Supplementary Figures

Synchronizing ice-core and U/Th time scales in the Last Glacial Maximum using Hulu Cave ^{14}C and new ^{10}Be measurements from Greenland and Antarctica

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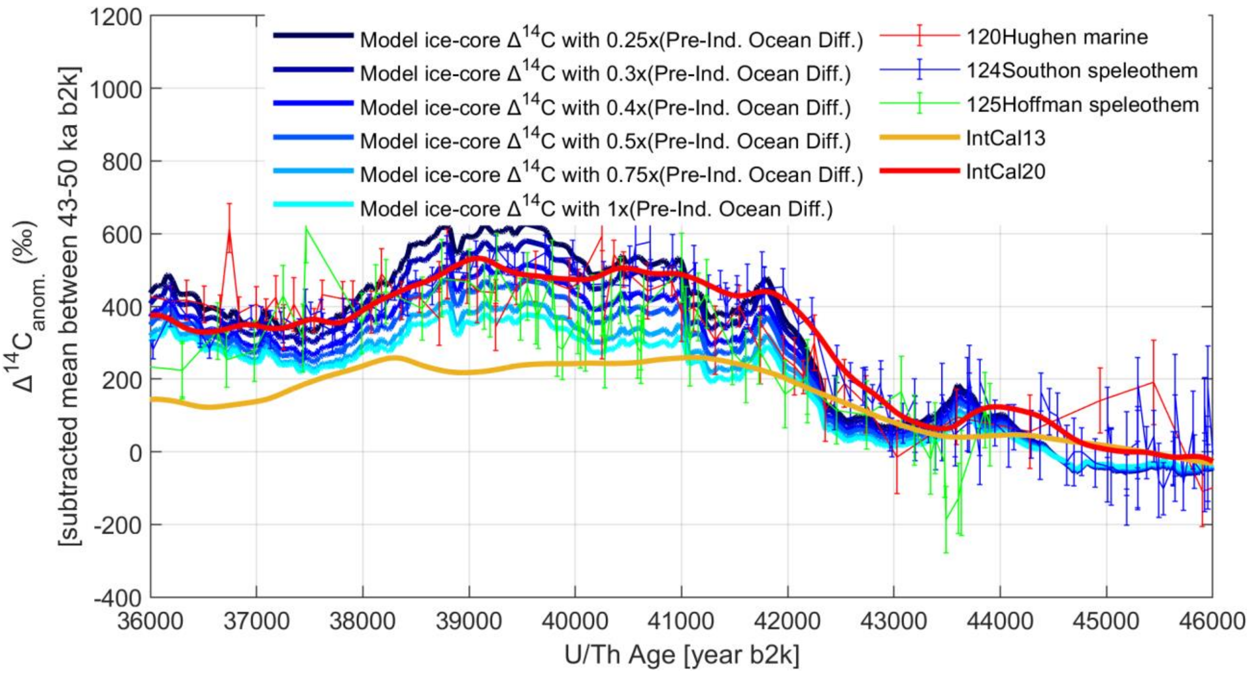

Figure S1 Modelling of GRIP data around the Laschamps event.
As a consequence of the lower shielding from GCRs, the geomagnetic excursion caused an increase both in the ^{10}Be and ^{14}C production rate. The average modelled $\Delta^{14}C$ between 43 and 46 ka b2k was subtracted from all datasets. The datasets underlying the IntCal20 curve show increases of about 400 ‰. By using the GRIP ^{10}Be data available at these ages (Yiou et al., 1997; Wagner et al., 2001; Muscheler et al. 2004), the agreement with the IntCal20 curve and the underlying data is observed to be best for an ocean diffusivity that is ~25-40% of the Holocene pre-industrial value. The timescale of GRIP was shifted by ~200 years according to the timescale offset inferred by Adolphi et al. (2018).

