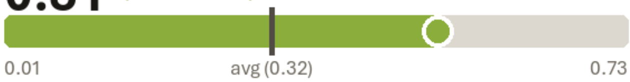
Upper San Pedro Groundwater Basin Profile

ARIZONA TRI-UNIVERSITY
RECHARGE AND WATER RELIABILITY PROJECT

Basin Summary Statistics

Size[1]: 1,820 square miles
Elevation[2]: Range: 3,309-9,453 ft; Median: 4,540 ft
Top 3 land cover types by area[3]: Shrub/Scrub (89%), Evergreen Forest (6.1%), Developed Open Space (1.8%)
Major surface watershed(s)[4]: San Pedro River
Groundwater subbasins[1]: Allen Flat, Sierra Vista
Groundwater-derived streamflow fraction[5]:

0.51 (Moderate)



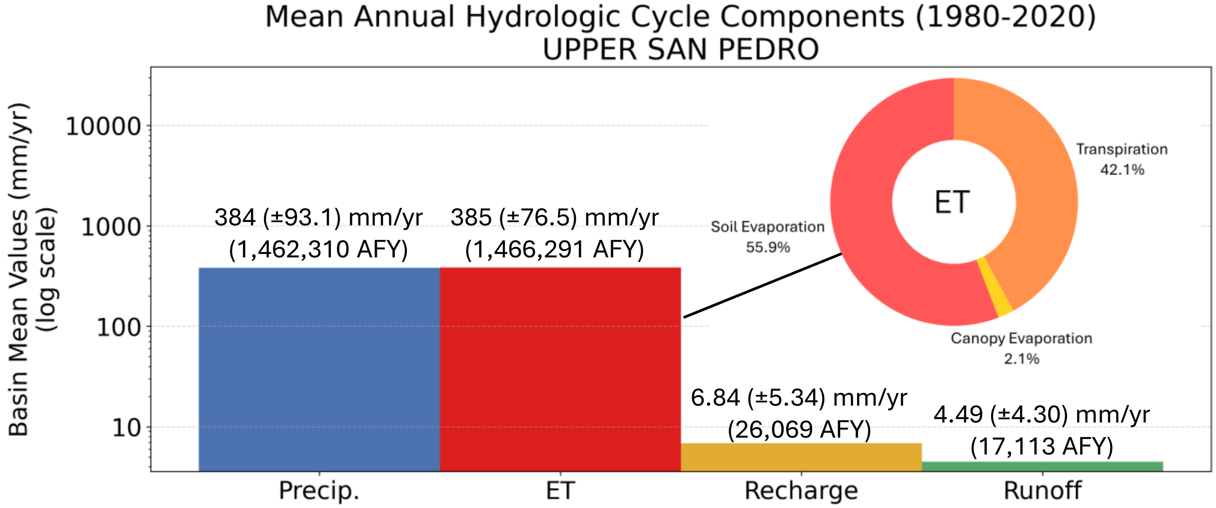


Figure 1 (above). Bar chart showing Noah-MP modeling results of the historical mean annual hydrologic cycle components (precipitation [P], evapotranspiration [ET], natural recharge, and runoff) in the basin from 1980-2020.[6] ET is partitioned into soil evaporation, canopy evaporation, and transpiration. It is possible for ET to be greater than P when there are other sources such as groundwater, surface water, or water in storage.

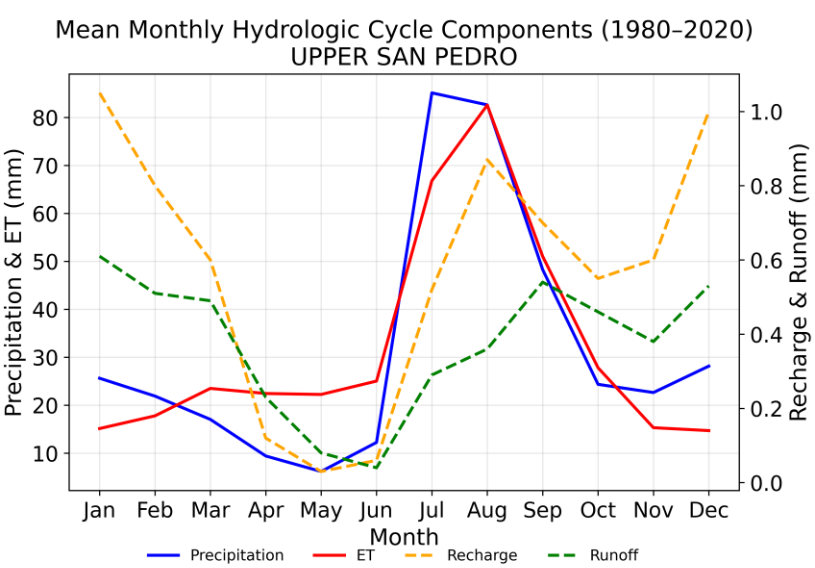


Figure 2. Graph showing monthly mean precipitation, ET, recharge, and runoff for the groundwater basin (1980-2020) from Noah-MP modeling results.[6]

