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Use of homogenized data to determine the influence of air temperature on the spring phenology phase of oak

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INTRODUCTION

European oak species (*Querus* sp.) are one of the most economically and ecologically important deciduous forest tree species in Europe. Oak species have an important ecological role, as they support various insects and their fruit (acorns) provide a valuable food source for many birds and mammals. The canopy of oaks allows a fair amount of light to pass through, permitting a diverse and enriched understory. About 10.6 % of the forest area in Slovakia is covered by oak forests. Only 6 species of oaks are common in Slovakia (*Q. petraea* L., *Q. robur* L., *Q. pubescens* L., *Q. dalechampii* L., *Q. rubra* L., *Q. polycarpa* Schur). The ecological and physiological optimums for the oak forests are both located at the 1st and 3rd vegetation degrees.
Between 1881 and 2021. Slovakia experienced a significant increase in annual mean air temperature of 0.15°C over 10 years. For annual atmospheric precipitation. we observed only a slight change of up to about 1%. However. there has been a change in the temporal distribution of atmospheric precipitation during the year. with an increase in the number of droughts. which are more intense and longer lasting, and an increase in the number of floods and flash floods (8NC SR, 2023).
The main purpose of this study was to show on the importance of homogenization. Thanks to the homogenized data, we analysed the relationship between the selected phenological phase of oak (leaf unfolding) and air temperature (period of March and April) for the period of 26 years (1997-2022).

CLIMATOLOGICAL AND PHENOLOGICAL DATA

Climatological data (monthly air temperature means) and **Phenological data** (onset of leaf unfolding) for the period of 26 years (1997-2022) were obtained from 20 climatological stations, respectively 21 phenological stations which are situated in a direct neighborhood of climatological stations. Climatological and phenological stations are monitored by Slovak Hydrometeorological Institute (SHMI).

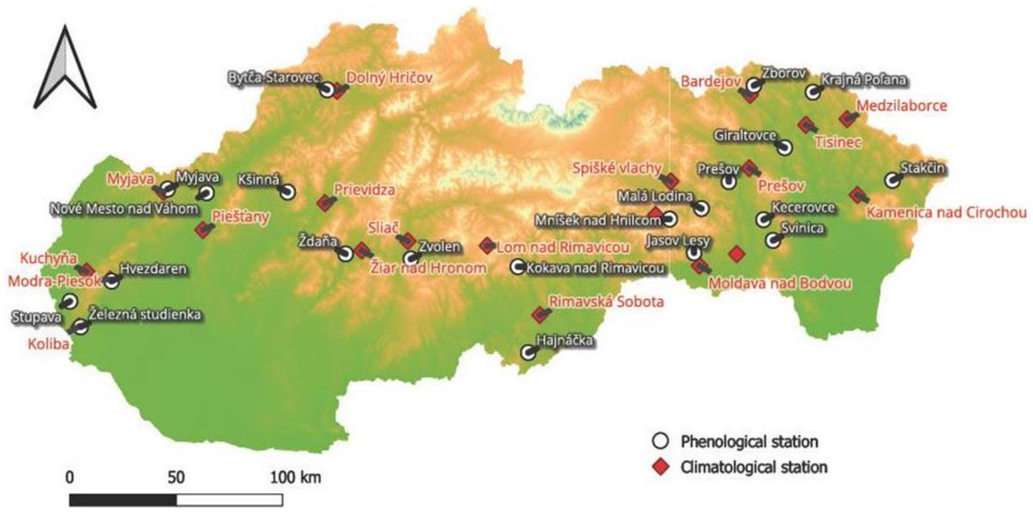


Figure 1: Map of Slovakia with position of selected phenological and climatological stations

METHODS

1. HOMOGENIZATION

For the purposes of the study. we used the MASH (T.Szentimrey) program to homogenize the data of daily air temperature on 20 climatological stations in Slovakia. MASH software also includes quality control and missing data implementation units. Depending on the climatic features. an additive or multiplicative model can be used. In our case. an additive model for air temperature was used. The used software version was MASHv3.03.

