



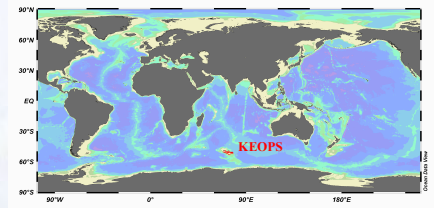
# A seasonal carbon budget for a naturally iron fertilized bloom (Kerguelen I., Southern Ocean)

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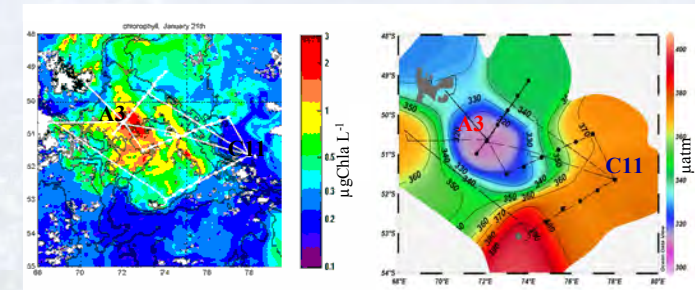
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## Introduction

The Kerguelen Ocean and Plateau compared Study (KEOPS) was carried out from 19 January to 13 February 2005 South East of the Kerguelen Island. KEOPS was designed to study the impact of a natural iron fertilization on the biology and biogeochemistry. The occurrence of a deep source dissolved iron (DFe) above the Kerguelen Plateau promoted the massive three-month bloom detected by satellite every years. Here we focus on the CO<sub>2</sub> parameters and we present the carbon budget for the mixed layer for station inside (A3) and outside (C11) the bloom. This allowed us to determine the daily carbon export for both contrasting areas.



## Bloom localization and sea surface distribution of fCO<sub>2</sub>



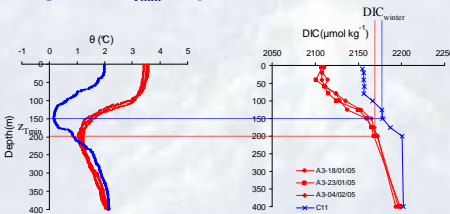
As result of the bloom development fCO<sub>2</sub> was 77 µatm lower in waters above the Kerguelen Plateau (A3) than in offshore waters (C11).

## Seasonal carbon budget

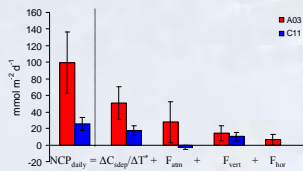
The apparent seasonal depletion of DIC ( $\Delta C_{sdep}$ ) is the difference between the concentration of DIC in the mixed layer (ML) during winter and the concentration of DIC in the mixed layer during summer:

$$\Delta C_{sdep} = (DIC_{winter} - DIC_{summer})_{z_{ML}} \rho_{ML}$$

The DIC in winter was estimated from the concentration of DIC at the depth of the minimum of temperature ( $z_{Tmin}$ ) (Figure below).

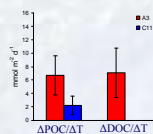


We derived the daily net community production (NCP<sub>daily</sub>) correcting  $\Delta C_{sdep}$  from vertical, horizontal inputs and CO<sub>2</sub> air-sea exchanges :



From the NCP<sub>daily</sub> we deduced the carbon export (C<sub>exp,daily</sub>) flux leaving the mixed layer subtracting the POC and DOC accumulation.

$$C_{exp,daily} = NCP_{daily} - \Delta POC / \Delta T - \Delta DOC / \Delta T$$



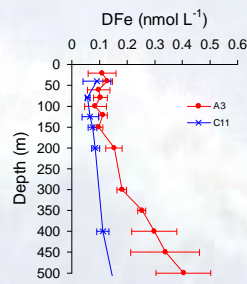
\*  $\Delta T$  is the bloom duration and was determined base on chlorophyll satellite images ( $\Delta T = 90$  days)

References  
Bakker, D.C.E., Bozec, Y., Nightingale, P.D., Goldson, L.E., Messias, M.J., de Baar, H.J.W., Liddicoat, M.I., Skjelvan, I., Strass, V., Watson, A.J., 2005. Iron and mixing affect biological carbon uptake in SOIREE and EisenEx, two Southern Ocean iron fertilization experiments. Deep-Sea Research 152, 1001-1019.  
Blain et al, in press. Impacts of natural iron fertilization on carbon sequestration in the Southern Ocean Boyd, et al., 2000. A mesoscale phytoplankton bloom in the polar Southern Ocean stimulated by iron fertilization. Nature 407, 695-702.  
Bozec, Y., Bakker, D.C.E., Hartmann, C., Thomas, H., Bellerby, R.G.J., Nightingale, P.D., Riebesell, U., Watson, A.J., De Baar, H.J.W., 2004. The CO<sub>2</sub> system in a Redfield context during an iron enrichment experiment in the Southern Ocean. Marine Chemistry 95, 89-105.

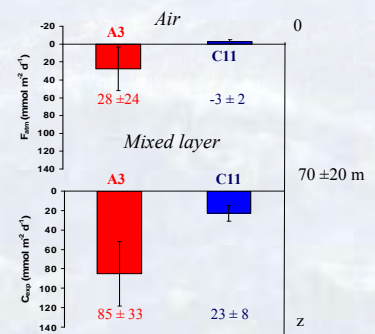
Acknowledgements  
KEOPS/OISO2 was supported by the Institut National des Sciences de L'Univers (INSU) Centre National de la Recherche Scientifique (CNRS), l'Institut Polaire Paul Emile Victor (IPEV). We thank the captain and the crew of the R/V Marion Dufresne. We thank also the Service National d'Analyse des Paramètres Océaniques du CO<sub>2</sub> (SNAPO-CO<sub>2</sub>) at LOCEAN/IPSL for DIC analyses.

## Natural iron fertilization pattern and vertical carbon fluxes

Fertilization of the surface water of the plateau resulted from  
- a higher winter stock at A3 than C11  
- an enhancement of the on going DFe supply

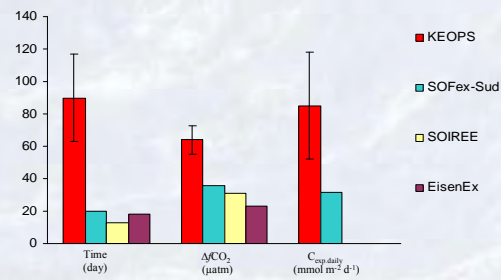


Source : Blain et al., in press



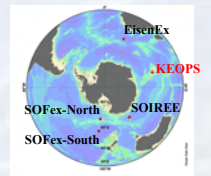
Bloom waters (A3) were a large CO<sub>2</sub> sink contrasting with HNLC waters (C11) which were a quite CO<sub>2</sub> source. The carbon export is more than 3 fold higher in the bloom than outside.

## Comparison of KEOPS results with artificial iron enrichment experiments



Sources : Bozec et al., 2004; Boyd et al., 2004; Bakker et al., 2005

Sites of the artificial iron enrichment experiments in the Southern Ocean



The longer bloom duration, (ie 3 months) above the Kerguelen Plateau, compared to the short period of observation of artificial blooms (ie few weeks) explains the deeper CO<sub>2</sub> sink and the largest carbon export flux. The duration of the bloom above the Kerguelen plateau is due to iron fertilization but also due to the concomitant supply of major nutrients.

Our results show that the biological pump triggered by a natural iron fertilization is 2 fold more intense compared to artificial iron enrichment experiments.