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Development of Extreme Precipitation Dataset of Qinghai–Tibet Plateau (1961–2017)

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Abstract: With the worsening of climate warming, more and more glaciers, snow, and other solid water bodies in Qinghai–Tibet Plateau have melted. This phenomenon has increased the water volume in the local water cycle, led more extreme precipitation events. Therefore, it is critical to understand the spatial distribution and variation in extreme precipitation events within Qinghai–Tibet Plateau. Based on daily precipitation data from 78 meteorological stations in Qinghai–Tibet Plateau, the threshold value of extreme precipitation was determined using the percentile threshold method. Four extreme precipitation indexes (R99D, R99P, R99I, and R99C) were then derived, and the Extreme precipitation dataset on Qinghai–Tibet Plateau (1961–2017) was developed. The dataset includes: (1) site location data; (2) the extreme precipitation threshold for each station (Table 1); (3) the times and precipitation amounts of extreme precipitation events at each station (Table 2); (4) the values of the four extreme precipitation indexes at each station (Table 3); and (5) the extreme precipitation index values from 1961 to 2017 (Table 4). The dataset is archived in .shp and .xls data formats with the data size of 459 KB (92.9 KB compressed into one file).

Keywords: Qinghai–Tibet Plateau; extreme precipitation; threshold value; 1961–2017

Dataset Availability Statement:

The dataset supporting this paper was published and is accessible through the *Digital Journal of Global Change Data Repository* at: https://doi.org/10.3974/geodb.2020.01.10.V1.

1 Introduction

Extreme precipitation is the leading factor in floods, which are sudden and destructive events that often have serious effects on society and the natural environment. Therefore, flooding caused by extreme precipitation events is one of the key topics of the International Hydrological Program led by UNESCO[1,2]. The results released by China's second comprehensive scientific investigation on Qinghai–Tibet Plateau indicate that the cryosphere of Qinghai–Tibet Plateau has melted rapidly over the past 50 years; moreover, a large amount of solid water (e.g., glaciers and snow) has been rapidly converted into liquid water, in-

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creasing lake area and surface runoff[3]. The imbalance of Asian water towers has caused the amount of water entering the water cycle to increase, further aggravating the already serious risk of flood disasters in Qinghai–Tibet Plateau[4,5].

Although the Qinghai–Tibet Plateau is vast in area, hydrological and meteorological observation stations are sparsely distributed. Moreover, observation equipment with high time resolution and high spatial resolution has been put into use in a short year. Thus, it is difficult to obtain data with long time series, high time resolution, and high spatial resolution. Based on daily precipitation data obtained from 78 meteorological stations on Qinghai–Tibet Plateau[6,7] from 1961 to 2017, this study (1) determined the extreme precipitation threshold for each station using the percentile threshold method, (2) used these thresholds to screen extreme precipitation events at each station, (3) calculated extreme precipitation indexes, and (4) analyzed the temporal variation and spatial distribution of extreme precipitation on Qinghai–Tibet Plateau.

2 Metadata of the Dataset

The metadata of the Extreme precipitation dataset on Qinghai–Tibet Plateau (1961– 2017)[8] are summarized in Table 1. The metadata include the dataset name, authors, geographical region, year range, temporal resolution, spatial resolution, data files, data publisher, and data sharing policy, etc.

Table 1 Metadata summary of Extreme precipitation dataset on Qinghai–Tibet Plateau (1961–2017)

