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

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The paper entitled "Parameter and state estimation with a time-dependent adjoint marine ice sheet model" by D. N. Goldberg and P. Heimbach presents how automatic differentiation can be used to infer unknown parameters and initial conditions.

Automatic differentiation is relatively new to the ice sheet modeling community and is a promising tool. The authors first describe their ice sheet model, which is part of the MITgcm, and how automatic differentiation is employed to derive the adjoint of a time-dependent problem. They then provide four experiments that illustrate how automatic differentiation can be used for different applications.

The manuscript is well written and clear. The approach is presented clearly and in ample detail, and the figures and tables are adequate. I highly recommend this manuscript for publication with some minor revisions outlined below.

- The stress balance and mass transport equations are referred to as *diagnostic* and *prognostic* models in the abstract. I would suggest keeping stress balance and mass transport for clarity, as diagnostic and prognostic are not straightforward for readers not familiar with the jargon of Glaciology.
- Throughout the text, slopes are expressed in tangent of degrees. I would simply use degrees for clarity (-tan(0.5°) → -0.5°).
- p2851: It would be nice to show the basal friction equation (on β_{eff}) instead of referring to a paper.
- p8252 line 20: Does *single location* mean cell (i.e. discretized field), or an arbitrary x, y point of the model domain (i.e. continuous formulation).
- p2854 line 27: is well → as well
- p2858 line 12: Gagliardini et al. 2011 present some interesting results about this topic. A reference to their paper would be relevant.
- p2859: merge lines 11–12 and 22–23, which seem to repeat each other.
- p2860 line 1: The figure the authors refer to is 2a, not 2b.
- p2862 line 19: missing period at the end of the sentence.
- p2865 eq. 14: remove km from the equation (eq 8 and 9 do not have units). Same thing for eq 18 and 19

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- p2868 line 10: Seroussi et al. 2011 indeed show that ice thickness data is a major source of error in ice sheet model. A reference to their paper would be relevant.
- p2873 line 16: A matrix is never inverted (the invert of a sparse matrix is dense). Linear systems are solved, but matrices are never inverted. (Same for p2875 line 3)
- Figures: speeds are expressed in m/a, but the text uses m/yr (same for β^2)

References:

Gagliardini, O., F. Gillet-Chaulet, G. Durand, C. Vincent, and P. Duval, Estimating the risk of glacier cavity collapse during artificial drainage: The case of Tete Rousse Glacier, Geophys. Res. Lett., 38, 1–5, doi:10.1029/2011GL047536, 2011.

Seroussi, H., M. Morlighem, E. Rignot, E. Larour, D. Aubry, H. Ben Dhia, and S. S. Kristensen, Ice flux divergence anomalies on 79north Glacier, Greenland, Geophys. Res. Lett., 38, L09501, doi:10.1029/2011GL047338, 2011.

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