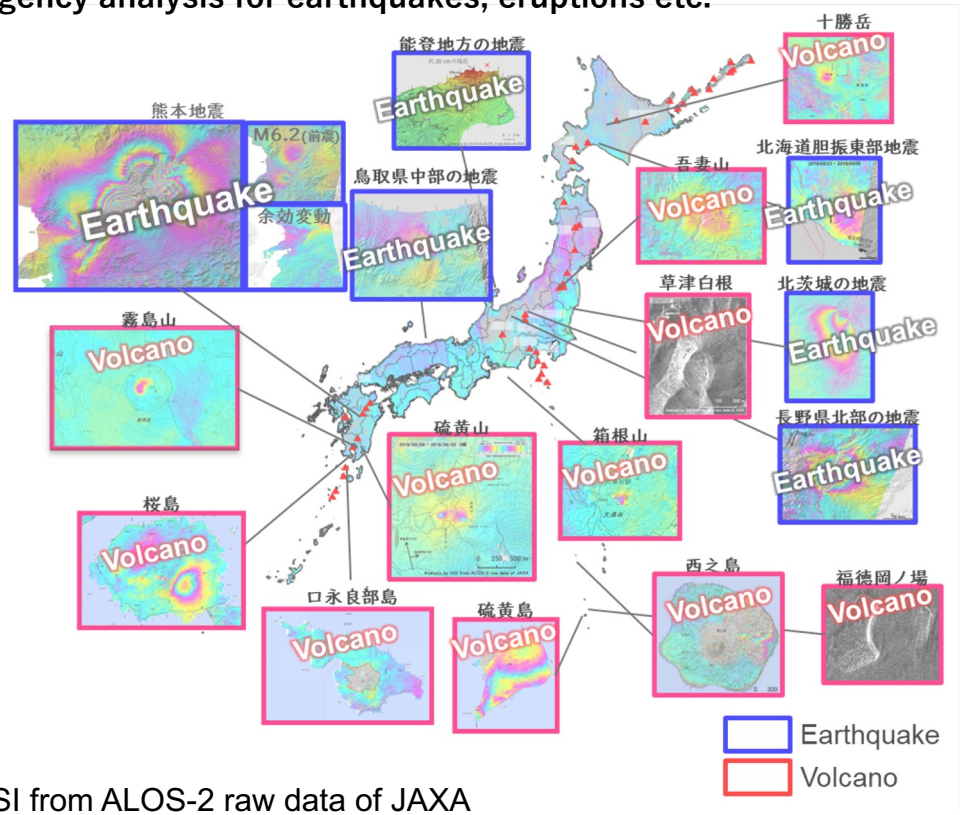
Nationwide land deformation monitoring

application of InSAR analysis to Japan

Tomokazu KOBAYASHI (Geospatial Information Authority of Japan)

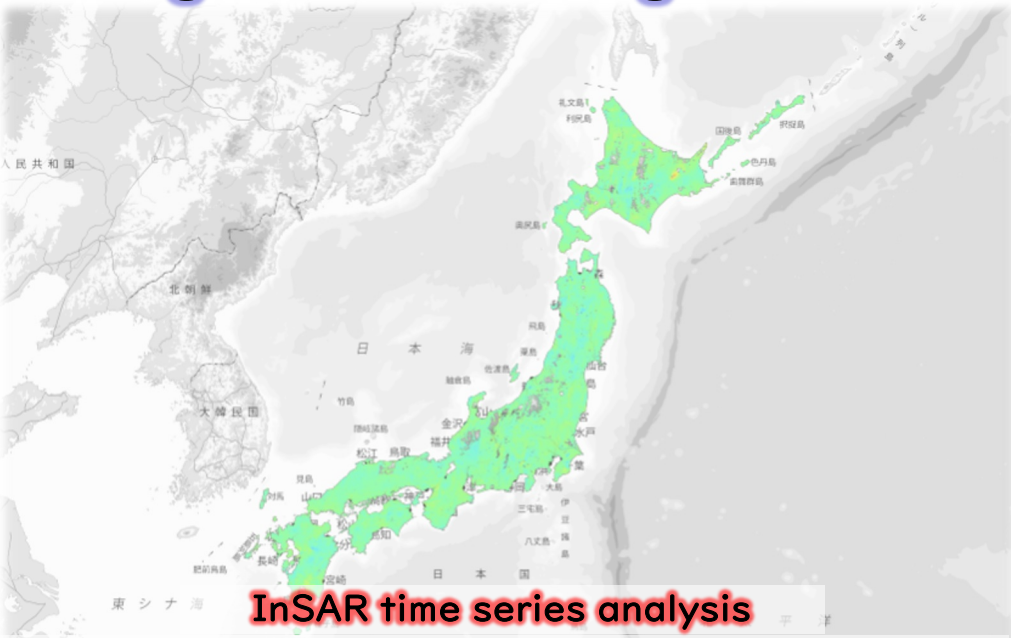
Ⅰ. Response to disasters

Emergency analysis for earthquakes, eruptions etc.



Analysis by GSI from ALOS-2 raw data of JAXA

2. Regular monitoring



InSAR time series analysis

Nationwide Monitoring ground surface changes that evolve slowly

(post-seismic deformation, long-term volcanic deformation, subsidence, landslide etc.)

