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CLIMATE CHANGE AND ITS POSSIBLE IMPACTS ON THE URBAN AREAS IN SW SLOVAKIA

Abstract: The paper is devoted to a brief analysis of possible climate change impacts on the sub-urban and urban areas of south-western Slovakia. Climate change due to the enhanced greenhouse effect can result in about 2.5°C increase in the mean global temperature until 2100. In Slovakia it is assumed to be a range of 2 to 4°C. On the other hand, additional warming of urban areas is caused mainly by a changed heat balance of the land surfaces in urbanized agglomerations (concrete, asphalt, buildings, cobblestones, etc.) and partly also by thermal pollution (release of energy from heating and other human activities). In smaller towns the urban effect causes warming by about 0.5°C, in the largest cities up to 2°C in the mean annual temperature on a long-term average. A review of research on urban climate in Slovakia to date is included. Future plans to study and improve urban climate are listed in the paper.

Key words: climate change, urban climate, Bratislava, Slovakia
Słowa kluczowe: zmiany klimatu, klimat miasta, Bratysława, Słowacja

Introduction

The south-western region of Slovakia represents the most populated and the most developed part of the country. Its territory is 2,053 sq km, with about 623,000 inhabitants. The GDP per capita in this region reaches about 116% of the EU 25 average and constitutes 26% of the Slovak GDP. Bratislava agglomeration has 853 sq km and 546,000 inhabitants. Over about 200,000 people travel to Bratislava as employees every day. The specifity of climatic conditions in Bratislava result partly from the special geography (the Little Carpathians ridge divides Bratislava region into two parts) and partly from the urban climate. It was found that the Bratislava centre is warmer by about 0.5°C compared to near sub-urban localities with the same topography. Considering exceptional synoptic situations, the deviations between air temperature in the city centre and in the sites outside of the city can reach even more than 15°C. Similar results were also found in the city of Kosice (Fig. 1). Climate change impacts

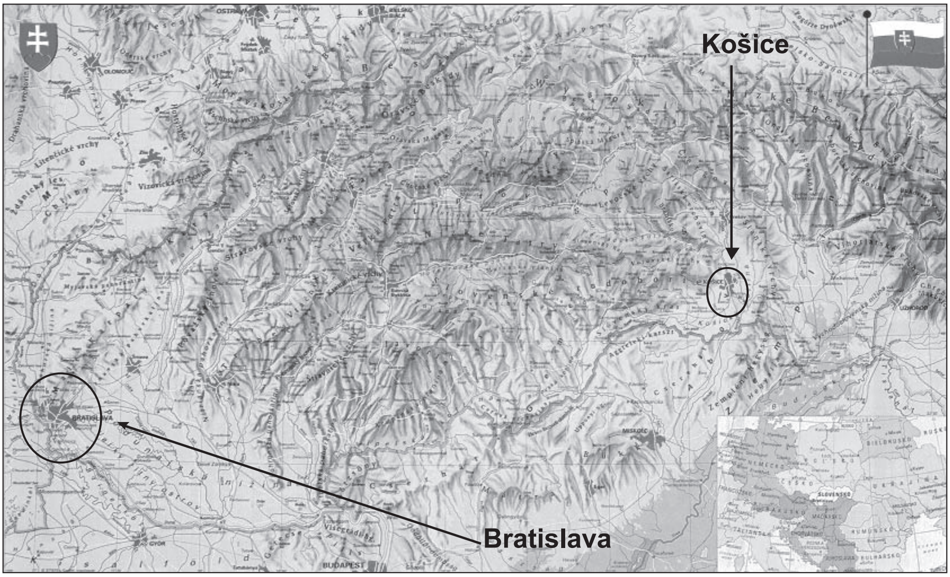

Fig. 1. Map of Slovakia with Bratislava and Kosice regions

Ryc. 1. Mapa Słowacji z rejonami Bratysławy i Koszyc

have been in the centre of interest since 1991 when the Slovak National Climate Program started its activities. It has been determined that the linear trend of mean annual temperature in Slovakia gained 1.7°C during the 129-year period 1881–2009. This temperature increase is much greater than the global temperature rise (*IPCC Publications* 2010). It is expected that another 2 to 4°C temperature increase can occur by the end of the 21st century.

