



Committee on Earth Observation Satellites

# Volcano Demonstrator

Susanna Ebmeier (University of Leeds)

Mike Poland (USGS) and many others

WG Disasters 17 (virtual)

15, 16, and 17 March 2022



## Updates March 2022:

### 1) Eruption/Unrest response:

Cordón Caulle, La Palma, Hunga Tonga–Hunga Ha‘apai

### 2) Research results:

Agung, St Vincent, Pacaya (all from PhD students!)

### 3) Future of the Volcano Demonstrator:

how to make the work sustainable



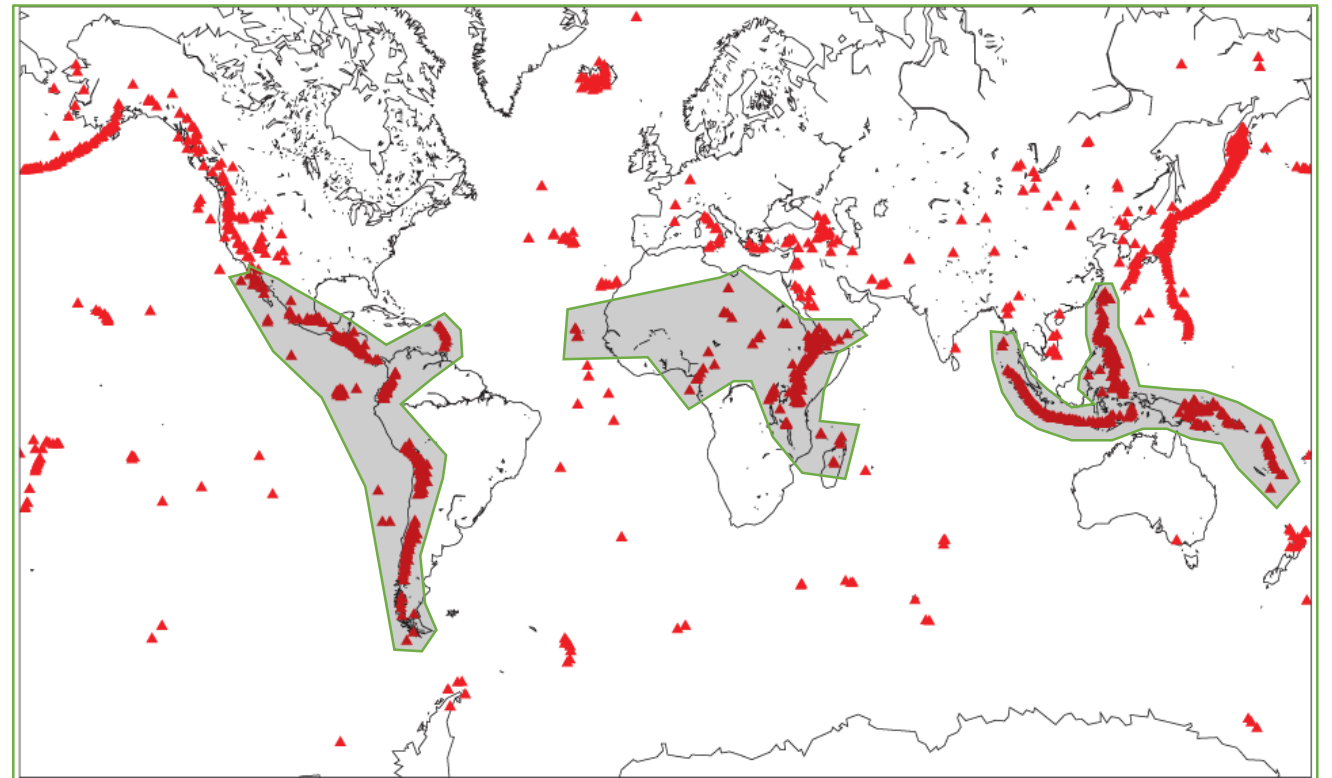
Attribution  
*Affiliation*

Event Response/Research



- Extension of project to African and SE Asian volcanoes
- Fill gaps in current monitoring
- Long term goal: to demonstrate the necessity and viability of international coordination of satellite tasking for volcano monitoring (after polar science community)

## Demonstrator (2019 -)





Cornell University

Latin America:  
**Matt Pritchard**  
Cornell University



University of  
**BRISTOL**

Africa:  
**Juliet Biggs**  
University of Bristol

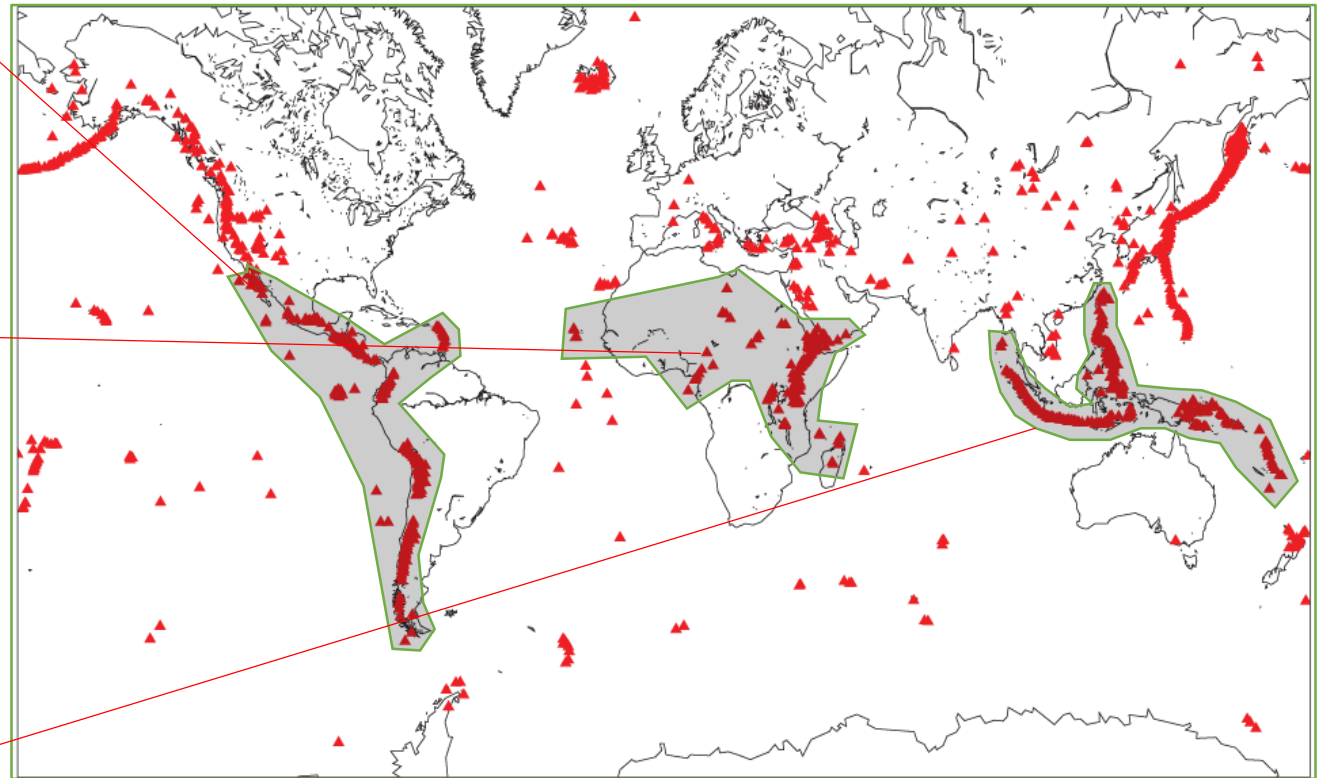


**東京大学**  
THE UNIVERSITY OF TOKYO

SE Asia:  
**Yosuke Aoki**  
University of Tokyo  
**Ian Hamling**  
GNS New Zealand



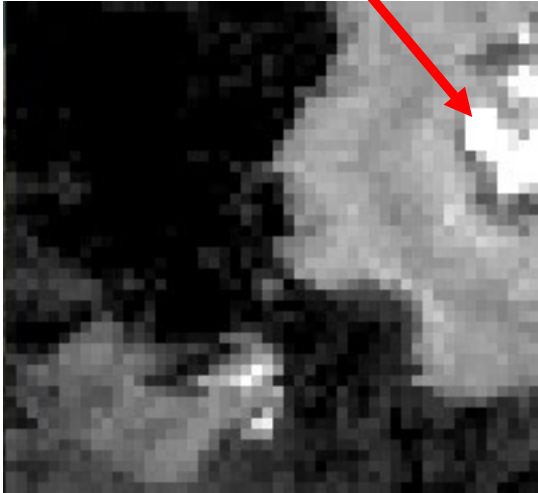
## Demonstrator (2019 -)



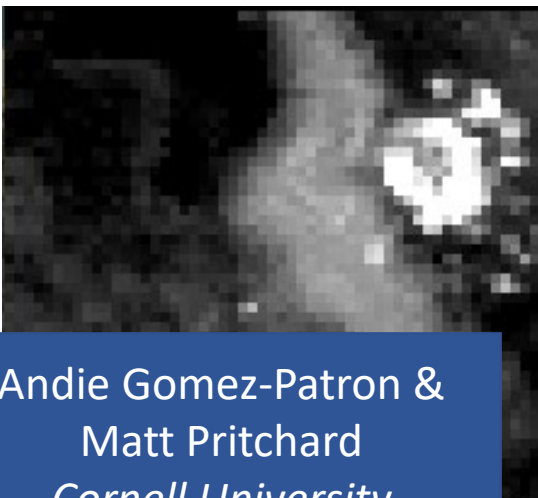
Reports from Chile that new thermal feature formed in 2020 or 2021 at **Cordón Caulle** volcano  
Used ASTER nighttime thermal infrared to pin down date to April 2020

