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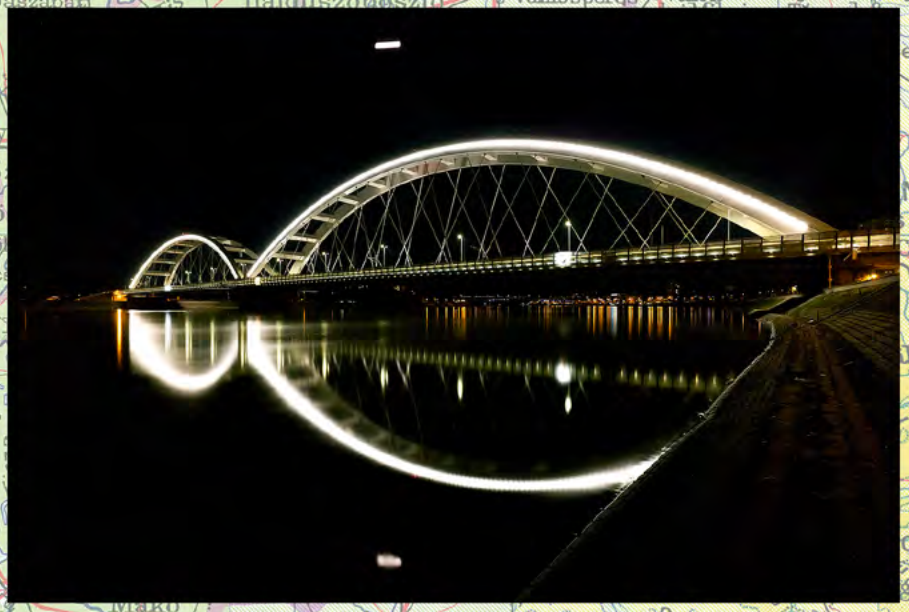

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DEPARTMENT OF GEOGRAPHY, TOURISM AND HOTEL MANAGEMENT

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Spatial and Temporal Variability of Precipitation Concentration in Iran

Sohrab Ghaedi[A], Ali Shojaian[A]

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Abstract

Precipitation concentration is an important factor to assess climate hazards such as flood and availability of water resources at a regional scale. This paper investigates the spatial and temporal changes of precipitation concentration using the precipitation concentration index (PCI) in 113 stations in Iran for a duration of 30 years (1988 –2017). The results show that the mean average of the annual rainfall in Iran varies from 55 mm in the eastern and central regions (Zabol and Yazd) to 1838 mm in the southwest coast of the Caspian Sea (Bandar Anzali). The highest coefficient of variation (CV) of precipitation is related to the southeastern and southern parts of the country, whereas the lowest CV is observed in the Caspian Sea coast and northwest region. Therefore, its value is mostly a function of latitude. Precipitation concentration and its CV are also influenced by topography and reveal more homogeneity in the northern regions. The Mann-Kendall (MK) test on precipitation concentration data indicates that except for 6 stations (ascending in 2 stations and descending in 4stations), there was no significant trend in others. The stations with non-significant ascending values are located mostly in the eastern, central and western parts of the country while the non-significant descending ones can be seen in the central and northeastern regions. The results of Sen's slope estimator are also similar to the values of the MK test.

Keywords: Precipitation concentration; Coefficient of variation; PCI trend; Sen Slope; Iran

Introduction

Precipitation, as an essential climatic element, determines the availability of water resources, the type and extent of agriculture, and the natural physical phenomena (droughts, floods, water stress, plant and animal life, soil erosion, and dust, to name only a few examples) (González-Hidalgo et al., 2011). The amount, time, intensity and frequency of precipitation are the most important factors which indicate the extent of climate change in any precipitation study for any region (Xiao et al., 2018). One consequence of climate change is the increase in the number of climate extreme events and thereby changing the precipitation behavior. Climate change can affect the monthly and seasonal distribution of precipitation. In arid and semi-arid lands like Iran, the spatial and temporal variations of precipitation are of high importance and affect all aspects of residents' lives and planning (Khalili et al., 2016). The low rainfall and severe fluctuations in daily, seasonal and annual time scales are inherent characteristics of Iran's climate (Raziei, 2018; Ghaedi, 2018). More than 2/3 of Iran's area is arid and semi-arid and precipitation in these regions is highly irregular. The results of the analysis of annual precipitation trend has indicated a significant downward trend during the last 30 years over Iran (Salehi et al., 2020).

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Investigating the precipitation structure provides a useful tool to determine the nature of climate phenomena and climate hazards associated with precipitation (Huang et al., 2016; Liu et al., 2016; Yan, 2017; Zubieta et al., 2017; Li et al., 2018; Huang et al., 2019). The analysis of precipitation concentration can provide us with temporal precipitation structure which is an important factor in determining the climate of a region (Zhang et al., 2019). The precipitation concentration determines the temporal distribution of precipitation in a region over a one-year period. Several concepts have been proposed in examining the concentration of precipitation including the daily concentration index (CI) which evaluates days with maximum precipitation against the annual amount (Martin-Vide, 2004), the precipitation concentration period (PCP) which presents the period (month) in which all annual precipitation is concentrated, the precipitation concentration degree (PCD) which shows the degree of rainfall distribution during all months of the year (Li et al., 2011), and the precipitation concentration index (PCI) which indicates the year-to-year variability of precipitation concentration.

Higher values of precipitation concentration in a certain region mean that rain would mostly concentrate in these particular areas within a shorter period of time. Higher precipitation concentration increases the length of the dry season which can reduce soil moisture. By reducing soil moisture, many plants are lost and, as a result, conditions will be ripe for wind erosion and desertification. In agriculture, this can reduce crop yields by reducing soil moisture storage and increasing the number of irrigation periods. In addition, the precipitation concentration can lead to climatic hazards such as droughts or floods (Shi et al., 2014).

Much research has been done on the spatio-temporal variability of precipitation concentration in different regions of the world over the past two decades. Some of these studies have been conducted by Zamani et al. (2018) in India, Rahman et al. (2019) in Bangladesh, Lu et al. (2019) and Zhang et al. (2019) in China, Velez et al. (2019) in Puerto Rico, Caloiero et al. (2019) in Italy, Sangüesa et al. (2018) and Sarricolea et al. (2019) in Chile, Botai et al. (2018) in South Africa, and Al-Shamarti (2016) in Iraq.

Research shows that the trend of precipitation concentration has been decreasing and this means that precipitation occurs in fewer days and months of the year. A study by Abolverdi et al. (2015) on precipitation concentration in Fars province (southwestern Iran) shows that precipitation concentration was increasing in most of the stations under the study. Khalili et al. (2016) surveyed precipitation concentration in 34 synoptic stations in Iran and found that the PCI has a strong irregularity in the central and southern regions with increasing annual trend in 50 percent of the stations. Khalili et al. (2017) studied the trend of precipitation concentration in Iran in 25 stations over the last half of the century (1961–2010) and observed an increasing trend in 40 percent of them. Also, Alijani et al. (2008) investigated the daily precipitation structure in 90 stations in Iran and found that the highest concentration index was related to the coasts of the Persian Gulf and the Caspian Sea. Amiri and Mesgari (2019) observed irregularities in the temporal distribution of PCI and a decreasing gradient from the southeast to the northwest of Chaharmahal and Bakhtiari province in Iran. Ramezani et al. (2020) investigated the PCI in the Lake Urmia basin and found that it was neither in regular nor in strongly irregular conditions at any of the stations studied.

The first purpose of this paper is to examine the precipitation concentration in Iran. The second objective is to calculate the trend and line slope of the precipitation concentration over a thirty-year period.

Data and Methods

Study area and data

Iran is located in the southwest of the Asian continent and except the Khuzestan plain and the Caspian Sea coasts, its other regions are situated on the plateau of Iran. The Alborz and Zagros Mountains are the limits of the plateau in the northern and western strips, respectively. Moreover, there are mountains in the central and eastern parts of the country. The area of Iran is more than 1648000 km² and lies between 25° 3' and 39° 47' northern latitude and 44° 5'- 63° 18' eastern longitude. The elevation of different regions of Iran varies between -28 m (Caspian Sea coasts) to 5670 m (the peak of Mount Damavand). The variation of elevation, the impact of various air mass systems from different directions, and its extension over a wide latitude range have caused diverse climate in this territory (Ghaedi, 2019).

The present research was carried out using monthly average precipitation data taken from 113 synoptic stations all over the country with data of 30 years (1 Jan 1988- 31 Dec 2017). The meteorological stations practically include all the territory of the climatic and elevation regions in Iran. The distribution of the stations and their elevation is presented in Figure 1. The uneven distribution of the stations under research is due to the existence of mountainous regions and vast deserts in central Iran.

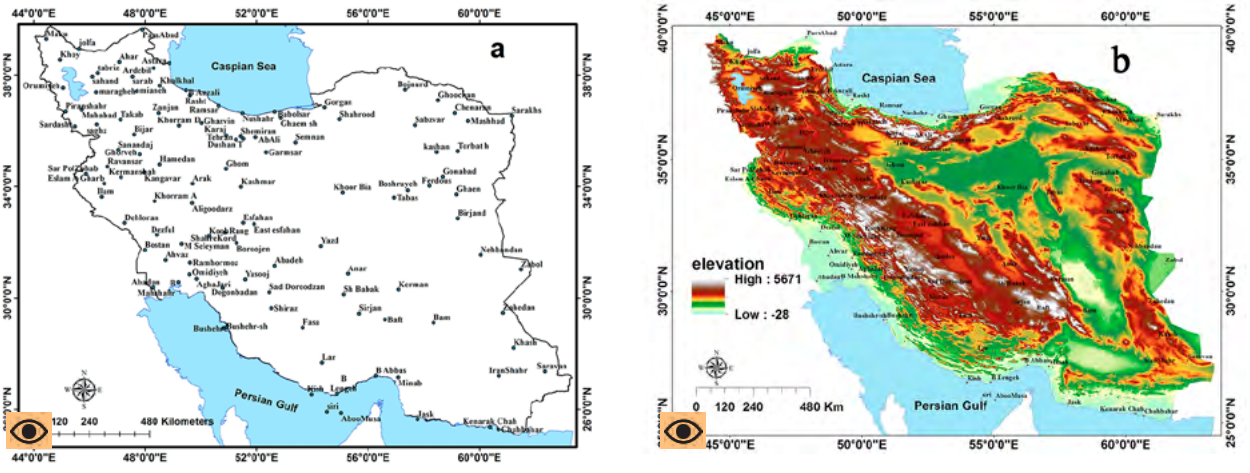

Figure 1. The location (a) and elevation (b) of the stations under the study

Precipitation Concentration Index (PCI)

Oliver proposed the PCI for the first time in 1980. PCI is used to measure the degree of monthly and seasonal precipitation concentration and can be calculated via the following relation:

$$PCI = \frac{\sum_{i=1}^{12} MP_i^2}{\left(\sum_{i=1}^{12} MP_i\right)^2} \cdot 100 \qquad [1]$$

Where MP_i is the monthly precipitation in the i^{th} month. According to this equation, if the annual rainfall occurs in only one month, the PCI will be the maximum and equal to 100. The minimum PCI is 8 and will be when the rainfall occurs evenly throughout all the months (Lu et al., 2019).

If PCI is less than 10, it will be indicative of uniform precipitation distribution (the precipitation has low concentration).

If PCI is between 11 and 15, that would indicate moderate precipitation concentration.

If PCI is between 16 and 20, it shows irregular distribution and when PCI is more than 20, this may indicate a strong irregularity (the precipitation has high concentration).

Mann Kendall trend test

The nonparametric Mann–Kendall test (Mann, 1945; Kendall, 1975) was used for the detection of the trend of PCI. One of the advantages of this method is that it does not consider any particular form of data distribution function. Several studies such as those by Trbić et al. (2017) and Ogrin et al. (2018) have employed the method and the details about Mann-Kendall trend test. In the present study, the data series was examined at the significance level of 95%. Commonly, the nonparametric MK trend test is based on the assumption of independence between observations. To remove the effect of possible autocorrelation on the trend test, autocorrelation analysis was initially used to check data randomness and independence on the time series. Therefore, function autocorrelation has been used in the present research (von Storch, 1995).

Zero lag coefficient for independent and random data series is near zero, which means that MK trend can be directly used to test the data series. Otherwise, if the autocorrelation coefficient is equal or more than one, pre-whitening procedure is necessary.

Sen's slope estimator

The Sen's slope method was applied to estimate the slope of PCI beside the MK trend test (Se, 1968). The Sen's method estimates the slope of the trend by applying a linear model, and the variance of the residuals at the time of calculation should be constant. Based on this method, summary slope is estimated as the median of all pair-wise slopes between each pair of points in the time series (Kumar et al., 2017).

Discussion and Results

Mean annual precipitation

The mean annual precipitation of Iran during the study period is presented in Figure 2. The amount of annual precipitation varies from 55 mm in the central and eastern regions to 1838 mm in the Caspian Sea coast. The two maximum rainfall belts are seen first on the Caspian Sea coastlines and then on the Zagros Mountains. In a framework between latitude 25° and 35° N and longitude 54° and 64° E, the amount of precipitation is less than 200 mm (including the Dasht-e Kavir and Dasht-e

Lut deserts and except for a small area south of Kerman including Lalehzar mountain). Minimum rainfalls occur due to low elevation and being far from moisture sources in the central and eastern regions. Topography (the elevation of the vast land of Iran with 1648195 km² area varies between -28 and 5671 meters), latitude (25° and 40° N) and distance from the Caspian Sea (the largest lake on earth and an important humidity source in the north of Iran) are the essential factors impacting the spatial distribution of precipitation in Iran.

Although the Persian Gulf and the Oman Sea as two moisture sources are available in the southern parts of the country, precipitation is very low. Because of their low latitude, the Mediterranean Sea and the Red Sea rainfall systems have been operating in these regions during part of the year. On the other hand, the altitude of these areas is low and the subtropical high pressure has been established for a long time. Arabian subtropical high pressure, which is the tongue of the Azores subtropical high pressure, is located over Iran from May to October and does not allow the arrival of precipitation systems, except in limited cases (Lashkari & Mohammadi, 2019). Mediterranean cyclones and the Red Sea trough cause rainfalls during the cold periods of the year (October to November) in all southern regions of Iran and Gang low pressure causes rainfalls during the warm periods of the year (June to September) more in the southeastern regions of Iran.

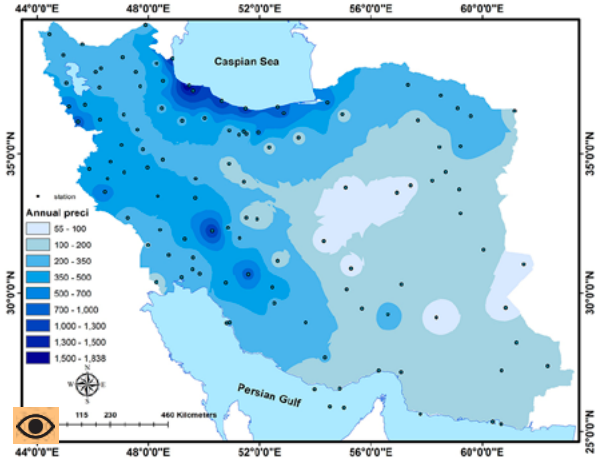

Figure 2. Spatial distribution of mean annual precipitation (mm) across Iran over the period 1988-2017

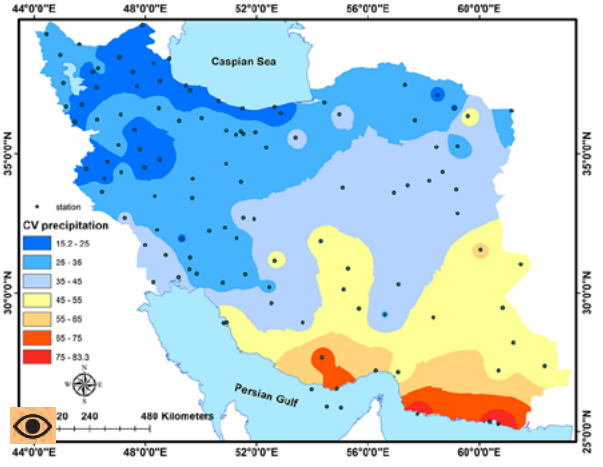

Figure 3. CV of annual precipitation across Iran over the period 1988-2017

Coefficient of variation (CV) of annual precipitation

Figure 3 illustrates the results of spatial variation for the CV of annual precipitation in the study region. According to this map, the CV for the stations ranged from 15.3 to 83.2 percent per year. The highest CV (83.2%) is related to Chahbahar station with a mean annual rainfall of about 112 mm per year, whereas the lowest CV (15.3%) is observed in Nushahr station with the mean annual precipitation value of 1295 mm per year. Therefore, it can be concluded that the CV of precipitation in humid and mountainous regions is less than that in the dry regions.

Much in the same way as precipitation, the CV of annual precipitation is also a function of latitude and topography. Regardless of the changes resulting from the elevation factor, CV of precipitation increases as we move from northwest to southeast. The mountainous regions including the Alborz mountains, the Zagros mountains and the Central zone partially decrease the CV of precipitation because the orographic ascent of air masses is one of the important factors in creating precipitation in Iran.

Spatial distribution of PCI

The spatial analysis of PCI indicates that precipitation has not occurred uniformly (less than 10) in any station. In general, the PCI values increase by moving from north to south and west to east. The lowest PCI values has to do with the regions distributed along the southern coast of the Caspian Sea and the regions with high elevation in northwestern Iran. In these regions, the annual precipitation is relatively distributed evenly throughout the year and the dry season is relatively short. In the mountainous regions of western, northern and northwestern Iran, the PCI values range from 15 to 30. This indicates that these stations are featured with a pronounced seasonality, and so they have a long dry season for half of the year. The PCI considerably increases eastward and southward to the low elevation regions and deserts of southern and central Iran. The highest PCI values (more than 30) are featured all among the regions located in southern and especially southeastern Iran, which itself shows that the total annual precipitation in this part of the country is extremely concentrated in less than a few months of the

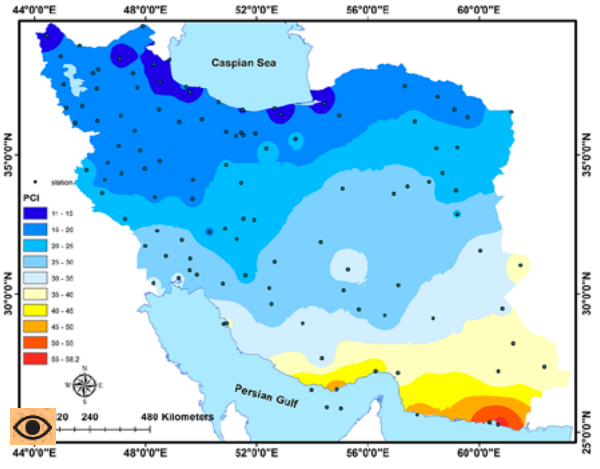

Figure 4. Spatial distributions of PCI across Iran over the period 1988-2017

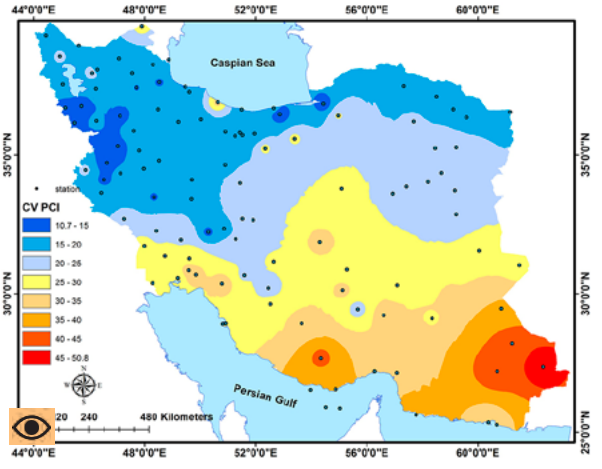

Figure 5. The coefficients of variation (CV) of PCI across Iran over the period 1988-2017

year. Therefore, in terms of latitude, the precipitation concentration decreases from south to north. The second factor that affects the spatial distributions of PCI is topography and hence it has led to a decrease in the precipitation concentration in the Zagros and Alborz mountains. This shows that orographic ascent plays an important role in rainfalls across Iran.

Coefficient of variation (CV) of PCI

The CV of PCI (Figure 5) has a relatively similar spatial distribution to the PCI (Figure 4). While the lowest values are observed in the southeastern coast of the Caspian Sea and in the northwest of the country, the highest values are seen in the southeastern parts (Sistan and Baluchestan province). The second highest center is related to the islands and the eastern coasts of the Persian Gulf. Therefore, two northwest–southeast and north-south gradients can be seen in spatial patterns. The role of the Zagros and Alborz elevations in decreasing the coefficient of variation is clearly visible. However, at a limited number of stations in the northwest region and southwestern coast of the Caspian Sea, the variability is higher than that in the surrounding area, which indicates variability in the arrival time of precipitation systems.

Mann Kendall trends analysis of PCI

The results of Mann Kendall trend test in 95% significance level are presented in Figure 6. Generally, regions with negative trends have been detected in the entire Central and northeastern parts of the country (in about 43% of the stations). Around 51% of the stations show a non-significant upward trend, mostly located in the southeast, central and western parts of the country. The positive trend of precipitation concentration in the western and southeastern regions indicates that in these regions the period of the activity of precipitation systems has decreased.

Sen's slope estimator of PCI

Figure 7 shows the spatial distribution of Sen's slope for the studied period. The positive and negative Sen's

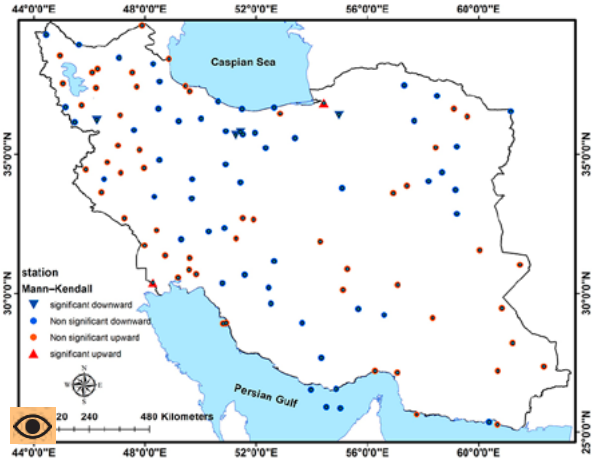

Figure 6. Results of the Mann–Kendall trend test across Iran over the period 1988-2017

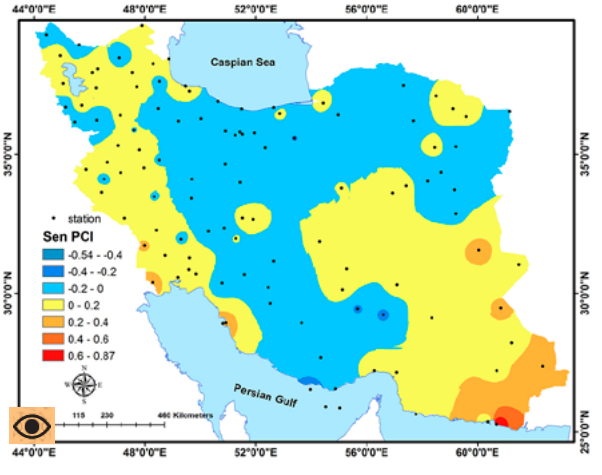

Figure 7. Spatial distribution of Sen's slope test across Iran over the period 1988-2017

slopes are very similar to the results of Mann Kendall trends. The findings of Sen's slope illustrate positive slopes in the western, southeastern and central regions. Among the regions with positive slope, from south to north and toward the northeast of the country, stations begin to have negative slopes. The values of Sen's slope vary from 0.87 in the southeastern part of the country to -0.54 in Siri and Kish islands in the Persian Gulf. Overall, a positive slope of precipitation concentration was observable in 52 percent of the territory under study.

Conclusion

The spatial variability of annual precipitation was investigated in Iran using rainfall data of 113 stations between 1988 and 2017. There is a lot of heterogeneity in Iran in terms of rainfall distribution, coefficient of variation, precipitation concentration and trends. Latitude, topography and distance from the Caspian Sea are the major factors in explaining the spatial distribution of these variations. The spatial distribution of mean annual precipitation illustrated that Iran's precipitation is a function of these factors. The lowest amount of rainfall occurs in the central and eastern parts while the highest annual precipitation occurs in the southwestern coast of the Caspian Sea. Thus, the distance from the Caspian Sea has a major impact on the amount of precipitation and its surrounding areas.

In terms of the CV of annual precipitation, the highest value (83.2%) is related to the southeastern region (Chahbahar station) whereas the lowest CV (15.3%) is observed in Nushahr station.

The maximum precipitation concentration values in Iran are mainly seen in the southeastern region. From this area to the north and northwest, the precipitation concentration gradually decreases. Precipitation concentration values of less than 20 (moderate and irregular distribution) are only observed at latitudes above 35° N; although the Zagros altitudes in the west of the country have slightly moderated the values to 32° N. Based on the PCI spatial distribution, the northern belt of Iran has a precipitation regime with a moderate seasonality, i.e., a very short dry season, while a defined precipitation seasonality with a longer dry season characterizes the mountainous regions of western and northern Iran. The most seasonal precipitation regime with the longest dry season is related to southern and especially southeastern Iran. Moreover, the spatial pattern of the dry period throughout Iran has a longitude gradient, although the topography disorders this pattern in the western and northeastern regions of the country.

The highest values of the CV of PCI were observed in southeastern and southern regions of Iran. The amount of the CV of PCI gradually increases from these regions toward northwestern and northern areas.

The study of the trends of precipitation concentration in the studied stations over a thirty-year period revealed that in 51 percent of stations the trends are non-significantly increasing at the significance level of 95%. It is significantly increasing in 2 percent of them which are mostly located in the southeast, central and western parts. However, in the central regions from the northern to the southern and northeastern parts, most of the stations have a decreasing trend (44% non-significant and 3% significant).

The results of Sen's slope estimator test indicated an increasing slope in the western, southeastern and central regions of the country (52%) and a decreasing trend in other regions (48%).

In addition to the decreasing trend of precipitation in Iran, the temperature trend in Iran is positive (Ahmadi et al., 2018) and this could mean the climate change has occurred in Iran. The findings of this research and those of other researches regarding the trend of climate variables can be used in water resource management, to reduce the risk of drought and floods, environmental conservation, and preparedness for disasters.

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Evaluation of Outdoor Thermal Comfort Conditions in Northern Russia over 30-year Period (Arkhangelsk Region)

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Abstract

The aim of the current paper is to evaluate spatial and temporal characteristics of the distribution of bioclimatic comfort within the Arkhangelsk region (Russian Federation) with two modern indices of thermal comfort: PET and UTCI. Its average values calculated for the modern climatic period (1981-2010) in the monthly mean give a clear picture of spatial heterogeneity for the warmest month (July) and for the coldest one (January). The spatial picture of both indices in July allows us to distinguish three large internal regions: the Arkhangelsk province, the continental part of the Nenets Autonomous Okrug (NAO) and Novaya Zemlya islands (NZ). Winter distribution of thermal discomfort is fundamentally different: the coldest regions (with extreme cold stress) are equally NZ and the eastern half of NAO; intermediate position is occupied by the west of the NAO and the extreme north-east of the Arkhangelsk region, the highest winter UTCI values are observed in the rest of the region. In Archangelsk-city extreme cold stress in January has repeatability 6.7%, in February - 4%, in December - 2.2%, respectively. The average number of time points during the year at which thermal stress is not observed is only 19%. Obtained results will be the basis for planning relevant health measures and providing reliable forecasts of the effects of climate change in the Arctic region.

Keywords: PET; UTCI; Thermal comfort; Arctic region; climate change

Introduction

Climate warming in the Arctic is proceeding faster than in other parts of the Russian Federation (Streletskiy, Shiklomanov, & Nelson, 2012); therefore, an assessment of existing and predicted climate risks is necessary. Arkhangelsk region is one of the most climate-depending in Russian Arctic, so it is needed to better understand the possible effects on public health in harsh climates. In the 21st century the Arkhangelsk region became one of the most significant regions of the Russian Arctic: "Arctic Gate". This was facilitated by the variety of natural conditions: from temperate to arctic type of climate and from forest zone to arctic deserts. Also, the Arkhangelsk region is the most populated of the Arctic regions of Russia: the population

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(2019) is about 1,144,000 people. This population is involved both in tourism and in fishing, transport, military and industrial spheres. The history of the region is also rich: Arkhangelsk was the first seaport in the Russian Empire in the 17-18 centuries.

Thus, it is reasonable to begin the assessment of the bioclimatic potential in the Russian Arctic precisely from the Arkhangelsk region. Episodic assessments have already been made recently in the Arctic zone of the Russian Federation - in the neighboring Murmansk region, in urban conditions (Gommershtadt et al., 2020). These were both assessments of thermal comfort and the nature of the urban heat islands (Varentsov et al., 2018; Konstantinov et al.2015), which, of course, were more likely to be made in urban cores. Assessment of modern thermal comfort indices (e.g. PET) in Russia in winter extreme climate conditions was also performed for Russian Far East urban conditions (Bauche, Grigorieva, & Matzarakis, 2013) in 2013 and for Russian South (Shartova, Shaposhnikov, Konstantinov, & Revich, 2019).

It is important to note that, despite the promising nature of the topic, there is not a large number of overlapping works in the world scientific literature either. Trends of meteorological parameters in North of Siberia was discussed in (Maksyutova & Bashalkhanova, 2019); in Finland some trends of air temperature and WCT (Wind Chill Temperature) described in (Founda et al., 2017), outdoor thermal comfort assessment for Sweden in (Yang et al., 2017). The connected urban climate research: Surface Urban Heat Island review for Fennoscandia was performed in (Miles & Esau, 2020), assessment of Arctic cities as an anthropogenic object in (Laruelle et al., 2019). Western Arctic trends and statistics of thermal indices PET and UTCI were illustrated for Canadian Quebec in (Provençal et al., 2016). Extreme-high latitude assessment was made for Franz Josef Land in (Araźny et al., 2019).

Also some recent study aimed to assess the impact of meteorological conditions on the use of public space in Scandinavia and Canada. Overall results showed that the most significant meteorological enablers for the use of outdoor public spaces in winter were solar gain, snowfall and snow-covered surfaces. Authors showed (Larsson & Chapman, 2020) that winter public space has a higher climatic design requirement to be successful than streets and pathways that are mainly used for soft mobility.

So, aim of this research paper is an evaluation of the spatiotemporal variability of thermal comfort throughout the Arkhangelsk region using different sources of meteorological data, namely, the gridded reanalysis data for the period of 1981-2010 with spatiotemporal resolution of (0.75°x0.75°x3 hours), and regular weather observations for a longer period of 53 years (1966-2018), which are available in some cities.

Materials and Methods

Arkhangelsk-city (64°33'N 40°32'E) is located in a temperate climate zone with some features of the marine one, with short cool summers and long moderately cold winters. Like the entire territory of the Arkhangelsk region, the city belongs to the Arctic zone of Russian Federation. The proximity of the Arctic Circle allows to observe white nights phenomenon from May 17 to July 26. Due to the coastal location, fast changes in weather conditions are habitual (e.g. cold invasions from the Kara Sea are possible). The annual temperature amplitude is 29.1 °C (Climate and weather of Russia, 2019), summing up the average monthly temperature of the coldest month - January (-12.7 °C) and the warmest - July (16.3 °C). The minimum of all the recorded temperatures was reached in 1885 and amounted to -45.2 °C; maximum 34.4 °C in 1972. The average annual rainfall is 606 mm per year.

Within the scope of this study, both spatial and temporal characteristics of the distribution of bioclimatic comfort within the Arkhangelsk region was decided to evaluate by most commonly used technologies. Two modern indices of thermal comfort were used as the main parameters: PET (Physiologically Equivalent Temperature) and UTCI (Universal Thermal Climate Index).

PET index (Höppe, 1984; Mayer & Höppe, 1987; Matzarakis et al., 1999) is calculated using the Human Energy-Balance Models for Individuals (MEMI). It can be defined as the air temperature at which, for ordinary room conditions, the thermal balance of the human body remains unchanged with the temperature of the internal organs and skin temperature. In addition to standard meteorological parameters (air temperature, wind speed and relative humidity, radiation and cloud cover), calculation of PET takes into account the processes of human metabolism, activity and thermal insulation properties of clothes. Currently, PET is one of the most commonly used indicators of human comfort. It is widely used in the field of biometeorology, especially for calculating the characteristics of the tourist climate, heat stress values, and also for urban planning in Europe, Asia and South America (Höppe, 2002; Lin & Matzarakis, 2011; Lopes et al., 2011; Matzarakis & Nastos, 2011; Mayer & Höppe, 1987; Milošević et al., 2016; Muthers et al., 2010; Paramita & Matzarakis, 2019; Unger et al., 2018).

