NOAA Technical Memorandum NWS ER-76

IS THERE A TEMPERATURE RELATIONSHIP BETWEEN AUTUMN AND THE FOLLOWING WINTER?

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I. INTRODUCTION

The New York City area during the late 1970s experienced some unusually harsh winters. This was true for most of the eastern part of the country. The run of severe winters included the second coldest January on record in Central Park. In the late 1970s the New York City area also had a run of unseasonally cool Octobers. October 1979 was the first close to normal October since 1975. Coincidentally, the 1979-80 winter was the first warmer than normal winter since 1975-76. The purpose of this research project is to determine if a relationship does exist between abnormally cold or warm winters and the mean temperature of the preceding autumn months.

The data for this study covers the period from 1900 to October 1987. This gives a sample of about 88 years to investigate. Figures 1a through 5a illustrate the variation of monthly and seasonal mean temperatures averaged over ten year periods for the fall months and the autumn and winter seasons. Figures 1b through 5b show the frequency distributions of mean temperatures for the same periods. Autumn is considered the three month period, September, October, and November, while winter consists of December, January, and February.

There was a concern that using data from the year 1900 may produce cold means. Figures 1a through 3a show that only one month, November, has warmed consistently since the start of the century. The mean temperature of November has risen almost three degrees since 1900. October's mean temperature variation by decade has been irregular, with the warmest decade being the 1940s. September's mean has shown little variation except for a cold period from 1910 to 1919. The winter season from the 1920s onward has been fairly steady having its warmest decade in the 1950s (Fig. 5a).

II. DETERMINATION OF CLIMATOLOGICAL CATEGORIES

In this study, we compare monthly mean temperatures of the autumn months to the mean temperature of the following winter. Mean temperatures are classified above or below normal. In this study the 87 or 88 year mean temperature was computed and used as the "normal temperature" for the month or season. The next question is to determine what range normal temperatures will have.

The Climate Analysis Center classifies 40% of all months or seasons as normal. The remaining 60% is split evenly between below and above normal. As strictly as possible, about 40% of all mean temperatures were placed in the normal category. The remaining percentages were split between cooler and warmer than normal. The class limit cut-off temperatures were determined by the mean which placed the appropriate percentage in that class. This produces a slightly skewed class limit in some months or seasons. Table 1 shows the evaluation results.

TABLE 1 - TABLE OF VALUES FOR MEAN TEMPERATURES AND CLASS LIMITS

	SEPTEMBER	OCTOBER	NOVEMBER	AUTUMN	WINTER
BELOW NORMAL YRS	24	24	25	25	25
NORMAL YEARS	39	40	38	38	37
ABOVE NORMAL YRS	25	24	24	24	25
MEAN TEMPERATURE	68.1	57.7	46.6	57.5	33.4
MEDIAN TEMP	68.2	57.65	46.4	57.3	33.3
STANDARD DEVIATION	2.2	2.6	2.8	1.7	2.8
CLASS LIMIT TEMPERATURES					
BELOW NORMAL	<66.8	<56.1	<45.0	<56.7	<32.0
NORMAL	66.8-69.6	56.1-59.2	45.0-48.3	56.6-58.4	32.0-35.1
ABOVE NORMAL	>69.6	>59.2	>48.3	>58.4	>35.1

III. METHODS OF EVALUATION

There were three types of cross evaluations done. We call one method the Climate Analysis Center method. The second method is a hybrid of the climate analysis method. The third evaluation is called the 50-50 method.

In the Climate Analysis Center method we looked only at the months or seasons which fell within the classification of below or above normal as listed in Table 1. The following winters were evaluated for the seasonal mean temperatures. The results of whether the winter was normal or not was determined by where in the class limits it fell. For example, October 1976 had a mean of 52.9 degrees, so it is classified as a cooler than normal month. The winter of 1976-77 mean temperature was 28.5 degrees. Therefore, it is classified as colder than normal. The same method was used for warmer than normal fall months or seasons. Results of this method can be found in tables 2 and 4.

The hybrid climate analysis method classifies the autumn months/season according to the class limit temperatures of Table 1, while the following winters are classified as above or below normal based on the 87 year mean and median only, with normal defined as the temperature range between the mean and the median. The normal winter mean for New York City in this study is 33.4 degrees. Being around the freezing level, a slightly colder or warmer than normal winter can make a significant difference in snowfall amounts and personal comfort. These results are shown in Tables 3 and 5.

