# Structural and Non-structural Measures Against Sediment Disasters

Prevention and Mitigation of Natural Disasters

## Structural

- Anti-seismic construction
- Development of a bank
- Development of a dam
- Improvement of a drainage pipe, etc.

**Sediment disaster countermeasures**
**Countermeasures against debris flow, landslide, slope failure, etc.**

- We do not know when structural measures become necessary even if it takes a vast amount of cost to build them. However, the disaster mitigation effect is immediate.
- It is not resilient against a disaster if the scale and intensity of the disaster exceeds assumptions and predictions
- Along with the expansion of human activities, the dangerous sites requiring measures increased, and the development is unable to keep up the pace.

## Non-structural

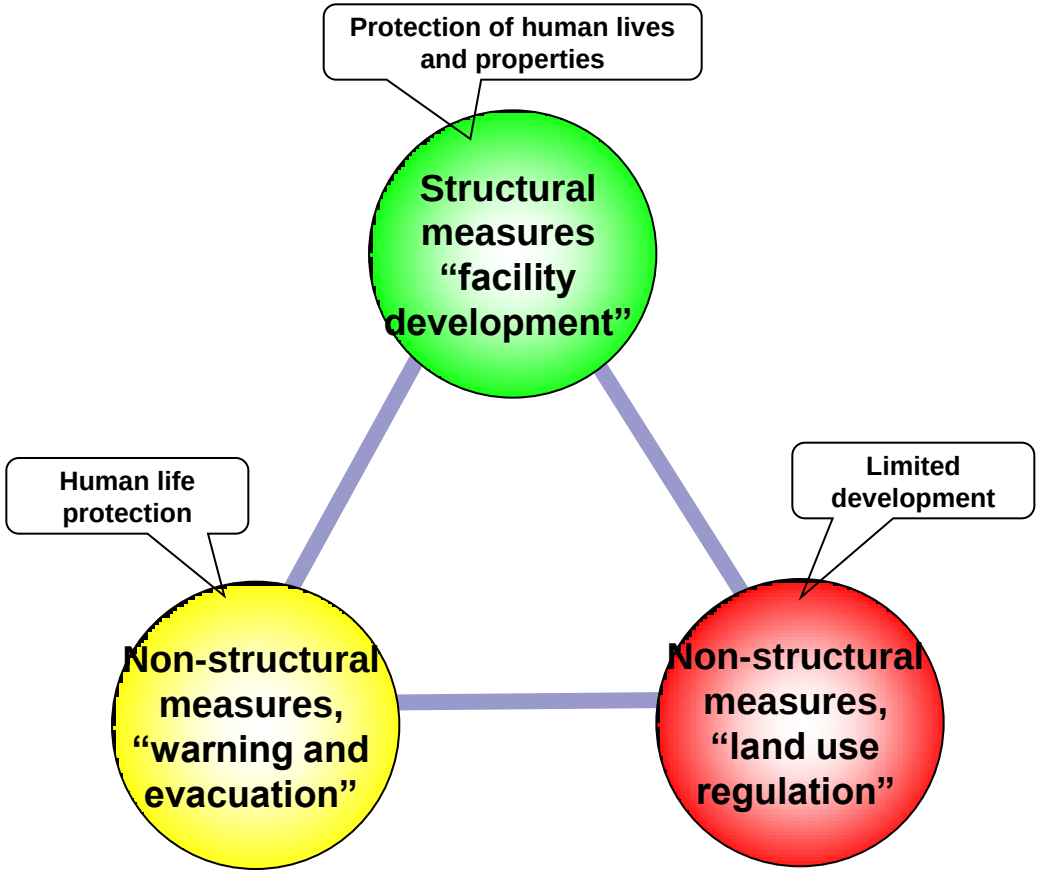
- Emergency response plan
- Hazard map
- Real-time disaster information
- Emergency measures
- Evacuation

**Measures against sediment disasters**
- Provision of information on sediment disaster prone sites and sediment disaster alert areas
- Setting up criteria for warning and evacuation
- Development of an information provision system, Development of a warning and evaluation system, such as information provision on evacuation methods and evaluation area, etc.

- Costs less than structural measures but the disaster mitigation effect does not occur unless the users understand and use the measures.
- Technical development (making information more advanced, detailed and real time) is not necessarily linked to disaster mitigation.
- Damage mitigated by disaster information is limited.

# Three pillars of sediment-related disaster prevention

1) Structural measures protecting human lives and properties, "**facility development**"
2) Non-structural measures protecting human lives through evacuation, "**warning and evacuation**"
3) Non-structural measures limiting new housing development in sediment-related disaster hazard areas, "**land use regulation**"



## Structural Measures

- Sabo works
- Steep slope failure prevention project
- Landslide prevention project

# Sediment control projects (sediment disaster measures)

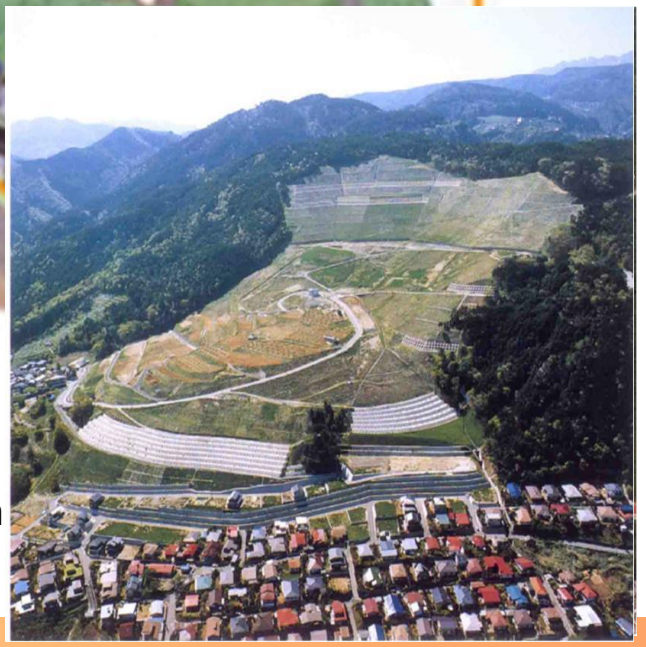
## Structural measures

Debris flow measures



Slope failure prevention measures

Landslide prevention measures



# Acts on prevention of sediment disasters

## ■Sabo Act

The Sabo Act was established in 1897 with an aim to restrict harmful actions within erosion control designated areas and to develop erosion control facilities, etc.

## ■Landslide Prevention Act

The Landslide Prevention Act was established in 1958 with an aim to prevent damage from landslides and thus contribute to the preservation of national land and stabilization of the people's livelihoods.

## ■Act on Prevention of Disasters Caused by Steep Slope Failure（Steep Slope Act）

The Act on Prevention of Disasters Caused by Steep Slope Failure（Steep Slope Act）was established in 1969 with an aim to protect people's lives from disasters caused by slope failure.

# Sabo projects

## What is erosion control project?

Developing erosion control facilities, such as erosion control dams and groundsills, in the basin areas designated as erosion control areas in order to preserve wasteland surrounding the mountain area and protect lives and properties of the residents from sediment disasters

## What is sabo designated Area?

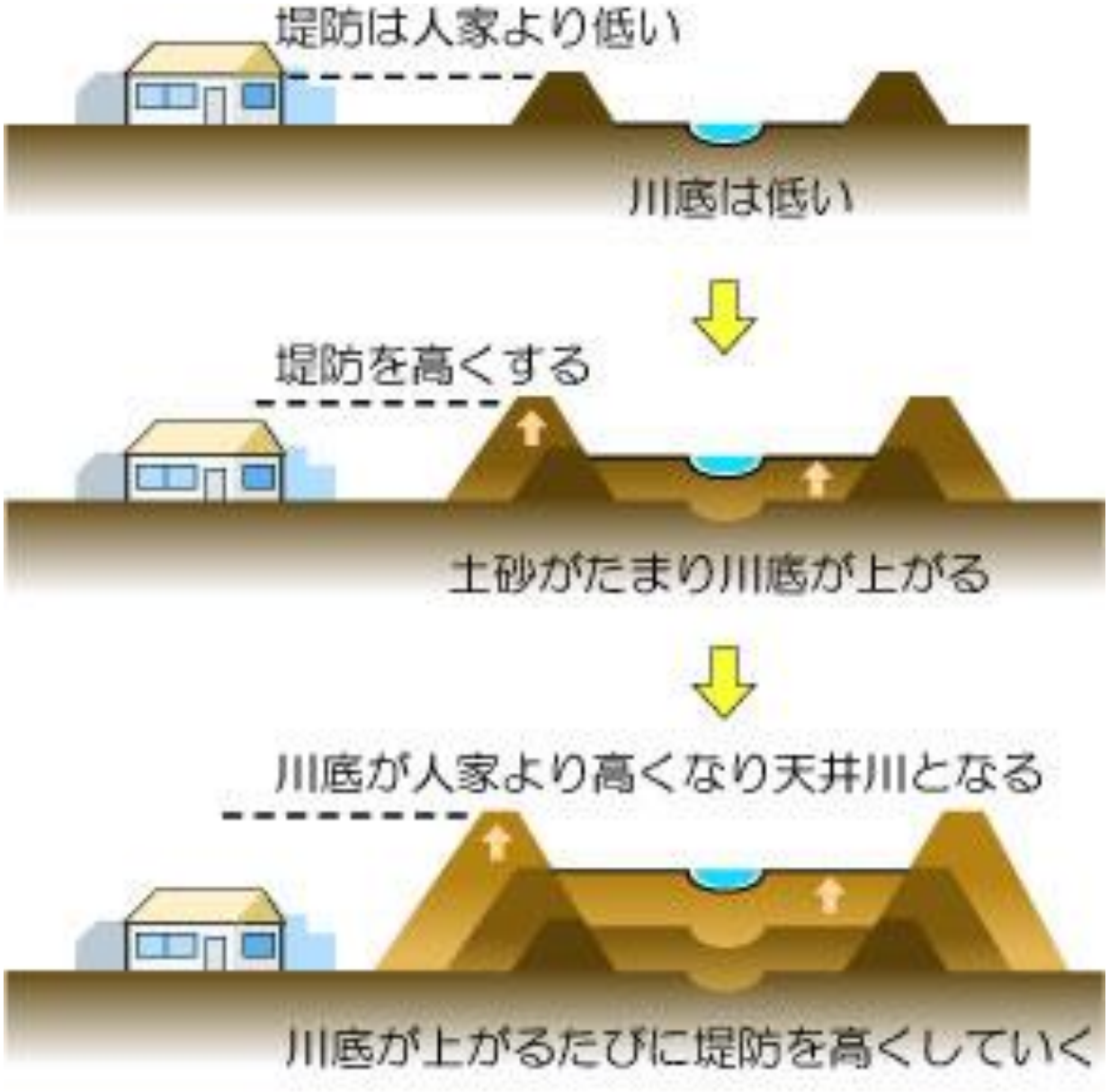
Pursuant to these Act (enforcement on March 30, 1897), the Minister of Land, Infrastructure, Transport and Tourism shall designate land requiring the development of erosion control facilities to prevent sediment from flowing into the downstream areas and land requiring prohibition or restriction of certain acts to prevent degradation of mountainous areas as Erosion Control Areas.

