The Cryosphere

Open Access

Discussions

EGU

Interactive comment on "21st century ocean forcing of the Greenland Ice Sheet for modeling of sea level contribution" *by* Donald A. Slater et al.

Surui Xie (Referee)

suruixie@mail.usf.edu

Received and published: 23 October 2019

Summary: To project Greenland Ice Sheet mass loss due to runoff and ocean property changes in different greenhouse gas emission scenarios, the authors present a modeling effort to apply ocean forcing on a continental scale. Two implementation approaches are presented, including "retreat" and "submarine melt". Both implementations require a parameterization for submarine melting, and the authors consider local ocean velocity and ocean thermal forcing as two primary parameters for submarine melting. The former is implemented through subglacial runoff, and the latter is by ocean temperature. In the retreat implementation, glacier terminus positions are determined by estimated submarine melt rates. It is accessible to all ISMIP6 ice sheet models, but ice dynamics such as glacier advance due to motion or retreat due to calving were not

considered. While the second implementation (submarine melt) takes into account of more factors affecting retreat projections, it is computationally expensive, and some of the considered factors are not currently well understood.

I think this paper is well motivated and well written. It provides a valuable framework for future modeling work of ocean forcing on Greenland Ice Sheet. I only have several fairly minor comments, listed below:

1) Atmospheric-driven runoff and ocean thermal forcing are two primary inputs for the models. While available data or models are limited, some of the assumptions made in this study need to be justified. In section 2.2.3, the runoff bias correction may be necessary to provide a continuous transition from present to future atmospheric forcing, but it may also result in spatial discontinuities, especially when applying a uniform temperature or salinity offset for the entire sector. Figure 2c shows a relatively small bias at Helheim – maybe this is a well monitored glacier so the models perform better? Many other glaciers have much larger values of runoff bias (please see your Figure S1). Could the sector-uniform offset and various bias be major contributors to the difference between different sectors in the projections? This question also applies to the ocean property correction.

2) Ocean temperature is a critical model input in this paper, and is detailed in section 2.3.3. I am curious about the temperature model selection. In Figure 3c, it seems to me that the MIROC5 model produces a quite different temperature profile than the observational EN4 data. Is it rational to use the EN4 data, by simply correcting the bias with a constant offset adding to the entire depth profile? I see that a depth-varying bias correction may lead to unphysical profiles, but is there a reason to choose the mean difference between the specified 200-500 m depth range? According to the authors, this range is perhaps "most relevant to tidewater glacier grounding lines in Greenland". But I feel a slightly different depth range (e.g., 100-400 m) can produce a significantly different offset – especially near the surface. Some discussion on the sensitivity of model to different temperature bias correction may be helpful.

3) For the two implementations, could the retreat history before 2014 be calculated? If this is possible and won't add too much extra work, figures illustrating the historic retreats before 2014 (and maybe comparison with available observations) would improve the integrity of modeling results. Such plots could be added to Figures 4 and 9 as positive retreats.

4) Page 17, line 18: Add "in" after "variability"?

5) Figure 5b: Maybe mark the ∼350 m depth point on the dashed red profile? This may help readers understand the effective depth. I had difficulties in understanding the "deepest point" at the beginning – I thought it was rather a shallow (if not shallowest) point at a distance of ∼33 km by looking at Figure 5, then I realized that this is a point along the depth of a certain location.

6) Figure 11: Maybe add a vertical line in each panel to mark the largest glacier in the corresponding sector?

Sincerely

Interactive comment on The Cryosphere Discuss., https://doi.org/10.5194/tc-2019-222, 2019.