Dr. Frank McDermott
Associate Editor
Geochimica et Cosmochimica Acta

October 9, 2017

Dear Dr. McDermott,

Re: Manuscript reference No. GCA-D-17-00136

Please find attached a revised version of our manuscript "Molecular diffusion of stable water isotopes in polar firn as a proxy for past temperatures", which we would like to re-submit for publication as an article in *Geochimica et Cosmochimica Acta*.

We thank you and the three reviewers for your comments and suggestions which has helped improving the manuscript. Specific comments to each reviewer is provided on the next pages. Text in bold is the reviewer's comment. Besides language improvements, two major changes are implemented in the revised manuscript:

1. **A seasonal temperature signal** that propagates down through the firn is included in the diffusion and densification model (Sec. 2 and Appendix B in manuscript). The seasonal temperature variation affects the firn diffusion length nonlinearly due to the saturation vapor pressure exponential dependence on temperature. The firn temperature profile is obtained by numerical solution of the heat equation. In the previous manuscript, an isothermal firn column was assumed.
2. **Uncertainties in the diffusion, densification and ice flow models** are now included. Previously, the presented precisions were based on the estimation of the diffusion length from data. It was therefore assumed that the accumulation rate, surface density, close-off density, surface pressure, ice flow thinning and ice diffusion were known (they had a constant value for each ice core section). In the revised manuscript, each of these parameters have an uncertainty used in the temperature reconstructions (Table 4.1 in paper). This facilitates a better comparison between the single and differential diffusion techniques in case the single diffusion length methods are more sensitive to uncertainties in the diffusion model.

Although the model used in this study has changed significantly by implementing a seasonal signal and including uncertainties in the diffusion, densification and ice flow model, the main conclusion remains the same; the single diffusion length techniques perform better than the differential diffusion methods. The difference in precision between the techniques has however decreased.

As suggested by reviewer 2, the power spectra of the ice core data are now presented in Appendix F in the manuscript. In order to shorten the paper, we want to ask the opinions of the reviewers and the editor, if all (or some of) the appendices should be supplementary material instead? We have also updated a reference in the test with the fractionation factor parameterizations. We now refer to the fully published study by Lamb et al (2017) instead of

the 2015 version. The used parameterization is identical so it does not change the results and conclusion.

As suggested by reviewer 1, we have included a figure that shows the impact of high temperatures on diffusion length (Fig. 2.2 in manuscript). This figure has already been published in Gkinis et al (2014), a paper which we authored. As the figure provides a good illustration on how both the accumulation rate and temperature affect the diffusion length, we ask the editor if he wants us to include the figure in this manuscript or refer to it.

We hope that the revisions in the manuscript and our accompanying responses will be sufficient to make our manuscript suitable for publication in *Geochimica et Cosmochimica Acta.*

We look forward to hearing from you.

Yours sincerely,

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