Hungarian Geographical Bulletin

Volume 71 Number 1 2022

Research Centre for Astronomy and Earth Sciences
GEOGRAPHICAL INSTITUTE

HUNGARIAN GEOGRAPHICAL BULLETIN

Quarterly Journal of the
GEOGRAPHICAL INSTITUTE
RESEARCH CENTRE FOR ASTRONOMY AND EARTH SCIENCES

Indexed by Elsevier-GEOBASE®, Elsevier-SCOPUS®,
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DOI: 10.15201/hungeobull.71.1.1 Hungarian Geographical Bulletin **71** 2022 (1) 3–19.

Estimating relative sunshine duration from commonly available meteorological variables for simulating biome distribution in the Carpathian Region

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Abstract

Bright sunshine duration (BSD) data are required for simulating biomes using process-based vegetation models. However, monthly global paleoclimate datasets that can be used in paleo data–model comparisons do not necessarily contain BSD or radiation data. Considering the theoretical and practical aspects, the scheme of Yin, X. (1999) is here recommended to estimate monthly time series of relative BSD using only monthly climate and location data. As a case study for the Carpathian Region, the efficiency of both the original and a variant of that scheme is analysed in this paper. The alternative scheme has high applicability in paleoenvironmental studies. Comparison of the estimated and observed BSD data shows that from May to August, the value of relative root mean squared error in more than 90 percent of the study area does not exceed the threshold of 20 percent, indicating an excellent performance of the original estimation scheme. It is also found that though the magnitude of overestimation for the alternative algorithm is significant in the winter period, the proposed method performs similarly well in the growing season as the original. Furthermore, concerning modelling the distribution of biomes, simulation experiments are performed to assess the effects of modifying some configuration settings: (a) the generation of relative BSD data, and (b) the algorithm used to create quasi-daily weather data from the monthly values. Under both the recent humidity conditions of the study region and the spatial resolution of the climate dataset used, the results can be considered sufficiently robust, regardless of the configuration settings tested. Thus, using monthly temperature and precipitation climatologies, the spatial distribution of biomes can be properly simulated with the configuration settings proposed here.

Keywords: sunshine duration, water balance, biome, plant functional types, data–model comparisons, CarpatClim

Received November 2021, accepted March 2022

Introduction

Today there are a number of tools available to translate climate model outputs into vegetation distribution patterns (see e.g., bioclimatic classification methods: Prentice, K.C. 1990; correlative vs. mechanistic biome models: Yates, D.N. *et al.* 2000; species distribution models: Elith, J. and Leathwick, J.R. 2009). Bioclimatic classification methods (BCMs)

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are tools used to transform a set of climate and soil variables into an index-class that can be directly related to biome-level vegetation units (Tapiador, F.J. *et al.* 2019). Correlative models determine a statistical relationship between vegetation distribution and environmental variables (e.g., climate, soil, etc.); then this link is applied to simulate the potential distribution of vegetation under the altered conditions (Yates, D.N. *et al.* 2000; Elith, J. and Leathwick, J.R. 2009). From this point of view, therefore, BCMs (e.g., Köppen, W. 1936) can be considered the simplest correlative biome models. Mechanistic biome models, in contrast, focus on mechanisms determining survival and performance of plants by simulating processes in soil–vegetation–atmosphere systems, such as water, carbon and nutrient cycles (Prentice, I.C. *et al.* 2007).

Paleoclimatological and paleoenvironmental studies often use both outputs from climate model simulations and proxy archives such as fossil pollen records in a common framework. These studies represent a special area of called paleo data–model comparisons (Harrison, S.P. 2013) that have essentially two distinct purposes: (a) to understand the mechanisms of past climate and environmental shifts (e.g., Miller, P.A. *et al.* 2008; Mauri, A. *et al.* 2014), and (b) to provide feedback on the performance of climate/environmental reconstruction approaches (e.g., Prentice, I.C. *et al.* 1998; Webb, III T. *et al.* 1998). These comparisons can be made in two ways, either by collating pollen-inferred climate with that simulated by climate models (e.g., Webb, III T. *et al.* 1998; Mauri, A. *et al.* 2014), or by comparing biome/species distribution estimated using paleoclimate model outputs with vegetation reconstructed from pollen assemblages (e.g., Prentice, I.C. *et al.* 1998; Miller, P.A. *et al.* 2008).

Currently, more and more global datasets are made publicly available that provide bias-corrected monthly climatologies (multi-year averages) from paleoclimate simulations in order to support distribution modelling experiments in various research areas (e.g., paleobiogeography, archaeology). However, these datasets differ significantly in terms of spatial resolution, temporal coverage and time step, and in terms of which climate variables they contain information on. Beyer, R.M. *et al.* (2020), for example, published a monthly global dataset (hereinafter HadCM3-120k), with a horizontal resolution of 0.5°, for temperature, precipitation, cloud cover, relative humidity, and wind speed, and additional parameters related to bioclimatic and biogeochemical conditions, covering the last 120,000 years at a temporal resolution of 1,000–2,000 years. For this, medium-resolution simulations generated by the HadCM3 general circulation model (GCM) for the last 120,000 years were combined with high-resolution simulations prepared by the HadAM3H GCM for the last 21,000 years and a recent observational dataset. (For details of the above-mentioned GCMs, see Valdes, P.J. *et al.* 2017.) Then, Krapp, M. *et al.* (2021) extended access to the climate variables in question for the last 800,000 years by performing a statistical-based reconstruction using the above-mentioned simulations. And recently, Karger, D.N. *et al.* (in review) shared with the scientific community their dataset, called CHELSA-TraCE21k v1.0, that includes monthly climatologies for both temperature and precipitation, and other bioclimatic variables, with a spatial resolution of 30 arc-sec at a 100-year time step for the last 21,000 years. For this, a transient simulation generated by the CCSM3 GCM (He, F. 2011) was downscaled considering the temporal change of orography.

The HadCM3-120k was specifically generated to feed mechanistic biome models, while the CHELSA-TraCE21k v1.0 was clearly developed to support paleoecological studies using correlative species distribution models (SDMs). In SDMs (e.g., MaxEnt: Phillips, S.J. *et al.* 2006), bioclimatic variables, i.e., annual and seasonal measures derived from monthly values of temperature and precipitation, are generally used as environmental predictors, besides topographic variables. In contrast, due to the simulation of energy and water fluxes, for applying mechanistic biome models, a meteorological variable directly related

to radiation (e.g., cloud cover, sunshine duration) is also required, besides temperature and precipitation data. Beyer, R.M. *et al.* (2020) and Krapp, M. *et al.* (2021), relying on their own datasets, also estimated the evolution of the global biome distribution using one of the best-known mechanistic biome models, called BIOME4 (Kaplan, J.O. 2001). The BIOME*n* models (e.g., BIOME: Prentice, I.C. *et al.* 1992; BIOME4) estimate the net radiation as a function of latitude, temperature, and bright sunshine duration (BSD). Thus, to apply the above-mentioned vegetation model to their own datasets, the authors used different empirical linear relationships (Doorenbos, J. and Pruitt, W.O. 1977; Hoyt, D.V. 1977) to convert cloud cover data to the percentage of possible sunshine hours. Unfortunately, the CHELSA-TraCE21k v1.0 does not contain cloudiness or BSD data, so it is not directly suitable for feeding the above-mentioned BIOME*n* models. However, estimating BSD data from commonly available meteorological variables may be a solution to overcome the lack of data.

Although there are several estimation methods for calculating monthly values of BSD (Kandirmaz, H.M. *et al.* 2014), in this study, the use of a method developed by Yin, X. (1999) is recommended. Yin, X. (1999) used monthly data of 729 worldwide stations for finding a generic algorithm that captures global variability of BSD data in relation to temperature, precipitation, and geographic location. Regression models for estimating monthly mean daily values of BSD are usually set only for smaller regions due to limited access to reliable station data (e.g., Italy: Stanghellini, C. 1981), and/or use parameters that are not readily available from global gridded climate datasets (e.g., the number of wet days per month: Castellvi, F. 2001). Thus, what makes the method proposed by Yin, X. (1999) special is that it is globally parameterized and uses only monthly climate and location data that are widely available.

To our knowledge, by means of gridded climate datasets, the performance of the estimation scheme proposed by Yin, X. (1999) has not yet been evaluated. Our current level of knowledge would indicate that there is currently no global gridded observational dataset to which the following three statements are true without exception: (i) it contains monthly values for BSD, temperature, and precipitation; (ii) it contains monthly meteorological data for a long period without time averaging; and (iii) it was developed based on station observations. Currently, there is only access to global datasets that also use remotely sensed and reanalysis data to produce gridded climate information, and for which values of BSD can only be derived from another meteorological variable (e.g., incoming solar radiation: TerraClimate, Abatzoglou, J.T. *et al.* 2018; cloud cover: CRU TS v4, Harris, I. *et al.* 2020). However, two regional climate databases are known that provide station-based meteorological fields for the above-mentioned three variables for continuous periods: CarpatClim (Spinoni, J. *et al.* 2015) and HadUK-Grid (Hollis, D. *et al.* 2019).

In consideration of the literature discussed above, the first objective of this study is to assess the accuracy of the scheme under discussion using the monthly climate data provided by the CarpatClim dataset. The second goal of this paper is to test how the quality of estimates changes as a result of proposed modifications of the approach, which are justified by its applicability in paleoenvironmental studies. The amount of incoming and outgoing radiation influences the growing conditions of plants, so the error in estimating the relative BSD can cause problems in the modelling of the biome distribution. Therefore, as a case study for the Carpathian Region, evaluation of the impact of the estimated relative BSD on simulation of energy and water fluxes and biome designation is the third aim of this study.

Materials and methods

Estimation of monthly mean relative sunshine duration

The monthly mean daily values of relative BSD (*RSD*, dimensionless) for a given month is estimated using the following parametric regression model as recommended by Yin, X. (1999):

$$RSD = e^{\left[-1.65 \cdot p \cdot f_o \cdot \left(1+\sum f_i\right)\right]}, \quad (1)$$

with

$$f_o = f(R_E) \cdot f(P) \cdot f(T, E_P) \cdot f(\phi), \quad (2)$$

where

$$f(R_E) = [1 + 0.756 \cdot R_E \cdot (3 - R_E)]^{-1}, \quad (3)$$

$$f(P) = \frac{1 + 0.785 \cdot P}{1 + 0.222 \cdot P}, \quad (4)$$

$$f(T, E_P) = 1 + \frac{(7.66 \cdot I_{T<0} - 4.98) \cdot T + E_P^2}{184}, \quad (5)$$

$$f(\phi) = 1 + 0.512 \cdot \sin\left(\frac{(\phi + 15) \cdot 2\pi}{77}\right), \quad (6)$$

and

$$f_i = \begin{cases} \dfrac{15.6 - T_{am}}{46.3}, & \text{if island or Australia} \\ 0.331 - 0.213 \cdot E_{Pam} - \dfrac{|T_{am}|}{72.5} + \dfrac{\max(T_{min}, 0)}{30}, & \text{if North America} \\ 0, & \text{if South America} \\ \dfrac{1}{10.2} + \dfrac{P_7 - P_1}{36.8 \cdot P_{am}} \cdot \left(2.3 - \dfrac{P_7 - P_1}{P_{am}}\right), & \text{if Eurasia} \\ -0.643 + 0.314 \cdot R_E + (31.8 - T_{am}) \cdot \left(\dfrac{T_{am}}{140}\right)^2, & \text{if monsoonal Asia} \\ \dfrac{7.26 - T_{ar}}{32.3}, & \text{if Africa} \end{cases}, \quad (7)$$

where p is the station atmospheric pressure in relation to the pressure at sea level, f_o represents global trends, f_i gives regional modifications, $\sum f_i$ is the summation of values of any regional functions that are applicable to a particular location, R_E is the monthly average of hourly solar irradiance for cloudless-sky conditions (in MJ m^{-2} hr^{-1}), P is the monthly mean precipitation intensity (in mm dy^{-1}), T is the monthly mean air temperature (in °C), E_p is the monthly average of daily potential evapotranspiration (in mm dy^{-1}), ϕ is the latitude (in decimal degrees), $I_{T<0}$ is a temperature indicator (1 if $T \leq 0$ °C, and 0 if $T > 0$ °C), T_{am} is the annual mean temperature (in °C), E_{Pam} is the annual average of daily potential evapotranspiration (in mm dy^{-1}), T_{min} is the lowest monthly mean air temperature (in °C), P_7 is the monthly mean precipitation intensity (in mm dy^{-1}) in the warmest month (fixed at July for the Northern Hemisphere, and January for the Southern Hemisphere), P_1 is the monthly mean precipitation intensity (in mm dy^{-1}) in the coldest month (fixed at January for the Northern Hemisphere, and July for the Southern Hemisphere), P_{am} is the annual mean precipitation intensity (in mm dy^{-1}), T_{ar} is the annual range of monthly mean air temperature (annual diurnal range) (in °C).

The values of R_E are calculated as proposed by Yin, X. (1997a), with a minor modification, using the daytime means of optical air mass and cosine zenith. The former is computed as recommended by Yin, X. (1997a), while the latter is estimated by using Eq. 5 of Yin, X. (1997b). Furthermore, in contrast to the original approach, where the solar constant was fixed at 4.9212 MJ m^{-2} hr^{-1}, its value is corrected, according to Yin, X. (1999), by calendar day for the variable ellipticity of the Earth's orbit using the scheme of Brock, T.D. (1981). In these calculations, the values of solar declination and daylength are derived by using the approach of Brock, T.D. (1981). The values of E_p are computed using Eq. A10 of Yin, X. (1998). The value of E_{Pam} is calculated as a weighted mean of the E_p values using the number of days in months as weights.

Simulation of biome distribution

In this study, the BIOME model (Prentice, I.C. *et al.* 1992) is applied to simulate the spatial distribution of biome-level vegetation units. First, the presence of each plant functional type (PFT) that is a group of plant types with similar ecophysiological behaviour is estimated under given climatic conditions. To do this, it is necessary to check which of the 14 PFTs defined can occur considering the environmental constraints associated with their climatic tolerances and requirements *(Table 1).* After this, the dominance class value (D) of each PFT is examined and only those in the highest class (with lowest D) present are retained. Finally, to infer the biome type, retained PFTs are combined with each other by taking into account rules formalized in *Table 2.*

Table 1. Dominance class (D) and environmental constraints for each plant functional type used in the model*

Abbreviation	Plant functional type	D	T_C		GDD_0	GDD_5	T_W	α	
			min	max	min	min	min	min	max
tr.e.t	Tropical evergreen tree	1	15.5	–	–	–	–	0.80	–
tr.r.t	Tropical rain-green tree	1	15.5	–	–	–	–	0.45	0.95
w-te.e.t	Warm temperate evergreen tree	2	5.0	–	–	–	–	0.65	–
te.s.t	Temperate summer-green tree	3	−15.0	15.5	–	1,200	–	0.65	–
c-te.c.t	Cool temperate conifer tree	3	−19.0	5.0	–	900	–	0.65	–
bo.e.t	Boreal evergreen conifer tree	3	−35.0	−2.0	–	350	–	0.75	–
bo.s.t	Boreal summer-green tree	3	–	5.0	–	350	–	0.65	–
sb.suc	Sclerophyll/succulent	4	5.0	–	–	–	22	0.28	–
wa.g.s	Warm grass/shrub	5	–	–	–	–	–	0.18	–
cl.g.s	Cool grass/shrub	6	–	–	–	500	–	0.33	–
cd.g.s	Cold grass/shrub	6	–	–	100	–	22	0.33	–
h.d.s	Hot desert shrub	7	–	–	–	–	–	–	–
c.d.s	Cold desert shrub	8	–	–	100	–	–	–	–
p.d	Polar desert	9	–	–	–	–	–	–	–

*T_C = mean temperature of the coldest month (in °C); GDD_0 = growing degree-days above a 0 °C base (in °C day); GDD_5 = growing degree-days above a 5 °C base (in °C day); T_W = mean temperature of the warmest month (in °C); α = Priestley–Taylor coefficient at an annual time scale (dimensionless).

Table 2. A list of biome types used in the model and their generation rules

Abbreviation	Biome type	Plant functional types
TRRA	Tropical rain forest	tr.e.t
TRSE	Tropical seasonal forest	tr.e.t + tr.r.t
TRDR	Tropical dry forest/savannah	tr.r.t
WAMX	Broad-leaved evergreen/warm mixed forest	w-te.e.t
TEDE	Temperate deciduous forest	te.s + c-te.c.t + bo.s.t
COMX	Cool mixed forest	te.s.t + c-te.c.t + bo.e.t + bo.s.t
COCO	Cool conifer forest	c-te.c.t + bo.e.t + bo.s.t
TAIG	Taiga	bo.e.t + bo.s.t
CLMX	Cold mixed forest	c-te.c.t + bo.s.t
CLDE	Cold deciduous forest	bo.s.t
XERO	Xerophytic woods/scrub	sb.suc
WAST	Warm grass/shrub	wa.g.s
COST	Cool grass/shrub	cl.g.s + cd.g.s
TUND	Tundra	cd.g.s
HODE	Hot desert	h.d.s
SEDE	Semi-desert	c.d.s
PODE	Polar desert	p.d

Note: Each biome type is arising as a combination of dominant plant functional types.

In the BIOME model, the plant-available moisture is characterized by the Priestley–Taylor coefficient (α, dimensionless). Here, the values of α at an annual time scale are computed by using the SPLASH v.1.0 model (Davis, T.W. *et al.* 2017), through the simulation of seasonal changes in both surface energy fluxes and climatic water balance. In the BIOME model, in order to quantify heat requirement, the growing degree-days (*GDD*, in °C day) is used, which can be obtained by summing the values of daily temperature above a certain base temperature. To calculate values of *GDD*, the values of daily mean temperature are required; furthermore, besides temperature and precipitation data, the relative BSD must also be used in the SPLASH v.1.0 model, on a daily basis. The methods for generating these daily values are described in more detail below.

Evaluation methodology

Monthly time series of the temperature, precipitation and sunshine duration, along with location data, are required for evaluating the performance of the procedure proposed by Yin, X. (1999). The CarpatClim dataset provides access to the three meteorological variables relevant to the assessment for the time period 1960–2010, with a horizontal resolution of 0.1°, covering nine countries with 5,895 grid cells *(Figure 1).* For this reason, using data derived from this dataset, *RSD* values for each year in the period 1961–2010 are estimated using the scheme developed by Yin, X. (1999), and the estimates are compared to the observed data. Observed values of *RSD* are determined by a two-step procedure, following Spinoni, J. *et al.* (2015): (i) the monthly amount of BSD to which the CarpatClim dataset provides access is divided by the number of days in a given month to calculate the monthly mean for BSD, and then (ii) this value is divided by the monthly mean for daylength that is calculated using Eq. 8.5.3 of Iqbal, M. (1983). Finally, in each grid cell, values of the root mean square error normalized by the mean value of observed data (*RRMSE*, in percentages) are computed between the observed and estimated 50-year time series of *RSD*, separately for each month.

To apply the parametric regression model proposed by Yin, X. (1999) to monthly global paleoclimate datasets already described in the introduction, two modifications are needed to use. A feature of such paleoclimate datasets is that they represent climatic conditions averaged over a longer period (typically 30 or 50 years) at each time step. For this reason, it is considered necessary to in-

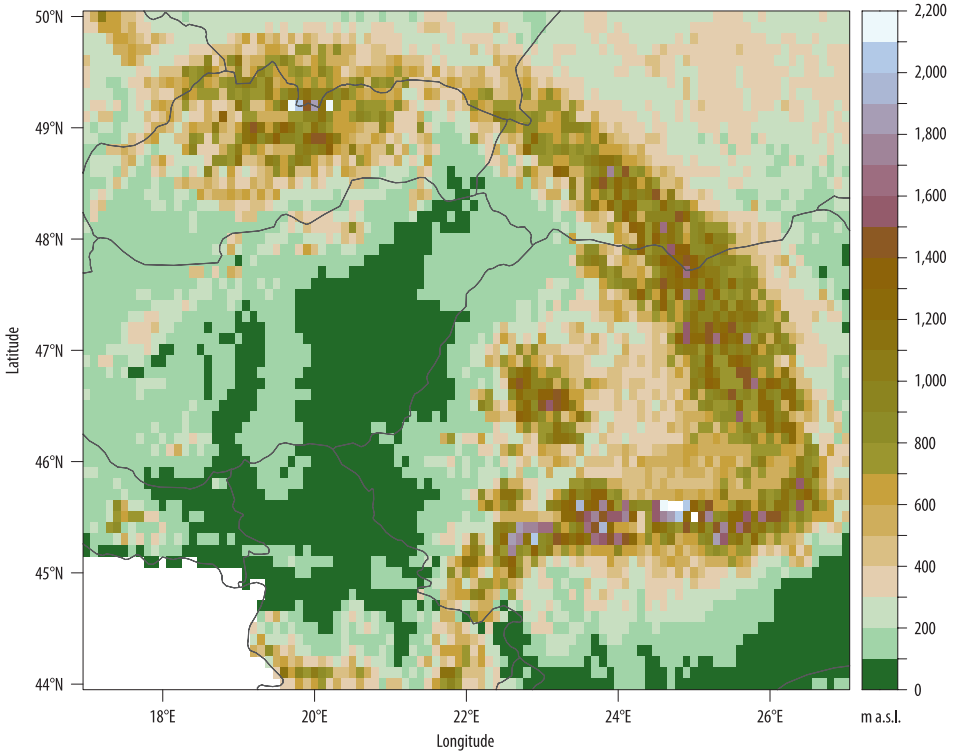


Fig. 1. Topography of the Carpathian Region based on the CarpatClim dataset (Spinoni, J. *et al.* 2015)

vestigate how the scheme performs when applied to multi-year averages instead of single year time series. Furthermore, the regression model of Yin, X. (1999) also uses the monthly mean of hourly solar irradiance to estimate the global trend, but uses an algorithm to estimate the value of R_E that cannot be applied without modification in paleoclimatological studies because it does not consider changes in the Earth's orbital parameters. For this reason, here, it is recommended that the value of R_E be calculated using the algorithm used in the SPLASH v.1.0 model, with the addition that orbital parameters are calculated using the method of Berger, A. and Loutre, M.F. (1991). In this approach, first, the daily solar radiation at the top of the atmosphere is calculated (Eq. 7 in Davis, T.W. *et al.* 2017), and then this value is multiplied by the atmospheric transmissivity to obtain the value of daily surface radiation. In this case, as well, cloudless conditions are assumed, i.e., the transmission coefficient is taken into account with a universal value of 0.75, however, its value is modified as a function of elevation by using the scheme of Allen, R.G. (1996). The daylength is calculated via Eq. 1.6.11 in Duffie, J.A. and Beckman, W.A. (1991), using the sunset hour angle (Eq. 8 in Davis, T.W. *et al.* 2017). Finally, the mean hourly surface radiation is derived as the quotient of the daily surface radiation and the daylength. In this study, using the CarpatClim dataset, values of *RSD* for the period 1981–2010 are computed in two ways: (A) by averaging the time series estimated using the initial scheme for each year, and (B) by applying the scheme to 30-year averages, with the provision that the values of R_E are calculated for year 1995 using the algorithm described above.

When modelling the distribution of biomes, monthly climatologies must be converted to daily values, in order to simulate seasonal changes in both surface energy fluxes and climatic water balance. In the description of the water balance module used in the initial version of the BIOME model, Prentice, I.C. *et al.* (1993) have recommended for this that monthly values are interpolated linearly between mid-month days. However, this approach is unsound because it is not mean-preserving (the monthly means of the interpolated daily values will generally not match the original monthly values). When presenting the SPLASH v.1.0 model, Davis, T.W. *et al.* (2017) simply suggested that monthly mean values are assumed constant over each day of the month. This procedure is suitable in terms of the monthly averages, but it generates unrealistic time series. In the 1990s, several mean-preserving methods (see e.g., Epstein, E.S. 1991; Lüdeke, M.K.B. *et al.* 1994) were developed to address this issue. Here, quasi-daily values are constructed in two ways: (a) monthly averages of temperature and *RSD* are assumed constant, and the monthly precipitation sum is divided equally across each day of the month; and (b) for temperature and *RSD*, the 'harmonic' interpolation technique described by Epstein, E.S. (1991) is used, with a correction of physically impossible values, and in the case of precipitation, the temporal scaling using an iterative interpolation technique described by Lüdeke, M.K.B. *et al.* (1994) is applied, with a damping variable of 0.7 for each month.

In this study, we assess the effects of the choice of the method used to generate the quasi-daily values and of the source of the BSD data on the results in terms of the spatial distribution of the bioclimatic variables used in the BIOME model. Finally, biome maps simulated under various model configuration settings are compared using the Kappa statistic (Cohen, J. 1960), which value ranges from 0 to 1, with 0 representing totally different patterns and 1 indicating complete agreement.

Results and discussion

One of the key objectives of this study is to attempt to evaluate the performance of the estimation procedure for *RSD* using data provided by the CarpatClim database. The performance of the scheme proposed by Yin, X. (1999) is assessed based on the root

mean square error normalized by the mean value of observed data (*RRMSE*, in percentages) calculated between the observed and estimated values for the period 1961–2010, separately for each month *(Figure 2).* From May to August, the *RRMSE* value in more than 90 percent of the study area does not exceed the threshold of 20 percent below which the model performance can be considered excellent, according to Bellocchi, G. *et al.* (2002). In the period from April to October, in nearly 99 percent of the grid cells with elevation smaller than 500 m a.s.l., the value of *RRMSE* is less than 40 percent, which is the limit of the model performance still considered acceptable based on the work of Bellocchi, G. *et al.* (2002). In the summer months, the *RRMSE* value in almost 90 percent of the lower regions (elevation < 500 m a.s.l.) does not even exceed the threshold of 15 percent. Interestingly, in the winter months, the estimation scheme performs better in the higher than in the lower elevation areas (66 ± 3% and 45 ± 28% of the regions at elevations above and below 500 m a.s.l., respectively, with a threshold of 40%). Although not within the scope of this study, it should be pointed out that the inconsistency between the measured and estimated values found in the Ukrainian section of the Carpathians suggests (see *Figure 2*) that one or even more of the climate fields used in the assessment may contain significant errors in this region. However, an explanation of this requires a more detailed analysis.

An important objective of this paper is to assess how the accuracy of the estimates changes when the scheme is adapted for applying to paleoclimate datasets. To study this, values of *RSD* for the period 1981–2010 are calculated in two ways *(Figure 3)*: (A) by averaging the time series estimated using the initial scheme for each year, and (B) by applying the scheme to 30-year averages. The estimated results are compared to the averages of the measured values over the period 1981–2010 *(Figure 3,* b*).* For the time window used here, we can see that in the period from March to September, the estimation method proposed here performs even better than the initial algorithm. In these months, i.e., in the most important period in terms of the evapotranspiration processes, with one exception, the value of *RRMSE* calculated for the whole study area does not exceed the threshold of 10 percent (see the second row in *Figure 3,* b), which indicates a very good quality of the estimates. (As previously indicated, the Ukrainian part of the Carpathians is the main contributor to the observed discrepancies.)

In the context of *Figure 3*, it is important to underline that when applying the modified estimation scheme to 30-year averages, the overestimation is very high in the winter months (in January, its value exceeds the value of 0.15 over almost half of the region), which, combined with a low (around 0.254 in January) benchmark, results in very high values of *RRMSE*: 60.8 percent in January and almost 30 percent in February. For both estimation methods, the difference in winter months, which is also highlighted above in relation to the *Figure 2*, is probably related to the formation of conditions for cold-air pool (CAP), which is a typical weather situation in the Carpathian Basin (Szabóné André, K. *et al.* 2021). Namely, the CAP conditions are extremely favourable for the formation of fog which lead to less surface solar radiation. Considering that the model is globally parameterized, it is impractical to expect it to capture such local effects, but fortunately, this model weakness has little relevance in simulating important processes for plants, as it will also be shown later.

The ultimate goal of this study is to examine how sensitive the BIOME model is to change configuration settings. We are interested in how the results change when on the one hand, the measured time series of *RSD* are replaced by estimates produced by different algorithms, and on the other hand, the technique for generating daily weather data is made more sophisticated. For the latter aspect, the simulations are performed in two ways: (a) monthly means are assumed constant over each day of the month, and (b) different mean-preserving interpolation techniques are applied (for details, see evaluation methods).

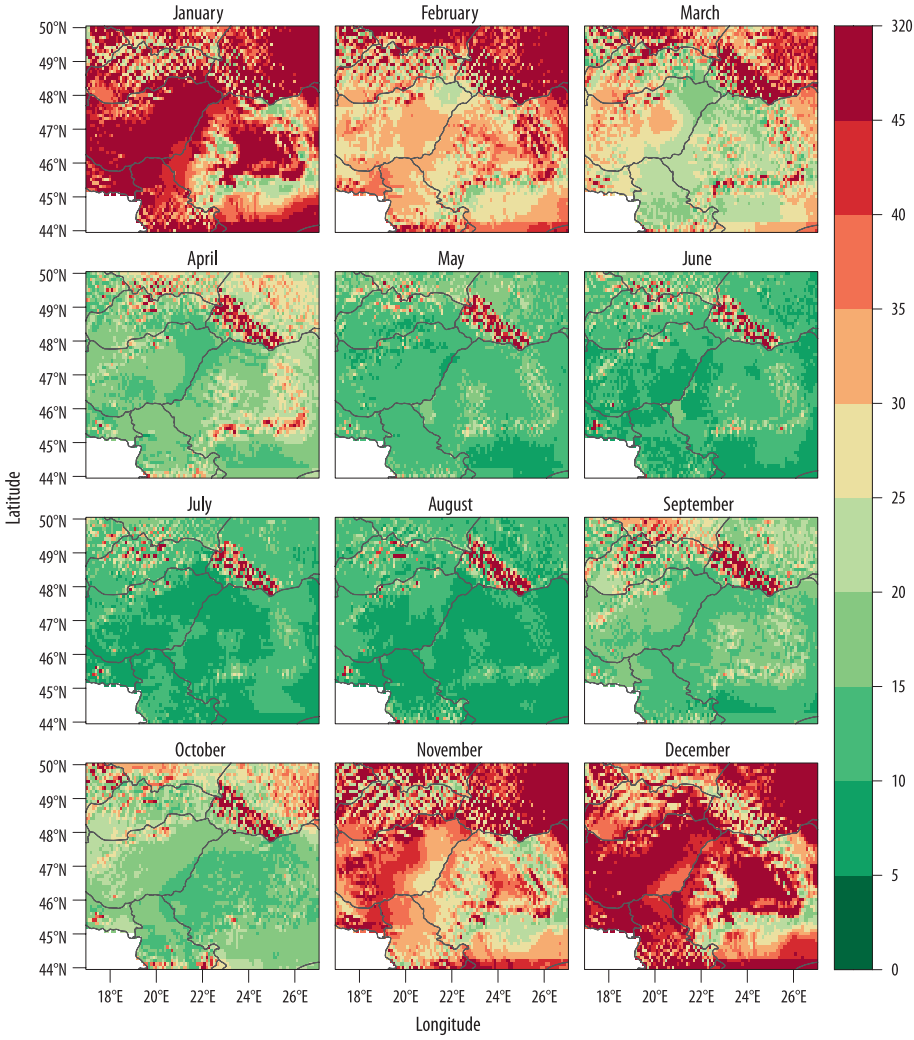


Fig. 2. Performance of the regression model developed by Yin, X. (1999) to estimate monthly time series of the relative sunshine duration (*RSD*, dimensionless), based on the root mean square error normalized by the mean value of observed data (*RRMSE*, in percentages). *RRMSE* values are calculated between the observed and estimated values for the period 1961–2010 using the CarpatClim dataset, separately for each month.

