Journal of Hydrology: Regional Studies 10 (2017) 35–46

Contents lists available at ScienceDirect

Journal of Hydrology: Regional Studies

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

A tool for drought planning in Oklahoma: Estimating and using drought-influenced flow exceedance curves

R.B. Miller[a], G.A. Fox[b,*]

[a] Department of Biosystems and Agricultural Engineering, Oklahoma State University, Stillwater, OK, USA
[b] Department of Biological and Agricultural Engineering, North Carolina State University, Raleigh, NC, USA

ARTICLE INFO

Article history:
Received 19 August 2016
Received in revised form 6 December 2016
Accepted 4 January 2017

Keywords:
Drought
Flow duration curve
Oklahoma
Streamflow
Water supply

ABSTRACT

Study region: The study region is the state of Oklahoma, USA, which has a varied climate. Precipitation increases west to east, and temperature decreases south to north across the state. Accordingly, Oklahoma has been divided into nine Climate Divisions, which reflect those climatic as well as regional differences in agricultural practices.
Study focus: Surface water is the dominant source for public water systems in Oklahoma and these supplies may be impacted by drought or climatic change. Hydrologic modeling is an important component of water resource planning, but may be beyond the budget of smaller communities. To create a freely available tool for initial assessment of drought streamflows, this study uses publicly available long-term precipitation records for climate divisions in Oklahoma to create flow duration curves (FDCs) from the drought-influenced subsets of streamflow records.
New hydrological insights for the region: The FDCs created from those subsets showed increased likelihood of reduced streamflows. The reduced flows were shown to increase water supply risk to run-of-river users. To eliminate the need for users to re-create these analytic steps, study results were compared to published FDCs and reasonable estimates of drought-influenced FDCs were produced by offsetting the expected exceedance by 10%.

1. Introduction

A drought is in its essence a deficit of water, primarily driven by a reduction in precipitation, and which may have significant impacts on human lives. The American Meteorological Society describes drought as a "complex interplay between (1) natural precipitation deficiencies, or excessive evapotranspiration over varying time periods and different areal extents, and (2) the demands of human and environmental water use that may be exacerbated by inefficiencies in water distribution, planning, and management" (AMS, 2013). Hence, the human experience of drought can depend both on the severity (e.g. duration and intensity) of the moisture deficit, and on the means for coping with the drought's effects.

* Corresponding author at: North Carolina State University, Department of Biological and Agricultural Engineering, Campus Box 7625, Raleigh, NC 27695-7625, USA.
E-mail address: garey.fox@okstate.edu (G.A. Fox).

http://dx.doi.org/10.1016/j.ejrh.2017.01.001

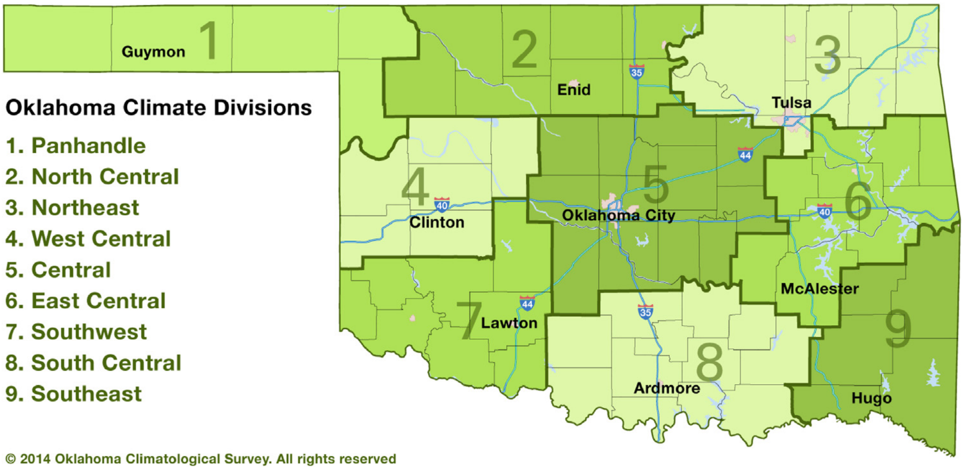

Fig. 1. Oklahoma Climate Divisions (OCS, 2016). Climate divisions follow political boundaries, and are based on physiographic factors such as soil type, topography and elevation, meteorological factors such as annual precipitation and temperature, and economic factors such as typical crop types (Guttman and Quayle, 1996).

