SCHOOL OF Geographical Sciences & Urban Planning
ARIZONA STATE UNIVERSITY
contact: kwmurphy@asu.edu

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Dual Heuristics for Assessment of Hydrologic Sensitivities to Climate Change in Watersheds of the Lower Colorado River Basin

Kevin W. Murphy, Arizona State University
Benjamin S. Murphy, Oregon State University Andrew W. Ellis, Virginia Polytechnic Institute and State University

OSU Oregon State University
College of Earth, Ocean, and Atmospheric Sciences
VirginiaTech Invent the Future

BACKGROUND

Uncertainties in climate change impacts on water resources can be reduced with a thorough understanding of a watershed's hydrologic sensitivity to temperature and precipitation. Land-surface hydrology models (LSHMs) entail computational complexity, data management challenges, exhausting recalculations per climate projections, and result in larger differences between LSHMs than the change examined. Alternatively, two efficient heuristics have been proposed. Their comprehensive descriptions are vital for semi-arid watersheds with distinct seasons, low runoff efficiencies, and highly skewed variability – such that nominal assessments are incomplete characterizations. The heuristics are:

Temperature Sensitivity of Streamflow

$$S_T = \frac{\Delta Q/Q}{\Delta T}$$ % change in streamflow for 1 degree temperature change (%/K)

Precipitation Elasticity of Runoff

$$\mathcal{E}_p = \frac{\Delta R/R}{\Delta P/P}$$ % change in runoff for 1% change in precipitation (unitless)

[In this analysis: runoff (R) = streamflow (Q) less base flow]

ANALYSIS METHODS

KRIGING – Ordinary Kriging, linear variogram model (see AGU2014 H51K-0753), 100x100 grid analysis.

REGRESSION – Partial differentials of regression solutions relative to nominal, and aggregate solutions.

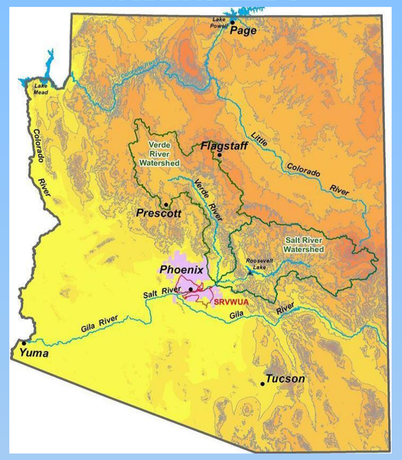
DATA

Temperature & Precipitation: PRISM, gridded per watershed, 1895 to present

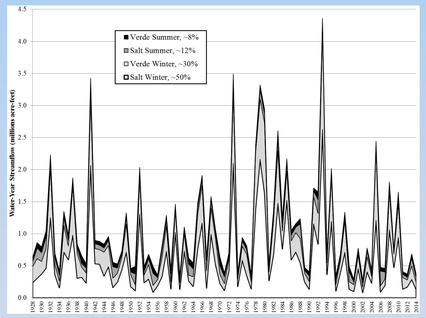
Streamflow: USGS stream gages (unregulated flows), from gage in service to present

Data prepared to seasons: Winter = Oct 1st to season transition (Verde May 1st ; Salt June 1st)
Summer = season transition to Sept 30th

