Pre-eruptive deformation of Kyushu Island volcanoes and magma source depth of Shinmoe-dake, Kirishima with L-band time series InSAR

UNIVERSITY OF MIAMI
ROSENSTIEL SCHOOL of MARINE & ATMOSPHERIC SCIENCE

Yunjun Zhang[1], Falk Amelung[1], Yosuke Aoki[2] and Heresh Fattahi[1]

(1) RSMAS, University of Miami, Miami FL, USA

(2) Earthquake Research Institute, University of Tokyo, Tokyo, JAPAN

yzhang@rsmas.miami.edu, famelung@rsmas.miami.edu

Fringe 2015, P2-188

ABSTRACT

Ryukyu volcanic arc is Japan's triple junction formed by the subduction of the Philippine Sea Plate beneath the Eurasian Plate. Lying on the north of this arc, Kyushu Island volcanoes could severely disrupt over 110 million people's everyday life (*Tatsumi and Suzuki*, 2014, PJA Ser.B) due to potential catastrophic caldera-forming eruption. 2011 Shinmoe-dake eruption is the latest magmatic eruption on Kyushu Island. GPS based modeling has been conducted, but no InSAR yet.

We processed three tracks of ALOS L-band SAR data covering Shinmoe-dake crater using time series InSAR technique. All show deflation on and around the crater. A shallow magma chamber of about 2.7 km under the summit is estimated using half-space Mogi model. This confirms that shallow magma source is preferential on strike-slip tectonic settings (*Chaussard and Amelung*, 2014, G[3]). Deflation and inflation activities are also detected on Kuju volcano and Sakurajima caldera.

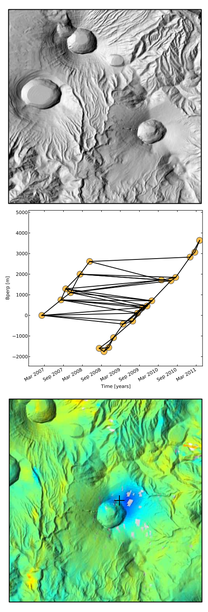
SAR Focusing (GAMMA)

InSAR Processing (ROI_PAC)

Time Series processing (PySAR)

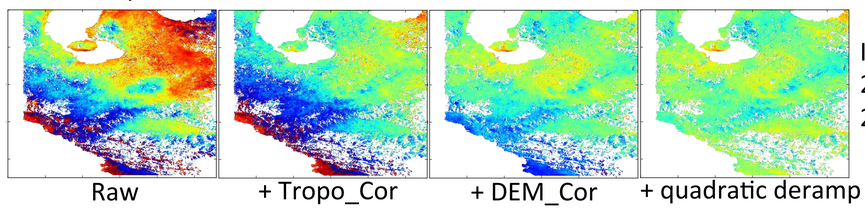
- SBAS Network selection
- Remove Tropospheric effect (PyAPS), DEM error & phase ramp
- Inversion of velocity and time series

Magma source modeling (GeodMod)



