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The Cryosphere Discussions

Interactive comment on "The Potsdam Parallel Ice Sheet Model (PISM-PIK) – Part 1: Model description" *by* R. Winkelmann et al.

Anonymous Referee #1

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Winkelmann and coauthors describe the three-dimensional thermomechanical ice sheet model PISM-PIK, which can be applied for simulating large-scale marine ice sheets. The model is largely based on an existing ice sheet model (PISM) with some further development specific for simulating marine ice sheets. The paper is generally well written and structured. In its present form though, it lacks substance and detail, since most of the novel aspects of the model are described in other (unpublished) documents. It is furthermore questionable whether the described model development represents an improvement over the state of the art of existing large-scale marine ice sheet models. In particular, the document lacks a discussion of how the model deals with grounding line migration, one of the key issues for simulating marine ice sheet evolution. Therefore, I suggest major revisions to be made.

General comments:

For a model description paper, I would expect all relevant aspects of the model to be described in detail, including the subgrid parametrisation (2.4) and the calving law (2.6). These parts are in the present form rough summaries of presently unpublished material. Even if these additional documents were published, the reader is asked to consult three additional publications to get a full model description, which I find unacceptable. I suggest to substantially expand sections 2.4 and 2.6 comparable to the review of relevant formulas in 2.1.

As opposed to conclusion 1291, l24-25 no details about the grounding line problem can be found in the manuscript. Attempts have been made in the past to improve the representation of grounding line migration in large-scale ice sheet models e.g. by including the Schoof boundary condition (Pollard and Deconto, Nature 2009). Although the authors seem to be aware of this work, it remains unclear how this issue is treated in the presented model. It should be clearly discussed which mechanisms control the grounding line movement in the model. The validation experiment (MISMIP) does not take into account lateral shearing and buttressing and is thus not a complete test case for grounding line migration. Further (idealized) experiments are needed to show the transient response of the grounding line relevant for simulating the evolution of whole marine ice sheets as motivated in the introduction.

I would suggest to reorder the document in order to separate review and changes of the original PISM model (2.1, 2.2, 2.5) from aspects specific for shelf configuration and marine ice sheet simulation (2.3, 2.4, 2.6).

It should be made clear in 2.2 why a different approach is used compared to the original PISM. Is the new approach considered better and why?

Detailed comments:

Abstract

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1278, l19-20: I suggest to remove "and is used for a dynamic equilibrium simulation ..." from the abtsract. This sentence is misleading, since it is not the second part of this paper, but rather another paper where this simulation is described.

1 Introduction

1278, l25 - 1279, l7: The given comparison between flow-line models, full-Stokes and higher-order models is misleading, since also flow-line problems can be solved with a higher-order approach.

1279, l14-15: SIA-based models also provide good approximations for regions with sliding, which seems to be excluded here.

1279, l19: The use of the SSA arises from another stress regime (without basal friction, as has been written) and has initially nothing to do with the velocity of the flow.

1280, l2: sheet in singular "regimes and speeds throughout sheet, streams ..."

1281, l2: It is not clear what "mode" refers to here

2.1 Field equations and shallow approximations

1281, l25: Remove "in each time step", or clarify

1282, l4-6: Reformulate - heat is advected, not temperature - the velocity field does not advect

1282, l9: add "heat" in "... and the geothermal heat flux ..."

1282, l13: replace "from" by "following"

1282, l19: remove flow in "... for a viscous fluid ..."

1283, l5: Reformulate - what is meant by "influenced by distant ice"

1283, l13: Remove "re-" in "... can be expressed in terms ..."

1283, l17: Replace "together" by "combined"

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1283, l20ff: Reformulate - shearing cannot dominate over stresses

1284, l6: Reformulate - what are dragging ice shelves?

1284, l10: Replace "the" by "that" in "... assumes that till ..." Reformulate - stresses cannot reach a stress

2.2 Velocity combination and sliding

1284, l16-17: This sentence needs a citation

1284, l19: Replace by "... were to depend on the local driving stress ..."

1285, l5: Reformulate - "SSA-as-a-sliding-law" is slang

1285, l6: The equation order should be reversed to be in line with the description v_b = v_SSA

1285, l10: I wonder if "superpose" is a good expression here. Maybe "add" would be more appropriate. Appears also in other places in the text.

1285, l9-14: Schoof and Hindmarsch (2010) are referred to show good transition between sheet and shelf, but in this context the discussion is about transition between frozen and sliding grounded ice. Could the authors clarify?

1285, l16-22: Reformulate, compare same section in Martin et al. as an example - what is a column contribution?

1285, l23ff: Please clarify. Is SIA contribution taken into account or not? l23 says so, but l25-26 denies it.

2.3 Calving front stress boundary condition

1286, l9: Remove "itself" in "... in PISM there is no ..."

1286, l11: Reformulate - what is meant with "choice of its strength"

1287, l16ff: Reformulate This whole paragraph remains unclear for me. What are

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"simulated icebergs"?

2.4 Continuous ice shelf advance and retreat through subgrid parametrization

1288, l13-15: Reformulate - mass cannot account for a calving rate

1288, l16: Reformulate - calving cannot advance into cells

2.5 Discretization scheme for mass transport

1288, l27: What is multiplied by what here?

1289, l11: Halfar solution needs a reference

1289, l14: Better compared to what?

3 MISMIP intercomparison

1290, l9: "MISMIP intercomparison" is not a good section title, since no intercomparison is presented here. I suggest "Validation experiments"

1290, l14-16: It is not clear why and in what aspect these two solutions differ. Does the representation of the grounding line change with the new boundary condition? Why is that the case? Should be analysed and discussed in detail.

1291, l10: The resolution is not indicated on the figure. Would be nice to be able to compare.

1291, l24: As stated above, "grounding line dynamics" should be further explored and needs a thorough discussion.

1292, l13: This is a validation rather than an application.

1292, l17: It is not the second part of this paper, but rather another paper

1300, Fig. 1 caption: It should be mentioned what the red arrows stand for

1302, Fig. 2 caption: I would add "arrows" in "(grey arrows)", "(black arrows)" since

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there is a lot of other black and grey in the figure

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