SM7: Climate associations with Polar Urals and Yamal chronologies

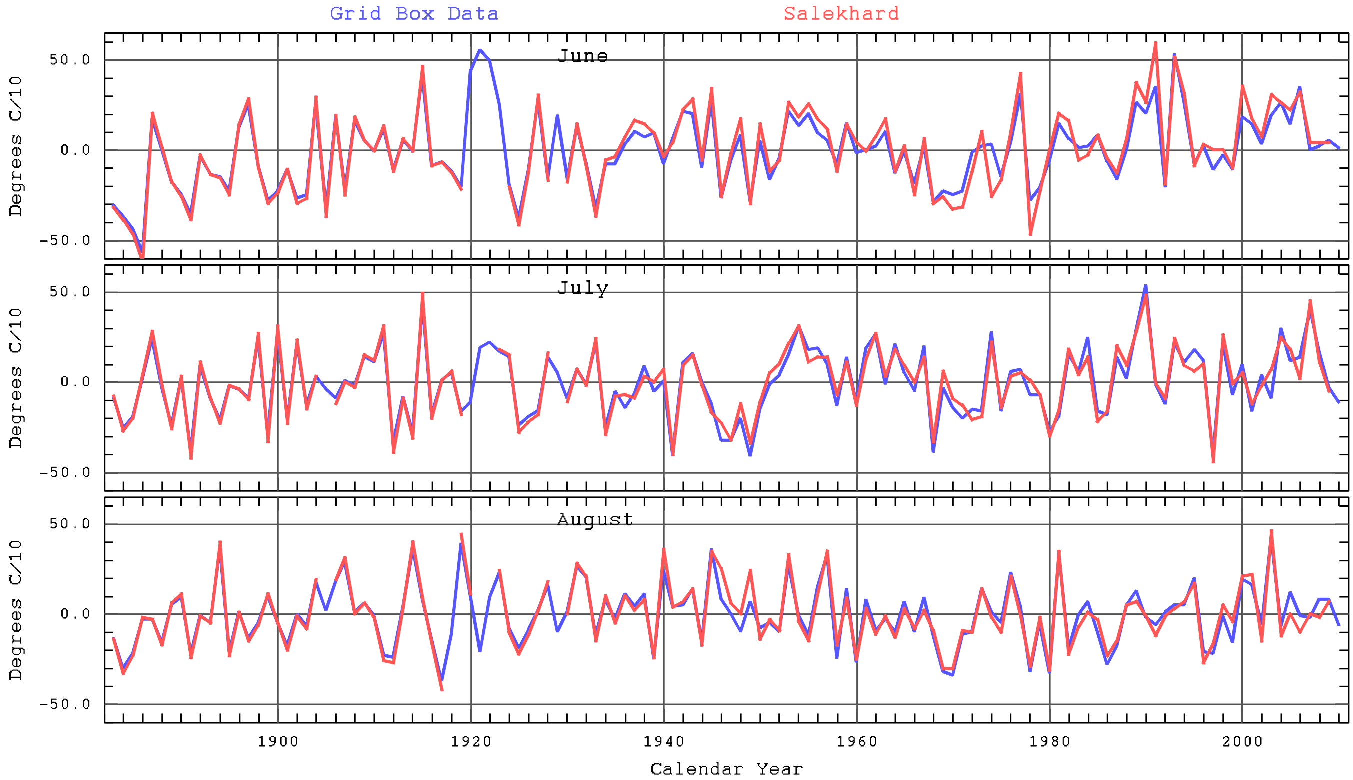
CA1: Gridded Climate data

Monthly-mean temperature data was obtained from CRUTEM4v (Jones et al. 2012) as anomalies from the period 1961 to 1990 (units of tenths of °C). The data variance has been adjusted for varying station counts. Data were downloaded for the 5° grid boxes which include the Polar Urals and Yamal sites and surrounding grid boxes with measurement data. The report "PY_Clim.prn" lists the range of data and counts of monthly measurements for the selected grid boxes, a cross-correlation report for each month of the year showing the relationship between data in the selected grid boxes, and a report of the details of the infilling process described below.

