JAPANESE AND EUROPEAN WINTER TEMPERATURES

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THE relationship between the derived 10-year averages of Tokyo winter temperatures 1440–1959 (Gray 1974) and the English Winter Index (EWI) 1100–1959 (Lamb 1966) has been studied. Both these series deal with decade temperatures over the months December, January, February; the former is derived from the freezing data of Lake Suwa, Japan, and the latter is the number of unmistakably mild minus the number of unmistakably severe months per decade in England. The winter of any one year is taken to start in the December of the previous year. Over the years 1700–1949, the correlation coefficient between the EWI and the Central England temperature series (Manley 1959) for the winter season in ten-year blocks is 0·844, so that the EWI is a good indicator of English winter temperatures. Where there are gaps in the Tokyo data as derived from Lake Suwa, in the means for 1870, 1880 and 1890, the measured winter temperature has been used. Both the EWI and the Tokyo winter (TW) series are illustrated in Fig. 1.

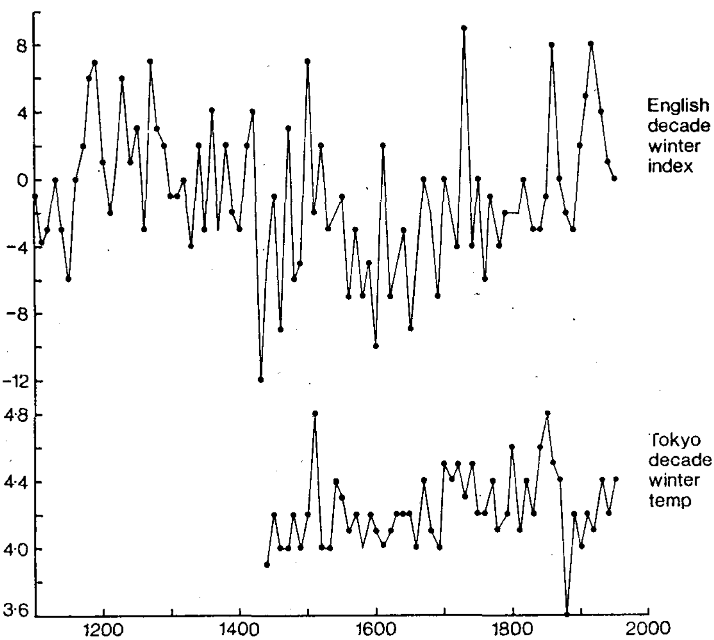

Fig. 1. Decade averages of the Tokyo winter temperatures and English decade winter index

The autocorrelation coefficients of the two series are shown in Figs 2 and 3. It can be seen that both the lag one coefficients are small and should not inflate the cross-coefficients appreciably. No obvious cycles are apparent in the TW, but there is a peak at lag 73 in the EWI which may indicate a periodicity of about 730 years. Some caution is needed however on account of instability of this coefficient at high lag and small sample size; it has not therefore been used for predictive purposes.

The autocorrelation coefficient used above is defined as:

$$r(\text{lag})=\sum_{t=1}^{N-\text{lag}}(x_t-\bar{x})\,(x_{t+\text{lag}}-\bar{x})\;/\;Sx^2.N$$

and for the cross-correlation coefficient, similarly,

$$R(\text{lag})=\sum_{t=1}^{N-\text{lag}}(x_{t+\text{lag}}-\bar{x})\,(y_t-\bar{y})\;/\;Sx.Sy.N$$

