Summary and general comments

A high-resolution product of liquid discharge from the Greenland Ice Sheet (GrIS) and the unglaciated area of Greenland is derived for the period 1979 – 2017 and provided with various static hydrological quantities (e.g. basins and outlet locations). Gridded runoff is taken from two regional climate models (RCMs) simulations (MAR and RACMO), whose output is statistically downscaled to a horizontal resolution of 1 km. Hydrological characteristics (e.g. basin delineation) are computed from surface elevation according to ArcticDEM. BedMachine surface and bed elevation data is additionally considered to assess the sensitivity of the routing network to uncertainties in surface topography and to consider subglacial ice sheet drainage.

This study addresses a very relevant topic, namely the quantification of liquid discharge from Greenland in the current climate and specifically the locations where this freshwater will enter the ocean. It closes the link between RCM simulations, which provide gridded runoff at increasingly higher horizontal resolution and the need for (high-resolution) liquid discharge locations, which are not directly provided from RCM simulations. The manuscript is well written but the structure needs some improvements in my opinion. Additionally, certain topics (particularly methods) are not explained with enough details.

Major comments

1) Improve structure of manuscript
In my opinion, the manuscript lacks a clear structure, as e.g. introduction of data and applied methods are not restricted to the data and methods sections but also appear e.g. in section 6. Furthermore, the partitioning of subtopics in results and discussion (sections 5 and 6) does not seem logical to me. I would suggest the following structure:

1. *Introduction*
2. *Input and validation data*
   2.1. *Downscaled gridded RCM data (part of current section 2)*
   2.2. *Time-invariant data (DEMs, ice/ocean masks) (part of current section 2)*
   2.3. *River discharge observations (part of current section 6.2)*
3. *Methods*
   3.1. *Masks and grid cell alignment (current section 3.1)*
   3.2. *Derivation of hydrological quantities (e.g. basins, outlet locations, etc.) (see next major comments for more details about the content of this section) (current section 3 and part of current section 6.3.1)*
4. *Product evaluation and assessment*
   4.1. *Main characteristics (current section 5)*
   4.2. *Comparison with previous similar work (current section 6.1)*
   4.3. *Validation/Comparison of product with observational river discharge (current section 6.2)*
   4.4. *Product uncertainties (current section 6.3)*
   4.5. *Remaining sources of freshwater input in fjords (current section 6.4)*
5. *Technical product description and data/code availability*
   5.1. *Product description (current section 4)*
   5.2. *Data and code availability (current section 7)*
6. *Conclusions*

2) Missing parts in method section
The method section should be extended – particularly the part about the derivation of the hydraulic characteristics. Specifically, I miss information about:
- How were (artificial) depressions in the DEM handled? With a filling algorithm?
- I'm confused about the applied flow direction algorithm. Was a single flow direction (SFD) or a multiple flow direction (MFD) algorithm used? And how were the basins delineated if a MFD algorithm was used (which has a dispersive character)?

Moreover, the method used for assessing the basin uncertainty (section 6.3.1) should be moved to this section. It should include a more detailed discussion of the equation used to compute the hydraulic head and how this equation is applied to derive the sensitivity experiments in the appendix (with various subglacial pressure).

3) Sensitivity of basins delineation to uncertainties in surface elevation and partitioning of surface/subsurface runoff

The evaluation of the Kangerlussuaq / Watson river catchment with river discharge data reveals that the accurate basin delineation is crucial. The sensitivity experiments with a different DEM for the surface and the consideration of subglacial drainage are thus extremely interesting and useful. I wonder if the uncertainty in the basin delineation, which is illustrated in the appendix, could be translated to runoff uncertainties (and be included in the runoff output product). One could for instance compute discharge at all (coastal) outlets for all sensitivity experiments and check the range in obtained runoff. This work would reveal catchments for which runoff quantifications are more (un-)certain. It's probably not necessary to include these runoff uncertainty values in the current product but it would be nice upgrade.

Minor comments

Content-related (text)

Page 1 line 10: "contributes an additional ~35% to the ice runoff " → confusingly stated (because the ~35% are referring to the total runoff I guess) → rephrase

P2L26-28: I don't understand to what "satellite basemap imagery" is referring to. To the ocean mask?

P2L29: Mention somewhere here that RACMO only provides runoff for the glaciate area of Greenland

P3L5-7: The runoff downscaling should be explained in more detail (or a reference for the procedure should be provided)

P3L8: Is it justified to assume that the firn layers in both simulations (MAR and RACMO) are in approximate equilibrium in 1979 (i.e. was there a spin-up performed or when did the simulations start?)

P3L14-17: How are (artificial) inland depression treated that would lead to erroneous inland outlets. Are such depressions apparent in the DEM? And if so, how are they removed?

P3L15: I'm confused by the part "multi-flow direction from eight neighbors". Does it imply that a multi-flow direction algorithm with dispersion was used? Or a D8 algorithm (because this algorithm also allows flow **from** (maximal) eight neighbors).

P3L26-27: I'm not sure if I understand this sentence correctly: so land pixels surrounded by ice are set to ice (but their elevation is left unchanged)?

