Department of Commerce • National Oceanic & Atmospheric Administration • National Weather Service

***NATIONAL WEATHER SERVICE INSTRUCTION 10-1101***
***MARCH 14, 2017***

***OPERATIONS AND SERVICES***
***Space Weather Services NWSPD 10-11***
***SPACE WEATHER PRODUCTS***

**NOTICE:** This publication is available at: http://www.nws.noaa.gov/directives/.

**OPR:** W/AFS24 (R. Rutledge) **Certified by:** W/AFS24 (W. Bauman)

**Type of Issuance:** Routine

***SUMMARY OF REVISIONS:*** This directive supersedes NWSI 10-1101, *Space Weather Products*, dated March 6, 2013. Changes made to reflect NWS Headquarter reorganization effective April 1, 2015

Other changes are noted below:

- Updated all references to legacy SWPC webpage to point to current webpage address
- Page 2 - Deleted "located in Boulder CO" in "2. Background" section (redundant)
- Page 5 - Added section 6. SWPC Product Subscription Service
- Page 18, Line 1 - Changed FXXX04 WMO ID to FOUS04
- Page 19 - Replaced A based Watches with K based (G scale) Watches in the Appendix table.
- Page 21 - Added Appendix B, Space Weather Definitions

Signed 2/28/2017
Andrew D. Stern Date
Director
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**1. General.** This instruction describes the space weather products provided by the Space Weather Prediction Center (SWPC) in Boulder, Colorado.

**2. Background.** SWPC is one of the nine National Centers for Environmental Prediction and is the nation's official source of space weather forecasts, watches, warnings, and alerts. SWPC provides a wide array of space weather products in two categories: Event-Driven and Regularly Scheduled Products.

**3. Space Weather Impacts**. The most significant impacts are noted in the following table:

| Category | Effects |
|---|---|
| X-Ray Flux | **HF Radio:** HF (high frequency) radio blackouts are possible on the entire sunlit side of the Earth. This results in degraded HF radio contact with mariners and aviators in the sunlit sector.<br>**Navigation:** Low-frequency navigation signals used by maritime and general aviation systems experience outages on the sunlit side of the Earth, causing loss in positioning. Increased satellite navigation errors in positioning are possible on the sunlit side of Earth, which may spread into the night side. |
| Radio Bursts | **Navigation:** GPS system performance may be significantly degraded due to difficulty in signal acquisition. Radar surveillance systems are also affected. |
| Energetic Electrons | **Spacecraft operations:** may experience surface charging that can cause temporary or permanent damage to spacecraft systems. |

| | |
|---|---|
| Energetic Protons | **Biological:** exposure to elevated radiation hazards is possible to astronauts on EVA (extra-vehicular activity) and passengers and crew in high-flying aircraft at high latitudes.<br>**Satellite operations:** satellites may be rendered useless, memory impacts can cause loss of control, may cause serious noise in image data, star-trackers may be unable to locate sources; permanent damage or reduction in efficiency to solar panels possible.<br>**Other systems**: blackout of HF (high frequency) communications possible through the polar regions, and electronic navigation may be prone to errors. |
| Geomagnetic Storms | **Power systems:** impacts can range from weak power fluctuations to widespread voltage control problems with grid system collapse and transformer damage.<br>**Spacecraft operations:** impacts can range from minor operations impacts to extensive surface charging, loss of orientation, uplink/downlink problems, and tracking problems.<br>**Other systems:** HF (high frequency) radio propagation may be impossible in many areas for one to two days, low frequency radio navigation may be disrupted |

**4.** **Event-Driven Products.** Watches, Warnings, and Alerts are the primary event-driven products issued by SWPC. They can be issued any time when conditions meet, or activity is expected to exceed, specified thresholds.

a. Watch: Issued when the highest expected K-index (G-scale) value is forecast to be above specific thresholds – for up to three days in advance of expected activity.

b. Warning: Issued when exceeding thresholds for energetic protons or geomagnetic activity is considered to be imminent. The messages contain the warning's valid period and the expected maximum level of activity. A high level of confidence is required before a warning is issued.

c. Alert: Issued when an event threshold is reached; contains information available at the time of issue. Alerts are issued for solar x-ray, radio, proton, and geomagnetic activity.

d. Summary: Issued after a solar x-ray, radio, or proton event ends; specifies the beginning, peak, and end of event times, along with the peak value of flux observed. Summary messages are also issued when geomagnetic activity ends subsequent to a sudden impulse.

Space weather notification messages are issued for these categories:

| Category | Watch | Warning | Alert | Summary |
|---|---|---|---|---|
| X-Ray Flux | | | ◆ | ◆ |
| Radio Bursts | | | ◆ | ◆ |
| Geomagnetic Sudden Impulse | | ◆ | | ◆ |
| Geomagnetic K-index | ◆ | ◆ | ◆ | |
| Electron Flux | | | ◆ | |
| Proton 10 MeV and 100 MeV | | ◆ | ◆ | ◆ |

These alerts are available at http://www.swpc.noaa.gov/alerts/index.html. Examples of some of these products can be found in Appendix A.

**5. Regularly Scheduled Products.** SWPC's regularly scheduled products are issued at specified intervals.

a. Report and Forecast of Solar and Geophysical Activity (RSGA): A joint product of NOAA and the US Air Force (USAF) issued daily at 2200 Universal Time Coordinated (UTC) and is the daily report prepared by SWPC forecasters. It provides a summary and analysis of solar and geophysical activity during the previous 24 hours, as well as the most recent solar indices. It also provides a forecast of solar and geomagnetic activity and indices for the following three (3) days.

b. Preliminary Report and Forecast of Solar Geophysical Data (commonly known as the Weekly): Compiled every Monday and made available on SWPC's website. It contains space weather highlights from the previous week and an outlook for the following 27 days, including tables and plots of solar and geophysical indices, data, activity and reports of special events and missing data not included previously.

c. GEOALERT: A coded message issued daily at 0330 UTC. It contains a summary of sunspot characteristics, energetic solar-geophysical activity, and selected solar-geophysical indices for the previous day. It also contains a brief encoded forecast of solar-geophysical activity that may affect people and systems. This product is issued by SWPC in its capacity as the International Space Environment Service (ISES) World Warning Agency for the space environment.

d. Solar and Geophysical Activity Summary (SGAS): A joint product of NOAA and the USAF issued daily at 0245 UTC. It is a brief list of solar and geophysical events and indices for the previous UTC day, including energetic solar flares, proton events, and geomagnetic activity.

e. The Solar Cycle prediction charts and tables: Used to track solar cycle progression, are updated monthly by the SWPC using the latest International Space Environment Service (ISES) predictions.

f. The Solar Region Summary (SRS), a joint product of NOAA and the USAF issued daily at 0030 UTC, providing a detailed description of active regions currently visible on the solar disk. Active solar regions are sources of potential x-ray flares that may affect people and systems.

g. 3-hourly Space Weather Conditions and Forecast (WWV.txt): Issued every 3 hours. Provides 10.7 cm radio flux information (from Penticton, Canada); A index (NOAA-

planetary average); and K index (NOAA-planetary average). The messages contain recent solar and geophysical indices, plus a summary of recent significant activity and a forecast of activity in the next 24 hours (based on NOAA Space Weather Scales).

h. Space Weather Advisory Outlooks: Issued every Monday, provide general descriptions of space weather conditions during the past week and an outlook for the next 7 days. Outlooks are based on the NOAA Space Weather Scales.

i. NOAA 3-Day Forecast: A plain language, single page forecast text product issued every 12 hours with both forecast and observed criterion now broken down for each of the three NOAA Scale categories. Each section includes a brief forecaster written rationale.

j. NOAA Space Weather Forecast Discussion: A free form, technical forecast discussion that details observed data, analysis, and forecast rationale, issued every 12 hours. Forecast and observed (summary) criterion is broken down into 4 sections by phenomenon type and 2 sub-sections; Summary and Forecast.

**6. SWPC Product Subscription Service (PSS).** SWPC provides a wide range of alerts, warnings, watches, and forecasts you can receive through e-mail.

a. The products mentioned above, as well as the table at the end of Appendix A below, provide an overview of the categories of events for which products are available, and then provide brief listings of the individual products.

b. To subscribe to SWPC's PSS, go to the SWPC webpage, select the SUBSCRIBE tab, and hit the SUBSCRIBE NOW radio button. Once the page pops up, select "New User" and fill out the information. The direct link to the Subscribe page is: https://pss.swpc.noaa.gov/LoginWebForm.aspx?ReturnUrl=%2fProductSubscriptionService%2f

c. Follow the procedures to register for an account and then select the products you wish to be notified by email for when they are issued.

## Appendix A – Space Weather Product Data

This appendix contains Space Weather product examples and descriptions. The most current issue/version of each product in this appendix can be found at http://www.swpc.noaa.gov/products-and-data

### 1. Space Weather Product Examples.

#### a. X-ray Flux

(1) Space Weather Message Code: ALTXMF
Serial Number: 180
Issue Time: 2012 Aug 18 0103 UTC

ALERT: X-Ray Flux exceeded M5
Threshold Reached: 2012 Aug 17 0100 UTC
NOAA Scale: R2 - Moderate

NOAA Space Weather Scale descriptions can be found at
http://www.swpc.noaa.gov/noaa-scales-explanation

Potential Impacts: Area of impact centered on sub-solar point (high noon) on the sunlit side of Earth. Extent of blackout of HF (high frequency) radio communication dependent upon current X-ray Flux intensity. For real-time information on affected area and expected duration please see http://www.swpc.noaa.gov/drap/index.html.

(2) Space Weather Message Code: SUMX10
Serial Number: 914
Issue Time: 2012 Sep 05 1901 UTC

SUMMARY: X-ray Event exceeded X10
Begin Time: 2012 Sep 05 1555 UTC
Maximum Time: 2012 Sep 05 1640 UTC
End Time: 2012 Sep 05 1858 UTC
X-ray Class: X17.0
Location: N20W44
NOAA Scale: R4 - Severe

NOAA Space Weather Scale descriptions can be found at
http://www.swpc.noaa.gov/noaa-scales-explanation

Potential Impacts: Area of impact widespread on the sunlit side of Earth, strongest at the sub-solar point. Navigation - Minor disruptions of GPS satellite navigation possible due to loss-of-lock and increased range errors for some applications. Radio - Wide area black out of HF (high frequency) radio communication for one to two hours.

**b. Radio Bursts**

(1) Space Weather Message Code: ALTTP2
Serial Number: 822
Issue Time: 2012 Sep 15 2344 UTC

ALERT: Type II Radio Emission
Begin Time: 2012 Sep 15 2259 UTC
Estimated Velocity: 681 km/s

NOAA Space Weather Scale descriptions can be found at
http://www.swpc.noaa.gov/noaa-scales-explanation

Description: Type II emissions occur in association with eruptions on the sun and typically indicate a coronal mass ejection is associated with a flare event.

(2) Space Weather Message Code: SUM10R
Serial Number: 566
Issue Time: 2012 Aug 18 0341 UTC

SUMMARY: 10cm Radio Burst
Begin Time: 2012 Aug 18 0322 UTC
Maximum Time: 2012 Aug 18 0322 UTC
End Time: 2012 Aug 18 0322 UTC
Duration: 0 minutes
Peak Flux: 100 sfu
Latest Penticton Noon Flux: 95 sfu

NOAA Space Weather Scale descriptions can be found at
http://www.swpc.noaa.gov/noaa-scales-explanation

Description: A 10cm radio burst indicates that the electromagnetic burst associated with a solar flare at the 10cm wavelength was double or greater than the initial 10cm radio background. This can be indicative of significant radio noise in association with a solar flare. This noise is generally short-lived but can cause interference for sensitive receivers including radar, GPS, and satellite communications.

