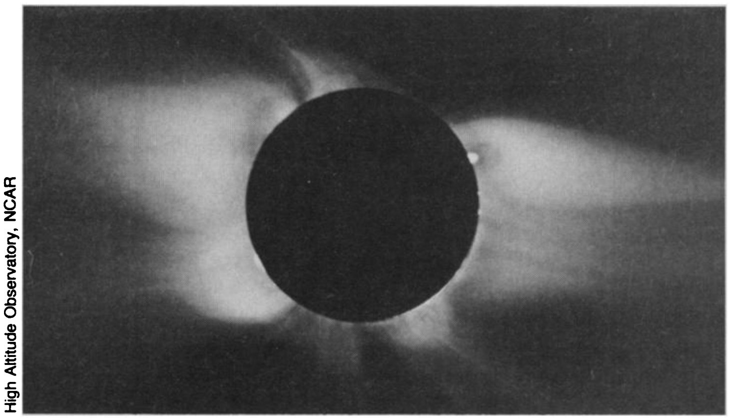
Sunspot-Weather Link Is Down But Not Out

The winter of 1989 has delivered a serious blow to an apparent connection between activity on the sun and the weather on Earth

Greenbelt, Maryland

WHEN RESEARCHERS A FEW YEARS AGO uncovered a strong link between the sunspot cycle and weather patterns on Earth, many atmospheric scientists were intrigued. Indeed, the correlation seemed so convincing that a few meteorologists even began to plug solar activity into official U.S. long-range forecasts. But the whole notion has taken a severe battering over the past year. It may have a tough time recovering.

Many skeptics, in fact, have always said that the postulated correlation was not as firm as it seemed. For starters, they pointed out that it could only be traced back 40 years, which struck them as too short a record to be convincing. On top of that, solar activity seemed to affect weather patterns one way when winds in the stratosphere above the equator were blowing in a westerly direction and another way when they were easterly; statistically speaking, that effectively halved an already short record. And most disturbing was the absence of any physical mechanism to explain such behavior. But the skeptics have nevertheless had a hard time disproving the link, which had withstood every statistical test—until the winter of 1989.



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A weather maker? *It now looks more complicated, but something from the sun (seen here in eclipse) seems to be affecting Earth's weather.*

According to the supposed correlation, heavy sunspot activity last year, coupled with stratospheric westerlies in the tropics, should have brought an exceptionally cold winter to the east-central United States. Instead, the exact opposite occurred, obliterating the statistical significance of the westerly half of the correlation. The skeptics, it seemed, had been proved right.

But some meteorologists are not yet willing to throw out the evidence of the past four decades because of one bad year. "The jury is still out on the 11-year solar effect. We're going to have to wait longer," meteorologist Anthony Barnston told the NASA Conference on the Climate Impact of Solar Variability last month.

One reason Barnston isn't throwing in the towel just yet is that he thinks he knows at least part of the reason the winter of 1989 was such a bust: The impact of solar activity on weather patterns last year was swamped by the effects of the El Niño cycle, he believes. Indeed, Barnston and his colleague Robert Livezey, who both work at the National Weather Service's Climate Analysis Center (CAC) in Camp Springs, Maryland, have sifted through the records of El Niño, sunspot activity, and stratospheric winds and have concluded that a weak sun-weather link may still be valid.

Their conclusion supports the correlations first put forward in 1987 by Karin Labitzke of the Free University in Berlin and Harry van Loon of the National Center for Atmospheric Research in Boulder, Colorado (*Science*, 23 October 1987, p. 479). Labitzke and van Loon are the latest in a long line of researchers to postulate a link between the 11-year solar cycle and weather patterns. But unlike previous claimants, whose theories could not withstand close examination or were soon contradicted by events, their data seemed solid.

Solid looking it may have been, but Labitzke and van Loon's proposed link was nonetheless bizarre. They contended that the sun's effect had been there in the weather record all along, but it had been muddled beyond recognition. Almost as if waving a magic wand, they unmuddled the relation between solar activity and weather by taking into account, of all things, the direction winds were blowing in the lower stratosphere. These east-west winds reverse every 1 to 1.5 years in a phenomenon called the quasi-biennial oscillation or QBO.

For example, the January-February temperature in Charleston, South Carolina, bore no obvious relation to sunspots until Labitzke and van Loon considered only the winters in which the QBO was in its west phase. Then Charleston's winter temperatures could be seen to have swung up at minima of the sunspot cycle and down at maxima. The difference between solar maxima and minima could mean a severe winter or a mild one for Charleston and the east-central United States.

The east-central United States was not alone in feeling the effects of solar variability, Labitzke and van Loon claimed. Other isolated regions around the globe waxed warmer or colder than normal depending on the level of solar activity. Some responded during the west phase of the QBO, but others responded during the east phase.

Barnston and Livezey were intrigued. They had debunked their share of proposed weather correlations, but according to Labitzke and van Loon's statistics, this one was exceptionally strong. If it held up, it could much improve the CAC's 30- to 90-day weather forecasts. Barnston and Livezey did their best to shoot it down, but it appeared to pass the test (*Science*, 25 November 1988, p. 1124), so they prepared to include it in CAC's forecasting procedures.

Then the disaster of the winter of 1989 struck. What went wrong? Apparently, the weather effects of the El Niño cycle and those of the solar cycle ran into each other head-on and El Niño won. The tropical Pacific was deep in its cold or La Niña phase of the cycle at the time. As was well known by then, La Niña reaches around the globe to bring about changes in the weather opposite to those of the warm El Niño. In hindsight, Barnston and Livezey can see that over and around North America La Niña's effects during westerly QBO winds work against those of high solar activity, but in this case La Niña appears to be something like two to three times stronger. Solar activity didn't have a chance.

