UAS photogrammetry analysis for coastal hazard assessment: the case study of MARONTI LANDSLIDE (Ischia, 2022)

N. A. Famiglietti[1], A. Memmolo[1], P. Miele[1], E. Marotta[2], P. Belviso[2], G. Avvisati[2], C. Grasso[1], R. Moschillo[1], A. Vicari[1]

[1] Istituto Nazionale di Geofisica e Vulcanologia - Sezione Irpinia, Italy
[2] Istituto Nazionale di Geofisica e Vulcanologia - Osservatorio Vesuviano, Italy

ABSTRACT

Continental and marine processes drive coastal areas' landscape changes. The morphoevolution results from both rapid catastrophic events and slower continuous processes such as landslides, storms, and coastal land use, influenced by sea actions. The cliff erosion rates are linked to geological features, including rock mass strength and fracture system properties. The assessment of erosion processes and quantification of coastal retreat are crucial for effective coastal planning and engineering mitigation (Callaghan et al., 2009). Various methods, including geological processes monitoring, are used to assess coastal hazards (Quesada-Román and Peralta-Reyes, 2023).

The present study focuses on Maronti Bay's coastal evolution on Ischia Island, which has historically been affected by slope stability issues due to volcanic activity, earthquakes, and coastal erosion (Del Prete and Mele, 1999). In this perspective, researchers of the INGV (Istituto Nazionale di Geofisica e Vulcanologia) carry out periodical surveys of the Ischia territory. Drone surveys were used to evaluate the difference between pre- and post-landslide Digital Surface Models (DSMs) to focus on the November 26th, 2022 landslide event (Figure 3C e 3D). That event affected the volcanic cliff and can be classified as debris avalanche (Hungr et al., 2014) causing severe problems to the nearby structures and a remarkable scarp retreat of about 20 m. Consequently, debris and large blocks with the creation of a deposition area invaded the beach. The pre (acquired on December 15th, 2021) and the post (acquired on January 31, 2023) datasets have been orthorectified and georeferred with PPK (Post Processing Kinematic) workflow (Famiglietti et al., 2021) using as GNSS base the station SANT (Santantuono) managed by INGV and located onto the Ischia island. Thanks to very high spatial resolution of products (1.7 cm) this analysis estimates mobilized volumes (Figure 3E) allowing the comparison with results presented by other authors (Massaro et al., 2023). The adopted approach offers a geometric understanding of coastal cliff evolution after the landslide impact. These insights are crucial for managing landslide risks on Ischia and for other similar environments, guiding the development of mitigation strategies to protect the environment and ensure residents' and visitors' safety.

MATERIALS AND METHODS

In this work, we are focused on the evolution of the coastal environment of **Maronti** bay on Ischia (figure 1), which has been traditionally affected by slope stability issues caused by volcanic activity, earthquakes, and coastal erosion (Del Prete e Mele, 1999). Hungr et al. (2014) classified the event that affected the volcanic cliff as a debris avalanche, which resulted in severe problems for nearby structures and a slope retreat of about 20 meters. As a result, debris and large blocks invaded the beach, resulting in a deposition area. For this reason, the researchers of the INGV (National Institute of Geophysics and Volcanology) carry out periodic surveys on the territory of Ischia. In this case, drones were employed to accurately reconstruct the pre-and post-landslide territory to evaluate the debris avalanche effects due to the **November 26, 2022 landslide** event. In particular, two photogrammetric surveys were carried out with a DJI Mavic 2 Pro drone, with PPK (Post Processing Kinematics) system installed on board, on 15/12/2022 **(PRE)** and 31/01/2023 **(POST)**. For each day of surveys were made two types of missions for the acquisition of images, programmed through the software UgCS in the Enterprise version:

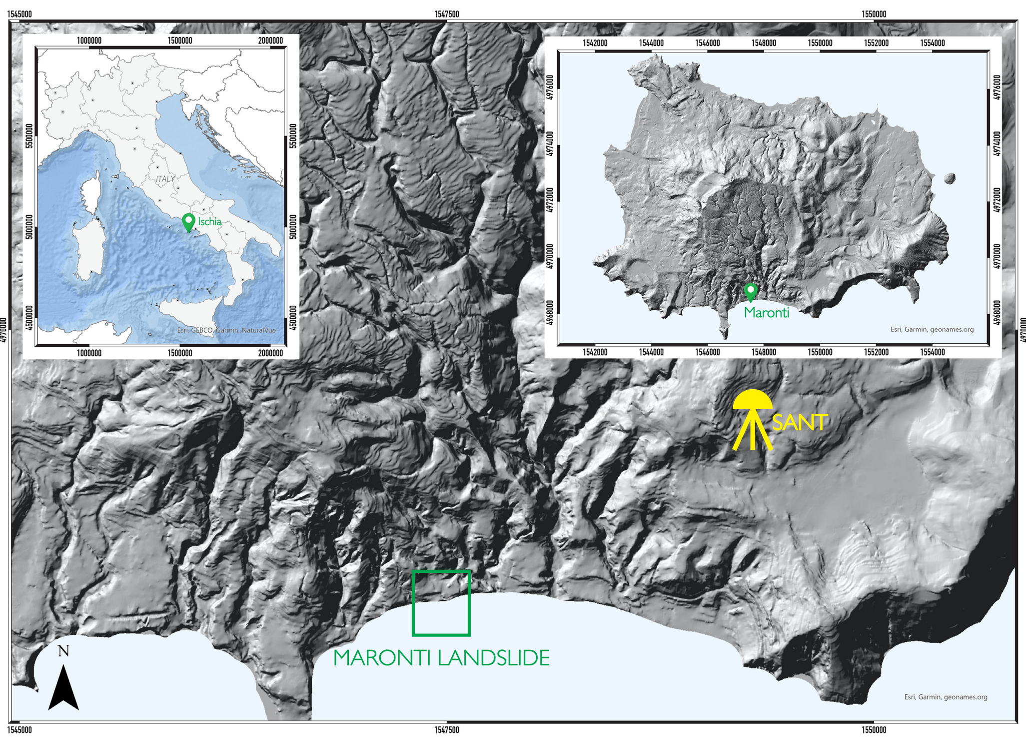

Figure 1 - Study area

The first was carried out with a double grid scheme with **nadiral** camera inclination, forward and side overlap respectively of 70% and 60%, at a speed of 3 m/s and with a maximum flight height of about 60 m Agl (Above ground level), reaching a GSD (Ground Sampling Distance) there about 1.5 cm (figure 2A).

The second one was carried out with a **vertical** relief through the appropriate tool "*facade*" integrated in the software. The acquisition resulted in seven horizontal trajectories with an inclined camera at 45°, forward and side overlap at 50%, and a distance of 20 meters from the area surveyed. In this case, a GSD of about 0.45 cm was reached (figure 2B).

