Arizona Statewide Profile

ARIZONA TRI-UNIVERSITY
RECHARGE AND WATER RELIABILITY PROJECT

Statewide Summary Statistics

Size[1]: 113,990 square miles
Elevation[2]: Range: 70-12,633 ft; Median: 4,596 ft
Top 3 land cover types by area[3]: Shrub/Scrub (79%), Evergreen Forest (13%), Grassland Herbaceous (2.2%)
Major surface watershed(s)[4]: Gila River, Little Colorado River, Colorado River
Groundwater-derived streamflow fraction[5]:

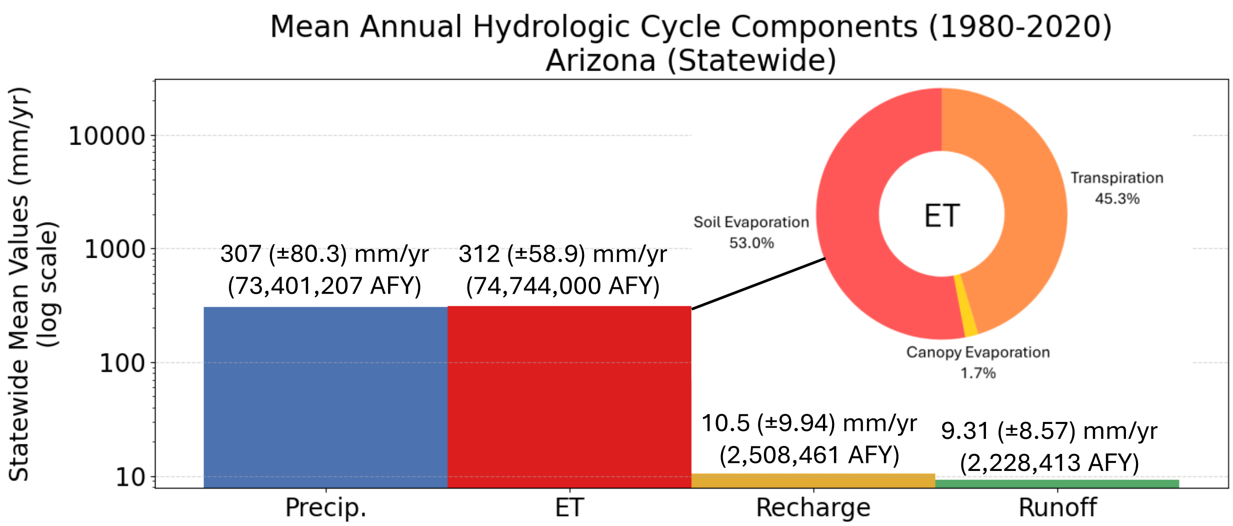


Figure 1 (above). Bar chart showing Noah-MP modeling results of the historical mean annual hydrologic cycle components (precipitation [P], evapotranspiration [ET], natural recharge, and runoff) statewide from 1980-2020.[6] ET is partitioned into soil evaporation, canopy evaporation, and transpiration.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

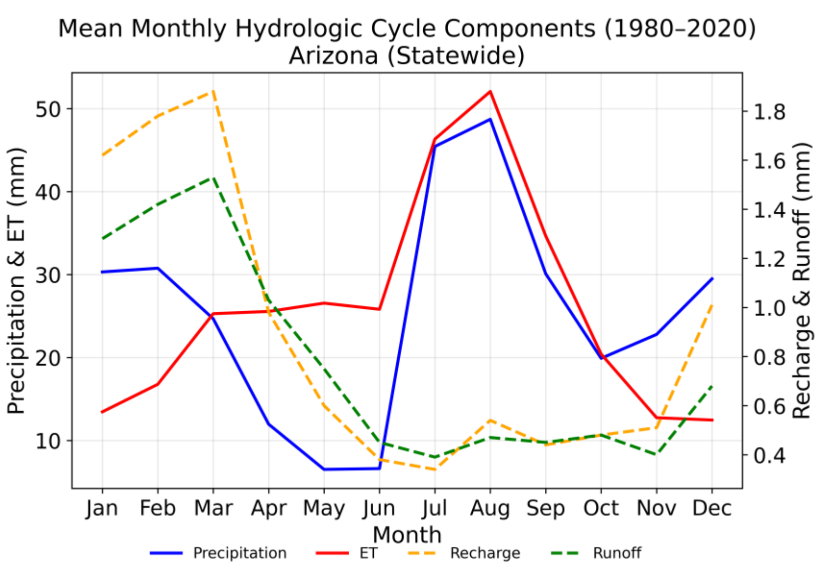


Figure 2. Graph showing monthly mean precipitation, ET, recharge, and runoff statewide (1980-2020) from Noah-MP modeling results.[6]

