MONITORING SEISMIC VELOCITY CHANGES AT CAMPI FLEGREI (NAPLES) USING SEISMIC NOISE INTERFEROMETRY - DO WE SEE PRECURSORS OF THE FUTURE VOLCANIC ACTIVITY?

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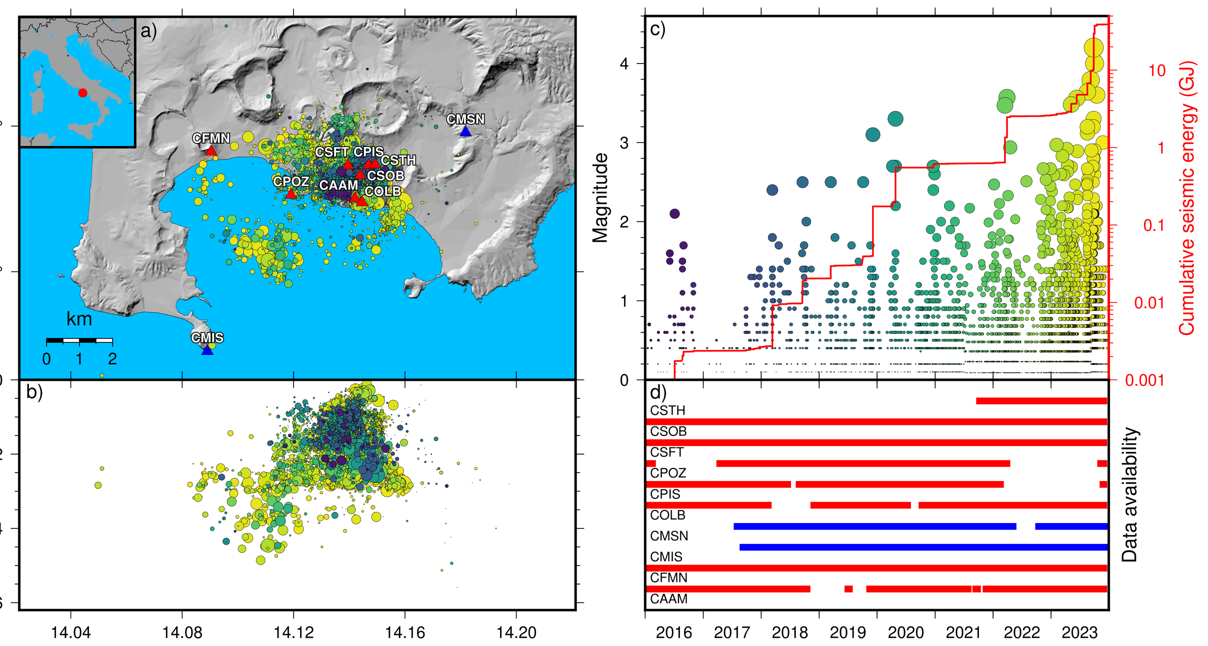
MOTIVATION

- The Campi Flegrei is a volcanic field located west of Naples (Italy), experiencing uplift since 2005 due to a shallow magma intrusion.
- The uplift is accompanied by increasing seismic activity. In September 2023, the strongest earthquake in the last 40 years was recorded with a magnitude of 4.2.
- This has raised concerns that Campi Flegrei may be on the verge of an eruption. We have taken this as an opportunity to analyze the velocity changes, as several studies have observed a decrease in velocity before an eruption.
- Ten broadband seismometers from the Italian National Seismic Network (INGV, 2005) are used to analyze velocity changes at different depth levels.