Partnership between GSI & JAXA

国土地理院

GSI
Geospatial Information Authority of Japan

= Mission =
Nationwide Monitoring
ground surface changes

Earthquake, volcano, landslide etc…

Request

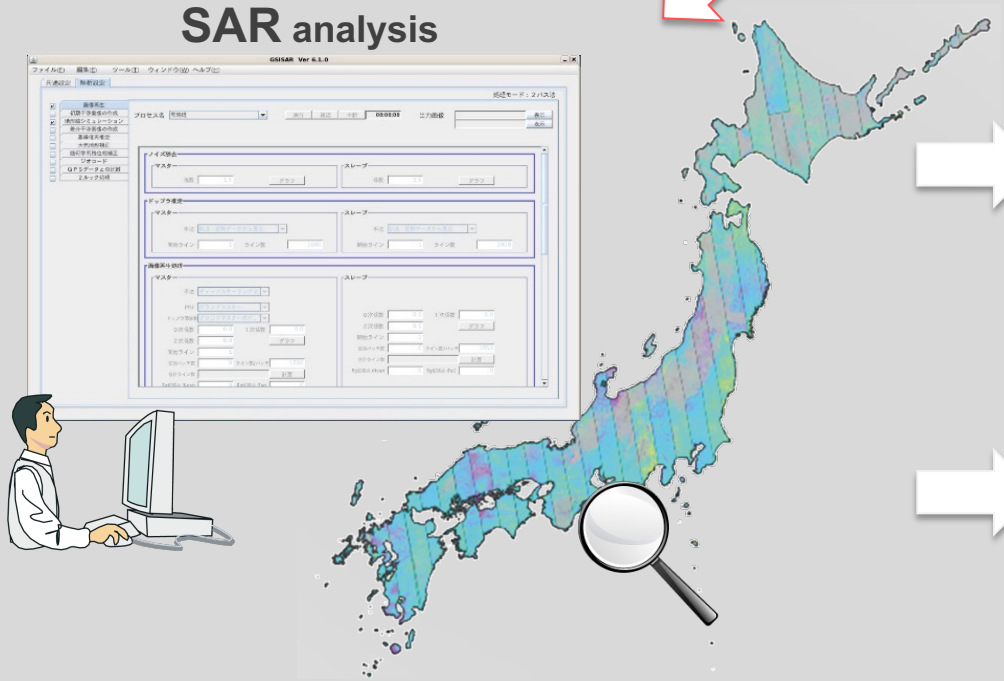
Agreement

Data

Disaster

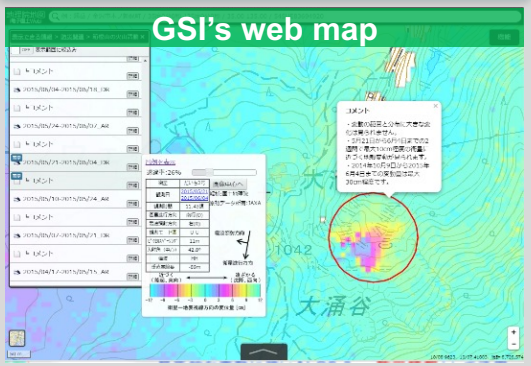


SAR analysis



【 Expert committee 】
Evaluation/Discussion
(What's going on? / What happened?)

- The Headquarters for Earthquake Research Promotion
- The Coordinating Committee for Earthquake Prediction, Japan
- The Coordinating Committee for Prediction of Volcanic Eruption



