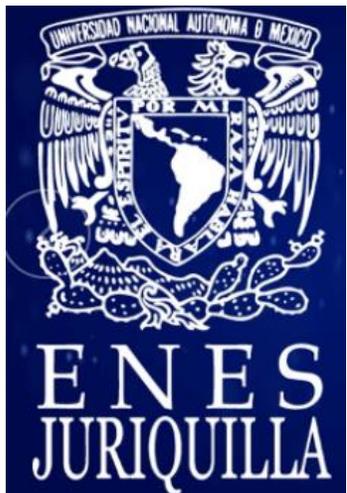


**UN-SPIDER / ZFL Regional Virtual Expert Meeting for Southern Africa  
"Space-based Solutions for Disaster Risk Management and Emergency  
Response"**

**"Multi-Temporal Radar Interferometry Analysis for Volcanic Activity  
Early Warning"**



**NATIONAL UNIVERSITY AUTONOMOUS  
OF MEXICO  
National School of Higher Studies,  
Juriquilla**

**UN-SPIDER**

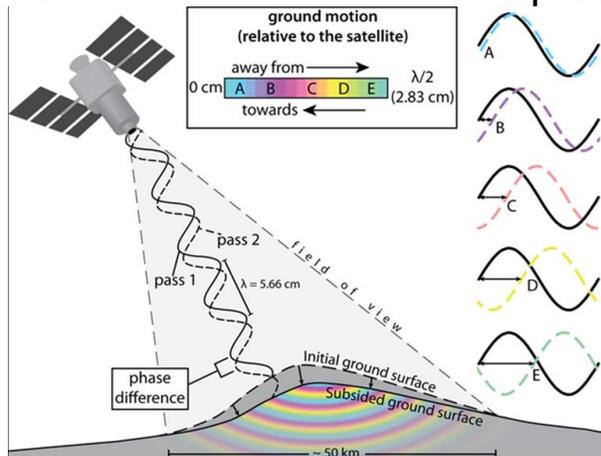
Aim:

to show an example of how the Earth Observation (EO) technologies are a useful tool to detect slope instability before a volcanic collapse event, and how a last eruption could provide us an opportunity to improve warning systems based on Big SAR Data.

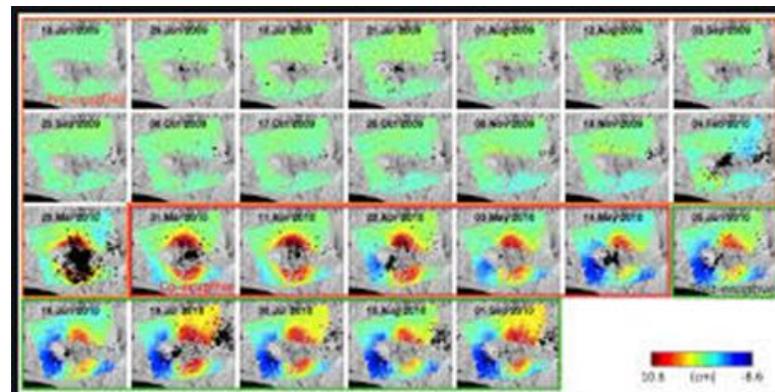
Previous work:

- Krakatau Volcano
- Taal Volcano
- Nevado del Chillan

### How Works a InSAR technique?



### Multitemporal INSAR

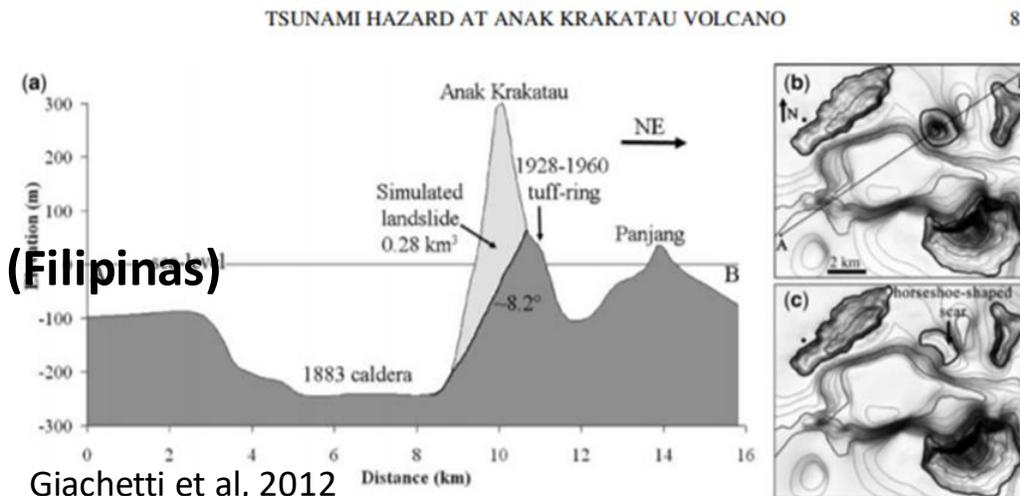
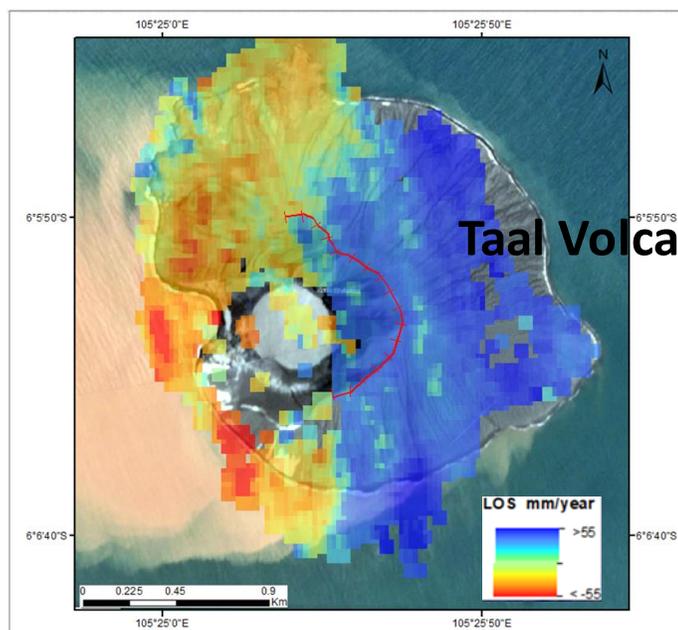
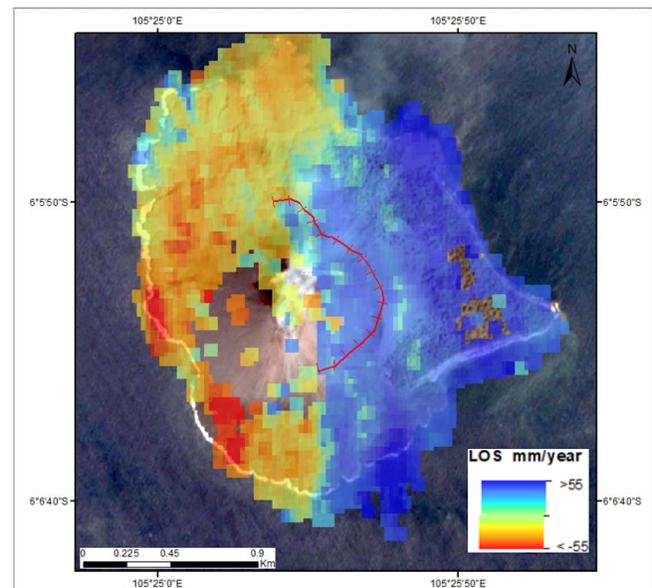


