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Supplement of

A high-resolution pan-Arctic meltwater discharge dataset from 1950 to 2021

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Contents

- Figure S1
- Figure S2
- Figure S3
- Figure S4
- Figure S5
- Figure S6

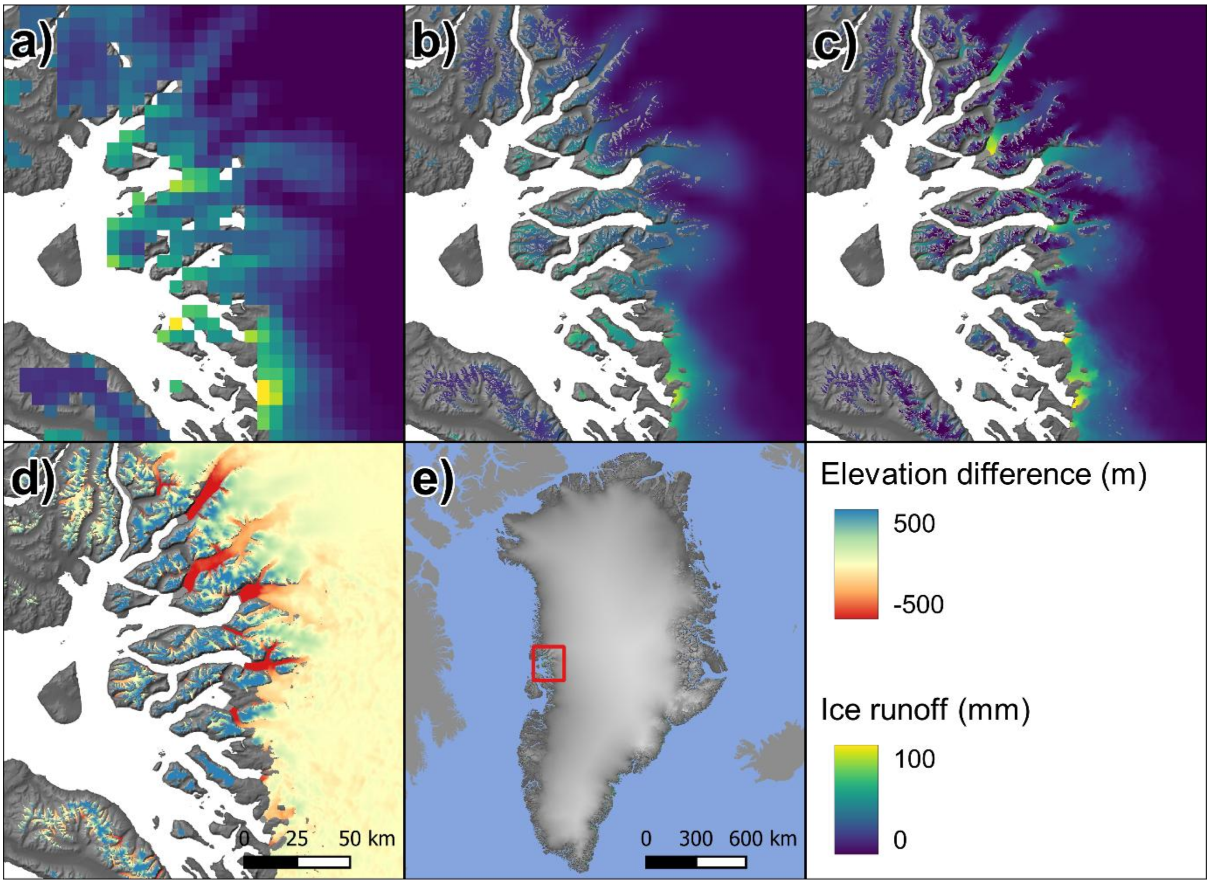

Figure S1. (a) Native resolution daily cumulative ice runoff for 19/July/2021 in West Greenland from MAR, runoff is plotted for fractional ice pixels; (b) ice runoff after upsampling to 250 m; (c) ice runoff after elevation correction, i.e. downscaling. (d) COP-250 DEM minus the upsampled MAR DEM within the RGI ice mask. (e) Overview map.