Item	Description		
Dataset name	Extreme precipitation dataset on Qinghai–Tibet Plateau (1961–2017)		
Dataset short name	ExtremePrecip_TibetanPlateau		
Authors	Ma, W. D. AAB-3337-2021, School of Geographic Science, Qinghai Normal University, mwd0910@sina.com Liu, F. G. L-8795-2018, School of Geographic Science, Qinghai Normal University, lfg_918@163.com Zhou, Q. AAB-3351-2021, School of Geographic Science, Qinghai Normal University, zhouqiang729@163.com Chen, Q. AAB-3346-2021, School of Geographic Science, Qinghai Normal University, qhchenqiong@163.com		
Geographical region	Qinghai–Tibet Plateau (26°00′12″N–39°46′50″N, 73°18′52″E–104°46′59″E), with a total area of about 2.57×10^6 km^2, including Qinghai, Tibet and parts of Xinjiang, Gansu, Sichuan, and Yunnan		
Year	1961–2017	Temporal resolution	Year
Data format	.shp, .xls	Data size	459 KB
Data files	(1) Site location data; (2) extreme precipitation threshold of each station (Table 1); (3) time and precipitation for extreme precipitation events at each station (Table 2); (4) values of four extreme precipitation indexes for each station (Table 3); and (5) extreme precipitation indexes from 1961 to 2017 (Table 4)		
Foundations	Ministry of Science and Technology of P. R. China (2019YFA0606900, 2019QZKK0906)		
Computing environment	Microsoft Excel 2016; ArcGIS		
Data publisher	Global Change Research Data Publishing & Repository, http://www.geodoi.ac.cn		
Address	No. 11A, Datun Road, Chaoyang District, Beijing 100101, China		
Data sharing policy	***Data*** from the Global Change Research Data Publishing & Repository includes metadata, datasets (in the *Digital Journal of Global Change Data Repository*), and publications (in the *Journal of Global Change Data & Discovery*). ***Data*** sharing policy includes: (1) ***Data*** are openly available and can be free downloaded via the Internet; (2) End users are encouraged to use ***Data*** subject to citation; (3) Users, who are by definition also value-added service providers, are welcome to redistribute ***Data*** subject to written permission from the GCdataPR Editorial Office and the issuance of a ***Data*** redistribution license; and (4) If ***Data*** are used to compile new datasets, the 'ten per cent principal' should be followed such that ***Data*** records utilized should not surpass 10% of the new dataset contents, while sources should be clearly noted in suitable places in the new dataset[9]		
Communication and searchable system	DOI, DCI, CSCD,WDS/ISC, GEOSS, China GEOSS, Crossref		

3 Methods

The daily precipitation data from 78 meteorological stations in Qinghai–Tibet Plateau lasting more than a half century (1961–2017) were taken from the China Meteorological Data Network.[1] First, according to long-term continuous daily precipitation data from the meteorological stations, which have not been moved since their establishment, the stations were screened. The outliers were then removed from the data for each station, and extremism and consistency tests were carried out.

3.1 Algorithm

Precipitation in China shows obvious spatial heterogeneity. Precipitation is concentrated in the monsoon region of central and eastern China, whereas precipitation is relatively scarce in the alpine region of Qinghai–Tibet and the arid region of northwest China. Defining extreme precipitation events based on specific thresholds (e.g., precipitation associated with heavy rains or rainstorms) in Qinghai–Tibet Plateau may result in over-containment, omission, or lack of data. Moreover, the extreme precipitation thresholds in different regions are not comparable. Therefore, the percentile threshold method was selected to determine the extreme precipitation threshold for each station in this study[10,11]. The daily precipitation data for each station were sorted in ascending order after eliminating null values. The percentile threshold method was then used to determine the extreme precipitation threshold of the station. The percentile threshold method effectively avoids the disadvantages of one-size-fits-all methods for threshold selection and results in thresholds that are comparable among different sites.

3.2 Data Development Process

Based on the daily precipitation data of the station from 1961 to 2017, the following steps were carried out (Figure 1):

(1) Daily precipitation data were arranged in ascending order according to the amount of precipitation, and the cumulative percentage of 99% was used as the threshold of extreme precipitation for each station according to the percentile threshold method;

(2) Extreme precipitation events were identified based on the extreme precipitation threshold for each station. An extreme precipitation event was determined to occur on a certain day if the precipitation at a certain station exceeded the extreme precipitation threshold for that station;

(3) According to the identified extreme precipitation events, the extreme precipitation indexes were calculated for each station;

(4) The temporal variation and spatial distribution of extreme precipitation events in Qinghai–Tibet Plateau were analyzed.

4 Data Results and Validation

4.1 Data Products

The resulting dataset includes the following: (1) site location data; (2) the extreme precipitation threshold for each station; (3) the times and precipitation amounts of extreme precipitation events; (4) the values of four extreme precipitation indexes for each station; and (5) the extreme precipitation index values from 1961 to 2017. After the 99^{th} percentile was used to

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[1] China meteorological data network, http://data.cma.cn/.

determine the extreme precipitation threshold for each station, the following four indexes were calculated to analyze the temporal and spatial variations in extreme precipitation events on Qinghai–Tibet Plateau: extreme precipitation index (R99P); extreme precipitation frequency index (R99D); extreme precipitation intensity index (R99I); and extreme precipitation contribution rate index (R99C). Definition of extreme precipitation indexes is shown in Table 2.

