Numerical modeling of fluvial processes and calibration of bedrock erodabilities in Andean basins.

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A forward numerical model is presented to estimate denudation rates in mountain ranges. The model integrates bedrock erodability, runoff rate, drainage area and local terrain slope to obtain values of fluvial erosion/sedimentation for each point. The algorithm applied is the stream power-law investigated previously by many authors (e.g. Tucker and Singerland, 1996, Whipple and Tucker, 1999). The model is useful for large spatial and long geological time-scales simulations rather than to describe transport processes at small scale. The computational mesh used in the model is a 90-m SRTM DEM of the eastern flank of the Bolivian Central Andes.

For each cell the model calculates the local terrain slope (S), the steepest descent routing, and the water discharge (Q) by multiplying the contributing drainage area with effective runoff rate (R^P). The exponent p used is 0.65 and reflects how diminish the influence of the precipitation in water discharge with its increment. This value was determined using empirical data from Andean denudation rates (Aalto *et al.*, 2006).

The dominant fluvial transport behavior in high mountain landscapes is the detachment-limited bedrock channels (Howard, 1994). In this situation the volume of sediment supplied from upstream cells is small or the thickness of the movable sediment cover on the channel is negligible. The rate of channel incision by bedrock erosion is then determined.

$$\frac{dh}{dt} = (S^m Q^n - T_h - Q_s)\, K_e$$

where m and n have values of 2/3 and 1/3 respectively. Those values were obtained from previous studies (Howard, 1994). T_h is a critical threshold stress to initiate motion and takes values of 1 m yr^{-1} (Tucker and Singerland, 1997). The variable Q_s is the net sediment charge that the stream is carrying from the watershed and K_e (yr^{-1}) is the bedrock erodability.

Published data of denudation rates measured in Andean mountain basins (Aalto *et al.*, 2006) were used to calibrate bedrock erodabilities by inversion of the stream power-law equation. Denudation rates for other drainage basins can be obtained once all erodabilities are calibrated.

References

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