On annual timescales, evapotranspiration (ET) is approximately equal to precipitation (P) on average statewide. P in Arizona is impacted by the North American Monsoon during the summer as well as large winter frontal systems during the cooler months. Seasonally, ET tracks with P from June to October when there is greater water availability, while P exceeds ET from October through March when evaporative demand is lower. Soil evaporation makes up the majority of ET across the state (53.0%). Transpiration comprises 45.3%, while canopy evaporation accounts for 1.7% of total ET. Natural recharge (10.5 mm/yr) and runoff (9.31 mm/yr) peak in March due to springtime snowmelt from Arizona's high-elevation regions.

Figure 3 (below). Gridded depiction of major water fluxes across the state from Noah-MP modeling from 1980-2020: (a) precipitation, (b) evapotranspiration, (c) recharge, (d) runoff.[6] Major cities are shown to help orient the reader.[7]

Statewide

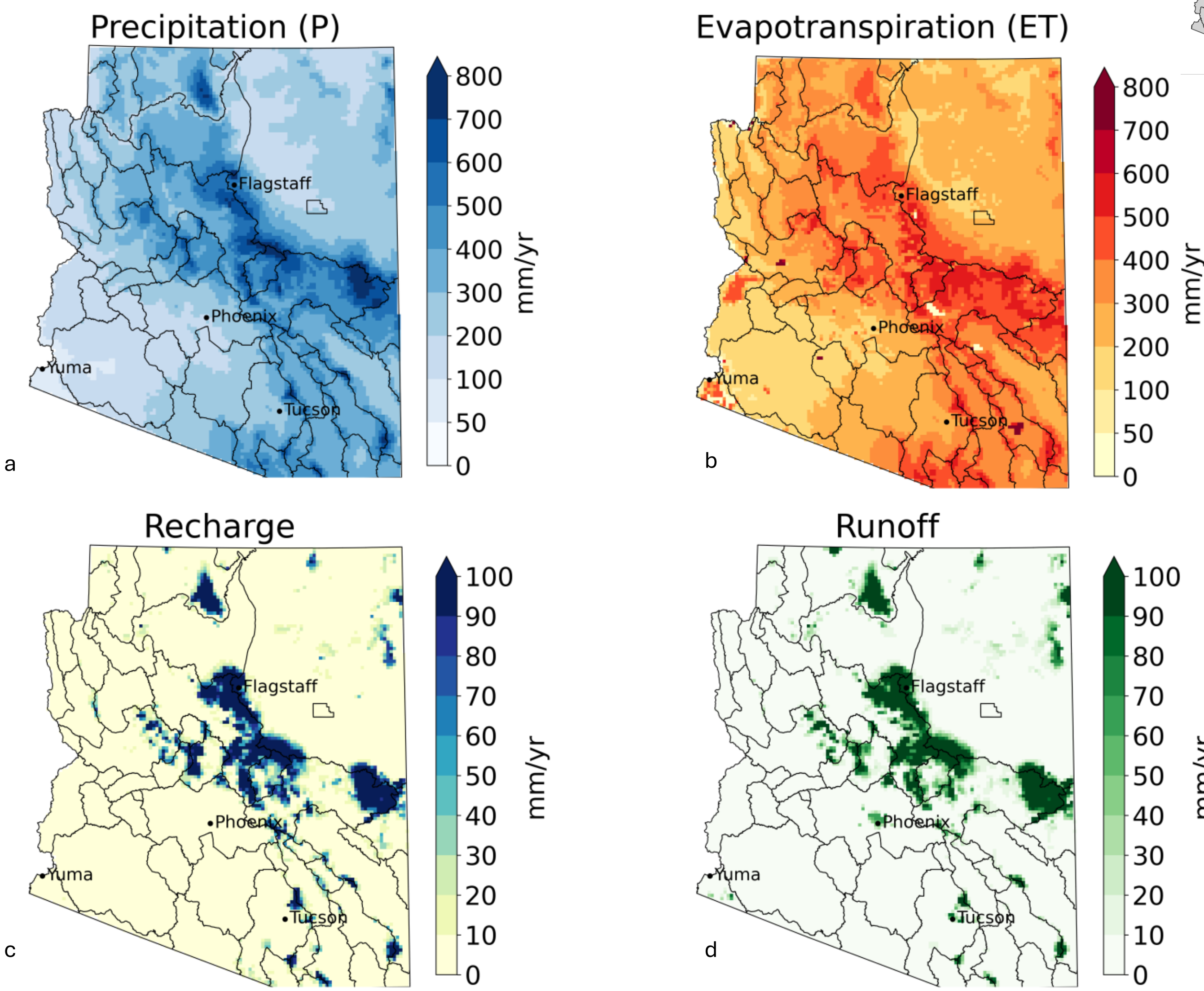
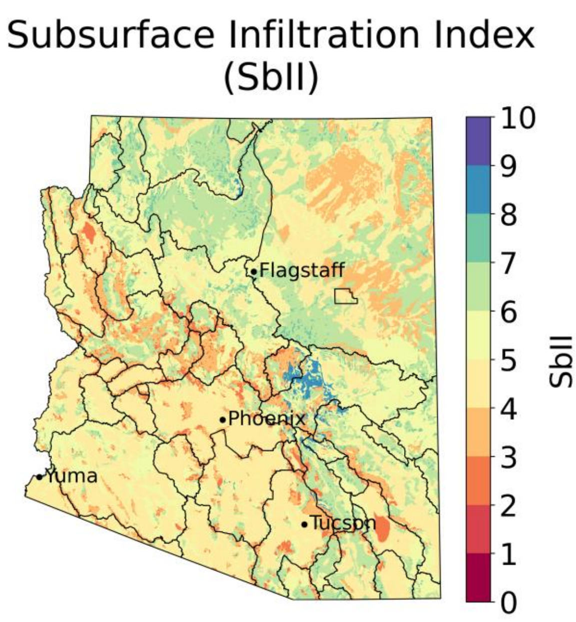