Thermal anomaly  
at laccolith

1/2/2020

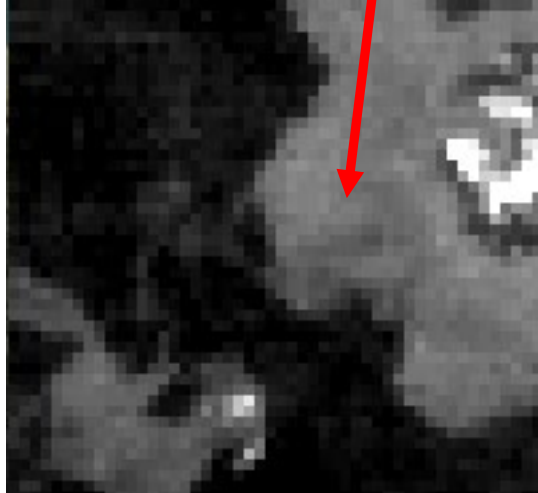


9/7/2020

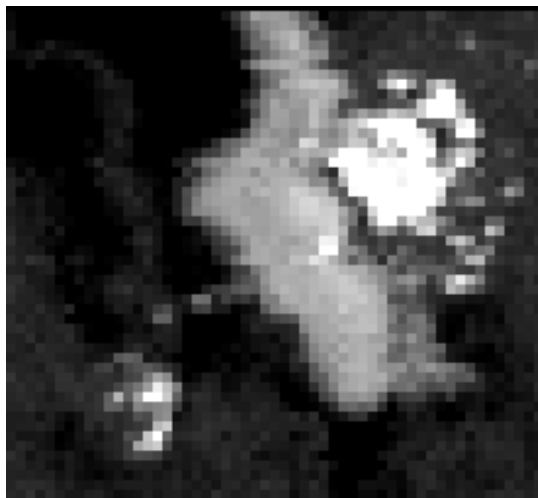


2011-2012  
lava flow

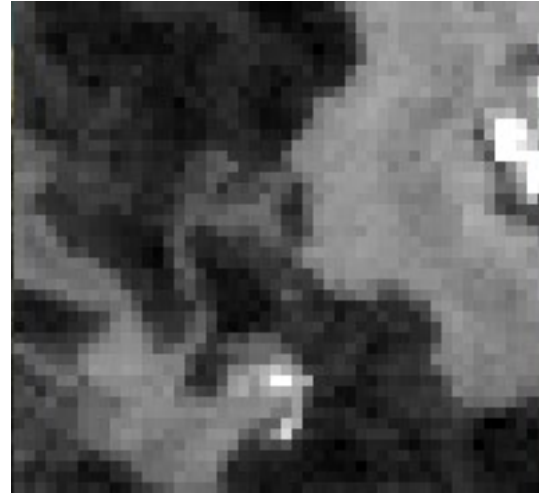
1/27/2020



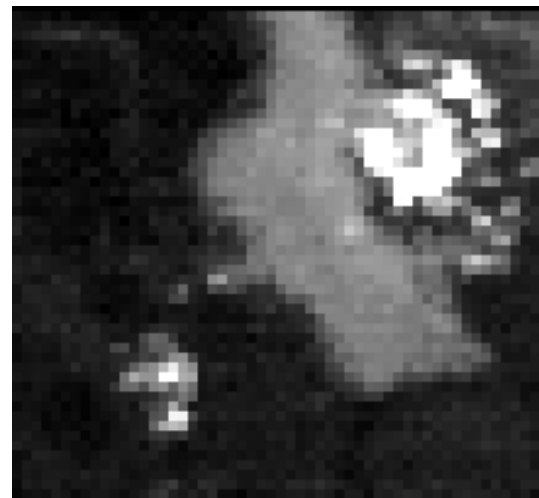
10/16/2020



3/6/2020

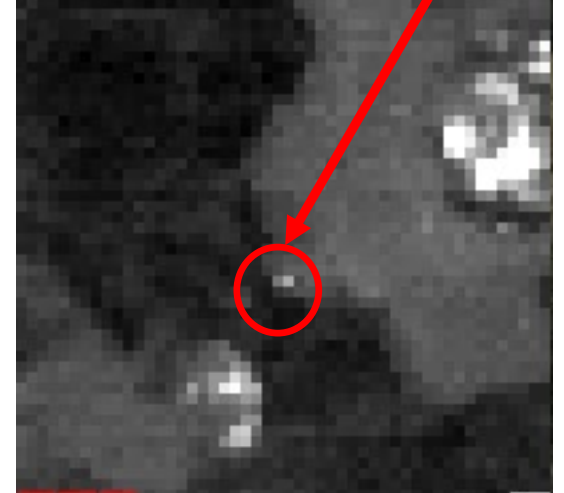


11/17/2020

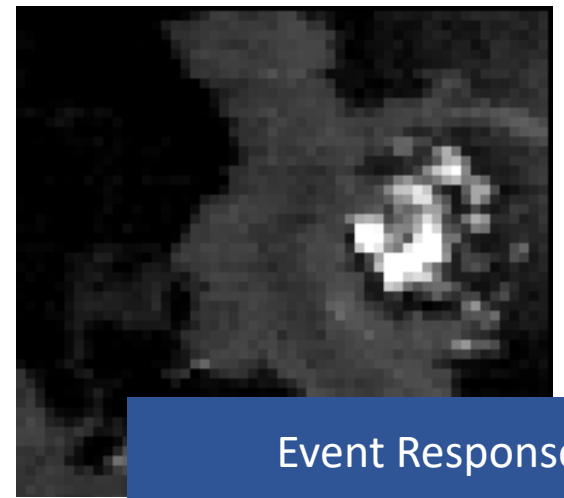


New thermal  
feature

5/2/2020



2/21/2021



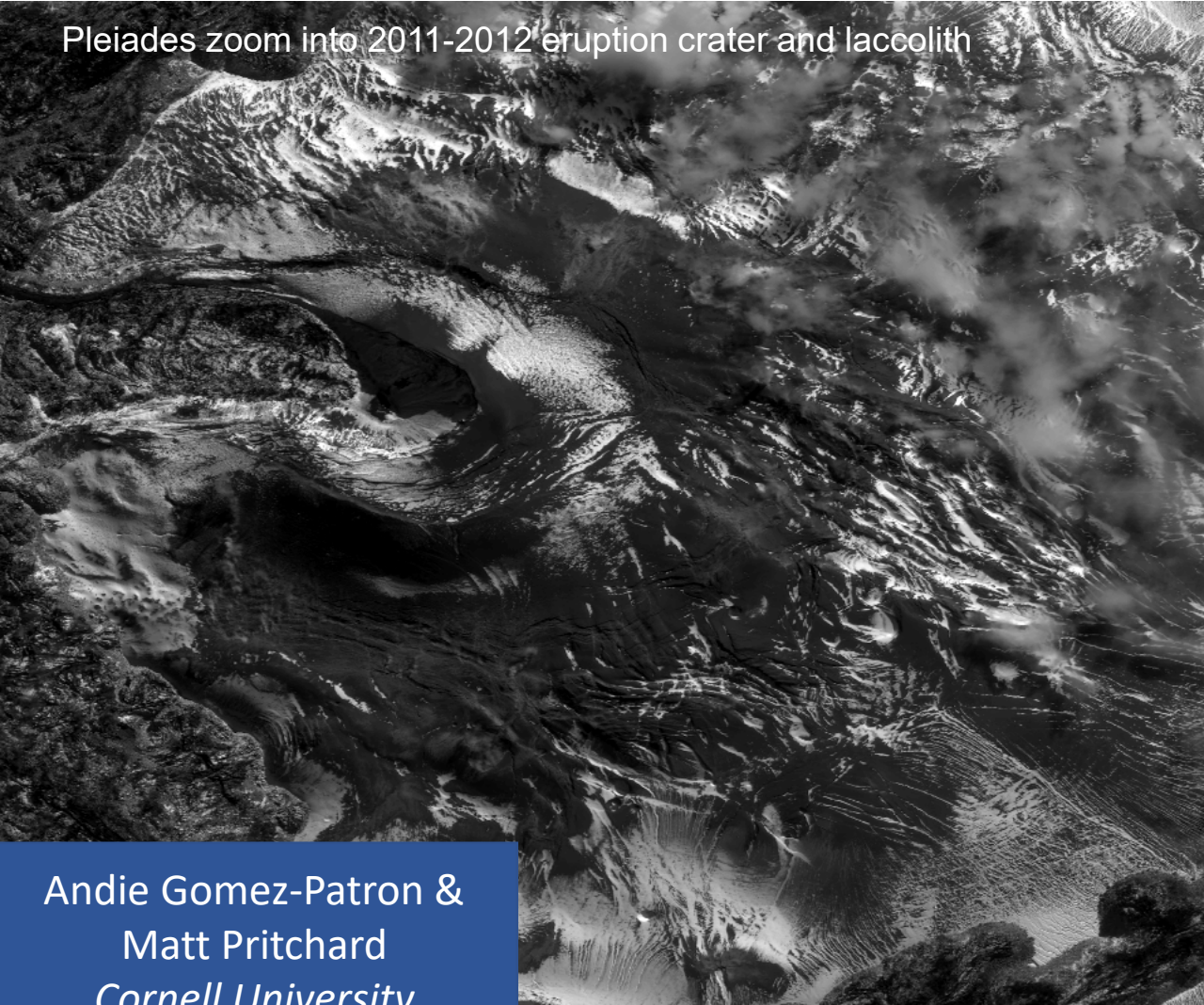
From:  
Andrea  
Gomez-  
Patrón,  
Cornell

Andie Gomez-Patron &  
Matt Pritchard  
Cornell University

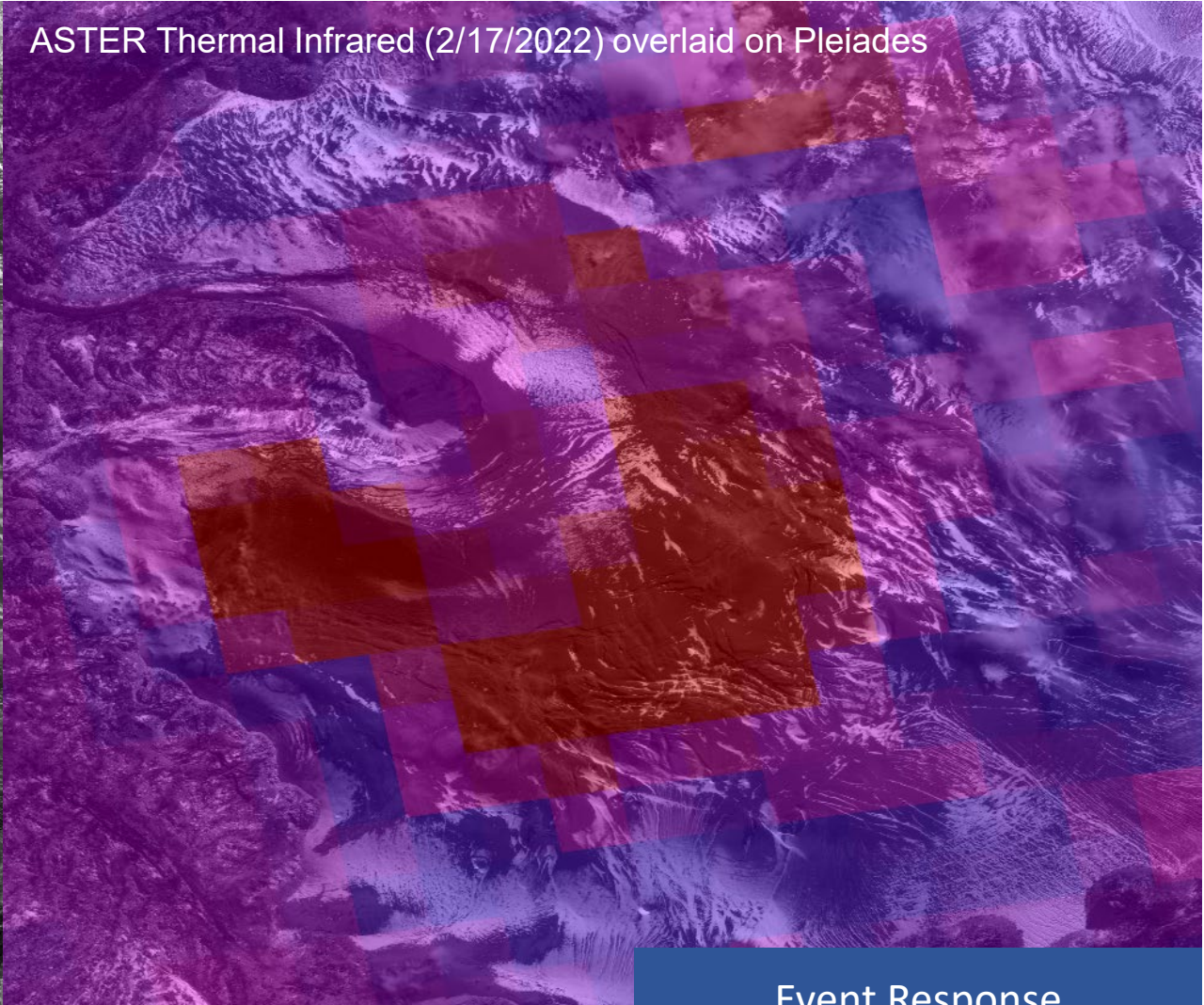
Event Response

# Pleiades reveals ground fractures and craters at **Cordón Caulle** and relation to thermal changes

Pleiades zoom into 2011-2012 eruption crater and laccolith



ASTER Thermal Infrared (2/17/2022) overlaid on Pleiades

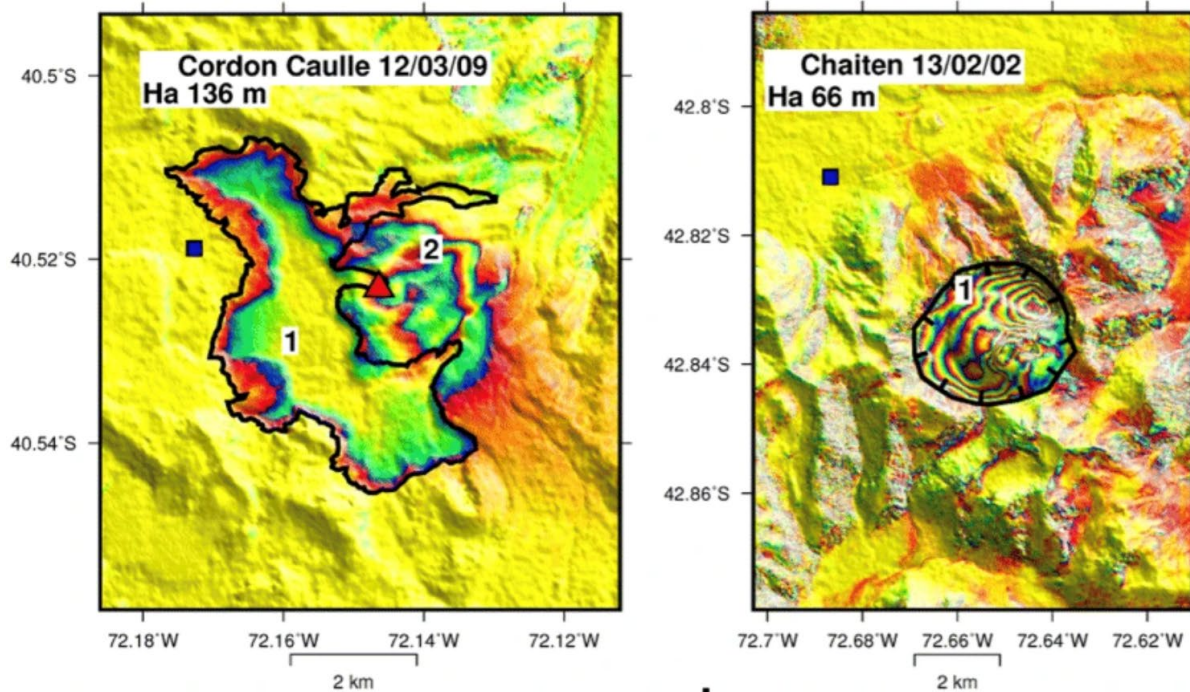


Andie Gomez-Patron &  
Matt Pritchard  
*Cornell University*

From: Andrea Gomez-Patrón, Cornell

Event Response

- Accurate, recent DEMs are critical for hazard assessment during an eruption:
  - Estimation of effusion rate, flow modelling and hazard assessment
  - **Critical for interpretation of high resolution SAR imagery (e.g., CSK, TSX especially spotlight modes)**



