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Trends in Graded Precipitation in China from 1961 to 2000

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ABSTRACT

Daily precipitation rates observed at 576 stations in China from 1961 to 2000 were classified into six grades of intensity, including trace (no amount), slight ($\leqslant$ 1 mm d^{-1}), small, large, heavy, and very heavy. The last four grades together constitute the so called effective precipitation ($>$ 1 mm d^{-1}). The spatial distribution and temporal trend of the graded precipitation days are examined. A decreasing trend in trace precipitation days is observed for the whole of China, except at several sites in the south of the middle section of the Yangtze River, while a decreasing trend in slight precipitation days only appears in eastern China. The decreasing trend and interannual variability of trace precipitation days is consistent with the warming trend and corresponding temperature variability in China for the same period, indicating a possible role played by increased surface air temperature in cloud formation processes. For the effective precipitation days, a decreasing trend is observed along the Yellow River valley and for the middle reaches of the Yangtze River and Southwest China, while an increasing trend is found for Xinjiang, the eastern Tibetan Plateau, Northeast China and Southeast China. The decreasing trend of effective precipitation days for the middle-lower Yellow River valley and the increasing trend for the lower Yangtze River valley are most likely linked to anomalous monsoon circulation in East China. The most important contributor to the trend in effective precipitation depends upon the region concerned.

Key words: trends, graded precipitation days, intensity, effective precipitation, warming, China

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1. Introduction

Many recent studies have reported long-term changes in annual mean precipitation and summer mean precipitation in various regions of China, such as in the Northwest China (Shi et al., 2003), and eastern parts (Weng et al., 1999; Gong and Ho, 2002). Climate in most parts of China shows high precipitation variability (Hu et al., 2003). Extreme weather and climate events, such as droughts and floods, have been recurrent natural disasters in the country (Yan and Yang, 2000; Xu, 2001). Liu et al. (2005) found that changes in precipitation amounts in China are mainly due to changes in the frequency and intensity of heavy precipitation events. Some studies have shown the presence of interdecadal variation in precipitation and have suggested various causes related to large-scale circulation changes in the East Asian summer monsoon system (Fu et al., 2004; Huang et al., 2004; Li et al., 2004; Wang et al., 2004; Yang and Lau, 2004). These large-scale circulation changes may affect convective activities that determine the intensity and frequency of rainfall events.

Recently, a daily precipitation dataset for the last 40–50 years was used to detect changes in precipitation characteristics in China (Zhai et al., 2005; Qian and Lin, 2005). In the study of Qian and Lin (2005), a number of extreme climate indices were used to characterize changes in the statistical distribution of precipitation. These indices were based on the 90th and 95th percentiles, as well as intensity and persistence. The precipitation intensity included, for example, the

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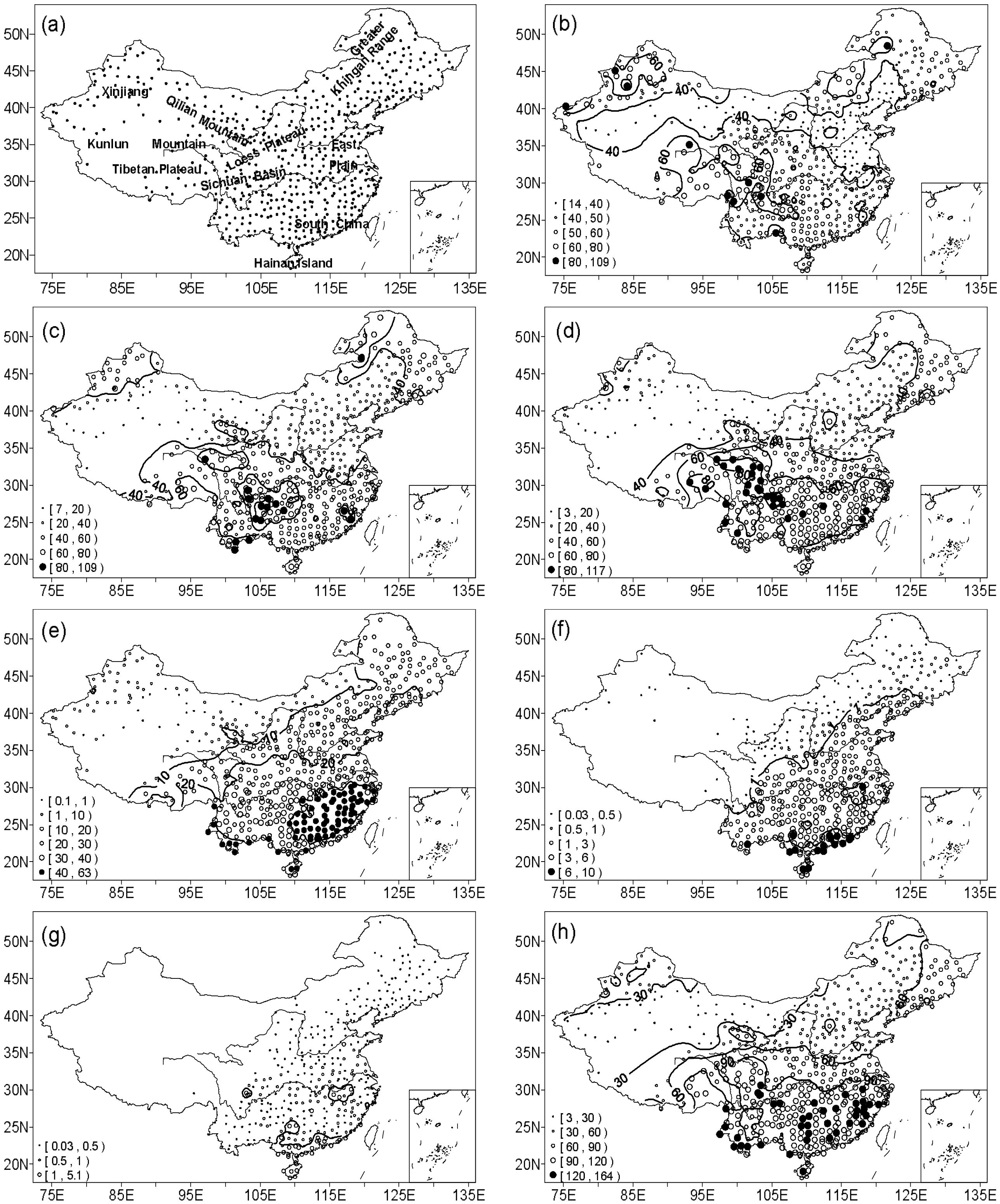

Fig. 1. (a) Geographical location of the stations used, and (b) the mean annual precipitation days (unit: days) during 1961–2000 for intensities of trace, (c) slight, (d) small, (e) large, (f) heavy, (g) very heavy, and (h) effective precipitation.

annual number of days of daily rainfall larger than 10 mm d^{-1} and the greatest 5-day total rainfall per year. It was shown that a decreasing trend of annual mean precipitation and extreme events extended from the southern part of Northeast China southwestward to the upper Yangtze River valley, but an increasing trend was found in Xinjiang and Southeast China (Qian and Lin, 2005).