**c. Geomagnetic Sudden Impulse**

(1) Space Weather Message Code: WARSUD
Serial Number: 120
Issue Time: 2012 Oct 08 0440 UTC

WARNING: Geomagnetic Sudden Impulse expected
Valid From: 2012 Oct 08 0515 UTC
Valid To: 2012 Oct 08 0545 UTC
IP Shock Passage Observed: 2012 Oct 08 0430 UTC

NOAA Space Weather Scale descriptions can be found at
http://www.swpc.noaa.gov/noaa-scales-explanation

(2) Space Weather Message Code: SUMSUD
Serial Number: 161
Issue Time: 2012 Oct 08 0527 UTC

SUMMARY: Geomagnetic Sudden Impulse
Observed: 2012 Oct 08 0515 UTC
Deviation: 21 nT
Station: BOU

NOAA Space Weather Scale descriptions can be found at
http://www.swpc.noaa.gov/noaa-scales-explanation

**d. Geomagnetic K-index**

(1) Space Weather Message Code: WATA20
Serial Number: 501
Issue Time: 2012 Oct 13 1842 UTC

WATCH: Geomagnetic Storm Category G1 Predicted

Highest Storm Level Predicted by Day:
Oct 14: G1 (Minor) Oct 15: None (Below G1) Oct 16: None (Below G1)

THIS SUPERSEDES ANY/ALL PRIOR WATCHES IN EFFECT

(2) Space Weather Message Code: WARK04
Serial Number: 2023
Issue Time: 2012 Nov 01 0725 UTC

WARNING: Geomagnetic K-index of 4 expected
Valid From: 2012 Nov 01 0730 UTC
Valid To: 2012 Nov 01 1900 UTC
Warning Condition: Onset

NOAA Space Weather Scale descriptions can be found at
http://www.swpc.noaa.gov/noaa-scales-explanation

Potential Impacts: Area of impact primarily poleward of 65 degrees Geomagnetic Latitude.
Induced Currents - Weak power grid fluctuations can occur.
Aurora - Aurora may be visible at high latitudes such as Canada and Alaska.

(3) Space Weather Message Code: ALTK04
Serial Number: 1616
Issue Time: 2012 Nov 01 1024 UTC

ALERT: Geomagnetic K-index of 4
Threshold Reached: 2012 Nov 01 1024 UTC
Synoptic Period: 0900-1200 UTC

Active Warning: Yes

NOAA Space Weather Scale descriptions can be found at
http://www.swpc.noaa.gov/noaa-scales-explanation

Potential Impacts: Area of impact primarily poleward of 65 degrees Geomagnetic Latitude.
Induced Currents - Weak power grid fluctuations can occur.
Aurora - Aurora may be visible at high latitudes such as Canada and Alaska.

**e. Electron Flux**

(1) Space Weather Message Code: ALTEF3
Serial Number: 1976
Issue Time: 2012 Oct 28 1436 UTC

ALERT: Electron 2MeV Integral Flux exceeded 1000pfu
Threshold Reached: 2012 Oct 28 1415 UTC
Station: GOES13

NOAA Space Weather Scale descriptions can be found at
http://www.swpc.noaa.gov/noaa-scales-explanation

Potential Impacts: Satellite systems may experience significant charging resulting in increased risk to satellite systems.

**f. Proton Flux**

(1) Space Weather Message Code: WARPX1
Serial Number: 385
Issue Time: 2012 Sep 28 0147 UTC

WARNING: Proton 10MeV Integral Flux above 10pfu expected
Valid From: 2012 Sep 28 0200 UTC
Valid To: 2012 Sep 28 1400 UTC
Warning Condition: Onset
Predicted NOAA Scale: S1 - Minor

NOAA Space Weather Scale descriptions can be found at
http://www.swpc.noaa.gov/noaa-scales-explanation

Potential Impacts: Radio - Minor impacts on polar HF (high frequency) radio propagation resulting in fades at lower frequencies.

(2) Space Weather Message Code: ALTPX1
Serial Number: 297
Issue Time: 2012 Sep 28 0315 UTC

ALERT: Proton Event 10MeV Integral Flux exceeded 10pfu
Begin Time: 2012 Sep 28 0300 UTC
NOAA Scale: S1 - Minor

NOAA Space Weather Scale descriptions can be found at
http://www.swpc.noaa.gov/noaa-scales-explanation

Potential Impacts: Radio - Minor impacts on polar HF (high frequency) radio propagation resulting in fades at lower frequencies.

(3) Space Weather Message Code: SUMPX1
Serial Number: 64
Issue Time: 2012 Sep 28 1455 UTC

SUMMARY: Proton Event 10MeV Integral Flux exceeded 10pfu
Begin Time: 2012 Sep 28 0300 UTC
Maximum Time: 2012 Sep 28 0445 UTC
End Time: 2012 Sep 28 1040 UTC
Maximum 10MeV Flux: 28 pfu
NOAA Scale: S1 - Minor

NOAA Space Weather Scale descriptions can be found at
http://www.swpc.noaa.gov/noaa-scales-explanation

**g. Report and Forecast of Solar and Geophysical Activity (RSGA)**

:Product: Report of Solar-Geophysical Activity
:Issued: 2012 Oct 26 2200 UTC
# Prepared jointly by the U.S. Dept. of Commerce, NOAA,
# Space Weather Prediction Center and the U.S. Air Force.
#
Joint USAF/NOAA Report of Solar and Geophysical Activity
SDF Number 300 Issued at 2200Z on 26 Oct 2012
IA. Analysis of Solar Active Regions and Activity from 25/2100Z to 26/2100Z:
Solar activity has been low. Region 1598 (S12E04), a Dko/Beta-Delta spot group, remained the most magnetically complex region, yet only produced a C1/Sf flare at 26/1607Z.
The most active region was an area of enhanced plage near S27W87, formerly Region 1594, where three low-level C-class flares originated. Region 1596 (N08W35) showed signs of umbral separation, and new Region 1600 (N09W14) was numbered today.
IB. Solar Activity Forecast: Solar activity is expected to be low with a slight chance for M-class flares for the next three days (27-29 October).
IIA. Geophysical Activity Summary 25/2100Z to 26/2100Z:
The geomagnetic field has been quiet for the past 24 hours. Solar wind speed, as measured by the ACE spacecraft, remained relatively steady at 350 km/s. The Bz component of the interplanetary magnetic field remained mostly positive, with minor deflections of ±4 nT, while the total field held steady at 4 nT. The greater than 2 MeV electron flux at geosynchronous orbit reached high levels during the period.
IIB. Geophysical Activity Forecast: The geomagnetic field is expected to be quiet for the next three days (27-29 October).
III. Event Probabilities 27 Oct-29 Oct
Class M 20/15/10

Class X 01/01/01
Proton 01/01/01
PCAF green
IV. Penticton 10.7 cm Flux
Observed 26 Oct 131
Predicted 27 Oct-29 Oct 135/130/115
90 Day Mean 26 Oct 122
V. Geomagnetic A Indices
Observed Afr/Ap 25 Oct 003/004
Estimated Afr/Ap 26 Oct 003/005
Predicted Afr/Ap 27 Oct-29 Oct 006/005-006/005-006/005
VI. Geomagnetic Activity Probabilities 27 Oct-29 Oct
A. Middle Latitudes
Active 05/05/05
Minor storm 01/01/01
Major-severe storm 01/01/01
B. High Latitudes
Active 15/15/15
Minor storm 10/10/10
Major-severe storm 05/05/05

**h. Solar and Geophysical Activity Summary (SGAS)**

:Product: Solar and Geophysical Activity Summary
:Issued: 2012 Oct 26 0245 UTC
# Prepared jointly by the U.S. Dept. of Commerce, NOAA,
# Space Weather Prediction Center and the U.S. Air Force.
#
Joint USAF/NOAA Solar and Geophysical Activity Summary
SGAS Number 300 Issued at 0245Z on 26 Oct 2012
This report is compiled from data received at SWO on 25 Oct
A. Energetic Events

| Begin | Max | End | Rgn | Loc | Xray | Op | 245MHz | 10cm | Sweep |
|---|---|---|---|---|---|---|---|---|---|
| 1846 | 1847 | 1849 | | | | | | 110 | |
| 2333 | 2333 | 2333 | | | | | | 100 | |

B. Proton Events: None
C. Geomagnetic Activity Summary: The geomagnetic field has been at quiet levels for the past 24 hours.
D. Stratwarm: Not Available
E. Daily Indices: (real-time preliminary/estimated values)
10 cm 130 SSN 058 Afr/Ap 003/004 X-ray Background B3.8
Daily Proton Fluence (flux accumulation over 24 hrs)
GT 1 MeV 3.1e+05 GT 10 MeV 1.1e+04 p/(cm2-ster-day)
(GOES-13 satellite synchronous orbit W76 degrees)
Daily Electron Fluence
GT 2 MeV 9.40e+07 e/(cm2-ster-day)

(GOES-13 satellite synchronous orbit W76 degrees)
3 Hour K-indices:
Boulder 1 1 2 1 2 2 1 1 Planetary 1 1 1 1 0 0 1 2
F. Comments: None.

**i. Solar Region Summary (SRS)**

:Product: Solar Region Summary
:Issued: 2012 Oct 27 0030 UTC
# Prepared jointly by the U.S. Dept. of Commerce, NOAA,
# Space Weather Prediction Center and the U.S. Air Force.
#
Joint USAF/NOAA Solar Region Summary
SRS Number 301 Issued at 0030Z on 27 Oct 2012
Report compiled from data received at SWO on 26 Oct
I. Regions with Sunspots. Locations Valid at 26/2400Z
Nmbr Location Lo Area Z LL NN Mag Type
1596 N08W35 152 0230 Eao 11 09 Beta
1598 S12E04 113 0340 Dko 07 17 Beta-Delta
1599 S11E30 087 0120 Hsx 02 01 Alpha
1600 N09W14 131 0040 Dso 04 04 Beta
IA. H-alpha Plages without Spots. Locations Valid at 26/2400Z Oct
Nmbr Location Lo
1593 N15W77 194
1594 S27W87 204
II. Regions Due to Return 27 Oct to 29 Oct
Nmbr Lat Lo
1585 S19 025

**j. Space Weather Advisory Outlook**

SPACE WEATHER ADVISORY OUTLOOK #12-49
2012 October 21 at 9:04 p.m. MDT (2012 October 22 0304 UTC)

**** SPACE WEATHER OUTLOOK ****

Summary For October 15-21

A Category R2 (Moderate) Radio Blackout occurred on 20 October and a Category R1 (Minor) Radio Blackout occurred on 21 October. Both Radio Blackouts were due to solar flares from a sunspot region near the southeast limb.

Outlook For October 22-28

Category R1 (Minor) Radio Blackouts are likely throughout the period.

Data used to provide space weather services are contributed by NOAA, USAF, NASA, NSF, USGS, the International Space Environment Services, and other observatories, universities, and institutions. More information is available at SWPC's Web site http://swpc.noaa.gov

**k. NOAA 3-Day Space Weather Forecast**

Product: NOAA 3-day Forecasts
Issued: 2012 Apr 30 0030 UTC
Prepared by the U.S. Dept. of Commerce, NOAA, Space Weather Prediction Center

A. NOAA Geomagnetic Activity Observation and Forecast

The Greatest Observed 3 Hr Kp on 29 Apr 2012 was 5 (NOAA Scale G1).
The Greatest Expected 3 Hr Kp for 30 Apr-02 May is 6 (NOAA Scale G2).

