Supplement to Brief Communication: annual large-scale atmospheric circulation reconstructed from a data assimilation framework cannot explain local East Antarctic ice rises' surface mass balance records

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S1 Observation error for ice core SMB

Table S1 details the observation error for each ice rise site for the ice-core based reconstruction. The observation error is a combination of the instrumental error based on the reported ice core uncertainties and the representativeness error obtained from the co-located radar constraints.

Table S1. Observation error determined from the ice core instrumental error and the representativeness error calculated from the co-located radar data for each ice rise site.

Site	ice core ($cm\ w.e.\ yr^{-1}$)		
	instrumental error	representativeness error	observational error
De	2.3	2.3	3.2
Lo	0.8	7.6	7.6
Ha	1.0	2.3	2.5
Le	1.4	2.3	2.7
Dj	1.3	6.2	6.3
KM	2.2	8.7	9.0
KC	0.7	2.3	2.4
BI	2.4	1.2	2.7

5 S2 Observation error for radar-derived SMB

To assess whether the reconstruction is influenced by the local noise at the ice core site, we assimilate the radar-derived SMB described in Cavitte et al. (2023) as a pointwise SMB record calculated as the spatial mean of the entire radar survey for each ice rise, with the associated observation errors (Supplementary Table S2). The observation error is combination of the instrumental error based on the radar uncertainties and the representativeness error (Cavitte et al., 2023) which is the same as 10 for the ice core time series. The model ensemble used as a prior remains unchanged.

Table S2. Observation error determined from the radar instrumental error and the representativeness error calculated from the co-located ice core and radar data for each ice rise site.

Site	radar (cm $w.e.$ yr^{-1})		
	instrumental error	representativeness error	observation error
De	1.2	2.3	2.6
Lo	2.1	7.6	7.9
Ha	0.8	2.3	2.4
Le	1.8	2.3	2.9
Dj	1.4	6.2	6.4
KM	1.9	8.7	8.9
KC	0.7	2.3	2.4
BI	1.2	1.2	1.7

To compare this radar-derived SMB record directly to the ice core SMB records, we interpolate the radar multi-annual SMB records onto an annual timescale, keeping the SMB constant between pairs of isochrones, resulting in a step-wise SMB record. There is therefore a bias by construction when assimilating a step-wise radar record with an annually resolved model ensemble which is not assessed here.

15 Supplementary Fig. S1 shows the results of this reconstruction. We obtain strong correlations between the radar records and the reconstruction (correlation values ≥ 0.5 ad p-value ≤ 0.05). However, these results must be taken carefully as in some cases, e.g. BI ice rise, correlations are certainly overestimated due to the low number of time intervals. Correlation of the reconstruction with RACMO2.3p is much weaker, as for the ice-core based reconstructions. The spatial correlation of the reconstruction with RACMO2.3p is much more variable than that obtained from the ice cores (Supplementary Fig. S1). Again, 20 the strength of the correlation should be interpreted carefully as it is dependent on the number of time intervals captured in the radar-derived SMB record and makes it difficult to inter-compare ice rises.
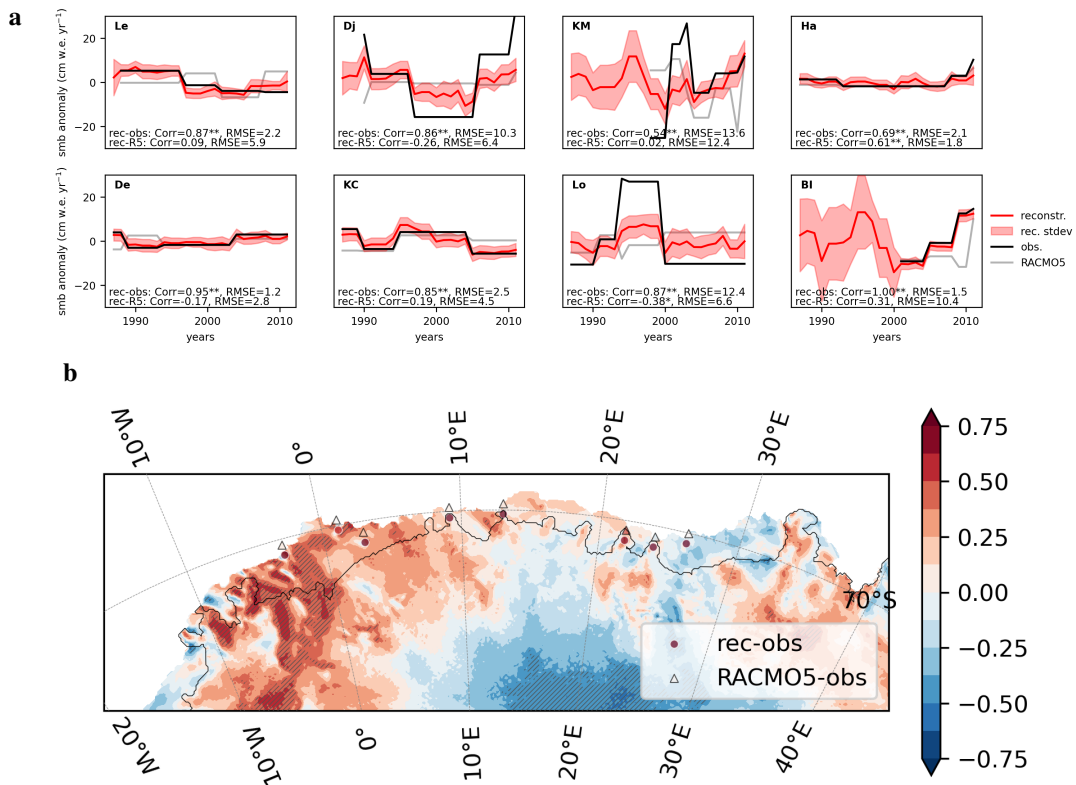
Figure S1. (a) SMB time series of the radar-derived SMB records (black) versus radar-based reconstruction (red) with reconstruction uncertainty in light red. Gray lines show the RACMO2.3p time series extracted at the ice core sites for comparison. Correlation and RMSE (in cm w.e. yr^{-1}) values are provided for each ice rise site, between the reconstruction ('rec') and the observations ('obs'), as well as the reconstruction and RACMO2.3p ('R5'). Correlations with a p-value $\leq$ 0.05 are double starred while a p-value of le 0.1 is starred. (b) Spatial correlation between RACMO2.3p SMB and the SMB reconstruction. Hatchings highlight areas with a p-value $\leq$ 0.05; circles locate the ice core sites and are colored according to the value of the correlation between the ice core SMB and the reconstructed SMB locally; triangles are colored according to the value of the correlation between the observations and RACMO2.3p SMB locally (the triangles are offset vertically for ease of reading).

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References

Cavitte, M. G. P., Goosse, H., Matsuoka, K., Wauthy, S., Goel, V., Dey, R., Pratap, B., Van Liefferinge, B., Meloth, T., and Tison, J.-L.: Investigating the spatial representativeness of East Antarctic ice cores: a comparison of ice core and radar-derived surface mass balance over coastal ice rises and Dome Fuji, The Cryosphere, 17, 4779–4795, https://doi.org/10.5194/tc-17-4779-2023, 2023.

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