Figure S1 shows an example of our downscaling for Greenland in the same manner as Figure 5 and 6 in the main text illustrate the downscaling in the Arctic Canada South region.

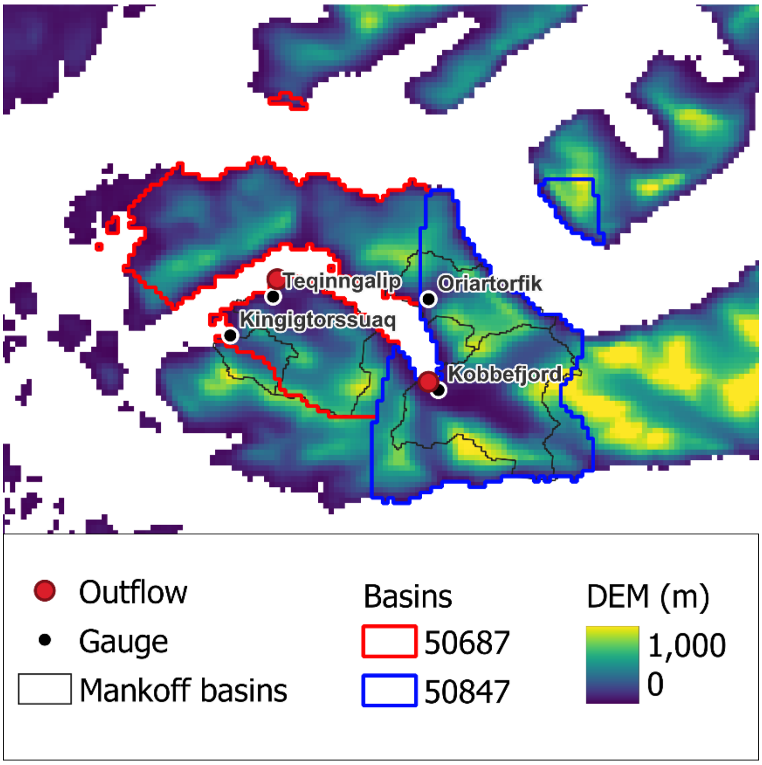

Figure S2. GEM river gauges, the outflow points, basins from Mankoff et al. (2020), and aggregated basins from our meltwater discharge product overlain on the COP-250 DEM.

Figure S2 shows the location of the GEM river gauges and their corresponding aggregated basins from our dataset. Non-aggregated drainage basins from Mankoff et al. (2020) are also included as reference. The Kobbefjord and Oriartorfik gauges cover a significant proportion - about two thirds – of the corresponding aggregated basin (basin ID: 50847). They also represent the two major valley systems within the aggregated basin. However, it is important note that the edges were merged from neighbouring smaller basins.

On the other hand, the Kingigtorssuaq and Teqinngalip gauges only represent about one third the aggregated basin that contains them. The northern side of the fjord which is assigned to this basin – by the aggregation procedure (Section 4.1) – is not represented at all by these gauges. We consider this a significant discrepancy and thus exclude these gauges from our comparisons.

