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SOLAR-TERRESTRIAL DISTURBANCES OF AUGUST, 1972

17. SUMMARY

By

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Sixteen papers in this special issue deal with the following topics of August 1972 events: (1) development of solar activity and flare-prediction, (2) characteristics of major solar flares, (3) disturbances in the earth's magnetosphere and the ionosphere, (4) propagation disturbances of radio waves in VHF through VLF bands. In the present summary, some figures and tables are given in order to show readers what is the whole scheme of the August 1972 events is and what part of the disturbances is discussed in each of the papaers.

Fig. 1 shows three charts of solar active centers as of August 4, 1972, recorded at optical, X-ray, and radio wavelengths. Among six major sunspot regions present on the solar disk, the McMath region No. 11976 was overhelmingly bright in soft X-ray and micro-wave observations and occupied a considerably wide region of the solar disk. During its presence on the visible disk, the region became extremely active and produced a series of solar flares in the first part of August.

Fig. 2 gives an overall view of the August 1972 solar-terrestrial events. The onset times and magnitudes of major flares that occurred in the region 11976 were shown in the upper part of the figure. They were selected with the following criteria: (1) the optical flare importance$\geq$2, (2) the peak flux of 10 cm radio outburst$\geq$100 units ($10^{-22}wm^{-2}Hz^{-1}$), and (3) the intensity of 1–8 A X-ray burst observed by Explorer 44$\geq 10^{-2}$ergs $cm^{-2}sec^{-1}$. Among the ten selected flares, four flares —2 on August 2, 1 on August 4 and 1 on August 7— F-1 through F-4, were especially big in their optical, radio, and X-ray characteristics. Following the four major solar flares, SID's, solar proton events and associated PCD's were detected by various radio sensors. The flare characteristics and the associated earth storms are shown in Table 1. The four major geomagnetic storms, M-1 through M-4 in the last column, were recognized by their well-developed Dst-fields (see Fig. 2).

The Radio Research Laboratories observed the solar-terrestrial disturbances and associated radio propagation disturbances by various techniques as shown in Table 2. Most of papers in the present issue deal with the results of these ground-based and satellite observations (2–15), along with space data published in the Solar-Geophysical Data, NOAA, USA. Important items and events discussed in the present issue are shown in Table 3 in chronological order. Ad-

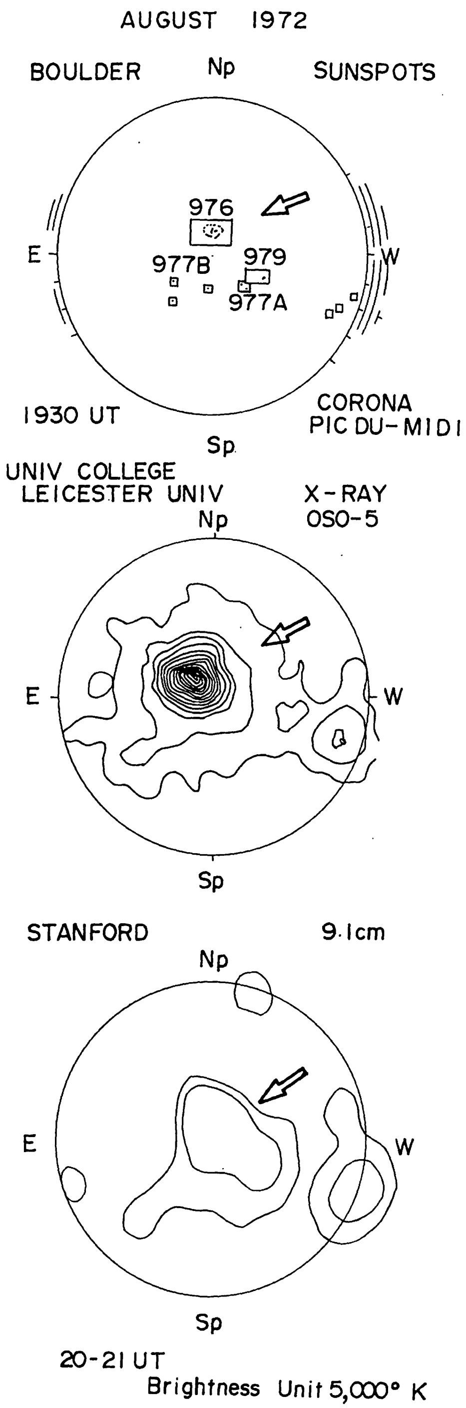

Fig. 1. Solar active regions on August 4, 1972.

