INVENTORY OF ANTHROPOGENIC CARBON IN THE ATLANTIC

R. Steinfeldt [(1)], M. Rhein [(1)], J. L. Bullister[(2)], T. Tanhua[(3)]

[(1)]Institut für Umweltphysik, Universität Bremen, Otto-Hahn-Allee, D-28359 Bremen, Germany, Email: rsteinf@physik.uni-bremen.de, mrhein@physik.uni-bremen.de
[(2)] National Oceanic and Atmospheric Administration Pacific Marine Environmental Laboratory, NOAA Building 3, 7600 Sand Point Way NE, Seattle, WA 98115-0007, USA, Email: John.L.Bullister@noaa.gov
[(3)] Leibniz-Institut für Meereswissenschaften an der Universität Kiel (IFM-GEOMAR), Marine Biogeochemie, Düsternbrooker Weg 20,D-24105 Kiel, Germany, Email: ttanhua@ifm-geomar.de

The oceans absorb and store a significant portion of the anthropogenic CO_2 emissions, but large uncertainties remain in the quantification of this sink. An improved assessment of the present and future oceanic carbon sink is therefore necessary to provide recommendations for long-term global carbon cycle and climate policies.
Here we make use of CFC data from the WOCE period and the CARINA dataset [1], a collection of carbon relevant parameters measured in the Atlantic within international and national programs, to calculate the inventory of anthropogenic carbon. CFC-11 and CFC-12 data are used to infer the mean age of the water, whereas the Peclet number is constrained by simultaneous CFC-11, CFC-12, CFC-113 and tritium observations. These TTD parameters (mean age and Peclet number), allow the computation of the concentration of anthropogenic carbon.
The total inventory of anthropogenic carbon in the Atlantic south of 65°N amounts to 51 ± 15 Pg C in 1997 and increases to 57 ± 16 Pg C in 2003. This finding is in agreement with the expected increase of anthropogenic carbon due to the rising atmospheric CO_2 concentrations. The differences towards the inventory calculated by [2] for 1994 based on the older GLODAP data are also small.
The column inventory of anthropogenic carbon (Fig.1) underlines the importance of the formation and transport of North Atlantic Deep Water (NADW) for the storage of anthropogenic carbon in the Atlantic. NADW provides a unique fast track for transporting anthropogenic CO_2 into the ocean's interior. High column inventories are found along the NADW pathway within the Deep Western Boundary Current, and especially in the Labrador Sea, where the upper NADW is formed.
Although the overall inventory change between 1997 and 2003 agrees with the increase expected from the rising atmospheric CO_2, the changes of the column inventories are regionally different (Fig. 1). The largest increase is found in the subtropical Atlantic, partially due to the arrival of LSW formed between 1988 and 1994 [3], which is rich in anthropogenic carbon. The smallest increase is observed in the western North Atlantic and can be linked to the variability in NADW formation.

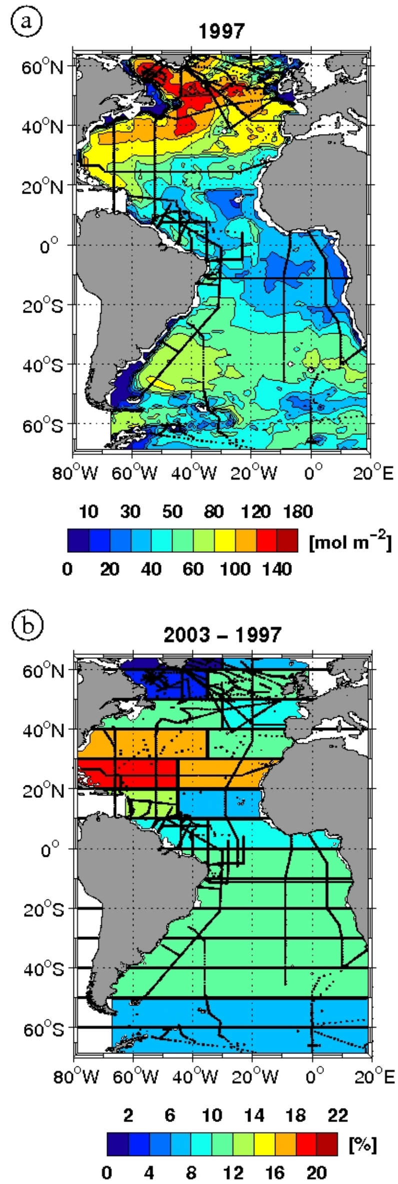

Figure 1. Column inventory of anthropogenic carbon in 1997 (a) and (b) its relative change between 1997 and 2003.

