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SPECIAL TOPIC ON REGIONAL CLIMATE CHANGE

Observed Climate Changes in Southwest China during 1961–2010

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Abstract

The present study focused on statistical analysis of interannual, interdecadal variations of climate variables and extreme climate events during the period of 1961–2010 using observational data from 376 meteorological stations uniformly distributed across Southwest China, which includes Yunnan, Guizhou, Chongqing, Sichuan and Tibet. It was found that temperatures in most of the region were warming and this was especially evident for areas at high elevation. The warming was mostly attributable to the increase in annual mean minimum temperature. The characteristics of high temperature/heat waves are increase in frequency, prolonged duration, and weakened intensity. Annual precipitation showed a weak decreasing trend and drier in the east and more rainfall in the west. The precipitation amount in flood season was declining markedly in the whole region; rainfall from extreme heavy precipitation did not change much, and the portion of annual precipitation contributed by extreme heavy precipitation had an increasing trend; annual non-rainy days and the longest consecutive non-rainy days were both increasing; the extreme drought had a decreasing trend since the 1990s; the autumn-rain days displayed a downward fluctuation with apparent periodicity and intermittency. The number of southwestern vortices was decreasing whereas the number of moving vortices increased.

Keywords: climate change; Southwest China; extreme climate events

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1 Introduction

The global climate has undergone a significant change characterized by the warming of surface air temperatures in the last 100 years or so [*IPCC*, 2007]. Within China, the climate has changed basically in tune with this trend [*ECSCNARCC*, 2011]. Extreme climate events such as high temperature, drought, storms, and flood occurred frequently and caused large hazards and exerted profound impacts on human society and natural environment. For example, over the past 50 years, extreme precipitation events in the Northern Hemisphere has increased; intensity and frequencies of extreme precipitation events in China have increased [*Zhai and Pan*, 2003; *Liu et al.*, 2006; *Wang and Zhai*, 2008].

Southwest China possesses complex topographies, which include the Yunnan-Guizhou Plateau, the Qinghai-Tibet Plateau, the Hengduan Mountains, and the Sichuan Basin. As a result, local climate change has significant regional characteristics due to the impact of local topographies. Previous studies revealed that the long-term trend of temperature in Southwest China was not necessarily in tune with global warming. *Ding and Dai* [1994] found that during 1951–1990 the Southwest China experienced a persistent cooling; *Ma et al.* [2006], using observed data for 1961–2000 from 139 meteorological stations in Southwest China,

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discovered that abrupt temperature change in Southwest China was later than that of the global temperature, and the abrupt change in higher altitude was earlier than that in lower altitude (in the basin and over the hills). Compared to the previous 40 years, there has been a significant increase in extreme drought and flood events in Southwest China since the start of the 21st century [*Duan et al.*, 2000; *Hu et al.*, 2006; *Huang*, 2011].

In this study, we will document the changes in several meteorological elements in the last 50 years. Compared to previous studies, more observed surface data will be used in this study and several extreme climate events will be analyzed and discussed to provide important information for climate change communities and policy-makers.

2 Data and method

The present paper uses observed daily precipitation, mean temperature, maximum temperature, minimum temperature, and monthly foggy days for 1961–2010 from 376 meteorological stations in Southwest China which have continuous records (Fig. 1). All data were screened following quality control procedures of Southwestern Regional Center for Climate Change. For evenly distributed stations and taking into account of the influence of geography and topography, a few missing observations were first interpolated by using average of the prior and next years' observed values. Then, tests of SNHT, TPR, Buishand, Pettitt and Von Neumann were used to correct data and conduct homogeneity test [*Alexandersson and Moberg*, 1997; *Andrew*, 1987; *Lund and Reeves*, 1999; *Slonosky et al.*, 1999; *Wijngaard*, 2003] to avoid the impact of relocation of some stations. The *t*-test is used to examine the significance at a confidence level of 95% for linear trend.

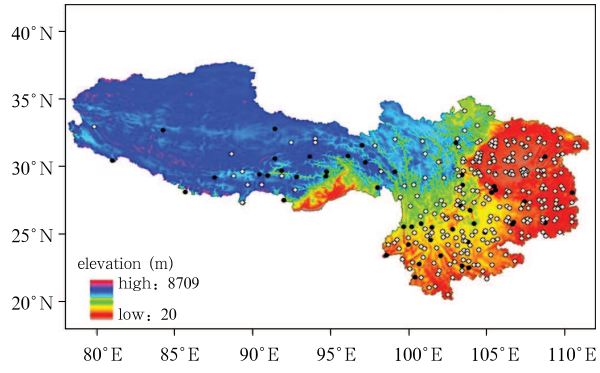

Figure 1 Stations in Southwest China (circle denotes homogeneous stations; solid dot denotes inhomogeneous stations)

The four seasons are defined as last December to February for winter, March to May for spring, June to August for summer, and September to November for autumn, respectively. The flood season refers to June to August. The definitions of climate events are given in Table 1.

3 Temperature

3.1 *Mean temperature*

During 1961–2010, annual mean temperature in Southwest China showed a statistically significant increasing trend of 0.12°C per decade (Fig. 2). This increasing rate was lower than the same period national rate of 0.22°C per decade [*ECSCNARCC*, 2007]. The rising temperature in this region was mainly due to the warming started in the mid-1990s; since then the temperature in most areas had shown a significant upward trend (Fig. 3); temperatures in northern and western Tibet had exhibited most significant increasing (at a rate of 0.4–0.5°C per decade). For seasonal mean temperatures, the most distinguished upward trend occurred in winter, followed by autumn, whereas spring and summer did not show a significant increasing trend (Table 2). In terms of spatial distribution, in all seasons the temperature increasing rate in Tibet and western Sichuan Plateau was greater than the other regions. In summer a cooling trend was seen in Chongqing, northeastern Sichuan Basin and northeastern Guizhou; all other areas showed a warming trend.

In Southwest China, the most significant warming during 1961–2010 was in winter season. The warming trend was mostly contributed by the increasing since the 1990s. The magnitude of warming increased with altitude, and the most distinguished upward trend occurred in the Qinghai-Tibet Plateau.