



Supplement of

Surface melting over the Greenland ice sheet derived from enhanced resolution passive microwave brightness temperatures (1979–2019)

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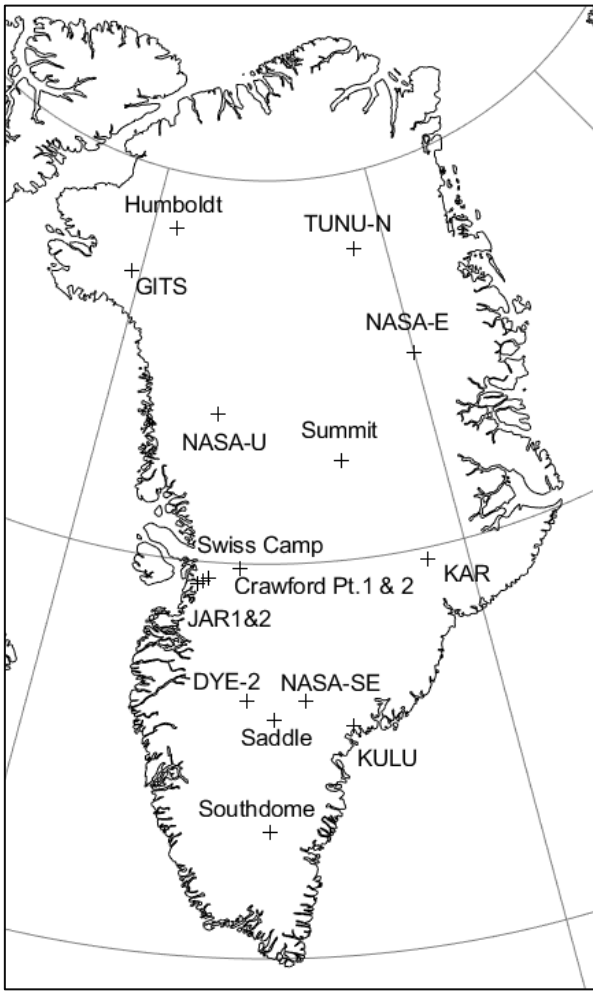
1 Supplementary material

In this Supplementary material, we report the additional information we do not show in the manuscript for the sake of brevity. Specifically, we report the results of the commission/omission error analysis for all the available stations. We also report here additional figures related to the coarse resolution dataset analysis. For graphical reasons we assign an ID to the stations as

5 follows:

Station	ID
Swiss Camp	01
Crowford Pt. 1	02
NASA-U	03
GITS	04
Humboldt	05
Summit	06
TUNU-N	07
DYE-2	08
JAR-1	09
Saddle	10
Southdome	11
NASA-E	12
Crowford Pt. 2	13
NASA-SE	14
KAR	15
JAR-2	16
KULU	17

Table S1 Automatic weather station ID



10 **Figure S1** Map of the automatic weather stations (AWS) of the Greenland Climate Network (GCNet) adopted for this study.

