Correlation Between Solar Flux and Sunspot Number

Carl Luetzelschwab K9LA

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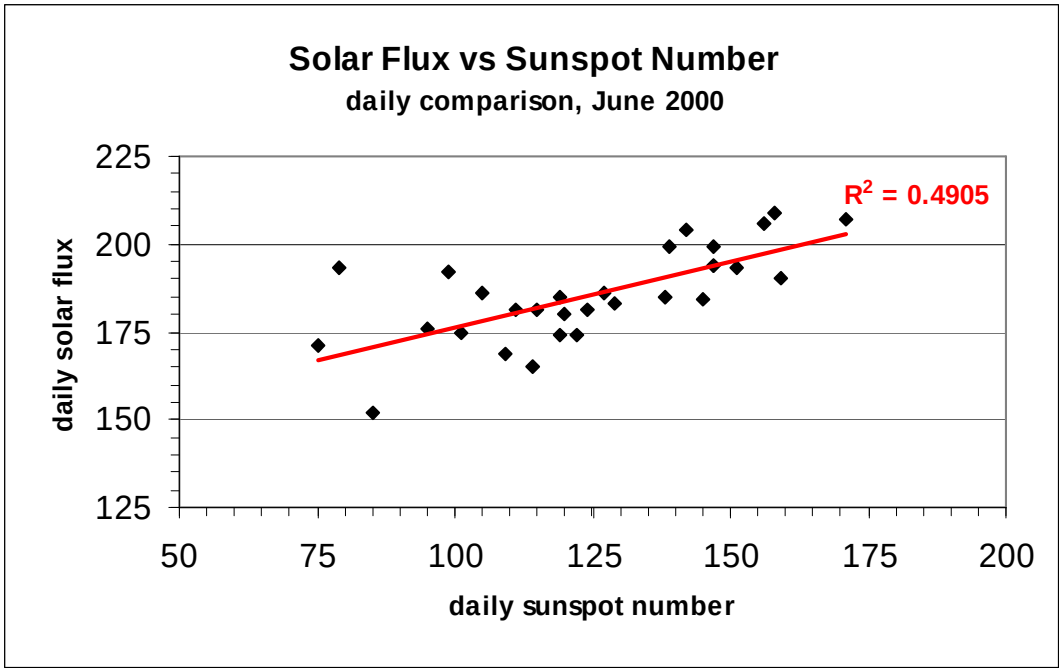
Our propagation prediction programs allow us to input either a value of the 10.7cm solar flux or a sunspot number to run predictions. That tells us that there is a correlation between solar flux and sunspot number. What is this correlation? Is it with daily values? Or is it with something else? The purpose of this article is to look at the correlation between solar flux and sunspot number.

Let's first look at the correlation between daily values. We'll do this by using a scatter plot of the daily solar flux data and the daily sunspot number data for June 2000.