Administrative agency
[Decision Making]
- Alert level
- setting no-go area

Response to Disaster
Local governments
Ordinary people

Academic study
Researchers

Survey
Local governments
Survey companies

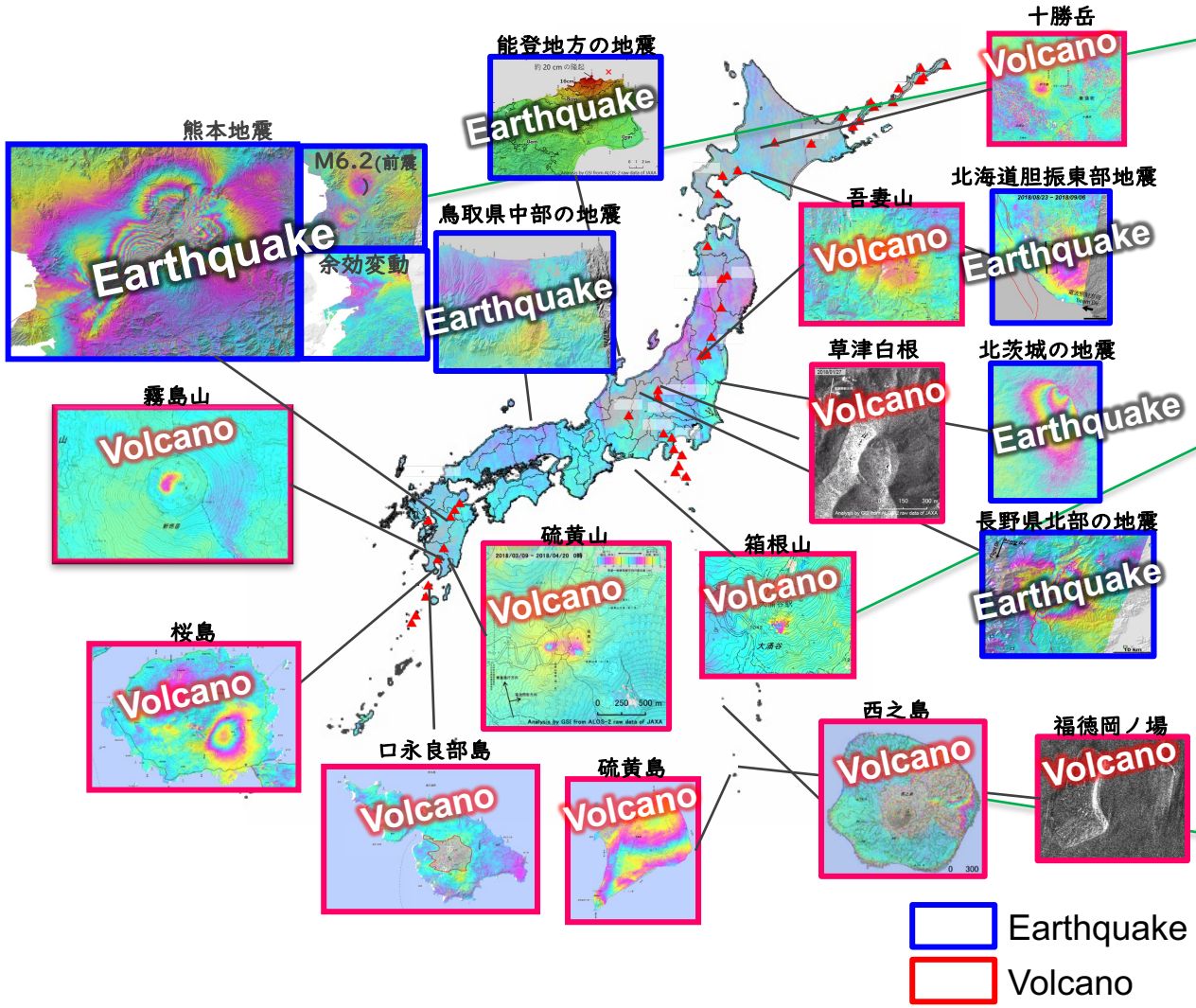
1. Response to Disasters

国土地理院

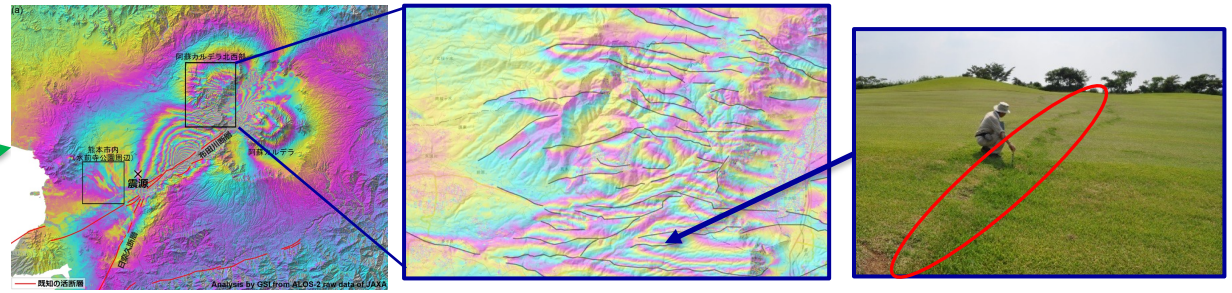
■Crustal deformation monitoring by GSI

Emergency analysis for natural disasters:

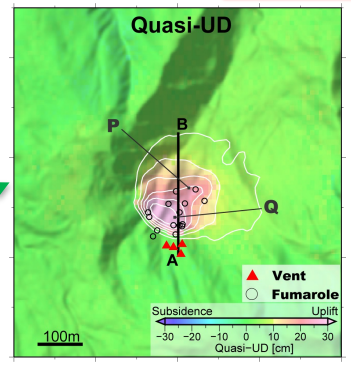
earthquakes and volcanic activities



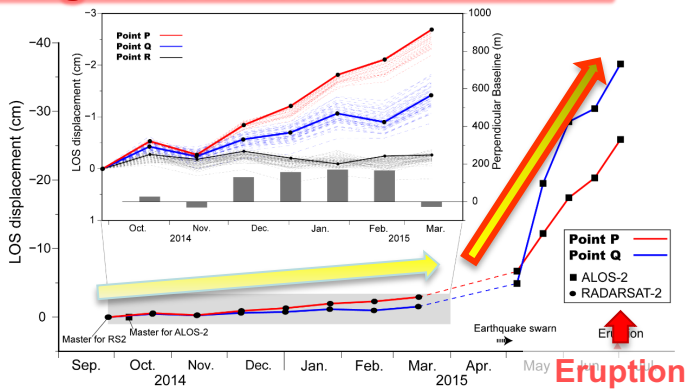
Fault-related ground deformaotion



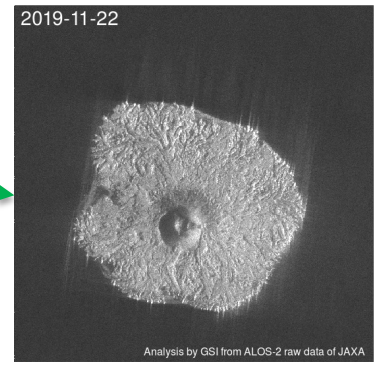
Anomaous ground deformation of volcano



Kobayashi et al. (2018)



