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On the determination of K-indices by computer

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At a magnetic observatory, a 'K-index' is assigned to each 3 h interval of recording to be a measure of whether conditions were quiet or active during this time. A K-index measures the maximum amplitude of disturbance variations, independent of the regular daily (or solar diurnal) variation. The numbers used for K-indices are the digits from 0 to 9, with higher numbers corresponding to greater magnetic activity. The K-index scale is quasi-logarithmic, and may be thought of as being like the magnitude scale for earthquakes in seismology. Thus K = 0 means very quiet magnetic conditions and K = 9 means a very strong magnetic storm. More information on K-index scales is given in Parkinson (1983).

The K-index was proposed in 1939 to classify the range of geomagnetic variations, and was soon adopted internationally to become the most widely used of all geomagnetic indices. Traditionally the K-index has been scaled manually by experienced observers. However, since the introduction of automatic digital geomagnetic observatories and the universal accessibility of computers, the traditional method of scaling K-indices has increasingly come under challenge in favour of automated scaling.

The principal difficulty in the determination of K-indices is the estimation and elimination of the non-K variations, in particular the regular solar diurnal variation or S_R. This subject is well documented. Over the past 25 years a number of techniques for estimating the non-K variations by computer have been presented (Alldredge 1960; Mayaud 1967; Van Wijk & Nagtegaal 1977; Rangarajan & Murty 1980; Riddick & Stuart 1984). As well as reducing the effort to produce K-indices these methods have been said to eliminate the subjectivity which is inevitably introduced by hand scaling. Ever since the notion of the automatic K-index was introduced argument has ensued with the traditionalists insisting that the K-index must be scaled without deviation from the rules set down for scaling by hand. By use of these rules, subjectivity was said to be virtually eliminated if hand scaling was performed by an experienced observer.

The computer methods which have been proposed for estimation of the S_R fall broadly into the categories: the use of nearby quiet days from which a mean quiet day and S_R is estimated which is assumed appropriate for the day to be scaled; the filtering of the data on the day to be scaled and assuming the long-period harmonics (3–6 hours) approximate the S_R; and a combination of both methods, where the long-period harmonics of the mean quiet day estimate the S_R.

Although none of the methods follow the rules set down for the estimation of non-K variations, their proponents would argue that this is unimportant since the consistency of computer produced indices compared with those hand scaled is comparable with the consistency between different observers hand scaling the same magnetogram.

Of the described techniques for estimating the S_R by computer, those which utilize nearby quiet days, seem, in principle, the least satisfactory, retaining vestiges of the so called 'iron-curve' method (Bartels 1957). They are unable to take proper account of the day-to-day variability in S_R; and still have an element of subjectivity in the choice of nearby quiet days. Alternatively, the method of filtering the data on the day to be scaled and approximating the S_R by long-period harmonics, whilst not utilizing information from nearby quiet days, cannot be corrupted by them either. The method does assume however that the S_R and K-variations have non-overlapping frequency spectra.

An harmonic analysis method to estimate the S_R has been applied to both quiet and disturbed magnetic conditions at the new digital magnetic observatory at Charters Towers, Australia. By consideration of power spectra it was found that during magnetically quiet conditions there was little power in both the *H* and *D* geomagnetic components, at periods less than approximately 4 h (Fig. 1) and this could be considered a convenient period at which to separate the non-K from the K-variations. Applications to magnetically disturbed periods proved the criterion to be inadequate since it became evident that K-variations did exist with periods greater than that of cut-off, leading to the underestimation of some K-indices (Fig. 2). Increasing the cut-off period leads to their overestimation during quiet periods.

It is concluded that, unless the definition of the computer generated version of the K-index is re-defined then its determination by computer must more closely follow the traditional criteria as used in hand scaling. To this end it is suggested that a functional expression for the S_R be defined, the parameters of which are allowed to vary within limits appropriate to the station and perhaps the ambient magnetic conditions as determined by the variance. Such a scheme is, in principle, similar to the harmonic analysis approach; the only difference is that a more specific function would be fitted, which also would have constraints on its parameters. The analogy with the 'experienced observer' is in the choice of function and limits of variability of its parameters.

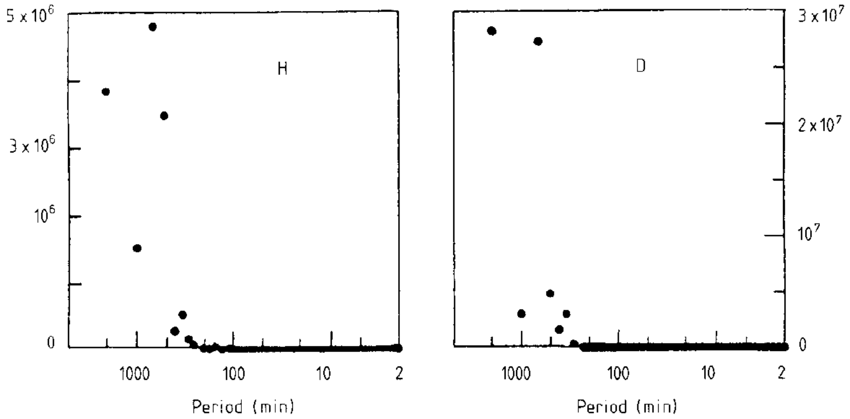

Fig 1 Power-spectra of geomagnetic variations in H and D components on a quiet day (4 February 1985) at Charter Towers.

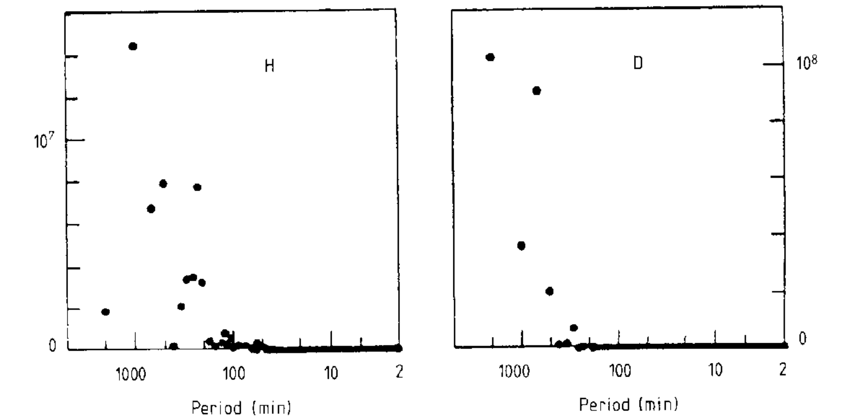

Fig 2 Power-spectra of geomagnetic variations in H and D components on a disturbed day (9 January 1985) at Charter Towers.

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