Goswami et al. (2006) found that seasonal mean rainfall over central India during the monsoon seasons of 1951–2000 do not show a significant trend, although there are significant rising trends in the frequency and magnitude of extreme rain events ($\geqslant$100 mm d^{-1}) and a significant decreasing trend in the frequency of moderate events ($\geqslant$ 5 mm d^{-1} but $<$ 100 mm d^{-1}). In China, there is no obvious trend of annual mean precipitation, but significant regional differences have been found from daily precipitation trends for various intensity groups based on thresholds of above 10, 50 and 100 mm d^{-1} by using data from 296 stations during 1951–1995 (Zhai et al., 1999b). Such studies have focused on upper percentile and high intensities of daily precipitation. However, trace and slight precipitation have not been considered. One exception is the study by Yan and Yang (2000), which investigated trace precipitation based on a sparse network of 60 stations in China. In applications, statistics of various daily precipitation intensities or grades are important. Further, changes in various precipitation intensities may be caused by different processes and mechanisms. As an example, a recent work (Gong et al., 2007) proposed a link between light rain events and air pollutants in China. Identifying changes for different precipitation grades may help in understanding relevant processes.

The purpose of this work is twofold. First, identification of regional trends in precipitation days as a function of precipitation intensity in the context of general warming and changing atmospheric circulation. Second, the determination of which grade of precipitation intensity makes the most important contribution to changes in effective precipitation days.

2. Data and analysis methods

Daily data from 726 stations were obtained from the Chinese National Meteorological Center. These data include daily maximum surface air temperature (T_{m}), daily minimum surface air temperature (T_{n}), and daily total precipitation (P_{r}). Over time, the number of observational stations in service have changed in number. Since 1958, the number that measure P_{r} and temperature has remained at around 660. In the early 1950s, the number of stations increased from 160 to 400. After considering the homogeneity of station distribution, daily precipitation and temperature of a total of 576 stations from 1961 to 2000 were used for the analysis. Figure 1a shows the distribution of these 576 stations, and their geographical locations are described in the text. A daily interval of 24 h was begun at 2000 LST. Daily mean temperature is calculated by:

$$\overline{T} = (T_{\mathrm{m}} + T_{\mathrm{n}})/2 \quad (1)$$

Daily rain rates at stations were classified into six grades of intensity (Table 1), including trace (no amount), slight (recorded but $R \leqslant 1$ mm d^{-1}), small (1 mm $d^{-1} < R < 10$ mm d^{-1}), large (10 mm $d^{-1} \leqslant R < 50$ mm d^{-1}), heavy (50 mm $d^{-1} \leqslant R < 100$ mm d^{-1}), and very heavy ($R \geqslant 100$ mm d^{-1}). The last four grades (small, large, heavy and very heavy) together constitute the so called effective precipitation ($>$ 1 mm d^{-1}).

A linear trend analysis is used in time series (Y) of temperature and days of various graded precipitation. A linear function of time t can be written as:

$$Y = at + b \quad (2)$$

where a is the regression coefficient which denotes the linear trend, and b is a constant. The t-test method is used to detect whether the trend of a series reaches statistical significance.

3. Precipitation days of the six grades

Annual mean days of the six precipitation grades for the period 1961–2000 in China are shown in Fig. 1. For trace precipitation (Fig. 1b), there are several areas with values of about 100 d yr^{-1}. These areas are located in Southwest China and the northern Xinjiang region. The highest value of trace precipitation (108.5 d yr^{-1}) is found in the west of Xinjiang (Station No. 51701, 3504.4 m above sea level). A low-value zone of trace precipitation ($<$40 d yr^{-1}) is located along the latitudes between 35°N and 40°N in northern China, even spanning to the north of the lower Yangtze River. The distribution of trace precipitation days indicates that more such events are found in mountainous regions than in the plains.

For slight precipitation days (Fig. 1c), three areas with relatively high values ($>$ 40 d yr^{-1}) can be noted, in north Xinjiang, northern Northeast China, and in southern China. A high value center of 60–100 d yr^{-1} is found in the middle reaches of the Yangtze River, including the Sichuan Basin. In the upper Yellow River, those high value centers are related to the Qilian Range and the eastern Kunlun Range. In Northeast China, three sites with values of $>$ 60 d yr^{-1} are associated with the Greater Khingan Range. A wide

