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ON THE CONSIDERATION OF THE DOUBLE SUNSPOT CYCLE IN CLIMATIC INVESTIGATIONS

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Abstract

On the basis of long series of temperatures taken at Stockholm and of water heights taken at Swinemünde it can be established that the variations connected with the double sunspot cycle are larger than those during a single sunspot cycle.

Among the results obtained from investigations into the effect of the double sunspot cycle upon climatic factors, the air pressure effect observed by HANZLIK [2,3] seems to be the most important. Hanzlik has proved from extensive data that the difference in air pressure between a sunspot minimum year and the immediately succeeding maximum year shows a period corresponding to the length of the double sunspot cycle. WILLETT [6] has since continued this line of research. HALE and collaborators have discovered that the magnetic polarity of spots varies according to the double cycle. A full magnetic cycle therefore covers two spot cycles and lasts, on the average, 22—23 years. This period is called the *Hale-period*.

Several investigations dealing with climatic variations show rhythms of 22—24 years. Such a rhythm has for instance been established by GROISSMAYR [1] for temperature and precipitation in different parts of the earth. In the North of Europe the effect of the double sunspot cycle appears especially in winter temperature values [4]. The water height variations in the Baltic also clearly show a rhythm of this kind [5].

In order to elucidate this question, the winter temperature in Stock-

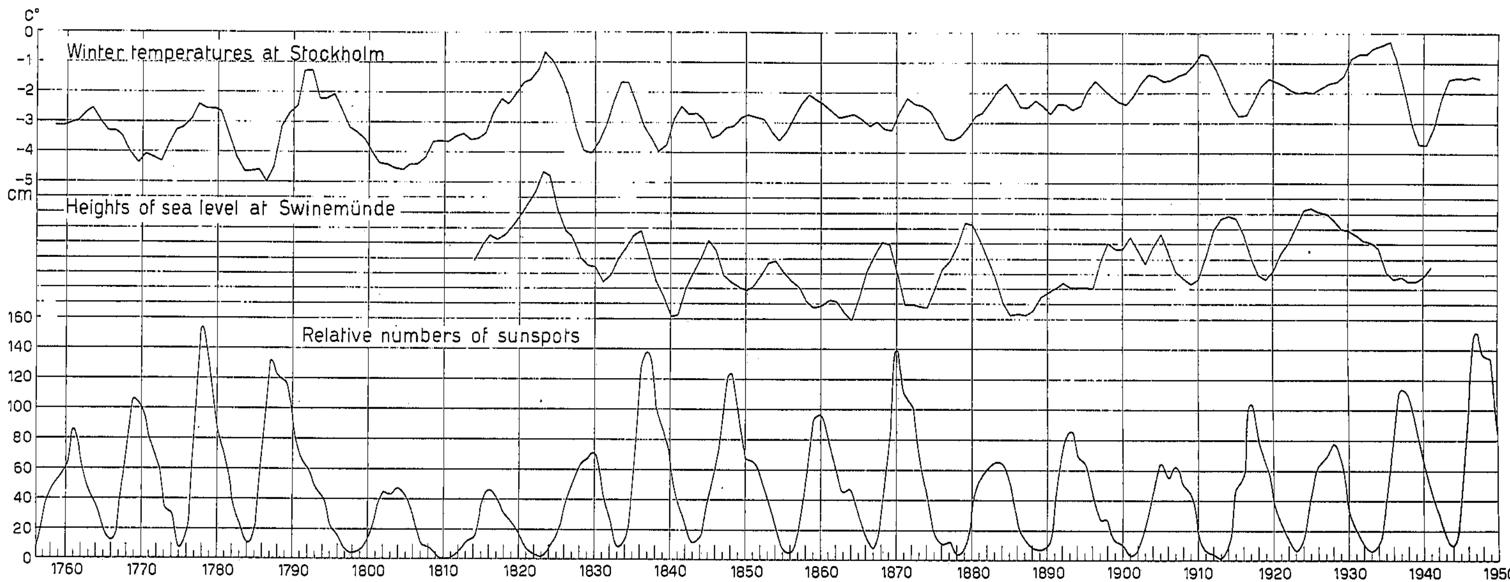

Figure 1. Changes of winter temperatures at Stockholm and relative heights of sea level at Swinemünde in comparison with the sunspot cycles.

holm, i.e. the average values for December up to and including March during the years 1756—1950, and the annual average values of the waterheight observations at Swinemünde during the years 1811—1943 have been examined in this report. The solid ground vertical movement due to geological factors has been eliminated from the Swinemünde waterheight observations by using the ground sinking value 0.5 mm/year.

Figure 1 gives a rough idea of the possible dependence of the variations in winter temperature in Stockholm and the waterheight at Swinemünde on the sunspot cycles. The lowest curve shows the relative number of sunspots, the middle one the course of the waterheight at Swinemünde and the topmost the variations in winter temperature in Stockholm. The two latter curves represent the weighted values and have been drawn by using first double and then quintuple weighted average values. The curves show that there is an obvious correspondence between the sunspot cycle and the variations in waterheight at Swinemünde. The extreme values of the waterheight appear in the extreme sunspot years or a little later, the waterheight minimum corresponding to a sunspot maximum year and the waterheight maximum to a sunspot minimum year. The variations in the winter temperature in Stockholm also seem to depend on the sunspot cycle in a familiar way: during the sunspot maximum year or a little later a severe winter or a group of severe winters occurs and during a sunspot minimum year or a little later the temperature during that winter and sometimes the following winters is higher than normal. However, the connection between the sunspot cycle and the winter temperature in Stockholm is not as obvious as that between the cycle and the waterheight variations at Swinemünde.