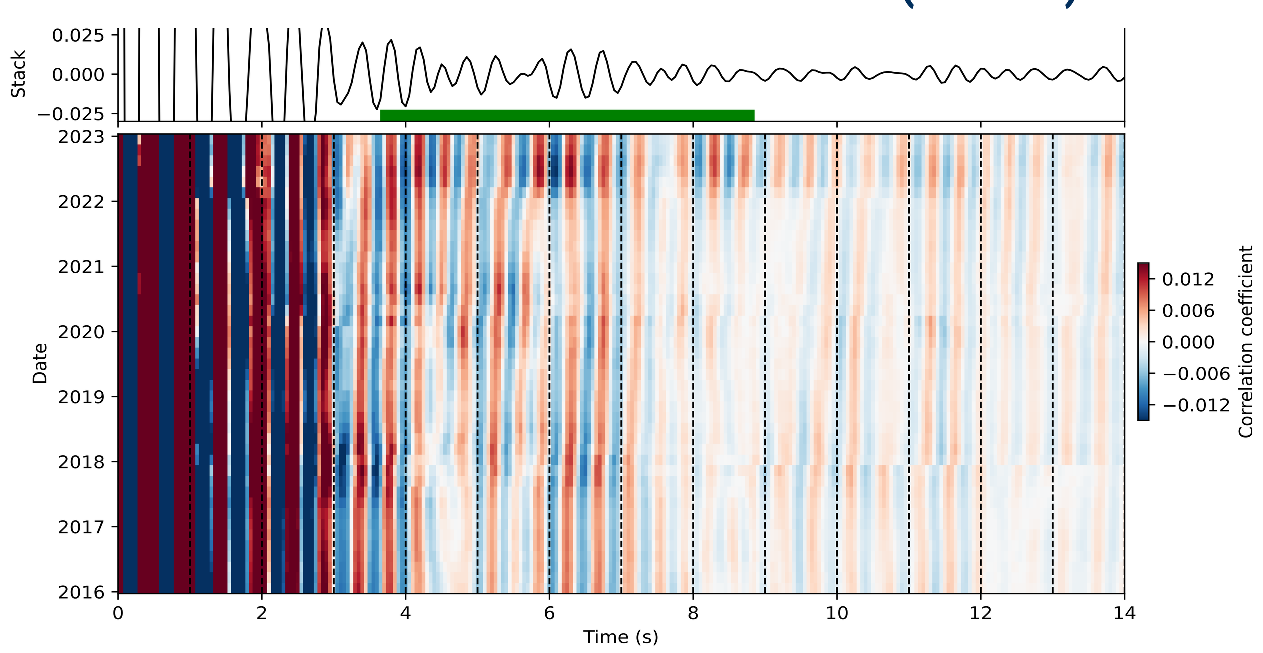
Map view of Campi Flegrei



METHOD

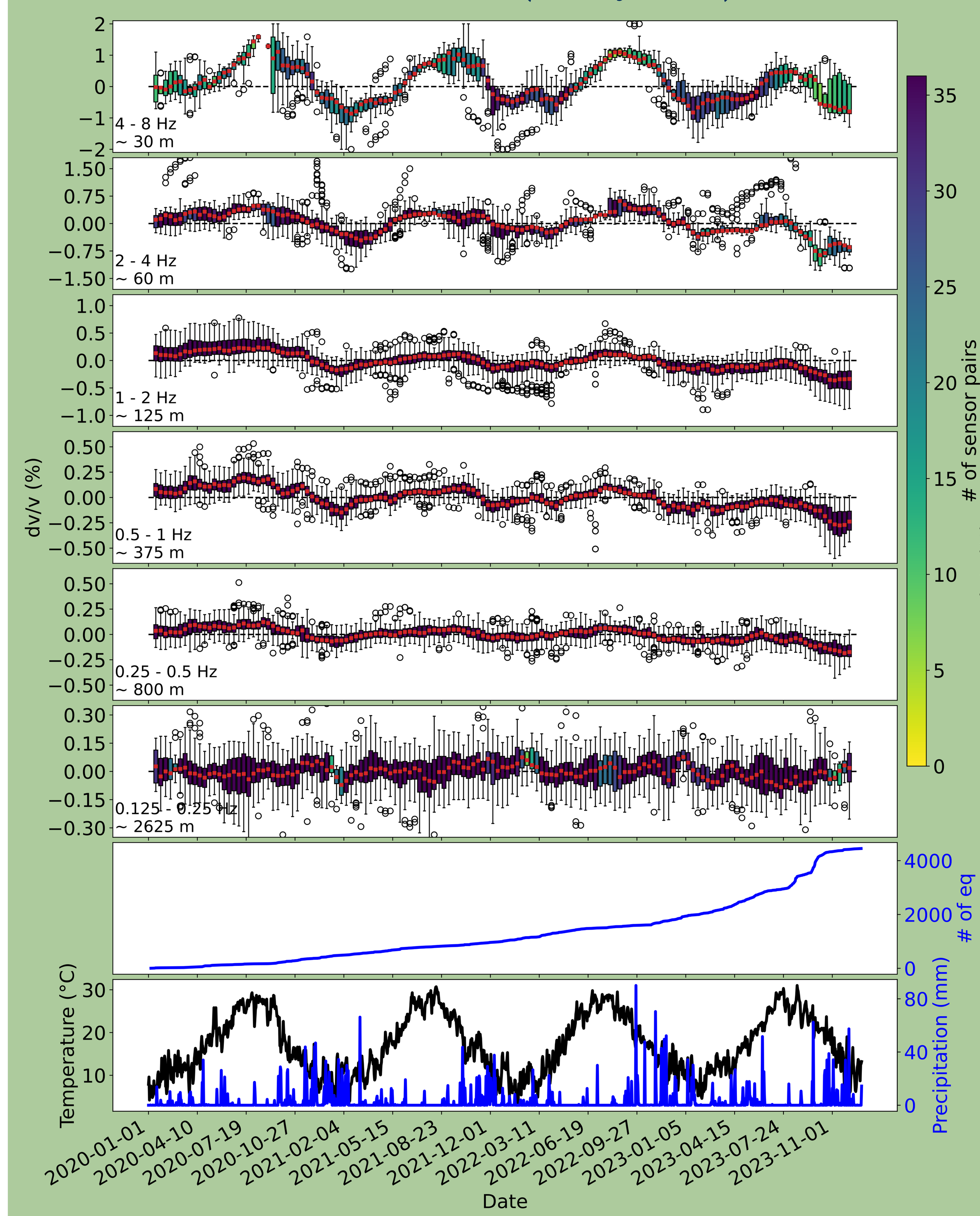
- We use YAM (Eulenfeld, 2023) to determine the relative velocity changes (dv/v) for the years 2016 to 2023.
- The Green's function describes wave propagation between two pairs of sensors and is obtained from autocorrelations and single-station cross-correlations of seismic noise.
- The Green's function is stacked in time and stretched against a reference function, while the stretching factor needed for the best fit yields the relative velocity change. Only results with a cross-correlation coefficient >0.8 are considered.
- Changes in the Green's function over time (e.g. at station COLB.HHN) are visible to the naked eye, both in the early and late coda.

