North America's carbon cycle

March 27 2019

UD Associate Professor Rodrigo Vargas, seen here at the St. Jones Reserve in Delaware, has worked extensively on research related to the carbon cycle. Credit: University of Delaware

University of Delaware associate professor Rodrigo Vargas and more than 200 experts from the United States, Canada and Mexico recently unveiled Second State of the Carbon Cycle Report (SOCCR2), a state-of-

the-art assessment of carbon cycle science across North America and its connection with climate and society.

Carbon is essential to the molecular makeup of all living things on Earth, playing a pivotal role in regulating global climate. Commissioned by the U.S. Global Change Research Program, the 878-page report applies to climate and carbon research as well as management practices on our continent and around the world.

This study is the second of its kind, building off of the 2007 First State of the Carbon Cycle Report (SOCCR). From an overview of the carbon cycle to consequences and ways forward, SOCCR2 analyzes the carbon cycle from 2004 to 2013.

"Moving to SOCCR2, we have much more information on both carbon dioxide and methane compared to when the first study was released [in 2007]," Vargas said.

The most recent report is broken down into 19 chapters. Vargas was recruited to co-lead a critical chapter—The North American Carbon Budget—with his research collaborator Daniel Hayes, assistant professor at the University of Maine. The pair was already working on a U.S. Department of Agriculture grant focusing on carbon dynamics across North America, so this new effort was a natural research step. In collaboration with other nine scientists, they synthesized findings of the atmosphere, land, inland waters and coastal ocean (chapters 8 to 16).

"It's called a budget because you need a balance of how much carbon is going out and how much is going in," said Vargas. "We account for carbon in a similar way that you would for your bank account budget. You have gains and losses. At the end, what is your budget—positive or negative? In your bank account, you would investigate deeper and see 'where is my spending' and 'what are the sources.' We can do the same in

a carbon budget."

There is a stock of how much carbon exists on Earth. Then a flux occurs. This term refers to the amount of carbon exchanged between the planet's carbon pools—ocean, atmosphere, land and living things. Carbon could be lost from the land to the atmosphere (via combustion of fossil fuels or terrestrial respiration processes), pulled down from the atmosphere to the land (a gain via plant photosynthesis), or a lateral movement takes place (as carbon transported from land to the coastal ocean). The net gain or loss determines the net carbon balance.

"Between 2004 and 2013, North America was a source of carbon dioxide to the atmosphere," added Vargas. "We had a net loss of carbon, contributing about 1,000 teragrams per year to the atmosphere."

One teragram is equivalent to 1,000,000,000 kilograms or about 2,205,000,000 pounds. If an African elephant weighs about 12,000 pounds, then 1,000 teragrams are equivalent to 183,750 elephants.

These fluxes come from a variety of sources—fossil fuels, wood products, land ecosystems, inland waters, tidal wetlands, estuaries and coastal oceans. As Vargas and Hayes explain in their SOCCR2 chapter, fossil fuel emissions were far and away the largest carbon source to the atmosphere from 2004 to 2013 on the continent. Interestingly, 43 percent of these emissions were offset by natural carbon sinks—natural systems that suck up and store carbon dioxide from the atmosphere—like North American land and the adjacent coastal ocean.

"The net uptake of terrestrial ecosystems is nearly 960 teragrams of carbon per year, while the net uptake of coastal waters is 177 teragrams, but more research is needed to increase the confidence of these estimates," Vargas said.

Comparing other continents, the North American proportion to the global total is decreasing as other countries like China have increased their carbon emissions.

"We had high confidence on the estimates of fossil fuel emissions, wood harvest and emissions from wood products," Vargas said. "On the other hand, there is low confidence on the estimates of lateral fluxes from land ecosystems to inland waters and from tidal wetlands to estuaries."

"Researchers have been thinking a lot about the vertical exchange of carbon between land and aquatic environments with the atmosphere," said Vargas, who has a National Science Foundation CAREER grant to study carbon dynamics in tidal wetlands—a critical interface between land and ocean. "But there is also a transfer of mass from land ecosystems to inland waters, from tidal waters to estuaries. And these lateral fluxes had one of the highest levels of uncertainty in the study."

About SOCCR2

Written by more than 200 scientists from the United States, Canada, and Mexico, the Second State of the Carbon Cycle Report (SOCCR2) provides an up-to-date assessment of scientific knowledge of the North American carbon cycle. This comprehensive report addresses North American carbon fluxes, sources, and sinks across atmospheric, aquatic, and terrestrial systems, as well as relevant perspectives from scientific observations and modeling, decision support, carbon management, and social sciences. The report presents key findings and actionable information on the observed status and trends within the North American carbon cycle, as influenced by natural and human-induced factors. These findings are based on multidisciplinary research that includes experimental, observational, and modeling studies from the last decade.

"This report is not intended to prescribe policy. It's not an opinion. It is a summary of scientific information that is available at this time," said Vargas.

The U.S. Global Change Research Program is made up with 13 agencies, including the U.S. Department of Agriculture (USDA), National Aeronautics and Space Administration (NASA), Department of Defense (DOD) and Environmental Protection Agency (EPA).

In addition to the specific chapters on ecosystems, the report studies the human impact on the carbon cycle, including the physical drivers—energy systems and agriculture—and social issues like tribal lands. The report also looks forward at potential consequences of future climate change.

SOCCR2 is a complement to the National Climate Assessment, which assesses the science of climate change and variability and its impacts across the United States—now and throughout the current century.

Provided by University of Delaware