Journal of Hydrology: Regional Studies 3 (2015) 199–210

Contents lists available at ScienceDirect

Journal of Hydrology: Regional Studies

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

Abrupt change in runoff on the north slope of the Catskill Mountains, NY, USA: Above average discharge in the last two decades

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ARTICLE INFO

Article history:
Received 12 August 2014
Received in revised form 1 November 2014
Accepted 13 November 2014
Available online 24 December 2014

Keywords:
Runoff
Climate change
Peak events
Daily vs annual comparisons

ABSTRACT

Study region: Schoharie Creek, Catskills Mountains, New York, USA.
Study focus: Total annual flow in Schoharie Creek, Catskills Mountains, was above the long-term average for most of the last two decades. We hypothesize that the end of the 20th century and early 21st century mark a change in the streamflow in the Schoharie watershed. To test this, we evaluated annual flow, center-volume (CV) and winter–spring center-volume (WSCV) dates, and average daily flow within four comparison periods purposefully selected to represent: average conditions, below average, above average and recent conditions Recurrence intervals of the 2-yr, 5-yr, and 10-yr daily maximum flow calculated for the comparison periods suggested that these event magnitudes were larger during the last decade.
New hydrological insights for the region: The increase in high-frequency event magnitude was most pronounced at the 5-yr daily maximum flow in the lower Schoharie. During the last decade the 5-yr event magnitude exceeded the record-long 10-yr daily maximum flow magnitude. Changes to peak daily flow implies more flow in the lower Schoharie more frequently. Seasonal differences drive above average winter runoff, shortened peak runoff in spring and in several cases below average summer and late summer flow. This flow pattern is not just a matter of more water all the time, but more water during the high-flow period and less water during the low-flow period, intensifying annual extremes.

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http://dx.doi.org/10.1016/j.ejrh.2014.11.006
2214-5818/

1. Introduction

Global climate models predict strong regional changes in temperature, precipitation and evaporation rates through the 21st century and into the next century (Barnett et al., 2005; Hayhoe et al., 2007, 2008). Shifts in regional temperature and precipitation patterns will impact surface water resources in the northeastern region in the United States (Collins, 2009; Hayhoe et al., 2007, 2008; Hodgkins and Dudley, 2011; Villarini and Smith, 2010; Wood et al., 2002; Xu et al., 2013). Regional climate predictions (e.g., Northeastern Climate Impact Assessment (NECIA), 2007) suggest that the northeastern region in the United States will receive more precipitation and that the amount of snowfall will decline (Frumhoff et al., 2008). This shift has important consequences for the hydrological runoff regimes for areas that are typically dominated by spring snowmelt runoff.

Unlike other regions in North America, the Northeast is not especially sensitive to synoptic-type climate anomalies (e.g., sea surface temperatures; Massei et al., 2011; McCabe and Wolock, 2002, 2011; Seager et al., 2012; Wood et al., 2002; Zhang et al., 2010) and therefore, short-term changes in the hydrological regime are not easily explained. However, given the current variability, a comparison of shorter time period patterns in one basin is warranted. For example, total annual flow in Schoharie Creek,[2] which is the primary river that drains the north slope of the Catskill Mountains, was above the long-term average for most of the last two decades. This above average flow has several implications for water resource management and policy decisions, but is expected given predictions by climate simulations.

Recent studies (e.g., Collins, 2009; Hayhoe et al., 2007; Seager et al., 2012; Villarini and Smith, 2010) reporting regional changes demand scrutiny at a local level. Local scrutiny is complicated by the fact the some rivers pose analytical challenges because of reservoirs and geographic position with respect to atmospheric systems. In this study, we investigate the possibility that the end of the 20th century and early 21st century mark an abrupt change in streamflow within the Schoharie watershed. To explore this possibility we purposefully compared flow during below average, above average, and average periods in the hydrologic record based on regional changes in precipitation (Hayhoe et al., 2007; Seager et al., 2012) and streamflow records downstream from Schoharie. In addition to analyzing annual flow data from the upper and lower reaches of the watershed, we evaluated the daily mean flow during each of these periods. Although comparatively small, changes within the Schoharie Watershed may be indicative of changes in adjacent watersheds and smaller ungaged subcatchments. In addition, Schoharie Creek is an important tributary to the Mohawk River that drains into the Hudson River. Several researchers and studies have presented comprehensive, regional evaluations of changes in precipitation and flow in the Northeast (e.g., Collins, 2009; Hayhoe et al., 2007, 2008; Hodgkins and Dudley, 2011; Seager et al., 2012; Villarini and Smith, 2010). The purpose of this study is to focus on the specific impacts in one watershed (Schoharie Watershed). In this paper, we present the watershed characteristics, describe our methodology and results and finally discuss our findings in the context of the regional studies, with a specific focus on the Schoharie Reservoir.

2. Watershed characteristics

Schoharie Creek flows north from the Catskill Mountains and merges with the Mohawk River at Fort Hunter (Fig. 1). It is one of two major tributaries to the Mohawk River, which in turn is the major tributary to the Hudson River. Flow within the Schoharie watershed is characterized by low-flow during the winter months, peak runoff occurring in the spring and receding into the lowest flows during the summer. Late summer and early fall flows are commonly punctuated by rain storm events generated by remnant tropical storm systems and convective storms (e.g., Seager et al., 2012; Villarini et al., 2009; Villarini and Smith, 2010). These events can generate heavy, intense rainfall with amounts in the Schoharie headwaters reaching over ten inches in several hours (Villani et al., 2012).

Landuse and activities in upstate New York have changed substantially since the first European explorers in the early 1600s reported on the landscape (Boyle, 1969; Henshaw, 2011; Litten, 2011a)

[2] Schoharie Creek is a river by most typical metrics, and the name is inherited from early settlers.