Global perspectives on past and future coastal eutrophication and carbon cycle

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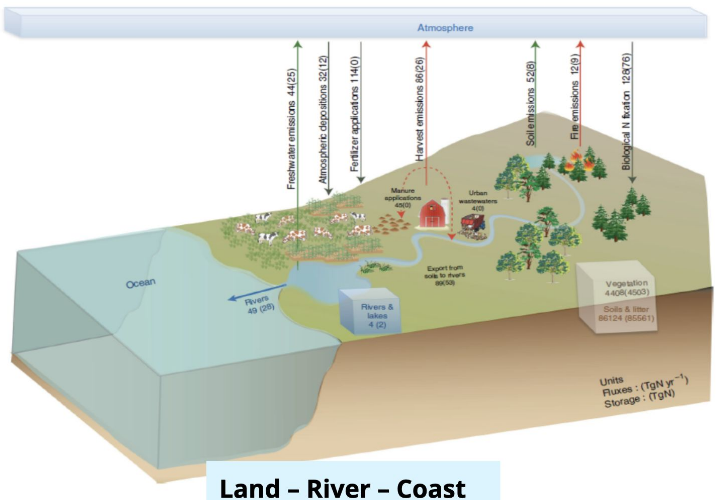
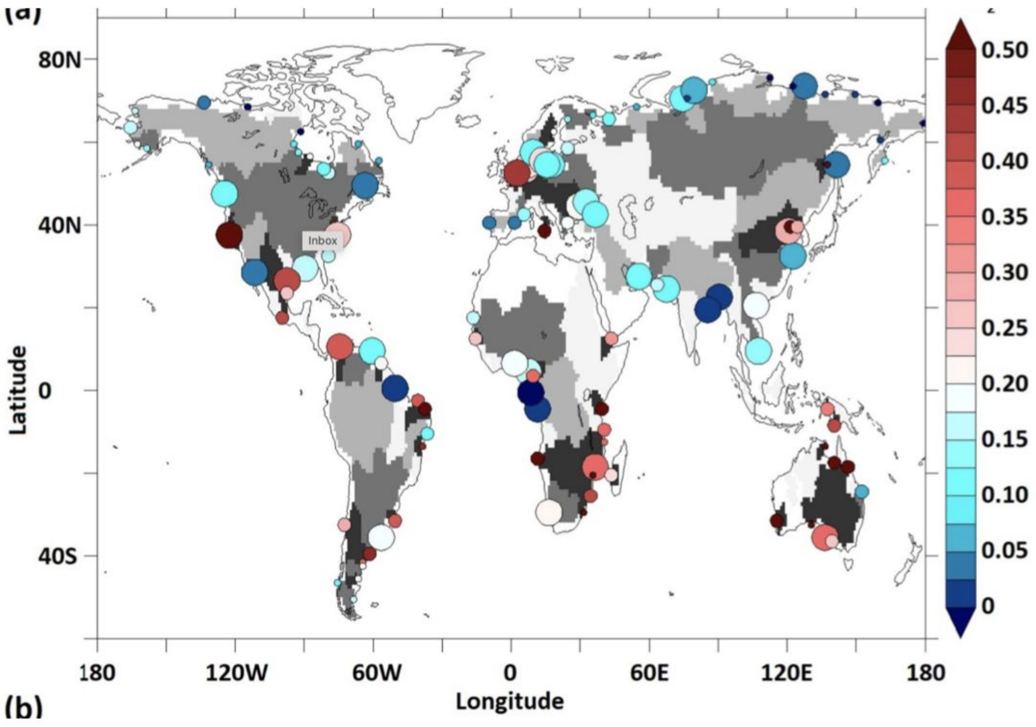
Q2: Concerning NOAA's key mission element of understanding, predicting, and projecting changes in the Earth System, how can GFDL drive further advances in these areas, including extremes and environmental hazards, through scientific innovation based on observations, theory, and modeling? Where are the strengths, gaps, and new frontiers?