Ground deformation

$$\delta\phi_{\text{int}} = \delta\phi_{\text{defo}} + \delta\phi_{\text{atmos}} + \Delta\phi_{\text{orbit}} + \delta\Delta\phi_{\text{topo}} + \delta\phi_{\text{noise}}$$

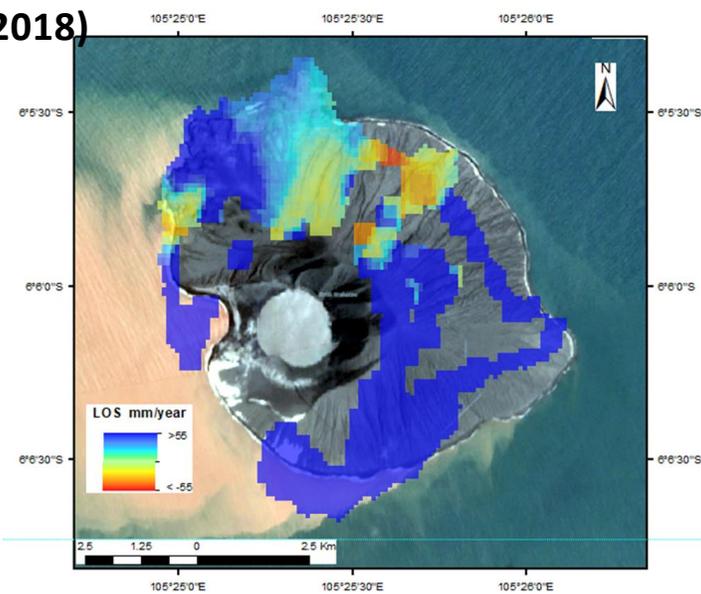
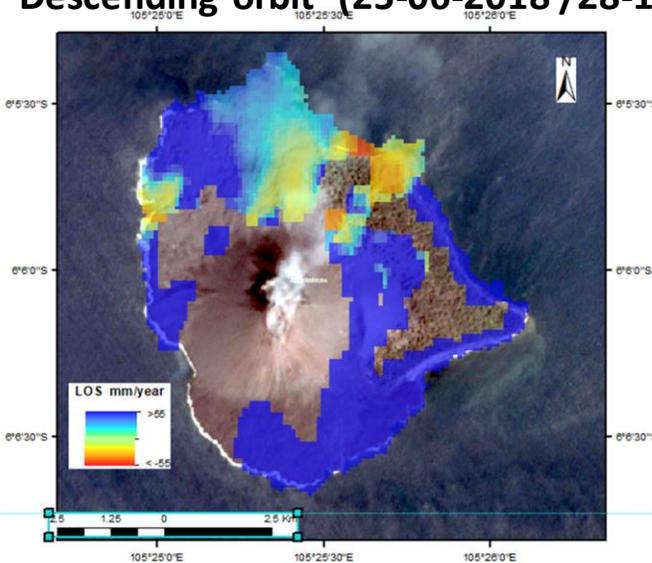
**Multitemporal analysis June-December  
Ascending orbit (27-07-2018 /07-12-2018)  
Mean displacement velocity**

