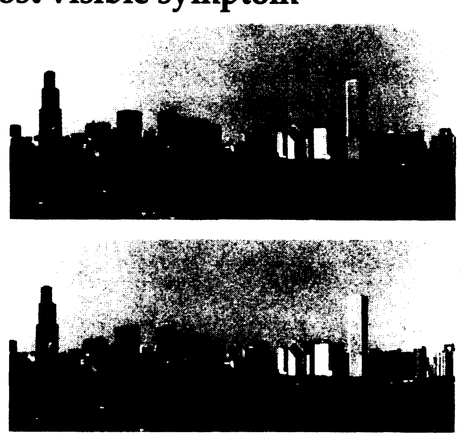
Environment

Janet Raloff reports from Hilton Head Island, S.C., at a National Acid Precipitation Assessment Program conference

Acid rain's most visible symptom



William Malm/National Park Service

On a clear day, you can see forever — or so the song goes. In reality, various light-scattering and light-absorbing factors in the air, such as gas molecules, limit the distance at which our eyes can distinguish landscape features. In dry, pristine environments, that "visual range" usually extends for about 230 kilometers; in the humid eastern and midwestern United States, the farthest one can see is about 150 km. Haze, however, currently limits the median visual range to about 150 km in the western states and to about 25 km east of the Mississippi River, says John Trijonis of Santa Fe Research Corp. in Bloomington, Minn.

About 85 percent of the current eastern haze and 50 percent of the western haze results from air-pollutant particles smaller than 2.5 microns in diameter, especially those contributing to acid rain, Trijonis and five co-workers report.

Sulfates — the leading constituents of acid rain — rob about 60 percent of the visual detail from eastern haze regions and up to 30 percent from western ones. Soot, organic particles and the nitrates formed by nitrogen oxide emissions (principally from cars) roughly match sulfates' haze contribution in western states, which burn much less coal.

The researchers took photographs in normally hazy regions on unusually clear days, then added filters to duplicate the light-robbing air pollutants now typical in those areas. A set depicting Chicago's skyline, shown here, demonstrates the visual range under hazeless conditions (top) and under today's typical conditions. Trijonis speculates that the eastern visibility improvements from the sulfur-emission controls in President Bush's clean-air legislation (SN: 6/17/89, p.375) would be "very minor," probably 15 to 20 percent.

What's the source of acid rain?

When President Carter set up the National Acid Precipitation Assessment Program (NAPAP) in 1980 (SN: 2/24/90, p.119), researchers lacked a reliable inventory assessing annual emissions of the primary pollutants responsible for acid rain. Even today, most emissions from human activities are estimated, not measured, using formulas for standard power plants and vehicles, notes Marylynn Placet, a Washington, D.C.-based policy analyst with Argonne (Ill.) National Laboratory. Nevertheless, NAPAP has now compiled "a fairly comprehensive and accurate picture" of those emission levels, she says.

The new report, coauthored by Placet, indicates that human activities in 1985 spewed 23.1 million tons of sulfur dioxide, 20.5 million tons of nitrogen oxides and 22.1 million tons of volatile organic compounds into U.S. air. That's a drop from 1970 of roughly 30 percent for sulfur dioxide and volatile organic compounds, and of 8 to 16 percent for nitrogen oxides. Large facilities, mainly electric power plants, became the major sulfur dioxide source only after 1960. Today, they produce more than 75 percent of that pollutant, though they contribute only 27 and 1 percent of the nitrogen oxides and volatile organic compounds, respectively. The Northeast emits more than 50 percent of the nation's sulfur dioxide, 39 percent of the nitrogen oxides and 40 percent of the volatile organic compounds.

Physics

Space gyroscopes for testing relativity

Scientists at Stanford University are starting to assemble a crucial experiment designed to test Einstein's general theory of relativity to an unprecedented level of precision. Known as Gravity Probe-B, the satellite-based experiment will attempt to detect two specific physical effects predicted by the theory but never before measured.

In Einstein's theory, the force of gravity is a manifestation of the curvature of space and time caused by the warping effects of concentrations of mass. For example, the Earth orbits the sun not because it's attracted to the sun but because it follows the shortest possible path in space-time distorted by the sun's mass. Although the general theory of relativity now plays a central role in astrophysics, much of the theory has never been tested or verified.

The Stanford experiment focuses on what should happen to a freely spinning gyroscope in orbit around the Earth. According to Newton's laws of motion, the axis of such a gyroscope should always stay pointed in the same direction. However, because an orbiting gyroscope would be moving through curved space-time around the Earth, Einstein's theory predicts the gyroscope should precess, or tilt, slightly as it spins. Known as the geodetic effect, the tilt would amount to 6.6 arc-seconds a year, or 360° in 200,000 years.

At the same time, the theory predicts the gyroscope should feel a second effect. As the Earth rotates, it drags space and time around with it. Just as a moving electric charge generates a magnetic field in addition to the electric field already present, the Earth's motion ought to generate a completely new kind of field — a gravitomagnetic field — different from the ordinary gravitational field surrounding a body. That effect would also cause a gyroscope to tilt. In a polar orbit the tilt due to the geodetic effect would be at a right angle to the tilt caused by the gravitomagnetic effect, making both effects detectable. However, the gravitomagnetic effect amounts to a minuscule 44 milli-arc-seconds a year.

To measure such tiny effects, the orbiting gyroscopes must be as free as possible from any interference. The satellite will contain four gyroscopes, each a ball of pure quartz 1.5 inches in diameter, ground so smoothly that deviations from roundness measure less than one-millionth of an inch. Each ball has a niobium coating, which becomes a superconductor at liquid-helium temperatures and thus permits the balls to be suspended electrically and any tilt to be measured. Jets of helium gas will set them spinning at 10,000 rotations per minute in a near-perfect vacuum.

Stanford researchers hope to test the assembled gyroscopes aboard the space shuttle in 1993 in preparation for a rocket launch three or four years later — the culmination of more than 20 years of thought and effort.

The stability of tiny diamonds

Microscopic diamonds, too small to be detected readily, may be far more common than scientists think, say researchers from the University of South Africa in Pretoria and the Los Alamos (N.M.) National Laboratory. According to their calculations, reported in the Jan. 18 NATURE, diamonds smaller than about 3 nanometers in diameter appear to be more stable than comparable hexagonal networks of carbon atoms, from which graphite forms.

These results provide an explanation for the surprising abundance of tiny diamonds in the sooty residue of explosions, indicating that simple chemical processes can create diamonds. The calculations suggest that neither high pressures nor extreme temperatures are needed to produce such small diamonds. Diamonds of a similar size are also found in meteorites (SN: 3/14/87, p.166).