Shifting Precipitation Patterns Drive Growth Variability and Drought Resilience of European Atlas Cedar Plantations

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Table S1. Spearman correlation coefficients calculated at the individual level (n = 130 trees) in Atlas cedar plantations. Variables' abbreviations: Dbh, diameter at breast height (1.3 m); Age, tree age estimated at 1.3 m; TRW, mean tree-rig width; AC1, first-order autocorrelation of ring-width data; MSx, mean sensitivity of ring-width indices; Corr, mean correlation of individual indexed series with the site mean series; NPY, frequency (%) of negative pointer years; Rc, recovery index; Rt, resistance index; Rs, resilience index. Bold values are significant correlation coefficients ($p < 0.001$).

	Dbh	Age	TRW	AC1	MSx	Corr	NPY	Rc	Rt
Dbh									
Age	**0.598**								
TRW	**0.399**	**−0.374**							
AC1	−0.167	−0.088	−0.198						
MSx	0.091	**0.549**	**−0.476**	**−0.362**					
Corr	0.119	0.164	0.052	**−0.279**	**0.393**				
NPY	0.008	**0.265**	−0.140	−0.243	**0.478**	0.188			
Rc	0.185	**0.493**	**−0.266**	**−0.335**	**0.901**	**0.418**	**0.764**		
Rt	0.177	**0.467**	−0.211	**−0.300**	**0.575**	0.170	**0.603**	**0.619**	
Rs	**0.338**	**0.537**	−0.150	−0.176	**0.430**	0.071	**0.732**	**0.645**	**0.750**

Table S2. Linear mixed-effect models selection table. For each response variable (Rt, resistance; Rc, recovery; Rs, resilience), the list of proposed models including the intercept and the three fixed effects (Age at 1.3 m; mean sensitivity, MSx; mean sensitivity; TRW, mean tree-ring width) are shown. The coefficient associated to each variable, the number of degrees of freedom of the model

