Where Was 6-Meter F_2 Propagation In Late October 2014?
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Over the years, 6-Meter DXers have learned to be on the lookout for 6-Meter propagation via the F_2 region when the 10.7 cm solar flux goes above 200. In October 2014, the 10.7 cm solar flux rose above 200 during six days: October 20 and October 22-26. October 21 wasn't far behind, but just missed the 200 mark. Figure 1 plots the 10.7 cm solar flux from August 1, 2014 through November 30, 2014.

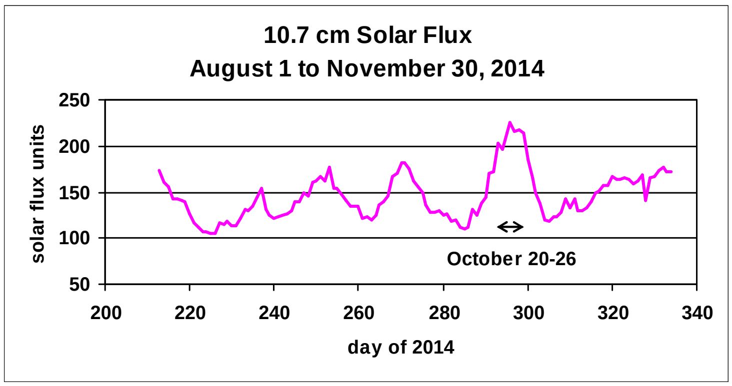

Figure 1 – Solar Flux

Why wasn't 6m F_2 available during this period in late October of increased 10.7 cm solar flux? The purpose of this article is to discuss the four issues that impact whether the F_2 region of the ionosphere can support 6-Meter propagation. These four issues are 1) the correlation of 10.7 cm solar flux to the true ionizing radiation, 2) the time of the year, 3) other parameters that affect the amount of ionization besides solar radiation and 4) our understanding of the ionosphere-Sun correlation.

Correlation of 10.7 cm Solar Flux to Ionizing Radiation

We should be very aware that radiation from the Sun at a wavelength of 10.7 cm is a proxy for the true ionizing radiation, just like sunspots are a proxy for the true ionizing radiation. The true ionizing radiation for the F_2 region is at extremely shorter wavelengths – from around 10 to 100 nm (which is EUV – extreme ultraviolet). Through Planck's Law, the true ionizing radiation is much more energetic than 10.7 cm solar flux, allowing the true ionizing radiation to strip an electron from a neutral atmospheric constituent. Energy at a wavelength of 10.7 cm is not high enough, by a factor of one million or so, to ionize anything.

Figure 2 shows the correlation between 10.7 cm solar flux and EUV on a daily basis for November 2001 (I used this period as I already had the data – it is very representative of other periods). EUV radiation from 26-34 nm is plotted, and this range produces approximately half of the electrons in the F_2 region.

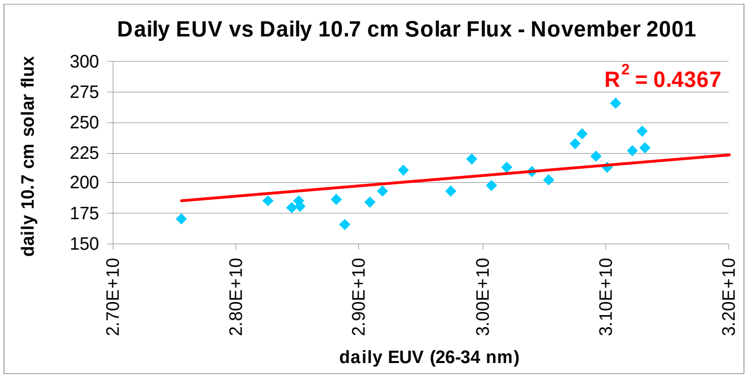

Figure 2 – Correlation of Solar Flux and 26-34 nm EUV

There certainly appears to be a correlation – as expected, the more the 10.7 cm solar flux, the more the 26-34 nm EUV. But this correlation is not extremely strong as seen in the R^2 correlation factor. In other words, for a given 10.7 cm solar flux, there is not a unique EUV. For a given 10.7 cm solar flux, the EUV could vary quite a bit.

Time of the Year

If ionizing radiation from the Sun was constant throughout the year, the highest monthly median MUF (maximum useable frequency) for a 3000 km hop at the best time of the day on a path in the northern hemisphere (for example, from W3 to Europe) would vary considerably by month. Figure 3 plots this data (from VOACAP) at a constant 10.7 cm solar flux of 130.

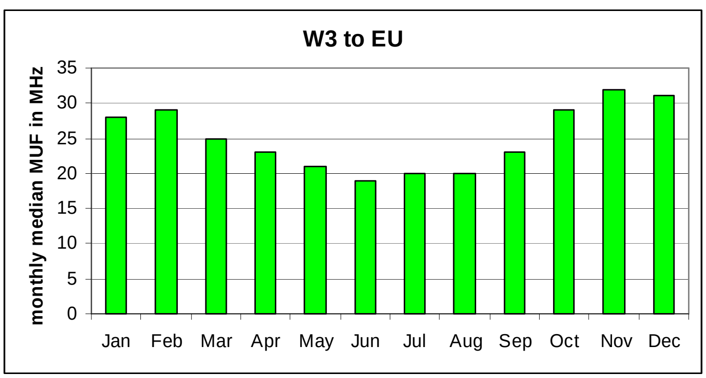

Figure 3 – MUF versus Month

The important observation here is that in the northern hemisphere, where most of the Amateur Radio population lives, the F_2 region of the ionosphere is best in the fall and winter months. This is due to the change in composition of the atmosphere throughout the year. During the fall and winter months, the ratio of atomic oxygen (important for electron production) to molecular oxygen and to molecular nitrogen (both important for electron loss) is highest.

