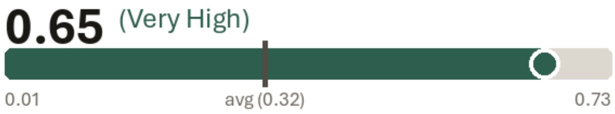
Willcox AMA
Groundwater Basin Profile

ARIZONA TRI-UNIVERSITY
RECHARGE AND WATER RELIABILITY PROJECT

Basin Summary Statistics

Size[1]: 1,911 square miles
Elevation[2]: Range: 4,134-10,690 ft; Median: 4,645 ft
Top 3 land cover types by area[3]: Shrub/Scrub (79%), Evergreen Forest (8.8%), Cultivated Crops (6.4%)
Major surface watershed(s)[4]: Willcox Playa, Whitewater Draw
Groundwater subbasins[1]: None
Groundwater-derived streamflow fraction[5]:



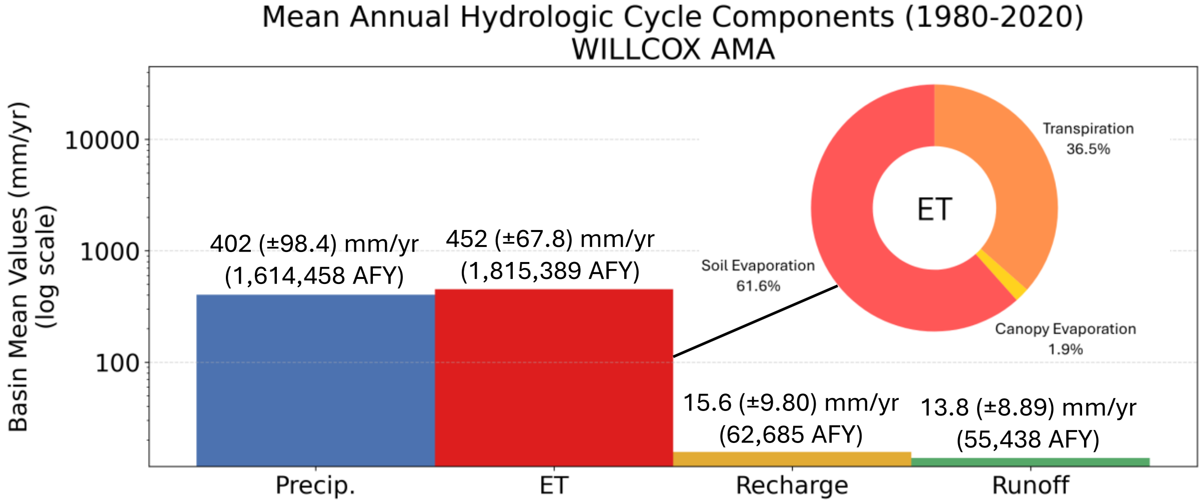


Figure 1 (above). Bar chart showing Noah-MP modeling results of the historical mean annual hydrologic cycle components (precipitation [P], evapotranspiration [ET], natural recharge, and runoff) in the basin from 1980-2020.[6] ET is partitioned into soil evaporation, canopy evaporation, and transpiration.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

