Why Southern Ocean uptake of anthropogenic CO_2 may be decreasing

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INTRODUCTION

- The atmospheric CO_2 concentration increases at 50% of the rate at which CO_2 is emitted into the atmosphere, because the land and ocean act as CO_2 sinks. The ability of the ocean to take up the CO_2 is highly variable (in time and space) and sensitive to climate influences on ocean circulations.
- The Southern Ocean (SO) plays a key role in modulating the global climate systems, because it not only takes up 50% of the anthropogenic CO_2 ocean uptake (2GtCy-1), but also regulates at least one third of the natural CO_2 flux of 100GtCy-1.
- The understanding of the SO dynamics is still limited because of a lack of *in situ* data, particularly at finer spatial and temporal scales that drive more than 50% of the vertical fluxes.
- Recent studies in the SO suggest a decrease in SO sink, the ability of the SO to take up CO_2 (Le Quere et al., 2007) due to stronger westerly winds which increases upwelling in SO, changing carbon buffering (Revelle factor) and reducing productivity.
- This work presents the carbon cycle (pCO_2, disolved inorganic carbon (DIC) and alkalinity (Alk)) data collected during the austral winter of 2012 (9 July to 3 August) on the Good Hope transect (Figure 1) between Cape Town and Antarctica and returning to Cape Town via Marion Island.
- This is the first winter data on the Good Hope transect.

