Manual for Space Weather Nowcasting

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In this manual… "≡" means "definition" "→" means "go to next web page"

1. SUN

Data	: Solar Monitor at NASA GSFC's SDAC : SOHO Real Time Movies
Daily Check Event	: SEC's Anonymous FTP Server : Sunspot number, Active region, Coronal hole : X-ray flare, CME, Filament disappearance, Proton event

Data

Latest Images/Movies of Solar Surface and Solar Corona

- > Solar Monitor
 - ♦ URL: <u>http://www.solarmonitor.org/index.php</u>
 - Latest solar images, SOHO(MDI and EIT), GHN, TRACE and GOES SXI, are available from this site.
- > SOHO LASCO/C2,3 EIT Real Time Movies
 - ♦ URL: <u>http://sohowww.nascom.nasa.gov/data/realtime/gif/</u>
- GOES SXI
 - ♦ URL: <u>http://www.sec.noaa.gov/sxi/index.html</u>
 - →Movies <u>http://sxi.ngdc.noaa.gov/sxi/servlet/sximovie</u>

Plots and Text Data

- SEC's Anonymous FTP Server
 - URL: <u>http://www.sec.noaa.gov/ftpmenu/index.html</u> (hereinafter referred to as "SECFTP")

Daily Check

• Sunspot Number

- Refer to "Daily Solar Data" issued by SEC
 - SECFTP →Latest Solar-Geophysical Data
 - → Daily solar Data <u>http://www.sec.noaa.gov/ftpdir/latest/DSD.txt</u>

Points to be checked are as follows.

Example) 2005.4.24.	:Prod :Issu # # Pr # PI #	uct: ed: O epare ease	Daily So 225 UT 2 d by the send com	olar Data 24 Apr 20 e U.S. De nments ar	a)05 ept. of nd sugge	DSD Commerce stions t	.txt , NOAA, o SEC.W	Space Vebmaste	Env r@n	iro oaa	nme . go	nt v	Cen	ter	
	#		L	_ast 30 [Days Dai	ly Solar	Data								
Announced with or delay. Update last Nowcasting.	ne day day's	/ 5	Radio Flux	SESC Sunspot	Sunspot Area 10E-6 Homis	S New Pagions	tanford Solar Mean	l GOES12 X-Ray Bkgd	 X	 	– F y	lar s	es Op	 tic	 al
	# Da #	03 25	82			Negrons 	000	Δ3 7				 1	 0	 	 0
	2005	03 26	78	41	140	0	-999	A3. 1	0	0	0	0	0	0	0
	2005	04 22	77	34	80	0	-999	A2. 6	0	0	0	0	0	0	0
	2005	04 23	79	35	80	0	-999	A5.5	0	0	0	0	0	0	0

• Active Regions (with Sunspots)

- Refer to "Solar Region Summary" issued by SEC
 - SECFTP →Alerts, Forecasts, and Summaries
 - →Solar Region Summary http://www.sec.noaa.gov/ftpmenu/forecasts/SRS.html
 - →MM DD Solar Region Summary (e.g. Apr 24 Solar Region Summary)
- > Points to be checked are as follows.

(Example) 2005.4.24.		
Count the number of regions listed here (3 in this example)	<pre>:Product: Solar Region Summary :Issued: 2005 Apr 24 0030 UTC # Prepared jointly by the U.S. Dept. of Commere</pre>	of the list is

• Coronal Hole

- > Refer to SOHO EIT, GOES SXI, and supplementary see also archives of the preceding cycle.
- > Check the location.
 - \diamond e.g. Appearing on the eastern rim, Coming close to the warning area, etc.