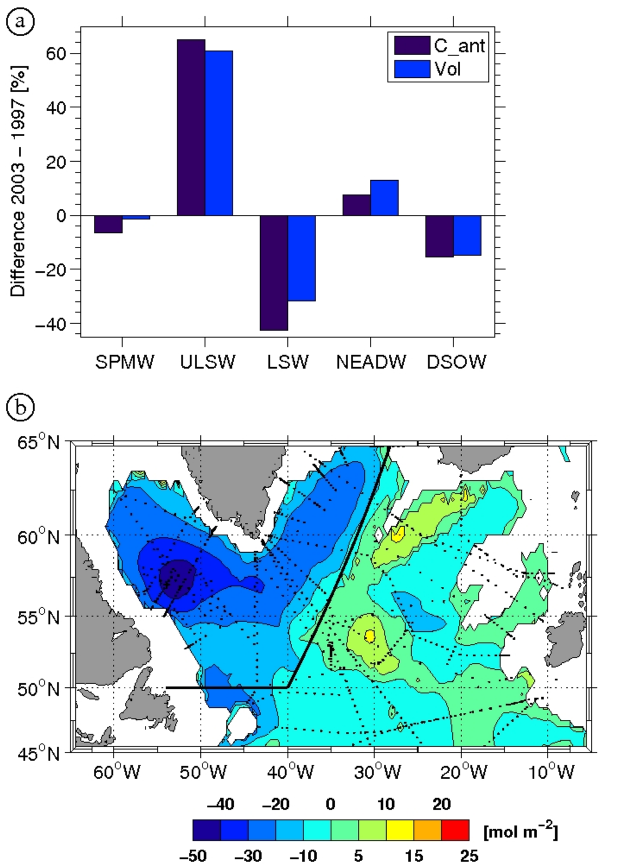

Figure 2. (a) Relative changes of volume and inventory of anthropogenic carbon between 1997 and 2005 for Subpolar Mode Water (SPMW), Upper Labrador Sea Water (ULSW), Labrador Sea Water (LSW), Iceland Scotland Overflow Water (ISOW), and Denmark Strait Overflow Water (DSOW) over the western North Atlantic. The values of anthropogenic carbon are time corrected. (b) Change of column inventory of anthropogenic carbon (time corrected) for the Labrador Sea Water layer between 1997 and 2005. The western North Atlantic region is limited by the bold black line.

The huge amount of CFC data collected in the subpolar North Atlantic allows to investigate this region in more detail. For different water masses (Subpolar Mode Water (SPMW), Upper Labrador Sea Water (ULSW), Labrador Sea Water (LSW), Iceland Scotland Overflow Water (ISOW), Denmark Strait Overflow Water (DSOW)), the changes of both volume and inventory of anthropogenic carbon over the period 1997 - 2005 is computed (Fig.2). For this comparison, the anthropogenic carbon is time corrected, so for a steady state ocean the change of both volume and anthropogenic carbon would be zero. Whereas the variability for SPMW and the overflow waters (ISOW & DSOW) is small, large changes occur for LSW and ULSW.

After 1995, no new LSW is formed, and the southward export of this water mass leads to the loss of both volume and anthropogenic carbon. Due to the absence of ventilation, LSW becomes older, so the concentration of anthropogenic carbon lacks the expected temporal increase. The loss of the time corrected inventory of anthropogenic carbon thus exceeds the loss of LSW volume. Fig. 2 illustrates that the decrease of anthropogenic carbon for LSW is mainly located in the water mass formation area and the adjacent regions.

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