Greenhouse gas source underestimated from the US Corn Belt, study shows

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Estimates of how much nitrous oxide, a significant greenhouse gas and stratospheric ozone-depleting substance, is being emitted in the central United States have been too low by as much as 40 percent, a new study led by University of Minnesota scientists shows.

The study, published today in the journal *Proceedings of the National Academy of Sciences*, measured how much nitrous oxide is emitted from streams in an agriculturally dense area in southern Minnesota. Agriculture, and specifically nitrogen fertilizers used in row-crop farming, is a major contributor to nitrous oxide emissions from streams, the paper notes.

Nitrous oxide emissions are measured at the University of Minnesota Tall Tower Trace Gas Observatory -providing a top-down constraint on the regional emissions. Estimates of nitrous oxide emissions also are calculated by combining on-the-ground (bottom-up) measurements within the region. These measurements are used to keep track of emissions and help inform strategies for reducing nitrous oxide loss from agricultural lands. However, very large differences have been observed between these top-down and bottom-up approaches, indicating large uncertainties, and undermining the development and assessment of mitigation practices.

The researchers found that some of the discrepancies between bottom-up emission measurements and those taken from the air can be attributed to variations in the size and flow of streams and rivers; by taking the

impact of stream networks into account, scientists can more accurately estimate and mitigate increased concentrations of nitrous oxide. A strong relation was observed between the emission strength of a stream and its size, known as stream order. The smallest streams, or those with the closest connections to the land, were the strongest sources. The researchers hypothesize that this is a consequence of both high nitrogen loading and higher turbulent exchange rates. As stream size increases, the potential of these processes to produce large emissions is diminished. These two mechanisms acting together help explain why headwater streams are such strong sources.

The findings suggest that nitrous oxide emissions from rivers have been underestimated by the IPCC (Intergovernmental Panel on Climate Change) by as much as nine-fold. By properly accounting for the emission factor of these sources, much of the difference between bottom-up and top-down approaches can be resolved.

"Nitrous oxide emissions from rivers have been an overlooked and uncertain source because the variability in stream sizes and land-use types has made an accurate estimation difficult," says Peter Turner, one of the study's authors and a PhD candidate in the university's Department of Soil, Water, and Climate.

"We identified an important relationship between the size of the stream and its potential to emit nitrous oxide that can be used to scale up emission estimates. Understanding the riverine nitrous oxide source is an important step forward for understanding the global nitrous oxide budget."

Since 2009, the team has been tracking down the sources of nitrous oxide emissions in the Upper Midwest using tall tower observations, soil and plant chambers, and a new system designed for investigating emissions from streams, says Tim Griffis, a professor in the university's

Department of Soil, Water, and Climate. "We have known for some time, based on atmospheric measurements, that nitrous oxide emissions within the region are underestimated. This study provides a key piece to solving that puzzle and will help land managers and scientists develop better strategies for mitigating nitrous oxide emissions."

The next step is to confirm that nitrous oxide degassing also occurs in drainage channels in other agricultural regions, such as China and India, where productivity is maintained by intensive use of nitrogen fertilizers, says Xuhui Lee, a Professor in the School of Forestry and Environmental Studies at Yale University and a collaborator on the study.

More information: Indirect nitrous oxide emissions from streams within the US Corn Belt scale with stream order, www.pnas.org/cgi/doi/10.1073/pnas.1503598112

Provided by University of Minnesota

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