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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.

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Summary This paper models a step by step water stable isotope ice core data distinguishing the climatic signal from intermittent precipitation and diffusion noises, using ERA-interim reanalyses. The analyses are then based on spectral observations. The identification of specific frequencies for a signal-to-noise equal to one allows a quantification of the resolution to consider to extract a climatic signal. These kinds of results are undoubtely very needed, and the approch proposed in this study could be very useful for ice core people. However, in this current state, the paper needs some read-

justments to make it easier to understand as well as more applied to specific sites, as outlined in the general comments. I thus highly recommend the publication of this paper, but after major modifications.

General comments - No dedicated paragraph can be found for the data. Could you introduce the ERA-interim reanalyses, CMIP5 models and snow pit data in a first paragraph of section 2 ? Also, no justification was given neither for ERA-interim : why not ERA5 wich show overall better performances ? See Vignon, Étienne, Olivier Traullé, and Alexis Berne. "On the fine vertical structure of the low troposphere over the coastal margins of East Antarctica." Atmospheric Chemistry and Physics 19.7 (2019): 4659-4683. Could you justify the choice of the 5 models among the CMIP5 models ? Finally, please give more details and references for the snow pit data you used.

- As you compare the outputs from your virtual cores, the precipitation data used should be the more realistic possible. Your method using ice core data from Thomas et al. is of great subtility, as the SMB data from Vaughan et al. was not checked by Athern et al. before their interpolation. However, could you make a prior validation of your method, by comparing it against data, for instance from Favier et al. : Favier, V., Agosta, C., Parouty, S., Durand, G., Delaygue, G., Gallée, H., ... & Krinner, G. (2013). An updated and quality controlled surface mass balance dataset for Antarctica. Or using the SMHiL data : Agosta, C., Favier, V., Krinner, G., Gallée, H., Fettweis, X., & Genthon, C. (2013). High-resolution modelling of the Antarctic surface mass balance, application for the twentieth, twenty first and twenty second centuries. Climate dynamics, 41(11-12), 3247-3260. Once robustly demonstrated, this could be reused.

- Some points of your method require clarity, as an explanation on the law power, and better explanations on the difference between τa and τb.

- The paper seems to be directed to ice core users, thus for applied purposes. I would suggest to better introduce which time scales analyses might be affected by the precipitation intermittency and the diffusion. For instance, the glacial-interglacial variability is

so strong, that it is not pointed in the line of sight of such questions. So please frame the use of your analysis for Holocene reconstructions. Also, it would be very practical to get quantative frequency thresholds (τ, associated with the best β fit) for every site you cited in Table 4, similarly as your work for EDML in Figure 4. That would be of a high contribution.

- Finally, could you specify for each correlation if it is significant (p<0.05) ?

Specific comments p1 l1-l3 : The sentence is confusing as one might think water stable ice core records result only from the surface temperature, the intermettency of precipitation and firn diffusion. p1 l8 : You are actually not giving a proper transfer function in the paper, that we could apply to extract the climatic from the whole record.

p1 l22 : please add Âń of the climatic signal Âż after Âń the temporal resolution Âż.

p1 l23 : please add more recent references for coastal sites, e.g. : Caiazzo, L., Baccolo, G., Barbante, C., Becagli, S., Bertò, M., Ciardini, V., ... & Gabrieli, J. (2017). Prominent features in isotopic, chemical and dust stratigraphies from coastal East Antarctic ice sheet (Eastern Wilkes Land). Chemosphere, 176, 273-287. Goursaud, S., Masson-Delmotte, V., Favier, V., Preunkert, S., Legrand, M., Minster, B., & Werner, M. (2019). Challenges associated with the climatic interpretation of water stable isotope records from a highly resolved firn core from Adélie Land, coastal Antarctica. The Cryosphere, 13(4), 1297-1324. Vega, C. P., Schlosser, E., Divine, D. V., Kohler, J., Martma, T., Eichler, A., ... & Isaksson, E. (2016). Surface mass balance and water stable isotopes derived from firn cores on three ice rises, Fimbul Ice Shelf, Antarctica. The Cryosphere, 10(6), 2763-2777.

p1 l8 : change Âń however Âż to Âń moreover Âż>

p2 l28 : For low accumulation sites, I would recommend citing : Frezzotti, M., Urbini, S., Proposito, M., Scarchilli, C., & Gandolfi, S. (2007). Spatial and temporal variability of surface mass balance near Talos Dome, East Antarctica. Journal of Geophysical

Research: Earth Surface, 112(F2).

p3 l14 : Remove Âń while Âż before Âń ...the actual value of Âż, and change Âń scale Âż by Âń are scaled Âż. I do not understand the end of your sentence related to uncertainty. Can you explain ?

p3 l21-22 : Âń This yields an intermittent virtual core ... Âż Please rewrite the sentence to make it understandable.

p4 l21 : change Âń providing Âż with Âń provided with Âż.

