PRESENTER
Damien Maure

Annual Surface Mass Balance is decreasing faster in the western Arctic than in the East.

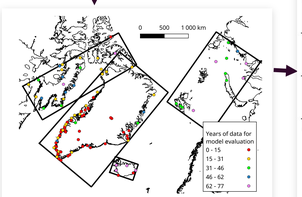
Background

It is known that the Arctic has been **warming as much a 4x faster** than the rest of the world, thus increasing the **ablation** at **unprecedented** rates in the recent past. However, there still lacks a **unified Surface Mass Balance** (SMB) **reconstruction** from 1950 up to present day.

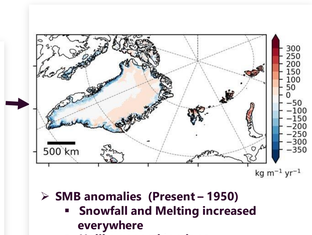
Methods & results

MAR — Regional Climate Model (RCM)

ECMWF — Global reanalysis from 1950 to present day



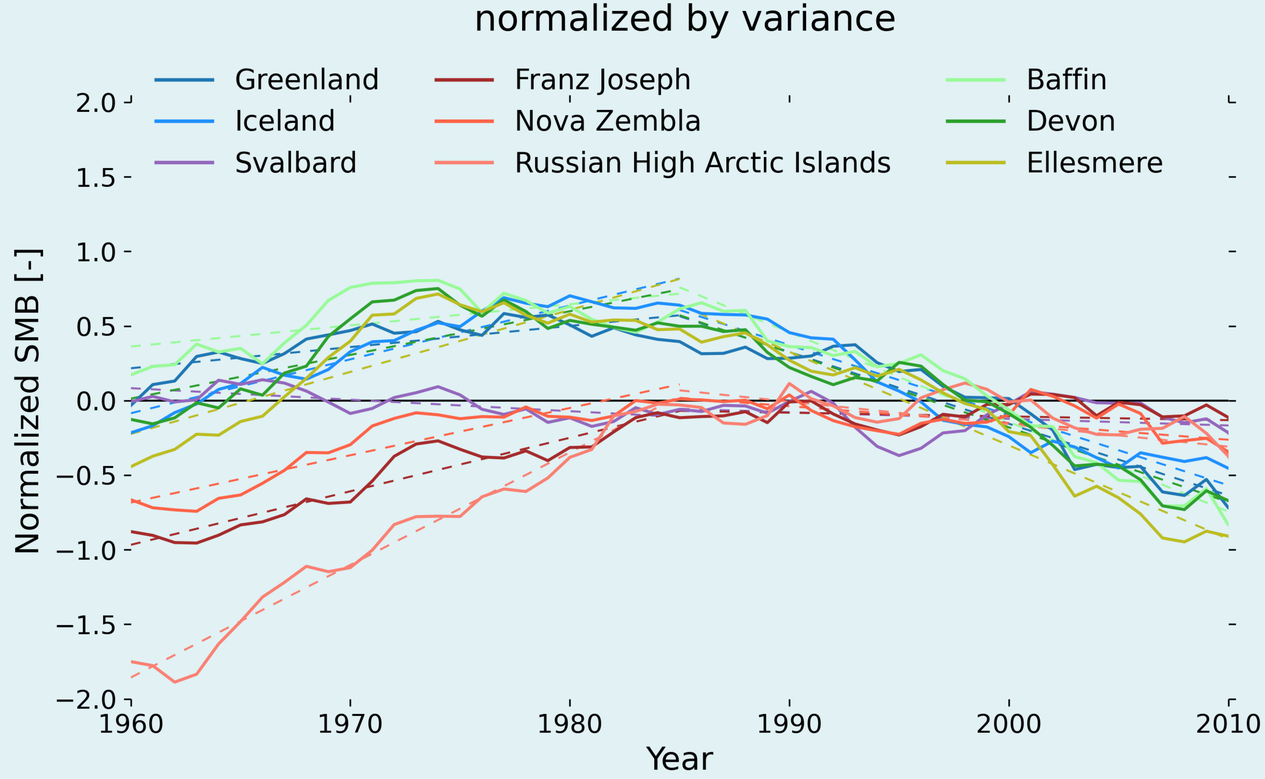
- 4 downscalling domains to cover all Arctic ice bodies