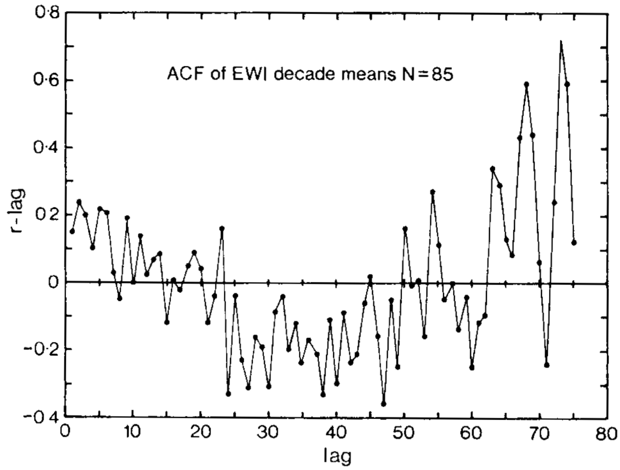

Fig. 2. Autocorrelation coefficients of English winter index

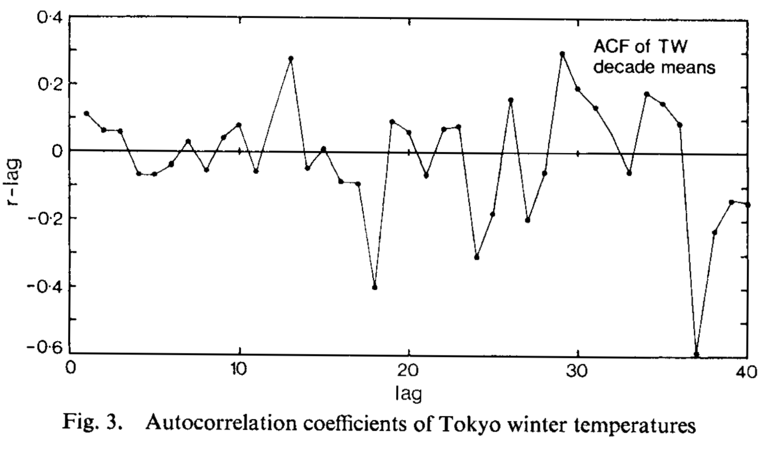

Fig. 3. Autocorrelation coefficients of Tokyo winter temperatures

Where $\bar{x}$ and $\bar{y}$ are the means of the EWI and TW series respectively, Sx and Sy their standard deviations, and N the number of points used in the calculation of any lag. Fig. 4 shows the values of the cross-correlation coefficients between the EWI and the TW. We can see that the maximum value of R(lag) occurs at a lag value of 22 decades.

Wherever a lag relationship appears, there is the possibility of using the lead series to predict values of the lagging series, in this case, the EWI. The values of R(lag) are sufficiently high to suggest that a regression equation could be formed between the TW and the EWI. By a stepwise method, those values of y are selected which increase the multiple regression coefficient (MRC) significantly.

Term	MRC
$Z_t = a + b_1 y_{t-22}$	0·450
$+ b_2 y_{t-19}$	0·578
$+ b_3 y_{t-16}$	0·625
$+ b_4 y_{t-10}$	0·642
$+ b_5 y_{t-7}$	0·654

The addition of further terms does not improve the MRC noticeably. Then

$$Z_t = a + b_1 y_{t-22} + b_2 y_{t-19} + b_3 y_{t-16} + b_4 y_{t-10} + b_5 y_{t-7}$$

is a prediction of the x or EWI series. The values of the constants are listed below:

$a = -95{\cdot}32$	$b_3 = 5{\cdot}36$
$b_1 = 8{\cdot}12$	$b_4 = 2{\cdot}26$
$b_2 = 4{\cdot}11$	$b_5 = 2{\cdot}63$

these give a multiple regression coefficient of 0·654 which accounts for 43 per cent of the x series. For this method of prediction to be valid, we must show that the residuals $n_t = Z_t - x_t$ are normally distributed random variables. We have a mean and standard deviation of the n distribution of 0·0 and 3·0 respectively, with third and fourth moments of 0·3 and 2·7, showing that the distribution is

