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Assessing the representation of human-made structures and dominant geomorphological features in high- and medium-resolution digital terrain models for hydro-sedimentological modelling in small Mediterranean catchments

Lukas Graf (1,2), Mariano Moreno-de-las-Heras (3), Maurici Ruiz (2,4), Aleix Calsamiglia (2,5), Julián García-Comendador (2,5), Josep Fortesa (2,5), José A. López-Tarazón (2,5,6), Joan Estrany (2,5)

(1) University of Salzburg, Geoinformatics, Salzburg, Austria (graflukas@web.de), (2) Mediterranean Ecogeomorphological and Hydrological Connectivity Research Team—MEDhyCON, Department of Geography, University of the Balearic Islands, Palma, Spain, (3) Surface Hydrology and Erosion Group—SHEg, Institute of Environmental Assessment & Water Research (IDAEA), Barcelona, Spain, (4) GIS and Remote Sensing Service—SSIGT, University of the Balearic Islands, Palma, Spain, (5) Institute of Agro-Environmental and Water Economy Research—INAGEA, University of the Balearic Islands, Palma, Spain, (6) Hydrology and Climatology, Institute for Earth and Environmental Sciences, University of Potsdam, Potsdam, Germany

Accurate representation of both artificial elements (e.g. agricultural terraces, drainage channels, roads) and naturally dominant geomorphological landscape features (e.g. rock outcrops, topographical depressions) in digital terrain models (DTMs) is considered as a major requirement for catchment hydro-geomorphological modelling in Mediterranean areas. In fact, in Mediterranean landscapes –as in other geographic regions– human activities have significantly altered catchment hydro-sedimentological functioning. Thus, the actual patterns of hydro-sedimentological connectivity observed within a landscape may largely differ from the spatial organization of water and sediment fluxes that could be expected under the original, natural state of the system.

We studied the terrain representation of human-made structures and naturally dominant landscape features for two high-resolution LiDAR DTMs (5 and 1-m spatial resolution) and two medium-resolution satellite-derived DTMs (ASTER GDEM V2 and SRTM C-SAR V3 DEM, ~30-m spatial resolution) along three small (3-5 km2) catchments and nested small-detail (50-ha) plots. Ground reference elevation data was collected using a real-time kinematic GPS, basic terrain descriptors such as the slope-area relationship were computed and a recently developed spatial index of surface flow connectivity (IC) was applied. The study areas –located in the Island of Mallorca, Spain– are characterized by land-use and geomorphological patterns that are representative for most Mediterranean environments, providing a suited framework for assessing the applicability of DTM in catchment hydro-sedimentological modelling.

The two studied LiDAR-based models and SRTM data showed in general a good agreement of modelled stream network as well as water and sediment flow patterns, while the large vertical inaccuracy (up to 16-m RMSE) and coarse ground sampling distance of the ASTER data largely limited its applicability for revealing surface patterns. Small-detail features (e.g. agricultural terraces, preferential flow patterns), however, were only captured by the high-resolution LiDAR models, thereby emphasizing the need for high spatial resolution (<5 m) data in hydro-sedimentological modelling. Meter to sub-meter wide features -such as artificial drainage channels- were underrepresented even for the 1-m model. In fact, the ability of high-resolution LiDAR-based terrain models to capture fine-grained catchment hydro-sedimentological connectivity can be considerably constrained where underlying point cloud density does not match the spatial scale of hydrologically determinant landscape features. The applied index of connectivity was revealed as a powerful tool for assessing the representation of dominant landscape features in DTM datasets and further catchment hydro-sedimentological modelling.