**Supporting Information**

**Table S1.** Correlation matrix among the signal-free tree-ring chronologies for the common period (772 AD – 1975 AD, *n* = 1204). All correlations are significant at 95% confidence.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **AYA** | **AAG** | **HUI** | **PTY** | **AAR** | **QUI\*** |
| **LEN** | 0.5 | 0.73 | 0.67 | 0.71 | 0.65 | 0.34 |
| **AYA** |  | 0.67 | 0.68 | 0.32 | 0.36 | 0.14 |
| **AAG** |  |  | 0.75 | 0.53 | 0.61 | 0.35 |
| **HUI** |  |  |  | 0.52 | 0.44 | 0.18 |
| **PTY** |  |  |  |  | 0.64 | 0.34 |

\* Common period 772 – 1918, *n* = 1147

**Table S2**. Weather stations used to calculate a regional mean maximum temperature record for the period 1959-2009.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Weather station** | **Latitude / Longitude** | **Elevation** | **Period** | **Source** |
| **(S) (W)** | **(m.a.s.l.)** |
| Pichoy Airport Valdivia | 39°39' / 73°04' | 21 | 1960 - 2016 | DMC1 |
| Universidad Austral Valdivia | 39°48' / 73°15' | 10 | 1960 - 2010 | UACH2 |
| Cañal Bajo Osorno | 40°36' / 73°09' | 61 | 1959 - 2016 | DMC |
| El Tepual Puerto Montt | 41°26' / 73°05' | 85 | 1960 - 2016 | DMC |
| Isla Teja Valdivia | 39°48' / 73°15' | 13 | 1851 - 1883 | Carlos Anwandter3 |

1 Dirección Meteorológica de Chile

2 Universidad Austral de Chile

3 Carlos Anwandter instrumental record

**Table S3.** Correlation Matrix among mean annual maximum temperature records (January-December) for the period 1960-2009. All correlations are significant (*p* < 0.05).

|  |  |  |  |
| --- | --- | --- | --- |
|  | U. Austral Valdivia | Cañal Bajo Osorno | El Tepual  Puerto Montt |
| Pichoy Airport Valdivia | 0.76 | 0.82 | 0.93 |
| Universidad Austral Valdivia |  | 0.53 | 0.73 |
| Cañal Bajo Osorno |  |  | 0.85 |

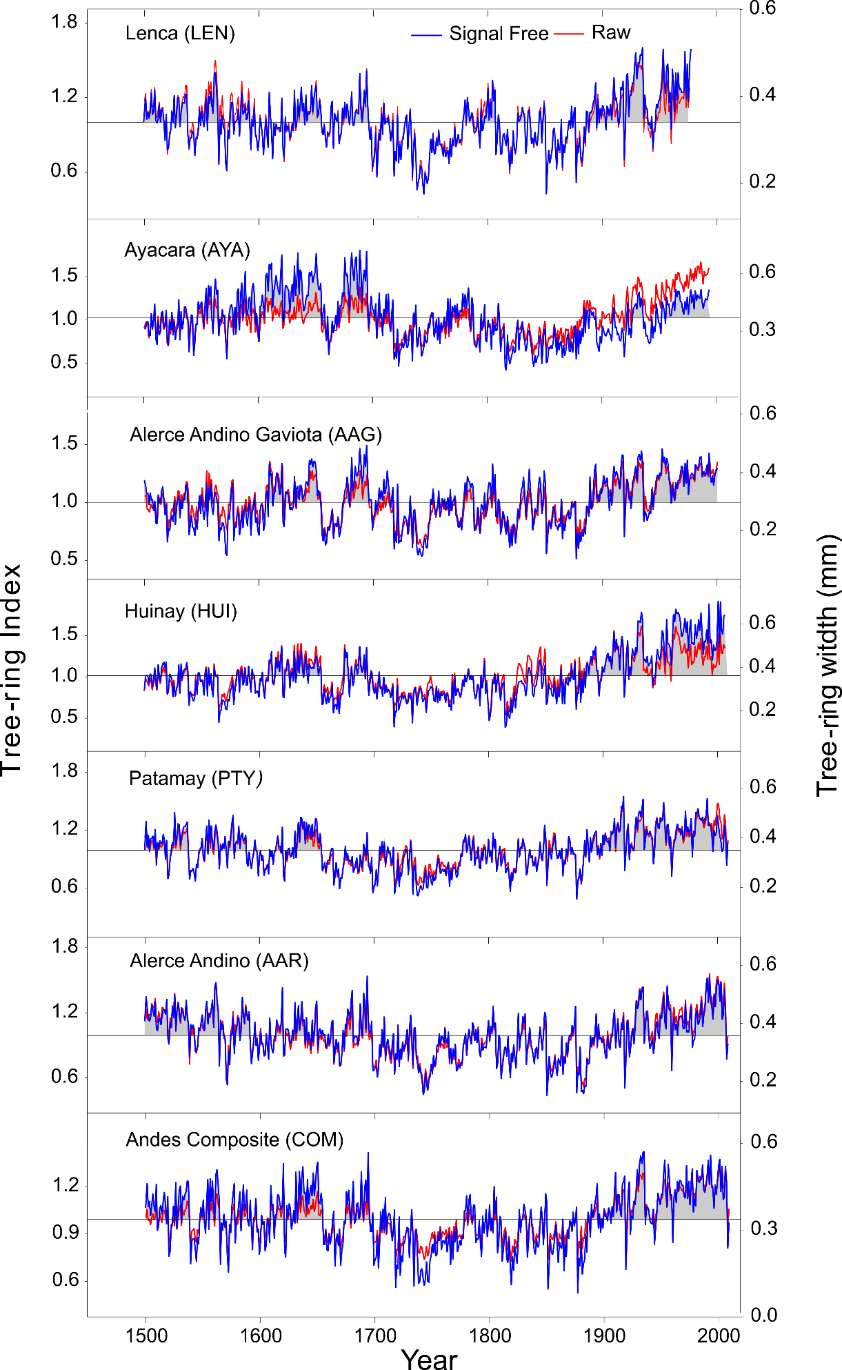
**Table S4**. Correlation Matrix among mean summer maximum temperature records (December-March) for the period 1960-2009. All correlations are significant (*p* < 0.05).