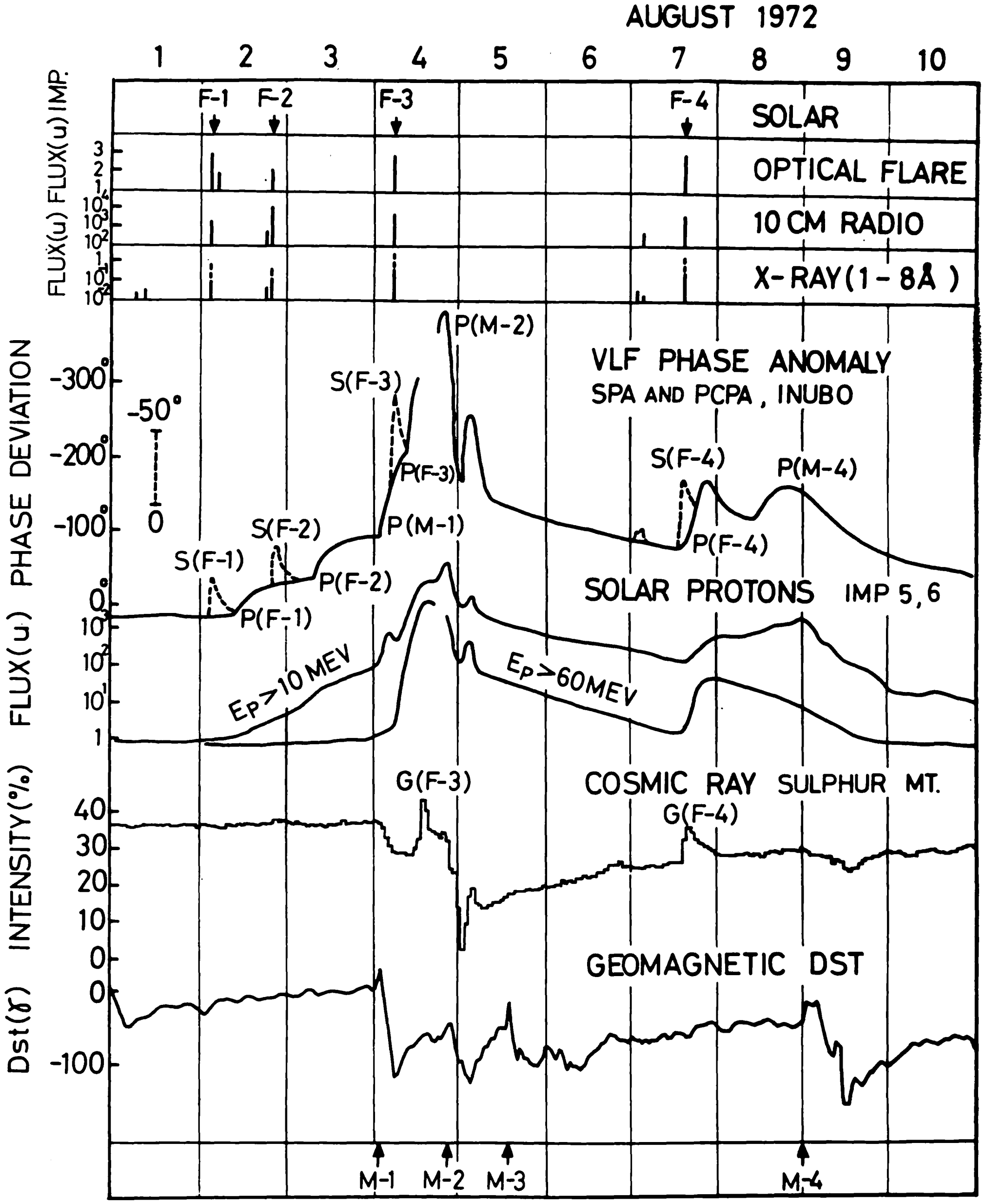

Fig. 2. Solar-Terrestrial Disturbances of August 1972: optical flares, 10 cm radio dursts, 1-8 Å X-ray flares, SPA's and PCPA's on VLF radio waves, solar protons (Ep>10 and 60 Mev), ground level increases and Forbush decreases of galactic cosmic rays, and geomagnetic disturbances. The onset times of four major solar flares, F-1 (Aug. 2/0310 UT), F-2 (2/1959), F-3 (4/0619), and F-4 (7/1505), and four geomagnetic storms, M-1 (4/0119), M-2 (4/2054), M-3 (5/1400), and M-4 (8/2354), are indicated by arrow marks.