Event

- > X-ray flare, CME and Filament disappearance
 - Refer to "Solar Event Report" SECFTP →Indices, Events, and Region Data →Solar Event Reports - - last 90 days <u>http://www.sec.noaa.gov/ftpmenu/indices/events.html</u>
 - \rightarrow YYYYMMDD Edited Events (e.g. 2005 Apr 24 Edited Events)
- Proton event

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- ♦ Refer to "GOES Energetic Proton and Electron Data"
 - SECFTP →Lists of Solar-Geophysical Data →GOES Energetic Proton and Electron Data <u>http://www.sec.noaa.gov/ftpmenu/lists/particle.html</u> →YYYYMMDD_G11part_5m.txt (e.g. 20050424_G11part_5m.txt)

• X-ray Flare

- In Solar Event Report
 - ♦ Check the Type "XRA" (X-ray event) with Particulars "C" or greater.
 - ♦ Time: Refer to 'Begin'
 - ♦ Location: Refer to 'Reg#'
- > Check the plot.

SECFTP →Plots of Solar-Geophysical Data →3-Day GOES X-ray Flux Plots <u>http://www.sec.noaa.gov/ftpmenu/plots/xray.html</u> →YYYYMMDD_xray.gif (e.g. 20050424_xray.gif)

• CME

Check Movies.

SOHO http://sohowww.nascom.nasa.gov/ LASCO-C2/C3

- In Solar Event Report
 - ♦ Refer to Type "RSP" (Sweep-frequency radio burst) with Particulars "II" (Slow drift burst)
 - ☆ Time: Refer to "Begin" (In case of "RSP" is not listed up in the report, determine by refereeing to LASCO-C2 movie)
 - ♦ Direction: 8 (NSEW, NE, SE, SW, NW) + 1(Halo)
 - ♦ In case of possibilities of far-side event, notify by comment (e.g. North(far-side))

• Filament Disappearance

- In Solar Event Report
 - ♦ Refer to Type "DSF." (Filament disappearance)
 - ♦ Time: Refer to "Begin."
 - \diamond Location: Refer to "Loc/Freq." (e.g. N13E78)
- Check Images (Solarmonitor.org—GHN/H-alpha)
- Check Movies (SOHO EIT)

Proton Event

- > Plots
- SECFTP \rightarrow Plots of Solar-Geophysical Data \rightarrow 3-Day GOES >10, 50, 100 MeV Proton Flux Plots<u>http://www.sec.noaa.gov/ftpmenu/plots/proton.html</u> \rightarrow YYMMDD proton.gif (20050424 proton.gif)
- Check if Proton flux with the energy >10MeV (Red line) exceed the threshold of e+01 (indicated by dashed line)
- In Text Data

→YYYYMMDD_G11part_5m.txt (e.g. 20050424_G11part_5m.txt)

- ♦ Refer to GOES11 / P>10
- ♦ Start Time: The time that GOES-P11 exceeds the threshold
- ♦ End Time: The time that GOES-P11 goes below the threshold
- > In case of GOES-P11 remains above the threshold: "in Progress"
- Points to be checked are as follows



Examples of Briefing

- --Quiet. Coronal hole appears on the East rim
- --Moderately active. Coronal hole comes close to the warning area.
- --Very active. A westward CME associated with filament disappearance.

Other

2. Interplanetary Space / Solar Wind

Data	: ACE Real Time Data
Daily Check	: IME (Bt and Bz) Solar Wind Speed, Density, and Temperature
Event	: Sector Boundary, CIR, CME (Magnetic Cloud), and Shock /Discontinuity

Data

- > ACE Real Time Solar Wind provided by SEC
 - SEC <u>http://sec.noaa.gov</u> \rightarrow Data and Products <u>http://sec.noaa.gov/Data/index.html</u> \rightarrow ACE RT Solar Wind <u>http://sec.noaa.gov/ace/</u>
 - →Dynamic Plots <u>http://sec.noaa.gov/ace/ACErtsw_data.html</u>
- When ACE Plasma Data is not available) SOHO CELIAS/MTOF Proton Monitor Data. http://umtof.umd.edu/pm
 - \diamond Add a note of the use of the SOHO data.

