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

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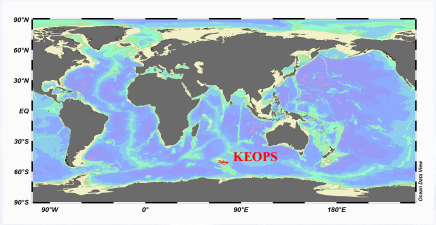
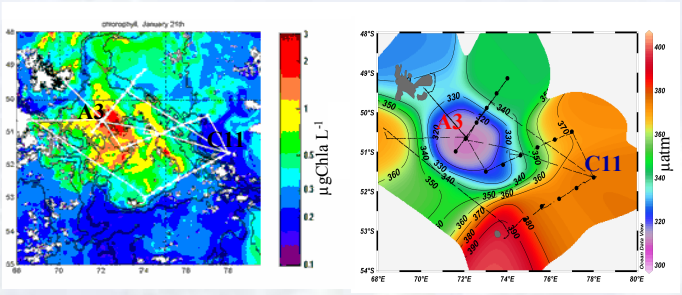
Introduction

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_2 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_2



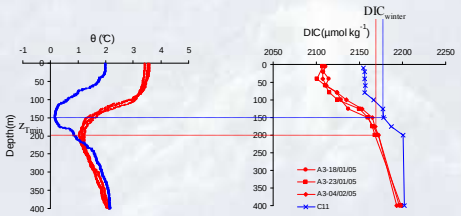
As result of the bloom developpement fCO_2 was 77 µatm lower in waters above the Kerguelen Plateau (A3) than in offshore waters (C11).

Seasonal carbon budget

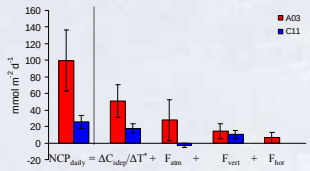
The apparent seasonal depletion of DIC (ΔC_{sdep}) is the difference between the concentration of DIC in the mixed layer (ML) during winter and the concentration of DIC in the mixed layer during summer:

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

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

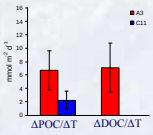


We derived the daily net community production (NCP_{daily}) correcting ΔC_{sdep} from vertical, horizontal inputs and CO_2 air-sea exchanges :



From the NCP_{daily} we deduced the carbon export ($C_{exp.daily}$) flux leaving the mixed layer subtracting the POC and DOC accumulation:

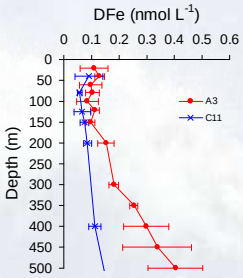
$$C_{exp.daily} = NCP_{daily} - \Delta POC/\Delta T^{*} - \Delta DOC/\Delta T^{*}$$



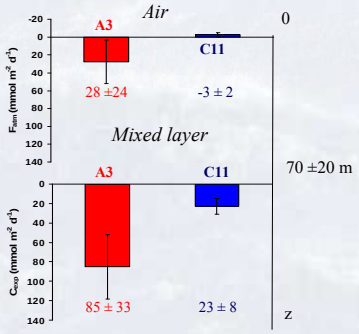
* ΔT is the bloom duration and was determined base on chlorophyll satellite images (ΔT = 90 days)

Natural iron fertilization pattern and vertical carbon fluxes

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

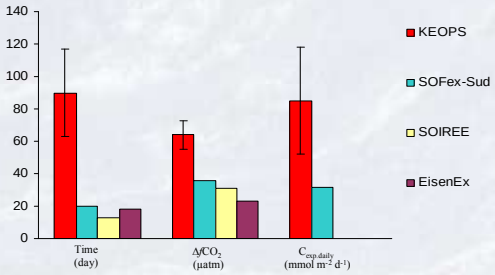


Source : Blain et al., in press

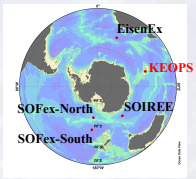


Bloom waters (A3) were a large CO_2 sink contrasting with HNLC waters (C11) which were a quite CO_2 source. The carbon export is more than 3 fold higher in the bloom than outside.

Comparison of KEOPS results with artificial iron enrichment experiments



Sites of the artificial iron enrichment experiments in the Southern Ocean



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

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_2 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.

References

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Acknowledgements

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