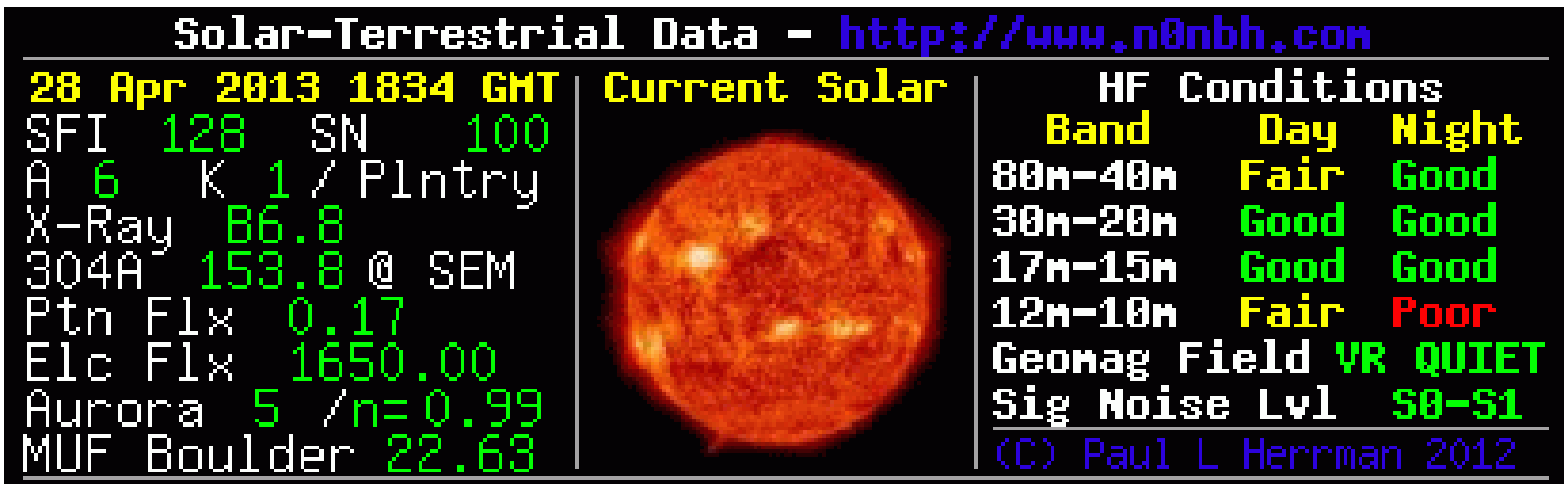
HF Propagation is mainly via Sky Wave (Skip)
Signals are refracted or reflected by Earth's Ionosphere and redirected back to earth at some distance from the transmitter.
The Ionosphere is made up of charged particles of atmospheric gases, where the degree of ionization Is determined mainly by Solar conditions.



The Ionosphere is made up of several layers at varying heights above the ground:

The lowest level is the D Layer (37 to 56 miles), which does not contribute to propagation, but actually works against world wide reception by absorbing most of the energy in the transmitted wave.
The dominant gases in the D layer are Nitric Oxide and Hydrogen, which is forced to emit ultra-violet and infra red emissions during the daytime hours. Ionization is mainly by hard X rays
These gases cannot hold ionization very long, hence, the D layer disappears rapidly after local sunset.

The E layer (56 to 75 miles) sometimes can produce sporadic HF propagation due to soft X ray emission and ultra-violet stimulation of Molecular oxygen (O_2). Sporadic E propagation is still not well understood and still is being investigated by planetary science.

The F1 and F2 layers (75 to 320 miles) are the layers that most contribute to HF propagation. Dominant gases are Hydrogen and Helium, with trace components of Neon, Argon, Xenon, and Krypton.
At night, the two layers merge and form a single F layer.
Ionization is mostly via solar UV emission.

Solar output determines the ionization of the Ionosphere by injection of charged particles during times of enhanced solar activity.

Ionization can vary widely, and has been shown to periodically change in relation to the 11 year Sunspot cycle.

The sun is a controlled fusion reactor where large quantities of solar hydrogen are fused to create heavier elements (mostly Helium), by super conduction due to compression by solar gravity.

This process has been in equilibrium for about 4 billion years, and the sun’s total output has been fairly constant since then.

Most of the sun’s output is heat energy in the form of yellow light, however, during sunspot maximum, the sun’s magnetic field undergoes changes that produce enhanced output at radio frequencies, and UV, which can influence conditions throughout the solar system.

