InSAR Detection of the Mt. Aso Volcanic Crater Activity at the event of Sept 14 2014 Eruption

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Synthetic Aperture radar can observe the earth surface with high resolution by the multiple transmission and reception of microwave signals. Since the microwave in L-band is not affected by the weather condition and the eruption ashes, it is adequate to detect the surface deformation from the space. This research will detect the deformation of the valocanic mountain by using the interferometric SAR technique. INSAR measures the differential distance between the satellite and the target between two different observations (dates) and visualization allows the accurate measurement of the distance. This research will detect the volcanic subsidence of the crater using this method and PALSAR-2 data, which was developed and operated by the JAXA since May 24, 2014.
Mt. Aso has been active for these years and had a small-scale eruption on Sept. 14 2014. PALSAR-2 data of UB mode with 85 MHz single polarization were acquired on Sept. 7 and 21 covering these areas, and were InSAR processed (including the atmospheric correction). It was found that there were three small subsidence areas western part of the main volcanic crater. Three these areas had 5cm subsidence in average vertically. This can be interpreted as that the eruption of the magma could reduced the mass of the magma. Validation of the results has been conducted using the GPS data acquired at three points by GSI and NIED, and measured the RSSE of 2.345cm. It can interpreted that the eruption of Sept. 14 2014 were observed by two adjacent PALSAR-2 images as the subsidence of 6.06 cm, the loss of the coherence at the crater area, and resultant loss of the mass were estimated, and thus the mountain could be shrunk.

Keywords: InSAR, eruption, subsidence

Estimation of surface displacement around Kuju volcano before and after the 2016 Kumamoto earthquake using SAR interferometry

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The 2016 Kumamoto earthquake occurred from Kumamoto prefecture to Oita prefecture along the Beppu-Shimabara graben. Kuju volcano is one of active volcanoes, which lies in the center of the Beppu-Shimabara graben, and even now volcanic fume is observed.
In this study, we estimated surface displacement around Kuju volcano before and after the 2016 Kumamoto earthquake using differential SAR interferometry (DInSAR) and SAR interferometry time-series analysis. We applied DInSAR analysis to SAR data acquired soon after the 2016 Kumamoto earthquake: ALOS2/PALSAR-2 images acquired at April 18 and June 13 2016 on an ascending orbit (path 23, frame 2950). On the other hand, we used Small Baseline Subset (SBAS) analysis, one of InSAR time-series analysis, for estimating spatio-temporal pattern of surface displacement before and after the Kumamoto earthquake. We used 6 PALSAR-2 data acquired from August 2014 to February 2016 on an ascending orbit (path 130, frame 650), and 13 PALSAR-2 data acquired from June 2016 to October 2016 on a descending orbit (path 23, frame 2950).
As a result of DInSAR analysis, we estimated surface displacement toward line-of-sight direction with about 4cm at Mt. Iwou, about 3cm in Mt. Kuju and about 2cm around the Hatchobaru geothermal field. Considering that the displacement occurred at almost all of Kuju volcano, and no significant seismicity has been observed, we interpreted that thermal fluid or magma at deeper than 5km depth have influenced the surface displacement.
SBAS analysis revealed surface displacement showing both upward and downward pattern at Mt. Iwou and Mt. Kuju before and after the 2016 Kumamoto earthquake. Despite the similarity of displacement pattern, we could not find clear correlation between the displacements before and after the earthquake. Moreover, we estimated a liner subsidence rate of about 14˜16 mm/year around the Hatchobaru geothermal field.
Although it is better to apply further analysis to larger number of SAR data for clarifying changes in surface displacement pattern.

Keywords: InSAR, DInSAR, SBAS Analysis, Kumamoto earthquake, Kuju volcano, ALOS2/PALSAR2

Disaster management issues of the displacement distribution map after 2016 Kumamoto earthquake based on time-series DInSAR analysis

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In this study, Differential SAR Interferometry (DInSAR) was applied for time series analysis of the ground surface displacement induced by the 2016 Kumamoto earthquake and subsequent forcing events (aftershocks and rainfalls). We developed a new visualization method (the displacement distribution maps) using ALOS-2 dataset as follows:
1) detecting displacement distribution from results of DInSAR analysis,
2) calculating amount of displacement from slant range differences, and
3) mapping the amount of displacement in mesh and road section.
Probable causes of the displacement detected from DInSAR analysis (e.g. landslide, subsidence, liquefaction of the ground induced by the earthquake) were examined by field observation. We found that some of the displacement were related with land cover changes such as vegetation growth and replacement of roads and houses.
Finally, the effectiveness of the displacement distribution map for disaster prevention and points for further improvement were discussed.

