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Climate, sea level and tectonics signal propagation – an analysis using 2DStratSim: a source-to-sink numerical model

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Introduction

Changes in the sediment record have been attributed to a variety of processes: climate, sea level, tectonics, storm events as well as autocyclicity (Leeder et al. 1998; Métivier et al. 1999; Clift 2006). However it is very difficult to relate individual beds or trends to their respective forcing. In some cases no representation of the original signal can be found (Brommer et al. 2009). Here an analysis is presented using the new source-to-sink model 2DStratSim to examine how different processes influence climate signal propagation from catchment to marine deposition.

Method

2DStratSim is a process-response model that simulates sediment deposition and transportation in a wave influenced fluvial marine system with attached floodplain. The model consists of three two-dimensional vertical modules: floodplain, delta and bar. Sediment and water fluxes from an external catchment are first transported along a floodplain, where storage and erosion can take place. The floodplain transports the fluxes to the delta module, where the majority of sediments are deposited. A fraction is also transported by long-shore currents to the bar module.

The simple 2D algorithms of 2DStratSim allow for very short run times, approximately 5 seconds for 1000 time steps, whilst retaining all important process interactions and generating realistic stratigraphy. The short computing time will allow future inversion applications, as these will require many ($>$ 100.000) model runs.

Results

Sediment and water fluxes from a catchment model (PACMOD) which is experiencing climate change (Forzoni et al. 2011) are passed onto 2DStratSim, where the expression of the climate signal is examined under various settings: presence of a floodplain, wave erosion, sea-level change and floodplain fault activity.

When sedimentation takes place on the delta without any secondary perturbation, the climate signal is clearly visible in the modelled stratigraphy. However, each added process was shown to alter the pattern in characteristic ways:

- The floodplain is sensitive to flood events, causing previously stored sediment to be washed to the delta. This is expressed in the delta by numerous coarse grained beds.
- Wave erosion causes a removal of fine sediment above the storm wave base. Under some settings this causes inversion of the sedimentary signal: a coarse wedge of sediments forms during small supply of coarse sediment, caused by a complex series of process interactions. Below the wave base sedimentation is not perturbed.
- Sea level change further obscured the climate signal, mainly due to the creation of unconformities.
- The presence of an active floodplain fault overprints the climate signal with locally derived pulses of coarse material.

The climate signal under influence of secondary processes is obscured in various, but predictable, ways. This shows promise for model inversion schemes.

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