Model-based investigation of inter-decadal trends in streamflow in the Brazos River Basin

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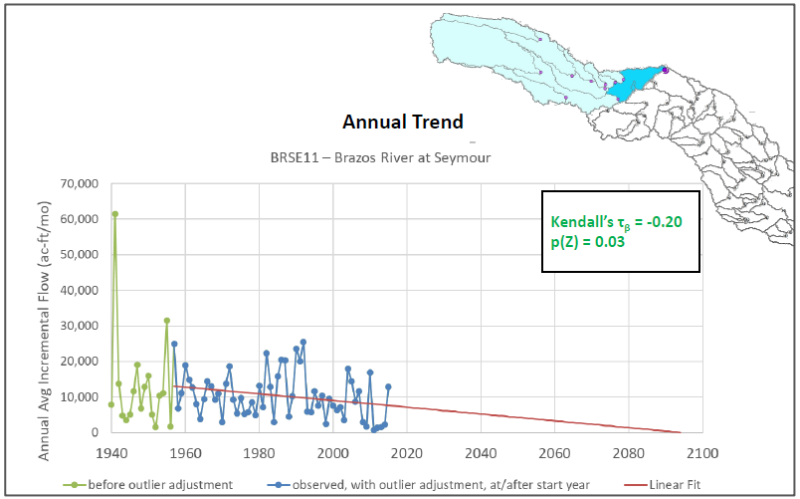
Motivations

- Downward trends in streamflow and runoff yields over the Upper Brazos
  - USGS-USACE study, 2020
  - Freese & Nichols, 2021
- Trends concerning to regional water suppliers
  - Will water yield diminish over time?

