Propagation Predictions and Wildly Varying Sunspot Numbers

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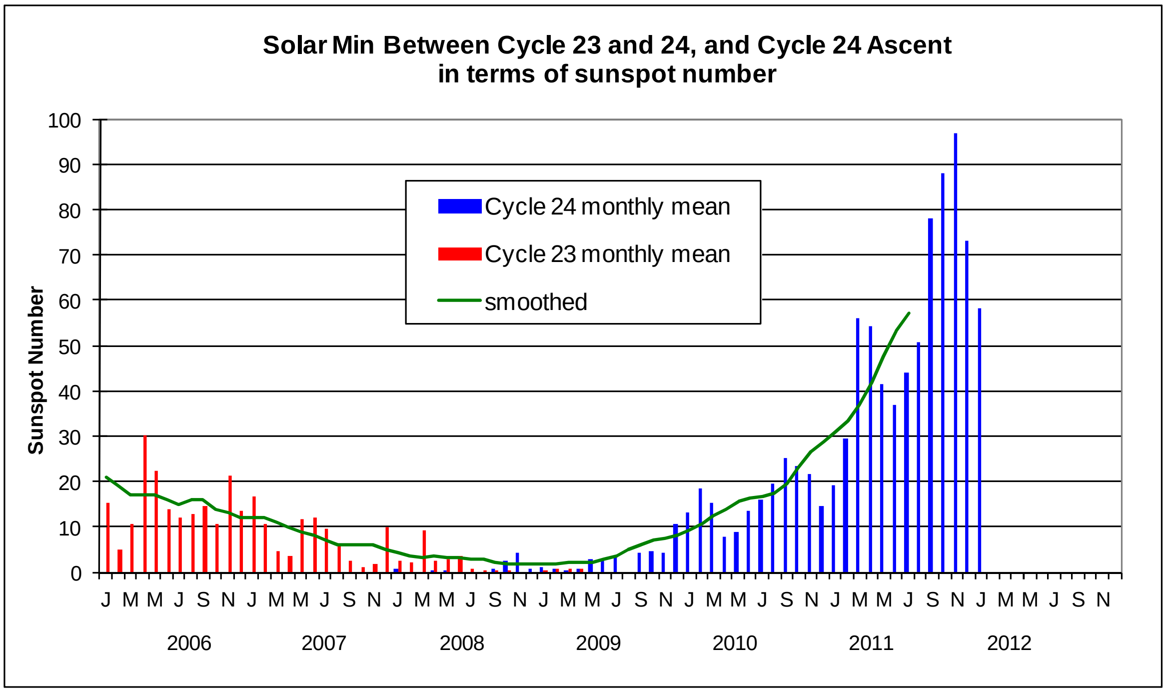
Cycle 24 began with its first sunspot region in January 2008. Solar activity remained very low until around May 2009, at which time Cycle 24 started its ascent. The following plot shows the latest data.



The plot gives the monthly mean (monthly average) sunspot numbers (the red vertical bars are for Cycle 23 and the blue vertical bars are for Cycle 24) and the smoothed sunspot numbers (green line). Note that new Cycle 24 sunspots were seen concurrently with old Cycle 23 sunspots – this is typical of a solar minimum period.

Also note that the monthly mean sunspot numbers are cyclic in nature. For several months the monthly means are higher, then for several months the monthly means are lower, then for several months the monthly means are again higher, and so forth. A good question to ask is "How do our propagation prediction programs handle these wild swings?"

They do it by employing a monthly median model of the ionosphere, in which monthly median ionospheric parameters are correlated to the smoothed sunspot number. We do not have a daily model of the ionosphere using daily sunspot number or daily 10.7 cm solar flux, or even a monthly model using monthly mean sunspot numbers, as the ionosphere varies short-term not only due to solar input (whether it be a sunspot number or a 10.7 cm solar flux value).

The ionosphere also varies short-term due to two other factors – geomagnetic field activity and events in the lower atmosphere coupling up to the ionosphere. We have a decent understanding of how geomagnetic field activity impacts the ionosphere (but it's more complicated than simply using the 3-hour K index). We're really lacking an understanding of how events in the lower atmosphere impact the ionosphere.

To get back to the earlier question, let's look at the months of December 2010 and March 2011. December 2010 had a monthly mean sunspot number of 14.4, and March 2011 had a monthly mean sunspot number of 55.8 – quite a difference. The smoothed sunspot numbers for December 2010 and March 2011 are 28.8 and 36.9, respectively. Data from the Millstone Hill ionosonde (located in MA) at 1900 UTC follow.

	MUF(3000)F2 over Millstone Hill ionosonde at 1900 UTC	
day	December 2010, monthly mean sunspot number = 14.4, smoothed sunspot number = 28.8	March 2011, monthly mean sunspot number = 55.8, smoothed sunspot number = 36.9
1	23.58	20.19
2	22.55	25.72
3	20.28	23.58
4	20.42	25.88
5	21.69	26.22
6	23.68	26.77
7	22.52	26.33
8	24.54	30.16
9	23.12	23.62
10	23.88	23.58
11	22.42	18.39
12	25.81	28.84
13	26.28	26.58
14	25.53	25.06
15	22.44	25.94
16	23.72	25.19
17	22.62	23.38
18	20.82	24.36
19	20.78	23.34
20	23.1	25.26
21	21.37	26.1
22	22.54	25.61
23	20	26.4
24	26.08	26.48
25	22.28	24.11
26	21.58	25.18
27	20.79	25.69
28	25.31	26.41
29	22.62	26.53
30	24.49	25.53
31	24.8	27.55
median	22.62	25.69
range	20.00 to 26.28 = 27.8% of median	18.39 to 30.16 = 45.8% of median

Although the difference in monthly mean sunspot numbers is very large (14.4 versus 55.8) for the two months under evaluation, the observed median MUFs (the green-highlighted second-to-last row in the table) still follow the ratio of the square root of the smoothed sunspot numbers (since critical frequencies are proportional to the square root of the ionization). Also note that the range of daily MUFs is greater in March – this makes sense since the Earth's magnetic field is more active in the equinox months (March, April, September, and October).

Another good question to ask is "how close to reality are our prediction programs compared to the observed monthly median results in the above table?" That's simple to determine – just set up a 3000 km path that has its mid point over the Millstone Hill ionosonde in December and March at the respective smoothed sunspot numbers. Doing that for a path from 33.0N/84.38W to 49.25N/55.25W gives the following results.

	observed median MUF	VOACAP median MUF	W6ELProp median MUF
December, smoothed sunspot number = 28.8, 1900 UTC	22.62 MHz	26.1 MHz	20.8 MHz
March, smoothed sunspot number = 36.9, 1900 UTC	25.69 MHz	22.1 MHz	24.2 MHz

VOACAP over-estimates the observed December data and under-estimates the observed March data. W6ELProp under-estimates both, but appears to be closer overall than VOACAP. Thus W6ELProp appears to be more accurate in the MUF arena for this one path, month, time, and solar activity level.

In summary, our propagation prediction programs handle the wild swings in daily and monthly mean sunspot numbers (and 10.7 cm solar flux) by correlating the smoothed sunspot number (or smoothed 10.7 cm solar flux) to monthly median ionospheric parameters. The downside to this is all we can say is that 10-Meters, for example, will be open on XX days of the month – but we don't know which days will be the good ones. It would be nice to say 10-Meters will be open today but not tomorrow, but we're just not there yet with our understanding of the short-term variations of the ionosphere.