PMW	AWS/MAR	17	16	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01
M+30	0°	0.39	7.03	1.15	2.5	1.36	1.17	2.79	5.57	3.93	8.97	3.81	1.21	5.63	2.94	5.33	6.12	3.2
M+30	-1°	0	6.66	0.76	2.06	0.19	1.14	2.46	4.8	2.8	6.67	3.54	1.21	4.96	2.57	4.91	4.57	2.42
M+30	-2°	0	5.11	0.38	1.42	0.19	1.09	2.11	3.91	2	5.04	3.15	1.19	4.43	2.1	4.4	3.27	1.71
M+30	MAR _{lm}	2.33	34.22	1.53	3.16	4.08	1.3	2.93	6.25	17.8	9.8	4.22	1.21	6.06	3.27	5.7	6.46	10.4
M+30	MAR _{sem}	2.33	30.84	1.53	2.72	3.69	1.29	2.62	5.68	13.2	9.18	4.2	1.21	6.01	3.14	5.44	6.36	7.58
M+35	0°	0	3.56	0.76	1.88	0.78	0.4	1.82	4.03	2.96	7.74	1.37	0.19	2.71	1.5	2.87	4.48	2.71
M+35	-1°	0	3.28	0.38	1.58	0	0.38	1.64	3.41	2.01	5.54	1.3	0.19	2.32	1.3	2.59	3.2	2
M+35	-2°	0	2.28	0.19	1.06	0	0.35	1.37	2.59	1.32	4.03	1.07	0.19	1.99	1.02	2.3	2.14	1.34
M+35	MAR _{lm}	1.55	28.28	1.15	2.32	3.5	0.5	1.98	4.54	16.3	8.72	1.76	0.19	3.04	1.8	3.06	5.02	9.76
M+35	MAR _{sem}	1.55	25.18	1.15	2.06	3.3	0.48	1.8	4.17	11.9	8.1	1.76	0.19	2.99	1.72	2.93	4.98	6.99
M+40	0°	0	1.82	0.38	1.58	0.78	0.3	1.38	3.11	2.16	6.85	0.64	0.11	1.44	0.75	1.74	3.9	2.51
M+40	-1°	0	1.73	0.19	1.34	0	0.28	1.24	2.61	1.34	4.78	0.57	0.11	1.18	0.63	1.58	2.75	1.82
M+40	-2°	0	0.91	0.19	0.93	0	0.27	0.98	1.92	0.84	3.38	0.43	0.11	0.98	0.52	1.37	1.77	1.21
M+40	MAR _{lm}	0.78	23.18	0.57	1.88	3.3	0.4	1.51	3.59	13.9	7.86	0.98	0.11	1.75	1	1.96	4.4	9.15
M+40	MAR _{sem}	0.78	20.71	0.57	1.71	3.11	0.38	1.43	3.32	10.1	7.24	0.98	0.11	1.73	0.92	1.88	4.41	6.59
MEMLS	0°	0.78	10.77	0.95	3.48	1.17	0.25	3.12	3.65	4.48	6.65	0.46	0.11	0.7	0.83	1.42	4.14	3
MEMLS	-1°	0.39	10.13	0.57	2.98	0	0.23	2.83	3.06	3.3	4.71	0.41	0.11	0.53	0.68	1.26	2.87	2.21
MEMLS	-2°	0.39	8.3	0.38	2.09	0	0.22	2.51	2.35	2.48	3.33	0.3	0.11	0.39	0.52	1.06	1.84	1.47
MEMLS	MAR _{lm}	3.1	40.6	1.34	4.2	3.88	0.35	3.29	4.2	19.3	7.65	0.77	0.11	0.93	1.1	1.64	4.7	10.4
MEMLS	MAR _{sem}	3.1	36.59	1.34	3.74	3.69	0.33	3.03	3.9	14.5	7.01	0.77	0.11	0.91	1.02	1.56	4.62	7.54
245K	0°	0	0.36	0	1.11	0.39	0	0.6	1.08	1.59	2.28	0.09	0.03	0.26	0.15	0.31	1.22	1.29
245K	-1°	0	0.36	0	0.87	0	0	0.53	0.93	1.06	1.58	0.09	0.03	0.19	0.13	0.26	0.85	0.87
245K	-2°	0	0.18	0	0.61	0	0	0.39	0.63	0.69	1.14	0.07	0.03	0.15	0.1	0.19	0.55	0.61
245K	MAR _{lm}	0.78	16.79	0	1.38	1.75	0	0.71	1.09	11.8	2.98	0.12	0.03	0.36	0.18	0.39	1.67	6.22
245K	MAR _{sem}	0.78	14.51	0	1.24	1.75	0	0.66	1.08	8.39	2.66	0.12	0.03	0.36	0.15	0.35	1.72	4.15