The presence of PFTs is fundamentally dependent on the plant-available moisture, which in the BIOME model is characterized by the α ranging from 0 to 1.26. Its value for the period 1981–2010 is calculated at an annual time scale using the SPLASH v.1.0 model, with a total of six settings *(Figure 4)*. The simulation performed using the measured values of *RSD* and assuming constant monthly means of each meteorological variable over each day of the month is considered as a reference *(Figure 4*, a*)*. Based on this, it can be concluded that there is sufficient moisture in the study area for all woody PFTs related to mid-latitudes (cf. *Figure 4*, a, and *Table 2*), with the spatial resolution and

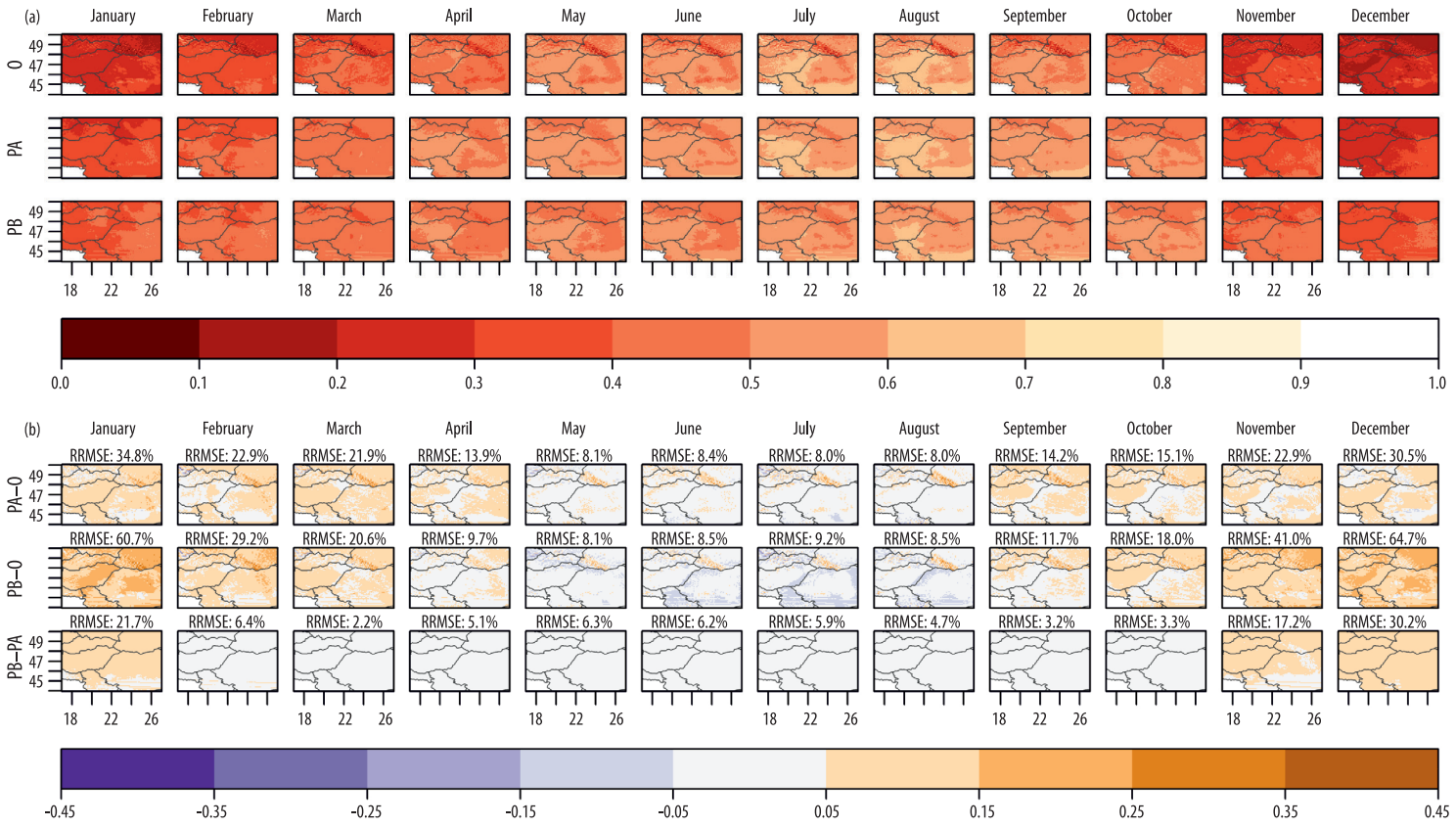
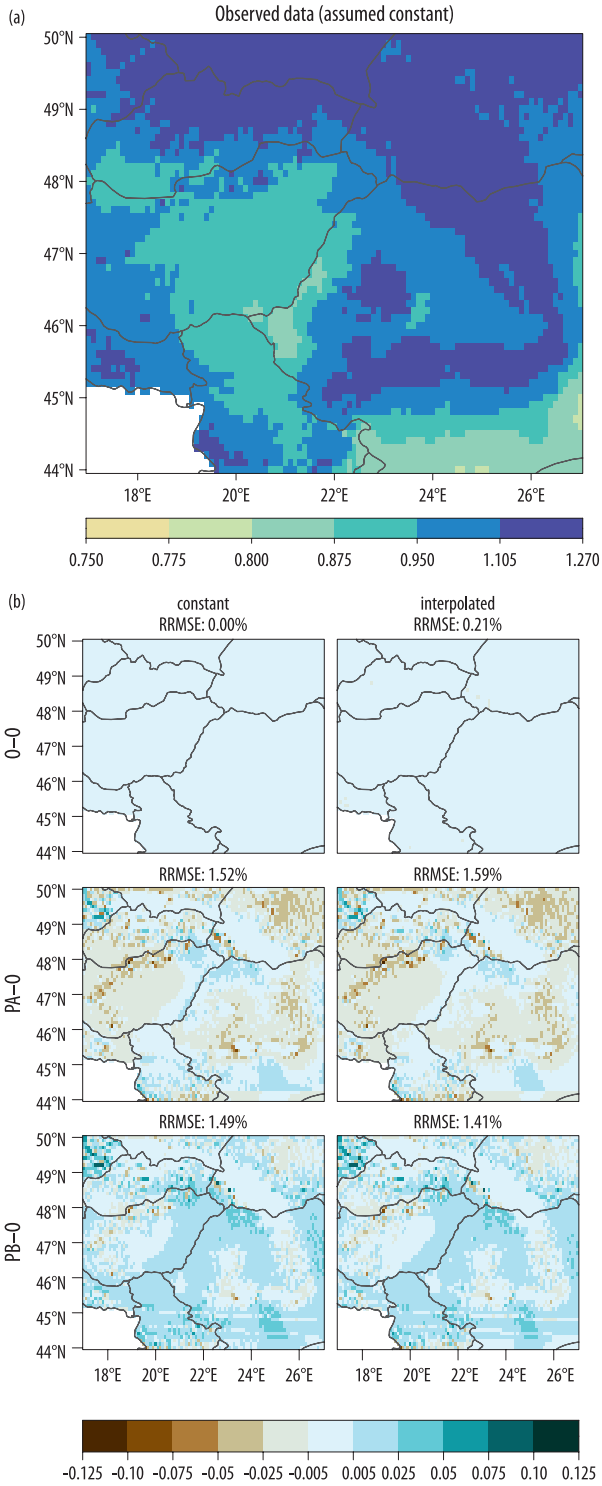


Fig. 3. Spatial distribution patterns of monthly mean of relative sunshine duration (*RSD*, dimensionless) in the Carpathian Region for the period 1981–2010: by averaging the observed time series for each year (O); by averaging the time series estimated using the scheme proposed by Yin, X. (1999) for each year (PA); and by applying the scheme to 30-year averages, with the provision that the term related to the solar irradiance in the model (see R_E in Eq. 3) is calculated for year 1995 using the algorithm used in the SPLASH v.1.0 model (for details see evaluation methodology) (PB). In addition to the values (a), the differences from the various sources are also mapped (b: PA–O, PB–O, and PB–PA), in the latter case showing the root mean square error normalized by the mean value of reference data (*RRMSE*, in percentages) over the whole target domain.



time window used here. The change in the methodology for generating daily weather data has little effect on the spatial distributions of this bioclimatic index over the study period: for only 13 out of the 5,895 grid cells, the value of α changes by more than 0.005 when the daily data required for the simulation are generated using more sophisticated techniques (see the first row of the second column in *Figure 4*, b). Regardless of the settings, the value of α for the period 1981–2010 does not change over at least one-third of the target domain, however, the spatial distribution of these unchanged areas varies depending on the choice of source for

Fig. 4. Spatial distributions of the Priestley–Taylor coefficient (α, dimensionless) in the Carpathian Region for the period 1981–2010: (a) the values of α are simulated by the SPLASH v.1.0 model using the observed values of monthly means of relative sunshine duration (*RSD*, dimensionless), assuming monthly means for each meteorological variable to be constant over each day of the month; and (b) the differences of α values modelled by the initial algorithm and estimated under various model configurations. In each cell of the panel (b), the references are derived from the panel (a). In each row of the panel (b), the estimates are calculated using the *RSD* values derived from various sources: (O) by averaging the single year time series of the observations; (PA) by averaging the time series estimated using the initial scheme for each year; and (PB) by applying the scheme to 30-year averages. In each column of the panel (b), the estimates are calculated using quasi-daily values of each meteorological variable generated by different approaches: (constant) monthly means are assumed constant over each day of the month; and (interpolated) different mean-preserving interpolation techniques are applied (for details, see evaluation methodology). In the panel (b), the root mean square error normalized by the mean value of reference data (*RRMSE*, in percentages) over the whole target domain is shown above each map.

the *RSD* data. When using the model driven by sunshine data estimated using multi-year averages, the unchanged areas are limited to the Carpathians that are the wettest regions of the target domain (see the third row in *Figure 4*, b). At this setting, wetter conditions compared to the reference are simulated over more than two-thirds of the study area (66.9% and 63.2%, respectively, for constant and interpolated daily data). While simulations using estimated single year time series of *RSD* show an underestimation in an area of a similar extent (see the second row in *Figure 4*, b). Overall, changing the configuration settings does not have a significant effect on this bioclimatic index, with the *RRMSE* for this index hovering around 1.5 percent, considering all simulation experiments.

Considering all five bioclimatic indices used in the BIOME model, in addition to α, the growing degree-days can also be significantly influenced by the approach used to generate daily temperature values. Thus, a sensitivity analysis is also performed for these two indices. Values of GDD_5 and GDD_0 for the period 1981–2010 are calculated using the two approaches described above, and their spatial distribution *(Figure 5*) is plotted (mostly) using the thresholds used in the BIOME model (see *Table 1*). Except for the highest peaks of the Carpathians, in the target domain, the value of GDD_5 exceeds the threshold of

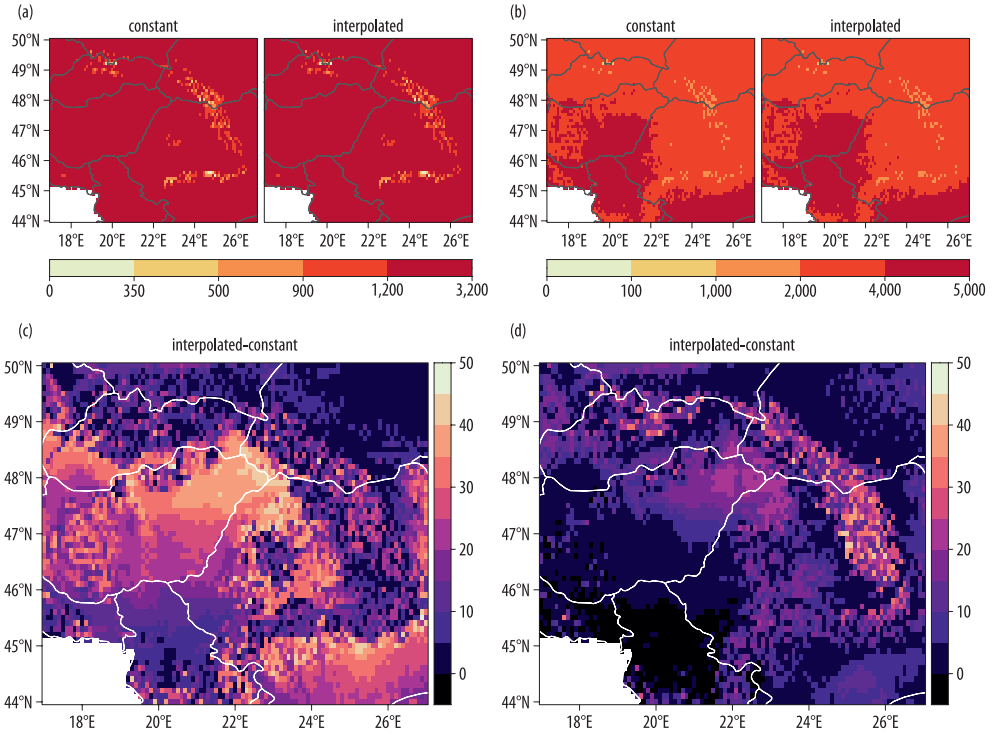


Fig. 5. Spatial distributions of growing degree-days above base temperatures of 5 °C and 0 °C (GDD_5 and GDD_0, in °C day) in the Carpathian Region for the period 1981–2010. Panels (a) and (b) show the spatial distribution of respectively GDD_5 and GDD_0 depending on how the quasi-daily temperature values required to compute these bioclimatic indices are constructed: (constant) monthly means are assumed constant over each day of the month; and (interpolated) the 'harmonic' interpolation technique described by Epstein, E.S. (1991) is applied. Panels (c) and (d) show the spatial distributions of the differences between growing degree-days calculated from interpolated and constant daily values, respectively, for GDD_5 and GDD_0.

1,200 °C day, regardless of the settings (see *Figure 5*), and thus, in these regions, the PFT "temperate summer-green tree" (te.s.t) can occur (see *Table 2*), due to the availability of sufficient moisture (see *Figure 4*). Although, in relation to the spatial distribution of these indices (*Figure 5*, a and b), a large difference between the two approaches cannot be observed, inter alia due the thresholds used to plotting, but the distribution maps for the differences (*Figure 5*, c and d) provide additional valuable information. In the case of GDD_5 (GDD_0), the areas with a difference of greater than 30 °C day are mostly located at altitudes lower (higher) than 500 m a.s.l. (cf. *Figure 5*, c and d, and *Figure 1*). For growing degree-days, the difference between the two algorithms is greater in grid cells where the monthly mean temperatures in the first and last months of the growing season are spread around the given base temperature and the annual diurnal range is relatively large. It is easy to understand that under a typical annual temperature course, in cases where the monthly mean temperature is equal to or slightly greater than 5 °C in both April and November, for the GDD_5, a larger amount of heat can be generated from interpolated values than from constant daily data.

As a final step in this study, it is checked how changing the configuration settings affects the biome designation. Thus, the main results of this study include the distribution maps of biomes under different configuration settings *(Figure 6)*. Here again, the reference simulation is prepared using the measured values of *RSD* and assuming constant monthly means (the first row of the first column in *Figure 6*). For the period 1981–2010, 5 out of the 14 extratropical biome types used by the BIOME model can be observed in the Carpathian Region, at a horizontal resolution of 0.1°. More than half (55%) of the target area is covered by the biome type "temperate deciduous forest" (TEDE), mostly limited to the lowlands (elevation < 250 m a.s.l.). With an areal proportion of 40.7 percent, the second most dominant biome type in the target domain is the "cool mixed forest" (COMX), covering significant areas in Slovakia, Ukraine and the mountains of Romania. The types "taiga" (TAIG) and "cool conifer forest" (COCO) together cover a total of 4.2 percent of the study area. As shown in *Figure 6*, these types appear most markedly in the Eastern Carpathians. The type "tundra" (TUND) covers slightly more than 0.1 percent of the target area (7 grid cells). Comparing the simulation experiments, it can be found that the choice of source for the time series of *RSD* has no effect on the biome distribution under given space and time conditions: values of the Kappa statistic between the maps derived from the reference simulation and from the remaining two experiments are equal to one, i.e., the spatial distribution patterns of biomes are completely identical (see the first column in *Figure 6*). Biome maps generated using interpolated daily values are consistent with each other (see the second column in *Figure 6*). Comparing them to the reference map, only a slight mismatch can be found (Kappa statistic = 0.9923). There is a disagreement between biome maps for only 24 of the 5,895 grid cells derived using different daily weather data. In all cases, this mismatch is explained by the discrepancy in the spatial distribution of GDD_5 (see *Figure 5*, c). The difference is ultimately due to the fact that in some grid cells of the Carpathians, certain heat-demanding woody PFTs (e.g., te.s.t) can occur in the case of the reference simulation, in contrast to the experiments using interpolated daily values. In summary, the BIOME model is not sensitive to modify configuration settings considered here.

Conclusions

In this paper, as a case study for the Carpathian Region, we inspect the efficiency of biome distribution simulation using only monthly temperature and precipitation climatologies. The biome maps were constructed by using a simple process-based vegetation model, the BIOME model, with one minor amendment: the water balance module of the model was

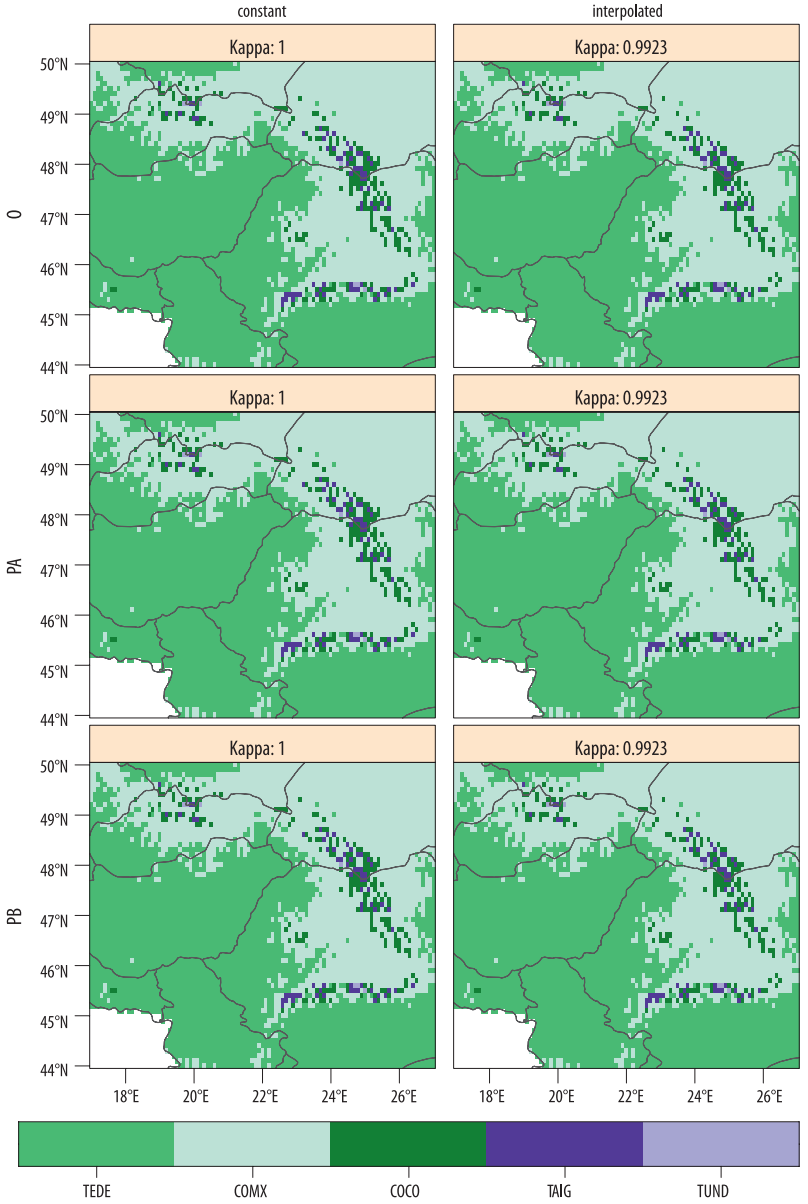


Fig. 6. Spatial distribution patterns of biomes simulated by the BIOME model in the Carpathian Region for the period 1981–2010. In each row, the biomes are derived using the sunshine duration data derived from different sources: (O) by averaging the single year time series of the observations; (PA) by averaging the time series estimated using the initial scheme for each year; and (PB) by applying the scheme to 30-year averages. In each column, the biomes are derived using quasi-daily values of each meteorological variable generated by different approaches: (constant) monthly means are assumed constant over each day of the month; and (interpolated) different mean-preserving interpolation techniques are applied (for details, see evaluation methodology). Above each map, the Kappa statistic reflecting the degree of similarity of the distribution patterns is shown, using the map in the first column of the first row as a reference in each case. The abbreviations of biome types can be found in *Table 2*.

replaced by the SPLASH v.1.0 model, thus switching to analytical expressions for calculating daily radiation, evapotranspiration and soil moisture. Monthly temperature and precipitation data, which were required to create the biome maps, were taken from the CarpatClim dataset for the period 1981–2010. The relative BSD data required to run the SPLASH v.1.0 model were taken from the CarpatClim dataset and also estimated by the scheme proposed by Yin, X. (1999) using the above-mentioned temperature and precipitation data. Comparisons between the observed and estimated relative BSD time series for the period 1961–2010 showed that the estimation procedure performed relatively well from late spring to early autumn, i.e., in the most important period in terms of the evapotranspiration processes. It was also examined the effects of two modifications justified by the applicability of the estimation method to paleoclimate datasets: (a) to apply the scheme of Yin, X. (1999) to multi-year averages instead of single year time series, and (b) to calculate the term related to the solar irradiance in the scheme by applying the algorithm used in the SPLASH v.1.0 model under changing orbital parameters of the Earth. It was found that although the magnitude of overestimation for the modified algorithm is significant in the winter period, the proposed procedure performs similarly well as the initial procedure in the period from March to October. When modelling the distribution of biomes, simulation experiments were performed to assess the effects of modifying some configuration settings of the model: (a) the generation of relative BSD data, and (b) the algorithm used to create quasi-daily weather data from the monthly climatologies. We found that under both the recent humidity conditions of the study region and the spatial resolution of the climate dataset used, the results can be considered sufficiently robust, regardless of the configuration settings tested. The choice of source for BSD data had no effect on the results, while the choice of the method for temporal downscaling of monthly temperature data had little effect on the distribution patterns of biomes. Thus, the main message of this paper is that using climate data available for Quaternary studies (i.e., monthly temperature and precipitation climatologies), the spatial distribution of biomes can be properly simulated via more sophisticated biome models than BCMs. We believe that by applying the modelling framework outlined here to the data provided by the CHELSA-TraCE21k v1.0, the evolution of biomes over the past millennia can be properly mapped.

***Acknowledgements*:** The work of the first author was supported by the European Union and the State of Hungary, co-financed by the European Social Fund in the framework of TÁMOP 4.2.4. A/2-11-1-2012-0001 'National Excellence Program'. The work of the second author was partly financed by the János Bolyai Research Scholarship of the Hungarian Academy of Sciences. The authors would like to thank the creators of the CarpatClim dataset (http://www.carpatclim-eu.org/) used in this study for sharing their datasets with the scientific community. The authors are also grateful to the software developers of the SPLASH model (https://bitbucket.org/labprentice/splash) for making available to everyone their source codes.

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DOI: 10.15201/hungeobull.71.1.2 Hungarian Geographical Bulletin **71** 2022 (1) 21–37.

Appearance of climatic cycles and oscillations in Carpathian Basin precipitation data

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Abstract

A number of climatic cycles and teleconnections are known on the Earth. By definition, the cycles can have a periodic effect on the global climate, while teleconnections can influence the weather at large distances. At the same time, it is overwhelmingly assumed that the hydrological cycle is permanently intensifying all over the world. In this study, we determine and quantify some connections among these climatic cycles and precipitation data from across Hungary. By using cross-correlation and cross-spectral analysis, the connections of the climatic patterns and oscillations with the precipitation of different Hungarian areas have been defined. We used the 1950–2010 timeframe in order to be able to detect effects of several climatic patterns, such as the El Niño-Southern Oscillation (ENSO), the Arctic Oscillation (AO), the North Atlantic Oscillation (NAO), the Pacific/North American teleconnection pattern (PNA) and the Atlantic Multidecadal Oscillation (AMO) on the rainfall events of the Carpathian Basin. Data from four different precipitation measurement sites and oscillation indexes from several databases were used. The results help to understand the patterns and regularities of the precipitation, which is the major source of natural groundwater recharge, and a handy tool for future groundwater management measures. Because of the defined connections, any changes in these teleconnections will probably influence the future utilization of the Hungarian groundwater resources.

Keywords: hydrological cycle, climatic anomaly, precipitation, groundwater recharge, oscillations

Received October 2021, accepted February 2022.

Introduction

Extreme weather conditions influence the hydrological cycle (Szűcs, P. *et al.* 2015). The observed effects are varied (Jakab, G. *et al.* 2019). In the measurement-based hydro-meteorological datasets both periodic as well as stochastic components can be observed. Teleconnections can influence the local weather conditions over large physical distances. In spite of the huge amount of available monitoring data, the patterns and periodicities, especially the latter, are still unsolved problems in hydrology (Böschl, G. *et al.* 2019).

The hydrological cycle is defined as the circulation and flow of water on Earth. As previously written (IPCC 2012): „The cycle in which water evaporates from the oceans and the land surface is carried over the Earth in atmospheric circulation as water vapour, condenses to form clouds, precipitates again as rain or snow, is intercepted by trees and vegetation, provides runoff on the land surface, infiltrates into soils, recharges groundwater, and/or discharges into streams and flows out into the oceans, and ultimately evaporates again from the oceans or land surface. The various systems involved in the

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hydrological cycle are usually referred to as hydrological systems."

One of the hypothetical consequences of the common scientific consensus of the climate change is that specific humidity increases with rising temperatures, and increased evaporation is associated with more precipitation.

It is normal to be expected that there will be approximately 3.8 percent more precipitation per additional degree of temperature. This hypothetical phenomenon is called the intensification or "acceleration" of the hydrological cycle (Del Genio, A. *et al.* 1991). Huntington, T. (2006) provided the first experimental support for the hypothesis. The study concluded, despite a number of uncertainties, that the behaviour of most hydrological variables is consistent with the assumed intensification of the hydrological cycle. The study (Huntington, T. 2006) was supported by others with additional data sets, to the extent that the intensification of the hydrological cycle has become almost universally accepted. However, in a comprehensive analysis, (Koutsoyiannis, D. 2020) refuted the claims about one-way trends in the elements of the hydrological cycle. Instead of monotonous tendencies, he showed all kinds of fluctuations in the hydrological cycle (from strengthening to weakening and *vice versa*), and in the 21st century, he showed the prevalence of weakening. A one-way trend was observed only in the increase in groundwater use, which leads to a small increase in sea level on a global scale.

The peculiarities of (Koutsoyiannis, D. 2020)'s approach are as follows: (1) he ignored what the models indicate for the future; (2) he used the longest possible time series available instead of shorter, selected periods; (3) he did not focus on certain limited areas (because it is a common experience that a hydrological indicator that becomes more intense in one place may simultaneously weaken in another); (4) he used a well-defined, transparent processing method; (5) he embraced the Aristotle principle "It is the mark of educated man to look for precision in each class of things just so far as the nature of the subject admits", which also has the necessary consequence that (Huntington, T. 2006) the estimated 2 percent increase in precipitation for the entire 20th century is below the error of definition.

The very first test point of the hypothesis of accelerating the hydrological cycle would normally be to test claims for an increase in atmospheric water vapor content itself. Long data sets (radiosonde measurements) are available from the troposphere alone; surface GPS, solar photometer and satellite data used to measure integrated water vapor of the atmosphere (IWV) go back too short a period of time. The question, of course, is how much definitional certainty the Aristotelian principle allows. According to the proponents of the intensification of the hydrological cycle, global warming can cause more uneven rainfall distribution, more devastating storms, torrential rains and unexpected flash floods, regardless of changes in atmospheric water vapour content (Szöllősi-Nagy, A. 2018). The hypothesis of accelerating the hydrological cycle becomes so complex and untraceable that it is less and less possible to check their truthfulness based on Feyman's scientific method (Feynman, R. 1964). In Feynman's interpretation we could address this by easily saying that such hypotheses are no longer scientific. The situation is even more complicated: it is quite likely that the arguments needed for an exact refutation may be lost in the Aristotelian swamp. On the one hand, it is necessary to analyse the most accurate and longest time period available in a local, regional and global context (e.g. Ilyés, C. *et al.* 2016) from Hungary), and on the other hand, it is necessary to analyze the in-depth theoretical studies on the characteristics of natural time series.

The main objective of this paper is to determine how various global climatic cycles and oscillations can influence the local precipitation, thus, all the other components of the hydrological cycle in the Carpathian Basin.

Sustainable utilization of groundwater resources in Hungary

Groundwater resources play a major role in Hungary's drinking water supply system.

Hydrogeologists have a responsible role in safeguarding the groundwater resources and managing their sustainable utilization in quantitative and qualitative terms (Szűcs, P. *et al.* 2013). During the past few years hydrogeologist experts had to face numerous global or local environmental challenges that may have significant effect on environmental elements, especially on groundwater (Kohán, B. and Szalai, J. 2014).

The natural replenishment of groundwater resources is a key factor concerning the future aspects of sustainable utilization (Szűcs, P. *et al.* 2015). The demand for groundwater resources is continuously increasing in Hungary as well as all over the world. Besides the drinking water supply, thermal water production is also significant in Hungary, which also underlines the importance of sustainability issues (Buday, T. *et al.* 2015). Extreme weather conditions can affect some components of the hydrological cycle, e.g. groundwater replenishment or natural recharge (Fehér, Z.Z. and Rakonczai, J. 2019).

Patterns and periodicities

Patterns and periodicities, especially the latter, have been still unsolved problems in hydrology (Böschl, G. *et al.* 2019). The pattern approach is relatively new. Looking back to the history, the weather predictability was based, from the beginning, on various – either observed or just assumed – periodicities. Examples: Indian and Chinese traditional calendars, based on a 60-year cycle known in the Indian tradition as the Brihaspati ("Jupiter") cycle, the biblical fourteen-year periodicity (Genesis 41: 18–30), and English folklore ("There is no debt so surely met as wet to dry and dry to wet"). Below we provide insight into the documented history of the periodicities.

A brief history of periodicity studies

A solar-weather connection was raised by Meldrum, C. (1873), followed by much discussion. (Marvin, C.F. 1921) introduced the term "periodocrite", in order to be able to separate obscure and hidden periodicities.

The mechanism of world-weather was found exceedingly complex (W. W. B. 1920). Even some bibliography collections were made on the possible influence of weather on crops. C. E. P. B. (1925) found a 28-month periodicity in weather and solar phenomena. (Abbot, C.G. 1939) discovered a 23-year periodicity. Priston, W.R. (1939) corrected it to 274 months and confirmed the existence of the quasi-biannual periodicity of 27 months.

