cient to inactivate the protein. That suggests that the lesser amount of double muscling in Piedmontese cattle is due to other genes that make up for the loss of myostatin.

Despite the interest in using the myostatin gene to improve beef production, researchers warn that it may be a difficult task. One possibility is to use either conventional breeding or genetic engineering to introduce the Belgian Blue mutation into other breeds. So far, however, U.S. breeders have only rarely attempted to do this, even by conventional breeding. This is partly for practical reasons. The need to deliver calves by cesarean section is a serious handicap in the United States, where cattle herds are larger and roam over much wider areas than they do in Belgium.

That problem might be overcome if researchers can find a less extreme myostatin mutation or identify another gene with a less drastic influence on muscle mass, allowing the calves to be delivered naturally. But there are also worries about whether the public would accept genetically engineered beef. The cattle industry has until now shied away from funding research into transgenic animals for human consumption. "They perceive it as too sensitive and risky an area," Smith says.

Another possibility would be to find some drug that can turn down myostatin activity in animals with the normal gene. And then there may be other genes that can be manipulated. Researchers in at least four countries are mapping the cattle genome, and reproductive physiologist Vernon Pursel of the USDA research labs in Beltsville, Maryland, says "we are getting to the point where there will be a number of genes" like myostatin identified in the near future. Extra helpings of tasty meat at essentially no cost could prove hard to resist.

–**Steven Dickman**

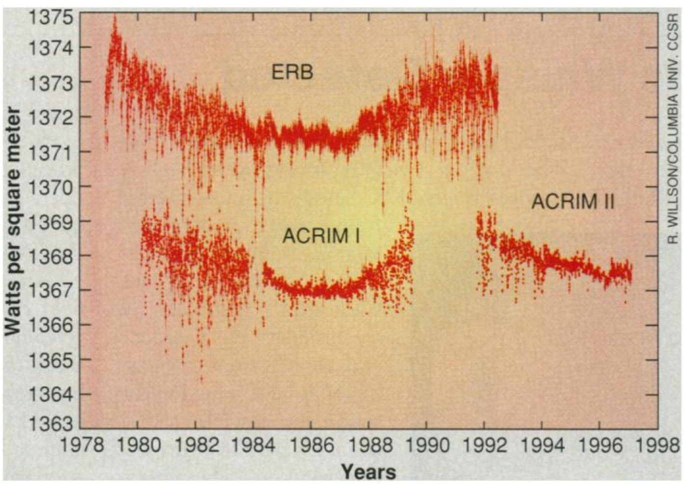
Steven Dickman is a writer in Cambridge, Massachusetts.

CLIMATE

Did Satellites Spot a Brightening Sun?

In the debate over whether greenhouse warming has arrived and just how bad it will get, the sun has been a relatively minor player. But even a tiny dimming of the sun—the climate system's sole energy source—could greatly slow any warming due to greenhouse gases, while a slight brightening could worsen what might already be a bad situation. Unfortunately, the longest running direct observations of the sun have been too short to say whether its brightness actually varies over the decades needed to influence climate. But by splicing together separate satellite records, an atmospheric physicist has constructed a record long enough to suggest a striking trend: a strong recent brightening.

On page 1963 of this issue of *Science*, Richard Willson presents his analysis of observations by three satellite-borne sensors that together have monitored solar brightness since 1978. Willson, from the Altadena (California) branch of Columbia University's Center for Climate Systems Research, finds enough brightening to make the sun a major player in climate change, if the change signals a long-term trend. But his finding is controversial. While some analyses of the same data being prepared for publication support Willson's finding, others do not.



Solar ups and downs. The long-running ERB sensor on Nimbus 7 bridges the gap between the ACRIM sensors on UARS.

The central question is the reliability of one of the three records. Willson's analysis, which used a less sophisticated sensor to tie together an interrupted record, "seems quite reasonable," says Lee Kyle of NASA's Goddard Space Flight Center in Greenbelt, Maryland, whose instrument produced the linking data set. "I think Willson is correct in saying the best evidence shows an increase. How strong that evidence is, is another matter." Some say it is not strong at all. "I think we are not able to do it at this point," says Claus Frohlich of the World Radiation Center in Davos, Switzerland. "We just don't know."

