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Recent climate change affecting rainstorm occurrences? A case study in East China

M. Domroes and D. Schaefer

Department of Geography, Mainz University, Germany

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Correspondence to: M. Domroes (domroes@uni-mainz.de)

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Abstract

The paper aims to investigate the occurrences of rainstorms and their relationship with the climate change scenario. The study period under investigation refers to the period of greatest recent warming between 1976–2000 whereas the study area covers China east of 105 E longitude. This region is commonly considered to be controlled by the monsoon type of climate over East Asia.

Positive (increasing) trends of rainstorm occurrences, both in annual and summer respects, have been shown for subtropical China whereas a non-uniform picture is associated with temperate China. The increase of rainstorms in subtropical China corresponds with an increasing trend of precipitation. At the same time, subtropical China experiences a mostly decreasing recent temperature change. No clear evidence could, however, be proved for a direct linkage between increasing temperatures and greater rainstorm occurrences. Within the climate change scenario a great risk of rainstorm occurrences must be regarded as part of the increasing risk of extreme weather events.

Rainstorm occurrences are of a great practical importance as they increase the risk for environmental hazards such as landslides, landslips and floods. Landuse planners must therefore pay a great attention to an increasing number of rainstorms and their adverse risk impact on the environment.

Such practical aspects need particular attention in subtropical China as the region of largest increase of rainstorm occurrences and where, at the same time, the mountains and hilly landscapes are particularly hazard-prone to landslides and floods.

1 Introduction

The climate change scenario is well known with the status of knowledge deliberately described in the latest IPCC report (IPCC 2007). It is shown that the total temperature increase from 1850–1899 to 2001–2005 is 0.76°C [0.57°C to 0.95°C]. The updated 100-yr linear trend (1906 to 2005) at a rate of 0.74°C [0.56°C to 0.92°C] is therefore larger than the corresponding trend for 1901 to 2000 given in the IPCC Third Assessment Report at a rate of 0.6°C [0.4°C to 0.8°C]. The linear warming trend over the last 50 years (0.13°C [0.10°C to 0.16°C] per decade) is nearly twice that for the last 100 years. Eleven of the last twelve years (1995–2006) rank among the 12 warmest years over the instrumental record of global surface temperature (since 1850), IPCC 2007. Climate change studies give also evidence that recent temperature increase is greatest in winter (IPCC, 2007).

A detailed description of warming in China was given by Domroes and Schaefer (2003) using 50-yr (1951–2000) data for 165 WMO-approved meteorological stations. Temperature trends are predominantly positive; the magnitude of increase, however, varies over space, mostly between 0.5–1.0°C, in exceptional cases even up to 2.6°C, referring to the 50-yr period 1951–2000. Corresponding with global observations, annual temperature increase in China results mainly from increasing winter temperatures. Summer temperatures were observed as slightly decreasing over most parts of China.

As far as precipitation is concerned, long-term trends from 1900 to 2005 have been observed over many large regions, including increased precipitation over central Asia whereas drying has been observed in parts of southern Asia. Precipitation is highly variable over space and time (IPCC, 2007). In China (Domroes and Schaefer, 2003) both, positive and negative trends of precipitation were observed for 1951–2000, mostly amounting upto a 100 mm increase (occurring in South China), or upto a 100 mm decrease over North China.

It is also widely supposed that, as a consequence of temperature change, extreme weather events are likely to increase, including rainstorms, associated with negative impacts on the environment, such as landslides and soil erosion.

2 Aim of the paper

The paper aims to investigate the occurrences of rainstorms and their relationship with the climate change scenario. The study period under investigation refers to the period of greatest recent warming between 1976–2000 whereas the study area covers China east of 105 E longitude. This region is commonly considered to be controlled by the monsoon type of climate over East Asia (Domroes and Peng, 1988).

3 Data and method of investigation

Daily precipitation data were evaluated for 112 stations which are fairly evenly distributed over space (Fig. 1). The data were derived from the Global Historical Climatology Network (Daily Version 1.0) and were available from the internet: http://www.ncdc.noaa.gov.