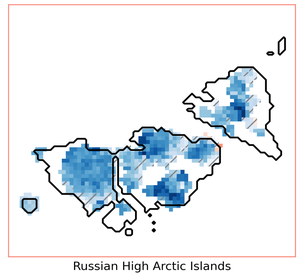
- SMB anomalies (Present – 1950)
  - Snowfall and Melting increased everywhere
  - Unlike general tendency, Russian archipelagoes have seen an increase of SMB
  - However, recent past results show unprecedented melt increase, even over the Russian Arctic.

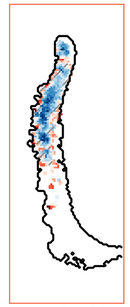
- Time series over sub-regions spatially integrated
  - Decrease has been

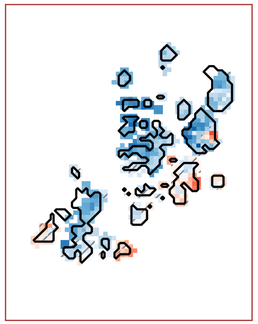
Anually integrated SMB anomalies over all Arctic regions, normalized by variance

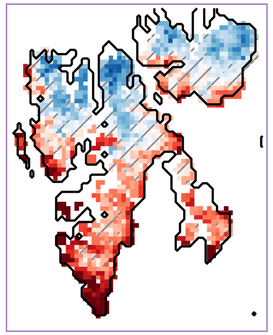


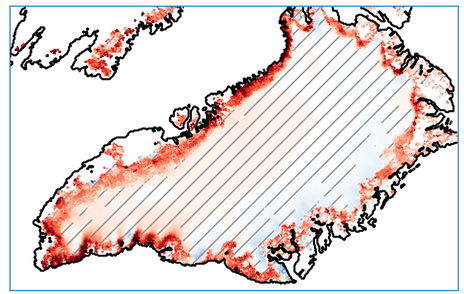
Regional anomalies

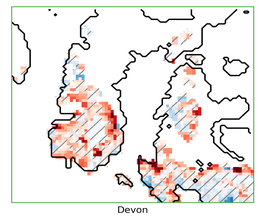

Russian High Arctic Islands

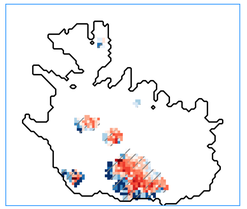

Nova Zembla

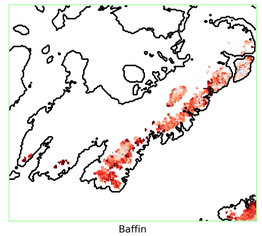

Franz Joseph

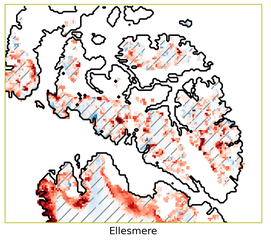

Svalbard

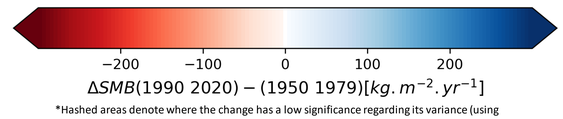

Greenland


Devon


Iceland


Baffin


Ellesmere



*Hashed areas denote where the change has a low significance regarding its variance (using student's t-test with 90% p-value)