The 50-50 method classifies both autumn months and the following winter season as above or below normal based on the mean and median temperature of Table 1. Months or seasons are classified normal when their mean temperature falls into the range between the mean and median of Table 1. This method increases the sample size and helps reduce random sampling error. These results are shown in Tables 6 and 7.

IV. EVALUATION RESULTS

The following results were determined from the three testing methods described above:

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TABLE 2 - WINTER CLASSIFICATION FOLLOWING A BELOW NORMAL FALL MONTH OR SEASON. CLIMATE ANALYSIS CLASS LIMITS

	BELOW NORMAL <32.0	NORMAL	ABOVE NORMAL >35.1
COOL SEPTEMBER	6	10	8
COOL OCTOBER	7	13	4
COOL NOVEMBER	11	9	5
COOL AUTUMN	9	11	5

* *

The results, shown in Table 2, indicate that cooler than normal Novembers lead to colder than normal winters. The November results may be misleading because more than half of the unseasonally cool Novembers occurred before 1927. The November results were probably aided by the colder winters in the first two decades of this century. We have not had many unseasonally cool Novembers recently. This result may be of little help since November has become much warmer in the latter half of this century.

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TABLE 3 - WINTER CLASSIFICATION FOLLOWING A COOLER THAN NORMAL FALL MONTHS OR SEASONS. HYBRID CLIMATE ANALYSIS METHOD

	BELOW NORMAL <33.3	NORMAL	ABOVE NORMAL >33.4
COOL SEPTEMBER	10	2	12
COOL OCTOBER	14	3	7
COOL NOVEMBER	16	2	7
COOL AUTUMN	15	3	7

* *

The results above show about 60% of the winters following cooler than normal Octobers, Novembers or the autumn as a whole were colder than normal. Colder than normal in this case is defined as less than 33.3 degrees. Another interesting statistic was found: 79% of the winters following an unseasonally cool November contained within an unseasonally cool autumn were colder than normal. There were only 11 instances this century when this occurred. The results seem to indicate that the later in the autumn it is cooler than normal, the more likely the winter will be colder than normal.

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TABLE 4 - WINTER CLASSIFICATION FOLLOWING A WARMER THAN NORMAL FALL MONTH OR SEASON. CLIMATE ANALYSIS CLASS LIMITS.

	BELOW NORMAL <32.0	NORMAL	ABOVE NORMAL >35.1
WARM SEPTEMBER	5	12	8
WARM OCTOBER	2	11	11
WARM NOVEMBER	5	14	6
WARM AUTUMN	3	12	9

* *

Table 4 shows that 92% of the winters following an unseasonally warm October were either normal or warmer than normal. This is a 22% increase over what normally would happen. Eighty eight percent of the warmer than normal autumns were followed by milder winters. November which was a good indicator of colder than normal winters when unseasonally cool (Table 2) here shows no relationship at all.

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TABLE 5 - WINTER CLASSIFICATION FOLLOWING A WARMER THAN NORMAL FALL MONTH OR SEASON. HYBRID CLIMATE ANALYSIS METHOD.

	BELOW NORMAL <33.3	NORMAL	ABOVE NORMAL >33.4
WARM SEPTEMBER	12	2	11
WARM OCTOBER	5	3	16
WARM NOVEMBER	10	4	11
WARM AUTUMN	8	2	14

* *

This evaluation also indicates warmer than normal Octobers are followed by warmer than normal winters. This is true 67% of the time which is 17% above what would be expected if there was no relationship.

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TABLE 6 - WINTER CLASSIFICATION FOLLOWING A COOLER THAN NORMAL FALL MONTH OR SEASON. 50-50 ANALYSIS METHOD.

	BELOW NORMAL <33.3	NORMAL	ABOVE NORMAL >33.4
COOL SEPTEMBER	19	6	17
COOL OCTOBER	26	5	12
COOL NOVEMBER	24	3	16
COOL AUTUMN	22	4	16

* *

The results shown in Table 6 are quite interesting. About 60% of the winters following a cooler than normal October (here less than 57.7) are colder than normal; this is close to the 58% found in Table 3. The percentage of colder than normal winters following cooler than normal Novembers dropped from 64% (Table 3) to 56% here. This would lead to the conclusion, if there is a relationship between November and winter, that it has to be an unseasonally cool November (by the climate analysis method).

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TABLE 7 - WINTER CLASSIFICATION FOLLOWING A WARMER THAN NORMAL FALL MONTH OR SEASON. 50-50 ANALYSIS METHOD.