**Cross section of batimetry and ancient Krakatau Volcano**



Giachetti et al, 2012

**Multitemporal analysis June-December  
Descending orbit (25-06-2018 /28-11-2018)**



**Estimated Fault Location of Anak Krakatau Volcano**

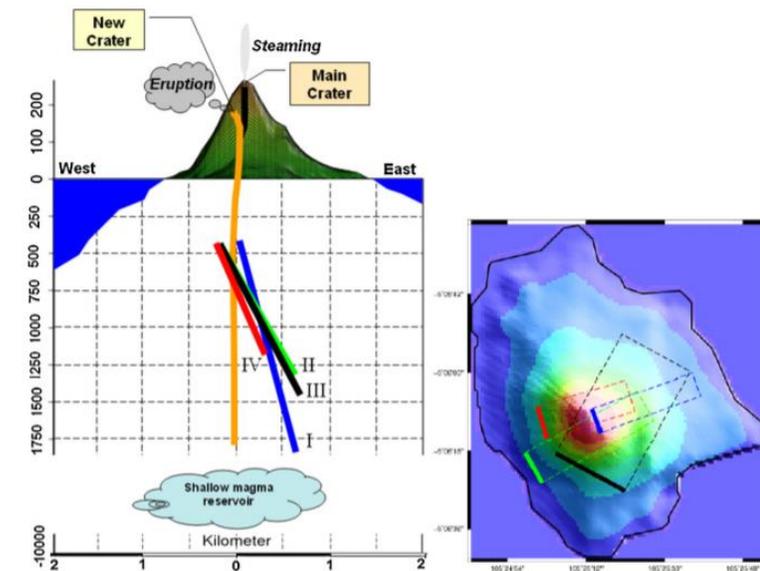
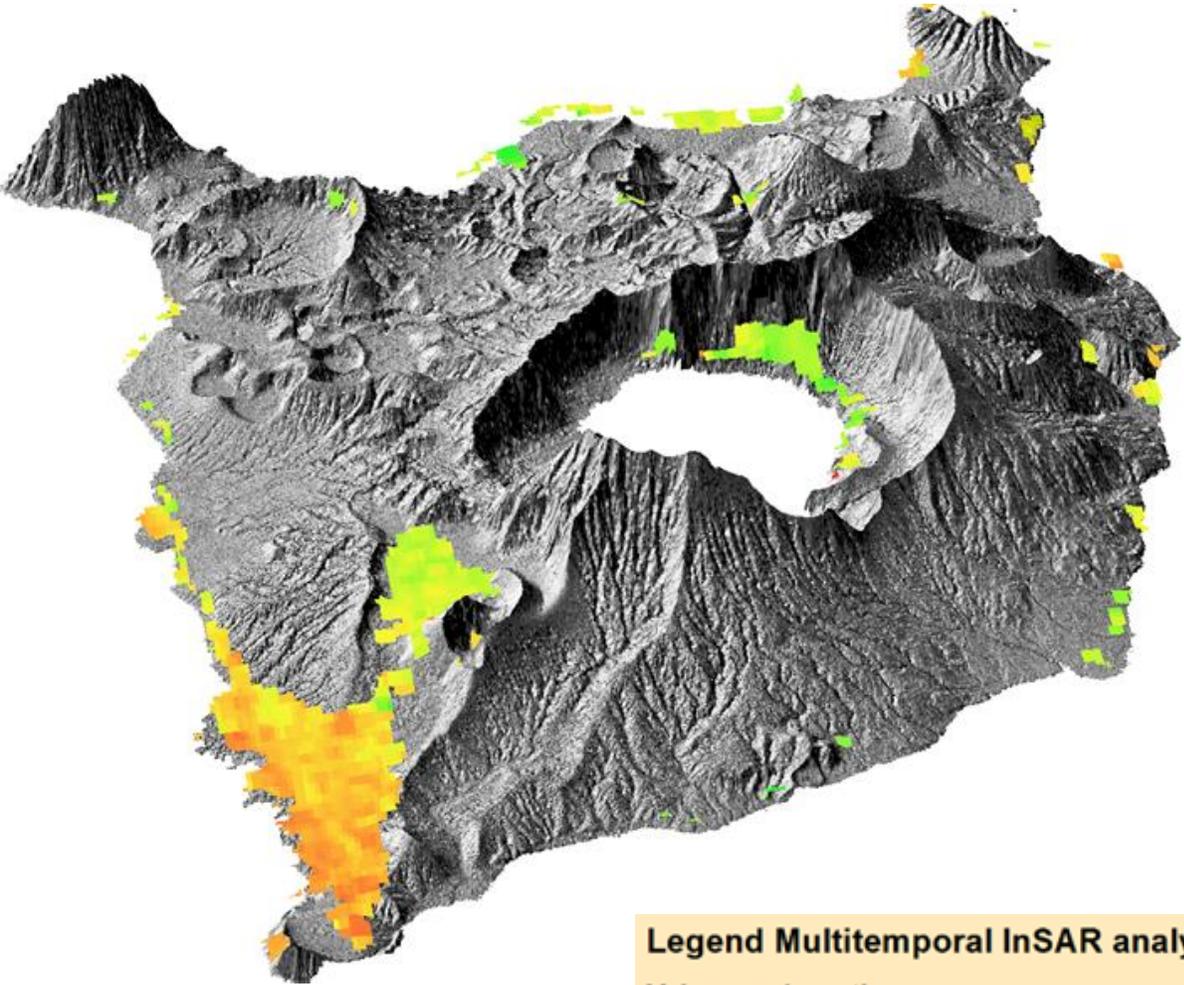


Fig. 6. The estimated location of rectangular fault for volcanic source model.