Nitrogen pollution from land to oceans (LM3-TAN)

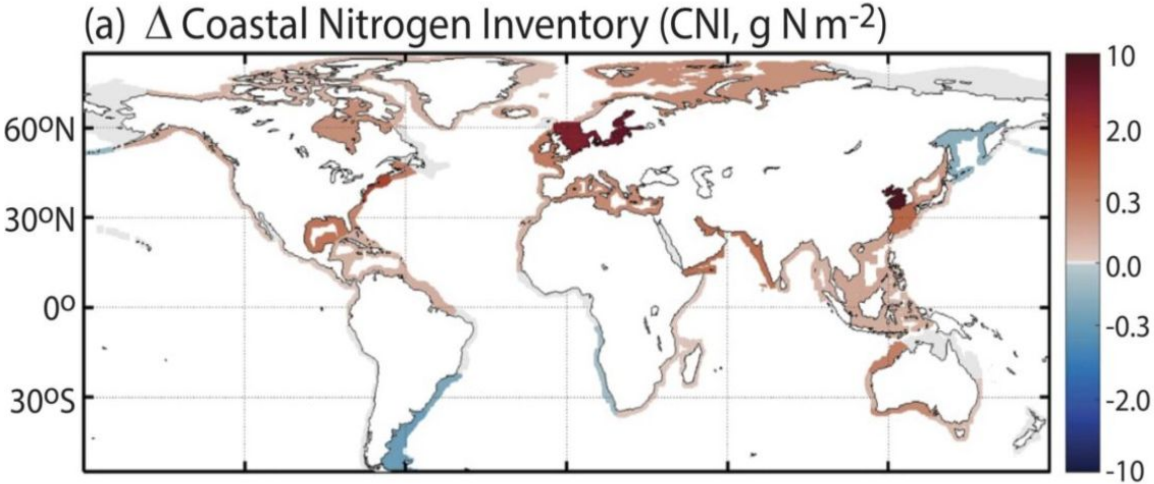


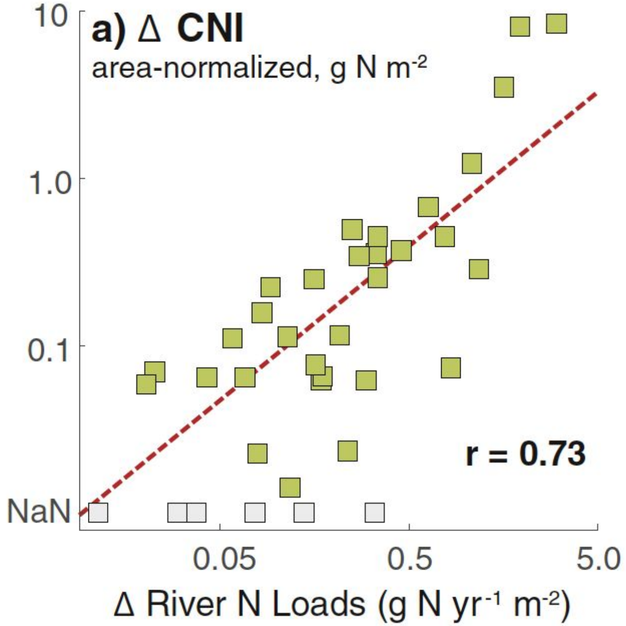
Land – River – Coast



Globally prevalent land nitrogen memory amplifies water pollution following drought years. Lee et al. 2019, 2021

Elevated river N loads increase coastal N inventory (1960-2010)