Thus if 6-Meters is going to open via F_2 between Europe, North America and Japan, it will likely occur in the fall and winter months if the Sun's EUV radiation is high enough.

Parameters Other Than Solar Radiation

The ionosphere varies significantly on a day-to-day basis – even if the solar radiation is constant (remember Figure 3 was in terms of the monthly median MUF). The problem is that solar radiation is not the only parameter that determines the amount of ionization at a given location at a given time. Yes, solar radiation instigates the ionization process, but geomagnetic field activity and meteorological events in the lower atmosphere modify the amount of ionization. Figure 4 shows this quite dramatically for the F_2 region MUF for a 3000 km hop for the month of August 2009 at 1700 UTC over Wallops Island.

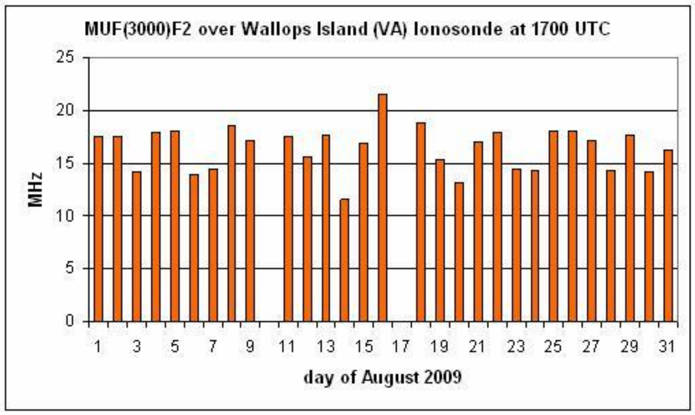

Figure 4 – F_2 MUF for August 2009

During the entire month of August 2009 (solar minimum between Cycle 23 and 24), the sunspot number was zero and the 10.7 cm solar flux was constant at around 67. But the F_2 region of the ionosphere was still varying on a day-to-day basis by a factor of 2:1 in spite of solar radiation being constant.

The Ionosphere-Sun Correlation

One of the first truths to emerge in trying to understand the relationship between the ionosphere and the Sun was that what the ionosphere was doing on a given day had little to do with what the Sun was doing on the same day.

In order to make sense of this (which includes data like in Figure 4), the model of the ionosphere for propagation prediction purposes ended up being based on the very high correlation between a smoothed solar index and monthly median ionospheric parameters (with median implying 50% probability). In other words, our predictions are statistical in nature over a month's time frame. Our propagation predictions were never meant to be used on a daily basis (due to the aforementioned poor correlation – but see Footnote 1).

Thus our understanding of the ionosphere is based on a longer-term view of a solar index. This suggests that looking at solar flux (or even sunspot numbers) over only several days doesn't really tell us what the ionosphere is doing. Table 1 summarizes monthly median

MUFs for a 3000 km hop over the Boulder ionosonde at 1700 UTC versus the smoothed 10.7 cm solar flux for various November months and for October 2014.

Month and year	Smoothed 10.7 cm solar flux	Monthly mean 10.7 cm solar flux	Monthly median MUF in MHz at 1700 UTC	MUF on the best day	Was there consistent 6m F2 propagation?
Nov 2008	68	69	19.6	24.9	no
Nov 2013	135	148	32.1	37.6	no
Oct 2014	138 (estimate)	153	32.0	37.9	no
Nov 2001	194	213	42.15	47.3	yes
Nov 1989	200	235	41.5	45.9	yes

Table 1 – MUF vs Solar Flux

Note that the monthly mean 10.7 cm solar flux is included. It turns out that the correlation between the median MUF and the monthly mean 10.7 cm solar flux is a bit lower than using a smoothed 10.7 cm solar flux, but it still gives a good indication of what the ionosphere is doing. To reiterate, this is a monthly view of the ionosphere.

Also note that November 2001 had a higher monthly median MUF than November 1989 in spite of the fact that November 1989 had a higher smoothed 10.7 cm solar flux and a higher monthly mean 10.7 cm solar flux. What we're likely seeing here is mostly the effect of a non-perfect correlation between solar flux and EUV (issue #1), with some contribution by other parameters affecting ionization (issue #3).

Also included is a column with the highest MUF during the month. What this indicates is the high limit for the distribution of the daily MUF about the monthly median MUF. The highest daily MUF is from 10 to 25% higher than the monthly median.

Summary

To have propagation on 6-Meters via the F_2 region, four items must work together:

1. the amount of 10.7 cm solar flux must correspond to a high EUV value
2. the high EUV must occur in a fall or winter month
3. geomagnetic field activity and meteorological events in the lower atmosphere must maximize ionization
4. a high amount of EUV must impinge on the atmosphere for more than just several days – so look at the monthly mean 10.7 cm solar flux for a better assessment

Those four items hint at why 6-Meter F_2 propagation is a low probability. All four of these items did not line up around the end of October 2014. It's also obvious from Table 1 that hop lengths greater than 3000 km (not unusual on 50 MHz) are needed to further elevate the MUF (the 4000 km MUF is about 10% higher than the 3000 km MUF).

Footnote 1: Nowadays we have a good idea of what the ionosphere is doing right now through the use of an effective sunspot number (SSNe). Visit **http://spawx.nwra.com/spawx/ssne24.html** for more details.