Atmospheric processes take place through spatial waves (i.e. patterns) and/or of temporal periods as units (Zhang, J-C. 1981). In this paper, a 10 years cyclicity in yearly rainfall values in Beijing was revealed.

In Burroughs, W.J. (1992), the history of cycle-searching was summarized, and a mathematical treatment was provided, illustrated with plenty of examples. An insight into extra-terrestrial aspects, including celestial mechanics, was given, too. It was assumed (C. E. P. B. 1925) that if there is no plausible physical earthbound process, the cause should be looked for outside Earth. Moreover, perturbations propagate downwards from high in the stratosphere.

Due to satellite observations, significant oscillations (patterns and periods) were (and have been) found, having regional or global weather and climate impacts. Various climate indices were defined, and a number of teleconnections were revealed. Below we provide a brief summary of the most significant ones.

A brief summary on oscillations

The Southern Oscillation Index (SOI) is one of the world most important climate indices. It is a common measurement of the El Niño/La Nina (ENSO) teleconnection (Power, S.B. and Kociuba, G. 2011), and is a standardized index based on the observed sea level pressure differences between Tahiti and Darwin, Australia (PSL 2020). During the El Niño event, the SOI tends to be negative, and the changes

in the ENSO drive major changes in rainfall, agricultural production and river flow all across the world (Power, S.B. and Kociuba, G. 2011). ENSO typically lasts from 6 to 18 months (Chen, S. *et al.* 2020), with a 2–7-year cycle (Kuss, A.J.M. and Gurdak, J.J. 2014).

The Atlantic Multidecadal Oscillation (AMO), believed to be caused by the North Atlantic thermohaline circulation, is defined by the Sea Surface Temperature (SST) anomaly over the Atlantic from 0°N to 70°N (Enfield, D. *et al.* 2001), characterized by a 50–70-year period (Dijkstra, H.A. *et al.* 2006). Its effect on the climate of Europe was examined in the UK (Knight, J. *et al.* 2006) and in Romania (Ionita, M. *et al.* 2012), as well as several other areas around the Atlantic (Folland, C. *et al.* 2001; Knight, J. *et al.* 2005).

The North Atlantic Oscillation – along with the AMO – is the most important phenomenon influencing the weather variability over Europe (Ionita, M. *et al.* 2012; Dvoryaninov, G.S. *et al.* 2016), with the periodicity of 3–6 years (Kuss, A.J.M. and Gurdak, J.J. 2014). The NAO index is defined as the difference of the normalized sea-level pressure at the Azores and Iceland (Mokhov, I. and Smirnov, D. 2006) at inter-annual and inter-decadal time scales. The changes in circulation associated with changes in the NAO index are determined from the difference in sea-level pressure (SLP) between winters with an index value greater than 1.0 and those with an index value less than -1.0 (Hurrel, J. 1995).

The Arctic Oscillation (AO) is defined as an opposing pattern of pressures between the Arctic and northern mid-latitudes (Chen, S. *et al.* 2020). When the pressure is high in the Arctic, it tends to be low in the northern latitudes. That is called a negative phase, while the opposite is called a positive phase. When positive, it causes a wetter weather in Alaska, Scotland and Scandinavia, and a drier weather in the US and Mediterranean. If reversed, it brings stormy weather to the more temperate climates (Mokhov, I. and Smirnov, D. 2006).

The Pacific/North American teleconnection pattern (PNA) is one of the most recognized, influential climate patterns in the Northern Hemisphere mid-latitudes beyond the tropics. It consists of anomalies in the geopotential height fields (typically at 700 or 500 mb) observed over the western and eastern United States. It varies from intra-seasonal (2–90 days) to inter-annual time scales (2–20 years) (Allan, A.M. and Hostetler, S.W. 2014). The PNA influences the climate in autumn and winter in the whole Northern Hemisphere (Soulard, N. and Lin, H. 2017).

The relationship of these teleconnections was also thoroughly examined, with the relation of the ENSO and the AMO (Mokhov, I. and Smirnov, D. 2016), and the PNA (Song, J. *et al.* 2009), while all of the major teleconnections were found to have a relation with the ENSO. The NAO (Mokhov, I. and Smirnov, D. 2006) and the AO (Chen, S. *et al.* 2020) are also closely linked to each other (Rogers, J. and McHugh, M. 2002), and the connection between the PNA and the NAO was also investigated (Soulard, N. and Lin, H. 2017). A clear interconnection among them was detailed by Lüdecke, H-J. *et al.* (2021) while investigating African rainfall.

Connection with regional hydrological data

The global and regional effects on precipitation and groundwater levels have been examined thoroughly across the globe. The influence of NAO on temperature and precipitation is a widely studied subject (Hurrel, J. 1995; Slonosky, V. and Yiou, P. 2001). The global effect of ENSO, as examined in (Sun, X. *et al.* 2015), varies substantially by seasons, and the extreme precipitation is only affected by one phase, and is asymmetric in most of Europe.

In the US, it was found that the ENSO has a significant effect in case of precipitation and groundwater level fluctuations, with the higher frequency climate models showing greater ENSO effect (Velasco, E.M. *et al.* 2017). Other results indicate that the groundwater levels are partially controlled by interannual to multidecadal climate variability, and ENSO has a greater effect than NAO or AMO (Kuss, A.J.M. and Gurdak, J.J. 2014). In Canada, the

effects of ENSO and NAO on streamflow and precipitation were examined, and the results show that a positive phase reflected drier conditions, with lower amount of precipitation, whereas the negative phase reflected wetter conditions, and higher amount of streamflow (Nalley, D. *et al.* 2019).

Concerning European groundwater well data, it was found, that there are significant correlations between NAO, AMO and ENSO (Liesch, T. and Wunsch, A. 2019). The average coherence for AMO is higher than for NAO, while it was the highest for ENSO, meaning a larger influence (Lüdecke, H-J. *et al.* 2021). Also, several year-long periods were calculated, namely, periods of: 4 and 13–14 for NAO; 15, 23–25 and 60–80 for AMO; and 2–5, 15–18, 31 and 56 for ENSO (Liesch, T. and Wunsch, A. 2019). In the case of AO, in the positive phase, higher pressure at mid-latitudes drives ocean storms farther north, while changes in the circulation pattern bring drier conditions to the Mediterranean (Thompson, D.W.J. and Wallace, J.M. 1998). It is known that the winters of 2009–2010 and 2015–2016 were affected by the NAO (Seager, R. *et al.* 2010).

According to (Domonkos, P. 2003), the winter precipitation in Hungary decreases significantly when the NAO index increases. (Matyasovszky, I. 2003) showed a nonlinear relationship between the climate of Hungary and the ENSO.

Periodicities in stochastic time series, such as precipitation, were also examined, with several local, regional deterministic components defined in rainfall data covering 110 years (Ilyés, C. *et al.* 2017). In the study annual, monthly and daily precipitation time series were calculated using spectral analysis to find deterministic patterns in them. With this method several regional/countywide periods were defined. Detailed studies revealed further local cyclic parameters (Ilyés, C. *et al.* 2018).

With this research the main objective was to find connections between these climatic patterns and the periods defined before, in order to better understand the main factors behind the periodicity of the precipitation in Central Europe. These atmospheric oscillations vary in their time scales and locations, and the impacts on local precipitation is complex. In this research paper a correlation and spectral analysis were used for determining the nature of the connection.

Methods and materials

To implement the investigation, the precipitation data were downloaded from the Hungarian Meteorological Service's online database (HMS 2019), containing 5 different monitoring sites, over the timescale of 1950–2010. As the calculations require equidistant sampling, the monitoring site Szeged needed to be dropped from one of the calculations due to missing data in the 1940s.

The collected precipitation data resembles the climatic patterns of the Carpathian Basin, as seen in *Figure 1.* Budapest is located at the banks of the Danube River, in the middle of the basin, while Szombathely lies at the foothills of the Alps mountain range. The Debrecen monitoring site represents the Hungarian Great Plain and the eastern part of the basin, while the climate of the southwestern monitoring site, Pécs, is somewhat influenced by the Mediterranean. The Szeged monitoring site represents the southern area of the basin, with the smallest annual rainfall and the warmest climate.

For the calculations, monthly precipitation data were used, with an equidistant one-month sampling rate.

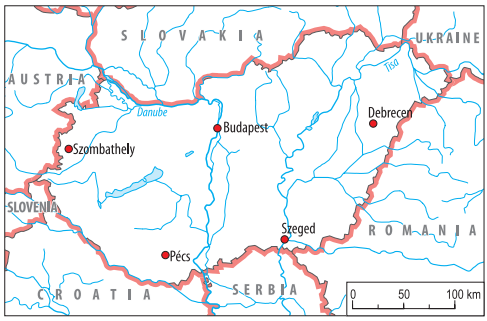

Fig. 1. The location of the monitoring sites in Hungary

The climatic data of the patterns and oscillations were collected from several open-source databases. The AMO data come from the Physical Sciences Laboratory at NOAA (PSL 2020), while the AO, NAO, PNA and SOI data were downloaded from the National Centres for Environmental Information at NOAA (NCEI 2020). The data has the January 1950 – December 2010 time frame in the cases of AO, PNA, NAO, and January 1951 – December 2010 in the case of SOI, while the AMO data are available from January 1901.

The method for examining a linear connection uses the following expressions to obtain the coefficients for correlation and cross-spectral analysis results. These methods were used to examine the connection between precipitation and karst water levels in several studies (Padilla, A. and Pulido-Bosch, A. 1995; Darabos, E. 2018) and the relation between teleconnections and streamflow (Pekarova, P. and Pekar, J. 2007).

Assume two discrete time series (x_t, and y_t), with n samples in each series. The cross-correlation function r obtained with the two series is not symmetrical, where $k = 0, 1, 2, \ldots m$, the shift of the two series.

$$r_{+k} = r_{xy}(k) = \frac{C_{xy}(k)}{\sqrt{C_x^2(0)C_y^2(0)}}$$

$$r_{-k} = r_{yx}(k) = \frac{C_{yx}(k)}{\sqrt{C_x^2(0)C_y^2(0)}},$$

where

$$C_{xy}(k) = \frac{1}{n}\sum_{t=1}^{n-k}(x_t - \bar{x})(y_{t+k} - \bar{y})$$

$$C_{yx}(k) = \frac{1}{n}\sum_{t=1}^{n-k}(y_t - \bar{y})(x_{t+k} - \bar{x})$$

$$C_x(0) = \frac{1}{n}\sum_{t=1}^{n}(x_t - \bar{x})^2$$

$$C_y(0) = \frac{1}{n}\sum_{t=1}^{n}(y_t - \bar{y})^2,$$

where $\bar{x}$ and $\bar{y}$ are the averages of the two series of x_t and y_t.

The t significance level of the calculated time lag can be examined with the following equation (MT18 2019):

$$t = \frac{2}{\sqrt{n-|k|}},$$

where n is the number of samples, and k is the time lag. If t is smaller than the calculated cross-correlation value, it has a significance level (α) of approximately 5 percent.

Because of the asymmetrical cross-correlation function, the spectral-density function must be expressed with a complex number:

$$\Gamma_{xy}(f) = |\alpha_{xy}(f)|exp[-i\Phi_{xy}(f)],$$

where i represents $\sqrt{-1}$, the $\alpha_{xy}(f)$ and the $\varphi_{xy}(f)$ are the values of the cross-amplitude in the phase functions with f frequency, in details:

$$\alpha_{xy}(f) = \sqrt{\Psi_{xy}^2(f) + \Lambda_{xy}^2(f)}$$

$$\phi_{xy}(f) = arctan\frac{\Lambda_{xy}(f)}{\Psi_{xy}(f)},$$

where the cross-spectrum, $\Psi_{xy}(f)$ and the quadrate spectrum, $\Lambda_{xy}(f)$ are:

$$\Psi_{xy}(f) = 2\left\{r_{xy}(0) + \sum_{k=1}^{m}[r_{xy}(k) + r_{yx}(k)]D_k\cos(2\pi fk)\right\}$$

$$\Lambda_{xy}(f) = 2\left\{\sum_{k=1}^{m}[r_{xy}(k) - r_{yx}(k)]D_k\sin(2\pi fk)\right\},$$

where D_k is the weighting function which is necessary to overcome the distortion caused by the two coefficients $Y_{xy}(f)$, and $L_{xy}(f)$.

For the calculations a custom-made python software was developed, featuring the equations (GH 2020).

Results and discussion

Our hypothesis was that the teleconnections mentioned above have a mathematically calculable effect on the rainfall events of the Carpathian Basin. A few important

teleconnections were chosen to represent a major part of the Earth. Our hypothesis for the direction of the connection was that the x_t teleconnection – calculated with its respective index – influences the precipitation time series y_t measured at five different monitoring sites.

The teleconnections are happening on a global scale, and in most cases, they represent climatic patterns far away from Central Europe. That means that instead of high correlation coefficients, only minor but calculable effects are expected.

AMO effects on precipitation in the Carpathian Basin

In the case of the AMO, a longer time interval was available, so precipitation data from the monitoring point of Szeged was not used because of missing values.

The Atlantic Multidecadal Oscillation seems to have an immediate effect on the precipitation data of the Carpathian Basin. In *Figure 2*, the maximum value is at around the 0-month mark for most monitoring sites. A clear one-year cycle is present, too. Although the correlation coefficient is not larger than 0.1, a clear connection can be identified in the graph.

In *Figure 3* a strong maximum amplitude is visible at frequency 0.083, corresponding to a time period of 1 year. There is another maximum value at a frequency of 0.021, corresponding to a period of 4 years. The other cyclic components are much less intense.

The results for Szombathely differ from those for three other ones. The reason for that is probably the slightly different precipitation pattern of Szombathely, detected in differences in the case of deterministic components calculated with spectral analysis of the same rainfall data (Ilyés, C. *et al.* 2017).

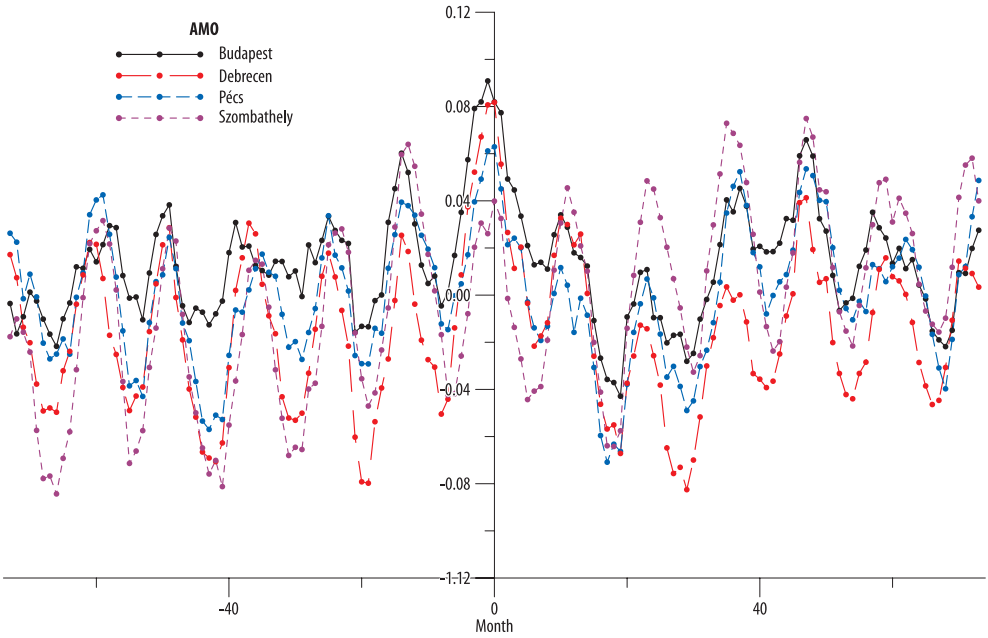

Fig. 2. Cross-correlation between AMO and the precipitation of the Carpathian Basin

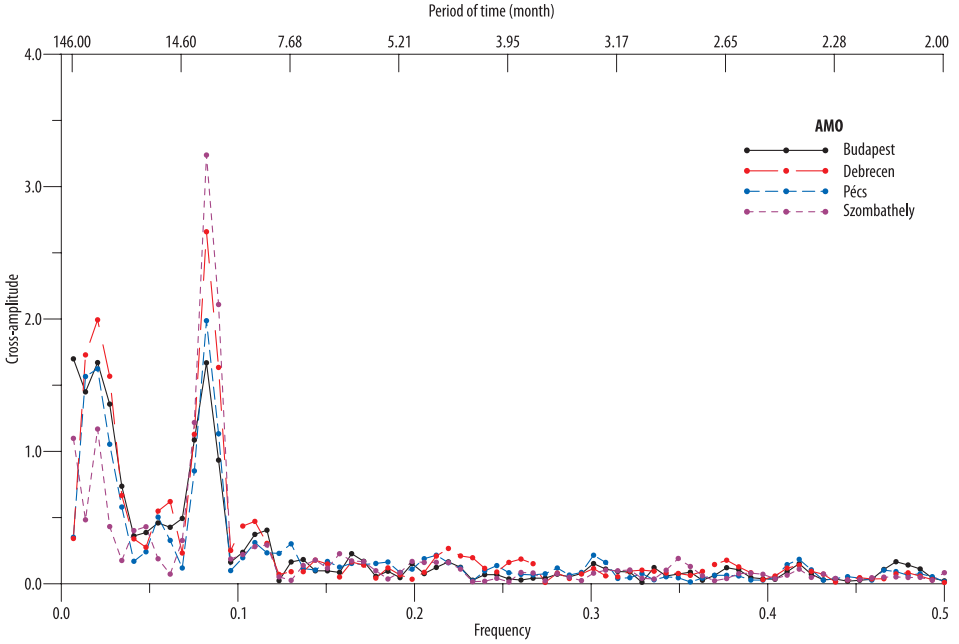

Fig. 3. Cross-amplitudes of AMO and precipitation of the Carpathian Basin

AO effects on precipitation in the Carpathian Basin

In the case of the Arctic Oscillation, most of the correlation coefficient has a negative peak at the 0 month mark, but at 37 month a positive peak can be detected, as seen in *Figure 4*. The negative significant peak may suggest that the direction of the effect is reverse, that is, the precipitation and the Arctic Oscillation have a negative linear connection, which would mean that an increase in AO causes a decrease in the amount of precipitation. An alternative, less probable explanation could be that the local time lag for the Carpathian Basin is 37 months. Similar to the case of AMO, for the monitoring site of Szombathely somewhat different results can be seen.

As for the cross-spectral analysis, there are clear patterns of periodicity. A strong one-year long cycle can be detected from the data, with maximum amplitude values at frequency 0.083, as well as a half-year long one (at frequency 0.166). The 6-month long periodicity has a larger amplitude than the 12-month long one, meaning a stronger cyclic pattern. Other major cycles are the 36, 7.7 and 9 month long ones, as shown in *Figure 5*.

NAO effects on precipitation in the Carpathian Basin

For the North-Atlantic Oscillation data, the 1950–2010 time interval was used. The cross-correlation coefficients *(Figure 6)* are again very low, but the connection can clearly be seen. As in the case of the AO, the direction of the effect is the opposite of what would have been guessed: for the correlation coefficient values of each of the five monitoring sites significant negative peaks with a larger than 0.1 amplitude were obtained at the 0 month mark. That refers to a negative linear connection. In *Figure 6*, a great volatility can also be seen, with no clear sign of periodicity. In the case of increasing NAO, precipitation in the Carpathian Basin seems to decrease.

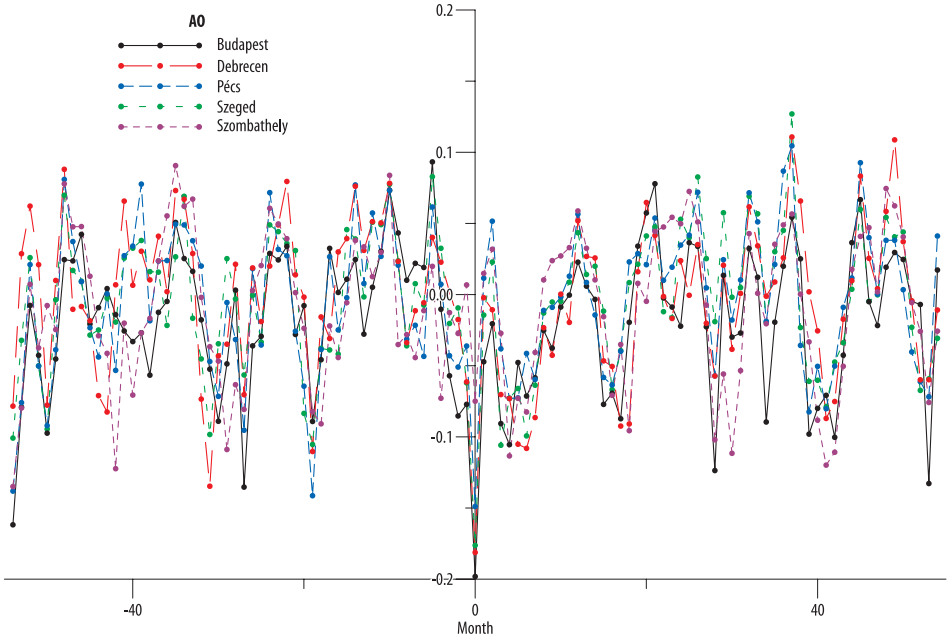

Fig. 4. Cross-correlation between AO and the precipitation of the Carpathian Basin

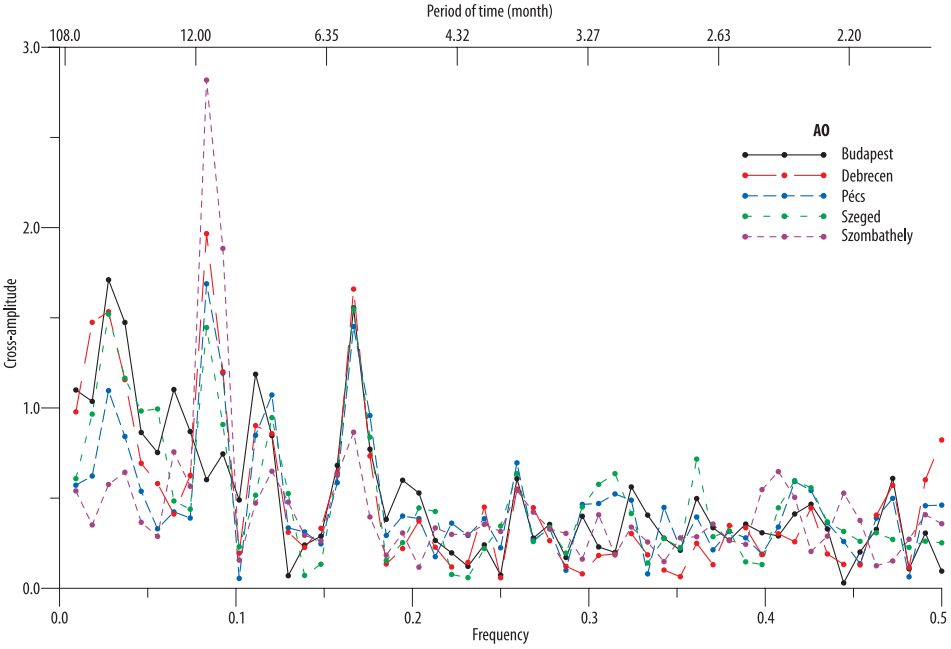

Fig. 5. Cross-amplitudes of AO and precipitation of the Carpathian Basin

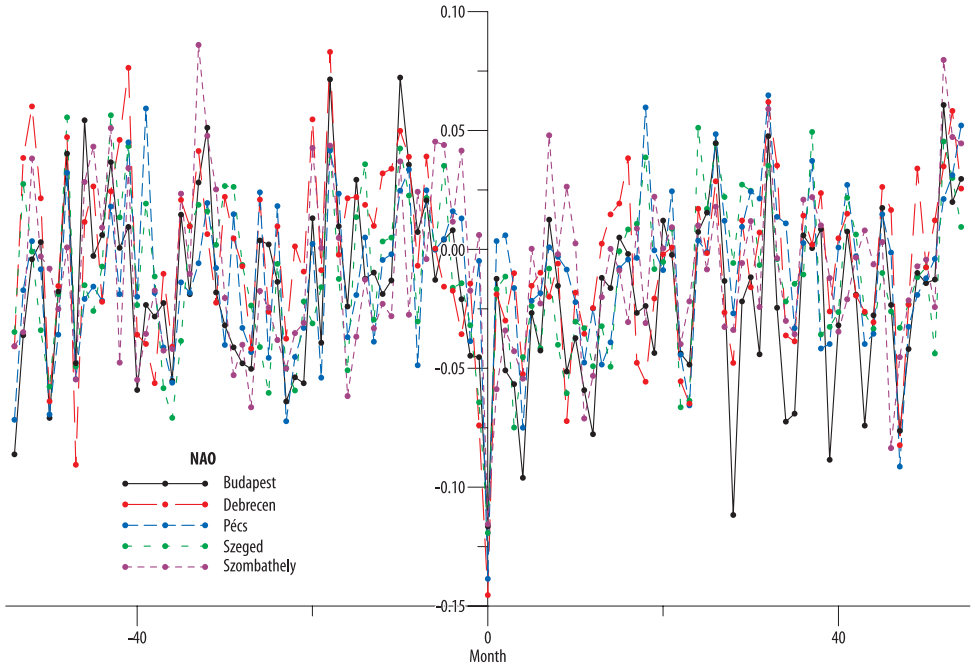

Fig. 6. Cross-correlation between NAO and the precipitation of the Carpathian Basin

The cross-spectral analysis *(Figure 7)* also shows irregular or random maximum values. Nevertheless, there are some similarities among the 5 cross-amplitude datasets. In four of the time series, a 3-year long cycle (at frequency 0.027) is seen, besides the one-year period (frequency 0.083), and the 6-month long one (frequency 0.166). A 8.3-month long period (frequency 0.12), and 4.9–5.1 month long periods (frequency 0.19–0.2) also occur. Szombathely again delivers an outlier result, because of a stronger local influence in its rainfall events.

PNA effects on precipitation in the Carpathian Basin

The Pacific/North American teleconnection influences the climate patterns in the Northern Hemisphere mid-latitudes beyond the tropics. As had been assumed, it does not have a significant effect on the precipitation of the Carpathian Basin.

The figure of the cross-correlation values *(Figure 8)* is the most volatile one. Time lag cannot be calculated, as the correlation coefficients have no common peaks.

The results of the cross-spectral analysis are shown in *Figure 8*. A few local cycles are seen, with some similarities: three of the monitoring stations showed a 12–13.5 month long cycle (frequency 0.08), as well as a 36-month long one (frequency 0.027). From the data a 6.5–7.2 month long period and a 5.6–6 month long period were calculated.

As seen in *Figure 9*, the data are too volatile to let one estimate a connection. The correlation coefficients are very low, and the effect on precipitation is negligible.

SOI effects on precipitation in the Carpathian Basin

The Southern Oscillation is the most well-known teleconnection index, measuring the

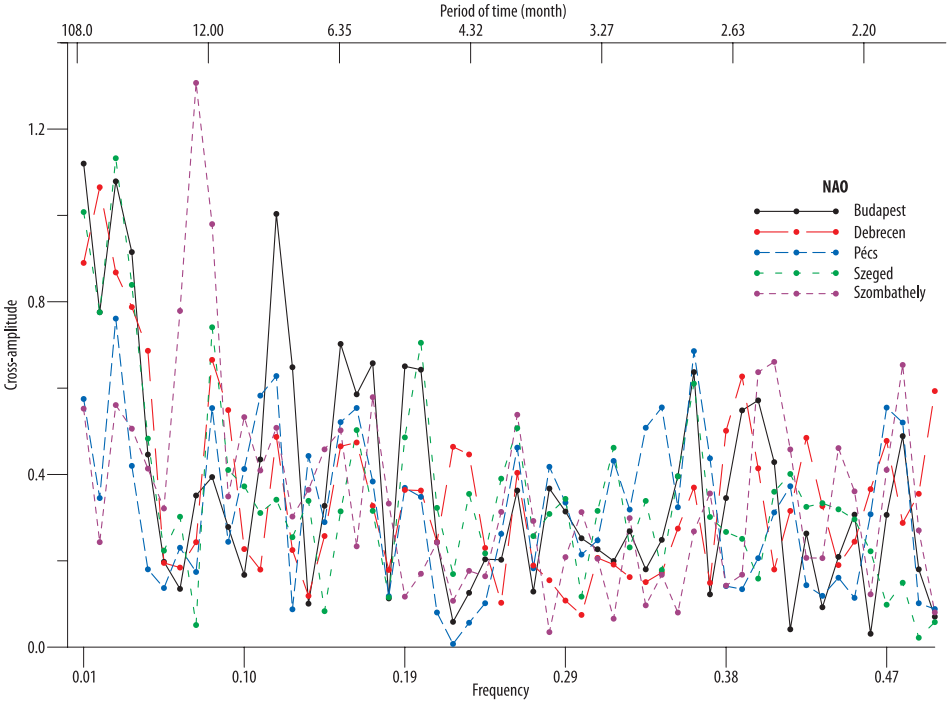

Fig. 7. Cross-amplitudes of NAO and precipitation of the Carpathian Basin

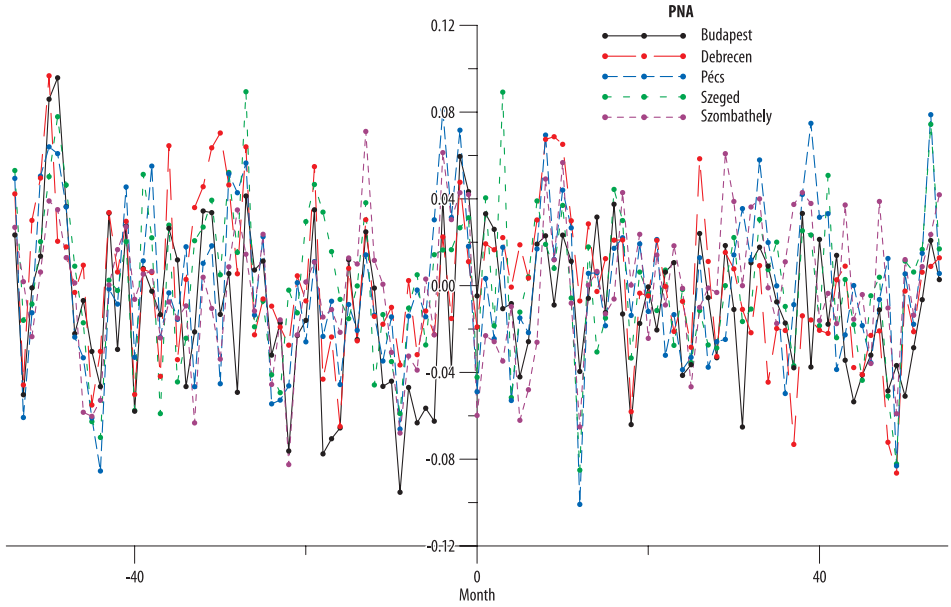

Fig. 8. Cross-correlation between PNA and the precipitation of the Carpathian Basin

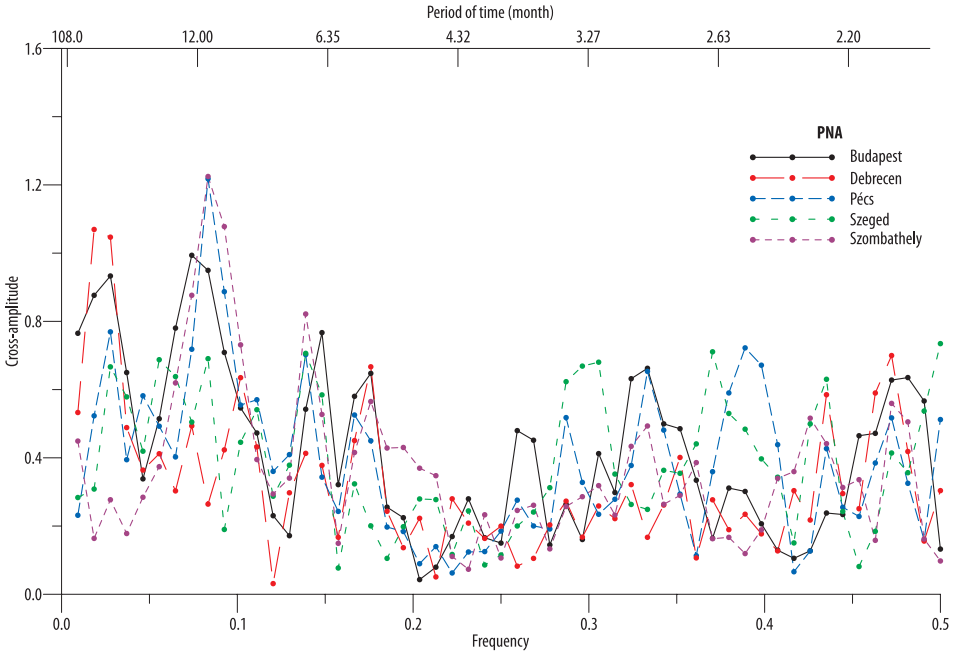

Fig. 9. Cross-amplitudes of PNA and precipitation of the Carpathian Basin

intensity of the El Niño or La Nina effects in the Pacific.

