New model revises estimates of terrestrial carbon dioxide uptake

Researchers at the University of Illinois have developed a new model of global carbon and nitrogen cycling that will fundamentally transform the understanding of how plants and soils interact with a changing atmosphere and climate.

The new model takes into account the role of nitrogen dynamics in influencing the response of terrestrial ecosystems to climate change and rising atmospheric carbon dioxide.

Current models used in the assessment reports of the Intergovernmental Panel on Climate Change do not account for nitrogen processing, and probably exaggerate the terrestrial ecosystem’s potential to slow atmospheric carbon dioxide rise, the researchers say. They will present their findings this week at the annual meeting of the American Geophysical Union in San Francisco.

In the face of global climate change, world leaders are in need of models that can reliably predict how land use and other human activities affect atmospheric carbon dioxide levels. Deforestation and the burning of coal and oil increase atmospheric carbon dioxide and contribute to global warming.

Growing plants take carbon dioxide from the air and store it as carbon in their tissues. This means that plant growth – especially that of trees – can help reduce the effects of rising carbon dioxide levels, which contribute to global warming.

Scientists have struggled for decades to build computer models that accurately predict how plants and soils will respond to rising carbon dioxide levels in the atmosphere.

In the 1990s, researchers reported that crop plants such as cotton or wheat are more productive when exposed to higher carbon dioxide levels. This “fertilization effect” increases CO2 uptake and was hailed by some as evidence that Earth’s forests also would take up more carbon dioxide as atmospheric levels increased.

But models of the carbon cycle have failed to take into account how nitrogen availability influences this equation on the global scale, said Atul Jain, a U. of I. professor of atmospheric sciences and principal investigator on the development of the new model.

Nitrogen is vital to carbon dioxide uptake in plants, and if the available nitrogen runs out, the plants won’t be able to make use of the added CO2, Jain said. In an agricultural landscape, nitrogen may be added as needed, he said, but forests have limited amounts of nitrogen in their soils.

The integrated science assessment model, originally developed by Jain, now has been expanded to take into account the net carbon impact of human activities and the role of rising atmospheric temperatures on the process of carbon uptake.

“Everything is integrated, not only the nitrogen, carbon and climate, but also we looked at land cover and land use changes,” Jain said. “A lot of deforestation and also aforestation and reforestation are going on, and that has a direct effect on the carbon dioxide release or absorption.”

The model accounts for different soil and vegetation types, the impact of climate and the inadvertent nitrogen deposition that results from fossil fuel and biomass burning.

Interestingly, warming temperatures in response to rising carbon dioxide levels could make more nitrogen available, said Xiaojuan Yang, a doctoral student in Jain's lab. This factor must also be weighed in any calculation of net carbon dioxide load, she said.

"Previous modeling studies show that due to warming, the soil releases more carbon dioxide through increased decomposition," she said. "But they are not considering the nitrogen effect. When the soil is releasing more CO2, at the same time more nitrogen is mineralized. This means that more nitrogen becomes available for plants to use."

Increased nitrogen availability allows plants to uptake more carbon dioxide, a factor that mitigates, somewhat, the added burden of carbon dioxide in the atmosphere.

Even so, Jain said, the failure to look at the role of nitrogen in the terrestrial landscape means that countries may be overestimating the amount of carbon dioxide-uptake their forests provide.

Source: University of Illinois at Urbana-Champaign