Running the Model Using Decadally-Averaged Data

The estimates of past sunspot number made by Solanki *et al.* from ice core data are something like decadal averages. In a sense this is nasty since it is close to but not equal to the solar activity cycle duration, which varies between 10 and 13 years. Figure 1 shows a plot of the decadal estimates by Solanki and the annually-averaged data we used in our paper, plus a smoothed version of that data.

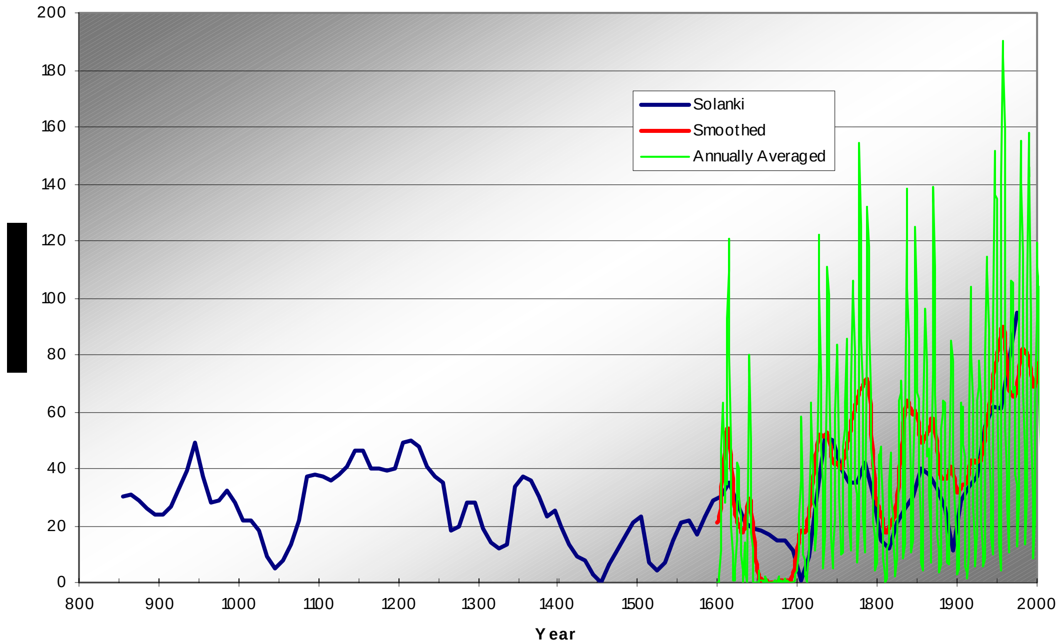

Figure 1: Solanki sunspot number estimates (black), annually-averaged sunspot number (green) and smoothed (red).

The observations more or less fit Solanki's estimates, so there could be some value in investigating the possibility they can be used to estimate irradiance further back in time.

The Annually-Averaged Model

In our paper (for which I have just got the proofs and have spent a lot of time so far correcting the editors' corrections to the English), we use annual averages and assume we have equilibrium conditions between input and output for the various components, so we end up with the equations:

$$S_{10.7} = \frac{N_s}{2}\left(2 - \exp(-0.01 N_s)\right)$$

$$\Phi_S = 0.446 S_{10.7}$$

$$\Phi_W = -0.14\Phi_S + 2.81\Phi_S^{1/2} + 45$$

$$I = 0.015\Phi_S + 0.003\Phi_W + 0.017\int_{t-\Delta t/2}^{t+\Delta t/2} S_{10.7}\,dt + 1364.5$$

Since these are already averages with derivatives=0, calculating irradiance from the annually-averaged sunspot number data and then smoothing it to remove the cycles should give the same result as smoothing the sunspot number data and then passing it through the irradiance model should be equivalent. The plot below, using the 1600-present sunspot number data used in our Maunder modelling seems to indicate this is the case.