The cross-correlation calculations show inconclusive results, with low coefficients, although 3 of the 5 monitoring stations show a minimum value at 22-month time lag. According to *Figure 10*, neither a clear linear relation nor any periodicity is visible.

The cross-spectral analysis shows some similarities among the 5 monitoring sites. As seen in *Figure 11*, for most of the monitoring sites, there is a 1-year long period (frequency 0.083). Data for 3 sites seems to have a 4.5-year long period (frequency 0.018), and a 1.9–2.2 year long period (frequency 0.04), with a 5.4 and 2.5 month long cycle in them. Other periods were defined locally with 9–10 periods in each dataset, respectively.

From all these results it is clearly seen that the teleconnections have a minimal, but calculable effect on the precipitation patterns of the Carpathian Basin. Most of the studied climatic patterns showed some periodicity when compared to the precipitation time series.

The teleconnections not far from Central Europe have an immediate effect on the rainfall events, while the Pacific/North Atlantic, and the Southern Oscillation index data showed no clear relationship. Events happening in the Pacific area have minimal effect on this side of the planet. It is important to keep in mind that teleconnections are interconnected. The PNA has been found to be strongly influenced by the El Niño-Southern Oscillation (ENSO) phenomenon, which itself is measured by the SOI.

The SOI and PNA results have similarities in case of the cross-spectral analysis. In both calculations 4.5, 1.5–1.8, 1.1–1.2 year long periods were defined, along with the one and half year long period, which was calculated from all of the parameters. The AO, NAO and PNA datasets had a 3 year long period, too.

The AO and NAO data also show similarities, with the 3.0, 1.1–1.2, and 0.69 year-long cycles in both of them.

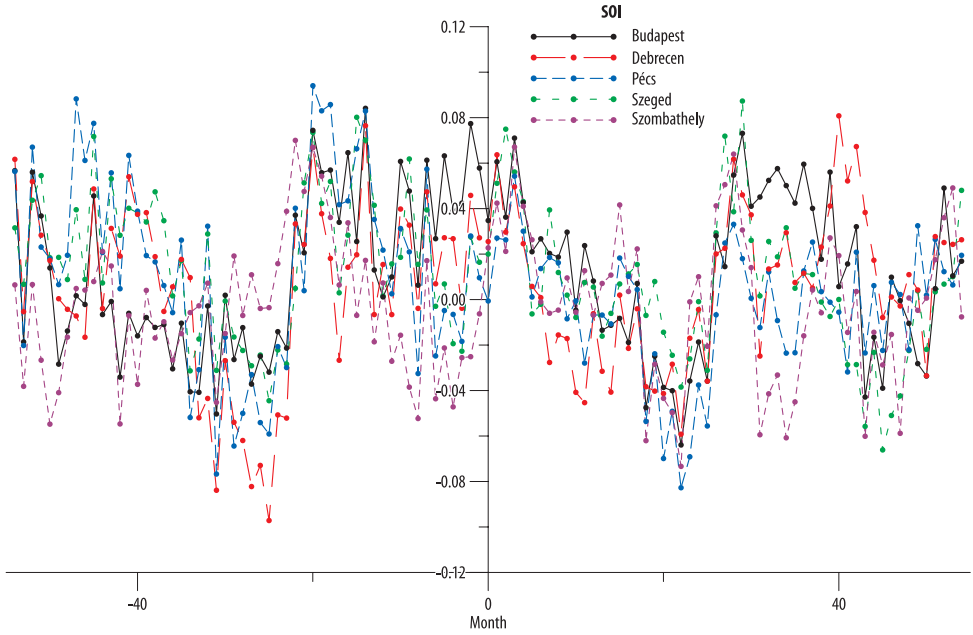

Fig. 10. Cross-correlation between SOI and the precipitation of the Carpathian Basin

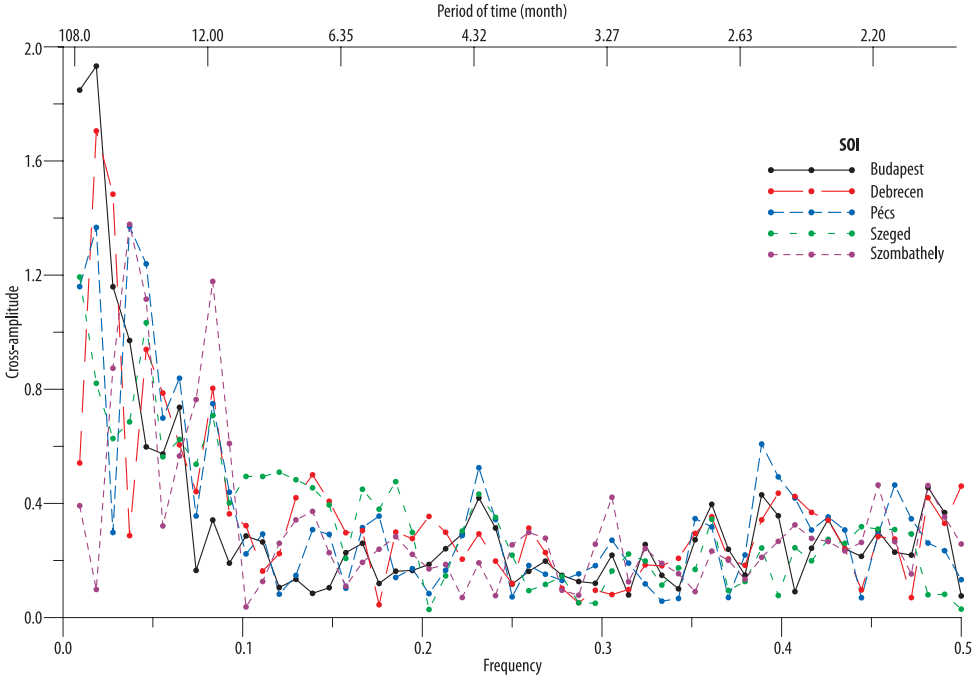

Fig. 11. Cross-amplitudes of SOI and precipitation of the Carpathian Basin

All the examined datasets have 0.69–0.71 and 1.1–1.2 year-long periodic components.

In previous research (Ilyés, C. *et al.* 2017), the cyclic components of these precipitation datasets were examined with spectral analysis, based on the Fast-Fourier transformation, with several deterministic components defined in them. Some of the cycles can be interpreted using the results of the present cross-spectral calculations. The 3 and 4–4.5 year-long periodicities with large amplitudes had been previously discovered using spectral analysis on annual precipitation data (Ilyés, C. *et al.* 2017).

The connection between the ENSO and NAO, and some meteorological parameters in Hungary, had been investigated previously, and a clear relation was found for both indices (Pongrácz, R. 2003). The main reason for the calculated results can be that the connection is not linear in case of these distant patterns.

Similar investigations (Pekarova, P. and Pekar, J. 2007) had been carried out for streamflow fluctuations in a neighbouring country (Slovakia). The effects of several teleconnections were calculated with the streamflow of two rivers in the country. Because of the different time intervals of the measurements, the longer periods couldn't be calculated for both of the research projects, but in the case of the AO and NAO, the ca. 3 year-long cycles were also determined along with the 2.25 year-long period from the AO data, meaning similarities can be found in the patterns of these data.

Conclusions

In the present study, relationships are detected between AO, NAO, PNA, SOI, AMO and precipitation cycles at five monitoring sites in the Carpathian Basin. With the applied method of cross-correlation and cross-spectral analysis, the correlation coefficient and deterministic components are revealed from the investigated datasets.

The results show that a minimal but calculable relation can be defined for climatic patterns taking place in the Northern Hemisphere, such as AO, NAO and AMO, although the method cannot quantify the connections with patterns from distant regions, such as SOI and PNA. The relationships for these climatic phenomena (AO, NAO and AMO) are quite immediate *(Table 1)* and can be connected to periods previously defined from the precipitations of the Carpathian Basin (Ilyés, C. *et al.* 2017). Several cycles, reported in previous studies, can be explained via teleconnections of these climatic patterns (Ilyés, C. *et al.* 2018). The results also show similarities to other results from Central Europe (Pekarova, P. and Pekar, J. 2007), and to a very recent cloud-pattern analysis (Sfica, L. *et al.* 2021).

Table 1. Summary of the findings relative to time lag, direction, and major detected cycles

Climatic phenomena	Time lag	Direction	Major cycles
AMO	~0	positive	1; 4 years
AO	0	negative	0.5; 0.6; 1; 3 years
NAO	0	negative	1; 3 years; 8.3; 4.9 month
PNA	No clear linear connection detected		
SOI			

With the calculated correlation and cyclic components, a clear interdependence has been revealed in the case of the Carpathian Basin rainfall events. As we have found, any change in the studied distant climatic patterns will have some precipitation effect in the Carpathian Basin, thus, affecting the recharge or natural replenishment of its groundwater aquifers. The obtained results highlight the importance of sustainability issues in the future utilization of groundwater resources.

For the future, a complex Wavelet coherence or partial Wavelet analysis with groundwater levels and streamflow data can help to better evaluate the nature of the defined connections of the oscillations and the hydrological cycle in Central Europe.

Acknowledgements: The research was carried out at the University of Miskolc both as part of the "More efficient exploitation and use of subsurface resources" project implemented in the framework of the Thematic

Excellence Program funded by the Ministry of Innovation and Technology of Hungary (Grant Contract reg. nr.: NKFIH-846-8/2019) and the project titled as "Developments aimed at increasing social benefits deriving from more efficient exploitation and utilization of domestic subsurface natural resources" supported by the Ministry of Innovation and Technology of Hungary from the National Research, Development and Innovation Fund in line with the Grant Contract issued by the National Research, Development and Innovation Office (Grant Contract reg. nr.: TKP-17-1/PALY-2020).

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DOI: 10.15201/hungeobull.71.1.3 Hungarian Geographical Bulletin **71** 2022 (1) 39–53.

Border divergence or convergence in the context of integration: A case study of the Russian-Belarusian and Russian-Kazakhstan borderlands

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Abstract

A state level integration process should first and foremost have a positive impact on the border areas. The current Russian-Belarusian and Russian-Kazakhstan borders acquired the status of 'state borders' in 1991 as a result of the collapse of the Soviet Union. While Russia and Belarus immediately embarked on the path of integration in the 1990s, effectively cancelling border controls, Russia and Kazakhstan were forced to resolve border security issues by strengthening their border and establishing customs control processes. The launch of the Customs Union in 2010 partially removed the existing trade contradictions, and the creation of the Eurasian Economic Union (EAEU) in 2015 significantly strengthened interstate interactions. However, despite the declared integration, it could not compensate for the dividing role of the border which separates the diverging political, legal, and economic spaces of the three countries. The purpose of this study is to determine whether divergence or convergence occurs in the considered border regions, as seen through the prism of demographic, ethno-cultural and economic changes. We rely on the results of a multi-year field research in various regions of the Russian-Belarusian and Russian-Kazakhstan borderland (2014–2018), data from official statistics, and some conclusions based on the authors' findings as part of their work on previous collective research projects. We found out that demographic processes became one of the reasons, as well as the main driver of divergence. The active depopulation evidently decreased the potential for cross-border cooperation (especially at the local level). The Russian-Belarusian borderland is still rather homogeneous in sociocultural sense, and the border between Russia and Kazakhstan is characterized by an increase in ethno-cultural divergence. The post-Soviet period of nation-building in Kazakhstan was a period of the revival of the national language and *kazakhization* of the public space. Our analysis demonstrates the crucial importance of path dependence in the economic cooperation on the whole and in the specialization of interregional interactions. We observed both autonomization and absence of cross-border cohesion in the economic sphere, and in many cases, we saw examples of competition.

Keywords: divergence, convergence, integration, post-Soviet borders, cross-border regionalization, Eurasian integration, EAEU

Received October 2021, accepted February 2022.

Introduction

Border regions often benefit from integration at the state level. For instance, intensive cross-border cooperation is observed along the borders within the European Union. Cross-border interactions have always played an important role in European integration. Even long before the massive enlargement of the EU in 2004, the border regions of Poland, the Czech Republic and other countries were "rising" to the level of a neighbour due to the instruments of cross-border cooperation. This topic was discussed in many research papers (Barthel, M. 2017; Wojcik, M. *et al.* 2018; Vaishar, A. and Šťastná, M. 2019).

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On the contrary, some studies disprove the idea of the borderless world and ubiquitous convergence along open borders (Kolossov, V. and Scott, J. 2013). Cooperation across borders can be achieved through "multilevel, multi-sectoral and long-term approaches that involve transformation at the international, national and local levels" (Kolossov, V. and Scott, J. 2013). The case of Russian-Belarusian and Russian-Kazakhstan borderlands is a practical example of this theoretical discourse.

We can consider these border areas from two positions. On the one hand, convergence and divergence are consequences of the common Soviet past and the processes of disintegration of a single economic, political and legal space. Strengthening of sovereignty could not go hand in hand with convergence in the 1990s, and further rapprochement was largely the restoration of previously created cooperative and social ties. On the other hand, convergence and divergence can also be considered in the context of traditional integration theory, comparing the processes taking place here with the experience of the European Union and other integration associations in the world. This is acceptable, since the integration processes of the 2010s in the Russian-Belarusian and Russian-Kazakhstan borderlands were not based on the Soviet past and were built on completely new principles. Moreover, within the European Union there are also examples of the development of convergence in the border areas of the countries that have survived the collapse (the case of Czechoslovakia).

Russia and Belarus border each other along six regions (*oblast*), three on each side of the border (1,239 km). The Russian-Kazakhstan border is the longest continuous land border in the world (7,598 km) which includes 12 regions on the Russian side and 7 regions on the Kazakhstan side.

For a long time, it seemed that the integration aspirations of Russia, Belarus and Kazakhstan, as well as the common historical background of their joint incorporation in the USSR, would allow to pursue the path of convergence. However, it later turned out that greater integration does not necessarily lead to convergence of the border areas of the three countries.

Russian-Belarusian and Russian-Kazakhstan borders acquired the status of state borders in 1991. During the first years after the collapse of the USSR, disintegration of both political and economic spaces took place. The borders formally remained transparent in terms of movement of people, but the opportunities for employment, education, and business development with neighbours were precipitously decreasing. The situation with regular cross-border traffic was worsening rapidly as well. Even on the border with Belarus, the end of suburban railway line (1993) and a fourfold reduction of cross-border bus routes led to an actual paralysis of cross-border contacts as early as in 1993–1994 (Katrovsky, A.P. 2015). Since 1995, the integration aspirations of Russia and Belarus brought about abolition of the border regime. At the same time, along with the integration processes between Russia and Kazakhstan in the second half of the 1990s, the reinforcement of border control took place. This was primarily caused by the lack of effective mechanisms to solve border security issues (Smith, J. 2017).

In 1995, the first attempt was made to create a Customs Union with the participation of Russia, Belarus, Kazakhstan, Kyrgyzstan (joined in 1996) and Tajikistan (in 1999). However, the activities of this organization turned out to be ineffective: it proved not possible to solve the problems of non-tariff regulation, as well as the issues of unification of a number of customs rules. In October 2000, Kazakhstan, Russia, Belarus, Tajikistan and Kyrgyzstan signed the Treaty on the Establishment of the Eurasian Economic Community (EAEC). A milestone for both sections of borders was the 2010–2011 period, when the Customs Union began its work, and customs control along the internal borders of the union was eliminated. In 2012, the Single Economic Space was launched introducing in addition to the free movement of goods, the freedom of movement of capital, services and labour. The creation of the Eurasian Economic Union in 2015 gave a

start to the functioning of the Eurasian space on the principle of "four freedoms". First of all, this allowed the participating countries to make a significant progress in trade integration. The movement of goods could now be carried out without state control (transport, phyto-sanitary and veterinary) (Morachevskaya, K. *et al*. 2018). On the contrary, single customs tariffs were characterized by a large number of exemptions and restrictions since countries initially agreed to allow such exemptions (Karpenko, M.S. 2019). They were used to protect the internal market on both sections of the border.

Despite the common history and the Eurasian integration of the post-Soviet period, today's cross-border cooperation practices are extremely fragmented making it difficult to speak about convergence unequivocally (Kolosov, V.A. and Sebentsov, A.B. 2020).

The objective of this paper is to determine whether divergence or convergence in terms of Eurasian integration occurs in the border regions in reality. We will try to answer several questions. How do these processes differ in the Russian-Belarusian and Russian-Kazakhstan borderlands? How are these processes running in the demographic, cultural and economic senses?

We rely on the results of a multi-year field research in various regions of the Russian-Belarusian and Russian-Kazakhstan borderland (2014–2018), and on the expert interviews with representatives from the government, business, and non-profit organizations in particular. 55 interviews were conducted in all regions of the Russian-Belarusian borderland and 46 interviews – in different regions of the Russian-Kazakhstan borderland. The key topics of the interviews were formats and spheres of cross-border cooperation, benefits and costs of integration, obstacles for mutual trade and business cooperation. To achieve the aim of this paper, we also used the data from official statistics, as well as the regulatory legal acts of integration initiatives. Moreover, some conclusions are based on the authors' results as part of their work on previous collective research projects (Cross-Border Cooperation Between the Regions of Russia, Belarus and Ukraine [2013] supported by the Eurasian Development Bank, and Russian Borderlands: Neighbourhood Challenges [2014–2019] supported by the Russian Science Foundation[3] and some others).

In the first section of the paper, we briefly describe theoretical approaches to the discussion on convergence or divergence of the border regions. We analyse how these issues have been discussed in the context of European integration. In the second section, we consider the demographic aspects of border regions comparison. Then we try to figure out the role of national (ethnic) and cultural policies in the convergence/divergence processes. The objective of the last section is to reveal whether any intensification has been taking place in cross-border economic cooperation during the period of integration processes at the state level (since 2010).

Theoretical approaches

In spatial economics and economic geography, convergence is often defined as spatial equilibrium, and divergence – as spatial disequilibrium (Lipshitz, G. 1992). In the economic context convergence means the process of reducing or eliminating regional inequality. This is achieved thanks to the free movement of production factors. If we are to talk about neighbouring territories, the concept would mean close economic ties at all levels. Regional divergence appears for instance when governments intervene in the spatial flows of production factors. Institutions, including integration units, could also determine the processes of convergence or divergence and act in combination with geographical factors, e.g. centre-peripheral differences. The removal of administrative

[3] For more details, see Cross-Border Cooperation of the Regions of Russia, Belarus and Ukraine, 2013. Available at https://eabr.org/analytics/integration-research/cii-reports/prigranichnoe-sotrudnichestvo-regionov-rossii-belarusi-i-ukrainy/ (In Russian); and Kolossov, V.A. *et al.* 2018.

barriers as part of an integration process often contributes to cross-border mingling, enhancing interactions. But the real (not de jure) integration process that leads to convergence should go hand in hand with eliminating discrimination for economic activities on both sides of the border.

From a sociological point of view, the key idea of convergence is the idea that societies move toward a condition of similarity (Herkenrath, M. *et al.* 2005). In the integration rhetoric, this means the prevalence of common values over national cultural policy.

A detailed contemporary analysis of the interpretation of "convergence" and "divergence" concepts was carried out by Benedek, J. and Moldovan, A. (2015). They suggest a "multidimensional perspective on convergence and divergence that means a combination of social and economic dimensions". Benedek and Moldovan emphasize the "interrelatedness of social and economic factors influencing development".

EU enlargement sparked a large number of studies on convergence and divergence (Benedek, J. and Moldovan, A. 2015; Lang, T. 2015; Čelan, T.J. 2016). It was shown that despite the growth in funding for cross-border cooperation projects, "the huge geographical handicap, the transport and language barriers and in general the strong periphery status of the border area in comparison to the capital" did not allow to achieve the convergence outside the internal borders of EU-15 (Čelan, T.J. 2016).

Van Nijnatten and Boychuk contributed to the discussion about convergence and divergence of the border regions in terms of integration at the national level. The case of Canada and the USA shows that convergence may exist at the state-province level and not be evident in national-level patterns (Van Nijnatten, D.L. and Boychuk, G.W. 2004). The intensively debated question is also evident in the regional identities in regard to social convergence and deterritorialization (Bufon, M. 006). Some authors proved that the course of convergence or divergence between regions depended on human capital, investments, population dynamics, and spillovers (Cartone, A. *et al.* 2021).

The problem of convergence and divergence in the border regions is often associated with the centre-peripheral paradigm. According to Benedek and Moldovan "polarization should be considered a special case of economic divergence" (Benedek, J. and Moldovan, A. 2015). Some researchers focus on the problem of regional equalization that suffers under the influence of urban agglomeration growth (Máliková, L. *et al.* 2016; Fedorov, G.M. and Mikhaylov, A.S. 2018; Kolosov, V. and Morachevskaya, K. 2020). This leads to the peripherization of the territories far away from capitals, such as border regions.

Lipshitz suggested to define four spatial outcomes related to the relations between convergence and divergence: paired combinations of economic development dispersion, population dispersion (rooting peripherality), economic development polarization, and population polarization (outflow to centres and capitals) (Lipshitz, G. 1992). Following Lipshitz's concept, we are attempting to find out the results to which the post-Soviet period led in the demographic sense, as well as economic interactions.

The border sections under consideration described in the context of integration have already become the objects of several separate studies. The level of centralization differs between Russia, Belarus and Kazakhstan and affects the current state of cross-border cooperation. Despite the relatively high level of centralization in modern Russia, it is even higher in neighbouring countries with a unitary form of government (Vieira, A. 2017). In any case, this does not contribute to the institutionalization of cross-border interactions at the local and regional levels. Belarus and Kazakhstan are characterized by a weak level of legal support for cross-border and interregional cooperation, and all three countries have fears of granting regions and municipalities additional opportunities in carrying out foreign relations (Sebentsov, A.B. 2018).

The project of the Union State of Russia and Belarus in the context of Eurasian integration

was studied by many scientists (Nikitenko, P. and Vertinskaya, T. 2006; Czerewacz-Filipowicz, K. and Konopelko, A. 2017; Vieira, A. 2017). Most of them came to the conclusion that the tendency of divergence existed in opposition to the primary premise of the project. Vieira showed that the present state of the Russian-Belarusian cooperation looked like "medium-term bilateral trade-offs" and did not focus on common integration.

Issues of Russian-Kazakhstan relations in the context of integration were considered in the works of Vardomsky, L.B. *et al.* (2019). Economic issues are also reflected in publications by the Eurasian Development Bank and some other authors (Limonov, L. *et al.* 2012; Vinokurov, E.Yu. *et al.* 2015). Security and cooperation issues were discussed in the works of Golunov, S.V. (2005), and the weakness of the institutions of cooperation was studied by one of the authors of this paper (Sebentsov, A.B. 2018). However, a comprehensive analysis of two different parts of the borderland within the Eurasian Economic Union has not yet been carried out. We will try to fill this gap in this work.

Depopulation and demographic divergence

Depopulation and peripheralization on the Russian-Belarusian borderland are historical in nature. The abolition of serfdom, agrarian overpopulation and rapid development of the largest cities – Saint Petersburg and Moscow – contributed to the drainage of the rural population into the cities. The subsequent construction of railways to the Volga region and Siberia strengthened these processes. One of the border regions with Belarus – the Pskov region – became "a population donor" for growing Saint Petersburg in 1870s and from the 1920s till the present it has steadily declined in population (Manakov, A. 2016). Similar processes were observed in the Smolensk region: by the first third of the 20th century, the relatively high natural population increase could not compensate for the migration loss (Fedorov, G.M. *et al.* 2020).

The migration outflow in the adjacent Belarusian regions was less intense due to the relative remoteness of the largest cities of the Russian Empire and became noticeable only after 1897 when the Belarusian border residents began to move to agricultural (Siberia, Far East of Russia) and industrial (Donbass) regions. However, earlier (in comparison with the Russian side of the borderland) Soviet industrialization made it possible to retain and even attract population to the newly created industrial enterprises, while strong agricultural sector made it possible to avoid large-scale depopulation.

The Russian-Kazakhstan borderland has been the area of intensive settling since the middle of the 19th century. Kazakhstan's incorporation into Russia (1730–1880s) played a significant role in the formation of the settlement system. The military fortifications that arose during the colonization period became the basis for urban settlement system. Railway construction at the beginning of the 20th century, resettlement of peasants, industrialization and cultivation of virgin lands led to the influx of more and more settlers. As a result, in all regions of the borderland population was observed to multiply several folds during the Soviet period.

The collapse of the USSR led to fundamental changes in the dynamics of demographic processes. What contribution have these changes made to the divergence of the border regions?

The depopulation trend in the Russian-Belarusian borderland has strengthened. As for the Belarusian side of the border, depopulation was about two times higher than the national average, while in the Russian part – almost eight times higher. The main reason for the population decline was natural decline. At the same time on the Belarusian side, the state still dominated the economy, so it was possible to preserve the largest industrial and agricultural enterprises and retain the rural population (Gorbachev, O. and Lin, D. 2013). Therefore, the demographic situation was more favourable. However, in the period from 1991 to 2020, although rela-

tively stable in the demographic sense, the Belarusian part of the borderland lost about 18 percent of its population compared to the Russian – 27 percent. This difficult demographic situation became a real challenge for the socio-economic development of the borderland (Zemlyak, S.V. *et al.* 2018).

The greatest changes were observed in the Russian-Kazakhstan borderland where the population began to decrease rapidly, especially on the Kazakhstan side. During the first stage (in the 1990s), the border regions lost more than 800,000 people as a result of the first wave of emigration from Kazakhstan. Most of the migrants were ethnic Russians, as well as Germans, Ukrainians, Belarusians, Koreans and some other ethnic groups. High net reproduction rate is a characteristic feature of ethnic Kazakhs, but it was unsufficient to compensate the population losses. In the Russian part of the borderland, natural population decline is observed in the majority of the region. At the same time, the flow of migrants from Kazakhstan (Central Asia) to the border regions of Russia throughout the 1990s remained a significant factor in compensating for the migration and natural losses (Mkrtchyan, N. 2002). In the 2000s, this flow sharply decreased, although the general outflow of population from the border regions continued.

The main consequence of the current demographic situation is a reduction in the social capital of cross-border cooperation. Depopulation of rural areas and relocation of their residents to large cities reduce the intensity of everyday contacts, which are some of the most important indicators of the real existence of cross-border communities (Zotova, M. *et al.* 2018). Depopulation and peripheralization are becoming more and more significant factors in the divergence of the border regions under consideration.

Nationalities and cultural policy as divergence factors

Integration in the economic and political spheres and the state building processes contradict each other in a number of aspects. These contradictions are often visible in the borderlands as places for the manifestation of state power, or of a special state policy (linguistic, historical, cultural, symbolic), which leads to ever greater divergence (Paasi, A. 2009).

The situation on the Russian-Belarusian borderland is relatively neutral in this matter. In the 1990s–2000s, there were organizations and active residents who promoted national traditions, but such movements were not supported by the president of the republic. However, in recent years, *belarusization* has become increasingly evident (Posokhin, I. 2019). The Belarusian leadership began to support an integrated national identity using the system of education, media, historical narratives, as well as to keep distance from Russia if the geopolitical situation in the world became unstable.

However, during the period covered in this study, there was no evident influence of the *belarusization* on the border interactions. It is partly explained by the fact that in ethno-cultural terms the Russian-Belarusian borderland is a zone with blurred borders (Grigoryeva, R. 2020).

Cultural divergence was most clearly manifested in the Russian-Kazakhstan borderland. From the very beginning of the 1990s, the process of *kazakhization* began. Its leitmotif was building a "new statehood based on the ethnic identity of the titular nationality" (Petrenko, E. 2011)[4].

First of all, *kazakhization* manifested itself in a new educational and language policy. Thus, in all border regions, an effort to reduce the number of "Russian" schools were undertaken, which was officially explained by a decrease in demand for Russian-language teaching. The expected transition of Kazakhstan to the Latin alphabet is also considered by many Kazakhstan researchers as a necessary meas-

[4] The term *kazakhization* is used in the context of nation-building in post-Soviet Kazakhstan and the Kazakh ethnic identity (Svanberg, I. 1994; Kaiser, R. and Chinn, J. 1995; Bremmer, I. and Welt, C. 1996; Davenel, Y.-M. 2012). The concept of *kazakhization* is discussed in detail in (Sarsembayev, A. 1999).

ure to strengthen the common Turkic identity (Kadyrzhanov, R. 2009).

Another sphere affected by *kazakhization* was the toponymic landscape. During the years of independence in Kazakhstan, many geographical areas were renamed. Of the 92 municipal districts located in the borderland of Kazakhstan, 43 districts have been renamed. In a number of cases, the renaming took place without involving the democratic choice of the local population, and in some exceptional cases, even in spite of it.

Great success has been achieved in *kazakhization* of the administrative elite in the border regions. The tradition of using clan ties as a social lift "allows Kazakhs to dominate numerically in the political system, even in those regions where the Kazakh ethnic group is not the majority of the population" (Kadyrzhanov, R.K. 2014).

Changes in the territorial division and the resettlement policy are also often viewed as part of *kazakhization*. Thus, due to consolidation of several northern border regions in Kazakhstan, there are no regions left with a clear predominance of the Russian population. For instance, as a result of the inclusion of the Semipalatinsk region into the East Kazakhstan region in 1997, the share of Kazakhs in the united East Kazakhstan region increased from 27 percent (1989) to 49 percent (1999), while the share of Russians fell from 66 percent (1989) to 45 percent (1999).