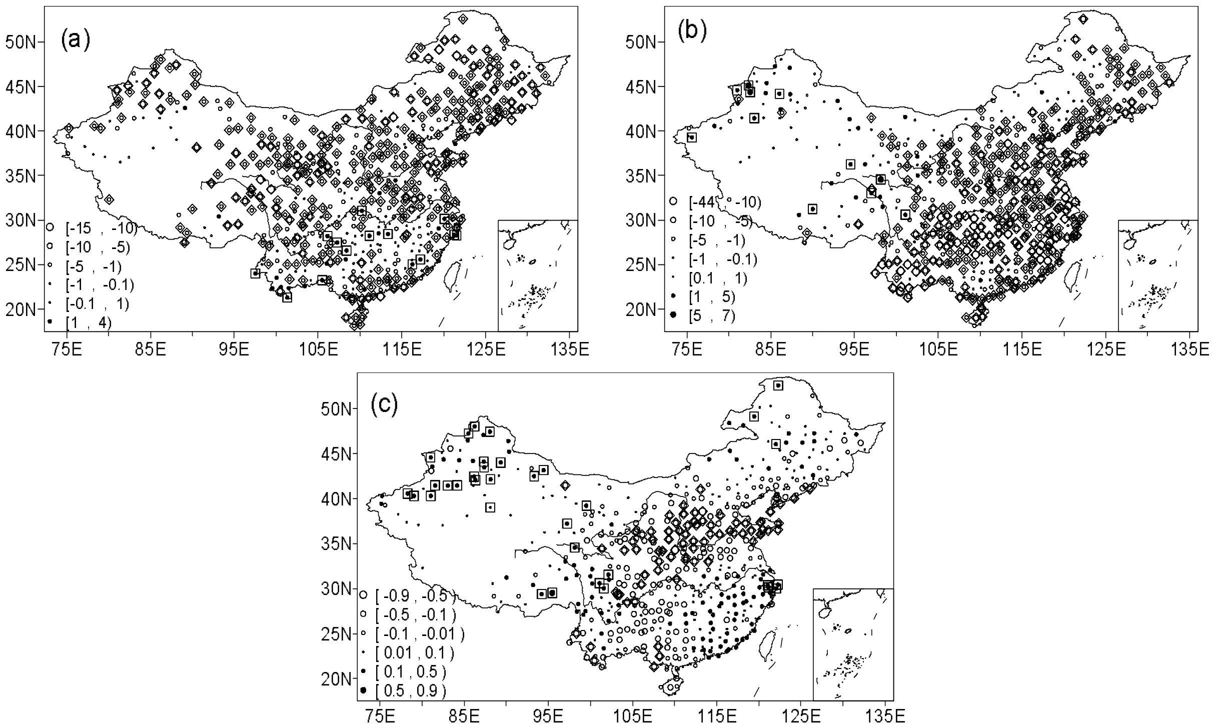

Fig. 2. Precipitation-day trends [units: d (10 yr)$^{-1}$] over 1961–2000 for (a) trace, (b) slight, and (c) effective grades in China. Solid dots denote an increasing trend and squares indicate statistical significance at the 0.05 confidence level for the upward trend, while open circles denote a decreasing trend and diamonds indicate statistical significance at the 0.05 confidence level for the downward trend.

Table 1. Intensity classification of daily precipitation.

	Grade					
	Trace	Slight	Small	Large	Heavy	Very Heavy
Amount (mm d^{-1})	No record	(0,1]	(1,10)	[10,50)	[50,100)	$\geqslant$ 100

zone with values of < 40 d yr^{-1} is found east-wards from the desert region in Northwest China, the Loess Plateau to the East Plain along the Yellow River.

Recorded daily precipitation that is greater than 1 mm d^{-1} is important for plant growth. Small precipitation days are plotted in Fig. 1d. A region with values from 3.3 to 20 d yr^{-1} is located in the desert areas of Northwest China. Three clusters can be identified from lower to higher days between the Yellow River and the Yangtze River. Crossing the Yellow River, days of small precipitation increase from a lower value (20–40 d yr^{-1}) to a higher value (40–60 d yr^{-1}). When crossing the Yangtze River, the value increases to 60–80 d yr^{-1}. A high center with a value of > 80 d yr^{-1} is located on the eastern side of the Tibetan Plateau due to the southwesterly humid flow. It is interesting to note that there are relatively low values (40–60 d yr^{-1}), in comparison to the high values in inland areas, near the south coast of South China, and the same feature can also be observed in Hainan Island. The high value zone in the south of the Yangtze River may be caused by frequent stationary frontal activity. Climatologically, small precipitation appears frequently in Southwest China, which may be linked to the activity of the southwest vortex (Xu, 1991).

Large precipitation appears on at least one day in the last 40 years for almost all stations in China, except for some scattered sites in the northwest region (Fig. 1e). The line of 10 d yr^{-1} divides China into two parts: the non-monsoon region to the west, and the monsoon region to the southeast. This line corresponds well to the northernmost limit of annual mean 4 mm d^{-1} precipitation in China (Qian et al., 2007). Climatologically, the high value area of > 40 d yr^{-1} is concentrated in southeastern China, frequently in the south of the lower Yangtze River. This distribution is directly linked to the activity of the East Asian monsoon and its coverage.

Heavy rainfall (Fig. 1f) is rare in Northwest China. On the other hand, climatologically, more than one day of heavy rainfall per year occurs in the southeast region of China. The high frequency of 3–10 d yr^{-1} extends from Hainan Island northeastward to the middle-lower Yangtze River. The highest frequencies of heavy rainfall, with values of 9.9 d yr^{-1}, 8.8 d yr^{-1} and 8.7 d yr^{-1}, are found at stations 59626 (Dongxin), 59663 (Yangjiang) and 59673 (Shangcun Island), respectively. For very heavy rainfall days (Fig. 1g), a center in the middle Yangtze River appears in the mei-yu (subtropical summer monsoon) season, and another high value zone in southern China is mostly caused by tropical storm activity.

Finally, effective precipitation days per year are shown in Fig. 1h. Values of < 30 d yr^{-1} of effective precipitation days are located in the desert region over Northwest China. Values of 30–60 d yr^{-1} appear in the dry and semi-dry regions of northern China. A line of 60 d yr^{-1} extends along the line of latitude 35°N and the 90 d yr^{-1} line occurs along the middle-lower Yangtze River. Actually, high value stations of effective precipitation days are found in inland areas of southern China. This is influenced jointly by the activities of the southwest vortex, the mei-yu front, and typhoons in southern China.

4. Graded precipitation trends and temperature

Temporal trends of precipitation days for various grades are shown in Fig. 2. For trace grade days, a significant decreasing trend can be found over almost all of China, except at several sites in the south of the middle section of the Yangtze River. This trend of trace precipitation days confirms the findings of a previous analysis based on a sparse network of 60 stations in China (Yan and Yang, 2000). The present study here also shows that there is a decreasing trend of slight precipitation days in eastern China, while an increasing trend exists in the eastern Tibetan Plateau and in Xinjiang (Fig. 2b). For effective precipitation days, a decreasing trend is observed along the Yellow River valley, in the middle reaches of the Yangtze River and in Southwest China, while an increasing trend is found in Xinjiang, the eastern Tibetan Plateau, Northeast China and Southeast China. Further, significant decreasing and increasing trends of effective precipitation days that reached the 0.05 confidence level are located along the Yellow River and in the Xinjiang region, respectively (Fig. 2c). This pattern of effective precipitation days is the same as that of daily rainfall exceeding the mean 95th percentile, and daily rainfall larger than the long-term 90th percentile for 1961–2000 (Qian and Lin, 2005).