During sunspot maximum, electron and proton flux numbers from enhanced solar activity react with atmospheric gases and increase the local electron/proton density, which changes the conduction, index of reflection, and index of refraction of the medium.

When the electron density is sufficient, the path of a traveling wave of RF energy can change in the same manner as a light beam traversing two mediums of different indices.

Different RF frequencies are affected in different ways, where higher frequencies require higher densities to undergo sufficient refraction to be returned to the earth's surface.

Once the ionization threshold is reached, ionosphere losses are reduced and strong signals can be re-directed into the skip distance.

Maximum path length depends on wave angle, and can approach 2500 miles for waves launched near the horizon.

Multi-hop skip is possible, where the wave may reflect off the surface of the earth, re-direct back into the ionosphere, and again be refracted, several times, as required.

World-wide skip is possible during ideal conditions, provided that sufficient electron density exists at the points where the wave enters the ionizing regions.

However, there are events on the sun that sometimes hinder radio wave propagation.

A very disturbed sun sometimes disrupts earth’s magnetic field, and can “pull” electrons out of the ionosphere and re-direct these electrons to the earth’s magnetic poles.

Also, these effects can cause high density clouds of charges to burrow into the D layer, causing absorption and greatly attenuating an RF signal.

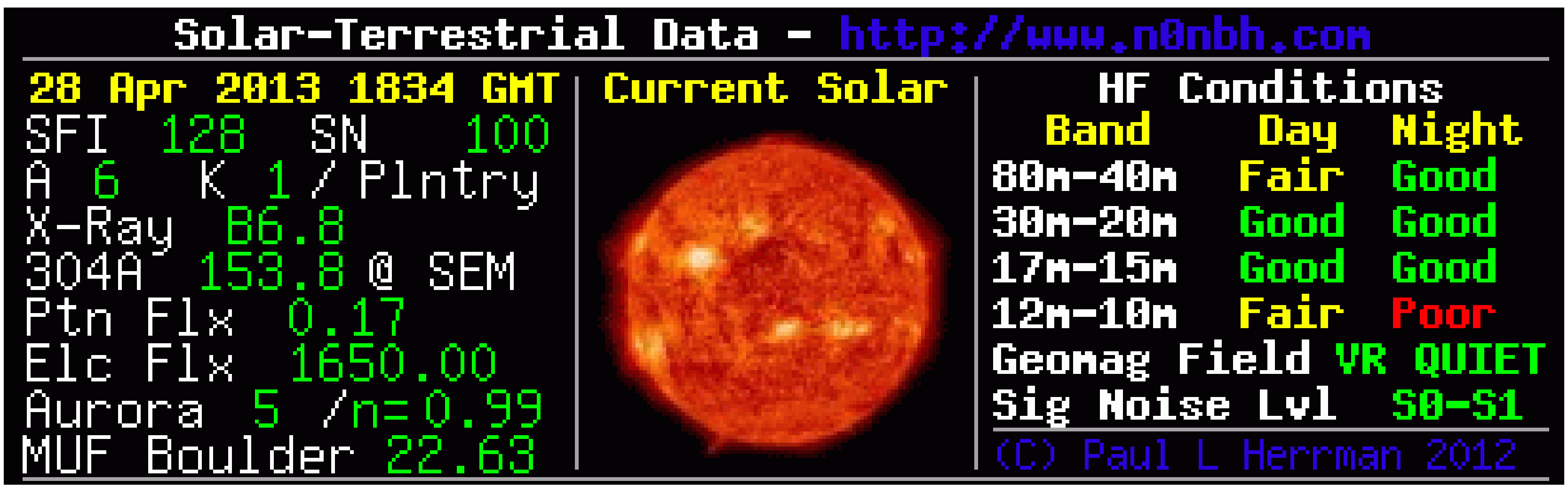
Solar flares, Coronal mass ejections, and solar noise storms are some examples of enhanced solar activity that disrupts communications.

Propagation forecasting:

Earth's magnetic conditions and ionosphere are monitored 24 hours a day by worldwide tracking stations.

Measurements are indexed and averaged to provide a propagation forecast to aid in determining signal conditions along propagating paths.

These indices are only a guide, and are not 100% accurate, but they can be used to plot trends to determine signal strength conditions along a path.



N0NBH, and others have set up a network to collect magnetosphere data as an aid in the determination of ionospheric conditions around the globe.

Data is collected by several countries (in the US in Boulder, Co.), averaged and updated several times a day.

