METEOROLOGY

A Fickle Sun Could Be Altering Earth's Climate After All

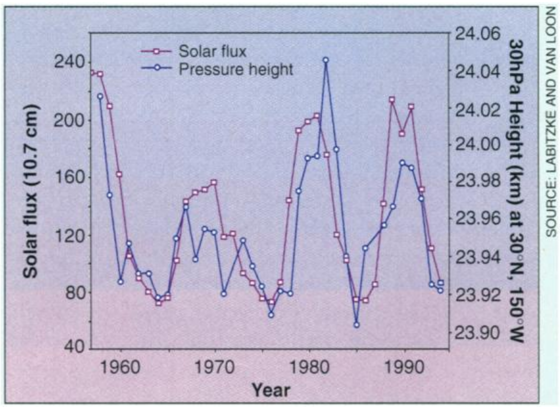
No, there's still little evidence that a brightening sun drove the last century's global warming, as some greenhouse skeptics argue. But the decades-long effort to link slight fluctuations in solar output with climate on Earth may finally have a shot at succeeding. Proposed sun-climate correlations have come and gone, but at last one has gotten stronger, not weaker, with time: A cycle of temperature changes in much of the middle and lower atmosphere that matches the 11-year sunspot cycle, first reported in 1987 over the North Pole, now seems to hold sway over much of the Northern Hemisphere.

And at last month's meeting of the International Union of Geodesy and Geophysics (IUGG) in Boulder, Colorado, climate modelers added more credibility to the connection. There they unveiled results from computer models of the atmosphere showing how the small changes in the intensity of solar radiation over the sunspot cycle might be responsible for the observed changes. Comments meteorologist Timothy Dunkerton of Northwest Research Associates Inc. in Bellevue, Washington: "I'm still a little skeptical [of the sun-climate connection], but it's intriguing."

The news marks a new upturn for a claim that has had a roller-coaster career. In 1987 Karin Labitzke of the Free University of Berlin reported that in records of atmospheric pressure over the North Pole extending back to 1958, the altitude at which a given pressure is found has been rising and falling in time with the cycling of solar radiation. Driving the polar pressure cycle is a temperature oscillation of a few degrees in the lower stratosphere and below. Labitzke and Harry van Loon of the National Center for Atmospheric Research, who joined her in the work, later found out that the temperature also oscillates elsewhere over the hemisphere, and in places the changes are felt all the way down to the surface, chilling Charleston, South Carolina, for example, by several degrees at solar maximum.

Unfortunately, Labitzke and van Loon could only show the polar correlation when the record was subdivided according to the phase of the so-called quasi-biennial oscillation (QBO), a roughly 13-month cycle in which stratospheric winds over the equator switch direction from east to west and back (*Science*, 11 May 1990, p. 684). That weakened the statistical significance of the oscillation and thus undermined many researchers' confidence in the sun-climate connection. And the doubts grew stronger after the U.S. Weather Service used an extrapolation of Labitzke and van Loon's oscillation in its long-range seasonal forecasts, only to see the oscillation break down 2 years in a row.

Since then, van Loon and Labitzke have given up the pursuit of sun-climate cycles at the surface and set aside the role of the QBO as a polar oddity. With more analysis of weather balloon data gathered all around the northern hemisphere, however, they have identified a middle-atmosphere cycle that the pair has dubbed the Ten-to-Twelve-Year Oscillation, or TTO. It is the same oscillation Labitzke first identified at the North Pole during the east phase of the QBO and is strongest in a crescent-shaped band in midlatitudes extending from the Middle East across the Mediterranean, the North Atlantic, North America, and the entire Pacific. There it accounts for as much as 50% of climatic variability in the upper troposphere and stratosphere, the pair reported last year. They also reported that the cycle affects the intensity of the global Hadley circulation, in which moist, warm air rises over the equator, spawning thunderstorms, then flows north and south and sinks toward the surface in the subtropics.



Coincidence or causation? Climate in the middle atmosphere (as traced by pressure changes) has followed the solar cycle (traced by radio emissions) for 37 years.

Since then, Labitzke and van Loon have extended their data set from 1958 up to last month—long enough to span nearly four solar cycles—with the same results. "The last cycle falls after we came out with [the correlation] initially, and things fared very well," says van Loon. "You might say it's an independent sample."

Correlation, of course, does not prove causation. But computer simulations run by Joanna Haigh of Imperial College in London have suggested a mechanism. "I'm able to simulate some of the features Labitzke and van Loon have seen," says Haigh, who reported her results at the IUGG meeting. To see how small changes in sunlight might drive these sizable climate changes, Haigh linked two models. The first model, which can simulate the effects of chemical changes on the atmosphere, showed that the 1% increase in ultraviolet radiation known to accompany the maximum in the 11-year sunspot cycle could generate 1% to 2% more stratospheric ozone. The ozone, in turn, could absorb more sunlight, warming the stratosphere and altering the warming of the troposphere by different amounts at different latitudes. But that is not the end of the chain.

Inserted into the next model, a three-dimensional climate model, this stratospheric warming redirected stratospheric winds and altered the travel of the atmospheric waves that carry energy from place to place in the atmosphere. Taken together, these changes in the model intensify the Hadley circulation, matching the findings Labitzke and van Loon reported last year. And, reproducing a climate shift at solar maximum that other researchers have reported, the model's intensified Hadley circulation also pushed storm tracks in midlatitudes northward.

Another pair of modelers, David Rind of the Goddard Institute for Space Studies in New York City and Nambath Balachandran of Columbia University, found that the solar cycle may also explain the QBO-dependent cycling Labitzke first detected. Rind and Balachandran had to force a QBO into existence, as no model has yet freely simulated a good one, and they exaggerated the 11-year variation in ultraviolet. But the results are "very interesting and intriguing" anyway, says Marvin Geller of the State University of New York, Stony Brook.

Geller and others caution that it would take a longer record of the TTO and much more modeling before atmospheric scientists would be ready to add the sun-climate connection to the textbooks. But with mysteries still lingering behind the warming of the past century and the chill of the 17th century's Little Ice Age, when solar activity hit rock bottom, there's plenty of incentive to get into the fickle field of sun-climate relations. The latest results may be just what it takes to ensure that van Loon and Labitzke have some company as they monitor the next sunspot cycle.

–Richard A. Kerr

Additional Reading

H. van Loon and K. Labitzke, "The 10–12-year atmospheric oscillation," *Meteorol. Zeitschrift* **3**, 259 (1994).