SM5: Polar Urals/Yamal chronology inter-comparisons

PY1. Some Testing (PY01-2)
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PY1 Some Testing

Figure PY01 Comparison of the shape of RCS curves created from Polar Urals TRW and Yamal TRW data sets. Each data set has been separately standardised using two-curve signal-free RCS. The four resulting RCS curves are plotted below. Over the first 100 years, the faster-growing Yamal trees have a far larger juvenile growth rate than the faster-growing Polar Urals trees. Over the first 50 years, the slower-growing Yamal trees have a larger juvenile growth rate than the faster-growing Polar Urals trees. It would not be optimal to combine these sets of data into a single file and then use common RCS curves to process all tree-measurement series because these juvenile growth rate differences are likely to produce systematic bias where component sample make up changes through time.

Such a difference is not entirely unexpected because these are quite different sites – Polar Urals trees are from mountain sides with rocky ground and Yamal trees are from valleys of lowland rivers with sandy soils.

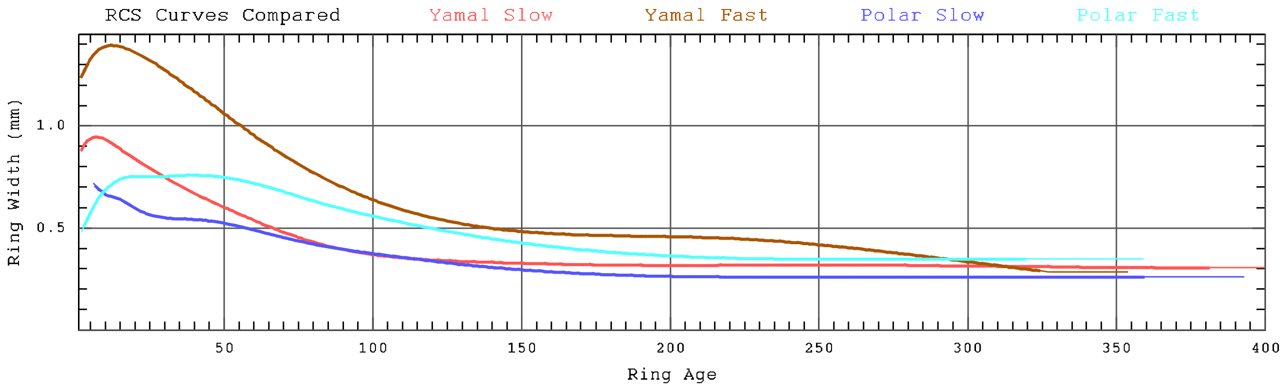
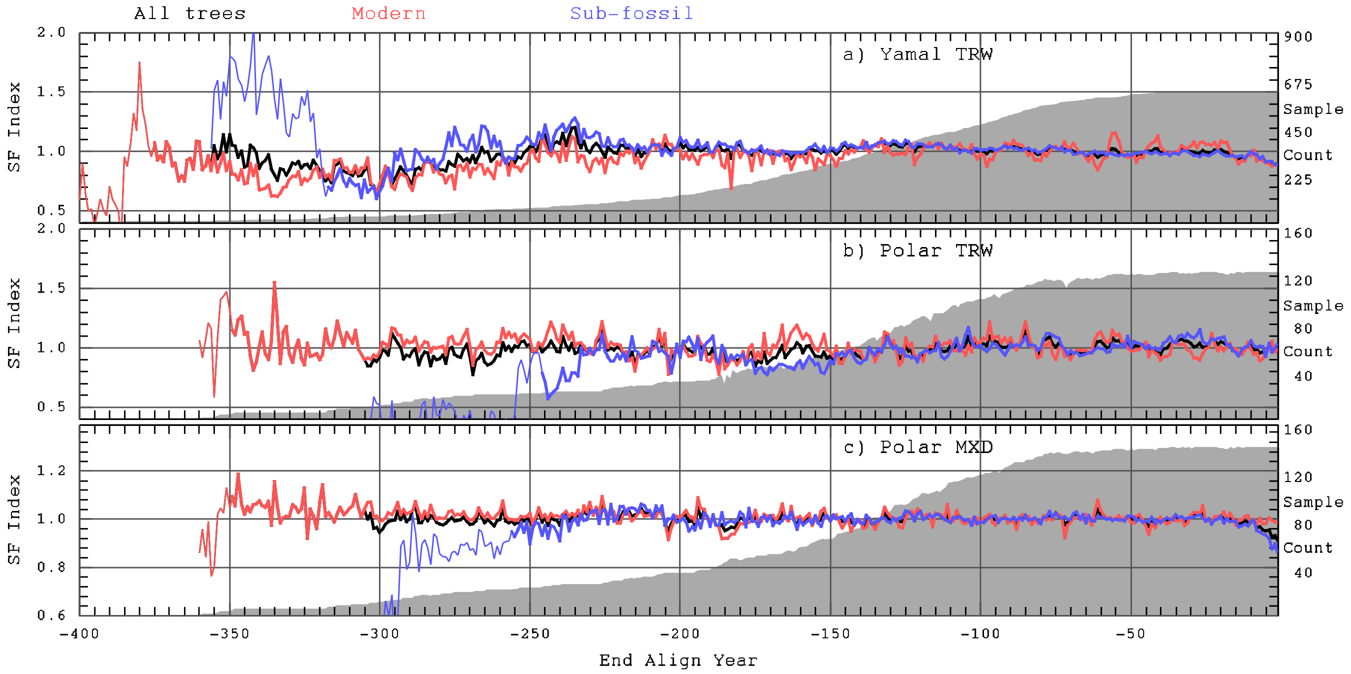


Figure PY02 Series of tree indices that have been divided by the chronology signal (i.e. both age-related signal and common forcing signal have been removed), here called "signal-free indices", should simply contain "noise". When these are end-aligned (realigned so that the last year of each sample coincides – Briffa and Melvin (2011)) and averaged they are expected to have means of 1.0 throughout but with some noise. If there is a common "mortality" signal it should show up and here we are testing for a problem seen at Torneträsk, N.W.Sweden (Melvin at al. 2013) where some MXD values appear to reduce in their final decades, possibly associated with the degradation of sapwood in sub-fossil material, and appear to diverge from the horizontal value of unity when plotted as in this figure. The Yamal TRW, Polar Urals TRW and Polar Urals MXD data sets are similarly tested here for any consistent "end effects". Separate chronologies were created for each data set using two-curve signal-free RCS. Tree indices were divided by the chronology signal to create signal-free indices and then each series was set to finish on the same year (i.e. the last year of each tree was set to -1 "end-aligning" all trees). The means of separate sub-groups of such data are plotted; for modern trees (all with a ring after 1950) in red, sub-fossil trees (all others) in blue and the mean of all trees in black for each data set: (a) Yamal TRW, (b) Polar Urals TRW and (c) Polar Urals MXD. Sample counts are shown by grey shading. There is a slight effect visible in the sub-fossil MXD but it is not specific to MXD when compared to the modern and sub-fossil Yamal TRW and is sufficiently small as to be considered negligible.



PY2 Index Distribution

Figure PY03 Plots of the distribution of tree indices created using various signal-free standardisation methods: a 30-year-spline detrend (blue), one-curve RCS (cyan), and two-curve RCS (red). Each set of tree indices was normalised (subtract mean and divide by standard deviation) and the resulting distribution (counts of values in each 0.01 range from -3.0 to +3.0) was smoothed with a 60-point (bin) spline. Separate calculations were performed for each of (a) Yamal TRW (yml-all.raw), (b) Polar Urals TRW (polar.raw), and (c) Polar Urals MXD (polarxs.mxd) data sets. For comparison, the distribution of a similar number (i.e. matching the count of tree indices at each site) of randomly generated values with a normal distribution is shown as a grey dotted line (similarly smoothed). The distribution of TRW indices created using a high-pass spline is close to being normal while TRW indices created by RCS are heavily positively skewed. The distributions of MXD indices are similar for all standardisation methods, are negatively skewed, and are much closer to being normally distributed than are TRW indices.

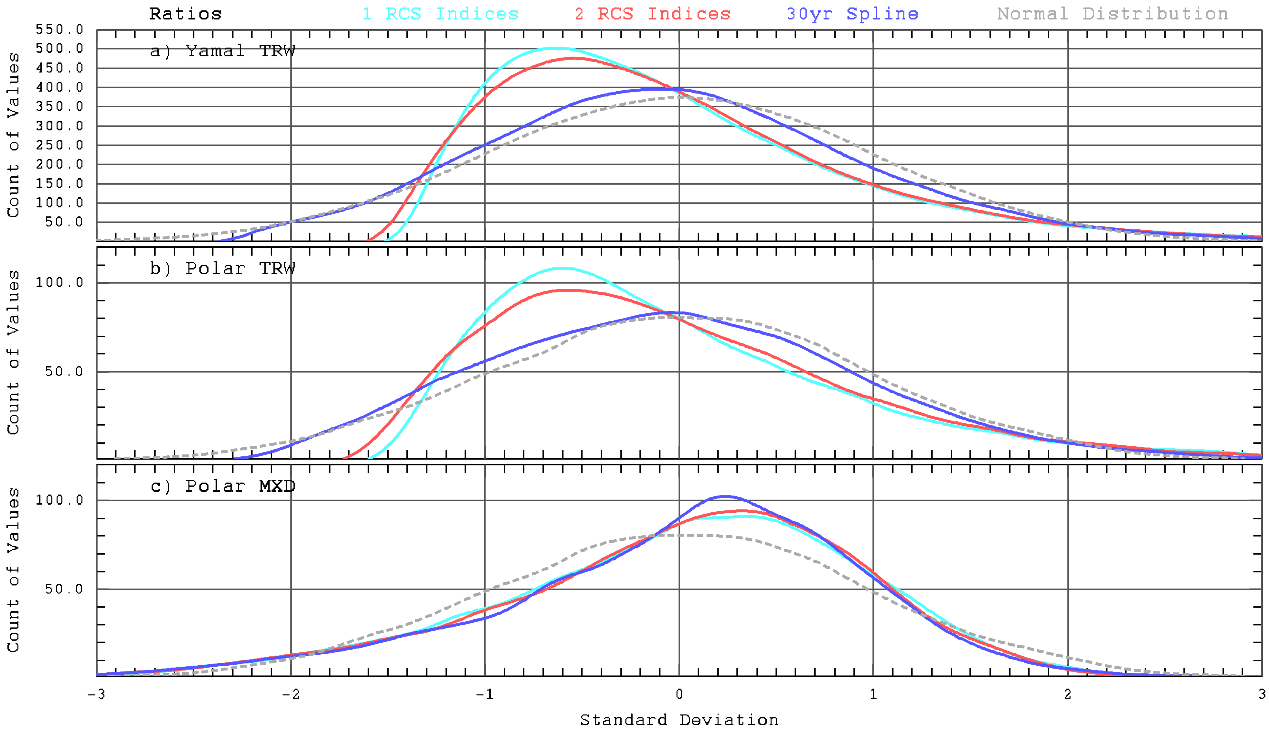


Figure PY04 Shows that for Yamal TRW there is some dependence of the standard deviation on the magnitude of index value and that this dependency can be removed by division of the former by the latter. The chronology created using two-curve signal-free RCS is shown in (a) along with sample counts (grey shading). The standard deviations are plotted by calendar year in (b), after sorting by index value (c), and after sorting by index value and scaled by index value (d). The relationship between mean chronology index value and chronology standard deviation for a year appears to be removed by the division, as might be expected with tree indices created as fractional deviations. The standard deviations are generally larger where sample counts are smaller, e.g. (a) and (d) in the BCE period.

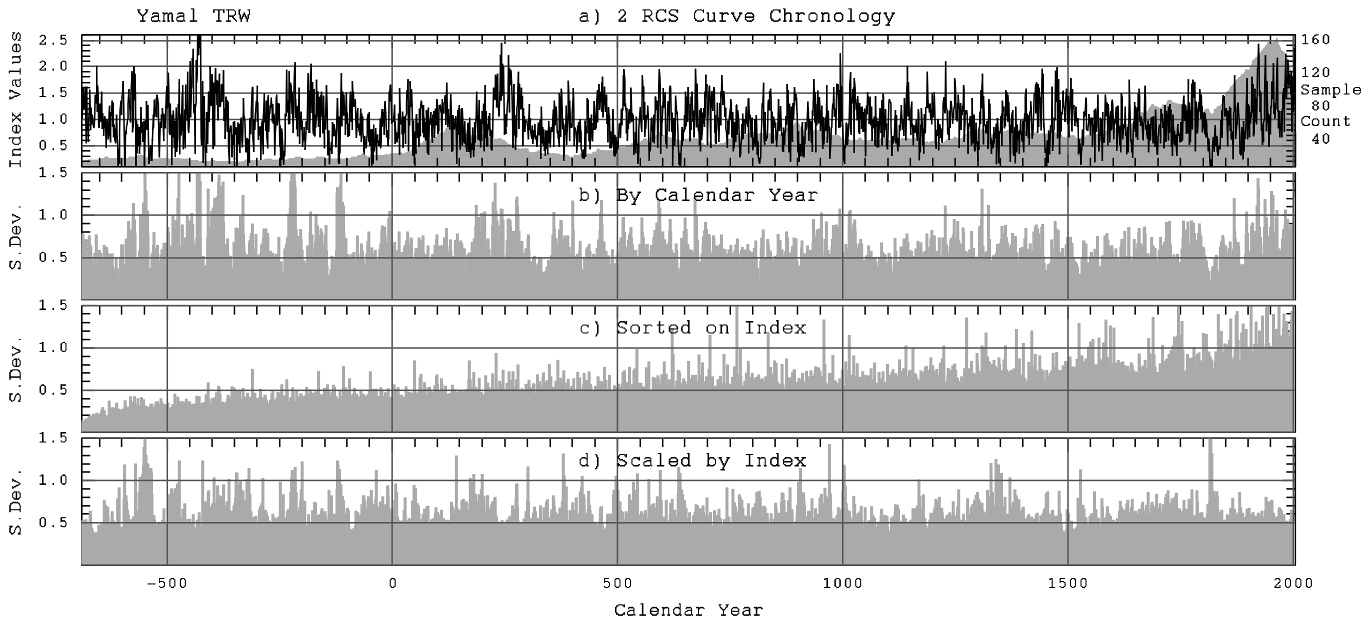


Figure PY05 shows that for Polar Urals TRW the standard deviation is dependent on index value and this dependency can be removed by division. Processing was as for PY04 above.