(df), the Second-order Akaike Information Criterion (AICc), the change in AICc (ΔAICc) and the probability that the selected model is the best models among the ranked models (AICc weight) are shown. The selected models based on AICc and parsimony (i.e., the model with the lowest number of degrees of freedom among those models with a ΔAICc < 2) are highlighted in bold.

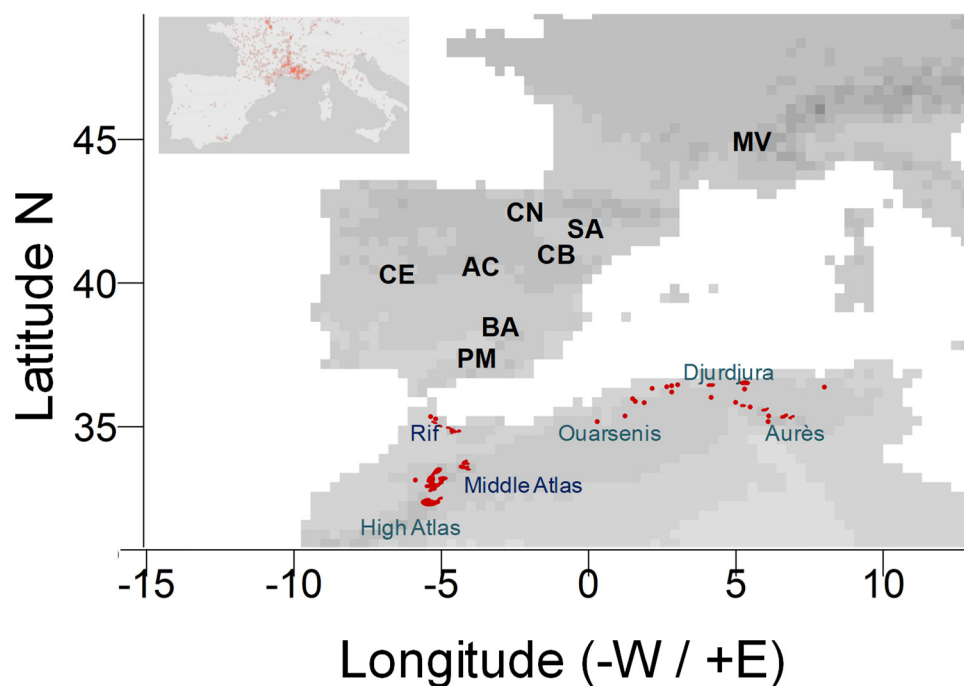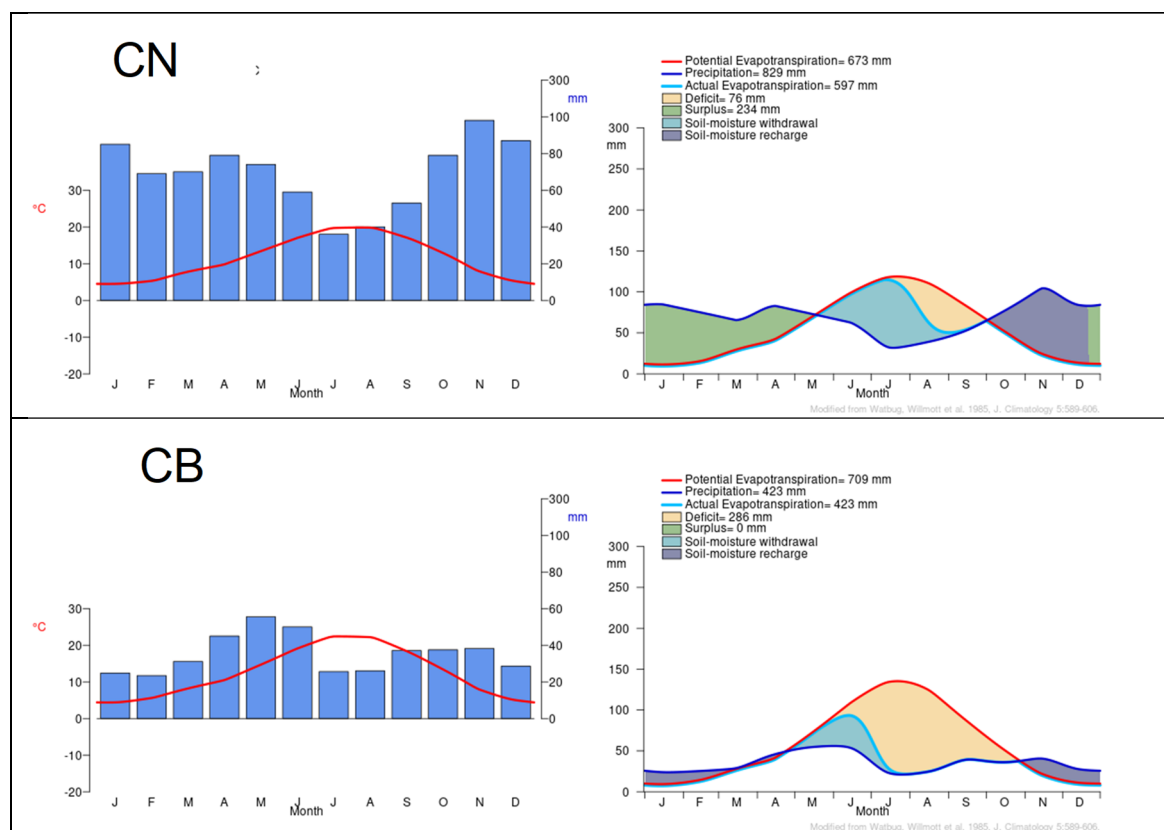| Resilience Index or Component	(Intercept)	Age	MSx	TRW	df	AICc	ΔAICc	AICc weight
Rt	**0.983**	**0.000**	**0.103**		**5**	**−639.033**	**0.000**	**0.675**
	0.989	0.000	0.098	−0.001	6	−637.015	2.019	0.246
	0.994		0.142		4	−633.824	5.209	0.050
	1.008		0.126	−0.003	5	−632.636	6.397	0.028
	1.026	0.001		−0.005	5	−625.939	13.094	0.001
	1.005	0.001			4	−624.786	14.247	0.001
	1.068			−0.009	4	−618.356	20.677	0.000
	1.043				3	−611.745	27.288	0.000
Rc	0.259	0.000	0.179	0.003	6	−903.861	0.000	0.584
	0.263		**0.186**	**0.003**	**5**	**−902.978**	**0.884**	**0.375**
	0.275		0.176		4	−897.883	5.979	0.029
	0.274	0.000	0.175		5	−896.026	7.835	0.012
	0.332	0.000		−0.005	5	−764.280	139.581	0.000
	0.354			−0.006	4	−761.541	142.320	0.000
	0.312	0.000			4	−759.209	144.652	0.000
	0.336				3	−752.349	151.512	0.000
Rs	**0.990**	**0.002**			**4**	**−498.364**	**0.000**	**0.393**
	0.980	0.001	0.053		5	−497.501	0.863	0.255
	0.976	0.002		0.004	5	−496.963	1.401	0.195
	0.957	0.002	0.061	0.005	6	−496.520	1.844	0.156
	1.019		0.156		4	−484.464	13.900	0.000
	1.024		0.151	−0.001	5	−482.338	16.026	0.000
	1.095			−0.008	4	−478.033	20.331	0.000
	1.073				3	−477.845	20.519	0.000

(**a**)

(**b**)

Figure S1. Views of (**a**) two Atlas cedar plantations, and (**b**) location of the study sites in south-eastern France and Spain. The red dots and patches show the natural distribution of Atlas cedar in northern Morocco and Algeria. The small map in plot (**b**) shows localities where Atlas cedar occurrences were reported in the Global Biodiversity Information Facility web page (https://www.gbif.org/).
