INTEGRATING HYDROLOGIC AND RIVER OPERATIONS MODELING WITH EXPLICIT SIMULATION OF GROUNDWATER AND SURFACE-WATER EXCHANGE

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Abstract: Existing hydrologic/river-operations model couplings found in the scientific literature adopt a feed-forward approach for updating groundwater surface-water (GW-SW) interactions in the operation component of the coupling, and likewise, for updating simulated diversions (including pumping) in the hydrologic model. In many western US river basins, where GW-SW is a significant component of the overall river budget, it is increasingly important to more accurately account for groundwater returns under increased climate variability and changes in groundwater and surface water management. Because standard functionality available in today's river operation models simulate GW-SW interaction using simplified one-dimensional equations or estimated stream-depletion factors, they do not accurately account for the spatially and temporally distributed influence of groundwater on operations, especially during periods of low-flow. To address this weakness, a generalized river basin Decision Support System and network flow model (MODSIM) is integrated with the modular three-dimensional groundwater flow model (MODFLOW). MODSIM is a river basin management decision support system capable of simulating complex administration of water rights and agreements in large-scale surface-water networks. MODFLOW is a physically-based distributed-parameter finite-difference model used for simulating groundwater systems. The strengths of each code compliment the current weaknesses of the other. That is, MODSIM's inability to simulate spatially-varying GW-SW interaction is a long-standing strength of MODFLOW through the use of the lake (LAK) and stream flow-routing (SFR2) packages. Conversely, MODSIM is well-equipped to administer available river flow and storage accounts among spatially distributed diversions and reservoirs while honoring the constraints of prior appropriation doctrine and in-stream flow requirements. Multiple attempts to inform river operations models with MODFLOW output have been found in the scientific literature, but the feed-forward nature of such attempts fails to synchronize their respective solutions. Recent efforts have focused on iteratively passing information (i.e., GW-SW exchanges, canal diversion amounts, reservoir releases) between MODSIM and MODFLOW in memory to achieve synchronization between the respective model solutions before advancing to the next time-step. To accomplish this goal, the Lake (LAK) and Streamflow-Routing (SFR2) packages available with MODFLOW were integrated with MODSIM. The newly developed code will provide water planners and managers in over-appropriated systems with a more robust decision making support tool than is possible with either model applied independently or run using a feed-forward implementation. A demonstration of third-party injuries (i.e., those not directly involved in the transfer of water use) resulting from proposed alternative management interventions during periods of low-flow is demonstrated with an example model.