The most easterly and northerly grid boxes only contain data from 1936 or later so these were not used. The grid box centred on 67.5N, 67.5E contained more than 120 years of data (from 1883 to 2010), includes the Polar Urals sites and is the nearest long data set to the Yamal sites. This was selected for further processing. This grid box data had several missing values in the 1920s. Data for the two grid boxes south of this grid box (and south of the trees), 62.5N, 67.5E and 62.5N, 72.5E, contained values during the missing period, correlated well with the selected grid, and so were used to estimate the missing values. The means and standard deviations of common years between target and predictors over the period of 1900 to 1940 were used to scale and shift the values of individual years of the predictors to match the means and standard deviations of the target series and these adjusted values (mean of two where more than one value was available) were inserted into the 67.5N, 67.5E grid box series and saved as "AdjT67.5N67.5E.dat".

The adjusted grid box data were compared with the long series of station data from Salekhard (66.6N, 66.5E) from which the earliest grid box data were derived. The mean values of the monthly Salekhard series were deducted (creating anomaly data) for comparison and June, July and August series are plotted for grid and station data below.

Figure CA1 Monthly temperature series showing in-filled values (blue).



The adjusted (infilled) CRUTEM4v data from 67.5N, 67.5E are used for comparison with the tree-ring chronologies and to calibrate the reconstructions of the regional temperature. Correlations of means of monthly temperature data against the TRW and MXD chronologies show that for TRW, data averaged over a June to July season correlate most highly while for MXD, June to August is optimal. These seasons were filtered to produce 100-year low-pass, 100- to 15-year band-pass, and 15-year high-pass series for these climate seasons. Filtering was performed using a cubic smoothing spline with 50% amplitude cut-off at the required frequency and high-pass data were created by subtracting the smooth fitted line from the original data. The data were saved in file “PY_Clim.dat” which also shows correlations between individual grid-box series by month and details of the infilling process.

CA2.Filtering

Note there may be some minor end effects with the spline filtering (see discussion in SM8) which are ignored for these plots/calculations.

Figure CA2 Chronologies created for Yamal TRW (a), Polar Urals TRW (b) and Polar Urals MXD (c) using two curve signal-free RCS. These chronologies were separated into 15-year high-pass, 15-100-year band-pass, and 100-year low-pass chronologies using smoothing splines. Because the indices of the RCS chronologies created here are fractional deviations, the signals were separated using division; as a result the product of the high-pass, band-pass and low-pass chronologies will be the full chronology. The adjusted CRUTEM4v temperature series for 67.5N, 67.5E (mean of June and July (d) for TRW and mean of June to August (e) for MXD) were also separated into 15-year high-pass, 15-100-year band-pass, and 100-year low-pass chronologies using smoothing splines but with separation by subtraction; the sum of the high-pass, band-pass and low-pass temperature series reconstitutes the “full” observed temperature series.