## Restricted actions in sabo designated Areas

Authorization from prefectural governor is required for the following:

1. Construction, renovation, transfer or removal of facilities or work pieces,
2. Cutting of trees and bamboo or transporting them by sliding or dragging,
3. Drilling, reclamation, raising the ground level and other acts of changing the shape of the land,
4. Collection, accumulation or disposal of sediment or gavel,
5. Exploitation, accumulation or disposal of minerals,
6. Digging up grass, and
7. Weed burning

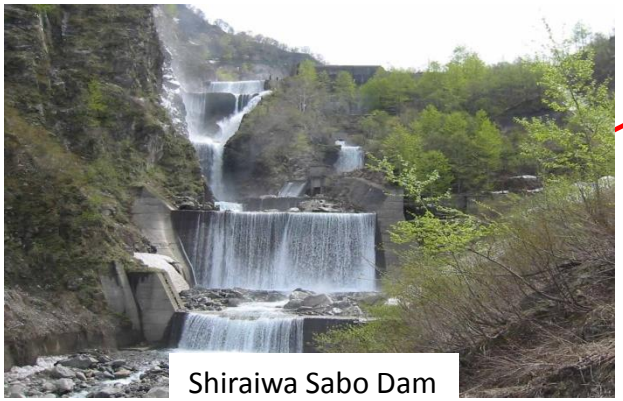
# Raised River Bed



# Sabo projects（major erosion control facilities）

●Sabo dam

Controls sediment outflow from upstream (adjustment function) and prevents collapse and erosion of the river bed and sides, preventing damage to the downstream area.

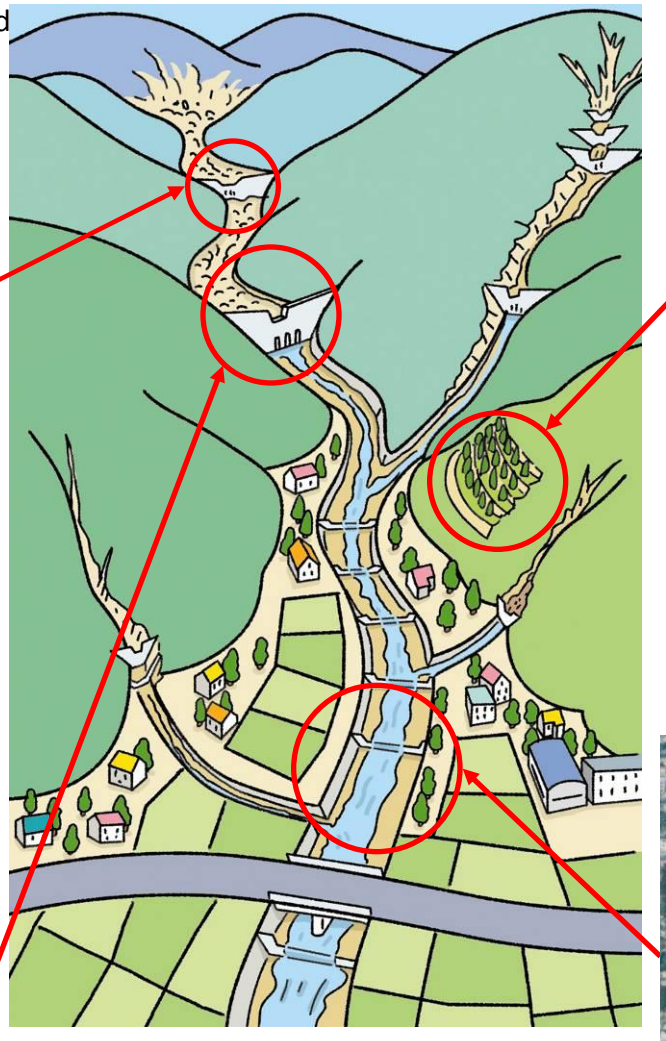


Shiraiwa Sabo Dam

●Sabo dam (Transmission type erosion control dam)

Having an adjustment function by flowing out the sediment with small and medium sized particles, capturing sediment containing large stones and driftwood at the time of massive flooding.

Ohtanasawa No.2 Sabo Dam



Erosion Control Facility

Created by the Sabo Department, MLIT

●Hillside work

To prevent collapse of the hillside and sediment outflow to recover the growth of plants and trees through end dam construction, draining work and planting.

Hillside planted with Pine trees

●Mountain stream conservation work

Control of turbulent flow and drift to prevent erosion of the river bed and side by combining groundsill work and revetment work in the alluvial fan.

Groundsill work for the Otani River

# Steep slope failure prevention projects

## What is a steep slope failure prevention project?

To implement collapse prevention work, such as retaining wall construction and slope works in the areas designated as steep slope failure hazard areas in order to protect houses and roads from slope failure.

## What is a steep slope failure hazard area?

Pursuant to the Act on Prevention of Disasters Caused by Steep Slope Failure (enforced on July 1, 1969), a prefectural governor shall designate the areas requiring the necessary measures which meet the following conditions in order to protect the people's lives and land from slope failure.

Conditions: Steep slopes (more than 30 degrees) and a height of over 5m on the verge of collapse.
Areas with more than five houses or areas with a public office, school, hospital and inn, etc. even if the area has less than five houses.

## Restricted actions in the steep slope failure hazard area

Authorization from prefectural governor is required for the following:

1. Releasing water or causing water stagnation or water seepage,
2. Establishing or renovating facilities or work pieces other than steep slope failure prevention facilities, such as reservoir and water channel,
3. Grading, cutting, excavation or filling works,
4. Collection and accumulation of soil and stones,
5. Cutting of trees and bamboo,
6. Transportation of trees and bamboo by sliding and dragging, and
7. Any other actions that may cause or induce steep slope failure.

# Steep slope failure prevention projects (major steep slope failure prevention facilities)

Slope failure disaster (Kagoshima-shi)


Image of slope failure measures

Protecting the residential area with a retaining wall

Protecting child welfare facilities with grating crib works

Protecting the facilities of evaluation area

Made by Sabo department, MLIT

# Landslide protection projects

## What is a landslide protection project?

A project implementing landslide protection works, such as catchment well work and horizontal boring work, in the areas designated as Landslide Prevention Area so as to protect houses, public buildings, rivers and roads, etc. from landslides.

## What is a Landslide Prevention Area?

Pursuant to the Landslide Prevention Act (enforced on March 31, 1958), the minister of Land, Infrastructure, Transport and Tourism, etc. shall designate areas closely related to public interests among the areas affected by landslides or having a high chance of landslides as landslide prevention areas.

## Restricted actions in a Landslide Prevention Area

Authorization from prefectural governor is required for the following:

1. Actions related to groundwater,
2. Actions related to surface water,
3. Actions related to grading works or earth cut,
4. Actions related to construction or renovation of facilities, and
5. Any other actions that may cause or induce a landslide.

# Landslide protection projects (major landslide protection facilities)

Landslide disaster (Nagano city)

Landslide protection measures

- Control: Mitigation/removal of natural conditions (geographic and geological features, groundwater, etc.) that could cause a landslide
- Prevention: Aiming to increase safety by structures designed to stop landslide movement.

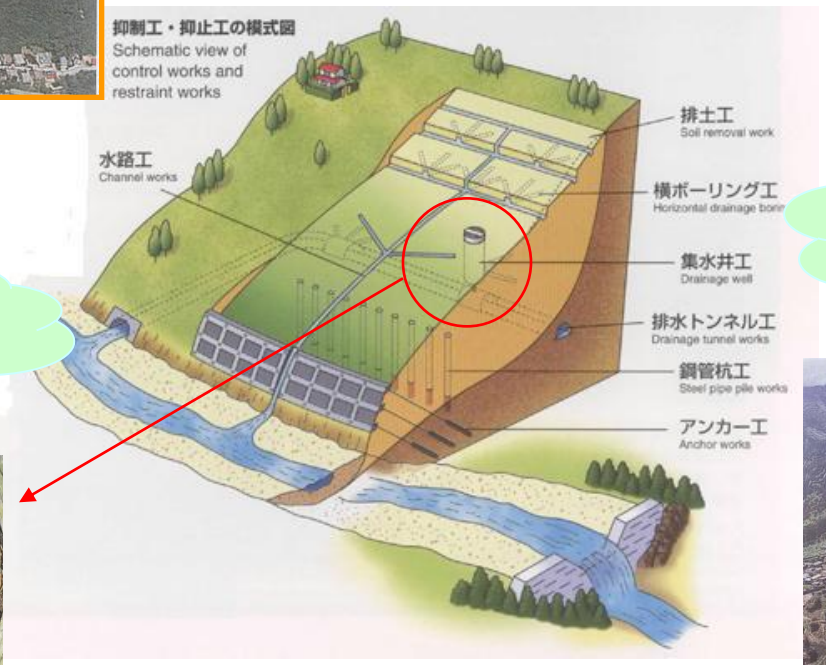



Image of landslide protection measures

To control the slide by pooling groundwater

Looking down the catchment well

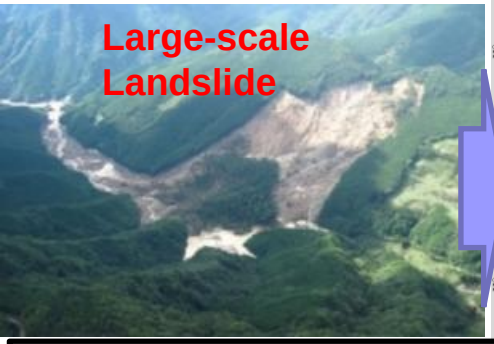
Protecting the residential area at the foot of the mountain by controlling the soil and rock slide

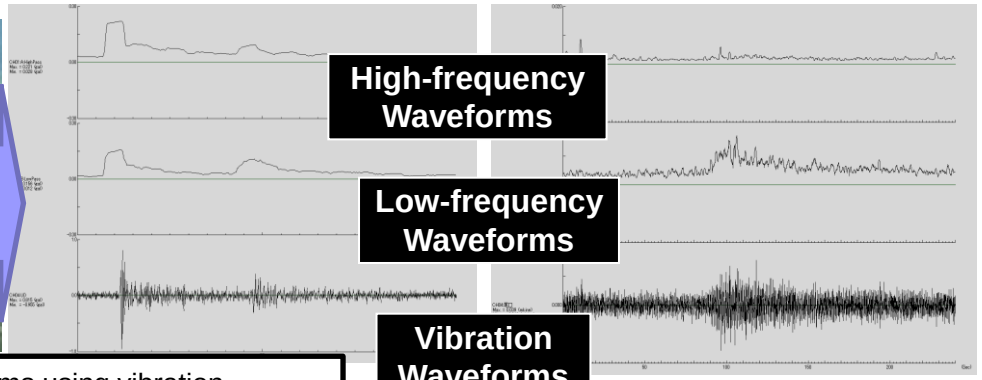
Made by Sabo department, MLIT

# Monitoring and Measurement for the Preservation of National Land



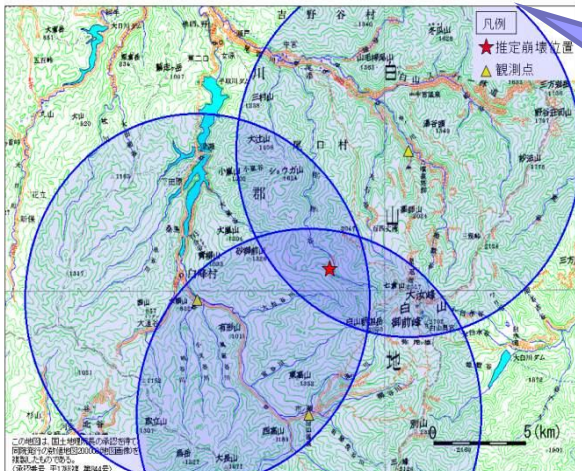
## Detect vibrations occurring from large-scale sediment movement




Construction of early detection systems using vibration sensors

## Focus on vibration waveforms to detect landslides




**Three points used to predict the occurrence site from the vibration arrival time differences**

Estimated frequency map of deep-seated landslides due to massive sediment movement