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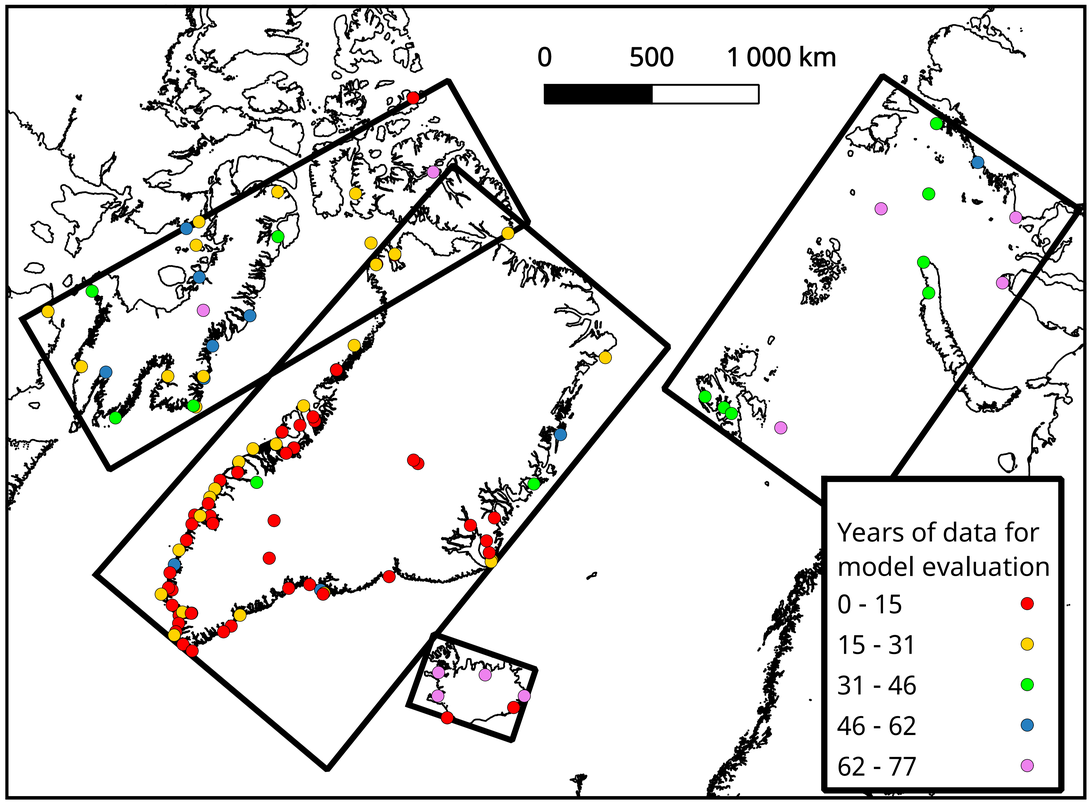
Contrasting effect of the climate warming on the grounded Arctic cryosphere:
complement on Cryosphere 2022 poster

Damien Maure, Christoph Kittel, Clara Lambin, Alison Delhasse, Xavier Fettweis

New MAR domains & evaluation



MAR domains used for the study (black boxes) and Automatic Weather Stations used for the evaluation (colored dots)

- 4 domains used for the downscalling of ERA5
- Evaluation done on surface temperature, pressure and wind speed (see next page)

- Regional Climate Model, forced by ECMWF ERA5 global product.
- 6km resolution, with 24 vertical layers and 7 boundaries pixels forcing

New MAR domains & evaluation

		Annual			Summer			Winter		
		Bias	CRMSE	R	Bias	CRMSE	R	Bias	CRMSE	R
T2m (°C)	Canada	-0.733	2.689	0.973	0.024	2.025	0.768	-0.708	2.768	0.901
	Iceland	-1.281	1.348	0.964	-0.688	1.251	0.825	-1.599	1.359	0.936
	Greenland	-1.301	2.706	0.954	-0.294	1.937	0.788	-1.977	3.024	0.884
	Svalbard	-3.060	2.475	0.965	-3.210	1.365	0.845	-2.978	3.168	0.925
	Russia	-0.561	3.039	0.970	-0.265	1.522	0.840	-0.590	3.826	0.883
P2m (hPa)	Canada	-17.270	2.077	0.983	-16.320	1.493	0.982	-17.914	2.310	0.986
	Iceland	-7.002	1.068	0.997	-6.961	0.741	0.997	-7.013	1.182	0.998
	Greenland	-36.664	3.428	0.929	-38.119	2.401	0.934	-38.968	3.739	0.944
	Svalbard	-36.065	10.113	0.993	-35.058	6.658	0.993	-36.628	11.623	0.993
	Russia	-4.018	1.738	0.987	-3.973	1.427	0.985	-3.888	1.859	0.991
WS2m (ms-1)	Canada	0.320	2.254	0.657	0.125	1.979	0.739	0.433	2.394	0.606
	Iceland	-0.430	2.180	0.746	-0.426	1.796	0.722	-0.329	2.475	0.717
	Greenland	-0.440	2.345	0.641	-0.522	1.785	0.588	-0.291	2.635	0.655
	Svalbard	-12.193	8.995	0.673	-10.863	6.815	0.575	-14.138	10.345	0.690
	Russia	-17.671	10.451	0.767	-15.675	8.300	0.720	-18.855	11.649	0.797