Figure 4 (below). Subsurface infiltration index (SbII) showing infiltration potential of the subsurface across the state on a scale of 1-10 based on geologic features.[8]



Modeling of the natural hydrologic cycle across Arizona reveals the Mogollon Rim as an area of critical importance to statewide water resources. Precipitation (P) is greatest along the Rim, where it exceeds 800 mm/yr on average at the highest elevations. Due to greater water availability, natural recharge (>100 mm/yr) and runoff (>100 mm/yr) are greatest in the higher-elevation regions of the state, including the Mogollon Rim and the Sky Islands. Evapotranspiration (ET) is greatest in the areas with highest water availability, including the Mogollon Rim (~500 mm/yr) and over open water such as lakes, reservoirs, and along the Colorado River (>1,000 mm/yr). Infiltration potential varies across the state, with areas of high potential along the Rim and in the Colorado Plateau province due to the presence of faults and fractures and karst-type geology. Across the Basin and Range, particularly in southern Arizona, alluvial deposits also present high infiltration potential.

Statewide

Climate change projections for the natural hydrologic cycle through the year 2100 were conducted using 14 dynamically downscaled and bias-corrected global climate models (GCM) at 9-km resolution and the Noah-MP land surface model under the Intergovernmental Panel on Climate Change (IPCC) Shared Socio-economic Pathway (SSP) 3-7.0.[9] This SSP scenario is considered an intermediate-high emissions scenario and the most commonly used scenario in recent IPCC and US climate modeling efforts. The results project robust and continuing temperature increases alongside decreasing runoff and natural recharge driven by rising evaporative demand and precipitation declines concentrated in the state's high-elevation water source areas. The following figures compare the results of the ensemble mean of the 14 GCMs for the last 40 years of the century (2061-2099) to the historical record from 1981-2020 under the IPCC Scenario SSP3-7.0 averaged spatially across the 51 Arizona Department of Water Resources (ADWR) groundwater basins.[1,9]