- 12m WorldDEM greatly enhances analysis of high resolution SAR imagery
- Requested by some volcano observatories

Pritchard et al., 2018



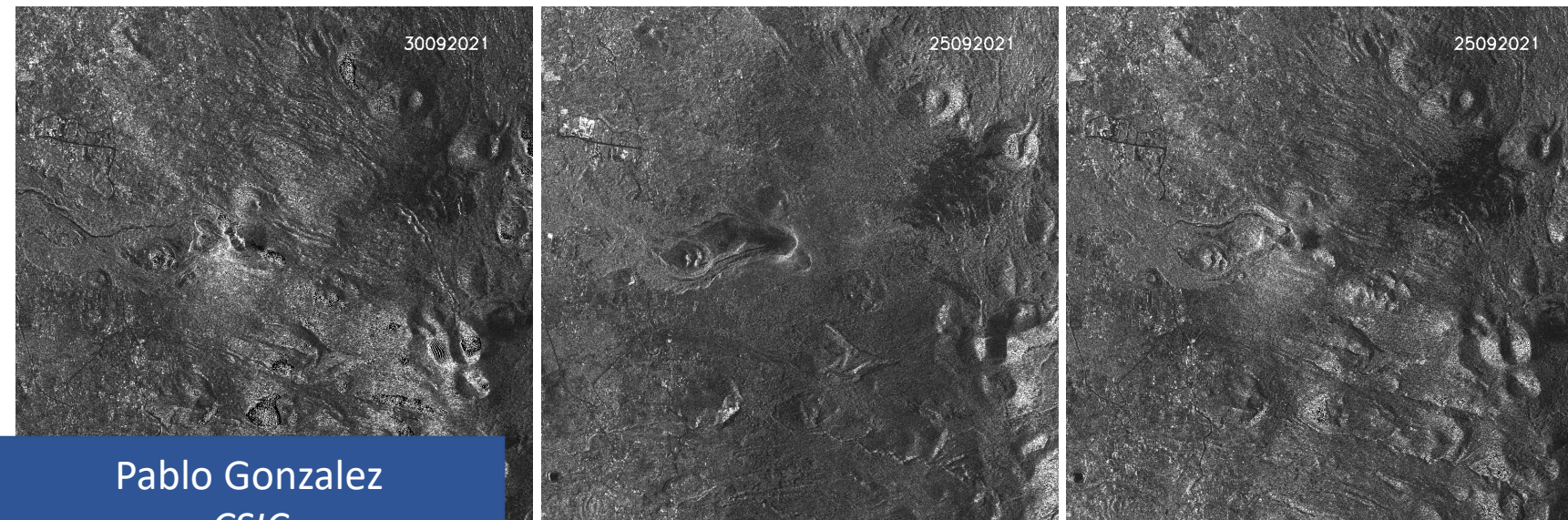


# COSMO-SKYMED multiple track acquisitions during the 2021 Cumbre Vieja eruption



Dense temporal CSK acquisitions provided high resolution images of near vent processes (impossible by other means) that informed how and why lava flows changed downslope

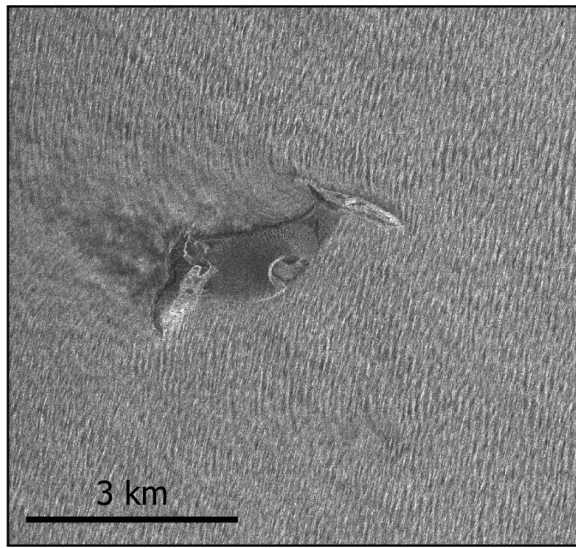
PEVOLCA – decision making



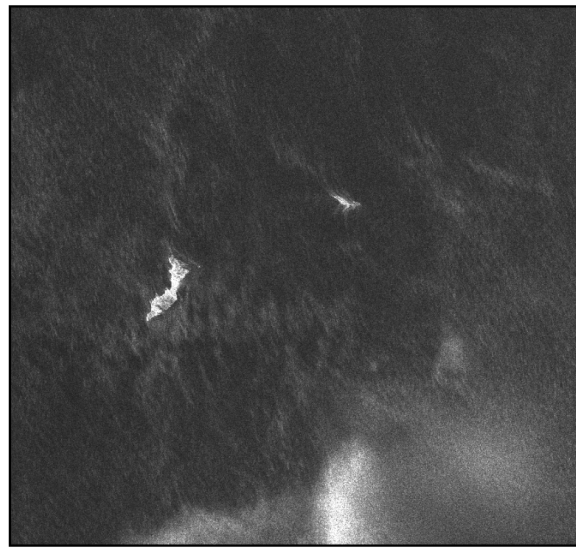
Pablo Gonzalez  
CSIC



Event Response

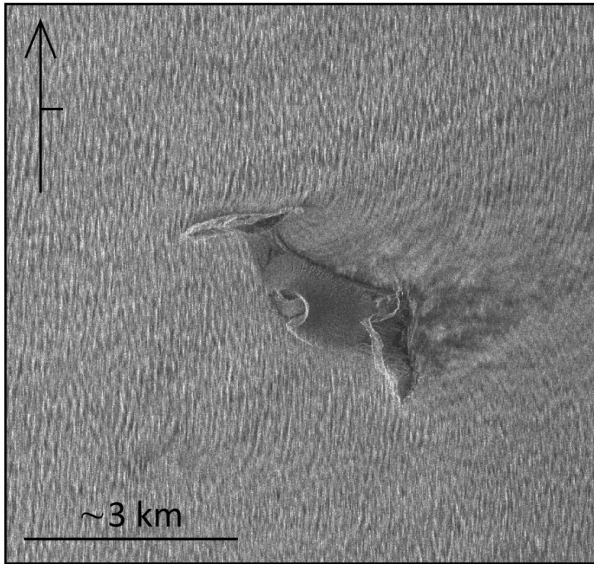


08/05/2017



16/01/2022

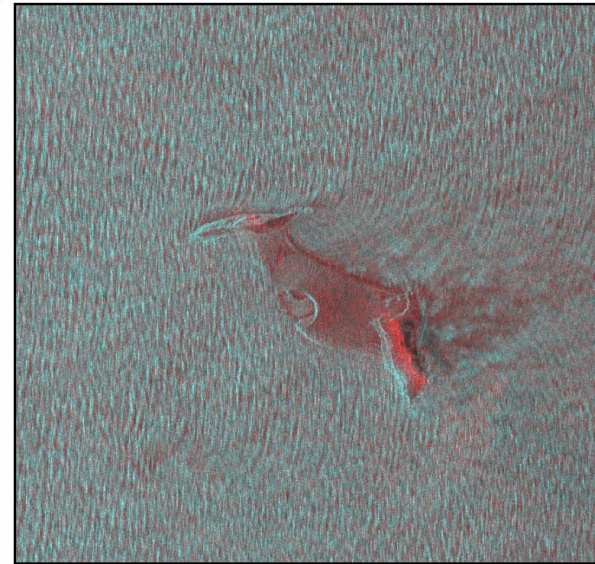
Eruption of submarine volcano Hunga Tonga–Hunga Ha'apai erupted in January 2022 generating a plume that penetrated the mesosphere, tsunamis all around the Pacific and severe destruction in Tonga



08/05/2017

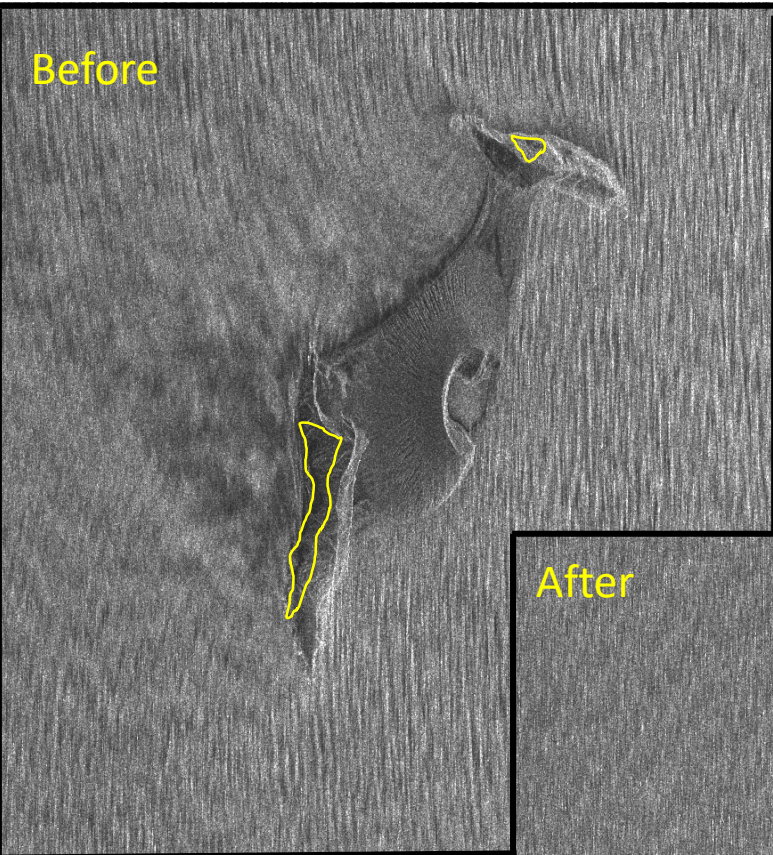


29/01/2022



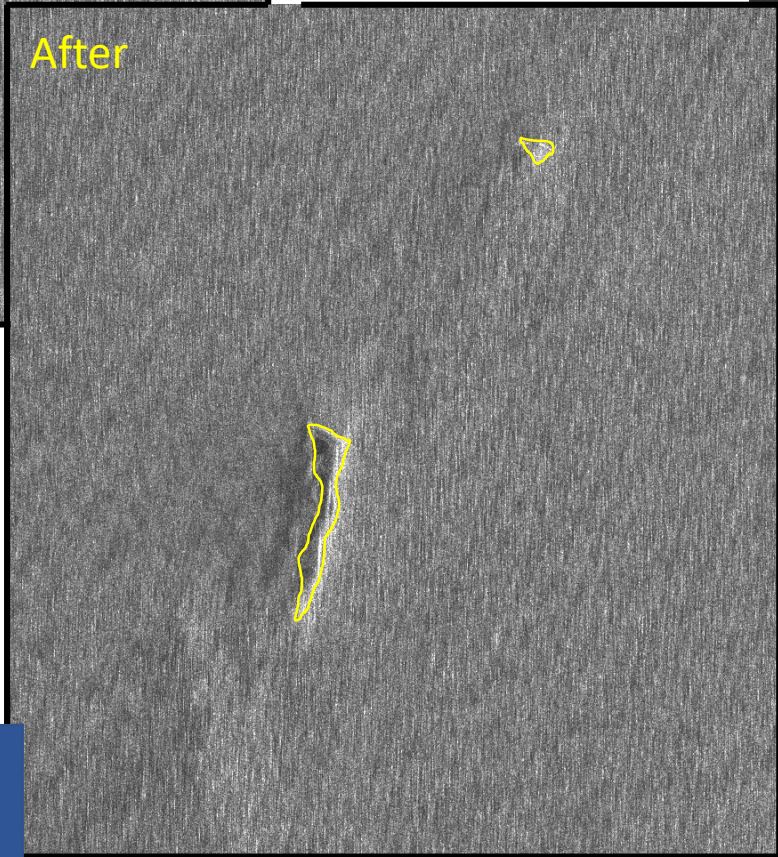
RGB change difference

Before



Early hypothesis of island wide subsidence of ~10 m not supported by new island shapes coming from this and other aerial data.