Evaluation results for surface temperature, pressure and wind speed for all the domains, annually and seasonally. Svalbard and Russia were separated though in the same domain because different observational datasets were used.

Regional results

Evolution of Surface Mass Balance (SMB), Runoff (RU) and Snowfalls (SF) over all different sub-regions of the study. Thin line is an annual mean while thick line is a 20-years running mean.

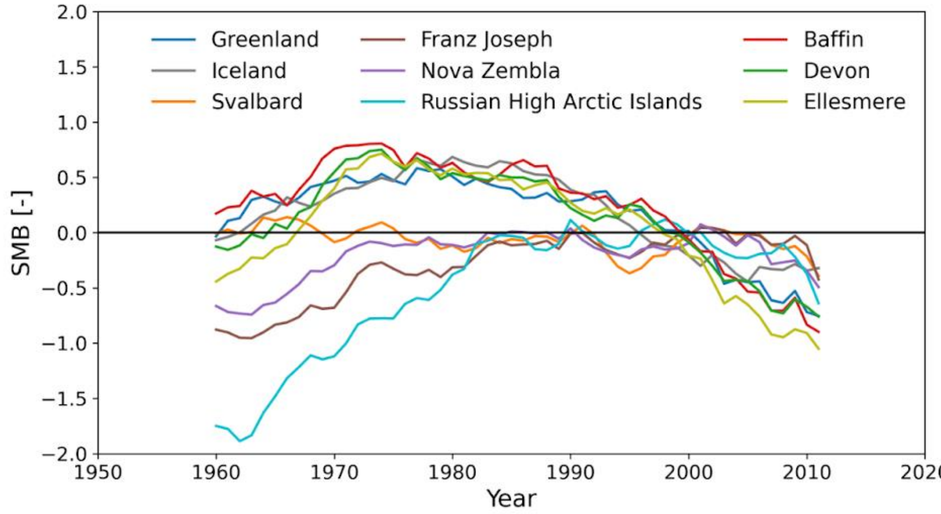
- Snowfalls are generally more stable than runoff
- A melting increase can be seen over nearly all regions since 2000