Rainstorm analyses were done for the annual and summer occurrences of rainstorms. No other season needed to be examined as summer (June–July–August, JJA) represents the predominant rainy season (Domroes and Peng, 1988).

Statistically, two methods for trend computation were applied: the commonly used least-square method aiming to compute linear trends, and the non-parametric approach (after Mann-Kendall) detecting all trends – no matter which form it has.

Rainstorms are defined in China by a rainfall total >50 mm/24 h (TAO, 1980). Though generally considered as typical, rainstorms are rare and uncommon climate hazard in China.

4 Results

4.1 Annual occurrences of rainstorms (Fig. 2)

Typically to be seen, rainstorm occurrences are unevenly distributed in spatial terms. Most regions experience only a small annual number (mostly below 3 events). A larger number (above 4, at the most 7 events) occurs only over smaller regions. Spatially, a greater number of rainstorms occurs over subtropical China, a smaller number over temperate China. Hence, a distinct south-to-north gradient of decreasing rainstorm occurrences can be observed.

4.2 Trend of annual occurrences of rainstorms (Fig. 3)

The trend of the annual number of rainstorms is shown with red symbols in case of a negative/decreasing trend and with blue symbols in case of a positive/increasing trend. The size of the symbols was classified into three categories expressing a trend between 0–1, 1–2 and above 2 (either positive or negative) rainstorm occurrences over the 25 yr observation period 1976–2000.

The findings show at the majority of stations a positive trend expressing increasing occurrences of rainstorms. The magnitude of trend is, however, rather low and accounts in most cases for only upto 1 rainstorm event. The next two larger trend categories of a greater increase of rainstorm occurrences (1–2, respectively over 2 events) occur for only a smaller number of stations. As the mean total number of rainstorms is commonly comparably low even such trends are worth to be noted.

In case of negative trends that demonstrate decreasing rainstorm occurrences again the lowest category for weakest decreases predominantly occurs. The next two larger categories were detected only for a small number of stations.

In spatial terms, it is worth questioning whether any regionalization according to positive or negative trends of rainstorm occurrences can be detected or not. It can be seen that the (wet) subtropical regions, with a few exceptions only, experience a positive trend of increasing rainstorm occurrences that mostly belong to the second and third categories of larger magnitudes.

Though the absolute values of the trends are rather small their percentage is high if compared with the (low) number of rainstorm events.

On opposite, the regions under temperate climates experience a non-uniform, mixed picture of either positive or negative trends (mostly a the lowest category) expressing a weakly positive or negative trend.

4.3 Occurrences of rainstorms during summer (Fig. 4)

Temporarily, most rainstorms are experienced in the rainy season commonly corresponding with summer (JJA). Only in southern China, the rainy season starts already in spring, but summer remains as the core season of precipitation (and rainstorms). No rainstorms occur, however, in winter.

Summer rainstorm occurrences are limited to a small number; at most stations less than two events of rainstorms are experienced. The higher categories of 2–3 events, and 3–4 events, respectively, are limted to small regions, preferably in parts of southeastern China.

4.4 Trend of occurrences of summer rainstorms (Fig. 5)

The composition of the trend of occurrences of summer rainstorms shows a similar pattern as the annual trends. In an overall approach, prevailingly increasing trends can be seen at most stations even at larger magnitudes. Decreasing trends, if occurring, are at lowest magnitudes.

Spatially, positive/increasing trends of rainstorm occurrences in summer are to be seen at nearly all stations in the subtropical regions whereas a non-uniform, mixed picture of both, increasing and decreasing trends, is shown for the temperate climate regions.

5 Discussion

A positive/increasing trend of rainstorm occurrences was observed at most reference stations, both for the annual totals and summer totals.

Spatial trend patterns widely correspond between the annual and summer totals showing synchronously a significantly increasing trend for the subtropical regions while a mixed pattern exists for the temperate climate regions. It can also be stated that the increasing trend is largest in the subtropical regions.

