Index of Sediment Connectivity: applications and future perspectives

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Outline of the presentation

• Index of sediment connectivity
• Tools
• Applications of the index at catchment scale
• Applications and testing of the index at regional scale
• Recent IC developments
• Final considerations and perspectives
Geomorphometric approach for the assessment of sediment connectivity

The connectivity index (IC) is computed using two components:

**Upslope component** $D_{up}$

potential for downward routing due to upslope area, mean slope and impedance factor.

**Downslope component** $D_{dn}$

flow path length that a particle has to travel to arrive to the nearest target or sink.

\[
IC = \log_{10}\left(\frac{D_{up}}{D_{dn}}\right)
\]


Slope (S) and flow direction

slope S (m/m) (steepest descent direction)
S < 0.005  => S = 0.005 to avoid \( \infty \) in the downslope component equation
S > 1  => S = 1 to limit the bias due to very high values of IC on steep slopes (e.g. rocky outcrop)

Flow direction: algorithm \( D^{\infty} \) (Tarboton, 1997)

The roughness value on each cell corresponds to the topographic variability over the investigated area (DTM resolution – moving window size)
The standardization of roughness value was introduced for three reasons:

(i) to have the same range of variation as for S factor in order to weight them equally in the model (0 – 1);

(ii) to remove the bias due to high RI values in steep areas;

(iii) to provide comparable values with USLE C-factor and therefore with the original model.

The use of a roughness index as weighting factor has several advantages:

• the weight is estimated objectively;

• it avoids the use of tabled data;

• it allows the model to be applied straightforwardly (only DTM as an input).
• Running under ArcGIS version 10.1 (with SP1!) and 10.2.
• It requires the installation of TauDEM 5.1 http://hydrology.usu.edu/taudem/taudem5/downloads.html
Open-source implementation (SedInConnect 2.0)

- It avoids the use of commercial GIS;
- It implements the “Sink” function.

http://connecteur.info/indices/
http://www.sedalp.eu/download/tools.shtml
Application at catchment scale
Applications at catchment scale

D’Haen et al. (2013)

Messenzehl et al. (2014)

Brardinoni et al. (2015)
Venosta Valley (Eastern Italian Alps) is a typical inner-Alpine dry valley, dominated by metamorphic lithologies.

1096 km² area – LiDAR DTM with 2.5 m resolution
IC vs. DTM resolution

- slight increase in IC values with decreasing resolution;
- more evident for the application of IC with regard to the Adige River;
- simplification of the flow paths due to increased cell size leads to an increase of IC values.
• different pattern when different impedance factors are used;
• overall lower IC values with Manning’s n.
Target: catchment outlet (fan apex)

When analyzing separately $Dup$ and $Ddn$:
• no relationship is observed between $Dup$ and catchment area;
• data show a positive correlation between $Ddn$ and catchment area.
Recent index developments

Sediment Connectivity Index

Channel width Model

Stream Power Model

Recent index developments

Sediment Connectivity Index

Channel width Model

Stream Power Model

Structural connectivity ➔ Functional connectivity

in collaboration with S. Keesstra and F. Comiti
Flood hazard along roads

Statistical modelling approach based on the identification of the Physical Catchment Descriptors (PCDs) (Kalantari et al., 2014) applied to 10 catchments in Western Sweden affected by a flood event in August 2004.


In collaboration with Z. Kalantari and C. Cantone
Final considerations and perspectives

• IC has proved very promising for a rapid spatial characterization of sediment dynamics both at catchment and regional scales;

• An integrated approach, encompassing sediment sources mapping and connectivity assessment, can improve hazard and risk assessment;

• Quality and resolution of DEM has a strong effect on IC results;

• Being a topography-based index, IC is focused on structural aspects of connectivity. Future development should also consider process-based connectivity and incorporate temporal variability;

• Indices need models to a certain degree; are there models that might need indices as parameters?

From static to dynamic
Thank you for your attention!

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