Committee on Earth Observation Satellites

Volcano Demonstrator Update

Susanna Ebmeier (University of Leeds)
Mike Poland (USGS) and many others

WG Disasters 18 (Nice – online presentation)
4-6 October 2022

1) Eruption/Unrest response:

March 2022: Cordón Caulle, La Palma, Hunga Tonga–Hunga Ha‘apai, Update from IG

October 2022: Sao Jorge unrest, Karthala unrest 2022, Ambae unrest 2022

2) Research results update:

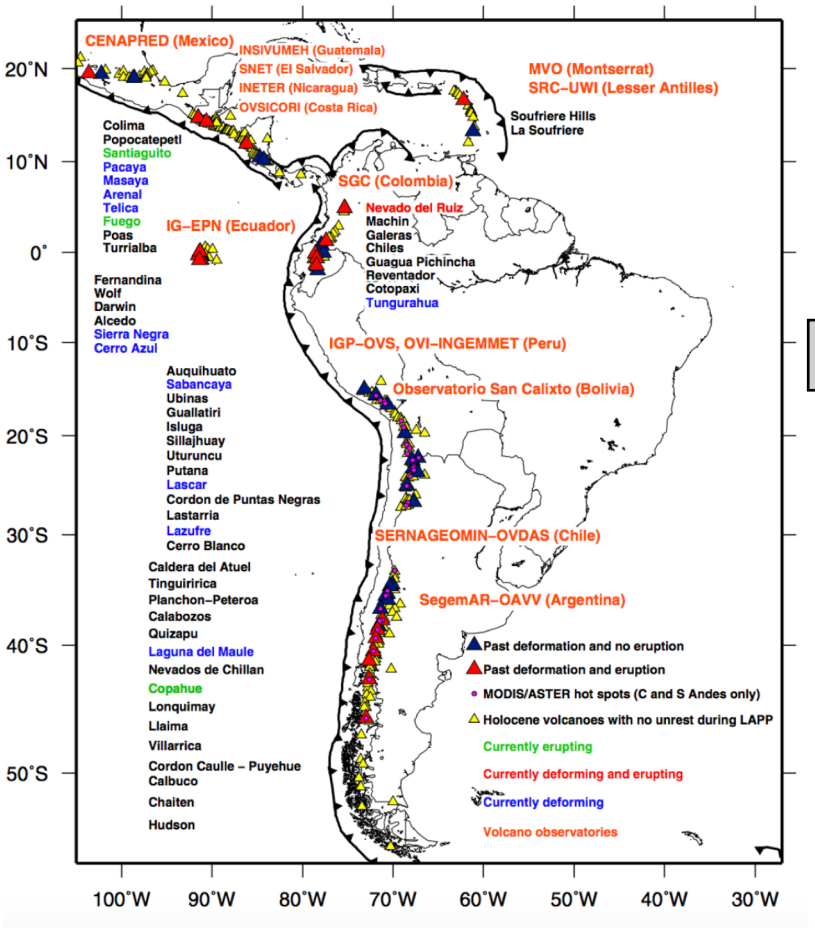
- final St Vincent update– Edna Dualeh
- Impact of DEM on high resolution processing – Mark Bemelmans
- new research from Merapi - Mark Bemelmans
- Sierra Negra trapdoor fault activation – Tara Shreve & Francisco Delgado

3) Ideas for a **Sustainable Volcano Demonstrator**

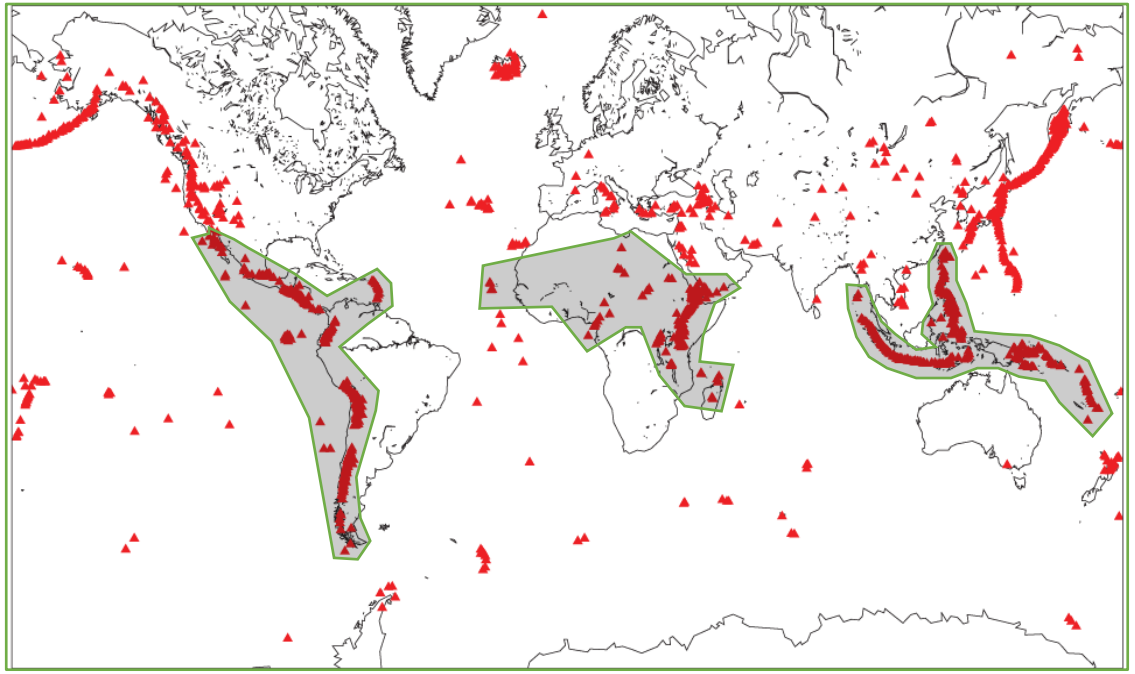
Attribution
Affiliation

Event Response/Research

Pilot (2014-2017)



Demonstrator (2019 -2022)



Long term goal: to demonstrate the necessity and viability of international coordination of satellite tasking for volcano monitoring

CEOS

Cornell University

University of BRISTOL

東京大学 THE UNIVERSITY OF TOKYO

GNS SCIENCE TE PŪ AO

Latin America:

Matt Pritchard

Cornell University

Africa:

Juliet Biggs

University of Bristol

SE Asia:

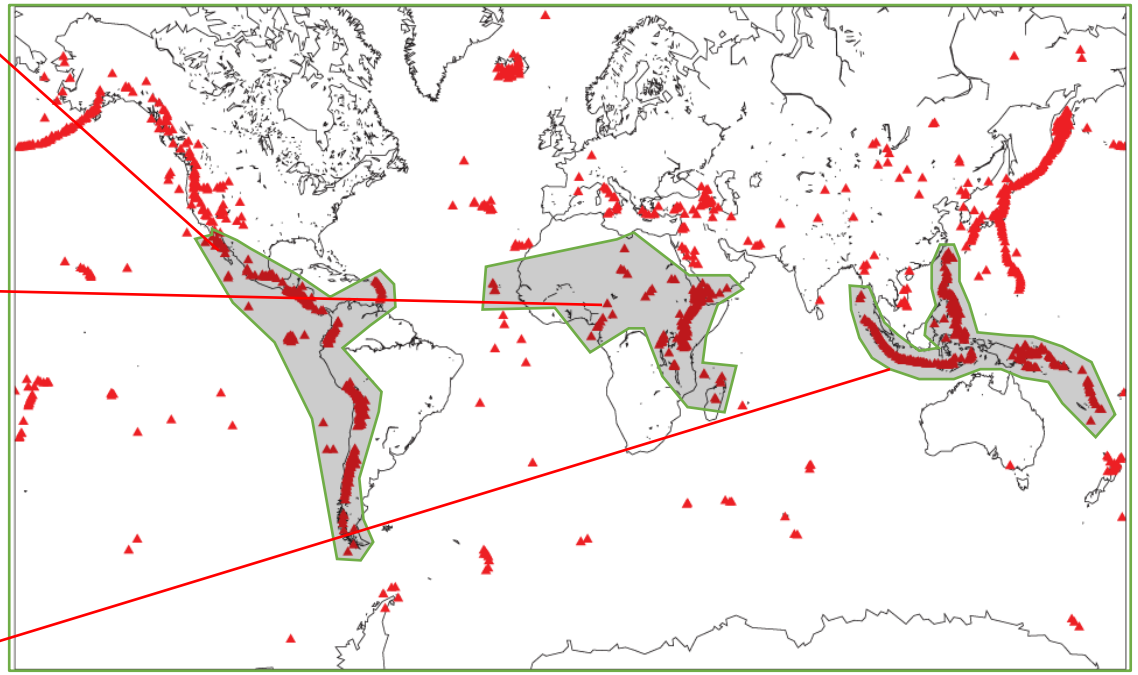
Yosuke Aoki

University of Tokyo

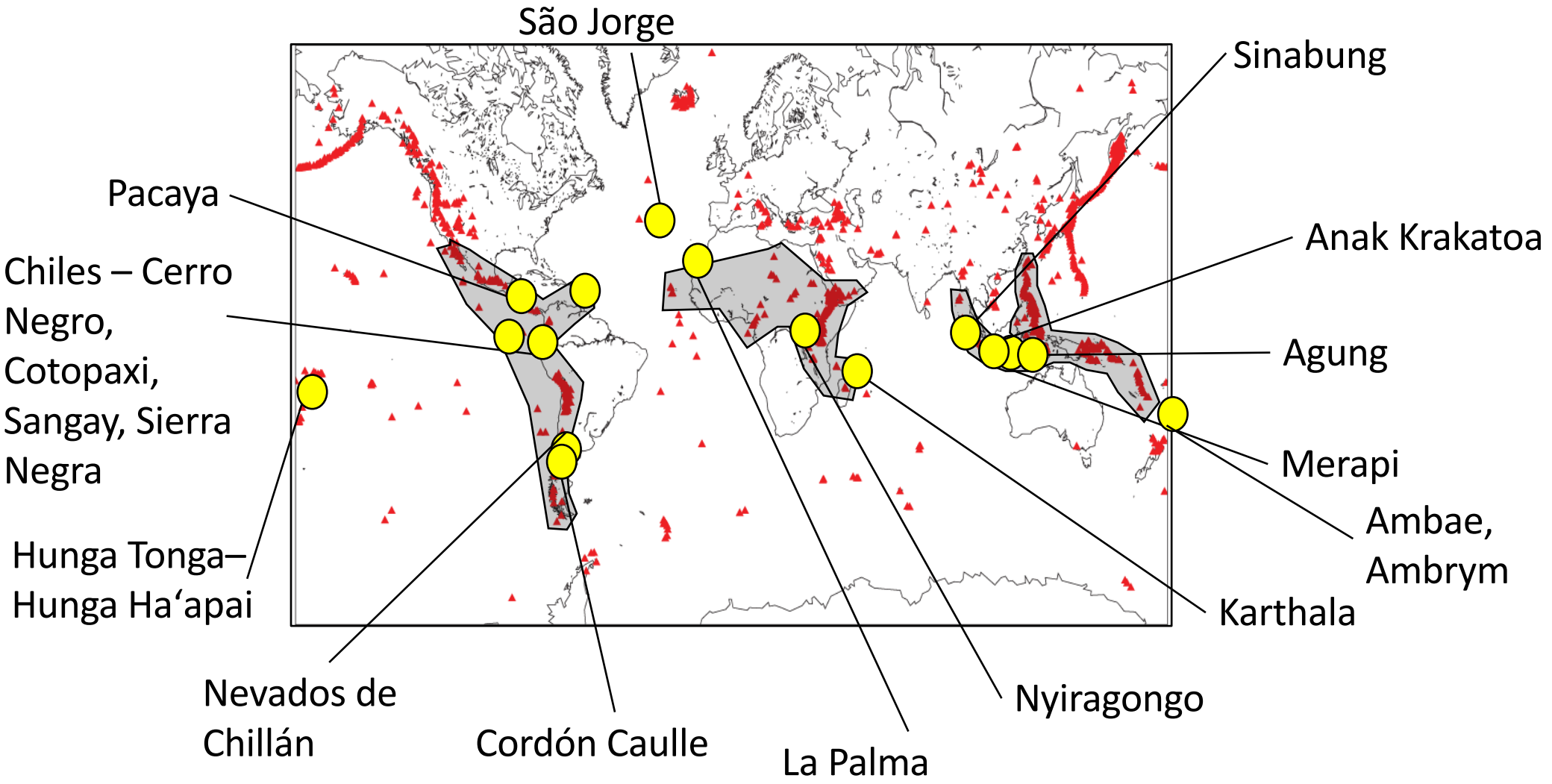
Ian Hamling

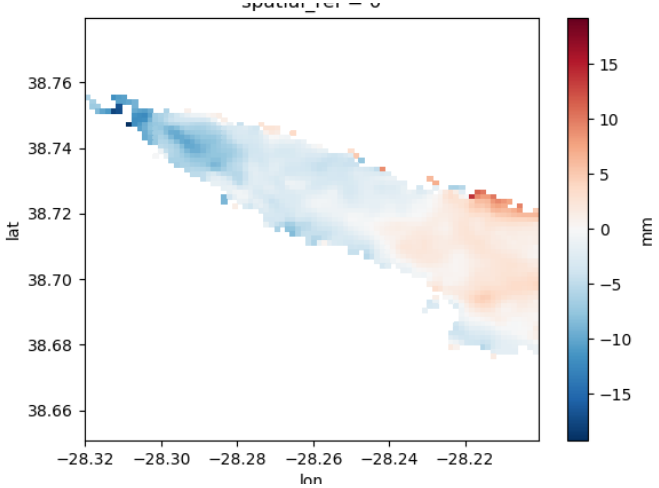
GNS New Zealand

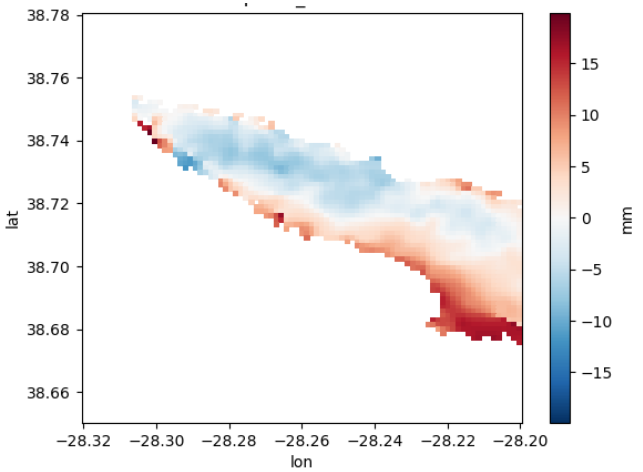
Demonstrator (2019 -)



Demonstrator response, monitoring and research (2019 -2022)





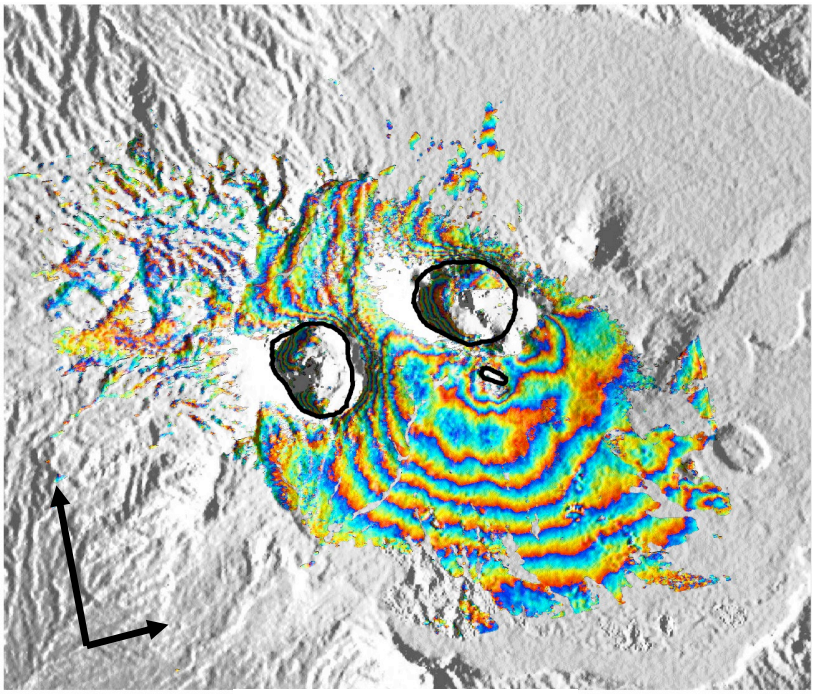


- Sao Jorge:
  - dyke intrusion caused high deformation on March 19-20, 2022
    - successfully captured by systematic Sentinel-1 acquisitions
  - seismic unrest continued following weeks, 1 GPS station shows (subtle) deformation till mid-April
- Cosmo SkyMed data:
  - CSK data after the 19 March event
  - We analysed the data by InSAR, and identified strong signal that we interpret as mainly due to atmospheric signal delay. We did not interpret the signal due to surface deformation, therefore we stopped further CSK observations