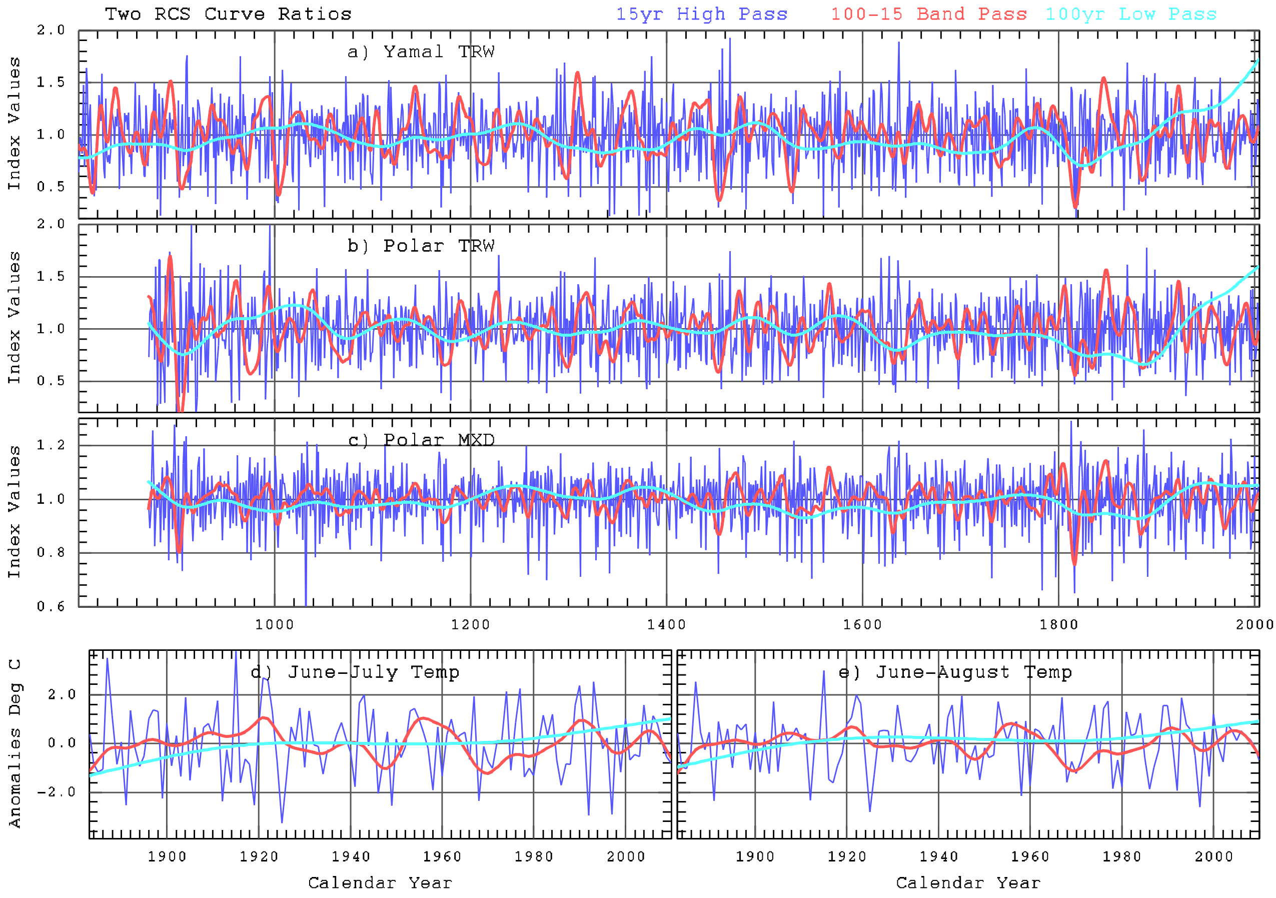


Figure CA3 Chronologies created for Yamal TRW (a), Polar Urals TRW (b) and Polar Urals MXD (c) using two curve signal-free RCS and tree indices converted to have a Normal distribution. These chronologies were separated into 15-year high-pass, 15-100-year band-pass, and 100-year low-pass chronologies using smoothing splines. Because the indices are approximately normally distributed in these chronologies, the signals were separated using subtraction; as a result the sum of the high-pass, band-pass and low-pass chronologies will be the full chronology. The adjusted CRUTEM4v temperature series for 67.5N, 67.5E (mean of June and July (d) for TRW and mean of June to August (e) for MXD) were also separated into 15-year high-pass, 15-100-year band-pass, and 100-year low-pass chronologies using smoothing splines, with separation by subtraction; the sum of the high-pass, band-pass and low-pass temperature seies reconstitutes the "full" observed temperature series.

