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Complex behaviour of a modelled fluvial system under Holocene environmental change

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The fluvial system is composed of a large number of interconnected processes that are active on the floodplain, for instance sediment transport and river avulsions. It is driven by external controls, in particular base level change, water supply and sediment supply from upstream. These controls vary over time as a result of environmental change. Internal controls are the processes of the system itself, and their interactions. Important system dynamics that represent the behaviour of a fluvial system are the evolution of the network of channel belts, the timing and location of avulsions, and the spatio-temporal patterns of erosion and deposition. The key question addressed in this presentation is whether these system dynamics are mainly determined by the external controls or by internal controls.

We use a new process-based model of the fluvial system that incorporates sediment transport in a network of channel belts, and evolution of the channel-belt network as a result of bifurcation and avulsion. In addition, the model simulates spatial patterns of overbank deposition and includes a surface runoff model for simulation of erosion on hill slopes. These interconnected processes are driven by external controls that can be defined as boundary conditions of the model. The model stores erosion and sedimentation as a 3D block of sediments, which is important to study the effect of floodplain dynamics on alluvial architecture.

The model is run for scenarios with an increase in base level or sediment supply over a time period of 10.000 years, using the rising limb of a sinuous curve. It is shown that

the type of external control is an important determinant of floodplain dynamics. An increase in sediment supply generates nodal point avulsions, and depositional patterns typical for alluvial fans, while an increase in base level generates avulsions over the whole floodplain and different depositional patterns.

Although different external controls create different floodplain dynamics, this is not at all obvious for different rates of change in a single external control. Temporal variation in key variables such as channel avulsion frequency, number of co-existing channels on the floodplain, and average sedimentation rate are observed that have a random character with a periodicity much shorter than the imposed periodicity of the change in the external controls. This short range variation in system dynamics is caused by internal forcing, consisting of negative and positive feedback loops that can be deduced from the interactions between the model components.

The results of this modelling study are relevant for interpretation of fluvial sequences. Under the assumption of a correct representation of processes in the model, it is shown that internal forcing has a major effect on floodplain dynamics and thus the alluvial architecture generated. Hence, the relation between environmental change and the resulting alluvial architecture is very complex and might in many cases be overshadowed by internal controls.