Search for Correlation Between Geomagnetic Disturbances and Mortality

by

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It is generally accepted that the sun affects the earth's magnetosphere and ionosphere by variations in the UV and x-ray radiation and in the solar wind due both to short-lived disturbances such as flares[1] and to long-lived structures such as that associated with the "sector structure" of the interplanetary magnetic field[2]. However there have been repeated claims, for well over one hundred years, that the sun influences many other processes on earth[3]. Possible association between solar activity and terrestrial weather is the subject of renewed interest and has been discussed at two recent symposia[4]. Evidence for a real association is impressive but no theoretical proposals, which might explain such an association, receive widespread support.

A more speculative branch of research on solar terrestrial relations has been concerned with a possible association between solar activity or geomagnetic disturbances, on the one hand, and human disorders on the other hand. Friedman, Becker and Bachman[5] have presented evidence for an association between geomagnetic storms, cosmic ray flux variations, and psychological behavior. The same authors have presented evidence showing that magnetic-field fluctuations in the frequency range 0.2 Hz apparently influence the functioning of the central nervous system[6]. Such fluctuations, termed "micropulsations", are known to be associated with geomagnetic disturbances.

A number of Russian scientists have, in recent years, claimed that there is a real association between solar activity and geomagnetic disturbances, on the one hand, and the incidence among man of various diseases, on the other hand. Some of this evidence has been reproduced by Spreiter[7], who draws in particular on the work of Chizhevskii[8].

Within this general area, one of the most active areas of current research in the Soviet Union appears to be the possible correlation of solar activity and miocardial infarction. Gnevyshev and Novikova[9] have presented evidence for such an association, and refer to the work of several other groups, accounts of which have been published in Russian in journals not accessible to us. Gnevyshev and Novikova hypothesize that this association, which they believe to be real, may be due to the effect of low frequency oscillatory magnetic fields on the fibrinolytic properties of the blood.

We have attempted to assess these findings by performing similar statistical analyses on data derived from United States sources. Geomagnetic data was derived from the World Data Center and mortality data from the National Center for Health Statistics.

We first analyzed daily numbers of deaths in the USA due to coronary heart disease and stroke for the years 1962 to 1966. Averaged over this period, there were 1507.1 deaths per day due to coronary heart disease, and 549.1 deaths per day due to stroke. These numbers were compared with a_p indices which are world indices of magnetic activity. The mortality data contained weekly and seasonal variations and a long-term secular trend. The data were normalized to remove these variations and this trend since we were looking for short-term correlations with natural events.

Our first step was to calculate the correlation coefficient r_k between the daily death rate D_i and A_i, the daily value of a_p, where $i(= 1, \ldots, N)$ enumerates days. In formula (1),

$$r_k = \frac{\sum_{i=1}^{N-k} (A_i - \bar{A})(D_{i+k} - \bar{D})}{(N-k)\ \sigma_A\ \sigma_D} \qquad (1)$$

we allow for a lag of k days and a similar formula allows for a possible lead; $\bar{A}$, $\bar{D}$ are the means of the time series, and σ_A, σ_D are the standard deviations. The standard error of r_k is given by

$$\sigma_{r,k} = (N-|k|-1)^{-1/2}\ (1 - r_k^2) \quad , \qquad (2)$$

for either lag or lead. The results, given in Table 1 for k in the range $-14 \le k \le 14$, give no evidence for a correlation.

The analysis was repeated for mortality due to strokes and the results are given in Table 2. Here again, there is no evidence for a real correlation.

As an alternative procedure, we constructed superposed epoch diagrams for the daily death rate referred to days with a_p in selected ranges. The results are shown in Figure 1 for coronary heart disease and in Figure 2 for strokes, plotted as deviations from the mean death rate of the total sample. The deviations are scaled such that each plot would have the same width of scatter if the selected subsets were simply a random selection from the total sample. The scale factor is given by $\sqrt{n/\sigma}$, where n is the number of superposed events and σ is the standard deviation from the mean of the total sample. Neither diagram gives evidence for an association.

