Supplementary document

Table S1: Summary of characteristics of Surface Mass Balance (SMB) estimates used for the computation of SMB loads, including temporal coverage, temporal resolution and spatial resolution.

Model	Start_year	End_year	Spatial Resolution	Temporal Resolution
RACMO_27	1979	2022	27 km	monthly
RACMO_2DS	1979	2022	2 km	monthly
RACMO_11	1979	2023	11 km	monthly
MAR_35	1980	2022	35 km	monthly
GEMB_10	1979	2022	10 km	monthly
HIRHAM5_12.5	1979	2023	12.5 km	monthly
MERRA2	1980	2024	12.5 km	5 days

Table S2: Summary of GNSS station details used in the study, showing station coordinates, start and end dates of observations, percentage of data availability, selected offset dates and preferred stochastic noise models used in time series analysis. Noise models are abbreviated as GGMWN, generalized Gauss-Markov plus white noise and PLWN, power-law plus white noise.

Station	Lat	Lon	Start date	End Date	Date availability	Offset dates	Preferred Noise model
A368	-74.29	66.79	14/01/2007	3/04/2010	77%	None	GGMWN
ABBZ	-77.46	166.91	6/02/2004	31/12/2021	64%	None	PLWN
ABOA	-73.04	346.59	1/02/2003	2/05/2021	89%	5/02/2010	PLWN
BACK	-74.43	257.52	27/12/2011	31/12/2021	79%	19/12/2016, 19/12/2016, 16/01/2018	PLWN
BELG	-77.87	325.37	3/02/1998	31/12/2020	54%	15/02/2005, 17/10/2010, 13/02/2014	PLWN
BENN	-84.79	243.54	15/12/2010	31/12/2021	95%	31/12/2012, 06/12/2014	GGMWN
BERP	-74.55	248.12	11/01/2011	20/01/2021	91%	None	PLWN
BRIP	-75.8	158.47	13/12/2007	5/02/2018	97%	None	GGMWN
BUMS	-85.96	174.5	28/01/2014	29/01/2020	95%	05/02/2015, 22/01/2016	GGMWN
CAPF	-66.01	299.44	27/11/2012	31/12/2021	82%	16/11/2013	GGMWN
CLRK	-77.34	218.13	4/01/2010	31/12/2021	92%	None	PLWN
CON2	-77.53	167.09	17/12/2012	31/12/2021	88%	None	PLWN
CONG	-77.53	167.09	21/12/2000	16/12/2012	60%	05/02/2004, 27/10/2004, 16/01/2012	PLWN
COTE	-77.81	162	29/01/2008	31/12/2021	96%	10/02/2017	GGMWN
CRDI	-82.86	306.8	14/01/2010	31/12/2021	97%	24/12/2013, 07/12/2016, 11/12/2019	GGMWN
DEVI	-81.48	161.98	5/12/2008	11/02/2018	97%	None	GGMWN
DUM1	-66.67	140	3/01/1998	20/03/2017	77%	None	PLWN
DUPT	-64.8	297.18	3/04/2009	31/12/2021	99%	None	PLWN

E1G2	-77.53	167.14	1/01/2003	13/04/2012	59%	10/12/2002, 18/01/2004	PLWN
FALL	-85.31	216.37	22/12/2009	21/07/2019	88%	None	GGMWN
FLM5	-77.53	160.27	25/11/2005	31/12/2021	89%	None	PLWN
FONP	-65.25	298.35	7/02/2010	31/07/2015	78%	None	PLWN
FTP4	-78.93	162.56	7/01/2006	2/02/2020	98%	6/12/2018	PLWN
GMEZ	-73.88	291.46	8/01/2010	31/12/2021	63%	None	PLWN
HAAG	-77.04	281.71	16/01/2010	31/12/2021	90%	7/12/2019	PLWN
HOOZ	-77.53	166.93	2/01/2004	7/11/2014	63%	None	PLWN
HOWE	-87.42	210.57	1/01/2010	14/02/2020	94%	06/12/2012, 14/12/2017	GGMWN
HOWN	-77.53	273.23	10/01/2008	31/12/2021	93%	7/12/2019	GGMWN
HTON	-74.08	298.27	1/03/2014	31/12/2021	60%	01/03/2014, 18/01/2022	PLWN
HUGO	-64.96	294.33	24/10/2009	25/05/2020	66%	02/04/2009, 20/06/2009, 23/10/2009, 04/03/2017	PLWN
IGGY	-83.31	156.25	28/01/2009	16/01/2017	94%	31/01/2008, 29/01/2009, 18/11/2009, 24/12/2009, 22/01/2011, 29/01/2011, 23/01/2012, 28/01/2014	GGMWN
JNSN	-73.08	293.9	30/12/2009	31/12/2021	50%	30/12/2009, 12/11/2013, 13/12/2018, 25/01/2021	PLWN
LEN1	-69.5	159.4	24/01/2008	17/04/2012	68%	None	GGMWN
LPLY	-73.11	269.7	14/12/2011	31/12/2021	95%	21/12/2018	PLWN
LWN0	-81.35	152.73	31/01/2008	7/02/2018	83%	None	GGMWN
MACG	-77.53	167.25	4/02/2008	1/12/2015	86%	None	PLWN
MCAR	-76.32	215.7	6/01/2010	31/12/2021	92%	None	PLWN
MCG2	-77.53	167.25	2/12/2015	15/10/2020	97%	26/01/2018	PLWN
MCM4	-77.84	166.67	25/01/1995	31/12/2021	92%	07/09/1999, 03/01/2002, 19/05/2006	PLWN
MCMC	-77.84	166.67	18/10/2005	4/12/2017	96%	None	PLWN
MCMD	-77.84	166.67	3/11/2005	31/12/2021	95%	05/01/2012, 03/11/2018	GGMWN
MIN0	-78.65	167.16	31/01/2007	31/12/2021	86%	None	PLWN
NONS	-72.01	2.53	17/02/2011	1/01/2021	94%	None	PLWN