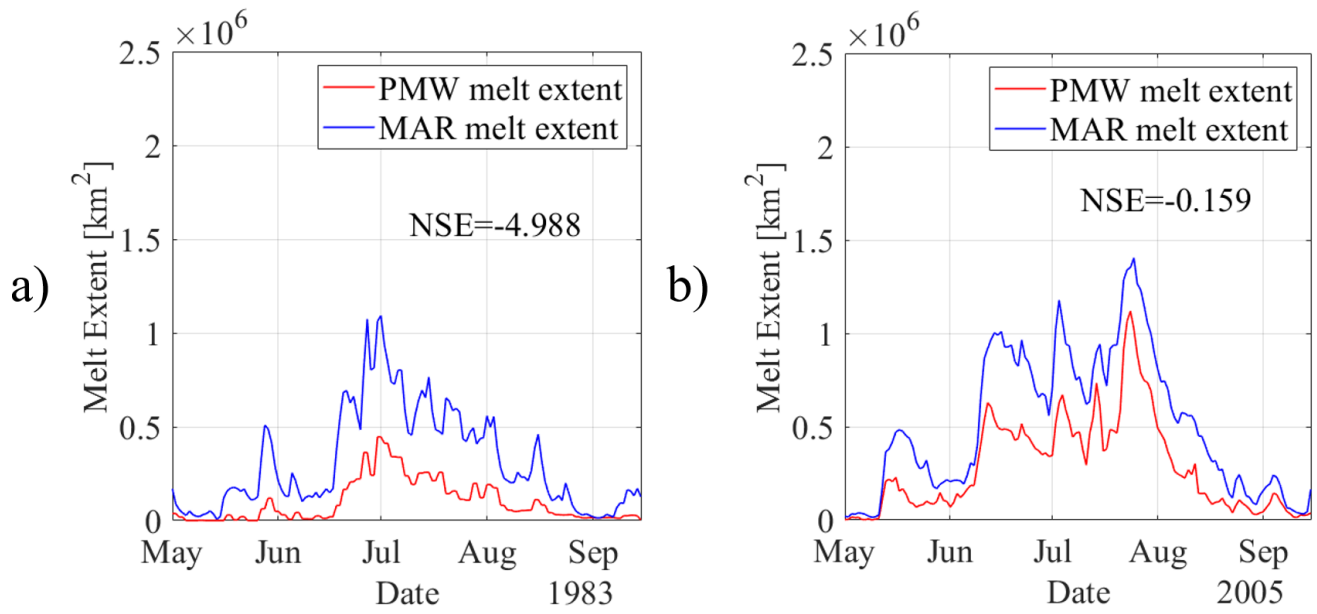
Table S2 Commission errors computed as percentage of the number of melting days detected by the specific algorithm (first column) with respect to 365 days for the 17 AWS (only days in which data are available from all the datasets have been considered).

