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WaTEM/SEDEM's capability in simulating watershed-scale soil conservation: Using the GLUE approach to analyse the representation of in-field processes and connectivity features along thalwegs

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Testing the performance of soil erosion models against observational data is a critical step in any model application. This is particularly important when models aid land-management decisions, e.g. planning and implementing soil conservation practices in agricultural landscapes. However, observational erosion data are uncertain and typically restricted to measurements of sediment fluxes at the outlet of a system, e.g. plot or watershed. This has limited utility for testing a model's representation of landscape sediment connectivity processes, which is crucial for planning soil conservation and off-site pollution control measures. Here, the performance of a Python-implemented version of the spatially distributed soil erosion and sediment yield WaTEM/SEDEM model was evaluated for simulating sediment yields under soil conservation conditions across contrasting watersheds at an experimental farm in Southern Germany. To do so, we used an eight-year monitoring dataset (1994-2001) that includes high-resolution measurements of soil properties, plant traits, and land management operations, as well as event-based sediment yield measurements for (I) four small-scale watersheds (0.8 to 4.2 ha) primarily representing in-field erosion processes (mostly supply-limited) and (II) two cascading watersheds (5.7 to 7.8 ha) dominated by sedimentation processes along a grassed waterway (mostly transport-limited). Further, we employed a Generalised Likelihood Uncertainty Estimation (GLUE) rejectionist framework utilising Monte Carlo simulations with 25,000 iterations to condition model parameters. The model performance was evaluated across two spatial scales - from individual watersheds to aggregated supply-limited and transport-limited watershed groups - and temporal scales ranging from single-year to eight-year averages. Model iterations were considered as behavioural when their simulated sediment yields fell within an estimated error range derived from the monitoring dataset. The model demonstrated capability in simulating low sediment yields when aggregated spatially and temporally. However, the annual-scale model applications were rejected due to insufficient representation of temporal dynamics. The results indicated a systematic overestimation of sediment yields across most watersheds, with a notable exception in one transport-limited catchment where underestimation occurred. The influence of retention features within watersheds was reflected by the behavioural parameter selection: in cases of sediment yield overestimation, parameters enhancing deposition produced superior results, while

in watersheds with underestimated sediment yields, parameters reducing deposition improved model performance. These observations underscore the model's capability to represent low sediment yields in agricultural landscapes under soil conservation while highlighting temporal resolution limitations and the importance of comprehensive uncertainty analysis in measured and simulated data.