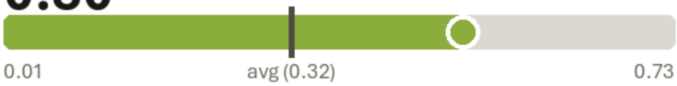
Tucson AMA
Groundwater Basin Profile

ARIZONA TRI-UNIVERSITY
RECHARGE AND WATER RELIABILITY PROJECT

Basin Summary Statistics

Size[1]: 3,870 square miles
Elevation[2]: Range: 1,772-9,347 ft; Median: 3,112 ft
Top 3 land cover types by area[3]: Shrub/Scrub (84%), Developed Low Intensity (4.6%), Developed Medium Intensity (3.0%)
Major surface watershed(s)[4]: Santa Cruz River, Rillito River
Groundwater subbasins[1]: Avra Valley, Upper Santa Cruz
Groundwater-derived streamflow fraction[5]:

0.50 (Moderate)



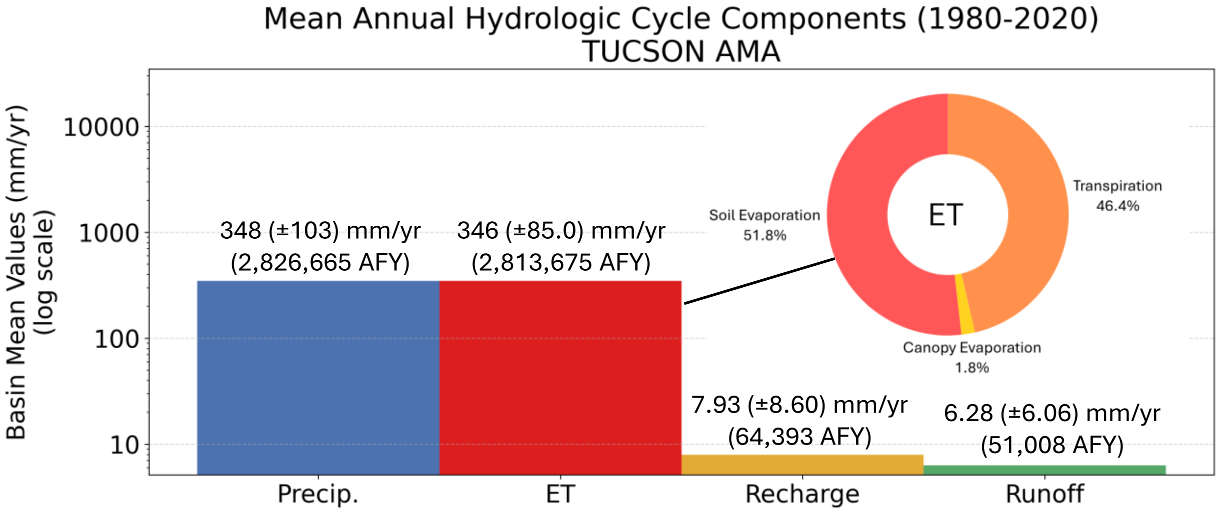


Figure 1 (above). Bar chart showing Noah-MP modeling results of the historical mean annual hydrologic cycle components (precipitation [P], evapotranspiration [ET], natural recharge, and runoff) in the basin from 1980-2020.[6] ET is partitioned into soil evaporation, canopy evaporation, and transpiration.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

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 (7.93 mm) and runoff (6.28 mm). P in the Tucson AMA is affected by the North American Monsoon during the summer months. ET tracks with P from mid-June through October and exceeds P from mid-February to mid-June by as much as ~20 mm on average (in May). Soil evaporation makes up 51.8% of total ET in the basin, while transpiration comprises 46.4% and canopy evaporation accounts for the remainder (1.8%). Natural recharge and runoff are highest in January due to winter precipitation and relatively low atmospheric demand during the cooler months.

