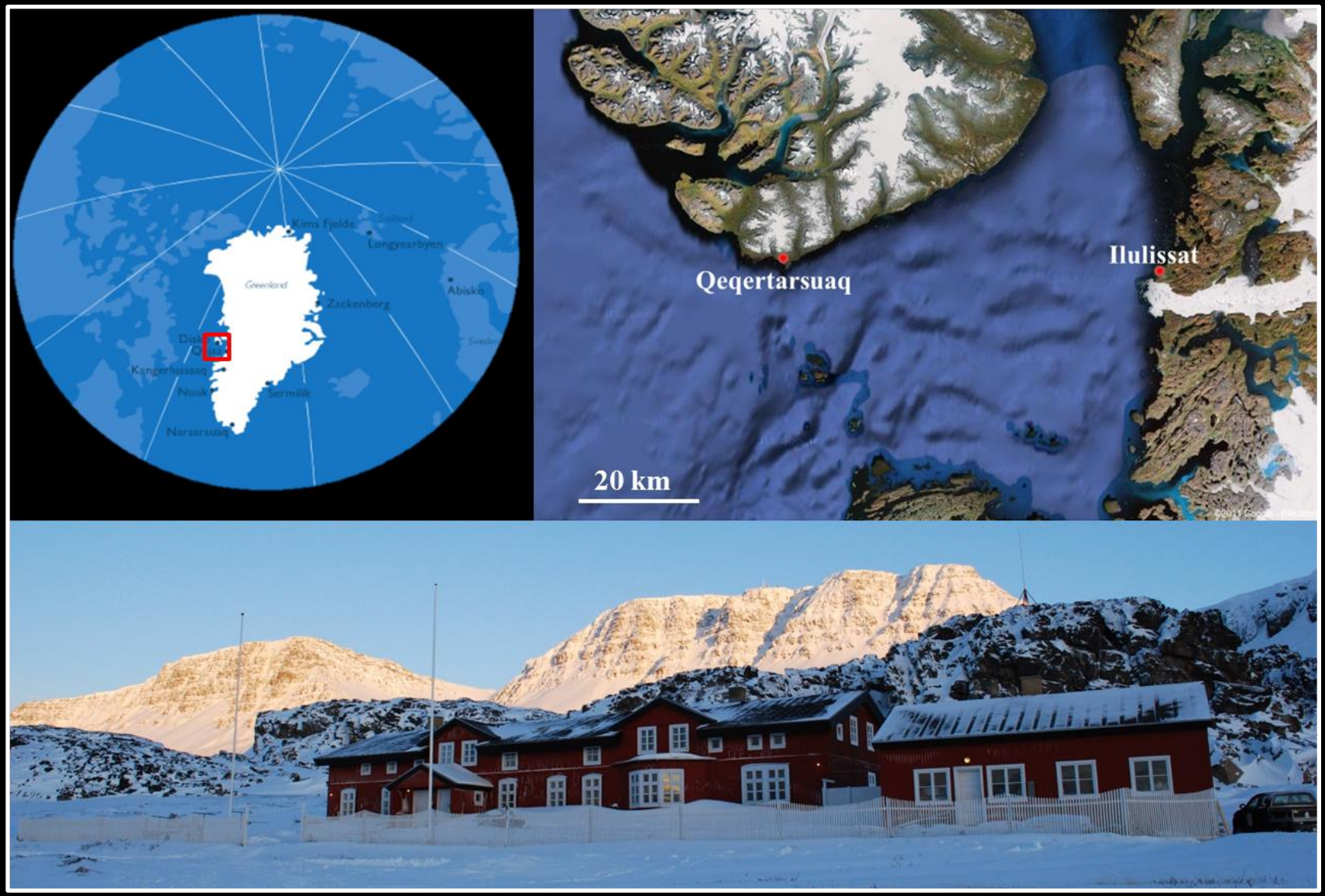
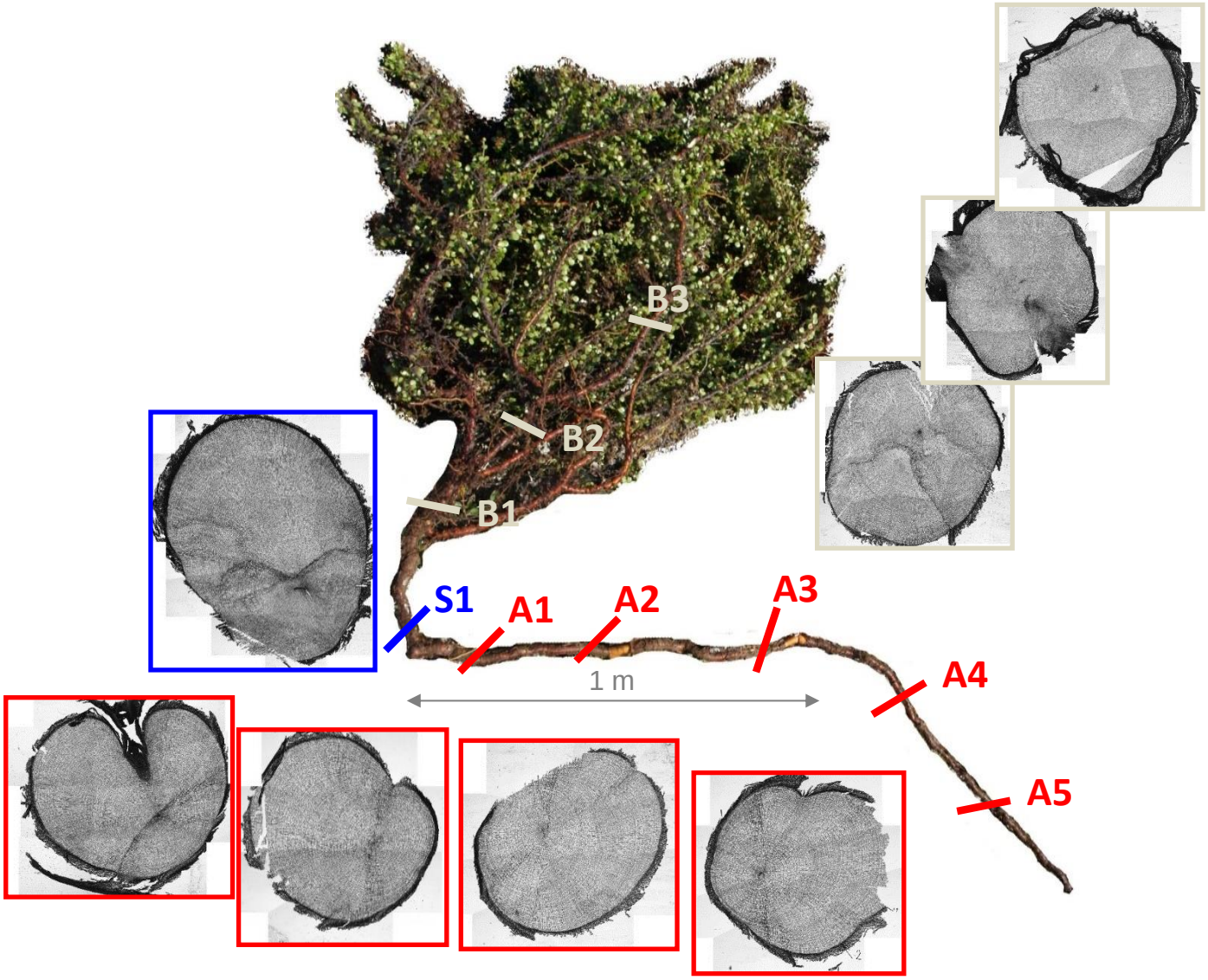
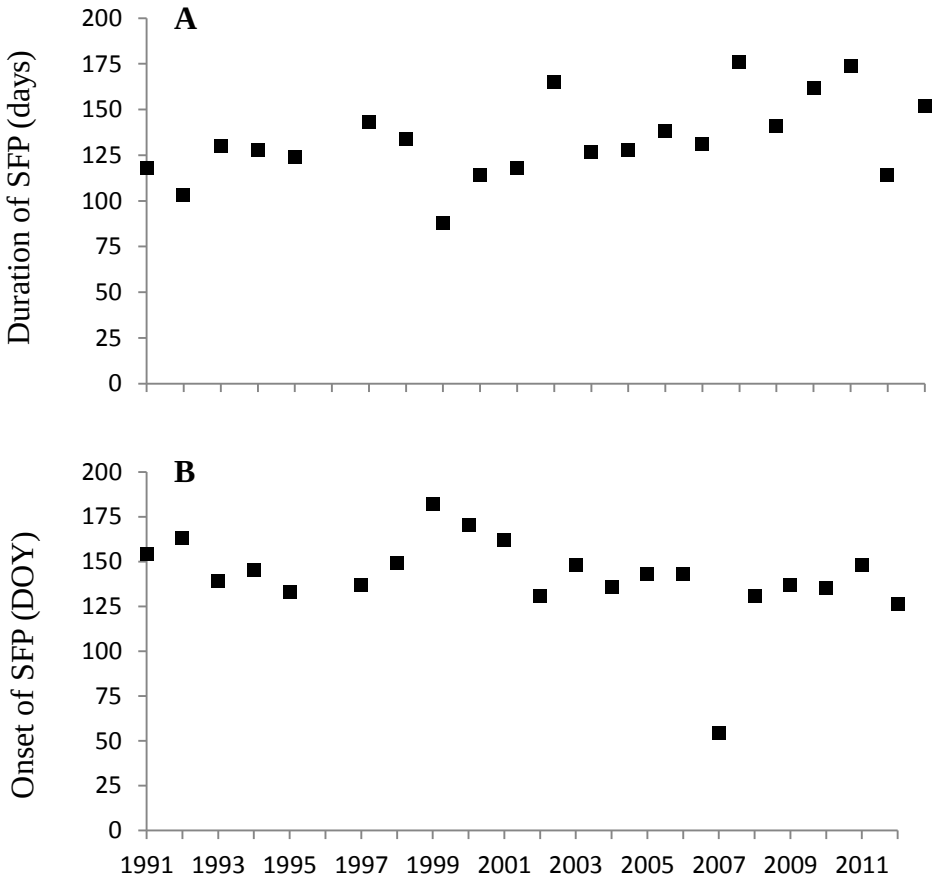
Supplementary figures: Winter warming as an important co-driver for Betula nana growth in western Greenland during the past century by Hollesen J., Buchwal A., Rachlewicz G., Hansen B.U., Hansen M.O., Stecher O. & Elberling B.