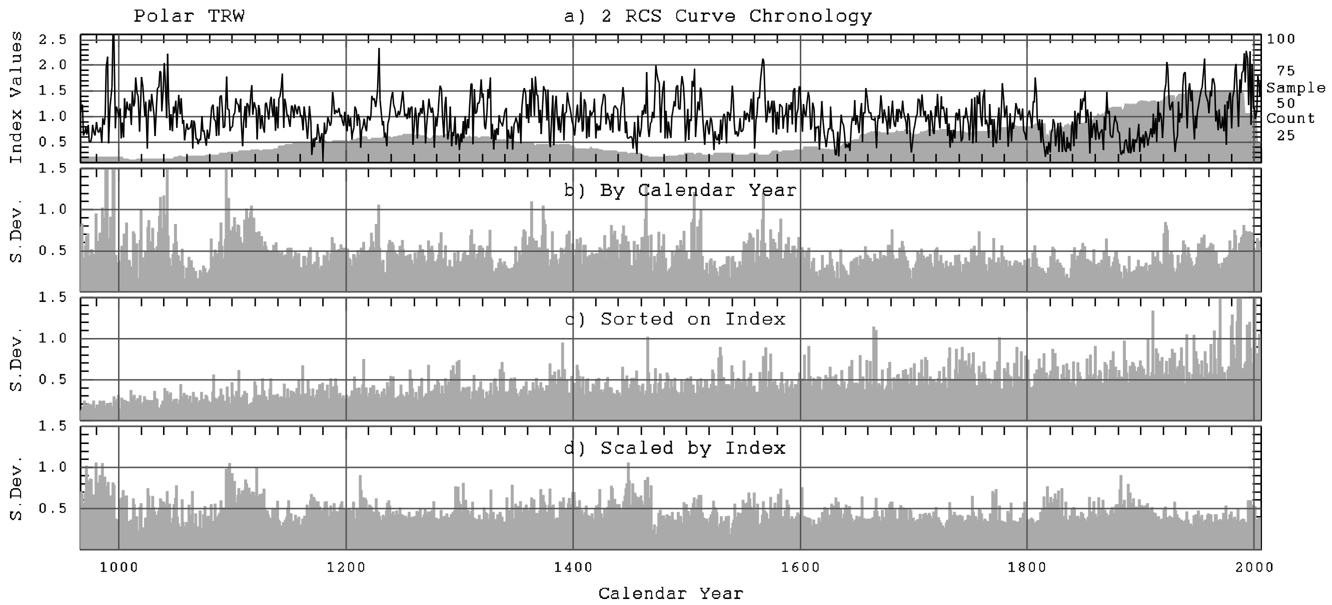


Figure PY06 shows that for Polar Urals MXD, the standard deviation does not appear to be dependent on index value. Processing was as for PY04 above.

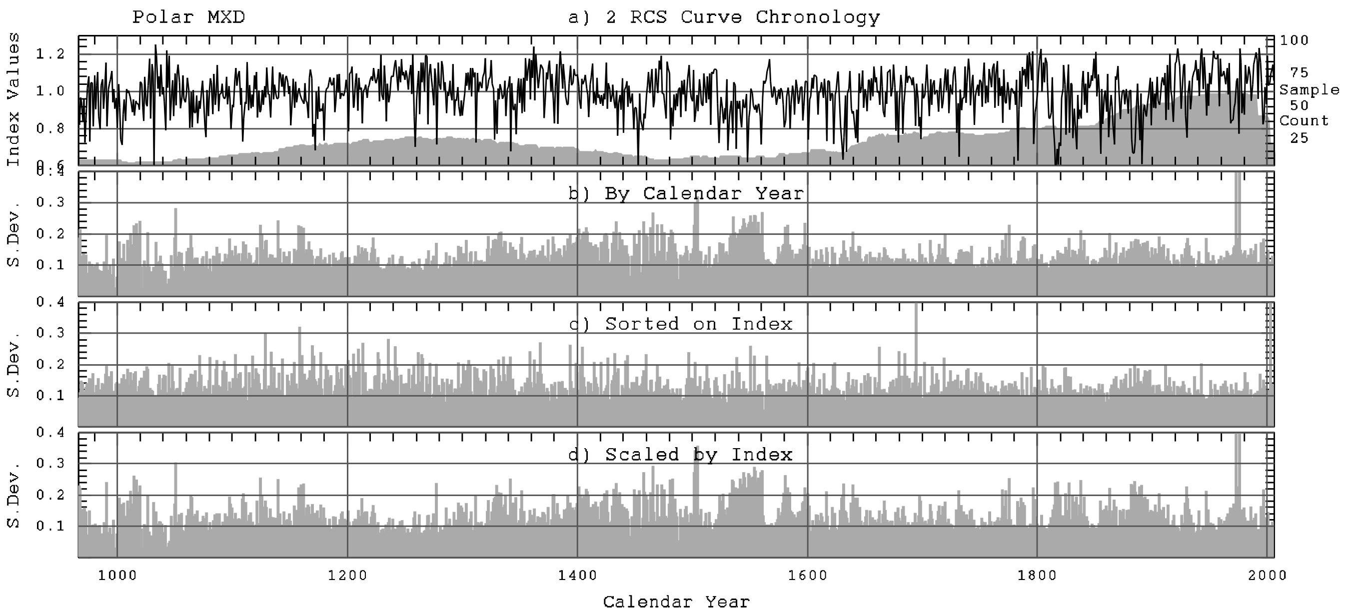


Figure PY07 A Yamal TRW chronology was created using two-curve signal-free RCS and the values of tree-indices developed during this process were transformed to have a normal distribution using the following empirical method. A series of random numbers with a normal distribution was generated, one for each tree index (in this case 96,599 values). Both data sets, tree indices and random numbers, were sorted into ascending order. Each tree index value was replaced with the value of the normal random number with the same relative position after sorting (i.e. the largest random number replaces the largest tree index, next largest etc). The relative sizes (larger than or smaller than) of tree indices are unchanged whilst they are given a normal distribution. The 'normally distributed' tree indices were averaged by correct calendar year to produce correctly-dated chronology index value and the standard deviation of chronology indices was calculated for each calendar year. The chronology values and sample counts are shown plotted by calendar year in (a). The standard deviations are plotted by calendar year in (b) and after sorting on index value in (c). These data show that for the Yamal TRW the dependency of standard deviation on chronology index values is removed by the transformation of tree-indices to have a normal distribution. As expected, the higher values of standard deviation generally occur in periods with smaller sample counts (e.g. the BCE period).

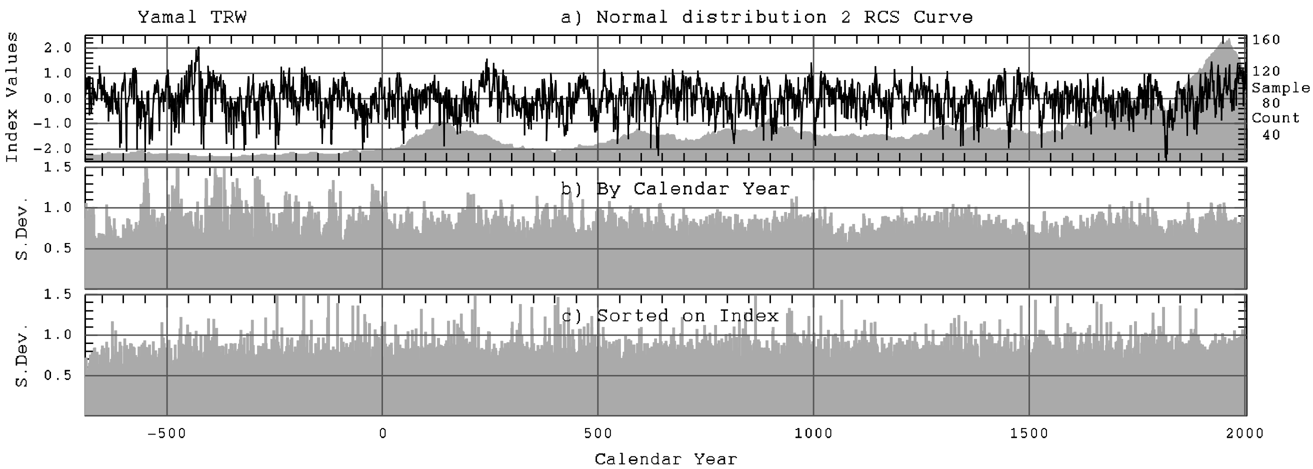


Figure PY08 Shows for Polar Urals TRW that the dependency of standard deviation on chronology index values is removed by the transformation of tree-indices to a normal distribution. Processing was as for PY07 above.

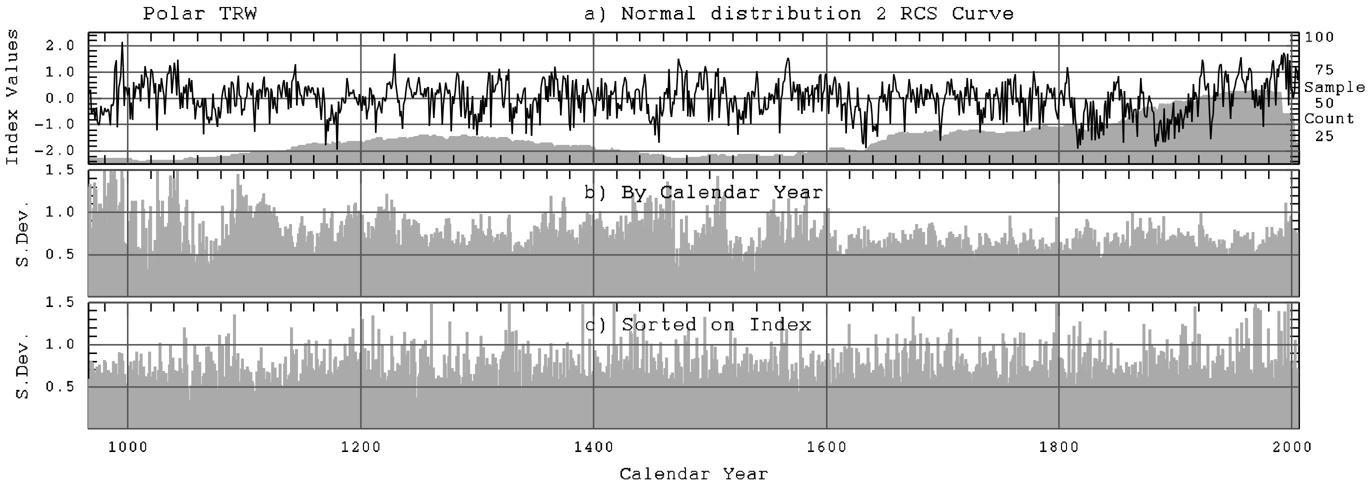
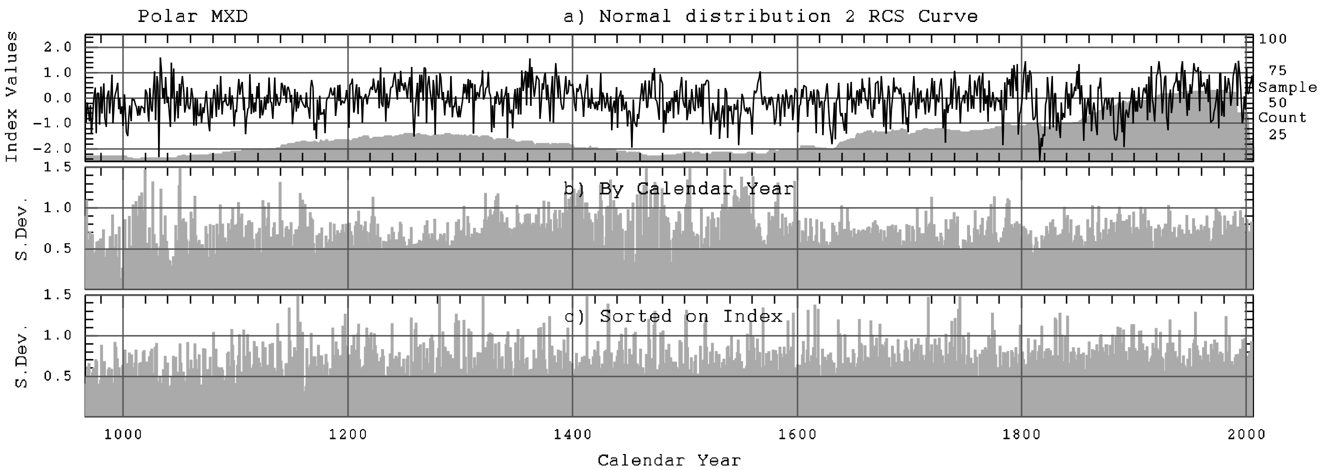


Figure PY09 Shows for Polar Urals MXD that there is no dependency of standard deviation on chronology index values in the chronology created from "normally" distributed tree indices. Processing was as for PY07 above.



PY3. Comparative Chronology Plots

Figure PY10 Illustration of the medium to high-frequency variability of tree growth in the separate Yamal TRW, Polar Urals TRW and Polar Urals MXD chronologies created using 100-year spline, signal-free standardisation. The Series have been normalised (by subtracting of the mean and division by the standard deviation) over the common period 872 to 2005.