p4 l23 : Please give more details. Is it acceptable within the range of variability ? Which is ? Also, you gave references mostly related to the Plateau. However, the outputs migth be optimistic when accounting for coastal areas and the Peninsula, see Figure 2 from : Goursaud, S., Masson-Delmotte, V., Favier, V., Orsi, A., & Werner, M. (2018). Water stable isotope spatio-temporal variability in Antarctica in 1960–2013: observations and simulations from the ECHAM5-wiso atmospheric general circulation model. Climate of the Past, 14(6), 923-946.

p5 l5 : change Âń had been themselves corrected Âż by Âń were preliminary corrected Âż.

p5 l25 : There might be much more recent publications related to the random occurency of precipitations. Please update the litterature. I would recommend citing : Turner, John, et al. "The Dominant Role of Extreme Precipitation Events in Antarctic Snowfall Variability." Geophysical Research Letters 46.6 (2019): 3502-3511.

p6 l12 : remove Âń for Âż before Âń the SNR for a given frequency Âż.

p6 l11 : - For people not familiar with the tools you usem this part of the paper is not easy to understand. Especially, it is difficult to follow the logic of the following paragraphs. What could help is to first give the role of each tool you use, ie SNR, τa and τb prior to the way they are obtained. - Âń either in the sampling, or by average samples Âż : I do not understand.

p9 l5 : move Âń only Âż after Âń conditions Âż.

p9 l8 : Could you define the Âń amount of lost variance Âż ? Is it the difference of variance between the climatic virtual core and the intermittency virtual core ? Or the variance of a core which is reduced with increasing frequencies ?

p9 l9 : please specify that the warm bias comes from ERA, and that it is emphasized on the plateau, thus referring to a more comprehensive study as : Fréville, H., Brun, E., Picard, G., Tatarinova, N., Arnaud, L., Lanconelli, C., ... & Van den Broeke, M. (2014). Using MODIS land surface temperatures and the Crocus snow model to understand the warm bias of ERA-Interim reanalyses at the surface in Antarctica. The Cryosphere, 8(4), 1361-1373. If you rather report to the higher amount of precipitation during summer compared to winter, you should not speak about bias. Please make it clear. But in all cases consider my previous comment, at least of the ERA description.

p9 l11 : Is this correlation significant ?

p9 l12 : r2=0.34 is not that high, so I would rather suggest a part explanation of lost variance due to precipitation intermittency.

p9 l13 : The sentence Âń Nevertheless... Âż is confusing because it does not refer to the correlation coefficient, but I guess it does ? If so, could you thus gather the two sentences the sentences related to the mean and range values of this correlation coefficient or give more clarity in anyway ?

p9 l18 : Here I do not understand what you used to compute the correlation coefficient, once more probably because It is not clear to me what the amount of lost variance is.

p9 l22 : Âń r=0.22 Âż. Previously, you gave r^2 and not r. Could you check it was your intention to give r here. Is it significant ? What is r between the diffused virtual core and the intermittent virtual core ?

p9 l28 Âń the seasonal cycle clearly dominates the signal by roughly two orders of magnitude Âż, compared to another time scale ? Please specify.

p10 l11 : remove the dot before Âń see section Âż.

p11 l6 : Even if the PSD dislpays the square of the amplitude, could you change it to the amplitude (thus in ‰, so it is more relevant for ice core people.

P12 l6 : Can you give more information on the power law for the PSD, especially the way it is been found. You refer to an entire book, so it is not easy to find the proper dedicated paragraph.

p13 l1-5 : Please add a robust justification for illustrating the power law only for β=0.6 and β=0.8.

p13 l5-8 and p15 l5-7: To support your argument, it would worth to add contours of accumulation in Fig. 5 and to comment it there.

p15 l8 : which snow pit data were used ? Could it be introduced into the data section ?

p17 l2 : change Âń bellow Âż to Âń below Âż.

p17 l6 : change Âń an Âż to Âń a Âż.

p19 l3 add Âń as Âż to Âń such Âż.

Figures Figure 2 : That is a very nice plot !!!

Figure 3 : Are all simulated relationships signficant ? Please remove are for not significant relationships, are put hatches. Could you add contours for r from r=0.9 and 0.8, to point areas where the intermittency does relatively weakly affect the climatic signal ? Could you use the same colours for intermittency only, and intermittency and diffusion plots to make the comparision easier.

Figure 4 : could you add a vertical line for the seasonal frequency so it could illustrate better lines 6-7 in the text above the figure. Also detail in the legend that these fits and outputs correspond the the EDML site.

Figure 5 : see the specific comment suggesting adding coutours of accumulation.

Figure 6 and 7 : please complete the description presently suspended Âń have affected the signal... Âż.

Tables Table 4 : I do not see where table 4 has been cited in the text. It shows that the results are very β-dependant, and that it would have been expected similar fits than those displayed on Figure 4, in order to point the β value to consider, and associated τ for each site.

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