OHI3	-63.32	302.1	7/02/2003	31/12/2021	81%	09/02/2010, 09/02/2012, 07/02/2013, 01/03/2014, 11/02/2015, 11/02/2019	PLWN
PAL2	-64.78	295.95	4/09/2006	31/12/2021	94%	None	PLWN
PALM	-64.78	295.95	23/04/1997	31/12/2021	90%	08/03/2008, 14/07/2021	PLWN
PALV	-64.78	295.95	4/04/2009	11/09/2017	91%	24/09/2014	PLWN
PATN	-78.03	204.98	28/01/2010	16/11/2017	71%	10/11/2015, 08/07/2016, 05/09/2017	GGMWN
PECE	-85.61	291.44	15/01/2010	31/12/2021	91%	14/01/2010, 07/12/2016, 14/12/2017, 09/12/2019	GGMWN
PHIG	-77.53	167.05	10/01/2013	31/12/2021	96%	None	PLWN
PIRT	-81.1	274.86	30/12/2013	31/12/2021	90%	25/11/2014	GGMWN
PRPT	-66.01	294.66	4/05/2014	31/12/2021	96%	None	PLWN
RAMG	-84.34	178.05	10/02/2008	27/01/2019	91%	None	GGMWN
RMBO	-83.87	293.61	6/01/2014	31/12/2021	98%	11/12/2019, 11/12/2019	GGMWN
ROB4	-77.03	163.19	30/11/2005	31/12/2021	98%	14/11/2012	PLWN
ROBN	-65.25	300.56	6/02/2010	31/12/2021	77%	17/02/2016	PLWN
ROTH	-67.57	291.87	3/01/2010	13/11/2021	74%	14/03/2011	PLWN
SCTB	-77.85	166.76	29/10/2004	31/12/2021	96%	26/10/2010, 17/09/2015, 01/11/2019	PLWN
SDLY	-77.14	234.03	9/01/2010	25/12/2020	83%	None	PLWN
SMR5	-68.13	292.9	26/02/2009	31/12/2020	83%	None	PLWN
SMRT	-68.13	292.9	23/04/1999	26/02/2009	83%	1/03/2007	PLWN
SPGT	-64.29	298.95	22/03/2013	31/12/2021	90%	None	PLWN
STEW	-84.19	273.75	8/01/2014	31/12/2021	98%	06/12/2014, 06/12/2016, 10/12/2019	GGMWN
SVEA	-74.58	348.77	14/11/2004	2/02/2014	57%	14/11/2004, 09/01/2010, 17/01/2013	GGMWN
SYOG	-69.01	39.58	27/03/1995	31/12/2021	92%	08/02/2000, 26/01/2007, 23/12/2013, 02/02/2014, 18/01/2020	PLWN
THUR	-72.53	262.44	19/01/2011	31/12/2021	92%	None	PLWN

TNB1	-74.7	164.1	24/11/1998	29/12/2021	68%	28/11/2015	PLWN
TNB2	-74.7	164.1	2/01/2010	29/12/2021	67%	None	GGMWN
TOMO	-75.8	245.34	1/02/2017	31/12/2021	78%	14/12/2019	PLWN
TRVE	-69.99	292.45	22/12/2009	31/12/2021	77%	23/01/2021	PLWN
VESL	-71.67	357.16	15/01/1998	31/12/2021	77%	12/01/2008, 11/02/2010	PLWN
VL01	-72.45	169.73	7/12/2014	31/12/2021	95%	None	PLWN
VL12	-72.27	163.73	17/12/2014	31/12/2021	99%	None	PLWN
VL30	-70.6	162.53	21/12/2014	31/12/2021	93%	None	GGMWN
VNAD	-65.25	295.75	1/04/2009	17/02/2017	96%	None	PLWN
WHN0	-79.85	154.22	16/12/2007	14/01/2017	93%	09/11/2003, 13/12/2007, 01/02/2011, 09/02/2012	GGMWN
WHTM	-82.68	255.61	19/01/2010	31/12/2021	87%	27/11/2014, 30/12/2015, 19/12/2019	GGMWN
WILN	-80.04	279.44	12/01/2010	31/12/2021	95%	28/12/2010, 01/01/2014, 12/12/2019	GGMWN
WLCH	-70.73	296.18	31/10/2012	31/12/2021	61%	10/01/2010, 07/11/2013, 02/07/2017, 26/01/2021	GGMWN
WLCT	-85.37	272.61	3/01/2014	31/12/2021	87%	06/12/2014, 06/12/2016, 06/12/2017, 09/12/2019	GGMWN
WWAY	-81.58	331.6	17/01/2014	12/12/2019	96%	28/01/2002, 01/01/2006, 17/01/2014, 25/12/2014	GGMWN
CAS1	-66.28	110.52	1/01/1995	31/12/2021	91%	05/02/2000, 03/12/2008, 13/11/2009, 11/12/2013, 22/05/2020, 07/07/2021	PLWN
DAV1	-68.58	77.97	6/01/1995	31/12/2021	92%	02/11/1999, 29/11/2000, 01/08/2007, 07/01/2009, 29/07/2009, 21/02/2011, 23/02/2017	PLWN

MAW1	-67.6	62.87	8/01/1995	31/12/2021	93%	24/08/1999, 07/12/2004, 25/12/2006, 07/01/2009, 27/02/2018, 02/03/2020	GGMWN
MAJK	-81.66	-21.87	20/01/2018	31/12/2021	98%	19/12/2018	GGMWN
SGP1	-65.56	-61.72	28/02/2019	31/12/2021	95%	None	GGMWN
MBIO	-64.24	-56.62	14/02/2013	31/12/2021	96%	19/11/2013	PLWN
ARHT	-77.83	166.66	8/03/2018	31/12/2021	90%	None	GGMWN
SGP5	-67.28	-64.89	3/12/2018	31/12/2021	91%	None	GGMWN
SPRZ	-63.4	-57	2/10/2016	31/12/2021	87%	19/03/2019	GGMWN
OHIG	-63.32	-57.9	11/03/1995	18/02/2002	70%	14/02/2000	GGMWN
OHI2	-63.32	-57.9	14/02/2002	31/12/2021	83%	23/02/2003, 12/11/2001, 30/01/2009, 02/03/2014, 02/06/2021	PLWN
DAL5	-62.24	-58.68	3/08/2017	31/12/2021	98%	None	PLWN
THRO	-79.13	-28.32	16/01/2018	8/08/2021	97%	22/01/2019	GGMWN
SUGG	-75.28	-72.18	20/11/2011	31/01/2019	98%	25/12/2014, 25/12/2016	GGMWN
GLDK	-72.23	-100.59	28/12/2018	31/12/2021	82%	31/12/2019	GGMWN
MRTP	-74.18	-115.1	16/12/2018	31/12/2021	94%	None	GGMWN
SGP4	-66.69	-62.46	20/12/2018	31/12/2021	80%	None	GGMWN