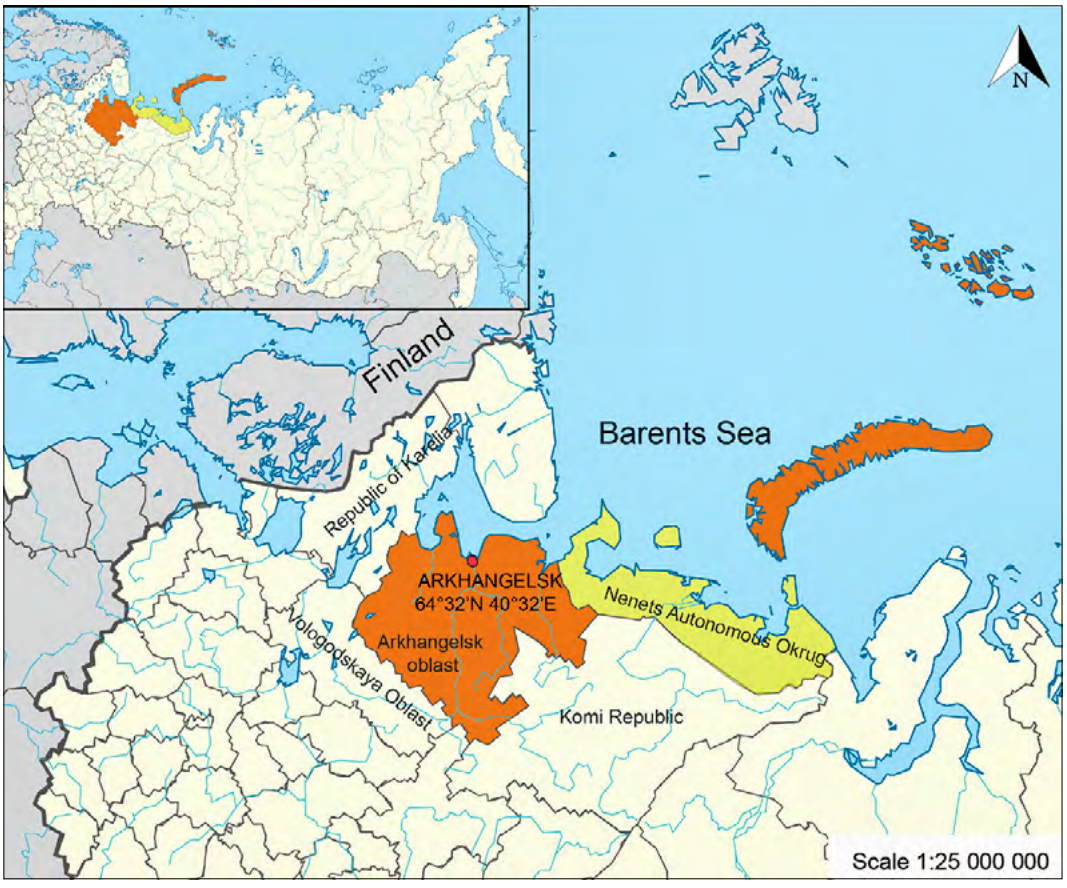

Figure 1. Location of the study area - Arkhangelsk region of Russian Federation: Archangelsk province, the continental part of the Nenets Autonomous Okrug (NAO) and Novaya Zemlya islands (NZ)

UTCI is also based on the model of human heat budget (Bajšanski et al., 2015; Havenith et al., 2012; Jendritzky et al., 2012; Lam & Lau, 2018; Milošević et al., 2017; Weihs et al., 2012). It is expressed as the equivalent ambient temperature of the reference environment, providing the same physiological reaction of the reference person in a real environment. In contrast to PET, when calculating UTCI, not only the heat-insulating properties of clothes are taken into account, but also the vapor tightness and insulation of the air surface layers. These parameters are exposed to changing wind speed and the movement of the human body and, as a consequence, affect physiological reactions. Thus, the modified insulating properties of clothing in a real environment are taken into account.

Table 1. Gradations of PET and UTCI indices (Matzarakis A.;Mayer H., 1996)

Thermal perception	Grade of physiological stress	PET-values (Western and Eastern Europe), °C	UTCI-values, °C
Extreme cold	Extreme cold stress		< -40
Very cold	Very strong cold stress	< 4	-40 – -27
Cold	Strong cold stress	4-8	-27 – -13
Cool	Moderate cold stress	8-13	-13 – 0
Slightly cool	Slight cold stress	13-18	0 – 9
Comfortable	No thermal stress	18-23	9 – 26
Slightly warm	Slight heat stress	23-29	26 – 32
Warm	Moderate heat stress	29-35	32 – 38
Hot	Strong heat stress	35-41	38 – 46
Very Hot	Extreme heat stress	> 41	> 46

The gradations of both indices are shown in the Table 1[1]*:

[1] In current study slightly cool stress is joined with moderate one.

PET and UTCI indices were calculated using the Rayman Pro 3.1 diagnostic model (Matzarakis et al., 2010) and meteorological data from the reanalysis database ERA-Interim (Dee et al., 2011) or from observations at WMO weather stations. ERA-Interim reanalysis database includes information about state of the Earth's atmosphere up to 10 hPa with a frequency of 3 hours (surface data) with a horizontal resolution of 0.75×0.75 degrees of the grid (1979-2018 period).

The original algorithm of processing the gridded reanalysis data using RayMan software was developed by the authors. The reanalysis data in NetCDF format was downloaded from ECMWF data portal (https://apps.ecmwf.int/datasets/data/interim-full-daily/levtype=sfc/) and used to assess the following atmospheric variables: the 2 m air temperature and 2 m dew point temperature, wind speed at a height of 10 m, total cloud cover fraction, and surface temperature. These variables were further processed to fit the RayMan input data requirements, which included calculation of the relative humidity from the dew point using the Magnus equation, unit conversation for the cloud fraction, and bringing the wind from a height of 10 m to a height of 1.1 m using the logarithmic wind profile and fixed roughness length parameter z0= 0.01 m, which corresponds to a short cut meadow. After preliminary processing, reanalysis data was saved in column-separated text files (with columns that corresponds to data & time, longitude, latitude, elevation and listed meteorological variables) and used as input for RayMan. The thermophysiological parameters in RayMan were set up as follows: male, 35 years old, 1.75 m tall, with a weight of 75 kg, with an internal heat production of 80 W, and a heat transfer resistance of the clothing of 0.9 clo. Total computing time of the algorithm for the whole territory of the Arkhangelsk region (including Arkhangelsk-province, NAO and NZ) demanded 138 hours. After running the RayMan, output text files with PET and UTCI indices were converted back to gridded NetCDF format. Routines for the listed data conversation operations were developed in Matlab software. Further statistical processing of obtained data included the calculation of a set of statistical parameters on PET and UTCI contemporary climatology for each reanalysis grid cell, including the mean values, repeatability of the different thermal stress categories and linear trend slope coefficients for the means and as well as for repeatabilities.

During the calculations, blocks of PET and UTCI containing fields zipped to 9.6 GB files were formed.

Results

Traditional UTCI-comfort diagram for Arkhangelsk, based on WMO station in city for period 1966-2015 can be seen on Figure 2. According to this graph, it is clear that there are no cases of two extreme "warm" gradations of stress, at all, only in July the frequency of periods with moderate thermal stress is 1.7%, in June and August it is less than 1%. But cases of extreme cold stress in January are well seen: 6.7%, in February - 4%, in December - 2.2%, respectively. The average number of time slots during the year at which thermal stress is not observed is only 19%. The most frequent PET-class during summer is "*no Thermal stress*" during winter - "*Strong cold stress*". Typical picture for city of moderate climatic zone situated on Arctic ocean board, where March is rather cold as November.

The values of the indices calculated for the climatic period (1981-2010) in the monthly averaging give a quite clear picture (Figure 3) of spatial heterogeneity for the warmest month (July) and for the coldest one (January). Thus, during summer, in July it is possible to distinguish three large quasihomogeneous regions: directly the Archangelsk province, the continental part of the NAO and NZ/ In opposite the winter picture is fundamentally different. Namely the coldest regions (with extreme cold stress) are both Novaya Zemlya and the eastern half of the NAO, the intermediate position is for the western part of the NAO, and the extreme north-east of the Archangelsk province. Highest winter UTCI values are observed in the western part of the region. Due to the low information content of the PET index during cold season, the map for its distribution is not shown there.

The spatial distribution of various "cold" gradations in the winter (Figure 4) confirms the above pattern, especially for the most dangerous values – for extreme cold stress. The east of the NAO is sharply contrasted with NZ (repeatability above 70%) and the Archangelsk province (35% and lower); an intermediate position is occupied by the western part of the NAO with the Kanin Nos Peninsula. The situation is similar for the

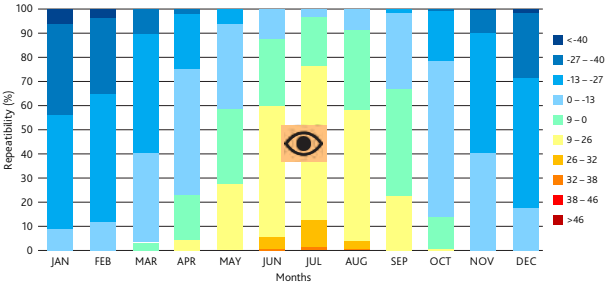

Figure 2. The repeatability of various UTCI gradations in Arkhangelsk-city (Period from 1966 to 2015). Based on data from WMO-stations

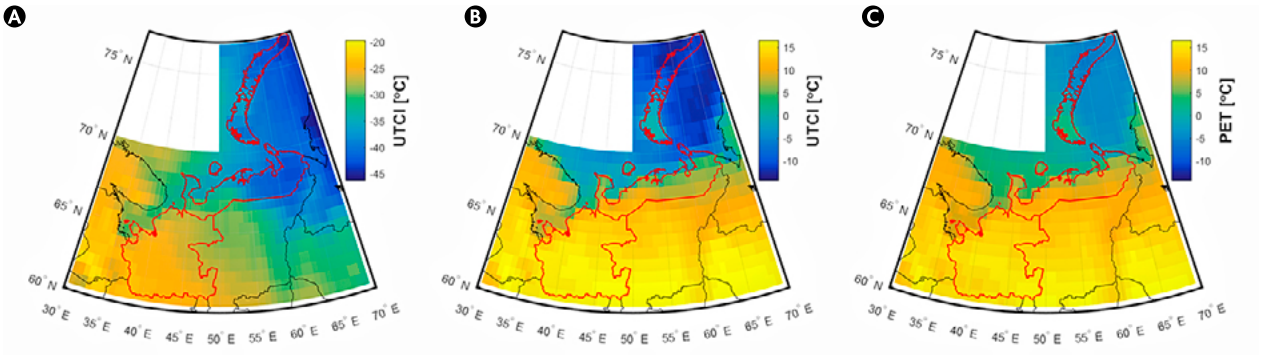

Figure 3. Mean UTCI-values in January (A) and July (B), mean PET-values in July (C)

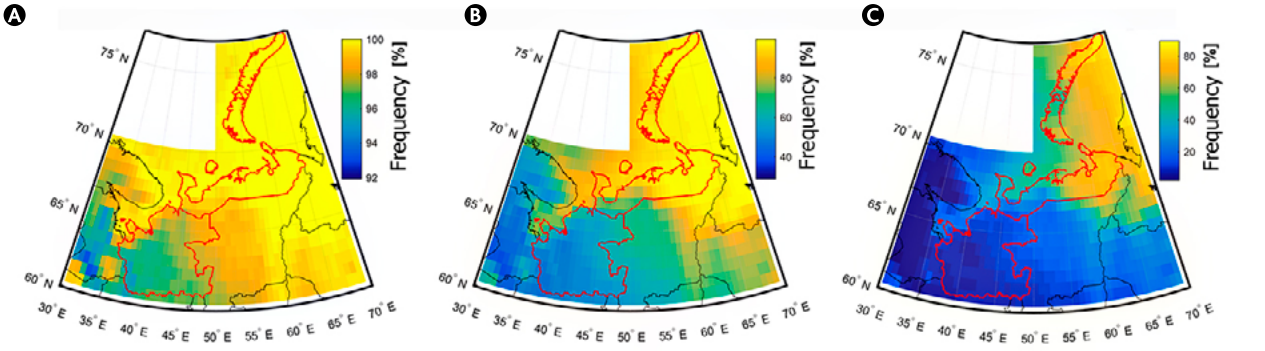

Figure 4. Spatial distribution of cold stress occurrence according to UTCI for the winter period (December-February) with gradations: strong cold stress (A) , very strong cold stress (B) and extreme cold stress (C)

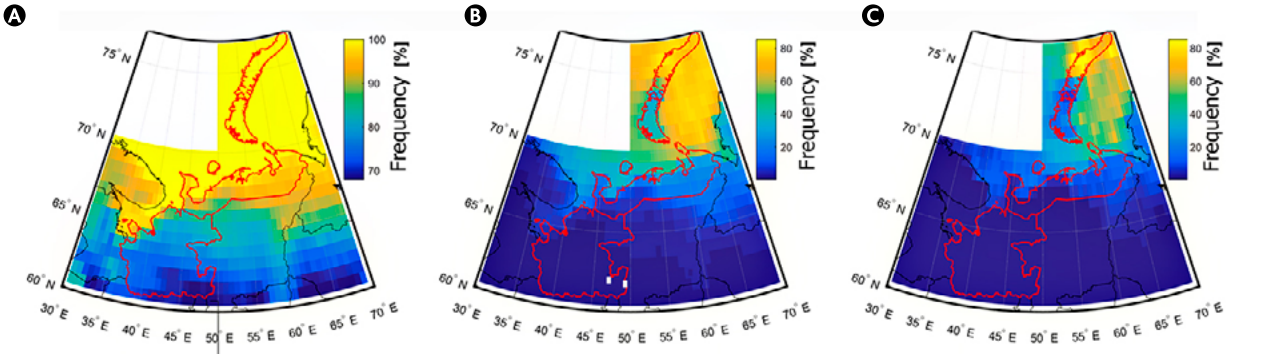

Figure 5. Spatial distribution of cold stress occurrence according to UTCI for the summer period (June-August) with gradations: moderate cold stress (A), strong cold stress (B) and very strong cold stress (C)

next discomfort gradation: "very strong cold stress". But for "moderate cold stress" the frequency of occurrence in whole research area is close to 100%.

Cold stress gradations (Fig.5) during summer period have a completely different geographical pattern: high repeatability of very strong cold stress (above 70%) is observed in the northern half of the NZ archipelago. The intermediate zone from 20 to 50% covers the east of the NAO and the southern part of NZ. In western part of the NAO and of Archangelsk province, the recurrence of very strong cold stress does not exceeds 10%. The same values of repeatability in Archangelsk province has "strong cold stress", but "moderate cold stress" on Novaya Zemlya is observed in 100% of cases, and in the rest of the region not less than in 70% of cases.

Summing up the above patterns, we computed the repeatability of days during which the PET and UTCI parameters did not exceed the comfortable values for the period under consideration (1981-2010) (Fig. 6)

Since the nature of the PET-index makes it more "narrow" when calculating comfortable conditions, its results differs with UTCI significantly. According to the PET analysis of "completely comfortable" days in the region, authors can state its complete absence. In the same time "completely comfortable" days according to the UTCI methodology are absent only in White Sea coast and on Novaya Zemlya. On the south

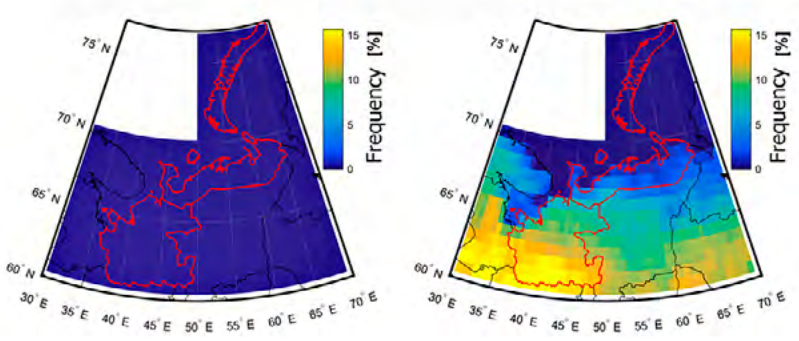

Figure 6. The spatial distribution of the frequency of days without heat stress (when the daily minimum and daily maximum both simultaneously satisfy the conditions) according to the PET (a) and UTCI (b) index

of the Archangelsk province there are no more than 15% of such days.

Discussing the spatial heterogeneity of the rates of change of climatic comfort parameters over the past 53 years, we consider trends in the main six WMO stations of the region. In Archangelsk province these are Arkhangelsk, Kargopol', Kotlas and Mezen', in the NAO – Narjan-Mar and in Novaya Zemlya - Malie Karmakuly station (Figure 7). Moreover, we consider here together both the trends in the average annual air temperature, measured at a height of 2m above ground, and the trends in the average annual value of the UTCI index (since the trends are also estimated not only for summer but also for winter period, for which the PET index is not applicable).

Discussing spatial inhomogeneity of trends we can see from Figure 7 that in settlements Malie Karmakuly and Mezen', the positive trend of both parameters is increasing approximately the same way, in the rest cities - the UTCI increases more intensively over time than air temperature. In all area UTCI and air temperature trends are both positive: for UTCI trend is from 0.4°C/10 years in Malie Karmakuly up to 2°C/10 years in Narjan Mar and for air temperature doesn't exceed 0.6°C/10 years.

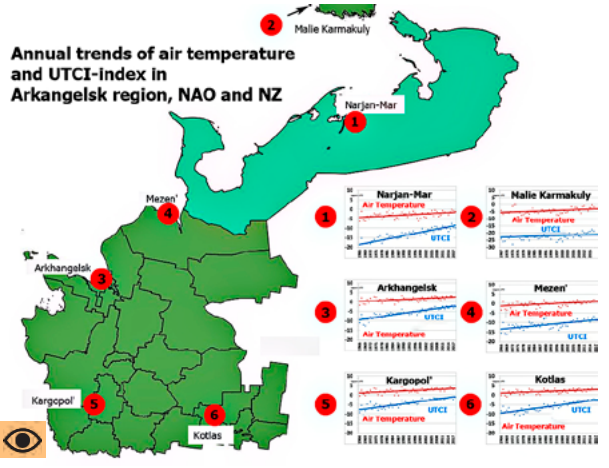

Figure 7. Spatial variability of 2m air temperature trends (annual means) and UTCI-trends (annual means) for Arkhangelsk province, NAO and NZ archipelago (far north). Trends were calculated based on data on WMO-stations for 1966-2018 period

Discussion and Conclusion

As a result of the study, the spatio-temporal variability of modern bioclimatic conditions of the Arkhangelsk region was analyzed According to the methodology of the PET analysis, "completely comfortable" days in the region are not observed at all; according to the UTCI method, it can be stated that there are no "completely comfortable" days only on the White Sea coast and Novaya Zemlya Archipelago (NZ). In the south of the Arkhangelsk region there are no more than 15% of such days. At most stations in the region, the growth rate of the average annual UTCI exceeds the growth rate of the average annual air temperature (excluding NZ region). On average, in Arkhangelsk for a year, extremely "warm" gradations of stress are not observed at all, only in July the frequency of periods with moderate heat stress is 1.7%, in June and August it is less than a percent. But cases of extreme cold stress can be observed: in January - 6.7%, in February 4%, in December 2.2%, respectively. The average number of time slots during the year at which thermal stress is not observed is 19%.

The few existing studies of thermal comfort in the Arctic show a rather variegated picture in different polar regions. Thus, an example of analysis of climatic conditions on the North of Siberia shown that slight warming (a rise of the air temperature) and small wind speed variability during the period from October to April in 1981–2015 resulted in a certain decrease in weather severity in relation to the period 1966–1980. However, the period 1981–2015 did not go beyond

limit of the interannual variability. Despite the stable increase in the air temperature in 1981–2015, no tendency to reduction of the number of days limiting human's stay in the open air was noted (Maksyutova & Bashalkhanova, 2019). In Quebec City, Canada, a city with a strong seasonal climatic variability, the UTCI was found to be slightly more sensitive to mean radiant temperature, moderately more sensitive to humidity and much more sensitive to wind speed than the PET. This dynamic changed slightly depending on the environment and the season. In hot weather, the PET was found to be more sensitive to mean radiant temperature and therefore reached high values that could potentially be hazardous more frequently than the UTCI. In turn, the UTCI's stronger sensitivity to wind speed makes it a superior index to identify potentially hazardous weather in winter compared to the PET. The urban environment produced favorable conditions to sustain heat stress conditions, where the indices reached high values more frequently there than in suburban locations, which advocates for weather monitoring specific to denser urban areas (Provençal et al., 2016).

Significant differences, mainly the variability of meteorological conditions: air temperature, wind speed and relative air humidity; and biometeorological indices: wind chill temperature, predicted clothing insulation and accepted level of physical activity were noticed on Franz Josef Land (in Teplitz Bay and Calm Bay) in the years 1899–1931. It employs meteorological measurements taken during four scientific expeditions to the study area. The analysis mainly covered the period October–April, for which the most complete data set is available. For that period of the year, which includes the part of the year with the Franz Josef Land's coldest air temperatures, the range and nature of changes in meteorological and biometeorological conditions between historical periods and the modern period (1981–2010) were studied. The data analysis revealed that during the three oldest expeditions (which took place in the years 1899–1914), the biometeorological conditions in the study area were more harsh to humans than in the modern period (1981–2010) or similarly harsh. In contrast, during the 1930/1931 expedition, which represents the Early Twentieth Century Warming (ETCW), conditions were clearly more favourable (including predicted clothing insulation being 0.3 clo lower and 4.0 °C higher wind chill temperature than conditions observed nowadays) (Araźny et al., 2019).

In European region at higher latitudes cities like Helsinki and Oulu exhibit particularly large warming trends in both Tmax and Tmin during the cold period of the year. Specifically, the warming rates of Tmin in winter is outstanding, exceeding 1 °C per decade. Lower but statistically significant positive trends are also observed in spring and summer. The frequency of cold-related discomfort conditions in northern cities dropped by more than 20% in the last decade compared to the decade 1976–1985. The decline is much higher in risk or high-risk levels (WCT < –28 °C) ranging from 36% at Oulu to 45% at Helsinki, also in agreement with the increasing trends in the 2nd percentile corresponding to high risk values. Caution heat conditions are becoming increasingly more frequent during the last decade. Such conditions are almost missing in the 1970s, while 'extreme caution' cases are not observed. Cities with colder local climates become markedly less cold in winter and autumn, with the warming rates in Tmax exceeding 0.7 °C/decade since the mid-1970s. The warming trends are even more striking in the winter Tmin though, exceeding 1 °C/decade and reaching up to 1.4 °C/decade since the mid-1970s (Founda et al., 2019).

For concluding it could be noticed that in Arkhangelsk region, mainly, throughout the year, the conditions of cold stress of varying intensity have a greater frequency in the region. But in the same time the geographical location of the districts allocated according to the conditions of discomfort does not coincide in the summer and winter, respectively.

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The Covariability of Sea Surface Temperature and MAM Rainfall on East Africa Using Singular Value Decomposition Analysis

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Abstract

The study assesses the covariability of Sea Surface Temperature (SST) and March to May (MAM) rainfall variability on East Africa (EA) from 1981 to 2018. Singular Value Decomposition (SVD) analysis reveals the significant influence of SST anomalies on MAM rainfall, with covariability of 91%, 88.61%, and 82.9% for Indian, Atlantic, and the Pacific Ocean, respectively. The Indian Ocean explains the variability of rainfall to the large extent followed by the Atlantic Ocean and the Pacific Ocean. The rainfall patterns over the EA correspond to SST variability over the western, central, and eastern Indian Ocean. Likewise, the variability of SST anomalies was observed over the central, south, and north of the Atlantic Ocean while the Pacific Ocean captured the El Nino Modoki (ENSO) like pattern in the SVD1 (SVD2). The heterogeneous correlation of Indian SST anomalies and rainfall over EA of the first (second) principal component (PC) shows a positive correlation over much of the domain (central region). The SST anomalies over the Pacific Ocean show higher correlation values with the rainfall over much of the study domain except over the southwestern highland and southern region of Tanzania. Over the Atlantic Ocean, the correlation result shows the patterns of positive (negative) values over the northern (southern) part for PC1, while PC2 depicts negative correlation values over much of the Ocean. SST anomalies over the Indian (Atlantic) Ocean are highly correlated with MAM rainfall when SST leads by 1(7) month(s). The Pacific Ocean shows a weak (strong) correlation across all (zero) lead seasons.

Keywords: SST; EA; MAM; Rainfall variability; SVD

Introduction

Rainfall is a very important parameter of weather and climate system in the region of EA. This is particularly common in the countries whose economy relies on rain-fed agriculture (Thornton et al., 2010; Ongoma et al., 2015; Brigadier et al., 2016), that contribute about 40% of gross development product (GDP) and employs about 80% of the active population (Mikova, 2015; Ongoma & Chen, 2017). Due to rainfall variability, the region of EA is affected by extreme weather events, such as floods and droughts (Anyah & Semazzi, 2006; Ber-

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hane & Zaitchik, 2014; MacLeod, 2018) which have impacts to the environmental and socio-economic activity of the region (IPCC, 2007; Ongoma, 2013).

The inter-annual rainfall variability over the region is attributed to the zonal circulation of the Indian ocean (Mafuru & Guirong, 2018; Limbu & Guirong, 2019). Previous studies discussed the influence of SST on seasonal rainfall variability over the region (Hastenrath et al., 2010; Mikova 2015). The same results have been found by Ngarukiyimana et al. (2018) and Camberlin (2018). During MAM rainfall season, the region receives intense rainfall due to the warmer SST in the western Indian ocean (Yang et al., 2015). The dry phases during the MAM season are associated with warmer SSTs over the western tropical Pacific and cooler SSTs over the central and eastern tropical Pacific (Lyon & Dewitt 2012; Lyon et al., 2014; Yang et al., 2015). Thus, correspond to the intensification of Mascarene and Saint Helen anticyclones which transport the humidity air from the Atlantic Ocean passing through the Congo basin and Lake Kivu bringing the moisture and enhance precipitation over the region (Anyah & Semazzi, 2006).

However, there are still many unresolved questions concerning the factors influencing MAM rainfall variability over EA meanwhile the prediction skill for MAM rainfall over the region is about 80% (Walker et al., 2019) which is not sufficient enough. This study aims to analyze how the SST varies with the rainfall over the region. The outcome of this study provides important information for climate services end users which help for reducing the vulnerability to the climate related destruction, damage, and losses.

The remaining parts are subdivided into the following sections: Data and methodology are detailed in section 2. The results and discussion are explained in the section 3. The final remarks of this study are addressed as the conclusion in section 4.

Data and methodology

Data sources

The gridded observation monthly precipitation dataset produced by the Climatic Research Unit (CRU) at the University of East Anglia was used in this study. The dataset is of version 4.03 (CRU TS 4.03) for the period 1981- 2018 covering the land surface at 0.5° x 0.5° resolution. The same dataset taken from http://data.ceda.ac.uk/badc/cru/data/cru_ts/cru_ts_4.03/data/pre was successfully used by Harris et al. (2019). Moreover, previous researchers used the CRU dataset to investigate the variability of rainfall over the study region (Ogwang et al.,2015; King'uza and Limbu, 2019). The SST dataset used is the Extended Reconstructed Sea Surface Temperature version 5 (ERSSTv5) with a resolution of 2° x 2° from 1981 to 2018. The dataset is acquired from the National Oceanic and Atmospheric Administration/ National Climatic Data Center, NOAA NCDC (http://iridl.ldeo.columbia.edu/SOURCES/.NOAA/.NCDC/.ERSST/. version5/. sst) and was used by Huang et al. (2017). These datasets were used to analyze how the SST varies with rainfall over EA.

Methodology

The SVD was used to analyze the covariability between MAM precipitation over EA and the SST in the Tropical Oceans (i.e. Atlantic, Indian, and Pacific). The SVD approach has the advantage of evaluating the cross-covariance matrix of two spatial-temporal fields to identify regions of similar behaviour (Aziz et al., 2010). The same technique was used by (Ogwang et al., 2016; Ogou et al., 2016; Dubache et al. 2019; Li & Zhao, 2019; Quishpe-Vásquez et al. 2019; Li et al., 2020) to investigate the response of rainfall on SST. This technique is applied to two jointly analysed fields to identify couples of the coupled spatial pattern and their respective temporal variations. The decomposition allows the extraction of dominant modes of the coupled covariability between the two analysed fields.

Correlation analysis was employed to reveal the simple relationships between two variables (Wilks, 2006). The Pearson's correlation coefficient (r) is used as a good indicator of the strength of the relationship between the two fields. The same method was used by Cattani et al. (2018) and Kalisa et al. (2019) over the study region. From the SVD analysis, the heterogeneous correlation represents the correlation coefficients between the values of each grid point of the field and the expansion coefficients of the other field. In this study, the heterogeneous correlation indicates how well the pattern of the precipitation (SST) anomalies relates to the expansion coefficient of SST (precipitation). The anomaly was obtained by subtracting a value from its climatological mean (mean value from 1981 to 2010). The heterogeneous correlation was performed by projecting the temporal expansion series of each field onto the appropriate singular vector. The time lag correlation coefficient was used to find out in what time step the Atlantic, Indian and Pacific Oceans have a strong and significant linear relationship with East African's MAM rainfall. The same technique has been used by other researchers (Kug et al., 2006; Otte et al., 2017) in the region.

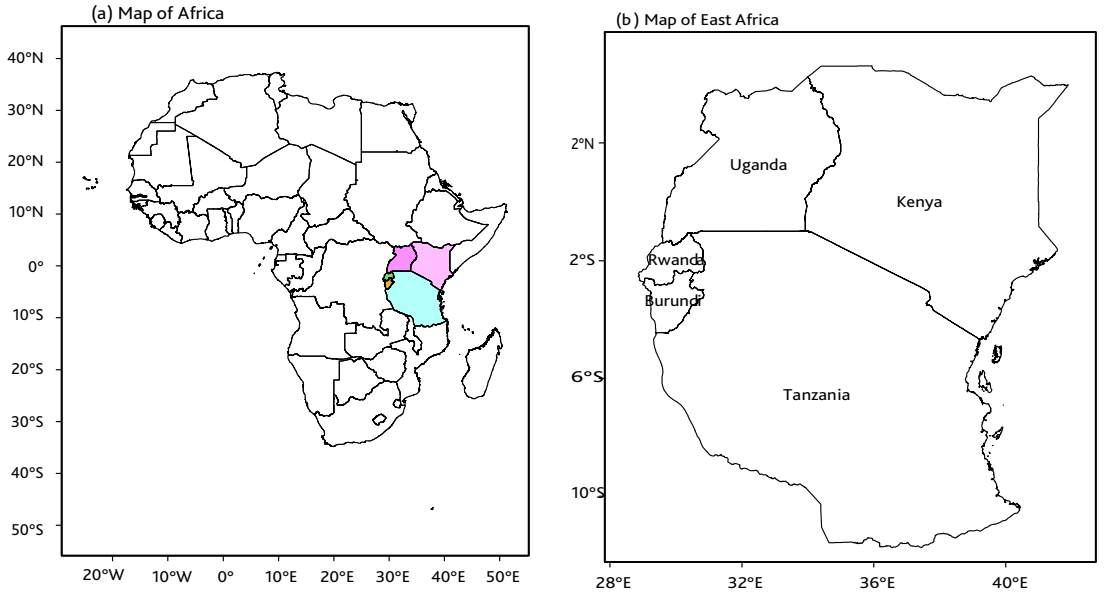

Figure 1. (a) Map of Africa showing the area of study (colored region)
(b) Map of East Africa showing countries used in this study

Study area

The EA region is located in the tropics bounded by a longitude of 280 E to 420 E and the latitude of 120 S to 50N (Fig. 1b). EA includes Tanzania, Kenya, Uganda, Rwanda, and Burundi. The climate of East Africa is characterized by two rainy seasons regimes, short rainy season, October to December (OND), and long rainy season, MAM (Nicholson, 2014; Rowell et al., 2015). This bimodal regime is due to the northward and southward movement of the Intertropical Convergence Zone (ITCZ) (Muhire et al., 2015; Camberlin, 2018). EA climate varies from one place to another in accordance with geographical location, altitude, relief, and vegetation cover.

