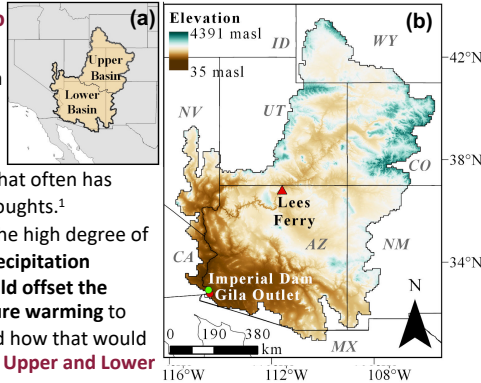


I. Introduction

The Colorado River Basin (CRB; a,b) is a major water source in the southwest United States that often has widespread droughts.¹ It is unclear if the high degree of interannual precipitation variability would offset the impacts of future warming to streamflow and how that would vary across the **Upper and Lower Basins (a)**.

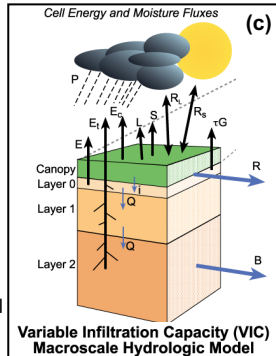


II. Modelling Approach

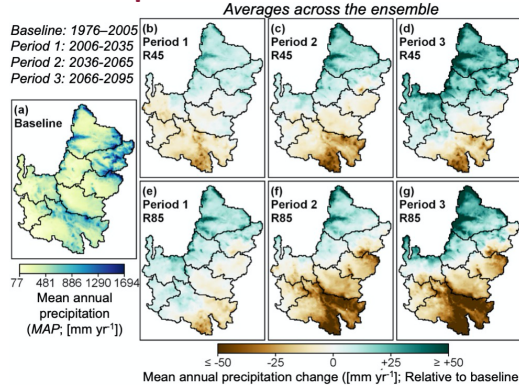
We forced the VIC model (c) with downscaled (~6 km resolution) CMIP5 outputs from eight select climate models under RCP 4.5 and 8.5 emission scenarios (R45, R85) and compared the hydrologic response across the domain.^{2,3}

Model enhancements:

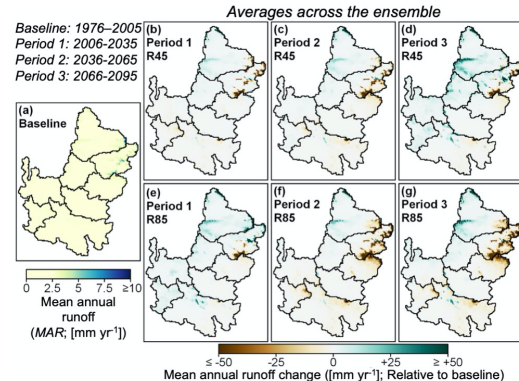
- Soil evaporation from inter-canopy spaces, delineated from MODIS products.⁴
- Spatially-distributed monthly vegetative parameters from Landsat and MODIS products.⁵
- Updated land cover classifications from 2011 NLCD and INEGI maps.⁵
- Improved hourly precipitation estimates based on meteorological station data.⁶



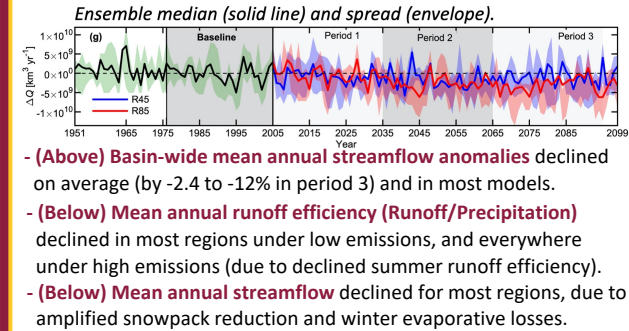
III. Impacts to Runoff Production



- (Above) Mean annual precipitation (MAP) had opposing trends between Upper and Lower Basins.
- (Below) Mean annual runoff followed MAP, but had minimal changes over 95% of the land area due to large evaporative losses.

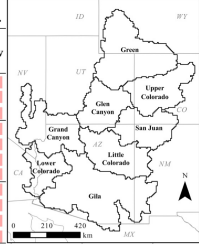


IV. Drivers of Streamflow Change



Period 3 changes relative to baseline. Averages of the ensemble.

	Low emissions (R45)		High emissions (R85)	
	Runoff efficiency (R/P)	Streamflow (Q)	Runoff efficiency (R/P)	Streamflow (Q)
Basin-Wide	-1.6%	-2.4%	-10.3%	-12.2%
Upper Basin	-3.2%	-0.5%	-12.4%	-9.8%
Lower Basin	+3.4%	-3.1%	-3.3%	-15.5%
Green	-0.2%	+4.3%	-6.7%	-0.7%
Upper Colorado	-7.2%	-4.9%	-18.8%	-18.4%
Glen Canyon	+5.1%	+12.4%	-1.8%	-3.1%
San Juan	-7.4%	-4.4%	-20.2%	-19.4%
Grand Canyon	+3.5%	+5.3%	-1.2%	-3.1%
Little Colorado	-3.9%	-11.9%	-11.3%	-31.6%
Lower Colorado	-3.9%	+6.2%	-11.3%	-10.9%
Gila	+0.8%	-14.1%	-6.2%	-31.8%



V. Summary and Conclusions

- Mean annual runoff changes were small compared to precipitation and restricted to high elevations.
- Streamflow declined from most regions and at the basin outlet under both scenarios due to large declines in runoff efficiency.
- Precipitation variability was unable to overcome the impacts of warming to streamflow (including amplified snowpack reduction and winter evaporative losses).

References (doi): ¹10.1029/2005WR004455. ²10.1029/94JD00483. ³10.1175/JHM-D-14-0236.1. ⁴10.1002/2015WR017934. ⁵10.1038/s41597-019-0150-2. ⁶10.5281/zenodo.1402223.