

2000

11 가 . 2000

가 가

가

(S_q)

3 K

가

1278 km/s

K
Kakioka

2000

SUMMARY

As the 21st century approaches, we are relying more and more on satellites which are increasingly vulnerable to variabilities of the near-earth space environment. Our Lab has been engaged in the prediction of significant disturbance in solar terrestrial environment by monitoring solar radio emission and geomagnetic field variation.

The type solar radio burst results from plasma emission generated by a shock as it propagates out through the solar corona. A shock typically takes 2 days to reach the Earth at 215 solar radii where it causes a sudden commencement (SC) of geomagnetic storms. From a practical point of view, predictions of SC are very important because their effects are sufficient to accelerate high-energy particles in the magnetosphere with deleterious consequences such as the electrostatic discharge and the EMI effects of spacecraft.

In this respect, it is important to understand the connection between coronal shock and geomagnetic disturbance. In order to understand this connection in the next solar maximum period (around 2000), we have analyzed not only the solar radio emission data to evaluate initial coronal shock speed but also the geomagnetic field variation data to derive the 3-hour geomagnetic activity K index. By employing an appropriate coronal electron density model, the various frequencies of the type radio burst were converted to corresponding heights in the solar corona and the frequency drift rate was also converted into coronal shock speed. The derivation of geomagnetic activity K index is based on the amplitude of the variation of the observed horizontal components after subtracting the corresponding solar regular variation (S_q) of the day.

This kind of study is expected to play an important role in studying the connection between coronal shock and geomagnetic disturbances in the next solar maximum.

1
2 23
1 23
2
3
1
2
3
4
1
2 K
5
.....

1

11 가 . 2000
1989
가 .
30 MHz 2500 MHz 2
1 1995
1997
(1997). 1997
() ()
(CME) (SC: Sudden Commencement)
(1997).
1 .
가
(CME: Coronal Mass Ejection)
(Pinter & Dryer 1990).
가
(Rust 1982).
가

1. (, 1997)

1982 11 26	GOES4 가 spin-scan radiometer가 45	
1989 3 13-14		
1994 1 20-21	Anik E1, Anik E2 Intelsat-K	가
1997 1 6-10	AT&T , Telstar 401 CATV , \$2	CME

CME : (Coronal Mass Ejection)

·
(Solar Radio
Burst) 3
K (geomagnetic activity K index)

· ,
·
- (Smart et al. 1984)
K

(Menvielle & Berthelier 1991).

23

2000 가

·

·

2 23

1 23

11

CME

CME 가

가 1 2

X 가 ,

12 15 ,

11 가 .

가

가

(Precursor

Method) . 가

23

Khaled(1997) 22 30% aa

23 158(± 18)

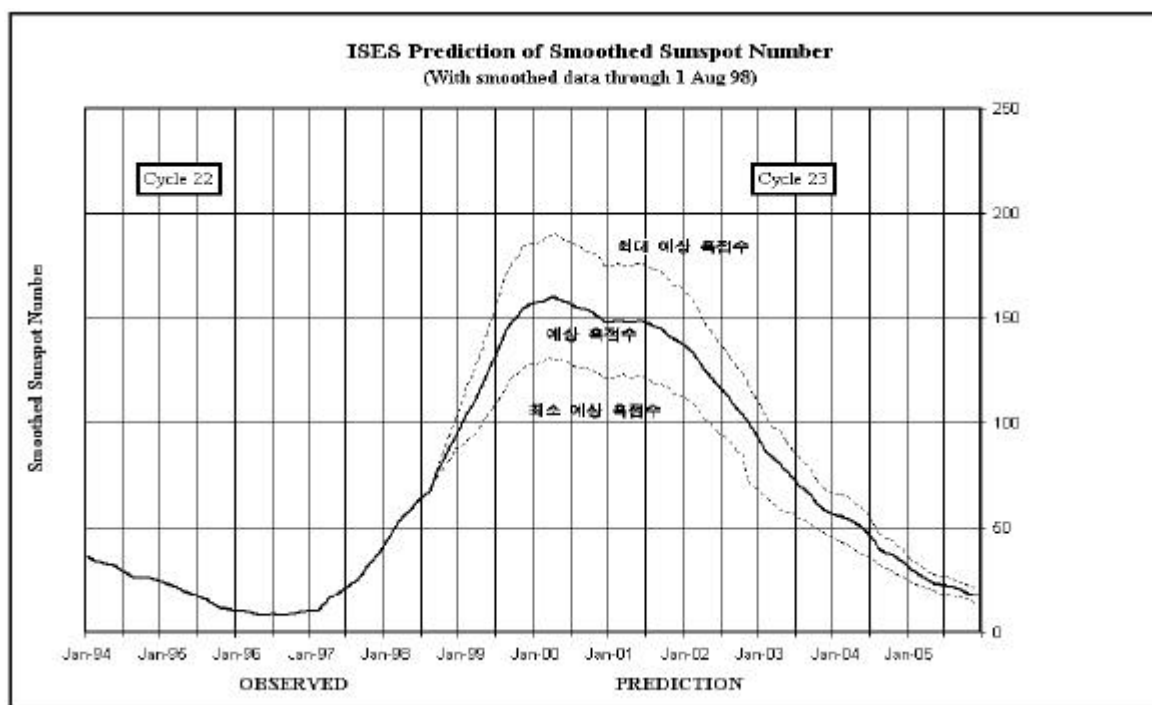
Kenneth(1996) SODA(SOLar Dynamo Amplitude)