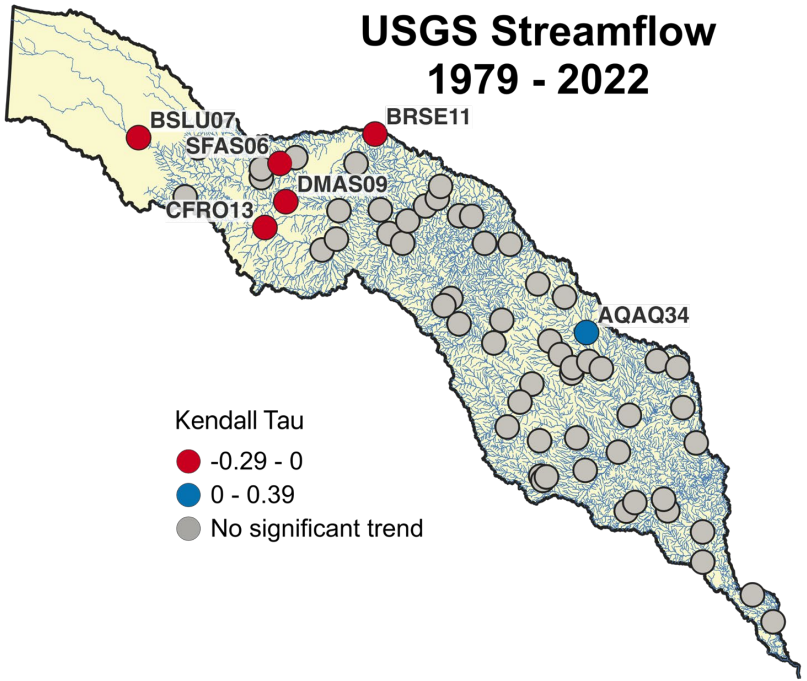


From Freese & Nichols, 2021

Questions and Project Goals

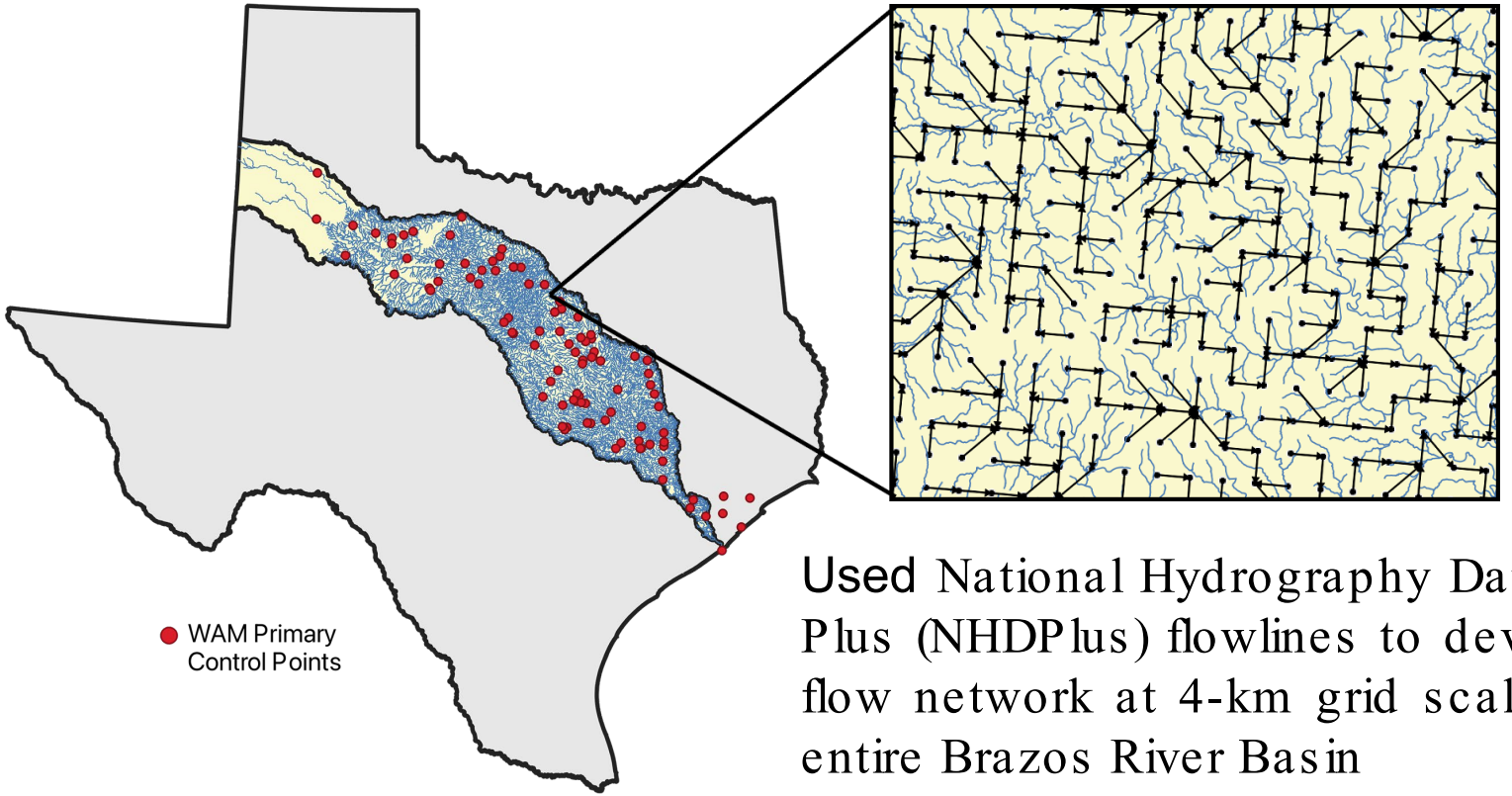
- What gave rise to the trends?
  - Changes in precipitation amounts and distribution?
  - Rising temperature?
  - Other factors?
- This project
  - Feb 2022-Feb 2024
  - Determines relative roles of drivers through model simulations
  - Focus on the past 42 years where data were relatively abundant

Statistically significant trends in USGS streamflow



- 6 USGS stations w/ significant trends and adequate record
- F-N study uses WAM flows which use regression to gap-fill missing data
- 5 stations with diminishing yield, all in the north