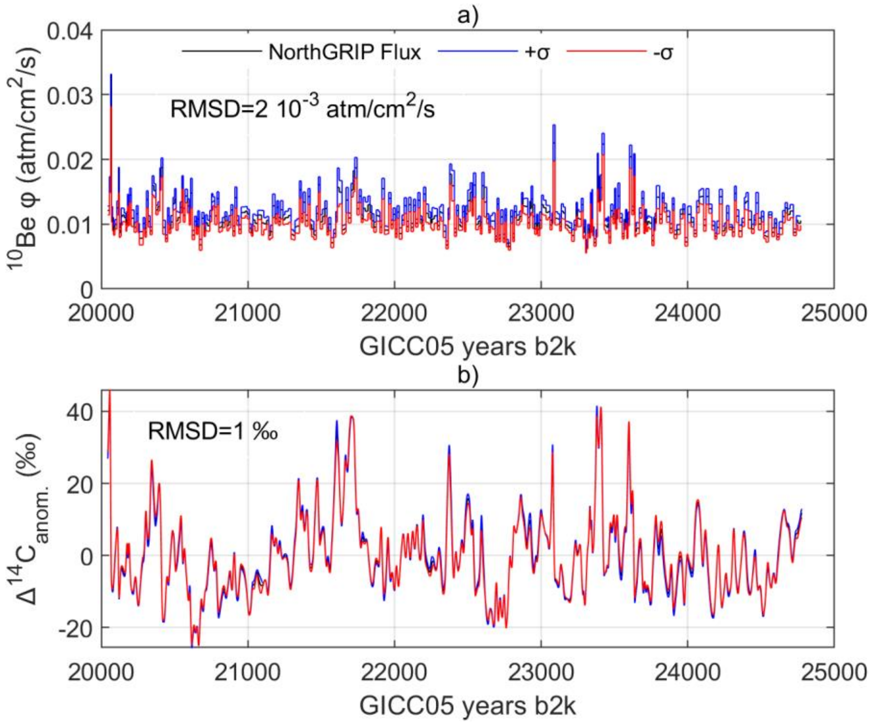

Figure S2 Derived modelling uncertainties from the measurement uncertainties of ^{10}Be fluxes, which are propagated from ^{10}Be concentration and the accumulation down-sampling.

We sum and subtract 1σ from the measurements to each measurement to obtain the two curves shown in panel (a). The RMSD between these curves is quoted in the figure. The data are used to model $\Delta^{14}C$ and shown in panel (b). The RMSD is 1 ‰, encompassing the remaining discrepancies between the curves, after detrending.