Monitoring growth of new volcanic island



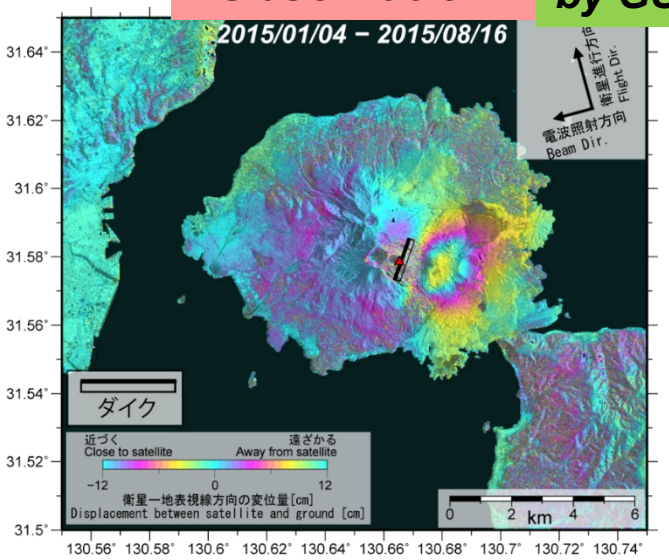


Contribution to evaluation of volcanic activity

国土地理院

2015 Sakurajima magma intrusion event

Observation *by GSI*



Evaluation (Alert) *by JMA*

The Coordinating Committee for Prediction of Volcanic Eruption

Assessment on volcanic activity

Alert Level 3

↓ (Aug. 15, 2015)

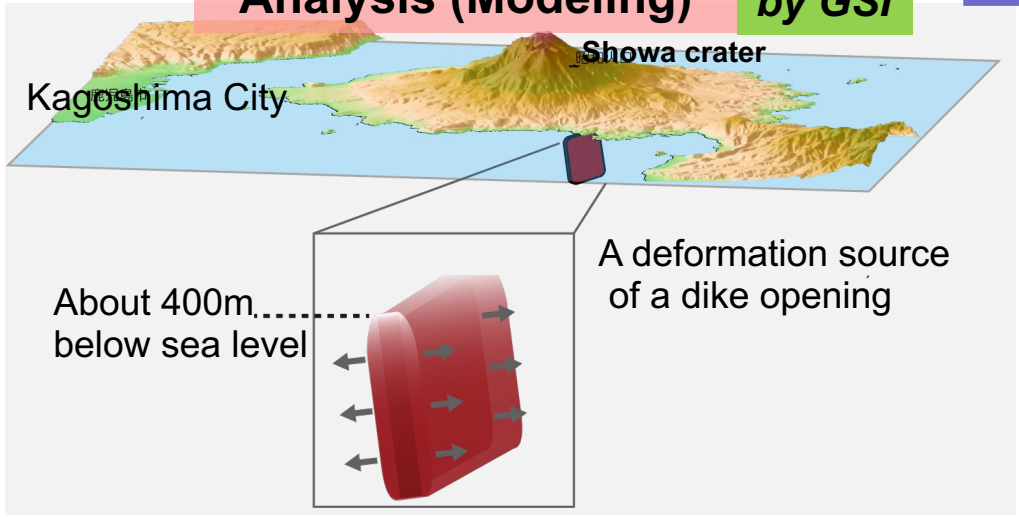
Alert Level 4

↓ (Sep. 01, 2015)

Alert Level 3

GSI's observation data & source model contributed to consideration on **alert level**

Analysis (Modeling) *by GSI*



Level / Keyword		Action to be taken by inhabitants	Action to be taken by climbers
Level 5	Evacuate	need to evacuate from dangerous residential areas.	–
Level 4	Evacuation of the elderly, etc.	Evacuation of the elderly and other persons in need of consideration in residential areas that need to be alerted, and preparation for evacuation of residents is necessary (target areas to be determined depending on the situation).	–
Level 3	Do not approach the volcano	Normal life (pay attention to the future volcanic activity. Mountain entry restrictions). Prepare for the evacuation of the elderly and other persons in need of consideration, depending on the situation.	Refrain from entering the danger zone.
Level 2	Do not approach the crater	Normal life (gathering information on volcanic activity, confirming evacuation procedures, participating in disaster drills, etc., depending on the situation).	the crater is subject to strict regulations which prohibits entry.
Level 1	Potential for increased activity		regulate not to enter a volcanic crater according to situations.

(Note: Target areas for evacuation or regulation differ depending on the regional situation and volcanic activity situation.)

Contribution to evaluation of earthquake

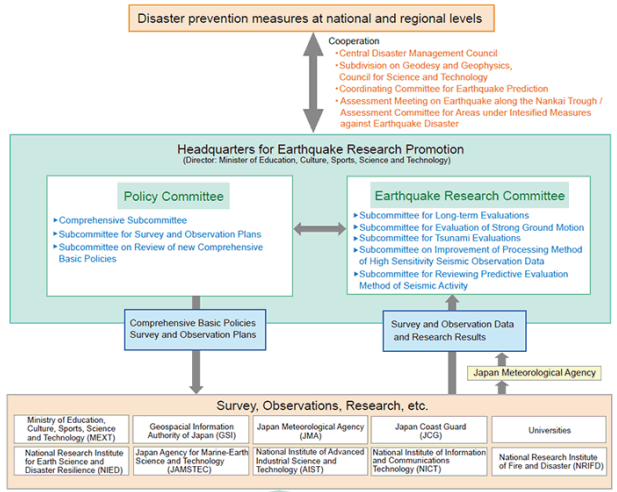
The Headquarters for Earthquake Research Promotion (HERP)