Results

The first two dominant coupled modes of SVD (Fig. 2) explain 88.61% of the total covariance, meaning that there is a good covariability between rainfall and SST over the Atlantic Ocean. The first SVD vector of precipitation in MAM (Fig. 2a) indicates the highest positive values over the South-east of Tanzania, which may be associated with positive SVD values over the northern Atlantic Ocean (where the Azores high is located) as well as negative values over the sub-tropical Atlantic Ocean (Fig. 2c). For the second SVD (Fig. 2b), the lowest negative values are featured over the south-east of Tanzania instead, and this is complemented by the disappearance of positive SVD values over the northern Atlantic Ocean where negative values have now dominated. However, still, negative values are over the subtropical Atlantic Ocean (Fig. 2d).

The first two dominant coupled modes of SVD explain 91% of the total covariance, meaning that there is a good covariability between rainfall and SST over the Indian Ocean (Fig. 3). There exist significant coupled modes of variability between SST in the Indian Ocean and the mean MAM rainfall over EA with the covariance of 83.9% of the first mode (SVD 1). SVD 1

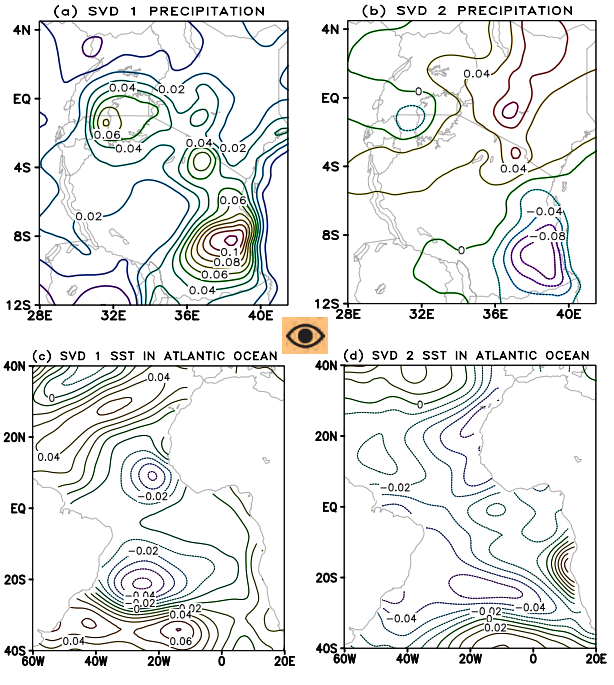

Figure 2. The homogeneous map of the first two modes of SVD for the Precipitation (mm/month) (a and b) and SST (°C) in an Atlantic Ocean (c and d).

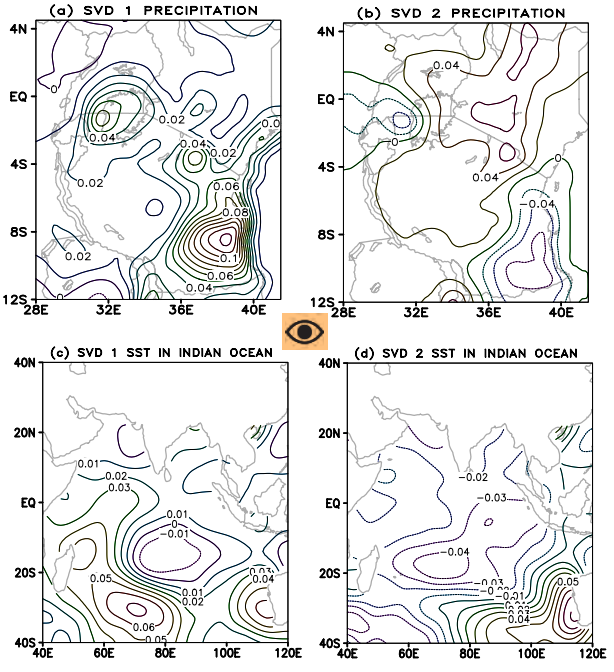

Figure 3. The homogeneous map of the first two modes of SVD for the Precipitation (mm/month) (a and b) and SST (°C) in an Indian Ocean (c and d)

(Fig. 3a) shows that the East African region is dominated by homogeneous positive loading all over the region with strong rainfall variability over the eastern coast and over the Lake Victoria basin. This is associated with positive loading SST anomalies (Fig. 3c) over the western and southwestern Indian Ocean and negative loading of SST anomalies over the central Indian Ocean.

SVD2 (Fig. 3b) depicts the presence of dipole patterns over the study area characterized by positive loading over the northern part extending towards the southwestern sectors, and negative loading over the eastern coast towards the southeastern and the western part of the Lake Victoria basin. The dipole pattern observed is associated with the dipole patterns of SST anomalies (Fig. 3d) over the Indian Ocean with positive loadings over the southeastern Indian Ocean and negative loadings over the remaining part of the Tropical Indian Ocean.

The first two dominant coupled modes of SVD explain 82.9% of the total covariance, meaning that there is a good covariability between rainfall and SST over the Pacific Ocean (Fig. 4). SVD 1 (Fig. 4a) depicts higher positive loading over bimodal rainfall regimes and the coastal belt of Tanzania. The same results persist in the southern region of Uganda including northern Lake Victoria while on the Kenyan side the loading occurs over the southwestern and coastal region. These loadings correspond with negative loadings over the central equatorial Pacific Ocean (160° -120° W) and other small SST anomalous over the Ocean (Fig. 4c). SVD 2 (Fig. 4b) reveals diagonal positive loading of rainfall across EA and several positive loadings over the southern part of Tanzania, northern part, and the coast of Kenya. These loadings correspond with mixtures of weak positive and negative loadings over the Pacific Ocean (Fig. 4d). The remarkable feature is positive loading over the central eastern Pacific Ocean, which acts on opposite to SVD 1, this suggests the existence of a sea-saw pattern of SST anomalous over the region of El Nino Modoki. This gives a clue of a weak relationship between this region and rainfall over EA due to a weak correlation (0.41) on a temporal scale. Hence, Pacific Ocean SST is less related to MAM rainfall season over EA. Similar results were obtained by Preethi et al. (2015) which show that El Niño Modoki events are associated with suppressing of rainfall over eastern Africa.

The correlation between EA precipitation and PC1 and PC2 of SST anomaly shows that much of the central to northern parts of the region feature weak to moderate positive correlation (Fig. 5a&b). The strongest values are indicated over northern Kenya as well as localized areas in Northern Tanzania, with correlation values as high as 0.4. Otherwise, the rest of the region, mainly Southern parts, features very weak negative correlations. The correlation between SST over the Atlantic Ocean and PC1 of precipitation show positive values over the subtropical region of the Ocean and North of the Equator. Meanwhile, in the South of the Equator to the mid-latitude, there are negative values of correlation (Fig. 5c). However, further south, positive correlation values are evident. For PC2, there is hardly any clear pattern (Fig. 5d); a relatively high

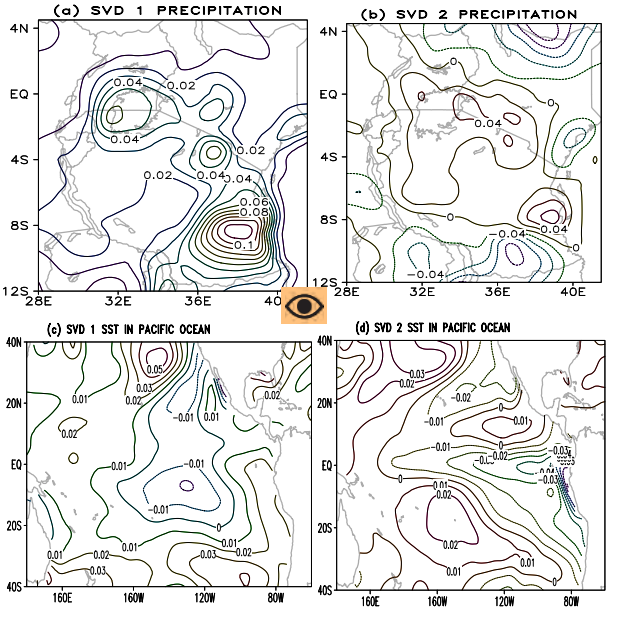

Figure 4. The homogeneous map of the first two modes of SVD for the Precipitation (mm/month) (a and b) and SST (°C) in Pacific Ocean (c and d)

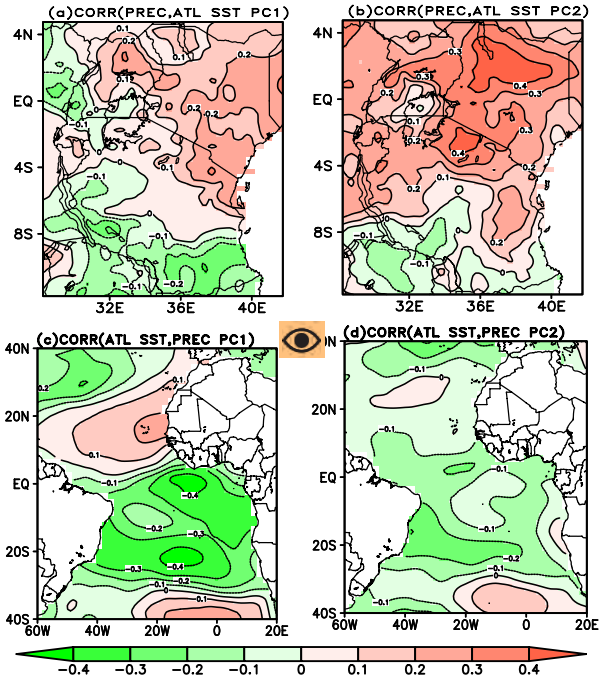

Figure 5. Heterogeneous correlation between precipitation over the study area and PC 1 and 2 of Atlantic SST (a and b) and heterogeneous correlation between Atlantic Ocean and PC 1 and 2 of precipitation (c and d)

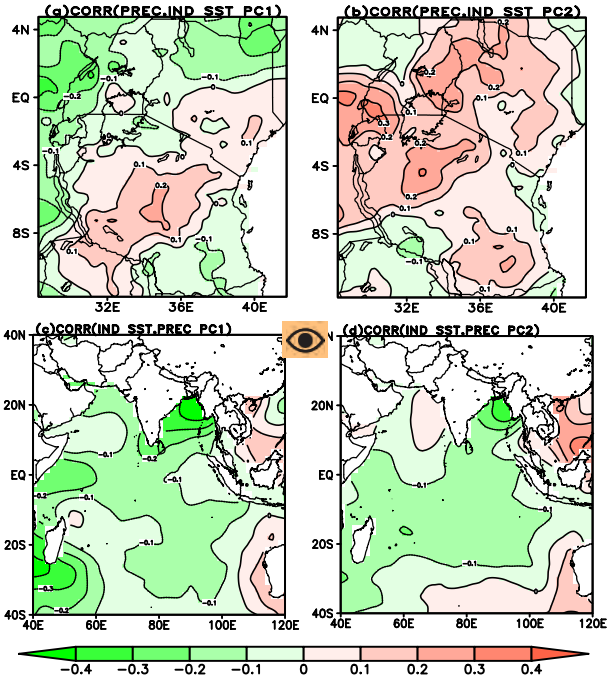

Figure 6. Heterogeneous correlation between precipitation over the study area and PC 1 and 2 of Indian SST (a and b) and heterogeneous correlation between Indian Ocean and PC 1 and 2 of precipitation (c and d)

negative correlation is over the sub-tropical region of the Western Atlantic Ocean (off the coast of Brazil) though.

For the Indian Ocean, a heterogeneous correlation of PC1 of SST anomaly is positively correlated with the EA rainfall over the northeastern extending towards the southwestern parts of the study area (Fig. 6a). On the other hand, a negative correlation is observed over the remaining part. The PC2 of the SST anomaly is positively correlated with the EA rainfall almost all over the study area (Fig. 6b). Heterogeneous correlations of PC1 and PC2 of EA rainfall are negatively correlated with SST all over the Indian Ocean except the southeastern and maritime continent regions (Fig. 6c&d). This suggests the existing influence of western and southwestern parts of the Indian Ocean to MAM rainfall variability over the EA.

The heterogeneous correlation between EA rainfall and Principal components of Pacific Ocean SST was also analyzed. PC1 (Fig. 7a) shows the domination of positive correlation over much of the domain region except the southwestern highland and southern region of Tanzania where negative correlation is observed. PC2 (Fig. 7b), shows quite similar patterns to PC1; however, over portions of northeastern Tanzania, a positive correlation is replaced by a negative correlation which makes the area to resemble the dipole structure. Otherwise, in PC1, there are generally higher correlation values over much of the domain. Likewise, the heterogeneous correlation between the Pacific Ocean SST and PC 1 and 2 of EA rainfall (Fig.

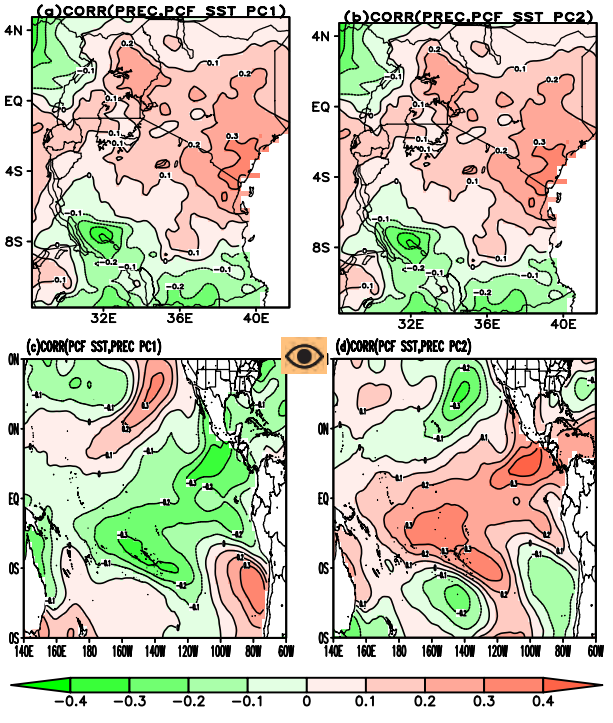

Figure 7. Heterogeneous correlation between precipitation over the study area and PC 1 and 2 of Pacific SST (a and b) and heterogeneous correlation between Pacific Ocean and PC 1 and 2 of precipitation (c and d)

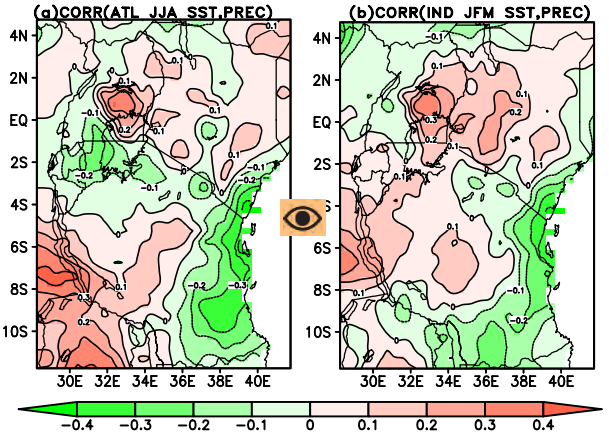

Figure 8. Lead correlation between precipitation and SST averaged over (a) Atlantic Ocean (b) Indian Ocean

7c&d) shows a sea-saw pattern of SST anomalies over the central east Pacific Ocean (ENSO like pattern). The opposite SST patterns over the Pacific Ocean have a little relationship on changing rainfall patterns over East Africa but the figures give us the clue on which region over the Pacific Ocean has a stronger correlation to EA precipitation.

Looking into the lead-lag relationship between MAM precipitation over the EA and spatially averaged SST over the Atlantic Ocean, the results indicate that most significant correlation values are found in 7-month lead time i.e. during JJA (Fig. 8a). This is evident with negative values as low as around -0.3 observed over some Southern areas of the Lake Victoria while positive correlation values as high as 0.3 observed over the area just north of the Lake Victoria over Uganda. In addition, along the coastal areas, mainly over Tanzania, negative values of correlation of down to -0.4 have been observed. The lead-lag correlation shows that the Indian Ocean SST has a fairly high correlation with MAM rainfall over EA when SST leads by 1 month i.e. during JFM (Fig. 8b), characterized by positive correlation all over the region except the eastern coastal region. As for the Pacific Ocean, the results generally show that the magnitude of positive correlation decreases slowly until replaced with negative correlation while moving toward previous seasons. The correlation coefficient values were weak across all leads; hence, we may say that SST over the Pacific Ocean has a little contribution to EA rainfall during MAM.

Discussion

The global Oceans SST has been found to have an influence on interannual and interdecadal variability of rainfall over different regions in the world. Changes in global SST over different regions may lead to intense rainfall or suppressed rainfall. The results from SVD analysis confirmed the complexity variability of rainfall over EA during the MAM rainfall season. SVD results have shown more insight into the modes of interannual rainfall variability over the region. The dominant modes representing zonal SST variability in the Indian Ocean which is consistent with other studies including Okoola (1996), Goddard and Graham (1999), Mutai (2003), Nyakwada (2009) among others. The study showed that MAM rainfall variability over EA is associated with warmer SST over the western Indian Ocean. The same result was found by Yang et al. (2015), where they documented that intense rainfall corresponds to warmer SST over the western Indian Ocean. It is also found that intense MAM rainfall is related to warmer SST over the northern Atlantic Ocean and vice versa. Moisture influx from the ocean is associated with an enhanced westerly circulation that also favours the incursions of moisture from the always wet tropical forests of Congo, Zaire, and other central African countries. The SST variability in the Atlantic Ocean reaches its maximum in the period from January to May (Wu et al., 2007). This may be due to the relaxation of Azores' high, which in turn, more moisture is pushed to the region with the aid of St. Helena high (Manatsa et al., 2014). Over the Pacific Ocean, the existence of El Nino Modoki over the central Pacific Ocean corresponds to positive rainfall anomalies over EA, especially over the bimodal regions. The result agrees with the study of Preethi et al. (2015) which explained that El Niño Modoki is associated with suppressing rainfall over eastern Africa. On the other hand, an ENSO-like pattern was captured in SVD 2 similar to that was shown by Kijazi and Reason (2005).

The characteristics of the SVD modes are closely related to some climate extremes affecting the region. These could be associated with the behaviour of these modes on the circulations, energy, and moisture induced by the ocean, and other inland generating systems. Barnston et al. (1996) explained that the time-space behaviour of the SST field alone influences the seasonal rainfall over the region both on different time-scales. This suggests that the large-scale changes in the global basins' SSTs have a significant influence on regional climate variability. To emphasize the importance of Oceans on regional climate variability, many studies have been done on the strong relationship between ocean currents and regional climate (Cai and Cowan, 2007; Keller et al., 2007; Valsala and

Ikeda, 2007). The results in this study provide important information for improving the prediction skills of MAM rainfall over EA. Improvement in prediction skills will help to reduce the vulnerability to climate-related destruction, damage, and losses. According to previous studies such as Lyon and DeWitt, (2012), and Ongoma and Chen (2017), MAM rainfall over EA shows a declining trend in the late 1990s. Therefore, we recommend future studies to focus on assessing the linkage of change in global SST especially on the regions identified with the declining trend of MAM rainfall over EA.

Conclusion

Results from this study point out the significant influence of SST anomalies over Indian, Pacific, and Atlantic Oceans on EA MAM rainfall seasonal variability. Indian, Atlantic, and the Pacific Ocean show good covariability of 91%, 88.61%, and 82.9% with EA rainfall respectively. This indicates that the Indian Ocean explains the variability of rainfall to the large extent followed by the Atlantic Ocean and the Pacific Ocean.

The first two modes of SVD between SSTs and rainfall show similar rainfall patterns over eastern, eastern highlands, and Lake Victoria basin except SVD 2 which corresponding to the Pacific Ocean. The rainfall patterns over EA correspond to SST variability over the western, central, and eastern Indian Ocean. Additionally, the Atlantic Ocean depicts negative (positive) loading over central (south and north). However, the Pacific Ocean shows negative (positive) loading over central and eastern (eastern and western) in SVD1 and SVD2 respectively. SVD 1 (SVD 2) captured the El Nino Modoki-like (ENSO-like) pattern.

The heterogeneous correlation of Indian SST anomalies over EA rainfall of the first (second) PC shows positive correlations over much of the domain (central region). The PC's of EA rainfall anomalies were negatively correlated with SST anomalies over much of the Indian Ocean. Generally, the correlation between PC1 of Pacific SST anomalies and EA rainfall shows higher correlation values over much of the domain except over the southwestern highland and southern region of Tanzania. PC2 depicts a similar pattern with a northward extension of negative correlation. The correlation between the first and second PC of rainfall anomalies over the Pacific Ocean shows the ENSO-like pattern. Meanwhile, flip-flop patterns of correlation values were observed over the northern and southern Pacific Ocean. Over the Atlantic Ocean, the correlation result shows the dipole patterns of positive (negative) values over the northern (southern) part for PC1, while PC2 depicts negative correlation values over much of the Ocean. The lead correlation between the Indian Ocean SST shows high correlations with East Africa MAM rainfall when SST leads by 1 month. Meanwhile, the results indicate the most significant correlation values when SST leads by 7 months (during JJA) for the Atlantic Ocean. The Pacific Ocean shows a weak correlation across all lead seasons.

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Conflict of interest

The authors declare that there is no potential conflict of interest whatsoever.

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Air Quality Changes in Ukraine during the April 2020 Wildfire Event

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Abstract

The paper analyzes air quality changes in Ukraine during a wildfire event in April 2020 and a dust storm episode during the 16th of April 2020. The wildfire event contained two episodes of active fires and huge pollutants' emission: 4–14 April and 16–21 April, respectively. Using the Sentinel-5P data of CO and NO_2 column number density and ground-based measurements, there was estimated air quality deterioration. Advection of polluted air masses and analysis of affected territories were made in combination with a web-based HYSPLIT model. Satellite data described air quality changes better than in-situ measurements. Data intercomparison showed better coincidence in regions that were not affected by wildfire emissions. The paper described the dust storm event based on absorbing aerosol index (AAI) data that occurred between two wildfire episodes.

Keywords: wildfire; air quality; carbon monoxide; nitrogen dioxide; dust storm; trajectory

Introduction

Frequent wildfires and "traditional" agricultural open burning are among the most challenging problems in Ukraine. In recent years, natural fire danger increased due to climate changes in the region (Balabukh & Malytska, 2017). As a result, lots of man-made "controlled" fires on agricultural fields are turning to uncontrolled wildfires. Each of these fires emits a huge amount of combustion products into the atmosphere that negatively influences human health. Carbon monoxide (CO), nitrogen oxides (NO_x), particulate matter (PM), including black carbon (BC), and volatile organic compounds (VOC) are among the pollutants that impact air quality (Knorr et al., 2017; Langmann et al., 2009). Moreover, wildfires become a significant contributor to climate change due to emitting greenhouse gases such as carbon dioxide (CO2) and methane (CH4) (Doerr & Santin, 2016).

Air quality changes under the influence of wildfire events require a complex approach for data analysis and research methods involvement. Usage of only ground-based data cannot identify the real consequences of pollutants' emission. In the case of the Ukrainian measurement network, there are two main problems. The first one is connected with the location of monitoring stations, which are appropriate only for analysis of urban anthropogenic emissions. As wildfires occur in remote regions, available stations rarely allow providing an accurate warning for the population. Moreover, it could be done only in the case of polluted masses advection toward the affected city. The second problem is spatial heterogeneity of the pollutants' distribution, and there are no background monitoring stations in Ukraine. A national air quality network was developed in the former Soviet Union several decades ago, where monitoring sites were located close to the main anthropogenic emission sources. As a result, all stations of the air quality network could not be considered as the background ones. Nowadays, the first steps have been done for changing national regulations and establishing background

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stations for air quality monitoring and management in the future. Hence, at the very close distances from in-situ observations (which show only huge anthropogenic pollution), there is no statistically reliable data, even after extra-/ interpolation. The main solution for both problems is the integration of satellite data and atmospheric modeling.

Remote sensing provides us with great spatial coverage, giving a day-to-day global view of air pollution, where the most precise spatial resolution reaches 7×7 km for Sentinel-5P satellite and the TROPOspheric Monitoring Instrument (TROPOMI) on it (Internet 1). During the wildfire events, it becomes possible for air quality analysis over remote regions (Sunar & Özkan, 2001) and compare results with background values. Mainly, two species (column number densities) are taken from satellite measurement for analysis of air pollution during wildfires: CO (Borsdorff et al., 2018a; Deeter et al., 2018; Turquety et al., 2007) and NO2 (Mebust et al., 2011; Schreier et al., 2015). Satellite data could be used for the estimation of burned products emission (Adams et al., 2019) and were implemented in the number of air quality applications (Levelt et al., 2018). TROPOMI data have already recommended itself for the purpose of air quality monitoring (Borsdorff et al., 2018b; Griffin et al., 2020; Kaplan & Avdan, 2020; Savenets et al, 2019; Theys et al., 2019).

Of course, satellite observations have some disadvantages (Brennan et al., 2019; Duncan et al, 2014; Engel-Cox et al, 2004; Ialongo et al., 2020; Voulgarakis & Field, 2015), e.g., an impossibility for the recalculation to near-ground values, complex atmospheric correction, uncertainties for burned area estimation, temporal/ spatial resolution, etc. However, modern satellites give a good qualitative picture of air quality changes.

Some disadvantages of remote sensing could be solved using atmospheric modeling, that also became very popular for studying wildfire events (Coen et al., 2013; Eastham & Jacob, 2017; Heilman et al., 2014; Lazaridis, et al., 2008; Lutsch et al., 2019), including the Ukrainian territory (Galytska et al, 2018; Mahura et al, 2019). For different kinds of events that are accompanied by pollutants' emission, the Hybrid Single-Particle Lagrangian Integrated Trajectory model (HYSPLIT) (Internet 2; Rolph et al, 2017; Stein et al, 2015) is popular for its availability as an offline and web-based software. HYSPLIT has already shown good results for the analysis of trajectories during huge anthropogenic (Rolph et al., 2014; Skrynyk et al., 2019) and natural (Lazaridis et al., 2008; Wentworth et al., 2018) pollutant's releases.

During April 2020, severe wildfires occurred in the north of Ukraine after numerous man-made agricultural burning distributed to forestry areas. The Chornobyl Exclusion Zone was among the territories with active fires. The most intense wildfires observed during 4–21 April caused huge pollutants' emission and affected the populated Ukrainian territories, including Kyiv metropolitan area. Despite the negative impact on air quality in April and great concern among people and media, the overwhelming majority of people who use open burning in the agricultural sector does not intend to change their usual practice. Analysis of the consequences after open burning and wildfires might become strong evidence for the agricultural sector and private gardening to change their practices and do not burn plants' remnants. Moreover, results of pollutant distribution during the wildfires will help to develop recommendations about the most appropriate location for background air quality stations and satellite data use for public warning. Considering the mentioned problems, the current study aimed to analyze air quality changes in Ukraine under the wildfires in April 2020. It will help to understand the disadvantages of the monitoring network, develop the methodology of satellite and ground-based data fusion during wildfires, and provide an informational basis for decision-makers.

Data and methods

Air quality changes over the territory of Ukraine has been analyzed using TROPOMI data from the Sentinel-5P satellite (Internet 1). Among available chemical species derived from Sentinel-5P, the most appropriate for air quality estimation during wildfires are CO (Borsdorff et al., 2018a; Deeter et al., 2018; Turquety et al., 2007) and NO_2 (Mebust et al., 2011; Schreier et al., 2015). CO column number density was selected as the indicator of wildfire emissions and combustion products in the atmosphere. NO_2 column number density was used for studying the general state of air quality as the indicator of all-type emissions: wildfire, stationary, and mobile anthropogenic sources. Moreover, CO and NO_2 are the only species that could be compared with ground-based measurements. The national monitoring stations for air quality still do not measure other chemical species that are emitted during wildfires: particulate matter (PM), ozone (O_3), carbon dioxide (CO_2), volatile organic compounds (VOC), etc. Absorbing aerosol index (AAI) derived from Sentinel-5P was used for the analysis of the dust storm case during the 16th of April 2020.

Sentinel-5P observed Ukrainian territory between 10 and 11 UTC that corresponds to 1:00 PM and 2:00

PM of local time. All TROPOMI data were downloaded as Level 2 Products. They were binned by latitude/longitude using "bin_spatial" procedure (available within "harpconvert" utility) to the grid of 0.05°×0.05° of latitude vs. longitude. Data filtering for the removal of statistically unreliable data was made with a quality assurance index exceeding 0.5.

The directions of CO and NO_2 distribution from the active fires applied using joint analysis with data from Visible Infrared Imaging Radiometer Suite (VIIRS) and Moderate Resolution Imaging Spectroradiometer (MODIS). Geospatial data about large heat releases (from 1 to 200 MWt) were downloaded from the Fire Information for Resource Management System (Internet 3). Despite fires localizations, there is information for visible spectrum allowing to analyze the direction of smoke distribution. It was used for controlling CO and NO_2 advection. Because of Ukraine's location in moderate latitudes, geographical coordinates were converted from grids to the coordinate system in equidistant conic projection with further polynomial interpolation.

Advection of polluted air masses was analyzed using the web-based HYSPLIT model (Internet 2; Rolph et al, 2017; Stein et al, 2015). It used the ensembles of forward trajectories for wildfires episodes and ensemble of backward trajectories for the dust storm case during the 16th of April 2020. Meteorological input was selected from the archive of Global Forecast System (GFS) data with the spatial resolution 0.25° of latitude vs. longitude. Comparison of HYSPLIT wind and relative humidity output with in-situ measurements implemented using radio-soundings data on the Kyiv station for 00 UTC (16 and 17 April) available at Wyoming University (Internet 4) databases.

Ground-based CO data obtained from the national air pollution measurement network (Central Geophysical Observatory named by Boris Sreznevsky). Overall, 100 stations in 30 cities (Figure 1) were involved in in-situ data analysis and intercomparison with the Sentinel-5P data. The closest stations to wildfires were located 85–100 km away in Chernigiv and Kyiv. Both cities have numerous local sources of anthropogenic emissions, therefore were highly influenced by them during the wildfire event. All stations in Ukraine are equipped with sensors from national production. There are no measurements of PM, VOC, BC, CO_2 at the Ukrainian national air quality network, hence, the analysis of wildfire pollution could be made using only NO_2 and CO data. Because of the short lifetime of NO_2 in the atmosphere and the distance to the closest stations, CO is the most appropriate pollutant for the study.

