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INTERNATIONAL CONFERENCE ON COSMIC RAYS AND THE EARTH STORM Part I

I-1-5. Similarity and Simultaneity of Magnetic Disturbance in the Northern and Southern Hemispheres

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The comparison of geomagnetic disturbances in the northern and southern hemispheres is made for the average disturbance-daily variation *SD* in the polar regions, and for individual disturbances observed at some selected stations in high latitudes.

The *SD*-field pattern in the southern hemisphere is almost a mirror image of the northern one with respect to the geomagnetic equatorial plane.

The magnetic activity at a station in the northern hemisphere shows the best correlation with that observed at geomagnetically conjugate point in the southern hemisphere. Two selected conjugate pairs of stations, one on the poleward side and the other on the equatorial side of the normal auroral zones, are especially examined. The correlation of individual simultaneous disturbances is fairly good even at the time of large magnetic storms for the equatorial pair of stations. On the other hand, the correlation becomes poor for the polar-side pair of stations in daytime and during disturbed periods, although the nighttime variations show almost one to one correspondence at these stations.

§ 1. Introduction

It is often considered or sometimes assumed that geomagnetic disturbance takes place simultaneously in both the northern and southern hemispheres. In this paper disturbances in high-latitude regions of the northern and southern hemispheres are compared quantitatively. The study is made for the average characteristics of magnetic storms and also for individual disturbances.

§ 2. Average disturbance-daily variation in high latitudes.

The data at 6 stations are used to derive the equivalent overhead electric current-system for the disturbance-daily variation, *SD*. The station used are: Scott Base (geomagnetic latitude −79.0°), Wilkes (−77.8°), Little America (−74.0°), Syowa Base (−69.7°), Halley Bay (−65.8°) and Macquarie Island (−61.2°). The data are mainly those of IGY, and some other data are also used. In order to derive the *SD*-field, the following method is used.

$$SD=Sd-Sq=A(Ts)\cdot SD^0(t)\ ,$$

where *Sd* and *Sq* are the daily variations at disturbed intervals and on quiet days respectively. $SD^0(t)$ is an idealized form of the disturbance-daily variation. *Ts* and *t* are the storm-time and local time. For the average of a number of magnetic storms, the average diturbance-daily variation will have the similar form as $SD^0(t)$, and the intensity will be dependent on the storm-time *Ts*, unless the disturbance-daily variation changes its form seriously with storm intensity. Some 25 storms of $Kp\geq 6_+$ are selected for the analysis. It has been shown that the polar disturbance is well developed after several hours from the sudden commencement of magnetic storms[1),2)], so that the values during 9–15 hours in storm-time were used to derive a typical *SD* variation of the well developed stage of magnetic storms. Fig. 1 shows the comparison of the *SD* current-systems in high-latitude regions of the northern and southern hemispheres. Fig. 1(b) is the electric current distribution for the *SD*-field obtained through the present analysis, while Fig. 1(a) is that for the Second Polar Year[3)]. We see at once very good similarity of the current distribution with each other in Figs. 1(a) and 1(b). The current intensity for the southern polar region during IGY 1957–58 is about twice as much as that for the northern one during the Second Polar Year 1932–33. The mean

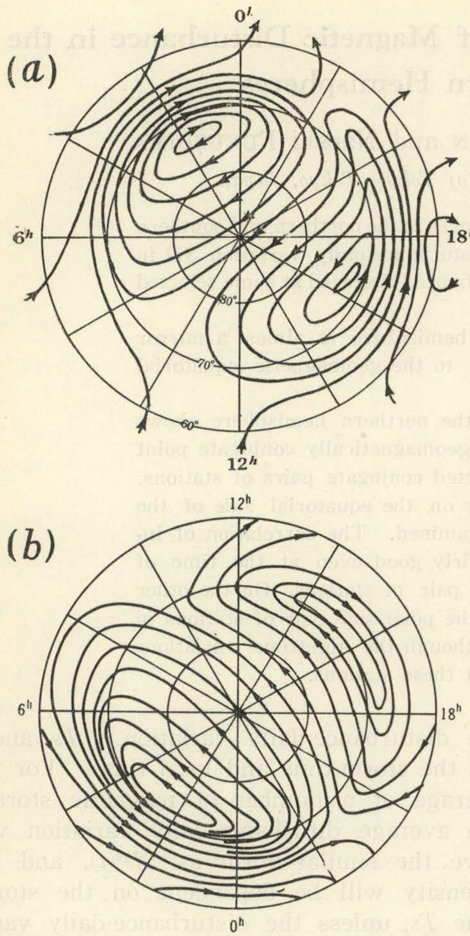

Fig. 1. The mean equivalent overhead electric current-system for the *SD*-field in high latitudes in geomagnetic latitudes and local time.