Urban climate research to date

The urban climate was studied in Slovakia in Bratislava in 1981–1985 and in Kosice in 1986–1990 within research projects ordered by the authorities of these cities. We used data from the regular climatological observing network at the stations: Bratislava-Airport, Bratislava-Koliba, Bratislava-city centre (Trnavska Street up to 1982, Bratislava-Mlynska dolina since 1982), Petrzalka, Maly Javornik, Kosice-letisko, Kosice-Podhradova, Kosice-Park gen. Petrova, Kosice-Heringes), 6 special-purpose stations in Bratislava and 4 in Kosice.

Apart from these we conducted so called measuring drives (measurements of temperature and relative humidity by automatic station sensors attached on top of a car) and expedition measurement of wind and other elements at selected sites during measuring rides (the results are published in research reports, in the journal *Meteorologické zprávy* (Lapin *et al.* 1987) and in the Proceedings (Zborník prác) of the Slovak Hydrometeorological Institute; *The 5th National Communication of the Slovak Republic on Climate Change* 2009). Some additional details from these analyses can be seen in Table 1 and Figure 2. Trnavka (TR) and Medicka Zahrada Park (MZ) are in the city centre, Raca (RA, 149 m a.s.l.) at the SE foot of the Little Carpathians, Kuchyna (KU, 213 m a.s.l.) and Kralova (KS, 123 m a.s.l.) lie 25 km from the city centre to NW and SE. The other stations: Zahorska Bystrica (ZB, 176 m a.s.l.), Mlynska Dolina (MD, 182 m a.s.l.) and Lamac (LA, 197 m a.s.l.) lie in western Bratislava, Petrzalka (PE, 135 m a.s.l.) and Rusovce (RU, 133 m a.s.l.) lie in southern Bratislava, Koliba (BK, 286 m a.s.l.) and Maly Javorník (MJ, 586 m a.s.l.) are situated in the mountainous part of northern Bratislava, Budkova cesta (BC, 254 m a.s.l.) is near the Bratislava Castle and Dolne Hony (DH, 132 m a.s.l.) lies in the SE part of Bratislava. These deviations represent both the regional temperature field and the impact of the urban effect.

Conclusions from the research of the urban climate in Bratislava and Kosice proved that the urbanized part of the city has a different microclimate compared to suburban places; the differences are greater between the urbanized parts closer to the city centre and outlying non-urbanized parts. Noticeably the differences in the monthly and annual temperature averages are documented. It is interesting that the summer

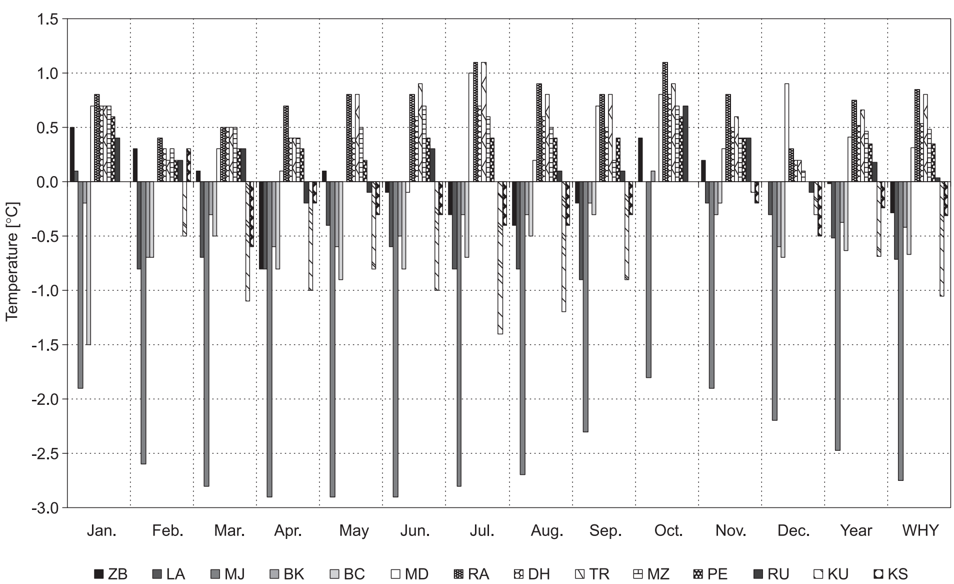

Fig. 2. Deviations of monthly, annual (Year) and seasonal (WHY – April to September) air temperature means between 14 meteorological stations in the Bratislava region and the Bratislava Airport station (131 m a.s.l.) in 1981–1984. Full names of the stations are explained in the text

