

Interactive comment on “The Gregoriev Ice Cap length changes derived by 2-D ice flow line model for harmonic climate histories” by Y. V. Konovalov and O. V. Nagornov

Anonymous Referee #2

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Surface Earth Discussion

"The Gregoriev Ice Cap length changes derived by 2-D ice flow line model for harmonic climate histories"

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General comments The aim of this paper is to infer the relationship between glacier length and annual air temperature using a 2D flow line model. In a first part, from Sections 2 to 4, the ice flow model, including surface evolution and heat equations, is presented. Then, the model is applied with the objective of inferring the coefficient

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entering the relation proposed by Oerlemans to link the glacier length to the annual air temperature.

I have found this paper very difficult to read, the main objectives and the important features do not clearly appear. A large part of the paper is dedicated to the flow model, whereas the main objective of the paper is clearly elsewhere. Even the part on the model is unclear and it is really difficult to see if they are new developments in this work. The paper contains 14 figures, but most of them are not discussed enough in the text.

This paper should be accepted only if major revisions are done. I present below some of the points that should be modified/clarified before publication.

Specific comments

- The way the model is presented is really open to criticism. It should be clearly stated which approximations are done and from which reference(s) the equations are inferred. The *mechanical equilibrium* equation should be named the momentum equilibrium equation or quasi-static equilibrium equation. Page 60, line 6, what does it mean *pressure exclusion*?. It seems that the model used assumes that the vertical Cauchy stress is equal to the hydrostatic pressure? This should be mentioned clearly. The model and all the equations should be presented in a more concise way with the appropriate references for the already published works.
- In Section 3.2, the basal boundary conditions are presented in a very technical way, and I think not necessary for the purpose of the paper. The fact that such conditions have to be written in a normal-tangential frame is well-known and should be written only once under the normal-tangential form. Going from the

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normal-tangential frame to the reference frame is not an issue.

- Moreover, the terminology is not correct for the friction law: the inclusion of the effective pressure N (should be named in the text) is not the condition to have a non-linear law. The effective pressure can also be included when $n = 1$. Why don't you have include the effective pressure when $n = 1$? In the present paper, it seems that the water pressure is nul so that N reduces to the normal stress at the base.
- A large part of the paper is dedicated to the presence or not of basal sliding. At the end, it is not clear why and when the basal sliding is introduced. The material regarding basal sliding should be regrouped in a single part of the paper and not dispersed in all the paper.

Technical corrections

- p56, l2: this first sentence is not clear: How these flow line lengths are obtained, from the model or from measurements?
- p56, l5: "by solving of steady state" should write "by solving the steady-state". Consider rewriting the whole sentence (too long, unclear).
- p57, l8 to l10: The sentence should be rewritten.
- p57, l14 to 21: I'm not sure that the ISMIP-HOM tests have shown that higher-order and full-Stokes models can access the glacier retreat and advance correctly. None of these tests was dealing with such phenomena (in the only prognostic test, F, there is no front).
- p57, l29: the anti-correlation is only found for one test (D ?). This should be mentioned.

- Equation (1): the second invariant of the strain-rate tensor should be defined. Use for example $\dot{\epsilon}_e$ to distinguish it from the strain-rate.
- Equation (7): give the unity of x and T in the formula.
- p62, l10: is 10 to 45 m the depth below the surface or above the bed. What is the total ice thickness? This should be specified if one want to conclude about the value of the geothermal heat flux.
- Equation (14): which reference of Oerlemans?

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