가 2000 5 ± 9

138(± 30) Brave(1997)

가

가 23 2001 190



1. (NOAA)

23

(1999)

2000 2 7 114.3

22.8

가

2000

가

1

(NOAA)

23

가

가 11

가

(1999)

25

19

40

21

8

48

2

1995
50%

75

2

2000

23

가

23

가

1

가

(CME)

MeV

가

single- event upset(SEU)

가

가

가

가

(differential

charging).

(bulk charging).

(Robinson, 1989).

CME

(, CME) -
(, -) (,
,) 가
가

가

가
(Sudden Commencement) (local K Index)
(H)

(S_q)

가 2000

가

shielding

· ,
·
가

· 1989 10 , GOES

6

· 1990 3

3 ·

4

·
·

3

1

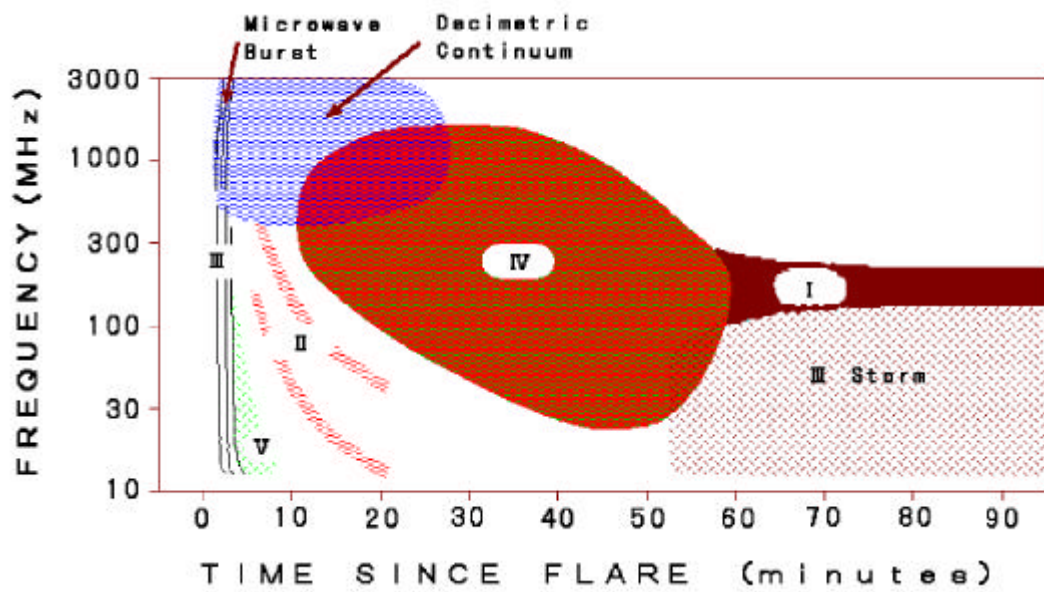
()
(Radio Bursts)
(30 MHz 300
MHz) (300 MHz 3000 MHz)

(dynamic spectrum : ,) 2
5 (Wild et al. 1963).

10
(drift)
1 2
가 . 가
가
가 (drift rate)

(Pinter & Dryer 1990).
1 (Primary Emission) 2
(Secondary Emission) ()

(e.g. FM, TV, Pager)



2.

(dynamic spectrum : ,)
 . ()

