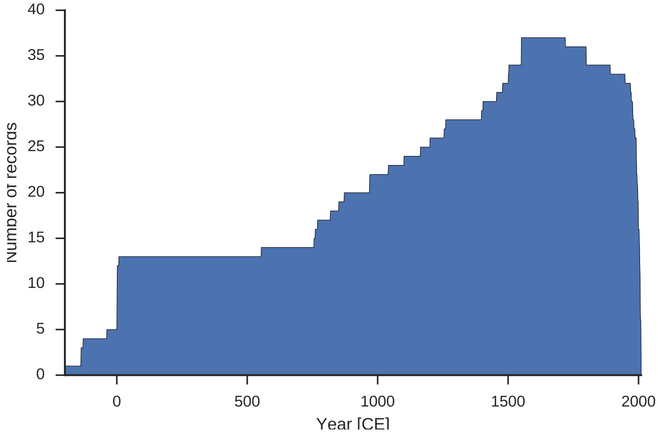
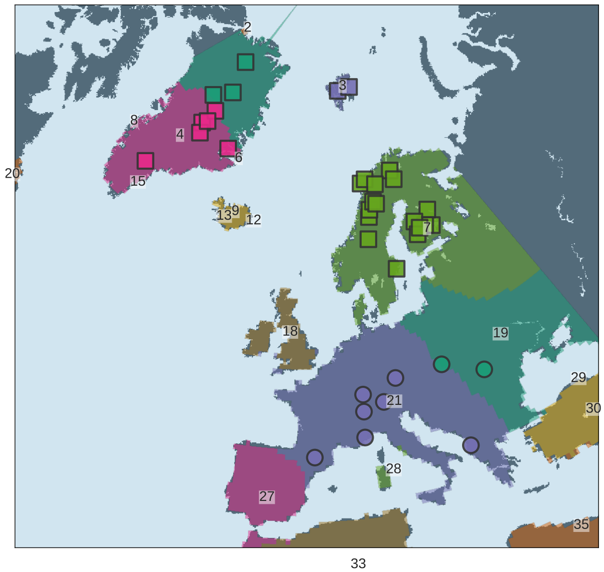
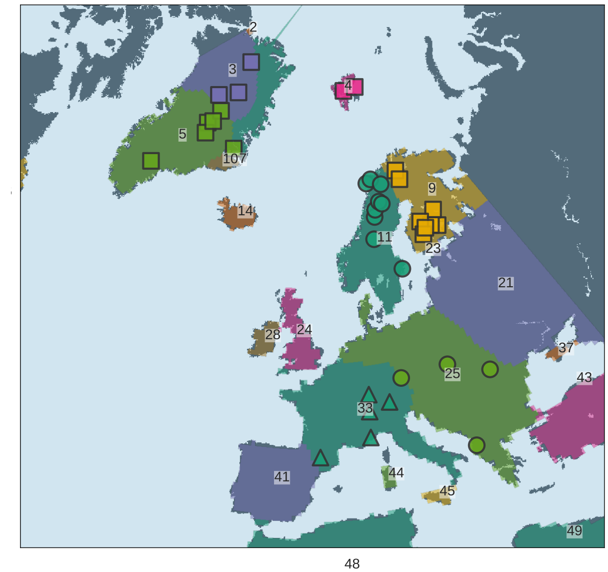


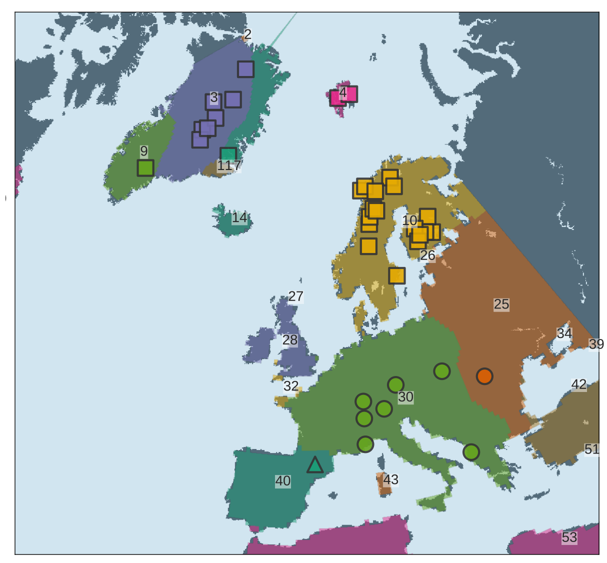
Figure S1. Number of records covering a given year.



