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Climate of the Past Discussions

# *Interactive comment on* "Climatic information archived in ice cores: impact of intermittency and diffusion on the recorded isotopic signal in Antarctica" *by* Mathieu Casado et al.

**Anonymous Referee #2**

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Review of Casado et al, Climatic information archived in ice cores. . .

Casado et al. develop a model to understand the timescale on which traditional water isotopes (dD and d18O) reflect climate. They assess two processes: diffusion and intermittency of precipitation. The primary result is a lower bound for the timescale at which climate variability can be reconstructed, which ranges from a year on the coast to a millennium in the interior. The manuscript is well written and the topic is of interest as the ability to measure water isotopes at cm resolution is becoming common. The underlying modeling is sound with a strong emphasis of spectral techniques. The results of what timescale of climatic information ice cores will contain are somewhat



underwhelming, since they vary by two orders of magnitude based on the assumed exponent for the power law representing long timescale climate variability. However, the primary interest of this work is not the conclusion, but rather the method development for a more quantitative understanding of processes limiting climate interpretation.

The assumption of the power law variability and the appropriate exponent does feel neglected in the paper. The authors use 1000-year runs of GCMs to estimate the climate variability, then seem to not like the result, so basically punt on the issue and use a range from 0 to 1, although the discussion primarily focuses on 0.6 (from a single study at EDML but seems to ignore the differences with WAIS in that same study) and 0.8. Someone reading this paper quickly would think that the appropriate range would be 0.6 to 0.8 because in three different figures, these are the only values plotted. A much fuller discussion of the appropriate value needs to be included so that the reader can understand not just the impact, but the state of knowledge. A single reference to one of the group's previous papers in CP is not enough for an assumption that dominates the results.

The forward model also seems to neglect two important processes: clear-sky precipitation and atmosphere-surface snow isotopic exchange. Both of these have the potential to offset the effect of precipitation intermittency. Assuming ERAi captures the timing of precipitation is fine in high precipitation areas, but these are also of the least interest since they receive precipitation relatively consistently. This assumption is much less valid for central East Antarctica, where clear-sky precipitation can make up a significant portion of total precipitation due to the infrequency and low volume of precipitation events. As to atmosphere-surface snow exchange, quantitative modeling would be challenging given the relative lack of information on the topic, but a qualitative discussion of its effect would be valuable.

Overall, this paper represents useful work that with a few improvements will contribute to water isotope analysis in ice cores.

Specific comments: This manuscript does not have line numbers, which should be remedied for future CP discussion papers because it makes referring to specific instances very difficult for both the referee and the authors.

- physico-chemical > why create this abomination of a hyphenation? Just write it out

- P2, last paragraph, consider using duration instead of size qualifiers, so replace larger with longer when referring to a timescale

- P2, last paragraph, change “read” to “interpret”

- P2, last paragraph, I think “virtually unlimited” is an overstatement given dispersion in CFA systems is still a limiting factor in the effective resolution

- P4, third paragraph, I’m really confused about what is being said in this paraph about perfect dating. I think I follow that because you tag the age of layers in the virtual core, you can compare these without age uncertainty to the original climate signal. However, you don’t explain how you then stretch between the tagged ages. And the discussion of the depth scale getting out of phase seems both obvious and also not relevant, adding confusion.

- P4, last paragraph. This paragraph misrepresents the impacts of wind scour. The references (i.e. Picard et al., 2019) appear to be focused solely on interior East Antarctica, whereas the authors here imply that Antarctica as a whole can lose 90% of its accumulation to wind scour, thus explaining the ERAi overestimation of total precipitation. The authors need to be specific about when they are writing about Antarctica as a whole, and when only specific regions. ERAi is well known to get precipitation timing correct, but magnitudes off, with Medley et al. 2013, GRL being a good reference.

- P5, first full paragraph, how can the satellite data of Arthern 2006 have been corrected to the data in a 2017 paper. Be clear with the reference. Either cite older sources, or be specific about what data in the Thomas paper was used.

- P6 – define SNR in an equation. It gets confusing because you use SNR in an



equation before your present an alternate SNR(f) in a subsequent equation.

- Figure 2: This is a well crafted figure that illustrates the methods well

- Figure 4: This figure is hard to interpret. There seems to be about every shade and thickness of red line possible. Differentiate the climate model coloring. Describe the beta=0.2 fit. Label each of the power law exponent lines on the left, rather than just varying the thickness. Or maybe you want to rethink this figure all together and break it into parts, more like Figure 2.

- Combine Tables 1 and 2 and use the caption as an opportunity to distinguish what tao_a and tao_b are.

- Figure 5, the use of just 0.6 and 0.8 feels misleading given the uncertainty in this parameter choice. At the least, I think beta=0.2 needs to be included, since it will show up in table 4. Same goes for Figures 6 and 9. Also, all these figures should have the ice core locations of sites in Table 4 shown.

- Table 3: I’m not sure what tao without a subscript is. Is this tao_a like in the caption?

- P17, “below” not “bellow”, but I would like to see “bellow” used in a CP paper sometime

- P20: section 4.3, I appreciate the inclusion of a section like this, but it seems like many limits of the approach were not discussed. Expand this with discussion of beta and atmosphere-surface snow isotopic exchange.

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