SOLAR WEATHER DATA

UNDERSTANDING MAIN SOLAR PARAMETERS

Not yet validated by an astrophysicist - there may be few errors. Tks to Niall F5VCV for english proofreading.

Main sources : NOAA, observatoire de Paris, CNRS, SolarHam, ARRL, eHam, CQ mag, SpaceWeather, HamQsl, N0NBH, etc.

By Eric Cordier F4FAP - v1d, jan 2020 • Available on radio-club F4KIO web pages, Rennes, France: ara35.fr

SUN FACTS : 4,7 billion years old • Life expectancy 5 billion years • 333.000 times the earth's density • 1.303.000 times bigger than earth • 3/4 hydrogen and 1/4 helium • Burns 620 million tons of hydrogen per second • Sun light time to the earth ≈ 8 min, sun particles 2 to 4 days • Produces 400 million billion joules every second • Magnetic field 5000 times the earth magnetic field • Rotation: 26 days at the equator, 37 days at the poles • Surface temp 5500°c, 15.000.000°c in the core • Accounts for 99.8% of the solar system's mass • Average solar cycle: 11 years (cycle 25: 2020→2031).

EARTH FACTS: 1/109th of solar diameter • 150.000.000 km away from the sun • Around the sun at 30 km/sec.

A, K -or- Ap, Kp -or- A Index, K Index ► PLANETARY (EARTH) GEOMAGNETIC INDEX

Effect of solar wind particles on the Earth's magnetic field (EMF) • **Kp** - horizontal component of EMF measured over 3h (updated 8 times/day) • **Ap** - EMF instability level measured over 24h (updated daily) • Correlated with Bz • A high Kp indicator associated with a low Ap indicator = sudden disturbance in the EMF.

Kp	Ap		
1	3	Quiet	G0
2	7	Unsettle, degraded	
5	48	Minor magnetic disturbance • Auroras at high latitudes (> 65°)	G1
6	80	Moderate magnetic disturbance • Aurora at latitudes ≥ 55°	G2
7	140	Strong magnetic disturbance • Fluctuating HF propagation • Aurora at lat ≥ 50°	G3
8	240	Severe magnetic disturbance • Possible HF black-out • Aurora at lat ≥ 45°	G4
9	400	Extreme magnetic disturbance • Probable HF black-out • Aurora at lat ≥ 40°	G5

Geomagnetic storm ► DISTURBANCE OF THE EARTH'S MAGNETIC FIELD

Statistics (days) during average solar cycle (11 years) : G1 = 900, G2 = 360, G3 = 130, G4 = 60, G5 = 4.

SN -or- SSN ► SMOOTHED SUNSPOT NUMBER

Act on ionization of F-layers • > 97% correlation with SFI • Daily updating ✪ *Theoretical radio band accessibility according to current SN and SFU (SFI) levels - source N0NBH.*

> 100	**High HF propagation** (*possible R3 to R5 radio blackout depending on conditions*) ✪ *SN 160↔250, SFU 200↔300 : up to ≈ 6 m* ✪ *SN 105↔160, SFU 150↔200 : up to ≈ 10 m, 6 m openings*	*1 SFU (Solar Flux Unit) = 10000 Jy (Jansky) 10^{-26}W/m²/Hz*	300 SFU (SFI)
100	**Moderate HF propagation** ✪ *SN 70↔105, SFU 120↔150 : up to ≈ 10 m* ✪ *SN 35↔70, SFU 90↔120 : up to ≈ 15 m*		↕
0	**Minor HF propagation** ✪ *SN 10↔35, SFU 70↔90 : possibly up to ≈ 20 m* ✪ *SN 0↔10, SFU 64↔70 : possibly up to ≈ 40 m*		60 SFU (SFI)

SFI -or- SF -or- F10.7 index ► SOLAR FLUX INDEX ON 10,7cm/2800 MHz

Good indication of F2 layer ionization: the higher the SFU, the higher the ionization and MUF (Max Usable Frequency) are • Correlation with : X-ray stream, 304A (≈ ≤110 SFU) and SN (>97%) • May exceed 300 SFU (june 1991 record of 55000) • Updated 3 times a day.

X-Ray -or- XRY ► X-ray stream

Influence mainly the D layer • Effect of solar flares • Updated 8 times a day • Measurement by GOES satellite • Statistic number of occurrences during an average solar cycle (11 years): M1 = 2000, M5 = 350, X1 = 175, X10 = 8, X20 = 1.

