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Efficient transfer of organic matter along the land to ocean aquatic continuum: Were pre-industrial continental shelves already a sink for atmospheric CO_2?

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The contribution of the coastal ocean to the global carbon (C) cycle and anthropogenic CO_2 budget is a subject of debate in literature, especially regarding its evolution over the historical period and in the future. Global ocean modelling studies up to now have either not considered the coastal ocean at all or strongly simplified the representation of coastal processes and land inputs of organic and inorganic C, as well as associated nutrients (N, P). We attempt to tackle this challenge by quantifying the effects of changing atmospheric CO_2 levels, variable land-derived water and C-N-P inputs as well as sediment recycling fluxes on the coastal C budget globally using the ocean biogeochemical model HAMOCC coupled to the ocean general circulation model MPIOM.
We simulate a global present-day coastal pCO_2 climatology in strong agreement with state-of-the-art observations (REF) and a net global CO_2 uptake of 0.15 Pg C yr-1, which is in line with most recent constraints of 0.15-0.25 Pg C yr-1 (Laruelle et al., 2014 and citations therein, Roobert et al., in prep.). We then examine the fate of terrigenous Dissolved Organic Matter (tDOM) in the ocean, using a plausible range of tDOM mineralization rates of 0.002-0.008 d-1 based on measurements in the global ocean and regional assessments. By performing simulations over the historical period (1850-present), our results suggest that in stark contrast with the common belief within the coastal community, the pre-industrial ocean could already have been a weak sink for atmospheric CO_2 (instead of a source). These results hold across a wide range of tDOM mineralization rates, which impact the Net Ecosystem Production (NEP = NPP – Rh, with Rh as community respiration) of the global coastal ocean. Our results reveal an efficient horizontal export of allochthonous (especially for tDOM) and autochthonous detrital organic matter due to short river plume residence times, leading to positive NEPs in many coastal regions that stimulate atmospheric CO_2 uptake under pre-industrial conditions. Similar to what is observed for the present-day from observations, the weak pre-industrial coastal CO_2 sink is dominated by the contribution of the large Northern European, Patagonian and East Asian Shelves. Overall, our results therefore suggest that the anthropogenic perturbation on coastal CO_2 fluxes could be smaller than previously thought.

Laruelle et al. (2014), Regionalized global budget of the CO_2 exchange at the air-water interface in continental shelf seas, Global Biogeochem. Cycles.
Laruelle et al. (2017), Continental shelves as a variable but increasing global sink for atmospheric carbon dioxide. Nature Communications.