To identify a long-term trend in solar brightness, or total solar irradiance (TSI), researchers need a record that spans at least one solar cycle—the 11-year cycle over which sunspots spread across the face of the sun and then vanish, with a corresponding rise and fall in the sun's brightness. The orbiting Active Cavity Radiometer Irradiance Monitor (ACRIM I) provided part of the necessary record from 1980 to 1989, showing that TSI fell 0.08% during the declining solar activity of an 11-year sunspot cycle. That's a sizable change, but too brief to overcome the climate system's inertia.

The space shuttle was supposed to launch a second instrument while the first was still operating, so that researchers could compare the readings from the two identical instruments and correct them to construct a seamless record. But the Challenger accident delayed the Upper Atmosphere Research Satellite launch by several years and opened a 2-year gap between ACRIM I, whose satellite failed in 1989, and the arrival of ACRIM II, which was finally launched in 1991.

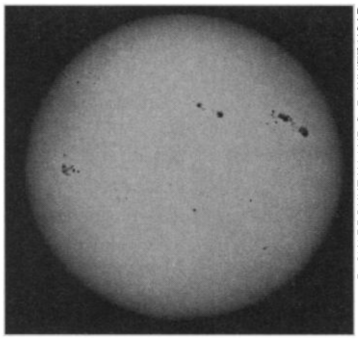
Lacking such a comparison, Willson and other researchers have bridged the gap with a less capable instrument, the Earth Radiation Budget (ERB) experiment on the Nimbus 7 spacecraft. When Willson combined the records, he found a brightening of 0.036% per decade from 1986 to 1996. That brightening, if sustained for many decades, would lead to solar warming in a league with greenhouse warming in the next century. The current best estimate for greenhouse warming at the end of the next century is 2.0 degrees Celsius, while such a solar brightening sustained for 100 years might produce a warming of about 0.4°C, says Willson.

But the strategy of relying on ERB to bridge the two ACRIM records leaves room for doubt. ERB cannot monitor how much its collecting surface has been degraded by the harsh solar glare, as ACRIMs can. However, ERB made less frequent measurements, probably minimizing its degradation during the 2-year gap, say its operators, Kyle and Douglas Hoyt, who is now at Hughes STX in Greenbelt. They did correct the ERB record after finding a jump in measured TSI that they attributed to a one-time shift in the sensitivity of the instrument.

Yet the results conflict with some other studies. Solar physicist Judith Lean of the Naval Research Laboratory in Washington, D.C., has made indirect estimates of long-term brightness changes based on the shifting balance between dark sunspots and relatively bright areas on the sun, called faculae and network. That is the process that explains much of the brightness variation within a solar cycle. Based on past sunspot records, she estimated that TSI has increased over the past 300 years at an average rate of only 0.008% per decade, less than one-quarter Willson's observed rate (*Science*, 8 March 1996, p. 1360). In fact, Lean inferred that the brightening of the sun over the past few decades has been negligible.

"That doesn't mean [Willson's finding] is wrong," Lean says, but it does mean that something other than changes in sunspots and faculae would be needed to produce the greater variability. But Willson is not worried about being forced to think about new mechanisms. Lean's dark-bright mechanism "works in a part of the solar cycle," says Willson, "but it doesn't work as well during solar maximum or minimum." To him, that suggests something apart from Lean's mechanism is also varying brightness within a solar cycle.

More worrying to some researchers are two studies, each of which claims to have found additional jumps in the ERB record that Kyle and Hoyt missed. The two studies—published within the past 2 years by Robert Lee of NASA's Langley Research Center in Hampton, Virginia, and his colleagues and by Gary Chapman of California State University in Northridge and his colleagues—use multiple proxies for TSI, such as solar radio emissions and the area encompassed by sunspots, faculae, and network. They then searched the ERB record for jumps that did not appear in the proxy records. Each group, although using a different mix of proxies and different data sets, identified similar spurious discontinuities in the ERB record at about the same times during the gap. If these two discontinuities are used to correct the ERB record, Willson's brightening trend would fade to near zero.



P. CHARBONNEAU AND O. R. WHITE/NCAR

An imperfect sun. Sunspots help modulate the sun's brightness.

"I can get either result, depending on how I do it," says solar physicist Dick White of the National Center for Atmospheric Research (NCAR) in Boulder, Colorado. His initial analysis of the ACRIM and ERB data with Werner Mende of the Free University of Berlin gave "basically the same result as Dick [Willson] got," says White.