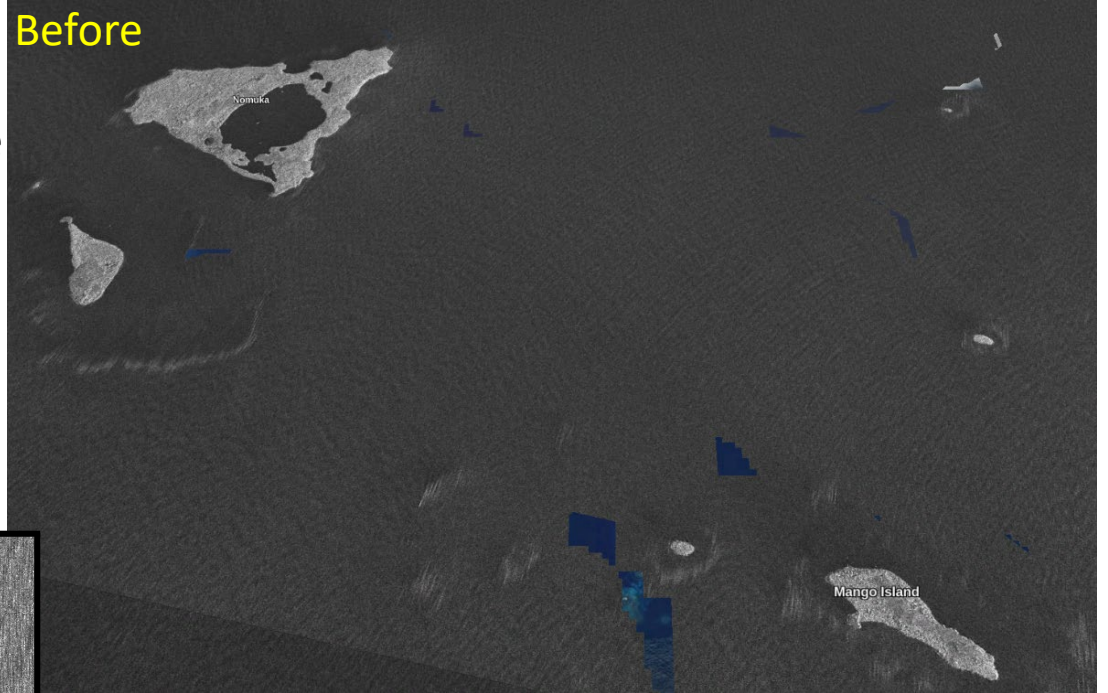
After



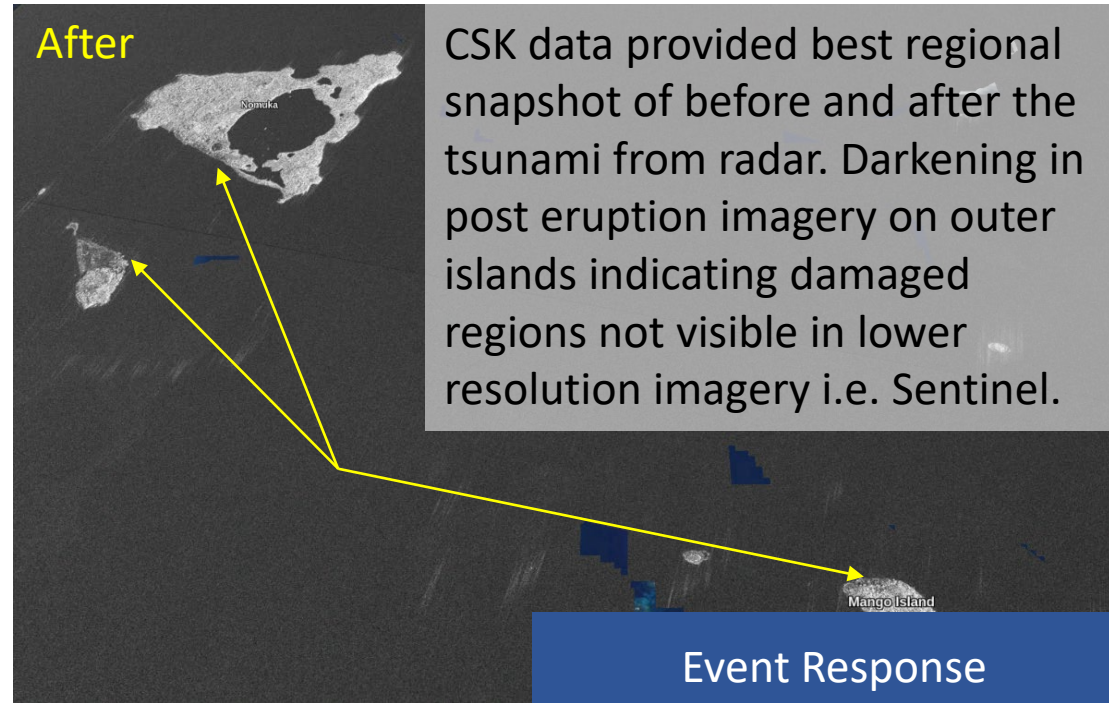
Hi-resolution imagery from both before and after the eruption provide additional constraints on our understanding of what happened during the eruption.

Ian Hamling  
GNS

Before



After



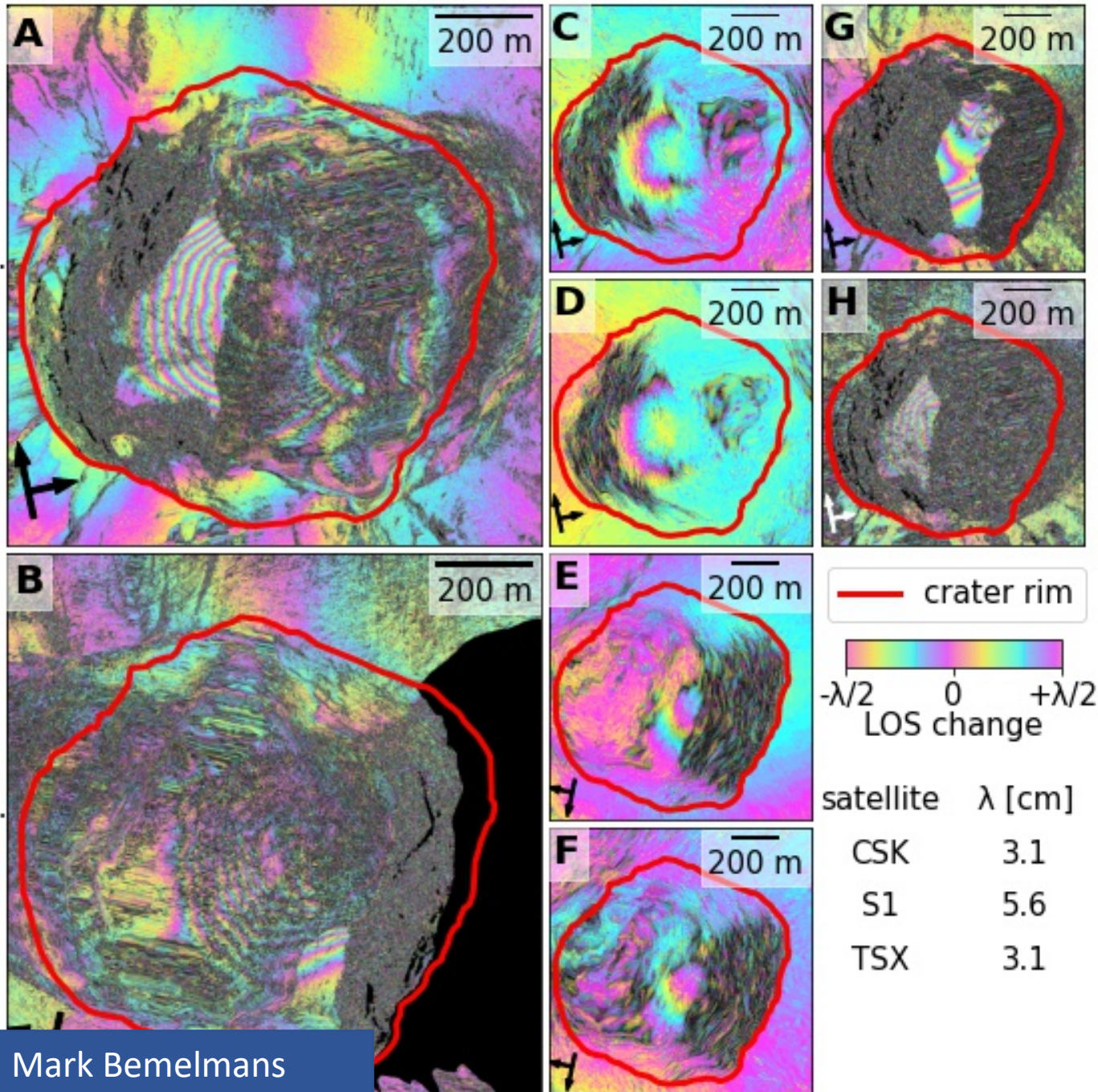
CSK data provided best regional snapshot of before and after the tsunami from radar. Darkening in post eruption imagery on outer islands indicating damaged regions not visible in lower resolution imagery i.e. Sentinel.

