Speleothem records from the eastern part of Europe and Turkey - discussion on stable oxygen and carbon isotopes

Zoltán Kern, Attila Demény, Aurel Perşoiu, István Gábor Hatvani

1. Climate of the EEu&T SISAL region

The southern regions, from the Dalmatian Coast through the Peloponnesus and large part of Anatolia are dominated by Mediterranean climate characterized with by dry, hot summers (minimum monthly precipitation amount < 40mm) hot (monthly mean temperature of the warmest month (Tmax) ≥ 22°C) and warm (Tmax<22°C and at least 4 monthly avg. temperature (T) ≥ +10°C) summers ([1]; Köppen-Geiger code: Csa, Csb respectively). Most of the studied region is characterized by wet continental or boreal climate (Figure S1), where continentality increases eastwards. Warm temperate/continental climate (monthly mean temperature of the coldest month (Tmin) is between -3 and 18°C) with warm summers and without a dry season (Köppen-Geiger code: Cfb) prevails over the elevated terrains of the Balkan Peninsula stretching northward to the Baltic Coast. In the meanwhile, humid warm temperate areas with hot summers (Köppen-Geiger code: Cfa) occur in the central part of the Balkan Peninsula and the south-eastern part of the Eastern European Plains.

Boreal climate with warm summers without a dry season (Köppen-Geiger code: Dfb) prevails over large part of the mountainous area (Carpathians, Dinarides, Thracian Massive) and the northeastern parts of the Eastern European Plains up to the Gulf of Finland. The appearance of its counterpart with cool summers and cold winters (Tmax < +22°C, the 4 monthly avg. T < +10°C and Tmin > -38°C; Köppen-Geiger code: Dfc) is restricted to the highest regions of the Carpathian Range (Figure S1).
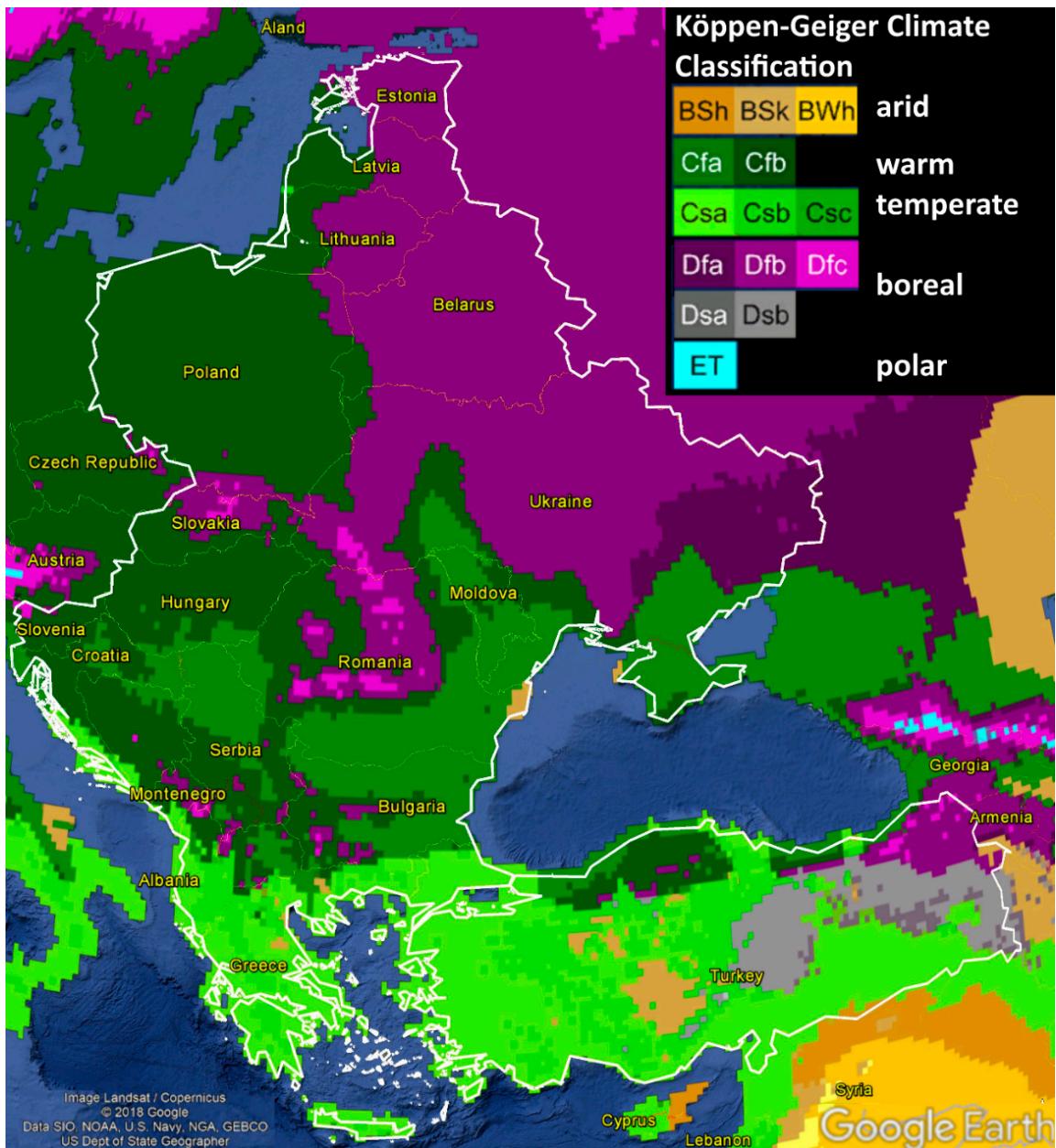
Figure S1. Climate of the Eastern Europe & Turkey SISAL region. Köppen-Geiger climate classification based on data for the period 1951 to 2000 [1,2]. The white hairline outlines the Eastern Europe & Turkey SISAL region. The base map was taken from Google on 11.10.2018.