	BELOW NORMAL <33.3	NORMAL	ABOVE NORMAL >33.4
WARM SEPTEMBER	17	2	19
WARM OCTOBER	14	2	26
WARM NOVEMBER	18	4	20
WARM AUTUMN	15	3	23

* *

Table 7 results show 62% of the winters following a warmer than normal October were milder than normal. This is down from the 67% results in the hybrid climate analysis (Table 5), but still indicates that the warmer the October, the more likely it will be followed by a warm winter.

V. STATISTICAL TESTING OF RESULTS

All the results presented in tables 2 through 7 were given chi-square tests. The chi-square test is a measure of the degree to which a series of observed events deviate from the expected or theoretical frequency. Chi-square tests were performed on the monthly and seasonal mean temperature distributions. To no surprise monthly means are normally distributed.

In the chi-square tests for tables 2 through 7, the null hypothesis used was there is no relationship between the monthly fall means and the following winters' average temperature. The level of significance was chosen at 0.1. There were four test failures which mean on some level there is a relationship between what happens in the fall and the ensuing winter. The following null hypotheses were rejected:

Table 3 - Unseasonally cool Novembers (<45.0) do not cause colder than normal winters (< 33.3)
Table 5 - Unseasonally warm Octobers (>59.2) do not cause warmer than normal winters (> 33.4)
Table 6 - Cooler than normal Octobers (< 57.7) do not cause cooler than normal winters (< 33.3)
Table 7 - Warmer than normal Octobers (> 57.7) do not cause warmer than normal winters (> 33.4)

It should be noted that any chi-square test involved with more than one degree of freedom passed. The chi-square test failures suggest on some simplistic level there is a relationship between what happens in October and November and what occurs the next winter.

VI. CONCLUSIONS

The study was expected to find unseasonally cool Octobers produced harsh winters. This is not the case. One definite conclusion which can be drawn is what happens in September has no noticeable bearing on the following winter. Other results which have some statistical backing are unseasonally cool Novembers are followed by colder than normal winters. Cooler than normal Octobers are followed by colder than normal winters. The later in the autumn season it is unseasonally cool the more likely the following winter will be colder than normal. Warmer than normal Octobers, especially unseasonally warm Octobers, are followed by warmer than normal winters.

*

Acknowledgments. I would like to thank everyone at WSO Newark and WSFO New York City who helped me compile the information and gave me insight into the project, especially DMIC Steven Thomas, OIC Eugene Hathaway, Pam Joyce, Eugene Salerno, and Ben Scott.

Fig. 1A. September Mean Temperature by Decades in the 20th Century for Central Park

