Open-**Ve**nt Volcano **R**emote **S**ensing Monitoring
using **S**paceborne Imagery

VeRSUS

Studying and Monitoring Open-Vent Volcanoes from Space

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Royal Museum for Central Africa, Belgium

What is a lava lake?

= Basin + open conduit + shallow reservoir

Model of persistent lava lakes

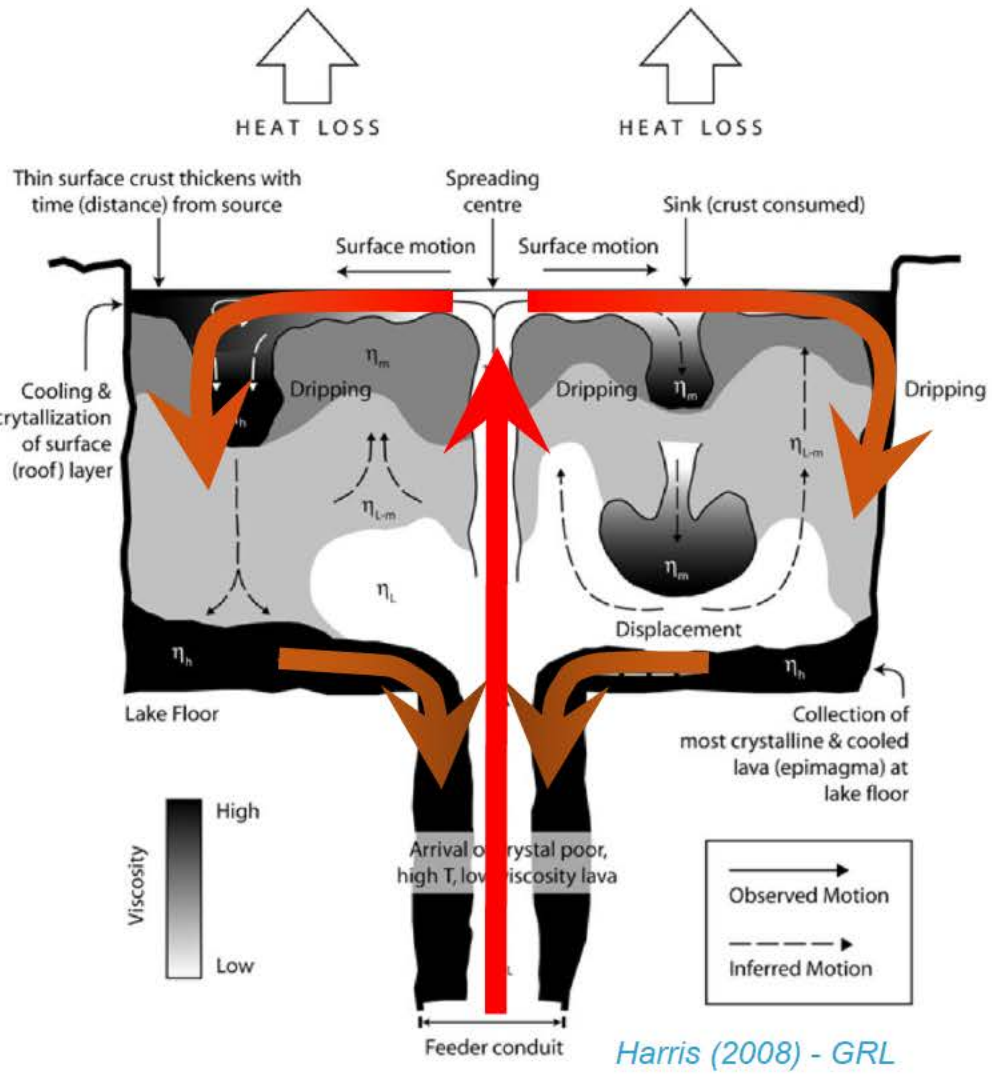
- Bi-directional flow of magma

Cyclic variations

- Gas piston effect
- Rising vs. sinking of magma

Sporadic and long term lava lake level changes

- Magmatic intrusions
- Flank eruptions
- Stress change
- …



Harris (2008) - GRL

The VeRSUS Project: Objectives

1.

Exploring and developing the **capability of new satellites sensors to provide complementary quantitative information** on the **dynamics** of persistent lava lakes

2.

Getting a **better understanding of the source mechanisms** of variations in the lava lake activity.

