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Recent changes in north-west Greenland climate documented by NEEM shallow ice core data and simulations, and implications for past-temperature reconstructions

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Table S1. *Correlation statistics between NEEM annual* $\delta^{18}O$ *and annual* $\delta^{18}O$ *from other Greenland ice cores and from their first principal component (PC1)* (Ortega et al., 2014)*. Initial and end years of individual records are ony reported when they deviate from the NEEM ice core time span (1723-2011). The first line is the result for all the available years ; the second line for the same time interval (1767-1966) ; the third line for the same time interval, after detrending. Non significant correlations are displayed in italics. Bold text indicates correlation significant at 95% confidence level or higher.*

Name	**Lat.**	**Lon.**	**Start Year**	**End Year**	**Correlation statistics with NEEM** $\delta^{18}O$
B16	-37.6	73.9		1992	**R=0.19 (n=269, p=0.001)** **R=0.23 (n=206, p=0.000)** **R=0.23 (n=206, p=0.001)**
B18	-36.4	76.6		1992	**R=0.20 (n=269, p=0.000)** **R=0.24 (n=206, p=0.000)** **R=0.22 (n=206, p=0.001)**
B21	-41.1	80		1993	**R=0.21 (n=270, p=0.000)**

					R=0.16 (n=206, p=0.010) **R=0.15 (n=206, p=0.014)**
B26	-49.2	77.3		1994	**R=0.24 (n=271, p=0.000)** **R=0.26 (n=206, p=0.000)** **R=0.25 (n=206, p=0.000)**
B29	-43.5	76		1994	**R=0.44 (n=271, p=0.000)** **R=0.47 (n=206, p=0.000)** **R=0.46 (n=206, p=0.000)**
Camp Century	-66.1	77.2		1967	**R=0.23 (n=244, p=0.000)** **R=0.24 (n=206, p=0.000)** **R=0.23 (n=206, p=0.001)**
Crete	-37.3	71.1		1973	**R=0.18 (n=250, p=0.002)** **R=0.19 (n=206, p=0.003)** **R=0.18 (n=206, p=0.004)**
Dye2	-46.2	66.4	1742	1974	**R=0.16 (n=233, p=0.008)** **R=0.17 (n=206, p=0.007)** **R=0.15 (n=206, p=0.017)**
Dye3-3	-43.8	65.2		1978	**R=0.25 (n=269, p=0.001)** **R=0.26 (n=206, p=0.000)** **R=0.23 (n=206, p=0.001)**
Dye 3-20D	-44.9	65	1767	1984	**R=0.24 (n=218, p=0.000)** **R=0.24 (n=206, p=0.000)** **R=0.23 (n=206, p=0.001)**
GISP2	-38.5	72.6		1987	**R=0.30 (n=264, p=0.000)** **R=0.33 (n=206, p=0.000)** **R=0.33 (n=206, p=0.001**
GRIP	-37.6	72.6		1979	**R=0.16 (n=256, p=0.005)** **R=0.18 (n=206, p=0.005)** **R=0.19 (n=206, p=0.003)**
MILCENT	-44.6	70.3		1967	**R=0.22 (n=244, p=0.000)** **R=0.26 (n=206, p=0.000)** **R=0.25 (n=206, p=0.001**

NGRIP	-42.3	75.1		1995	**R=0.40 (n=272, p=0.000)** **R=0.49 (n=206, p=0.000)** **R=0.48 (n=206, p=0.000)**
RENLAND	-26.7	71.3		1986	**R=0.29 (n=263, p=0.001)** **R=0.18 (n=206, p=0.004)** **R=0.17 (n=206, p=0.007)**
SITE A	-35.8	70.6		1986	R=0.10 (n=261, p=0.053) *R=0.09 (n=206, p=0.111)* *R=0.08 (n=206, p=0.141)*
PC1			1761	1966	**R=0.48 (n=206, p=0.000)** **R=0.48 (n=206, p=0.000)** **R=0.47 (n=206, p=0.000)**