가

가

3

3

4가

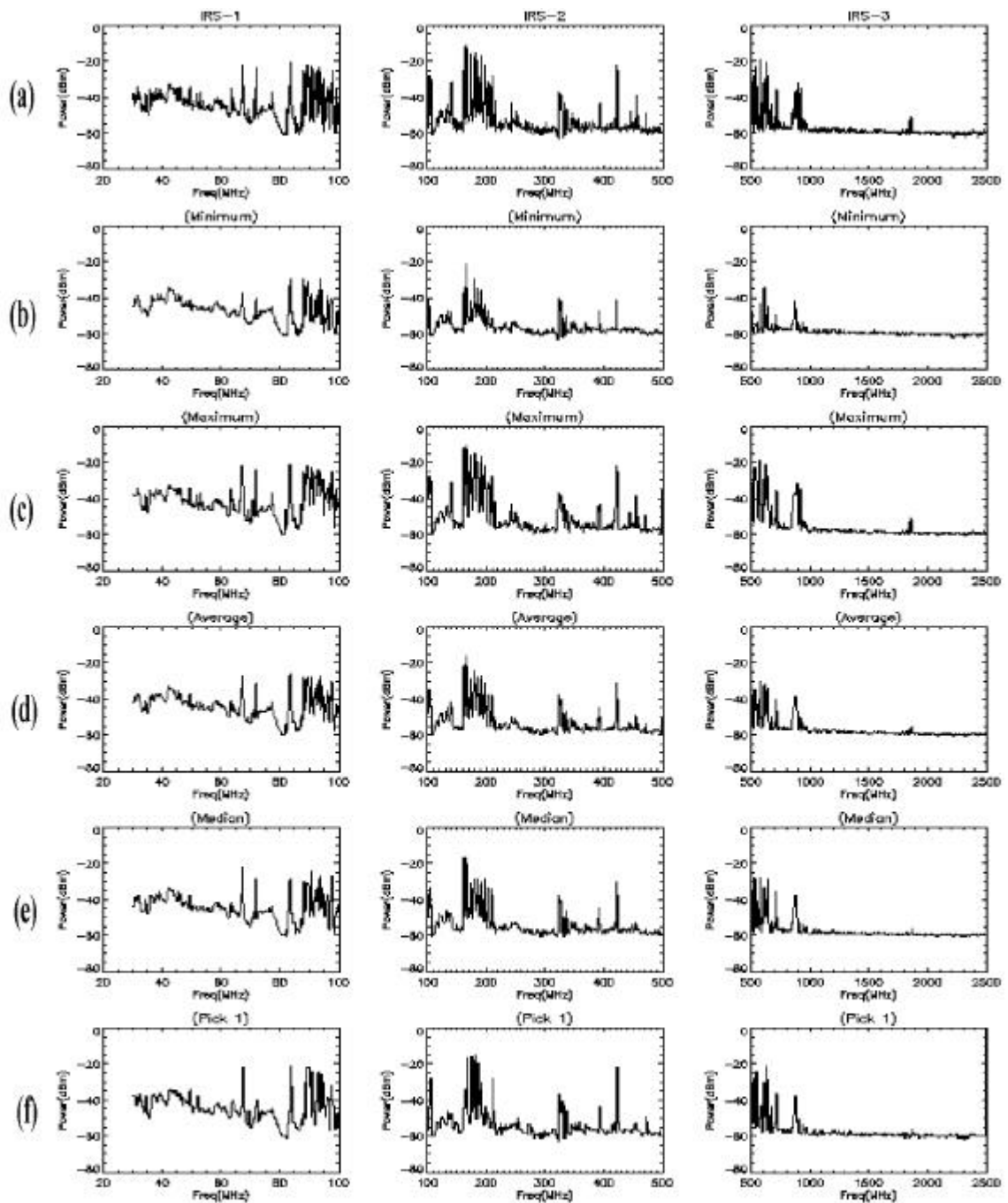
가

가

4

5 1998 5 29 00 56

가



3. (e.g. FM, TV, Pager)

(Minimum)

47†

. (a) 30MHz 2500MHz

(b)

(Minimum) (c)

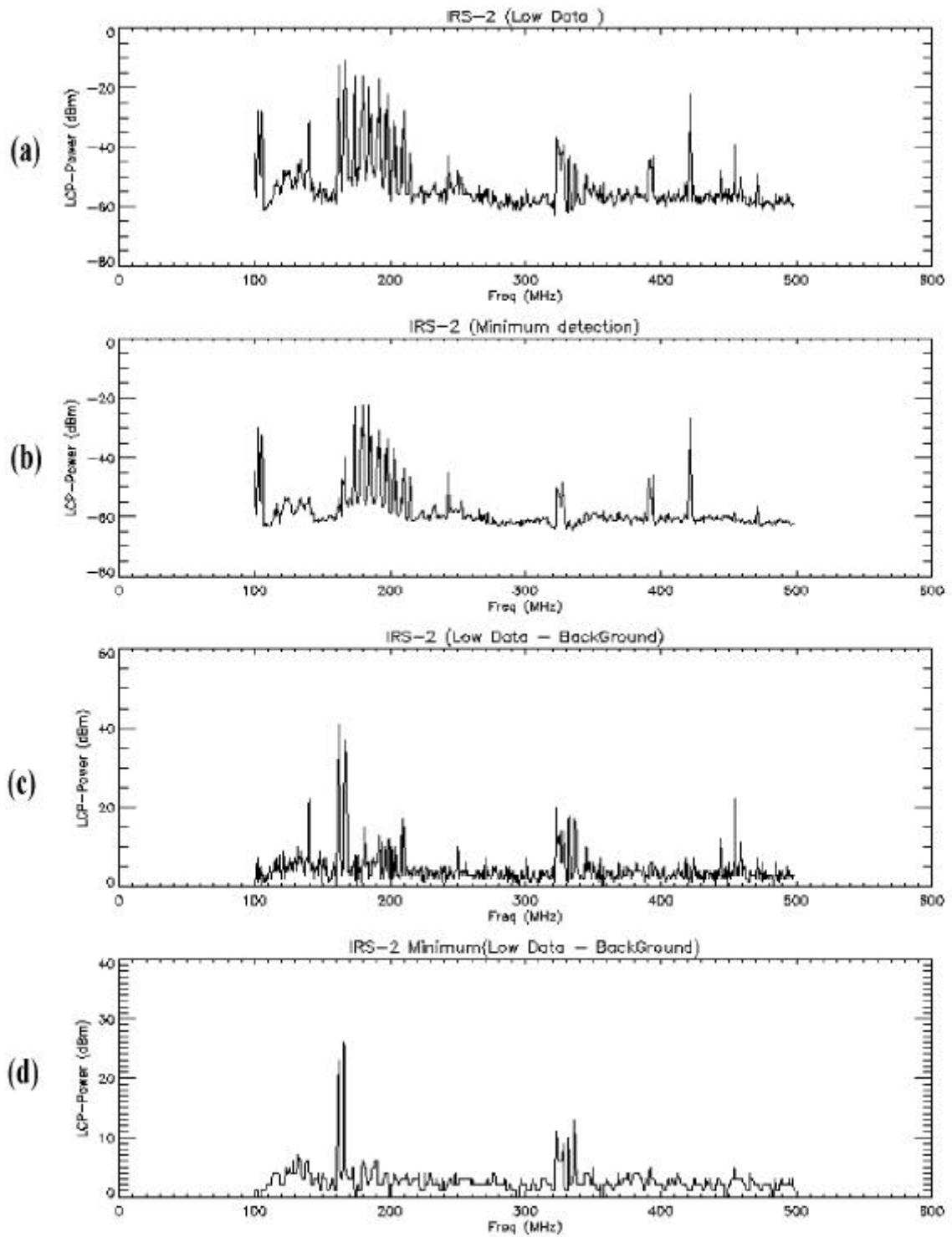
(Maximum) (d)

