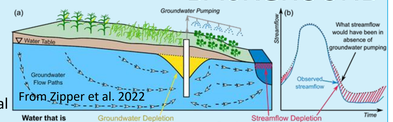
USING NATIONAL DATASETS TO DETECT STREAMFLOW DEPLETION IN THE MIDDLE ARKANSAS WATERSHED, KANSAS

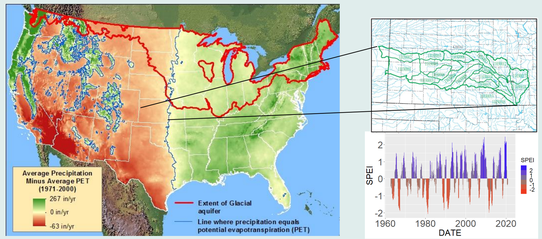
Misty E Porter[1], Andrea E. Brookfield[2], Samuel Zipper[3], Mary C. Hill[1] [1] Geology, University of Kansas; [2] Earth and Environmental Sciences, University of Waterloo; [3] Kansas Geological Survey

BACKGROUND

- Streamflow decline factors: groundwater pumping, land use change, climate change …
- Streamflow depletion evolves slowly, invisible for years to decades
  - masked by natural and/or climate change-induced streamflow variability
  - Negatively effects human and ecological systems
- **Water managers need ways to carefully evaluate available data**



STUDY AREA – MIDDLE ARKANSAS RIVER



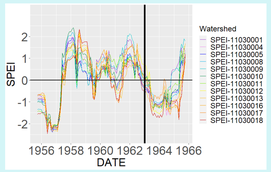
- ~52,000 km^2
- Agricultural
- Extensive surface water and groundwater irrigation
- Semi-arid climate

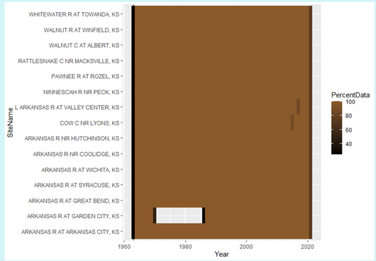
https://www.usgs.gov/media/images/map-gridded-values-1971-2000-avg-precipitation-minus-avg-pet

METHODS

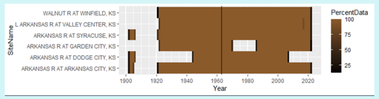
DATA SETS FOR ANALYSIS

1) High-density data beginning in climate neutral year (determined by SPEI-12 for watershed)
- 01 OCT 1963 – 30 SEP 2021





2) Long-data from gage stations with more than 100 years of records
- 1904 – 30 SEP 2021



ANALYSIS METHODS

- Streamflow metrics: **mean discharge, mean baseflow, MAM7, Q10, Q50, Q90, Q95** (Helsel et al. 2020; Gustard and Demuth 2009)
  - Compute annually over hydrologic year
- Mann-Kendall rank test to evaluate whether metrics have increased or decreased over time

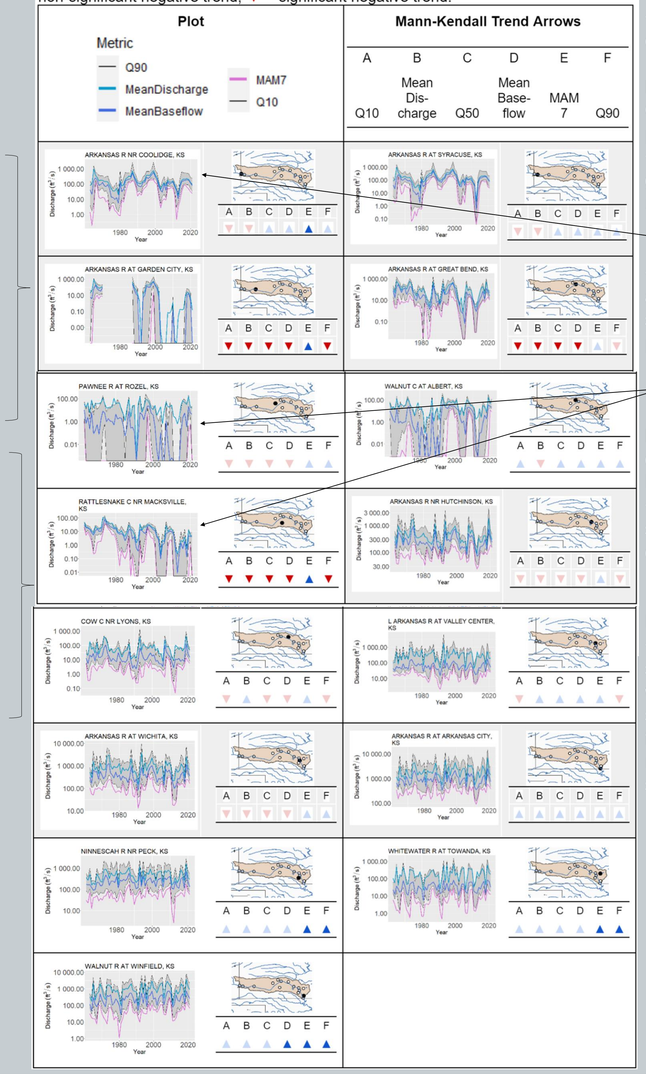
VISUALIZATION METHODS

DiscoverStreams is a web-based app being developed DiscoverFramework https://github.com/mistyblue17/DiscoverFramework_v1.2/

ARKANSAS RIVER
- Often dry at Garden City
- Streamflow diversions and gw pumpage predates data availability

RATTLESNAKE CREEK
- Declining streamflow due to irrigation pumping
- Impacts US Wildlife Refuge
- Stop pumping orders being negotiated. Very tough process.

