Review of revised version of Munch 2015: Regional climate signal vs. local noise: a two–dimentional view of water isotopes in Antarctic firn at Kohnen station, Dronning Maud Land

reviewer 1

1 General Comments on the revised version

This revised version of this work presents many improvements compared to the initial submission. I would like to thank and congratulate the authors for delivering a text that reads significantly easier and presents results and conclusions in a much improved way. I think that especially the restructuring of the text was a successful move. The manuscript can be with a little bit more work be ready for acceptance and thus I recommend its publication with minor revisions.

I have one rather major comment that I would like the authors to look into and consider some small changes in the text and a few minor corrections/suggestions.

1.1 The influence of diffusion

With the revised version came a rather extensive consideration on the effects of firn isotope diffusion. This is very welcome; almost necessary though with this extra material added I was able to spot caveats that need extra consideration in my view.

In their answer to the first review Mü nch et al suggest that (p3l85 – 90) diffusion works equally on the climatic signal as well as the post depositional noise. Sure enough if you are only focusing on the inter-annual signals diffusion will equally attenuate post depositional noise and anything climatic-driven in these frequency bands. But obviously when you are looking at two meters of core at a place wth accumulation as low as 6 cm/y ice eq. there is more than inter-annual you are looking at. And certainly this is also the case when you are after "warming" trends in the Holocene section of the EDML deep core. You can certainly not expect diffusion to work equally on those bands.

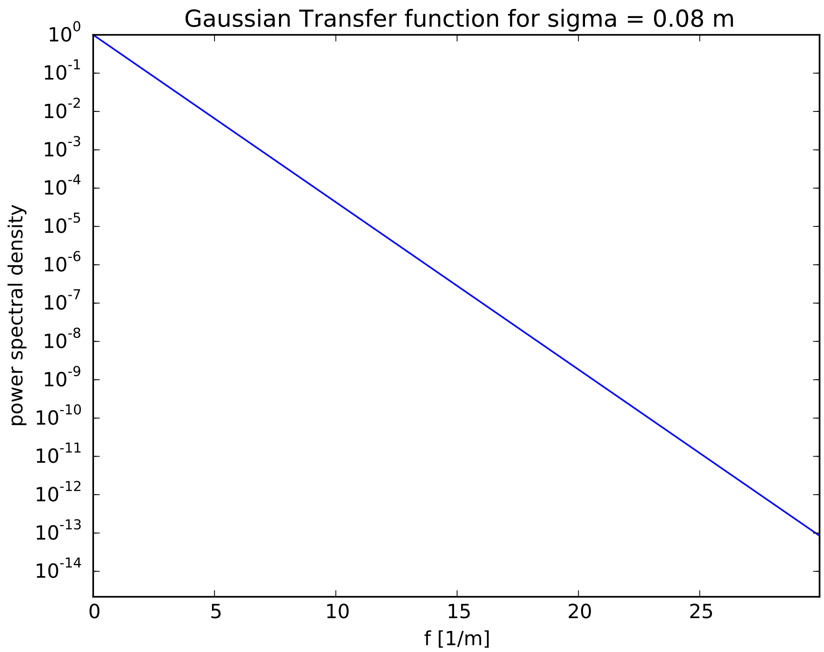
1.1.1 On Appendix B

Firstly I would like to point out that even though mathematically correct your eq. B2 is not what you see in van der Wel et al or any of the other diffusion works that I am aware off. It works much more intuitively that the units of the diffusion length σ should be the same as the units of the frequency axis ie expressed in terms of depth or time. I can understand that by introducing the accumulation term b in there you out things in order but I am also afraid this may create confusion. I will leave it up to the authors to decide what works best.

However I think there is an error in your treatment of diffusion in this section and subsequently on the conclusions you draw from this thereafter. Calculating the integral over the 0 to f_{nyq} band will indeed give you the variance of your signal. But it will give you the total variance or total power of the signal over the full spectrum of frequencies your analytical resolution is able to deliver. As a result, I think you are wrong by saying that the reduction of the annual signal power (you write "annual noise power" but I assume you mean "annual signal power") is only 0.095 of P_0. In fact all you are calculating in eq. B3 is the cumulative distribution function of your Gaussian transfer function. And this reflects the loss of power you have because of your non–perfect sampling scheme of $0.05\,yr^{-1}$. If you were able to sample at infinite frequency there will be no loss really.

Instead what you probably want to look into is the value of eq. B1 for the various frequencies (depth or time domain). Suppose we are looking at a section close to the firn–ice transition. The annual layer thickness there is about 7 cm ice eq. With a diffusion length of 8 cm your diffusion transfer function gives (eq. B1) for $f = 14.2\text{m}^{-1}$ roughly $10^{-6} - 10^{-7}$. Essentially at that depth diffusion has "killed" everything in the range of 5-10 cm. This is roughly anything sub annual, annual and slightly longer than that. In fact decadal signals at this depth have lost 75% of their power.

In your analysis you choose a hypothetical value for the $f_{nyq} = 0.05\text{yr}^{-1}$. This is equivalent to a resolution of 10 years and very roughly a sample resolution of more than 1 meter..! The whole discussion becomes irrelevant if you sample your core at a 1 m resolution. Can you double check this value and redo your calculations with something more relevant? I would say



a 0.05 m sampling scheme is something to start with.

1.1.2 On Table 2 and section 4.2 in the manuscript

In Table 2 and section 4.2 the authors calculate the comparison of measurement noise to the variance of the post depositional noise on various time scales. The Table works very nice as it is (though I would strongly suggest a change in the symbol of the measurement noise – see comment below).

Nevertheless I think that it would be very informative to calculate the effect of diffusion on these cycles at the firn–ice transition (where the diffusion process is finished and pore are well closed) as well and presented in the same or a separate table. This will give a more representative picture of how things really look like when one wants to look further deep in the core. In fact I have some of these back of the envelope calculations ready here for the authors. All calculations assume 8 cm diffusion length for δ^{18}O and an accumulation of 7 cm/y ice eq. With $\mathcal{G}$ I symbolise the value of the Gaussian transfer function.

- Seasonal (I use 0.25 of a year – 0.0175 m – 57.1 m^{-1}): $\mathcal{G} = 10^{-25}$ Diffusion kills all...practically zero of this signal is left. Measurement noise dominates everything in this frequency band.

- Annual case 1 (0.07 m – 14.2 m^{-1}): $\mathcal{G} = 6 \cdot 10^{-6}$, Practically same as seasonal. Measurement noise dominates again.

- 10 yr case 2 (0.7m – 1.42 m^{-1}: $\mathcal{G} = 0.25$, variance of noise = 0.75/4 = 0.1875 permile $\Delta\delta^{18}$O/0.1875 = 0.48. So roughly post depositional and measurement noise contribute equally in this case

1.2 Specific comments

I have a few specific comments on the rest of the manuscript:

- P5L1–8: It would be nice for the readers to have a feeling of how much time it took sampling the two trenches. In other words for how long was the snow–firn of the trenches exposed to the air before they were sampled?

- P16L2: I am not sure that adding the term "anthropogenic" is very relevant here. You are investigating the detectability of the isotope signal in resolving a warming trend. This does not necessarily say anything about the origin of the warming trend

- P16L8: I do not understand why densification is of importance only for undated samples. Can you elaborate?

- P16L10: 5% is not a correct estimate. See comments above on Appendix B

- Throughout the text and in Table 2 I would suggest that you change the measurement noise to something like σ_{CRDS} or similar. The symbol Δ often refers to an offset or an excess signal or a bias in measurements.