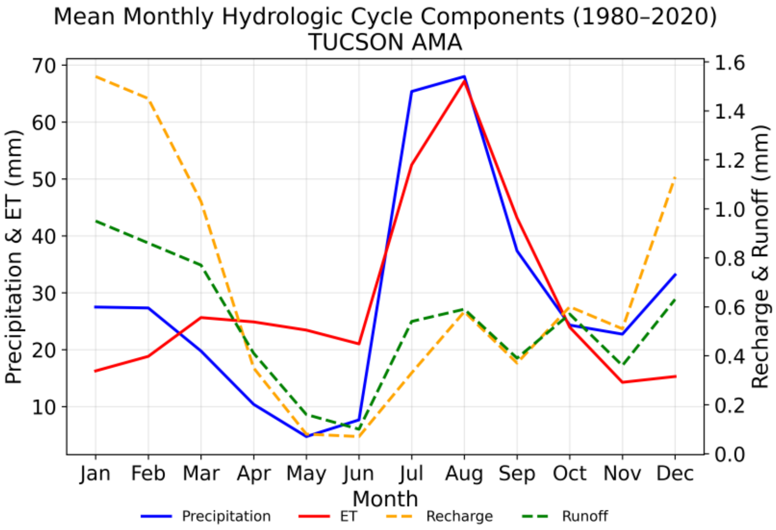


Figure 2. Graph showing monthly mean precipitation, ET, recharge, and runoff for the groundwater basin (1980-2020) from Noah-MP modeling results.