Sao Jorge
Teresa de Jesus Lopes Ferreira, UAC

Material provided by Milan Lazecky

Total Displacement 2019-2022



Away Towards

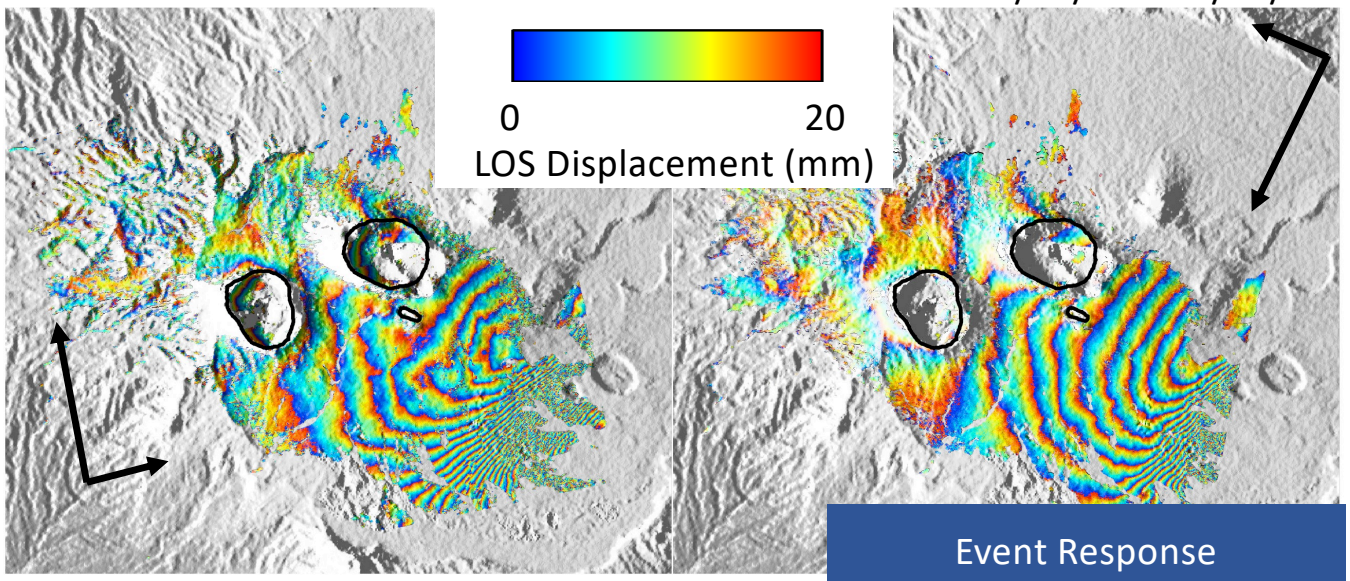
0 50

LOS Displacement (mm)

- Since late 2019, TerraSAR-X data over Ambrym, Vanuatu, has detected ~300 mm of apparent uplift with the caldera.
- In June 2022, a large deformation event occurred to the south east of the main cones showing ~200 mm of LOS increase.

28/05/22 – 30/06/22

15/05/22 – 17/06/22



0 20

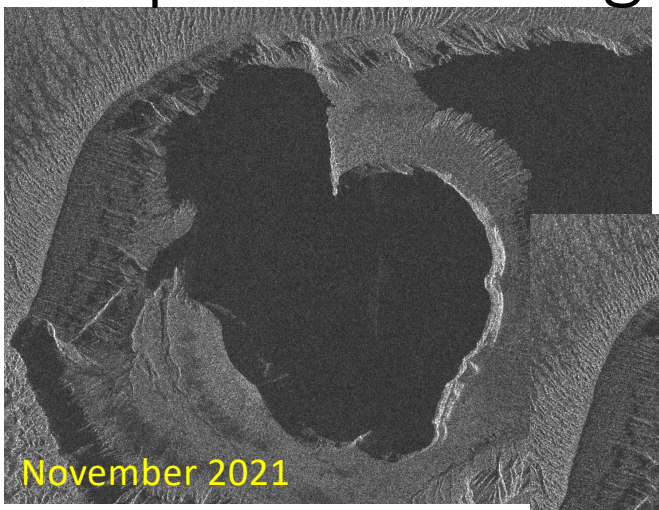
LOS Displacement (mm)

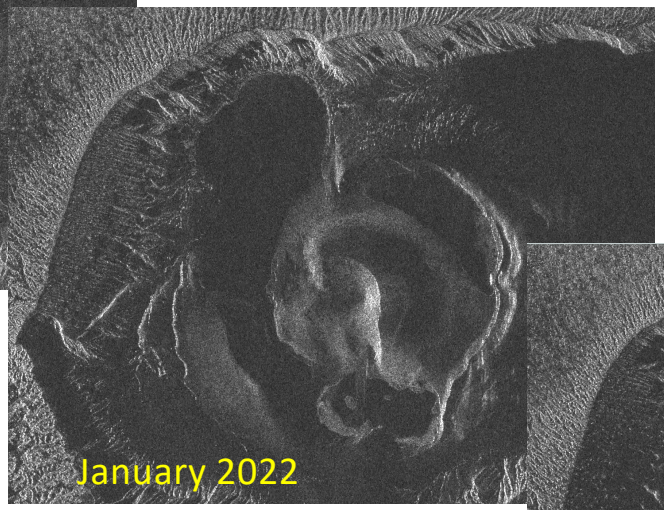
Ambrym

Ian Hamling, GNS

Event Response

Amplitude changes Ambae, Vanuatu





Small eruption reported in December 2021 with TerraSAR-X amplitude data revealing growth of new island.

