C and CO_2 dynamics in the Coastal Ocean: Spatiotemporal variability, drivers, and implications for the global C budget

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The transfers and transformations of carbon (C) at the coastal interface are important components of the global C cycle, not only for the mean, but also with regard to past and future changes. Although the present-day spatiotemporal dynamics of the coastal ocean C cycle is increasingly constrained at the global scale, large uncertainties remain regarding the underlying physical and biogeochemical drivers of change while much remains to be elucidated with respect to past and future trends in coastal ocean C fluxes.

This contribution synthesizes some recent advances in global coastal ocean C cycle research. First, we present a 0.25° resolution, seasonally resolved climatology of the sources and sinks of CO_2 for the global coastal ocean. We show that high-resolution global ocean biogeochemistry models can reproduce the mean and spatiotemporal patterns in air-sea CO_2 fluxes. We then use a data-model fusion approach to attempt an attribution analysis of seasonal CO_2 changes to factors such as wind speed, sea-ice cover and air-sea pCO_2 gradient, the latter being further decomposed into chemical, biological and physical drivers. We find that annual mean CO_2 flux densities are generally comparable in magnitude and pattern to those of the adjacent open ocean, that the majority of the seasonal variations stem from the air-sea pCO_2 difference (dominated by the thermal effect and complex, partly compensating effects between non-thermal terms), and that the most intense CO_2 invasion occurs in the summer.

Second, we expand our analysis to the entire land-to-ocean aquatic continuum (LOAC) and attempt a full C cycle budget for the present-day and preindustrial states. One aim is to assess whether the recent upward revision of the pre-industrial riverine carbon fluxes obtained from an ocean perspective is reconcilable with an independent estimate from a LOAC perspective. We show that both views are convergent and suggest plausible mechanisms explaining why preindustrial land-to-ocean C transfers could have been higher than previously thought.