The policy of *kazakhization* along with the infringement of the non-titular population rights (Bremmer, I. 1994; Lebedeva, N. 1995) have been the main reasons for emigration intentions among the non-Kazakh population (primarily Russians, Ukrainians, Belarusians and Germans). After the first waves of emigration in the 1990s, the intensity of the migration outflow has noticeably decreased. Currently, the bulk of emigrants are Russians from four border regions of northern and north-eastern Kazakhstan. In 2019, they accounted for 60 percent of the total flow of emigrants, of which 88 percent moved to Russia.

After the collapse of the USSR, Russia did not take special measures to strengthen national identity on the borders with Belarus and Kazakhstan. However, on the Russian-Kazakhstan border, some civil activists note the lack of "Kazakh schools" or at least separate Kazakh-speaking classes (Gerasimenko, T.I. 2020). At the same time, local residents and experts in interviews noted that such classes are not popular, and "Russian Kazakhs", if they have a choice, prefer to send their children to the "Russian schools".

Cross-border economic cooperation: Did intensification take place in the context of integration?

Cross-border economic cooperation between Russia and Belarus has always been carried out in the forms of mutual assistance. In Soviet times, the industrial complex of the Russian-Belarusian borderland was not highly integrated. Economic cooperation (including cross-border) between Russia and Kazakhstan, on the contrary, was well-developed, and the production ties of individual enterprises were very tight. What has changed during the post-Soviet period?

After the collapse of the USSR, an active transformation of the economic structure went on in all regions of the borderland. The main direction of this transformation was a gradual decrease in the share of agriculture and industry with a simultaneous increase in the share of the service sector. In the Belarusian part of the Russian-Belarusian borderland, this process progressed slowly due to the protectionist policies of the central authorities. In contrast, a deeper decline was observed on the Kazakhstan side of the Russian-Kazakhstan borderland. However, de-industrialization and the decline of the main industries were followed by the rapid development of raw materials production, especially in the energy sector.

Today, in Belarus economic potential is concentrated in capital city and its surroundings (Minsk and Minsk region). However, border

regions with Russia are leading in a number of indicators (for instance, share in the volume of industrial production) and count 25 percent of the GDP. The percentage of total GDP for Kazakhstan associated with their borderlands is 37 percent, thus, they concentrate the economic potential of the country.

For Russia, the role of border regions in the economy is much lower. For Belarus, 0.9 percent of the Russian GDP and for Kazakhstan, 12 percent. In terms of GRP per capita, Russian and Belarusian regions differ from each other by just a little. However, for the Russian-Kazakhstan border area, the situation is much more variable *(Figure 1).*

Today, there are quite a lot of enterprises with Belarusian investments in the Russian border regions. Most of them are small enterprises in the food, chemical and woodworking industries. In fact, there are only two examples of large-scale cooperation – a joint venture Bryanskselmash (agricultural machinery) founded in 2005, and the Amkodor-Bryansk Plant (loaders) founded in 2009. In both cases, the creation of joint ventures has a positive effect for both Russian and Belarusian sides. For Russia, it includes creating new jobs, increasing tax revenues to the regional budget, and for Belarus – access to the Russian market and Russian support programs. Intensification of industrial cooperation has slowed downed in recent years.

Belarusian small business is widely represented in the Russian part of the borderland where it has been attracted by more favourable taxation and enterprise registration requirements. Our interviews with representatives of small businesses showed that the Russian border regions are not the main arena for Belarusian business development, but rather a test site of access to the Russian market. The experts we interviewed, as well as representatives of governmental bodies often noted that there are also many cases of enterprises being registered in the Russian border regions, yet their operations' sites are difficult to determine for taxation purposes. Under such conditions, it remains unclear whether the local economies benefit from such small businesses significantly. In addition, due to the protectionist nature of the Belarusian economic interactions, there is a noticeable asymmetry in the counter part of Russian small businesses on the Belarus side of the border.

In the Russian-Kazakhstan borderland, the strongest economic interactions have been established in the fuel and energy complex. The experts we interviewed in 2017 repeatedly mentioned natural gas from the West Kazakhstan region (Karachaganak) being processed at the Orenburg gas processing plant as one of the most successful examples.

Economic cooperation in the oil sector is associated with Russian oil processing at the Pavlodar Refinery. As compensation for oil supplied from Russia, Kazakhstan provides about 5 million tons of its own oil to the Atasu-Alashankou export oil pipeline, thus fulfilling part of Russia's export obligations to the Chinese side of the arrangement (Karpenko, M.S. 2019). Along with this, Kazakhstan oil companies provide raw resources for Russian refineries in Samara and Orenburg regions.

The trend of recent decades has been the gradual autonomization of the economic life of the border regions in the "old" areas of cooperation. Among the most notable is the reduction in Kazakh coal volumes used as fuel at Russian power plants. Some of the Russian power plants in the border regions of Russia have already switched to alternative fuels (gas and oil) (Karpenko, M.S. 2019). At the same time, the nationalization of production (for example, the creation of an aluminium cluster in Pavlodar region) contributed to the formation of more advanced industrial cooperation schemes, including those with partners from the EAEU countries (Russia).

Foreign trade is one of the best indicators of converging or diverging economies. The case of the Russian-Belarusian borderland shows that on the whole, the inherited (from the USSR) functions of the regions in trade turnover persist. The export potential of the Russian regions is limited due to the low industrial capacity and geographical position (Morachevskaya, K.A. *et al.* 2018). On the con-

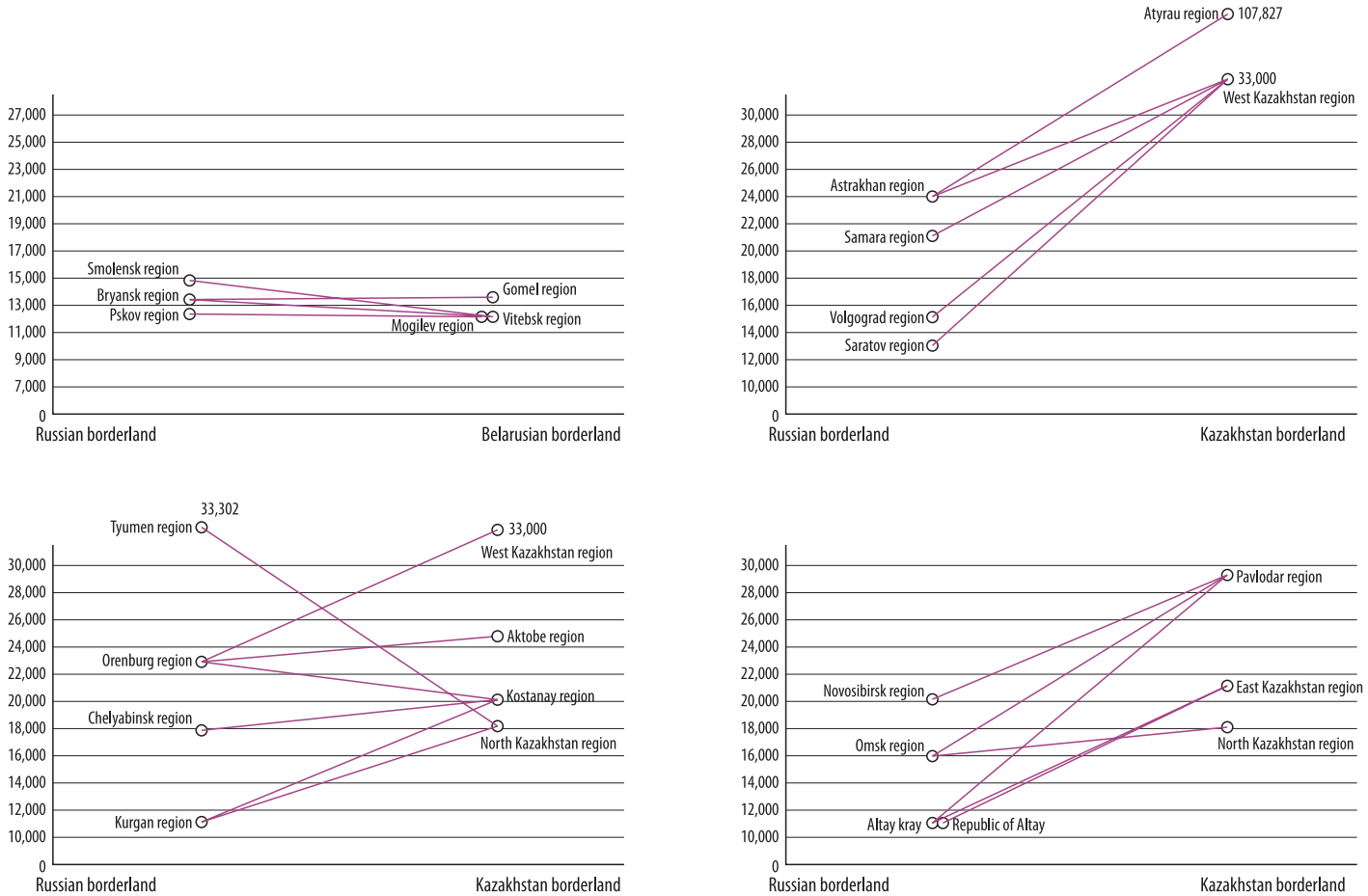

Fig. 1. Gradients of GRP (PPP) per capita between the border regions of Russia, Belarus and Kazakhstan in 2019 (USD). *Source*: Compiled by the authors based on the data of the National Statistical Committee of the Republic of Belarus, the Federal State Statistics Service of Russia, the Bureau of National Statistics of the Republic of Kazakhstan.

trary, the economy of the Belarusian border regions is export-oriented towards Russia.

Contradictory trends are noticeable in the dynamics of exports and imports. The share of imports from Belarus in all border regions of Russia was growing in 2010–2019. Calculations based on the data of the customs services show that it varied from 20 percent in Pskov region to 70 percent in Smolensk region. On the contrary, exports to Belarus increased during this period only in Smolensk region (from 30% to 40%), which played an important role as a transit territory to the Moscow Capital region. In the Pskov region, exports to Belarus decreased twofold (from 50% to 20%). All Belarusian regions experienced a slight decrease in the share of exports to Russia in 2010–2019. This can hardly be associated with diverging economies, but is more likely due to exchange rate fluctuations and a decrease in purchasing power in Russia. Imports from Russia increased notably only in the Gomel (Homieĺ) region (from 71% to 83%). It can be stated that the mutual importance of the border regions in terms of trade volumes is still high. Fluctuations are not related to the changes in convergence or divergence of the regional economies, but to external factors. Only the Mogilev (Mahilioŭ) region has a positive trade balance in recent years.

The leading position in commodities flow in the Belarusian border regions has not changed. The largest share in exports is represented by chemical products, petroleum products (mostly produced from the Russian oil), metals and related products, food products, pulp, and paper. The commodity structure of foreign trade in the Russian border regions has been more volatile. While in the past, products with high added value prevailed in exports from the Pskov region, it is metal scrap that dominates the export market now. The Russian border regions also export chemical products, timber, and goods made from precious metals (Smolensk region) to Belarus.

There are amazing examples in trade relations that are poorly visible in statistics, but seriously affect cooperation. One such example is associated with the traditional sphere of trade relations between Russia and Belarus – food products. Since Soviet times, large food enterprises in Belarus have focused primarily on the Russian market. In the post-Soviet period, the Belarusian enterprises have been receiving governmental support. One of the unforeseen effects of the interstate integration has manifested itself in the opportunity to re-export cheap Russian oil and its refined products, resulting in Belarus receiving funds for the development of its own agriculture, and agricultural products going to the Russian market. Consequently, Belarusian products flooded the Russian market, resulting in many processing enterprises in the Russian part of the borderland to be forced out of business. This phenomenon is most acute in the Smolensk region, where, along with competition, deficit of raw materials is serious especially in the dairy industry. Thus, the share of food items in the import from Belarus is consistently high (and the highest in the Smolensk region – more than 40%).

The lack of customs control even in the 1990s allowed Belarusian enterprises to obtain exclusive access to the huge Russian market for many years. Since the late 2000s, there are so-called "milk wars" in relations between Russia and Belarus, expressed in the temporary bans on import of certain products into Russia (most often – dairy products). These bans seriously complicate the situation of Belarusian enterprises, whose exports are strongly oriented towards Russia. The periods of prohibitions, which according to the official position are associated with technical and sanitary requirements, coincide with the time of tensions in the interstate relations. These events force Belarusian businesses to look for new markets (for example, China and Venezuela), but so far, a massive export reorientation has not happened due to Belarus' inland geographical position.

Restrictions on food imports from Western countries (in response to sanctions against Russia) have caused additional tensions in trade relations with Belarus. Taking advantage of the transparency on the border,

Belarusian manufacturers repackaged goods imported from the EU, selling them in Russia under their own brands. Such processes make foreign trade relations less open, less predictable and transparent. It also affects the level of trust between economic actors in the borderlands.

Thus, on the one hand, the border regions of Russia and Belarus are long-standing trade partners. On the other hand, conjuncture processes, fluctuations in political relations between countries, repeated unsolvable contradictions (such as "milk wars") often affect foreign trade between the two countries. Moreover, changes in the export structure from Russia to Belarus are associated with the state of enterprises on the Russian side. The negative state of equipment manufacturing, for example, has reduced its share in exports. At the same time, changes in the export structure from Belarus to Russia are associated not only with the export opportunities for Belarusian enterprises, but with the volume that the Russian side is ready to consume (taking into account the level of income and the financial capacity of potential buyers).

The case of the Russian-Kazakhstan border area is different. In 2016 and 2019, almost all regions of the Russian part of the borderland had a positive trade balance, while Kazakhstan regions had a predominantly negative one.

For a number of Russian regions, Kazakhstan is a key trade partner, the relationship determined by the trade structure preserved here since the Soviet times. Thus, the mutual trade between the Chelyabinsk and Kostanay regions is 80 percent formed by the supply of ore minerals from Kazakhstan and finished metallurgical products from Russia. Since the Soviet times, the Pavlodar region has been supplying thermal coal to Russian power plants in the Urals and Siberia. Russia is also one of the key importers of alumina and unprocessed aluminium, ferroalloys and chemical products (aluminium oxide, etc.) from the Pavlodar region. The export opportunities of the Aktobe region are represented mainly by various types of raw materials – various ores and concentrates, ferroalloys, the main market for which is in Russia (including enterprises located in the border area). In total, three border regions – the Kostanay, Aktobe and Pavlodar regions form 87 percent of the export potential of the Kazakhstan side of the borderland, while the remaining four regions hardly participate in export at all. The largest role in the mutual trade between the Russian regions and Kazakhstan belongs to the Chelyabinsk region (in 2019), which forms 37 percent of exports of the entire border area.

Since 2018, Kazakhstan has repeatedly resorted to short-term bans on the import of fuels and lubricants from Russia by rail in order to avoid overstocking the domestic market. According to some experts, the forecasted balance of fuel supplies from Russia to Kazakhstan will "rapidly tend to zero"[5]. The modernization of oil refining capacities in Kazakhstan allows to completely abandon the import of those types of fuel, including Russia's, which Kazakhstan is now able to produce in sufficient quantities independently.

Recently, similar bans have appeared in the field of exporting scrap to foreign countries by rail and road. Metallurgical enterprises located in the regions of Russia bordering Kazakhstan suffered more than others (Russia imported up to 94% of scrap metal from Kazakhstan). The issue was resolved (October 2020) and the supply of scrap metals to the domestic market of the EAEU countries resumed.

Our interviews in Kazakhstan showed that for local entrepreneurs, as well as on the border with Belarus, the greatest problem is related to the access of local agricultural products to the Russian market, since Russia is overuse phytosanitary restrictions. Official authorities also note the unequal conditions for charging cargo carriers from Kazakhstan for travel on Russian roads, problems with access to cheap Kazakhstan alcohol on the Russian market, etc.

[5] https://inbusiness.kz/ru/last/indikativnyj-balans-po-postavkam-gsm-mezhdu-kazahstanom-i-r

As in the Russian-Belarusian borderland, the integration processes did not have a noticeable impact on the change in the foreign trade structure in the Russian-Kazakhstan borderland. In addition, the dominance of raw materials in mutual trade still remains here. The dynamics and volumes of mutual trade depend on the current situation in the world economy, economic crises and contradictions both at the macroeconomic and international levels.

Conclusions

The processes of post-Soviet integration have long been considered an instrument of the "civilized divorce" of the former Soviet republics. Eurasian integration became a new step that provided for the free movement of goods and services, as well as common policies in the energy, foreign trade and investment, customs, technical regulation, and other sectors. It was expected that the key beneficiaries of these processes will be the internal border areas of the EAEU between Russia, Belarus and Kazakhstan. However, it later became clear that the removal of border barriers was not a cure for peripherality. We found many examples proving that the regions continued to diverge without the planned benefits of integration. The drivers of this discrepancy are measures of national-state construction implemented with different intensity in the economic, institutional, social and political spheres in each state, as well as depopulation and limited examples of economic cooperation.

The most noticeable discrepancies appeared in national and cultural policies. The Russian-Belarusian borderland is still rather homogenous in the sociocultural sense. The ethnic composition of the borderland population, the close identity of the Russian and Belarusian peoples, openness of the border, and maintenance of a high level of cross-border mobility explain a less pronounced state policy of *belarusization*. The Russian-Kazakhstan borderland, on the contrary, is characterized by the increase of the ethnocultural divergence. The post-Soviet period of nation-building in Kazakhstan is a period of the revival for the national language and *kazakhization* of their public space. The growth of ethnic barriers on the Russian-Kazakhstan border is caused by the ongoing outflow of the Russian population.

Demographic processes have become another kind of manifestation of divergence and at the same time a driver of it. In the Russian-Belarusian part of the border area, depopulation has a large historical backdrop, but it has increased significantly in the post-Soviet period and continues to do so to this day. In the Russian-Kazakhstan borderland, a settlement zone during the Soviet era, depopulation trends are relatively new. While in the 1990, the massive outflow of the Russian population from the Kazakhstan side of the border area alleviated the effects of depopulation on the Russian side, today it is the Russian side that is losing its population especially quickly. An important problem for all considered sections of the borders is the depopulation of the border zone itself, which reduces the potential for cross-border interactions and depletes the demographic base essential to the local economy.

Integration processes have not had a significant impact on the nature of economic cooperation in the border regions of Russia, Belarus and Kazakhstan so far. Economic cooperation is still determined by the ties developed during the Soviet era. Examples of new economic cooperation projects are rare. Moreover, the number of such examples is decreasing. Integration rhetoric contradicts with the increasing competition in cross-border sales markets. For instance, significant preferences provided by the government of Belarus to local agricultural enterprises (direct subsidies, reduced VAT rates, etc.) in spite of the similar specializations in the nearby Russian regions have a negative impact on their development. This model of economic cooperation influences foreign trade of the three countries, which on the one hand, is characterized by the similarity of the

sectoral structure of trade, and on the other hand, depends strongly on changes in the macroeconomic situation.

On both sides of the borders, integration is perceived by local communities not as a mechanism for finding common approaches to solving common problems, but as a realization of the competitive advantages of one of the parties to the detriment of the interests of the other. The asymmetry of benefits and costs forces parties to resort to the use of non-tariff measures to regulate foreign trade.

Our investigations demonstrate that national policies still greatly prevail over common interests. This fact, as well as the history of the relations between Russia, Belarus and Kazakhstan, shows that the experience of the European Union cannot be copied in the border areas of these countries "in the mechanical manner". Nevertheless, it can be assumed that EAEU probably needs more time to develop a policy for convergence of its own internal border regions, which are still outside the attention of both the Eurasian Economic Commission and the countries' central governments.

Acknowledgements: This work was supported by the Russian Academic Excellence Project at the Immanuel Kant Baltic Federal University. The study of the Russian-Kazakhstan Borderlands was completed as part of the state assignment (theme "Problems and Prospects of Territorial Development of Russia in the Conditions of its Unevenness and Global Instability" № 0148-2019-0008).

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DOI: 10.15201/hungeobull.71.1.4 Hungarian Geographical Bulletin **71** 2022 (1) 55–65.

The geographical scales of fear: spatiality of emotions, emotional spatialities

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Abstract

A multi-scalar understanding of fear has not been completely absent from geographical theory, however, it has not been given the attention it deserves and definitely has not been utilised in empirical research to the extent it has explanatory power to our globalised world infused with fears. By a multi-scalar understanding I refer to geographical scale as social production or social construction following critical geographers, who see the relationship between these scales as non-hierarchical. This paper draws on and combines theoretical works understanding fear as a socially and politically produced *emotion* that is politically exploited – most often through Othering – and operates on multiple geographical scales. It is an everyday experience that is produced and made sense across the scales of the body, home, neighbourhood, city, nation, region, supranational unions, the global scale and beyond. This paper draws together three particular areas concerning fear related research; (1) it emphasises that fear is an emotion; but (2) it is deeply embedded in social, economic, political and spatial relations and often closely linked to – if not dependent on – Othering and marginalisation; and (3) fear is reproduced in a trans-scalar way at all geographical scales. By drawing together these three interlinked approaches to fear, on the one hand, this paper aims to contribute to the literature by demonstrating the way the "us" versus "them" nexus is reimagined at different scales according to political convenience. On the other, it hopes to inspire more research in the field of emotional geography in general and that of fear in particular in Hungary (and more broadly in the CEE region), where this sub-field has been underrepresented even though its great explanatory potentials.

Keywords: geographical scale, fear, emotion, multi-scalar understanding

Received December 2021, accepted March 2022

Introduction

Fear is a truly personal emotion which both reflects social relations and has influence on them. Most often, the consequences of fear take spatial forms. Fear has the power to modify spatial realities. Without a spatial dimension, fear would be nothing much but a feeling – a state of mind. (Koskela, H. 2010, 389).

A multi-scalar/trans-scalar understanding of fear has not been completely absent from geographical theory (Pain, R. 2009; Abu-Orf, H. 2013; Pavoni, A. and Tulumello, S. 2020; Tulumello, S. 2020), however, it has not been given the attention it deserves – not in the international literature, even less so in the Central and Eastern European region – and definitely has not been utilised in empirical research to the extent it has explanatory power to our globalised world infused with fears. By a multi-scalar understanding I refer to geographical scale as social production or social construction following critical geographers, who see the relationship between these scales as non-hierarchical (Smith, N. 1992; Delaney, D. and Leitner, H. 1997; Marston, S.A. 2000).

This paper primarily draws on and combines the theoretical works of critical theorists and feminist scholars in particular – including Liz Bondi, Rachel Pain, Leslie Kern, Hille Koskela –, which led me to understand fear as a socially and politically produced *emotion*

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that is politically exploited and operates on multiple geographical scales. Fear is an everyday (space-)experience that is produced and made sense at the scale of the body, home, neighbourhood, city, nation, region, supranational unions, at a global scale and beyond.

This review article provides with a theoretical frame for understanding the socio-spatial (re)production of fear across geographical scales and the way fear shapes and is shaped by space. To do so, this paper draws together three interconnected literatures in human geography that defines the structure of the following sections too. The first section, following the introduction, gives an insight into the literature on the *geographies of emotions, affects and feelings*, suggesting that it is important to be conscious about the fact that fear is an emotion (and/or an affect and/or a feeling) and research dealing with it should not ignore the complexities of the production and lived experience of emotions. The second, focuses on the tight connection between fear and 'Othering', while aiming to *conceptualise fear beyond an individual experience*, embedded in socio-political relations. Finally, the third section moves *towards a multi-scalar understanding of fear*. Here, the importance of a multi/trans-scalar understanding of fear is highlighted, while discussing the way the "us" versus "them" nexus is reimagined at different scales according to political convenience. With the latter hoping to contribute to the existing literature.

The present paper, thus, draws together a multi-scalar/trans-scalar, emotional, spatial, and political understandings of fear and suggests that familiar versus unknown or "us" versus "them" dichotomies are reimagined at all scales (private-public; home-out; domestic-foreign) and concerning discourses jump scale according to political interest. They do so through Othering, on the one hand, by utilising a perceived fear of the unknown and on the other hand, by the reproducing of the idea of imagined communities (Anderson, B. 1983).

Furthermore, this paper hopes to inspire more research in the field of emotional geography in general and that of fear in particular in Hungary (and more broadly in the CEE region), where this sub-field has been underrepresented. Such absence of emotional considerations is particularly concerning in a region, where emotions have played particularly important role in the legitimisation of decision-making, effecting socio-economic and spatial processes and everyday life.

Geographies of emotions, affects and feelings

The meaning of fear has been often taken for granted in (geographical) research, when addressing fear of crime, fear of violence, fear in public space and so on. However, fear as an emotion is a lot more complex than to ignore the processes behind its production (Davidson, J. *et al.* 2005). Following the affective or emotional turn in social sciences there has been an increasing interest in the international geographical literature too, to incorporate discourses on "affect", "emotion", "embodiment", "performance" and "practice" by primarily drawing on post-structuralist and feminist literature (Thrift, N. 1997; Anderson, K. and Smith, S.J. 2001; Davidson, J. and Milligan, C. 2004; Thrift, N.J. 2008). Affective or emotional geography is an interdisciplinary subfield of geographical understanding of the world focusing on "theoretical and substantive considerations of emotion, space, and society" (Thien, D. 2017, 1702). While the connection between emotions and space and place has appeared in philosophical discussions for a long time (Sartre, J.-P. 1962; Smith, M. *et al.* 2012), human geography had been reluctant to address such connection, which can be linked to its continues self-defence within the wider field of geography, where emotion (allegedly opposite of *reason*) is often judged as ambiguous and non-scientific (Bondi, L. 2009). Even so, primarily with the help of feminist and gender scholarship's critique of dichotomous thinking (about emotions/reason), 'emotional ways of knowing' has enriched geographical research (Bondi, L. 2009), humanistic and phenomenological approaches, with a particular focus on feminist, health, social, cultural, critical race, and other geographies (Thien, D. 2017).

Considering word limitations and the focus of this paper, the conflicting views on the use of the terms, 'emotion', 'affect' and 'feeling' will not be discussed here. However, drawing on Bondi's (2009) summary, the most general differentiation between these concepts is that (1) *affect* is a feeling/emotion prior to cognition and rationality and therefore it is hard if impossible to translate it into words. In general, it has been used by geographers to express the bodily/sensory/unconscious experience of space; (2) *emotion* is something more available to thought, definable, expressible; and (3) those interested in *feeling* are mostly concerned with the bodily sensation (e.g., touch) and perception. The distinction between these terms has also been challenged for a variety of reasons. Among others Simonsen, K. (2007) highlights one that is particularly relevant to this paper. She argues for a relational and multi-scalar understanding of emotions, focusing on the social practices in a system of interconnected geographical scales (Simonsen, K. 2007; Pain, R. 2009).

Emotional turn in geography can be linked to a number of particular, overlapping schools; phenomenology or humanistic geography, feminist geography, psycho-analytic and non-representational geography (Bondi, L. 2005; Smith, M. *et al.* 2009; Blazek, M. 2015). Humanistic geography – inspired by phenomenological and existential philosophy –, understands the lived world(s) as "perceived and produced through our emotionally laden activities", focusing on the "subjective dimensions of human life" and the way people experience love, fear, hate, and other feelings in relation to places and spaces (Smith, M. *et al.* 2009, 10–11). Humanistic geography, arguing for a more "holistic understanding of the human experience in the sense of subjectivity" in the 1970s played an instrumental role in reinstating the importance of *subjective* human experience of the world as a critique of the hegemonic *objectivist* approach to space "informed by the assumptions of neo-classical economics, in which human beings are assumed to behave as autonomous, economically rational actors" (Bondi, L. 2005, 435).

Feminist geography's critique of such dualism overlaps with the phenomenological understanding, but it takes it further, by drawing on post-structuralism, generalizing the critique of dichotomous approach (of geographical thought) to the understanding of the world in general. Beyond, problematizing binary oppositions – such as body/mind, masculinity/femininity, structure/agency, nature/culture, rationality/emotion, objective/subjective – it has highlighted that such pairs are always in a hierarchical relationship and always aligned with each other (Timár, J. 1993; Massey, D. 1994; Bondi, L. and Rose, D. 2003; Timár, J. 2005, 2018). Feminist geography aims to unsettle these aligned associations made between masculinity and objectivity – leading to the exclusion of emotions from the spaces identified as spaces of rationality and masculinity (i.e., spaces of production, work, politics, public space, city centre) – and between femininity and subjectivity – where spaces of emotions (i.e., spaces of reproduction, home, care) assumed to lack rationality (McDowell, L. 1983; Bondi, L. and Rose, D. 2003; Fenster, T. 2005; Kirmani, N. 2015). They argue that such alignment result "in oppressive gendered production of space" (by Rose, G. [1993] in Blazek, M. 2015, 1998). Additionally, feminist geography brings "a critical awareness of gendering emotions", most typically fear for that matter (Valentine, G. 1989; Koskela, H. and Pain, R. 2000; Smith, M. *et al.* 2009, 11).

Non-representational theory (NRT, later also referred to as more-than-representational theory [Lorimer, H. 2005]) argues that human geography has been bound up with the analysis of representation, neglecting practice and embodied experiences (Thrift, N. 1999; Thrift, N.J. 2008), in fact, according to NRT representation should not be the primary explanatory tool of the world. To put simply NRT is interested in "what people do and not in what people say they do" (Thrift, N. 1997; Bondi, L. 2005; Lorimer, H. 2005; Smith, M. *et al.* 2009, 12). As NRT seeks to challenge the dominance of cognition in epistemology, it has a preference of the term 'affect' over 'emotion'.

Bondi, L. (2005) complements these approaches by including a psychoanalytic perspective, highlighting the blurry border between individual subjectivity and social identities. Leading to the next section, psychoanalytic approach emphasises emotions' influence on both individual mental health as well as on socio-political cohesion that shapes "social relations through the mediation of the self's relations to those deemed 'other', drawing and redrawing boundaries between you and me, them and us via feelings of attraction, repulsion, and so on" (Smith, M. *et al.* 2009, 12). Such boundaries are reinforced through spatial formations – borders – defining (who/where is) within and without/outside.

Conceptualising fear beyond an individual experience from a geographical perspective

As the previous section concluded that emotions are more than individual experiences, this section highlights how fear – as an emotion – makes sense in its wider context. In fact, fear as a social problem has appeared in many subfields of geography, such as those linked to urban research, criminology, anthropology, gender studies, geo-informatics and so on (Koskela, H. 2010). As Koskela, H. (2010, 389) writes "as a research topic, fear is fascinating", because it is: individual, social, and spatial. Fear and fear of crime, in particular – Koskela, H. (2009, 335) argues – "is constantly modifying spatial realities" leading people to take different routes or staying at home when its dark outside. There have been several ways in which geographers and spatial theorist have approached fear. In fact, more often than being considered as an emotion, fear is researched as a by-product of criminal activities, terrorism, or lack of security. There are other ways in which these approaches can be categorised, but a chronological overview that provides insights into ideological differences as well is a helpful way to see how different schools have transformed over the time and the way they defined sources of danger (i.e., Others). In particular, Koskela, H. (2009, 2:335) identifies three overlapping traditions in the geography of fear. First is a *macro scale approach* linking back to the sociologists of the Chicago School of the 1920s–1930s without much emphasis on emotion. The primary focus of this tradition is on fear of crime and the way it can be mapped in order to paint a picture of more fearful areas, cities etc., using cognitive mapping and survey questionnaires. Such research has entered a new phase with technological and methodological development utilising geographic information systems (GIS), and big data sources, such as social media as tools. As Koskela, H. (2009, 335) notes "a characteristic of this tradition is that it recognizes space as a surface". Macro scale approaches, unintentionally, often contribute to the Othering of spaces.