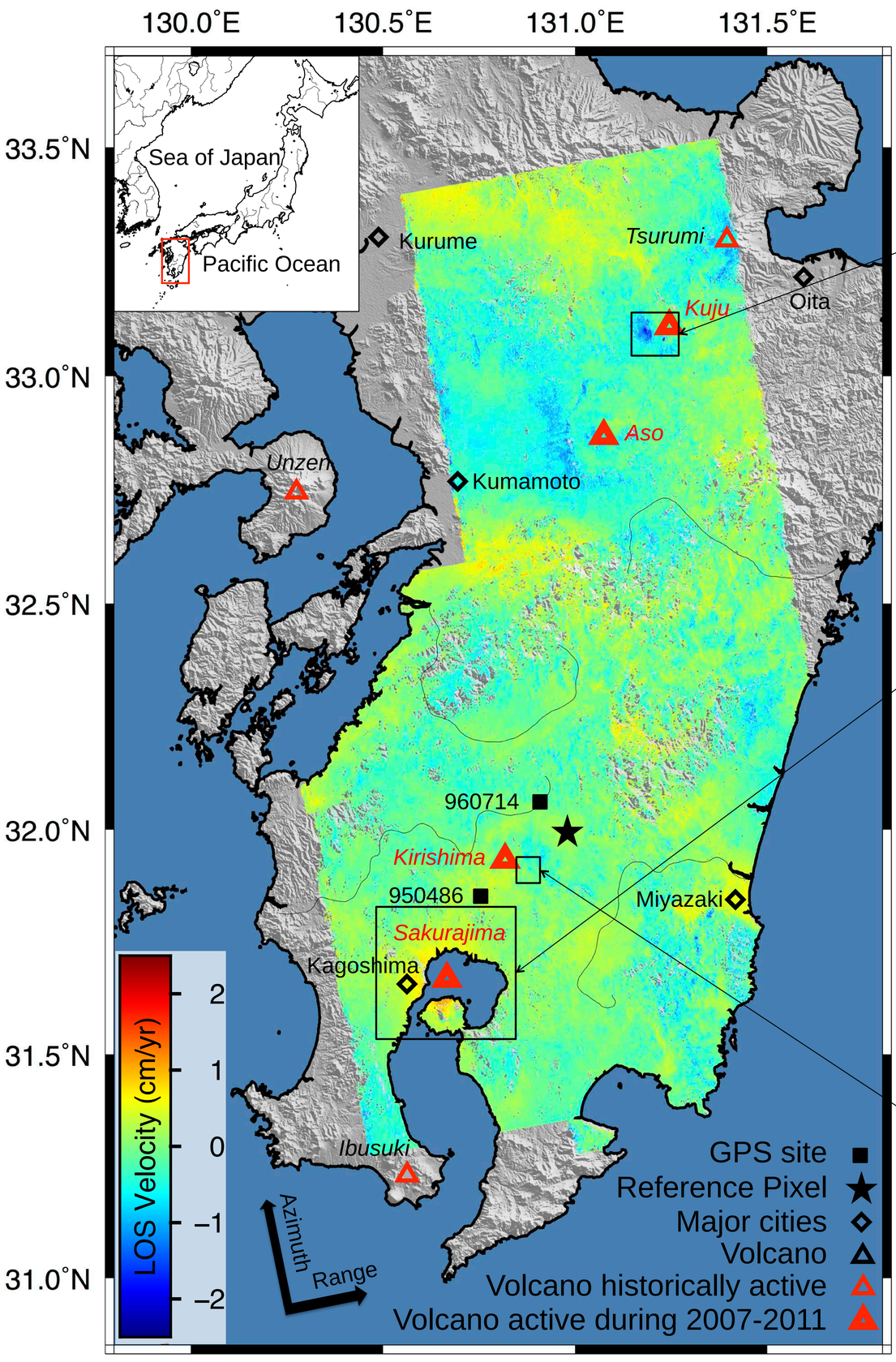
METHODOLOGY

- Data: 4 tracks (2 Asc, 2 Desc) 276 ALOS images (2006-2011) from JAXA, and 0.4 arc-second (~10 m) Digital Ellipsoidal Height Model from GSI, Japan [*Tobita et al.*, 2002]
- InSAR processing: 331 interferograms (Ifgs) produced after generating SLCs with Gamma.
- Time series InSAR: Small Baseline Subset (SBAS) [*Berardino et al.*, 2002, TGRS] using PySAR developed at Univ of Miami.

