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A simplified GIS-based model for large wood recruitment and connectivity in mountain basins

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The mobilization of large wood (LW) elements in mountain rivers channels during floods may increase their hazard potential, especially by clogging narrow sections such as bridges. However, the prediction of LW transport magnitude during flood events is a challenging topic. Although some models on LW transport have been recently developed, the objective of this work was to generate a simplified GIS-based model to identify along the channel network the most likely LW-related critical sections during high-magnitude flood events in forested mountain basins.

Potential LW contribution generated by landsliding occurring on hillslopes is assessed using SHALSTAB stability model coupled to a GIS-based connectivity index, developed as a modification of the index proposed by Cavalli et al (2013). Connected slope-derived LW volumes are then summed at each raster cell to LW volumes generated by bank erosion along the erodibile part of river corridors, where bank erosion processes are estimated based on user-defined channel widening ratios stemming from observations following recent extreme events in mountain basins. LW volume in the channel is then routed through the stream network applying simple Boolean rules meant to capture the most important limiting transport condition in these high-energy systems at flood stage, i.e. flow width relative to log length. In addition, the role of bridges and retention check-dams in blocking floating logs is accounted for in the model, in particular bridge length and height are used to characterize their clogging susceptibility for different levels of expected LW volumes and size.

The model has been tested in the Rienz and Ahr basins (about 630 km^2 each), located in the Eastern Italian Alps. Sixty percent of the basin area is forested, and elevations range from 811 m a.s.l. to 3488 m a.s.l.. We used a 2.5 m resolution DTM and DSM, and their difference was used to calculate the canopy height. Data from 35 plots of the National Forest Inventory were used to estimate forest stand volume by a semi-empirical model. Ddatabase on shallow landslides along with precipitation depth was utilized to calibrate the parameters for the SHALSTAB model. Orthophotos (0.5 m pixel resolution) and existing technical maps were used to delimitate the channel banks, which were used to calculate automatically channel width for each grid cell.

The model output provided information about the expected volume and mean size of LW recruited and transported during a 300 yr flood event in the test basins, as well as the location of the most probable clogged sections (mostly related to infrastructures) along the channel network. The model thus shows the capability to assist river managers in identifying the most critical sections of river networks and to assess the effectiveness and location of different mitigation options such as wood retention structures or forest management practices.