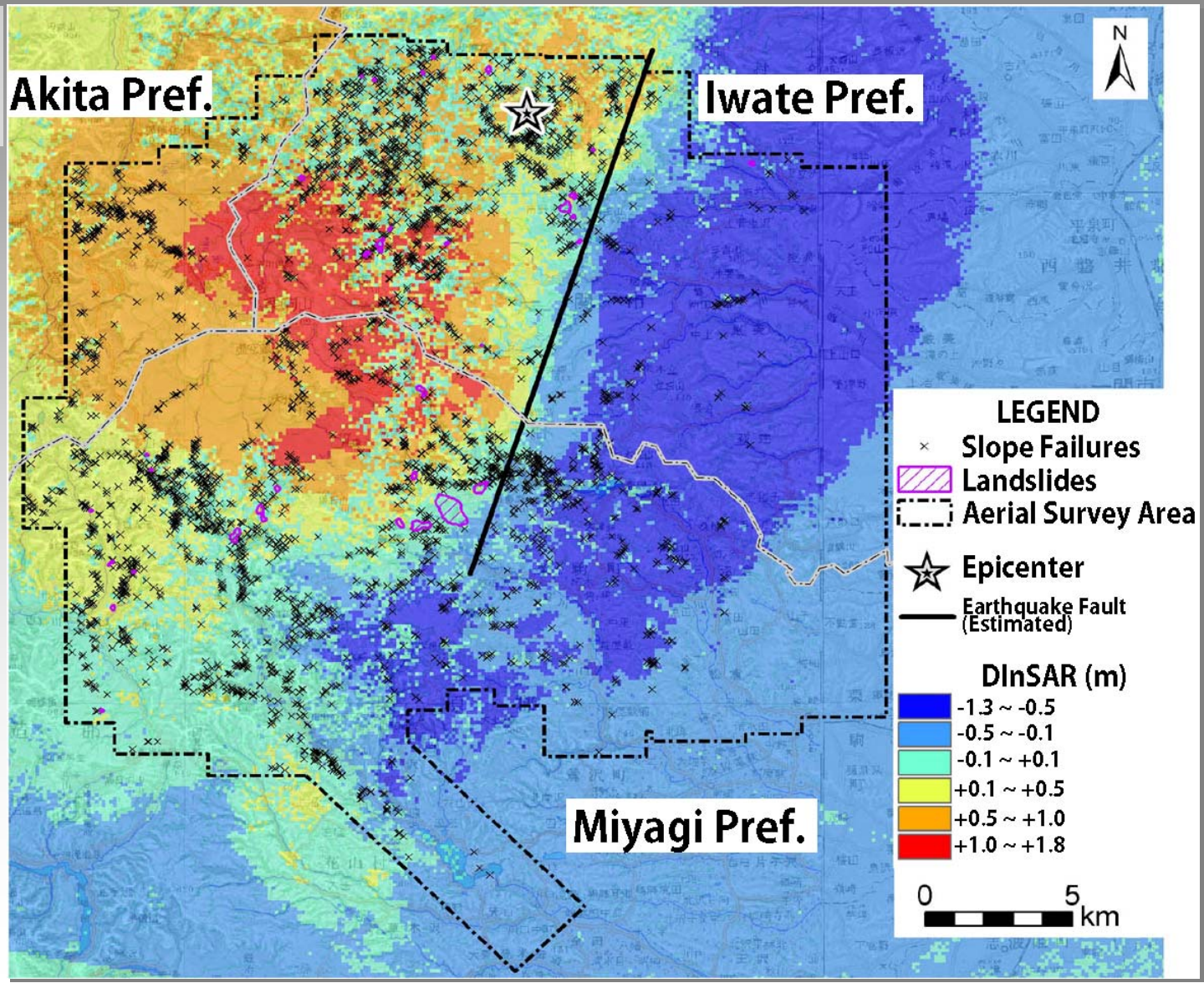


Massive Landslide at Aratozawa Area



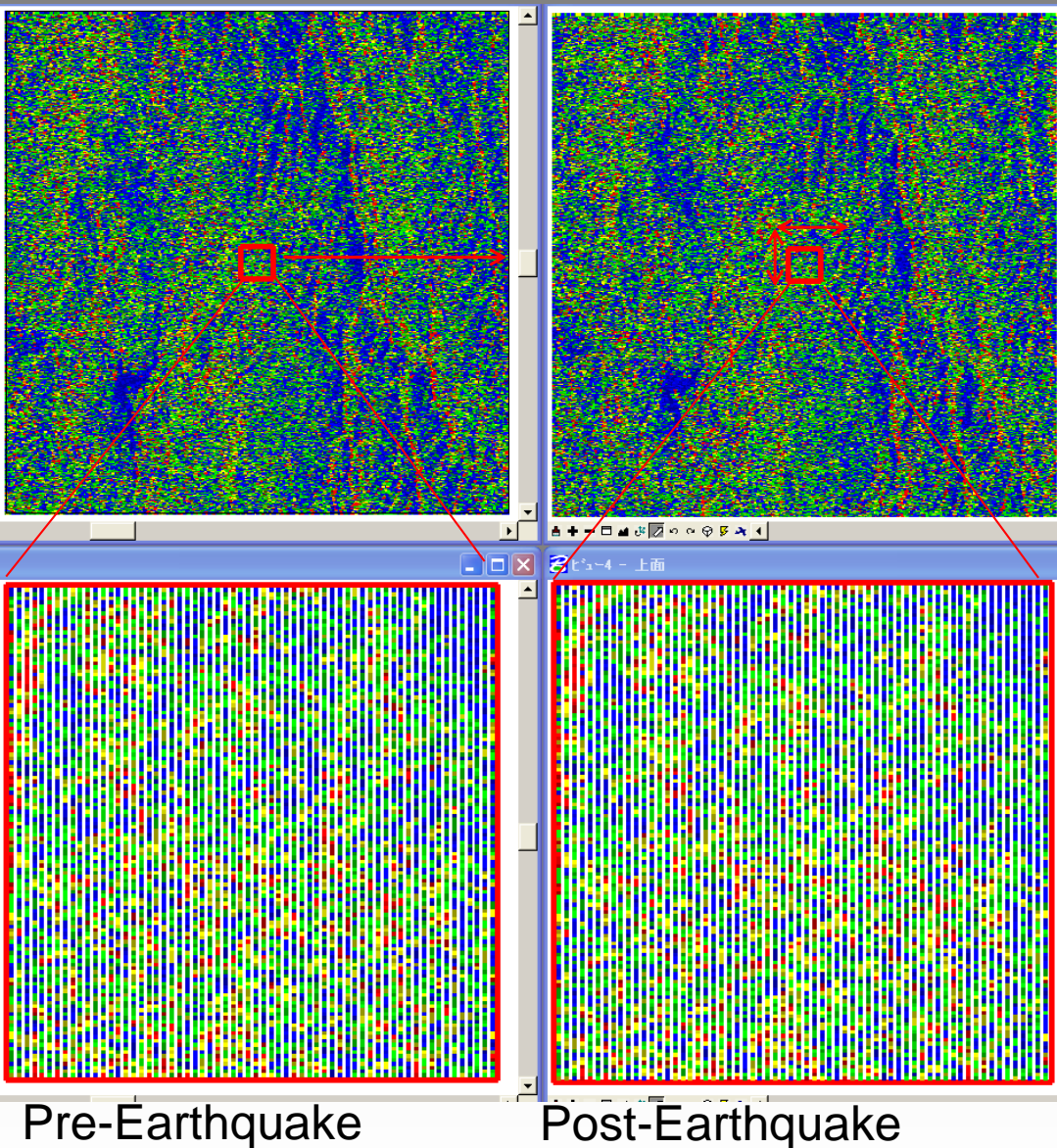
Aerial Photo Interpretation

- Slope failure: 2,975
- Landslide: 37

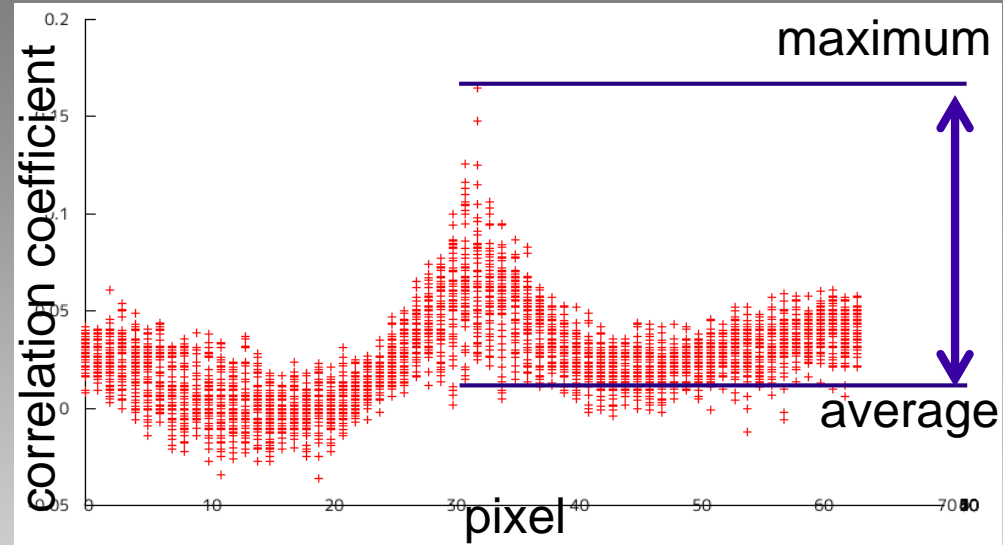


SAR pixel-offset method

SAR Intensity Images and Moving Window



