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Analysis and Correction of Precipitation Observation Error in Henan Province

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Abstract: Accurate precipitation data is the basis for studying regional hydrological cycle and climate change, and correcting the precipitation observation error can effectively improve its accuracy. Therefore, based on the daily observation data (including snow and rain types) of 111 meteorological stations in Henan Province from 1960 to 2017, the precipitation observation error correction equation obtained from the precipitation error comparison observation experiment conducted in the Urumqi River Basin of China in the International Cooperation Project on Solid Precipitation Observation carried out by the World Meteorological Organization in 1980 was used to systematically correct the dynamic loss, wetness loss and trace loss of precipitation at 111 meteorological stations from 1960 to 2017. The main conclusions are: (1) The absolute error of each season decreases from south to north, the average absolute error in summer is the largest, 47.30mm, and the winter is the smallest; while the relative error is the opposite, the largest in winter and the smallest in summer. (2) The absolute error of the average annual precipitation in the entire region is above 60mm, gradually increasing from north to south, and the error in most areas is 70-160mm; The relative error varies little from region to region, and the error range is 10%-16%. (3) The average annual rainfall before the correction was 761.92mm, and the average annual rainfall after the correction was 881.1mm, and the corrected value was 119.18mm. There was a decreasing trend in rainfall before and after the correction from 1960 to 2017, but the trend of reduction in the revised rainfall series was greater than that in the measured series.

Keywords: Precipitation, Observation error, Correct, Seasonal precipitation, Annual precipitation, Henan.

1. Introduction

As one of the key hydrometeorological elements, precipitation plays a pivotal role in the study of regional hydrological cycle processes and climate change characteristics [1]. Precipitation is obtained mainly by radar, satellites and rain gauges, which are widely regarded as the most accurate instruments for obtaining rainfall [2] and have been widely used around the world for centuries. However, many studies have long found that existing instruments still have deficiencies in measuring precipitation because they often underestimate actual precipitation [3-4] due to systematic errors such as micro losses, loss of moisture, loss of evaporation, and loss of power when observing precipitation by rain gauges. Systematic errors can systematically deviate precipitation observations from actual precipitation, which has important implications for precipitation trends, climate change and drought assessment [5-6], so it is necessary to analyze and correct them.

Foreign research on precipitation observation error began in the 50s of the 20th century, and the United States, Britain, the Soviet Union and other countries carried out comparative experiments on precipitation observation by different rain gauges and achieved many important results. American expert Allis[7] et al. found that the capture rate of liquid, mixed and solid precipitation by ordinary rain gauge cylinders was 97%, 53% and 12%, respectively, through the results of the comprehensive comparison of precipitation in Nebraska. In the 80s, domestic scholars Zhang Helun, Lin Zhiguang [8-9] and others began to pay attention to the problem of small precipitation observed by rain gauges, and their corresponding research also began to begin. In order to determine a common precipitation observation error correction scheme, the World Meteorological Organization (WMO) launched the International Cooperation Project on Solid Precipitation Observation in 1985 [10], and compared rain gauges in 20 observation fields in 13 countries, including the Chinese Standard Rainfall Gauge (CSPC), between 1986 and 1993 [11], of which systematic precipitation observation error comparison experiments were carried out in the Urumqi River Basin from 1985 to 1991 [12]. At present, WMO has summarized the precipitation error correction method for the internationally commonly used rain gauge[11-13]. These methods mainly use daily meteorological data such as temperature, wind speed and precipitation type to correct daily precipitation data. These corrections are widely used around the world, and the corrections have significantly improved the original precipitation [14-15]. The global average is 11% improvement [16]. Based on the daily observation data (including precipitation types) of 111 meteorological stations in Henan Province from 1960 to 2017, this paper uses the precipitation observation error correction equation obtained from the precipitation error comparison observation experiment in the Urumqi River Basin of China in the International Cooperation Project on Solid Precipitation Observation carried out by the World Meteorological Organization in 1980, systematically corrects the dynamic loss, wetness loss and trace loss of precipitation at 111 meteorological stations from 1960 to 2017, and analyzes the temporal and spatial variation characteristics of each loss correction. The changes in precipitation before and after correction were compared, which provided a reference for the observation loss of precipitation in Henan Province, and provided a more accurate basis for studying precipitation and climate change in Henan Province.

2. Study the Regional Overview

Henan Province is located in the central and eastern part of China, with a total area of 167,000 Km2, with the terrain high in the west and the east with Funiu Mountain as the main body

in the west, the Taihang Mountain Range in the north extending southwest along Anyang, Hebi and other areas, the Tongbai Mountain Range and the Dabie Mountain Range in the south of the province, the eastern and central alluvial plains, spanning the four major river basins of the Yangtze River, the Huai River and the Yellow River and the Haihe River. Henan Province belongs to the continental monsoon climate of the north-south climate transition zone, with rain and heat at the same time, uneven spatial and temporal distribution of precipitation, frequent drought and flood disasters, and annual precipitation of 462.9-1078.7mm. The total water resources and per capita water resources of Henan Province are lower than the national average, and it is a province with serious water shortage.

3. Information and Methodology

3.1. Data selection

In this paper, 111 meteorological stations in Henan Province were selected for daily observation data (including snow and rain types) from 1960 to 2017, with uniform spatial distribution, and the data were of good quality after preliminary quality control.

