

# A CHANGE IN RAINFALL GRADIENT IN WESTERN VICTORIA AND ITS EFFECT ON THE ASSESSMENT OF THE 1966 CLOUD-SEEDING

By E. E. Adderley

Division of Radiophysics, CSIRO, Sydney

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## 1. INTRODUCTION

During the months of August, September and October 1966 the Victorian Department of Agriculture carried out a cloud-seeding operation in Western Victoria. This was an operation and not a planned experiment. In December 1966, at the request of the Department of Agriculture, the author attempted an assessment of the operation.

The assessment was based on a simple order test of the ratio of the seeded target area rainfall to the unseeded control area rainfall for the three months (August, September, October) of the operation. The ratio was compared with similar ratios for the years 1925 to 1965. The details were published in June 1968 (Adderley, 1968).

It has been pointed out independently by Jardine (1968) and White (1968)\* that the assessment is invalid because of a statistically significant dependence of the ratio on time.

This paper further examines the evidence and gives an amended assessment of the 1966 operation.

## 2. CHANGE IN RAINFALL GRADIENT

The distribution of rainfall gauges used in the original assessment is given in Figure 1.

$T_i$  is defined as the mean of the target-area gauge-readings for the months of August, September and October in the year "i";  $C_i$  is the mean of the control area gauge readings for the same months and the same year.

A convenient way to examine the stability of the ratio  $T_i/C_i$  is to plot  $\Sigma T_i$  against  $\Sigma C_i$  ( $i = 1925 \dots 1965$ ). Such a "double mass" plot is extensively used by hydrologists to examine the consistency of river-gauging calibrations.

The plot of  $\Sigma T_i$  vs.  $\Sigma C_i$  is given in Figure 2. It is immediately obvious that the ratio  $T_i/C_i$  changed during the period 1954 to 1957. The ratio became larger and remained at a mean value approximately 20 percent higher than the preceding 32 years.

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\* Editor's Note : See also paper by B. J. White on page 95 of this issue.

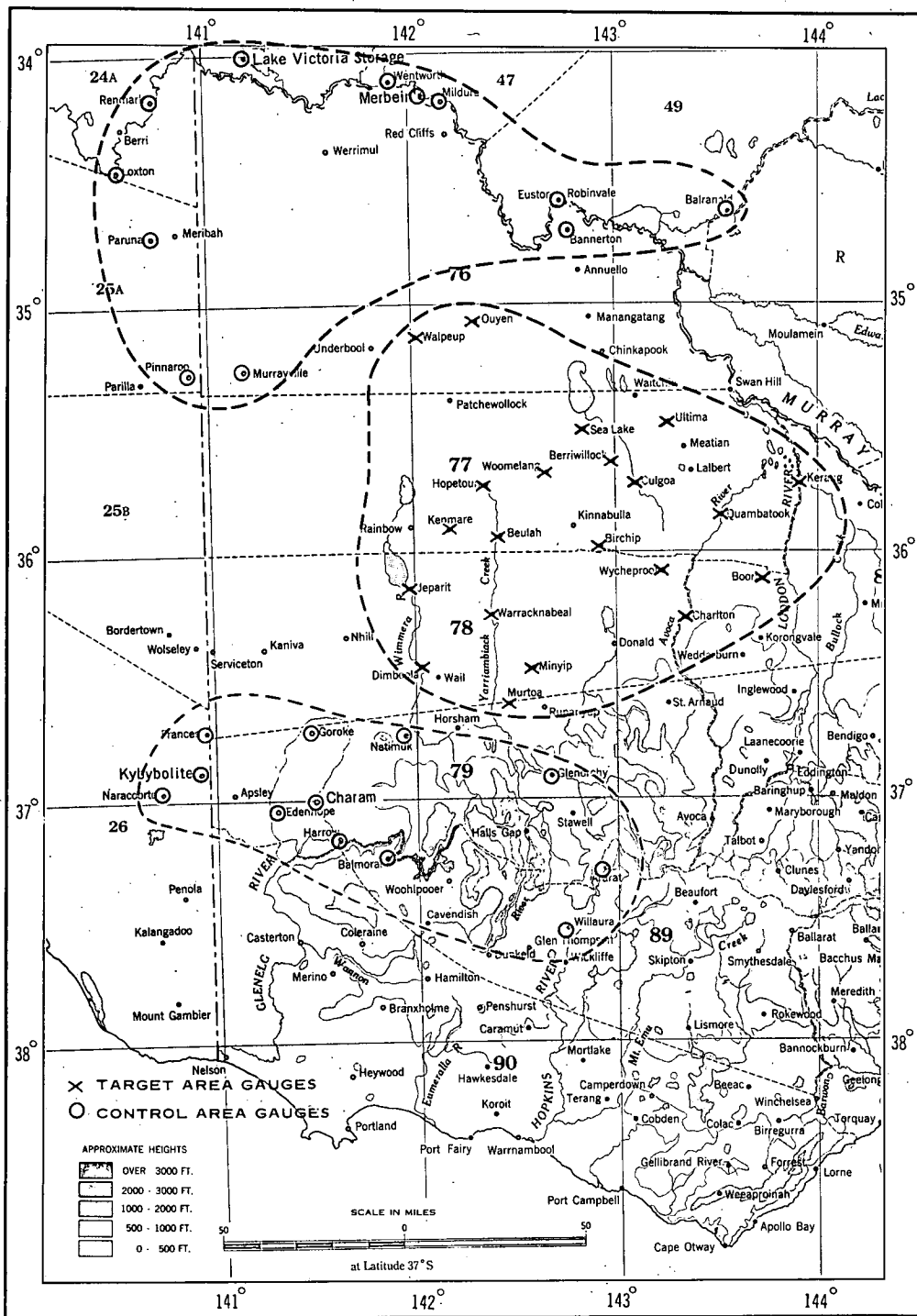


Fig. 1 Distribution of rain gauges used for cloud-seeding operations in Western Victoria.

