Why We Need Smoothed Solar Indices – Part 2
Carl Luetzelschwab K9LA – February 2014

Last month's column discussed the first reason why we need a smoothed solar index – to best characterize a solar cycle. This month's column addresses the second reason why we need a smoothed solar index – to achieve the best accuracy with propagation predictions.

To analyze this second reason, we'll focus on the CQ World Wide SSB contest at the end of October last year (by the way, the higher bands were excellent). We'll use ionosonde data for the one month period centered on October 26 and 27 (the weekend of the contest). We'll use the Boulder (Colorado) ionosonde from October 12 through November 10 at 1900 UTC as it had tabular data for both October and November 2013. Figure 1 presents this data, along with the 10.7 cm solar flux for the same period.

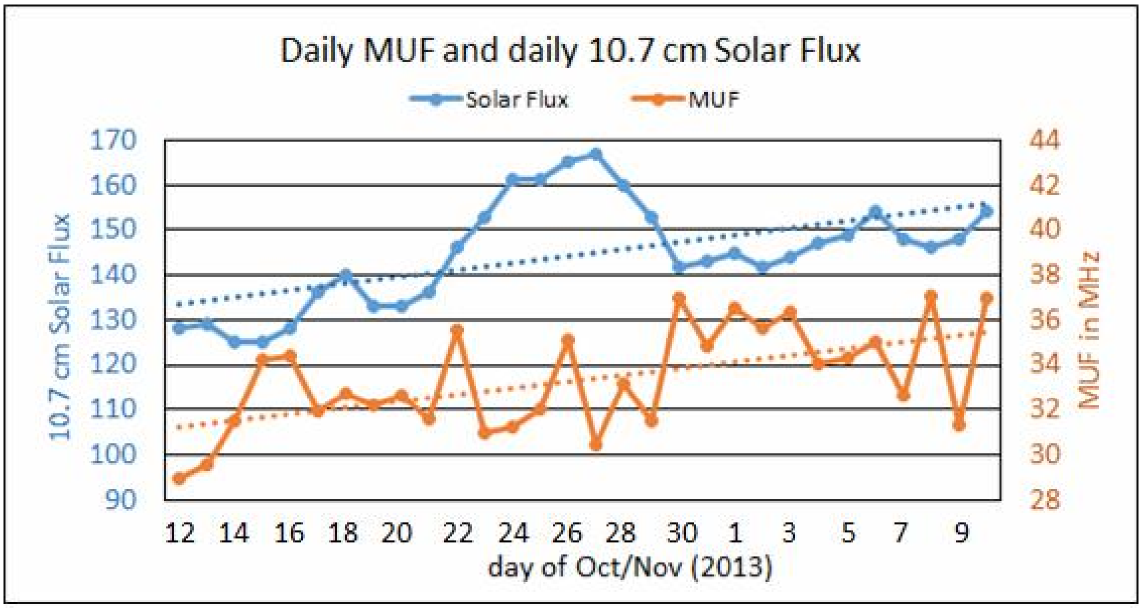

Figure 1 – Solar Flux and Boulder Data

There is a lot of information in Figure 1.

1. The solid orange curve is the daily MUF (maximum useable frequency) over the Boulder ionosonde assuming it's the midpoint of a 3000 km F2 region hop. Note that it varied from a low of 29 MHz on October 12 to a high of 37 MHz on November 8. There were many ups and down throughout the one-month period.

2. The dotted orange curve is a linear trend line for the MUF, and indicates that the MUF had an overall increasing trend during the period.

3. The solid blue curve is the daily 10.7 cm solar flux. It started at a value of 128, dipped to a low of 125 on October 14 and 15, peaked at a high of 167 on October 27, decreased to around 140 and then increased at the end of the period.

4. The dotted blue curve is a linear trend line for the 10.7 cm solar flux, and indicates that the 10.7 cm solar flux also had an overall increasing trend during the period.

We can draw two important conclusions from this data. The first conclusion is that the MUF and solar flux do not appear to be very well correlated on a daily basis. This is best seen from October 21 to October 30, when the solar flux reached its highest values but the MUF was up and down significantly. In fact, the highest solar flux on October 27 resulted in one of the lowest MUFs during the entire period.

A better way to see the correlation between the daily solar flux and the daily MUF is through a scatter plot. Each daily solar flux value and daily MUF value is plotted for each day, and then a trend line is added to determine the correlation factor R-squared. An R-squared value of 1.00 means perfect correlation – all the data points would be on the trend line. An R-squared of 0.00 means no correlation – all the data points would be scattered widely about the trend line. Figure 2 is the scatter plot for the data in Figure 1.

