Study of geomorphological changes by high quality DEMs, obtained from UAVs-Structure from Motion in highest continental cliffs of Europe: A Capelada (Galicia, Spain)

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1. INTRODUCTION

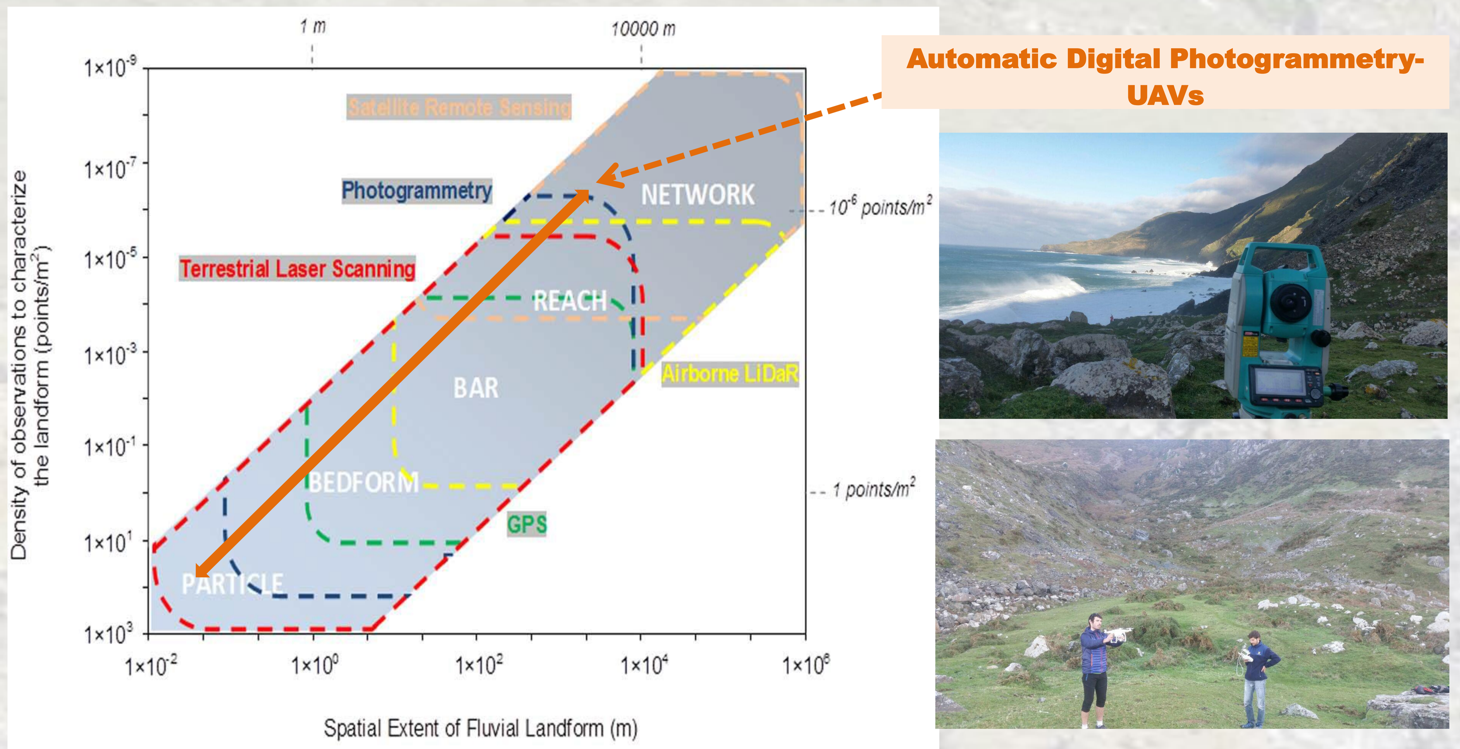


Fig 1. Relationship of topography techniques to the density of topographic observations necessary for a correct representation of different landforms associated to different spatial scales (modified by *Brasington et al., 2012*). We are using Sf-MVS from UAVs and TPS-GPS in highly dynamic coastal reach.

