Do we have enough pieces of the jigsaw to integrate CO_2 fluxes in the Coastal Ocean ?

Borges A.V. [1], B. Delille [1], V. Schoemann [2] & M. Frankignoulle [1]

surface ocean solas lower atmosphere study

Open Science Conference
13-16 October 2004, Halifax, Canada

✓Abstract:

Carbon dioxide (CO_2) dynamics, in particular the exchange of CO_2 across the air-water interface in continental shelf environments have recently been the subject of intense research, triggered partly by the work of Tsunogai et al. (1999). These authors extrapolated CO_2 fluxes obtained in the East China Sea to the global continental shelf surface area and calculated a CO_2 sink of about 0.5 Pg C yr^{-1}. This would correspond to about 30% of the atmospheric CO_2 pump in the Open Ocean, presently estimated to 1.6 Pg C yr^{-1} (Takahashi et al. 2002). Thus, if the continental shelf pump hypothesis is world-wide confirmed, it would have major implications on our understanding of the global C cycle and a significant revision of the estimate of the oceanic pump for atmospheric CO_2. We present a compilation of available data on CO_2 fluxes in various coastal ecosystems. We attempted to upscale them to derive for the first time ever a global integration in the Coastal Ocean. We show that the Coastal Ocean has a significant impact on the overall CO_2 fluxes of the Global Ocean but that the effect is different in direction and magnitude in the three considered latitudinal bands: high (>60°), temperate (30°-60°) and tropical (<30°).

✓Introduction:

Although continental shelves represent only about 7 % of the oceanic surface area, they account for about 20% of the total oceanic organic matter production, 80% of total oceanic organic matter burial, 90% of total oceanic sedimentary mineralization, and 30% of total oceanic production and 50 % accumulation of particulate inorganic carbon (Gattuso et al. 1998a; Wollast 1998). Hence, intense air-water CO_2 exchanges can be expected from such significant carbon fluxes. Furthermore, human activities are changing the continental water cycle, and the flows of sediment, carbon and nutrients to the Coastal Ocean with likely consequences for the sequestration or emission of anthropogenic CO_2.

✓Results & Discussion:

Annually integrated air-water CO_2 flux data in 44 coastal environments were compiled from literature (**Fig. 1**). Data were gathered in 8 major ecosystems (inner estuaries, outer estuaries, whole estuarine systems, mangroves, salt-marshes, coral reefs, upwelling systems and open continental shelves), and up-scaled in the first attempt to integrate air-water CO_2 fluxes over the Coastal Ocean, taking into account its geographical and ecological diversity.

Two up-scaling attempts were performed, excluding (**Fig. 2**) and including (**Fig. 3**) inner estuaries and non-estuarine salt-marshes, **since there is considerable uncertainty regarding the surface area estimate** of these two ecosystems.

If estuaries and salt-marshes are <u>not</u> taken into account in the up-scaling (**Fig. 2**), the **Coastal Ocean behaves as a sink for atmospheric CO_2 (-1.17 mol C m^{-2} yr^{-1}) and the uptake of atmospheric CO_2 by the Global Ocean increases by 24%**. The inclusion of the Coastal Ocean increases the estimates of CO_2 uptake by the Global Ocean by 57% for high latitude areas and by 15% for temperate latitude areas. At subtropical and tropical latitudes, the contribution from the Coastal Ocean increases by 13% the CO_2 emission to the atmosphere from the Global Ocean.

If estuaries and salt-marshes are taken into account in the up-scaling (Fig. 3), the Coastal Ocean behaves as a source for atmospheric CO_2 (+0.38 mol C m^{-2} yr^{-1}) and the uptake of atmospheric CO_2 from the Global Ocean decreases by 12%. At high and subtropical and tropical latitudes, the Coastal Ocean behaves as a source for atmospheric CO_2 but at temperate latitudes, it still behaves as a moderate CO_2 sink. A rigorous up-scaling of air-water CO_2 fluxes in the Coastal Ocean is hampered by the very poorly constrained estimate of the surface area of inner estuaries. However, the present estimates clearly indicate the significance of this biogeochemically highly active region of the biosphere in the global CO_2 cycle.

