GLOSSARY OF SOLAR TERRESTRIAL TERMS

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The solar terrestrial forecasts which are being distributed over the networks contain some language that may not be very clear to many people unfamiliar with solar terrestrial terms. Since the reports are intended to be intelligable by the general public, this glossary of terms has been compiled to help provide some explanations for terms which may be used in the reports.

This glossary is not meant to be exhaustive, but is rather meant to provide people with a well-rounded vocabulary and a basic knowledge of some of the terms and classifications used in the reports. Definitions are not in any particular order.

Solar Flux:

The 10.7 cm (2800 MHz) radio flux is the amount of solar noise that isemitted by the sun at 10.7 cm wavelengths. The solar flux is measured and reported at approximately 1700 UT daily by the Penticton Radio Observatory in British Columbia, Canada. Values are not corrected for variations resulting from the eccentric orbit of the Earth around the Sun.

The solar flux is used as a basic indicator of solar activity. It can vary from values below 50 to values in excess of 300 (representing very low solar activity and high to very high solar activity respectively). Values in excess of 200 occur typical during the peak of the solar cycles.

The solar flux is closely related to the amount of ionization taking place at F2 layer heights (heights sensitive to long-distance radio communication). High solar flux values generally provide good ionization for long-distance communications at higher than normal frequencies. Low solar flux values can restrict the band of frequencies which are usable for long distance communications. The solar flux is measured in "solar flux units" (s.f.u.). One s.f.u. is equivalent to 10^-22 Wm^-2 Hz^-1.

Sunspot Number:

This term is basically self-explanatory. It represents the number of observed sunspots and sunspot groups on the solar surface. It is computed according to the Wolf Sunspot Number formula: R = k (10g + s), where 'g' is the number of sunspot groups (regions), s is the total number of individual spots in all the groups, and k is a scaling factor that corrects for seeing conditions at various observatories.

Sunspot number varies in phase with the solar flux. Sunspot numbers can vary between zero (for sunspot minimum periods) to values in excess of 350 or 400 (in the very active "solar max" period of the suns 11 year cycle). Solar flux is related to the sunspot number, since sunspots produce radio emissions at 10.7 cm wavelengths (as well as at other wavelengths).

X-Ray Background Flux:

This represents the average background x-ray flux as measured on theprimary GOES satellite. This value basically represents the amount of x-ray radiation that is being received at the Earth by the Sun. Generally, active regions emit more x-ray radiation than non-active solar regions. Therefore, this value can be of use in determining the overall state of the solar hemisphere facing the Earth.

This value is also useful for propagation prediction models (ie. PROPHET models), since ionospheric layer ionization is closely correlated with the background X-ray flux. This flux is stated using the same classification scheme for x-ray flares (given below).

Proton Fluence:

Altough this term will seldom be referenced within the reports, it may be of use to make a note of it. Proton fluence is simply the total number protonparticle fluxes measured by the GOES spacecraft at geosynchronous altitudes for protons of energies >1 Million electron Volts (MeV), >10 MeV and >100 MeV.

The higher the proton fluence, the more intense proton bombardments are at geosynchronous altitudes. It can also be used implicitly to determine the approximate amount of ionization occurring in the upper atmosphere, as well as the proton penetration level into the atmosphere and possible satellite anomalies caused by the solar proton bombardments. Fluence for particles are given in the units: particles cm^-2 steradian^-1 day^-1.

Tenflare:

A tenflare is associated with optical and x-ray flares. Solar flares emit radiation over a very wide range of frequencies. One of the more significant frequencies observed is the 10.7 cm wavelength band (2695 MHz). When a solar flare erupts, "noise" from the flare is received over this very wide range of frequencies.

When the noise received on the 10.7 cm wavelength band surpasses 100% of the background noise level during a solar flare, a Tenflare is said to be in progress. The more intense solar flares are associated with tenflares. Almost all major flares are associated with tenflares.

Generally, the greater the intensity of the burst of noise observed at the 10.7 cm wavelength band, the more significant the flare is said to be. The duration of the tenflare can also be used to determine the severity of the flare.

Other important flare characteristics are also determined from the radio data observed from flares, which are closely related to the various physical processes which occur in flares. These characteristics are far beyond the scope of this document.

Electron Fluence:

Again, this term will seldom be referenced within the reports. It is analagous to "proton fluence" but is measured for electrons with energies >2 MeV. Fluence measurements are the same as those for proton fluence.

Magnetic A-Index:

The geomagnetic A-Index represents the severity of magnetic fluctuations occurring at local magnetic observatories. During magnetic storms, the A-index may reach levels as high as 100. During severe storms, the A-index may exceed 200. Great "rogue" storms may succeed in producing index values in excess of 300, although storms associated with indices this high are very rare indeed.

