Susan West reports from the "Solar-Terrestrial Influences on Weather and Climate" symposium at Ohio State University

Intruding stratosphere

Very intense low pressure areas may pull down the stratosphere as they form. In some instances, especially near the jet stream, the sudden intensification of lows can cause sinking of the troposphere (the atmospheric layer containing our weather) in the north, rising in the south and a short-lived "fold" in the troposphere which traps the lowering stratospheric air. The phenomena are called stratospheric intrusions. Their highly complex formation involves intensified circulation patterns.

Since 1973, researchers atop a three-kilometer mountain in Germany have recorded an estimated 40 percent increase in stratospheric intrusions two to three days following a solar flare. Reinhold Reiter and co-workers from the Institute for Atmospheric Environmental Research of the Fraunhofer Society in Garmisch-Partenkirchen detected the intrusions by an increase in recorded Be_7, which is produced in the stratosphere by absorption of cosmic rays and carried down with an intrusion.

In addition, Reiter told the meeting, intrusions are coupled with a decrease in detected cosmic rays (which can be blocked or deflected by high solar activity) and a rise in lower stratospheric ozone concentration at the time of solar flares. Reiter proposes a link between the blocking of cosmic rays and increased intrusions. A decrease in absorbed cosmic rays reduces nitric oxide production in the stratosphere. This in turn increases production of ozone. Reiter and other researchers believe that increased ozone, through absorption of ultraviolet, may heat the lower stratosphere. If this occurs, it can set up the intensified circulation necessary to create an intrusion, Reiter said.

Drought-solar link

An association between recurrent droughts and the 22-year double, or Hale, sunspot cycle has been studied for several years (SN: 2/28/76, p. 134). Work by Murray Mitchell of the National Oceanic and Atmospheric Administration and Charles Stockton and David M. Meko of the University of Arizona using tree ring data from 40 to 65 sites west of the Mississippi indicated that in the western United States the total area affected by drought from 1700 to 1962 fluctuated with a 22-year cycle, suggesting a relationship to the sunspot cycle.

Recent refinements reported by Mitchell at the meeting strengthen that link. Extensive statistical tests have verified the significance of the drought cycle and shown that the drought and sunspot cycles are locked in phase. In addition, the extent of drought seems to be modified by the strength of the sunspot cycle. During a weak sunspot cycle (a cycle having fewer total sunspots) the maximum drought area coincides with the sunspot minimum — the lowest number of sunspots. During a strong sunspot cycle, the maximum drought area occurs two to three years after the sunspot minimum. The responsible solar activity—which is conveniently tracked using the sunspot cycle—therefore must occur two years before the sunspot minimum during weak cycles, Mitchell says.

Based on data presented by H. H. Sargent of the Space Environment Data Service in Boulder, Colo., Mitchell says the activity responsible may be the occurrence of coronal holes. Sargent's data indicate that long-term geomagnetic activity, found to be related to coronal holes (SN: 4/22/78, p. 252), fluctuates with an amplitude and rhythm similar to the drought cycle. Mitchell says he is "somewhat unnerved" by the data, and he hesitates to make any drought predictions until more long-term data can be accumulated for other regions. Whatever the causal link and mechanism, Mitchell sees solar activity as a modifier rather than a direct cause of drought—"It makes the bed more comfortable or uncomfortable for drought to proceed."

Drought signature

The role of solar influences in drought can be illuminated by studying droughts' meterological characteristics, according to Jerome Namias of Scripps Institution of Oceanography. Studies of the 1976/1977 West Coast drought, the 1972 Russian drought, the 1976 British drought, the 1952 to 1954 Southwest drought and the 1930s Dust Bowl reveal a "drought signature" that includes:

- Sinking air (as much as 700m per day) which, by compression, produces warmer and drier air, preventing air packets from rising and condensing to form rain.
- An unusually strong high pressure cell over the drought area.
- Unusually strong "companion cells" of high pressure on either side of the continental high, usually occurring over the oceans. These companion cells sustain the continental high.

Abnormal sea surface temperatures may help form the companion cells and cause recurring droughts, Namias told the meeting. Anomalous heating or cooling of the water by various processes can create the unusual highs over the oceans. And because oceans retain heat longer than the atmosphere, they may "force" drought-inducing atmospheric conditions in later seasons.

Drought also may be prolonged by dust carried into the air which prevents cloud formation, Namias said. While not denying a possible solar influence, Namias cautioned that the search for a solar-drought link must consider all these global and local characteristics.

Constant solar constant?

The amount of energy received from the sun changes annually as the earth swings through its elliptical path—as evidenced by the change of seasons. But the sun's actual energy output—or solar constant—doesn't waver, or does it? A recently reported drop in the sun's temperature (SN: 2/25/78, p. 118) was thought to also indicate a change in solar constant, according to William C. Livingston of Kitt Peak National Observatory in Tucson, Ariz. The gradual drop, because it seemed to track with increasing sunspot activity, harbored all sorts of possibilities — a cyclic decrease in the sun's energy output might be the common denominator for observed sun-weather relationships.

But according to Livingston, since February the temperature dropped only a few more degrees and has leveled off, while sunspot activity has increased steadily. More than that, Livingston now believes that the solar constant may remain constant, but the apparent change and temperature drop may be due to a change in the sun's irradiance.

Irradiance is the distribution by wavelength of the sun's photon output. The solar constant is the total of the irradiance over all wavelengths. Livingston believes a phenomenon called line-blanketing can shift the distribution of the photon output from the blue end of the spectrum to the red, or infrared.

Line-blanketing is caused by Fraunhofer lines — energy-absorbing lines that occur most often in the blue end of the spectrum. When the lines intensify (possibly in response to the solar cycle), they block escaping energy. The energy, as heat, builds up and escapes through the other end of the spectrum — the infrared. Livingston said a one percent variation in the intensity of the lines can cause as much as a .5 percent increase in infrared output. Though the total energy output would remain the same, the shift may alter the perceived temperature of the sun. Livingston called irradiance "the prime candidate for [explaining] the sun-climate connection." But the idea remains speculation, he stresses, until satellite and ground monitoring of the solar constant and output at each wavelength provide long-term data.