The regional differences in the trend of rainstorm occurrences, both in annual respects and for the summer season, may be correlated with the respective pattern of precipitation distribution over China.

Figure 6 shows the distribution of mean annual precipitation over China, Fig. 7 the distribution of summer precipitation. In both cases, a similar pattern of distribution can be observed showing the higher precipitation totals in southern (subtropical) China and a decreasing gradient towards northern (temperate) China.

Evidently a remarkable decrease of the annual total and summer total of precipitation can be seen from south to north over China (east of 105 E longitude) and accordingly also the length of the wet season decreases; synchronously, also the occurrences of rainstorms and their recent trend decrease.

The observations on the trend of rainstorm are remarkably correlated with the mean annual, resp. summer precipitation totals over East China (Domroes and Schaefer, 2003). In both cases, subtropical East China experiences greater totals of precipitation and also a distinctive South-to-North-gradient of decreasing precipitation must be observed. It can be followed that a positive (increasing) trend of rainstorms observed for subtropical China corresponds with greater precipitation totals while a negative (decreasing) trend of rainstorms corresponds with lower precipitation totals; this relationship can synchronously be observed for the annual and summer trends of rainstorms.

The clearly seen greater trend of rainstorms over southern, subtropical China may also be correlated with the recent trends of annual precipitation and summer precipitation, respectively (Figs. 8 and 9). A positive relationship can be seen between the increasing annual precipitation and the increasing number of rainfall events. For the trend of summer precipitation, both positive and negative trends can be observed over China with predominantly increasing trends across subtropical China. The same observations are given for the summer trend of precipitation. It can, therefore, be followed that a greater frequency of rainstorms is directly correlated with a greater amount of precipitation and the observed increased trends of precipitation, and vice-versa.

Within the climate change scenario it is also argued that the occurrences of rainstorms would increase as a consequence of global warming. Such possible relationship seems, at the present state of knowledge, difficult to be proved by the present study.

It is, however, definitely proved (Domroes and Schaefer, 2003) that temperatures over China have even strikingly increased during the past 50 years. The distribution of annual temperature trends (1951–2000) is shown in Fig. 10; isolines express the trends [°C] per decade. As an overall result of the observations it must be stated that the annual temperature trend over China is of an approximately double magnitude compared with the global trend.

As far as trend of annual temperature change over China is concerned, at 87 percent of all stations a positive trend was recorded. It shows the weakest increase across the subtropical regions (at a rate mostly between 0.5–1.0°C/1951–2000).

For the trend of summer temperatures, East China experiences negative (decreasing) trends over most parts of subtropical China and positive (increasing) trends over temperate (northern) China. In both cases, trend values are, however, rather small (Fig. 11).

As rainstorms mostly derive from singular weather anomalies at certain small localities their correct detection is therefore a great problem and stationary observations at specific meteorological sites may not properly detect them.

Rainstorm events are, if at all occurring, by nature specifically associated with typhoons which mostly hit the coastal lowlands of Zhejiang, Fujian and Guangdong provinces. Additionally, also the risk area of typhoon visitations is confined to the coastal areas in subtropical China, and the larger trend of rainstorm occurrences may be linked with the frequency of typhoons. It needs, however, to be investigated whether the frequency of typhoons has increased during the recent period of greatest warming between 1976–2000.

Though the number of rainstorm occurrences is small their adverse affect on the environment, both the physical and human (by soil erosion, landfalls and floods, respectively on housing and livelihood), is often most serious.

CPD
4, 289–308, 2008

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Fig. 1. China east of 105° E and location of stations under study.