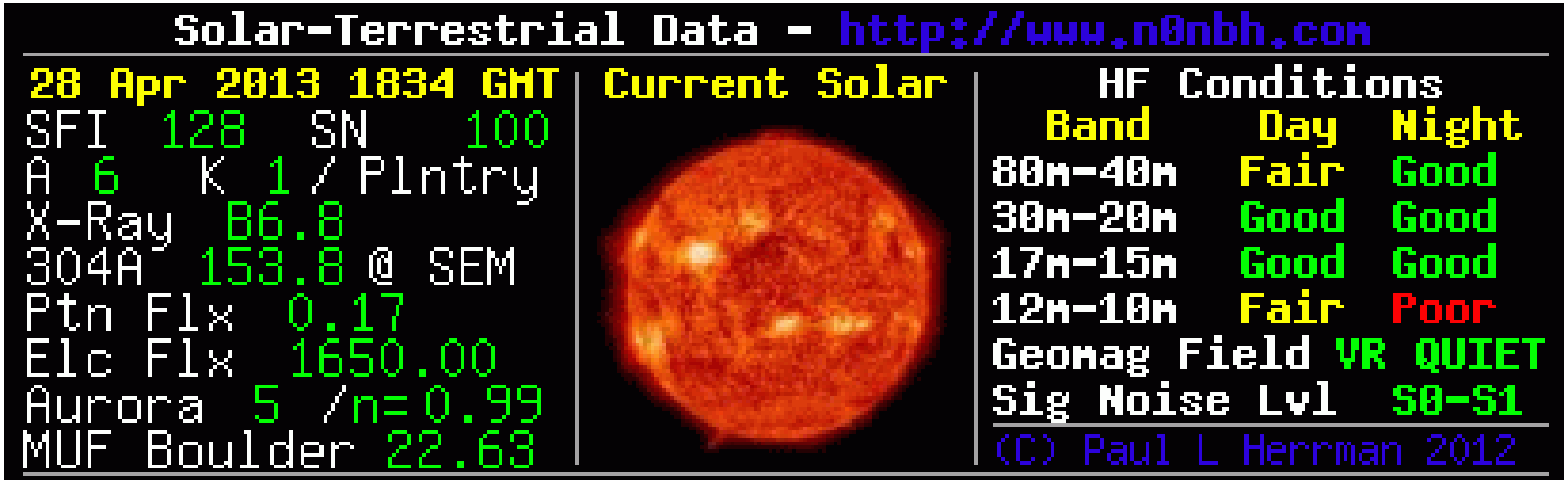
Abnormal events are measured and recorded, bulletins are sent to technical services to warn of solar hazards or disruptive conditions to communications (Magnetic storms, aurora, HF blackouts, etc)

Coronal Mass Ejections (CME's) are particular hazards since radioactive heavy particles sometimes are directed at earth which can trigger a magnetic field disturbance, and also be a risk for a biohazard condition for humans in space or flying at high altitude.

A CME could result from a high intensity X-Ray flare triggered by an unstable sunspot grouping on the sun.

Also, a large solar flare could disrupt earth's magnetic field and produce a Sudden Ionospheric Disturbance (SID)

These would be an examples of enhanced solar activity having a negative effect on the earth.



Terminology:

Solar Flux Index (SFI) is a measure of RF emissions from the Sun at a frequency of 2800 Mhz. Unit of SFI is 10^4 Janskys, in honor of Karl Jansky, the father of modern radio astronomy.

One Jansky = 10^{-26} W / m^2 / Hz

It has been determined experimentally that SFI correlates closely with Sunspot Number, and is related to the amount of Ultra Violet energy in solar emissions

Sunspot Number (SN) the number of active sunspot groups on the entire disc of the sun.

K Index measures earth's geomagnetic activity. Data is taken at several locations on the globe, then averaged to form the Planetary K index (Kp)

A index is a 24 hour log average of the K index, Ap is the 24 hour average of the Kp index. A values range to 400, with >30 = storm

X Ray Index is a measurement of solar X ray emissions. The following ratings are used: A B C M and X, with each letter further broken down from 1 to 10. A is the lowest, X is the highest, which would correspond to an X-Ray emission solar flare.

304A is the 304 Angstrom UV emission from the sun, which is responsible for the ionization of Helium in ½ of the F2 layer.

Proton Index (PTN Number) is the amount of proton emission from the sun as a heavy particle

Electron Flux (ELC Flux) is the amount of free electrons emitted by the sun to ionize the upper F layer.

Aurora Activity is the probability of solar emissions generating a visible aurora for high latitude locations. The (n) number is the estimated confidence in actual aurora power estimates, >(2) n numbers could mean low accuracy estimates

Grey Line is an imaginary line linking opposite sides of the earth that are simultaneously either at local sunrise or sunset.