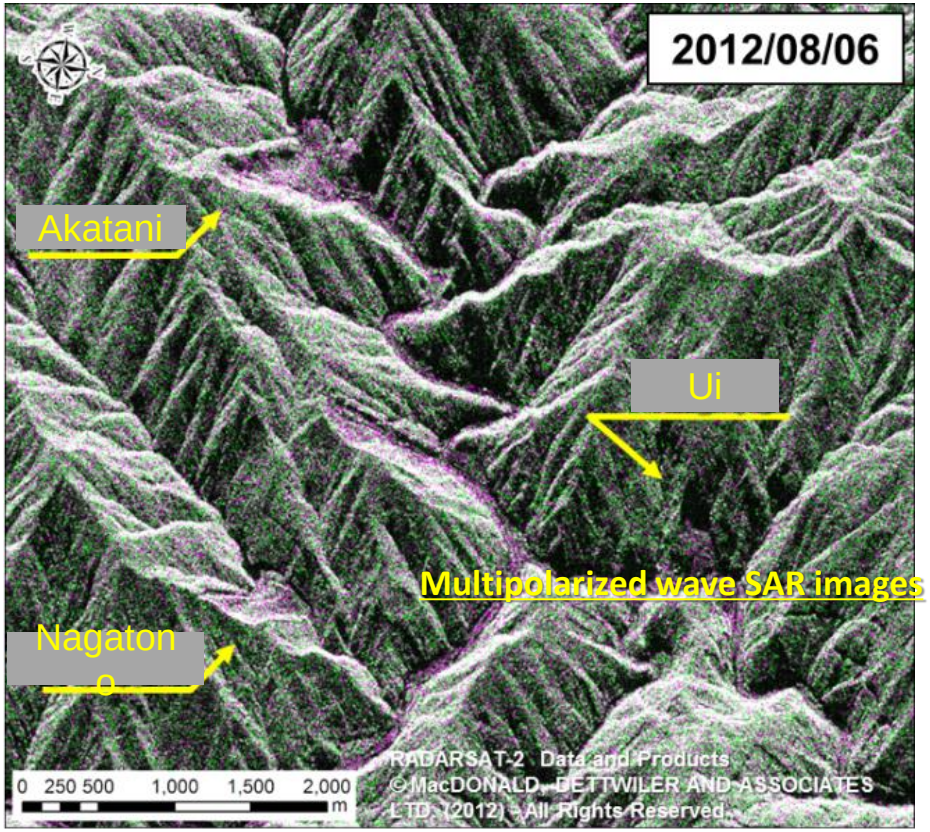

*Vibration sensor locations are under review

○Reduction in the time it takes to recognize the occurrence site of large-scale sediment movement.
○Monitoring also possible during bad weather and at night

Enables rapid evacuation and disaster response in event of a disaster

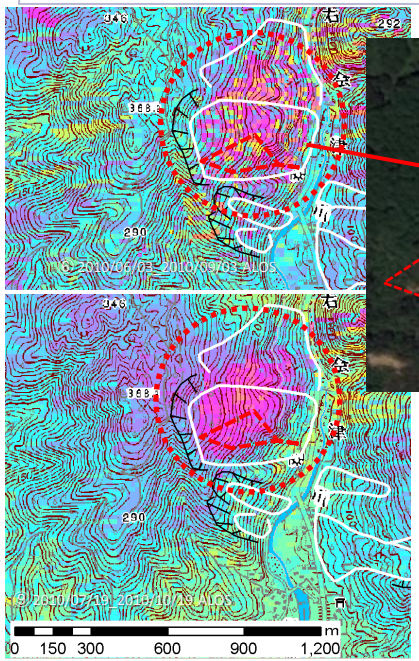
- **Aim to establish method to find sites such as landslide dam sites and warning methods to detect incidents such as large-scale landslides for large-scale landslide monitoring systems that utilize satellite SARS**

## ①Development of methods to comprehend unexpected disaster situations immediately after a disaster occurs

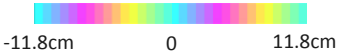



## ②Development of methods for long-term monitoring of prone areas

Development of technology to detect small changes by sensors before occurrence of large-scale sediment-related disasters such as deep-seated landslides



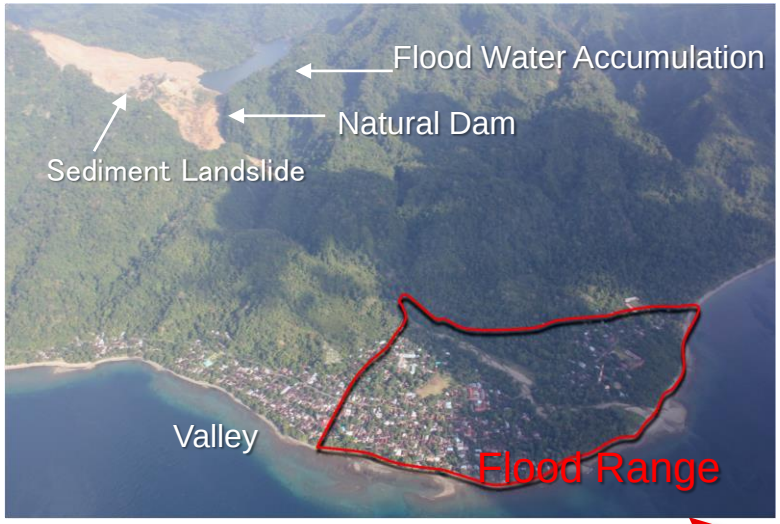





InSAR Image of the following year
Example of debris flow
(Typhoon No. 12, Tanabe-shi Kamiakizu, NILIM)

NILIM

<Prone Areas to Large-Scale Sediment-related Disasters>




Natural Dam Formation

Natural Dam Outburst


Flooding of downstream village

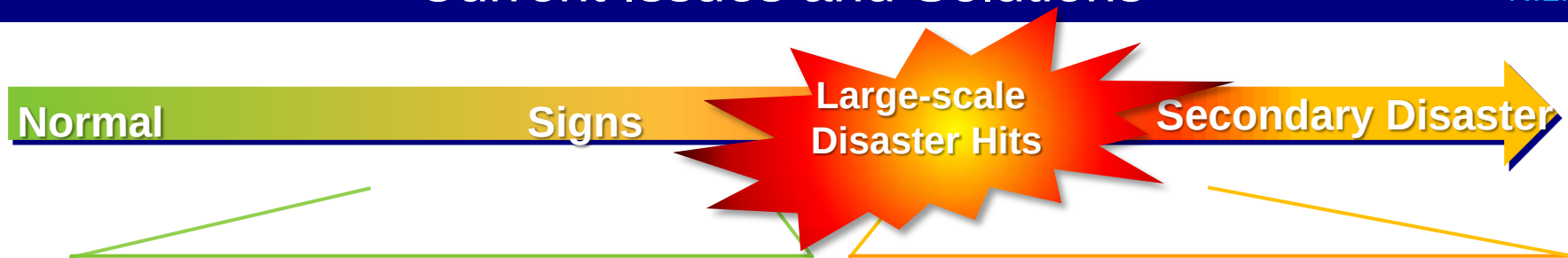
**Normal** → **Signs** → **Large-scale Disaster Hits** → **Secondary Disaster**

Cracking of slope etc.

Expansion of landslides
Outburst of natural dams etc.

Early signs of sediment-related disaster (onset signs) by regular observations of land during normal times (diagnosis). Early detection of sediment-related disaster (onset) during torrential rain or an earthquake. Damage prevention by urgent investigation (precision inspection) and measure implementation (actions).

# Current Issues and Solutions




**① Where will signs of sediment-related disasters appear?**

**② Where will sediment-related disasters occur?**

**Current State**

■ Widen the monitoring range to areas prone to deep-seated landslides and areas that are difficult to observe regularly

(Conventional Aerial Survey)
■ Difficult to conduct during bad weather or at night
■ Takes time to conduct an extensive survey

**Solution**

Technology makes it possible for a regular observations at a wide range during bad weather and at night

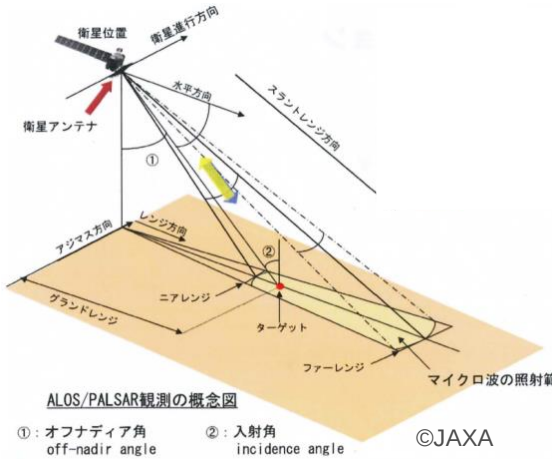
Use of satellite-borne synthetic aperture radar (SAR)

# What is a Synthetic Aperture Radar (SAR)?

NILIM

## Synthetic Aperture Radar (**SAR: S**ynthetic **A**perture **R**adar)

Microwaves are emitted from an artificial satellite and an active sensor receives information about the distance (phase) and strength of the waves

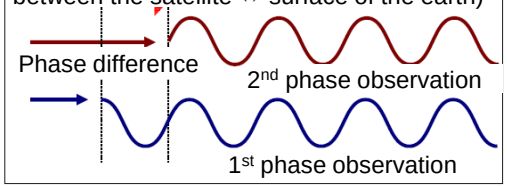


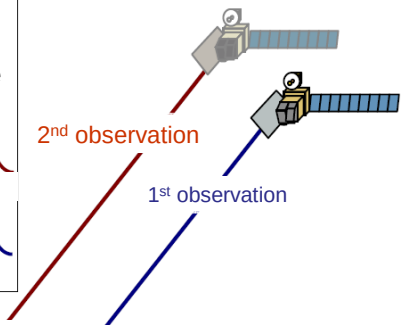
©JAXA

### Capture of earth variations by distance change: InSAR Analysis

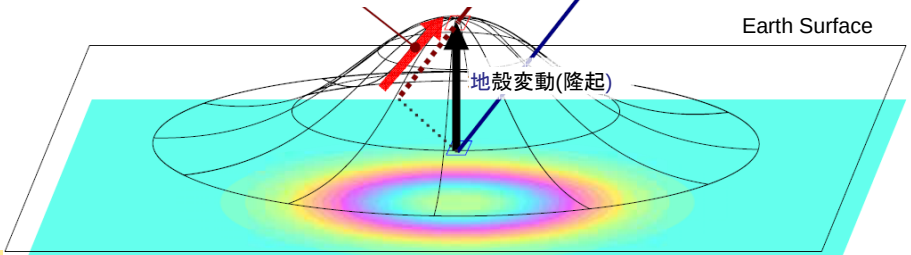
If crustal movement occurs, the distance between the satellite ⇔ surface changes.
⇔ received by phase changes of waves

Crustal movements (changes in the distance between the satellite ⇔ surface of the earth)



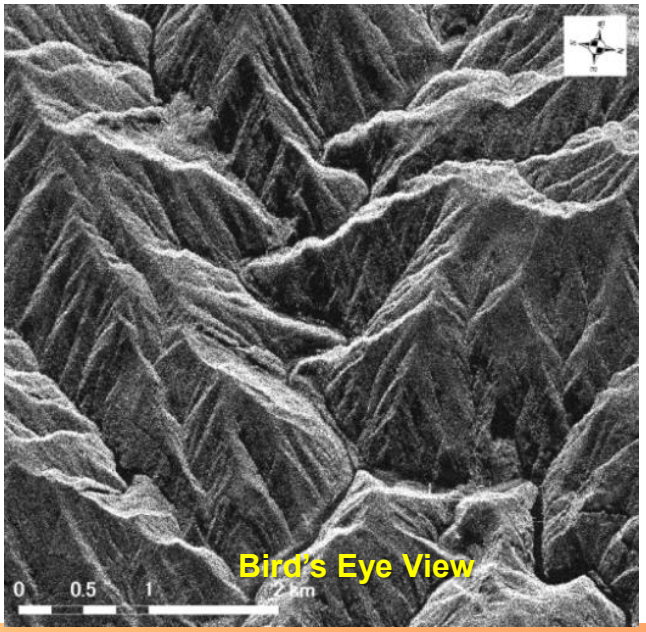

Close variations obtained by InSar analysis
Changes in the distance between the satellite ⇔ surface