- In the last few years, it has been experienced heavy advanced in application of topographical techniques for quantification of processes in geomorphology. In: (i) geomatic (i.e. TPS, GPS-RTK, TLS), (ii) remote sensing (high resolution satellite images, Airborne-LiDAR, photogrammetry, automated digital photogrammetry, UAVs - unmanned flight platforms, etc.) The newest techniques offer a low cost and high quality-quantity topographical information (Structure from Motion-Multi View StereoScan, UAVs, drones, historical images). In a context of current global change, the advancement of these technologies plays a key role.
- The application of this techniques has increased exponentially in the geomorphology disciplines: fluvial (Lejot et al., 2007; Hervoue et al., 2011; Flener et al., 2013; Fonstad et al., 2013; Tamminga et al., 2015; Woodget et al., 2015), glacial (Whitehead et al., 2013; Immerzeel et al., 2014), landslides (Baldi et al., 2008, Prokop et al., 2009, Niethammer et al., 2012; Abellán et al., 2014; Lucieer et al., 2014; Turner et al., 2015) and coastal (Delacourt et al., 2009; Harwin and Lucieer, 2012; Goncalves and Henriques, 2015).

2. STUDY SITE

- A Capelada cliffs are highest continental cliffs of Europe (the maximum altitude is 612 m), and they are cut perpendicularly by small valleys open by fractures. These are flat-topped cliffs that surpass, in most of the sectors, the 32º of slope, arriving in some places at 88º. In addiction, in its upper part flattened surfaces extend that do not reach 8º in some places and 16º in others. Teixidelo Valley (0.15 km^2) is in contact with the flattened surfaces in the head section, forming a strip of steep slopes. In the sectors closest to the coastal front the valley is wider and slopes smoother (Fig. 2).
- The valley is highly dynamic. We have been measured the erosion/deposition balance between 2010 and 2016 (i.e. DoD 2016-2010). Two types of processes control the geomorphology: (i) a heavy coastal erosion caused by high frequency marine storms, and (ii) inter-year landslide and solifluction processes after heavy rainfalls. The GSD of the sediment domine a big heterometric and chaotic classification (i.e.10^{1}-10^{-10}meters) wrapped in a clay matrix similar to proglaciar environments.