2. Relationship between $\delta^{18}O$ and $\delta^{13}C$ in EEu&T SISAL_v1 records
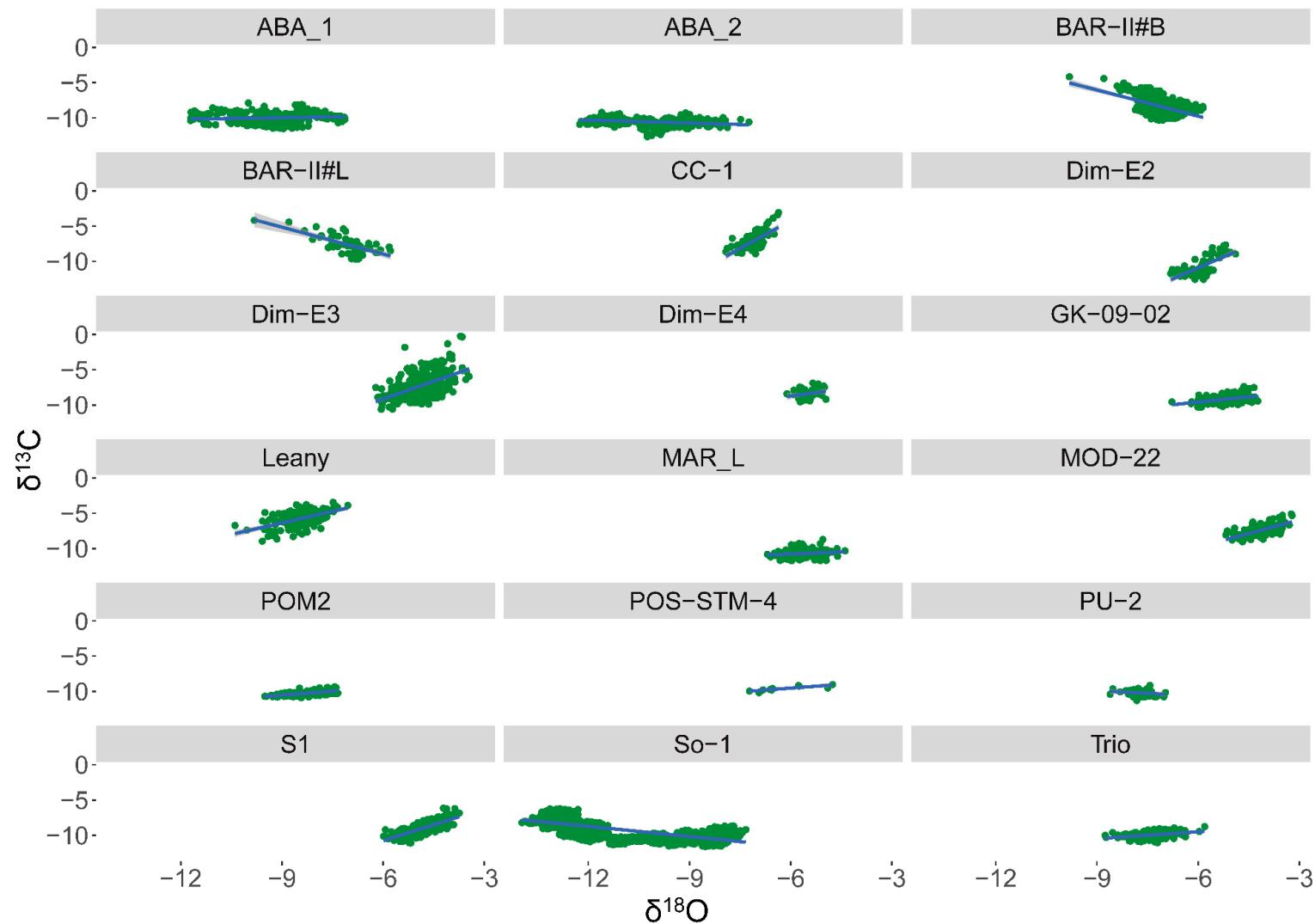
Figure S2. $\delta^{13}C$ vs. $\delta^{18}O$ where the blue lines mark the least squares regression lines and the grey envelope curves mark the confidence intervals of the models. The statistics of the plotted regression models can be found in Table S1.

