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Impact of external forcing and catchment response on sediment flux

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Numerical modeling work (Kettner et al., 2009; van Balen et al., 2010) highlighted how major changes of sediment supply occur as a result of upstream climatic changes. On the other hand sediment budgeting work (Brommer et al., 2009; Metivier et al., 1999), evidenced the lack of an upstream sediment supply forcing signal in the marine stratigraphic record. What occurs to the sediment flux signal during its downstream propagation towards the marine domain? How is the climatic and tectonic forcing translated to a sediment flux signal and how is it modified and buffered?

Inspired by other studies focused on signal propagation in fluvial drainage systems (Jerolmack et al., 2010; Densmore et al., 2007; Veldkamp et al., 2001) and sediment flux modeling work (Boogart et al., 2003), we have developed, tested and applied a new catchment numerical modeling tool to investigate sediment flux signal generation and downstream propagation in river catchments: PaCMod.

PaCMod (Palaeo-Catchment Model) is a spatially lumped model which, based on climatic data, drainage basin characteristics and a number of user defined parameters, calculates long time series (10^3-10^6years) of fluvial water discharge and sediment load at the catchment outlet. Key aspects of the model are:

1. The influence of uplift rate on the sediment flux.
2. The delayed response of the system to perturbation and thus the importance of catchment history.
3. The lumped approach, allowing fast simulations and preserving the same level of detail from palaeo-climatic conditions and tectonic reconstructions.
4. The modeling of high magnitude low frequency events, during which most of the stratigraphy is built.

PaCMod applications using synthetic scenarios show how the sediment flux response to external forcing is highly dependent on catchment landscape reaction time. Furthermore the interaction of external forcing components produces a complex output with signal buffering or amplifications and to the alternation of supply- and transport-limited conditions. Finally PaCMod experiments show how high rates of uplift amplify the climatic signal and lead to an increase of bedload flux.

Besides being a tool to analyze catchment response and dynamics, PaCMod quantitatively predicts suspended load and bedload sediment volumes. This makes it suitable for studying real world cases and to feed fluvial and deltaic stratigraphic models (de Jager G. (submitted abstract)).

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