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2001. 1. 15.

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2. : 2000. 1. 3 - 2000. 12. 31

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(%)		20%		30%		30%		20%		100%				

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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. Such variable conditions, on the Sun in the solar wind, magnetosphere, ionosphere and thermosphere that can influence the performance and reliability of space-born and ground-based technological systems are collectively referred to space weather. The purpose of space weather is to provide the timely specification and forecast of space environment eventually to mitigate the social-economy impacts on mankind.

According to scientists from NASA and NOAA, the Sun is near the peak of its 11-year cycle of activity (around 2000). Solar maximum is the two-to-three year period around the that peak. Variations in the solar activity cause disturbances in the earth magnetosphere. The magnetosphere disturbances have a significant impact on human activities in space and on the ground. The space environment, particularly near the geo-synchronous orbit where a number of satellites serve to support modern society, is one of major concerns for satellite operators. On the ground, magnetospheric storms and substorms cause a wide variety of problems in short-wave communication, navigation, and technological systems such as the power grid.

Many of the informations on space weather describe the space environment, but few have described the effects that can be experienced as the result of environmental disturbances. We have intensively examined many space environment observational data and informations to introduce space weather scales as a way to communicate to the generic public the current and future space weather conditions and their effects on people and system. These scales will be useful to produce our own nowcast and forecast services of space environment for users who are interested in space weather effects.

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19

40

21

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48

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(, 1999).

(S-Ramp, 2000)

ASCA()

10

(1)

(Joe H. Allen, 2000).

NASA NOAA

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1. 2000 (Joe H. Allen, 2000)

3 3	Satmex 5	84 ,
3 21	Hotbird 2	9
3 31	Echostar IV	22 50%
4 28	Turksat 1C	55
7 15	ASCA (Astro- D)	,
8 27	Solidaridad 1	
9 28	Galaxy VIII- i	10
10 26	Terra	16
10 31	Echostar IV	44 26
11 4	Insat 2B	
11 22	Galaxy VII	,

2000

가 가
가 가 . 가
가 .
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(ISES)

1999

(NOAA Space Weather Scales) .

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(, 1997)

(, 1999) 가 .

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2005

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2.

	30MHz~2.5GHz	
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	Ionogram	

3.

	http://www.lmsal.com/SXT/img/First_Light.gif http://128.171.5.17/ARMaps/Today/latest.gif http://www.nso.noao.edu/synoptic/ch4.gif http://sohowww.nascom.nasa.gov/data/realtime/mpeg/	1
	http://www2.crl.go.jp/uk/uk223/service/27day/ http://www2.crl.go.jp/uk/uk223/service/1day/ http://www2.crl.go.jp/uk/uk223/service/ptr/ http://www2.crl.go.jp/uk/uk223/service/nnw/ http://umtof.umd.edu/pm http://sec.noaa.gov/ace/EPAM_24h.html http://sec.noaa.gov/ace/SWEPAM_24h.html http://sec.noaa.gov/ace/MAG_24h.html	Dst 48
	http://crlgin.crl.go.jp/sedoss/geomag-interface http://crlgin.crl.go.jp/sedoss/geoact-j http://wdc-c2.crl.go.jp/ionog/fggraph/now/foes_p.html http://wdc-c2.crl.go.jp/ionog/fggraph/now/fof2_p.html http://ionet-us.crl.go.jp/ionog/sumsite/now/fdata.html	K Es F2
	http://crlgin.crl.go.jp/sedoss/solact3 http://www.sec.noaa.gov/today.html http://crlhir.crl.go.jp/tserdin/plain_report/yymmdd_region.html http://crlhir.crl.go.jp/tserdin/plain_report/yymmdd_scd_r.html http://crlhir.crl.go.jp/tserdin/plain_report/yymmdd_activity.html	1 , /
	http://crlhir.crl.go.jp/cgi-bin/tserdin/AandF http://crlhir.crl.go.jp/tserdin/plain_report/yymmdd_forecast.html http://crlhir.crl.go.jp/tserdin/plain_report/culmoryymmdd.html http://crlhir.crl.go.jp/tserdin/plain_report/culaftyymmdd.html http://crlhir.crl.go.jp/cgi-bin/telephone.pl#abstract http://crlhir.crl.go.jp/forecast/stef_latest.html	IPS IPS 1 1

. (1) (2)

(3) .

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1

1.

가.

(30 MHz

300 MHz) (300 MHz 3000 MHz)

.

(dynamic spectrum : ,)

, 4 5

(Wild et al. 1963).

(e.g.

FM, TV, Pager)

. .

1

. II (1-b) 1 (Primary Emission)

2 (Secondary Emission)

.

(, 1999) .

4.

Type I		Prominence ,
Type II	Fundamental, Harmonic (Drift)	
Type III	,	
Type IV	Stationary, Moving Type IV	Plasmoid
Type V	Type III group 1 ~ 2 ,	

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(Smart et al. 1984)

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(QBSA:Quarterly Bulletin on

Solar Activity, 1975)

(5) .

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5 .

