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Structural and functional connectivity in the agricultural Can Revull catchment (Mallorca, Spain)

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Unravelling the spatio-temporal variability of the sediment transfer within a catchment represents a challenge of great importance to quantify erosion, soil redistribution and their impacts on agricultural landscape. Structural and functional connectivity have been identified as useful aspects of connectivity that may clarify how these processes are coupled or decoupled in various types of catchment sediment cascades. In this study, hydrological and sediment connectivity in a Mediterranean agricultural catchment (1.4 km2) modified through traditional drainage systems (i.e. ditches and subsurface tile drainages) was assessed during two contrasted rainfall events occurred in October 2016 (20 mm in 24 h –return period < 1 yr–, I30 6.6 mm h-1 with 32 mm accumulated in 14 days) and in December 2016 (99 mm in 24 h –return period ≈ 25 yr–, I30 23 mm h-1 with 39 mm accumulated in 14 days). A morphometric index of connectivity (IC) was calculated to study the spatial patterns of structural connectivity. The identification of the main sediment pathways –in terms of functional connectivity– was conducted by field mapping, whilst the estimation of erosion and deposition rates by the analysis of high resolution digital terrain models (i.e. 5 cm pix-1; RMSE < 0.05 m) obtained from automated digital photogrammetry and unmanned aerial vehicle (UAV). The IC estimations allowed the identification of the most (dis-)connected areas related with the anthropogenic control in the resisting forces of the catchment. On the one hand, in the upper part of the catchment, depositional compartments were created by dry-stone walls that separate agricultural properties laminating flash floods. On the other hand, in the lower part of the catchment these depositional compartments were generated by an orthogonal network of ditches situated topographically above the natural thalwegs. In its turn, the most connected areas are located in the steepest parts of the catchment under rainfed herbaceous crops without dry stone walls and also within the lowland depositional compartments where the pathways are diverted generating parallel concentrated flows because of the greater elevation of these ditches. The observed spatial patterns of functional connectivity showed significant differences between the two events, although well fitted with IC as a clear evidence of anthropogenic controls in the resisting forces. During the October 2016 event –representative of high frequency-low magnitude events in the catchment– traditional drainage systems controlled the water and sediment transfer which was mainly concentrated within the ditches. By contrast, during the event of December 2016 –representative of extreme events– this transfer process was controlled by the natural morphology of the catchment, which activated coupling mechanisms between different compartments, increasing the effective area and triggering erosion processes including the formation of rills and incipient gullies. The spatial location of the sediment mobilization and deposition areas during the extreme event in December 2016 is well fitted with the IC estimations. The application of IC, therefore, may provide useful information to improve the drainage systems design and the implementation of measures to prevent soil losses.