National Aeronautics and Space Administration

FY23 Strategic University Research Partnership (SURP)

Satellite observations of volcano topography change: A critical but immature measurement for eruption forecast models

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Objectives (Year 2)

1. What surface deformation and topographic change happened during the 2016-2023 eruption of Nevados de Chillán?
2. Can we model the eruption dynamics using a physics-based model?

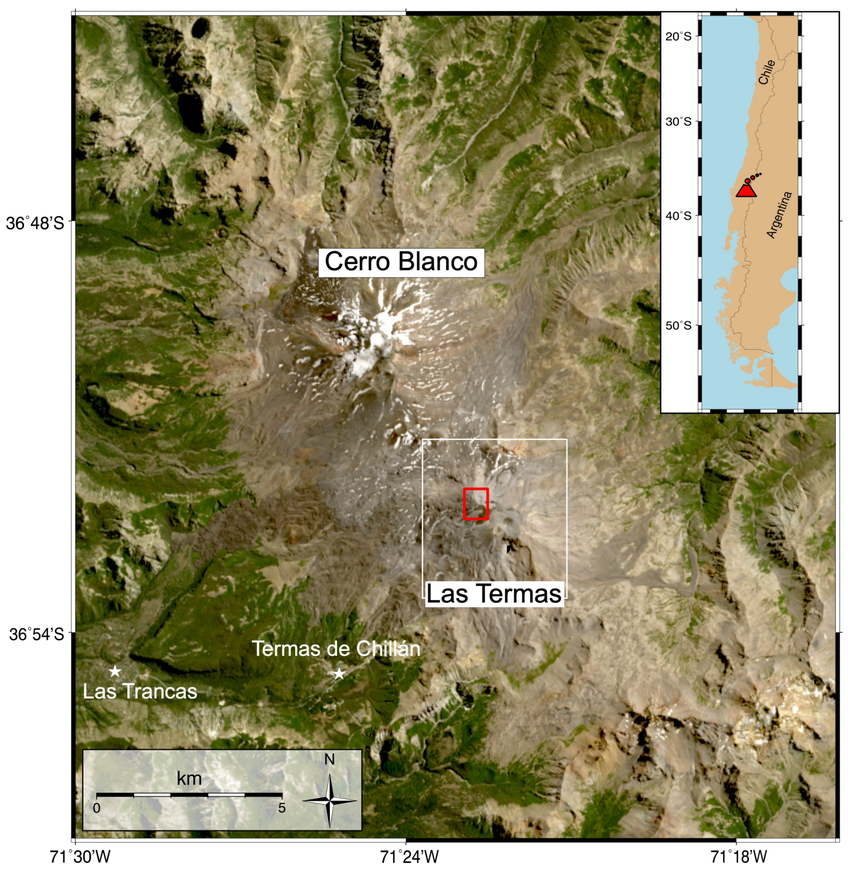


Figure 1. (above) Nevados de Chillán, Chile. The 2016-2023 eruption occurred in the Las Termas subcomplex, with the red box showing the region of interest in Fig. 4. White stars show nearby towns.

Background

- Topography and how topography changes over time are critical datasets for developing **physical models of volcanic eruptions** [1].
- **Nevados de Chillán** is one of the most active volcanoes in Chile (Fig. 1) [2]. The most recent eruption occurred from 2016-2023.
- Previous modeling work mostly focused on using geodetic data to invert for non-predictive kinematic models. Our work will combine topographic and geodetic data into a **time-dependent numerical model** that can forecast the duration and volume of eruption.

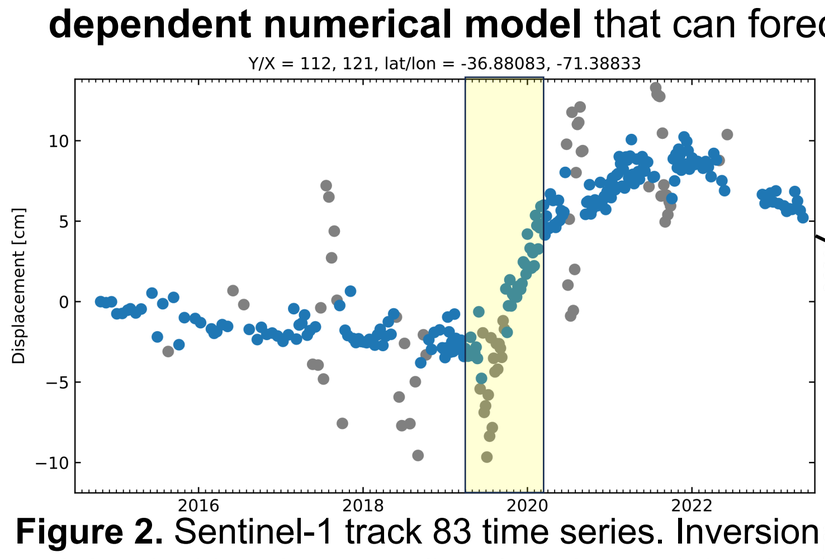


Figure 2. Sentinel-1 track 83 time series. Inversion weighted with coherence (blue) and unweighted (gray). Yellow box shows span of ifgram (Fig. 3).