Keywords: Displacement distribution map, Differential SAR Interferometry, Landslide, The 2016 Kumamoto earthquake, ALOS-2

Deformation monitoring at Tokachi-dake volcano, by using GNSS, tiltmeter, and DInSAR observations

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Tokachi-dake volcano is located in central Hokkaido, Japan, and is the most active volcano in Tokachi-dake volcano group. Middle sized eruptions occurred in 1926, 1962, and 1988-1989, and several small phreatic eruptions also occurred in the meanwhile. After the latest eruption in 1988-1989, many volcanic tremor and active seismicity were revealed. Fumarolic activities from Taisho crater and 62-2 crater have been observed.
Surface deformation in volcano area is one of signals of volcanic activities. There are observation network including V-net by NIED and GEONET by GSI around Tokachi-dake volcano, and deformation monitoring by GNSS and tiltmeter have been operated to detect regional deformation. Geological Survey of Hokkaido and Hokkaido University have several GNSS stations in summit area, and they have been operated to detect local deformation. Moreover, deformation monitoring with higher spatial resolution has been carried out by using satellite SAR interferometry. In this study, we introduce the results from deformation monitoring at Tokachi-dake volcano, by using continuous data from GNSS and tiltmeter of V-net and GEONET, and satellite SAR data from ALOS-2/PALSAR-2 and TerraSAR-X.

Keywords: SAR, Deformation, Tokachi-dake

SAR interferometry using RADARSAT-2, ALOS and ALOS-2 data; case study in Kanto region

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Radar frequency bands used for satellite SAR are mainly L-, C- and X-band. The used frequency band is an important factor for InSAR because difference of the frequency band have a great impact on coherence and measurement precision of displacement. Each frequency band has advantages and disadvantages, therefore, selected use of an appropriate frequency band depending on targets or combined use of multiple frequency bands can enhances the capability of detection of displacement.

In Japan, Japanese L-band satellites ALOS and ALOS-2 data are often used. However, these data have disadvantages such as lower measurement precision and lower observation frequency than other satellites' data. Moreover, no data exists for more than three years, from May 2011, when ALOS stopped its operation, to August 2014, started observations by ALOS-2, meaning that no surface displacement can be investigated. It is important to fill the blank period for objectives such as subsidence and volcanoes, which should be monitored continuously over a long period, especially because the blank period is just after the 2011 off the Pacific coast of Tohoku Earthquake.

Canadian C-band RADARSAT-2 is one of the few SAR satellites operated in the blank period of the ALOS series. C-band has higher measurement precision and larger amount of data in a specific region than L-band, whereas C-band is more vulnerable to vegetation than L-band. We were provided with RADARSAT-2 data in Kanto region, Japan, including the blank period of the ALOS series, under bilateral cooperative agreements of GSI-JAXA and JAXA-CSA. In this presentation, we will report results of InSAR analysis using RADARSAT-2, ALOS and ALOS-2 data in Kanto region including around the Tachikawa fault and the Hakone volcano, and their comparison.

Keywords: InSAR, RADARSAT-2, ALOS, ALOS-2, C-band, L-band

Temporal variation of ice sheet and ice shelf on East Antarctica using Synthetic Aperture Radar data

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Three years have passed since the launch of ALOS-2 and Sentinel-1A, and these satellites are collecting polar data smoothly. In recent, polar observations with high frequency, multi-band and wide area have archived as compared with ERS-1/SAR observation begun in 1991. In last year's JpGU, it was possible to analyze and report on the sudden discharge of fast ice in LH Bay using multiple SAR data. Based on the results of last year,
our study focus on the analysis of the subsequent change of the fast ice in the LH Bay and time series SAR data analysis of East Antarctica, which is said to have a slow response to Climate Change compared with the West Antarctica, in particular Syowa Station and its surrounding area and Prinsesse Lagnhild Kyst.
For analysis using SAR data, time series analysis of Grounding Line variation using InSAR and time series change of backscatter intensity are performed. We also try to quantitatively grasp the change amount of shelf ice in this area by using altimeter data as analysis results of these SAR data. For time series analysis, we will also try to use Google EarthEngine, which can use the SAR intensity image relatively easily.

Keywords: SAR, Time Series analysis

Monitoring of Plantation Forests using Polarimetric SAR Data

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Industrial plantation forests have rapidly expanded throughout many parts of the world. Therefore, the sustainability of plantation forests must be ensured through continuous monitoring. Especially in regions of persistent water vapor and clouds, which cannot be continuously monitored by optical sensors, microwave sensors are particularly advantageous in forest monitoring. However, microwave backscattering mechanisms in plantations remain poorly understood.

This study attempts to understand backscattering characteristics under different forest structural conditions in plantation forests of fast-growing acacia trees in Sumatra, Indonesia. A general four-component scattering power decomposition method was applied to ALOS PALSAR data. The variation in decomposition powers was compared to forest inventory data with visual assessments of stand conditions.

