

## Supplementary Materials

### Mathematical Description of the deviation tracheidogram approach

#### Input data:

1.  $T = \{t_1, \dots, t_7\}$  — Set of trees.
2.  $Y(t) = \{y_{t1}, \dots, y_{tn_t}\}$  — Set of years for which the measurements for the tree  $t$  are available,  $t \in T$
3.  $Y = \bigcup_{t \in T} Y(t)$  — Set of all years for which the measurements are available.
4.  $T(y) = \{t_{y1}, \dots, t_{ym_y}\}$  — Set of trees for which the measurements for the year  $y$  are available,  $y \in Y$

$$\left( T \equiv \bigcup_{y \in Y} T(y) \right)$$

5.  $e^{raw} = e^{raw}(t, y) = \{e_1^{raw}, \dots, e_\varepsilon^{raw}\}$  — Raw tracheid data where:

$$e_k^{raw} = e_k^{raw}(t, y) \in \{d_k^{raw}, c_k^{raw}\}$$

$$d_k^{raw} = d_k^{raw}(t, y) \text{ — Diameter of the } k^{th} \text{ cell in a raw tracheid}$$

$$c_k^{raw} = c_k^{raw}(t, y) \text{ — Cell wall thickness of the } k^{th} \text{ cell in a raw tracheid}$$

$$k = \overline{1, \varepsilon}, t \in T, y \in Y(t)$$

6.  $N$  — Number of cells for tracheid normalization.

#### Normalization procedure description:

For each  $e^{raw}$  an intermediate sequence is constructed:

$$e^* = \{\underbrace{e_1^{raw}, \dots, e_1^{raw}}_N, \underbrace{e_2^{raw}, \dots, e_2^{raw}}_N, \dots, \underbrace{e_\varepsilon^{raw}, \dots, e_\varepsilon^{raw}}_N\}$$

And tracheid data  $e = \{e_1, \dots, e_N\}$  normalized to  $N$  cells are obtained:

$$e_i = \frac{1}{\varepsilon} \sum_{j=\varepsilon \cdot (i-1)+1}^{\varepsilon \cdot i} e_j^*, i = \overline{1, N}$$

Using this procedure the following was obtained:

$d = \{d_1, \dots, d_N\}$  — data on the tracheid cell diameters normalized to  $N$  cells

$c = \{c_1, \dots, c_N\}$  — data on the tracheid cell wall thicknesses normalized to  $N$  cells

#### Normalized tracheid description:

$R(t, y) = d \cup c = \{d_1, \dots, d_N, c_1, \dots, c_N\}$  — Tracheid normalized to  $N$  cells. Where:

$d_i = d_i(t, y)$  — Diameter of the  $i^{th}$  cell in a normalized tracheid

$c_i = c_i(t, y)$  — Cell wall thickness of the  $i^{th}$  cell in a normalized tracheid

$i = \overline{1, N}, t \in T, y \in Y(t)$

**Description of the methods for forming objects for clustering:**

*Method A:*

$$R^A(y) = \frac{1}{|T(y)|} \sum_{t \in T(y)} R(t, y), y \in Y$$

$$R_{mean}^A = \frac{1}{\sum_{t \in T} |Y(t)|} \sum_{t \in T} \sum_{y \in Y(t)} R(t, y)$$

