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Automatic calibration of an erosion and sediment yield distributed conceptual model: application to the Goodwin Creek experimental river basin (USA)

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In the last decades, distributed hydrological models have achieved a fundamental importance in Hydrology, mainly for their capacity to describe the spatial variability of the basin processes. TETIS is a distributed conceptual model created to simulate rainfall-runoff processes.
In the same way, a distributed approach to erosion and sediment yield modelling can lead to improvements for the solution of several sedimentological and geomorphological problems, such as sediment redistribution, localization of heavy erosion and soil loss zones, estimation of soil erosion and sediment yield and assessment of land use change effects on the sediment cycle.
Following these considerations, the TETIS model has been coupled with a sediment cycle module with the purpose of representing erosion and sediment transport at basin scale. TETIS-SED is the result of integrating the erosion submodel of CASC2D-SED into the hydrological model TETIS.
In the TETIS-SED model, the erosion/sedimentation rates are calculated as a function of the hydraulic properties of the flow, the physical properties of the soil and the surface characteristics. The modified Kilinc-Richardson equation is used to determine the upland sediment transport by grain size (silt, clay, and sand) from one cell into the next one. Sediment by size fraction is routed in the channels and the Engelund and Hansen equation is used to compute the transport capacity in one dimension. This formulation in both cases depends on hydraulic parameters (hydraulic radius, flow velocity and friction slope) and particle characteristics (specific gravity and particle diameter).
Due to the uncertainty affecting the sediment parameters, the calibration stage may be a key issue in erosion and sediment yield modelling. In the TETIS model, automatic calibration is carried out by adjusting up to 9 hydrological correction factors with an automatic calibration algorithm, the Shuffled Complex Evolution (SCE-UA). In this work, 3 sedimentological correction factors have been included in the TETIS-SED model, calibrating respectively the hillslope sediment discharge generated by sheet and rill erosion, the gully erosion capacity and the channel erosion capacity. The calibration of sediment correction factors is also carried out by means of the SCE-UA algorithm, providing shorter computational times and more accurate results.
Model sensitivity to the correction factors and to the initial conditions of available sediments has also been evaluated. In this work it is shown that the sediment initial conditions in the basin strongly affect the simulation results. Estimation of the initial available sediments has also been analysed, by using different estimation methods.
This work demonstrates that TETIS-SED is a reliable model, and that its results are satisfactory when compared to other models previously used on the selected case study (the Goodwin Creek experimental river basin, located in the US). The TETIS-SED model was consistent in reproducing both the observed sedimentographs and the observed water discharge/ sediment load relations.