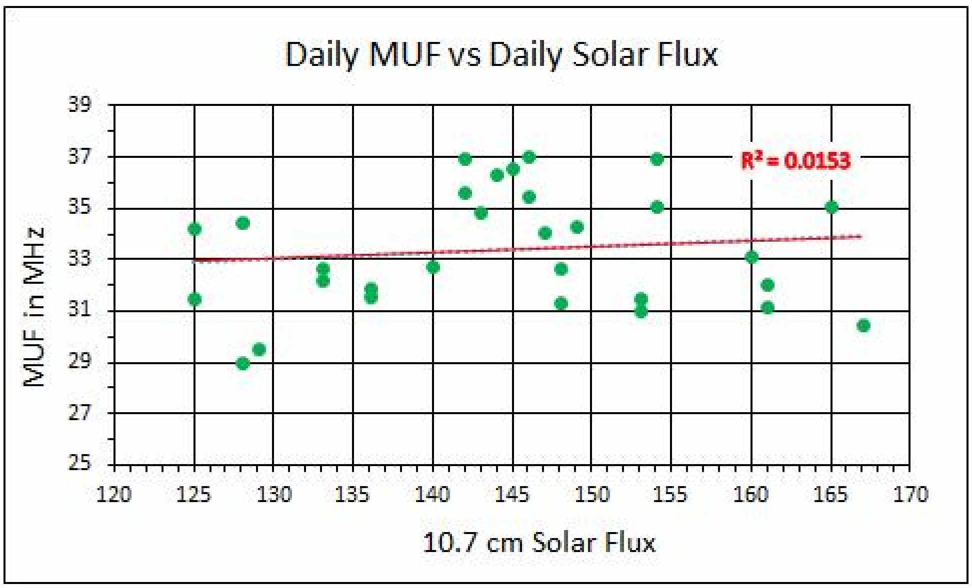

Figure 2 – Scatter Plot

As expected, the extremely low value of R-squared (highlighted in red) tells us the correlation between the daily solar flux and the daily MUF is poor. For example, for a solar flux of 128, the MUF could have been 29 MHz or 34.5 MHz. In other words, a daily solar flux value does not map to a unique daily MUF.

The second conclusion is due to the fact that the solar flux and MUF trend lines are parallel, which tells us that solar flux and MUF follow a linear relationship. But this relationship is on a long-term basis – not on a daily basis. As can be seen, the higher the solar flux, the higher the MUF. This should not be new news. The fact that this does not apply on a daily basis may be new news to you.

Why doesn't the daily MUF follow the daily solar flux? The reason is although solar radiation certainly instigates the ionization process, ultimately the ionization at any given location is also dependent on geomagnetic field activity and events in the lower atmosphere coupling up to the ionosphere. See my August 2004 column titled "The Day-to-Day Variability of the Ionosphere" for more details on this issue (it's available on my web site at http://k9la.us/ under the General link). Also included in the August 2004 column are scatter plots showing the poor correlation between the daily 10.7 cm solar flux and the daily MUF over the Millstone Hill (Massachusetts) ionosonde.

If the daily correlation is poor, how was a model of the ionosphere developed for propagation predictions purposes? When scientists discovered that the correlation was poor between daily values, they moved on to a longer-term correlation – which turned out to be between a smoothed solar index and monthly median parameters of the ionosphere. What this means is our model of the ionosphere is a monthly median model. This inherently says our propagation predictions are probabilities over a month's time frame.

To better understand the improved correlation with a smoothed solar index, let's look at some scatter plots that compare the daily correlation to the smoothed correlation. We'll do this for the Boulder ionosonde (but at a different date than the data in Figure 1) and the Canberra (Australia) ionosonde. Figure 3 shows this data.

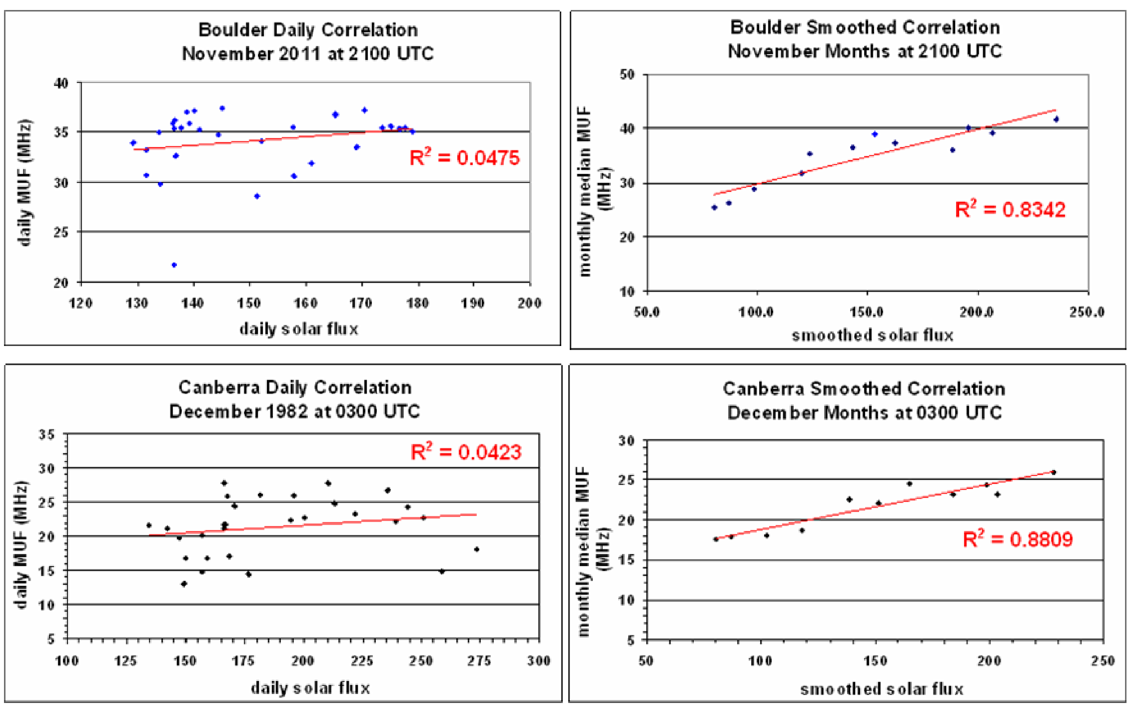

Figure 3 – Daily versus Smoothed Correlations

At both ionosondes, the daily solar flux versus daily MUF results in poor correlation. But the correlation between the smoothed solar flux and the monthly median MUF is extremely high. What this means is a smoothed solar flux value maps much better to a unique monthly median MUF. This is what is needed for accurate propagation predictions, and is the second reason why we need a smoothed solar index.

Next month’s column will review smoothed solar indices, monthly median ionospheric parameters and the interpretation of propagation predictions.