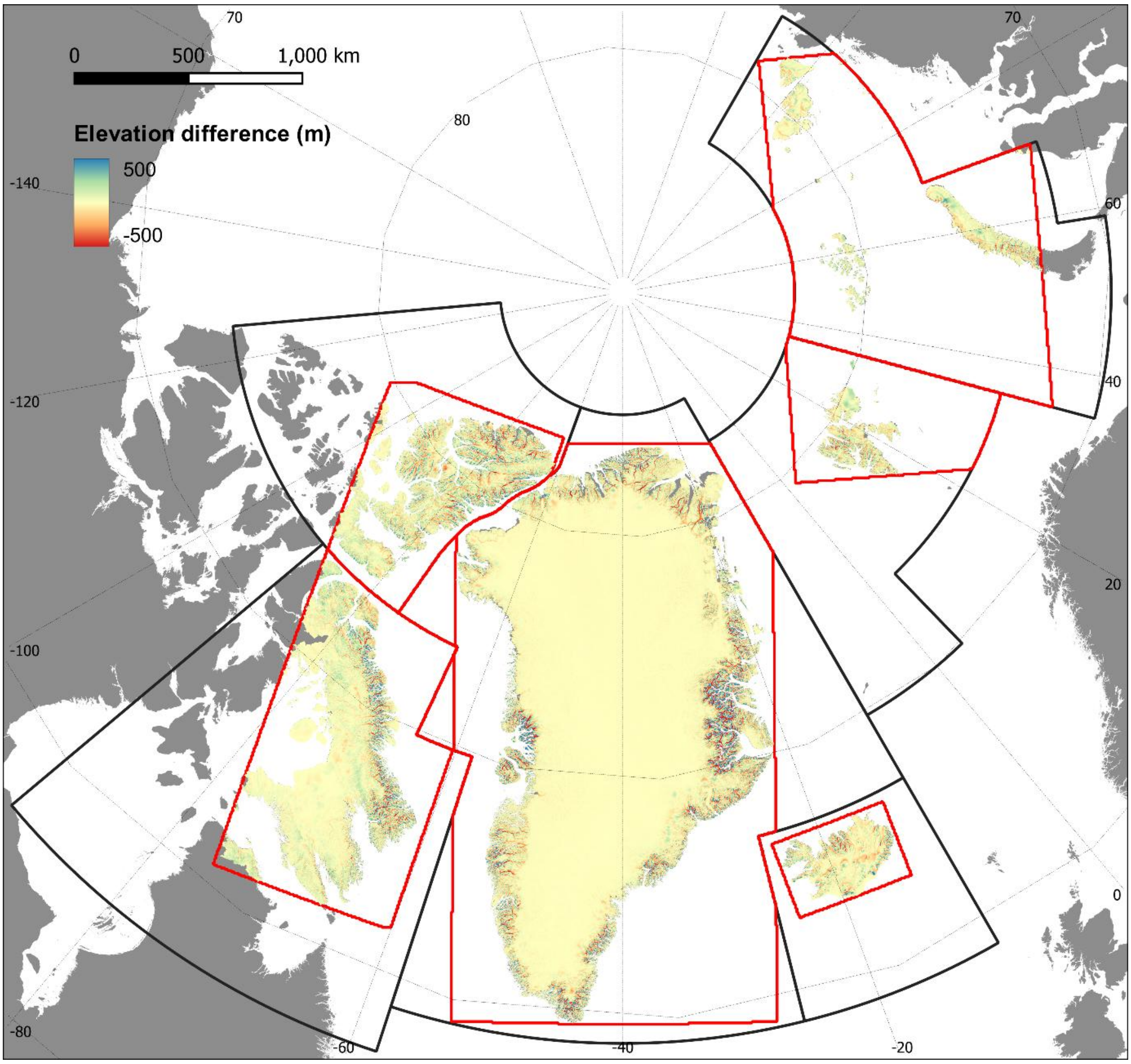

Figure S3. Difference between the COP-250 DEM and the unsampled MAR DEM (COP-250 DEM minus MAR DEM) for all the investigated RGI regions.

Figure S3, shows the difference between the high-resolution COP-250 DEM and the unsampled low resolution MAR DEM. Most of the differences occur near the Greenland Ice Sheet margin and mountainous regions elsewhere. COP-250 DEM tends to be lower than MAR DEM within confined valleys, and higher along ridges, cirques, peaks, and small plateaus. Flat areas match relatively well.

