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INTERNATIONAL CONFERENCE ON COSMIC RAYS AND THE EARTH STORM Part I

I-1-7. Solar-Terrestrial Relationships during the IGY and IGC

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During the IGY and IGC solar activity was very high, so that many aeronomical disturbances were observed. We have studied the relation between solar phenomena and their terrestrial effects, on the basis of solar-geophysical data during this period, and the following results have been obtained.

§1. Geomagnetic storms

(*a*) *Relation between geomagnetic storms and solar flares.*

1) First we have examined the dependence of the magnitude of magnetic storms (say *Dst* which indicates the maximum range of the main phase of magnetic storms in the equatorial region) on the heliographic longitude of the position of corresponding solar flares, and it is found that large storms are associated with flares that appeared near the central meridian on the solar disk, as has been pointed out by many other researchers.

2) By plotting the magnitude of magnetic storms (*Dst*) and sudden commencements (ssc) against the importance of corresponding flares, it is found that both of them are not always in good correlation with flare importance.

(*b*) *Relation between geomagnetic storms and solar radio emissions.*

3) In 136 magnetic storms examined here, 62 storms are associated with flares accompanied by Continuum radio burst (*i.e.* it is equivalent to 46%); 27 storms by Type II burst (20%); 16 storms by Continuum or Type II burst (12%); and 31 storms by others or uncertain (22%). So it seems that almost all ssc-magnetic storms are associated with solar flares accompanied by great radio bursts such as Continuum and Type II.

4) There is no relation between the magnitude of magnetic storms (*Dst*) and the smoothed flux intensity of corresponding radio bursts. However, if we take the total flux intensity (*i.e.* the product of the smoothed intensity and the duration) instead of the smoothed intensity alone, then good correlation is found between them in the meter-wave region, as shown in Fig. 1. This result may strongly suggest that the radio waves at meter-wavelengths are emitted from solar plasma which causes magnetic storms, or conversely it seems to be possible to deduce the magnitude of magnetic storms from the total flux intensity of radio waves at meter-wavelengths. And the same result has also been obtained by K. Sinno[1].

5) Although the amplitude of ssc has no relation with the intensity of corresponding solar radio emission, its time-gradient is fairly well related with the total flux intensity in the meter-wave region, and this result seems to be interesting in relation to the interpretation of ssc.

(*c*) *Some remarks on geomagnetic storms.*

6) There is no distinct relation between the amplitude of ssc's and the magnitude of storms (*Dst*). However, if we take the ssc-gradient instead of the amplitude of ssc's, then good correlation is seen between them, as shown in Fig. 2.

7) The relation between the amplitude and the rise-time of ssc's is shown in Fig. 3. Although the points plotted are appreciably scattered, there is a tendency that the larger the amplitude, the shorter the rise-time. This result may support the theoretical interpretation of ssc's by A.J. Dessler *et al*[2].

8) Finally, by examining the relation between the auroral-zone *SD* and the equatorial *Dst*, it is found that the diurnal amplitude of *SD* is in good positive correlation with *Dst*, when *Dst* is less than about 200 gammas; whereas there is no perfect correlation when magnetic storms are very large.

§2. Ionospheric storms

9) We have also considered the relation between the diurnal amplitude of geomagnetic *SD* in the auroral zone and the magnitude of ionospheric storms as indicated by Δf_0F_2 (root-mean-square deviation of f_0F_2 during a magnetic storm) and $\Delta(M3000)F_2$ (root-mean-