Daily Check

• Averaged State/ Overall Condition/ General Condition

- > IMF-Bt, N, T, and Vsw: Take Mean Values.
- > IMF-Bz: Give a detailed description.
 - ♦ Example statements
 - --Southward 5nT (Northward turning 00:00UT, 00:00UT, and 00:00UT)
 - --Northward Generally 3nT(Max=5nT)
 - --Southward generally -3nT(Min=-5nT)

--Oscillating in the range -5nT to 5nT, between -2 and 4nT, around 1nT(Amplitude=3nT), etc.

Event

• Sector Boundary

- Information for identification
 - $\label{eq:constraint} \diamond \quad \mbox{Direction of IMF (} \phi(\mbox{IMF angle on ecliptic plane}) \mbox{ or (Bx, By))}$
- Supporting information
 - Sector structure of the last rotation

• CIR

- Diagnostic character
 - low speed Solar Wind \rightarrow Interaction region (increase of Bt and N, highly fluctuating IMF) \rightarrow high speed Solar Wind \rightarrow (Alfvenic oscillation/ stabilized Bt and N)
 - (See Figure B-1 in Appendix B-1.)
- Supporting information
 - ♦ location of coronal holes

• CME (Magnetic Cloud)

- > Diagnostic character
 - Shock in front of Magnetic Cloud →Sheath →Main Body of Magnetic Cloud(increase of Bt, rotation of IMF in tens of hours ~ a few days)
 - (See Figure B-1. in Appendix B-1.)

> Supporting information

 Occurrence of CME during the last few days (the exact arriving time depends on the speed of solar wind)

• Other

> Shocks, Discontinuities and disturbances

Examples of Briefing

--Solar wind speed, density, and Magnitude of IMF are on a decreasing trend.

--Solar wind speed continues to decrease. Density and Magnitude of IMF are stable. (in a stabilized region.)

- --Solar wind speed decreases to 300s of km. Sector boundary crossing at 20:20UT
 - (Day 27 in Figure.2-1)
- --Density is very low. / Very low-density solar wind / In the very low density solar wind. (Day 29 and 30 in Figure 2-1)
- --Solar wind speed, density, and Magnitude of IMF are on an increasing trend.
- --Entering the Corotating interaction region. solar wind speed increases to 600s of km. (Day 01 in Figure 2-1)
- --Escaping from Corotating interaction region. In the high-speed solar wind region (from coronal hole)
- --Continues to be in a stabilized region.



Figure 2-1. An Example of ACE real time 7-day plot

3. Magnetosphere

Data	: Geomagnetic indices : Geomagnetic Raw Data
Daily Check Event	: GOES satellites Data : Dst index, Pc index : Geomagnetic Storm, Substorm, Geomagnetic Pulsation, etc.

Data

- Dst index, AE index
 - ♦ WDC <u>http://swdcwww.kugi.kyoto-u.ac.jp/index.html</u>
 - →Data Service <u>http://swdcwww.kugi.kyoto-u.ac.jp/wdc/Sec3.html</u>
- Pc index and Geomagnetic pulsation
 - ♦ Kyushu University / SERC
- World Wide Magnetometer Chains
 - ♦ IMAGE <u>http://www.ava.fmi.fi/image/index.html</u> →Data <u>http://www.ava.fmi.fi/image/data.html</u> →Near-real time data
 - ♦ (CANOPUS)
 - ♦ HAARP<u>http://www.haarp.alaska.edu/</u>
 - →Data from the site <u>http://www.haarp.alaska.edu/haarp/data.fcgi</u> →Magnetometer Chain
- Geostationary Orbit Environment
 - ♦ GOES Magnetometer, Electron flux provided by SEC

Daily Check

• Dst index

- Refer to Dst index provided by WDC
 - ♦ WDC /Data Service (sited avobe)
 - →Dst index http://swdcwww.kugi.kyoto-u.ac.jp/dstdir/index.html
- Pc index
 - > Refer to Pc 3, 4, and 5 indices derived from the KUJ real time data. ######