Ryc. 2. Odchylenia średnich temperatur miesięcznych, rocznych (Year) i sezonowej (WHY – kwiecień-wrzesień) pomiędzy 14 stacjami meteorologicznymi w rejonie Bratysławy a stacją Bratysława Lotnisko (131 m n.p.m.) w latach 1981–1984. Pełne nazwy stacji – w tekście

Table 1. Statistics of deviations in daily minimum air temperature measurements ≥5°C and ≤-5°C at two stations in Bratislava (Bratislava Trnavska (BA Tr) and Bratislava Airport (BA Ap)) and two stations in a 25 km distance from Bratislava to the north-west (Malacky and Kuchyna) in per-mille

Tab. 1. Statystyka odchyleń od pomiarów dziennych temperatur minimalnych ≥5°C i ≤-5°C na dwóch stacjach w Bratysławie (Bratislava Trnavska (Ba Tr) i Bratysława Lotnisko (BA Ap)) oraz dwóch stacjach położonych 25 km na północny-zachód od Bratysławy (Malacky i Kuchyna) w promilach

Stations	Winter	Winter	Spring	Spring	Summer	Summer	Autumn	Autumn	Year	Year	Mean deviation [°C]
	≥5°C	≤-5°C	≥5°C	≤-5°C	≥5°C	≤-5°C	≥5°C	≤-5°C	≥5°C	≤-5°C	
BA Tr – BA Ap	17	0	21	0	14	0	8	0	15	0	1.0
BA Tr – Malacky	136	0	272	0	371	0	259	0	260	0	3.3
BA Tr – Kuchyna	147	0	275	0	245	0	201	0	218	0	2.9
BA Ap – Malacky	37	3	43	8	71	1	55	7	51	5	1.4
BA Ap – Kuchyna	45	8	64	20	29	8	30	16	42	13	1.2

differences are more pronounced. This proves the theoretical hypothesis on a greater share of changed energetic balance than energy produced by the heating in winter. The greatest differences were observed during the late evening hours and the smallest in the early afternoon. The changed temperature conditions also influenced other climatic elements, mainly the relative air humidity during the night and in the morning.

In Figures 3 and 4 a significant shift of climatic zones in the southern half of Slovakia can be seen. A mild climate with equally distributed precipitation during the year (Cfb after Köppen) increased its territory nearly to the whole Slovakia. The dry region (after the Konček classification) increased its extent approximately two times between the 1901–1950 and 1961–1990 periods, and a completely new, very

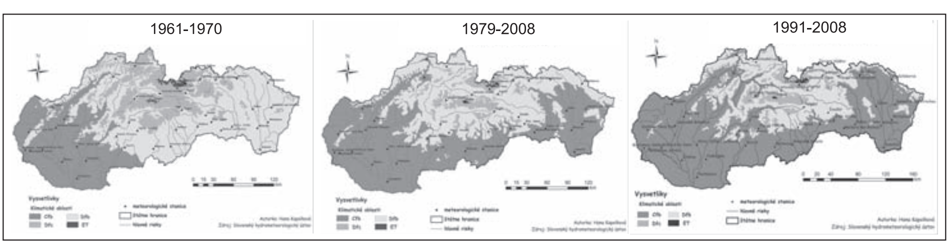

Fig. 3. Shift of the climatic zones (according to Köppen) in Slovakia, the Cfb temperate climate (dark colour) and the Dfb continental climate (fair colour) in particular, after Kapolkova (2010)

