Global Carbon Project
GCP-Boston

BOSTON COLLEGE
SCHILLER INSTITUTE FOR INTEGRATED SCIENCE AND SOCIETY

Happy New Year!

Dear Colleagues and Friends:

Founded through a partnership between the Global Carbon Project (GCP) and the Schiller Institute for Integrated Science and Society at Boston College, GCP-Boston and CES3 were inaugurated on December 5, 2023. This newsletter highlights key research and activities conducted throughout 2024.

- Hanqin Tian, Inaugural Director and Institute Professor of Global Sustainability

Coordinating Lead Authors (CLA)

Dr. Hanqin Tian was appointed as one of the Coordinating Lead Authors for the Global N_2O Assessment by Climate & Clean Air Coalition, UN Environmental Program

2024 Activity Highlights:

Tian, H. (Left) and Qu, D (Right)

Dr. Tian attended the CLA workgroup meeting at UN Food and Agriculture Organization (FAO) in Rome on June 24-25. He also attended the Agri-Food Assessment Kick-off meeting, held at FAO where he met with Dr. Dongyu Qu, General Director and Dr. Kaveh Zahedi, Director, Office of Climate Change, Biodiversity and Environment during June 26-28.

Tian, H (Left) and Zahedi, K. (Right).

Workshop on the State of GHG and Climate Action:

Dr. Philippe Ciais, a senior researcher at LSCE (Laboratory for Climate and Environmental Sciences, IPSL, France) and former GCP Co-Chair delivered a Keynote Speech titled "Risks of Destabilization of the Carbon Cycle." This event was organized by GCP-Boston and held at Boston College on December 5-6, 2024. Nine other Speakers from Boston College (Profs. David Deese, Yi Ming, Susan Pan, Hanqin Tian, Tony Wang), Boston University (Prof. Mike Dietze), MIT (Dr. Angelo Gurgel), Northeastern University (Prof. Yang Zhang), and Yale University (Prof. Sparkle L. Malone) gave presentations on various topics covering the budgets of GHGs (CO_2, CH_4 and N_2O) and climate action. Dr. Laura J. Steinberg, Executive Director of Schiller Institute for Integrated Science and Society, introduced Dr. Philippe Ciais and extended a warm welcome to the other speakers.

10 Speakers: Wang, Zhang, Pan, Tian, Ciais, Malone (Front row from left); Ming, Gurgel, Dietze, Deese (Back row from left)

Ciais, P. (Left) and Tian, H. (Right)

GCP-Boston Talk:

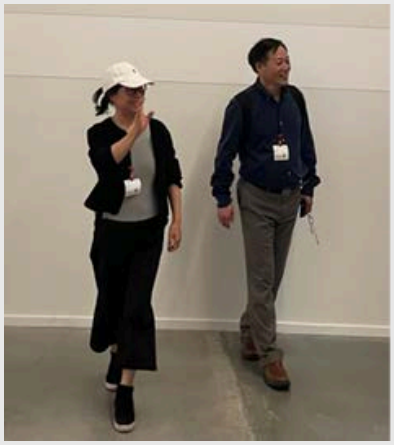
In collaboration with Boston College's Schiller Institute for Integrated Science and Society and Department of Earth and Environmental Sciences, GCP-Boston launched the GCP Talk series to showcase significant advancements in global carbon and nitrogen cycles, GHG Budgets, food-energy-water nexus, and climate action within and beyond the GCP community.

The 1st GCP Talk: "Decoding Our Carbon and Climate Futures, and the Imperative for Net-Zero Emissions, "given by Dr. Josep G Canadell, GCP Executive Director and CSIRO Chief Research Scientist, on December 5, 2023, BC.

The 2nd GCP Talk: "Deep Learning to Monitor Forest Carbon Change from Tree to Globe," given by Dr. Philippe Ciais, Former Co-Chair of GCP and Senior Researcher at LSCE, France, on December 6, 2024, BC.

Stanford's Methane Meeting:

Dr. Hanqin Tian and Dr. Susan Pan attended Stanford's methane meeting from May 21-23, 2024, organized by the GCP Methane Office at Stanford University. GCP-Boston contributes to the GCP effort on Near-Real Time (NRT) global CH_4 emissions by providing the simulated CH_4 emissions data from global rice paddies, inland waters, and wetlands. Following the NRT-CH_4 meeting, Dr. Tian and Dr. Pan, GCP leaders Dr. Pep Canadell, Dr. Philippe Ciais, and other colleagues, visited the Googleplex (HQ) in Mountain View, CA.



