



Supplement of

Advancing Last Glacial Maximum paleoclimate reconstructions in Europe using pollen data: a multi-method (mega)biomization approach

Gabriel Fénisse et al.

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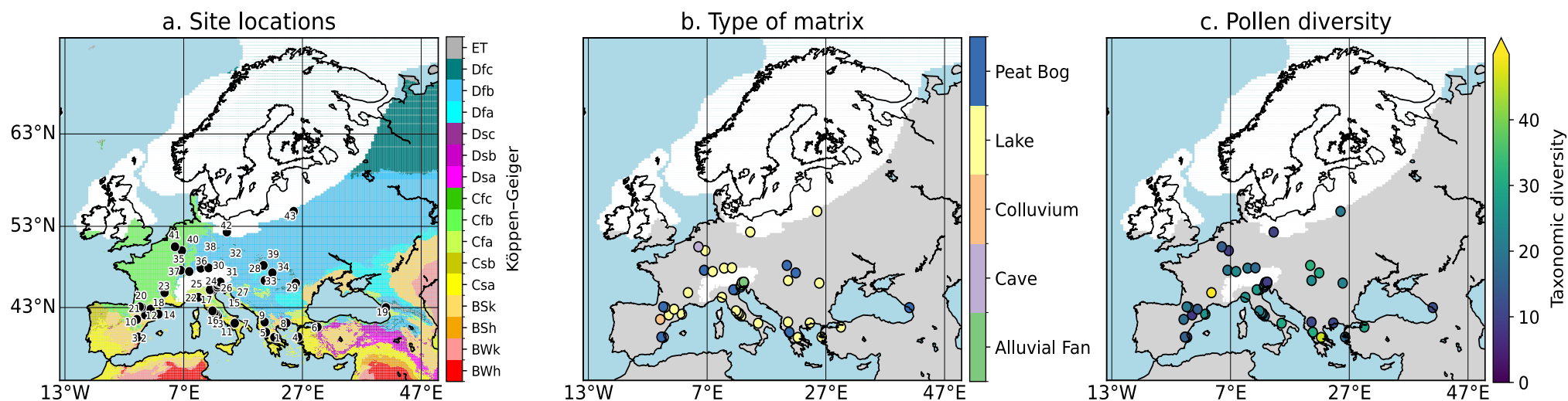
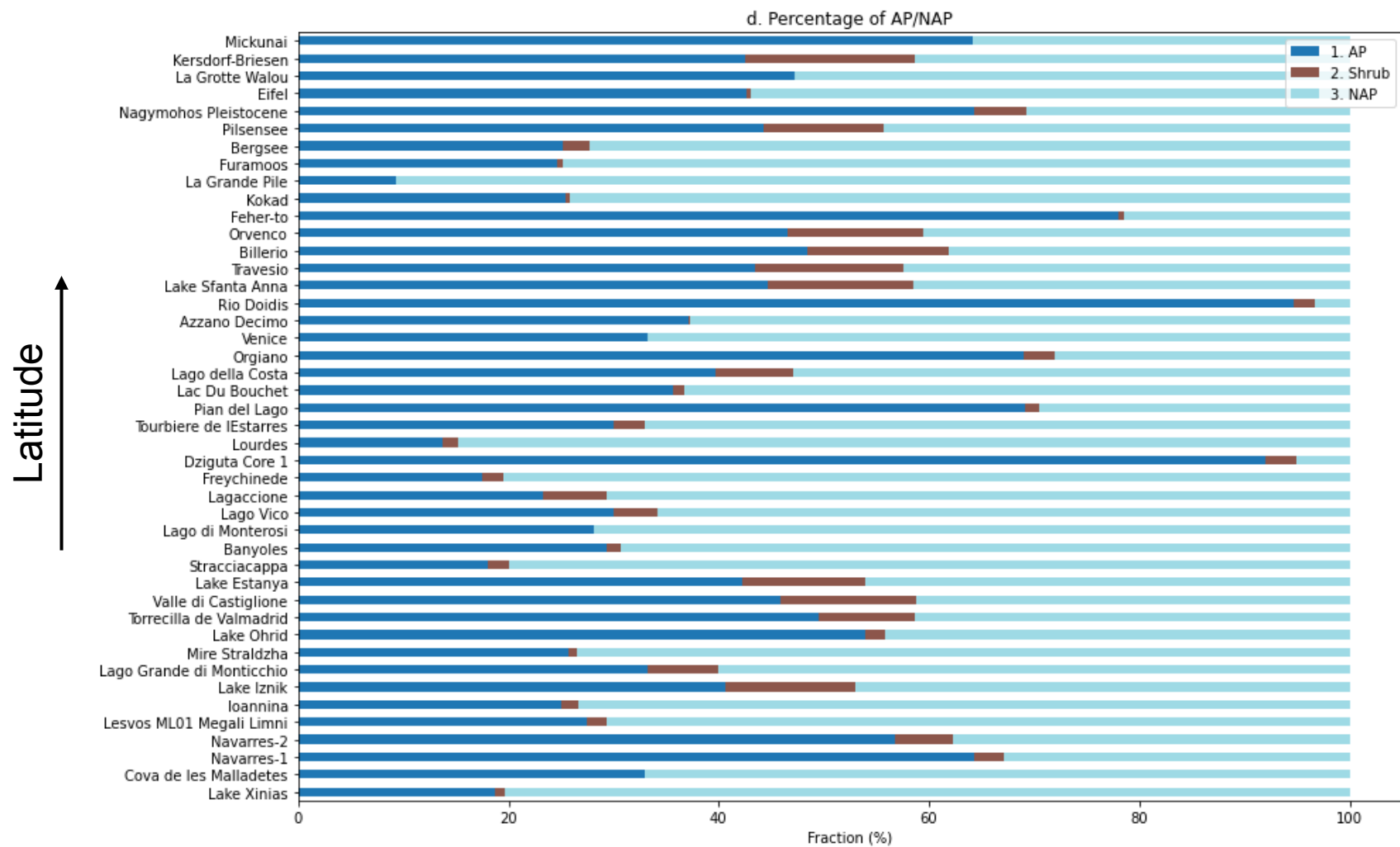
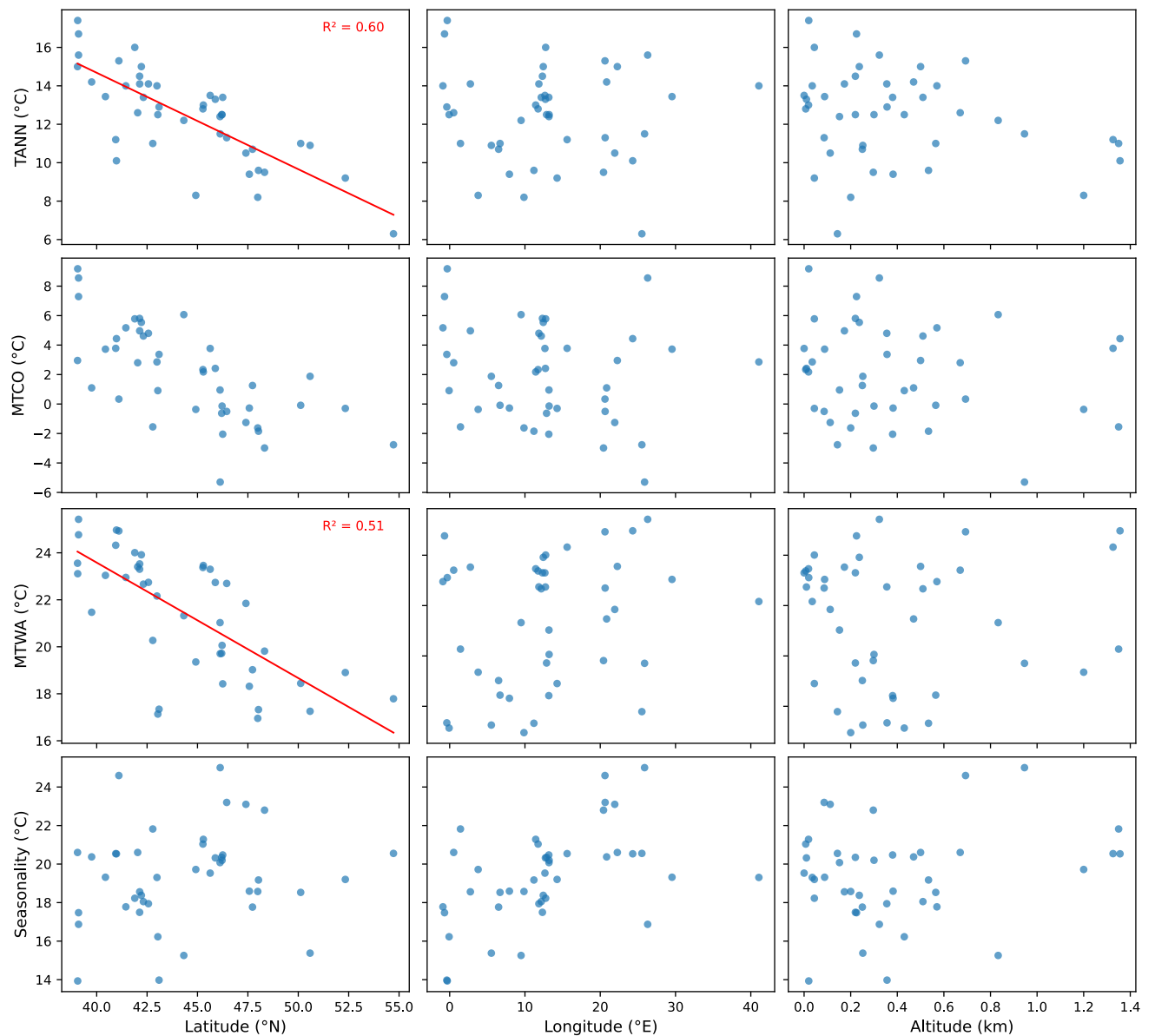