The A-index varies from observatory to observatory, since magnetic fluctuations can be very local in nature. The A-index for Boulder Colorado (the same value reported on WWV and WWVH) will be the one referenced most often within the reports.

Occassionally, the A-index for higher latitude stations may also be referenced for purposes of comparison. Magnetic fluctuations monitored locally here at Solar Terrestrial Dispatch will also be referenced, particularly during storm periods for descriptive purposes.

Magnetic K-Index:

The geomagnetic K-Index is related to the A-index. K-indices are scaled by comparing the H and D magnetometer traces (representing the horizontal and declination magnetic components) to assumed "quiet-day curves" for H and D. Each UT day is divided into 8 three-hour intervals, starting at 0000 UT.

In each 3-hour period, the maximum deviation from the quiet day curve is measured for both (H and D) traces, and the largest deviation (the most disturbed trace) is selected. It is then input into a quasi-logarithmic transfer function to yield the K-index for the period. The K-index ranges from 0 to 9 and is a dimensionless number. It is assigned to the end of the 3 hour period.

The K-Index is useful in determining the state of the geomagnetic field, the quality of radio signal propagation and the condition of the ionosphere. Generally, K index values of 0 and 1 represent Quiet magnetic conditions and imply good radio signal propagation conditions. Values between 2 and 4 represent Unsettled to Active magnetic conditions and generally correspond to less-impressive radio propagation conditions. K-index values of 5 represent Minor Storm conditions and are usually associated with Fair to Poor propagation on many HF paths. K-index values of 6 generally represent Major Storm conditions and are almost always associated with Poor radio propagation conditions. K-index values of 7 represent Severe Storm conditions and are often accompanied by "radio blackout" conditions (particularly over higher latitudes). K-indices of 8 or 9 represent Very Severe Storm conditions and are rarely encountered (except during exceptional periods of solar activity). K-indices this high most often produce radio blackouts for periods lasting in excess of 6 to 10 hours (depending upon the intensity of the event).

Sudden Storm Commencement or SSC:

An SSC is the magnetic signature of an interplanetary shockwave most often produced by solar flares. It is always a precursor to increased geomagnetic activity, most often followed within 3 to 8 hours by a Minor to Major geomagnetic storm. It appears on the H (horizontal) trace of magnetometers.

This phenomenon is detectable at almost all magnetic observatories world-wide within 4 minutes of eachother.

Sudden Impulse or SI:

A sudden magnetic impulse is similar to an SSC. It represents a rapid momentary fluctuation of the geomagnetic field over a period of only a few minutes. It is generally associated with interplanetary shockwaves produced by energetic solar events and can (but need not always) be followed by increased geomagnetic activity.

Satellite Proton Event:

Proton events are almost always associated with energetic solar activity such as major flares. They are periods of increased proton bombardments at satellite altitudes. They can affect satellite transmission/reception if intense enough and can cause other satellite anomalies.

Proton events may affect the ability of a HAM operator to establish contact with a satellite, and may affect the quality of television signals received by satellite (ie. cable tv may be affected). Satellite proton events occur within a few hours of a major proton flare. They are also often followed by a PCA event (see below).

Polar Cap Absorption Event or PCA:

A PCA is almost always produced by an intense solar proton flare. PCAs are the result of copious quantities of high-energy solar protons penetrating the Earths atmosphere to levels of the order of 50 km, producing intense ionospheric ionization. The result is a complete (or near-complete) radio blackout over polar latitudes.

A typical PCA lasts from 1 to 5 days and can severely effect the propagation of radio signals near or through polar regions. In intense, long-lasting events, direct entry of the high-energy solar protons to the upper atmosphere can extend equatorward as far as about 50 degrees geomagnetic latitude. They occur almost coincident with satellite-level proton events, maximize in intensity within a few hours and then begin a slow decay that can last up to 10 days for intense events.

A PCA is often followed within 48 hours by a SSC and a subsequent Minor to Major geomagnetic storm about 3 to 8 hours later.

Sunspot Classifications:

Sunspots are classified according to size, shape and spot density. They are classified using a set of three coded letters (Zpc) as follows:

Z - Modified Zurich class, labelled A through F plus H.

A - Single small spot (single magnetic polarity).

B - Very small distribution of small spots.

C - Two or more small spots, at least one of which has a detectable penumbra.

D - Moderately sized group of spots, several of which may have noticable penumbrae. Magnetic complexity of D-type regions are usually capable of producing C and low-intensity M-class flares.

E - Moderate to large area of a fairly complex system of sunspots, several of which have noticable penumbrae and good definition. Often capable of producing minor C-class as well as major M-class flares.

F - Large to very large area of a complex system of sunspots. These regions are often capable of producing major X-class flares as well as numerous major M-class and many C-class events (depending on their magnetic complexity).