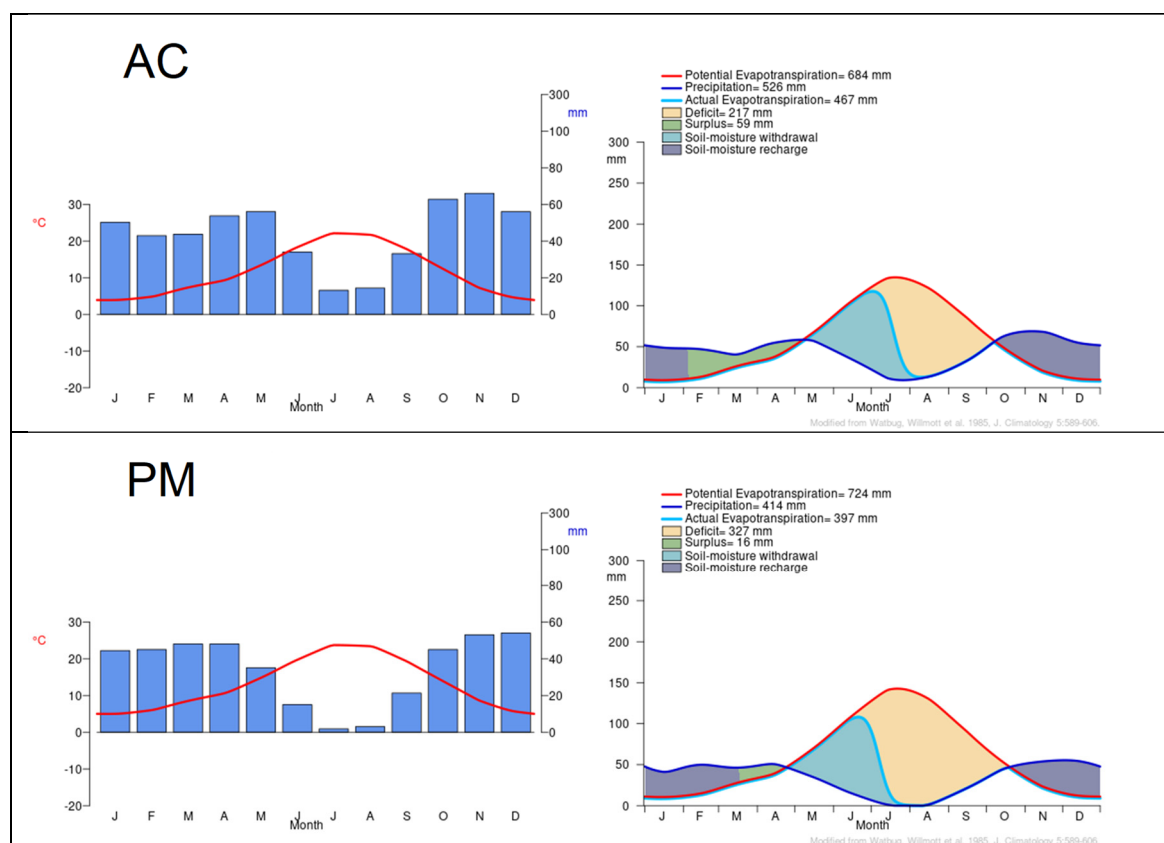
Figure S2. Climate diagrams and water balance plots from selected study sites (see sites' abbreviations in Table 1).
