Aerosols: Critical question for climate

In the 1970s, some scientists suggested that particles of air pollution called aerosols could help Earth slip into an ice age by blocking sunlight and cooling the planet's surface. But as global temperatures climbed and concern grew over the threat of greenhouse warming, most research on the aerosol-climate link entered a deep freeze. That was a major mistake, two climate experts say.

The paucity of aerosol data greatly hampers efforts to predict how growing concentrations of greenhouse gases might change the climate, assert James E. Hansen and Andrew A. Lacis of NASA's Goddard Institute for Space Studies in New York City. Pollutant aerosols might be slowing the greenhouse warming and altering rainfall patterns in certain areas of the world today, they note in the Aug. 23 NATURE.

"I think we don't know the importance that aerosols have because we don't have the data on them. That's a very important point because we're not gathering the data, either," Hansen told SCIENCE NEWS. One of the more outspoken researchers in the climate field, Hansen set politicians and the media abuzz in 1988 when he became the first leading scientist to express near-certainty that the greenhouse warming had already started.

The term aerosol refers to tiny liquid and solid particles entering the atmosphere from natural sources and from "anthropogenic" sources such as fossil-fuel combustion and the burning of plants. The highest concentrations occur in the industrialized regions of the Northern Hemisphere. Coal burning represents the major U.S. source, emitting sulfur dioxide that turns into sulfate aerosols.

Aerosols reflect sunlight back toward space, thereby cooling Earth's surface. They also cool the planet indirectly by helping water vapor condense into cloud droplets, making the clouds more reflective to sunlight. And recent experiments demonstrated that anthropogenic aerosols can also increase cloud reflectivity by inhibiting rainfall (SN: 8/12/89, p.106).

In their analysis of existing data, Hansen and Lacis calculate that anthropogenic aerosols could play a major or minor role in the climate, depending on their levels and their impact on clouds. "To some extent, aerosols must partially cancel the greenhouse effect. But we really don't know to what extent. It could be anything from zero to 50 percent," says Hansen. That means anthropogenic aerosols could exert a cooling effect about half as strong as the warming force from the buildup of greenhouse gases.

Joyce Penner of the Lawrence Livermore (Calif.) National Laboratory goes farther, suggesting that the current aerosol impact might even balance the effect of greenhouse gases. Penner told SCIENCE NEWS she bases her estimate on highly simplified computer simulations tracing the effects of aerosols from burning grasslands and tropical forests.

Hansen thinks the aerosol question is as significant as that concerning the role of clouds, often cited as the wild card in today's climate models. Other climate experts may quibble with that assertion, but they agree that aerosols inject serious uncertainty into their forecasts. Despite the unknowns, Hansen says policymakers shouldn't wait until it's too late to prevent global warming. Instead, he recommends creating programs that address the greenhouse issue and other problems at the same time. Although President Bush has endorsed this philosophy, Hansen says the administration is not doing enough to improve energy efficiency and develop alternative energy sources.

In their report, Hansen and Lacis make an appeal for efforts to monitor aerosols and to study their effects on clouds. But that appeal comes too late for the U.S. aerosol-monitoring network. The National Oceanic and Atmospheric Administration decided in June to abandon the project because of inadequate funding.

— R. Monastersky

Accelerated rise in CO_2

Atmospheric levels of carbon dioxide, a major greenhouse gas, climbed much faster in the last four years than during previous years, according to findings from some 30 stations around the globe.

Since 1986, the concentration of carbon dioxide has increased 1.71 parts per million (ppm) a year, the National Oceanic and Atmospheric Administration (NOAA) reported last week. In 1988, the level rose by more than 2 ppm—a record jump. The recent four-year growth rate represents a dramatic increase over the long-term average of 1.4 ppm for the last 15 years, says Pieter Tans of NOAA's Climate Monitoring and Diagnostics Laboratory in Boulder, Colo. The current concentration of atmospheric carbon dioxide measures about 350 ppm.

The rise stems primarily from fossil-fuel burning and tropical deforestation. But only about half of the additional gas produced each year stays in the air; the rest gets stored in "sinks" in the oceans and in plant material on land. Atmospheric scientists still don't know how much each sink absorbs, and the uncertainty greatly hampers their ability to predict how quickly carbon dioxide levels will build in the future (SN: 8/26/89, p.132). Variations in growth rates should help them determine where the carbon dioxide goes, Tans says. □

Quantum swirls in superfluid helium

At sufficiently low temperatures, liquid helium becomes a superfluid, flowing without friction. This curious property is one of the more startling consequences of the role quantum mechanics plays in determining the bulk properties of liquid helium.

Physicists have known since 1938 that helium-4, the most abundant helium isotope, can turn into a superfluid. Obtaining clear evidence that the much less common helium-3 becomes a superfluid has proved more difficult.

Physicist Richard E. Packard and his collaborators at the University of California, Berkeley, now report the best experimental evidence yet that the behavior of liquid helium-3, cooled to temperatures below 0.0003 kelvin, matches the current theoretical prediction of how a helium-3 superfluid should behave.

"It is truly exciting to see such a fundamental and exotic prediction come true in the laboratory," Packard says. He described his group's findings this week at a conference in Brighton, England, on low-temperature physics.

Packard and his co-workers studied the flow properties of liquid helium-3 in a specially constructed, rotating refrigerator containing a long, thin cylinder. A fine wire made from a superconducting material and stretched along the cylinder's central axis served as a sensor, allowing the researchers to measure the flow of liquid helium-3 within the rotating cylinder. Sending a pulse of electrical current through the sensor would cause the wire to vibrate like a guitar string, and any fluid motion around the wire would alter its vibrations in a characteristic, detectable way.

The team found that chilled liquid helium-3 remains at rest when the cylinder rotates at low speeds. "When we reach a certain critical speed, we can see the [helium] circulation begin to change in a fairly erratic way," Packard says. "We stop rotation, and either the circulation disappears or it goes to a new stable state." A similar pattern holds for higher rotational speeds, with the liquid helium either coming to rest or jumping to a well-defined quantum flow state. In contrast, an ordinary liquid would always flow so that it kept up with the container's walls.

The Berkeley experiments clearly show that the flow of liquid helium-3 is quantized: Its rate increases in steps, each a multiple of a fundamental unit involving double the mass of a helium-3 atom. That finding confirms a theoretical prediction that helium-3 becomes a superfluid only if its atoms are coupled in what are known as Cooper pairs.

— I. Peterson