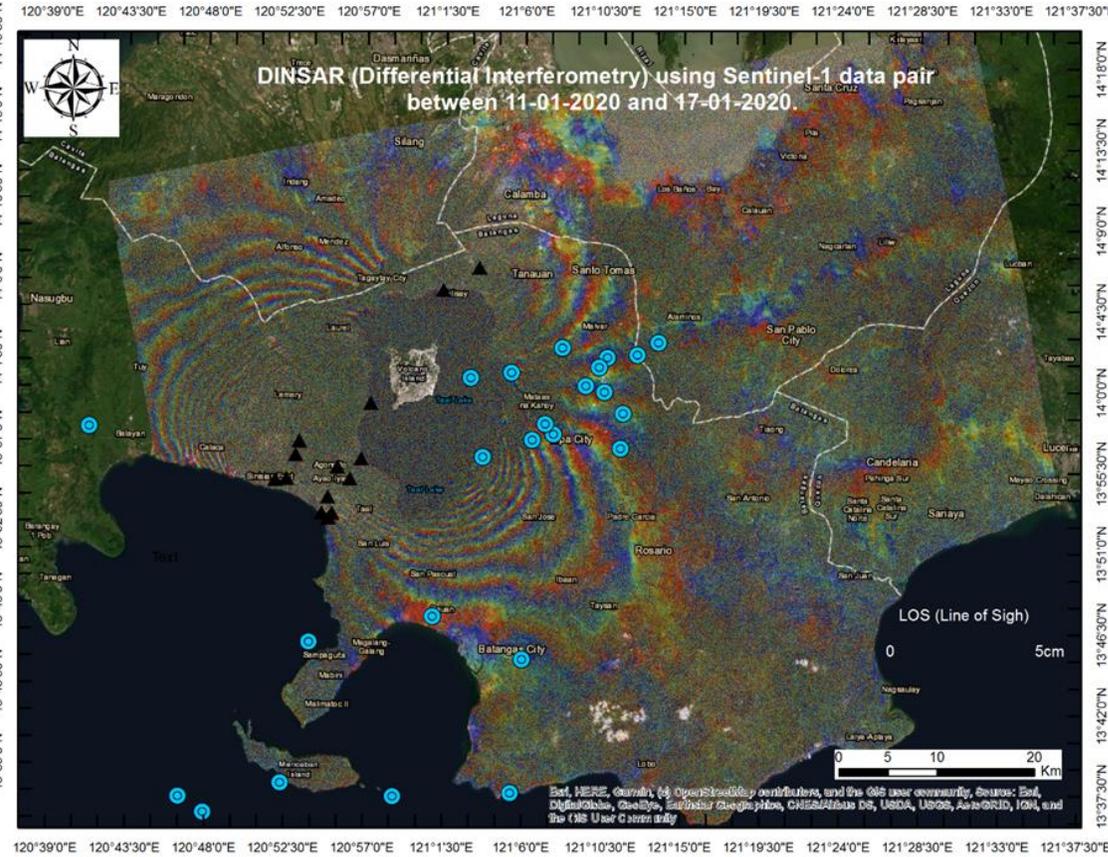
Agustan et al., 2012

# Taal Volcano (Filipinas)

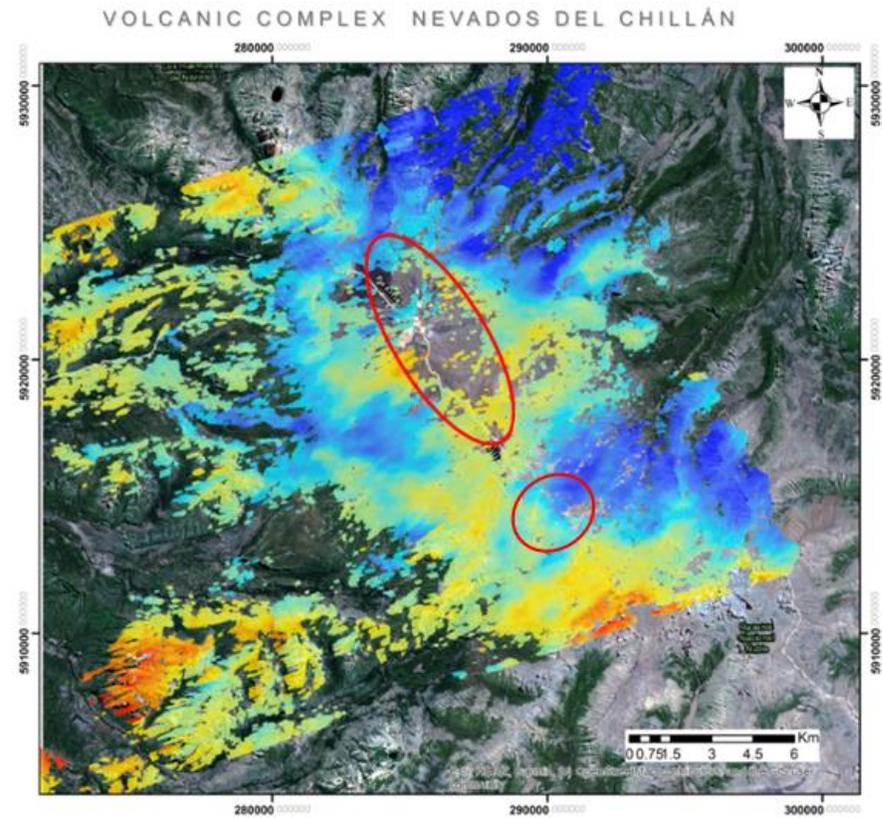
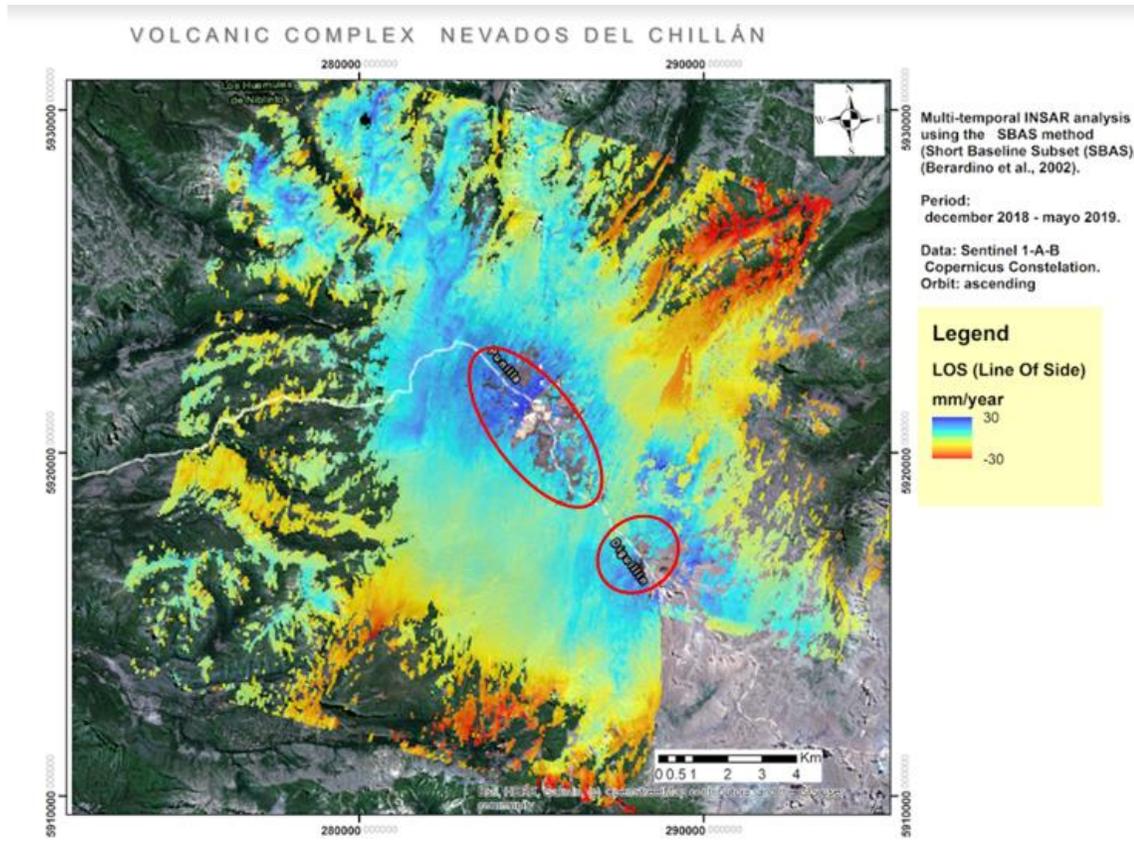
12 January, 2020 started an important explosive type eruptive phase (phreatomagmatic)



