

DISTINCTION BETWEEN THE CLIMATIC EFFECTS OF THE SOLAR CORPUSCULAR AND ELECTROMAGNETIC RADIATION

T. BARANYI and A. LUDMÁNY

*Heliophysical Observatory of the Hungarian Academy of Sciences
H-4010 Debrecen P.O.Box 30. Hungary*

Abstract. We study the possibilities of the separation of solar electromagnetic and corpuscular impacts on the terrestrial lower atmosphere by examining their characteristic differences. We focus on the behaviour of the solar-meteorological correlation with respect to characteristic magnetic properties. Examples are given that the solar meteorological correlation - the efficiency of the solar impact - depends on the Sun-Earth attitude, the polarity of the solar main dipole field (and IMF) and the type of the geomagnetic events. This can explain the virtual disappearance or reversal of certain solar-meteorological effects.

1. Introduction

The majority of the solar-meteorological literature uses the tacit assumption that the variations of the meteorological processes are the results of the variations in the solar radiation flux because the other possible energy source, the corpuscular flux is 6-7 orders of magnitude smaller than the radiative one. However, as is well known, most of the reported regularities and correlations may disappear or alter their signs apparently without detectable reasons.

We think that it is a simplification when the intensity is the only measure of the input, as in the electromagnetic case. The impact of the corpuscular flux can be confused with that of the radiative flux in certain periods, because they have more or less parallel trends. However, the corpuscular radiation has additional properties: strong anisotropy and the varying spatial features of the interplanetary magnetic field (IMF), so these conditions should be taken into account and perhaps their variations could explain some previously unexplained results. Moreover, the relatively small but highly anisotropic corpuscular impact might be more efficient in generating atmospheric inhomogeneities and circulations than the electromagnetic radiation.

We study not only the simple correlations between geomagnetic activity (induced overwhelmingly by corpuscular streams) and surface temperature but also its dependence on additional conditions such as the Earth's position in the IMF, polarity of the IMF and the nature (temporal run) of the particle events. We refer partly also to results of former papers: Baranyi and Ludmány (1992) (Paper I) and Baranyi et al. (1993) (Paper II). The aa-index of the geomagnetic activity was used (Mayaud, 1972) along with

surface temperatures of 22 European stations on a hundred-year period (see detailed list in Paper II).

2. Dependence on the Earth's Position

Twice a year the Earth gets into the "right" positions, around the equinoxes, enabling higher geomagnetic activity levels than around the solstices; this causes the well-known semiannual wave of geomagnetic activity (Crooker and Siscoe, 1986). Similar semiannual fluctuation can be observed in the correlations between solar and meteorological parameters measured in Budapest, Hungary (Paper I). We computed correlation values for monthly mean aa-index versus monthly mean temperature and monthly total precipitation for data sets of each separate month of the year, i.e. for 119 january values, 119 february values and so on. The distribution of these correlation values shows a similar property to the geomagnetic activity: extremes around the equinoxes. The extremes are positive for temperature and negative for precipitation. This can be interpreted also in terms of the varying terrestrial orientation: the equinox position is more efficient in transmitting the solar corpuscular effects to the lower atmosphere than is the solstice.

Surprisingly, the Wolf-number - precipitation correlation distribution has also a semiannual character, which can be explained only by the above mentioned aspect: the radiation variability obviously cannot cause a semiannual fluctuation but the corpuscular variability certainly can, and as the different factors of solar activity vary more or less similarly, the precipitation and Wolf-numbers may have a virtual interconnection. This is an indirect artifact demonstrating the need of a corpuscular electromagnetic distinction.

3. Dependence on the IMF-Polarity

For the sake of completeness we refer to an even more characteristic result which has recently been submitted for publication (Paper II). We have studied the temperature data of 22 European stations. The semiannual fluctuation cannot be pointed out at all stations, but if we separate two subdivisions of the whole interval studied according to the polarities of the main solar magnetic dipole field (Makarov and Sivaraman, 1986) which may be considered as the IMF-polarity (Rosenberg and Coleman 1969), then the semiannual fluctuation works by parallel solar and terrestrial magnetic fields, and it is missing in the antiparallel intervals. This is not true at three seaside-towns (Genova, Lisbon, Trondheim) but it is fairly remarkable at the other 19 stations plotted in Figure 1. Further details are in Paper II. We conclude that the IMF-polarity plays an important role in these relations, this result is consistent with those of Wilcox et al. (1976) and Rostoker and Sharma (1980).