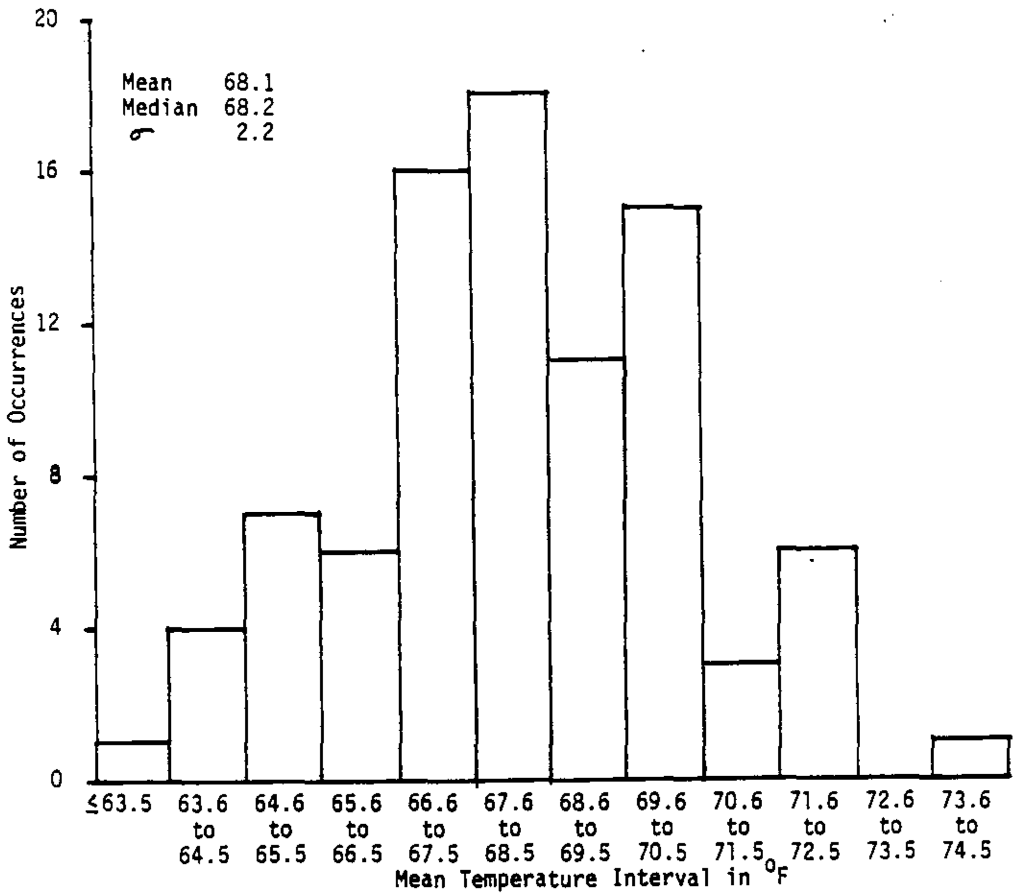

Fig. 1B. Frequency Distribution of September Means from 1900-87, Central Park

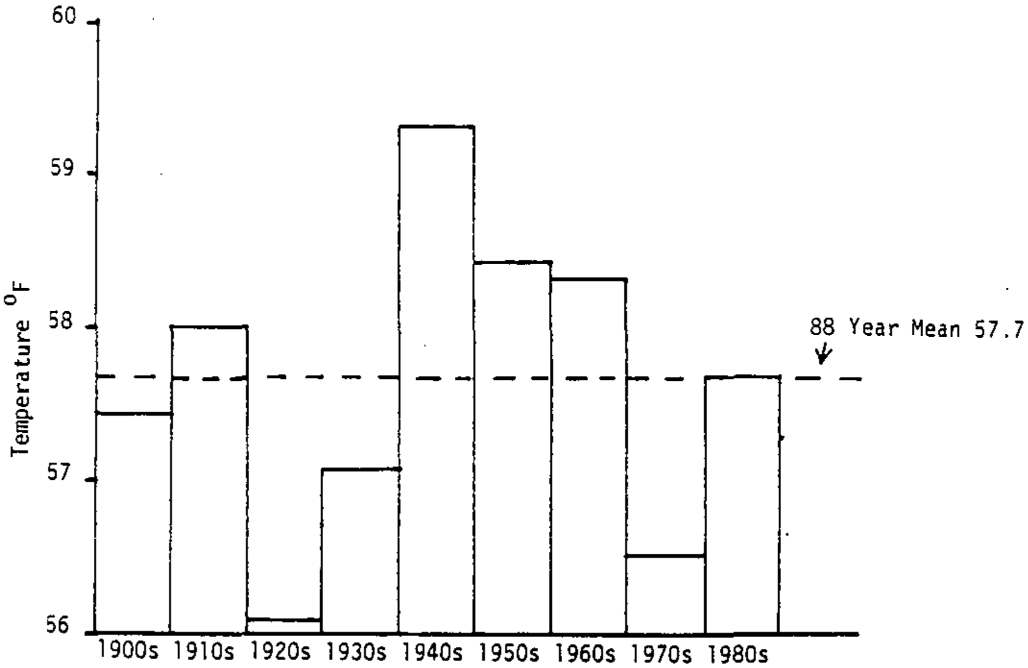

Fig. 2A. October Mean Temperature by Decades in the 20th Century for Central Park.