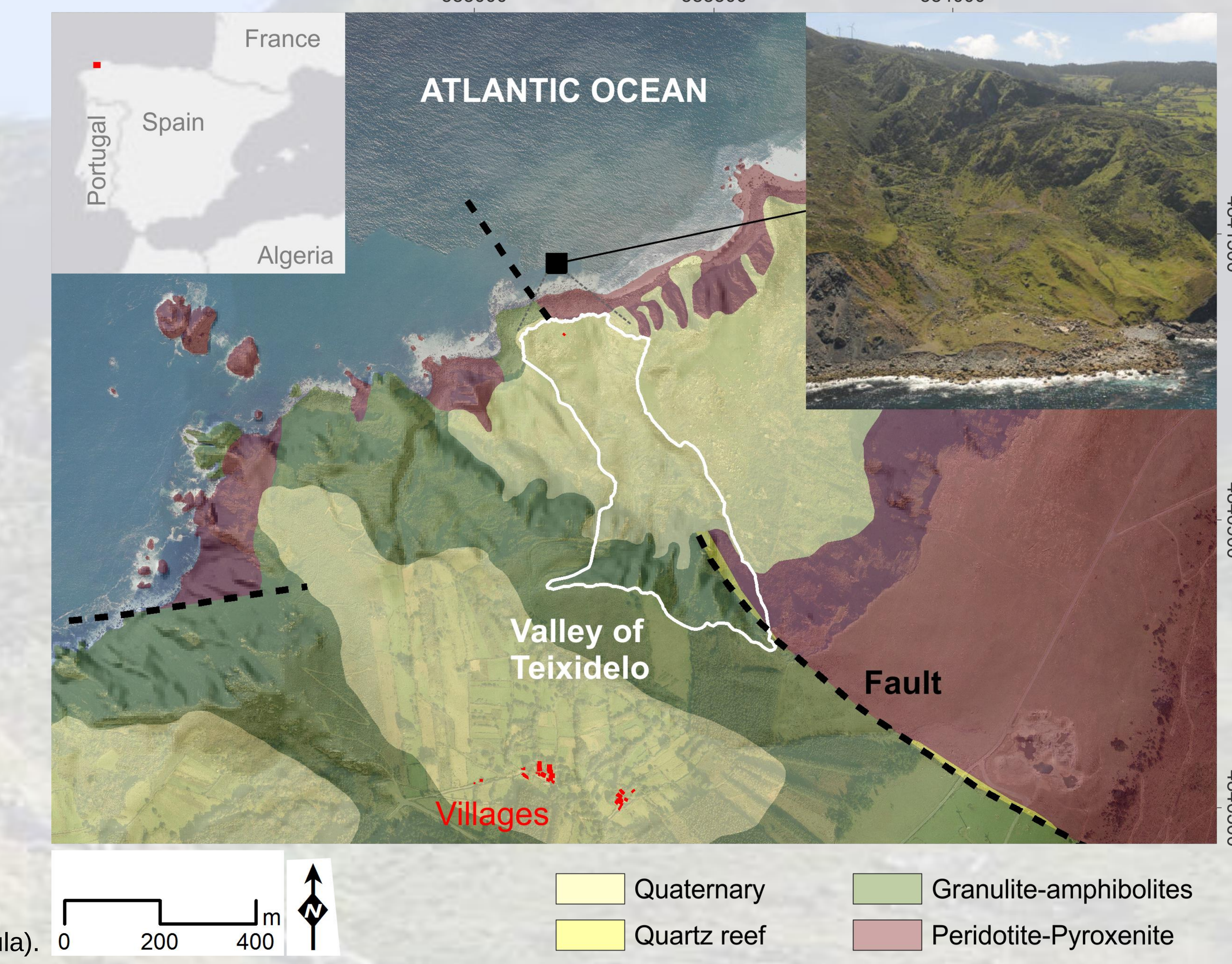


Fig 2. Study site: A Capelada's cliffs (Galiza, NW Iberian Peninsula).