Talbe 1. Characteristics of four major solar flares in August, 1972

	RADIO BURST				X-RAY		OPTICAL		PROTON BURST (EARTH)				MAGNETIC STORM
	10 cm		peak										
	onset time	rise time	peak flux	freq.	ΔF(1-8Å) estimated	dur.	imp.	long.	onset time	delay time	max. rigidity	peak flux 〉10Mev	
		min.	unit	GHz	unit	h				h	GV	unit	
F-1	2/0310	55 slow	3	4	0.3-0.7	13	3N	E34	2/10	7 slow	0.07 soft	>6	M-1(4/0119)
F-2	2/1959	109 slow	10	4	~0.2	10	2B	E28	3/03	7 slow	0.07 slow	>1070	M-2(4/2054)
F-3	4/0619	17 fast	500 25	0.2 20	1-2	9	3B	E08	4/08 b	<1.7 fast	1.5 GLE	1.1×10[6]*	M-3(5/1400) M-2*
F-4	7/1505	23 fast	20 27	0.1 10	0.8-4	12	3B	W37	7/1540	0.6 fast	3 GLE	3530	M-4(8/2354)

Units: peak flux 10^{-19}wm^{-2}Hz^{-1}; X-ray ergs cm^{-2}sec^{-1}; proton peak flux protons cm^{-2}sec^{-1}str^{-1}

ditional informations quoted from other publications (17–23) are also shown when they are considered to be necessary for the understanding of the whole scope of the present solar-terrestrial disturbances.

The occurrences of these major flares and subsequent earth storms were successfully predicted. The ennanced activity in the McMath region No. 11976 had become apparent in various ground-based observations, such as sunspot numbers, radio S-component flux intensity at 3 cm, and flux ratio of 3 cm to 10 cm. All of the features were used for the prediction of proton-producing flares. In addition to the method of flare-prediction which traces energy-storage processes in the sunspot region, a thought was also proposed that the solar

Table 2. Data Used In The Present Synthetic Study.

Solar Data	
sunspot magnetic field	Solar-Geophysical Data (SGD)
Hα flare	TAO (Mitaka) data, SGD
Solar radio	35 GHz (Kokubunji), 17 GHz (Nobeyama), 9500 MHz (Hiraiso) 9300, 3750, 2000, 1000 MHz (Toyokawa), 500, 200 MHz (Hiraiso), 160 MHz (Nobeyama), 100 MHz (Hiraiso), 50, 30, 20 MHz (Hiraiso, Syowa Station), SGD
solar X-ray	Explorer 37, 44, OSO-5 (SGD)
solar proton	IMP 5, 6, Pioneer 9 (SGD)
solar wind	Pioneer 9 (SGD)
Geomagnetic Data	Kakioka, Hiraiso, Wakkanai, SGD
Ionospheric Data	
vertical sounding	Wakkanai, Akita, Kokubunji, Yamagawa, Okinawa
riometer	Hiraiso, Syowa Station
topside sounding	ISIS 2 (Kashima)
topside VLF	ISIS 2 (Kashima)
Faraday rotation	ATS 1, Syncom 3 (Wakkanai, Kokubunji)

Radio Propagation

frequency	transmitting station	receiving station
10.2, 12.2, 13.6 kHz	Aldra, Haiku	Inubo
16.0, 17.8, 18.6, 22.3, 23.4 kHz	Rugby, Cutler, Jim Greek, N. W. Cape	Inubo
40 kHz	Kemigawa	Akita
100 kHz	Iwojima	Hiraiso
750 kHz	Sapporo	Hiraiso
1.85 MHz	Hachijo-jima, Ohkamasaki	Hiraiso
2.5, 5 MHz	Koganei	Akita
10, 15, 20, 25 MHz	Ft. Collins, Maui	Hiraiso
6-23 MHz	Hamburg, Teheran, Shepparton, Lima	Hiraiso
4-64 MHz	St. Kilda	Yamagawa
32 MHz	Adelaide	Yamagawa Wakkanai
48, 72, 88, 102 MHz	Darwin	Yamagawa

Table 3. Chronological Tabulation of August 1972 Events.

