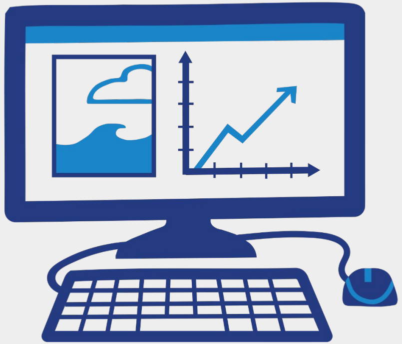


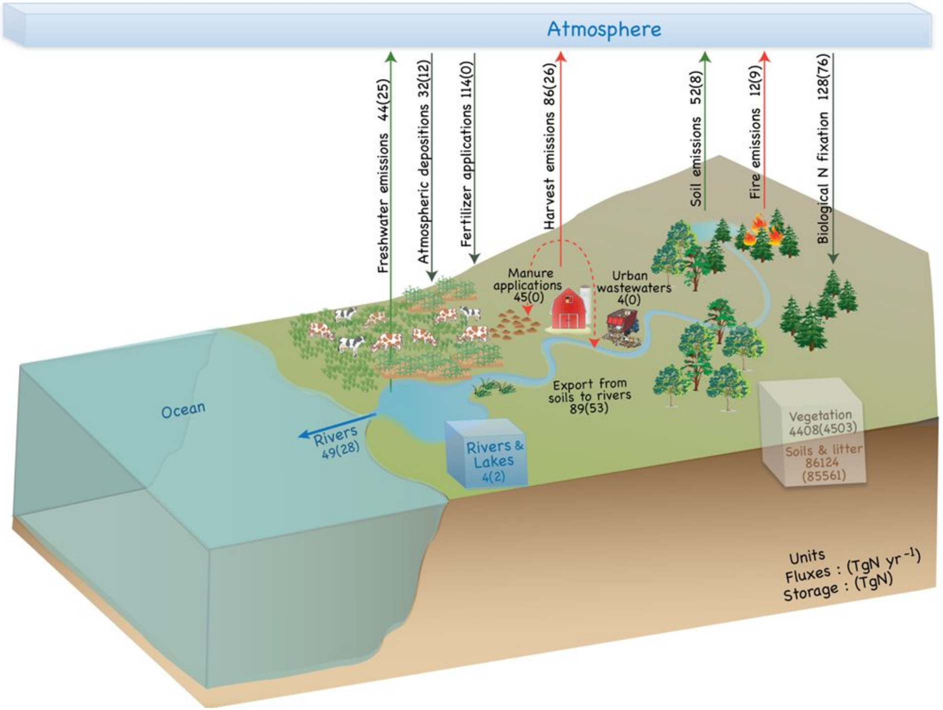
Advances in terrestrial and freshwater BGC

Minjin Lee

Q1: Concerning GFDL's core strength of building and improving models of the weather, oceans, and climate for societal benefits, how can GFDL leverage advances in science and computational capabilities to improve its key models? What are the strengths, gaps, and new frontiers?

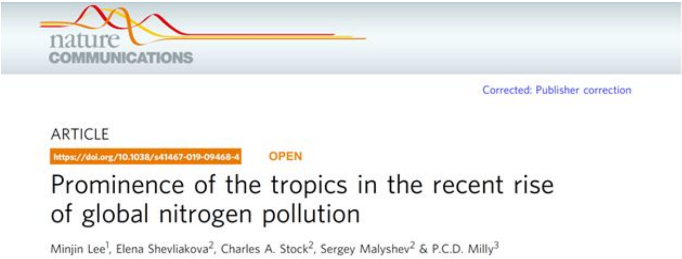
GFDL Land Model LM3-TAN (Terrestrial and Aquatic Nitrogen)

- Vegetation and soil C dynamics and biophysics [Shevliakova et al., Global Biogechem Cy, 2009]
- Terrestrial N dynamics [Gerber et al., Global Biogechem Cy, 2010]
- Terrestrial-river-lake hydrology, river routing [Milly et al., J Hydrometeorol, 2014]
- Linking terrestrial and freshwater N dynamics [Lee et al., Biogeosciences, 2014]



Contemporary (1981-2010 average) and preindustrial (1831-1860 average in parenthesis) times