$$O_A(y) = \frac{R^A(y)}{R_{mean}^A}, y \in Y$$

$O_A(y)$  — object for the year  $y$  obtained by *Method A*

*Method B:*

$$R^B(t) = \frac{1}{|Y(t)|} \sum_{y \in Y(t)} R(t, y), t \in T$$

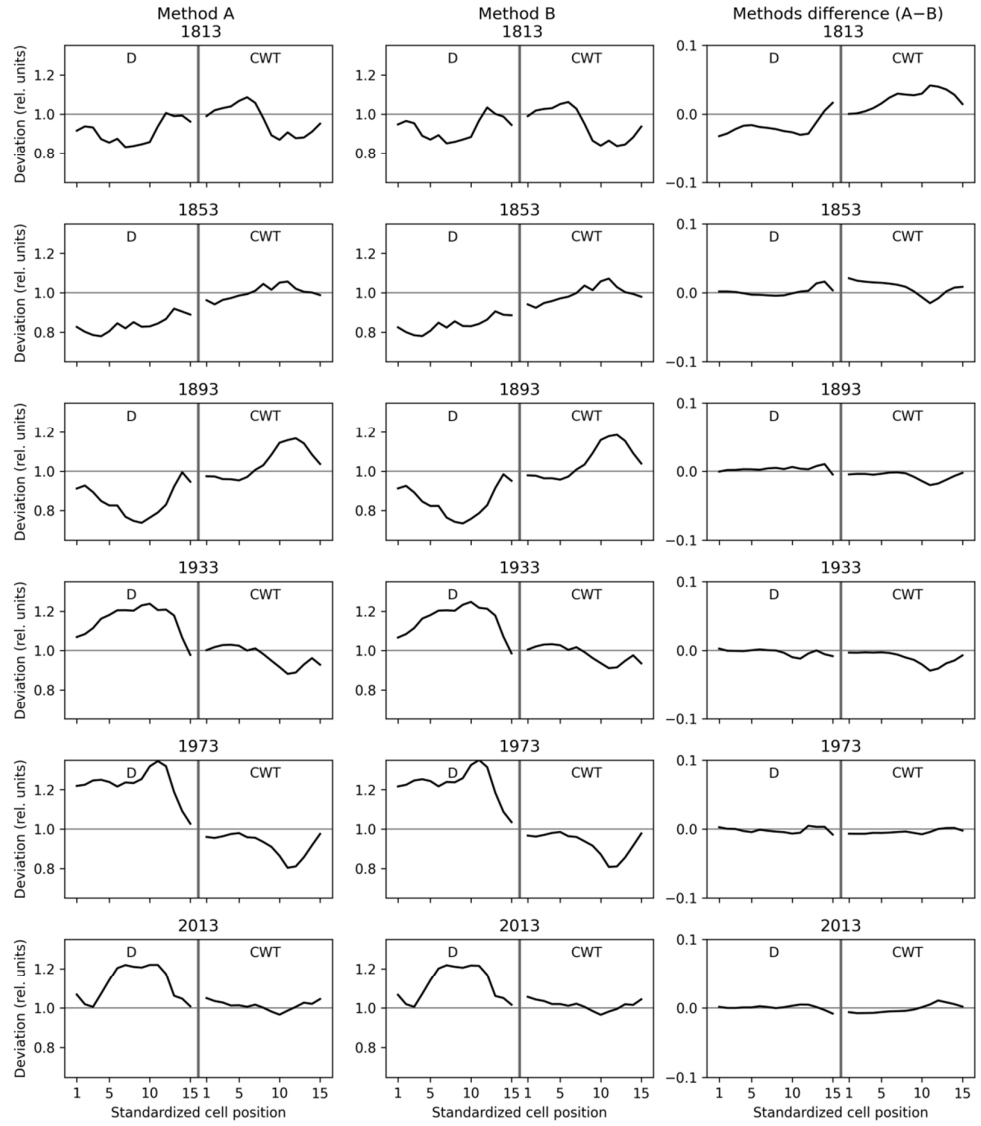
$$o_B(t, y) = \frac{R(t, y)}{R^B(t)}, t \in T, y \in Y(t)$$

