The Cryosphere Discuss.,
https://doi.org/10.5194/tc-2020-232-RC2, 2020

The Cryosphere Discussions
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Interactive comment on "Review Article: Earth's ice imbalance" *by* Thomas Slater et al.

Anonymous Referee #2

Received and published: 27 October 2020

This manuscript (MS) gives a nice review of the ice imbalance on the Earth and a direct measure of global climate change, when it in the last part of the MS relates to the energy needed to melt the ice. The MS is generally well written and gives an overview of the methodology used in assessing each of the components. However, the level of references is kept to a minimum and mostly citing work directly related to numbers derived in this MS. Relying only on a limited number of studies makes the error propagation hard to assess. The title of the paper may also lead the reader to think it is a review of earth ice balance estimates, I would suggest the title to be more specific such as "Budget of the Earth meteoric ice masses". In the view of a budget-study, I only have minor comments to the manuscript.

L.16: Suggest removing "from"

L.19: It is not clear from the title nor abstract that you only consider meteoric ice. I

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suggest adding “not accounting for changes in permafrost, . . .”. The melting permafrost will also require energy from the “energy imbalance.”, and therefore adding to the error estimate of the derived numbers in the MS.

L24: suggesting rephrasing: Meteoric ice is stored in the Earth’s cryosphere land components; Ice sheets, Ice caps and glaciers, and its ocean components; ice shelves and sea ice (fig 1).

L.29: subglacial melt and evaporation are missing.

L31: as the manuscript is relevant for a broader audience, please use a few more words on the Weertman reference.

L32: are there 343 ice shelves or more than 340?

L35 remove “on”

L42: Missing a couple of lines about the change in Earth albedo with the loss of sea ice.

L50: The smaller components will add to the imbalance, please give numbers on the approximate magnitude of these components.

L53: “6”-> “six”

L60: The accumulation area is limited, but assuming fixed ice-density in the volume to mass conversion of the glaciers is an overestimate, this should be included in the uncertainty.

L64: please list the observational sources which are the only estimate available.

L67: How is the uncertainty propagated in time? This is a more general question as it is general hard to grasp from the MS how uncertainty is propagated, both for the individual estimates and the total imbalance. Please add information in the relevant sections of the manuscript.

Fig2: please change the colors so the studies can be separated.

L72: What is a close agreement? Please report the magnitude of 1 standard deviation, it is not readable from the figure. Maybe add a table (maybe in supp.).

L77: -10,130pm1713 Gt -> -10,130pm1,713 or -10130pm1713. This is a general comment and should follow the same convention throughout the MS. You also give Tt in some cases please consider the number of significant digits.

L96: Much of the uncertainty in the ice thickness is in the areas where it is modeled. “measured”-> “estimated”.

L117: this statement with the reference to fig 3 is hard to follow as figure 3 only shows the peninsula. Please be specific as to which ice shelves are included in the study.

Fig 3 the color bar for time is not readable.

L120: Again, how is figure 3 informing on calving? Please add information in the caption to help the reader to better understand the figure.

L127: A polynomial-fit to elevation data is not trivial, which parameters are included in this, please elaborate on this equation and give references.

L130: the altimetry is adjusted for firn air, guess this is from RACMO, but not mentioned in the text. Additional information about the firn would be of high relevance.

L150: The reference guidelines https://www.the-cryosphere.net/submission.html#references states “Informal or so-called ‘grey’ literature may only be referred to if there is no alternative from the formal literature”. Please give an argument for not having other references and therefore need to use “personal comm”. This appears multiple places in the MS. Then I will leave it with the editor to see if this is justified.

The sea ice section more generally: For the density of sea-ice “glacier-ice” density is chosen for PIOMAS and GIOMAS, which is normally associated with first-year ice. Timco and Frederking (1996) report “in situ density of first-year sea ice range from

0.84 to 0.91 Mg m−3 for the ice above the waterline, and 0.90 to 0.94 Mg m−3 for the ice below the waterline." Please comment on the volume conversion and the effects on the uncertainty conversion. The neglect of multi-year ice densities in the model estimates (multi-year is included in Tilling's CS2 estimate) seems to overestimate the mass derived from the models. This should at least be included in the uncertainty.

L165: how is this uncertainty derived?

L186: The text states 1.2pm0.3 and the table states 1.2pm0.9, which is the right number?

Table1: As the periods are not the same it would be informative if the numbers could be given both as rates and totals in this table.

L220: Is the temperature of -20 used for all ice bodies? E.g. -20 seem cold for sea-ice with snow on top and water below.

L222: What is the uncertainty on this number? Figure 4 please add the cumulative uncertainty.

Reference: Timco and Frederking, A review of sea ice density Cold Reg. Sci. Technol., 24 (1996)

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