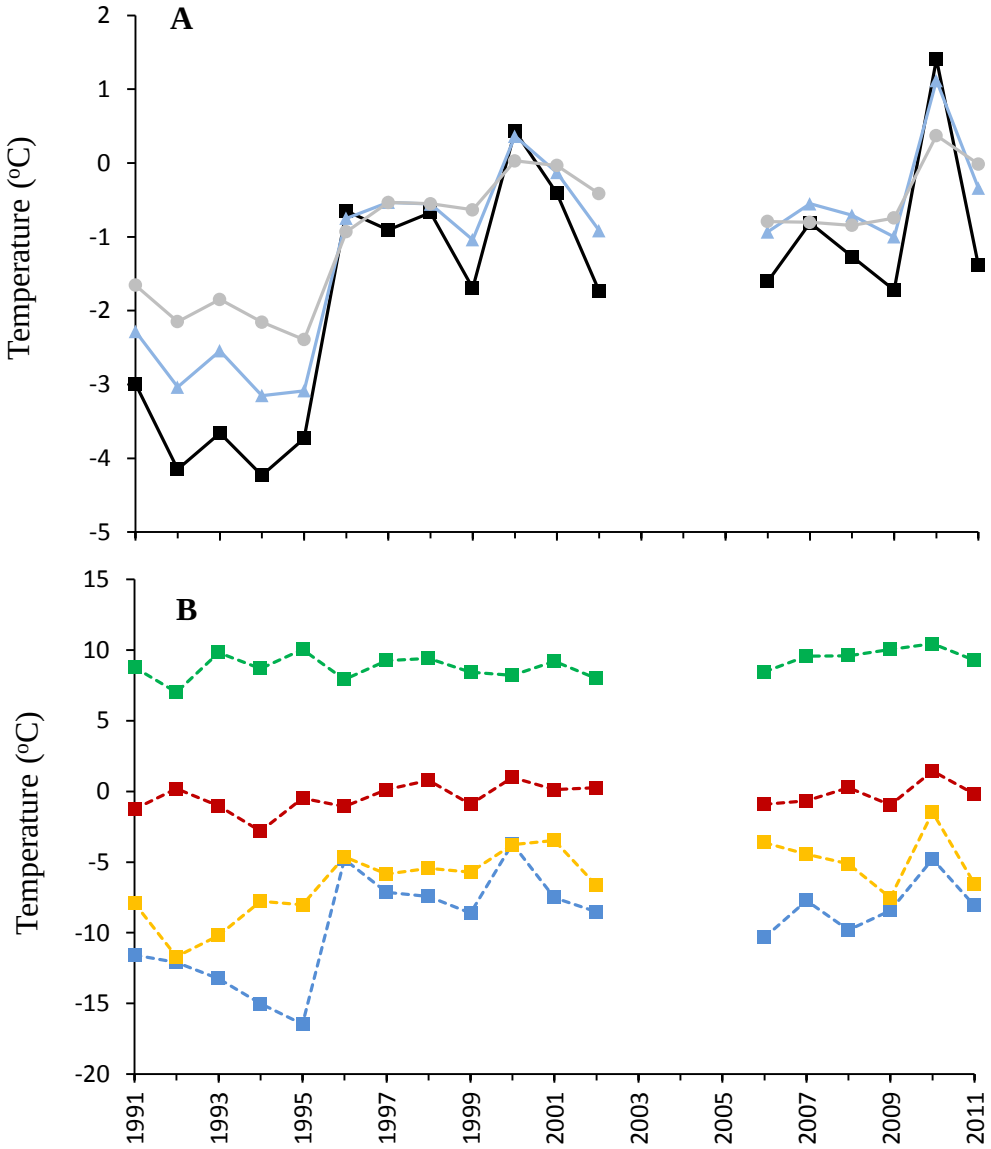
Supplementary figure S1: Location of the Arctic Station 2 km east of Qeqertarsuaq at Disko Island in western Greenland.



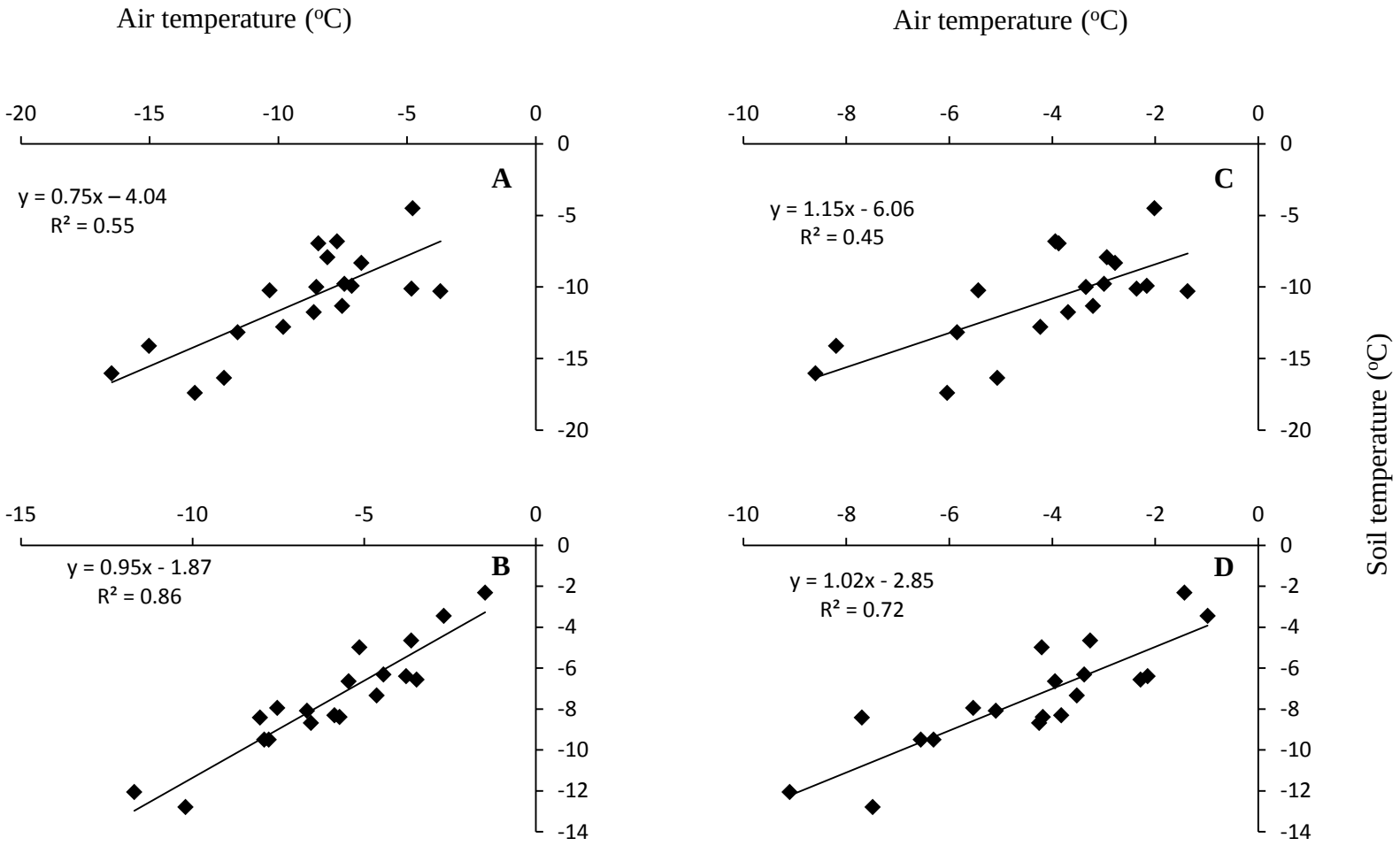
Supplementary figure S2: An example of serial sectioning of *Betula nana* individual collected near Arctic Station on Disko Island (western Greenland) with eight cross-sections taken from the main root (A1-A4), stem-like part (S1) and main above-ground shoot (B1-B3).