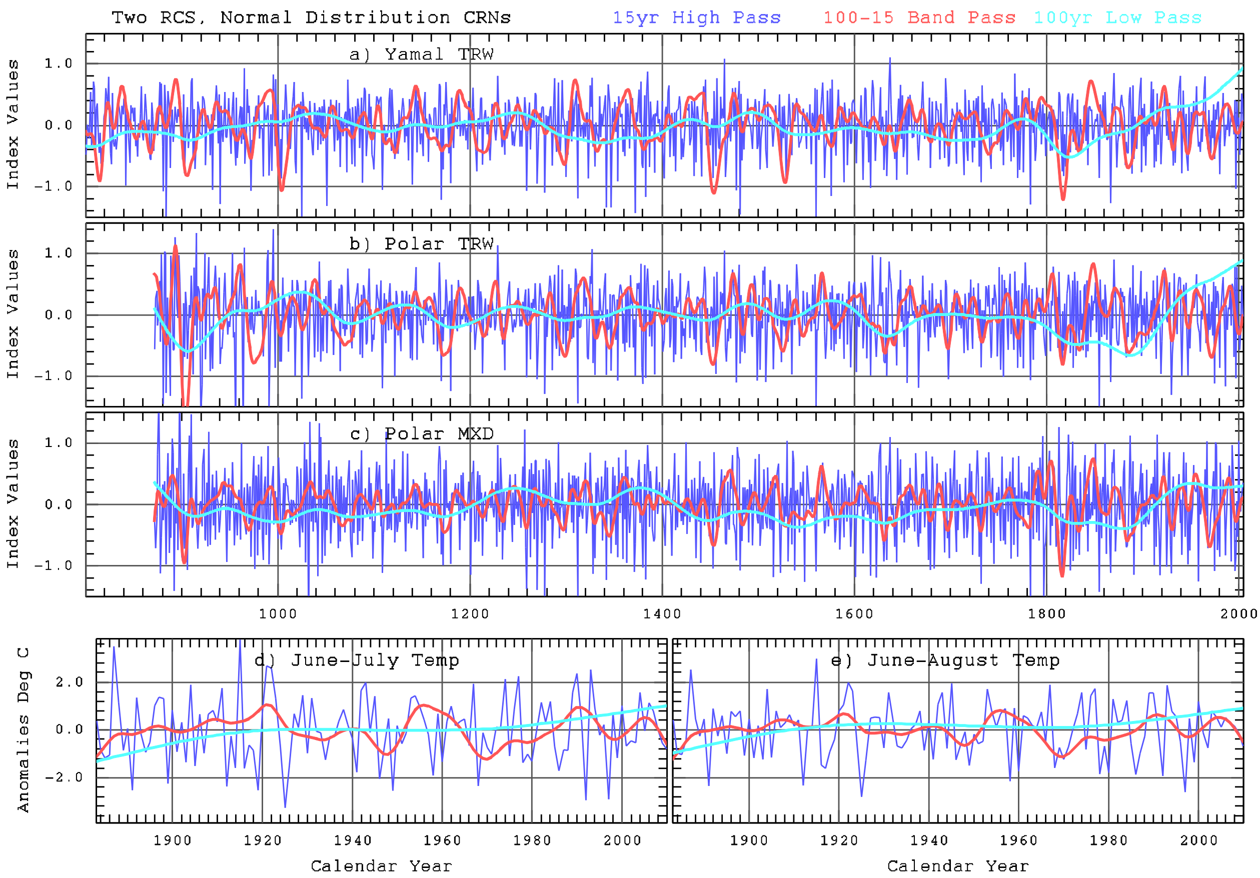


Figure CA4 Chronologies were created using processing methods as described in Figure CA2 using two-curve, signal-free RCS which produces tree indices as ratios and compared with temperature data. Series are plotted over the common period between chronologies and temperature data for different frequency divisions (from the top all frequencies, 100-year low-pass, 15-100-year band-pass, and 15-year high pass) and for the three separate chronologies from left to right: Yamal TRW, Polar Urals TRW and Polar Urals MXD.