Analysis of ground-based data was made considering the national air quality standards: for CO, the daily average threshold value is 3.0 mg/m³, for NO2 – 0.04 mg/m³. Satellite data cannot be recalculated to ground-based values. However, some approximations could be done for the analysis of pollutants' content over wildfires. Let us suppose the pollutant distributes

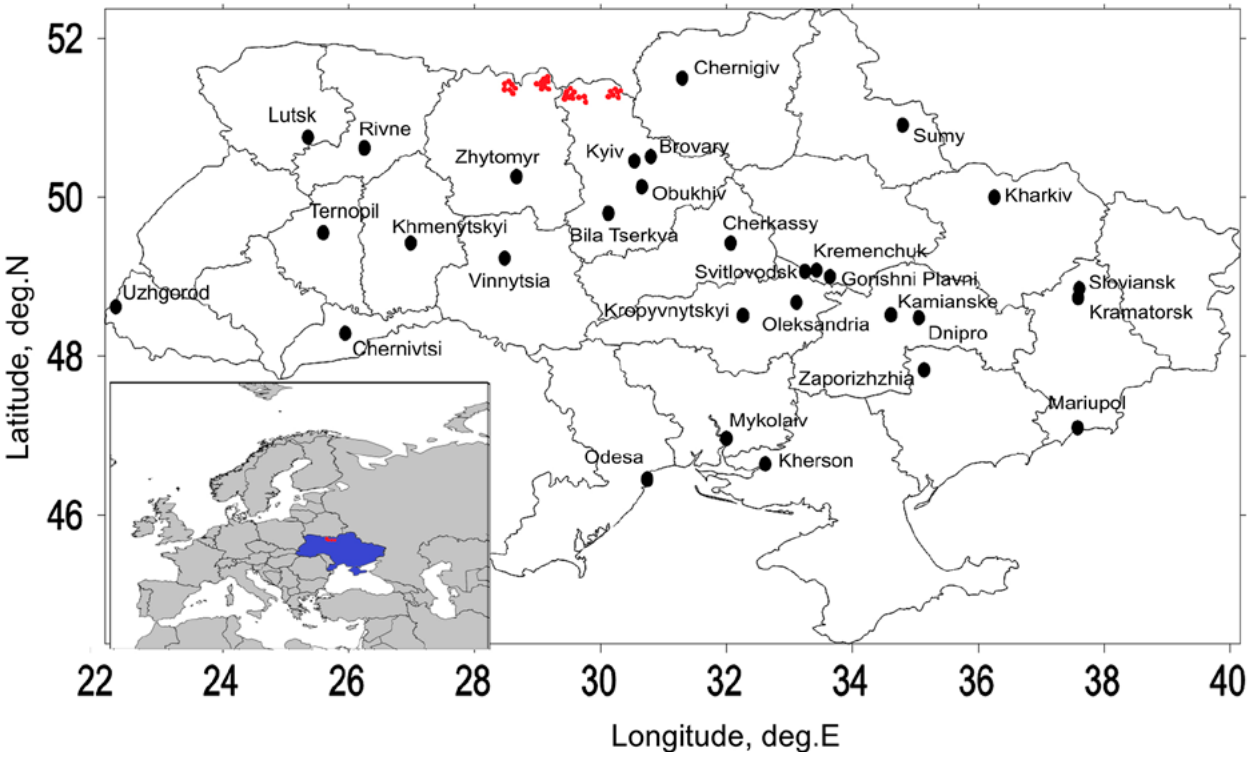

Figure 1. Cities with ground-based measurements (black dots) and locations of main wildfires that affected air quality the most (red dots)

in the lower 200 meters layer (H) over wildfire and its concentrations (C) are equally distributed through the layer H. Therefore, the approximate near-ground value in [mg/m3] is:

$$C = \frac{C_{col}}{H} \cdot M \cdot A$$

where C_{col} – pollutant column content [mol/m²], M – molar mass [g/mol], A – constant that equals 1000 – for conversion from [g/m³] to [mg/m³]. H is expressed in [m]. According to our assumptions, near-ground values could reach dangerous for human health air quality levels (according to the national threshold standard) if column number density reaches 200 mmol/m² for CO and 130 μmol/m² for NO_2.

Results

Wildfire episodes and air quality changes

The wildfire event in April 2020 in the northern part of Ukraine could be divided into two main episodes: 4–14 April and 15–21 April. During the first episode, wildfire emissions spread from two large burning areas of the north of the Kyiv oblast (region). One burning area located near Krasiatychi on the north-west, another one – in the Chornobyl Exclusion Zone. The second period corresponded to the wildfires in the north of the Zhytomyr oblast (region) with the most severe fires near the border of the Kyiv oblast.

Background values of CO column number density were 30 mmol/m² that accidentally increased to 40–50 mmol/m² after the largest wildfire emissions. Local CO maximums which were observed in the first days of April did not correspond to the wildfires and appeared over the territories with intense agricultural burning. Emission of burning products from the fields caused CO content, increasing up to 70–90 mmol/m². During 1–4 April, CO column number density over agricultural lands was 1.5 times higher than over wildfires and 2–2.5 times higher than background values. Nevertheless, recalculation to ground-based values did not show dangerous levels of CO for human health. NO_2 column number density varied within 30–70 μmol/m² with higher content over big cities and industrial zones, reaching 120 μmol/m² that approximately was close to threshold limits after approximate recalculation to ground-based values. NO² maximums with the values of 350–1500 μmol/m² observed over wildfires, however, at the distances of about 30–50 km away from burning areas, NO² column number density was close to the levels over industrial regions (Figure 2). These concentrations were 3–10 times higher than threshold values.

Severe wildfires and huge pollutants' emission occurred on the 6th of April. It caused CO column number density to increase to 100–190 mmol/m² (Figure 3) and exceed 250 mmol/m² during 12–13 April. These CO values have exceeded 200 mmol/m² which we assume equals the national standard threshold value for CO. Before the 7th of April, deterioration of air quality observed near the territories of active fires in the Chornobyl Exclusion Zone. Further emissions caused CO spreading far from the burning areas, influencing air quality in highly populated regions. NO_2 emissions during 6–14 April affected insignificantly cities located at distances more than 50 km away from the wildfires. Moreover, during one of the biggest wildfire emissions on the 12th of April, there were detected extremely high NO_2 maximum over Kyiv (of about 200 μmol/m²) of local anthropogenic origin. That day, the NO_2 column number density was 3 times higher than over adjacent territories. It had happened af-

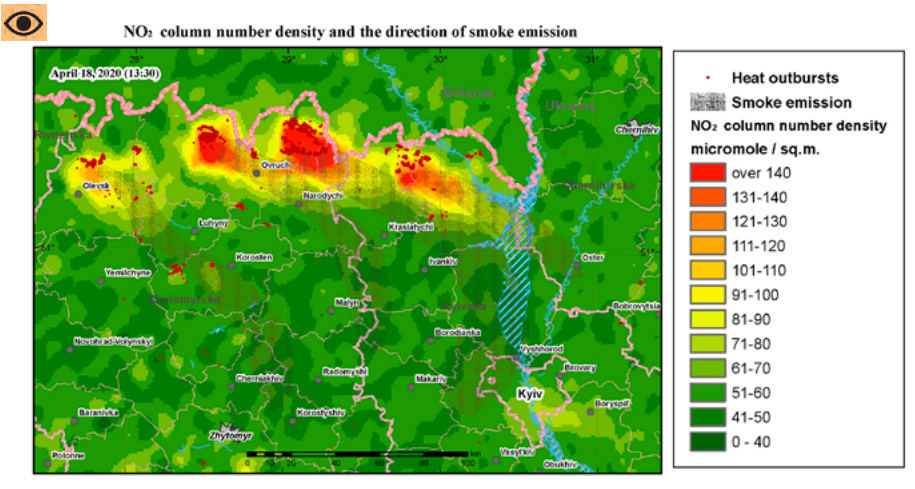

Figure 2. Spatial distribution of NO_2 column number density on 18 April 2020

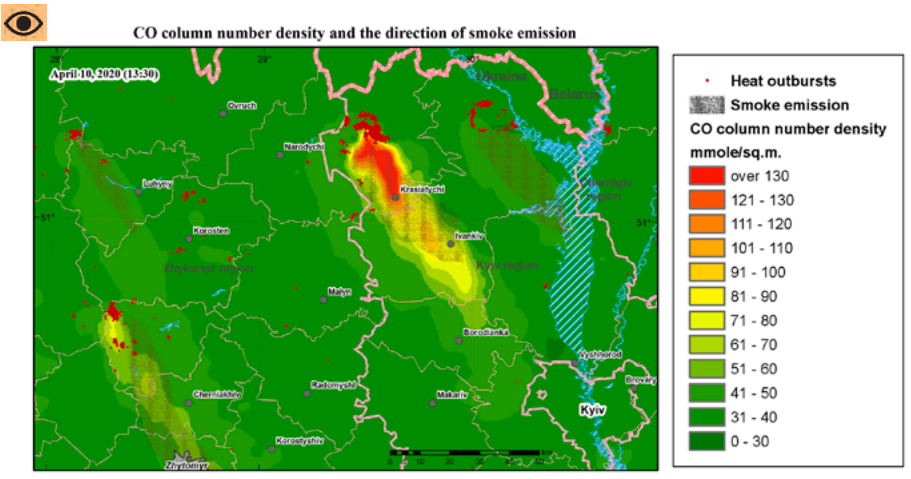

Figure 3. Spatial distribution of CO column number density on 10 April 2020

ter a previous 2-day wind blowing from the Chornobyl Exclusion Zone towards Kyiv as seen from Figure 3. Even though the wind had already changed direction and air quality had deteriorated after local emissions, it caused a great concern of local citizens, who did not believe authorities about real air quality levels and blamed for ineffective actions towards extinguishing wildfires.

Using the HYSPLIT model, the trajectories of burning products spreading were calculated (Appendix A). Joint analysis with TROPOMI data allowed finding territories affected by elevated pollution levels. Trajectories were calculated from the largest active fires starting from 00 UTC. Each point on trajectories shown on the maps in Appendix A represents the air mass location 1hour after the previous one.

During the first episode from the 4th to 14th of April 2020, only 4 days were characterized by wildfire emissions spreading out from the Chornobyl Exclusion Zone (Appendix A). During the 8th of April, west wind caused a burning products distribution towards the north-eastern part of Ukraine. The Belarusian territories were affected by elevated pollution levels on the 9th of April and the whole Kyiv oblast (region) during 10–11 April. These events resulted in 1.5–2 times CO increase over background values reaching 80 mmol/m². During the 12th of April, wildfire emissions from the areas near Krasiatychi distributed to Belarus, whereas burning products from fires in the Chornobyl Exclusion Zone – to the north-eastern part of Ukraine.

The first episode of the wildfire event ended on the 14th of April after precipitation that helped firefighters to extinguish the open fires. During the second episode of the wildfires with the largest ones in the north of the Zhytomyr oblast (region), huge emissions occurred after strong west wind on the territory of Ukraine. Maximum values of CO column number density reached 190 mmol/m². During 16–19 April, polluted air masses spread to the east through the south-east with CO content of 80–110 mmol/m² at the distances of about 260–300 km from active fires (Figure 4). NO_2 column number density was high near active fires reaching 1300 μmol/m² which was about 10

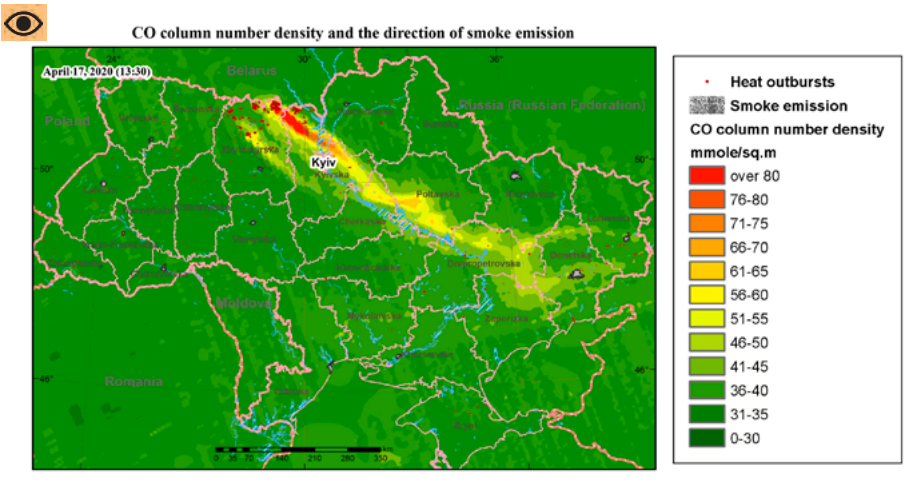

Figure 4. Spatial distribution of CO column number density on 17 April 2020

times higher than approximate recalculation to near-ground threshold values. Local maximums also were observed over big cities and industrial regions with values of about 200 μmol/m².

The maps from Appendix B clearly show that burning products have spread at large distances due to strong winds. On the 16th of April, it took about 6 hours for air masses to pass 400 km. Wind speed gradually decreased during 17–19 April, and these days it took 12 hours for burning products to spread over 450 km, 350 km, and 250 km, respectively.

Most wildfires were extinguishing after the 20th of April, and CO content rapidly decreased to values lower than 70 mmol/m². The background CO values were between 40 and 50 mmol/m².

In-situ carbon monoxide variability

Ground-based CO data weren't as sensitive to the wildfire emissions as CO total column changes derived from Sentinel-5P. Despite air quality was getting worse, and the stable smell of burning products was in the atmosphere, monitoring stations in most cities showed only a slight CO increase during the periods of active spreading toward cities (Figure 5). The overwhelming majority of stations are located close to huge anthropogenic sources, and there are no background stations in Ukraine. Thus, CO variability mainly showed usual behavior that is typical for anthropogenically loaded places. As was mentioned above, NO_2 concentrations significantly increased over the regions with active fires. Therefore, analysis of NO_2 changes in cities does not make sense because the concentrations' maximums represent only local anthropogenic emissions. Some impacts might have the altitudes of pollutants' distribution. Usually, vertical motion was observed, and concentrations ascended above the heights where ground-based sensors were located. However, the stations' location from the available ground-based network was unable to properly indicate air quality worsening in cities during the wildfire event.

There are three regions in Ukraine where the fingerprint of the wildfire emissions could be seen at the lowest atmospheric layer in cities. The closest territories in the northern part of Ukraine (represented by Kyiv in Figure 5), the central part (e.g. Zaporizhzhia), and the eastern – north-eastern regions (e.g. Kharkiv). The orange-colored background on the plots from Figure 5 corresponds to CO values that exceed the threshold according to the national standard (3 mg/m³ for average values).

Cities in the north of Ukraine were affected mostly by the burning products spread during 10–11 April and 17–19 April. CO concentrations during these episodes were approximately 10–20% higher. However,

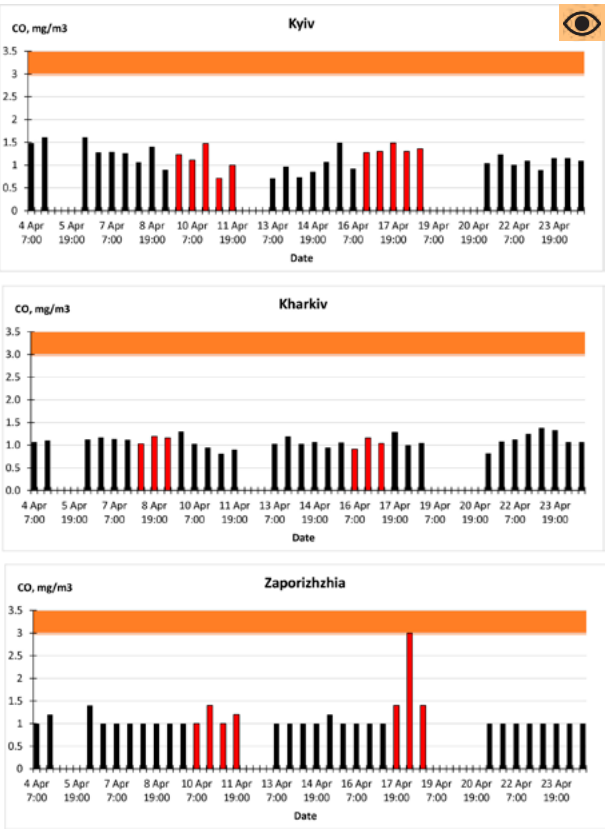

Figure 5. Temporal variability of ground-based CO (mg/m³) measurements. Red columns represent measurements during the periods of burning products spreading over cities. Orange background indicates threshold CO values according to the national regulations

maximums observed after local anthropogenic emissions within cities (e.g. the 8th and 15th of April as seen in Kyiv) and after open burning episodes during the first days of April (e.g. 4–6 April).

Cities in the north-eastern and eastern parts of Ukraine were affected mostly on the 8th of April and during 16–17 April (see Kharkiv in Figure 5). In both cases, maximum values were detected 12–24 hours after polluted air masses reached the territories. The possible explanation could be CO descent to the surface layer after it spread to the region at higher altitudes. However, the differences between observed values were less than 10%.

The central part of Ukraine was the only region where ground-based stations detected wildfires emissions in cities rather well (see Zaporizhzhia in Figure 5). During the second episode of the wildfire, polluted air masses appeared during 17–19 April and resulted in the in-situ CO concentrations leaping to 200–250% in comparison to average content.

The April 2020 wildfire event showed the main problem of the available ground-based network that did not indicate background, especially during pollutants' emission in remote regions. Appropriate analysis of health risks cannot be done only by using in-situ

data. Usage of satellite data must give necessary information for decision-making in Ukraine during the possible future wildfire events and their negative impact on air quality.

Relation between satellite and ground-based data

Intercomparison of satellite and ground-based CO data is a complex task for the Ukrainian network. The main problem is a 6-hour difference between Sentinel-5P sensing (approximately 1:00–2:00 PM of local summertime) and CO in-situ measurements (7:00 AM and 7:00 PM). Hence, no direct intercomparison is possible. Historically, the network was established near powerful emission sources in cities: thermal power plants, factories, busy roads, etc. As a result, CO measurements largely showed huge anthropogenic emissions and there are only a few stations that could be considered as urban background. This fact negatively impacts the signal/noise ratio during the analysis of the wildfires' fingerprint in the CO time series. Moreover, approximately half of the stations measure CO with an accuracy of 0.1 mg/m³, while others – 1 mg/m³. Therefore, many values are too rough for precise analysis.

All mentioned problems influenced CO data intercomparison; and, as expected, the correlation between satellite and ground-based data was insignificant (lower than r=0.15). However, CO at some stations rather well coincided with TROPOMI data. First of all, the 7:00 AM data were better comparable than the 7:00 PM ones, reaching a statistically significant correlation on 36 out of 96 stations located in 25 cities. The highest values (r=0.70-0.82) were in Gorishni Plavni and Zaporizhzhia (the central part of Ukraine), where a large number of stationary CO emission sources are located. In both cities, the maximum values were detected during 17–18 April, when wildfire emissions spread from the northern part of Ukraine. During this episode, CO column number density reached 60 mmol/m² and 40 mmol/m² over Gorishni Plavni and Zaporizhzhia, respectively. CO near-ground concentrations were 3-5 times higher than average values: 1 mg/m³ and 3 mg/m³, respectively.

High correlation up to r=0.70 was also on the stations in the western part of Ukraine, e.g., in Ternopil, Khmelnytskyi, etc. These cities weren't affected by wildfire emissions. In general, TROPOMI data better represented pollution over the cities, which were episodically affected by short-term wildfire emissions spreading. The closer the city to active fires and the more frequent CO advection observed, the worse correlation with satellite data was. Nevertheless, the episodes of the most severe elevated pollution levels at the surface layer coincide with satellite data.

Despite rather low coincidence between single CO values, the analysis of grouped data showed significant linear dependence (Figure 6).

If in-situ CO values are within 0-1 mg/m³ interval, the average CO column number density does not exceed 40 mmol/m². According to the found relation, every 2 mg/m3 in the surface layer represented the average CO column number density increase by 1 mmol/m². On the one hand, Figure 6 represents a clear relation between satellite and ground-based data. On the other hand, changes in average values corresponding to particular gradation are too low. As a result, it is difficult to create a reliable analytical solution for the combination of Sentinel-5P and in-situ CO measurements from the Ukrainian network. Results of intercomparison might be used for future ground-based network optimization.

Dust storm during 16 April and corresponding changes

On the 16th of April, strong winds formed the dust storm which passed the northern part of Ukraine. Despite the end of the first wildfire episode, air quality in Ukraine was significantly affected by aerosol spreading. Dust storm occurred in the daytime and preceded the second wildfire episode that started later in the evening. Sentinel-5P sensing at 1000–1030 UTC caught the dust storm at the moment it passed Zhy-

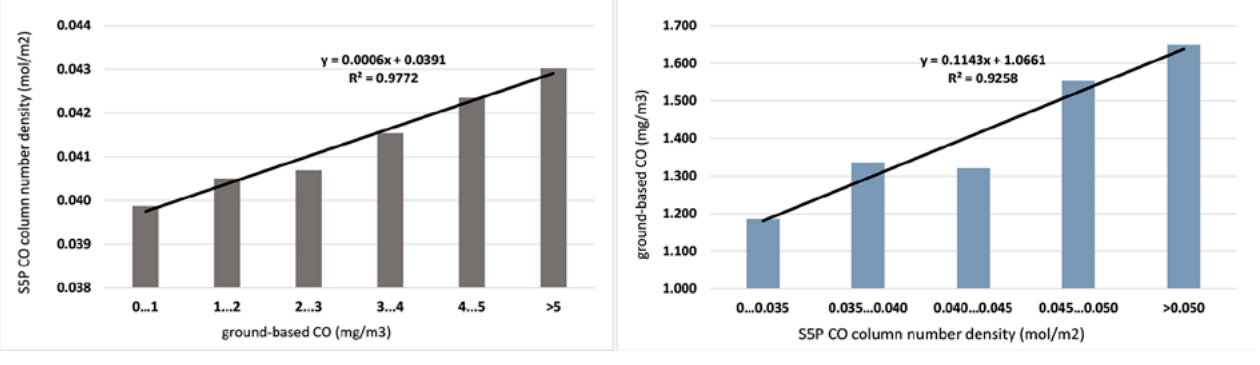

Figure 6. Dependencies between ground-based CO (mg/m³) measurements and TROPOMI CO column number density (mol/m²) data

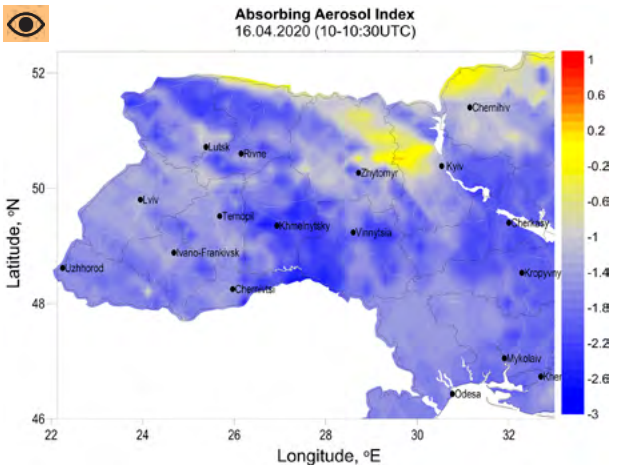

Figure 7. Spatial distribution of AAI during the dust storm on 16 April 2020

tomyr and before reaching Kyiv as shown in Figure 7. AAI over the area affected by the dust storm reached 0.8–1, while adjacent territories were characterized by negative values.

Based on HYSPLIT backward trajectories (Figure 8), there were analyzed the territories in which air mass passed before the moment of Sentinel-5P sensing. During the dust storm, there was a persistent smell of burning products in the atmosphere, but the air masses did not pass any territories with active fires. From March through the beginning of April, agricultural open burning was widespread on the territories the air masses passed. Considering these facts, the burning products probably were raised from the ground and were not connected with the wildfire event described in this study.

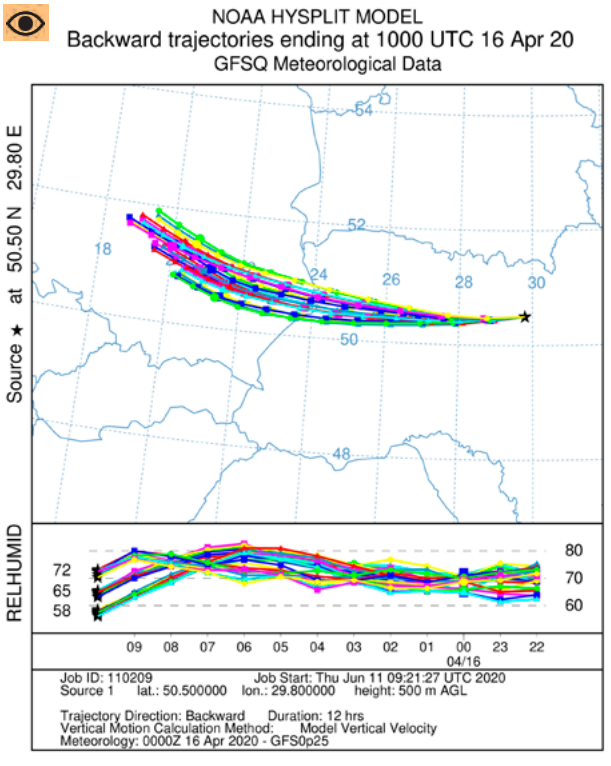

Figure 8. Ensemble of backward trajectories based on the HYSPLIT model and relative humidity distribution on the way of the dust storm

Air masses, which caused the dust storm, penetrated the Ukrainian territory approximately at 03–04 UTC and it takes about 6–7 hours to pass 400 km before the Sentinel-5P measured elevated aerosol content (approximately at 1000–1030 UTC). Based on the HYSPLIT model results, the wind speed was about 15 m/s at the height of 500 m above the surface. If we take a look at radio-soundings data available for 00 UTC on the 16th and 17th of April (Figure 9), we could see similar values. At the near-surface layer, the wind speed was about 4 m/s, gradually increasing up to 12 m/s at 500 m above the surface. At the height of more than 1200 m, there were observed significant differences in wind speed before and after the dust storm. The wind speed difference between two neighbor observations reached 8 m/s at 2000 m above the surface (an increase from 16 to 24 m/s). Taking into account the values and constantly increasing strong wind during the 16th of April, the reasons for dust storm formation under the long period of dry atmospheric conditions in Ukraine become clear.

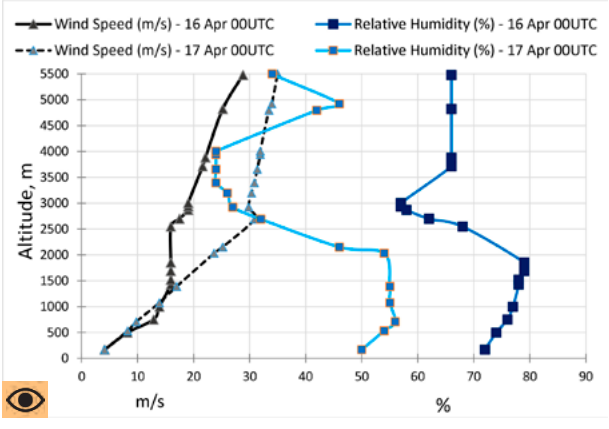

Figure 9. Vertical distribution of wind speed and relative humidity on the Kyiv station before and after the dust storm

Relative humidity on the way of the air masses which caused the dust storm varied from 58% to 80% (Figure 8). However, the difference in water vapor content is well seen on radio-soundings data. At 00 UTC on the 16th of April, before the dust storm occurred, relative humidity was about 65–80% at the lowest 2000 m layer. After the advection of new air masses, relative humidity decreased by 20–40% depending on the height. At 00 UTC on the 17th of April, the highest ever observed value in the vertical profile of relative humidity was 58% (approximately 600 m above the surface). Such unfavorable conditions were also one of the causes of the dust storm.

Discussion

The study showed an accurate scenario of atmospheric air pollution as a result of the wildfire event. Data derived from Sentinel-5P had been used for decision-making of the State Emergency Service of Ukraine in April 2020. The study also gives the evidence of possibility for wildfire emissions tracking using satellite measurements that have been previously mentioned in different studies (Abida et al., 2017; Edwards et al., 2006; Sundström et al., 2020). Nevertheless, some disadvantages appear when hourly data is needed. In this case, satellites cannot satisfy and provide a continuous picture of pollutants changes. Atmospheric and chemistry modeling significantly improves results (Konovalov et al., 2011). Hence, it is better to use modeling for different vertical levels in the future.

After a comparison with ground-based data from the national air quality monitoring network, some uncertainties were found. These uncertainties have appeared because of a bit outdated stations which are located close to the main anthropogenic sources (there are no background stations). Overall, TROPOMI data achieves better accuracy in comparison to previous satellite missions (Cooper et al., 2020; Yurganov et al., 2011). All these results prove the opportunity to use Sentinel-5P for air quality monitoring, including wildfire events. NO2 total column data were found to be biased between 20-30% (Verhoelst et al., 2020). CO field comparison with the ECMWF assimilation system showed a 3.2 ± 5.5% mean difference (Borsdorff et al., 2018b). TROPOMI total columns underestimate ground-based observations but slightly overestimate small total column values (Ialongo et al., 2020). We found dependencies for CO column number density only between certain groups of values.

A comparison of satellite and ground-based data in our study showed better coincidence for CO column number density. It happened due to a longer CO lifetime in the atmosphere, therefore, it was detected far away from the active fires. Usually, CO exists for more than 10 days in the atmosphere (Adams et al., 2019; Whitburn et al., 2015). Approximate recalculation of Sentinel-5P data to near-ground values was well-compatible with a wildfire episode in 2010 (Konovalov et al., 2011). We calculated that CO was higher than 5 mg/m^3, whereas over the Moscow region in 2010, it increased up to 10 mg/m^3 (Konovalov et al., 2011).

The wildfire event in April 2020 has revealed a number of problems of the national monitoring network that significantly complicates adequate society warning. Firstly, the location of stations in cities near sources of strong anthropogenic emissions makes it difficult to define real consequences for air quality. Secondly, CO is measured only at 7:00 AM and 7:00 PM (local time), which makes a direct comparison with Sentinel-5P data available approximately at 1:00 PM (local time) impossible. Thirdly, a poor set of species that are measured at monitoring sites provides only CO and NO_2 data for wildfire emissions monitoring. The solution divides into two directions: the establishment of background stations and improvement of sensors which must measure at least PM and O_3 providing air quality data more frequently than 2-4 times per day.

Forward and backward trajectories derived from the HYSPLIT model partially fill the gap in observations and allow defining the areas affected by pollution distribution. Recently, HYSPLIT has already been used for the analysis of wildfires (Chai et al., 2020; Kim et al., 2020; Li et al., 2020) and dust storm episodes (Kalkstein et al., 2020).

AAI is commonly used to identify dust storms, including its early warning (UNEP, 2013) and identification of the sources (Broomandi et al., 2017). The current study also contains results of AAI satellite data usage for the operational purpose in Ukraine. On the 16th of April 2020, the dust storm was caught by Sentinel-5P over Ukraine. It had happened a few hours before the dust covered Kyiv, the capital of Ukraine. Using satellite near real-time data, the State Emergency Service of Ukraine was informed about the oncoming dust storm.

Conclusions

During the April 2020 wildfire event, different Ukrainian territories were affected several times by elevated pollution levels. The wildfire occurred in the north of Ukraine and consisted of two main episodes: 4–14 April and 16–21 April. CO column number density reached 250 mmol/m^2 near active fires during the first episode; however, 50 km away from the fires, CO content was 2-3 times lower. NO_2 column number density reached 1300 μmol/m^2, and concentrations sufficiently decreased at the same distance being close to typical values over urban areas. During the second episode, wildfire emissions were lower, however, polluted air masses spread for more than 300 km away from active fires due to unfavorable weather conditions with strong unidirectional wind.

Ground-based air pollution measurements insufficiently indicated wildfire episodes, despite the persistent smell of burning products in the air. It is connected with the stations' locations close to huge anthropogenic sources that weren't so sensitive to remote wildfire emissions. There were identified regions where in-situ measurements identified the fingerprint of wildfires: the northern, north-eastern, and central parts of Ukraine.

Intercomparison of TROPOMI CO column number density and ground-based concentrations mainly showed bad results due to a 6-hour difference between Sentinel-5P sensing (10:00 AM UTC) and in-situ measurements. Thus, a statistically significant correlation with 04 UTC ground-based data was found. The highest correlation up to r=0.70 was found with stations that weren't affected by wildfire emissions. In general, the closer the city is located to active fires and the more often polluted air masses are emitted, the worse correlation is found.

During the 16th of April, the dust storm affected air quality in the north of Ukraine. It was visible by Sentinel-5P via AAI distribution. The main reasons for this dust storm formation were high wind speed and low humidity with the values of 50–60% in the surface layer.

