Relations Between the El Niño-Southern Oscillation and River Flow in Oregon and Northern California

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I. Introduction

- The El Niño-Southern Oscillation (ENSO) plays a major role in western U.S. precipitation patterns, resulting in El Niño (warming) or La Niña (cooling) events.
- Indices like the Trans-Niño Index (TNI) measure ENSO strength, and the Oceanic Niño Index (ONI) indicates El Niño or La Niña based on SST anomalies.
- Fleming and Dahlke (2014) discovered significant parabolic relations between ENSO and river flow in major rivers throughout the Northern Hemisphere.
- This project expanded their research focusing on the eastern Pacific Ocean, Oregon, and northern California.

II. Objectives

- Determine if there are significant statistical linear or quadratic relations between ENSO indices and river stream flow Oregon, and northern California.

III. Methods

- Compiled data on streamflow, winter precipitation, and peak annual snow water equivalent (SWE) from eight basins in southern Oregon and California (1980-present) Basins had varying numbers of gauges or stations (1-8), and average/max annual precipitation and average SWE values were obtained).
- Data sourced from the Natural Resource Conservation Services (NRCS) and ENSO indices (TNI and ONI) data obtained from NOAA and NCAR websites.

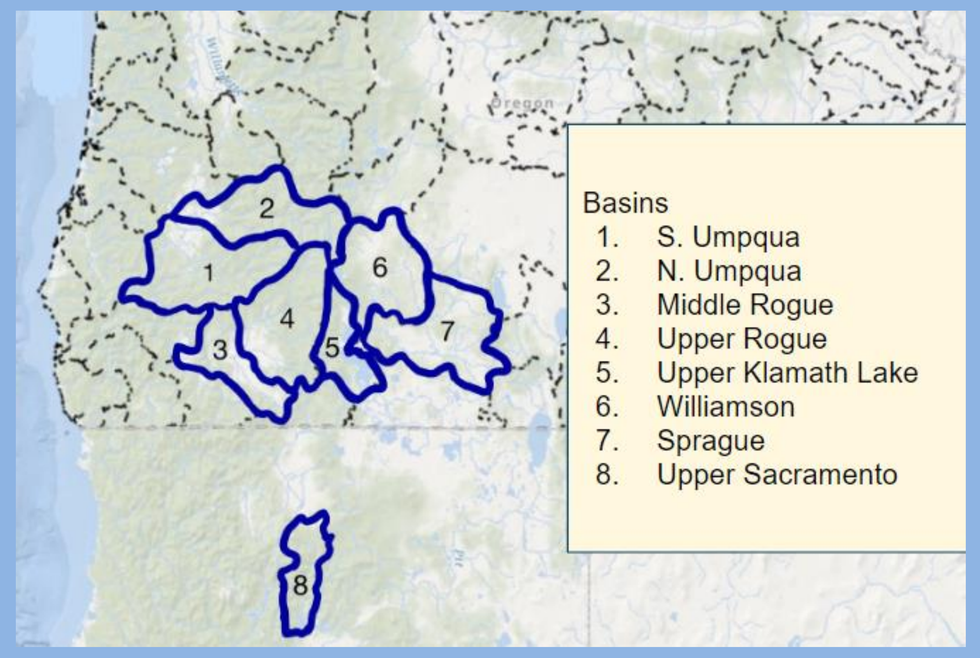
ENSO Strength (index)
- Oceanic Nino Index
  - Measure of SSTA strength
- Trans-Niño Index
  - Measure of longitude of the SSTA
- Winter values

Precipitation
- Cumulated Rainfall (in)
  - Oct 1 - Mar 31
- Yearly peak snow water equivalent (in)
  - Apr 1

Streamflow
- Cubic ft/sec
- Apr - July

- Data compiled in Excel, and two statistical analyses conducted in R. First analysis examined relations between ENSO and cumulative precipitation and peak annual SWE at SNOTEL stations. Second analysis explored the relationship between streamflow, precipitation, and ENSO strength.