(300 3000MHz) , (30 300MHz) ,

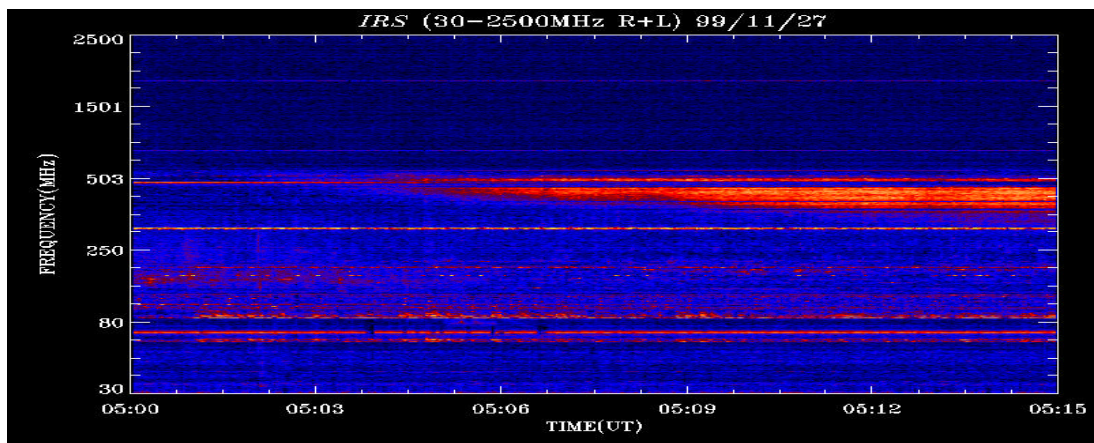
(1=weak, 2=moderate, 3=strong) 1 (SFU)

(1 50 SFU , 2 50 500 3

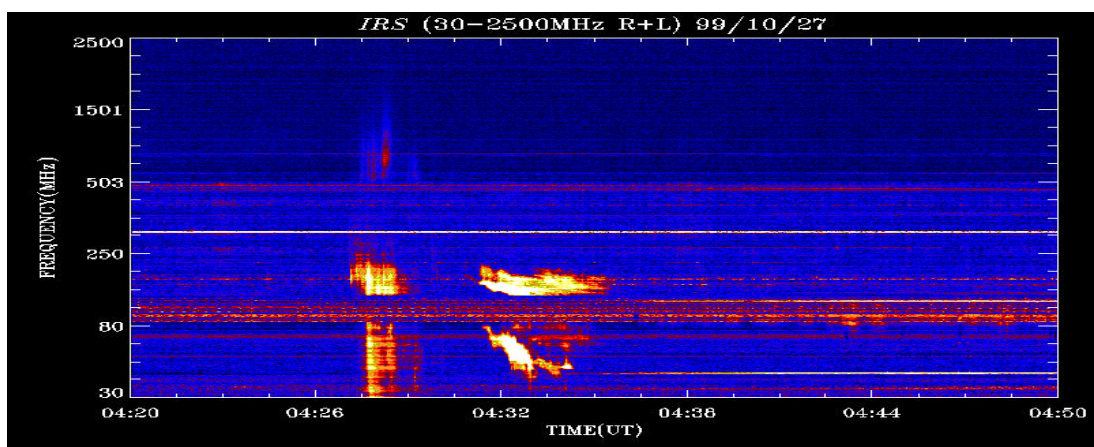
500) 3 .

5 . 6

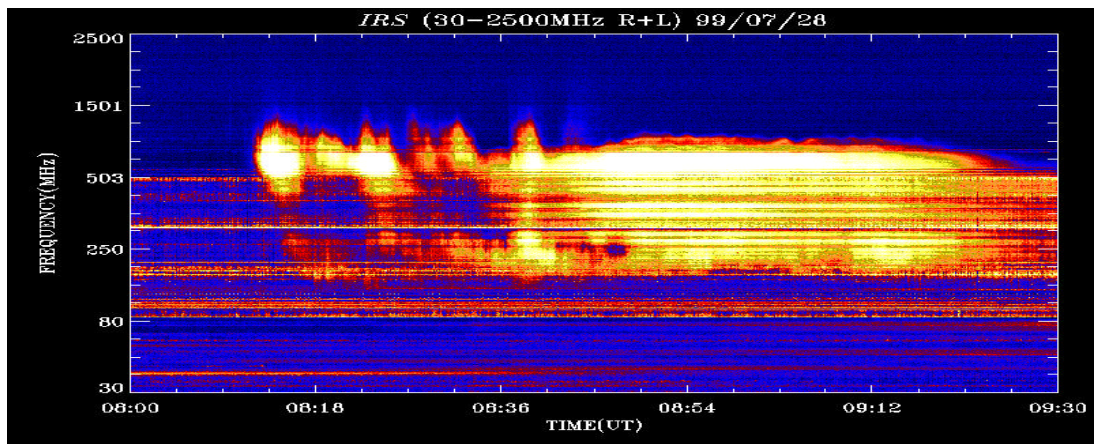
.



(a) I



(b) II, III



(c) IV

5.

DEC 2000	Time of Obs.		Station	Events						Spectral Type	Pol & Position Remark
	Start	End		Decimetric Band			Metric Band				
				Start	End	INT	Start	End	INT		
1											

6.

B		RS	(reverse slope burst)
G	10	DP	(drift pairs)
GG	10	DC	(drift chains)
C		H	Herring bone
S		W	
		P	
N		MOV	(Type IV)
U	U	STA	(Type IV)

2.

