Quaternary International xxx (2015) 1–11

Contents lists available at ScienceDirect

Quaternary International

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

Changes in precipitation extremes in Southeastern Tibet, China

Jinshan Zhang [a,*], Xingju Shen [b], Baolong Wang [c]

[a] Key Laboratory of Mountain Hazards and Earth Surface Processes, Institute of Mountain Hazards and Environment, CAS, Chengdu 610041, China
[b] College of Tourism and History & Culture, Southwest University for Nationalities, Chengdu 610041, China
[c] A Yang Middle School of Tianshui, Lanzhou 730070, China

ARTICLE INFO

Article history:
Available online xxx

Keywords:
Precipitation extremes
Temporal characteristics
Southeastern Tibet

ABSTRACT

Based on daily precipitation records at five meteorological stations during 1978–2013 periods, the spatial and temporal characteristics of twelve indices of extreme precipitation in Southeastern Tibet have been investigated. Most precipitation indices do not exhibit consistent or statistically significant trends across the region. Regionally averaged total precipitation, consecutive dry days (CDD), heavy precipitation days (R10) and simple daily intensity index (SDII) have increased, but only consecutive dry days (CDD) are statistically significant. At the same time, there has been an insignificant decrease in regionally averaged very heavy precipitation days (R20), extremely heavy precipitation days (R25), consecutive wet days (CWD), very wet days (R95p) and extremely wet days (R99p), maximum 1-day precipitation amount (Rx1day), maximum 5-days precipitation amount (Rx5days) and Wet days (NW). The distribution of positive and negative slopes in the area is extremely irregular. The spatial and temporal distributions of indices of climate extremes in monthly precipitation extremes show differences. In addition, there were significant correlations between annual total precipitation and precipitation extremes, except consecutive dry days. Change of most extreme precipitation indices is affected by the South Asia summer monsoon (SASM) evolution.

1. Introduction

Due to the numerous extreme events which are usually defined by unusually high or low values in the total range of observations (IPCC, 2012), such as hurricanes, droughts, floods, landslides and group-occurring debris flows, leading to long-term increases in economic losses in different regions (Changnon et al., 2000; Easterling et al., 2000; Prudhomme et al., 2003; Houghton et al., 2001), significant attention is being paid to the changing features, causes and mechanisms of extreme weather events at regional and global scales (Milly et al., 2002; Min et al., 2011; Mladjic et al., 2011; You et al., 2011; Zhang et al., 2011; Wang et al., 2013b). As an aspect of environmental and economic conditions, precipitation can be considered as the most important climatic element, whose changes can seriously impact on the natural water supply, river discharges, and crop yields, as well as natural vegetation (Radinović and Ćurić, 2009). Extreme precipitations events usually generate extreme hydrological events, having strong potentially negative impact (Zhang et al., 2005; Alexander et al., 2006; Nandintsetseg et al., 2007; Toreti and Desiato, 2008; Choi et al., 2009; dos Santos et al., 2011; Radinović and Ćurić, 2012). As climate changes have different effects on geographically diverse regions, changes in extreme events show large regional variations, including both negative and positive trends. As far as regional trends are concerned, significant positive trends are observed in continental Europe (Todeschini, 2012; Rajczak et al., 2013), the UK (Fowler and Ekström, 2009; Chan et al., 2014), Japan (Kamiguchi et al., 2011), across central United States (Kunkel et al., 2012) and Australia (Fiddes et al., 2014), whereas the magnitudes of different extreme precipitation parameters, including both negative and positive trends, are observed in India (Revadekar and Preethi, 2012; Preethi et al., 2011) and China (You et al., 2011; Fu et al., 2013). Although the changes in the water cycle that are expected to result from adjustments in the atmospheric circulation due to changes in the climate (Trenberth, 1999) relate to a large range of spatial and temporal scales, they can be affected by local conditions and regional specificities. Some studies maintain that changes in precipitation distribution could have far more impact than the more often-cited risk of warming (Allen and Ingram, 2002). Moreover, many other research studies have been focusing on climate change in the last twenty years (Easterling et al., 1997; Allen and Ingram,

* Corresponding author.
E-mail address: zjszj@163.com (J. Zhang).

http://dx.doi.org/10.1016/j.quaint.2015.02.009
1040-6182/

Please cite this article in press as: Zhang, J., et al., Changes in precipitation extremes in Southeastern Tibet, China, Quaternary International (2015), http://dx.doi.org/10.1016/j.quaint.2015.02.009

2002; Alexander et al., 2006; IPCC, 2007; Wentz et al., 2007; Zhang et al., 2007).

Southeastern Tibet, a part of the southeastern Qinghai–Tibetan Plateau, is affected by the Tibet Plateau and the warm-moist air current from the Indian Ocean (Deng et al., 2013). In the past years, glacier debris flows occurred frequently, posing a threatening to the local people, traffic facilities and trans-border rivers (Deng et al., 2013). Because of abundant precipitation for glacier development, glaciers are sensitive to temperature changes in southeastern Tibet (Shi and Liu, 2000). The rainy season is mainly concentrated from June to September, especially in July and August, marked by debris flows and landslides (He et al., 2012). In addition, glacial lake outburst is one of the main hazards on the Tibetan Plateau (Yang et al., 2012). Although the intensity and frequency of precipitation extremes in Plateau are less than in coastal areas and other regions in China, the risks of secondary disasters are very high and losses extensive. Because of the significant increment of heavy snowstorm processes, snow disasters on the Tibetan Plateau are getting more serious and frequent since the 1990s (Zhou et al., 2000).