Table S2. *Correlation statistics between NEEM annual accumulation and annual accumulation records from other Greenland ice cores and from their first principal component (PC1), calculated using the same method as implemented for* $\delta^{18}O$ *(Ortega et al., in press). Initial and end years of individual records are only reported when they deviate from the NEEM ice core time span (1723-2011). The first line is the result for all the available years ; the second line for the same time interval (1767-1966) ; the third line for the same time interval, after detrending. Non significant correlations are displayed in italics. Bold text indicates correlation significant at 95% confidence level or higher.*

Name	**Lat.**	**Lon.**	**Start Year**	**End Year**	**Correlation statistics with NEEM accumulation**
B16	-37.6	73.9		1992	*R=0.09 (n=268, p=0.079)* *R=0.07 (n=206, p=0.141)* *R=0.07 (n=206, p=0.142)*
B18	-36.4	76.6		1992	*R=-0.03 (n=268, p=0.286)* *R=-0.04 (n=206, p=0.283)* *R=-0.04 (n=206, p=0.277)*
B21	-41.1	80		1993	*R=0.05 (n=269, p=0.194)* *R=0.08 (n=206, p=0.137)* *R=0.07 (n=206, p=0.148)*
B26	-49.2	77.3		1994	*R=0.10 (n=269, p=0.194)* *R= 0.07 (n=206, p=0.151)* *R=0.07 (n=206, p=0.151)*
B29	-43.5	76		1994	**R=0.35 (n=270, p=0.000)** **R=0.38 (n=206, p=0.000)** **R=0.38 (n=206, p=0.000)**
Camp Century	-66.1	77.2		1967	**R=0.32 (n=217, p=0.000)** **R=0.38 (n=206, p=0.000)** **R=0.44 (n=206, p=0.000)**
Crete	-37.3	71.1		1973	*R=0.02 (n=251, p=0.367)* *R=0.06 (n=206, p=0.214)*

					R=0.06 (n=206, p=0.199)
Dye2	-46.2	66.4	1742	1974	**R=0.11 (n=233, p=0.047)** R=0.11 (n=206, p=0.054) **R=0.14 (n=206, p=0.024)**
Dye3-3	-43.8	65.2		1978	*R=0.03 (n=254, p=0.335)* *R=0.10 (n=206, p=0.076)* *R=0.11 (n=206, p=0.064)*
GISP2	-38.5	72.6		1987	**R=0.13 (n=255, p=0.019)** **R=0.17 (n=206, p=0.009)** **R=0.17 (n=206, p=0.009)**
GRIP	-37.6	72.6		1979	**R=0.16 (n=255, p=0.006)** **R=0.15 (n=206, p=0.014)** **R=0.15 (n=206, p=0.014)**
MILCENT	-44.6	70.3		1967	**R=0.18 (n=244, p=0.002)** **R=0.20 (n=206, p=0.002)** **R=0.20 (n=206, p=0.002)**
NGRIP	-42.3	75.1		1996	**R=0.34 (n=271, p=0.000)** **R=0.38 (n=206, p=0.000)** **R=0.38 (n=206, p=0.000)**
PC1			1761	1966	**R=0.39 (n=206, p=0.000)** **R=0.39 (n=206, p=0.000)** **R=0.40 (n=206, p=0.000)**

Table S3. *Statistics of linear correlation between NEEM records, coastal SW Greenand temperature (Vinther et al., 2006), NAO instrumental index (Vinther et al., 2003), AMO records (based on instrumental datasets, AMO1 : (Trenberth and Shea, 2006), AMO2 : (Enfield et al., 2001) ; and based on reconstructions, AMO3 : (Svendsen et al., 2014)). Italics indicate non significant correlation, while bold text indicates correlation significant at 95% confidence level or higher. The time span of each meteorological record is indicated in the left column. The number of years used for correlation analysis depends on the NEEM series (as the accumulation record ends in 2007 and the isotope record ends in 2011). In each cell, the upper statistics are for the raw records, and the lower statistics for detrended records.*