Correlation Coefficient and Local Pixel Offset



Correlation Coefficients Inside a Moving Window

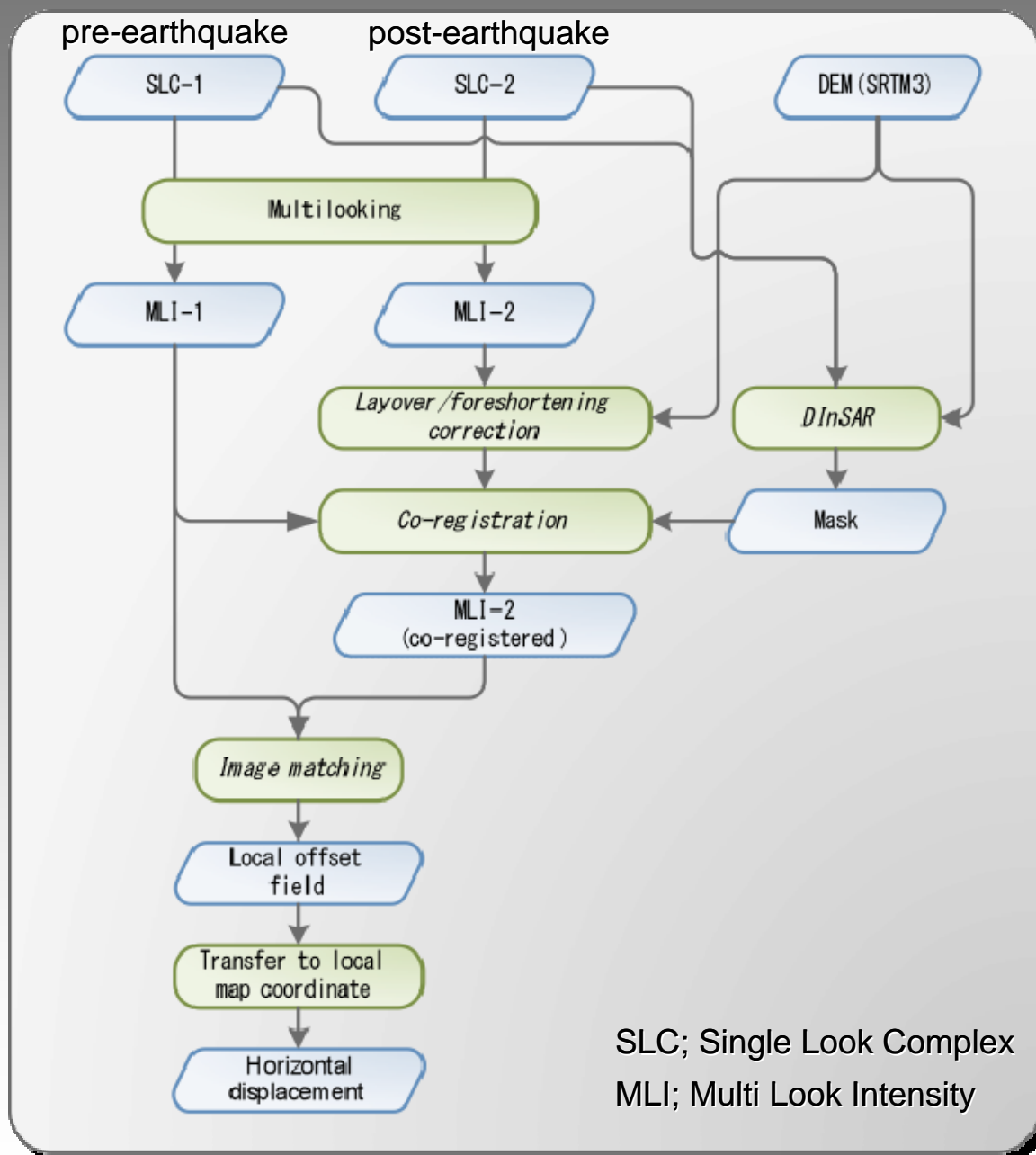
$$\rho(u, v) = \frac{\sum_i \sum_j [X(i, j) - \bar{X}] [Y(i, j) - \bar{Y}]}{\sqrt{\sum_i \sum_j [X(i, j) - \bar{X}]^2} \sqrt{\sum_i \sum_j [Y(i, j) - \bar{Y}]^2}} \dots (1)$$