IV. Map of Basins



V. Table of linear and Quadratic Relations

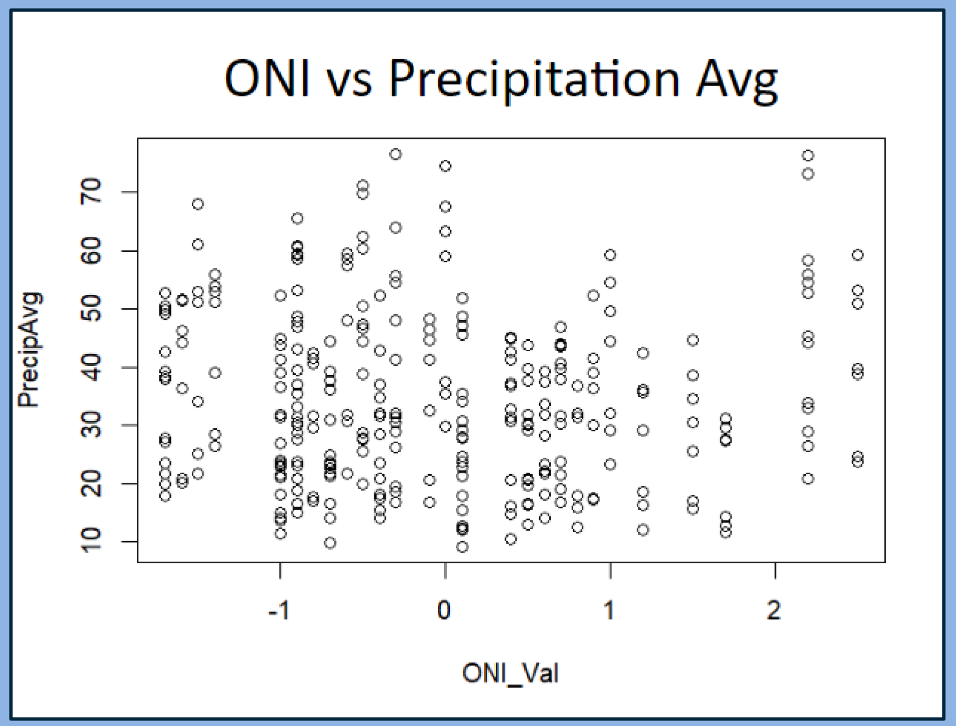
Response ~ Independent	P-values		Corr. Coef.	
	Linear	Quadratic	Linear	Quadratic
Precip Avg ~ TNI	<2e-16	<2e-16	0.000	-0.041
Precip Avg ~ ONI	0.395	< 2e-16	0.000	-0.039
SWE Avg ~ TNI	<2e-16	4.36e-11	0.000	-0.038
SWE Avg ~ ONI	<2e-16	<2e-16	0.000	-0.041
Streamflow ~ TNI	<2e-16	1.12e-05	0.000	-0.062
Streamflow ~ ONI	0.000189	4.07e-10	0.001	-0.058

Table 1: P-values and correlation coefficients categorized by variable and analysis type.