University Ethics and Social Trust Panel:

Dr. Hanqin Tian participated in the 2024 Summer Colloquium on Global Ethics and Social Trust (June 18–20), where he spoke on the "University Ethics and Social Trust" panel. His presentation focused on climate change, ethics, GHG mitigation, and their connections to the UN Sustainable Development Goals. He also collaborated with faculty from Boston College, Sophia University, and Pontifical Catholic University of Chile on a project on small island climate resilience.

The Global Summit 2024:

BC Schiller Institute Professors Dr. Tian and Dr. Yi Ming attended the Global Summit 2024: Building the Climate Workforce, at Harvard Club of Boston on September 25-26, 2024. Governor Maura Healey, speaking at the Global Summit 2024, emphasized the urgency of reducing greenhouse gas emissions and called for bold action to build a skilled, inclusive climate workforce as a cornerstone of sustainability efforts. This aligns closely with GCP-Boston's mission. We explored potential involvement with local communities to further enhance climate action and workforce development.

(From left: Ming, Healey and Tian)

2024 AGU Fall Meeting in Washington, DC:

During the AGU College of Fellows' event, Dr. Tian and Dr. Robert B. Jackson (GCP Chair), both terrestrial biogeochemists, met with marine biogeochemists Dr. Minhan Dai (Xiamen University) and Dr. Wei-Jun Cai (University of Delaware) to discuss bridging terrestrial and marine carbon cycles. Dr. Tian and Dr. Tony Wang (Boston College), along with Dr. Eric Davidson (University of Maryland) and Dr. Brian Buma (EDF), also led a session on "Global and Regional Nitrous Oxide Budget and Nitrogen-Climate Interactions: From Science to Solutions" at the AGU Fall Meeting (Dec. 9-13, 2024).

(From left: Dai, Jackson, Tian and Cai)

From left: Sun, Tian, Liu

Efforts to End Poverty and Hunger:

Dr. Hanqin Tian visited the International Food Policy Research Institute (IFPRI) on December 12, 2024, highlighting a promising opportunity for interdisciplinary collaboration. During the visit, Dr. Tian met with Dr. Yanyan Liu, a Senior Research Fellow at IFPRI, and Prof. Ying Sun from Cornell University to discuss potential partnerships for ending Poverty (SDG 1) and achieving Zero Hunger (SDG 2). Dr. Tian showcased the capabilities of the Dynamic Land Ecosystem Model (DLEM), emphasizing its value as a decision-support tool. The model provides a comprehensive framework to guide strategies for achieving SDGs in underdeveloped and emerging regions, particularly in Africa, Asia and South America.

"Who Has Eaten the Planet (WHEP)" Project Kick-Off Meeting:

A collaborative initiative has been established with an international research team led by Eduardo Aguilera in Spain on an ERC-funded project titled "Who Has Eaten the Planet? The Paths of Food Systems Beyond the Safe and Just Operating Space." This project represents a major step forward in understanding the long-term evolution of food-related environmental impacts and food provision. It aims to map the trajectories of each country within the safe and just operating space. At the kick-off meeting of this collaborative initiative on November 18, 2024, Dr. Tian delivered an invited seminar titled "Understanding and Quantifying Terrestrial Carbon and Nitrogen Cycles and the GHG Budgets: Where We Are, Where We Need to Go."

In the Media:

- BC News: The Global N2O Budget
- The Conversation: Food has a climate problem: Nitrous oxide emissions are accelerating with growing demand for fertilizer and meat – but there are solutions (2+ million reads!!)
- Heavy rains deliver largest amounts of fertilizer-derived nitrogen pollution to the Gulf
- More than 600 Press Releases on the Global N2O Budget: For example: Newsweek - Laughing Gas Is a Serious Problem for the Climate. Better Farming Can Help.

Congratulations!

Dr. Yongfa You, a Postdoctoral Fellow in GCP-Boston and CES3, will assume the assistant professor position at Virginia Tech in August 2025. He will continue affiliating with GCP-Boston and working on Agricultural GHG.

Dr. Hanqin Tian, Director of GCP-Boston and CES3, is among global 6,886 Highly Cited Researcher awards in 2024, ranking in the top 1% by citations for cross-fields (Web of Science).