Event Response

CSK

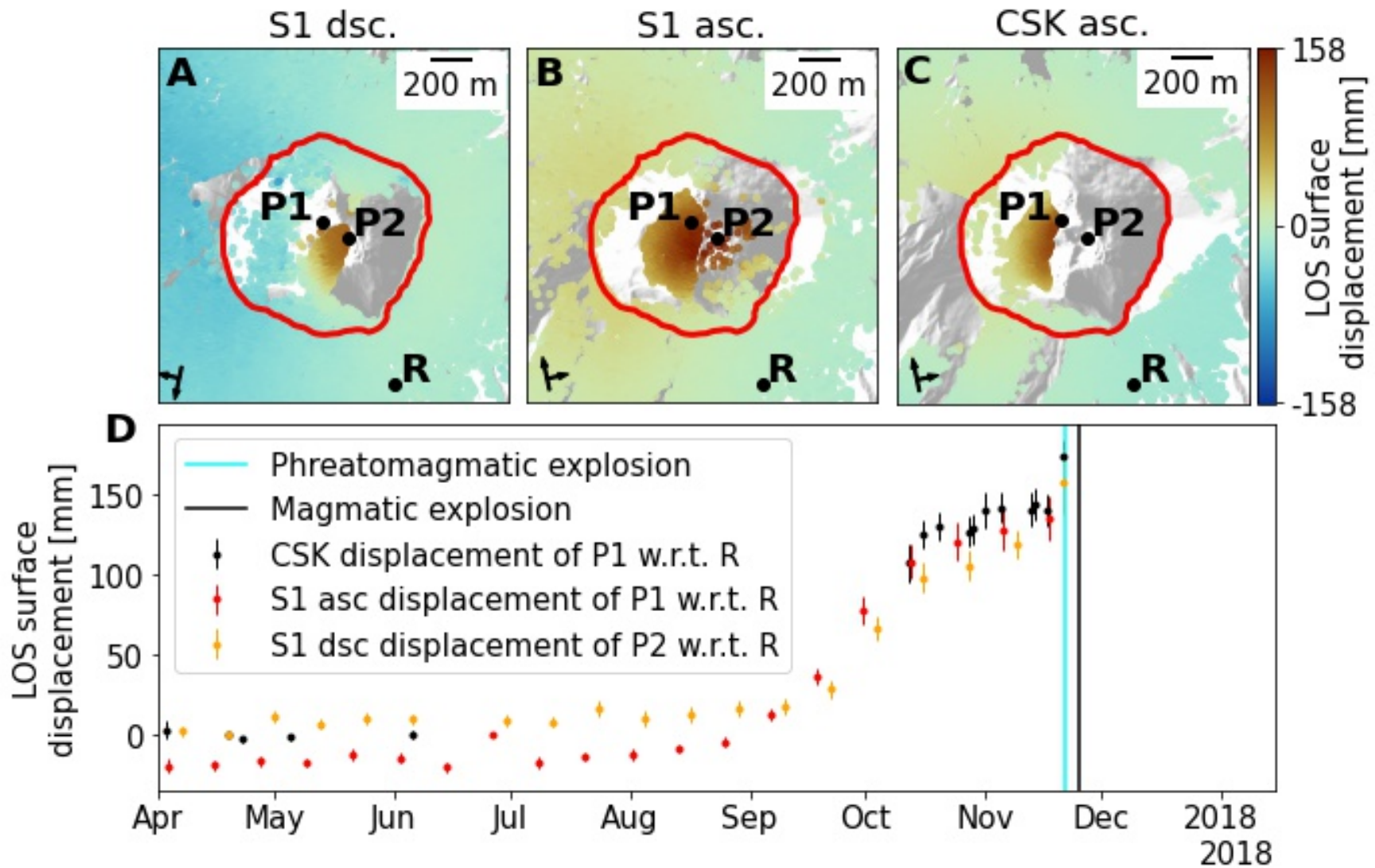
S1

TSX

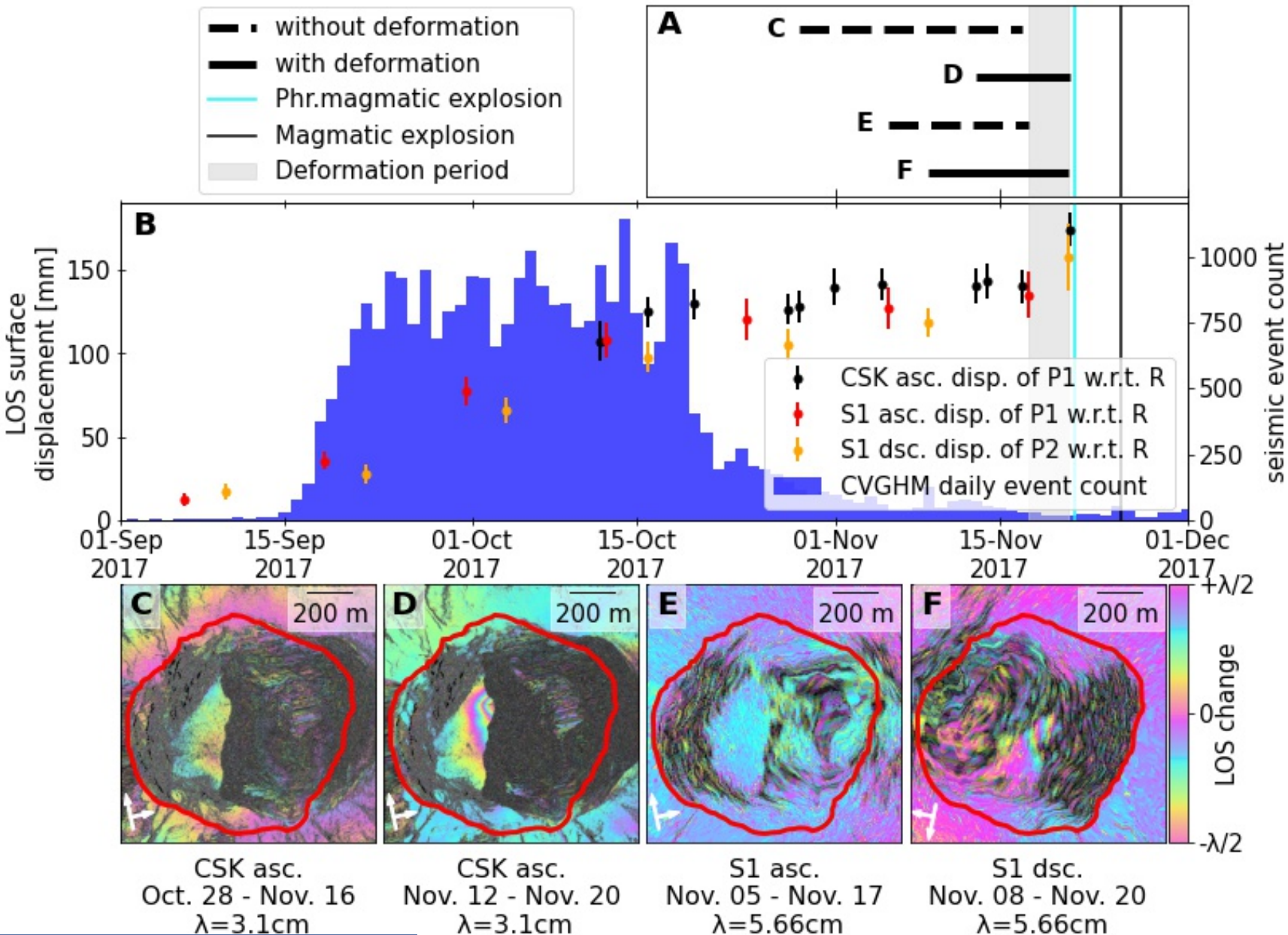


Interferograms showing deformation on the crater floor of Mount Agung (Indonesia) prior to its 2017 eruption.

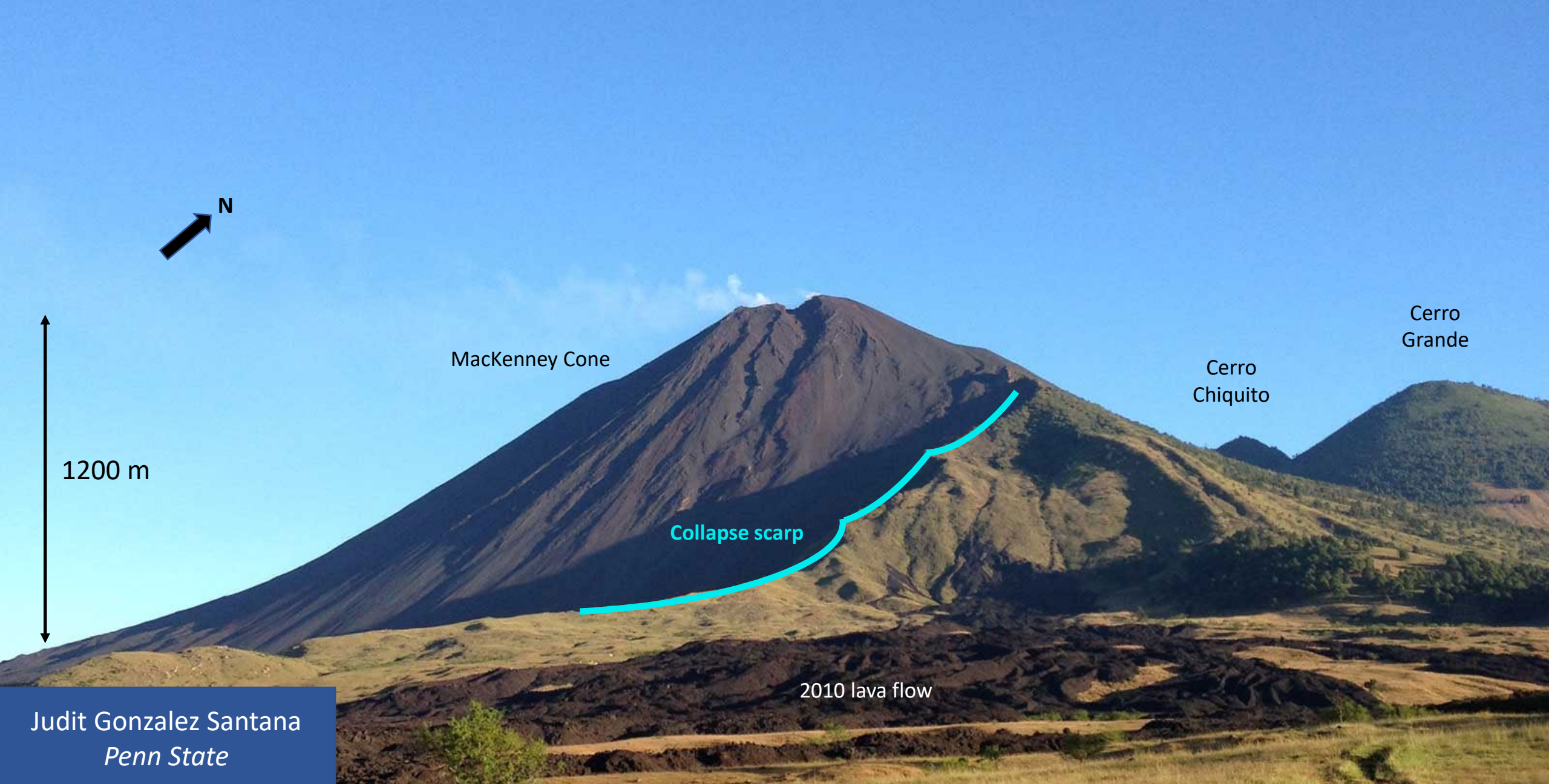
CSK and TSX data at 1 meter resolution  
S1 data at 11-by-14 meter resolution



Total LOS displacement on crater floor of Mount Agung Indonesia from April-early November 2017, prior to the 2017 eruption of Agung. After the start of unrest in September, the CSK acquisitions became more frequent but are lacking from early June to mid October.