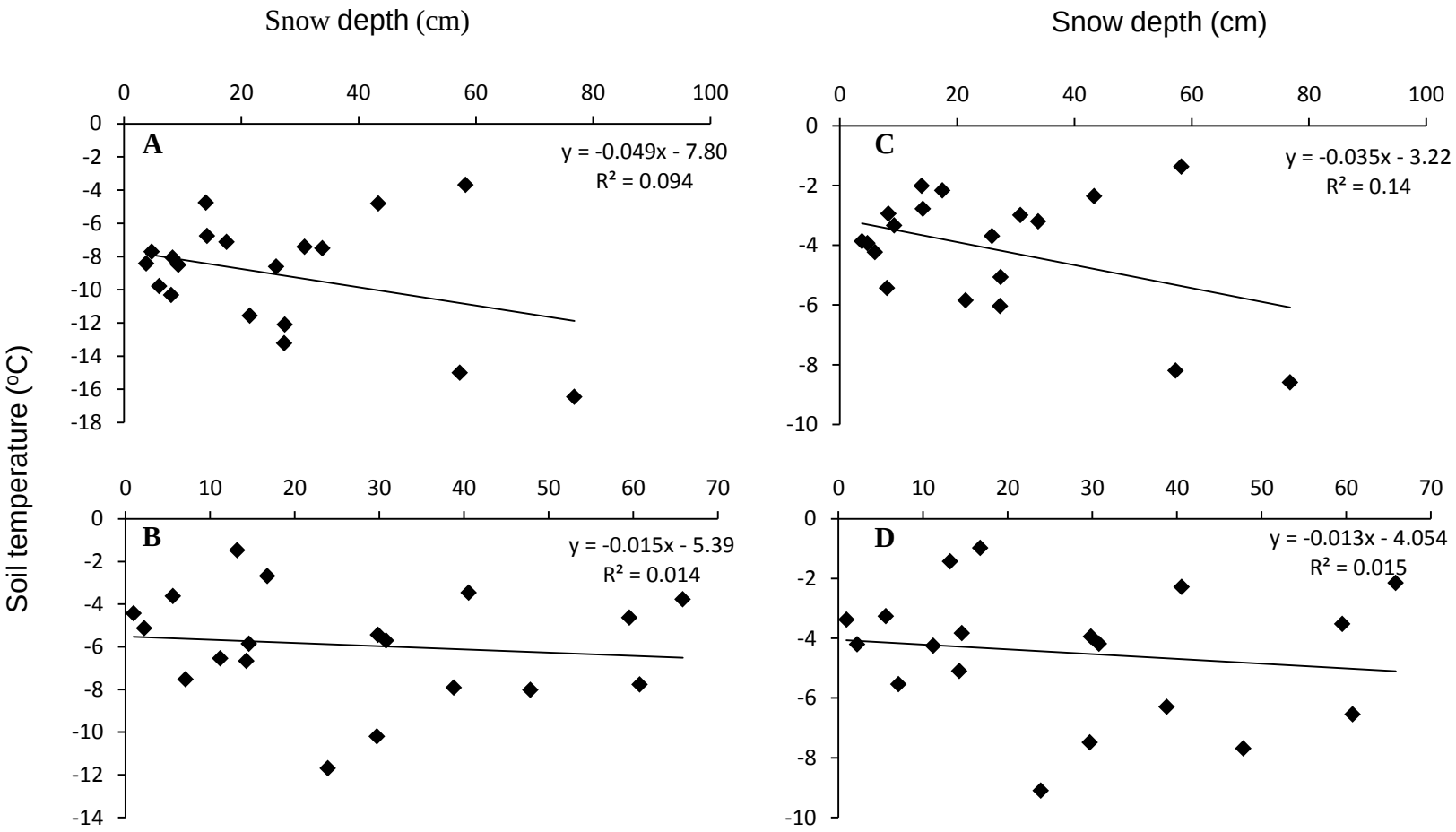
Supplementary figure S3: Duration **A**) and onset **B**) of the snow free period (SFP) at Arctic Station (Disko Island, western Greenland) from 1991-2012.



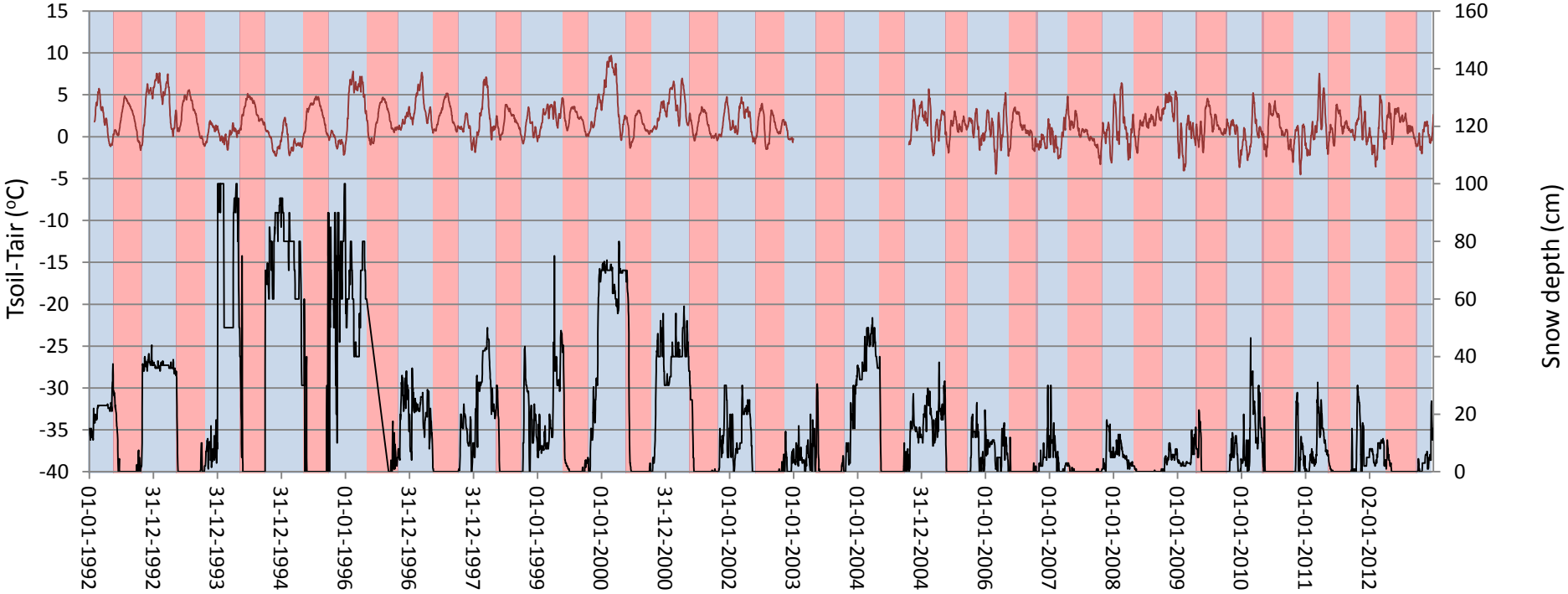
Supplementary figure S4: **A**) mean annual soil temperatures at 0.05 m (black), 0.60 m (blue) and 1.70 m (grey) at Arctic Station (Disko Island, western Greenland) from 1991-2011. **B**) Seasonal temperature trends in 0.05 m depth for the winter (blue), spring (yellow), summer (green), and autumn (red).



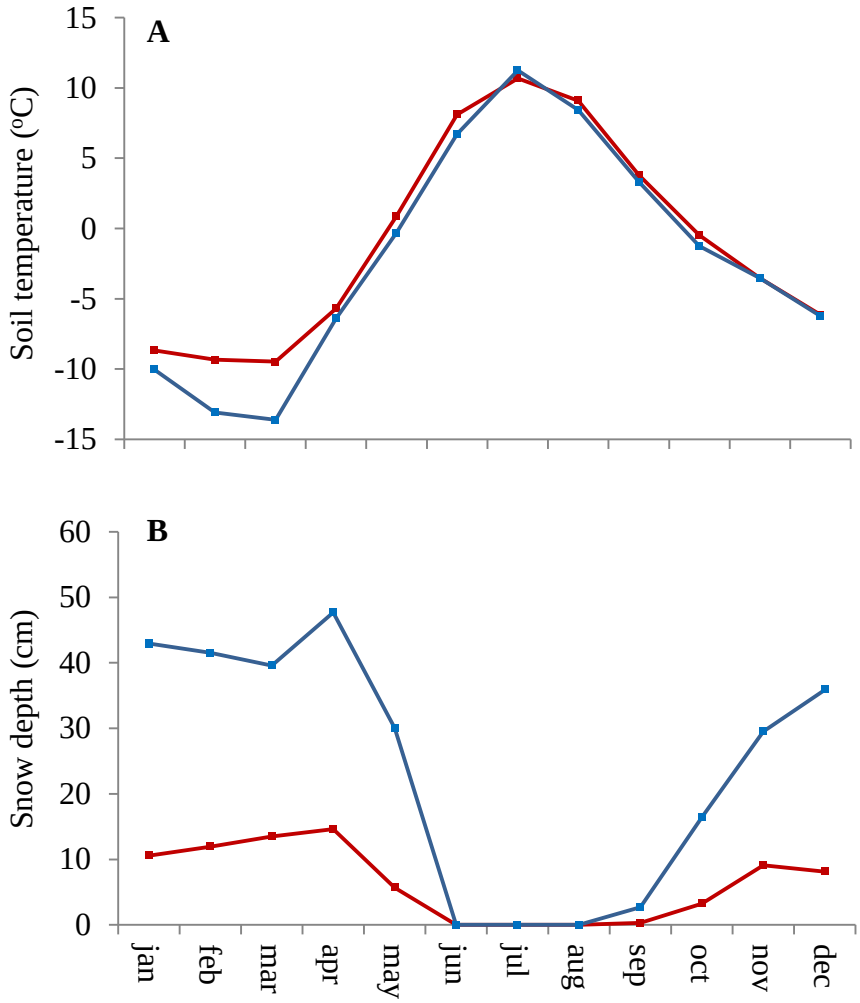
Supplementary figure S5: Correlation between seasonal air temperatures and soil temperatures at Arctic Station (Disko Island, western Greenland) from 1991-2011 for **A**) 0.05 m depth winter, **B**) 0.05 m depth spring, **C**) 0.60 m depth winter and **D**) 0.60 m depth spring.



