A 1200-Year History of Total Solar Irradiance

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In the introduction to their paper on solar irradiance variations over the last 1200 years, Bard *et al*. (2000) list some of the many different types of information that have been used to reconstruct past solar variability, including "the envelope of the SSN [sunspot number] 11-year cycle (Reid, 1991), the length and decay rate of the solar cycle (Hoyt and Schatten, 1993), the structure and decay rate of individual sunspots (Hoyt and Schatten, 1993), the mean level of SSN (Hoyt and Schatten, 1993; Zhang *et al*., 1994; Reid, 1997), the solar rotation and the solar diameter (Nesme-Ribes *et al*., 1993), and the geomagnetic aa index (Cliver *et al*., 1998)." They also note that "Lean *et al*. (1995) proposed that the irradiance record could be divided into 2 superimposed components: an 11-year cycle based on the parameterization of sunspot darkening and facular brightening (Lean *et al*., 1992), and a slowly-varying background derived separately from studies of sun-like stars (Baliunas and Jastrow, 1990)," and that Solanki and Fligge (1998) have developed an even more convoluted technique.

In the case of the paper that is the subject of this Editorial (Bard *et al*., 2000), an entirely different approach is used. Rather than directly characterizing some aspect of solar variability, certain *consequences* of that variability are assessed. Specifically, the authors note that magnetic fields of the solar wind deflect portions of the primary flux of charged cosmic particles in the vicinity of the earth, leading to reductions in the creation of *cosmogenic nuclides* in earth's atmosphere. Consequently, histories of the atmospheric concentrations of ^{14}C and ^{10}Be can be used as proxies for solar activity, as noted many years ago by Lal and Peters (1967).

In employing this approach to the problem, the authors first created a 1200-year history of cosmonuclide production in earth's atmosphere from ^{10}Be measurements of South Pole ice (Raisbeck *et al*., 1990) and the atmospheric $^{14}C/^{12}C$ record as measured in tree rings (Bard *et al*., 1997). This record was then converted to Total Solar Irradiance (TSI) values by "applying a linear scaling using the TSI values published previously for the Maunder Minimum," when cosmonuclide production was 30-50% above the modern value.

The authors' work resulted in an extended TSI record that suggests, in their words, that "solar output was significantly reduced between 1450 and 1850 AD, but slightly higher or similar to the present value during a period centered around 1200 AD." Hence, they say "it could thus be argued that irradiance variations may have contributed to the so-called "little ice age" and "medieval warm period."

In discussing this idea, Bard *et al*. amazingly downplay their own suggestion, because, as they report, "some researchers have concluded that the 'little ice age' and/or 'medieval warm period' [were] regional, rather than global events." Noting that the TSI variations they developed from their cosmonuclide data "would tend to force global effects," they felt they could not associate this *global* impetus for climate change with what other people were calling *regional* climatic anomalies.

With respect to these thoughts, we note that "some researchers" have indeed been working overtime to rewrite this aspect of earth's climatic history, claiming that both the Little Ice Age and Medieval Warm Period were restricted to lands bordering on the North Atlantic Ocean. However, as may readily be seen by perusing the many materials we have filed under the headings of Little Ice Age and Medieval Warm Period in our Subject Index, *these phenomena were truly global in extent*. Hence, when Bard *et al*. say their TSI variations "would tend to force global effects," they truly hit the nail on the head, as their *global* forcing function meshes well with the *global* climatic response of the earth.

Additional support for the TSI record developed by Bard *et al*., as well as its global climatic implications, is provided by two other studies we have reviewed. Rigozo *et al*. (2001) developed a 1000-year record of sunspot number, which they say "reproduces well the great maximums and minimums in solar activity, identified in cosmonuclide variation records, and, specifically, the epochs of the Oort, Wolf, Sporer, Maunder, and Dalton Minimums, as well [as] the Medieval and Modern Maximums." Likewise, Pang and Yau (2002) -- using similar data, but augmented by numerous Chinese, Japanese and Korean records of sunspot sightings -- developed an 1800-year history of solar brightness change that reveals these same solar minima and maxima, which include those found by Bard *et al*.

Truly, the evidence for the solar forcing of climate on centennial and millennial time scales, as well as both shorter and longer periods, is overwhelming. And with each passing day, it grows ever more substantial.

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