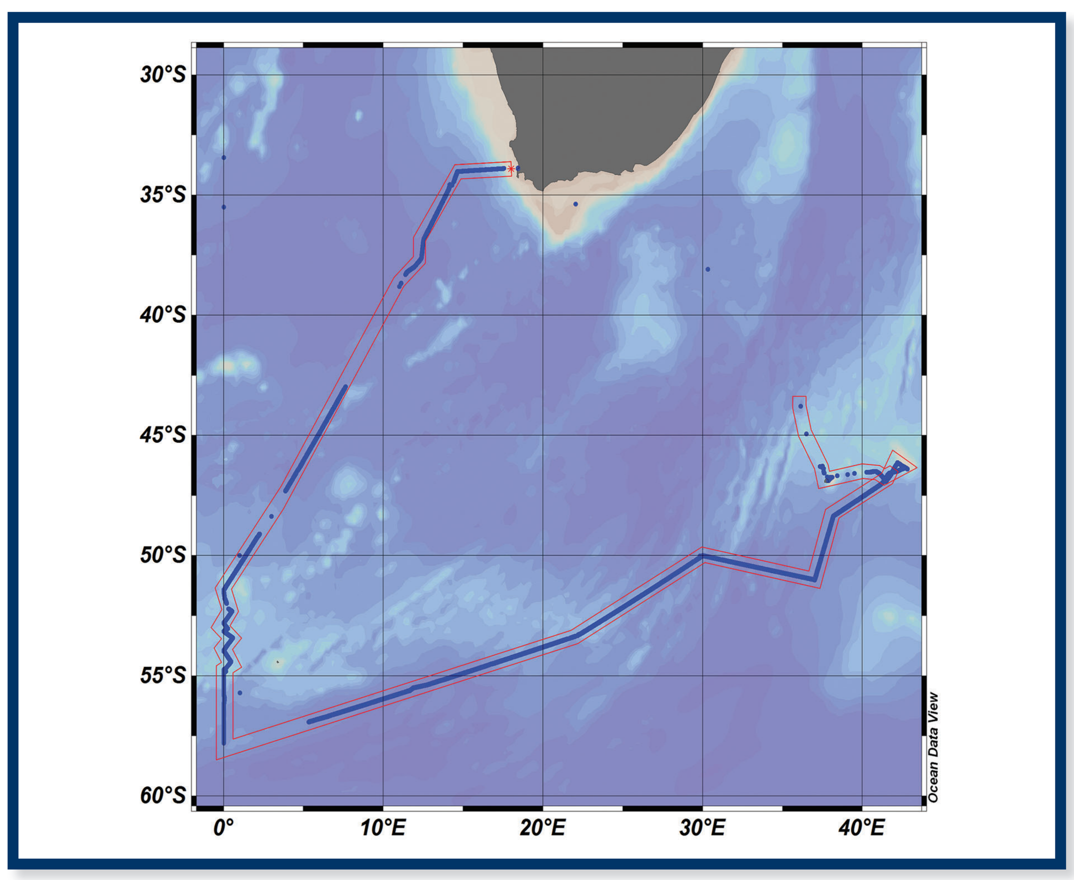

Figure 1: The transect for the cruise during which this data was collected

RESULTS AND DISCUSSION

The deep SO water (+500 m) has very high DIC (**Figure 3**). The elevated concentration of DIC in SO bottom water is mostly sustained by the sinking of organic material fromprimary productivity in the euphotic zone. This organic carbon is then converted into the inorganic form through bacterially mediated remineralisation.

The upper 200 m (euphotic zone) have low DIC due to uptake by biological activity, which increases southwards due to the upwelling of circumpolar deep water south of 50S (**Figures 3, 4 and 6**).

The high salinity, alkalinity and temperature of the surface waters at the 35S to 40°S region are mostly influenced by the Agulhas current retroflection. The pCO_2 is also lowest in this region due to the warm surface water and its influence on CO_2 solubility (**Figures 2 and 3**).

The decline is DIC with depth correlates with the decrease in temperature (**Figures 2 and 3**), as colder water holds more CO_2. The Southern Ocean has particularly high DIC values, because in addition to remineralisation, the thermohaline circulation transports mode and intermediate waters into the ocean interior via this region. When pCO_2 in the ocean exceeds that of the atmosphere, the ocean outgasses CO_2 by pressure gradient. This process takes place from about 50° southwards (**Figures 3 and 6**).