(Average) (e)

(Median) (f)

(Pick 1)

.



4.

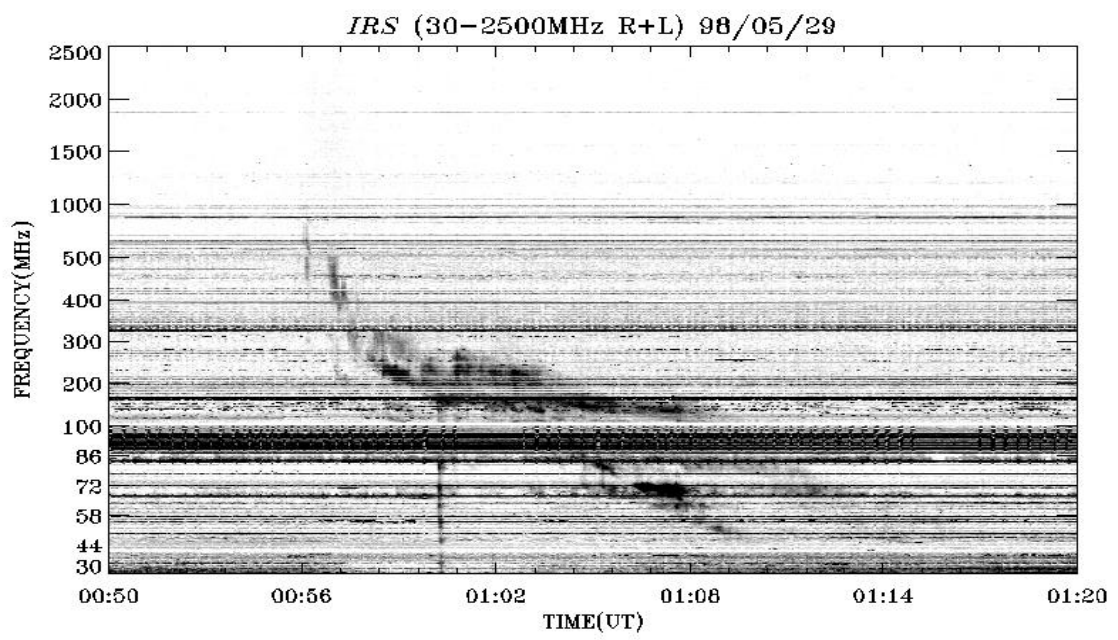
(a)

(b)

