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Using a parallel Surface-Subsurface Flow Model to assess the Effects of geologic Heterogeneity on River-Aquifer Exchange

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Geologic heterogeneity is a key component controlling river re- and discharge processes and is therefore of great importance for water- and ecological management of river systems. The subsurface distribution of high and low permeability zones can result in preferential flow paths and the formation of perched aquifers (in hydraulically disconnected reaches), both of which have an important influence on river gains and losses (seepage) from or to the aquifer. Spatial patterns of these connected zones of high and low hydraulic permeabilities are a result of the former sedimentological environment. In alluvial systems patterns with strong permeability contrasts are common. Often such systems are also characterized by deep water tables due to heavy use of groundwater resulting in hydraulically disconnected reaches characterized by variably saturated flow between the river and the aquifer. How small to intermediate scale heterogeneities (20m - 2000m) in the alluvial sediments affect the spatial patterns and temporal dynamics of river-aquifer exchange in such an alluvial system was investigated with a powerful parallel computer code for surface and subsurface flow (PARFLOW). An alluvial river in California (Cosumnes River) was used as a test case. The different hydrofacies in the alluvial aquifer were characterized with a geostatistical model based on Markov chains and transition probabilities. It was assumed that within individual hydrofacies bodies hydraulic conductivity is normally distributed, which was implemented in the model through additional Gaussian simulations on a sub-grid scale. The model domain was discretisized into a uniform 20m x 50m x 0.5m grid and covers a total area o f 10 km^2. A 5 km long river reach was implemented in the center of the model domain. Transient river flow and variably saturated subsurface flows were simulated with a parallel finite difference code based

on a Newton-Krylov-multigrid solver running on a Linux cluster. The model was run for a 30-day river hydrograph with an adaptive time stepping scheme. Three different hydrofacies models were evaluated. Effects of sub-grid heterogeneity were assessed in a Monte Carlo framework. Preliminary simulation results show complex patterns of river-aquifer exchange in time and space. All models show local saturated zones that develop between the river and deeper aquifer, which account for most of the seepage and groundwater recharge. Perched zones developed between the river and deep water table with potential implications for river base flows and riparian vegetation.