CPD
4, 289–308, 2008

Climate change and rainstorms in East China

M. Domroes and
D. Schaefer

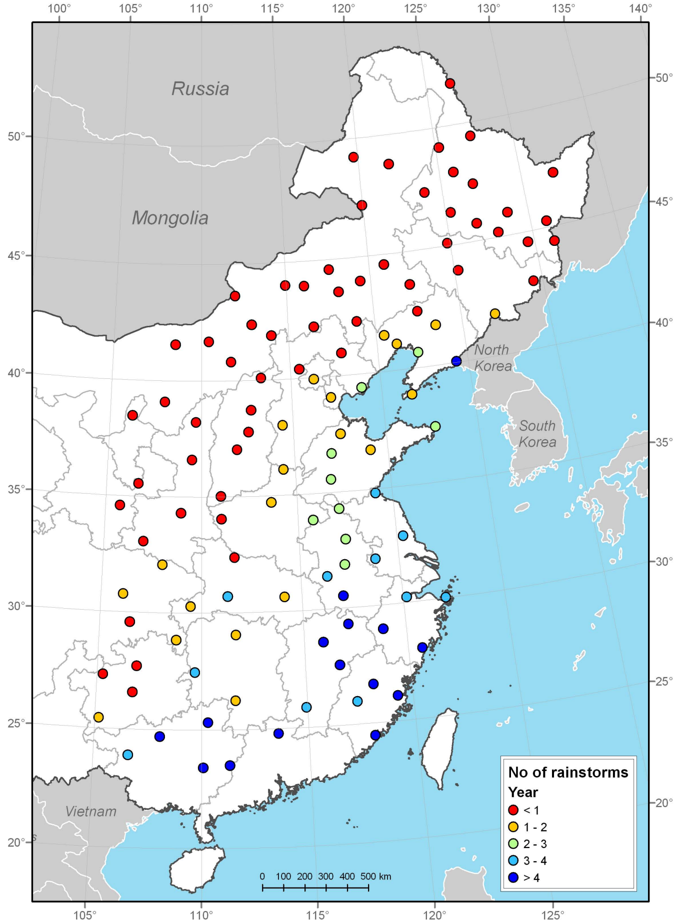

Fig. 2. Number of rainstorms/yr over East China, 1976–2000.

CPD
4, 289–308, 2008

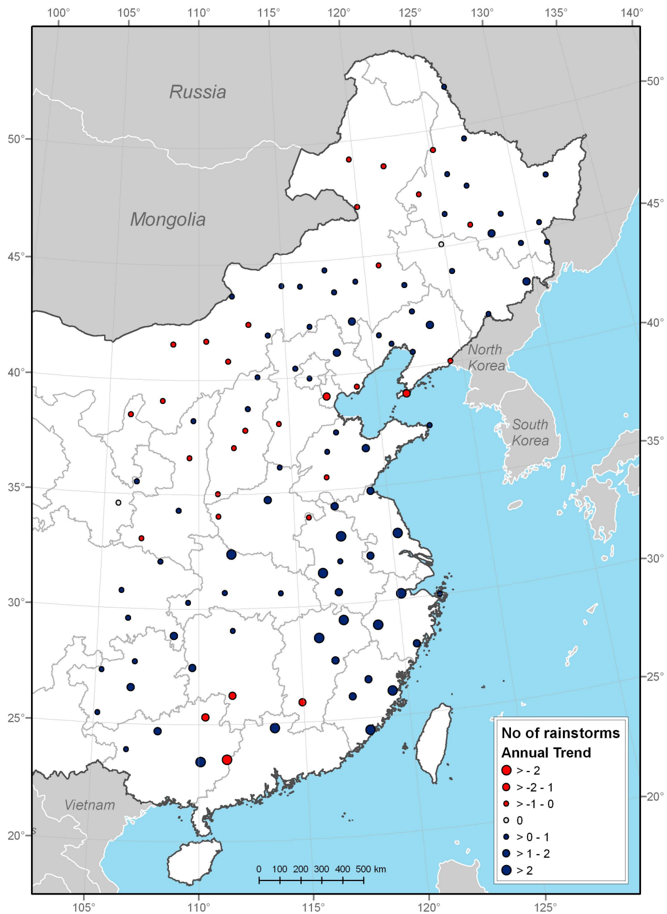

Fig. 3. Trend of number of rainstorms/yr over East China, 1976–2000.