NOAA Kp index Breakdown 30 Apr - 02 May

| | Apr 30 | May 01 | May 02 |
|---|---|---|---|
| 00-03UT | 4 | 3 | 4 |
| 03-06UT | 4 | 3 | 4 |
| 06-09UT | 3 | 3 | 6 (G2) |
| 09-12UT | 2 | 2 | 6 (G2) |
| 12-15UT | 2 | 2 | 5 (G1) |
| 15-18UT | 2 | 2 | 5 (G1) |
| 18-21UT | 3 | 3 | 4 |
| 21-00UT | 3 | 4 | 4 |

Rationale: NOAA Scale G2 conditions are forecast due to anticipated CME effects midday on 02 May.

B. NOAA Solar Radiation Activity Observation and Forecast

Solar Radiation as observed by NOAA GOES-13 was below S-Scale storm level Thresholds.

Solar Radiation Storm forecast for Apr 30 – 02 May

| | Apr 30 | May 01 | May 02 |
|---|---|---|---|
| S1 or greater | 05% | 05% | 01% |

Rationale: Less than a slight chance for Solar Radiation conditions exceeding NOAA Scale S1 is forecast due to a lack of solar regions with the observed potential to produce event level activity.

C. NOAA Radio Blackout Activity and Forecast

Radio blackouts reaching the R2 Levels were observed several times over the past

24hrs. The largest was at 1823Z on 29 Apr.

Radio Blackout forecast for Apr 30 – 02 May

| | Apr 30 | May 01 | May 02 |
|---|---|---|---|
| R1-R2 | 50% | 50% | 50% |
| R3 or greater | 20% | 20% | 20% |

Rationale: Radio blackouts of NOAA Scale R2 are likely and a chance for R3 conditions exist for the next 3 days due to the size, magnetic complexity, and historical activity of Regions 1499 and 1501.

## l. NOAA Space Weather Forecast Discussion

Product: NOAA Space Weather Forecast Discussion
Issued: 2012 Apr 30 0000 UTC
Prepared by the U.S. Dept. of Commerce, NOAA, Space Weather Prediction Center

Solar Activity

24hr Summary...The solar disk is currently dominated by two very large sunspot regions, Region 1486 (S15E45, FKC/BGD with 2200 millionths), and Region 1484 (N04W28, DKC/BGD, with 1700 millionths). Region 1484 has been slightly more active, producing 4 C-class flares and 1 M-class flare during the past 24 hours. Region 1484 does not appear to be growing but continues to be very complex with two major inversion lines cutting through joined penumbral areas (multiple delta configurations). Region 1486 does not appear to be growing but like 1484 is also very complex magnetically with multiple strong delta configurations. Noteworthy flare events during the interval were a long duration C8 from 1486 which peaked at 1712 UTC (duration of 3 hours, 19 minutes) which was associated with a slow CME (about 380 km/s) off the southeast limb at 24/1654 UTC. Region 1486 was also responsible for the largest event of the period, an M1/2n at 0446 UTC. Updated imagery from SOHO/LASCO provided new information about the fast CME associated with yesterday's M4/1f flare from Region 1486: current estimated of the plane of sky speed is around 1233 km/s. The CME does not appear to be earthward directed. There is a moderate-sized coronal hole in the northern hemisphere which is just approaching central meridian at this time.

Forecast...Solar activity is expected to be high. Additional major flare activity is expected from both Region 1484 and Region 1486, although Region 1486 appears to be the most likely source at this time.

Energetic Particle

24hr Summary...A weak enhancement of 10 MeV protons began around 24/0415 UTC and appeared to reach maximum of 2 pfu at about 24/1115 UTC. The most likely source was the fast CME associated with yesterday's M7 flare (24/0254 UTC) from Region 486.

Forecast...There is a chance for moderate or even larger proton events, especially if major flare activity should be realized in Region 1484 which is now in a more favorable location for particle transport to Earth. In the longer term, Region 1486 should also be considered to be a threat for proton events as it rotates to more westerly longitudes over the next few days.

Solar Wind

24hr Summary...per previous discussions, observations at the ACE spacecraft clearly indicate the continued passage of a fairly strong interplanetary CME. Solar wind speed continues to be elevated around 550 km/s and the total magnetic field Bt is still elevated around 10 nT. At this time the strongest part of the ICME appears to have passed, and the orientation of the z-component of the interplanetary magnetic field has been generally northwards during the past 10 hours, which has moderated the geoeffectiveness of this transient.

Forecast...Since there are not anymore known earthward transients, conditions at ACE are expected to continue to moderate and gradually return to nominal levels. There is a chance for a co-rotating interaction region followed by a high speed stream in about 3-4 days due to the position of a coronal hole on the solar disk. In addition, there is a chance for an additional major flare and fast CME from either of Region 1484 or Region 1486 which would certainly change the expected conditions in the solar wind.

Geospace

24hr Summary...moderate (G2) storm level activity with some strong-to-severe (G3-G4) levels at high latitudes were seen early in the interval (24/1530-25/0000 UTC), but activity has clearly decreased since then with quiet to unsettled levels prevailing.

Forecast...Generally quiet to unsettled levels should prevail but there is a chance for some isolated active or minor storm (G1) periods due to local substorms during the nighttime hours. An increase to active levels is forecast for 28 October due to a favorably positioned coronal hole. In addition, there is a chance for higher storm level activity during the next few days if Region 1484 should manage to produce a fast, earthward directed CME.

**2. Space Weather Product Identification.** The following are specific identification for SWPC products, issued under the SWPC's World Meteorological Organization (WMO) identifier, KWNP. A complete list of SWPC Space Weather Products transmitted on the National Weather Wire Service (NWWS) Direct Broadcast Systems can be found at http://www.swpc.noaa.gov/content/subscription-services.

Note: WMO header identifiers appear on messages from NWS systems, but not on SWPC messages.

| AWIPS ID | WMO ID | Title | Issue Frequency/Time |
|---|---|---|---|
| SWXDAYTDF | | NOAA 3-Day Space Weather Forecast | Twice Daily, 0030&1230 UTC |
| SWXDAYDIS | FXXX12 | NOAA Space Weather Forecast Discussion | Twice Daily, 0030&1230 UTC |
| SWXCURIND | AXXX83 | Current Space Weather Indices – Current Day | Hourly, beginning 0035 UTC |
| SWX3HRCON | FOUS04 | 3-hourly Space Weather Conditions and Forecast | Every 3 hours, beginning 0000 UTC |
| SWXDAYSGA | AXXX01 | Solar and Geophysical Activity Summary | Daily at 0245 UTC |
| SWXDAYSRS | AXXX02 | Solar Region Summary | Daily at 0030 UTC |
| SWXDAYIND | AXXX81 | Daily Space Weather Indices | Every 6 hours beginning 0015 UTC |
| SWXDAYOBS | AXXX82 | Summary of Space Weather Observations – Previous Day | Daily after 0030 UTC |
| SWXDAYEVT | AXXX80 | Space Weather Event Reports – Previous Day | Daily after 0250 UTC |
| SWXDAYDSF | FXXX01 | Consolidated Daily Summary | Daily after 2200 UTC |
| SWXDAYPRE | FXXX04 | Geomagnetic and Flare Probability Predictions | Daily after 2200 UTC |
| SWXWEKHIL | FXXX06 | 7-Day Space Weather Highlights | Tuesdays, 2212 UTC |

| AWIPS ID | WMO ID | Title | Issue Frequency/Time |
|---|---|---|---|
| SWXWEKFOR | FXXX02 | 27-Day Space Weather Forecast | Tuesdays, 2212 UTC |
| SWXWEKOUT | FXXX05 | 27-Day Space Weather Outlook Table | Tuesdays, 2212 UTC |
| SWXADVOUT | NWXX04 | Space Weather Advisory Outlook | Tuesdays, 1800 UTC |
| SWXADVBUL | NWXX05 | Space Weather Advisory Bulletin | As needed |
| SWXADVMSG | NWXX06 | Space Weather Advisory Messages – General messages from SWPC | As needed |
| SWXxxxxxx (See first column below for xxxxxx) | See second column below (add KWNP) | Space Weather Alerts (See third column below) | As conditions warrant |

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|---|---|---|---|---|
| **X-ray Flux Alert and Event Summaries** | | | | |
| **ALTXMF** | WOXX01 | **ALERT: X-ray Flux exceeded M5** | **R2** | |
| **SUMXM5**<br>**SUMX01**<br>**SUMX10**<br>**SUMX20** | WOXX01<br>WOXX02<br>WOXX02<br>WOXX02 | **SUMMARY: X-ray Event exceeded M5**<br>**SUMMARY: X-ray Event exceeded X1**<br>**SUMMARY: X-ray Event exceeded X10**<br>**SUMMARY: X-ray Event exceeded X20** | **R2**<br>**R3**<br>**R4**<br>**R5** | |
| **Radio Burst Summaries** | | | | |
| **ALTTP2**<br>**ALTTP4** | WOXX04<br>WOXX04 | **ALERT: Type II Radio Emission**<br>**ALERT: Type IV Radio Emission** | | |
| **SUM10R** | WOXX03 | **SUMMARY: 10cm Radio Burst** | | |
| **Geomagnetic Warnings, Alerts, and Watches** | | | | |
| **WARSUD** | WOXX10 | **WARNING: Geomagnetic Sudden Impulse expected** | | |
| **SUMSUD** | WOXX10 | **SUMMARY: Geomagnetic Sudden Impulse** | | |
| **WARK04**<br>**WARK05**<br>**WARK06**<br>**WARK07** | WOXX13<br>WOXX11<br>WOXX12<br>WOXX14 | **WARNING: Geomagnetic K-index of 4 expected**<br>**WARNING: Geomagnetic K-index of 5 expected**<br>**WARNING: Geomagnetic K-index of 6 expected** | **G1**<br>**G2**<br>**G3 or greater** | **Extended Warning**<br>**Extended Warning**<br>**Extended Warning** |