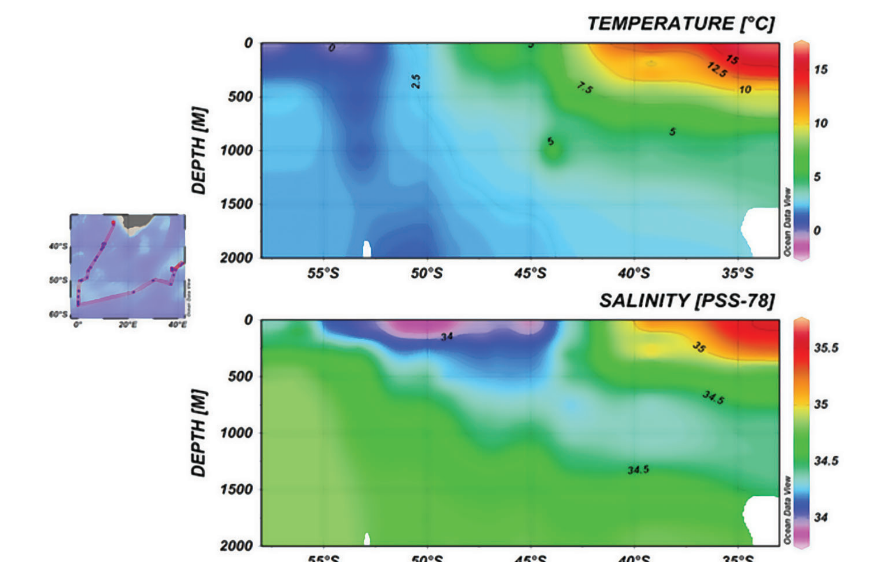

Figure 2: Temperature and salinity

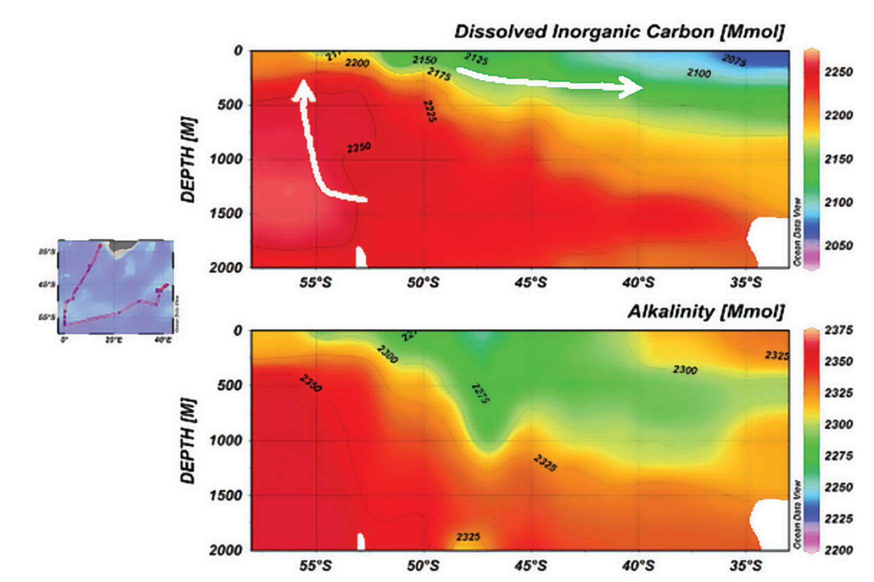

Figure 3: Alkalinity and DIC

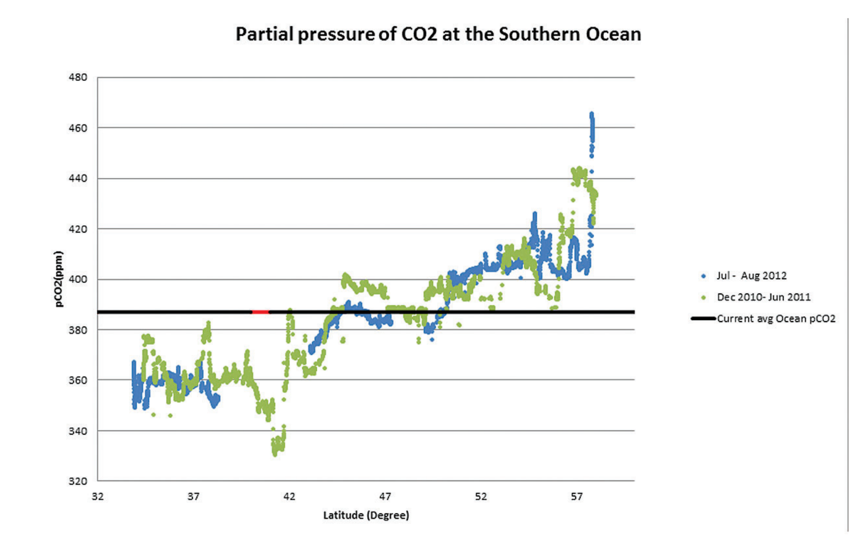

Figure 4: Partial pressure of CO_2 (pCO_2)

