The sun and weather: 'Things are popping'

It wasn't long ago that the subject of connections between solar variability and the weather on earth was considered not quite respectable. This was with some justification, notes Walter Orr Roberts, who says that during the past century and a half the field of research on such short-term connections has produced "many papers of great complexity and dubious quality." Until recently, he says, the empirical connections proposed were on extremely shaky ground.

Yet, as Roberts puts it, "Things are beginning to pop in this whole field." As reports presented by him and others at the American Geophysical Union meeting in San Francisco show (SN: 12/17/77, p. 404), more and more signs of connections are turning up. He cautions that you can't claim a connection until you have a physical mechanism to explain it. "Yet a number of lines of research show bona fide promise."

John M. Wilcox of Stanford University and colleagues have shown that the amount of vorticity in the earth's atmosphere over the Northern Hemisphere drops one day after passage of a solar sector boundary past the earth. As the sun rotates in its 27-day cycle, four sectors of the interplanetary magnetic field are, in effect, carried around with it. Adjacent sectors have opposite polarity (magnetized either toward the sun or away from the sun). A boundary between solar sectors thus sweeps across the earth about every seven days, and it is this passage that Wilcox has shown to be statistically correlated with reduced vorticity. Vorticity is a measure of the amount of large-scale rotation in the atmosphere. With increased vorticity, storm systems deepen, extend farther south and carry more moisture.

The association discovered by Wilcox has been independently confirmed, says Roberts, by Colin Hines, using far more sophisticated analysis techniques. It shows the same signature effect. "These results suggest very, very strongly that there is a real association here," says Roberts.

Roberts and colleague R. H. Olson, now both at the Aspen Institute of Humanistic Studies in Boulder, had found in examination of weather maps for 1953 that low-pressure troughs over the Gulf of Alaska, which affect weather across North America, were more intense after sun-caused geomagnetic disturbances.

Now P. B. Duffy (a Harvard senior who researched the problem this summer at Stanford), Wilcox, Roberts and Olson have shown that the size of such troughs seems to be influenced by the polarity of the solar sector the earth is in. The analysis shows that during all but two winters from 1950 through 1973 the area of these low-pressure troughs was 15 percent larger when the polarity of the interplanetary magnetic field was away from the sun on the day the troughs were formed. This larger-than-usual size persisted throughout the entire 12-day lifetime of the troughs.

Many physical quantities vary with the interplanetary magnetic polarity (the solar sector structure), and it is not known yet which of them may be involved in the physical mechanism of this effect.

Other studies have shown that the accuracy of standard 24-hour weather forecasts takes a dip after passage of a solar sector boundary, indicating that something affects the weather. And yet, Roberts laments, none of these effects are incorporated into any forecasting models.

"Just think," says Roberts. "What if we could predict that one out of five low-pressure storm systems would sweep 200 miles farther south [than they ordinarily would due to increased vorticity]. Two hundred miles is a big difference. That affects a lot of people."

On an important longer scale, Charles W. Stockton of the University of Arizona described the tree-ring data analyzed by him, J. Murray Mitchell and David M. Meko. They examined the extent of drought and found an apparent 20-year periodicity in major drought occurrence since the year 1700. The maximum drought area appears to occur an average of two years following a sunspot minimum.

Other reports at the AGU meeting noted a variety of possible shorter-term associations between solar variability and weather. John R. Herman of the Radio Science Co. described evidence that global thunderstorm activity increases following solar flare eruptions, and said that he sees evidence that the frequency of thunderstorms is associated with crossings of the solar sector boundary. Herman also showed a statistical correlation between thunderstorm occurrence and the 11-year sunspot cycle. He proposed several direct or indirect possible physical explanations.

J.W. Follin of Johns Hopkins University proposed a mechanism whereby cosmic rays can trigger the initiation and control the development of lightning in thunderstorms. He reported evidence for such a mechanism in the correlation of cosmic ray statistics and a variety of measurements of lightning characteristics.

And R. H. Holzworth of the University of California at Berkeley elaborated on his previous report (SN: 6/18/77, p. 388) of the first direct observation of solar-flare modification of thunderstorm-driven electric fields, following the enormous Aug. 4, 1972, solar flare. The flare's arrival was immediately followed by a dramatic world increase in very-low-frequency whistlers, which are generated by lightning and therefore related to thunderstorms.

Most of the newly identified associations of solar variability and weather, says Roberts, come from our "fantastic increase in knowledge of magnetic fields, particles and all the things coming from the sun" resulting from our ability to directly measure changing physical properties in space with satellites. It is this new ability, coupled with the slowly increasing understanding of the atmosphere itself that has finally opened up the possibility of understanding how the sun affects weather on earth, he says. □

Chemical producers must report to EPA

Under an order announced Dec. 22, the nation's 5,400 chemical companies and petroleum refiners must notify the Environmental Protection Agency by May 1 about what chemicals and petroleum products they made during 1977. This is the first time the federal government has asked them to do so. These "inventory reporting rules," are designed to "put an end to haphazard gambling with untested chemicals," says EPA's administrator, Douglas Costle. "By itself, this may not sound like much — a block-long laundry list of unpronounceable chemical names. But what we learn about the production activity of the chemical industry is crucial in deciding where toxic problems might exist and what other steps may be needed to carry out the [Toxic Substances Control] act," Costle said.

In addition, companies with more than $5 million in 1977 chemical sales must inform EPA of the quantities of chemicals they produced and where. Costle says the inventory "is as important for what it doesn't say as what it does," because "under the toxics law, 30 days after the inventory is published, a chemical producer wishing to make a substance not listed must notify EPA of this fact" with 90-day lead time. "We can then make a judgment from existing information as to whether the chemical appears safe for manufacture or whether additional health-effects testing is needed, or whether it appears too hazardous to allow production under any circumstances," he says.

Costle says the inventory will also help EPA decide where it and other regulatory bodies "should concentrate their studies of people and the environment for possible contamination." It may also help to rapidly pinpoint the source of emergency chemical spills, he says.

There are 70,000 chemicals now in use and another three to four million under research and development. Firms affected by the new rules include producers of acids, alkalies, and organic chemicals; plastics and synthetic fibers; dry colors and pigments; soaps and detergents; paints and fertilizers; and petroleum refiners and producers of gasoline, oils, lubricants and petroleum chemicals. □