The Cryosphere Discuss., 7, C1424–C1427, 2013
www.the-cryosphere-discuss.net/7/C1424/2013/
© Author(s) 2013. This work is distributed under
the Creative Commons Attribute 3.0 License.

The Cryosphere
Discussions
Open Access

Interactive comment on "Parameter and state estimation with a time-dependent adjoint marine ice sheet model" *by* D. N. Goldberg and P. Heimbach

M. Nodet (Referee)

maelle.nodet@inria.fr

Received and published: 13 August 2013

General remarks

This paper by N. Goldberg and P. Heimbach presents the first ever variational data assimilation system in glaciology based on the exact adjoint. Indeed, a lot a previous works used a similar method to solve inverse problems, but all of them used an approximate adjoint, valid for linear rheology only. Such adjoint is generated mostly thanks to automatic differentiation, except for a part containing the iterative resolution of a linear system, which is derived by hand.

This paper is therefore groundbreaking, and I highly recommand its publication. I still

have a couple of questions/reservations about the choice of the experiments, which in my opinion are too far from realistic frameworks to provide a strong proof of concept.

Specific points

1. p2848 l15 please also cite the first and grounding works of adjoint assimilation in oceanogaphy, there are relevant papers in the 90's
2. p2851 I agree with M Morlighem: it would be nice to have the equation for β_{eff}
3. p2862 l1 There are plenty of past works on the subject of experiment 2, and a lot of them deal with real data, please mention this kind of works and refer to at least some of them.
4. p2863 (and fig3) l21-25 Could you please show on your figure what initial guess you choose for β. In particular, is it close to the background? Why couldn't you use something else, such as a linear β, or a sine plus random noise, etc.
5. p2863-2864 experiment 2: I find it difficult to assess the performance of the method based only on cost function graphs. You say the inverted β is very close to the true one, but to get a clear idea it would be nice to see the corresponding sliding velocity, compared to the true one and to the one inverted by MacAyeal method.
6. Questions about experiment 3:
   (a) the accuracy you require on S through σ_s really is unrealistic at the moment, what are the results if you choose a realistic value (a few meters)?
   (b) is it interesting to look for H ten years ago? wouldn't we want to provide forecasts for the glacier evolution in the future instead? in that case, the

knowledge of the last 5 years would be enough. could you please provide references to papers where people ask this kind of questions?

(c) why not use also surface velocity information for the last 5 years? does it not make any difference?

7. Also a lot of things are bothering me with this experiment:

   (a) centimetric accuray on S

   (b) bed supposed perfectly known, but in practice it is also measured, so it would mean more errors, on ice thickness in particular

   (c) looking at the thickness in fig 4c it seems that the experiment focus on a hill which is around 5 meters high. In that case is the hybrid model accurate the model such fine scale phenomenom?

   (d) the prescribed β does not depend on time, but usually in such transient phenomenom we do have a time-dependant β.

8. Thus I would have suggested a more realistic experiment instead of exp 3:

   (a) similarly: known bedrock, observed surface velocities, thickness unknown

   (b) S observed for 10 years, $\sigma_s =$ a few meters

   (c) β variable in time and unknown

   see e.g. the framework of the surge of Variegated glacier by M. Jay-Allemand and others http://www.the-cryosphere.net/5/659/2011/tc-5-659-2011.html

9. p2870 l21 why does the model run for only a single timestep? what happens for longer time-windows?

10. p2889 experiment 4 fig7: could you also please provide either a figure (or information reg. RMS errors) for the sliding velocity associated to the inverted β versus the velocity without assimilation?

11. did you implement a classical method (approximate adjoint) for experiment 4 as well? it would be nice to see how it performs compared to the full adjoint method.

12. p2871 eq (21): in reality s is not trully known but observed with measurement errors, so that the method your propose could not really be extended to real data. what happens if you do what you say line 21 and penalyze the misfit of s in the cost function?

Technical point

1. p2884 I think there is a problem in figure 2b: the y coordinate does not seem to correspond to what you describe. Shouldn't it be $y \in [0; 150]$ instead?

Interactive comment on The Cryosphere Discuss., 7, 2845, 2013.