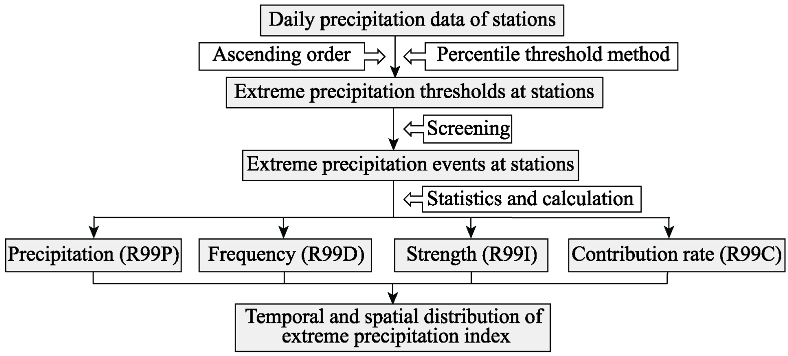

Figure 1 Flowchart of the dataset development

Table 2 Definition of extreme precipitation index

Index	Abbreviation	Definition	Unit
Extreme precipitation index	R99P	The sum of annual daily precipitation exceeding the 99th-percentile value	mm
Extreme precipitation frequency index	R99D	The sum of the frequency of annual daily precipitation exceeding the 99th-percentile value	d
Extreme precipitation intensity index	R99I	The ratio of R99P to R99D	$mm \cdot d^{-1}$
Extreme precipitation contribution rate index	R99C	R99P as a percentage of total annual precipitation	%

4.2 Data Results

4.2.1 Extreme Precipitation Threshold Values for Each Station

The distribution of extreme precipitation threshold values for all stations is shown in Figure 2. The minimum and maximum threshold values were 7.84 mm in Xiaozaohuo (Qaidam Basin) and 51.90 mm in Gongshan (Hengduan Mountain area), respectively, and the average value was 23.11 mm. The spatial distribution of extreme precipitation threshold indicates a decreasing trend in threshold value moving from southeast to northwest.

4.2.2 Extreme Precipitation Indexes and Their Spatial Distributions

The extreme precipitation index ranged from 26.32–53.04 mm with an average of 37.59 mm. The extreme precipitation frequency index ranged from 0.82–1.55 days with an average of 1.22 days. The extreme precipitation intensity index ranged from 27.33–33.61 $mm \cdot d^{-1}$ with an average of 30.79 $mm \cdot d^{-1}$. The contribution rate of extreme precipitation index ranged from 5.72%–10.28% with an average of 7.94%.

The spatial distributions of the four extreme precipitation indexes are shown in Figure 3. As shown in Figure 3(a), the annual extreme precipitation index for Qinghai–Tibet Plateau ranged from 2.11–139.44 mm. In Gongshan and Bomi, both the precipitation and extreme precipitation index had high values. However, in Nyalam and Zoige, although the precipitation was not high, the extreme precipitation index was high.

The average annual extreme precipitation frequency at the different stations ranged from 0.14–2.23 days. From the spatial distribution shown in Figure 3(b), high values of extreme precipitation frequency were distributed in the Hengduan Mountains, Zoige Plateau, the southern part of the Qingnan Plateau, and the southern valley of Tibet. Low levels of extreme precipitation frequency were found in the Qiangtang Plateau, Kunlun Mountain, and the entire Qaidam Basin.

Extreme precipitation intensity ranged from 9.81–62.59 mm·d^{-1}, with large differences observed among stations. The extreme precipitation intensity was high in Gongshan, where it reached 62.59 mm·d^{-1}.