SALT & VERDE RIVER WATERSHEDS

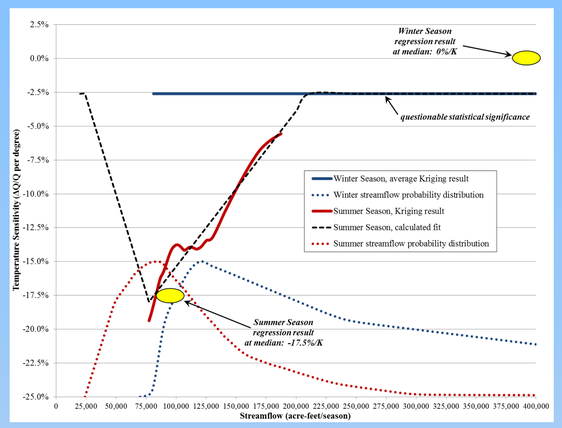


Historical Streamflow

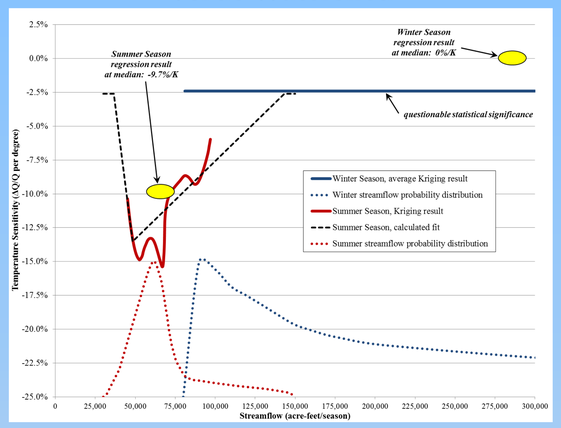


TEMPERATURE SENSITIVITY OF STREAMFLOW

Salt Watershed



Verde Watershed

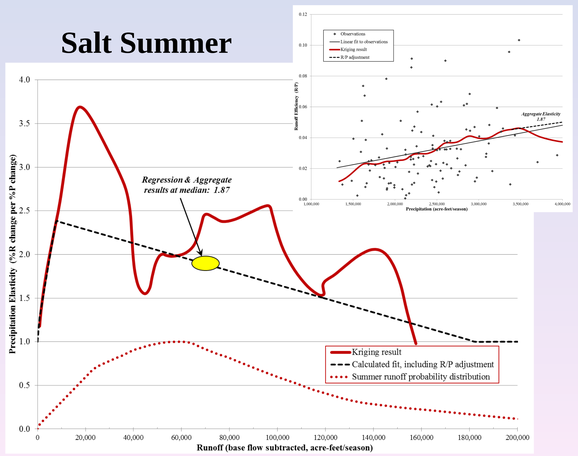


PRECIPITATION ELASTICITY OF RUNOFF

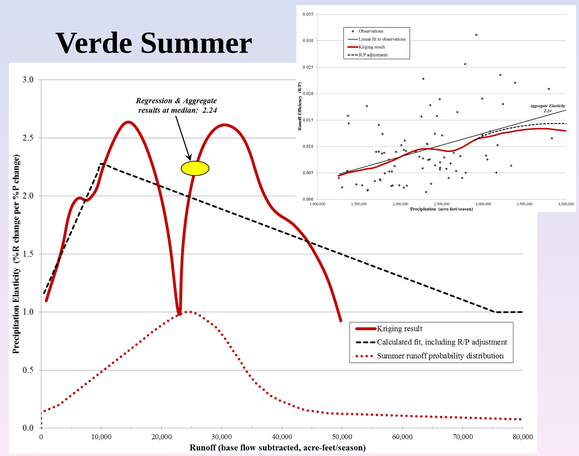
Salt Winter

Verde Winter

Salt Summer

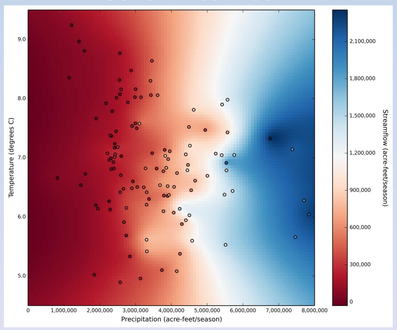


Verde Summer

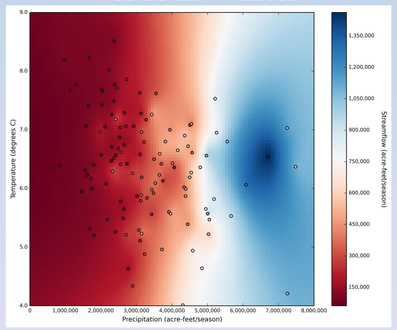


KRIGING RESULTS

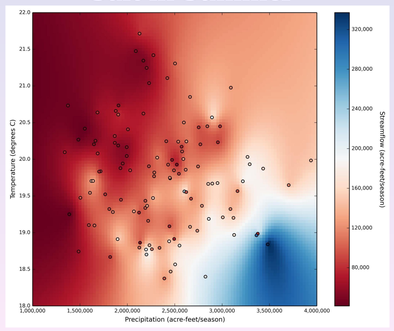
Salt in Winter



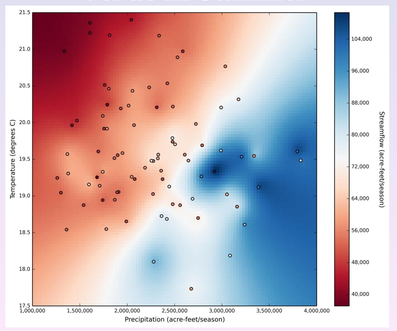
Verde in Winter



Salt in Summer



Verde in Summer



CONCLUSIONS

- Assessments at the mean/median are overly simplistic for highly skewed, non-linear watershed response.
- Relative position within probability distributions has important implications for flow response to precipitation and temperature changes.
- Seasonal flow proportions moderate overall flow impairment when winter temperature sensitivities are small and summer sensitivities are large.
- Dual-heuristic approach provides evidence-based hydrologic sensitivities that are readily interpretable and easily applied to a range of long-term climate change scenarios for assessment of water resource sustainability.