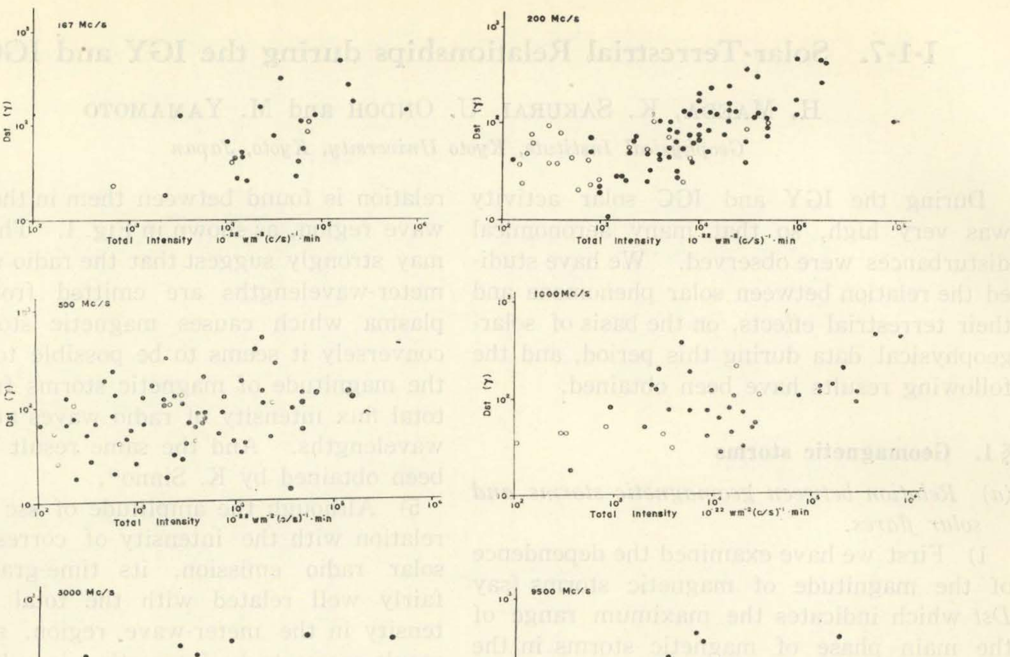

Fig. 1. Relation between the magnitude of magnetic storms (*Dst*) in the equatorial region and the total flux intensity of corresponding solar radio emission, where the black circles refer to the reliability *A* and the white circles to *B*.

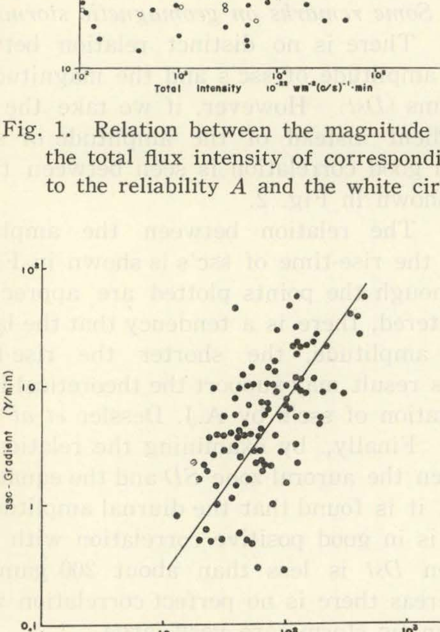

Fig. 2. Relation between the time-gradient of ssc's and the magnitude of magnetic storms (*Dst*) in the equatorial region.

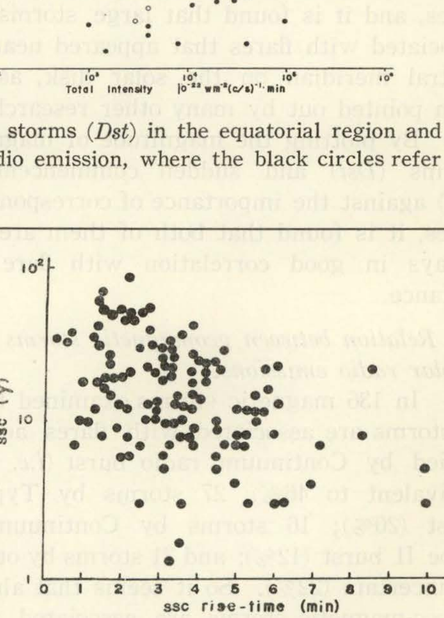

Fig. 3. Relation between the amplitude and the rise-time of ssc's.

square deviation of $(M3000)F_2$ during a magnetic storm) at Fribourg, and it is found that there is a significant positive correlation between them. This result may support the drift theory (proposed originally by D. F. Martyn[3)]) for the interpretation of ionospheric storms.

