Earth Sciences

Chlorine clues to quakes?

Scientists hoping to predict earthquakes have for many years been on the lookout for changes in radon levels in the soils and groundwater near faults. Indeed, high concentrations of the inert radioactive gas have often preceded seismic activity (SN: 5/5/79, p. 297). But according to Naoji Koizumi and colleagues at the Disaster Prevention Research Institute at Japan's Kyoto University, it may be easier, in practice, to monitor concentrations of other elements, especially the major chemical ions — some of which have also been loosely tagged in past studies as seismic precursors.

These ion studies, however, have been limited, so Koizumi's group set out to do a more thorough job. The researchers measured chlorine ion concentrations in a mineral spring near the Yamasaki fault in southwest Japan almost every day for seven years. During that period, eight earthquakes with magnitudes greater than 3.5 shook the region.

The scientists report in the August GEOPHYSICAL RESEARCH LETTERS that chlorine ion levels radically changed in association with these quakes, but that the character of these changes was not the same for every event. In some cases, for example, earthquakes occurred several days after chlorine levels had gradually increased and then rapidly dropped; in other cases the drop in chlorine concentrations happened during or just after quakes. Nonetheless, the researchers conclude in their paper that chlorine ion "concentration measurement at carefully chosen mineral springs along an active fault may be useful for earthquake prediction even if some problems remain to be solved in the future."

Tree ring cycles in the Corn Belt

Ten years ago, David M. Meko and Charles W. Stockton, looking at tree ring data, found that the total area of drought-stricken land in the western United States has fluctuated over the last 300 years almost in sync with the 22-year sunspot cycle. Other studies have suggested a link between rainfall, as measured by the width of tree rings, and an 18.6-year rhythm in the lunar tide. Finding such periodicities is a vital step toward understanding what triggers droughts like those that laid waste to sections of the United States in the 1930s and 1950s. Recent research, however, indicates that some of these connections are tenuous at best.

Links between climate and celestial forces are only as strong as the data used. And when Meko and Stockton, of the Laboratory of Tree-Ring Research at the University of Arizona in Tucson, did their 1975 study, they had essentially no direct information on the grain-producing regions of the Great Plains, where past droughts have taken an especially great toll. Recently, with a vastly improved data set for the Corn Belt, the researchers looked again for cyclic influences of the sun and moon on that region's climate. Together with Terence Blasing at Oak Ridge (Tenn.) National Laboratory, they examined tree rings grown from 1680 to 1980 at 15 sites in Iowa and Illinois.

They found no evidence for periodicity in the Illinois sites, the researchers report in the July 26 SCIENCE. In the Iowa data, they found an 18.33-year rhythm, which they cannot ascribe directly to either the lunar or solar cycles. Further statistical analysis, however, weakly supports their previous finding that the most severe droughts follow two years after alternate lows in the number of sunspots observed.

"These results offer more support for a solar rather than lunar cycle influence," says Meko. "But they are not conclusive." It's still possible that the moon has some subtle influence on climate and that the sun combines with other forces to trigger droughts. The new results are tantalizing, says Meko, but there are no clear-cut answers and "we are still a long way from being able to forecast drought in the western United States."

Physical Sciences

DI Herculis relates to relativity

One of the dangers of writing down a universal theory of gravity, as Einstein did with his general relativity, is that it lies open for any obscure object in the universe to detract from it. Edward F. Guinan and Frank P. Maloney of Villanova (Pa.) University now present "an apparent discrepancy with general relativity" in the motion of the binary star system DI Herculis, an eighth-magnitude (very dim) object that was not discovered until 13 years after Einstein published his theory of general relativity.

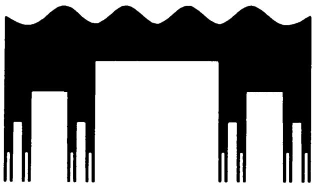
Orbital motions are the classic testing grounds of theories of gravity. Precession of the orbit of the planet Mercury determined the superiority of Einstein's theory over Newton's. Precession is a motion of the orbit as a whole: Not only does Mercury go around the orbit; at the same time the orbit itself swings around like the hand of a clock. In planets the latter motion is called precession of perihelion; in stars it is either precession of periastron or precession of apsides.

DI Herculis is an eccentric (highly elliptical) eclipsing system. Its orbit lies at such an angle that, viewed from earth, it has deep and narrow eclipses as one of the stars passes in front of the other. It is also fast, completing an orbit every 10.55 days. These characteristics make it favorable for such a test.

To calculate what the precession should be, Guinan and Maloney calculated the amount predicted by classical (Newtonian) theory as 1.93° per century, to which should be added the correction due to Einstein, which comes to 2.34° per century. The sum, 4.27° per century, is about seven times the observed precession of 0.65° per century, they report in the August ASTRONOMICAL JOURNAL.

To the rescue may come, they say, the "nonsymmetric gravity theory" of John W. Moffat of the University of Toronto (SN: 9/3/83, p. 152). Unlike Einstein's theory, Moffat's permits backward precession. The Moffat correction for DI Herculis is −1.40° per century. Combining that with the classical value yields 0.53° per century, very close to the observation.

Interfaces groove fractally


Liu/Phys. Rev. Letts.

Junctions between dissimilar substances — for example, between metal and semiconductor — are ubiquitous in electrical circuitry. An alternating current crossing such a boundary should experience the effect of a resistance and a capacitance. But to get the total impedance offered to the current, as S.H. Liu of Oak Ridge (Tenn.) National Laboratory points out, a physicist also must add in a "mysterious" constant-phase-angle element (CPA), which is somehow related to the roughness of the surface.

In a paper in the July 29 PHYSICAL REVIEW LETTERS, Liu presents an analysis of this relation on the basis of a fractal description of the shapes of such surfaces. Even polished surfaces show long lines of scratches, he points out. He describes the roughness of a given surface in terms of fractals, as a self-similar pattern of grooves within grooves (see illustration). The roughness depends on the stage to which this self-subdividing pattern is taken. Liu can then calculate the CPA from the fractal dimension of the surface, which is defined by the stage of roughness.

Such an interface contributes noise to the signal moving through the circuit. The fractal model of the interface can be represented by an equivalent circuit in which each groove is represented by a partial resistance-capacitance combination. This equivalent circuit would produce noise having the same spectrum as that observed in so-called $1/f$ noise, which is ubiquitously present in electronic circuits. In consequence, Liu suggests that $1/f$ noise originates at these interfaces.