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On the Frequency of the Rhytms appearing in the Annual Course of Temperature with Regard to the Atmospherical Circulation

by

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Abstract

The frequency of the rhythms in the annual course of temperature is shown to be almost constant within a large area. Similarly also circulation index seems to be non-varying.

An examination of the annual course of air temperature as determined on the basis of the mean values of a period shorter than a month, e.g. a week or 5 days, shows that the annual rise and fall in temperature occurs irregularly. The annual temperature curve shows several shorter periods or rhythms with varying length caused by occasional cold spells or relatively warm periods. The present article discusses the conclusions that may be drawn from the number of such oscillations or rhythms during the year as well as the interconnection between these temperature rhythms and the general atmospheric circulation.

The number of temperature rhythms was determined in the following manner: the number of relative minima and maxima occurring in a one-year period was calculated from the temperature curve based upon the mean 5-day or pentad temperature with an accuracy of 0.1° C. Thus no attention was paid to the magnitude of these extremes. Since the number of the relative minima and maxima may differ by 1 from each other during a one-year period, the number of the relative minima occurring during a year will be taken as the number of the temperature rhythms in the following. The meteorological year was defined as the period from the beginning of October to the end of September. It has been shown that the frequency of temperature rhythms is very constant for different years.

Table 1. The frequency of temperature rhythms during a year determined on the basis of pentad temperatures.

Observation station	The frequency of the rhythms			Observation period
	Mean	Minimum	Maximum	
Potsdam	20	18	23	1916/17—30/31
Gothenburg	19	16	21	1921/22—42/43
Helsinki	19	16	23	1921/22—50/51
Karesuando	20	17	23	1921/22—42/43
Jan Mayen	21	19	25	1921/22—38/39
Spitsbergen	19	14	22	1921/22—39/40

In Table 1 the frequency of the temperature rhythms during a year is 19—21 within an area which extends from about 52° lat. (Potsdam) to 78° lat. (Spitsbergen). The maximum frequency of rhythms noted at Jan Mayen probably results from the fact that the amplitudes of the temperature rhythms at this maritime station are small, especially during the summer, relative extremes therefore being more frequent. In determining the frequency of the rhytms the magnitude of their amplitudes has been disregarded. The next largest value noted is that for Karesuando in Lapland. It is self-evident that both local conditions and general climatological conditions within a region influence the temperature course and thus also the frequency of the rhythms. The same average frequency has, however, been found e.g. in the series for Helsinki and Spitsbergen, though at Spitsbergen the extreme values are lower.

Figure 1 shows the frequency values of the temperature rhythms in Helsinki. Similar frequency tables may be worked out for the other stations studied.

As a characteristic of the general circulation the circulation index [1] has been chosen determined as the difference of the pentad values for surface pressure in Helsinki (60° 10′ N, 24° 57′ E) and Oulu (65° 01′ N 25° 27′ E). These stations are situated approximately on the same meridian.

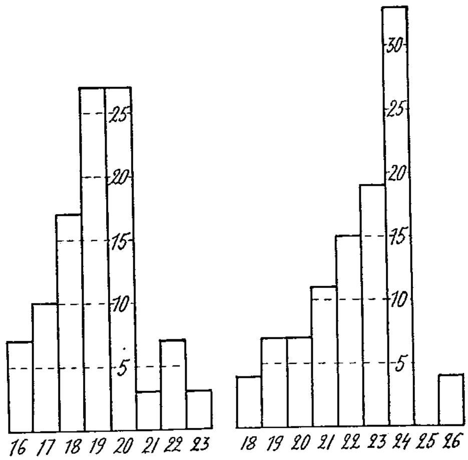

Fig. 1. Frequency distribution (%) of the rhythms for temperature in Helsinki (left) and for the circulation index Helsinki-Oulu (right) 1921/22—50/51.

