GCP

The Global Carbon Program (GCP) is now fully engaged in two major activities: Vulnerabilities of the carbon cycle in the 21st Century, and Urban and Regional Carbon Management.

Vulnerabilities: Starting this year, there will be several working groups producing new assessments of the vulnerability of carbon pools in the ocean and on land due to warming and land use change. The selected pools in the ocean are: solubility, soft-tissue and carbonate pump pools, and methane hydrates; on land: permafrost, peatlands, vegetation/fires, soil carbon.

Carbon Management: A network of regional case studies has been established with the purpose to compare evolution of greenhouse gases emissions over the last 20 years and relate them to their proximal and ultimate drivers. The comparative analyses will allow designing future development pathways with lower GHGs signature.

The Inter-American Institute for Global Change Research (IAI) is a regional inter-governmental organization created by a treaty between 19 countries in the Americas. IAI is dedicated to promoting scientific excellence, international cooperation, and the full and open exchange of scientific information relevant to global change. In addition to funding cooperative research, the IAI funds and organizes training and education, such as the IAI Training Institute on Climate and Health in the Americas (November 7-18, 2005, Kingston, Jamaica). There are also IAI-NCAR Training Workshops and IAI/NCAR Postdoctoral Fellowships. The IAI sponsors, jointly with the Institute for Agriculture in the Tropics and the German Academic Exchange Service, DAAD, a 2005 Summer School on Integrated Resource Management in the Tropics (September 19-30, 2005, Göottingen, Germany) which brings together specialists from Forestry and Agriculture involved in sustainable management and land use with a regional focus in Latin America.

Alberto V. Borges from the Chemical Oceanography Unit of the Université de Liège (Belgium) works on carbon and carbonate cycling in coastal ecosystems with particular emphasis on air-sea exchange of CO_2 and on the coupling between inorganic carbon dynamics and biological processes.

Budgeting sinks and sources of CO_2 in the coastal ocean: Diversity of ecosystems counts

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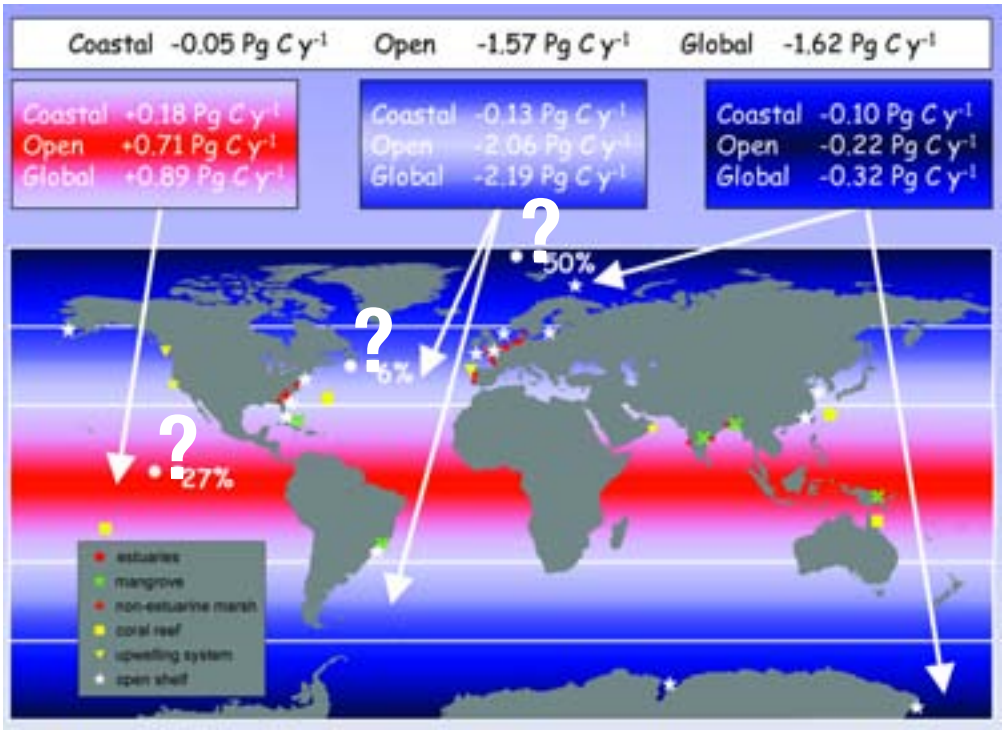
The coastal ocean has been to a large extent ignored in global carbon budgets, even if the related flows of carbon and nutrients are disproportionately high in comparison with its surface area. It receives massive inputs of organic matter and nutrients from land, exchanges large amounts of matter and 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.

