Groundwater-Surface Water Exchange in Agro-Urban River Basins as Impacted by Climate Change

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Abstract

Integrated management of surface water and groundwater is the key to achieve sustainable water resources and secure water availability, especially in arid and semi-arid regions of the world. With generally scarce surface water resources, groundwater often is the primary source of water supply in such regions, with significant groundwater-surface water (GW/SW) interactions often occurring in irrigated regions. The objective of this study is to quantify the variation in stream seepage and groundwater discharge fluxes in an agro-urban river basin as impacted by climate change. To achieve this goal, i) an integrated hydrologic modeling code that accounts for groundwater and surface water processes and exchanges in large regional-scale managed river basins is developed for the South Platte River Basin (72,000 km^2), Colorado, and ii) possible future impacts imposed by climate change on surface water and groundwater exchange in a basin-scale complex semi-arid region is assessed. The developed updated version of SWAT-MODFLOW is forced with five different CMIP5 climate models downscaled by Multivariate Adaptive Constructed Analogs (MACA), each for two climate scenarios, RCP4.5, and RCP8.5, for 1980-2100. The projected GW/SW fluxes from 2000 through the end of the century are presented in 4 different time intervals along the South Platte River and its tributaries- current (2000-2020), near future (2021-2040), mid-century (2041-2070), and end of the century (2071-2100) in dry (February) and wet (May) months of the year. The changes in stream seepage and groundwater discharge fluxes in dry and wet months of the year follow different patterns, as groundwater discharge to streams decreases during the dry months while the water table elevation declines. Overall, under the most extreme climate condition groundwater discharge will decrease by approximately 10% by 2100.

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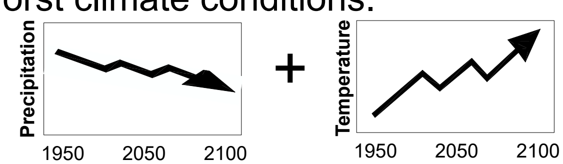
Challenges

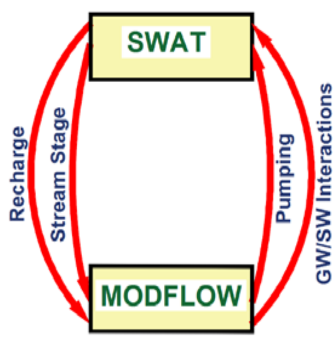
- Necessity of considering the surface water and groundwater as a holistic system.
- Necessity of applying the model at a large scale (>1000 km^2)

The developed model is tested in South Platte River basin (SPRB), Colorado and can be used in similar large agro-urban river basins across the world.

Solutions

- A hydrological modeling tool is developed (entitled SWAT-MODFLOW) that integrates groundwater (GW) and surface water (SW) in large-scale regions with urban, agricultural and industrial water demand.
- This explicit approach considers various interactions between water resources, climate, irrigation, crop yield, and human activities. All major water transfer pathways are included in the model.
- Addressing the basin-wide impacts of climate change on water availability and agricultural productivity under the worst climate conditions.





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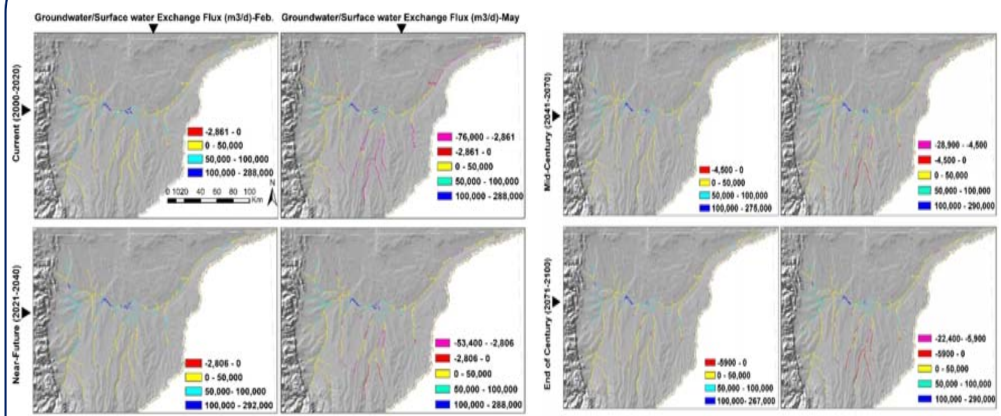
Results



Positive values show the volume of water entering the stream from the aquifer, and the negative values indicate the volume seeps from the stream to the aquifer.

		Stream Seepage (m^3/d)	Groundwater Discharge (m^3/d)
Feb.	2000-2020	-634	38600
	2021-2040	-580	39300
	2041-2070	-1070	36700
	2071-2100	-1470	35200
May	2000-2020	-16600	39400
	2021-2040	-12300	40100
	2041-2070	-6930	40400
	2071-2100	-5320	39600

Audience

- Water managers, who quantify the total available water supply in large agro-urban river basins;
- Environmental managers, who assess the risk of surface water contamination, which might be transferred by groundwater;