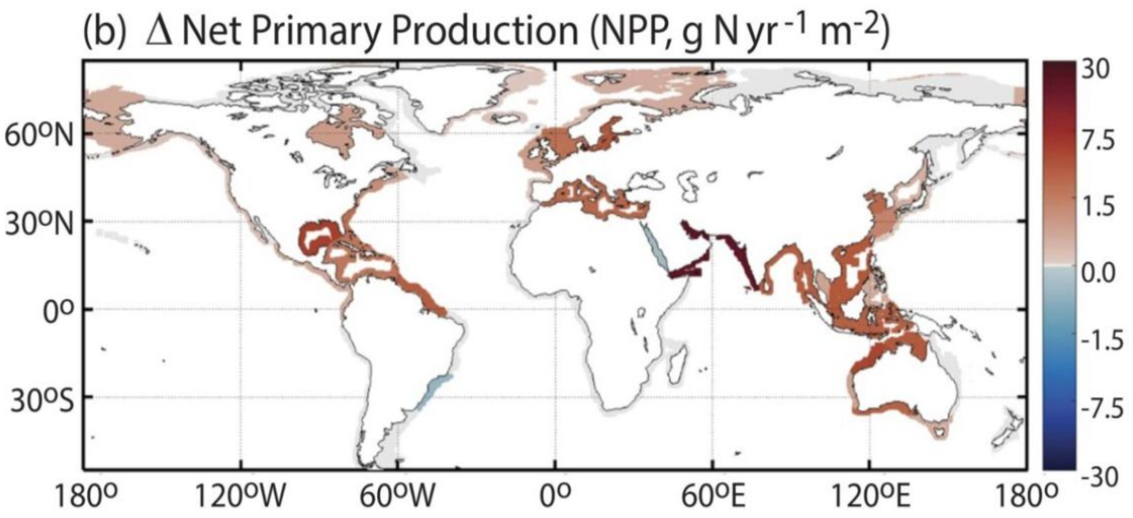


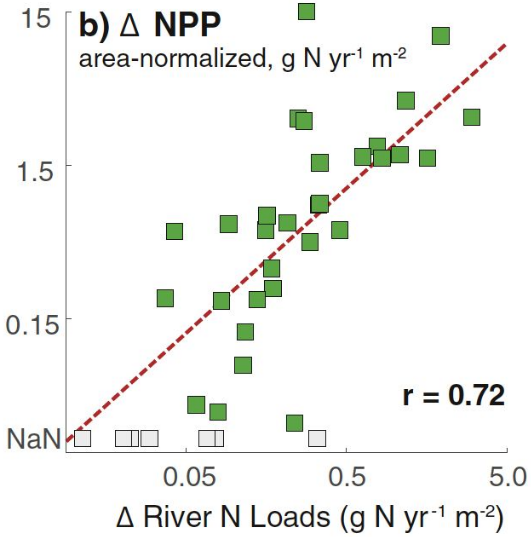


- Nitrogen river pollution adversely affect coastal ecosystems
- Elevated river nitrogen loads resulted in a 5.5% increase in the global coastal nitrogen inventory over the past half century, though this impact vary considerably across the globe

Liu et al 2021

Elevated river N loads increase coastal productivity (1960-2010)





- Response of coastal productivity to increasing river N loads vary considerably across the globe
- The response in coastal ecosystems with long residence times and high levels of nitrogen limitation, however, could be 2-5 times the global mean response