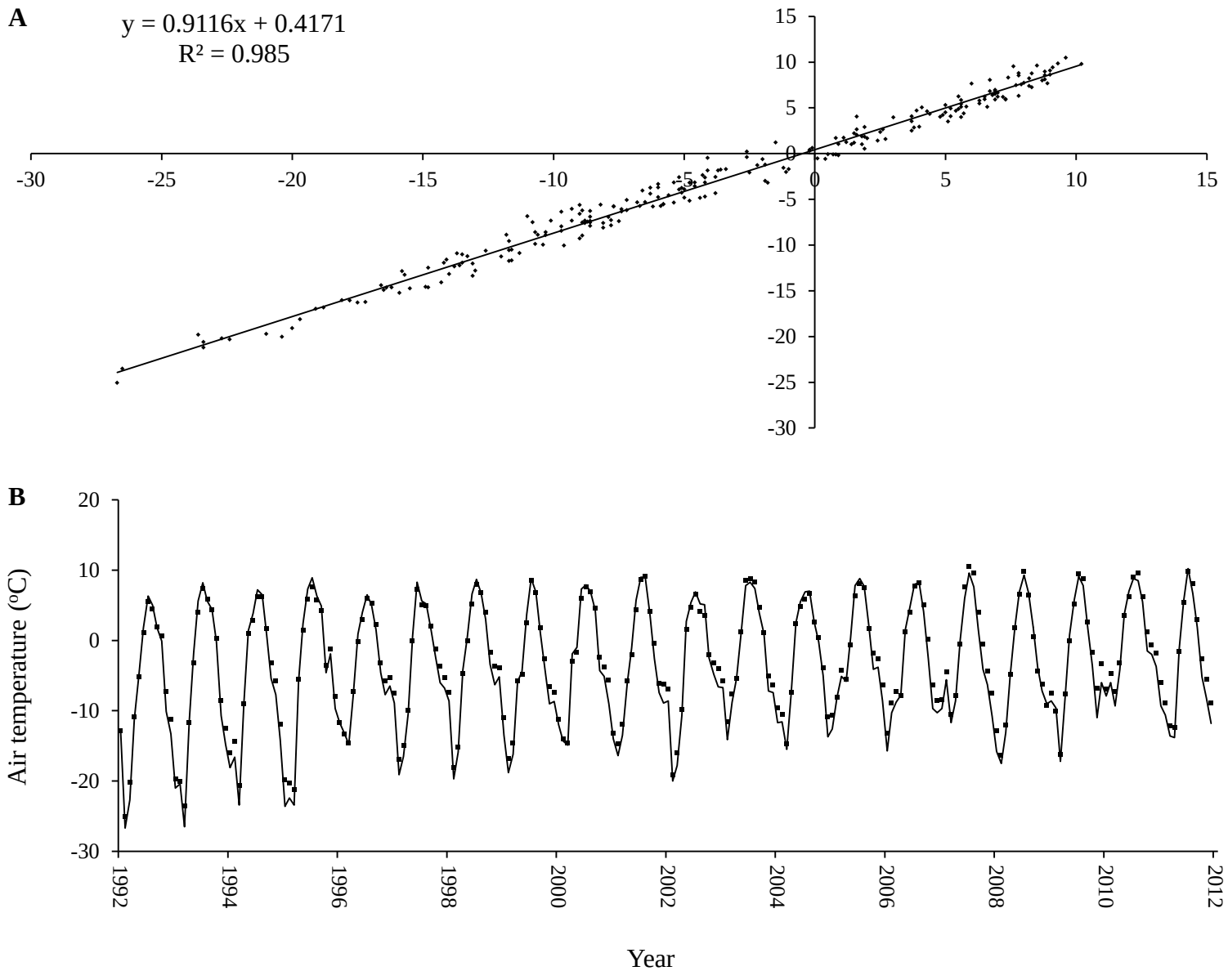
Supplementary figure S6: Correlation between seasonal snow depths and soil temperatures at Arctic Station (Disko Island, western Greenland) from 1991-2011 for **A**) 0.05 m depth winter, **B**) 0.05 m depth spring, **C**) 0.60 m depth winter and **D**) 0.60 m depth spring.



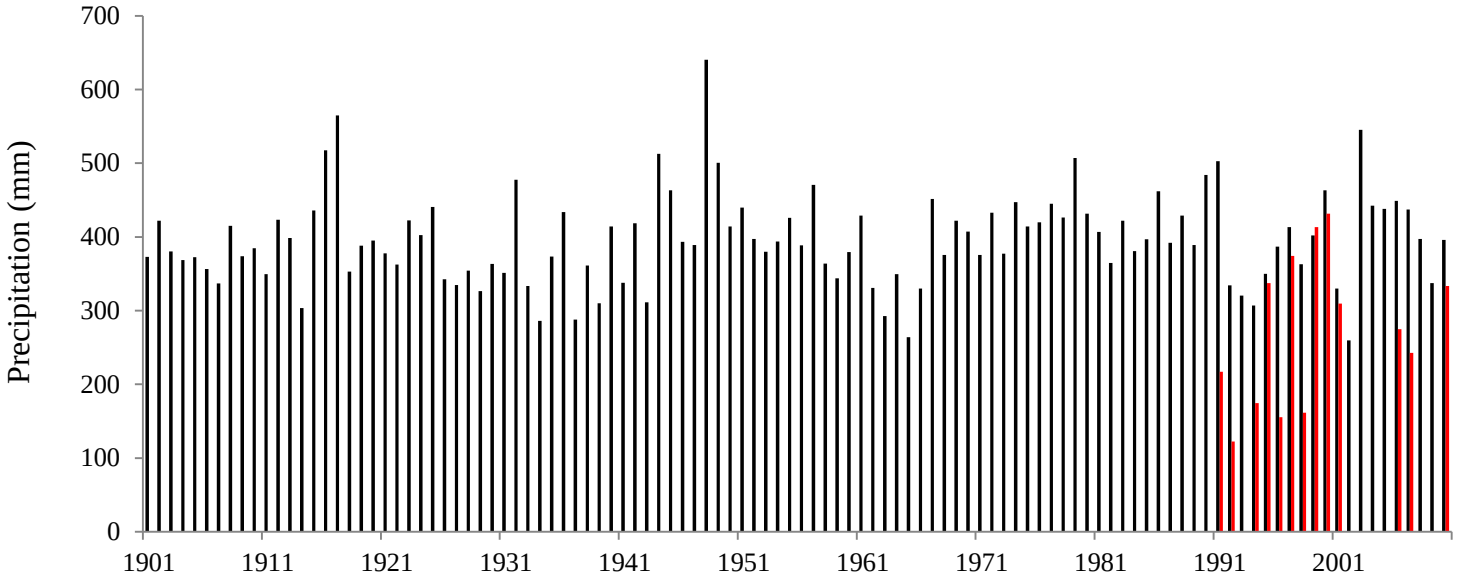
Supplementary figure S7: The upper red line shows a 14 days running average of the soil temperature (0.05 cm depth) subtracted the air temperature. Positive values indicate that soil temperatures are higher than air temperatures and vice versa. The lower black line show snow depths. Blue colors indicate the period with snow and the red the snow free period.



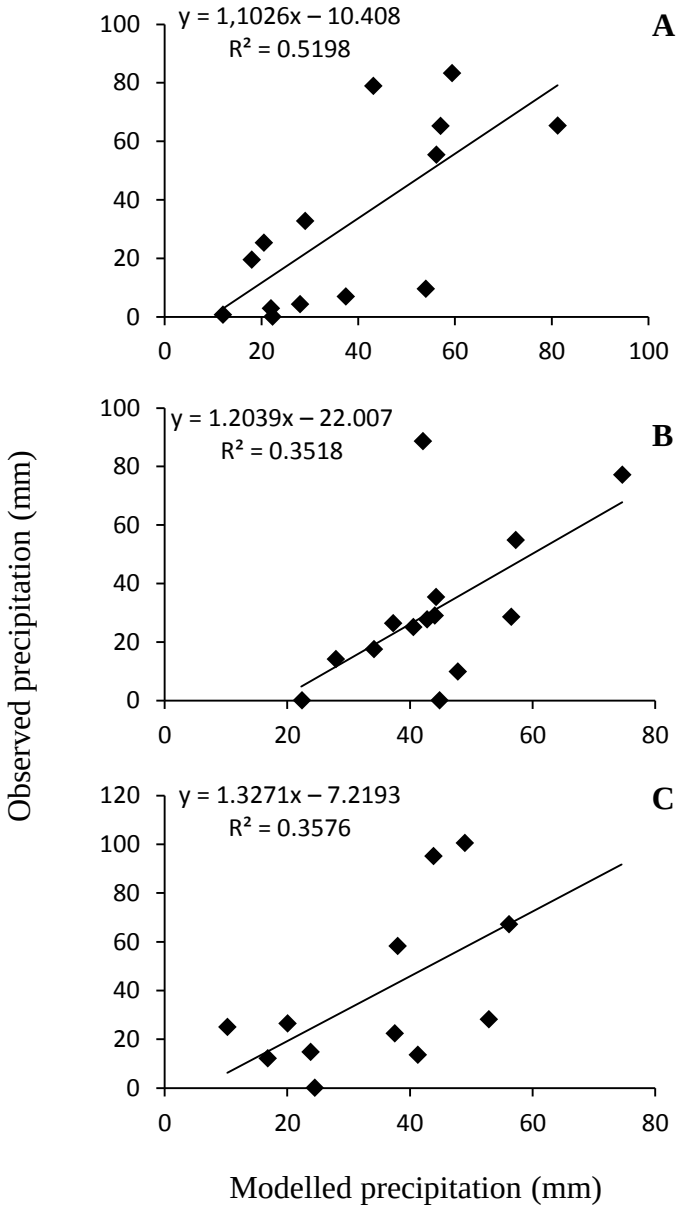
Supplementary figure S8: Soil temperatures **A**) and snow depts **B**) measured at Arctic Station (Disko Island, western Greenland) for the periods 1991-2000 (blue) and 2002-2011 (red).



