Towards joint modelling and inversion of surface displacements and microgravimetric temporal variations for the characterization of eruptive sources at the Piton de la Fournaise volcano

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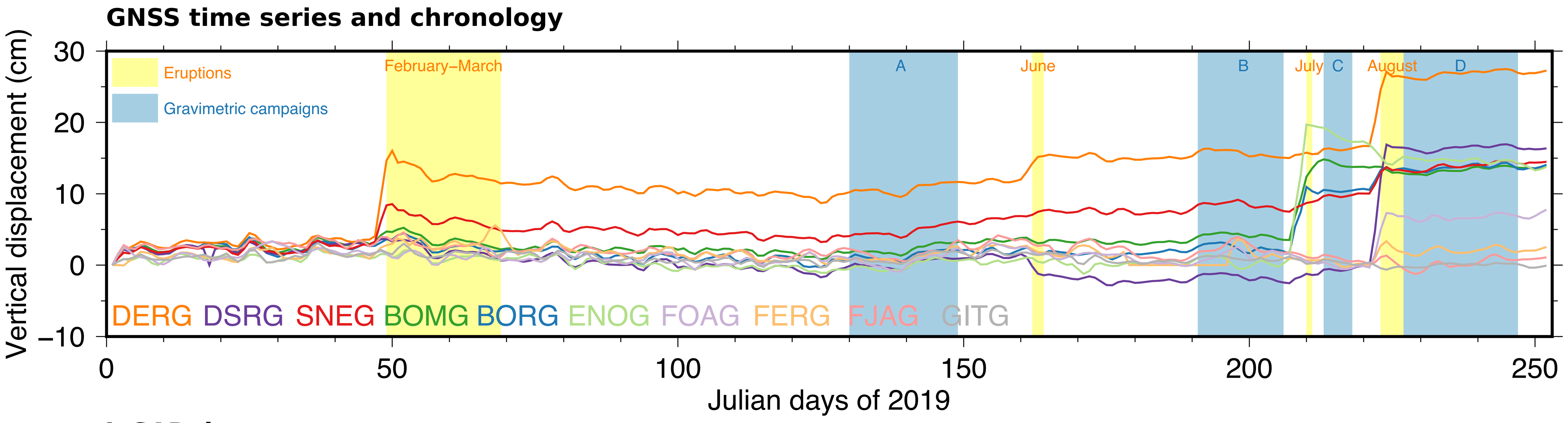
June 2019

