47. Monitoring Building Deformations from PS-InSAR Data and Integration into the MEDUSA Digital Twin

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The study, developed within the MEDUSA project (MEDiterraneo: Uso Sostenibile dell'Ambiente), funded by ASI (Boosting Future in Space @ Matera Space Center Lab call, Complementary Fund to the PNRR), proposes a methodology to estimate the structural vulnerability of buildings in urbanized coastal areas from COSMO-SkyMed interferometric stacks (first and second generation, 2015-2025). Persistent Scatterers (PS), identified via PS-InSAR™ in ascending and descending geometries, are combined to retrieve the vertical displacement component. After selection through a coherence threshold, the irregularly sampled time series are resampled at 14 days with PCHIP interpolation, which preserves local monotonicity and avoids overshooting, and decomposed into trend, seasonality (analyzed through the ACF) and residual; predictive validation follows a backtesting protocol with additive Holt-Winters. RBF interpolation, with smoothing weighted by the standard deviation of the PS and post-interpolation clipping to local values, generates continuous surfaces organized into a NetCDF raster cube. A Python algorithm (OOP, multithreading, CustomTkinter) integrates these surfaces with building footprints from the Regional Topographic Geodatabase (TGDB), extracting from the long-term trend mean cumulative displacement, differential range and maximum spatial gradient. Based on configurable thresholds, each building is classified as stable, with functional criticality or with structural criticality; a robust linear regression projects its evolution over three years, constrained not to fall below historical maxima to reflect the irreversibility of damage. The procedure is implemented in the bidirectional MEDUSA Digital Twin, which allows interactive modification of thresholds and instant recalibration of criticalities, with GeoPackage output compatible with the GIS Temporal Controller.