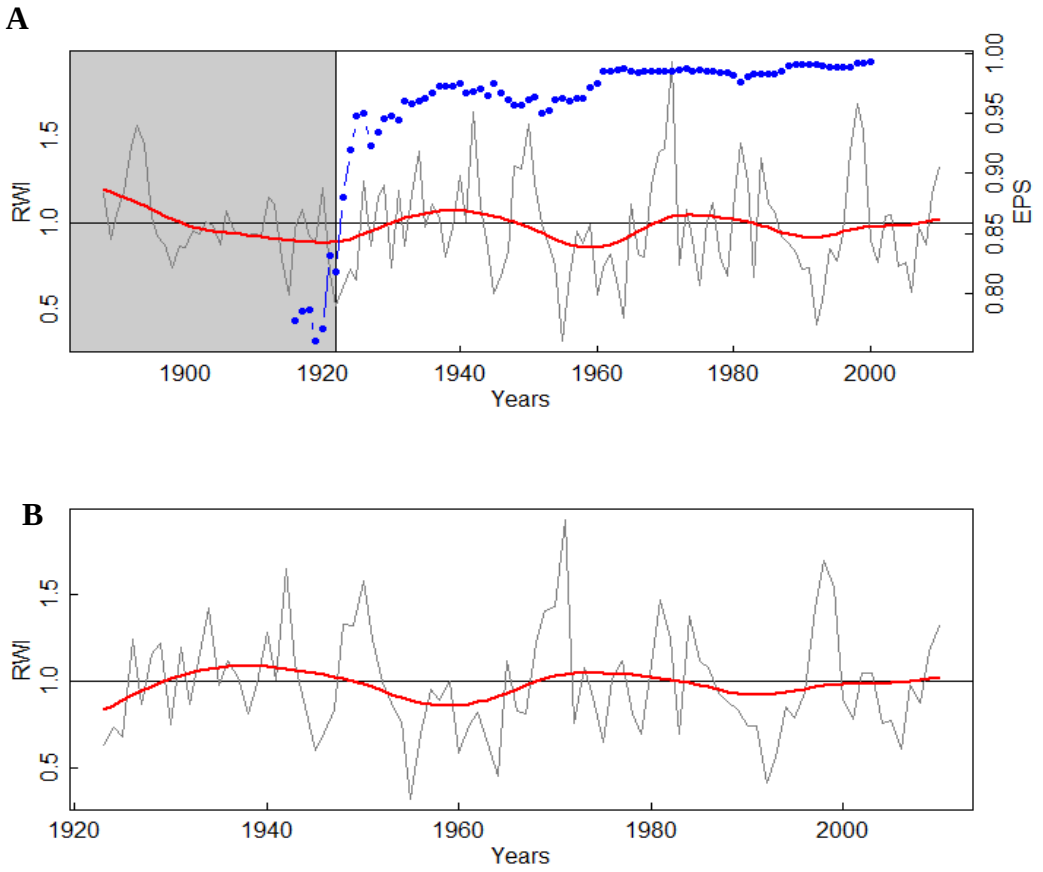
Supplementary figure S9: **A**) correlation between monthly air temperatures measured at Arctic Station (Disko Island) and Ilulissat (western Greenland). **B**) Monthly air temperatures from Arctic Station (squares) and Ilulissat (line).



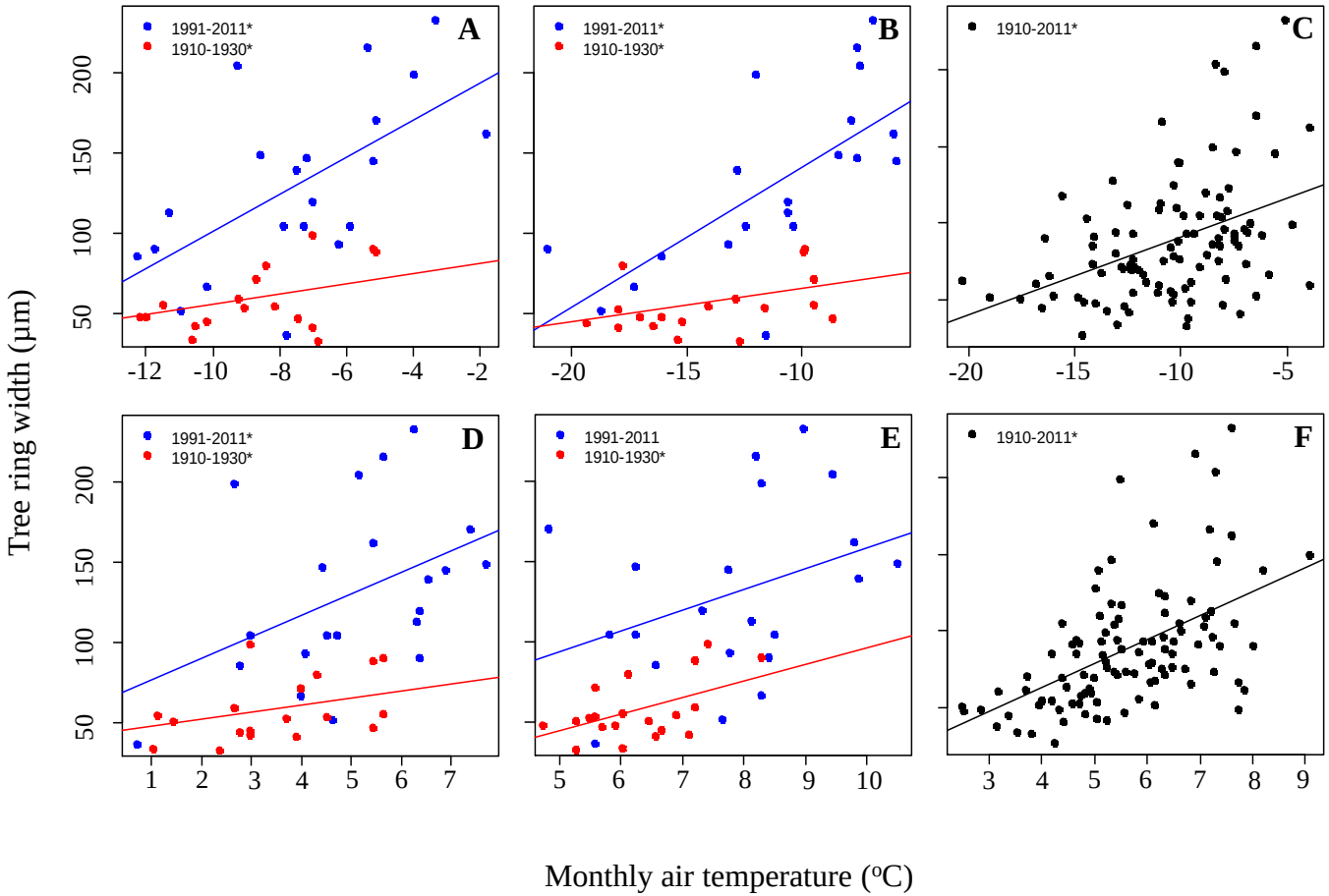
Supplementary figure S10: Annual precipitation rates for the period 1901-2010 derived from the NOAA precipitation model (Schneider *et al.*, 2011) shown as black bars and observed annual precipitation rates measured at the Arctic Station 1991-2010 shown as red bars.



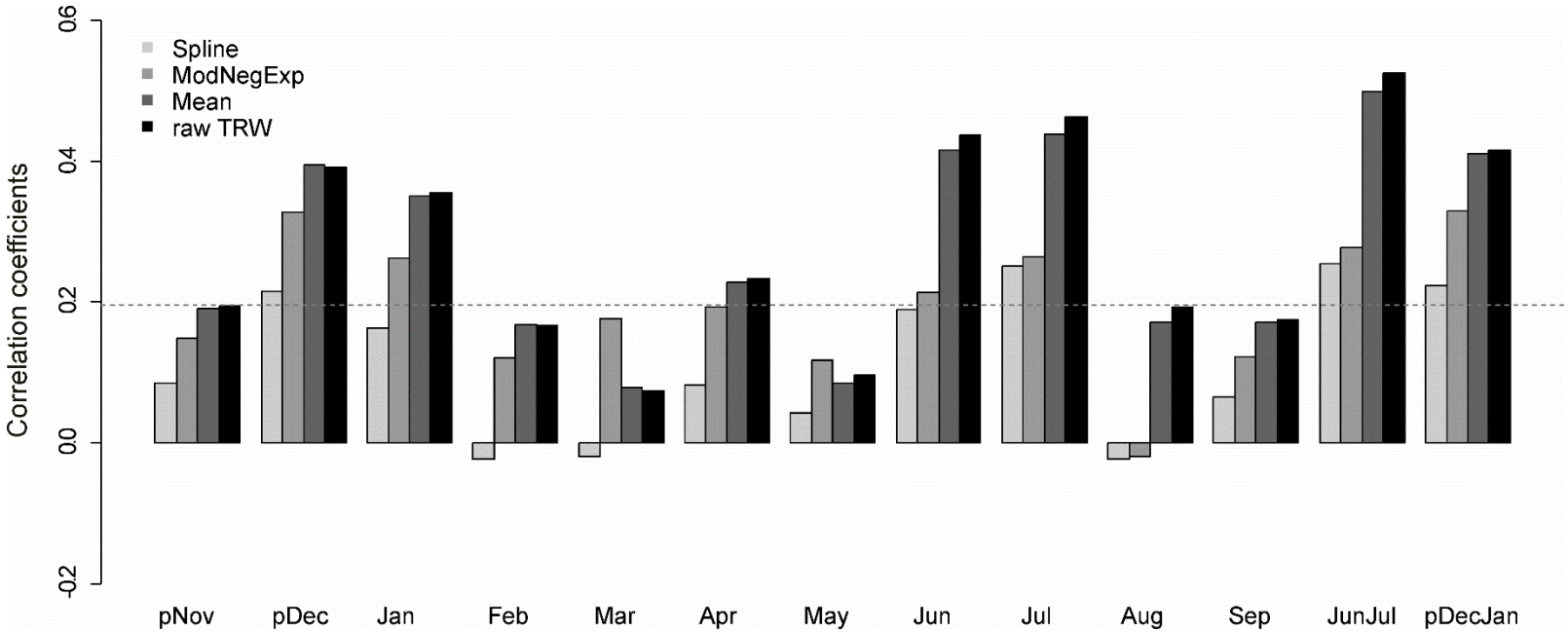
Supplementary figure S11: Correlation between monthly precipitation rates from 1991-2010 measured at Arctic Station (Disko Island, western Greenland) and derived from NOAA precipitation models (Schneider *et al.*, 2011) for: **A**) June, **B**) July and **C**) August.