To explore a possible role played by general warming in China, Fig. 3 shows the annual series of three graded-precipitation days and the annual mean temperature in China. Significant decreasing trends are observed for trace precipitation days (at the 0.05 significance level) and slight precipitation days (at the 0.05 significance level), while interannual variability is the dominant variation for effective precipitation days, causing no significant trend. The increasing temperature trend reaches the 0.001 significance level with an increasing magnitude of about 0.8°C over the 40 year period. To determine if there is a real correlation between rising temperature and decreasing trends of trace and slight precipitation days, trends for both data series need to be removed. After removing the trends for temperature, trace and slight precipitation days, a significant (at the 0.05 significance level) interannual correlation between temperature and trace precipitation is found. A negative correlation is also established between temperature and slight precipitation days on the interannual timescale, but this correlation does not reach a level of statistical significance. Table 2 gives the precipitation-day trends of trace, slight and effective precipitation in China as a whole and in eastern China (east of 100°E). According to these trends, trace precipitation has decreased by about 10 days, while slight precipitation has decreased by about 15 days for the whole of China over the 40 year period. Effective precipitation in eastern China has also decreased by about two days. Figure 4 shows the spatial distribution of annual mean temperature trends from 1961–2000 in China. The trend of increasing temperature is about 0.3–0.5°C $(10\ yr)^{-1}$ in most stations of northern China, while a decreasing temperature trend is observed in the middle reaches and the south of the Yangtze River. It is interesting to compare the trends of trace precipitation days (Fig. 2a) and those of annual-mean temperature (Fig. 4). The established significant and consistent trends of trace precipitation days are of a large scale, similar to the general warming trend in China for the last half century (Yan and Zhang, 1993; Zhai et al., 1999a; Zhai and Pan, 2003; Qian and Lin, 2004; Qin et al., 2005). High temperatures could increase the condensation height of precipitable cloud and reduce cloud amount so that trace or slight precipitation days are in turn reduced. Kaiser (1998, 2000) analyzed the total cloud amount over China and indicated that daytime and nighttime total cloud cover exhibited significant decreasing trends of 1%–2% $(10\ yr)^{-1}$ for both day and night observations between 1951 and 1994. The significant negative correlation between trace precipitation days and temperature on the interannual times-

Table 2. Precipitation-day trends [d (10 yr)$^{-1}$] of trace, slight and effective intensities across China as a whole and in eastern China (east of 100°E); bold numbers indicate the trend value at the 0.01 significance level.

	Trace	Slight	Effective
Whole China	**−2.86**	**−3.77**	−0.26
Eastern China	**−2.80**	**−4.44**	−0.52

Table 3. Same as Table 2 except for all four seasons in China as a whole.

	Trace	Slight	Effective
Winter	**−0.96**	**−1.21**	0.25
Spring	**−0.71**	**−0.38**	0.08
Summer	**−0.56**	**−0.76**	0.00
Autumn	**−0.66**	**−1.48**	**−0.59**

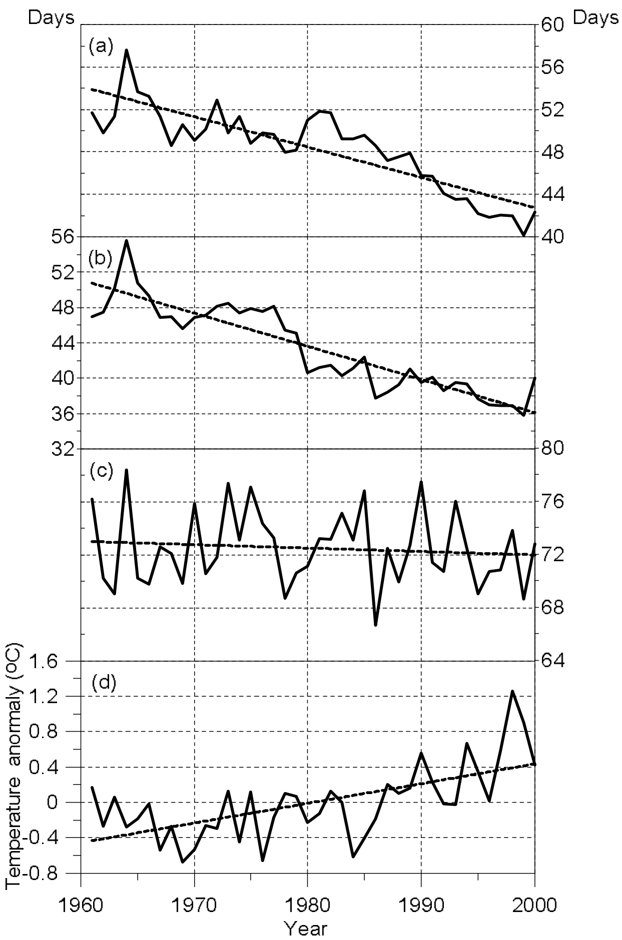

Fig. 3. Annual series of precipitation days in China as a whole for (a) trace, (b) slight, (c) effective grades, and (d) annual mean temperature anomaly (°C).

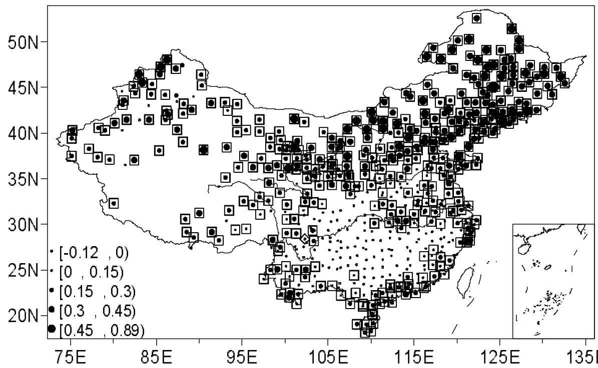

Fig. 4. Same as Fig. 2 except for the trends of annual mean temperature from 1961–2000.

cale supports the hypothesis that the decreasing trend of trace precipitation days may be a response to the increasing trend of temperature. However, more studies need to be carried out in order to establish this link and to uncover the mechanisms behind the link.

