Table S1. Antarctic ice core sites regionally adjacent to MBS with annual snow accumulation records spanning >250 years.

Site Name	Latitude	Longitude	Elevation (m)	Years CE	Reference
LGB65	-71.85	77.92	1850	1745–1996	Xiao et al. (2004)[a]
200th km	-68.25	94.08	1990	1640–1988	Ekaykin et al. (2017)[a]
Law Dome DSS	-66.77	112.81	1370	-11–2016	Roberts et al. (2015); Jong et al. (2022)

[a] Annual accumulation dataset obtained from Thomas et al. (2017)

S1 Strain thinning adjustment with Nye

An important step in the development of an accumulation record is converting the true depth to ice equivalent depth, which removes the effect of depth-dependent density in the firn layer by numerically representing this material as glacier ice. This means that any portion of a given column of firn or ice will have the same mass, which is important for calculations involving stress and strain. Ice equivalent depth $\mathcal{Z}$ can be calculated by integrating the density-depth relationship throughout the depth of the ice sheet, as in Jong et al. (2022). The ice equivalent depth can then be used for calculations such as the Nye (1963) flow model.

$$\mathcal{Z}(z) = \int_0^z \frac{\rho(\eta)}{\rho_{\mathrm{ice}}} \mathrm{d}\eta \tag{S1}$$

The Nye flow model Nye (1963) is the simplest method of strain thinning adjustment, and is commonly used in shallow/intermediate length cores (within the top 10-15% of the ice sheet) (Thomas et al., 2015, 2008; Mulvaney et al., 2002). The model assumes a uniform vertical strain rate and no basal melting. It follows that the total vertical strain rate of a given layer equals the total vertical strain rate of the ice below it (expressed as a simple ratio):

$$\frac{\lambda}{\dot{b}} = \frac{h}{H} \tag{S2}$$

Where λ is the observed layer thickness, $\dot{b}$ is the original accumulation, h = current height above the bed, and H = total sheet ice thickness when the layer was deposited (all in ice equivalent). Thus the thinning function is $\frac{h}{H}$. No explicit assumption of steady state is made, however in practice, H is usually assumed to be the current ice sheet thickness. This ratio states that thinning is directly proportional to depth, e.g. a layer buried at a depth of 10% of the ice sheet height will have thinned by 10%.

We converted the ice equivalent layer thickness to original accumulation using the Nye model, with H = 1978 m ice equivalent. H and h were converted to ice equivalent using Eq. S1, and the observed layer thickness for each year was converted to ice equivalent (i.e. corrected for density variations with depth) using Eq. 2 (from main text). Because Nye depends only on the normalized vertical coordinate h/H, rather than absolute ice thickness, it is insensitive to uncertainties in total ice thickness for relatively shallow cores. We tested the sensitivity to the ice thickness H by varying H by around $\pm 10\%$. Setting H = 1800 m and 2200 m both resulted in a 1.6 % change in layer thickness in the deepest part of the core (with larger H resulting in slower thinning), compared to H = 1978 m.

We then compared the resulting accumulation record for Mount Brown South (MBS) using the two different strain thinning methods: Nye and ApRES vertical displacement rates and ultimately decided to use the ApRES method for the development of the MBS snow accumulation record (see Sections 3.2 and 5.4 in main text, and Fig. S1).