Lee's proxies had not seemed directly enough linked to TSI to warrant the additional corrections, says White, but 2 weeks ago at a meeting, Lean and Chapman made him aware for the first time of the full implications of Chapman's 1996 paper. White was impressed by the more direct connection between Chapman's proxies and TSI. Now, after using the proxies to correct the ERB record, White thinks "the final conclusion will be that the TSI has changed by less than" a fifth of the value reported by Willson.

But Willson, who became aware of the implications of the Chapman paper only last week, isn't persuaded. "ACRIM data are fundamental physical measurements," he says. Correlating proxies to TSI "is a statistical construct, not physics. I don't think this kind of analysis can give you precise insight into a subtle trend like this." The proxy indices have not been measured as precisely as TSI has, says Willson, and the physical relation of TSI to the kinds of solar activity reflected in the indices is not well understood. "When people tell me these statistical indices are better than the observations, I just can't see it. This is a classic difference between experimentalists and theoreticians," he says.

A middle ground in the debate may be emerging, however. After analyzing the combined ACRIM/ERB data and including the additional corrections, Frohlich finds no brightening. But that doesn't make him a critic of Willson, either: "I'm not saying one or the other is correct; we're just doing things differently." What is needed, says Frohlich, is ACRIM-type instruments that could span two solar minima. But that means researchers will have to wait at least another decade before deciphering the sun's role in global change.

–Richard A. Kerr

PLANETARY SCIENCE

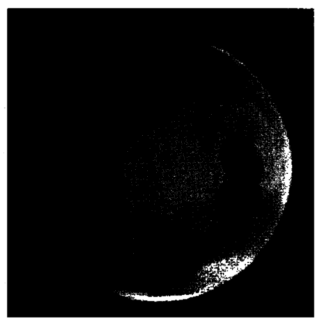
Martian Magnetic Whisper Detected

Planetary scientists knew that Mars was no magnetic powerhouse, but for decades they have been frustrated in their efforts either to write it off as magnetically inert like Venus or active like Mercury and Earth. Last week, the Mars Global Surveyor provided the long-sought answer during one of its first low passes over the planet.

"It looks like strong evidence for a planetary magnetic field," says space physicist Mario Acuña of NASA's Goddard Space Flight Center in Greenbelt, Maryland, who is the principal investigator for Surveyor's magnetometer. Previous missions to Mars carried magnetometers that weren't sensitive enough to pick up the field, met with disasters like the 1993 loss of Mars Observer, or, like the 1989 Russian Phobos spacecraft, did not pass close enough to the planet, says Acuña.

P. JAMES/UNIV. OF TOLEDO & S. LEE/UNIV. OF COLORADO/NASA/HST

But Surveyor's discovery came with a puzzle: At about 1/800 the strength of Earth's field, Mars's magnetism is surprisingly strong. That's about twice as strong as researchers thought it could be based on limits inferred from Russian missions, says Acuña. Planetary physicist David Stevenson of the California Institute of Technology in Pasadena adds that "it's not that easy to get as large a field as the spacecraft has found." Indeed, it's hard to figure out how Mars could be generating any field, let alone one of the strength that Surveyor has detected.



Magnetic after all. Mars proves to be magnetic but still mysterious.

Theoreticians assume that Mars is too small to have retained the internal heat needed to drive an Earth-like magnetic dynamo, in which the churning of a molten-iron core produces electrical currents and thus the magnetic field. If Mars ever had an Earth-like dynamo, says Stevenson, it's likely it has turned off. Stevenson has speculated that Mercury's field might be generated thermoelectrically, as in some batteries, if temperature differences across an iron core and rocky mantle could produce a closed electrical circuit. The same process might be at work in Mars, he suggests. Even so, some sort of dynamo would be required to enlarge the internal field into one detectable above the planet.

Another possibility is that Mars imprinted a field on its crustal rock before the planet's geodynamo wound down, and Surveyor is picking up those imprints. Remnant magnetism has been reported in meteorites from Mars, including ALH84001 with its putative evidence of ancient life. (Indeed, if Mars did have an early, strong field, it might have fended off cosmic rays deleterious to life.) But "it's hard to imagine how you would build up a large, coherent field" from remnant magnetization, says Stevenson. Earth's moon, for example, has remnant magnetism frozen into lavas when they solidified, but it's patchy and doesn't add up to a global field.

Surveyor will map the field in detail as it settles into orbit around the planet, and its observations could "sort out whether it is a remnant crustal field or a dying dynamo," says Acuña. "We have a long way to go."

–Richard A. Kerr