On annual timescales, evapotranspiration (ET) is approximately equal to annual precipitation (P) across the basin, resulting in low basin-wide annual averages for natural recharge (6.84 mm) and runoff (4.49 mm). P in the Upper San Pedro basin is affected by the North American Monsoon during the summer months. ET approximately tracks with P throughout the year, although it exceeds P from mid-February to mid-June by as much as ~15 mm on average (in May). Soil evaporation makes up 55.9% of total ET in the basin, while transpiration comprises 42.1% and canopy evaporation accounts for the remainder (2.1%). Natural recharge and runoff are highest in January due to winter precipitation and relatively low atmospheric demand during the cooler months.

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Figure 3 (below). Gridded depiction of mean annual water fluxes across the groundwater basin from Noah-MP modeling (1980-2020): (a) precipitation, (b) evapotranspiration, (c) recharge, (d) runoff.[6] Major cities/towns[7] and Native American Reservation boundaries[8] are shown (as applicable) to help orient the reader.

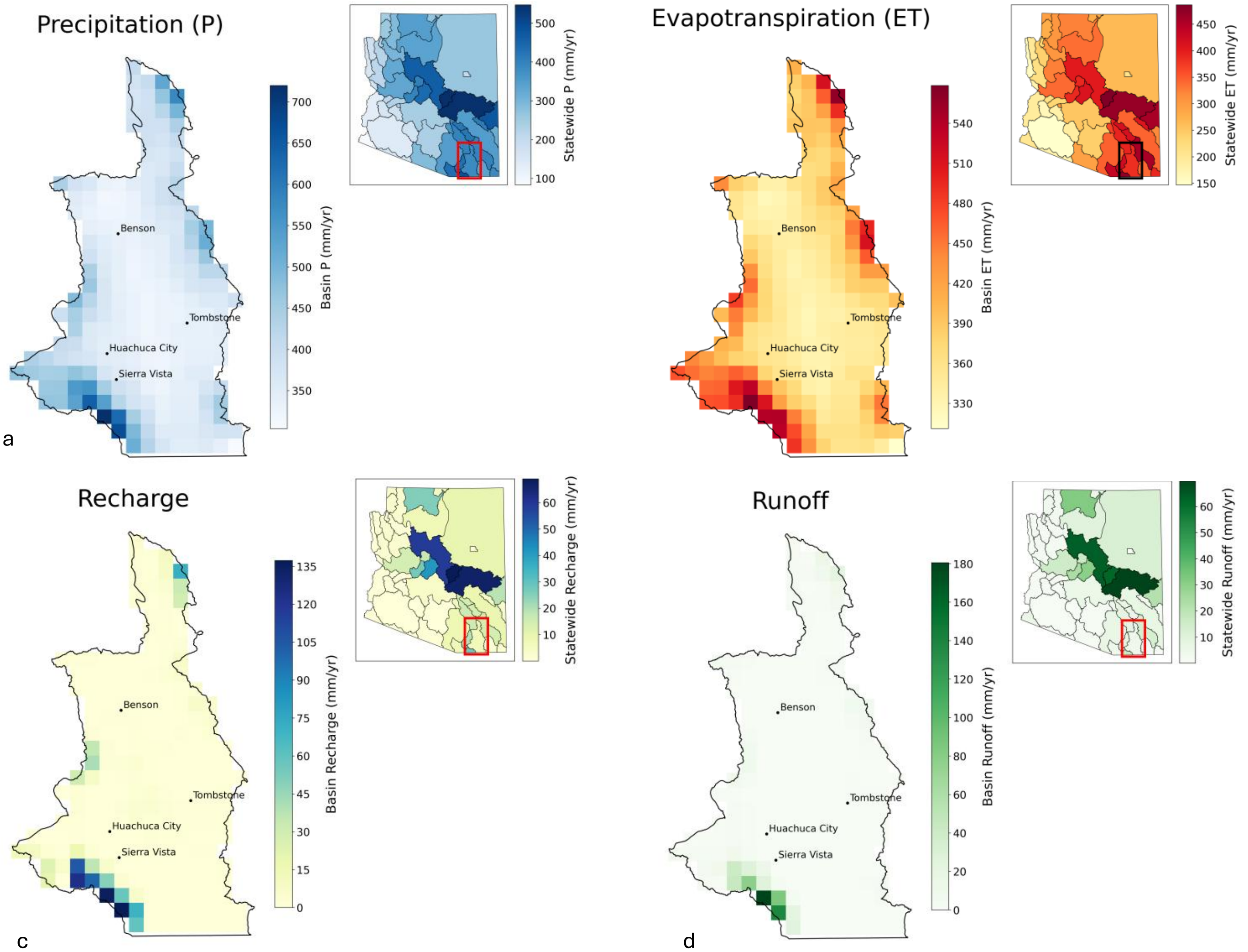
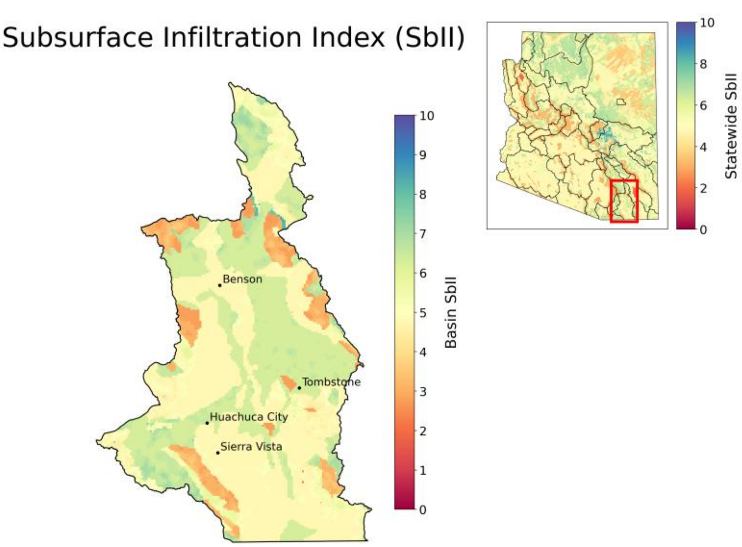


