Geophysical Research Abstracts
Vol. 18, EGU2016-3843, 2016
EGU General Assembly 2016

New multi-scale approach to improve explanation of patterns of contemporary morphodynamics in the badland landscapes of Central Italy: the important Quaternary context

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Spatial patterns and magnitudes of short-term erosional processes are often the result of longer-term landscape-wide morphodynamics. Their combined analysis, however, is challenged by different spatial scales, data availability and resolution. Integrating both analyses has thus rarely been done though urgently needed to better understand and manage present day erosional dynamics and land degradation.

In this study we aim at overcoming these shortcomings by exploring a multi-scale approach, based on a nested experimental design that integrates the traditional monitoring of erosion processes at local and short time scale, with the longer-term (over the last 10^3-10^5 yr) and basin-to-morphostructure scale analysis of landscape morphodynamics. We investigated the geomorphological behaviour of a Mediterranean active badland site located in the Upper Orcia Valley (Southern Tuscany, Italy). This choice is justified by the availability of decadal erosion monitoring datasets at a range of scales, and the rapidity of development of erosion processes.

Based on the analysis of drainage network and its longitudinal and planform pattern, we tested the hypothesis that this rejuvenating, actively erosional landscape presents hotspots of denudation processes on hillslope and in channel network that are largely associated with (a) knickpoints on stream longitudinal profiles, (b) sites of strong connectivity, and (c) sites of strong divide competition with adjacent, aggressive and non-aggressive systems.

To illustrate and explore this nested approach, we extracted the channel network and analysed stream longitudinal profiles using the MATLAB-based TopoToolbox program, starting from the 27x27 m Aster GDEM. The stream network morphometric analyses involved computing and mapping χ-values, a transformation that normalizes the longitudinal distance by upslope area and which serves as a proxy of the dynamic state of river basins based on the current geometry of the river network. Finally, we projected on the longitudinal profiles of the Orcia River and some of its main tributaries a full range of geomorphic features which are relevant for the interpretation of the landscape morphoevolution, connectivity and erosion/deposition dynamics: i) competitive divides; ii) sites with different degree of connectivity within the drainage system; iii) sites experiencing different erosion rates; iv) sites with in-channel depositional features and landslide deposits; v) remnants of relict geomorphic surfaces. The plano-altimetric distribution of such features, compared with the drainage network evolutionary stage, allowed to better understand the morphodynamics of badland areas and to define future scenarios in the perspective of a better management of hazardous processes.