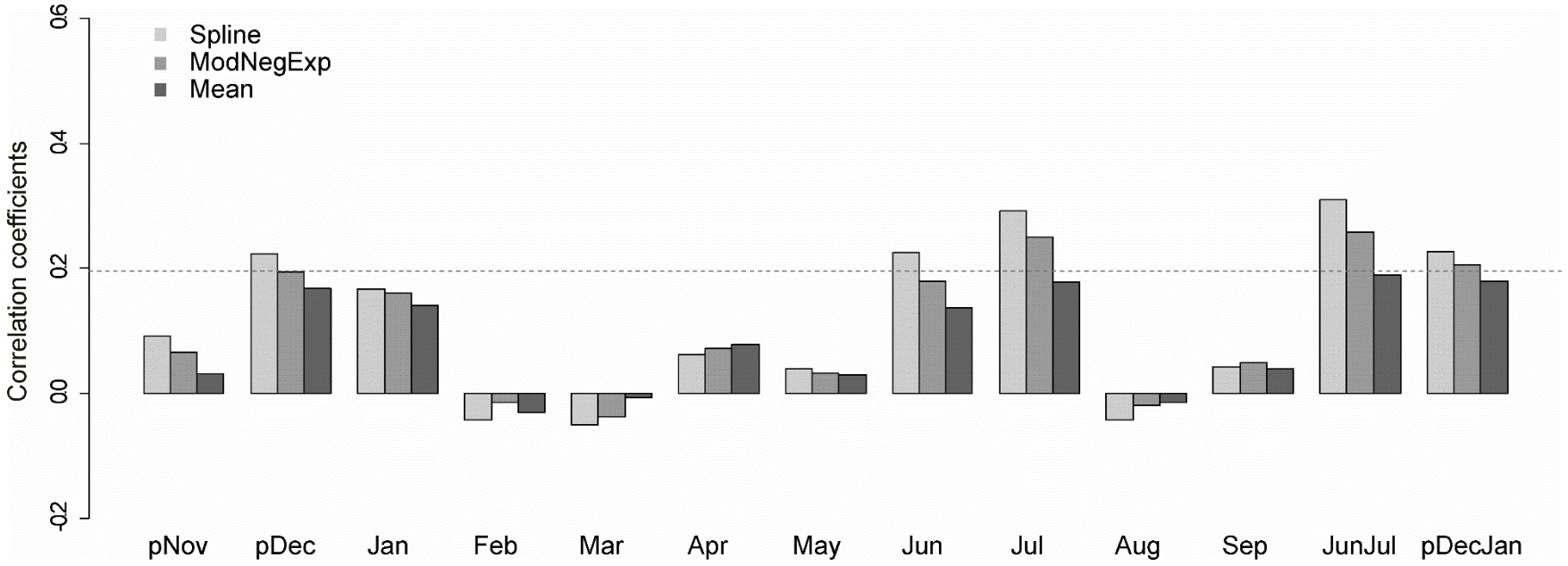
Supplementary figure S12: **A**) *Betula nana* ring-width chronology for southern Disko Island (western Greenland) (detrended method: 32-years spline) with running EPS values (window length=20, window overlap=19), **B**) *Betula nana* chronology after cut off, showing the period of chronology with the EPS>0.85. RWI = ring-width index; EPS = expressed population signal (Wigley *et al.*, 1984).



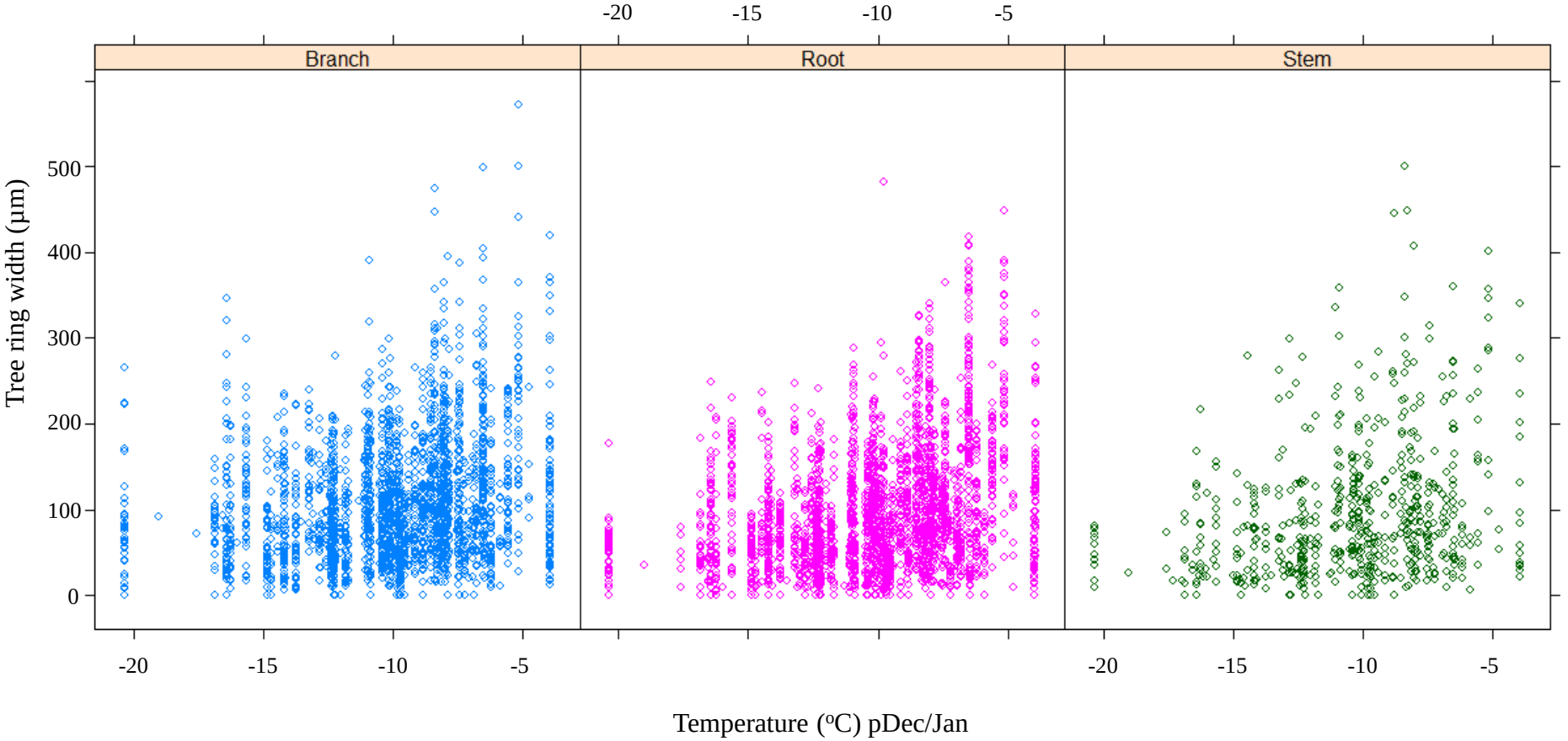
Supplementary figure S13: *Betula nana* ring-width chronology for southern Disko Island (western Greenland) and correlations with mean monthly temperatures for: **A**) previous December, **B**) January , **C**) previous December and January, **D**) June, **E**) July, and **F**) June and July. Highly significant correlations are marked with a * ($p<0.05$). See Supporting Tables for equations, r and p-values.



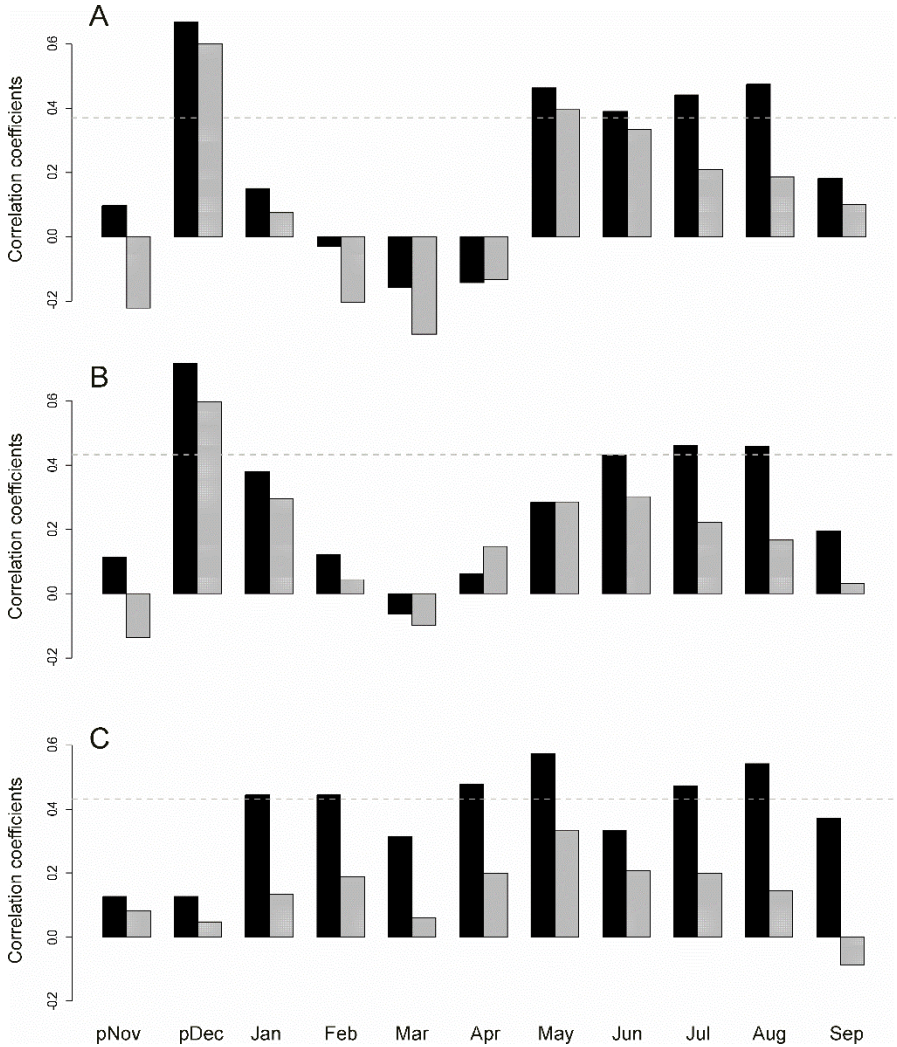
Supplementary figure S14: Pearson's correlation coefficients between raw (black bars) and standardized (grey bars) *Betula nana* chronologies (Disko Island, western Greenland) and air temperature for the period 1910-2011 ($p<0.05$, dashed line). Three detrending methods of raw series consists of a 32-year smoothing spline („Spline"), a modified negative exponential curve („ModNegExp") and a horizontal line („Mean").