Satellites: Sentinel-1, -2, -3, 5P, COSMO-SkyMed, PlanetScope, Pléiades, …

3. The VeRSUS Project: Case studies

Kīlauea (Hawaii, USA)

- LL activity: 2008-2018
- Well monitored lava lake
- LL drained in May 2018
- Best for pre-eruptive lava lake activity

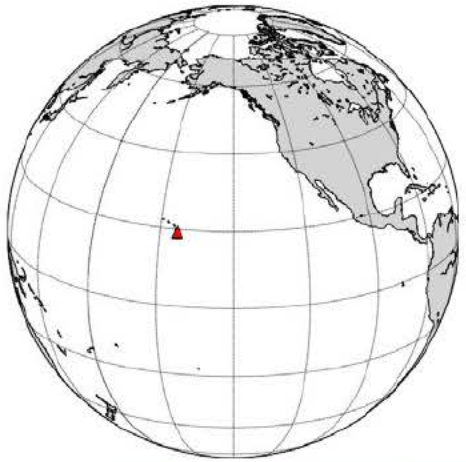


Photo © USGS

Nyiragongo-Nyamulagira (D.R.Congo)

- LL activity: 2002 – Present
- Modern monitoring developed recently
- Best for studying LL persistence and LL “birth”

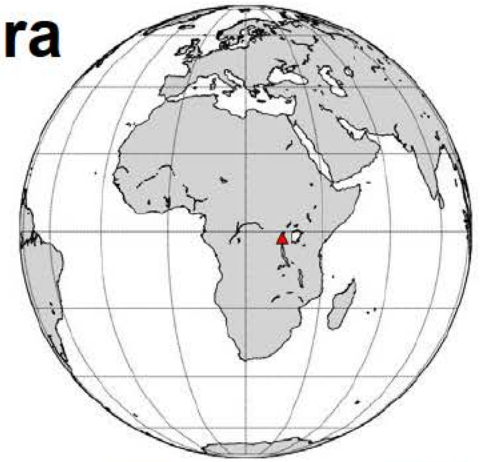
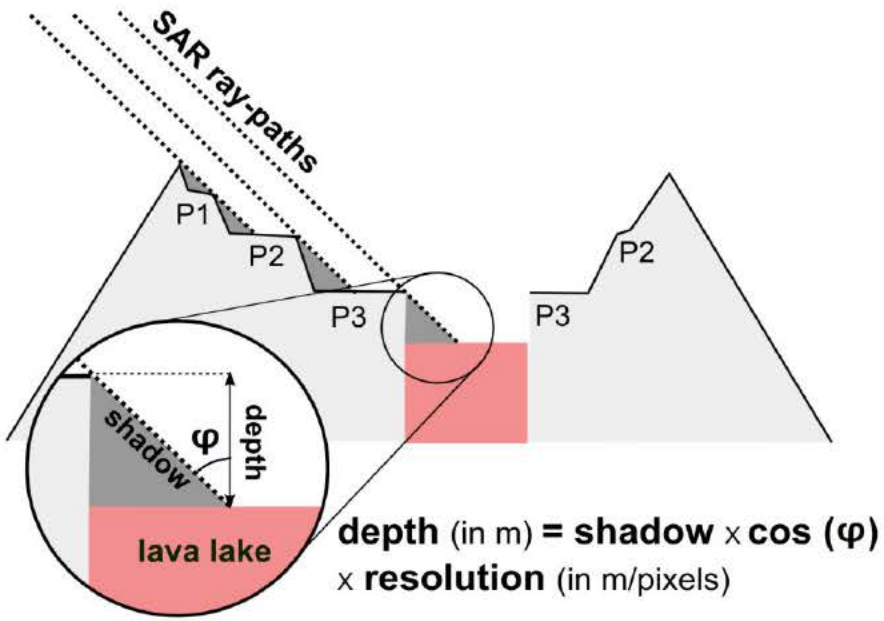
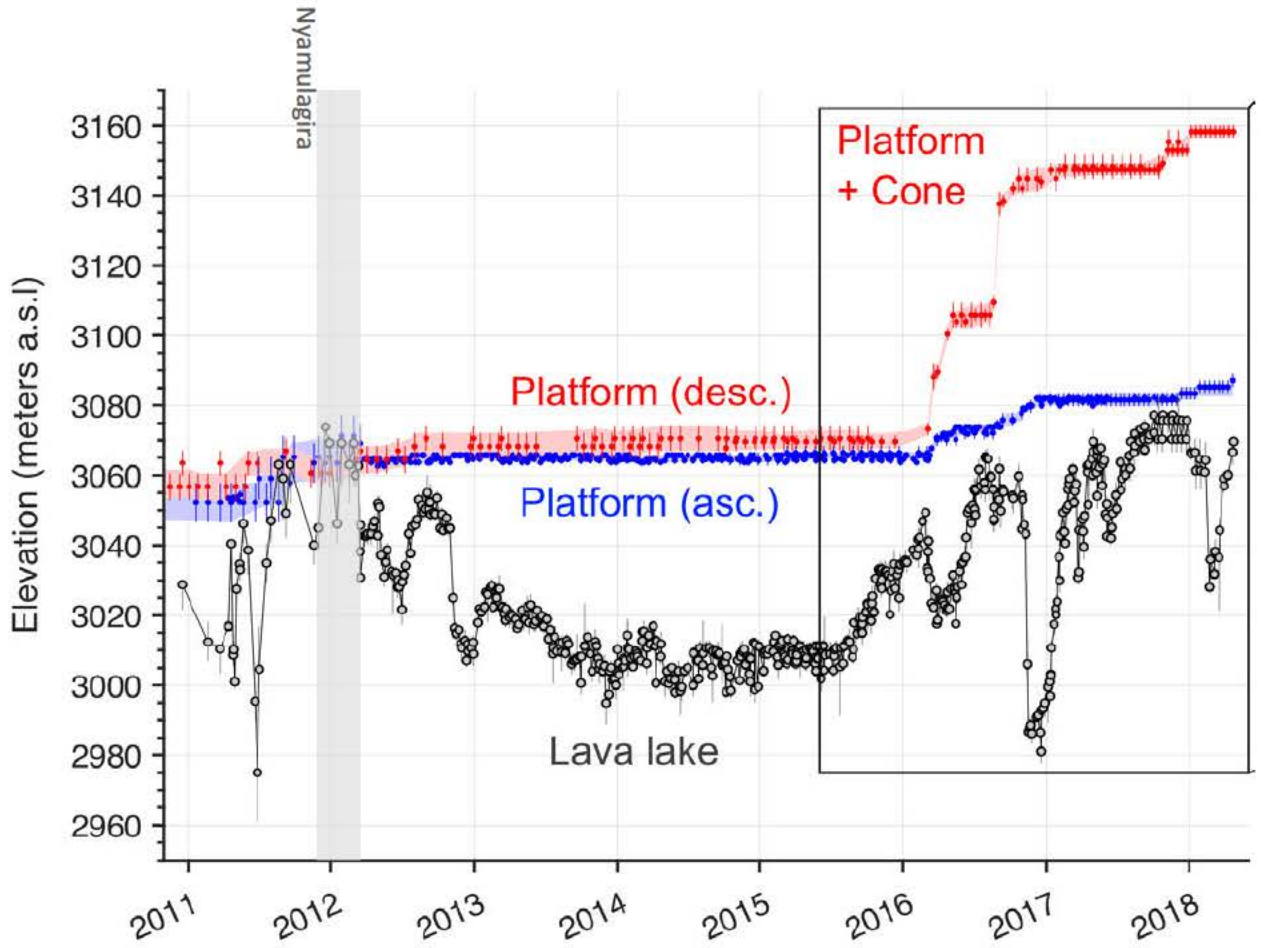