Table 3 shows the precipitation-day trends of the three grades of precipitation in China as a whole for all four seasons. Significant decreasing trends are noted for trace and slight precipitation days in all seasons, but for effective precipitation the trends are not significant, except in fall. There is strong evidence showing large-scale decreasing trends for trace and slight precipitation across the whole of China, while the trends of effective precipitation have various regional features. Fall is the only season with the most significant and consistent decrease in precipitation days of all the three categories. Putting trace and slight grade days together, the decreases in fall and winter are larger than those in spring and summer. A recent analysis (Qian and Qin, 2005) showed that temperature in China has larger increasing trends in winter and fall than in spring and summer. This may be taken as further support of the proposed link between general warming and the reduction in trace and slight precipitation days. Another more direct cause of reduced trace and slight precipitation days may be associated with the decreasing trend of extra-tropical cyclone frequency in China during the last half century in the winter half of the year (Qian et al., 2002).

5. Regional features of the trends

This section shows the regional patterns of the precipitation-day trends for various intensities during the 40-year period (Fig. 5). A significant decreasing trend of small precipitation days is mainly concentrated in the north of the Yangtze River. There are significant decreasing trends in the middle-lower Yellow River valley and increasing trends in northern

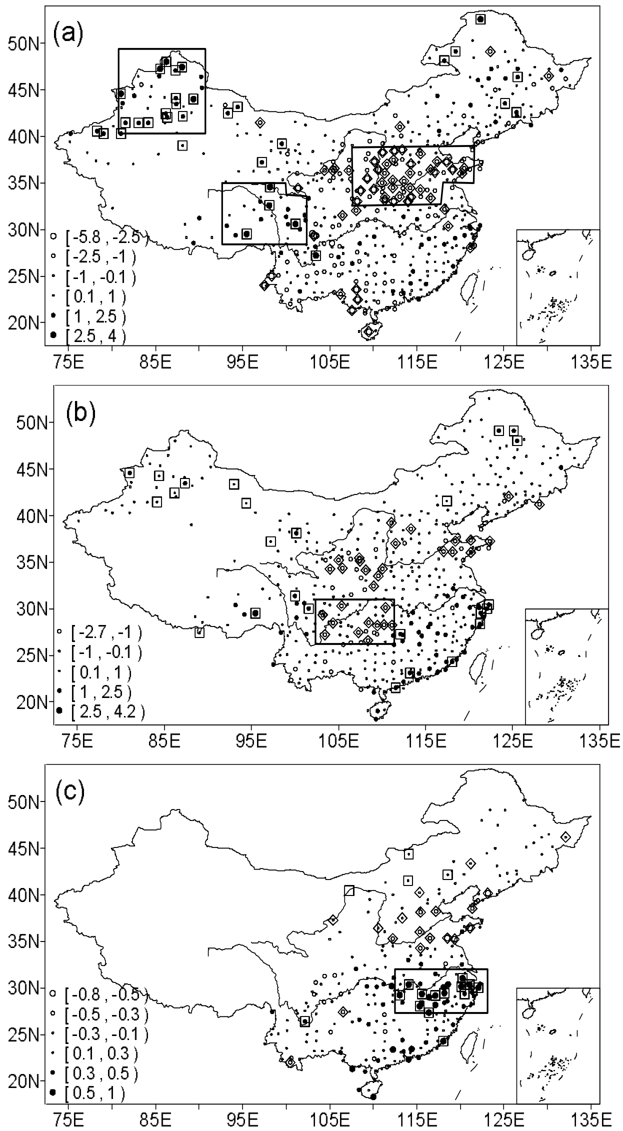

Fig. 5. Same as Fig. 2 except for (a) small, (b) large, and (c) heavy grades. The five areas are boxed in northern Xinjiang, the eastern Tibetan Plateau, the middle-lower Yellow River valley, and the middle and the lower Yangtze River valley, respectively.

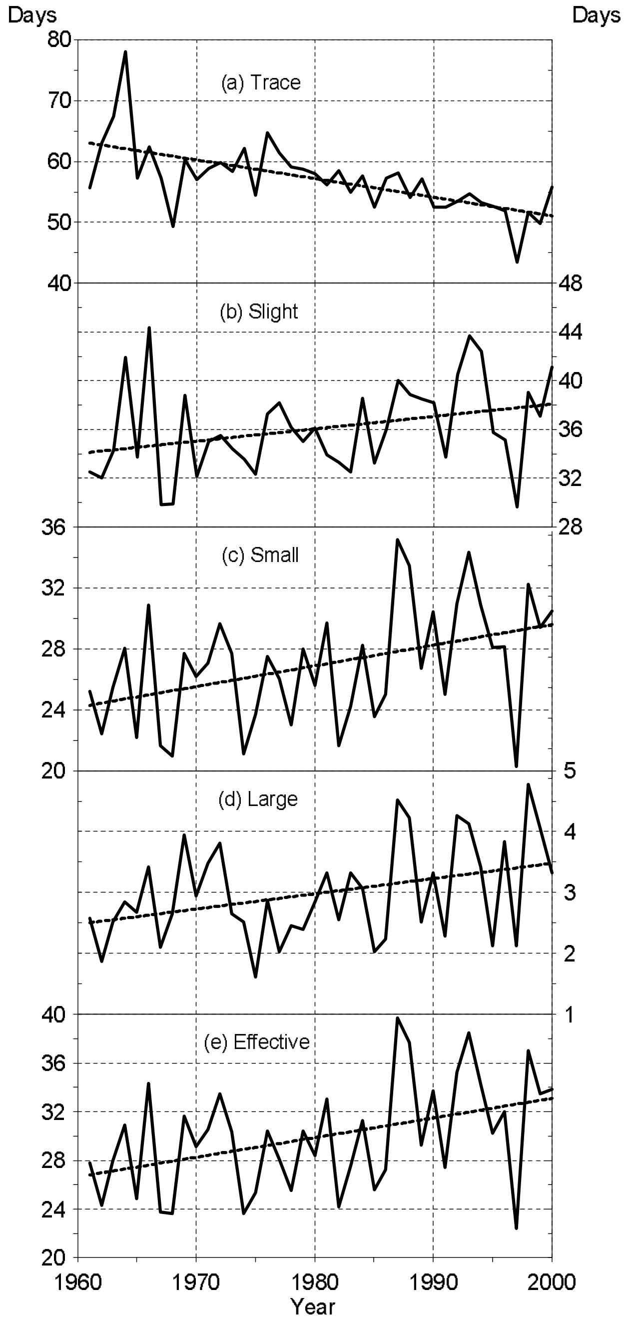

Fig. 6. Time series of precipitation days for various grades in north Xinjiang.