Autocorrelation of station COLB.HHN (2 - 4 Hz)



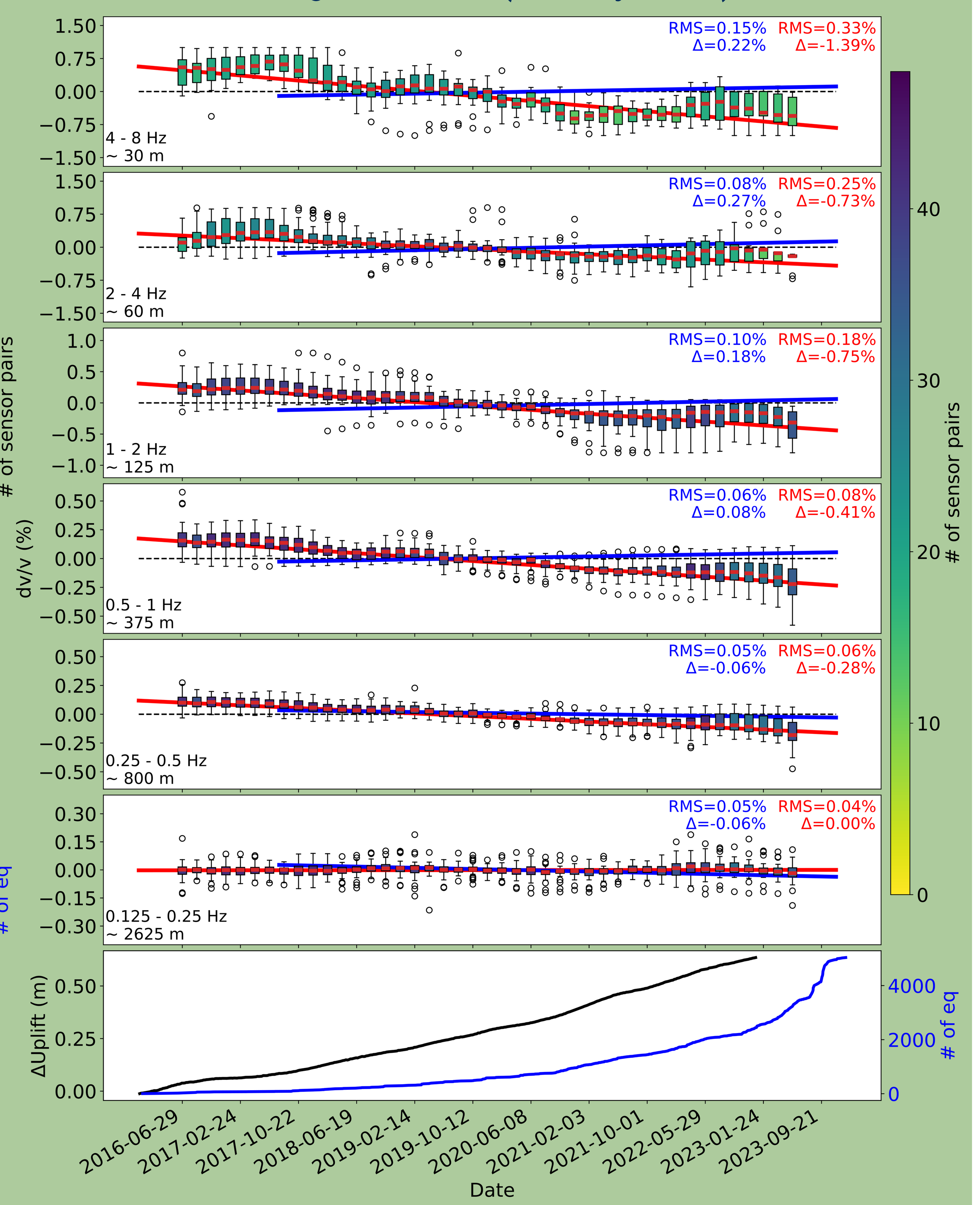
VELOCITY CHANGES

Short-term trend (30 day stack)



- Results of short-term velocity changes at stations above the seismically active area.
- Strong velocity changes near the surface, which decrease with increasing depth.
- A reduction in correlation coefficients is observed at high frequencies with the onset of the earthquake swarms in August and September/October 2023. This also results in larger error bars for dv/v measurements.
- Velocity changes are primarily driven by temperature and groundwater level (RCAA, 2024) changes.

Long-term trend (360 day stack)



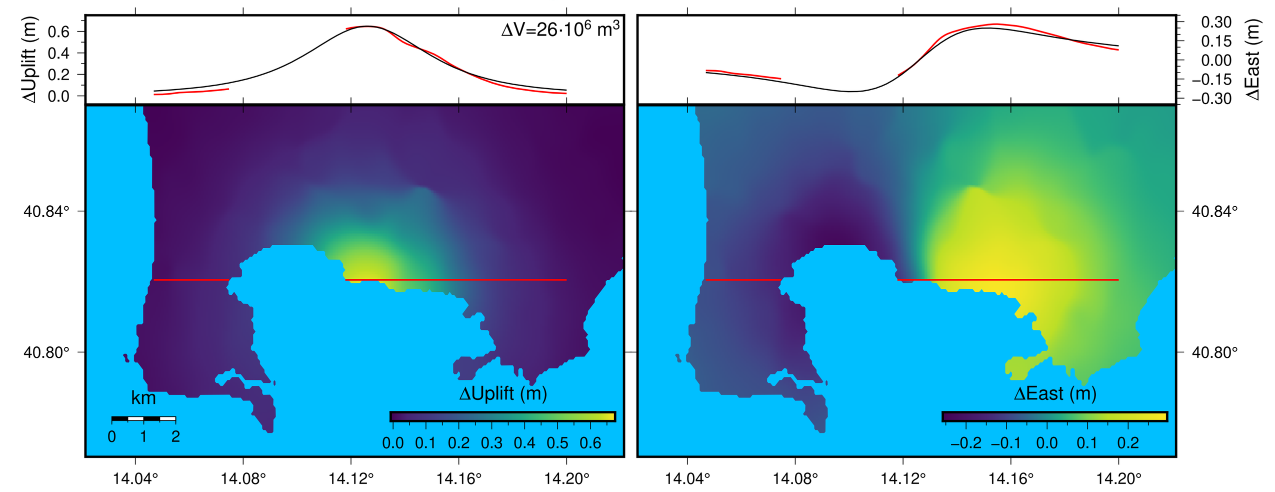
- Results of long-term velocity changes Δ of stations above (red) and outside (blue) the seismically active area.
- Strong decrease in velocity near the surface (-1.39%), decreasing with increasing depth.
- Velocity changes in the center of Campi Flegrei anticorrelate with the uplift of the surface, while velocity changes away from the center correlate near the surface and anticorrelate at greater depths.
- Velocity changes are caused by deformations (opening/closing of microcracks or pores) in the subsurface and can be explained by the volumetric strain.

→ Short-term velocity changes are driven by temperature and groundwater level changes and are not related to volcanic activity. Long-term velocity changes are caused by inflation of the shallow magma chamber.