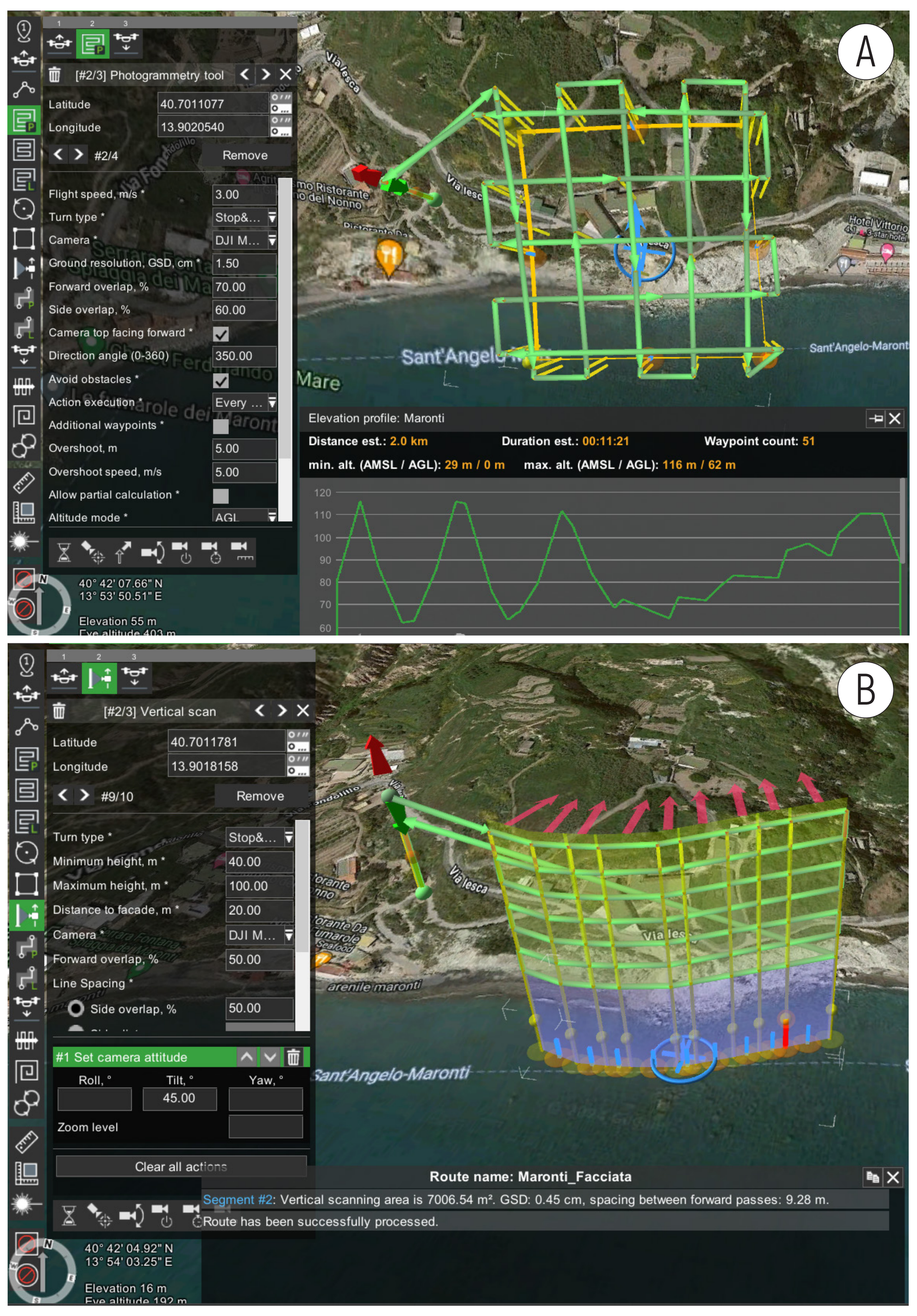

Figure 2 - UAS mission planning

All datasets have been orthorectified and geo-referenced using the **PPK** (Post Processing Kinematic) workflow (Famiglietti et al., 2021) respect the **GNSS** (Global Navigation Satellite System) base station **SANT** (Santantuono), managed by INGV, located on the Ischia Island (as shown in figure 1). In order to evaluate the systematic errors, several checkpoints were selected and measured with **RTK** (Real Time Kinematics) GNSS technique in the unchanged areas around the landslide.

RESULTS AND CONCLUSIONS

As a result, the point clouds, multi-temporal **DEMs**, orthomosaics and **3D Models** (figure 3A-B) of landslide topography were obtained using Agisoft Metashape software. In this work, the **VOLUMES** of the landslide are generated by the difference from comparing the reconstructed rupture surface with the pre-event DEM (figure 3C) and the post-event DEM (figure 3D). Thanks to the use of data from the same permanent GNSS station for both elaborations, the geodetic correction of the products was highly reliable, enabling the comparison of the DEMs and calculation of the volumetric offset. In Figure 3E is shown a single section of both DEMs where are highlighted about **11800 m³** of material mobilized, about **8500 m³** of material laid on the beach, and the remaining part (about **3500 m³**) submerged.

