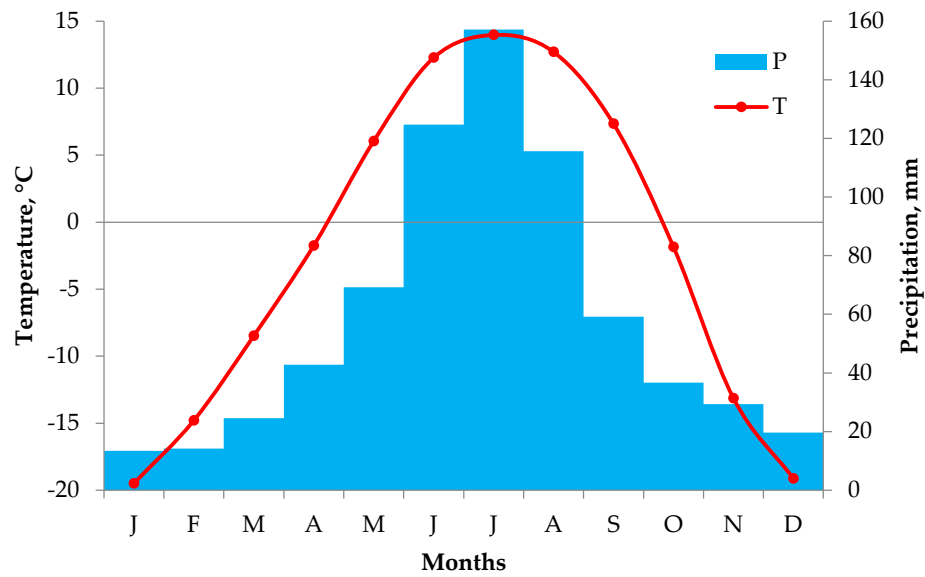# Supplementary materials

Figure S1. Average monthly climatic diagram of the study region (ERA-20C reanalysis over 1900-2010 for 49.7-52.5°N 89.3-90.7°E): P, precipitation; T, temperature.
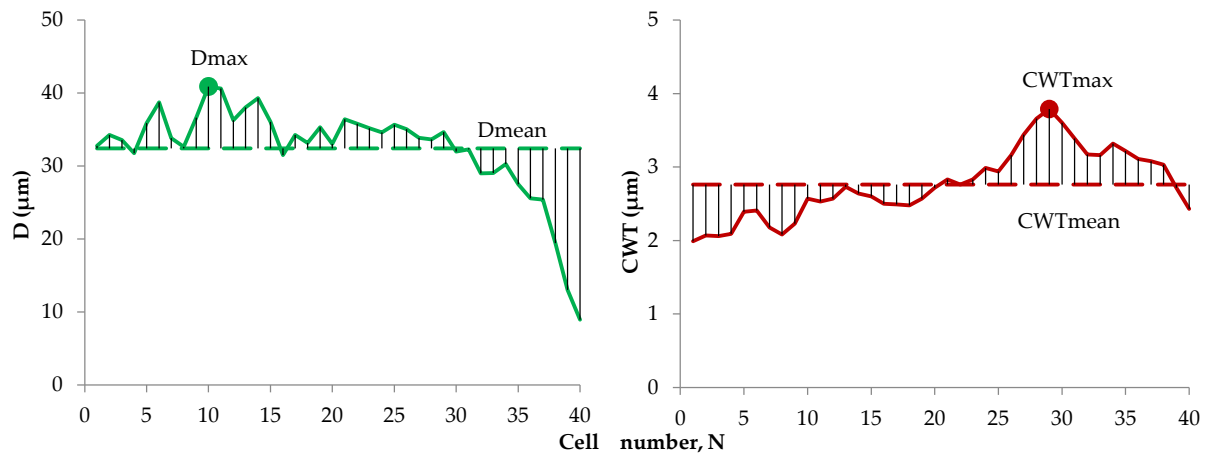

Figure S2. Calculation of tree-ring characteristics from tracheidograms of cell radial diameter D and cell wall thickness CWT on example of Tree_1, ring formed in 1690.