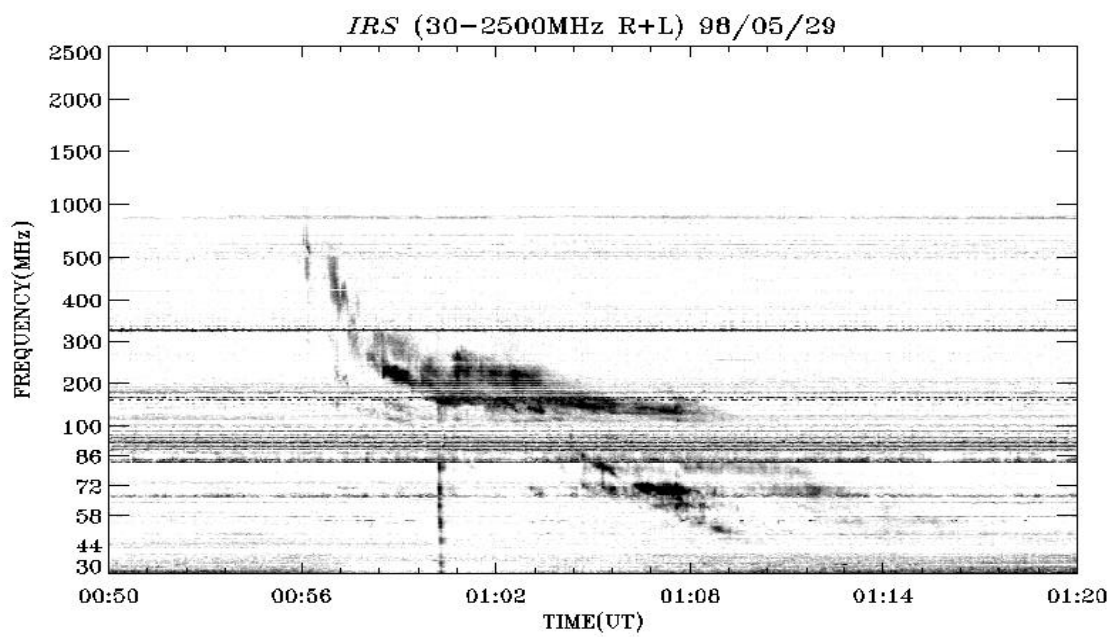
(c)

가

(d)



(a)



(b)

5. 1998 5 29 00 56

(Smart et al. 1984)

1998 5 29
(5(b)) UT 05 56 1000 MHz 44 MHz
가 (drift) 1 1 800 MHz
58 MHz 2
가
가 가
(Plasma oscillation)

Saito(1970)

Baumbach- Allen(1947)

Saito r cm³

(N)

$$N(r, \phi) = F \times \left(\frac{3.09 \times 10^8}{r^{16}} \times (1 - 0.5 \sin \phi) + \frac{1.58 \times 10^8}{r^6} \right. \\ \left. \times (1 - 0.95 \sin \phi) + \frac{2.51 \times 10^6}{r^{2.5}} \times (1 - \sin^{0.5} \phi) \right) \quad (1) \quad (cm^{-3})$$

ϕ F 1, 4

10 $\phi = 0$ F 4

Baumbach- Allen r

cm^3 (N) .

$$N(r)=10^{14}\times(1.55\times r^{16}+2.99\times r^6)$$
 (2)

가

(Plasma oscillation) 가

$1\quad 2$

(f)

(N) (1) (2)

r .

$$f=9\times N^{0.5}\quad (kHz)$$
 (3)

$6\quad (1)\quad (2)\quad (\quad)$

(3)

(Plasma Oscillation frequency)

가 가 .

Saito F
 . (phi)

Allen saito

$F=1$ saito

.

.

$V,$ t

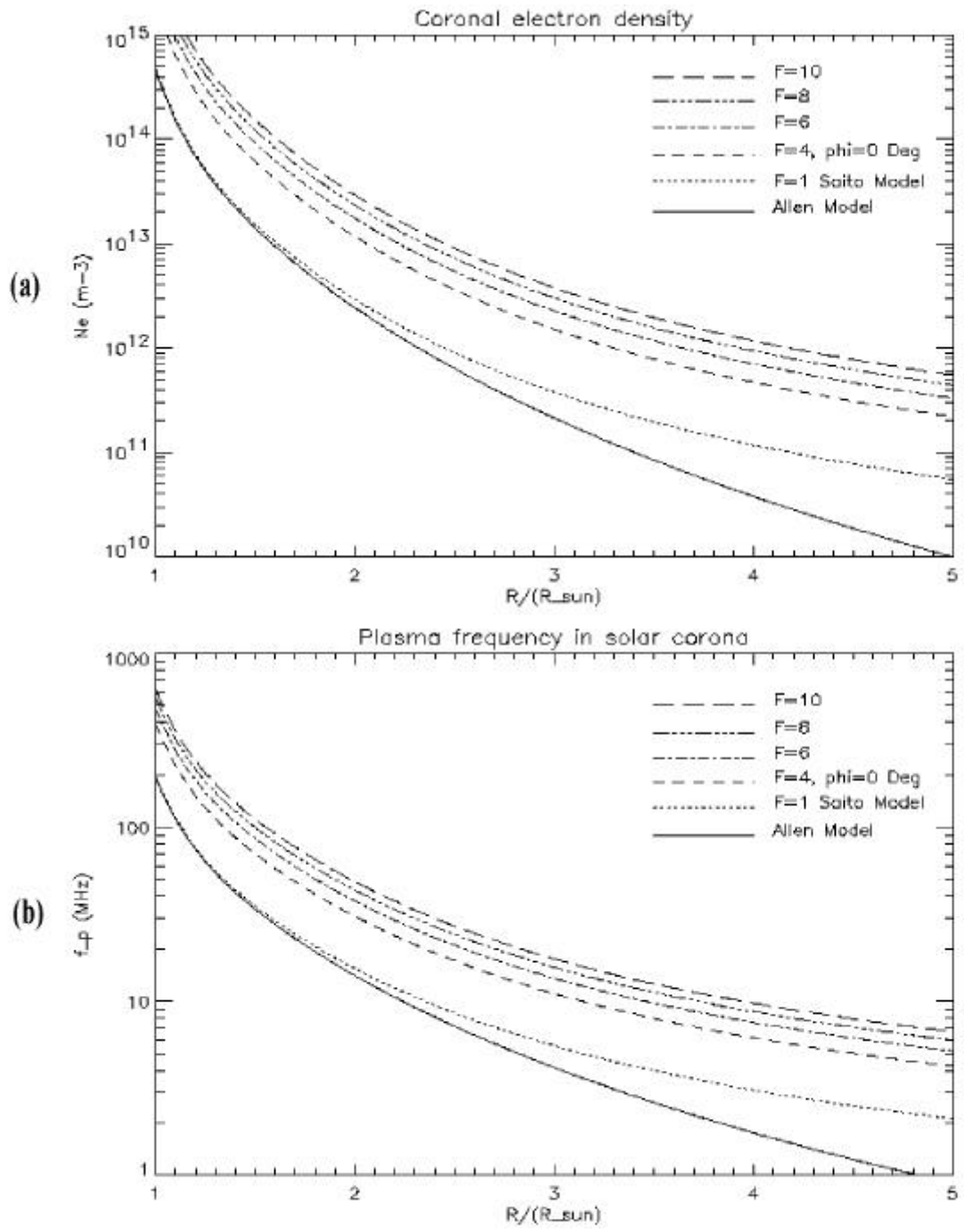
$r(f)=Vt$ t, f V .