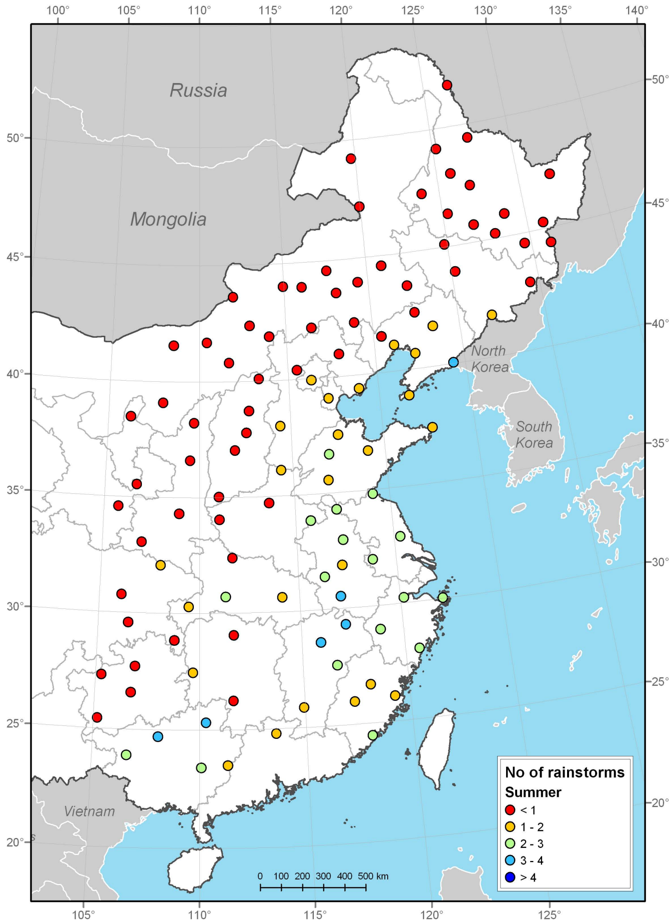

Fig. 4. Number of rainstorms/summer (June–July–August) over East China, 1976–2000.

CPD
4, 289–308, 2008

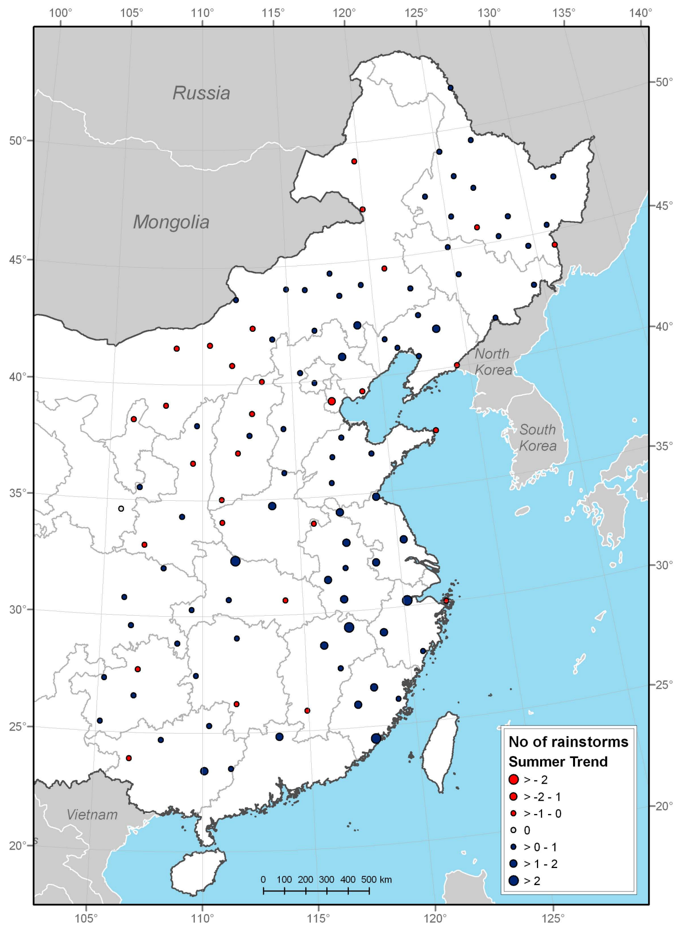

Fig. 5. Trend of number of rainstorms/summer (June–July–August) over East China, 1976–2000.