Model Implementation



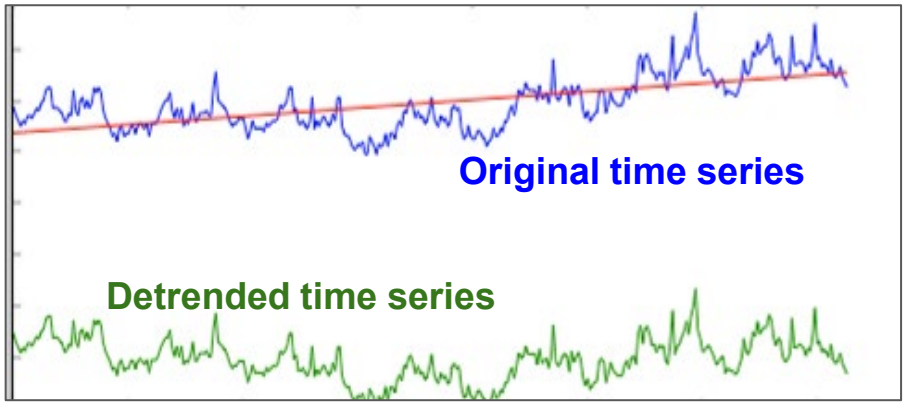
Used National Hydrography Dataset Plus (NHDPlus) flowlines to develop flow network at 4-km grid scale for entire Brazos River Basin

SAC-SMA and SAC-HTET

- SAC-SMA was implemented as baseline
  - Does not account for temperature in calculating evapotranspiration
- SAC-HTET
  - An enhanced version of SAC
  - Integrates temperature in calculating evapotranspiration

Methodology

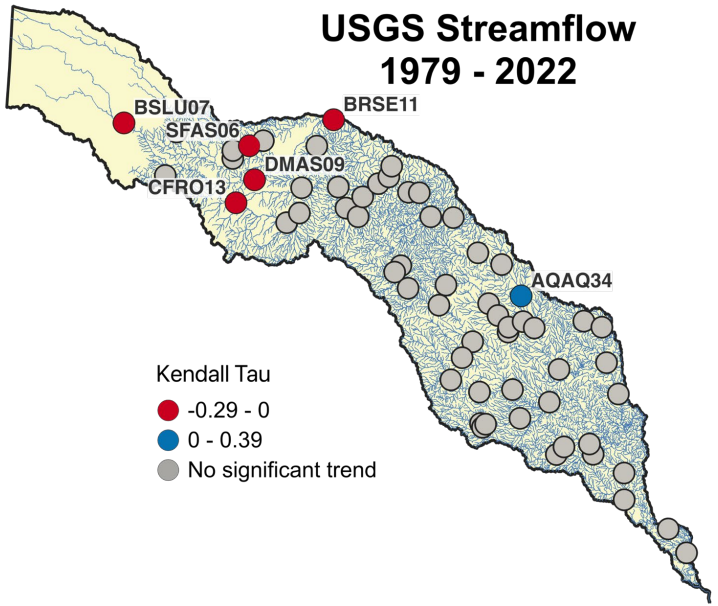
- Simulation window: 1980-2020
- Baseline simulations
  - SAC-SMA
- Control experiments
  - Reference: SAC-HTET with original temperature as input
  - Control: SAC-HTET with detrended temperature as input