(C)GSI

InSAR image

### Imaging



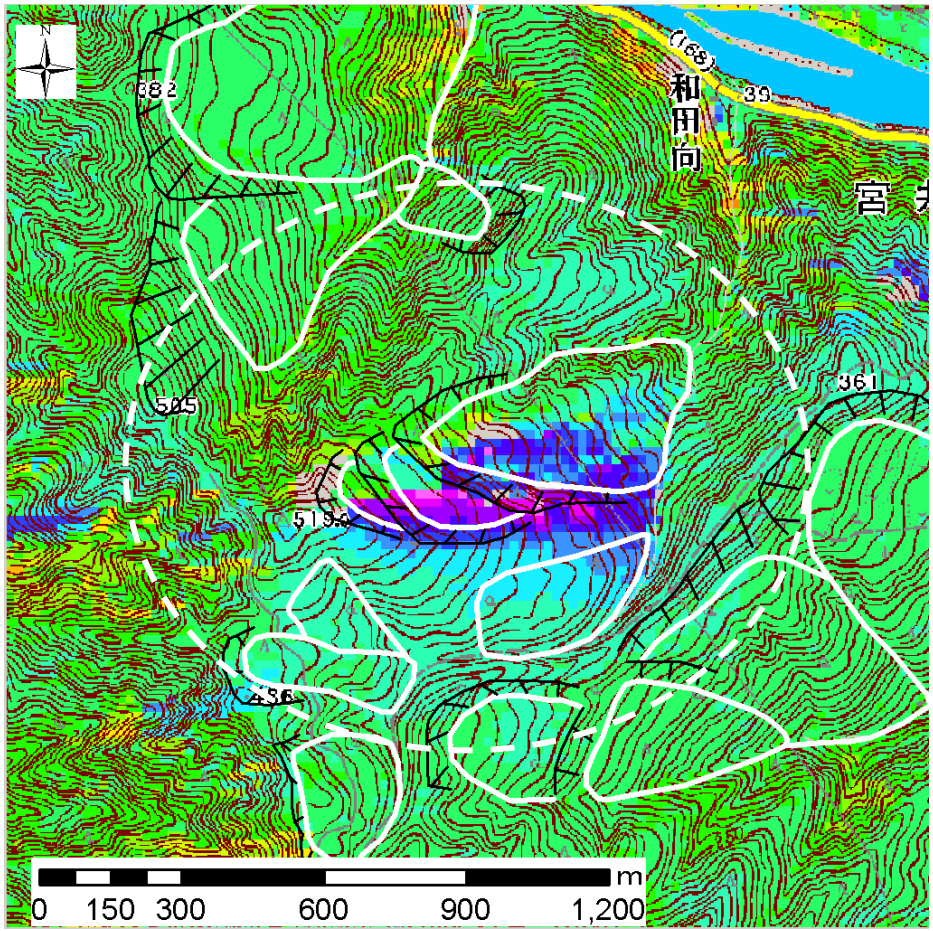

nt, MLIT, JAPAN

SAR Image

# Findings by InSAR Analysis

- Findings are revealed by further investigation at the site

  Very small changes in the land can be found (slope change)

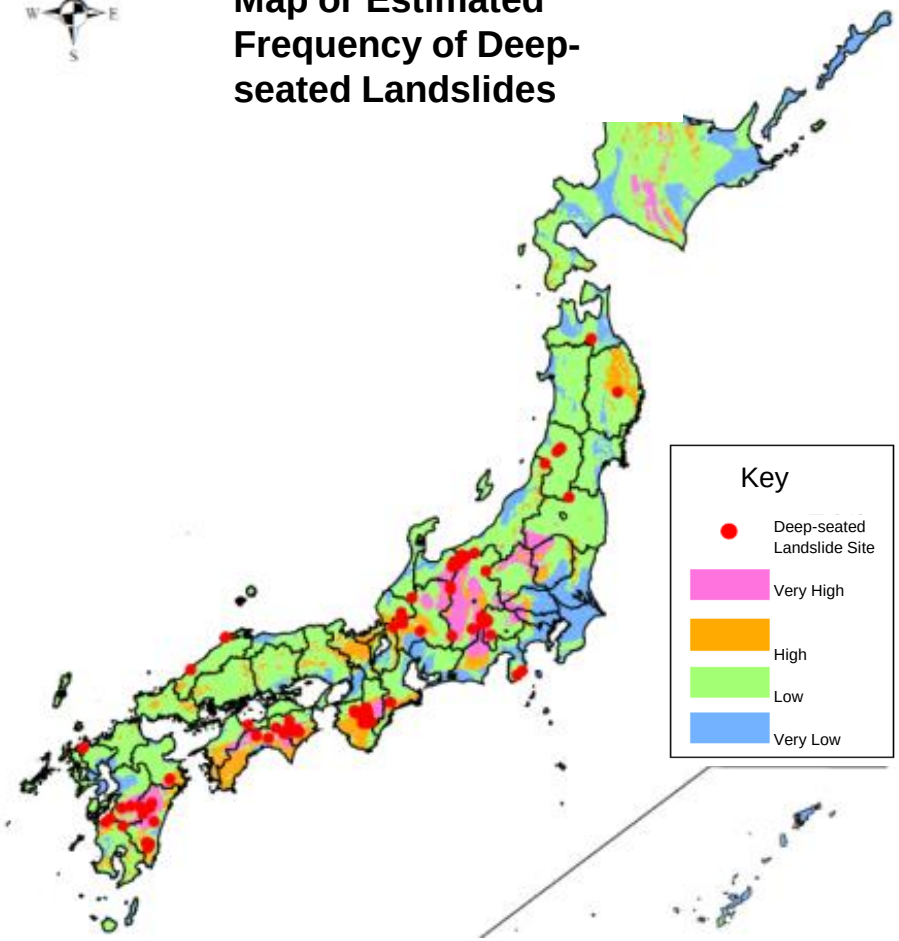



Cracks have appeared in the slope surface (sign)

# How to Use Images for Regular Diagnosis of Land

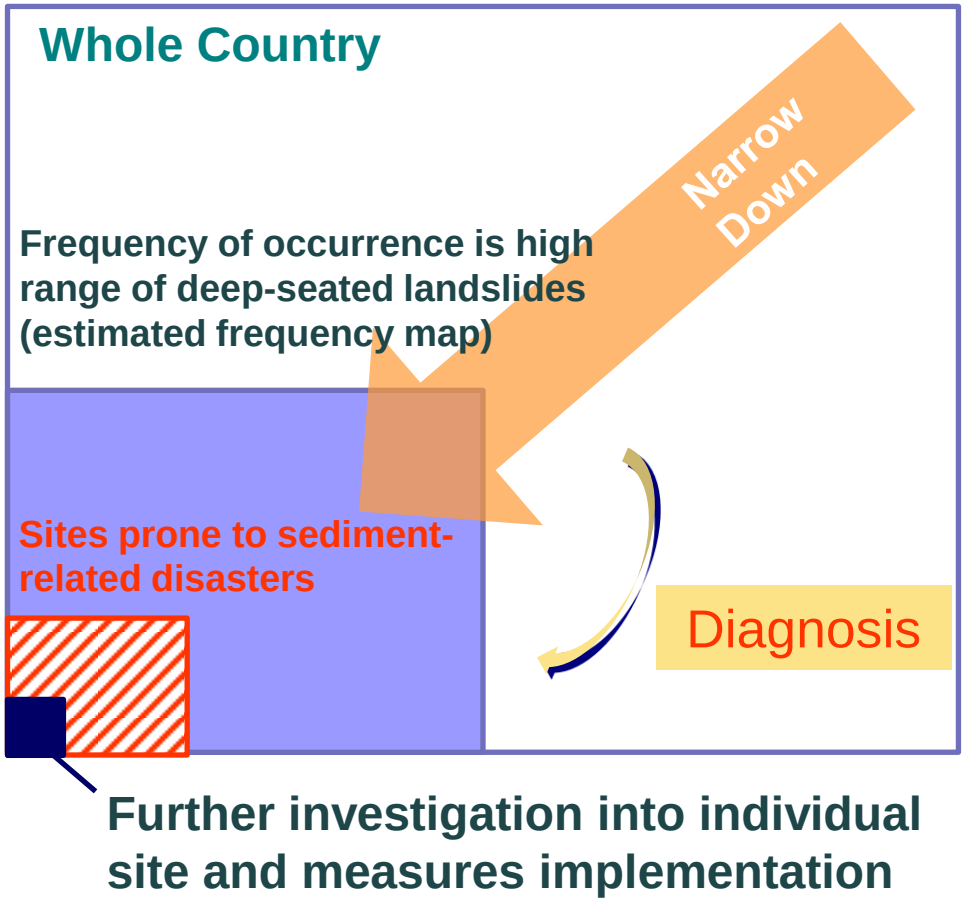
NILIM

**Map or Estimated Frequency of Deep-seated Landslides**




Source) Ministry of Land, Infrastructure and Transport (August 11, 2010)

■Narrow down prone to sediment-related disaster, and create preventive measures



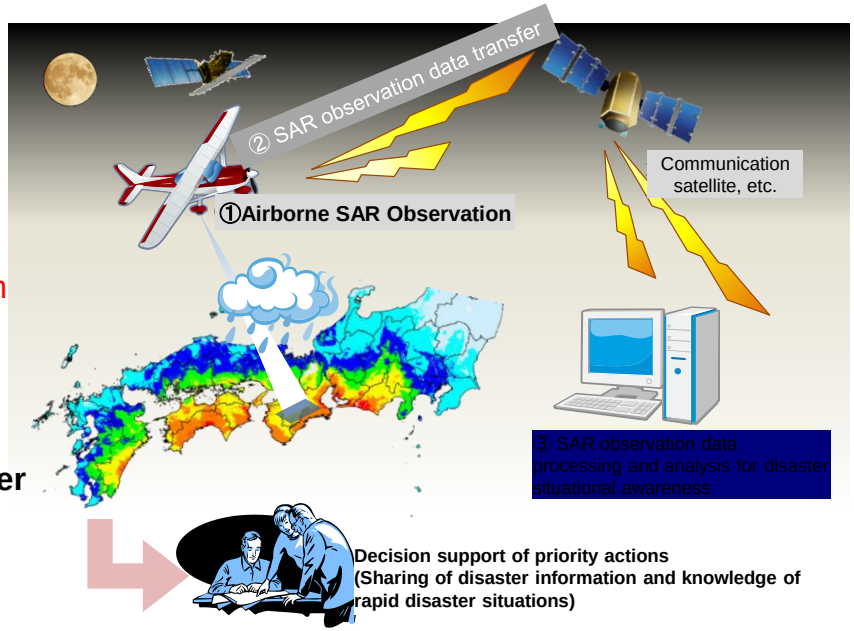
# Development of Disaster Response Techniques by Miniature Airborne SAR

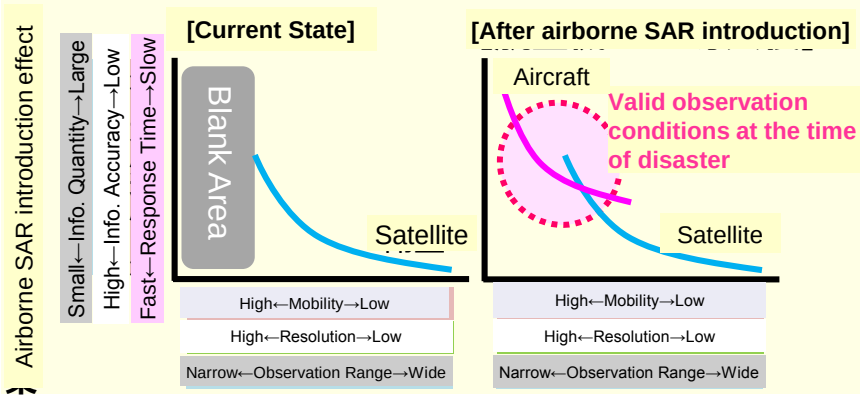
## ◆ Basic Policy

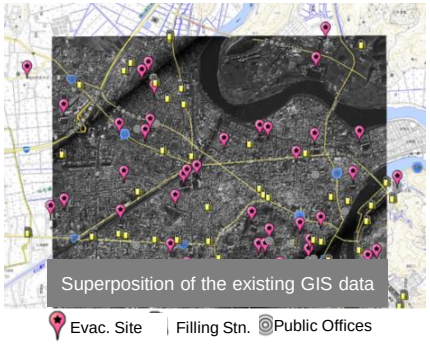
Use of SAR sensor technology is possible during adverse weather or at night in order to promptly understand the extent of the disaster situation. However, satellite SAR is still in the production stage and there are many difficulties with immediate observations directly after the disaster strikes because the observation relies on satellite orbits. Airborne SAR has a high mobility compared to the satellite, and the acquisition of high-resolution data can be expected. Therefore, we studied **the development towards practical use of airborne** to build a mechanism to provide rapid disaster situational awareness to incidents such as disruptions to routes caused by hillside landslides.

