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Past century increases of terrestrial nutrient inputs impact both the coastal and open ocean carbon cycle

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Past century increases in terrigenous N and P inputs to the ocean due to industrialization, agricultural practices and wastewater have been reported to have dramatic consequences for ecosystems in various coastal regions. Yet, the impacts of increased nutrient inputs through river transports and atmospheric deposition on the coastal and open ocean carbon cycle have yet to be quantitatively investigated at the global scale. To address this gap of knowledge, we enhanced the ocean biogeochemical model HAMOCC at a horizontal resolution of around 0.4° in order to improve the representation of temporal changes of riverine fluxes and of coastal ocean dynamics in the model. Through a series of simulations with differing model forcings, we isolated individual effects arising from (1) increasing atmospheric CO_2 levels, (2) a changing physical climate and (3) alterations in oceanic inputs of terrigenous P and N inputs, all over the 1905 to 2010 period. Our results indicate a strong response of the coastal ocean ecosystem to increased terrestrial nutrient inputs, which induce the global coastal Net Primary Production (NPP) to increase by 14% over the simulation time span. This eutrophication signal is, furthermore, partly exported to the open ocean, which undergoes an increase in NPP of 1.75 Pg C yr^{-1}, or 4 % in relative terms, in the simulations, owing to the cross-shelf export of 33-46% of the anthropogenic P and N inputs to the coastal ocean. As a whole, increased P and N inputs lead to an overall global ocean NPP rise of around 2.15 Pg C yr^{-1}, or 5% (combined coastal and open ocean). This net increase attributed to land-ocean couplings exceeds the simulated global oceanic NPP decrease of 4 % associated with stronger upper ocean thermal stratification over the time span, a feedback that been under stronger scrutiny in published literature. Our results suggest that increased riverine nutrient concentrations due to anthropogenic activities may also have substantial impacts for ecosystems in the open ocean, in contrary to what was assumed until now, although this is dependent on the rate of transfer of the nutrients from the coastal to the open ocean.