$1\quad 2$ 7

9 . $1\quad (a,b,c,\ldots)\quad 2$

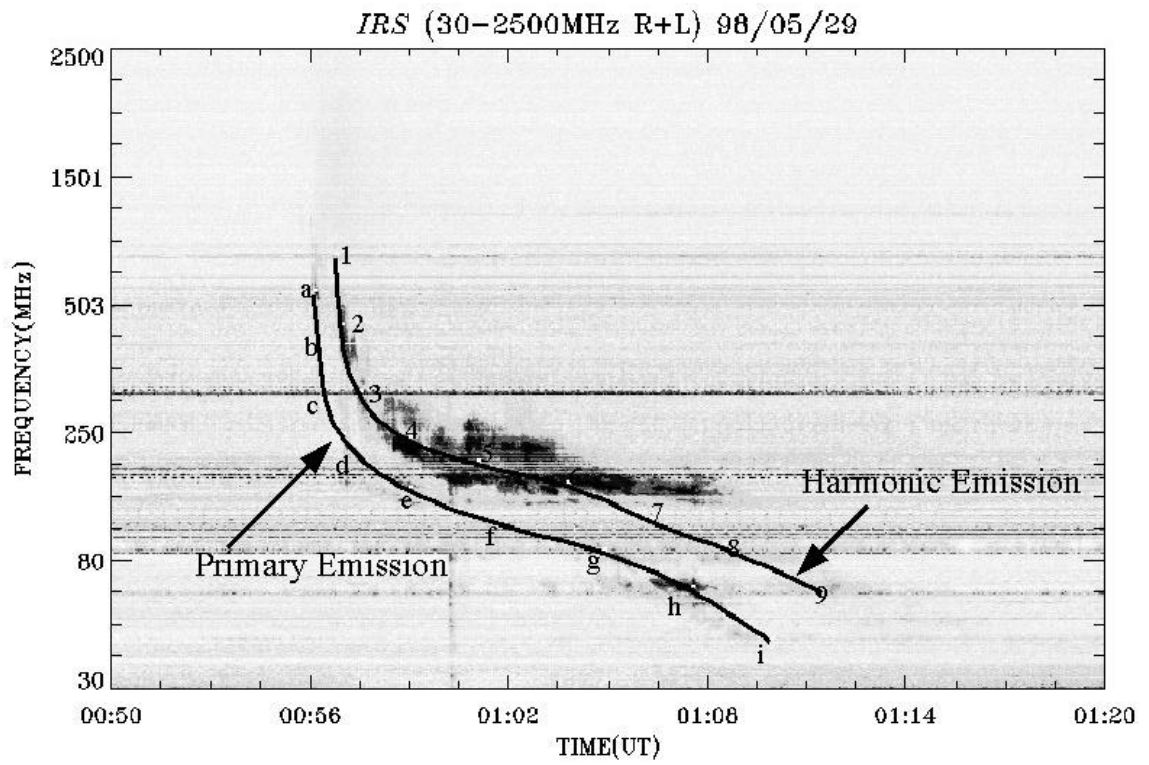
(1, 2, 3, ...)

.