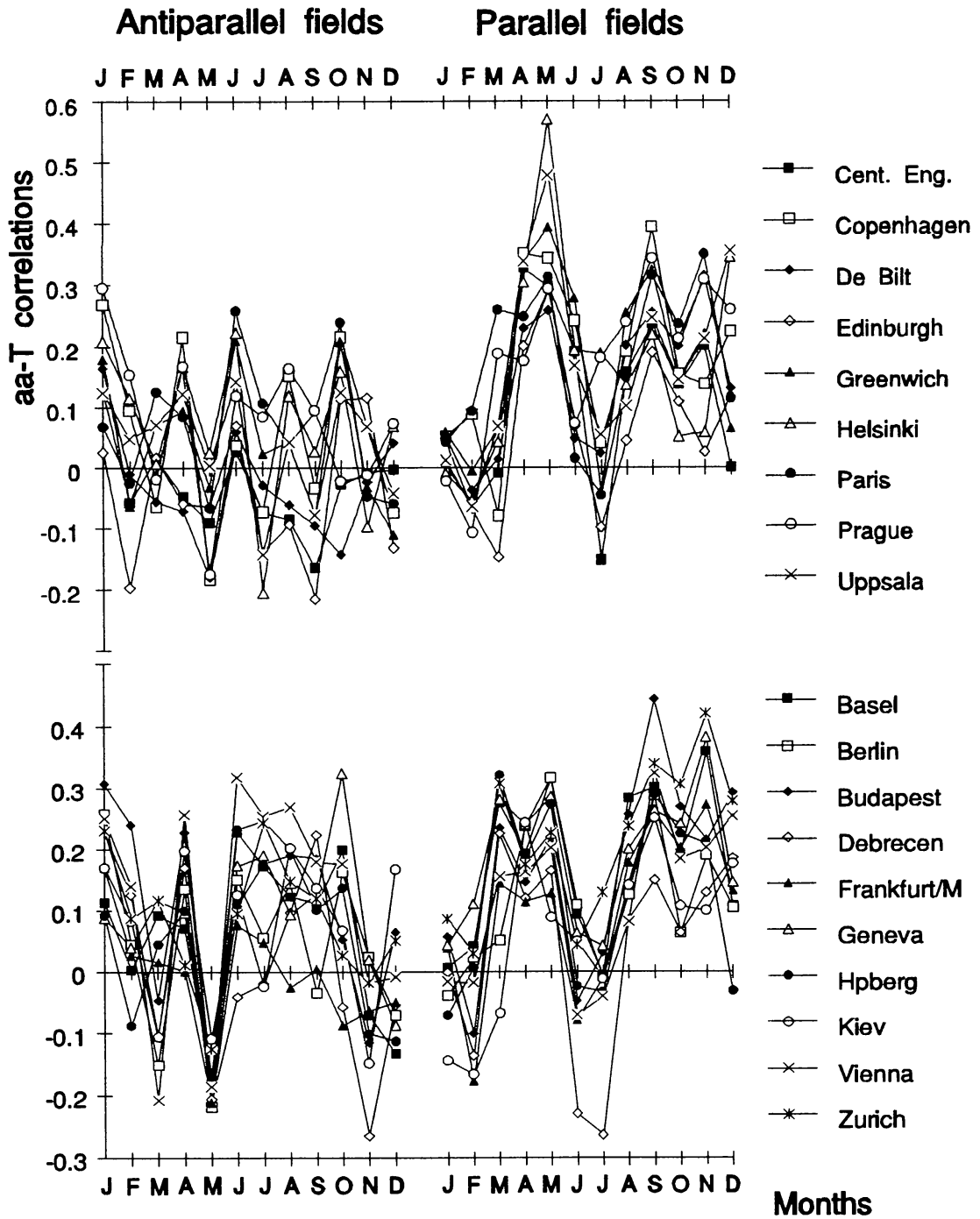


Fig. 1. Annual distributions of the temperature-aa index correlations in the years of antiparallel and parallel orientations of solar and terrestrial magnetic dipole fields at 19 European stations. For a given station and orientation the January value means the correlation between monthly mean temperature and monthly mean aa-index values of all Januaries involved, and so on.