The second category that Koskela identifies comprises of research that focuses on the *micro scale*. This can be more directly linked to the above mentioned humanistic, phenomenological, and earlier waves of the feminist approaches of the 1970s–1990s that are more interested in fear as experienced and the *way* it is aroused by "physical forms" and "social situations". Beside the above methods, it also uses (in depth) interviews as it aims to develop an understanding of space that is beyond a surface (Koskela, H. 2009) or a container. Early feminist research on fear, however, often ended up reinforcing dichotomies by reinforcing vulnerable women and perpetrator Others (Hall, A. 2010).

The third category, Koskela, H. (2009, 336) named as the *production of space approach* according to which "fear cannot be presented just as a combination of frightening physical structures and social situations but that the physical and social dimensions are fundamentally intertwined". Rather than being curious with mapping out spaces of fear, this approach goes beyond seeing fear as a "private problem of an individual" and is concerned with the power structure contributing to the social production of fear as an emotion (Fenster, T. 2005; Koskela, H.

2009). It is therefore pay close attention to the processes of 'Othering' and in fact argues that "if there was no Other there would be no reason to be afraid"; that said, "fear has an unholy alliance with prejudice, hate and anger" (Koskela, H. 2010, 390).

More recent studies have increasingly considered intersectional approaches leading to further unsettle dichotomous approaches to fear (i.e., white middle class women as victims and racialised Others as perpetrators) (Rodó-de-Zárate, M. and Baylina, M. 2018), as well as Sara Ahmed's notion of emotion as cultural practices, not as psychological states. In her interpretation, cultural politics of emotions produce "others" by defining which bodies belong within and which bodies should be marginalized through representation and (material) rhetoric (Ahmed, S. 2004).

Tulumello, S. (2015, 2020) also discusses representation in relation to fear, , but through the notion of the landscape of fear (or 'fearscape' – see also Rashmi, R. and Rai, A.K. 2019), based on cultural geography's discourse on landscape as the representation of nature/environment. He does so by drawing on the conceptualization of the landscape of fear by Tuan, Y. (1979) – "putting psychological states and tangible environments into dialogue" – and its development by Gold and Revill – highlighting the political nature behind (Gold, J.R. and Revill, G. 2003) – entwined with marginalisation and othering. Tulumello, S. (2020, 129) highlights the central role "distance" plays in the existence of landscape, writing that landscape "exists because of the distance between the observer and the observed". Similarly, fear exists through such distances; without actual experiences of violence the construction of dangerous Others happens as a consequence of imagery (representation) and results in the shaping of space (Tulumello, S. 2020). Tulumello argues for reducing such 'distance', as only by crossing socio-spatial borders, through proximity and by 'living the space' can one make sense to its frightfulness and potentially unlearn the fear associated with certain spaces. This account of fear, not only highlights that by the production of distance, the practice of Othering becomes easier, but also leads to the conceptualisation of fear as trans-scalar (Tulumello, S. 2020, 29).

Towards a multi-scalar understanding of fear

The previous sections have argued, first, that it is important to reflect on the emotional qualities of fear and, second, that fear as an emotion should be understood through social, political, economic, and spatial relations. This section places fear in a multi-scalar/trans-scalar frame by drawing on the existing literature and by beginning to unfold the arguments of the present paper; that is (1) familiar-Other dichotomies are reimagined at all scales (private-public, home-outside, domestic-foreign, etc.) to serve various political interests and (2) while fear associated with Others (and Other places) is socially and politically reinforced, being afraid of familiar people and places tend to be "tabooised" and seen irrational.

A more traditional, "methodological" approach to geographical scale understands geographical scales as a hierarchical system of cities, regions, countries etc. where each layer may provide with an aggregated average of social, economic, or political information, but they hide the difference and inequalities within (Latour, B. 1987; Berki, M. 2014). Driven from such limitation the concept of scale has been objected to theoretical reflections in human geography, now, for decades motivating debates across its subfields (for examole as discussed by Marston, S.A. *et al.* 2005), primarily focusing on the social production/construction of scale (Smith, N. 1992; Delaney, D. and Leitner, H. 1997; Marston, S.A. 2000). Research by Pain, R. (2009) has been fundamental to developing such non-hierarchical, multi-/trans-scalar understanding of fear and particularly important in highlighting the problematic nature of the idea that fear is produced at a larger – global, international, 'political' – scale, dripping "down into people's minds, bodies and everyday lives" as passive receivers (Pain,

R. 2009, 472). She makes this observation in relation to the geopolitics of fear that she argues – in a paradoxical way – lacks interest in emotion itself, reinforcing "a fixation with the global as the key scale for analysis" and "disempowering identities for its supposed subjects" (Pain, R. 2009, 472). Such shortfalls, however, have been addressed in subsequent research by Pain, R. and of others through research focusing geopolitics and/or planetary urbanism leading to a more emotional multi-/trans-scalar conceptualisation of fear that considers Othering as central to the production of fear (Abu-Orf, H. 2013; Pain, R. and Staeheli, L. 2014; Listerborn, C. 2015; Pain, R. 2015; Christian, J. *et al.* 2016; Pavoni, A. and Tulumello, S. 2020; Tulumello, S. 2020).

Hoping to achieve a trans-scalar (Tulumello, S. 2020) approach, thus, not falling into a hierarchical review of fear at different scales, the following paragraphs discuss the interconnected nature of re/production of fear from the scale of the body to the to the global scale considering the processes of 'Othering' as a central element. With relying on examples primarily from the Hungarian context the following paragraphs address the second goal of this paper that is to highlights the importance and relevance of a trans-scalar understanding of fear in the context of Hungary (and perhaps in the region in general).

Trans-scalar production of fear and the re/production of Othering across scales

Crossing the road due to the fear of passing by a stranger at night is beyond an individual instinctive reaction. It is a practice informed by one's understanding of their body in a given cultural, social, political and economic context. Drawing on Susan de Beauvoir's 'theory of the situation of the women' and Maurice Merleau-Ponty's 'theory of the lived body' Young, I.M. (1980, 144) in her paper, "Throwing like a girl: A phenomenology of feminine body comportment motility and spatiality" argues that a woman as a human existence (as a subject) understands her *objectification*, her 'Othered' status. Young identifies two main manifestations of this understanding; the lack of confidence and the fear of getting hurt, both of which girls acquire throughout their development/socialisation, through the learning process whereby "a girl comes to understand that she is a girl" (Young, I.M. 1980, 154).

While crossing the road to avoid passing by a – potentially gendered, classes, and/or racialised Other – stranger at night is seen normal, fear within one's home, among family has been marked by taboos, hysteria and/or shame. The romanticisation of home has been central to western culture and the idea that one's home would not provide with security, love and comfort has been long ignored along with the diverse meanings 'home' may entail (Blunt, A. 2005). It is so, as in the general imagery, harm comes from Others and happens in other spaces (Datta, A. 2016) beyond the borders of home. As this paper argues such borders define every scale, but with enlarged concepts of 'home'. A multi-scalar understanding of home (Blunt, A. *et al.* 2021) and of (domestic) violence in particular has been also discussed – in feminist geopolitics – in relation to global terrorism and the politics of fear emphasising that violence at home is overshadowed by the war on terror (Pain, R. 2014) and the securitization of public spaces. This has been conspicuously demonstrated, in the case of Hungary, for example, by its' reluctance to ratify the Istanbul Convention that stands against violence against women and domestic violence. The Istanbul Convention was left unsigned by the government following a debate in the European Parliament that managed to politicise the content of the Convention (Krizsán, A. and Roggeband, C. 2021). The argument against the ratification was that the Convention uses the "non-consensual and ambiguous term 'gender'" (Kováts, E. 2020, 91). This (non)action showcases the prioritisation of national politics over personal experience through an international policy used for national political goal.

As opposed to home, the scale of the city, and public spaces in particular have been considered as dangerous, violent and fear-

ful spaces (Pavoni, A. and Tulumello, S. 2020). This notion has been utilised in everyday and political discourse both to limit the movement of women and children as well as to justify penal/regulatory policies towards those considered as the source of danger, reinforcing (urban) fear as inherently gendered phenomena (Bondi, L. and Rose, D. 2003; Kern, L. 2007, 2010, 2020). In this context, urban Others (e.g., homeless people, Roma people, prostitutes) as perpetrators and white middle-class women as victims has been "a ubiquitous topos of public representation" even though it is known "that sexual violence is more often committed by acquaintances, (ex-)partners, or relatives" (Hall, A. 2010; Tulumello, S. 2020, 128). Mostly in western context such issues have been addressed through new forms of privatisations in urban planning to enable/empower women through planning and policies (Beebeejaun, Y. 2009). However, these practices (e.g., gated parks) are often in the favour of reinforcing traditional gender roles (Kern, L. 2010) as well as reinforcing other forms of differences and discriminations (Koskela, H. and Pain, R. 2000; Lawton, C.A. and Kallai, J. 2002; Phillips, D. 2006; Beebeejaun, Y. 2009; Koskela, H. 2010).

While homeless people are generally pictured as sources of fear in the context of urban violence, when the migration crisis of 2015 has hit Hungary, a discourse comparing the support given to refugees and local homeless by civil organisation has risen. Government related media outlets expressed their disapproval of helping (with food and warm clothes) refugees – deemed dangerous – as opposed to supporting 'our own' poor. Regarding the terror attacks and terrorism discourses of the early 21st century, Pain, R. (2009, 436) argues, that "the idea that governments are increasingly manufacturing, drawing upon and reproducing fear (at least, certain sorts of fears) has become the predominant focus of attention." This has been conspicuously demonstrated during the arrival and subsequently by the approach to non-white migrants (refugees) arriving at the Hungarian borders (Feischmidt, M. 2020), reproducing narratives that situate (white) western populations within the boundaries of the Homeland, and dangerous Others outside (Pain, R. 2009). However, whether the (Central and) Eastern European region is part of the club also shift from time to time or even more from discourse to discourse leading to the formation of a variety of supranational formations, the re-imagination of "imagined communities" (Anderson, B. 1983), and the liquidity and trans-scalar nature of 'home/land'. That is to say, such discourses "jump scale" (Smith, N. 1992) easily.

Regional level groupings, such as the union of the four Visegrad (V4) countries or the European Union, allow the definitions of different "us" and "them" narratives. As Lamour, C. (2021) argues in the case of the EU, but just as much relevant in the case of the V4 countries the link between populism and regionalism and related complex "economic power geometries" has reproduced and reinforces new forms of regionalism, "regional vison"; and has led to new forms of "uneven development, socio-spatial polarization and a transformation of solidarity regulations" (Lamour, C. 2021, 3).

Then there are fears that are beyond any forms of borders, organised around fears that are often so abstract and far from everyday personal experiences that can be generalised as much as they can develop meaning anywhere. Bondi, L. (2009) refers to these as "globalised fears", arguing that "local threats" were replaced/combined with "global threats" and similarly so, Koskela, H. (2010) argues that "local Others" were replaced – I would argue – or combined with "global Others". At least so, global Othering gained local meanings.

The multi-scalar nature of fear is further mediated by a variety of globalised sources of culture, information and knowledge, such as international news portals, social media, movies, and providers such as Netflix. That is to say, individual emotions not only reflect experiences re/produced at different scales, but also their media representation (Bondi, L. 2009).

In fact, media outlets have peculiar effects on blending together – and scaling up – fears determined at different scales. Even more, they contribute to the globalisation of fears where fear loses its "spatial and temporal" terms, becoming unpredictable and uncontrollable (Beck, U. 2002; Pain, R. 2009). Increasingly so in the cases of climate change, immigration flows or diseases such as the COVID-19.

Conclusions

The present paper combines and draws on the existing literature on multi-scalar/trans-scalar, emotional, spatial, and political understandings of fear (1) to contribute to the literature by highlighting the way the political production of fear can jump across scales, and (2) to highlight its relevance in the Hungarian (and Central and Eastern European) context.

I suggest that "familiar" versus "unknown" or "us" versus "them" dichotomies are reimagined at all scales (private-public; domestic-foreign) and concerning discourses jump scale according to political convenience. Such discourses jump scale by the constant definition and re-definition of Others and imagined communities. Fear associated with others and other spaces are socially and politically reinforced, while being afraid of familiar people or spaces is often 'tabooised' and seen irrational.

The affective/emotional turn in geography have greatly affected the discipline resulting in ground-breaking research and a more nuanced understanding of the world. There are greatly valuable and inspiring research in this field, many noted above. However, often there is an argument from researchers from the semi-periphery of Europe in particular that emotions are out of the horizon of this region because there are materialities that need faster fix. Studies (e.g., on the post-socialist transformation in CEE) have shown that there are views according to which just like there is no time to deal with gender equality (Timár, J. 1993), there is no time for emotions either. This paper, however, wants to point out that there *should be* time as emotions are not bourgeois mischiefs, or boredom of the western middle class. This paper argues that emotions structure political and economic systems at every scale, in fact emotions contributes to multi-scalar politics – both top-down (e.g., in the form of oppression) and bottom-up (in the form of resistance).

There is an important point that has not been highlighted in this paper so far that is the question of whose fears matter. As Pain, R. (2010, 471) writes there are "assumptions about the ways in which emotions originate, travel, and affect and [i]ronically, geographers have sometimes joined in the universalization of fear, applying it with a broad brush across a flat earth". This is another argument for more relevant research to be conducted in Hungary, Central and Eastern Europe and outside of the core countries in general. While in the Anglo-American world geographical research have immersed in emotions in the last decade, in Hungary barely any geographers have been inspired by the concepts of emotion, feeling and affect, at most tangentially (Czirfusz, M. 2014; Fabók, M. and Berki, M. 2018), in relation to tourism (Michalkó, G. and Rátz, T. 2008; Irimiás, A. *et al.* 2021), care migration (Németh, K. and Váradi, M.M. 2018), and the politics of commemoration (Erőss, Á. 2017). From outside of the discipline, probably the most relevant reading is a recently published book that approaches the geographies of affect through the analysis of contemporary literature and visual culture (Györke, Á. and Bülgözdi, I. 2020; Sági, M. 2021), but environmental psychologists have also actively engaged in understanding the relationship between emotions and space (Dúll, A. 2022), however, with less consideration of the production of space.

'Fear' has been somewhat more popular topic in human geography in Hungary (e.g., Molnár, A. 2012; Pődör, A. *et al.* 2016; Jakobi, Á. and Pődör, A. 2020), however, in most cases with little attention to its complexities either as an emotion or as a social construction, but rather as a consequence of crime. I believe that locally specific matters – such as debates over (the persistent relevance

of) post-socialist cities (Bodnár, J. 2001; Grubbauer, M. 2012; Csomós, G. *et al.* 2020; Fabula, Sz. *et al.* 2021) – would also benefit from further exploring non-hierarchical approaches to scale in general (e.g., Timár, J. 2004; Czirfusz, M. *et al.* 2018; Szalai, Á. *et al.* 2021) and in relation to emotion and fear in particular, while also providing with a comparative lens and new perspectives about existing knowledge elsewhere (Robinson, J. 2016) on the multi-scalar production of fear.

Acknowledgement: Project no. 138713 ("Marginalised space experience in the context of uneven geographical development") has been implemented with the support provided by the Ministry of Innovation and Technology of Hungary from the National Research, Development and Innovation Fund, financed under the K_21 funding scheme.

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DOI: 10.15201/hungeobull.71.1.5 Hungarian Geographical Bulletin **71** 2022 (1) 67–81.

The geography of electoral volatility in Hungary: a core-periphery perspective

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Abstract

Electoral volatility is understood in the literature as a sign of political instability, weakening social cohesion and the declining influences of existing political parties which threatens the healthy functioning of representative democracy. In this paper, using the Pedersen Index we measure electoral volatility in Hungary at the settlement level between the last three parliamentary elections (2010, 2014 and 2018), with special attention to the geographical aspects of the phenomenon. According to our preliminary assumptions those social groups switch their votes frequently who are marginalised, therefore, the level of volatility may reflect peripheriality. Our results show that high volatility can be detected in the two opposite sides of the settlement hierarchy in Hungary: in bigger cities and smaller villages, but for very different reasons. This study gives evidence that electoral volatility can also be considered as a possible indicator in the delimitation and classification of peripheral areas and settlements. The paper aimed to contribute to the understanding of cleavage formation at the regional level by adding a spatial perspective while connecting the socioeconomic profile of the voting population and electoral volatility.

Keywords: electoral geography, volatility, Pedersen Index, cleavages, party system, core-periphery, Hungary

Received January 2022, accepted March 2022

Introduction

In democracies, political parties have the primary role for integrating diverse interests and social forces in the governing institutions, hence they are crucial for legitimizing the regime (Diamond, L.J. *et al.* 1989; Pridham, G. 1990; Toka, G. 1995; Elster, J. *et al.* 1998; Kitschelt, H. *et al.* 1999). Highly volatile elections and abrupt shifts in the party system often reflect political instability, economic and social tensions within the society. Electoral volatility is understood in the literature as the total change in the percentage of seats or votes won or lost by all parties between elections caused by a mix of party-switching, differential turnout rates and generational replacement (Gomez, R. 2015). Electoral volatility is usually measured by the Pedersen Index which can be calculated as the sum of percentage gains of all winning parties in an election or the sum of the losses, and has a theoretical range running from zero to 100 (Ascher, W. and Tarrow, S. 1975; Pedersen, M.N. 1979). Since the index has significant variability over time and space, it seems to be a suitable proxy indicator for economic prosperity versus decline, political and social stability versus instability at the regional and local level. Highly volatile election results are thought to endanger governability and even the stability of democratic regimes, hence researchers consider high electoral volatility as a sign of weakening social cohesion and the

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structural decline of parties which is threatening to the healthy functioning of representative democracy (Mainwaring, S. and Scully, T. 1995; Mainwaring, S. and Zoco, E. 2007; Powell, E. and Tucker, J. 2014; Bértoa, F.C. and Rama, J. 2020).

Comparative analysis of Bakke, E. and Sitter, N. (2005) revealed that different patterns of stabilisation have been driven largely by strategic choices made by parties. Haggard, S. and Kaufman, R.R. (1995) argue that stable and strong party systems are crucial for the success of economic reforms in new democracies. This paper focuses on the recent parliamentary elections of post-communist Hungary (i.e. 2010, 2014 and 2018). The so-called new democracies of East Central Europe have seen several twists and turns in parliamentary party-representation since the collapse of communism along the main national-populist / civic-democratic divide, albeit with a stable core (Szabó, B. 2013; Kovács, Z. and Vida, Gy. 2015; Szczerbiak, A. 2017; Kevický, D. 2021). Hungary was no exception in this regard, and right-left voter fluctuations were significant in the country between 1990 and 2010. However, in 2010 the Fidesz-KDNP party alliance established itself as the anchor on the centre–right side of the party system, concentrating the majority of non-left-liberal votes, winning three subsequent elections (2010, 2014, 2018) and securing a comfortable two-third majority in the parliament (Kovalcsik, T. *et al.* 2021). The weak position of the left-liberal parties (MSZP and SZDSZ) routed in the political scandals during the previous government period (2006–2010) and the 2008 monetary crisis which affected Hungary more severely than other countries in the region. Due to the financial crisis the country was close to bankruptcy and the rate of Hungarian public debt increased from 60.0 percent to 79.7 percent between 2005 and 2010 (KSH, Eurostat). Consequently, the parliamentary elections held in 2010 resulted in a substantial rearrangement among the parliamentary parties. The moderate-right MDF fell out of the parliament, while the national radical party (Jobbik) got into the Hungarian National Assembly with a robust voters' support of 16.7 percent (Ágh, A. 2016; Enyedi, Z. 2016; Palonen, E. 2018). The expansion of the radical right continued until 2014 when Jobbik won its second parliamentary term with 20.3 percent (Ilonszki, G. and Várnagy, R. 2016). By 2018 the support of Jobbik slightly decreased (19.1%), nevertheless, it remained the second biggest party in the parliament. Simultaneously, the mainstream conservative party Fidesz-KDNP gradually shifted to the right in order to attract voters' support from Jobbik. The ruling Fidesz-KDNP party alliance enjoyed a seemingly stabile voting base in the last three elections (winning 52.7%, 44.9% and 49.3% of the votes) and a comfortable majority in the parliament, nonetheless, it is an intriguing question if electoral volatility could be measured in Hungary in the 2010s.

The main aim of this paper is to measure electoral volatility in Hungary after 2010, with special attention to the geographical aspects of the phenomenon. We focus on electoral volatility between 2010 and 2014, and 2014 and 2018, when the economic downturn seemed to reverse and electoral volatility became more moderate compared to the previous decades. We would like to investigate regional differences of electoral volatility within Hungary and explore possible reasons behind it. The main question is whether electoral volatility reflects socio-economic and/or regional factors of party preference? Are poorer, deprived people living in peripherized regions tending to change their vote more likely? For the sake of analysis, we use various socio-economic indicators and methods to explore possible factors of volatility vs. stability at the settlement (i.e. municipality) level.

The rest of this paper is organised as follows. The second section discusses existing works on electoral volatility and their interpretations in different countries. The third section presents the methods of data acquisition and processing. A section then follows with the main findings of the research, pre-

senting the differences of electoral volatility within settlement hierarchy and its regional pattern. Finally, we present our conclusions, discuss their wider implications, highlight the limitations of our method and explore possible future work in the field.

Concepts on electoral volatility: a literature review

Studies on electoral volatility have identified three main groups of causal variables: (1) economic factors, (2) political institutions, and (3) social cleavages (Bartolini, S. and Mair, P. 1990; Roberts, M. and Wibbels, E. 1999; Birnir, J.K. 2004; Coppedge, M. 2018). Electoral volatility can be an important indicator of economic conditions, as a prosperous economy may reduce electoral volatility by solidifying support for the political status quo, making volatility an inverse linear function of the strength of economic performance. Many researchers pointed out substantial evidence of economic voting in the United States (Kinder, D.R. and Kiewiet, D.R. 1979; Fiorina, M.P. 1981; Kiewiet, D.R. 1983; Markus, G.B. 1988), Latin America (Remmer, K.L. 1991; Roberts, M. and Wibbels, E. 1999), Western Europe (Lewis-Beck, M.S. and Rice, T.W. 1984; Lewis-Beck, M.S. 1990; Powell, G.B. and Whitten, G.D. 1993), and East Central Europe (Pacek, A.C. 1994). Most of these studies emphasize that economic inequality leads to political polarisation, higher levels of protest voting, elite-challenging behaviour, and lower levels of support for democratic institutions (Kern, A. *et al*. 2015; Kriesi, H. and Pappas, T. 2015). The literature on economic voting assumes that incumbent governments are more likely to be punished for bad management of the economy in countries where inequality is high, because voters' perceptions of the economy are more likely to shape voters' behaviour in these societies (Goubin, S. *et al*. 2020).

Second, political institutions may also affect electoral volatility through the stability of the broader regime institutions in which parties compete, as well as through the properties of the party system itself. Haggard, S. and Kaufman R.R. (1996) identified political institutions and the degree of their fragmentation an important factor in the political consolidation of economic reforms in emerging democracies. Bartolini, S. and Mair, P. (1990) noted that institutional modifications (e.g., the amendment of the electoral law) resulting significant changes in voter turnout or the proportionality of representation can be associated with higher levels of volatility. The permissiveness of the institutional arrangements toward new competitors in the electoral arena has also effects on electoral instability. The positive relationship between volatility and the number of parties is often confirmed. Pedersen, M.N. (1983) also suggested that volatility increases in multiparty systems because the greater the number of parties and the smaller the ideological differences between them voters can more easily transfer from one party to another. Roberts, M. and Wibbels, E. (1999) claim that the degree of polarisation of the party system reduce electoral volatility by increasing the policy distance between different parties, furthermore the age of the main parties also affects the degree of electoral volatility since older parties are likely to have deeper, more stable roots in society than younger ones.

The third approach explaining electoral volatility – i.e. social cleavages – is structural, as it links electoral volatility to the structure of socio-political cleavages and their degree of organisational closure. Cleavages of class, religion and ethnicity are institutionalised through partisan competition and the construction of mass party and labour union organisations (Lipset, S.M. and Rokkan, S. 1967). A group of scholars argues that major changes in political representation have occurred in Western Europe after World War II, often in association with the structural transformation of national economies and labour markets when the 'materialist' values – emphasising economic and physical security – declined, while 'post-materialist' values – emphasising autonomy and self-ex-

pression – became increasingly widespread (Inglehart, R. 2008). Traditional class cleavages have been undermined by the growth of white-collar service sector, the relative decline of the industrial proletariat, the weakening of blue-collar labour unions, and the emergence of a post-materialist dimension of political competition, which in turn result higher volatility in voting behaviour (Daalder, H. and Mair, P. 1983; Crewe, I. and Denver, D. 1985). Many authors claim that party systems are more stable when they are grounded in well-defined and well-organised societal cleavages (Dalton, R.J. *et. al.* 1984; Inglehart, R. 1990; Piven, F.F. 1991; Franklin, M.N. *et al.* 1992; Kitschelt, H. 1994; Dalton, R.J. 1996). Bartolini and Mair (1990) provided quantitative evidence, showing that high levels of working class organisation and ethnic and religious diversity tended to dampen electoral volatility in Europe between 1885 and 1985. Authors argue that, "the stronger and more pervasive is the strength of the cleavage system of a given country or period, the lower will be the elasticity of the vote and, therefore, the lower will be the level of electoral instability" (Bartolini, S. and Mair, P. 1990).

There is a growing body of literature on electoral volatility in post-communist East Central Europe, too (Powell, E. and Tucker, J. 2017; Emanuele, V. *et al.* 2020). As an antecedent Johnston, R.J. *et al.* (1987) analysed the geographical stability in the pattern of electoral support for political parties in East European countries. Authors argue that the nature of each party's electoral appeal is the major determinant of the geographical stability of its support and parties with a strong class base depend very much on "socialisation in place" and have high levels of stability. Tavits, M. (2005) used longitudinal cross-section data on election results from 15 East European countries and found that, right after the collapse of communism electoral volatility increased but the trend gradually reversed when democracy stabilised. Author also investigated ethnic cleavages and argued that it had no effects on stability while social cleavages affected electoral stability only during economic downturns. She also claimed that, both institutions and economic performance influence the stability of party support; but the effect of the latter diminishes over time when democracies mature. Findings of other studies also imply that, instability is more likely in the initial phase of party system evolution, and it is often associated with the behaviour of inexperienced voters (Van Biezen, I. 2003; Tavits, M. 2008).

In their studies Powell and Tucker (2014, 2017) gave a new impetus to volatility studies in post-communist countries, elaborated a new approach and expanded the time frame of investigation. Authors differentiated Type A and Type B electoral volatility based on the expanded collection of elections in the region. They defined Type A Volatility when volatility is caused by party entry and exit, i.e. the change in the party system. In their approach, Type B Volatility occurs when voters switch their votes among stable parties and this type of volatility considered a healthy component of representative democracy, which essentially reallocates power between political actors that are already integral parts of the political process. The sum of Type A Volatility and Type B Volatility is equal to the traditional Pedersen Index. Authors argue that the best predictor of electoral volatility is the GDP change between two elections, and that mixed systems (like e.g. in Hungary) tend to be more volatile than presidential systems. They measured only in Hungary higher Type B Volatility than the traditional Type A Volatility. Authors also suggest that post-communist young democracies may at some point start to resemble the more traditional volatility patterns of consolidated democracies.

Birch, S. (2001, 2003) measured the average volatility scores by countries in East Central Europe and found that Latvia and Lithuania had been the most unstable along with Romania. Until 2003 the countries of the former Soviet Union had only two or three democratic elections, so it was difficult to describe a trend there, but all countries have

experienced a decrease in volatility after the first elections. The representative patterns in the Czech Republic, Slovakia, and even Ukraine seem to be more stable than in the Baltic States. To date most research on electoral volatility in post-communist countries has measured on volatility at the national level and only few focused on the sub-national level (see e.g., Schaub, M. and Morisi, D. 2020). This aspect seems to be especially relevant because the free movement of global capital has resulted in a rapid polarisation and a weakening cohesion within post-communist societies, reconfiguring core-periphery relations at the sub-national level (Szabó, B. and Tátrai, P. 2011; Lang, T. 2015; Voda, P. and Svačinová, P. 2020).

Data and methods

If we try to measure electoral volatility several difficulties appear. For instance, incumbent vote change could not be measured with absolute values. In addition, there is the question of how to handle votes that do not result mandate due to threshold restrictions, as party systems are increasingly characterised not only by the emergence of new parties, but also by splits, splinters and mergers (Ocana, F. 2007; Bértoa, F.C. *et al.* 2017). Even when focusing on post-communist countries some of the parties in East Central Europe can be labelled as 'genuinely new' (Sikk, A. 2005), but many more fall to the category of old. The changing ideological platforms of small parties make longitudinal comparative studies of electoral volatility nearly impossible. Due to these reasons, we do not engage here with the results of parties below the parliamentary threshold. Present study focuses on the results of three last parliamentary elections in Hungary when only two 'newcomer' parties won seats in the parliament in 2010 (Jobbik and LMP) next to the mainstream Fidesz-KDNP and MSZP, but later Democratic Coalition (DK) separated from Socialist Party (MSZP) in 2018. Thus, our study focuses on the results of five parties during the last three consecutive parliamentary elections in Hungary.

In political science the electoral volatility index of Mogens Pedersen (1979) is widely used to measure the changes in party systems. It calculates the absolute value of the net change of a particular characteristic (*P*), for every entity (*i*) between two periods (*t* and *t*+1) divided by the sum of the same characteristic (*P*) at both time periods. Most of the researchers use this formula:

$$Volatility = \frac{\sum_{i=1}^{n} \left| p_{i,t} - p_{i(t+1)} \right|}{2},$$

where $p_{i,t}$ is the vote (or seat) share of party (*i*) at the first election (*t*) and is the vote (or seat) share of party (*i*) at the second election (*t* + 1) (Pedersen, M.N. 1983). The main advantage of the index of electoral volatility as an indicator is that it can be obtained for a great number of countries, regions and elections, which allows for large-n comparative analyses.

In this research a cluster analysis of electoral volatility was performed on the basis of the results of three parliamentary elections in 3,151 Hungarian municipalities (i.e. settlements) between 2010 and 2018. The electoral system of Hungary is unicameral and mixed since the collapse of communism (1990) where each voter is eligible to cast two votes: one for a district candidate and another for a political party list. The country consists of 106 constituencies since the 2011 Electoral Act, when the number of electoral districts was reduced from 176 to 106, and the number of parliamentary seats decreased from 386 to 199. Due to these fundamental changes in the electoral system, we investigated only the party list votes and the results of constituencies were not considered.

This paper focuses on stability versus volatility in the electoral behaviour of people in Hungary based on the assumption that ethnic and social cleavages will affect electoral volatility. If ethnic minorities and socially disadvantaged groups do not feel well represented by the mainstream par-

ties, they may exhibit high levels of electoral volatility. To test Lipset and Rokkan's (1967) classic concept, we would like to explore the voting behaviour of different socio-economic and ethnic groups that are marginalised and suffer from socioeconomic disadvantages. According to our preliminary assumptions, these groups switch their votes particularly frequently since they have little reason to establish enduring ties to political parties that fail to cater to their needs and often choose another party.