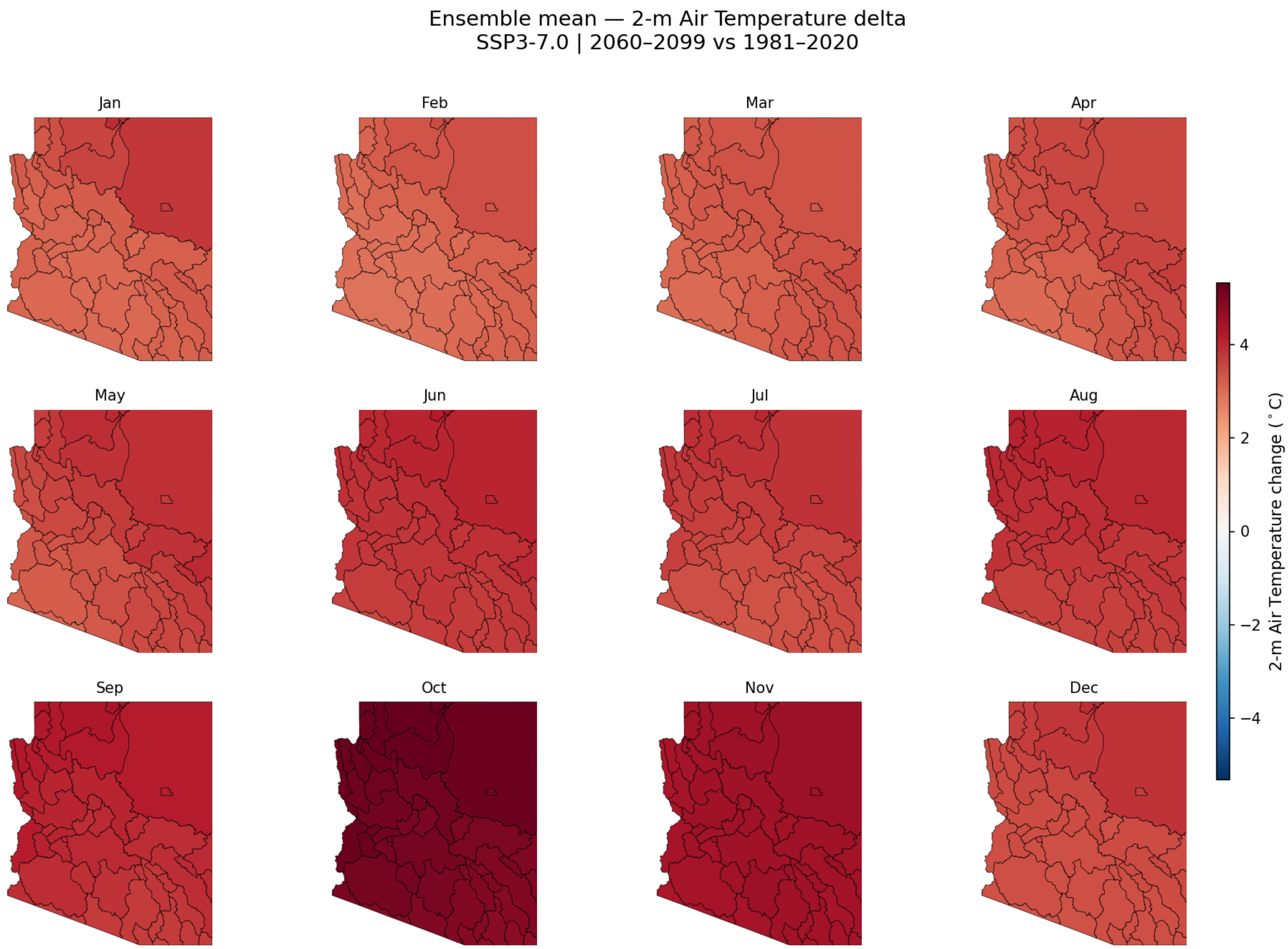


Figure 5. Figure showing projected changes (delta) in temperature statewide for each month of the calendar year. Basin-wide averages for the monthly projected change in temperature at the end of the 21st century (2061-2099) under the IPCC SSP3-7.0 are compared to the historical record from 1981-2020 for each of the 51 ADWR groundwater basins.

Projections show surface air temperature is projected to increase at a statistically significant rate of 0.05 °C/year over the period of 1981–2099. Seasonally, the greatest change in temperature is projected to occur during October (~5 °C by the end of the century). Spatially, projected changes in temperature appear fairly consistent across the state (3-5 °C depending on the season).

Statewide

Statewide annual precipitation shows no statistically significant trend over the period of 1981-2099; however, this area-averaged result masks important spatial heterogeneity, as shown in Figure 6 below. Results for 2061–2099, when changes are projected to be most pronounced, indicate substantial decreases in annual precipitation over high-elevation areas. These high-elevation zones, such as the Mogollon Rim and White Mountains, function as Arizona's primary water sources and therefore dominate the area-averaged hydrological trends. The apparent contradiction between a statistically insignificant statewide precipitation trend and significant regional decreases reflects the state's diverse topography. Seasonally, the greatest changes in precipitation are projected to occur in August (10-15 mm in the Mogollon Rim and White Mountains), however, drier springs (March-May) and early winters (November-December) are also projected for most of the state. In contrast, September and October are projected to be 5-15 mm/month wetter across much of the state by the end of the century, which is consistent with a projected increase in extreme events associated with hurricane and tropical cyclone activity.