Climate change and rainstorms in East China

M. Domroes and D. Schaefer

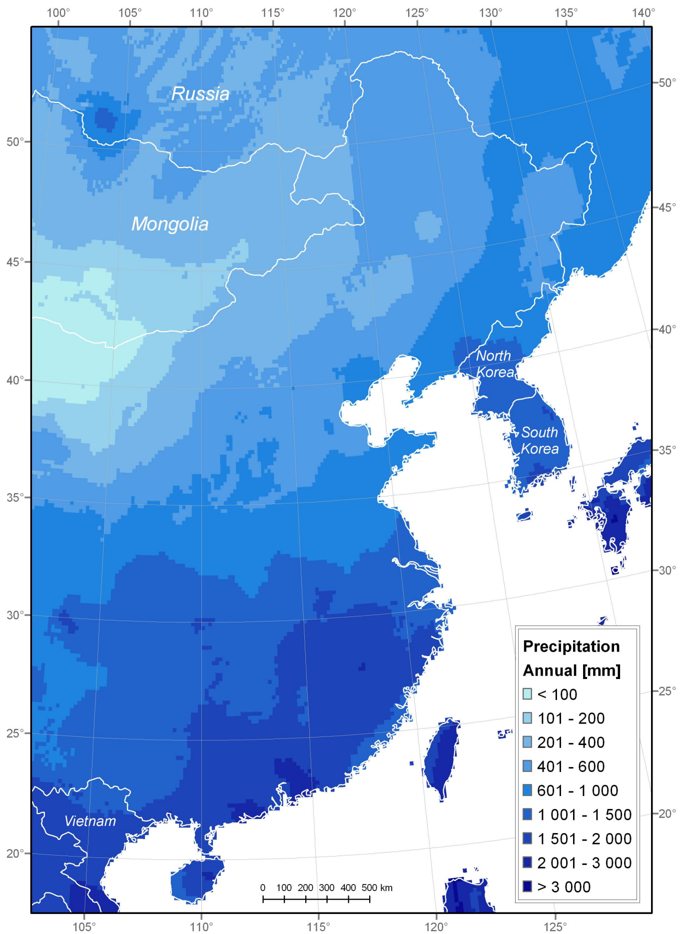

Fig. 6. Mean annual totals of precipitation over East China, 1951–2000.