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| | | **WARNING: Geomagnetic K-index of 7 or greater expected** | | **Extended Warning** |
| **ALTK04**<br>**ALTK05**<br>**ALTK06**<br>**ALTK07**<br>**ALTK08**<br>**ALTK09** | WOXX13<br>WOXX11<br>WOXX12<br>WOXX14<br>WOXX15<br>WOXX16 | **ALERT: Geomagnetic K-index of 4**<br>**ALERT: Geomagnetic K-index of 5**<br>**ALERT: Geomagnetic K-index of 6**<br>**ALERT: Geomagnetic K-index of 7**<br>**ALERT: Geomagnetic K-index of 8**<br>**ALERT: Geomagnetic K-index of 9** | **G1**<br>**G2**<br>**G3**<br>**G4**<br>**G5** | |
| | | | | |
| **WATA20**<br>**WATA30**<br>**WATA50**<br>**WATA99** | WOXX20<br>WOXX21<br>WOXX22<br>WOXX23 | **WATCH: Geomagnetic Storm Category G1 predicted**<br>**WATCH: Geomagnetic Storm Category G2 predicted**<br>**WATCH: Geomagnetic Storm Category G3 predicted**<br>**WATCH: Geomagnetic Storm Category G4 or greater predicted** | **G1**<br>**G2**<br>**G3**<br>**G4 or greater** | |
| **Electron Flux Alert** | | | | |
| **ALTEF3** | WOXX30 | **ALERT: Electron 2MeV Integral Flux exceeded 1000pfu** | | |
| **Proton Flux Warnings, Event Alerts, and Event Summaries** | | | | |
| **WARPX1** | WOXX32 | **WARNING: Proton 10MeV Integral Flux above 10pfu expected** | **S1 to S5** | **Extended Warning** |
| **ALTPX1** | WOXX32 | **ALERT: Proton Event 10MeV Integral Flux exceeded 10pfu** | **S1** | **Continued Alert** |
| **ALTPX2** | WOXX32 | **ALERT: Proton Event 10MeV Integral Flux exceeded 100pfu** | **S2** | **Continued Alert** |
| **ALTPX3** | WOXX32 | **ALERT: Proton Event 10MeV Integral Flux exceeded 1000pfu** | **S3** | **Continued Alert** |
| **ALTPX4** | WOXX32 | **ALERT: Proton Event 10MeV Integral Flux exceeded 10000pfu** | **S4** | **Continued Alert** |
| **ALTPX5** | WOXX32 | **ALERT: Proton Event 10MeV Integral Flux exceeded 100000pfu** | **S5** | **Continued Alert** |
| **SUMPX1** | WOXX32 | **SUMMARY: Proton Event 10MeV Integral Flux exceeded 10pfu** | **S1** | |
| **SUMPX2** | WOXX32 | **SUMMARY: Proton Event 10MeV Integral Flux exceeded 100pfu** | **S2** | |
| **SUMPX3** | WOXX32 | **SUMMARY: Proton Event 10MeV Integral Flux exceeded 1000pfu** | **S3** | |
| **SUMPX4** | WOXX32 | **SUMMARY: Proton Event 10MeV Integral Flux exceeded 10000pfu** | **S4** | |

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| **SUMPX5** | WOXX32 | **SUMMARY: Proton Event 10MeV Integral Flux exceeded 100000pfu** | **S5** | |
| **WARPC0** | WOXX31 | **WARNING: Proton 100MeV Integral Flux above 1pfu expected** | | **Extended Warning** |
| **ALTPC0** | WOXX31 | **ALERT: Proton Event 100MeV Integral Flux exceeded 1pfu** | | **Continued Alert** |
| **SUMPC0** | WOXX31 | **SUMMARY: Proton Event 100MeV Integral Flux exceeded 1pfu** | | |

## Appendix B – Space Weather Definitions

This appendix contains frequently used Space Weather terms and definitions. A more comprehensive glossary is located at http://www.swpc.noaa.gov/content/space-weather-glossary.

### DEFINITIONS

**Active** A descriptive word specifically meaning (1) a probability of ~50% for an M- class x-ray flare (see x-ray flare class); (2) disturbed geomagnetic levels such that 16 < Ak index < 30.

**Active Dark Filament (ADF)** A filament displaying motion or changes in shape, location, or absorption characteristics.

**Active Prominence** A prominence above the solar limb moving and changing in appearance over a few minutes of time.

**Active Region (AR)** A localized, transient volume of the solar atmosphere in which plages, sunspots, faculae, flares, etc., may be observed. Active regions are the result of enhanced magnetic fields; they are bipolar and may be complex if the region contains two or more bipolar groups.

**AFR** The Ak index observed at Fredericksburg, Virginia.

**Ap index** Formally determined from the eight daily Ap indices. However, for daily operational uses, NOAA/SWPC estimates the value of the Ap index by measuring the geomagnetic field in near-real time at several magnetometer stations around the world. The real-time station indices are used to estimate the official Kp and Ap based on historical data. The value of this estimated Ap index is reported in NOAA daily and weekly summaries of geophysical activity.

**Arcade** A series of magnetic loops, overlying a solar inversion line. Can become visible or enhanced following a nearby coronal mass ejection.

**Arch Filament System (AFS)** A system of small, arched linear-absorption H-alpha features connecting bright, compact plage of opposite polarity. An AFS is a sign of emerging bipolar magnetic flux and possibly rapid or continued growth in an active region.

**AU** The mean distance between the Earth and Sun equal to 1.496 x10"m

**Aurora** A faint visual phenomenon associated with geomagnetic activity that is visible mainly in the high-latitude night sky. Aurorae occur within a band of latitudes known as the auroral oval, the location of which is dependent on geomagnetic activity. Aurorae are a result of collisions between atmospheric gases and precipitating charged particles (mostly electrons) guided by the geomagnetic field from the magnetotail. Each gas (oxygen, nitrogen molecules, and atoms) emits a particular color depending on the energy of the precipitating particles, and atmospheric composition varies with altitude. Since the faster precipitating particles penetrate deeper, certain auroral colors, originate preferentially from certain heights in the sky. The auroral altitude range is 80 to 1000 km, but typical aurorae are 100 to 250 km above the ground; the color of the typical aurora is yellow-green, from a specific transition of atomic oxygen. Auroral light from lower levels in the atmosphere is dominated by blue and red bands from molecular nitrogen and oxygen. Above 250 km, auroral light is characterized by a red spectral line of atomic oxygen. Aurorae in the Northern Hemisphere are called the aurora borealis or ”northern lights.” Aurorae in the Southern Hemisphere are called aurora australis. The patterns and forms

of the aurora include quiescent arcs, rapidly moving rays, curtains, patches, and veils.

**Auroral Oval** An elliptical band around each geomagnetic pole ranging from about 75 degrees magnetic latitude at local noon to about 67 degrees magnetic latitude at midnight under average conditions. Those locations experience the maximum occurrence of aurorae. The aurora widens to both higher and lower latitudes during the expansion phase of a magnetic substorm.

**Autumnal Equinox** The equinox that occurs in September. Compare vernal equinox.

**B-angle** As viewed from the Earth, the heliographic latitude of the center of the solar disk. The center of the solar disk usually does not coincide with the heliographic equator due to a tilt of the solar axis with respect to the ecliptic. (See B under solar coordinates.)

**Bartels' Rotation Number** The serial number assigned to 27-day rotation periods of solar and geophysical parameters. Rotation 1 in this sequence was assigned arbitrarily by Bartels to begin in January 1833, and the count has continued by 27-day intervals to the present. The Sun has an average rotation period (as seen from the Earth) of 27.27 days. Therefore, solar longitude slowly drifts with respect to the Bartels rate. Compare Carrington longitude.

**Bow Shock** A standing shock wave in front of the magnetosphere, arising from the interaction of the supersonic solar wind with the Earth's magnetic field.

**Bright Surge on the Disk (BSD)** A bright stream of gas seen against the solar disk. BSDs are often flare related and commonly fan out from the flare site. See also bright surge on the limb.

**Bright Surge on the Limb (BSL)** A bright stream of gas emanating from the chromosphere that moves outward more than 0.15 solar radius above the limb. It may decelerate and return to the Sun. Most BSLs assume a linear radial shape but can be inclined and/or fan shaped.

**Burst** A transient enhancement of the solar radio emission, usually associated with an active region or flare.

**Bz** A measure of the North/South orientation of the interplanetary magnetic field measured perpendicular to the ecliptic plane. When Bz is southward, or antiparallel to the Earth's magnetic field, geomagnetic disturbances become much more severe than when Bz is northward.

**Carrington longitude** A system of fixed solar longitudes rotating at a uniform synodic period of 27.2753 days (a sidereal period of 25.38 days). Carrington selected the meridian that passed through the ascending node of the Sun's equator at 1200 UTC on 1 January 1854 as the original prime meridian. The daily Carrington longitude of the central point of the apparent solar disk is listed (with other solar coordinates) in The Astronomical Almanac published annually by the U.S. Naval Observatory. Compare Bartels' rotation number.

**Chromosphere** The layer of the solar atmosphere above the photosphere and beneath the transition region and the corona. The chromosphere is the source of the strongest lines in the solar spectrum, including the Balmer alpha line of hydrogen and the H and K lines of calcium, and is the source of the red color often seen around the rim of the moon at total solar eclipses.

**Convection** The bulk transport of plasma (or gas) from one place to another, in response to mechanical forces (for example, viscous interaction with the solar wind) or electromagnetic forces.

**Coordinated Universal Time (UTC)** By international agreement, the local time at the prime meridian, which passes through Greenwich, England. It was formerly known as Greenwich

Mean Time, or sometimes simply Universal Time. There are 24 time zones around the world, labeled alphabetically. The time zone centered at Greenwich has the double designation of A and Z. Especially in the military community, Coordinated Universal Time is often referred to as Z or Zulu Time.

**Corona** The outermost layer of the solar atmosphere, characterized by low densities ( < 109 cm-3) and high temperatures (> 106 K).

**Coronagraph** An optical device that makes it possible to observe the corona at times other than during an eclipse. A simple lens focuses the Sun onto an occulting disk that prevents the light from the solar disk from proceeding farther along the optical path, effectively providing an artificial eclipse.

**Coronal Hole** An extended region of the corona, exceptionally low in density and associated with unipolar photospheric regions having ”open” magnetic field topology. Coronal holes are largest and most stable at or near the solar poles, and are a source of high-speed solar wind. Coronal holes are visible in several wavelengths. Transequatorial coronal holes are the source of many recurrent geomagnetic disturbances since their lifetimes are months to years. The solar wind emanating from these holes is characteristically high in velocity and low in density.

**Coronal Loops** A typical structure of enhanced corona observed in EUV lines and soft x-rays. Coronal loops represent “closed” magnetic topology.

**Coronal Mass Ejection (CME)** An outflow of plasma from or through the solar corona. CMEs are often, but not always, associated with erupting prominences, disappearing solar filaments, and/or flares. CMEs vary widely in structure, density, and velocity. Large and fast CMEs can approach densities of 1016 g and velocities of 2000 km/s. Earth impacting CMEs can result in significant geomagnetic storms.

**Coronal Streamer** A large-scale structure in the white-light corona often overlying a principal inversion line in solar photospheric magnetic fields.

**Coronal Transients** A general term for short-time-scale changes in the corona. Includes CMEs.

**Cosmic Ray** An extremely energetic and relativistic charged particle. Galactic Cosmic Rays originate from outside the solar system and the Sun can produce "cosmic rays" during energetic proton events.

**Critical Frequency** In ionospheric radio propagation, that frequency capable of penetration just to the layer of maximum ionization under vertical propagation. Radio waves of lower frequencies are refracted back to the ground; higher frequencies pass through.

**Crochet** A sudden deviation in the sunlit geomagnetic field H component (see geomagnetic elements) associated with extra-ordinary solar flare x-ray emission. The effect can be as much as 100 nT and characteristically lasts up to approximately 30 minutes. The event is also known as a SFE (solar flare effect).

**Cusp(s)** In the magnetosphere, two regions near magnetic local noon and approximately 15 degrees of latitude equatorward of the north and the south magnetic poles. The cusps mark the division between geomagnetic field lines on the sunward side (which are approximately dipolar but somewhat compressed by the solar wind) and the field lines in the polar cap that are swept back into the magnetotail by the solar wind.

**D-Region** A daytime region of the Earth's ionosphere beginning from approximately 40 km to 90 km altitude. Radiowave absorption in layers in this region can be significantly increased in response to increased ionization associated with solar x-ray flares.

**Dark Surge on the Disk (DSD)** Dark gaseous ejections on the Sun visible in Ha. They usually originate from small subflare-like brightenings. Material is usually seen to be ejected, then decelerate at a gravitational rate, and to flow back to the point of origin. DSDs can occur intermittently for days from an active region.

**Declination** (1) The angular distance of an astronomical body north (+) or south (-) of the celestial equator. (2) In geomagnetic applications, the angle between true north and the horizontal component of the local geomagnetic field.