PMW	AWS/MAR	17	16	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01
M+30	0°	5.43	9.67	0.19	4.43	0.78	0.18	2.51	2.72	5.65	3.31	0.53	0.14	0.51	0.45	0.64	3.25	4.25
M+30	-1°	6.2	11.5	0.57	6.62	2.33	0.37	3.7	3.99	7.65	5.46	1.12	0.26	0.93	0.87	1.66	5.1	5.81
M+30	-2°	9.69	13.6	2.1	8.82	5.44	0.82	5.56	5.8	9.76	7.53	2.28	0.58	2.16	1.37	2.91	6.94	7.95
M+30	MAR _{lm}	3.49	2.37	0.19	2.4	0.78	0.05	2.14	1.79	2.37	3.73	0.16	0	0.19	0.02	0.48	3.01	2.5
M+30	MAR _{scm}	3.49	4.47	0.38	3.45	2.91	0.12	2.72	2.95	3.06	4.17	0.27	0.08	0.31	0.12	0.71	3.06	2.85
M+35	0°	8.53	12.3	0.19	4.88	0.78	0.22	2.69	3.08	6.84	3.57	0.62	0.14	0.63	0.52	0.85	3.61	4.7
M+35	-1°	9.69	14.3	0.57	7.2	2.72	0.42	4.03	4.51	9.02	5.82	1.41	0.26	1.32	1.1	2.01	5.73	6.34
M+35	-2°	13.1	16.9	2.29	9.53	5.83	0.89	5.96	6.38	11.2	8.01	2.72	0.6	2.76	1.79	3.49	7.81	8.53
M+35	MAR _{lm}	6.2	2.55	0.19	2.62	0.78	0.05	2.33	1.98	2.93	4.14	0.23	0	0.21	0.05	0.52	3.57	2.75
M+35	MAR _{scm}	6.2	4.93	0.38	3.85	3.11	0.12	3.04	3.33	3.93	4.58	0.36	0.08	0.33	0.2	0.87	3.67	3.2
M+40	0°	13.5	15.7	0.38	5.1	0.97	0.22	2.85	3.3	9.15	3.99	0.69	0.14	0.67	0.58	0.92	3.85	5.56
M+40	-1°	14.7	17.9	0.95	7.49	2.91	0.42	4.22	4.85	11.4	6.38	1.48	0.26	1.49	1.25	2.19	6.1	7.21
M+40	-2°	18.2	20.8	2.86	9.94	6.02	0.9	6.17	6.84	13.8	8.67	2.88	0.6	3.05	2.1	3.75	8.26	9.45
M+40	MAR _{lm}	10.4	2.65	0.19	2.72	0.78	0.05	2.46	2.17	3.69	4.6	0.25	0	0.22	0.07	0.61	3.77	3.19
M+40	MAR _{scm}	10.4	5.66	0.38	4.03	3.11	0.12	3.27	3.62	5.19	5.04	0.37	0.08	0.38	0.22	1.01	3.93	3.85
MEMLS	0°	3.49	6.66	0.19	4.03	0.78	0.22	2.53	3.03	4.54	4.04	0.73	0.14	0.77	0.57	0.93	3.62	4.12
MEMLS	-1°	4.26	8.3	0.57	6.15	2.33	0.42	3.75	4.48	6.49	6.55	1.53	0.26	1.68	1.2	2.21	5.75	5.68
MEMLS	-2°	7.75	10.1	2.29	8.12	5.44	0.9	5.64	6.46	8.58	8.87	2.97	0.6	3.31	2	3.78	7.86	7.79
MEMLS	MAR _{lm}	1.94	2.01	0.19	2.06	0.78	0.05	2.17	1.96	2.13	4.63	0.25	0	0.24	0.07	0.63	3.61	2.54
MEMLS	MAR _{scm}	1.94	3.47	0.38	3.08	3.11	0.12	2.8	3.38	2.71	5.05	0.37	0.08	0.39	0.22	1.03	3.67	2.88
245K	0°	13.5	21.7	0.57	5.28	2.14	0.32	3.04	4.4	12.2	7.57	1.01	0.14	0.98	0.85	1.08	5.72	10.7
245K	-1°	14.7	24	1.34	7.67	4.47	0.53	4.49	6.3	14.8	11.3	1.87	0.26	1.99	1.62	2.46	8.74	12.6
245K	-2°	18.2	27.4	3.24	10.2	7.57	1.04	6.55	8.68	17.4	14.5	3.4	0.6	3.72	2.55	4.17	11.5	15.2
245K	MAR _{lm}	10.4	3.65	0.19	2.87	0.78	0.05	2.64	2.8	5.23	7.86	0.27	0	0.33	0.12	0.63	5.59	6.68
245K	MAR _{scm}	10.4	6.84	0.38	4.2	3.3	0.13	3.48	4.51	7.15	8.59	0.39	0.08	0.5	0.32	1.08	5.78	7.84

Table S3 Omission errors computed as percentage of the number of melting days detected by the specific algorithm (first column) with respect to 365 days for the 17 AWS (only days in which data are available from all the datasets have been).