Xinjiang and the eastern Tibetan Plateau (Fig. 5a). The decreasing trend of large precipitation days is mainly located in the middle Yangtze River valley and the middle-lower Yellow River valley, while the increasing trends are dispersed throughout Northwest China, the eastern Tibetan Plateau, Northeast China, and Southeast China (Fig. 5b). Further, significant contrasting trends of heavy precipitation days are situated in the lower Yangtze River valley and the lower Yellow River valley (Fig. 5c).

Based on the regional features of the precipitation-day trends, five regions with consistent trends can be defined, which are indicated by the boxes in Fig. 5. A comparison among various precipitation intensities for northern Xinjiang is shown in Fig. 6. Trace precipitation experiences a reduction of about 10 days in the 40-year period, while other intensities of precipitation show an increasing trend. In the Xinjiang region, Shi et al. (2003) indicated that a climate regime shift

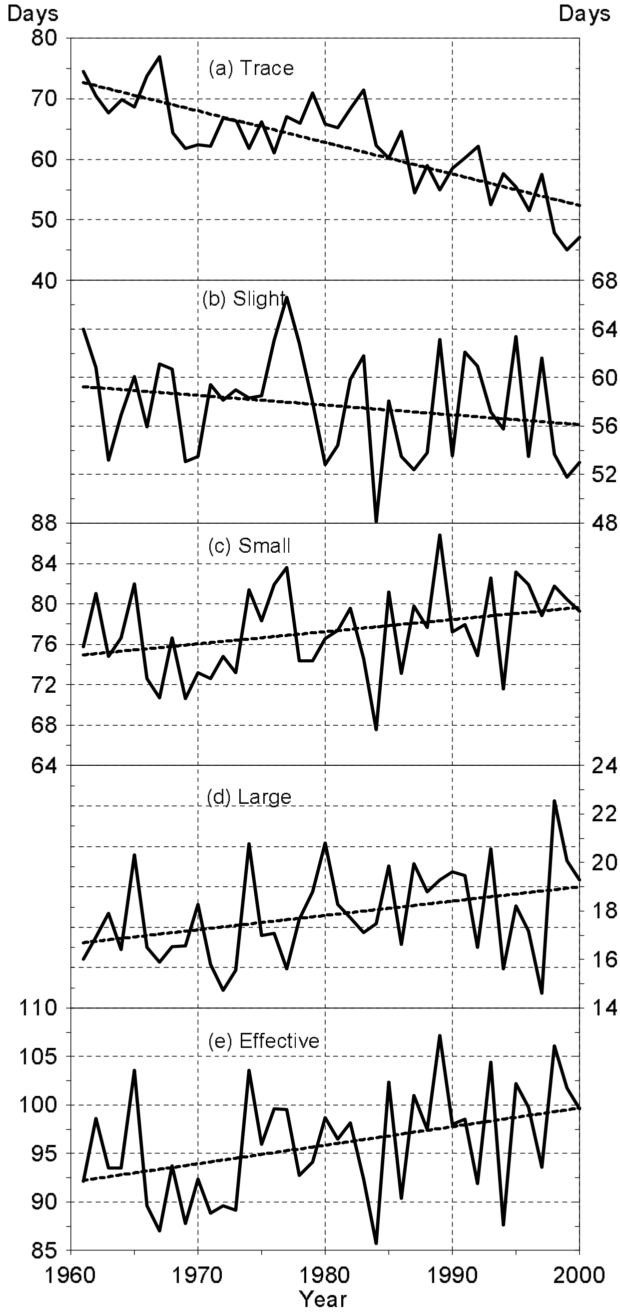

Fig. 7. Same as Fig. 6 except for the eastern Tibetan Plateau.

occurred in the 1980s from a cold-dry state to a warm-wet state. Qian and Qin (2007) also detected a significant interdecadal transition of annual mean precipitation in the Xinjiang region, from a low level to a high level around 1987. An analysis of the precipitation-day series of various intensities shows that significant increases in precipitation amounts mainly come from the effective precipitation days since 1987.

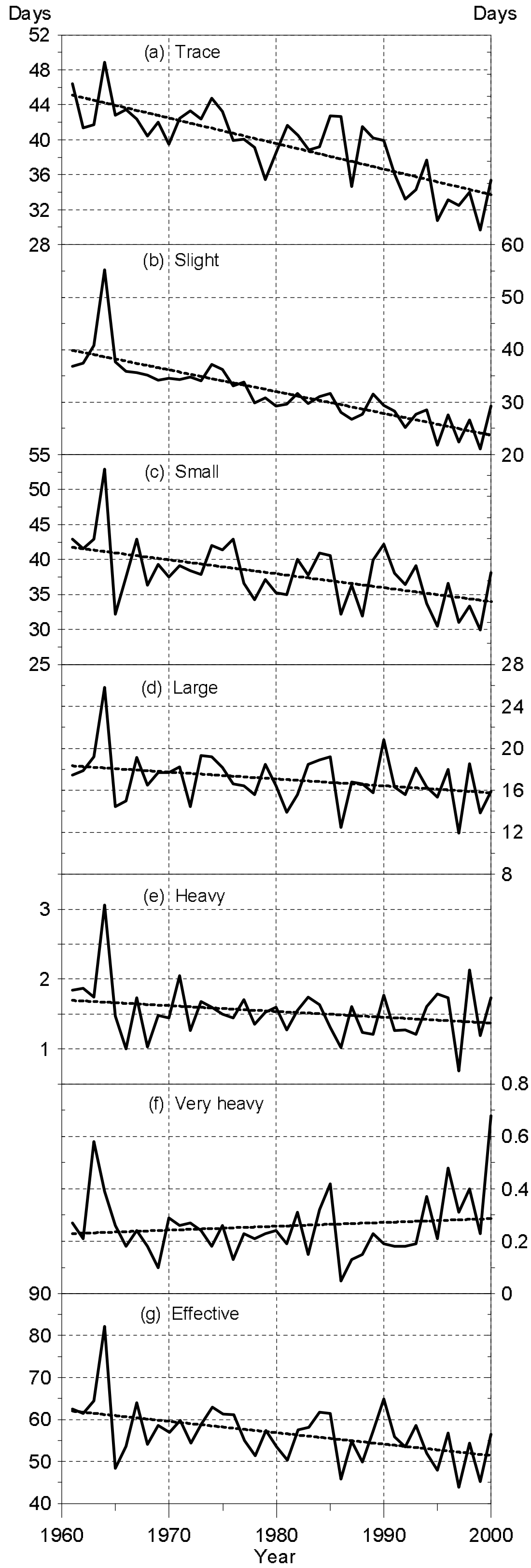

Fig. 8. Same as Fig. 6 except for the middle-lower Yellow River valley.