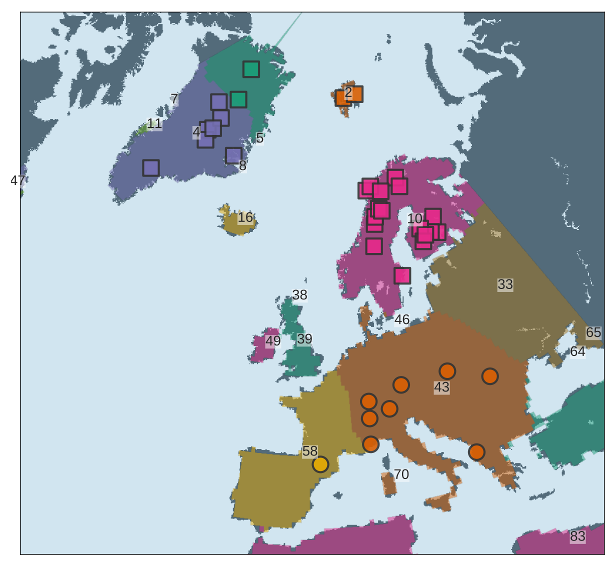
(a) JJA temperature, $\alpha_C = 0.008$



(b) DJF temperature, $\alpha_C = 0.007$



(c) all seasonal temperatures, $\alpha_C = 0.0115$



(d) annual temperature, $\alpha_C = 0.008$

Figure S2. Obtained geographical clusters based on different temperature-related variables obtained from the ERA-20C reanalysis.