The Past Two and Half Centuries of Land N Simulations


nature COMMUNICATIONS

Corrected: Publisher correction

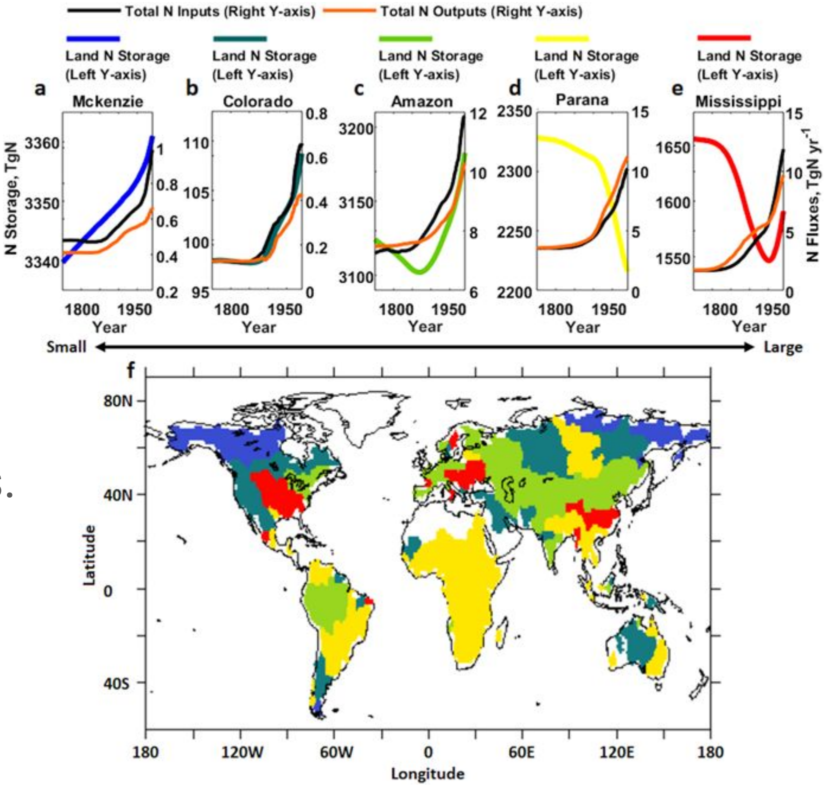
ARTICLE

https://doi.org/10.1038/s41467-019-09468-4 OPEN

Prominence of the tropics in the recent rise of global nitrogen pollution

Minjin Lee[1], Elena Shevliakova[2], Charles A. Stock[2], Sergey Malyshev[2] & P.C.D. Milly[3]

- Globally, land currently sequesters 11 (10-13)% of annual N inputs.
- Some river basins, releasing >25% more than they receive, are mostly located in the tropics.
- The tropics produce 56±6% of global land N pollution despite covering only 34% of global land area and receiving far lower amounts of fertilizers than the extratropics.

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Article

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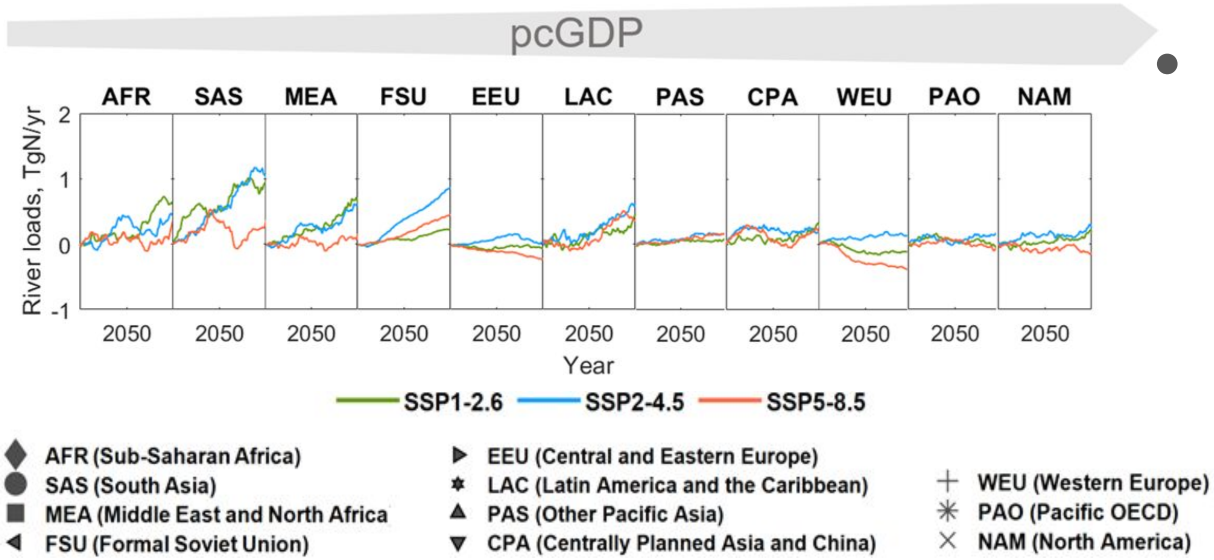
Uneven consequences of global climate mitigation pathways on regional water quality in the 21st century

