ADVANCES IN CLIMATE CHANGE RESEARCH 4(1): 12–19, 2013
www.climatechange.cn
DOI: 10.3724/SP.J.1248.2013.012

SPECIAL TOPIC ON REGIONAL CLIMATE CHANGE

Features of Climate Change in Northwest China during 1961–2010

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Abstract

In this study, observational data from 141 meteorological stations in Northwest China, including temperature, precipitation, dust storm, gale days and wind speed, were analyzed statistically to gain insight of the features of basic climate index and extreme climate events. The results showed that the annual mean temperature and seasonal mean temperature rose significantly, and the rising rate of the annual mean temperature is 0.27°C per decade; the extreme high temperature days have increased; the interdecadal change of annual precipitation is marked, and the precipitation in winter and summer increased slightly, while decreased slightly in spring and autumn. The annual precipitation increased in the area west of the Yellow River, whereas decreased in the area east of the river. The drought had an increasing trend. There were 17 droughts during 1961–2010, and 10 droughts from 1991 to 2010. The number of droughts in spring and autumn increased, while decreased in summer.

Keywords: climate index; extreme climate event; drought; Northwest China

Citation: Sun, L.-D., C.-J. Zhang, H.-Y. Zhao, et al., 2013: Features of climate change in Northwest China during 1961–2010. *Adv. Clim. Change Res.*, **4**(1), doi: 10.3724/SP.J.1248.2013.012.

1 Introduction and objective

It was pointed out in the IPCC Fourth Assessment Report that the global average surface temperature had increased by 0.74°C in the last 100 years, and the rate of warming was 0.13°C per decade in the most recent 50 years [*IPCC*, 2007]. From 1951 to 2009, the average surface air temperature increased by 1.38°C in China, and the rate of warming was 0.23°C per decade, consistent with the global warming [*ECSCNARCC*, 2011]. Northwest China is located in the transitioning area of the three natural zones, namely the eastern monsoon region, northwestern arid area, and the Qinghai-Tibetan Plateau. It contains four major types of climate: tropical monsoon climate, temperate monsoon climate, temperate continental (arid) climate, and plateau alpine climate from south to north. The regional geological, geomorphologic and ecological systems are complex and diverse. These natural factors and climate change are intertwined, making regional economic and social developments extremely challenging. The regional economic community has demonstrated a high degree of sensitivity to these changes. The research shows that there has been a significant warming trend in Northwest China since 1951 [*Wang et al.*, 2007; *Yu et al.*, 2005]. The annual precipitation

Received: 31 January 2013
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in Hexi regions of Gansu province and the Qinghai Plateau increases slightly, whereas the annual precipitation in Hedong regions of Gansu, Ningxia, and Shaanxi decreases slightly. The caveat of the research is also obvious. Because the meteorological stations in Northwest China are distributed unevenly, regional-averaged precipitation using the arithmetic method will definitely lead to large errors. In recent decades, extreme weather and climate events have been increasing [*Chen et al.*, 2012]; the pressure of disaster prevention and mitigation becomes greater. In order to support better decision-making for the regional economic development service, there is an urgent need of objective and detailed analysis of climate change in Northwest China. Therefore, it is imperative that we take advantage of the latest meteorological data for the period of 1961–2010 to analyze the characteristics of the regional climate changes in Northwest China.

2 Data and method

Northwest China, in this paper, is referred to as the region of four provinces: Shaanxi, Gansu, Qinghai and Ningxia. The gauge data used in this paper are from 141 meteorological stations (Fig. 1). The variables include monthly mean temperature, monthly mean maximum temperature, monthly mean minimum temperature, daily maximum temperature, monthly and daily precipitation, sandstorm days, gale days, and mean wind speed in the period of 1961–2010. The gale data are available from 1971 to 2010, because the gauge instrument was replaced in 1970. The regional mean surface air temperature is calculated using arithmetic average; the regional mean precipitation is calculated by the Kriging interpolation [*Li et al.*, 2000; *Zheng and Wang*, 2003]. The statistical method of *t*-test is used to test the linear trend significance [*Shi et al.*, 1995]. In this paper, the significant level is set as 0.05. The definitions of climate indices used in this analysis are listed in Table 1.

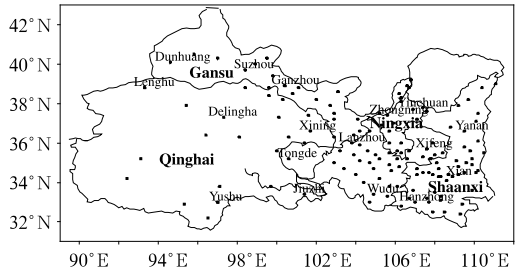

Figure 1 Regional meteorological stations in Northwest China

Table 1 Definitions of climate indices

Term	Definition
Extreme high temperature	Daily maximum temperature greater than the 95th percentile
Extreme heavy precipitation	Daily precipitation greater than the 95th percentile
Drizzle	Precipitation (P)<10 mm in 24 hours
Moderate rain	In 24 hours 10$\leqslant P <$25 mm
Heavy rain	In 24 hours $P \geqslant$ 25 mm
Dust storm	Strong winds sweep clouds of dust, causing horizontal visibility less than 1 km
Gale	Instantaneous wind speed $\geqslant$ 17.0 m s^{-1}
Drought	Monthly precipitation percentage anomaly (Pa)$\leqslant$–50%
Moderate drought	–85%$< Pa \leqslant$–70%
Severe drought	–95% $< Pa \leqslant$–85%

3 Temperature

3.1 *Significant temperature increasing and warming in most of the region*

During 1961–2010, the regional annual mean temperature has increased significantly in Northwest China, with a increasing rate of 0.27°C per decade (Fig. 2), higher than the global and the national average rates. The annual mean temperature has increased by 1.4°C in nearly half a century. The annual mean temperature increased gradually after 1987, while rose rapidly after 1996, with the anomaly increasing from 0.4 to 1.4°C, reaching the era of highest average