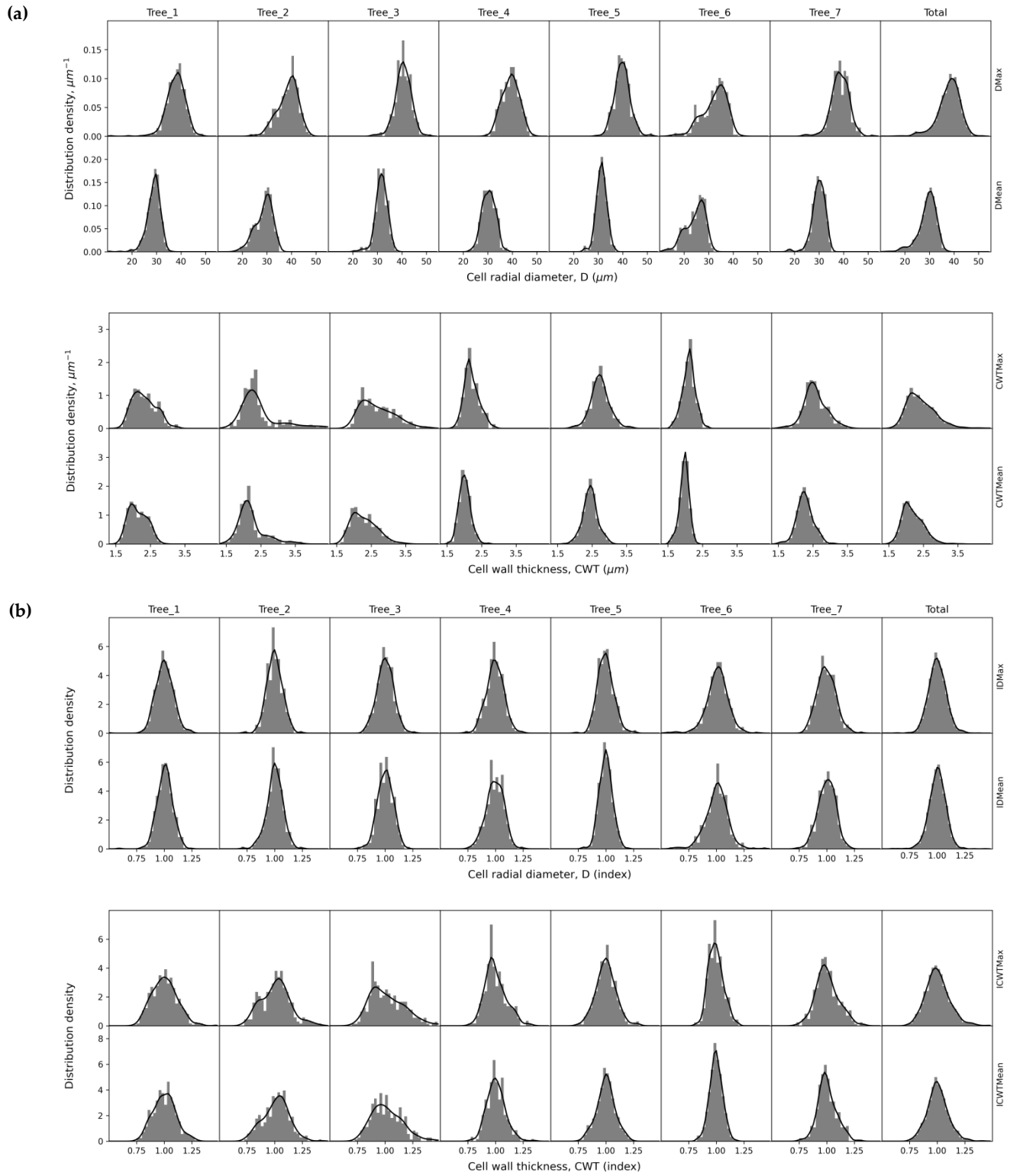
Figure S3. Distribution density of measured **(a)** and indexed **(b)** tree-ring anatomical characteristics for seven individual trees and total sample.
