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Spatial scale dependency of runoff and sediment connectivity in small sub-catchments in the Spanish Pyrenees

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An increasing number of scientific articles and conference sessions have recently dealt with the role of linear landscape elements and human infrastructures on the hydrological and soil particles connectivity processes at different spatial (hillside, field, catchment and basin) and temporal scales (short and long term processes). Runoff and erosion processes are often non-linear and scale dependent, which increase the uncertainty of model predictions. One of the reasons for scale dependency is the influence of sinks, i.e. areas of infiltration and sedimentation, which lower the hydrological connectivity and decrease the area-specific runoff and sediment yield. In this work the effect of the catchment size and the density of linear landscape elements on the runoff and sediment connectivity is analyzed and results are discussed in the context of modelling enhancement. A typical Mediterranean agro-ecosystem was selected to run the index of connectivity (IC) of Borselli et al. (2008) [Catena 75(3): 268–277] which accounts the characteristics of the drainage area (upslope module) and the flow path length that a particle has to travel to arrive at the nearest sink (downslope module). The Estaña catchment (246 ha) is located in the Central Spanish Pre-Pyrenees, it includes fifteen endorheic sub-catchments and 41% of its surface is used for agricultural purposes. Step and check-dam agricultural terraces, irrigation channels, settlements, unpaved trails, natural scarps and topographic sinks (with presence of boulder grounds) make up the natural and anthropogenic linear landscape elements (LLEs). All maps were derived and the model was run at a spatial resolution of 5 x 5 meters. Results showed that the average IC for each sub-catchment increased with increasing the area of the sub-catchments and increasing the density of LLEs. Moreover, the sediment and runoff connectivity increased with the decrease of the percentage of the study area covered with natural vegetation. Higher connectivity was also described with increasing the mean slope steepness and decreasing the length of the mean stream for each sub-catchment. Hence, under similar topographic conditions deposition-prone areas are more frequent in those sub-catchments where linear landscape elements are scarce and natural vegetation prevails against agricultural land uses. The IC model successfully represented the intense hydrological connectivity processes that take place in the irrigation channels and in the walls of the agricultural terraces showing a good agreement between the model predictions and the field observations. On the other hand, the vegetation factor (type, location and extension of the patches of the different land uses) appeared to be as important as the presence and density of LLEs to explain the spatial variability of the connectivity at catchment scale. The IC provides an estimate of the potential connection between the soil eroded from hillsides and the stream system and thus it becomes an excellent tool to improve and validate the models of soil erosion and deposition. Correlation of the values of the IC was very good with available data of soil erosion predicted with the RMMF model (López-Vicente and Navas, 2010; Environ. Earth Sci. 61(1): 143–158) in the same study area (r = 0,85). We propose that the IC model will be of interest in further research to improve the description of the processes of soil redistribution and deposition and thus make more valuable the predictions of the RMMF model and other models of soil erosion that usually do not consider the processes of soil particle deposition. The information gained in this study is of special relevance in areas disturbed by humans and those with complex topography such as most of the productive agro-ecosystems in all the countries.