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Modelling landscape evolution: from simulation to inspiration

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A few decades ago, the field of geomorphology experienced a rapid transformation with the advent of new dating methods (such *U-Th/He* and cosmogenic isotope dating) and the emergence of landscape evolution models. Empirical relationships that had been proposed, sometimes a hundred years earlier, such as the apparent link between river discharge, slope and incision rate, could now be formalised, tested and constrained. Computer models played an important role in illustrating old concepts and formulating new ones, under the assumption that Earth's landscapes are shaped by the combined effects of tectonic uplift and erosional processes under a range of climatic conditions. Models also suggested that couplings and feedbacks must exist between the different processes at play, which led, for example, to suggest that the deformation of the Earth's crust and lithosphere is, in part, controlled by the intensity of erosional processes and thus climate - a postulate that has proven very difficult to demonstrate in nature.

Nowadays, landscape evolution models have been greatly enriched by the parameterisation of various processes such as glacial erosion or weathering, and attempts to include the effects of vegetation or, more generally, the biota. Models are also regarded as "integrator" of geological data that can be inverted using Bayesian and, more recently, machine learning methods to determine the range of acceptable model parameters and, most importantly, likely tectonic and climatic scenarios.

But models also continue to inspire us with new concepts and ideas. I will focus this lecture on a few questions being currently addressed in geomorphology with a special emphasis on those that involve the use of numerical methods. These are:

- How much do deep mantle processes directly contribute to Earth's surface topography and to which degree can their effects be identified in the geological record?
- How do climate and in particular climate variability affect the efficiency of erosional and transport processes at the Earth's surface and under which conditions may variability be more important than mean precipitation?
- How much does landscape evolution control the evolution of life and the spatial distribution of biodiversity and species endemism that we observe today at the Earth's surface?
- What controls the geometry of continental drainage systems and how do they respond to changes in climatic forcing, the tilting of continents or base level geometry.
- What are the surface processes at play in non-tectonic areas and how does weathering in low relief continental interiors contribute to the long-term carbon cycle and its control on Earth's climate?