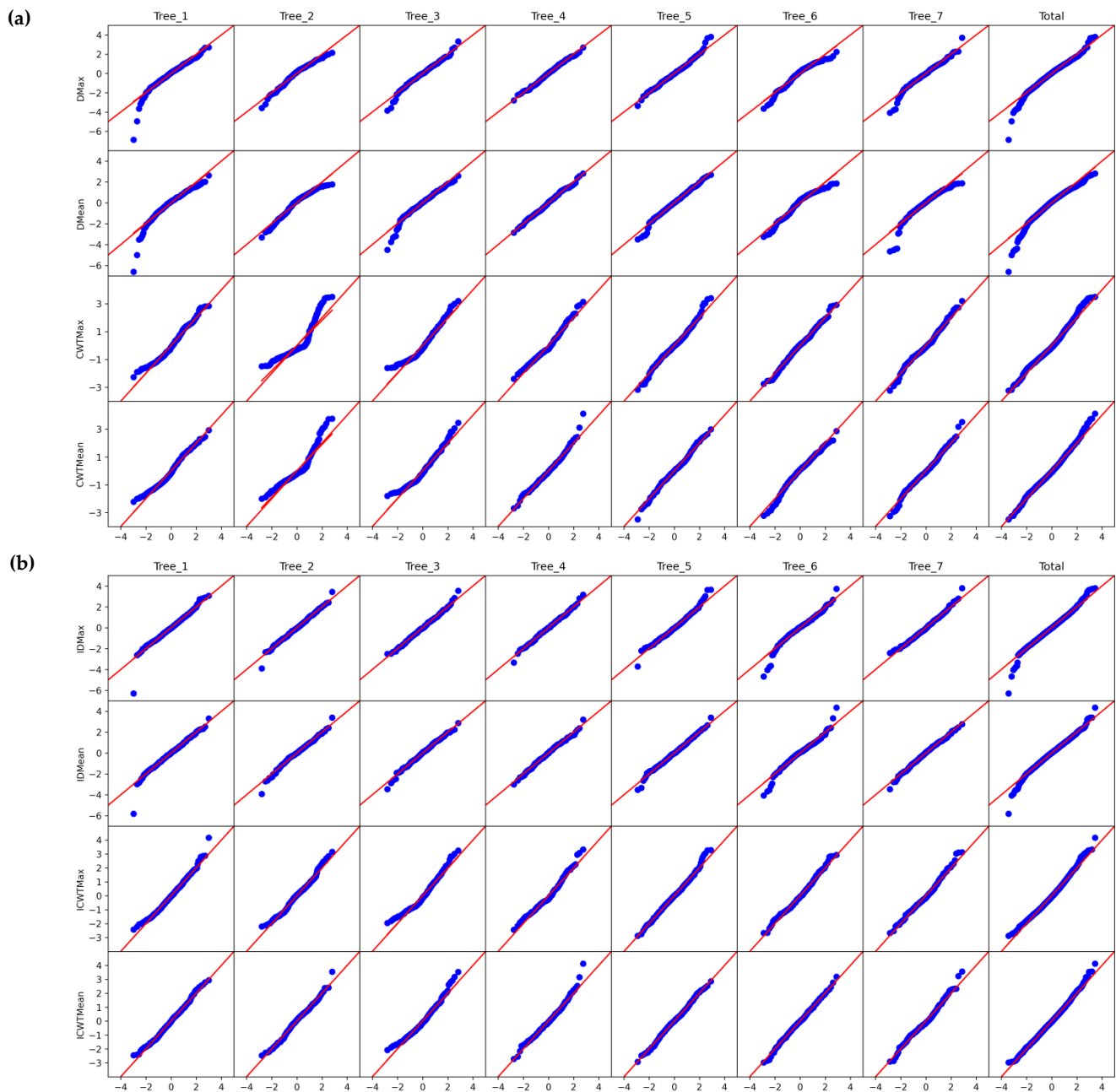
Figure S4. Quantile-quantile plots of measured **(a)** and indexed **(b)** tree-ring anatomical characteristics standardized to z-scores (mean 0, standard deviation 1) against standard normal distribution. Red line represents one-to-one ratio; blue dots represent actual tree rings.
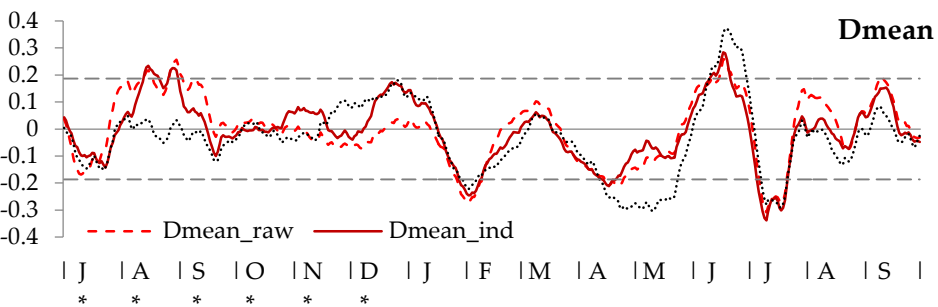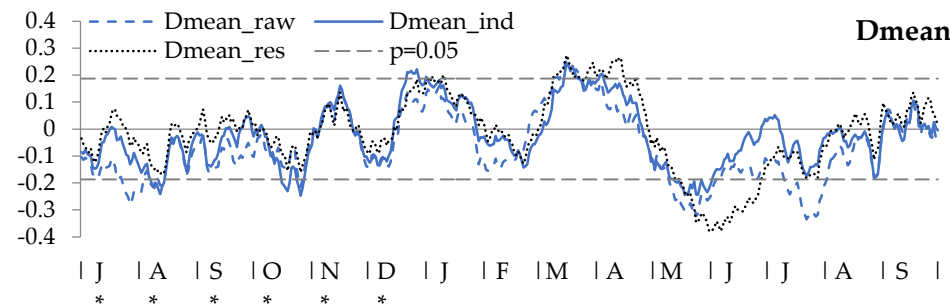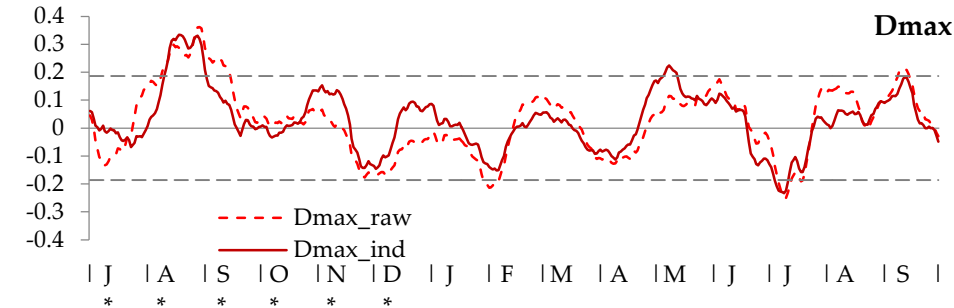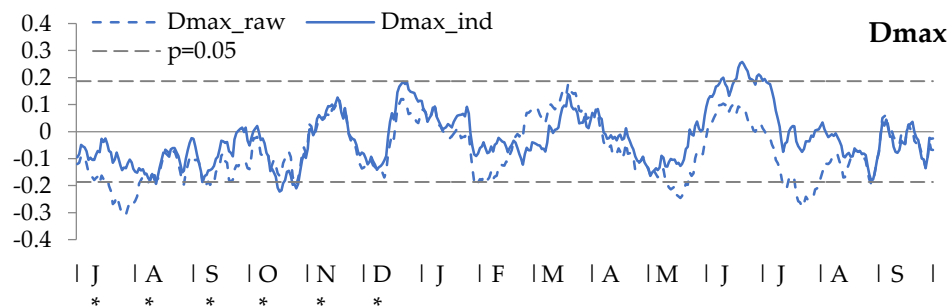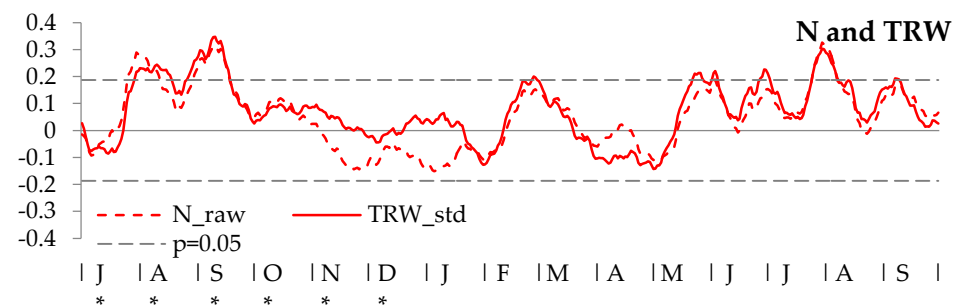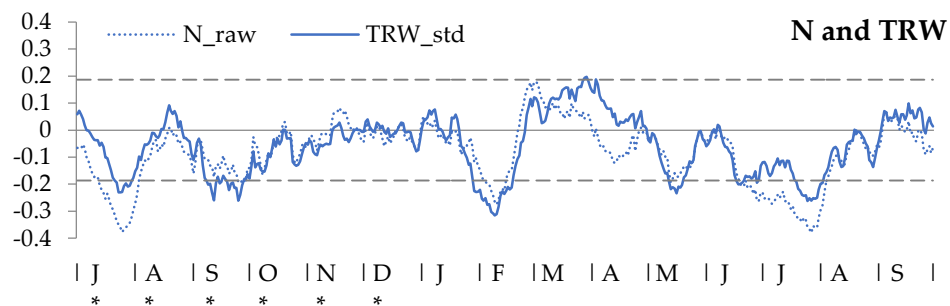
Figure S5. Correlations between local chronologies of tree-ring traits and moving average series of precipitation and temperature (window 21 day, step 1 day): standard chronology of tree-ring width, TRW_std; measured cell number, N_raw; measured and indexed maximal radial diameter and maximal cell wall thickness: Dmax_raw, Dmax_ind, CWTmax_raw, CWTmax_ind; measured, indexed and residual mean radial diameter and mean cell wall thickness, Dmean_raw, Dmean_ind, Dmean_res, CWTmean_raw, CWTmean_ind, CWTmean_res.