Multitemporal ascending analysis  
Period: July 2019- January 2020



# Nevado del Chillan Volcanic Complex



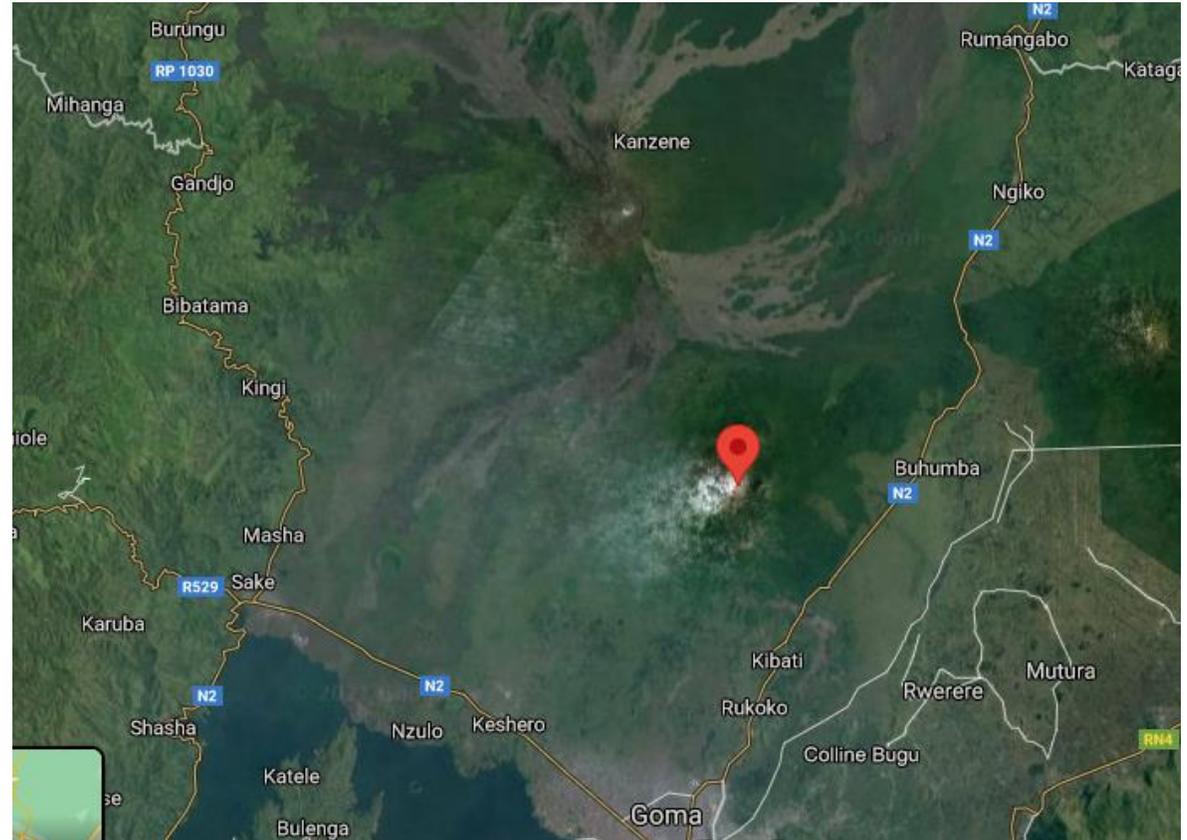
# MULTITEMPORAL SBAS ANALYSIS IN NYIRAGONGO VOLCANO

## Background

**Nyiragongo volcano** is located in the Democratic Republic of the Congo at 10km from Goma City.

-At least 15 deaths have been confirmed and at least 3000 were displaced or relocated.

-Last erupted in 2002, killing 250 people and making 120,000 homeless.



# International Charter Space and Major Disasters

## Nyiragongo Volcano, Democratic Republic of the Congo: Deformation Analysis



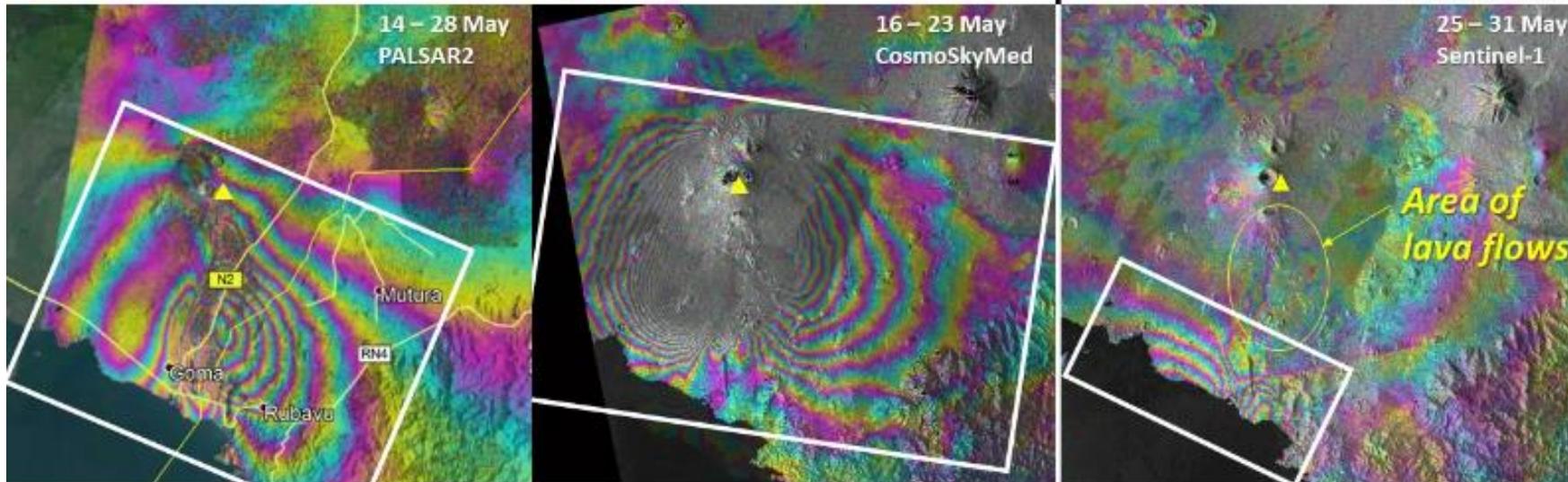
NASA/JPL-Caltech/ASU Product  
ALOS-2 data © 2021 Japan Aerospace Exploration Agency  
904010 8/21/21



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Copernicus  
Europe's eyes on Earth



The deformation associated with the draining of the lava lake and feeder conduit beneath Nyiragongo Volcano and the dike emplaced within the rift system, 22-23 May 2021

Modified from Global Volcanism Program report on Nyiragongo May 2005  
Global Volcanism Program, 2005. Report on Nyiragongo (DR Congo) (Volcano, 2, vol. 1). Bulletin of the Global Volcanism Network, 2005. Smithsonian Institution. <https://doi.org/10.5479/si.GVN.20050001.2005001>



Smithsonian Institution  
National Museum of Natural History  
Global Volcanism Program

