Some Definitions and Comments

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Over the years I've written about many topics. And I've used a lot of terms that are tied to the ionospheric and to solar issues. So I made a long list of these terms, and definitions and comments follow for ten of them. I would hope that many of them will be a refresher, and not new material. Look for more definitions and comments in future monthly features.

Smoothed Solar Index

We measure the daily sunspot number and the daily 10.7 cm solar flux. Averaging the daily values over a month's time frame gives us the monthly mean sunspot number and the monthly mean 10.7 cm solar flux.

If we take thirteen months of monthly mean values centered on the desired month (but only using one half of the value of the end months in order to have twelve full months), we can calculate an average and it is called the smoothed sunspot number and the smoothed 10.7 cm solar flux.

We use a smoothed solar index for two reasons. First, we can better see what a solar cycle is doing because the spiky nature of the daily values and even of the monthly mean values has been "smoothed" out. Second, the best correlation between what the Sun is doing and what the ionosphere is doing is through the use of a smoothed solar index, and results in predictions outputting monthly median ionospheric parameters.

Solar cycles are officially measured using a smoothed solar index. Historic data is usually in the form of the smoothed sunspot number due to the amount of old data available. The measurement of 10.7 cm solar flux didn't start until 1947, whereas sunspots go back several centuries.

FOT

This acronym comes from the French language, and stands for "optimum traffic frequency". Our propagation predictions were developed to input a smoothed solar index and output a monthly median MUF (maximum useable frequency). The word "median" implies a 50% probability. Thus if the MUF is predicted to be, say, 23 MHz, then on half the days of the month (15 days) 23 MHz could be supported.

The FOT is just another point on the probability curve, and it implies a 90% probability. With a MUF of 23 MHz, the FOT would be roughly 19.55 MHz. Thus on 27 days of the month (90% of 30 days), 19.55 MHz could be supported. In other words, the FOT is pretty much a sure thing for the entire month with respect to the amount of ionization. Don't forget that the other half of the requirement for a QSO is adequate signal strength, and the prediction of it is a monthly median, too..

Magneto-Ionic Theory

This simply means the theory of propagation in an ionized medium that is immersed in a magnetic field.

Because of the magnetic field, the ionosphere is bi-refractive. In other words, it has two indices of refraction. This then says two different characteristic waves propagate through the ionosphere.

Ordinary and Extraordinary Waves

The two characteristic waves that propagate through the ionosphere are the ordinary wave and the extraordinary wave.

The tips of the polarization vectors for the ordinary and extraordinary waves for all intents and purposes trace out a circle on our HF bands (80-Meters through 10-Meters) and higher. This is circular polarization, and both waves propagate pretty much similarly through the ionosphere (but the tips of the polarization vectors rotate in opposite directions).

On 160-Meters, the tips of the polarization vectors trace out a thin ellipse. Being close to the electron gyro-frequency, the extraordinary wave on 1.8 MHz is more heavily attenuated than the ordinary wave. Thus the ordinary wave is the only one considered to be useful.

Gyro-Frequency

This tells us the frequency at which a charged particle spirals helically about a magnetic field line.

The charged particle we are most interested in is the electron, and its gyro-frequency varies worldwide from about 700 KHz to 1.7 MHz. There are other gyro-frequencies –for example, the proton gyro-frequency is around 762 Hz.

The fact that our 160-Meter band is close to the electron gyro-frequency means the magnetic field will have a profound effect at these frequencies on propagation through the ionosphere. These effects are seen in the refraction process, in the absorption process and in the determination of polarization.

Neutral Atmospheric Constituent

The important atoms and molecules in the atmosphere that are involved in the formation of the ionosphere are atomic oxygen (O), molecular oxygen (O_2), molecular nitrogen (N_2) and nitric oxide (NO). These constituents, prior to ionizing radiation hitting them, are not charged, and thus are called neutral atmospheric constituents.

After the ionization process, which creates free electrons, the free electrons become negative ions while the neutral atmospheric constituents become positive ions. That's a simple view of the ionosphere, and in reality it is much more complicated – especially in the lower ionosphere.

Electron-Neutral Collision Frequency

When an electromagnetic wave passes through the ionosphere, it can set free electrons in motion. These free electrons then collide with neutral atmospheric constituents, and the electromagnetic wave loses energy. This is the basic concept of the absorption process.