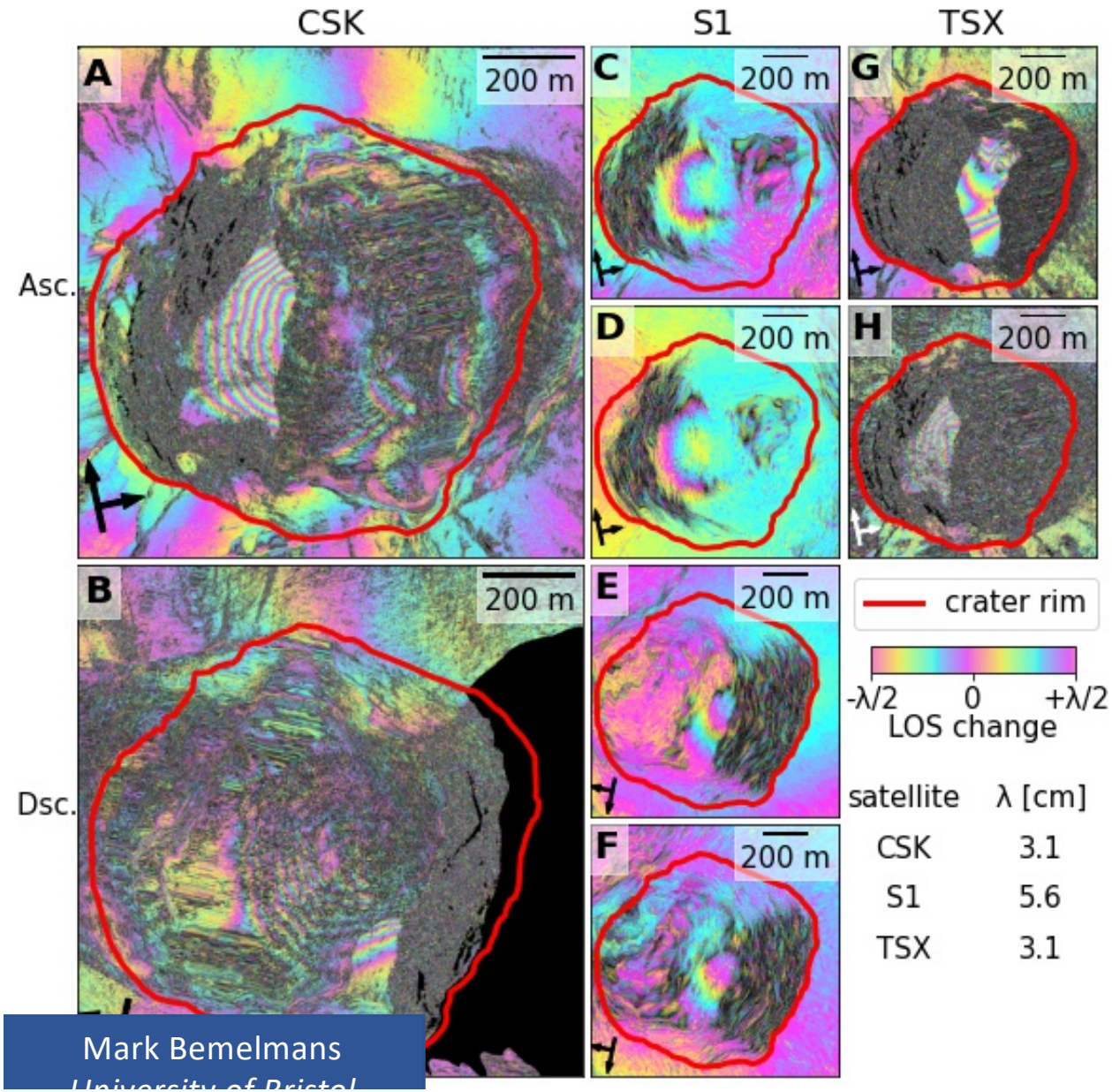
Subsequent images show major re-working of crater floor, removal of crater lake and new ash deposits

Despite large detected changes, the eruption was short lived and small compared with 2018

Growth of island was preceded by a small uplift signal in vicinity of the summit area suggesting injection of fresh material high in the edifice.

Ambrym
Ian Hamling, GNS

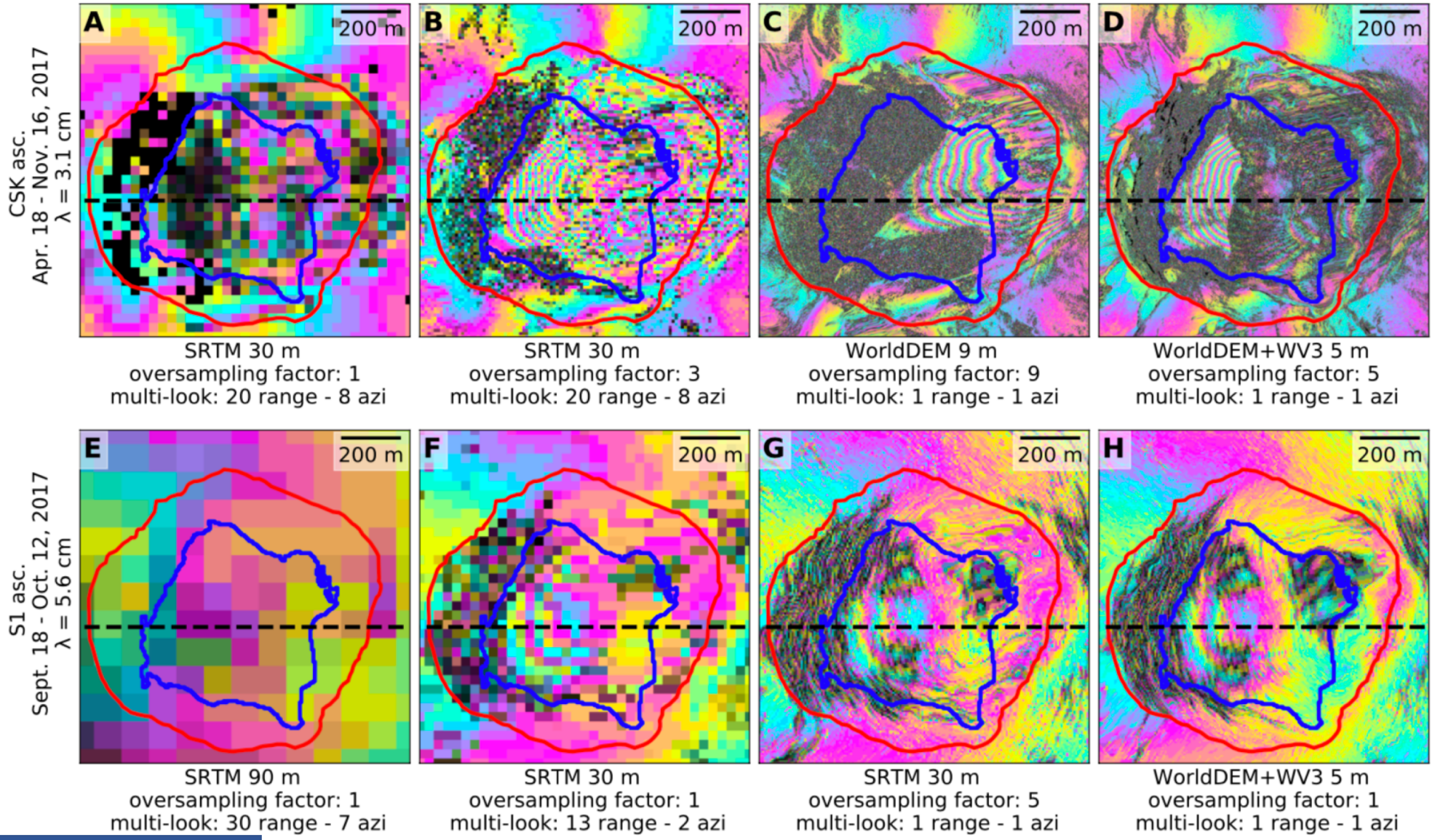
Event Response



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

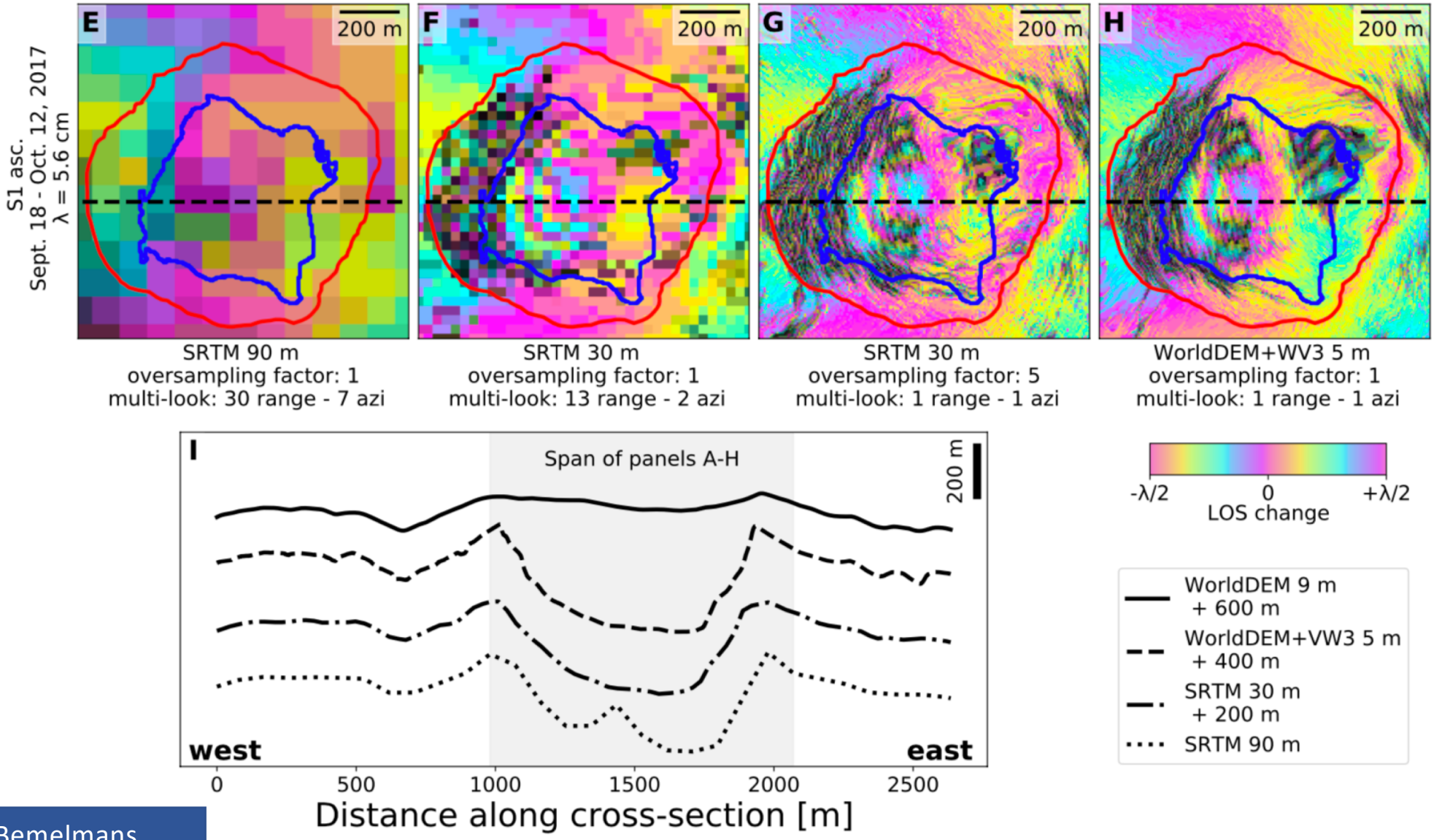
CSK and TSX data at 1 meter resolution
S1 data at 11-by-14 meter resolution