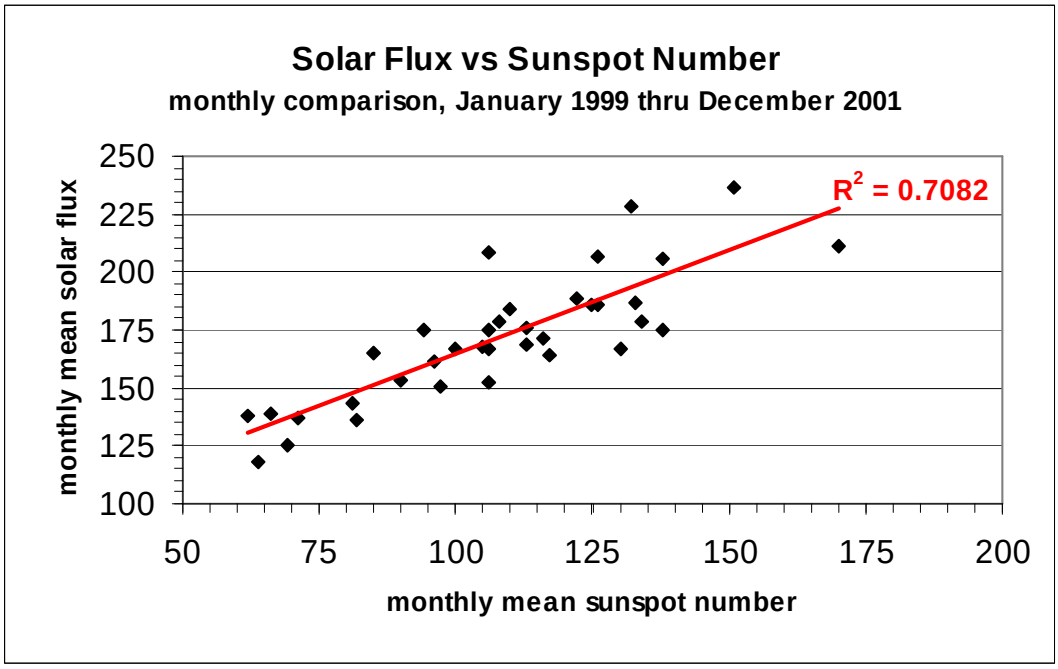


The R^2 value in the upper right corner of the plot tells us how well correlated the two daily values are. The red line is a best-fit linear trend line.

$R^2 = 1$ indicates perfect correlation, and all the data points would fall right on the red best-fit linear trend line. $R^2 = 0$ indicates no correlation, and the data points would be widely scattered about the best-fit linear trend line.

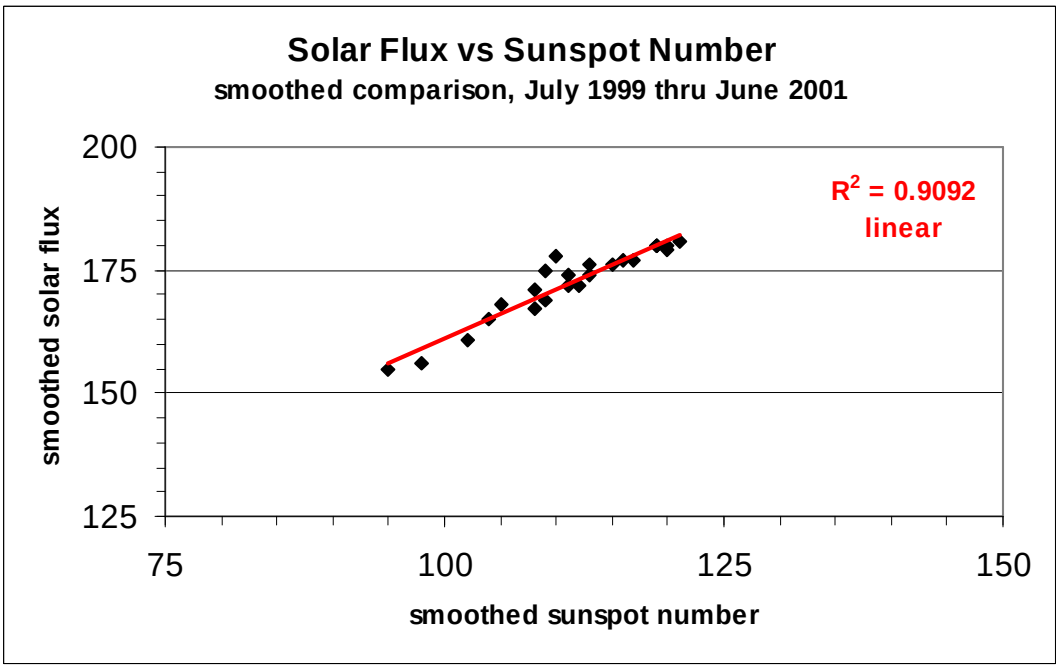
With an R^2 of 0.4905, we conclude that the daily solar flux and the daily sunspot number are somewhat correlated. Can it be better? Yes – if we use monthly mean (average) values of solar flux and sunspot number.

