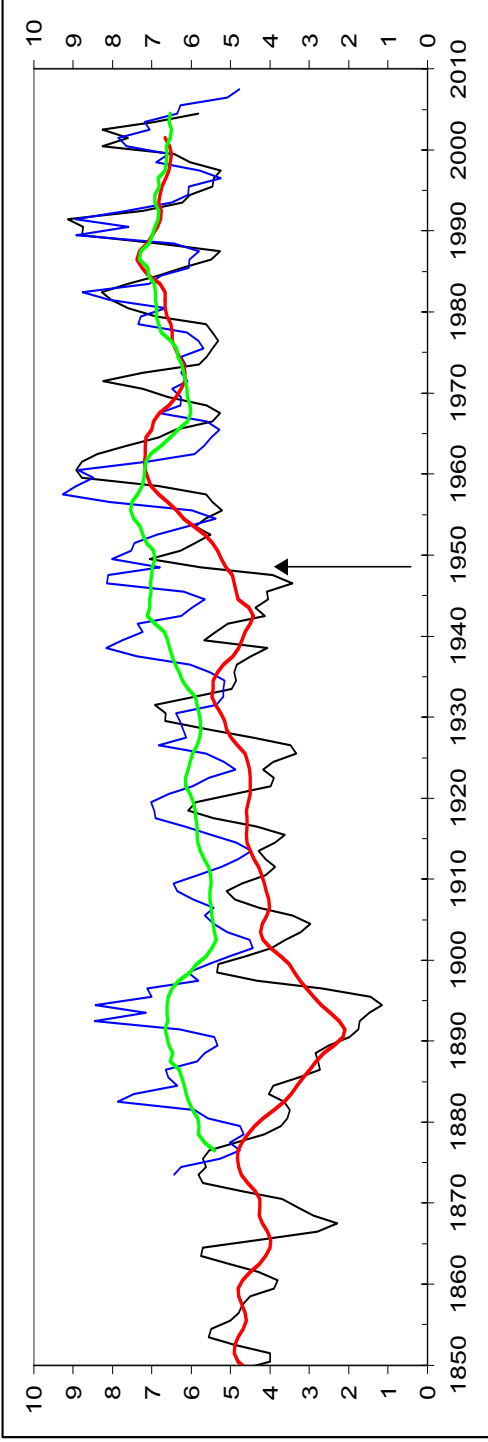
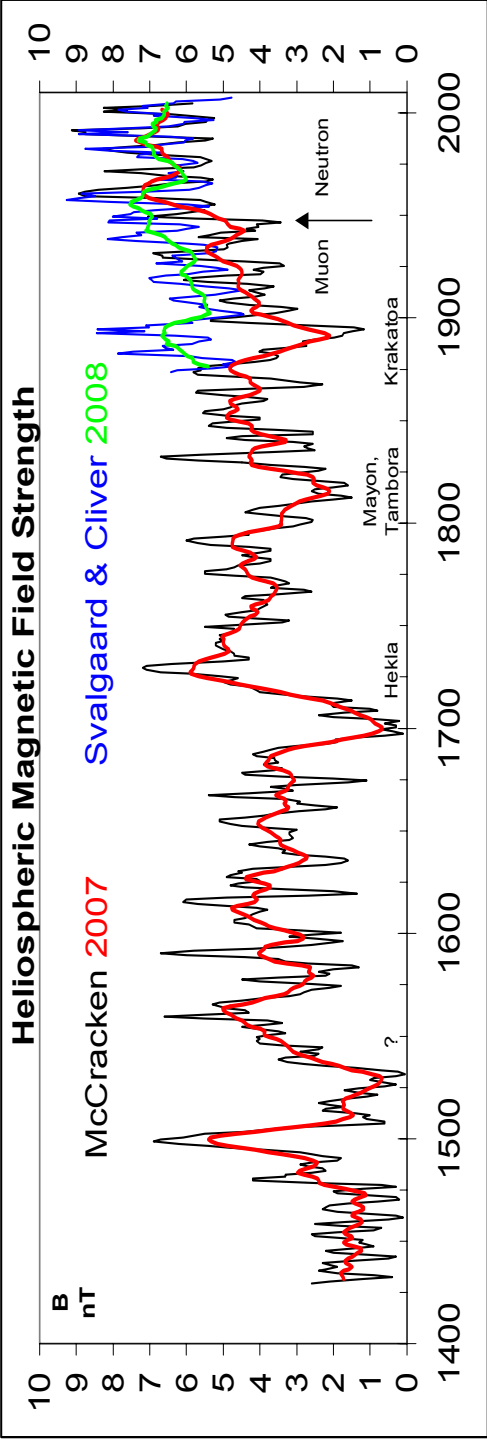