(a) In the northern hemisphere by means of the Second Polar Year data. Electric current between adjacent stream lines is 2.9×10^4 amperes.

(b) In the southern hemisphere by means of the IGY data. Electric current between adjacent stream lines is 5×10^4 amperes.

value of *Kp* for the storms during the Second Polar Year used for the analysis is about 5_0, while the mean for the selected storms during IGY is near 6_+. From the scaling for *Kp*-index, the average disturbance force of the selected magnetic storms during IGY is approximately twice as intense as that of storms during the Second Polar Year. When this quantitative difference of the disturbance for these different periods is taken into consideration, one may say that the intensity of the electric current-system for the *SD*-field is nearly the same in the northern and southern polar regions, when the storms of the same *Kp* value are dealt with. Therefore we may conclude that the *SD* current-system in the southern hemisphere is almost a mirror image of the current-system in the northern hemisphere, so far as the yearly mean aspect is concerned.

§ 3. General comparison of the simultaneous disturbance field observed at different stations.

The magnetic disturbance often shows simultaneous increase and decrease all over the world. This tendency is confirmed also by a quantitative examination by means of *Q*-indices reported from various high-latitude stations. Fig. 2 shows four examples of the calculation of the correlation $r(X(t), Y(t+\Delta t))$ for rather disturbed period of Sept. 2–6, 1957. $X(t)$ is the *Q*-index value at a time t at a station X, and $Y(t+\Delta t)$ is the Q value at a time $t+\Delta t$ at another station Y, where Δt is variable from -12 to 12 hours with 15-minute interval. The positions of two stations X and Y as well as their difference are given for both geomagnetic and geographic coordinates. One can see in the examples in Fig. 2 that the simultaneous values at two stations show the highest correlation value. This tendency is generally held also for many other combinations of stations.

§ 4. Comparison of the disturbance observed at geomagnetically conjugate points.

The comparison of the simultaneous magnetic disturbances in the northern and southern hemispheres has been made in fair detail, especially for the disturbance observed at two stations situated nearly conjugate to each other from the standpoint of geomagnetic field distribution[4),5)].

In this paper the correlation of the disturbance at night, in daytime, and at the time of large magnetic storms is especially examined for two selected pairs of nearly conjugate stations; one pair on the poleward side and the other on the equatorial side of the normal auroral zones. Fig. 3 shows the positions of the magnetic observatories, whose data are used for the present analysis. The stations of the polar-side pair are Baker Lake (abbreviated to BL; 73.7°, 315.1° in

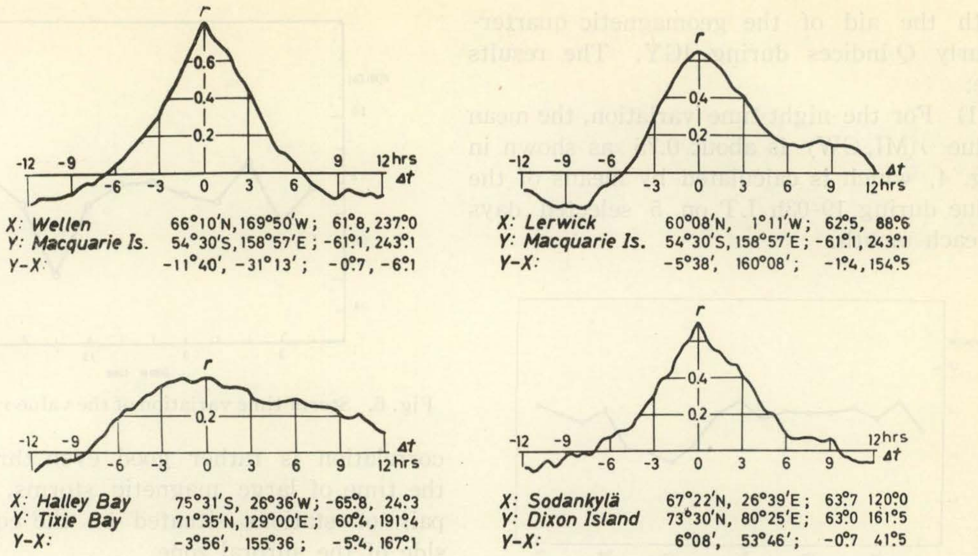

Fig. 2. Correlation value $r(X(t), Y(t+\Delta t))$ of the geomagnetic Q-indices at two stations for the period of September 2–6, 1957 (Ap=102, 135, 145, 112, 36).

