The Cryosphere Discuss., 8, C2704–C2708, 2014
www.the-cryosphere-discuss.net/8/C2704/2014/

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

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Received and published: 21 December 2014

This document includes our reply to the anonymous reviewer #1.

We thank the Reviewer for his frank evaluation of the paper. We think to be able to improve the quality of the paper by taking advantage of some of his comments.

1 Inverse methods are not 'popular' in glaciology

The authors state that inverse methods are not' popular' in glaciology. Although one can argue what the exact meaning of

'popular' is in this context, the fact is that inverse methods are now routinely used in glaciological modelling work. The use of inverse methods is now such a standard procedure that it appears puzzling how one can state that they are not 'popular'.
We performed a statistical analysis with the Scopus data base and the results are listed in table 1. The number of papers with keywords related to inverse problems ("invers*", "inverse problem", "inversion", "model calibration", "parameter identification") and keywords related to geophysics ("Geophys*"), glaciology ("Glaci*") and (surface or sub-surface) hydrology ("hydro*") have been extracted from the Subject areas "Earth and planetary sciences", "Environmental Science", "Physics and astronomy". Table 1 shows that the percentage of papers dealing with glaciological studies whose keywords are related to inverse modelling is one order of magnitude less than that for the whole field of geophysics. Moreover, even if the analysis is compared with other restricted fields of geophysics, e.g., hydrology, the results show that there is a difference by a factor close to 2; moreover, notice that the papers extracted for the keyword "Hydro*" are sometimes related to fields different from geophysics (e.g., biology).
These results clearly show that the use and application of inverse modelling in the cryosphere sciences is much more limited than in other fields of geophysics. This motivates the statement that inverse modelling is not yet "popular" in the glaciological community.

(By the way the reference to Gudmundsson 2014 which allegedly supports this claim is incorrect. That work was published in 2011 and not 2014, and I could not find any statements in that article to this effect.)
We thank the Reviewer, who found the error in the publishing year of the paper by Gudmundsson (2011) and put in evidence that the citation was not placed in the correct position. In fact, Gudmundsson (2011) specified that "using formal inverse models is rather limited" to infer effective viscosity from surface measurements.

2 Nature of the paper

The discussion is rather general. Which raises the question of the nature of this paper. Is presenting new scientific work, is it an overview paper discussion existing work, or does it aim at being a tutorial on the use of inverse methods? I did not see any important new findings that could be of use to the glaciological community. The forward model used is trivial and can at best only be used as a toy model to illustrate some general concepts. The conclusions are weak. The authors claim to have unified different notations and facilitated formal definitions. This does not count as a hard new scientific result. I did not find anything that is not generally known to all well-informed practitioners in the field.

From the Reviewer's comment, we realize that the goals of the paper were not clearly described in the submitted manuscript. We are aware that our paper does not introduce "hard" and "new" scientific methods, but we are convinced that it proposes a formal and general framework which could help to close the gap between theoretical papers and applications.

Moreover, we stress that some basic concepts (e.g., identifiability, conditioning, global sensitivity) are very rarely analysed and considered by researchers working on inverse problems in glaciological sciences.

As an overview paper it misses too many key publications and quite frankly gives a much distorted view of the field.

We are aware that many other papers could be cited, but we made a choice, trying to select the most important and accessible papers. If the Reviewer can be more precise about the missing key papers, according to his opinion, we will be very happy to modify and possibly extend our reference list. Unfortunately, the second part of this

comment is quite general and we do not understand along which line we give a "much distorted view of the field". We would be very happy to revise the paper in order to fix this problem, if the Reviewer could be more precise.

And as a tutorial, one can find better introduction to the subject in designated textbooks on this subject.

We are aware that textbooks provide a more extended description, but – at our knowledge – no textbook on inverse problems specifically dedicated to glaciology is still available and we think that it is important to provide a tutorial for researchers, in order to facilitate the link between theoretical works and practical applications. However, we shall try to provide a "better introduction to the subject", both by putting more emphasis on the differences with the standard set-up of the inverse problem given in text books and by adding a list of guidelines in the concluding section.

3 Planned changes for the revised version

The main changes that we intend to include in the revised version of the paper, are listed below.

1. The discussion on the diffusion of inverse modelling in glaciological sciences will be supported by some statistical analyses, similar to those listed in table 1. Morevoer, we are going to evaluate if it is possible and interesting to prepare a figure which shows the temporal evolution of the weight of inverse-related papers in glaciology and geophysics.

2. We shall correct the publication year of Gudmundsson (2011); we will also clarify that the citation to Gudmundsson (2011) refers to an excellent review on the same topic of our paper, so that it will not be directly related to the relatively limited diffusion of inverse modelling in the glaciological scientific community.

3. We shall modify the introduction to clarify the goal of the paper and its value for researchers in glaciological sciences.

4. We shall include a list of guidelines in the conclusions, so that the paper will be more useful for those researchers who are starting to deal with inverse modelling in glaciological studies.

	Geophys*	Glaci*	Hydro*
Paper with inverse-related keywords	2,102	222	6,105
Total number of papers	31,556	31,038	501,400
Ratio	6.7%	0.7%	1.2%

Table 1. Analysis with the Scopus data base

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