The Concept of Monthly Median Predictions

Carl Luetzelschwab K9LA – March/April 2014

My January 2014 column reviewed one reason why we use a smoothed solar index – to better characterize a solar cycle. My February 2014 column reviewed the other reason why we use a smoothed solar index – to achieve the best accuracy with propagation predictions.

So what is a smoothed solar index? It can be in terms of sunspots or 10.7 cm solar flux (or the many other solar activity measurements). The first task is to calculate the monthly mean (the same as the monthly average). Simply add all the daily values in the month and divide by the number of days in the month.

With a whole bunch of monthly means, we can calculate the smoothed value. Add the monthly means for the desired month, the five months before the desired month, the five months after the desired month, and one-half of the monthly means for the sixth month before and after the desired month. Then divide by 12 since we have twelve full months of data (remember we used one-half of the two outermost months). We now have the smoothed solar index for a desired month. It is heavily average to eliminate the short-term spikes in the daily and monthly values – hence it is "smoothed".

With the smoothed solar index described, now let's tie in the fact that our propagation predictions (for best results) take the smoothed solar index as an input, and output a monthly median ionospheric parameter.

So what does "monthly median" mean? First, the term 'median' tells us a probability is involved as median implies 50%. And the term 'monthly' says it's a probability over a month's time frame. Let's go thru an exercise to calculate the monthly median MUF (maximum useable frequency) for a 3000 km hop using real data. The data we'll use is the data plotted in Figure 1 of last month's column (the February 2014 column).

Last month's Figure 1 plot was done using columns one and two of the tabular data in Table 1. The first column is each day of the one-month period beginning October 12 and ending November 10 (of 2013 – a total of 30 days). The second column is the MUF for each day. This data comes from the Boulder ionosonde at 1900 UTC for each day.

day of 30-day period	MUF (MHz) on indicated day	MUF (MHz) ordered from lowest to highest
Oct 12	28.52	28.52
13	29.545	29.545
14	31.5	30.472
15	34.202	31.008
16	34.441	31.212
17	31.926	31.31
18	32.754	31.5
19	32.2	31.518
20	32.648	31.605
21	31.605	31.926
22	35.52	32.025
23	31.008	32.2
24	31.212	32.648
25	32.025	32.655
26	35.096	32.754
27	30.472	33.17
28	33.17	34.048
29	31.518	34.202
30	36.966	34.32
31	34.87	34.441
Nov 1	36.54	34.87
2	35.616	35.056
3	36.34	35.096
4	34.048	35.52
5	34.32	35.616
6	35.056	36.34
7	32.655	36.54
8	37.072	36.936
9	31.31	36.966
10	36.936	37.072

Table 1 – MUF Values

Since ‘median’ implies 50%, it also says half the data is above the median value and half the data is below the median value. Thus the third column is the MUF data ordered from lowest value to highest value, from which we can determine the monthly median MUF where half the data is above and half the data is below.

Since I have 30 data points, the median is between the fifteenth and sixteenth data points, which are October 26 and October 27. The monthly median MUF for a 3000 km hop centered over the Boulder ionosonde at 1900 UTC for the designated 30-day period is thus halfway between 32.754 MHz and 33.17 MHz, which is 32.962 MHz.

Now we know the measured monthly median MUF. Let’s compare it to the predicted value. We’ll use VOACAP over a 3000 km north-south path centered on Boulder with an estimated smoothed sunspot number of 70 (my best guess for the 30-day period based on what’s happening with the Sun), and at 1900 UTC. Doing that gives a monthly median prediction of 31.0 MHz.

In summary, the predicted monthly median MUF is about 6% lower than what was actually measured. It would have been nice to have the predicted value the same as the measured value. But we have to remember that the ionosphere is a very dynamic system, and a 6% difference is really pretty good. Also, in last month’s column we saw that the correlation between the smoothed solar index and monthly median ionospheric

parameters was significantly better than the correlation between a daily solar index and daily ionospheric parameters – but it was not perfect.

Earlier I mentioned that 'median' implies a probability. We now know the median, but we still need to know how the data is distributed about the median. Knowing this will allow us to determine how likely it is to have a band open. We'll use the same VOACAP data generated a couple paragraphs back.

Figure 1 tells us the probability of a band being open during this 30-day period. It comes from the MUFday values in the VOACAP output.

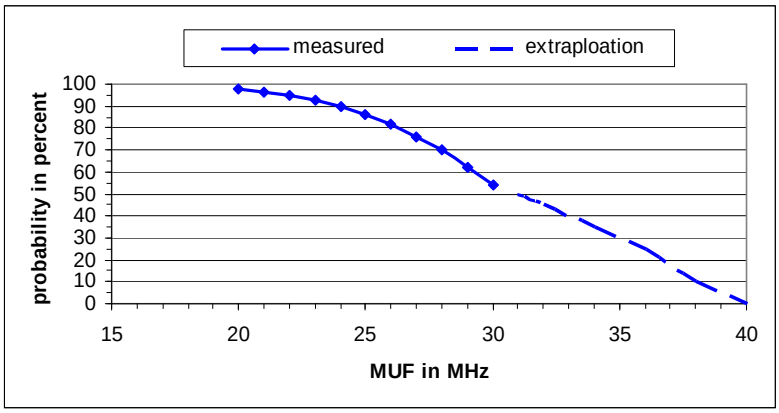

Figure 1 – Probabilities

The solid line with data points is the VOACAP data. Since VOACAP only goes up to 30 MHz, I added an extrapolated dashed line for data above 30 MHz (derived from MUF variability tables in ionospheric literature). Note that 31 MHz is at a 50 percent probability – that's what we expected since VOACAP predicted a monthly median of 31.0 MHz and 'median' implies 50%.

So what is the probability of 10m being open at 1900 UTC? Assuming 10m is 29 MHz, we see that 10m should have been open 60% of the time – in other words, on 18 days of the 30-day period (60% times 30 days). 15m should have been open on 95% of the days of the 30-day period – about 28 days. 20m should have been open every day of the 30-day period. 39 MHz should have been open on only 1 day of the 30-day period.

Unfortunately it's tough to tell which days are 'good' and which days are 'not good'. That's because the correlation between the daily MUF and daily solar index is extremely poor (as seen in Figure 2 in last month's column). This probability issue with the MUF extends to signal strength, too. Our propagation predictions report the monthly median signal strength, and it also has a distribution about the median. In other words, on each day the signal strength could be higher or lower than the monthly median signal strength.

There you have it – how to interpret our propagation predictions. Just remember that we have a statistical monthly median model of the ionosphere – not a deterministic daily model.