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Coupled erosion-deposition numerical models as a strong tool to unravel sedimentary archives

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Erosion and sedimentation act together to shape landscape and built sedimentary archives. Evidences of erosion in catchments are often scarce and difficult to access while on the contrary, sedimentary records are often more continuous and easier to access. Sedimentary archives thus appear as great recorders of landscape evolution through time. An accurate understanding of sediment transfer from sources to sinks is nonetheless required to understand the recorded landscape evolution signal. Numerical simulations have proven to be of great support on this topic as they allow the separation of the different processes at stake and exploration of a wide range of values of the various input parameters.

Most numerical models consider separately the domain of sediment production (mountain range) from the domains of sediment accumulation (foreland or marine basins). Yet, these areas are dynamically coupled by numerous feedbacks between erosion and deposition. In addition, although each domain is dominated by one process (mountain ranges are mostly in erosion, basins are mostly in deposition), erosion and deposition can occur anywhere. In consequence, to unravel landscape history and sensitivity to external forcings from sedimentary archives, and to better understand the transfer of sediments from sources to sinks, we need to consider the coupling between erosion and deposition, along the whole sedimentary system.

To achieve this objective, we develop a new numerical landscape evolution model that accounts for both erosion and deposition onshore, as well as sediment deposition in the marine domain. To describe the sediment dynamics, we introduce a new onshore deposition coefficient that has been calibrated from field data. In the marine domain, sediment deposition is described by a diffusion equation and the diffusion coefficient has been re-calibrated from natural delta geometries. This model is highly efficient and allows for inverse simulations to be run.

The model allows to address a large variety of questions, in various setups. In this presentation, we explore the impact of perturbations in climate and in tectonics on the stratigraphic architecture, as well as on the fluxes delivered to the foreland and to the marine domain. We show for example that a given perturbation can be recorded in opposite manners in the range, the foreland or the marine domain.
Finally, applied in a specific case study, the inverse modeling is a powerful tool to determine, based on the usual sparse available data, the best possible scenarios in terms of climatic or tectonic reconstructions, or to determine the evolution of several key parameters (such as the deposition or diffusion coefficients).

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