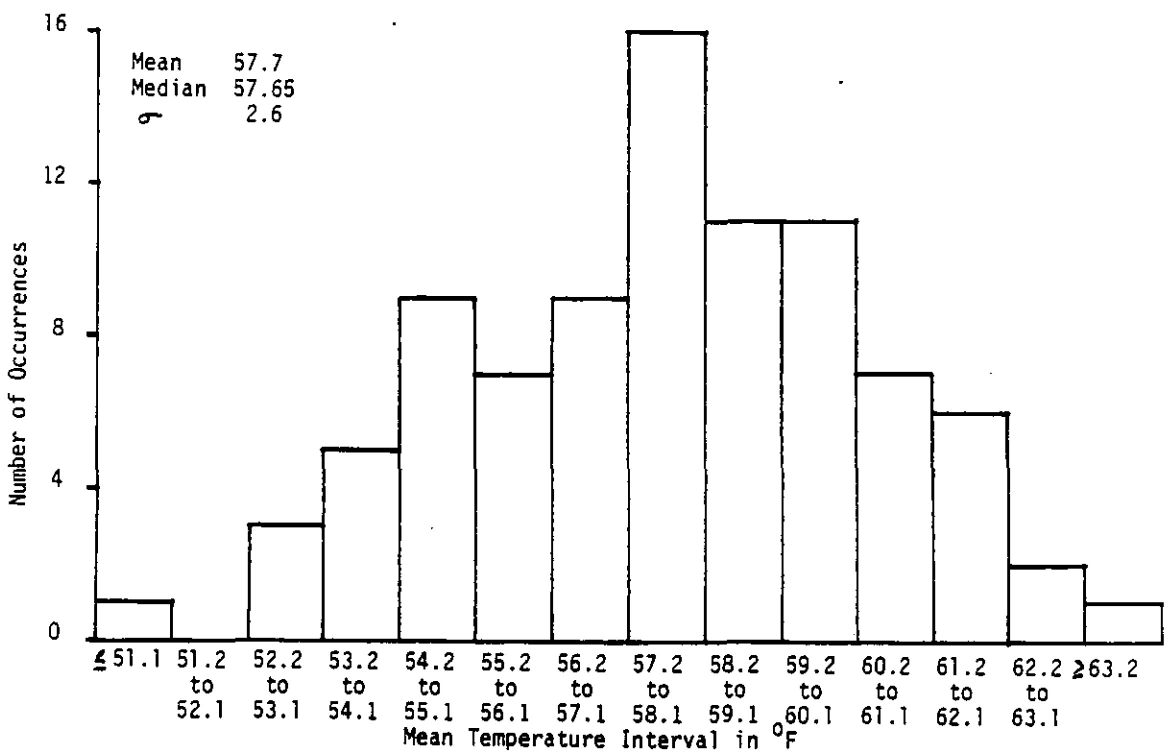

Fig. 2B. Frequency Distribution of October Means from 1900-1987, Central Park.

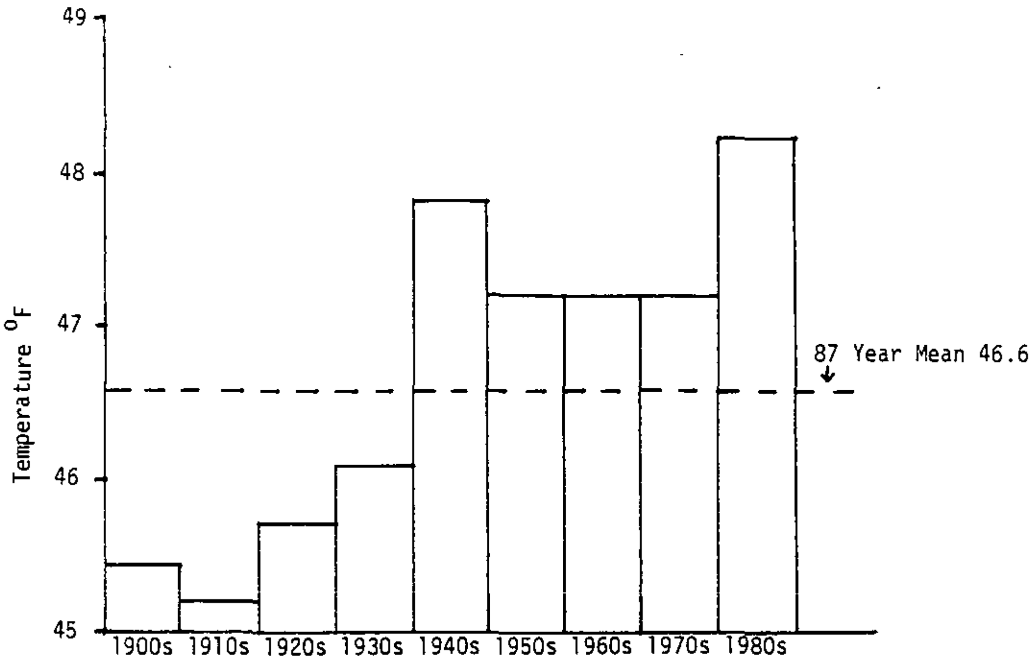

Fig. 3A. November Mean Temperatures by Decades in the 20th Century for Central Park

