MULTI-FREQUENCY SATELLITE RADAR INTERFEROMETRY DATA PROCESSED WITH MULTIPLE TECHNIQUES FOR LANDSLIDE MAPPING AND MONITORING: PART OF THE ITALIAN SPACE AGENCY'S MEFISTO PROJECT OUTCOMES

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Purpose: In the last two decades, satellite Multi-Temporal InSAR (MTInSAR) techniques became consolidated tools for studying slow landslides. The availability of satellites that use different SAR band frequencies and the development of processing algorithms have constantly improved. One of the main aims of the Mefisto project(1) of the Italian Space Agency (ASI) was to test the potentiality of multi-frequency (X, C and L bands) MTInSAR data processed with different methodologies applied to a multi-scale slow landslide analysis.

Methods: Multi-sensor exploitation was planned, using datasets from Sentinel-1 (C-Band) and Cosmo-SkyMed (X-Band) satellites. A preliminary analysis of L-Band SAOCOM is also under investigation, despite the small number of available images. A two-step strategy was adopted based on a small scale (low-resolution) analysis followed by a high-resolution processing. Two different high-resolution processing were considered: one implemented at full resolution, via tomographic approach (specifically DTomoSAR in Fornaro et al., 2014), and the other on the CAESAR algorithm (Verde et al., 2020) that allows increasing the spatial density of measurement points on sparsely vegetated areas. Post-processing procedures were applied to obtain complementary information (e.g., the resolved velocity (EW and Vertical) vectors or the projection along the slope (VSlope)).

Results: The Sentinel-1 data processed with DTomoSAR allowed for updated landslide movement over large areas. It was possible to classify the activity state and its spatial distribution of about 60% of the deep-seated gravitational slope deformation (DsGSDs) in the Valle d'Aosta Region (Northwestern Italian Alps) (Figure 1A). The Sentinel-1 data processed with CAESAR showed good data density performance on a low-vegetated area (e.g. talus or debris) compared to DTomoSAR (Figure 1B), allowing for an increase in detectable landslides. The combined use of the Sentinel-1 datasets acquired over ascending and descending orbits, processed by CAESAR algorithm, and their post-processing products allowed us to map with high-detail geostructural sub-sectors of some selected DsGSDs (Figure. 1C). The Cosmo-SkyMed dataset provided accurate landslide displacement and time series mapping, allowing for correlation with damages to buildings in the village of Mendatica (Ligurian Alps, Italy) (Figure 1D).

Conclusions: The results of the Mefisto project confirmed that a multi-frequency InSAR approach is suitable for investigating diverse slow slope instability phenomena and the study areas' characteristics. Its potential ranges from large scale DsGSD activity assessment using free and open data of C-band satellites (e.g. Sentinel-1), to high-resolution X-band satellites able to track single-building displacement and damages over landslides that affect worldwide villages in mountain areas.

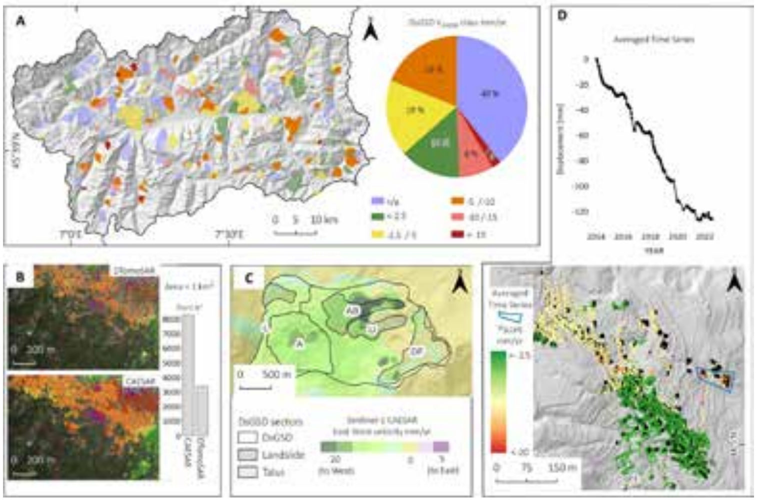

Fig. 1: A) State of activity classification of DsGSD in Valle d'Aosta Region based on Sentinel-1 DTomoSAR; B) Data density comparison between DTomoSAR and CAESAR; C) Mapping DsGSD sub-sectors using East-West interpolated velocity; D) Vslope and time-series of the Cosmo-Skymed dataset over the landslide affecting Mendatica village.

References

1. Fornaro et al. 2014 https://doi.org/10.1109/JSTARS.2014.2316323
2. Verde et al. 2020 https://doi.org/10.1109/TGRS.2020.3007927

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