Review of a manuscript "Similitude of ice-sheet dynamics against scaling of geometry and physical parameters " by J. Feldmann and A. Levermann.

The manuscript presents similarity solutions for the isothermal Shallow Shelf Approximation (SSA) equations. Though, to my knowledge, such solutions for the SSA have not been derived before, the manuscript has a number of conceptual inconsistencies and cannot be published in its present form.

Major concerns

The first major concern is an assumption that ice is isothermal and the independence of the ice softness parameter of other parameters, e.g. ice thickness or surface mass-balance. Thicker ice is usually softer than thinner ice, hence more deformable. Physically, $A^{-1/n}$ decreases with increasing ice thickness. The constant θ (eqn. 9) implies the opposite. Though, mathematically there is nothing wrong with this assumption, the derived similarity solutions are not suitable for glaciological applications. One possibility to resolve this inconsistency could be to consider temperature itself (or depth-averaged or depth-integrated temperature) instead of the ice softness parameter A. It still can be spatially uniform in the horizontal direction, but vary with an ice-stream of ice-shelf characteristic thickness.

The second major concern is the chosen dependence of the surface mass-balance ratio δ on the friction-coefficient ratio γ (eqn. 15). Physically, the surface mass-balance depends on a climate, and has no connection to ice-stream properties like basal friction. Though, there is a connection between the basal friction coefficient and the ice stiffness parameter (eqn. 16), it is very weak, as frictional heating affects ice temperature, hence its stiffness, only very small part of the ice column, close to its bottom.

There is no relevance of the similarity solutions derived in this study to the Shoof's (2007) boundary layer theory. The system of equations considered in both studies is the same, so it is not

surprising that the flux formulation is identical (in a non-dimensional form).

Throughout the text, the described ice flow is referred to as "ice-sheet" flow. This is misleading, because the SSA equations are valid only in ice-stream and ice-shelf settings, and are inapplicable to the rest of an ice sheet. Equally, the use of the Vialov profile (even as a motivation) is incorrect. This profile is derived based on the Shallow Ice Approximation (SIA).

The mass-conservation equation (4), for some reasons called in this studythe "ice thickness equation (ITE)", omits the basal mass-balance. This may be appropriate for ice streams, however, on ice shelves with strong basal melting neglecting this term is incorrect.

The abstract implies that the similarity analysis has never been applied in glaciology. This is not true; Halfar (19833) and Buler et al. (2005) describe similarity solutions for various configurations of the SIA.

Minor concerns

P. 3 Line 20 $\alpha, \beta < 1$ suggests that α and β can be negative.

P.3 Lines 41-51. Sentences starting with "In Eq. (9)..." do not make sense. A statement "$\psi \ll \theta$, holding for ice frozen to bedrock" is incorrect. The SSA is inapplicable in circumstances where ice is frozen to bedrock.

P. 3 eqn (14) and P.4 eqn (17), though mathematically are correct, physically not so. The ice softness and surface mass balance are unlikely scale identically. The basal friction is independent (to a leading order) of the surface mass-balance.

P.5 Lines 50-55. The numerical simulations are one-dimensional (a flow-line setup) and two-dimensional (channel-flow setup). The SSA are vertically integrated equations and do not have vertical dimension.

In many places references are missing (e.g. p.7 line 34).

In summary, the presented similarity analysis of the SSA equations has little to do with ice-stream and ice-shelf flow. The derived set of the dimensionless parameters is perfectly fine for an abstract

set of equations of the SSA form. However, shortcomings of the study described above most likely lead to erroneous conclusions of the similarity behaviour of the ice streams, ice shelves and grounding lines.

Rerences

Bueler, E., Lingle, C. S., Kallen-Brown, J. A., Covey, D. N., Bowman, L. N. (2005), Exact solutions and verification of numerical models for isothermal ice sheets, J. Glac., 51(173), 291-306, doi:10.3189/172756505781829449.

Halfar P. (1983), On the Dynamics of the Ice Sheets 2 J. Geophys. Res., 88(C10), 6043-60, doi:10.1029/2011JF002246.