LARGE TEMPORAL AIR-SEA CO_2 FLUX VARIATIONS IN THE SOUTHERN OCEAN SOUTH OF TASMANIA

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ABSTRACT

We analysed the temporal variations of the CO_2 system in the Southern Ocean south of Tasmania and compared the seasonality of the carbon dioxide fugacity (fCO_2) and the air-sea CO_2 flux during spring and summer for two different years: 1996/97 and 2002/03. In summer, the CO_2 flux presents large and contrasting interannual changes in the Permanent Open Ocean Zone (POOZ, 53-61°S): the oceanic CO_2 sink varies from about –0.3 $mmol.m^{-2}.d^{-1}$ in 1997 to –20.6 $mmol.m^{-2}.d^{-1}$ in 2003. This strong sink in February 2003 was related to an increased phytoplankton biomass in this high-nutrient, low-chlorophyll (HNLC) region.

INTRODUCTION

To reach a more realistic global carbon budget estimate, it is essential to have a better understanding of the seasonal and interannual variations of the oceanic carbon cycle at global scale. Recent models indicate that the Southern Ocean would be very sensitive to climate change. Its study is crucial to predict reliable changes in the coming decades. Furthermore in this area, the lack of long-term monitoring *in situ* data leads to large carbon budget uncertainties. A few data are available in the Southern Ocean south of Tasmania, most of them in summer. For the first time, this region was sampled 8 times in 2002/03, from the end of winter (October) to late summer (March), as part of the long term observational programs, MINERVE/OISO.

DATA COLLECTION

In situ data were collected during OISO10 cruise onboard the R.V. *Marion-Dufresne* and 5 MINERVE cruises onboard the S.S. *Astrolabe*, in spring-summer 1996/97 and 2002/03. The fCO_2 in surface seawater was continuously measured between Hobart (43°S, Tasmania, Australia) and Dumont D'Urville (67°S, Adelie Land, Antarctica). Complementary hydrological and biogeochemical parameters (dissolved inorganic carbon (TCO_2), nutrients and chlorophyll-a) were also collected. CO_2 fluxes were calculated based on measured ocean fCO_2, atmospheric fCO_2 and satellite derived wind speeds using the gas transfer coefficient proposed by Wanninkhof and McGillis, 1999.

RESULTS

The Southern Ocean is known from previous work to be a jigsaw of CO_2 sinks and sources [e.g. *Metzl et al.*, 1991] the intensity and location of which evolve with time. In this study, the Southern Ocean south of Tasmania, appears to be also a moving spatio-temporal mosaic of sinks and sources of CO_2. As an example, Fig.1 shows a conceptual diagram depicting calculated net air-sea CO_2 fluxes in February 1997 and 2003 south of Tasmania. The surface waters of the SubAntarctic Region (SAR) were an intense CO_2 sink in February 1997 and 2003 driven by a strong biological activity (-13.6 $mmol.m^{-2}.d^{-1}$ and –12.3 $mmol.m^{-2}.d^{-1}$ respectively). During these summers the CO_2 flux exhibits a pattern (a deep CO_2 sink) already noticed south of Tasmania by Metzl *et al*. [1999] and Inoue and Ishii [2005]. On the contrary, south of 62°S, there is not yet a clear conclusion concerning the sign of the CO_2 flux, which reminds that closer to Antarctica, the extend and evolution of the sea ice appear to influence the air-sea fluxes.

The largest interannual contrast in the CO_2 system observed on this transect between February 1997 and 2003 took place south of the Polar front: In the POOZ, the sink occurring in February 2003 was due to an increase of the phytoplanktonic biomass when all previous observations indicated this region was a small sink or near-equilibrium in summer [*Inoue and Ishii*, 2005] as it was in 1997.

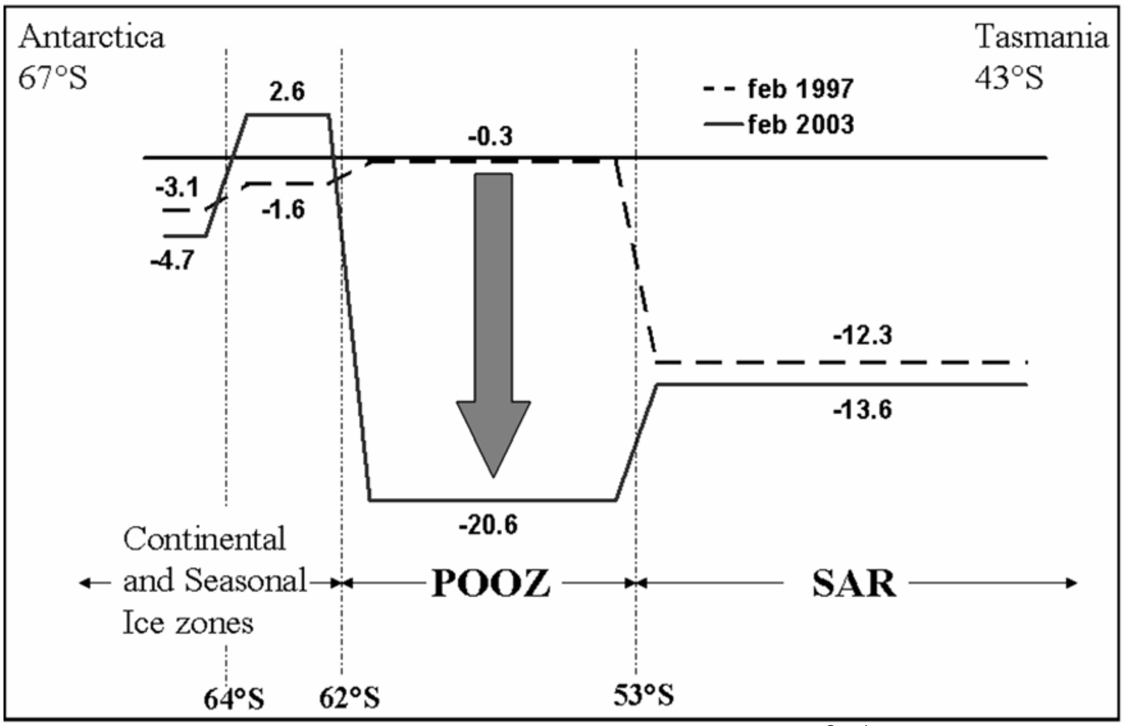

Fig. 1 Conceptual diagram depicting the air-sea CO_2 fluxes ($mmol.m^{-2}.d^{-1}$) observed in the 4 distinct zones during February 1997 (black dashed line) and February 2003 (black solid line). The arrow highlights the dramatic change in the POOZ.

CONCLUSION

The different features in the CO_2 flux patterns in the POOZ of the Southern Ocean highlights the necessity to progress in the understanding of the mechanisms involved to explain such a variability. Furthermore, the special conditions of 2002/03, allow us to revive the discussions about the limiting factors of primary production in HNLC zone. As a multidisciplinary approach of this question, necessary to understand the influence of oceanic and atmospheric forcings, several processes were explored and analysed (changes in solar radiation, ocean stratification, clouds cover, phytoplankton species and distribution, dust storms input). All these processes will be discussed.

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