GROUND DEFORMATION

- By using the Mogi equations (Mogi, 1958), we can deduce the increase in volume of a point source in the subsurface from ground deformations.
- The Mogi source expands isotropically in a homogeneous and elastic half-space.
- To determine the volume increase ΔV, we use ground deformation data from the European Ground Motion Service (Crosetto et al., 2020) for the period 2016 to 2022.

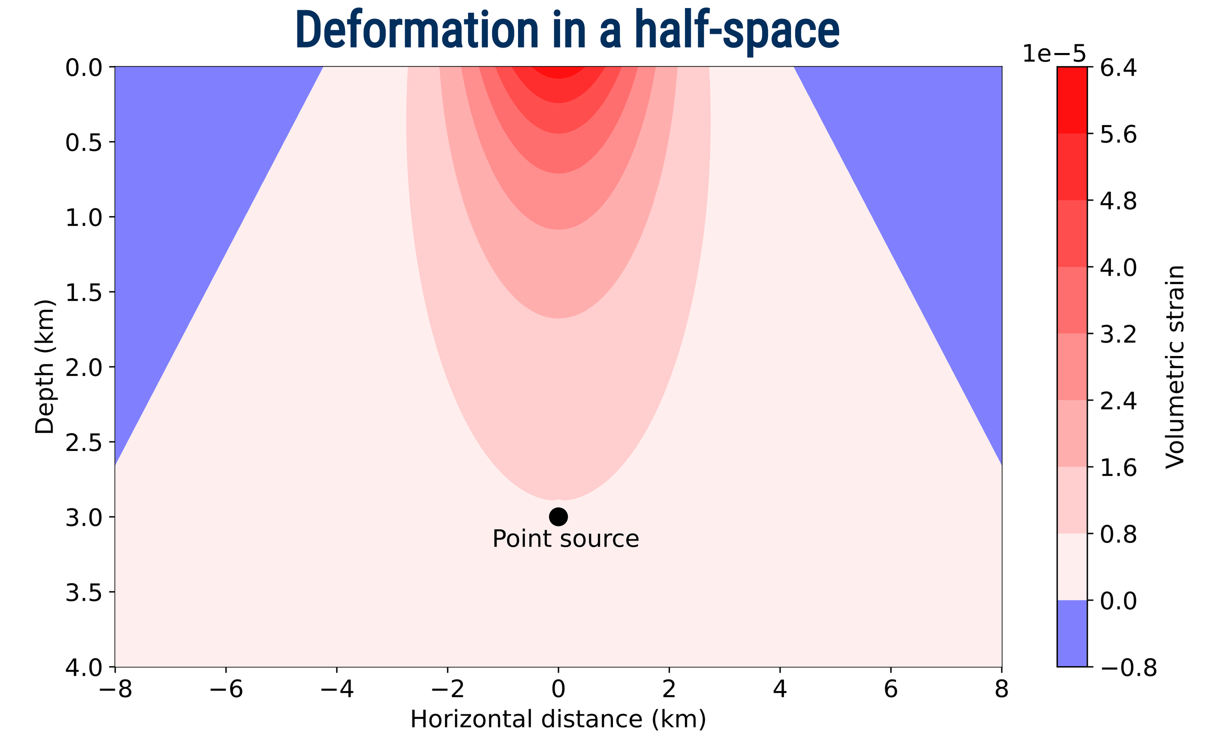
Ground and Mogi source deformations



VOLUMETRIC STRAIN

- We have determined the volumetric strain along a 2-D profile using Okada's equations (Okada, 1992) for an inflationary point source (black dot).
- Dilatation (positive volumetric stress) causes microcracks or pores to open and is the strongest near the surface above the source.
- At greater distances, (e.g. stations CMIS & CMSN), microcracks or pores close due to contraction (negative volumetric strain).

Deformation in a half-space



References:
Crosetto et al., 2020, [Dataset], The Evolution of Wide-Area DInSAR: From Regional and National Services to the European Ground Motion Service
Eulenfeld, T., 2023, [Software], yam: Yet another monitoring tool using correlations of ambient noise
INGV, 2005, [Dataset], Istituto Nazionale di Geofisica e Vulcanologia (INGV), Rete Sismica Nazionale (RSN)
Mogi, K., 1958, Relations between the eruptions of various volcanoes and the deformations of the ground surfaces around them
Okada, Y., 1992, Internal deformation due to shear and tensile faults in a half-space
RCAA, 2024, [Dataset], Regione Campania - Assessorato Agricoltura, Agrometeorologia

Abstract

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