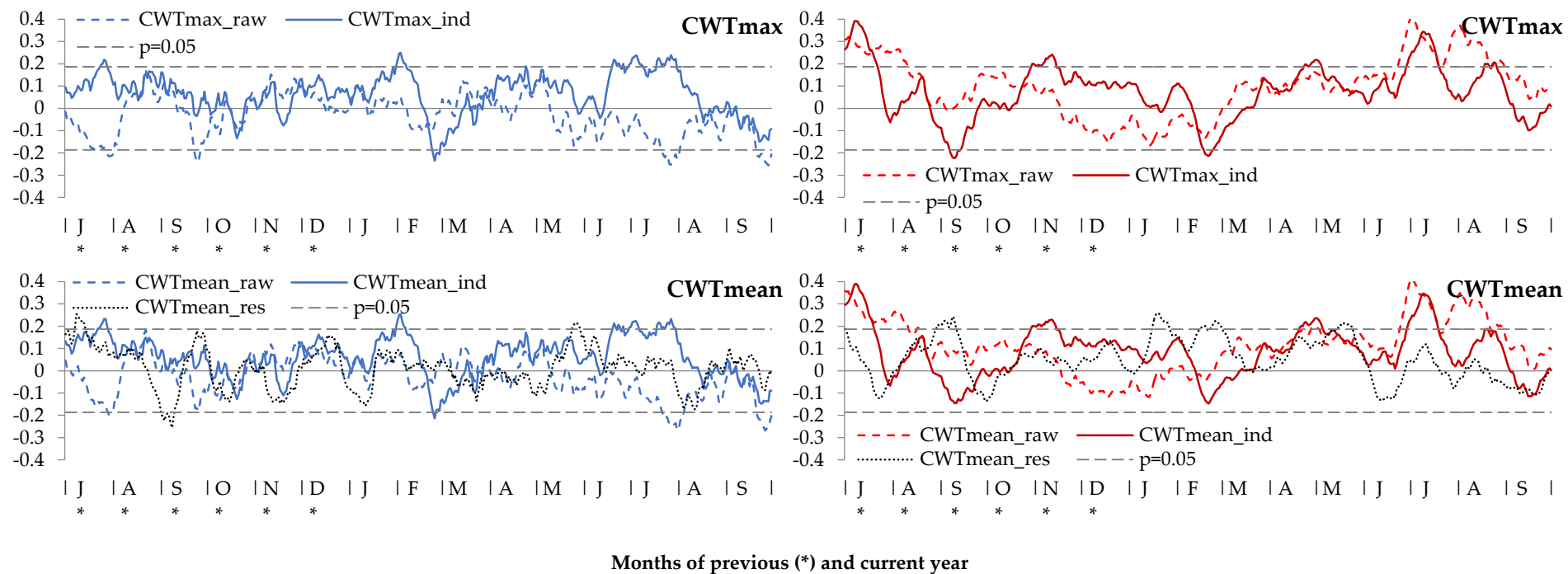
Figure S5. Continued.
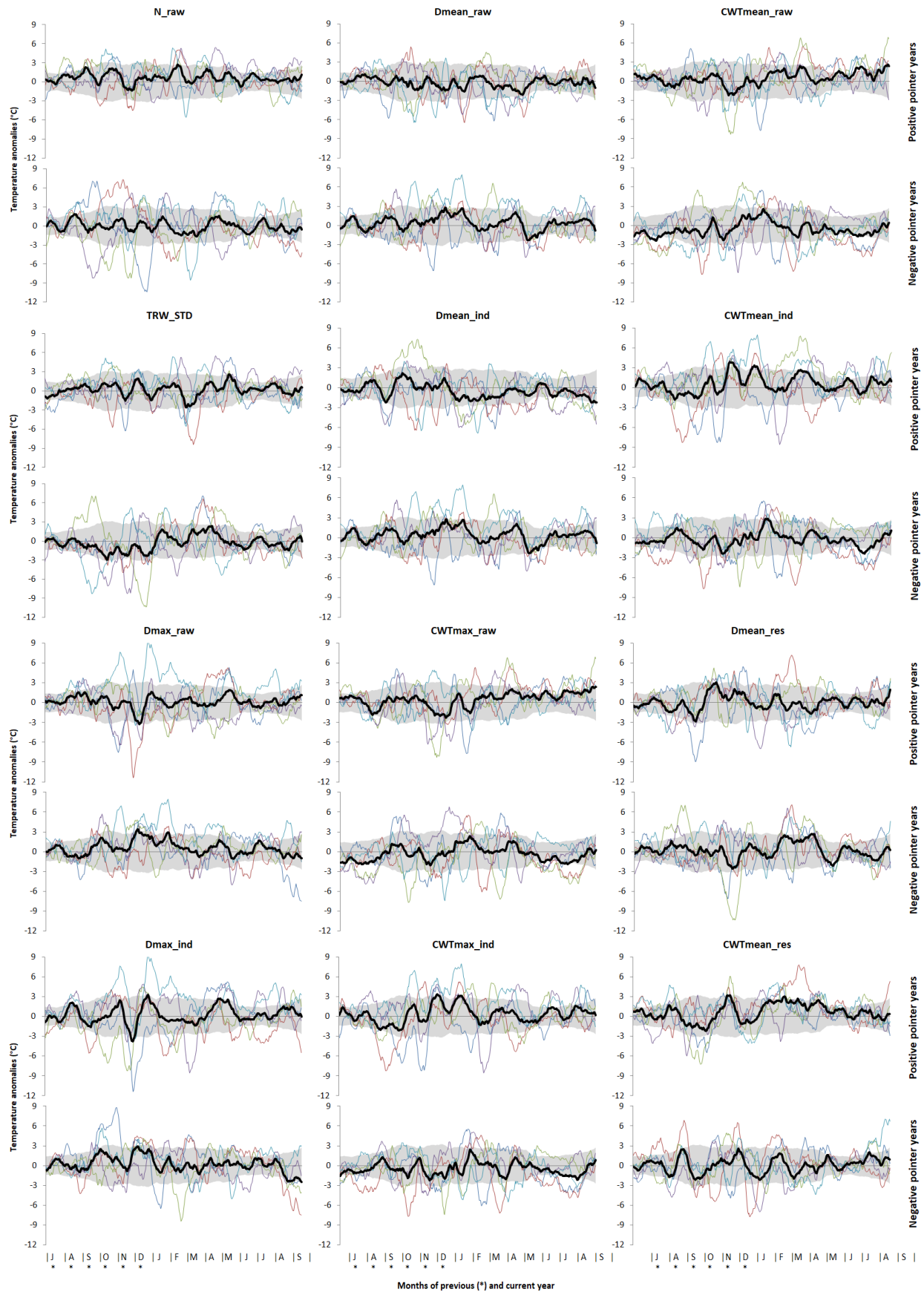
Figure S6. Temperature anomalies smoothed by 21-day moving average for positive and negative pointer years in chronologies of tree-ring parameters. Thin lines are individual years, bold lines represent their average, and shade represents standard deviation for each DOY.

Table S1. Correlation coefficients between tree-ring chronologies and temperature-related characteristics of vegetative season defined through threshold value T_{thr} in regional temperature series. Bold black correlation values are significant at $p < 0.05$.

| Threshold temperature, T_{thr} (°C *)	N raw	TRW std	Dmax raw	Dmean raw	CWTmax raw	CWTmean raw	Dmax ind	Dmean ind	CWTmax ind	CWTmean ind	Dmean res	CWTmean res
Duration of T > Tthr for current year, Dur												
7	-0.019	-0.042	0.024	-0.094	0.017	0.043	0.069	-0.071	0.048	0.076	-0.169	0.114
7.5	-0.096	-0.109	0.012	-0.123	-0.006	0.053	0.103	-0.059	0.100	0.146	-0.185	**0.196**
8	-0.092	-0.095	-0.011	-0.149	0.118	0.185	0.089	-0.086	**0.190**	**0.230**	-0.211	**0.201**
8.5	0.041	0.009	0.019	-0.133	0.181	**0.245**	0.036	-0.150	0.140	0.183	**-0.254**	**0.196**
9	0.064	0.048	0.035	-0.118	**0.249**	**0.303**	0.044	-0.144	0.173	**0.208**	**-0.252**	0.177
9.5	0.084	0.071	0.014	-0.103	**0.253**	**0.273**	0.006	-0.142	0.146	0.154	**-0.213**	0.069
10	0.055	0.099	0.085	-0.035	**0.213**	**0.221**	0.082	-0.060	0.116	0.118	-0.167	0.039
10.5	0.012	0.094	0.093	0.028	**0.187**	0.183	0.100	0.025	0.138	0.129	-0.059	0.006
11	0.025	0.051	0.111	0.052	**0.214**	**0.215**	0.101	0.038	0.143	0.135	-0.042	0.012
11.5	0.140	0.155	0.136	0.127	**0.263**	**0.236**	0.080	0.081	0.123	0.093	0.041	-0.072
Beginning date of T > Tthr for current year, Dbeg												
7	0.112	**0.192**	-0.120	0.084	-0.010	-0.048	**-0.197**	0.042	-0.077	-0.105	**0.250**	-0.124
7.5	0.123	0.179	-0.067	0.132	0.075	0.024	-0.159	0.078	-0.060	-0.102	**0.267**	-0.170