Table a – Site locations

Af = Tropical, rainforest	Cwc = Temperate, dry winter, cold summer
Am = Tropical, monsoon	Dsa = Cold, dry summer, hot summer
Aw = Tropical, savannah	Dsb = Cold, dry summer, warm summer
BSk = Arid, steppe, cold	Dsc = Cold, dry summer, cold summer
BSh = Arid, steppe, hot	Dwa = Cold, dry winter, hot summer
BWk = Arid, desert, cold	Dwb = Cold, dry winter, warm summer
BWh = Arid, desert, hot	Dwc = Cold, dry winter, cold summer
Csa = Temperate, dry summer, hot summer	Dwb = Cold, dry winter, warm summer
Csb = Temperate, dry summer, warm summer	Dfa = Cold, no dry season, hot summer
Csc = Temperate, dry summer, cold summer	Dfb = Cold, no dry season, warm summer
Cfa = Temperate, dry summer, hot summer	Dfc = Cold, no dry season, cold summer
Cfb = Temperate, dry summer, warm summer	Dfd = Cold, dry winter, very cold winter
Cfc = Temperate, no dry season, cold summer	EF = Polar, frost
Cwa = Temperate, dry winter, hot summer	ET = Polar, tundra
Cwb = Temperate, dry winter, warm summer	



Supplement 1. Site location in the map of the Köppen-Geiger classes from [Beck et al. 2018](#) (**a**, additional fossil sites compared to [Davis et al. \(2024\)](#) are shown in green), type of archives (**b**) and pollen description using taxonomic diversity parameters (**c**) and AP/NAP percentages (**d**) in 43 pollen LGM records. In **Fig S1.a**, site names are arranged in ascending order of latitude (i.e., down to top). Ages are calibrated CLAM v. 1.2 (BACON routine in R, [Blaauw, 2010](#); calibration curve of [Reimer et al., 2021](#)), to correspond to the LGM period, between 19 and 23 ka (cal BP). Table (**a**) reports the acronym of Köppen-Geiger classes. The white area represents the ice sheet extent.



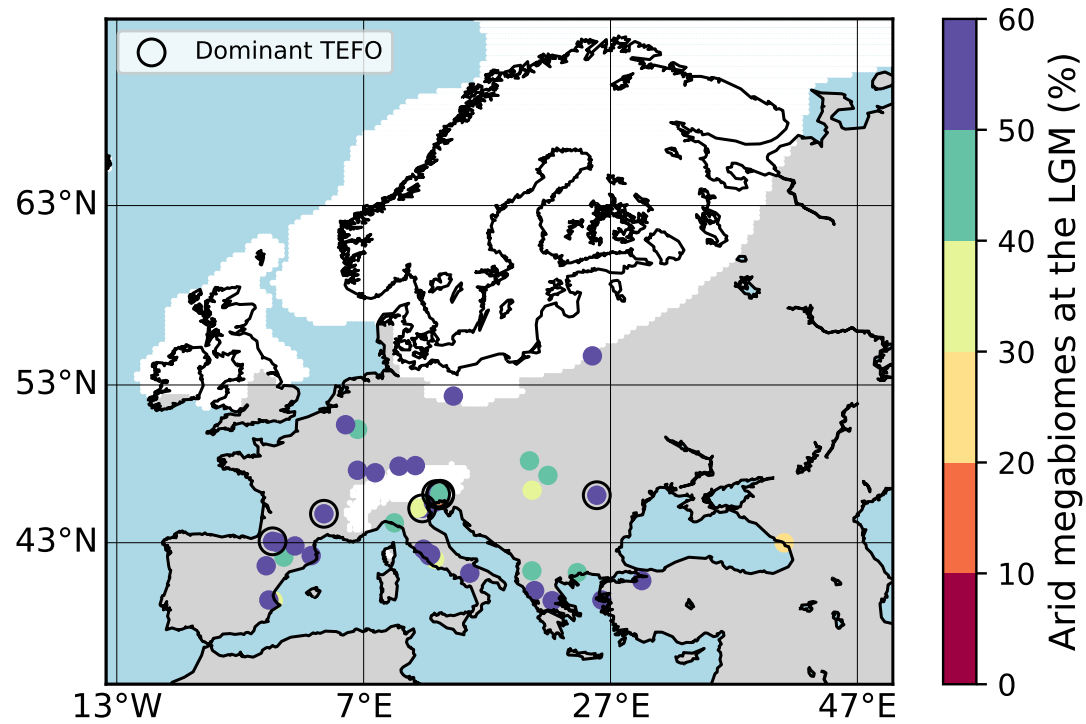
Supplement 2. Relationships between site geography and modern climate variables. Scatterplots showing the relationships between site latitude, longitude and elevation and key modern climate parameters: mean annual temperature (TANN), mean temperature of the coldest month (MTCO), mean temperature of the warmest month (MTWA), and temperature seasonality (MTWA – MTCO). Each point represents a pollen site (**Table 1**). Linear regressions are computed for all relationships, but only statistically strong relationships ($R^2 > 0.5$) are displayed to highlight robust spatial–climatic gradients. The figure highlights the dominant latitudinal control on temperature-related variables and the weaker but detectable influence of longitudinal gradients.