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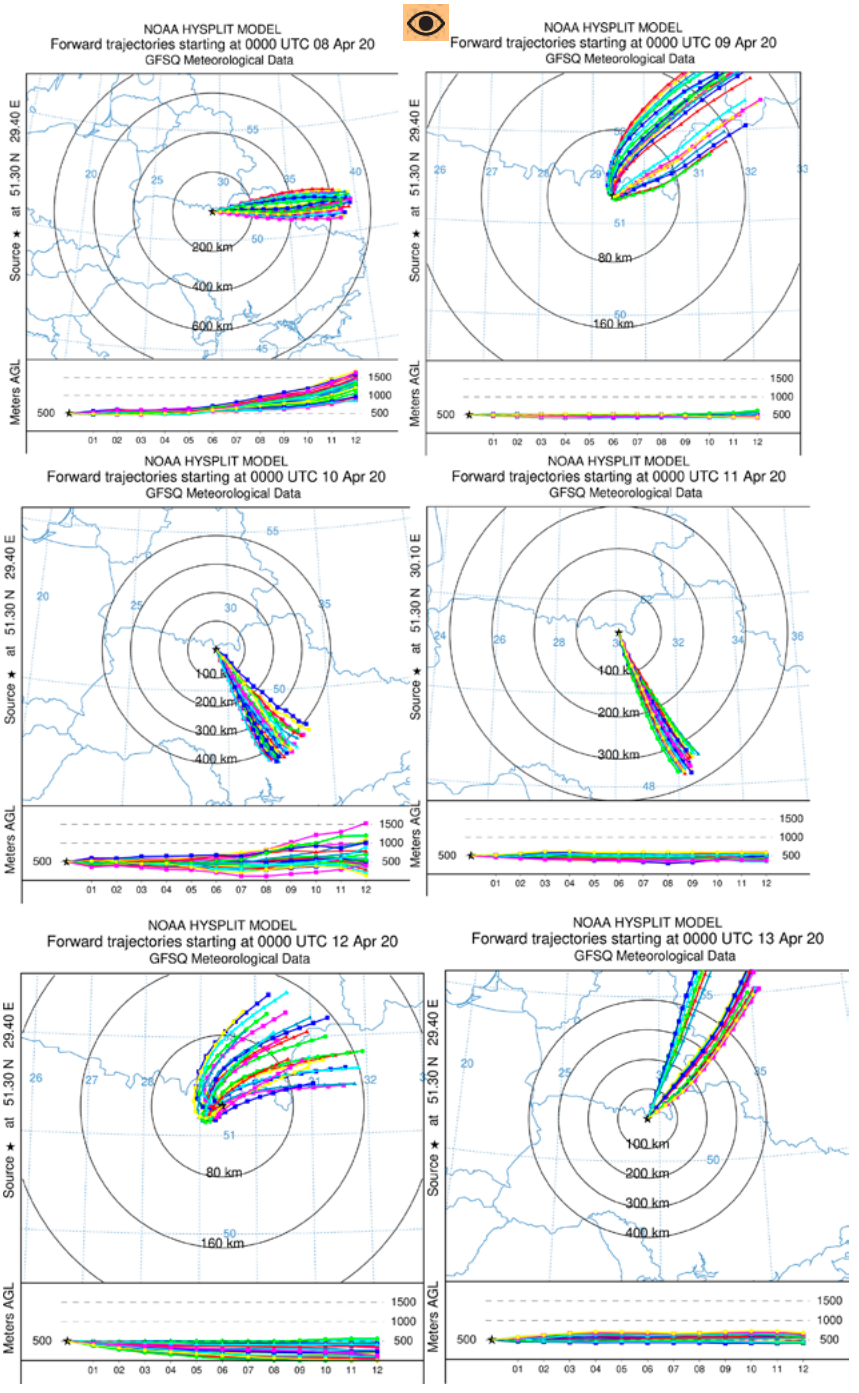
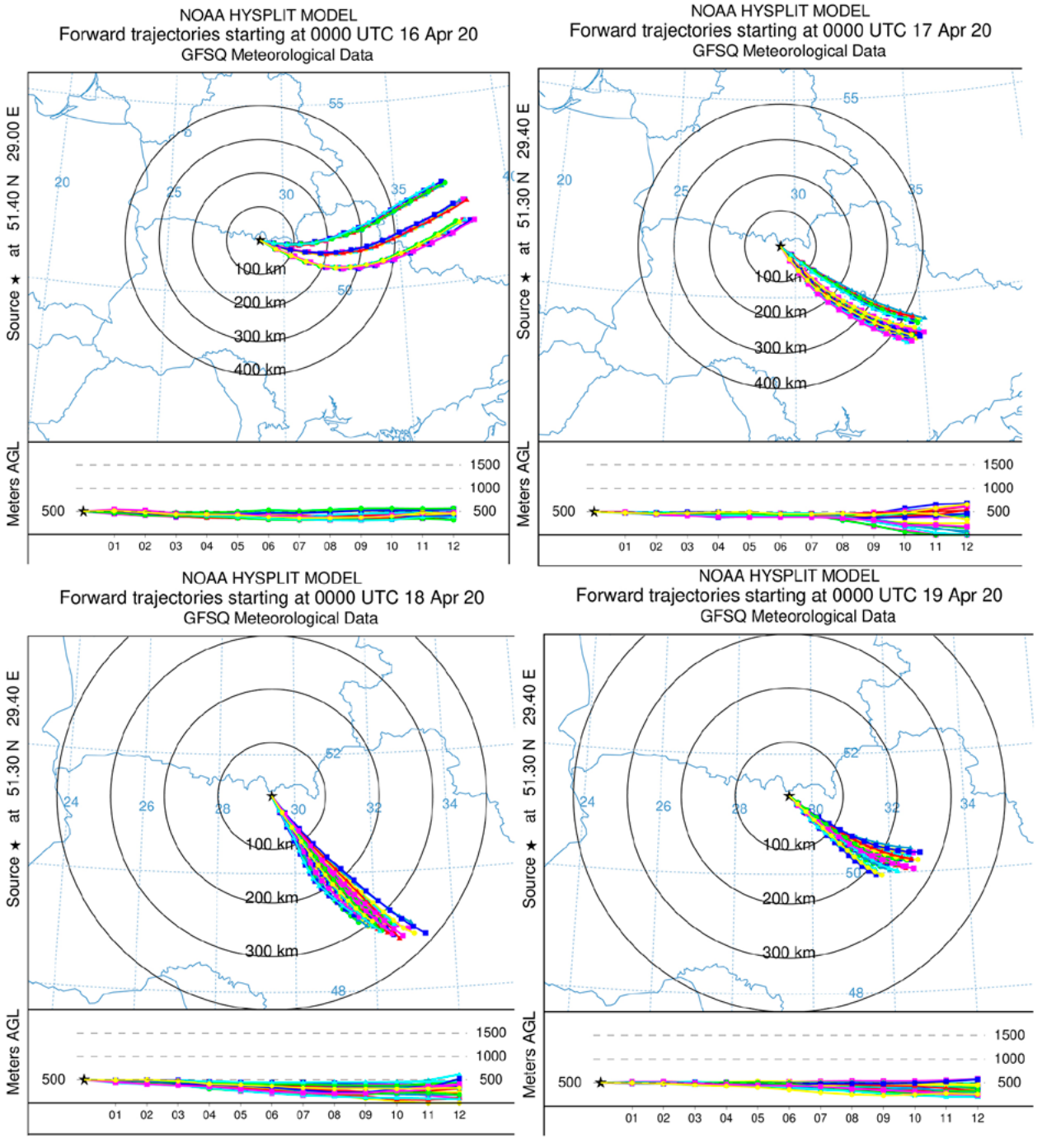
Appendix A

Directions of burning products transportation from active fires during 8–13 April based on HYSPLIT ensemble trajectories



Appendix B

Directions of burning products transportation from active fires during 16–19 April based on HYSPLIT ensemble trajectories



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The use of Geocoding for Home Healthcare Application and Management an Epidemic Situation. Case of COVID-19 Virus Outbreak

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Abstract

The lack of an addressing system is one of the problems of urban management in Algeria, which makes it hard to find the addresses concerned, especially in case of crisis where the decision-makers need accurate data in real-time. Like many countries, Algeria follows up the world health organization guidelines that declared the COVID-19 virus as pandemic and recommended the full quarantine and reduces the social contact as much as possible; however, these procedures weren't enough to control the increasing number of confirmed cases, which exceeded the hospital's capacities. To face up the outbreak of this pandemic, the Algerian health professionals decided to treat most coronavirus cases at home. This study aims to use a geocoding tool developed in C# programming language and ArcGIS Software Development Kit (SDK) to help in the epidemiological control operation in Ain Touta city and simplifies the interventions using a spatial approach. These problems are addressed by a tool to collect, analyze, store, and process archiving of the geographic data using a geodatabase server.

Keywords: Geocoding; COVID-19; quarantine; address; home healthcare

Introduction

The Algerian cities are mosaics with random and uncontrolled urban evolution for many reasons (economics, politics, security, historic…etc.), so the territory control and data flow such as the addresses is difficult to handle due lack of accurate information, the local government of many cities finds problems to implement coherent management, weaknesses of the territory control, and the lack of coordination (Akakba & Filali 2017).

By March 2020, Algeria was detected the first confirmed COVID-19 case, after few days the government announces the province of Blida under full quarantine for 24/24 hours and 7/7 days and till now (by 24th July 2020) over 80% of the country under the health quarantine. After the outbreak of the COVID-19 virus in Ain Touta and recording more than 200 confirmed cases, the local hospital reaches its maximum capacity (50 beds). This epidemiological situation in Ain Touta forced the decision-makers to choose the home healthcare for stable Coronavirus cases where the control of their health condition is done by sending the medical staff to houses for monitoring the health condition of the patients.

Our paper suggests using a graphical user interface (GUI) tool programmed on the C# programming language and ArcGIS SDK to use the geocoding technology, and take the advantages of the addresses to simplify the home healthcare, at the same time limiting the spread of the epidemic by applying the social isolation principle.

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Literature review

The process to convert addresses into geographic locations is known as geocoding, which is a basic operation in geographic information systems (GIS) (Longley et al. 2005), it's widely using in space management (Davis & Fonseca, 2007; Edwards et al., 2014; Zandbergen, 2014), healthcare and epidemiologic (Krieger et al., 2002; Mazumdar et al., 2008; Oliver et al., 2005), even in civil security (Ratcliffe 2004).

Today, the Internet is affecting GIS in three major areas: access to GIS data is now simpler than before, spatial information dissemination, and GIS modeling/processing. It provides GIS users easy access to GIS data from different data sources and improve data "infrastructure" for providing a basis for valid GIS studies (Yang et al., 2004), because of GIS servers available on the internet such as GeoServer, MapServer, Mapnik, MapGuide, QGIS server, etc.

Online geocoding become a good example of this development and increase its functionality to the Internet users (Roongpiboonsopit & Karimi 2010). all these servers are open source servers i.e. freely available. ArcGIS also provides server but it is not available for free, but with many extra on features. The most used services are Google maps and OpenStreetMap but there is a difference in their quality (Präger et al., 2019).

Geocoding is available to implement in three addresses models: as a points, parcels, and as a street networks models; but the geocoding quality have been compared each other in many studies such (Zandbergen, 2014) who compares the previous address data models and find that out of 163,886 original samples of addresses, 36% weren't used in the final analysis because they could not be reliably geocoded using either street or parcel geocoding. Also, according to (Zandbergen, 2007) that used geocoding to detect quality on environmental exposure assessment of children living near high traffic roads (measure pollution on individual address, the result is very accurate) conclude that "Results of the case-study presented here strongly suggest that typical street geocoding is insufficient for fine-scale analysis and more accurate alternatives need to be considered".

There are many potential problems with street geocoding, which have been well described by (Ratcliffe, 2001; Ward et al., 2005; Whitsel et al., 2004; 2006), several studies (Bonner et al., 2003; Cayo & Talbot, 2003; Dearwent et al., 2001; Karimi et al., 2004) have determined to quantitative estimates of the positional accuracy of street geocoding by comparing the street geocoded locations with the 'true' location based on taking field measurements using a Global Positioning Systems (GPS) unit, The results in urban areas are generally more accurate than in rural areas. This suggests that the positional error of street geocoding can be substantial and needs to be characterized in a meaningful manner relevant to the use of the geocoded locations.

Study area

The city of Ain Touta is located at the intersection between several important roads, particularly National Road number 03 (RN03), connecting Constantine and Biskra, National Road number 28 (RN28) who linking M'sila and Batna city, as well as the Constantine-Biskra railway line. It's the third most populated city in the province with more than 100000 inhabitants in the city.

Ain Touta is at 450 km in the South-East of the Algiers capital, between 6° 7'to 6°13' east longitude and 35°34' to 35°31 north latitude, it's located between two mountain ranges with an altitude ranging between 900 and 950 meters.

Ain Touta has one hospital with a capacity of only 50 beds to serve about 100,000 people, as a result, the local health sector of the city suffers from high pressure, which is negatively affecting the quality of the health service, in addition to the spread of the Coronavirus, that threatens the global health system, not to mention the local ones.

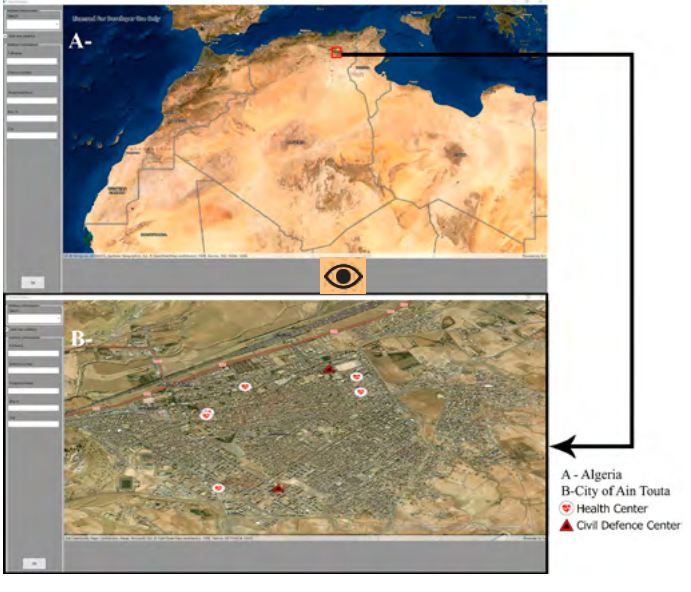

Figure 1. Geographic location of the study area and the user interface of the tool

The current outbreak caused pressure on local governments, as a result the health infrastructures become unable to take care all coronavirus cases, since the first case recorded in the city on June 1, 2020, raising the number on June 14 to 11 cases, and by the end of the month of June, hundreds of cases recorded. And hundreds of unconfirmed cases.

By 20 June the local hospital reaches its maximum capacity and the local health department proposed the "Home healthcare" for Coronavirus cases, and the medical staff check the patients periodically at home.

To handle the home healthcare management, we propose to create a geographic database to store attributes of every confirmed case and managed by an application that using the geocoding technic.

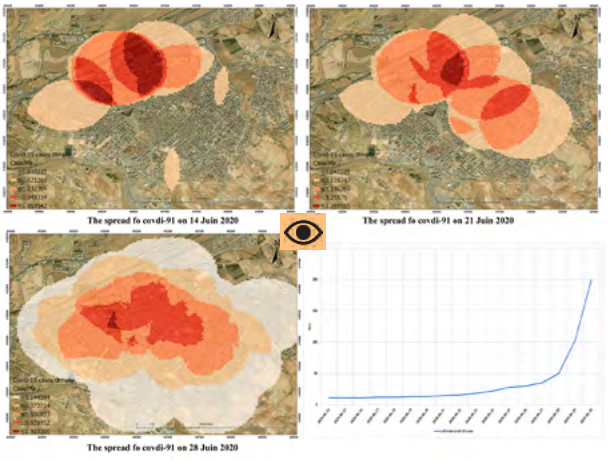

Figure 2. Spread of covid-19 between 1 June – 1 July 2020 in Ain Touta

Address data modelling

There are many challenges to building a good reference data (Arctur & Zeiler, 2004; Yang et al., 2004), and technically the addresses can be associated with many kinds of feature classes in a reference database; for example, road centerlines, parcel boundaries, address points, building structures (Zandbergen, 2007). We can organize geocoding model into four different models as follow: the geographic model, street network model, parcel data model, and address point model

The geographic unit model can consist of postal codes (such as ZIP codes in the United States), counties, cities, census enumeration areas, or any other geographic boundary considered meaningful. In the geocoding process, the location assigned to a particular address is the polygon (or the polygon centroid) representing the geographic unit. Location within the unit is not specified, but analyses can be carried out using data associated with the geographic unit. In the case of our study area the geographic unit address is refereeing to the administrative boundary and to the neighborhoods (represented by a polygon).

The street network model is most widely employed address data model and based on street network data. In this approach, a street network is represented as street line segments that hold street names and the range of house numbers and block numbers on each side of the street. Address geocoding is accomplished by first matching the street name, then the segment that contains the house numbers, and finally placing a point along the segment based on a linear interpolation within the range of house numbers.

The street network address model facilitates storing different names and address ranges for different sides of the street and enables validation of cases where there is no address range for one side of the street. It also supports cases where streets have multiple address ranges and names. Some additional attribute characteristics include the use of full block address ranges for major roads. While this results in a better spatial location for known valid addresses, this can also be problematic. When approximated addresses are geocoded against the centerline the records fail to match since the value does not fit into the existing range. The street address in Ain Touta is collected from OpenStreetMap server, local government department and from field.

Parcel boundaries is another address model which is traditionally the most spatially accurate data with address information available. Geocoding against parcels allows for matching against individual plots of land (or the centroids of those polygons) rather than interpolating against a street centerline. This is particularly useful in areas where parcels are not regularly addressed (such as on roads with mixed parity) or those parcels that may be quite a distance from the centerline. The parcel boundaries in our study area are not accurate due historical and planning reasons (The parcels are mostly out of control of the local government and was located far from the city at first time so they were not integrated into the official plan of the city and didn't benefit from an official addressing system till now, of course there is a new geocoding system proposed by the Algerian government to solve this situation started earlier this year 2020).

To overcome the limitations of parcels for geocoding, address points have emerged as the main address data model. The address point data model can also be constructed from several existing data layers such as parcel data. The point address model is the most accurate model because it can be constructed from several existing address data and merged into one geocoding

database, this is called the composite address. This is the preferred model to solve no-structuring address in our study, which is constructed from:

- the geographic address model that represent the administrative and neighborhoods boundaries,
- the street model that store the house number in both side if any,
- partially, the parcel model as this address model is new and not full adopted officially;

Geocoding in Algeria

Geocoding is the ability to transform the indirect spatial reference of a piece of information into a direct spatial reference, many geocoding web services have been developed to fulfill this need (Google Geocoding API, Mapzen1), public agencies or from the open-source community (OSM Nominatim3, Gisgraphy4). Geocoding in Alegria is classed on the 3rd level on the quality of the address which is the lightest-shaded countries, this level provides a fair geocoding experience. Address searches sometimes result in matches to point address and street address levels, but more often match to the street name and admin levels ("Geocode coverage—ArcGIS REST API: World Geocoding Service | ArcGIS for Developers", 2020).

To understand the address in Algeria and improve its quality, it is essential to answer the following questions:

- What are the obstacles preventing the use of Geocoding in Algeria?
- What type of model should it adopt in Algeria?
- What is the preferred model to standardize addresses in Algeria?

To answer these questions, the approach used consists of analyzing the main models of address geocoding and the possibility of composing a standard model suitable for our cities. This data contains indirect textual references about location, such as place names (toponyms) or postal addresses. To map such data, each item needs to be geocoded, i.e. assigned with coordinates through the matching of an indirect spatial reference with entities identified in a geographical data source (e.g. a map georeferenced in a well-known coordinate reference system) (Goldberg et al., 2007).

This paper aims to develop a geocoding tool to:

- Use ArcGIS SDK. Net framework to handle geocoding information.
- Create a graphic user interface (GUI) to add, edit, update, and find the address.
- A qualification of geocoding results in textual and spatial terms.
- Synchronize database between online server and offline user.
- Solve no-structuring address data and simplify manage the urban space.

Approaches

This approach is to simplify the management of the addresses geographically as follow:

- Use ArcGIS SDK and C# programming language to create a desktop user interface (UI) and assure the connection between the UI and server database.

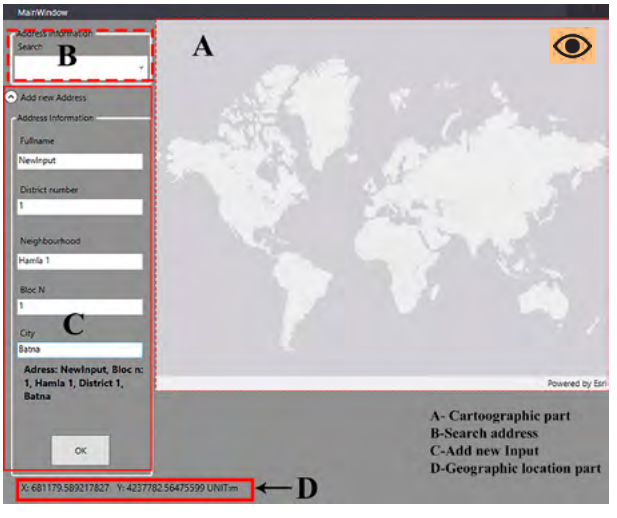

Figure 3. Different parts of the User Interfaces (UI) Tool

- Create Geo-server database: provided the requested data such as base maps.
- The desktop user interface has 4 mains parts:
  a) Geographical map that display the map and locations of addresses.
  b) Part to display related information current location, current address selected.
  c) A part that can add, modify addresses.
  d) Assure synchronize data between offline-online geodatabase.
- GeoServer: it hosts all addresses information and locations for every single address, it's stocked online to make it possible to work online or archiving, or save a copy of it offline file (.gpkg). The following figure illustrates the approach taken.

The data is directly associated with geographical coordinates with inputs, output, and algorithms as below:

- Inputs: are the addresses text information such as:12 Mustakbal street, stand, Ain Touta, Algeria) or incomplete information such (al-moujahidine,

the full name) or (rue louchen taher.) or simply refer to a landmark (theatre de Batna, radio ourass, rahba…etc).

- Outputs: are a referenced geographically dataset that select the location they are most often rendered into simple two-dimensional points associated with inputs.
- The processing algorithm: consists in finding the best-matching element from the reference dataset.

Collecting Data

The data provided in this this paper are collected from different sources and it's a personnel field survey that started from 01st June 2020 until 1st of July 2020. The exact Coronavirus confirmed number in the city and the most important the location (the addresses) of patient are officially unavailable because of the patient privacy policy.

It should be mentioned that the personal data was hidden to protect the privacy of the infected patients, but in a way that does not negatively affect the scientific value of this scientific paper.

Locator address

The locator address is generated previously using GIS software; it's a composite geocoding that merges:

- District locator address: this locator contained the district number of neighborhoods.
- Neighborhood name locator; this is simple locator created for demonstrate purpose, it contains one neighborhood, but we can include all neighborhoods in Ain Touta city.
- Bloc number: a locator represents the bloc number of every bloc.
- The city locator is to represent the city, but as mentioned before in literature review, we can use any online geocoding server to get the geographic address (state, zip, city…etc.).

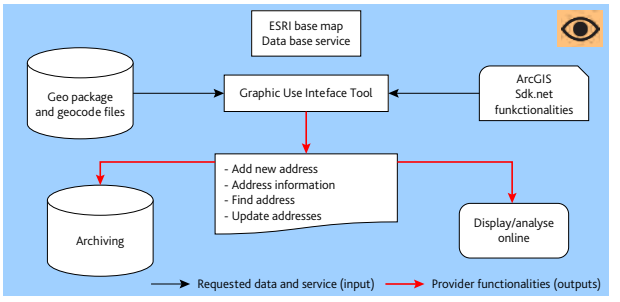

Figure 4. Model and approach

The feature to represent the address geographically is the point, according to previous cited studies, the point is the most accurate data and give us very accurate result compared to street and parcel and geographic address.

Open source file

It's possible to use traditional database file extension (*.shp, geodatabase) in the SDK, but we prefer to convert all files to an (*. gpkg) file. Because Geopackage allow the following features:

- Open source extension.
- Compatible with OGC standard.
- Broadly implemented (GDAL, QGIS, R, Python, Esri, …)
- More lightweight than a real geodatabase, but as fast as a geodatabase
- Everything is contained in a single file and easier file management with GeoPackage than with Esri Shapefile
- Faster work-flow than with Shapefiles.
- There are nearly no limitations

Resultants and discussions

The proposed tool has geographical part and descriptive part as we explain before in the approach.

The source code and functions using is explained as follow:

1. **Initiate all necessary files**
   In this initiate part (See '**Initiate database and necessary files**' section in annex), it uploads all the necessary files and databases, framework…etc. including:
   - Address Geo-package file with (*.gpkg) extension it's a free open source file that hold all attribute table.
   - The geocoding (*.loc) file: a file store offline geocoding data in case of unavailable of an online geocoding service.
   - Esri Basemaps and online resources,

2. **Add new address and save it as (*.gpkg) file.**
   In this part we create an attribute table programmatically (See '**Add new address and save it as (*.gpkg) file**' section in annex), this table contains five attributes to store necessaire address parts (admirative address, a neighborhoods name, door number, apartment number), the table also stores the full name as a string of character and every new input is assigned automatically to an ID.

Figure 5. Add new address from field

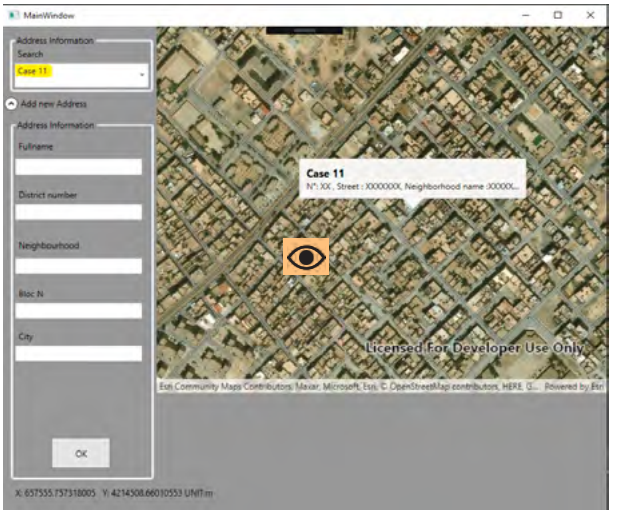

Figure 6. Find the patient by address and display information as needed

The next figure (Figure 5) shows the result of executing the previous command.

3. **Show information about selected item**
   The search process code (See **'Show information about selected item'** section in the annex) is dynamic so we can search by name or by address and the result will show: the corresponding full name, the complete address (the door number, parcel number, street name and neighborhood) , geographic location, and any other information as needed (health status, date of recovery, last medical examination…etc.), this part of the code will facilitate patient access for medical intervention, increase healthcare quality as a result of reducing pressure on the hospital, and help in epidemiological development analysis.

4. **Archiving and real-time information**
   The main purpose of this tool is to standardize addresses and in the same time help the medical stuff to work in the field using a mobile device to collect data, especially in cases like the COVID-19 pandemic, where the ability of collected data from the field and make it available to display, to make analyses…etc., is very essential for the decision-maker. This tool is hosted by a local cartographic server that created for this purpose. Also, collecting data operation is synchronized with decision-maker who controls all operations from the control center.

Conclusion

The geocoding tool is used for crisis management and detect proximal service for healthcare which is very important in the Algerian case (Lahmar et al., 2020). In this paper we try to expand the use of geocoding as an important technic in health geography, to simplify the following data through one common platform that simplifies the exchange of information and search for it in the real-time. As the main result of this paper is to use the geocoding to handle the quarantine crisis using home healthcare. Geocoding was also used to monitor the pandemic situation in Ain Touta city and help in assembling and management of the local health resources.

To achieve the goals of the research, we based on a digital approach by accomplished a geographic database that was localized in a cartographic server and exploiting by developing an interface (application) using the C# programming language to access the database in the cartographic server.

Downloading the application using smartphones and tablets which help the medical staff to work directly on the ground and make it easy to do statistics like census and update data periodically, so that every intervention in the field is recorded and stored the process on the server at the level of the crisis management center.

Among most important results are:

- Contribute significantly to the success of the quarantine and social isolation.
- Using the home healthcare improved the health system flexibility and extended its capacity from capacity 40 patients in the hospital to over 200 patients using home healthcare.
- Using objective inquiry to determine the needs of the patients.
- Determine the type of disease and medication for those with chronic diseases to benefit from periodic home healthcare.

- Using the spatial statistics to know the number and distribution of patients in each neighborhood, and to determine the geographical area of each health facility.
- Using network analysis and geocoding to determine addresses and travel paths between the health facility and patient's homes.
- Increase principle of the proximity in services so every facility assures the need of the nearest population, as a result the territory will be more hierarchy.

This paper is treated 4 main issues at the same time: Crisis management, database, and data flow management in the territory, and simplify the territory problems; in our case, we handle the unstructured addresses, using a server to store, display, and analyses data in order to generalize this approach throughout any territory, it is necessary to fill and preserve information and ensure that data input in real-time.

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ANNEX

Initiate database and necessary files

```
string geoPackagePath = @"Adresses.gpkg";

try
{
       // Open the GeoPackage
        myGeoPackage = await GeoPackage.OpenAsync(geoPackagePath);
       // Read the feature tables and get the first one
       geoPackageTable = myGeoPackage.GeoPackageFeatureTables.FirstOrDefault();
      // Make sure a feature table was found in the package
       if (geoPackageTable == null) { return; }
       newLayer = new FeatureLayer(geoPackageTable);
       await newLayer.LoadAsync();
       // iterate through all addresses in Adresses.gpkg and load them to the user
interface list.
       LoadAddressesToCombobo();
       //Load Geoccode file
        string locatorPath = Directory.GetCurrentDirectory() +
@"\buildingPolygon_All_CreateAd.loc";
        _geocoder = await LocatorTask.CreateAsync(new Uri(locatorPath));

}
// catch any error
catch (Exception e)
{
       MessageBox.Show(e.ToString(), "Error");
}
```

Add new address and save it as (*.gpkg) file

```
Try
{
       // Create a new feature in Address.gpkg file
       Feature feature = geoPackageTable.CreateFeature();

       // Get Attribut from User input and assign it to the new feature.
       feature.SetAttributeValue("Fullname", _fullname);
       feature.SetAttributeValue("DoorN", _Bloc);
       feature.SetAttributeValue("Ads", _Ads);
       feature.SetAttributeValue("StreetName", _streetname);
       feature.SetAttributeValue("DistrictN", _district);

       // Add the new feature to Address.gpkg  table
       await geoPackageTable.AddFeatureAsync(feature);

       // Refresh
       feature.Refresh();


}
// catch any error
catch (Exception error)
{
       MessageBox.Show(error.StackTrace + " " + error.Message);
}
```

Show information about selected item

```
// Get Selected Combobo box Fullname
string fullnaletofindaddress = Addresses_Combo.SelectedValue.ToString();
try
	{
		//Clear slected text and selected point in Map
		MyMap.GraphicsOverlays[0].ClearSelection();
		MyMap.GraphicsOverlays[0].Graphics.Clear();
		newLayer.ClearSelection();

		// Get full address of the slected name (user) then select the feature by
	attribut (name).
		string _strqueey = "Fullname=" + "'" + Addresses_Combo.SelectedValue.ToString()
	+ "'";
		QueryParameters query = new QueryParameters();
		query.WhereClause = _strqueey;
		var g = geoPackageTable.QueryFeaturesAsync(query);
		FeatureQueryResult Myresult = g.Result;
		List<Feature> features = Myresult.ToList();

		// find the address geographically (longtitude and latitude)
		string enteredText = features[0].GetAttributeValue("DoorN").ToString() +" "+
		features[0].GetAttributeValue("DistrictN").ToString() + ", District " +
		features[0].GetAttributeValue("StreetName").ToString() + " " +
		features[0].GetAttributeValue("Ads").ToString();
		IReadOnlyList<GeocodeResult> geocodeResults = await
	_geocoder.GeocodeAsync(enteredText);

		// Show a graphic for the address.
		GeocodeResult firstSuggestion = geocodeResults.First();
		IReadOnlyList<GeocodeResult> addresses = await
	_geocoder.GeocodeAsync(firstSuggestion.Label);

		SimpleMarkerSymbol pointSymbol = new SimpleMarkerSymbol()
		{
			Color = System.Drawing.Color.Black,
			Size = 10,
			Style = SimpleMarkerSymbolStyle.Circle
		};

	Graphic point = new Graphic(addresses.First().DisplayLocation, pointSymbol);
	//Add selected feature as point in the map.
	MyMap.GraphicsOverlays[0].Graphics.Add(point);
	MyMap.GraphicsOverlays[0].SelectGraphics(MyMap.GraphicsOverlays[0].Graphics);
	// Zoom to selected feature.
	MyMap.SetViewpoint(new Viewpoint(addresses.First().Extent));
	// Create Callout to display the user name and the address graphically in the map.
	MapPoint _pt = await GetNewAddressLocatioAsync();
	Graphic pinGraphic = new Graphic(_pt, pointSymbol);
	MyMap.GraphicsOverlays[0].Graphics.Add(pinGraphic);
	string calloutTitle = Addresses_Combo.SelectedValue.ToString();
	string calloutDetail = enteredText;
	CalloutDefinition calloutBody = new CalloutDefinition(calloutTitle, calloutDetail);
	Point ttpoint = new Point(_pt.X, _pt.Y);
	// Show the callout on the map at the tapped location.
	MyMap.ShowCalloutForGeoElement(pinGraphic, ttpoint, calloutBody);
}
// Catch any error
catch (Exception ex)
{
	MessageBox.Show(ex.Message);
}
```

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On the Perpetuation and Contestation of Racial Stigma: Urban Roma in a Disadvantaged Neighbourhood of Szeged

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Abstract

Stigmatisation of Roma people has long received attention in the academic literature but the internalisation of stigma among segregated urban Roma has been little researched. By adopting a theoretical perspective on collective identity and (urban Roma) racial stigmatisation, this paper aims to 1) understand the broader nature of urban Roma stigmatisation maintained by the non-Roma people and among the Roma, and 2) better position the internalisation of stigma and the burden of Roma stigmatisation. The paper uses Participatory Action Research (PAR) as a research methodology, taking a disadvantaged neighbourhood of the city of Szeged, Hungary as a case study. The findings suggest that stigmatisation against urban Roma is a process which has deeply rooted historical backgrounds, and current efforts which strive for desegregation and integration of urban Roma will be difficult to implement, as stigmatisation remains in the collective mentality. The importance of this study rests on bringing all major dimensions of stigma together, highlighting what policymakers should consider when addressing them in the longer term. We argue that the existing urban policies towards the Roma people need to be readdressed, with clear power given to the voices of the Roma, particularly from institutions which aim to protect them.