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3

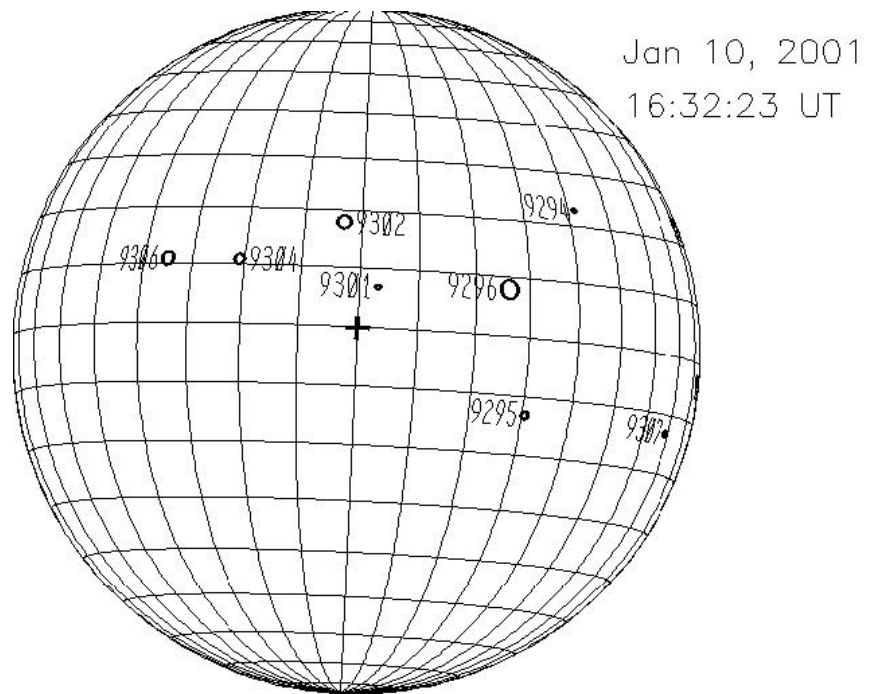
H α

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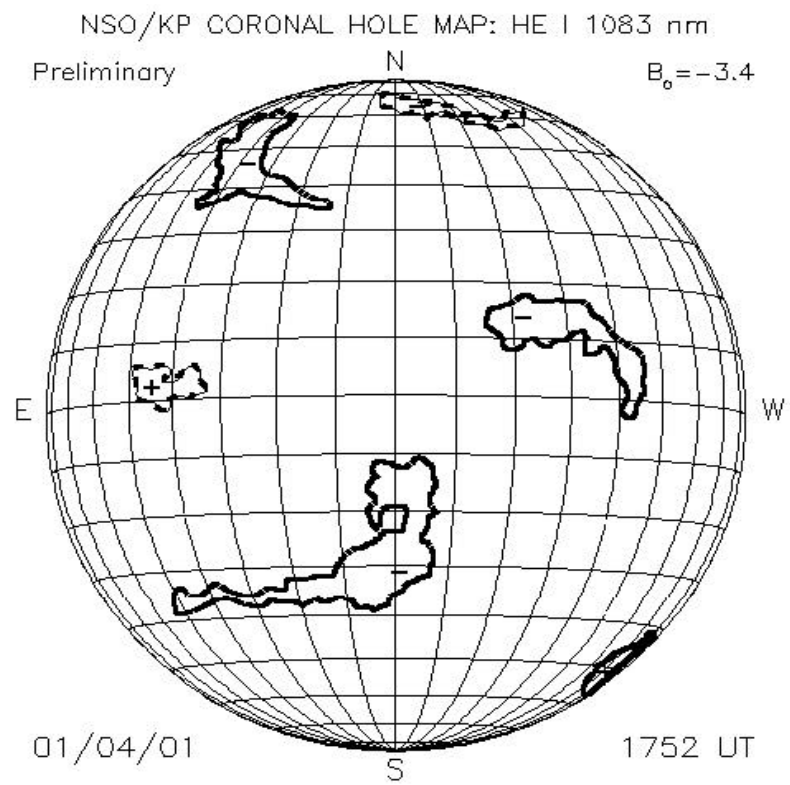
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NOAA



2. NOAA



3. (NSO)

(2) .

1 .

$H\alpha$

(Square Degree) . S(2.0), 1(2.1
5.1), 2(5.2 12.4), 3(12.4 24.7), 4 (>24.7) (F),
(N), (B) . 1N 2.1 5.1,

ISES 3

(CME: Corona Mass Ejection)

가 3 ()

()

(1)

가 (2) 가
MeIntosh E F A D
(1 2) 가 가
가 , 가
가 .

8가 UGEOA (GEOALERT)
(Quite)

UGEOA 0, C-
50% . C- 50%

(Eruptive) UGEOA

1 . M- 50%
(active) UGEOA 2

가 X- 50%
(Major) 가 UGEOA
3 . 가
50%

UGEOA 4 .
 가
 (Warning), UGEOA 8, Nil(UGEOA
 9), UGEOA /
 . C, M, X GOES
 X .
 가 .
 RWC
 .
 , McIntosh ,
 neutral line , X
 가 . (http://spaceweather.com) 24 ,
 48 M , X
 가 (1996)
 regression , , X
 2.8 GHz .

2

1.

가.

() ()

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

K

CETP() , , FMI

K (, 1998)

3 K

3

K

7 , SI, Bay

(H)

(SC) (SG)

가(SSC) 1 3

가가 (Initial Phase). (main phase)

SSC

H nT SC

H 가

SI 1

가 Bay 4

7.