		<i>Associated megabiome</i>	
<i>Biome Classification</i>	<i>Biome appellations</i>	<i>Megabiome Classification</i>	<i>Megabiome appellations</i>
Cold deciduous forest	CLDE	Temperate forest + Boreal forest	TEFO + BOFO
Taiga	TAIGA	Tundra and polar desert + Temperate forest + Boreal forest	TUND + TEFO + BOFO
Pioner	PION	Boreal forest + Tundra and polar desert	BOFO + TUND
Cold mixed forest	CLMX	Temperate forest + Boreal forest	TEFO + BOFO
Cool conifer forest	COCO	Temperate forest + Boreal forest	TEFO + BOFO
Temperate deciduous forest	TEDE	Temperate forest + Warm temperate forest + Tundra and polar desert	TEFO + WTFO + TUND
Cool mixed forest	COMX	Tundra and polar desert + Boreal forest	TUND + BOFO
Warm mixed forest	WAMX	Warm temperate forest + Tundra and polar desert	WTFO + TUND
Xerophytic shrubs	XERO	Tundra and polar desert + Boreal forest + Warm temperate forest	TUND + BOFO + WTFO
Tundra	TUND	Tundra and polar desert	TUND
Cool steppes	COST	Grassland and dry shrubland	STEP
Warm steppes	WAST	Grassland and dry shrubland	STEP
Cold desert	CODE	(Warm) Desert	DESE
Hot desert	HODE	(Warm) Desert	DESE
Aquatic	AQU	NA	NA
Anthropogenic	ANTH	NA	NA

Supplement 3. Relationship between biome classification and mega-biome used in this study. Biome vs. megabiome associations are estimated based on the strongest consistencies among the taxa involved in the construction of the PFTs. The megabiome relationships showing the strongest agreement with the biomes are ranked in decreasing order of similarity. From this table, we test the relatability of our classification in this global spatial resolution. Appellations are summarized in [Fig.1](#). NA indicates an unknown correspondence.

Arboreal vegetation (AP)	Shrub vegetation	Herbaceous vegetation (NAP)		Aquatic
Betula	Juniperus	Poaceae	Gentianaceae ind.	Myriophyllum
Pinus	Betula nana	Cyperaceae	Centaurea scabiosa, t.nigra, Centaurium, Gentiana & Swertia	Nymphae
Corylus	Caprifoliaceae t. Lonicera & Sambucus	Artemisia	Lamiaceae t. Mentha, Hedysarum & Teucrium	Alisma
Quercus	Ephedra t. distachya & fragilis	Brassicaceae	Plantago t. lanceolata, major, media & montana	Menyanthes
Ulmus	Ericaceae t. ind. & Calluna	Caryophyllaceae	Polygonaceae ind.	Potamogeton
Alnus	Hippophae	Chenopodiaceae/Amaranthaceae	Polygonum bistorta & t.aviculare	Sparganium
Tilia	Rhamnaceae t.Paliurus & Ramnus	Helianthemum	Ranunculaceae t.Trollius	Lemna minor
Fraxinus excelsior	Ribes	Thalictrum	Rumex	Typha
Salix	Myrica	Ranunculaceae ind.	Sanguisorba minor	
Hedera	Viburnum	Armeria	Saxifraga t. granulata & t.oppositifolia	
Acer	Viscum	Boraginaceae t. Cerinthe & Onosma	Scrophulariaceae ind. & t.Euphrasia	
Abies		Campanulaceae	Valerianaceae ind. & t.Valeriana	
Carpinus		Cichorioidae	Urticaceae	
Fagus		Crocus	Euphorbia	
Larix		Dipsacaceae/Caprifoliaceae t. Dipsacus & Scabiosa	Apiaceae ind., t.Heracleum, Hydrocotyle, Pimpinella, Seseli, Apium, Pleurospernum	
Picea		Ericaceae t. Listera ovata	Filipendula	
Rosaceae t. Prunus & Sorbus		Fabaceae ind., t. Lotus, Ononis, Trifolium & Genista	Sanguisorba officinalis	

Supplement 4. Pollen taxon observed from the fossil pollen cores. Classification proposes 4 Classes: Arboreal (AP), Shrub, No-Arboreal and Aquatic vegetation.



Supplement 5. Proportion of arid megabiomes (STEP, DESE, SAVA and TUND) at the LGM across 43 pollen sequences. Black-outlined points highlight samples assigned to TEFO as the dominant temperate megabiome. The white region indicates the reconstructed ice sheet extent during the LGM.

a. Climate anomaly results from biomes

Mean multi-method results

	TANN MAT	TANN WA-PLS	TANN CREST	MTWA MAT	MTWA WA-PLS	MTWA CREST	MTCO MAT	MTCO WA-PLS	MTCO CREST	TANN	MTWA	MTCO
Lake Xinias	-8 ± 4	-7 ± 3	-6 (-4 / -8)	-4 ± 3	-4 ± 3	-4 (-2 / -6)	-8 ± 5	-7 ± 5	-4 (-1 / -7)	-7 (-4 / -10)	-4 (-1 / -7)	-6 (-2 / -11)
Cova de les Malladetes	-6 ± 3	-8 ± 4	-8 (-4 / -12)	-2 ± 3	-2 ± 3	-3 (0 / -5)	-9 ± 5	-9 ± 6	-11 (-5 / -16)	-7 (-4 / -11)	-2 (0 / -5)	-10 (-4 / -15)
Navarrés	-9 ± 4	-10 ± 3	-9 (-7 / -12)	-5 ± 3	-7 ± 3	-7 (-5 / -9)	-10 ± 5	-13 ± 4	-11 (-7 / -14)	-10 (-6 / -13)	-6 (-4 / -9)	-11 (-6 / -16)
Megali Limni	-12 ± 3	-10 ± 3	-9 (-6 / -11)	-11 ± 3	-8 ± 3	-8 (-6 / -10)	-17 ± 5	-15 ± 5	-12 (-8 / -15)	-10 (-7 / -14)	-9 (-6 / -12)	-14 (-10 / -19)
Ioannina	-6 ± 3	-7 ± 3	-5 (-3 / -7)	-3 ± 3	-3 ± 3	-3 (0 / -5)	-3 ± 5	-4 ± 5	-1 (1 / -4)	-6 (-3 / -9)	-3 (0 / -5)	-3 (2 / -7)
Lake Iznik	-7 ± 3	-6 ± 3	-5 (-2 / -7)	-4 ± 3	-3 ± 3	-4 (-2 / -6)	-11 ± 6	-8 ± 5	-5 (-2 / -8)	-6 (-3 / -9)	-4 (-1 / -6)	-8 (-3 / -13)
Lago Grande di Monticchio	-3 ± 3	-4 ± 3	-3 (-1 / -6)	-6 ± 3	-6 ± 3	-6 (-4 / -8)	-5 ± 5	-7 ± 5	-6 (-3 / -9)	-3 (0 / -6)	-6 (-3 / -8)	-6 (-2 / -10)
Mire Straldzha Kupena-3	-6 ± 3	-5 ± 3	-4 (-1 / -7)	-6 ± 3	-7 ± 3	-7 (-4 / -9)	-16 ± 5	-12 ± 5	-10 (-5 / -14)	-5 (-2 / -8)	-7 (-4 / -9)	-13 (-7 / -18)
Lake Ohrid	-6 ± 3	-7 ± 3	-6 (-4 / -8)	-5 ± 2	-5 ± 3	-5 (-3 / -8)	0 ± 4	-3 ± 4	-1 (2 / -4)	-6 (-3 / -9)	-5 (-3 / -7)	-1 (3 / -5)
Torrecilla de Valmadrid	-3 ± 3	-6 ± 3	-5 (-3 / -7)	-2 ± 2	-3 ± 3	-3 (-1 / -5)	-4 ± 4	-8 ± 4	-7 (-4 / -10)	-5 (-2 / -8)	-3 (0 / -5)	-6 (-2 / -10)
Valle di Castiglione	-5 ± 3	-7 ± 3	-8 (-5 / -10)	-2 ± 2	-4 ± 2	-5 (-3 / -7)	-4 ± 4	-8 ± 4	-8 (-5 / -11)	-7 (-4 / -10)	-4 (-1 / -7)	-7 (-3 / -11)
Lake Estanya	-8 ± 3	-7 ± 3	-5 (-3 / -8)	-6 ± 3	-5 ± 3	-5 (-3 / -7)	-11 ± 5	-9 ± 5	-7 (-3 / -11)	-7 (-4 / -10)	-5 (-3 / -8)	-9 (-4 / -14)
Stracciaccia	-8 ± 4	-8 ± 3	-9 (-6 / -12)	-3 ± 3	-4 ± 3	-6 (-4 / -9)	-15 ± 7	-13 ± 5	-12 (-7 / -16)	-9 (-5 / -12)	-5 (-2 / -8)	-13 (-7 / -19)
Banyoles	-8 ± 4	-7 ± 3	-7 (-4 / -10)	-4 ± 3	-4 ± 3	-5 (-3 / -7)	-14 ± 6	-11 ± 5	-9 (-5 / -13)	-7 (-4 / -11)	-4 (-2 / -7)	-11 (-6 / -16)
Lago di Monterosi	-10 ± 3	-9 ± 3	-10 (-6 / -13)	-4 ± 3	-5 ± 3	-6 (-3 / -8)	-14 ± 5	-13 ± 5	-13 (-9 / -17)	-10 (-6 / -13)	-5 (-2 / -8)	-13 (-8 / -18)
Lago Vico	-6 ± 3	-6 ± 3	-6 (-3 / -8)	-3 ± 3	-3 ± 3	-4 (-2 / -6)	-10 ± 6	-9 ± 5	-8 (-4 / -12)	-6 (-3 / -9)	-4 (-1 / -6)	-9 (-4 / -14)