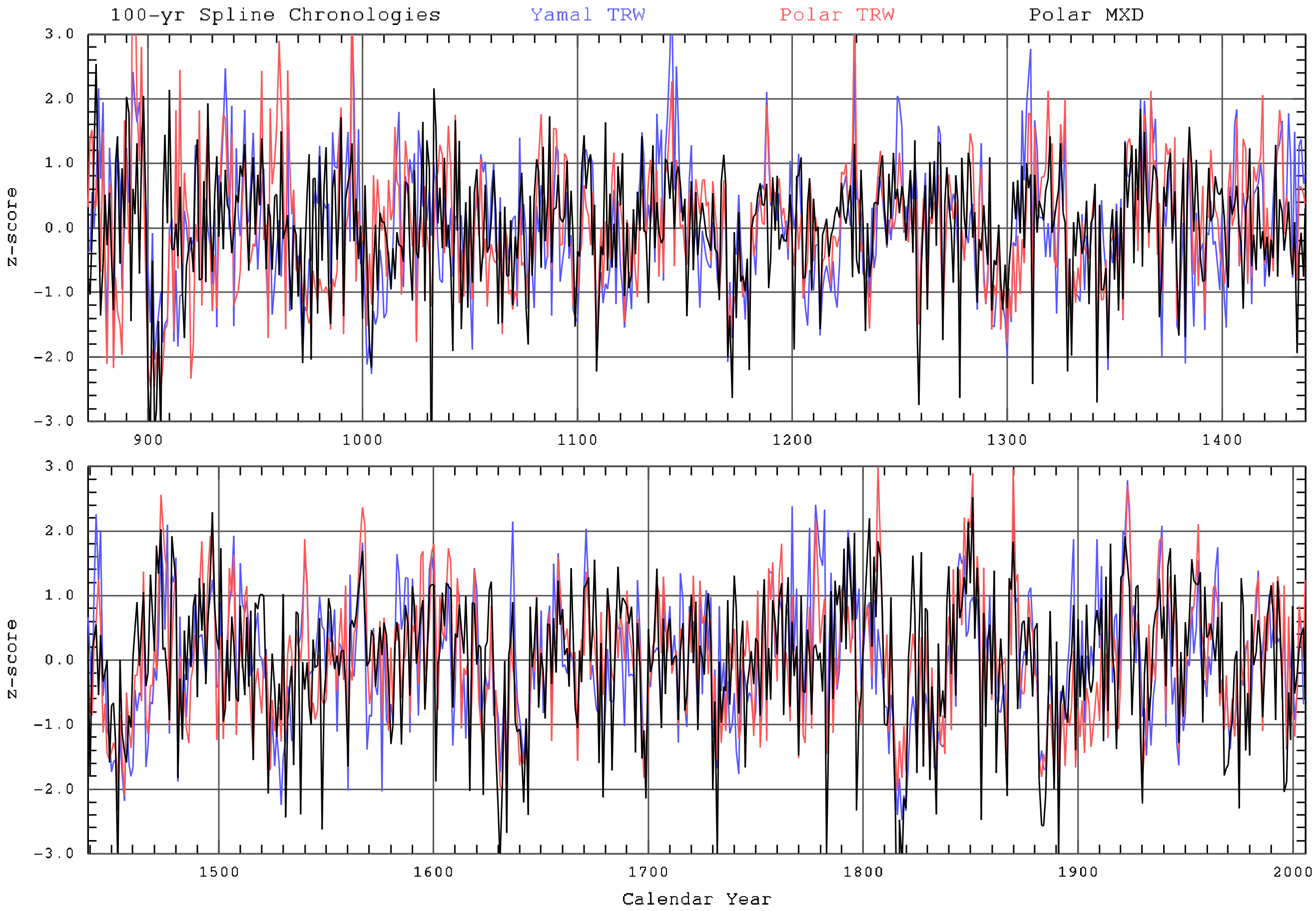


Figure PY11 Separate chronologies were created using one-, two- and three-curve signal-free RCS for each of the Yamal TRW (a) and (b), Polar Urals TRW (c) and Polar Urals MXD (d) data sets. Chronologies were smoothed with a 50-year spline for display purposes and thin lines are used where counts are <6. The main difference arising from the use of two rather than one RCS curves is a reduction in the slope of the last 4 centuries in both chronologies. Chronologies created using two-curve and three-curve RCS are generally similar. Using only one RCS curve the slope of the modern end of the chronology is likely affected by "modern sample bias" and the use of multiple RCS curves appears to reduce this problem. Other than the last 4 centuries, the use of a 2nd RCS curve is removing very little long timescale variance. The Polar Urals TRW data has reduced slope in the last 4 centuries but also has reduced values in the 13th and 14th centuries using two-curve RCS compared to the one-curve case and the chronology created using three-curve RCS differs only slightly from that using two-curve RCS..

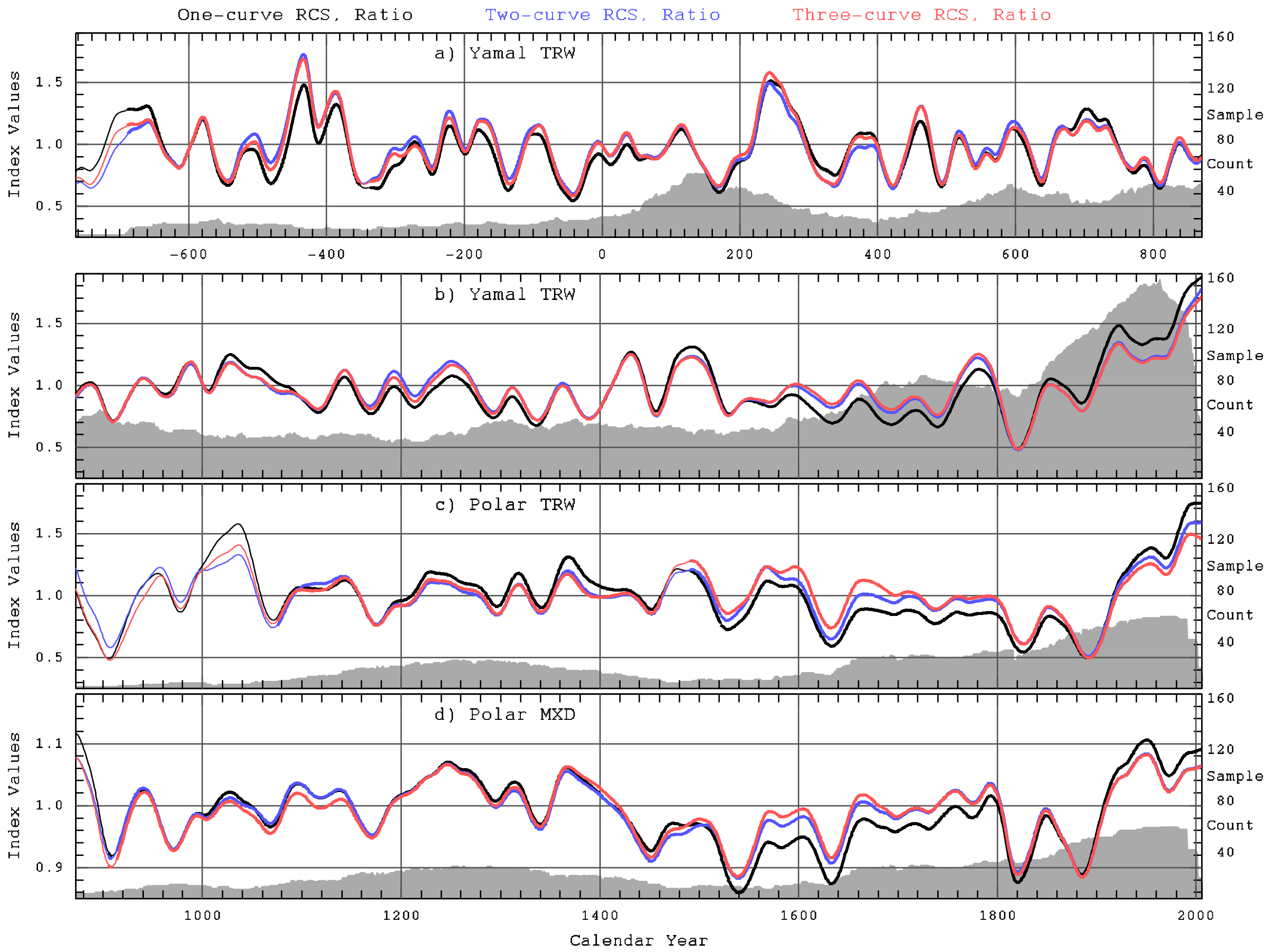


Figure PY12 Comparison of Yamal TRW (using yml-all.raw) chronologies created using two-curve signal free RCS and using two curve signal-free RCS and tree indices transformed to have a normal distribution. For each of these chronologies, three further chronologies were created by filtering the chronology index series to produce; 100-year low-pass, 100 to 15-year band pass, and 15-year high pass chronologies. The process of conversion, as expected, has produced a chronology with a more normal distribution; the large range of high-value indices has been reduced and the narrow range of the low-values indices has been widened.

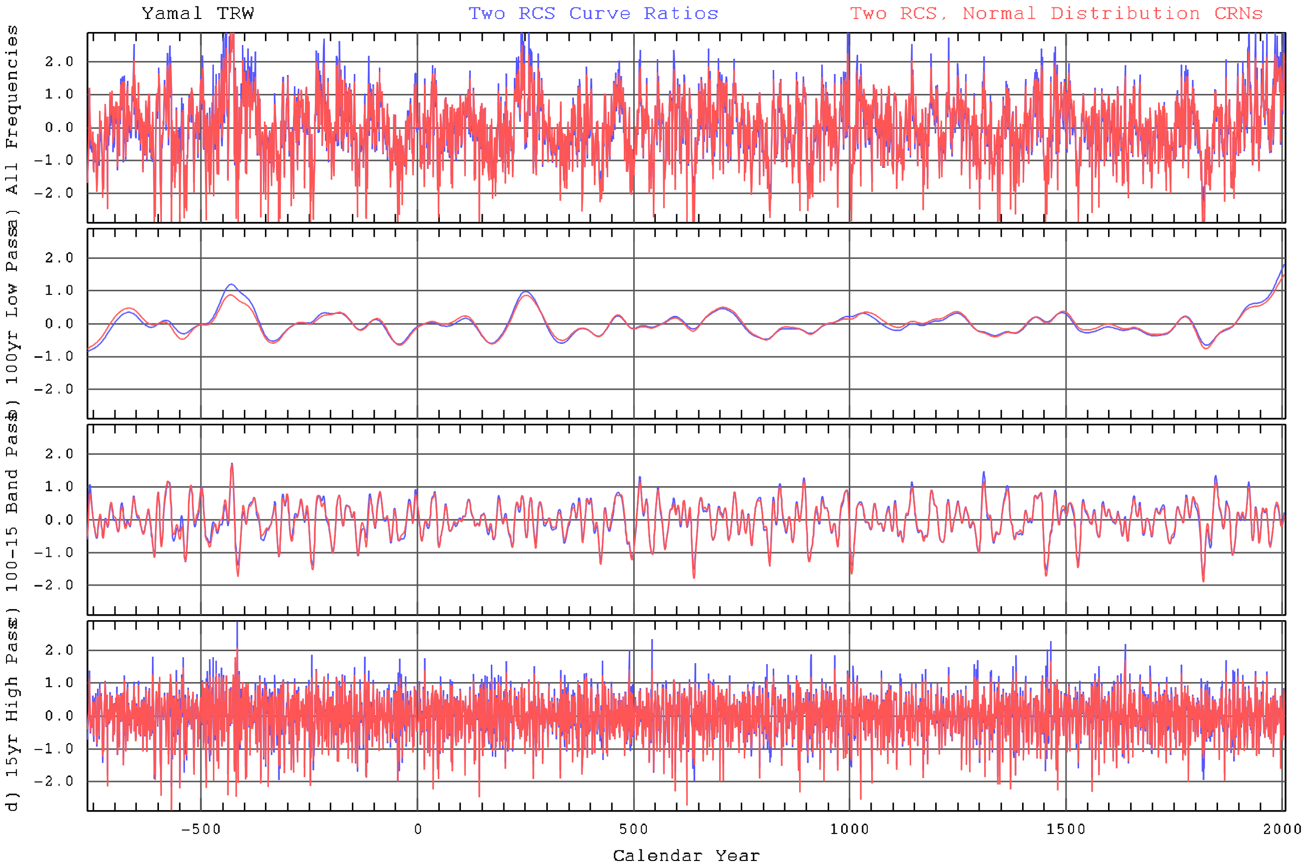


Figure PY13 Comparison of Polar Urals TRW (using polar.raw) chronologies created using two-curve signal free RCS and using two curve signal-free RCS with tree indices transformed to have a normal distribution. For each of these chronologies, three further chronologies were created by filtering the chronology index series to produce; 100-year low-pass, 100 to 15-year band pass, and 15-year high pass chronologies. The process of conversion has produced a chronology with a more normal distribution; the large range of high-value indices has been reduced and the narrow range of the low-values indices has been widened.

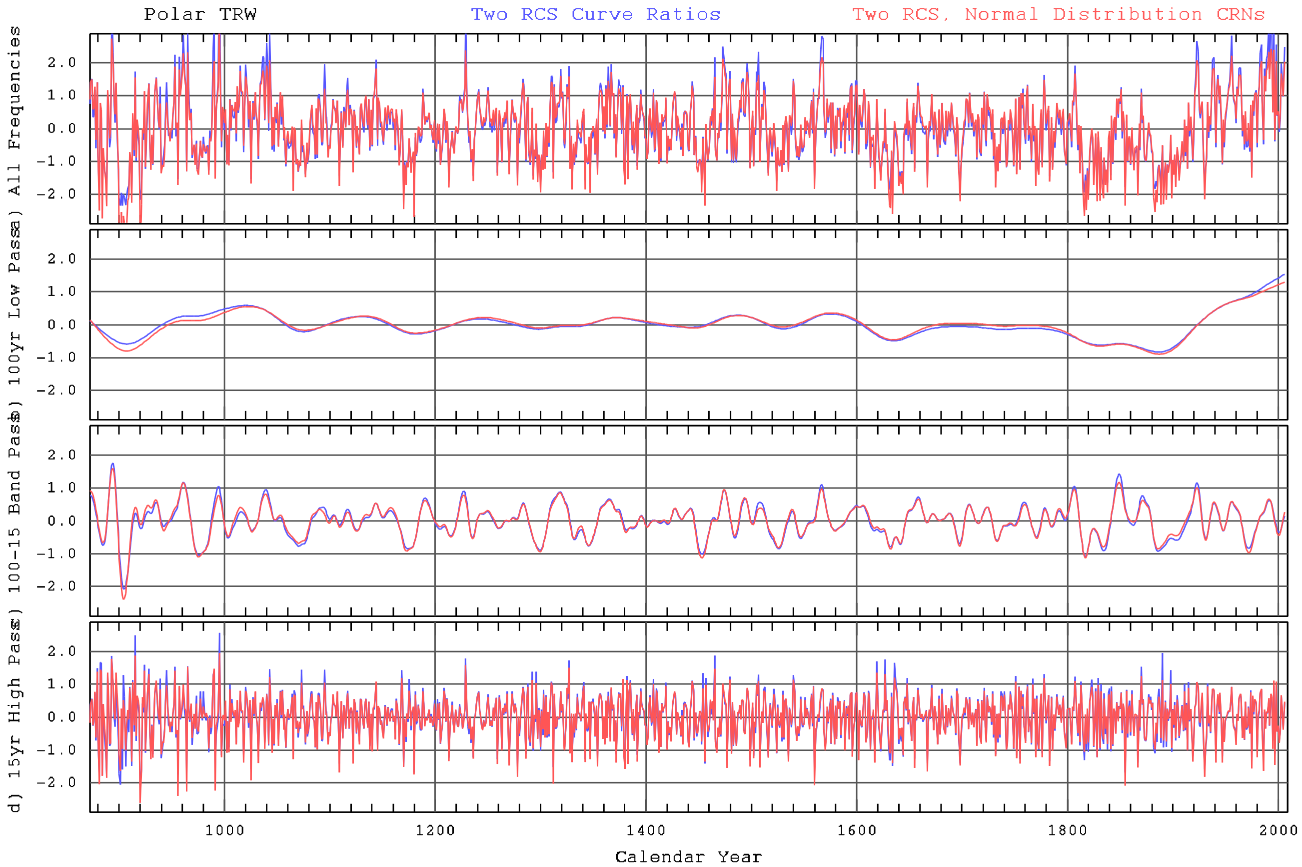


Figure PY14 Comparison of Polar Urals MXD (using polarxs.mxd) chronologies created using two-curve signal free RCS and using two curve signal-free RCS with tree indices transformed to have a normal distribution. For each of these chronologies, three further chronologies were created by filtering the chronology index series to produce; 100-year low-pass, 100 to 15-year band pass, and 15-year high pass chronologies. The effect of setting this normal distribution on MXD indices is less extreme and of opposite sign for Polar Urals MXD. The process of conversion has produced a chronology with a more normal distribution; the small range of high-value indices has been increased and the larger range of the low-values indices has been narrowed.