	NEEM $\delta^{18}O$	**NEEM accumulation**	**NEEM deuterium excess**
NAO DJFM 1823-2011	R=-0.11, n=189, p=0.061 *R=-0.05, n=189, p=0.232*	**R=-0.14, n=185, p=0.025** **R=-0.20, n=185, p=0.003**	**R=0.21, n=189, p=0.001** **R=0.19, n=189, p=0.004**
NAO JJAS 1822-2011	**R=-0.13, n=189, p=0.034** **R=-0.20, n=189, p=0.003**	*R=-0.06, n=186, p=0.210* **R=-0.17, n=186, p=0.009**	*R=0.07, n=190, p=0.176* *R=0.04, n=190, p=0.272*
SW Greenland temperature DJFM 1784-2011	**R=0.32, n=199, p=0.000** **R=0.22, n=157, p=0.000**	**R=0.25, n=195, p=0.000** **R=0.17, n=153, p=0.000**	*R=-0.04, n=199, p=0.300* *R=-0.06, n=157, p=0.217*
SW Greenland temperature JJAS 1807-2011	**R=0.49, n=182, p=0.000** **R=0.44, n=157, p=0.000**	**R=0.24, n=178, p=0.001** **R=0.20, n=153, p=0.006**	*R=0.13, n=182, p=0.045* *R=0.06, n=157, p=0.231*
AMO1	**R=0.17,**	**R=0.21,**	*R=-0.11,*

1870-2011	**n=141, p=0.020** **R=0.14,** **n=141, p=0.045**	**n=138, p=0.008** **R=0.20,** **n=138, p=0.009**	*n=141, p=0.098* *R=-0.10,* *n=141, p=0.111*
AMO2 1856-2011	**R=0.18,** **n=156, p=0.013** **R=0.20,** **n=156, p=0.005**	**R=0.22,** **n=156, p=0.001** **R=0.20,** **n=152, p=0.006**	**R=-0.25,** **n=156, p=0.001** **R=-0.24,** **n=156, p=0.001**
AMO3 1781-1807	*R=0.09,* *n=206, p=0.092* *R=0.03,* *n=206 p=0.424*	*R=0.03,* *n=206, p=0.329* *R=0.01,* *n=206, p=0.424*	**R=-0.22,** **n=206, p=0.001** **R=-0.28,** **n=206, p=0.000**

Table S4. *Analysis of linear correlation between the first and second principal component of sea level pressure north of 70°N and NEEM records, for two intervals (1870-2010 and 1930-2010), for data at annual resolution (1 year) and smoothed over 3 and 5 years. One asterisk (*) indicates correlation coefficients significant at 95% confidence level. Two asterisks (**) indicate correlation coefficients significant at 99% confidence level.*

Sea level pressure north of 70°N	**NEEM $\delta^{18}O$**	**NEEM deuterium excess**	**NEEM accumulation**
PC1 (Arctic Oscillation) 1870-2010	*1 yr: -0.04* *3 yr: 0.00* *5 yr: 0.07*	*1 yr: 0.11* ***3 yr: 0.27***** ***5 yr: 0.37*****	*1 yr: -0.15* *3 yr: -0.19** *5 yr: -0.15*
PC1 (Arctic Oscillation) 1930-2010	*1 yr: 0.09* ***3 yr: 0.29***** ***5 yr: 0.48*****	*1 yr: 0.01* *3 yr: 0.14* ***5 yr: 0.29*****	*1 yr: 0.03* *3 yr: 0.11* ***5 yr: 0.25****
PC2 (Arctic Dipole) 1870-2010	*1 yr: 0.09* *3 yr: 0.13* *5 yr: 0.15*	*1 yr: 0.08* *3 yr: 0.15* *5 yr: 0.19**	*1 yr: 0.02* *3 yr: 0.07* *5 yr: 0.15*
PC2 (Arctic Dipole) 1930-2010	*1 yr: 0.11* ***3 yr: 0.28***** ***5 yr: 0.41*****	*1 yr: -0.06* *3 yr: -0.03* *5 yr: -0.08*	*1 yr: 0.12* *3 yr: 0.24** ***5 yr: 0.38*****