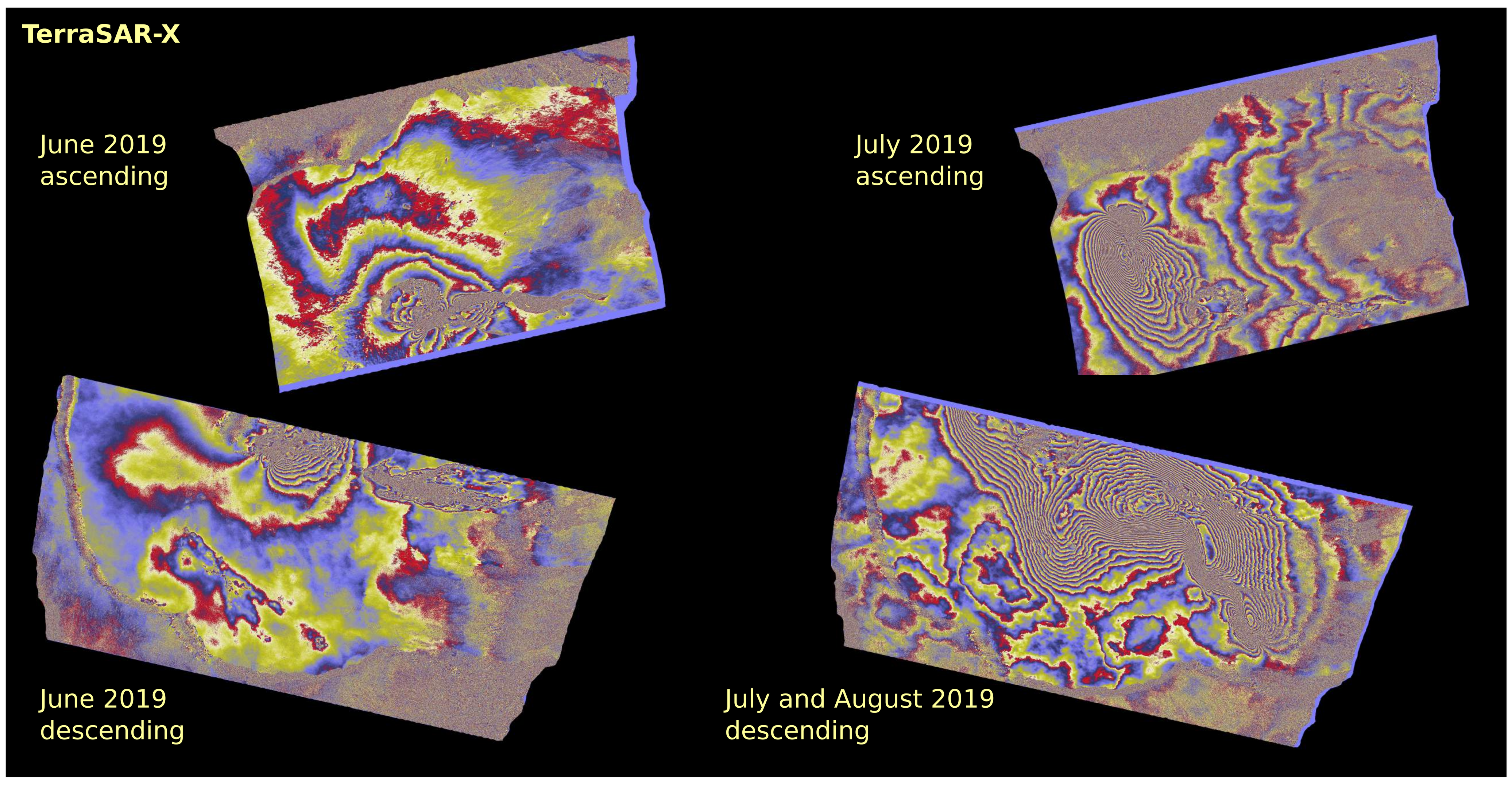
July 2019

August 2019

GNSS time series and chronology



InSAR data



Motivation and proposal

Surface displacements constrain the location, geometry and volume change of deformation sources while gravimetric variations bring information on **mass transfers** at depth (Carbone et al. 2017), shedding light on the nature and dynamics of the **fluids** involved (magma, hydrothermal fluids, gas).

So far analyses of temporal variations of gravity and displacements have relied on analytical solutions for a homogeneous flat Earth (Battaglia et al. 2008). However, numerical models show that neglecting the topography or the structural heterogeneities can lead to erroneous interpretations (Charco et al. 2007, Currenti et al. 2007).

We aim at developing tools to **jointly** model and invert surface displacements (InSAR/GNSS) and gravimetric temporal variations to characterize eruptive sources at the Piton de la Fournaise volcano. Our modelling method is based on **finite elements** to take into account the topography and the heterogeneities. It uses a **fictitious domain** formulation to model the source induced deformation at a reduced computational cost (Bodart et al. 2016). The joint inversion will be developed using a **Bayesian formalism** to provide an estimation of uncertainties on the source parameters (Tarantola 2005).