X : Intensity of pre-earthquake SAR image

Y : Intensity of post-earthquake SAR image

i, j : Range and azimuth position of SAR images

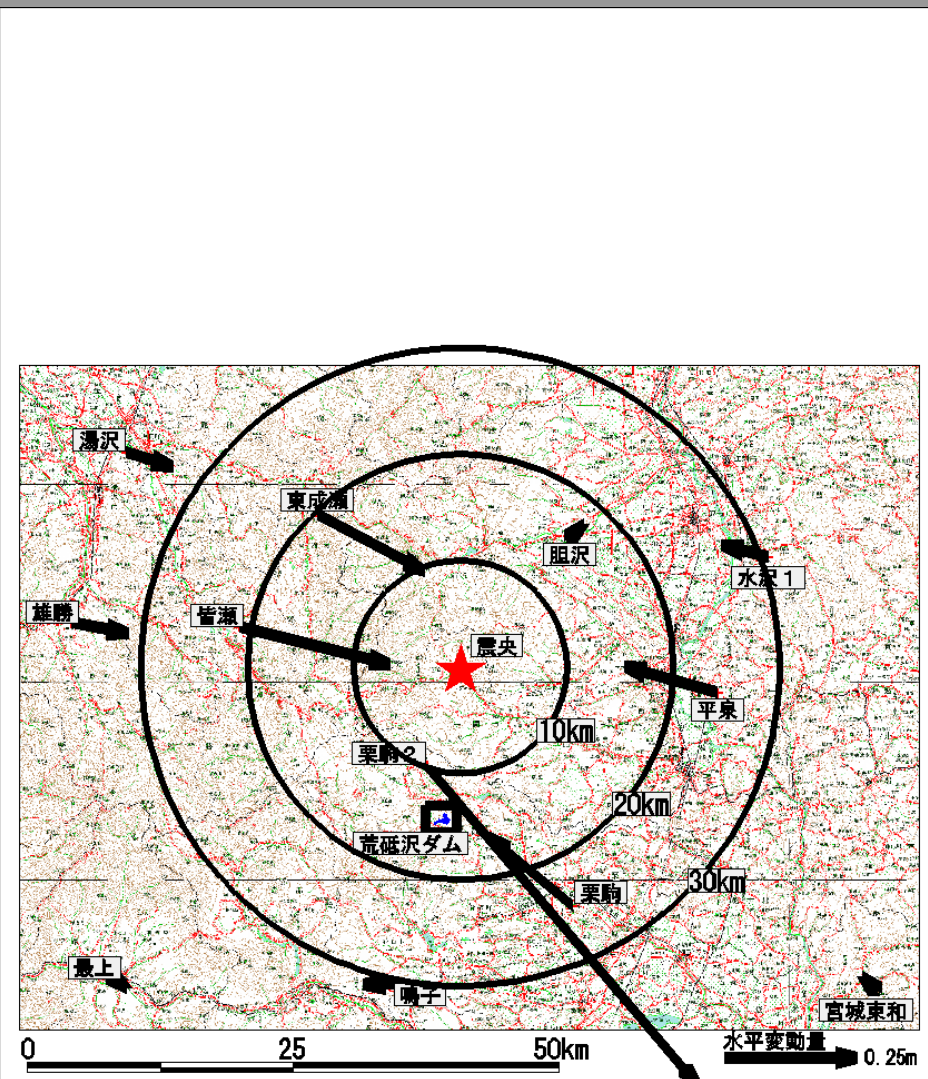
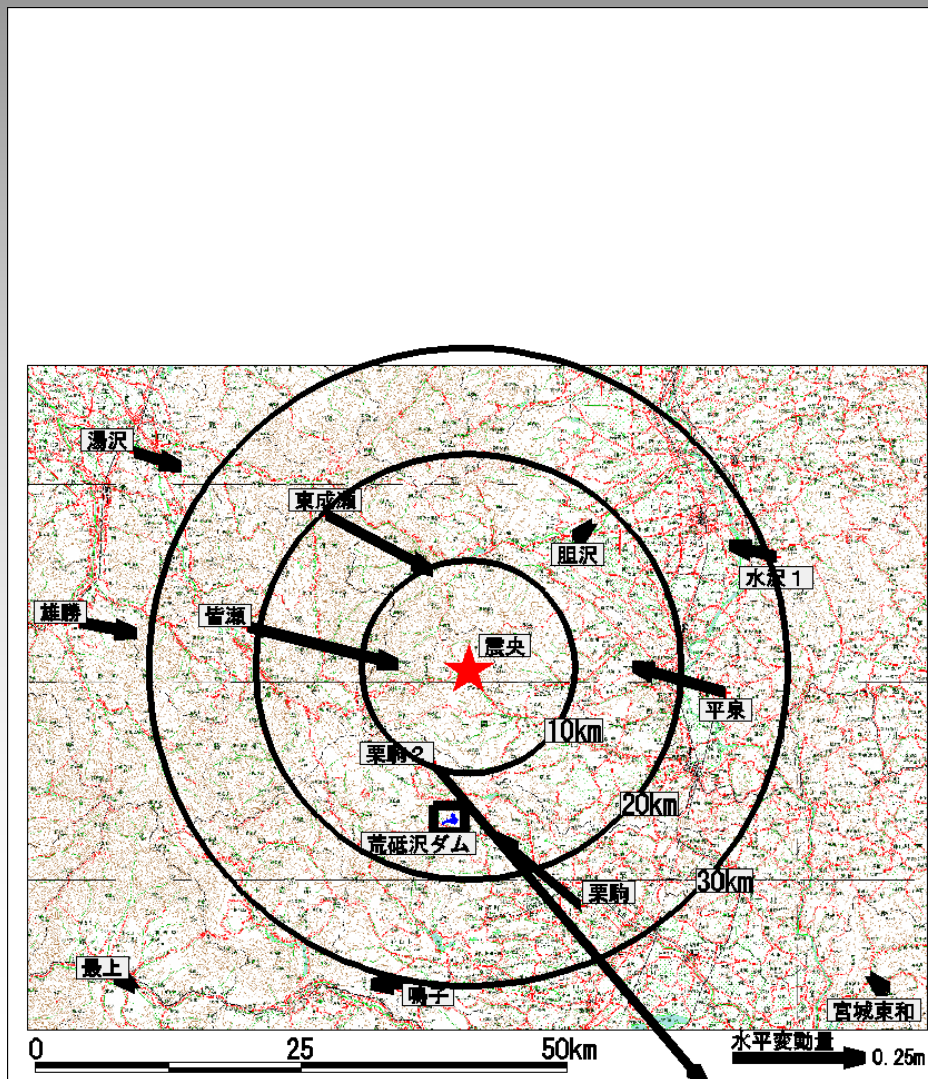
Processing Flow



ALOS/PALSAR Data Set

| date | mode | latitude longitude | path | frame | column line |
|---------------|-------------------|-----------------------|------|-------|----------------|
| Aug. 27, 2007 | HH / FBS Dec | 39.137 140.941 | 57 | 2830 | 14100 3925 |
| Jun. 14, 2008 | Earthquake | | | | |
| Jul. 16, 2008 | HH / FBS Des | 39.122 140.950 | 57 | 2830 | 14100 3900 |