Table S5. *Statistics of linear correlation between NEEM records, and the four main North Atlantic weather regimes (Ortega et al., in press) in winter (DJFM) and summer (JJAS), for 1900-2011 (isotopes) and 1900-2007 (accumulation). In each cell, the upper statistics are for the raw records, and the lower statistics for detrended records. Asterisks* (*) *denote correlations which are still significant when considering the period 1960-2011.*

Weather regimes 1900-2011	**NEEM annual $\delta^{18}O$**	**NEEM annual accumulation**	**NEEM annual deuterium excess**
Summer (JJAS)			
NAO+	**R=-0.21*, n=112, p=0.015** **R=-0.21*, n=112 p=0.013**	**R=-0.14*, n=108, p=0.013** R=-0.14*, n=108, p=0.073	*R=0.11, n=112, p=0.131* *R=0.11, n=112 p=0.120*
NAO-	**R=0.27*, n=112, p=0.002** **R=0.29*, n=112 p=0.001**	*R=0.07, n=108, p=0.235* *R=0.08, n=108, p=0.203*	*R=0.09, n=112, p=0.176* *R=0.07, n=112, p=0.231*
Atlantic Ridge	*R=0.03, n=112, p=0.384* *R=0.02, n=112, p=0.407*	*R=0.12, n=108, p=0.100* *R=0.12, n=108, p=0.106*	*R=0.01, n=112, p=0.441* *R=0.02, n=112, p=0.417*
Scandinavian Blocking	*R=-0.10, n=112, p=0.158* *R=-0.10, n=112, p=0.135*	*R=-0.04, n=108, p=0.347* *R=-0.04, n=108, p=0.328*	**R=-0.20, n=112, p=0.016** **R=-0.19, n=112, p=0.020**
Winter (DJFM)			
NAO+	*R=0.00, n=112, p=0.495* *R=-0.01, n=111, p=0.455*	*R=-0.07 n=108, p=0.245* *R=-0.07, n=108, p=0.228*	*R=0.10, n=111, p=0.153* *R=0.10, n=111, p=0.158*
NAO-	*R=0.03,*	*R=0.10,*	*R=-0.08, n=112,*

	n=112, p=0.365 *R=0.04,* *n=112, p=0.331*	*n=108, p=0.142* *R=11,* *n=108, p=0.133*	*p=0.221* *R=-0.03, n=112, p=0.373*
Atlantic Ridge	**R=-0.19,** **n=112, p=0.024** **R=-0.18** **n=112, p=0.027**	*R=-0.09,* *n=108, p=0.191* *R=-0.09,* *n=108, p=0.188*	*R=0.03,* *n=112, p=0.364* *R=0.06* *n=112, p=0.268*
Scandinavian Blocking	R=0.155 n=112, p=0.052 R=0.156 n=112, p=0.051	*R=0.03* *n=108, p=0.360* *R=0.04* *n=108, p=0.352*	*R=-0.05* *n=112, p=0.298* *R=0.00* *n=112, p=0.479*

***Figure S1** : 1st Principal Component (PC1, left) and 1st Empirical Orthogonal Function (EOF, right) of annually resolved snow accumulation records from Greenland ice-cores. All time-series are standardised with respect to their common period (1761-1966) before performing the Principal Component Analysis. The position of NEEM is marked by a purple star. The same methodology was initially applied to $\delta^{18}O$ records, we refer the reader to (Ortega et al., 2014). The leading mode of snow accumulation across Greenland depicts a monopole-like pattern, with maximum values at Summit (GRIP-GISP2), and particularly low values in the vicinity of NEEM (e.g. B26).*