Job Opportunities:

https://www.globalcarbonproject.org/gcpjobs.htm

Contact Information:

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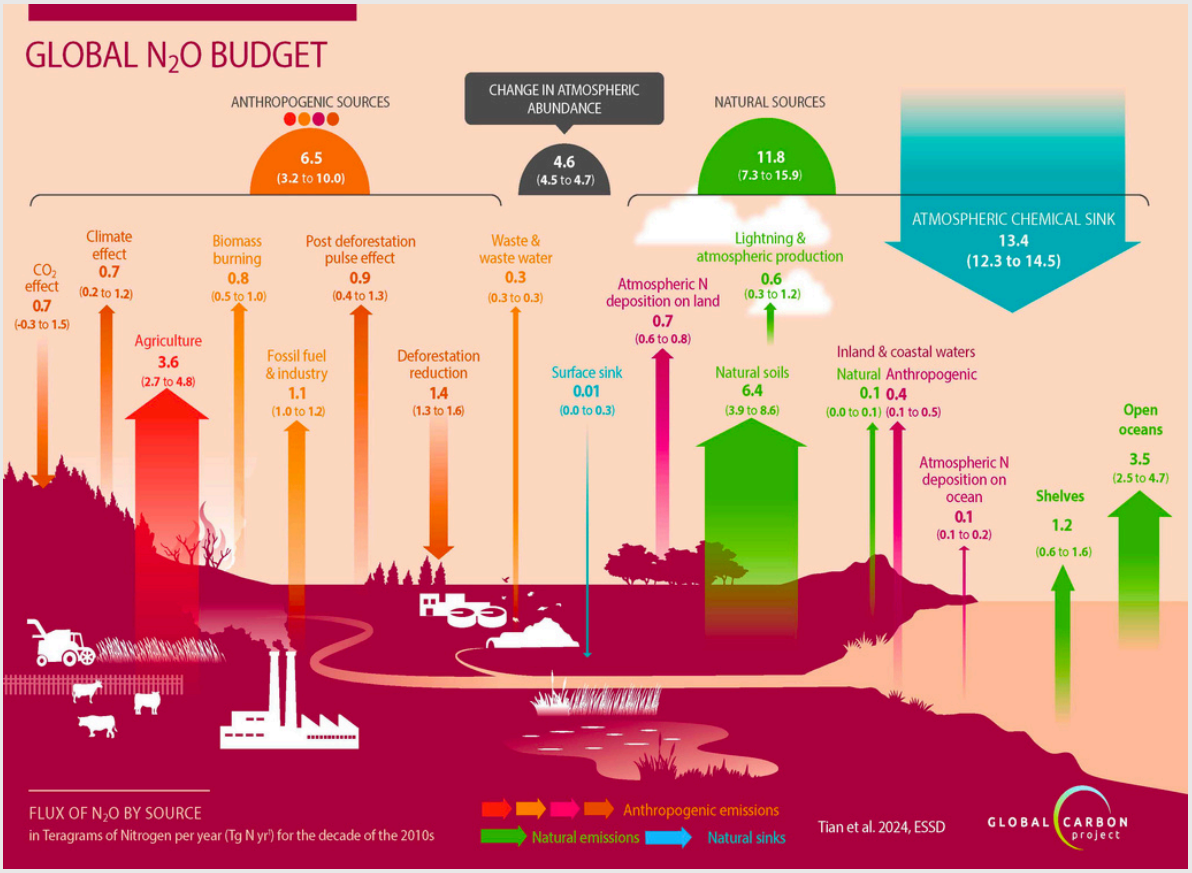
Dr. Susan Pan (panshu@bc.edu), Research Director and Associate Professor, GCP-Boston and CES , Department of Engineering, Boston College, 245 Beacon St., Chestnut Hill, MA 02467, USA.

