The Sun Is Fading

The decrease in solar brightness is small but possibly climatically significant; a turnaround may be in the offing

THREE independent measures of the brightness of the sun as seen from Earth now show the same 0.02 percent per year decrease during at least the past 5 years. Thus, as suspected in the early years of these observations, the sun does seem to be fading. But it is fading too fast for it to be part of a long-term change, so the decrease is presumably linked to some well-known solar cycle, such as the 11-year sunspot cycle or more probably the 22-year magnetic cycle. Over a decade or two, such changes could affect climate.

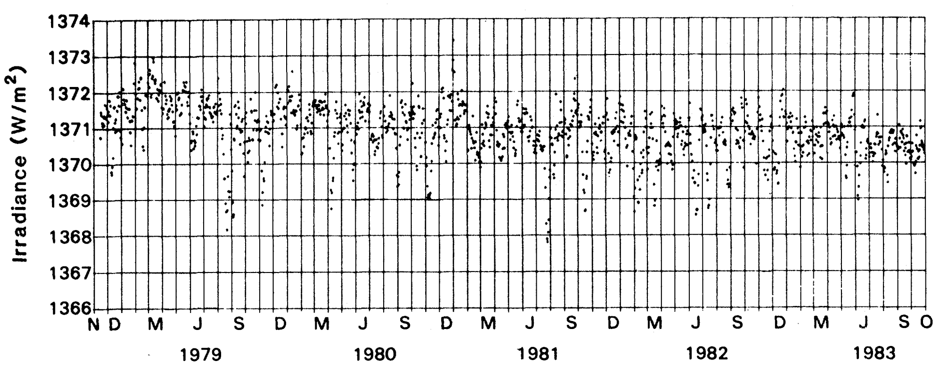
Richard Willson of the Jet Propulsion Laboratory reported on one measure of solar brightness or irradiance at last month's meeting of the American Geophysical Union. The Active Cavity Radiometer Irradiance Monitor (ACRIM) on board the recently repaired Solar Maximum Mission satellite has measured a total decrease in solar irradiance between February 1980 and early 1985 of 0.09 percent. That is quite a change for a property that astronomers thought to be so stable that they called it the solar constant. As determined by Claus Fröhlich of the Physical Meteorology Observatory in Davos, this downward trend of 0.018 percent per year has a confidence interval of ±0.0024 percent per year.

To minimize the chances that charged-particle or ultraviolet radiation had degraded the sensor and produced a false irradiance decrease, ACRIM periodically compared the sensor in continuous use with an identical sensor that is otherwise shielded. Less frequently, the second sensor is compared with a third protected sensor.

A second satellite experiment has found about the same irradiance decrease as ACRIM has, according to John Hickey of the Eppley Laboratory, Newport, Rhode Island. Hickey has analyzed results from the Earth Radiation Budget (ERB) experiment on the NIMBUS 7 satellite launched in 1978 and found a 0.015 percent per year decrease, one which extends throughout the record. The ERB experiment operates on the same basic principle as the ACRIM but was designed independently.

An obvious criticism of these results is that despite the experimenters' best efforts the effects of sensor degradation have crept into the results; the agreement of the two satellite experiments might then be a coincidence. New irradiance measurements have now seriously undercut that criticism.

Willson flew another of his instruments on sounding rockets in 1980, 1983, and the end of 1984, carefully calibrating it before and after. Fröhlich flew his instrument on high-altitude balloons in 1980 and 1983, and in 1983 and 1984 on the same rocket flights as Willson used. The downward trend in irradiance determined from these seven instrument flights over 5 years is 0.016 percent per year compared with the 0.015 to 0.019 percent per year determined by the satellites.



A slow but steady decline in the sun's brightness

Although sunspots cause an apparent flicker, the long-term downward trend in the ERB-determined solar "constant" is clear. [From Kyle et al., Bull. Am. Met. Soc. **66**, *1378 (1985)*]

The solar irradiance decrease seems real enough, but what known solar behavior is associated with it remains uncertain, so that predictions of the direction of future irradiance changes and any climatic effects remain uncertain as well. In accordance with the 11-year cycle, the number of sunspots has been decreasing since the ACRIM launch, but if the irradiance decrease detected by the ERB experiment beginning in 1978 was real, irradiance was also decreasing while sunspot numbers were increasing to their 1980 peak.

That trend suggests a possible association instead with the 22-year magnetic cycle, during which sunspot numbers peak twice but the magnetic polarity of sunspots reverses to the opposite sign and back only once. A cycle much longer than 22 years having such rapid changes in irradiance seems unlikely, says John Eddy of the National Center for Atmospheric Research in Boulder. The resulting climate change would far exceed any seen. Even so, an irradiance cycle only 22 years long might be climatically significant. Ten years of such a decrease would produce an overall 0.2 percent irradiance reduction, although a decrease as small as 0.1 percent over a decade or more could be climatically significant, he notes.

Longer term variability might still be achieved by irradiance changes over a number of 22-year cycles, as happens with the peak in sunspot numbers from cycle to cycle. Eddy has proposed one such longer term irradiance-climate connection. Between about 1500 and 1850, sunspots were rare, and Europe and other regions were in the grip of the Little Ice Age. A 1 percent decrease in irradiance could have caused that estimated 1°C cooling. What happens to irradiance during the next few years as sunspot numbers hit a minimum and start heading back up could determine whether the 22-year cycle is involved.

The direct cause of the irradiance decrease may still remain unknown. It is certainly not the tendency of sunspots to block solar radiation in the direction of Earth, as discovered by ACRIM, since the effect is in the wrong direction. There is an intriguing solar phenomenon that could be involved. As recently suggested by Martin Woodard, now at JPL, and Robert Noyes of the Harvard-Smithsonian Center for Astrophysics in Cambridge, the sun seems to be expanding. By analyzing ACRIM data, Woodard and Noyes detected a shift in the frequency of the sun's 5-minute oscillation, a bell-like ringing of the whole sun. A plausible explanation, they say, is that the sun has expanded roughly 100 kilometers. The link between size and irradiance is not worked out to anyone's satisfaction, but the coincidence of the two trends is interesting. ■ RICHARD A. KERR

ADDITIONAL READING

M. F. Woodard and R. W. Noyes, "Change of solar oscillation eigenfrequencies with the solar cycle," *Nature (London)* **318**, 449 (1985).