Photo © B. Smets

SAR Imagery – Lava lake level measurement (RESIST heritage)

SAR-shadow technique

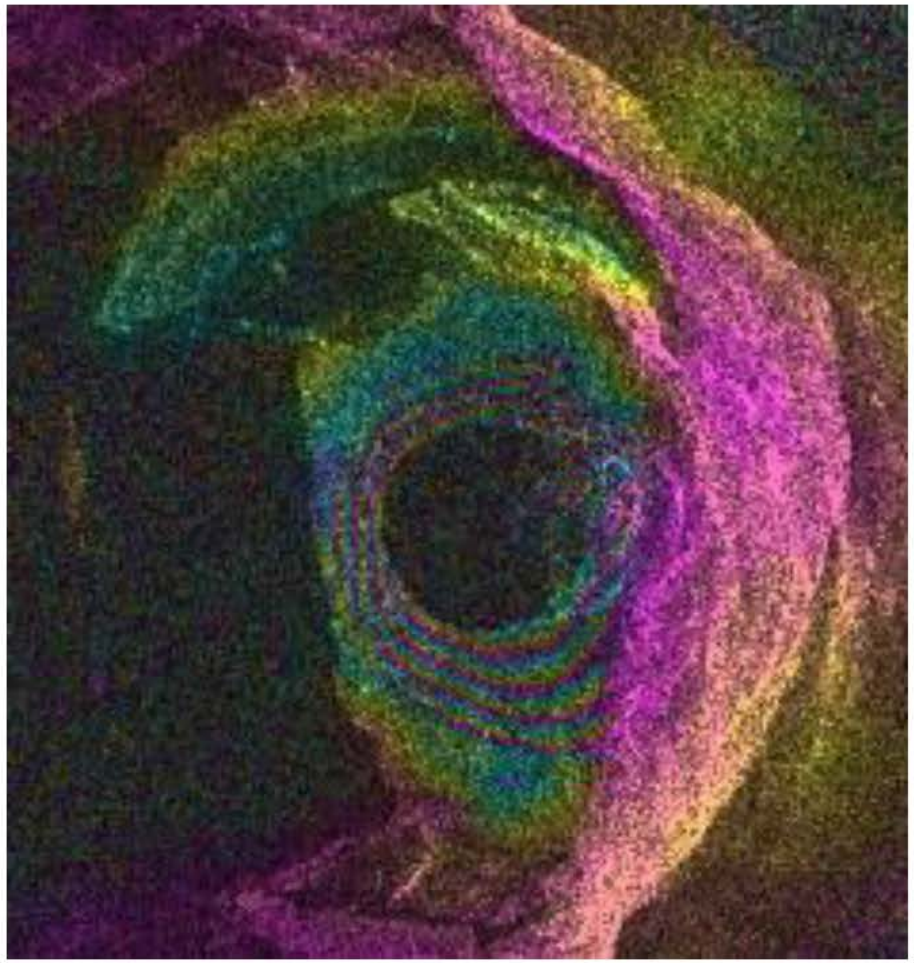




Courtesy of N. d'Oreye (ECGS)

SAR Imagery – Ground deformation (RESIST heritage)

InSAR and MSBAS time-series



Courtesy of N. d'Oreye (ECGS) and H. Geirsson (U. Iceland)