## ◆ R&D Topics (Red font: items for 2015)

1. **Design policy for airborne SAR observation systems**
   - Gain an understanding of disaster situations by airborne SAR
   - Establish a disaster response scenario
   - Understand developing trends of peripheral technology including SAR sensor and data transfer
   - Examine the detailed specifications of the SAR observation system
2. **Airborne design of the SAR sensor**
3. **Demonstration, evaluation, and improvement of practical deployment**
4. **Design of SAR observation data transfer systems**
5. **Construction of image interpretation support systems for disaster situational awareness**
   - Design and trials of image interpretation support systems



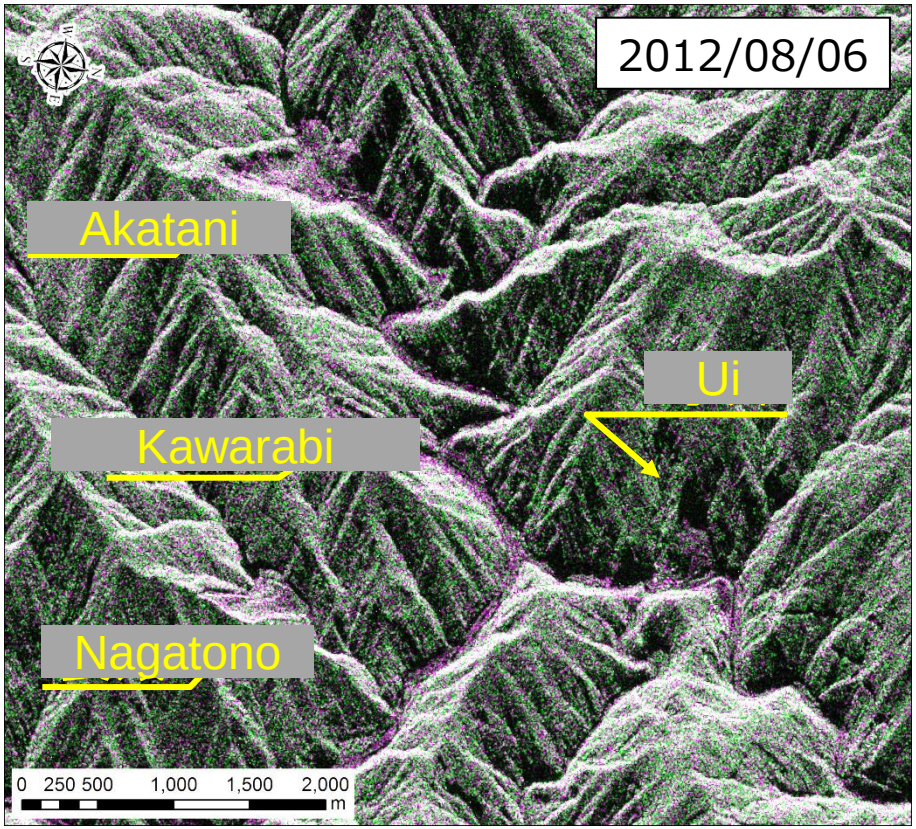


©Pi-SAR-L2/JAXA 2013

# Proposals and Improvement of the Survey Method

■Create a survey methodology manual (draft) to ensure accurate surveys are performed in a short period of time for emergencies (NILIM material)
*Survey how people interpret the images (there is a high degree of difficulty)

■Future Efforts
Consider methods to automatically find sites prone to landslides from SAR images
→Easier, more efficient, and more accurate interpretation surveys




Natural dam site of the Kii Peninsula flood

RADARSAT-2 Data and Products
© MacDONALD, DETTWILER AND ASSOCIATES LTD. (2012) - All Rights Reserved

# Benefiting from SNS Disaster Prevention as a Social Sensor

NILIM

## Current State of Affairs

Bottom up information transmission from the municipality to the country. This method is reliable but slow.

Even if reliability low, isn't it helpful to obtain early information about what is going to happen and what is happening?

## Administrative Necessity

Is it not possible to share disaster prevention information (social media information) via SNS in real-time by using the information obtained from the observations and comments of people in the region?

## Topics and the State of Technology Developments

The technology exists to analyze the language of people to determine the things that are needed at the affected area. However, there is no technology to detect signs and occurrence of disasters in real-time by using social media information.

**Rapid municipal support possible by using Social Media information analysis!**

## Technology to be Developed

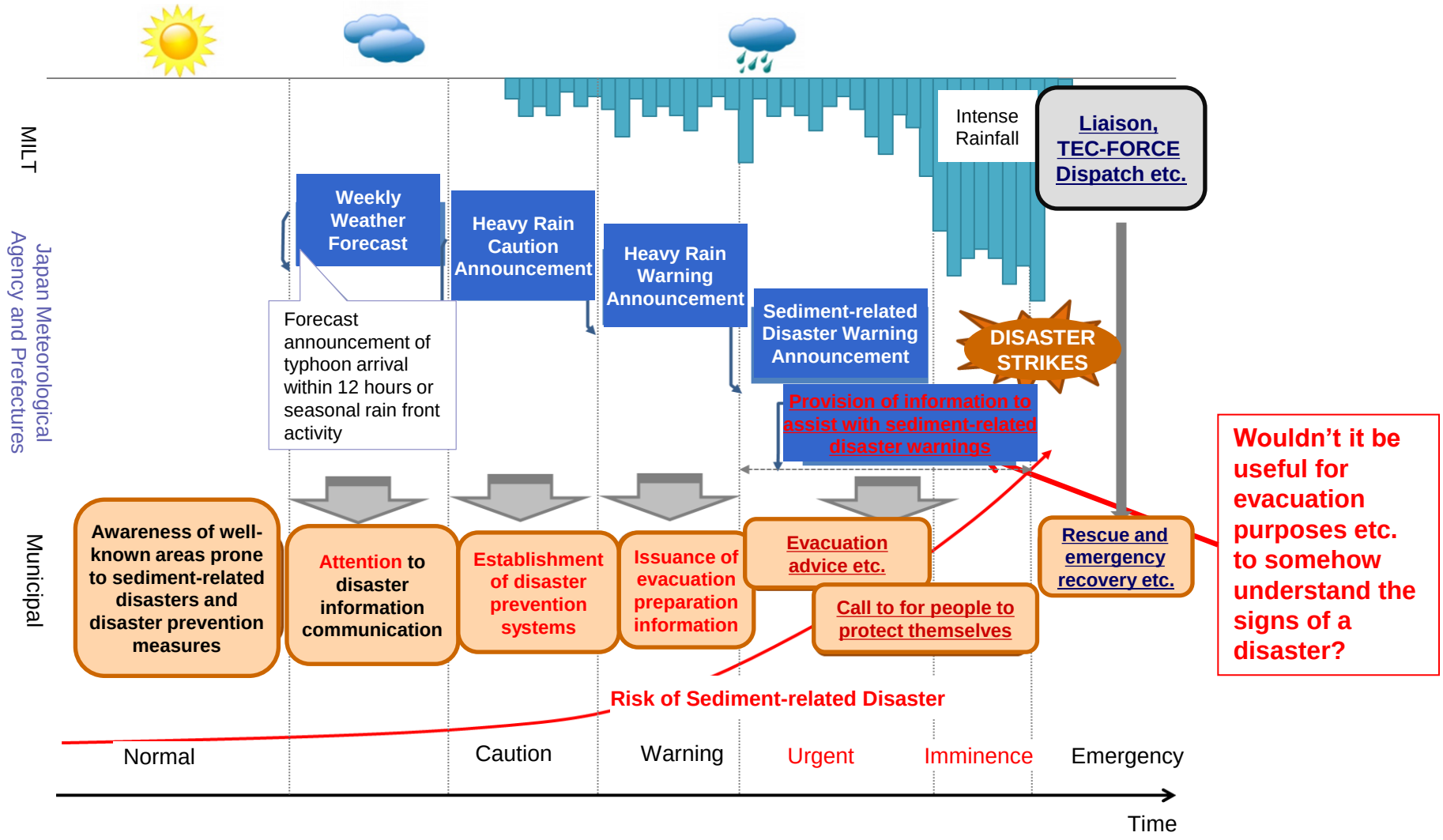
① Detection of an abnormal number of tweets and other such social media events
② Detection of signs and occurrence of disasters by use of language analysis
③ Regardless of the GPS information, identification of the municipal facing imminent treat by use of language analysis

## Application of Technology

Ability to grasp the urgency level even before reports from the municipal arrives