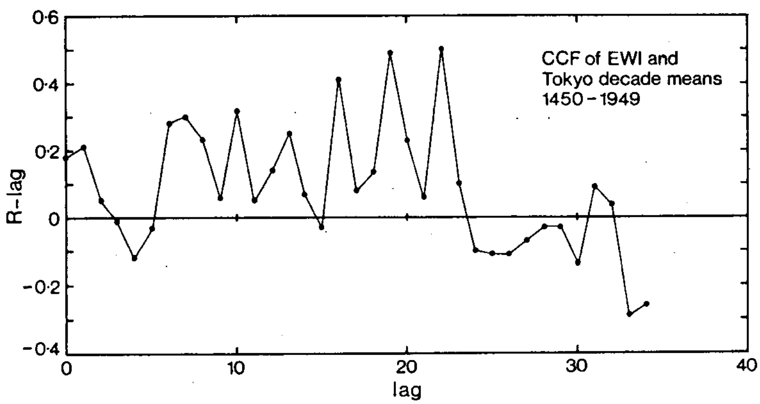

Fig. 4. Cross-correlation coefficients between the English winter index and the Tokyo winter temperatures

approximately normal. The first two autocorrelation coefficients of the n series are $-0{\cdot}12$ and $0{\cdot}03$, indicating randomness. The Durbin-Watson statistic $d=\sum(\Delta n)^2 / \sum n^2=2{\cdot}21$, which is well above the 1 per cent confidence limit at 5 degrees of freedom of $1{\cdot}62$ for $N=28$, shows that the residuals are not serially correlated.

We see from the graph in Fig. 5 that the agreement between the predicted and actual series is good in the early part of the range, and less good as the number of steps increases. We can check the predicted values for 1950–59, 1960–69 and 1970–79 by comparison with the measured Central England winter temperatures (CEWT) for 1950–74.

CEWT (1700–1949) Mean$=3{\cdot}73$°C, $Sx=1{\cdot}29$

EWI (1670–1949) Mean$=-0{\cdot}393$, $Sx=3{\cdot}95$

Then we can derive a regression equation between the CEWT and the EWI.

$$\mathrm{EWI}+0{\cdot}393=(3{\cdot}95/1{\cdot}29)\{0{\cdot}844\,(\mathrm{CEWT}-3{\cdot}73)\}$$

which gives us the following results:

Period	CEWT (°C)	CEWT prediction (°C)	EWI	EWI prediction
1950–59	3·89	3·69	0	−0·3
1960–69	3·55	5·81	−0·9	5·2
1970–74	4·76	3·17	2·4	−1·9
Mean	4·07	4·15	0·5	1·0

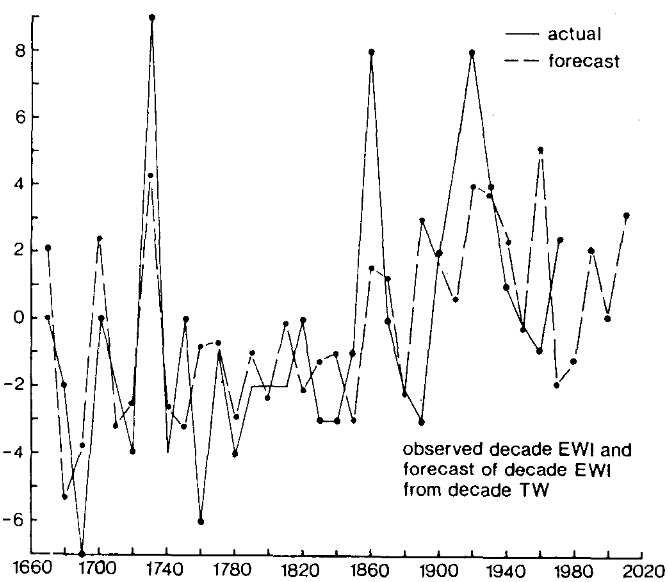

Fig. 5. Actual English winter index compared with that forecast from the Tokyo series