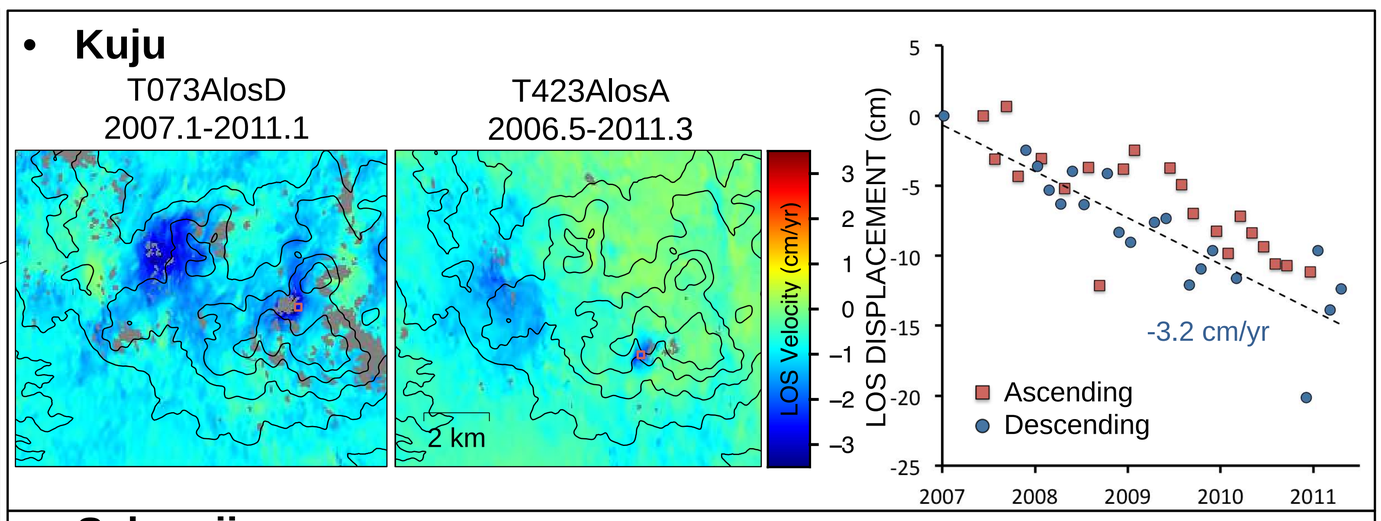


  - Pairs selection: threshold (1000 days and 1 km), drop low coherent Ifgs manually.
  - Phase correction: tropospheric phase estimation using ECMWF weather re-analysis data with PyAPS [*Jolivet et al.*, 2011, GRL], DEM error correction [*Fattahi and Amelung*, 2013, TGRS] and quadratic ramp removal.
- Magma source modeling: half-space Mogi model with GeodMod.