CPD
4, 289–308, 2008

Climate change and rainstorms in East China

M. Domroes and D. Schaefer

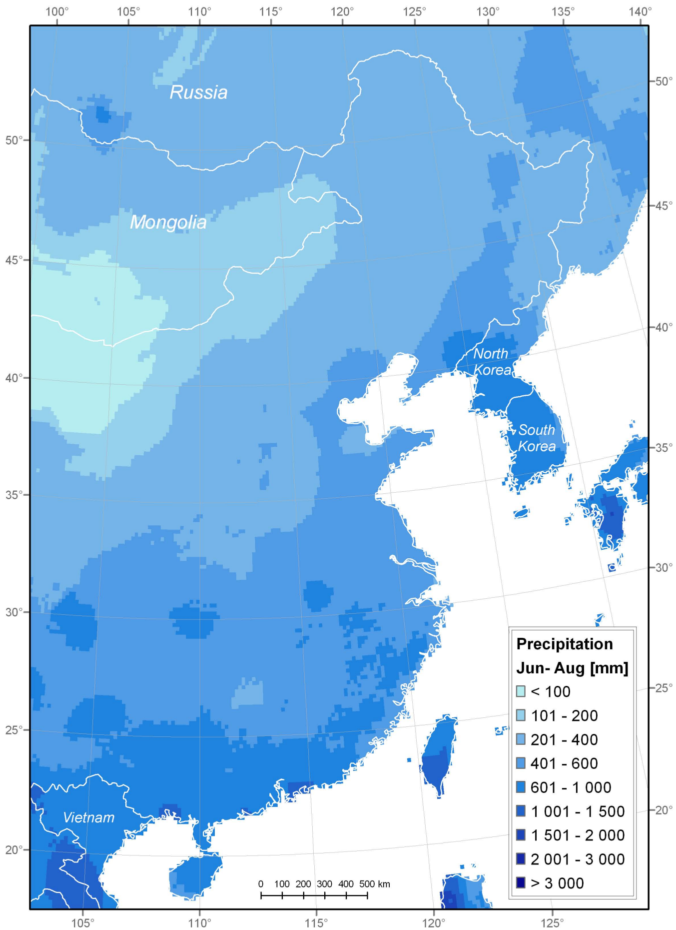

Fig. 7. Summer totals of precipitation over East China, 1951–2000.

CPD
4, 289–308, 2008

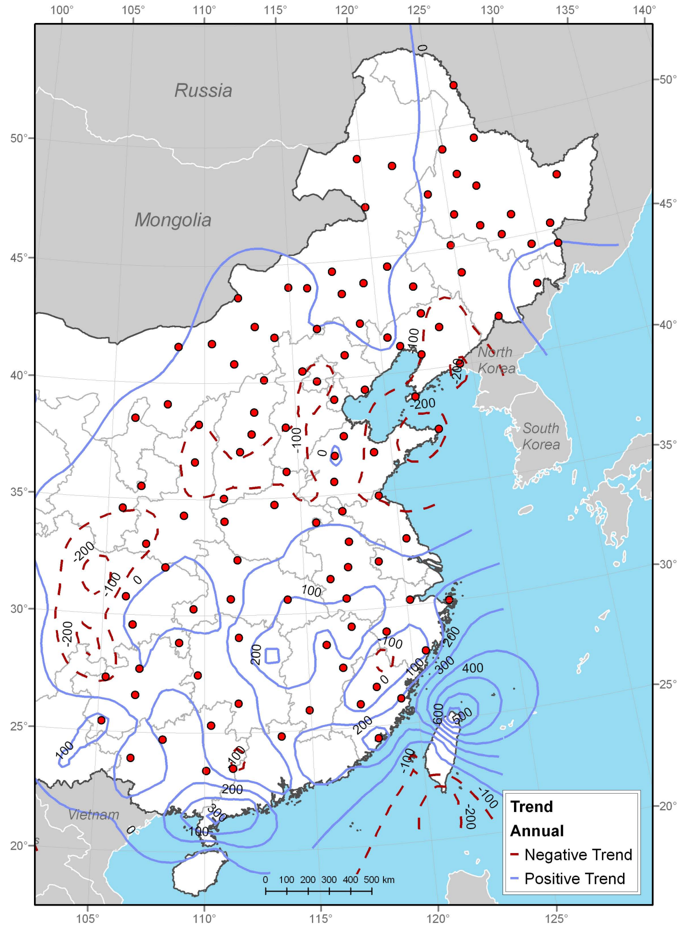

Fig. 8. Trend of annual precipitation over East China, 1951–2000, mm/50 yr (Domroes and Schaefer, 2003).

Climate change and rainstorms in East China

M. Domroes and D. Schaefer

Fig. 9. Trend of summer precipitation over East China, 1951–2000, mm/50 yr (Domroes and Schaefer, 2003).