§ 3. Sudden ionospheric disturbances

During the IGY and IGC, about 1500 SWF's

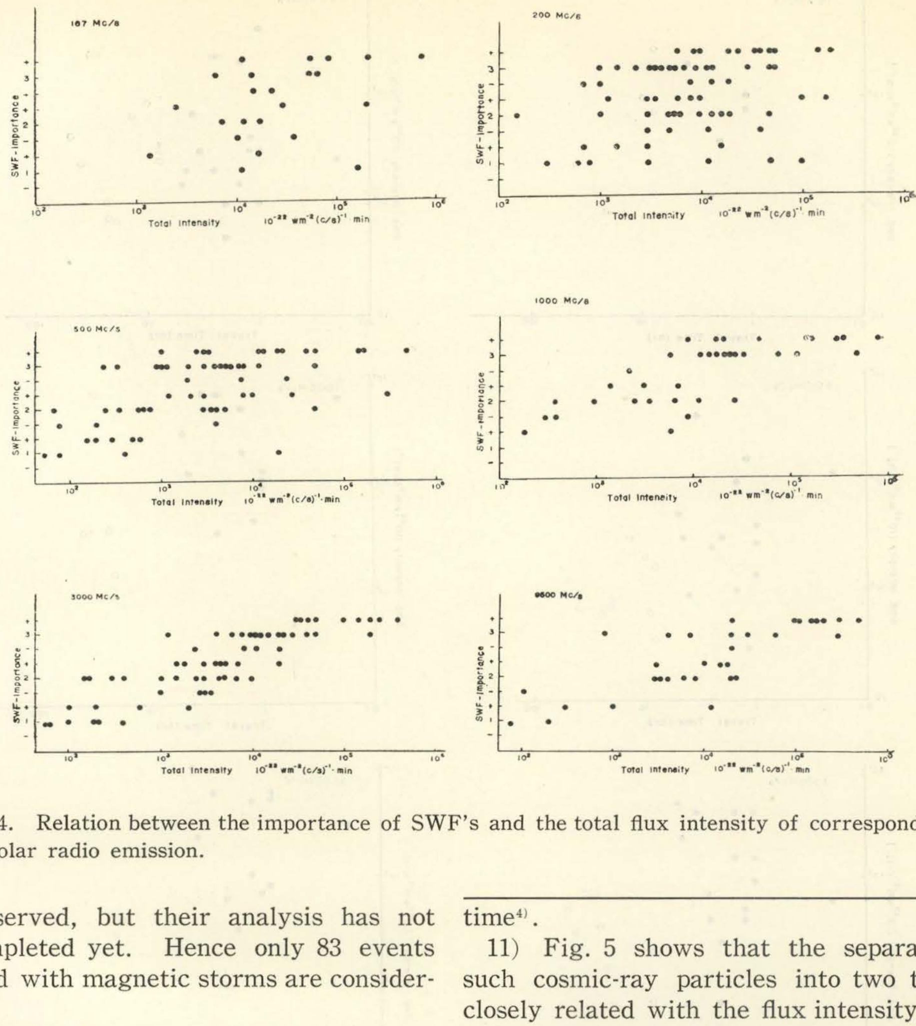

Fig. 4. Relation between the importance of SWF's and the total flux intensity of corresponding solar radio emission.

were observed, but their analysis has not been completed yet. Hence only 83 events associated with magnetic storms are considered here.

10) Fig. 4 shows a good correlation between the importance of SWF's and the total flux intensity of corresponding solar radio bursts in the centimeter-wave region. This result seems to imply that the far-ultraviolet solar radiation, probably in the X-ray region, responsible for SWF's is closely connected with the solar radio emission at centimeter-wavelengths.