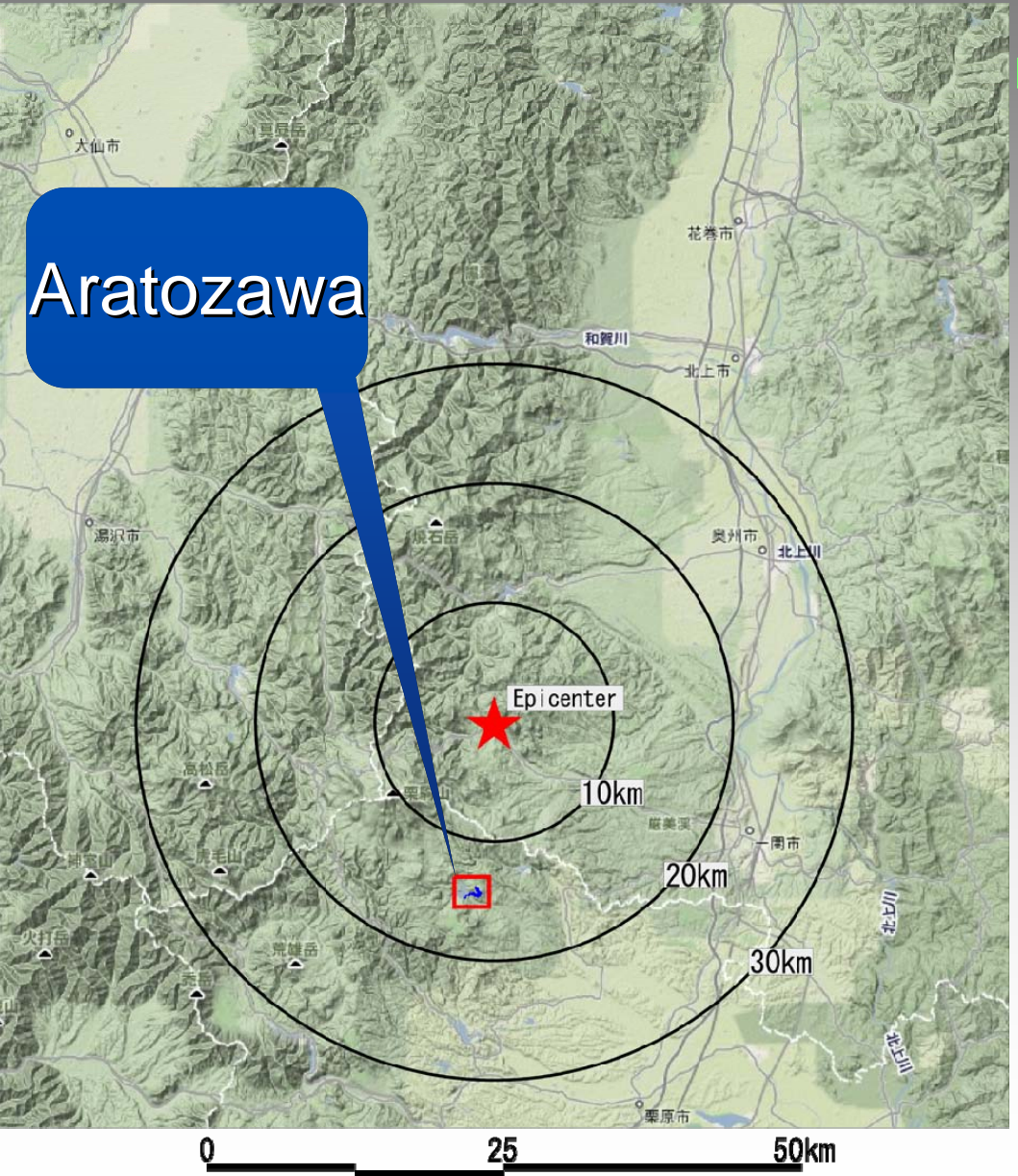
Processing Result



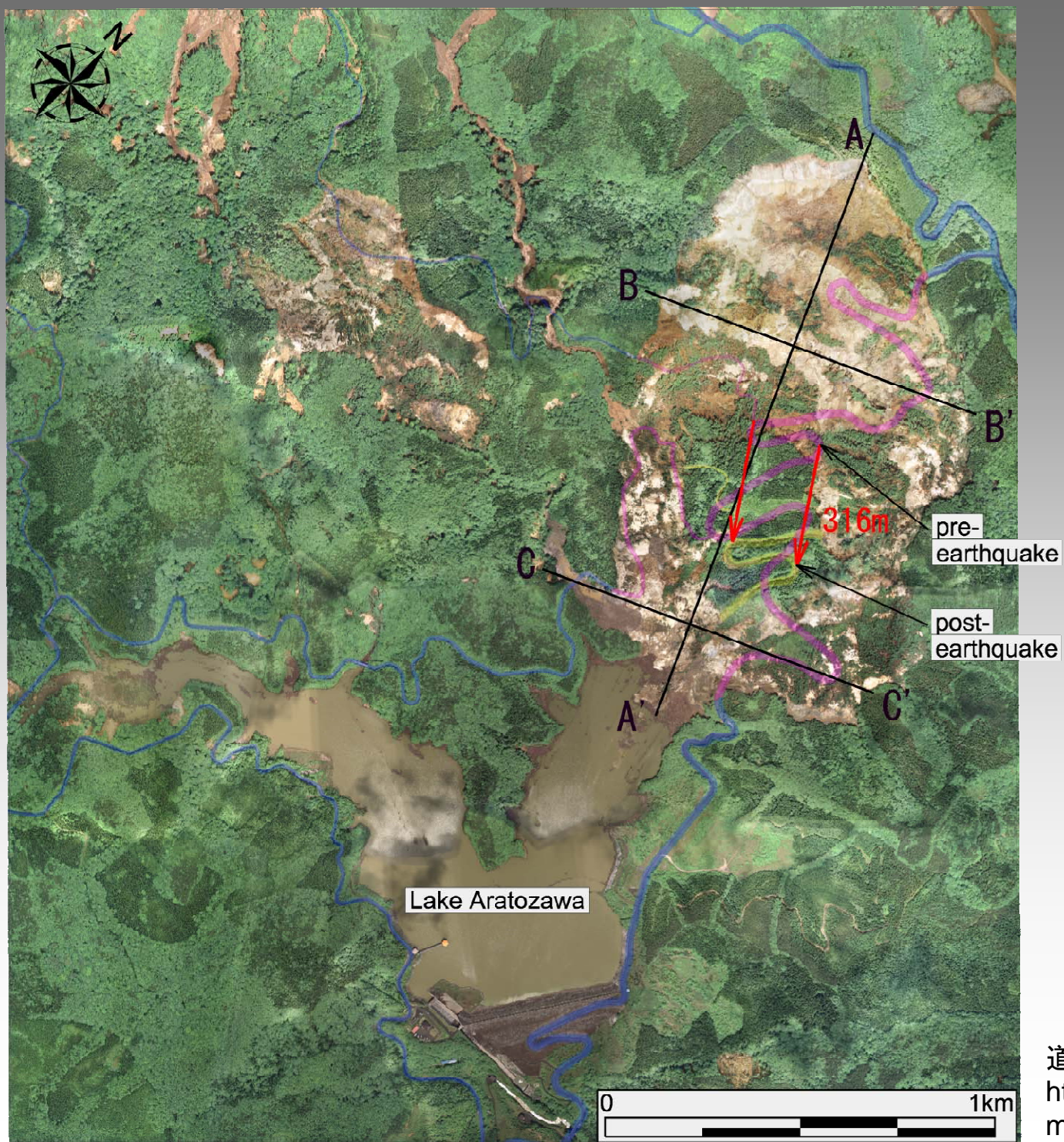
Comparison with GEONET

| Station # | GEONET | | SAR average | | SAR-GEONET | |
|-----------|---------------|---------------|---------------|---------------|---------------|---------------|
| | $\Delta E(m)$ | $\Delta N(m)$ | $\Delta E(m)$ | $\Delta N(m)$ | $\Delta E(m)$ | $\Delta N(m)$ |
| 0029 | -0.087 | 0.021 | 0.5 | -0.2 | 0.6 | -0.2 |
| 0796 | 0.025 | 0.025 | -0.6 | 0.3 | -0.6 | 0.3 |
| 0912 | -0.174 | 0.048 | 0.4 | 0.5 | 0.6 | 0.4 |
| 0173 | -0.155 | 0.127 | 0.0 | 0.3 | 0.2 | 0.2 |
| 0174 | -0.064 | -0.001 | 0.6 | 0.3 | 0.7 | 0.3 |
| 0913 | 1.015 | -1.199 | 1.4 | -2.3 | 0.3 | -1.1 |
| 0193 | 0.284 | -0.073 | -0.2 | 0.4 | -0.4 | 0.4 |
| 0554 | 0.086 | -0.027 | 0.5 | -1.6 | 0.4 | -1.6 |
| 0928 | 0.200 | -0.106 | 0.5 | 0.2 | 0.3 | 0.3 |
| RMSE | | | | | 0.5 | 0.7 |