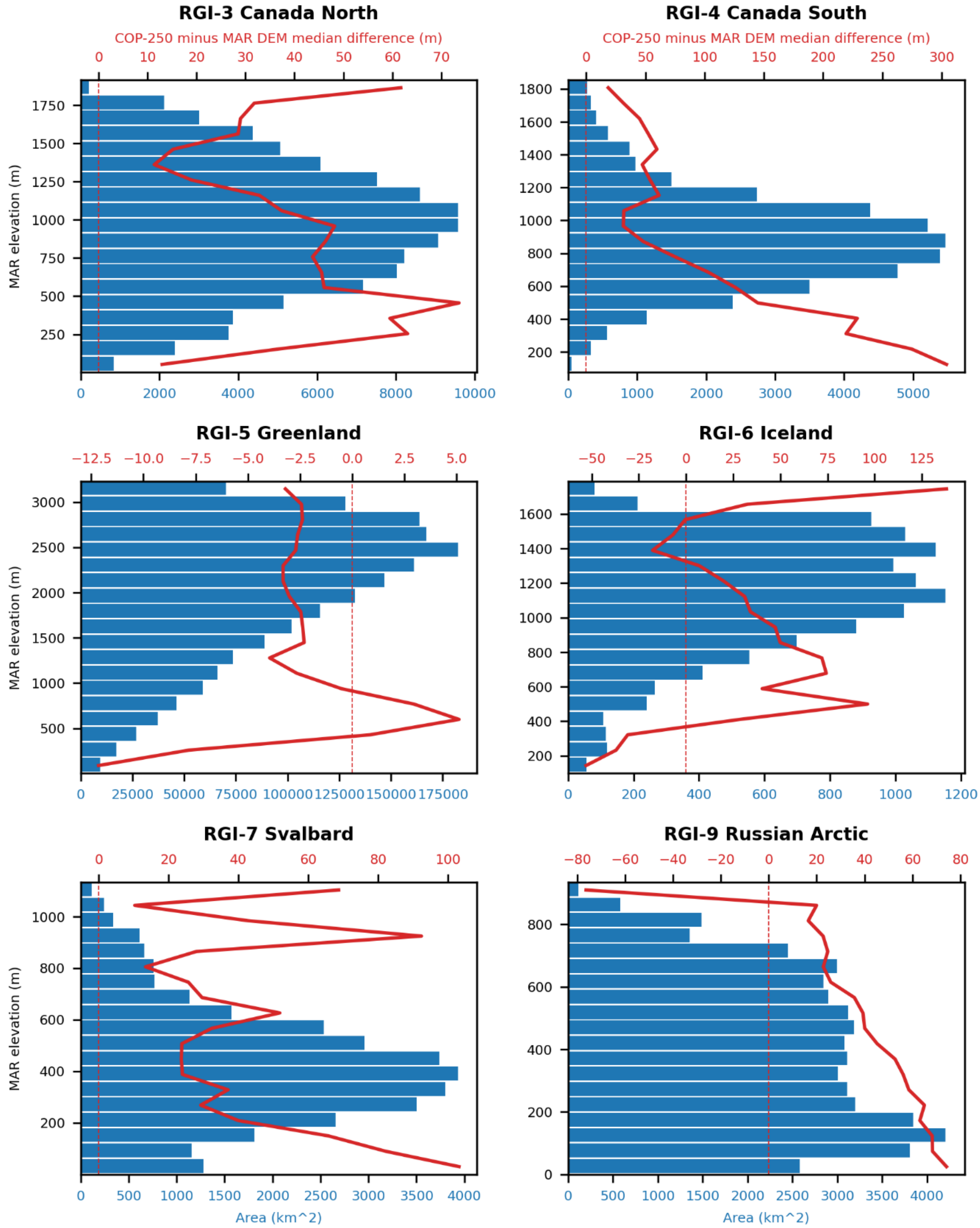

Figure S4. Ice area histograms are computed by binning the upsampled MAR DEM for each region, after masking it with the high-resolution ice masks. Median differences between the COP-250 DEM and the upsampled MAR DEM (COP-250 DEM minus MAR DEM) are calculated for each elevation bin.