8	0.063	0.146	-0.061	0.133	-0.064	-0.106	-0.150	0.090	-0.137	-0.166	**0.276**	-0.145
8.5	-0.067	0.026	-0.043	0.157	-0.076	-0.141	-0.049	**0.197**	-0.053	-0.106	**0.335**	**-0.206**
9	-0.053	0.001	-0.017	0.125	-0.087	-0.142	-0.039	0.138	-0.079	-0.126	**0.239**	**-0.194**
9.5	-0.024	0.032	0.089	0.176	-0.128	-0.136	0.067	**0.194**	-0.131	-0.138	**0.220**	-0.063
10	0.001	-0.028	0.015	0.162	-0.174	-0.164	-0.041	0.154	**-0.220**	**-0.212**	**0.264**	-0.036
10.5	-0.017	-0.090	-0.094	-0.004	-0.159	-0.155	-0.124	-0.014	-0.186	-0.181	0.098	-0.035
11	0.006	-0.054	-0.079	-0.063	-0.156	**-0.187**	-0.091	-0.075	-0.181	**-0.200**	-0.022	-0.122
11.5	-0.076	-0.133	-0.157	-0.186	-0.186	**-0.201**	-0.150	**-0.198**	-0.133	-0.139	-0.146	-0.062
Ending date of T > Tthr for current year, Dend												
7	0.094	0.148	-0.096	-0.043	0.012	0.010	-0.114	-0.056	-0.015	-0.006	0.028	0.029
7.5	-0.011	0.032	-0.056	-0.041	0.074	0.108	-0.019	-0.003	0.086	0.109	0.014	0.110
8	-0.075	0.004	-0.079	-0.090	0.112	0.170	-0.018	-0.037	0.147	0.177	-0.037	0.154
8.5	-0.003	0.037	-0.012	-0.047	**0.193**	**0.226**	0.007	-0.035	0.155	0.168	-0.058	0.093
9	0.042	0.066	0.034	-0.057	**0.268**	**0.295**	0.027	-0.081	0.170	0.178	-0.145	0.079
9.5	0.090	0.121	0.097	0.018	**0.221**	**0.240**	0.066	-0.017	0.078	0.082	-0.089	0.036
10	0.082	0.118	0.140	0.110	0.141	0.162	0.080	0.064	-0.047	-0.038	0.017	0.022
10.5	0.000	0.051	0.044	0.040	0.121	0.118	0.023	0.024	0.015	0.006	0.014	-0.028
11	0.044	0.020	0.083	0.012	0.156	0.127	0.056	-0.022	0.025	-0.007	-0.086	-0.109
11.5	0.128	0.096	0.047	0.006	**0.200**	0.147	-0.027	-0.072	0.049	0.001	-0.079	-0.161
Sum of T > Tthr for current year, GDD												
7	0.152	**0.247**	-0.007	-0.016	**0.274**	**0.284**	-0.032	-0.048	**0.199**	**0.209**	-0.040	0.094
7.5	0.106	0.186	0.006	-0.017	**0.316**	**0.338**	0.003	-0.028	**0.246**	**0.258**	-0.045	0.116
