Figure S 1. Cumulated surface melt production (Gt) for the 2020-2021 melt season as modeled by MAR without assimilation (MAR_{ref} in light red), with data assimilation ($Assim_{member}$ in dashed lines), and their averaged value ($Assim_{mean}$ in blue). Shaded areas represent the range of the assimilations.
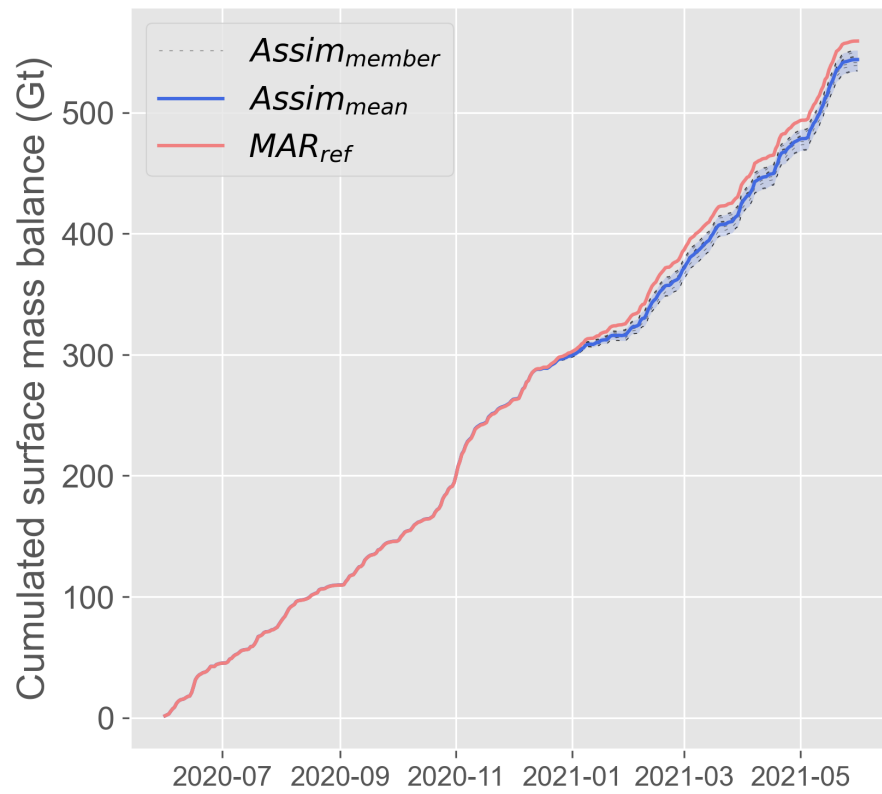
Figure S 2. Cumulated surface mass balance (Gt) for 2020-2021 melt season as modeled by MAR without assimilation (MAR_{ref} in red), with data assimilation ($Assim_{member}$ in dashed lines), and their averaged value ($Assim_{mean}$ in blue). Shaded areas represent the range of the assimilations.