Aratozawa Area ~ Massive Landslide ~

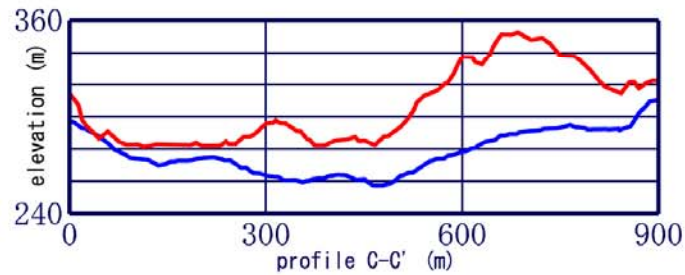
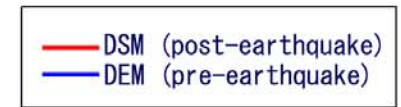
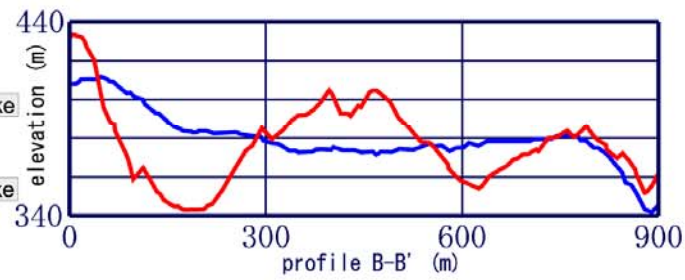
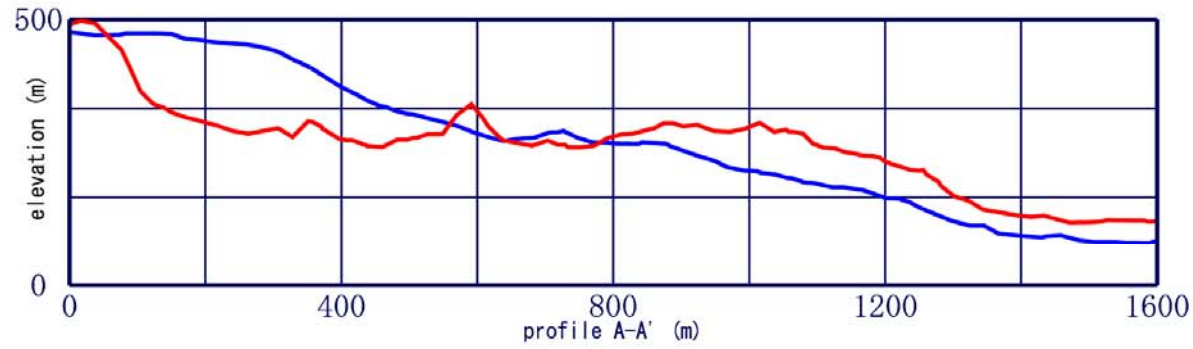
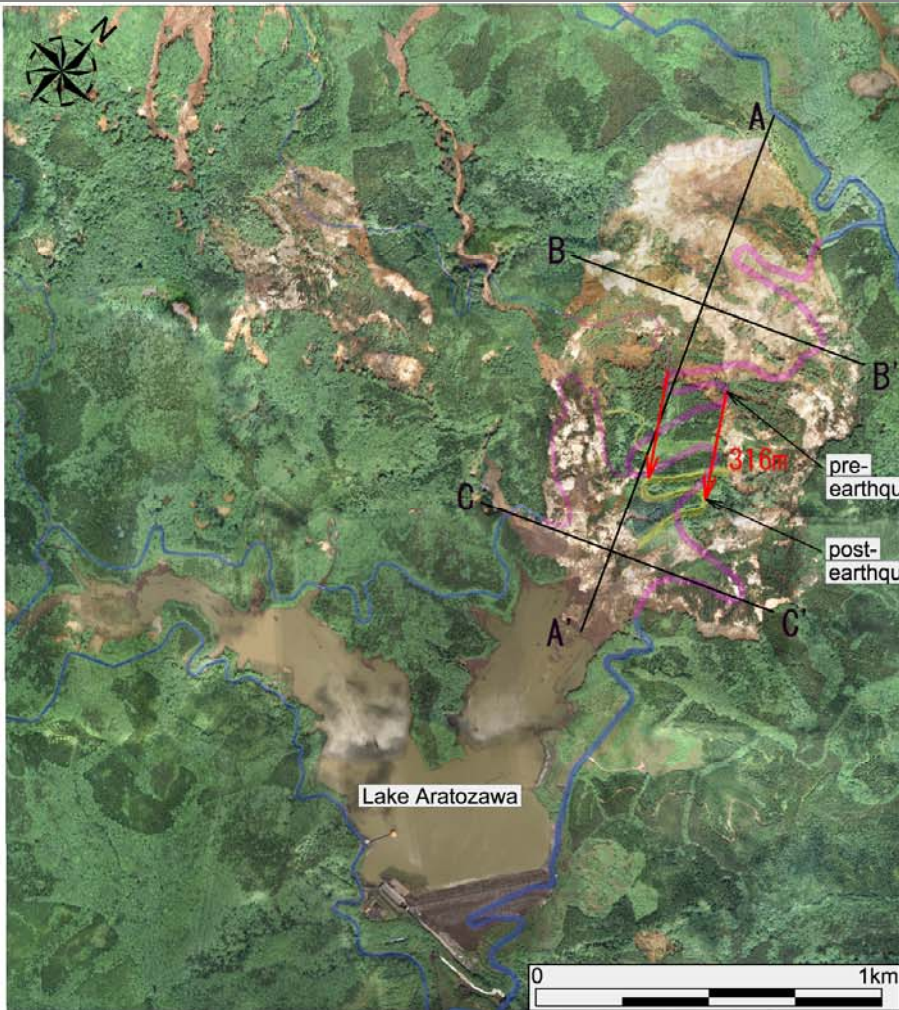