3. METHODOLOGICAL DESIGN AND APPLICATION

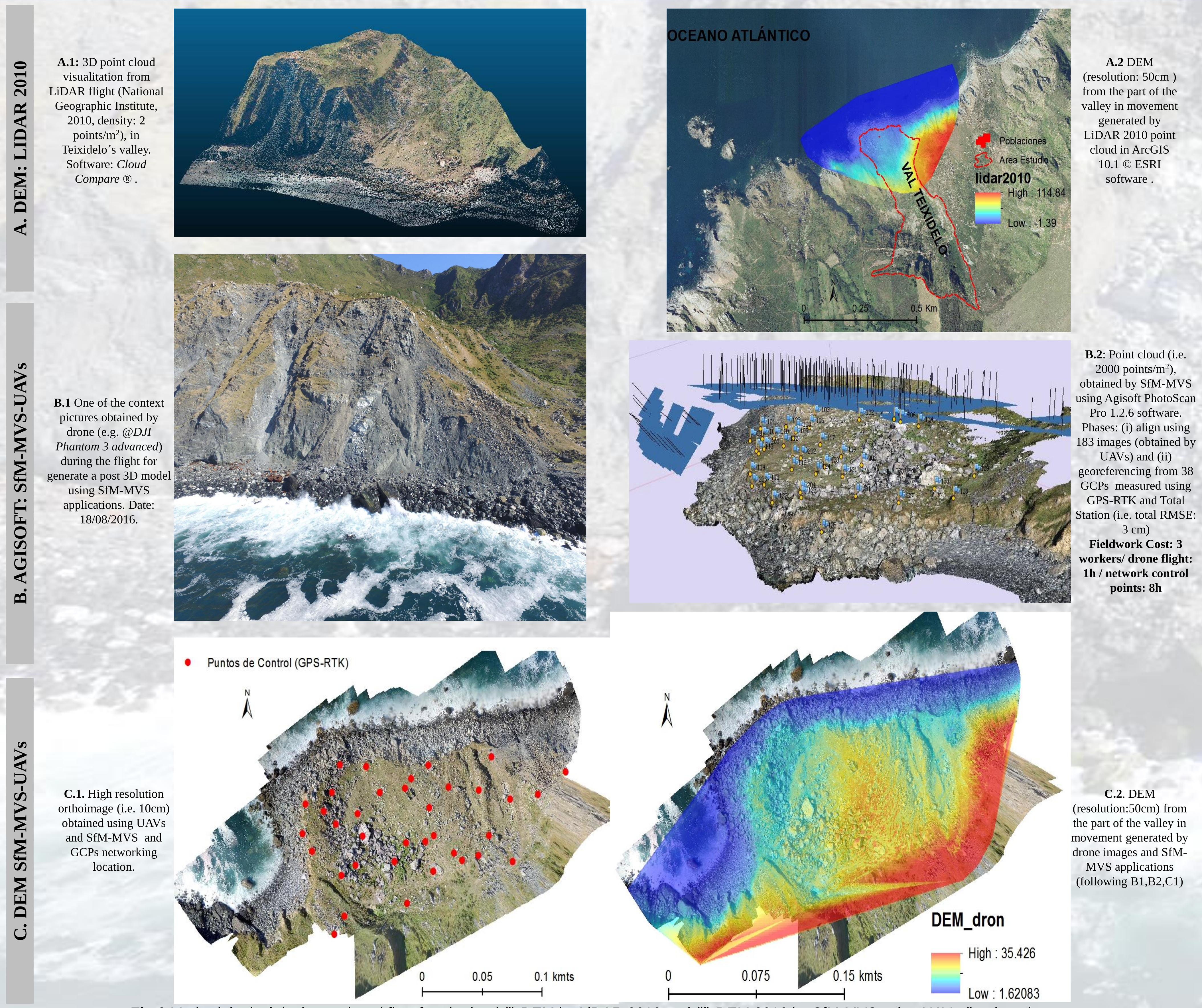
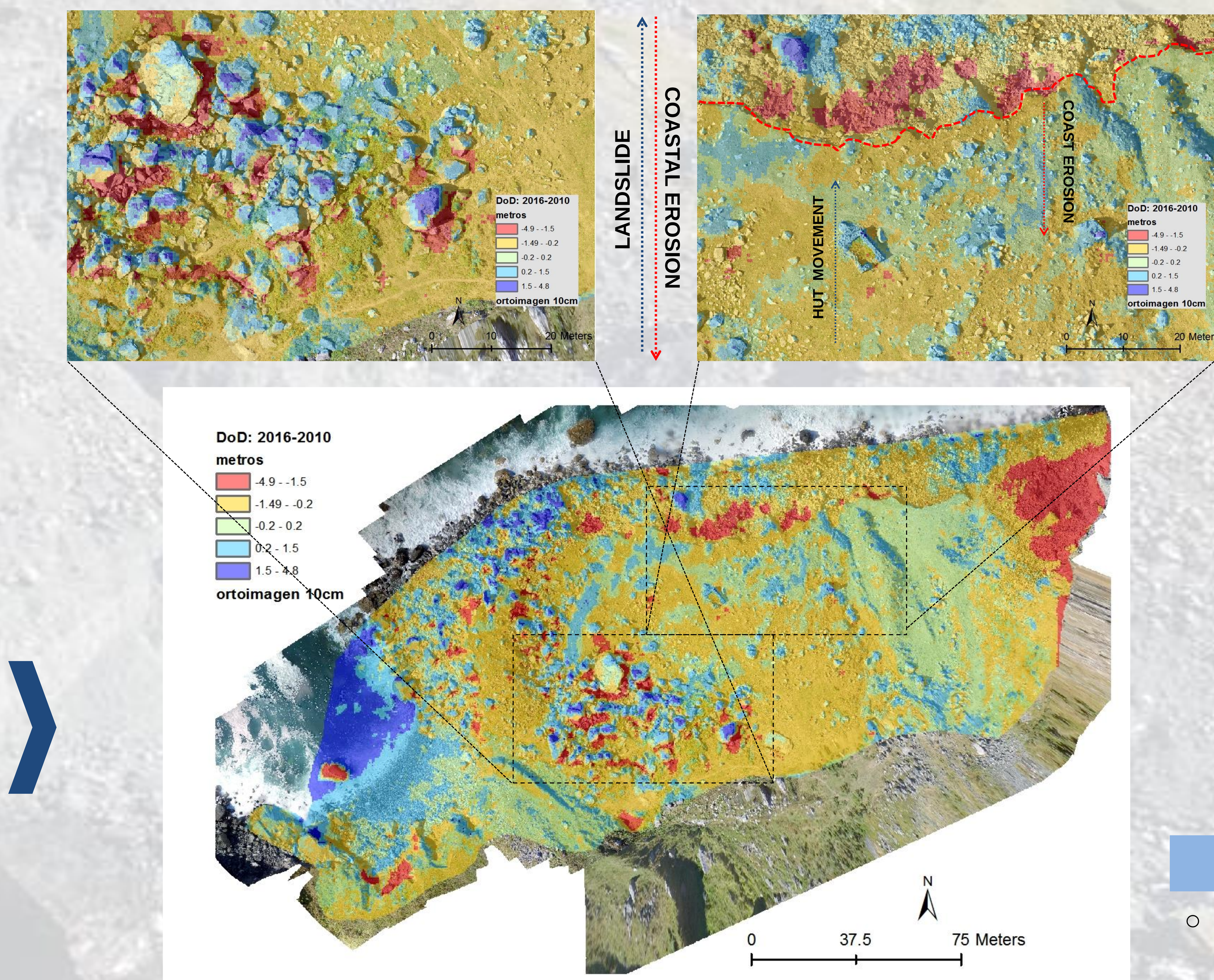


Fig 3 Methodological design and workflow for obtained (i) DEM by LiDAR 2010 and (ii) DEM 2016 by SfM-MVS using UAVs (i.e drone).