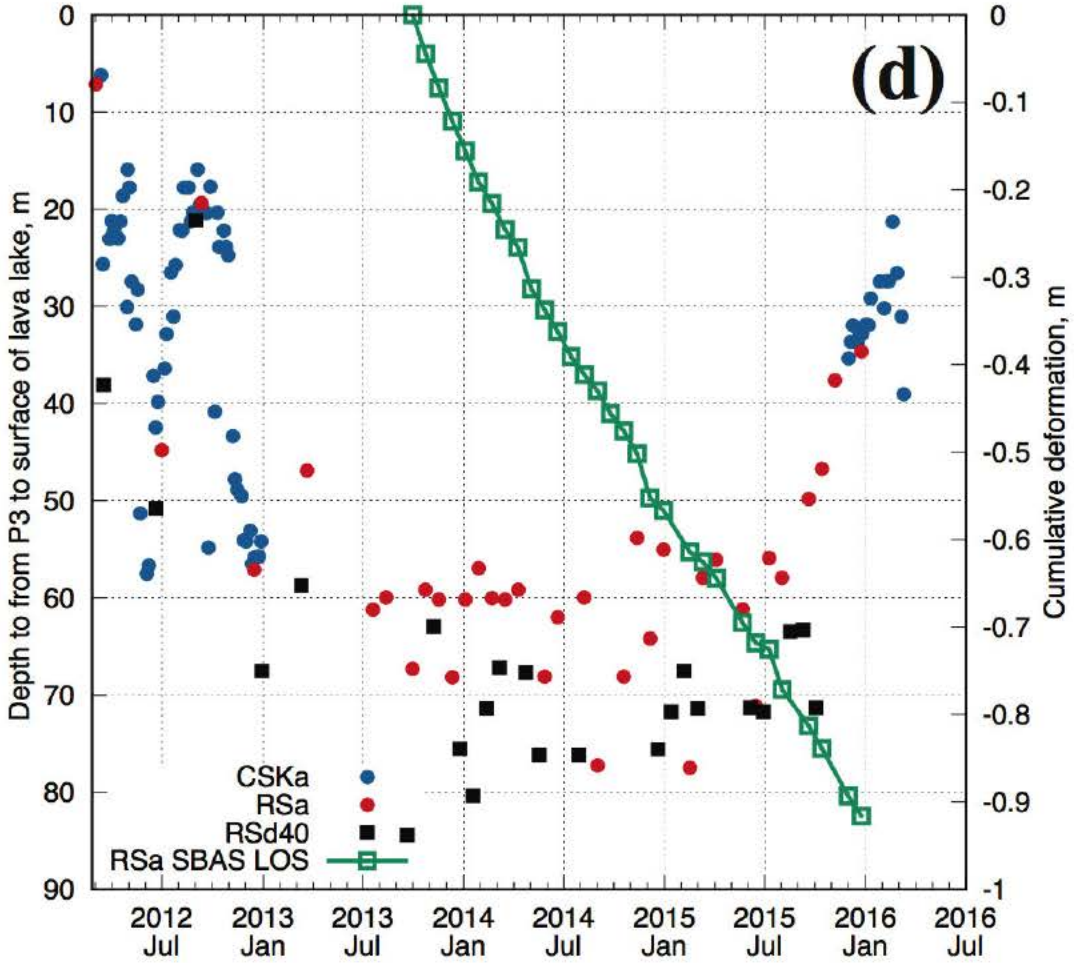
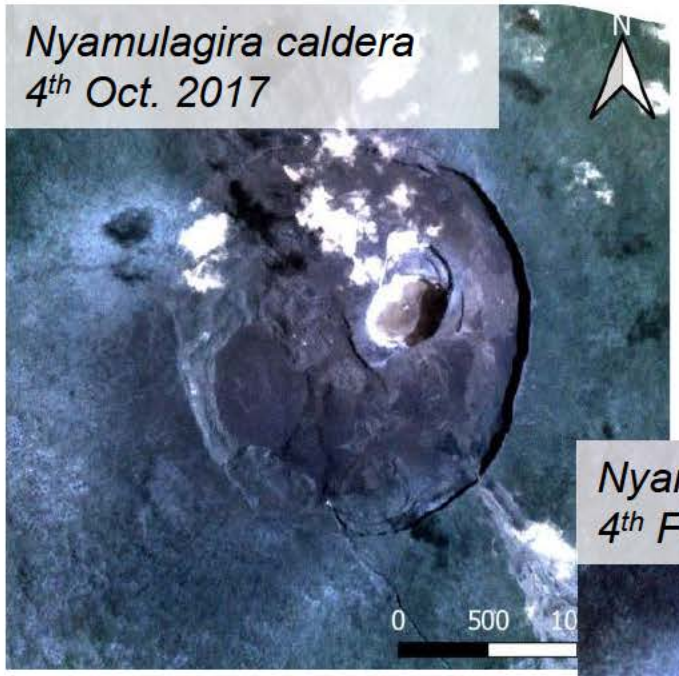
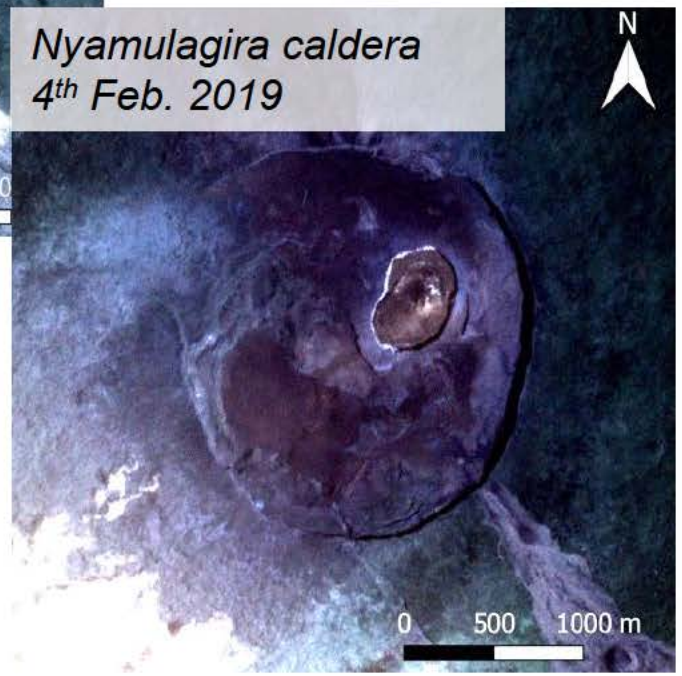


