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Clouds drive differences in future surface melt over the Antarctic ice shelves

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S1 Comparison of MAR cloud properties with Cloudsat-Calipso

We provide a comparison of the mean summer Liquid Water Path (Fig.S1) and Ice Water Path (Fig.S2) from MAR and Cloudsat-Calipso (Van Tricht et al., 2016; Lenaerts et al., 2017) over 2010–2016. Due to the difference in grid resolution (2° for the CloudSat-Calipso product vs 35km for MAR), we compared each product on its own grid as interpolating one product on the other grid would increase the uncertainties.

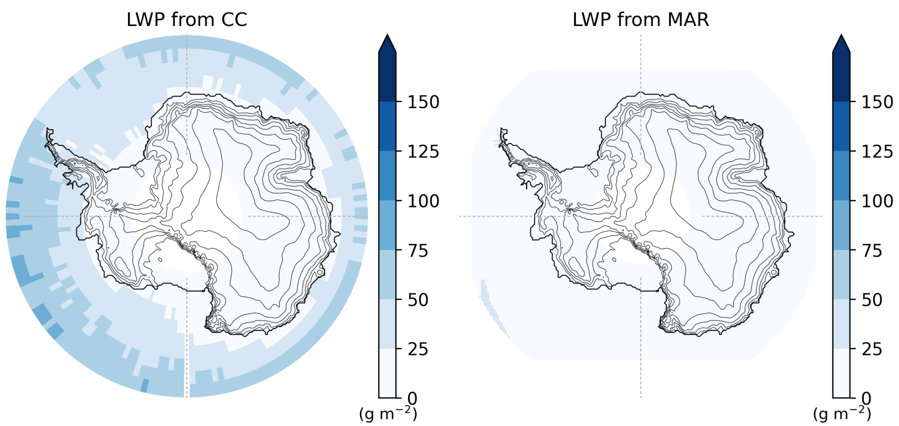

Figure S1. Mean summer Liquid Water Path ($g\,m^{-2}$) over 2010–2016 deduced from Cloudsat-Calipso profiles (left) and simulated by MAR (right).

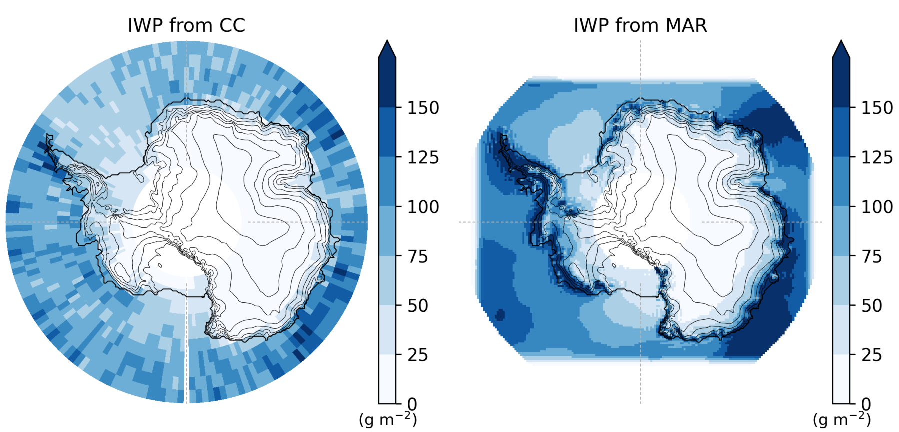

Figure S2. Mean summer Ice Water Path ($g\,m^{-2}$), computed as the sum of both ice and snow particles over 2010–2016 deduced from Cloudsat-Calipso profiles (left) and simulated by MAR (right).