|  |  |  |  |
| --- | --- | --- | --- |
|  | U. Austral Valdivia | Cañal Bajo Osorno | El Tepual  Puerto Montt |
| Pichoy Airport Valdivia | 0.88 | 0.89 | 0.85 |
| Universidad Austral Valdivia |  | 0.78 | 0.86 |
| Cañal Bajo Osorno |  |  | 0.80 |

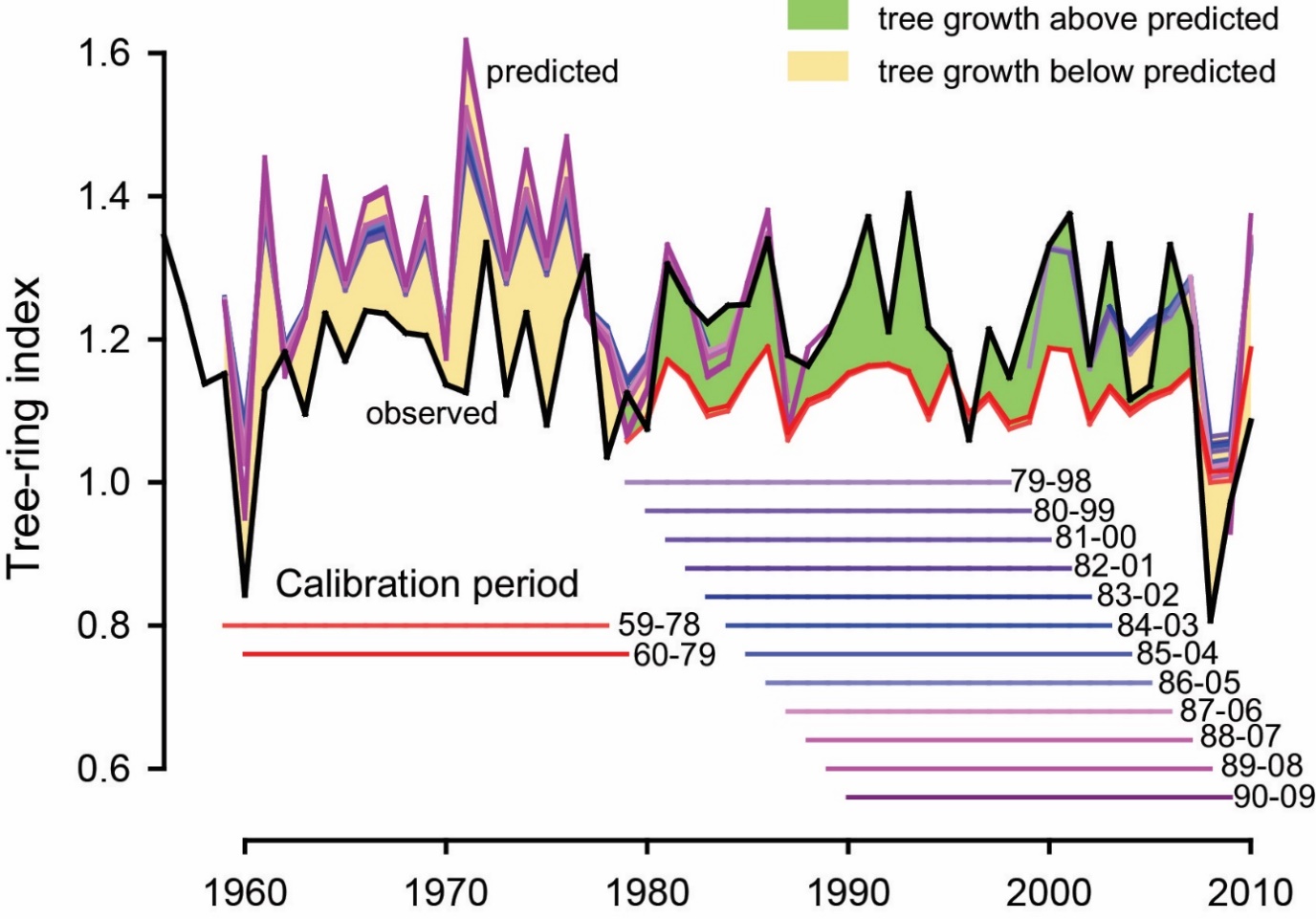
**Table S5.** Correlation between 4-month periods of mean summer maximum temperature and tree-ring width from the adjusted and non-adjusted chronologies for the 1959-2009 period. Significant correlations (*p* < 0.05) are indicated in red.

|  |  |  |  |
| --- | --- | --- | --- |
| Period | | Non-adjusted Chronology | Adjusted Chronology |
| From | Through |
| pJan\* | pApr | -0.21 | -0.25 |
| pFeb | pMay | -0.23 | -0.23 |
| pMar | pJun | -0.18 | -0.13 |
| pApr | pJul | -0.07 | -0.03 |
| pMay | pAug | 0.06 | 0.02 |
| pJun | pSep | 0.12 | -0.01 |
| pJul | pOct | 0.16 | 0.02 |
| pAug | pNov | 0.26 | 0.15 |
| pSep | pDec | 0.00 | -0.02 |
| pOct | Jan | -0.16 | -0.15 |
| pNov | Feb | -0.30 | -0.33 |
| pDec | Mar | -0.47 | -0.70 |
| Jan | Apr | -0.36 | -0.41 |
| Feb | May | -0.25 | -0.26 |
| Mar | Jun | -0.15 | -0.11 |
| Apr | Jul | -0.07 | -0.03 |
| May | Aug | -0.02 | -0.05 |
| Jun | Sep | -0.04 | -0.14 |
| Jul | Oct | 0.00 | -0.10 |
| Aug | Nov | 0.07 | 0.03 |
| Sep | Dec | 0.01 | 0.03 |

