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The Climates of Southwestern North American Megadrought: Multi-Proxy, Multivariate Observations and Analysis

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Abstract: In the southwestern United States, there is no element of climate variability of greater concern to stakeholders than drought. The drought of the 1950's, and the even more severe drought of the 2000's (exacerbated by greater warmth), both highlight the major impacts that multi-year droughts can have on key sectors of the Southwest (e.g., water supplies, ranching, agriculture, and public lands management). Nonetheless, these recent "droughts of record" pale in comparison to the "megadroughts" (multidecadal periods of drought) that apparently occurred regularly over the last 2000 years. Much is known about these paleodroughts from prior work, but our understanding is far from complete, and outstanding questions remain: What role did anomalous temperature, snowpack, and atmospheric dust loading play in past megadroughts, and are there any paleo-analogs for the warm droughts of the last ten years in the Southwest? To what extent are tree-ring based reconstructions underestimating the severity and low frequency characteristics of drought, and can a multi-proxy approach be used improve the estimation of past drought variance and severity, as well as provide improved assessments of future drought risk for decision-makers? How have external forcing, SST forcing, and atmospheric circulation contributed to past severe, sustained droughts in the Southwest? In light of the past droughts, what are the implications for decision-making in the Southwest, and how can information about extreme paleodroughts be optimized to assist adaptation to future climate variability and change?

Our primary focus in this study will be on iconic drought and megadrought over the past 2000 years in the region that encompasses the headwaters of the Colorado and the Rio Grande rivers. We plan to employ an integrated multi-proxy approach employing both lake sediment and tree ring data to gain an improved understanding of both the high and low frequency characteristics of Southwest megadroughts and their relationships to temperature, snowpack and dust. Our proposed work will integrate existing and newly collected tree-ring data, including several sites co-located with two lake sites, from which we will also obtain new very high-resolution multiproxy sediment records in order to separate climate signal from local lake- and proxy-related variance. Completed fieldwork – including wood and sediment core collection - allows us to focus requested resources (and the PhD work of two students) on dating and multi-proxy climate reconstruction using proven methods. Tree-ring work will focus on using samples from six new living and remnant collections sites to generate a network of high-resolution moisture-sensitive bristlecone pine chronologies from the same general region, whereas the lake work will focus on quantitative temperature and hydrologic reconstructions using multiple independent methods for each of the two lakes. Our goal is to combine proxy information from all sources for a more complete understanding of the nature and characteristics of these megadroughts, as well as the conditions during transitions into and out of megadroughts. We will synthesize existing paleodata for the headwaters region with our new record, as well as with information on the large-scale controls on these droughts. Through the Climate Assessment of the Southwest

(CLIMAS) program, we will expand on our previous efforts with stakeholders to optimize the manner in which the new drought data and information are used to improve water and land management (e.g., for the Colorado and Rio Grande basins and the population of over 30 million people in eight states and two countries that the rivers serve).