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# Quantifying global carbon cycle through terrestrial-aquatic exchanges by using an advanced eco-hydrologic and biogeochemical coupling model

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Recent research has shown that inland water (rivers, lakes, and groundwater) plays some role in carbon cycling, although the extent of its contribution has remained uncertain due to the limited amount of reliable data available (Cole et al., 2007; Battin et al., 2009). Quantifying physical and chemical connections through terrestrial-aquatic exchanges is critical for understanding the dynamics of carbon cycle in inland water. To evaluate global carbon cycle under human influence in major rivers including 130 tidal estuaries during 1998-2015, the author used an advanced process-based model by coupling a process-based National Integrated Catchment-based Eco-hydrology (NICE) model with various biogeochemical cycle models (NICE-BGC) (Nakayama, 2020, 2022). The new model used Dirichlet boundary condition at the downstream of global major rivers by using some variables (water temperature, salinity, dissolved oxygen, nutrient, alkalinity, and pH, etc.) in coastal ocean. The simulated result showed that total nitrogen and phosphorus fluxes in overland flow were found to increase with nutrient application. In contrast, total suspended sediment decreased in some regions because the vegetation was able to expand to cover the ground, resulting in less erosion. NICE-BGC simulated the difference in carbon budget in major rivers with and without nutrient application. Generally, $CO_2$ degassing across the air-water interface decreased and particulate organic carbon (POC) increased in most rivers through variations in carbon budget, where excess nutrients might stimulate gross primary production of carbon-rich algal biomass. The simulated result also showed that the estuarine carbon cycle was sensitive to intense anthropogenic disturbances reflected by nutrient load, seawater temperature, increases in sea level, and ocean acidification under Representative Concentration Pathways (RCPs) (Moss et al., 2010). Extension of previous studies only by categorizing MARgins and CATchments Segmentation (MARCATS) (Laruelle et al., 2013) showed that the estimated total $CO_2$ flux from the world's estuaries was 0.14 Pg C/yr. Generally, the simulation showed that incorporation of the nutrient cycle into the terrestrial-aquatic-estuarine continuum improved estimates of net land flux and carbon budget in inland water, thus emphasizing that the effect of estuarine inland water should be explicitly included in the global carbon model to minimize the range of uncertainty.