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Modelling hydrological connectivity in semi-arid flat areas: effect of the flow accumulation algorithm on the spatial pattern

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Much of the water and sediment fluxes in semi-arid landscapes are found to be concentrated in localized pathways. Identifying the location of these pathways is important for management and restoration. This task becomes more complicated in flat areas, such as alluvial terraces, where geomorphic features of concentrated overland flow (rills and ephemeral gullies) are scarce or inexistent. Field identification of sediment delivery pathways as well as depositional areas is also difficult and challenged. The concept of hydrological connectivity (HC) helps us to express the complexity of landscape non-linear responses to rainfall inputs. One of the unsolved issues in overland flow modelling studies is the choice of the right flow accumulation algorithm (FAA). There is an abundant literature on runoff generation under semi-arid conditions, and relating HC and land use management and changes. However, we found a scientific gap in the literature focussed on modelling of HC in flat areas under semi-arid conditions. This study aims to fill in this gap by modelling HC in alluvial terraces (28 ha) in NE Spain under semi-arid conditions (342 mm / year), mainly devoted to rain-fed cereal fields, by using eight FAA. For this purpose, we applied a modified version of the Borselli's index of runoff and sediment connectivity (IC). The study area includes seven fields on flat alluvial terraces, three fields on a gentle slope, small patches of scrubland, and twelve grass buffer strips that are located between each set of fields. Gentle and flat areas (S < 4%) cover 38% of the total surface. A photogrammetry-derived DEM was obtained through a flight, using a photographic camera installed in a professional mapping drone (model eBee by senseFly Ltd.). In order to minimize the effect of the vegetation on the photogrammetry restitution technique, pictures were taken in early spring, before the growth of the cereals. Then, several DEMs were generated independently. For this study, we chose the DEM at 0.5 x 0.5 m of spatial resolution. Before running the IC model, the continuity of the flow path lines throughout the landscape was ensured by removing the local depressions of the DEM with the algorithm of Planchon & Darboux (2001). Taking in mind the low slope of the area, we considered a minimum slope gradient of 0.01 degrees that can be associated with unrealistic sinks or DEM artifices. We run the IC model with the following eight flow accumulation algorithms, without using threshold values for linear flow: four single flow (D8, Rho8, KRA and D-Infinity) and the four multiple flow (MD, BDR, DEMON and TMD). Input working out and GIS calculations were done with three software: QGIS©-64 2.14.0-Essen, SAGA©-64 2.1.2 and ArcGIS© 10.3. As used by many authors, we used the C-RUSLE factor to assess the landscape-weighting factor of the IC model. Simulated HC was validated in the field by identifying the stable, erosion, delivery and sedimentation forms. This study will contribute to hydrological modelling studies in flat and gentle areas and where soil redistribution processes are of low magnitude.