Photo-interpretation and mapping



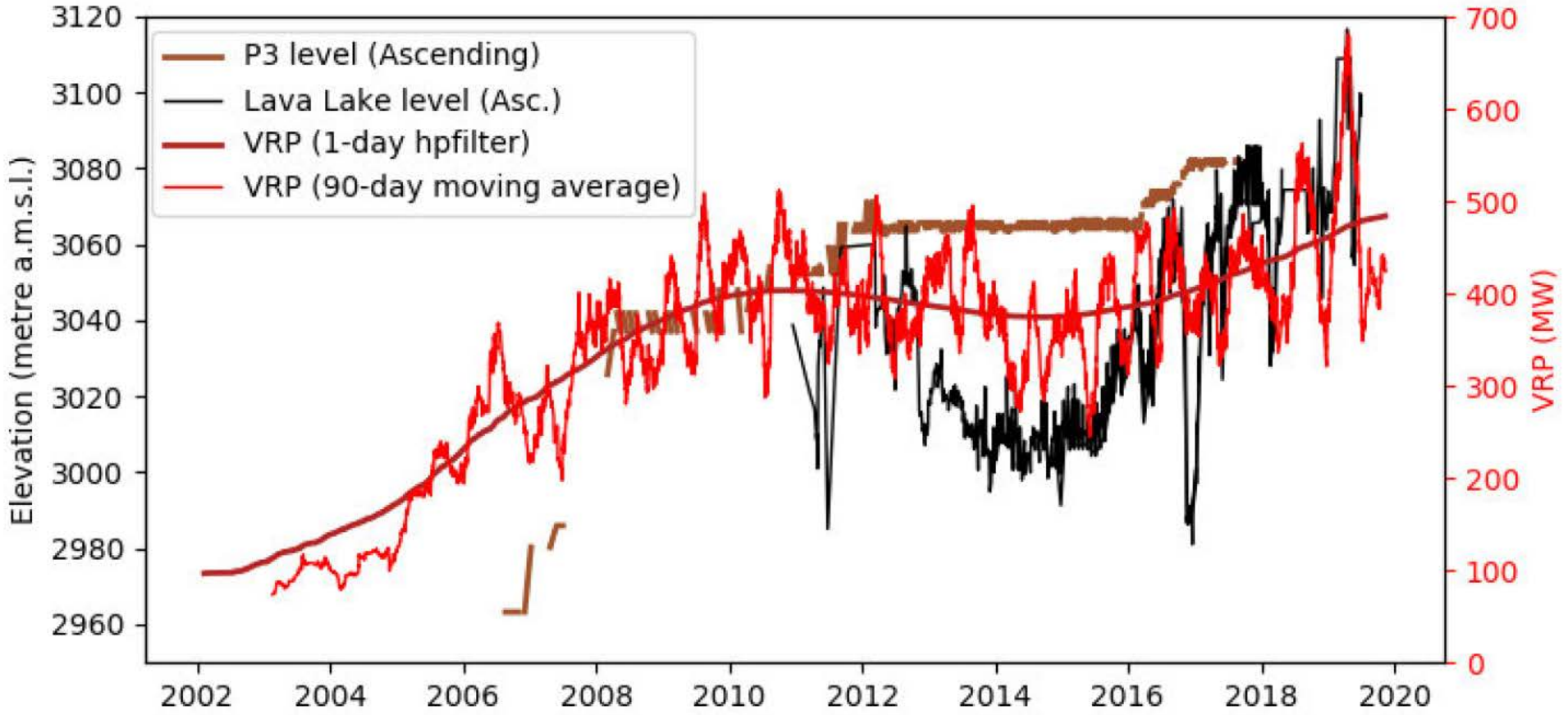


Volcano: Nyamulagira
Sat.: PlanetScope

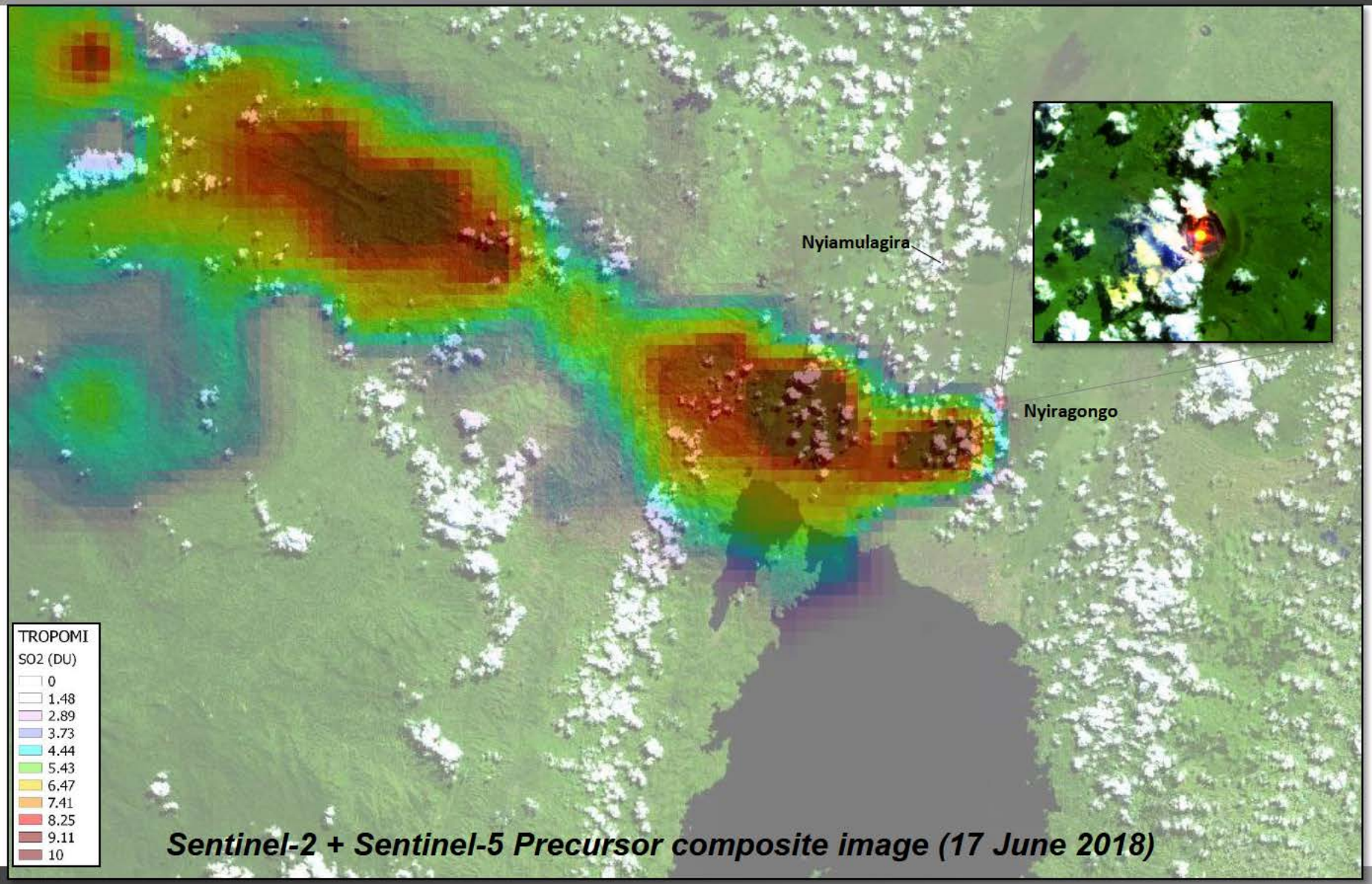
Volcano: Nyamulagira