Ryc. 3. Przesunięcie stref klimatycznych wg Köppena na Słowacji, w szczególności klimatu umiarkowanego Cfb (ciemny kolor) i kontynentalnego Dfb (jasny kolor), za Kapolkovą (2010)

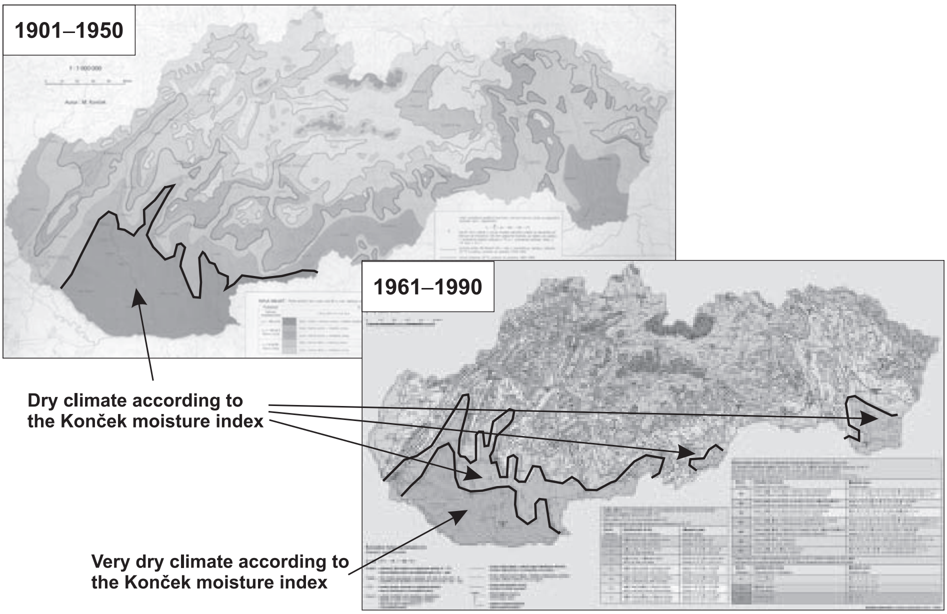

Fig. 4. Increase of aridity in Slovakia between 1901–1950 and 1961–1990. Shift of the climatic zones in Slovakia according to the Konček moisture index (dry climate and very dry climate predominantly), after *Atlas podnebia Československa* (1958), *Výskum mezoklímy Bratislavy* (1958) and *Atlas krajiny Slovenskej republiky* (2002)

Ryc. 4. Wzrost suchości w Słowacji między okresami 1901–1950 i 1961–1990. Przesunięcie stref klimatycznych wg współczynnika wilgotności Končeka (w szczególności klimatu suchego i bardzo suchego), za *Atlas podnebia Československa* (1958), *Výskum mezoklímy Bratislavy* (1958) i *Atlas krajiny Slovenskej republiky* (2002)

dry region, has originated in south-western Slovakia recently. This development is likely to accelerate in the future decades.

Future plans

Because of a significant shortage of research projects funding only selected activities are planned. They will include a project on climate change scenarios based on daily outputs of Regional Circulation Models (RCMs) and General Circulation Models (GCMs) outputs (Canadian CGCM3.1 as principal). Methods of statistical and dynamic downscaling into selected sites and more dense grids developed by our workplace will be used. Such scenarios enable to solve possible impacts of extreme weather events and trends in climatic characteristics using long-term data series.

Vulnerability and impacts assessment will be concentrated mainly on the damages caused by low and high precipitation totals, heat waves, changed evapotranspiration, flash floods, drought, changed water resources and atmospheric circulation as well as health and dwelling conditions change.

A project concerning adaptation options will be prepared in collaboration with impacted socio-economic sectors. The most important are: flood protection and prevention, drought, drinking water resources, instability in ecosystems, land use change, health and dwelling worsening risk, as well as a reduction of negative impacts due to mitigation options implementation (greenhouse gases and aerosols emission reduction).

There are planned two new projects: "TOPOCLIMA of Bratislava 2010" and "REGIOCLIMA of the Bratislava Region 2010" funded by city and region administration (partly also by the EU funds). Within this projects a set of new automatic meteorological stations performance is supposed. These projects are not approved yet up to the end of June 2010.