An exhaustive literature survey of air-water CO_2 fluxes was conducted and data in 44 coastal environments 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[1]. 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.

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[2] or the North Sea[3]. 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%).

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.

Acknowledgements

Dedicated to Michel Frankignoulle and Roland Wollast, two dear friends and invaluable scientists.

References

[1] Takahashi, T., S. C. Sutherland, C. Sweeney, A. Poisson, N. Metzl, B. Tilbrook, N. Bates, R. Wanninkhof, R. A. Feely, C. Sabine, J. Olafsson, and Y. Nojiri (2002), Global sea-air CO_2 flux based on climatological surface ocean pCO_2, and seasonal biological and temperature effects, Deep-Sea Res. II, 49, 1601-1622.

[2] Tsunogai, S., S. Watanabe, and T. Sato (1999), Is there a "continental shelf pump" for the absorption of atmospheric CO_2?, Tellus B, 5, 701-712.

[3] Thomas, H., Y. Bozec, K. Elkalay, and H. J. W. De Baar (2004), Enhanced open ocean storage of CO_2 from shelf sea pumping, Science, 304, 1005-1008.

Further reading

Borges, A.V. (2005), Do we have enough pieces of the jigsaw to integrate CO_2 fluxes in the Coastal Ocean ?, Estuaries, 28, 3-27.

Borges, A.V., B. Delille, and M. Frankignoulle (2005), Budgeting sinks and sources of CO_2 in the coastal ocean: Diversity of ecosystems counts, Geophys. Res. Lett., submitted

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°

Areas that require more research:

- a more complete description of the latitudinal and temporal variability of air-water CO_2 fluxes in marginal seas and near-shore ecosystems
- the uncertainty of surface area estimates of near-shore systems, in particular estuaries and the aquatic compartment associated to intertidal habitats (mangroves and marshes)
- the neglect of river plume data characterized by large fluxes and surface areas, although under-sampled and for which no global surface area estimate is available
- the lack of data in high-latitude estuaries and river plumes
- the assumption of a zero atmosphere-ice CO_2 flux at high latitudes that is inconsistent with recent data in the Artic and in Antarctica
- the lack of data in certain coastal ecosystems such as highly productive seagrass and macrophyte dominated communities, systems mainly influenced by ground water inputs, and tidal and non-tidal lagoons.

national reports

Canada

Canadian SOLAS (C-SOLAS) is a major climate research project initiated in 2001. The SERIES (Subarctic Ecosystem Response to Iron Enhancement Study) campaign involved the introduction of iron to produce a phytoplankton bloom in the subarctic Pacific. Highlights of SERIES can be found in Boyd et al. (Nature 428, 449-553) and in the early 2006 Deep-Sea Research II Special Issue.

SABINA (Study of Air-Sea Biogeochemical Interactions in the Northwestern Atlantic) was a series of three cruises and aircraft overflights which followed natural phytoplankton blooms. SABINA's results include a better understanding of seasonal variations of climatically-active gas fluxes in the NW Atlantic and will be published in 2006.

A recent Letter of Intent for a Canadian Arctic SOLAS Network has been accepted for full proposal in early 2006 to conduct an east-west research study across Baffin Bay and Lancaster Sound during the International Polar Year 2007. For further information on C-SOLAS, go to www.csolas.dal.ca

China

The China National Committee for IGBP formally approved the establishment of the China IGBP-SOLAS Working Group in November of 2002 as the 'China Surface Ocean-Lower Atmosphere Study: Biogeochemical and Physical Process Coupling'. This program has been funded by the NSFC (National Natural Science Foundation of China) as a major project with a 4-year duration from 2004 to 2008. China SOLAS investigates air-sea biogeochemical interactions in the South China and Yellow Seas with two cruises in 2005 and one planned for 2006. In addition, a ground-based station, Qianliyan Island, which is located at 36°16N, 121°23E, will be set up for meteorological measurements and aerosol, trace gases and water sampling from autumn 2005. The China SOLAS project underscores the study of Asian dust and nitrogen deposition, their transport, flux into ocean and impact on the marine primary productivity. The China SOLAS Working Group is hosting and planning the next SOLAS Open Science Conference in Xiamen, 6-9 March 2007.