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CORRESPONDENCE

Comments on "Biennial Variation in Springtime Temperature and Total Ozone in Extratropical Latitudes"

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In two recent contributions to the *Monthly Weather Review* by Angell and Korshover (1967, 1968), evidence was presented for the existence of long-term periodicities of the order of 16 to 20 yr in the even- minus odd-year differences of selected parameters. It was suggested that they may be due to the modulation of the annual cycle by the quasi-biennial cycle.

It is the purpose of this note to show that these long-term periodicities can be induced by the method of analysis whenever quasi-biennial components are present in the original data.

The analysis procedure used by Angell and Korshover to emphasize the year-to-year variations of various mean parameters is similar to the "difference periodogram" technique of Brooks (1924). The difference periodogram is constructed by taking differences of successive mean values for time sections of length U, reversing the sign of the alternate differences, and smoothing the resulting series. If the original data contain an oscillation of period P, then an appropriate choice of U leads to a more easily recognized oscillation of a longer period. If the resulting difference curve is simple and shows regular fluctuations, its amplitude and period can be read off; and the original periodicity can be calculated as follows.

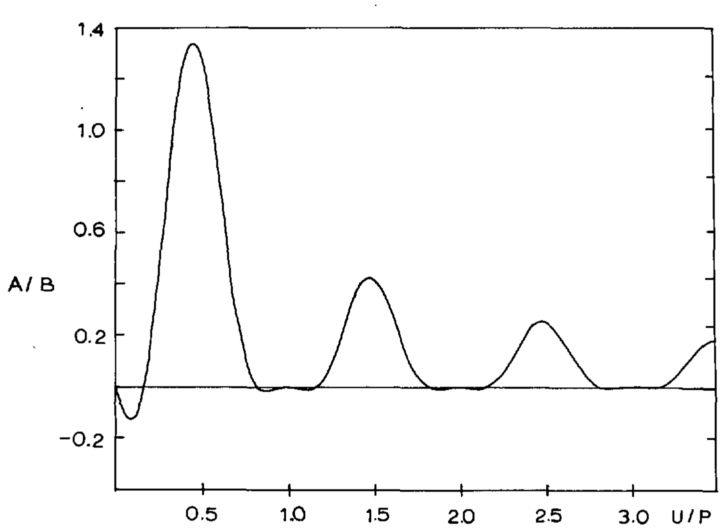

FIGURE 1.—The variation of amplitude ratio A/B with the ratio U/P.

Let the smoothed difference curve represent a periodic function of amplitude A and period C, and the original oscillation have amplitude B, period P, and phase ϕ. Then it can be shown for a difference curve smoothed by three-term running means that

$$A/B=(2/3\pi)(P/U)\sin^2(\pi U/P)[4\sin^2(\pi U/P)-1]. \quad (1)$$

For $P>U$ and $C>2U$, two alternative period and phase relations exist:

$$P=2\,CU/(C+2U),\ \phi=2\pi-2\pi T_0/C \quad (2)$$

or

$$P=2CU/(C-2U),\ \phi=2\pi T_0/C \quad (3)$$

where T_0 is the time of the first maximum of the difference curve.

The filter characteristics of the procedure are shown in figure 1. It is seen that for $U/P=0.25$, 0.65, the amplitude ratio A/B is reduced to half; but in the range $0.29<U/P>0.53$, the original amplitudes are preserved or even enhanced. Thus, a choice of a value of U near 0.5 P causes the selective amplification of the period P. The method breaks down for $U=0.5\,P$. The ambiguity in the determination of P by (2) or (3) can be resolved by constructing two or more difference curves for slightly varying values of U.

If this method is to be used for the filtering of quasi-biennial periodicities, then U must obviously be near 1 yr, and C is expected to lie in the range of 10 to 30 yr.

As an example, the method has been applied to the analysis of 100-mb monthly mean temperatures for a number of stations in a Southern Hemisphere quasi-meridional Pacific cross section, which is similar to but not identical with the cross section in the contribution by Angell and Korshover (1967). The annual cycle has been eliminated from the data by subtracting the long-period monthly means. The difference curves for 1-yr time sections are shown in figure 2. The estimated periods of these curves are also given where they could be determined with some accuracy. The difference curves show shorter period oscillations at the low-latitude stations, and there is no suggestion of a poleward progression of phase as noted by Angell and Korshover (1967). Besides the latitudinal variations, the difference curves at each station also show variations from season to season. The periods, which during the spring (fig. 3) range from about 10 yr at Canton Island to 21 yr at higher latitudes, are only about half as large during the autumn (fig. 4).

