A 30-year study of ground movement in Lettomanoppello town (Central Italy) based on satellite InSAR observations

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Lettomanoppello, a historic town on the northwestern slopes of the Maiella Massif (Central Italy), is affected by a slow-moving, deep-seated landslide that has long been known to impact its western flanks. However, until recently, the full extent of the instability remained uncertain. Previous investigations focused on localized damage and assumed partial involvement of the town.

In this study, we provide the first long-term satellite-based reconstruction of ground deformation using Interferometric Synthetic Aperture Radar (InSAR), spanning over 40 years from 1992 to 2023. By integrating multi-sensor SAR data from ERS, ENVISAT, and Sentinel-1 missions, and applying advanced multi-temporal InSAR techniques on both ascending and descending orbits, we estimate vertical and east-west components of displacement with high spatial resolution.

Our analysis reveals that the entire urban area of Lettomanoppello is affected by measurable ground motion. This represents a significant advancement in understanding the landslide' s real extent. Displacement rates exceed 1.5 cm/yr in some sectors and show consistent seasonal and long-term trends, reflecting both hydrological forcing and deep-seated gravitational creep. Importantly, ground motion is not limited to peripheral zones but extends across the historic center and affects residential buildings, critical infrastructure, and public places.

This finding significantly changes the risk scenario for the town. What was once thought to be a partially localized landslide is now recognized, thanks to satellite data, as a widespread, ongoing process involving the whole urban area. Our results call for urgent updates to hazard assessments, civil protection planning, and mitigation priorities.

The InSAR-based displacement data are being integrated with in situ geotechnical investigations and numerical modeling to support a new interpretation of the landslide process. This combined approach enhances the understanding of landslide susceptibility and contributes to a more accurate assessment of landslide hazard and, where vulnerability and exposure are known, the associated risk.

Keywords: InSAR, Landslide, Lettomanoppello, Creep