Sat.: COSMO-SkyMed

2. Thermal Remote Sensing

Volcano: Nyiragongo
Sat.: Terra/Aqua MODIS



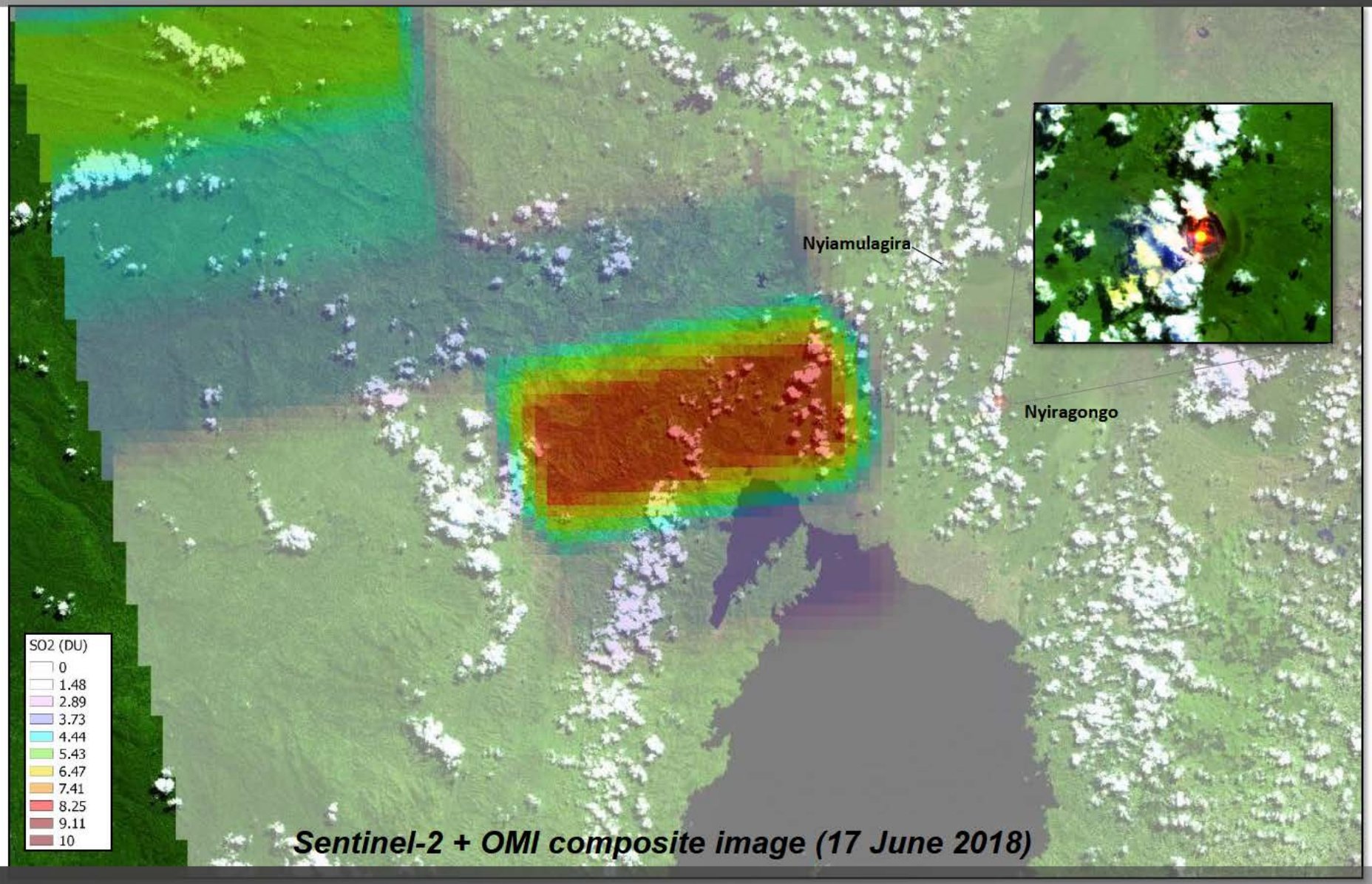
SO_2 Emissions – TROPOMI: improved detection limit



