Science News: How Humans Have Disrupted The Nitrogen Cycle

June 5, 2009 — More and more, scientists are getting a better grip on the nitrogen cycle. They are learning about sources of nitrogen and how this element changes as it loops from the nonliving, such as the atmosphere, soil or water, to the living, whether plants or animals. Scientists have determined that humans are disrupting the nitrogen cycle by altering the amount of nitrogen that is stored in the biosphere.

The chief culprit is fossil fuel combustion, which releases nitric oxides into the air that combine with other elements to form smog and acid rain. But it has been difficult to know precisely the extent to which such emissions have altered the nitrogen balance.

Researchers from Brown University and the University of Washington have found a new way to make the link. The scientists show that comparing nitrogen isotopes in their deposited form — nitrates — can reveal the sources of atmospheric nitric oxide. In a paper published June 5 in *Science*, the group traces the source of nitrates to nitric oxides released through fossil fuel burning that parallels the beginning of the Industrial Revolution. The group also reveals that the greatest change in nitrogen isotope ratios occurred between 1950 and 1980, following a rapid increase in fossil fuel emissions.

"What we find is there has been this significant change to the nitrogen cycle over the past 300 years," said Meredith Hastings, assistant professor of geological sciences at Brown and the paper's lead author. "So we've added this new source — and not just a little bit of it, but a lot of it."

To make the link, Hastings, with Julia Jarvis and Eric Steig from the Department of Earth and Space Sciences at the University of Washington, examined at high resolution for the first time two isotopes of nitrogen found in nitrates in a Greenland ice core. The core, 100 meters long and taken at the peak of the Greenland ice cap in June 2006, contains a record of nitrates from about 1718 to 2006, according to the group.

Tests showed the ratio of the nitrogen-15 isotope to the more common nitrogen-14 isotope had changed from pre-industrial times to the present.

"The only way I can explain the trend over time," Hastings said, "are the nitric oxide sources, because we've introduced this whole new source — and that's fossil fuels burning."

Steig said the work also addresses a long-standing question about changes in lake chemistry in remote regions. "Sediment cores in Arctic lakes show that there have been significant 20th-century declines in the nitrogen isotopic composition of organic nitrogen," Steig said. "It's been unclear whether these are due to changes in the lake biogeochemistry or to the direct effect of changes in the isotopic composition of the incoming nitrate from the atmosphere. Our study makes it clear that it is primarily the latter."

The group now wants to determine the ratio of nitrogen-14 and nitrogen-15 isotopes for individual sources of nitric oxides, including lightning, biomass burning, bacterial "fixing" of nitrogen, and fossil fuel burning. The goal would be to pinpoint sources of nitrogen overloading, whether natural or human-caused.

"For example in Narragansett Bay, we could distinguish between nitrogen caused by sewage overflows or vehicular pollution, power plants, fertilizers, or other sources and know how to attack the problem," Hastings said.

Even more, the researchers want to quantify changes in the natural sources of nitric oxides and see whether climate change is influencing those processes.

The task is complicated, however, because nitrogen, when cycling through the atmosphere or deposited on land or in water, is subject to influences that can alter the isotopic ratios, thus masking the source. So, the scientists will need to tease out the extent of those alterations to trace the isotopic signatures of nitric oxide sources accurately.