Lagaccione	-7 ± 3	-7 ± 3	-6 (-4 / -9)	-3 ± 3	-3 ± 3	-4 (-2 / -6)	-11 ± 6	-10 ± 5	-8 (-4 / -12)	-7 (-4 / -10)	-4 (-1 / -6)	-9 (-5 / -14)
Freychinede	-8 ± 3	-7 ± 3	-4 (-1 / -7)	-2 ± 3	-2 ± 3	-2 (0 / -4)	-12 ± 5	-8 ± 5	-4 (0 / -8)	-6 (-3 / -10)	-2 (1 / -5)	-8 (-2 / -13)
Dziguta	-8 ± 3	-8 ± 3	-6 (-3 / -8)	-3 ± 2	-4 ± 3	-3 (-1 / -5)	-8 ± 5	-10 ± 5	-5 (-1 / -9)	-7 (-4 / -11)	-3 (-1 / -6)	-8 (-3 / -13)
Lourdes	-7 ± 4	-6 ± 3	-6 (-3 / -8)	-1 ± 3	1 ± 3	1 (3 / -1)	-5 ± 5	-6 ± 5	-5 (-1 / -8)	-6 (-3 / -10)	0 (3 / -3)	-5 (-1 / -10)
Tourbiere de l'Estarres	-7 ± 3	-7 ± 3	-5 (-2 / -7)	-1 ± 3	0 ± 3	1 (3 / -2)	-5 ± 4	-8 ± 5	-5 (-1 / -9)	-6 (-3 / -9)	0 (3 / -3)	-6 (-2 / -11)
Pian del Lago	-8 ± 3	-8 ± 3	-5 (-3 / -8)	-4 ± 2	-4 ± 3	-4 (-2 / -6)	-14 ± 5	-14 ± 5	-10 (-7 / -13)	-7 (-4 / -10)	-4 (-2 / -6)	-13 (-8 / -17)
Lake Bouchet	-3 ± 4	-3 ± 3	-1 (2 / -4)	-1 ± 3	-1 ± 3	-1 (1 / -4)	-8 ± 6	-6 ± 5	-4 (0 / -8)	-2 (1 / -6)	-1 (2 / -4)	-6 (-1 / -11)
Lago della Costa	-10 ± 3	-9 ± 3	-7 (-4 / -9)	-8 ± 3	-7 ± 3	-7 (-5 / -9)	-11 ± 5	-11 ± 5	-7 (-3 / -10)	-9 (-5 / -12)	-7 (-5 / -10)	-9 (-5 / -14)
Orgiano	-10 ± 4	-10 ± 3	-8 (-6 / -10)	-8 ± 3	-7 ± 3	-7 (-5 / -9)	-10 ± 5	-12 ± 5	-9 (-5 / -12)	-9 (-6 / -13)	-7 (-5 / -10)	-10 (-5 / -15)
Venice	-8 ± 4	-10 ± 3	-9 (-7 / -12)	-6 ± 3	-7 ± 3	-6 (-4 / -9)	-11 ± 6	-12 ± 5	-11 (-8 / -15)	-9 (-6 / -12)	-6 (-4 / -9)	-11 (-7 / -16)
Azzano Decimo	-10 ± 5	-11 ± 4	-10 (-7 / -14)	-7 ± 4	-7 ± 3	-6 (-4 / -9)	-10 ± 8	-12 ± 5	-11 (-6 / -16)	-10 (-6 / -15)	-7 (-4 / -10)	-11 (-5 / -17)
Rio Doidis	-4 ± 5	-6 ± 4	-8 (-3 / -12)	-1 ± 4	-2 ± 3	-3 (0 / -6)	-5 ± 8	-7 ± 7	-9 (-3 / -16)	-6 (-1 / -11)	-2 (2 / -5)	-7 (0 / -14)
Lake Sfanta Anna	-5 ± 3	-8 ± 4	-6 (-4 / -9)	-3 ± 3	-3 ± 3	-3 (-1 / -5)	3 ± 5	-4 ± 5	0 (3 / -4)	-6 (-3 / -10)	-3 (0 / -6)	0 (5 / -6)
Travesio	-7 ± 3	-10 ± 3	-7 (-5 / -9)	-3 ± 3	-4 ± 3	-3 (-1 / -5)	-4 ± 5	-9 ± 5	-5 (-2 / -8)	-8 (-5 / -11)	-3 (-1 / -6)	-6 (-1 / -11)
Billerio	-3 ± 3	-9 ± 3	-7 (-5 / -10)	-1 ± 3	-3 ± 3	-3 (-1 / -5)	0 ± 4	-8 ± 5	-6 (-3 / -9)	-6 (-3 / -10)	-2 (0 / -5)	-5 (1 / -10)
Orvenco	-7 ± 3	-10 ± 4	-8 (-6 / -11)	-3 ± 3	-2 ± 3	-2 (0 / -4)	-2 ± 5	-8 ± 6	-4 (0 / -8)	-9 (-5 / -12)	-2 (1 / -5)	-4 (1 / -10)
Feher Lake	-5 ± 3	-8 ± 4	-6 (-3 / -8)	-6 ± 3	-7 ± 3	-6 (-4 / -8)	-4 ± 5	-8 ± 5	-5 (-1 / -8)	-6 (-3 / -10)	-6 (-4 / -9)	-6 (-1 / -11)
Kokad	-2 ± 4	-7 ± 4	-6 (-3 / -10)	-4 ± 4	-6 ± 3	-5 (-3 / -8)	-1 ± 6	-7 ± 5	-6 (-2 / -10)	-5 (-1 / -9)	-5 (-2 / -9)	-4 (1 / -10)
La Grande Pile	-6 ± 3	-6 ± 4	-4 (-1 / -7)	-3 ± 3	-2 ± 3	-1 (2 / -3)	-8 ± 5	-8 ± 5	-4 (0 / -8)	-5 (-2 / -9)	-2 (1 / -5)	-7 (-2 / -12)
Furamoos	-4 ± 3	-5 ± 3	-3 (0 / -6)	-1 ± 3	-1 ± 3	1 (3 / -2)	-4 ± 5	-6 ± 5	-4 (0 / -9)	-4 (0 / -7)	-1 (2 / -3)	-5 (0 / -10)
Bergsee	-6 ± 3	-6 ± 4	-4 (-1 / -6)	-3 ± 3	-3 ± 3	-1 (1 / -3)	-9 ± 5	-8 ± 5	-4 (-1 / -8)	-5 (-2 / -9)	-2 (1 / -5)	-7 (-2 / -12)
Pilsensee	-8 ± 3	-7 ± 4	-3 (0 / -5)	-3 ± 2	-2 ± 3	0 (2 / -2)	-7 ± 4	-7 ± 5	-1 (2 / -4)	-6 (-2 / -10)	-2 (1 / -5)	-5 (0 / -10)