Sentinel-2 + Sentinel-5 Precursor composite image (17 June 2018)

Courtesy of N. Theys (BIRA)

SO_2 Emissions – TROPOMI: improved detection limit



Courtesy of N. Theys (BIRA)

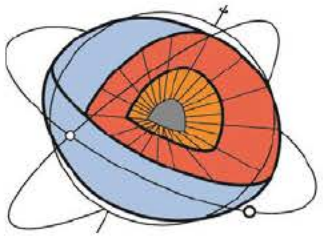
The VeRSUS Team

AFRICA museum

B. Smets, F. Kervyn
Optical/SAR Remote Sensing, UAV, Photogrammetry
Expertise on Virunga volcanoes

BIRA·IASB

N. Theys, H. Brenot
UV-Visible-IR Remote Sensing
Expertise on SO_2/BrO gas emissions



N. d'Oreye, J. Barrière, A. Oth
SAR Remote Sensing, Seismology, Geodesy
Expertise on Virunga volcanoes

USGS
science for a changing world

C. Kern
UV-Visible-IR Remote Sensing
Expertise on Hawaiian volcanoes

The VeRSUS Project: Expected outcome

Deliverable	*Due (Month, relative to the beginning of the operations of the project)*
WP0: **PROJECT COORDINATION**	
D0.1 – Minutes of meeting	After each meeting
D0.2 – Periodic reports	M5, M30, M36
D0.3 – Steering committee organization	M5, M30, M36
D0.4 – Field mission plan and report	M15
WP1: **VISIBLE-NIR AND RADAR OBSERVATIONS**	
D1.1 – Updated time-series of lava lake level measurements (SAR-shadow technique)	M30
D1.2 – Updated InSAR MSBAS time-series on Nyiragongo, Nyamulagira and Kīlauea	M30
D1.3 – Quantitative description of the eruptive activity using VNIR satellite imagery	M30
D1.4 – Ground-based measurements during a field expedition at Nyiragongo and Nyamulagira	M15
WP2: **THERMAL RADIATION**	
D2.1 – Time-series of volcanic heat fluxes from various satellites	M30
D2.2 – Ground-based TIR camera measurements of the lava lake activity	M15
WP3: **SO_2 EMISSIONS**	
D3.1 – Time-series of SO_2 fluxes from S5P TROPOMI	M30
D3.2 – Ground-based UV spectroscopy of volcanic plumes	M15
WP4: **INTERPRETATION OF MAGMATIC PROCESSES**	
D4.1 – Improved 2D Modelling of the lava lake dynamics and the related magmatic intrusions	M36
D4.2 – Key aspects to use lava lake observations as a volcano monitoring tool	M36

Expected output

- Quantitative monitoring of lava lakes using multidisciplinary RS
- New insights into lava lake dynamics
- Key knowledge and tools for further research and improved volcano monitoring

THANK YOU