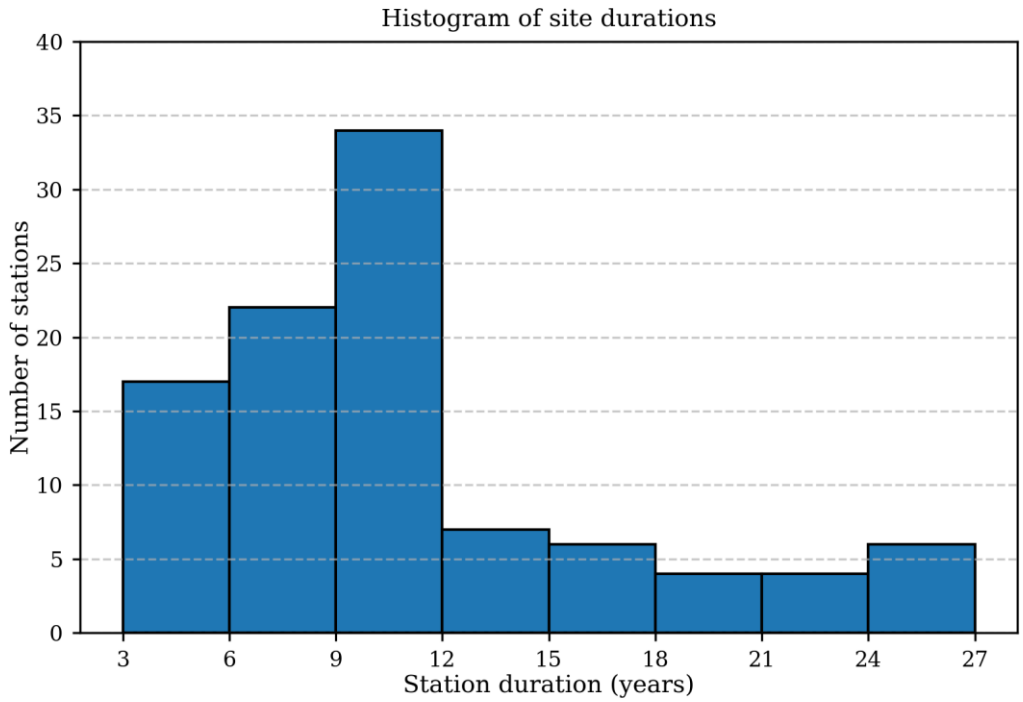
Histogram of site durations
Number of stations
Station duration (years)
0
5
10
15
20
25
30
35
40
3
6
9
12
15
18
21
24
27

Figure S1: Histogram of site duration, considered for this study as shown with brown circles in Figure 2.

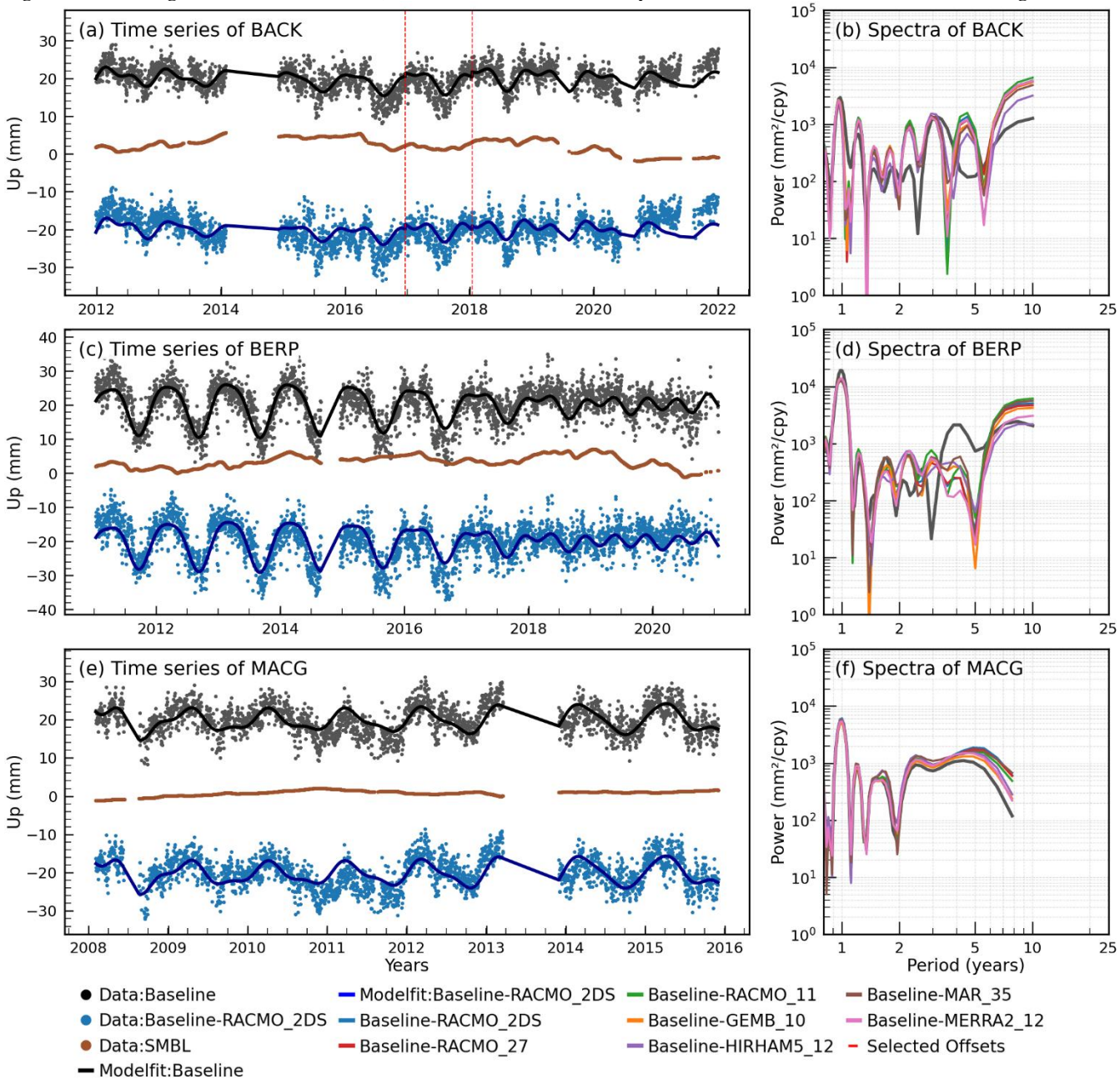

Figure S2: (Left Panels) Detrended vertical GPS time series for the stations BACK (a), BERP (c) and MACG (e). Gray dots correspond to detrended REGAIN vertical time series corrected for NTOL (REGAIN-NTOL; baseline) and vertically offset by +20 mm for visual clarity. Brown dots represent detrended SMBL time series from RACMO_2DS model and the blue dots correspond to the resulting time series after applying the SMBL correction (REGAIN-NTOL-SMBL), vertically offset by –20 mm. Solid blue and black lines show the linear models estimated before (offset by +20 mm) and after (offset by -20 mm) SMBL correction, respectively. Red dashed lines mark the dates of identified offsets. The time series in panels (a), (c) and (e) span different observation periods. (Right Panels) Lomb-Scargle spectra for stations BACK (b) and BERP (d) and MACG (f).