Maximum Useable Frequency (MUF) is the highest frequency that will be refracted to earth in a given time period.

Interpreting the data:
Propagation data is similar to the data supplied to the US Weather Bureau. There are many variables and a 100% Propagation Forecast is not possible:

Some guidelines:

Solar Flux Index (SFI):

- < 70 is poor
- 80 – 90 is Low
- 90 – 100 Average
- 100 – 150 Good
- > 150 is excellent

The SFI has little effect on 160 – 30 meter propagation

The Sunspot Number correlates with Solar flux and may have Values from 0 to > 250, but > 200 is very rare.
Sunspots only affect propagation when they face the earth
SN may be interpreted as follows:

- < 50 Extremely Poor
- 50 -75 Poor to below average
- 75 – 100 Average to Good
- 100 – 150 Very good
- > 150 Excellent

K Index:

A falling value in the K Index usually indicates improving conditions:
K Index mostly affects propagation from 20 m to 10 m
The values of the K index range from 0 to 9

- 0 -1 are best from 20m to 10 m conditions
- 2 - 3 Good conditions
- 4 - 5 Average conditions
- 5 - 9 are poor conditions

The Kp Index is usually used to determine conditions on the lower frequency bands, 30 m to 160 m:

- 0 -1 is best
- 2 - 4 good
- 5 - 9 generally poor

X Ray Index usually is an indication of absorption in the D Layer

- A low absorption loss
- B moderate loss
- C high levels of attenuation
- M very high attenuation
- X very disturbed conditions with almost complete absorption

304 A (Ultra violet excitation) is a measure of the amount of UV is being received from the Sun, range is 0 to ∞

UV is responsible for at least ½ of the electron density in the F layer

In general, the higher the number, the greater the ionization.

Proton Number (PTN) ranges from 0 to ∞

It affects mainly the E layer for sporadic E propagation, but very high values of PTN could black out HF for higher latitudes

Electron Flux (ELC Flux) also ranges from 0 to ∞

Also mainly affects the E layer, also high values of ELC could cause HF black out for the higher latitudes.

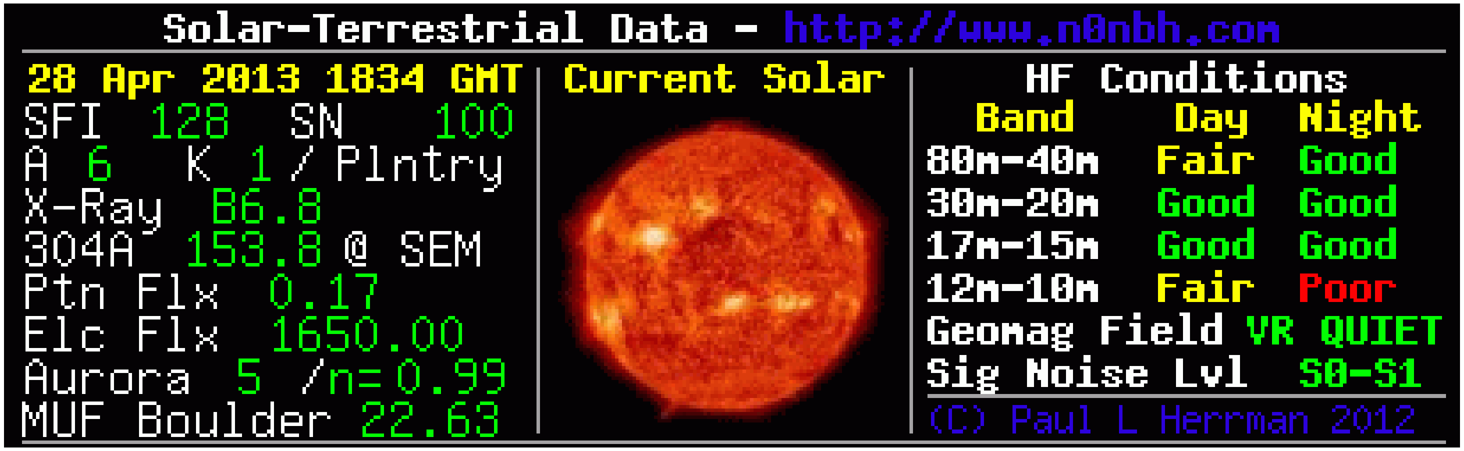
N (Aurora Activity) ranges from 0 to 10, < 2 is a low probability of aurora.