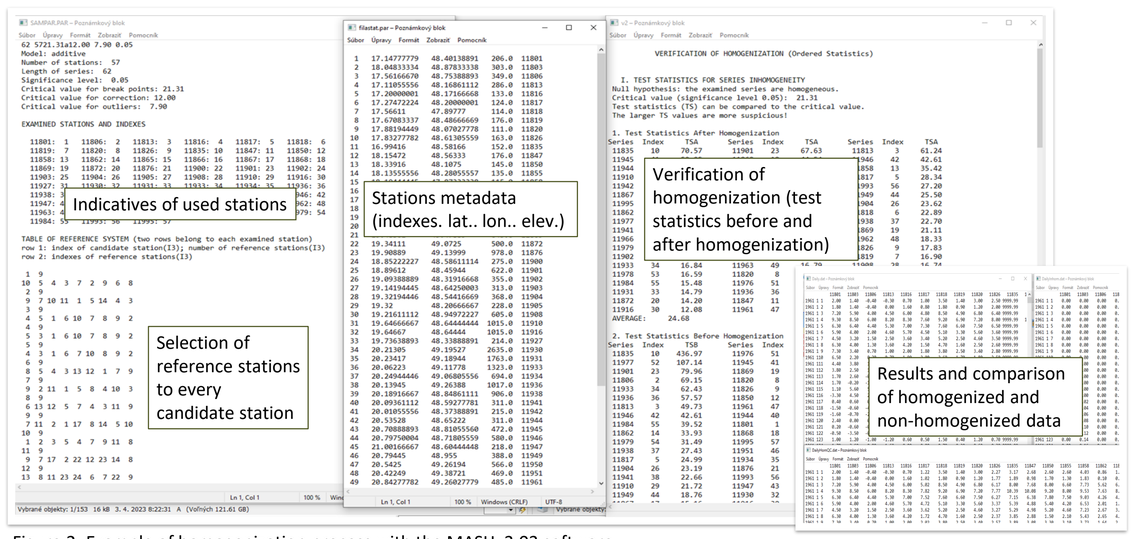


Figure 2: Example of homogenization process with the MASHv3.03 software

2. MEANS OF MONTHLY AIR TEMPERATURES

A methodology of phenological observations was created according to the methodology used by the SHMI for the long-term monitoring of forest plants (Braslavská et Kamenský 1996). The onset of phenological phases was expressed as a sequence of days counted from 1 January to the day of the year (DOY). Monthly air temperatures (homogenized data of temperature) used in the analysis, was calculated as the mean of monthly air temperatures over the periods of two months (March-April) preceding the onset of leaf unfolding (BBCH 15) of oak (according to modified methodology from Braslavská et Borsányi 1996).

3. CATEGORY OF PHENOLOGICAL STATIONS

Oak forests was divided to 3 categories based on the altitude:
1. category represents 5 phenological stations (**150 - 250 m a.s.l.**)
2. category represents 11 phenological stations (**250 - 350 m a.s.l.**)
3. category represents 5 phenological stations (**> 350 m a.s.l.**)

RESULTS

Our analyses confirmed statistically significant trends (P<0.05) and a medium negative correlation between air temperature (period of March-April) and the onset of the spring phenophase (leaf unfolding) in the 1st category (expect Giraltovce stations) and 2nd category (expect Zvolen, Kecerovce, and Bytča-Starovec stations). However, non-significant trends, but a medium negative correlations was found in the 3rd category (expect Hvezdáreň, and Myjava stations). We also found that leaf unfolding of oak has shifted to an earlier start during the period of 26 years (1997-2022).

Table 1. List of phenological stations

Category	Fenological station	Altitude [m a.s.l.]	R value	P value	Shift of phase/decade [day]
1	Stupava	177	-0.42	0.030	-3.7
	Nové Mesto nad Váhom	196	-0.42	0.031	-3.7
	Železná studienka	220	-0.44	0.022	-2.7
	Hajnáčka	220	-0.46	0.015	-3.1
	Giraltovce	240	-0.36	0.067	-2.1
2	Stakčín	256	-0.37	0.055	-2.1
	Svinica	272	-0.48	0.010	-2.6
	Jasov Lesy	280	-0.41	0.032	-3.0
	Krajná Poľana	295	-0.4	0.040	-2.1
	Zvolen	300	-0.38	0.052	-3.0
	Žďaňa	300	-0.39	0.044	-3.1
	Bytča-Starovec	305	-0.38	0.051	-2.8
	Kšinná	314	-0.43	0.026	-2.7
	Kokava nad Rimavicou	325	-0.38	0.048	-3.0
	Zborov	325	-0.45	0.020	-2.6
3	Kecerovce	328	-0.36	0.067	-2.9
	Myjava	383	-0.47	0.013	-3.2
	Prešov	388	-0.36	0.068	-3.0
	Malá Lodina	420	-0.35	0.069	-3.0
	Mníšek nad Hnilcom	471	-0.34	0.078	-3.0
	Hvezdaren	531	-0.43	0.026	-2.7