Figure 4 (below). Subsurface infiltration index (SbII) showing infiltration potential of the subsurface across the groundwater basin on a scale of 1-10 based on geologic features.[9]



The Huachuca Mountains account for the highest precipitation in the Upper San Pedro basin, receiving ~700 mm/year. These mountain woodlands also account for the highest evapotranspiration in the basin. Natural recharge and runoff are higher near the Huachuca mountain front than elsewhere in the basin (both greater than 120 mm/year). Infiltration potential varies throughout the basin, but is generally greater along the high permeability tributary alluvial fan deposits to the east and west of the San Pedro River.

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Climate Change Projections: Changes in Temperature, Precipitation, ET, Recharge, and Runoff (2060-2099 vs. 1981-2020)

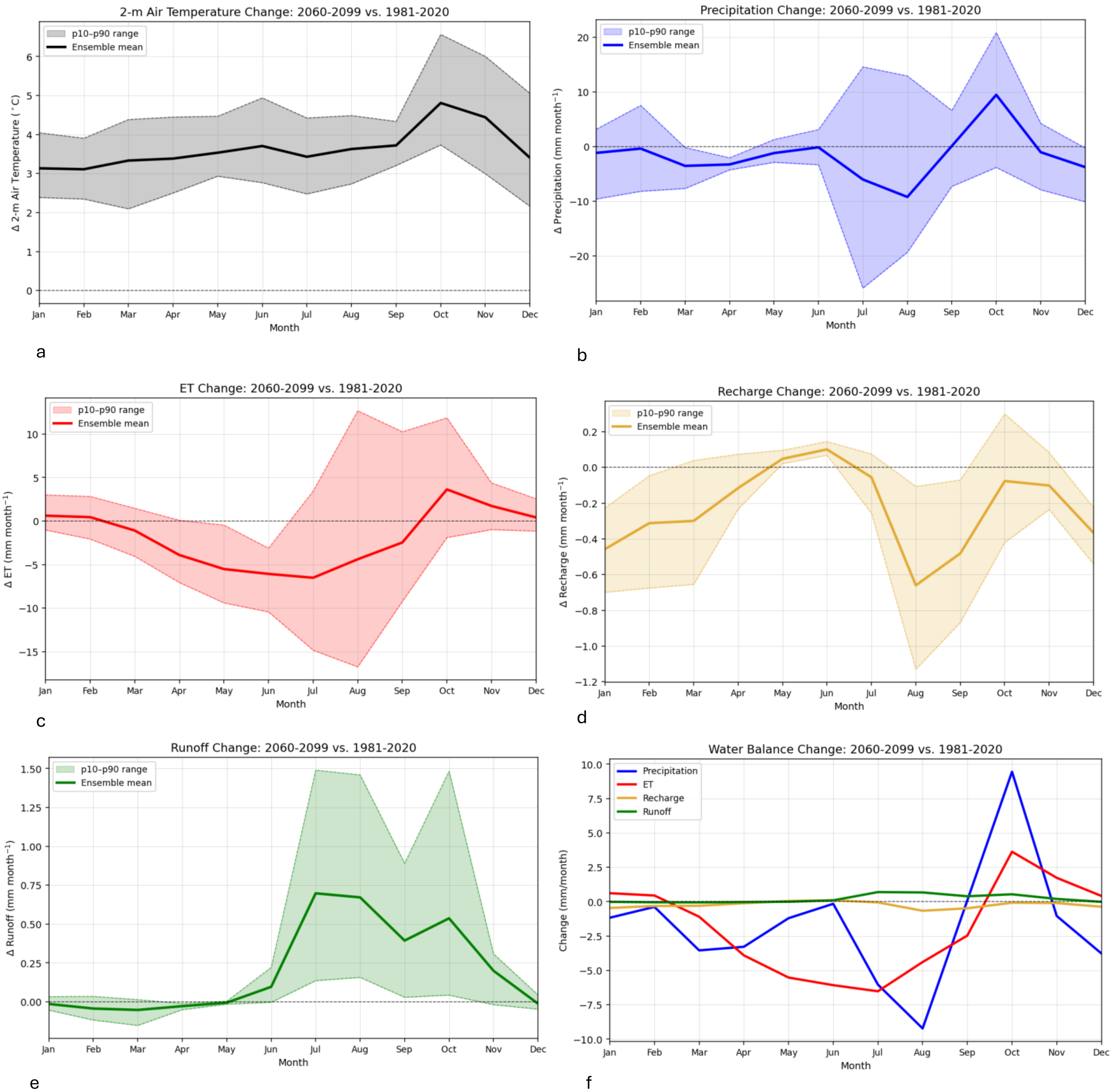

Figure 5. Plots (a)-(e) show projected changes in (a) temperature, (b) precipitation, (c) evapotranspiration (ET), (d) natural recharge, and (e) runoff statewide, comparing end of the 21st century to the historical record from 1981-2020 under the IPCC Scenario SSP3-7.0.[10] Plot (f) shows the change in the water balance components (P, ET, recharge, and runoff) on a single graph for direct comparison. The analysis uses 14 dynamically downscaled global climate models (GCM) at 9-km resolution and the Noah-MP land surface model. The ensemble mean of the 14 GCMs is shown in bold for each component of the hydrologic cycle, with the 10-90th percentile shaded to show model projection uncertainty.

