Postprint: Statistical Analysis of Winter Aircraft Artificial Snow Enhancement Operations in Karamay City

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Date: 2018-10-23T00:00:00+00:00

Abstract

Using December precipitation observation data from the Karamay District Meteorological Station from 1957 to 2016, and employing statistical methods such as serial test, unpaired rank-sum test, and t-test method, a systematic difference analysis was conducted on the December precipitation amounts from a 31-year historical period prior to winter aircraft artificial snow enhancement operations and a 29-year operational period, which were used as statistical variables. The results indicate that after the implementation of winter aircraft artificial snow enhancement operations, December precipitation in Karamay City during winter increased significantly, with the average precipitation increasing by 2 mm. The significance level of the non-parametric unpaired rank-sum test reached 0.025, and the significance level of the parametric t-test was also close to 0.025. Selecting a confidence interval at the 0.1 significance level, it was calculated that after implementing winter aircraft artificial snow enhancement operations, the absolute increase value of average annual December precipitation in Karamay City was 1.15 mm, with a relative increase rate of 24.5%. It is thus concluded that after the implementation of winter aircraft artificial snow enhancement operations, winter precipitation in Karamay City has increased significantly.

Full Text

3 Statistical Analysis Methods

3.1 Sequence Test

The sequence test analyzes systematic differences in December precipitation between the 31-year historical period and the 29-year operational period of aircraft artificial snow enhancement in Karamay. The test compares maximum precipitation values, yielding $\Delta R = x\ - x\ = 2.02$ mm, with an enhancement rate $E = (x\ - x\ ) \times 100\%\ \ 42.98\%$. The absolute increase in December precipitation

attributable to the snow enhancement operations is 2.02 mm, corresponding to a relative increase of 42.98%.

3.2 Rank Sum Test

The rank sum test is a non-parametric method used to evaluate systematic differences between two independent samples. For a significance level of = 0.05, the critical region is defined by u-values outside the interval (-1.96, +1.96). If the test statistic u falls within this range, the null hypothesis cannot be rejected; if u falls outside, the difference is statistically significant at the 0.05 level. For a one-tailed test, the critical value is u 1.64 (or u -1.64).

Applying this to the Karamay data with n = 29 and n = 31, we obtain T = 1016 and u 1.95. Since u > 1.64, the test indicates a statistically significant increase in December precipitation following the implementation of aircraft artificial snow enhancement. The significance level for this non-parametric test is 0.025, and the corresponding parametric t-test yields a similar significance level of approximately 0.025.

3.3 t-Test

The t-test is a parametric method for assessing systematic differences between sample means. When sample sizes are small (n < 30) and the population standard deviation is unknown, the t-statistic is calculated using sample standard deviations to determine statistical significance. The test compares the means of two periods to evaluate the effect of snow enhancement operations.

3.3.1 References

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Statistical Analysis of Effect of Aircraft Artificial Snowfall Enhancement in Winter at Karamay

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Abstract: In order to objectively evaluate the effect of aircraft artificial snowfall enhancement in winter in Karamay, Xinjiang, China, it is necessary to analyze the systematic significance of snowfall enhancement. Utilizing the sequence test, unpaired rank sum test and t-test of statistical methods, the systematic differences of annual precipitation in December of the former historical period 31a and the latter period 29a of carrying out the aircraft artificial snowfall enhancement are analyzed in Karamay, with annual precipitation data of Karamay Weather Station in December from 1957–2016, as a beginning to carry out the aircraft artificial snowfall enhancement in 1988. The results show that the precipitation in December in Karamay was significantly increased in December after the operation of the aircraft artificial snowfall enhancement, regardless of the maximum, minimum and average value. It added 2.3 mm, 1.1 mm and 2.02 mm respectively. In particular, the minimum rainfall period is 12 times that of the historical period. This would play a positive role in alleviating the shortage of water resources. The inspection significance level of non-parameter unpaired rank sum test is 0.025, and the inspection significance level of parametric t-test is also close to 0.025. According to the calculation, the absolute increase of the precipitation in Karamay in December is 1.15 mm, and the relative enhancive rate is 24.5% after carrying out the aircraft artificial snowfall enhancement in winter in Karamay when the statistical significant level =0.1 is chosen. Therefore, through carrying out the aircraft artificial snowfall enhancement in winter,

it is significant for the precipitation enhancement in Karamay, it has a certain effect on the local tense production and domestic water consumption in arid areas. Remarkable social and economic benefits. This paper makes a reasonable utility of statistical methods to analyze the effects of aircraft artificial snowfall enhancement in the winter in Karamay, and concludes the qualitative conclusions and the quantitative results. It is of some guiding significance to design and evaluate the application of aircraft artificial precipitation enhancement in science.

Keywords: aircraft artificial snowfall enhancement; effect; statistical analysis

Note: Figure translations are in progress. See original paper for figures.