8	0.066	0.166	0.005	-0.040	**0.335**	**0.369**	0.022	-0.038	**0.278**	**0.294**	-0.077	0.137
8.5	0.101	0.174	0.028	-0.031	**0.364**	**0.380**	0.020	-0.054	**0.268**	**0.272**	-0.097	0.092
9	0.115	0.186	0.043	-0.037	**0.409**	**0.424**	0.029	-0.071	**0.292**	**0.293**	-0.131	0.091
9.5	0.136	**0.219**	0.073	0.003	**0.375**	**0.389**	0.047	-0.036	**0.242**	**0.243**	-0.098	0.073
10	0.137	**0.220**	0.098	0.062	**0.317**	**0.332**	0.051	0.015	0.155	0.159	-0.027	0.062
10.5	0.083	0.184	0.032	0.033	**0.314**	**0.315**	0.008	0.008	**0.204**	**0.198**	0.004	0.039
11	0.115	0.143	0.030	0.004	**0.359**	**0.341**	0.000	-0.035	**0.223**	**0.199**	-0.052	-0.021
11.5	0.161	**0.192**	0.028	0.046	**0.369**	**0.331**	-0.028	-0.007	**0.227**	**0.189**	0.016	-0.070
Duration of T > Tthr for previous year, Dur*												
7	0.098	0.073	-0.031	-0.025	0.019	-0.038	-0.079	-0.069	-0.059	-0.088	-0.025	-0.123
7.5	0.080	0.092	-0.022	-0.091	-0.048	-0.054	-0.043	-0.122	-0.066	-0.062	-0.137	-0.004
8	0.117	0.146	0.047	-0.048	0.153	0.120	0.049	-0.061	0.085	0.058	-0.136	-0.075
8.5	**0.187**	**0.214**	0.021	-0.060	**0.265**	**0.259**	-0.033	-0.131	0.107	0.097	-0.160	-0.008
9	**0.206**	**0.212**	0.002	-0.074	**0.206**	0.180	-0.049	-0.145	0.065	0.046	-0.166	-0.052
9.5	**0.197**	**0.223**	0.140	0.009	**0.216**	**0.205**	0.095	-0.051	0.058	0.047	-0.165	-0.023
10	**0.190**	**0.269**	0.131	0.044	0.175	0.153	0.058	-0.030	0.024	0.011	-0.099	-0.039
10.5	0.095	**0.229**	0.136	0.078	0.155	0.139	0.070	0.020	0.053	0.042	-0.038	-0.026
11	**0.203**	**0.237**	0.136	0.063	**0.256**	**0.261**	0.044	-0.027	0.101	0.106	-0.081	0.045
11.5	**0.225**	**0.221**	0.184	0.085	**0.207**	**0.200**	0.090	-0.006	0.053	0.057	-0.095	0.028
Ending date of T > Tthr for previous year, Dend*												
7	-0.035	-0.064	-0.072	-0.032	0.062	0.034	-0.041	-0.001	0.082	0.063	0.038	-0.047
7.5	0.039	0.051	-0.030	-0.051	0.008	0.040	-0.001	-0.027	0.033	0.060	-0.038	0.106