A third method of presentation was to plot the average death rate as a function of magnetic index for k in the range $-20 \leq k \leq 20$. When the resulting curves were compared with the standard deviations, it was clear that there was no evidence for a significant effect.

Since the work of Gnevyshev and Novikova[9] sought relationships between mortality rates and geomagnetic indices for individual cities, rather than an entire continent, we decided to repeat the above analyses for three metropolitan areas. We paired the daily death rates due to coronary heart disease in Phoenix, Honolulu and Washington D.C. for the years 1964 and 1965 with the K indices from the Tucson, Honolulu and Fredericksburg observatories. (K indices are local indices of magnetic activity.) The results showed no evidence for a real correlation.

Finally, we compared the daily death rates due to coronary heart disease in San Francisco for 1964 and 1965 with the W-index for micropulsations, measured at the Stanford Radioscience Laboratory. We made this test because Gnevyshev and Novikova attribute their claimed relationship between geomagnetic activity and mortality rates to low frequency fluctuations of the earth's magnetic field. This analysis also showed no evidence for a real association.

In summary, our study does not support the findings of Gnevyshev and Novikova[9]. It is possible either that the correlations which they find are either not statistically significant, or that the correlation which they find is not due to a causal relationship between geomagnetic disturbances, on the one hand, and coronary heart disease or stroke, on the other hand. If their correlations are indeed indicative of a causal relationship, it will be necessary to determine whether this relationship is sensitive to geographical location, to phase of the solar cycle, or to some other parameter which might distinguish the sample which we have analyzed from that which the Soviet scientists have analyzed.

We wish to thank Professor Paul Switzer, of the Statistics Department, Stanford University, for helpful discussion. This work was supported by the National Science Foundation under grant GA-42401 and by the National Aeronautics and Space Administration under grant NGL 05-020-272.

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k	CORRELATION COEFFICIENT r_k	STANDARD ERROR σ_k
-14	-.00076	.02349
-13	.00041	.02349
-12	.01593	.02347
-11	.03333	.02345
-10	.02020	.02346
- 9	.00524	.02346
- 8	-.00897	.02345
- 7	-.01629	.02344
- 6	.00288	.02344
- 5	.00183	.02343
- 4	.00886	.02343
- 3	.02052	.02341
- 2	.00033	.02341
- 1	-.00623	.02341
0	-.01811	.02339
1	-.03053	.02339
2	.00544	.02341
3	.00593	.02342
4	-.01337	.02342
5	.00408	.02343
6	.03896	.02340
7	.04310	.02340
8	.02950	.02343
9	.00376	.02346
10	-.02349	.02345
11	-.01728	.02347
12	-.01530	.02347
13	.00316	.02349
14	.00384	.02349

TABLE 1: Correlations between geomagnetic index a_p and daily U.S. mortality from coronary heart disease, 1962 - 1966. Deaths lag behind geomagnetic event if $k > 0$, and lead if $k < 0$.