Figure S4 shows elevation dependent differences between the COP-250 DEM and the upsampled MAR DEM, for the ice-covered section within our investigated RGI domains. In Greenland, the ice-covered regions are generally lower in COP-250 DEM than MAR DEM, especially in the lowest lying sections, the only exception is the small elevation range between about 500 m and 800 m a.s.l. In other regions COP-250 DEM is generally higher than MAR DEM with few exceptions. We propose that this is due to the topographical configuration of the ice coverage, i.e. the predominant type and geometry of ice bodies (e.g. valley glaciers versus ice caps).

The Greenland Ice Sheet has many topographically confined marine terminating outlet glaciers, where elevation is overestimated by the MAR DEM. These features outweigh the influence of glaciated ridges, cirques and plateaus where MAR underestimates elevations. The effect of the huge interior of the ice sheet is neutral (Figure S3).

In other regions, small ice caps, plateau glaciers, and valley glaciers dominate the glaciated landscape, though marine terminating outlet glaciers also occur – especially in Svalbard and Arctic Canada North. Smaller ice caps, glaciated plateaus and ridges are fairly small and thus poorly resolved by the MAR DEM. These features outweigh the influence of smaller valley glaciers – that often terminate at higher elevations – and outlet glaciers which are less frequent.

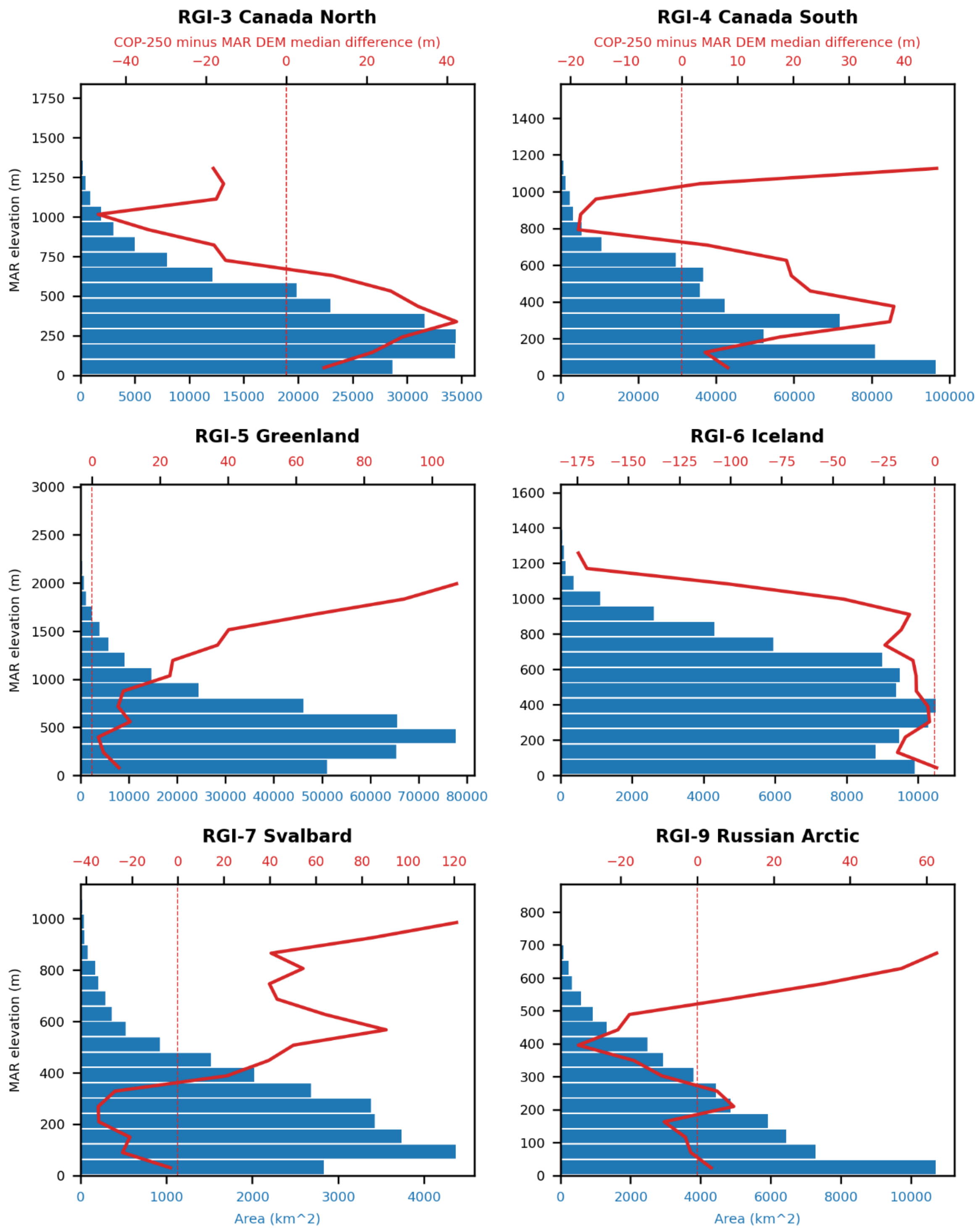