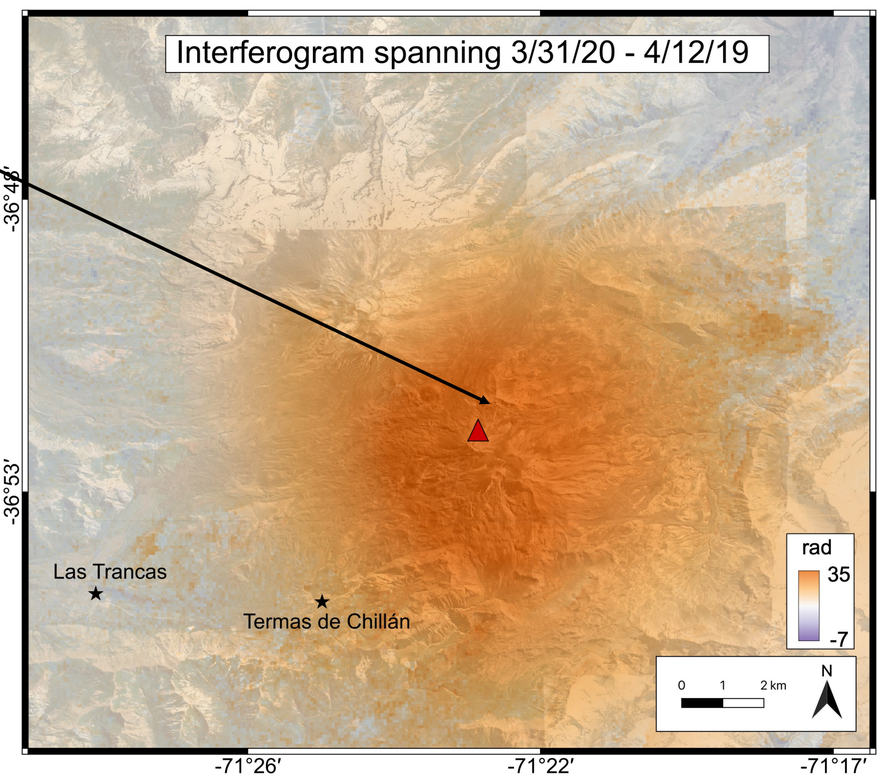
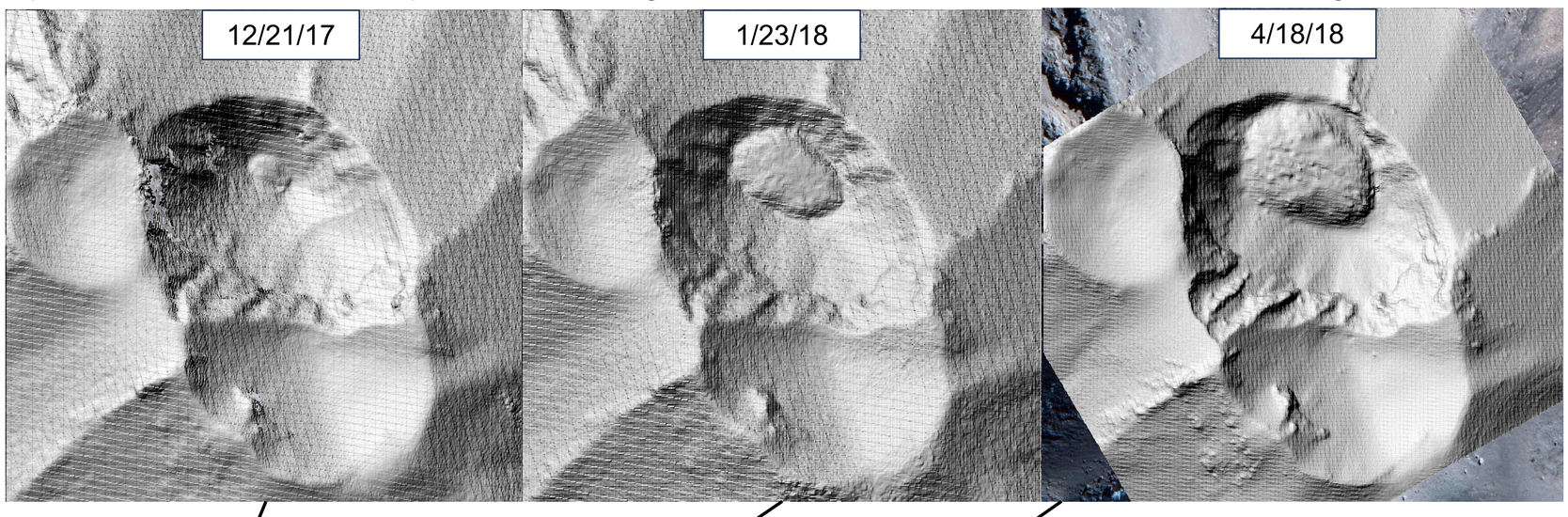