Reconstructing TSI from Heliospheric Magnetic Field as Deduced by McCracken from Cosmic Ray Modulation

Leif Svalgaard

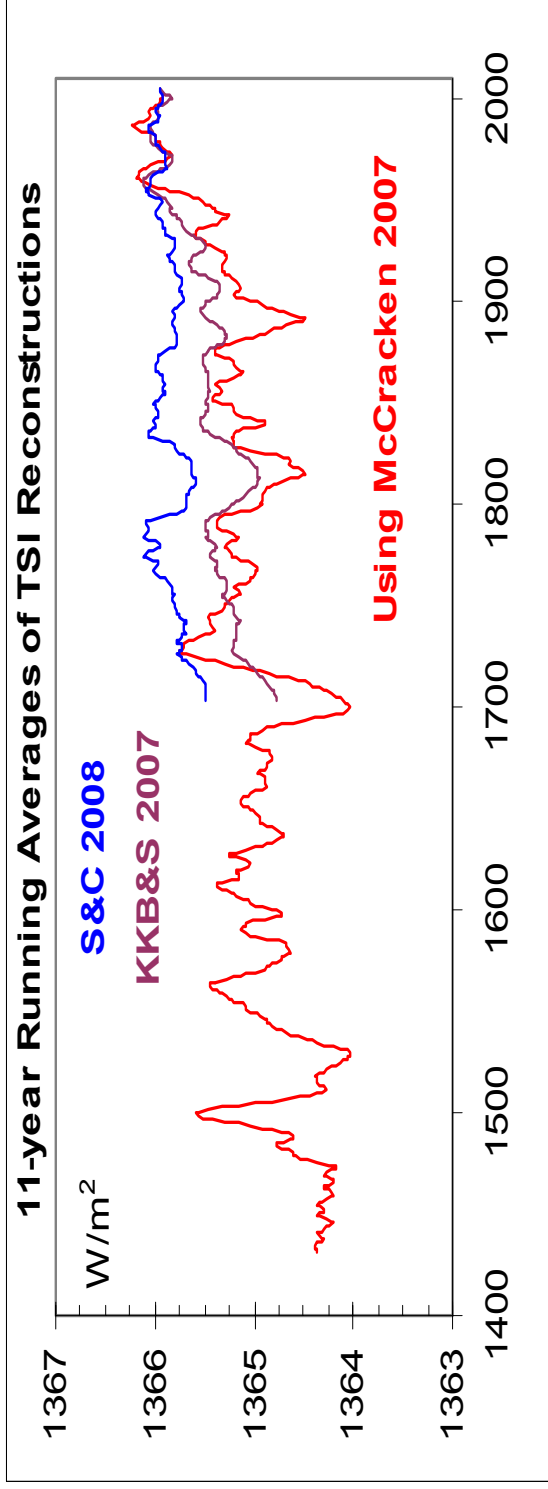
In recent papers [McCracken, K. G. & J. Beer, JGR *112*, A10101, 2007: Long-term changes in the cosmic ray intensity at Earth, 1428-2005; McCracken, JGR *112*, A09106, 2007: Heliomagnetic field near Earth, 1428-2005] McCracken has constructed a ‘Pseudo-Climax-Neutron-Count’ series and ‘inverted’ it to obtain the Heliospheric Magnetic Field strength [HMF B]. Although we question the calibration of the series [Svalgaard L. & E. W. Cliver, under review JGR, 2008; <http://www.leif.org/research/Comment%20on%20McCracken.pdf>] it is of interest to examine some of the consequences of the inversion should it turn out to be valid. A salient feature of the reconstruction of HMF is the very large systematic variation of [yearly average] B , from ~ 0 nT in the 15th Century to ~ 9 nT in the late 20th Century. Solar cycle averages vary from 1.5 nT for the first 50 years of the series to 6.7 nT for the last 50 years. Occasionally there are large ‘spikes’ that are unexplained. A solar cycle variation of ~ 2 nT is superimposed on this general secular variation. Figure 1 shows yearly values of the HMF for 1428-2005 as given by McCracken [actually laboriously hand-scaled from his published Figure 5]. The red curve is the 11-year running average. The blue [and light green 11-year average] curve is our reconstruction of B [from Svalgaard L. & E. W. Cliver, JGR *110*, A12103, 2005: The IDV index: its derivation and use in determining long-term variations of the interplanetary magnetic field strength]. After ~ 1950 , the reconstructions agree, but the addition of the earlier muon data from ionization chambers introduces a discontinuity in HMF of 1.7 nT at or about ~ 1950 , that is not evident in the geomagnetic record. The lower panel of Figure 1 shows the most recent ~ 160 years of the data. One may note a slight error in the construction of the ^{10}Be -based HMF in that no account was taken of the ~ 2 years delay [or phase difference] due to atmospheric residence time. We shall not dwell on such minutia, but for the sake of the argument assume that McCracken’s reconstruction is correct and see where it takes us.