Earthquake Research Committee

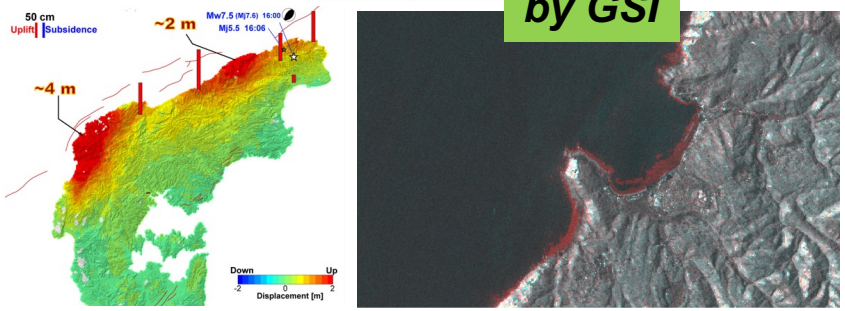
地震調査研究推進本部
The Headquarters for Earthquake Research Promotion

Discussion Evaluation

manner and to publish evaluation results. In addition, ad hoc meetings are
marked seismic activity. The meeting seeks to assess the current activity and the probability of aftershocks.
The Headquarters for Earthquake Research Promotion formulated its new policy, which was titled: "New Promotion of Earthquake Research - Comprehensive Basic Policies for the Promotion of Seismic Research through the Observation, Measurement, and Survey -." This policy is a guideline of earthquake research for the next 10 years, and was released in 2009 (revised in September 2012).



Report ***by GSI***



The 2024 Noto Peninsula Earthquake

Official evaluation

令和６年１月２日
地震調査研究推進本部
地震調査委員会

令和６年能登半島地震*の評価

○　１月１日16時10分に石川県能登地方の深さ約15kmでマグニチュード(M)7.6(暫定値)の地震が発生した。この地震により石川県羽咋郡（はくいぐん）志賀町（しかまち）で最大震度７を観測したほか、能登地方の広い範囲で震度６弱以上の揺れを観測するなど、被害を伴った。また、石川県では長周期地震動階級４を観測した。この地震の発震機構は北西－南東方向に圧力軸を持つ逆断層型で、地殻内で発生した地震である。

○　現在も活発な地震活動が継続している。１月１日以降の地震活動は北東－南西に延びる150km程度の範囲に広がっており、１日16時から２日13時までの間に、最大震度１以上を観測した地震が169回（震度７：１回、震度５強：３回、震度５弱：６回）発生した。

○　今回の地震により、輪島港（港湾局）観測点で1.2m以上、金沢（港湾局）観測点で0.9m（いずれも速報値）など、北海道から九州にかけての日本海側で津波を観測している。

○　ＧＮＳＳ観測によると、今回の地震に伴って、輪島観測点（国土地理院）で西南西方向に１.２m程度の変動、１.１m程度の隆起が見られるなど、能登半島を中心に広い範囲で地殻変動が観測された。また、陸域観測技術衛星２号「だいち２号」が観測した合成開口レーダー画像の解析によると、輪島市西部で最大４m程度の隆起、最大１m程度の西向きの変動が検出された。

○　１月１日に発生したM7.6の地震に伴って、志賀町のK-NET富来（とぎ）観測点で2,828gal（三成分合成）など、大きな加速度を観測した。

○　１月１日以降、地震活動の範囲は広がっている。揺れの強かった地域では、地震発生後１週間程度、最大震度７程度の地震に注意が必要である。特に、地震発生後２～３日程度は、規模の大きな地震が発生することが多くある。また、海底で規模の大きな地震が発生した場合、津波に注意する必要がある。

ALOS-2 data contribute to official comprehensive evaluation of survey results for the earthquake

2. Regular monitoring

国土地理院

Introduction of InSAR time series analysis to GSI's routine operation

～2020	2021	2022

GSITSA (ver2)

Development of software for ALOS-2 time series analysis "GSI-TSA(Time Series Analysis)"

Volcano monitoring

Use for volcanic crustal deformation monitoring
→ improvement of detectability of slow-progressing deformation



Contribution to evaluation of volcanic activity

The Coordinating Committee for Prediction of Volcanic Eruption



Nationwide monitoring

From local (volcano) to total national land

Sequential release from the north

Jun. 2022 **Hokkaido area**

Jan. 2023 **East Japan**





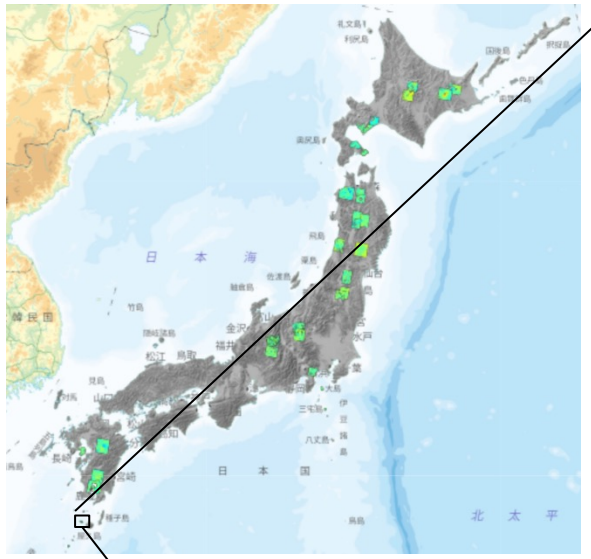
Mar. 2023 **All areas are available**

Volcano monitoring

国土地理院

Open to the public on GSI's map

Routine analysis → (Routine submission) → **Expert committee** (The Coordinating Committee for Prediction of Volcanic Eruption) → **Contribution to evaluation of volcanic activity**