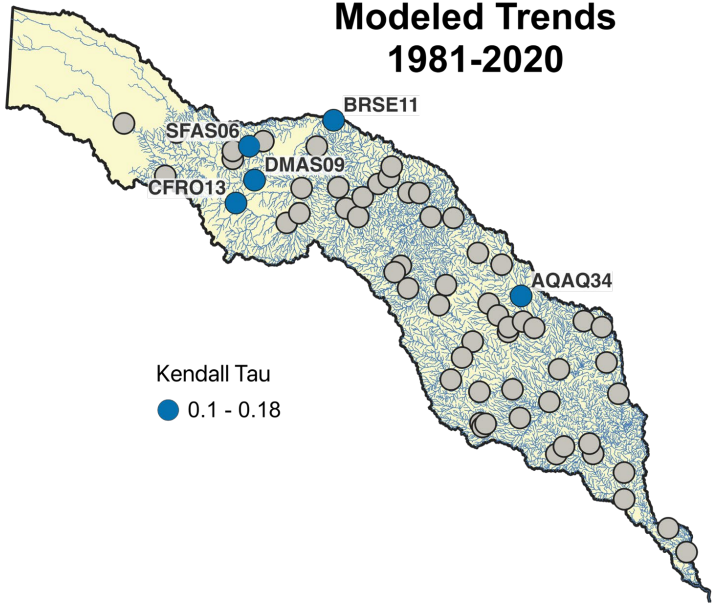


Comparison streamflow simulations from reference and control determines potential impacts of rising temperature on runoff yield

Preliminary Simulations using SAC-SMA

Modeled vs. Observed Trends (SAC-SMA)