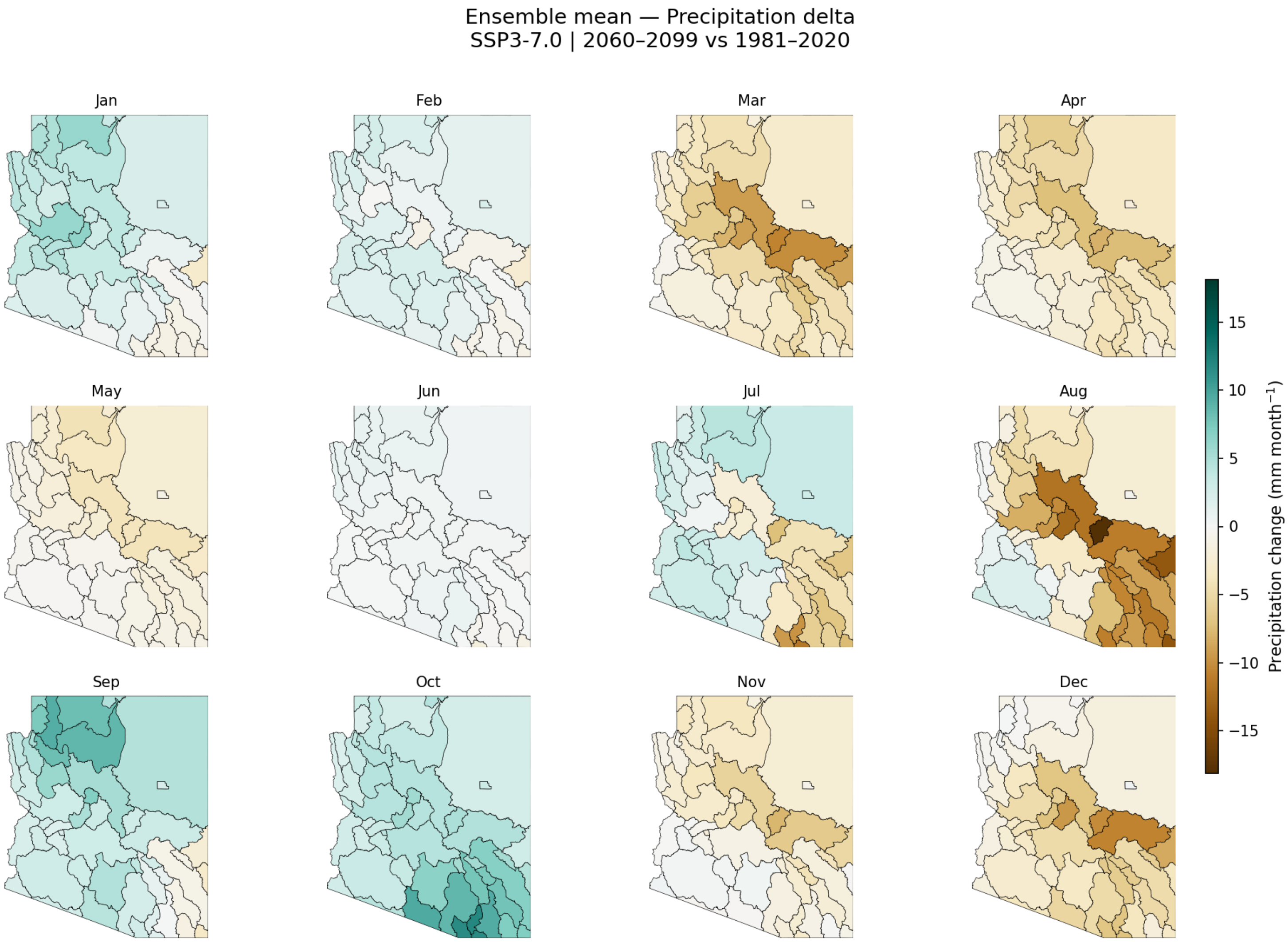


Figure 6. Figure showing projected changes (delta) in precipitation statewide for each month of the calendar year. Basin-wide averages for the monthly projected change in precipitation at the end of the 21st century (2061-2099) under the IPCC SSP3-7.0 are compared to the historical record from 1981-2020 for each of the 51 ADWR groundwater basins.

Statewide

At the statewide scale, the interannual variation of evapotranspiration (ET) from 1981-2099 closely tracks that of precipitation, consistent with the water-limited regime characteristic of semi-arid environments like Arizona, where atmospheric moisture supply, rather than energy availability, is the primary constraint on ET. Projected changes in annual ET are spatially complex. Across most high-elevation areas, reduced precipitation drives a corresponding decrease in ET, consistent with a water-limited regime. This trend is visible along the Mogollon Rim and White Mountains, particularly during the North American Monsoon season (June-August) in Figure 7 below. While not visible in Figure 7 due to area-averaging across the 51 ADWR groundwater basins, it should be noted that a subset of the highest-elevation mountainous areas is projected to experience increased ET by the end of the century, potentially attributable to shifts in snowmelt timing, which can alter the seasonal distribution of moisture availability.