H - Single large to very large sunspot (not usually capable of producing significant energetic events). This type of sunspot is usually manifest in the dying phase of a sunspot group.

p - Penumbra type of the largest spot in the group.

x - Single spot.

r - Rudimentary.

s - Small symmetric.

a - Small asymmetric.

h - Large symmetric.

k - Large asymmetric.

c - Relative sunspot distribution or compactness of the group.

x - Single spot.

o - Open group (separated by quite a wide space).

i - Intermediate (moderate sunspot compactness in the group).

c - Compact (very dense and complex spots within the group).

Example: *A sunspot group classified as type DKO would be of moderate overall size (that is, the region encompassing all of the sunspots within the group would be of moderate size), the penumbra of the largest spot within the group would be large and asymmetric in shape, and the group would be "open" indicating that the sunspots within the region are not notably close together.*

Magnetic Class:

The magnetic class of sunspots is important in determining how potentially volatile particular active regions may be. Sunspots are regularly observed using instruments capable of determining the magnetic polarity of sunspots and active regions. By also applying laws which have been formulated over the years, visual observations can also be used to establish the magnetic polarity and complexity of spot groups. There are basically 7 magnetic types of sunspots that are classified. They are described as follows:

Type

A - Alpha (single polarity spot).

B - Beta (bipolar spot configuration).

G - Gamma (atypical mixture of polarities).

BG - Beta-Gamma (mixture of polarities in a dominantly bipolar configuration).

D - Delta (opposite polarity umbrae within single penumbra).

BD - Beta with a Delta configuration.

BGD - Beta-Gamma with a Delta configuration.

Example: *A region labelled as having a magnetic classification of BG indicates that the sunspot region contains a mixture of magnetic polarities, but the dominant polarity of the group is bipolar. Potentially very powerful and potent regions are those which have classifications of BG, BD and BGD. As magnetic complexity increases, the ability of an active region to spawn major energetic events likewise increases.*

Solar Activity Description:

Solar activity is described (also applicable on WWV and WWVH) according to the number of flares which occur during the day. Activity is basically classified as follows:

Very Low : X-ray events less than class C.

Low : C-class x-ray events.

Moderate : Isolated (one to 4) M-class x-ray events.

High : Several (5 or more) M-class x-ray events or isolated (1 to 4) M5 or greater x-ray events.

Very High : Several M5 or greater x-ray events.

Flare Classifications:

Flares are classified using one of two different systems. The first classification ranks the event by measuring its peak x-ray intensity in the 1-8 angstrom band as measured by the GOES satellites. This x-ray classification offers at least two distinct advantages compared with the second system of classification (optical): it gives a better measure of the geophysical significance of the event and it provides an objective means of classifying geophysically significant activity regardless of its location on the solar disk or near the solar limb. The classification scheme is as follows:

Class Peak Flux (1-8 Angstroms in Wm^-2)

A < 10^-7

B < 10^-6 but > class A

C < 10^-5 but > class B

M < 10^-4 but > class C

X > 10^-4

The letter designates the order of magnitude of the peak value. Following the letter the measured peak value is given. For descriptive purposes, a number from 1.0 to 9.9 is appended to the letter designation. The number acts as a multiplier. For example, a C3.2 event indicates an x-ray burst with a peak flux of 3.2 x 10^-6 Wm^-2. Since x-ray bursts are observed as a full-Sun value, bursts below the x-ray background level are not discernable. The background drops to class A level during solar minimum; only bursts that exceed B1.0 are classified as x-ray events. During solar maximum, the background is often at the class M level, and therefore class A, B and C x-ray bursts cannot be seen. Bursts greater than 1.2 x 10^-3 Wm^-2 may saturate the GOES detectors. If saturation occurs, the estimate peak flux values are reported.

The second system of classification involves a purely optical method of observation. A flare event is observed optically (in H-alpha light) and is both measured for size and brightness. This classification therefore includes two items of information: a descriptor defining the size of the flare and a descriptor defining the peak brightness of the flare. They are listed below:

Importance

S - Subflare area <= 2.0 square degrees.

1 - 2.1 <= area <= 5.1 square degrees.

2 - 5.2 <= area <= 12.4 square degrees.

3 - 12.5 <= area <= 24.7 square degrees.

4 - area >= 24.8 square degrees.

Brightness

F - Faint.

N - Normal.

B - Brilliant.