Received: 14 March 2023

Accepted: 21 June 2024

Minjin Lee[1], Charles A. Stock[2], Elena Shevliakova[2], Sergey Malyshev[2], Maureen Beaudor[3] & Nicolas Vuichard[4]

Future Projections of River N Pollution over the 21st Century



Loads generally

- increase in low-income regions
- remain stable or decrease in high-income regions where agricultural advances, low food and feed production and waste, and/or well-enforced air pollution policies balance biofuel-associated fertilizer burdens.

Geosci. Model Dev., 17, 5191–5224, 2024
https://doi.org/10.5194/gmd-17-5191-2024

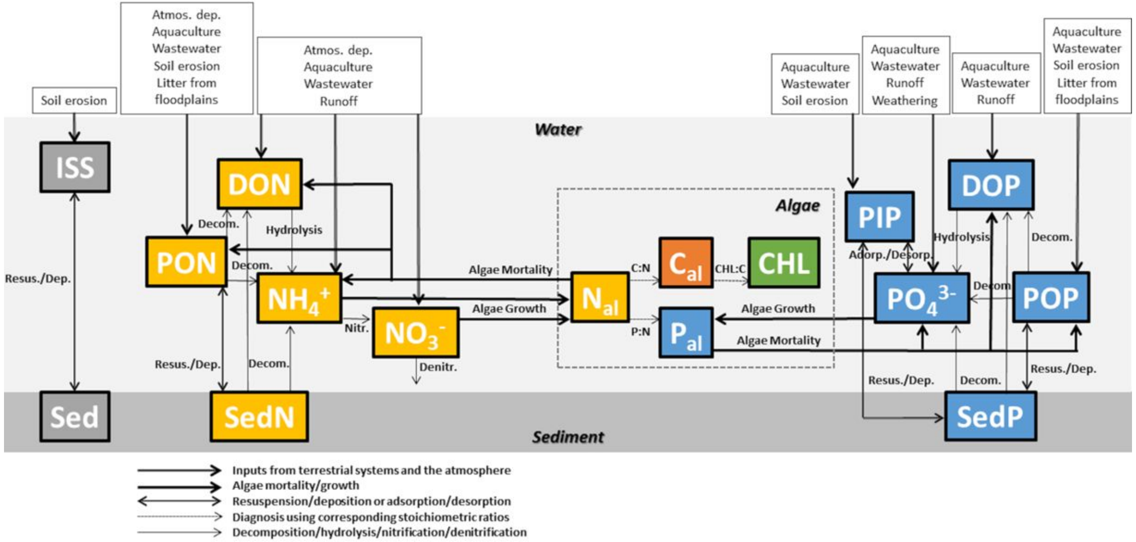
Geoscientific Model Development
Open Access
EGU
Model description paper

Linking global terrestrial and ocean biogeochemistry with process-based, coupled freshwater algae–nutrient–solid dynamics in LM3-FANSY v1.0

Minjin Lee[1], Charles A. Stock[2], John P. Dunne[2], and Elena Shevliakova[2]

LM3-FANSY (Freshwater Algae, Nutrient, and Solid Cycling and Yields)