北海道

アトサヌプリ　雌阿寒岳　雄阿寒岳　大雪山
十勝岳　樽前山　倶多楽　有珠山　北海道
駒ヶ岳　恵山

本州

岩木山　八甲田山　十和田　秋田焼山　八幡平　岩手山　秋田駒ヶ岳　鳥海山　栗駒山
蔵王山　吾妻山　安達太良山　磐梯山　草津白根山　浅間山　焼岳　御嶽山　箱根山

伊豆諸島

伊豆大島　三宅島　硫黄島

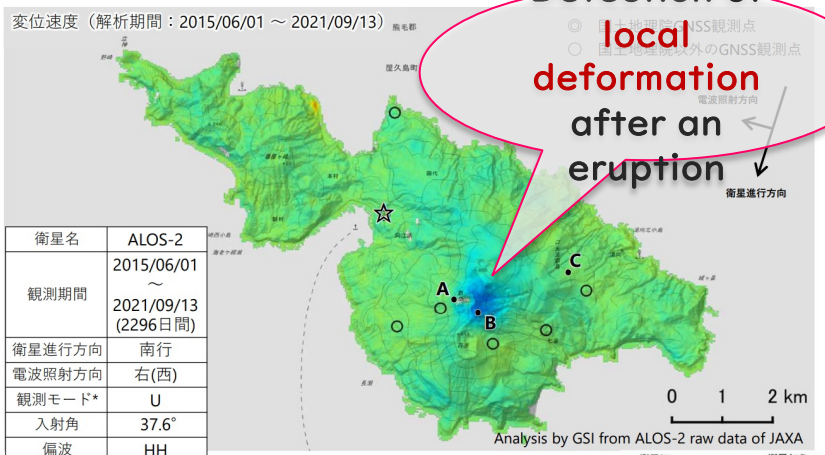
九州・南西諸島

阿蘇山　雲仙岳　霧島山　桜島　薩摩硫黄島
口永良部島　諏訪之瀬島

第１４９回火山噴火予知連絡会　　国土地理院

口永良部島の干渉SAR時系列解析結果（南行）

新岳の地点B周辺に、衛星から遠ざかる変動が見られます。



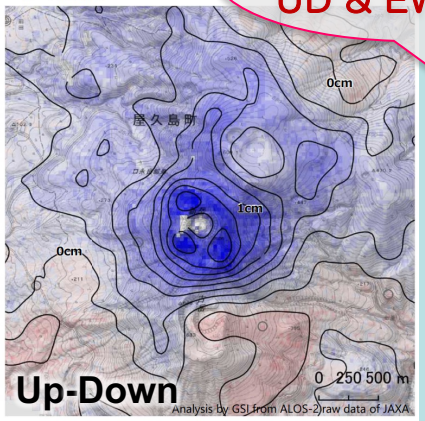
衛星名	ALOS-2
観測期間	2015/06/01 ～ 2021/09/13 (2296日間)
衛星進行方向	南行
電波照射方向	右(西)
観測モード*	U
入射角	37.6°
偏波	HH
データ数	28
干渉ペア数	65

* U：高分解能(3m)モード

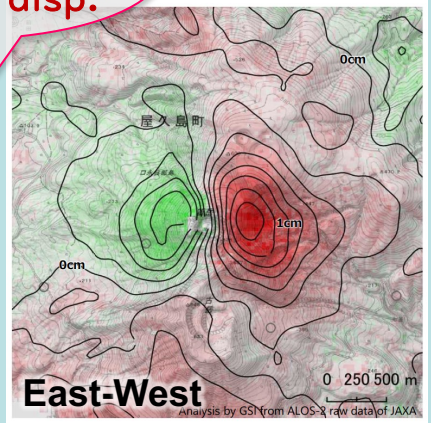
背景：地理院地図 標準地図・陰影起伏図・傾斜量図
干渉SAR時系列解析手法：SBAS法
※参照点付近（☆）

Detection of local deformation after an eruption

準上下方向

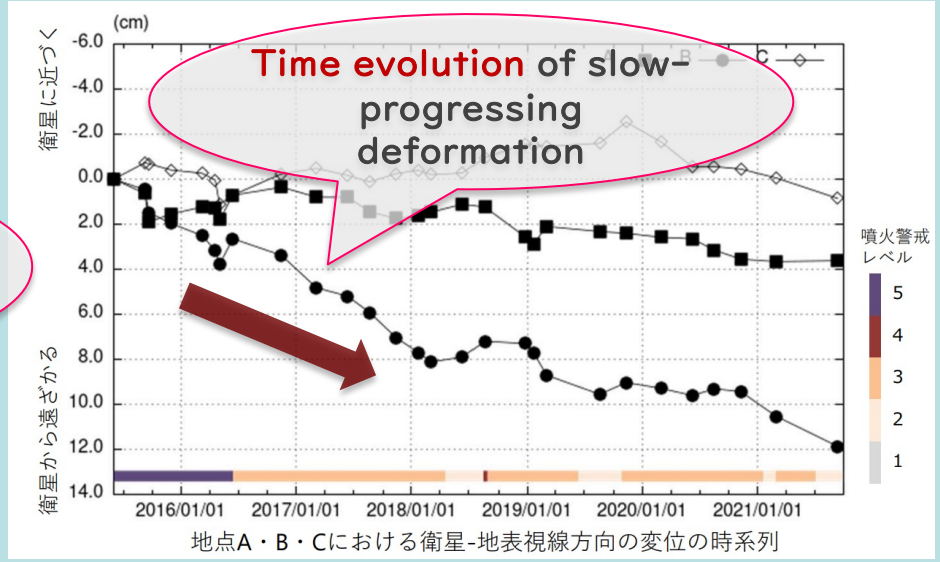


Up-Down



East-West

Estimate of UD & EW disp.