**Differential Rotation** The change in solar rotation rate with latitude. Low latitudes rotate at a faster angular rate (approximately 14° per day) than do high latitudes (approximately12° per day).

**Disappearing Solar Filament (DSF)** A solar filament that disappears suddenly on a timescale of minutes to hours. The prominence material is often seen to ascend but can fall into the Sun or just fade. DSFs are probable indicators of coronal mass ejections.

**E region** A daytime region of the Earth's ionosphere roughly between the altitudes of 90 and 160 km. E region characteristics (electron density, height, etc.) depend on the solar zenith angle and solar activity. The ionization in the E layer is caused mainly by x-rays in the range 0.8 to 10.4 nm. (See also sporadic E.)

**Eclipse** The obscuring of one celestial body by another. (1) A Solar Eclipse occurs when the moon comes between the Earth and the Sun. In a total eclipse, the solar disk is completely obscured; in a partial eclipse the solar disk is only partly obscured: (2) A lunar eclipse occurs when the moon enters the shadow cast by the Earth: (3) Spacecraft in the Earth's shadow are said to be in eclipse.

**Ecliptic** The great circle made by the intersection of the plane of the Earth's orbit with the celestial sphere. (Less properly, the apparent path of the Sun around the sky during the year.)

**EIT** Extreme ultraviolet Imaging Telescope. Instrument on the Solar Heliospheric Observer. EIT continuously observes the full disk Sun at 17.1 nm, 19.5 nm, 28.4 nm, and 30.4 nm.

**Electrojet** (1) Auroral: A current that flows in the ionosphere in the auroral zone. (2) Equatorial: A thin electric current layer in the ionosphere over the dip equator at about 100 to 115 km altitude.

**ElectroStatic Discharge (ESD)** An abrupt equalization of electric potentials. In space, ESD can occur between objects or portions of a single object (see differential charging); ESD may occur locally within a dielectric or cable. The consequences may include material damage, a spacecraft anomaly, phantom commands, disrupted telemetry, and contaminated data.

**Emerging Flux Region (EFR)** An area on the Sun where new magnetic flux erupts. An EFR is a bipolar magnetic region that first produces a small bipolar plage visible in the chromosphere, which may develop an arch filament system and the initial spots of a sunspot group. An EFR may be isolated from other solar activity or may occur within an active region.

**Ephemeris** An astronomical almanac listing solar coordinates and the positions of the Sun and other heavenly bodies at regular intervals in time.

**Equinox** One of the two points of intersection of the celestial equator and the ecliptic. The Sun passes through the vernal equinox on about 21 March and through the autumnal equinox on about 22 September.

**Eruptive** With regard to solar flare predictions, a probability of >50% that an active region will produce C class x-ray flares. (See x-ray flare class.)

**Eruptive Prominence on Limb (EPL)** A solar prominence that becomes activated and is seen to ascend away from the Sun; sometimes associated with a coronal mass ejection. (See also disappearing solar filament.)

**Estimated Kp** Estimated 3-hourly Kp indices are derived in real time from a network of western hemisphere ground-based magnetometers. These indices may differ from the final Kp values derived monthly by the GeoForschungsZentrum, Potsdam, Germany, using a global network of magnetometers.

**Extreme UltraViolet (EUV)** A portion of the electromagnetic spectrum from approximately 10 to 100 nm.

**Extremely High Frequency (EHF)** That portion of the radio frequency spectrum from 30-300 GHz.

**Extremely Low Frequency (ELF)** That portion of the radio frequency spectrum from 30 to 3000 Hz.

**Facula** White light plage. Bright region of the photosphere seen in white light, seldom visible except near the solar limb. Corresponds with concentrated magnetic fields that may presage sunspot formation.

**Fibril** A linear feature in the H-alpha chromosphere of the Sun, occurring near strong sunspots and plage or in filament channels. Fibrils parallel strong magnetic fields, as if mapping the field direction.

**Filament** A mass of gas suspended over the chromosphere by magnetic fields and seen as dark ribbons threaded over the solar disk. A filament on the limb of the Sun seen in emission against the dark sky is called a prominence.

**Filament channel** A broad pattern of fibrils in the chromosphere, marking a portion of a magnetic polarity inversion line where a filament may soon form or where a filament recently disappeared. Filament channels are frequently observed in soft x-rays images as dark lanes.

**Flare** A sudden eruption of energy in the solar atmosphere lasting minutes to hours, from which radiation and particles are emitted. Flares are classified on the basis of area at the time of maximum brightness in H-alpha and on the peak flux of 1 minute averaged GOES XRS 0.1 – 0.8 nm band x-rays. For x-ray flare classifications, see the definition for x-ray flare class. The H-alpha classifications are given here:

Importance 0 (Subflare): <= 2.0 hemispheric square degrees

Importance 1: 2.1-5.1 square degrees

Importance 2: 5.2-12.4 square degrees

Importance 3: 12.5-24.7 square degrees

Importance 4: >= 24.8 square degrees

[One square degree is equal to (1.214 x 104 km2) = 48.5 millionths of the visible solar hemisphere.] A brightness qualifier F, N, or B is generally appended to the importance character to indicate faint, normal, or brilliant (for example, 2B).

**Fluence** Time integrated flux. In NOAA use, a specified particle or 0.1-0.8 nm flux accumulation over 24 hours.

**Flux** The rate of flow of a physical quantity through a reference surface.

**Follower spot** In a magnetically bipolar or multipolar sunspot group, the main spot in that portion of the group east of the principal inversion line is called the follower or f-spot. Leader and follower describe the positions of spots with respect to apparent motion due to solar rotation. (Compare leader spot.)

**Foreshortening** The apparent distortion of solar features viewed near the limb of the Sun.

**Gamma rays** High-energy radiation (energies in excess of 100 keV) observed during large, extremely energetic solar flares.

**GEOALERT** An ISES special message summarizing by code the current and predicted levels of solar activity and geomagnetic activity.

**Geomagnetic activity** Natural variations in the geomagnetic field classified quantitatively into quiet, unsettled, active, and geomagnetic storm levels according to the observed a index:

| | |
|---|---|
| quiet | 0 - 7 |
| unsettled | 8 - 15 |
| active | 16 - 29 |
| minor storm | 30 - 49 |
| major storm | 50 - 99 |
| severe storm | 100 - 400 |

**Geomagnetic elements** The components of the geomagnetic field at the surface of the Earth. These elements are usually denoted thus in the literature:

X-the geographic northward component

Y -the geographic eastward component

Z-the vertical component, reckoned positive downward

H-the horizontal intensity, of magnitude (X2 + y2 )1/2

F-the total intensity (H2 + Z2 )1/2

I-the inclination (or dip) angle, tan -1 (Z/H)

D-the declination angle, measured from the geographic north direction to the H component direction, positive in an eastward direction.

D = tan-l (Y/X)

However, in NOAA use, the geomagnetic northward and geomagnetic eastward components are called the H and D components. The H axis direction is defined by the mean direction of the

horizontal component relative to the geomagnetic north by using the small-angle approximation. Thus the D component = H (the horizontal intensity) multiplied by delta D (the declination angle relative to geomagnetic north, expressed in radians).

**Geomagnetic field** The magnetic field in and around the Earth. The intensity of the magnetic field at the Earth's surface is approximately 32,000 nT at the equator and 62,000 nT at the north pole (the place where a compass needle points vertically downward). The geomagnetic field is dynamic and undergoes continual slow secular changes as well as short-term disturbances (see geomagnetic activity). The geomagnetic field can be approximated by a centered dipole field, with the axis of the dipole inclined to the Earth's rotational axis by about 11.5 degrees. Geomagnetic dipole north is near geographic coordinate 79 degrees N and 71 degrees W (near Thule, Greenland), and dipole south is near 79 degrees S and 110 degrees E (near Vostok, Antarctica). The observed or dip poles, where the magnetic field is vertical to the Earth's surface, are near 77 degrees N and 102 degrees W, and 65 degrees S and 139 degrees E. The adopted origin of geomagnetic longitude is the meridian passing through the geomagnetic poles (dipole model) and the geographic south pole. (See also corrected geomagnetic coordinates.)

**Geomagnetic storm** (1) A worldwide disturbance of the Earth's magnetic field, distinct from regular diurnal variations. A storm is precisely defined as occurring when the daily Ap index exceeds 29, or (2) NOAA Space Weather Scale (G) for geomagnetic storm disturbances (see Appendix A).

**Geomagnetically Induced Current (GIC)** A quasi-DC current induced into long conductors such as electrical transmission lines or pipe lines. This occurs during geomagnetic storms at the Earth due to the movement of the field lines in the vicinity of the conductors.

**Geosynchronous** Term applied to any equatorial satellite with an orbital velocity equal to the rotational velocity of the Earth. The geosynchronous altitude is near 6.6 Earth radii (approximately 36,000 km above the Earth's surface). To be geostationary as well, the satellite must satisfy the additional restriction that its orbital inclination be exactly zero degrees. The net effect is that a geostationary satellite is virtually motionless with respect to an observer on the ground.

**GPS** Global Positioning System: a network of Earth-orbiting satellites used for precise position-finding in surveying and navigation.

**Gradual commencement** The commencement of a geomagnetic storm that has no well-defined onset.

**Granulation** Cellular structure of the photosphere visible at high spatial resolution. Individual granules, which represent the tops of small convection cells, are 200 to 2000 km in diameter and have lifetimes of 8 to 10 minutes.

**Greenwich Mean Time (GMT)** See Coordinated Universal Time.

**Ground-Level Event (GLE)** A sharp increase in ground-level cosmic ray count to at least 10% above background, associated with solar protons of energies greater than 500 MeV. GLEs are relatively rare, occurring only a few times each solar cycle. When they occur, GLEs begin a few minutes after flare maximum and last for a few tens of minutes to hours. Intense particle fluxes at lower energies can be expected to follow this initial burst of relativistic particles. GLEs are detected by neutron monitors, e.g., the monitor at Thule, Greenland.

**Halo CME** A faint ring of enhanced emission seen around most or all of the edge of the occulting disk of a coronagraph. Indicative of a spatially large CME on the front side (Earthward) or back side of the Sun. The source region is usually nearer to solar central meridian than the limbs. Full halo CMEs from the front side of the Sun almost always result in geomagnetic storms at Earth, especially when accompanied by a solar proton event.

Ha or H-alpha The first atomic transition in the hydrogen Balmer series; wavelength = 656.3 nm. This absorption line of neutral hydrogen falls in the red part of the visible spectrum and is convenient for solar observations. The Ha line is commonly used for patrol observations of solar flares, filaments, prominences, and the fine structure of active regions.

**Heliographic** Referring to coordinates on the solar surface referenced to the solar rotational axis.

**Heliopause** The boundary surface between the solar wind and the external galactic medium.

**Helioseismology** The study of wave oscillations in the Sun using acoustic, gravity, and surface gravity waves.

**Heliosphere** The magnetic cavity surrounding the Sun, carved out of the galaxy by the solar wind.

**Helmet streamer** A feature of the white light corona (seen in eclipse or with a coronagraph) that looks like a ray extending away from the Sun out to about 1 solar radius, having an arch-like base containing a cavity usually occupied by a prominence.

**High Frequency (HF)** That portion of the radio frequency spectrum between 3 and 30 MHz.

**High latitude** With reference to zones of geomagnetic activity - 50 to 80 degrees geomagnetic latitude. The other zones are equatorial, middle latitude, and polar.

**High-speed stream** A feature of the solar wind having velocities exceeding approximately 600 km/s (about double average solar wind values). High-speed streams that originate in coronal holes are less dense than those originating in the average solar wind.