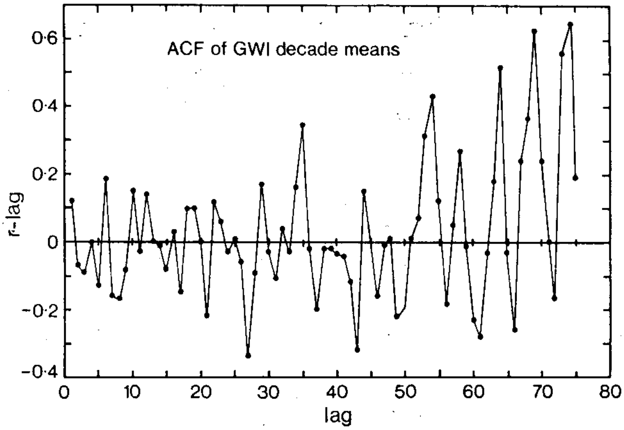

Fig. 6. Autocorrelation coefficients of the German winter series

Clearly the agreement is not good decade by decade, but the mean CEWT of 4·2°C predicted for 1950–79 is not far from the actual value measured, 4·1°C for 1950–74. The total EWI value predicted for 1900–1949 is 11·3 and the actual measured total was 20. The predicted value for 1950–1999 is 3·9, a considerable fall from the preceding fifty-year value. This corresponds to a CEWT predicted mean of 4·15°C, as against the 1900–1949 mean CEWT value of 4·20°C.

Similar series to the EWI are available for Germany at about 10°E longitude (GWI) (Fig. 6) and Russia at about 35°E longitude (RWI) (Fig. 7) from the same source. If we look at the cross-correlation coefficients between the GWI and TW,

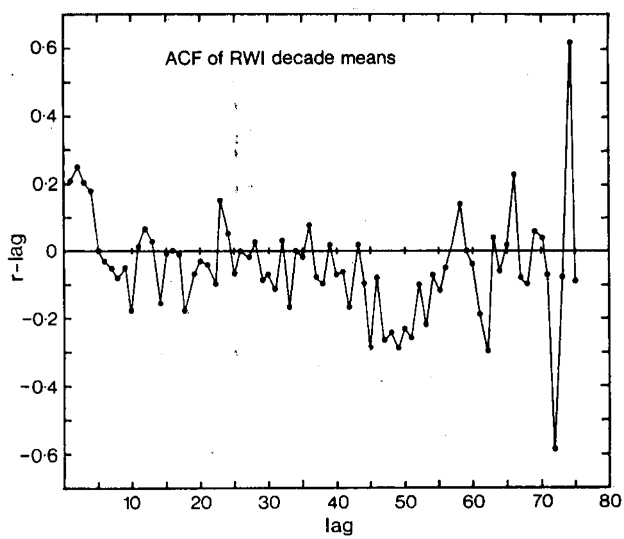

Fig. 7. Autocorrelation coefficients of the Russian winter series

TABLE 1. Philadelphia winter temperatures (PW) 1738–1968 (°F)

Decade	Temp (°F)	50-yr Mean	Decade	Temp (°F)	50-yr Mean
1738–39	33·0				
1740	34·8	33·9 (12)			
1750	36·8		1850	33·1	
1760	36·4		1860	33·0	
1770	35·4		1870	33·4	
1780	31·6		1880	33·7	
1790	33·1	34·7	1890	33·6	33·4
1800	34·7		1900	32·6	
1810	31·4		1910	33·6	
1820	33·8		1920	35·1	
1830	31·9		1930	35·1	
1840	33·4	33·0	1940	34·9	34·3
			1950	35·3	
			1960–68	32·2	33·8 (18)

