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Gas properties in annual lake ice from 4 lakes in a permafrost area, Stordalen Mire, northern Sweden: implication for greenhouse gases budget.

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Gas composition, total gas content and bubbles characteristics in annual lake ice are studied and discussed for four lakes in Stordalen Mire (northern Sweden) a discontinuous permafrost area. Many studies are led on gas production from permafrost lakes sediment during the open water period, especially on methane and carbon dioxide but only a few have looked at the gases enclosed in the annual ice-cover, which are released in the springtime. In this work, we show and discuss the variability of methane and carbon dioxide concentration in relation with the bubbles facies, the proximity of the sediment and the distance from the bank. Different types of bubbles are identified according to their shapes and gas properties. We can clearly differentiate bubbles resulting from the exsolution of dissolved gas as a result of the ice cover formation from those coming from the sediment degassing. The later indeed show a much larger methane content (up to 50% of CH_4). The methane production has its origin in the anaerobic degradation in the sediments. Our methane concentrations display a large range which clearly differs from the one observed in previous studies which looking at bubbling measured at the water surface by mean of gas accumulation chamber. Our CH_4 concentrations suggest that gas exchange occurs between the bubbles and the water before entrapment in the ice. The O_2/N_2 ratio provides new information about biogeochemical processes in the water column and/or between the water and the sediments. This ratio decreases (from $\sim$0.3 to $\sim$0.05) with depth and suggests oxygen depletion with no related effect on the carbon dioxide concentration. The combined study of the four lakes enables us to identify local effects vs. global behaviour on gas trapping by the growing lake ice. Indeed, our analysis reveals a simultaneous event of bubbling recorded in the ice for all the lakes. We correlated this event with the meteorological parameters and it seems that an abrupt atmospheric pressure decrease could be responsible for this global gas release. Comparison between the lakes further shows that gas contents depend on the hydrological properties of the lakes, mostly the “open” vs. “closed” nature of the lakes. We show that an “open” lake (connected to a river and to an other lake) will form an ice-cover nearly devoid of air bubbles. This observation has to be taken into account while attempting an integrated gas budget from lake ice for the whole permafrost area.