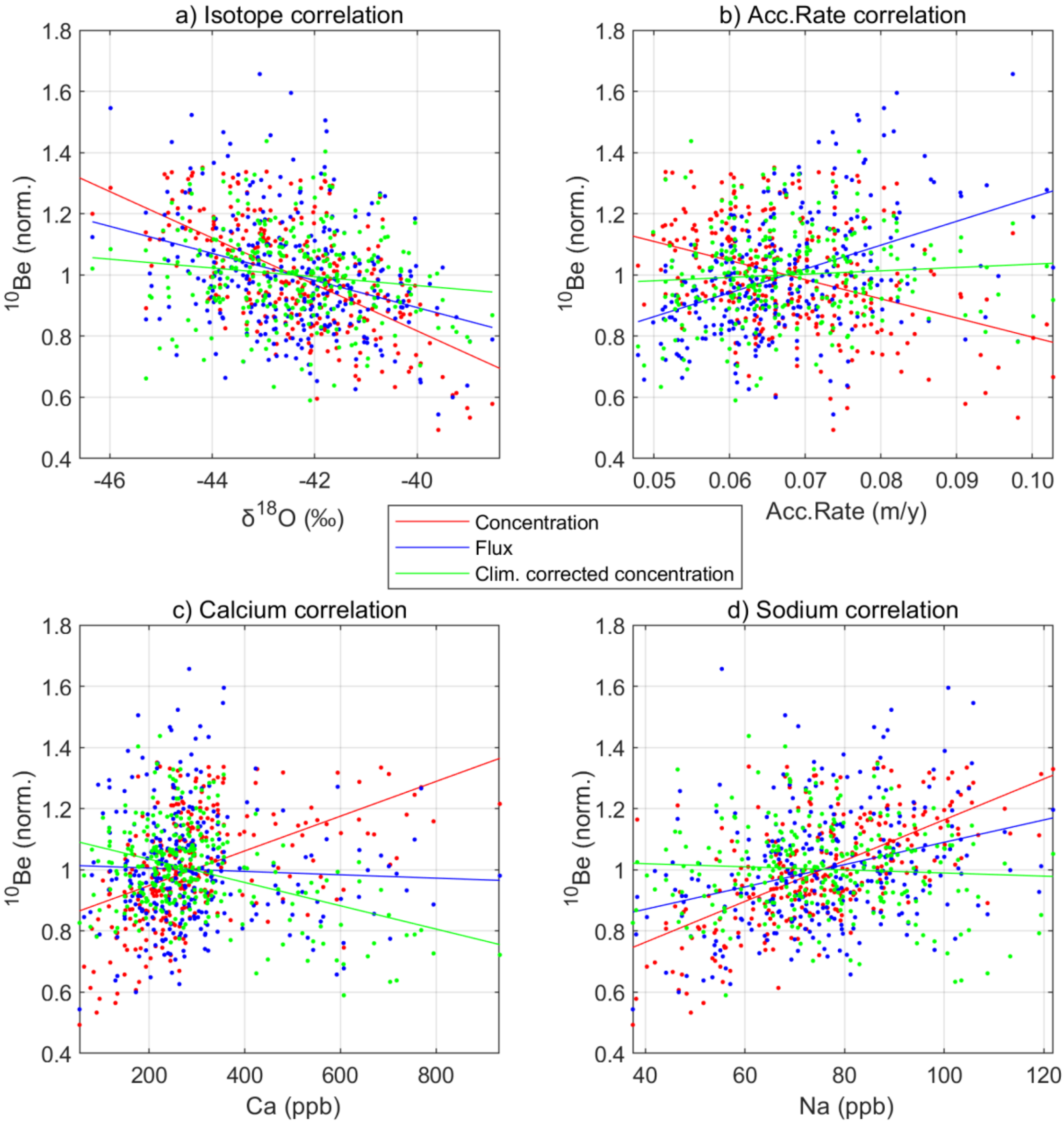

Figure S3 Correlation plots of NorthGRIP ^{10}Be data with climatic proxies.

Correlations between ^{10}Be concentrations and climate proxies is to be expected, since the dilution of ^{10}Be in ice follows the amount of precipitation on the ice sheet. Correlations in the fluxes, however, indicate that the conversion does not completely eliminate the dependence of the ^{10}Be signal on the deposition effects or might even add some dependency. An alternative conversion from concentrations to production rate was obtained by multi-linear regression of ^{10}Be concentrations versus climatic proxies, i.e. by subtracting the linear trend detected in ^{10}Be concentrations against water isotopes, accumulation rates, calcium, and sodium (the mean of the data was added at the end for comparison to the original); the resulting ^{10}Be data series is called "climate corrected" (Adolphi & Muscheler, 2016).

(a) Correlations of ^{10}Be data series to δ^{18}O. Residual negative correlations are measured in the fluxes, concentrations, and in the climate corrected concentrations, although the latter suffers the least from it.

(b) The accumulation rate is anticorrelated to ^{10}Be concentrations, i.e. inversely proportional, as expected, the concentrations recording the dilution of the signal. After conversion, the fluxes get a positive correlation, which is possibly an over-correction of dilution effects. (c, d) The correlation to both calcium and sodium is mostly removed when using the fluxes. For calcium, the low correlation to fluxes is reassuring us that ^{10}Be atoms did not experienced enhanced deposition (or get deposited by recycled ^{10}Be attached to dust) that may have been affecting the signal balance over the dust peak.

