Review of Mankoff et al. (2021)

<u>General comments:</u>

This study describes a new operational mass balance product of the Greenland Ice Sheet produced using the input-output method. The different external products used in this study, and the methods for the derivation of this new mass balance estimate are sound and well described. This new mass balance estimate is also compared against independent estimates of mass balance, showing overall good agreement.

I have a few general comments that should not be hard to address:
- In Section 4, I recommend adding a table to summarise the different data products used to generate the final mass balance estimate with the different periods they cover and what field(s) they provide
- I think that the consistency of the description of the three RCMs in Section 4.3. can be improved by matching the level of details between the different SMB models/products described (for instance what ice mask is used in each RCM)
- I'm not convinced about the difference in MB* between the various IO estimates (Mouginot/This Study and Colgan/This Study) being attributed to differences in SMB as described in the text in sections 6.1 and 6.2. From the figures and the SMB/MMB comparisons, it seems that the differences between the various IO estimates arise from differences in MMB rather than SMB.

Overall, this is a great effort to generate the first operational product of Greenland mass balance by making use of already existing methods and data products, which I think will be of interest to anyone interested in the state of the Greenland Ice Sheet. Therefore, I'm happy to recommend this paper to be published after minor revisions.

I made some specific comments and suggestions below, which I hope will help improve this paper.

<u>Specific comments:</u>

L1: 'Greenland Ice Sheet <u>(GIS)</u>'

L5-6: please rephrase this sentence to distinguish the products (from which mass loss is estimated) and the processes (from which the mass loss originates)

L10: 'general agreement <u>with</u> ~~among~~ six other products'

L19: 'process<u>es</u>'

L18-21: add typical spatial resolution of the GMB and VC estimates and the typical temporal resolution of VC estimates to quantify what is lower/higher

L25-26: can you be a bit more specific here: state how frequent ice velocity updates are and the reason for this new capability (for instance new satellite missions (e.g. Sentinel) allowing better temporal sampling of ice velocity time-series)

L25: I would also add that IO is limited by the scarcity of thickness data in some areas

L31-32: be more specific here and state the positive and negative SMB fields

L35: define 'marine mass balance' here

L35: I'm not sure 'forecasted' is the right word here, as rather than being forecasted the MMB is updated assuming steady-state conditions since the last velocity update

L61: what 'properties'?

L61-62: 'These ~~This~~ Greenland sum data'

L67: Not sure what you mean by 'includes the restricted data to 1840' maybe rephrase with something along the lines 'The ice-sheet-wide product includes data from 1840 through next week while the sector and region-scale products includes data from 1986 through next week.'

L70: '<u>are</u> external to this work'.

L75: By curiosity, why do you use runoff from MAR only? I assume that runoff is also modelled by HIRHAM and RACMO and that the same approach used for the SMB models (i.e. combining the models when they overlap and using MAR runoff from yesterday through next week) could be applied for runoff?

L97: specify the min/max of the layer thicknesses

L106-107: can you add a few words to specify the benefits of including these observations? Does the model perform better?

L113: specify the min/max thickness of the firn layers in MAR

L110-123: It's fine to refer the reader to Fettweis et al. (2020) but it would be good to expand this paragraph a bit more, and ensure that the same level of details is provided in each RCM description

L114: add citation for the NCEP-NCARv1 reanalysis

L116: 'GridMARv3.10', is it different from MARv3.10?

L116: no need to mention the inclusion of a new module if it is not used here

L121: please provide more background on the recent SMB decrease and the validation with GRACE. This is important as both the SMB and runoff fields are used in this study

L122: 'increase ~~of~~ <u>in</u> runoff'

L129-130: is runoff also forecasted? Also add that you use <u>SMB</u>, forecasted SMB and runoff

L165: replace 'add [..] a later end date' by 'extend the reconstruction in time up to the end of 2012'

L182-183: 'is ~~now~~ updat~~ing~~ed'

L186: which surface elevation change product do you use?

L211-212: what proportion of the Greenland Ice Sheet bed area is frozen, uncertain or thawed? Can you add the % bed area covered in the text?

L212: ', ~~(respectively)~~'

L215: ~~on~~ at the ice-sheet scale~~s~~

L226: 'these products are the most ~~similar and~~ recent'

L261: ~~BMB~~ BMB$_{VHD}$

L272: missing word 'We compute *h* and [?] from that streams and outlets'

L307-308: can you say how much smaller are the Zwally sectors and Mouginot regions compared to the RCM ice domains and what proportion of the SMB losses is not considered if the RCM domain is cropped to the Zwally/Mouginot delineations?

Table 1: For IMBIE2, BMB is included in both GMB and VC

Table 1: The numbers in the table and in the related figures are slightly different, especially for the bias values (for instance for Mouignot the bias is -4 Gt/yr based on Table 1 and -2 Gt/yr based on Figure 5).

L339: Isn't the MB* difference between This Study and Mouginot dominated by the MMB term rather than the SMB term, with the SMB disagreement adding only a small amount of noise? (You showed before a 23 Gt yr^{-1} bias in MMB and a very good agreement in terms of SMB between This study and Mouginot)

L363-365: Here as well, it seems that the difference in MB* between This Study and Colgan is dominated by differences in MMB, rather than differences in SMB? Or do you speak in terms of short-term temporal variability when you're referring to 'the variation in Colgan et al (2019) MB*'? Either way, this needs to be clarified.

L368: 'peripheral glaciers <u>and ice caps</u>'

L379: <u>ice sheet boundar<u>ies</u>

L391-393: Could the disagreement between This Study and the VC estimates in 1992 and 2019 come from the fact that these two years are the end members of the time-series (perhaps edge effects could be the origin of the disagreement), rather than being driven by changes in the radar scattering horizon? 2012 was also an extreme melt year with the scattering horizon of the radar being shifted upwards closer to the ice sheet surface; however there is a good agreement between This Study and the VC estimates in this particular year (Figure 7b).

L409: '<u>assess</u><s>es</s>'

L449: '<u>and these grid cells are ignored.</u> <s>It is ignored.</s>'

Figure 5 and Figure B1: on Figure 5 there is a very good agreement in SMB between This Study and Mouginot (r^2 0.97 and bias -1) but Figure B1 suggests otherwise. It seems from Figure B1 that the agreement in SMB is much lower across all the regions of the Greenland Ice Sheet with r^2 <0.40 for all regions?

Figures B1 and C1:

- Is the BMB term included in the MMB and MB* terms here? Specify this in the caption.
- Maybe use a different yrange for the y-axis for the different regions/sectors as it is difficult to read the figures in some cases (for instance NO, NE or SW MMB)