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An Analysis of Heliospheric Magnetic Field Flux, Prediction for the Coming Solar Minimum, and Alfvén Radius based on Sunspot Number from 1749 to Today

It has been established that the Heliospheric Magnetic Field (HMF) intensity fluctuates with the solar cycle. During the recent protracted solar minimum of cycle 24, the HMF intensity fell to a record observed low. As well, after the relatively small maximum of cycle 24, it has been shown that the magnetic and particle fluxes only made a partial recovery. Building on Schwadron et al. [2010], we show that the decreased flux levels at maximum will lead to an even lower coming minimum.

Using the model from Schwadron et al. [2010] and monthly average sunspot numbers, we computed a monthly average HMF intensity from 1749 to the present. As comparisons, we used Omni2 data and the work of McCracken [2007], who modeled the HMF intensity from the levels of paleogenic nucleotide ^{10}Be. These three estimations of flux as well as sunspot number are shown in Figure 1, with a strong correlation and a clear hysteresis.

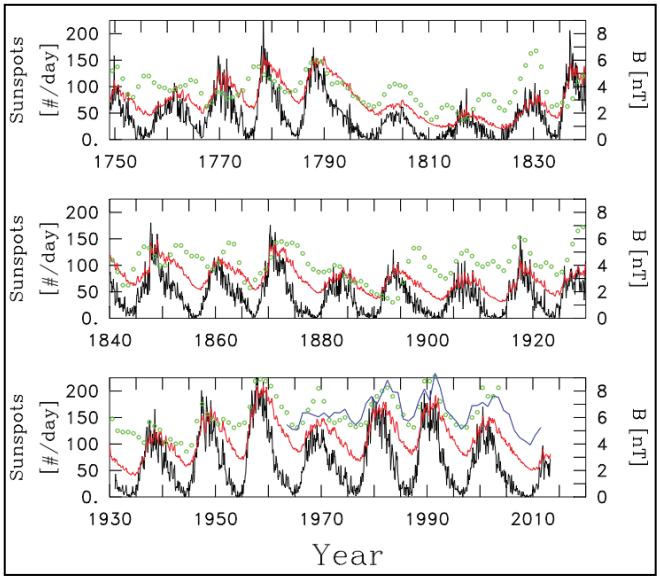

Figure 1: (black) Monthly ave SSN. (red) Predicted Parker comp. of the HMF intensity. (green) Yearly ave HMF intensity derived from ^{10}Be data. (blue) Measured yearly-averaged HMF intensity (Smith et al. [2013]) from Omni2 data.

Of note is the Dalton minimum, from ~1790 to ~1830. The recent protracted solar minimum was a remarkably similar cycle to the beginning of the Dalton minimum. From this, we can predict that coming solar cycles will continue to be lower. As a prediction, we used the sunspot data from the historical record from 1805 onward (not shown), which gives an intensity of 2.5-3.4 nT.

The sunspot number to HMF intensity model can also be applied to calculate the changing Alfvén radius. If the HMF varies according to the Parker spiral [Parker, 1958, 1963], we can derive a crossing point where the Alfvén speed is equal to the solar wind speed. This value, the Alfvén radius, can be calculated from Omni2 data. The result fluctuates with the solar cycle, and can therefore be scaled to the sunspot record, as shown in Figure 2. During the Dalton minimum, the minima were protracted, but not driven unusually low. The maxima however, were much lower than previous years. The same can be seen in the recent protracted solar minimum, and can be used as a prediction for the coming solar minimum.

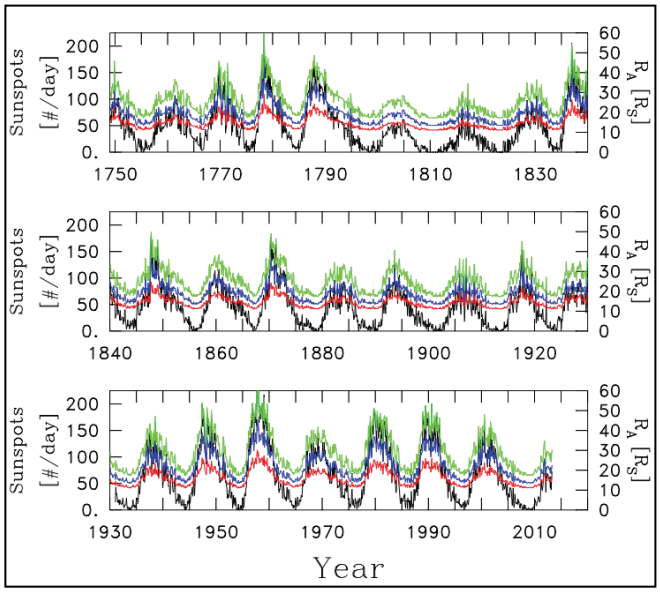

Figure 2. Years 1749 to 2013 showing monthly average SSN (black) and predicted Alfvén radius derived from best fit (blue) and bounding lines (red and green).

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