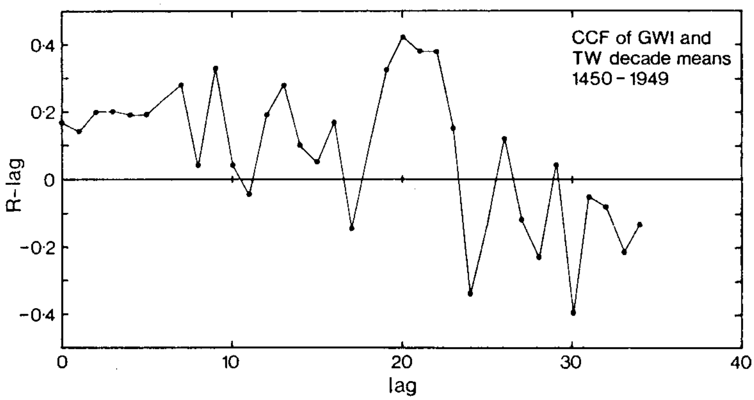

Fig. 8. Cross-correlation coefficients between the German and Tokyo winter series

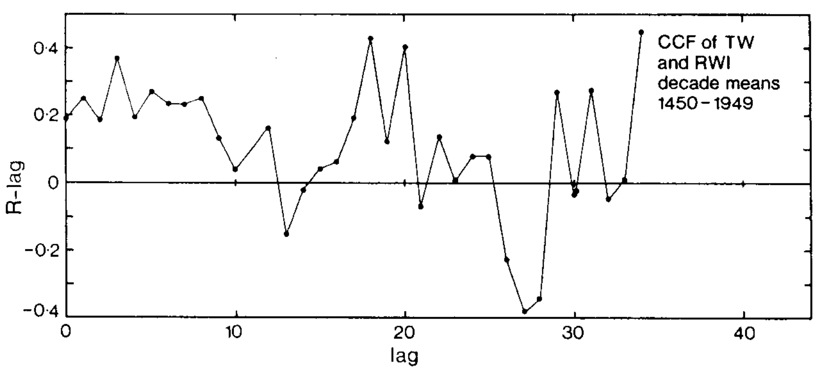

Fig. 9. Cross-correlation coefficients between the Russian and Tokyo winter series

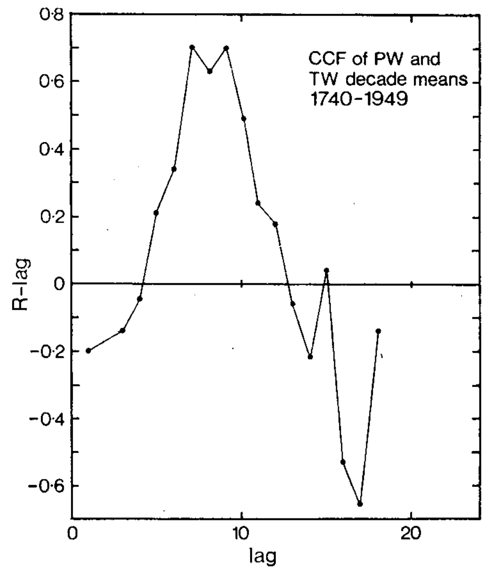

Fig. 10. Cross-correlation coefficients between the Philadelphia and Tokyo winter series

and the RWI and TW, we see that the maximum value of R(lag) for the GWI arises at a lag of 200 years, and for the RWI at 180 years lag (Figs. 8 and 9).

By comparison with Europe, we may examine the Philadelphia decade winter temperature estimates 1760–1960 (Landsberg *et al.* 1968), listed in Table 1. Cross-correlation coefficients between this series (PW), and TW are shown in Fig. 10, and the autocorrelation coefficients for the PW series in Fig. 11. There is

