Geophysical Research Abstracts
Vol. 16, EGU2014-5582, 2014
EGU General Assembly 2014

Application and testing of a GIS-based sediment connectivity model in the Venosta valley (Eastern Italian Alps)

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Sediment connectivity plays a significant role in geomorphic systems since it reflects the potential of sediment, deriving from soil erosion and remobilization of storages, to be transferred within or between landscape compartments. Understanding sediment movement and delivery to given areas of interest or sinks (e.g. channel network, urbanized area, catchment outlet) is an important issue for efficient management strategies. Thanks to the availability of high-resolution Digital Terrain Models (DTMs) different methods for mapping connectivity have been developed, but few examples of their application over large areas are available so far.

In this study, a GIS-based model of sediment connectivity developed following the approach of Borselli et al. (2008) with ad hoc refinements devised to adapt the model to mountain catchments using high-resolution DTMs (Cavalli et al., 2013), has been applied to the upper and middle sectors of the Venosta Valley (1096 km^2) in the Eastern Italian Alps. The output of the model is a topography-based index aiming at evaluating the potential connection between hillslopes and features acting as targets (e.g. catchment outlet, roads) or storage areas (sinks, retention basin) for transported sediment. The index is composed by an upslope and a downslope component. The first represents the forcing for downward routing of the sediment potentially available upslope and the latter considers the flow path length that a sediment particle has to travel to reach the nearest target or sink. In both components, two weighting factors are used: the slope and a proxy of the impedance to sediment fluxes. In the application to the Venosta valley two different impedance factors were tested: one based on the surface roughness and one derived from tabled values of hydraulic roughness (Manning's n).

The main objective of the study is to test the applicability of the model to a regional context which encompasses areas with a large variability in topography and land use. In particular, the aim is to investigate the effect of DTM resolution on model results and the comparability in terms of connectivity values between catchments of different size. The latter issue was analyzed by selecting 17 catchments characterized by different size, mean slope, shape and sediment transport dynamic.

Results show that the application of the model over a large spatial scale gives a realistic spatial characterization of sediment connectivity and highlights the role of the alluvial fans in decoupling upstream catchments from floodplain. The proposed sediment connectivity appears independent from DTM resolution whereas a quite strong dependency on catchment size appears in the analysis, mainly due to the downslope component of the index. This result suggests that the model can be used to compare quantitatively only catchments of similar size. Nevertheless, it has proved very promising for a rapid spatial characterization of sediment dynamics related to some of the most important transfer processes in mountain catchments (i.e. debris flow and channelized sediment transport) in a complex and large setting as the Venosta valley.

References:

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