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ABSTRACT

The Hale double sunspot cycle may have been subject to a predicted phase reversal between 1800 and 1880 A.D. Several climatolcgical parameters normally correlated with this cycle do not exhibit a corresponding phase reversal during this period. This apparent discrepency can be resolved by suitable observations during the upcoming half decade.

ARE CLIMATOLOGICAL CORRELATIONS WITH THE HALE DOUBLE SUNSPOT CYCLE MEANINGFUL?

Recently much statistical evidence has been offered to support the conclusion that several climatological parameters are correlated with the Hale double sunspot cycle,[1] which has an approximate periodicity of twenty-two years. A long-term extrapolation (100-200 years) of the double cycle by Sleeper[2] predicts phase reversals at intervals of 80 and 100 years which, if real, introduce inconsistencies in these correlations. Since the next phase reversal is expected by 1978, we suggest that the inconsistencies can be resolved within the next half decade.

The Hale double sunspot cycle contains two nominal 11-year solar periods. The beginning of the second 11-year half is characterized by a reversal of the magnetic polarity of the bipolar sunspot groups from that during the first 11 years. The full double cycle is normally composed of the positive- followed by the negative-polarity 11-year period. The polarity sign has been accurately determined since 1908 using the spectroscopic Zeeman effect.[1]

Sleeper[2] extrapolated this magnetic behavior to earlier years (Fig. 1) using a theory developed by Jose.[3] (The indicated polarity since 1908 in Figure 1 is based on measurements.) Jose's theory is predicated on considerations of the rate of change of instantaneous angular momentum of the sun relative to the center of mass of the solar system. One startling result of this theory is that