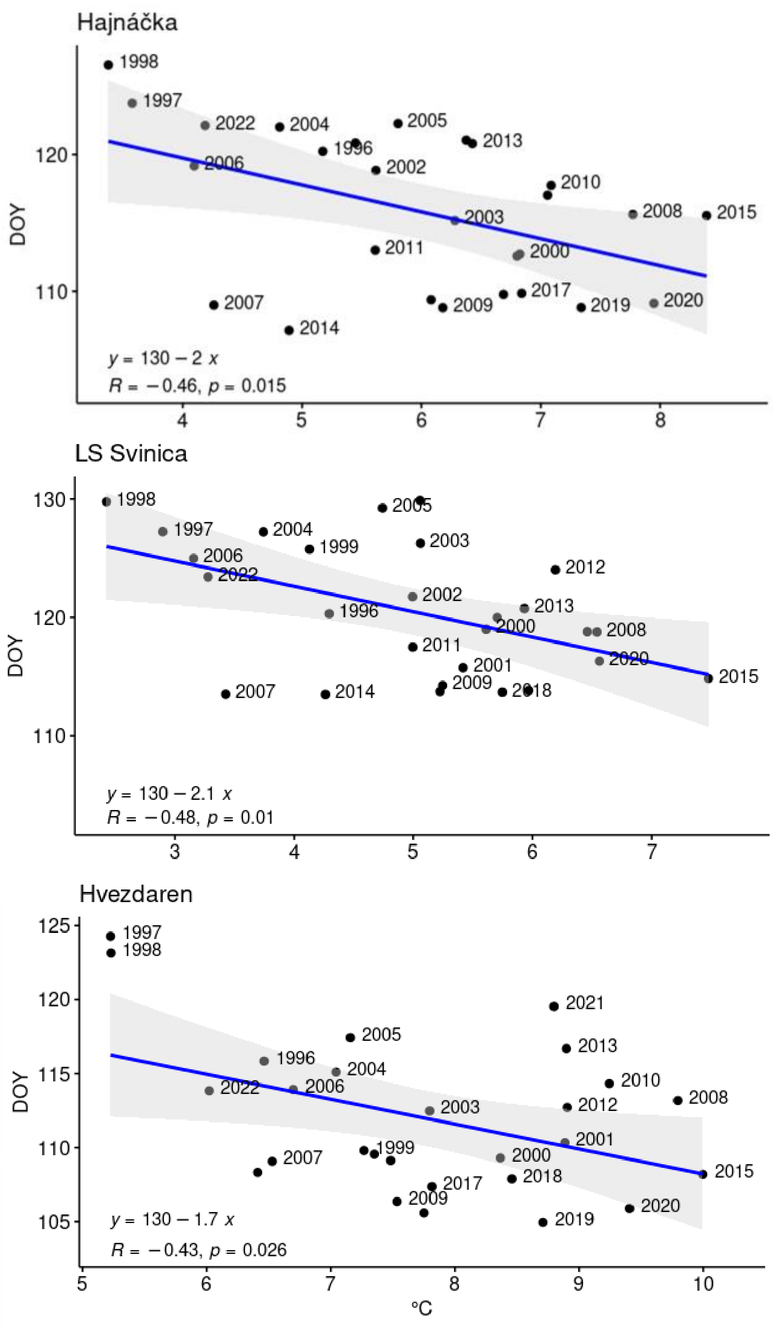
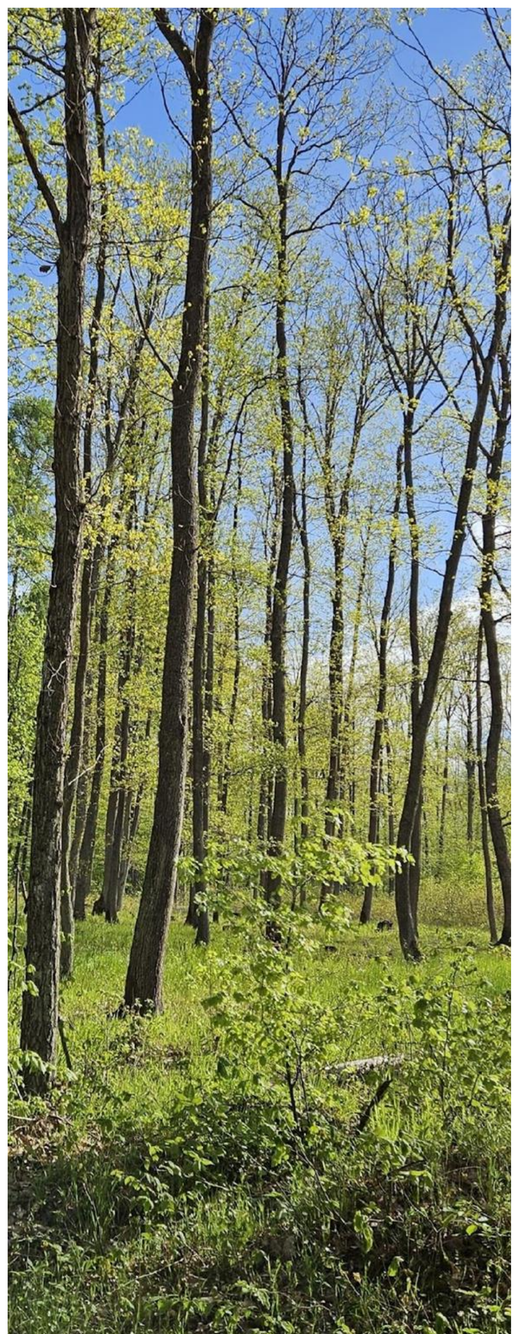


Figure 3: Relationship between air temperature and day of year



Conclusions

Our results indicate that temperature modified vegetative development of oak species. The analysis revealed a statistically significant, intermediate degree of correlation between the temperatures in spring (March–April) and the onset of leaf unfolding (in the 1st and the 2nd category). Trend analysis pointed to an earlier onset of leaf unfolding during the period of 26 years (1997-2022). This study shows the meaning and importance of homogenized data. Thus, we can analyse the long-term phenological events, like the leaf unfolding of oak.

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