

Groundwater storage loss and associated streamflow declines – Implications of warming in the East River, Colorado



INARCH | Stanley, Idaho | October 10, 2023



Key Collaborators

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<u>Funding</u>: Lawrence Berkeley National Laboratory's (LBNL) WFSFA through the US Department of Energy Office of Science, Office of Biological and Environmental Research under contract DE-AC02-05CH11231.

DOE LBNL East River

Watershed Function Scientific Focus Area



Grand Challenge Question:

How do mountainous watersheds retain & release water, nutrients, carbon & metals over episodic to decadal timeframes?



Community Watershed

Atmosphere

Integrated Hydrologic

Model



Previous Work: Groundwater in Copper Creek (24 km²)



Hydrologic modeling, Particle Tracking & Gas-Tracers in Copper Creek

Carroll et al., 2020



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Carroll et al., 2019



Wet & Cool

Creek

Carroll et al., 2020



Carroll et al., 2019

Dry & Warm

Increasing Aridity





Average Basin Water Balance (% P by volume)

Sapflux--Berkelheimer et al.





Average Basin Water Balance (% P by volume)

Average Basin Water Balance (% P by volume)



Elevation Gradient = Vegetation Gradient



Elevation Gradient = Climate Gradient





Elevation Gradient is a first-order control on groundwater flow



Average Water Year

Streamflow Generation Primarily Occurs in the Forested Subalpine







Streamflow Generation Primarily Occurs in the Forested Subalpine

📕 dS 📕 ET 📕 Qgw 📕 Qfr





- Groundwater storage aggregates 4 years of climate (+1y lag) and able to modulate historical wet and dry period.
- Extremely dry water years results in large declines in groundwater storage.
- Period of low-no monsoon coupled with a very dry year produces unprecedented groundwater declines.



- With +4C warming the groundwater system exceeds historical losses after the first extremely dry water year (2002) and does not stabilize in the 36y simulation
- Groundwater storage never rebounds to the historical mean condition even with very wet periods simulated.





Groundwater declines are not uniformly distributed across space.



Jessica Lundquist (UW), Ethan Gutmann (NCAR), Oct 4, 2023



relief and conifer cover are primary predictors of decline (HUC12)

Streamflow Changes



Streamflow Changes



Key Points

Groundwater is a critical component of mountain hydrology and ignoring will underestimate streamflow declines in a warmer future.

Questions