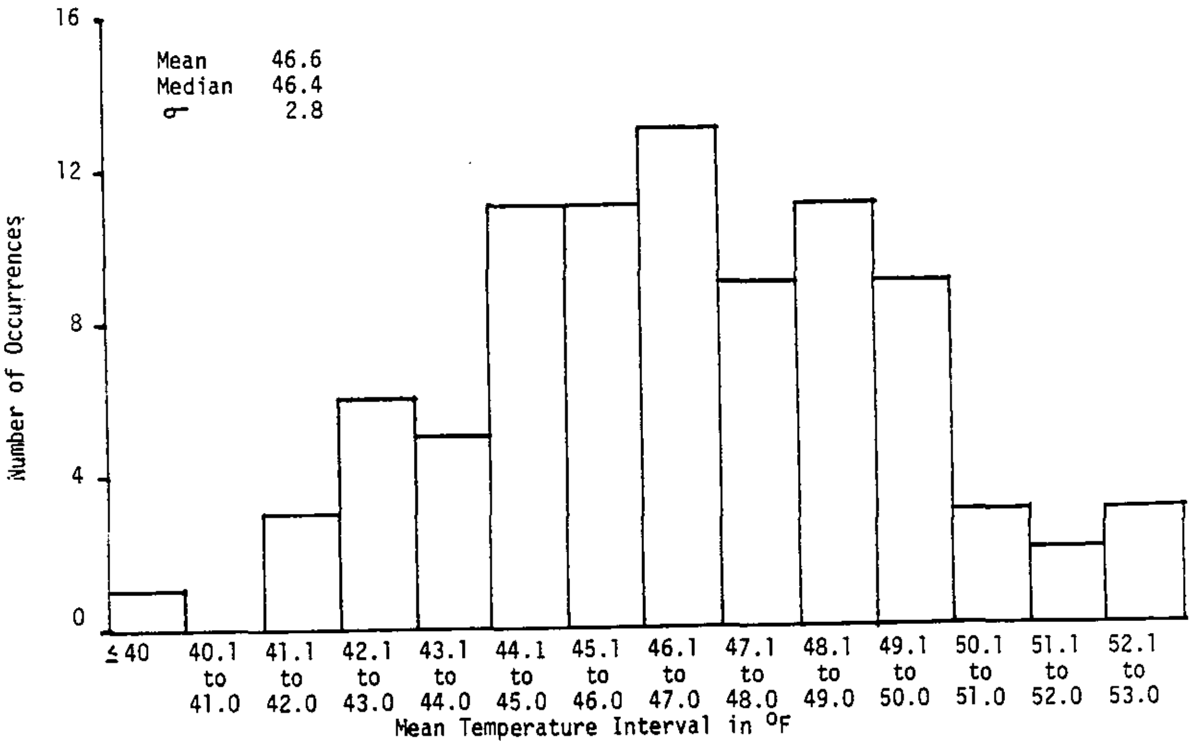

Fig. 3B. Frequency Distribution of November Means from 1900-86, Central Park

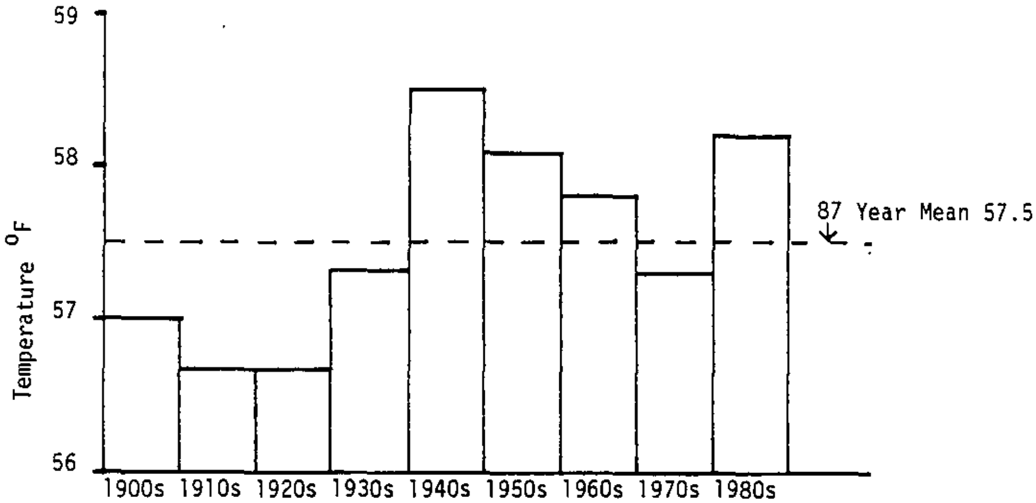