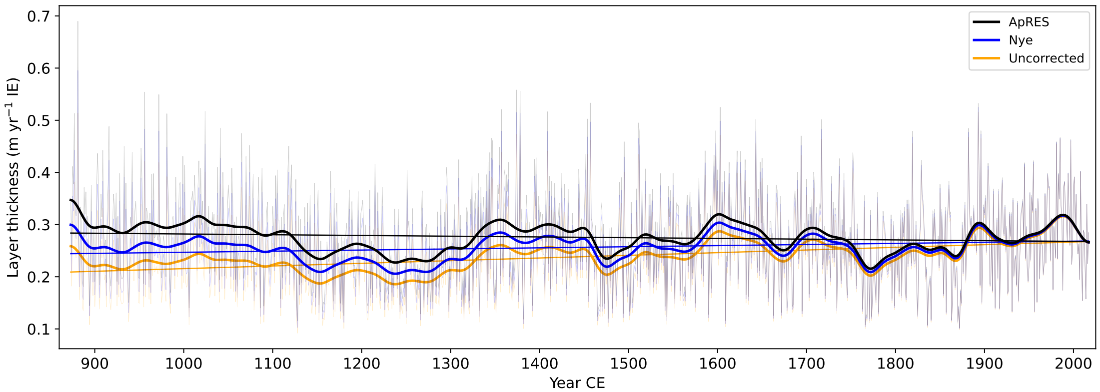

Figure S1. A comparison of the MBS snow accumulation record using two different strain thinning adjustment methods. The Nye method is shown in blue, the ApRES method in black, and the uncorrected layer thicknesses in orange. The linear trend (thin straight line) and the Gaussian smoothed (sigma=10, approx. 30 year running mean) accumulation rate are shown for each method. Note that the accumulation rates for each method differ very little near the surface, and the difference increases with age. The Nye method results in a long term mean accumulation of 0.256 ± 0.08 m yr^{-1} ice equivalent, with a slight positive linear trend (2.13×10^{-5} yr^{-1} , p=0.003), roughly equal to 2 cm per millennium. The ApRES strain rate from vertical displacement data method results in a mean accumulation of 0.276 ± 0.08m yr^{-1} ice equivalent, with no significant trend. The difference in long term mean accumulation between the methods is about 7%. The difference in annual accumulation rates increases with age, with the oldest layer differing by 13.7 %.

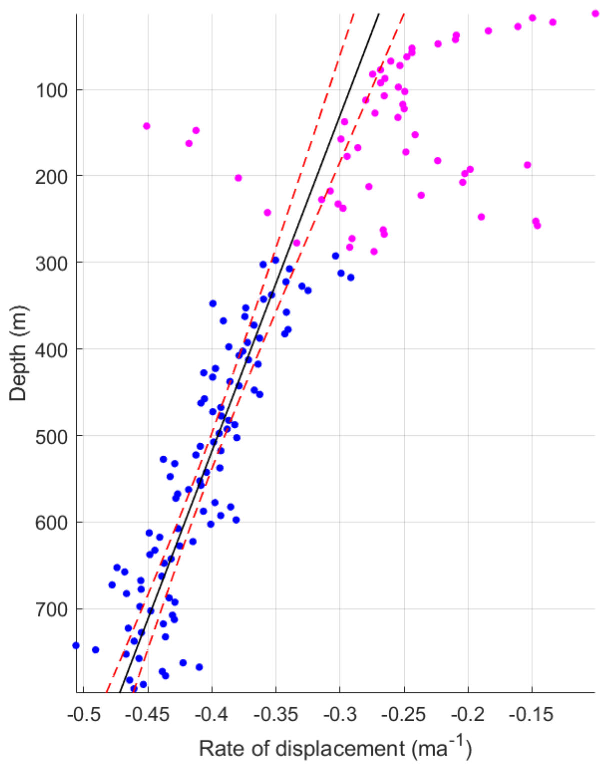

Figure S2. Scatter plot of the rate of vertical displacement of each 5 m depth section, with the linear fit. The data points not used in the linear fit are shown as magenta.

Table S2. Regime shift index (RSI) of each change point identified with regime shift analysis, and a comparison of the regime means (m yr^{-1} ice equivalent) before and after each change point. P-values represent the results of Welch's two-sample t-tests comparing the mean accumulation between adjacent regimes.

Change Point	RSI	Mean Before	Mean After	Absolute Change	% Change	p-value
1127	0.202	0.299	0.242	-0.056	-18.9	0.0000
1322	0.304	0.242	0.298	0.056	23.2	0.0000
1461	0.391	0.298	0.232	-0.066	-22.1	0.0000
1509	0.191	0.232	0.276	0.043	18.7	0.0029
1595	0.138	0.276	0.317	0.041	14.9	0.0056
1651	0.175	0.317	0.273	-0.043	-13.7	0.0026
1754	0.347	0.273	0.240	-0.033	-12.2	0.0013
1880	0.236	0.240	0.290	0.050	20.9	0.0000

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