Event

• Geomagnetic Storm

- Refer to Dst index.(cited above)
- (See Figure B-2 as a reference for the followings.)
- Item 1. Initial Phase
 - Start time (begging time): rise of Dst (There is no initial phase in SG type storms.)
- Item 2. Main Phase
 - ♦ Start time : start of decrease of Dst
 - ♦ Magnitude: absolute value of [(Dst minimum) minus (Dst at the beginning of main phase)]
 - ♦ Duration: (Start time of Recovery phase) minus (Start time of Main phase)
- Item 3. Recovery Phase
 - ♦ Start time: the time when Dst reached the minimum
- Examples of the statement
 - ♦ Gradual Geomagnetic Storm occurred at about **:**UT
 - SC-type Geomagnetic Storm occurred at **:**UT
 - ♦ SC-type Geomagnetic Storm started on ** entered the recovery phase.
 - ♦ Geomagnetic Storm ends.

- > Examples of statements in the remark column
 - ♦ Due to the strong Southward IMF-Bz during the CIR
 - ♦ Due to the arrival of the CME. Amplitudes of the SC are 0nT (Dst) and 0nT (KUJ).

Substorm

- Refer to all of the available data (including AE index, Magnetic data of worldwide observatories, Pi2 pulsation, and magnetic field measurements at geostationary orbit)
- Item 1. Start time (Onset)
 - ♦ Determine by refereeing to onset of sudden decrease of AL index and Pi2 pulsation
 - ♦ Take into account that effects of the local time and another factors.
- > Item 2. Maximum amplitudes of Pi2 pulsation
 - Amplitude, in this case, means the difference between peak and peak.
- Item 3. Maximum of AE index
- Item 4. Remarks
 - ♦ Dipolarization: can be considered associated event if it occurred within onset -+30min
 - Multiple Onset: In this case, take the maximum of AE index and amplitude of Pi2 pulsation during the period. And write down its time.
- > Example

Table	3-1.
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Time	Pi2	AE	Remark
06:45UT	0.2nT	400nT	Dipolarization
13:15UT	0.5nT	450nT	Dipolarization uncertain
15:10-19:30UT	0.4nT(15:50UT)	600nT(17:30UT)	Multiple onset

• Geomagnetic Pulsation

- > Refer to real time magnetometer data provided by MAGDAS. ######
- Item 1. Mean Amplitude
- Item 2. Peak Frequency
 - ♦ Refer to Dynamic Spectrum
 - ♦ Examples of notation: wideband, 15mHz, 30-35mHz

• Other Events

SI, Magnetopause Crossing, etc. (See Table 3-2.)

Table 3-2.

Time	
11:40UT	SI : Amplitude 20nT(KUJ) 30nT(GOES-12)
18:00UT	Mangnetopause Crossing(GOES-12,13)

Examples of Briefing

--Very disturbed. Moderate Gradual Geomagnetic Storm occurred.

--Disturbed. Minor to moderate Substorms frequently occurred.

--Quiet. Isolated minor Substorms occurred.

4. Appendix A.

• Glossary of Abbreviations

Organizations

NASA (National Aeronautics and Space Administration) <u>http://www.nasa.gov/home/index.html</u> >GSFC (Goddard Space Flight Center)<u>http://www.nasa.gov/centers/goddard/home/index.html</u> >SDAC (Solar Data Analysis Center) <u>http://umbra.nascom.nasa.gov/</u> >Solarmonitor.org <u>http://www.solarmonitor.org/index.php</u>

(U.S. Commerce Department <u>http://www.commerce.gov/</u>) NOAA (National Oceanic and Atmospheric Administration) <u>http://www.noaa.gov/</u> >National Weather Service <u>http://www.nws.noaa.gov/</u> >National Centers for Environmental Prediction <u>http://www.ncep.noaa.gov/</u> >SEC (Space Environment Center) <u>http://www.sec.noaa.gov/</u>

ISES (International Space Environment Service) <u>http://www.ises-spaceweather.org/</u> ISES code book <u>http://www.ises-spaceweather.org/codebook/index.html</u>

