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**Climate of the Past Discussions**

# *Interactive comment on* "Objective identification of climate states from Greenland ice cores for the last glacial period" *by* D. J. Peavoy and C. Franzke

**Anonymous Referee #1**

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The paper is dedicated to studying and modelling GISP2, GRIP and NGRIP $\delta^{18}O$ Greenland temperature proxies using Bayesian approach. The authors identify three distinctive patterns (regimes) in the increments of the paleorecords, which oscillate between colder and warmer climate states.

I first note that the authors mention canonical Dansgaard-Oeschger (DO) events between 11.5 and 110 kyr BP (p.2 of the Discussions manuscript), but then they plot data in the interval 82-10 kyr BP (Fig.1). What was the reason to choose this particular interval whereas GRIP and NGRIP series with resolution 50 yr are available for periods since 112/122 kyr BP? I think it would be good to add a comment on this.

I further note that although the authors talk about three identified states, their "termination state" is, in fact, not a state of the climate potential but rather a transitional regime



between warmer and colder states. See (Ditlevsen, GRL 1999) and (Kwasniok and Lohmann, Phys. Rev. E 2009) where the climate potential in the last glacial period is described as double-well with noise-induced oscillations. I suggest these references be added to the manuscript.

What is new in the present paper is that it proposes a flexible random walk model with directed forcings according to the data pattern in the inteval 82-10 kyr BP (using increments of the series), thus reproducing saw-tooth character of DO events. However, the asymmetric transitions from warmer to colder state are not an additional climate state, and this should be clearly stated in the manuscript.

Using Bayesian analysis, the authors first identify the number of climate regimes (they choose between two types of models, absolute values of temperature proxies and their increments) and then they model data using increments of a random walk with variable forcings of three types (relaxation, DO and termination). Furthermore, they test properties of the modelled samples and parameters of posterior distributions against the data. I would suggest that the title of the paper be changed to reflect this. This is not a paper about objective identification of climate states. This is a paper about modelling DO events using Bayesian approach. The title should be like "Bayesian modelling of DO events in the Greenland ice cores". Also, I suggest that the sentence in the abstract "We find that these models are far superior to those that differentiate between the states based on absolute temperature differences only" should be omitted.

It is not discussed why GRIP series, which is so similar to NGRIP, does not require the model with three regimes. Can the authors comment on this? And if for this series three-forcing model is not favoured, why in Fig.4 the authors show posterior distribution for GRIP with three states?

Bayesian approach is powerful, and this is an interesting paper. The proposed model is finely tuned to reproduce ensemble properties of the Greenland ice cores and typical features of DO events. However, since Bayesian posterior distribution provides infor-

mation about probabilities and averaged properties of data (whereas the real dynamics is also important in the case of such nonstationary series as Greenland records, see how data changes between 40-25 kyr BP and 25-15 kyr BP), this should be mentioned in the discussion.

I recommend that the paper is accepted for final publication only after suggested corrections and adjustments.

**Further comments**

- The authors should state in the text that $S_i = 0$ is relaxation, $S_i = 1$ is DO, and $S_i = 2$ is termination (only $S_i = 1$ for DO is mentioned at present).
- In section 2, better to omit "hidden state" in the title. The same in subsection 2.1. The transitional regimes between colder and warmer states (which the authors identify using increments) are visible in the ice core data.
- In Fig.2b, I see problems with modelling temperature decrease events. My guess is this is precisely because this transitional behaviour is not an additional state. Would it be possible to plot one of the modelled samples to see how similar is modelled data to Greenland proxies? From the model description, I expect it to be more homogeneous and less nonstationary than the real data. Panels with increments (data and model sample) would also be interesting to see.
- In Fig.2, panel (b), the authors show posterior probability with values less than 0.5, whereas in panel (a) those are omitted. This should be done in (b) as well. And this should be mentioned not only in the text, but also in the figure caption.
- The discussion of Table 1 should be extended - Table 1a is mentioned but Table 1b is not. The authors say they considered up to four states in their test, but in Table 1 they show values of the marginal likelihood only for three states. It would be interesting to see the values for the four states as well.



- As I understand the Bayes factor, it is $B = \frac{pr(D|H_1)}{pr(D|H_2)}$ for two models with marginal likelihoods $pr(D|H_1)$ and $pr(D|H_2)$ (Kass 1995). When in Section 3 the authors say that the ratio between two models is typically of order $10^3$ and for GRIP it is 1.2, it is not clear to me what models they compared - increments and absolute values with the same number of states or different numbers of states for each type of model? I cannot see how they get 1.2 for GRIP with the values provided in Table 1. This should be clarified in the text or Bayes factor values be added.

**Minor comments**

- The authors do not mention the length of samples they generated (only the number number of samples and the burst period).
- In Fig.3, what are those H letters in the legend? It is not explained either in the text or in the figure caption.
- Figs. 2 & 5 are better to plot in two long panels one above another. I cannot see results in panel (a) of Fig2, it is too narrow with dense data.
- In the caption of Fig.4, I suggest to mention relaxation, DO, termination.

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Interactive comment on Clim. Past Discuss., 6, 1209, 2010.