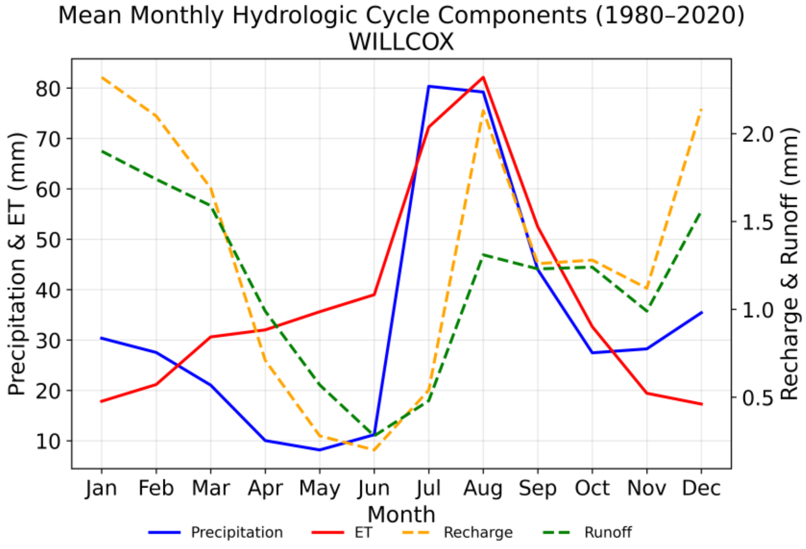


Figure 2. Graph showing monthly mean precipitation, ET, recharge, and runoff for the groundwater basin (1980-2020) from Noah-MP modeling results.[6]

On annual timescales, evapotranspiration (ET) exceeds annual precipitation (P) across the basin, resulting in relatively low basin-wide annual averages for natural recharge (15.6 mm) and runoff (13.8 mm). P in the Willcox 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. Soil evaporation makes up 61.6% of