Geophysical Research Abstracts
Vol. 17, EGU2015-3558, 2015
EGU General Assembly 2015

The resilience of river valleys to deformation in experiments: competition between tectonic advection and channel dynamics

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In oblique collision settings, parallel and perpendicular components of the relative plate motion can be partitioned into different structures of deformation and may be localized close to the plate boundary, or distributed on a wider region. In the Southern Alps of New Zealand, it has been proposed that two-third of the regional convergence was accommodated by the Alpine Fault, while the remaining motion was distributed in a broad area along the Southern Alps orogenic wedge. To better document and understand the regional dynamics of such systems, reliable markers of the horizontal tectonic motion over geological time scales are needed.
In numerical models, it has been shown that river networks are able to record a large amount of distributed strain, and that they can thus be used to reconstruct the mode and rate of distribution away from major active structures (Castelltort et al, NGeo, 2012). In order to explore the controls on river resilience to deformation in a less constrained system, we developed an experimental model to investigate river pattern evolution over a doubly-vergent orogenic wedge growing in a context of oblique convergence. We use a rain-fall system to activate erosion, sediment transport and river development on the model surface. The evolution of the wedge is fully recorded through space and time so we are able to follow the drainage geometry deformation.
These experiments confirm that rivers record the distribution of motion along the wedge. Image analysis of channel time-space evolution shows how the fault-parallel and fault-perpendicular components of motion decrease toward the fault and impose rotation to the main trunk valleys. However, the capacity of rivers to act as passive markers of deformation competes with the natural lateral channel dynamics and hillslope-channel couplings which both modify the valleys boundaries. In this sense rivers are dynamic markers, which write both a story of passive rotation imposed by the tectonic velocity field and a story of their own dynamics.

References:
Castelltort et al, NGeo, 2012. River drainage patterns in the New Zealand Alps primarily controlled by plate tectonic strain.