S2 Projected cloud cover changes

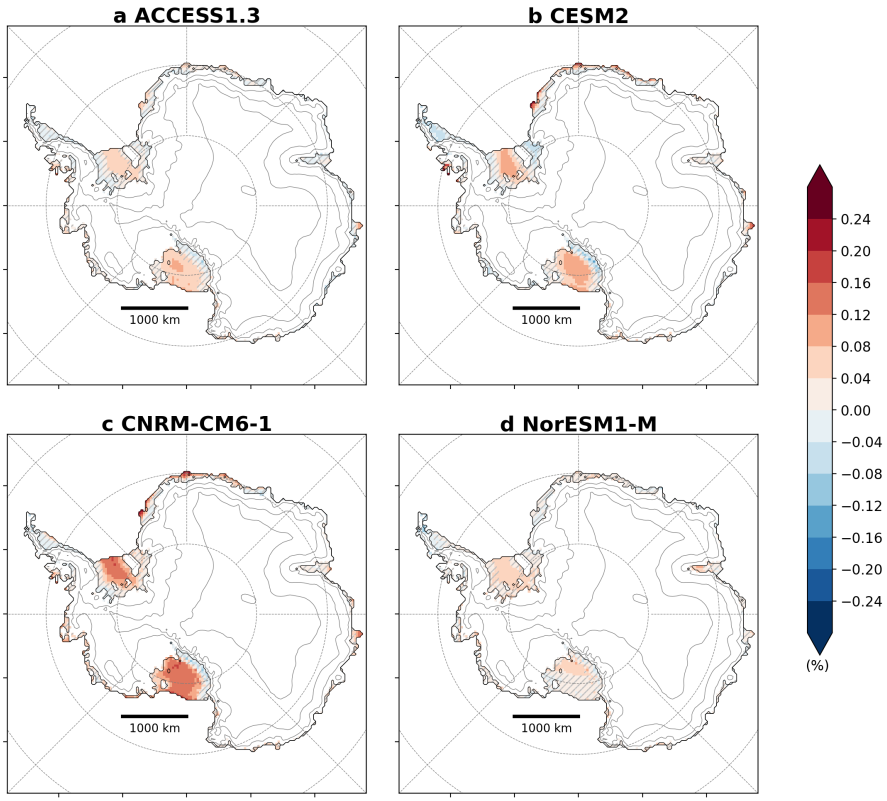

Figure S3. Summer CC changes (%) in 2071–2100 compared to 1981–2010 projected by MAR driven by ACCESS1.3 (a), NorESM1-M(b), CNRM-CM6-1 (c), and CESM2 (d). Changes lower than the present variability (standard deviation) are hatched.

S3 Projected albedo changes

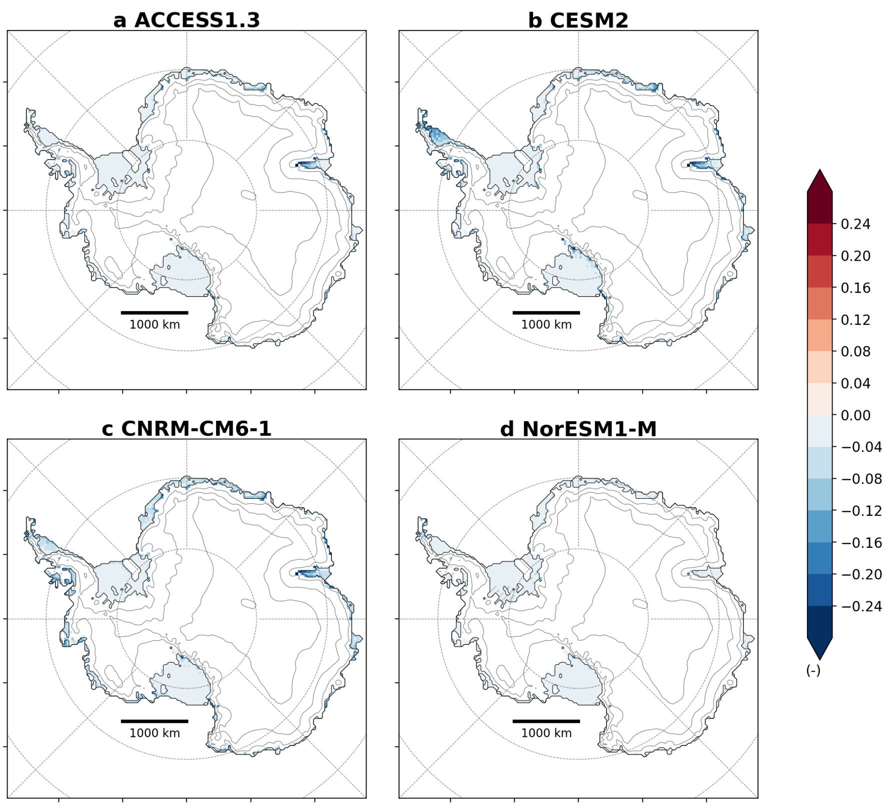

Figure S4. Summer albedo changes (-) in 2071–2100 compared to 1981–2010 projected by MAR driven by ACCESS1.3 (a), NorESM1-M(b), CNRM-CM6-1 (c), and CESM2 (d). Changes lower than the present variability (standard deviation) are hatched.

