Earth Science

An unexpected release of carbon dioxide

For scientists trying to predict future climate change, the role of vegetation and soils remains a thorny issue. Some believe the two will slow global warming by absorbing substantial amounts of carbon dioxide now accumulating in the atmosphere from the burning of fossil fuels. Others think the warming will cause plants and soils to release more carbon dioxide, exacerbating the problem. A new report from Russian scientists raises the ante on this question by suggesting that Siberian soils emit much more carbon than previously realized.

While plants store carbon dioxide through photosynthesis, microbes in the soil release this greenhouse gas by breaking down organic matter in the dirt. That much of the carbon cycle is clear during the summer, when the sun is strong and the ground surface unfrozen. But what happens when winter comes to the far northern latitudes? Biologists had presumed that microbial activity grinds to a halt when the ground freezes solid, just as photosynthesis shuts off when the sun disappears. But S.A. Zimov from the Pacific Institute for Geography in Vladivostok and his colleagues report that microbes remain busy releasing carbon dioxide long after winter arrives.

Zimov's team measured carbon dioxide emissions from the soil at a site in northeast Siberia, 100 kilometers from the Arctic ocean. Although the gas production varied substantially, depending on the place and time of measurement, the soils released an average of 13.8 grams of carbon per square meter for the three months from December through February, the scientists report in the March 20 JOURNAL of GEOPHYSICAL RESEARCH.

"These results were certainly unexpected," says Walter C. Oechel of San Diego State University, who studies carbon dioxide emissions from tundra in Alaska. Oechel recently reported that summertime measurements in northern Alaska reveal that the carbon dioxide balance has shifted there in the last few decades (SN: 2/13/93, p.100). Instead of storing carbon as it has for millennia, the Alaskan tundra has become a net source, releasing more carbon dioxide than it absorbs during summer. He believes that a pronounced warming since the 1970s in northern Alaska has dried the soils and increased microbial activity there, enhancing carbon dioxide emissions.

Oechel wonders whether Zimov's wintertime measurements apply to a large area of the Arctic or only the small region that was studied. He plans to visit Siberia this summer to compare measurement techniques with Zimov. Oechel's team in Alaska will also extend its measurements further into the fall than it did previously. If Zimov is correct, microbes in Arctic soils can release carbon dioxide almost year round, meaning these soils can produce much more of the greenhouse gas than scientists have assumed. In that case, Arctic soils might react to a global warming in a way that substantially enhances the problem.

An observer immune to frostbite

Researchers studying Earth's magnetic field might have a hard time finding a grad student to camp in the middle of Antarctica and gather data during winter. Even if one volunteered, it would be difficult to keep that person alive. So the U.S. Antarctic Program, run by the National Science Foundation, commissioned six unmanned observatories to do the job instead. Late last year, technicians set up the first of these Automated Geophysical Observatories (AGO), placing it 480 kilometers from the South Pole, the nearest manned station.

The AGO has six instruments designed to measure the aurora and other aspects of the magnetic field. Early this month, it weathered its first storm, which caused the instruments to shut down temporarily. One of the devices has not turned back on yet, but engineers will fix that fault when they visit the AGO next austral summer during their annual trip to refuel the observatory and download data collected by the instruments.

Physics

Ivars Peterson reports from Washington, D.C., at an American Physical Society meeting

Tidying up the kilogram

Preserved as a gleaming cylinder of platinum and iridium, the international standard for the kilogram rests in pristine splendor under glass at the International Bureau of Weights and Measures at Sèvres, France. But this isn't good enough for perfectionists.

Stored in air, this cylinder readily accumulates a microscopically thin, but palpable film of "dirt." It's difficult to remove this coating and return the metal cylinder precisely to its original state with each cleansing. Moreover, the cylinder ages in an unknown manner, possibly changing its mass by as much as 50 parts per billion in 100 years. And there's only one. Because of fears that it may be damaged, it can't be used routinely for calibrating the standard kilograms at national measurement laboratories throughout the world.

Metrologists have long dreamed of defining the kilogram in terms of the universally agreed upon and unchanging values of fundamental physical constants rather than by an ill-defined lump of grungy matter. Researchers at the National Institute of Standards and Technology (NIST) in Gaithersburg, Md., and the National Physical Laboratory (NPL) in Teddington, England, have now taken a step toward providing one such basis for the kilogram. Both groups use electrical measurements in somewhat different ways to link the mass standard to Planck's constant, a fundamental quantity in quantum physics.

Originally proposed by NPL's Bryan P. Kibble, the technique requires an apparatus consisting of a movable coil of wire suspended in the magnetic field of a strong magnet. Moving the coil through the magnetic field at a certain velocity causes a current to flow in the coil. Researchers measure the velocity of the coil, the current and voltage induced in the suspended coil, and the acceleration due to gravity. From these data, they can derive a mass. Because voltage and resistance can now be expressed remarkably precisely in terms of constants derived from quantum effects involving individual electrons (SN: 1/13/90, p.30), electrical measurements provide a means of defining a mass standard of equivalent accuracy.

So far, neither the NIST nor the NPL researchers have achieved anywhere near the accuracy and reproducibility they would ultimately like to have, but the preliminary results indicate this technique shows promise. "The whole measurement is incredibly clean," Kibble says.

Redefining the kilogram represents more of a tidying up of the international system of units (SI) than a response to a need for an improved mass standard. "At the present time, there's no problem with the current level of accuracy," admits NIST's Barry N. Taylor. "Although the present definition of the kilogram has its problems, [this effort] may be more of an intellectual exercise than a practical necessity."

Seeking the top quark

Of the six types of quarks that physicists postulate as the constituents of matter, only the top quark remains unobserved. Particle physicists working with two detectors—called CDF and D0 — at Fermilab's Tevatron collider in Batavia, Ill., have observed three collisions of a proton and an antiproton that may have produced a top quark. However, these events also fit alternative scenarios that do not include creation of a top quark. Until they obtain additional evidence, the researchers refuse to draw any conclusion about the top quark's discovery.

"This is not going to be a 'eureka' moment," says John Peoples, Fermilab director. "It's going to take time."

Analyzing accumulated data from billions of collisions that produced no top quark, physicists using the CDF detector now report 108 billion electron-volts (108 GeV) as the new lower limit on the top quark's mass. This result raises the limit from last year's reported value of 91 GeV (SN: 3/21/92, p.189).