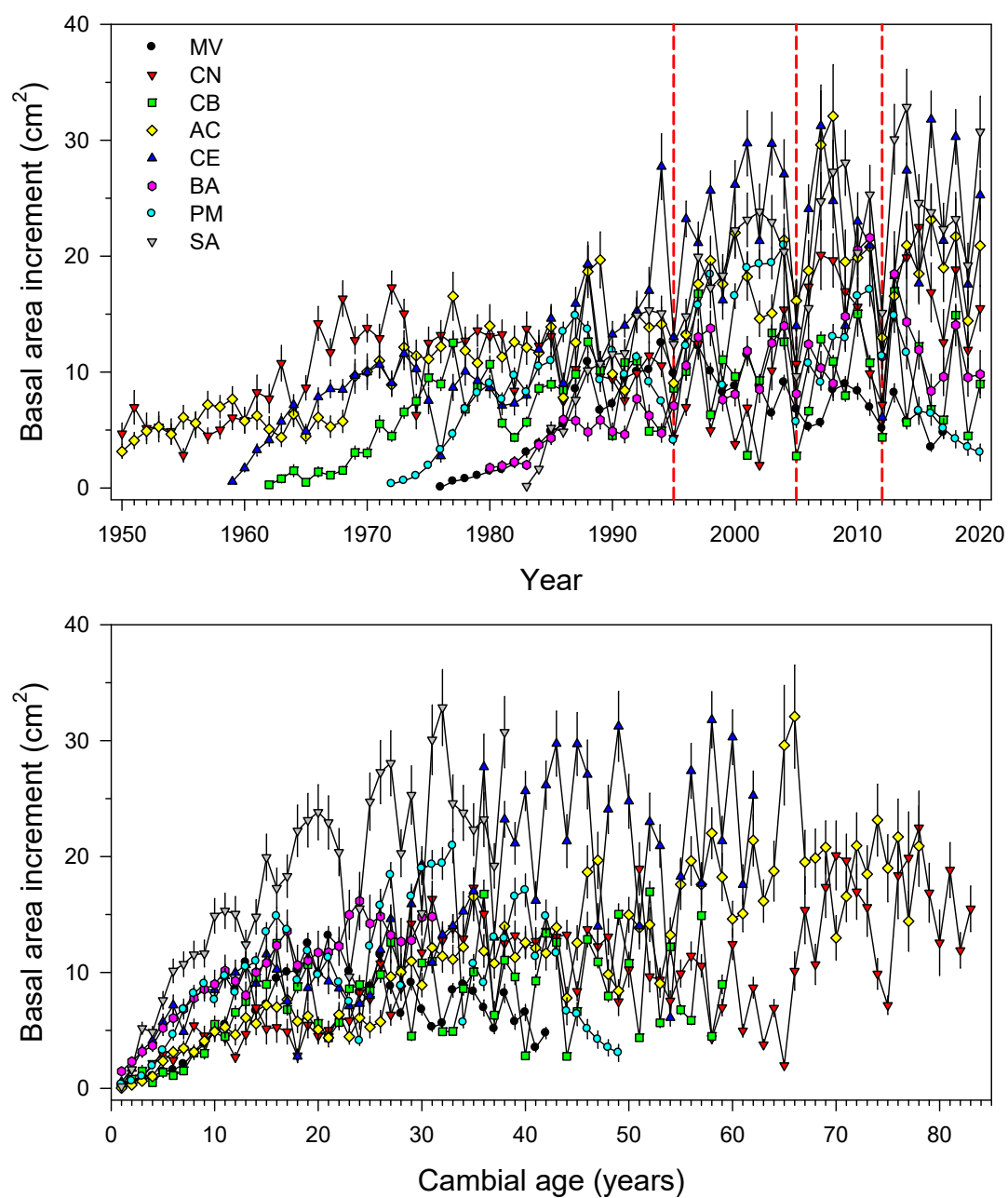
Figure S3. Series of basal area increment for the eight study Atlas cedar plantations plotted as a function of year or cambial age (in years). Values are means ± SE. In the uppermost plot the dashed vertical lines indicate the 1995, 2005 and 2012 droughts.