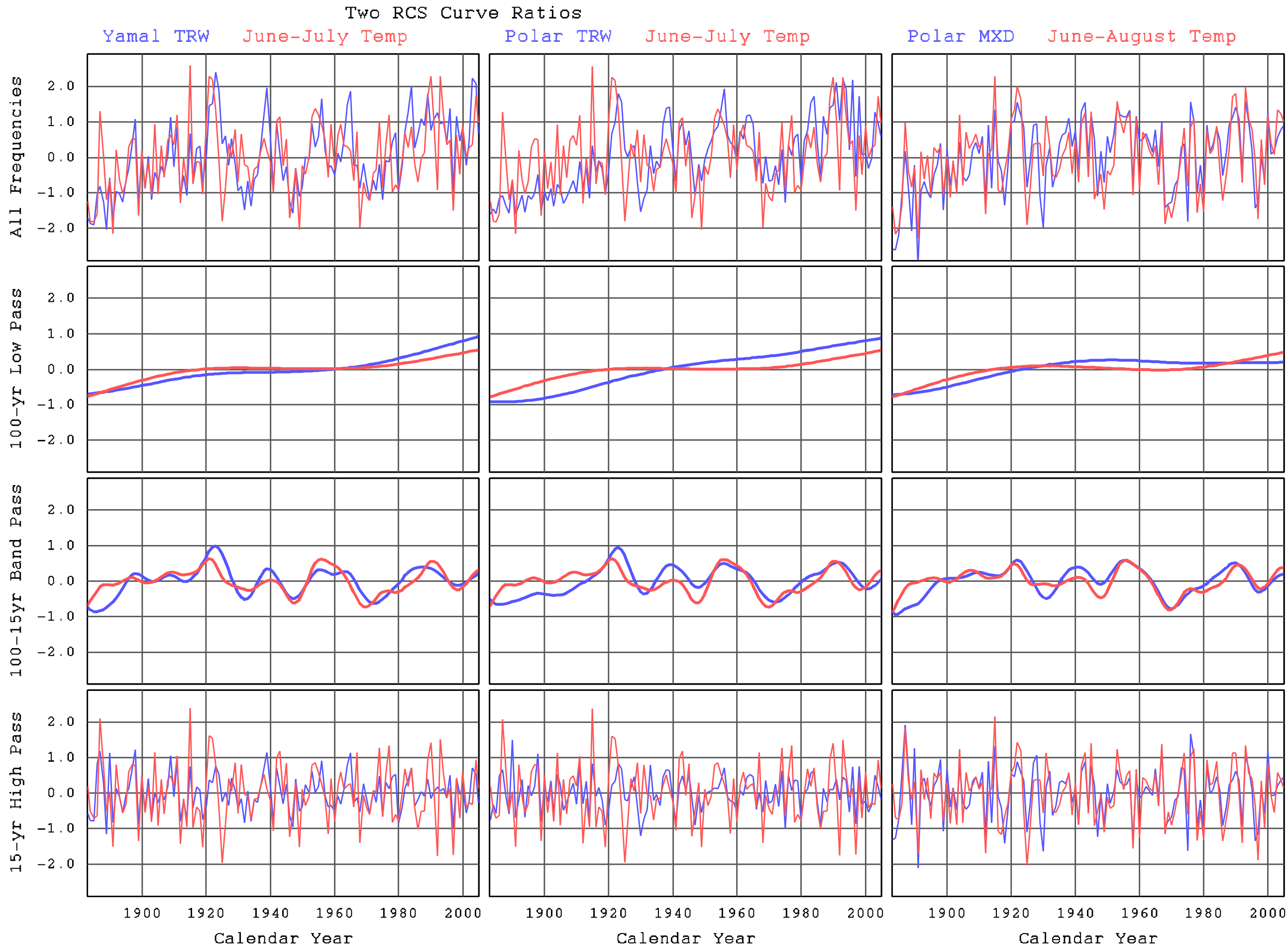


Figure CA5 Chronologies were created using processing methods as described in Figure CA3 using two-curve, signal-free RCS with tree indices transformed to have a normal distribution. Series are potted over the common period between chronologies and temperature data for each of the frequency divisions (from the top all frequencies, 100-year low-pass, 15-100-year band-pass, and 15-year high pass) and for the three separate chronologies from left to right: Yamal TRW, Polar Urals TRW and Polar Urals MXD.

