Quantifying spatiotemporal variability of water source contributions to coastal urban canal networks

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Background

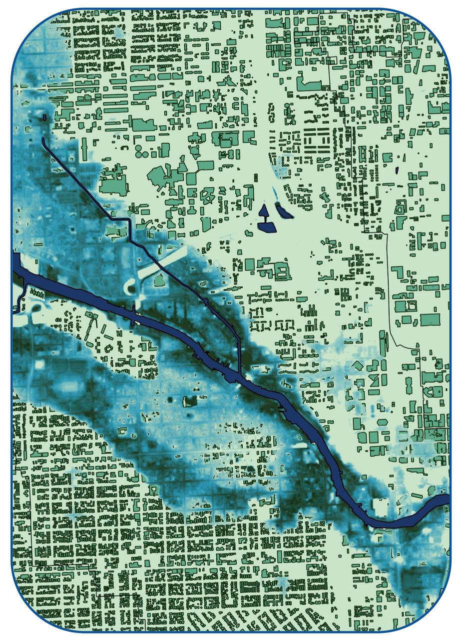


Figure 1. 1-6 foot sea level rise projections in downtown Miami, FL through year 2100

Shifts in rainfall and tidal patterns due to climate change drastically alter the timing and source of water contributions to coastal river networks.[1] Increased frequency and magnitude of high tides and pluvial flood events further exacerbate the variability of water quantity and quality supplied to coastal waterways which, in turn, affect proper ecosystem functioning. While water sources are expected to change in response to tides and rainfall, few have quantified the proportion of water source contributions across sub-hourly, daily, and seasonal time scales.[1,2]

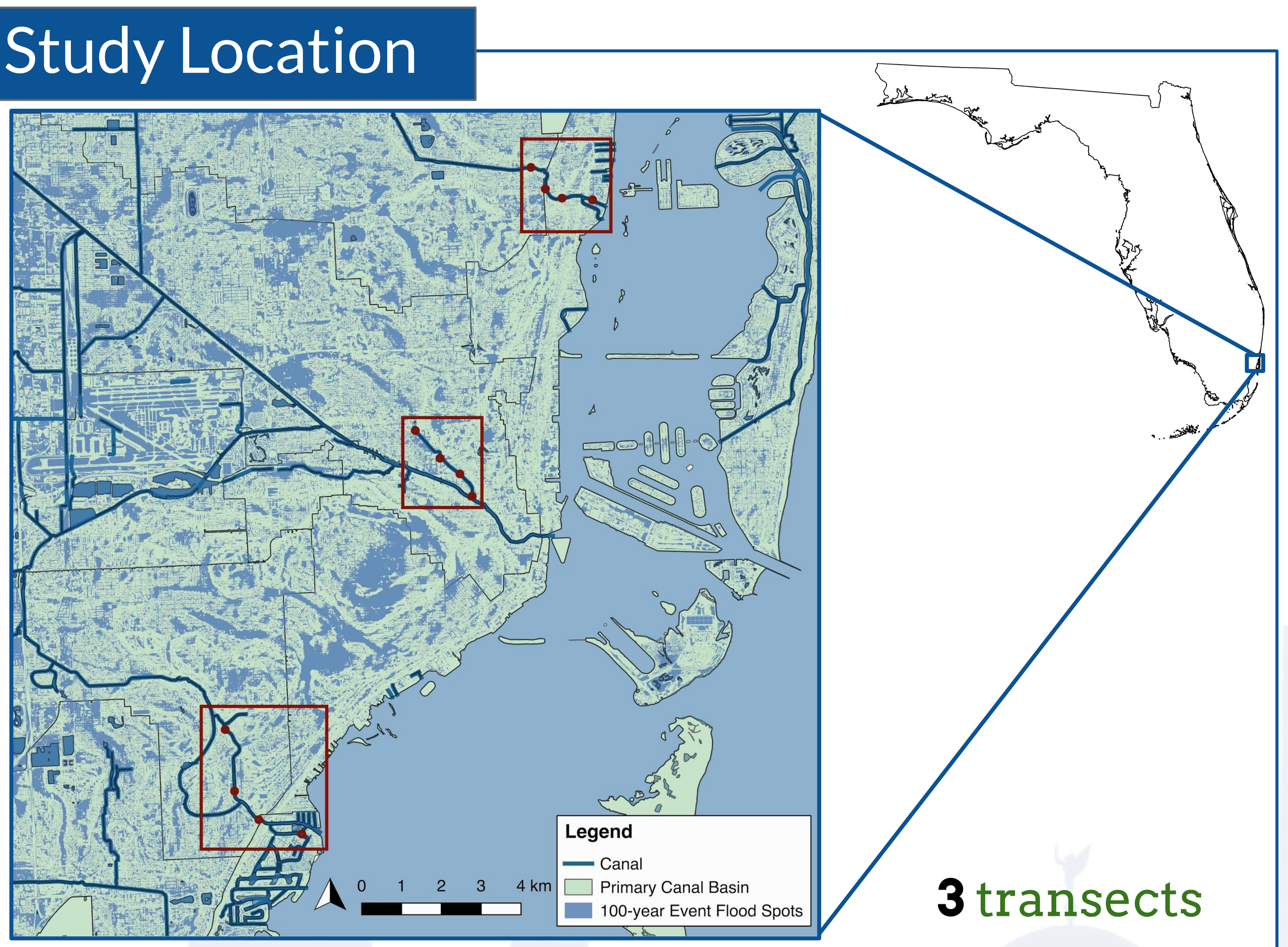
Our research objectives were to:

- Quantify spatial and temporal differences in water quality parameters across three coastal urban canal networks
- Differentiate water source contributions across tidal amplitude and seasonal wet-dry season

Research Questions

1. Can isotopic, organic, and chemical tracers be used to identify water source contributions to coastal urban canals?
2. How do water source contributions vary with seasonal rainfall or tidal amplitude in mixed-use urban watersheds ?

Study Location



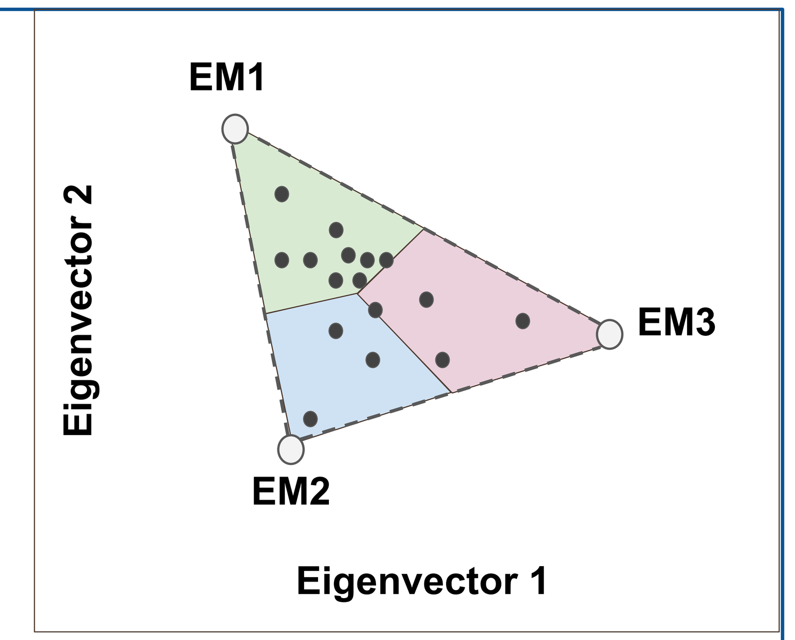
3 transects

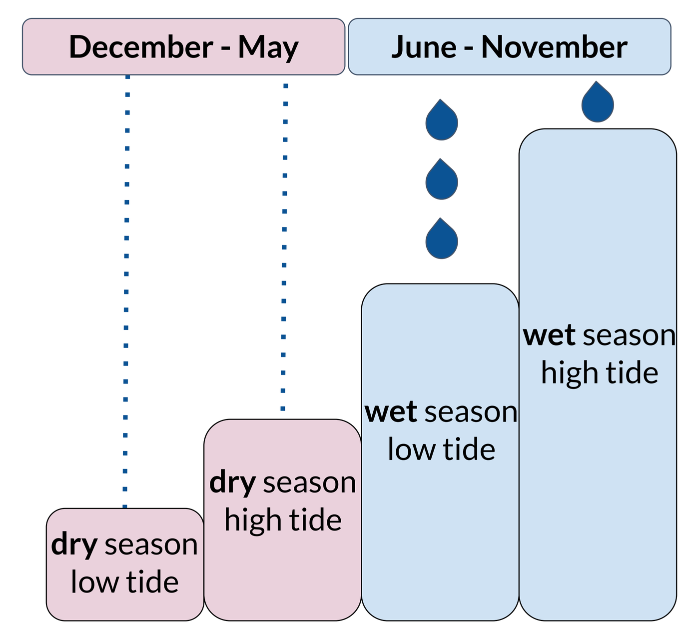
12 sites

Figure 2. Sampling map of primary urban canals draining three stormwater basins in Coral Gables (CG), Wagner Creek (WC), and Little River (LR). Four locations in each canal are sampled monthly during low-high tide and across wet-dry season

Methods

- Monitor fluctuations in water level and baseline conditions of temperature, dissolved oxygen (DO), salinity, and DOC concentration
- Measure DOC fluorescence, δ^2H and δ^{18}O stable isotopes, and chloride (Cl^-) during (1) monthly baseflow events, (2) high v. low tide, and (3) wet v. dry season (n=216)





- Develop endmember mixing model (EMMA) to differentiate between three water sources (rainwater, groundwater, marine water) in mixed canal water
- Quantify relative proportions of water source endmembers through coupled principal component analysis (PCA) and statistical regression analysis