The electron-neutral collision frequency is the frequency at which electrons collide with neutral atmospheric constituents. The higher the collision frequency, the higher will be the amount of absorption. The collision frequency is low in the higher ionosphere and is much greater in the lower ionosphere.

Stratwarm

This is a shortening of the term "stratospheric warming". It refers to an increase in the temperature of the stratosphere, which then can impact daytime propagation by introducing more absorption.

Butterfly Diagram

At the beginning of a solar cycle, sunspots form at the higher solar latitudes in both hemispheres. As a solar cycle progresses, sunspots form at ever decreasing solar latitudes. At solar minimum, sunspots form near the solar equator.

If you plot the latitude at which sunspots emerge over a solar cycle, you will get a diagram as in Figure 1.

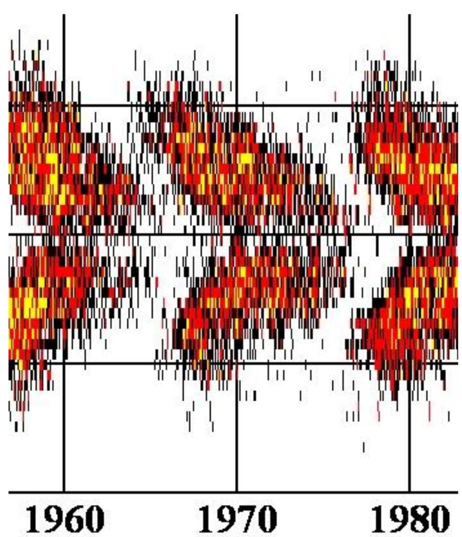

Figure 1 – Cycle 20 butterfly diagram

The full set of data in the middle is Cycle 20. The partial data on the left is Cycle 19. The partial data on the right is Cycle 21.

Note that sunspots can emerge asymmetrically in the two solar hemispheres. In Cycle 20, the northern hemisphere dominated early on (which also happened in Cycle 24).

Ducting

Many of our longer distance QSOs are via a multi-hop mode. In other words, the electromagnetic wave successively refracts from the ionosphere and reflects from the ground. As expected, the many transits through the absorbing region of the ionosphere and the many ground reflections take their toll on signal strength.

All that absorption and ground reflection loss is generally tolerable on the higher bands since absorption is inversely proportional to the square of the frequency. But on the lower bands (especially on 160-Meters), absorption and ground reflections can add up quickly to where the signal is below the noise after a relatively short distance. For example, it appears that the limit for multi-hop propagation on 160-Meters with legal limit power and quarter-wave verticals is around 10,000 km.

So how do we make QSOs longer than 10,000 km on 160-Meters? We likely do this via ducting. There's a valley in the electron density above the E region peak in the nighttime ionosphere, and it provides natural upper (F region) and lower (E region peak) boundaries in which 160-Meter RF can be refract up and down without making transits through the absorbing region and without incurring ground reflections. Figure 2 shows a typical ducting mode on 160-Meters.

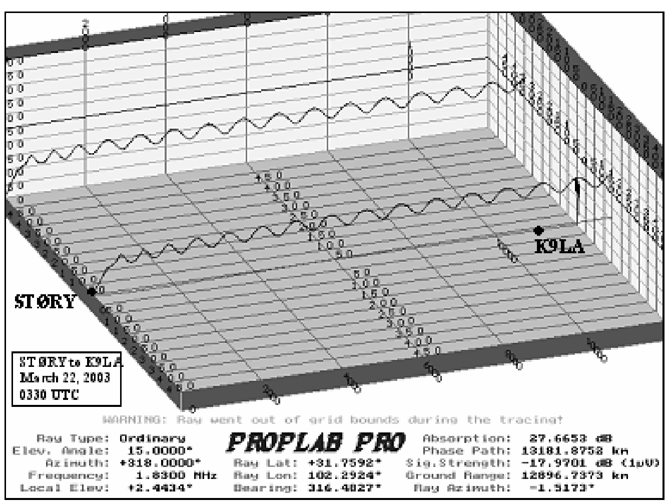

Figure 2 – Ducting on 160-Meters

The example shown is from the STØRY DXpedition to my QTH in March 2003. Although the RF is shown to fly over my QTH, it can come out of the duct due to ionospheric irregularities.