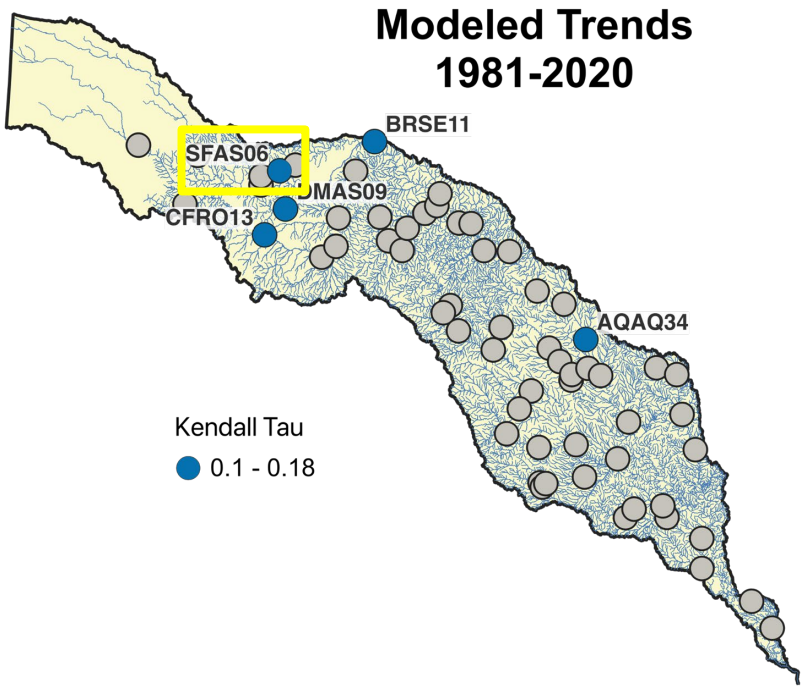


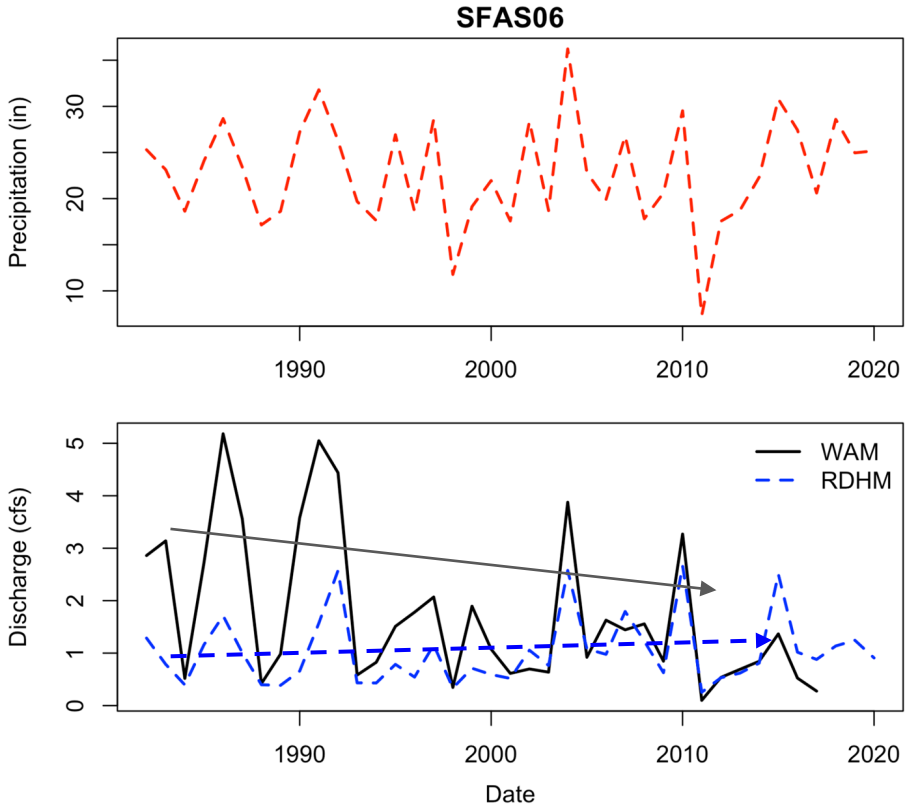


Model simulations unable to reproduce the downward trend

- Trends positive at all six locations

Model performance 1981-2020

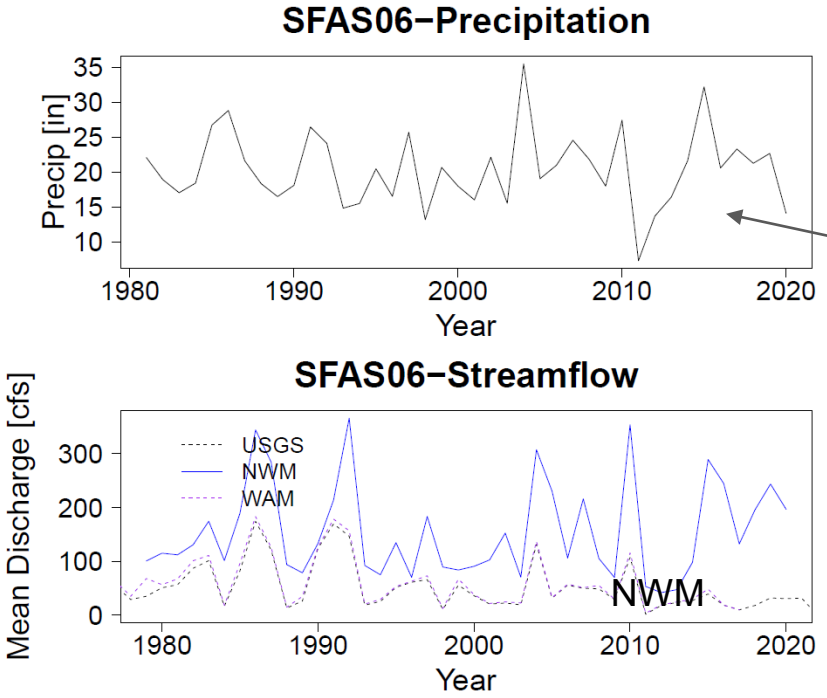


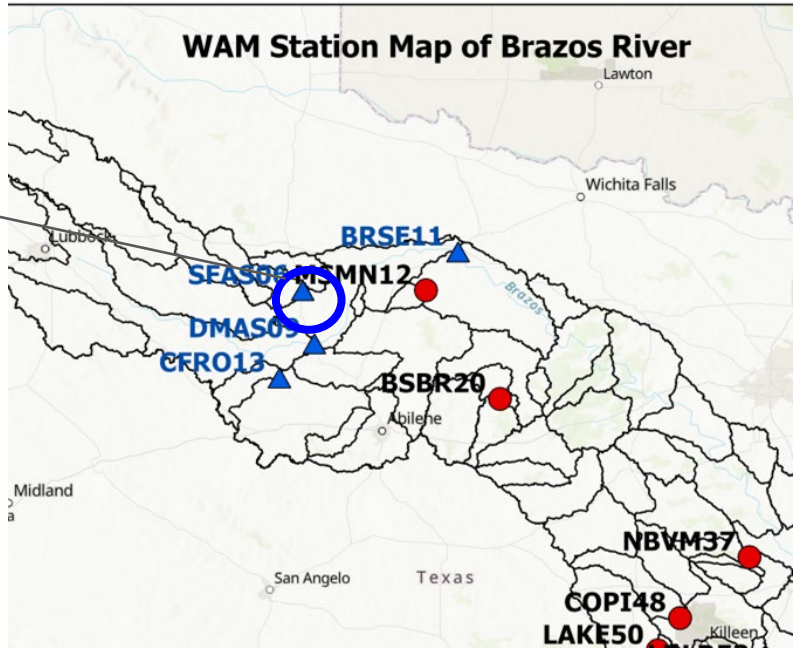


Analysis of National Water Model Output

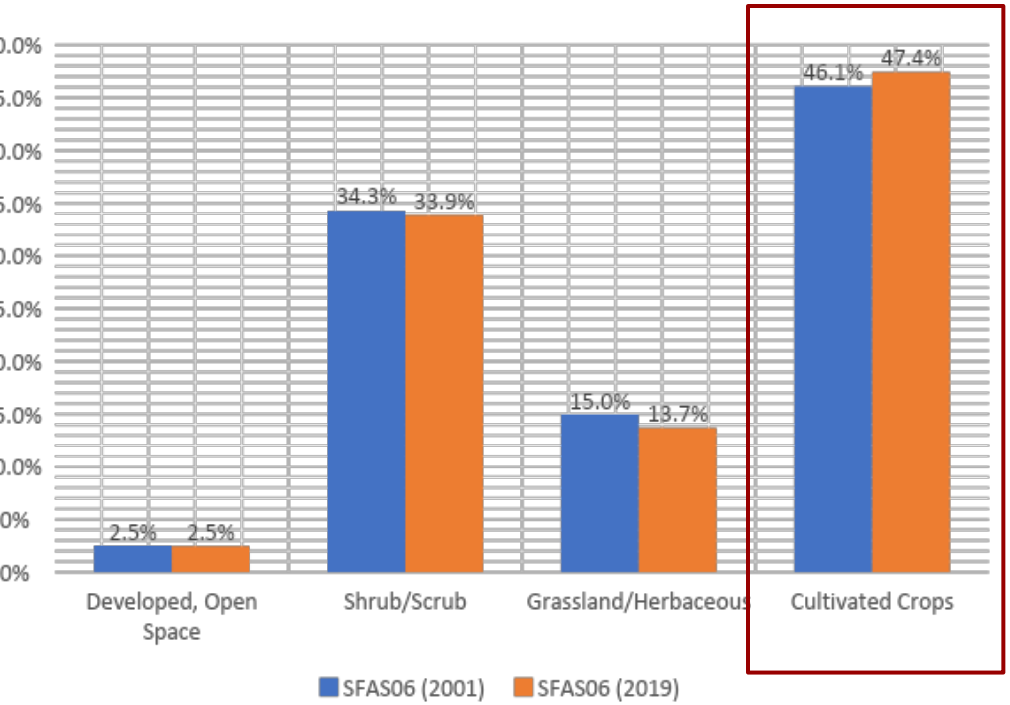
- National Water Model takes both precipitation and temperature as forcing variables in computing runoff
- Reanalysis 2.1 available for 1979-2020

Trend in National Water Model Reanalysis





Land Cover Analysis



- Many watersheds in the upper basin experience small, but appreciable increases in cultivated land over the past 20 years
- Lack of consistent data for 1980/90, but anecdotal evidence points to sustained rise in agricultural activities

Summary

- In only a few USGS stations are trends significant
  - Many stations with large data gaps
- Models unable to reproduce the downward trends in runoff
  - Even a model that uses dynamic temperature cannot do so
- Experiments still ongoing to determine impacts of temperature
- Land cover analysis
  - Small, but conspicuous expansion in agricultural activities
  - Likely a sustained pattern through history