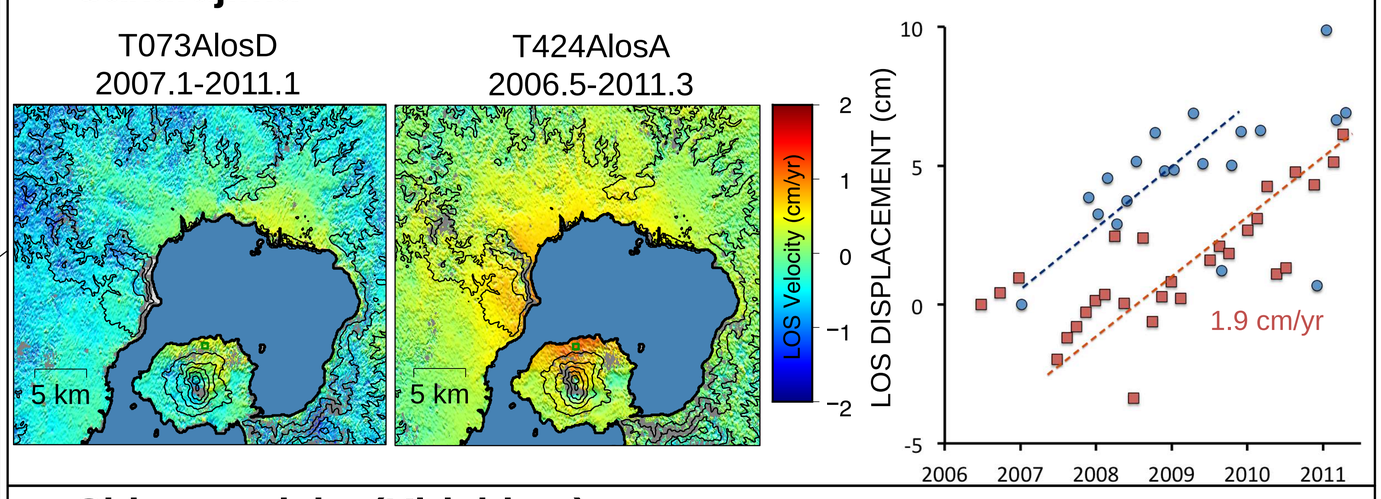
1 PRE-ERUPTIVE DEFORMATION OF VOLCANOES ON KYUSHU ISLAND



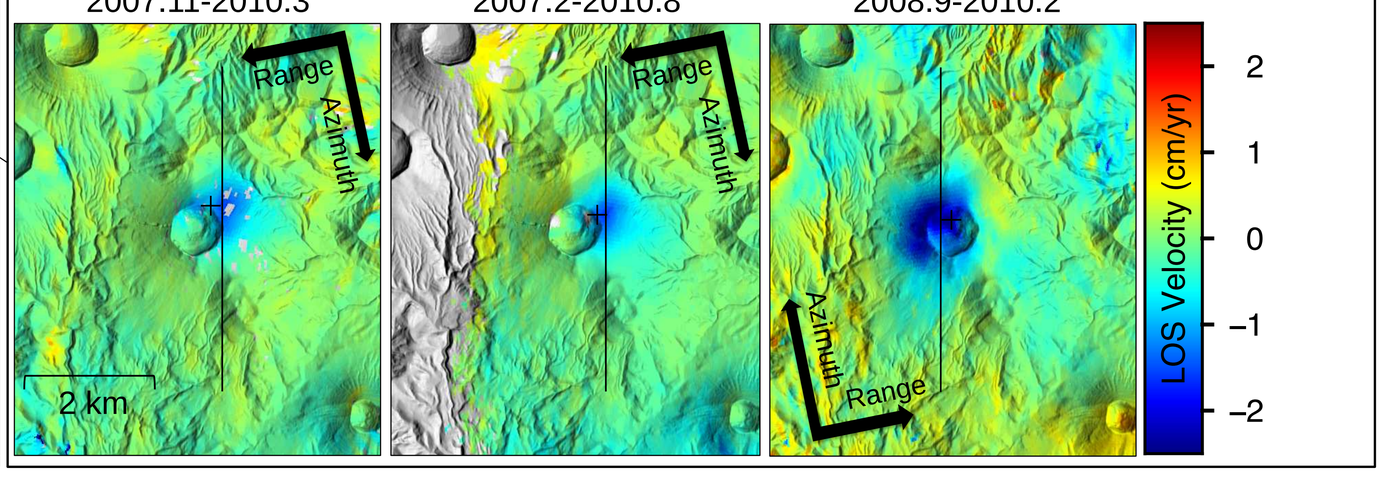
- **Kuju**



- **Sakurajima**

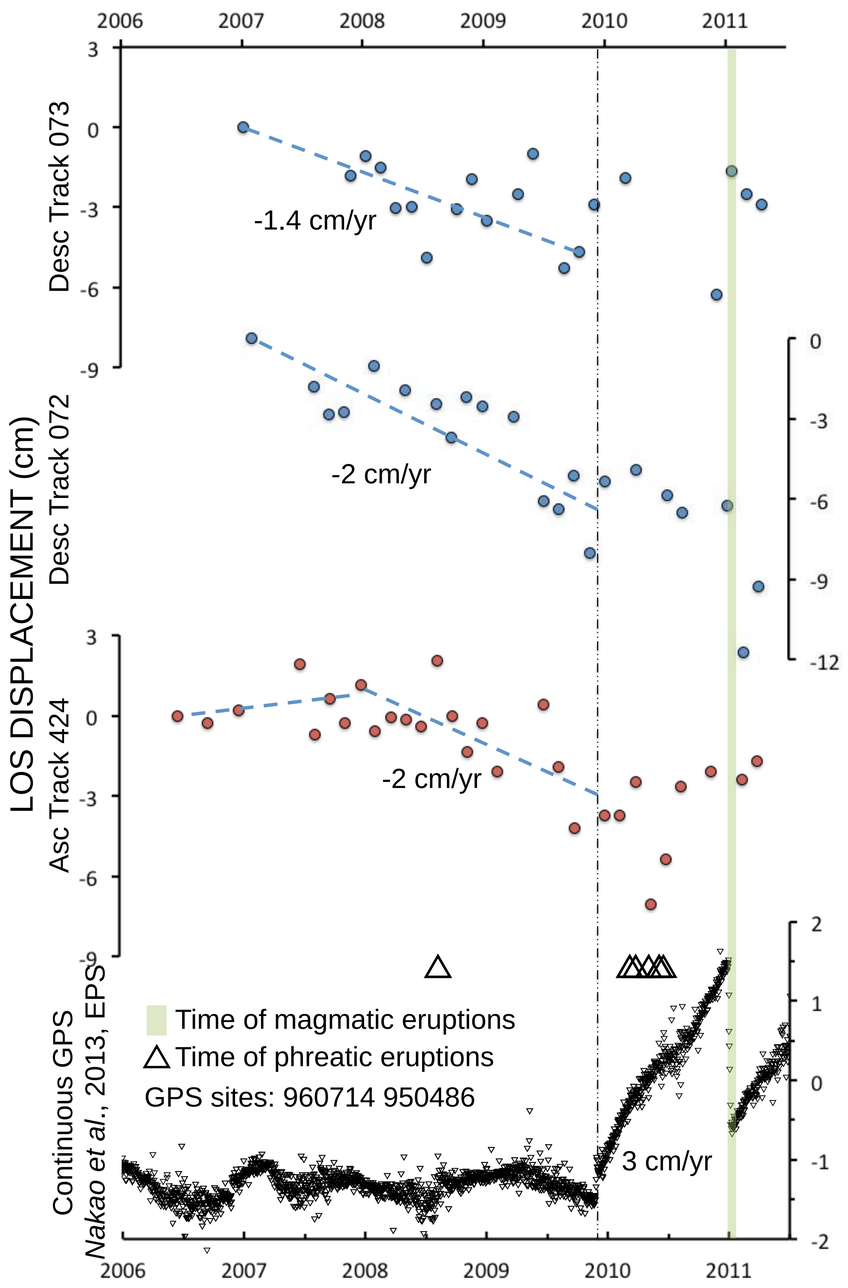


- **Shinmoe-dake (Kirishima)**



2 SHINMOE-DAKE

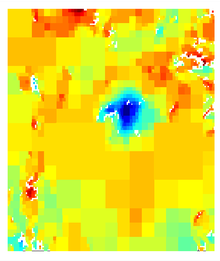
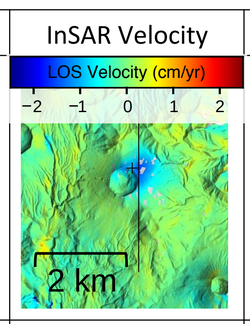
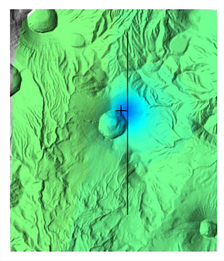
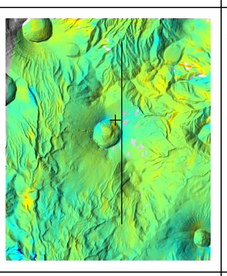
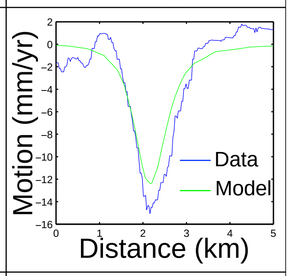
