Geophysical Research Abstracts
Vol. 20, EGU2018-18235-1, 2018
EGU General Assembly 2018

Quantifying soil erosion in terraced landscapes: integration of high-resolution topography, RPII morphological index and hydrological modeling

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Agricultural terraces are principally designed to retain and control overland flow, in order to facilitate cultivation and minimize the risk of land degradation. However, terraced landscapes are increasingly confronted with challenges such as climate intensification, land abandonment or unsuitable expansions, which compromise the land stability. In Mediterranean Europe, for instance, vineyard terraces represent among the strongest degrading landscape types, while carrying strong cultural and economic value.

In this context, the aim of this study is to investigate the capability of a morphological index (Relative Path Impact Index RPII) and a hydrological-hydraulic model to detect and quantify the effect of terraces on flow propagation and erosion. The RPII was initially developed as a preliminary tool to evaluate the effect of hillside roads on potential runoff concentration. The index considers the contributing drainage area as a proxy of preferential flow path formation, while comparing the artificial landscape with a smoothed landscape. The effectiveness of the RPII was found in applications beyond mountain trails, e.g. in detecting potential critical areas in terraced landscapes where water accumulation can cause superficial erosion, wall collapse or landslides. On the other hand, numerical hydrological-hydraulic modeling is a tool commonly used to evaluate the effect of land use management on flood propagation and sediment transport. The numerical simulations were performed using the two-dimensional FLO-2D model, which has long been validated as an efficient tool in the simulation of the flow propagation. The Soil Conservation Service-Curve Number approach, implemented in the FLO-2D software, was used to perform the hydrological modeling. Differently, flow propagation in two dimensions was ensured by the model through the application of the general constitutive fluid equations, which include the continuity equation and the equation of motion, solved with a central, finite difference numerical scheme.

Investigations were carried out in two study areas located in the Veneto Region (Northeastern Italy), within the Prosecco DOCG consortium. Both the morphological index and the hydraulic model are based on high-resolution topography obtained from UAV-based photogrammetry technique. UAV surveys were conducted during the winter season to avoid the disturbance of the vegetation. High-resolution topography data offers an important source of information needed for the analysis and modeling of terraced landscapes.

The integration of the adopted methodologies allowed the identification of the main instabilities, the extraction of points where runoff concentrates, and a quantification of the soil erosion. Finally, the overlapping of methods provided an added value to take decisions on the best sustainable practices in terraced landscapes.