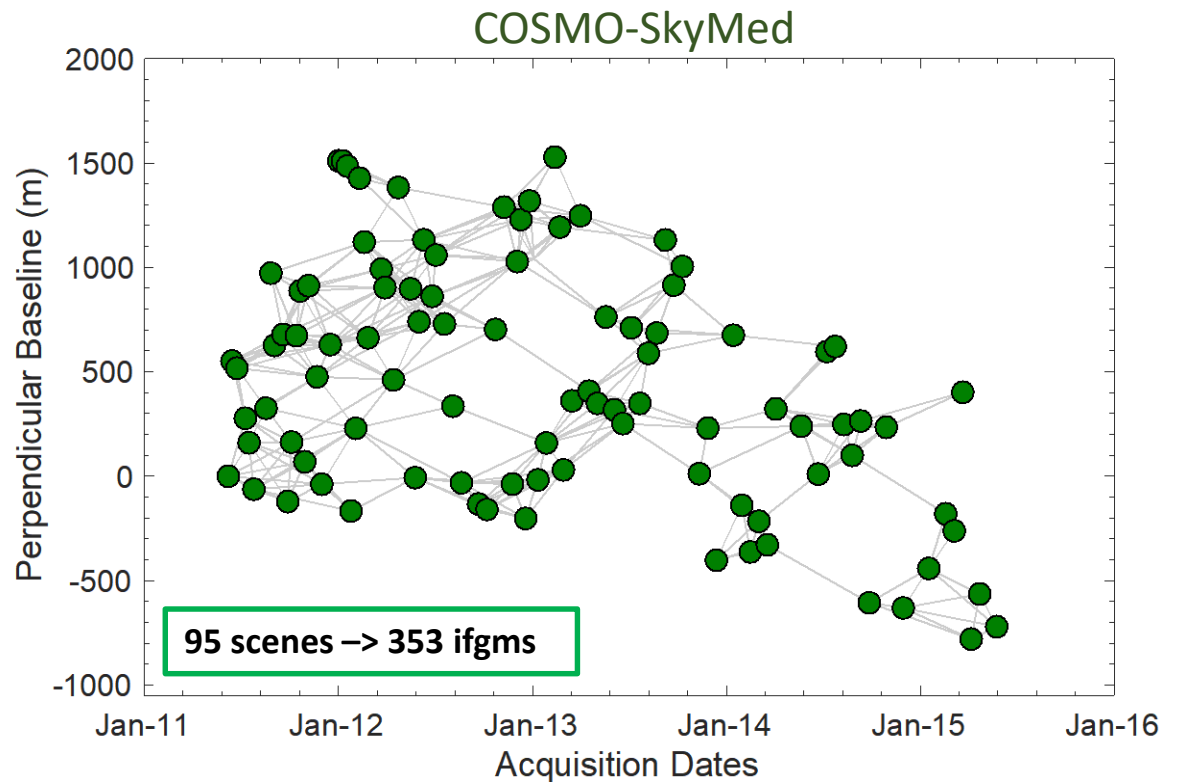
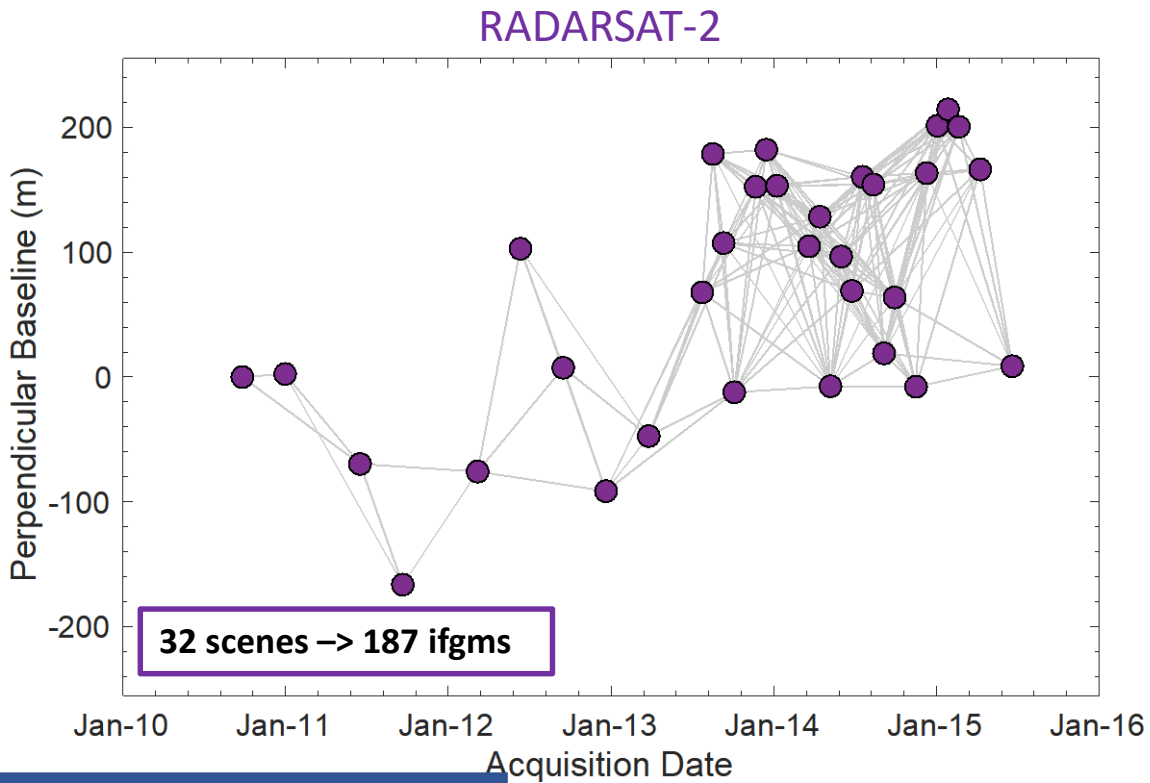
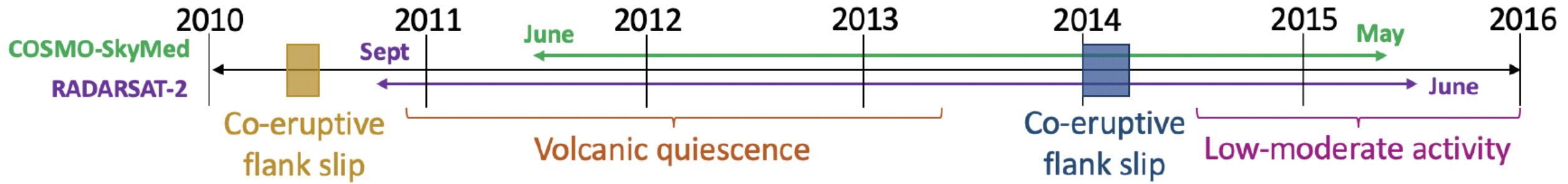


CSK and S1 data used to detect intra-crater deformation from 4 days to 11 hours before the start of the 2017 eruption at Agung (Indonesia). Panel C-D in particular show the great detail achieved with CSK at 1 m resolution and make the detection of this deformation undisputable.



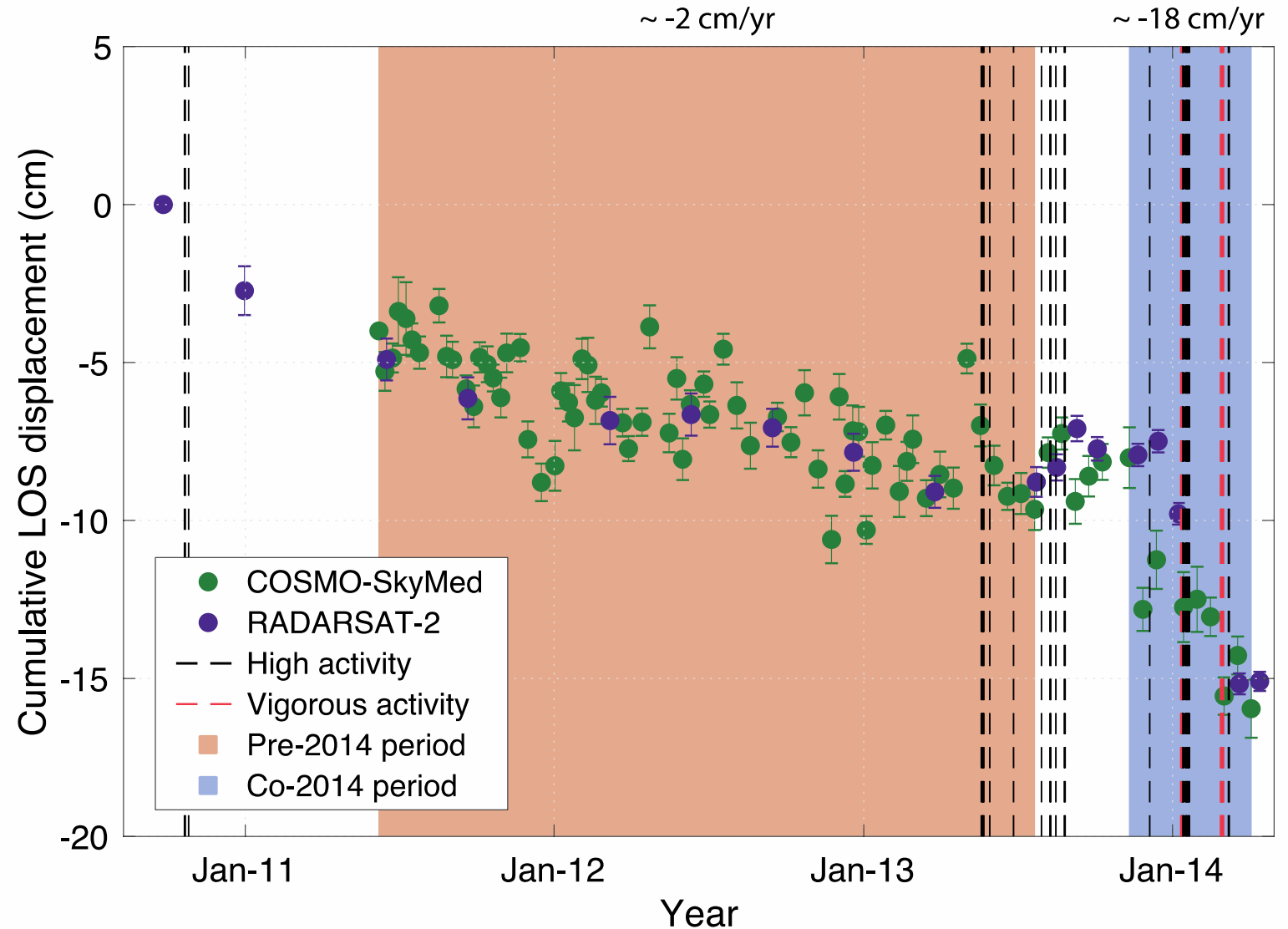
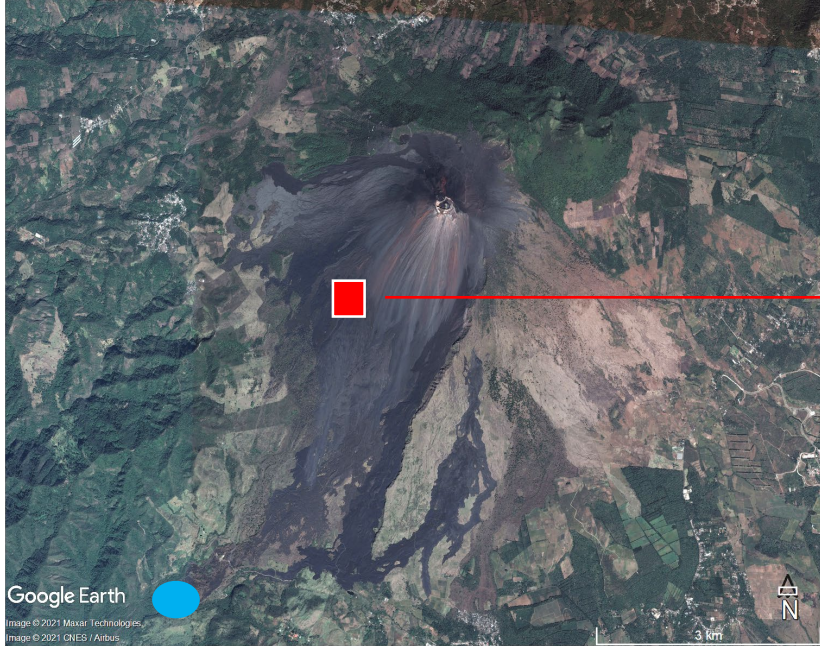
Judit Gonzalez Santana  
*Penn State*