§ 4. Polar-cap ionospheric disturbances

During the IGY and IGC, about 28 polar cap disturbances which seemed to be caused by low-energy cosmic rays of solar origin were observed. We carefully examined these events, and it was found that there are two types in their travel-time from the sun to the earth, and that both types have a similar tendency of western shortness in travel-time[4].

11) Fig. 5 shows that the separation of such cosmic-ray particles into two types is closely related with the flux intensity of corresponding solar radio emission. Moreover, it seems from this figure that the early-type events are associated with the radio emission at centimeter-wavelengths; whereas the late-type events with that at meter-wavelengths. These results may suggest that the particles of the two types are emitted at different heights above the photosphere.

This is a preliminary report, and the full paper will be published in the near future.

References

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2) A. J. Dessler, W. E. Francis and E. N. Parker: J. Geophys. Res., **65** (1960) 2715.
3) D. F. Martyn: Nature **171** (1953) 14; Proc. Roy. Soc. London, A, **218** (1953) 1.
4) K. Sakurai and H. Maeda: J. Geophys. Res., **66** (1961) 1966.

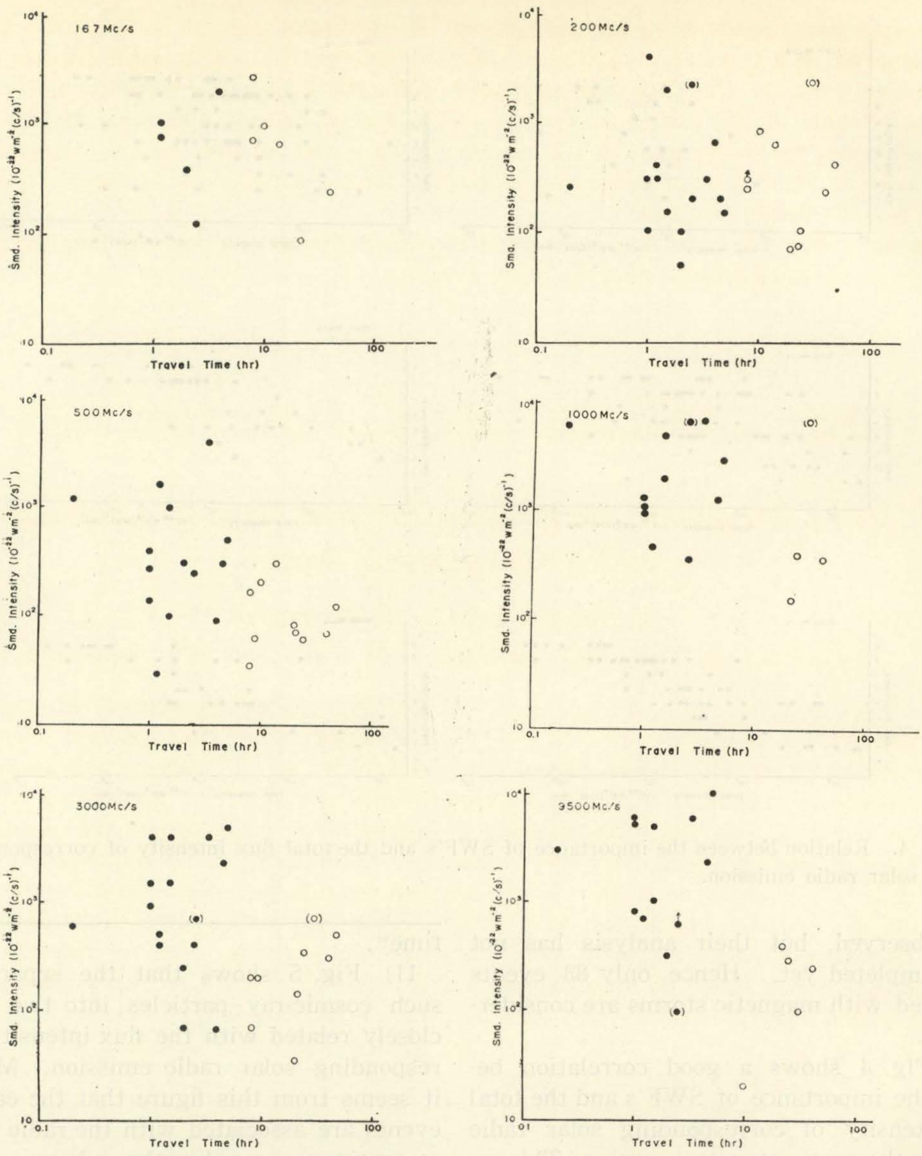

Fig. 5. Relation between the travel-time of low-energy cosmic rays and the smoothed flux intensity emitted from the flares corresponding to each cosmic-ray event. The early and late types are indicated by black and white circles, respectively.

Discussion

Obayashi, T.: Is there any significant difference of the solar radio emission events related to the early onset of solar cosmic rays and slow or late onset of solar cosmic rays?

Maeda, H.: Yes, it seems likely that the early onset type is in good correlation with the solar radio emission at *centimeter* wavelengths, and the late onset type with that at *meter* wavelengths.

Cook, F.E.: Do you know of any relationship between the travel-time of solar cosmic ray particles (ΔT_p) and the travel-time of the corresponding magnetic-storm particles (ΔT_m)?

Maeda : Yes, there is a positive correlation between ΔT_p and ΔT_m for the latetype cosmic-ray particles, but no correlation between them for the early-type particles.

This fact has already been pointed out by Dr. K. Sinno too.

Hultqvist, B.K.G.: You showed a relation between the heliographic longitude and the travel-time for the fast solar particles producing PCA. Are also the fairly high-energy events of the last years similar to the one of 23 Feb. 1956 when the PAC was accompanied by an increase of the cosmic-ray flare also at the earth's surface? In other words, have you not made any allowance for the differences in energy spectrum between the different cases?