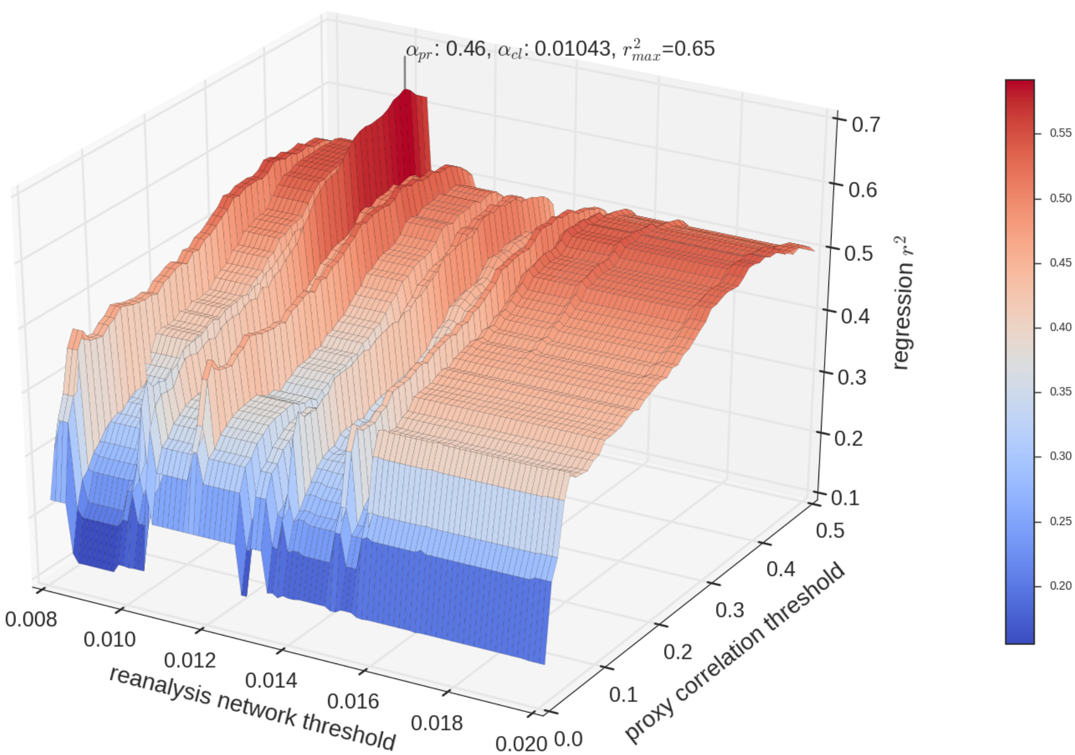


Figure S3. r^2 values of the OLS regression models obtained for different parameter combinations of α_{pr} and α_C. The resulting clusters of each parameter setting (determined by α_C) have been used to fit a linear model (see main text for details) based upon the cross-link densities to the 50 year-averaged NAO reconstruction by Ortega et al. (2015). The parameter values used within the main paper are those that maximize r^2.