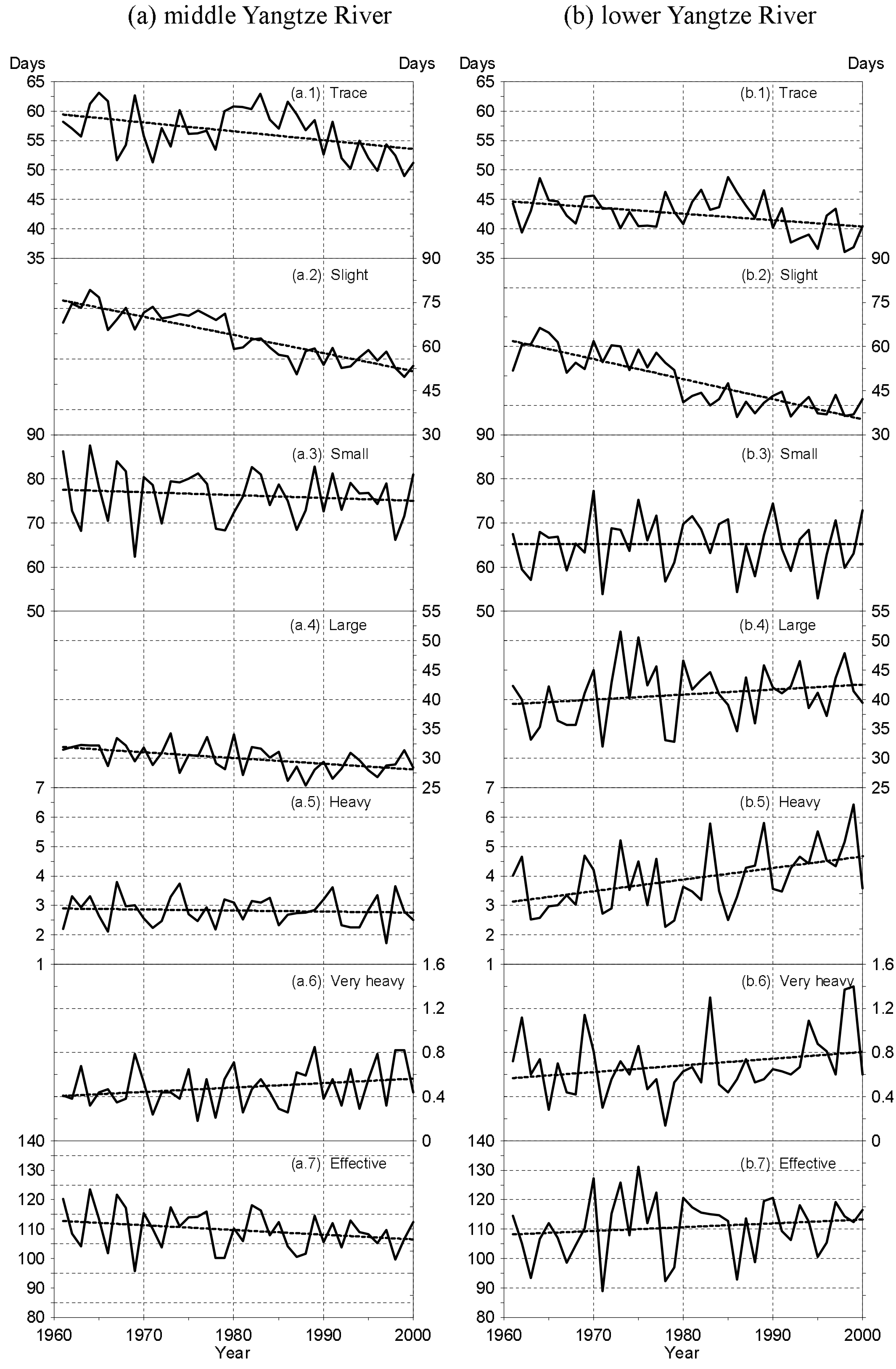

Fig. 9. Same as Fig. 6 except for the (a) middle and (b) lower Yangtze River valleys.

It is also worth explaining why there is a difference between trends of trace and effective precipitation days in the Xinjiang region. The increasing trend of annual temperature reached a value of 0.3°C (10 yr)$^{-1}$ in northern Xinjiang (Qian and Qin, 2005), which may have contributed to the opposite trend in trace precipitation days as described above. Increasing trends of total precipitation and effective precipitation days in the Xinjiang region were caused by the increase of water vapor transported through the westerly flow in the last half century (Qian et al., 2007).

Figure 7 shows the days of various precipitation intensities in the eastern Tibetan Plateau. A decreasing trend of trace precipitation days can also be found in that region. Slight precipitation days have a decreasing trend too, and strong interannual variability. The decreasing trends of trace and slight precipitation days are opposite to the rising trend of temperature [0.1°C (10 yr)$^{-1}$] in the area. For the middle-lower Yellow River valley, there is a consistent decreasing trend for trace, slight and effective grades, while very heavy precipitation shows an opposite trend (Fig. 8). The highest record of trace, slight and effective precipitation days appears in the year 1964, while the second highest record of very heavy precipitation day is found in 1963. The highest record of very heavy precipitation days appears in 2000. The deceasing trend of effective precipitation days in the middle-lower Yellow River valley may be linked to weakened monsoon circulation (Huang et al., 2004, Wang et al., 2004) and decreased water vapor transportation (Qian et al., 2007).

To identify eventual differences in the middle and lower sections of the Yangtze River valley, Fig. 9 shows the annual precipitation days for various intensities for these two areas separately. In the middle section, the trends of various precipitation days are similar to those in the middle-lower Yellow River valley. The same trends for trace and slight precipitation days are found in both areas along the middle and lower reaches of the Yangtze River valley, but opposite trends are observed in effective precipitation days. For small precipitation days, there is a slightly decreasing trend in the middle reaches of the Yangtze River, but no perceptible trend is found in the lower reaches. For large, heavy and very heavy precipitation days, an increasing trend exists in the lower Yangtze River. An increasing trend of extremely high precipitation intensity, namely very heavy precipitation, is predominant from the middle to the lower reaches of the Yangtze River. It is interesting to note that opposite trends of precipitation days between the middle and lower Yangtze River only come from daily precipitation greater than or equal to 10 mm but less than 100 mm. These features imply that effective precipitation is sensitive to the monsoon flow variation in eastern China.