Maeda: No, we have not, because we have no information about the detailed energy spectrum of solar cosmic rays for each event.

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I-1-8. Details of the Relation between Type IV-Outbursts and sc-Geomagnetic Storms

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Introduction

Since recent years it has been shown that solar radio-noise outbursts of spectral type IV (great burst of long duration covering a major part of the spectrum) are very often followed by a sc-geomagnetic storm (cf. de Feiter *et al.*, Planet. Space Sci. 2, p. 223, 1960). This paper deals with some details of this relation. It is based on material covering the period 1956 January 1—1961 July 31. Unfortunately the spectral patrol coverage is not very complete. Therefore the spectral classification of the solar radio noise material has been left out of consideration. On the contrary, single-frequency data are available for the three frequency ranges about 200, 500 and 3,000 MHz to a high degree of completeness. Since the beginning of the IGY complete coverage on 200 and 545 MHz is available by the coorperation of the three stations NERA, Paramaribo and Hollandia, the records of which were at our disposal. The 3,000 MHz-range is nearly completely covered by the records made at NERA and the published data from the observatories Ottawa, Tokyo and Toyokawa and Berlin. Up to 1957 July 1, 200 and 545 MHz-records of the observatory NERA were completed by data from various other observatories, as published in the Quarterly Bulletin on Solar Activity. The advantage of the single-frequency over the spectral data is the possibility of a better calibration of the former records. The significance of this will appear from this paper: the energy-content of the outburst is an important quantity in the relation between outbursts and ssc's.

Previous studies have shown that type IV-outbursts can be seen as important marks of the occurrence of eruptive sources of corpuscular radiation. However, it is well known that by no means every source is accompanied by a type IV-outburst. This is illustrated by the fact that only 40% of all ssc's are preceded by such a burst within reasonable intervals of time. But it appears that the important sources are more often marked by type IV-bursts: 73% of the sc-storms reaching at least $Kp=8$ are preceded by such bursts.

Since this paper is concerned with solar radio noise events, the optical flare-data have only been used to give information about the approximate position of the outburst on the solar disc. In particular the optical importance has been left out of consideration.

§ 1. Magnitudes of outbursts, responsible for ssc's

In order to investigate the relationship between outbursts and ssc's, we measure