**Hyder flare** A filament-associated two-ribbon flare, often occurring in spotless regions. The flare is generally slow (30-60 minutes rise time in Ha and x-ray) and follows the disappearance of a previously quiescent filament. The Hyder flare is named for Dr. C. Hyder, who published studies of such flares in 1967.

**Inclination of the geomagnetic field** The angle between the local geomagnetic field direction and the horizon. (See geomagnetic elements.)

**Integral particle flux** The integral directional particle flux J(E,w) is literally the mathematical integral, with respect to the energy E, of the differential particle flux j(E,w). It denotes the number of particles of energy equal to or greater than E, per unit area, per unit solid angle, per unit time, passing through an area perpendicular to the viewing direction.

**Interplanetary Magnetic Field (IMF)** The magnetic field carried with the solar wind.

**Interplanetary medium** The space between planets and other solid bodies in the heliosphere. Populated by solar and cosmic particles, magnetic fields, and photons.

**Inversion line** The locus of points on the solar surface where the radial magnetic field vanishes. Inversion lines separate regions of opposing polarity and are often superposed by thin, dark

filaments. Inside active regions, the areas close to and along inversion lines are preferred places of flare occurrence. Filament channels, plage corridors, arch-filament systems, and fibril patterns surrounding active regions can be used to infer the positions of inversion lines.

**Ionosphere** The region of the Earth's upper atmosphere containing free electrons and ions produced by ionization of the constituents of the atmosphere by solar ultraviolet radiation at short wavelengths < 100nm) and energetic precipitating particles. The ionosphere influences radiowave propagation of frequencies less than about 300 MHz. (See D region, E region, F region.)

**Ionospheric storm** A disturbance in the F region of the ionosphere, which occurs in connection with geomagnetic activity. In general, there are two phases of an ionospheric storm, an initial increase in electron density (the positive phase) lasting a few hours, followed by a decrease lasting a few days. At low latitudes only the positive phase is usually seen. Individual storms can vary, and their behavior depends on geomagnetic latitude, season, and local time.

**K index** A 3-hourly quasi-logarithmic local index of geomagnetic activity relative to an assumed quiet-day curve for the recording site. Range is from 0 (quiet) to 9 (severely disturbed). The K index measures the deviation of the most disturbed component (see geomagnetic elements). Also see Kp.

**Kp index** Kp is a common index used to indicate the severity of the global magnetic disturbances in near-Earth space. Kp is an index based on the average of weighted K indices at 13 ground magnetic field observatories. It is based on the range of the magnetic field variation within 3 hour intervals that is caused by phenomena other than the diurnal variation and the long-term components of the storm time variations. The values of the Kp range from 0 (very quiet) to 9 (very disturbed) in 28 discrete steps, resulting in values of 0, 0+, 1-, 1, 1+, 2-, 2, 2+,...9.

An Estimated Kp is calculated by NOAA in near-real-time.

The official, after-the-fact, 3-hourly planetary index of geomagnetic activity is calculated twice per month by the German GeoForschungsZentrum (GFZ) (Research Center for Geosciences), from the K indexes observed at 13 stations primarily in the Northern Hemisphere. The Kp indices, which date from 1932, are used to determine the ap indices.

**L1** Lagrangian orbit number 1. A location on the Earth/ Sun line where gravitational forces can be balanced to maintain a stable orbit. Approximately 1.5 million km upstream of the Earth. Solar wind monitors located there allow a 20-60 minute (depending on solar wind velocity) warning of geomagnetic disturbances at Earth.

**LASCO** Large Angle Spectrometric COronagraph experiment on SOHO capable of imaging CMEs from 1.1-32 solar radii.

**Leader spot** In a magnetically bipolar or multipolar sunspot group, the main spot in that portion of the group west of the principal inversion line; also called the preceding or p-spot. Leader and follower describe the positions of spots with respect to apparent motion due to solar rotation.

**LEO** Among satellite operators, a common abbreviation for Low Earth Orbit.

**Limb** The edge of the solar disk.

**Limb darkening** For certain solar spectral lines, a lessening of the intensity of the line from the center of the solar disk to the limb, caused by the existence of a temperature gradient in the Sun and the line-of-sight through the solar atmosphere. Limb darkening also occurs in some radio wavelengths.

**Limb flare** A flare at the edge (limb) of the solar disk; the elevated portions of the flare are seen with particular clarity against the dark sky background.

**Long Duration Event (LDE)** With reference to x-ray events, those events that are not impulsive in appearance. The exact time threshold separating impulsive from long-duration events is not well defined, but operationally, any event requiring 30 minutes or more to decay to one-half peak flux is regarded as an LDE. It has been shown that the likelihood of a coronal mass ejection increases with the duration of an x-ray event, and becomes virtually certain for durations of 6 hours or more.

**Longitudinal Component** That component of the solar magnetic field vector parallel to the direction of view, radial from the solar surface at disk center.

**Loop Prominence System (LPS)** A system of prominences in the form of loops associated with major flares, bridging the magnetic inversion line. The lifetime of an LPS is a few hours. Loop prominences observed in H-alpha are distinctly brighter than other prominences, and material typically flows downward along both legs from condensation "knots" near the top of the loop. Can be observed on the solar disk with good viewing conditions.

**Low frequency (LF)** That portion of the radio frequency spectrum from 30 to 300 kHz.

**Lowest Usable Frequency (LUF)** The lowest frequency that allows reliable long-range HF radio communication by ionospheric refraction.

**Magnetic cloud** In general, any identifiable parcel of solar wind. More specifically, a region of about 0.25 AU in radial dimension in which the magnetic field strength is high and the direction of one component of the magnetic field changes appreciably by means of a rotation nearly parallel to a plane. Magnetic clouds are one manifestation of coronal mass ejections in the interplanetary medium.

**Magnetic Local Time (MLT)** On Earth, analogous to geographic local time. MLT at a given location is determined by the angle subtended at the geomagnetic axis between the geomagnetic midnight meridian and the meridian that passes through the location. 15 degrees = 1 h. The geomagnetic meridian containing the sub-solar point defines geomagnetic local noon, and the opposite meridian defines geomagnetic midnight. (See geomagnetic field.)

**Magnetic sunspot classifications** See Mount Wilson magnetic classification.

**Magnetogram** A plot showing the amplitude of one or more vector components of a magnetic field versus space or time. Solar magnetograms are a graphic representation of solar magnetic field strengths and polarity.

**Magnetopause** The boundary surface between the solar wind and the magnetosphere, where the pressure of the Earth's magnetic field effectively equals the dynamic pressure of the solar wind.

**Magnetopause current sheet** An electric current sheet that more or less coincides with the magnetopause.

**Magnetosheath** The region between the bow shock and the magnetopause, characterized by very turbulent plasma. For the Earth, along the Sun-Earth axis, the magnetosheath is about 2 Earth radii thick.

**Magnetosphere** The magnetic cavity surrounding a magnetized body, carved out of the passing solar wind by virtue of the magnetic field, which prevents, or at least impedes, the direct entry of the solar wind plasma into the cavity.

**Magnetotail** The extension of the magnetosphere in the antisunward direction as a result of interaction with the solar wind. In the inner magnetotail, the field lines maintain a roughly dipolar configuration. At greater distances, the field lines are stretched into northern and southern lobes, separated by a plasmasheet. There is observational evidence for traces of the Earth's magnetotail as far as 1000 Earth radii downstream.

**Maunder minimum** An approximately 70-year period, centered near 1670, during which practically no sunspots were observed.

**Maximum Usable Frequency (MUF)** The highest frequency that allows reliable HF radio communication over a given ground range by ionospheric refraction. Frequencies higher than the MUF penetrate the ionosphere and become useful for extraterrestrial communications.

**Medium Frequency (MF)** That portion of the radio frequency spectrum from 0.3 to 3 MHz.

**Mesosphere** The region of the Earth's atmosphere between the upper limit of the stratosphere (approximately 30 km altitude) and the lower limit of the thermosphere (approximately 80 km altitude).

**Microwave burst** A radiowave signal sometimes associated with optical and/or x-ray flares. Microwave bursts are generally broadband, often extending into the millimeter and decimeter domains. (See also U-burst.)

**Microwaves** Generically, any radio frequency of 500 MHz or more.

**Middle latitude** With reference to zones of geomagnetic activity, 20 degrees to 50 degrees geomagnetic latitude. Other zones are equatorial, polar, and high latitude.

**Mount Wilson magnetic classification** Classification of the magnetic character of sunspots according to rules set forth by the Mount Wilson Observatory in California.

alpha (a). A unipolar sunspot group.

beta (B). A sunspot group having both positive and negative magnetic polarities (bipolar), with a simple and distinct division between the polarities.

gamma (G). A complex active region in which the positive and negative polarities are so irregularly distributed as to prevent classification as a bipolar group.

beta-gamma (BG). A sunspot group that is bipolar but which is sufficiently complex that no single, continuous line can be drawn between spots of opposite polarities.

delta (D). A qualifier to magnetic class (see below) indicating that umbrae separated by less than 2 degrees within one penumbra have opposite polarity.

beta-delta (BD). A sunspot group of general beta magnetic classification but containing one (or more) delta spot(s).

beta-gamma-delta (BGD). A sunspot group of beta-gamma magnetic classification but containing one or more delta spot(s).

gamma-delta (GD). A sunspot group of gamma magnetic classification but containing one or more delta spot(s).

**Neutral line** The line that separates solar magnetic fields of opposite polarity, typically determined from solar magnetograms recording the longitudinal magnetic component.

NOAA Space Weather ScalesA shorthand classification scheme developed to convey to the general public the complex and often confusing levels of disturbances in the solar-terrestrial environment. Three typical events are represented as: Geomagnetic Storms (G), Solar Radiation Storms (S), and Radio Blackouts (R). A numerical qualifier is added to the event type to indicate the severity of the disturbance. These qualifiers are defined as follows:

1 Minor
2 Moderate
3 Strong
4 Severe
5 Extreme

See Appendix A for complete descriptions of normal terrestrial system effects, threshold levels, and event frequency of occurrence.

**Noise storm** A transient enhancement of solar radio emission, particularly near 250 MHz, consisting of an elevated background emission. These storms may last hours to days.

nT nanotesla = 10-9 Tesla

**Partial halo** A partial halo is a CME spanning greater than 120 degrees of solar latitude at the limb and encompassing at least one of the solar poles.

**Particle flux unit (p.f.u.)** 1 p cm-2 s-1 sr-1

**Penumbra** The sunspot area that may surround the darker umbra or umbrae. In its mature form it consists of linear bright and dark elements radial from the sunspot umbra.

**Persistence** Continuation of existing conditions. When a physical parameter varies slowly, the best prediction is often persistence.

**Photosphere** The lowest visible layer of the solar atmosphere; corresponds to the solar surface viewed in white light. Sunspots and faculae are observed in the photosphere.

**Plage** On the Sun, an extended H-alpha emission feature of an active region that is seen from the time of emergence of the first magnetic flux until the widely scattered remnant magnetic fields merge with the background. Magnetic fields are more intense in plage, and temperatures are higher than in surrounding, quiescent regions.

**Plasma** A gas that is ionized sufficiently to be a good electrical conductor and be affected by magnetic fields.

**Plasmapause** The outer boundary of the plasmasphere.

**Plasmsheet** In the magnetosphere, the core of the magnetotail in which the plasma is hotter and denser than in the tail lobes north and south of it. The plasmasheet is thought to be separated from the tail lobes by the sheet of the ”last closed field lines” and it typically lies beyond geosynchronous orbit.

