

Interactive comment on “GEOtop 2.0: simulating the combined energy and water balance at and below the land surface accounting for soil freezing, snow cover and terrain effects” by S. Endrizzi et al.

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The comments of the reviewers are in bold, the answers of the authors in italic.

In their manuscript “GEOtop 2.0: simulating the combined energy and water balance at and below the land surface accounting for soil freezing, snow cover and terrain effects”, the authors present the latest version of the model suite GEOtop. The main components of the model are described in a very detailed manner. These are the soil volume heat flux equation, the water flow components, proce-

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dures to calculate radiative and turbulent fluxes, as well as the impact of complex terrain and the treatment of a seasonal snow cover. After referring to some validation efforts in the supplement of the paper, a synthetic model experiment and according results are presented.

We thank the reviewer for his/her work and for the general appreciation of our manuscript modeling goals. In the following we provide a “point to point” sequence of answer to his/her comments. We tried to fulfill all of her/his requests where it was feasible.

General Comments

The manuscript is in general of high technical quality. It is very well written, organized, and presented. The content has a value for the scientific community, as a very interesting model with innovative approaches is described. Specifically, the calculation of the energy-balance coupled to the water fluxes is very promising. However, this directly leads to my main concern regarding this work. Large parts of the paper consist of model descriptions, whereas the validation section is practically non-existent (or only refers to supplementary material), and the result section showing the model experiment is kept very short and results are rather limited. The relation between pure model description (85 To overcome this imbalance and enhance the manuscript, I think it is necessary to intensely rework the results sections and possibly move some of the model descriptions to the appendix. More validation results including the respective figures should be presented in the manuscript. Actually, the most interesting validation results (which are quite impressive and good) are only shown in the supplement. Why not just extend section 6 (“Testing GEOtop”) and show these results in the manuscript?

We followed the reviewer suggestions and moved the complimentary material in the main text, and part of the technical description in section 5.6 to the appendix. We like to point out that we deliberately designed this manuscript to largely be a model

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description and, that we avoided the term “validation”. For such a complex simulator, the amount of possible testing is nearly infinite and one will never be able to claim full validity for any application. The testing presented here is intended only to satisfy a first-order curiosity whether this approach generates plausible, and indeed interesting results. The actual testing will (so we hope) be performed with each application study using this simulator.

It would also be very interesting to see some more (point?) validation of the very interesting model approaches, if the respective measurements are available. E.g. the dynamic discretization scheme for the snow pack is a promising concept and approach, but unfortunately, the reader gets no idea how well this performs regarding e.g. snow temperature profiles and respective heat and mass fluxes. The aggregated results shown in the supplement (SWE and snow height) are quite good, but how well is the stratification actually represented? There is no result shown in the paper that focuses on this part of the model, so the description should be moved to the appendix.

We agree with the curiosity (and possible doubt) reflected in this comment, and at the same time, cannot show all details in this manuscript, which is very long already. With this paper we want to show the model components, which are extensively described because they fit well with the journal purposes. The interest of the paper is mainly in the capability to describe processes and their interactions rather than comprehensively discuss their results.

The reworked results section could also focus on a topic (e.g. stratification of the snow pack, or permafrost depth, or water fluxes) and show some more specific results (either of the experiment, or – even better - using validation data). I really like such idealized model experiments, as they can give highly valuable insights in complex systems. However, I am not sure if the presented model has undergone enough real validation efforts to give representable results (specifically regarding the modules that are in the focus here: thawing and freezing,

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active layer depth, snow layering scheme, 3D Richards-equation).

Again, a “validation” is not the purpose of the paper. However, particular aspects of the model were already the subjects of other papers. For example, the algorithm for soil freezing and thawing was thoroughly described in Dall’Amico et al. (2011) and the effects of vegetation on snow melting was described in Endrizzi and Marsh (2010). Della Chiesa et al. (2014) recently proposed another type of testing.

The results in the supplement do only show the reproduction of soil temperatures and total snow amounts, but what about water fluxes in the saturated and unsaturated zones, groundwater table, routed runoff, etc.). In any case, as is, the validation and experiment sections definitely need some additional structuring in subsections (e.g. setup, input data, results, . . .).

Again, we agree that this would be very interesting, but for the present manuscript, this is impossible for us to accomplish (see comments above).

Specific Comments:

The following specific suggestions and comments are referenced in page and line numbers.

Where not specified we followed verbatim the suggestion given by the reviewer.

P. 6280, L. 1/2 Rephrase to avoid repetition of “represents”.

Done

P. 6283, L. 12 Please rephrase “. . . are here described.” C2682

We rephrased as follows: “The core components of GEOtop are here presented. The description will particularly consider the soil volumetric system and the equations to be solved, the interaction with the atmosphere, the effects of complex terrain, the numerics, the representation of the snow cover, and the distribution of the meteorological data. It is shown that the simulator produces plausible results in its major components.”

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P. 6302, L. 19 Remove the brackets.

In our opinion the expressions in brackets should be retained, as they report the technical definition for the processes described.

P. 6309, L. 6-9 The sentence “We also discuss...” is partially incomplete/corrupted.

It was corrected in the text.

P. 6312, L. 1/2 Which data were used for the spin-up? Please explain!

We used the same meteorological data used in the simulations, repeated for 100 years.

P. 6312, L. 25 Rephrase “. . . and results significantly colder . . .”

Changed to “and in the simulation results are significantly colder”

Fig. 4 Why are the slopes presented opposed to Fig. 2? Please turn around one of the figures and consider adding a north arrow!

This was a mistake. Fig. 2 was redrawn and a north arrow added.

Fig. 4 and Sect. 7 What is the horizontal resolution within the synthetic experiment? Please add explanation in the manuscript. I understand that this is not that vital here, because of the artificial setup, nevertheless it is interesting, as “real” elevations and station data are used.

Resolution is 20 m. This was already indicated in Fig. 2, but it was added also in the text.

Interactive comment on Geosci. Model Dev. Discuss., 6, 6279, 2013.