Mark Bemelmans
University of Bristol



Mark Bemelmans
University of Bristol

Research



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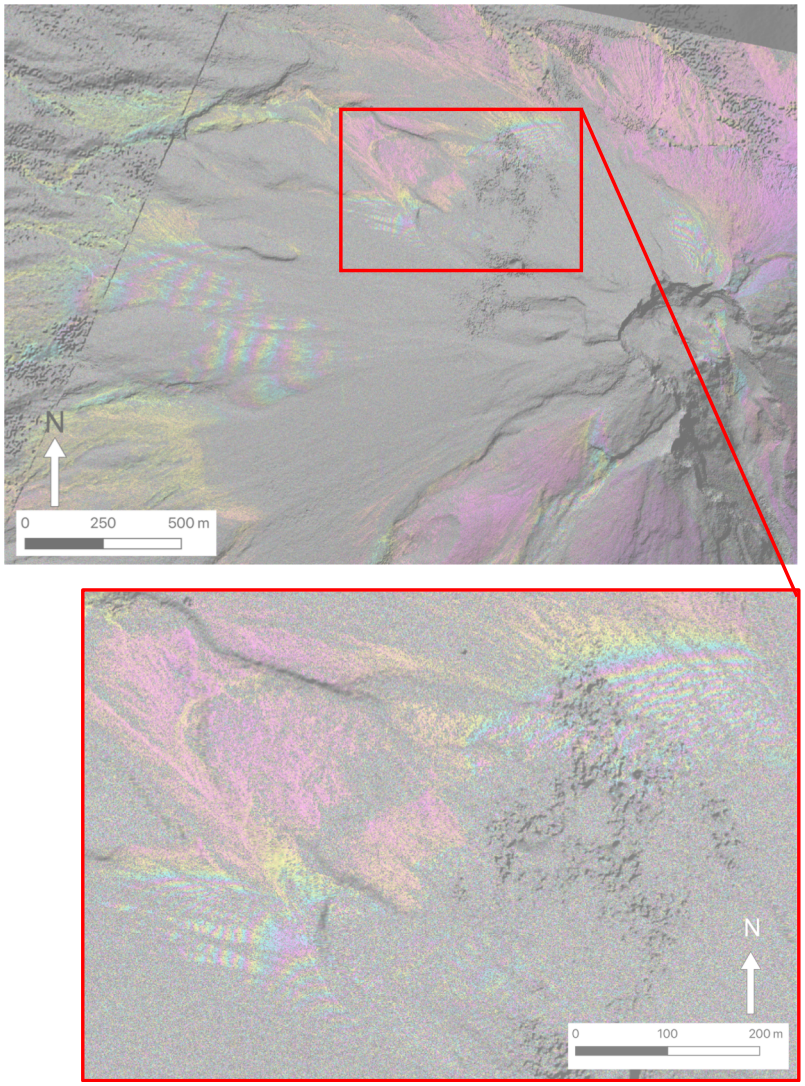
University of Bristol