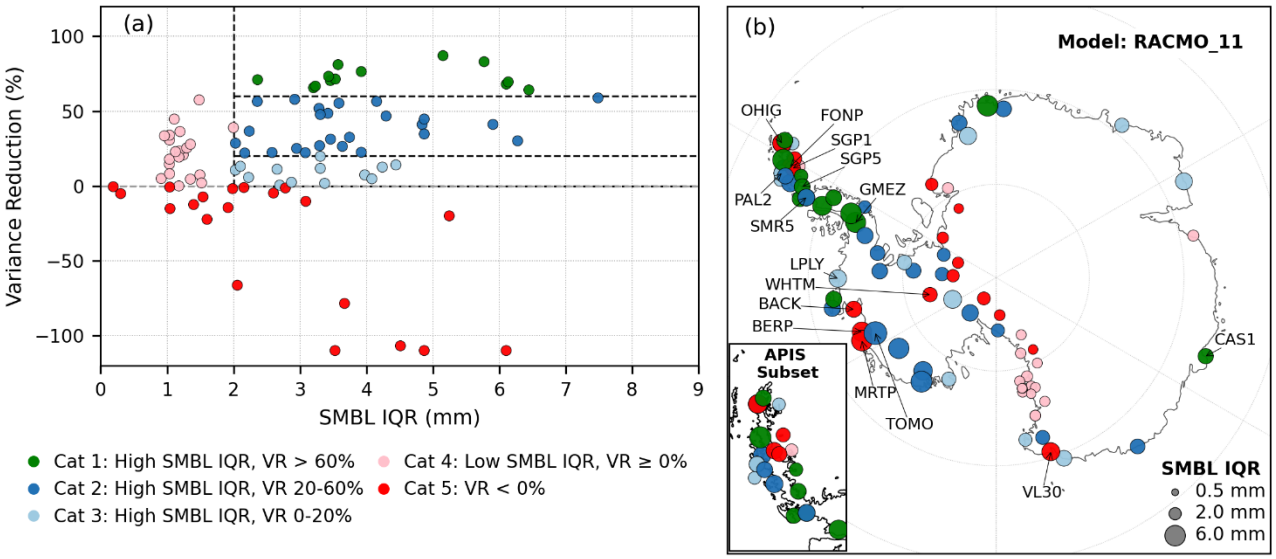

Figure S3: (a) Variance reduction at GPS stations as a function of SMBL IQR, for RACMO_11 model. Colours reflect categorisation into five categories based on SMBL IQR and variance reduction of the model. (b) GPS sites with colours reflecting the same categories as in a) and symbol sizes reflecting SMBL IQR. GPS site names discussed in the text are annotated.

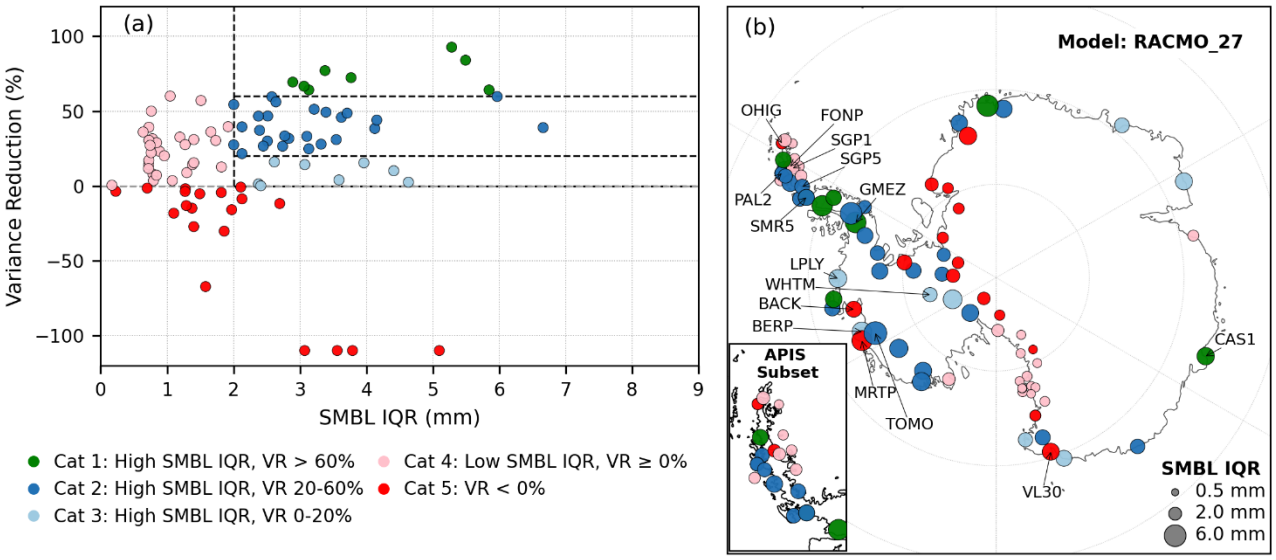

Figure S4: (a) Variance reduction at GPS stations as a function of SMBL IQR, for RACMO_27 model. Colours reflect categorisation into five categories based on SMBL IQR and variance reduction of the model. (b) GPS sites with colours reflecting the same categories as in a) and symbol sizes reflecting SMBL IQR. GPS site names discussed in the text are annotated.