$$O_B(y) = \frac{1}{|T(y)|} \sum_{t \in T(y)} o_B(t, y), y \in Y$$

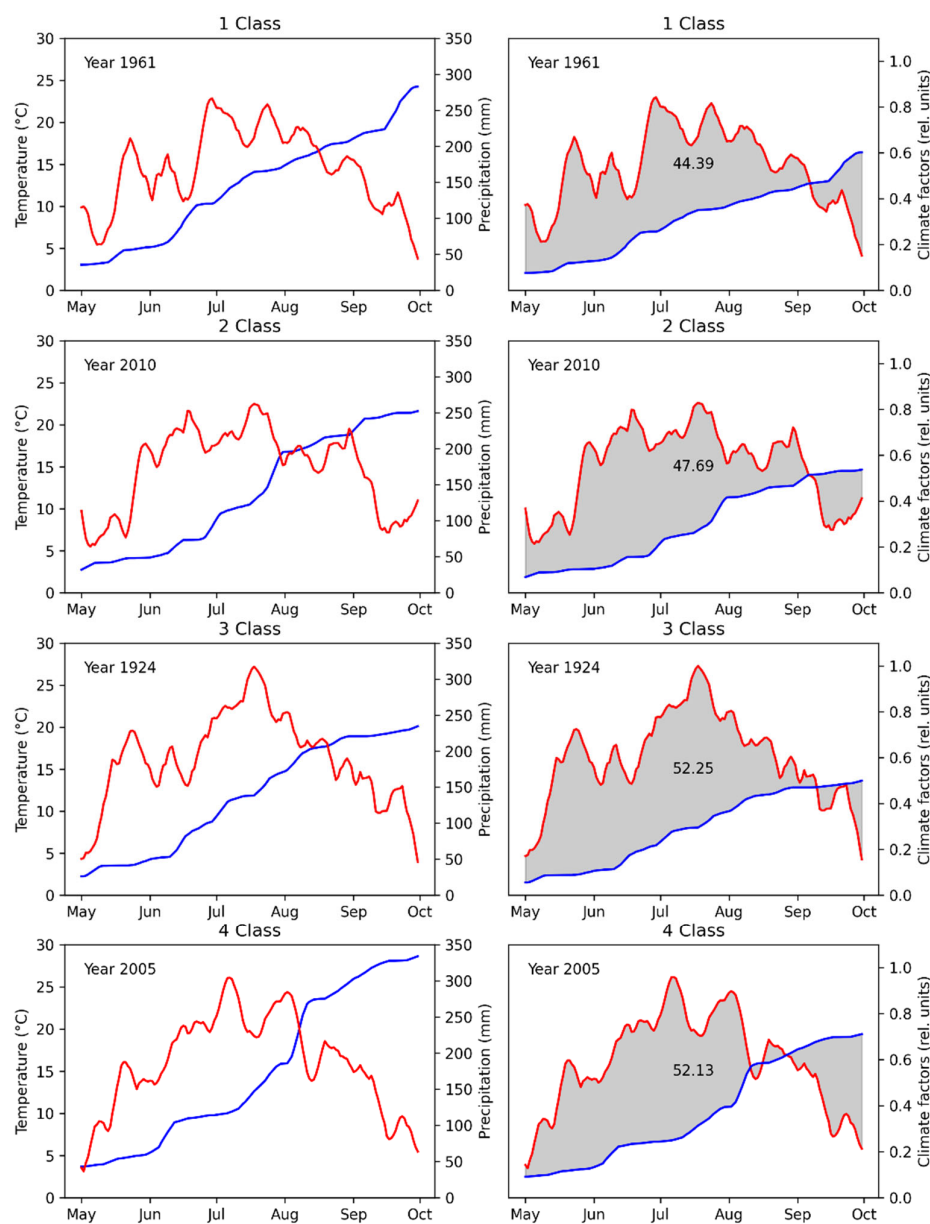
$O_B(y)$  — object for the year  $y$  obtained by *Method B*

**Table S1.** Bootstrapped correlations between standard tree-ring chronology (std), residual chronology (res), scPDSI (Mean\_PDSI) and SPEI (Mean\_SPEI) averaged from May to September, squared area obtained as a difference between scaled temperature and precipitation (Area), classes of tracheidograms (Class).