For the sake of analysis, we selected different socio-economic indicators from the National Census in 2011, and from TeIR published by the Hungarian Central Statistical Office annually. We collected data at the settlement level, reflecting local demographic, socio-economic and ethnic conditions. We used the following five indicators in the research:

(1) settlement size / population,
(2) age structure,
(3) rate of higher educated,
(4) rate of unemployment,
(5) rate of minority (Roma).

The so-called Pedersen Index was calculated for each settlement and groups of settlements according to socio-economic indicators. By combining all these data, we could get information on voters' behaviour in the light of settlement size, demographic, socio-economic and ethnic conditions reflecting the presence of different social cleavages and the effects of socio-economic factors on voters' behaviour. During the research different statistical analyses were applied, among them cluster analysis.

Results

In this section first we focus on the five main socio-economic indicators and measure electoral volatility of Hungarian settlements. Second, we take a closer look at the smaller settlements and use cluster analysis to investigate the role of different factors behind volatility. During the calculations the votes of Democratic Coalition (DK) a fraction of the Socialist Party (MSZP) splitting by 2018 were considered both jointly with the mother party and independently, since the voting base of these two parties are very close to each other *(Table 1).*

According to our results electoral volatility shows a U-shape in the settlement hierarchy and it is high at the upper and lower levels of the hierarchy. Smaller settlements below 2,000 inhabitants and bigger towns above 50,000 people are more volatile than the middle part of the settlement hierarchy (typically big villages and small towns), but for completely different reasons. Voters of bigger towns and cities (especially Budapest) are more open to new political movements and new ideas, and they tend to change their preferences more frequently. On the other hand, residents of smaller settlements are more vulnerable to challenges caused by economic restructuring, globalisation and changes in lifestyle. They tend to be more inclined to follow the advices of local politicians (e.g. mayors) and opinion formers (e.g., priests, general practitioners, entrepreneurs) and change their vote between two elections. Tiny villages below 500 inhabitants seem to be especially volatile in the parliamentary elections.

Regarding the demographic structure of the population, our data show that increasing weight of elderly is accompanied by a higher rate of volatility. As small and tiny villages are hit by population ageing, and they are home to a disproportionately large share of elderly, the demographic conditions reinforce high volatility experienced in small settlements. This suggests also that the decline and the reorganisation of left-liberal parties after 2010 and the rise of the radical Jobbik resulted in shifts in party choice especially among the elderly. In terms of the level of education (measured by the proportion of higher education graduates) we can observe again a dichotomy similar to the settlement hierarchy. Volatility is high if the share of university graduates is either high or low. The former is the case in cities and the latter in small vil-

Table 1 Explanatory factors of electoral volatility (2010–2018)

Indicator		Electoral volatility	Electoral volatility where DK calculated jointly list with MSZP
Population size			
< 500		14.8	14.5
500–2,000		12.8	12.4
2,000–5,000		12.1	11.5
5,000–10,000		11.9	11.1
10,000–20,000		12.6	11.7
20,000–50,000		13.3	12.2
50,000 <		13.9	13.4
Age structure, %			
under 40 years	< 20	18.6	18.6
	20–30	14.5	13.9
	30–40	14.2	13.8
	40–50	13.2	12.6
	50 <	13.3	12.8
over 65 years	< 5	12.9	12.5
	5–10	14.6	14.3
	10–20	13.2	12.7
	20–30	13.6	13.2
	30–40	14.9	14.4
Higher education graduates, %			
< 5		14.6	14.3
5–10		12.9	12.5
10–15		12.7	12.0
15–20		13.1	12.3
20 <		14.1	13.0
Unemployed people, %			
< 5		13.0	12.3
5–10		13.2	12.7
10–20		13.9	13.6
20–30		14.1	14.0
30 <		19.9	18.4
Roma minority, %			
< 5		13.8	12.6
5–15		13.5	13.3
15–30		14.0	13.7
30–45		14.0	13.9
45 <		15.3	15.0

Source: Own calculations based on data of the National Census 2011, and the National Election Office.

lages. Regarding labour market conditions higher unemployment rates are accompanied by higher volatility which is an obvious consequence of economic vulnerability.

The role of ethnic factor in electoral volatility is measured by the share of Roma population, the biggest ethnic minority in Hungary with a great deal of marginalisation (Taylor, A. *et al.* 2018). According to our results higher proportion of Roma results higher volatility at the settlement level. Our results correspond previous findings of Madrid, R. (2005) and contradict the claims of Birnir, J.K. (2006). Studying ethnic vote stability in new democracies since 1945 worldwide Birnir found that ethnic diversity stabilises initial vote behaviour in heterogeneous countries above and beyond that of homogeneous countries. Ethnic heterogeneity tends to induce stability of voting, but an important prerequisite of

voting stability is the existence of ethnic parties. However, if the interests of ethnic groups are not represented properly in government (or parliament) ethnic vote instability can be observed. Madrid, R. (2005) found higher volatility rates in regions of Latin America with high proportions of indigenous groups. Leading parties in these countries failed to address the needs and demands of indigenous people and they have regularly shifted their votes away from these parties towards unstable new parties (Madrid, R. 2005). Although volatility in these regions was more robust than in the Hungarian case, we should bear in mind that as previous research findings confirmed the ruling party alliance Fidesz-KDNP enjoys significant support among the Roma minority, which gives certain level of stability (Bertus, Z. 2014).

As a next step we analyse the spatial pattern of electoral volatility versus stability in Hungary. The maps showing settlements with low and high electoral volatility clearly reflect geographical differences within the settlement system. The eastern lowland part of the country (Great Plain) is dominated by larger settlements, typically between 5,000–10,000 inhabitants with market town character, where volatility is relatively low *(Figure 1).* In this part of the country the ruling party alliance Fidesz-KDNP is also traditionally strong, which reinforce voter stability. Similarly, low level of volatility can be observed in the economically most prosperous North Western region of the country. However, in the North Hungarian Range and in Southern Transdanubia, where the share of settlements with less than 500 inhabitants is high, the economy is less prosperous and the share of Roma population is above the national average we find high values of the Pedersen Index, reflecting high levels of volatility *(Figure 2).* Research results also confirm that the more liberal political climate of cities and the openness of their residents towards emerging political actors (i.e. newcomers) like Hungary's Green Party (LMP) a "green-liberal" party as well as dissatisfaction with the government's politics is accompanied by increasing levels of electoral volatility in highly urbanised regions (e.g. the agglomeration of major cities, most notably Budapest).

As the first stage of our analysis confirmed, even though rural areas show relative electoral stability among them the smaller settlements are highly volatile regarding voting. However, we also assume that next to settlement size the conditions of the local economy and the socio-demographic composition of the population also matter. Therefore, as a next step we focus exclusively on the settlements with less than 10,000 inhabitants (altogether 3,007 municipalities with ca. 40 percent of the population in Hungary) and investigate their socio-economic circumstances more thoroughly using various indicators in order to refine the picture. We examine the differences regarding electoral volatility within this group of settlements by using the method of cluster analysis. The indicators considered are: the proportion of people employed in the agricultural sector, data on ageing, income (on the basis of tax payments) the proportion of people who are involved in public work, the proportion of corporations and unincorporated enterprises in the agricultural sector and the proportion of the long-term (at least one year) unemployed among active earners *(Table 2).* We assume that due to globalisation and economic transformation (Egedy, T. *et al.* 2018) the previous role of agriculture has been lost in many rural communities (Hruška, V. *et al.* 2015) resulting in unemployment, relative poverty and social insecurity which in turn provides fertile ground for increasing electoral volatility.

Using the complex methodology and considering the Pedersen Index we could distinguish three major groups of settlements with less than 10,000 inhabitants, what we called 'volatile rural', 'less volatile rural' and 'stable urban' clusters. The size of these groups varies significantly, 70 percent of the investigated settlements (n = 2,104) belong to the 'volatile rural' group with an average of 553 inhabitants. The 'less volatile rural' group contains 24 percent (n = 721) of the settle-

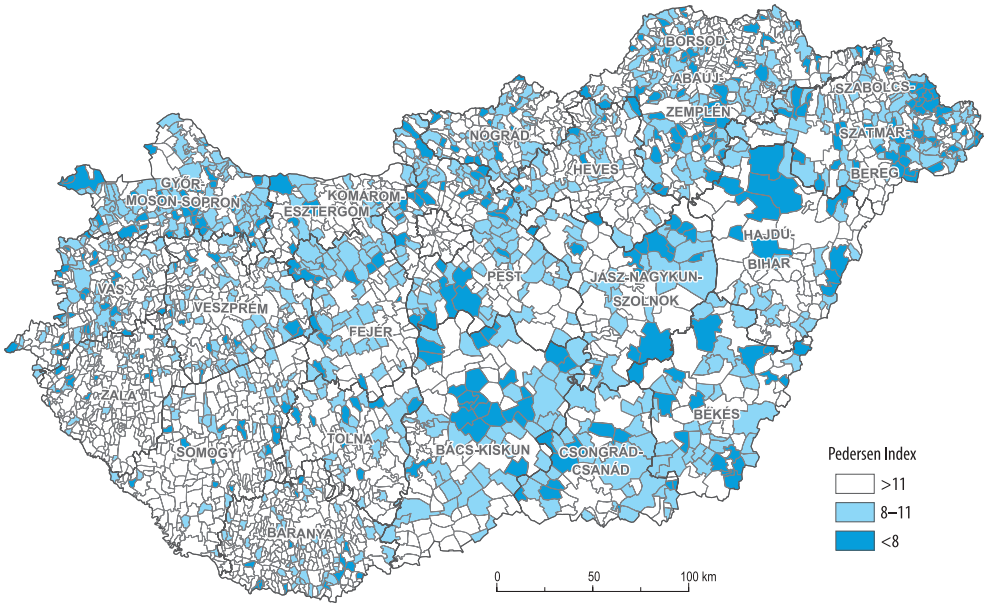

Fig. 1. Settlements with low electoral volatility in Hungary (2010–2018). *Source*: Own calculations based on data of the National Election Office.

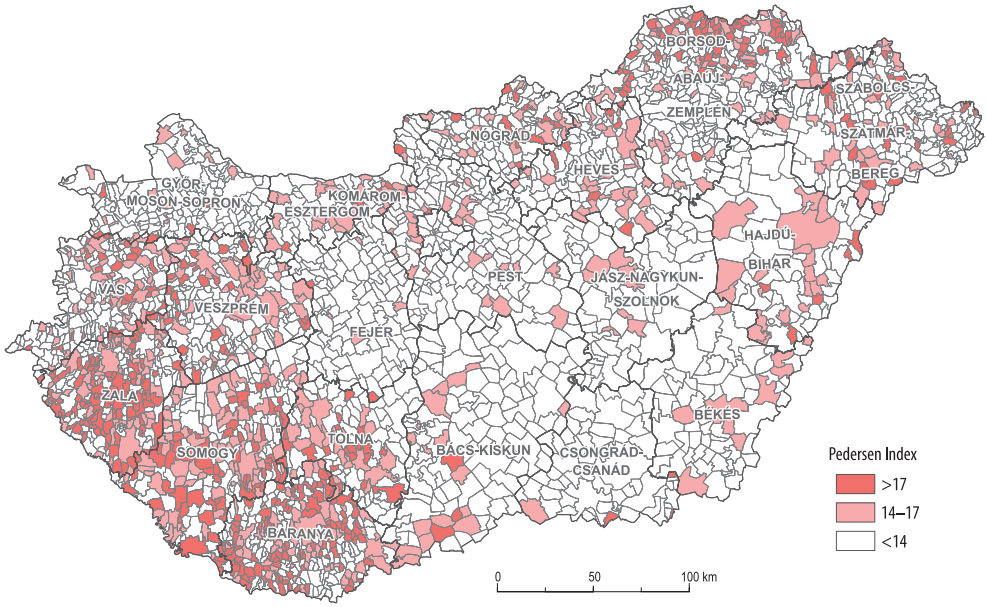

Fig. 2. Settlements with high electoral volatility in Hungary (2010–2018). *Source*: Own calculations based on data of the National Election Office.

Table 2. Cluster analysis of settlements below 10,000 inhabitants (Cluster Centres)

Indicator	Cluster		
	Volatile rural	Less stable rural	Stable urban
Average electoral volatility, 2014–2018 (Pedersen Index)	13.6	11.7	11.2
Number of settlements	2,104	721	182
Average population size	553	2,344	6,188
Average change of population, 2014–2018, %	-2.2	-0.2	0.0
Average amount of personal income tax base per taxpayers, 2018	2,054	2,347	2,485
Ageing: average proportion of population aged under 40 years	45.3	48.6	48.8
average proportion of population aged over 65 years	18.9	16.2	16.1
University graduates as a percentage of 25-year-old population, 2018, %	6.9	10.1	12.7
Proportion of Roma minority, 2011, %	6.6	5.3	3.8
Share of jobseekers registered for more than one year, 2014, %	1.4	1.2	1.1
Share of jobseekers registered for more than one year, 2018, %	1.1	0.9	0.8
Employment by major economic sectors:			
– Agriculture and forestry, 2014, %	11.7	8.7	7.4
– Manufacturing, construction, 2014, %	33.3	34.6	32.2
– Services, 2014, %	55.0	56.7	60.4
Share of active earners participating in public works, 2014, %	5.2	3.3	2.6
Share of active earners participating in public works, 2018, %	5.0	3.0	2.0
Number of enterprises in agriculture and forestry per 1,000 inhabitants, 2018	9.5	5.0	4.1

Source: Own calculations based on data of TeIR, Lechner Knowledge Centre.

ments with an average size of 2,344 people. The smallest group (6%) is comprised by the so-called 'stable urban' settlements (n = 182) with an average of 6,188 residents. The mean values of population size reflect that bigger municipalities with more urban character tend to be more stable, although there are significant differences within each group. In the 'volatile rural' group we find several bigger municipalities with around 1,500 inhabitants (Hangony, Pusztaszer, Petőfiszállás), just like in the 'stable urban' cluster we find settlements with slightly above 4,000 inhabitants (e.g., Pilisszentiván, Tószeg, Etyek). Therefore, next to size we should consider other factors that may influence electoral volatility. As data show residents of 'volatile rural' settlements are generally older and less skilled than those in the other two groups and the share of Roma is higher. People in active-age (below 65) tend to work in these settlements above average in agriculture and forestry, they suffer more from long-term unemployment and the amount of personal income tax is the lowest here among the three groups.

As a next step we split up the 'volatile rural' group and we considered only those settlements where the Pedersen Index of volatility was above 10.0 both between 2010–2014 and 2014–2018. Altogether there are 1,158 such municipalities where approximately 6.5 percent of the Hungarian population lived in 2018. The spatial distribution of settlements with persistent volatility shows a distinct geographical pattern and reaffirms the historically evolved core-periphery dichotomy in the country *(Figure 3)*. Peripherisation of communities is often conceptualised as powerless and passive victims of some superordinate processes beyond their control (Pénzes, J. 2013; Lang, T. 2015; Pósfai, Z. and Nagy, G. 2017; Pénzes, J. and Demeter, G. 2021). However, peripheral position of settlements, their vulnerable position is also well reflected in fluctuating voting behaviour, abrupt shifts among different political parties and ideological traits. In frustrated peripheral settlements it is common that opposition attitudes develop, furthermore the continuous transformation of opposition parties has in many cases been accompanied by the instability of their voting base.

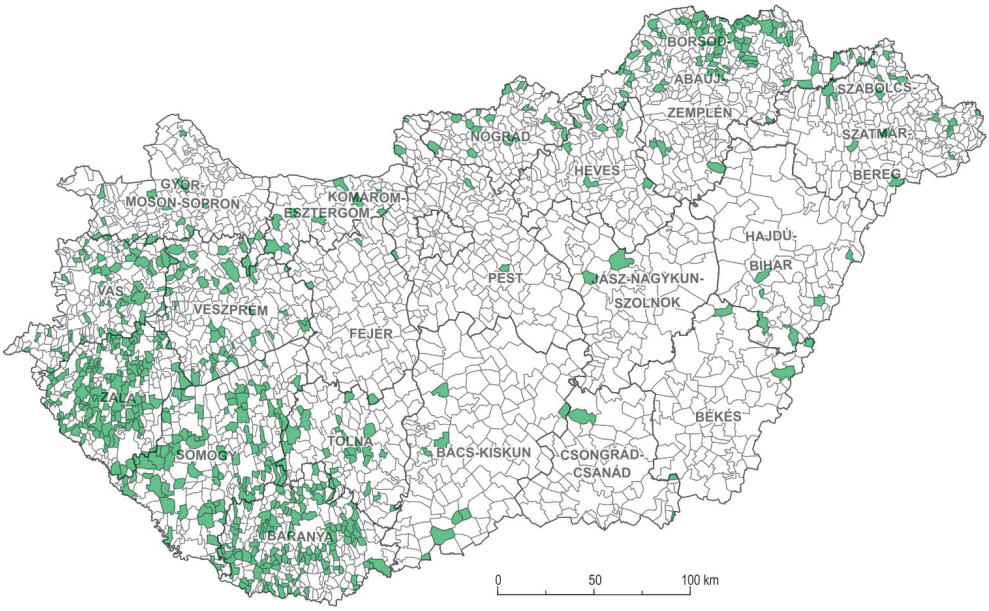

Fig. 3. Settlements with persistent electoral volatility in Hungary after 2010. *Source*: Own calculations based on data of the National Election Office.

Discussion and conclusions

In this paper, building on previous findings of Bartolini, S. and Mair, P. (1990), Mainwaring, S. and Scully, T. (1995), Roberts, M. and Wibbels, E. (1999), Madrid, R. (2005), Mainwaring, S. and Zoco, E. (2007), Powell, E. and Tucker, J. (2014) we investigated the socioeconomic and geographical aspects of electoral volatility in post-socialist Hungary between 2010 and 2018. The results show that high volatility can be detected in the two opposite sides of the settlement hierarchy: in bigger cities and smaller villages. However, the reasons behind this phenomenon are very different. Residents of bigger, economically striving cities are more open to new political ideas and parties, and they are also more critical towards the ruling party, therefore, they tend to change their political opinion more often, search for political alternatives and change their vote. Voting behaviour of people in smaller settlements is also volatile but as our research showed not only the group of the smallest and at the same time the most vulnerable settlements show higher electoral volatility. In this case socioeconomic factors, labour market conditions attached to long-term core-periphery relations play a significant role.

With this paper we aimed to contribute to the understanding of cleavage formation at the regional level by adding a spatial perspective while connecting the socioeconomic profile of the voting population and electoral volatility. During the study we focused on different groups of settlements as possible explanatory framework of volatility deepening our understanding on factors shaping the level of volatility, including the age structure of inhabitants, economic performance (economic factors), social factors such as income, class and ethnic divisions.

As our research findings suggest economic factors and social cleavages (Powell, E. and Tucker, J. 2014) played a dominant role in the post-2010 Hungarian elections, and the role of political institutions remained limited. Only

two new parties (Jobbik and LMP) appeared in the parliament after 2010 replacing two leading parties (MDF and SZDSZ) of the 1990 change of regime (Ilonszki, G. and Várnagy, R. 2016). The newly formed LMP incorporated much of the traditional (mostly urban) voters of SZDSZ, while Fidesz-KDNP managed to attract much of the centre-right votes. Thus, only Jobbik represented a genuinely new political alternative with its radical nationalist narratives. The analysis of the electoral volatility between 2010 and 2018 period showed that the urban-rural cleavages have clearly increased in Hungary compared to the previous elections.

Based on our research results we can say that a strong correlation exists between electoral volatility and peripherality at the local level. As recent studies demonstrate (e.g., Pénzes, J. 2013; Papp, S. *et al.* 2017; Pósfai, Z. and Nagy, G. 2017; Uzzoli, A. *et al.* 2020; Pénzes, J. and Demeter, G. 2021) the delimitation of peripheral areas has been high on the agenda in Hungary, and authors generally consider multiple indicators and different methods in defining peripheriality. This study provided evidence that electoral volatility can also be considered as a possible indicator in the delimitation and classification of peripheral areas and settlements.

Regarding electoral stability versus volatility an important question for the future whether the Hungarian party system develops further towards a two-party system, as it is desired by Fidesz-KDNP and DK, or a proliferation of new political movements (and parties) takes place after the 2022 elections. In the latter case the dimensions of electoral volatility and the role of political institution in the process will most probably increase. Scholars distinguish within-system and extra-system volatility in the literature. Extra-system volatility is an important phenomenon in the so-called new democracies where new parties appear, whereas within-system volatility means transitory shifts within the existing system. The processes described in this paper resemble within-system volatility as there have been no rearrangements in the Hungarian party-system, but this might change in the future.

As far as future research in the field is concerned it is an intriguing question whether the aftermath of Covid-19 would impact the public perception of existing political parties resulting in transformations in the party system and vote transfer, and increasing volatility, after the relatively stable 2010s. We also think that future studies in the field of electoral geography should focus more on the role of local politicians, opinion leaders and various government programmes (e.g., public works) and analyse to what extent they are able to influence the votes of vulnerable social and ethnic groups, like the Roma.

Acronyms used in this paper:

Fidesz-KDNP: Federation of Young Democrats and Christian Democratic People's Party.
DK: Democratic Coalition.
Jobbik: Movement For a Better Hungary.
LMP: Hungary's Green Party ('Politics Can Be Different').
MSZP: Hungarian Socialist Party.
MDF: Hungarian Democratic Forum.
SZDSZ: Alliance of Free Democrats.

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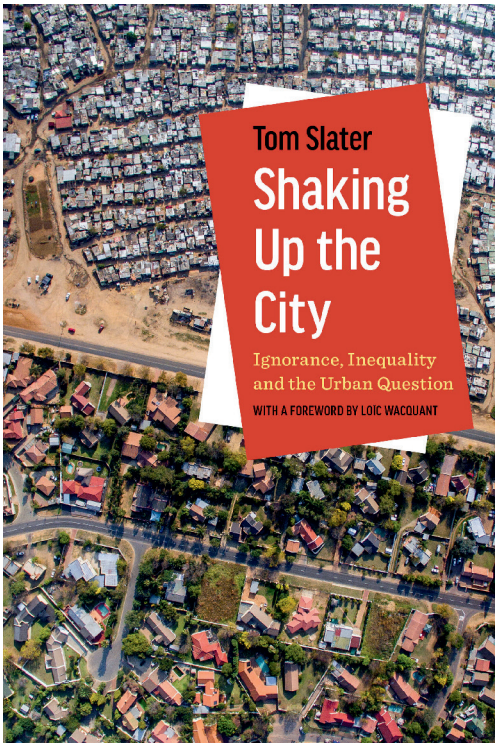
BOOK REVIEW SECTION

Slater, T.: Shaking Up the City: Ignorance, Inequality and the Urban Question. Oakland, University of California Press, 2021. 258 p.

In recent decades, social inequality and marginality have become one of the most important concerns in social urban studies. A deeply polarised social (class) structure has become a challenge for central and local governments, bringing new policy dilemmas about gentrification and homelessness; degradation of districts and the return migration of bourgeois families looking for public amenities and infrastructural rebuilding; rent control and skyrocketing real estate prices; and bureaucratic changes produced by fiscal cost-cutting and neoliberal restoring of the state. Consequently, new discourses have emerged about the city and urban injustice. A welcome contribution to this ongoing debate can be found in *Shaking Up the City*. The book addresses the causal mechanisms behind urban inequality, material deprivation, marginality, and social suffering in cities across several international contexts, and while doing so, it scrutinises how knowledge (and all too often ignorance) on these issues is produced by a range of urban actors. The 8 chapters and 257 pages of the book offer the reader new interpretations of socio-spatial processes and present a strong call for a more critically reflexive approach to urban social science. It is rooted in an institutional political economy approach to urban geography and, therefore, focuses primarily on the political and economic structures shaping inequalities in cities.



In each chapter, Tom Slater takes us back and forth, clarifying well-known theories and showing in which way they can be used to produce either fallacies or good knowledge about the city. He expresses well the tension between the idea of epistemology (that is, the production of knowledge) and the idea of agnotology (that is, the production of ignorance). Drawing on Robert Proctor's notion of agnotology and Pierre Bourdieu's concept of symbolic power, Tom Slater defines his 'agnotological approach' and argues that "it allows us to understand the institutional arrangements and symbolic systems that fuse and feed off each other to structure the deeply unequal social relations behind the profound differences we see in life chances in cities in so many geographical contexts today" (p. 23). The author operationalises this by bringing together the co-production of knowledge and ignorance as a field of inquiry, and this is a powerful and most important input, in my opinion, into critical urban studies.

Slater presents a critique of misunderstanding or ignorance in the use of well-known notions like urban resilience, gentrification and neighbourhood effect, sink estates and ghetto, rent control and housing justice. The considerations are supported by empirical examples from various cities such as Edinburgh, Glasgow, Cape Town, Vancouver, and many more. Moreover, the author deconstructs the views that influence the modern way of thinking about the city. Jane Jacobs and William Whyte (p. 2) and Gehl Architects (p. 3) are criticised for their utopian thinking. Tom Slater discusses the views of Andres Duany on gentrification, pointing to "a false choice between gentrification (a form of reinvestment) and a concentration of poverty (disinvestment)" (p. 53) or Matthew Desmond (p. 86) about an important study on eviction, paying attention to a lack of conclusions that would frontally tackle the structural and institu-

tional arrangements behind the extremely high cost of rental housing. On the other hand, we can hear a strong voice of Loïc Wacquant, along with Neil Smith, as key interlocutors in this book and to a lesser extent Pierre Bourdieu and David Harvey.

In Chapter 1 (*Challenging the Heteronomy of Urban Research*), the author introduces and operationalises the book. He starts with an explanation of 'the heteronomy of urban research.' He refers to the condition of scholars being constrained in asking their questions about urbanisation, instead of asking questions and using categories invented and imposed by various institutions that have vested interests in influencing what is off and on the urban agenda. As a result, there is a rise of "policy-driven research at the expense of research-driven policy" and, with it, "decision-based evidence-making at the expense of evidence-based decision making" (p. 4). Slater states that this book is a critical response to 'the steady erosion of intellectual autonomy' and a call for more critical urban studies. Moreover, he shows the mechanisms governing urban research, pointing to the high dependence of researchers on funds obtained from different (also politically involved) institutions. The final part of the chapter brings us to the aforementioned conceptual articulation of agnotology and symbolic power.

Chapter 2 (*The Resilience of Neoliberal Urbanism*) starts with an analysis of the Chicago School of Human Ecology and presents the history of concepts being brought from biological science to social sciences. In particular, he criticises the production and circulation of 'urban resilience' as one of the most recent examples of such a term. According to Slater, urban resilience has a large institutional apparatus. The author gives an example of the Rockefeller Foundation's 100 Resilient Cities competition (2013–2019), which offered cash prizes to city administrations that show the most initiatives to return their cities to market-driven planning as quickly as possible after economic shocks and a significant number of urban managers participated in the program. Based on Glasgow and Cape Town examples, Tom Slater argues that the positive narration of building resilience makes acceptable claims to "unlock economic potential and de-risk development to create opportunities associated with sites in order to attract developers" (p. 33). In that sense, resilience appears as a political concept that moves the responsibility for economic and environmental crises and stresses to people, rather than addressing the underlying causes of these crises and precluding questions or practices of resistance. Through this approach, we avoid asking questions about who the resilient city is for and who is evicted to make way for it.

Chapter 3 (*Gentrification beyond the False Choice Urbanism)* shows how the production of ignorance about gentrification has emerged. He explains that most of the research deals with the pros and cons of gentrification, worrying about threats to social diversity, housing affordability, but finally concludes that gentrification is good on balance because it represents the reinvestment that stops the neighbourhood from decaying. What I find interesting in this chapter is that the author demonstrates that gentrification and urban decay are not "opposites, alternatives or choices, but rather tensions and contradictions in a global system of capital circulation, amplified and aggravated by the global crisis of affordable housing, a system that relies on propitious conditions for accumulation laid down by the neoliberal states" (p. 25). In this chapter the author discusses rent theory in general as the most useful concept that explains the political economy of gentrification and responds to the agnotology that circulates about the supposed benefits of gentrification. Referring to Neil Smith, Slater indicates that the rent theory is "a theory of the state's role in creating economic conditions for gentrification" (p. 65), which helps understand the speculative interests of land developers or the activation of territorial stigma. Moreover, what I find very interesting is that the author discusses how the rent gap theory explains gentrification accompanied by displacement beyond the Global North.

In the next section, titled *Displacement, Rent Control, and Housing Justice* (Chapter 4), Slater considers the displacement of the working class from urban space as the most harmful effect of gentrification and presents the role of rent control in mitigating against it. The author discusses different studies that refer to and critique rent control and emphasises that it is one of the misunderstood policies across a variety of disciplines and professions concentrating on urban issues. Slater exposes and dissects three of the prevalent myths about rent control: "1. that it negatively affects the quality of rented properties; 2. that it negatively affects the supply of housing and 3. that it leads to 'inefficiencies' in housing markets" (p. 25). This brings us to an urgent question of housing justice, and according to the author, rent control is just one among many instruments that can be used to reframe the debate around housing away from assets and profit and investments to community, family or home. The chapter ends with the positive conclusion that the history of rent strikes teaches us that when landlords, the housing industry or profit-driven state legislation refuse to "concede any ground, tenants also fight back and often win" (p. 108).

Chapter 5 (*Neighborhood Effects as Tautological Urbanism*) presents a discussion on the meaning of neighbourhood effect and on different studies about it. Slater points out that research on neighbourhood effects came from an understanding of society that is based on the assumption that where you live affects your life chances. This brings us to the belief that neighbourhoods matter and shape the fate of residents, and therefore urban policies must be con-

centrated on poor neighbourhoods, seen not "as expressions of social dysfunction but its incubators" (p. 117). Acceptance of the neighbourhood effects thesis misses the key structural question of why people live where they do in cities. Slater uses a very interesting case study of Cape Town and inverts the neighbour effects thesis. He points to the problem of how differential life chances in cities are produced. He highlights the injustices inherent in letting the market be the force that determines the cost of housing and where people live. This goes in line with the remarks of Roger Andersson and Sako Musterd (2005) that "problems in the neighbourhood are seldom problems of the neighbourhood" (p. 132) or Loïc Wacquant (2008) that "in reality, they track the extent to which the state works or fails to equalise basic life conditions and strategies across places" (p. 132).

Chapter 6 (*The Production and Activation of Territorial Stigma)* highlights the need to pay more attention to how territorial stigmatisation emerges and how people are discredited, devalued, and poorly treated due to the place with which they are associated. Tom Slater discusses how the concept of symbolic power matters in the analysis of urban inequality. He quotes Loïc Wacquant (2008) who claimed that territorial stigmatisation is "arguably the single most protrusive feature of the lived experience of those trapped in the sulphurous zones" (p. 142) and focuses on two aspects. First, that some areas of disrepute in many societies have become nationally infamous and denigrated, so now not only policy elites or upper class have negative opinions about these districts, but also their inhabitants themselves. Second, that spatial disgrace has become so powerful that it is partially autonomised from other forms of stigmatisation, like poverty, ethnoracial origin or working-class position, or unemployment, even if it may be closely tied to them in certain contexts. Later in the chapter, the author explores the genealogy of the term 'sink estate.' He traces that it was invented by journalists and adapted by politicians in the United Kingdom and now is used to criticise social housing, distracting attention away from the discussion that social housing is connected with an urgent necessity during a serious crisis of affordability, but also an incubator of community, solidarity, shelter, and home.