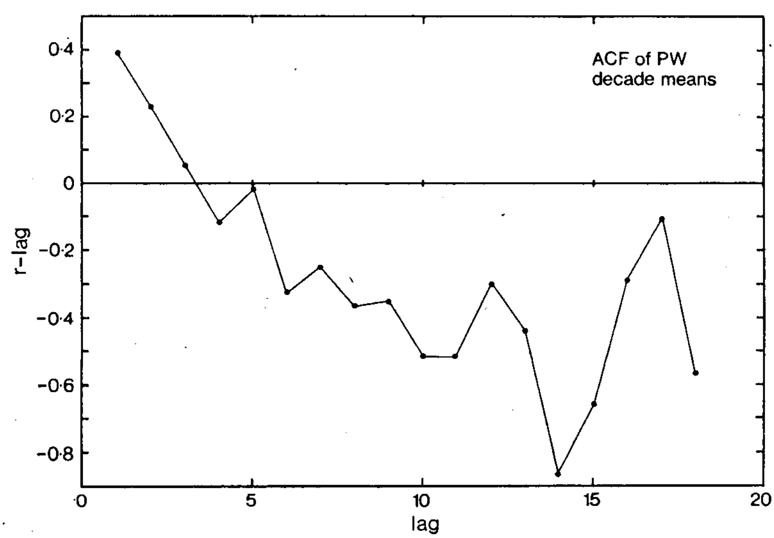

Fig. 11. Autocorrelation coefficients of the Philadelphia series

an autocorrelation coefficient of $-0{\cdot}866$ at a lag of 140 years, which is 1 per cent significant with 12 degrees of freedom, and suggests a possible 280-year cycle in the Philadelphia record. If we suppose this to be true, it implies that the high value of R(lag) at 70 years lag would be followed by another high value at lag 350 years.