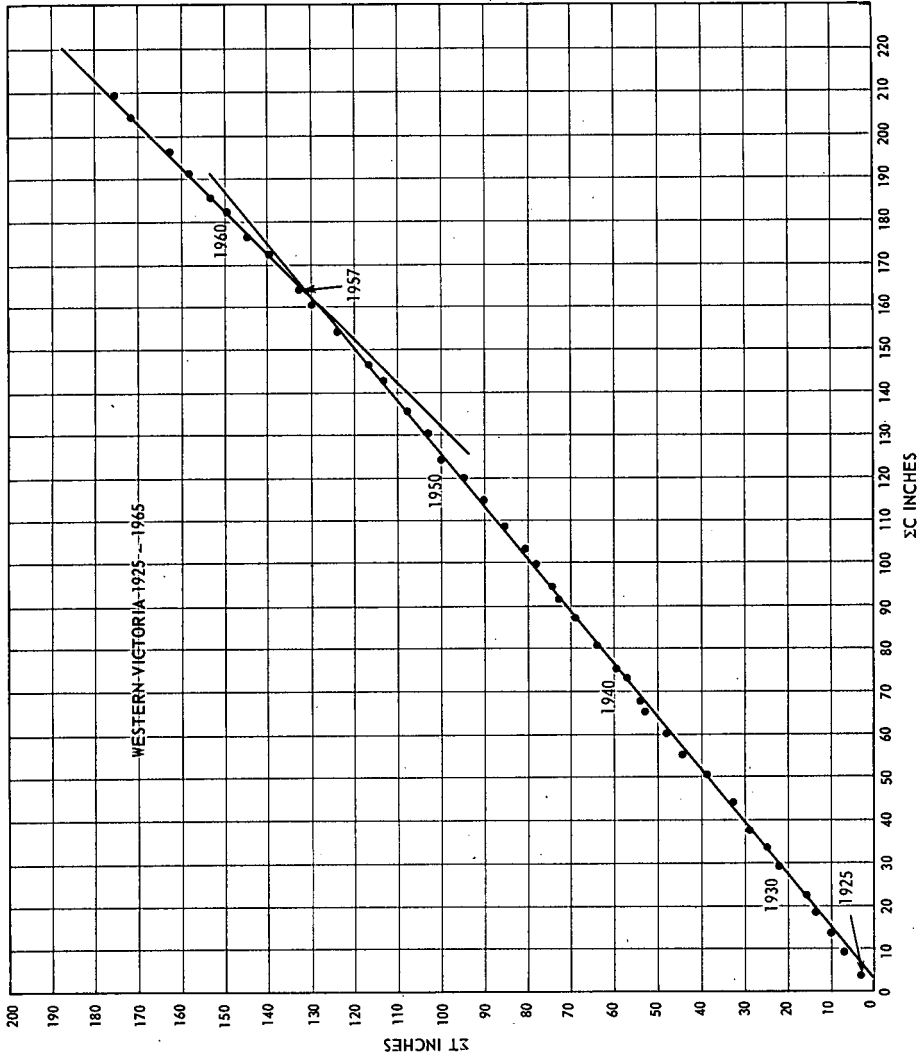


Fig. 2 Double mass plot of rainfall in target and control areas in Western Victoria.

A regression of  $T_i/C_i$  on time or a partial regression with time as one of the independent variables would therefore show a positive dependence of the ratio on time, and it has been shown by Jardine and White that the dependence is statistically significant.

The reasons for this discontinuity in rainfall gradient are not obvious and would require an extensive climatological study of the region.

### 3. ASSESSMENT OF CLOUD-SEEDING OPERATION

The original 1966 assessment of the operation compared  $T_{1966}/C_{1966}$  with all the previous 41 values. It is obvious from Figure 2 that an appropriate comparison can only be made with values from 1957 onwards. Such a comparison is given in Table 1.

Table 1. Ratio of Target Area to Control Area Rainfalls for the years 1957 to 1966

T/C	Year
1.085	1959
1.045	<u>1966</u>
1.037	1961
1.029	1964
1.025	1963
0.974	1960
0.863	1962
0.854	1958
0.851	1965
0.616	1957

The revised assessment of the 1966 operation is thus that the 1966 value has a probability of 0.20 of being equalled or exceeded with a 50 percent chance that an increase due to seeding was at least 4.5 percent or 0.19 inches. This new assessment is well removed from the region of statistical significance.

### 4. CONCLUSIONS

An examination of rainfall relationships in Western Victoria during the months of August, September and October for the years 1925 to 1965 showed that a discontinuity occurred in the mid 1950's. This discontinuity has necessitated a reassessment of the cloud-seeding operation carried out in the region in 1966. The reassessment results in a large change in the probability of rainfall increases due to cloud seeding.

Sudden changes in rainfall relationships as shown here are one of the main weaknesses in the use of historical data for statistical analysis, particularly those methods which use models including linear trend with time. This weakness was pointed out by Adderley and Twomey in 1958 (Adderley and Twomey 1958).

It is important, as stated in a previous paper (Adderley 1968), "that operations such as this be repeated for a number of successive years". The potential benefits of cloud seeding are too great for it to be lightly dismissed.

#### REFERENCES

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