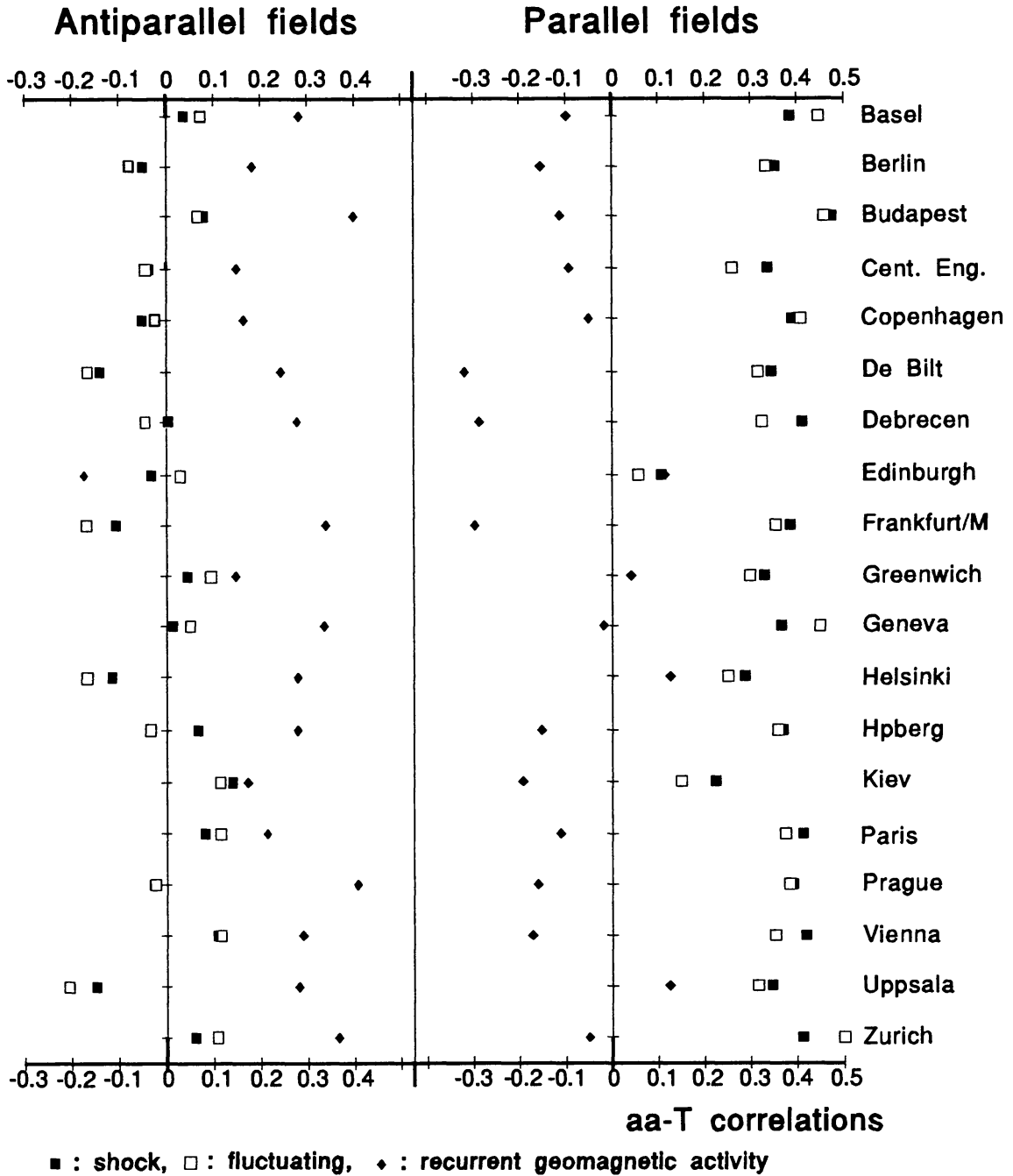


Fig. 2. Dependence of the temperature - aa-index correlation on the orientation of the solar vs. terrestrial magnetic dipole fields as well as on the type of the corpuscular impact (shock, recurrent or fluctuating) for 19 European stations. The temperature data are annual means, the aa-index data are annual sums of the given type.

4. Dependence on the Type of Disturbance

The most pronounced and complex effect of the corpuscular radiation revealed in our studies so far is the clear dependence on the type of the geomagnetic disturbance. These disturbances may be caused by different impacts of solar origin. (1) The recurrent geomagnetic activity arises on account of the streams from the polar coronal holes, (2) the shock activity is caused by active regions and (3) the fluctuating activity is released by moderate velocity wind sources. This distinction is extensively studied by Legrand and Simon (1985) and Simon and Legrand (1986, 1987), they also compiled classification lists of these events. On the basis of their classification scheme, a remarkable regularity can be revealed by using the annual sums of these activity types as different aa-activity indices (Figure 2): the correlations of the temperature with the shock, fluctuating and recurrent disturbances show opposite behaviour in the periods of parallel and antiparallel orientations of the solar and terrestrial magnetic fields in most cases. The separation is clearer in the parallel case like the semiannual fluctuation.

As the shock and fluctuating activity originate from the solar equatorial belt, it is not surprising that their correlations with the temperature behave similarly to each other and reverse to that of the recurrent disturbances coming from the polar region. But it is not quite obvious that they change their roles after the IMF polarity reversal, this may refer to an important feature that is not yet clear.

5. Discussion

The figures imply a rather complicated process, a complex spatial and temporal behaviour; they reflect some features of its peculiar geometry: different solar locations of different disturbance types, their different temporal runs, varying position of the Earth with respect to the IMF-environment and alternating polarity of the IMF. All these factors play some roles in the solar-meteorological effects.

We think that the disappearances of many relationships might be related to these phenomena. Any virtual relationship can be observed with, say, the Wolf numbers and after, for instance, the IMF-polarity reversal it disappears unexpectedly, simply because we did not observe the relevant factors and the really significant process. In addition, if we mix the inversely working periods or factors, then the effect can be smeared out which is also demonstrated by the results of Labitzke and Van Loon (1988).

We can draw the conclusion that the solar corpuscular radiation is probably concurrent with the electromagnetic influence; it may even prevail in spite of its comparative weakness, at least on a shorter range. This can be the case even on a cycle-long interval as was shown in Paper I. On longer

time scales the radiative flux is surely determinant.

6. Acknowledgements

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