Figure 3. (above) Sentinel-1 descending track 83 unwrapped interferogram spanning 3/31/20-4/12/19 shows ~35 radians (~13 cm) of uplift. Arrow points to Fig. 2 time series location.

Figure 4. (below) Digital elevation models generated from helicopter overflights and Pléiades stereo-optical data over the initial period of dome growth. Area shown is outlined in red box in Fig. 1.



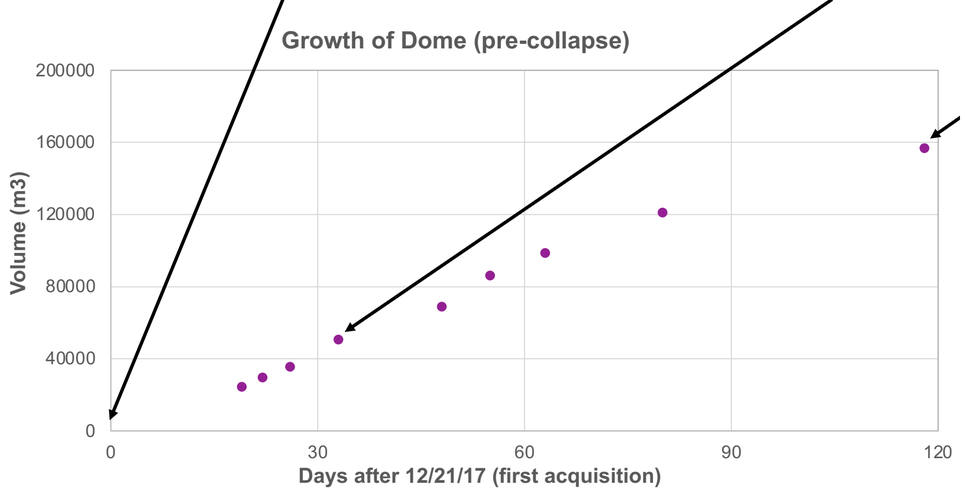


Figure 5. (left) Volume of the first dome that occurred during this eruption (active from December 2017 – early 2019, with collapses beginning in mid-2018). Data provided by Yves Moussallam and Talfan Barnie [4].

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Approach

1. Combine surface deformation time series from ARIA-generated Sentinel-1 interferograms (Figs. 2 and 3) and local GNSS stations [3].
2. Calculate volume erupted over the course of the eruption using Pléiades, TanDEM-X, Worldview, and helicopter overflights (Figs. 4 and 5) [4].
3. Integrate datasets into physics-based model of eruption.

Benefits to JPL and NASA

The deliverables from this project will be directly relevant for Surface Topography and Vegetation (STV) future mission proposals. The DEM and physics-based modeling capabilities developed in the second phase of the project will be implemented as part of the Advanced Rapid Imaging and Analysis project.

References: **[1]** Delgado, F., Kubanek, J., Anderson, K., et al. (2019). Physicochemical models of effusive rhyolitic eruptions constrained with InSAR and DEM data: A case study of the 2011-2012 Cordón Caulle eruption; **[2]** Moussallam, Y., Bani, P., Schipper, C. I., et al. (2018). Unrest at the Nevados de Chillán volcanic complex: a failed or yet to unfold magmatic eruption? *Volcanica*; **[3]** Cardona, C., Gil-Cruz, F., Franco-Marín, L., et al. (2021). Volcanic activity accompanying the emplacement of dacitic lava domes and effusion of lava flows at Nevados de Chillán Volcanic Complex – Chilean Andes (2012 to 2020). Journal of Volcanology and Geothermal Research; **[4]** Moussallam, Y., Barnie, T., Amigo, Á., et al. (2021). Monitoring and forecasting hazards from a slow growing lava dome using aerial imagery, tri-stereo Pleiades-1A/B imagery and PDC numerical simulation. Earth and Planetary Science Letters.

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Publications:

Elizabeth Eiden, Matt Pritchard, Paul Lundgren, "Spatial and Temporal Resolution Needs for Volcano Topographic Change Datasets based on Past Eruptions (1980-2019)," submitted to *Earth and Space Science*, 2023 (in review).

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