Geomagnetic Storm (SSC)	H 가(SSC)	1 ~
Sudden Impulse (SI)	H 가(SSC)	
Solar Flare Effect (SFE)		
Bay	가	1

•

•

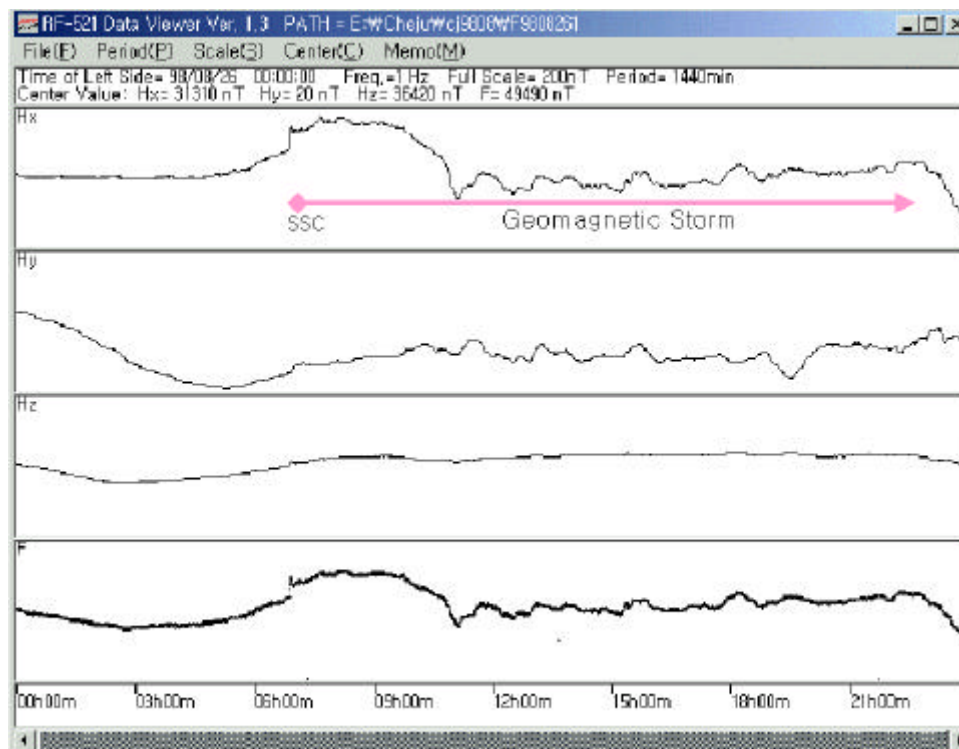
•

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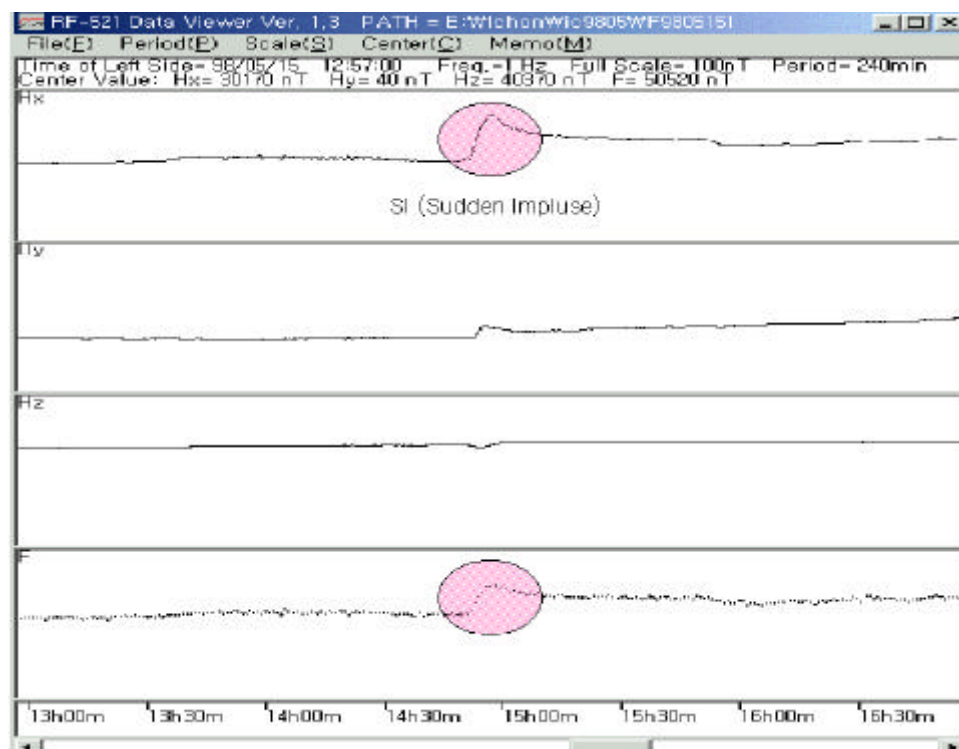
•

8.

DEC 2000	Station	K Index								K	Event	Activity
		0- 3	3- 6	6- 9	9- 12	12- 15	15- 18	18- 21	21- 24			
1	ICHON											
	YONGIN											
	CHEJ U											