Nagymohos	-6 ± 3	-6 ± 4	-2 (0 / -5)	-5 ± 3	-4 ± 3	-2 (0 / -4)	-3 ± 5	-6 ± 5	0 (3 / -3)	-5 (-1 / -9)	-4 (-1 / -6)	-3 (2 / -8)
Eifel	-3 ± 3	-5 ± 4	-4 (-1 / -8)	0 ± 3	-1 ± 3	0 (2 / -3)	-3 ± 5	-5 ± 6	-5 (1 / -10)	-4 (-1 / -8)	0 (2 / -3)	-4 (1 / -10)
La Grotte Walou	-7 ± 3	-6 ± 3	-5 (-3 / -8)	-2 ± 3	0 ± 3	-1 (1 / -3)	-10 ± 5	-7 ± 5	-6 (-3 / -10)	-6 (-3 / -9)	-1 (2 / -4)	-8 (-3 / -13)
Kersdorf-Briesen	-7 ± 3	-5 ± 3	-4 (-1 / -7)	-3 ± 3	-3 ± 3	-2 (0 / -5)	-10 ± 5	-7 ± 5	-4 (-1 / -8)	-5 (-2 / -9)	-3 (0 / -6)	-7 (-2 / -12)
Mickunai	-3 ± 3	-1 ± 3	1 (3 / -1)	0 ± 3	-1 ± 3	-1 (2 / -3)	-9 ± 4	-2 ± 5	1 (4 / -2)	-1 (2 / -4)	-1 (2 / -3)	-3 (2 / -9)
Mean population SD	-7 ± 2	-7 ± 2	-6 ± 2	-4 ± 2	-4 ± 2	-4 ± 2	-8 ± 5	-9 ± 3	-6 ± 4	-7 ± 2	-4 ± 2	-7 ± 3

b. Climate anomaly results from megabiomes

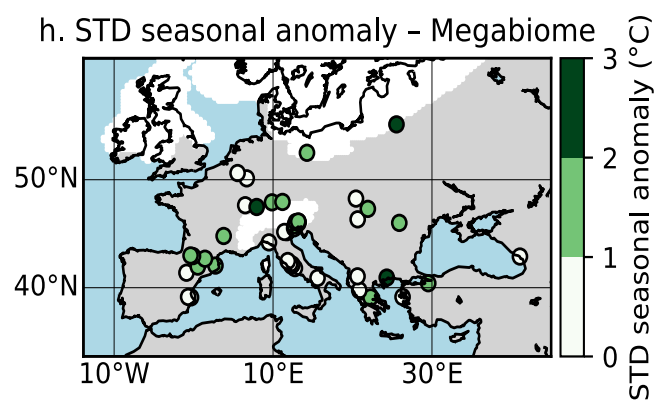
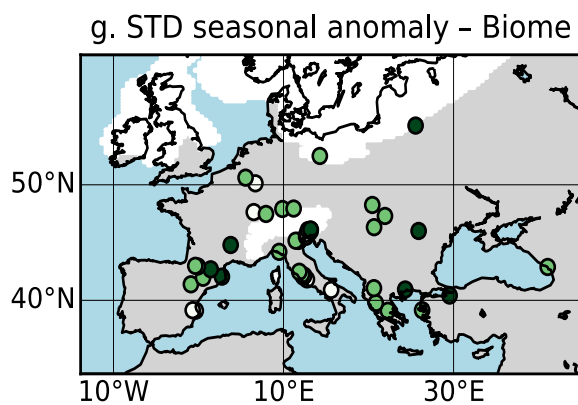
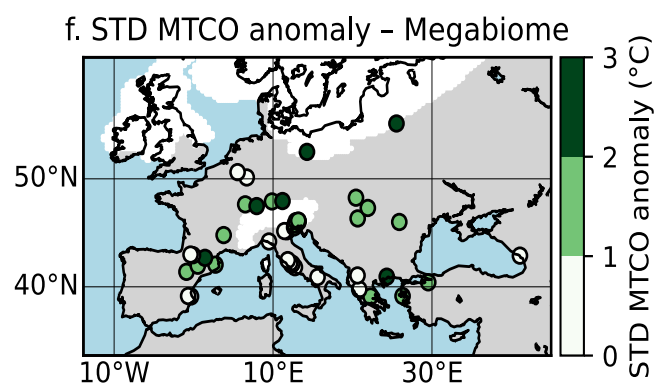
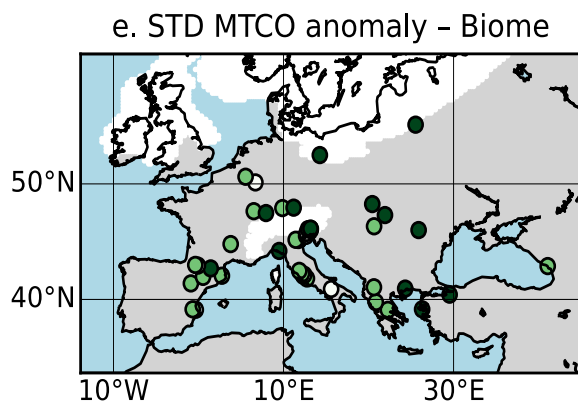
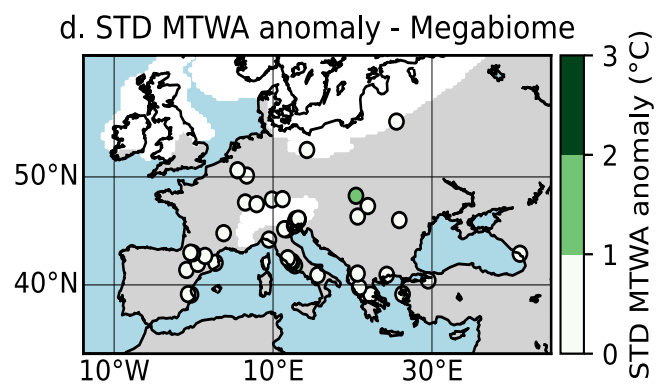
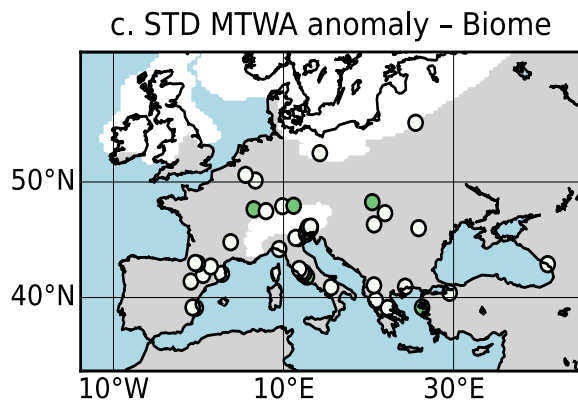
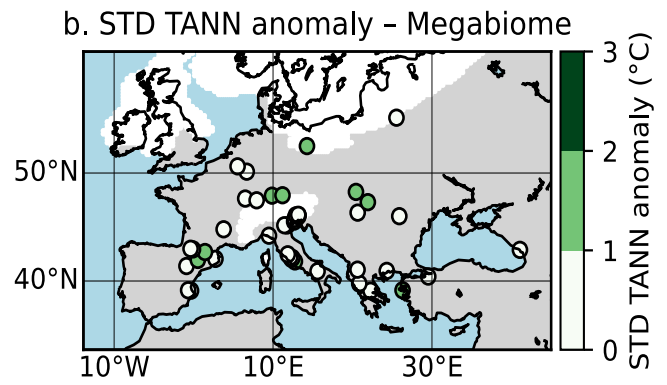
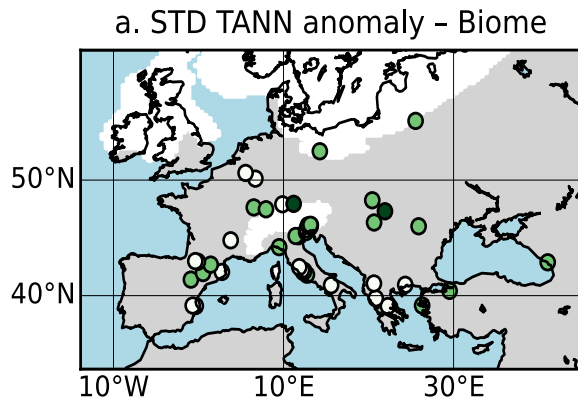
Mean multi-method results

