Nitrous oxide dynamics in sea ice

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Fluctuations in greenhouse gases (GHGs) concentration alter the energetic budget of the climate system. There is high confidence that natural systems related to snow, ice and frozen ground (including permafrost) are affected. Nitrous oxide (N₂O) is one of the potent GHG naturally present in the atmosphere, but witch has seen his concentration growing since industrial era. N₂O has a lifetime in the atmosphere of 114 years and a global warming potential (GWP) of 298 to be compared to carbon dioxide that has a GWP of 1. N₂O is also describe as the dominant ozone-depleting substance emitted in the 21st Century. Yet, there are still large uncertainties and gaps in the understanding of the cycle of this compound through the ocean and particularly in sea ice. Sources and sinks of N₂O are therefore still poorly quantified.

The main processes (with the exception of transport processes) involved in the N₂O cycle within the aquatic environment are nitrification and denitrification. To date, only one study by Randall et al. present N₂O measurements in sea ice. Randall et al. pointed out that sea ice formation and melt has the potential to generate sea-air or air-sea fluxes of N₂O, respectively.

Study on ammonium oxidation and anaerobic bacterial cultures shows that N₂O production can potentially occur in sea ice. Denitrification can act as a sink or a source of N₂O. In strictly anaerobic conditions, N₂O is removed by denitrification. However, denitrification can also occur in presence of O₂ at trace level concentrations (>0.2 mg L⁻¹), and in these conditions there is a large N₂O production.

Recent observations of significant nitrification in Antarctic sea ice shed a new light on nitrogen cycle within sea ice. It has been suggested that nitrification supplies up to 70% of nitrate assimilated within Antarctic spring sea ice. Corollary, production of N₂O, a by-product of nitrification, can potentially be significant. This was recently confirmed in Antarctic land fast ice in McMurdo Sound, where N₂O release to the atmosphere was estimated to 4 µmol.m⁻².yr⁻¹. This assessment is probably an underestimate since it only accounts for dissolved N₂O while a significant amount of N₂O is likely to occur in the gaseous form like N₂, O₂ and Ar.

Finally, nitrification produces little N₂O in oxygenated waters but the N₂O production yield from nitrification strongly increases as O₂ levels decrease. Hence, it is not possible to distinguish the sources of N₂O solely based on bulk N₂O concentrations or environmental conditions, while deepened knowledge of processes is needed to well understand N₂O emissions.

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