Results

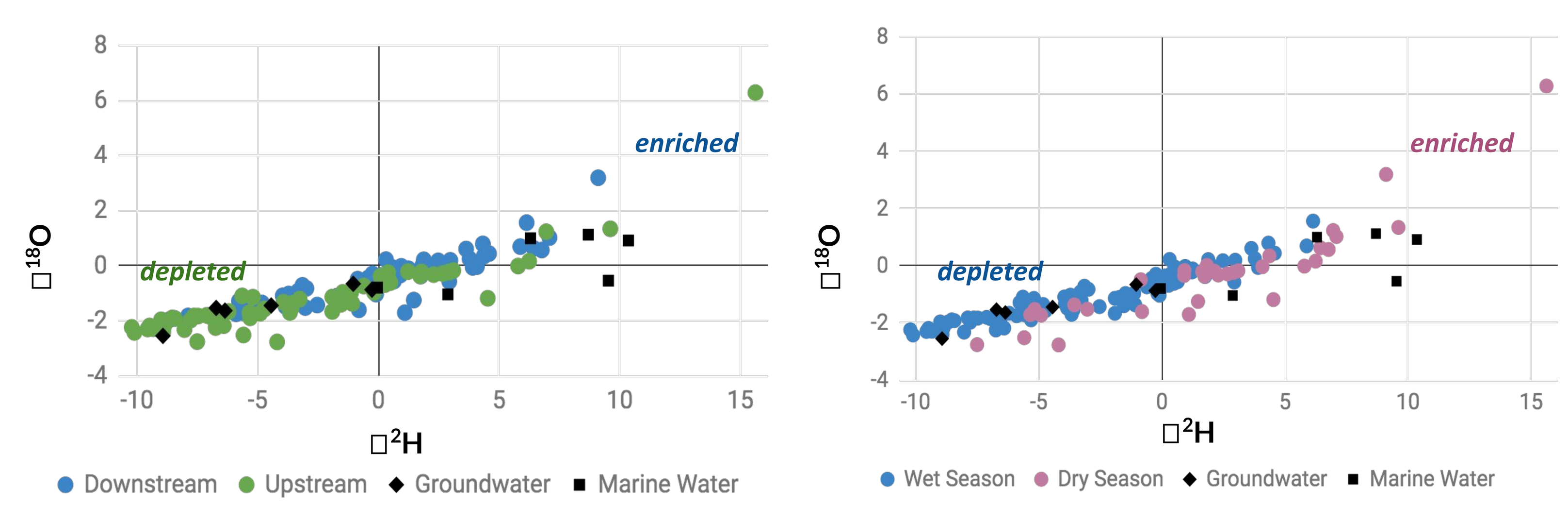


Figure 3. Stable isotope plot of canal water across wet (June-November) and dry seasons (December - February), including endmembers of groundwater and marine water (n=135)