The following plot is a scatter plot of the monthly mean solar flux (the average of the month's worth of data) and the monthly mean sunspot number.



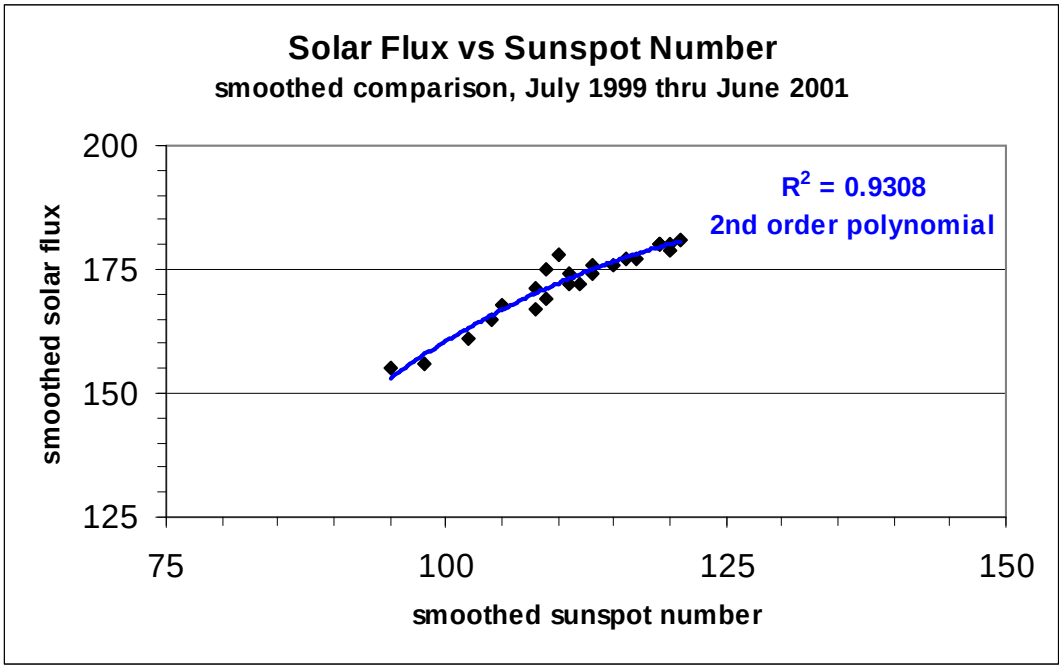
With an R^2 value of 0.7082 (again using a linear trend line), the monthly mean correlation is better than the daily correlation. But there's still uncertainty. For example, the monthly mean solar flux was anywhere from 150 to 210 when the monthly mean sunspot number was around 105.

Let's go to the next level and compare smoothed solar flux to smoothed sunspot number (smoothed solar flux is calculated in the same way as the smoothed sunspot number). This is done for July 1999 through June 2001.



This is much better. The data nicely hugs the red best-fit linear trend line. The R^2 value of 0.9092 indicates a high degree of correlation.

But we can do even better (a higher value of R^2) with a second order polynomial trend line.



This correlation between smoothed solar flux and smoothed sunspot number using a second order polynomial trend line is the basis for the equation seen in our propagation literature. Using the term φ_{12} for the smoothed solar flux and the term R_{12} for the smoothed sunspot number:

$$\varphi_{12} = 63.75 + 0.728\ R_{12} + 0.00089\ (R_{12})^2 \qquad \text{[equation 1]}$$

Alternately:

$$R_{12} = (93918.4 + 1117.3\ \varphi_{12})^{1/2} - 406.37 \qquad \text{[equation 2]}$$

These equations were derived from much more data than what is presented in the above smoothed plot.

Also note that these two equations are intended to be used with smoothed values. Thus using these equations to convert from daily solar flux to daily sunspot number or vice versa will result in much uncertainty.