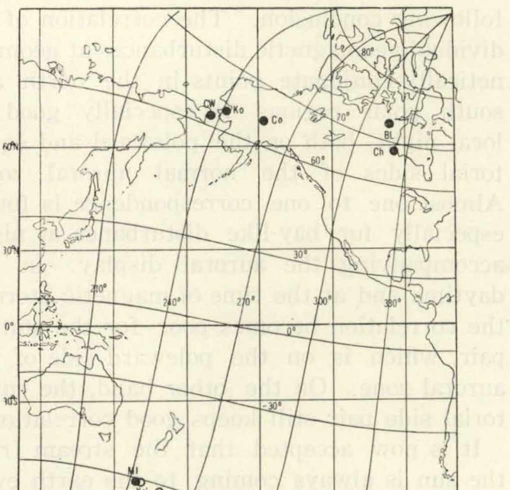

Fig. 3. Distribution of geomagnetic observatories, whose data are used for the analysis of simultaneous disturbances in the northern and southern hemispheres. (White circles are the conjugate points of the northern hemisphere stations by means of Vestine's expression for the permanent magnetic field of the earth.)

geomagnetic coordinates) and Little America (LA; −74.0°, 312.0°). The white circles BL′ and Ch′ near the full circle LA in Fig. 3 show, for information, the positions of the calculated conjugate points of BL and Ch (Fort Churchill) with Vestine's expression of the permanent geomagnetic field. The correlation of the simultaneous disturbances at BL and LA, simply denoted by r(BL, LA), is examined by means of the magnitude of horizontal disturbing vector. The result is summarized as follows, as already published[4].

(1) For the night-time variations
r(BL, LA)=0.76 by means of instantaneous values,
r(BL, LA)=0.85 for 10-minute average values.

(2) For the daytime variations
r(BL, LA)=0.40 for instantaneous values,
=0.51 for 15-minute average values,
=0.37 for 30-minute average values,

(3) At the time of magnetic storms
r(BL, LA)=0.32 for 30-minute average values,
=0.40 for 1-hour average values.

On the other hand, the analysis for the pair of stations, Macquare Island (abbreviated to MI; −61.1°, 243.1° in geomagnetic coordinates) and Cape Wellen (CW; 61.8°, 237.0°), which are situated just on the equatorial side of the auroral zone, is made conventionally with the aid of the geomagnetic quarter-hourly Q-indices during IGY. The results are:

(1) For the night-time variation, the mean value r(MI, CW) is about 0.75 as shown in Fig. 4, which is calculated by means of the value during 19–03h LT on 5 selected days in each month.

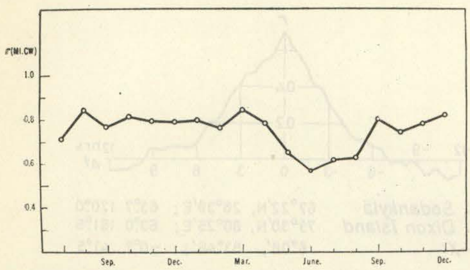

Fig. 4. The correlation value r(MI, CW) of the simultaneous magnetic disturbance observed at Macquarie Island and Cape Wellen on 5 selected disturbed days in each month.

(2) For the daytime variation on rather disturbed days the correlation is about 0.73. This value is nearly as high as that at night.

(3) At the time of magnetic storms, the change of r(MI, CW) with storm-time is shown in Fig. 5. For this calculation, 27 storms of maximum $Kp \geq 6_0$ during IGY are selected. The similar calculation for the correlation of the simultaneous Q-indices reported from Macquarie Island and College (Co; 64.7°, 256.5°) for 11 selected magnetic storms shows the similar result as shown in Fig. 6. It is worth mentioning that the

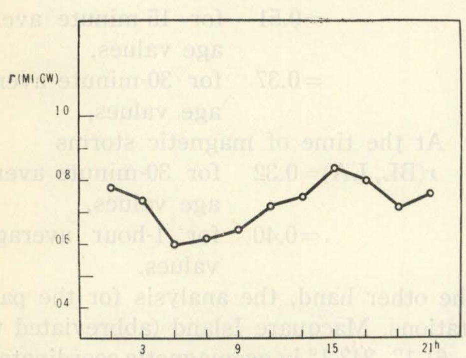

Fig. 5. Storm-time variation of the value r(MI, CW) obtained from 27 large magnetic storms during IGY.