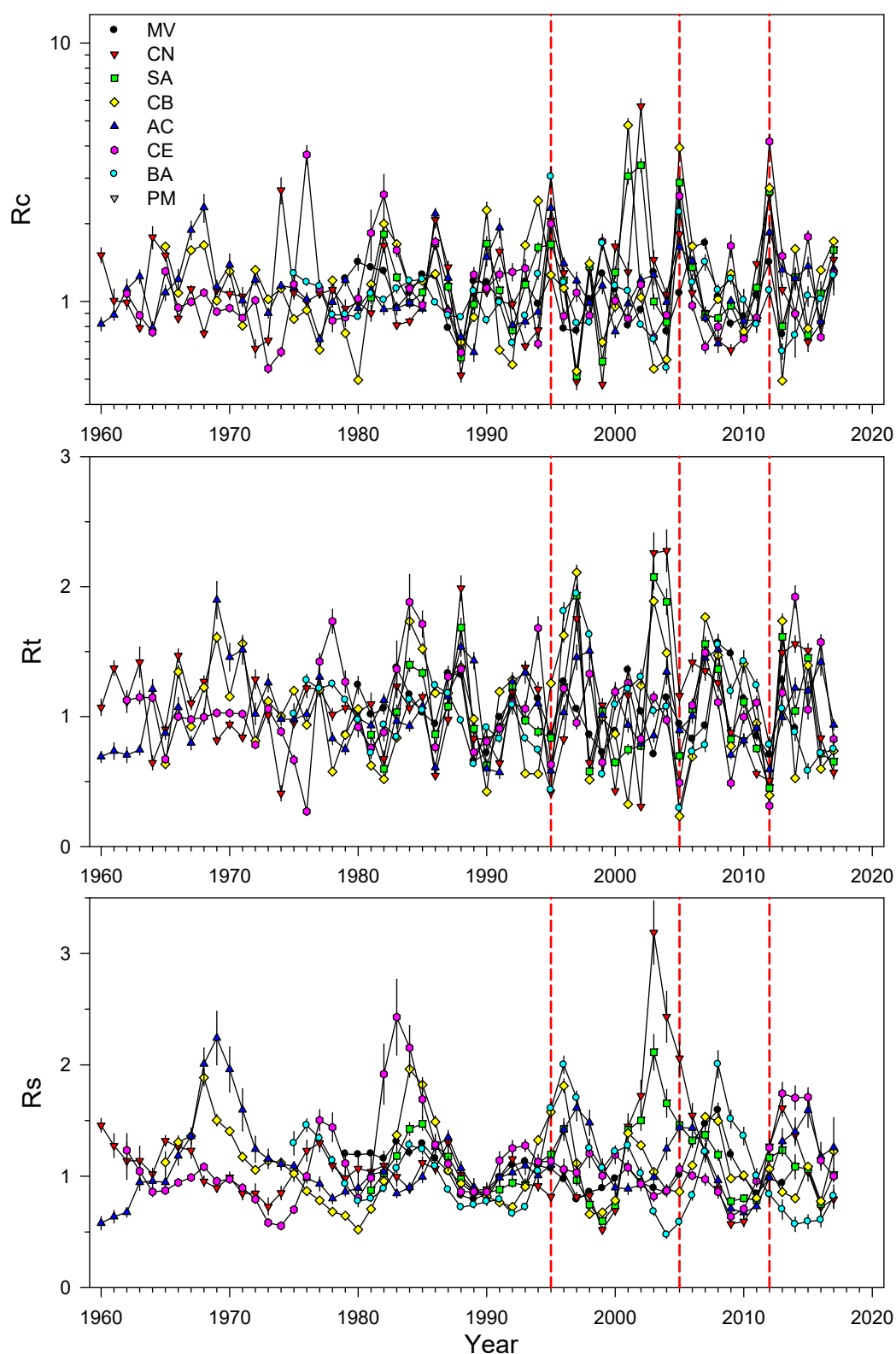
Figure S4. Resilience indices (Rc, recovery; Rt, resistance; Rs, resilience) calculated for the study Atlas cedar plantations. Values are means ± SE. See sites' codes in Table 1. The dashed vertical lines indicate the 1995, 2005 and 2012 droughts.
