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Micro-optodes in sea ice: a new approach to investigate oxygen dynamics during sea ice formation

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Abstract:

Oxygen micro-optodes were used to measure oxygen dynamics directly within the microstructure of sea ice by freezing the sensors into the ice during its formation. The experiment was conducted in a 4 m^3 mesocosm filled with artificial seawater and inoculated with a unialgal culture of the common Antarctic ice diatom *Fragilariopsis cylindrus* (Bacillariophyceae) to a final chlorophyll *a* (chl *a)* concentration of 11 µg l^{-1}. Ice growth was initiated 7 d after inoculation by reducing the air temperature to −10 ± 2°C and terminated 17 d later. The final ice thickness was 27 cm. One optode was frozen into grease ice and 2 others into the skeletal layer of the growing ice sheet. Increasing oxygen concentrations during ice crystal formation at the water surface and the ice-water interface revealed a strong inclusion of oxygen, which was either physically trapped and/or the result of photosynthesising diatoms. The major portion of oxygen was present as gas bubbles due to super-saturation as a result of increasing salinity and oxygen production by diatoms. An increase in salinity due to a concurrent decrease in ice temperatures during subsequent sea ice development reduced the maximum concentration of dissolved oxygen within brine. Thus, dissolved oxygen concentrations decreased over time, whereas gaseous oxygen was released to the atmosphere and seawater. The sensors are a significant advance on more conventional microelectrodes, because the recordings can be temperature and salinity compensated in order to obtain precise measurements of oxygen dynamics with regard to total (dissolved and gaseous) and dissolved oxygen in sea ice. Optodes do not consume oxygen during measurement over a long period under extreme conditions, which is another advantage for long-term deployment in the field.

Key-words: Fragilariopsis cylindrus, oxygen, methods, micro-optodes, sea ice, biogeochemistry