Date	Time	Events	Ref. No.	Association
July 28		ELP of McMath region 11976, increases in solar radio and X-ray S-components	2, 3, 4	
August 1-2		Sudden increase in activity (11976)	2, 3, 4	
2	03:10	Solar Hα flare	2	F-1
		Radio outburst	3	
		X-ray flare, SPA and SFA (VLF)	4	
		SPA and SFA (LF)	14, 15	
		SWF and SIF (MF, HF)	4, 8, 12, 13	
		SID effect on TEP waves	11	
2	07:30[b]	Onset of proton event (Pioneer 9)	5	F-1
	10:00	〃 (IMP 5, 6)		
	14:00	Onset of PCPA (VLF), Proton flux increase		
2	19:59	Hα flare, radio outburst, X-ray flare, various SID's	2, 3, 4, 8, 11 12, 12, 13, 14	F-2
3	03:00	Onset of proton event (IMP 5, 6)	5	F-2
	08:10	Onset of PCPA		
4	01:19	Sudden Commencement of geomagnetic storm	18	M-1
		Forbush decrease of galactic cosmic ray	19	
		Increases in PCPA and proton flux	5	
		Onset of PCA (riometer, Syowa Station)	6	
		TID observed	9	
		Unusual increase in f_0F2	8	
		Unusual increase in total electron content	10	
4	04:00	Auroral sighting in Illinois, Wyoming, and Colorado	17	M-1
4	06:19	Giant Hα flare, radio burst, X-ray flare, γ-ray flare (OSO 7), various SID including F-layer SID	2, 3, 4, 6, 8 10, 11, 12, 13, 14, 15	F-3
4	07:54	Onset of PCPA, proton event (IMP 5, 6), GLE	5, 19	F-3
4	09:00	Decreases in f_0F2 and total electron content	8, 10	M-1
4	14-15	Peak of proton flux and GLE	5, 19	F-3
		Increases in MOF and TEP signal strength	11	
4	20:54	Giant SSC	18	M-2
		Unusual increase in cosmic ray intensity	19	
		Unusual increases in PCPA, PCA, proton flux	5, 6	
		Radiation damage on solar cells (Intelsat IV)	22	
		Aurora in North America and Europe	17	
		Doppler shift (JJY, 5 and 10 MHz)	20	
		Violent changes in f_0F2, N-h profile, and total electron content	8, 10	
		frequent observation of short whistler	7	
		SSC-effect on TEP	11	
		TID observed	9	
4	22:30	Strong radio aurora in Texas, Georgia and Alabama	17	M-2
		Damage on power lines and underground cables by SIC (Solar-induced current)		

		in North America		
		Maximum of geomagnetic Ds field	18	
5	01:00	SIC-effects in North America	17	M-2
		Maximum of geomagnetic Dst field	5	
5	02	Decreases in PCPA, proton flux, cosmic ray intensity	5, 19	M-2
	04	Secondary increase in cosmic ray intensity		
	05	PCPA an proton flux increase		
5	11:30	f_0F2 decrease by 50% (Kokubunji)	8	M-2
5	14:00	SSC	18	M-3
		SIC-effects in North America	17	
		SSC-effect on TEP	11	
5	14-19	Abnormal absorption observed (MF, HF)	13	M-3
7	01:01	electron density measurement by rocket (Syowa Station)	6	
7	02:50	SID (LF, MF, HF)	12, 13, 14	
7	03:45	SID (LF, MF, HF)	12, 13, 14	
7	08:11) 08:28)	Topside sounding (ISIS 2) Latitude dependence of F-layer storm	7	M-3
		Plasmapause L=4.0, Kp=3+		
7	15:05	Giant Hα flare, radio outburst, X-ray and γ-ray flares, SPA, SWF	2, 3, 4, 12	F-4
7	15:40	Onset of GLE	19	F-4
	16-17	Maximum of GLE		
	16:12	Onset of PCPA and proton event (IMP 5, 6)	5	F-4
8	21:25	SID (LF, HF)	12, 14	
8	23:54	SSC	18	M-4
		Forbush decrease in cosmic ray	19	
		enhancements of PCPA and proton flux	5	
		f_0F2 increase, SSC-effect on TEP	8, 11	
9	07:45) 07:48)	Topside VLF observation (ISIS 2), whistler triggered emission and narrow band hiss observed, plasmapause L=2.9 (Kp=7−)	7	M-4
9	11-12	Maxima of geomagnetic Dst and Forbush decrease, radio aurora	17	M-4
9	14:45	Enhancement of night airglow intensity	23	M-4
		spread F, enhancement of f_0F2	8	
9	19	Decrease in f_0F2	8	M-4
11	12:00	Hα flare, radio burst, SID	2, 3	
		No corresponding PCD, SSC		
11		WLP of McMath region 11976		

activity might be controlled by tidal forces produced on the solar surface by the planets, Mercury, Venus the earth, and Jupiter (16).

The present study has enabled us to realize serious effects of solar-terrestrial disturbances on various radio services. The environmental disturbances are summarized in Table 4. Necessity of the disturbance warning for various radio services over wide frequency bands was thus recognized.

Table 4. Effects of Solar-Terrestrial Disturbances on Various Radio Services

Services / Disturbances	VLF, LF	MF, HF	VHF	
	radio navigation, standard frequency	radio communication broadcasting, maritime and aeronautical mobile, radio navigation, standard frequency, space research	space research, space communication, space operation	Others
Solar Radio Outbursts			interferences	
SID Solar X-ray Bursts	SPA SFA	SWF SIF	SWF	
PCD Solar Proton Bursts	PCPA PCFA	PCA	(PCA)	radiation damage on solar cells, radiation damege on astronauts
Geomagnetic Storm				SIC-effects on power lines and underground cables
AZD	AZPA AZFA auroral hiss	AZA		
F-layer Storm		changes in field intensity	changes in field intensity	

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