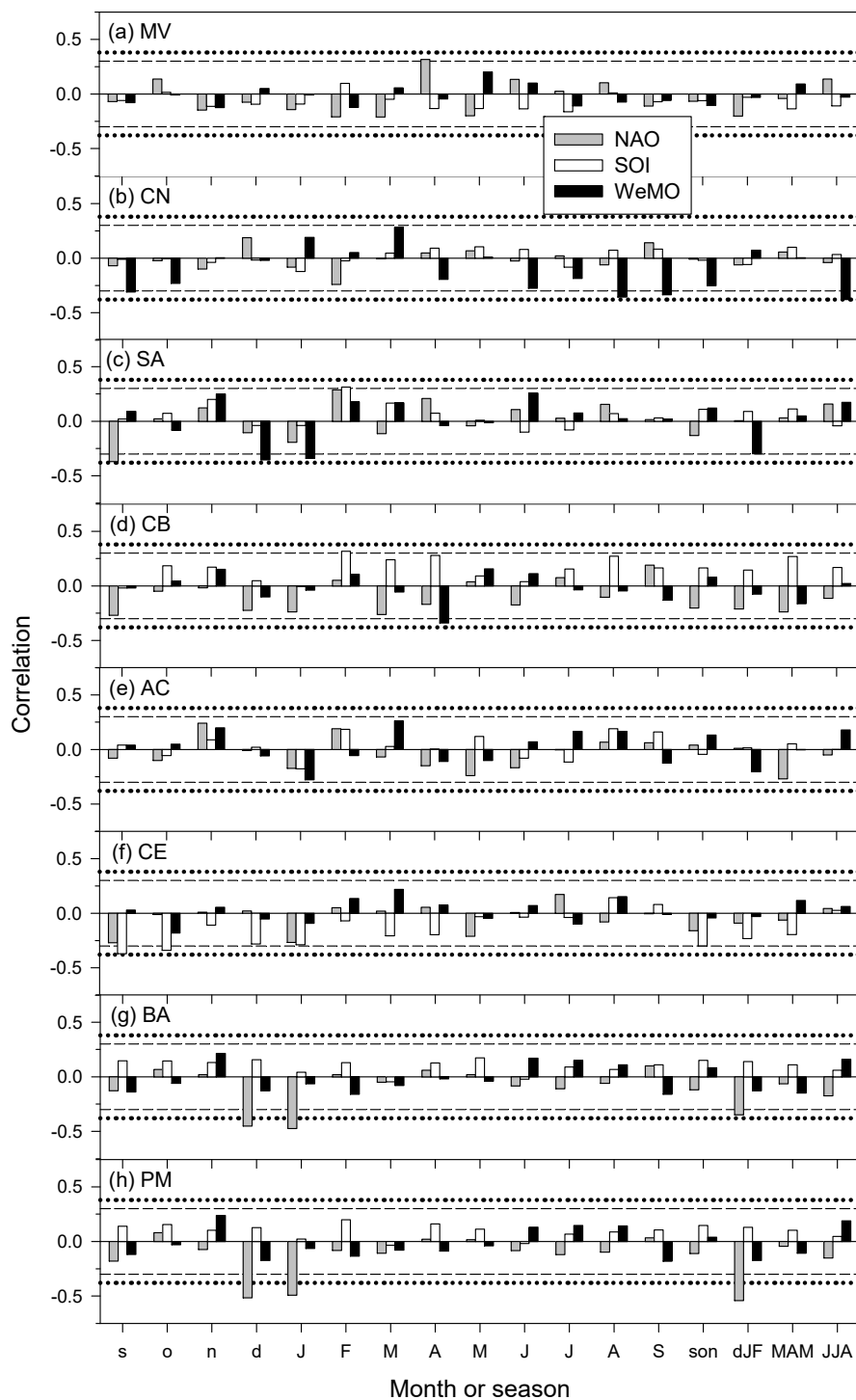
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Figure S5. Climate indices-growth relationships assessed in eight Atlas cedar plantations (see sites' codes in Table 1). Bars show the Pearson correlations calculated by relating monthly or seasonal data of climate indices representing different atmospheric circulation patterns (NAO, SOI and WeMO) and sites' mean series of ring-width indices. Correlations were calculated from prior to current September and month abbreviated by lowercase and uppercase letters correspond to the previous and current years, respectively. Horizontal dashed and dotted lines indicate the 0.05 and 0.01 significance levels, respectively.