Aratozawa Area ~ Massive Landslide ~



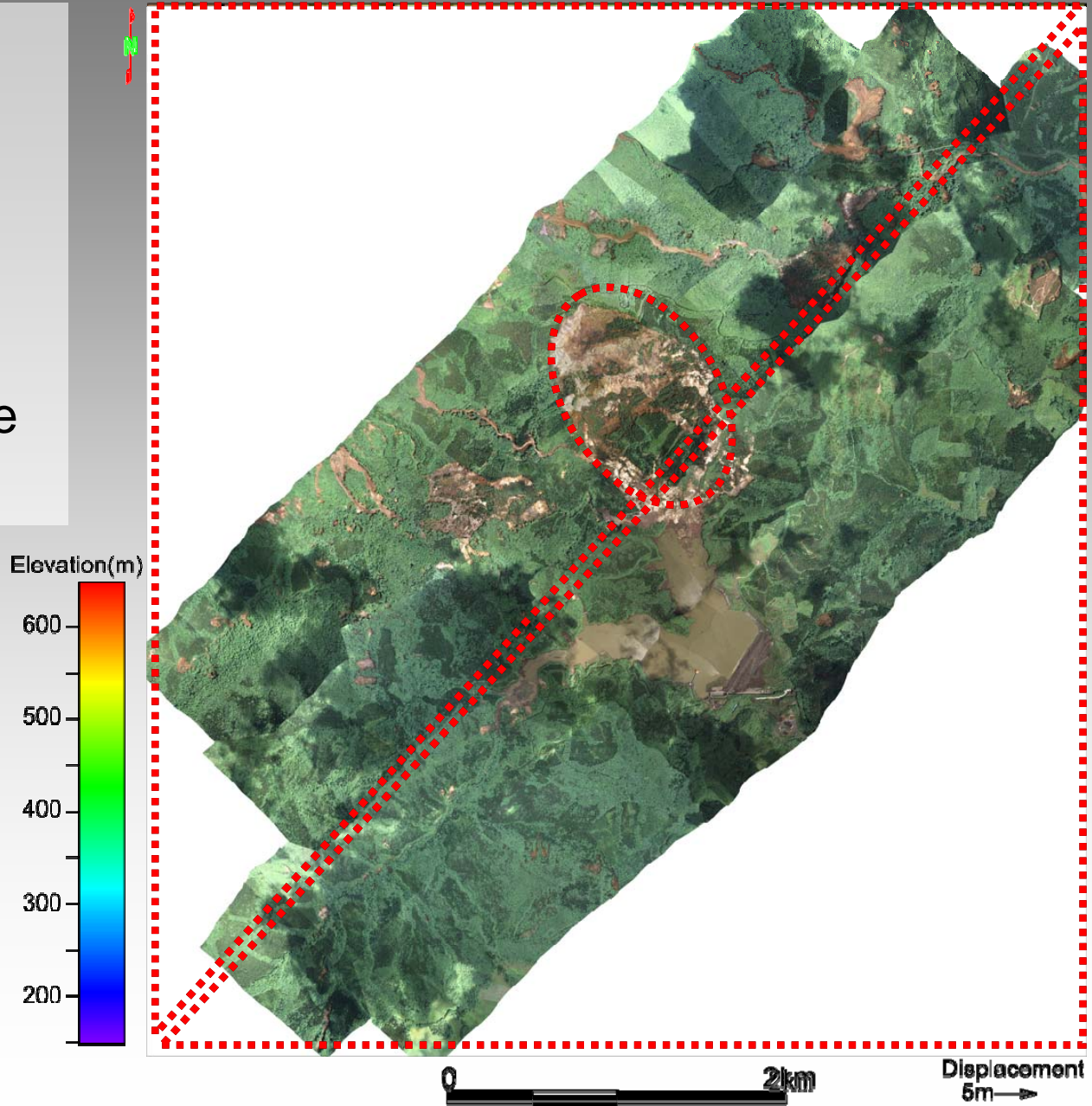
道路位置は基盤地図情報より引用
<http://www.gsi.go.jp/kiban/index.html>

Aratozawa Area ~ Massive Landslide ~



Pixel-Offset Result

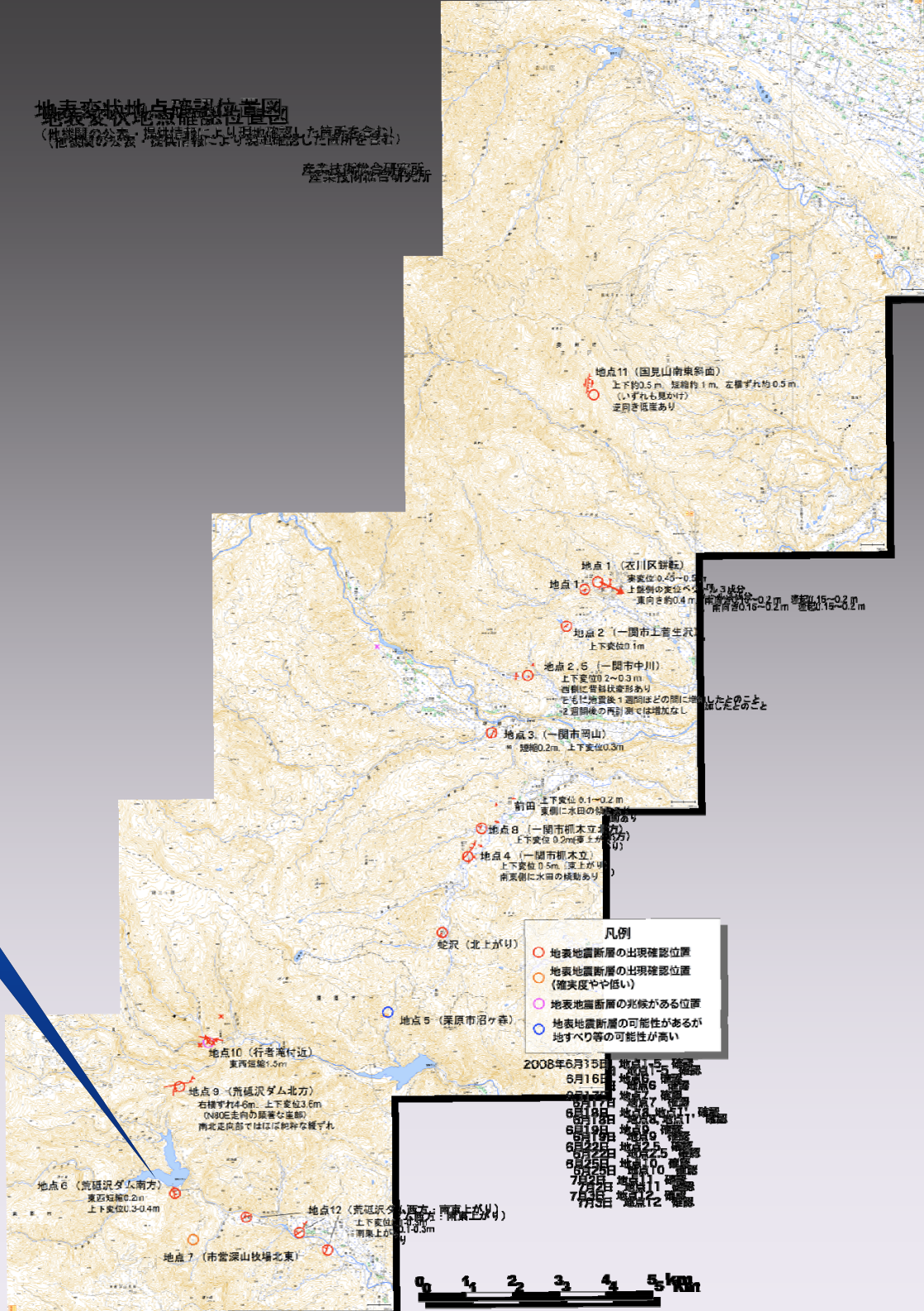
- North-West zone:
3 ~ 4m South-East-bound
- South-East zone:
Lower than 1m
- Massive landslide could not be detected



Other Research Ground Survey (AIST AFERC 2008)