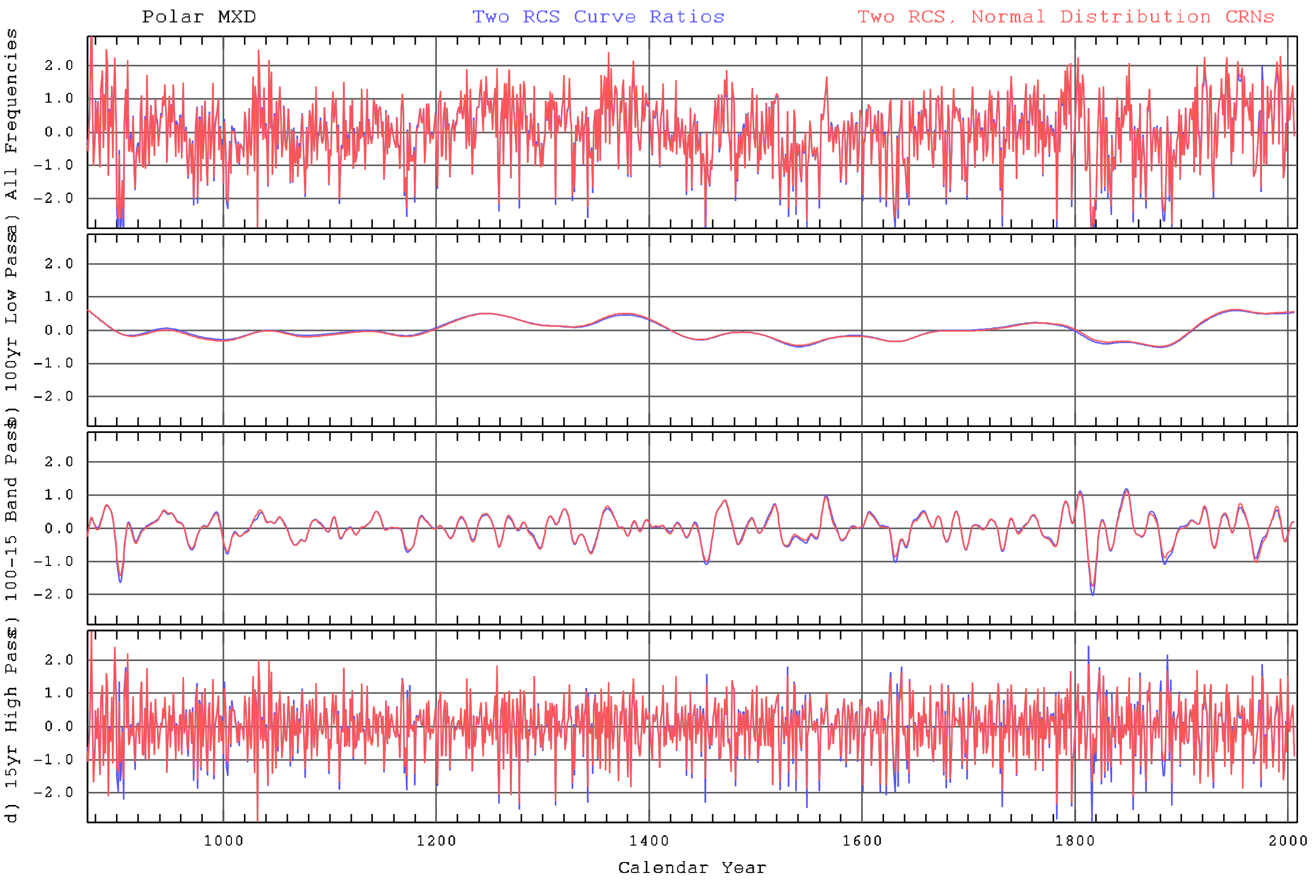


Figure PY15 Chronologies were created using two-curve signal-free RCS using Yamal TRW, Polar Urals TRW and Polar Urals MXD data sets. These chronologies were compared using running 50-year running correlations (red) and the full-period correlation (blue) over the period 906 to 2005 CE for Yamal TRW v Polar Urals TRW (a), Yamal TRW v Polar Urals MXD (b), and Polar Urals TRW v Polar Urals MXD (c). The full-period correlations are 0.69, 0.53 and 0.56 respectively.

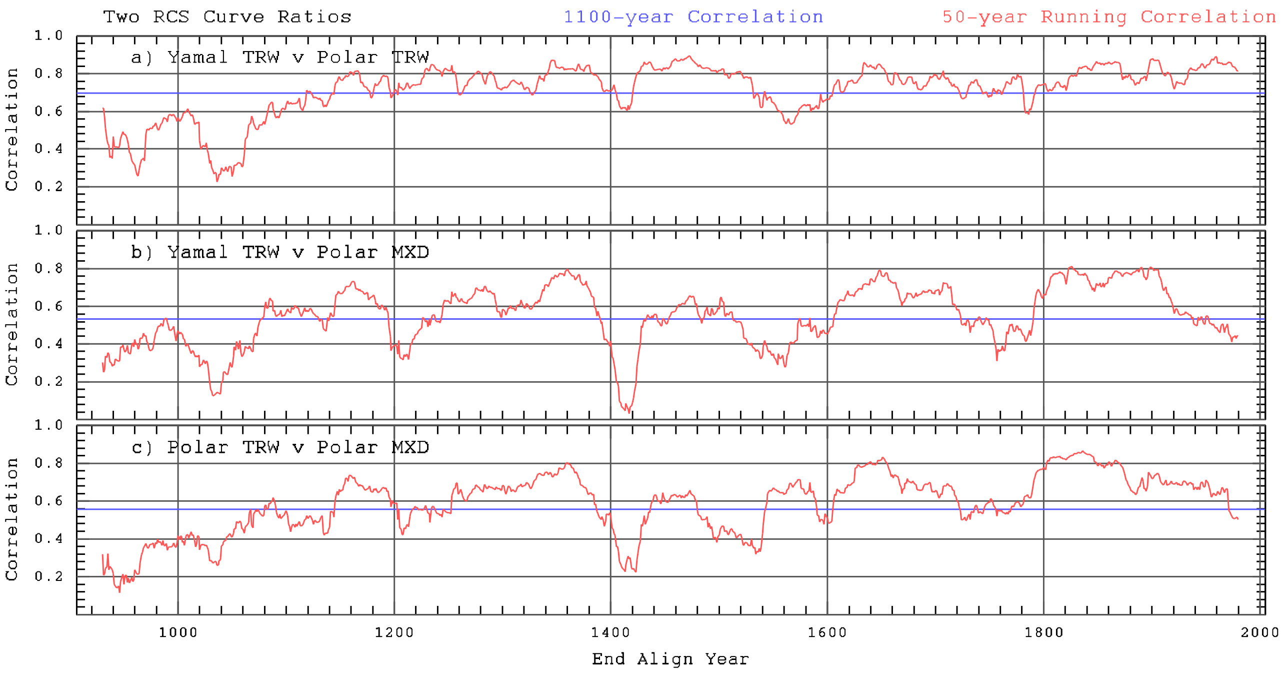


Figure PY16 As for PY15 but using chronologies created using two curve signal-free RCS with tree indices transformed to have a normal distribution. The full-period correlations are 0.71, 0.55 and 0.59 respectively. Because correlation is heavily weighted towards high-frequency variance the correlations with and without the transformation are similar but the transformation to have a normal distribution has produced a consistent if slight improvement in the overall correlations.

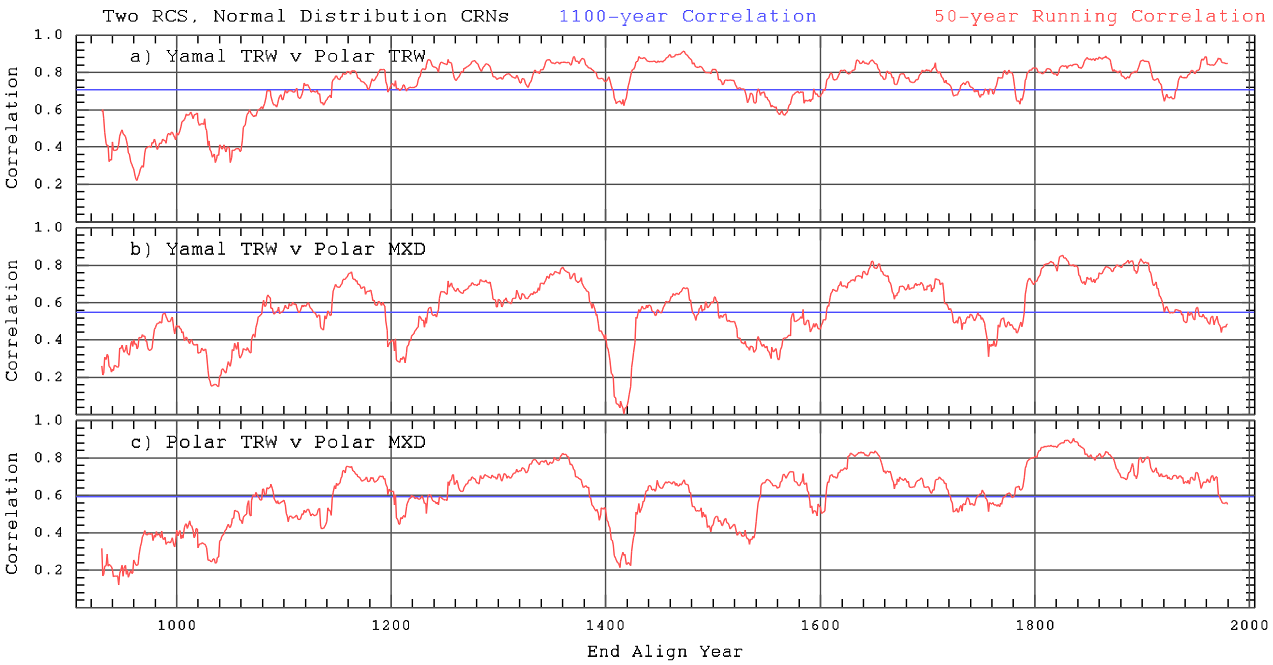


Figure PY17 Comparison of chronologies created using two-curve signal-free RCS with tree indices transformed to have a normal distribution, for different frequency ranges; all frequencies (a), 100-year low-pass (b), 100-15-year band-pass (c), and 15-year high-pass (d). Yamal TRW (yml-all.raw) are compared to Polar Urals TRW (polar.raw). The low-frequency Polar Urals TRW indices are lower than those of Yamal during the 1850 to 1900 period and before this, the reduced confidence of the poorly replicated Polar Urals TRW makes comparison difficult. There is a good match in medium- and high-frequency variance of both chronologies.

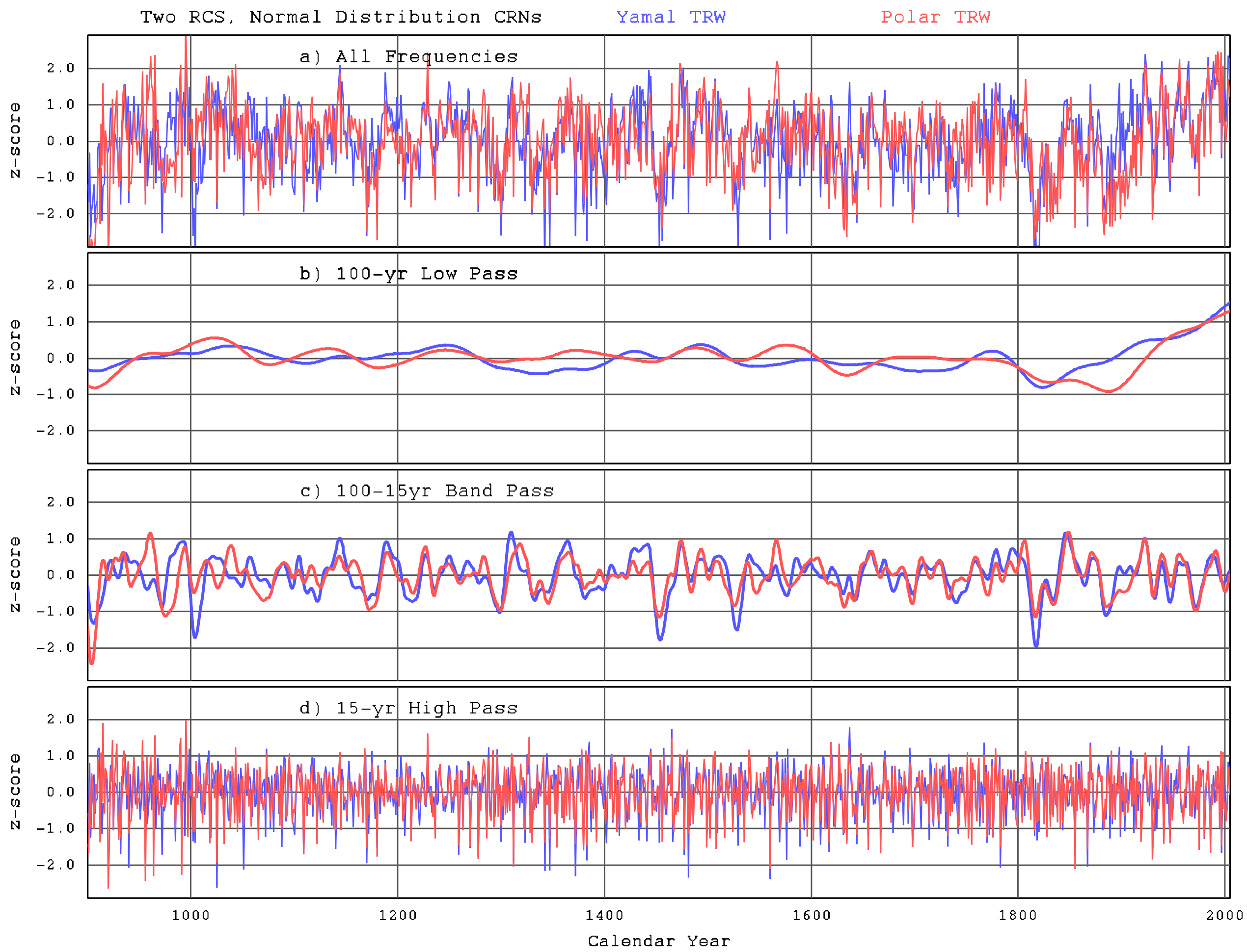


Figure PY18 Comparison of chronologies created using two-curve signal-free RCS with tree indices transformed to have a normal distribution, for different frequency ranges; all frequencies (a), 100-year low-pass (b), 100-15-year band-pass (c), and 15-year high-pass (d). Yamal TRW (yml-all.raw) are compared to Polar Urals MXD (polarxs.mxd). The low-frequency Polar Urals MXD indices do not match those of Yamal TRW very well. There is a reasonable match (good at times) between the medium-frequency chronologies.