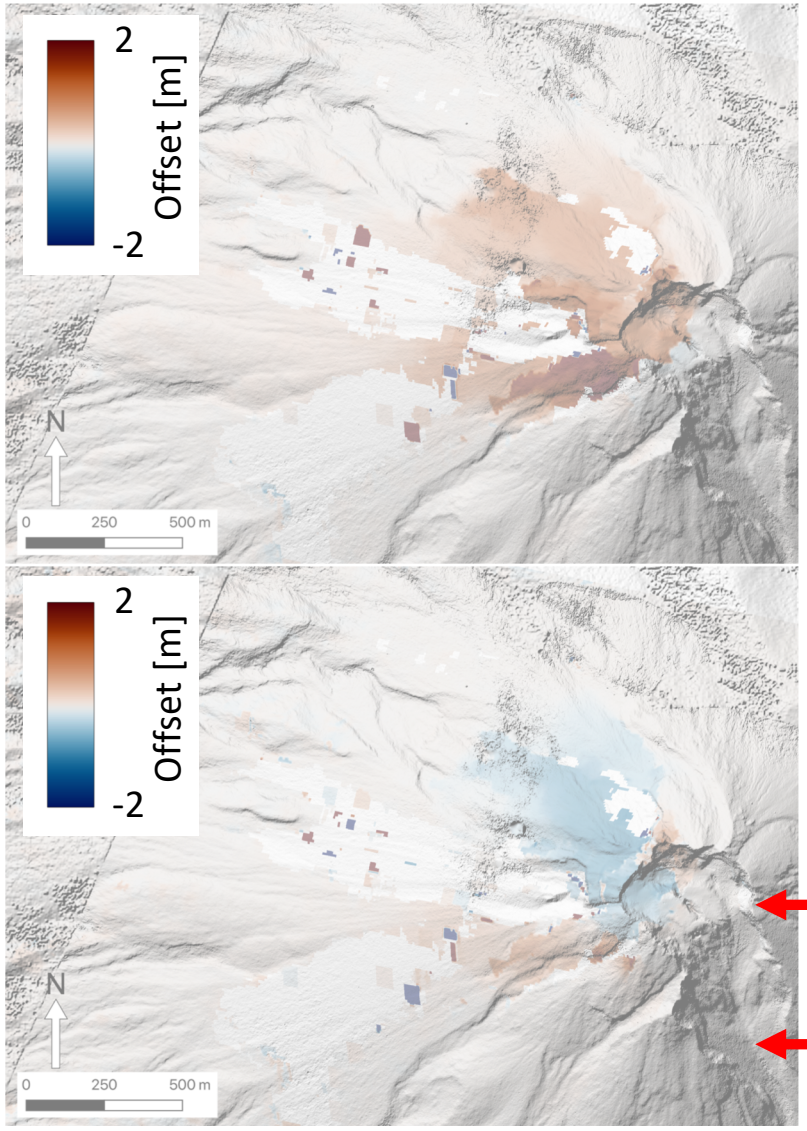
Research

TSX staring spotlight (dsc.)
high-res InSAR Nov. 27 – Dec. 8 2020



InSAR
X-band (3.1 cm)
Every fringe is 1.55 cm of LOS change

TSX staring spotlight (dsc.)
feature tracking Nov. 27 – Dec. 8 2020

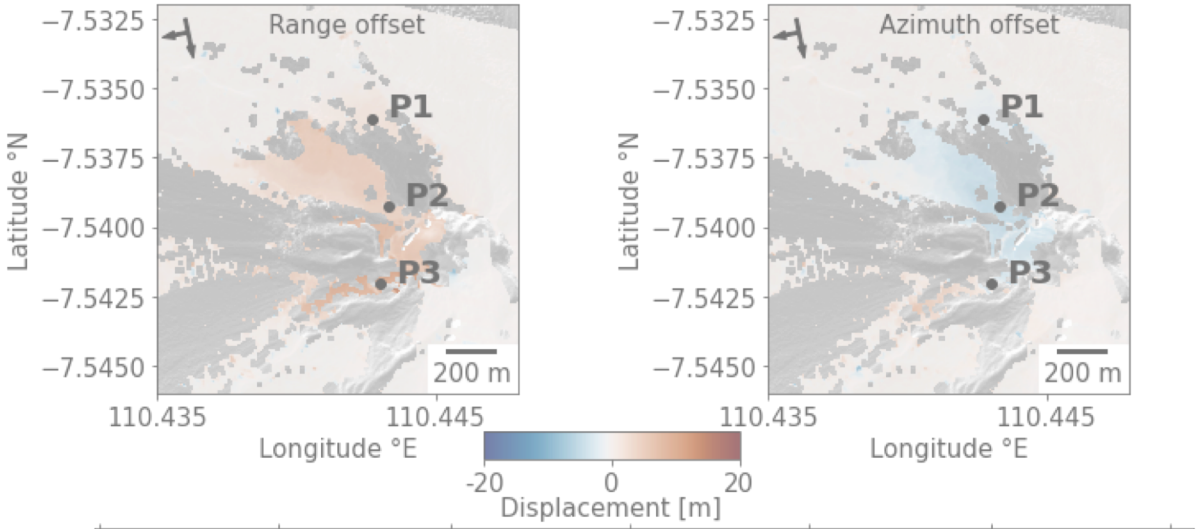


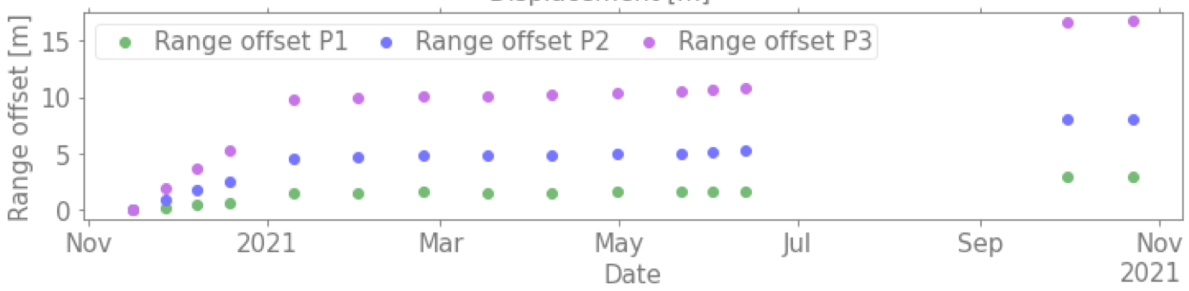
Range offset:
Red means subsidence and/or displacement to the west
(blue vice versa)

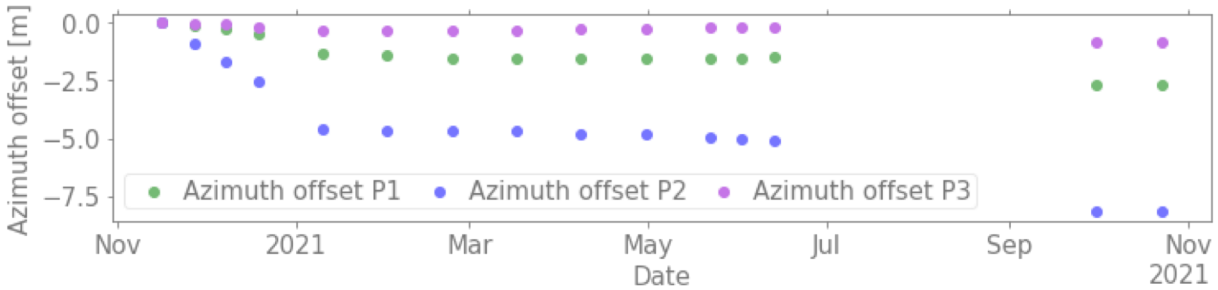
Azimuth offset:
red means displacement to the south
(blue vice versa)

Summit crater

Gendol Breach (2010 eruption)







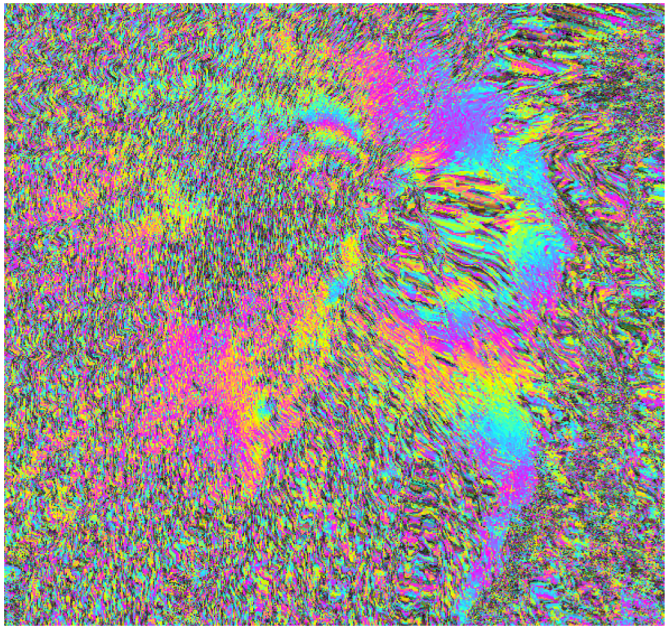
SAR feature offset tracking
TSX staring spotlight track 134 (descending)
From Nov. 16, 2020 to Oct. 23, 2021

Related observations:
Sept 2020 – Jan 2021: EDM line shortening ~10 cm/day
Jan 4, 2021: New lava dome SW of summit.
Jan 2021-June 2021: Extrusion rate steady, no EDM line change
June 2021 – Aug 2021: EDM line shortening 5-10 cm/day
June 2021 – present: Approx. constant lava dome volume

Sentinel-1 at Merapi (DEM/resolution influence)

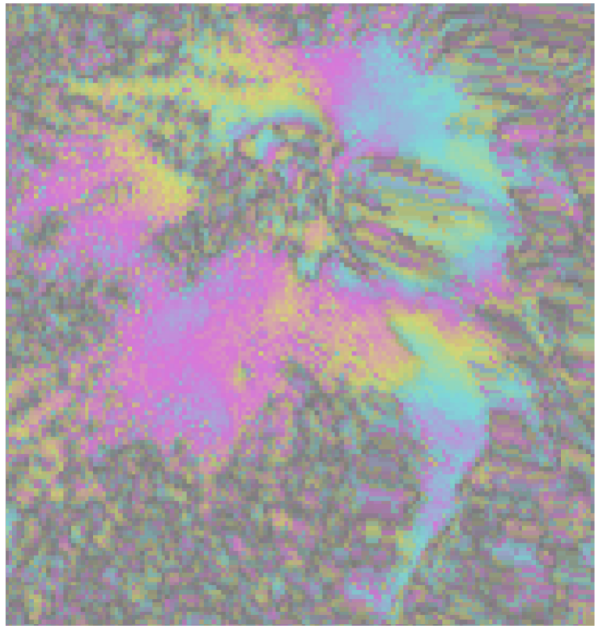
June 28 – Aug 15 2020
1m DEM from 2012-2017
(TLS+UAV+TDX)

No multi-looking
2.3-by-14 m resolution
(here interpolated to 1 m DEM)
2 fringes to NW