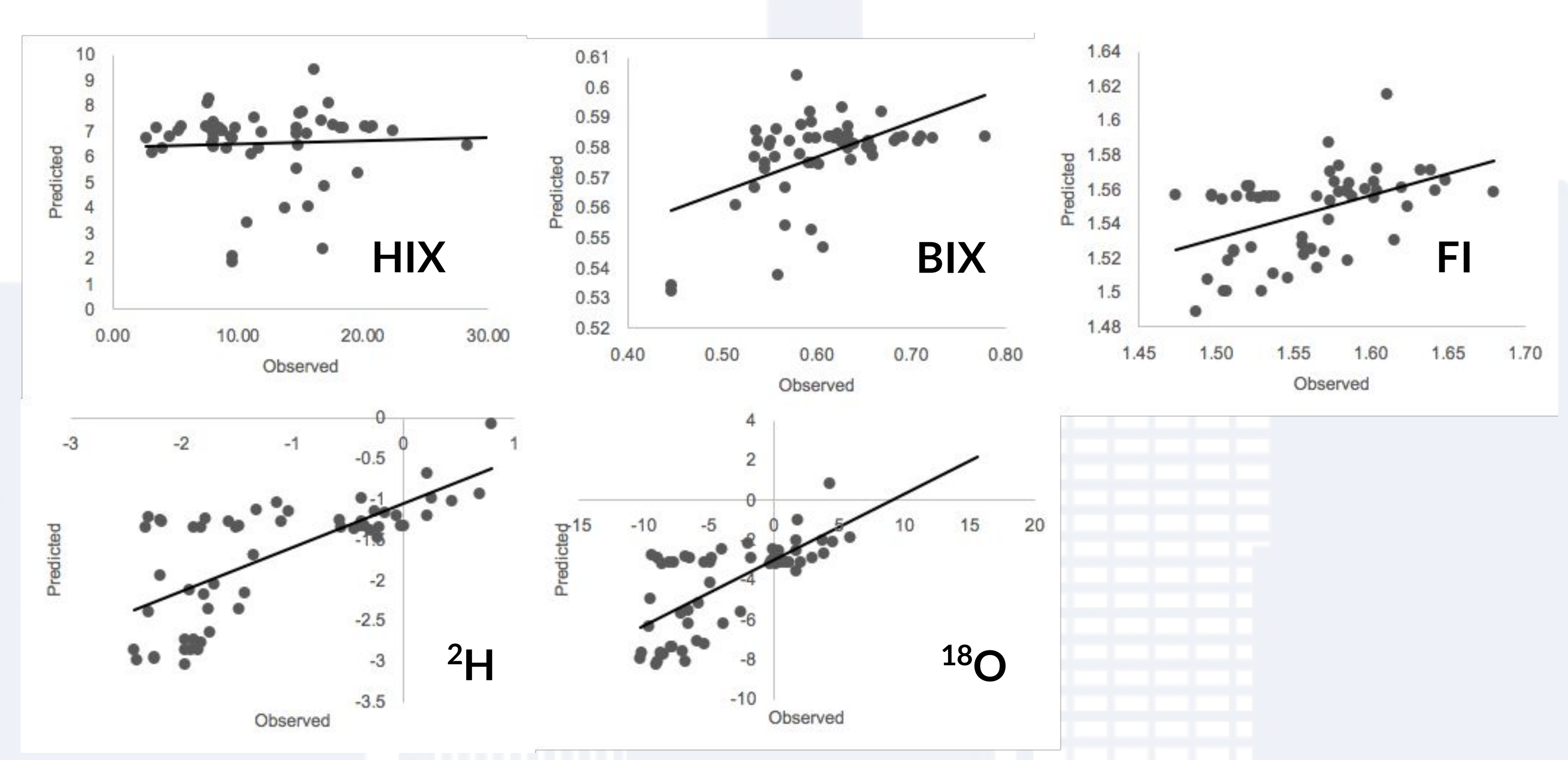
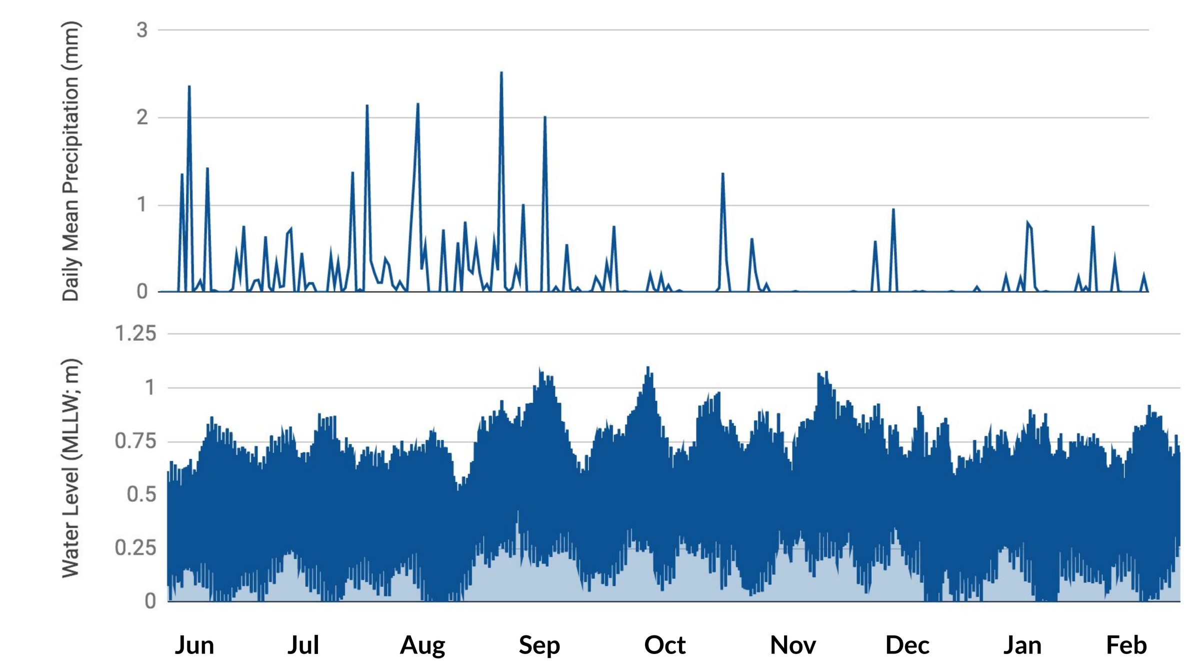


Figure 4. Observed vs. predicted values for five of six tracers used in mixing model including humification index (HIX), biological index (BIX), fluorescence index (FI), deuterium (δ^2H) and δ^{18}O isotopes