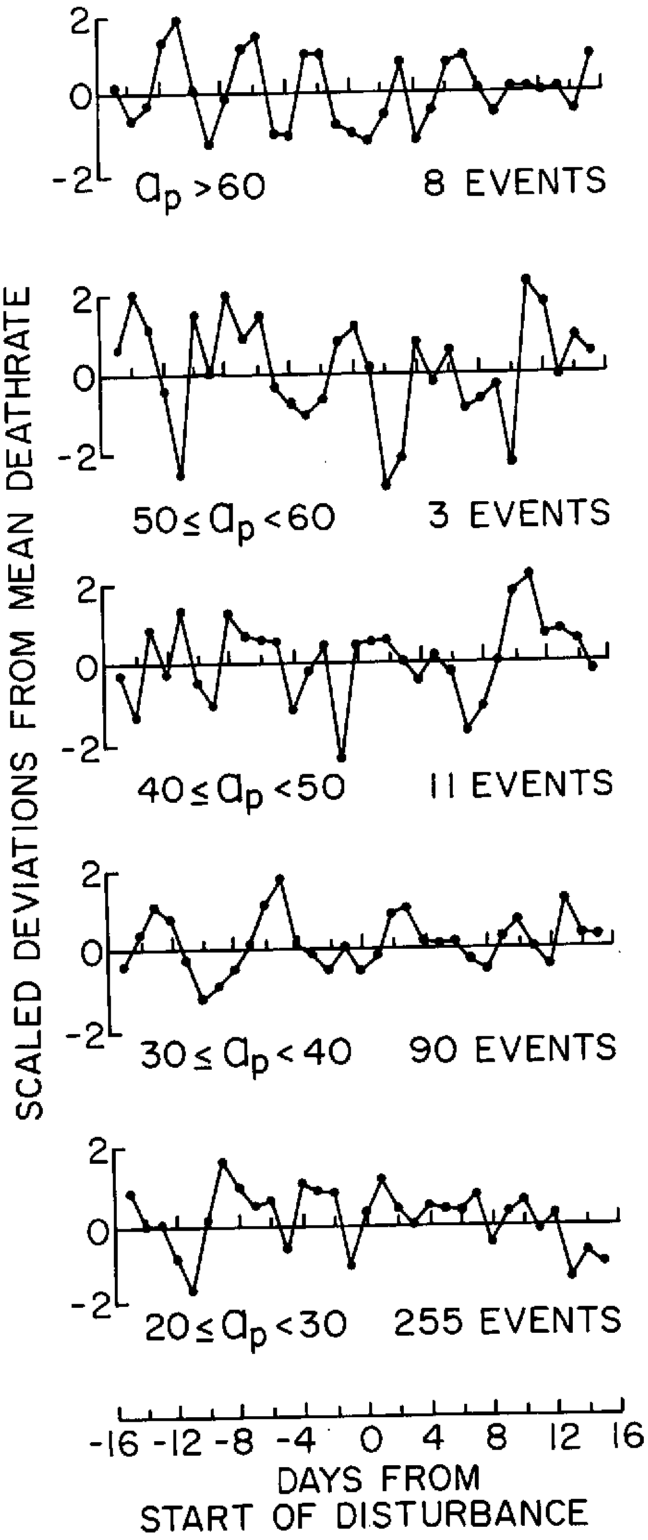
k	CORRELATION COEFFICIENT r_k	STANDARD ERROR σ_k
-14	-.00494	.02349
-13	.01640	.02348
-12	.01231	.02348
-11	.00416	.02347
-10	.02718	.02345
- 9	-.01035	.02346
- 8	-.02608	.02344
- 7	-.02037	.02344
- 6	-.01243	.02344
- 5	.01861	.02343
- 4	.00983	.02343
- 3	.01847	.02341
- 2	-.01148	.02341
- 1	-.00303	.02341
0	.03014	.02338
1	.03533	.02338
2	.02523	.02340
3	.00853	.02342
4	.02363	.02341
5	.01845	.02343
6	.01360	.02344
7	.01188	.02344
8	.02203	.02344
9	.02847	.02344
10	-.02852	.02345
11	-.00389	.02347
12	.02045	.02347
13	.00940	.02348
14	.02702	.02347

TABLE 2: Correlations between geomagnetic index a_p and daily U.S. mortality from strokes, 1962- 1966. Deaths lag behind geomagnetic event if $k > 0$, and lead if $k < 0$.