total ET in the basin, while transpiration comprises 36.5% and canopy evaporation accounts for the remainder (1.9%). Natural recharge and runoff are highest in January due to winter precipitation and relatively low atmospheric demand during the cooler months. Natural recharge also increases in August as a result of high intensity monsoon storms.

Willcox AMA

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.

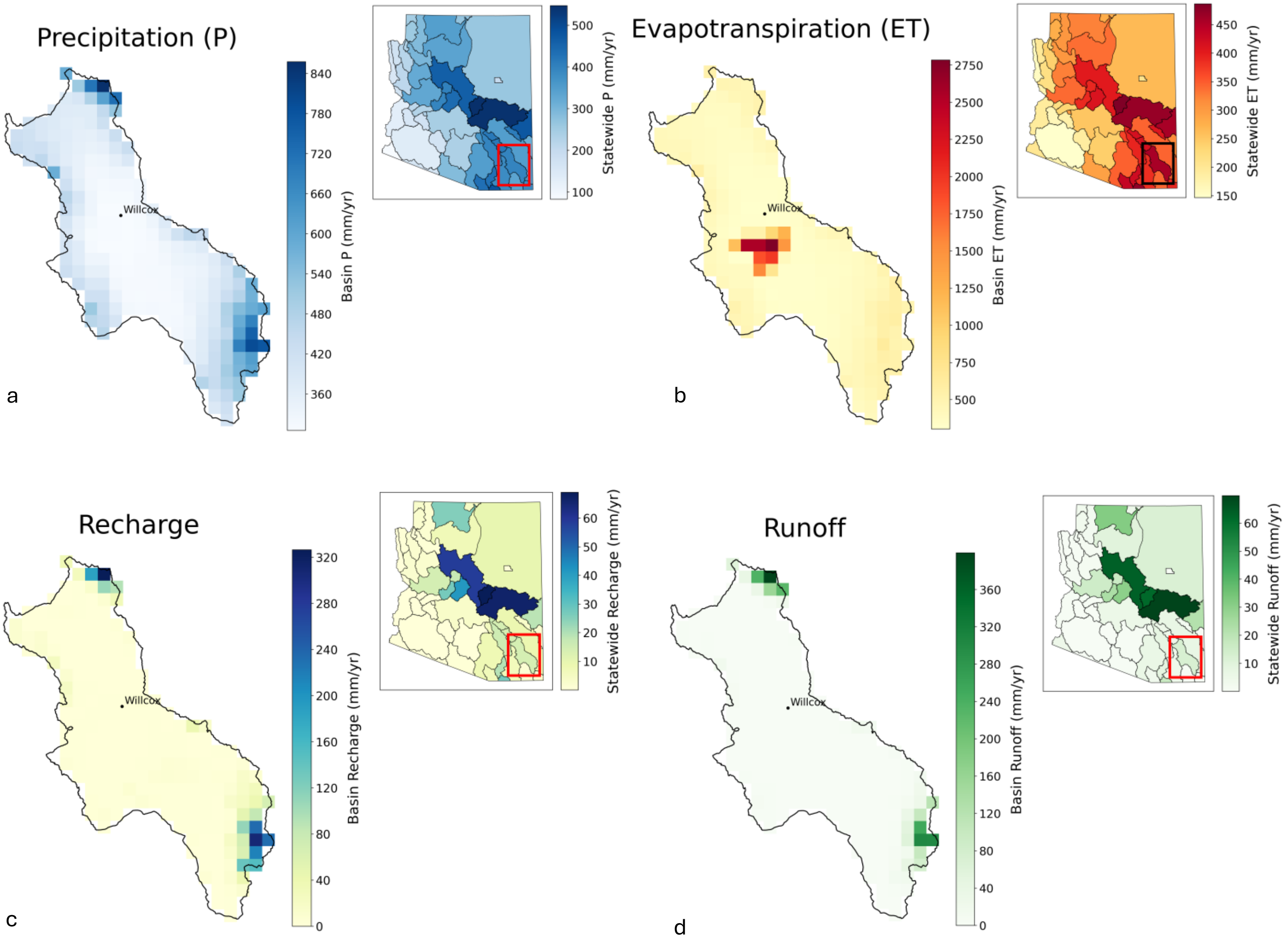
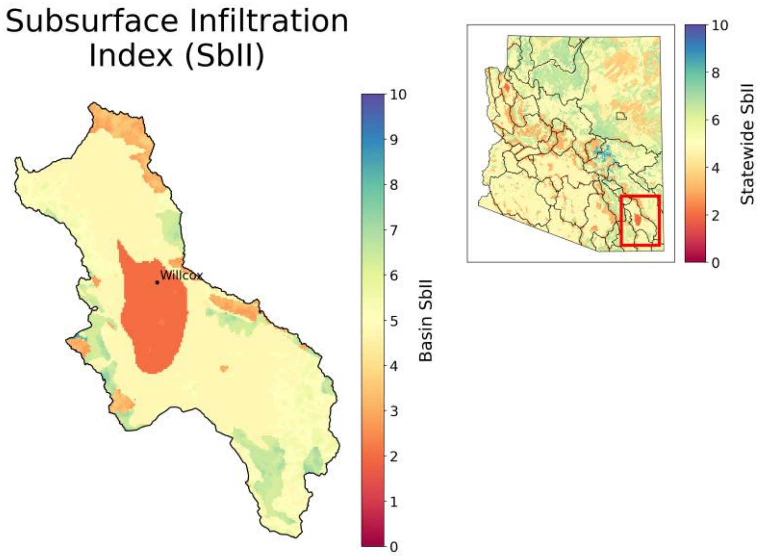


