Abstract: Based on the precipitation data of 13 observatories in Tianjin from 1986 to 2008, the precipitation characteristics and the weather modification influence are studied in this article. The results show that: the spatial distribution of precipitation is uneven, the difference is small in west-east direction, otherwise large in north-south direction. The rainfall present descending trend from north to south, and the isolines are dense in north while sparse in south. The speed of decreasing rainfall become slow down from north to south. The difference is obvious in different season, the rainy days and precipitation rain fall mainly concentrate in summer, the precipitation is less in spring and autumn while is least in winter. The weather modification doesn’t change the correlation coefficient of rainfall in Tianjin, and it also has little influence on the spatial distribution. These relate to the characteristics of weather modification in Tianjin. The weather modification works have influence on probability distribution of the rain-type, but the influence is small. After comparing the probability distribution of different rain-type in 1986-2001 and 2002-2008, we can find that the probability of light-rain days is relative low while probability of moderate-rain days is high after the weather modification works, but these differences are not significant.

Key words: Tianjin; precipitation characteristics; weather modification

1. Introduction

With the rapid development of our economy and society, water shortage has seriously affected the industrial and agricultural production and socio-economic development. Precipitation is an important source of water, so the study of precipitation characteristics is very important for exploiting air water resources. Many people have studied on the precipitation characteristics of whole country or a region\(^{[1-6]}\). There are many factors that affect precipitation and many studies are conducted for natural factors. As man-made factors, weather modification that affects precipitation has been few studied, this paper will study this issue and analysis of the impact on precipitation of weather modification.

Tianjin is located in the northeast part of the North China Plain, belonging to the continental monsoon climate. Most part of Tianjin is plain, to the north is Yanshan while to the east is Bohai Sea which is a landlocked bay. There are four distinct seasons during a year, they are spring, summer, autumn and winter.

In this paper, precipitation characteristics of Tianjin area are analyzed by using daily rainfall data of all stations from 1986 to 2008. Large-scale artificial rainfall in Tianjin was carried out from 2002 and its main operating tools are aircraft, rockets and artillery. Based on analysis of natural precipitation, the impact of operations on the precipitation was studied in this paper by comparing the differences of precipitation characteristics before and after adding human factors.

2. Data

The data we used in this study is daily rainfall material of 13 sites all over the Tianjin city from 1986 to 2008.
3. Analysis of precipitation Feature

3.1. Spatial distribution feature

Figure 1 is the average precipitation distribution of 16 years from 1986 to 2001 in Tianjin area. It can be seen from this figure that the rainfall present descending trend from north to south, and the isolines are dense in north while sparse in south. The decrease rate of precipitation reduced from north to south. The rainfall in the east-west direction is similar which present a symmetrical distribution. So it can be summarized that the spatial distribution of precipitation is uneven, the difference is small in west-east direction, otherwise large in north-south direction.

Figure 1. The average precipitation distribution of 16 years from 1986 to 2001 in Tianjin area

Correlation coefficients of 13 districts in Tianjin are calculated in order to further study the spatial distribution of rainfall. Table 1 is the daily precipitation correlation coefficient of 13 observatories. It can be seen from the table: the correlation coefficient of regional rainfall has a relationship with the two relevant regional spatial distance, the closer of the distance the correlation coefficient is bigger and the farer of the distance the correlation coefficient is smaller. Correlation coefficient of the two regions is not the highest each other, such as the largest correlation coefficient of Jixian is Baodi, but the biggest correlation coefficient of Baodi is not Jixian. The correlation coefficient of the two areas is higher when the two regions are similar in area and the regional area is quite small.

