OERLEMANS, J. 2011. *Minimal glacier models. Second edition*. Utrecht, Utrecht University. Igitur, Utrecht Publishing & Archiving Services. 90pp. ISBN 987-9-067-01022-1, paperback. Available free from j.oerlemans@uu.nl and as free download from http://igitur-archive.library.uu.ni.

In 2011, when computing time does not restrict the complexity and resolution of numerical models, the return to simple and minimal models is like the return from doing to thinking; to a kind of thinking, however, that is possible only on the basis of experience with the complexity of real nature. In this book Hans Oerlemans uses flat-bed circular ice sheets and rectangular glaciers of uniform bed slope in equilibrium state to show the essentials of the reaction of glaciers to climate and topography. He then admits time as a further variable, forces the equilibrium-line altitude (ELA), explains the ensuing changes in volume and length and demonstrates various kinds of response times, always comparing his models with real glaciers.

I suggest you read the epilogue first and then take time to carefully read the first chapter. This will give you the proper introduction to minimal models. I like to play with minimal hydro-meteorological models of glacierized basins myself and I have gained some basic understanding from them. With that experience I receive Oerlemans's *Minimal glacier models* very positively. I recommend that you go through the examples treated in the book: you will develop a better feeling for the essentials of glaciers and it will train you to abstract and reduce complex problems in a way similar to Harte (1988).

In engineering as in bookkeeping, all variables need to be known precisely. In geosciences hardly any variable is known better than to 1% of its natural range or variance. And if that natural variance is small compared with that of other terms involved, it may as well be neglected and the variable be taken as a constant. This is another rationale of minimal glacier models.

In the introduction the author says 'in the case of minimal models the integration is done over the entire glacier'. I would add that even models of intermediate complexity (e.g. central flowline models) still have many of the advantages displayed here for entire-glacier models. Oerlemans' minimal models use mean specific balance, volume, length, ELA, ice thickness and basal stress and are capable of reproducing feedback effects, i.e. they use time derivatives. The altitudinal balance gradient is either zero or linear or a combination of the two. Temperature is not a variable, i.e. the models refer to temperate glaciers. Oerlemans explains the physical meaning of the equations and the implications of each abstraction or simplification so that the reader can judge the consequences of the minimalization.

The introductory chapter gives the reader the necessary basis for the following seven applications. I will not go into details of their presentation but rather list the topics and some of the subtopics:

2. Equilibrium states.

2.1 The simplest glacier models. '[T]he real simple glacier has a uniform width, rests on a bed with a constant slope and has a constant balance gradient'.

2.2 More complex geometry.

2.3 Including feedback of length on ice thickness (nonlinear model).

2.4 Calving glaciers I (constant accumulation rate) and II (mass-balance field depending on altitude).

3. Time-dependent modelling including climate-change experiments and an application to Nordenskiöldbreen, Svalbard.

4. A short chapter on surging glaciers.

5. Varying bed slope. Including overdeepenings and the hysteresis connected to the nonlinear effect of the height–mass-balance feedback.

6. Calving glaciers with an application to Hansbreen, Svalbard.

7. Linear modelling. 'The models discussed so far were simple, but not linear. We looked at the response of glaciers to large-amplitude forcing. However, for smaller changes in climate it might well be that a linear (or linearised) approach is useful'. The chapter includes a first-order linear model of glacier length, backward modelling and estimating response times from length records.

8. A combination of previous models for varying width and a concave bed applied to McCall Glacier, Alaska, and Vadret da Morteratsch, Switzerland.

This is not a beginners' book. Although calculus, linear differential equations and numerical methods are required only at a moderate level, the value of this book will be appreciated fully by those who have been working with nonminimal models and who have experience in formulating the complex interactions of ice flow with mass balance and climate.

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