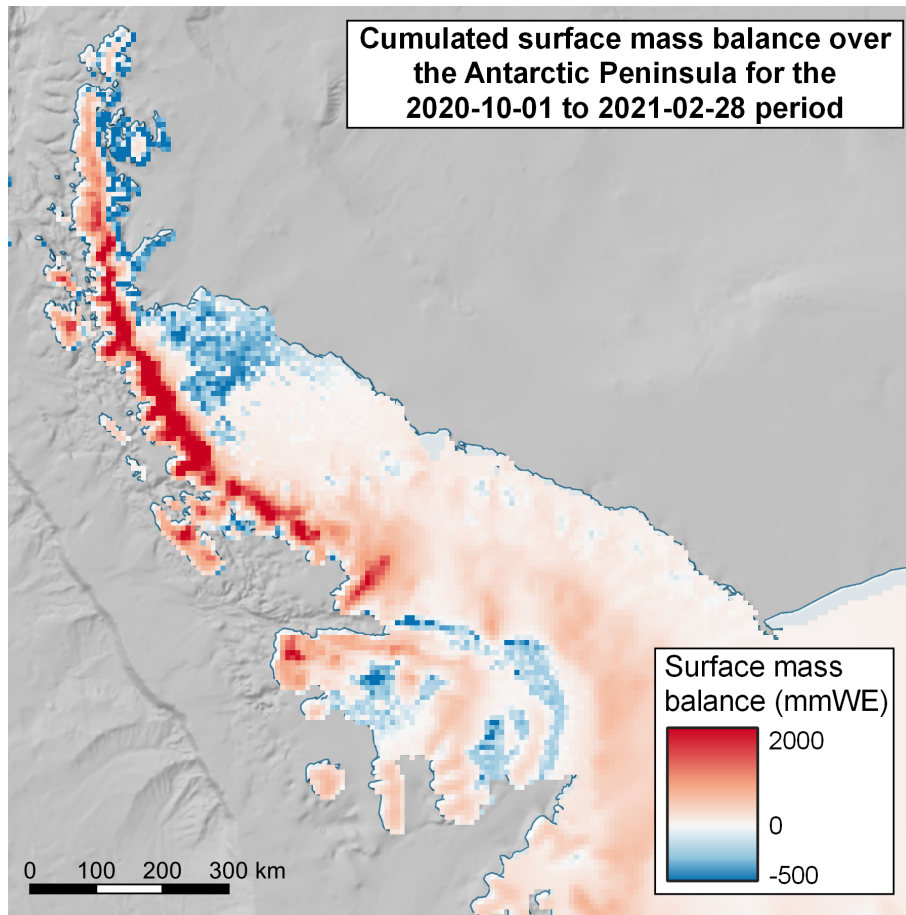
Figure S 3. Cumulated SMB (mmWE) from 2020-10-01 to 2021-02-28 over the AP as modeled by $Assim_{ref}$. Larsen C is outlined in purple, Georges VI in green, and Wilkins in red. The ice shelves and the northernmost coastlines are experiencing a decrease in SMB in opposition to the rest of the AP.
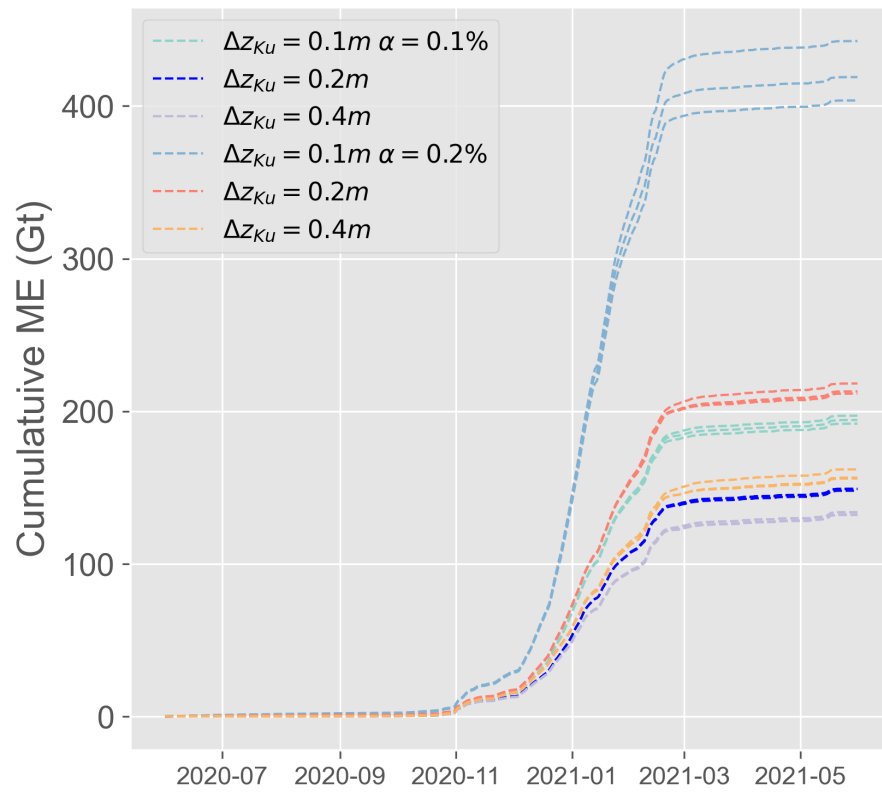
Figure S 4. Cumulated surface melt production (Gt) for 2020-2021 melt season as modeled by the different assimilation. Curves of the same color have different Δ_z for the C-band sensors.
