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COMMENT ON 'EVIDENCE FOR STRONG ARTIFICIAL COMPONENTS OF THE EQUIVALENT LINEAR AMPLITUDE GEOMAGNETIC INDICES' BY D. M. BUBENIK AND A. C. FRASER-SMITH

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We wish to comment on some of the conclusions stated by Bubenik and Fraser-Smith [1977] because they could be misleading. Basically, the judgement made on the magnetic indices is taken only from a statistical point of view (a study of the frequency distributions) without considering the geophysical properties of the phenomenon to be measured in a continuous way.

A first example of this misunderstanding is the following sentence: 'thus on the basis of this study of their frequency distributions, neither aa (or Aa) nor ap (or Ap) appears to have a definite advantage over the other as an index of worldwide geomagnetic activity during intervals for which both indices are available.' This statement is true if one considers only the frequency distributions, but it is a narrow view of the problem. (1) One knows that the magnetic activity varies with local time, with latitudes, from one hemisphere to another. Then the ap index derived from six European stations, four North American stations, and only one Australasian station which are given the same weight in the computation (note that two supplementary stations presently used - Lovo and Toolangi - are associated with the weight 1 to Rude Skov and Amberly) cannot seriously be said to be a planetary index. This is all the more true, since frequency distributions of the K indices at the Kp stations vary greatly from some stations to others because of differences in latitudes and K indices for a given 3-hour interval are averaged without taking such differences into account; a supplementary heterogeneity in longitude is thus introduced. The aa index does not suffer from this defect, since the same weight is given to two stations that are approximately antipodal and as with the am index, an attempt is made to take latitude differences into account. (2) The Kp index is obtained by averaging the standardized K indices of the Kp observatories, corresponding to a geometrical mean of the amplitudes. Such a process is certainly less correct than the use of an arithmetic mean as made with the aa (or am) index. (3) The standardized K indices used in the Kp computation aim at eliminating the local time variation of the magnetic activity of each station. The process used is such that it increases the activity level to the nighttime level; then the Kp index does not give the true level of the activity but a pseudo nighttime level. Furthermore, values thus obtained are more or less distorted because the local time of the activity maximum at each Kp observatory varies and the single local time chosen for all of them introduces spurious effects. With the aa (or am) indices, one aims at eliminating the local time variation of the activity by the use of a uniform distribution in longitude of the stations. (4) The homogeneity of the ap series also suffers from various severe discontinuities. First, the sample which formed the basis for the conversion tables of the K indices into Ks indices (K standardized) is too short ($3\frac{1}{2}$ years) and nonrepresentative; in particular, it does not contain years with extensive M region activity. Second, these conversion tables are strongly contaminated by wrong K scalings using the iron curve method (elimination of an average Sq daily variation instead of that of the regular variation S_R for the day in question); so there is feedback from these incorrect scalings in the present computation. Third, no new conversion tables have been computed at the time of the change of sites, which are Cheltenham-Fredericksburg, Abinger-Hartland, Agincourt-Ottawa, and soon Amberley-Lauder and Toolangi-Canberra. The aa series does not suffer from such defects. No conversion tables are needed. K scalings have been checked and remade if necessary. Changes of sites have been taken into account, which explains the 'complex process of correction'. this last fact is obviously one of the causes of the irregularities of the aa distribution displayed by Bubenik and Fraser-Smith in their Figure 3; the main cause is, however, the difference, in local time, between the two antipodal stations (see Table 1 of Mayaud [1976] for the various sets of K indices observed at both stations). (5) Only the use of a large number of stations in each hemisphere (made with the am index) can overcome that difficulty. However, when one is judging the aa series, one must not forget the goal for which it was established: to provide the scientific community with a series longer than the Ci series but one that is quantitative and homogeneous (the Ci series does not possess these two characteristics). When one of us constructed the aa series he did not pretend to establish a 3-hour planetary index but only a half-daily or, better, a daily index, as recalled by Bubenik and Fraser-Smith; if 3-hour aa indices have been communicated to the World Data Centers in magnetic tape, it was to provide for computing any local time daily value wished or for statistical studies. But it would be wrong to consider that a given 3-hour aa index is a significant estimation of the planetary activity level. There exists in such indices, apart from the well-known McIntosh daily variation, a residual daily variation due to the fact that the two observatories used are not completely antipodal in longitude (10 hours apart from each other). Such a defect appears clearly when Figures 5a and 5b of Bubenik and Fraser-Smith are compared: the activity is higher in the second part (Figure 5b) of the Greenwich day. This does not prevent a