地表変位地点確認位置図
 地表変位地点確認位置図
 (他機関の公表、提供情報により変更された箇所を含む)
 産業技術総合研究所

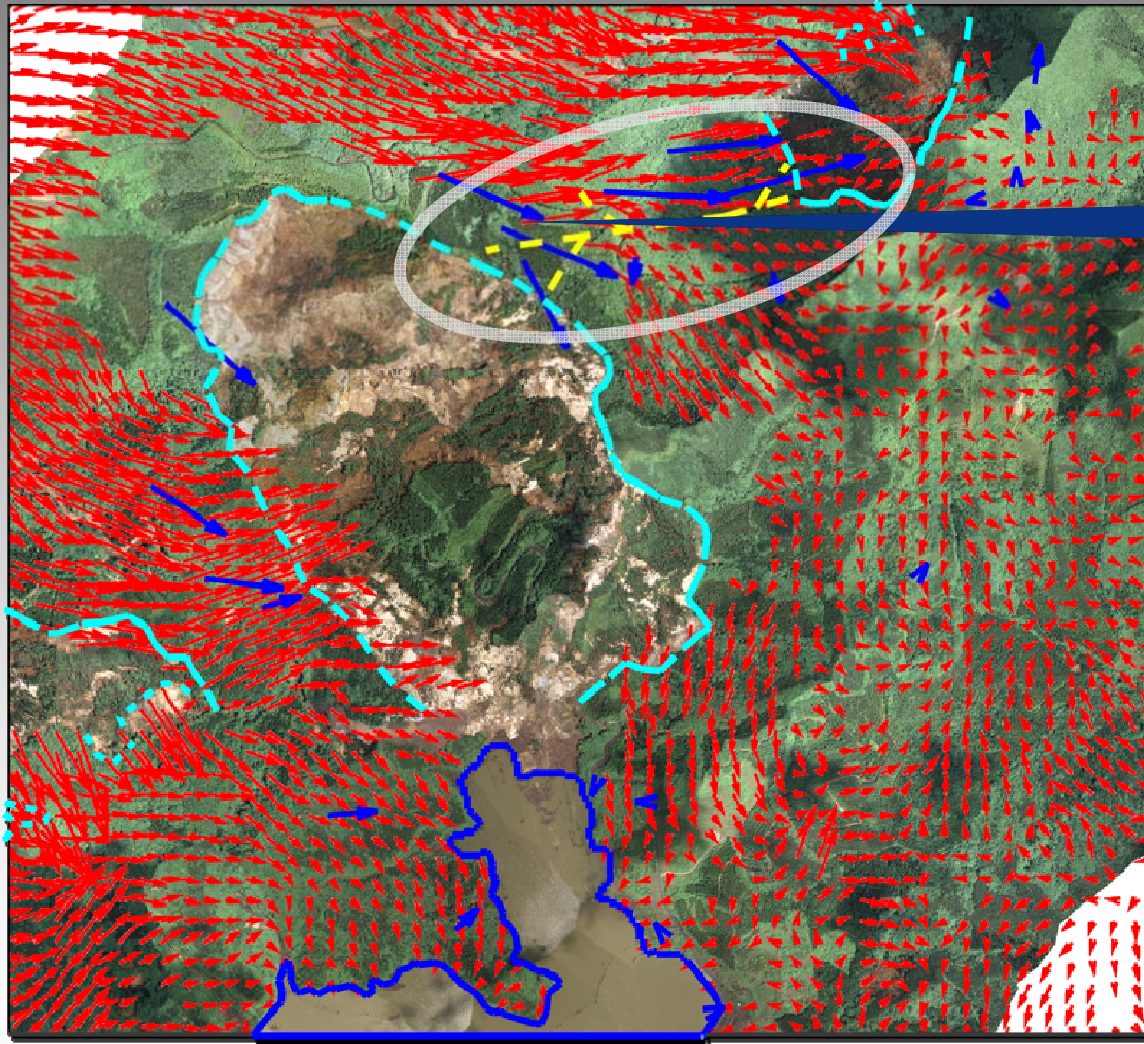
Aratozawa




Comparison with other researches

Fault scarp

- Ground survey (AIST, 2008) uplifting 3.6m east-bound 4 - 6m
- SAR Pixel-Offset (this study) east-bound 3 - 4m



- - - - - - fault scarp(AIST, 2008)
- - - - - - landslide and slope failure
-  water

displacement (m)

- 5m  blue: aerial photo (Kamiya et al.,2008)
- 5m  red: SAR



Other Research

Aerial Photogrammetry (Kamiya et al., 2008)

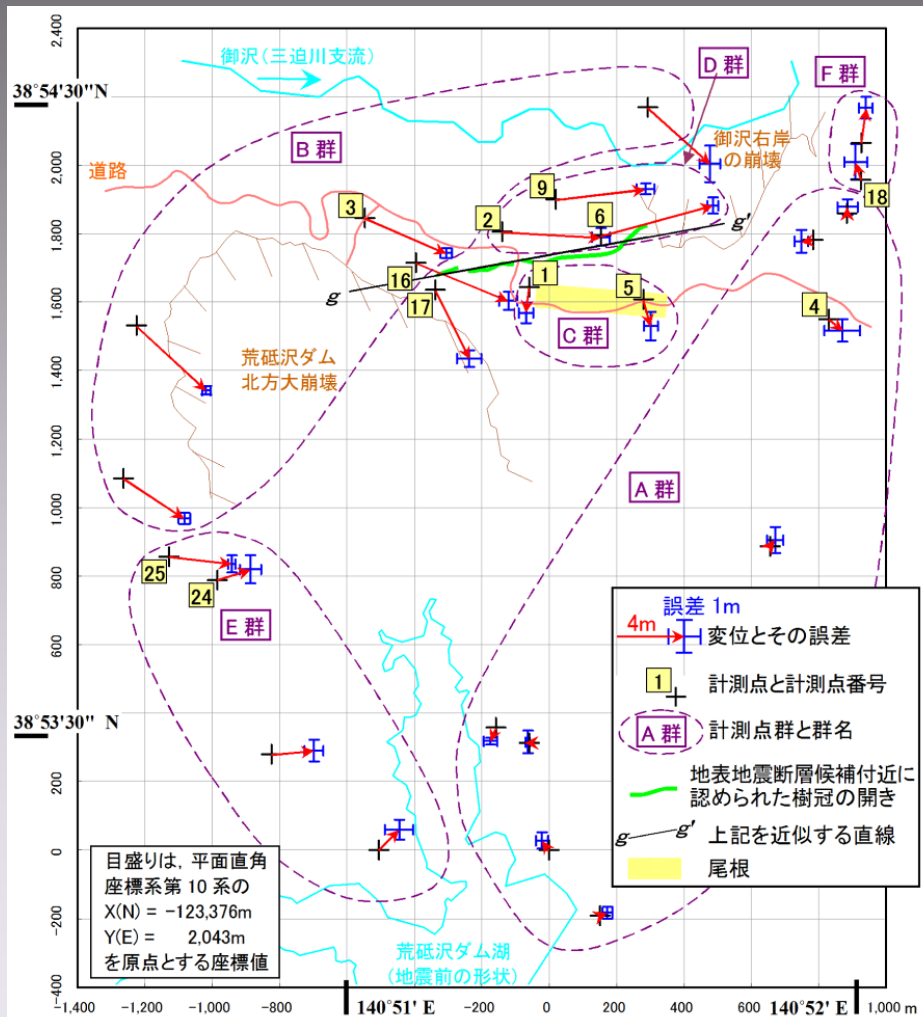
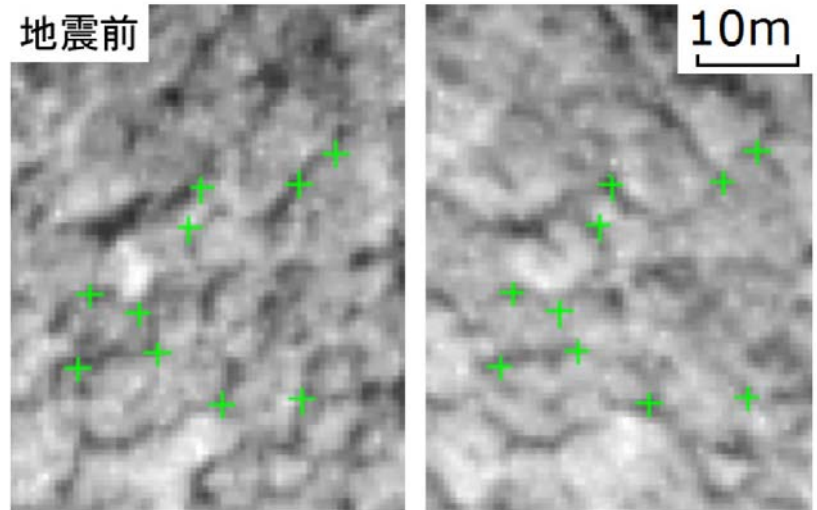
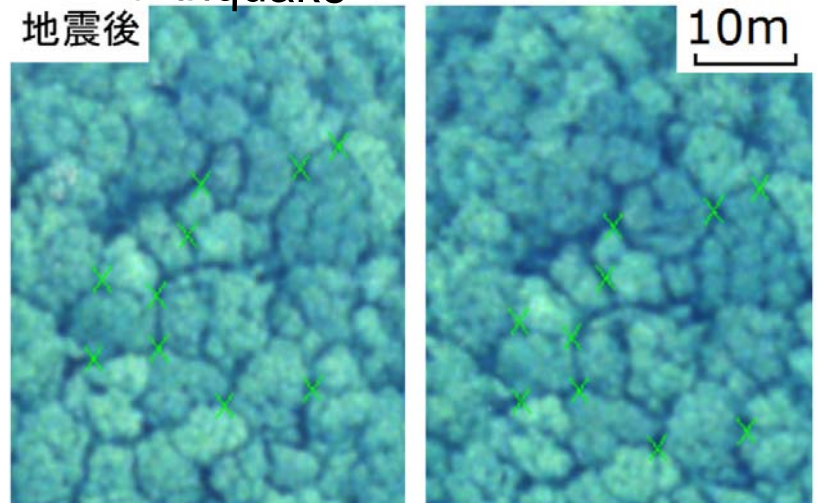