High aurora values could indicate high HF noise levels masking weak signals

Also, aurora activity could make over the pole propagation difficult due to the fluttery nature of the disturbed ionosphere.

Grey Line shows stations that are in simultaneous Sunset / Sunrise

Since the D layer dissipates shortly after sunset, and the F layer starts to enhance just after sunrise, the Grey Line shows one of the best times for station to station communication

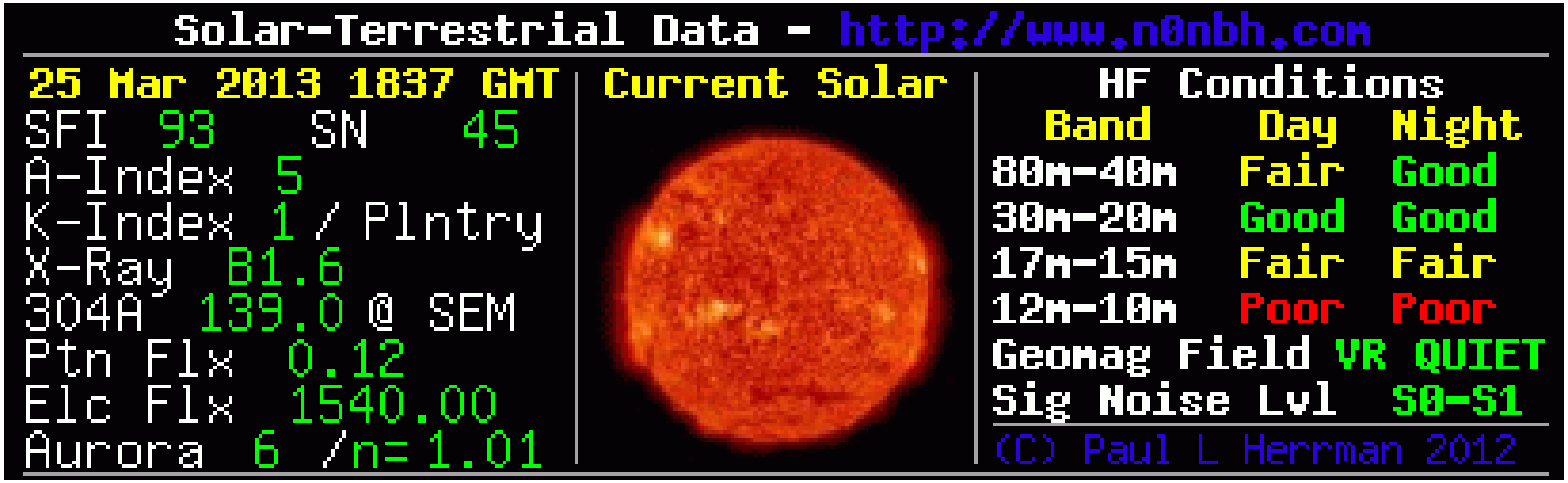


Example above for April 28th of this year:

SFI = 128	Sunspot Number 100	304A = 153.8
A index = 6	K index = 1 Planetary	
MUF 22.63	Aurora 5 / n = 0.99	

The above chart could be interpreted to indicate:

- An above average value of solar flux (good conditions for 20 m through 10 m ?)
- A moderate number of sunspots (but no indication of how many spots are facing the earth)
- A index of 6 could indicate that a magnetic storm has occurred, and is abating, but may have affected the higher bands?
- Kp index of 1 seems to indicate improving conditions, but with the A value of 6, this may indicate only Fair for the high bands
- MUF of 22.63 would indicate that 15 meters is the highest useable band for sky wave propagation on this day.
- Moderate aurora activity , expectation for low to moderate HF noise levels
- Geomagnetic Field is quiet, indicating stable signals



Solar / Terrestrial data for Mar 25th of this year

SFI = 93 SN = 45

A Index = 5 K Index =1 / Planetary

X Ray B1.6 304A = 139

Proton Flux = 0.12 Electron Flux = 1540

Aurora 6 /n =1.01

No MUF data available

Final comments:

It is important to evaluate all the data variables before rendering a judgment of propagation conditions.

Also, the forecast of propagation is not an exact science, because of the complexity of the data sets.

It is not unusual to have little propagation when data seems to indicate otherwise (and vice-versa)

This is especially true on the higher bands when sporadic E can occur at any time; also sporadic E can mix with F layer effects which could lead to some unusual signal conditions.

Finally, a band which seems “dead” might be so because no one is actively transmitting a signal. Do not hesitate to call CQ; a dead band may suddenly come alive as soon as one station initiates a call.