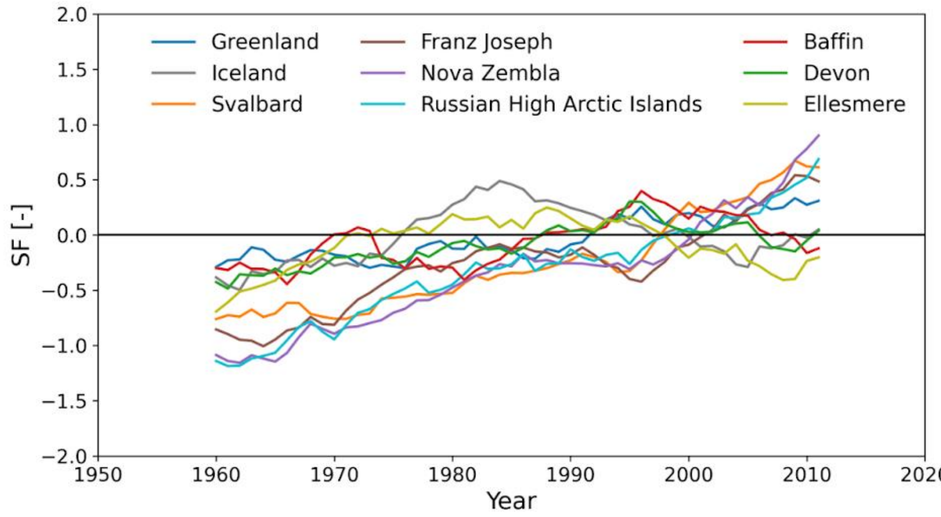
Regional results

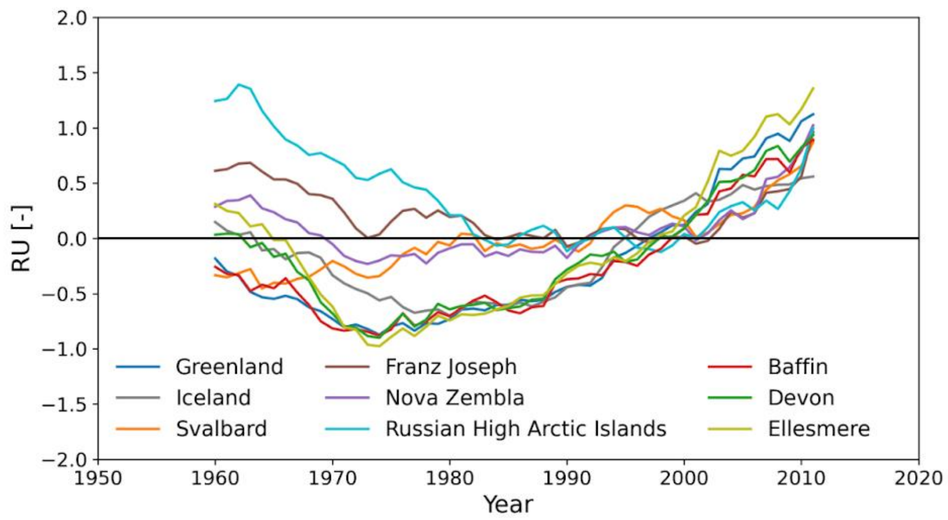
- Snowfalls have increased in nearly all regions, except in Iceland and in the Canadian Arctic where the rise stopped near 1990

- Melting rates have decreased during the second half of the XXth century, followed by a constant rise in all regions

- Over the whole period, the Russian Arctic SMB has increased





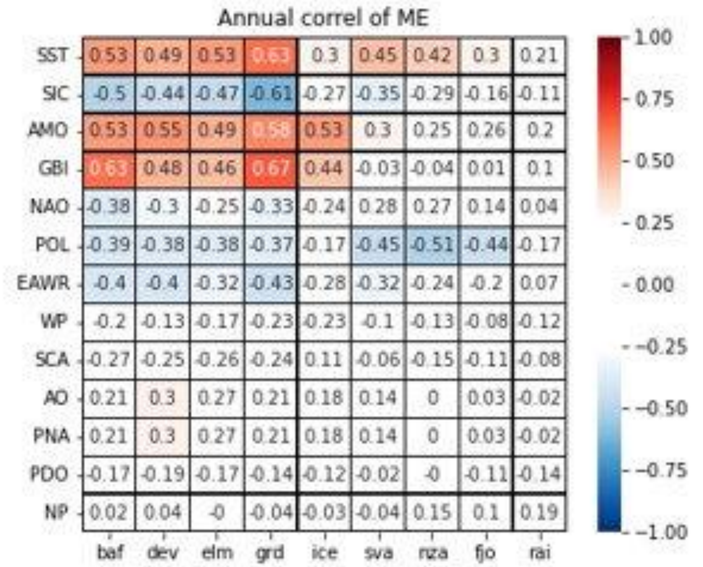


Normalized evolution of SMB, RU and ME over all regions (20-years running mean)

Correlation to large scale indices

- Strong correlation between Canadian Arctic and Greenland melting rates and the GBI / AMO indices (see Fettweis et al. 2013)

- Snowfall over Svalbard and Russian Arctic correlated to mean Sea Surface Temperature (SST) and inversely correlated to Sea Ice Concentration (SIC) (booth computed as annual means above 70°N)

