Tree-Ring Extension of Precipitation Variability at 12-km Grid Points in Eastern Nevada: Implications for Drought Analysis

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Abstract

Space-time geostatistical models can improve kriging estimates when long temporal sequences of observations exist at relatively few points on the landscape. In the Great Basin of North America, ecotonal environments characterized as lower forest border sites are ideally suited for tree-ring reconstructions of hydroclimatic variability. A network of 22 chronologies, some longer than 800 years, from single-leaf pinyon (Pinus monophylla) tree-ring samples for eastern Nevada, in the Great Basin of North America, provides a record of long-term precipitation variability. The period in common among all tree-ring chronologies, i.e., 1650-1976, was used to reconstruct October-May total precipitation using the Line of Organic Correlation (LOC) method. Individual site reconstructions were then combined using spatio-temporal kriging to produce 327 annual maps on a 12x12 km grid (315 total), covering ~230 km in the N-S direction and ~155 km in the E-W direction, with 500 m of elevation range (~1930-2430 m).

The 22 site reconstructions, mapped (left) and plotted (right) by year, were interpolated on 12x12 km grid cells (315 total), covering ~230 km in the N-S direction and ~155 km in the E-W direction, with 500 m of elevation range (~1930-2430 m).

Space-time kriging of October-May reconstructed precipitation

The 3 driest years were 1934, 1879, and 1782, and the three wettest years were 1914, 1868, and 1726. To estimate the likelihood of severe and sustained drought, multi-year events were numerically identified using their duration, magnitude, and peak. At the annual time scale, the most remarkable episode in the entire reconstruction was the early-1900s pluvial, followed by the late 1800s drought. The 1930s ‘Dust Bowl’ drought was in 8th position, making it a remarkable hydro-climatic episode for at least the past few centuries. After smoothing the annual values with a 7.5-year cubic spline to emphasize interannual variability, the early 1900s pluvial remained the strongest episode, but the 1950s drought became the second strongest one. Besides showing how regional drought severity varies across the Great Basin, these results directly address the needs of water managers with respect to planning for ‘worst case’ scenarios of drought duration and magnitude. For instance, it is possible to analyze which geographical areas and hydrographic basins are more likely to be impacted during the most extreme droughts, at annual or multiannual timescales AND at the km-spacing used by regional climate models. This approach allows water managers not only to evaluate drought patterns for single watersheds, but also to determine if episodes that occurred during the instrumental period can be used for long-term planning, thereby increasing their ability to design management practices aimed towards resiliency to future changes.

To estimate the likelihood of severe and sustained drought, multi-year events were numerically identified using their duration, magnitude, and peak (calculated at 5-year intervals).

The 10 (out of 150) annual strongest episodes (1650-1976)

The 10 (out of 55) interannual strongest episodes (1890-1976)

The early-1900s pluvial, a most remarkable episode in the last few centuries, biases the instrumental record. However, water management policies in eastern Nevada basins could use the 1920-30’s drought as a relevant worst-case scenario.

Acknowledgments

I thank J.D. Salas, L. Salo, and J. Leising for helpful discussions of statistical and hydrological issues. I am also extremely grateful to all the people and DendroLab personnel, especially Scotty Strachan, who contributed, either in the field or in the laboratory, in the development of the tree-ring network. This research was supported, in part, by Southern Nevada Water Authority, by the Office of the Vice President for Research at the University of Nevada, Reno, and by the US National Science Foundation under Cooperative Agreement EPS-0814372 and Grant No. P2C2-0823430. The views and conclusions contained in this document are those of the author and should not be interpreted as representing the opinions or policies of the funding agencies.

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