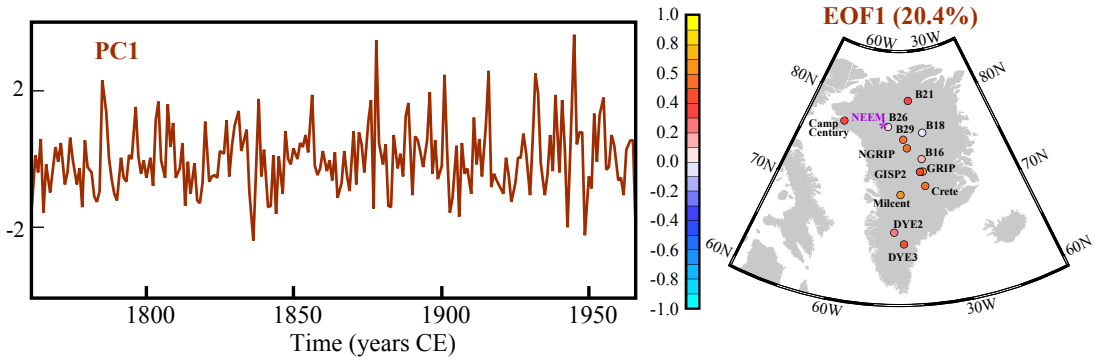
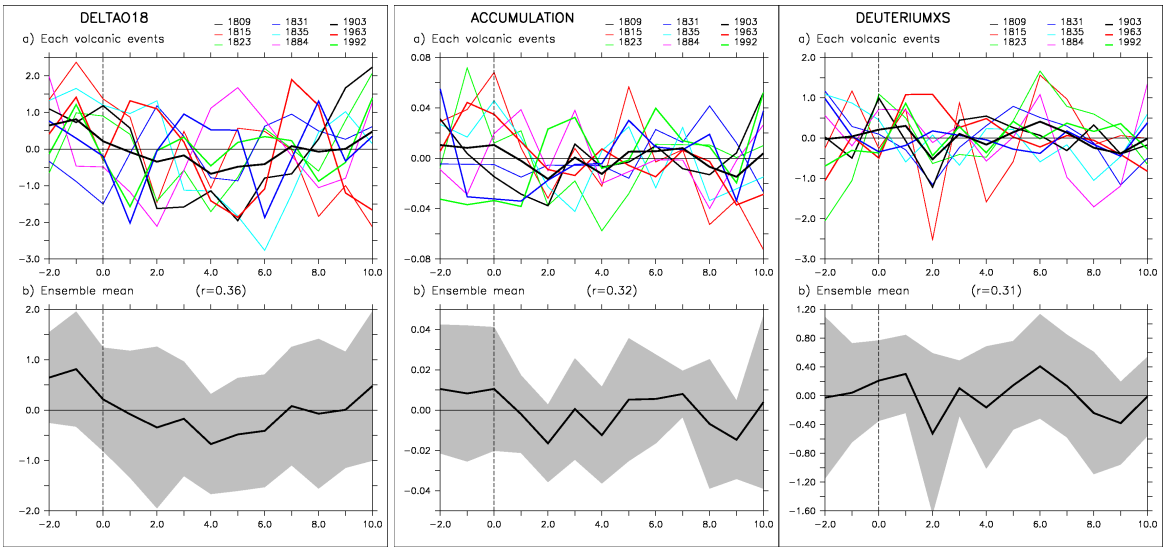


Figure S2 : *Individual (upper panels) and composite (lower panel) response of NEEM $\delta^{18}O$ (left), accumulation (middle) and deuterium excess (right panels) following major volcanic eruptions of the 19th and 20th centuries. The correlation coefficient reported on each lower panel is the average correlation coefficient between the ensemble mean and the response following each volcanic event.*



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