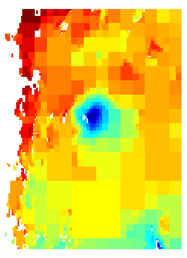
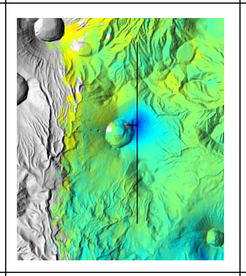
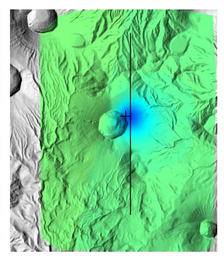
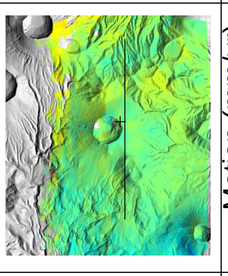
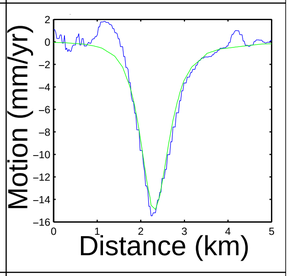
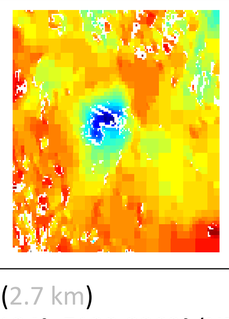
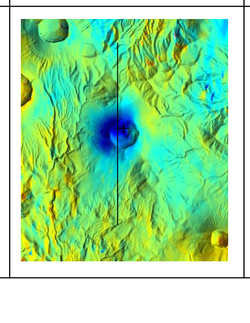
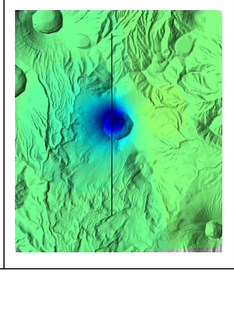
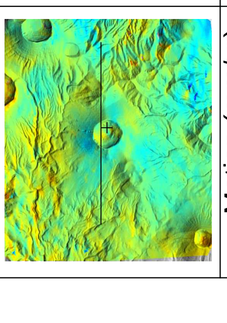
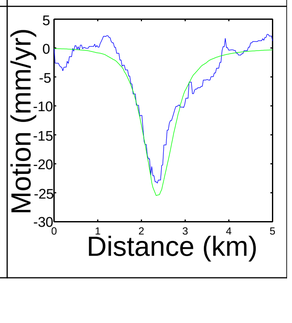
a) Time series - InSAR vs. GPS



