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Advection and evolution of river basins in mountain ranges.

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Fluvial networks determine to a large extent the structure and geometry of erosive landscapes in mountain ranges. As a consequence it is fundamental to understand how they develop in order to reconstruct and predict landscape evolution in orogens. A particularly important problem with relevance for our future ability of "inverting" landscapes is the degree to which fluvial networks and basin boundaries evolve and change with time. The key question is: are river valleys and basins largely static in the landscape or are they rather dynamic, changing and reorganizing frequently during orogen evolution? A "dynamic" view has long found support in a variety of observations (wind gaps, hanging valleys, inferred changes of sources of clastics) interpreted as evidences of river captures and drainage network changes, and has been reproduced in certain analogue and numerical models. It also seems intuitively reasonable when considered in parallel with the high magnitude and frequency of cenozoic climatic changes combined with the very high rates of vertical and horizontal movements of rocks in active orogens which suggest that landscapes may have changed congruently.
However, support for a "static" view has also long existed based on the ubiquitous observation of antecedent rivers and drainage systems cutting through lithological and geological structures (folds and faults), extending behind the main drainage divide in large mountain ranges, or the preservation of superficial cover rocks adjacent to valleys deeply incised into the basement. Spectacular plane deformation of large river basins in the East Himalayan syntaxis also illustrates the possible difficulty encountered by river systems to reorganize (Hallet and Molnar 2001). In the debate over the mechanisms responsible for the consistent width-to-length aspect of the main transverse river basins observed in linear mountain belts of different ages, width and tectonic and climatic regimes (Hovius, 1996), Castelltort and Simpson (2006) have proposed a mechanism which involves (1) the idea that river networks in the lowland plains are incorporated in the orogen as it widens, and (2) that they do not change after their incorporation, thus "importing" a geometry acquired outside of the range independently of the tectonic and climatic influences acting inside the uplifting zone. This mechanisms implies rather a "static" view of river networks which serves as an alternative to models in which river networks continuously reorganize inside uplifting topography in such a way as to maintain a statistical geometry dictated solely by geomorphic processes.
In the present work our approach to this problem is to measure and compare the form of river basins in the lowlands and in the uplands of the Himalayas, New-Zealand, Taiwan, the European Alps, the Pyrenees and the Apennines. We first present the method we employ to measure the shape of river basins and the data used. Second, we analyse and discuss our results which show a correlation between the shape of networks developed in the pro-lowlands of active orogens and their upland counterparts whereas such a correlation does not exist on the retro-side of the considered orogens. Our results thus support (1) the horizontal advection of river basins from the pro-lowlands to the pro-uplands, (2) a certain amount of reorganization by widening of basin boundaries, and (3) the existence of a different mechanism of drainage network evolution in the retro-side of the orogens.

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