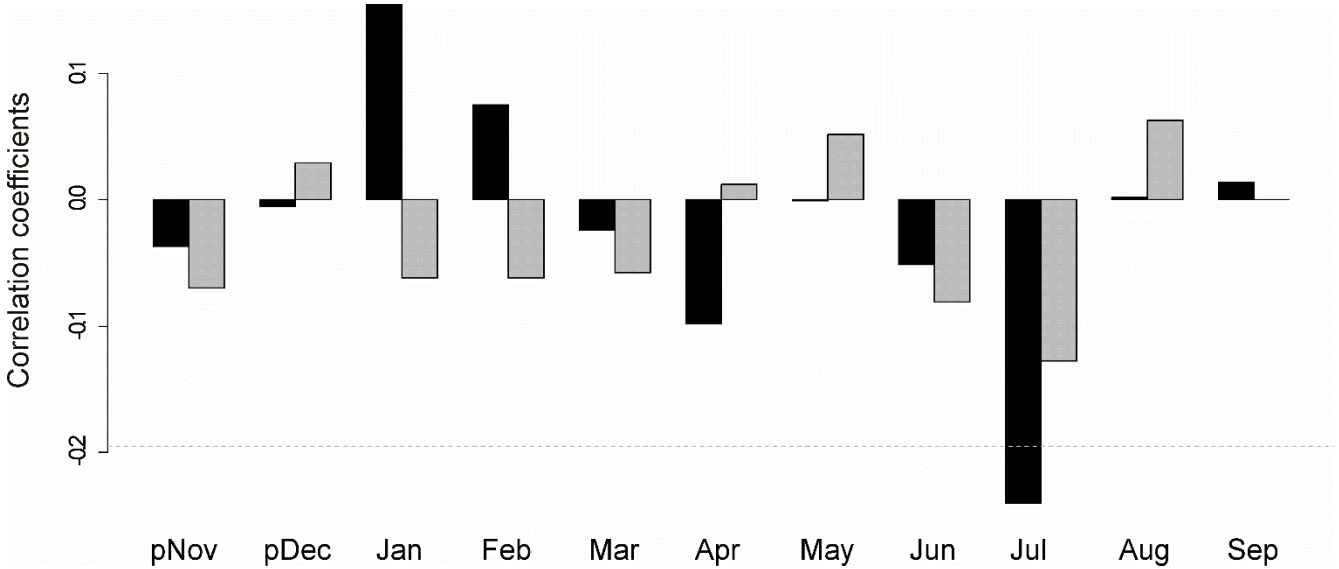
Supplementary figure S15: Pearson's correlation coefficients between standardized *Betula nana* chronologies (Disko Island, western Greenland) and standardized monthly mean air temperature data for the period 1910-2011, Values above dashed line are significant at $p<0.05$. Three detrending methods of raw growth ring series consists of a 32-year smoothing spline („Spline"), a modified negative exponential curve („ModNegExp") and a horizontal line („Mean"). Climate data were standardized by fitting a 30-year smoothing spline into a raw climate records.



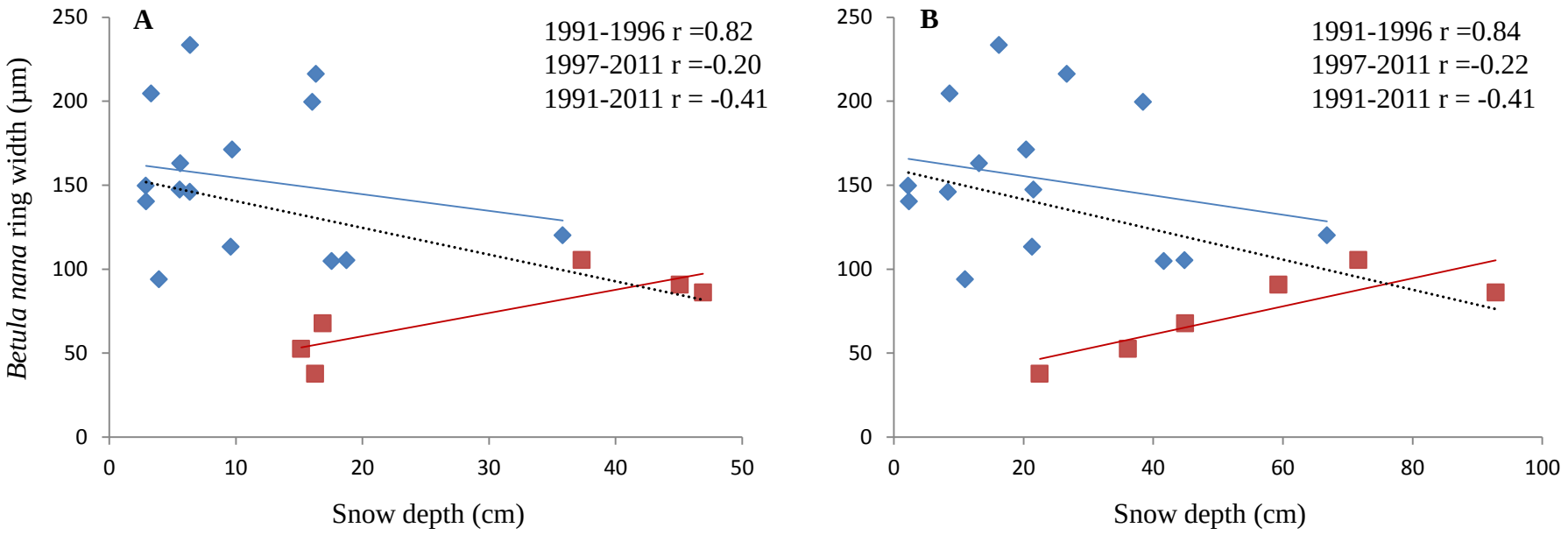
Supplementary figure S16: Correlation between *Betula nana* ring-width (1910-2011) in above-ground and below-ground parts and previous December and current January air temperature (pDecJan) for Arctic Station (Disko Island, western Greenland).



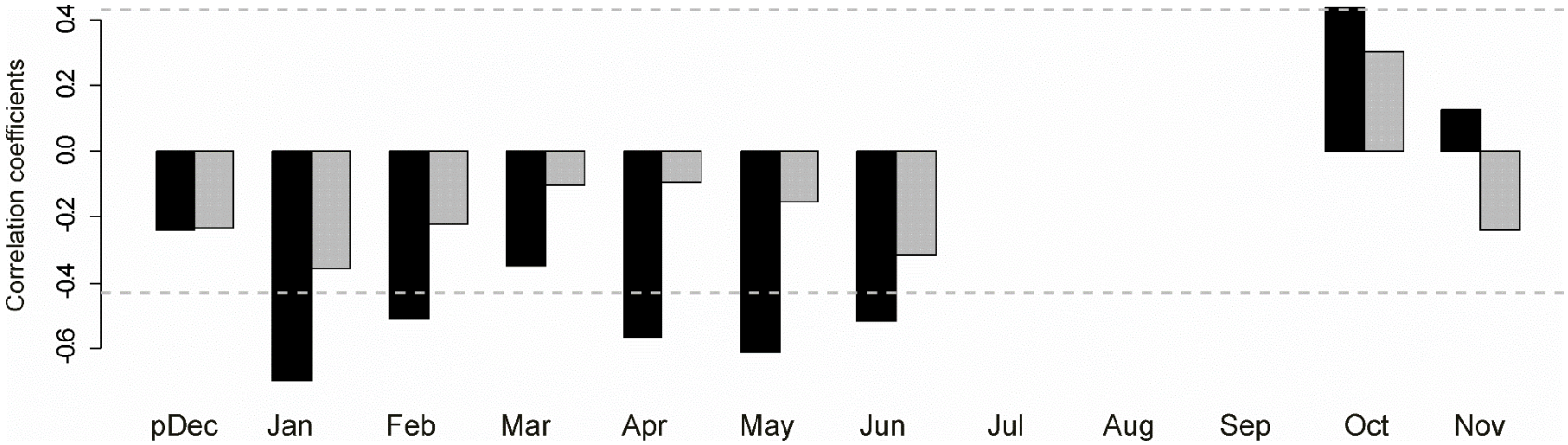
Supplementary figure S17. Pearson's correlation coefficients between *Betula nana* ring-width chronology for Arctic Station (Disko Island, western Greenland) (black=undetrended; grey=detrended) and **A**) mean monthly growing degree days (GDD) derived from Arctic Station for 1991-2011; **B**) mean monthly thawing degree days (TDD) for 1991-2011; and **C**) soil temperatures at 60 cm depth derived from Arctic Station (1991-2011). Significance levels ($p<0.05$) are indicated by horizontal dashed lines.