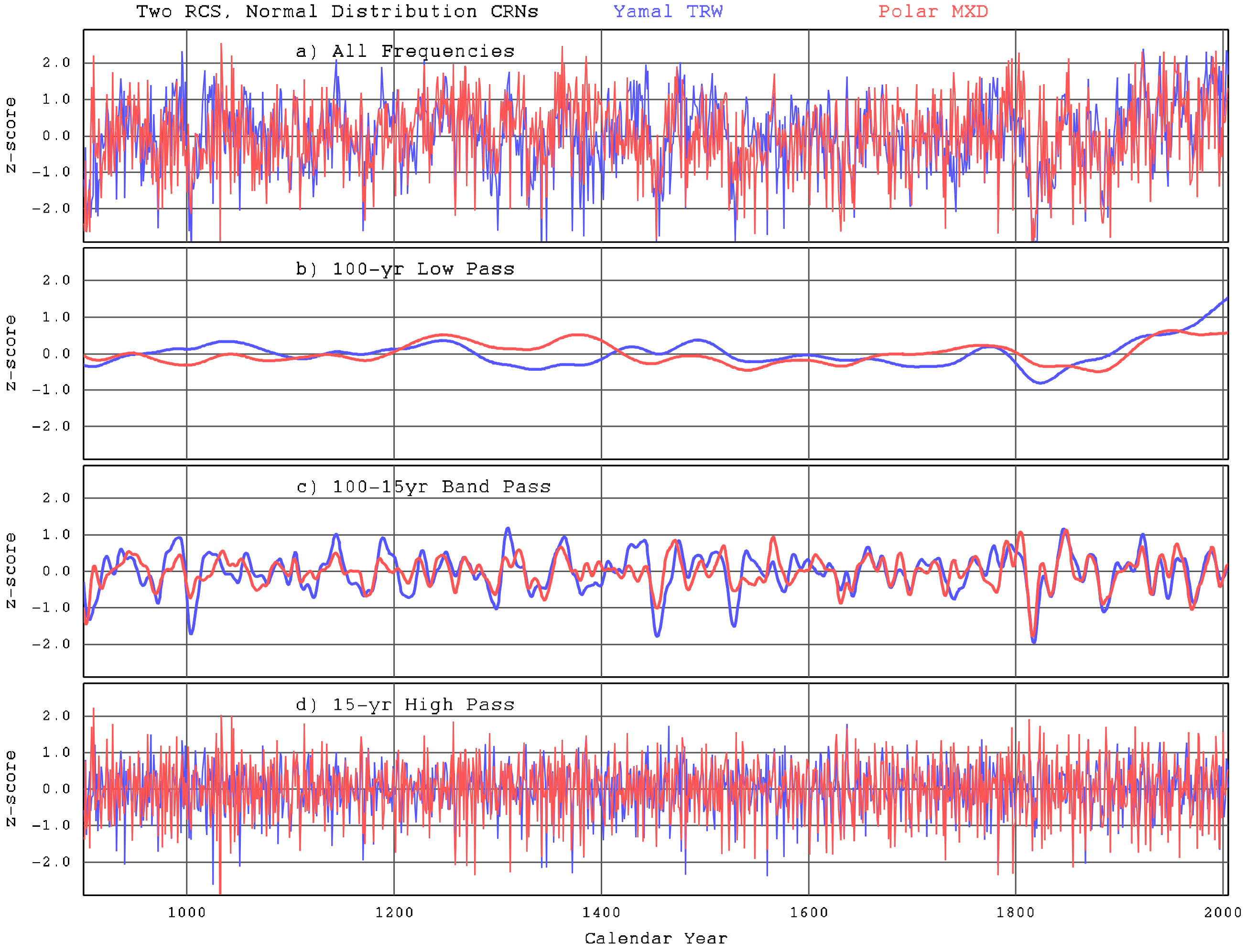


Figure PY19 Comparison of chronologies created using two-curve signal-free RCS with tree indices transformed to have a normal distribution, for different frequency ranges; all frequencies (a), 100-year low-pass (b), 100-15-year band-pass (c), and 15-year high-pass (d). Polar Urals TRW (polar.raw) are compared to Polar Urals MXD (polarxs.mxd). The low-frequency Polar Urals MXD indices do not match those of Polar Urals TRW very well. There is a reasonable match (good at times) between the medium-frequency chronologies.

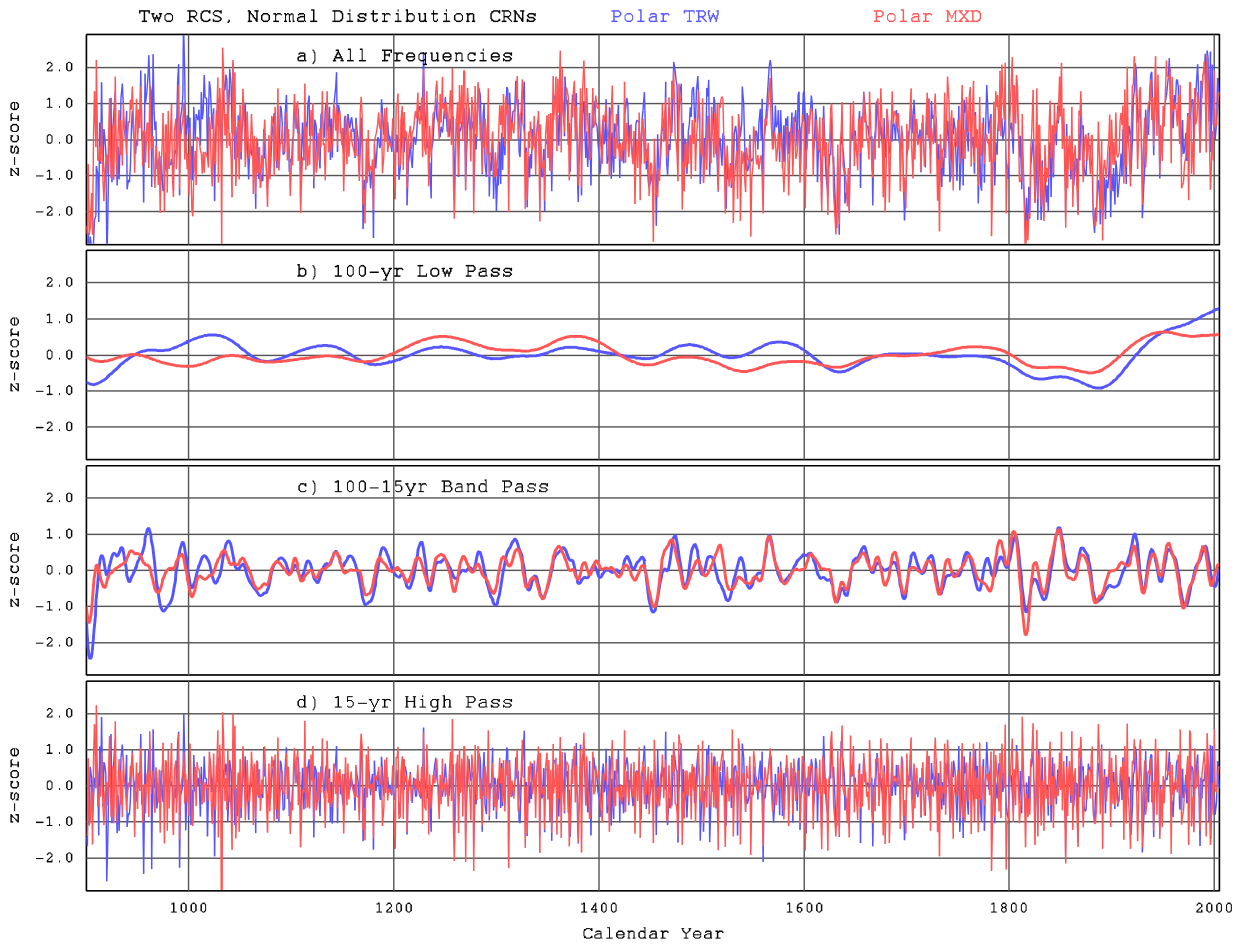


Figure PY20 Chronologies were created for Yamal TRW (yml-all.raw), Polar Urals TRW (polar.raw), and Polar Urals MXD (polarxs.mxd) using two-curve, signal-free RCS with tree indices transformed to have a normal distribution. A fourth chronology was created called Yamalia TRW by combining the tree-index series from Yamal TRW and Polar Urals TRW derived above (this is not shown as it is almost identical to Yamal TRW). Filtered versions of all four chronologies were created by filtering the individual series of tree indices prior to averaging into a chronology. When averaged to create chronologies, the resultant chronologies are not always smooth (see especially the 100-year low pass results) because the chronology value can suddenly change when a constituent tree index series begins or ends. The advantage of filtering the tree indices rather than the chronology itself is that an estimate of the chronology error associated with a particular timescale can be obtained using the standard deviation of the filtered tree indices in any one year (these error estimates are shown in Figure PY21). Four filters are used: a) all frequencies (i.e. no filter), b) 15-year high-pass, c) 15-100-year band-pass, and d) 100-year low pass.

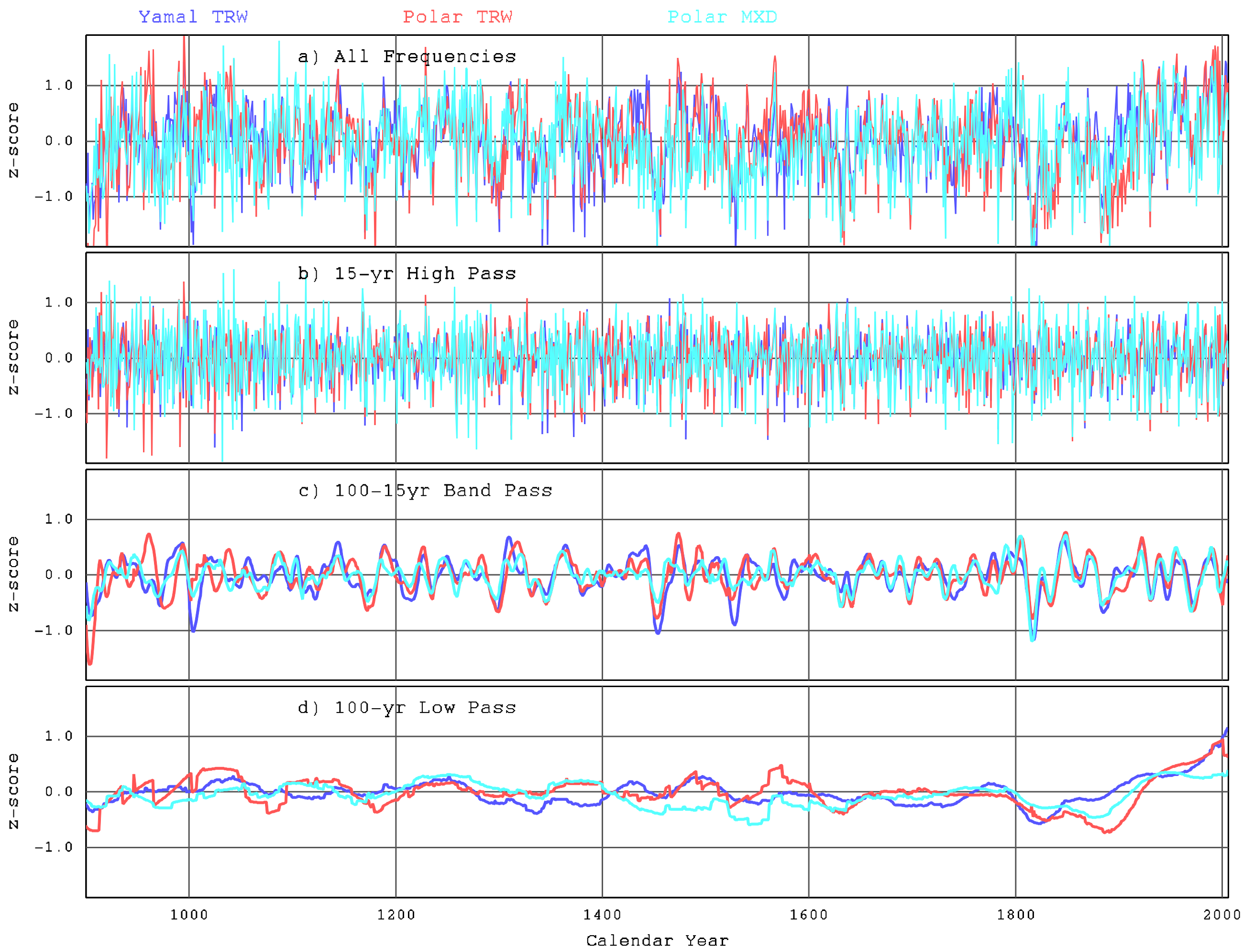
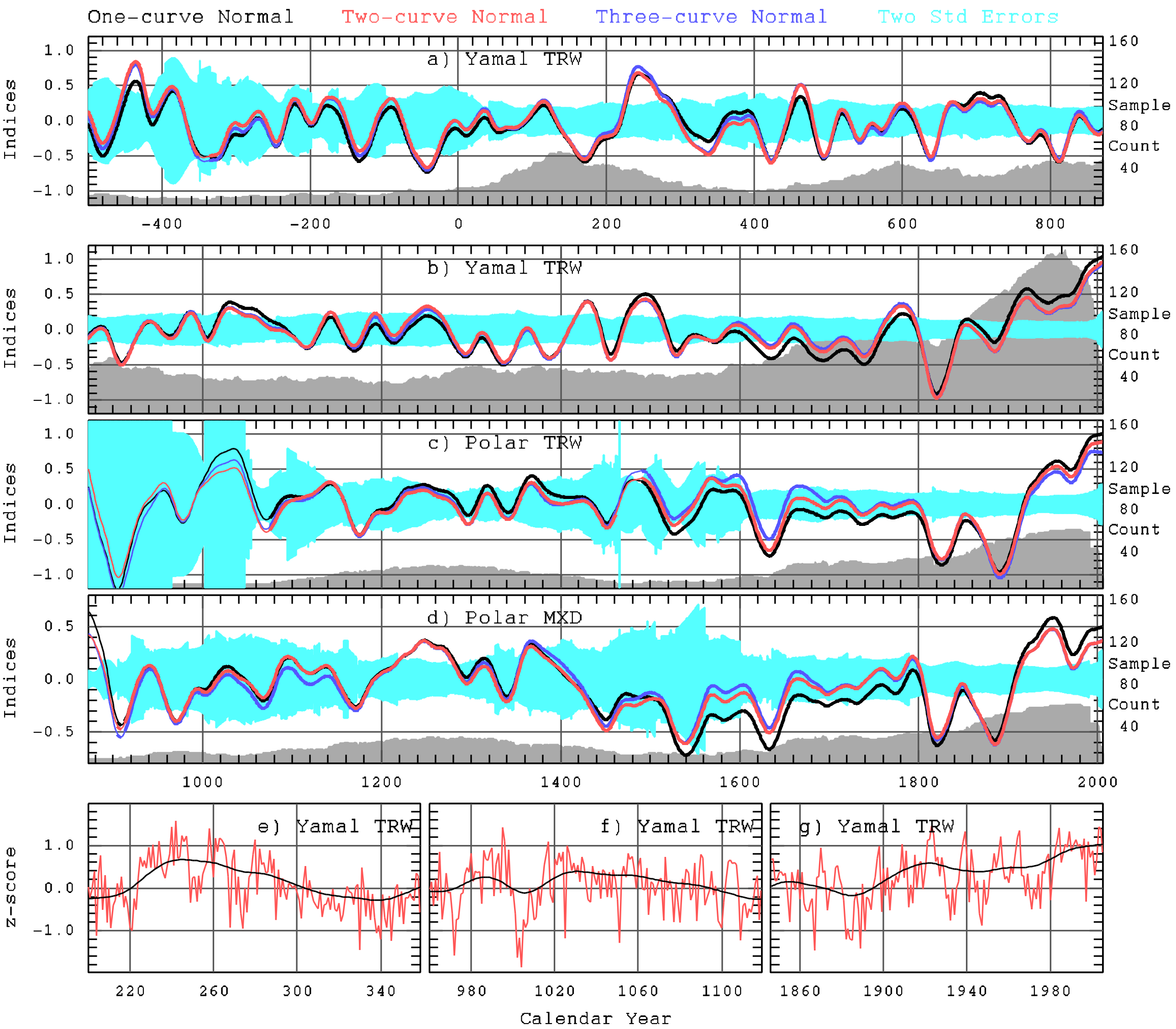