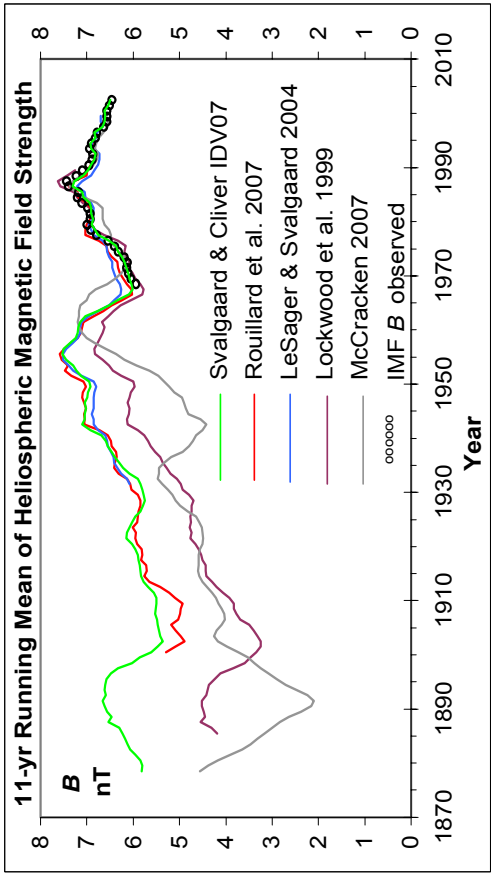
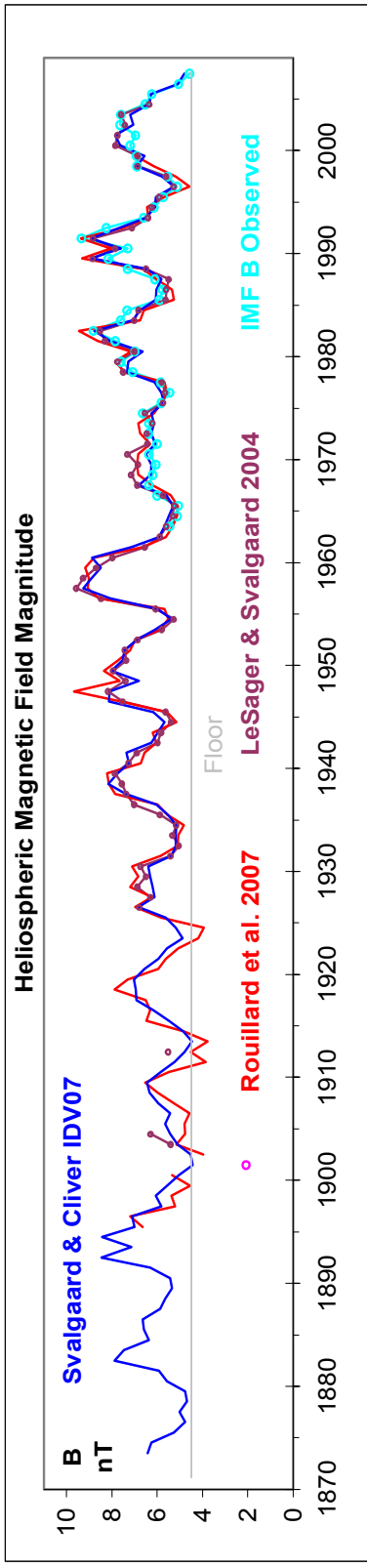
Fröhlich notes [Fröhlich, C., AGU Fall 2007, Abstract CU43A-0857: Total Solar Irradiance Time Series since 1975] that some [but not all] time series show a slight downward trend of TSI values for the last three solar minima, following an upward trend in other solar indices prior to 1980. He interprets this as an influence of the Sun's open magnetic flux on TSI and from Foster's estimate of TSI for zero magnetic field [1363.8 W/m²] finds an apparent sensitivity of TSI to HMF B of $k = 0.33 \text{ Wm}^{-2}/\text{nT}$ [Fröhlich, C., *SORCE*, 2008]. We shall model the solar cycle average $\langle TSI \rangle_{11}$ by