<table>
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Table 1. The daily precipitation correlation coefficient of 13 observatories
3.2. Temporal distribution feature

Figure 2 is the distribution of average monthly precipitation from 1986 to 2001 and table 2 (Table omitted) the distribution of assoeeted rain days monthly from 1986 to 2001 in Tianjin. It can be seen from the figure and table: the precipitation is mainly concentrate in summer, the rainfall is greater in June, July and August, the total precipitation this three month reached nearly 70% of annual precipitation. Compared to summer, precipitation in spring and autumn is less and the average rainfall of these two seasons is only 30mm that account for just about 25% of annual precipitation. Thus, it can be concluded that the monthly rainfall distribution is uneven and the difference of precipitation is obvious in different seasons.

![Figure 2. The distribution of average monthly precipitation from 1986 to 2001 in Tianjin](image)

4. Analysis of Weather Modification Influence

Artificial hail suppression is mainly carried out in Tianjin before 2000 and using both rockets and Artillery began from 2001. Aircraft artificial rainfall experiments are carried out from the autumn in 2002. It can be seen from the above analysis that there is no change with the precipitation characteristics after artificial work. So how much influence on precipitation of weather modification will be studied in the following paper.

4.1. The influence on precipitation spacial distribution

The 13 sites are paired and each set of data have 2350 pairs of samples. Random samples are carried out for each set of data and 586 pairs of samples are selected every time, such random sampling done 10000 times and the correlation coefficient to be calculated of each samples. 10000 correlation coefficients can be obtained and then sorted from small to large, the 500th and 9500th of these correlation coefficients are took as the 90% distribution range. Then calculate the correlation coefficient of each set of data from 2002 to 2008 (a total of 586 set of samples) and the results are listed in the following table. The $r-$ and $r+$ represent low and upper boundary of 90% correlation coefficient distribution. It can be seen from the table 3 (Table omitted) that all the correlation coefficients obtained from the samples of 2002-2008 at the regional distribution of 90% probability which means the significance of correlation coefficient change does not exceed 0.05 except the Beichen and Ninghe this group. It shows that regional rainfall correlation coefficient does not change after artificial precipitation. In other words, artificial rainfall does not increase in precipitation in some locations significantly, because the correlation coefficient of the two areas will change if a significant increase in regional precipitation happen. It means that the artificial rainfall does not play a role? Of course not, the precipitation enhancement operating points almost throughout the entire region of Tianjin,
so each region can obtain equivalent artificial rainfall results even if the cloud seeding work and the correlation coefficient between regions will not be affected by such weather modification work.

4.2. The influence on rainy days distribution

The purpose of artificial rainfall is to increase the precipitation of the Target Area, so it may make the rain type of natural precipitation (rainfall level) changes if the cloud seeding plays a role.

The rainfall is divided into five levels: light rain, moderate rain, heavy rain, rainstorm and heavy rainstorm. Each type of rainy days probability is calculated respectively both of 1986-2001 and 2002-2008. The results are shown in the following table.

As can be seen from the table (Table omitted) the probability of moderate rainfall pattern of 2002-2008 is generally higher than that of 1986-2001 but lower for the probability of light rain. Take the July as an example, the light rainfall probability is 64.22% of 1986-2001 and 62.59% of 2002-2008, the moderate rainfall probability is 18.36% of 1986-2000 and 25.71% of 2002-2008.

5. Conclude

(1). Spatial distribution of precipitation is uneven, the difference is small in west-east direction, otherwise large in north-south direction. The rainfall present descending trend from north to south, and the isolines are dense in north while sparse in south, The speed of decreasing rainfall become slow down from north to south.

(2). The difference of precipitation is obvious in different season, the rainy days and precipitation rain fall mainly concentrate in summer, the precipitation is less in spring and autumn while least in winter.

(3). Weather modification has little influence on the spatial distribution. These relate to the characteristics of weather modification in Tianjin.

(4). Weather modification works have influence on probability distribution of the rain-type, but the influence is small. After comparing the probability distribution of different rain-type in 1986-2001 and 2002-2008, it can be find that the probability of light-rain days is relative low while probability of moderate-rain days is high after the weather modification works, but these differences are not significant.

References