The Cryosphere Discuss., 8, C2571–C2574, 2014
www.the-cryosphere-discuss.net/8/C2571/2014/

The Cryosphere Discussions

Open Access

Interactive comment on "Model calibration for ice sheets and glaciers dynamics: a general theory of inverse problems in glaciology" *by* M. Giudici et al.

Anonymous Referee #3

Received and published: 3 December 2014

1 General comments

This paper aims to provide details on theoretical aspects underlying inverse problems for the calibration of ice sheet models. These aspects are illustrated with a simple numerical example.

The paper is generally well written and the theoretical concepts issued are clearly described. However I am concerned by the relevance of this paper in a scientific journal dedicated to glaciology. The description of inverse problems and their theoretical aspects remains general and can be found in any good textbook dedicated to inverse problems. There is no focus on potential theoretical aspect of inverse problems specifically encountered in glaciology. The numerical application to ice flow is unfortunately only illustrative and not really representative of inverse problems for the calibration of ice sheet models.

2 Specific comments

The paper proposes to provide a "*thorough and rigorous conceptual framework for inverse problems in cryospheric studies"* and aims to remain general. However several shortcomings prevent the paper from achieving its goal completely. I list them below:

- The paper oscillates between tackling inverse problems in glaciology or restraining its purpose to the calibration of ice sheet models. This ambiguity is noticeable in the text but also in the title of the paper itself. If the goal is to issue inverse problems in glaciology, then important fields of application such as ice core dating or the calibration of snow models are missing.
- It is rather surprising that, after mentioning more than 15 papers dedicated to the use of inverse modelling for the calibration of ice sheet models with different methods, the authors state that "*IP theory (...) has not yet become popular in glaciological sciences*". The absence of recent key publications in operational glaciology might explain such comment.
- Linked to the previous point, it would have been interesting to recall which variables and parameters of ice sheet models are generally calibrated by inverse modelling and with which data in the list of citations given in the introduction.
- The first part of section 3 (p. 5518) defining an inverse problem is clearly based on optimal control theory but this point is not mentionned in the text.

- The authors state (p. 5520, l. 1) that "*most of the applications of the Bayesian approach compute the optimal parameters by means of the maximum likelihood method*". As a consequence the paper forgets to mention that estimating posterior pdfs is more and more popular in geosciences as it gives more information than a maximum likelihood method. Methods such as Markov Chain-Monte Carlo are even used for the calibration of ice sheet models in palaeoglaciology (see Tarasov et al., 2012).

- Section 4 lists different usefull notions for inverse problems such as the identifiability of the direct problem or the conditionning of a system. It also states that the inverse problem might be unstable due to either ill-conditioning, non-identifiability or non-uniqueness. Providing more details on this important issue would have been usefull as it would have helped the reader to select which of these notions is the most important for the resolution of her/his inverse problem.

- The selected numerical application is not really usefull as it only illustrates a well-posed and well-conditioned problem. Unfortunately many inverse problems (including inverse problems for the calibration of ice sheet models) are ill-posed or ill-conditioned. Detailing an example in such configuration would have been more usefull.

3 Minor comments

- p. 5517, l. 1: $\mathbf{p}^{(\mathrm{cal})} = (E, M)$.

- p. 5518, l. 23: $\mathscr{J}$ is more classical for objective functions than $\mathscr{O}$ (commonly used in Landau notation).

- p. 5519, l.4: "*the the algorithm*"

TCD

8, C2571–C2574, 2014

- p. 5521, l.27: define SD (I guess it means standard deviation).

Interactive comment on The Cryosphere Discuss., 8, 5511, 2014.