Fig. 4A. Autumn Mean Temperature by Decades in the 20th Century for Central Park

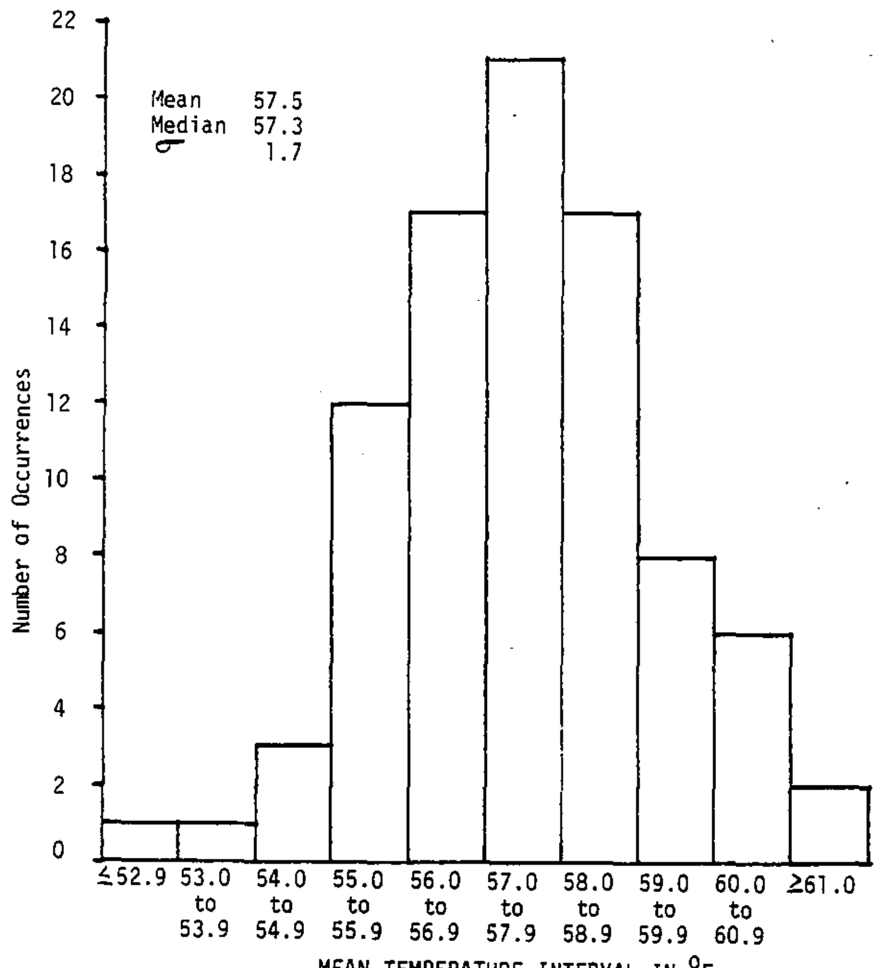

Fig. 4B. Frequency Distribution of Autumn Means from 1900-86, Central Park.