図3 水平変位量の計測結果

pre-earthquake



post-earthquake



Comparison with other researches

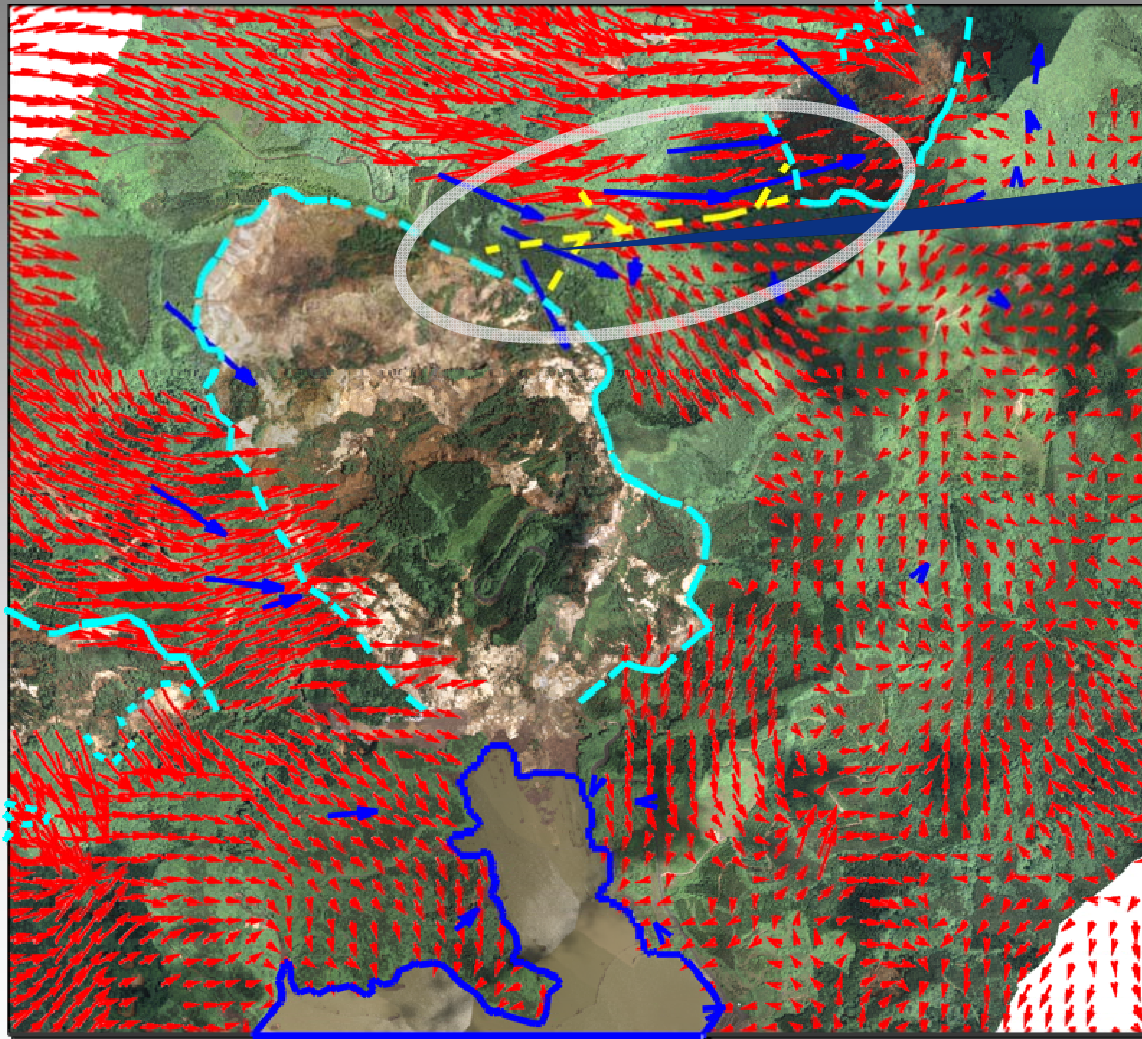
Fault scarp

Aerial photo (Kamaya et al. 2008)

- east-bound 6.2 - 6.7m

SAR image correlation (this study)

- east-bound 3 - 4m



----- fault scarp(AIST, 2008)

----- landslide and slope failure

----- water

displacement (m)

5m — blue: aerial photo
(Kamaya et al.,2008)

5m — red: SAR



Summary

We assessed earthquake disaster by SAR Pixel-Offset method and Aerial Survey,

- 2,975 slope failures and 37 landslides were newly founded by aerial photo interpretation.
- The minimum detectable magnitude of SAR Pixel-Offset (ALOS/PALSAR FBS mode) is about 1m.
- Estimated displacement has good consistency with other results in direction and position.
- Magnitude is smaller than the other results.
- Massive landslide could not be detected with this method.

ACKNOWLEDGEMENTS

- The ownership of original ALOS/PALSAR data belongs to METI (Ministry of Economy, Trade and Industry) and JAXA (Japan Aerospace Exploration Agency).
- GEONET data, 50m gridded DTM, other GIS data are provided by GSI (Geographical Survey Institute of Japan).
- AIST AFERC (National Institute of Advanced Industrial Science and Technology Active Fault and Earthquake Research Center) has published useful field research information.

Thank you for your time



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