In small alpine headwater catchments, an important aspect related to sediment dynamics is represented by sediment connectivity, i.e., the degree of linkage between sediment source areas and downstream areas. The context of morphological conditions on connectivity acts both through hillslope-channel coupling and decoupling, and through sediment delivery along the channel network. The spatial characterization of connectivity patterns in the catchment is fundamental in the analysis of sediment dynamics because it permits to estimate the contribution of a given part of the catchment as sediment source, and defines sediment transfer paths. The availability of high-resolution digital terrain models (DTMs), such as those derived from aerial LiDAR, improves our capability to quantitatively extensively sediment connectivity. A geomorphometric index, based on the approach proposed by Borselli et al. (2008), has been developed to assess spatial sediment connectivity and is applied to three small headwater catchments of the Eastern Alps.

The Gadria and Strimm catchments (Rhaetian Alps) have been chosen as study areas because they are two adjacent basins with contrasting morphology and affected by different types and intensities of sediment transfer processes. A third catchment, the Rio Cordon basin (Dolomites), has been selected in order to evaluate the connectivity of sediment source areas, since a detailed inventory map of sediment sources, compiled by means of field survey and LiDAR data analysis, is available.

**Spatial connectivity analysis at basin scale**

High resolution LiDAR-derived DTM of the catchments are the only input of the model. IC is defined in the range of (−∞, +∞) and connectivity increases when IC grows.

The geomorphometric analysis is then coupled with field surveys, which enable the comparison with field evidences. IC has been calculated in order to evaluate the connectivity between:

1. Headsets and outlet of the catchments (a and e) (IC outlet).
2. Headsets and sinks (IC sinks): main channels and lakes in Gadria and Strimm (b), and main channel and wetlands in Cordon (d) catchment.

**Comparison between catchments**

- The difference in IC between each pair of catchments (t-test) is statistically significant (p-value < 0.01).
- The difference is independent from the sink chosen for the computation (catchment outlet vs. main stream and lakes or wetlands).
- The Gadria basin shows highest values of IC and lowest standard deviation.
- Lower values of IC can be observed in the two bedload stream catchments.
- Strimm catchment displays the highest variability because of its elongated shape.

**Spatial connectivity analysis of sediment source areas**

The spatial connectivity index model can be also useful for the characterization of sediment source areas. In the Rio Cordon basin sediment source areas are widespread, covering an area of about 650,000 m² (12.9 % of the total basin area).

- The approach followed revealed to be very promising for the characterization of sediment dynamics in the complex morphological settings of alpine headwaters.
- The comparison between different catchments results in highest connection between hillslope and outlet or sinks for the catchment (Rio Gadria) featuring debris flow processes.
- The results of the application of the connectivity index are consistent with field observation of hillslope-channel coupling and decoupling and with evidence of transport processes (debris flow and bedload).
- Using an index of roughness as Weighting factor allows the model to be applied straightforwardly, requiring only DTM as input.

**Results**

Scatterplots of standardized IC for different types of sediment source areas versus the downstream distance to outlet. Symbols of different sizes correspond to the area of sediment sources.

- Mean changes with respect to the original model:
  - Weighting factor Wl, related to the impedance to water and sediment fluxes (e.g., USLE RUSLE in the original model), is computed using an index of residual topographic roughness (Rz):
    \[ W = 1 - \left( \frac{R_z}{R_{z,\text{ref}}} \right) \]
    With Rz defined as standard deviation of residual topographic variation in a 5x5 m moving window (Cavalli et al., 2008).
  - Slope S (m/m) ranges from 0.005 to 1. Lower limit is necessary to avoid zeros and infinites in IC calculation whereas upper limit (5 > S > 1) avoids bias due to very high values of IC on steep slopes.
  - Upslope catchment area is computed for the Dc component by using Dm flow directions (Tarboton, 1997) instead of D8 algorithm to better model orvalent flow on hillslopes.
  - The approach followed revealed to be very promising for the characterization of sediment dynamics in the complex morphological settings of alpine headwaters.
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In small alpine headwater catchments, an important aspect related to sediment dynamics is represented by sediment connectivity, i.e., the degree of linkage between sediment source areas and downstream areas. The context of morphological conditions on connectivity acts both through hillslope-channel coupling and decoupling, and through sediment delivery along the channel network. The spatial characterization of connectivity patterns in the catchment is fundamental in the analysis of sediment dynamics because it permits to estimate the contribution of a given part of the catchment as sediment source, and defines sediment transfer paths. The availability of high-resolution digital terrain models (DTMs), such as those derived from aerial LiDAR, improves our capability to quantitatively extensively sediment connectivity. A geomorphometric index, based on the approach proposed by Borselli et al. (2008), has been developed to assess spatial sediment connectivity and is applied to three small headwater catchments of the Eastern Alps.

**Introduction**

**Study areas**

**Results**

**Spatial connectivity index model**

**Conclusions**