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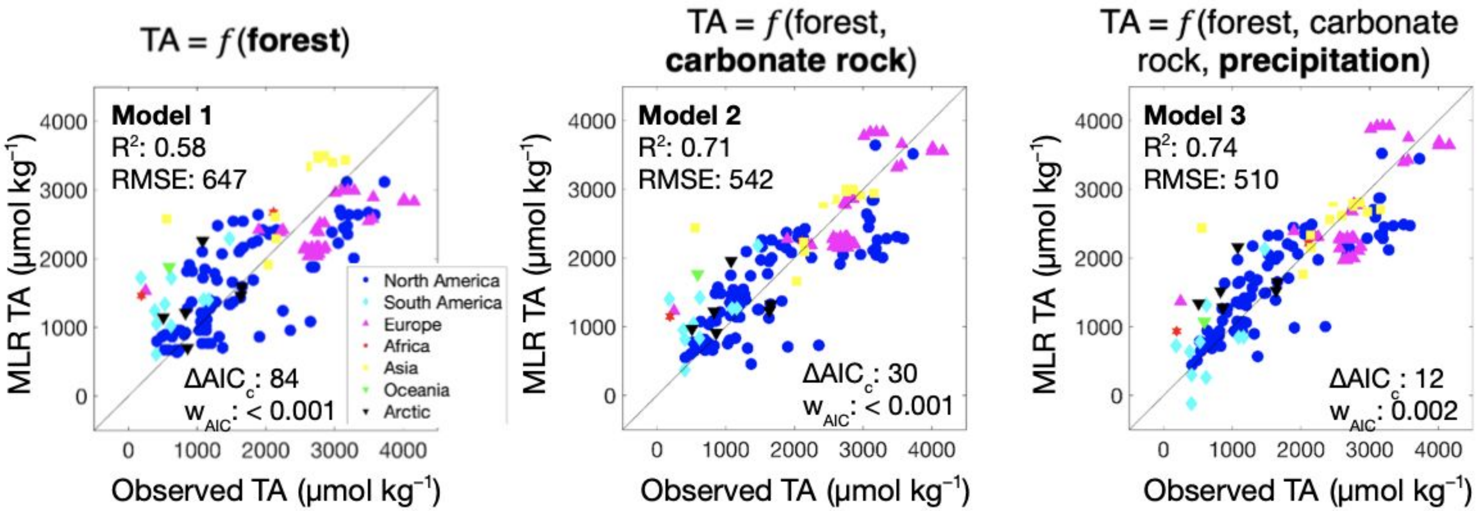
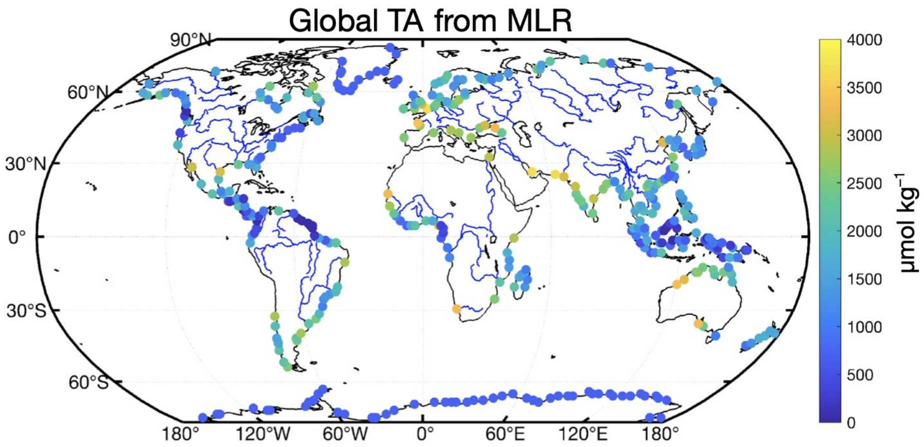
Multiple linear regression for river total alkalinity (TA)

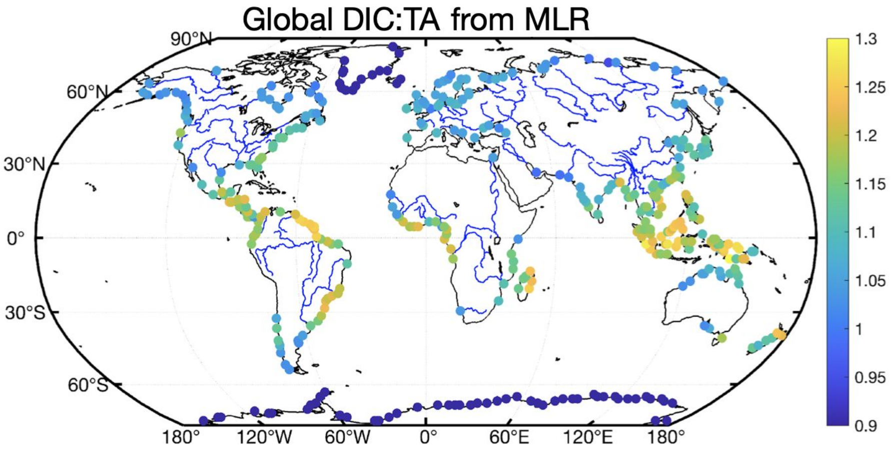


- Forest coverage is the best single predictor (negative)
- Carbonate rock extent is a positive predictor
- Precipitation is a negative predictor and reflects dilution effect