**Plasmasphere** In the magnetosphere, a region of relatively cool (low energy) and dense plasma that may be considered an outer extension of the ionosphere with which it is coupled. Like the ionosphere, the plasmasphere tends to co-rotate with the Earth.

**Polar Cap Absorption (PCA)** An anomalous condition of the polar ionosphere where HF and VHF (3-300 MHz) radiowaves are absorbed, and LF and VLF (3-300 kHz) radiowaves are reflected at lower altitudes than normal. PCAs generally originate with major solar flares, beginning within a few hours of the event and maximizing within a day or two of onset. As measured by a riometer, the PCA event threshold is 2 dB of absorption at 30MIlz for daytime and 0.5 dB at night. In practice, the absorption is inferred from the proton flux at energies greater than 10 MeV, so that PCAs and proton events are simultaneous. However, the transpolar radio paths may be disturbed for days, up to weeks, following the end of a proton event.

**Polar crown** A nearly continuous ring of filaments occasionally encircling either polar region of the Sun (latitudes higher than 50’).

**Pore** A feature in the photosphere, 1 to 3 arc seconds in extent, usually not much darker than the dark spaces between photospheric granules. It is distinguished from a sunspot by its short lifetime, 10 to 100 minutes.

**Ppost-flare loops** A loop prominence system often seen after a major two-ribbon flare on the visible disk. Lifetimes are several hours.

**PRESTO** An alert issued by a Regional Warning Center to give rapid notification of significant solar or geophysical activity in progress or just concluded.

**Prominence** A term identifying cloud-like features in the solar atmosphere. The features appear as bright structures above the solar limb and as dark filaments when seen projected against the solar disk. They are most clearly and most often observed in H-alpha.

**Proton event** The measurement of proton flux reaching and sustaining ~ 10 p.f.u. (1 p.f.u. = 1 particle cm-2 s-l sr-1) for at least 15 min. at energies > 10 MeV by the primary NOAA geosynchronous satellite. The start time of the event is defined as the earliest time at which event thresholds have been reached. The end time is the last time 10 p.f.u. was observed. This definition allows multiple injections from flares and interplanetary shocks to be encompassed by a single event.

**Proton flare** Any flare producing significant counts of protons with energies exceeding 10 MeV in the vicinity of the Earth.

**Quiescent prominence** A long, sheet-like prominence nearly vertical to the solar surface. Except in an occasional activated phase, shows little large-scale motion, develops very slowly, and has a lifetime of several solar rotations. Quiescent prominences form within the remnants of decayed active regions, in quiet areas of the Sun between active regions, or at high solar latitudes where active regions seldom form. (See filament.)

**Quiet** A descriptive word specifically meaning (1) a probability of less than 50% for a C-class flare (see x-ray flare class) in a sunspot region and (2) geomagnetic activity levels such that Ak < 8.

**Quiet day curve (QDC)** Especially in connection with the components of the geomagnetic field (see geomagnetic elements), the trace expected in the absence of activity. The K index and Q index are measured from deviations relative to a QDC. Riometer and neutron monitor deviations are also measured relative to a QDC.

**Radiation belts** Regions of the magnetosphere roughly 1.2 to 6 Earth radii above the equator in which charged particles are stably trapped by closed geomagnetic field lines. There are two belts. The inner belt is part of the plasmasphere and corotates with the Earth; its maximum proton density lies near 5000 km. Inner belt protons are mostly high energy (10-50 MeV range) and originate from the decay of secondary neutrons created during collisions between cosmic rays and upper atmospheric particles. The outer belt extends on to the magnetopause on the sunward side. The altitude of maximum proton density is near 16,000-20,000 km. Outer belt protons are lower energy (about 200 eV to 1 MeV) and come from the solar wind. The outer belt is also characterized by highly variable fluxes of energetic electrons. The radiation belts are often called the ”Van Allen radiation belts” because they were discovered in 1968 by a research group at the University of Iowa led by Professor J. A. Van Allen.

**Radio Blackout NOAA Space Weather Scale** A measure of the severity of solar x-ray bursts that cause radio blackouts at Earth. (See Appendix A).

**Radio emission** Emission of the Sun in radio wavelengths from centimeters to dekameters, under both quiet and disturbed conditions. Some patterns, known variously as noise storms, bursts, and sweeps, are identified as described below. These types of emission are subjectively rated on an importance scale of 1 to 3, 3 representing the most intense.

**Type I**. A noise storm composed of many short, narrow-band bursts in the meter wavelength range (300-50 MHz), of extremely variable intensity. The storm may last from several hours to several days.

**Type ll**. Narrow-band emission that begins in the meter range (300 MHz) and sweeps slowly (tens of minutes) toward dekameter wavelengths (10 MHz). Type II emissions occur in loose association with major flares and are indicative of a shock wave moving through the solar atmosphere.

**Type III**. Narrow-band bursts that sweep rapidly (seconds) from decimeter to dekameter wavelengths (500-0.5 MHz). They often occur in groups and are an occasional feature of complex solar active regions.

**Type IV**. A smooth continuum of broad-band bursts primarily in the meter range (300-30 MHz). These bursts occur with some major flare events; they begin 10 to 20 minutes after flare maximum and can last for hours.

**Type V**. Short-duration (a few minutes) continuum noise in the dekameter range usually associated with Type III bursts.

**Recurrence** Used especially to express a tendency of some solar and geophysical parameters to repeat a trend and sometimes the actual value of the parameter itself every 27 days (the approximate rotation period of the Sun).

**Region number** A number assigned by NOAA to a plage region or sunspot group if one of the following conditions exists: (1) the region is a group of at least sunspot classification C; (2) two or more separate optical reports confirm the presence of smaller spots; (3) the region produces a solar flare; (4) the region is clearly evident in H-alpha and exceeds 5 heliographic degrees in either latitude or longitude. (See also active region.)

**RI** The international standard relative sunspot number.

**Ring current** In the magnetosphere, a region of current that flows from east to west in a disk-shaped region near the geomagnetic equator in the outer of the Van Allen radiation belts. The current is produced by the gradient and curvature drift of the trapped charged particles. The ring current is greatly augmented during magnetic storms because of the hot plasma injected from the magnetotail. This increase in the ring current causes a worldwide depression of the horizontal geomagnetic field during a magnetic storm.

**Rudimentary** A type of sunspot penumbra characterized by granular (rather than filamentary) structure, brighter intensity than the umbra, and narrow extent, and possibly only partially surrounding the umbra. Penumbrae are typically rudimentary during the sunspot formative and decay phases.

**Satellite anomaly** The usually undesirable response of spacecraft systems to variations in the space environment. High energy particles cause detector noise and/or physical damage to solar cells, electronics, and memory devices (single event upsets or "bitflips"). Large and varying low-to-medium energy particle fluxes can result in a charge buildup between spacecraft components especially during the eclipse season and during spacecraft maneuvers. Atmospheric drag on spacecraft below approximately 1,000 km can increase during geomagnetic storms, resulting in cross-track and in-track orbit errors and orientation problems. Various communication interference problems result during solar radio bursts from flares when the Sun is within the field of view of the ground tracking dish. Ionospheric irregularities during geomagnetic storms can cause radio telemetry scintillation and fading.

**Scintillation** Describing a degraded condition of radio propagation characterized by a rapid variation in amplitude and/or phase of a radio signal (usually on a satellite communication link) caused by abrupt variations in electron density anywhere along the signal path. It is positively correlated with spread F and to a lesser degree, sporadic E. Scintillation effects are the most severe at low latitudes, but can also be a problem at high latitudes, especially in the auroral oval and over the polar caps.

**Sector boundary** In the solar wind, the area of demarcation between sectors. which are large-scale features distinguished by the predominant direction of the interplanetary magnetic field, toward the Sun (a negative sector), or away from the Sun (a positive sector). The sector boundary separating fields of opposite polarity is normally narrow, passing the Earth within minutes to hours as opposed to the week or so needed for passage of a typical sector. The solar wind velocities in the boundary region are typically among the lowest observed.

**S.F.U**. Solar flux unit. 1sfu = 10-22 W m-2 Hz-1 = 10,000 Jansky

**Shock** A discontinuity in pressure, density, and particle velocity, propagating through a compressible fluid or plasma.

**Short Wave Fade (SWF)** An abrupt decrease of HF radio signal strength, lasting from minutes to hours, caused by increased dayside ionization from some solar flares. A SWF is one

effect under the broad category of sudden ionospheric disturbances (SIDs).

**Single Event Upset (SEU)** With reference to the effects of energetic particles on spacecraft microcircuits - an unexpected change in the logic state of a single digital bit. SEUs can be either "soft" (the microcircuit is not damaged and can be rewritten to either state), or a latch up, which cannot easily be reset.

**Smoothed sunspot number** An average of 13 monthly RI numbers, centered on the month of concern. The 1st and 13th months are given a weight of 0.5.

**Solar activity** Transient perturbations of the solar atmosphere as measured by enhanced x-ray emission (see x-ray flare class), typically associated with flares. Five standard terms are used to describe the activity observed or expected:

***Very low*** - x-ray events less than C-class.

***Low*** - C-class x-ray events.

***Moderate*** - isolated (one to 4) M-class x-ray events.

***High*** - several (5 or more) M5 or greater x-ray events.

**Solar coordinates** Specifications for a location on the solar surface. The location of a specific feature on the Sun (for example, a sunspot) is complicated by the fact that there is a tilt of 7.25 degrees between the ecliptic plane and the solar equatorial plane as well as a true wobble of the solar rotational axis. (Only twice a year are the solar north pole and the celestial north pole aligned.) Consequently, to specify a location on the solar surface, three coordinates (P, B, L) are necessary to define a grid. Daily values for the coordinates in Coordinated Universal Time (UTC) are listed in The Astronomical Almanac published annually by the U.S. Naval Observatory. The terms used to refer to the coordinates are defined as follows:

P-angle: The position angle between the geocentric north pole and the solar rotational north pole measured eastward from geocentric north. The range in P is plus or minus 26.31°.

Bo: Heliographic latitude of the central point of the solar disk; also called the B-angle. The range of B is plus or minus 7.23°, correcting for the tilt of the ecliptic with respect to the solar equatorial plane.

Example: If (P, B) = (-26.21°, -6.54°), the heliographic latitude of the central point on the solar disk is -6.54° (the north rotational pole is not visible), and the angle between the projection onto the disk of the geocentric north pole and the solar north rotational pole is 26.21° to the west.

L: Heliographic longitude of the central point of the solar disk. The longitude value is determined with reference to a system of fixed longitudes rotating on the Sun at a rate of 13.2 degrees/day (the mean rate of rotation observed from central meridian transits of sunspots). The standard meridian on the Sun is defined to be the meridian that passed through the ascending node of the Sun's equator on 1 January 1854 at 1200 UTC and is calculated for the present day by assuming a uniform sidereal period of rotation of 25.38 days. Once P, B, and L are known, the latitude, central meridian distance, and longitude of a specific solar feature can be determined as follows:

Latitude. The angular distance from the solar equator, measured north or south along the meridian.

Central meridian distance (CMD). The angular distance in solar longitude measured from the central meridian. This position is relative to the view from Earth and will change as the Sun rotates. Therefore, this coordinate should not be confused with heliographic positions that are fixed with respect to the solar surface.

Longitude. The angular distance from a standard meridian (0 degrees heliographic longitude), measured from east to west (0 to 360 degrees) along the Sun's equator. It is computed by combining CMD with the longitude of the central meridian at the time of the observation, interpolating between ephemeris values (for 0000 UT) by using the synodic rate of solar rotation (27.2753 days, 13.2 degrees/day).

