

## Earth system models overstate carbon removal: New findings suggest nitrogen fixation is 50% lower than thought

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High levels of atmospheric carbon dioxide intensify climate change, but high carbon dioxide levels can also stimulate plant growth. Plant growth removes carbon dioxide from the atmosphere, partially mitigating the effects of climate change. However, plants only grow faster in the presence of high levels of carbon dioxide if they can also acquire enough nitrogen from the atmosphere to do so.

The actual amount of nitrogen acquired from the atmosphere was reassessed in a [previous study](#) co-led by Columbia faculty that was published this summer; it was shown to be significantly lower than previously estimated.

The climate implications of the overestimation of nitrogen fixation are the focus of a [new study](#) published in the *Proceedings of the National Academy of Sciences*. This new

study found that, in Earth system models, the amount of natural nitrogen fixation directly correlates to future plant growth. Therefore, the lower amount of natural nitrogen fixation than previously thought means that Earth system models have been overestimating future plant growth.

Earth system models are used by organizations like the Intergovernmental Panel on Climate Change (IPCC), among others, to project future climate change.

Plants can only use nitrogen if it is in the right form, and most nitrogen is in the atmosphere in a form that plants cannot use. This atmospheric nitrogen must be "fixed" by microorganisms. This nitrogen fixation occurs in natural ecosystems, but also on agricultural land.

Sian Kou-Giesbrecht, a professor at Simon Fraser University in Canada and a former Columbia doctoral student in the lab of Professor Duncan Menge, is the paper's lead author. Other authors include Menge and two other former doctoral students in his lab, Benton Taylor, now a professor at Harvard, and Anika Staccone, now at Earthshot Labs.

"We're proud that we can continue to build on these important findings on nitrogen fixation, and assess their full implications for the future climate," Menge said.

The researchers compared different Earth system models with current nitrogen fixation values and found that they have been overestimating the nitrogen fixation rate on natural land by about 50%. Consequently, this overestimation of nitrogen fixation means that Earth system models have been overestimating the carbon dioxide fertilization effect by about 11%. The authors, therefore, advocate revising Earth system models to better reflect the real amount of nitrogen fixation that is occurring naturally.

**More information:** Sian Kou-Giesbrecht et al, Overestimated natural biological nitrogen fixation translates to an exaggerated CO<sub>2</sub> fertilization effect in Earth system models, *Proceedings of the National Academy of Sciences* (2025). DOI: [10.1073/pnas.2514628122](https://doi.org/10.1073/pnas.2514628122)

**Journal information:** [Proceedings of the National Academy of Sciences](#)

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