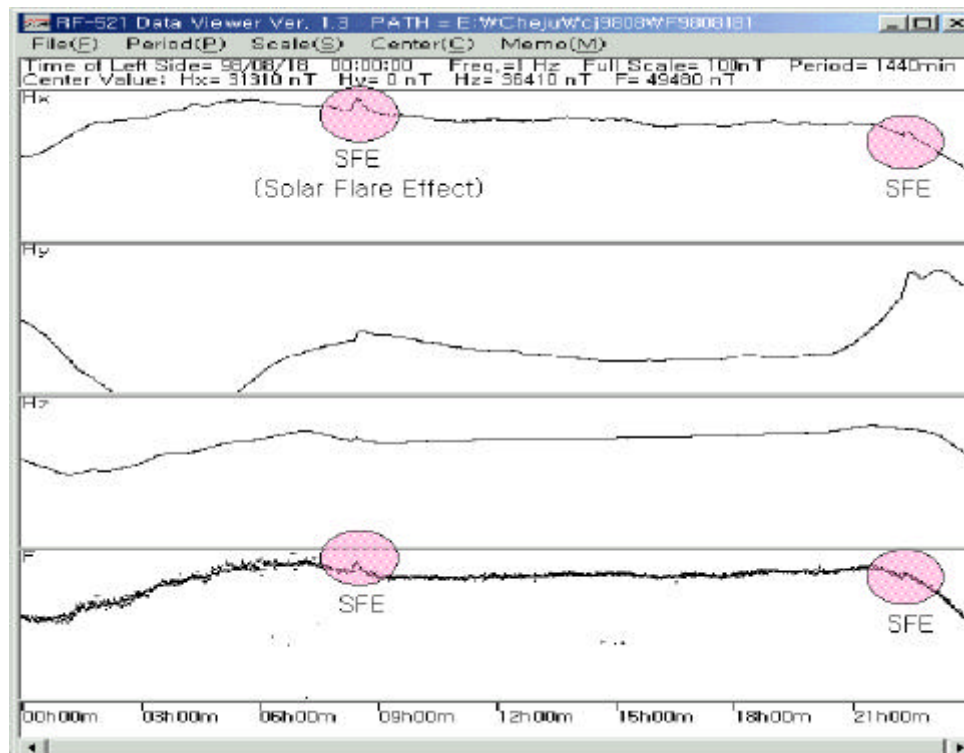


(a)

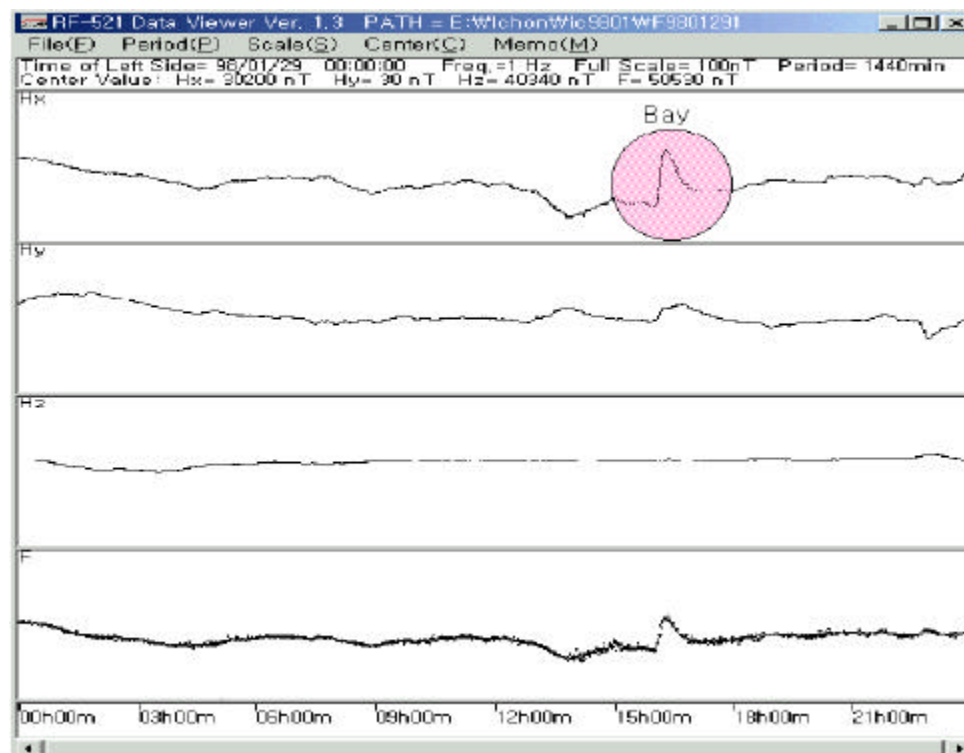


(b)

(Sudden Impulse)



(c) (Solar Flare Effect)



(d) bay

9.

0	Calm	5	Bay Disturbance
1	Giant Pulsation (IFS Period is short than 3 minute)	6	Impulsive Disturbance
2	Oscillation (PC)	7	Sudden Commencement of Geomagnetic Storm (SSC)
3	Irregulator Disturbance	8	The First Phase of Geomagnetic Storm
4	SFE (Solar Flare Effect)	9	The Main Phase of Geomagnetic Storm

2.

(CME), , ,
 ,
Halo CME가 40 70
가 .
(SEC)
 . (1) Halo CME , (2)
2N , (3) II, IV 가
 , (4) 30 ° 가 .
가
27
3 5 .
1 K 5
가 IUWDS MAGNE KA
3 K
UGEOA . UGEOA
K 3

(Quite) UGEOA 0 , 4
 (active) UGEOA 1, 5
 (Minor Storm) UGEOA 2, 6
 (major Storm) UGEOA 3, 7
 (Minor Storm) .

K가 4 UGEOA
 5 .

(Warning), UGEOA 8,
 Nil(UGEOA 8), UGEOA / 가

1 K (K) 24 .
 : $0 \leq K \leq 16$
 : $17 \leq K \leq 24$
 : $25 \leq K \leq 32$
 : $33 \leq K$

3

1.

2000
 (1) . MeV
 () 가
 (CME)
 3가
 , single-event upset(SEU) . 가
 .
 , . 가

가 (differential charging).

.
(bulk charging).

.
(Robinson 1989).

가 .

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가

. 1989 10 , GOES

6

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2.

(GOES)

()

.