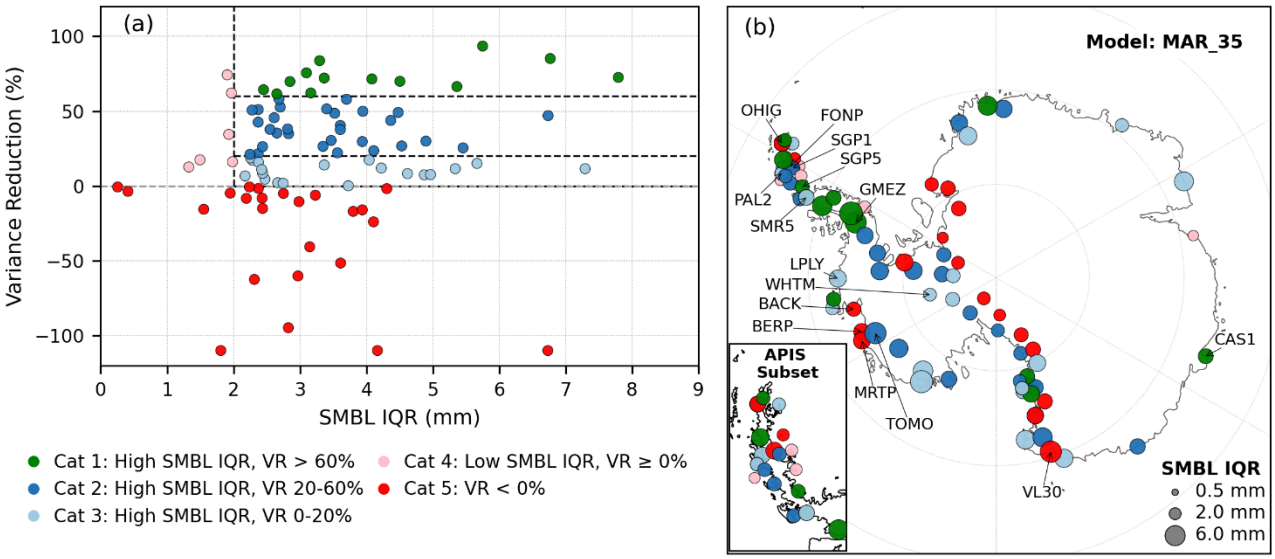

Figure S5: (a) Variance reduction at GPS stations as a function of SMBL IQR, for MAR_35 model. Colours reflect categorisation into five categories based on SMBL IQR and variance reduction of the model. (b) GPS sites with colours reflecting the same categories as in a) and symbol sizes reflecting SMBL IQR. GPS site names discussed in the text are annotated.

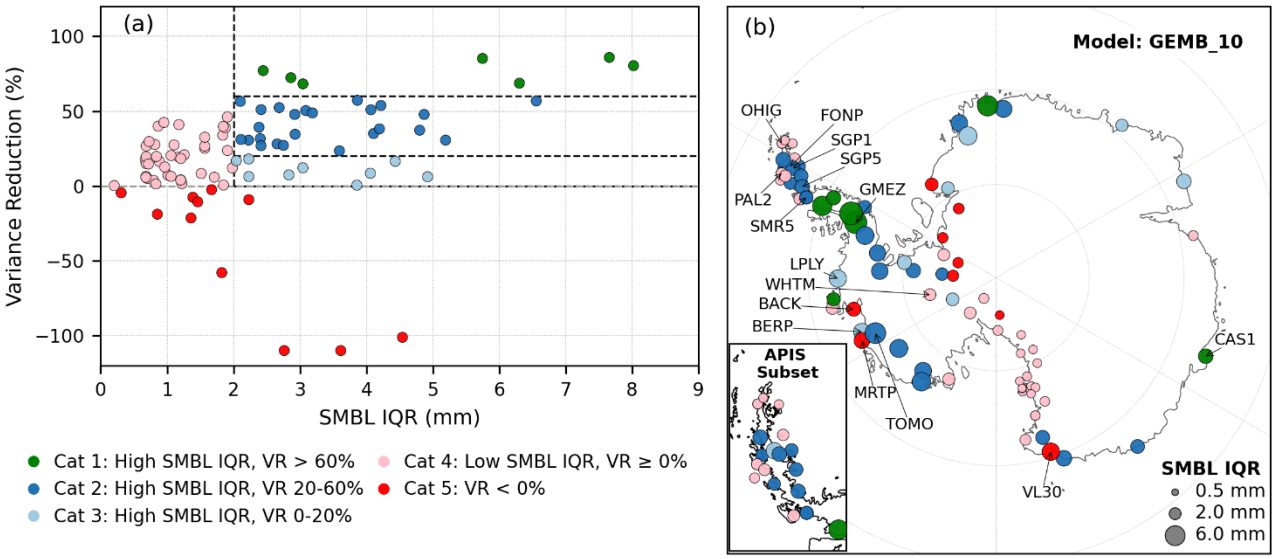

Figure S6: (a) Variance reduction at GPS stations as a function of SMBL IQR, for GEMB_10 model. Colours reflect categorisation into five categories based on SMBL IQR and variance reduction of the model. (b) GPS sites with colours reflecting the same categories as in a) and symbol sizes reflecting SMBL IQR. GPS site names discussed in the text are annotated.

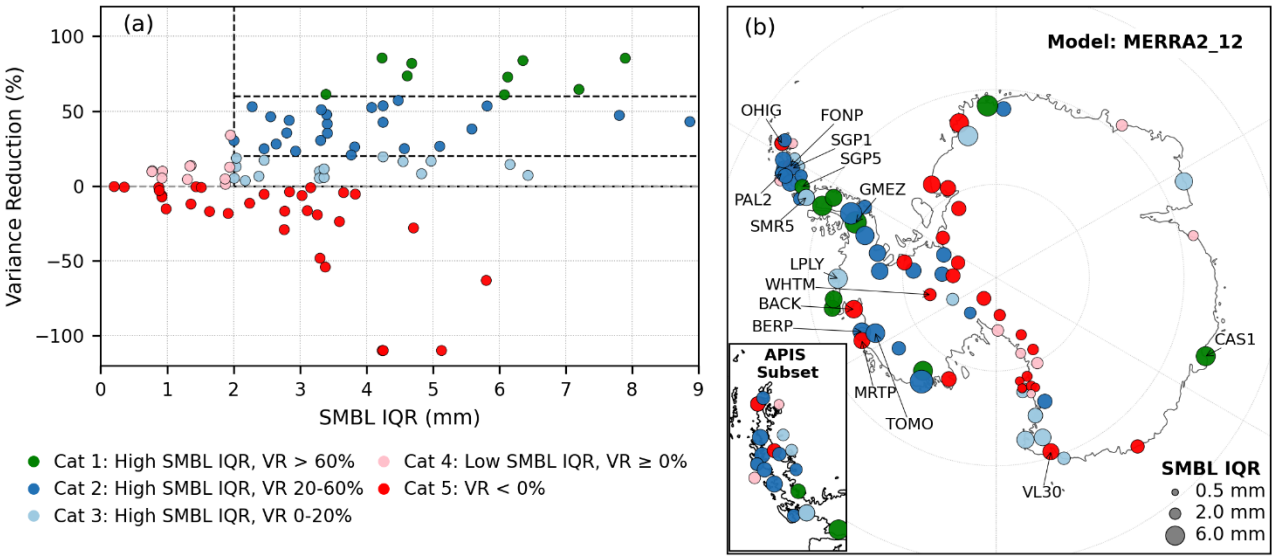

Figure S7: (a) Variance reduction at GPS stations as a function of SMBL IQR, for MERRA2_12 model. Colours reflect categorisation into five categories based on SMBL IQR and variance reduction of the model. (b) GPS sites with colours reflecting the same categories as in a) and symbol sizes reflecting SMBL IQR. GPS site names discussed in the text are annotated.