P4L18-20: I don't understand this part: Is the downscaled gridded runoff data provided on an EPSG:3413 map projection (because I guess the direct output from the RCMs is on a rotated lon/lat-grid)? And the EPSG:3413 projection is based on WGS 84 (and thus an ellipsoid). But some data is provided in a coordinate system based on a sphere (earth spheroid)?

P4L22-23: It should be stated in this section that land quantities (e.g. basin polygons and runoff) also include the same quantity from the glaciated part (I assume). So I guess runoff from land contains both runoff from the unglaciated and the glaciated part?

P5L8-10: Why are the more larger land basins than ice basins? Do the land basins incorporate the ice basins?

P5L20-22: It should be more clearly stated in this sentence that the 4380 m^3 refers to runoff from a single basin.

P5L24: I assume the ±30 km^3 represent the RCM runoff uncertainty of 15% (this should be clearly stated here). And shouldn't it rather be ±60 km^3? And how is this value of 15% derived (is there a reference)? I think it would be useful to mention this uncertainty value already in section 2 (input data).

P6L8-11: This sentence does not belong here but rather in section 6.3.1. Furthermore, I find the sentence a bit hard to understand (particularly the last part) – could it be rephrased? It states that flow-path derived from the ArcticDEM generally agree better with satellite images than flow-path derived from BedMachine data, right?

P6L17: Could you explain the reason why the increase in spatio-temporal resolution increases the signal-to-noise ratio in more detail? And I would include a reference to section 6.3.4 here (so that the reader knows where this strategy is discussed in the manuscript).

P6L18-26: I would move this part to the data section (2).

P7L33-34: "MAR runoff slightly overestimates the GEM observations early in the year, and slightly underestimates the observation late in the year" → this is an interesting finding and probably related to storage of water in the (un-)glaciated area of the basin on intraannual time scales

P8L3-4: This step-like change in MAR runoff is rather strange. Are you certain that this is not an artefact (e.g. caused by an issue in MAR, the statistical downscaling procedure of runoff or the alignment of the 1 km and the 100 m masks)?

P8L12-13: It seems a bit arbitrary to exclude the 27th and 28th July.

P8L27: "slight lag between models signals and the observations." → could this time lag be related to the neglect of routing travel time?

P8L28-29: What is the reason for the significantly higher temporal variability in RACMO? Could this be linked to the different treatment of liquid water retention on bare ice between the RCMs?

P9L1-5: Why was the existing proxy data not used for further model validation (if it exists)?

P9L12: There is no equation 1

P9L15: "because large volumes of runoff usually come from large areas." → I do not understand this part of the sentence, could it be rephrased?

P10L4-5: What is meant by "hydraulic jumps"? I guess not the physical phenomena in hydraulics. If not, this term should be replaced to avoid ambiguity.

P10L11: This equation (and the corresponding text) should be moved to the method section.

P10L17-19: I find the transition between the previous and this part a bit strange. The part before explains how routing and basin delineation is derived when bed elevation is considered (this part should anyway be explained in the methods section in my opinion) but this section compares basin delineation based on two different **surface** topographies.

P10L30: Can you provide a reference for this value of 15%? Also, this value should already be mentioned in the data description (section 2).

P11L4-5: Replace "highlighted above" with reference to relevant section. Additionally, are you certain that the step-like changes in RCM runoff originates from the actual RCM simulation (and is not generated by the subsequent postprocessing steps (e.g. downscaling or grid cell alignment).

P11L15: "current limitation" → future RCM simulation will still only capture features and process of certain spatial scales. But do you think that the most crucial scale will be represented in these simulations with higher resolution?

P12L4-5: Can you provide a reference that supports this (net storage is approximately zero) assumption?

P12L21-23: This sentence should be rephrased or removed. Making a prediction about fjord precipitation from the Greenland-wide fraction of land runoff is not reasonable in my opinion.

P13L6-7: "perhaps due to temporal directionality" → I don't understand this part

P13L7: Is "version of the dataset" meant here?

P13L20: Again, are the stated uncertainty values correct?

Typos, phrasing and stylistic comments

Page 1 line 10: Change "over the time series" to "over time"

P2L4-5: I don't understand the meaning of this sentence ("Immediately upstream from…") – isn't it obvious that no submarine melting occurs upstream of the grounding line?

P3L12-13: "Each outlet has one upstream basin and each basin has one outlet" → I don't understand the meaning of this sentence, isn't this fact obvious?

P3L22: Change "100 m^2 pixel" to "10,000 m^2 pixel"

P4L12-13: "In the case of a small basin," → this sentence is a bit oddly stated – could it be rephrased?

P4L30-31: I would remove "four per year" (and optionally change "provided as annual NetCDF files" to "provided as four annual NetCDF files").

P5L6-7: "Runoff ice products…" → oddly stated sentence → rephrase

P5L21: "2012-08-06" → write date out

P5L27: "contributes an additional 35% to the ice runoff" → again, I find this a bit confusingly stated (I guess the 35% refer to total liquid runoff?). Maybe better: "contributes 35% to total runoff"

P6L5: Maybe change "and additional data products." to "and is provided with additional data."