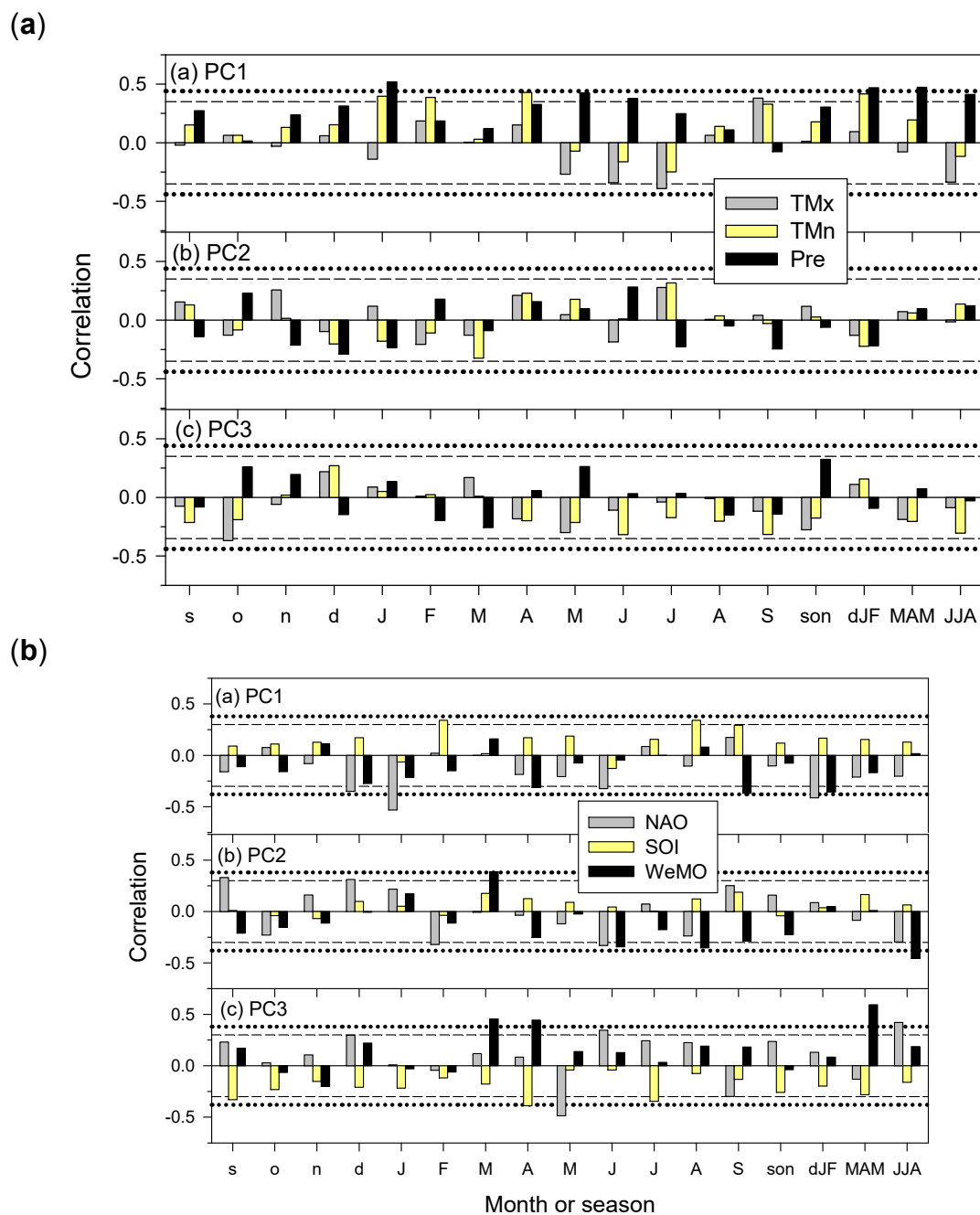
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(a)

(b)

Figure S6. (**a**) Climate- and (**b**) climate indices-growth relationships assessed in the first principal components (**a**, PC1; **b**, PC2; and **c**, PC3) calculated on the matrix of ring-width series from eight Atlas cedar plantations (see sites' codes in Table 1). Bars show the Pearson correlations calculated by relating monthly or seasonal data of climate data (mean maximum – TMx– and minimum –TMn– temperatures, total precipitation –Pre) or indices (NAO, SOI and WeMO) and sites' mean series of ring-width indices. Climate data were obtained for the region delimited by coordinates 5.75 W–1.00° E and 37.00–44.25° N. Correlations were calculated from prior to current September and month abbreviated by lowercase and upper-case letters correspond to the previous and current years, respectively. Horizontal dashed and dotted lines indicate the 0.05 and 0.01 significance levels, respectively.