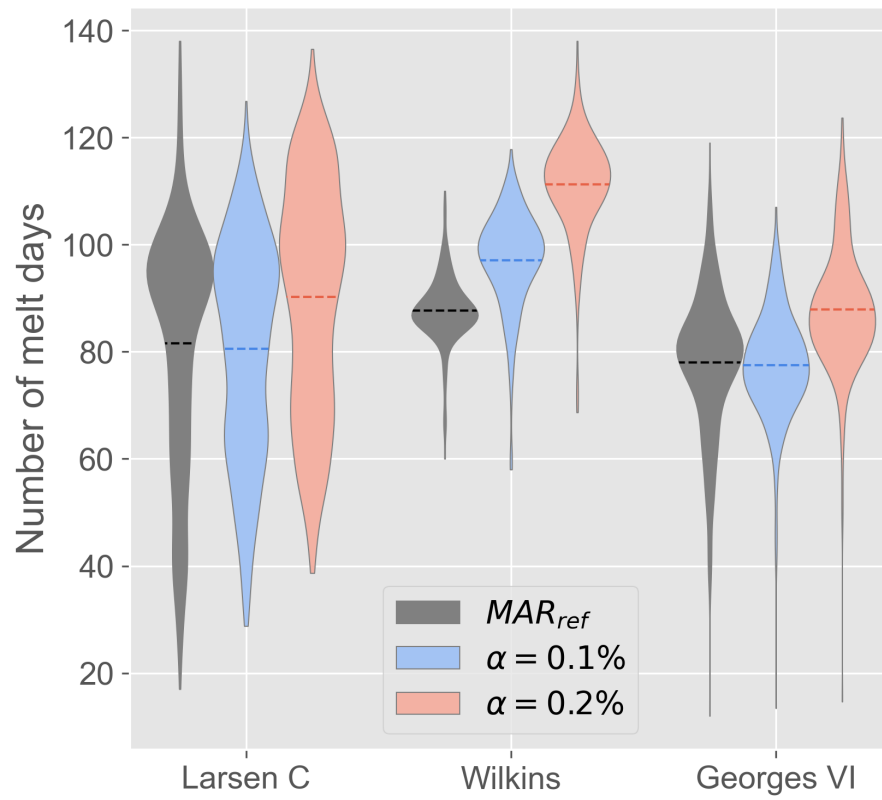
Figure S 5. Distribution of the number of melt days fot the 2020-2021 melt season as modeled by MAR_{ref} and the assimilations for the two values of α for the three studied ice shelves. Dashed lines represent the mean value of the distribution.
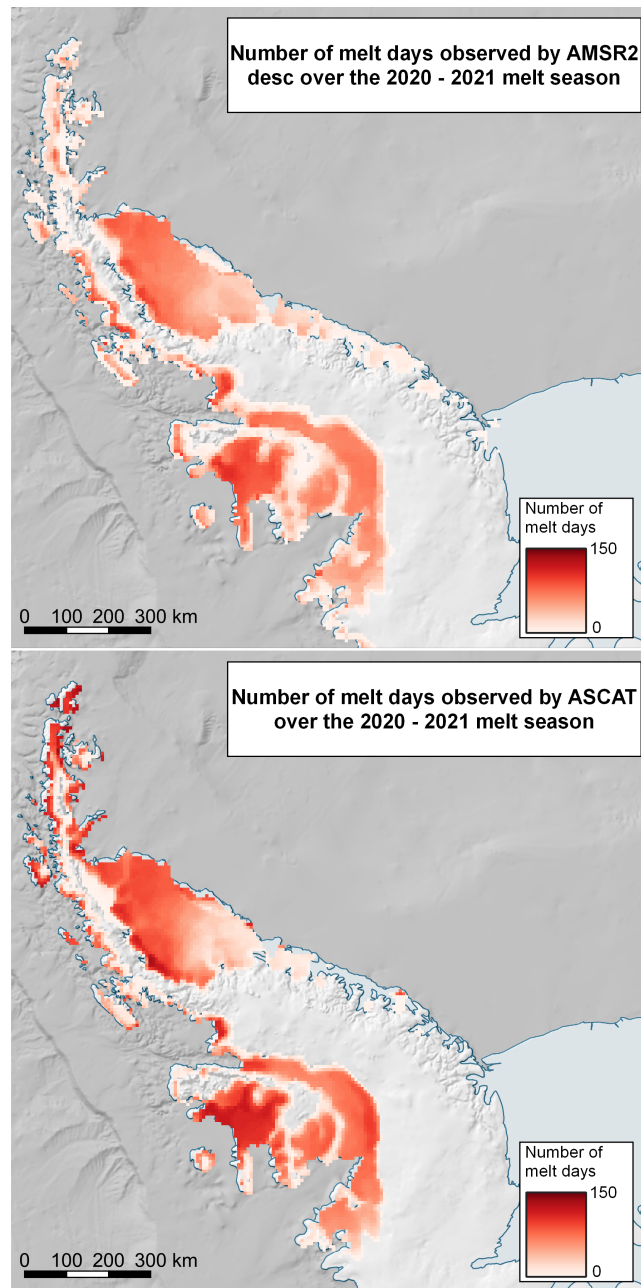
Figure S 6. a) Number of melt days observed by AMSR2 on the AP for the 2020-2021 melt season. b) Number of melt days observed by ASCAT on the AP for the 2019-2020 melt season.