S4 Maximal contribution of summer atmospheric temperature to LWD increase over the ice shelves of the West Antarctic Sector

Estimation of the maximal contribution of summer atmospheric temperature approximating the atmosphere as a longwave-opaque and black body (ε = 1) in Eq. 1:

$$LWDT = \varepsilon \times \sigma \times T^4, \tag{1}$$

Table S1. Near-surface temperature over 1981–2010 ($^\circ$C) (first column), over 2071–2100 Mean ($^\circ$C) (second column), increase in longwave downwelling radiation attributed to the increase in near-surface temperature ($\mathrm{W\,m^{-2}}$) (third column) and simulated (fourth column) by MAR driven by ACCESS1.3, CESM2, CNRM-CM6-1, NorESM1-M in 2071–2100 compared to 1981–2010.

ESM	$TT_{1981--2010}$ ($^\circ$C)	$TT_{2071--2100}$ ($^\circ$C)	$\Delta LWDT$ ($\mathrm{W\,m^{-2}}$)	ΔLWD ($\mathrm{W\,m^{-2}}$)
ACCESS1.3	-10.3	-5.4	+20.7	+26.9
CESM2	-10.4	-4.3	+26.0	+32.4
CNRM-CM6-1	-10.3	-3.7	+28.2	+39.5
NorESM1-M	-10.7	-7.3	+14.2	+19.6

S5 Future mean (vertical) changes over the ice shelves of the west Antarctic sector in 2071–2100

Table S2. Changes in summer near-surface air temperature ($^{\circ}$C), atmospheric specific humidity ($\mathrm{g\,g^{-1}}$) and temperature ($^{\circ}$C) between 925 hPa and 200 hPa in 2071-2100 compared to 1981-2010 as projected by MAR driven by ACCESS1.3, CESM2, CNRM-CM6-1, NorESM1-M.

ESM	$\Delta Near-Surface\,air\,Temperature$ ($^{\circ}$C)	$\Delta Specific\,Humidity$ ($\mathrm{g\,kg^{-1}}$)	$\Delta Air\,Temperature$ ($^{\circ}$C)
ACCESS1.3	+4.9	+0.32	+2.5
CESM2	+6.1	+0.50	+4.0
CNRM-CM6-1	+6.6	+0.48	+3.6
NorESM1-M	+3.4	+0.22	+1.8

