

Dynamic processes in sea ice captured by the temporal evolution of its biogeochemical properties

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One of the fundamental questions arising today in polar oceans in the context of climate change, is to understand how sea ice affect gas exchange between the atmosphere and the ocean. In this framework, a survey was carried out on first-year landfast sea ice in the Arctic (Barrow, Alaska), from January to June 2009. Several ice cores, brines and under-ice seawater were collected to investigate seasonal physical and biogeochemical sea ice processes and how they affect gas dynamics within the ice (O_2 , N_2 , Ar, CH_4).

Based on results obtained from key stations, with special focus on gas composition (O_2 , N_2 , Ar, CH_4), we observed 4 main stages in the evolution of physical and biogeochemical properties: (1) a winter stage characterised by a poor permeability in sea ice (apart from the basal part) and a relatively low concentration of chlorophyll a; (2) an early spring stage where the major part of sea ice is still below the permeability threshold, but with a higher chlorophyll-a content. The accumulation of ammonium and the concentration of nitrate and phosphate suggested development of remineralisation processes; (3) significant increase of temperature and induced higher permeability lead to dramatic changes: chlorophyll-a and Rayleigh numbers suggest brine drainage; analyses of nutrients, oxygen and hydrogen isotopes and gas concentration ratios ($O_2:N_2$, $O_2:Ar$) indicate a partial replacement of drained brines by seawater; (4) lastly, permeability increases further and induces a size discrimination on autotrophs: only the largest autotrophs remain in the ice porosity. Nutrients concentrations are below the dilution curve of seawater. The volume of total gas and the gas ratios show an increased gas exchange between sea ice and atmosphere/seawater, and O_2 production by photosynthesis.

Besides first measurements of $O_2:Ar$ in sea ice, we also present first values of methane concentration in sea ice. They exceed the atmospheric concentration during the whole sampling period and suggest thus an important concentration in the seawater below the sea ice cover. Sea ice thus acts as a temporary storage for CH_4 .

To conclude, sea ice is not an impermeable barrier as usually considered in current climatic models. It can be permeable in certain conditions as theoretically suggested by Golden et al. (2007). Moreover, our results show that sea ice does not only act as a barrier, but play in active role in carbon transfer due to both sea ice related processes: biological production by sympagic communities and potential oxidation of methane. Thus, sea ice appears to be a key component in carbon fluxes in polar oceans and then in the climate system that cannot be neglected in future model developments.

References

Golden et al. (2007) Thermal evolution of permeability and microstructure in sea ice, *Geophysical Research Letters* 34, L16501.