	Commission					Omission				
	0°	-1°	-2°	MAR _{1m}	MAR _{5cm}	0°	-1°	-2°	MAR _{1m}	MAR _{5cm}
01	2.21	1.54	0.95	8.53	6.28	6.76	8.53	10.53	3.83	4.25
02	2.19	1.39	0.84	3.07	2.95	5.64	8.51	11.33	5.94	5.96
03	0.97	0.86	0.72	1.2	1.12	0.99	2.34	3.85	0.65	0.97
04	0.53	0.42	0.32	0.72	0.63	0.44	0.91	1.56	0.02	0.13
05	0.53	0.42	0.25	0.65	0.65	0.82	1.64	3.24	0.19	0.32
06	0.08	0.08	0.08	0.08	0.08	0.17	0.29	0.67	0	0.11
07	0.4	0.36	0.27	0.69	0.69	0.88	1.66	3.12	0.29	0.44
08	4.25	2.8	1.73	5.16	4.74	5.66	8.68	11.35	6.42	7.1
09	6.06	4.86	4	20.05	15.98	6.63	8.65	10.68	2.7	3.28
10	2.08	1.66	1.18	2.38	2.27	3.24	4.95	6.89	2.82	4.36
11	0.74	0.63	0.46	0.8	0.8	3.07	4.25	6.23	2.76	3.6
12	0.23	0.23	0.21	0.34	0.34	0.27	0.48	1.01	0.06	0.17
13	0.58	0	0	2.72	2.52	1.36	3.5	6.6	0.78	3.11
14	0.91	0.72	0.46	1.07	0.97	0.91	0.72	0.46	1.07	0.97
15	0.57	0.38	0.19	0.76	0.76	0.38	0.95	2.67	0.19	0.38
16	7.3	6.93	5.75	31.93	28.65	13.23	15.15	17.61	3.38	5.57
17	0	0	0	0.39	0.39	18.6	19.77	23.26	15.12	15.12

15 **Table S4 Omission errors computed as percentage of the number of melting days of the Mote dataset (25 km) with respect to 365 days for the 17 AWS (first column, only days in which data are available from all the datasets have been).**



20 **Figure S2** Melt extent estimation from Mote (2014) dataset and the regional climate model MAR. Timeseries were obtained using LWC average in the first 5 cm of snowpack for the years (a) 1983 and (b) 2005.