	TANN MAT	TANN WA-PLS	TANN CREST	MTWA MAT	MTWA WA-PLS	MTWA CREST	MTCO MAT	MTCO WA-PLS	MTCO CREST	TANN	MTWA	MTCO
Lake Xinias	-10 ± 3	-8 ± 3	-8 (-5 / -10)	-6 ± 2	-6 ± 3	-6 (-4 / -8)	-9 ± 5	-6 ± 5	-6 (-2 / -9)	-8 (-5 / -11)	-6 (-4 / -8)	-7 (-3 / -11)
Cova de les Malladetes	-10 ± 2	-10 ± 3	-11 (-8 / -14)	-7 ± 2	-7 ± 2	-7 (-5 / -10)	-10 ± 3	-10 ± 4	-12 (-8 / -16)	-10 (-8 / -13)	-7 (-5 / -9)	-11 (-7 / -15)
Navarrés	-10 ± 3	-10 ± 3	-11 (-9 / -13)	-7 ± 2	-8 ± 3	-8 (-6 / -10)	-11 ± 4	-11 ± 4	-13 (-10 / -16)	-10 (-8 / -13)	-8 (-5 / -10)	-11 (-7 / -16)
Megali Limni	-12 ± 3	-10 ± 3	-10 (-7 / -13)	-11 ± 2	-9 ± 3	-9 (-7 / -11)	-16 ± 4	-14 ± 4	-13 (-9 / -17)	-11 (-8 / -14)	-10 (-7 / -13)	-14 (-10 / -18)
Ioannina	-8 ± 3	-7 ± 3	-7 (-4 / -9)	-5 ± 3	-5 ± 3	-4 (-2 / -6)	-5 ± 5	-4 ± 5	-3 (0 / -6)	-7 (-5 / -10)	-5 (-2 / -7)	-4 (0 / -8)
Lake Iznik	-7 ± 3	-6 ± 3	-6 (-4 / -9)	-5 ± 2	-5 ± 3	-7 (-5 / -9)	-8 ± 5	-6 ± 5	-6 (-2 / -9)	-6 (-4 / -9)	-6 (-3 / -8)	-7 (-2 / -11)
Lago Grande di Monticchio	-4 ± 3	-4 ± 3	-5 (-2 / -7)	-7 ± 2	-7 ± 2	-8 (-6 / -10)	-6 ± 4	-6 ± 4	-7 (-4 / -10)	-4 (-1 / -7)	-7 (-5 / -10)	-6 (-2 / -10)
Mire Straldzha Kupena-3	-6 ± 3	-6 ± 3	-5 (-2 / -8)	-7 ± 2	-9 ± 3	-9 (-6 / -11)	-15 ± 4	-13 ± 5	-10 (-5 / -14)	-6 (-3 / -9)	-8 (-6 / -11)	-13 (-8 / -17)
Lake Ohrid	-7 ± 3	-7 ± 3	-7 (-5 / -9)	-7 ± 2	-7 ± 2	-7 (-5 / -9)	-1 ± 4	-2 ± 4	-1 (2 / -4)	-7 (-5 / -10)	-7 (-5 / -9)	-1 (2 / -5)
Torrecilla de Valmadrid	-5 ± 3	-6 ± 3	-7 (-5 / -9)	-4 ± 2	-4 ± 3	-5 (-3 / -7)	-6 ± 4	-6 ± 4	-8 (-6 / -11)	-6 (-3 / -9)	-5 (-2 / -7)	-7 (-3 / -11)
Valle di Castiglione	-6 ± 3	-8 ± 3	-9 (-6 / -11)	-4 ± 2	-6 ± 3	-7 (-4 / -9)	-6 ± 5	-7 ± 4	-8 (-4 / -11)	-7 (-4 / -10)	-6 (-3 / -8)	-7 (-2 / -11)
Lake Estanya	-9 ± 3	-7 ± 3	-6 (-3 / -8)	-7 ± 2	-7 ± 2	-5 (-4 / -7)	-11 ± 5	-7 ± 4	-8 (-5 / -11)	-7 (-4 / -10)	-6 (-4 / -9)	-9 (-4 / -13)
Stracciaccappa	-9 ± 3	-8 ± 3	-10 (-7 / -13)	-6 ± 2	-6 ± 3	-8 (-6 / -11)	-14 ± 4	-10 ± 4	-12 (-8 / -16)	-9 (-6 / -12)	-6 (-4 / -9)	-12 (-7 / -16)
Banyoles	-9 ± 3	-7 ± 3	-8 (-6 / -11)	-6 ± 2	-6 ± 2	-7 (-5 / -9)	-12 ± 5	-9 ± 4	-9 (-6 / -13)	-8 (-5 / -11)	-6 (-4 / -9)	-10 (-6 / -15)
Lago di Monterosi	-10 ± 3	-10 ± 3	-11 (-9 / -14)	-6 ± 2	-7 ± 2	-9 (-7 / -11)	-14 ± 4	-12 ± 4	-13 (-9 / -17)	-11 (-8 / -13)	-8 (-5 / -10)	-13 (-9 / -18)
Lago Vico	-7 ± 3	-6 ± 3	-7 (-5 / -9)	-5 ± 2	-5 ± 2	-6 (-4 / -8)	-9 ± 4	-7 ± 4	-8 (-5 / -12)	-7 (-4 / -10)	-5 (-3 / -8)	-8 (-4 / -12)

