Dear Christian Haas,

Thank you very much for considering our manuscript for possible publication.

We have revised the manuscript with particular attention to the results section and we have modified it in a way to make it more clear.

With respect to your minor comments made

-Structure of the results section can still be improved.

R: we have worked on this section, in particular in the section 3.1. We carefully modified it to make this result section clearer, as followed:

3.1 Sea ice core characteristics

The ice floe was formed by FYI and ridged/rafted ice. The ice thickness at the sampled stations varied greatly between 90 and 280 cm, while snow thickness on top of the ice varied from 0 to 90 cm (Table 1). Of the nine ice cores sampled across the ice floe, eight were taken in the ridged/rafted site along a 1.2 km transect (Fig. 1d). Ridged and rafted ice can be especially relevant for the methane cycling, due to the fact that they remain more consolidated even in the melt season (in comparison to FYI) and thus allow us to investigate methane-related processes in certain layers of these ice structures. Backward drift trajectories suggest that our floe originated in the Siberian Sea, while the sea ice was estimated to be 1-3 years old (Wollenburg et al., 2020). Vertical profiles of temperature, salinity, BVF, NO_3^-, CH_4 concentration and the $\delta^{13}C$-CH_4 for all ice cores are shown in Fig. 2 with additional information in Table 1. Following Golden et al. (1998), a BVF above 5 % was used to classify ice permeable for gas migration (see methods). In the following, we describe the sea ice physical and biogeochemical properties of FYI and ridged/rafted ice separately. We also classified the ridged/rafted ice depending on: i) Cores with still impermeable ice layers within the ice, and permeable ice layers at the bottom of the ice, ii) A core with permeable ice layers enclosed by impermeable ice layers, and iii) Cores with fully permeable ice layers.

3.1.1 First Year Ice

Station C3b was characterized by thin FYI and used as a 'standard ice conditions' to compare with thicker ridged/rafted ice. In situ sea ice temperatures were almost homogenous towards the ice bottom (< 100 cm) and varied only between -1.8 and -1.7 °C (Fig. 2). Salinity ranged from 3.7 to 5.8 with the highest values at 20 cm and homogenous from 40 cm down to the ice bottom. The BVF varied between 10 and 15 %, with the upper part of the core (0-40 cm) being

more permeable than the lower part, reflecting the surface melt onset. Nitrate concentration ranged between 0.24 and 0.87 µmol L^{-1} and it increased at the bottom of the ice. Methane concentration ranged from 4.7 to 5.5 nmol L^{-1}, with the highest values in the middle of the core. The $\delta^{13}C\text{-}CH_4$ values varied from -49.09 to -42.89 ‰ VPDB, with no clear pattern.

3.1.2 Ridged/rafted ice with impermeable and permeable ice layers

Stations C1, C8 and C11 were characterized by impermeable ice layers in the middle of the core, and permeable ice layers both at the top and bottom of the ice. In situ sea ice temperatures ranged from -3.7 to -0.2 °C. In general, the lowest values were found in the middle of the core (Fig. 2). Salinity varied from 0.5 to 6.2, showing an increase with ice depth. The BVF ranged from 3 and 22 %, showing a general increase with ice depth and reflecting the onset of basal melt. Nitrate concentration ranged from 0.02 to 2.51 µmol L^{-1}, and it increased at the bottom of the ice. Methane concentration ranged between 3.8 and 5.5 nmol L^{-1}. In C1, the highest methane concentration coincided with low BVF. In C11, a pronounced decreased at the bottom of the ice coincident with an increasing nitrate concentration was detected, while in C8 a homogenously distribution within the ice was observed. The $\delta^{13}C\text{-}CH_4$ values ranged from -47.48 to -41.05 ‰ VPDB. In impermeable ice layers of C1, we detected $\delta^{13}C\text{-}CH_4$ values more enriched in ^{13}C, compared to the impermeable ice layers in C8 and C11. In permeable ice layers of both C8 and C11 we detected $\delta^{13}C\text{-}CH_4$ values more enriched in ^{13}C, compared to permeable ice layers in C1.

3.1.3 Ridged/rafted ice with a water pocket

At station C6 we found an ice core that contained a "water pocket", i.e. mixture of ice and water (slush) upon core extraction from 90-160 cm. In situ sea ice temperatures varied from -4.3 to -2 °C with the lowest values in the middle 90-160 cm of the ice core (Fig. 2). Salinity highly varied between 4.3 and 11.7, showing a general increase from top to bottom with the highest values from 100 to 170 cm. Over the cold middle layer, salinity was high with a pronounced peak of 11.7 at 150 cm. The BVF varied between 5.6 and 15 %, with the highest permeability in the middle (90-160 cm, within the water pocket). Nitrate concentration ranged between 0.39 to 2.5 µmol L^{-1}, and exhibited highly variable values towards the ice bottom. The methane concentrations were mostly homogeneous (approximately 2.7 nmol L^{-1}), except for a spike of 5.6 nmol L^{-1} at 140 cm within the water pocket. The $\delta^{13}C\text{-}CH_4$ values ranged from -44.57 to -38.29 ‰ VPDB. In the impermeable layers, we detected $\delta^{13}C\text{-}CH_4$ values more

enriched in ^{13}C, compared to the impermeable ice layers in C1, C8 and C11.

3.1.4 Ridged/rafted ice with fully permeable ice layers

Stations C4, C7, C9 and C10 were characterized by permeable ice layers throughout the ice cores. In situ sea ice temperatures varied from -2.6 to -0.1 °C (Fig. 2). Salinity values varied from 1.1 to 8.2 with no clear pattern found between the ice cores. The BVF varied between 7.5 and 59 %, i.e. fully permeable. Nitrate concentration ranged between 0.04 to 2.98 µmol L^{-1}, with a heterogenous vertical distribution, except of C10 where an increase at the bottom of the ice was detected. Methane concentration ranged from 3.5 to 5.3 nmol L^{-1}, with a homogenous distribution throughout the ice in C4 and C7. A decrease at the bottom of the ice coincident with an increasing nitrate concentration was observed in C10. By contrast, in C9 we observed high values at the top and at the bottom of the ice and a decrease in concentration in the middle of the core. The $\delta^{13}C\text{-}CH_4$ values fluctuated highly from -53.12 to -37.89 ‰ VPDB. Overall, $\delta^{13}C\text{-}CH_4$ values more enriched in ^{13}C coincided with lower methane concentration.

Many thanks for the careful revision of the manuscript and valuable feedback.
With best regards on behalf of all co-author.
Josefa Verdugo