Our flickering sun: Fluctuating solar flux

A question that had tantalized solar astronomers for more than a century was finally settled in 1980 after only five months of operation of the Solar Maximum Mission satellite: Is the so-called "solar constant" — the sun's output of electromagnetic radiation — really constant? The answer was no.

The first high-precision spaceborne instrument capable of measuring the solar output to the necessary accuracy showed small but unmistakable fluctuations in solar luminosity on virtually a week-to-week basis. The amounts of change were generally tiny, about 0.05 percent, or 1 part in 2,000. But the 153-day record from February to July 1980 revealed two much larger dips, representing reductions of up to 0.2 percent, over periods of seven to ten days. Solar astronomers hailed the results. The data confirmed suspicions that solar luminosity indeed varies, and the technology was the first step toward accumulating a much-dreamed-of long-term observational record of that variability.

Last week Richard C. Willson of Jet Propulsion Laboratory — designer of the instrument aboard the SMM satellite — announced results of its observations through the end of 1981, a nearly 23-month record. They continue to show frequent variations in the solar flux of plus or minus 0.05 percent or more departure from the 23-month mean, with several up to 0.1 percent. And there's one drop of about 0.23 percent — the deepest dip yet measured by SMM — in late July 1981. Furthermore, Willson identifies a long-term decrease in the solar flux of about 0.1 percent over the 18-month period from February 1980 to August 1981, when the output begins rising again.

The biggest drops in observed luminosity once again coincide with the passage of major sunspot groups across the central part of the solar disk, Willson says. This apparent "blocking" effect was first observed in the first five months of data in 1980, and it continues strikingly through 1981, says Willson. In fact the deep dip in late July 1981 coincides with passage of the largest sunspot group seen in the two years of SMM operation. The sunspot area covered 6,000 millionths of the sun's disk, says Willson. "It was a whopper."

The short-period increases in radiation correlate with passage of faculae, bright, extra-hot solar regions.

Solar astronomers and climatologists are excited about the data. This is the kind of long-term information about solar output they have wanted, and they hope these measurements can continue for several decades. But while they welcome the new insights into the sun, they are displeased that public statements made last week about the results attempted to link the 18-month decline to the bitter cold weather in the United States during the winter of 1982. There is no justification for doing so, they believe. (A report on the past winter begins on p. 298.)

"It is much too early" to suggest any such connections, says solar astronomer John A. Eddy of the National Center for Atmospheric Research. The observed drop is too small and of too short a duration to have perceptible climatic effects, he says. He finds the data, if real, potentially "exciting" however, because they would confirm suspicions by Eddy and others that the solar output does vary slightly not only with quick ups and downs but gradually over periods of years. Many years of such observations would be necessary to show whether there is an "envelope" of changing solar output that overlays the 11-year sunspot cycle in some way. Eddy hopes the data aren't the result of a degradation in the instrument's sensitivity. Willson says his tests indicate that any degradation effect is much smaller than the changes in luminosity measured.

Climatologist Stephen H. Schneider of NCAR, who has long championed long-term spaceborne measurements of the solar constant, says he's "thrilled" about the new data and much admires Willson's work. But he is upset about the claimed connection to the winter of 1982. The enormous heat capacity of the oceans much delays any effects on climate of a change in solar output, he says, and different mixing rates in different parts of the oceans, land-sea effects and other local effects all make such hypothetical connections exceedingly difficult to decipher. Besides, the effect is just too small, he says.

Schneider says the best computer models suggest that a 0.10 percent drop in solar output could eventually cause a $^{1}/_{10}$°C drop in average hemispheric temperature. But they indicate that it would take five years to see half of that effect "and an additional one hundred years to see the other half.

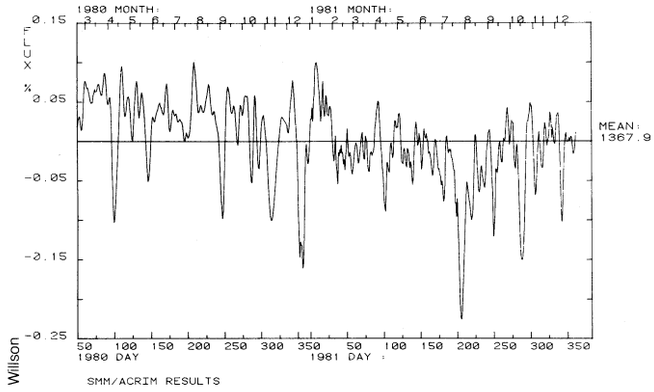
"So on a scale of a few years you wouldn't even get to half of the effect. You would expect less than a one-tenth degree change," he says. "One-tenth of a degree is comparable to instrument fluctuations, and one-hundredth of a degree is not even detectable." Furthermore, he points out, in any one region the normal year-to-year difference in temperature is on the order of 2°C, an enormously larger variance.

If the solar change detected by Willson is a factor at all in recent weather, it "has to be an infinitesimal part — a triviality," says Schneider. However, if such a long-term decline of 0.05 percent a year were to continue for 10 years, then, says Schneider, "we'd have a real good candidate for a climatic signal." As for now, he thinks the vast high-altitude dust clouds circling earth from several recent volcanic eruptions are a far more interesting and important potential influence on climate over the next year or so.

Richard C.J. Somerville, head of the Climate Research Group at Scripps Institution of Oceanography, echoes those reservations. "The wonderful thing is that we actually have this measurement capability," he says of the instrument on SMM and Willson's new solar results. He calls it a "tremendous technology" and says he "is delighted that the measurements are being made." But he says it is an enormous conceptual leap to say the small solar radiation decline has anything to do with the recent winter or to any other recent weather. We don't have any physical model to justify any such rapid link, he says.

The scientists agree that these latest revelations about the variable sun are a valuable step in accumulating the long-term record of solar variability they have so long wanted. But they are unanimous in cautioning against premature and unsupportable conjectures about effects, if any, on earth. Says Somerville: "People don't understand the degree to which we are unable to unscramble these eggs."

—*K. Frazier*



Willson's new satellite data show numerous small fluctuations in solar output and a gradual, 18-month decline until August 1981, when a rise began.