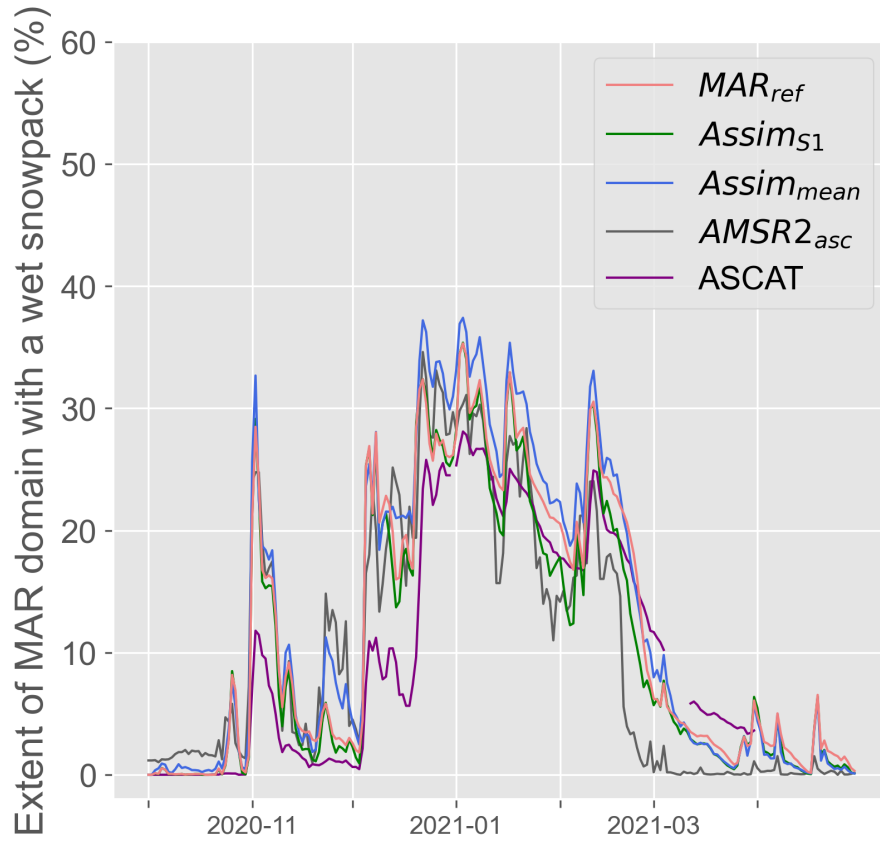
Figure S 7. Evolution of the surface melt extent during the 2020-2021 melt season as modeled by MAR_{ref} (in light red), $Assim_{mean}$ (in blue), the assimilation of only S1 melt mask ($Assim_{S1}$, in green), and as observed by AMSR2 in ascending orbit (in grey), and by ASCAT (in purple).