It is doubtful whether meaningful interpretations can be made of the difference periodogram oscillations

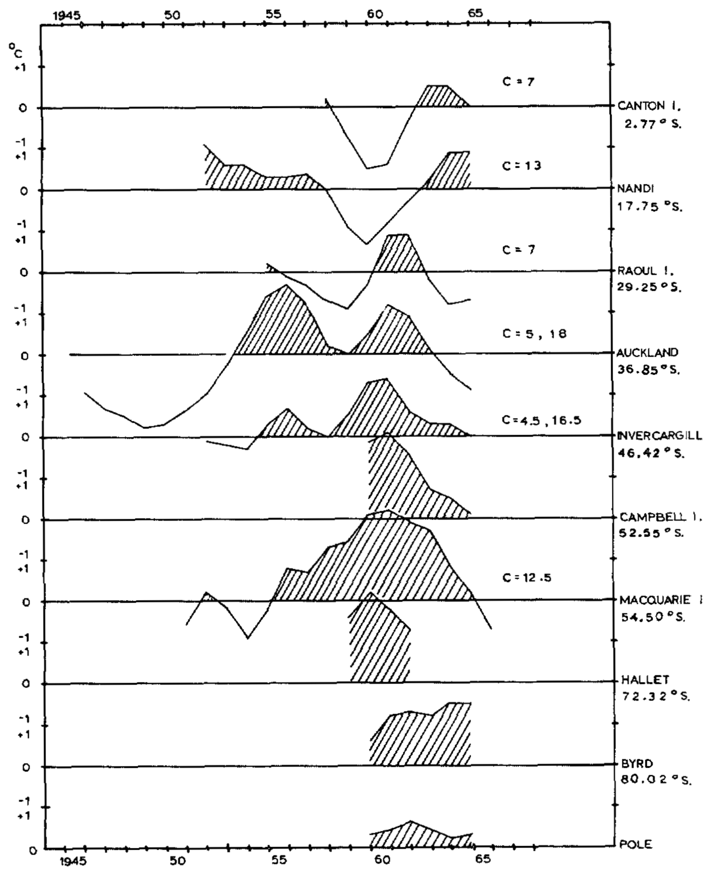

FIGURE 2.—Difference curves of the yearly mean 100-mb temperatures. Estimated periods (C) are given in years.

resulting from the year-to-year differences of individual seasons. After applying equations (2) and (3), two sets of periods are obtained for the original series. The shorter periods calculated from (2) increase poleward and range from 20 to 22 mo in the spring and 18 to 21 mo in the autumn. The alternative longer periods obtained from (3) decrease poleward with corresponding values of 30 to 26 mo in spring and 35 to 27 mo in autumn. Because of the discontinuous nature of the seasonal data, a choice between these alternative periods cannot be made by the construction of further difference curves for varying time sections. This can be done, however, for the continuous series of monthly mean temperature departures by the use of two more averaging periods of 8 and 15 mo, together with the yearly averages discussed above. The comparison of periods calculated by equations (2) and (3) from all three sets of curves led to the adoption of the following values of the original oscillations: 33 mo at Canton Island and 21 or 22 mo at all other stations. These periods agree closely with the principal periods derived from spectral analysis of similar temperature data (Farkas, 1964, and unpublished analysis).

It can be concluded that, because of its simplicity, the difference periodogram method might be used to advantage in the preliminary search for the existence of quasi-biennial periodicities in a long series of data only. The evaluation of difference curves is uncertain when their expected periods and the length of the originating series of data are of the same order. This was the case in both the present example and in the stratospheric temperature analysis presented in the contribution by Angell and Korshover (1967), and it may partly account for their different results.

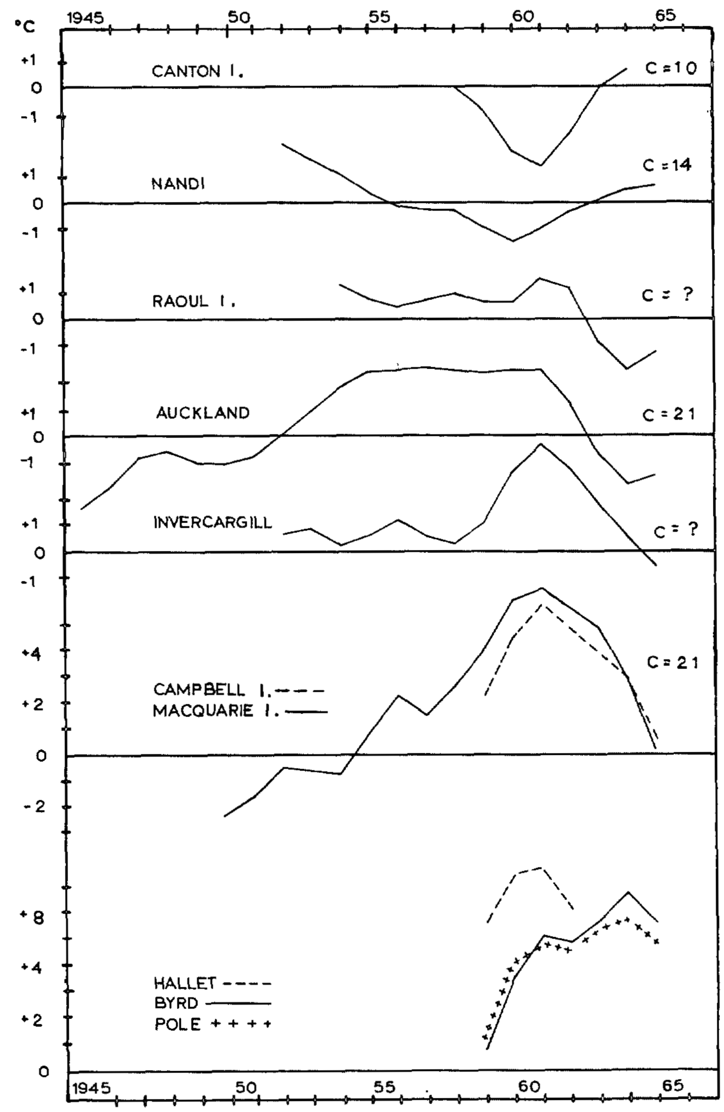

FIGURE 3.—Difference curves of the 100-mb mean temperatures for the spring (September–November).