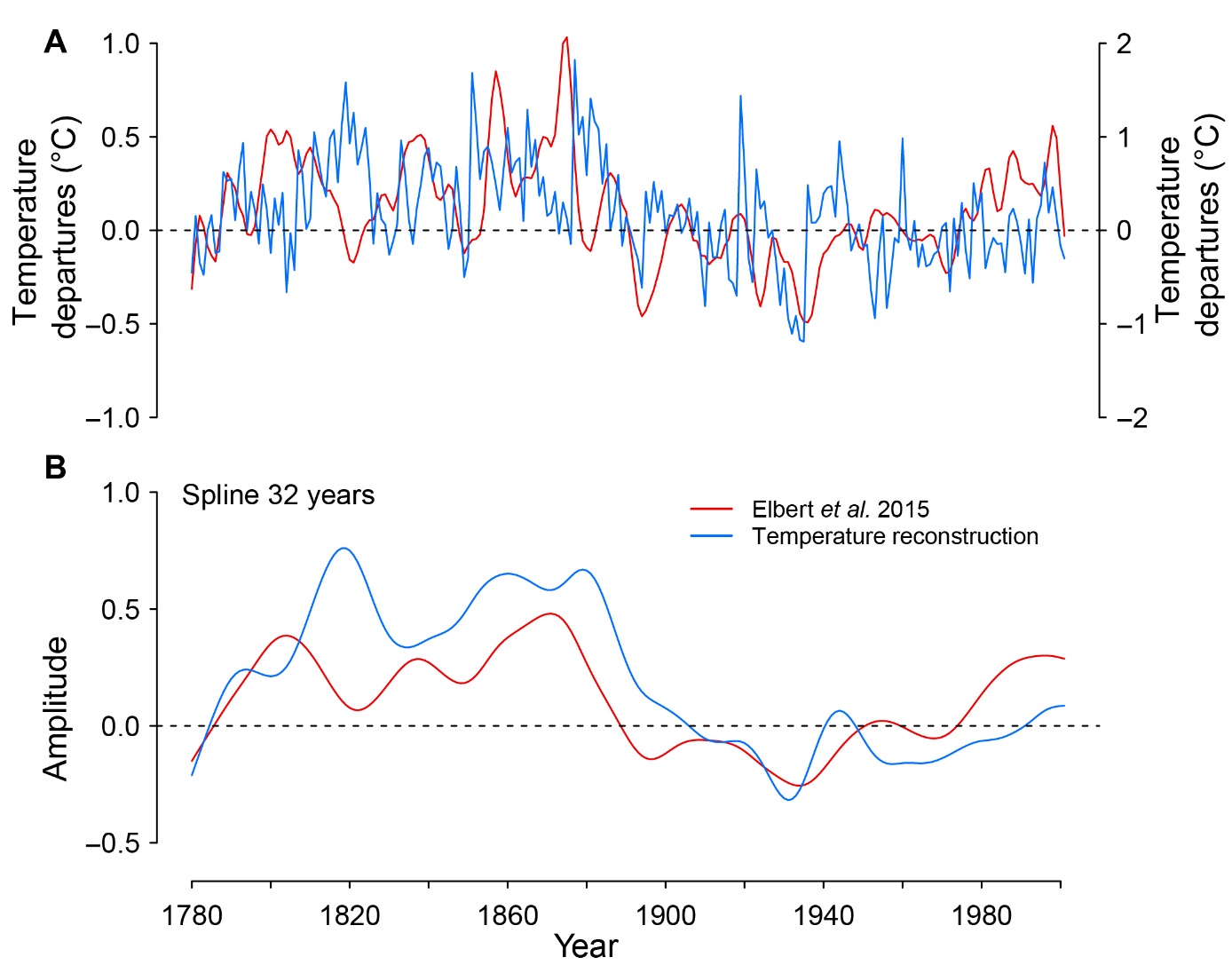
\* p indicates the previous growing season.



