Ground deformation of Nishinoshima Island associated with volcanic activity using ALOS-2/PALSAR-2

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- The ownership of PALSAR-2 data belongs to JAXA.

- We used RINC software (Ozawa, 2015) to process SAR images in this study. We would like to thank Dr. Ozawa (NIED) for his kind offer.

- In the process of the InSAR, we used ‘the digital elevation map 2.5m-mesh’ provided by GSI.
Outline

● Introduction
  - Location of Nishinoshima Island
  - History of activity
  - Latest activity

● Result
  - Intensity images
  - Coherence images
  - InSAR images

● Summary
Where’s Nishinoshima island?

Latitude: 27°14’49″N, Longitude: 140°52’28″E, Elevation: 25m (before eruption)
Small volcanic island off the coast of Japan. Roughly 620 miles south of Tokyo.
History of activity on Nishinoshima Island

  ➢ 14 Sep. 1973: New Island was formed.
  ➢ 21 Dec. 1973: Japan Coast Guard (JCG) named the new Island "Nishinosima-shinto"

● Eruption type was phreatomagmatic and magmatic.

● According to the airborne survey by JCG, the island area is 0.316km$^2$ (including Shinto: 0.238 km$^2$).

● Erupted Magma = 0.017 km$^3$ DRE.
Latest activity on Nishinoshima Island

- According to observation conducted by JCG and JMSDF on 20 Nov. 2013, an eruption near Nishinoshima had formed a new island.

- Aerial observation conducted by JCG on 26 Dec. 2013 revealed that two tips of a lava flow from the northern part of the new island had reached “Old Nishinoshima”, thereby uniting the two landmasses.

- The newly formed land was around 1,900 m in the east-west direction and 1,950 m in the north-south direction for a total area of around 2.68 km² (12 times of its pre-eruption size) as of 18 Aug. 2016 (by JCG).

※ Volume on the surface of the sea level was 8.8 km³ as of 9 Dec. 2015 (by GSI).
## ALOS-2/PALSAR-2 observations

In this study, we used all data except Scan-SAR mode observations.

<table>
<thead>
<tr>
<th>Orbit</th>
<th>Direction</th>
<th>Mode</th>
<th>Path</th>
<th>Frame</th>
<th>Beam No.</th>
<th>Cross-Track</th>
<th>Inc. Angle</th>
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ALOS-2/PALSAR-2 has regularly observed around Nishinoshima Island since Aug. 2014. ALOS-2/PALSAR-2 observed the island from 11 paths. Many of the observation (25 scenes as of Aug. 2016) are spotlight (SPT) mode. For paths which have multiple observations, we applied interferometric analysis.
The island expanded northward (Aug. - Nov. 2014), northwestward (Nov. - Dec. 2014), eastward (Jan. - Mar. 2015), then southeastward (Apr. - Jun. 2015). After Jun. 2015, no area change have been observed. The most important result is that the central crater has not changed its position throughout the observation period. As a result, a pyroclastic cone is formed around the crater.
This figures show land area variation using cyan-red composition of two successive observations. Expansion of the land area stopped at Jun. 2015. Amplitude change around central crater is also seen until Oct. 2015.
Low-coherence area that reaches the coast is observed until May 2015. After that, low-coherence area is limited to the central pyroclastic cone and around. Since Oct. 2015, almost no decorrelated area is observed. ※ Note that the long time separation can also cause decorrelation.
Top diagram shows the change of the land area estimated from amplitude images of all paths. Bottom diagram shows the change of decorrelated area in path 14.

With reference to the land area at Aug. 2014, the island has grown 1.7 times larger at Dec. 2014, 1.8 times at Mar. 2015 and twice larger at Jun. 2015. After Jun. 2015, there has been no little change in area. This result is well consistent with the reports of other institutes such as JCG.

Even though the difference in observation period could affect the estimation of area of decorrelation, it should be safe to mention that the decorrelation is almost absent since Oct. 2015. This suggests that the volcanic activity ceased (or greatly reduced) at Oct. 2015.
Area of low phase stability and low coherence (previous page) show good agreement with the route of lava flow observed by other observations. Region neighboring the decorrelated area shows phase change which indicates LOS distance increase (displacement away from the satellites). Since Nov. 2015, decorrelated area is not seen except for the Feb.-Jul. 2016 pair which shows roughly 6 cycle (70cm) of the fringe at the southeast of the central pyroclastic cone.
We have examined the interferograms of other paths to determine "when" the deformation observed in the path 14 interferogram (E) took place. Similar LOS distance increase is detected in all interferograms, which confirms that the deformation is real, but not May-Aug. 2016 (C') in Path 17.

Since the interferogram of Path 16, Apr.-Jul. 2016 (D) does show the fringe pattern, these facts indicates that the deformation occurred "after April" and "before May", 2016.
We performed 2.5-dimensional analysis using the combination of "A-C" and "B-E". The 2.5-dimensional analysis (Fujiwara et al, 2000) is a method of decomposing the two LOS direction displacement into quasi up-down and east-west components. The downward (blue) and upward (red) arrows represent the subsidence and upheaval, respectively. Both results show a significant subsidence at the southeastern part of the central pyroclastic cone.
Models that explain the deformation at the southeastern part of the central pyroclastic cone. Both model estimate $10^4 \text{m}^3$ order of volume change at shallow depth below sea level.
Summary

● We applied interferometric analysis to ALOS-2/PALSAR-2 spot light mode data which observes Nishinoshima Island.

● Phase change in direction away from the satellite was remarkable in region neighboring the decorrelated area.

● The deflating source was estimated to explain the deformation at the southeast side of the central pyroclastic cone that occurred between April and May 2016.

● Volume change and the depth of the source were estimated to be $10^4 \text{m}^3$ order at shallow depth below sea level by the simulation, which assumed a point source or a dyke-like source.