Figure S5. Tundra area histograms are computed by binning the upsampled MAR DEM for each region, after masking out ice areas using the high-resolution ice masks. Median differences between the COP-250 DEM and the upsampled MAR DEM (COP-250 DEM minus MAR DEM) are calculated for each elevation bin.

Figure S5 shows elevation dependent differences between the COP-250 DEM and the upsampled MAR DEM, for the tundra-covered section within our investigated RGI domains.

The pattern is less straightforward than for the ice covered domain. COP-250 DEM is generally lower than MAR DEM towards lower elevations in Svalbard and the Russian Arctic. This indicates that confined unglaciated valleys dominate the tundra landscape within these regions. In such situations downscaling will increase runoff. This aligns well with our downscaling results, the largest – positive – difference between our downscaled tundra runoff and the original MAR runoff was observed in the Svalbard and Russian Arctic regions.

The opposite situation, i.e. COP-250 DEM higher than MAR DEM towards lower elevations, is typical in the other four regions, especially in Arctic Canada (both North and South). However, it is important note that the difference between COP-250 DEM and MAR DEM sharply decreases towards the lowest elevations. This could indicate the presence of confined unglaciated valleys, though their effect is still counterbalanced by other topographical factors, e.g. the presence of steep ridges. Accordingly, though downscaled tundra runoff is still higher than the original MAR runoff in these regions, the difference is smaller than in Svalbard and the Russian Arctic.