Keywords: urban Roma; racial stigma; internalisation of stigma; segregation; disadvantaged neighbourhood; Szeged; Hungary

Introduction

The burden of stigmatisation has been a challenge for the Roma people in Europe for centuries (Powell & Lever, 2017). From the slavery period to the current neoliberal pressures and nationalist extremism extending to all levels of European society, Roma people have often been placed at the bottom of modern societies, leading to actions of Romaphobia (McGarry, 2017; van Baar, 2011). Images of Roma beggars paired with the media portrayal of Roma as thieves and drug addicts, linking them to prostitution activities, have been increasingly prevalent both in the political and mass-media space (Creţan & O'Brien, 2019). Attitudes of vilification of Roma people are not usually seriously considered by political actors and policymakers, indirectly maintaining a form of "invisibilisation" of anti-Roma racism (Powell & van Baar, 2019), and highlighting a need for a more critical perspective on 'whiteness' and the ongoing injustices against Roma communities (McElroy, 2020; Shmidt & Jaworsky, 2020).

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By being less focused on relevant relations, interactions and experiences of the Roma people (Grill, 2018), the existing literature on Roma tends to focus more on disadvantages visible in relations with the state institutions, as well as the impact of punitive policies. State discrimination and the mechanisms of governing Roma migration (Humphris, 2019; Picker, 2017; Toma & Fosztó, 2018; van Baar et al., 2019; Vrăbiescu, 2017), as well as its ghettoised and racialised education and socioeconomic position (Berescu, 2011, 2019; Clough Marinaro, 2017; Filčák & Steger, 2014; Ivasiuc, 2020; McElroy, 2020; O'Nions, 2010; Picker, 2017; Vincze & Raţ, 2013; Vincze, 2019; Voiculescu, 2019) are issues that have been extensively debated, yet little is known about the everyday manifestations of contemporary stigmatisation of the Roma (see Creţan et al., 2021; Pulay, 2018).

Hungary is one of the European countries where Roma communities have always been stigmatised, with structural racism accounting for the post-socialist period at a higher level. Elements of stigmatisation, discrimination and marginalisation accompanied by a narrative of vilification allow for Roma communities to be blamed for the majority of the weaknesses in Hungarian society (Málovics et al., 2019a).

The present paper aims to a) understand the broader nature of urban Roma stigmatisation maintained by the non-Roma people and among the Roma, and b) better position the internalisation of stigma and the burden of Roma stigmatisation through the voices of the Roma in one of Hungary's biggest cities, Szeged.

The present paper begins by presenting the literature review on collective identity, disadvantaged urban communities and the burden of urban stigmatisation. The second part of the paper draws on positioning the segregated areas in Szeged. The following section highlight methodology and data used in the study. Lastly, the results and a thorough discussion of the findings and conclusions of the research are presented.

Collective identity, disadvantaged urban communities, and the burden of racial stigmatisation

Collective identities aid in the establishment of important directions around whether groups are accepted or rejected. Shared meanings and cultural representations are negotiated and (re)produced through individuals interacting with each other (Hunt & Benford, 2004). Adherence to certain norms allows members to rely on some general guidelines of their shared identity. Such cohesion could bring into discussion the presence of the 'other', especially in a context in which collective identities might reinforce patterns of exclusion.

Stigmatisation is an important tool through which collective identities can be preserved, supporting 'the logic' of maintaining distance from 'the others'. Goffman's (1963) concept of stigma has proved valuable in the development of public understandings of stigmatisation. Power relations can recount to economic, social, or political background and recent research on stigma has been focused on 'where stigma is produced, for what purposes, and by whom' (Tyler & Slater, 2018).

Territorial stigmatisation is associated to certain urban areas of excluded groups, ultimately strengthening these power relations (see Wacquant, 2008; Wacquant et al., 2014). The place-based nature of urban stigma is a useful concept in understanding the occurrence of disreputable places and the practices through which power relations are produced. Furthermore, a clear understanding of the 'territorial' in territorial stigma is important to define (Sisson, 2020, because the neoliberal restructuring of capital resulted in different forms of resistance to territorial stigmatisation. Within this context, by focusing on gentrification in Parkdale, Toronto, Mervyn Horgan (2018) argues that legal, material and discursive practices are important when discussing territorial stigma, with issues of destigmatisation delineated on two levels: one that works to symbolically reinscribe stigmatised persons and housing forms, and another which operates in relation to gentrification-led displacement.

Place-based stigma reproduces negative stereotypes, constructing an internal moral order, creating a vicious link between place, class, and race. In this context, the discrepancy between the production of stigma by the external world and residents who internalise stigmatisation is less clear (Tyler & Slater, 2018). Furthermore, there is a blurred line between internalisation of stigma and territorial stigma per se (Pinkster et al., 2020), with stigmatised residents holding a strong desire to create distance between place and space (Wacquant et al., 2014). In a study on spatial denigration in social media, Butler et al. (2018) emphasise that sometimes local residents reinforce stigmatising labels, creating unequal power relations which impact stigmatised people both from the outside and within the neighbourhood, irrespective of housing or human/individual stigma.

Racial stigmatisation against the Roma is a long historical process and urban racial issues have been abundantly accounted for in contemporary literature (Picker, 2017). Ethnic and/or racial segregation have a strong impact on the groups and individuals involved, strongly influencing their welfare. The nature of the impact caused by segregation strongly depends on the degree of involvement of different cultural influences at collective identity levels (Kaplan & Douzet, 2011). The segregation phenomenon occurs when specific groups be-

longing to one cultural identity exist in the space of different cultural origins. These groups may be either within or outside the social context but are frequently perceived as different in the majority society.

Roma stigmatisation in Central and Eastern Europe has benefited from ample research. Studies in the field have emerged from theoretical understandings of 'Romaphobia' in an attempt to underline stereotypes in the construction of Roma identity (McGarry, 2017; van Baar, 2011). Many of such studies have focused on the socioeconomic deprivation of urban and rural Roma communities, addressing issues including but not limited to territorial segregation, lack of education and labour market exclusion (Clough Marinaro, 2017; Foszto, 2018; Maestri, 2014; O'Nions, 2010; Picker, 2017; Powell, 2008; Voiculescu, 2019). The effect of corrective policies on the neglect of everyday experiences and interactions is also present in contemporary debates (Grill, 2018; Pulay, 2015), leading to increasing discussions of securitisation issues around the Roma people in Europe (van Baar et al., 2019). Moreover, the threat of racism in the current neoliberal times is obvious (Goldberg, 2019), with more racial trends against the Roma people on all levels, including housing and socioeconomic practices (Ivasiuc, 2020; Teodorescu, 2019; Vincze, 2019).

Eviction and stigmatisation of Roma communities in Central and Eastern Europe are two key factors that have been prevalent both in the urban space and in broader national contexts (Creţan & O'Brien 2019; Creţan & Light, 2020; Lancione, 2017; Málovics et al. 2019a; Málovics et al., 2019b; McElroy, 2020; Méreiné Berki et al., 2017; Méreiné Berki et al., 2021; Zamfirescu & Chelcea, 2020), highlighting an inherent need for more radical housing policies (Lancione, 2019). However, despite the acknowledgement of such needs, insufficient efforts have been made to understand the everyday manifestations of contemporary stigmatisation of the Roma, what the layered dimensions of racial stigmatisation of the marginalised urban Roma communities are, and how these are internalised by the local Roma people. In the context of urban marginalisation, there is an important gap in the existing literature, with approaches focused on identifying bottom-up initiatives directly from the experiences of Roma people lacking, and little understanding of how critical engagement in eradicating those dimensions of stigma can be established for solid empowerment policies for the Roma people to be implemented.

Placing segregated Roma in Szeged

Szeged is the fourth largest city of Hungary, located approximately 15 kilometres from the Serbian border and 30 kilometres from the Romanian border. The city is the administrative, cultural, and economic centre of the South-Great Plain region of Hungary, currently populated by approximately 167000 people.

The 20th century was marked by the emergence of new industries, including textile, cable, rubber, and cosmetics businesses that were established in the city alongside the already present traditional industrial fields (paprika and hemp processing, tinned food, and salami production). However, most of these dissolved after the Hungarian regime change of 1989. Present-

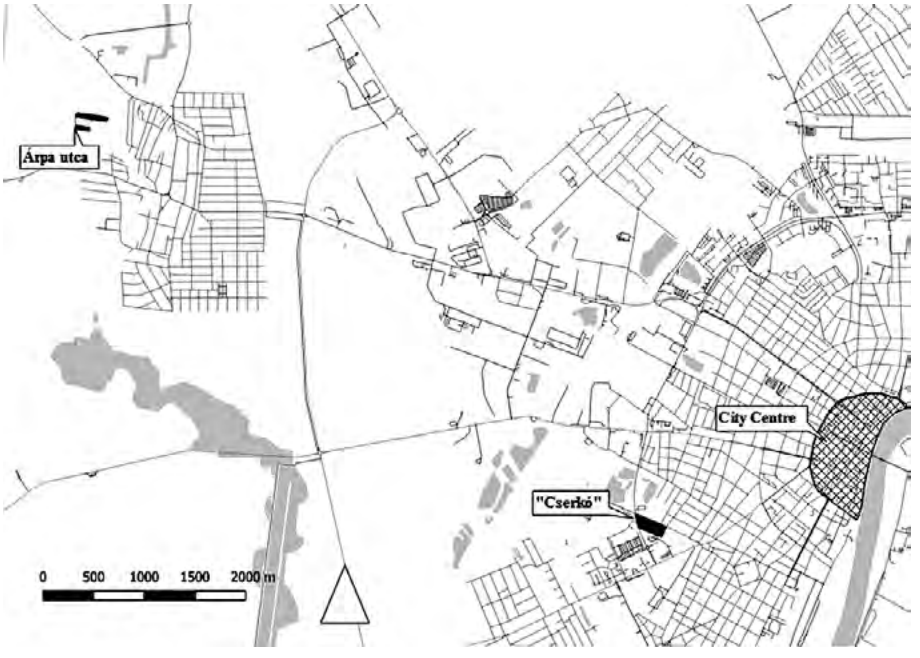

Figure 1. Segregated Roma neighbourhoods within the city of Szeged, Hungary
Source: own illustration - shape file was created from OpenStreetMap data and it is licensed under the Open Database 1.0 License from: http://www.geofabrik.de/data/shapefiles.html

ly, Szeged has no dominant private economic sector, and the economy of the city is strongly reliant on the University of Szeged as the largest employer of the city (Bajmócy et al., 2017).

Since their arrival in the city towards the end of the 19th century, Roma communities have primarily lived in segregation, marginalised from the rest of the society. The "Cserepes sor segregated area" ("or "Cserkó", as called by its inhabitants) emerged during the 1970s, when the elimination and resettlement of the so-called "nagy putri" began (Málovics et al., 2019a). Ever since, Szeged maintains two segregated Roma areas, where approximately 400 Roma people lived until 2017. The *smaller* space of Kiskundorozsma, Árpa utca, includes houses in which about 125 inhabitants live in 4 buildings (16 flats). It is situated on the outskirts of the city. The second and *larger* area of Cserepes sor (see Figure 1), where interviews were carried out, is located at walking distance from the city centre and used to host approximately 250 inhabitants until 2017 when its removal begun (see Méreiné Berki et al., 2021). Segregated Roma neighbourhoods are primarily characterised by extreme poverty, inadequate and uncertain housing conditions, low level of education and an obvious lack of legal and stable employment opportunities.

In the context of spatial segregation of Roma communities, two main issues have impacted the life in the Cserepes sor segregated area to an essential extent until 2017, details of which are present in the empirical part of this paper. Firstly, community members have primarily had a diverse housing status, with some owning land and properties whilst others rented living spaces from the city council. The more unfortunate ones lost the legal occupancy rights due to overdue or unpaid rent, becoming illegal squatters. Such instances have increased the difficulty of accurately estimating the real number of segregated occupants, with the latest official census data in 2011 reporting a total of 217 occupants, a number that does not account for illegal squatters and individuals who have lost their legal rights to permanent housing (see Méreiné Berki et al., 2021).

The underestimation of the real number of occupants, paired with the desegregation process that started during the present research was conducted has contributed to the emergence of significant conflicts within the community. Such conflicts have been amplified by the hope that the desegregation process will offer occupants certain benefits, under the presumption that (1) tenants will receive new, higher standard social housing for a slightly increased rent; and (2) owners will either receive the value of the property or an alternative flat/house in exchange whilst (3) illegal squatters and families without legal status will be displaced without any compensation. Under such presumptions, some owners and tenants have shown a slight tendency towards supporting the desegregation process, viewing it as an opportunity for a better life, whilst illegal squatters and families without legal status have opposed it, since the proposed process of desegregation plunges them into precarity and potential homelessness.

Secondly, the extended use of Novel psychoactive substances (NPS) by community members – a general problem in Hungary amongst marginalised youth (Kaló et al., 2017) – has also weakened inter-community ties and consequently led to increased inner-community conflicts. The presence of these drugs is often associated with the moving in of residents of a former segregated neighbourhood called "Airport", an area in close proximity to the local airport which was eliminated in 2005 by the local city council of Szeged.

The city council hired an association to persuade 17 families with approximately 70 people living in 11 flats of 28-30 square meters, in a building which also served as the local homeless shelter, to accept housing outside of Szeged. This proposal offered housing on farmsteads in smaller villages, 60-70 kilometres from Szeged, and some additional cash in exchange for flats at the Reptér segregated neighbourhood. Following intense persuasion, families accepted the deal however, most families could not integrate into the new environment. People continuously returned to Szeged – certain families after a few weeks while others after years – and occupied flats which were by then out of use in the Cserepes sor area, becoming illegal squatters. The inter-community divide emerged as an "old resident" versus a "newcomer" attitude, creating tension towards former Reptér residents.

The number of Roma living in Szeged is likely to be around 4500-5000 according to self-declared members of the local Roma community, with approximately 10 % of them living in the two mentioned segregated areas. The social situation of Roma in Szeged highlights a diversified circumstance: many Roma live close to the city centre, as tenants in old houses owned by the city, often concentrated in "mini-segregated spaces" (smaller flats owned by the city council, often lacking basic levels of sanitation and comfort). Additionally, a significant proportion of the Roma population lives in the areas scattered with concrete blocks of flats, most of which are also tenants in properties owned by the city.

During the socialist period, full employment was amongst the major political, economic, and ideological goals of the state (see Kornai, 1980). In consequence, state-owned companies provided employment for everyone and being unemployed counted as a crime. Roma in Szeged mostly worked in traditional and new industries settled by the socialist regime during this time, employed primarily as unskilled labour. In the context of education of the Roma community

during the socialist regime, segregated schools in Szeged provided the community with education of rather low quality. Consequently, most adult Roma have only benefitted from primary education whilst many are illiterate. Despite the socialist system providing (forced) employment for the Roma, it did not enhance their level of education. However, school segregation is no longer present in Szeged, with the last segregated school of the city being closed down in 2007.

Following the regime change in 1989-1990 which brought about a swift decrease in the demand for unskilled labour, members of the Roma community could not integrate in the new job market as a consequence of low levels of education and continuous stigmatisation, becoming the first ones to lose their jobs. As a result, many members of the Roma community were forced to rely on social aid on from informal or illegal economic activities and work. Due to these historical processes of exclusion and stigmatisation, the majority of the Roma population still live in relative (or sometimes extreme) poverty in the city (Málovics et al., 2019a).

Based on property relations, the community can be divided by the extent to which "those who have property or legally rent here would literally kill illegal squatters", as stated by one of our interviewees. Those legally living in apartments are eager to leave the disadvantaged neighbourhood by selling their flats to the municipality due to certain behaviours (e.g. criminal activities) and the local atmosphere attributed to illegal squatters. Conversely, families without legal status and illegal squatters now face complete uncertainty and desperation, being ignored in all official planning documents and political decisions.

As a consequence of the desegregation process and despite owners' and tenants' contentment, considerable stress, challenges, and dangers are entailed for illegal squatter families. Although the interests of owner and tenant groups are acknowledged by the city council, illegal squatters remain the most marginalised within the segregated Roma community. Most illegal squatter families face enormous socio-economic problems including, but not limited to learned hopelessness, disabilities, alcohol and addiction, and their pure existence is denied by the municipality. As we presented above, most illegal squatter families are from the former 'Reptér' disadvantaged neighbourhood.

Method and data

The present research is based on semi-structured interviews that were carried out within a Participatory action research (PAR) process, with the involvement of local Roma and scholar activists starting in 2011 (see Málovics et al., 2018).

One of the authors of the present study has worked with segregated communities since 2015. Besides keeping a reflexive research diary during the whole period, she carried out qualitative data collection (fifteen semi-structured interviews) both in 2016, before the desegregation process had begun, and after the start of the desegregation process in 2018. The results of the present study are based on the interviews carried out in 2018. Interviews are part of the empirical research of the given author – providing a wider interview scope related to life and social capital in segregated urban Roma neighbourhood, as well as attitudes towards, and impacts of desegregation on the social capital and life of (de)segregated inhabitants. A total of 15 semi-structured interviews were conducted with 23 participants (see Table 1).

The reason for conducting both individual face-to-face and small group interviews stems from the fact that people in segregated areas tend to move freely between each other's homes (Málovics et al., 2019b) – in the context of the present research, friends and relatives, also living in the segregated neighbourhood, simply entered the room and joined the interview process.

During the analysis of the results, it was observed that stigmatisation – even though not directly addressed by interview questions – is a substantial factor for interviewees, and has an enormous impact on their life. Different forms of stigmatisation, varying from personal/group (e.g. the Roma) stigmatisation to territorial and institutional stigmatisation, as well as patterns of internalisation of stigma, frequently appeared during the interviews.

Given the demographic diversity of the sampled community, the present research aimed to target a balanced sample, accounting for various characteristics – including age, gender and housing status (see Table 1). Approximately half of the interviewees had already moved out of the segregated area at the time of interviewing, whilst the other half still lived there.

With the consent of the participants, interviews were tape recorded and later typewritten, including the field notes of the context of each interview. Due to ethical constraints, the real names of the participants cannot be revealed. Instead, interviewees were coded in this article by using nicknames including age and gender.

Beside its ability to provide a bottom-up community perspective, PAR is an appropriate approach for the present research for many reasons. First, combining actions with observations and the explicit commitment of PAR towards equal and democratic academ-

Table 1. Housing status and demographic characteristics of the interviewees

№	Gender and age	Housing status	Still lived in/moved out of the segregated neighbourhood at the time of the interview
1	male 57, female 56	renter	moved
2	male 40, female 29	owner	moved
3	female 48	owner	moved
4	male 60	squatter	moved
5	male 68, male 32	owner	moved
6	female 31	Renter	moved
7	male 61	Renter	moved
8	female - died at the age of 50, male 55	squatter	moved
9	female 56	Renter	still lived in the segregated neighbourhood
10	male 56, female 49, male 32	owner	still lived in the segregated neighbourhood
11	female 69, male died at the age of 66	squatter	still lived in the segregated neighbourhood
12	male - died at the age of 51	squatter	still lived in the segregated neighbourhood
13	male 51	Renter	still lived in the segregated neighbourhood
14	female 29	squatter	still lived in the segregated neighbourhood
15	male 41, female 47	squatter	still lived in the segregated neighbourhood

ic - non-academic relations means that academics and scholars can get involved in numerous actions alongside non-academic partners. This allows the conventional "researcher versus subjects" roles to be replaced by a collaborative perspective, encouraging all voices to be expressed and to address '*undiscussables*' (Bradbury & Reason, 2003, p. 165). This is of utmost importance particularly in situations where researchers work with (and aim to produce valid knowledge about) stigmatised and segregated peoples, "closed" communities often being distrustful towards outsider researchers and research in general. It is therefore no surprise that structured qualitative inquiry, combined with cooperation and activism (although not necessarily within the framework of PAR), are popular approaches in empirical research on stigmatised, segregated Roma communities because they can ensure the validity of findings by supporting deep observations (see Clough Marinaro, 2017; Grill, 2018; Lancione, 2017).

The context of interviewing heavily defined the focus of interviews. Interviews were carried out with both present and former inhabitants of a segregated Roma neighbourhood in Szeged, Cserepes sor, which used to house approximately 240 inhabitants until 2017, when its elimination begun. 7 out of 24 houses have been destroyed until the present time.

During the interview process, four inhabitant groups were identified based on their housing situation: (1) apartment owners; (2) tenants renting apartments from the local public property company; (3) families legally residing in their apartment despite loss of legal status due to unpaid rent/overheads; and (4) illegal squatters without legal status who remain in their apartments, and illegal squatters in empty apartments.

We employed a qualitative content analysis (see Titscher et al., 2000) in order to create an open data analysis process, in which the study defines "stigma" in an open way, according to which perceptions of stigma and related social processes are left open to the perception of segregated Roma community members. In vivo codes were created during the first stage of the analysis. Then the codes were organised into different categories and their relationship was analysed. All interviews were analysed by two researchers and the results were compared and discussed until agreement was reached.

Results

Dimensions of 'outside' / non-Roma stigma

In general, Roma people are stigmatised by Hungarians. Several participants (e.g. Pál, male 51; István, male 60) emphasised that there is a huge difference between pre- and post-1989 political periods. Before 1989, Roma individuals had work and steady incomes and they were therefore not in such precarious financial positions, were better integrated and had more personal connections with Hungarians. After 1989, the employment opportunities for Roma have drastically dropped, leading to consistent lack of income, poverty, and social aid. Such processes have increased the separation

of Roma communities from other groups and have negatively impacted their social relations with native Hungarians, leading to increased stigma and prejudice narratives. The vilification of Roma communities in Hungary is present even in highly educated individuals, with one participant arguing that:

> *There was no such friction [before]. There used to be togetherness between Roma and Hungarians. We do not have it anymore. Hungarians, high school students, university students, they are all very racist* (Ilona, 56 years old Roma woman).

Such statements are in line with Foszto's (1918), and Creţan & O'Brien (2019)'s ideas, addressing the fact that during socialism, the Roma people were also stigmatised and communities encountered hardships, but post-socialist neoliberal period has brought further major issues of job insecurity and unsafe housing. Therefore, post-socialism has been a gate for reinforcing racism, especially by intellectuals and politicians. Moreover, even in multicultural urban societies of Central and Eastern Europe, planning and policy documents do not account for the Roma people (Vesalon & Creţan, 2019), which highlights policy neglect for the Roma people wellbeing in cities of this European region.

Occurrences of othering Roma can stem from the use of specific language and names, with one prominent example vilification of the name Kolompár, a typical name for Roma in Hungary: You should try to live with the name Kolompár for one year!"(Kriszti, Roma female, 29 years old). Another interviewee state that

> *If they [the Hungarians] hear "Kolompár", it makes their hair skin crawl. 80% of non-Roma feels like that* (Pál, 51 years old Roma man).

As a consequence of the negative association with the name, some Roma often even consider changing their 'Kolompar' names.

Despite surnames being easily changed, Hungarian accent provide another stigmatisation opportunity for those othering Roma. Most Hungarian Roma that we engaged with in our PAR activities speak Hungarian with a specific accent, making them recognisable as Roma and allowing those they communicate with to form opinions based on the way they speak. Our personal experience highlights this during a collaboration with a Roma lady looking for work (cleaning). The woman called a phone number provided in a job advertisement to apply, but was rejected immediately under the argument that "the position had been filled", despite one of the authors also calling the number 5 minutes after from a different phone number, only for the person on the other line to attempt to persuade her for 5 minutes to take the job.

In this context, Roma family and personal names as well as their Hungarian accent is shown as a major problem that segregated Roma could encounter. Racism is reinforced on these patterns of Roma - non-Roma encounters in Hungary. The stereotyping of Roma communities is often also linked to their *appearance*. Hungarians seem to justify such attitudes by considering that there is a lack of sanitary infrastructure for the Roma communities, impeding their ability to have a bath every day, which reinforces their categorisation as *others*.

Besides stigma and prejudice associated with certain names, accents and physical appearance, illegal activities - such as *stealing*, are also often associated with members of the Roma community, as emphasised by a shop assistant who asked if school could teach [them] to stop stealing. This question was posed in light of the fact that only one of the several hundreds of Roma costumers, a mentally disabled teenager has ever been involved in an action of thievery in the shop. The vicious circle of poverty and stigma is further heightened by the lack of adequate education, employment opportunities and the often precarious housing situation of Roma communities (see Figure 2 and Figure 3), factors which reinforce stigmatisation, discrimination and marginalisation.

Figure 2. Roma housing conditions in Szeged
Source: Méreiné Berki's photo collection

Figure 3. Demolished Roma house in Szeged
Source: Méreiné Berki's photo collection

In East-Central Europe there is a huge debate about the Roma considered as 'outsiders' due to stealing and begging (Creţan & O'Brien, 2019) and being highly considered as marginal people even during the current COVID-19 pandemic period (Creţan & Light, 2020). Such stereotypes come from populism and different forms of superiority that some of the white majority reinforce in the public sphere.

Housing is another factor that impacts the level of stigmatisation and discrimination of Roma communities. Lousing and housing poverty (e.g. housing without basic labels of comfort paired with spatial segregation) makes Roma people prone to further vilification, which can explain why "*lousy gypsy*" remains a stereotypical insult in Hungarian language. Louse stigma leads to ostracism in kindergarten and school, with such cases highlighted addressed further in the discussion section. Furthermore, there is an apparent lack of rights and access to public services for the Roma in Szeged. For example, illegal squatters have no access to numerous public services and support like free food in school for kids and housing subsidies (*Research diary*). Such degrading attitudes against the Roma have been largely documented in post-socialist Europe, leading to extremist attitudes as Romaphobia (McGarry, 2018; van Baar, 2011).

Dimensions of intra-Roma stigma: stigmatising each other within the disadvantaged neighbourhood

In the Cserepes sor segregated area there is an interesting pattern of Roma stigmatising other Roma. Those Roma who are in a better socioeconomic position and are fortunate to have better jobs and own flats/legal rents within the segregated area stigmatise those who find themselves in more precarious circumstances (most of all those "from the Reptér", "illegal squatters", or "drugged Roma"), as emphasised by some of the participants in this research who detail the effect of the demolishing of one of the segregated area and the changes the space has suffered as a consequence:

> *I was born there [in the segregated area] and it did not use to be like this. There were more Hungarians than Roma living there. In 2000s the Reptér was demolished, and those gypsies came to Cserepes sor and this avalanche started: drugs, prostitution….* (Tamás, Roma man, 40 years old).

In addition to illegal squatting and activities linked with prostitution, the use of drugs is an extreme problem in present context, emphasising a major pattern of territorial stigma amongst the Roma from those in better socio-economic positions. Some of the interviewed participants discuss the negative impact of squatters on the general perceptions of the area, emphasising that illegal tenants are visibly more disadvantaged, leading to avoidance, discrimination, and marginalisation. One participant highlights the otherness within the community by arguing that

> *The normal ones have already moved out, those who had private property. They were the ones who were in a better position regarding their understanding. Those having legal rents, they also moved, and those who are still there, the illegal ones, the drug addicts, they are really the trash* (Brigi, Roma woman, 29 years old).

Many of these segregated and stigmatised families "*are so used to this milieu (of the segregated area) that it is impossible for them to integrate in the society*" (Ákos, Roma male, 32 years old) – meaning that the segregated area is not part of "the society", but rather a place of otherness, with the society surrounding the segregated space. This issue has been discussed with a number of participants, some arguing that "*many families that are illegal squatters could not fit in elsewhere. They act in a barbarian way, with each other, with others around them.*" (Edit, Roma female, 48 years old). Another participant addressed issues of appearance in the same context, emphasising the disapproval of squatting Roma towards her wanting to "*be clean*", her dress code, attitude, and general appearance, in comparison to Hungarians who appear to appreciate that. These perceptions of otherness, despite belonging to the same community, are detailed by the same participant in relation to the cleanliness of the living space, arguing that

> *When I told the Roma at Cserepes sor to join together and collect the garbage, they said I behave as a*

Hungarian. I want to be clean (Brigi, Roma female, 29 years old).

Personal relations can generate exceptions to the majority attitudes and behaviours (see Wacquant, 2008). The interviews uncovered one family that is frequently mentioned as such an exception, described as people "*who would deserve not to be put on the street but to be given at least a small hole to stay*", whilst "*others, who previously had legal houses but left or sold them*", should "*get out of here, because they do not deserve [them]*" (Edit, Roma female, 48 years old). Within this context, participants argue that, amongst the segregated community, there are those who "deserve" support and fair treatment, and those who "do not deserve" it, emphasising the intra-community stigmatisation discussed before:

You have to help those who want change. If you go to someone's place, you see whether she wants to change the whole thing. In case there is order, in case there is cleanliness, you can see the want for change. Otherwise not (Ilona, Roma woman, 56 years old).

Such attitudes and the increase of intra-community tensions are also the result of a previous displacement activity of the municipality concerning the Reptér segregated area – people from there moved in Cserepes sor area, became illegal squatters and "*could not fit in*", but changed the spaces in a way in which "*everyone, who lived here for 25-30 years, said that we have to leave, it is unbearable*" (Pál, Roma male, 51 years old), creating "*an environment where it is impossible to raise children normally because of these (drug addicts and their behaviours*)" (Kriszti, Roma female, 29 years old). People associate better behaviours with individuals and kids who managed to move out of the segregated area, with some participants arguing that, as a result of the move, these people have become more calm, relaxed and "normal", highlighting the benefit of integrating into the majority society and living amongst Hungarians (Kriszti, Roma female, 29 years old; János, Roma male, 57; Edit, Roma female, 48; Tamás, Roma male, 40; Brigi, Roma female, 29). The prospect of being able to leave the segregated area offers hope of a future that is not achievable otherwise.

Stigmatising the area itself by former or present residents is also visible in different narratives, with interviewees arguing that

When we got there (in the segregated area) everyone thought we were Hungarians. They came to us to see who we were. They stole and took everything they reached. We were just watching […] something always disappears – cigarettes, remote controller. You get used to it (Lajos, 68 years old Roma man).

One of the participants who managed to leave the segregated area admitted to not missing anything about the space, being more relaxed, open, and happy (Brigi, Roma female, 29 years old). The same participants declared to now feeling like outsiders when looking at Cserepes sor, wondering how they had the strength and ability to survive in the segregated neighbourhood for as long as they did.

The stories that are presented above are part of an interesting form of 'in-group' territorial stigmatisation. Stigmatising their own territory refers to how the general society has influenced Roma's attitudes against the places they live in, and how Roma internalise such forms of vilification. Therefore, squatters are seen by most of the segregated Roma as 'the enemy other', the ones who are not part of their ethnic group. Such forms of vilification have increased mainly after the desegregation process appeared with increased stigmatisation emerging as a desegregation process result.

Roma stigmatising other Roma – generally not related to the given area

Throughout the research, several interviewees consider that stigmatising other Roma in Hungary is a norm amongst most of the community due to a consistent lack of unity and group cohesion. One of the participants argued that "*it is ok that I am a gypsy, I was born to be a gypsy, I am proud of it, just as my family, but I will not be trash. I can show that I make out from the other gypsies.*" (Tamás, Roma man, 40 years old), whilst another Roma justifies the intra-community stigmatisation by arguing that "*gypsies are very greedy*" and "*would be glad if [my] children would marry Hungarians, and not Roma, because Hungarians are not as rubbishy as Roma.*" (Edit, Roma female, 48 years old).