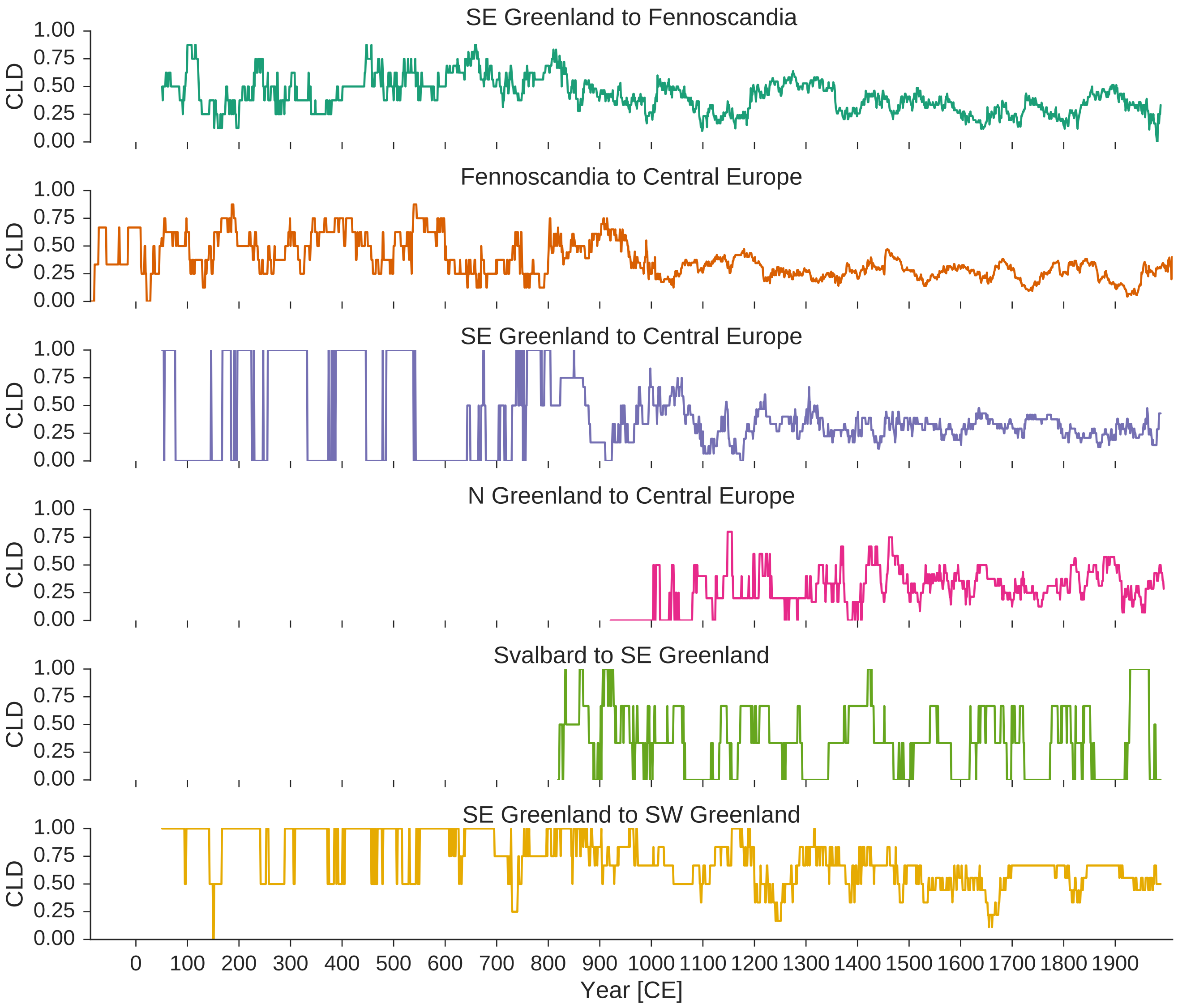


Figure S4. Evolution of the six cross-link densities with the largest regression coefficients of our linear model (see Tab. S2).

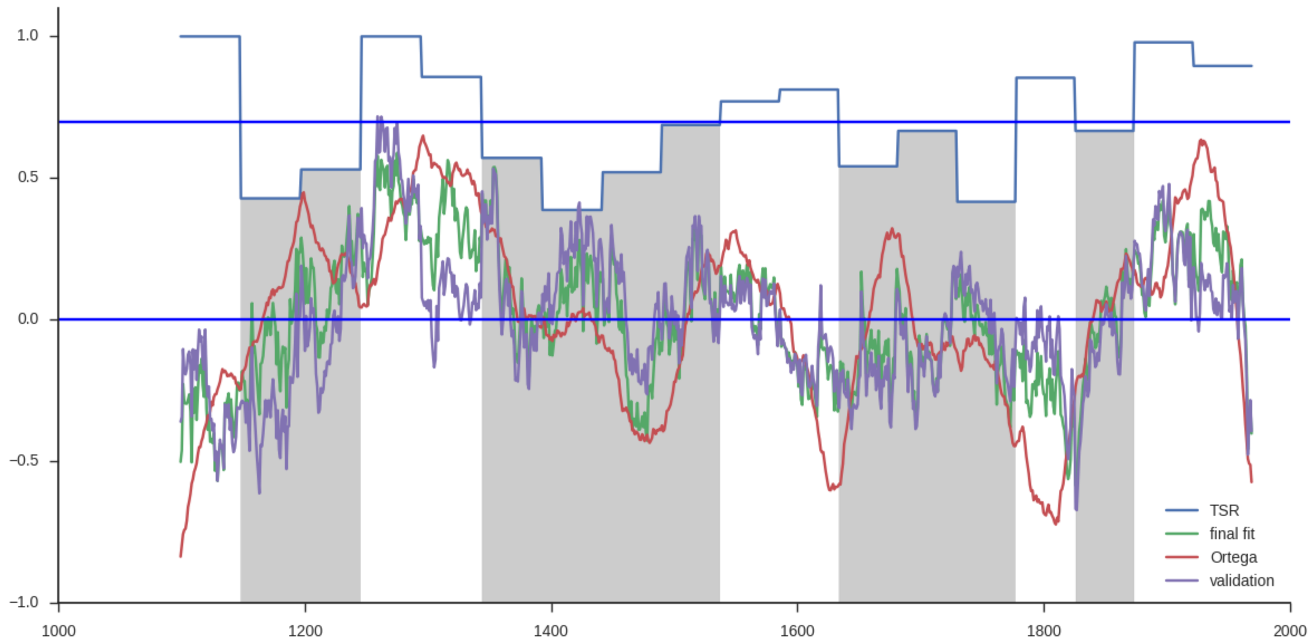


Figure S5. Testing the regression quality by using (mutually exclusive) 50-year time windows as validation data and the rest as training data for our regression model. The red line corresponds to the regression target, the 50-year running average of the NAO reconstruction by Ortega et al. (2015). The purple line indicates the values predicted by our model for each individual time window, the green line denotes the median of the final regression model, and the blue line shows the true sign ratio (TSR) for each window. The horizontal line marks the mean value of TSR (0.69); periods with lower values are shaded in gray.

