Assessing groundwater surface water interactions using an integrated hydrologic model of the Continental US

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We evaluate groundwater surface water interactions using the first high-resolution integrated hydrologic model of the continental US developed for Use Case 3 of the Interoperable Design of Extreme-scale Application Software (IDEAS) project. Spatial patterns in the physical controls of groundwater depth and flux are assessed using a steady state predevelopment simulation. Results illustrate clear multi scale behavior and regional shifts in the relative control of topography, geology and climate on groundwater. In agreement with previous studies, this simulation demonstrates relatively greater topographic control and more significant groundwater exchanges along streams in the arid west than in the humid east. Dynamic interactions from the groundwater to the land surface are simulated using ParFlow-CLM for a one-year transient simulation spanning water year 1985. Model outputs are validated against more than 30,000 groundwater and surface water gauges with available observations for the simulation period. We use the combination of high-resolution (1 km^2) outputs covering a large spatial extent (~6.3 million km^2) to characterize groundwater surface water exchanges across a broad range of hydroclimatic settings and spatial scales.

Building from the existing CONUS model, we are also working with an interdisciplinary team to expand the domain from coast-to-coast and increase the spatial resolution to 250 m^2. Information on aquifer characteristics, such as thickness and conductivities, was not previously available at this level of detail and is needed to improve model performance. As a next step towards the development of a hyper-resolution model for the US, we developed the first US aquifer map including information on aquifer thicknesses and spatial distribution of alluvial aquifer systems and consolidated aquifers. The aquifer map is based on a combination of USGS data on spatial distribution and reported thicknesses of the upper alluvial aquifers, and an estimate of local river valley thicknesses, mainly based on terrain attributes. Consolidated aquifer thicknesses were estimated assuming declining conductivities with increasing depth. The new aquifer map will be incorporated into the expanded ParFlow-CLM model and used to evaluate the impacts of aquifer parameterization on simulated groundwater surface water interactions. Overall, the progress made in Use Case 3 highlights advances in large scale integrated modeling and the potential for such tools to improve our understanding hydrologic interactions and sensitiveness at unprecedented scales.