Geophysical Research Abstracts
Vol. 13, EGU2011-7077, 2011
EGU General Assembly 2011

An integrated source-to-sink model simulating sediment flux through a river system and fluvio-deltaic stratigraphy

Andrea Forzoni, Gerben de Jager, and Joep Storms
Netherlands (a.forzoni@tudelft.nl)

The evolution of fluvio-deltaic and shallow marine sedimentary systems is primarily controlled by eustatic sea level, tectonics and sediment supply. The first two variables are generally well constrained, but it is very difficult to reconstruct the amount of sediment transported by rivers over time. Therefore, in order to reconstruct such sediment flux signal and its variability on geological time scales, a source-to-sink numerical model has been developed.

The model simulates two linked sedimentary environment (floodplain and delta-shelf system) by mimicking sediment erosion, transport and deposition and the associated stratigraphy on a 2D downslope profile. The 3D spatial variability of field data and sedimentary processes are collapsed into two dimensions using averaging techniques parameterized descriptions of sediment transport principles (behavior modeling approach). The model structure is a coupled version of the existing DELTASIM (Overeem et al., 2003) and two newly developed modules: a floodplain module and a 1D catchment module CATCHMOD.

CATCHMOD is able to calculate long ($>10^3$ y) time series of daily fluvial discharge and sediment load values, both as suspended load and bedload, as a function of climate, tectonics and catchment properties. It applies to the upstream, erosion-dominated area of a river system. The hydrological and sediment routines are based on PALEOFLOW (Bogaart et al., 2003) and on the BQART model (Syvitski and Milliman, 2007). Realistic palaeo-weather conditions are produced using general global circulation models predictions and palaeo-environmental reconstructions, which are interpolated by using a stochastic weather generator. Regional tectonic activity, derived from geomorphological and seismological data, is assumed to control the rate of sediment production (changes in weathering rate) and the transport capacity (changes in relief and slopes). The main catchment properties are calculated based on a digital elevation model. CATCHMOD was tested on two present day fluvial systems, the Meuse and the Po river, and its results matched closely the measured data. Fluvial discharge and sediment load volumes from CATCHMOD are used as input for the floodplain module, which acts as a transfer/buffer of sediment from the upstream reaches to the delta. Fluvio-deltaic processes and stratigraphy in a fluvial-dominated delta-shelf environment are simulated in DELTASIM.

The coupled modules have been applied for both hypothetic and real world scenarios in order to investigate their response to different climatic conditions, tectonics and sea level changes. The different experiments showed the ability of the models to reproduce distinct stratigraphic patterns and, in detail, to model the effect of high-magnitude low-frequency events (floods, storms) in the stratigraphic record. Sediment flux signals are attenuated and shifted through time by floodplain sediment storage/erosion and by shallow marine reworking. This implies that the external forcing on the system can be extracted from stratigraphic data in an inversion scheme (Charvin et al., 2008).

References

Bogaart, P. W., van Balen, R. T., Kasse, C., and Vandenberghe, J. 2003. Process-based modelling of fluvial system response to rapid climate change—I: model formulation and generic applications. Quaternary Science reviews 22: 2077-2095.

Charvin, K., Gallagher, K., Hampson, G. L., and Labourdette, R. 2008. A Bayesian approach to inverse modelling of stratigraphy, part 1: method. Basin Research 21(1): 5-25.

Overeem, I., Veldkamp, A., Tebbens, L., and Kroonenberg, S. B. 2003. Modelling Holocene stratigraphy and depocentre migration of the Volga delta due to Caspian Sea-level change. Sedimentary Geology 159: 159-175.

Syvitski, J. P. M.and Milliman, J. D. 2007. Geology, geography and humans battle for dominance over the delivery of fluvial sediment to the coastal ocean. Journal of Geology 115: 1-19.