Figure PY21 Comparison of chronologies created using one-curve (black), two-curve (red) and three-curve (blue) signal-free RCS with tree-indices transformed to have a normal distribution for (a) the early and (b) the later sections of the Yamal TRW data and the Polar Urals TRW (c) and Polar Urals MXD (d) data sets. Chronologies have been smoothed with a 50-year spline for display purposes and thin lines show where tree counts are <6. For the preferred (red) curve, +/- 2 S.E. of the mean are shown for 50-year smoothed data as cyan shading. Where <4 samples are available S.E. is not calculated and the cyan shading spans the full y-axis range. Annual and smoothed values of the "preferred" two-curve RCS chronology are shown for three sub-periods (200 to 350 (e), 970 to 1120 (f), and 1840 to 2005 CE (g)). Sample counts are shown by grey shading. Note the different horizontal scales in the top and three panels below it. The use of a third RCS curve slightly reduces the amplitude of the smoothed Yamal chronology in the Common Era while having a larger effect on the less well replicated parts of the chronologies.



PY4 Chronology Extreme Anomaly periods

Figure PY22 Chronologies were created for Yamal TRW (yml-all.raw), Polar Urals TRW (polar.raw) and Polar Urals MXD (polarxs.mxd) two-curve, signal-free RCS with tree indices transformed to have a normal distribution. A combined Yamalia chronology was also created using TRW tree indices from above. For each chronology 25-year, 50-year and 100-year running means are plotted (near the middle of each window).

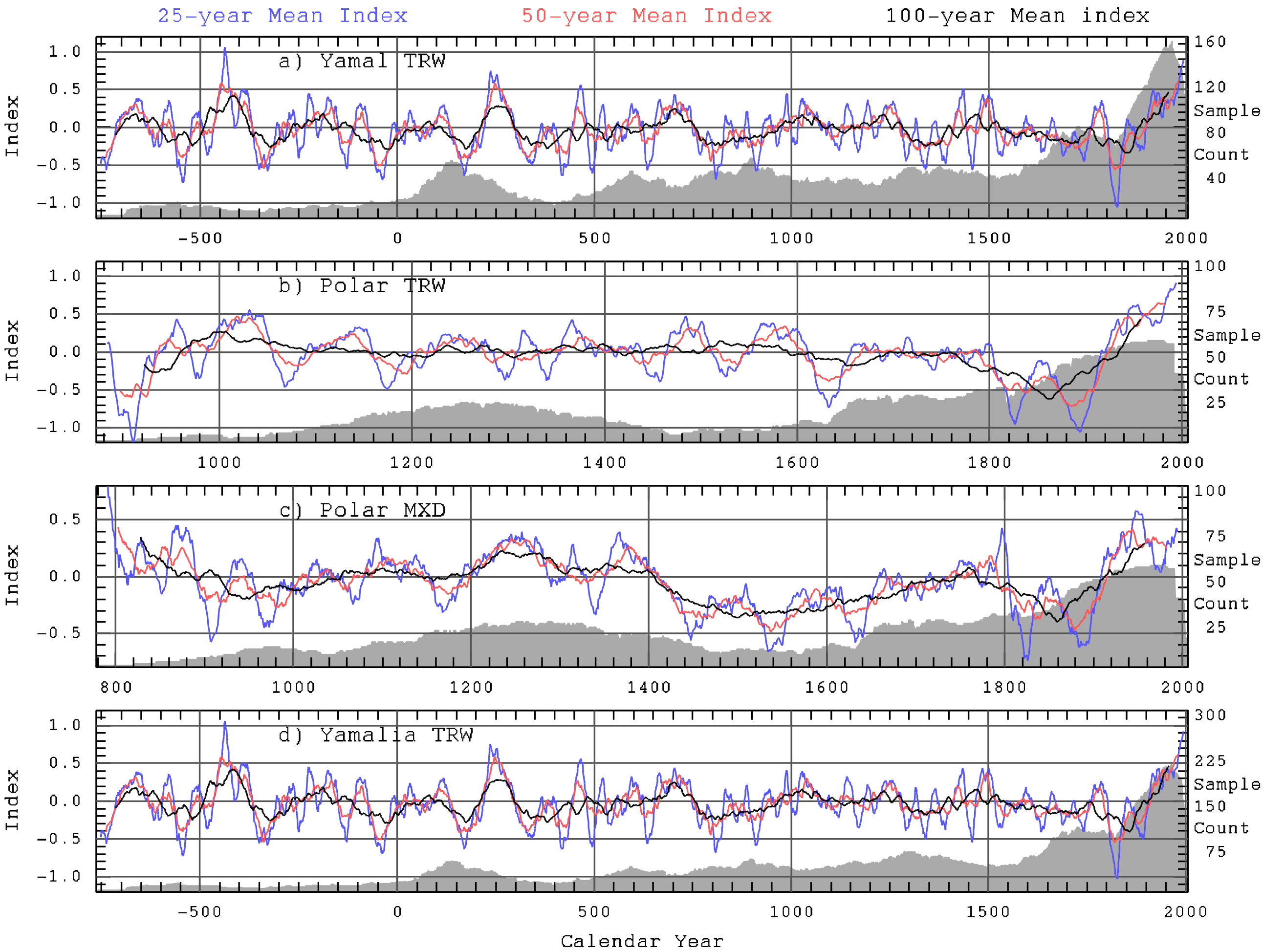


Figure PY23 Chronologies were created for Yamal TRW (yml-all.raw), Polar Urals TRW (polar.raw) and Polar Urals MXD (polarxs.mxd) two-curve, signal-free RCS with tree indices transformed to have a normal distribution. A combined Yamalia chronology was also created using TRW tree indices from above. For each chronology running means of standard deviations are plotted for 25-years (blue), 50-years (red) and 100-years (black) with values plotted near the centre of each window.

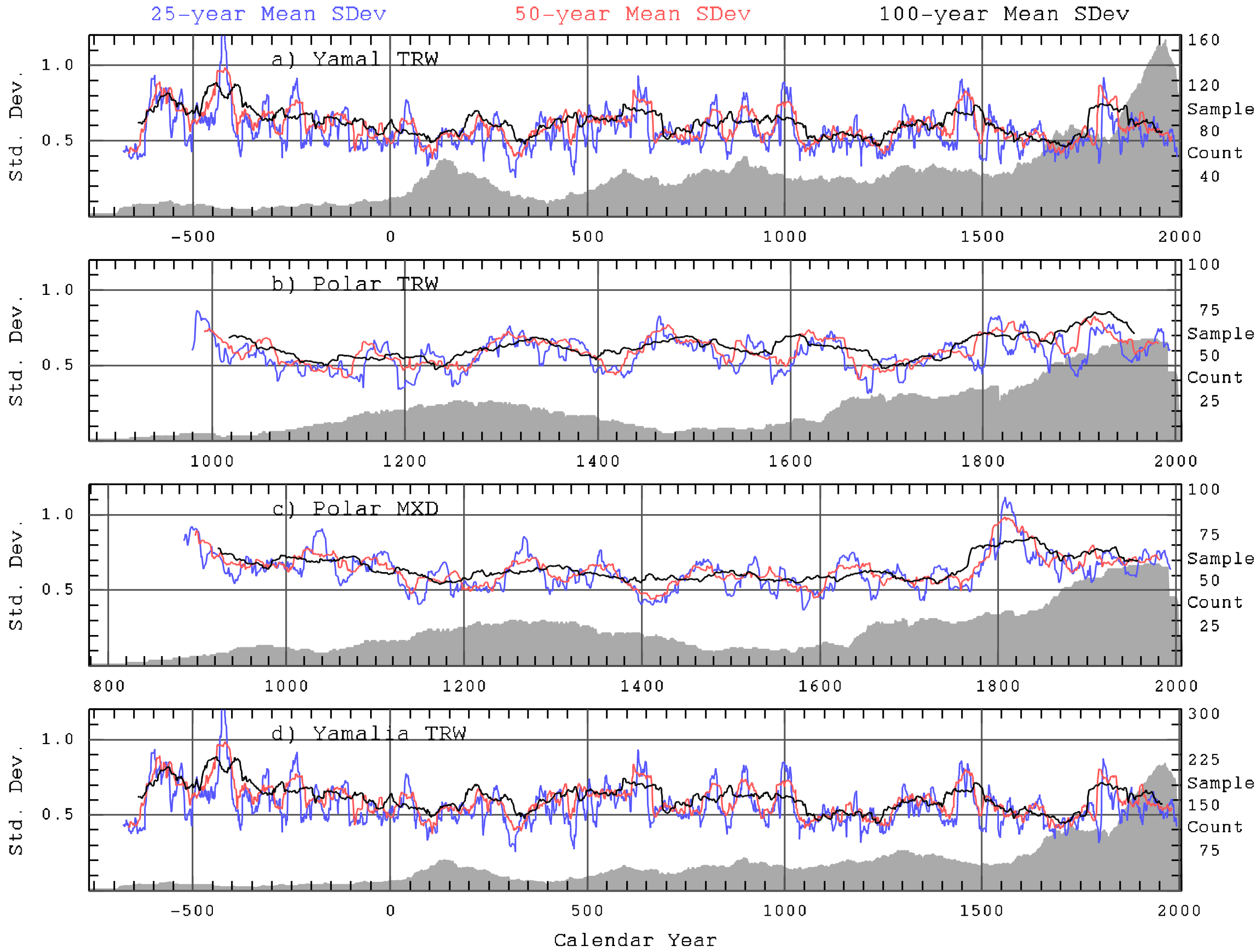


Table PY1 Non-overlapping periods with the highest and lowest mean values for the Polar Urals TRW chronology (polar.raw) spanning 872 to 2006 CE. The chronology was created using two-curve, signal-free RCS with tree indices transformed to have a normal distribution. Means of chronology values and annual standard deviations of those chronology values are shown for 25-year, 50-year and 100-year non-overlapping periods.

Positive Anomalies				Negative Anomalies			
Rank	Period	Mean	S.D.	Rank	Period	Mean	S.D.
25-year Periods							
1	1982 to 2006	0.92	0.61	1	1882 to 1906	-1.06	0.46
2	1942 to 1966	0.62	0.52	2	1814 to 1838	-0.96	0.57
3	1020 to 1044	0.56	0.62	3	1621 to 1645	-0.74	0.60
4	1473 to 1497	0.47	0.67	4	1162 to 1186	-0.49	0.59
5	993 to 1017	0.44	0.63	5	1056 to 1080	-0.47	0.39
50-year Periods							
1	1951 to2000	0.65	0.64	1	1860 to 1909	-0.71	0.58
2	994 to 1043	0.47	0.63	2	1810 to 1859	-0.52	0.73
3	1563 to 1612	0.34	0.51	3	1608 to 1657	-0.39	0.65
4	1465 to 1514	0.32	0.65	4	1169 to 1218	-0.30	0.54
100-year Periods							
1	1907 to 2006	0.44	0.71	1	1811 to 1910	-0.62	0.66
2	957 to 1056	0.28	0.72	2	1602 to 1701	-0.18	0.62
3	1470 to 1569	0.15	0.68	3			

Table PY2 As for Table PY1 but for the Polar Urals MXD chronology (polarxs.mxd) spanning 778 to 2006 CE.

Positive Anomalies				Negative Anomalies			
Rank	Period	Mean	S.D.	Rank	Period	Mean	S.D.
25-year Periods							
1	1936 to 1960	0.58	0.60	1	1814 to 1838	-0.74	0.86
2	856 to 880	0.45	0.66	2	1522 to 1546	-0.66	0.51
3	1981 to 2005	0.43	0.64	3	1872 to 1896	-0.63	0.61
4	1785 to 1809	0.43	0.70	4	1620 to 1644	-0.58	0.70
5	1355 to 1379	0.40	0.58	5	895 to 919	-0.58	0.64
50-year Periods							
1	1918 to 1967	0.41	0.67	1	1512 to 1561	-0.49	0.59
2	1220 to 1269	0.34	0.62	2	1854 to 1903	-0.48	0.64
3	831 to 880	0.27	0.79	3	1435 to 1484	-0.37	0.66
4	1353 to 1402	0.26	0.56	4	1595 to 1644	-0.35	0.66
5				5	1797 to 1846	-0.32	0.89
100-year Periods							
1	1907 to 2006	0.29	0.69	1	1809 to 2008	-0.40	0.74
2	1184 to 1283	0.23	0.61	2	1449 to 1548	-0.37	0.63
3	1302 to 1401	0.12	0.60	3	1553 to 1652	-0.27	0.58
4				4	894 to 993	-0.20	0.70

(Note: Table 1 in main text contains the equivalent table for the Yamal TRW chronology and Table1.prn contains values for Yamalia.)

