

The Cryosphere Discuss., referee comment RC2
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Comment on tc-2021-147

Anonymous Referee #2

Referee comment on "Fractionation of O₂/N₂ and Ar/N₂ in the Antarctic ice sheet during bubble formation and bubble-clathrate hydrate transition from precise gas measurements of the Dome Fuji ice core" by Ikumi Oyabu et al., The Cryosphere Discuss.,
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The article "Fractionation of O₂/N₂ and Ar/N₂ in the Antarctic ice sheet during bubble formation and bubble-clathrate hydrate transition from precise gas measurements of the Dome Fuji ice core" by Ikumi Oyabu presents new $\delta\text{O}_2/\text{N}_2$ and $\delta\text{Ar}/\text{N}_2$ data, measured on Dome Fuji ice cores using the method of Oyabu et al. 2020. The authors are able to provide data from samples stored at low temperatures of -50°C in the freezer and show that under these conditions gas loss fractionation after coring is almost negligible. They also discuss their data in the context of a wide range of $\delta\text{O}_2/\text{N}_2$ and $\delta\text{Ar}/\text{N}_2$ measurements from other ice core sites and other measurement and storage strategies. They examine their data in four depth intervals attributed to different fractionation mechanisms (bubble ice, upper BCTZ, deep BCTZ and clathrate zone) through a simple regression analysis of $\delta\text{O}_2/\text{N}_2$ versus $\delta\text{Ar}/\text{N}_2$ and $\delta\text{O}_2/\text{N}_2$ versus $\delta^{18}\text{O}-\text{O}_2$ to disentangle possible fractionation mechanisms (mass-independent/size-dependent vs. mass-dependent fractionation). Furthermore, the authors show that using a simple diffusion model to model permeation in conjunction with high-resolution data can explain the reduction in data variance due to diffusive smoothing in the clathrate hydrate zone.

The paper is well written and structured. I enjoyed reading this paper and look forward to its publication. Most of my "major" criticisms of this work have already been addressed by reviewer 1, and I am pleased to see how the authors have responded. In particular, the new schematic illustration about the different fractionation mechanisms will help the reader to understand the work better. There are only a few minor points to change, which I list below.

Minor points:

Line 15: Please avoid expressions like "high precision" or specify with numbers.

Line 21: Yes, analysing long ice samples can help to average the data scatter later, but how long should these samples be? Please specify a number here.

Line 72/73: Please combine minus sign and number in the same line.

Line 160ff: For the data shallower than 800 m, I do not see much agreement with the insolation data. The depth range is too short to support this statement. For the deeper depth range, I agree.

Line 161: "We evaluate ... low-pass filtered curves": Please indicate here the cut-off period used and explain how the low-pass filtering was performed.

Line 255/256: As already stated, the similarity of the bubble-ice data to the solar radiation curve is not robust in my opinion.