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clear advantage of the aa series over the ap series: 3-hour ap indices are not sensitive to the McIntosh daily variation, a prominent property of the magnetic activity; they are not worldwide indices; they are not an estimation of the true level of the activity; one cannot be confident in the homogeneity of the series when one is studying monthly and yearly values.

We proceed now to another misunderstanding: most of the present geomagnetic activity indices are range indices, i.e., they are derived from the difference, in a 3-hour time interval, between the absolute maximum and the absolute minimum of the amplitude trace for certain of the magnetic components H, D, and Z.' This statement would be correct, apart from the length interval, for the R or Q indices; it is doubly wrong for the K indices and the planetary indices derived from them. (1) the Z component has not been used since 1964 in scaling the K indices, and the scalings recently made for the aa indices prior to that date have been carried out without using the Z component; such a component has been disregarded because it is too sensitive to abnormal underground induction effects and is sensitive to sources of fields localized at latitudes other than the latitude of the station. (2) The scaling of the K indices is not the direct difference between absolute maximum and absolute minimum but includes (it is its single difficulty) the elimination of the regular daily variation S_R. This constitutes the essential, and not always rightly appreciated, progress carried out by Bartels [1938] when he introduced the K indices: discriminating in the records between the regular variations, a permanent feature of the transient variations in spite of their variability, and the irregular variations or disturbances because these two species of variations correspond to geophysical phenomena that are fundamentally different. Now, solving that problem is the crucial point of any good magnetic activity index, which must aim at being a measure of the irregular variations only. The way in which Bartels solves it is very elegant: he measures a class of amplitudes of the irregular variations within a given time interval instead of the true amplitude of them because an exact scaling of the latter is impossible to do (see Mayaud [1967] for that problem). The result is what Bubenik and Fraser-Smith call the quantization of the K indices, i.e. a discrete series of values when one returns to the amplitudes by giving to each amplitude class (or K indice) a value equal to the midamplitude of the class.

Would it be possible to overcome the quantization by using the 'geomagnetic fluctuation power' or the 'standard deviation of the components in the 3-hour interval'? (1) We strongly believe that such methods would not readily solve the problem of the S_R elimination, which is, again, the crucial one in constructing good magnetic activity indices. One would have to automate such an elimination. Research into this problem is not an active endeavor at the present time, and one of its chief difficulties is that there exists an overlap between the periods (or pseudo periods) of the regular variation S_R and those of irregular variations. The experienced observer can solve the problem by looking in the records at the morphology of small sharp moves; such features escape the computer technique. (2) Given the properties of the magnetic activity, a good planetary index necessitates a derivation from a rather dense network well distributed in longitude and latitude. Even if a computer technique could solve the problem mentioned above, the cost of the derivation would be extremely high. On the contrary, K indices are normally rather quickly scaled by the experienced observer.

Finally, the am index, derived from 23 observatories, partly overcomes the apparent spurious quantization of individual K indices; if the aa index does not overcome it, the cause is the nonexistence of suitable observatories during the first decades of the series. But various 'geophysical' results obtained from the am series (or, as well, from the aa series) prove that the geophysical significance of the K index, apparently questionable at a first glance (a defect even more important than the quantization problem) especially to anyone doing K-scalings, is sufficient enough to warrant deriving planetary indices.

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