ARIZONA TRI-UNIVERSITY
RECHARGE AND WATER RELIABILITY PROJECT

Phoenix AMA
Groundwater Basin Profile

Basin Summary Statistics

Size[1]: 5,386 square miles
Elevation[2]: Range: 738-5,861 ft; Median: 1,491 ft
Top 3 land cover types by area[3]: Shrub/Scrub (69%), Developed – Medium Intensity (10%), Developed – Low Intensity (8.0%)
Major surface watershed(s)[4]: Salt, Verde, and Gila Rivers
Groundwater subbasins[1]: Lake Pleasant, Carefree, Hassayampa, West Salt River, East Salt River, Fountain Hills, Rainbow Valley
Groundwater-derived streamflow fraction[5]:

0.36 (Moderate)

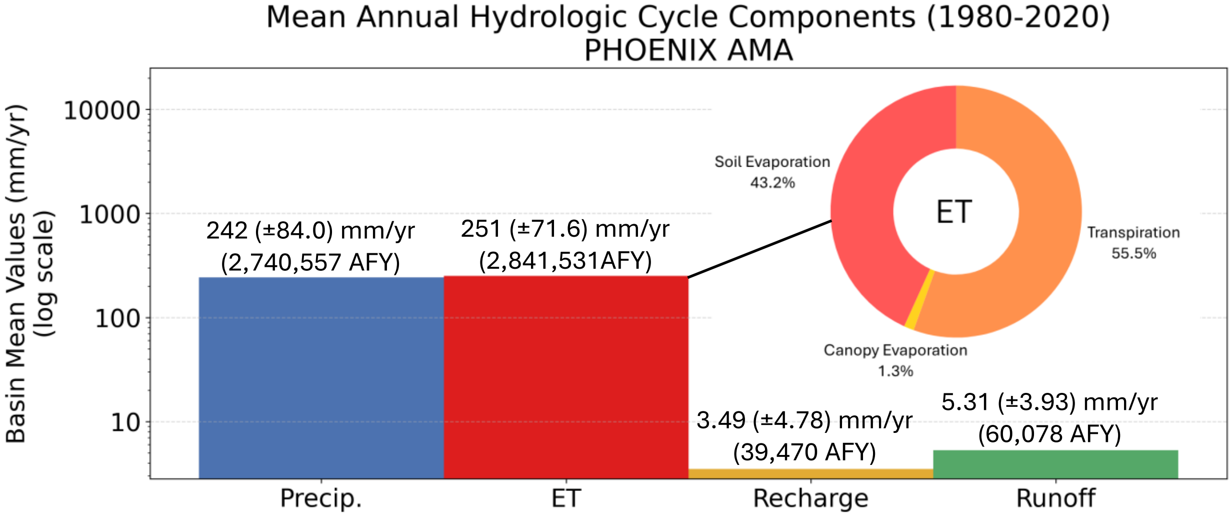

Figure 1 (above). Bar chart showing Noah-MP modeling results of the historical mean annual hydrologic cycle components (precipitation [P], evapotranspiration [ET], natural recharge, and runoff) in the basin from 1980-2020.[6] ET is partitioned into soil evaporation, canopy evaporation, and transpiration.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

