matters arising

Temperature cycle in the North Pacific

SIR,—I suggest that the evidence presented by Favorite and McLain[1] for trans-Pacific displacement of temperature anomalies at the ocean surface, is far from conclusive and that there is no evidence that waves progress around the North Pacific gyre.

The eastward advance of the anomalies across the Pacific Ocean from 1954 to 1960 is not immediately obvious or orderly. An explanation of the widespread warming in 1955 of the eastern Pacific between 35°N and 40°N, in terms of an eastward displacement of the maximum, implies a rate of advance of some 15 km d^{-1}. This is about three times greater than the generally accepted pattern of geostrophic flow, which is slightly more than 5 km d^{-1}. Similarly, the rate of advance of the positive anomaly from the western side to the eastern side of the ocean from 1956 to 1957 would have been some 15–20 km d^{-1}. Conversely, there was very little change from 1958 to 1960, when, according to the proposed hypothesis, the negative anomaly should have progressed eastwards to embrace the western coast of North America. Another discrepancy is the westward movement of the negative anomaly in the eastern Pacific from 1955 to 1956.

If the rate of advance of the temperature anomalies, indicated by geostrophic calculations, is slightly more than 5 km d^{-1} and the circumference of the North Pacific gyre is some 18,000 km, then the time required for a water parcel to complete one circuit would be nearer 9 yr than the 6 yr suggested.

Suggestions that there is evidence of the temperature cycle as far back as 1930 in the western subartic region carry little weight in view of the statement that "it is difficult to establish normal conditions at any time or place that would allow the detection of anomalous conditions in a water column at the western side of the ocean."

A simpler explanation of the 5–6 yr cycle in sea surface temperature anomalies in the North Pacific is that heating and cooling occur *in situ*. Baur[2] has shown that the intensity of the solar beam undergoes a double systematic variation, amounting to 0.5%, within the 11-yr sunspot cycle, with primary maximum strength at about 0.4 of the rising phase and a secondary maximum at about 0.6 of the declining phase of solar disturbance; a sharp minimum of the solar constant occurs just before sunspot minimum, with a secondary minimum at about 0.6 of the rising phase. These variations of the solar constant have been applied to the known years of sunspot extremes from 1950 to 1968 (ref. 3). Figure 1 shows that there is a high positive correlation between sea surface temperature anomalies in the North Pacific, and fluctuations of the solar constant.

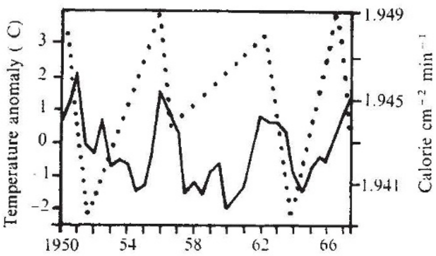

FIG. 1 ——— semiannual anomalies of mean sea surface temperature in Marsden square 163, quadrant 1 (40–45°N, 170–175°E) from 20 yr mean, 1948–67 (from ref. 1). Average variation of solar constant from phase to phase of the 11 yr sunspot cycle[2] applied to the sunspot extremes[3].

There are other well documented relationships between variations in the output of solar energy and meteorological and climatological phenomena. The height of the tropopause at Leopoldville, near the equator, rose by more than 1 km between the 1954 solar minimum and the 1957 maximum (ref. 4). This could be interpreted as resulting from a strengthening of the ascending branch of the Hadley cell associated with greater energy transfers in the atmosphere at the time of increasing output of solar radiation. In East Africa, the level of Lake Victoria was highest in 1952, 1957 and 1964, some 1–2 yr after maxima[3] of the solar constant. Again, an increase in surface heating at the time of maximum solar output would lead to an increase in convection and thus to an increased tropical rainfall. In European Russia there were sharp fluctuations in the mean temperature from month to month at times when solar activity was increasing in 1956–57[5] and in 1967–69[3]. The strength of the westerlies over New Zealand tended to increase about 10 months after rises of solar activity (B. N. Parker, unpublished information). More generally, large fluctuations of Baur's solar index[6] in the extreme sunspot cycles since about 1940 coincide with decades of increased variability of wind circulation, with falling values of indices of the strength of the zonal windstreams and with increasing variance of climatic elements in many parts of the world[3]. Processes by which solar activity may influence weather and climate are discussed by Lamb[3].

Thus, the 5–6 yr temperature cycle in the North Pacific could possibly be caused by systematic variations of surface heating resulting from variations in the output of solar energy during the 11-year sunspot cycle. This simple pattern would be modified by ocean–atmosphere interactions and quasistationary waves, to produce regional variations in the timing of the maxima and minima. The geographical distribution of temperature anomalies at each phase of the sunspot cycle would then not be expected to be the same in each cycle. In fact the coherence evident during the 1958–60 cycle was not readily apparent during 1948–52 or 1961–67 (ref. 1). It is to be expected that the effects of these variations in the output of solar energy should also be evident in temperature anomalies in other oceans.

Yours faithfully,

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Macromolecular structures for undergraduates

MEYER[1] and Feldman *et al.*[2] describe the use of computer displays for the three-dimensional study of macromolecular structures. They suggest that, in the near future, such systems will be available for teaching purposes. As students we should like to point out that computer graphics have disadvantages for teaching in England, and that there are now available molecular models which may be used to emphasise different aspects of structure in an immediately