[6]

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.

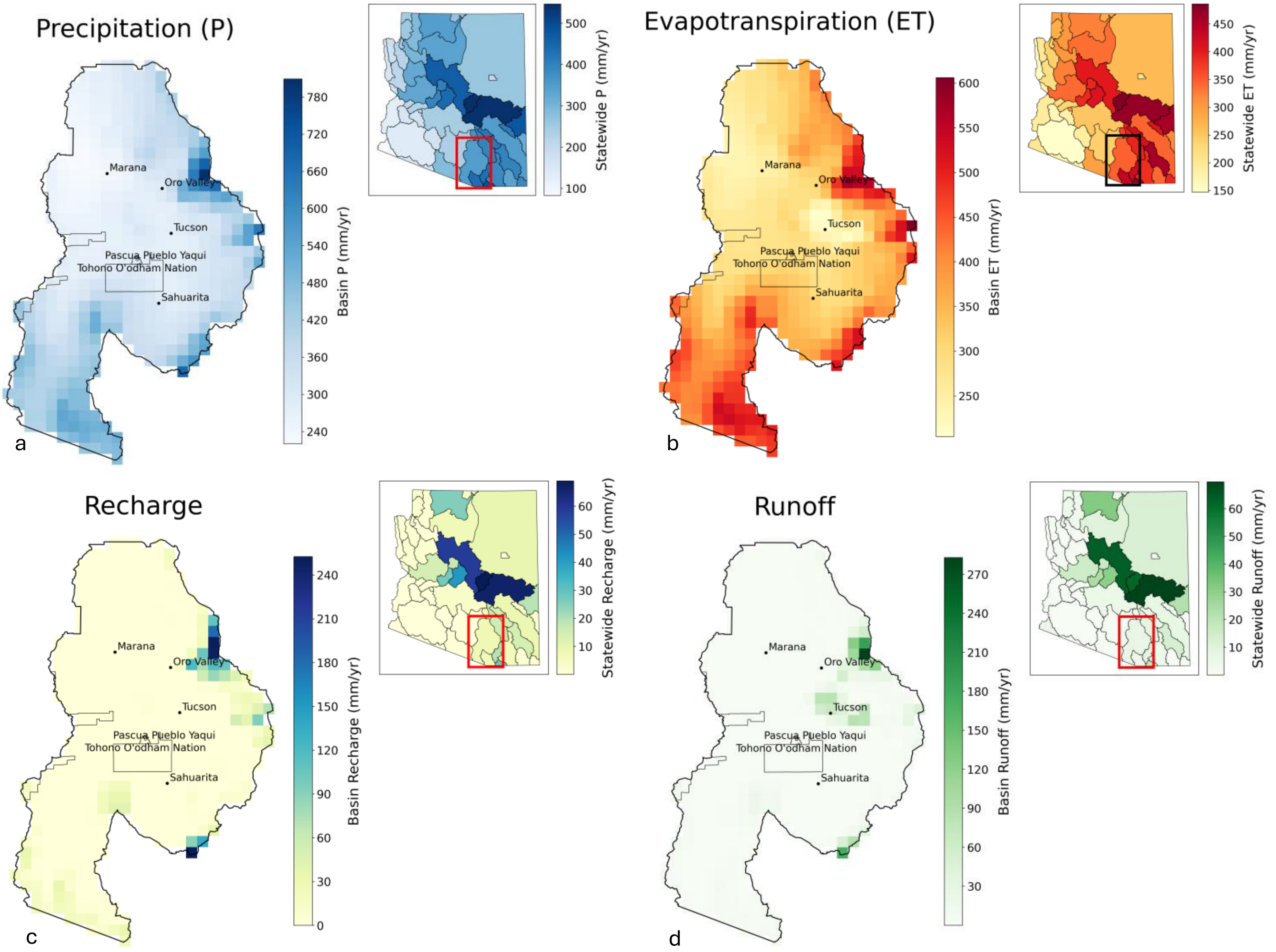
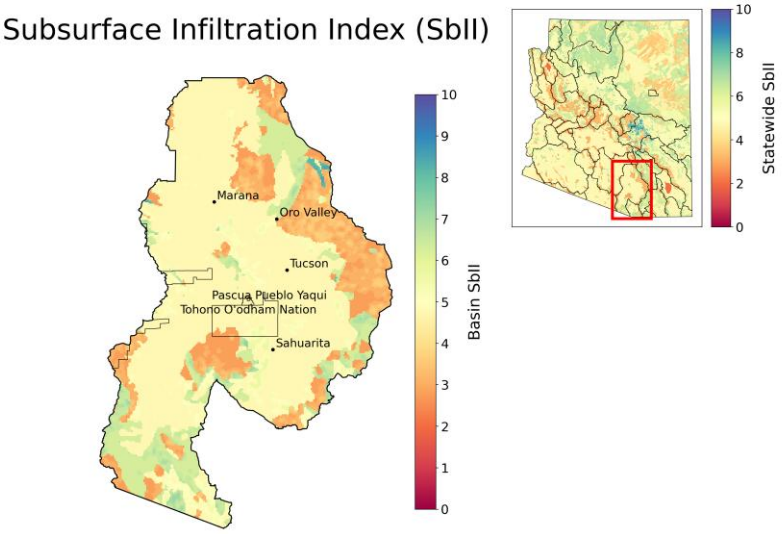