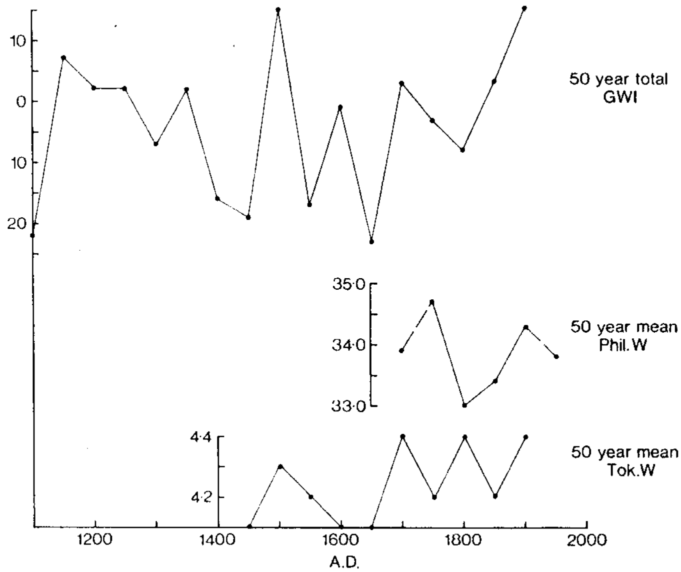

Fig. 12(a). Fifty-year averages for the German, Philadelphia, and Tokyo series

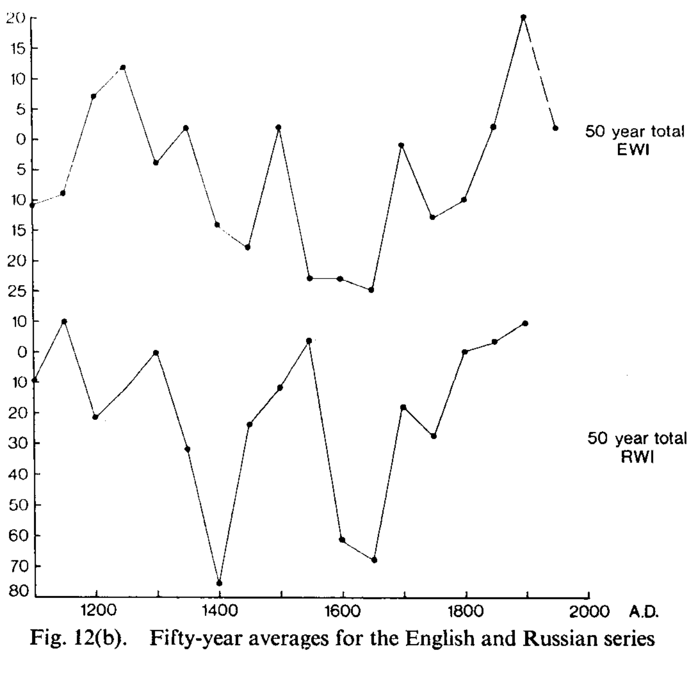

Fig. 12(b). Fifty-year averages for the English and Russian series

TABLE 2. A comparison of 50-year estimates of China temperatures and Japanese winter temperatures

50-yr Period	Japan	China
1450	4·1	
1500	4·3	Medium
1550	4·2	Warm
1600	4·1	Medium
1650	4·1	Cold
1700	4·4	Cold
1750	4·2	Medium
1800	4·4	Warm
1850	4·2	Cold
1900	4·1	Warm

Fig. 12 shows the 50-year averages for the TW, PW series, and 50-year totals for the three European series. From the 25 years data available after 1950, we have an estimate for the PW and EWI series, which appears to agree with the fall in TW from 1700 to 1750.

From the curves of temperature estimates in China published by Chu Ko-chen (1972), we can make a rough approximation to 50-year block means in China. The curves published are assumed to contain annual estimates. Table 2 compares these 50-year estimates with the 50-year TW averages. We see that from 1500–1750, China, at an estimated average longitude of 110°E, showed a typical lag of 50 years behind Japan.

DISCUSSION

A curious and unexplained result now emerges. If we divide the longitudinal distance in degrees westward from Tokyo by the number of years which give a maximum value of R(log) against the TW series we have the following result:

	Years lag	Deg. west of Tokyo	Result (deg/yr)
China	50	30	0·60
Russia	180	105	0·58
Germany	200	122	0·61
England	220	140	0·64
Philadelphia	350	220	0·63

It is as though a disturbance was being propagated around the hemisphere westwards with a mean speed of 0·61 degrees longitude per year which is equivalent to 590 years for passage right around the hemisphere. This disturbance produces the same sense of temperature swing at each location in turn, but it cannot be an actual temperature wave, as the maximum range is smaller at Tokyo (0·3 deg C or 0·54 deg F) than at Philadelphia (1·5 deg F).

King (1974) has suggested that a cold wave passed slowly westwards around the northern hemisphere from the Far East in the twelfth century to western

Europe in the seventeenth century. The findings of this paper support this idea in so far as we see a warm wave, presumably, a recovery period, passing in the same way from Japan in the sixteenth century to Europe in the eighteenth century. This is presumably one aspect, probably hitherto unrecognised, of the behaviour of wave number one, which expresses the eccentricity of the circumpolar vortex.

The phenomenon studied accounts for less than half of the variance of the decade mean winter temperatures. The remaining variance almost certainly includes the world wide peaks and troughs of climate, such as the global aspects of the Little Ice Age and the global warming peaking at 1900–1950.

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SOME GENERAL PRECIPITATION—RIVER FLOW RELATIONSHIPS IN ENGLAND AND WALES

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SABBAGH and Bryson (1962) and Horn and Bryson (1960) have presented excellent analyses of the timing of maximum precipitation throughout the United States. The purpose of this brief paper is to analyse for a limited number of stations in England and Wales both the timing of maximum precipitation and the timing of maximum riverflow and to attempt an interpretation of the resulting spatial patterns.

A popular technique in the analysis of precipitation and river flow time series is harmonic analysis (Craddock 1968; Brooks and Carruthers 1953). This is so since it allows both the temporal and spatial distributions of such series to be described objectively. The basis of the technique is that sine curves of different frequencies can be summed to reproduce a time series of empirical data. In the fitting of the curves to the data the amplitude and phase (the time of occurrence of the maxima or minima) are the only aspects of the curves which are modified. The reader is referred to Brooks