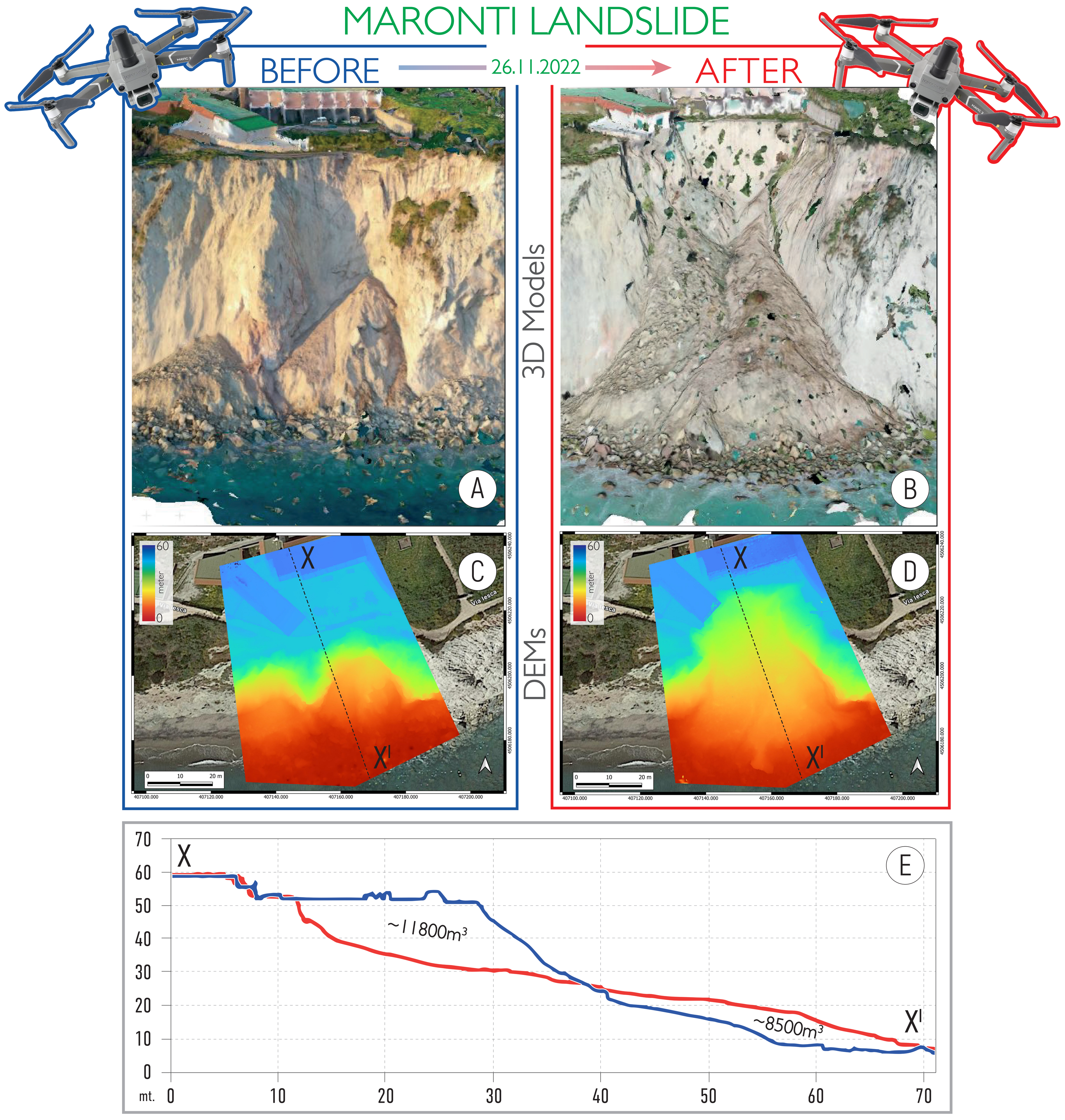

Figure 3 - 3D models PRE (A) and POST (B) - DEMs PRE (C) and POST (D) - Section (E)

Thanks to the very **high spatial resolution** of the products **(1.5 cm)** this analysis estimates the volumes mobilized allowing the comparison with results presented by other authors (Massaro et al., 2023).

The adopted approach offers a geometric understanding of coastal cliff evolution after the landslide impact.

The development of mitigation strategies to protect the environment and protect residents and visitors is aided by these insights that are crucial for managing landslide risks on Ischia and in other similar environments.

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*Special thanks to INGV - Osservatorio Vesuviano for actively supporting the study and providing the GNSS data used.