Comparing High Accuracy tLiDAR and UAV-derived Point Clouds for Change Detection in Two Semi-mountainous Mediterranean Catchments in Central Evia Island, Greece

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Introduction
Wildfires and soil erosion are among the most significant environmental issues resulting in soil degradation, therefore soil loss quantification is considered vital (Dregne 2002, Skahsby 2011). The reduction on soil productivity caused by the enhanced soil erosion makes the prevention's measures a necessity. Emerging tools such as Unmanned Aerial Vehicles (UAVs) in combination with well-established tools such as Terrestrial Laser Scanning (TLS) provide accurate results on change detection research (Gulyayev et al. 2004, Nethammer et al. 2012, Rosca et al. 2018). This study presents the combined application of these two methods in the same sites, aiming to introduce the scientific community to a multi-source (TLS and UAV-derived) point cloud comparison at multitemporal perspective, under fast changing circumstances in terms of erosion and vegetation growth after a wildfire.

Study area
Central Evia was selected after the devastated wildfire of August 2019. The wildfire destroyed the wider area consisted of coniferous forest in combination with a transition of woodland and shrubs (Corine, 2016). Two 30° slopes were selected within two different sub-basins. The mean elevation is about 80 m for S1 and 475 m for S2, above sea level. Regarding the site geology, the wider study area is considered to be part of the Subpelagonian unit. The east-facing slope (S2) is covered by tulas cones and alluvial deposits with a significant topsoil thickness, while the west-facing slope (S1) is located within the ophiolitic complex of Upper Jurassic-Lower Cretaceous, consisting of serpentines, diabase and peridotites (Figure 1a, 2a, 2b).

Methodology
Preliminary research included a first geomorphological study of the burnt area to select a suitable region of interest (ROI). Both sites were chosen after applying the Huc-Minimized Burn Ratio index (dBNR, Keely 2009) to delineate the burnt area by using Landsat 8 pre-fire and post-fire images, and after using geomorphological and geological data, supported by intensive field work. Three field campaigns were held, the first in October 2019, followed by the next in February 2020 and the last survey was conducted in October 2021 to estimate and locate the annual erosion. The last survey took place only at S1, due to the vegetation outburst at S2. Following the data collection, the demanding vegetation removal of each point cloud (derived from both DJI Phantom 4 and Iris Optech t-LiDAR), was finally, manually achieved, due to existing low-height grass canopy. The M3C2 algorithm (Lague et al. 2013) was applied and the vertical distances er calculated (Figure 1c).

Results
The derived high quality point clouds appear to accurate estimate soil erosion. Results indicate a more precise local erosion assessment by UAV photogrammetry compared to the TLS method. On the other hand, TLS technique represents more accurately the total slope erosion rate. It is noted that topsoil's movements in the order of a few centimetres, occurring within a few months after the wildfire, can be estimated. Erosion at S2 is precisely delineated by both methods, yielding a mean value of 1.5 cm within four months (Figure 3c,d), while at S1, UAV-derived point clouds' comparison quantifies annual soil erosion more accurately, showing a maximum annual erosion rate of 48 cm (Figure 3a,b).

Conclusions
✓ Our study introduces the scientific community to a multi-source (TLS and UAV-SIM-derived) point cloud analysis at multitemporal perspective under fast changing environments such as erosion-prone areas in Mediterranean region.
✓ The point-to-point direct comparison and M3C2 distance algorithm considered to be a suitable methodology on soil erosion estimation.
✓ UAV based photogrammetry is a more suitable, cost-effective technique when focusing on local erosion rates (Figure 3a, representing sites of maximum channel erosion).
✓ TLS approach appears to be more accurate when focusing on slope wash (Figure 3b).
✓ Vegetation proves to be an issue for both techniques.
✓ TLS performed better in total erosion rate computation, compared to UAV based photogrammetry, due to the existence of grass height of 1–2 cm.
✓ Shadow effect due to the line-of-sight angle of the TLS considered a great issue where scan position change is limited.

Table 1. (a) Range of local erosion (cm), (b) Volume of erosion in channel (m3) and (c) Mean slope derived erosion (cm)

Table 2. (a) Mean XYZ error (mm), calculated by the GCPs (GNSS reference). (b) GCPs registration error (mm) at each point cloud (c) Total amount of points and (d) Density of the derived point clouds, demonstrating the mean number of points per m² of each point cloud.

More details in Alexiou et al. 2021

References