(SEC)

GOES - 8

(5)

. 5 SEC

3

(10MeV, 50MeV, 100MeV)

5

10 MeV

(cm^2), (sec), (sr) 10

,

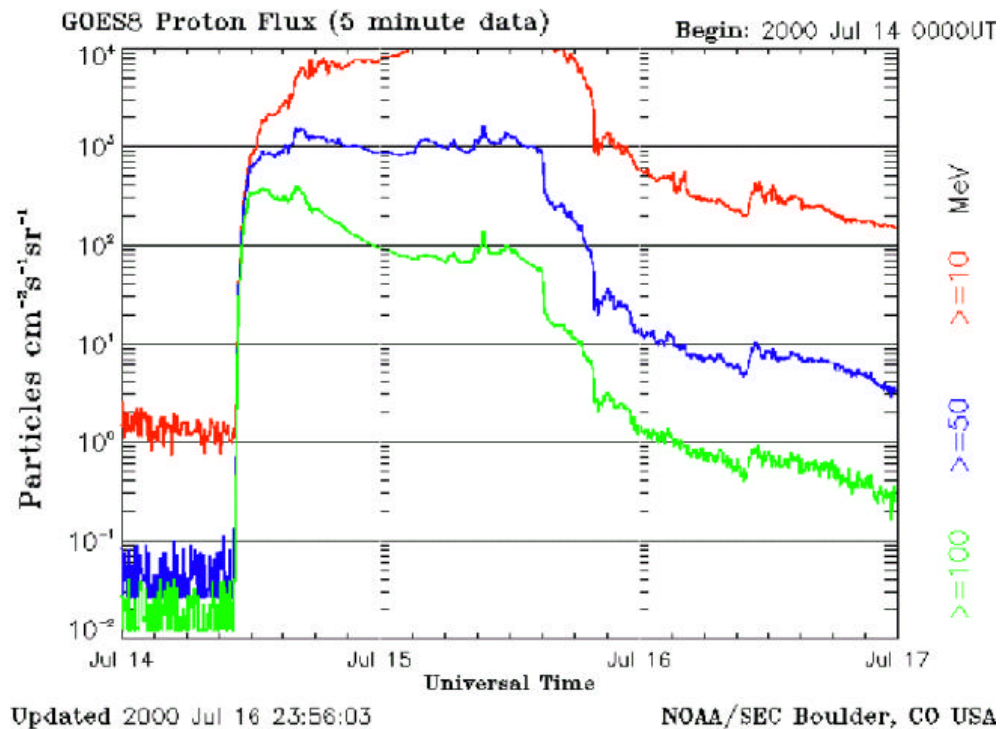
.

10 MeV

(F : $protons/cm^2/sec/sr$)

: F < 10
 : 10 F < 100
 : 100 F < 1000
 : 1000 F

(1) X 가, (2)
 , (3) II, IV 가
 , (4) , (5) open
 close ,
 (6) , (7) (neutral line) .



GOES

pfu(Proton Flux Unit (protons/cm²/sec/str))

UGEOA

0 , 10 MeV

가 10 pfu

UGEOA

1

. 100

MeV

가 100 pfu

UGEOA

2

100 MeV

가가

UGEOA

7

.

UGEOA

8,

9, 가

/

. 2000

7

14

(5)

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3

1

1. (X)

X

가

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GOES

X

10

5가

(ISES)

X

3가

6

GOES

1 8

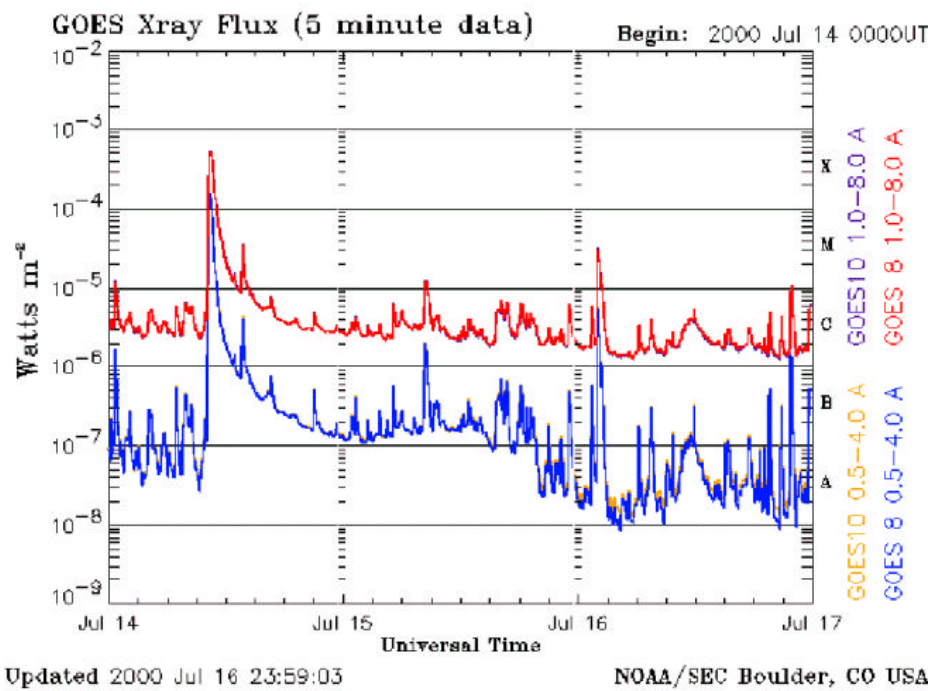
(0.1 0.8 nm)

0.5 4.0

(0.05 0.4 nm)

5

X



6. GOES

3

X

10. (X)

X *		(SEC) †	(ISES)
X20 (2 × 10 ⁻³)	Extreme	R5	Major
X10 (10 ⁻³)	Severe	R4	Major
X1 (10 ⁻⁴)	Strong	R3	Active
M5 (5 × 10 ⁻⁵)	Moderate	R2	Active
M1 (10 ⁻⁵)	Minor	R1	Eruptive

* X : 1 0.8 nm , W · m⁻²

† R : Radio Blackouts

2. ()

(PCAs : Polar Cap
Absorption events) HF

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X
가 가
가 .