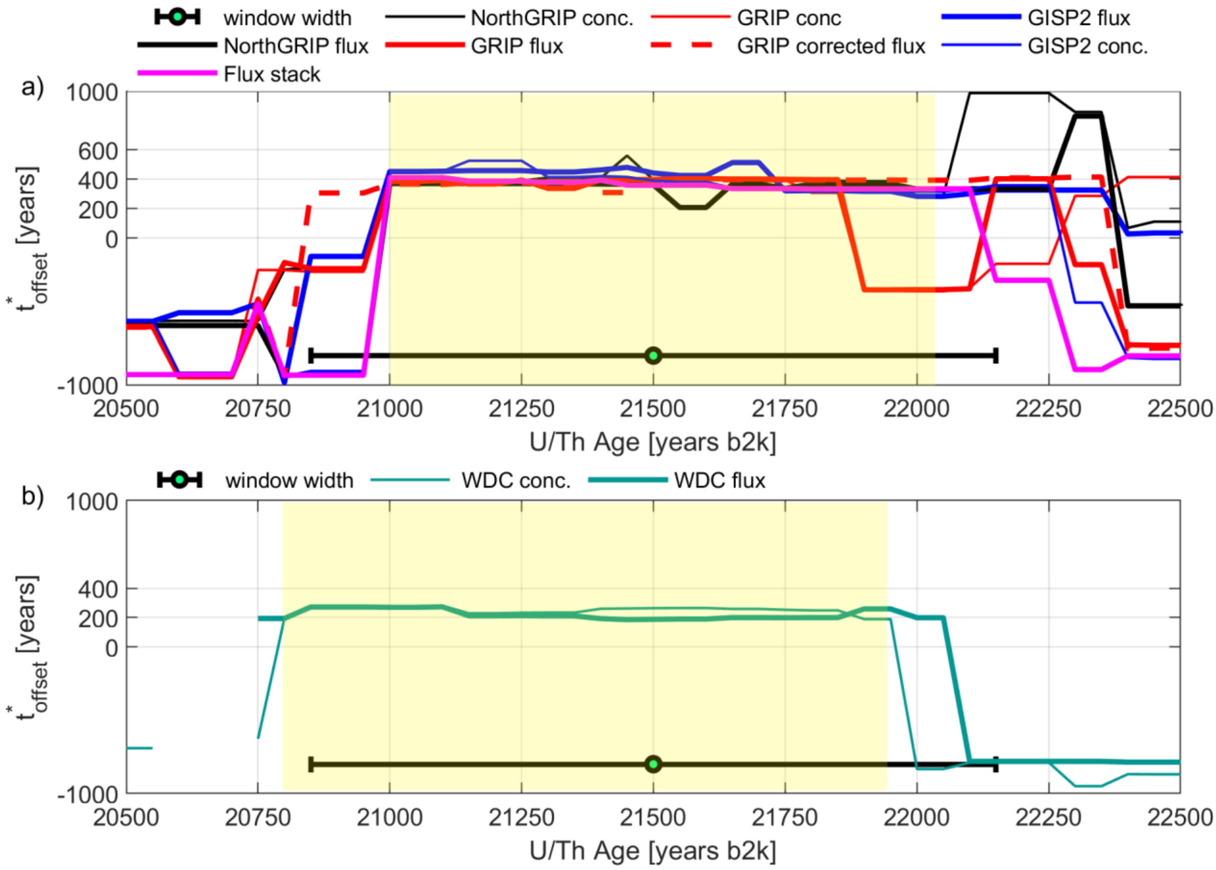

Figure S4 Initial wiggle-matching result, before adjusting the Δ^{14}C uncertainties to satisfy the χ^2 test, for Greenland, 370 years (a), and the WDC core, 225 years (b).
The time scale offset function $t^*_{offset}(\overrightarrow{W})$ was calculated as the mode of the underlying 2-dim probability density function, estimated by the algorithm. The window width (horizontal black bar) is highlighted to show that each data-point represents the data comparison within the windows $\overrightarrow{W}$. Across the intervals highlighted in yellow, the individual ice-core datasets agree about the offset for each ice-core timescale. We also observe that the offset is not strongly time-dependent, hence we average over the entire time interval. Outside the yellow interval, edge effects or the lack of synchronizable features cause the offset instability.

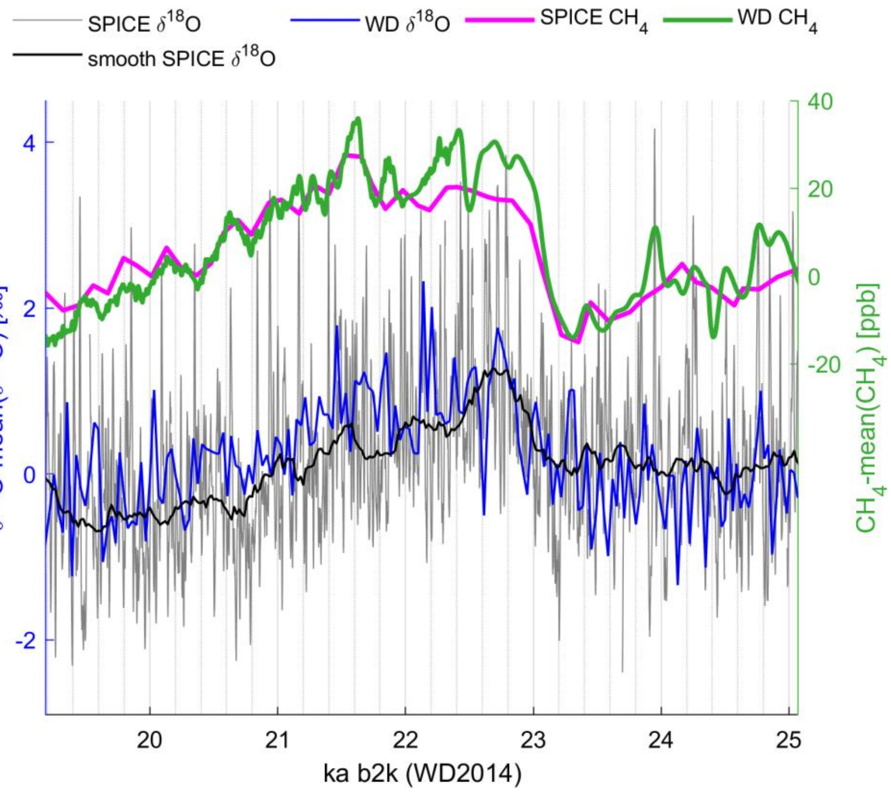

Figure S5 Stable isotope and methane data from WDC and SPICE (Brook , 2020; Steig et al., 2021). The data from two very distant locations show similar features in the gas and in the isotope signal of the AIM-2. The smoothed version of the SPICE $\delta^{18}O$ (200-year window; black) indicates the AIM-2 peak at 23.8±0.1 ka b2k.

References:

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