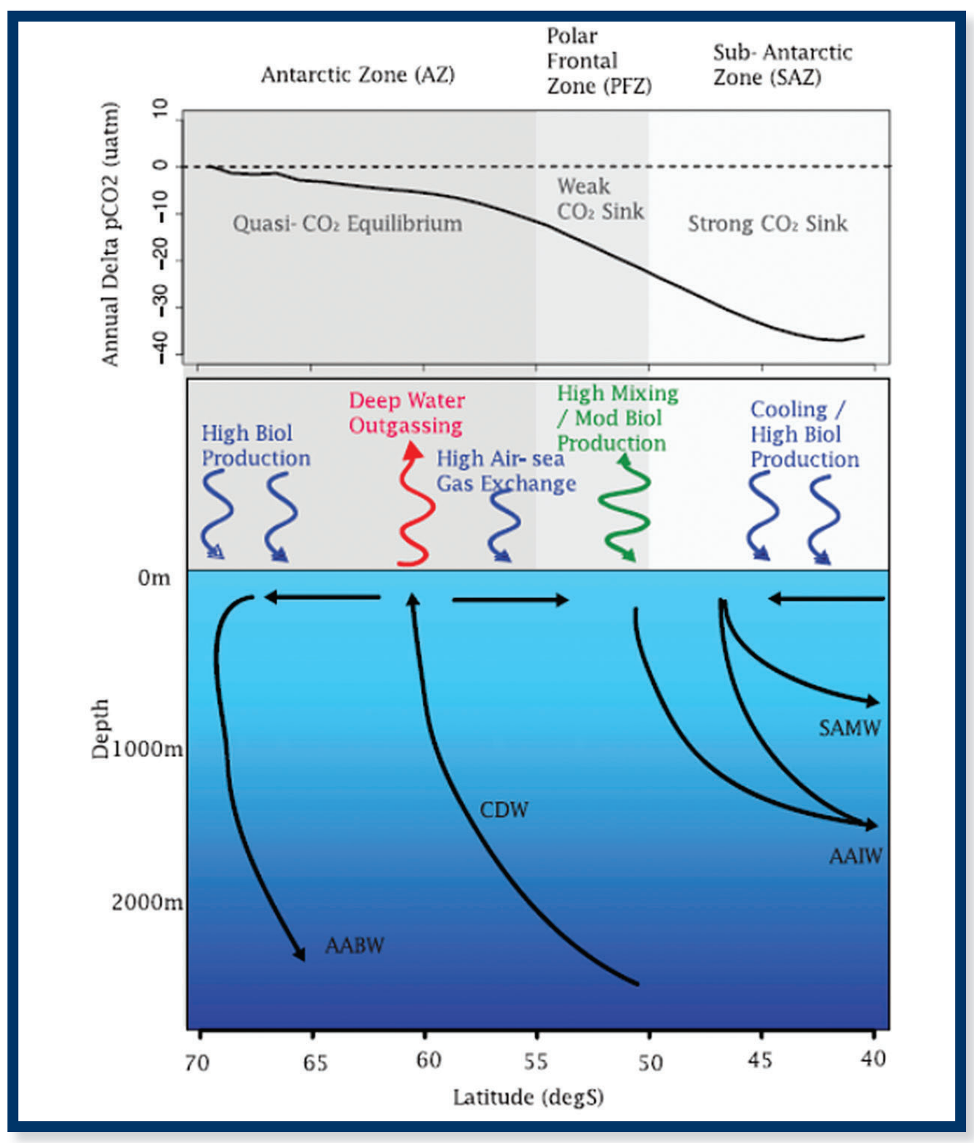

Figure 5: SO circulation dynamics (McNeil et al., 2007

The understanding of the carbon dynamics of the Southern Ocean is limited because of a lack of in situ data. This project presents the first winter data on the Good Hope transect of the SA Agulhas II.

Figure 6: The SA Agulhas II

When this process takes place, the ocean becomes a CO_2 source as opposed to sink. Factors affecting the ability of the ocean to absorb and hold CO_2 are highly variable and sensitive to climate. One of the factors influencing this process is the wind-driven upwelling in the SO. The westerly winds in the SO deflect surface water, resulting in the upwelling of the bottom sea water to replenish the deflected surface water. As this process takes place, bottom sea water, saturated with CO_2, is brought to the surface and causes the degassing of CO_2 (**Figures 3, 4 and 6**).

Due to the effect of climate change and the reduction of the stratospheric ozone, the change in pressure gradient results in stronger westerly winds and the southwards drifting of the winds. As a result of the stronger westerly winds, upwelling is expected to intensify, emitting more CO_2 into the atmosphere.

If the westerly winds intensify and drift more southwards, upwelling is also expected move more southwards, which may result in more intense CO_2 outgassing. The emitted CO_2 contributes to green house gases, which alter the heat balance and result in increased average temperatures.

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