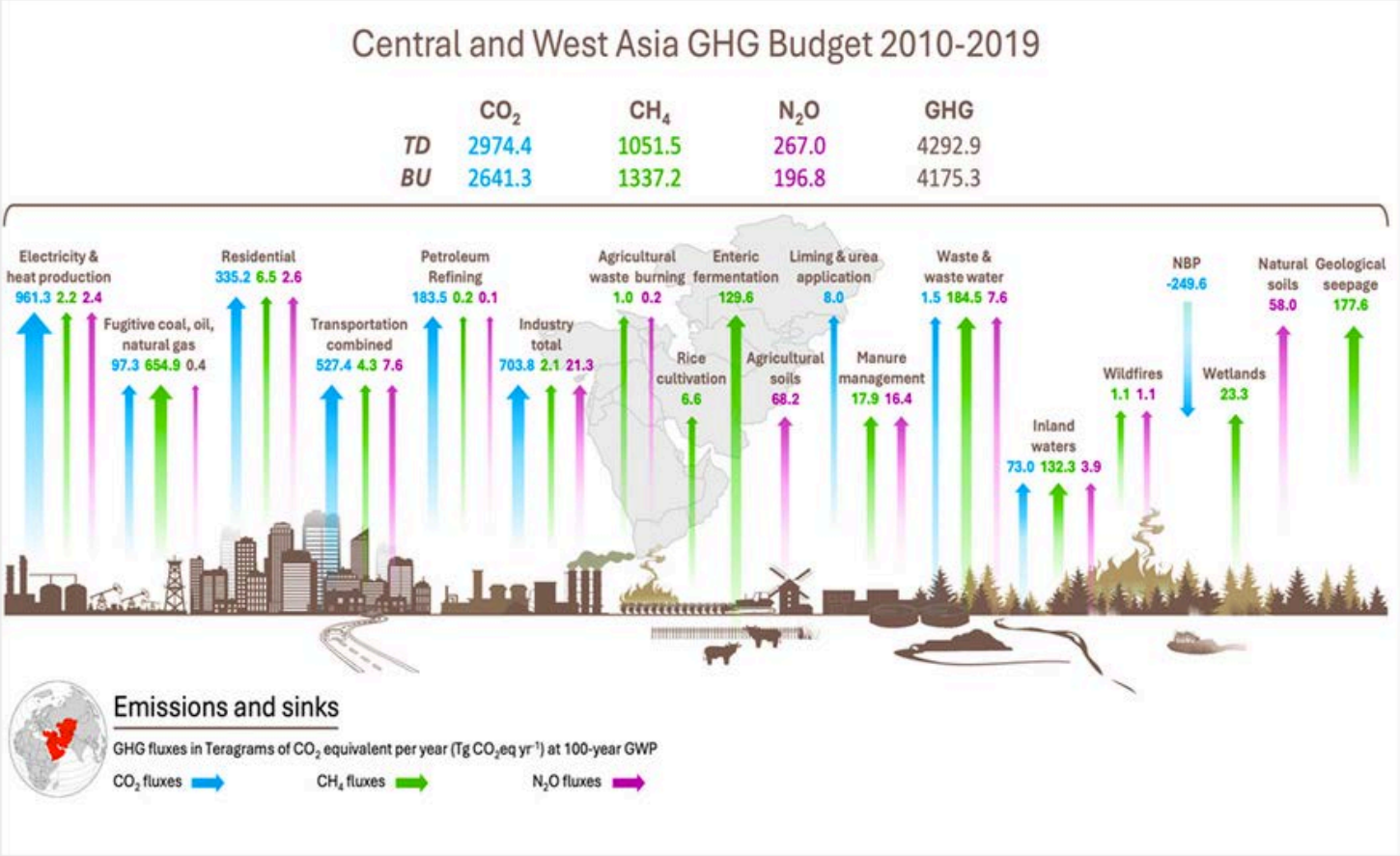
2024 Research Highlights

Global Nitrous Oxide Budget (1980-2020), published on 12 June 2024, marks the second iteration of its kind and the inaugural release as a dynamic data collection in the journal *Earth System Science Data* (Tian et al. 2024). Nitrous oxide (N2O) is the third most significant greenhouse gas, following carbon dioxide (CO2) and methane (CH4), in contributing to human-induced global warming. It is 273 times more powerful than CO2 as a greenhouse gas over a 100-year time horizon, underscoring its critical role in climate change. We report the N2O trends and budgets for the last four decades using observations, biospheric modeling, observation-upscaled synthesis products, activity-based inventories, and atmospheric observations and modeling. We report on a total of 18 natural and anthropogenic source sectors and 3 sinks of global N2O. N2O emissions from human activities have increased by 40% (3 million metric tons of N2O per year) in the past four decades. Agricultural production (due to the use of nitrogen fertilizers and animal manure) contributed 74% of the total anthropogenic N2O emissions in the last decade. The observed atmospheric N2O concentrations in the past decade have exceeded the most pessimistic illustrative future GHG trajectories used by the IPCC. This comprehensive assessment was completed by 58 authors from 55 organizations and 15 countries led by GCP in partnership with INI (International Nitrogen Initiative). For further details, please refer to the accompanying BC Press Release.