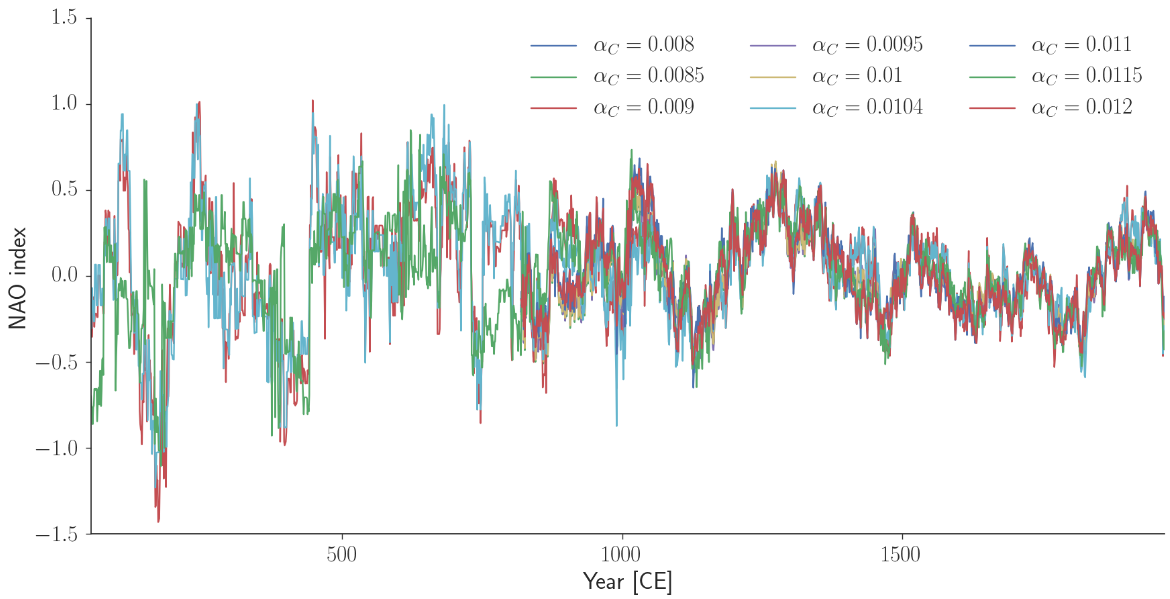


Figure S6. Qualitative NAO reconstructions obtained with different parameters of α_C.

