EGU General Assembly 2022 GMPV9.4

The Deformation Style of Somma-Vesuvius

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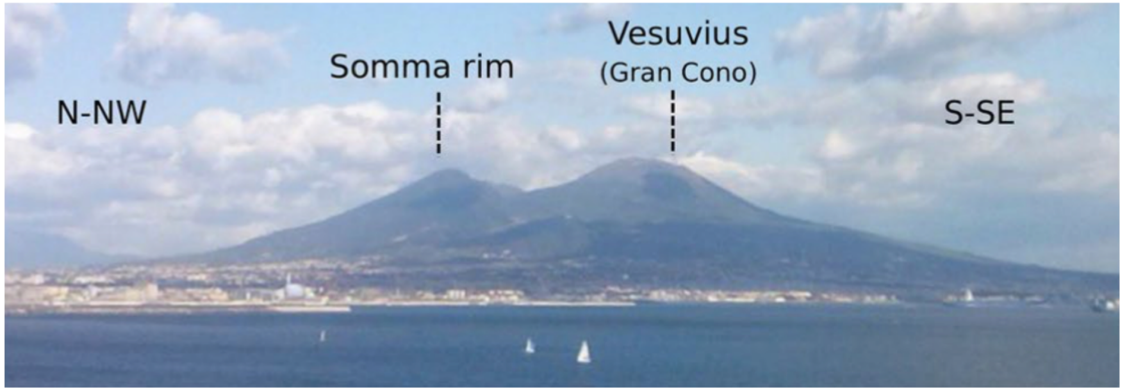
THE SUBJECT

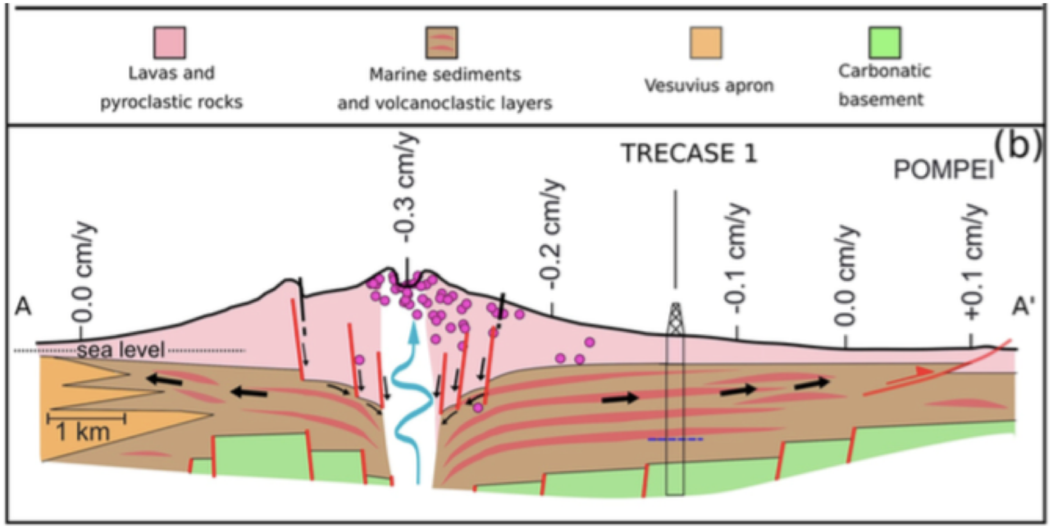
Volcanic edifices of sufficient mass are capable of deforming substrata under their own weight. Identifying the deformation style characterizing a volcanic edifice is useful when considering the evolution of its volcanic activity.

The Somma-Vesuvius volcano is one of the most dangerous on the Earth due to its proximity to the city of Napoli (Southern Italy). Thus, understanding its deformation style and corresponding structural evolution are critical aspects for risk reduction.

MODELING

The volcanic edifice has a typical asymmetric shape: the truncated cone of Mt. Somma topped by the Vesuvius "Gran Cono". Somma-Vesuvius last erupted in 1944 and is currently quiescent, experiencing fumarolic activity, low-energy seismicity and slow ground deformation (subsidence of the edifice itself and uplift in the surrounding area).