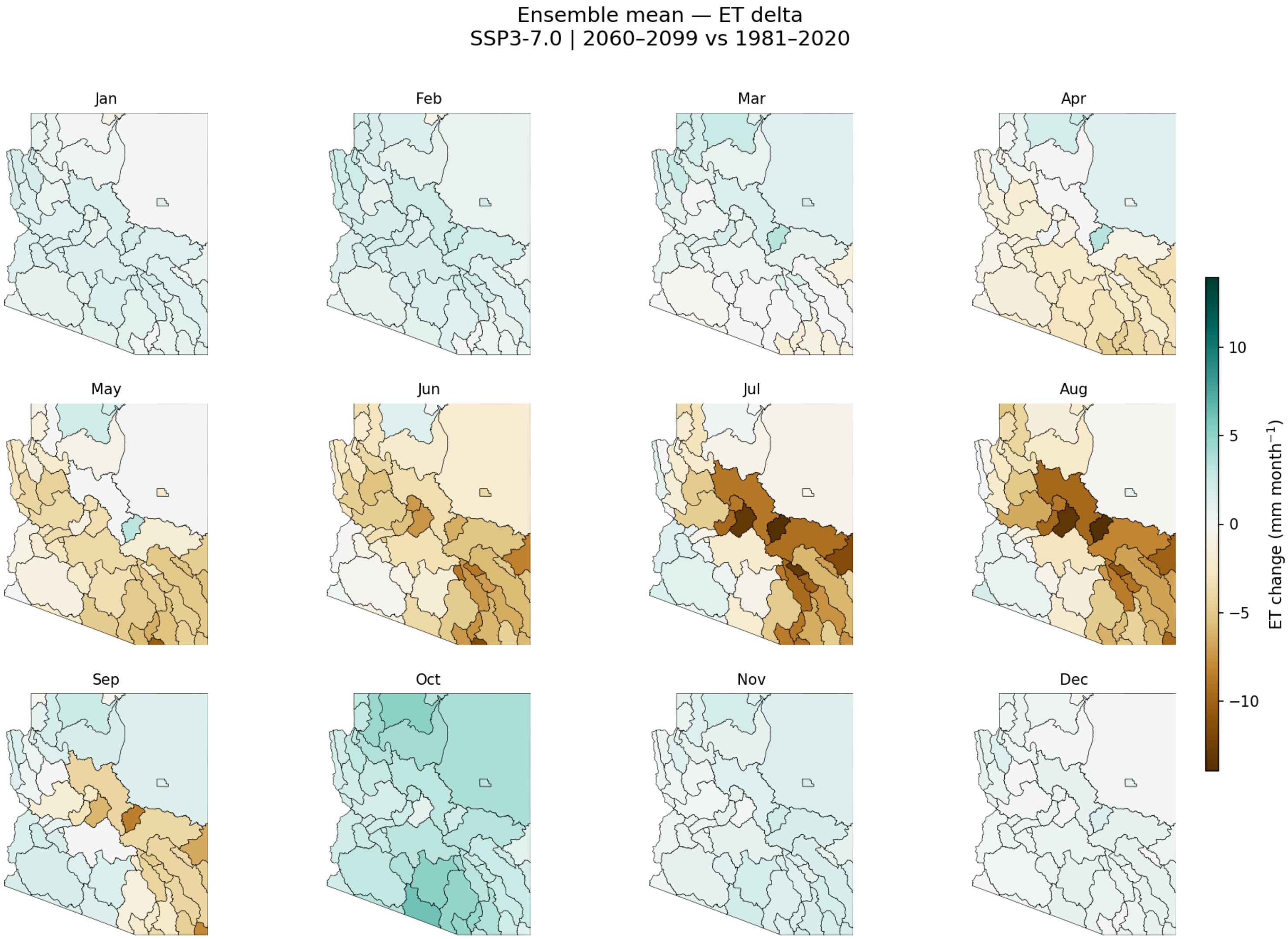
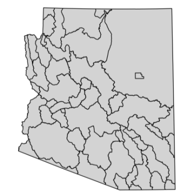


Figure 7. Figure showing projected changes (delta) in evapotranspiration (ET) statewide for each month of the calendar year. Basin-wide averages for the monthly projected change in evapotranspiration at the end of the 21st century (2061-2099) under the IPCC SSP3-7.0 are compared to the historical record from 1981-2020 for each of the 51 ADWR groundwater basins.