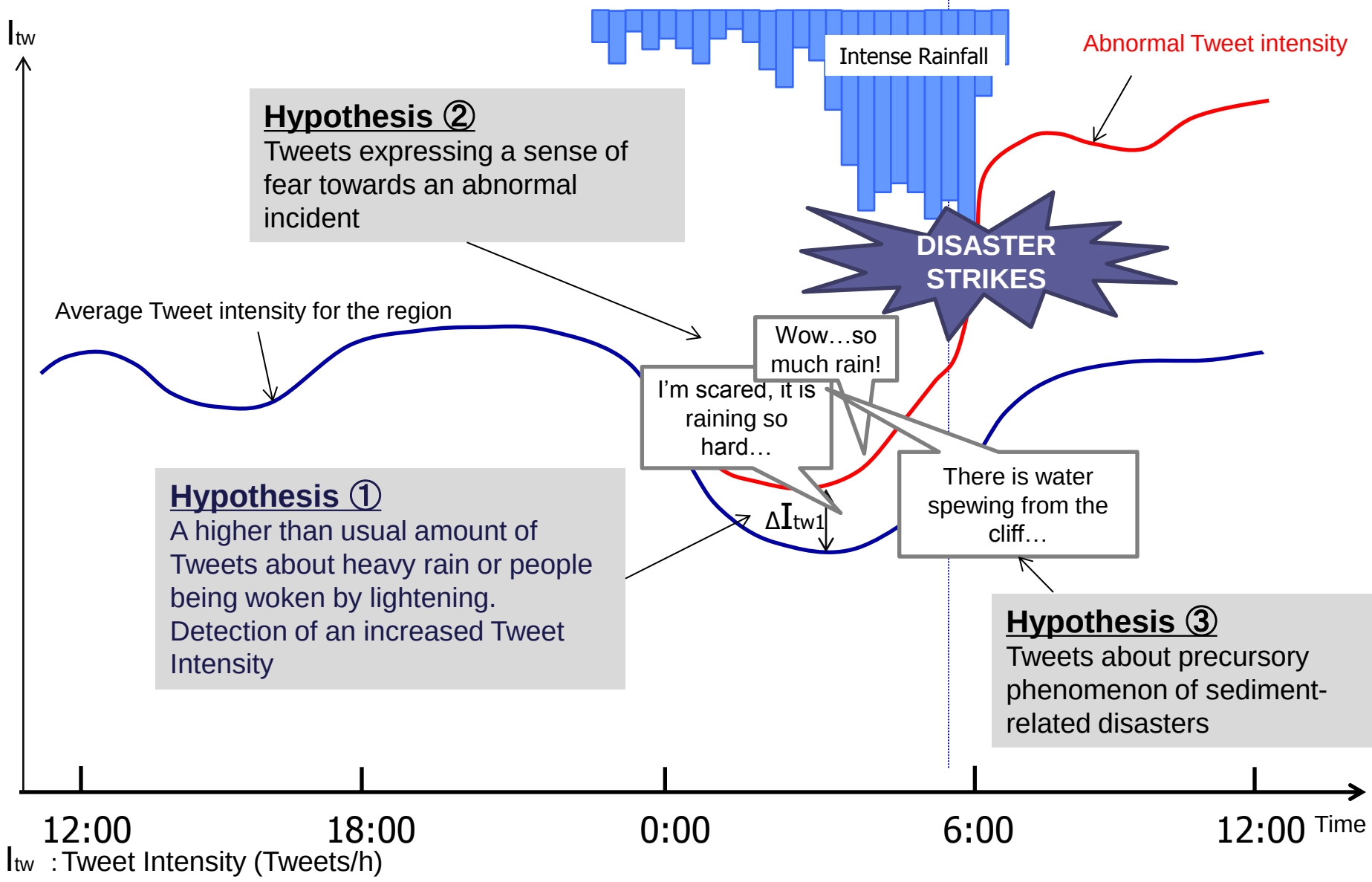
Early liaison, possible to determine the TECFORCE dispatch

- Without information about the situation at the location, information cannot be provided for evacuation instructions or for residents to take actions to protect themselves.
- Desire to understand the level of urgency of the location as early as possible to provide TEC-FORCE support to the municipal.



- **Effectively Utilize Risk Communication Tools**
  - Awareness of the needs of the affected people
    - Spontaneous sharing of information related to the disaster situation and needs of the affected people: Examples include Saku-shi during a heavy snow disaster (February 2012).
- **Effectively Utilize Social Sensors (SS) on Natural Phenomena**
  - Early detection of signs and occurrence of natural phenomena
    - (Reference) US Spotter System: Registered volunteers report detected information about SS functions
    - Understanding of disaster signs and occurrence by effective utilization of social media: Possible to understand signs of disasters by using social media information including keywords related to the precursor phenomena

- **Problems and Challenges to Understand the Signs and Occurrence or Sediment-related Disasters by effectively utilizing SS**
  - Accurate information is not always distributed
  - Location of the information is not always understood
  - The information distribution volume is expected to be low
  - There are limits to the detection of sediment-related disasters because there are a variety of scales and formations


Itw
Intense Rainfall
Abnormal Tweet intensity
Hypothesis ②
Tweets expressing a sense of fear towards an abnormal incident
DISASTER STRIKES
Average Tweet intensity for the region
Wow…so much rain!
I'm scared, it is raining so hard…
There is water spewing from the cliff…
ΔItw1
Hypothesis ①
A higher than usual amount of Tweets about heavy rain or people being woken by lightening. Detection of an increased Tweet Intensity
Hypothesis ③
Tweets about precursory phenomenon of sediment-related disasters
12:00
18:00
0:00
6:00
12:00
Time
Itw : Tweet Intensity (Tweets/h)

# Increased Tweet Detection due to Abnormal Events and Identification of Location

- Detection of an increase in the number of Tweets due to an abnormal event
  - Effective utilization of technology that removes inaccurate information by language analysis
  - Detection of an increase in the number of Tweets due to an abnormal event (deviation from the average Tweet intensity)
  - Effective utilization of technology that estimates the location of the abnormal even regardless of GPS
    - There is only a small number of users with access to GPS information
    - In addition, there is a possibility that information is gathered from a different location to the location of the abnormal event
- Detection of high quality information (increase the likelihood of detection)
  - Residents take actions to protect themselves and are aware of precursory phenomena of sediment-related disasters
    - The possibility to distribute high quality information increases by increasing the knowledge and awareness of residents
  - Launch a campaign to inform residents about the usefulness of Tweets in disaster prevention
    - Social media it is expected to advance in its function as a social sensor as the usefulness of social media information spreads.
      - For example, disaster related information in unified campaigns such as “# ○○ city disaster”
      - Actions of people should be prioritized to protect themselves

# Selection of Valid Keywords

- Keywords that might express the anxiety of people or a sign of a sediment-related disaster

① Keywords expressing anxiety

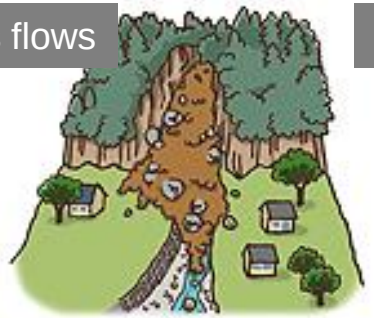
② Keywords expressing precursory phenomena such as sediment movement, debris flows, cliff landslides and other landslides

③Keyword changes on the time axis

Imminent, impending, occurrence × different causes (heavy rain, melting snow…)

(Reference) The most common comments about main precursory phenomena of sediment-related disasters

**debris flows**



- Mountain rumbling
- River water turbidity, driftwood
- Rotten soil smell
- Low river water levels
- Sounds of tearing trees and striking stones

**Slope failure**

- Cracks in the cliff
- Sound of falling pebbles
- Water gushing from cliff
- Spring water stoppage, turbidity
- Other rumbling noise

**Landslides**

- Cracked ground, cave-ins
- Water gushing from cliff or slope
- Turbid well or swamp water
- Other rumbling, mountain rumbling
- Leaning trees
- Occurrence of cracks and faults in structures

# Research of the Sediment movement situation using the topography model

# Sediment movement situation and topo data

Debris flow 24 JUN

Debris flow 5 JUL

Debris flow 28 JUL

| 年 | 日時 | 曜日 | 地形データ | 備考 |
|---|---|---|---|---|
| 2009年 | | | ○DEM  | 航空レーザ計測（1m分解能） |
| | 6月24日 | 水 | | 11:00 土砂崩壊発生（第1報）<br>12:00 土砂崩壊発生（第2報）土石流有<br>18:15 土石流が発生 |
| | 6月28日 | 日 | ●DSM  | TEC-FORCE ドローンによる上空調査<br>⇒4フライト動画から画像切り出し（画像418枚採用） |
| | 7月3日 | 金 | | 小斜面崩落 1回<br>濁流（土砂流出）1回 |
| | 7月4日 | 土 | | 小斜面崩落 6回<br>濁流（土砂流出）2回<br>土砂流出 4回 |
| | 7月5日 | 日 | | 斜面崩落、土石流有 2回<br>小斜面崩落 2回<br>防災ヘリコプター「はるかぜ号」による上空調査 |
| | 7月6日 | 月 | | 小斜面崩落 6回<br>土砂流出 9回 |
| | 7月7日 | 火 | 不採用 | 小斜面崩落 1回<br>TEC-FORCE ドローンによる上空調査<br>⇒1フライト動画から静止画切り出し⇒写真不足のため、崩壊地一部データ欠損 |
| | 7月8日 | 水 | ○DEM  | 航空レーザ計測（1m分解能） |
| 2015年 | 7月10日 | 金 | | 小斜面崩落 8回 |
| | 7月11日 | 土 | | 小斜面崩落 6回 |
| | 7月12日 | 日 | | 小斜面崩落 2回 |
| | 7月13日 | 月 | | 小斜面崩落 3回<br>土砂流出 1回 |
| | 7月15日 | 水 | | 小斜面崩落 3回 |
| | 7月16日 | 木 | | 小斜面崩落 1回 |
| | 7月17日 | 金 | | 小斜面崩落 2回<br>土砂流出 1回 |
| | 7月18日 | 土 | | 小斜面崩落 3回 |
| | 7月19日 | 日 | | 小斜面崩落 1回 |
| | 7月21日 | 火 | | 土砂流出 1回 |
| | 7月22日 | 水 | | 小斜面崩落 1回 |
| | 7月23日 | 木 | | 小斜面崩落 1回 |
| | 7月25日 | 土 | | 小斜面崩落 1回 |
| | 7月26日 | 日 | | 小斜面崩落 4回 |
| | 7月27日 | 月 | | 土砂流出 5回<br>小斜面崩落 18回 |
| | 7月28日 | 火 | | 小斜面崩落 18回<br>土石流 2回<br>土砂流出 1回 |
| | | | ●DSM  | 防災ヘリコプター「はるかぜ号」による上空調査<br>⇒斜め写真（208枚採用） |