Da et al. *submitted*

Global river TA and DIC:TA data product





- 380 major watersheds globally (discharge > 500 m3 s-1)
- Estimates show significant spatial variability

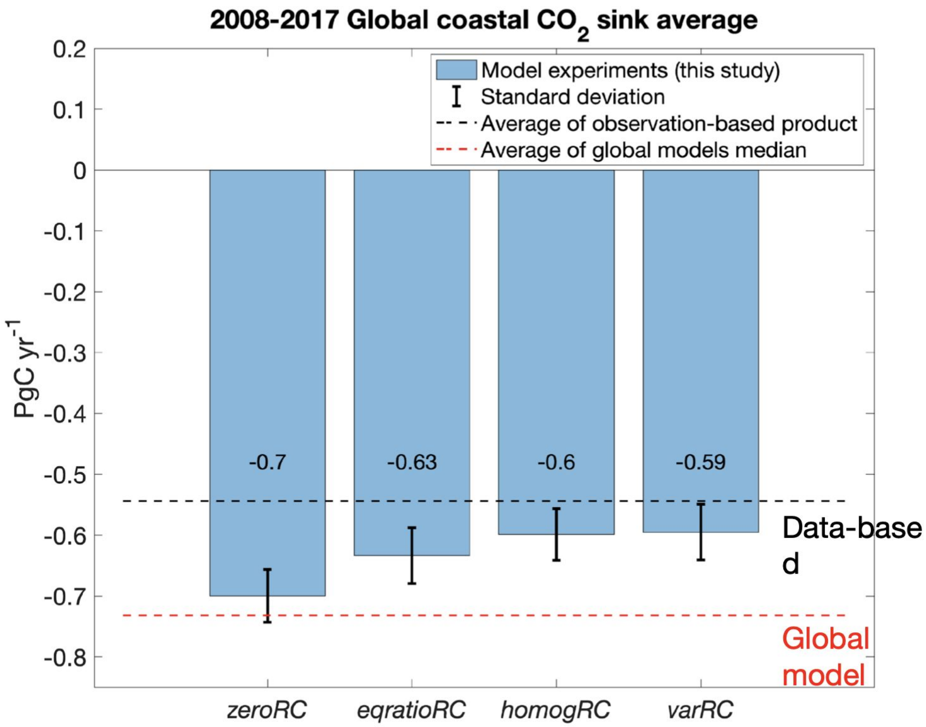
Da et al. *submitted*

Improved model estimates of coastal CO2 flux

- MLR-derived river TA and DIC reduce the high bias in modeled coastal CO2 uptake by 0.11 Pg-C yr−1

- (~70% of the bias) 0.07 Pg-C yr−1 due to MLR-derived TA, and 0.04 Pg-C yr−1 due to DIC:TA ratios (64% vs. 36%)

Da et al. *submitted*



Ongoing work: a mechanistic river TA module

Weathering flux rate of soil $CaCO_3$

- Total surface area of $CaCO_3$ rock in soils (Holford and Mattingly, 1975)
- Weathering rate per unit area of $CaCO_3$ as a function of temperature, water content, and soil pCO_2 (Plummer et al., 1978; Jassal et al., 2005)
- Allows perturbation from human activities (e.g., agricultural liming)

Weathering flux rate of carbonate sediment rocks

- Lithological map by Hartmann and Moosdorf (2012)
- A temperature-dependent weathering rate (Romero-Mujalli et al. 2019)

In-stream processes that alter sources and sinks of TA and DIC

- DIC changes due to algae growth, decomposition of organic matter, and air-water CO_2 exchange
- TA changes due to production and consumption of ammonium and nitrate (Lee et al., 2024)