The two CAC researchers never saw the collapse of the sun-weather relation coming because never before in the 40 years of observations since the record of the QBO began had a strong La Niña, a solar maximum, and a west-phase QBO coincided. That points up the shortness of the record that skeptics had warned about. Asking how the solar influence might fare in the face of

La Niña "should have been an obvious question," concedes Livezey, "but we just didn't notice. We were so wrapped up in analyzing the signal itself that we didn't consider what would happen."

Barnston and Livezey have now sorted out the roles of QBO winds, the sun, and the El Niño cycle. It turns out that part of the strength of the west-phase correlation was actually El Niño at work.

The sun-weather relation "is shaky in the lower atmosphere," Barnston says. But there is still a detectable solar effect during the west phase of the QBO that may be "worthwhile" in long-range forecasting, he says. It can explain perhaps 15% of the variability of winter temperatures and pressure patterns from year to year even after including the disastrous 1989 case. That's far less than the 50% that it seemed to explain before; forecasters might do better to ignore the sun-weather connection when they think it will be swamped by the El Niño effect.

Barnston sees other causes for guarded optimism about the utility of sun-weather relations in forecasting. The other half of the proposed sun-QBO-weather relation, the one that applies to the QBO's east phase, held up nicely during the winter of 1990. And in the stratosphere, the relation has held during both phases, even in 1989.

Meanwhile, the skeptics are as skeptical as ever, if not more so. When new rules are made up in this sort of game, such as bringing in El Niño, "the statistical rules in the textbooks don't work and can be very misleading," says meteorologist John Wallace of the University of Washington. He wants to wait until all the rules that determine the apparent strength of the correlation are fixed before he starts crediting new observations as supporting it.

The skeptics may be right, but proving them wrong could take a generation or longer. Unless defenders of the theory suddenly discover a mechanism by which the sun affects the weather, which doesn't seem to be in the cards just now, they would need to gather data for another 20 years—for a total of six solar cycles—to meet the traditional standards of verification. Alternatively, researchers are attempting to push the record of QBO winds and sun-related weather variations back before 1950.

For now, Labitzke remains confident. "We are still convinced that we have something here," she says. The next test of that confidence comes this winter when the sun and, if it actually makes an appearance, El Niño should work together, not in opposite directions as in 1989. "If we don't get the expected pattern," notes Livezey, "we're going to have to do a serious reconsideration of all this." ■ Richard A. Kerr

"Superantigens" May Shed Light on Immune Puzzle

Bacterial toxins may illuminate why the immune system responds to some antigens but not others

The bacteria and viruses that cause disease can sometimes be extremely creative in finding ways to escape the defenses of the hosts they infect. In fact, they can be so creative that sometimes they stump not only the immune system but also the researchers who attempt to figure how their escape mechanisms operate. That was the case for decades with the toxins produced by some of humanity's most serious pathogens, the staphylococcal and streptococcal bacteria that cause toxic and septic shock, food poisoning, and autoimmune diseases such as rheumatic fever.

Superspeculation. *Philippa Marrack and John Kappler theorize about the role of superantigens in evolution.*

The picture was puzzling partly because immunologists knew that the toxins trigger a paradoxical response in the infected organism: a gross overstimulation of the immune system and, at the same time, a profound immunosuppression. That is, the immune system operates in overdrive, but fails to respond to the invaders.

What the immunologists didn't understand was how this paradox was accomplished at the molecular level. But in the past year or so, they have finally begun solving the problem—at least on the overstimulation side. In so doing they have also come up with some deep evolutionary speculations about the functions of the bacterial toxins and about one of the fundamental mysteries of immunology: why the immune system responds to some antigens and ignores others.

On page 705 of this issue, Philippa Marrack and John Kappler, both of the Howard Hughes Medical Institute and the National Jewish Center for Immunology and Respiratory Medicine in Denver, outline the developments that have led up to this new understanding. At the heart of the matter are surprising observations, made over the past few years in their lab and others, that the bacterial toxins act very much like mysterious immune molecules discovered nearly 20 years ago by Hilliard Festenstein of London Hospital Medical College.

Festenstein discovered those molecules—known as minor lymphocyte stimulating (Mls) antigens—when he mixed lymphocytes from two different mouse strains. Both sets carried the same major histocompatibility complex (MHC) proteins: cell surface proteins that play a key role in triggering immune cell activation. Hence, the cells should have been immunologically compatible and not reacted with one another. But they did: the mixture stimulated the proliferation of one type of lymphocyte, the T cell. Festenstein therefore inferred the existence of a second kind of antigen, which he called "minor" to distinguish it from the MHC proteins.

But what class of molecule might the Mls antigens be? And what might their function be? To this day, neither question has been answered definitively. Most immunologists, however, think the antigens are proteins, and the recent toxin work may provide clues to their function.

As early as the 1970s some similarities had been noted between Mls antigens and the bacterial toxins. Immunologists knew that both types of molecule stimulate massive T cell proliferation against a broad range of antigens. Each group of T cells responds only to specific antigens, a specificity that is mediated by the T cell receptor. Ordinary immune reactions are very specific, stimulating the proliferation of only a fraction of 1% of all T cells. In contrast, the bacterial toxins and Mls antigens can activate as many as 10% of the mouse's T cell repertoire. The range of the response prompted Marrack and Kappler to suggest the name "superantigens" for molecules like the toxins.