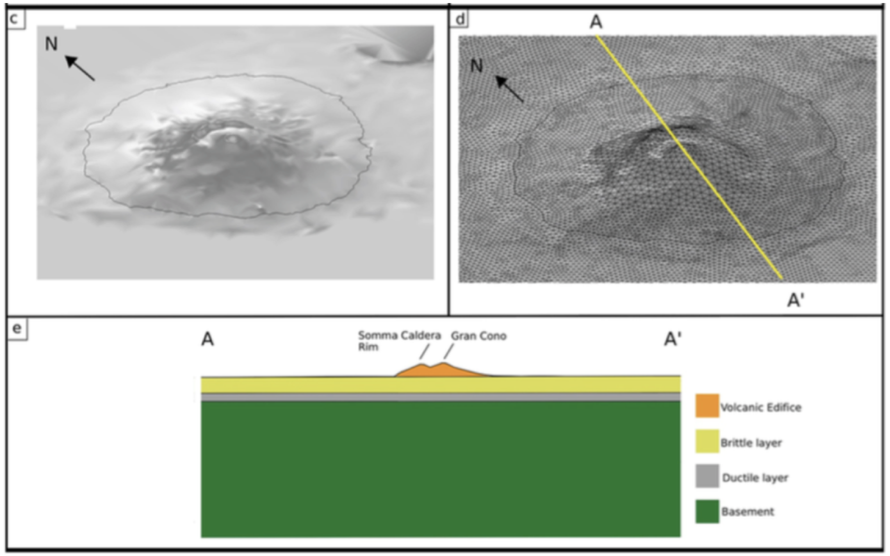
Schematic cross-section of the Somma-Vesuvius. The numbers along the profile indicate the vertical ground deformation rate. (From: De Matteo et al., 2022, mod.)

MODELING

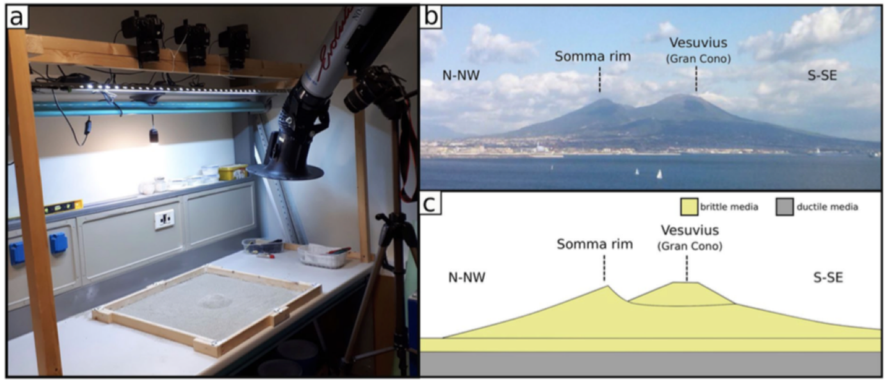
We performed an integrated numerical-analogue modeling aimed at refining the current state of deformation of the Somma-Vesuvius volcano.

Numerical models were built using a Finite Element (FE) method, implemented with a three-dimensional time-dependent fluid-dynamic approach, representative of both 1:100,000 and 1:1 scales.

Analogue models were built at a scale of 1:100,000, using sand mixtures as brittle medium and polydimethylsiloxane as a ductile one.