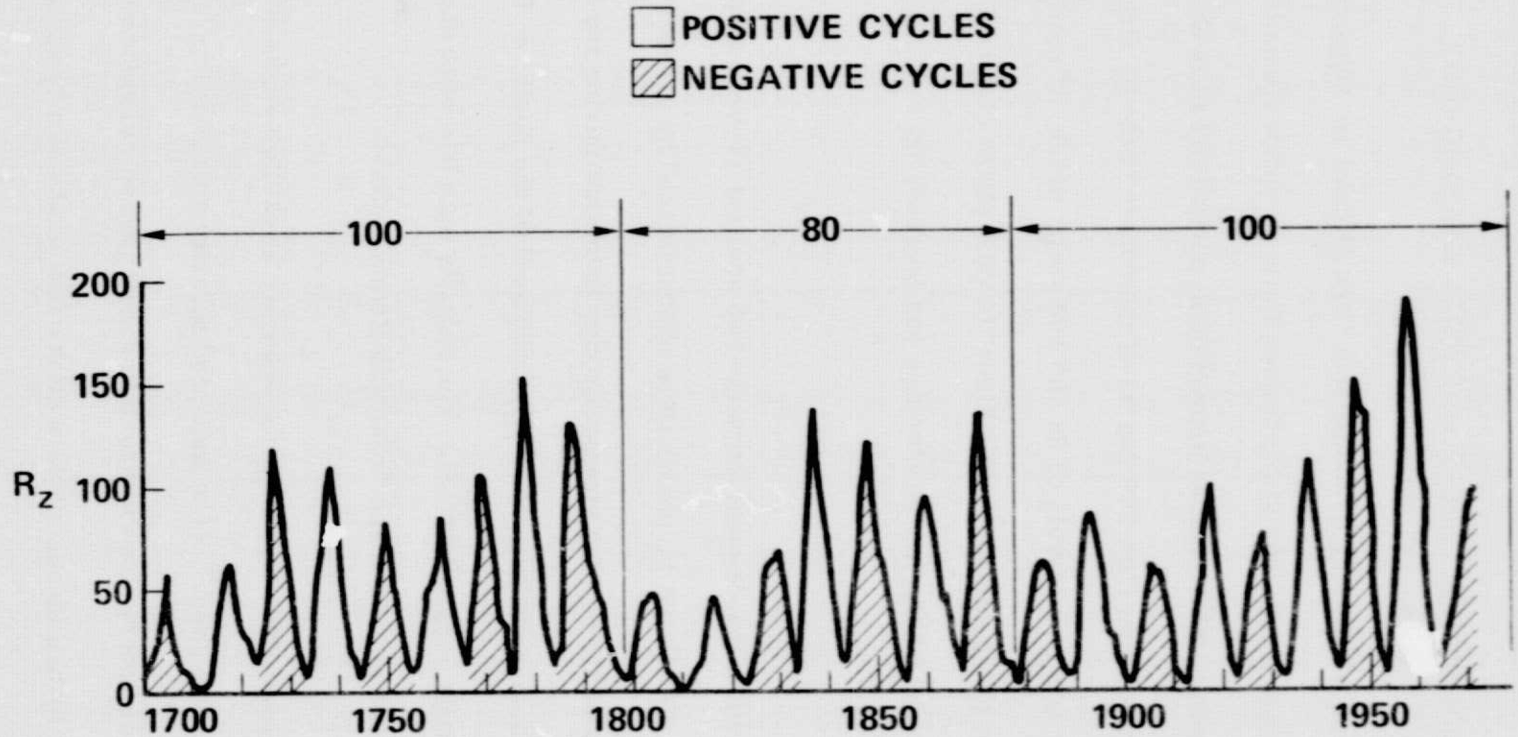

Figure 1. Annual smoothed sunspot numbers. Positive and negative phases of the double cycle are indicated by the key. The approximate 80 and 100 year periods are also designated. (After Sleeper[2])

the approximate 180-year planetary resonance period (precisely 178.7 years and representing a complete rotation of the sun about the solar system center of mass) divides into two subperiods of about 80 and 100 years. The beginning of each subinterval is marked by a reversal of sign of the rate of change of angular momentum; at these times Jose and Sleeper infer that the sunspot magnetic structure must reverse and produce two consecutive negative 11-year cycles. This in turn would cause a phase reversal in the magnetic polarity sense of the double (22-yr) sunspot cycle. As can be seen in Figure 1, the last two phase reversals occurred in 1800 and 1880, and the theory predicts the next will occur by the year 1978.

There are at least two ways to determine the physical validity of the double negative cycle and its possible influence on climate. The first, which we attempt below, is to re-examine historical data and reported correlations for evidence of inconsistencies near 1800 and 1880. A second way, which we strongly recommend, is to conduct a careful analysis of climatological observations and sunspot magnetic polarity measurements during the next half decade, covering the critical years 1976-1978.

The most significant climatological parameters reported to be positively correlated with the double sunspot cycle are geographically localized rainfall,[4] drought intervals,[5,6,7] and temperatures.[4,8,9,10] Surface atmospheric pressures reportedly follow a 22-year cycle,[11] but these results have been disputed and are currently subject to re-evaluation.[12] These data are summarized in Figure 2 and Table 1 for comparison with the double sunspot cycle.

