Crops help to drive greater seasonal change in CO2 cycle

November 19 2014

Credit: SC Department of Agriculture

Each year in the Northern Hemisphere, levels of atmospheric carbon dioxide (CO2) drop in the summer as plants inhale, and then climb again as they exhale and decompose after their growing season. Over the past 50 years, the size of this seasonal swing has increased by as much as half, for reasons that aren't fully understood. Now a team of researchers led by Boston University scientists has shown that agricultural

production may generate up to a quarter of the increase in this seasonal carbon cycle, with corn playing a leading role.

"In the Northern Hemisphere, there is a strong seasonal cycle of vegetation," says Mark Friedl, professor in BU's Department of Earth and Environment and senior author of a paper about the research published today in *Nature*. "Something is changing about this cycle; the ecosystems are becoming more productive, pulling in more atmospheric carbon during the summer and releasing more during the dormant period."

Most of this annual change is attributed to the effects of higher temperatures driven by climate change—including longer growing seasons, quicker uptake of carbon by vegetation, and the "greening" of higher latitudes with more vegetation. "But that's not the whole story," says Josh Gray, BU research assistant professor and lead author on the paper. "We've put humans and croplands into the story."

The scientists gathered global production statistics for four leading crops—corn, wheat, rice and soybeans—that represent about 64 percent of all calories consumed worldwide. They found that production of these crops in the Northern Hemisphere above the tropics has more than doubled since 1961, and translates to about a billion metric tons of carbon captured and released each year.

These croplands are "ecosystems on steroids," says Gray, noting that they occupy about 6 percent of the vegetated land area in the Northern Hemisphere but are responsible for up to a quarter of the total increase in seasonal carbon exchange of atmospheric CO2, and possibly more.

This growth in seasonal variation doesn't have a huge impact on global terrestrial carbon uptake and release, since essentially all carbon in the harvested crops is released each year.

However, understanding the effects of agricultural production, the researchers say, will help to improve models of global climate, particularly in examining how well natural ecosystems will buffer rising levels of CO2 in the future.

Funded primarily though programs supported by the National Aeronautics and Space Administration (NASA) and the National Science Foundation (NSF), the study began in a dinner conversation among the BU scientists, who use remote sensing to study changes on the earth's surface, and atmospheric chemist Eric Kort of the University of Michigan in Ann Arbor.

Kort, a co-author on a 2013 paper by Heather Graven of Imperial College, London and colleagues that demonstrated the overall shift in seasonal CO2 levels but did not look in detail at agricultural production, suggested that contributions from crops could help to explain the magnitude of the shift.

"We thought, somebody should do the math," recalls Gray. Doing a quick analysis with data from the UN's Food and Agriculture Organization, he found that the contribution from crops could be in the right ballpark.

Following up, the BU investigators from the Land Cover & Surface Climate Group collaborated with a team of experts including Kort, Steve Frolking of the University of New Hampshire at Durham, Christopher Kucharik of the University of Wisconsin at Madison, Navin Ramankutty (then at McGill University and now at the University of British Columbia at Vancouver), and Deepak Ray of the University of Minnesota Institute on the Environment. This team used data on Land Cover and Phenology from the NASA Moderate Resolution Imaging Spectrometer (MODIS) Land Cover and Phenology along with many other measurements and statistical products in this study.

The work highlighted the extraordinary increases in crop production in recent decades. "It's a remarkable story of what we've done in agriculture in general," says Friedl. "And in particular corn, which is one crop that's just exploded. Corn alone accounts for two-thirds of the crop contribution to the increased seasonal exchange in carbon, and nearly 90 percent of that is produced in the Midwestern United States and China."

"Over the last 50 years, the area of croplands in the Northern Hemisphere has been relatively stable, but production has intensified enormously," he adds. "The fact that such a small land area can actually affect the composition of the atmosphere is an amazing fingerprint of human activity on the planet."

More information: dx.doi.org/10.1038/nature13893
dx.doi.org/10.1038/nature13957

Provided by Boston University