RECCAP2-CWA and Beyond:

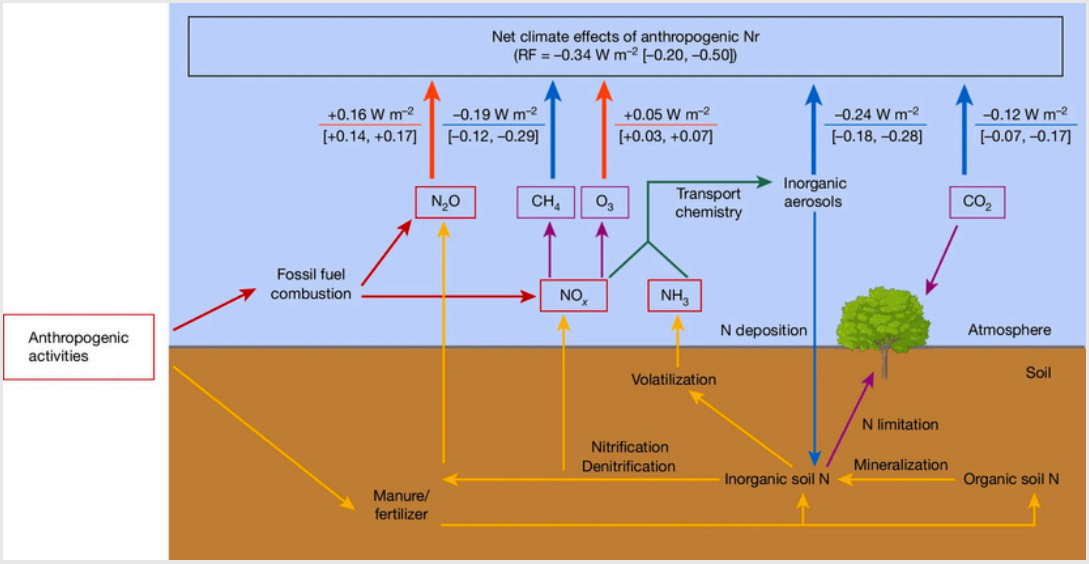
As part of RECCAP2 (Regional Carbon Cycle Assessment and Processes Phase 2), GCP-Boston led an international team in a study on the greenhouse gas budgets of Central and West Asia (CWA) from 2000 to 2020. This study (Qin et al., Submitted to GBC) quantifies CO2, CH4, and N2O emissions, revealing CWA's significant contribution to global GHG emissions, averaging about 4,234 million tons of CO2 equivalent annually in the 2010s. Fossil fuel combustion was the largest source, comprising 61% of the total emissions, while non-CO2 gases like methane accounted for 32% (GWP100) or 57% (GWP20) of the total. Overall, CWA contributed about 8% of global GHG emissions in the 2010s. GCP-Boston has also contributed to GHG assessments in North America, Eastern Asia, South Asia, Southeastern Asia, Europe, and Africa.



Global Net Climate Effects of Anthropogenic Reactive Nitrogen:

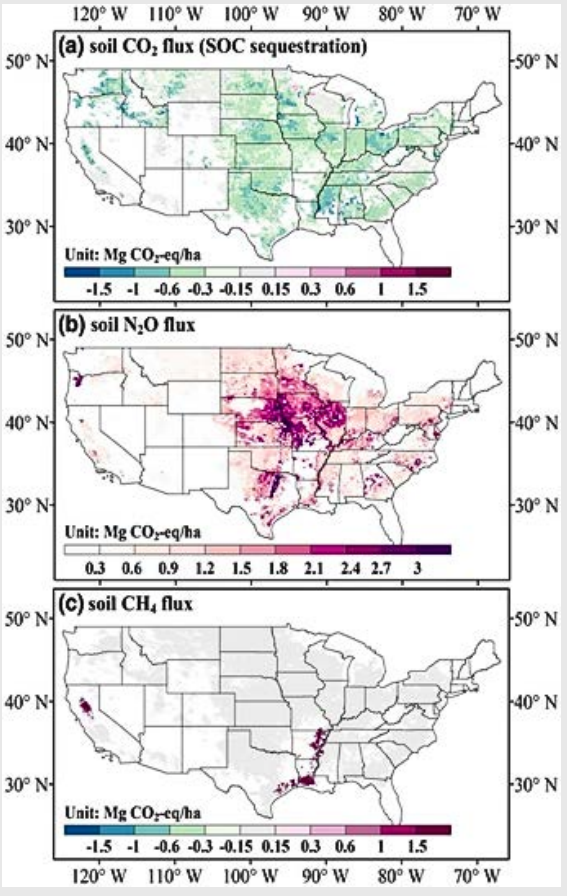
As a part of NMIP2 (global N/N2O Model Intercomparison Project -phase 2), a study by Gong et al (2024), published in *Nature*, assesses the climate effects of nitrogen emissions from fertilizers, animal manure, and fossil fuels, revealing that while nitrogen compounds contribute to environmental harm, they also produce a net cooling effect on the climate. The research highlights the complex interplay between different forms of nitrogen and their climate impacts.

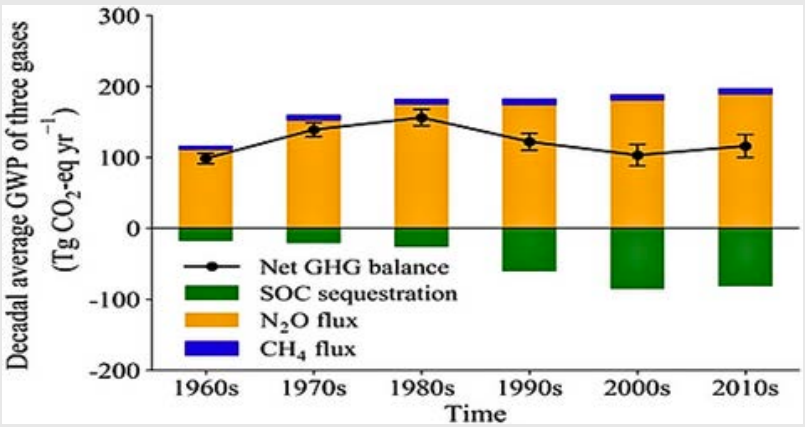
While nitrogen emissions may have mitigated some warming, they pollute the air and drinking water, lead to excessive nutrient enrichment in water and soil, decrease biodiversity, and harm the ozone layer. Improved agricultural practices and reduced nitrogen inputs can benefit both the environment and climate, but tackling greenhouse gases remains essential for effective climate change mitigation. For further details, please refer to the accompanying MPI Press Release



How Can Soil Be Part of Climate Solution?

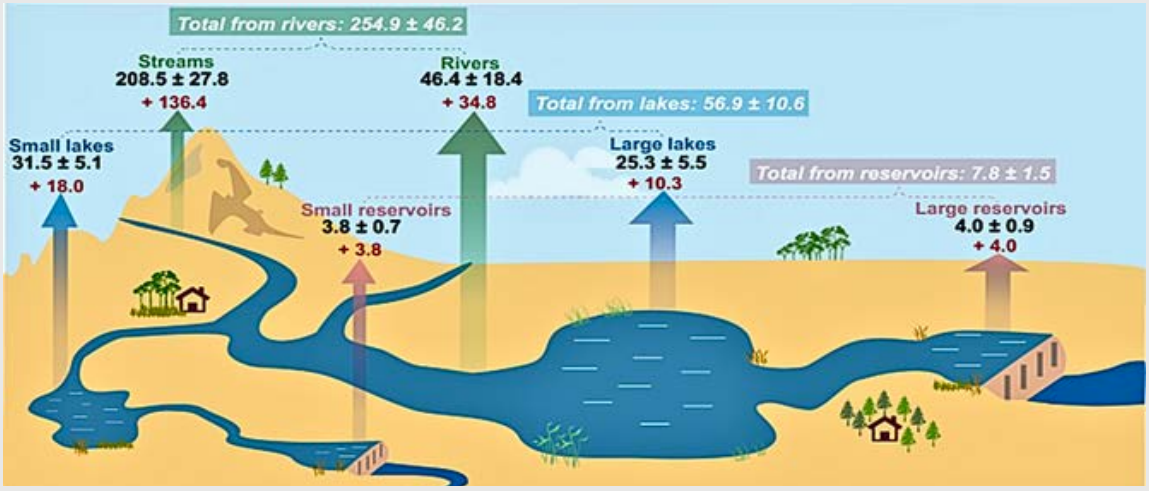
Agricultural soils play a dual role in regulating the Earth's climate by releasing or sequestering carbon dioxide (CO2) in soil organic carbon (SOC) and emitting non-CO2 greenhouse gases (GHGs) such as nitrous oxide (N2O) and methane (CH4). Understanding how agricultural soils can play a role in climate solutions requires a comprehensive assessment of net soil GHG balance (i.e., sum of SOC-sequestered CO2 and non-CO2 GHG emissions) and the underlying controls. A study by You et al. (2024), published in *Global Change Biology,* indicates that the sequestered SOC offset ~28% of the climate-warming effects resulting from non-CO2 GHG emissions in U.S. cropland. However, improving management practices to mitigate N2O emissions represents the biggest opportunity for achieving net-zero emissions in U.S. croplands.