Our results were highly consistent with the field-measured data and suggest that the forest structural conditions can be understood from the yearly variations of the polarimetric parameters. The main findings are that (1) after the rapid growth phase, when the trees retain fewer leaves, canopy scattering is contributed by both forest canopy and understory vegetation. Four-component power decomposition is useful for distinguishing the growth of the canopy itself from growth of the understory vegetation; (2) in the investigated plantation, the relative canopy scattering increases in healthy mature stands before harvest time because the remaining tree canopy is supplemented by understory vegetation. At the same time, the understory growth strongly interferes with the double-bounce scattering, in which remarkable decrease is observed. This result indicates that the understory conditions must be considered in the analysis of L-band SAR data, especially in this plantation and other sparse forests; (3) physical leaf damage is associated with a distinct decrease in relative canopy scattering, and also by increased relative surface and double-bounce scatterings. Partial damage in a forest compartment is reflected in the ALOS PALSAR data. Moreover, even in younger forest stands, the fluctuation in the canopy scattering reflects the growing conditions, and provides useful information for measuring growth states.

This study on a single-layered forest elucidated how the fundamental characteristics of radar backscattering vary with forest structures and conditions. Such understanding will assist forestry researchers to interpret scattering mechanisms in natural forests.

Keywords: Scattering Power Decoposition, L-band, plantation forests

A study on measurement error of topography using cross-track interference SAR

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Synthetic aperture radar (SAR) has been developed to obtain radar images with high spatial resolution. Applying digitally signal processing, SAR obtains higher processing abilities, like the cross-track interferometric SAR (XTI SAR) technique to measure the topography of wide area. In these days, the improvement of accuracy is strongly required for quick topography measurement at the disaster scenes.

The XTI SAR technique uses more than two antennas with spatial separation perpendicular to the moving direction of platform. All antennas receive the scattered signal from the same target. The differences of target ranges between each antenna pairs are measured from the difference of signal phases received by each antenna with sensitivity of sub-wavelength order. The target position is determined by combining the antenna positions and the differences of target ranges.

On the processing of XTI SAR, the antenna positions measured on ground are dealt as known value, because the position measurement in flight is quite difficult. However, the real antenna positions in flight may differ from the measured positions on ground due to the different conditions of circumstances. Moreover, the platform altitude, which is needed to solve the ambiguity in difference of target ranges, may include error. In addition, the target ranges measured each antenna also include pseud lengths due to the time delays in electronic circuits. These errors of measurement parameters on XTI SAR may lead the measurement error of topography.

In this paper, considering the simple XTI SAR technique using two antennas, the relations between the errors of measurement parameters and the measurement error of topography is studied. Based on these relations, the features of measurement errors due to each error of measurement parameters are simulated and the influences are discussed.

Keywords: Synethtic Aperture Radar (SAR), Cross-track interfelometric SAR, topography

InSAR atmospheric correction using Geostationary Meteorological Satellites

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InSAR is effective tool to detect land deformation precisely with high spatial resolution. And addition to the spatial resolution, the SAR observations can measure deformation more frequently than leveling. ESA's Sentinel-1 constellation are observing Japan area each 12 days for example. More finely and frequently observation, we face critical problems caused by the atmospheric effects. And to correct this effects there are many ways proposed. The major one is using metrological analysis model like ECMWF. This corrections are very successful in several observations. But there are some problems remained. 1st is that the models aren’t synchronized SAR observation time. JAXA's ALOS-2 orbit to synchronize the time is designed to observe nearly 0:00 or 12:00 at local time. But the time is not exactly 0:00 or 12:00, varied by orbit. This gap has problems because of the phase shift by the water vapor every second changing. 2nd is the cost of calculation. To simulate atmospheric model like ECMWF we need high performance computers like KEI. It is difficult to use that computers for everyone who want to calculate certain time. And the other methods including GNSS correction also have advantages and disadvantages.
To solve those problems we propose using Geostationary Meteorological Satellites to correct InSAR results.
Next generation geostationary meteorological satellites like Himawari-8 and GOES-16 can observe visible range at every 5 minutes. Especially Himawari-8 can observe Japan area at every 2.5 minutes. And the wavelength ranges are significantly increasing from former generations. Using this wavelength ranges and frequent observation by GMS, we can calculate the phase shift of SAR by the water vapor.
We made InSAR results and using Himawari-8 images to correct these results. To confirm SAR satellite's wavelength effects in correction using Himawari, we used ALOS-2 images and Sentinel-1 images after starting the Himawari-8's observation. SAR processing software we used is GAMMA SAR. And used parameter files of the software to calculate SAR satellite information. Using SAR satellite information and Himawari-8 satellite information, we calculated the length change from SAR satellites by the snell's law. And calculated the phase shift from this length changes.
Himawari-8 data that was used in this study was supplied by the P-Tree System, Japan Aerospace Exploration Agency (JAXA).

Keywords: SAR, InSAR, ALOS-2