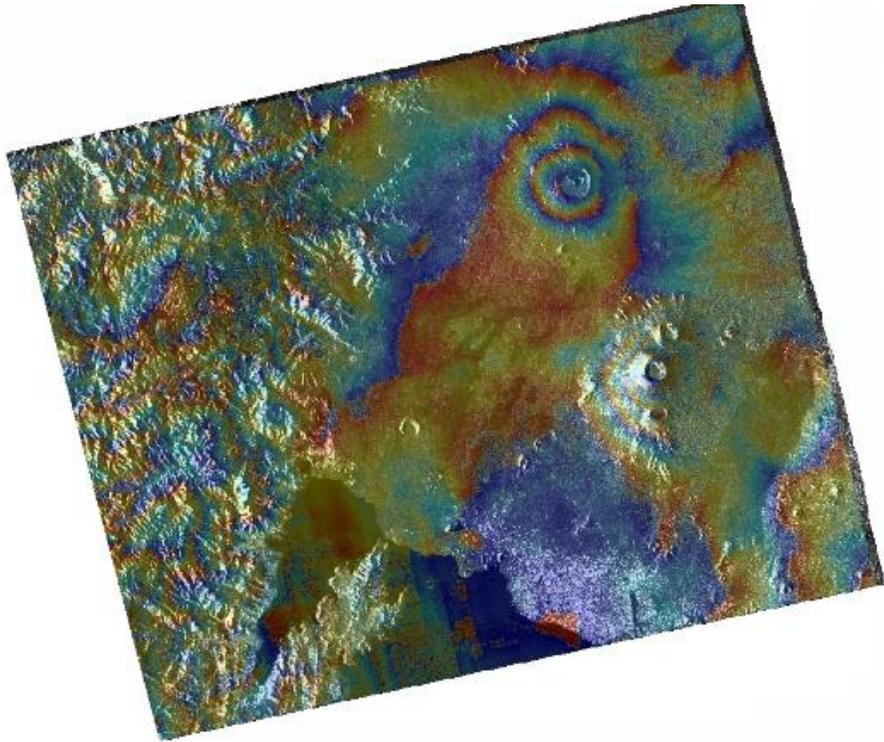


Following the eruption, this is the deformation of the distal portion of the dike that was emplaced during the rift zone eruption

Source: COSMO-SkyMed © ASI 2021 processed under license from ASI – Agenzia Spaziale Italiana. All rights reserved. Distributed by e-GEOS, ALOS-2 © JAXA, Map produced by USGS