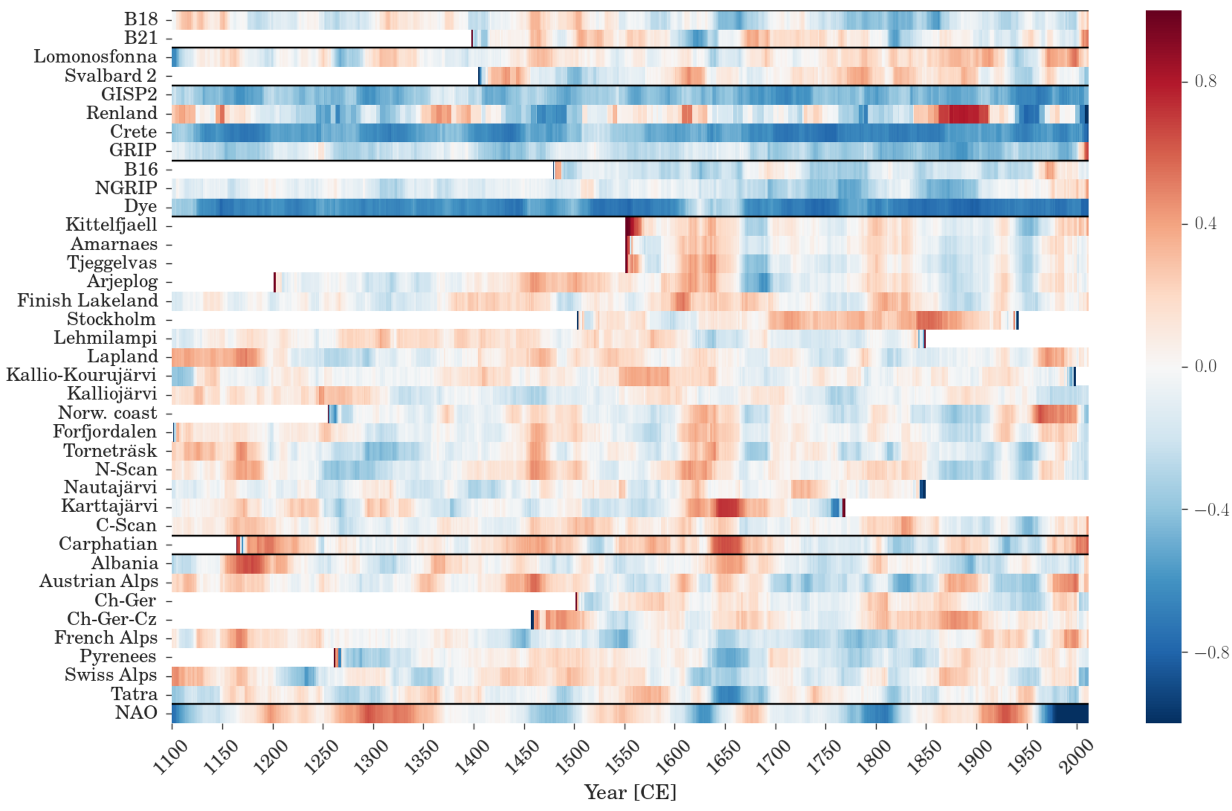


Figure S7. Correlations between the different records used in our study and the NAO reconstruction by Ortega et al. (2015) for 50-year running windows. Spatial clusters as discussed in the main paper are separated by black lines.

Table S1. The data used in this analysis.