A1 → A9	$<10^{-7}$ Watt/m²	Nil to low incidence on day side	---
B1 → B9	$\geq10^{-7}$ $<10^{-6}$ Watt/m²		
C1 → C9	$\geq10^{-6}$ $<10^{-5}$ Watt/m²		
M1 → M9	$\geq10^{-5}$ $<10^{-4}$ Watt/m²	Minor to moderate absorption (black out) on day side	R1 to R2
X1 → ∞	$\geq10^{-4}$ $<10^{-3}$ Watt/m²	High to extreme absorption (black out) on day side *Possible correlation with SN -and/or- high SFI*	R3 to R5
Super X	$\geq10^{-3}$ Watt/m²		

► RADIO BLACK-OUT

Caused by X-ray stream • Statistics (average black out days) during average solar cycle (11 years): R1 = 950, R2 = 300, R3 = 140, R4 = 8, R5 <1.

Ptn Flx -or- Pf ► RADIATION LEVEL

Density of charged protons present in the solar wind • Influences mainly the E layer • 5 min averaged • Measurement by GOES satellite • Statistics in number of occurrences during an average solar cycle (11 years) : S1 = 50, S2 = 25, S3 = 10, S4 = 3, S5 <1.

S1	*MeV measured (Mega-electron-Volt)* *10 MeV = 1 PFU (Proton Flux Unit)* **As of S2, health risk at high altitude and high latitudes (source NOAA).*	*> 10 PFU*	Minor solar radiation
S2*		*> 100 PFU 10²*	Moderate solar radiation
S3*		*> 1000 PFU 10³*	High solar radiation • Degraded polar area HF propagation
S4*		*> 10000 PFU 10⁴*	Severe solar radiation • Possible polar area HF black out
S5*		*> 100000 PFU 10⁵*	Extreme solar radiation • Probable polar area HF black out

Bz -or- MAG ►INTERPLANETARY MAGNETIC FIELD

Force and direction of interplanetary magnetic field (IMF - solar magnetic field

which is dragged out from the solar corona by the solar wind flow), 50 nT to -50 nT (nano Tesla) ● Positive value: same direction as earth magnetic field (to the north) ● Negative value: as of -10nT, marked weakness of the Earth's magnetosphere in the solar wind (south trend) ● Unpredictable ● Hourly updated.

📖 *The interplanetary magnetic field (IMF) has three components: Bx, By and Bz (three-dimensional field). Bz, which represents the north-south direction of the IMF (thus perpendicular to the plane of the ecliptic), is one of the most important parameters for the auroral activity on Earth, measured by the ACE satellite. A negative Bz index indicates that the IMF is "in phase" with the Earth (because their polarities are opposite), facilitating the penetration of solar wind particles into the Earth's atmosphere. These particles are then transported to the lines of the Earth's magnetic field where they collide with oxygen and nitrogen atoms, radiate and emit light, usually in polar areas.*

304A ►ULTRA VIOLET Relative intensity of ultraviolet solar radiation over the wavelength of 304 angströms (30,4 nm) ● Responsible for ≈ half of the F-layer ionization (the other half is due to the protons and electrons of the solar wind, as well as the X-stream) ● Partial correlation with SFI (≈ ≤ 110 SFU) ● Average solar minimum value ≈ 134 ● Average value at the solar maximum ≈ 200 or more ● « @SEM » indicates a measurement of the SOHO satellite ● « @EVE » indicates a measurement of the SDO satellite ● Hourly update.

📖 *Approximately 5% of solar electromagnetic energy is emitted as UV radiation, classified according to it's wavelength: UV-A (400-315 nm), UV-B (315-280 nm) and UV-C (280-100 nm). The above measurement (304A or 30.4 nm) is classified as XUV (Extreme UV Radiation). NOTE: the EVE instrument on board SDO is newer (2010) and more sensitive to changes in intensity than the SOHO SEM instrument (1995). Moreover, these satellites do not have the same position in relation to the sun.*

Ef -or- Elc Flx ►ELECTRON FLUX Density of charged electrons present in the solar wind ● Influences mainly the E layer ● The higher the value (given in number of particles/ cm2.s.sr), the more the ionosphere is influenced ● Sensored by GOES satellite ● Averaged over 5 min.