$$\langle TSI \rangle_{11} = 1363.8 + k \langle B \rangle_{11}$$

where $k = 0.33$. The result [red curve] is shown in Figure 2 below. Also shown are the (11-year average) TSI-reconstructions by Svalgaard & Cliver [blue] and by Krivova, N. A., L. Balmaceda, & S. K. Solanki [Astronomy & Astrophysics 467, 335, 2007] [purple]:



The McCracken HMF-series claims support from the Lockwood, M., R. Stamper, & M. N. Wild 1999 paper [A Doubling of the Sun's Coronal Magnetic Field during the Last 100 Years, *Nature* 399, 437, 1999]. The Krivova et al. [2007] reconstruction is based on a Solanki et al. [2000] model that was specifically tuned to explain the '100-year Doubling'. Svalgaard and Cliver [2005] did not confirm the 'doubling' and a recent paper by the Lockwood group [Rouillard, A. P., M. Lockwood, & I. Finch, *JGR 112*, A05103, 2007: Centennial changes in the solar wind speed and in the open solar flux] gives values for B that are very close to ours [the pink data point for 1901 is in error (Rouillard, *Pers. Comm.*, 2007)]:



Left we show 11-yr running means of the HMF B derived by different methods and authors. Note how close the Rouillard et al. [2007] curve [red] matches the Svalgaard & Cliver curve [green]. McCracken's curve [grey] does indeed match the [now] superceded Lockwood et al. [1999] curve [purple], but seems at variance with the emerging consensus B [Rouillard 2007, Svalgaard & Cliver 2005, 2007, LeSager & Svalgaard 2004]. Note, in particular, the large difference around 1890.

Conclusion

We have used a recent reconstruction of the long-term solar wind magnetic field based on cosmic ray data [McCracken, 2007; McCracken and Beer, 2007] to infer the secular variation in TSI, based on a sensitivity of $0.33 \text{ Wm}^2/\text{nT}$. The TSI inferred in this manner increases by $\sim 2 \text{ W/m}^2$ from 1428 to 2005 (Figure 1); most of that change being an abrupt increase by $\sim 1.5 \text{ W/m}^2$ in the middle of the 20th Century, a result that finds no support in other recent TSI reconstructions which show at most a $\sim 0.5 \text{ W/m}^2$ increase over this period (Figure 2). This result casts further doubt on the McCracken [2007] solar wind magnetic field reconstruction which is at strong variance with other recent HMF reconstructions (Figure 3). Alternatively, the sensitivity of TSI to HMF could be much smaller than $0.33 \text{ Wm}^2/$.