Figure PY24 – A chronology was created for Yamal TRW using two curve signal-free RCS with tree indices transformed to have a normal distribution. Annual values (black) and 50-year low pass (red) chronologies also plotted in 300-year segments from -700 to 800 CE.

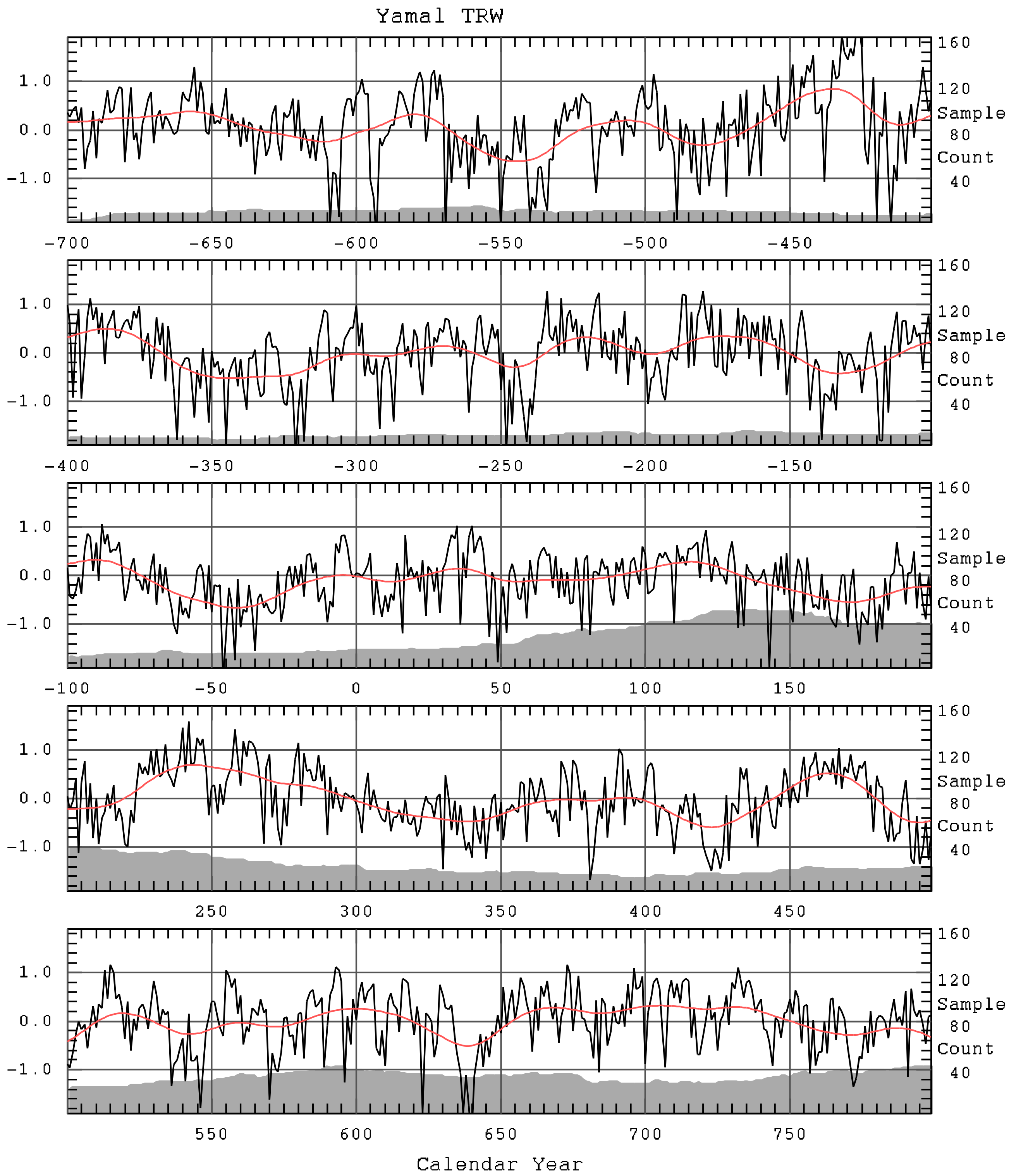


Figure PY25 – A chronology was created for Yamal TRW using two curve signal-free RCS with tree indices transformed to have a normal distribution. Annual values (black) and 50-year low pass (red) chronologies plotted in 300-year segments from 800 CE to "present".

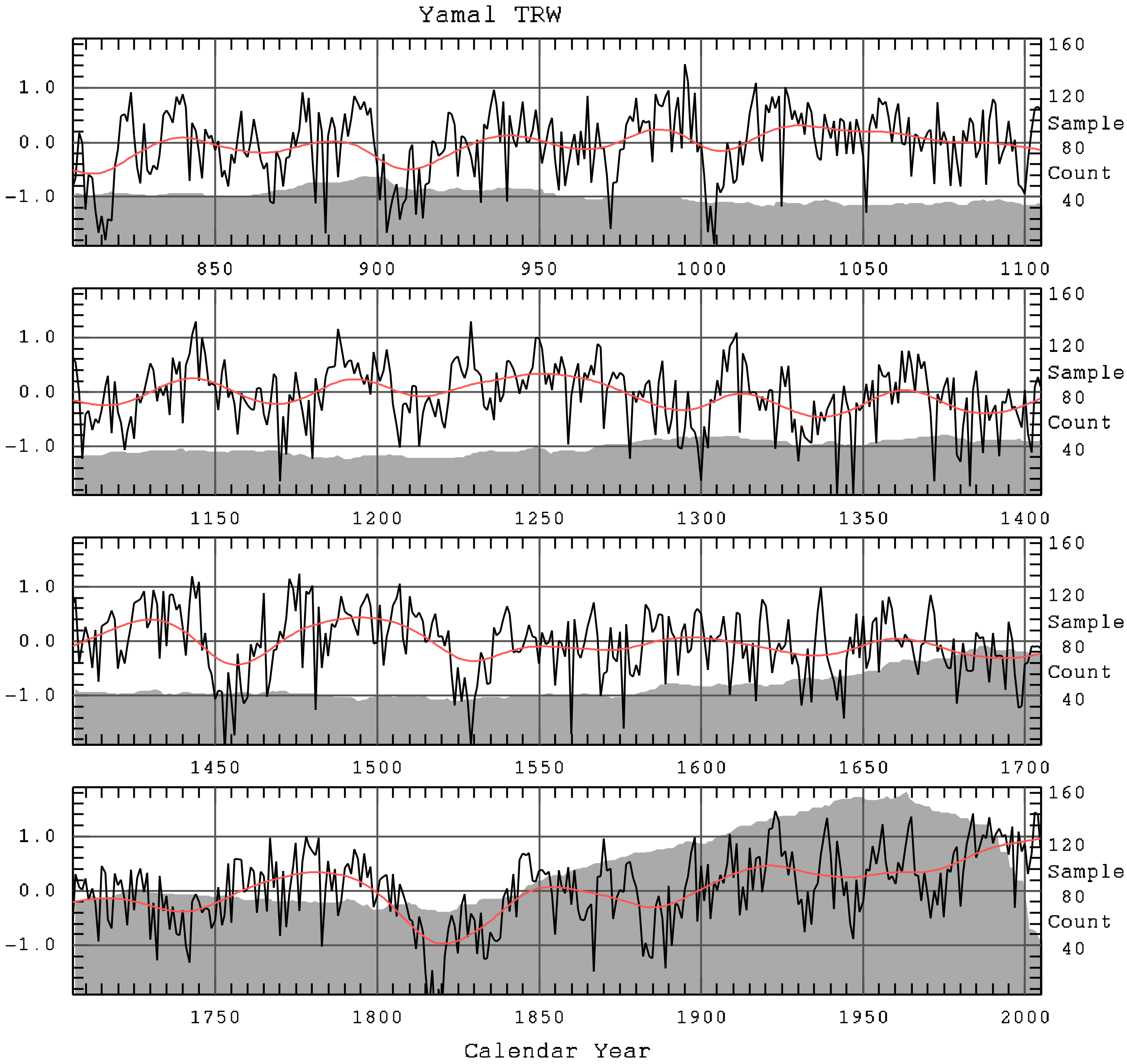


Figure PY26 - A chronology was created for Polar Urals TRW (polar.raw) using two curve signal-free RCS with tree indices transformed to have a normal distribution. Annual values (black) and 50-year low pass (red) chronologies plotted in 300-year segments.

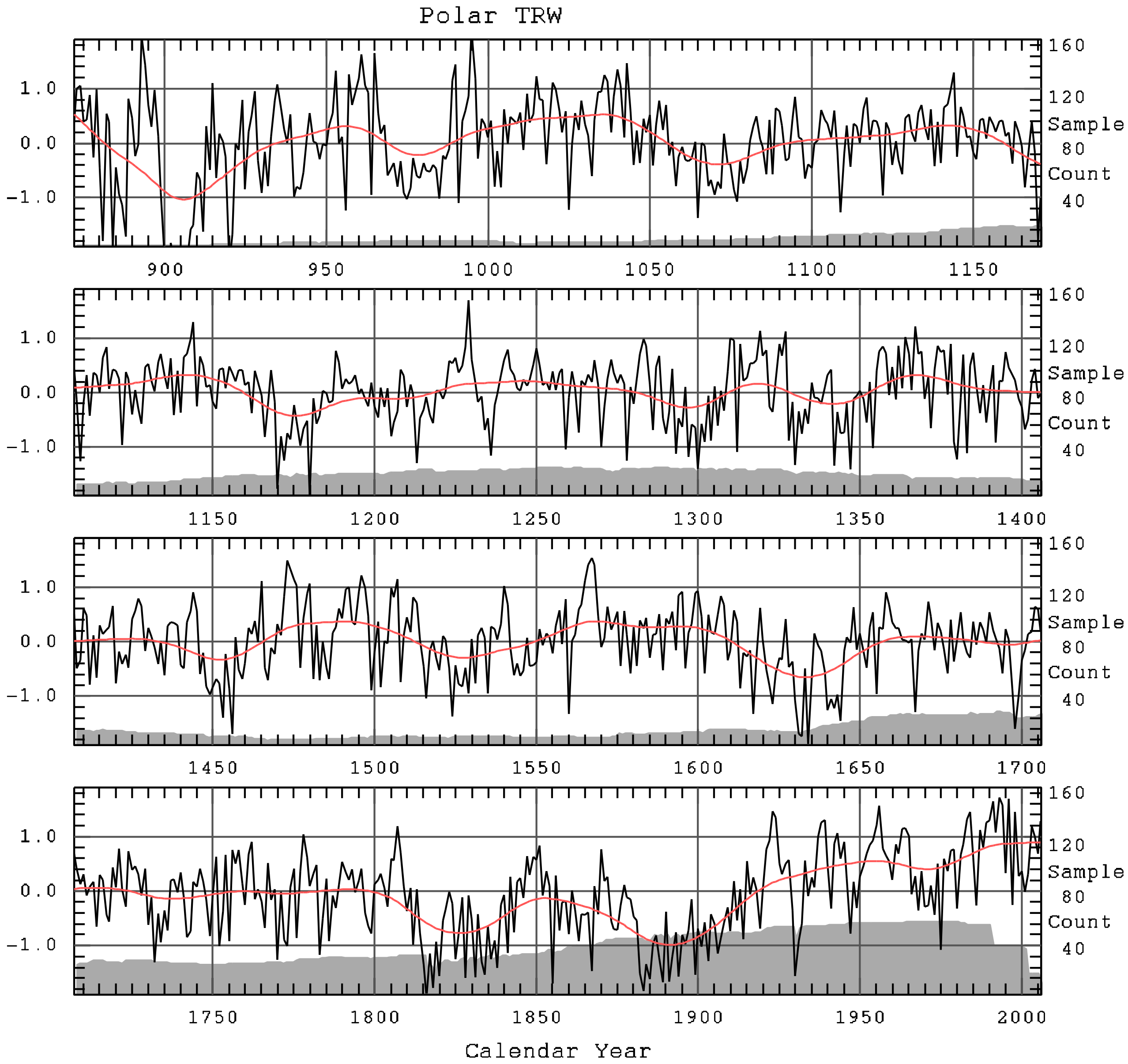
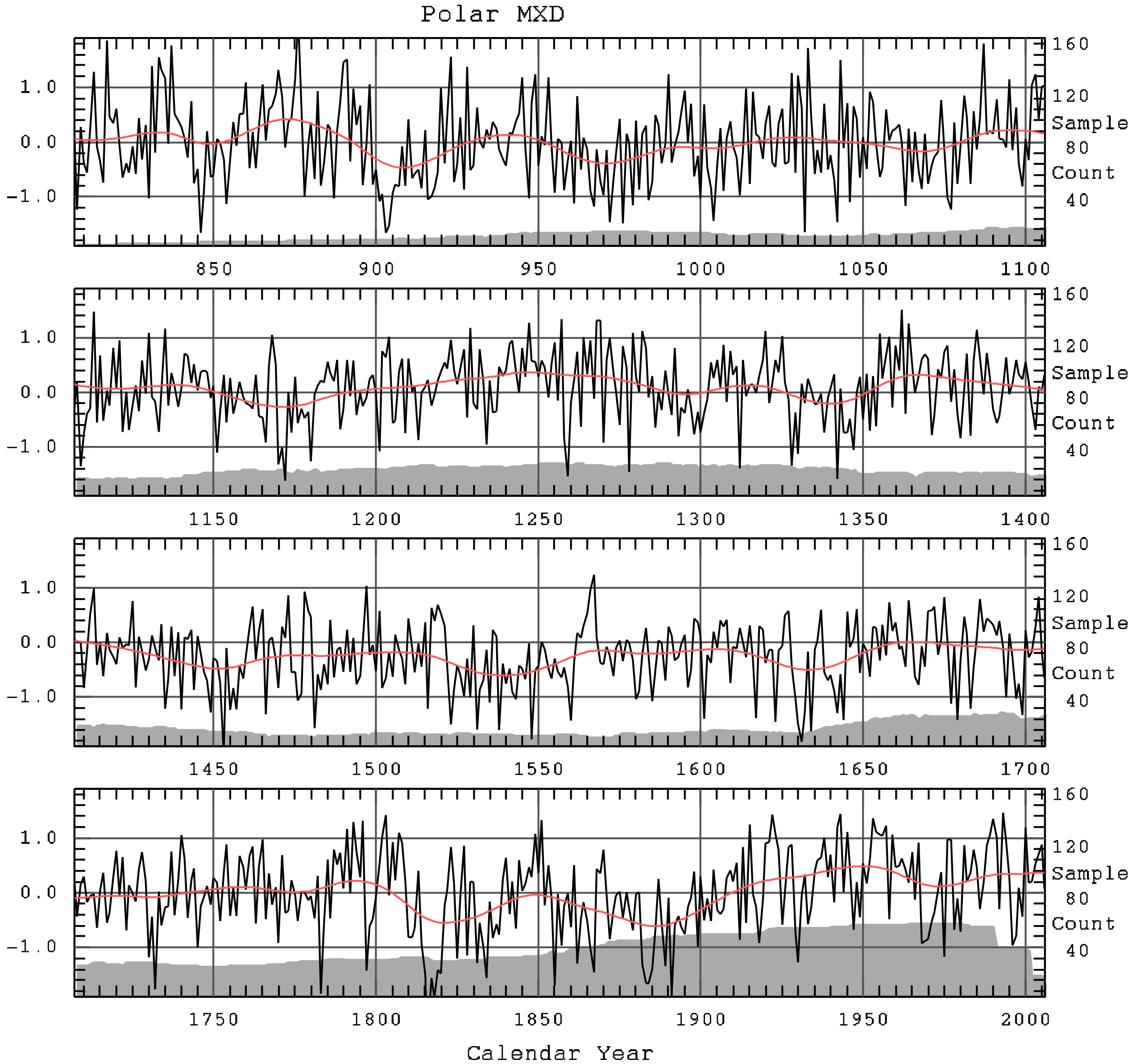


Figure PY27 - A chronology was created for Polar Urals MXD (polarxs.raw) using two curve signal-free RCS with tree indices transformed to have a normal distribution. Annual values (black) and 50-year low pass (red) chronologies plotted in 300-year segments.



