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Modelling sediment transport on three scales - a case study in the German lowlands

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Water induced movement of sediment through the landscape affects human activities and biota from the macroscale down to the microscale. Erosion in agriculturally used catchments directly impacts farming practices and influences stream and river sediment processes through the input of nutrient-loaded fine sediment. Instream erosion and deposition processes can alter conveyance, cause undesired siltation or damage waterways and hydraulic structures. In the aquatic ecosystem, instream sediment dynamics, substrate properties and its (in-)stability are important characteristics determining species habitats. In the 50km^2 Kielstau catchment located in the northern German lowlands we have investigated and modelled sediment transport on different scales in order to assess the mentioned effects.

On the catchment scale, erosion from fields has been modelled with the Soil and Water Assessment Tool (SWAT, Arnold et al. 1998). Impact of artificial tile drainages on the sediment load have been assessed with a GIS-based tool utilizing empirical relationships and erosion prediction formulas (SEPAL, Kiesel et al. 2009). Transport processes in the stream channel of the main river reach have been depicted with the one dimensional River Analysis System (HEC-RAS, USACE 2010) and the implemented Toffaleti sediment transport formula. Substrate stability and siltation have been modelled on a 150m long stream section with the two dimensional Adaptive Hydraulics Modelling System (ADH, Berger and Tate 2010). The freely available models are linked in the ArcGIS environment where data exchange is enabled. The simulation methodology, including input data, model setup, calibration and coupling is described for the different model applications.

Results show that modelled to measured sediment loads as well as the temporal dynamics are consistent. Catchment sediment input from agricultural fields and drainages are a minor contributor to total sediment fluxes at the catchment outlet while major sediment sources are the rivers banks. As can be anticipated for lowland regions, model results show that interference of field erosion with farming practices is marginal. However, siltation of lakes and downstream reaches is caused by instream movable sediment, which is mostly made of fine sand and smaller particle sizes. Findings from the two dimensional hydraulic simulation on the micro scale include detailed spatial distributions of substrate changes caused by certain flow stages and according sediment loads. The described methodology gives a practical example of sediment transport modelling from the micro- to the macroscale. Emphasis should be paid to an extensive and sound database which is crucial for a successful model application.