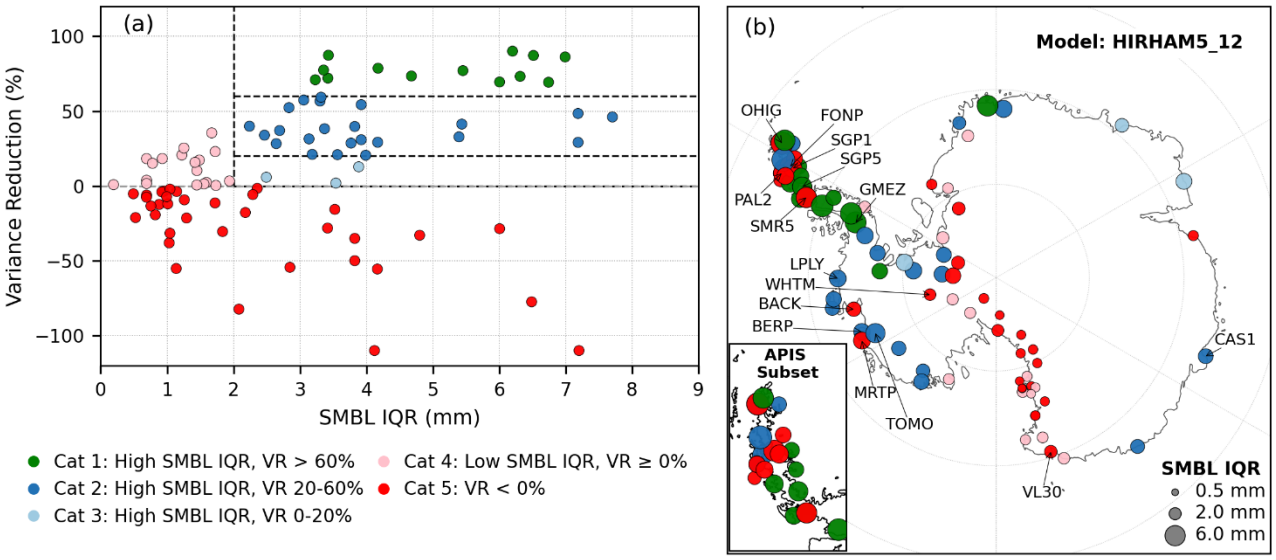

Figure S8: (a) Variance reduction at GPS stations as a function of SMBL IQR, for HIRHAM5_12 model. Colours reflect categorisation into five categories based on SMBL IQR and variance reduction of the model. (b) GPS sites with colours reflecting the same categories as in a) and symbol sizes reflecting SMBL IQR. GPS site names discussed in the text are annotated.