3.2. Rainfall observation error correction method

Precipitation observation errors usually include micro fall, evaporation loss, wetting loss to rainfall barrels, and losses caused by the reduction of rainfall barrel capture rate caused by the change of rain barrel to wind field, called dynamic power loss, precipitation observation error error correction equation is [17]:

$$P_c = K(P_g + \Delta P_w + \Delta P_e + \Delta P_y)$$

Formula: is the corrected rainfall; precipitation observed for rainfall buckets; For wetting loss, The wetness loss is 0.3mm for snowfall, about 0.29mm for precipitation or sleet, and the wetness loss on precipitation days is calculated once a day; for evaporation loss, because China's rain gauge for rainfall observation has a glass bottle containing water, it greatly inhibits evaporation; and snowfall observation has no glass bottle, evaporation loss is relatively large, considering that there are many influencing factors affecting evaporation, it is difficult to give a credible estimate for a while, and at the same time, the evaporation loss of most meteorological stations in China is relatively small, and this loss correction is not considered in the precipitation error analysis in this paper. K is the dynamic correction coefficient, which is mainly determined by the wind speed and precipitation type, and the size of K is generally greater than 1; For micro precipitation, micro precipitation can be assumed to be between 0.05 ~ 0.15mm, taking into account the number of precipitation observations, etc., for micro precipitation days, it is corrected by 0.1mm, due to the small amount of precipitation and small, this item generally does not consider the correction of power loss.

4. Analysis of Error Correction Results

4.1. Seasonal precipitation error correction analysis

There are obvious seasonal differences in precipitation in Henan Province, and the seasonal differences in precipitation will cause the difference in the seasonal influence of observation errors, which can be corrected by errors. From the absolute error, the seasons are absolutely wrong difference. It gradually decreases from northwest to southeast, and the high-value areas occur in the southern area of Xinyang. The absolute error in the north and south regions in spring and summer is quite different, the absolute error in northern Yu is within the range of 15-25mm in spring, while the error in western Yu is in the range of 45-65mm, and most other areas are between 25-35mm. In summer, the absolute error is between 25-35mm in northern Yubei, 55-70mm in western Yu, and 40-50mm in other areas. The absolute error between the north and south in autumn and winter is not much different, and the error in autumn is mostly between 20-40mm; Winter errors are mostly between 8-20mm.From relative error. Let's see, The areas with high relative error values are basically concentrated in the southern areas of Puyang, Anyang, Xinxiang and Nanyang, among which the relative error gap between the north and the south of spring, summer and autumn is small, and the relative error of the whole region is below 20%, while the relative error of winter is large in the north and south, and the whole region is basically above 20%.

4.2. Years precipitation error correction analysis

Average annual precipitation is an important parameter that indicates precipitation in an area. From the spatial distribution of micro loss of average precipitation over multiple years, moisture loss and power loss. Overall, the micro loss showed a clear decreasing trend from east to west, with a range of 2.57-4.38mm; the wet loss and power loss showed a clear decreasing trend from north to south, the humidity loss ranged from 18.91-36.51mm, of which the loss range in most areas was between 20-30mm, the loss in Anyang, Puyang and Hebi areas was less than 20mm, and the loss of a few sites in the southern Xinyang area was more than 30mm. The power loss range is between 35-160mm, most of which the loss range is between 40-140, a few stations in Luoyang have a loss of less than 40mm, and only a few stations in Xinyang have a power loss of more than 140mm.

For the absolute error and relative error of the average precipitation for many years, from the absolute error distribution, the overall error of the entire Henan Province is above 60mm, gradually increasing from north to south, and the southern area is significantly higher than the northern region, which is also consistent with the average rainfall distribution measured for many years, most of which have an error of 70-160mm, a few stations in Jiyuan, Luoyang and northern Anyang have an error of less than 70mm, and a few stations in the southern part of Xinyang have an error greater than 160mm. From the perspective of the distribution of relative error, there is little difference between regions, the error range is 10%-16%, the average value is 12.45%, and the distribution of relative error is consistent with the relative error distribution of the four seasons, the high-value area is concentrated in the central region of Henan, and the low-value area is Luoyang and the northern area of Jiyuan.

4.3. Comparison of precipitation before and after correction

The precipitation series and its change trend before and after the correction in Henan Province from 1960 to 2017 have changed, and the correction of rainfall observation error not only affects the size of rainfall, but also changes the trend of rainfall. The actual observed annual rainfall in Henan Province from 1960 to 2017 was 462.9-1078.7mm, the

average annual rainfall was 761.92mm, the revised annual rainfall was 557.9-1286.9mm, the average annual rainfall was 881.1mm, and the revised value was 119.18mm. From 1960 to 2017, there was a decreasing trend in rainfall before and after the correction, but the reduction trend of the corrected rainfall series was greater than that of the measured series, in which the measured series changed the trend -3.15mm/10a, the corrected series changed the trend -11.99mm/10a, and the trend difference was -8.84mm/10a.

5. Conclusion

Based on the daily observation data (including snow and rain types) of 111 meteorological stations in Henan Province from 1960 to 2017, this paper systematically corrects the dynamic loss, wetness loss and micro loss of precipitation at 111 meteorological stations from 1960 to 2017, and the results show that:

(1) The absolute error of each season showed a small trend from south to north, and the average absolute error in summer was the largest and significantly higher than that of the other three seasons, 47.30mm and the minimum in winter was 10.83mm; while the relative error was the opposite, the largest in winter and the smallest in summer.

(2) The absolute error of the average annual precipitation in the entire region is above 60mm, gradually increasing from north to south, and the error in most areas is 70-160mm; The relative error varies little from region to region, and the error range is 10%-16%, and the average value is 12.45%.

(3) The average annual rainfall before the correction was 761.92mm, and the average annual rainfall after the correction was 881.1mm, and the corrected value was 119.18mm. There was a decreasing trend in rainfall before and after the correction from 1960 to 2017, but the trend of reduction in the revised rainfall series was greater than that in the measured series.

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