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Investigating hydrologic and nonpoint source pollution processes under varying hydro-climatic conditions

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The dominant factors and processes in the coupled terrestrial-aquatic environment vary dramatically between different hydro-climatic conditions. However, previous research was often limited on a specific condition, lacking the understanding the relative difference which is essential to support model development, diagnostic evaluation, and to prioritize efforts in watershed management. In the hydrologic part of this study, a comparison-based procedure combining the Non-dominated sorting genetic algorithm (NSGA-II), Regional sensitivity analysis, and Generalized likelihood uncertainty estimation is developed to support parameter estimation, identify model drivers, and test the applicability of the Hydrological Simulation Program Fortran (HSPF) model in the aggregated period and various types of representative storm events. The calibrated parameters for the different conditions show marked differences and storm-dependent parameters are identified. The parameters related to gravity drainage and outflow remain significantly sensitive. Uncertainty results indicates that the performance on the aggregate condition is greatly limited by several extreme rainfall events and low flows, which reflects input and structural uncertainty to some extent. Events with relatively small and uniformly distributed precipitation are well estimated, whereas intense events are poorly estimated. For the sediment modeling, we used the time-varying and multi-timescale (TVMT) method, which incorporates the moving window approach and Fourier amplitude sensitivity test method, to characterize the temporal dynamics of parameter sensitivity at different timescales and hydro-climatic conditions. The sensitivities of parameters (SMPF, AFFIX, and COVER) directly related to the management practices increase during storm events, but are trivial in other periods. The conservation practices implemented on the overland such as contouring, strip-cropping, terracing, and tillage may be effective to mitigate erosion loadings from storm events. Grassed waterways are inferred by the identification of TAUCS, because they may keep the sediment on the bed from being scoured and thus reduce the critical shear stress. In addition, seven evaluation timescales are used to identify sensitive parameters at the short event, long event, monthly, seasonally, and yearly scales. This thorough consideration is intended to provide contrasting pictures of model response related with the peak values and long-term balance. The length of the measurements needs to be appropriate to identify the processes and parameters of interest during the design of monitoring plans. For the study of the nonpoint source (NPS) pollution, the HSPF model is first calibrated and validated to cope with various types of events. The corresponding relationship between the NPS pollution characteristics, the storm event factors, and anthropogenic factors are explored. The antecedent precipitation index, maximum rainfall intensity, and fertilizer rate are the most important factors on the NPS pollution export.