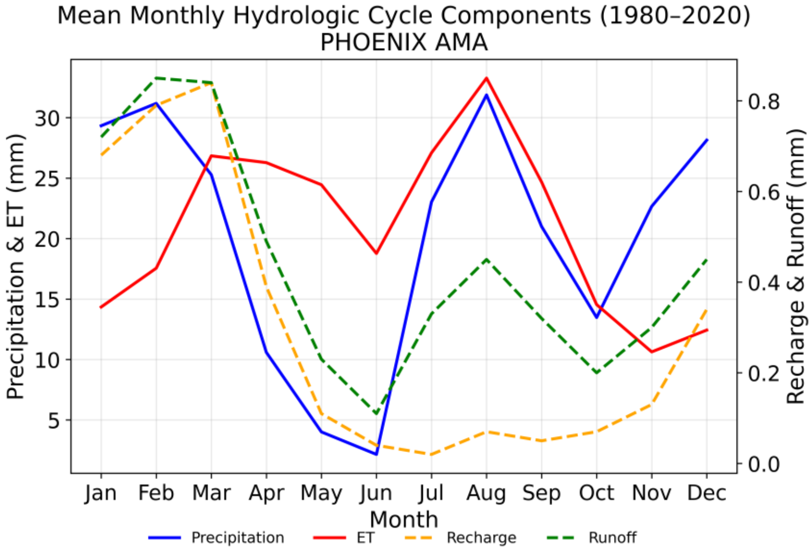

Figure 2. Graph showing monthly mean precipitation, ET, recharge, and runoff for the groundwater basin (1980-2020) from Noah-MP modeling results.[6]

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 (3.49 mm) and runoff (5.31 mm). ET is greater than P from March through October. Soil evaporation makes up 43.2% of total ET in the basin, while transpiration comprises 55.5% and canopy