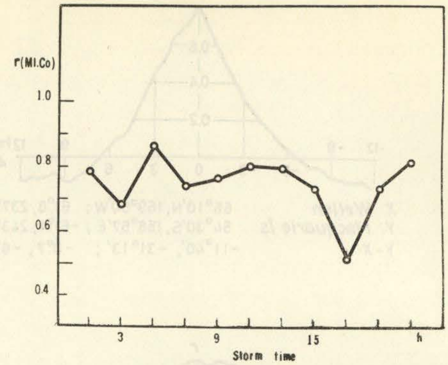

Fig. 6. Storm-time variation of the value r(MI, Co).

correlation is rather good even throughout the time of large magnetic storms, for the pair of stations situated on the equatorial side of the auroral zone.

§ 5. Conclusion

Summarizing these results we obtain the following conclusion. The correlation of individual geomagnetic disturbances at geomagnetically conjugate points in the north and south polar regions is especially good at local night, both on the poleward and equatorial sides of the normal auroral zone. Almost one to one correspondence is found especially for bay-like disturbance at night accompanying the auroral display. In the daytime and at the time of magnetic storms, the correlation becomes poor for the station pair, which is on the poleward side of the auroral zone. On the other hand, the equatorial side pair still keeps good correlation.

It is now accepted that the stream from the sun is always coming to the earth even on geomagnetically quiet days, and this is called the solar wind. The presence of persistent magnetic agitation in the polar cap especially on the sunlit side of the earth will be interpreted by the effect of the persistent solar wind[6]. The kinetic pressure of the solar corpuscular stream becomes intense at the time of magnetic storms. Distortion of geomagnetic lines of force caused by the increased kinetic pressure of solar stream may break up the link of geomagnetic line of force at two stations in high latitudes, which are conjugate to each other on quiet days. The station pair BL and LA, which is situated just on the poleward side of the auroral zone, seems to be well connected by geomagnetic line of force at night on quiet days, but the connection may be broken up occasionally in daytime or at the time of magnetic storms. On the other hand, the pair MI and CW(or Co) keeps good connection even on disturbed days. This will mean that the connection of these stations by geomagnetic line of force is hardly broken at any time. Although the connection by geomagnetic line of force is often disturbed for individual disturbance in high latitudes, the average disturbance field such as the *SD*-field is symmetric with respect to the geomagnetic equator as shown in Fig. 1, because irregular variations are smoothed out.

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INTERNATIONAL CONFERENCE ON COSMIC RAYS AND THE EARTH STORM Part I

I-1-6. World Wide Changes in the Geomagnetic Field

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It is found that world wide changes in the geomagnetic field are not limited to ssc or si, and are frequently observed. Not only an increase, but also a decrease in the horizontal intensity occurs on a world wide scale. The morphology of this phenomenon is studied, and is found to show a pronounced similarity with that of ssc and si. This is consistent with the idea that there is a permanent interaction between the solar corpuscular stream and the geomagnetic field.

§1. Introduction

The continous existence of a solar corpuscular stream proposed by Biermann (1957) indicates the possibility that world wide changes of the geomagnetic field take place rather frequently, and are not limited to ssc or si. The earth's magnetic field is confined in a space of finite extent by the the impact pressure of the solar corpuscular stream and the geomagnetic field is changed on a world wide scale when the physical state of the stream changes, as shown by Parker (1958), Piddington (1960) and Dessler *et al.* (1960). Thus through the continuously flowing solar corpuscular stream world wide features of the geomagnetic field are always related, with some time lag, to the physical state of the sun. Since the physical state of the solar atmosphere is quite variable, it seems reasonable to expect world wide changes in the geomagnetic field to occur quite frequently. From this point of view, the number of occurrences of world wide changes of the types already known—ssc and si—seems to be too small.

Thus world wide changes of the geomagnetic field other than ssc or si were looked for, making use of magnetograms obtained from an extensive network of stations during a three-month period of the IGY. It was found, as was expected, that world wide changes, including both an increase and a decrease in the horizontal intensity, take place almost every day, at least around sunspot maximum. In this paper, examples and the morphology of this phenomenon are