Asymmetric quantification of stream-groundwater interaction based on Stream Aquifer Flow Exchange (SAFE) method

The interaction between stream and groundwater is an important component of the hydrologic cycle. The quantification of the flow exchange between streams and aquifers is critical for the conjunctive use of surface water and groundwater. Commonly, the quantification is achieved with the use of integrated surface-groundwater simulation models such as Modflow, IWFM etc. In these models the seepage (stream water loss to groundwater) is typically estimated as a function of the head difference between the stream and groundwater head and the “leakage coefficient” which is an empirical parameter estimated via calibration. In addition, these approaches cannot make a distinction between seepage occurring on the left and right side of the stream in response to different pumping/recharge stresses occurring on either side.

In this study we adopt the Stream Aquifer Flow Exchange (SAFE) method which replaces the calibrated “leakage coefficient” with a dimensionless conductance calculated based on analytical solution of the flow exchange between streams and hydraulically connected aquifers. Furthermore, the parameters of SAFE (e.g. riverbed conductivity) have a physical meaning that assist the calibration process and considers a time varying conductance for transient models. To date, the SAFE method has been developed only for structured-grid based numerical simulation codes i.e. finite difference models. Here we demonstrate the applicability of the SAFE method for both structured and unstructured (e.g. finite element) grids. In addition, we have modified the SAFE method to quantify independently the seepage occurring on the left and right side of the stream. We first applied the SAFE methodology to a hypothetical example and provide a sensitivity analysis of the method. Next, we applied the method to a real-world example to quantify stream seepage in the Central Valley alluvial basin, California, which consists of a large, interconnected network of rivers, canals, sloughs etc. The results show that SAFE is a promising approach that can provide left and right quantification of seepage discharge considering the different stresses.