Figure 4 (below). Subsurface infiltration index (SbII) showing infiltration potential of the subsurface across the groundwater basin on a scale of 1-10 based on geologic features.[9]



Precipitation (P) in the Willcox AMA is greatest near Mount Graham to the north and in the Chiricahua Mountains to the southeast. In these regions, P can exceed 800 mm/yr. ET is highest over the Willcox Playa, where it exceeds 2,000 mm/yr on average. Runoff (>300 mm/yr) and natural recharge (>250 mm/yr) are highest at the mountain front regions of the basin. Infiltration potential varies across the basin; however, the Willcox Playa is highlighted as an area of particularly low infiltration potential due to the presence of low permeability, fine-grained sediment.

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

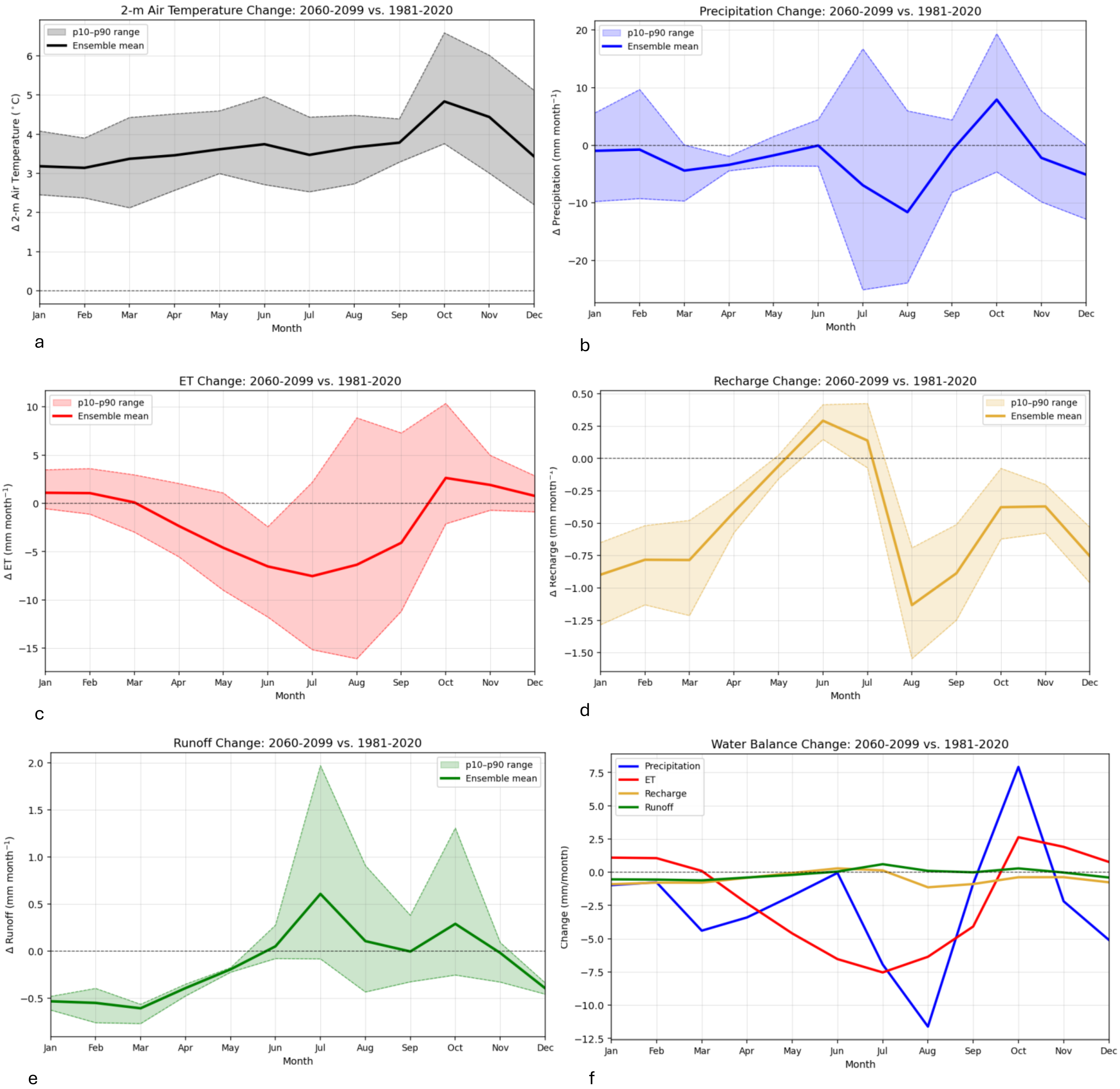


Figure 5. Plots (a)-(e) show projected changes in (a) temperature, (b) precipitation, (c) evapotranspiration (ET), (d) natural recharge, and (e) runoff statewide, comparing end of the 21st century to the historical record from 1981-2020 under the IPCC Scenario SSP3-7.0.[10] Plot (f) shows the change 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.

Willcox AMA

Climate change projections across the Willcox AMA show drier springs (19-39% drier March through May) and a drier July-August (8-15%), November (9%), and December (14%). October is projected to be 29% (8.0 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 and August) are projected to have declines of 57% (-0.93 mm) and 76% (-1.1 mm), respectively. Recharge is projected to be slightly negative* (-0.03 to -0.22 mm/month) from May through July. While remaining below 1 mm/month, runoff is projected to increase in July (0.61 mm), August (0.11 mm), and October (0.30 mm) by the end of the century. Projected increases in temperature range from approximately 3.2 °C in February to 4.9 °C in October. Higher temperatures and greater water availability from precipitation lead to a projected 8-10% (1.8-2.6 mm) increase in evapotranspiration (ET) in October-November compared to the baseline period, while less water availability April to September leads to projected declines in ET (7-17%, or -2.4 to –7.5 mm/month) 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.

References

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