Convective storms and runoff generation in a highly altered urban center of north-central Texas, USA: from observations to modeling

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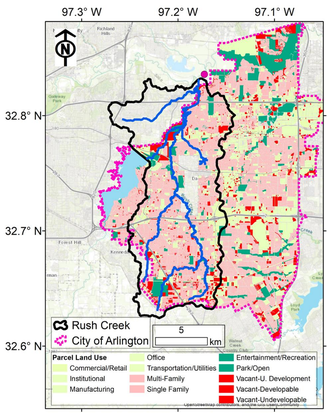
Research Questions

- What are the main factors influencing stable isotope variations of precipitation in north-central Texas?
- What are the predominant urban water sources involved in streamflow generation during extreme precipitation events?
- Can extreme precipitation events be a pollution driver in urban streams, where different water sources are mixed during peakflow and baseflow recession?

Hypotheses

- Extreme precipitation events can significantly affect the hydrological response of urban streams, storm runoff from mixed water of unknown urban sources can substantially affect the water quality in the stream.
- The rapid mobilization and subsequent redistribution of hazardous pollutants during periods of heavy precipitation and/or flooding are expected to influence the water and environmental quality of urban streams as sediment deposition into the stream increase .

Study site: Rush Creek watershed

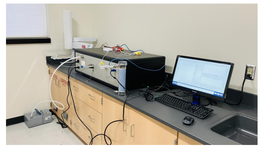


- Watershed area: 126 km².
- The area mainly comprises residential use (49%).
- Infrastructure related to commerce, industry, transportation, and parking lots covers 31.6%. Parks and vacant parcels comprise 9.9 and 9.8%, respectively.

Methodology

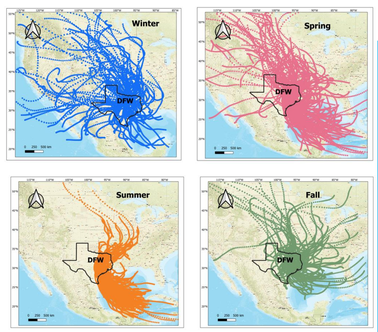
Precipitation and stream water event-based sampling during 2022-2024, HYSPLIT modeling, and discharge measurements.

Water stable isotopes analysis (laser spectroscopy) and Bayesian mixing models.

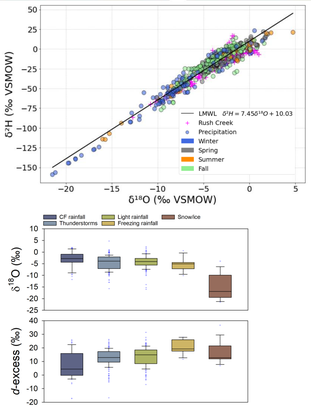


Water quality measurements to study C-Q patterns and high-frequency imagery using a Gaugecam system in the stream.

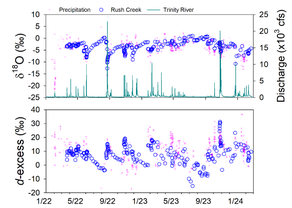
Results



- Moisture sources from Arctic and northern cold fronts, the Gulf of Mexico, and westerlies play a remarkable role in controlling isotope variations in north-central Texas.

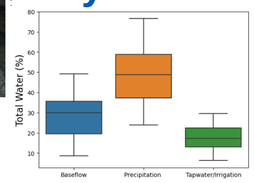


- $\delta^{18}O$ in precipitation values varied from +4.74 to -21.47‰, with a mean of -4.56‰ and between 36.7 to -17.3, with a mean of 12.5 for *d*-excess

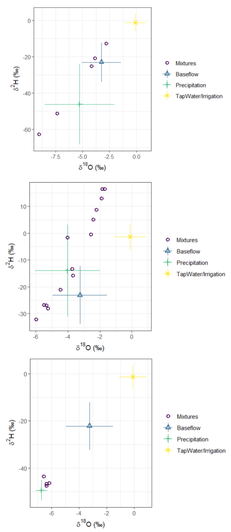


- Stream response is governed by convective storms; isotope compositions suggest potential water mixing from previously unknown urban sources

Bayesian mixing analysis



- Mixing analysis from 14 precipitation events revealed that the contribution of new water (precipitation) into the stream via surface runoff ranged between 40% and 60%.
- Baseflow contribution is between 20% and 39%, and irrigation water (tap water) between 12% and 23%.

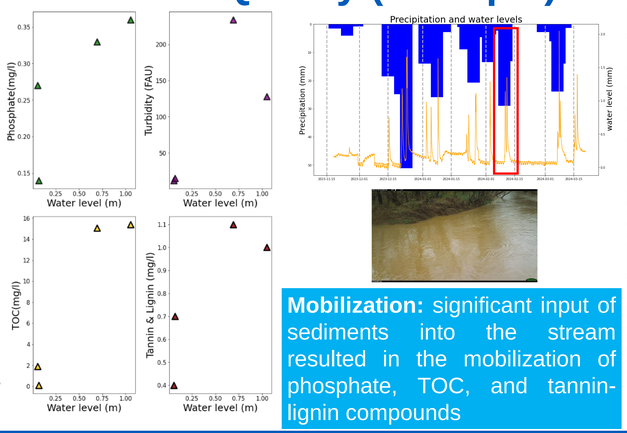


Event 1: This event was recorded during the last days of August 2022 (a 1,000-year return period event), with 55% of new water from storm runoff contributing to the stream.

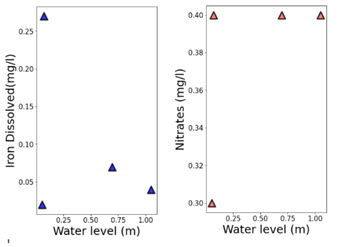
Event 2: This event was recorded in November 2023, with a contribution of 56% of new water to the stream from storm runoff and 17% of irrigation/new tap water into the stream.

Event 3: This event occurred in February 2024, and storm runoff contributed 84% of new water to the stream.

Water Quality (example)



Mobilization: significant input of sediments into the stream resulted in the mobilization of phosphate, TOC, and tannin-lignin compounds



Dilution & Chemostasis
Dissolved iron concentrations decrease as streamflow increases, while nitrate concentrations remain invariant during storm events.

Examples of different stream colors

Conclusions

- The direct influence of large precipitation events is clear in Rush Creek's flashy hydrological response. However, Bayesian mixing results revealed water inputs into the stream from other potential urban sources, such as irrigation.
- Phosphate, TOC, Turbidity, and Tannin-Lignin concentrations increased during storm events, suggesting an important sediment transport into the urban stream.

Future Research

- Study the temporal shifts in water sources and establish a tracer-aided model to improve understanding of Rush Creek's hydrological behavior.
- Our objective is to utilize water quality data alongside stream imagery spanning two hydrological years to create machine learning models capable to predict water quality through analysis of fluctuations in water color using the HSV color scale.

Acknowledgements

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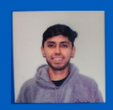

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