Approach to Data Access, Hydroclimate Modeling & Scenario Development

Aniket Gupta, University of Arizona
Abdul Moiz, Arizona State University
Why the Hydroclimate Team?

1. Collect all available **hydrometeorological observations** in Arizona
2. Apply a suite of **hydrologic models** to reconstruct key water balance variables across the state, with a focus on:
   a. Potential aquifer recharge regions
   b. Areas of high evapotranspiration (ET)
3. Build **confidence in models** via thorough validation against observations
4. Perform **ad-hoc high-resolution hydrologic simulations** in specific basins to support capture and recharge solutions
5. Assess **future changes of key water balance variables** using climate model outputs under different greenhouse gas emission scenarios
Collection of Hydrometeorological Datasets

Hydrometeorological Observations

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Variables</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analysis of Record for Calibration (AORC)</td>
<td>Precipitation, Air Temperature, Other Meteorological Variables</td>
<td>1-km, 1-hour</td>
</tr>
<tr>
<td>FLUXNET Tower</td>
<td>Evapotranspiration</td>
<td>Point, 30-min</td>
</tr>
<tr>
<td>USGS Gages</td>
<td>River Discharge</td>
<td>Point, 15-min</td>
</tr>
<tr>
<td>SNOTEL Stations</td>
<td>Snow Water Equivalent</td>
<td>Point, 1-day</td>
</tr>
</tbody>
</table>

Hydrologic Models

- **National Water Model** (NWM; available from NOAA at 1 km, 1 hr)
- **Noah-MP** (applied by the team at 4 km, 1 hr)

Period: 1980 - 2023
Water Budget

\[ \text{RE} = \text{P} - \text{ET} - \text{R} \]

- Observation
- Simulation
- Observation/Simulation

RE = Recharge
P = Precipitation
ET = Evapotranspiration
R = Runoff

Applied at multiple time scales at each 1- or 4-km pixel and HUC8 basin

Credit: Hayley Corson-Dosch/USGS VizLab
Examples of Observations and Simulations

Mean annual AORC precipitation (1980-2020)

Mean annual NWM ET (1980-2020)

AORC = Analysis of Record for Calibration

NWM = National Water Model
Building Confidence in Models

Validation of ET against eddy covariance estimates

Daily

FLUXNET Tower Observation
National Water Model

Simulated Average Annual Evapotranspiration (mm)

Site: US-Fuf; Frequency: Daily; Land Cover Type: Evergreen Needleleaf Forests

Monthly

Site: US-Fuf; Frequency: Monthly; Land Cover Type: Evergreen Needleleaf Forests
Building Confidence in Models

Validation of river discharge

USGS gages with >95% data (1980-2022)

Normalized Nash Sutcliffe Efficiency (NNSE)

- Daily
  - USGS Gage Observation
  - National Water Model
  - Carrizo Creek near Show Low, AZ
    - NNSE = 0.67
    - (1980 – 2022)
  - Discharge (m³/s)

- Monthly
  - NNSE = 0.66
  - (1980 – 2022)
  - Discharge (m³/s)
High-Resolution Land Surface Modeling in Arizona

Historical Simulations

• To estimate the water budget (including ET, runoff, recharge, SWE, etc.) during 1980-2020 in the HUC8 basins over Arizona.

• To find the factors that dominate the spatial and temporal variations in recharge during the historical period.

Future Simulations

• To project the recharge in the middle and end of this century under different emission scenarios.

• To understand the effect of future climate change on recharge.
Historical Simulations

<table>
<thead>
<tr>
<th>Model</th>
<th>Noah-MP which can represent surface ponding and dynamic root water uptake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domain</td>
<td>HUC8 watersheds (see blue lines in the right figure) over Arizona</td>
</tr>
<tr>
<td>Period</td>
<td>1980-2020</td>
</tr>
<tr>
<td>Resolution</td>
<td>4 km (spatial) and 1 hr (temporal)</td>
</tr>
<tr>
<td>Forcing data</td>
<td>CONUS404 (dynamically downscaled results of ERA5), AORC (based on multiple observation and analysis datasets), and IMERG (satellite data, 2001-2020)</td>
</tr>
</tbody>
</table>
For most of the basins, the model’s relative bias is between -10% and 10%.

$ET_{wb} \approx P - RF_{usgs}$

$ET_{wb}$ and $ET_{model}$ are very close, with $R=0.81$. 
The model can reproduce the annual runoff for the Verde (Salt) Basin with $R=0.86$ (0.93) and bias=11% (33%)
Recharge Efficiency and Its Historical Trend

- Very similar mean areal recharge efficiency (2.79% for CONUS404 and 2.89% for AORC)

- Both simulations suggest that recharge efficiency has significantly decreased by about 0.1% per year
Hydroclimate Team Summary

1. Collection of high-resolution point and gridded hydrometeorological observations across Arizona
2. Validation of the latest National Water Model retrospective simulations and Noah-MP ad-hoc simulations in AZ
3. Generation of recharge maps from models and observations for the historical period
4. Estimation of changes in water balance components under future climate scenarios