evaporation accounts for the remainder (1.3%). P exceeds ET during the winter months when there is lower atmospheric demand. This cool weather precipitation yields slightly higher values of natural recharge and runoff from January through March.

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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.

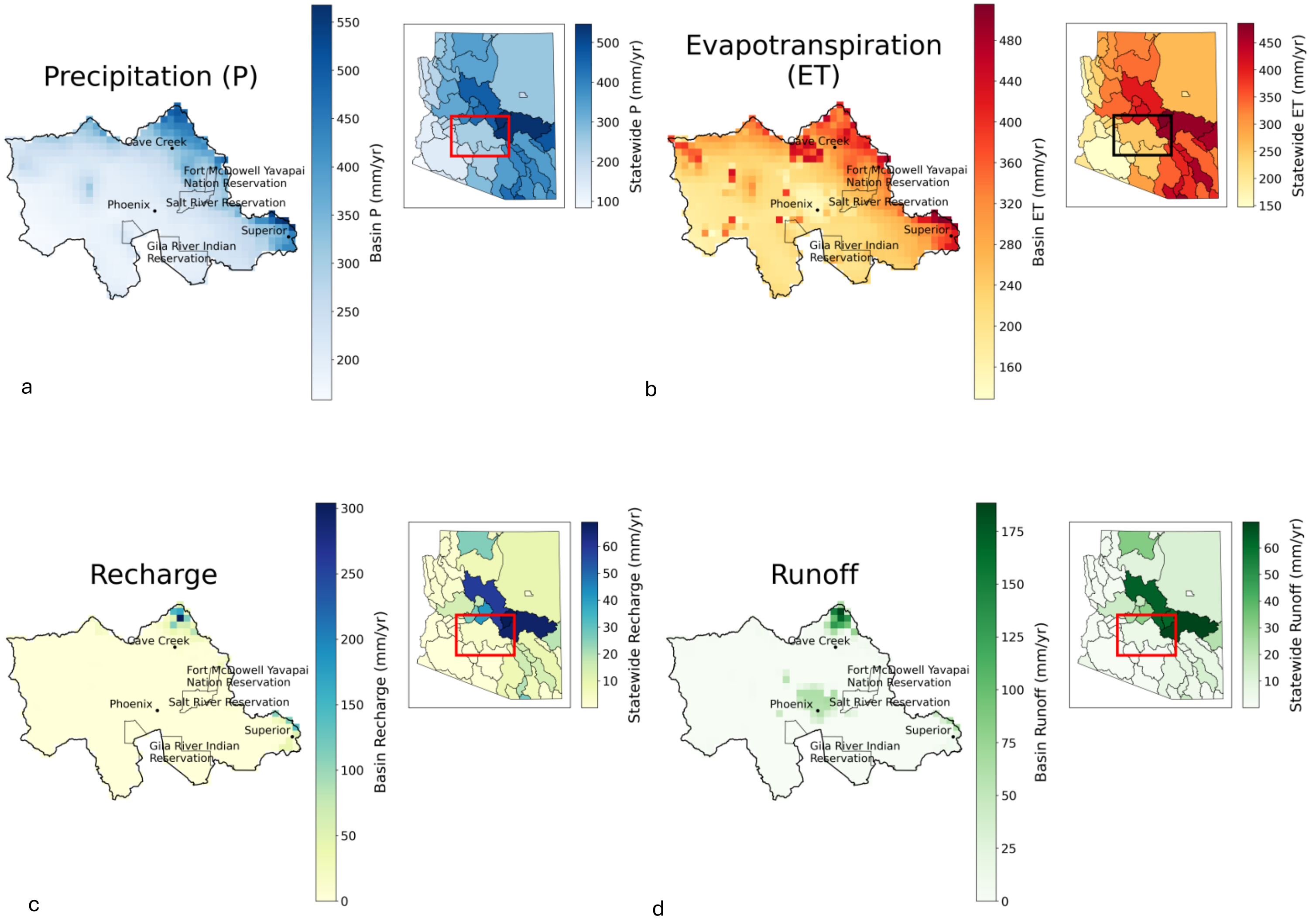
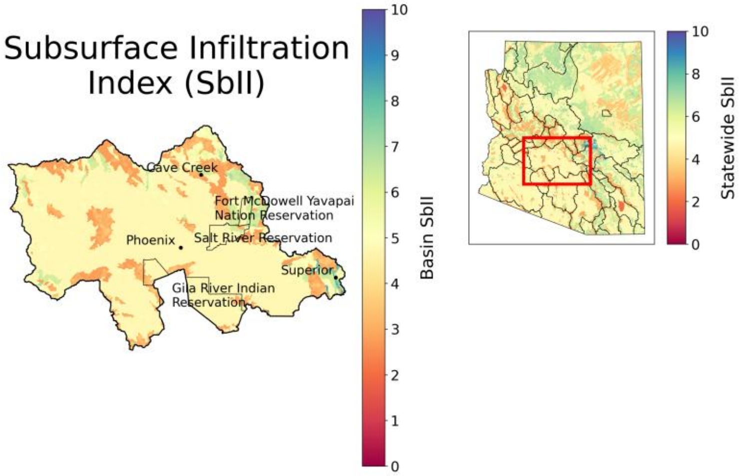