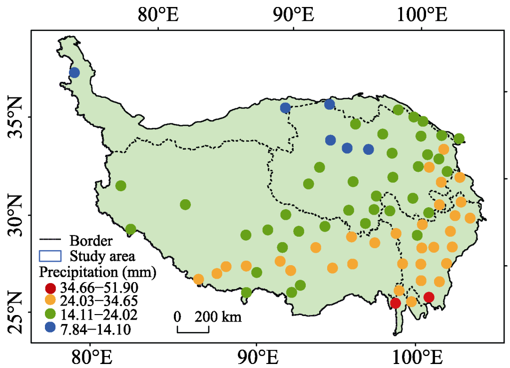

Figure 2 Spatial distribution map of extreme precipitation threshold in Qinghai–Tibet Plateau[12]

The contribution rate of extreme precipitation index ranged from 7.34%–14.12%. The stations with high values were mainly distributed in the southwestern and northern regions of the plateau (Figure 3(d)). In Qaidam Basin, while the values of the extreme precipitation and extreme precipitation frequency indexes were not high, the contribution rate of extreme precipitation index was high. This indicates that while this area did not have high precipitation, a large proportion of total precipitation was extreme precipitation.

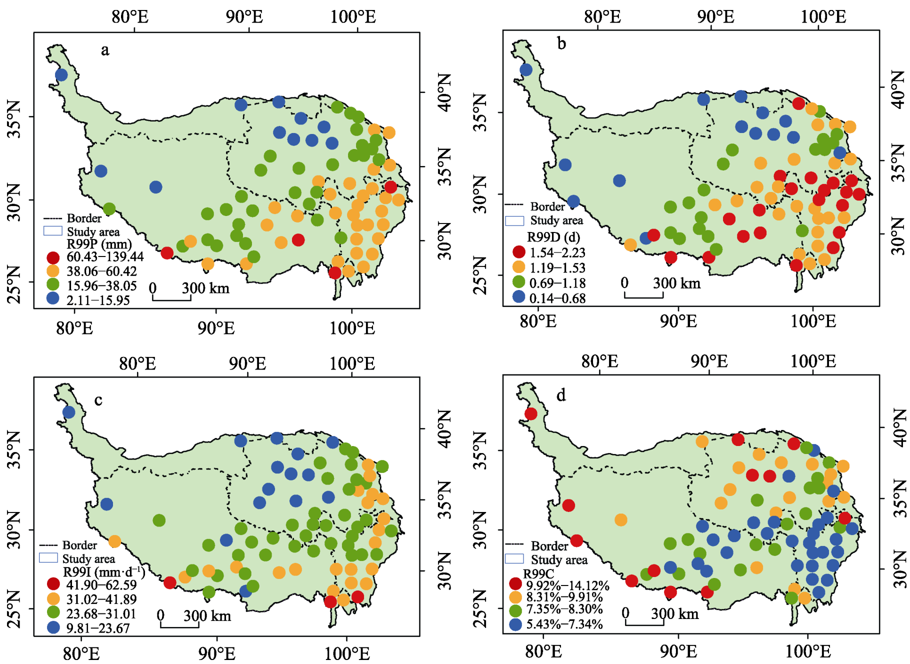

Figure 3 Spatial distributions of four extreme precipitation indexes in Qinghai–Tibet Plateau

5 Discussion and Conclusion

Based on meteorological station data, a dataset describing the temporal and spatial distributions of extreme precipitation in Qinghai–Tibet Plateau was developed for the time period (1961–2017). The percentile threshold method was adopted to determine the threshold of extreme precipitation at each station, thereby eliminating the effect of spatial differences in precipitation in the region and allowing the characteristics of extreme precipitation to be compared among stations. The resulting dataset is a valuable reference for the study of regional precipitation characteristics. The dataset provides reference data for the early warning and forecasting of extreme weather and meteorological disasters and also provides a basic index for assessing meteorological disaster risk. This dataset only depicts the temporal and spatial distributions of extreme precipitation of Qinghai–Tibet Plateau as a whole. To evaluate the characteristics of extreme precipitation locally or at a certain station, further analyses can be conducted based on the extreme precipitation events.

The dataset generated in this study reflects changes in extreme precipitation over time in the study area as a whole or at a certain station. However, it cannot reflect the changes in extreme precipitation at high spatial resolution. In the future, spatial interpolation methods should be considered, and the effects of various influencing factors, including both natural elements and unnatural elements, should be incorporated to correct the interpolation results and obtain extreme precipitation data with higher spatial accuracy.

Author Contributions

Liu, F. G. developed the overall design for the dataset; Zhou, Q. and Ma, W. D. collected and processed the extreme precipitation data; Chen, Q. designed the algorithm; and Ma, W. D. wrote the paper.

Conflicts of Interest

The authors declare no conflicts of interest.

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