- Deflation trend before 2010 due to depressurized magma chamber
- Sudden deflation after 2011 magmatic eruption
- Rapid accumulation on deep magma reservoir (9 km from GPS) and unobvious accumulation on shallow magma chamber (0.5 km from InSAR) before eruption

b) Magma Storage

Elastic homogeneous, isotropic half-space **Mogi model**. **Positions** of best fitting sources are calculated using **Annealing inversion** with **GeodMod** software (). **Depths** are shown **relative to the half space (black)** and to the summit (gray).

Dataset	Quad tree Sampling	InSAR Velocity	Mogi Model	Residuals	Profile: Data / Model
Desc Track 073 Depth= **0.53 km** 2.76 km					
Desc Track 072 Depth= **0.48 km** 2.71 km					
Asc Track 424 Depth= **0.50 km** 2.73 km					

- Source depth: 0.5 km (2.7 km)
- Source center: N 31.9134°, E130.8863° (NE crater)

CONCLUSIONS

- Active volcanic systems on Kyushu Island detected by InSAR:
  → Fast deflation on Kuju volcano
  → Constant inflation on Sakurajima caldera
  → Complex activities on Shinmoe-dake, Kirishima. Years before eruption: crater subsiding, reservoir no deformation; one year before eruption: complex deformation pattern on the crater, compared with rapid magma accumulation in the deep magma reservoir.

- Result shows Shinmoe-dake has a magma chamber of 2.7 km deep relative to its summit, located at the northeast part of its crater. This confirms shallow volcanic magma source's preference on strike-slip setting.

REFERENCES

- Berardino, P., G. Fornaro, R. Lanari, and E. Sansosti (2002), A new algorithm for surface deformation monitoring based on small baseline differential SAR interferograms, *Geoscience and Remote Sensing, IEEE Transactions on*, *40*(11), 2375-2383, doi:10.1109/TGRS.2002.803792.
- Chaussard, E., and F. Amelung (2014), Regional controls on magma ascent and storage in volcanic arcs, *Geochemistry, Geophysics, Geosystems*, *15*(4), 1407-1418.
- Fattahi, H., and F. Amelung (2013), DEM Error Correction in InSAR Time Series, *Geoscience and Remote Sensing, IEEE Transactions on*, *51*(7), 4249-4259, doi:10.1109/TGRS.2012.2227761.
- Jolivet, R., R. Grandin, C. Lasserre, M. P. Doin, and G. Peltzer (2011), Systematic InSAR tropospheric phase delay corrections from global meteorological reanalysis data, *Geophysical Research Letters*, *38*(17), L17311, doi:10.1029/2011GL048757.
- Nakao, S., Y. Morita, H. Yakiwara, J. Oikawa, H. Ueda, H. Takahashi, Y. Ohta, T. Matsushima, and M. Iguchi (2013), Volume change of the magma reservoir relating to the 2011 Kirishima Shinmoe-dake eruption—Charging, discharging and recharging process inferred from GPS measurements, *Earth Planets Space*, *65*(6), 505-515.
- Tatsumi, Y., and K. Suzuki-Kamata (2014), Cause and risk of catastrophic eruptions in the Japanese Archipelago, *Proceedings of the Japan Academy. Series B, Physical and biological sciences*, *90*(9), 347.