4. RESULTS



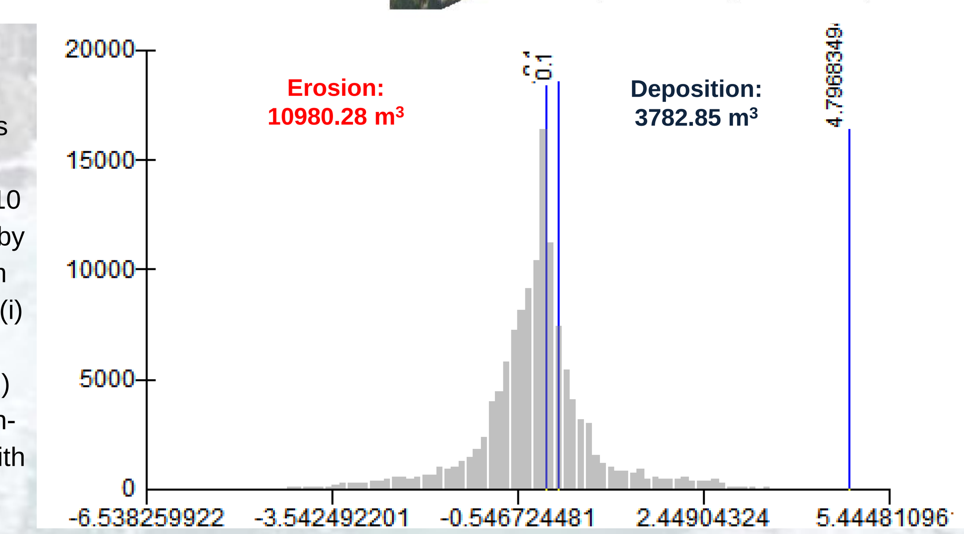


Fig 4. DEM of Differences (2016-2010, resolution: 50cm) between LiDAR 2010 flight and model obtained by drone august 2016. Zoom with 2 types of processes: (i) coast erosion (red line; eroded front coast) and (ii) landslide of Teixidelo earth-sea direction. Histogram with erosion/deposition ratio.

- 14000m^3 of material, 74.4% (i.e. 10980 m^3) of sediment has been eroded, whereas that 24.6% (i.e. 3782.85m^3) has been sedimented. Maximum of elevation changes in erosion/deposition ratio was in order that 5 meters between 2010 and 2016 (Fig 4) .
- Of the total sediment, more than 90% has been moved caused by two principal processes. The rest of sediment remained stabled.
- The spatial distribution of erosion/deposition ratio explain the two dominant geomorphic control phenomena (zoom, Fig 4). Coastal erosion has caused a heavy erosion in coastal front of the valley having been predominant (close term duration, more competitive). Nevertheless, the landslides and solifluction processes (long term duration, less competitive) with valley-sea direction (i.e. south-north) has caused the horizontal movement for the sediment, when both phenomena (i.e. same erosion/sedimentation ratio of the sediment) can be seen (e.g. hut building at the middle). Mean horizontal (i.e x,y coordinates) movement was about 2.5meters in the last 6 years.

5. CONCLUSIONS

- Study site is highly dynamics (i.e. 90% of the sediment was removed between 2010 and 2016).
- In the balance, erosion was predominant over deposition.
- We observed two different and contrasts geomorphological processes: (i) coastal erosion and (ii) solifluction-landslides.
- New successfully case study using UAVs-drones and SfM-MVS techniques for study landscape evolution and monitoring coastal geomorphic processes.