Table S1. Statistics for the regression models δ¹³C vs. δ¹⁸O, where adj. R² stands for adjusted R², σ for the standard deviation, df for the degrees of freedom and std. error for the standard error. The model p-values insignificant at p= 0.05 are in italics. The estimated δ¹⁸O slopes and p-values are shaded from blue to red to indicate the lower and higher values respectively. The rows are sorted according to the slopes.

Entity_name	Model					Intercept			Estimated δ^{18}O		
	R^2	adj. R^2	σ	p.value	df	Coeff.	std.error	p.value	Slope	std.error	p.value
BAR-II#L	0.460	0.451	0.948	0.000	2	-16.61	1.31	4.408E-18	-1.28	0.18	4.836E-09
BAR-II#B	0.240	0.238	0.995	0.000	2	-17.18	0.70	7.842E-88	-1.24	0.10	1.368E-31
So-1	0.584	0.584	0.816	0.000	2	-14.47	0.07	0.000E+00	-0.48	0.01	0.000E+00
PU-2	0.035	0.009	0.446	*0.252*	2	-12.08	1.60	5.461E-09	-0.24	0.21	2.518E-01
ABA_2	0.103	0.101	0.479	0.000	2	-12.00	0.21	9.068E-206	-0.14	0.02	5.592E-12
ABA_1	0.012	0.009	0.729	0.044	2	-9.32	0.34	7.562E-88	0.07	0.04	4.450E-02
MAR_L	0.031	0.026	0.451	0.011	2	-9.66	0.41	1.565E-60	0.19	0.07	1.056E-02
Trio	0.166	0.163	0.409	0.000	2	-7.55	0.32	1.520E-69	0.32	0.04	8.464E-13
POS-STM-4	0.681	0.641	0.219	0.003	2	-7.40	0.53	7.131E-07	0.35	0.09	3.299E-03
POM2	0.347	0.343	0.252	0.000	2	-7.19	0.35	1.923E-45	0.37	0.04	2.141E-15
GK-09-02	0.165	0.161	0.466	0.000	2	-6.61	0.44	7.630E-34	0.50	0.08	1.767E-08
Dim-E4	0.059	0.039	0.671	*0.089*	2	-4.89	2.03	1.990E-02	0.64	0.37	8.911E-02
Leany	0.321	0.317	0.902	0.000	2	3.47	0.97	4.509E-04	1.09	0.12	1.923E-17
MOD-22	0.476	0.471	0.632	0.000	2	-2.05	0.54	2.218E-04	1.29	0.13	5.522E-17
S1	0.618	0.617	0.523	0.000	2	-1.68	0.31	1.161E-07	1.52	0.06	1.738E-75
Dim-E3	0.312	0.311	1.381	0.000	2	0.89	0.59	1.281E-01	1.67	0.12	1.136E-37
Dim-E2	0.523	0.518	0.846	0.000	2	1.54	1.27	2.275E-01	2.08	0.21	1.694E-15
CC-1	0.464	0.458	0.898	0.000	2	11.62	2.04	1.354E-07	2.64	0.29	6.535E-15

References

1. Kottek, M.G., Jürgen; Beck, Christoph; Rudolf, Bruno; Rubel, Franz. World map of the köppen-geiger climate classification updated. *Meteorologische Zeitschrift* **2006**, *15*, 259-263.
2. Rubel, F.; Brugger, K.; Haslinger, K.; Auer, I. The climate of the european alps: Shift of very high resolution köppen-geiger climate zones 1800–2100. *Meteorologische Zeitschrift* **2017**, *26*, 115-125.