Example: *A major flare rated as a class M7.4/2B event indicates that the flare attained a maximum x-ray intensity of 7.4 x 10^-5 Wm^-2. The "2B" portion of this specification indicates that the flare was an importance 2 flare (>= 5.2 and <= 12.4 square degrees) and was optically Brilliant. This sample flare is a powerful event. Flares that reach x-ray levels in excess of class M4 can begin to have an impact on the Earth. Likewise, flares rated 2B or greater are generally capable of influencing the Earth, particularly if accompanied by Type II and IV radio sweeps (discussed below).*

Sweep Frequency Events (Type II, III, IV and V events):

Energetic solar events often produce characteristic radio "bursts". These bursts are generated by solar material plunging through the solar corona. Type III and type V events are caused by particles being ejected from the solar environment at near relativistic speeds. Type II and IV events are caused by slower-moving solar material propagating outward at speeds varying between approximately 800 and 1600 kilometers per second. Type II and IV radio bursts are of particular importance.

These sweep frequency radio events are signatures of potentially dense solar material which has been ejected from the solar surface. If the region responsible for these events is well positioned, the expelled solar material may succeed in impacting with the Earth. Such an impact often causes an SSC followed by Minor to Major geomagnetic storm conditions and significantly degraded radio propagation conditions. It is therefore interesting to pay attention to events which cause Type II and/or IV radio sweep events, since they may indicate the potential for increased magnetic activity (and decreased propagation quality) within 48 hours. It should be noted, however, that predicting degraded terrestrial conditions is significantly more complex than simply observing whether the energetic event had an associated Type II or IV radio sweep. Flare position, proton spectra, flare size, event duration, event intensity and a host of other variables must be analyzed before a qualitative judgement can be made.

It should also be noted that sweep frequency radio events are capable of producing Short Wave Fades (SWFs) and Sudden Ionospheric Disturbances (SIDs). Depending on the severity of the event, the duration of SWFs and SIDs may last in excess of several hours with typical values being approximately 30 minutes. SWFs and SIDs cause absorption of radio signals (due to intense ionization) at frequencies up to and well in excess of 500 MHz. Microwave continuum bursts can affect frequencies up to 30 GHz. Frequencies in the HF region can be completely blacked out for a period of time during intense energetic events.

Classifications of Auroral Activity used in the Reports:

Auroral activity is rated as either not visible, low, moderate, high, very high or extremely high. These classifications are defined according to the brightness achieved by auroral activity, visual activity (ie. changes of form or structure), whether the aurora is pulsating, and according to the intensity and fluctuations of color in the aurora. The various levels of activity are defined below:

- **Not visible**: Self-explanatory.

- **Low**: Low intensity aurorae consisting mostly of diffuse, dim, and lifeless activity. Generally no rapid changes in form or structure are discerned with auroral activity that is classified as "low."

- **Moderate**: Moderate intensity auroral activity which consists of diffuse aurorae intermixed with curtain aurorae or other forms of relatively-low activity aurorae. Moderate activity may include beams or rays of aurorae which travel either east or west with time. No color fluctuations or significant brightenings of aurorae are associated with moderate intensities.

- **High**: High intensity auroral activity is activity associated with very bright, active displays that may exhibit changes of color and rapid pulsations. High activity is generally confined to curtain aurorae and moderate-intensity pulsating aurorae.

- **Very High**: Very high intensity auroral activity is usually only experienced over the high latitude regions where zenith aurorae and significant auroral displays occur. Activity classified as very high consists of most auroral forms of activity, but the activity is always very bright and extremely active. Curtain aurorae may change form and color rapidly. Zenith aurorae may become exceedingly bright and colorful.

- **Extremely High**: Extremely high auroral activity is only rarely encountered. Activity at this level of intensity is most often experienced within the middle and/or low latitude zones during significant periods of geomagnetic activity. The expansion of the auroral zone equatorward and poleward produces the intense activity over regions equatorward of the normal position of the auroral oval. This activity usually consists of exceedingly bright, rapidly fluctuating, strongly pulsating, color-varying auroral activity. Levels of auroral activity this high are usually only associated with "rogue flares", which may occur only once or twice during a solar cycle.

The approximate latitudinal boundaries for observing aurorae (biased for North America and Australia/New Zealand) follow. The locations of these boundaries for Europe will be higher than for North America. The locations for Asia will be correspondingly higher than for Europe. The Southern Hemisphere estimates are valid for Australia and New Zealand. Locations of the boundaries for southern areas of South America will be higher than for Australia and New Zealand.

NORTHERN HEMISPHERE:
High latitudes >= 55 deg. N.
Middle latitudes >= 40 < 55 deg. N.
Low latitudes < 40 deg. N.

SOUTHERN HEMISPHERE:
High latitudes >= 55 deg. S.
Middle latitudes >= 30 < 55 deg. S.
Low latitudes < 30 deg. S.

For a good discussion on the topic of solar flares and terrestrial impacts, consult the book ***"Solar Flares" by H.J. Smith and E.V.P. Smith (publisher: Macmillan, New York).*** Although this book is a few years old (1963), it provides an excellent knowledge base to build upon and a wealth of information on flares in general.

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