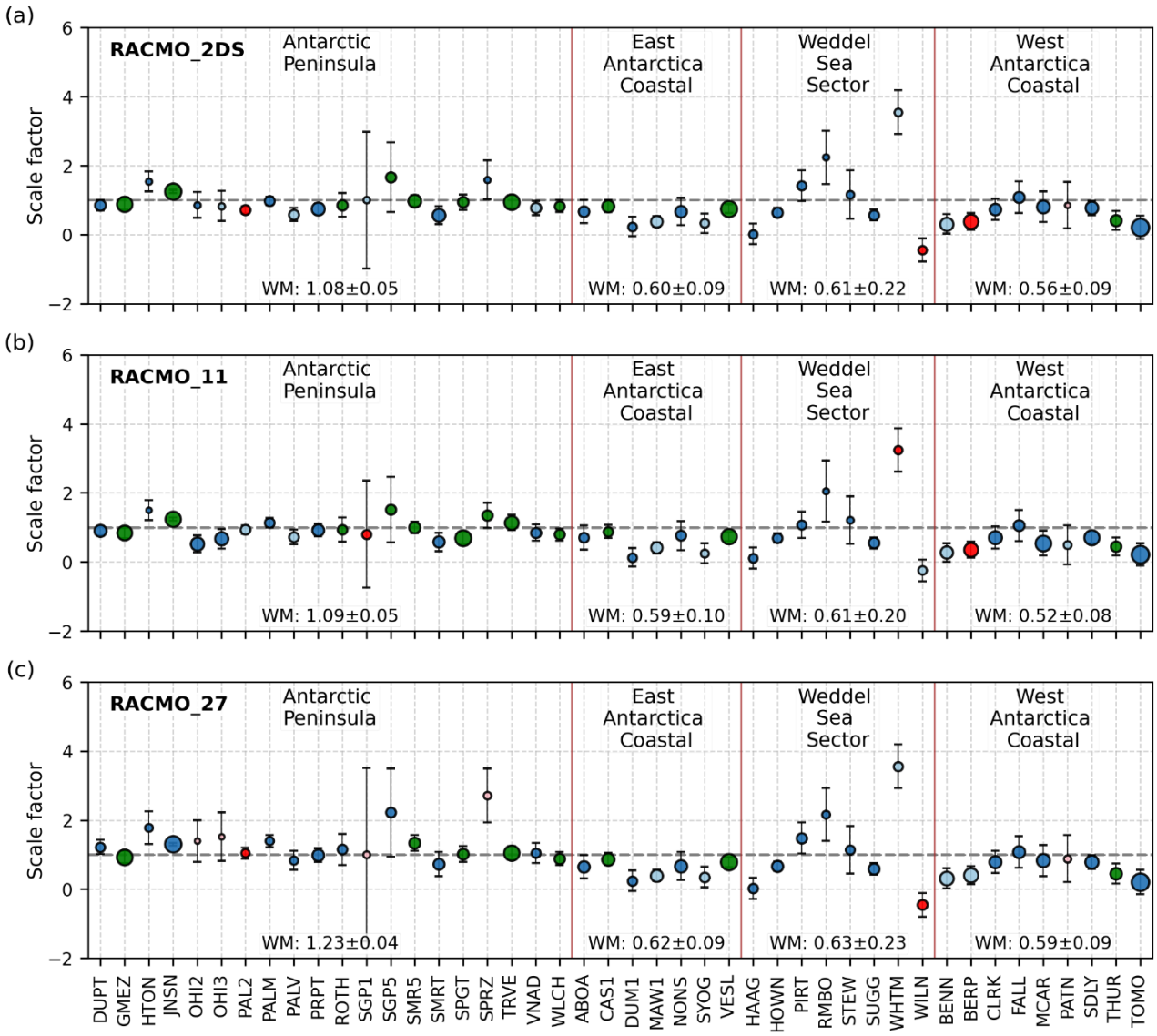

Figure S9: Scale factors and associated uncertainty for (a) RACMO_2DS (b) RACMO_11 and (c) RACMO_27 models grouped by geographical region. The size of the markers indicates the respective SMBL IQR and the colours indicates the categories of the sites as in Figure 5. Error bars indicate a 1-sigma uncertainty. The horizontal dashed line marks a scale of 1.

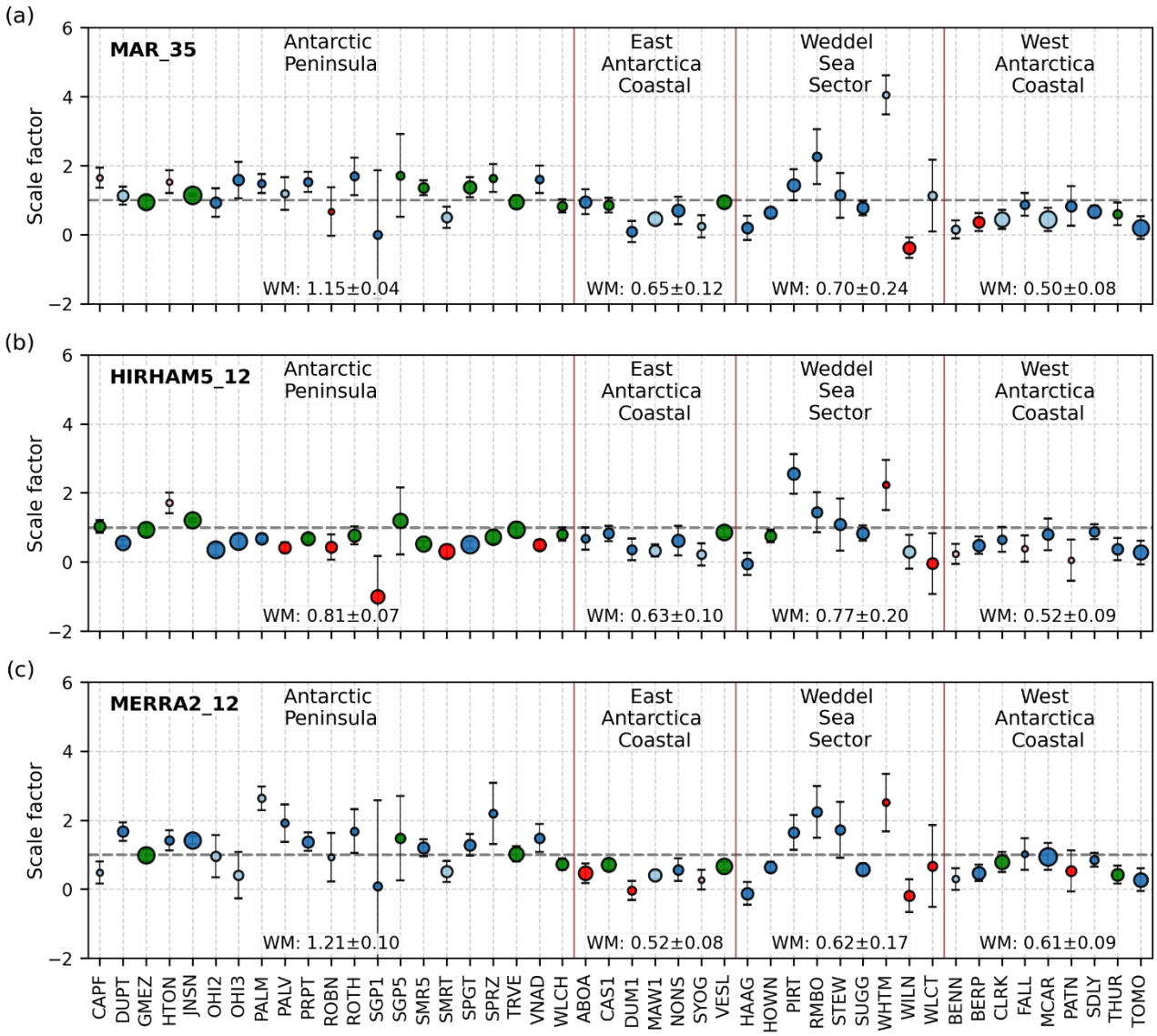

Figure S10: Scale factors and associated uncertainty for (a) MAR_35, (b) HIRHAM5_12 and (c) MERRA2_12 models grouped by geographical region. The size of the markers indicates the respective SMBL IQR and the colours indicates the categories of the stations as in Figure 5. Error bars indicate a 1-sigma uncertainty. The horizontal dashed line marks a scale of 1.