8	0.034	0.050	-0.026	-0.090	0.156	0.153	0.036	-0.048	0.173	0.161	-0.105	0.007
8.5	0.127	0.162	0.014	-0.040	**0.238**	**0.252**	-0.021	-0.088	0.137	0.139	-0.108	0.044
9	**0.213**	**0.229**	0.033	-0.051	**0.211**	**0.204**	-0.030	-0.135	0.070	0.062	-0.168	-0.009
9.5	**0.223**	**0.262**	0.164	0.066	**0.220**	**0.226**	0.096	-0.010	0.033	0.030	-0.107	-0.002
10	**0.232**	**0.264**	0.131	0.068	**0.205**	**0.194**	0.021	-0.043	-0.043	-0.055	-0.082	-0.054
10.5	0.136	**0.203**	0.159	0.099	0.124	0.111	0.091	0.037	-0.034	-0.046	-0.033	-0.054
11	**0.282**	**0.269**	**0.214**	0.156	0.090	0.114	0.077	0.036	-0.136	-0.108	-0.020	0.062
11.5	**0.256**	**0.229**	**0.239**	0.167	0.024	0.062	0.144	0.082	-0.129	-0.080	-0.017	0.137
Sum of T > Tthr for previous year, GDD*												
7	0.045	0.076	-0.004	-0.049	**0.234**	**0.192**	0.010	-0.052	**0.212**	0.183	-0.086	-0.045
7.5	0.098	0.145	0.025	-0.050	**0.214**	**0.210**	0.035	-0.060	0.182	0.181	-0.120	0.049
8	0.098	0.138	0.012	-0.093	**0.292**	**0.272**	0.039	-0.095	**0.255**	**0.236**	-0.176	0.003
8.5	0.138	0.180	0.031	-0.069	**0.318**	**0.307**	0.010	-0.113	**0.226**	**0.214**	-0.175	0.020
9	0.173	**0.206**	0.020	-0.090	**0.317**	**0.291**	-0.009	-0.150	**0.216**	**0.195**	**-0.210**	-0.014
9.5	0.166	**0.218**	0.101	-0.027	**0.336**	**0.317**	0.077	-0.076	**0.220**	**0.198**	-0.184	-0.016
10	0.167	**0.210**	0.064	-0.035	**0.331**	**0.293**	0.013	-0.107	0.179	0.146	-0.168	-0.069
10.5	0.092	0.157	0.065	-0.030	**0.273**	**0.240**	0.042	-0.071	**0.188**	0.159	-0.144	-0.049
11	**0.187**	0.170	0.091	0.007	**0.259**	**0.229**	0.012	-0.078	0.115	0.097	-0.125	-0.031
11.5	0.171	0.146	0.100	0.016	0.173	0.157	0.047	-0.045	0.087	0.089	-0.111	0.032

* Threshold temperature values are presented according to regional series averaged for geographic grid; temperatures at the sampling site are assumed to have the same pattern of inter- and intra-annual variation, but they are lower than values presented in table.