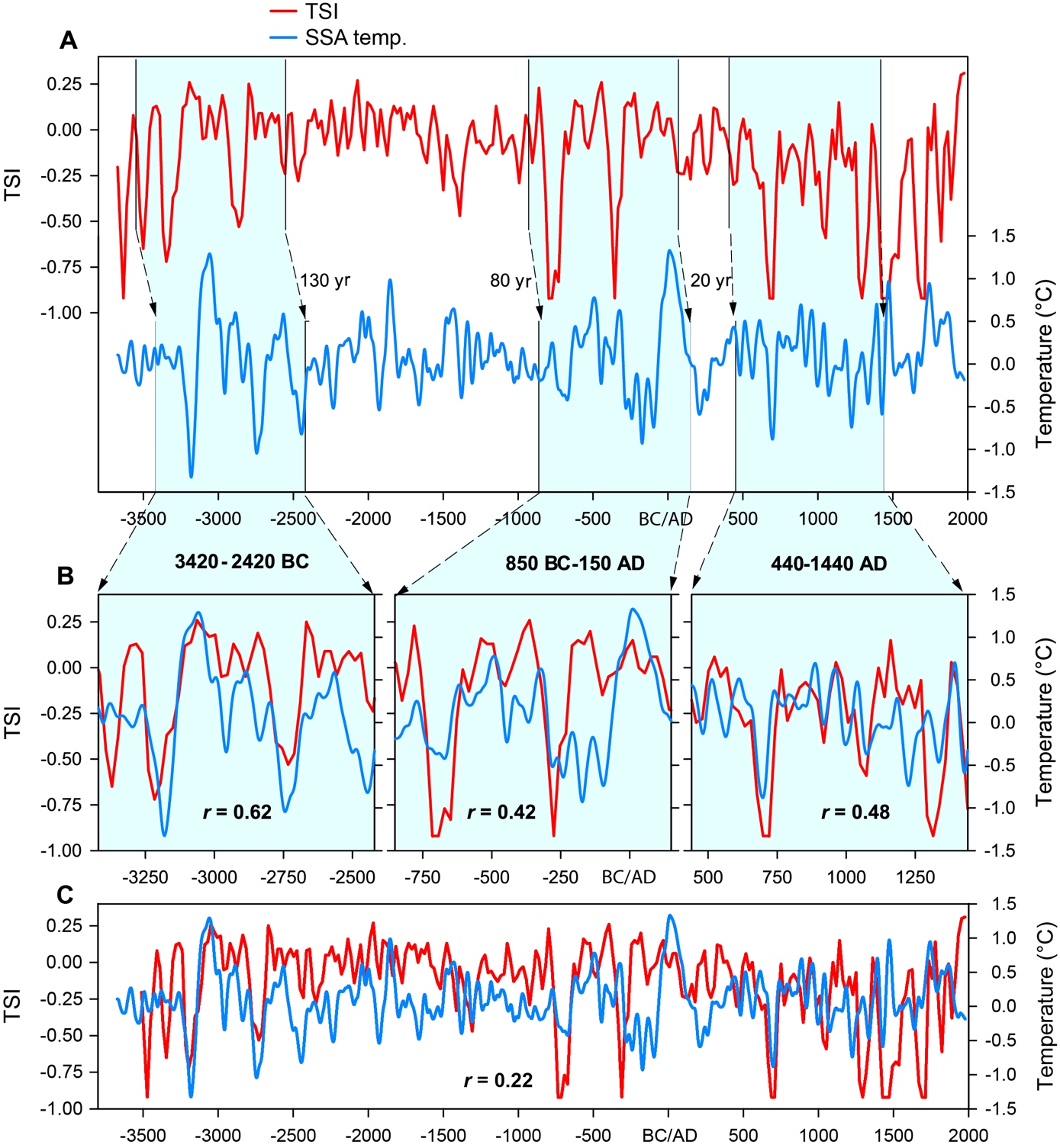
**Figure S1**. Comparison of *Fitzroya* raw and standardized (Signal Free Method) tree-ring chronologies since 1500. The composite chronology is depicted at the bottom. The grey shading below the standardized chronologies indicates tree-ring indices above the mean and highlights the positive trend in most of the chronologies since 1900. Quildaco (QUI) chronology was not included since it only reaches up to 1918.