CPD

4, 289–308, 2008

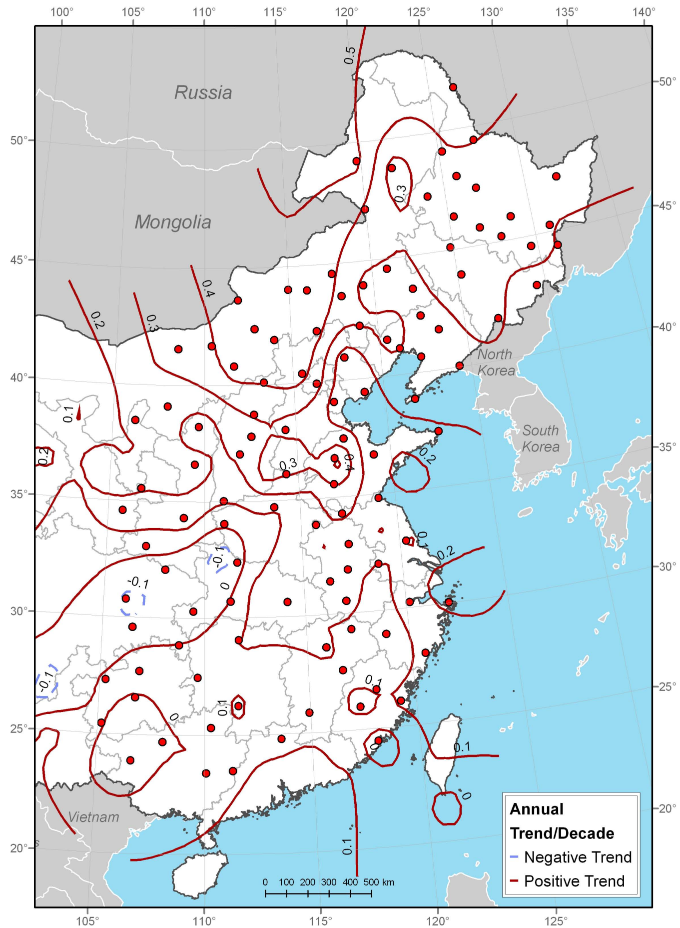

Fig. 10. Trend of annual temperature change over East China, 1951–2000, °C/decade (Domroes and Schaefer, 2003).

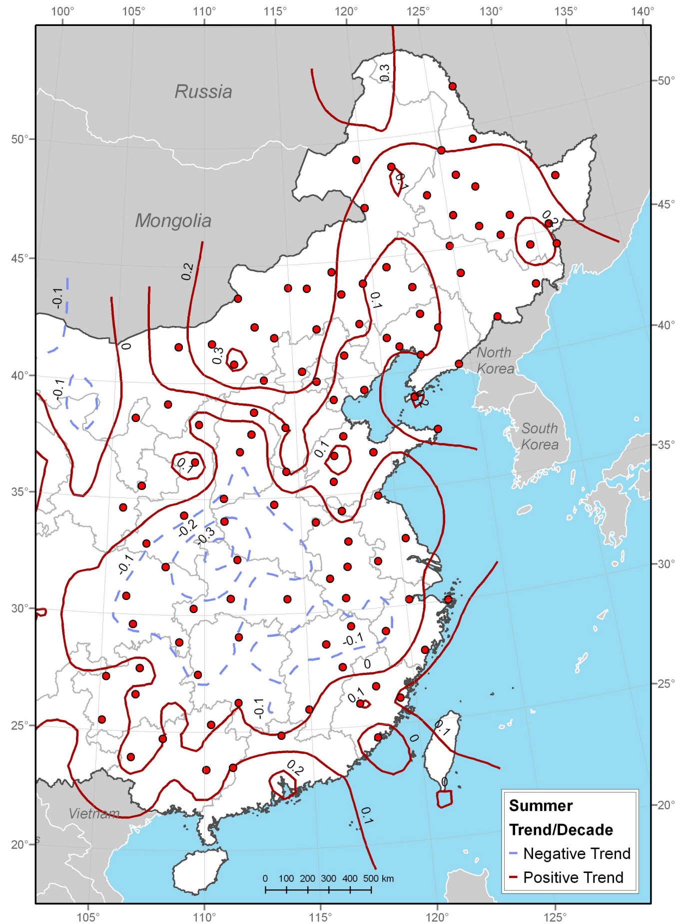

Fig. 11. Trend of summer temperature change over East China, 1951–2000, °C/decade (Domroes and Schaefer, 2003).

CPD
4, 289–308, 2008

Climate change and rainstorms in East China

M. Domroes and D. Schaefer