In order to obtain a more exact idea of the dependence of these factors on the sunspot cycle the material has been grouped according to the extreme sunspot value years. The values of three years around the extreme value year have been taken into consideration. The grouping has been carried out for both the single and the double sunspot cycles. The first double sunspot cycle taken into account is considered as beginning at the sunspot minimum year 1766, the following from the year 1784, and so on. The following abbreviations have been used to indicate the double cycle extreme values: Min_1 for the spot minimum at the start, Max_1 for the immediately succeeding maximum, Min_2 for the next minimum in sequence and Max_2 for the second maximum. The results obtained by grouping are shown in Table 1 as deviations from the average values of all the observation series.

Table 1. Deviations from the average values of the winter temperature in Stockholm and the waterheight at Swinemünde grouped according to the extreme values of the sunspot cycle.

Sunspot extreme	Stockholm		Swinemünde	
	Δt °C	number of cases	Δh cm	number of cases
Min_1	—0.5	9	+1.1	5
Min_2	+0.7	8	+2.4	6
Min_1+Min_2	+0.1	17	+1.8	11
Max_1	—0.1	9	+0.5	6
Max_2	—0.7	9	—1.6	6
Max_1+Max_2	—0.4	18	—0.5	12

It appears from the table that the grouping according to a single cycle shows relatively small deviations from the average during the minimum and the maximum years ($Min_1 + Min_2$ and $Max_1 + Max_2$). On the contrary, the deviations during every second minimum year and the immediately succeeding maximum year (Min_2 and Max_2) have been considerably greater.

This result is confirmed by the distribution of the values in question. In the frequency table (Table 2) $M—\sigma$ and M and $M + \sigma$ have been taken as class limits, where M marks the arithmetical mean value of the whole observation series and σ the dispersion. As above, three years' observations of the extreme spot value years have been taken into account in the distribution table. Thus, the annual average value dispersion of 105 cases of winter temperature in Stockholm and 69 cases of waterheight at Swinemünde have been entered in the table.

Table 2. The frequency percentage of winter temperature (t) in Stockholm and waterheight at Swinemünde (h) during extreme sunspot years.

Sunspot extreme		$M-\sigma$		M		$M+\sigma$		
	t	h	t	h	t	h	t	h
Min_1	22	7	37	33	30	33	11	27
Min_2	17	6	17	28	38	28	29	39
Min_1+Min_2	20	6	27	30	33	30	20	33
Max_1	15	0	33	56	44	33	7	10
Max_2	33	17	33	50	22	28	11	6
Max_1+Max_2	24	8	33	53	33	31	9	8

The frequencies ($Min_1 + Min_2$ and $Max_1 + Max_2$) corresponding to a single cycle show slight evidence of the regularity appearing in Table 1. This is particularly true of the winter temperature in Stockholm during spot minimum years. The frequencies corresponding to a double cycle, on the other hand, clearly show that during Min_2 a relatively large number of winters have been milder than normal and that during Max_2 winters more severe than normal have been relatively numerous. A similar phenomenon is indicated by the frequencies of the waterheight at Swinemünde. The extreme spot value Max_2 last occurred in the year 1937 and the next spot maximum Max_2 will be about 1958. Thus, in accordance with the statistical rule obtained there will be a severe winter or some severe winters in the next years.

It appears from the above that there are greater deviations in the elements considered during a double sunspot cycle than in connection with a single cycle. However, it is doubtful whether this offers sufficient grounds for assuming a corresponding course in the sun's activity. The variations in the electromagnetic radiation of the sun, the solar constant, are so small that the phenomenon in question cannot be considered as caused by them. Variations in corpuscular radiation may, however, have a greater influence. In addition, other complicated atmospheric processes have to be taken into account.

REFERENCES

1. GROISSMAYR, F. B., 1942: Die 24jährige Witterungsperiode. *Annal. d. Hydrogr. u. Marit. Met.*, Heft III, 80—90.
2. HANZLIK, S., 1930: Der Luftdruckeffekt der Sonnenfleckenperiode. *Gerlands Beiträge zur Geophysik*, **28**, 114—125.
3. —»— 1931: Der Luftdruckeffekt der Sonnenfleckenperiode für die Monate Dezember, Januar, Februar und Juni, Juli, August. *Ibid.* 29, 80—90.
4. SIMOJOKI, H., 1954: Die Periodizität der Wintertemperatur in Stockholm und Helsinki. *Fennia*, **78**, 1—11.
5. —»— 1956: Les variations à langues périodes de niveau de la mer dans la Baltique. *Bulletin D'Information du Comite Central D'Oceanographie D'Etude des Cotes*, **6**, 268— 273.
6. WILLETT, H. C., 1949: Long-period fluctuations of the general circulation of the atmosphere. *J. Met.*, **6**, 34—50.