Results



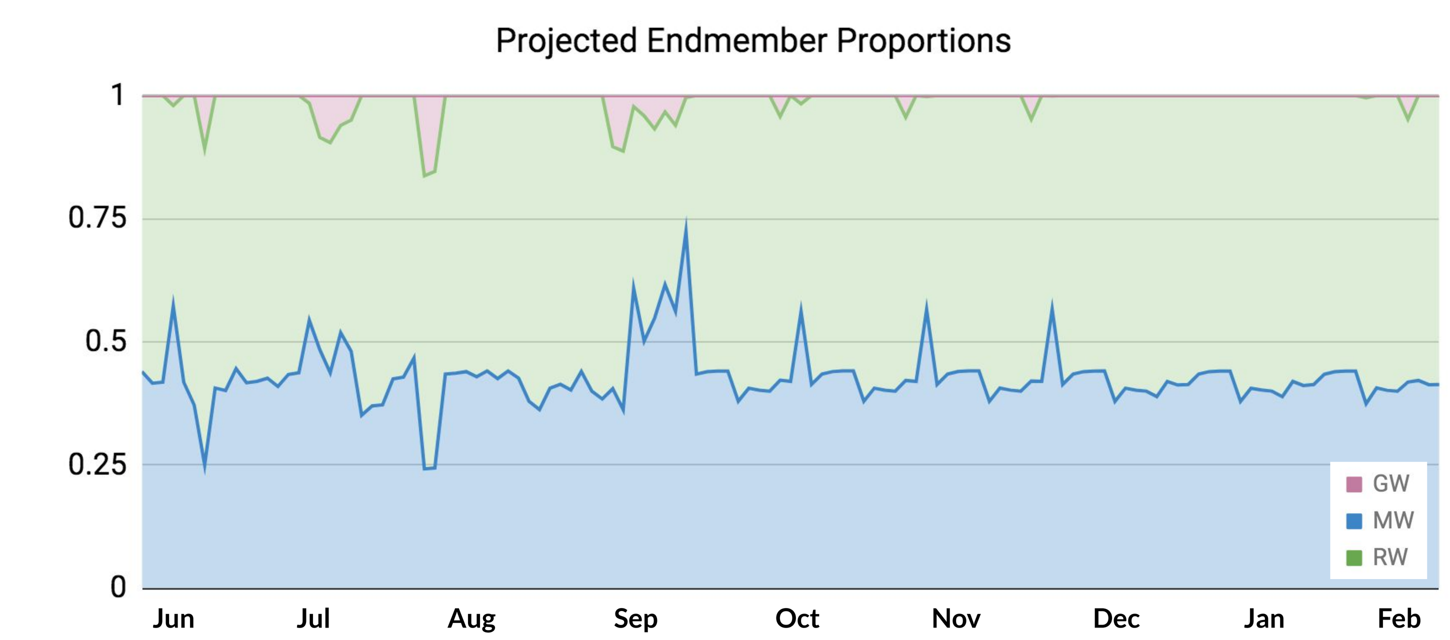


Figure 5. Constrained relative proportions of groundwater (GW), rainwater (RW), and marine water (MW) across sites from June 2018 to February 2019 (n=135)

- Proportion of groundwater is highest during peak wet season when tidal amplitude and total runoff are strongest
- Baseline water contributions mimic site-specific tidal ranges

Conclusions

- Application of mixing model to predict tracer concentrations and water source is supported by seasonal changes in rainfall and tidal influence
- Greatest change in tracer concentrations following extreme events
- Sub-hourly sampling during extreme runoff events is required to confirm signature of terrestrial (organic) tracers in stormwater
- This information will support site-specific water management aimed at controlling freshwater delivery and saltwater intrusion into urban waterways

Literature Cited:

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[2] Junk, W., Bayley, P.B., and Sparks, R.E. (1989) The flood pulse concept in river-floodplain systems. Pages 110-127 in Dodge, ed., Proceedings of the International Large River Symposium (LARS). Canadian Special Publication of Fisheries and Aquatic Sciences 106.

This research was supported by the National Science Foundation (Grant No. 1444755). Any opinions, findings and conclusions expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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