Fig 5. Coast front in the study site with high erosion ratio

References

Abellán, A., Oppikofer, T.,Jaboyedoff, M., Rosser, J.N., Lim, M., Lato, J., 2014. Terrestrial laser scanning of rock slope instabilities. Earth Surf. Process. Landf. 39 (1), 80–97. **Baldi, P., Cenni, N., Fabris, M., Zanutta, A., 2008**. Kinematics of a landslide derived from archival photogrammetry and GPS data. Geomorphology 102, 435–444**. Delacourt, C., Allemand, P., Jaud, M., Grandjean, P., Deschamps, A., Ammann, J., Cuq, V., Suanez, S., 2009**. DRELIO: an unmanned helicopter for imaging coastal areas. J. Coastal Res. Spec. Issue 56, 1489–1493. **Flener, C., Vaaja, M., Jaakkola, A., Krooks, A., Kaartinen, H., Kukko, A., Kasvi, E., Hyyppa, H., Hyyppa, J., Alho, P., 2013**. Seamless mapping of river channels at high resolution using mobile LiDAR and UAV-photography. Remote Sens. 5 (12), 6382–6407. **Fonstad,M.A., Dietrich, J.T., Courville, B.C., Jensen, J.L., Carbonneau, P.E., 2013**. Topographic structure frommotion: a new development in photogrammetric measurement. Earth Surf. Process. Landf. 38 (4), 421–430. **Goncalves, J.A., Henriques, R., 2015**. UAV photogrammetry for topographic monitoring of coastal areas. ISPRS J. Photogramm. Remote Sens. 104, 101–111.Harwin, S., Lucieer, A., 2012. Assessing the accuracy of georeferenced point clouds produced via multi-view stereopsis from unmanned aerial vehicle (UAV) imagery. Remote Sens. 4 (6), 1573–1599. **Hervoue, A., Dunford, R., Piegay, H., Belletti, B., Tremelo, M.L., 2011**. Analysis of post-floodrecruitment patterns in braided-channel rivers at multiple scales based on an imageseries collected by unmanned aerial vehicles, ultra-light aerial vehicles, and satellites. GISci. Remote Sens. 48 (1), 50–73.Immerzeel, **W.W., Kraaijenbrink, P.D.A., Shea, J.M., Shrestha, A.B., Pellicciotti, F., Bierkens, M.F.P., de Jong, S.M., 2014**. High-resolution monitoring of Himalayan glacier dynamics using unmanned aerial vehicles. Remote Sens. Environ. 150, 93–103. **Lejot, J., Delacourt, C., Piegay, H., Fournier, T., Tremelo, M.L., Allemand, P., 2007**. Very high spatial resolution imagery for channel bathymetry and topography from an unmannedmapping controlled platform. Earth Surf. Process. Landf. 32 (11), 1705–1725. **Lowe, D. (2004):** Distinctive image features from scale-invariant keypoints. International Journal of Computer Vision, 60: 91-110 (440**). Lucieer, A., de Jong, S.M., Turner, D., 2014**. Mapping landslide displacements using structure from motion (SfM) and image correlation of multi-temporal UAV photography. Prog. Phys. Geogr. 38 (1), 97–116. **Muñoz-Narciso, E., Béjar, M.; Tena, A., Vericat, D., Ramos, E., Brasington, J., Gibbins, C.N. y Batalla, R.J. 2014**: Generación de modelos topográficos a partir de fotogrametria digital automatizada en un río de gravas altamente dinámico. En: XIII Reunion Nacional de Geomorfologia, 335-338. **Niethammer, U., James, M.R., Rothmund, S., Travelletti, J., Joswig,M., 2012**. UAV-based remote sensing of the Super-Sauze landslide: evaluation and results. Eng. Geol. 128, 2–11. **Prokop, A., Panholzer., 2009**. Assessing the capability of terrestrial laser scanning for monitoring slow moving landslides. Nat. Hazards Earth Syst. Sci., 9, 1921–1928. **Tamminga, A., Hugenholtz, C., Eaton, B., Lapointe, M., 2015**. Hyperspatial remote sensing of channel reach morphology and hydraulic fish habitat using an unmanned aerial vehicle (UAV): a first assessment in the context of river research and management. River Res. Appl. 31 (3), 379–391**. Turner, D., Lucieer, A., de Jong, S.M., 2015**. Time series analysis of landslide dynamics using an unmanned aerial vehicle (UAV). Remote Sens. 7 (2), 1736–1757. **Whitehead, K.,Moorman, B.J., Hugenholtz, C.H., 2013**. Brief communication: low-cost, ondemand aerial photogrammetry for glaciological measurement. Cryosphere 7 (6), 1879–1884. **Woodget, A.S., Carbonneau, P.E., Visser, F., Maddock, I.P., 2015**. Quantifying submerged fluvial topography using hyperspatial resolution UAS imagery and structure from motion photogrammetry. Earth Surf. Process. Landf. 40 (1), 47–64**. Vericat D., Brasington J., Wheaton J. y Cowie M, 2009**: Accuracy assessment of aerialphotographs acquired using lighter-than-air blimps: low-cost tools for mapping river corridors. River Research and Applications 25(8): 985-1000.

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