To compare the regional trends of various precipitation days, Table 4 lists the annual precipitation-day trends of various intensities and effective precipitation in the five regions. A decreasing trend of trace precipitation days is found in all five regions and a decreasing trend of slight precipitation days is also found in four regions, except in northern Xinjiang. Effective precipitation days show an increasing trend in northern Xinjiang, the eastern Tibetan Plateau and in the lower reaches of the Yangtze River valley, while decreasing trends are found in the middle-lower Yellow River and the middle Yangtze River. Very heavy precipitation days have an increasing trend over the 40-year period in the Yellow and Yangtze River basins. The increasing trend of precipitation days in the lower Yangtze River is mainly concentrated in intensities of greater than 10 mm d^{-1}, while the decreasing trend of precipitation days in the middle-lower Yellow River and the middle Yangtze River is concentrated within all grades except very heavy precipitation days. The contrasting trends of effective precipitation days may be linked to the weakened monsoon flow over the middle-lower Yellow River (Wang, 2001) and increased flow convergence in the lower Yangtze River (Qian et al., 2007).

6. The most important contributing factor to effective precipitation trends

Figure 10 presents the precipitation intensity that makes the most important contribution to trends in effective precipitation. The decreasing trend of effective precipitation covers the middle-lower Yellow River, the

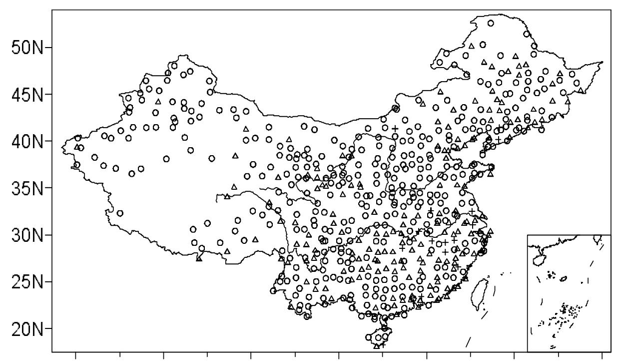

Fig. 10. The most important contributor to the trend of effective precipitation. The contributor is indicated by the open circle, triangle, cross, and diamond, which denote small, large, heavy and very heavy precipitation days, respectively.

Table 4. Precipitation-day trends [d (10 yr)$^{-1}$] of various intensities in northern Xinjiang, the eastern Tibetan Plateau, the middle-lower Yellow River, and the middle and lower Yangtze River. Bold numbers and underlined numbers indicate the trend value at the 0.01 and 0.05 significance levels, respectively.

	Trace	Slight	Small	Large	Heavy	Very heavy	Effective
North Xinjiang	**−3.07**	1.01	**1.36**	0.25			**1.61**
East Tibet	**−5.20**	−0.80	1.21	0.71			1.91
Mid-low Yellow River	**−2.92**	**−4.15**	**−1.99**	−0.66	−0.08	0.01	**−2.72**
Mid Yangtze River	**−1.50**	**−7.21**	−0.64	**−0.97**	−0.04	0.04	−1.65
Low Yangtze River	**−1.09**	**−6.82**	−0.01	0.85	**0.39**	0.06	1.29

middle reaches of the Yangtze River and Southwest China. The most important contribution to the decreasing trend over middle-lower Yellow is mainly attributed to small precipitation days, while the main contributors are the small and large categories for the middle reaches of the Yangtze River and Southwest China. In the region of Xinjiang, the maximal contribution to the increasing trend of effective precipitation is detected from small precipitation days. In the upper Yellow River, the upper Yangtze River and Northeast China, the maximal contributions to the increasing trend come from both small and large precipitation days. In Southeast China, the main contribution is found from both large and heavy precipitation days.

7. Summary

Spatiotemporal characteristics of various grades of precipitation days in China have been analyzed based on data from 576 stations during 1961–2000. Daily precipitation rates were classified into six grades depending on intensity. The main results of the study can be summarized as follows:

(1) Climatologically, small precipitation that appeared frequently in Southwest China appears to be linked to the activity of the southwest vortex, while the highly frequent days of large precipitation concentrated in Southeast China are directly linked to the activity of the East Asian monsoon and its coverage. The inland areas of southern China have a relatively high amount of effective precipitation days, which is a result of combined influences from the southwest vortex, the mei-yu front and typhoon activities.

(2) A significant decreasing trend of trace precipitation days occurred in mainland China except for several sites over the south of the middle Yangtze River. A decreasing trend of slight precipitation days also appeared in eastern China, while an increasing trend occurred in the eastern Tibetan Plateau and Xinjiang. For effective precipitation days, a decreasing trend is observed along the Yellow River and in the middle reaches of the Yangtze River and Southwest China, while an increasing trend is found in Xinjiang, the eastern Tibetan Plateau, Northeast China and Southeast China. Significantly decreasing and increasing trends of effective precipitation days are concentrated along the Yellow River and in the Xinjiang region, respectively. The contrasting trends of effective precipitation days in the middle-lower Yellow River and the lower Yangtze River can probably be linked to the weakened monsoon circulation.

(3) The decreasing trend of trace precipitation days corresponds with the increasing trend of temperature in China and a negative correlation between trace precipitation and temperature with trends removed can be demonstrated. This points to a possible role played by general warming in modifying the cloud formation process.

(4) For the middle-lower Yellow River basin, the most important contribution to the decreasing trend of effective precipitation days is from small precipitation days. In the upper Yellow River, the upper Yangtze River basins, the increasing trend of effective precipitation days is attributed to changes in both the small and large intensities. In Southeast China, the increasing trend of effective precipitation days is from both large and heavy precipitation. Very heavy precipitation days have increased over the 40-year period in the Yellow River and the Yangtze River basins. The increasing trend of precipitation days in the lower Yangtze River is mainly concentrated in the range of more than 10 mm d^{-1}, while the decreasing trends of precipitation days in the middle-lower Yellow River and the middle Yangtze River are contributed to by all the grades apart from very heavy precipitation days.

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