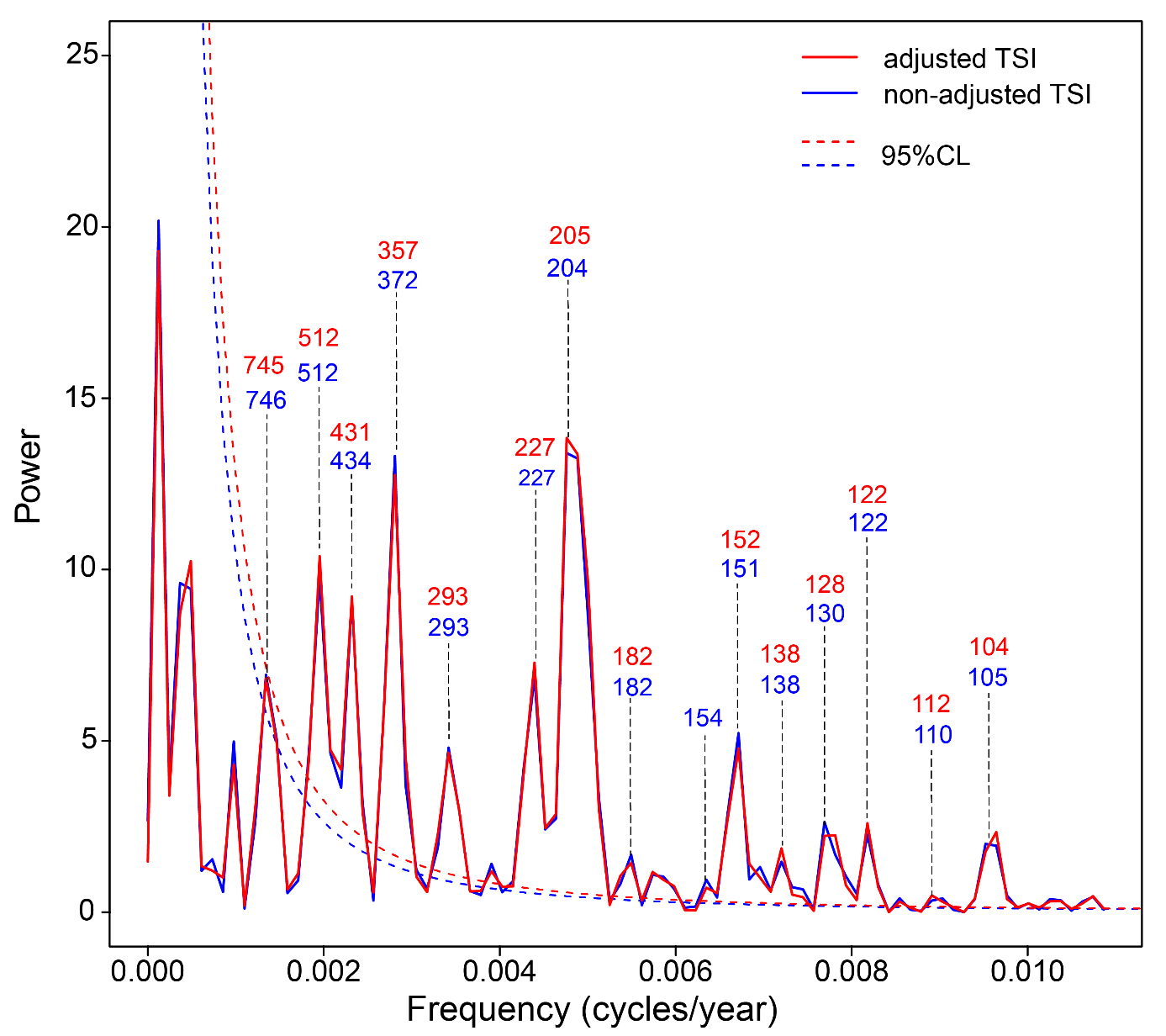
**Figure S2**. Diagram depicting the differences between observed (black curve) and predicted tree growth (different colours) using mean maximum temperature as the independent variable. Different moving 20-year calibration periods lagged 1 year over the 1959-2009 period are shown. Only the periods when the regression models explained more than 25% of the variance are depicted, and these were used to predict growth in the remaining 31-year period. Differences between observed and predicted growth were related to differences in mean intrinsic water use efficiency (iWUE) between the calibration and prediction intervals.



**Figure S3**. (A) Comparison between our mean maximum summer temperature reconstruction and the mean spring-summer temperature reconstruction for 47° S from varved sediments from El Plomo Lake (Elbert et al., 2015) for the 1780-2009 period. The Pearson correlation coefficient was *r* = 0.22 (*P* < 0.001); (B) Comparison between both records using a 32-year spline to highlight (decadal and multidecadal) frequency variability.



**Figure S4**. (A) Visual comparison of the temperature reconstruction for SSA and the TSI record (Steinhilber et al., 2012) showing an increasing off-set between both; (B) Comparisons for selected 1.000 year-periods showing common patterns between both records, when the TSI reconstruction is moved back 20 years respect to the temperature record for the 440 - 1440 AD period, 80 years for 850 BC - 150 AD, and 130 years for the 3420 BC – 2420 BC intervals; (C) Comparison between the long-term variations of the SSA temperature and the TSI record after an accumulated linear adjustment for the TSI temporal scale deleting ~3 years per centurybefore 757 AD was applied. The overlapping period between both records is 3672 BC – 1977 AD.



**Figure S5)** (A) Significant cycles identified by the Multi-Taper Method (MTM, Lees & Park, 1995) for the adjusted and non-adjusted total solar radiation record (TSI, Steinhilber et al., 2012), showing the spectrum for cycles > 100 years.