The pentad values for surface pressure were calculated with an accuracy of 0.1 mm. The circulation index has been determined for the period 1921/22—1950/51. Because of interruptions in the observations the years 1922/23, 1943/44, and 1944/45 have been omitted. This does not, however, influence the character of the results.

The frequency of the rhythms occurring in the course of the circulation index for different years has been determined in the same manner as for temperature. The following result has been obtained : in the annual course of the circulation index an average of 22 rhythms occurs, the smallest value being 18, the largest 26. Figure 1 shows the frequency values for the rhythms of the circulation index. The frequency table has a similar asymmetry as that of the temperature.

Table 2. The average frequencies for the rhytms of circulation index n_c and for temperature n_t in Helsinki at the end of different months, beginning with October.

	O	N	D	J	F	M	A	M	J	J	A	S
n_c	1.8	3.6	5.5	7.3	9.1	11.0	12.8	14.7	16.5	18.4	20.4	22.4
n_t	1.6	3.1	4.8	6.4	8.1	9.6	11.1	12.7	14.0	15.7	17.6	19.1

The average increase in the frequency of the rhythms for the circulation index and for the temperature in Helsinki determined from the beginning of October one year to the end of September another year is given in Table 2. The increase of the circulation index from one month to another is on the whole almost constant, i.e. about 1.9. The increase in the frequency of temperature rhythms is not so regular, although, according to Figure 2, it is on the whole linear. The table shows that not all pressure variations correspond to variations in temperature.

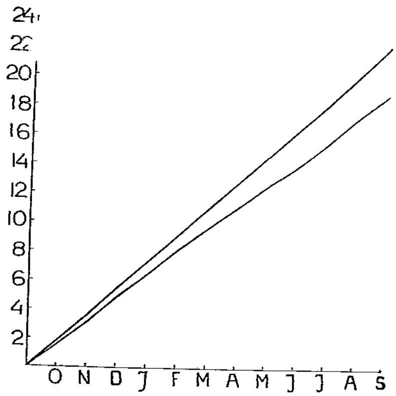

Fig. 2. Cumulative values of the frequencies for the rhythms of the circulation index Helsinki-Oulu (upper) and for temperature in Helsinki (lower) 1921/22—50/51.

The average annual circulation index is given in Figure 3. The largest values of the circulation index appear in autumn and in the beginning of winter, diminishing towards summer. The above-mentioned rhythms are very distinct. Their frequency is greater than during individual years as

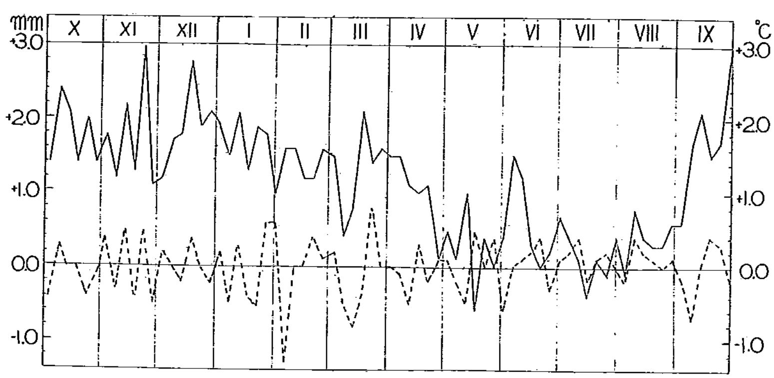

Fig. 3. Mean annual course of the circulation index Helsinki-Oulu (full line) and mean temperature deviations in Helsinki (broken line) 1921/22—50/51.

the time of appearance of the different rhythms varies from year to year. The figure also shows the temperature deviations in Helsinki $\Delta t = t_m - \bar{t}_m$, where t_m is the average value for a given pentad during the period 1921/22 — -50/51 and $\bar{t}_m$ the graphically smoothed average value for the same pentad obtained by calculating the mean values for four consecutive pentads. This smoothing is permissible in that according to the above the average lenght of the temperature rhythms is about 20 days. Because of the considerable smoothing the Δt-values are small, but the figures show a distinct correspondence between these values and the circulation index, especially during autumn and winter. In November correspondence is complete, but later on in the winter the temperature rhythms begin to retard. During summer the correspondence is not as distinct; this may be explained in part by the weak circulation index during this time. It may be noted moreover that the circulation index in summer generally has an opposite influence upon the temperature to that in winter. A study of the individual years gives a more distinct picture of the connexion betveen circulation index and temperature.

