Journal of Hydrology: Regional Studies 2 (2014) 49–68

Contents lists available at ScienceDirect

Journal of Hydrology: Regional Studies

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

Review

Characteristics and changes of streamflow on the Tibetan Plateau: A review

Lan Cuo [a,*], Yongxin Zhang [b], Fuxin Zhu [a], Liqiao Liang [a]

[a] Key Laboratory of Tibetan Environmental Changes and Land Surface Processes, Institute of Tibetan Plateau Research, Chinese Academy of Sciences, Beijing, China
[b] Research Applications Laboratory, National Center for Atmospheric Research, Boulder, CO, USA

ARTICLE INFO

Article history:
Received 5 June 2014
Received in revised form 7 August 2014
Accepted 13 August 2014
Available online 29 September 2014

Keywords:
Streamflow
River basins
Tibetan Plateau
Climate change
Human activity

ABSTRACT

Study region: The Tibetan Plateau (TP).
Study focus: The TP exerts great influence on regional and global climate through thermal and mechanical forcings. The TP is also the headwater of large Asian rivers that provide water for billions of people and numerous ecosystems. Understanding the characteristics and changes of streamflow on the TP will help manage water resources under changing environment. Three categories of rivers (the Pacific Ocean, the Indian Ocean, and the interior) on the TP were examined for their seasonal and long term change patterns. Outstanding research issues were also identified.
New hydrological insights for the region: Streamflow follows the monthly patterns of precipitation and temperature in that all peak in May–September. Streamflow changes are affected by climate change and human activities depending on the basins. Streamflow is precipitation dominated in the northern, eastern and southeastern basins. In the central and western basin either melt water or groundwater, or both contributes significantly to streamflow. Human activities have altered streamflow in the lower reaches of the eastern, northern and western basins. Long-term trends in streamflow vary with basins. Outstanding research issues include: (1) What are the linkages between streamflow and climate systems? (2) What are the basin-wide hydrological processes? And (3) What are the cryospheric change impacts on hydrological processes and water balance?

* Corresponding author at: Institute of Tibetan Plateau Research, Chinese Academy of Sciences, Building 3, Courtyard 16, Lincui Road, Chaoyang District, Beijing 100101, China. Tel.: +86 010 84097091.
E-mail address: lancuo@itpcas.ac.cn (L. Cuo).

http://dx.doi.org/10.1016/j.ejrh.2014.08.004

Contents

1. Introduction

Often referred to as the “Roof of the World” or the “Third Pole” or the “Water Tower of Asia”, the Tibetan Plateau (TP) is the source region of major rivers in Southeast and East Asia that flow down to almost half of humanity. With an area of 2.5×10^6 km^2, the TP is the largest and the highest plateau on Earth, and exerts great influence on regional and global climate through thermal and mechanical forcing (Manabe and Broccoli, 1990; Yanai et al., 1992; Liu et al., 2007; Nan et al., 2009; Lin and Wu, 2011). The TP also has the largest cryosphere outside the Arctic and the Antarctic (Zhou and Guo, 1982; Zhou et al., 2000; Cheng and Jin, 2013). Vast areas of snow, glaciers, permafrost and seasonally frozen ground distribute over the TP throughout the year.

Different from the Arctic and the Antarctic, climate change and the induced hydrological and cryospheric changes on the TP directly affect the lives of people and animals that depend on the rivers originating from the TP. It is important to examine the changes in hydrology in the context of climate change over the TP for understanding the links between the changes and for developing a sustainable water resource strategy for the region.

Streamflow of major rivers is an important component of fresh water resource that is crucial for both human societies and natural ecosystems. Streamflow is the product of the integrated processes of atmosphere, hydrosphere, pedosphere and cryosphere in a basin, and is directly affected by climate change and human activities (Wigley and Jones, 1985; Milly et al., 2005; Barnett et al., 2005). Understanding the characteristics and long-term changes of streamflow on the TP is therefore essential for water resource management and ecosystems in the whole region. This work, with a focus on the hydrological changes, will rely on the published literature and draw conclusions on the hydrological changes and the links to climate change. Based on a number of the published literatures, we synthesize the long-term streamflow records for the rivers that originate on the TP and summarize the major characteristics and changes of streamflow, and the relationship between precipitation/temperature and streamflow. We also strive to point out the outstanding issues and possible directions for future research in hydrology on the TP.

Being the first of its kind, by reviewing the vast Chinese and English literatures on the hydrological changes over the TP, most of which are not easily accessible to international readers, this work provides up-to-date knowledge of the findings and the understanding in the characteristics and changes of streamflow over the TP for the international researchers and readers, and can serve as a foundation for focused surface hydrological studies on the TP. It is our hope that this work could further encourage interests and promote collaboration in the TP surface hydrology research. Also, we hope that through the review we could raise the awareness of the importance of hydrological data sharing among scientific communities in China.