Figure 4 (below). Subsurface infiltration index (SbII) showing infiltration potential of the subsurface across the groundwater basin on a scale of 1-10 based on geologic features.[9]



Precipitation (P) in the Phoenix AMA is greatest in the higher-elevation areas to the north and east of the Phoenix metro area. In these regions, P can exceed 500 mm/yr. ET is highest over the open water of Lake Pleasant and in the mountains where there is greater water availability. Runoff (>150 mm/yr) and natural recharge (>200 mm/yr) are highest in the northernmost portion of the basin north of Cave Creek. Infiltration potential varies across the basin, with high potential highlighted in the eastern portion of the basin near the town of Superior due to the presence of faults and karst-type geology in this area.

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

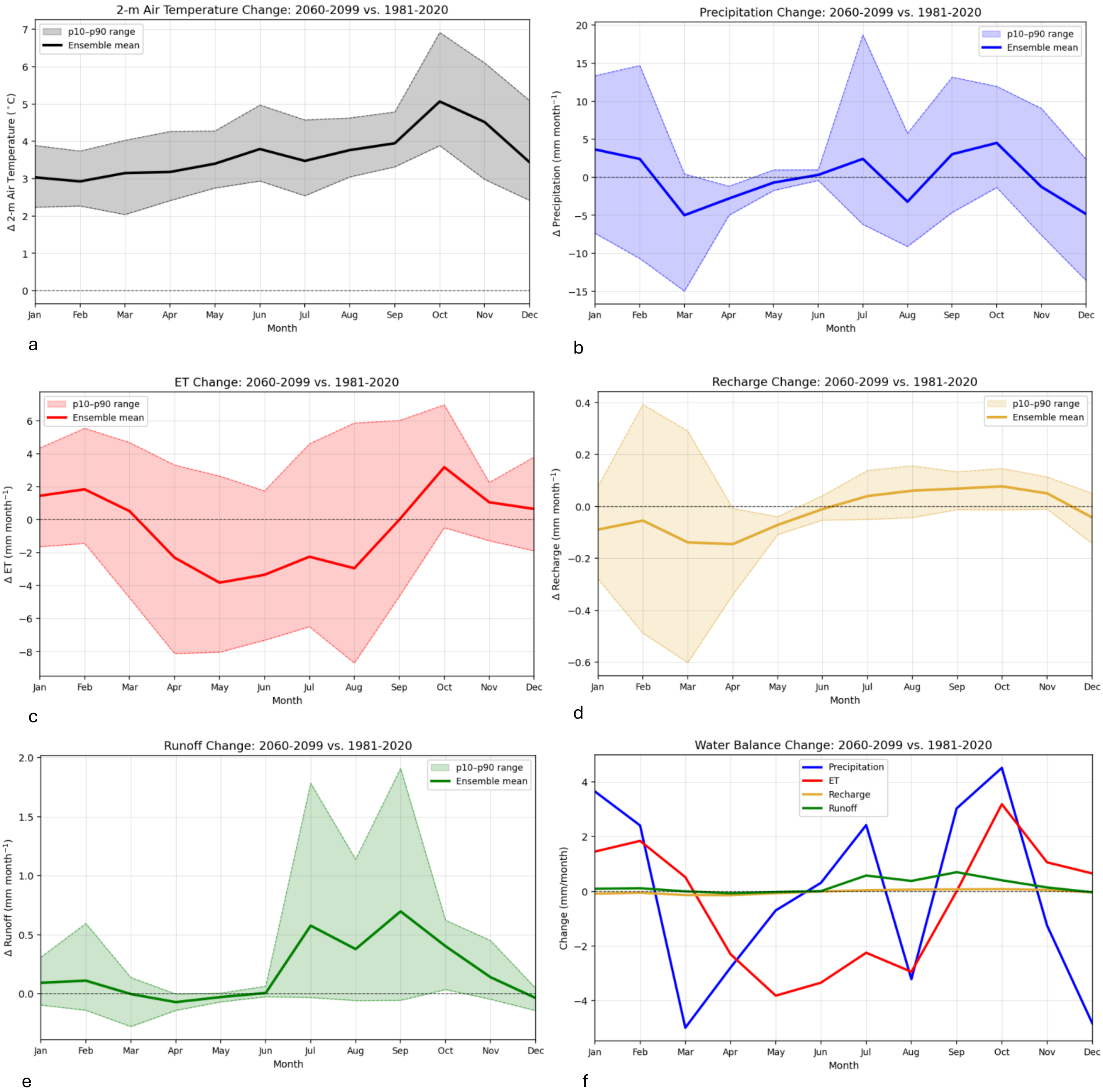

Figure 5. Plots (a)-(e) show projected changes in (a) temperature, (b) precipitation, (c) evapotranspiration (ET), (d) natural recharge, and (e) runoff statewide, comparing end of the 21st century to the historical record from 1981-2020 under the IPCC Scenario SSP3-7.0.[10] Plot (f) shows the change 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 Phoenix AMA show drier springs (17-33% drier March through May) and a drier August (10%), November (6%), and December (16%). September and October are projected to be 14-28% (2.9-4.6 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. The months with the highest natural recharge (January-April) are projected to have declines of 12-41% (-0.07 to -0.15 mm/month). Despite showing less water loss from the system (i.e., a positive increase in Figure 8(d)), recharge projections from June through November remain near zero and are slightly negative (-0.02 to -0.10 mm/month).* While remaining below 1.1 mm/month, runoff is projected to increase by 0.14-0.71 mm/month from July to November by the end of the century. Projected increases in temperature range from approximately 3.0 °C in February to 5.1 °C in October. Higher temperatures and greater water availability from precipitation lead to a projected 21% (3.2 mm) increase in evapotranspiration (ET) in October compared to the baseline period, while less water availability April to August leads to projected declines in ET (9-23% or -2.3 to -3.9 mm) during the warmer months.

*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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