A Decade-Long Trend in Dissolved Carbon Dynamics and CO_2 Fluxes in the Lower Mississippi River

Anamika Dristi[1]*, and Y. Jun Xu*[1,2]

[1] Louisiana State University, Baton Rouge, LA, USA

[2] Coastal Studies Institute, Louisiana State University, Baton Rouge, LA, USA

Rising global temperatures and shifting precipitation patterns have had a substantial impact on dissolved carbon dynamics, water temperature, and river discharge in recent decades, resulting in altered carbon transport and increasing greenhouse gas emissions from rivers around the world. The Mississippi River reflects worldwide trends with changes in dissolved carbon levels and carbon dioxide (CO_2) outgassing, highlighting its evolving role in the regional and global carbon cycle. Covering over 41% of the total land surface area in the contiguous USA, the Mississippi River is the largest river system in North America. Discharging approximately 520 km^3 of freshwater annually into the Northern Gulf of Mexico (NGOM) in the recent decade, the Mississippi River (MR) contributes significantly to carbon export and coastal food chain in the NGOM. This study investigated decade-long concentrations and mass fluxes of dissolved organic carbon (DOC), dissolved inorganic carbon (DIC), and CO_2 during 2015–2024 in the Lower Mississippi River. Monthly field measurements were conducted on partial pressure of riverine CO_2 (pCO_2), water temperature, dissolved oxygen, pH, chlorophyll-a, CDOM, and turbidity in the Lower Mississippi at Baton Rouge. River water samples were collected, and DIC and DOC concentrations were analyzed. CO_2 outgassing was calculated by analyzing the CO_2 exchange between pCO_2 in water and CO_2 in the atmosphere using a gas exchange coefficient. Over the past 10 years, DIC concentration in the Mississippi ranged from 9.57 to 41 mg/l with an average of 26 ± 5 mg/l, while DOC fluctuated largely from 0.15 mg/l to 14.20 mg/l with an average of 9.10 ± 4.6 mg/l. Annually, the river delivered a large quantity of DIC (12.25 – 15.90 Tg C) and DOC (3.95 - 4.90 Tg C) from dry to wet years. The Lower Mississippi River's surface water showed a large variation in pCO_2 ranging from 518 to 5911 µatm (mean ± sdt: 1869 µatm ± 1113), indicating continuous CO_2 supersaturation. CO_2 outgassing rates in the river varied largely from 0.57 to 56 mmol C m^{-2} hr^{-1} with an average 10.28 mmol C m^{-2} hr^{-1} ± 7.68, primarily controlled by seasonal temperature and hydrology. This long-term study is critical to understanding how continuous environmental shifts, such as rising temperatures and changed river flows, affect dissolved carbon transport and CO_2 emissions in the Mississippi River. By studying these trends over a decade, we can better forecast future changes in riverine carbon dynamics, assess their consequences for the global carbon budget, and improve management measures to limit climate change's effects on freshwater systems.