General stigma towards Roma is apparent and sometimes even parallel, with one participant mentioning that they are facing "*prejudices both because we are Roma and also because of Cserepes sor. Cserepes sor is infamous even in Budapest or Dunaújváros*" (Tamás, Roma man, 40 years old).

Furthermore, another participant admitted to not wanting to live amongst Roma and preferring to live amongst Hungarians, because "*Roma blood is awfully bad. Everyone is so unimaginative.… Roma are worse than Hungarians.*" (Endre, Roma man, 51 years old).

Emotional responses of local Roma residents to stigma

Emotional geographies on the Roma people are obvious in several of the most recent Roma studies, main-

ly in those studies centred on the Roma narratives (see Grill, 2018; Creţan et al., 2021). Roma people usually reveal different forms of internalised stigma and responses to stigma (Creţan & O'Brien, 2019; Creţan et al., 2021). The present study identifies several different responses of local Roma to stigmatisation: *subordination; (de)humanisation; leaving the (segregated) area due to stigma, lack of trust and anger against other ethnic groups who stigmatise the Roma; cohesiveness and feeling safe together; and being and looking like Hungarians.*

Subordination and internalising the stigma seems to be the preferred regular coping mechanism, with one participant arguing that some of the individual's talents, strengths and attributes that help them have a decent life within the segregated area would be worth very little outside the community, forcing them to bow down to the superiority of Hungarians (János, Roma man, 57 years old), whilst another participant believes that

> *Hungarians judge us for good reasons. We are bad in their eyes. We do not want to work. Indeed, we avoid what is demanding. Learning is very demanding, because we are dumb – globally, I believe. We are still littering, still use drugs, we could not show anything [of worth] in the past 5-10-15-20 years* (Endre, 51 years old Roma man).

(De)humanisation has also been uncovered as an important issue that segregated Roma communities deal with. Numerous Roma participants talked about "nice Hungarians" that they know personally, including the owner of the flat they used to rent (*Research diary*), shop assistants in shops that they regularly visit or school directors at schools their children used to attend before they moved out of the segregated area, highlighting that *personal relations can work against stigma*:

> *First, when I went there, they came after me to see if I steal or not, and now they are interested in me as a person* (Brigi, 29 years old Roma woman).

Another instance of personal relationships is further highlighted by another participant who describes his Hungarian neighbour as kind and helpful but emphasises that this relationship is the result of a successful, well-paid employment opportunity offered by the neighbour (Edit, Roma female, 48 years old).

Leaving the (segregated) area appears to be the only opportunity for change and a better life, as highlighted in previous sections as well. Furthermore, one participant's response emphasises that

> *The environment of the [segregated] area pulls you down. It is not good if there are many Roma in the same place, they are also envious if someone has more, steal and ostracise* (Tamás, 40 years old Roma man).

Lack of trust and anger. Lack of trust in other ethnic groups and individuals that do not belong to the Roma community is sometimes a result of Roma stigma, with one participant arguing that, despite working and being in close contact with Hungarians, one can never know what their true intentions, beliefs and attitudes are (Anna, Roma female, 47 years old). Anger has also been identified as a possible coping mechanism against stigma and discrimination. One of the participants argued that Roma communities suffer from stigmatisation, stereotyping, and discrimination, despite often having similar behaviours to other people, particularly in relation to unemployment:

> *We were once at the changing room at work and one of my colleagues said: "those gypsies…". Well, I am a gypsy, why do you have to judge all of us? Why do you have to say "gypsies"? …I feel hate, and the problem is that not only towards that given person who says it, but towards all Hungarians. […] but after a while I forgive and then I can concentrate on the given person who talks like that* (Ilona, 56 years old Roma woman).

Being (looking, living, and behaving) like Hungarians is another aspect that appears to be desired by some of the participants who admit that it would help them integrate. Despite their traditional views, some interviewees would like their children to marry Hungarians rather than other Roma:

> *This would provide my children with the opportunity to live normally. I do not want my children and grandchildren to go through the same racism I had to go through. […]* (Tamás, 40 years old Roma man).

Cohesiveness and feeling safe together have also been identified as defence methods against the repressive behaviour of the majority towards the Roma community. Feelings of safety stem from the unity of the group, as exemplified by one of the participants who describes an incident during which one of the community members was attacked and all other members rallied up in her support:

> *If someone is in trouble, the whole team goes to fight for him/her. This gives a sense of security for people* (Brigi, 29 years old Roma woman).

Furthermore, the fear of not being able to integrate in other communities, paired with feelings of otherness increase the cohesion of the group, as reflected by another interviewee:

It is also characteristic that if someone is self-confident in this place and milieu, because he is respected here, he loses it if he has to step out. Elsewhere he feels he is looked down on. He loses that self-confidence. […] (Tamás, 40 years old Roma man).

Participants also highlighted that the primary positive aspect about living in the segregated area is the one for all, all for one attitude that is characteristic of close, segregated communities and generates feelings of safety, respect, and community spirit.

The above elements are clear-cut forms of perceived stigma by the segregated Roma in Szeged, which range from subordination to de-humanization. Different elements of feeling safe together and personal relations have been presented in the current literature as major lines of keeping the family united in urban outcasts (Wacquant, 2008). Such elements of family cohesion as a response to stigma have been met in certain instances in East-Central urban areas (Creţan & O'Brien, 2019; Creţan et al., 2021). All these elements are completed by feelings of anger and lack of trust towards 'the others' but, at the same time, make most Roma wonder whether it would be better to be integrated and look, live and behave like Hungarians.

Territorial and institutional stigma

The negative impact of stigma in public spaces and institutions has been highlighted throughout this research, with numerous participants emphasising instances of discrimination in shops and other public spheres. *Intra-community stigmatisation* is also apparent and strongly justified throughout the responses of some of the participants, with one interviewee arguing that:

Half of the gypsies are banned from the tobacco shop and Aldi. You know why? They stink, they are dirty and sleazy. They smell of alcohol and do not take care of themselves. Not even the basic hygiene (Brigi, 29 years old Roma woman).

Similar responses emphasise that banning certain members of the community can be justified through their own behaviour and appearance, disregarding the stigma attached to the entire community.

Instances of *institutionalised racism and stigmatisation* towards the residents of Cserepes sor are also apparent in the responses of the participants, with one participant in particular detailing such experiences in the context of police brutality:

The police came there (Cserepes sor) at least 20 to 30 times a day, and if they saw a gypsy, they sprayed him and beat him up with their truncheon, even if he did not do anything (wrong) (Tamás, 40 years old Roma man).

One of the authors of the present article was also stopped by police when leaving the segregated area. After delivering firewood to two of the resident families, police officers stopped and performed a random drug search. After further enquiries, the police officer admitted having stopped the author because of visiting the segregated area, and not for any other reasons. Issues regarding the way police officers deal with the community of the segregated neighbourhood were also addressed by several participants (Erzsi, Roma female, 69 years old; Edit, Roma female, 48, and Miklós, Roma male, 56), who argue that instances of theft and illegalities within the segregated area are left to be dealt with by the community members themselves, despite police checks being performed quite often in the area (Miklós, Roma male, 56). Instances of intra-community violence are also dismissed by police according to interviewees who state that

When policemen see gypsies fighting with each other, they do not intervene, they just watch. […] as long as no one is bleeding, they do not intervene (Ilona, 56 years old Roma woman).

The support of public offices and the access to public services is also severely limited for the community, with participants discussing several instances of appealing to public services for social aid and being met with dismissive and condescending attitudes (Brigi, Roma female, 29 years old). One of the participants highlights the effect of stigma in relation to the collection of waste in the Cserepes sor area by describing the extent to which the area is ignored by public waste disposal services and the blame the community receives, despite having no control over who disposes of garbage in the area:

There is a waste disposal site at both sides of a house, within the Cserepes sor segregated area. They collected the garbage once, but generally do not care about it. It is not only gypsies who dump their garbage there. Hungarians come by car and quickly empty their garbage there during the night. But it does not matter who puts it there, people who live there are blamed for the garbage anyway (Miklós, 56 years old Roma man).

Throughout the research, many statements relating to the unfairness of public service charges were uncovered, with many providers charging high amounts of money for different public services at certain times for the inhabitants of the ghetto. Extremely high liv-

ing costs could be related to the fact that many of the houses within the segregated area are handled administratively as block of flats by the municipality. Thus, legal owners/tenants are expected to pay for the consumption of water, electricity and common services of the inhabitants who do not financially contribute within the block (e.g. illegal squatters).

The access to educational services and kindergartens in the area is also limited. There is a single kindergarten appointed for both segregated areas (including Cserepes sor) that accepts gypsy kids, but others, which are considered to be better, do not. This is clearly a stigmatising policy that maintains the segregation of the community, not only addressed by Roma members, but also by the director of one of these kindergartens. Generally, access to education for the Roma in Europe is limited, with segregation in school as a major pattern (O'Nions, 2010). By taking an insight into the interactions between teachers, school mediators, and Roma adults, Cerasela Voiculescu (2019) argued that current neoliberal state education include an utopian character of social integration for the Roma. The author points to a need for a constructive dialogue between state education and idiosyncratic Roma forms of knowledge and culture. Such a dialogue could help the Roma people to embrace authentic forms of empowerment.

Instances of stigma and unfair treatment of community members have also been observed in the private sector of service providers, with one participant arguing that the entire segregated area has been placed on a blacklist:

> *I phoned each and every service providers but they told me that they were sorry, but the computer shows that the Cserepes sor is on the blacklist, and they cannot provide us with internet subscriptions* (Tamás, 40 years old Roma man).

As Pinkster et al. (2020) argue, territorial stigma and internalisation of stigma work together, and it is difficult to make a delineation between the two, but the 'stickiness' to certain territories and categories of people could be visible. If Alistair Sisson (2020)'s idea of defining the territory in 'territorial stigma' is to be considered, things look more complicated because for the Roma squatters in Szeged, 'home' and 'territory' is where they previously lived, the segregated area, even if that territory is a 'blemish of place' for the other segregated Roma.

Discussions

Collective identity is an important cultural form of identity (Hunt & Benford, 2004). The Roma people have struggled hard to preserve their traditional values even though are living in segregated areas or in the mainstream society. Some of Roma's norms and habits are perceived by members of some other collective groups as disrepute and therefore bringing ahead issues of (territorial) stigmatisation against the Roma community. For instance, segregated Roma people in Szeged have been fighting with stigmatisation for decades (Málovics et al., 2019a; Málovics et al., 2019b; Méreiné Berki et al., 2017; Méreiné Berki et al., 2021). Dimensions of stigma are diverse and internalised in different forms, leaving the Roma at the bottom of the Hungarian society.

Furthermore, offers from the municipality towards the owners in exchange for their flats is also lacking transparency and are often considered unfair by members of the community who argue that the same offer should be made to all those who are in the situation of being able to sell their properties. Within this context, it becomes crucial to highlight that such instances are not only anti-gypsyism but also processes of anti-poorness. In Szeged – and in most other parts of Hungary– there is basically no social housing system serving the poorest and most disadvantaged. Most poor Roma are forced to rely on public work and unregulated employment which results in them not being able to apply to social housing support, since the per/capita official income limit (120 Eur/capita) is too high for them.

Being able to apply for social housing is not only limited by employment history and income but also by other administrative factors, included but not limited to people having been legally evicted in the past five years because of back rents and living costs. Additionally, the school system does not compensate for poverty to a significant extent either. It also does not deal with counteracting the stigmatization of Roma students in school on an institutional level, an issue highlighted by the same participant.

Stigma is highly reproduced due to housing conditions. Houses without basic levels of comfort result in additional stressors for the inhabitants, with daily struggles for people trying to fulfil their basic needs. Furthermore, inappropriate housing conditions also impact the opportunities for social mobility, as presented by Lancione (2017), who unveiled the post-human entanglements that shape human actions. Many Roma participants in Szeged have daily struggles of living in improper residential conditions.

The segregated area is legally organised into *units of block of flats* – meaning that even if someone has a pri-

vate flat/house or rent in the segregated area, it is legally part of a larger housing unit, where the primary owner (owning more than 50% of the flats/houses) is the IKV, a local public property company. This gives the company a lot of power over other owners according to Hungarian housing law, particularly in relation to living costs.

The story of anti-segregation and the calculated informality of the local council have deepened the existing stigma. For a decade (more specifically from 2007 to 2017), the public property company (IKV) provided unjust buying offers for the apartments of the segregated Roma, paired with little to no coverage of the cost of relocating. Extremely small apartments, without basic levels of comfort, were offered in exchange for their present homes in the segregated neighbourhoods. These offers only began to improve in 2017 when the local public property company started to offer acceptable prices and exchanged the apartments with reasonable alternatives. Finding legal rent is almost impossible in Szeged (or even in other cities of Hungary) if you are a member of the Roma community, an issue repeated extensively by a large number of the participants. During the present research, petitions against Roma buying properties in an integrated part of the city were rising. Furthermore, the representative of the *Local Roma Minority Self-government* (LRMSG) also addressed instances of local representatives being afraid of placing Roma families in their voting districts out of fear of losing votes and the respect of the electorate.

The lack of transparency in addressing the anti-segregation process is further highlighted by members of the community without legal housing, who admit to feeling cheated and defenceless due to the lack of formal communication and information relating to their future residential status. This process deepened the stigma between segregated Roma and illegal squatters.

Illegal squatters are viewed from lack of transparency to total negligence. They do not officially exist for the city council in the desegregation process, often facing displacement, forced eviction and complete uncertainty. In the case of illegal squatters, Cserepes sor is seen as a last resort, whilst the negligence of administrative and development policies only serves to increase the hardships of those most marginalised. Given the uncertainty of tomorrow, the only possible outcome for illegal squatters in the context of desegregation processes is for them to move to another empty flat within the same building, creating a cycle of displacement. The risk of homelessness increases drastically for illegal squatters, pushing them from one stigmatised life to yet another. Due to stigma, the only employment opportunity for Roma in general is either public work or hard physical labour characterised by exceedingly difficult circumstances and severe uncertainty (see Messing & Beremény i, 2017).

Territorial stigmatisation is a particularly important concept for understanding how spatial, social, and symbolic processes are interconnected in producing urban inequality (Pinkster et al., 2020; Sisson, 2020; Wacquant et al., 2014). In Szeged (territorial) stigma appears rooted in the balance between institutions and street-level bureaucrats. Generally, it can be argued that even if institutions themselves are not stigmatising the disadvantaged Roma, they do not support the empowerment of Roma either.

Even though, as acknowledged throughout this paper, there are institutional forms of support (e.g. free food in primary school and kindergarten; social services of the family support offices) that relate to social aid for the economically disadvantaged, including the Roma community, institutions do not provide meaningful assistance for empowerment (and social mobility), and the inadequacy of their support is heightened by stigmatisation. Institutions and their actors try to deliver forms of 'territorial destigmatisation' (Horgan, 2018) but their practices lead in fact to reinforced (territorial) stigmatisation. The services delivered are inadequate for meaningful social change for the community, an opinion emphasised both by the participants as well as further field observations. Although there are few examples of positive experiences linked to public officers (as street-level bureaucrats) who provide support to the community by helping them fill in paper work and offer advice and information, experiences towards institutions themselves is about hostility, stigmatisation and neglect.

The stigmatisation of Roma communities and, in particular, of members of the community who live in the segregated area, becomes apparent at the level of political debates too. During the interviews of the present research, numerous instances of othering the community in political and public debates, justifying the stigma through true versus untrue Hungarians have been highlighted by participants The othering of Roma communities is reproduced in the use of language by politicians, with some Roma arguing that the use of the word "minority" itself creates differentiation and stigma. The political and public vilification of the community does not consider the fault of the government itself, apparent through the consistent neglection of marginalised, disadvantaged people.

The role of *Local Roma Minority Self-government* (LRMSG) is quite limited in defending stigma. The system of LRMSGs is an extremely contradictory one in Hungary. Minority self-governments, including local Roma minority self-governments, are institutions created by Hungarian law to enhance political representation and inclusion of the Roma minority. Local

Roma representatives in Szeged are members of the LRMSG, officially representing the local Roma community. Most of them grew up in the segregated Roma neighbourhoods and now live as socially integrated Roma citizens, committed to supporting their still marginalised and segregated peers. However, LRMSG rather hinders Roma representation and inclusion instead of supporting it. Some of the system's flaws include the lack of resources appointed to local Roma minority self-governments, corruption, ethno-business, and manipulation by "big politics". It is well-known that corruption among political elites in cities of Central and Eastern Europe is a malpractice which could lead to questioning the right to the city (Creţan & O'Brien, 2020).

Even though the system lacks adequate resources, it is still the only official institution for representing the interests of the community and members have expectations of their representatives that cannot necessary be fulfilled. The expectations of the community are often beyond the capacities and resources of the representatives and the system. In this context, the institution becomes the apparent scapegoat, allowing big politics to blame the lack of support on the LRMSG instead of dealing with the issues and policies themselves. Despite the awareness of "big politics" towards such situations and issues, their aim is not to change them, an opinion that appears often in the discussions with our participants. Institutional limitations often fall back upon Roma representatives. *There is a need for representatives who really represent the rights of Roma. Current representatives mostly represent themselves.* However, some of the members of the community are aware and understand the limitations of the institution.

Conclusions

The aim of the present research was to understand the perpetuation and internalisation of stigmatisation in the segregated urban space of Szeged. Therefore, the different dimensions of stigma and the various ways in which Roma communities internalise and contest it, have also been accounted for. Based on insight into the experiences and narratives of Roma individuals in Szeged, the present research highlights the nature of stigmatisation of urban Roma as reproduced mainly by non-Roma individuals but also by Roma community members.

In the context of urban stigmatisation of Roma communities, the results of this paper emphasise that the stigma process is complex and deeply rooted: the Roma are perceived as 'Kolompar', lousy, stinky individuals, who would never be able to get out of their condition, attitudes which lead to strong feelings of stigma internalisation for the local Roma people. Furthermore, the process of stigma grows from internalisation of stigmatisation for the Roma people, to territorial and institutional forms of stigma. Stigmatisation is reproduced on three levels: by the non-Roma against the Roma; by the segregated Roma towards other Roma within the segregated area; and by the segregated Roma people against other (segregated) Roma people..

The study highlights the harshest effects of stigma, uncovering that these are often generated by non-Roma, challenging issues of subordination, dehumanisation, actions of making the segregated urban Roma leave the (segregated) area, feelings of lack of trust and anger towards the non-Roma, as well as a desire for being, living, and behaving more like Hungarians. Territorial and institutional stigma are also internalised as strong patterns of vilification. Cohesiveness through personal relations and feeling safe together remain the only tools for the Roma to defend themselves against stigma. Against the 'ineducability' perception highlighted frequently in the neoliberal society (Shmidt & Jaworsky, 2020), the Roma people have a very profound way of thinking practically. Their narratives indicate they are sensible people who internalise differently the actions of perpetuation of stigma.

Among the current causes of reproduction of stigma, the results of the present study address housing policies in particular. The lack of communicative transparency concerning the demolition and displacement process serves as an additional stressor for a community already facing precarious circumstances, a major issue emphasised by a number of the participants who are left not knowing what will happen, and how their lives will change. Moreover, illegal Roma squatters have emerged as a result of desegregation processes and form a new form of citizen in Szeged. Individuals belonging to this group have no idea when they will have to leave the segregated area, and their liminal condition has created an emergence of a process of in-group stigmatisation: the Roma stigmatising and discriminating against the other Roma.

In the context of traditional values and cultural differences, numerous Roma believe that stigmatisation and the implicit segregation of Roma communities stems from the cultural differences between the community and the majority group. The behavioural differences of both cultures are described by some Roma, who discuss not wanting to move to a flat offered by the city council, as the move would mean sharing the backyard with a Hungarian family leading to instanc-

es of inter-ethnic conflict, which could arise as a result of cultural differences. However, contrary to dominant perceptions of Roma as unwilling to integrate, many Roma are agents of integrative bonds and trustful interactions (see Creţan et al., 2021).

Aside from the deeply rooted historical background, contemporary efforts towards desegregation and integration of urban Roma will be difficult to implement, especially because stigmatisation remains in the collective mentality of the majority. The findings of this research highlight an excruciating need for new studies to be conducted in (urban and rural) marginal areas, where Roma communities live, in order to determine if different forms of development, maintaining and contestation of internalisation of stigma can be observed. The limitations of the present study raise issues concerning the perspectives of local stakeholders on how to eradicate racial stigma towards the Roma people. This indicates a need for longitudinal ethnographic studies about the opinions of stakeholders on how to deal with the pressure of stigma on those communities. Moreover, as desegregation is a recent process in Szeged's disadvantaged neighbourhoods, at the moment we cannot make assumptions that desegregation has deepened certain patterns of stigma against the Roma. Therefore, further studies should take into consideration a longer time perspective on the relationship between desegregation processes and racial stigmatisation towards the Roma community.

The cycle of poverty and stigmatisation are connected to the lack of adequate education, employment opportunities and the precarious housing situation of Roma communities. Such elements reinforce patterns of stigmatisation and marginalisation. In this respect, the existing urban policies regarding the Roma people need to be readdressed, with clear power given to the voices of the Roma, particularly from institutions which aim to protect them.

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Constructing a Nation Branding Model – the Case of Serbia

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Abstract

This paper aims to understand the concept and fundamental terms related to nation branding as a strategic tool for improving Serbia's international market position, a post-communist and former Yugoslav country. The author intends to gain insight into Serbia's current brand perception as a developing country that can find an opportunity for rebirth and parting with the legacy implementation of the nation branding concept. The quantitative research methods were applied in this paper, and the questionnaire developed for the research investigated the perception of brand Serbia by leaning on Risitano's framework. Our analysis finds that national treasury, people, tourism and business destination were recognized as the most important points for country and nation positioning.

Keywords: nation brand; Serbia; nation branding model; tourism

Introduction

Since the dissolution of great communist states at the end of the 20th century, Europe's landscape has dramatically changed. The turbulent times brought 28 new states in Central and Eastern Europe (CEE) (Ociepka, 2018). For more than 20 years, the new states have been investing wide-ranging and complicated efforts to position themselves on the geographic and mental map of Europe, but also to present themselves to the world as democratic and politically stable countries with developing economies (Hall, 2002; Florek, 2005; Szondi, 2007; Popesku et al. 2010; Aronczyk, 2013; Merkelssen & Rasmussen, 2016; Novčić Korać & Šegota, 2017; Cheregi & Bargaoanu, 2020). The path of transition from a centralised to a market economy, from an authoritarian, one-party system to a multi-party, democratic society, has included the systemic change of a nation's identity and image (Saunders, 2016; Kaneva, 2017; Hedling, 2019). Aronczyk (2013) notes that countries in transition focus on internal problems, and only several years into transition, they start grasping the importance of the image they present externally.

Leading authors in the field of nation branding agree that the CEE countries, due to their similar geographical, economic, political, social system and historical roots, constitute a fertile ground for research and analyses of the undertaken nation branding efforts (Szondi, 2007; Anholt, 2013; Surowiec 2016; Ociepka, 2018). Literature review points that academic researchers and practitioners have analyzed nation branding initiatives in certain Central and Eastern European countries (Konecnik & Go, 2007; Volcic & Andrejević, 2011; Surowiec, 2016; Pawlusz & Polese, 2017; Andrei, 2017; Novčić Korać & Miletić, 2018). All of the above indicates that the branding of former communist countries, which are today independent nations, has significantly evolved in less than two decades. This fact enabled researchers and practitioners to identify the most frequent challenges, problems and patterns of nation branding applied in CEE countries. Novčić Korać

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& Šegota (2017) argues that nation branding will enable countries in transition to part from the legacy of the former system, change entrenched stereotypes that are often negative or wrong, find and reconstruct the sometimes blurred nation's identity. Considering the significance and benefits that nation branding can bring to countries in transition, especially post-communist states, this work will analyse the application of nation branding on the examples of Serbia, a state of former Yugoslavia. Therefore, the paper aims to bring deeper knowledge into construct of nation branding, how it is performed, and what influences various stakeholders' perceptions of a post-communist, ex-Yugoslav and transitioning country.

The case of Serbia

It is not possible to begin a story about the former Yugoslav states, the emergence of the new nations in the late 20th century and their efforts to create a recognisable image and identity without introducing the roots and creation of Yugoslavia. In the first decades of the 20th century, on the remnants of the Ottoman and Austro-Hungarian empires, the Kingdom of Yugoslavia was formed - the Kingdom of Serbs, Croats and Slovenes (Petranović, 1988), as the central Balkan state (Petranović, 1988). Yugoslavia was a state that brought together South Slavs and other non-Slav communities; the Orthodox, Catholics, Muslims; members of different cultures (Popesku et al., 2010). The geographical position of the Kingdom of Yugoslavia, at the crossroads of the East and West, ensured favorable conditions for economic development and overall progress. After the Second World War, there was a government change, and the monarchy and the Kingdom of Yugoslavia ceased to exist. With Josip Broz Tito at the helm, there emerged the Socialist Federal Republic of Yugoslavia (SFRY) (Novčić Korać & Miletić, 2018). The author further observes that the SFRY was a community of five peoples that lived in six republics: Slovenia, Croatia, Bosnia and Herzegovina, Serbia, Montenegro and Macedonia. With the change of the state entity, a new ideology was introduced, socialism. The new social and economic system based on socialism and communism directly reflected in the changes in social values, customs, myths, and patterns of behaviour that were considered socially acceptable.

Throughout history, Serbia was part of several large state entities: the Kingdom of Yugoslavia; the Federal People's Republic of Yugoslavia; the Socialist Federal Republic of Yugoslavia; the Federal Republic of Yugoslavia and the State Union of Serbia and Montenegro (Mulec & Wise, 2012). As a consequence of the turbulent political and social past, Serbia changed its name several times for almost a century. Finally, on 5 June 2006, the National Assembly declared the independence of the Republic of Serbia. Thus, Serbia's newly-formed state restored the name last used during the time of the Kingdom of Serbia and simultaneously launched the process of seeking the identity of the nation, which was subordinate to the identity of the broader community in the time of Yugoslavia. Similarly to other former Yugoslav countries, after declaring independence, Serbia faced the challenges of positioning the nation and improving the image and reputation (Novčić Korać & Šegota, 2017).

However, the journey towards an independent Serbia was marked by dynamic historical, political and economic changes, the civil war, international sanctions and NATO bombing, which significantly contributed to creating a negative picture and image of Serbia as "a bad guy" (Kaneva, 2017; Cvijanović et al., 2018). Although it may seem that almost all negative associations linked to the nations involved in the conflicts disappeared with Yugoslavia, some associations continued to haunt the young states, including Serbia. Apart from the significantly tarnished image, Serbia was faced with its nation brand's poor recognisability on the international scene. However, Serbia was probably facing an even bigger problem internally – unclear, inconsistent and somewhat confusing perceptions of Serbia's identity seen by its nationals.

Branding Serbia

Defining the newly-formed nations' identity gained in importance with the end of the conflict in the former Yugoslavia and became one of the main imperatives of the young states. As a need to separate from the past and Yugoslavia, young people seek and recognize a somewhat forgotten identity, returning to their roots, history and tradition. It was in this period that nation branding began being recognised as the way to improve the tarnished image and forgotten identity of Serbia. Dwyer et al. (2016) note that in the 1990s, ethnic identity was used in Serbia as a tool for seeking national identity, often with a political purpose. The author further observes that the historical legacy was the primary source and constituent element of

the Serbian nation's forgotten identity. The first initiatives on this topic emerged with the recognition of the importance of a strategic approach to nation branding (Novčić Korać & Šegota, 2017).

Similarly to most states of the former Yugoslavia, the simplest way for the government bodies to start the complex process of nation branding was to launch initiatives in tourism and present Serbia as an attractive tourism destination. In the late 1990s, the National Tourism Organisation of Serbia (NTOS) presented a promotional brochure, under the slogan "Serbia: Landscape painted from the heart", where mainly elements of ethnic identity were woven into the presentation of Serbian tourism (Novčić Korać & Šegota, 2017). In the publication by NTOS, the term 'landscape' was described with nature and culture. Apart from the landscape, the Serbian, Orthodox tradition was also emphasized, while other communities' cultures and traditions were presented only symbolically (Cvijanović et al., 2018). The change of the political regime at the start of the new millennium brought about a shift in nation's branding direction. In 2000, the new state administration hired the advertising agency Saatchi and Saatchi, to create a new promotional campaign for Serbian tourism. Presenting Serbia as a multi-ethnic country (Paunović, 2014) made the new tourism campaign's backbone.

During the early 2000s, the Serbian state administration invested considerable efforts to improve Serbia's image, strengthening the country and nation's position among Western European countries and attracting foreign investment (Kaneva, 2017). The efforts resulted in the first systematically conceived and strategically created initiative at a national level, aimed at improving Serbia's image globally and building the nation brand. With the idea of creating nation brand, in 2006, the Government of Serbia and the Ministry of Foreign Economic Relations published a call for consultants and agencies that would help improve the nation's image and create a branding platform (Novčić & Štavljanin, 2015). Many leading nation branding experts, including Simon Anholt, were interested in joining the project. In late 2006, the Government's initiative established a state body called the Council for Serbia's Promotion, colloquially known as the Council for Branding of Serbia. The main goal of forming the Council was to create the National Strategy for the Promotion of Serbia that the Government would later adopt.

In cooperation with the NTOS, the Council and the Ministry of Trade and Tourism launched two promotional videos for presenting Serbia's tourist offer, under the slogan "Sights and Sounds of Serbia" and as part of the campaign "Moments to Remember". The first video was screened on *CNN Today* in 2007 (Mulec & Wise, 2012). However, the work of the Council for Branding of Serbia was followed by many controversies, partly stemming from the inadequate communication of essential information related to its mission and expected outcomes. Although the Council launched several initiatives, such as hosting the Eurosong 2008 and the Summer Universiade 2009, the undertaken efforts had a short-term effect. The media and political turmoil related to the Council's work led to animosity on the general public's part towards the Council and the entire nation branding concept (Paunović, 2014). In a short period, the Council was dismantled. This occasion led to a shift in the state administration's focus from developing and implementing the nation branding strategy and setting the strategic framework for Serbia's promotion to higher priority issues for the country. Today, the branding initiatives focus primarily on presenting Serbia as a tourism destination, with the NTOS at the helm of almost all initiatives. Since 2015, the main focus of NTOS promotional campaigns have been divided into two streams, and the internal campaign called "*My Serbia*" and the external campaign "*The Danube in Serbia: 588 Impressions*" (Novčić Korać & Šegota, 2017).

Just as an increasing number of governments turn to the marketing and branding techniques to emphasize their differential advantages, Serbia also needs to embrace nation branding as a strategic goal at a national level. Some of the main problems arising in the implementation of nation branding in Serbia are false understanding of the concept, insufficient commitment, complexity, a large number of stakeholders and the lack of a solid model (Novčić Korać & Miletić, 2018). Hence, this research aims to provide the conceptualization of the Serbia nation branding model.

Conceptualization of nation branding model

For this research's purpose, the destination branding model developed by Risitano (2006) was a starting point for the conceptualization of the Serbia nation branding model. Risitano's model, presented below, as a result of the author's work on the branding platform for regional park Campi Flegrei, an area west from Naples's city in Italy. Campi Flegrei is famous as a volcanic region rich in archaeological sites and insufficiently researched and inadequately communicated destination.

The model analyzes the place brand from the point of brand creators (who initiate communication) and the brand "consumer" (brand users, communication recipients). The brand creators are in charge of defin-

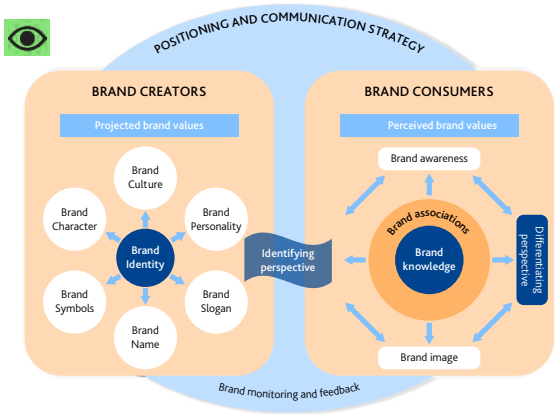

Figure 1. Destination branding model
Source: Risitano (2006)

ing, selecting and developing the elements of place brand identity such as brand name, slogan, personality, character, culture and symbols. The designed elements of brand identity that are in line with the current perception and the brand's desired position are based on a place's unique brand values. Therefore, the elements of brand identity are only manifestations of the defined brand values. Place brand creators, on the other hand, are also obliged to analyse how various brand consumers perceive the selected values by determining current brand perception, analysing brand knowledge, brand association, brand image and brand awareness. Both aspects of the model are equally important, but Risitano underlines that the creation of a relevant place brand needs a focus on the core of the model - the brand identity of a place. The essence of brand identity in the model consists of identifying brand perspectives and points of difference, which are the foundation for developing a brand positioning strategy.