Topographic data ①

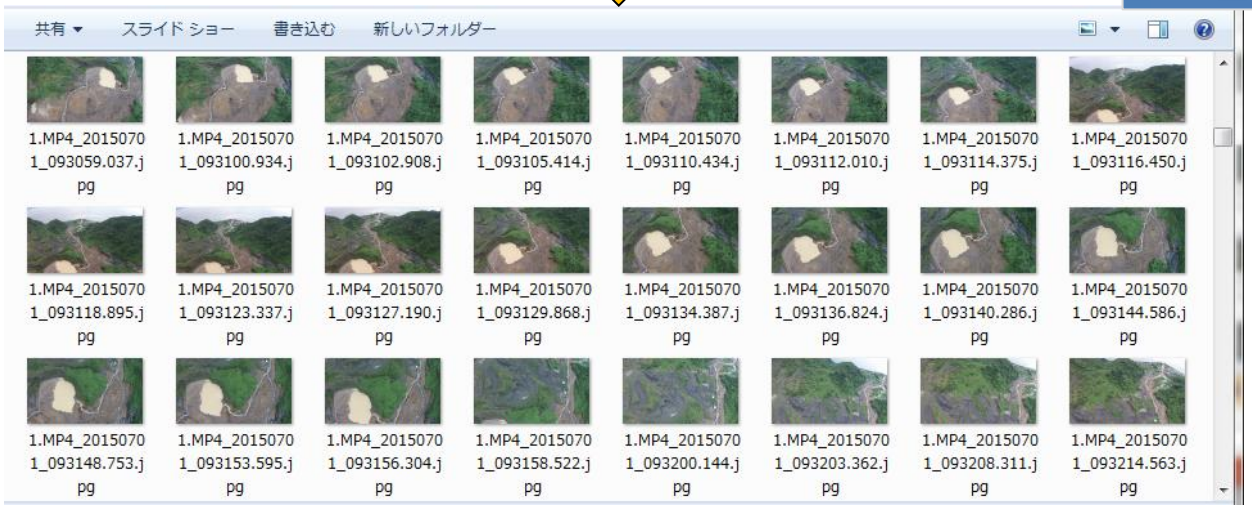
Topographic data ②

Topographic data ③

Topographic data ④

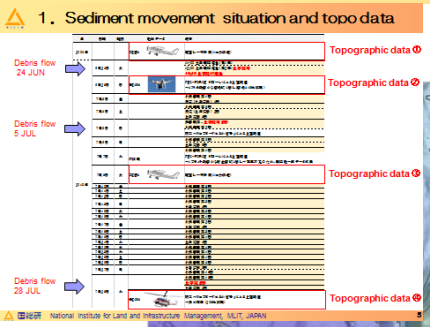
# The use of video from a drone

28 JUN




418 images

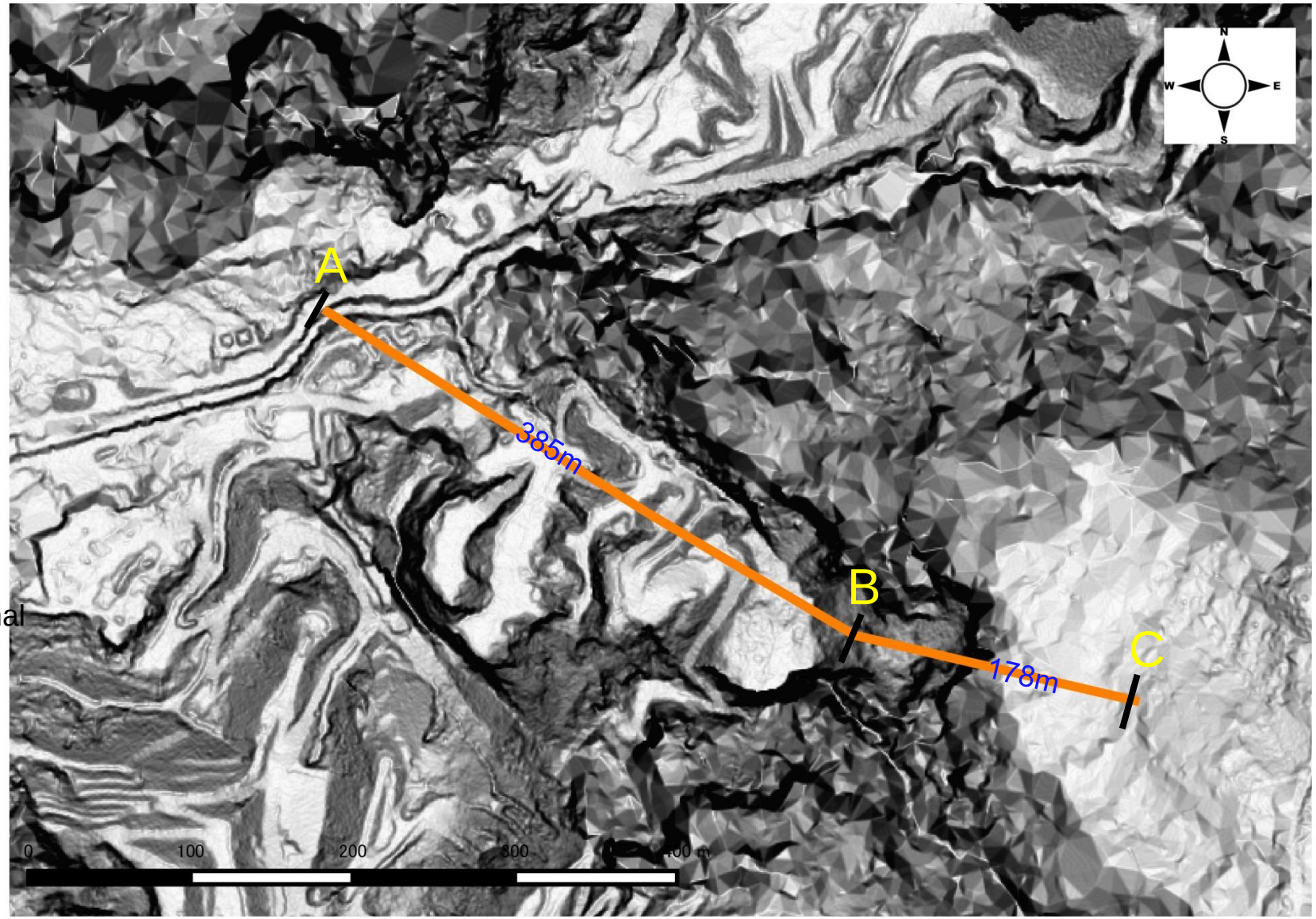
# Topographic data ① (2009)