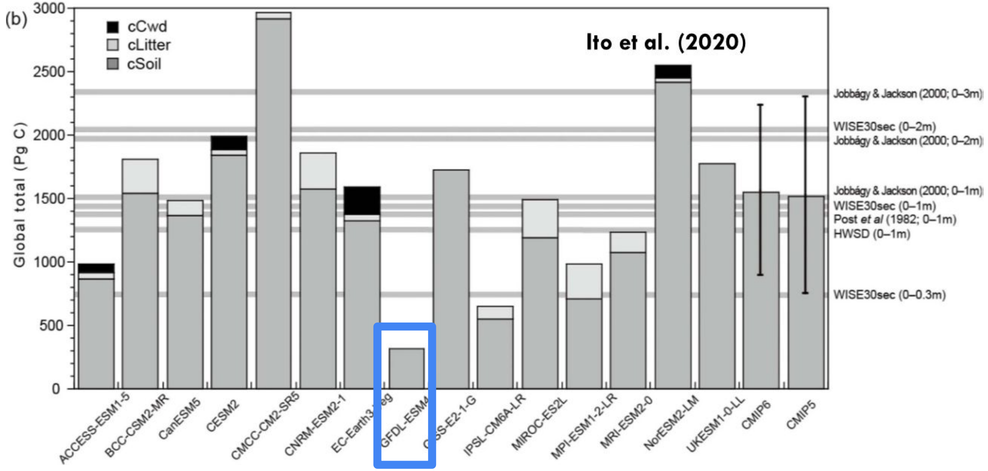
A baseline for eventual linking of global terrestrial and ocean biogeochemistry in next generation Earth System Models



simulates SS, N, and P in multiple forms (particulate /dissolved, organic/inorganic) and units (yield, load, and concentration) across globally distributed large rivers, with an accuracy comparable to other global empirical models.

Motivation for the Global Integrated Microbial Interactions with Carbon in Soil (GIMICS) Development

- CMIP6 Earth System Models (ESMs), except for the NOAA/GFDL ESM4.1, do not explicitly represent soil microbial dynamics.
- ESM4.1's soil C module (i.e., CORPS) represented soil C dynamics above permafrost and underpredicted the total amount of soil C.



Ito et al. (2020)

- Observational data shown by grey horizontal bars
- 15 CMIP land model estimates
  - Soil: 1413±688
  - Litter: 185±88 (11.9, 1.7-27.8% of soil)
  - Total: 1553±672

Basic Structure of GIMICS

Retained structure from CORPSE

- 2 aboveground (1 coarse wood litter, 1 leaf litter) layers
- 40 belowground (20 rhizosphere , 20 bulk soil) vertically resolved layers in 10 m depth

Adoption from MIMICS

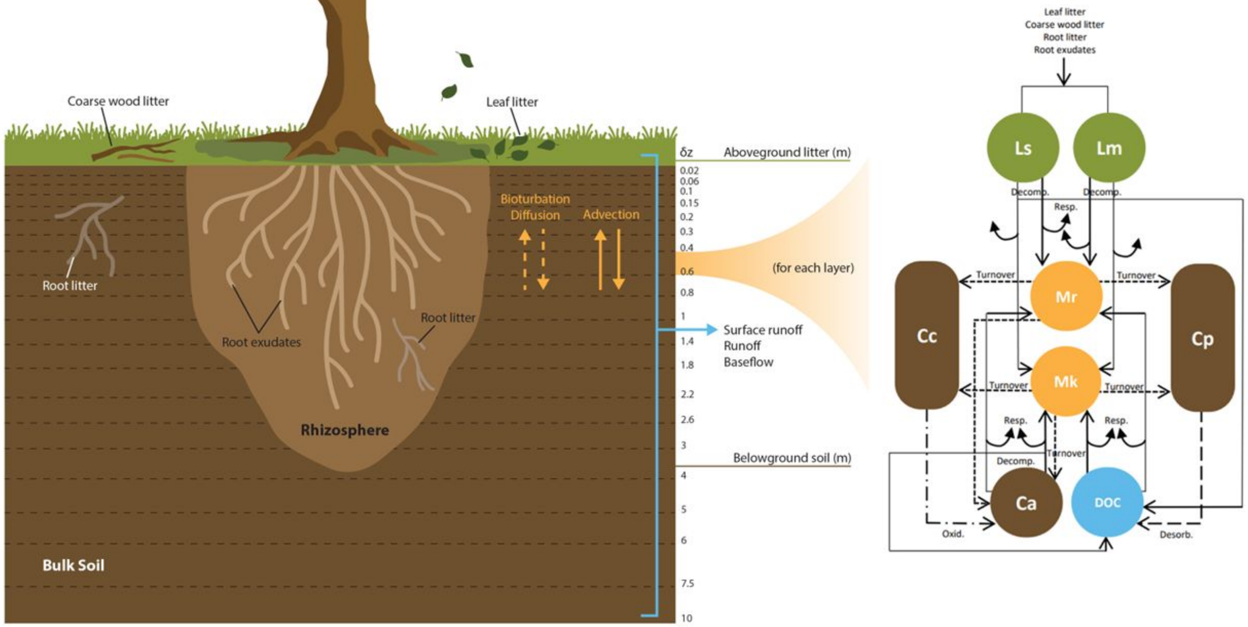
- Equations of MIMICS demonstrating the microbial physiology and soil physiochemical principles