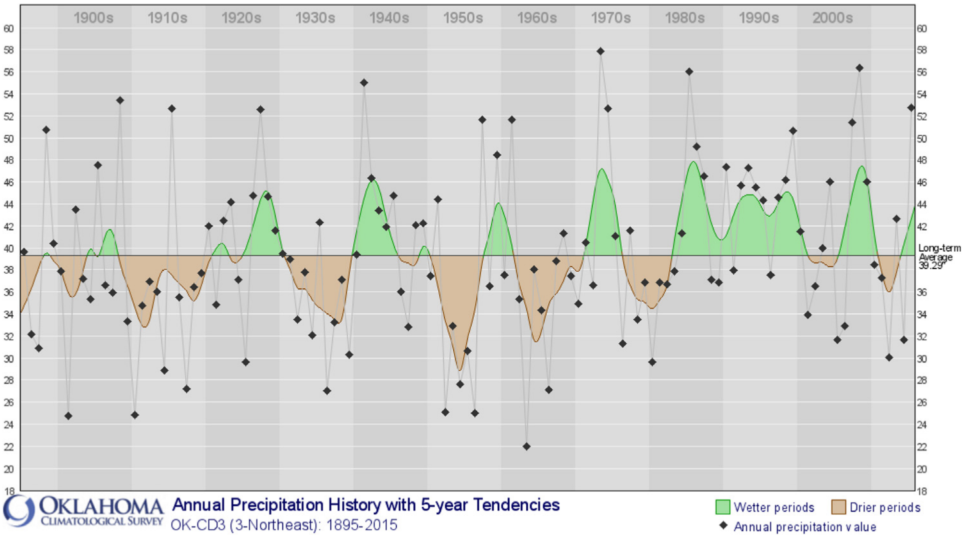

Fig. 2. Annual precipitation history for Oklahoma CD 3 (Northeast Oklahoma), showing the overall mean precipitation for the period 1895–2015 (39.3 in, 99.8 cm), as well as annual precipitation totals and the 5-year moving average (OCS, 2016). Periods below the overall average are colored brown, and above the average are colored green.

1.1. Oklahoma climate and drought planning

Oklahoma has a varied climate influenced by differences in terrain as well as by precipitation that increases west to east and temperature that decreases south to north. The Oklahoma Climatological Survey (OCS) has divided the state into nine distinct Climate Divisions (CDs) (Guttman and Quayle, 1996; OCS, 2016) (Fig. 1). Precipitation plots based on records dating from the 1890's have been prepared for each of the CDs, reflecting how the climatic and physical gradients affect precipitation in each of those (Fig. 2). Those precipitation plots illustrate the high variability over time including historic droughts in the 1930's and 1950's. Additionally, climate change projections for Oklahoma may include higher temperatures and increased periodicity of rainfall over current norms (Liu et al., 2012; OWRB, 2012).

Surface water is the dominant water source for users in Oklahoma outside of irrigated agriculture, representing 70% of the supply (Fig. 3). Municipal water suppliers are among the largest single water users in Oklahoma, representing 35% of all water and 60% of surface water use. Variations in the amount and timing of rainfall would be expected to have effects on surface water supplies, and in turn affect much of the state's population and economy.

Drought response involves many aspects of planning, including prediction and monitoring of drought events as well as mitigation of drought effects (Wilhite et al., 2000; Pirie et al., 2004; Goodrich and Ellis, 2006; Wilhite and Svoboda, 2007). Oklahoma is one of a majority of states whose drought-planning emphasis has been placed on prediction and monitoring,