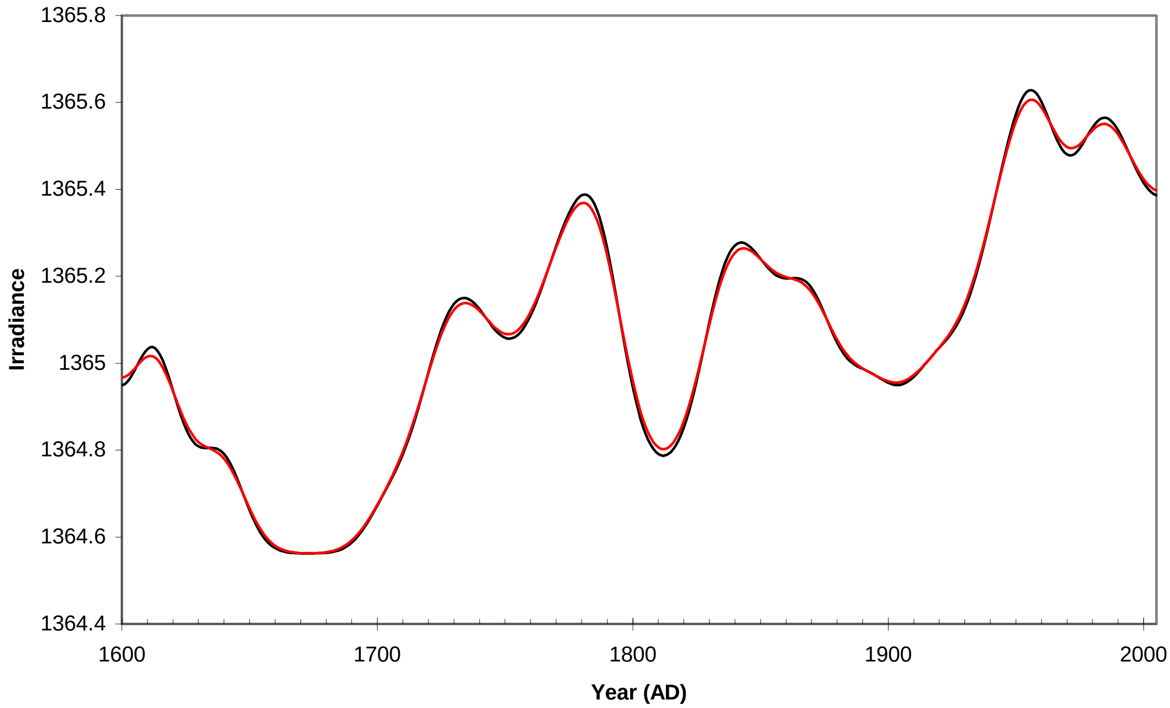

Figure 2: Smoothed irradiance obtained from annual sunspot number and irradiance obtained from smoothed sunspot number.

Before simply plugging the Solanki time series into our model we need to know if there are any "scaling factors" we need to take into account. The plot below shows the Solanki numbers plotted against decadally averaged sunspot number data. It's clear the correlation is not that marvellous. It's not clear even whether we should apply an offset or not. For the moment, we assume not, and that the Solanki number and sunspot number are purely related by some sort of scaling factor. Out of curiosity, since the linear correlation coefficient is so yucky, I fitted a second-degree polynomial too.

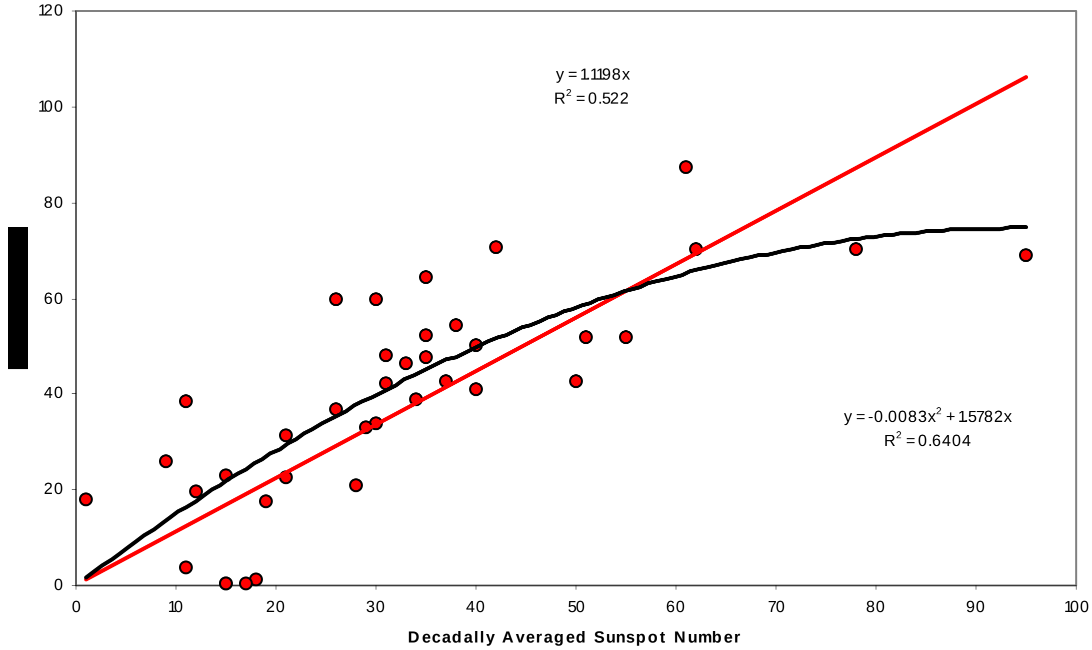

Figure 3: Solanki number plotted against sunspot number, with a fitted straight line and a second-order polynomial.