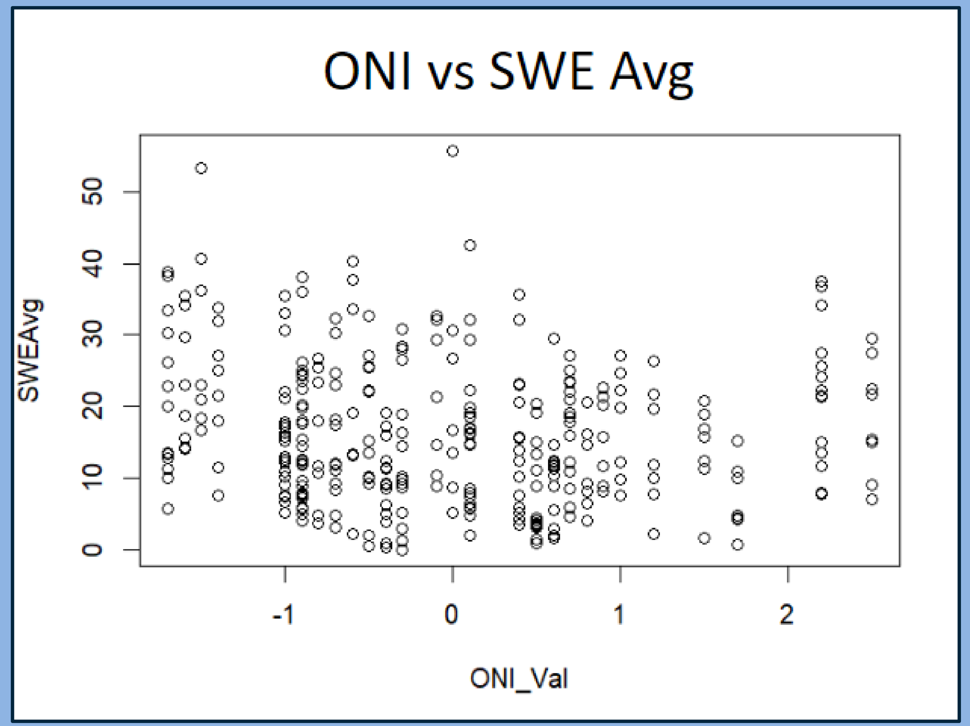
VI. Results

Statistically significant linear and quadratic relations between average cumulative precipitation and ENSO indices (ONI and TNI) as well as snow water equivalent (SWE), were determined in the examined eight basins. However, despite statistical significance, the correlations in quadratic models were only slightly larger, suggesting limited predictability across the full span of ENSO indices and precipitation or streamflow.

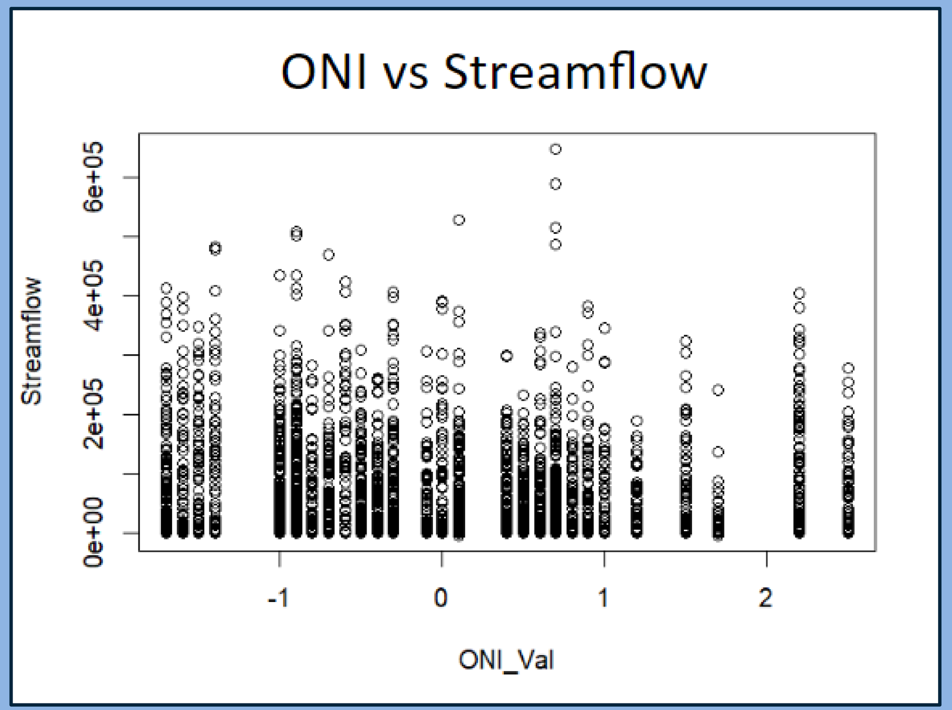
a)



b)



c)



d)