SW ►SOLAR WIND In km/sec ● Varies in speed and temperature depending on solar activity ● Average speed: ≈ 450 km/sec ● Influences the ionosphere in proportion to its velocity ● Measured by satellite ● Hourly update.

📖 *The solar wind is a hypersonic flow of low-density burning plasma, consisting mainly of ions, protons, electrons and helium nuclei. These charged particles are ejected from the upper atmosphere of the sun. The flow varies in speed and temperature over time and with solar activity.*
The satellite measurement provides a delay of 15 to 60 minutes, depending on the solar wind speed, before the earth collision.

Aur Lat ►AURORA LATITUDE Lowest onset latitude calculated by the Ovation model ● Value in degrees of latitude (°) : from 67,5 to <45 ● Hourly update.

📖 *Some sites provide a measurement in GW (Gigawatt) of the Earth's upper atmosphere, the amount of electrical energy transferred by the solar particles necessary for the appearance of the aurora. Probability calculation obtained via the Ovation model (with satellite measurements) ranges from 20 GW (very low) to >100 GW (very high). Updated every 5 min.*

GeoMag Field ►GEOMAGNETIC FIELD Simplified indication based on the "Kp" index that indicates the state of the Earth's magnetic field ● The highest indications may be the cause of a HF blackout and/or aurora (see Kp) ● 3 hours updating.

Sig Noise Lvl ►SIGNAL NOISE LEVEL Calculated value ● Indicates the value in units of "S meter" of the noise level generated by the interaction of the solar wind with the terrestrial geomagnetic activity ● NoRpt means « *No report* » ● Updated every 30 min.

MUF ►MAXIMUM USABLE FREQUENCY 0 to 100 MHz value ● Gives the MUF from one of the 11 measurement sites in the world (the site from which the measurement comes is usually indicated) ● NoRpt means « *No report* ».

📖 *The MUF does not guarantee success in HF communications. A rule of thumb is to use a coefficient of 80 to 90% (or less) of the MUF. Moreover, the MUF of one site is not representative for the whole world.*

CME ►CORONAL MASS EJECTION Gives a forecast of the UTC date and time of the Earth impact of a solar flare ● Graduated color according to severity : **green**→**yellow**→**red** ● Updated by NOAA/SWPC when a CME is detected.

📖 *CMEs are plasma bubbles produced in the solar corona, often linked to a solar flare. These huge clouds (up to several tens of solar rays), made up of hundreds of millions of tons of electrons and protons, superimpose themselves on the solar wind, travel through space (100 to 2500 km/sec) and, if they cross the earth, disrupt the Earth's magnetosphere. In addition to the appearance in the sky of aurora borealis or southern lights, these phenomena can cause power failures, degrade or interrupt radio transmissions, damage or destroy satellites, cause failures on board aircrafts and/or subjects persons on board to excess radiation, etc.*

►PROTON DENSITY Measured in number of protons per centimetre³ (p/cm³) in solar wind: <10 = weak, 10 to 20 = sparse, >20 = dense to very dense ● Correlated to *Ptn flux (-or- Pf)* and *SW* ● Measurement done by satellite ● Updated every 10 to 30 min.

📖 *Protons are also galactic (extra-solar) and account for about 90% of the total particle flow. These protons often have a higher energy and a much more uniform and stable intensity than those from the Sun (usually associated with CMEs).*

►SUN SPOTS 8 classes of sunspots according to their lifetime, evolution, complexity, structure, and polarity.

Four main spot types:		
- Class -	- Description -	- Influence/impact -
📖 *The number of sunspots is counted daily, generating the "Wolf International Relative Number" which allows us/one to evaluate the activity of the sun in addition to the measurement*		
α - Alpha	Inorganic unipolar magnetic field.	Low threat
β - Beta	Bipolar magnetic field with simple polarity division.	C class X stream, possibly M.
γ - Gamma	A complex region in which negative and positive polarities are irregularly distributed so that they cannot be classified as bipolar regions.	- - -
δ - Delta	Strong bipolar field between spots.	Can be very active - produces the most intense solar flares. High potential for class M to X flows.

💻 A few sites (among dozens of others) where to get all these solar parameters :
solarham.net ● f6gci.com ● dk0wcy.de ● sunspotwatch.com ● hamqsl.com