5 GOES - 8 (cm²),
(sec), (sr) (10 MeV) 11
5 . ISES
(cm²), (sec), (sr) 10 MeV
10 ,

100 .

가 .

11.

*		(SEC) †	(ISES)
10 ⁵	Extreme	S5	Major P- Event
10 ⁴	Severe	S4	Major P- Event
10 ³	Strong	S3	Major P- Event
10 ²	Moderate	S2	Major P- Event
10	Minor	S1	Proton Event

* 10MeV 5 Flux (/ sec / ster / cm²)

† S = Solar Radiation Storm

3.

2 2

CME , ,

, X ,

GOES - 8(W75) GOES - 10(W 135)
(Hp) 1 (7)

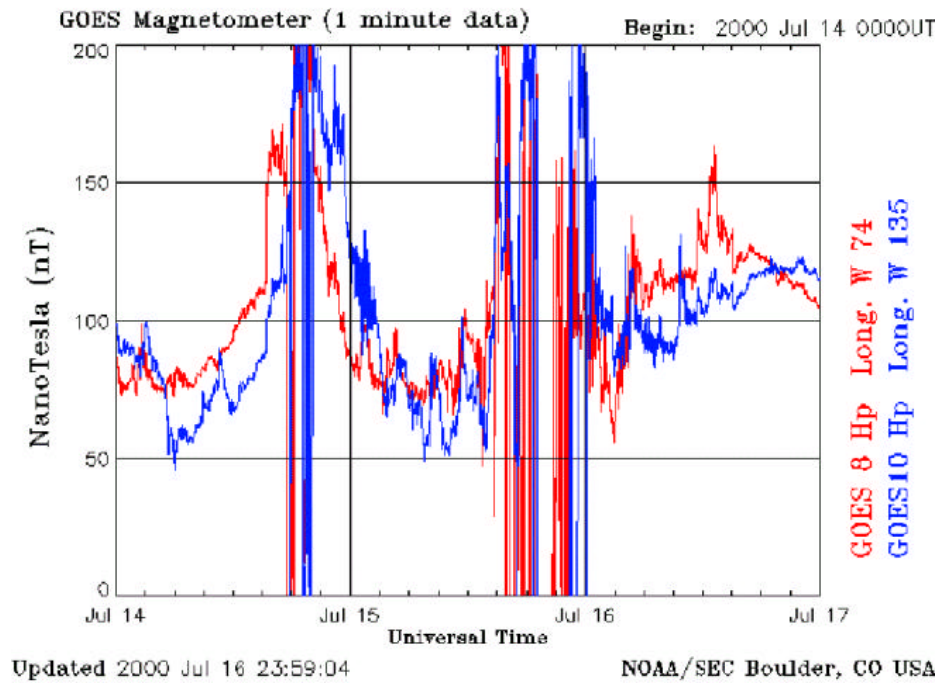
8
Kp (8) .

Hp (GOES)

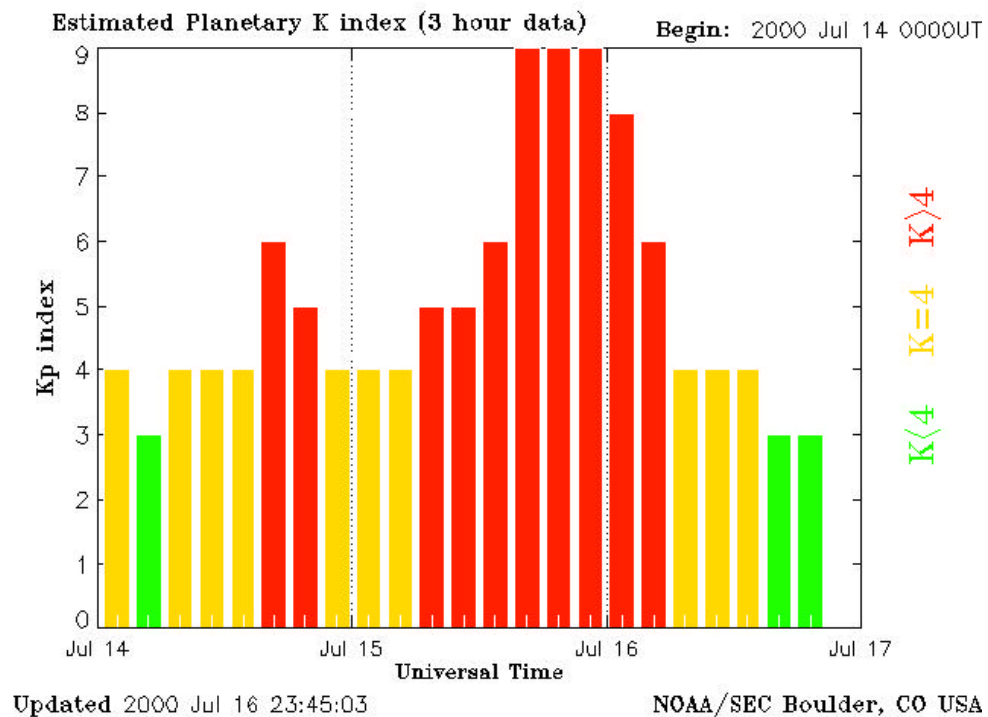
(dayside) 0 가

()

(night side)



7. GOES (Hp) 1



8. 8

Kp

12.

