

Geosci. Model Dev. Discuss., referee comment RC1  
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## Comment on gmd-2021-90

Anonymous Referee #1

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Referee comment on "fenics\_ice 1.0: a framework for quantifying initialization uncertainty for time-dependent ice sheet models" by Conrad P. Koziol et al., Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2021-90-RC1>, 2021

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The uncertainty in model data is propagated to a Quantity of Interest (QoI) in ice sheet simulations using a Bayesian approach. This kind of analysis has been published previously but the authors extend it here to time dependent QoIs. They show how to reduce the uncertainty in the prior by utilizing Bayes' formula for the posterior. The method is tested with the SSA ice sheet equations solving an ISMIP-HOM problem. Parameters are varied in numerical computations. Examples of possible future work are given in the final section. The code for the experiments is available for free.

The paper is suitable for GMD and is improved if the comments below are addressed somehow in a revised version.

### General comments

Sect. 2.4:  $\gamma_{\text{post}}$  depends on how  $r$  is chosen. If there is a gap in the eigenvalue distribution then  $r$  can be chosen such that the gap is between  $\lambda_r$  and  $\lambda_{r+1}$ . But in general there is no gap. How should  $r$  be chosen in a general case? This question is related to the choice of  $\gamma$ , see Fig 4a. If we believe in prior data then  $\gamma$  should be large but if we don't then give data lower weight (or should  $\gamma$  be viewed only as a regularization parameter?).

Sect. 4, (33): Why is this particular QoI chosen? A bit longer motivation would be welcome.

Sect. 4: How is the prior  $c_0$  chosen? Maybe this is mentioned somewhere but it could be repeated here. A discussion of how to select  $c_0$  and its impact on the posterior

result would be interesting.

Sect. 5.3: One would expect that the linear approximation of QoI should work for sufficiently small perturbations. Maybe the perturbations are too large when the regularization is small ( $\gamma_1$ ) and for smaller perturbations the approximation will work.

Sect. 6: The issues above with choice of  $r$ ,  $\gamma$ ,  $c_0$  and QoI could also be discussed in the last section.

Specific comments

line 93: Euclidean inner product of  $a$  with  $\Gamma^{-1}_{\text{obs}}b$ ? Next line  $|a|_{\Gamma^{-1}_{\text{obs}}}$ ?

105: Is there a weight missing in front of the prior term? Maybe  $\gamma$ ?

110: Tell that you maximize over  $\bar{c}$ .

145: Define  $\delta$ .  $\mathcal{L}$  is defined for a function in (9). In (10)  $\mathcal{L}$  is applied to a vector  $c$ , at least  $c$  is a vector after the last equality in (10). Should  $J_{\text{reg}}^c$  depend on a weight too?

149: Should the definition of  $L$  have only one  $\mathcal{L}$  in the integral? What are the bars over  $\phi$ ?

171: Mention that the eigenvalues are ordered such that  $\lambda_i \geq \lambda_{i+1}$ .

179: leading eigenmodes  $\rightarrow$  leading eigenmodes with large eigenvalues

242: Specify parameters  $B$  and  $n$

251, 253: Specify  $\delta$  which is different from  $\delta$  in (9). Tell what o.w is.

321, 322: Is weight  $\gamma$  missing here? Is  $c$  a function in the integral after the first equality and a vector in the second term after the second equality?

515: The uncertainty in the QoI is not only lower than the uncertainty in the parameters due to the filtering but also due to the choice of QoI. With a different QoI it may be larger even with filtering.

Technical corrections

line 138:  $J_c \rightarrow J^c$

176:  $H \rightarrow \bar{H}_{\text{mis}}$  ?

223: (Section ?)

302, 304:  $C^2$  or  $C$  here?

385: say something about ..... intervals?

413: maybe move ....?

665, 677: missing journals