WDC (World Data Center for Geomagnetism, Kyoto) http://swdcwww.kugi.kyoto-u.ac.jp/index.html

Project

IMAGE (International Monitor for Auroral Geomagnetic Effencts) <u>http://www.ava.fmi.fi/image/index.html</u> HAARP (High Frequency Active Auroral Research Program) <u>http://www.haarp.alaska.edu/</u>

Spacecrafts and instruments

- SOHO (Solar and Heliospheric Observatory) LASCO (Large Angle and Spectrometric Coronagraph) EIT (Extreme ultraviolet Imaging Telescope) MDI (Michelson Doppler Imager)
- GHN (Global H-alpha Networks)
- > ACE (Advanced Composition Explorer)
- GOES (Geostationary Operational Environmental Satellites) SXI (GOES Solar X-ray Imager)

Technical Terms

- CME (Coronal Mass Ejection)
- CIR (Corotating Interaction Region)
- LDE (Long Duration Event)
- > Pc (Pulsation Continues), Pi (Pulsation Irregular)
- SC ((Storm) Sudden Commencement), SG (Gradual Storm), SI (Sudden Impulse)

• Criteria and Definitions

(Items in conformity with ISES code book are marked with asterisks.) $\ensuremath{\textbf{Flare}}$

- *LDE: Decay time of X-ray intensity by half > 3hrs
- *Category of X-ray Flare

Table A-1. Category of X-ray Flare							
Class	<b< td=""><td>С</td><td>Μ</td><td>>X</td></b<>	С	Μ	>X			
Activity Level	Quiet	Moderately Active	Active	Very Active			

- \diamond In case of LDE(#), upgrade the activity level by one rank.
- ♦ In case of Class-C or grater, if there is 3 or more events with the intensity >5.0, up the activity level by one-rank. i.e. Event>C5.0 (M5.0) occurred more than 3 times: Moderately Active (Active)→Active (Very Active)

Coronal Hole

➤ *Warning Area = latitude < 30 and west from longitude 30 west</p>



Figure A-1.

*Proton Event

▶ = Proton Flux with the energy>10MeV exceeds the threshold of 10PFU (PFU=cm⁻² sr¹ s⁻¹)

Sector Boundary

- \succ = Switch of IMF direction
- > Basically, IMF is classified into 'Away' (away from the sun) or 'Toward' (toward the sun).

Figure A-2. Coordinate System of Interplanetary Space



CIR

- Interaction region between low-speed solar wind and high-speed solar wind (emanating from the coronal hole)
- ➢ Recurrent.

Geomagnetic Storm

Table A-2. Category of Geomagnetic Storm

	gerj er etern	agnette eterm	
Magnitude of Main Phase (nT)	< 50	50≤ <150	150≤
Level	Minor Storm	Major Storm	Severe Storm

Substorm

Table A-3. Category of Substorm

Maximum of AE index (nT)	< 500	500≤ <1000	1500≤
Level	Minor	Moderate	Major

Overall Condition of Magnetosphere

Refer to Estimated Kp <u>http://www.sec.noaa.gov/today.html</u>

Table A-4. Category of Overall Condition of Magnetosphere

Estimated Kp	< 4(Green)	4	>5
Level	Quiet	Slightly Disturbed	Disturbed

5. Appendix B.



Figure B-1. Interplanetary space and solar wind observation made by the ACE satellite during the period of 00:00UT on January 21, 2005 – 00:00UT on January 31, 2005. (An Example of CME and CIR). Shown from top are the magnitude and three components of IMF (in nT), proton number density (in /cm³), earthward component of solar wind velocity (in km/s), and proton temperature (in Kelvin).



Figure B-2. A Monthly Dst index (An Example of SI, SC and SG) supplemented with text boxes.



Figure B-3. Interplanetary Observations obtained by ACE. Corresponding to Geomagnetic events exemplified in Figure B-2, i.e. (a) for SC, (b) for SG, and (c) for SI. Each figure format is the same as that of Figure B-1.