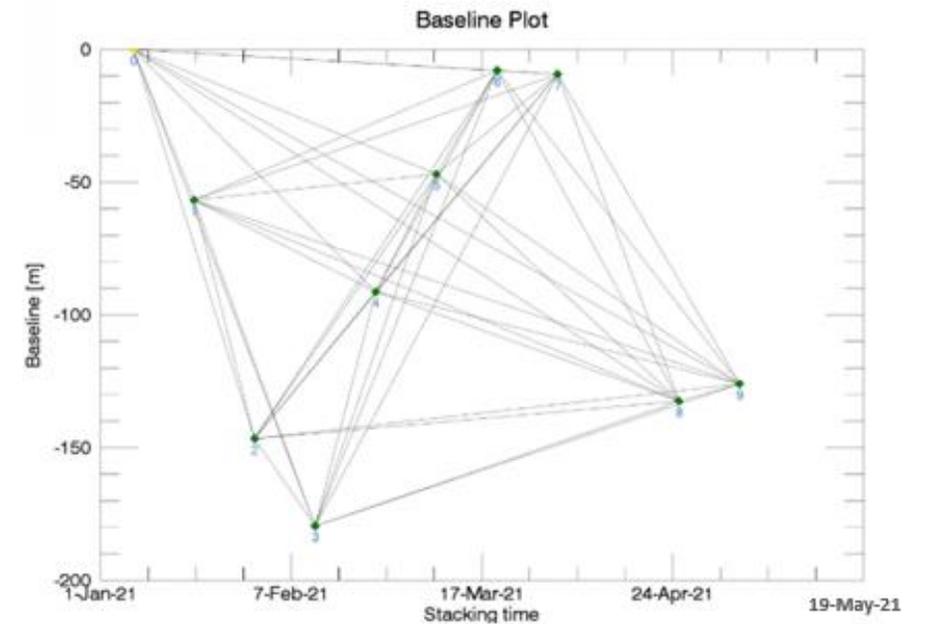
## MULTITEMPORAL SBAS ANALYSIS IN NYIRAGONGO VOLCANO

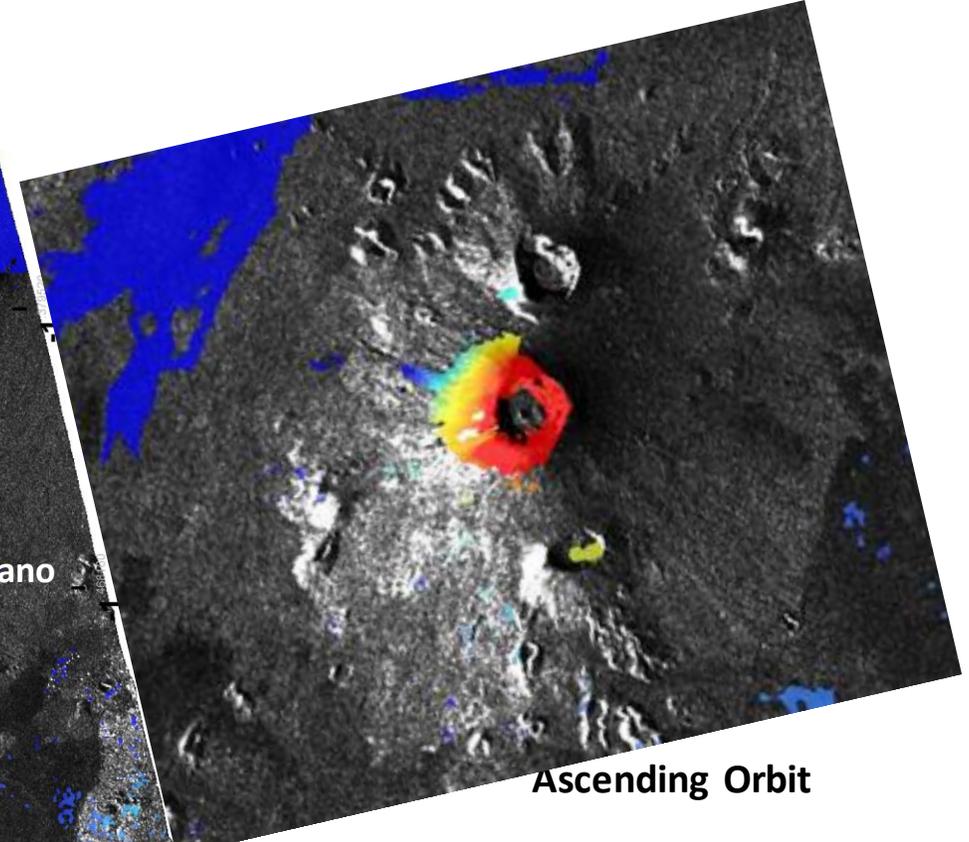
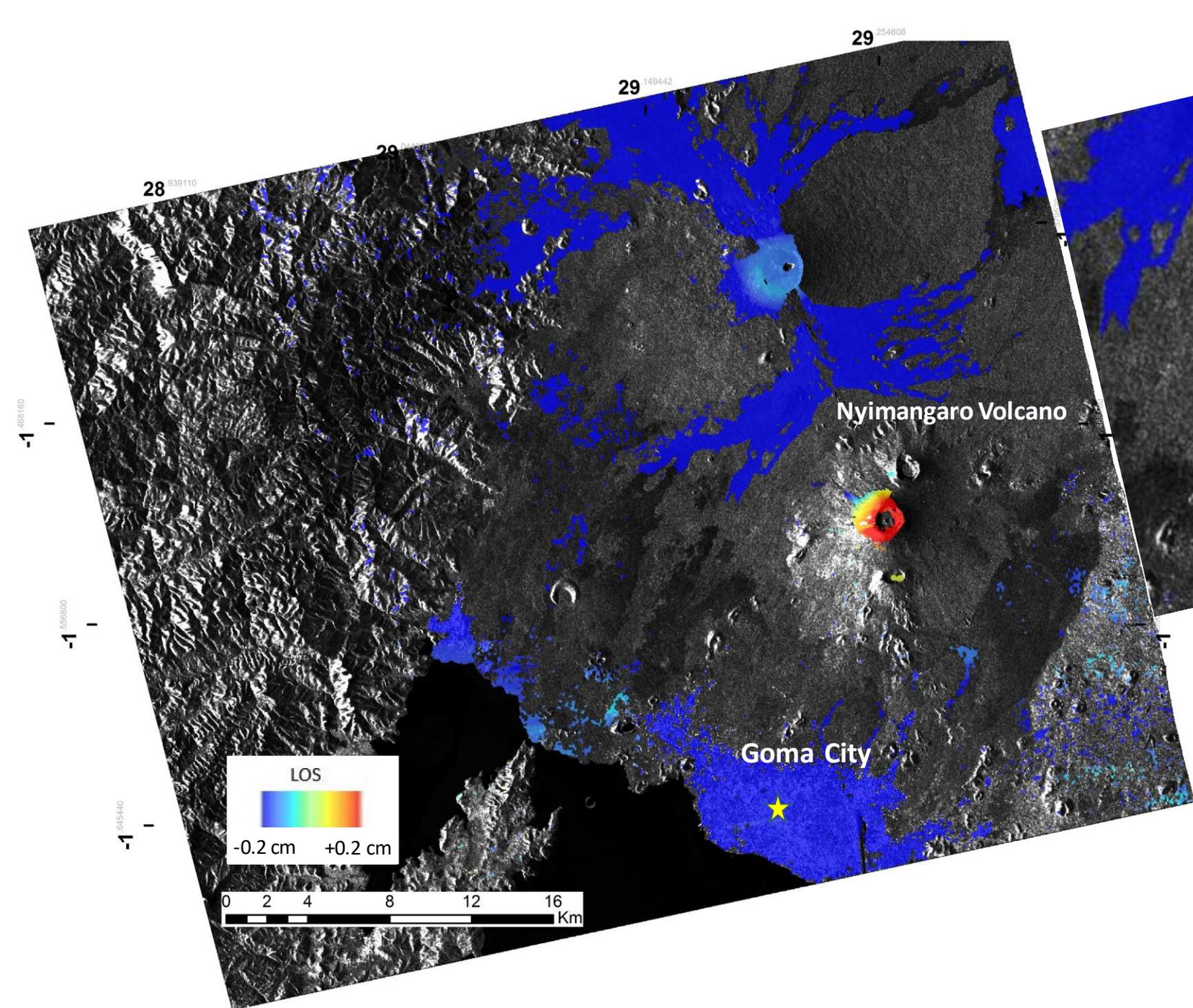
The SBAS analysis was carried out six months earlier to last eruption in ascending orbit with a stacking of 15 images from Sentinel-1



Example of Diferential Interferogram  
Band C, period 7-May to 19-May 21

Method: SBAS (min baseline)  
Software: GMTSAR  
Baseline min/max : 15 / 182m





Ascending Orbit

**Multitemporal Analysis:**  
01-Jan-21 to 19-May-21

**The Nyimangaro Volcano shows a minimum deflation process (max 0.2 cm).**

The complex phase was solved  
In all those areas with a strong backscattering response

## Final Comments

- The preliminary results have shown a complex pattern of ground deformation in different active volcanoes.
- We presented InSAR evidence of inflation over east side of volcano (> 55mm) and deflation in the west side of volcanic cone (-24mm- 63mm) six months before the eruption.
- Sentinel allows to collect more data than any Earth observation program before, allowing the monitoring of volcanic activity even in small active volcanoes.
- The last eruptions in active volcanoes around the world allowing an opportunity to improve the early warning systems based on Big SAR Data