# Time-series datasets

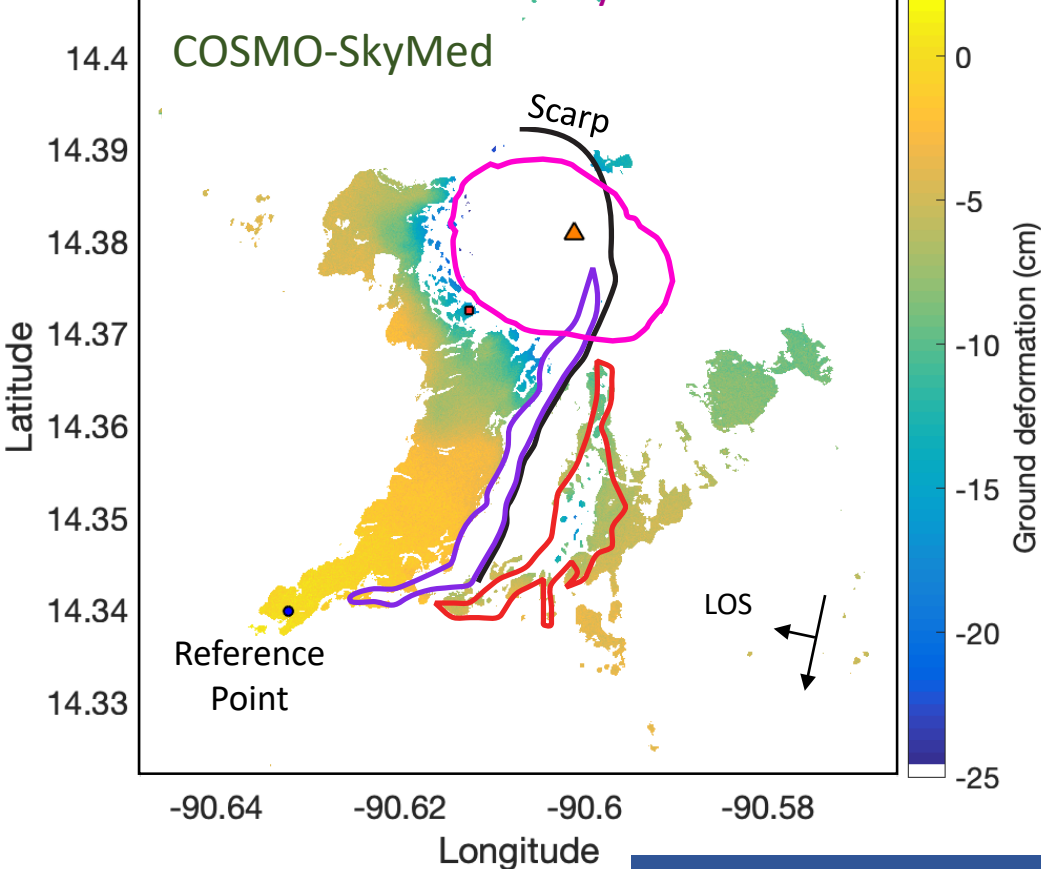
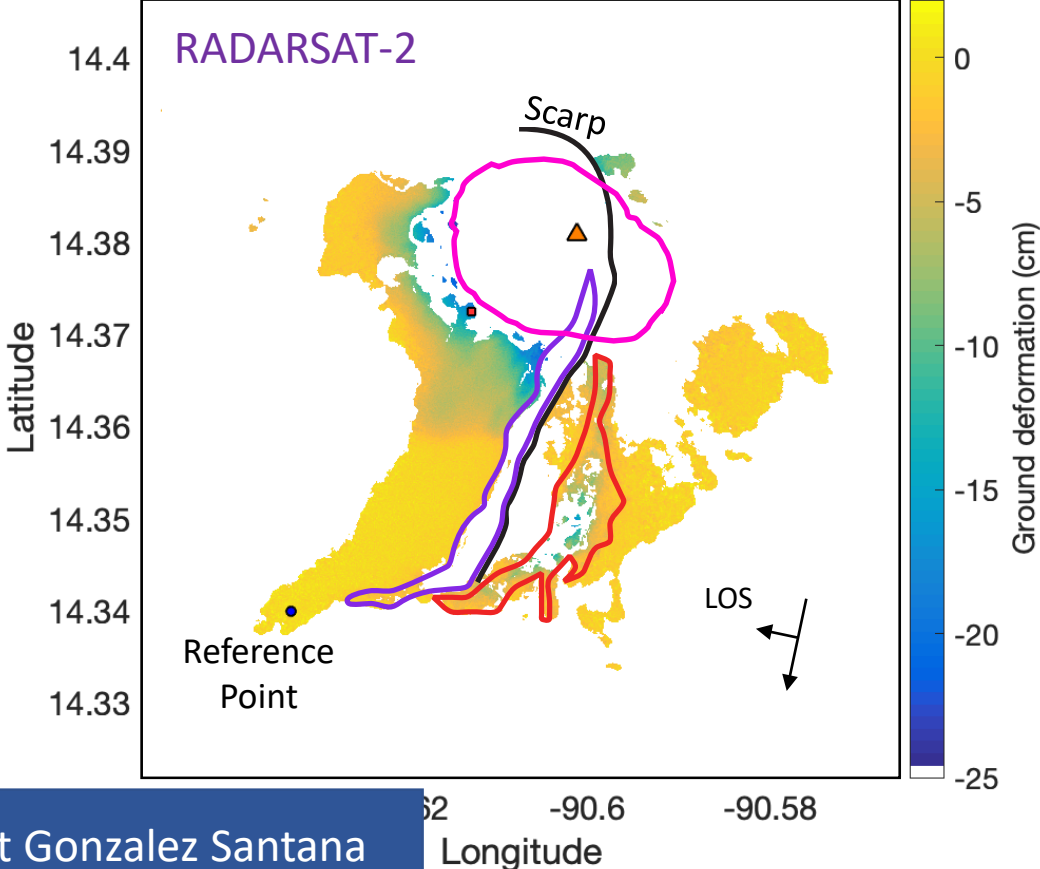
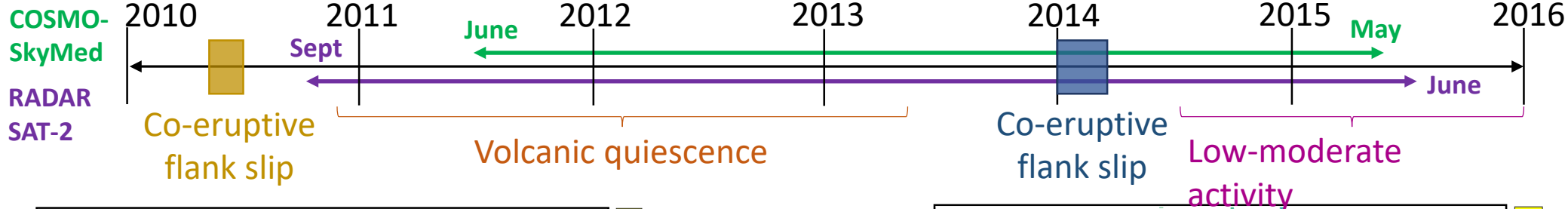