In Chapter 7 (*Ghetto Blasting*), Slater explores territorial stigmatisation by analysing the meaning of the term ghetto. He criticises the excessive ease in calling workers or immigrant places a ghetto and goes back to the definition of Wacquant (2012) that ghetto is an instrument of ethnoracial closure that employs space to fulfil two conflicting functions: to maximise the material profits extracted from a category deemed defiled and defiling, and to minimise intimate contact with its members to avert the threat of symbolic corrosion and contagion they are believed to carry (p. 172). Based on different examples of ghetto formation, Slater concludes the chapter with a strong statement taken from Morgan Adamson: "understanding contemporary spaces of racial oppression as internal colonies seem necessary in the face of ongoing white ignorance, visible in stigmatising labels such as ghetto and in the violent processes of predatory capitalism" (p. 182), which expresses that territorial stigmatisation can be treated as a new way of 'internal colonialism.'

In the final chapter (*Some Possibilities for Critical Urban Studies*), the author emphasises that the conceptual frames of agnotology and symbolic power can offer some potential pathways for the field of critical urban studies. He proposes reframing the discussion on urban inequality and more focusing on the relationships between urban knowledge, urban ignorance, and urban struggles.

An undoubted strength of the book is the fact that it presents varied concepts that are not amenable to simple and universal explanations regarding their formative processes, their patterns, and their impact. Slater demonstrated a critical approach to urban studies positioned against vested interest urbanism and against "the prevailing political wind of the steady erosion of intellectual autonomy" (p. 185). The book is dominated by theoretical considerations. There is some lack of practical solutions that would be an alternative to the practices criticised by the author so far. Nevertheless, the book reveals the crucial importance of confronting different approaches and contexts in understanding urban dynamics. Such economic, social, cultural, and institutional contexts differ not only in the way cities developed over time but also in what kind of narration and why it is used to transform them. The examples presented by the author show that social inequality and marginality still are visible despite many years of efforts to promote urban justice.

The book is deeply rooted in Anglophone urban geography. Therefore, not all nuances can be interpreted similarly by researchers from other regions. Slater tries to show that even if concepts like the rent gap theory or gentrification have been constructed in a particular cultural, economic, and historical context, it is not a valid reason to dismiss them or unlearn them in different contexts today. The challenge is to take geographically diverse localisations seriously and learn about processes in contexts beyond the Global North. I agree with this, as the local conditions, circumstances, for example, in the Global North and the Global South are radically different. Additionally, in the case of Central and Eastern Europe, some of the concepts like, for example, rent control, are seen differently because of different former experiences.

The book certainly encourages critical thinking, which seems particularly important in the context of changes taking place in Central and Eastern Europe.

The transformation that has been taking place for many years has made us adopt Western European solutions as the best for our cities without questioning them. This is particularly evident in the discussion on revitalisation and gentrification, reinvestments in degraded districts, and current studies on urban resilience. Recent urban research projects on Central and Eastern Europe (e.g. Tammaru, T. *et al.* 2015) show an increase in social disparities, also as a result of over-trust in neoliberalism. Our study on residential segregation at the local level in Warsaw, Poland, indicates that even if segregation indices are still quite low, urban inequality is growing (Jaczewska, B. *et al.* 2017). Therefore, this seems to be a good time to consider more critically the future of cities and the needs of our city residents.

This book is an essential reading for anyone concerned with the main ideologies of urban renewal and developing modes of analysis to facilitate the pursuit of more democratic and equitable urban futures. It can be recommended to a wide audience, especially scholars and students (in second-cycle studies) as well as urban activists. It will be of particular assistance to academic lectures if they are seeking inspiration on how to start critical discussion on urban studies.

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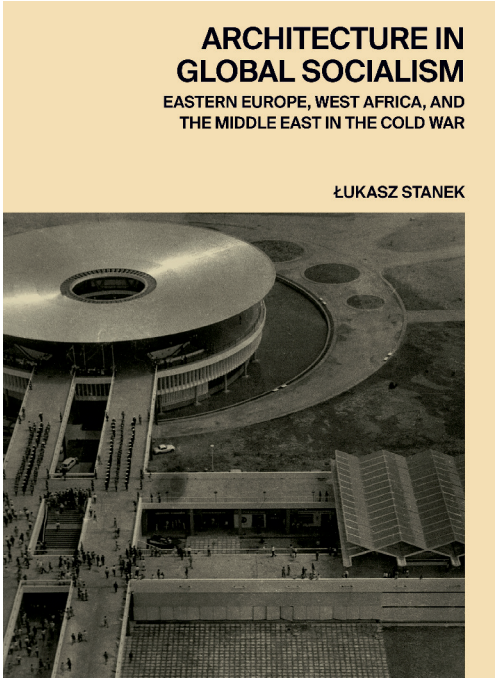
Stanek, Ł.: Architecture in Global Socialism: Eastern Europe, West Africa, and the Middle East in the Cold War. Princeton and Oxford, Princeton University Press, 2020. 357 p.

Many academic publications serve the understanding of capitalist versus socialist and North versus South relations during the Cold War. Beyond geographical and geopolitical works, the viewpoints of other disciplines may also be useful for geographers. The book of Łukasz Stanek, associate professor at Manchester School of Architecture (UK) deals with post-WWII global architecture, nesting the topic into the broader historical, political economical, and geographical context, through case studies from West Africa and the Middle East. By doing so, it also provides new aspects for understanding the global urbanization process.

The novelty of Stanek's work is enhanced not only by the fact that, beyond the two characteristic groups of architectural actors in postcolonial states (former colonizers and colonized nations), it draws attention to a third group formed by experts from socialist countries, but that it examines and presents these relations through the lens of the Global South. We get to know these actors primarily through the architecture they designed in postcolonial countries and their relationship with local actors. However, opportunities for these architects and planners to realize their visions were significantly affected by diverse geographical circumstances and changing political climate (i.e. the considerably different reception of socialism).



Studies on architectural mobilities, joint ventures and international cooperations among Eastern Europe, West Africa and the Middle East during the Cold War are scarce in Western literature. Even in the countries concerned, knowledge about collaboration has survived mainly in the archives and experts' recollections. Collecting, systematizing and analyzing these sources is a gap-filling work. Stanek's book also aims to develop a conceptual framework to better understand architecture and urbanization in the Global South.

During the Cold War, newly independent postcolonial countries, many of them members of the Non-Aligned Movement (NAM), were trying to reduce their economic and political dependence on the former colonizers. The NAM countries' demand for greater independence met with the Soviet leader Nikita Khrushchev's policy of socialist internationalism, which emphasized that the socialist bloc would provide help without exploiting these countries. Therefore, from the questions of housing and design-and-build of public buildings to the scale of urban planning, Eastern European professionals were welcome in NAM countries to share their knowledge. This was further enhanced by the narrative that Eastern European countries were claimed victims of semi-colonization by Western Europe in the 19th century, meaning that they had also significantly left behind in the process of modernization. Hence, the involvement of Eastern European professionals fostered the idea of emancipation, at least in theory.

During the 1960s, the narrative of socialist internationalism was legitimized by the economic progress in the USSR based on scientific results and increasing social welfare. That time, Soviet-type planned economy seemed to be a well-functioning framework, and communist anticolonial rhetoric aroused sympathy in several countries of the Global South. Although numerous postcolonial countries were even hostile to the idea of socialism, they were interested in cooperating with the members of the Eastern Bloc, because their bargaining position seemed better than with the leading capitalist economies. In addition, since these countries had limited reserves of hard currency, they found favorable the barter agreements preferred by the USSR.

However, from the 1970s onwards, socialist countries started to increasingly consider postcolonial countries as suppliers of raw materials. The rhetoric of solidarity was, thus, replaced by the rhetoric of mutual benefit. The oil crises and growing public depts in COMECON countries forced these to export their

design-and-build services in exchange for crude oil. As state contractors often competed with each other, COMECON countries did not form a cohesive bloc from a Southern perspective. Consequently, relations with smaller countries from the Eastern Bloc did not appear to cause too much vulnerability, compared to their relations with the much stronger USSR.

As a result, various architectural mobilities took place in terms of scale, actors and contract types. The book focuses on the spatial and institutional relations among the main actors, notably individual architects, design institutes, state contractors, and foreign trade organizations (FTOs) that coordinated contracts. Through individual career paths, the reader gains insight into the architects' motivations (i.e. the reasons for working abroad) and opportunities (i.e. financial recognition and mobility limits compared to their Western counterparts). Similarly, we get an insight into the strategic goals of design institutes and state contractors. The author's declared aim is to analyze the mobility of the above mentioned actors, whom he calls the *vessels of architectural mobilities*. In addition, his book provides an overview of the mobility of other actors (e.g. administrators, managers, educators, foremen and workers) and a comparison of the narratives about mobility (whether it was rather the result of export contracts or directly served individual professional experience).

Łukasz Stanek examines whether architectural mobility from socialist countries has indeed brought antagonism and differentiation into urbanization in the Global South through the concept of *"worldmaking"* (based on the concept of *"mondialization"*) (Lefebvre, H. 2009 [1978]; Stanek, Ł. 2011). According to this, a "world" is not only a piece of the Earth's surface delimited along spatial, social and economic characteristics, but "a 'social' or 'concrete' abstraction that becomes 'true in practice'" (p. 29) and becomes perceptible through diversity. Stanek's interpretation of worldmaking is "the production of the world from within its many, often antagonistic, options" (p. 30). In this context, "socialist worldmaking" was an existing reality, and it provided an alternative in the process of global urbanization. It created networks and interactions that influenced the development of postcolonial states.

Chapters 2 to 5 show in detail how path-dependency caused by Western colonizers was differentiated as a result of socialist worldmaking. Chapter 2 *("A Global Development Path")* illustrates the direct spread of the socialist path in the 1950 and 1960s through the example of Accra. For Kwame Nkrumah, the first president of independent Ghana, planned economy and one-party system seemed to be suitable for realizing decolonization and modernization, as well as to achieve his ambitions of pan-African leadership. The Ghana National Construction Company started cooperating with architects from the Soviet Union and other contractors from the Eastern Bloc. For Ghana, the main motivation for cooperation was to fill the gap of local experts and to reduce the country's dependence on the West, while partners from the USSR followed Khrushchev's policy toward postcolonial states along the official claims of "fraternal assistance" and "peaceful coexistance." Although the Soviet housing plans presented in the book chapter have not been materialized, the author does not interpret that as a failure, rather as an attempt of the translation of Soviet technologies into different climatic and cultural conditions. According to contemporary narratives, this effort was legitimized by the modernization of the USSR's Central Asian cities. However, the adaptation was ambiguous. While prefabricated elements of the buildings were adapted to the local needs of shading, ventilation and earthquake protection, no attention was paid to the cultural roots of future inhabitants. The layout of housing estates forcefully promoted the socialist way of life.

In the case of the International Trade Fair, finished in 1967, one year after Nkrumah was toppled, there was no direct spread of socialism. Eastern European experts were motivated by the professional challenges of tropical architecture. Yet, only marginal reports appeared in prominent Western architectural literature about the spectacular investment, which can be seen as an imprint of Cold War relations.

In summary, although the geopolitical importance of West Africa was not so great, it served as a testing ground for the Eastern Bloc to realize Global Socialism. At the same time, limited freedom and opportunities of actors had a noticeable impact on "socialist worlmaking."

Chapter 3 *("Worlding Eastern Europe")* takes the reader to Nigeria in the 1970s. Although the country's political leadership was hostile to socialism, contracts with COMECON companies were signed to diversify international actors. Socialist countries were open to such agreements, because they expected crude oil from the Western African country. The legitimacy of their presence was ensured by the narrative of transferring the experience gained during the elimination of underdevelopment in Eastern Europe.

The first case study is especially close to us, as it deals with the Hungarian architect Charles Polónyi. According to Polónyi, conditions in rural Hungary in the 1950s did not differ much from those in postcolonial countries one or two decades later. Based on former studies and articles of the CIAM East group (a regional subdivision of International Congresses of Modern Architecture, formed by Central European architects), he drew attention to the structure of Hungarian market towns, where the implementation of traditional forms of urban fabric by using modern tools can ensure efficient functional operation. He was involved too in regional planning in Ghana (Bui Study), then in Nigeria (Survey and Development

Plan for Calabar). He utilized his previous experiences of the Balaton Plan and Mohács Island Plan, plans that had been designed with a focus on specific regions of Hungary. Meanwhile, he never emphasized links between his plans for African countries and either Hungary or the socialist system, rather the use of international principles and methods in architecture.

The next two case studies also show how previous responses to peripherality were reconsidered, and how concepts and techniques were translated into the Western African context. Zbigniew Dmochowski made significant efforts on the decolonization and emancipation of traditional Nigerian architecture, using the methods of architectural typification applied in Poland. With his work, he also helped lay the foundations for the modern school of architecture in Nigeria. As for the construction of the International Trade Fair (ITF) in the Western African country, it "brought Yugoslavia into Lagos." As a co-owner and technical partner of the Nigerian Engineering and Construction Company, the Yugoslavian Energoprojekt supplied a team of experts, with the purpose of developing the local construction industry as well. Finally, the emancipatory aims nearly went lost, so according to local opinions, Energoprojekt exploited them similarly to Western companies. However, the project did not become totally controversial, as the ITF provided acceptable solutions to urbanization challenges in Lagos.

Chapter 4 *("The World Socialist System")* takes us to the Middle East. *Worldmaking* already appears as a practice of international trade, in the framework of the *world socialist system* (Yagodovsky, L. 1975). We read about the relationship between COMECON and affiliated countries through the examples of Iraqi urban planning and architectural projects. The Baath regime designated a "non-capitalist" development for Iraq (as a "socialist Arab state"), which reinforced cooperation with Eastern European contractors. For COMECON member states, the emphasis was on "mutual benefit" in foreign trade, which was expected to eliminate the dichotomy between raw material producing countries and industrially developed countries, originating from colonial times. After the oil crisis of 1973, Eastern European countries became increasingly interested in exporting design-and-build procedures, as they were able to incorporate these as "salable" products into petrobarter agreements.

The Polish contractor Miastoprojekt had a leading role in creating the Baghdad Comprehensive Development Plan. Miastoprojekt's position was legitimized by its eminent role in the post-WWII reconstruction of cities in Poland. However, it had to successfully compete with Western design offices during the tender process. A main reason for its success as a large socialist company was its capacity to involve a large number of employees to carry out multi-scale studies, and to elaborate possible scenarios in a largely consultative manner. The cooperation later continued within the framework of the General Housing Project for Iraq. However, Iraqi expectations diverged in the late 1970s, driven by cultural considerations. The aim of Iraqi leaders was to represent and regain the former greatness of Baghdad, that required significantly different architectural solutions than the modernist plans of Miastoprojekt. Finally, other companies were invited to develop a new vision for Iraqi urbanization.

As another remarkable case, the story of Baghdad's abattoir reveals the anomalies of economic harmonization among socialist states. The conflict between the general contractor from the German Democratic Republic and the subcontractor from Romania was even politically embarrassing, as it undermined the credibility of the whole COMECON.

By the end of the Cold War, not much remained from the original emancipatory discourse. Still, the *world socialist system* has not become a failed project of globalizing architecture, as the Middle East served as a testing ground for socialist contractors to respond to expectations in the international market.

Chapter 5 *("Socialism within Globalization")* expands the focus to the Persian Gulf, as a paradigmatic place of architecture's globalization. It highlights that actors from socialist countries were not negligible in this process. To ensure their position, they presented their previous experiences in Africa and the Middle East as evidence of their ability to adapt to Western norms. They have successfully deterritorialized and reterritorialized those experiences. Although they were no longer competitive in technology, their design services could be sold profitably, as "intellectual and immaterial export." As traditional urban structures were drastically overwritten during the modernization of the cities in the Persian Gulf, dissatisfaction was emerging by the 1980s. Mediation, i.e. the reconciliation of modernism and Arab culture has become necessary.

The contract between the local Tayeb Engineering and the Bulgarian Technoexportstroy (TES) for the Municipal and Town Planning Department in Abu Dhabi was based on the fact that TES provided Western type organizational culture, financing practices and technical solutions, and at the same time, the proposed plan met the elite's expectations in the United Arab Emirates. They used modern elements, prefabricated panels and flexible modular systems, in parallel with traditional forms, where the characteristic motifs on the building can be read as cultural references. In addition, the whole complex was visually well-suited to the wider urban development plans.

The examples of individual architects' carriers in Kuwait give us an insight into the significantly changed practice of architectural mobilities. Individual contracts through FTOs became common, and many professionals arrived directly to private companies. Their level of mobility and professional freedom was much greater than those of expatriate architects in the 1960 and 1970s. They could gain professional skills that were still

not accessible in their home country. As a result, when many of them returned to Eastern Europe in the years the socialist bloc collapsed, they had the opportunity to transfer international experience to their homeland.

While in the 1960 and 1970s *"thinking Baghdad through Warsaw"* was typical in architectural mobilities, after the collapse of socialist regimes *"thinking Sofia through Abi Dhabi"* has become dominant. In the meantime, some successors of contractors in former socialist countries have managed to maintain their activities abroad in a path-dependent manner, based on their previously gained positions.

At the end of the book, the reader gets an insight into the diverse research methods and sources Stanek applied. Research sites included national archives, document repositories of different organizations and societies, and the private collections of individual actors. In addition, he examined relevant publications from scientific journals and the daily press, as well as propagande materials. The case studies are based on a large number of interviews and discussions. The author took into account the context in which the illustrations were previously published, and collided these often contradictory sources to make the case studies transnational and situated.

All together, the chapters of the book provide a nuanced view on socialist worldmaking in an ever-changing environment. Their novelty is the recalibrated perspective, or in other words, "the view from the South" on the architectural mobility from socialist countries. Stanek does not define what architecture is in a normative way, but collects all the activities that were connected to the protagonists of the book, and the frameworks in which architectural mobility was realized. Thereby he reconceptualizes architecture as part of the global urbanization process. The constant change and the contradictions around *socialist labor* causes "the main dilemma of this book: the relationship between the studied architectures and the project of socialism" (p. 305.). Based on an idea from an interview, Stanek writes: "the Cold War appears as a clockwork mechanism in which cogs of antagonostic worldmaking projects sometimes gnashed and ground, and sometimes complemented each other to mutually productive effect" (p. 33.). Although the reader meets a number of failed or heavily criticized projects, the book goes far beyond them, and "contributes to a more heterogeneous and antagonistic historiography of global urbanization and its architecture" (p. 4).

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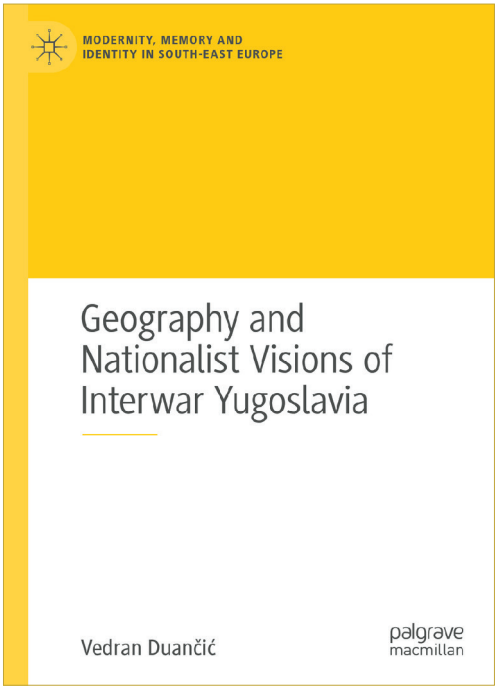
Duančić, V.: Geography and Nationalist Visions of Interwar Yugoslavia. Cham, Palgrave Macmillan, 2020. 286 p.

Vedran Duančić's monograph represents a very significant and important contribution to investigating nation building processes in their connection with geographical knowledge, related to the context of South Slavic regions. The research is well situated in the interdisciplinary debate concerning the contribution of geographical knowledge and cartography in shaping the idea of nation and in naturalising the spatial dimension of the modern, territorial state, as well as in contributing to the personification of nation state, thus strengthening the bound between the territorial state and the national community. The most innovative contribution compared to the existing literature is the deep comparative analysis of geographical works produced by several figures of Serbian, Slovenian and Croatian geographers, such as the Croatian Filip Lukas (1871–1958) or the Slovenian Anton Melik (1890–1966). Thanks to this comparative analysis of different scholars, Duančić's analysis goes well beyond the traditional and mainly exclusive focus on the Serbian geographer Jovan Cvijić. Moreover, connecting all these figures and showing their educational background and theoretical approach, the author gives an important contribution to comprehending the processes of knowledge circulation related to geographical ideas in the first half of the 20th century.



From the beginning of the book and in line with recent trends in international literature from Benedict Anderson (1986) to Guntram Herb (1997), Steven Seegel (2018) and Charles Withers (2001), Duančić stresses the role of geographers and geography in nation building processes, sustaining how far this "played an exceptional role in making and breaking interwar Yugoslavia" (p. 2). In his perspective, the different figures who at this time developed scientific studies in the field of geography and cartography, significantly contributed to the processes of integration or – on the contrary – separation of the different ethnical and cultural components that characterised the Balkan region. This happened due to the geographical skill, which enabled a homogeneous description of physical and cultural landscapes, thus integrating, and reinforcing other historical and/or political narratives. On one side, geographical representation and narrations were aimed to stress the territorial unity of Yugoslavia, also in response to threatening politics of the neighbor countries – especially Germany, Hungary, and Italy. On the other side, various geographical perspectives between Yugoslavian geographers also reflected the political fragmentation and the tensions between different Yugoslavian cultural entities, such as e.g., the ambition of a unified and independent Croatia, as formulated by the Croatian geographer Filip Lukas.

From a theoretical perspective, Duančić situates his reflection in the crossing and circulation of geographical ideas at the time, specifically in the production of German language geography with its reflections on the different national geographies of Eastern Europe, notably in Poland with Eugeniusz Romer, in Hungary with Pál Teleki and, of course, in Serbia with Jovan Cvijić. The book is based on an extensive research and analysis of printed sources. In fact, primary sources are basically related to geographical works of academic geographers, mainly Yugoslavian and German and Austrian, but also some Polish, French and American works are taken into account. Despite the rich references to primary literature sources, the work considers and analyse limited archive sources, which could have shed better light on the relations and networks between scholars and the circulation of European geographical ideas in the Balkan.

A second critical point of the book is the almost neglected comparative analysis with Italian geographical works and Italian geography in general. Despite, as stated before, the author considers the danger represented by Italian politics towards Yugoslavia and underlines the importance of geographical unity as a tool for political discourses, the book lacks a comparative analysis of the methodologies that sustained Italian argumentation against the political and sci-

entific discourse developed in the same period by Yugoslavian geographers.

The book begins with a rich introductive chapter, that discusses international literature on nation building and geographical contribution to nationalism, situating these discourses in the historical and political context of South Slavic regions at the beginning of the 20th century. The second chapter of the book is dedicated to the origin of Yugoslavian geography, especially in its relationship with German geography and, above all, in connection with the German geographer Albrecht Penck's theorisation and methodologies. The author recalls the different figures, which animated Slovenian, Croatian and Serbian geography since the first decades of the 20th century. These figures are put in connection with the further steps in the establishment of academic and governmental geographical institutions in South Slavic lands. The third chapter presents and discusses the fundamental figure of the Serbian geographer Jovan Cvijić, in relation to the establishment of modern geography in academic studies. Under a scientific-theoretical point of view, Duančić analyses Cvijić's understanding of geography, putting his interpretation close to the development of geomorphological studies, and stressing the analogies and differences with the German geographer Friedrich Ratzel. Other aspects concern Cvijić's political explanation of geographical unity, specifically his national idea of a unified Serbia which was then applied to understand the whole Yugoslavian state. This intellectual process culminated with the publication of the volume La Péninsule balkanique, Cvijić's most renowned work, that became a masterpiece of Balkan geography and a manifesto of Yugoslavia political unity. Chapter 4 describes the geographical discourses that formed the base for establishing the Yugoslavian state, starting from Cvijić's fundamental work. The narration also considers the role of different European powers in promoting and shaping the unification process of Yugoslavia.

The fifth chapter introduces the topic of geopolitics and its reception by Yugoslavian scholars in the field of geography. In this context, it highlights the figure of the Croatian lawyer Ivo Pilar who firstly introduced political geographical issues to the Yugoslavian debate, particularly in relation with border questions. The work of the Swedish geographer Rudolf Kjellén, regarded as the founding father of geopolitics, received much attention by Yugoslavian geographers. The last chapter comes back to the Croatian geographer Filip Lukas, whose work was already presented in Chapter 4, in order to discuss the new anti-Yugoslavian discourse he developed starting from the late 1920s. First, Lukas criticised on scientific basis the idea of a geographical unity of Yugoslavia, thus questioning its political project, even if he admitted the absence of a geographic unity of a Croatian state, as this also lacked natural boundaries. However, in sustaining the idea of a unified and independent Croatian state, the main point of Lukas' theorisation was anchored to a geographical principle. He recognised four different geographical regions inside Croatian territory, whose differences had shaped the character and the identity of Croatian people. His work became one of the most important intellectual contributions to establishing the pro-Fascist state of the Ustasha regime in the 1940s.

One of the strong points of the book is the great reconstruction of the networks and circulation of ideas that sustained the emergence of geographical research in the Balkans. In particular, very interesting and original is the analysis of Lukas' works and theories, presented for the first time in an international publication and connected to the theorizations of European and North American geographical ideas. Another remarkable contribution of the book concerns the debate about Eastern European national geographies in comparison with, and in relation to, Western European and specifically German language geography in the first half of the 20th century, as already done by scholars such as Steven Seegel (2018) and Maciej Górny (2018).

The book would have benefitted from a broader archival investigation of primary sources, especially to extend the analysis of intellectual relations and networks, as well as a deeper comparison with Italian geographical works and intellectual figures. Despite of that, the book is a very rich contribution to the debate on histories of geographies and their involvement in nation building processes.

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CHRONICLE

In memoriam Leszek Starkel (1931–2021)

Leszek Starkel, an outstanding figure of Polish and international geomorphology, paleohydrology and Quaternary paleogeography passed away on 6 November 2021. He was born in Wierzbnik, in a mining settlement which now belongs to Starachowice in the Świętokrzyskie (Holy Cross) Voivodeship.

After completing his studies at the Jagellonian University in Cracow in 1954, he began working with the Institute of Geography and Regional Organization of the Polish Academy of Sciences, where he defended his doctoral dissertation in 1959 and obtained habilitation in 1964. In the long period 1968–2001 he was director of the Institute of Geomorphology and Mountain Hydrology, later Institute of Geography and Spatial Organization of the Polish Academy of Sciences in Cracow. The principal goal of research in the Institute was the design of rational land use based on the detailed survey and evaluation of the Carpathian landscapes. The Institute established wide-scale international contacts within the frame of the Carpatho-Balkan Geomorphological Commission and organized expeditions to Mongolia (1974–1980) and India (since 1983), where Professor Starkel was always present and an active participant.

He enjoyed high international reputation as one of the most respected geomorphologist in the eastern half of Europe. In 2004, he was the second Pole after Paweł Edmund Strzelecki, to receive the Gold Founder's Medal, the highest distinction of the British Royal Geographical Society. In 2017, he was awarded the Medal of Wincenty Pol, by the President of the Polish Academy of Sciences at the request of the Committee of Geographical Sciences. He received the Knight's Cross and the Officer's Cross of the Order of Polonia Restituta. His international honours include the honorary fellowship of the International Association of Geomorphologists, the honorary fellowship of INQUA. He was also a member of the Polish Academy of Sciences and the Polish Academy of Arts and Sciences, as well as the honorary fellow of the Association of Polish Geomorphologists.

His rich contributions to geomorphology reflected his manifold interests and an extraordinary ability to see causal relationships in nature and between nature and humans. Some of his most often cited works in Polish are the paleogeography textbooks Paleogeografia holocenu (Paleogeography of the Holocene) (1977) and Geografia Polski – Środowisko przyrodnicze (Geography of Poland – The natural environment) (1991), edited by him, and the monograph Ewolucja doliny Wisły od ostatniego zlodowacenia do dziś (Evolution of the Vistula river valley from the last glaciation until the present-day) (2001). In English language he published on The role of catastrophic rainfall in the shaping of the relief of the lower Himalaya (Darjeeling Hills) (1972), The role of extreme (catastrophic) meteorological events in the contemporary evolution of slopes (1976), and The reflection of hydrologic changes in the fluvial environment of the temperate zone during the last 15,000 years (1983). To commemorate his 90th birthday a collection of papers was issued in Studia Geomorphologica Carpatho-Balkanica, where the most distinguished Polish and foreign geographers presented their research findings.

Two geographical regions were of outstanding importance in his research career. One was the Polish Carpathians and their foreland, including the Vistula river. There detailed research led by him revealed a variety of geomorphic processes, from weathering through hillslope to fluvial. He also loved travelling, particularly to India. Since 1968 he was a regular visitor to the Darjeeling Himalayas and the Meghalaya Plateau. Several generations of Indian geomorphologists followed his guidelines in the study of hillslope and channel processes. It was an unforgettable experience to listen to his field explanations of landslides, tectonics and braided rivers in north-east India. The impact of human activities has never avoided his attention and raised his concern on environmental problems on the subcontinent.

Professor Starkel initiated bilateral cooperation between Polish and Hungarian geographers and was an active participant of several Polish-Hungarian seminars. In 1993 he became honorary member of the Hungarian Geographical Society and in 1995 he received our Society's highest distinction, the Lóczy Medal.

He was a basically optimistic person with a never disappearing smile on the face, who met all problems with good humour. His optimism was grounded on deep trust in the generations of young Polish and foreign geographers who followed in his footsteps. Recently he published an autobiography in Polish under the title Drogi mojego życia (The roads of my life) (2019), with valuable pieces of advice for his successors. We will equally keep him in remembrance as a scientist and as a human being.

Dénes Lóczy

Manuscript reviewers

2019–2021

The editors of the Hungarian Geographical Bulletin would like to thank the following experts who have offered their assistance in reviewing manuscript submissions to our journal issues between Number 1 in 2019 and Number 4 in 2021. Their efforts and useful comments have been of great service for the authors and the journal.

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Publisher:
Research Centre for Astronomy and Earth Sciences
1121 Budapest, Konkoly Thege Miklós út 15–17., Hungary

Editorial office:
Geographical Institute, Research Centre for Astronomy and Earth Sciences
1112 Budapest, Budaörsi út 45., Hungary
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E-mail: geobull@mtafki.hu, kovacs.zoltan@csfk.org
Distribution: GABRIELLA PETZ, petz.gabriella@csfk.org
Full text is available at https://ojs3.mtak.hu/index.php/hungeobull

Typography: ESZTER GARAI-ÉDLER
Technical staff: FANNI KOCZÓ, ANIKÓ KOVÁCS, GÁSPÁR MEZEI

Cover design: ANNA REDL
Printed by: Premier Nyomda Kft.

HU ISSN 2064–5031
HU E-ISSN 2064–5147

Distributed by the Geographical Institute, Research Centre for Astronomy and Earth Sciences

Subscription directly at the Geographical Institute, Research Centre for Astronomy and Earth Sciences (H-1112 Budapest, Budaörsi út 45), by postal order or transfer to the account IBAN: HU24 10032000-01730841-00000000. Individual copies can be purchased in the library of the Institute at the above address.