A relation between solar activity and winter temperatures in Holland between 1634 and 1975

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ABSTRACT

There is some correlation between the maximum sunspot number for each 11-years cycle and the average winter temperature in Holland per cycle, for the period 1634–1975.

A relation between solar activity and climate is occasionally claimed. This claim is supported by the observation that during the "Maunder minimum" (~1645 to ~1715 A.D., when solar activity was exceptionally low) winters in Western Europe were colder than at present. This seems also to have been the case for the "Spörer minimum" (~1400 to ~1510 A.D.), cf. Eddy (1976, 1977).

But searches for relations between sunspot numbers and weather or climate indicated no such correlation. Shaw (1965) who investigated the relation between the sunspot number and the temperatures measured in central England (from 1698 to 1955), New York (1822 to 1956) and The Netherlands (1735 to 1944) found no other periodicities than the annual one.

A more modern periodogram analysis by Schönwiese (1978) again resulted in little or no correlation between sunspot numbers and temperature data. And Pittock (1978) who critically reviewed the various claimed sun-weather relationships concluded that "little convincing evidence has yet been produced for real correlations between sunspot cycles and the weather/climate on the 11- and 22-years time scales, although evidence for correlations with solar events on time scales of days appear to exist".

Hence it seems that no correlation exist on time scales of the order of the 11-years cycle. But, as Eddy (1977) suggested, long term modulation of the solar cycle might show its effects in weather or climate. A search for such long-term effects was difficult because systematic records of temperature data over more than two centuries are rare. For Holland, such a series covers the period 1735 – present. The observations had been made at different places, but have been reduced to the present seat of the Royal Meteorological Institute at the Bilt, by Labrijn (1945). This series, however, is still too short since it does not extend into the Maunder minimum.

This series has recently been extended – as far as average winter temperatures are concerned – to 1634 by Van den Dool et al. (1978). They used a long series of data, giving the annual number of days on which certain Dutch canals were frozen. By calibrating these numbers for those years on which winter temperature data were available they could obtain average winter temperatures $\bar{T}_w$ for the years 1634 – present. For the period 1634–1735 these data have a mean error of $\pm 1^{\circ}.1$.

For these data we have examined the relation between sunspots and climate. In the line of our previous comments we did not attempt to search for a relation between the annual sunspot index and the annual average winter temperature, not only because previous investigations showed already that such a relation does not exist, but also because it looks unlikely that periodicities with periods slightly longer than the obvious annual temperature cycle (i.e. timescales of a few years) would be detectable: the temperature data are too uncertain and would not significantly demonstrate such periodicities, if existing at all. In addition, since the *solar* influence on climate must be primarily related to solar flares, specifically their UV and X-ray emissions, but particularly the associated streams of energetic particles – effects influencing the ionosphere (radiation), and the high-latitude upper atmosphere (particles) – the first effect to be looked for should be the 11-years cycle since flaring activity varies greatly during the cycle. However, as is noted above, and as can easily be ascertained, even over eleven years no significant correlation should be detectable, because of the combination of the numerical uncertainty and the physical scatter of the average winter temperature data.

Therefore, it only makes sense to look for longer periodicities. Systematic long-period variations are known to characterize solar variability – an 80-years period in solar periodicity has been claimed to exist, as well as other periods.

Schuurmans (1978) and Van den Dool et al. (1978) already drew attention to the gradual increase in the winter temperatures in Holland since the seventeenth century, but the next question that arises is whether variations on time scales reflecting long-term solar variability (~50–100 years) are also visible. To eliminate the strong variations in flare-related emissions during individual solar cycles we considered spot and $\bar{T}_w$ data over consecutive *solar cycles* – from a sunspot minimum to the next.

For the sunspot index representative for the individual solar cycles we could have taken the average sunspot number over the cycles, but since this value correlates very well with the *maximum sunspot number* R_{max} for the cycle we took this latter value. Fig. 1 shows (dots) the mean value of the average winter temperatures $\langle \bar{T}_w \rangle$, where means have been taken over successive sunspot cycles, from each minimum to the next. Crosses give the maximum values of the Zürich sunspot number, R_{max}, for each cycle. These data were read from Waldmeier (1954, table 33 and table 32, and relevant issues of the Astronomische Mitteilungen der Eidgenossischen Sternwarte Zürich) for the period since 1750, and from Eddy (1976) for the earlier period. We took Eddy's values as they were published but note that Legrand and Simon (1981) gave empirical evidence that R_{max} cannot have been lower than ~40, instead of the values near zero, given by Eddy.

The correlation between R_{max} and $\langle \bar{T}_w \rangle$ is given in fig. 2. The correlation coefficient is 0.42, which is significant at the 5% level. By taking Legrand and Simon's R_{max} values for the Maunder minimum we would even have improved the correlation.