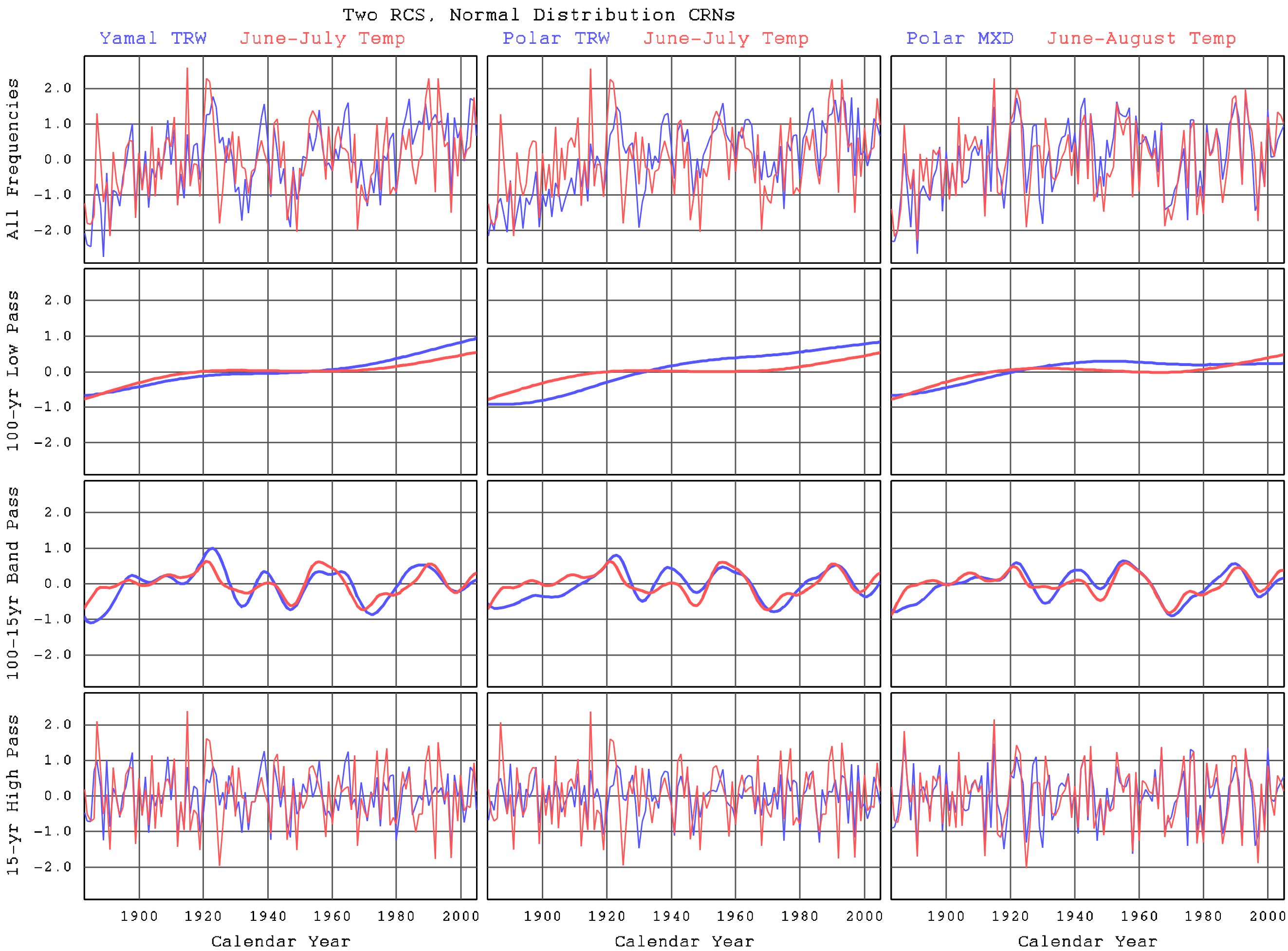


Table CA1 shows the variance between various unfiltered and filtered versions (HP high-pass, BP band-pass and LP low-pass) of chronologies (Yamal TRW, Polar Urals TRW and Polar Urals MXD) and mean temperature series (June to July and June to August). Internal variance is the squared correlation of filtered with unfiltered series. The variance proportion is the fraction for each filtered series of the sum of total variance of all three filtered series.

Common Period		HP	BP	LP	Sum	
Chronologies Internal Variance						
872	2005	0.55	0.45	0.18	1.18	Yamal TRW
872	2005	0.56	0.44	0.21	1.21	Polar TRW
872	2005	0.74	0.29	0.12	1.14	Polar MXD
Chronologies Variance Proportion						
872	2005	0.47	0.38	0.15	1.00	Yamal TRW
872	2005	0.46	0.36	0.17	1.00	Polar TRW
872	2005	0.64	0.25	0.10	1.00	Polar MXD

Climate period		HP	BP	LP	Sum	
Chronologies Internal Variance						
1883	2005	0.53	0.49	0.27	1.29	Yamal TRW
1883	2005	0.37	0.46	0.50	1.32	Polar TRW
1883	2005	0.67	0.38	0.22	1.27	Polar MXD
Chronologies Variance Proportion						
1883	2005	0.41	0.38	0.21	1.00	Yamal TRW
1883	2005	0.28	0.35	0.38	1.00	Polar TRW
1883	2005	0.53	0.30	0.17	1.00	Polar MXD

Climate period		HP	BP	LP	Sum	
Climate Internal Variance						
1883	2005	0.77	0.28	0.12	1.18	JJ-Yam
1883	2005	0.77	0.28	0.12	1.18	JJ-Pol
1883	2005	0.79	0.30	0.13	1.21	JJA MXD