Kp *		(SEC)	(ISES)
Kp = 9	Extreme	G5	Severe Storm
Kp = 8, 9	Severe	G4	Severe Storm
Kp = 7	Strong	G3	Severe Storm
Kp = 6	Moderate	G2	Major Storm
Kp = 5	Minor	G1	Minor Storm

Kp : 3

Kp >4 : Active

Hp 0 가
(Substorm)

Kp

12

Kp 가 5

ISES 3가

SEC 5 .

2

(X) , ()

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(Space Environment Center;

SEC, <http://sec.noaa.gov>) 1999

(NOAA Space Weather Scale) .

1.

(X) , ()
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(X-)

가 GPS

(Hefley, 1972).

VHF UHF (30 MHz 3 GHz)

. , - ,
가
, 가
가 .

가

HF

가

(;
scintillation) VHF UHF

(30 MHz 3 GHz)

LORAN OMEGA

. 8

OMEGA

km

가

HF

13.

Extreme	HF , LF 가	R5
	HF 가	S5
	1~2 HF 가 LF	G5
Severe	1~2 HF , HF LF (Outage)	R4
	HF 가	S4
	HF (Sporadic)	G4
Strong	HF 1, HF LF (Degrade)	R3
	HF (Degrade)	S3
	LF HF	G3
Moderate	HF 10 10 LF	R2
	HF	S2
	HF (Fade)	G2
Minor	LF	R1
	HF	S1
		G1

2.

()

가

가 가

가 (differential charging).

(bulk charging).

(Robinson, 1989).

가

가

(14)

3.

가

가

14.

	, /	
Extreme	,	S5
	, ,	G5
Severe		S4
		G4
Strong	single event upset,	S3
	(drag)	G3
Moderate	single event upset	S2
		G2
Minor		S1
		G1

15.

Extreme	가	G5
Severe		G4
Strong		G3
Moderate		G2
Minor		G1

(Kappen-man and Albertson, 1991).

(15)

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가
가 .

(X) , ()

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(ISES)

1999

(NOAA Space Weather Scales)

X

, X

1. 1996, ,
2. 1999, , 15
3. 1996, ,
4. , , 1996, ,
5. , & 1997, , 14, 320
6. , & 1999, , 105
7. , & 1997, , 14, 126
8. Cliver, E. W., Kahler, S. W. & McIntosh, P. S. 1983, ApJ., 264, 699
9. Hefley, G., *The Development of LORAN - C navigation and Timing*,
National Bureau of Standards, Monograph, No. 129, p.118, 1972
10. Joe, H. A. 2000, Satellite anomalies, Recent Events, and Possible
Causes, Proceedings of the S-RAMP Symposium, Sapporo, Japan
11. Kappenman, J. G., and V. D. Albertson, Cycle 22:Geomagnetic storm treats
to power system continue, IEEE Power Engineering Review, p. 3, Sept. 1991
12. Robinson, P. A., Spacecraft Environment Anomalies Handbook, Report
#GL-TR-98-0222, Air Force Systems Command, Hanscom AFB, MA
901731, 1989
13. Smart, D. F. & Shea, M. A. 1984, Solar-Terrestrial Prediction
Proceedings, 471
14. Wild, J. P., Smerd, S. F. & Weiss, A. A. 1963, ARA&A, 1, 291

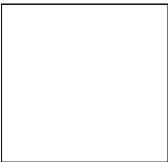
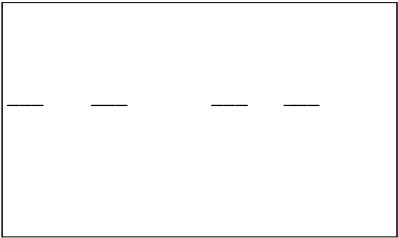
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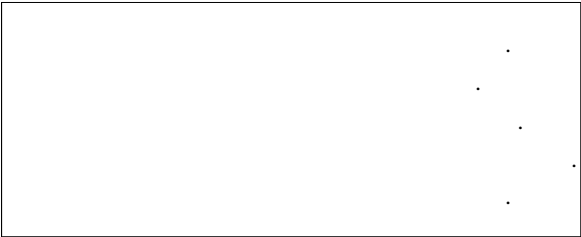
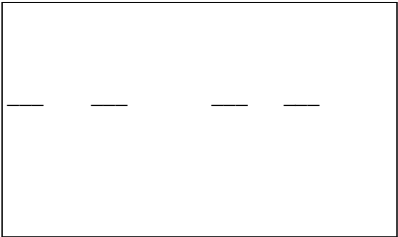
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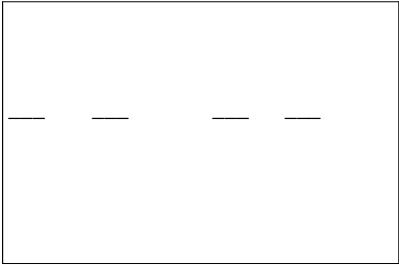
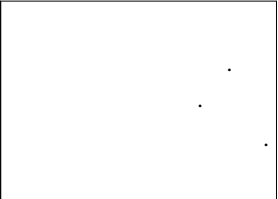


가
가



.

CME
→



→



가
가



2

— — — □ — □ — □

□ —

— — □ 가

— — — □ B — C — M — X — F — N — B

10.8cm 가

1 2 3 4 5 shock km

CME

— — □ — , □ —

3

— — —

— — — —

— — — —
— — — —

SC
SG

— nT

— — — — — nT

— — — — — nT

— — — —
— — — —

SI가
Bay가

4

— — —

가가
가

— — — —
— — — —

가 가
가 가

가

— — —

— PFU
— PFU

— — — —
— — — —

5

E
E

6

____, ____
____, ____
____, ____
F 10.7
K ____
K ____
____, ____