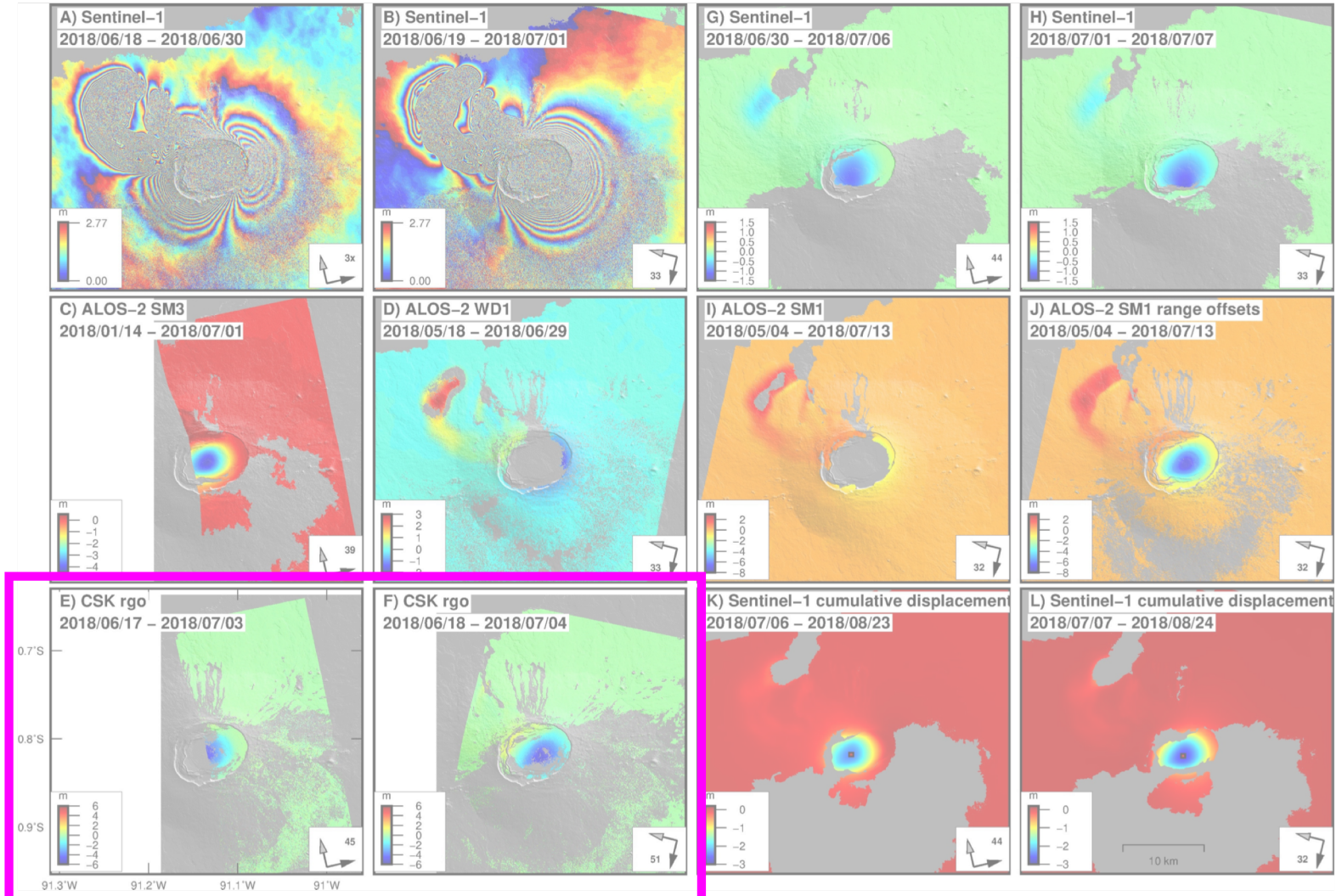


June 28 – Aug 15 2020
30 m SRTM DEM from 2000 (outdated)

multi-look:
4 range – 2 azimuth ~30 m resolution
fringes not clear



Contribution to multi-sensor study of Sierra Negra, Galapagos



Shreve & Delgado (submitted to EPSL)

Tara Shreve & Francisco Delgado
Carnegie Institute, University of Santiago

Research

How can we make SAR backscatter useful for volcano monitoring and research?

