Nationwide Study of the Response of Municipal Outdoor Water Use to Climatic Factors

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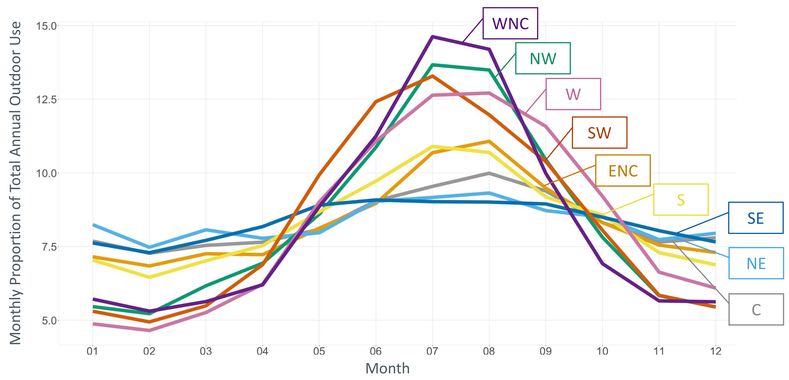
Background and Motivation

- Urban water supply planning has become increasingly challenging under the effects of climate change, population growth, and altered land use patterns (Brown et al., 2013; Roy et al., 2012), with over 70 percent of U.S. county water supplies projected to be “at risk” by 2050 (Roy et al., 2012)
- Previous studies show that outdoor water use can account for over 50 percent of total annual household use (Grimond and Oke, 1986; Mayer et. al, 1999), and therefore is a major component of the urban water budget.
- Literature lacks a nationwide assessment of the response of outdoor water use to climatically-driven factors

SEASONAL VARIATION ACROSS CLIMATES:



Research Questions

1) Which climatic variables are important for explaining the variability in outdoor municipal water use for landscape irrigation?
2) How does the response of outdoor water use to climatically-driven factors vary between climate regions across the U.S.?

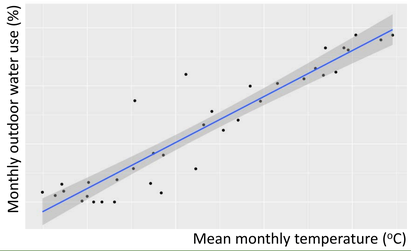
Data and Methods

DATA:

- Aggregated monthly water withdrawal data for 230 cities from *Brown, T. C., R. Foti, and J. A. Ramirez (2013), Projected freshwater withdrawals in the United States under a changing climate, Water Resour. Res., 49.*
  - Most cities contain 1-4 years of data between 2000-2007
- Monthly temperature and precipitation rasters obtained from PRISM Climate Group for 1990-2007 and processed for each city
- Monthly actual evapotranspiration (ET_a) rasters from SSEBop for 2000-2007

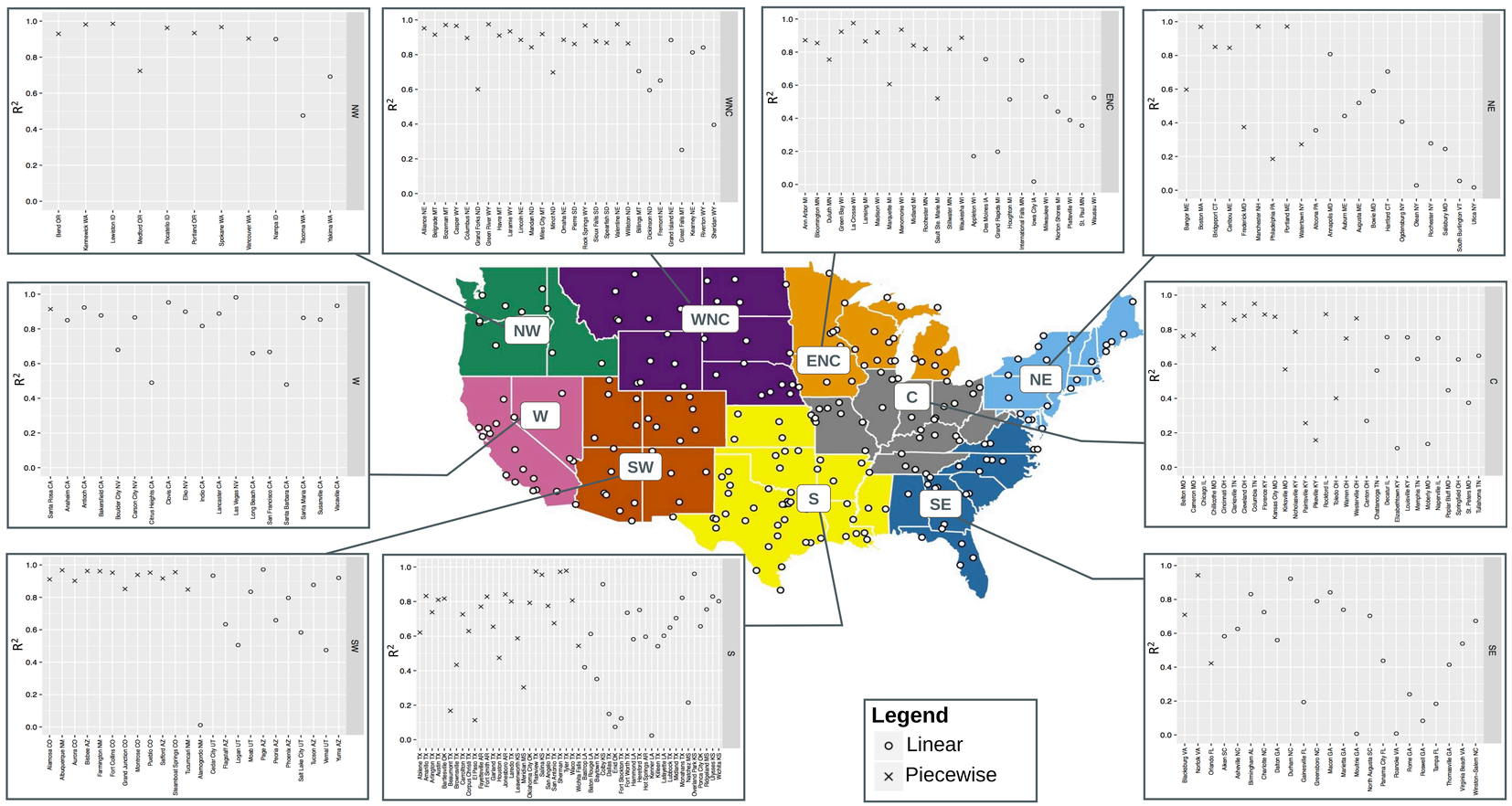
MINIMUM MONTH METHOD ANALYSIS:

- Outdoor use is derived from the assumption that winter water deliveries are relatively constant and can be used as a proxy for indoor use
- Linear and piecewise regressions determine how much of the variance in outdoor use can be explained by each climate variable for each city
  - Units of the water use dataset were normalized by calculating the monthly proportion of total annual use as a percentage

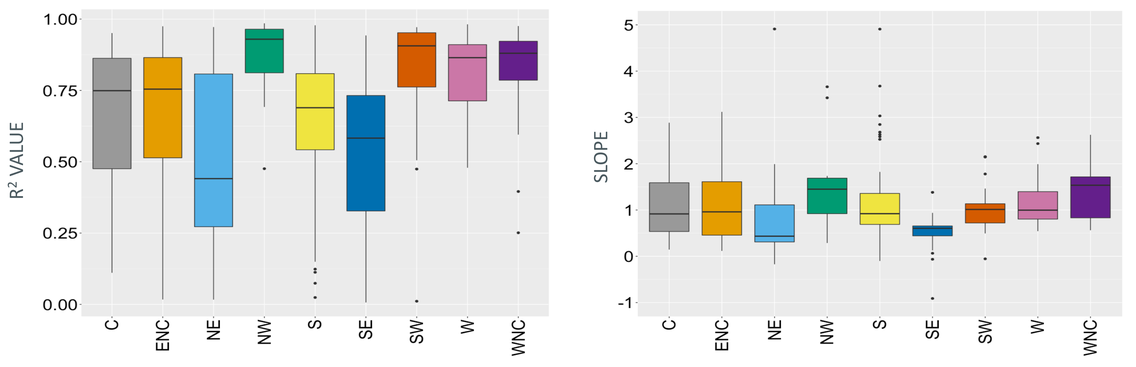


Results

R^2 VALUES FOR EACH CITY WITH MEAN MONTHLY TEMPERATURE AS THE EXPLANATORY VARIABLE:



MEAN MONTHLY TEMPERATURE STATISTICS SUMMARIZED BY CLIMATE REGION:



PRECIPITATION RESULTS:

- Regressions with total monthly precipitation as an explanatory variable showed no correlation to outdoor water use
- Average R^2 values ranged from 0.06 to 0.38 and showed both increasing and decreasing trends
- Suggests that irrigators do not adjust their outdoor water use by an observable amount in response to discrete rainfall events when assessed at a monthly time scale

Conclusions and Future Work

- Variability in outdoor water use is explained well using mean monthly temperature as an explanatory variable, with average R^2 ranging from 0.41-0.76
- Slope values indicate certain climate regions are more responsive to seasonal changes in temperature (e.g. W, NW, WNC, SW)
- Climate regions with high slope values also had low variability in R^2 values, suggesting outdoor use was well predicted by temperature in those locations
- Total monthly precipitation was not correlated to monthly outdoor water use, with average R^2 ranging from 0.06-0.38
- Future work will involve interpreting correlations between additional explanatory variables such as the Palmer Hydrologic Drought Index and ET_a, as well as correlations for variations of temperature and precipitation measurements such as deviation from normals, number of precipitation events, and number of heating/cooling degree days