REFERENCES

Angell, J. K., and Korshover, J., "Biennial Variation in Springtime Temperature and Total Ozone in Extratropical Latitudes," *Monthly Weather Review*, Vol. 95, No. 11, Nov. **1967**, pp. 757–762.

Angell, J. K., and Korshover, J., "Additional Evidence for Quasi-Biennial Variations in Tropospheric Parameters," *Monthly Weather Review*, Vol. 96, No. 11, Nov. **1968**, pp. 778–784.

Brooks, C. E. P., "The Difference Periodogram—A Method for the Rapid Determination of Short Periodicities," *Proceedings of the Royal Society of London*, Ser. A., Vol. 105, Mar. **1924**, pp. 346–359.

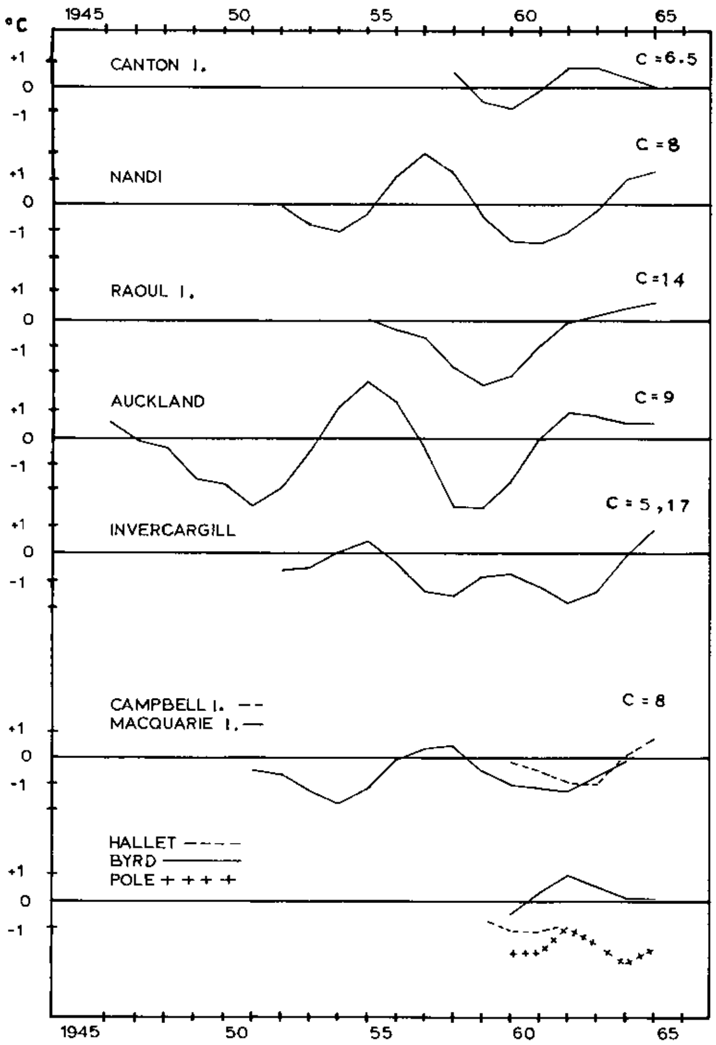

FIGURE 4.—Difference curves of the 100-mb mean temperatures for the autumn (March–May).

Farkas, E., "Long-Period Fluctuations of Upper Level Winds and Temperatures over the South Pacific," *Proceedings of the Symposium on Tropical Meteorology, Rotorua, New Zealand, November 1963*, New Zealand Meteorological Service, Wellington, **1964**, pp. 180–189.

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Reply

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We wish to thank Farkas for pointing out the similarity of our differencing technique to the "difference periodogram" of Brooks. We admit to not being aware of either the Brooks reference or his "difference periodogram." However, we do not believe that Farkas has demonstrated the inadequacy of our technique by means of her analysis. In fact, her figures 2 and 3 appear to support our findings. In both figures, there is evidence for an out-of-phase relation between tropical and temperate latitudes as well as some evidence for a poleward progression of phase in temperate and polar latitudes. Furthermore, the trend is much clearer in figure 3 (spring) than in figure 4 (fall), also in agreement with our findings. Farkas may be quite correct, however, in emphasizing the uncertainty in the differencing technique when the data record is of the same length as the periodicity sought, and this will be considered in future analyses.

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