In the recent years, the study of precipitation extremes in the Tibetan Plateau has obtained more fruitful results. Dong et al. (2001) discussed the climatic character of snow disasters in east Qinghai–Xizang Plateau livestock farm, and noted that the inter-annual anomaly of the subtropical high in the West Pacific Ocean is a main factor. Chen et al. (2006) analyzed the spatiotemporal evolution characteristics of heavy rainfall in the northeast Tibetan Plateau. Yang et al. (2014) investigated the temporal and spatial variability in extreme precipitation events in Tibet during 1961–2010 by applying threshold, frequency, and intensity based on the daily rainfall data. Zhou et al. (2000) studied the basic characteristics of heavy snowstorm process and snow disaster distribution in eastern pastoral areas of Qingai–Xizang Plateau. Jian et al. (2012) assessed temporal–spatial distributions of severe precipitation events during flooding in Tibet in the last 30 years. You et al. (2008) focused on annual extreme climate events on the middle and eastern Tibetan Plateau during 1961–2005 and ignored the relatively short observation period, monthly changes and the mechanism analysis. Wang et al. (2013d) concentrated on changes in daily extremes of temperature and precipitation over the western Tibetan Plateau during 1973–2011. In addition, other studies primarily paid attention to the average precipitation (Yang et al., 2013). Although some studies have analyzed precipitation extreme events using the comprehensive indices, there are limitations to discuss the impacts of the South Asian Summer Monsoon on these precipitation indices and monthly precipitation extremes in Southeastern Tibet.

In order to investigate the recent changes in frequency, intensity, duration, and monthly changes of precipitation extremes in Southeastern Tibet, observed daily precipitation during the period 1978–2013 were collected from the China Meteorological Administration (CMA), and several widely-applied indices were calculated. Changes in the selected precipitation indices as well as the relationship between precipitation extremes and atmospheric circulation are analyzed in this paper. The studies are convenient for quantitative comparison of regional research results, which contributes to a better understanding of the reasons for changes in extreme precipitation worldwide. Moreover, the studies play an important role in assessing and predicting the influence of extreme precipitation in Southeastern Tibet.

2. Data and methods

2.1. Study region and data quality

Southeastern Tibet is situated in the junction area of the Nyainqentanglha (north), Hengduan (east) and Himalayas (west) Mountains. Landform and geological structure are very complex, with deep canyons and larger fluctuating terrains. It belongs to subtropical mountain climate zone of southwest monsoon, and has abundant rainfall owing to the influence of the southwest monsoon. There are at least 10 meteorological stations in southeastern Tibet observed by the China Meteorological Administration at present. As 5 were established after 1990, data from the 5 previous meteorological stations (from northwest to southeast) were selected during 1978–2013 (Fig. 1). The geographical coordinates of the stations are presented in Table 1. Daily precipitation at the stations was provided by the National Climate Center, China Meteorological Administration.

Table 1
Geographical coordinates of the weather stations.

WMO number	Station	Latitude	Longitude	Elevation (m)
56202	Lhari	30°40″	93°17″	4488.8
56312	Nyingchi	29°40″	94°20″	2991.8
56227	Bomi (Bowo)	29°52″	95°46″	2736
56331	Zogang	29°40″	97°50″	3780
56434	Zayü	28°39″	97°28″	2327.6

Stations are ranked from northwest to southeast.

Data quality control is needed to assure reliability in climate change research and is a prerequisite for calculating climatic indices (dos Santos et al., 2011). A series of methods in data quality control were attained by the National Meteorological Information Center of China Meteorological Administration to correct the errors (Li and Xiong, 2004; Wang, 2004). After that, simple quality control and homogeneity assessment of raw data were achieved using RClimDex V1 software (Zhang and Yang, 2004) and RHtest V3 software (Wang, 2008), respectively. Both programs are obtainable from http://etccdi.pacificclimate.org.

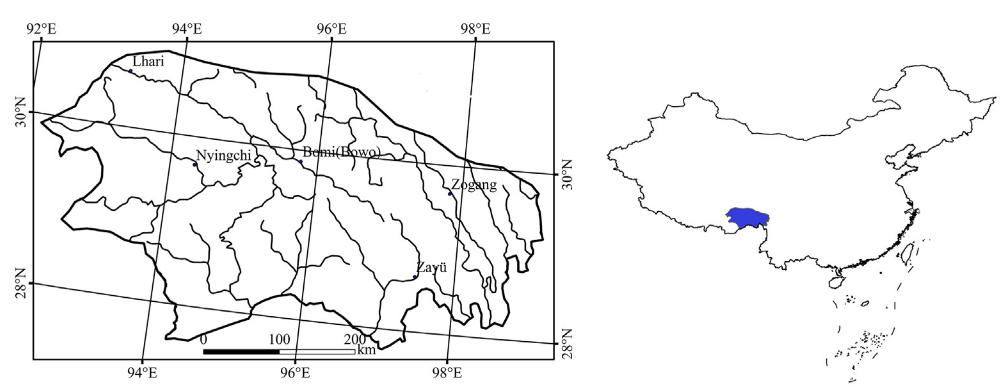

Fig. 1. Distribution of its meteorological stations in Southeastern Tibet, China.

Please cite this article in press as: Zhang, J., et al., Changes in precipitation extremes in Southeastern Tibet, China, Quaternary International (2015), http://dx.doi.org/10.1016/j.quaint.2015.02.009