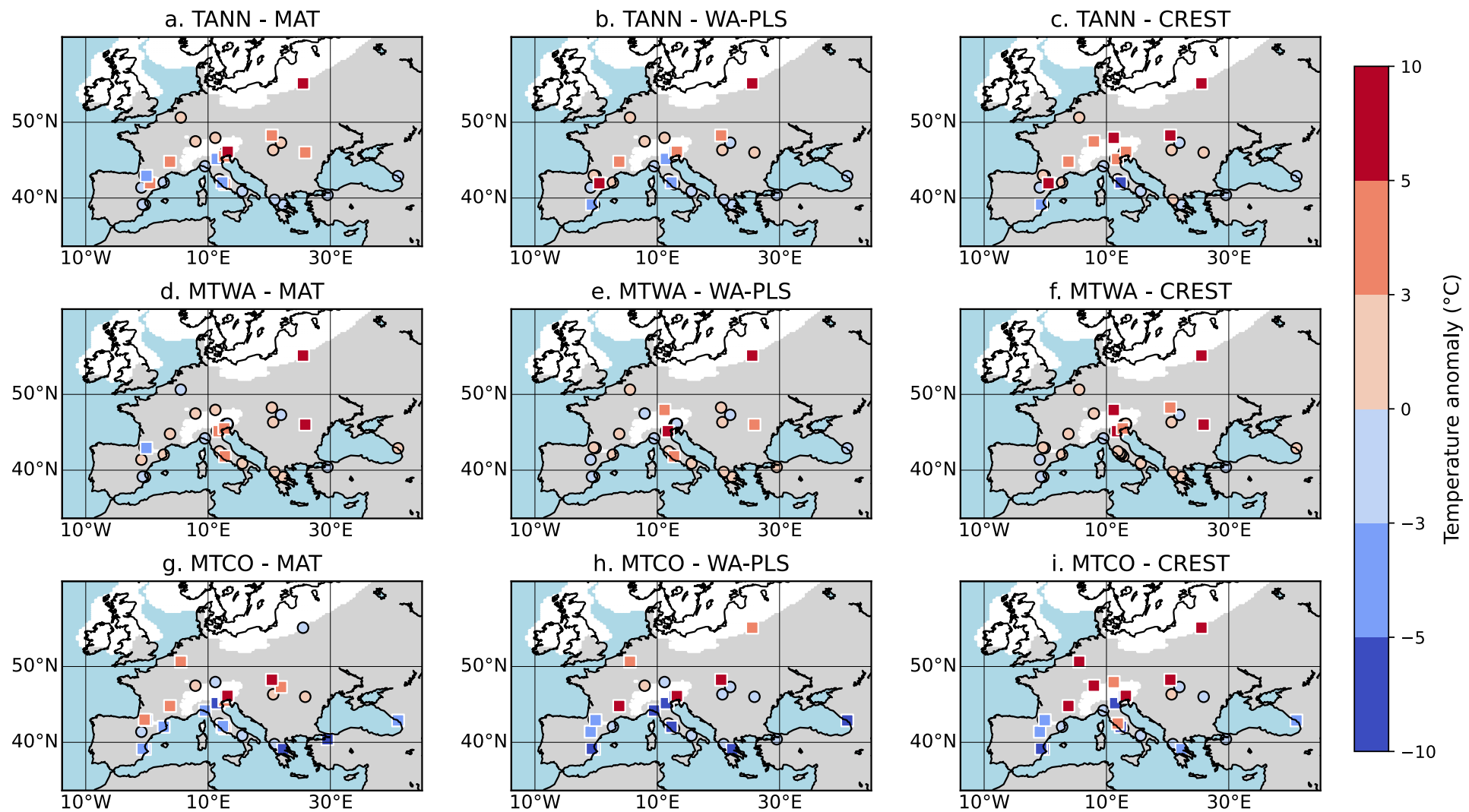
Lagaccione	-8 ± 3	-7 ± 3	-8 (-5 / -10)	-5 ± 2	-5 ± 2	-6 (-4 / -8)	-9 ± 4	-8 ± 4	-9 (-5 / -12)	-7 (-5 / -10)	-6 (-3 / -8)	-8 (-4 / -12)
Freychinede	-7 ± 2	-6 ± 3	-5 (-2 / -7)	-3 ± 2	-4 ± 2	-3 (-1 / -5)	-8 ± 4	-6 ± 4	-3 (0 / -7)	-6 (-3 / -9)	-4 (-1 / -6)	-6 (-1 / -10)
Dziguta	-9 ± 3	-8 ± 3	-8 (-6 / -10)	-5 ± 2	-5 ± 3	-5 (-3 / -7)	-9 ± 5	-8 ± 5	-9 (-6 / -12)	-8 (-5 / -11)	-5 (-3 / -7)	-9 (-5 / -13)
Lourdes	-7 ± 3	-6 ± 3	-7 (-4 / -9)	-2 ± 3	-1 ± 3	-1 (1 / -3)	-5 ± 4	-4 ± 4	-5 (-2 / -9)	-7 (-4 / -10)	-1 (1 / -3)	-5 (-1 / -9)
Tourbiere de l'Estarres	-6 ± 3	-7 ± 3	-7 (-4 / -9)	-1 ± 2	-1 ± 3	-1 (1 / -3)	-5 ± 4	-7 ± 5	-6 (-3 / -10)	-6 (-4 / -9)	-1 (1 / -4)	-6 (-2 / -10)
Pian del Lago	-6 ± 3	-7 ± 3	-6 (-4 / -9)	-5 ± 2	-5 ± 3	-5 (-3 / -7)	-12 ± 4	-13 ± 5	-11 (-7 / -14)	-7 (-4 / -9)	-5 (-3 / -7)	-12 (-8 / -16)
Lake Bouchet	-3 ± 3	-2 ± 3	-2 (1 / -5)	-2 ± 2	-3 ± 2	-3 (-1 / -5)	-7 ± 5	-4 ± 4	-4 (0 / -7)	-3 (0 / -5)	-2 (0 / -5)	-5 (0 / -9)
Lago della Costa	-9 ± 3	-8 ± 3	-6 (-4 / -9)	-8 ± 3	-8 ± 3	-7 (-5 / -9)	-9 ± 4	-8 ± 5	-6 (-3 / -10)	-8 (-5 / -11)	-8 (-5 / -10)	-8 (-4 / -12)
Orgiano	-10 ± 3	-9 ± 3	-8 (-6 / -10)	-8 ± 2	-8 ± 3	-7 (-5 / -9)	-9 ± 5	-10 ± 5	-9 (-6 / -12)	-9 (-6 / -12)	-8 (-5 / -10)	-9 (-5 / -13)
Venice	-7 ± 4	-9 ± 3	-9 (-6 / -12)	-6 ± 2	-8 ± 3	-8 (-6 / -10)	-9 ± 6	-11 ± 5	-10 (-6 / -15)	-9 (-5 / -12)	-7 (-4 / -10)	-10 (-5 / -15)
Azzano Decimo	-9 ± 4	-10 ± 3	-9 (-6 / -12)	-8 ± 3	-8 ± 3	-7 (-5 / -10)	-8 ± 6	-10 ± 5	-8 (-4 / -13)	-9 (-6 / -13)	-8 (-5 / -11)	-9 (-4 / -14)
Rio Doidis	-5 ± 4	-5 ± 4	-7 (-4 / -10)	-4 ± 3	-3 ± 3	-5 (-3 / -7)	-3 ± 6	-3 ± 5	-5 (-1 / -10)	-5 (-2 / -9)	-4 (-1 / -7)	-4 (2 / -9)
Lake Sfanta Anna	-5 ± 3	-7 ± 3	-6 (-4 / -8)	-3 ± 2	-4 ± 3	-3 (-1 / -5)	2 ± 4	-1 ± 5	0 (4 / -3)	-6 (-3 / -9)	-4 (-1 / -6)	1 (5 / -4)
Travesio	-8 ± 3	-8 ± 3	-7 (-5 / -9)	-4 ± 2	-5 ± 3	-3 (-1 / -5)	-4 ± 4	-6 ± 5	-4 (-1 / -7)	-7 (-5 / -10)	-4 (-2 / -6)	-5 (-1 / -9)
Billerio	-5 ± 3	-7 ± 3	-6 (-4 / -8)	-2 ± 2	-4 ± 3	-3 (-1 / -4)	-1 ± 4	-5 ± 5	-5 (-2 / -8)	-6 (-3 / -9)	-3 (-1 / -5)	-3 (1 / -8)
Orvenco	-8 ± 3	-9 ± 3	-7 (-5 / -10)	-3 ± 2	-3 ± 3	-2 (0 / -4)	-1 ± 4	-5 ± 5	-2 (1 / -5)	-8 (-5 / -11)	-3 (0 / -5)	-3 (2 / -7)
Feher Lake	-7 ± 3	-8 ± 3	-6 (-4 / -9)	-8 ± 2	-9 ± 3	-8 (-6 / -10)	-5 ± 4	-7 ± 5	-4 (-1 / -8)	-7 (-4 / -10)	-9 (-6 / -11)	-5 (-1 / -10)
Kokad	-4 ± 3	-6 ± 4	-6 (-3 / -10)	-6 ± 3	-6 ± 3	-6 (-3 / -8)	-2 ± 5	-5 ± 5	-5 (0 / -10)	-6 (-2 / -9)	-6 (-3 / -8)	-4 (1 / -9)
La Grande Pile	-7 ± 3	-6 ± 3	-5 (-2 / -8)	-4 ± 3	-4 ± 3	-3 (-1 / -5)	-8 ± 4	-6 ± 5	-5 (-1 / -8)	-6 (-3 / -9)	-4 (-1 / -6)	-6 (-2 / -11)
Furamoos	-3 ± 3	-5 ± 3	-3 (0 / -6)	-1 ± 3	-2 ± 3	0 (2 / -3)	-3 ± 5	-7 ± 5	-3 (1 / -8)	-3 (0 / -7)	-1 (2 / -4)	-4 (1 / -9)
Bergsee	-6 ± 3	-6 ± 3	-4 (-2 / -7)	-3 ± 2	-5 ± 3	-3 (-1 / -5)	-8 ± 4	-7 ± 5	-3 (1 / -6)	-5 (-2 / -8)	-4 (-1 / -6)	-6 (-1 / -10)
Pilsensee	-9 ± 3	-7 ± 3	-4 (-2 / -7)	-5 ± 2	-4 ± 3	-3 (-1 / -5)	-7 ± 4	-6 ± 5	-1 (2 / -5)	-7 (-3 / -10)	-4 (-1 / -7)	-5 (0 / -10)