Figure 4 (below). Subsurface infiltration index (SbII) showing infiltration potential of the subsurface across the groundwater basin on a scale of 1-10 based on geologic features.[9]



The Catalina, Rincon, and Santa Rita mountains account for the highest precipitation in the Tucson basin, all of which receive over 700 mm/year. Runoff is also greatest in these regions, exceeding 250 mm/year in the Catalinas. These mountain forests account for the highest evapotranspiration in the basin. Natural recharge is highest at the Catalina and Santa Rita mountain fronts. Infiltration potential varies across the basin, but is generally greater along the eastern and southern mountain fronts.

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

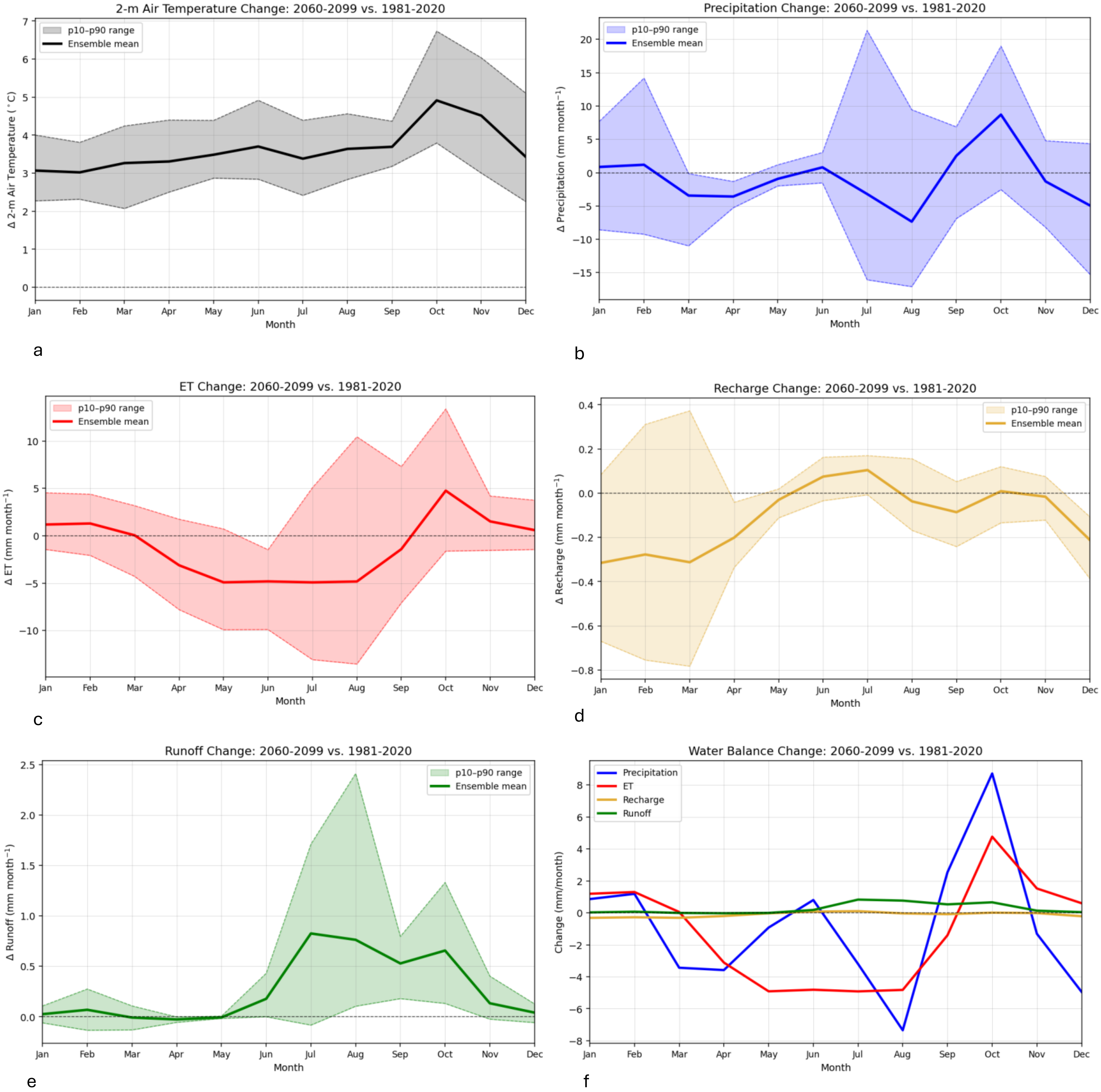

Figure 5. Plots (a)-(e) show projected changes in (a) temperature, (b) precipitation, (c) evapotranspiration (ET), (d) natural recharge, and (e) runoff statewide, comparing end of the 21st century to the historical record from 1981-2020 under the IPCC Scenario SSP3-7.0.[10] Plot (f) shows the change 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 Tucson AMA show drier springs (15-40% drier March through May), a drier July-August (5-10%), and a drier November-December (7-14%). September and October are projected to be 7-35% (2.5-8.8 mm/month) 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 28-47% (-0.20 to -0.34 mm/month) are projected for the highest recharge months (January to April). Despite showing less water loss from the system (i.e., a positive increase in Figure 8(d)), recharge projections are slightly negative (-0.09 to -0.10 mm/month) in June and July.* Runoff is projected to increase by 0.53 to 0.81 mm/month from July through October by the end of the century. Projected increases in temperature range from approximately 3.1 °C in February to 5.0 °C in October. Higher temperatures and greater water availability from precipitation lead to a projected 19% (4.8 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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