6. ()
(b)

(a)
(Plasma Oscillation frequency)
가



7.

$$\begin{aligned}
 & (f_1, f_2, \dots) \quad (t_1, t_2, \dots) \quad . \\
 & (f_1, f_2, \dots) \quad (\text{Plasma Oscillation}) \quad (3) \\
 & N_e \quad . \quad N_e \quad \text{Saito} \quad ((1)) \\
 & \text{Baumbach- Allen} \quad ((2)) \\
 & r(r_1, r_2, r_3, \dots) \quad . \quad n \\
 & \quad \quad \quad (\text{Globally- Convergent Newton Method}) \\
 & . \quad 1, 2 \quad (f_1, f_2, \dots) \quad (r_1, r_2, \dots)
 \end{aligned}$$

2. 1998 5 29 00 56

Primary Emission									
	1 : 2	2 : 3	3 : 4	4 : 5	5 : 6	6 : 7	7 : 8	8 : 9	
Saito	1529.23	1634.62	1595.03	1409.06	1198.18	1023.27	952.95	884.44	1278.34
Allen	1391.87	1477.10	1430.88	1250.70	1052.24	884.04	809.17	731.06	1128.38
Secondary Emission (Harmonics)									
	a : b	b : c	c : d	d : e	e : f	f : g	g : h	h : i	
Saito	1790.46	1841.44	1808.08	1583.37	1394.43	1110.78	996.91	989.35	1439.38
Allen	1623.45	1658.45	1606.33	1365.22	1191.28	915.04	811.59	783.60	1244.37

$(dr_1=r_2-r_1)$.

$(dt=t_2-t_1)$ V1,

V2, ... $\frac{dr}{dt}$.

() 가

-

3

(df/dt)

1 , 2 2
가 가

1

가 2 .

1, 2 Saito
 Baumbach-Allen 가
 . $(1\sim2)\times10^3$ km/s
 (Lin & Hudson 1976; Cliver et al. 1983). 1972 1982
 39 Pinter &
 Dryer (1990) 가 1560 km/s .

.
 .

4

1

() ()

H(North- South), D(East- West), Z(Upward- downward)

3

(1997). 3

H, D, Z $\pm 65,000$ nT, 0.1 nT

1 가 10

Pc(continuous Pulsation) Pi(irregular Pulsation)

(1996).

(SEC: Space Environment Center)

(1996).

가 .

(K , a , A)

(K_p , a_p , A_p) . K

3 0 9 log

scale a A K 0 400

. a 가 3

A 24

a_p a

3. a_p K_p

a_p		K_p		a_p
0	<	0	<	1
1	<	0+	<	3
3	<	1	<	6
6	<	2	<	11
11	<	3	<	21
21	<	4	<	36
36	<	5	<	62
62	<	6	<	103
103	<	7	<	167
167	<	8	<	269
269	<	9-	<	350
350	<	9	<	400

. K_p (3) a_p 0

9 .

0 9 .00 .33 M(-), .34

.66 Z(0), .67 .99 P(+) 가 .

K_p 가 4.26 4M 4- .

A_p 8 a_p 1

. A_p 1

16 29

(Active) 50 99

(Major Storm)

3

K .

K a, A 가 a, A a_p, A_p 가 . K_p

a_p . 24 A, A_p 3

$$a, a_p, K_p$$

K 가
3 K . K

가 1 8 K
 $K_{\max} < 3$ $K_{\max} = 4$,

$K_{\max} = 5$, $K_{\max} > 6$.

K
 (S_q) .

.

2 K

가

K

.

K 가

($K9$) .

가

4 30.

IGRF- 1995

.

L . L
 가 . 가
 .
 6400 km
 2,380 km .
 K^3
 log scale K_0 K_9 10
 (5).
 K_9 .
 가 K_9 .
 K_9 , 300 nT
 280 nT . CETP()
 .
 K
 Bartels- Mayaud rule hand scale (Menvielle
 1995).
 FMI 11 K .
 Menvielle (1995) hand scale
 , FMI 가
 가
 .
 FMI 가 3
 H D . FMI
 3 K .
 24 3 K
 K K .
 K 5
 harmonic fitting 1

1 SR (Solar Regular) . H, D SR
K . *K*
5
harmonic fitting 2 SR . H, D 24

4. L *K* 9

	SYMBOL					L	<i>K</i> 9
	ICH	37.15 ° N	127.55 ° E	30.63 °	199.88 °	1.37 RE	300 nT
	YON	37.24 ° N	127.08 ° E	30.74 °	199.43 °	1.38 RE	300 nT
	CHE	33.45 ° N	126.57 ° E	26.82 °	198.75 °	1.28 RE	280 nT

L : 가

K 9 :