Edna Dualeh's thesis defended 27.9.2022

CEOS Demonstrator data

Volcán de Fuego, Guatemala

Supersite data

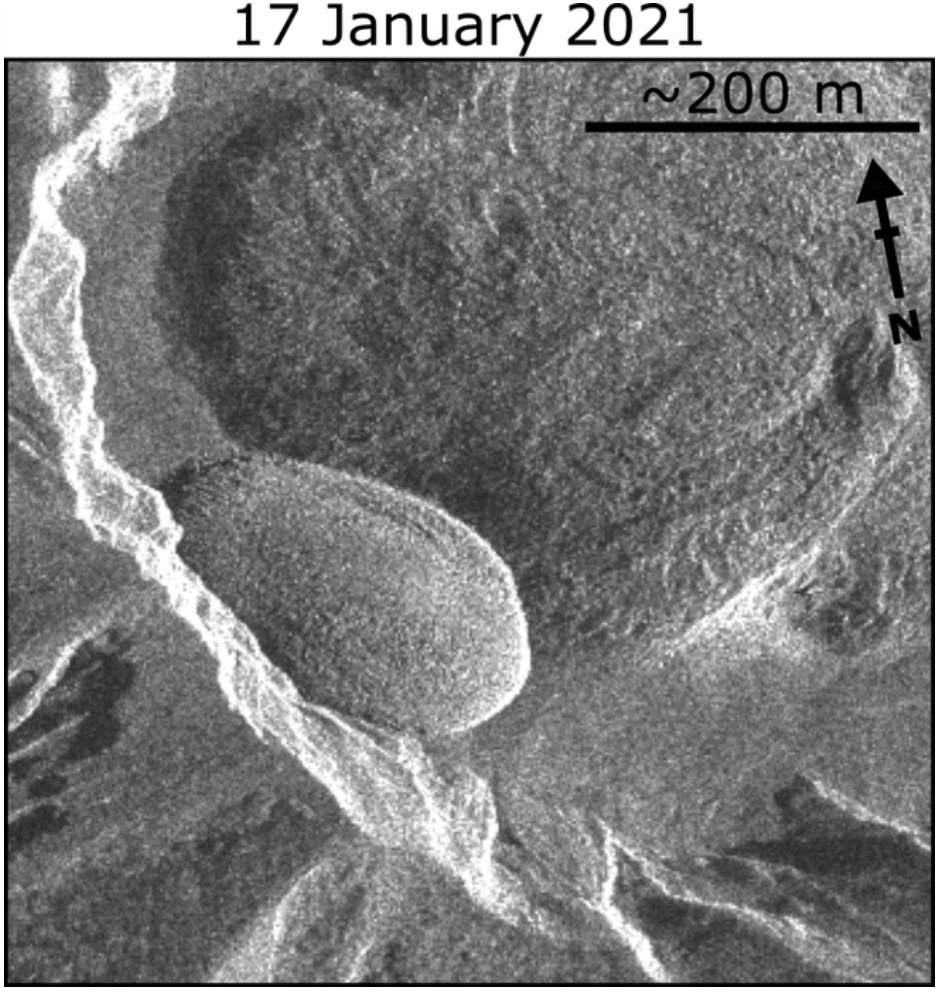
Pu'u Ō'ō, Kīlauea, Hawai'i

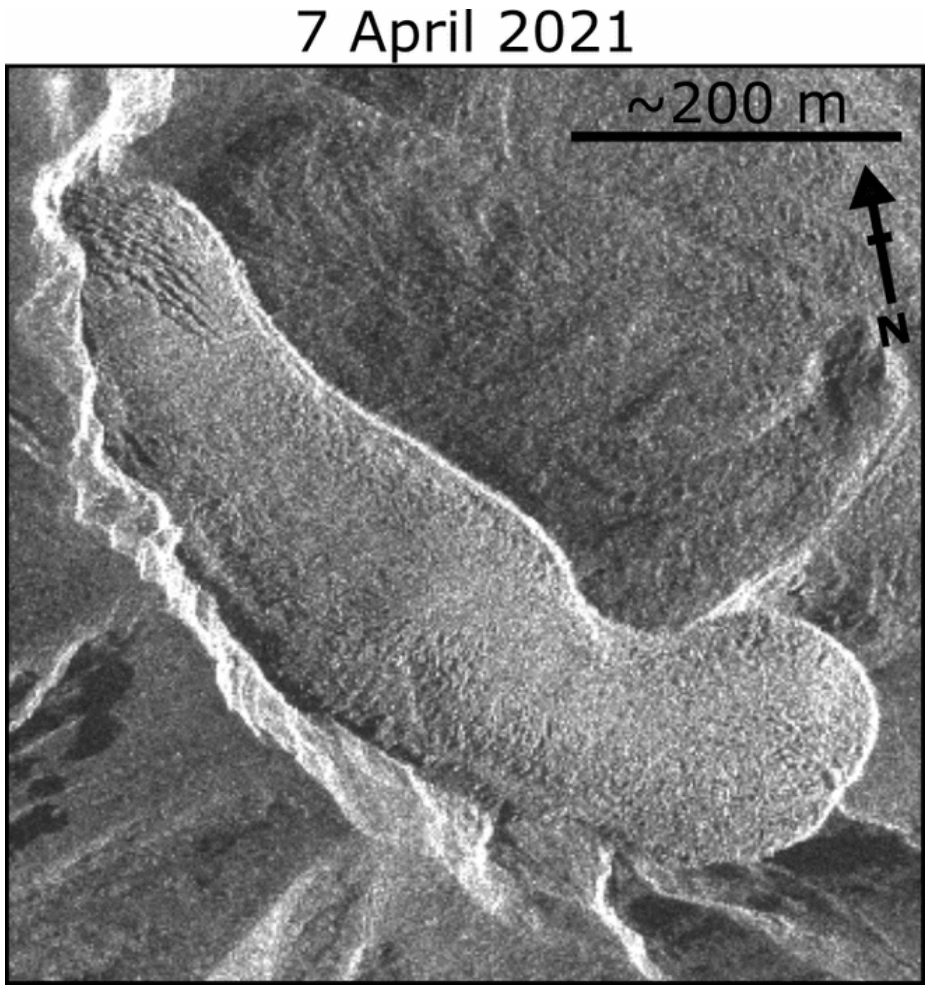
CEOS Demonstrator data

La Soufrière, St. Vincent

Edna Dualeh
University of Leeds

Research





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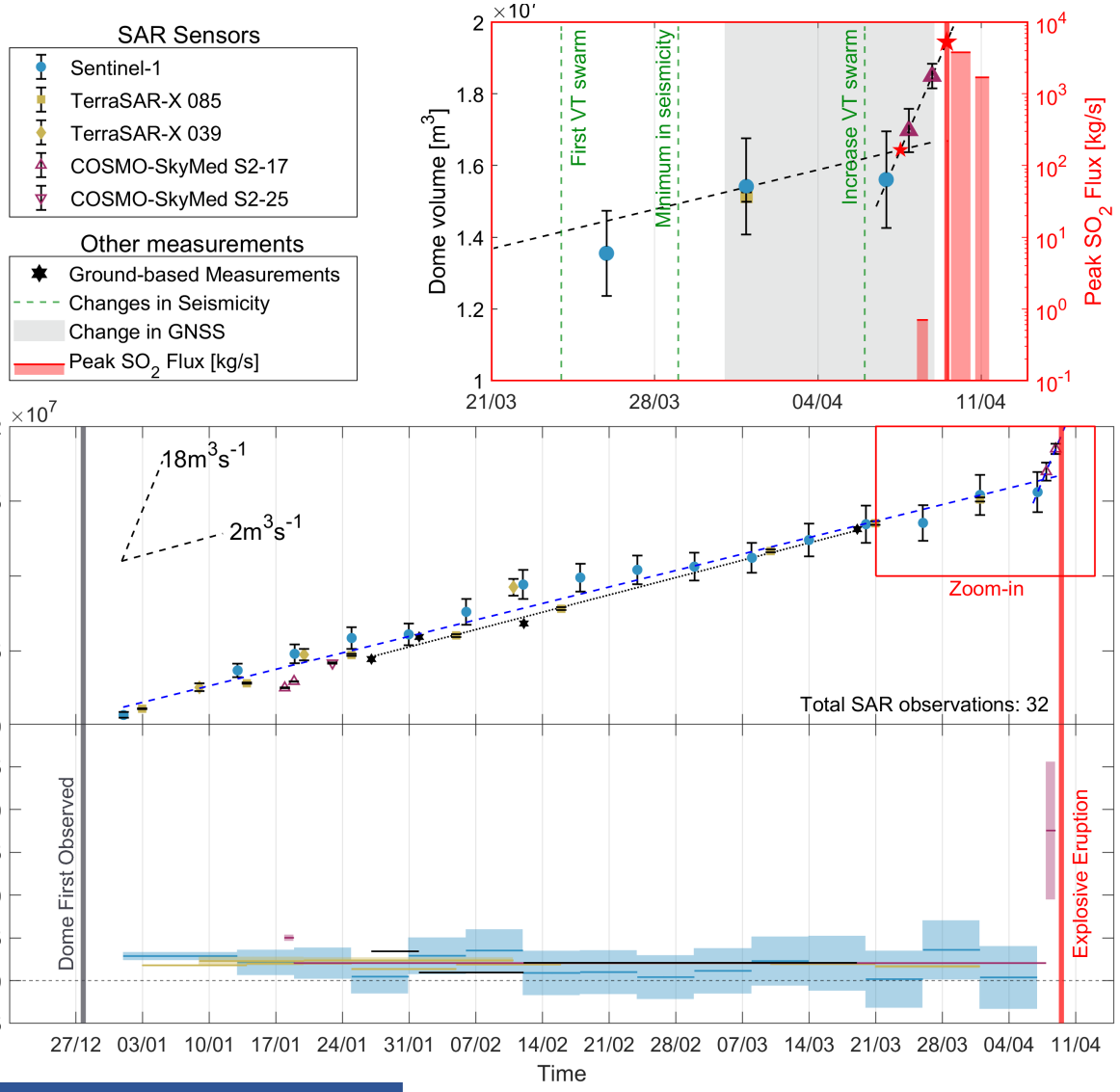

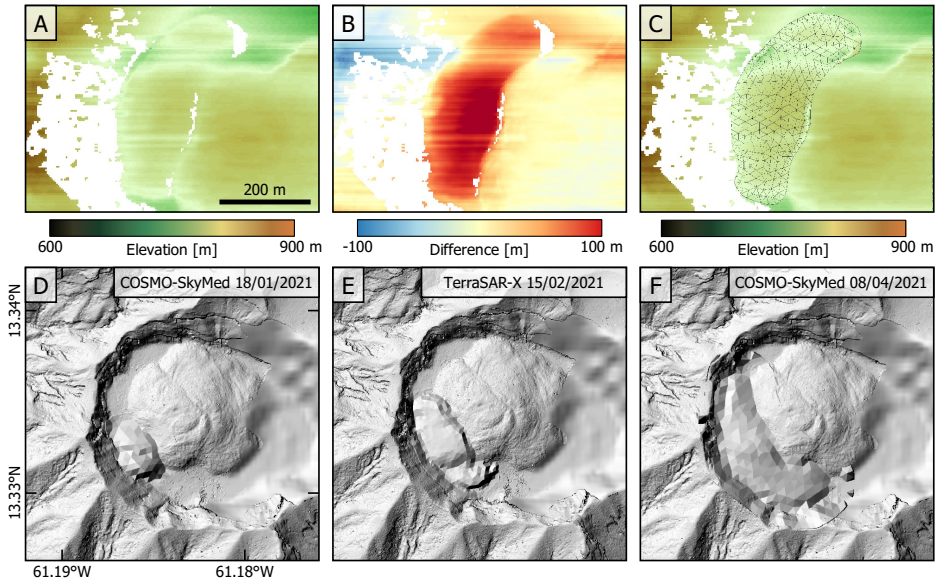

- Retrieval of volcanic topography and therefore effusion rate from SAR backscatter and pre-eruptive DEM.

- Effusion rate increased by an order of magnitude in the days before the transition from effusive to explosive eruption.

Edna Dualeh
University of Leeds

Research

Questions for the group:

- How can we work with space agencies to limit effort on their part?

- Latency is a priority for us – getting the imagery as soon as possible after a crisis starts is critical to its usefulness.

  - should we be limiting requests for rapid ftp delivery?

  - would it be helpful to have separate ‘active tasking’ vs ‘archive’ quotas

From initial sustainability discussions:

- **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)

Our priorities:

(1) strategy and capacity for long term monitoring and science acquisitions

(2) nimble tasking for response to unrest and eruption

(3) International coordination and cooperation

‘International Virtual Volcano Observatory’

- Global ‘live’ mode rapid tasking and data provision during volcanic crises

- Background **monitoring** in countries with less capacity

- Background tasking globally to ensure baseline datasets exist