Reconstructing NCP from O2 and Ar concentrations in winter sea ice of the Ross Sea (Antarctica)

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Measuring the net community production (NCP) – which is the balance between O_2 production by primary producers and the respiration of the entire community – in sea ice is very challenging due to its heterogeneous nature (mixture of pure ice, brines, gas bubbles and salts). Different techniques are currently used to determine NCP: either by direct (i.e. ^{14}C incubation) or indirect (ice-water O_2 interface eddy correlation, gas analyses) measurements. These techniques are still in the process of inter-calibration in sea ice (SCOR ECVice).

NCP measurements are scarce in sea ice, peculiarly in the winter. Here we present a reconstruction of the NCP levels by measuring the concentrations of O_2 and Ar at high resolution using gas chromatography in sea ice cores collected during the PIPERS (Polynyas, Ice Production and seasonal Evolution in the Ross Sea) field project. This project is one of the rare that took place in the Ross Sea during the austral winter. It aims to document the physical and biogeochemical properties of pack ice and to study the dynamics of the polynyas of the Ross Sea and of Terra Nova Bay. Polynyas are open water areas of strong sea ice production under sustained coastal katabatic winds originating on the ice sheet.

Two main conclusions can be drawn from this study: it has been possible to dissociate the biotic and abiotic controls on O_2 concentrations in sea ice and therefore to reconstruct the levels of Net Community Production during this winter period. The discrimination of abiotic and biotic controls is based on the use of O_2/Ar ratios because dioxygen concentration is modified by physical processes (temperature and salinity changes, brine convection) and by biological activity (photosynthesis and respiration) whereas Ar is only influenced by physical processes. A dominance of the physical processes was highlighted in most of the stations considered, with a contrast between the stations of polynya where no trace of biological activity could be identified, whereas a non-negligible biological activity could be observed in the centre of the Ross Sea.

To reconstruct the levels of NCP, a multidisciplinary approach was used because of the spatial and temporal variability of the cores sampled during the mission. Estimates of the age of the cores (and thus of the period of biological activity) required the use of satellite data and of a thermodynamic model. The concentrations measured in the ice made it possible to calculate the deviation from the saturation ratio ($\Delta(O_2/Ar)$), the equilibrium O_2-concentration in the brines and eventually, the O_2-concentration due to biological activity. From the time evolution of the latter, the NCP allowed us to determine the general regime (auto- or heterotrophic) in place. These NCP values are compared to the literature for the winter period and the good correspondence confers reliability to our results.