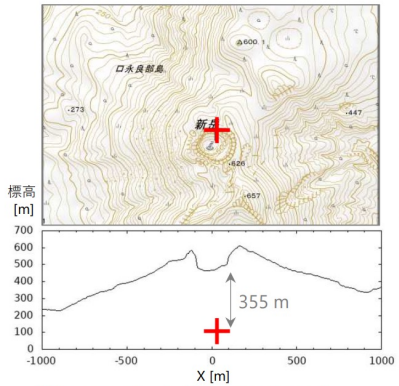


Time evolution of slow-progressing deformation

地点A・B・Cにおける衛星-地表視線方向の変位の時系列

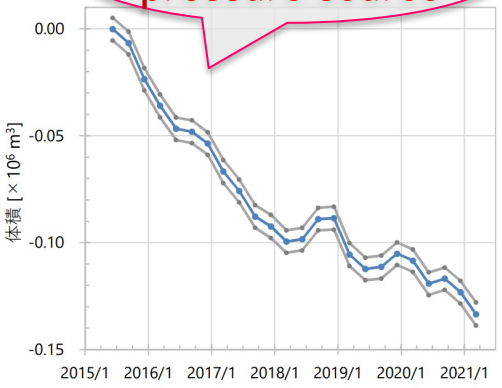
口永良部島の干渉SAR時系列解析結果について
（インバージョン解析による圧力源の位置と体積変化）

変位速度から推定した圧力源の位置



緯度：30.44674°　経度：130.21554°
標高：110 m（火口底下深さ：355 m）

体積変化（体積変動）



Estimate of pressure source

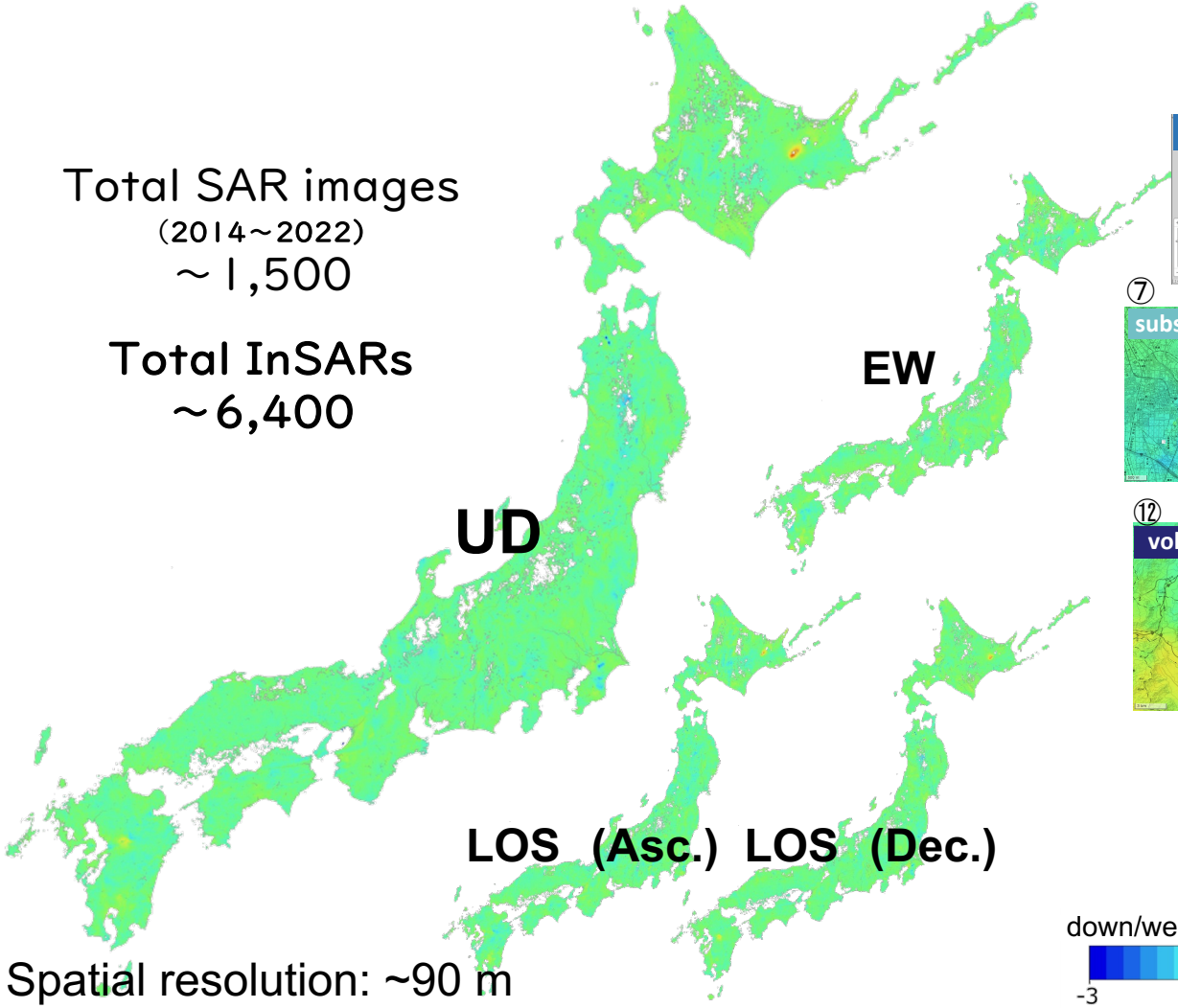
Release (28th Mar. 2023): Nationwide InSAR time series analysis