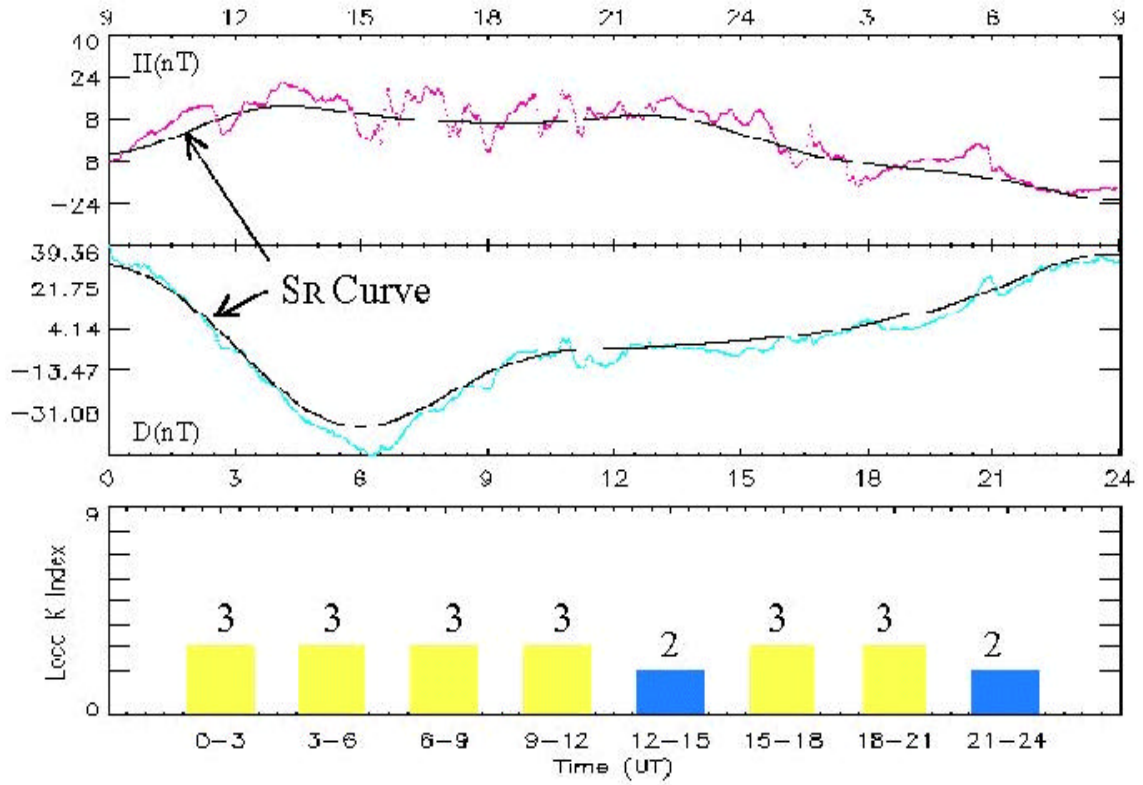
5. *K*

K				
0	<	$K0$	<	$0.01 \times K9$
$0.01 \times K9$	<	$K1$	<	$0.02 \times K9$
$0.02 \times K9$	<	$K2$	<	$0.04 \times K9$
$0.04 \times K9$	<	$K3$	<	$0.08 \times K9$
$0.08 \times K9$	<	$K4$	<	$0.14 \times K9$
$0.14 \times K9$	<	$K5$	<	$0.24 \times K9$
$0.24 \times K9$	<	$K6$	<	$0.40 \times K$
$0.40 \times K9$	<	$K7$	<	$0.66 \times K9$
$0.66 \times K9$	<	$K8$	<	$K9$

ICHON (H,D-comp)
 Compensation Field = 30168, 5 nT

99 / 06 / 08

40 nT/div (60sec averaged)



8. 1999 6 8
K

H, D

2 SR

K

3

FMI

1999 6 8

1

H, D

FMI

SR

fitting

FMI

K 2 3

5

23

2000 가

가

가

가

(e.g. FM, TV, Pager)

가

1278 km/s

K

가

FMI

K

Kakioka

.

K

.

-

K

.

가

.

shielding

.

.

가

-

.

1. , , , p. 195, 1997
2. 1999, , 15
3. 1996, ,
4. 1996, ,
5. , 1999, , 23
6. , & 1997, , 14, 320
7. , & 1997, , 14, 126
8. Allen, C. W. 1947, Mon. Not. R. Astron. Soc., 107, 426
9. Bravo S. Stewart G. A 1997, Solar Physics, 173, 193
10. Cliver, E. W., Kahler, S. W. & McIntosh, P. S. 1983, ApJ., 264, 699
11. Kenneth H. S., Daniel J. M. & Sabatino S. 1996, Geophysical Research Letter, 23, 605.
12. Khaled H. B., Edward W. C. & Valentin B. 1997, Solar Physics, 176, 211
13. Lin, R. P. & Hudson, H. S. 1976, Solar Phys., 50, 153
14. Menvielle, M. & Berthelier, A. 1991, Reviews of Geophysics, 29(3), 415
15. Menvielle, M., Papitashvili, N., Hakkinen, L. & Sucksdorff, C. 1995, Geophys. J. Int, 123, 866
16. Menvielle, M 1999, private communication
17. Pinter S. & Dryer, M.. 1990, Bull. Astron. Inst. Czechosol. 41, 137
18. Rust D. M. 1982 Science 216, 939
19. Robinson, P. A., Spacecraft Environment Anomalies Handbook, Report #GL- TR- 98- 0222, Air Force Systems Command, Hanscom AFB, MA 901731, 1989
20. Saito, K. 1970, Ann. Tokyo Astron. Obs., 12, 53
21. Smart, D. F. & Shea, M. A. 1984, Solar- Terrestrial Prediction Proceedings, 471
22. Wild, J. P., Smerd, S. F. & Weiss, A. A. 1963, ARA&A, 1, 291