Nagymohos	-6 ± 3	-7 ± 3	-4 (-1 / -6)	-6 ± 2	-7 ± 3	-4 (-2 / -6)	-3 ± 5	-4 ± 5	0 (4 / -3)	-5 (-2 / -8)	-5 (-3 / -8)	-2 (3 / -7)
Eifel	-5 ± 3	-6 ± 3	-6 (-3 / -8)	-3 ± 2	-4 ± 2	-3 (-1 / -5)	-3 ± 4	-4 ± 4	-4 (0 / -9)	-6 (-3 / -8)	-3 (-1 / -6)	-4 (1 / -8)
La Grotte Walou	-5 ± 3	-5 ± 3	-5 (-3 / -8)	-2 ± 2	-2 ± 2	-2 (0 / -5)	-5 ± 4	-5 ± 4	-5 (-1 / -8)	-5 (-2 / -8)	-2 (0 / -4)	-5 (-1 / -9)
Kersdorf-Briesen	-6 ± 3	-5 ± 3	-3 (-1 / -6)	-5 ± 3	-4 ± 3	-4 (-2 / -6)	-7 ± 4	-5 ± 5	-2 (1 / -5)	-5 (-2 / -8)	-4 (-2 / -7)	-5 (0 / -9)
Mickunai	-2 ± 2	-1 ± 3	0 (2 / -2)	-1 ± 2	-3 ± 3	-2 (1 / -5)	-6 ± 4	-2 ± 5	1 (4 / -2)	-1 (2 / -4)	-2 (1 / -5)	-3 (2 / -7)
Mean population SD	-7 ± 2	-7 ± 2	-7 ± 2	-5 ± 2	-5 ± 2	-5 ± 2	-7 ± 4	-7 ± 3	-6 ± 4	-7 ± 2	-3 ± 2	-8 ± 3

Supplement 6. Climate anomaly results (°C) for TANN (mean annual temperature), MTWA (mean temperature of the warmest month), and MTCO (mean temperature of the coldest month) from three different methods using the biomization **(a)** and mebiomization **(b)** procedures across 43 pollen sites. CREST error bars indicate uncertainty ranges (i.e., lower and upper uncertainty bounds), not standard deviations. In the “Mean multi-method results” column, errors (1σ) represent the combined uncertainty, calculated as the square root of the sum of inter-point variance and mean internal errors. In contrast, in the row “Mean population SD”, values represent the mean of population standard deviations (SD), calculated using population variance (N), without internal error propagation.



Supplement 7. Standard deviation of annual temperature (**a and b**), MTWA (**c and d**), MTCO (**e and f**) and seasonal (**g and h**) anomaly results (LGM – Modern climate) using averages of biomization and megabiomization results from 3 different methods (**Fig 8**). The white area represents the ice sheet extent.



Supplement 8. Mean annual (**a, b and c**) and monthly (**d-i**) anomalies (LGM – Modern climate) reconstructed using three methods based on biomization and megabiomization, compared with [Davis et al. \(2024\)](#) (i.e., mean ((mega)biome results) – results from [Davis et al., 2024](#)) Anomalies are calculated as differences between our reconstructions and the results of [Davis et al. \(2024\)](#). Squared points indicate anomalies outside the $[-3; 3]^{\circ}\text{C}$ range. The white area represents the extent of the Fennoscandian ice sheet.