What will happen to soil carbon as the climate changes? A team of scientists seeks answers

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(PhysOrg.com) -- The ground beneath your feet could hide a sleeping giant. Globally, soils store three times as much carbon as there is in the atmosphere or in living plants.

Scientists don't know what will happen to this carbon in response to climate change. It could enter the atmosphere as CO2, a greenhouse gas, and further accelerate climate change. But how much — and when — remain a mystery.

An international group of scientists has proposed a new approach to soil carbon research that seeks answers to these questions. Their roadmap is published in the October 6 issue of the journal *Nature* and is co-authored by Lawrence Berkeley National Laboratory (Berkeley Lab) soil scientist Margaret Torn.

The collaboration started two years ago when Torn and 14 other scientists from ten countries met at a thousand-year-old monastery in Lake Constance, Switzerland. It was an eclectic gathering, reflecting the wide-ranging scope of the problem. Until recently, what scientists thought they knew about soil carbon was wrong. And new insights haven't yet been fully implemented into global climate models.

The stone hallways echoed with the voices of an archaeologist, soil scientists, marine chemists, experts in microbial genomics, and others.

For four days, the Lake Constance Think Tank on Global Change and Feedback From Global Carbon Dynamics — the name given to the group by the European Science Foundation — discussed what's known about soil carbon cycling and what's needed to better predict how soil organic matter will respond to climate change.

In the Q&A below, Margaret Torn explores why the group got together and what the future holds.

Q: Why is it important to gain a better understanding of how soils store carbon?

A: Plants photosynthesize carbon, which then enters the soil via fallen leaves or root material. The fluxes between soil carbon in the form of organic matter and carbon in the atmosphere as CO2 are very large. A small change in carbon cycling can have a huge affect on atmospheric CO2 concentrations, and therefore a huge feedback to climate change.

As an example, a ten percent change in the soil carbon flux to the atmosphere would roughly double the net CO2 input. And if soils released only 0.3 percent of their carbon stores, it would equal year 2010 fossil fuel emissions.

Q: How has scientists' understanding of soil carbon changed over the past decade?

A: For many years, scientists thought that organic matter (which contains carbon) persists in soil because it forms large molecular structures that don't easily break down. But it's not that simple.

We now know that many forms of organic matter in soils are simple biomolecules, not large macromolecules. In addition, new research indicates that whether or not carbon persists in soil hinges on interactions between soil organic matter and microbes, minerals, moisture, and the temperature — everything that makes up the soil ecosystem.

Compounds such as lignin, which we thought were stable, may only last five years in soil, while proteins, which we thought were decomposable, may last more than one thousand years.

All of this means that we need new conceptual and numerical models to predict how soil organic matter responds to climate change.

The time is ripe to capitalize on a lot of new science. We have a much better understanding today than we did 15 years ago of how soil carbon works at the molecular scale. We need to use this knowledge to learn if, when, and how soils will form positive feedback to climate change. This will take a coordinated effort by scientists from many disciplines, which was reflected in the diversity of researchers who attended.

Q: What new technologies have enabled scientists to better understand soil organic matter?

A: There are several. Thanks to genome sequencing techniques such as those at the Department of Energy's Joint Genome Institute in Walnut Creek, California, we now have a much better idea of what microbes are in soil, what they're doing, and what proteins they're producing. That's important, because a handful of soil can teem with millions of microbes, some of which break down soil organic matter.

At the Advanced Light Source, which is located at Berkeley Lab, scientists can study soil organic matter the way it appears in the real world. This enabled researchers to learn that soil organic matter doesn't exist in large molecular complexes called humics. Instead, it exists in small fragments and is often associated with mineral surfaces.

There're also C-13 and C-14 isotopic analysis techniques, which allow scientists to determine how long carbon has been in soil. These isotopic, spectroscopic, and molecular marker tools are reshaping what we know about soil organic matter.

Q: How can a new generation of research help scientists improve predictions of soil carbon's response to climate change?

A: Research on the molecular-level mechanisms that affect soil organic matter will provide a stronger foundation for numerical models. And this will help us make better predictions.

I expect that in some places we'll see a much greater vulnerability to rapid carbon destabilization than we expected. For example, instead of being intrinsically difficult to decompose, perhaps old carbon happened to be in a soil condition that inhibits decomposition. Once this condition changes, say through drying or thawing, the carbon could be released into the atmosphere.

In addition, most research on carbon has focused on the soil surface and temperate regions. In the past, we've looked at the top ten inches of soil, but soil is measured in meters. Fortunately, the scientific community is starting to look at the Arctic as well as deeper into the soil.

Q: Can this research also help scientists develop climate change mitigation strategies?

A: As scientists, we're driven by the idea that a more accurate understanding of the earth system will help us do a better job of being stewards. And that applies here.

Our research could help evaluate carbon emissions-reducing technologies such as biofuels and biological carbon sequestration. Michael Schmidt, a co-author of the *Nature* paper from the University of Zurich, has already found that biochar, which is charred material from wildfires or a kiln, is not stable as previously believed. It also readily decomposes. Some scientists had believed that biochar could be used to sequester carbon, but this may not be the case.

Our research could also improve predictions of how soil carbon responds to changes in land use and vegetation.

More information: The scientists' article "Persistence of soil organic matter as an ecosystem property," is published in the October 6, 2011 issue of the journal *Nature*. www.nature.com/nature/journal/ … ull/nature10386.html

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