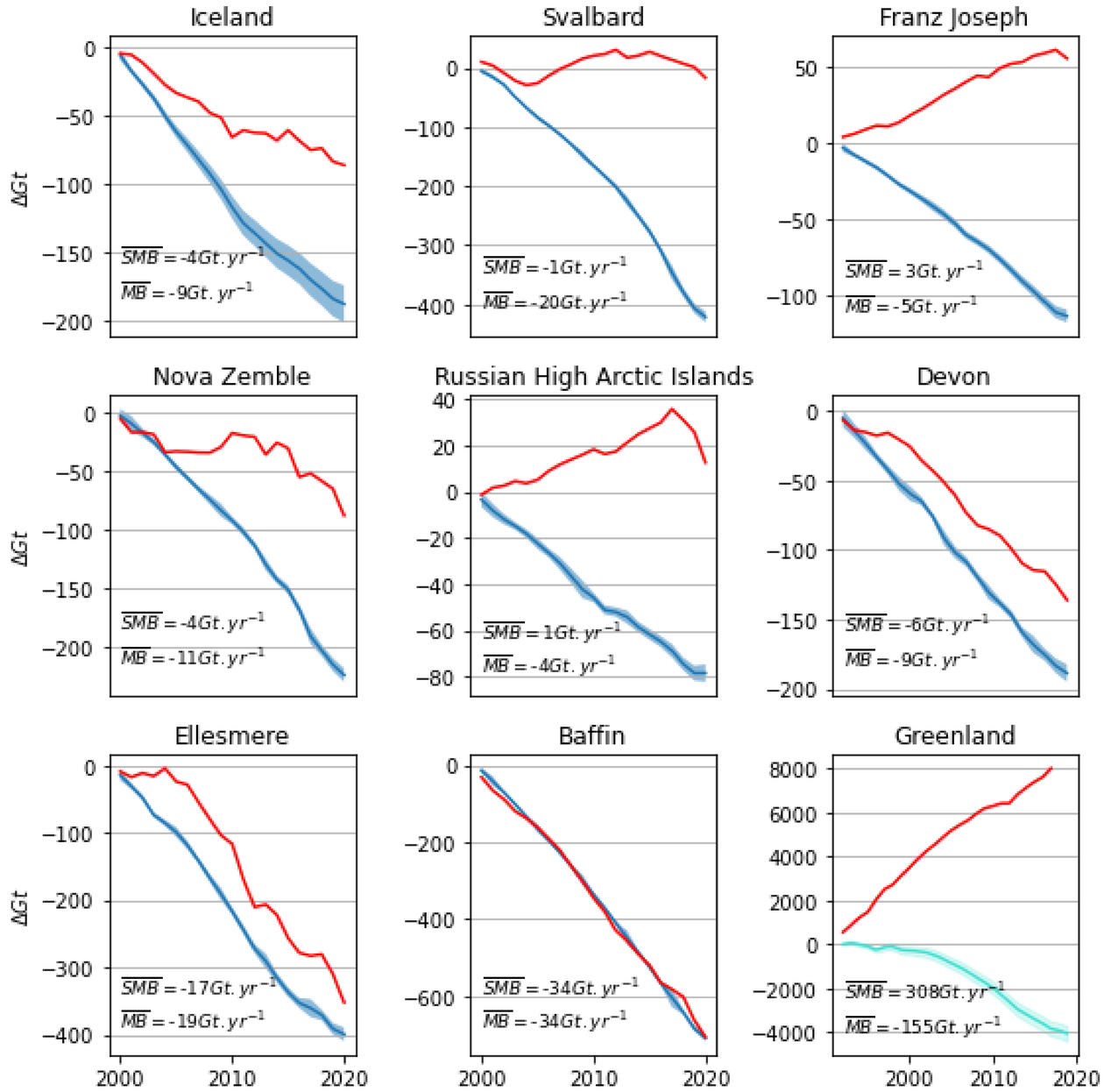


Annual mean correlations of large-scale atmospheric indices to Snowfalls (SF) and Melt (ME)

Comparison to Mass Balance estimates

- Mass Balance estimates from GRACE satellite products for Greenland, and global altimetry/gravimetry products of Hugonnet et al. 2021 for other regions

- Though the SMB is still positive over the Russian High Arctic Islands and Franz Joseph land, the overall mass balance is negative everywhere through increased dynamic ice loss



Cumulative Surface Mass Balance (red) and total Mass Balance (Blue)