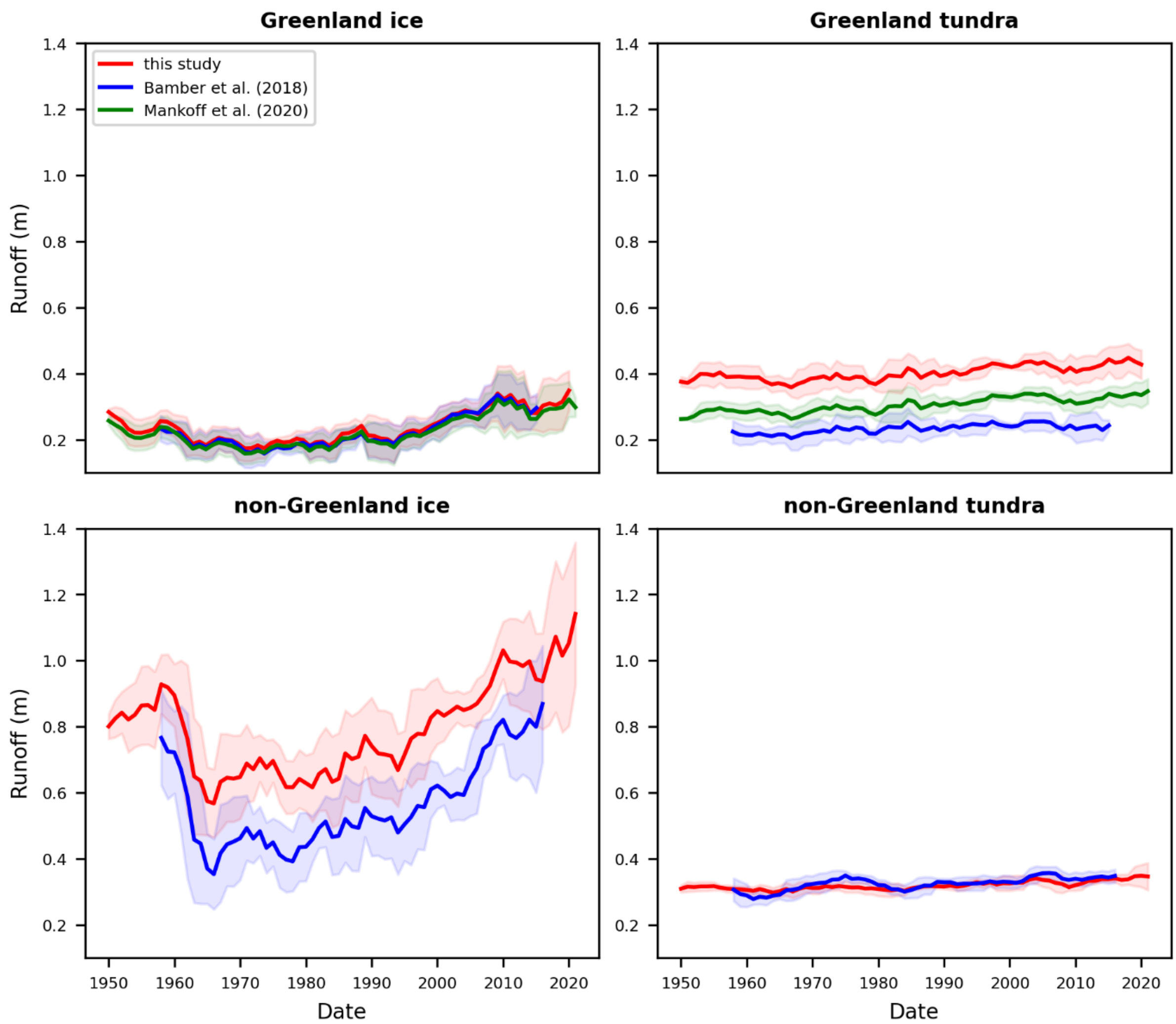

Figure S6. Bulk ice and land/tundra runoff for Greenland and all other Arctic regions, except the Russian Arctic. Bulk runoff is divided by the area of the corresponding region, the resulting unit area bulk runoff shows the characteristic mean runoff from the region. Graphs show the 5-year running means, while shaded areas show the 5-year running standard deviation. Note that Greenland ice includes PGIC.

Figure S6 shows bulk runoff – derived from the different datasets – that is divided by the area of the corresponding region. This reveals the specific intensity of runoff contribution to freshwater flux from different sources. The main feature of this graph is the strong freshwater flux contribution from glaciers and ice caps outside Greenland, which has been increasing significantly since 2000. These ice bodies are smaller and lie at lower elevations than the Greenland Ice Sheet, which explains the more intensive runoff per unit area.