Table S 1. Surface mass balance (SMB), and average snowpack density (ρ) and snowpack liquid water content (LWC) for MAR_{ref}, the reference assimilation ($Assim_{ref}$) and the mean value of the assimilations ($Assim_{mean}$) over the Antarctic Peninsula for the 2020-2021 melt season. The range comprises all 19 assimilations. LWC and ρ are taken at a depth of 0.2 m and 1 m while the other variable are given as a snowpack cumulated value.

	ME (Gt yr^{-1})	RU (Gt yr^{-1})	SMB (Gt yr^{-1})	$\rho_{0.2m}$ (kgm^{-3})	ρ_{1m} (kgm^{-3})	$LWC_{0.2m}$ (kgkg^{-1})	LWC_{1m} (kgkg^{-1})
MAR_{ref}	111	36	559	429	432	0.003	0.003
$Assim_{ref}$	149	49	546	447	450	0.002	0.003
$Assim_{mean}$	168	52	544	448	452	0.002	0.003
Range	132 - 218	44 - 61	534 - 551	442 - 452	446 - 457	0.002 - 0.003	0.002- 0.004
Evolution (%)	51.1	43.7	-2.7	4.3	4.4	-17.8	-18

Table S 2. Evolution of surface melt production (ME), runoff (Ru), surface mass balance (SMB), snowpack density (ρ), and snowpack liquid water content (LWC) for MAR_{ref}, the reference assimilation ($Assim_{ref}$) and the mean value of the assimilations ($Assim_{mean}$) over the 3 studied ice shelves for the 2020-2021 melt season. LWC and ρ are given at a depth of 0.2 m and 1 m while the other variable are given as a snowpack average value.

Larsen C	ME (Gt yr^{-1})	RU (Gt yr^{-1})	SMB (Gt yr^{-1})	$\rho_{0.2m}$ (kg m^{-3})	ρ_{1m} (kg m^{-3})	$LWC_{0.2m}$ (kg kg^{-1})	LWC_{1m} (kg kg^{-1})
MAR	30	5.7	20	605	595	0.0006	0.0008
$Assim_{ref}$	41	9.2	16	625	633	0.0005	0.0007
$Assim_{mean}$	47	11	14	629	639	0.0005	0.0007
σ	11	1.5	1.1	111	41	0.0005	0.0006
Wilkins	ME (Gt yr^{-1})	RU (Gt yr^{-1})	SMB (Gt yr^{-1})	$\rho_{0.2m}$ (kg m^{-3})	ρ_{1m} (kg m^{-3})	$LWC_{0.2m}$ (kg kg^{-1})	LWC_{1m} (kg kg^{-1})
MAR	5.9	1.4	5.8	564	605	0.0002	0.0002
$Assim_{ref}$	8.6	3.7	3.5	626	675	0.0002	0.0002
$Assim_{mean}$	10	4.1	3.1	634	678	0.0002	0.0002
σ	2.7	1.4	1.4	82	80	0.0002	0.0002
Georges VI	ME (Gt yr^{-1})	RU (Gt yr^{-1})	SMB (Gt yr^{-1})	$\rho_{0.2m}$ (kg m^{-3})	ρ_{1m} (kg m^{-3})	$LWC_{0.2m}$ (kg kg^{-1})	LWC_{1m} (kg kg^{-1})
MAR	10	1.9	11	592	590	0.0003	0.0004
$Assim_{ref}$	13	3.4	10	624	627	0.0003	0.0004
$Assim_{mean}$	15	3.5	10	620	621	0.0003	0.0004
σ	3.2	3.5	0.7	87	66	0.0003	0.0003

Table S 3. Comparison between the melt season length and number of melt days modeled for the three studied ice shelves for MAR_{ref} and the assimilations for the 2020-2021 melt season.

Larsen C	Melt season length (days)	Number of melt days modeled
MAR_{ref}	209	113
$\alpha = 0.1\ \%$	208	116
$\alpha = 0.2\ \%$	209	127
Wilkins	Melt season length (days)	Number of melt days modeled
MAR_{ref}	200	99
$\alpha = 0.1\ \%$	201	119
$\alpha = 0.2\ \%$	207	132
Georges VI	Melt season length (days)	Number of melt days modeled
MAR_{ref}	200	98
$\alpha = 0.1\ \%$	200	95
$\alpha = 0.2\ \%$	200	113