Quaternary Science Reviews xxx (2016) 1–6

Contents lists available at ScienceDirect

Quaternary Science Reviews

journal homepage: www.elsevier.com/locate/quascirev

Short communication

Magnitude and frequency of wet years under a megadrought climate in the western Great Basin, USA

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ARTICLE INFO

Article history:
Received 11 May 2016
Received in revised form
20 September 2016
Accepted 21 September 2016
Available online xxx

Keywords:
Great Basin
Interannual variability
Megadrought
Paleohydrology
Terminal lake
Western United States

ABSTRACT

Megadroughts are not devoid of interannual precipitation variability. However, the frequency and magnitude of occasional wet years must be limited in order to be consistent with geologic evidence indicating terminal lake lowstands during past megadroughts. We present a series of hydrologic model simulations of Walker Lake, a western Great Basin terminal lake, where varying return intervals of increased cool-season (October–April) precipitation are superimposed upon a megadrought climate. Estimated megadrought lowstands are achieved with wetter years returning every 5–10 years. Total cool season moisture transport derived from the 20th Century Reanalysis between 1895 and 2012 A.D. was positively correlated with cool-season precipitation during the corresponding year (0.49, $p < 0.01$). Daily moisture transport exceeding the 95th percentile is used as a surrogate for atmospheric river events. Wetter (drier) years had a greater (lesser) fraction of total cool season transport occurring on atmospheric river days, indicating their important role in driving western Great Basin hydroclimate variability.

1. Introduction

Severe multidecadal droughts (hereafter megadroughts) in the western United States are well documented by paleoproxy evidence during the middle-late Holocene (Stine, 1994; Benson et al., 2002; Adams, 2007; Mensing et al., 2013). Despite interannual precipitation variability during megadroughts (Cook and Krusic, 2004), the frequency and magnitude of occasional wet years must be limited in order to be consistent with geologic evidence of drought conditions (Stine, 1994; Adams, 2007). Great Basin terminal lakes such as Walker Lake (Fig. 1a) offer ideal locations to study changes in regional hydroclimate because as closed hydrologic systems their surface area and elevation represents the balance between gains from direct on-lake precipitation and watershed-derived runoff and losses due to evaporation. For example, to achieve Walker Lake levels consistent with two extreme lowstands that took place during the megadroughts of the Medieval Climatic Anomaly (MCA; 850–1300 A.D., Stine, 1994), cool-season (October–April) precipitation reductions on the order of 30–40% compared to a baseline climate of 1971–2000 A.D. averages are required (Hatchett et al., 2015). These values are comparable with other estimates of MCA precipitation reductions (Stine, 1994; Graham and Hughes, 2007; Kleppe et al., 2011). In their simulations, Hatchett et al. (2015) assumed that the drought climates were persistent and each year had similar precipitation. Walker Lake is sensitive to interannual precipitation variability, however decadal-multidecadal persistence of climate conditions is required for complete hydrologic oscillations to occur (Hatchett et al., 2015).

Known modulators of interannual-decadal climate variability in the Walker Lake region include Pacific and Atlantic extratropical and tropical sea surface temperature (SST) variability and the associated atmospheric teleconnections (Wallace and Gutzler, 1981), with the El Niño-Southern Oscillation (ENSO) of particular importance (Dettinger et al., 1998; Cayan et al., 1999). However, the Walker Lake region sits near the inflection point of the western United States ENSO dipole (Dettinger et al., 1998; Wise, 2010)

Abbreviations: 20CR, 20th Century Reanalysis; ENSO, El Niño-Southern Oscillation; MCA, Medieval Climate Anomaly; PRISM, Parameter Regression Independent Slopes Model; WL, Walker Lake.

