Decadal changes of carbon dioxide in the Southern North Sea

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Since late 2000, we have acquired partial pressure of CO_2 (pCO_2) data underway with an equilibrator coupled to an infra-red gas analyser on all the cruises carried out on RV Belgica. Here, we discuss the decadal changes of pCO_2 during winter-time in the Southern North Sea. The trends are faster than those reported in open oceanic waters, although strongly modulated by inter-annual variability that seems to be related to the North Atlantic Oscillation.

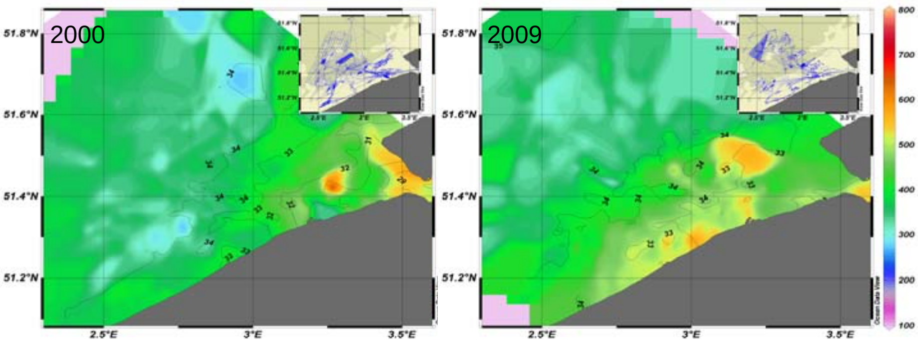

Figure 1: Sea surface salinity climatology superimposed to the climatology of pCO_2@10°C from september to december in 2000 (left) and 2009 (right). The track of the cruises is in the insert.

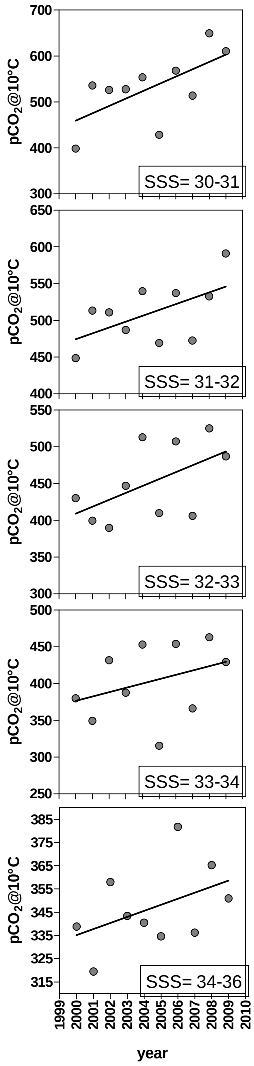

Figure 2: Plot of annual mean pCO_2@10°C per sea surface salinity (SSS) ranges from 30 to 35 PSU. The straight line exhibits the best fit of the linear regression.

The *RV Belgica* has been equipped with an equilibrator coupled to an infra-red gas analyser (Frankignoulle *et al.*, 2001) for surface partial pressure of carbon dioxide (pCO_2) measurement, in addition to the ocean data acquisition system (ODAS) that acquires sea surface temperature (SST), salinity (SSS) and position every minute during scientific cruises. Since late 2000, more than 1.6 10^6 pCO_2 measurements have been made from the North Sea to the Gibraltar Straight. This dataset is exploited, here, in the belgian coastal zone (BCZ) to describe decadal changes in the Southern North Sea (Fig. 1). We endeavour describing the inter-annual variability of pCO_2 by focussing on the low biological activity period (september-december). In order to remove the influence of sea surface temperature, pCO_2 was normalized to 10°C (pCO_2@10°C) after Takahashi *et al.* (1993) and averaged for salinity ranges from 30 to 36.

An overall increase of pCO_2 is observed from 2000 to 2009 in the BCZ in every ranges of salinity (Fig. 2). In the more saline waters of the BCZ, the annual change of pCO_2 accounted for +2.610 ± 1.855 µatm yr^{-1} during this period. Such a value is comparable to the recent estimate of +2.68 ± 0.3 to 3.18 ± 0.3 µatm yr^{-1} from 1990 to 2006 at [52.5°N; -2.5°E] and [47.5°N; -2.5°E], respectively (Schuster *et al.,* 2009). In the water masses influenced by the Scheldt, between salinities of 30 and 34, the mean annual increase of sea surface pCO_2 exceeds that of the Atlantic Ocean. The significant relationship moreover suggests higher increase of sea surface pCO_2 at lower salinities (Fig. 3).

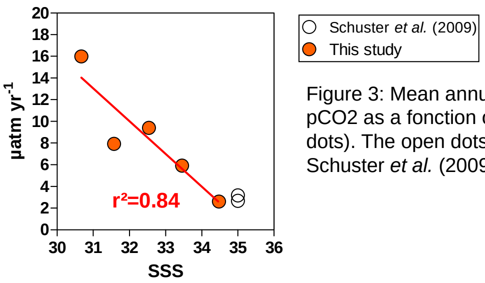

Figure 3: Mean annual increase of sea surface pCO2 as a fonction of the mean salinity (grey dots). The open dots refet to the estimates by Schuster *et al.* (2009).

Since the industrial revolution, the amount of CO_2 released by the anthropogenic activities has increased into the atmosphere. The rise of atmospheric CO_2 has globally accelerated in the recent years to a rate of 1.93 µatm $yr^{-1}$from 2000 to 2006 (Canadell *et al.*, 2007) and lead to ocean acidification. In such a coastal eutrophized area, the combined effect of CO_2 rise and nutrient disequilibrium on the coastal ocean acidification problem (Borges & Gypens, 2009) is alarming for the preservation of benthic calcifiers wich are an important compartment, economically and in terms of biodiversity and ecological equilibrium.

References
Canadell J. G. *et al.* (2007) Contributions to accelerating atmospheric CO_2 growth from economic activity, carbon intensity, and efficiency of natural sinks. *PNAS* **104**, 18866-18870.
Borges A.V. and Gypens N. 2009. Carbonate chemistry responds more strongly to eutrophication than ocean acidification in the coastal zone. XXXX
Frankignoulle M., Borges A. V., and Biondo R. (2001) A new design of equilibrator to monitor carbon dioxide in highly dynamic and turbid environments. *Wat. Res.* **35**, 1344-1347.
Schuster U. et al. (2009) Trends in North Atlantic sea-surface fCO_2 from 1990 to 2006. *DSR Part II* **56**, 620-629.
Takahashi T. et al. (1993) Seasonal variation of CO_2 and nutrients in the high-latitude surface oceans: a comparative study. *Glob. Biogeochem. Cycl.* **7**, 843-878.