New introduction to GIMICS

- Explicit DOC cycling
- Vertical and horizontal transport of C through bioturbation, diffusion, advection, and runoff to rivers
- Soil moisture effects on decomposition/oxidation
- Turnover rate dependence on microbial density
- Dependence of microbial growth efficiency on temperature

Basic Structure of GIMICS

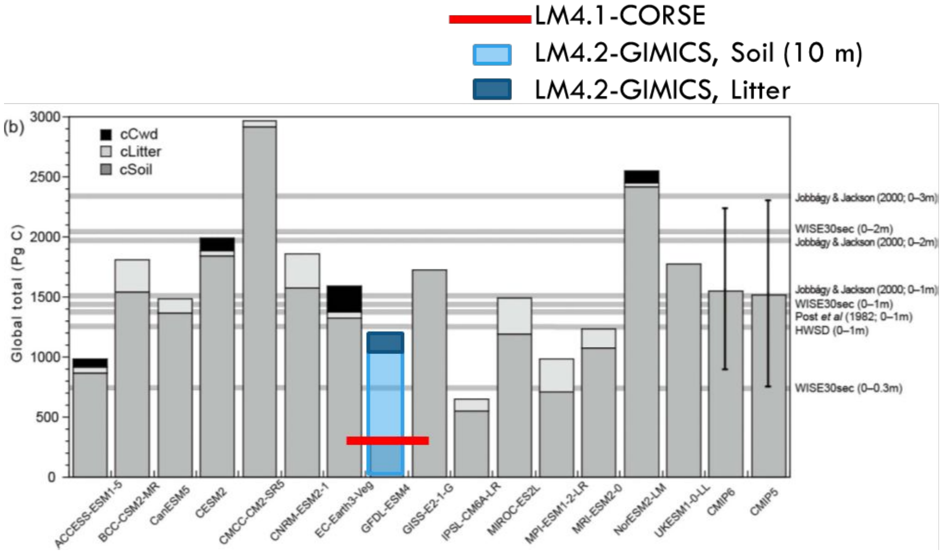
Integrated with LM4.2 including dynamic vegetation and wildfire

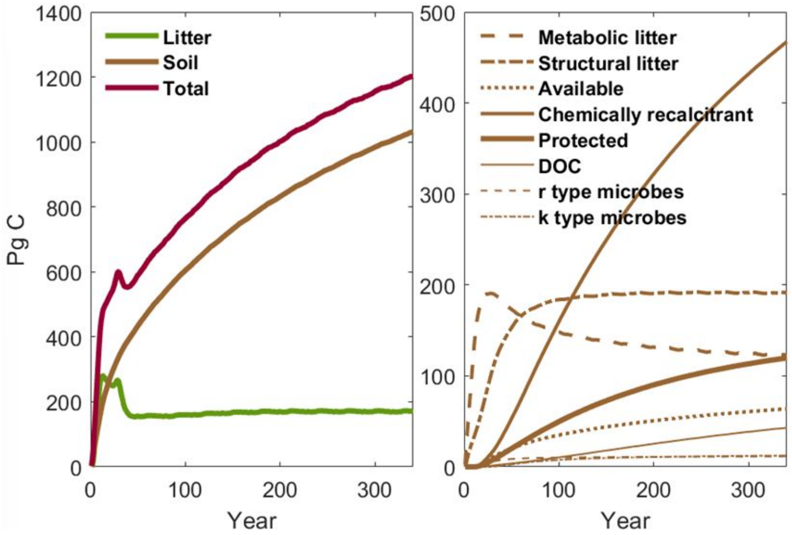


Preliminary On-going Global Spin-up Simulation of LM4.2-GIMICS

Viscarra Roseel & Hicks (2015); Xu et al. (2013)

