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A fully integrated surface-subsurface flow model for assessment of hydrologic impacts of drainage systems in Iowa

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Recent large magnitude floods in Iowa have created a need for better understanding of the impacts of artificial drainage, especially tile drainage, on streamflow hydrology regarding its importance to the state's agricultural productivity. Apart from previous work, this study aims at extending the spatial scale of modeling capabilities from field to watershed behavior as well as representing all flow partitioning mechanisms present in drained landscapes. Thus, achievement of these goals requires quantification of spatial and temporal heterogeneity of water fluxes through use of a physically based, coupled surface water/ groundwater model. Being an advanced model in terms of these qualities, HydroGeoSphere code has been chosen as the modeling tool in this study. HyroGeoSphere simultaneously solves the flow and transport equations in surface flow, tile drain and groundwater flow pathways as well as determining the exchange fluxes between these continua. The study area to be modeled is South Fork watershed which is one of the most intensively managed agricultural areas in Midwest. Approximately 80% of the watershed being tiled, stream discharge is highly dominated by drain flow. Although previous studies have mainly focused on the subsurface drainage, we target an expanded scope to include the alterations that have been made to the surface drainage network through stream channelization and construction of drainage ditches. By including the assessment of impacts of surface intakes, drainage capacity of the subsurface drainage conveyance systems, and intensity of infield drainage systems, we seek to explore a thorough understanding of the effects of tile drains on variations in volume, rate and frequency of surface and subsurface flows as a function of the spatial scale (ranging from field to watershed extent) under a range of climatic events. Furthermore by looking at pre and post drainage alteration scenarios, we aim to describe how land use changes including drainage have altered the hydrologic behavior of South Fork watershed. In realization of these goals, a fully integrated coupled surface water/ groundwater model has been developed for the study area using HydroGeoSphere code. The model includes 2D overland flow, 3D groundwater flow components combined with 1D tile flow. In order to enhance validation of the model, (in addition to existing data) selected field monitoring is planned. Hydraulic head distributions and nested discharge data (tile flow, surface flow, streamflow) and stable isotopes of water collected at different spatial scales will be utilized for calibration purposes. We anticipate the results of the model to serve as a guideline to develop control measures for future flooding events as well as inform water resources and land management practices.