In Figure 5 a map of heavy precipitation risk in Slovakia is shown as an example. Because of a possible increase in the mean temperature up to 4°C by the end of the 21st century also an increase in the specific air humidity by 25% in the case of cyclonic situations and heavy thunderstorms are expected. This will cause a 40%

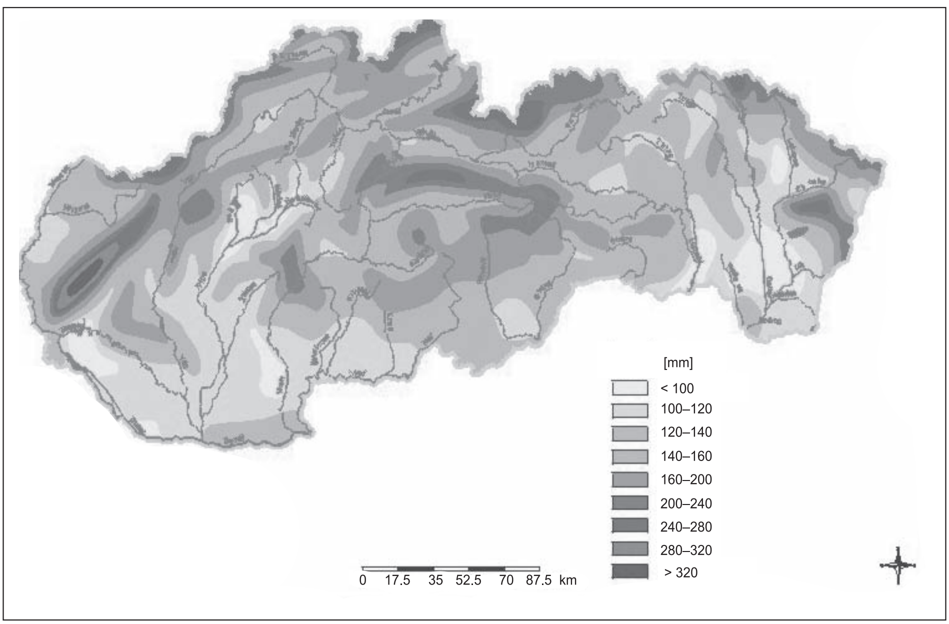

Fig. 5. Annual maximum in 5-day precipitation totals in Slovakia with 100-year return period, based on the data from the Slovak Hydrometeorological Institute

Ryc. 5. Roczne maksima sum opadów 5-dniowych o 100-letnim prawdopodopobieństwie wystąpienia na Słowacji, na podstawie danych ze Słowackiego Instytutu Hydrometeorologicznego increase in the precipitation totals of heavy rains with a return period of 50 or 100 years. The infrastructure of the urbanized area in the Bratislava region is not prepared for such a significant change of flood risk.

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Zmiany klimatu i ich potencjalny wpływ na tereny zurbanizowane południowo-zachodniej Słowacji

Streszczenie

W pracy przedstawiono krótką analizę możliwych wpływów zmian klimatu na podmiejskie i miejskie obszary południowo-zachodniej Słowacji. Wynikiem ocieplenia klimatu spowodowanego zwiekszeniem efektu cieplarnianego może być wzrost globalnej temperatury o około 2,5°C do 2100 roku. Na Słowacji w skali wieloletniej przyjmuje się wzrost temperatury od 2 do 4°C na rok. Zdaniem autorów dodatkowe ocieplanie się stref miejskich jest spowodowane zmienionym bilansem ciepła powierzchni w terenach zurbanizowanych (zamiana powierzchni naturalnych na sztuczne – beton, asfalt, bruk, budynki, itd.), a częściowo również emisją sztucznego ciepła (uwalnianie energii podczas ogrzewania, produkcji przemysłowej itp.). W małych miastach „efekt miejski" powoduje ocieplenie o 0,5°C, w większych do 2°C na rok. W artykule zarysowano dotychczasowy stan badań klimatu miejskiego na Słowacji oraz przedstawiono możliwości dalszych badań i propozycje poprawy klimatu miejskiego.

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