FIGURE CAPTIONS

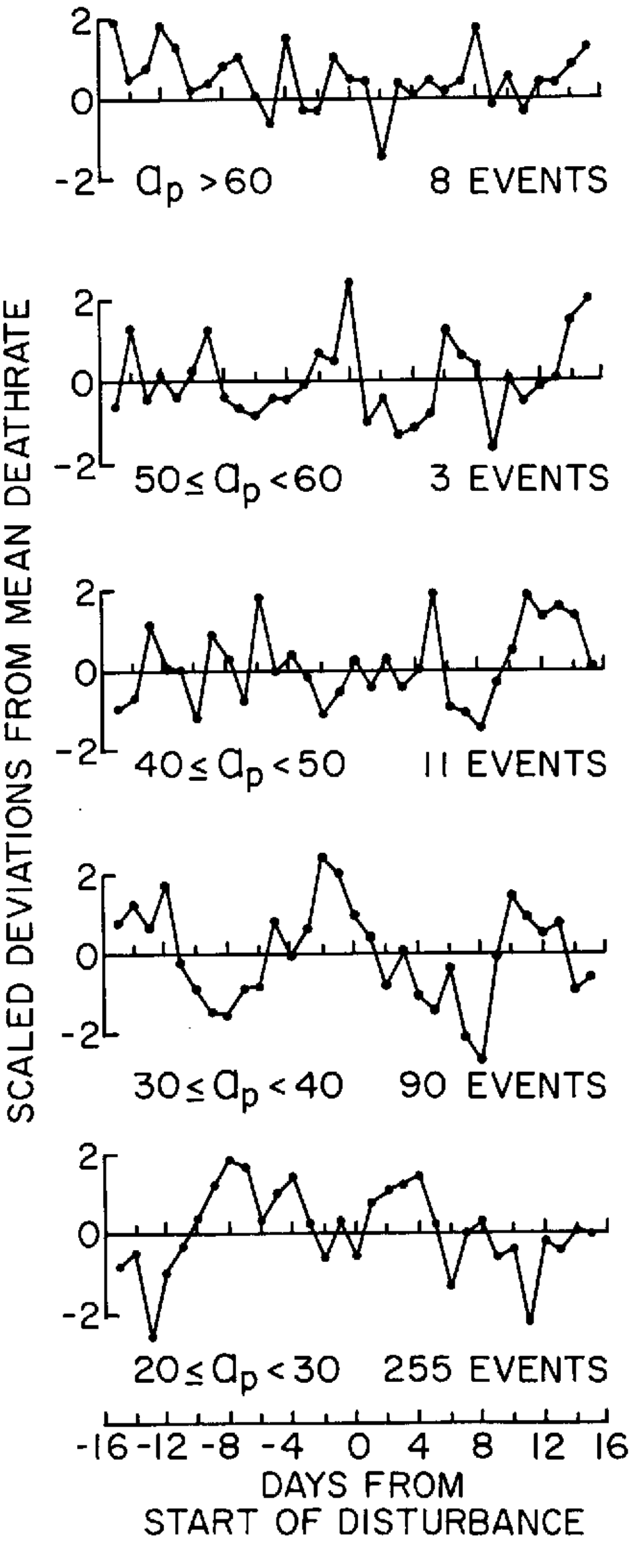
Figure 1. Superposed epoch diagrams for mortality due to cardiovascular disease. a_p on day zero lies in the ranges given. Total sample has a mean death rate of 1507.1 per day and a standard deviation about the mean of 57.9. Departures from the mean are measured in units of $57.9/\sqrt{n}$ where n is the number of events. See text for details.

Figure 2. Superposed epoch diagrams for mortality due to strokes. Description is similar to that of Figure 1. Total sample has mean 549.1, standard deviation 27.3.



SCALED DEVIATIONS FROM MEAN DEATHRATE
2
0
-2
$a_p > 60$
8 EVENTS
$50 \leq a_p < 60$
3 EVENTS
$40 \leq a_p < 50$
11 EVENTS
$30 \leq a_p < 40$
90 EVENTS
$20 \leq a_p < 30$
255 EVENTS
-16 -12 -8 -4 0 4 8 12 16
DAYS FROM
START OF DISTURBANCE

FIGURE 1



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90 EVENTS
$20 \leq a_p < 30$
255 EVENTS
-16 -12 -8 -4 0 4 8 12 16
DAYS FROM
START OF DISTURBANCE

FIGURE 2