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Climate change projections across the Upper San Pedro basin show drier springs (19-38% drier March through May), a drier July-August (7-11%), and a drier November-December (5-12%). October is projected to be 37% (9.6 mm) wetter on average, which is consistent with a projected increase in extreme events associated with hurricane and tropical cyclone activity by the end of the century. Declines in recharge ranging from 32-50% are projected for highest recharge months, from January to March (-0.30 to -0.47 mm/month) and August to September (-0.49 to -0.67 mm/month). Despite showing less water loss from the system (i.e., a positive increase in Figure 8(d)), recharge projections are slightly negative (-0.04 mm/month) in June.* Runoff is projected to decrease slightly January through April (-0.01 to -0.05 mm/month), while increasing by 0.10 to 0.70 mm/month from June through November. Projected increases in temperature range from approximately 3.1 °C in February to 4.8 °C in October. Higher temperatures and greater water availability from precipitation lead to a projected 12% (3.6 mm) increase in evapotranspiration (ET) in October compared to the baseline period.

*Projected negative recharge values are attributed to increased capillary rise from the aquifer through the vadose zone due to climate factors, resulting in water loss from the system. Because the Noah-MP model does not include groundwater pumping, this indicates that climate-driven factors play a significant role in groundwater storage decline in Arizona.

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