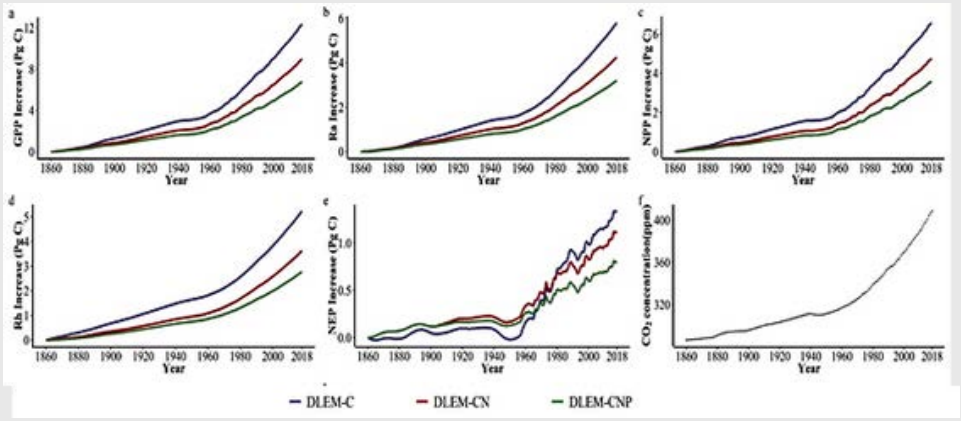
Global Inland Water N2O Emissions Since 1850s:

A study by Li et al. (2024), published in *Nature Communications*, estimates that N2O emissions from global inland waters (rivers, lakes, and reservoirs) in the 2010s were 319.6 ± 58.2 Gg N per year. Global lentic systems emitted 64.6 ± 12.1 Gg N2O-N per year in the 2010s, increased by 126% since the 1850s. Global riverine N2O emissions reached 254.9 ± 46.2 Gg N per year, marking a twofold increase from the estimated levels in the 1850s.



Nutrient Limitations to The CO_2 Fertilization Effect In Tropical Forests:

Tropical forests store approximately three-quarters of the global forest biomass carbon and contribute about one-third of the global net primary productivity (NPP). The CO_2 fertilization effect, which enhances CO_2 concentrations in leaves and boosts plants' carbon fixation capacity, has been a key mechanism for sustaining and increasing tropical forest productivity. However, its future remains uncertain, partly due to nutrient limitations. A study by Wang et al. (2024), published in *Forest Ecosystems*, presents a new carbon-nitrogen-phosphorus coupled biogeochemical model, the Dynamic Land Ecosystem Model (DLEM-CNP), to examine how phosphorus (P) limitation affects carbon fluxes in tropical forests.



The research, conducted by a multidisciplinary team from the United States, Japan, and China, found that phosphorus limitation significantly reduced the productivity response of tropical forests to rising atmospheric CO_2 levels. Combined nitrogen and phosphorus limitations further diminished the CO_2 fertilization effect on gross primary production (GPP), net primary productivity (NPP), and net ecosystem production (NEP) by 45%, 46%, and 41%, respectively.

2024 Publications

Journal Articles:

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