Climate Variance Proportion						
1883	2005	0.66	0.24	0.10	1.00	JJ-Yam
1883	2005	0.66	0.24	0.10	1.00	JJ-Pol
1883	2005	0.65	0.25	0.10	1.00	JJA MXD

Climate Period		All	HP	BP	LP	Sum	
Trees to Full Climate Variance							
1883	2005	0.44	0.31	0.18	0.08	0.57	Yamal TRW
1883	2005	0.33	0.25	0.18	0.06	0.49	Polar TRW
1883	2005	0.67	0.58	0.21	0.06	0.84	Polar MXD
Trees to Full Climate Variance Proportion							
1883	2005		0.53	0.32	0.14	1.00	Yamal TRW
1883	2005		0.51	0.37	0.12	1.00	Polar TRW
1883	2005		0.69	0.25	0.07	1.00	Polar MXD

Climate Period		All	HP	BP	LP	Sum	
Trees to Climate Sub-sets Variance							
1883	2005	0.44	0.34	0.61	0.89	1.84	Yamal TRW v JJ-Yam
1883	2005	0.33	0.28	0.53	0.79	1.60	Polar TRW v JJ-Pol
1883	2005	0.67	0.63	0.67	0.73	2.03	Polar MXD v JJA MX

CA3. Seasonal Cross Correlations

Figure CA6 – Shows a cross correlation summary of the association between (left) 15yr high-pass chronologies and seasonal temperatures and (right) 15 to 100-year band pass chronologies and seasonal temperatures. Chronologies were created for Yamal TRW, Polar Urals TRW and Polar Urals MXD data using two-curve, signal-free RCS with tree indices transformed to have a normal distribution. Seasonal temperatures are the means of seasons of varying lengths between 1 and 8 months (bottom to top) and correlation values (*100) are plotted at the mid-point of the series of months.