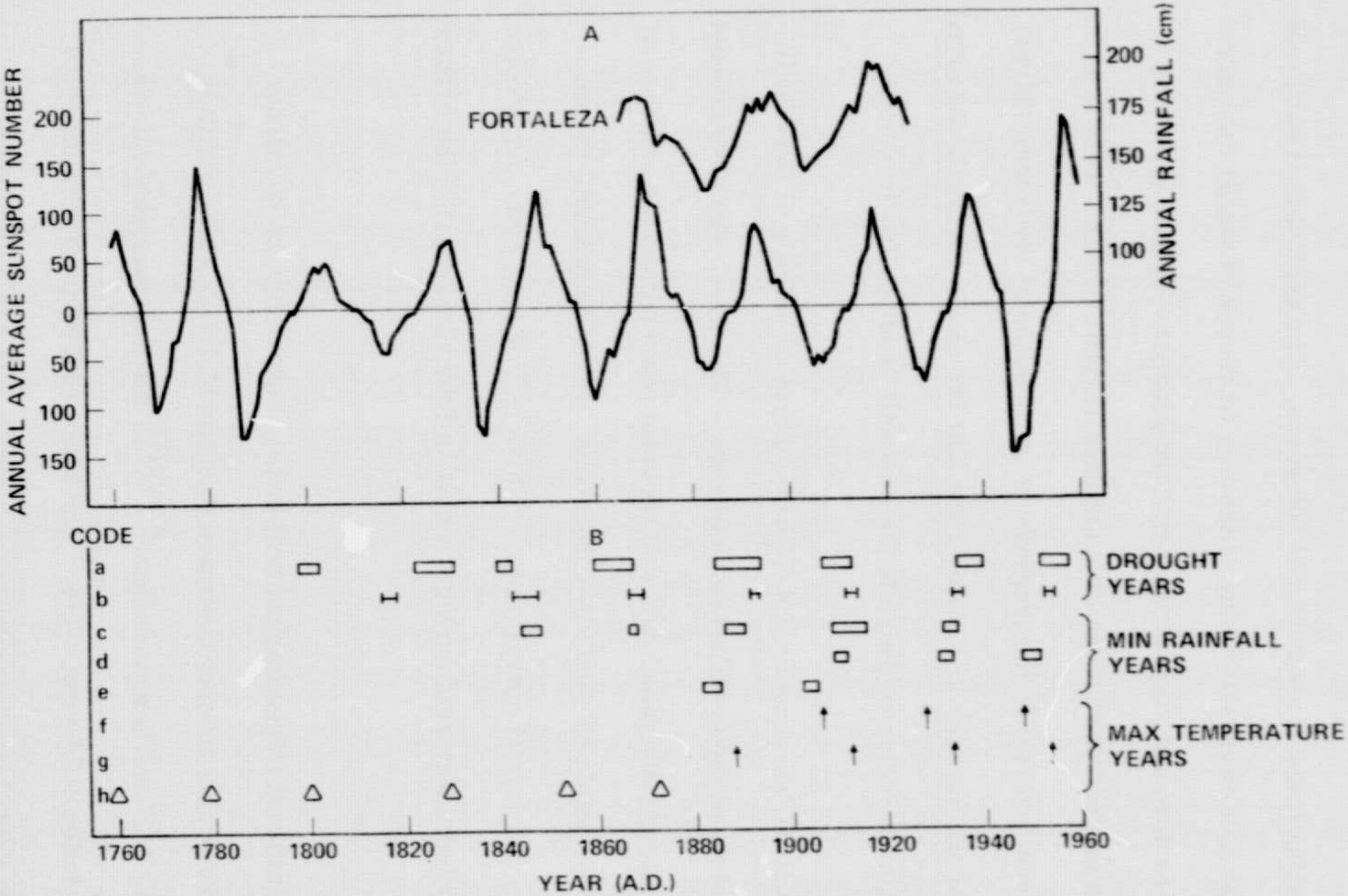

Figure 2. (A) Sunspot cyclic behavior since 1760 plotted in a twenty-two year format by representing alternate cycles above and below the abscissa. The annual rainfall measured at Fortaleza, Brazil between 1865 and 1925 is also shown. (B) Summary of climatological parameters known to correlate with the double sunspot cycle. The climatological extremes illustrated are to be compared with the sunspot cyclic behavior shown in Figure 2A. Locality and references for these correlations are summarized in Table 1.

Table 1

Key to Figure 2B

Code	Site	Reference
a	Nebraska	7
b	U.S. High Plains	6
c	Adelaide	4
d	South Africa (3 Station Average)	4
e	Fortaleza	4
f	Maryland/Virginia	9
g	Omaha (Summer)	10
h	Central England (Summer)	4

The double cycle is plotted according to the usual practice of extrapolating the positive and negative halves backward in time without regard to the Jose and Sleeper prediction of phase reversal. From 1800 to 1880 the phases are thus opposite in Figures 1 and 2.

Drought data in the midwestern United States cover the longest time span, and show a most striking correlation; viz, the recurrence of droughts near times of sunspot minimum following a negative maximum. The correlation holds true throughout the period 1800-1955, and shows no abnormal change around 1880. This would seem to indicate that either the drought occurrences are unrelated to sunspot magnetic polarity, or the double negative cycle failed to occur.

Minimum rainfall years for Adelaide, Australia and the South African stations at Rustenburg, Bethal, and Dundee correspond with the U.S. drought years. Fortaleza, Brazil also exhibits an apparent dependence on the double cycle from the beginning of the record in 1865 to 1925, but minimum rainfall tends to occur a few years earlier, near a negative sunspot maximum. No apparent change in 22-year periodicity of Fortaleza rainfall occurs around the crucial year of 1880, but as King[4] pointed out, the cycle reversed after 1925.

Atmospheric temperatures in Maryland and Virginia (1900-1960), Omaha, Nebraska (1871-1970), and Central England (1750-1880) follow a 22-year cycle. Maximum summer-temperature years in Omaha correspond to midwestern drought years, while those in Maryland and Virginia have occurred coincidentally with negative maximum sunspot years. Finally, July temperatures in Central England varied in phase with the double cycle from 1760 to 1880, but after the latter year the phase reversed.[4] There was no such reversal around 1800 as would be indicated by the double negative sunspot period extrapolated by Sleeper.[2]

The conclusions drawn from these comparisons seem to imply that the climatological parameters selected for correlative study may only coincidently exhibit a twenty-two year cyclic behavior in parallel with the normal double sunspot cycle phasing. Otherwise, if these parameters do relate to the solar sunspot magnetic polarity, then the predicted double negative cycle must be nonexistent. In the first case, one could argue that the rainfall behavior is coincidental, since the correlative relationship and phasing has deteriorated since 1925.[4] Some evidence for this behavior is also exhibited in the temperature data after 1910. On the other hand, the midwestern drought periodicity has maintained a strong correlative relationship up to the present time.

Jose[3] has predicted that the next year marking the midpoint of the double negative cycle will occur within the next three years. By 1980 sufficient data should exist to establish validity of this prediction. Selection of suitable climatological parameters for detailed study during this period should permit further insight concerning possible mechanisms responsible for the observed behavior.

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