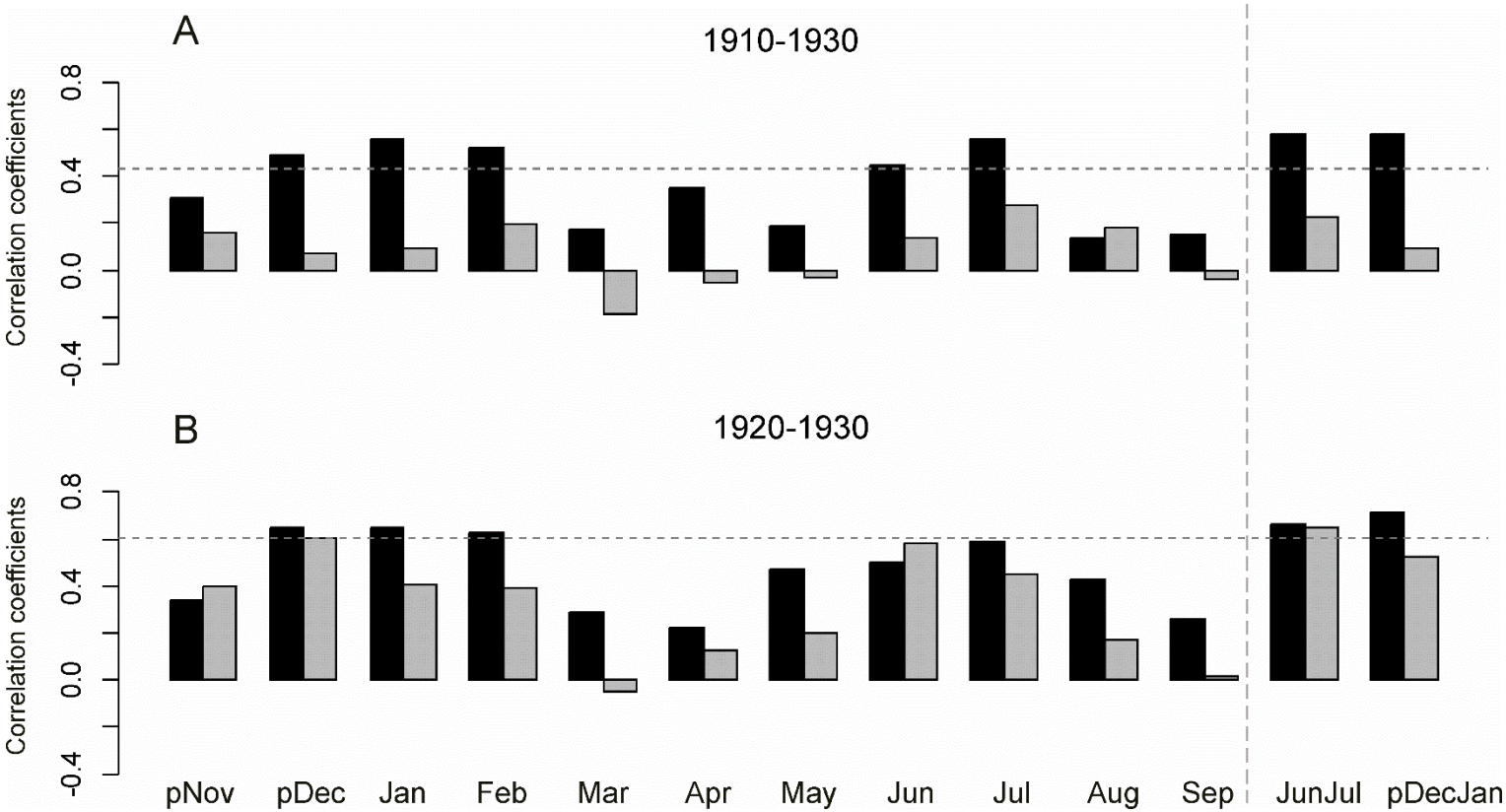
Supplementary figure S18. Pearson's correlation coefficients between *Betula nana* ring-width chronology for Arctic Station (Disko Island, western Greenland) (black=undetrended; grey=detrended) and modelled average monthly precipitation rates from NOAA precipitation models 1910-2011 (Schneider *et al.*, 2011). Significance levels ($p<0.05$) are indicated by horizontal dashed lines.



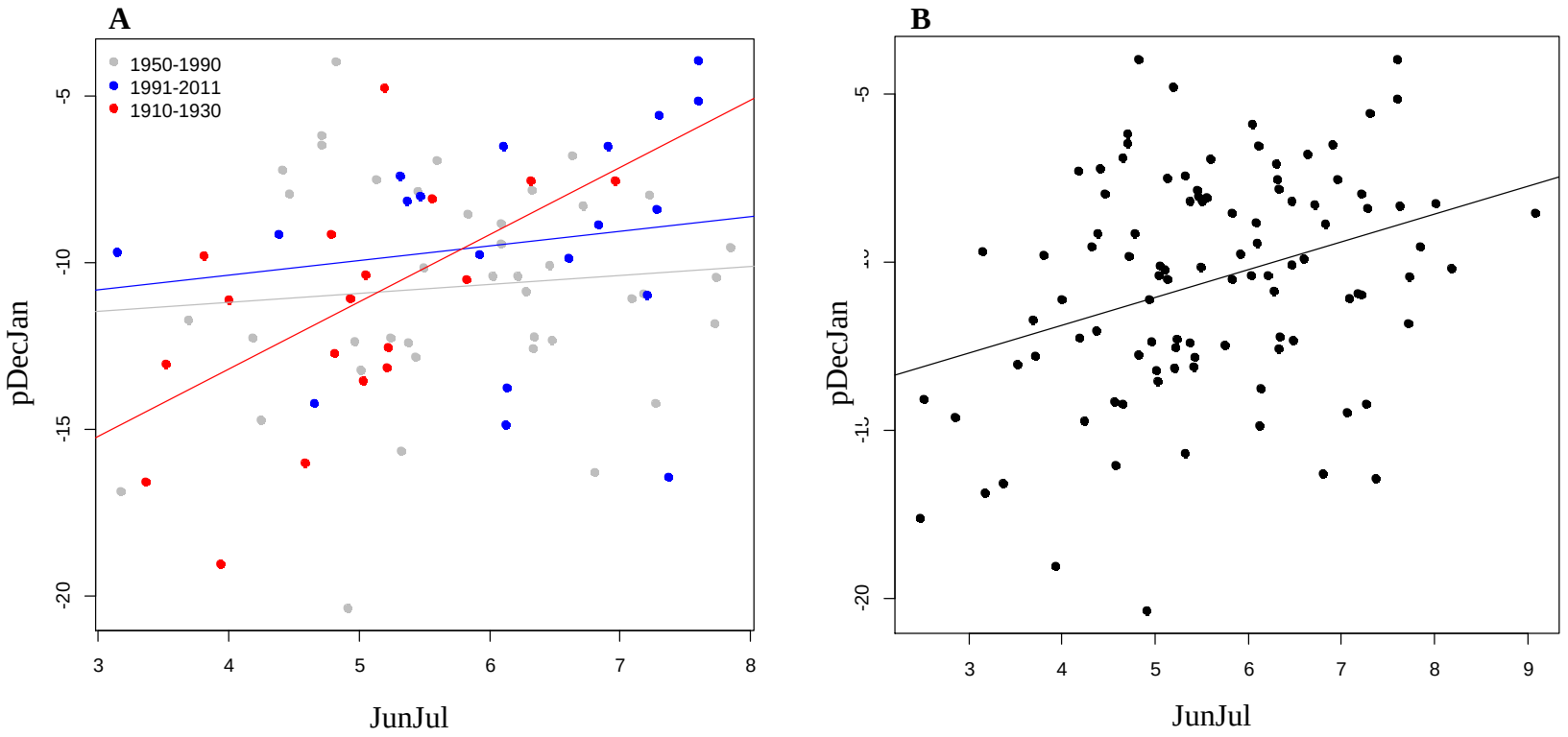
Supplementary figure S19: Correlations between *Betula nana* ring-width chronology for southern Disko Island (western Greenland) and measured snow depths from 1991-1996 (red), 1997-2011 (blue) for **A**) pDec-Feb and **B**) April. The black dotted line show the linear fit for the whole period 1991-2011.



Supplementary figure S20: Pearson's correlation coefficients between *Betula nana* tree-ring width chronology (black=undetrended; grey=detrended) and mean monthly percentage of sea ice cover observed at Arctic Station from 1991-2011 (Disko Island, western Greenland). Significance levels ($p<0.05$) are indicated by horizontal dashed lines.



Supplementary figure S21: Pearson's correlation coefficients between *Betula nana* ring-width chronology (black=undetrended; grey=detrended) and monthly air temperature derived from Arctic Station (Disko Island, western Greenland) for **A**) 1910-1930, **B**) 1920-1930. Significance levels ($p<0.05$) are indicated by horizontal dashed lines.



Supplementary figure S22: Relationships between mean monthly air temperatures for previous December and current January and current June and July derived from Arctic Station (Disko Island, western Greenland) for the periods **A**) 1910-1930, 1950-1990, 1991-2011 and **B**) 1910-2011.

Supplementary table S1: Significance (p-values) resulting from Pearson's correlations between *Betula nana* ring-width chronology and mean monthly air temperatures for Arctic Station (Disko Island, western Greenalnd). Highly significant values ($p<0.05$) are marked in bulk.

Time interval	pDecember	January	June	July	JunJul	pDecJan
1910-2011	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
1910-1930	**0.02**	**0.01**	**0.04**	**0.01**	**0.01**	**0.01**
1920-1930	**0.03**	**0.03**	0.12	0.06	**0.03**	**0.01**
1931-1960	0.22	0.62	0.54	0.07	0.14	0.32
1961-1990	0.72	0.95	0.51	0.06	0.12	0.91
1991-2011	**0.003**	**<0.001**	**0.05**	0.11	**0.03**	**<0.001**

Supplementary table S2: Significance (p-values) resulting from correlations between *Betula nana* ring-width chronology and mean monthly soil temperatures (°C) for Arctic Station (Disko Island, western Greenland). Highly significant values ($p<0.05$) are marked in bulk.

	pDec	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**
Soil temp. (-0.60 m) p	0.60	**0.05**	0.05	0.18	**0.03**	**0.008**	0.15	**0.04**

Supplementary table S3: Correlation coefficients and significance (p-values) resulting from correlations between curremt June and July (JunJul) and previous December and current January (pDecJan) and between previous December (pDec) and current June (Jun) monthly air temperatures for Arctic Station (Disko Island, western Greenalnd).Highly significant values ($p<0.05$) are marked in bulk.

Time interval	Cor JunJul vs. pDecJan	Cor pDec vs. Jun
1991-2011		
cor	0.18	0.12
p	0.43	0.61
1950-1990		
cor	0.09	-0.05
p	0.57	0.77
1910-2011		
cor	**0.33**	**0.25**
p	0.001	0.01
1910-1930		
Cor	**0.67**	**0.54**
p	0.001	0.01