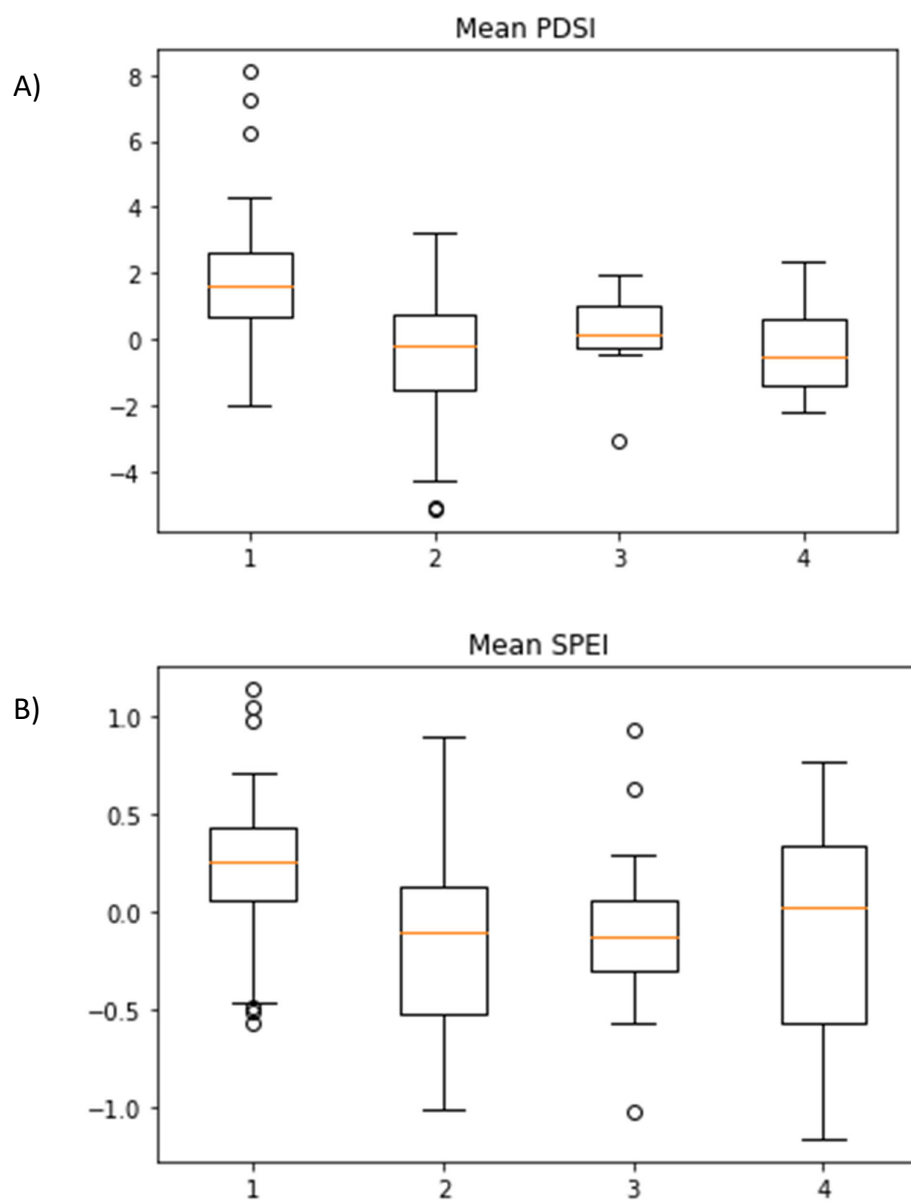
	<b>std</b>	<b>Res</b>	<b>Mean PDSI</b>	<b>Mean SPEI</b>	<b>AREA</b>	<b>CLASS</b>
<b>std</b>		0.91 (p=0.000)	0.39 (p=0.000)	0.24 (p=0.010)	-0.29 (p=0.003)	-0.51 (p=0.000)
<b>res</b>	0.91 (p=0.000)		0.37 (p=0.000)	0.22 (p=0.015)	-0.34 (p=0.000)	-0.53 (p=0.000)
<b>Mean PDSI</b>	0.39 (p=0.000)	0.37 (p=0.000)		0.69 (p=0.000)	-0.44 (p=0.000)	-0.41 (p=0.000)
<b>Mean SPEI</b>	0.24 (p=0.010)	0.22 (p=0.015)	0.69 (p=0.000)		-0.39 (p=0.000)	-0.29 (p=0.001)
<b>AREA</b>	-0.29 (p=0.003)	-0.34 (p=0.000)	-0.44 (p=0.000)	-0.39 (p=0.000)		0.39 (p=0.000)
<b>CLASS</b>	-0.51 (p=0.000)	-0.53 (p=0.000)	-0.41 (p=0.000)	-0.29 (p=0.001)	0.39 (p=0.000)	



**Figure S1.** Deviation tracheidograms obtained by Method A (left panel) and Method B (central panel) and their differences (right panel) over 1813-2018.



**Figure S2.** Temperature (red curve) and cumulative precipitation (blue curve) 7 day moving average over the growing season (from May, 1st to September, 30th) in absolute values (Left Panel) and the climate factors scaled by the MinMax approaches in relative units (Right Panel) for the years with the median Area in the corresponding Class. The dashed grey area is the area of differences between the rescaled temperature and precipitation over the growing season. The number above the dashed area is the value of Area statistics for the corresponding year.



**Figure S3** Box and Whiskers plots for scPDSI (A) and SPEI (B) corresponded to four classes of tracheidogram: orange line – median; box – 25% and 75% quartiles; whiskers non-outlier minimum and maximum.