name	long. [°W]	lat. [°N]	archive	proxy	variable	first [CE]	last [CE]	res.	reference
Albania	41	20	TR	TRW	TRW index [-]	968	2008	1	Seim et al. (2012)
Austria	47	10.7	TR	TRW	T [°C]	1	2003	∼1	Büntgen et al. (2011)
Ch-Ger-Cz	49	13	hist.		T [°C]	1500	2007	1	Dobrovolný et al. (2010)
Carphatian	47	25.3	TR	TRW	T [°C]	1163	2005	1	Popa and Kern (2009)
French Alps	44	7.5	TR	TRW	TRW index [-]	969	2007	1	Büntgen et al. (2012)
Pyrenees	42.5	1	TR	MXD/TRW	T [°C]	1260	2005	1	Dorado Liñán et al. (2012)
NScan	68	25 TR	MXD	T [°C]		1	2006	1	Esper et al. (2012)
Swiss Alps	46.4	7.8	TR	MXD	T [°C]	755	1892	∼1	Büntgen et al. (2006)
Stockholm	59.32	18.06	hist.		T [°C]	1502	1892	1	Leijonhufvud et al. (2010)
Korttajärvi	62.33	25.68	LS	XRD	XRD	0	1720	1	Tiljander et al. (2003)
Kittelfjael	65.2	15.5	TR	MXD	RSF$_i$	1550	2007	1	Björklund et al. (2013)
Amarnaes	65.9	16.1	TR	MXD	RSF$_i$	1550	2010	1	Björklund et al. (2013)
Tjeggelvas	66.6	17.6	TR	BI	BRSF$_i$			1	Björklund et al. (2013)
Arjeplog	66.3	18.2	TR	BI	BRSF$_i$	1200	2010	1	Björklund et al. (2013)
Lomonosfonna	78.87	17.425	IC	δ^{18}O	δ^{18}O [‰]	769	1997	1	Divine et al. (2011)
Ch-Ger	48	8	hist.		T [°C]	1454	1970	1	Wetter and Pfister (2011)
GISP2	72.1	-38.8	IC	δ^{18}O	δ^{18}O [‰]	818	1987	1	Grootes and Stuiver (1997)
Lehmilampi	63.62	29.1	LS	VT	VT [mm]	1	1800	1	Haltia-Hovi et al. (2007)
Lapland	69	25	TR	TRW	T [°C]	0	2000	1	Helama et al. (2009)
Svalbard 2	79.83	24.02	IC	δ^{18}O	δ^{18}O [‰]	1400	1998	∼ 1	Isaksson et al. (2005)
Kallio-Kourujärvi	62.33	27.04	LS	VT	VT [mm]	-129	149	1	Saarni et al. (2015)
Kalliojärvi	63.13	25.22	LS	VT	VT [mm]	-137	2000	1	Saarni et al. (2016)
Norw. coast	68.78	15.75	TR	TRW	TRW index	1254	1993	1	Kirchhefer (2001)
Forfjordalen	69.08	17.22	TR	TRW/MXD	trsgi	1100	2007	1	McCarroll et al. (2013)
Torneträsk	68.26	19.6	TR	TRW/MXD	T [°C]	-39	2010	1	Melvin et al. (2013)
Nautajärvi	61.81	24.68	LS	OM	OMA	0	1800	1	Ojala and Alenius (2005)
B16	73.94	-37.63	IC	δ^{18}O	δ^{18}O [‰]	1478	1992	1	Fischer et al. (1998)
B18	76.62	-36.4	IC	δ^{18}O	δ^{18}O [‰]	871	1992	1	Fischer et al. (1998)
B21	80	-41.14	IC	δ^{18}O	δ^{18}O [‰]	1397	1992	1	Fischer et al. (1998)
Tatra	49	20	TR	TRW	T [°C]	1040	2011	1	Büntgen et al. (2013)
NGRIP	75.1	-42.32	IC	δ^{18}O	δ^{18}O [‰]	0	1995	1	Vinther et al. (2006)
Renland	71.27	-26.73	IC	δ^{18}O	δ^{18}O [‰]	3	1993	5	Vinther et al. (2008)
Crete	71.12	-37.32	IC	δ^{18}O	δ^{18}O [‰]	553	1973	1	Vinther et al. (2010)
Dye	65.18	-43.83	IC	δ^{18}O	δ^{18}O [‰]	1	1978	1	Vinther et al. (2010)
GRIP	72.58	-37.64	IC	δ^{18}O	δ^{18}O [‰]	850	2011	1	Vinther et al. (2010)
CScan	63	14.05	TR	MXD	T [°C]	850	2011	1	Zhang et al. (2016)

Table S2. Mean values and standard deviations of the MCMC regression coefficients corresponding to the individual cross-link densities used in this study.

connection	mean value	standard deviation
SE Greenland to Fennoscandia	1.9	0.09
Fennoscandia to Central Europe	- 0.73	0.1
SE Greenland to Central Europe	-0.59	0.09
N Greenland to Central Europe	-0.26	0.05
Svalbard to SE Greenland	0.23	0.05
SE Greenland to SW Greenland	0.21	0.05
Svalbard to Central Europe	0.14	0.04
SE Greenland to Central Europe	-0.13	0.08
N Greenland to SW Greeland	0.11	0.03
N Greenland to SE Greenland	-0.11	0.03
SW Greenland to Fennoscandia	-0.11	0.09
N Greenland to Svalbard	-0.04	0.02
N Greenland to Fennoscandia	0.04	0.08
Svalbard to SW Greenland	-0.03	0.03
Svalbard to Fennoscandia	- 0.003	0.05

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