Table #. Metrics for Middle Arkansas River watershed from 1963 - 2021Time series plots of six selected metrics, Mann-Kendall (MK) results for six annual streamflow statistics in the. ▲ = significant positive trend, △ = non-significant positive trend, ▽ = non-significant negative trend, ▼ = significant negative trend.



RESULTS: HIGH-DENSITY

- Impact of water removal is evident in some places.

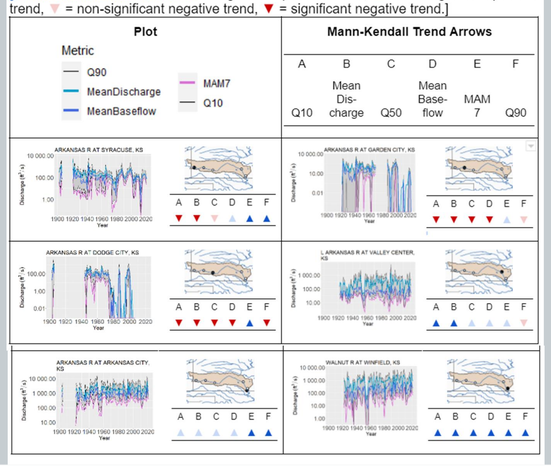
Difference between Q10 and Q90 (spread of gray band on plots)
- Smaller spread may be a good indicator of control by upstream dam.
  - Ex: Arkansas R at Coolidge
- Greater spread seems to be a good indicator of depleted streams depleted by pumpage and diversions.
  - Ex: Rattlesnake Creek, Pawnee R.

Difference between Mean discharge and mean baseflow
- Greater when river is stressed by groundwater declines.
  - Ex: Pawnee R

Inconsistent metric trends
- High flow metrics may show significant decreases in flow while low flow metrics may show significant increases in flow, or metric trends may be mixed significant and non-significant.
  - This could indicate that this section of the river is influenced by a dam, surface water diversion, or other flow regulatory activities.
  - Ex: Arkansas R at Syracuse, Arkansas R at Garden City

RESULTS: LONG DATA, TEMPORL TRENDS

Metrics for Middle Arkansas River watershed streamflows from 1902 - 2021, including time series plots of six selected metrics, and Mann-Kendall (MK) results for six annual streamflow statistics. Maps use black dots to identify location. In time-series plots, gray is to to highlight the area bounded by the Q90 and Q10 metrics.
[Mann Kendall trend arrows: ▲ = significant positive trend, △ = non-significant positive trend, ▽ = non-significant negative trend, ▼ = significant negative trend.]



CONCLUSIONS

- In Middle Arkansas Basin:
  - West of Garden City, Arkansas is mostly dry with significant downward trends in both high-density and long-term gage stations
  - Central watershed trends are neutral
  - Eastern stations have significant increasing in both high-density and long-term gage stations
- This work demonstrates temporal and spatial trends throughout the Central Arkansas basin and provides methodology to assess streamflow changes in other basins.

ACKNOWLEDGEMENTS

Funded by U.S. Geological Survey Powell Center Grant G20AC00197.

Working Group: Poster authors and **Hoori Ajami** (Univ of California Riverside), **Jessica Ayers** (Univ of California Berkeley), **Jillian Deines** (Stanford), **Holly Doremus** (Univ of California Berkeley), **William Farmer** – co PI (USGS Northeast Climate Adaptation Science Center), **Laura Foglia** (Univ of California Davis), **Tom Gleeson** (Univ of Victoria), **John Hammond** (USGS Water Science Center Maryland-Delaware-DC), **Ben Kerr** (Foundry Spatial Ltd, Victoria BC), **Howard Reeves** (USGS Water Science Center Upper Midwest), **Chloe Wardropper** (Univ of Illinois), **Gabriele Villarini** (Univ of Iowa)

REFERENCES

Ayers, J. R., Villarini, G., Jones, C., Schilling, K., 2019. Changes in monthly baseflow across the U.S. Midwest. Hydrological Processes, 33(5), 748–758. https://doi.org/10.1002/hyp.13359

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., Gilroy, E.J., 2020. Statistical Methods in Water Resources Techniques and Methods 4 – A3. USGS Tech. Methods. Kansas Geological Survey, 2020. WIZARD Water Well Levels Database [WWW Document]. URL http://www.kgs.ku.edu/Magellan/WaterLevels/index.html (accessed 9.9.22).

Kansas Geological Survey, Kansas Department of Agriculture, 2020. WIMAS water use trends [WWW Document]. URL http://hercules.kgs.ku.edu/geohydro/wimas/query_setup.cfm (accessed 9.9.22).

McMillan, H., 2020. Linking hydrologic signatures to hydrologic processes: A review. Hydrol. Process. 34, 1393–1409. https://doi.org/10.1002/hyp.13632

Tallaksen, L. M. and Van Lanen, H. A. J. 2004 Hydrological Drought: Processes and Estimation Methods for Streamflow and Groundwater. Developments in Water Science 48, Amsterdam: Elsevier.

U.S. Geological Survey, 2020a. National Water Information System: Streamflow Measurements for Kansas [WWW Document]. URL https://waterdata.usgs.gov/ks/nwis/measurements?search_criteria=county_cd&submitted_form=introduction (accessed 9.9.22).

Zipper, S. C., Farmer, W. H., Brookfield, A., Ajami, H., Reeves, H. W., Wardropper, C., Hammond, J. C., Gleeson, T., and Deines, J. M., (2022). Quantifying Streamflow Depletion from Groundwater Pumping: A Practical Review of Past and Emerging Approaches for Water Management. Journal of the American Water Resources Association 58(2), 289– 312. https://doi.org/10.1111/1752-1688.12998.