P6L23: change "results to all observations that we have been able to find that are publicly accessible" to "results to all publicly accessible observations we could find"

P7L1: change "with high melt or runoff; Basin" to "with high runoff (and associated melt): Basin"

P7L7: change "include ice to the south of itself" to "include a glaciated area to the south"

P7L23: "and a without an ice basin does have RCM ice cells" → odd formulation → rephrase (e.g. change "without an ice basin" to "unglaciated"

P8L11-12: Rephrase sentence, e.g. to "The MAR relative runoff bias ranges from -20% (last day of time series) to +140% (28 July)."

P8L25: change "models than the observations" to "models than in the observations"

P8L7: change "discussed below" to "still discussed in Sect. 6.3.2."

P8L8: change "source uncertainty – the routing model, which exhibits in two different ways: Spatial (basin delineation) and temporal (runoff delay)" to "source of uncertainty – the routing model, which generates both spatial (basin delineation) and temporal (runoff delay) uncertainty"

P9L10-11: Rephrase to e.g.: "Temporal uncertainty is not systematically addressed in this work but a method to reduce it is discussed in Sect. 6.3.4."

P10L19-20: Change sentence to e.g. "Results from additional sensitivity experiments (with different input data and hydraulic head computations) are shown in the Appendix."

P10L29: rephrase "they do not precisely nor accurately capture reality" to e.g. "they represent reality discretised and simplified."

P12L11: change "That ice downstream" to "The downstream ice"

P12L26: Change "are approximately steady state" to "are approximately in steady state"

P12L30: Replace "GIS-wide ice sheet surface runoff" with "Greenland-wide ice sheet surface runoff". Otherwise, "GIS" is used both for "Greenland Ice Sheet" and "Geographical Information System"

P13L2: Replace "This work in its entirety is available" with "Output data of this work and part of the discharge observations are available"

P13L8-9: This sentence is a bit oddly stated. Could you rephrase it?

P13L12-15: This sentence is rather complicated to read and understand. Could you rephrase it?

P13L15: change "differences in needed" to "differences are needed"

P13L21: change "displaying and overall increase in both magnitude and variability" to "an overall increase in both its magnitude and variability"

P13L22: change "scale" to "scales"

Figures and Tables
Figure 1: Change caption to: "Overview showing ice basins (blue), land basins (green) and locations of following map figures (black)."
Figure 2: Change "Sec." to "Sect." in caption (also other occurrences)
Figure 3: What is meant with "(this)" in the caption?
Figure 4: Maybe the error bars should be removed from this figure to improve readability. Additionally, "(this product based on ArcticDEM basins in Fig. 5)" should be rephrased.
Figure 5: It's difficult to distinguish between different basins in this plot. Maybe readability could be improved by only plotting the basin's boundaries (without hatching). Could you also plot the Lindbäck et al. (2015) basin and the one you used to produce the right panel of figure 4?
Figure 6: A reference to this figure only appears in section 6.3.1, so its number and position should be changed accordingly. The legend is hard to read (it could be moved outside of the map area). Additionally, I would remove the sentence: "Region is zoomed in near Sermeq Kujalleq (Jakobshavn Isbræ)."
Figure 7: Change "Fig. 10" to "Fig. 10 and 11" and "visible is basin artefact" to "visible is a basin artefact". Is the "RCM ice" mask showing the mask from RACMO or from MAR (also in the following figures)?
Figure 8: Use "Fig." or "figure" consistently.
Figure 10: Change "Only 2017 shown" to "Only 2017 is shown"
Figure 11: Again, I would remove error bars to increase readability.
Figure 13: Change "Uncertainty only shown for total MAR runoff, not ice or land components." to "Uncertainties are only shown for MAR total runoff and not the individual land/ice components."
Figure 15: This plot is very hard to read. Again, I would remove the error bars. It also difficult to distinguish MAR from RACMO. Additionally, "MAR" should be removed from the y-axis labelling.

Supplementary material
Figure B1: Remove "not zoomed in". Additionally, I would always provide all necessary information in the figure caption about the comparison (experiment setting, margin/coastal outlet). References to other figures implies constant switching between figures. This also applies for the following figures.

Review of provided dataset

The presented dataset provides, to my knowledge, a unique and new source for high-resolution discharge data for the GrIS and the unglaciated part of Greenland for the present-day climate (1979 – 2017). The dataset seems very useful for downstream application in various field like e.g. hydrology, ecology and oceanography (particularly for fjord systems). The dataset can be accessed via the provided link, is complete and sufficiently supported with metadata and seems to be of good quality.

However, the description of certain processing steps is insufficient in my opinion and should be improved in the manuscript (see point 2 under "Major comments").

Minor issues
- I was not able to found units for the Qaanaaq discharge dataset (https://promice.org/PromiceDataPortal/api/download/0f9dc69b-2e3c-43a2-a928-36fbb88d7433/version_01/meltwater_discharge/qaanaaq)
- When checking the static data (basin polygons, outlet locations and streams), I found some inland outlet locations near Kangerlussuaq. What is the reason for this?