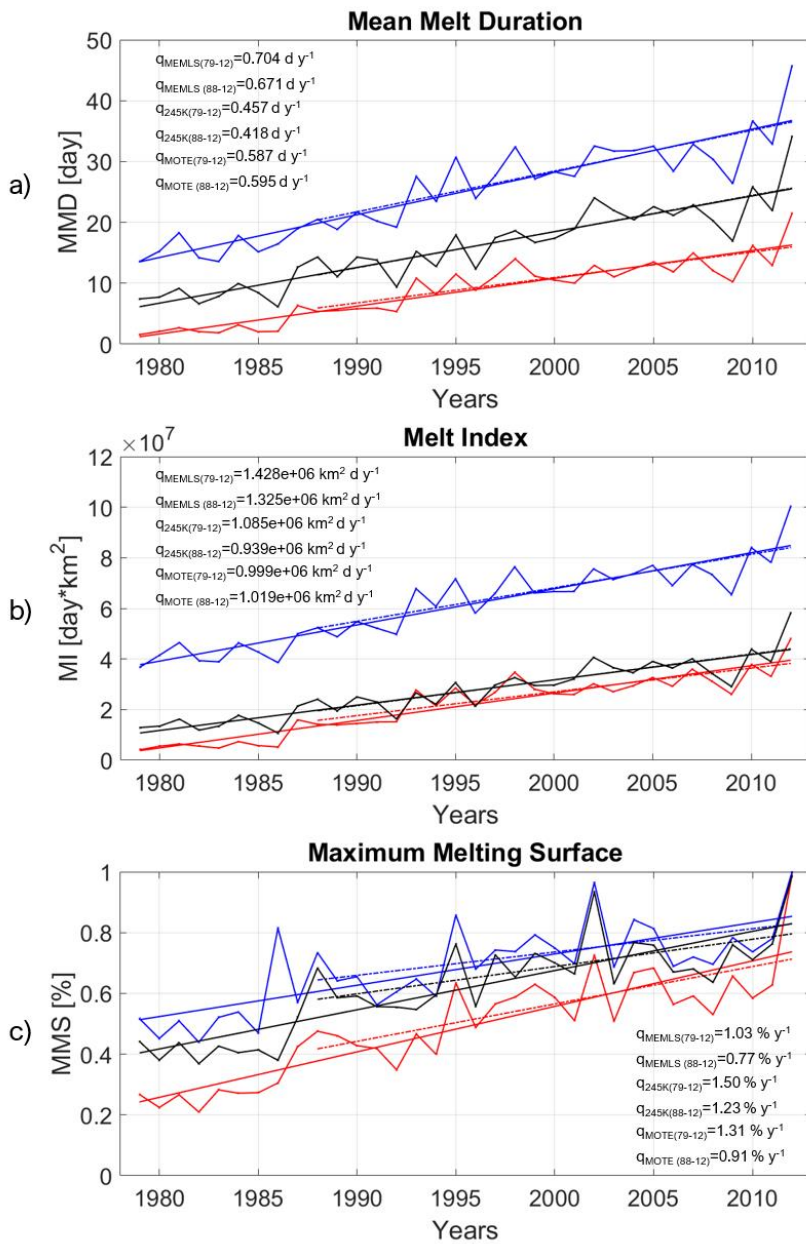
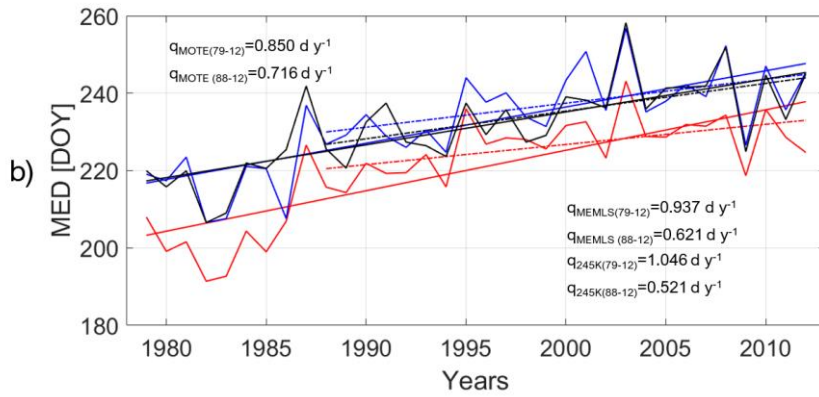
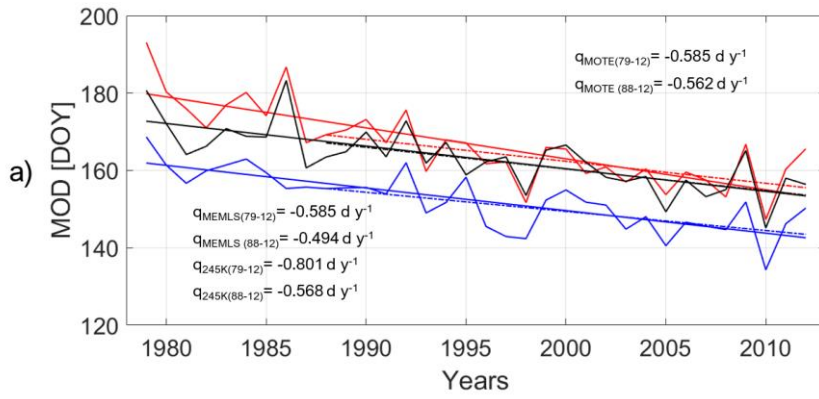
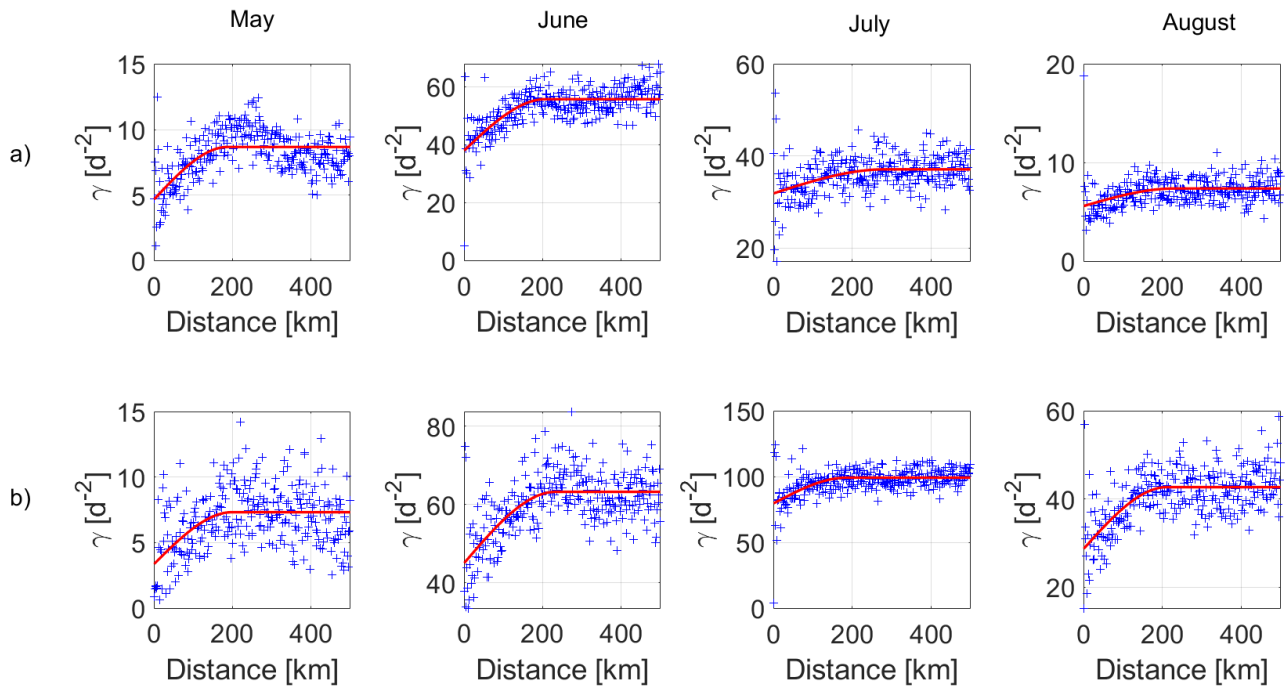


Figure S3 Time series of annual a) mean melt duration (MMD), b) melt index (MI) and c) maximum melting surface (MMS) fraction. Regression lines computed for the periods 1979-2012 (solid line) and 1988-2012 (dashed-dot line). MMD is averaged over all the ice sheet pixels. Red lines refer to 245K, blue lines to MEMLS and black lines to the coarse resolution dataset.



25

Figure S4 Time series of annual a) mean melt onset date (MOD) and b) mean melt end date (MED). Regression lines computed for the periods 1979-2012 (solid line) and 1988-2012 (dashed-dot line). Red lines refer to 245K, blue lines to MEMLS and black lines to the coarse resolution dataset.



30 **Figure S5** Empirical (blue crosses) and modelled (red line) semi-variograms for Greenland melt duration (MD) computed from MAR_{5cm} (a) and MAR_{1m} (b). Table 7 reports range, sill, nugget and R^2 values of these semi variograms.