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http://dx.doi.org/10.1016/j.quascirev.2016.09.017

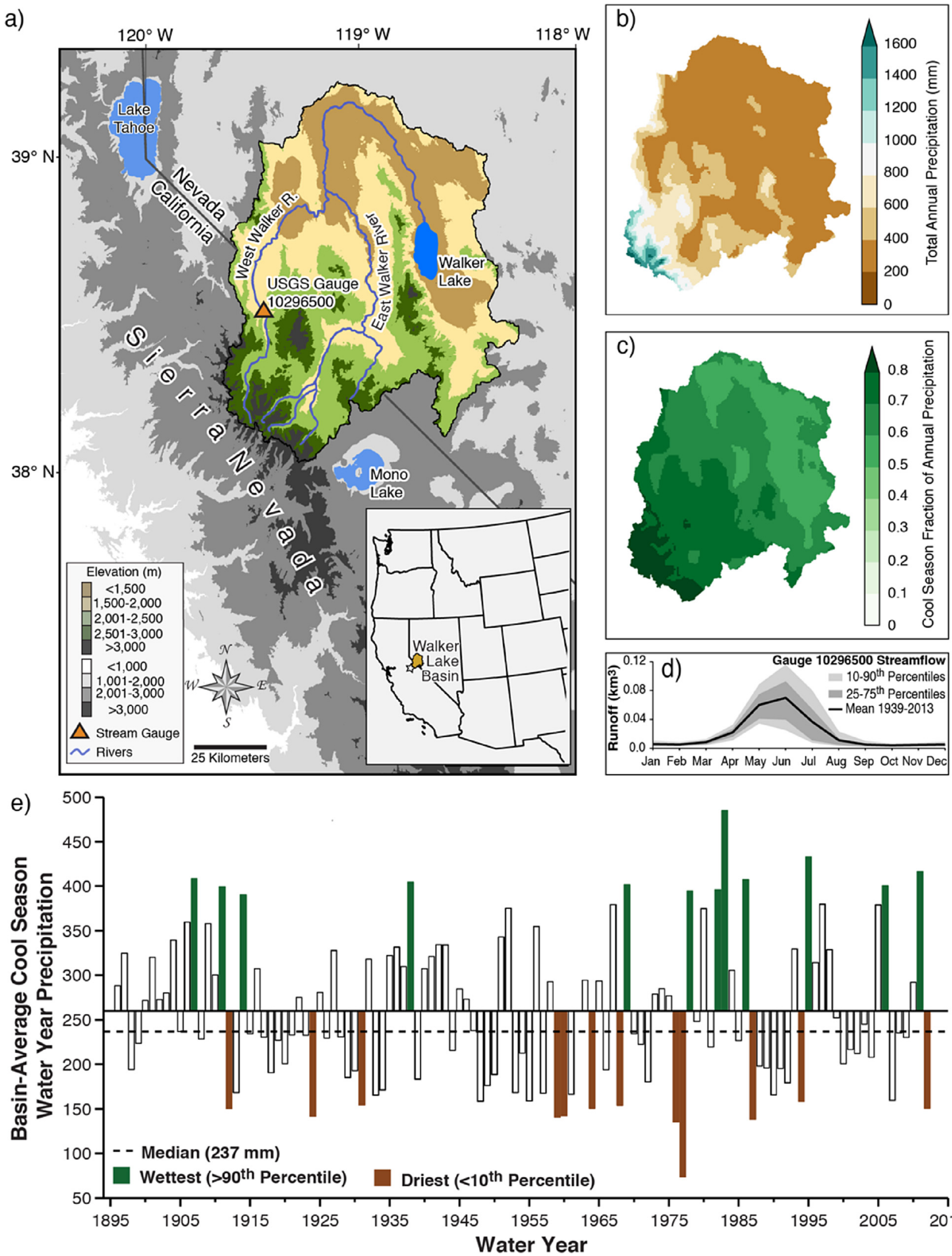

Fig. 1. a) The Walker Lake Basin study area (elevations within basin are colored, outside are grayscale) showing the forks of the Walker River and USGS stream gauge 10296500 along the West Walker River (triangle). The star on the inset map shows the grid point where upstream moisture fluxes were calculated. b) PRISM-estimated total annual precipitation in mm. c) Fraction of total annual precipitation occurring during the cool season (October–April). d) Observed monthly mean streamflow (km^3) at the USGS gauge. e) Walker Lake Basin average cool-season precipitation for water years 1896–2012.