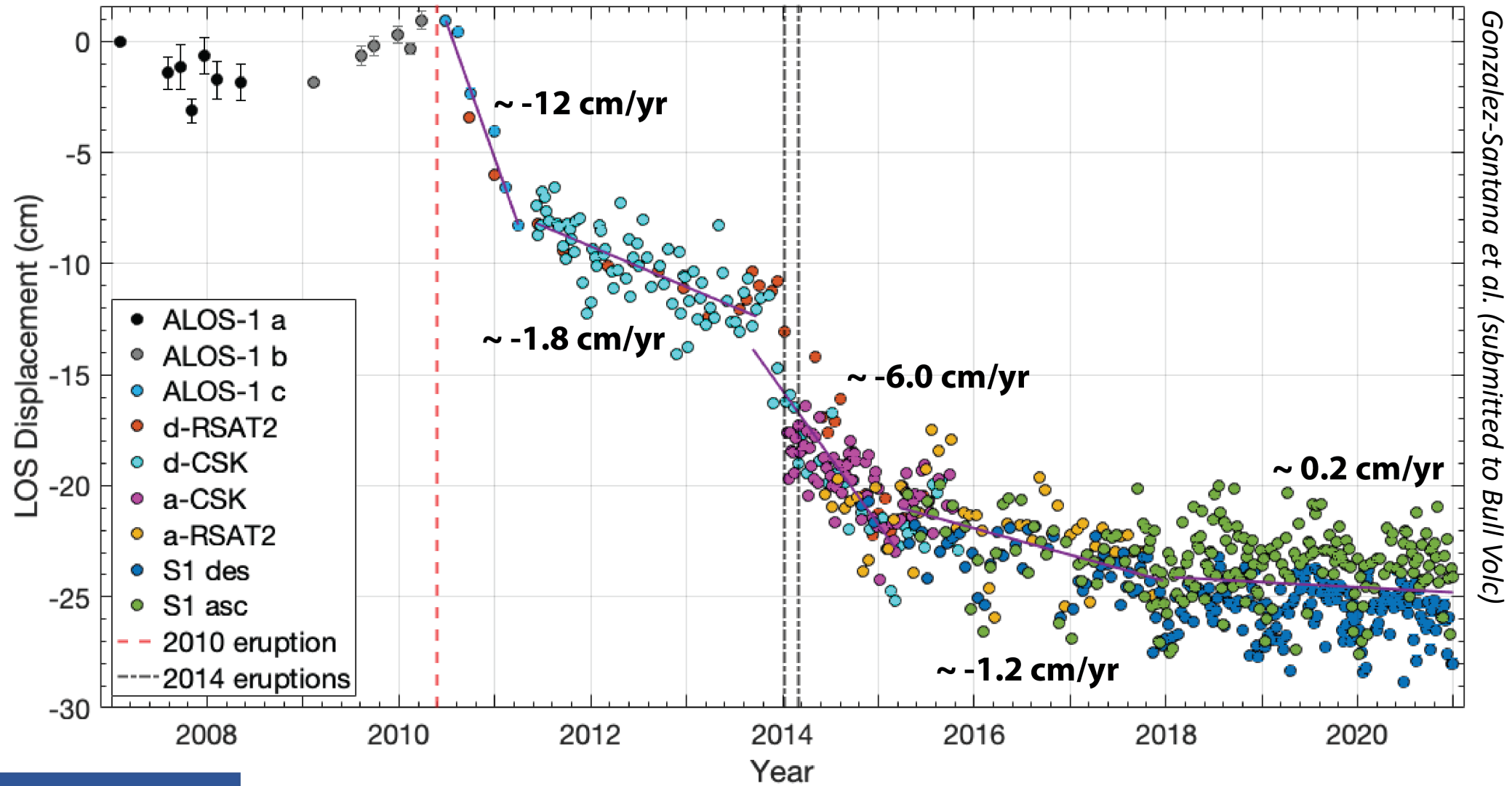
# Time-series analysis results



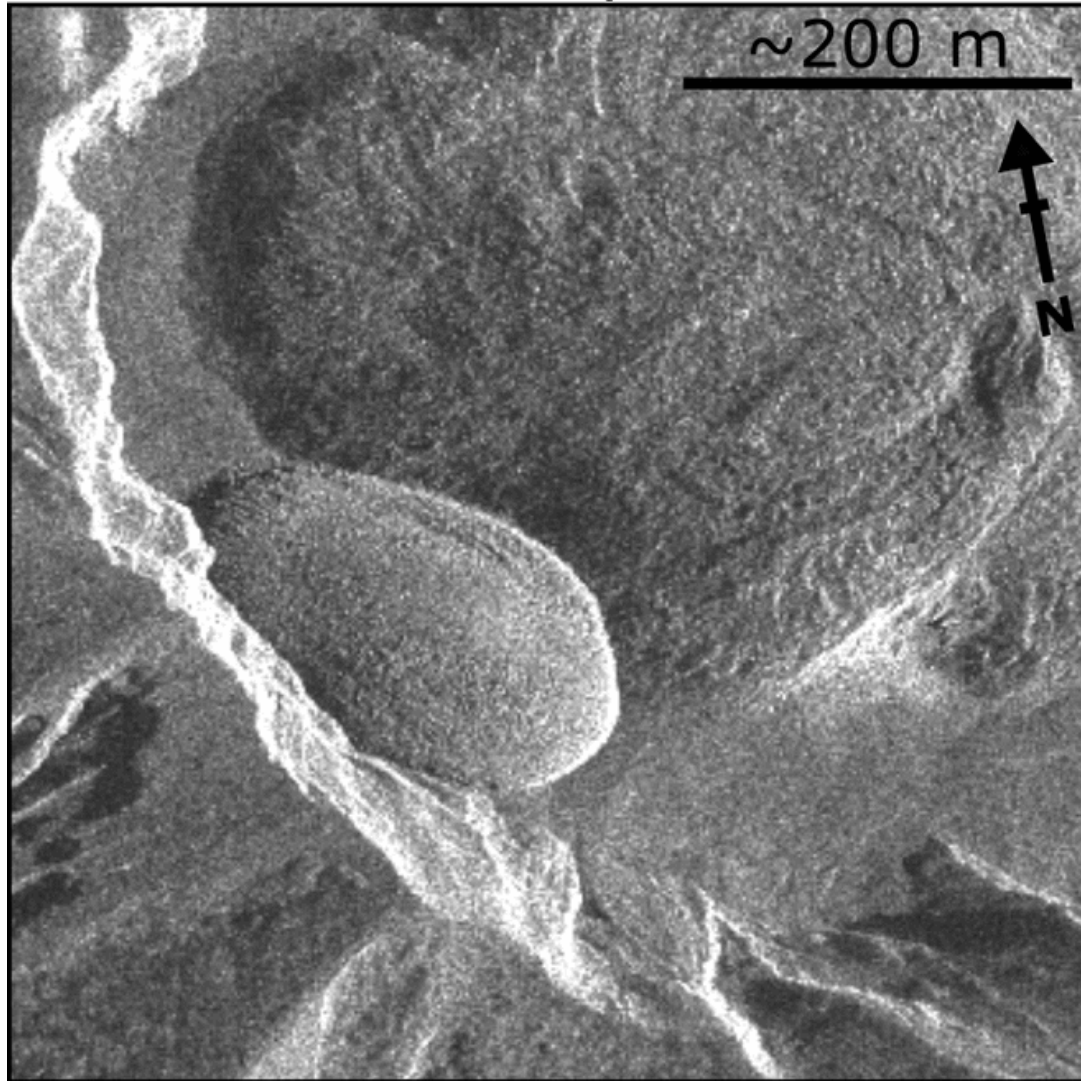
# Cumulative ground displacement



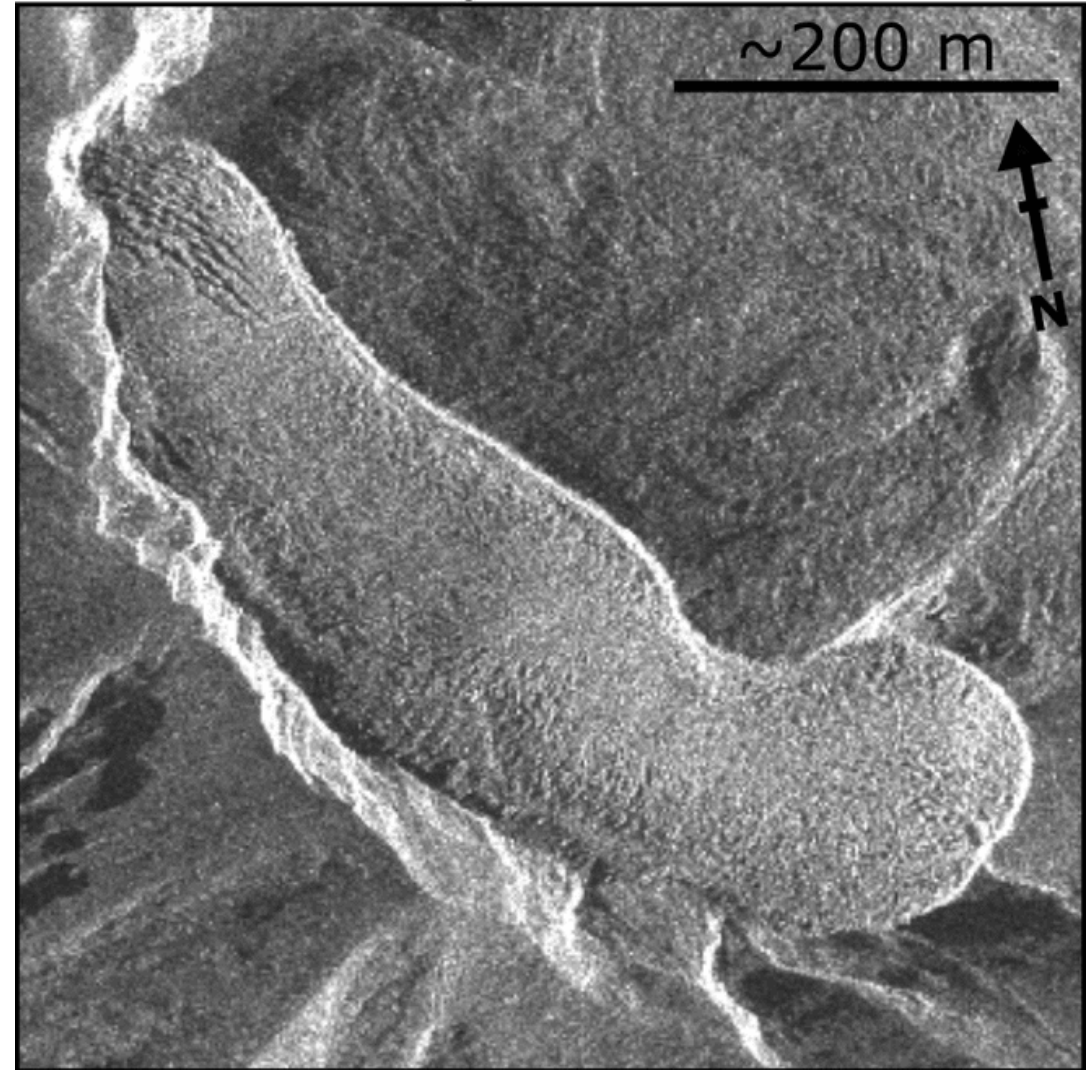
# Changes in rate of flank motion correlate with volcanic eruptions

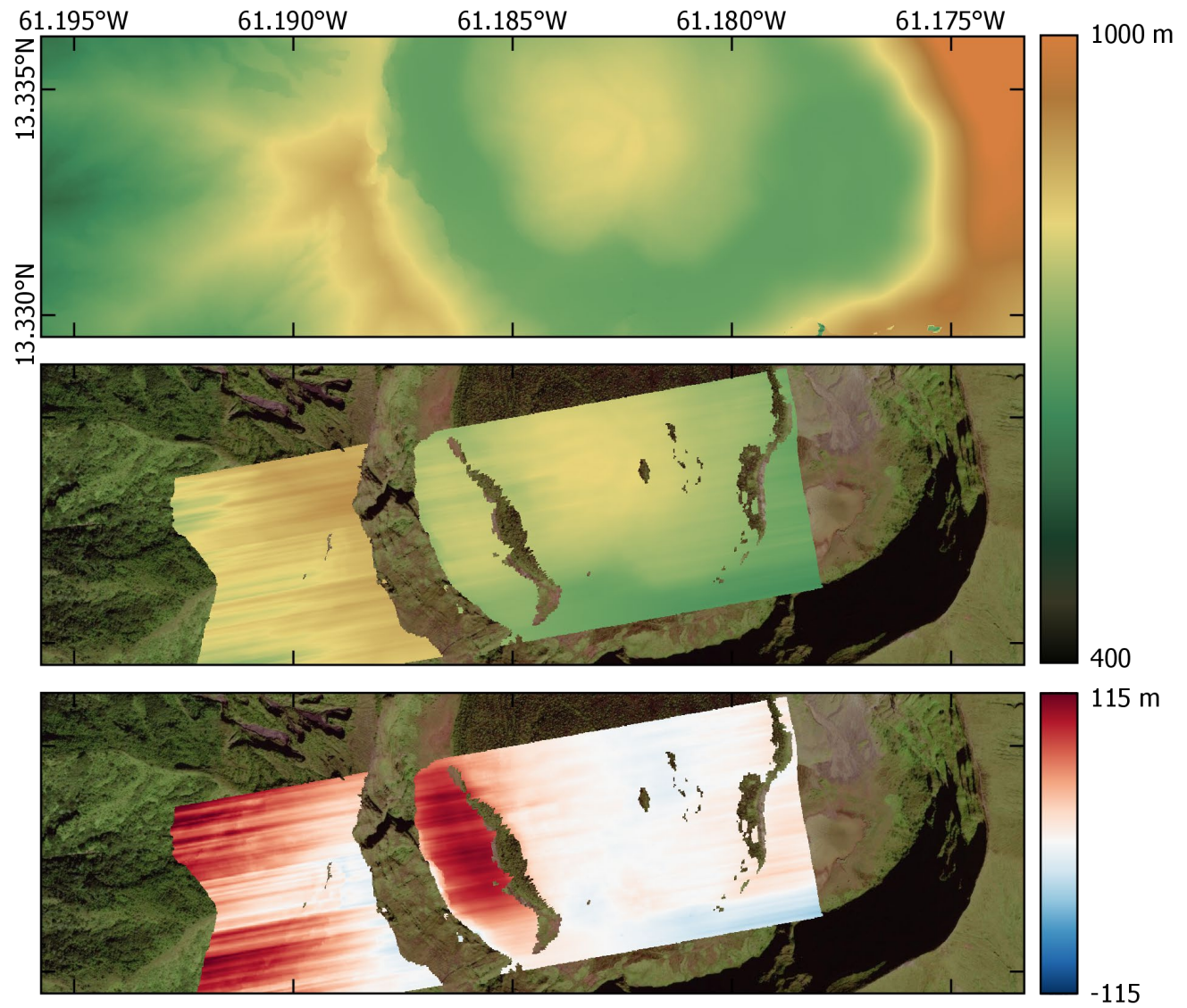
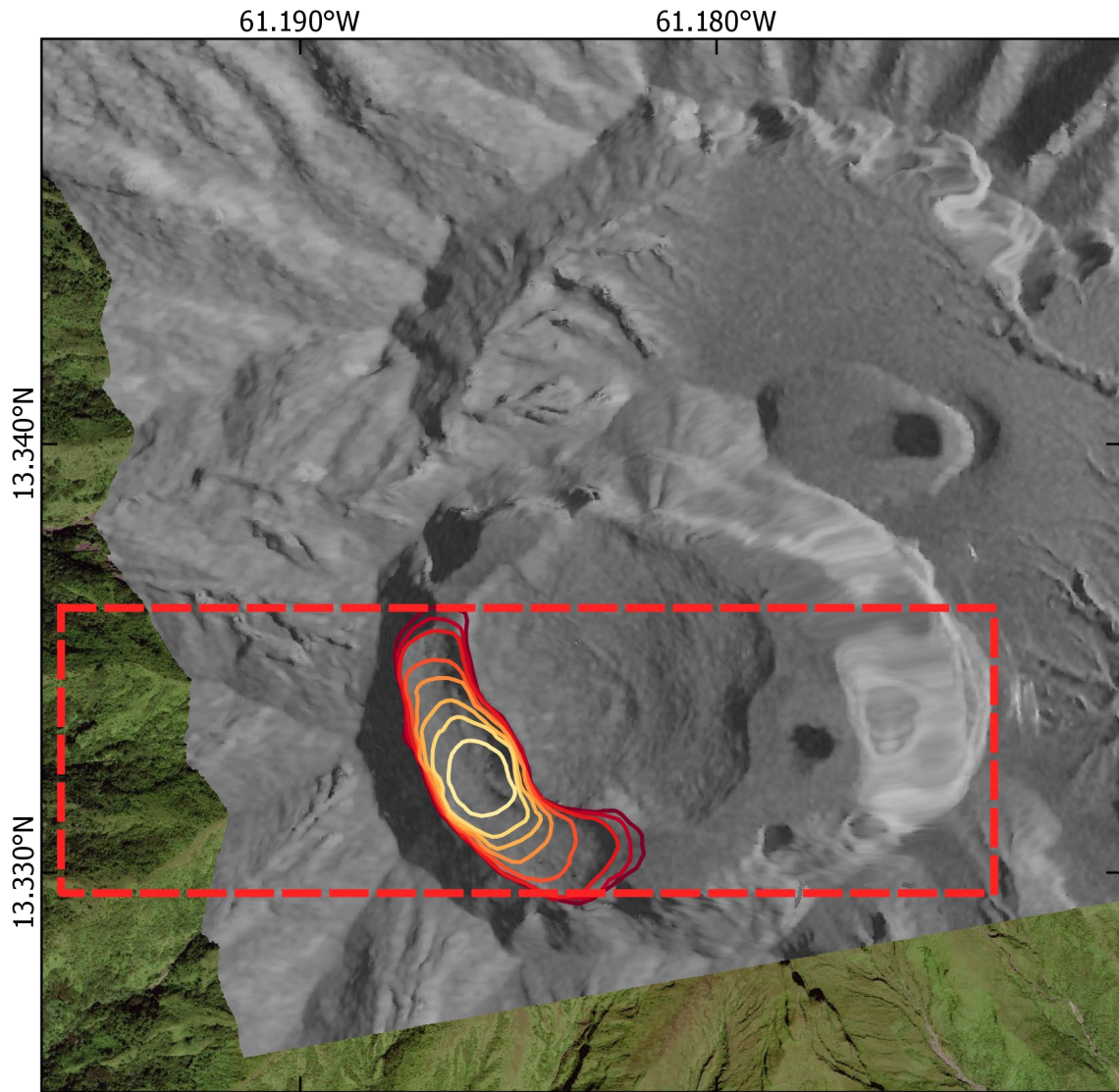


17 January 2021



7 April 2021





## Discussions with Mike and Andrew:

- **What would sustainable version of the demonstrator look like?**

- **Status quo:** 'best efforts' response to events, support of monitoring and research; demonstrator quotas given finite extensions
- **Ideal place:** funded time to manage data coordination, tasking, analysis and support to observatories (could we fund in-observatory positions?)

**Ideally need the flexibility to incorporate new satellite datasets into our organization as they come online (e.g., commercial instruments, new SAR instruments etc)**

**Thoughts welcome!**