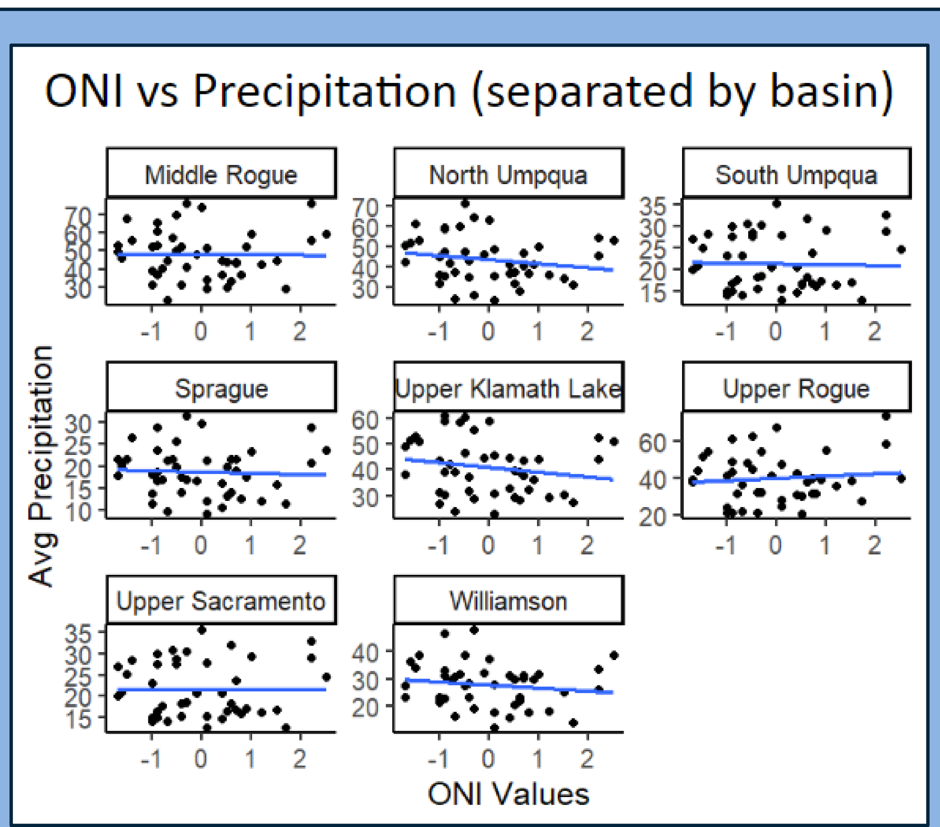


Figure 1: Relation between ONI values and a) average cumulative October-March precipitation, b) Peak SWE average and c) River stream flow d) Across 8 basins in Oregon and northern California.

VII. Conclusions

- Linear and quadratic relations were found between average cumulative precipitation, ONI, TNI, and SWE, and between streamflow and ONI and TNI, all statistically significant.
- Correlations in quadratic models were slightly larger but did not exceed -0.062, indicating limited predictability across the full span of ENSO indices.
- Low p-values were expected due to large sample sizes.
- Visualizing the data in R revealed a lack of clear shape but a slight dip in precipitation values at higher ONI values, with some higher values at the extremities.
- Past relations may not enable future predictions, especially if future climate variables deviate from historical ranges.

VIII. Future Works

- Expand range of river selection.
- Try alternate non-linear regressions methods.
- Expand on TNI relations in reference to SSTA longitude.
- Wider range of dates for data to look at peak timing.

IX. References

1. Beebee, R. A., & Manga, M. (2004). VARIATION IN THE RELATIONSHIP BETWEEN SNOWMELT RUNOFF IN OREGON AND ENSO AND PDO. *Journal of the American Water Resources Association*, *40*(4), 1011–1024. https://doi.org/10.1111/j.1752-1688.2004.tb01063.x
2. Fleming, S. W., & Dahlke, H. E. (2014). Parabolic northern-hemisphere river flow teleconnections to El Niño-Southern Oscillation and the Arctic Oscillation. *Environmental Research Letters*, *9*(10), 104007. https://doi.org/10.1088/1748-9326/9/10/104007
3. Kennedy, A. M., Garen, D. C., & Koch, R. W. (2009). The association between climate teleconnection indices and Upper Klamath seasonal streamflow: Trans-Niño Index. *Hydrological Processes*, *23*(7), 973–984. https://doi.org/10.1002/hyp.7200
4. Luke, S. G. (2016). Evaluating significance in linear mixed-effects models in R. *Behavior Research Methods*, *49*(4), 1494–1502. https://doi.org/10.3758/s13428-016-0809-y

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