Statewide



On average statewide, natural groundwater recharge and runoff are projected to decrease by approximately 0.07 mm/yr and 0.05 mm/yr, respectively, through the end of the century. This statewide decline is driven by increasing evaporative demand under rising temperatures even in the absence of a significant precipitation trend. As with precipitation and ET, declines in natural recharge and runoff are spatially nuanced and projected to be greatest in the areas of the state that have greatest water availability – the Mogollon Rim and White Mountains. As shown in Figure 8 (natural recharge) and Figure 9 (runoff), these declines are greatest in the spring months (March-May). This may be attributable to the projected declines in winter and early-spring precipitation by the end of the century, with significant implications for water resources planning across the state. Additional information related to climate change projections and impacts on the state's water resources can be found in Section 2 of the Arizona Tri-University Recharge and Water Reliability Project Report to the Arizona Department of Water Resources.

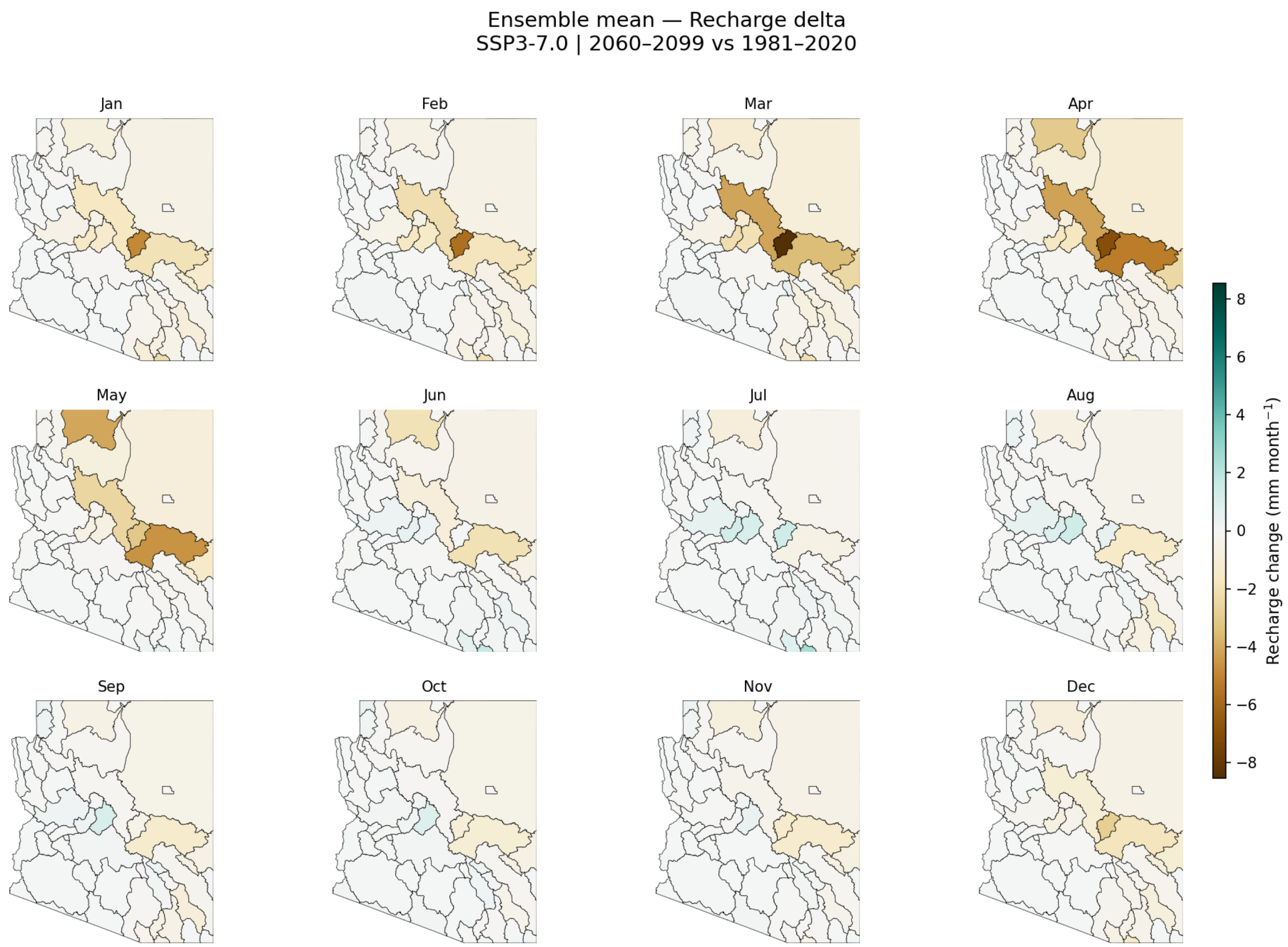


Figure 8. Figure showing projected changes (delta) in natural recharge statewide for each month of the calendar year. Basin-wide averages for the monthly projected change in natural recharge at the end of the 21st century (2061-2099) under the IPCC SSP3-7.0 are compared to the historical record from 1981-2020 for each of the 51 ADWR groundwater basins.