S6 Changes in humidity projected by the forcing ESMs

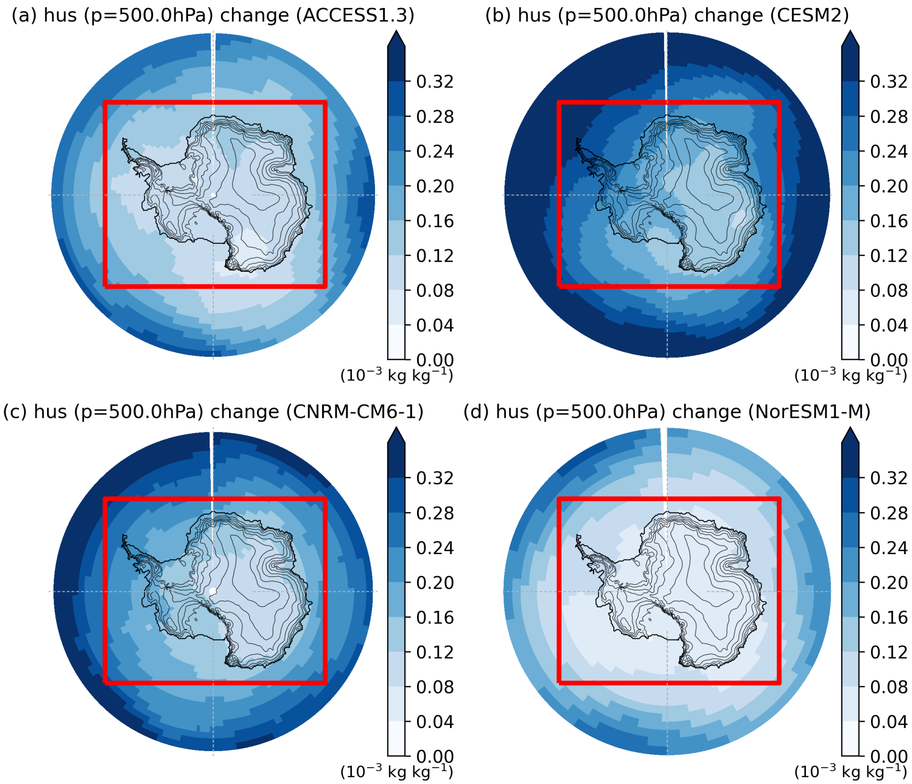

Figure S5. Humidity change ($\mathrm{kg\,kg^{-1}}$) at 500hPa projected by the ESMs over 2071-2100 compared to 1981-2010. The red box corresponds to the MAR domain.

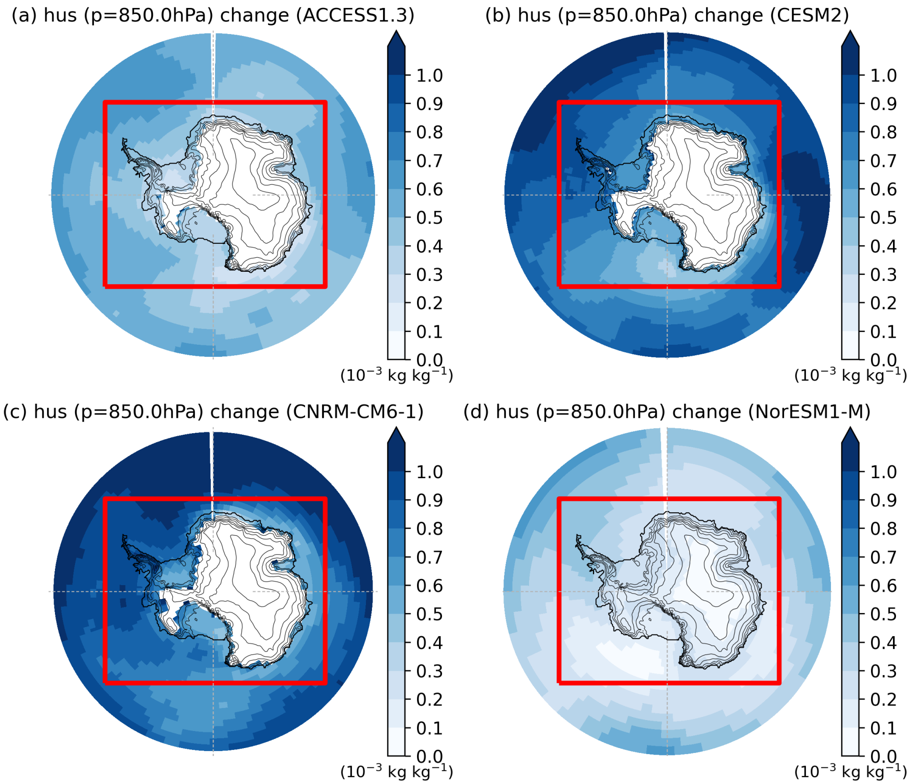

Figure S6. Humidity change ($\mathrm{kg\,kg^{-1}}$) at 850hPa projected by the ESMs over 2071-2100 compared to 1981-2010. The red box corresponds to the MAR domain.

References

Lenaerts, J. T., Van Tricht, K., Lhermitte, S., and L'Ecuyer, T. S.: Polar clouds and radiation in satellite observations, reanalyses, and climate models, Geophysical Research Letters, 44, 3355–3364, 2017.

Van Tricht, K., Lhermitte, S., Lenaerts, J. T., Gorodetskaya, I. V., L'Ecuyer, T. S., Noël, B., van den Broeke, M. R., Turner, D. D., and van Lipzig, N. P.: Clouds enhance Greenland ice sheet meltwater runoff, Nature communications, 7, 1–9, 2016.