**Solar maximum** The month(s) during a sunspot cycle when the smoothed sunspot number reaches a maximum.

**Solar minimum** The month(s) during a sunspot cycle when the smoothed sunspot number reaches a minimum.

**Solar Radiation Storms NOAA Space Weather Scales** A measure of the severity of solar proton events as depicted in the NOAA Space Weather Scales. (See Appendix A.)

**Solar rotation rate** (1) synodic: 13.39 degrees -2.7 degrees sin2 J per day (J = solar latitude). (2) sidereal: 14.38 degrees -2. 7 degrees sin2 J per day. The difference between sidereal and synodic rates is the Earth orbital motion of 0.985 degrees/day.

**Solar Sector Boundary (SSB)** The boundary between large-scale unipolar magnetic regions on the Sun's surface, as determined from inversion lines mapped using filaments and filament channels, or large-scale magnetograms. The supposed solar signature of an interplanetary sector boundary.

**Solar wind** The outward flow of solar particles and magnetic fields from the Sun. Typically at 1 AU, solar wind velocities are near 375 km/s and proton and electron densities are near 5 cm-3. The total intensity of the interplanetary magnetic field is nominally 5 nT.

**Solstice** A point on the ecliptic where the Sun reaches its greatest absolute declination. There are two of these points, halfway between the equinoxes; they mark the beginning of summer and winter.

**South Atlantic anomaly (SAA)** A region of the Earth centered near 25S and 50W (near the Atlantic coast of Brazil) of low geomagnetic field intensity owing to the fact that the geomagnetic field axis is offset from the center of the Earth. One consequence of the SAA is that trapped particles in the plasmasphere drift closer to the Earth's surface and can more easily be lost into the atmosphere. The result is that the F region (see ionosphere) is highly variable in this region, and satellites in low Earth orbits suffer greater radiation doses when they pass through the SAA. There is a corresponding location of maximum geomagnetic field intensity in Southeast Asia.

**Spacecraft charging** A term that encompasses all the charging effects on a spacecraft due to the environment in space. Occasionally this term is used in a more limited sense to mean surface charging.

**Spicules** Rapidly changing, predominantly vertical, spike-like structures in the solar chromosphere observed above the limb. Spicules appear to be ejected from the low chromosphere at velocities of 20 to 30 km/s, reaching a height of about 9000 km and then falling

back or fading. The total lifetime is 5 to 10 minutes.

**Sporadic E (Es)** Transient, localized patches of relatively high electron density in the E region of the ionosphere, which significantly affect radiowave propagation. Sporadic E can occur during daytime or nighttime, and varies markedly with latitude. Es can be associated with thunderstorms, meteor showers, solar, and geomagnetic activity.

**Stratosphere** That region of the Earth's atmosphere between the troposphere and the mesosphere. It begins at an altitude of temperature minimum at approximately 13 km and defines a layer of increasing temperature up to about 50 km.

**Substorm** A geomagnetic perturbation lasting 1 to 2 hours, which tends to occur during local post-midnight nighttime. The magnitude of the substorm is largest in the auroral zone, potentially reaching several thousand nanotesla. A substorm corresponds to an injection of charged particles from the magnetotail into the auroral oval.

**Sudden Commencement (SC, or SSC for Storm Sudden Commencement)** An abrupt increase or decrease in the northward component (see geomagnetic elements) of the geomagnetic field, which marks the beginning of a geomagnetic storm. SCs occur almost simultaneously worldwide but with locally varying magnitudes.

**Sudden Impulse (SI + or SI - )** A sudden perturbation, positive or negative, of several nanotesla in the northward component (see geomagnetic elements) of the low-latitude geomagnetic field, not associated with a following geomagnetic storm. (An SI becomes an SC if a storm follows.)

**Sudden Ionospheric Disturbance (SID)** Any of several radio propagation anomalies due to ionospheric changes resulting from solar or geophysical events. Anomalies include short wave fades, enhancements of atmospherics, phase shifts, cosmic noise absorptions, and signal enhancements.

**Sunspot** An area seen as a dark spot, in contrast with its surroundings, on the photosphere of the Sun. Sunspots are concentrations of magnetic flux, typically occurring in bipolar clusters or groups. They appear dark because they are cooler than the surrounding photosphere. Larger and darker sunspots sometimes are surrounded (completely or partially) by penumbrae. The dark centers are umbrae. The smallest, immature spots are sometimes called pores.

**Sunspot classification (Modified Zurich Sunspot Classification)** As devised by McIntosh, a 3-letter designation of the white-light characteristics of a sunspot group. The general form of the designation is Zpc. One letter is chosen from each of the following three categories.

Z (the modified Zurich class of the group):

A - A small single sunspot or very small group of spots with the same magnetic polarity, without penumbra.

B - Bipolar sunspot group with no penumbra.

C - An elongated bipolar sunspot group. One sunspot must have penumbra, and penumbra does not exceed 5 ° in longitudinal extent.

D - An elongated bipolar sunspot group with penumbra on both ends of the group; longitudinal extent of penumbra is more than 5°, but does not exceed 10°.

E - An elongated bipolar sunspot group with penumbra on both ends. Longitudinal extent of penumbra exceeds 10° but not 15°.

F - An elongated bipolar sunspot group with penumbra on both ends. Longitudinal extent of penumbra exceeds 15°.

H - A unipolar sunspot group with penumbra. Class H sunspot groups become compact Class D or larger when the penumbra exceeds 5 degrees in longitudinal extent.

p (the penumbra type of the largest spot in the group):

x-no penumbra

r-rudimentary

s-small (<2.5 degrees north-south diameter), symmetric

a-small, asymmetric

h-large (>2.5 degrees north-south diameter), symmetric

k-large, asymmetric

c (the compactness of the group):

x-a single spot

o-open

i-intermediate

c-compact

**Sunspot cycle** The approximately 11 year quasi-periodic variation in the sunspot number. The polarity pattern of the magnetic field reverses with each cycle. Other solar phenomena, such as the 10.7 cm solar radio emission, exhibit similar cyclical behavior.

**Sunspot number** A daily index of sunspot activity (R), defined as R = k(10g + s) where s = number of individual spots, g = number of sunspot groups, and k is an observatory factor (equal to 1 for the Zurich Observatory and adjusted for all other observatories to obtain approximately the same R number). The standard number, RI, once derived at Zurich (see Wolf number), is now being derived at Brussels and is denoted by RI. Often, the term ”sunspot number” is used in reference to the widely distributed smoothed sunspot number.

Super High Frequency (SHF) That portion of the radio frequency spectrum from 3 to 30 GHz.

**Supergranulation** A system of large-scale velocity cells that does not vary significantly over the quiet solar surface or with phase of the solar cycle. The cells are presumably convective in origin with weak upward motions in the center, downward motions at the borders, and horizontal motions of typically 0.3 to 0.4 km/s. Magnetic flux is more intense along the borders of the cells.

**Surge** A jet of material from active regions that reaches coronal heights and then either fades or returns into the chromosphere along the trajectory of ascent. Surges typically last 10 to 20 minutes and tend to recur at a rate of approximately 1 per hour. Surges are linear and collimated in form, as if highly directed by magnetic fields.

**Solar x-ray imager (SXI)** Full disk soft x-ray (0.6-6 nm) imager flown on many of the GOES geosynchronous weather satellites.

**Synoptic chart** A map of the whole Sun in absolute heliographic coordinates, displaying an integrated view of solar features observed during a Carrington rotation.

**Tenflare** A solar flare accompanied by a 10cm radio burst of intensity greater than 100% of the pre-burst value.

**Thermosphere** That region of the Earth's atmosphere where the neutral temperature increases with height. It begins above the mesosphere at about 80-85 km and extends to the exosphere.

**Total Electron Content (TEC)** The number of electrons along a ray path between a transmitter and a receiver. Units are electrons per square meter. This number is significant in determining ionospheric effects such as refraction, dispersion, and group delay on radio waves, and can be used to estimate critical frequencies. The TEC is strongly affected by solar and geomagnetic activity.

**Transition region** That region of the solar atmosphere lying between the chromosphere and the corona where the temperature rises from 104K to 106K. The transition region is only a few thousand kilometers thick.

**Transverse** Component of magnetic field vector perpendicular to the direction of view and parallel to the solar surface at disk center.

**Troposphere** The lowest layer of the Earth's atmosphere, extending from the ground to the stratosphere at approximately 13 km of altitude.

**Two-ribbon flare** A flare that has developed as a pair of bright strands (ribbons) on both sides of an inversion line of the solar magnetic field.

**Type I, II, III, IV, V** See radio emission.

**U-burst** A radio noise burst associated with some flares. It has a U-shaped appearance in an intensity vs. frequency plot. The minimum intensity falls roughly between 500 and 2000 MHz. A U-burst is sometimes called a Castelli U.

**Ultra High Frequency (UHF)** That portion of the radio frequency spectrum from 300 MHz - 3 GHz.

**Ultraviolet (UV)** That part of the electromagnetic spectrum between 5 - 400nm.

**Umbra** The dark core or cores (umbrae) in a sunspot with penumbra, or a sunspot lacking penumbra.

**Unipolar Magnetic Region (UMR)** A large-scale photospheric region where the magnetic elements are predominantly of one polarity (for example, the solar polar regions).

**Universal Time (UT)** A shortened form of the more correct Coordinated Universal Time (UTC).

**Unsettled** With regard to geomagnetic activity, a descriptive word between quiet and active such that the Ak index is between 8 and 15.

**Van Allen radiation belts** See radiation belts.

**Vernal equinox** The equinox that occurs in March. Compare autumnal equinox.

**Very High Frequency (VHF)** That portion of the radio frequency spectrum from 30-300 MHz.

**Very Low Frequency (VLF)** That portion of the radio frequency spectrum from 3 - 30 kHz.

**White light (WL)** The sum of all visible wavelengths of light (400-700 nm) so that all colors are blended to appear white to the eye. No pronounced contribution from any one spectral line (or light-emitting element) is implied.

**Wolf number** An historic term for sunspot number. In 1849, R. Wolf of Zurich originated the general procedure for computing the sunspot number. The record of sunspot numbers that he began has continued to this day.

**WWV** Call letters of the radio station over which National Institute of Standards and Technology broadcasts time-standard signals at 2.5, 5, 10, 15, and 20 MHz. Solar-terrestrial conditions and forecasts are broadcast at 18 minutes past the hour.

**X-band** Designates those radio frequencies between 5.2 and 10.9 GHz.

**X-ray** Radiation of extremely short wavelength (generally less than 1 nm).

**X-ray background** A daily average background x-ray flux in the 0.1 to 0.8 nm range. It is a midday minimum given in terms of x-ray flare class.

**X-ray burst** A temporary enhancement of the x-ray emission of the Sun. The time-intensity profile of soft x-ray bursts is similar to that of the H-alpha profile of an associated flare.

**X-ray flare class** Rank of a flare based on its x-ray energy output. Flares are classified by the NOAA according to the order of magnitude of the peak burst intensity (I) measured at the Earth by satellites in the 0.1 to 0.8 nm band as follows:

Peak, 0.1 to 0.8 nm flux

(W m-2)

B I < 10-6

C 10-6 <= I < 10-5

M 10-5 <= I < 10-4

X I>= 10-4

A multiplicative factor is appended to the end of the class (e.g. M8 = 8 x 10-5 W m-2)

**Zulu Time** (See Coordinated Universal Time.)

**Z component of the geomagnetic field** See geomagnetic elements.

**Zurich sunspot classification** See sunspot classification.

**Zurich sunspot number** See sunspot number.