Statewide

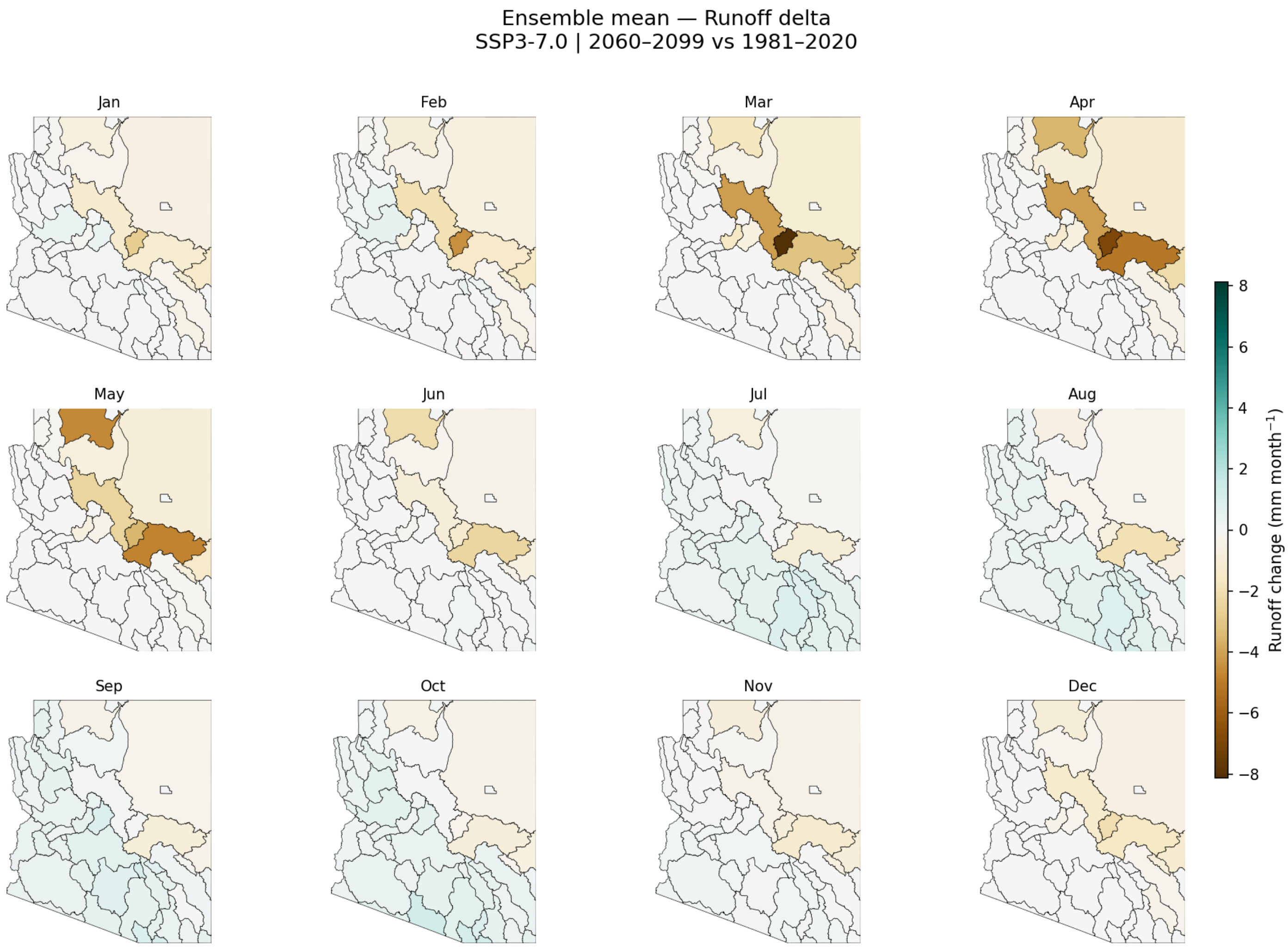
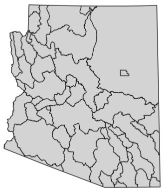


Figure 9. Figure showing projected changes (delta) in runoff statewide for each month of the calendar year. Basin-wide averages for the monthly projected change in runoff at the end of the 21st century (2061-2099) under the IPCC SSP3-7.0 are compared to the historical record from 1981-2020 for each of the 51 ADWR groundwater basins.



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