Having everything said, Risitano's model was found to be the only theoretical model that comprehends both internal and external perspectives of place brand creation and management and gives an overall understanding of what place/nation branding exactly means. Compared to other available models and indexes, Risitano's model proved to be very useful when analyzing different perspectives of place branding above all because of its complex and layered approach (Popesku et al. 2010). Therefore, Risitano's model of destination branding was found to apply to different levels of place brands (Novčić Korać & Šegota, 2017), more specific to nation branding and due to this, the model was chosen as a basis for the development of Serbia nation branding model. The initial branding model was adapted to the nation branding concept and tested in this research.

To start developing a nation brand, it is first necessary to determine the nation's current perception and evaluate the initial position. In their work, Bolin (2016) and Hedling (2019) highlight the short-term effects of destination brand development and management, focusing only on inputs from one group of stakeholders. To get the whole picture of a brand's current perception and determine the points of difference for Serbia's brand identity, internal and external stakeholders are examined. The starting point for the survey conduct in this research is that *the internal and external perception of the key elements of the brand identity directly affects the positioning of Serbia*. After examining the available literature on nation branding, we conclude that there is a small number of original research papers and projects on Serbia's branding, which makes this topic insufficiently explored and particularly interesting for further research. Also, we found that *perceptions of brand Serbia have not been examined (quantitatively or qualitatively), nor has the nation's image been presented from various groups of stakeholders' viewpoints.* Also, *there are no research papers that identify the key points of difference for Serbia's brand or those proposing a nation branding model for Serbia.* Identifying the key points of difference for the nation brand and defining the nation branding model for Serbia could enable the development of an adequate strategy for improving the market position and perceptions of Serbia's image on the international stage. Moreover, it has been concluded that there is no systematic approach to branding Serbia at a higher institutional level, intending to improve the global market position. The paper aims to gain insight into Serbia's current brand perception, a developing country, which can find an opportunity for rebirth and parting with previous legacy in the implementation of the nation branding concept. This research also aims to reveal and understand the hidden structure of brand Serbia from internal and, even more important, external stakeholders. The paper's main idea is to propose a Serbia nation branding model, built upon internal and external stakeholder perception.

Methodology

Quantitative research with statistical methods is applied to a satisfactory sample (greater than 150 participants) and provides results with a satisfactory level of significance (Nath, 2007). Quantitative methods determine internal and external brand identity models and identify the dominant values (points of difference) of brand Serbia, which create the Serbia nation branding model.

Serbia's internal and external perception was conducted in four states for three and a half years, from October 2011 to April 2015. Bearing in mind that the first part of the survey included respondents in three foreign countries (external stakeholder groups), external research was conducted in the following three stages:

1. October 2011, SLOVENIA (N=2,063);
2. November 2013 - July 2014, ITALY (N=323);
3. May 2014 - February 2015, AUSTRIA (N=317).

The second part, the internal research, was carried out in Serbia in March and April 2015. The survey among internal stakeholders was conducted via the Internet, using online questionnaires, and the call to participate was advertised on social networks Facebook, Twitter and LinkedIn. In informing the respondents about the survey, companies' and specialized organizations' mailing lists were used. Influential bloggers and forums also free willingly posted a call to participate in the survey. The research sparked great interest and positive comments by the internal public as it explores a hot topic – Serbia's branding. In a survey of Serbia's internal perceptions over 25 days, 1,710 responses, of which 1,650 valid (96.5%) were collected.

Questionnaire

The primary tool for collecting data is an online questionnaire. The questionnaire was designed upon Risitano's (2006) work, which proposed a theoretical framework for analyzing nation brand identity elements. The questionnaire consists of seven clusters of questions: 1. *General questions* – demography referring to gender, age, educational background, employment, citizenship, and consumer behavior when using a brand (purpose and frequency of visits); 2. *Brand culture* – important features of culture, seen from two aspects: a) culture of a nation (Serbs): "spirit" of people, tradition, important events, gastronomy, etc. and b) culture of a country (Serbia): cultural heritage, historical landmarks, monuments, archaeological sites, monasteries and churches; 3. *Brand personality* – describing the nation as a person with demographic characteristics such as gender and age; 4) *Brand character* – exploring the perceived character of a brand; 5) *Brand symbols* – the elements that fundamentally determine the brand, primary and secondary brand associations (famous people, events, landmarks, cities, music groups, etc.); 6) *Brand name* – associate ions to brand name in terms of uniqueness, strength, and recognition; and 7) *Brand slogan* – recall and recognition of brand slogan.

The questionnaire designed for internal and external research includes a combination of open and closed questions. The final questionnaire for internal research consists of 7 open, 11 closed questions and 38 attitudinal statements, while the questionnaire designed for external study contains an additional closed question. The questionnaire consists of a relatively large number of attitudinal statements on several frequent stereotype attitudes shared in the discourse of everyday communication, media, history and the collective consciousness of the Serbs. Attitudinal statements were collected over 12 months from national media (TV and newspapers) and ten focus groups (Novčić et al., 2012). Within ten focus groups, where representatives of all social segments participated, previously collected attitudinal statements were tested, and only appropriate ones were chosen for the research. In confirmatory research, PCA was used to distinguish the significant from the insignificant elements of Serbia brand identity and reveal the hidden structure of the brand. To measure attitudes, a five-item Likert scale was used with strongly disagree – weight of 1, and strongly agree – weight of 5, as the scale anchors and "I don't know" answer was offered as well. Closed questions exploring brand personality (gender, age and brand letter) and brand symbols (state symbols: national flag colors, state amblem and moto) were measured based on predefined answers. Within this group of questions, "I don't know" answer was also offered. The questionnaire's form and structure were the same in all countries covered by the research, with minor variations depending on whether the questionnaire was intended for the internal or external survey. In the survey conducted in Italy, Austria and Slovenia, the questionnaires were translated into those countries' official languages.

Sample and sampling

Respondents were divided into two groups, internal and external stakeholders. The population within the first group of respondents consists of internal stakeholders (members of the Nation), primarily Serbian residents. According to official data, in January 2014, the estimated size of Serbia's population was 7,146,759 (Statistical Office of RS, 2014). Data analysis indicated that the Serbian nation members with a permanent residence in another country also participated in the survey. The diaspora was included in Serbia brand perception research because it counts around 4 million Serbs (Ministry of Foreign Affairs of the Republic of Serbia, 2014), as well as due to Serbia's economic dependence on the diaspora. National Bank of Serbia (2013) states that the diaspora in 2012 sent Serbia 1.73 billion Euros, equivalent to 6.5% of GDP. For these reasons, internal perception research included all members of the Serbian nation older than 18 (residents of Serbia and the diaspora), regardless of residence.

The second group of respondents included the most important external stakeholders for Serbia, which significantly impacted the creation and presentation of Serbia's image in Europe and the world. External stakeholders involved in the study consisted of business class members in Italy, Austria and Slovenia. The main criteria for the selection of the three countries were: number of direct foreign investments in Serbia, economic relations (the value of exports and imports), business cooperation (number of foreign companies operating in Serbia), the frequency of visits, and historical, cultural and social tie. There are over 500 Italian companies doing business in Serbia (Serbian Chamber of Commerce, 2013). In the first half of 2014, Italy was Serbia's number one trading partner, first by the value of exports (1.43 million dollars) and second by imports (1.23 million dollars) (PKS Milano Info, 2014). On the other hand, Austria is the largest single foreign investor and second-largest by the number of companies (around 400), directly or through representatives operating in Serbia (SIEPA, 2014; Serbian Chamber of Commerce, 2015). Italy, Austria and Slovenia are the three leading partners of Serbia in the number of projects and value of investments (SIEPA, 2014).

Several sampling techniques were applied in the study. For online research, a combination of convenient and snowball sample was applied, and random online sampling. Samples in all countries surveyed are three-digit, stratified according to the criteria of gender, age and educational level. A total number of 4,353 responses was acquired: 2,703 external and 1,650 internal survey.

Surveying techniques

For the online survey, the questionnaire was created using the online survey tool www.kwiksurveys.com. In implementing the research in Italy, Austria and Slovenia, the participants were informed about the survey through social networks and mailing lists. The questionnaire and survey were advertised on professional social networks (such as LinkedIn), and in groups of business associations, in the countries covered by the survey. Also, information about the research and a link to the survey were posted on professional associations' websites. In conducting the research in Italy, Austria and Slovenia, of great importance were business contacts and mailing lists obtained from the consulate and Economic Attaché in the Embassy of the Republic of Serbia. As a result, the research was supported by the Embassy of the Republic of Serbia in Italy and Austria, which added value to the research and contributed to a large number of responses. Serbian Chamber of Commerce, with its representative offices, along with the Austrian and Italian Chamber of Commerce also supported the research by providing their business contact lists.

In order to determine the current state of internal and external perception of brand Serbia and to reveal the hidden structure of brand Serbia, several statistical tools were applied. Data collected through internal and external research were coded, entered and analyzed using SPSS 21.0. Guided by Pallant (2007) good practice and Malhotra (2007), data screening was performed before data analysis to check for possible errors, incomplete data, and delete duplicate responses. After data screening was completed, it was proceeded to data processing using the following statistical tools:

1. *Descriptive statistics* (mean, mode, standard deviation, frequency analysis) determine the average values of the investigated problem.
2. *Explorative factor analysis* – EFA, principal component analysis (PCA) was used to reveal the hidden structure of brand Serbia and to discover dominant elements of Serbia's brand identity. To establish the optimal number of factors, a parallel analysis was conducted using the Monte Carlo simulation. Having determined the optimal number of factors, EFA identified the dominant elements and variables that constitute brand Serbia. The ultimate goal of factor analysis was to identify elements of the nation brand identity that are reliable and can be interpreted in each of the samples. Based on the results, EFA identified the main components, variables and their interrelations, which created internal and external brand identity models. Serbia brand identity models and the Serbia nation branding model were created based on the results of EFA.

Data analysis

The final survey sample consisted of 4,353 examinees (2,703 external samples and 1,650 internal sample - Serbian nationals). All four groups in terms of size, were suitable for PCA. As this study aimed to reveal the hidden structure of brand Serbia and determine the dominant elements (points of difference) in internal and external stakeholders' perception, the first step was to split the dataset into four groups – internal (Serbian nationals) and external stakeholders: Italy, Austria and Slovenia, and conduct separate analyses. Based on the obtained results, the second step was to propose internal and external brand identity models for Serbia, which will serve as a foundation for the development of the Serbia nation branding model in the final step.

Brand identity analysis – external perception

The external sample was divided into three groups: Italy, Austria and Slovenia and analyzed separately to perform suitable PCA. After the results from all three groups were obtained, they were compared, and the external brand identity model was proposed.

Italy – The examined Italian sample (n=323) was, on average, 41.37 years old (SD 10.366, median 40, mode 40, range 23-71 years). Before performing PCA, data were assessed for suitability, PCA was performed five times, and all attitudinal statements with communalities below .5 were excluded. After the final PCA iteration, 17 out of 38 attitudinal statements were left with communalities exceeding .5 and PCA was then entirely performed (see Table 1).

Table 1. PCA indicators for Italy

Indicators	Values
No. of variable (communalities < 0.5)	17
KMO	.894
Bartlett's test	.000
No. of factors	6
Parallel analysis (final number of factors)	4
Total variance explained	64.9%

Source: authors calculation

The obtained four-component solution explained 64.9% of Serbia brand structure, and all elements met the minimum requirements of reliability. Therefore, it was proceeded to data interpretation (see Table 2 for the results of PCA). After a detailed analysis of the Italian perception of brand Serbia, the following four elements (components) of Serbia brand identity were identified and named: C1) **People and mentality**, C2) **Business destination**, C3) **Media influence** and C4) **National treasures**.

Table 2. Serbia brand identity Italian perception – rotated component matrix for PCA with Oblimin rotation for 4 factors solution

Attitudinal statements	Pattern/structure coefficients				Comm.
	C1	C2	C3	C4	
Serbs love to know everything	.777	-.091	.034	-.009	.651
Serbs love folk music	.768	-.012	-.026	-.026	.576
Serbs are good lovers	.731	-.187	-.017	-.046	.619
Serbs are greeting with three fingers	.724	.023	.026	.098	.592
Celebrations play vital role in the lives of Serbians	.675	.028	.003	.211	.623
Serbia is safe and secure	.101	-.821	-.021	-.029	.719
Serbia is a country in which one should invest	.096	-.795	.037	-.106	.622
Serbia is a country of hospitality	.101	-.742	-.061	.176	.769
Serbia is a country I would recommend to every foreign visitor	-.076	-.701	-.067	.128	.551
Serbia is a country with high-quality products	.170	-.546	.057	.166	.514
The image of Serbia in media is better than reality	.060	.083	.769	.025	.606
The image of Serbia in the media is positive	-.210	-.323	.769	.011	.664
Serbia is as presented by the foreign media	.151	.256	.692	-.037	.570
Serbia is rich in monuments	-.014	-.001	-.021	.894	.790
Serbia is rich in nature beauties	-.079	-.026	.032	.825	.638
Serbia is rich in archeological sights	.113	-.036	.010	.814	.791
Serbia is rich in monasteries	.143	-.002	-.024	.778	.738
	C1	C2	C3	C4	
% of variance explained	36.9	10.9	9.5	7.6	
Cronbach alpha	.832	.848	.600	.879	
Mean	4.26	3.73	2.40	4.18	
St. deviation	1.39	1.43	1.03	1.28	

Source: authors calculation

Austria - A total of 317 representatives of the Austrian business class, participated in the survey. The sample's average age was 40.6 years (SD 11.442, median 39.50, mode 29, range 23-73 years). Data were checked for suitability, PCA was performed five times, and 12 attitudinal statements were left with communalities higher than 0.5. After that, PCA was fully performed (for PCA indicators, see Table 3), and the final results revealed four brand identity elements.

Table 3. PCA indicators for Austria

Indicators	Values
No. of variable (communalities < 0.5)	12
KMO	.807
Bartlett's test	.000
No. of factors	6
Parallel analysis (number of factors)	4
Total variance explained	67.31%

Source: authors calculation

The results which emerged from PCA on Austrian perception explained almost 70% of Serbia brand structure, and all elements met the minimum requirements of reliability. After a detailed analysis of the obtained results, data were interpreted (see Table 4 for results of PCA), and four elements (components) of Serbia brand identity were identified: C1) **National treasures**, C2) **Business destination**, C3) **Media influence**, and C4) **People and mentality**.

Slovenia – The Slovenia sample consisted of 2,063 representatives of the Slovenian business class, with an average age of 41.35 (SD 43.860, median 40.00, mode 35, and range 22-74 years). Before the application of PCA, the suitability of data for factor analysis was assessed. PCA was repeated three times to exclude attitudinal statements with communalities lower than 0.5, until 16 attitudinal statements were left. PCA was then fully performed (see Table 5).

Table 5. PCA indicators for Slovenia

Indicators	Values
No. of variable (communalities < 0.5)	16
KMO	.759
Bartlett's test	.000
No. of factors	7
Parallel analysis (number of factors)	5
Total variance explained	66.3%

Source: authors calculation

The results of factor analysis uncovered a simple and straightforward structure of elements that constitute Serbia's brand identity (for results of PCA, see Table 6). As the final result, a five-element (component) solution emerged, obtained results were interpreted,

Table 4. Serbia brand identity Austrian perception – rotated component matrix for PCA with Oblimin rotation for 4 factor solution

Attitudinal statements	Pattern/structure coefficients				Comm.
	C1	C2	C3	C4	
Serbia is rich in monuments	.840	-.048	.016	.052	.729
Serbia is rich in archeological sights	.824	-.056	.003	.116	.739
Serbia is rich in nature beauties	.794	.045	.039	-.101	.622
Serbia is rich in monasteries	.771	.071	-.009	-.046	.598
Serbia is safe and secure	-.020	.884	-.053	.020	.768
Serbia is country with high-quality products	.184	.681	.044	.142	.638
The image of Serbia in media is better than reality	.118	-.126	.836	.052	.765
Serbia is as presented by the foreign media	.022	-.074	.780	.158	.672
The image of Serbia in media is positive	-.030	.423	.616	-.158	.598
Serbs love to know everything	.094	-.076	-.009	.819	.714
Serbs are good lovers	-.071	-.009	.160	.754	.598
Serbs are nicely up brought	.058	.349	-.086	.661	.636
	C1	C2	C3	C4	
% of variance explained	33.96	11.46	11.35	10.54	
Cronbach alpha	.831	.654	.687	.688	
Mean	4.46	3.41	3.17	4.17	
St. deviation	1.31	1.47	1.63	1.57	

Source: authors calculation

Table 6. Serbia brand identity Slovenian perception – rotated component matrix for PCA with Oblimin rotation for 5 factor solution

Attitudinal statements	Pattern/structure coefficients					Comm.
	C1	C2	C3	C4	C5	
Serbia is rich in archeological sights	.876	-.009	.077	.011	.130	.709
Serbia is rich in monuments	.803	.020	.031	-.016	-.093	.714
Serbia is rich in nature beauties	.782	-.023	-.046	-.021	-.012	.619
Serbia is rich in monasteries	.731	.018	-.061	.020	-.093	.595
Serbia is safe and secure	.001	.856	-.008	.072	.029	.704
Serbia is a country of comfort food	.008	.825	.007	.167	.002	.632
Serbia is country of hospitality	-.032	.688	-.011	-.172	-.047	.571
When mentioning Serbia, I only have nice associations	.028	.594	.004	-.255	.011	.503
Serbia is as presented by the foreign media	.011	-.007	.907	.002	.007	.823
Serbia is as presented by the domestic media	-.004	.008	.906	-.004	-.028	.825
Serbia is modern and developed	.004	-.048	-.009	-.882	-.007	.758
Serbia is European country	-.026	.051	.013	-.805	-.012	.672
Serbia is mainly urban	.023	.011	-.004	-.733	.028	.544
Church plays vital role in lives of Serbian people	.001	.016	-.051	-.017	-.846	.687
Celebrations play vital role in the lives of Serbians	-.043	-.019	.091	-.001	-.832	.714
In Serbia, tradition is specially nurtured	.076	-.001	-.020	.029	-.698	.531
	C1	C2	C3	C4	C5	
% of variance explained	20.2	18.0	10.4	9.4	8.3	
Cronbach alpha	.819	.742	.791	.746	.717	
Mean	3.61	3.95	2.59	2.55	4.05	
St. deviation	.85	.89	.88	.82	.84	

Source: authors calculation

and elements of brand identity were identified in the following way: C1) **National treasures**, C2) **Tourism destination**, C3) **Media influence**, C4) **Underdevelopment**, and C5) **Cultural heritage**.

Brand identity analysis– internal perception

The surveyed Serbian nationals were (n=1,650), on average 31.73 years old (SD 31.324, median 31, mode 30, range 19-76 years). Before performing PCA, the suitability of data for factor analysis was assessed. PCA was repeated six times with the exclusion of attitudinal statements with communalities lower than 0.5. From the initial 38 attitudinal statements, 13 were suitable. PCA was then fully performed (for more details, see Table 7).

Table 7. PCA indicators for Serbia

Indicators	Values
No. of variable (communalities < 0.5)	13
KMO	.756
Bartlett's test	.000
No. of factors	5
Parallel analysis (number of factors)	5
Total variance explained	66.6%

Source: authors calculation

The obtained results met the minimum requirement of reliability for all of the five elements and it has proceeded to the interpretation of results. As Table 8 shows, factor analysis revealed Serbia's hidden structure brand, which was very simple. Based on the results obtained from factor analysis of the internal perception of brand Serbia and supported by a reliability test, it could be concluded that the most dominant elements of brand identity were: 1) **National treasures**, 2) **Distorted image**, 3) **Tourism destination**, 4) **Media influence** and 5) **People**.

Table 8. Serbia brand identity Serbian perception –rotated component matrix for PCA with Oblimin rotation for 5 factor solution

Attitudinal statements	Pattern/structure coefficients					Comm.
	C1	C2	C3	C4	C5	
Serbia is rich in monuments	.829	-.010	-.009	-.004	-.232	.631
Serbia is rich in archeological sights	.801	-.002	-.007	.029	-.035	.655
Serbia is rich in monasteries	.733	.024	.008	-.039	.153	.608
Serbia is rich in nature beauties	.637	-.023	.070	.017	.232	.569
The image of Serbia in media is positive	.005	.858	.124	-.028	-.015	.721
The media image of Serbia is better than reality	-.006	.825	-.125	.015	-.001	.735
Serbia is safe and secure	-.065	-.040	.816	-.028	-.163	.649
Serbia is country of hospitality	.036	.065	.733	.058	.185	.669
Serbia is country I would recommend to every foreign visitor	.124	-.009	.716	.013	.116	.600
Serbia is as presented by the domestic media	.031	-.063	.066	-.883	.084	.703
Serbia is as presented by the foreign media	-.033	.094	-.088	-.765	-.086	.680
Serbs are talented for sports	.016	-.021	-.005	.007	.833	.676
Serbs are beautiful nation	-.012	-.020	.045	-.005	.810	.758
	C1	C2	C3	C4	C5	
% of variance explained	25.7	113.4	10.9	8.4	8.1	
Cronbach alpha	.747	.595	.669	.540	.647	
Mean	4.24	2.63	2.40	2.27	4.27	
St. deviation	.87	1.14	.95	1.01	.82	

Source: authors calculation

The proposition of a nation branding model

At the core of every branding model are brand values that fundamentally determine and differentiate the brand. Accordingly, the foundation for developing a nation branding model is to define the key values and unique brand elements that would indicate the areas for brand Serbia to focus. Therefore, the Serbia nation branding model development's foundation would be external and internal brand identity models (see Figure 2). Quantitative research helped identify internal and external brand identity models propositions, and they will be used to develop the Serbia nation branding model.

Serbia brand identity model – external perception

The hidden structure of external brand perception pointed to elements with a dominant position in external respondents' organized knowledge about Serbia. Elements identified as the most important in Italy, Austria and Slovenia represent inputs for Serbia's external brand identity model. Respondents in all countries covered by the research are unanimous, outlining national treasures and media influence as the most important brand Serbia elements. Aside from those as mentioned above, it was discovered that external stakeholders recognize Serbia as a desirable business (Italy and Austria) and tourism (Slovenia) destination, so both components found its place in the model. The Serbian nation (people) and specific Serbian mentality are the least important elements of brand Serbia. In order to position Serbia in Italy, Austria and Slovenia, Serbia external brand identity model proposition should consist of the following elements:

1. **National treasures**. Identified as the most recognizable element and the most dominant value of Serbia and is defined by monuments, archaeological sites, monasteries and natural beauties. National treasures are related to all elements in the model and directly impact the element "business and tourism destination".
2. **Media influence**. Although it may seem like the media do not find its rightful place in the nation brand identity model, one needs to bear in mind that media have the most substantial influence on creating Serbia's awareness and image among external stakeholders. The second-place element in the model confirms the role of media in creating and presenting image externally. Foreign media who project bias, negative and unrealistic images represent the main source of information for Serbia and Serbs' external stakeholders. For this rea-

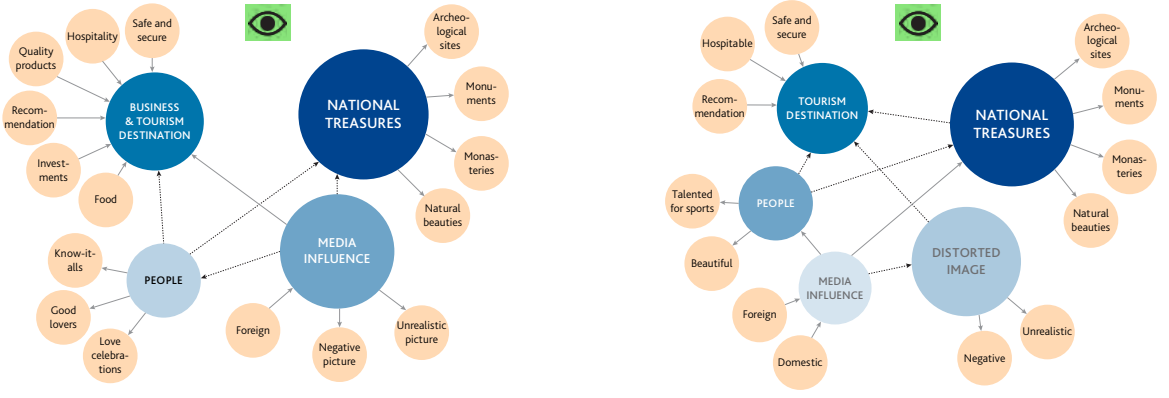

Figure 2. Serbia brand identity models proposition

son, foreign media influence is directly connected to other elements in the model, shaping the representation of the Serbian nation, national treasures, tourism and business opportunities.

3. **Business and tourism destination**. Serbia's potential as a business and tourism destination is also recognized in the model and defined by the following characteristics: safe and secure, hospitable, high-quality products, recommendation, investment potential and gourmet cuisine. Due to the complex nature of the element "business and tourism destination", all factors in the model directly influence the element.
4. **People and mentality.** The Serbian nation is perceived as inquisitive people, good lovers, and people whose lives celebrations have an important place. This element's very nature points out the impact and roles that people have in creating a tourism and business destination and in the presentation of national treasures.

Of great importance for the brand identity model's development are roles and relations between the selected elements and their pertaining variables.

Serbia brand identity model – internal perception

The results from the exploratory factor analysis on internal stakeholders' attitudes and opinions referred to an invisible structure of brand Serbia seen through the Serbian nation's eyes. The internal perception results revealed a slightly different structure of brand Serbia and gave a new dimension to the observed phenomenon. Analysis of internal perception discovered the following dominant elements of brand Serbia:

1. **National treasures**. The most dominant element of brand Serbia, with the same place, role and relations with variables (archaeological sites, monuments, monasteries and natural beauties) as in the external perception model.
2. **Distorted image.** The next element by importance in the model is a distorted image that holds an important place in internal stakeholders' consciousness. The projection of the distorted, negative and unrealistic image has a strong, direct influence on image creation and presentation of Serbia as a tourism destination.
3. **Tourism destination.** In the internal brand identity model, Serbia is recognized exclusively as a tourism destination and determined as safe and secure, hospitable, and a destination to recommend to every foreigner.
4. **People.** Internal stakeholders also outline members of the nation as one of the most important components of brand Serbia. The element is defined by two variables: a talent for sports and a beautiful nation, implying a different internal and external perception of the nation's features. An important role of nation members in the model was confirmed through relations with the majority of elements. Therefore, people have a direct impact on tourism and national treasures.
5. **Media influence.** In addition to the distorted image, domestic and foreign media's impact is recognized, which is confirmed by the direct influence of media on creating Serbia's unrealistic image. The Serbian nation shares the opinion that Serbia's image is not what is presented both by domestic and foreign media. The media also have a weaker impact on the everyday life of the nation and the presentation of treasures.

The proposed external and internal brand identity models presented a hidden structure of brand Serbia and insight into the different levels of significance of selected brand elements. Although organized brand knowledge overlaps in internal and external perception, far more important are the results that indicate a divergence in the perception of fundamental brand elements. To harmonize the differences in percep-

tion and achieve a better position of Serbia in the consciousness of internal and external stakeholders, it is necessary to choose a set of elements that will be attractive to both groups. Identified brand elements are foundations for nation's competitiveness and basis for nation branding model development.

Serbia nation branding model

To materialize the concept of nation branding, the Serbia nation branding model was created (see Figure 3). The results of this research on the current state of external and internal perception of brand Serbia pointed to the following nation's competitiveness: **national treasures**, **tourism destination**, **business destination** and **people**. The identified nation's competiveness are areas on which future Serbia branding strategy should focus. Through further analysis of the nation branding model, the important role that media (local and foreign) have in representing brand Serbia, shaping the nation's image and perception internally and externally, is evident. Therefore, the creation of an adequate branding strategy for Serbia needs to rely on the media's influence.

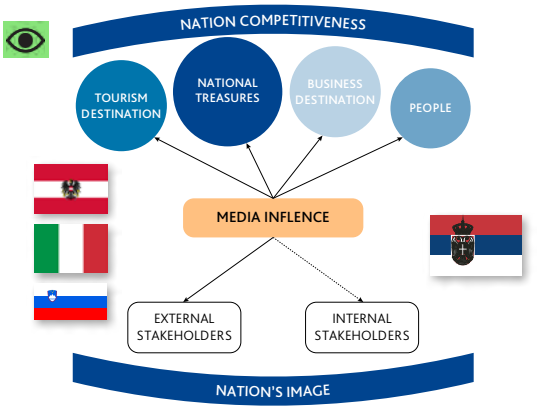

Figure 3: Nation branding model for Serbia

Conclusion and discussion

Although gaining significance over the past decade, nation branding is still a relatively new concept in Serbia that is in the initial phase. After analysing the situation in practice, it can be concluded that since gaining independence, Serbia has recognized the importance of the implementation of the nation branding concept. Moreover, initiatives have been launched to take a systemic approach to create a strategic framework, national strategy and platform at a national level that would result in concrete branding actions. However, due to the lack of understanding of the very concept, influential factors, and the need for a long-term perspective of nation branding, no initiative has taken root. Novčić Korać & Miletić (2018) identified the following shortcomings as the main limiting factors for branding Serbia: the lack of financial backing for the branding project, pressures to achieve short-term results when there is a need for long-term investments in building a consistent nation brand, which is further reflected in sending inconsistent messages and difficulties in developing a coherent brand platform for Serbia. Today, the promotion of Serbia, as a result of the mentioned influences, boils down to presenting Serbia primarily as a tourism destination (Novčić Korać & Šegota, 2017).

For the first time, this study gives an overview of Serbia's organized knowledge from the perspective of internal and the most important external stakeholders of Serbia. By proposing internal and external Serbia brand identity models, the most important elements of brand Serbia's hidden structure are revealed. Elements identified as the nation's competitiveness in the proposed Serbia nation branding model present core values and brand Serbia's essence. Due to the significant place that the selected elements have in the consciousness of external and internal stakeholders, Serbia can build a unique market position by focusing on the above-mentioned. It is important to note that although some elements have a more important place in the model, all nation's competitiveness must be treated equally in nation branding. By applying this approach, the elements which are currently less important in the model may, in the long run, have the desired differentiating effect in stakeholders' consciousness. In support of the conclusion, it has to be pointed out that people (members of the nation) are recognized as a brand element with the greatest potential to change the current and create the future, new image of Serbia. The proposed internal and external Serbia brand identity models and the Serbia nation branding model, can serve as a first step in the implementation of a nation branding in Serbia.

Future research on the topic of nation branding can rely on the data gained from this research and further explore whether and how perceptions change over time by exploring different time series on the same sample. Considering that this research investigates the only external perception of business class in Italy,

Austria and Slovenia, future research should explore other stakeholder groups within each country. Finally, the future course of the research of Serbia's brand perception should consider widening the research sample to new countries that could become important stakeholders over time.

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ERRATUM

Investigating micrometeorological differences between steppe, forest-steppe and forest environment in northern Serbia during a clear and sunny autumn day
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In the article authored by Milošević D., Dunjić J., and Stojanović V., entitled „Investigating micrometeorological differences between steppe, forest-steppe and forest environment in northern Serbia during a clear and sunny autumn day" which was published in issue 3 (vol. 24) of Geographica Pannonica journal, one of the stated formulas (Method and data section, page 180, Humidex formula) has been misspelled in the stage of technical preparation of the article. We sincerely apologize to the readers for the inconvenience. With the author's permission, in this issue we publish the corrected formula.

misspelled formula

$$H = T_{air} + \frac{5}{9}\left(6.112 \cdot 10^{\frac{7.5 \cdot T_{air}}{237.7 + T_{air}}} \cdot \frac{RH}{100 - 10}\right)$$

corrected formula

$$H = T_{AIR} + \frac{5}{9} \cdot \left(6.112 \cdot 10^{\frac{7.5 \cdot T_{AIR}}{237.7 + T_{AIR}}} \cdot \frac{r_H}{100} - 10\right)$$

Editorial board