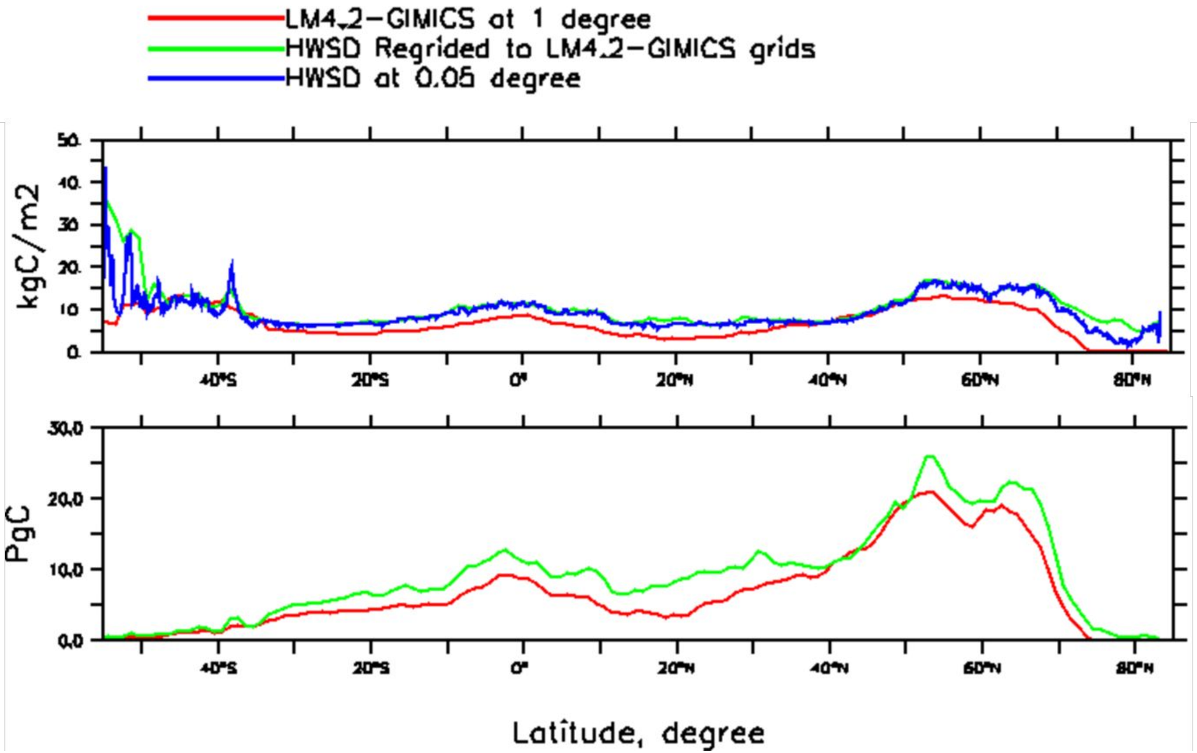
- HOC (Cc): ~46-60%; ROC (Cp): 25-33%; POC (Ca): 12-23%
- Microbes: 2 (0.5-5)% of soil





Preliminary Global LM4.2-GIMICS Zonal Results

Comparison with observation-based global soil dataset, Harmonized World Soil Database v 1.2 (**HWSD**)



Further Model Development Plans - LM4-GIMICS-FANSY

Continued GIMICS enhancements

- Addition of erosion processes
- Introducing the CH4 cycle
- Coupling with the N cycle (NO-GIMICS)

Continued FANSY enhancements

- Coupling with freshwater C and alkalinity dynamics
- Introducing anthropogenic hydraulic controls
- Enhancement of sediment dynamics