PY5 Scatter-plot Comparisons

Figure PY28 Scatter plots of the chronology values for the final Polar Urals and Yamal TRW series. Values where the chronology replication is < 10 are shown by open circles rather than solid dots. Correlations between the two chronologies are marked on each panel, based on all values, only those with replication < 10 (“poor_repl”), and only those with replication >= 10 (“good_repl”). Results are shown for four cases, top left: no filtering; top right: high-pass deviations from a 15-year spline; bottom left: band-pass filtering using 15- and 100-year splines; bottom right: smoothed with a 100-year spline.

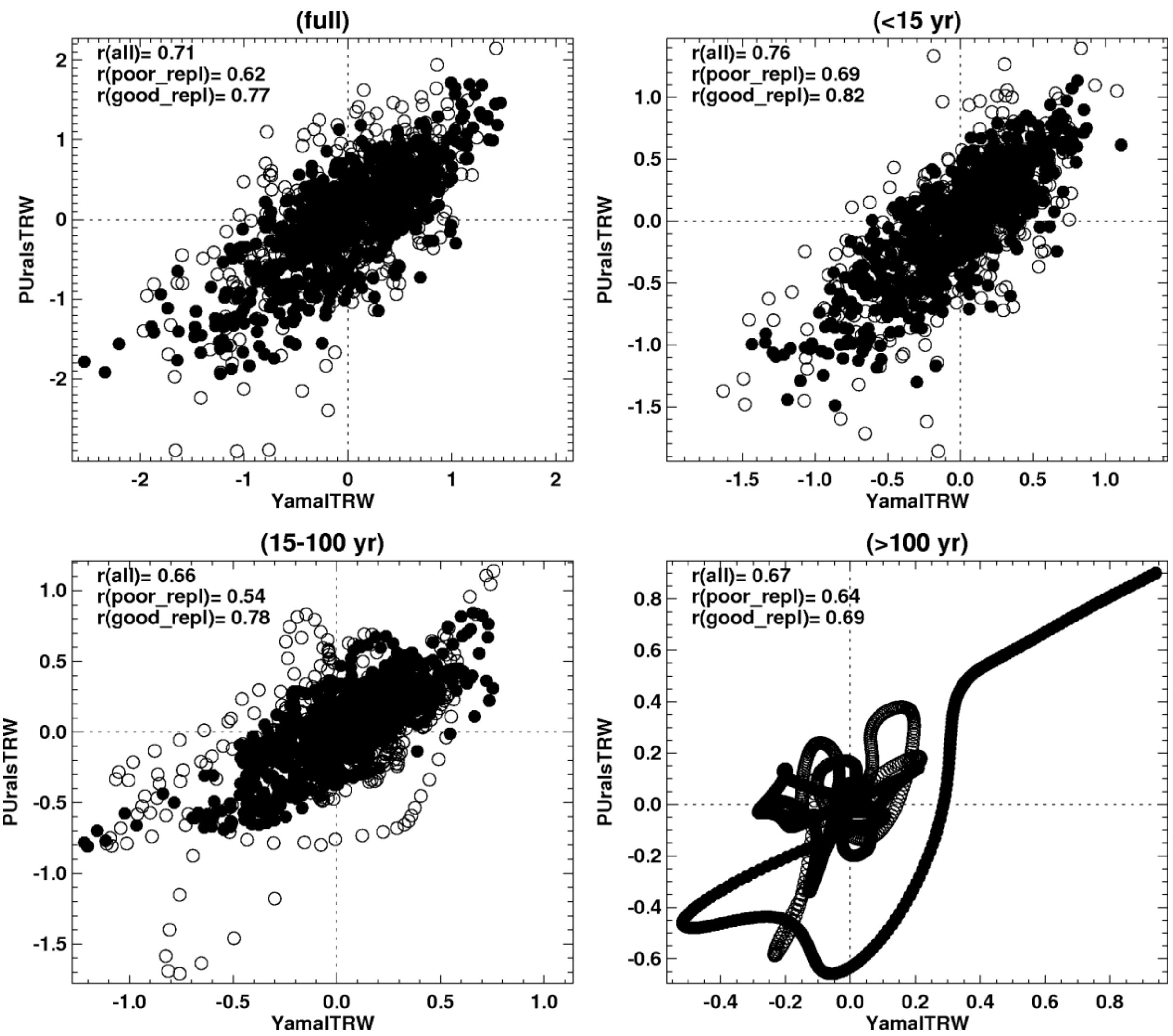
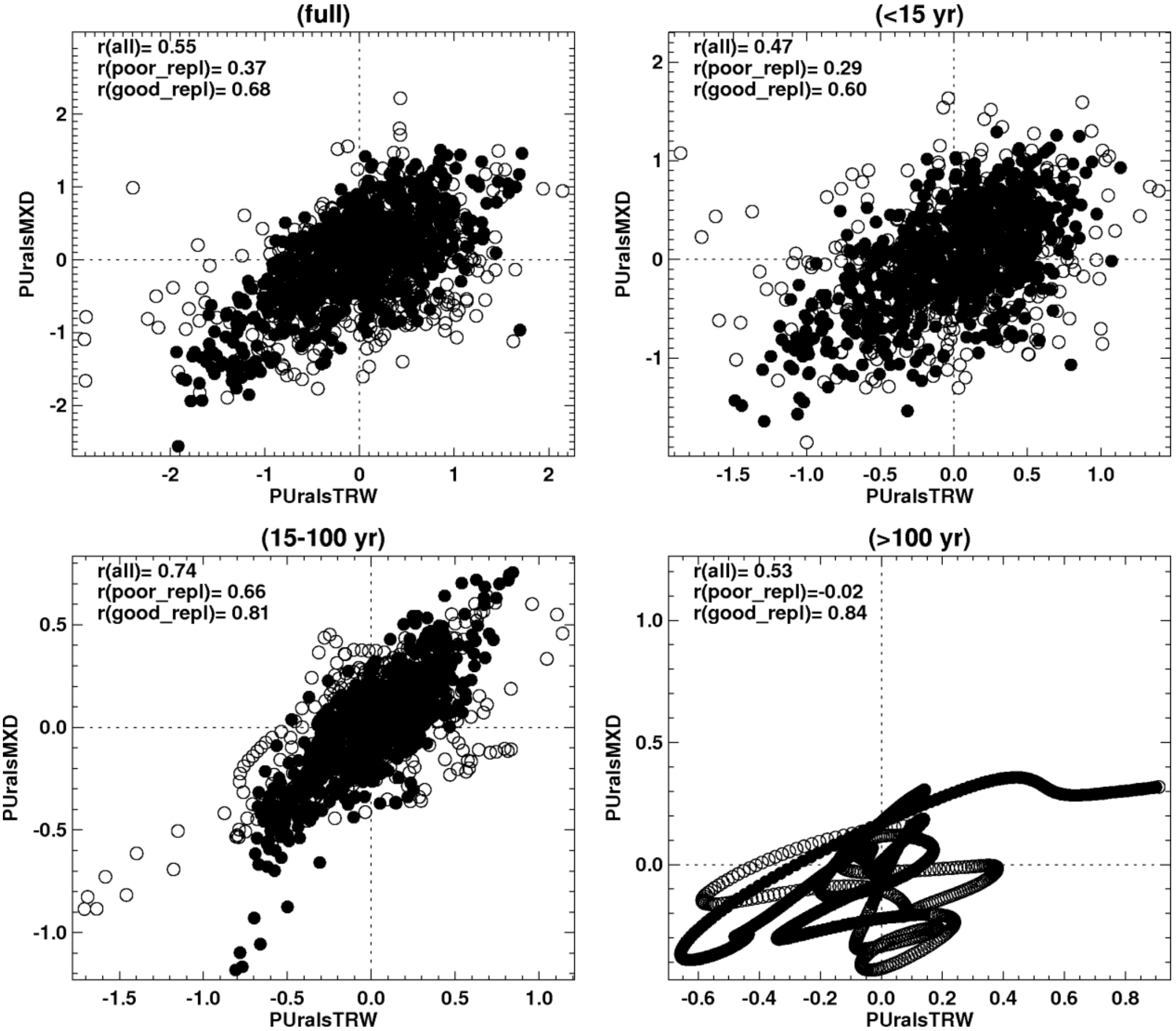


Figure PY29 Same as Figure PY28, but for the final Polar Urals MXD and TRW chronologies.



PY6 Previous chronologies

Figure PY30 Historical development of the Yamal chronologies; a) corridor standardised chronology of Hantemirov and Shiyatov (2002); b) simple RCS processed chronology of Briffa 2000; c) simple RCS processed chronology of Briffa et al. (2008); d) RCS chronology of Briffa and Melvin (2009) with additional living-tree samples and including Khadytla data; and e) the current two-curve, signal-free, RCS chronology formed as the average of tree indices converted to have a normal distribution. All series have been normalised here (by subtracting the mean and dividing by the standard deviation) over the common period 1 to 1996 AD. Gray shading shows sample replication.

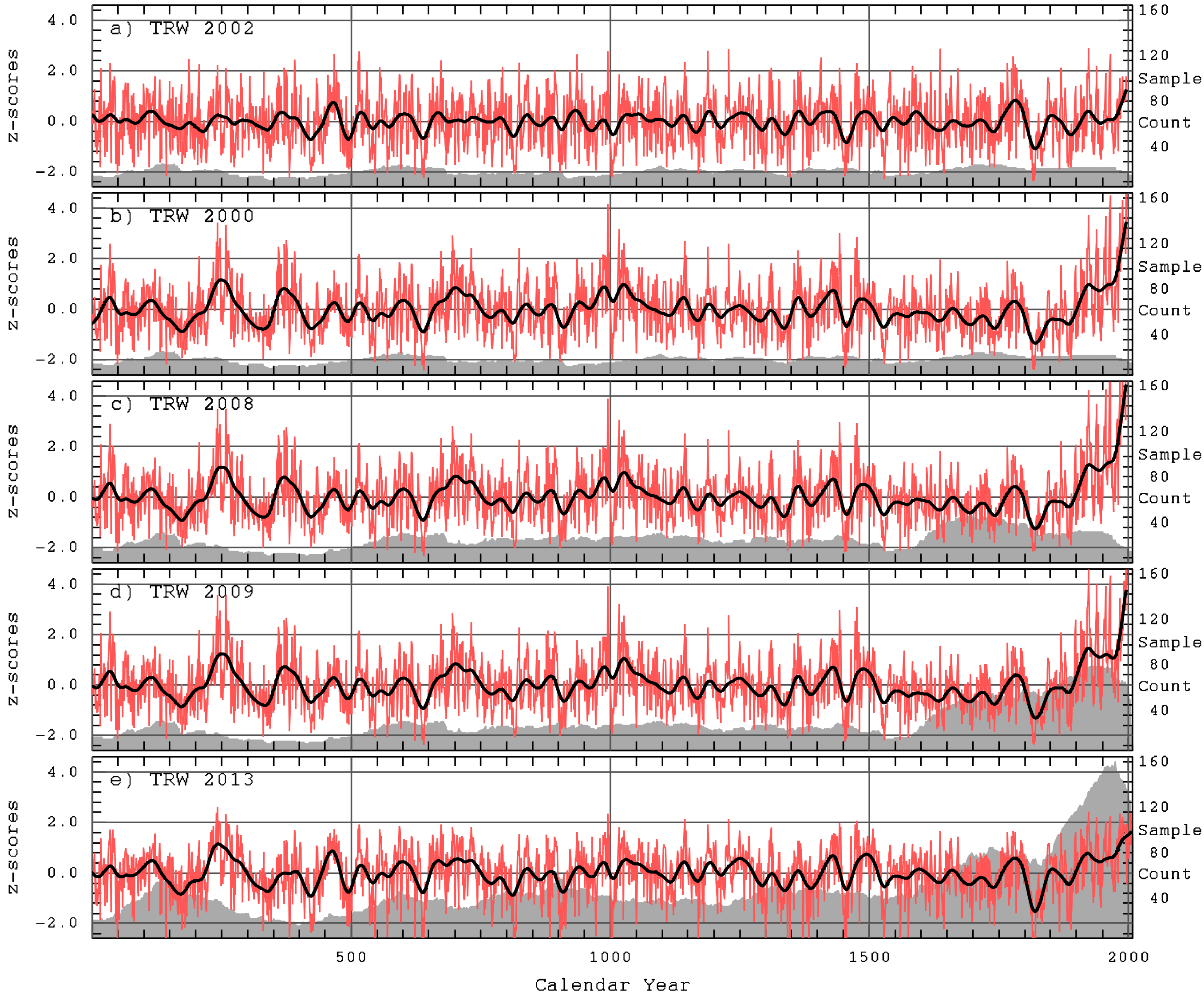


Figure PY31 Historical development of the Polar Urals chronologies; a) corridor standardised temperature reconstruction, based on TRW, of Graybill and Shiyatov (1989); b) RCS temperature reconstruction (primarily weighted to simple RCS standardised MXD) of Briffa 1995; c) simple RCS processed TRW chronology shown in Briffa et al. (1996); d) simple RCS processed MXD chronology shown in Briffa et al. (1996); e) the Polar Urals component of Esper et al. (2002) consisting of larch (pou_la and Polurula) larch and spruce (pou_pc) TRW data and including the root-collar samples discussed in SM3 part PU3; f) the current two-curve, signal-free, RCS TRW chronology formed as the average of tree indices converted to have a normal distribution; and g) the current two-curve, signal-free, RCS MXD chronology equivalent to f). All series have been normalised here (by subtracting the mean and dividing by the standard deviation) over the common period 961 to 1969 AD.