Laser profiler, 1mDEM, 2009

# Topographic data ① (2009)

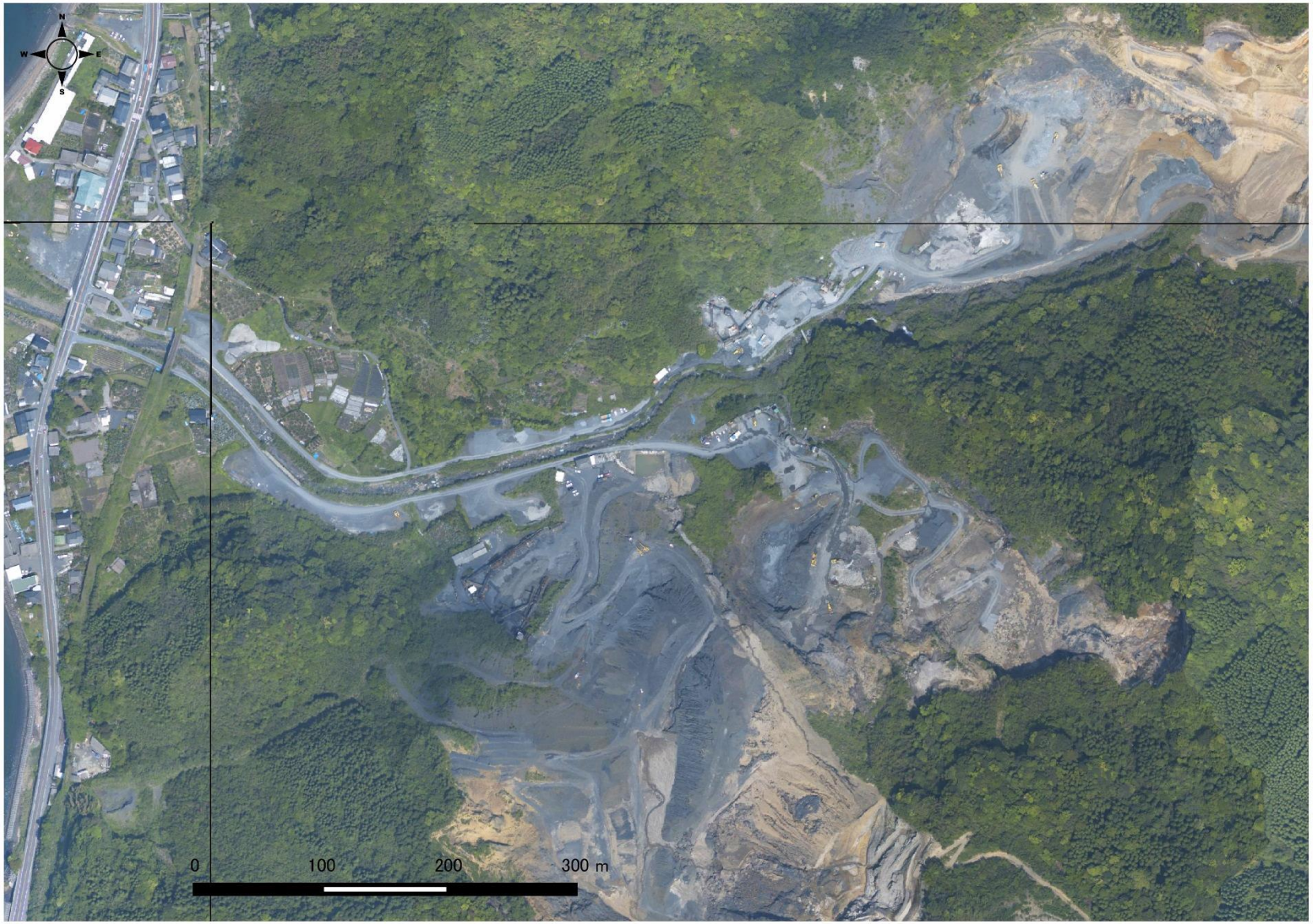
Laser profiler, 1mDEM, 2009




Sectional line

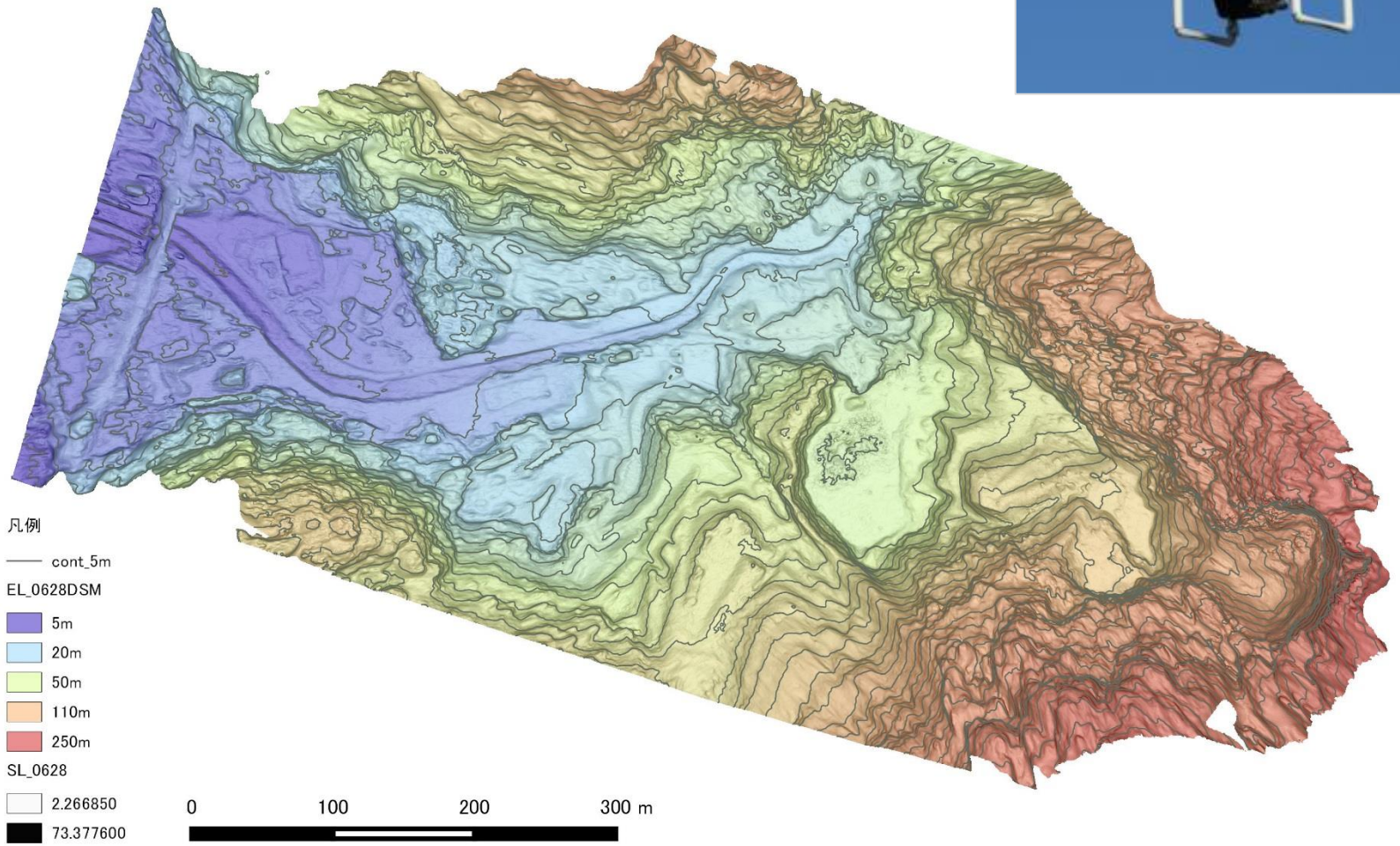
# ① Ortho photo 2009

By aircraft



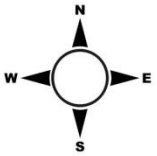
# Topographic data ② 28 JUN

DSM made from images from drone



# Topographic data ② 28 JUN

DSM made from images from drone



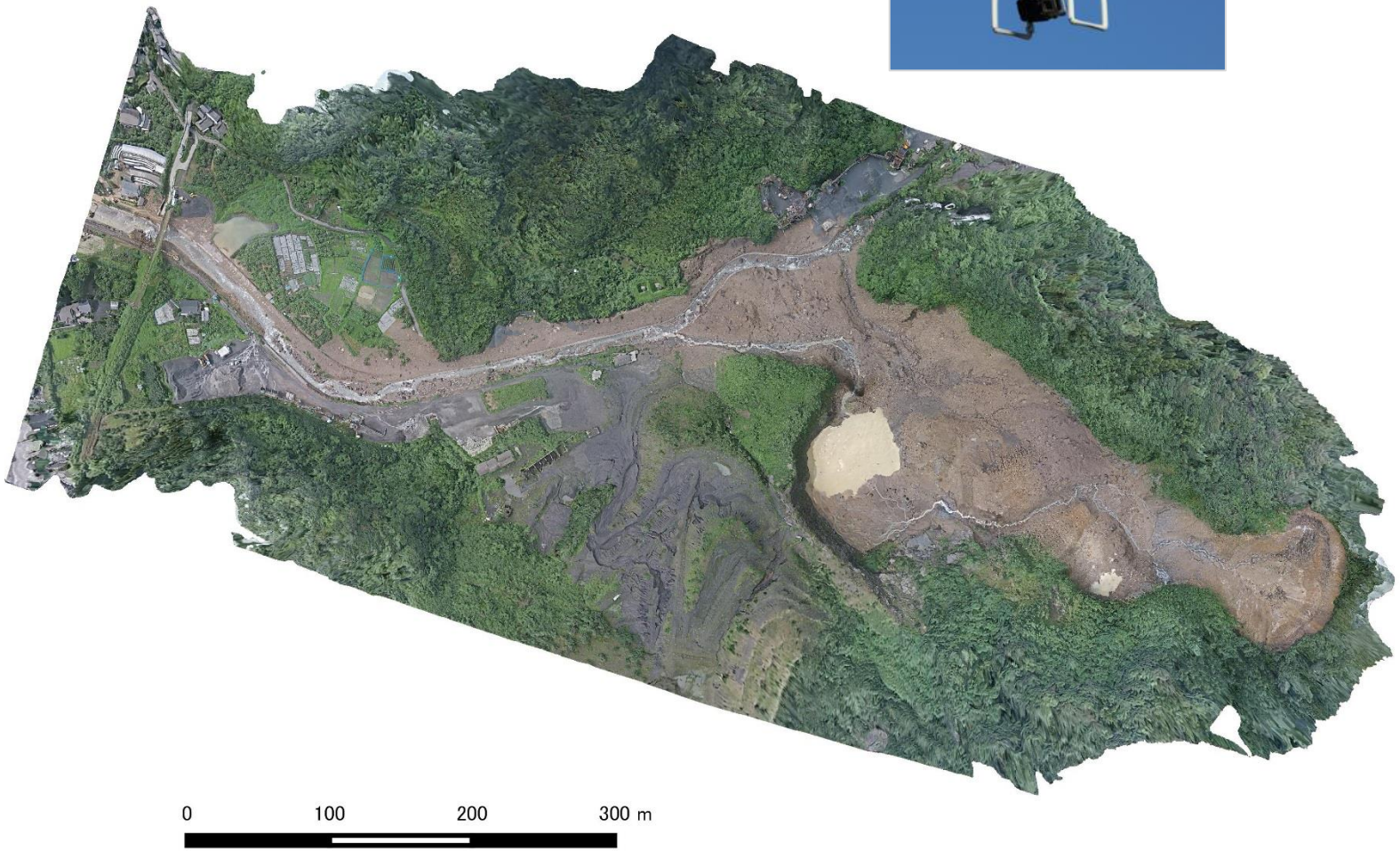




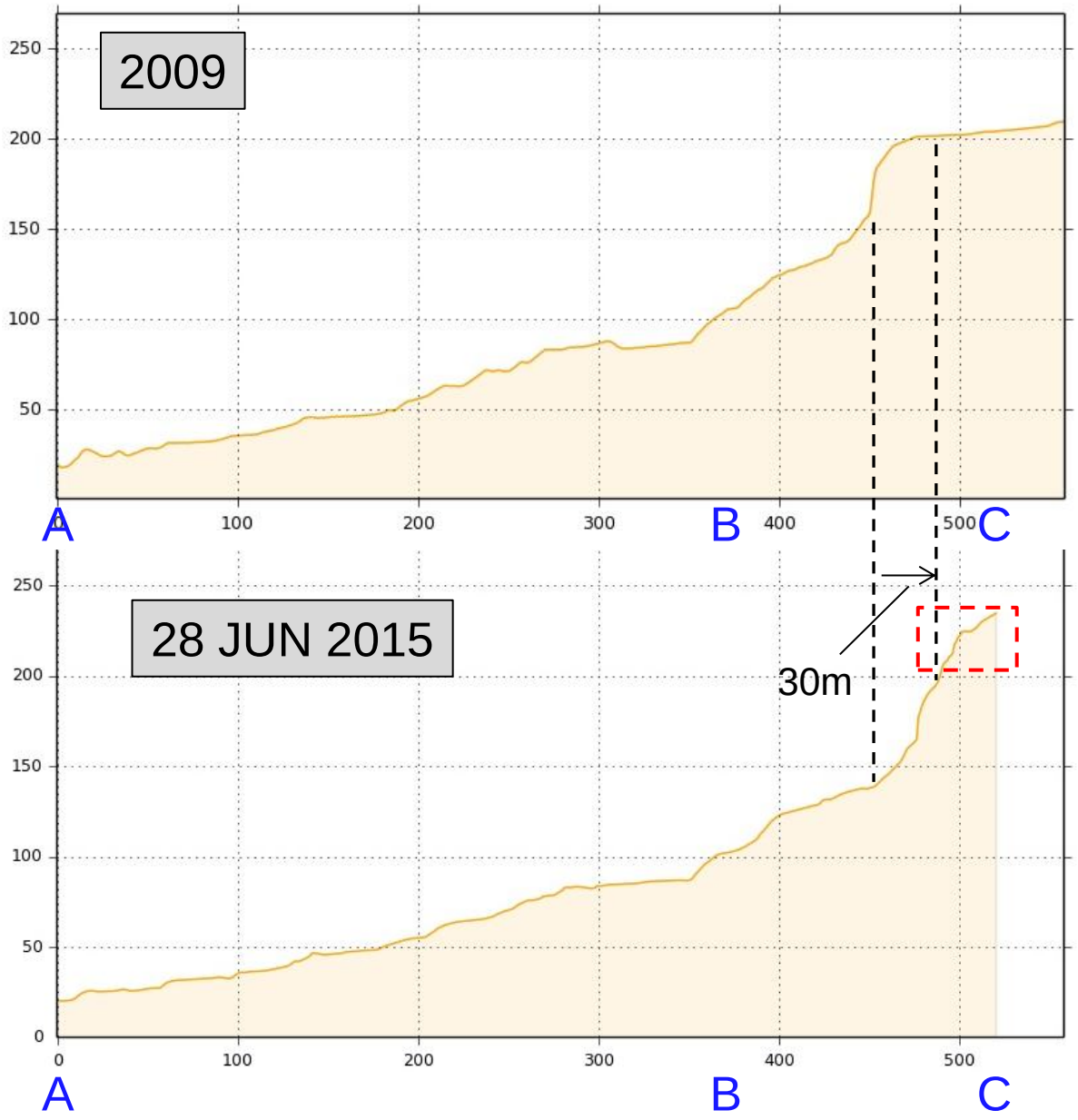
Sectional line

# ② Ortho photo 28 JUN

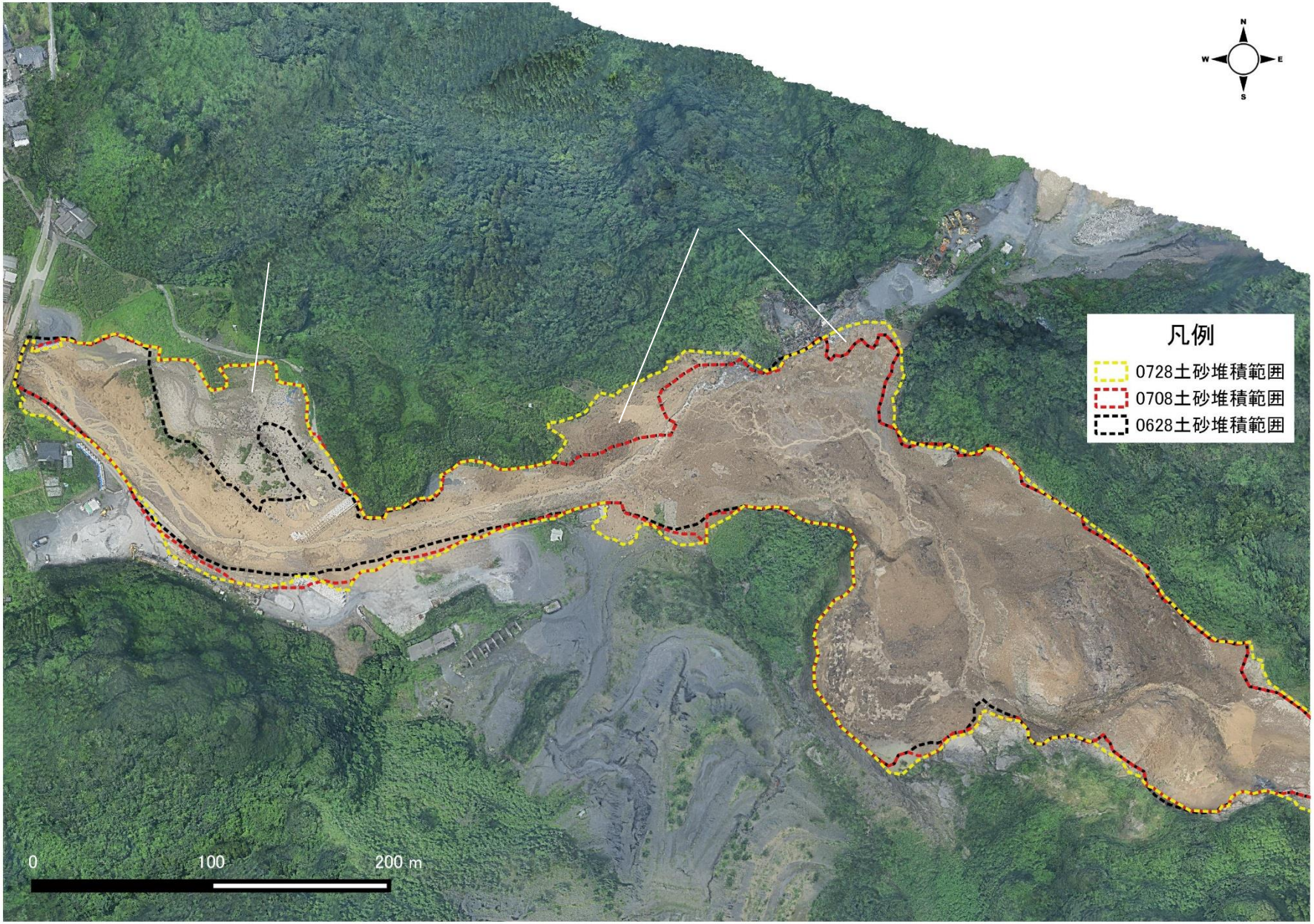
By drone



# Sectional line



# Sediment deposit area



# Thank you so much for your Attention and Participation

# ありがとうございました