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From a source to a sink: the role of biological activities on atmospheric CO_2 exchange along the river-ocean continuum.

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Freshwater transports organic and inorganic carbon (C) from the terrestrial biosphere to the coastal ocean, yet this transfer is not conservative, as freshwater ecosystems produce, degrade, store organic C and exchange carbon dioxide (CO_2) with the atmosphere. Freshwater ecosystems are often reported as net heterotrophic, whereby the organic C respiration is higher than the autochthonous production of organic C, and excess organic C consumption is maintained by inputs of allochthonous organic C. Net freshwater heterotrophy promotes the emission of CO_2 to the atmosphere, with global emission from continental waters being significant for global CO_2 budgets. Coastal waters further process the matter received from rivers, and can either act as source or a sink for atmospheric CO_2. A mechanistic chain of biogeochemical models, taking into account the transfer and transformation of C, N, P, Si, was implemented to study the C cycle and the air-water CO_2 flux in river, estuarine and coastal environments. For this application, the model was applied to the anthropized Scheldt basin and the Belgian coastal zone and the evolution of the pCO_2 and air-sea CO_2 flux was simulated for the year 2006. Results show that two processes control the value and seasonal evolution of water pCO_2: exchange of CO_2 with the atmosphere and net ecosystem production (NEP). In both the Scheldt River and its estuary, whereas the emission of CO_2 to the atmosphere sets the overall background pCO_2 values, NEP controls the seasonal variations. In the Belgian coastal zone, on the contrary, the pCO_2 levels and seasonality are mainly controlled by NEP while the exchange of CO_2 with the atmosphere has a minor role in pCO_2 dynamics. This is related on one hand to the very high pCO_2 values brought by ground waters in the river, leading to very intense emissions of CO_2 to the atmosphere, and on the other hand on the higher buffering capacity of saline compared to brackish and freshwaters. On an annual basis, biological activities lead to a source for atmospheric CO_2 in the river and the estuary and as a sink or a source for CO_2 in the coastal environment depending on the relative importance of C and nutrient inputs. Model results are also used to compute annual air-water CO_2 budgets.