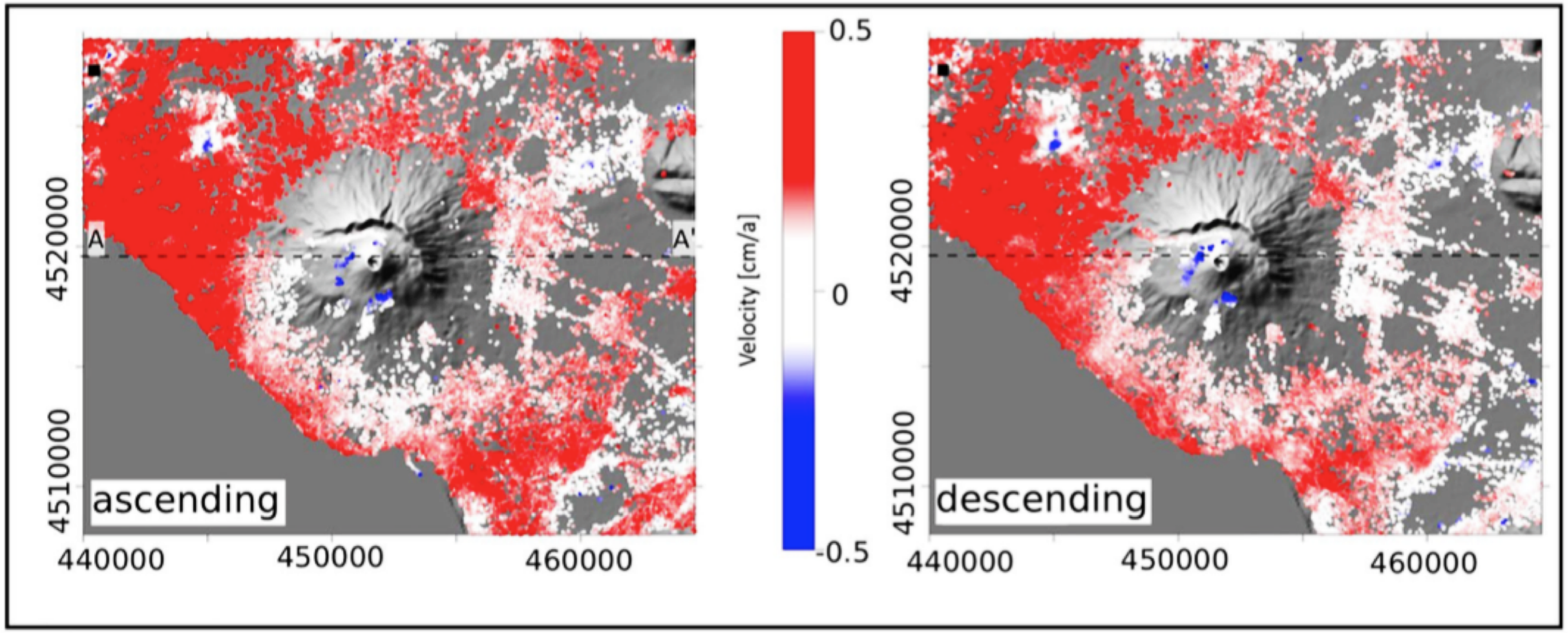
Numerical models setup: (c) 3D geometry and (d) mesh of the tetrahedral elements used for the finite element model related to the real Somma-Vesuvius. (e) Sketch of the geometry used to represent the real Somma- Vesuvius in the FE simulations, taken along with AA’ (From: De Matteo et al., 2022, mod.).



Experimental setup of the analog model, (b) profile of the Somma-Vesuvius edifice (for scale, the summit is 1,281 m above sea level), and (c) a sketch of the geometry used to represent the edifice in the experiments.

COMPARISON WITH ACTUAL DEFORMATION

A comparison with the actual Somma-Vesuvius deformation velocity patterns, obtained by differential interferometric synthetic aperture radar (DInSAR) and GPS measurements, allowed the selection of a pair of analog/numerical models that faithfully reproduced the field and remote sensing observations.



Line of sight (LOS) projection components (ascending and descending) of the mean deformation velocity observed at Somma-Vesuvius from 1993 to 2010 (achieved by DInSAR-SBAS processing. (From: De Matteo et al., 2022, mod.).