国土地理院

4 types of displacement rate map

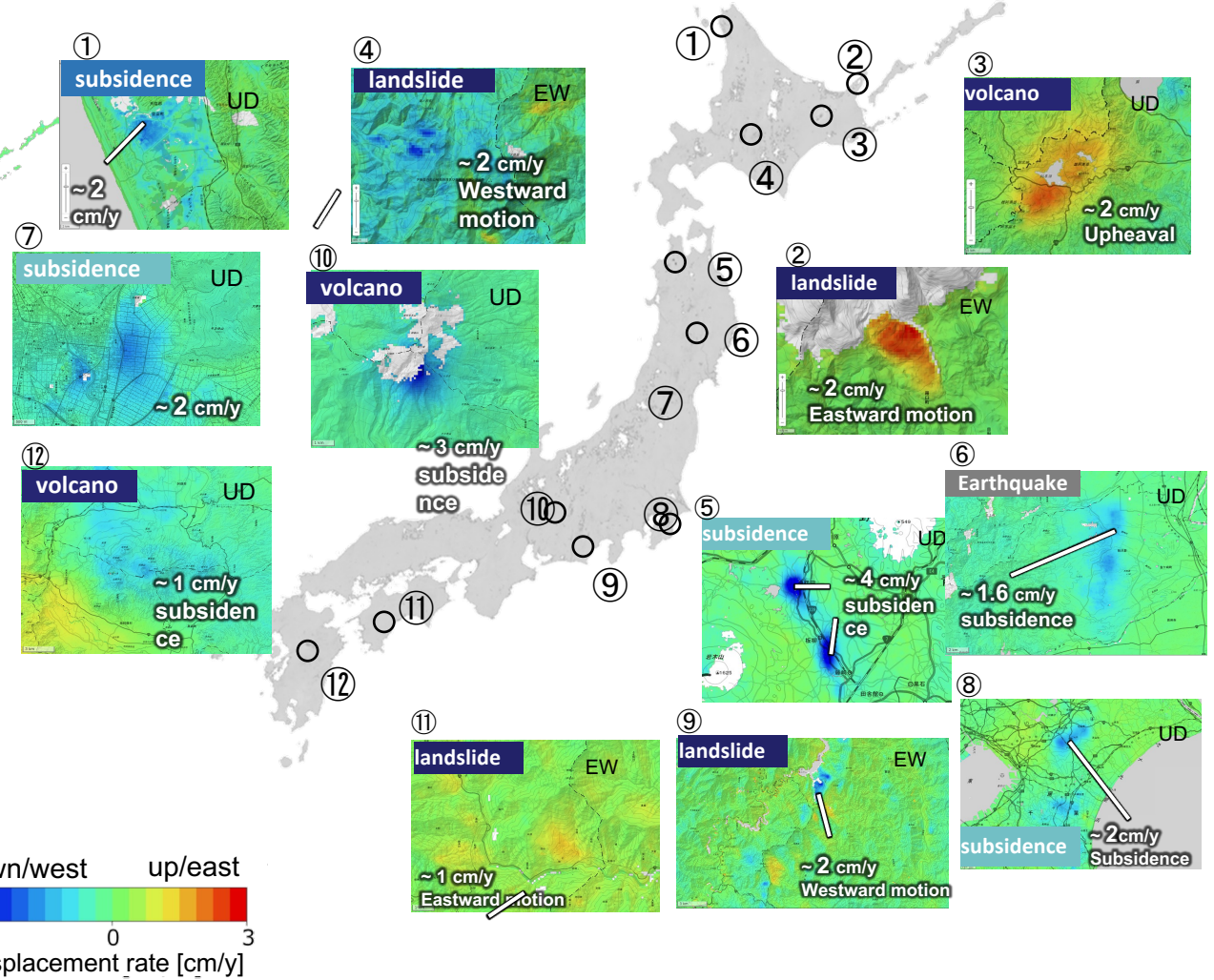
Total SAR images
(2014~2022)
~1,500

Total InSARs
~6,400



Spatial resolution: ~90 m

Nationwide regular monitoring for Earthquake, Volcano, Subsidence , Landslide



Analysis by GSI from ALOS-2 raw data of JAXA

Expectations for international SAR satellite constellation

Quick & High Frequency Observations

for quick response to disasters

【Needs】

- 1st acquisition as quick as possible
- subsequent observations with short intervals

【Expectations】

- Combination of different observation time
  Dawn-Dusk orbit satellite and Noon-MidNight orbit satellite and 9-21 orbit and 3-15 orbit…
- Promotion of combined use of space agency-based and commercial-based satellites

【Requirements for practical use】

- Quick data distribution to users Not archived data but Fresh-picked data
- An environment in which data users can quickly request observations to any satellites

Target: volcano | A volcanic phenomenon sometimes evolves drastically during short time

Expectations for international SAR satellite constellation

High Frequency Observations for InSAR

for regular monitoring by InSAR time series analysis

【Needs】

- Long-term & sustainable observations with high temporal resolution & measurement accuracy

【Expectations】

- High frequency observations on focused deformation areas with multiple satellites

For future

- Same flight orbit and microwave band with multiple satellites so that InSAR can be applied:
  L-band combination of ALOS series & NISAR series & ROSE-L series …

2D- & 3D-displacement map

for ground deformation monitoring

【Needs】 Not line-of-sight but EW, NS, UD components

【Expectations】

for 2D - Combination of right-looking and left-looking observations ALOS-2, ALOS-4, NISAR

for 3D - A new satellite with specification that is sensitive to measurement of North-South component