Figure 4 represents the course of the circulation index for the years 1929/30 and 1941/42 on the one hand and the deviations of the temperature pentads in Helsinki from the above-mentioned smoothed normal values on

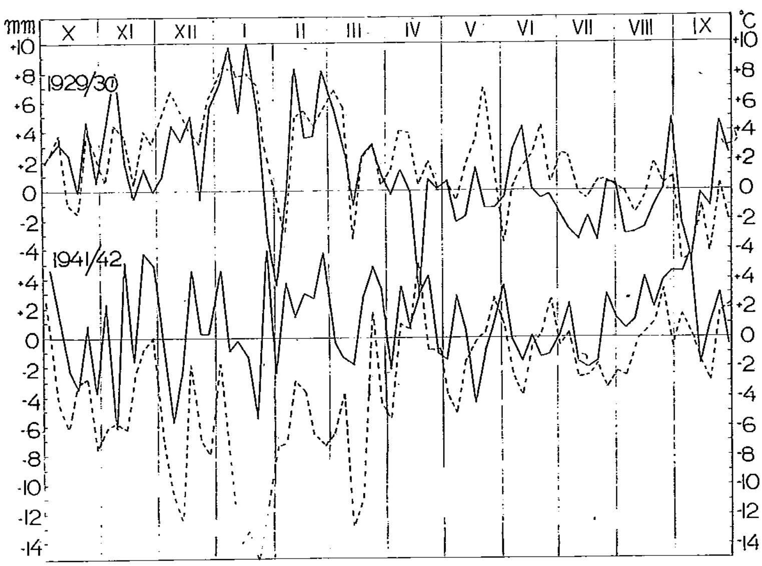

Fig. 4. Circulation index Helsinki-Oulu (full line) and temperature deviations in Helsinki (broken line) for a »mild» and a »cold» winter.

the other. The winter during the former year was exceptionally mild, that of the latter exceptionally cold. The figure shows a prolonged period with a positive circulation index during the mild winter, i.e. continuous warm westerly currents; during the cold winter numerous periods appear with a negative circulation index, i.e. cold easterly currents. The same fact appears from the following values which give the monthly means for the circulation index determined for the 9 mild and the 9 cold winters during the 27 years under consideration. The grouping is based on the average temperature for the months December—March.

	A	S	O	N	D	J	F	M	A	M
Mild winters	1.1	2.4	1.5	2.8	3.7	2.7	2.2	1.3	1.1	0.1 mm
Cold »	0.0	1.1	1.6	1.7	1.3	0.6	0.6	0.7	0.8	0.6 »

The above shows that the difference between cold and mild winters may be noticed even in the circulation index values during August and September. In October the circulation index value is the same in both cases; later on the difference begins to increase again and reaches the maximum in December and January. This result corresponds to the average temperature course during cold and mild winters [2].

During mild winters the length of the rhythms seems to be somewhat greater than during cold winters, particularly in January and February. In March, on the contrary, the length of the rhythms in the group of mild winters is slighly less.

According to the above the frequency of the temperature rhythms during a year is approximately constant. (Its average length is about 18—19 days). The same fact is distinctly noticeable in the annual course of the circulation index. Furthermore, the difference between cold and mild winters may be established in August and September already, though it becomes quite distinct first in December. These results may be utilised in working out long-range weather forecasts.

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