✓Conclusions:

A rigorous up-scaling of air-water CO_2 fluxes in the Coastal Ocean is hampered by the very poorly constrained estimate of the surface area of inner estuaries. However, the present estimates clearly indicate the significance of this biogeochemically highly active region of the biosphere in the global CO_2 cycle. Future research should concentrate on:

- evaluating the surface area of salt-marshes, inner and outer estuaries and its latitudinal partitioning with some accuracy
- determining the air-water CO_2 fluxes in high latitude inner and outer estuaries (presently, the values at temperate latitudes was used)
- constraining air-ice CO_2 fluxes to include them in the upscaling (presently, a zero air-ice CO2 flux was assumed)
- gathering air-water CO_2 fluxes in highly productive macrophyte (seagrass and macroalgae) ecosystems
- evaluating inter-annual variability of air-water CO_2 fluxes in coastal ecosystems (in relation to ENSO or NAO)

✓This poster is based on a manuscript submitted to *Estuaries* (http://estuaries.olemiss.edu/)

Fig. 1 : Location of 44 coastal environments where annual integrated air-water CO_2 fluxes are available from literature

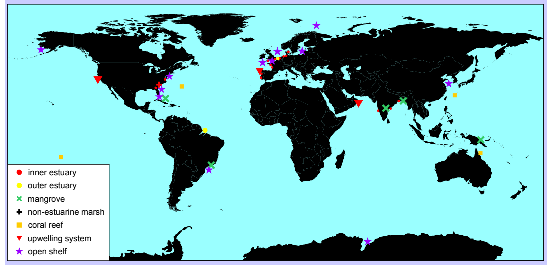


Fig. 2 : Upscaled air-water CO_2 fluxes <u>EXCLUDING</u> inner estuaries and salt-marshes

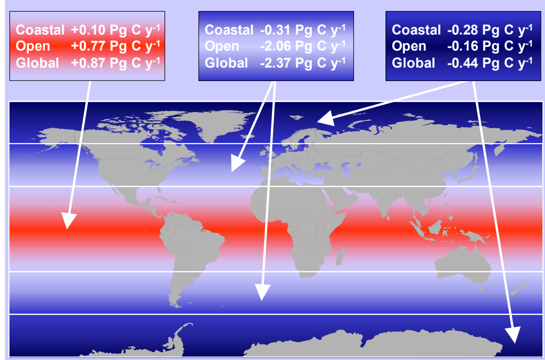
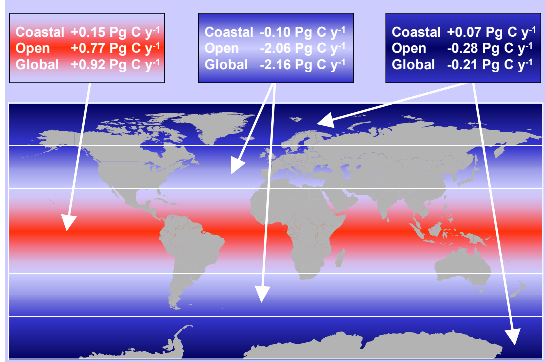


Fig. 3 : Upscaled air-water CO_2 fluxes <u>INCLUDING</u> inner estuaries and salt-marshes



✓References:

Takahashi et al. 2002. Deep-Sea Research Part II 49(9-10):1601-1622.

Tsunogai et al. 1999. Tellus Series B 51(3):701-712.

www.ulg.ac.be/oceanbio/co2/

Acknowledgements:
This work was accomplished in the framework of EU project EUROTROPH (EVK3-CT-2000-00040), Federal Office for Scientific, Technical and Cultural Affairs BELCANTO (EV/12/7E) and CANOPY (EV/03/20) projects, and Fonds National de la Recherche Scientifique (FNRS) projects 2.4545.02, 2.4596.01 and 1.5.066.03. Thanks to Gwenaël Abril, Steven Bouillon, Wei-Jun Cai, Ioen Delille, Jean-Pierre Gattuso, Frédéric Gazeau, Jack J. Middelburg, Abdirahman Omar and Frédérique Seyler.

[1] Université de Liège, Belgium (Alberto.Borges@ulg.ac.be)
[2] Université Libre de Bruxelles, Belgium