These figures indicate that the long-term modulation of sunspot numbers and Dutch winter temperatures are slightly correlated. Mainly the low average winter temperatures during the Maunder minimum, as well as the decreased winter temperatures during the "small Maunder minimum" around 1810 are detectable in fig. 1.

In addition, it seems of some importance to note that virtually no correlation would have been found when only the data for the period after 1840 would have taken, hence excluding the deep depressions during the Maunder minimum and the small Maunder minimum. This is evidently related to several causes: first, the variations in $\langle \bar{T}_w \rangle$ and R_{max} are smaller for this period, and since $\langle \bar{T}_w \rangle$ will certainly not *only* depend on R_{max} – other effects will also influence $\langle \bar{T}_w \rangle$ – a possible relation between $\langle \bar{T}_w \rangle$ and R_{max} may be obscured during this period. In

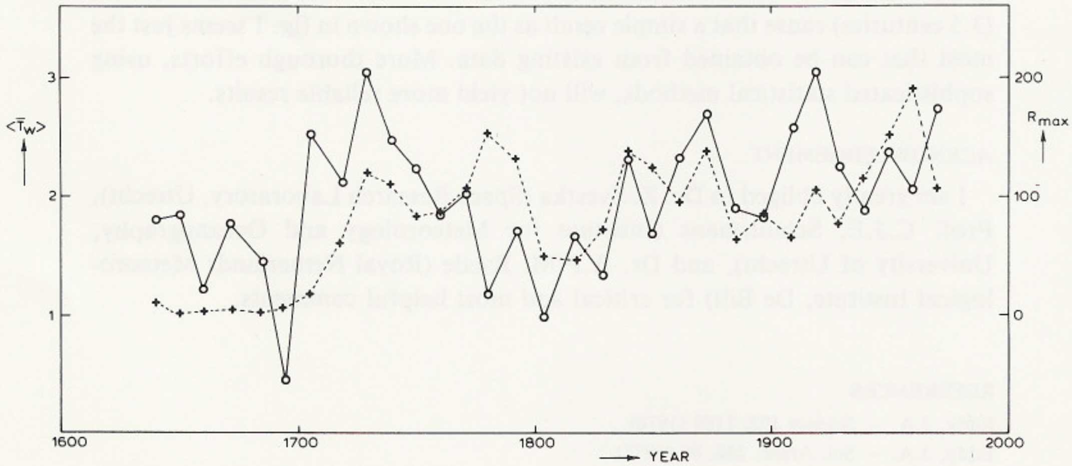

Fig. 1. Values of $\langle \bar{T}_w \rangle$ in degrees centigrade (circles) and R_{max} (crosses) for the sunspot cycles between 1634 and 1975.

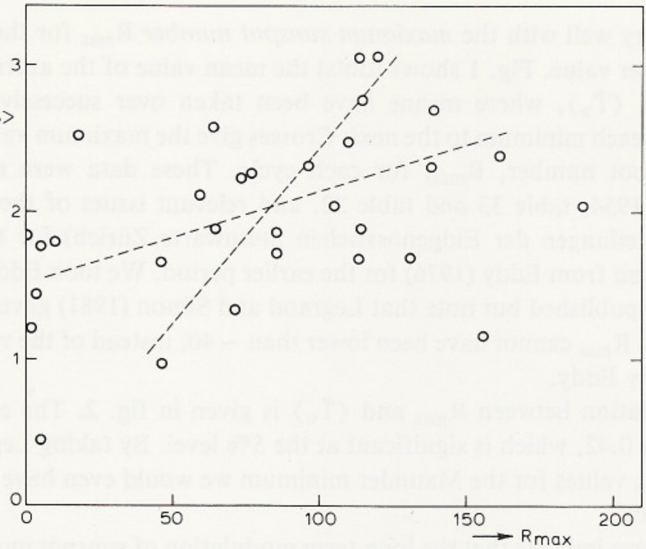

Fig. 2. Correlation between $\langle \bar{T}_w \rangle$ (in degrees centigrade) and R_{max}. The dashed lines are regression lines.

addition, large changes have taken place in The Netherlands during the last 150 years: industrialisation, change of large sea water areas into fresh water, land reclaiming. These changes may have influenced the T_w-behaviour.

This short investigation shows, in addition, the obvious limitation of this kind of research. The existing data on $\bar{T}_w$ are inaccurate, while the solar effect is hidden among many other influences that determine the winter temperatures in Holland. Furthermore, the data on R_{max} are certainly not the most appropriate ones for studying the relation between solar activity and climate. The combination of these two circumstances, as well as the short time interval available (3.5 centuries) cause that a simple result as the one shown in fig. 1 seems just the most that can be obtained from existing data. More thorough efforts, using sophisticated statistical methods, will not yield more reliable results.

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