BUDGETING SINKS AND SOURCES OF CO_2 IN THE COASTAL OCEAN: DIVERSITY OF ECOSYSTEMS COUNTS

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ABSTRACT

Air-water CO_2 fluxes were up-scaled to take into account the latitudinal and ecosystem diversity of the coastal ocean, based on an exhaustive literature survey. Marginal seas at high and temperate latitudes act as sinks of CO_2 from the atmosphere, in contrast to subtropical and tropical marginal seas that act as sources of CO_2 to the atmosphere. Overall, marginal seas act as a strong sink of CO_2 of about -0.45 Pg C yr^{-1}. This sink could be almost fully compensated by the emission of CO_2 from the ensemble of near-shore coastal ecosystems of about 0.40 Pg C yr^{-1}.

INTRODUCTION

The coastal ocean has been to a large extent ignored in global carbon budgets, even if the related flows of carbon and nutrients are disproportionately high in comparison with its surface area. It receives massive inputs of organic matter and nutrients from land, exchanges large amounts of matter and energy with the open ocean across continental slopes and constitutes one of the most biogeochemically active areas of the biosphere. Hence, intense air-water CO_2 exchanges can be expected in the coastal ocean that could lead to a major re-evaluation of CO_2 flux budgets at regional or global scales. Also, 80% of the surface area of the coastal ocean is located in the Northern Hemisphere, with possible consequences for global atmospheric CO_2 inversion models and inter-hemisphere carbon transport estimates.

RESULTS AND DISCUSSION

An exhaustive literature survey of air-water CO_2 fluxes was conducted and data in 44 coastal environments (Fig. 1) were gathered in 6 major ecosystems (marginal seas, upwelling systems, estuaries, mangrove and salt-marsh waters, and coral reefs). Marginal seas at high (Barents Sea, Bristol Bay, Pryzd Bay, and Ross Sea) and temperate (Baltic Sea, North Sea, Gulf of Biscay, US Middle Atlantic Bight, and East China Sea) latitudes are net annual sinks of atmospheric CO_2 but at sub-tropical and tropical latitudes they are net annual sources of CO_2 to the atmosphere (US South Atlantic Bight, South China Sea, and Southwest Brazilian coast). Near-shore ecosystems (estuaries, saltmarsh waters, mangrove waters, coral reefs, and coastal upwelling systems) are net annual sources of CO_2. The most intense fluxes are located at the land-aquatic interface (estuaries, saltmarsh waters, and mangrove waters) due to inputs of terrestrial organic carbon that fuel the net heterotrophy of the aquatic compartment. Air-water CO_2 fluxes in the coastal ocean were up-scaled by latitudinal bands of 30°, taking into account its geographical and ecosystem diversity, and an overall integration of CO_2 fluxes was carried out using the most recent climatology for open oceanic waters [*Takahashi et al.*, 2002]. The coastal ocean would act as a net CO_2 sink at high and temperate latitudes and as a net CO_2 source at tropical latitudes. The inclusion of coastal air-water CO_2 fluxes would strongly increase the overall CO_2 sink at high and temperate latitudes, but would significantly increase the overall CO_2 source at subtropical and tropical latitudes (Fig. 1). Marginal seas act as a significant CO_2 sink (-1.62 mol C m^{-2} yr^{-1}; -0.45 Pg C yr^{-1}) in agreement with previous estimates based on the extrapolation to worldwide continental shelves of data from the East China Sea [*Tsunogai et al.* 1999] or the North Sea [*Thomas et al.*, 2004]. This agreement is due to the fact that although tropical and subtropical marginal seas are CO_2 sources they only represent 6% of the total surface area of the coastal ocean compared to 56% and 27% for, respectively, temperate and high latitude marginal seas. However, the global sink of CO_2 in marginal seas could be almost fully compensated by the emission of CO_2 (+11.09 mol C m^{-2} yr^{-1}; +0.40 Pg C yr^{-1}) from the ensemble of near-shore coastal ecosystems, mostly related to the emission of CO_2 from estuaries (0.34 Pg C yr^{-1}). On the whole, the coastal ocean would act as a small CO_2 sink (-0.05 Pg C yr^{-1}) and would lead to a modest increase of the CO_2 sink from the global ocean (-1.57 versus -1.62 Pg C yr^{-1}, 3%).

CONCLUSIONS

The present up-scaling of air-water CO_2 fluxes shows the contrasted behavior of the proximal coastal ocean (ensemble of near-shore ecosystems) strongly influenced by terrestrial inputs and the distal coastal ocean (marginal seas) that exports carbon to the adjacent deep ocean as DIC and as organic carbon. This up-scaling also clearly illustrates the importance of the diversity of ecosystems and latitudinal variability in the overall role of the coastal ocean as a sink or a source of CO_2. This has significant consequences on our understanding of global cycles of carbon and CO_2.

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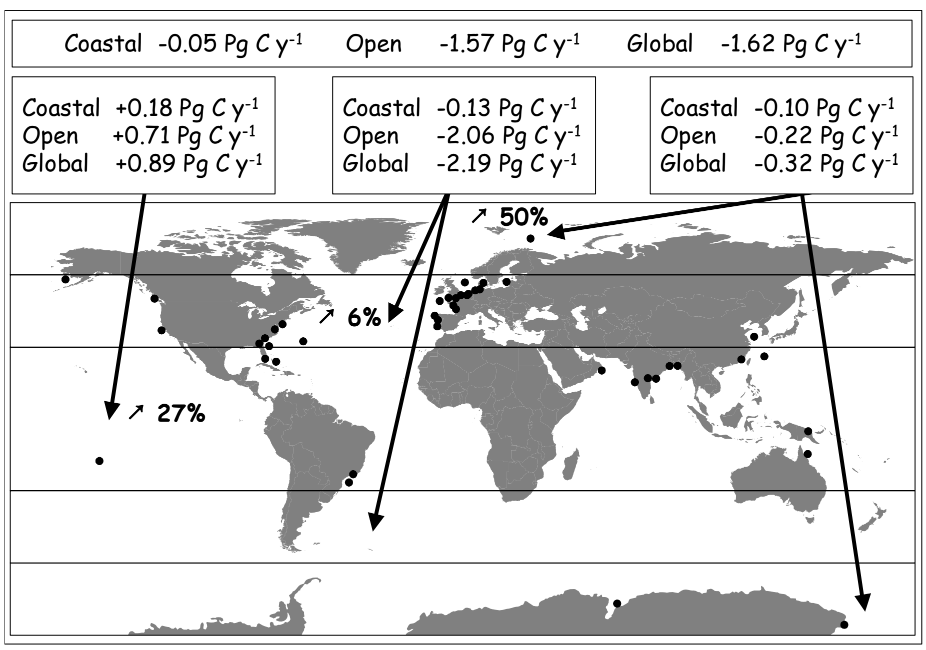

Fig. 1 Location of 44 coastal environments where annual integrated air-water CO_2 fluxes are available from literature and up-scaled fluxes in coastal, open and global oceans by latitudinal bands of 30°, based on *Borges* [2005] and *Borges et al.* [2005].