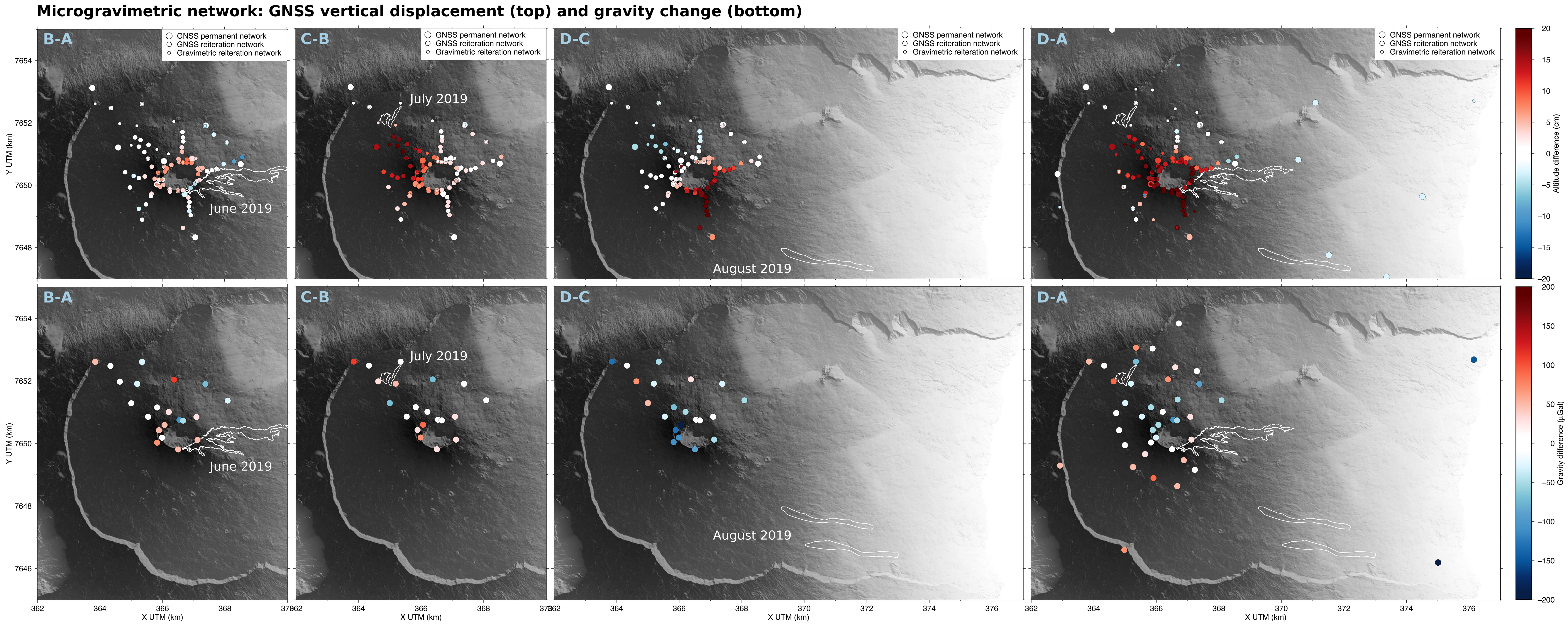
New data for the Piton de la Fournaise volcano

The Piton de la Fournaise volcano erupts several times a year. It is one of the best monitored volcanoes on Earth, making it a perfect target to develop the method. This poster presents the InSAR, GNSS and gravimetric data acquired for the three small consecutive eruptions of June, July and August 2019.

The volcano observatory (OVPF/IPGP) operates a permanent continuous **GNSS** network and a campaign GNSS network remeasured after each eruption. The OI² national service (OPGC) provides **InSAR** displacements. Microgravimetric surveys are not performed routinely at the Piton de la Fournaise volcano. A microgravimetric repetition network was maintained between 1992 and 1998 (Bonvalot et al. 2008). In 2019, we established a **new microgravimetric network** with Scintrex CG5 and CG6 relative meters (Gmob-RESIF). The network was entirely measured in May and August (campaigns A and D), encompassing the eruptions of June, July and August. Half of the network was measured inbetween each of the three eruptions (campaigns B and C).

While **surface displacements** are mostly sensitive to the **dike** propagation, the observed **gravimetric variations** seem to be mostly caused by the processes ongoing in the **reservoirs** at depth. Indeed, significant variations are observed around the summit craters, in particular above the superficial magma chamber:
- a rise in gravity is observed for the June and July eruptions (B-A and C-B), indicating a refill of the superficial magmatic chamber;
- a drop in gravity is observed after the August eruption (D-C), indicating that the superficial magmatic chamber might have been emptied.
Besides, over the whole period, significant variations are observed around the Enclos Fouqué (D-A). These variations might be due to deeper processes.

Microgravimetric network: GNSS vertical displacement (top) and gravity change (bottom)



Acknowledgements

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