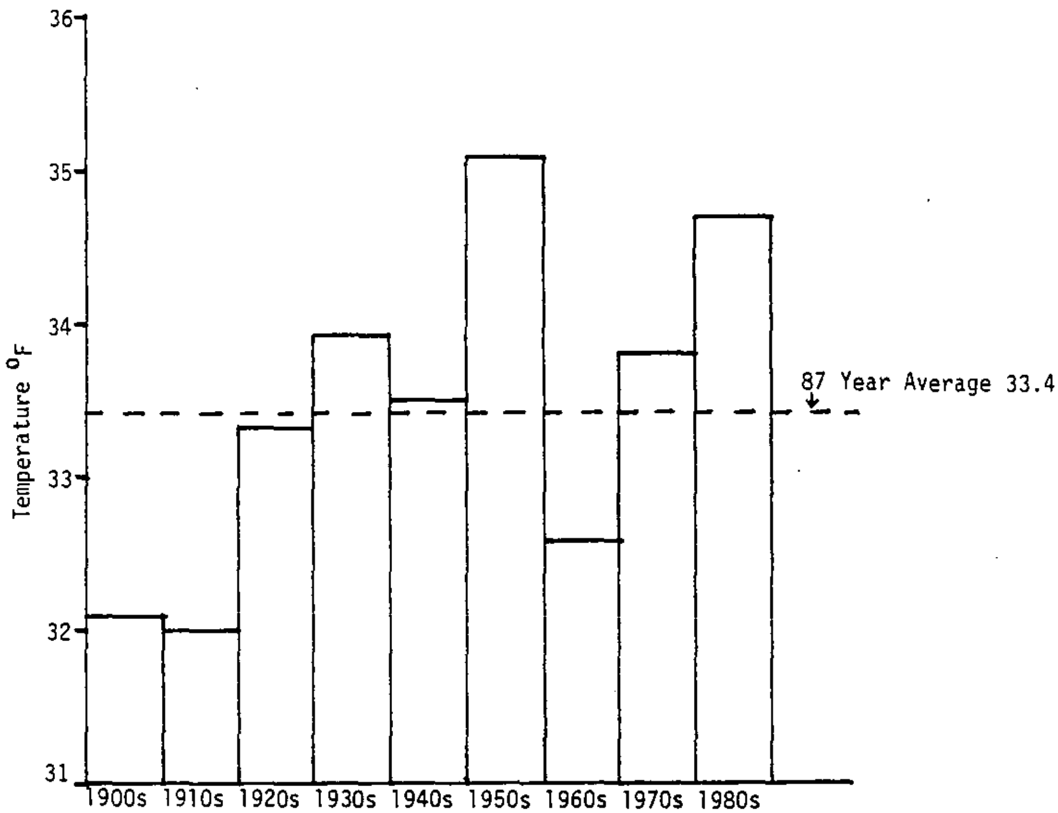

Fig. 5A. Winter Mean Temperature by Decades in the 20th Century for Central Park

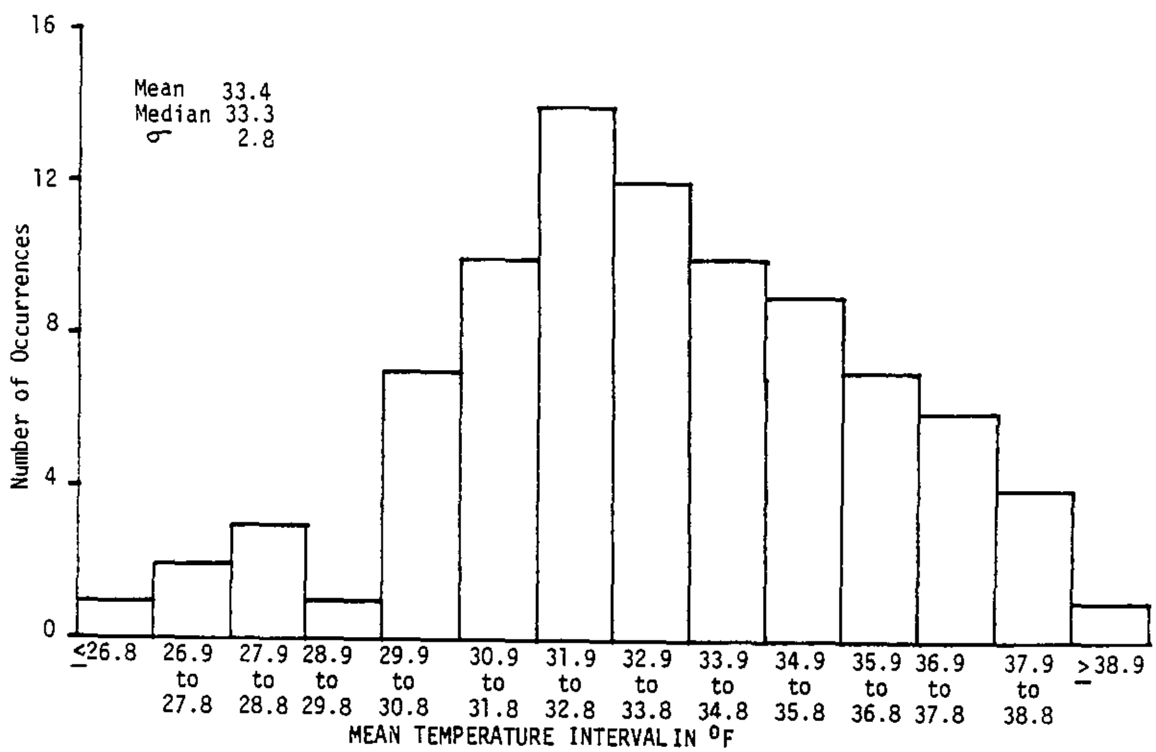

Fig. 5B. Frequency Distribution of Winter Means from 1900-87, Central Park