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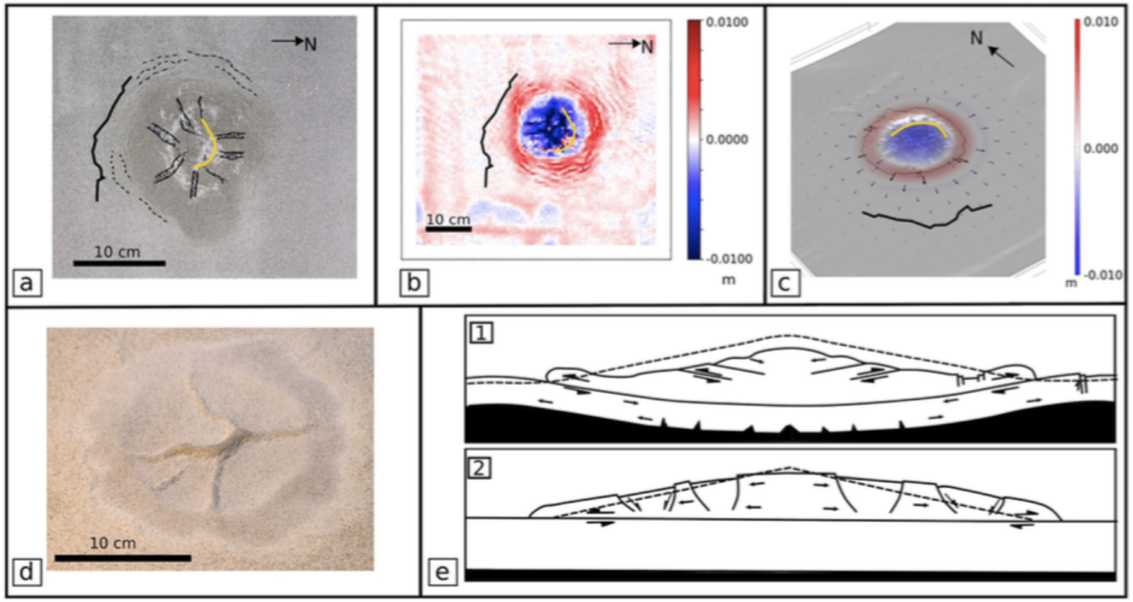
MAIN RESULTS

The modeling procedure adds new constrains supporting **a combined gravitational spreading-sagging process** governing the deformation of the Somma-Vesuvius volcano.

The recognized deformation processes support the presence of a tensional regime. This has the potential implication of **reducing the loading stress on the magmatic reservoir system** and, consequently, of **decreasing the Volcanic Explosive Index** of eruptive events.

The refined knowledge of the actual deformation process affecting Somma-Vesuvius should be a key contribution to a **reliable volcanic surveillance system**.



a)Top view of the best model of the Somma-Vesuvius, peripheral flexural bulge (dashed lines), radial faults, and graben are highlighted. Black line, coastline; yellow lines, Somma caldera rim. b,c) Vertical deformations (b, analog; c, FE), black arrows are the horizontal displacement. d) Top view of the ductile layer of model at the end of the experiment. (e) Schematic diagrams of the **hybrid sagging-spreading architecture (1)** and endmember spreading architecture (2) (From: De Matteo et al., 2022, mod.).

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RESEARCH ARTICLE

10.1029/2021JB022338

Key Points:

- Analog and numerical modeling highlighted an active spreading-sagging process at the Somma-Vesuvius volcano
- A comparison of models with differential interferometric synthetic aperture radar (DInSAR) deformation data validated the modeling procedures
- The spreading process affecting the Vesuvius volcano allowed inferring about the near-future eruption style

An Integrated Modeling Approach for Analyzing the Deformation Style of Active Volcanoes: Somma-Vesuvius Case Study

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De Matteo, A., Massa, B., Castaldo, R., D'Auria, L., James, M. R., Lane, S. J., et al. (2022). An integrated modeling approach for analyzing the deformation style of active volcanoes: Somma-Vesuvius case study. *Journal of Geophysical Research: Solid Earth*, *127*, e2021JB022338. https://doi. org/10.1029/2021JB022338

Thank you for your attention!

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