Abstract. Power spectrum analyses of temperature series at New York City (1822-1956), the Netherlands (1735-1944), and central England (1698-1955) show that the only significant energy in these spectrums appears at the annual period of 12 months. No significant energy was found corresponding to any known sunspot periodicity. Correlation coefficients between January and July temperatures for the years of each series are uniformly low, ranging from 0.09 to 0.17 for the three series. This indicates a lack of correlation between winter and summer temperatures contrary to what might be expected if temperature variations were controlled to some extent by sunspot variations. It is concluded that no demonstrable connection exists between midlatitude temperatures and sunspots. Effects depending on temperature variations, such as sea level variations, are also independent of sunspot variations.

Introduction. There have been many suggestions through the years of a possible relationship between sunspots, air temperature, and sea level [e.g. Willett, 1949; Landsberg et al, 1959; Fairbridge, 1963]. To test one aspect of this hypothesis, long temperature records in central England from 1698 to 1955 [Manley, 1953], the Netherlands from 1735 to 1944 [Labrijn, 1945], and New York City from 1822 to 1956 [U. S. Dept. Commerce, 1958] were subjected to power spectrum analysis using a hamming spectral window by methods described by Blackman and Tukey [1958]. Schove's [1955] sunspot data for 1700 to 1953 were also subjected to power spectrum analysis.

Although the relationships have been postulated for the tropics, mid-latitude data were chosen here for two reasons: (1) the only temperature series sufficiently long to resolve an 11-year cycle by spectrum analysis are in mid-latitudes, whereas temperature records for the tropics rarely extend for 50 years; (2) if the sunspot-temperature effect is real, it ought to be observable at any latitude but would tend to be masked by the midlatitude cyclone noise. However, power spectrum analysis, on a sufficiently long series of temperatures, would detect the relevant periodicities.

Data preparation. The original temperature data are in the form of monthly means. In addition to the raw monthly values of temperature, 12-month running means were calculated and analyzed. This procedure has the effect of completely suppressing the 12-month periodicity and reducing the amplitude of all shorter periods to almost zero while leaving the amplitude of the longer-period constituents virtually unchanged. For example, at a period of 11 years the amplitude of a spectral component is only reduced by 4%. By using the 12-month running means I avoid contaminating the longer-period part of the spectrums with side lobe energy from the predominant 12-month periodicity. 'Prewhitening' of the data, which in this case was accomplished by the use of these running means, was used to reduce the energy appearing in the side lobes.
Power spectrums. The power spectrums for all of the data are shown in Figure 1. The 80% confidence limits are shown by vertical lines. The number of lags used in the calculations of the power spectrums was about 10% of the record length for the temperature data and about 20% for the sunspot data. The 20% value used for the sunspots is recognized to be rather high, but the periodicity sought must be coherent throughout the whole record; in such a case a value as high as this is justified.

Figure 1a, the spectrum for the sunspot data, shows a rather broad peak centered at about 133 months (11 years) and is the well-documented 11-year cycle. Figure 1b, the spectrum for the raw (not pre-whitened) data for New York City, shows a high-amplitude sharp peak at 12 months, and at longer periods the points alternate between relatively high- and low-energy levels, showing the effect of the side lobes. Figures 1c, 1d, and 1e, spectrums for the pre-whitened data, are very much alike, and they all show that the 12-month running means completely suppress the energy at that period. At longer periods the spectrums are smooth, with no indication of any instabilities. There is no evidence of any significant periodicity in these spectrums.

Discussion. Other investigators using different climatic indicators reached similar results. Anderson and Koopman [1963] performed harmonic analysis on varves from various areas throughout the world and found no 11-year cycle. Brier's spectrum analysis of precipitation data for stations in the United States and western Europe also showed no such cycle [Brier, 1961]. Bryson and Dutton [1961] analyzed tree-ring and varve data from the western United States with negative results. Schulman [1951] concluded that there are no regular periodicities in tree-ring data. These results from data representative of both arid and humid climates corroborate the findings of the present study: using sophisticated statistical analysis techniques, I could find no detectable 11-year cycle in temperatures or temperature-dependent climatic indicators.

It was not practical to analyze any sea level data for this study. Shaw and Donn [1964] have shown that sea levels are to a great extent controlled by air temperature, and it is therefore unlikely that the sea level spectrum

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**Fig. 1.** Power spectrum analyses of: (a) sunspot data, (b) New York City raw temperature data, (c), (d), (e) temperature data for New York City, the Netherlands, and central England pre-whitened by 12-month running means. In all cases the 80% confidence interval is shown by a vertical line at the right-hand side. CPM denotes cycles per month.
would show any markedly different spectral peaks in the period range of interest.

Fairbridge \cite{1963} describes instrumentally identifiable perturbations to mean sea level of 2 to 3, 11, 22, 40 to 44, and 160 to 170 years. The first he relates to the southern oscillation \cite{1962} and the remainder to some sort of sunspot periodicities, whereas in this analysis only the 11-year cycle is apparent in the spectrum analysis of the sunspot data. Because of lack of resolution, the longer-period cycles are difficult to analyze. The results given here do not support earlier references to sunspot variations longer than the 11-year cycle.

As a further test of the hypothesis that sunspot variations are related to temperature, correlation coefficients between January and July temperatures for each of the three series were calculated. If sunspot variations do affect temperatures they ought to cause changes in a consistent manner over the year. It is not possible to predict how the circulation of the atmosphere and therefore air temperature would react to solar changes, but, whatever the mode of atmospheric response, it might be reflected in some systematic way between summer and winter; e.g., warm summers would correlate with warm winters or possibly warm summers would correlate with cold winters. In any case the calculated values and corresponding 95% significance levels (Table 1) are uniformly low. Although slightly positive, they are not significantly different from zero and therefore do not support the hypothesis that there is correlation between winter and summer temperatures.

**Table 1. Correlation Coefficients for January–June Temperatures**

<table>
<thead>
<tr>
<th>Station</th>
<th>Correlation Coefficient</th>
<th>95% Significance Levels</th>
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<tbody>
<tr>
<td>New York City</td>
<td>0.17</td>
<td>0.00 to 0.33</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>0.10</td>
<td>-0.02 to 0.25</td>
</tr>
<tr>
<td>Central England</td>
<td>0.09</td>
<td>-0.04 to 0.20</td>
</tr>
</tbody>
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References


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