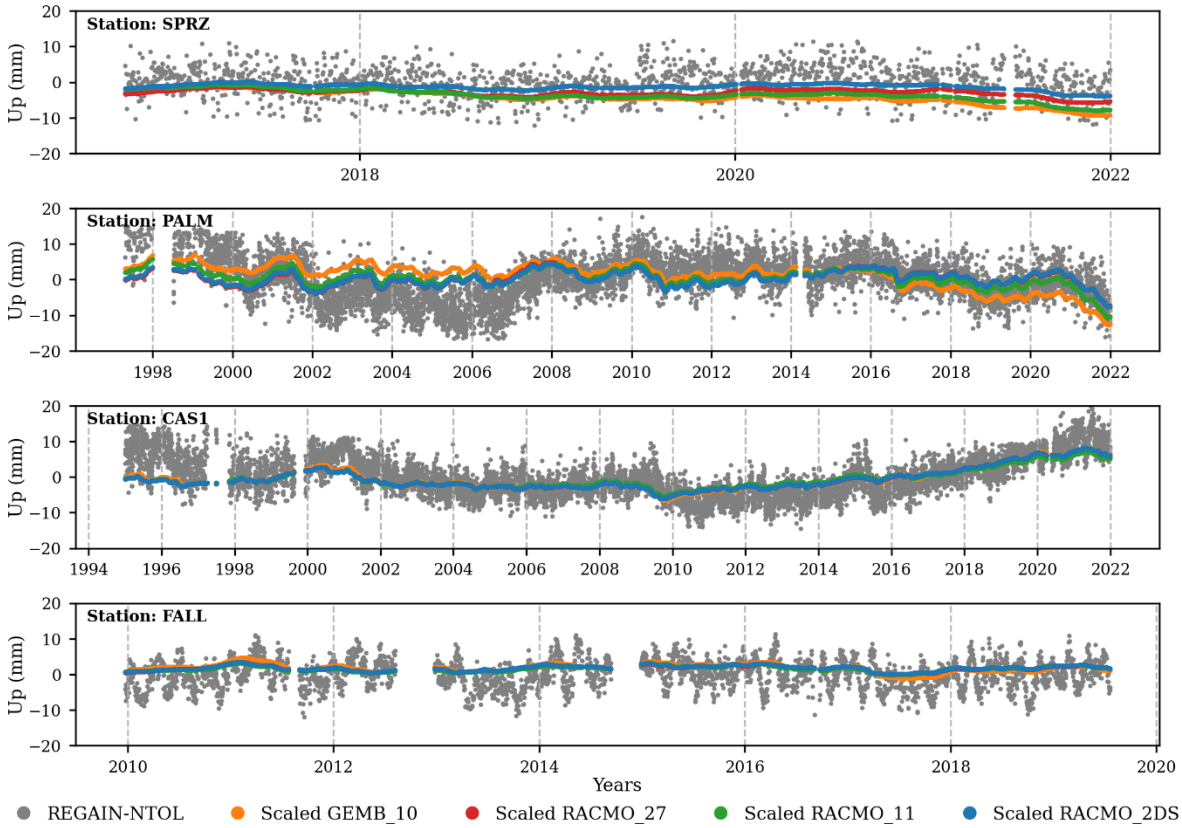

Figure S11: Comparison between detrended scaled SMBL time series with detrended REGAIN-NTOL time series. Grey dots show the detrended REGAIN-NTOL vertical timeseries in all panes. Panels (a-d) correspond to stations SPRZ, PALM, CAS1 and FALL respectively and show detrended vertical SMBL time series from GEMB_10 (orange), RACMO_27 (red), RACMO_11 (green) and RACMO_2DS (red).

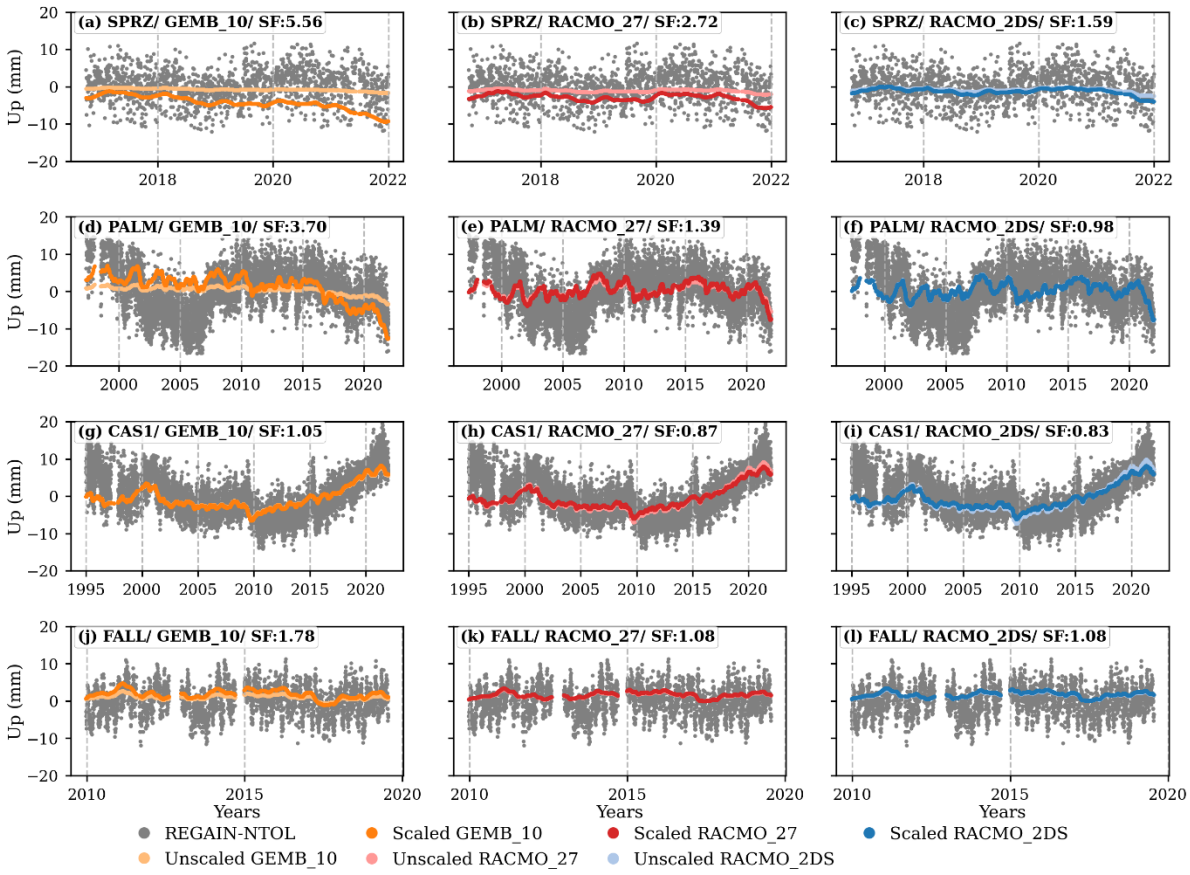

Figure S12: Comparison between detrended SMBL time series and their scaled counterparts with the REGAIN-NTOL time series. Grey dots show the detrended REGAIN-NTOL vertical timeseries in all panes. Panels (a-c), (d-f), (g-i) and (j-l) corresponds to stations SPRZ, PALM, CAS1 and FALL, respectively, and show unscaled (light-coloured dots) and scaled SMBL (dark-coloured dots) from GEMB_10 (orange), RACMO_27 (red) and RACMO_2DS (blue).