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SPECIAL TOPIC ON REGIONAL CLIMATE CHANGE

Basic Features of Climate Change in North China during 1961–2010

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Abstract

The spatial and temporal variations of some important near-surface climate parameters and extreme climate events in North China during 1961–2010 are analyzed by using 94 meteorological stations' data in the study area. Results show that the annual mean surface air temperature in North China increased at the rate of 0.36°C per decade, higher than the national average in the same period. Increasing was particularly significant since the mid-1980s, with maximum increase in the middle and northeastern parts of Inner Mongolia. Increasing rate of the annual mean minimum temperature is much higher than that of the maximum temperature, which results in the decrease of the annual mean diurnal temperature range. Noticeable decrease is also observed in the frequency of cold wave. Annual precipitation shows a slight decreasing trend, with more pronounced decrease in southern Shanxi and eastern Hebei provinces, which is mainly represented as decreasing in contribution rates of rainstorm and heavy storm in flood-season (May to September). During 1961–2010, North China is characterized by a noticeable reduction in annual extreme precipitation, and an increase in high-temperature days over most parts, as well as more frequent droughts. There are remarkable reductions in annual sunshine duration and mean wind speed, associated with the most significant reduction of mean wind speed in mid-western and eastern parts of Inner Mongolia. Meanwhile, North China has experienced a noticeable decrease/increase in annual mean sanddust/haze days during the study period. However, there is no significant trend in fog days, except a pronounced decrease since the 1990s.

Keywords: North China; temperature; precipitation; extreme climate events

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1 Introduction

The global mean surface temperature over the past 100 years (1906–2005) has increased by 0.74°C, and the linear warming trend from 1956 to 2005 is nearly twice as that from 1906 to 2005 [*IPCC*, 2007]. From 1951 to 2009, the warming rate of the averaged land surface air temperature in China is 0.23°C per decade. Since 1951, the frequency and intensity of extreme climate events (e.g., high temperature, low temperature, heavy rainfall, drought, typhoon, dense fog, sanddust) have experienced obvious changes, and with enormous regional differences. Climate change has various impacts on different sub-regions of China, and those sub-regions with vulnerable ecological environment are subject to more notable influence [*EC-SCNARCC*, 2011]. North China is one of the regions with the most stable and significant warming in China

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[*Ren et al.*, 2005a]. In this paper, North China includes Beijing city, Tianjin city, Hebei province, Shanxi province and Inner Mongolia autonomous region, covering the cold temperate, temperate, and warm temperate zones from north to south, and passing through the semi-humid, semi-arid, and arid climate zones in turn from southeast to northwest, resulting in large climate differences. Besides, climate in the study region is subject to wide variations as a result of the influence of the topography, demonstrating significant regional or local features of climate change. North China is rich in resources and has experienced rapid economic development. Moreover, it is one of the most sensitive and vulnerable areas impacted by climate change. Recently, North China has been in the critical period of accelerating regional cooperation, economic development mode transformation and ecological civilization construction. Therefore, it will suffer from a higher disaster risk as a result of climate change [*Shi et al.*, 2010; *ECSCNARCC*, 2011]. In order to get comprehensive and systematic understanding of the basic facts of climate change over North China in the past few decades, this paper has performed a detailed analysis of temperature, precipitation, mean wind speed, sunshine duration, fog, haze, sanddust weather, and some extreme climate events by using observation data from meteorological stations in the study area during 1961–2010.

2 Data and methods

2.1 *Data*

The data used in this paper are daily observations from 403 meteorological stations for the period 1961–2010 provided by five provincial (autonomous regional and municipal) Climate Centers in North China. The data homogeneity is influenced by great changes in the observation environment of some stations after relocation. Therefore, the homogeneity test was applied to the temperature data for the correction of non-homogeneous station data based on standard normal homogeneity test [*Alexandersson*, 1986; *Alexandersson and Moberg*, 1997] and the two-phase regression test [*Reeves et al.*, 2007]. Based on a comprehensive consideration of factors, such as spatial distribution of stations, and length, integrity and representativeness of the data time series, only data from 94 meteorological stations were chosen for analyzing the basic features of climate change in North China (Fig. 1).

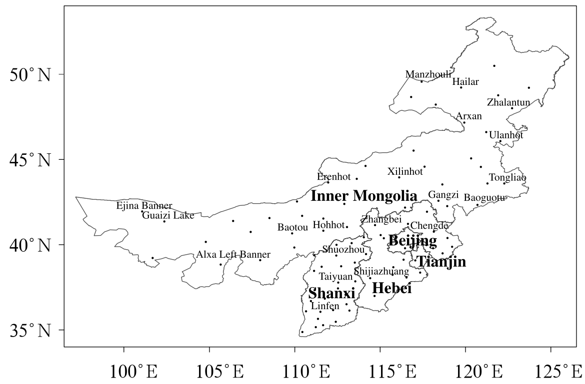

Figure 1 Distribution of the 94 meteorological stations over North China used in this paper

2.2 *Methods*

Regional averaged time series of the parameters are calculated by the arithmetic mean of all the chosen observation stations in North China. The climate means of 1971–2000 are used in the calculation of anomalies for all the parameters. Seasons are defined as follows: spring (March to May), summer (June to August), autumn (September to November), and winter (last December to February).

High-temperature days are defined as days with daily maximum temperature $\geqslant$35°C. Precipitation days are defined as days with daily precipitation total (R) $\geqslant$0.1 mm, which are classified into five grades of intensity: 0.1 mm$\leqslant R <$ 10 mm (light rain), 10 mm $\leqslant R <$ 25 mm (moderate rain), 25 mm $\leqslant R <$ 50 mm (heavy rain), 50 mm $\leqslant R <$ 100 mm (rainstorm), and R $\geqslant$ 100 mm (heavy storm). The contribution rate of different rainfall grade is the ratio of the sum of rainfall with corresponding intensity to the precipitation total over a period. The percentile threshold method is used to define extreme climate events [*Zhai and Pan*, 2003; *Zhai et al.*, 2007; *Wang et al.*, 2012]. The amount and frequency of extreme precipitation are defined as the sum of rainfall and number of days, respectively, based on days with precipitation above the 95th percentile of the standard period 1971–2000. The indicators of