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Coupling a spatio-temporally distributed soil water budget with stream-depletion functions and a groundwater numerical model to constrain stakeholder-driven management of groundwater-dependent ecosystems

Laura Foglia (1,2), Alison McNally (2), and Thomas Harter (2)

(1) Technische Universität Darmstadt, Institute of Applied Geosciences, Germany (lfoglia@ucdavis.edu), (2) University of California Davis, Land, Air and Water Resources Department

Excessive groundwater use may significantly impact groundwater dependent ecosystems through increased streamflow depletion, particularly in semi-arid and arid regions. The effects may be seasonal or long-term trends. They may be further exacerbated by climate change. Here, we develop a spatio-temporally distributed soil water budget model and that is coupled with an analytical model for stream depletion from groundwater pumping to assess seasonal impacts of groundwater pumping on streamflow during critical low flow periods. We demonstrate the applicability of the tool for the Scott Valley in Northern California, where protected salmon depend on sufficient summer streamflow, which is impacted by seasonal pumping. In this example, results suggest that increased recharge of snowmelt-driven runoff in the period immediately preceding the critical low streamflow season, and transfer of groundwater pumping during the critical period away from the stream are promising tools to address ecosystem concerns. Comparison to numerical model results suggests that the water mass balance model coupled to an analytical streamflow model provides a potentially powerful tool to build intuitive system knowledge among stakeholders enabling them to creative scenario development. Detailed impacts of management practices are evaluated with fully-three-dimensional groundwater-surface water flow model linked to the soil water budget model. Sensitivity analysis and calibration are performed on the coupled soil water budget – groundwater – surface water model. The results drive data collection efforts and are applied to develop uncertainty analyses for future scenarios.