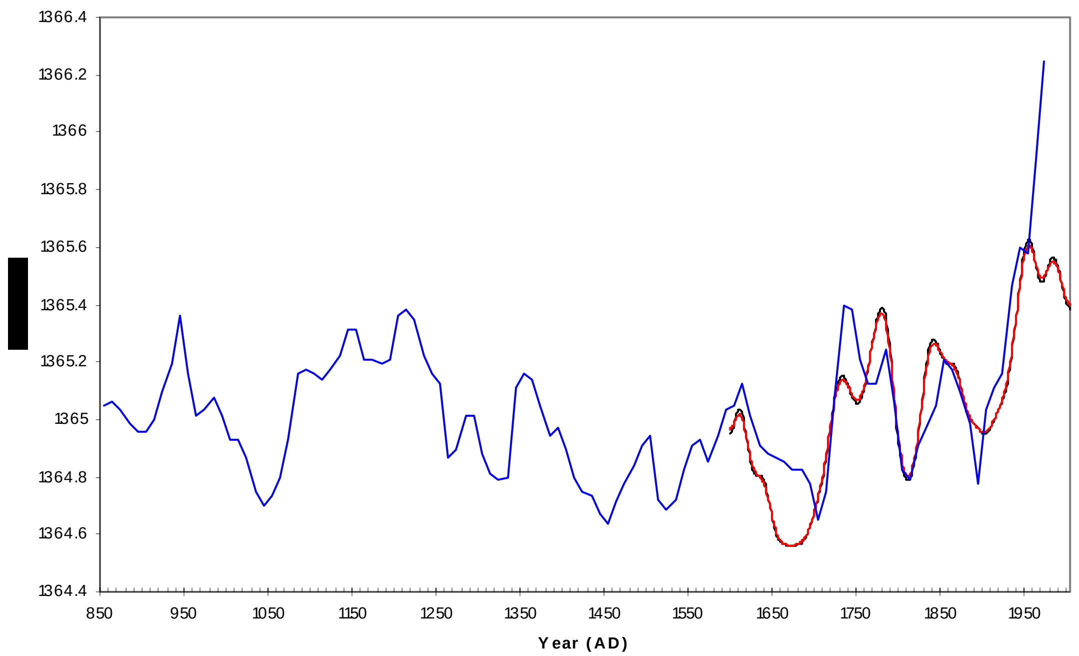

Figure 4:Irradiance modelled from Solanki Number using the linear relationship between sunspot number and Solanki Number.

There is a sort of agreement, but the recent fit, which is the part of the record where we have real observations, does not look that great. Just for the heck of it, let's try the second order polynomial to see if it “looks” and better. Not that we have any particular justification for this.

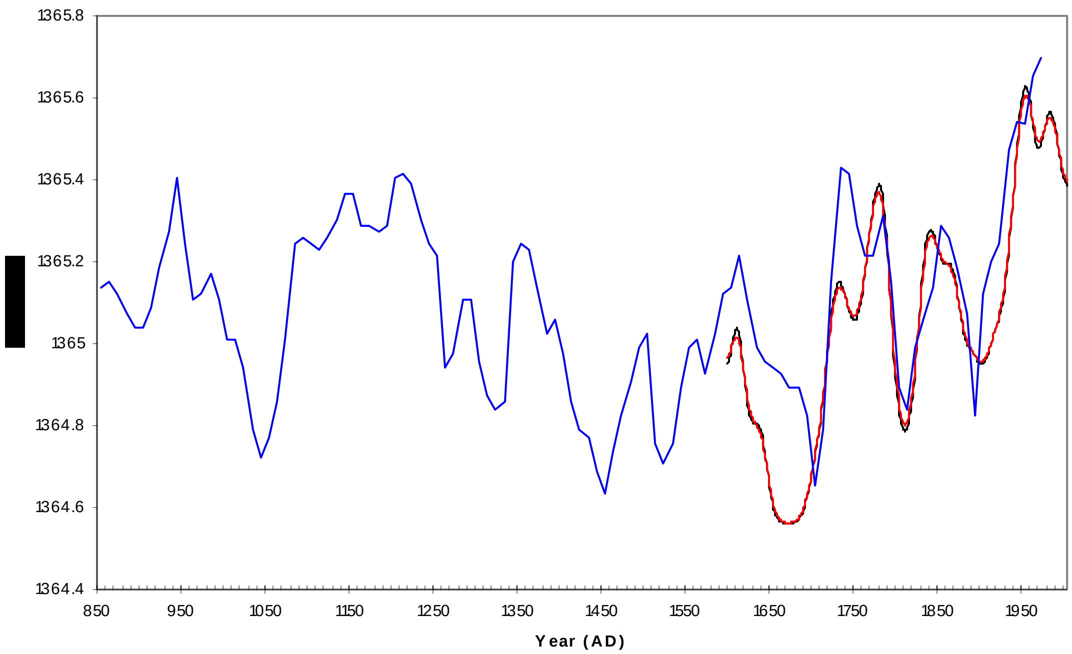

Figure 5: Modelled irradiance assuming the quadratic fit between Solanki number and sunspot number.

This actually looks better. Since the Solanki number is derived from terrestrial proxies, there is no real reason the relationships should be linear.

The Maunder Minimum is interesting in that it suggests there really was solar activity during that period, that is, the basic rhythm was still at work. The poor fit between our attempt to model pre-Maunder irradiance and the Solanki-based estimate could be due to the poor quality of our attempt to estimate sunspot number before the MM.