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ANALYSIS OF THE AIR TEMPERATURE AND PRECIPITATION DEVELOPMENT AT LOCALITY KUCHYŇA

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Abstract. In recent decades the study of climate change has raised awareness. People felt that change especially with regard to air temperature and precipitation. Winters in our conditions compared to the past are longer and generally warmer, in the summer there are more extremes of air temperature and an uneven distribution of precipitation. Storm precipitation change small streams to wild rivers and cause significant property damage. Therefore, in this paper, we devote to the expected forecast of the air temperature and precipitation development. The simulation of these two meteorological elements for the meteorological station of Slovak Hydrometeorological Institute (SHI) Kuchyna on Záhorie was made by the CGCM 3.1 model for two scenarios - pessimistic A2 and optimistic B1. Differences between each scenario are significant at the end of 21st century. Generally, it can be state that with the rise of air temperature will arise to the increase in extremes of precipitation.

Keywords: climate change, modeling, scenario, air temperature, precipitation.

Introduction

On the issue of climate change experts have different opinions. Some argue that the warming of the Earth is a natural process, regardless of human activity, and others argue that man is primarily responsible for these changes, especially since the beginning of the industrial revolution. Another group of scientists incline to the golden mean that these changes occur naturally, but anthropogenic activity accelerates this process. We live too short and we have not enough relevant observations that we can confidently assess whether this change is natural or influenced by human activity. We can build on the historical records, which can be truth, but we need not believe it. Earth's climate must be studied for several decades and only than it is possible to separate climate change from natural change. The fact is that in the atmosphere occur some changes, which the current one sees mainly in the form of air temperature and precipitation changes. In our condition winter months are warmer than in the past and in the summer we can feel the increase of storm precipitation and of longer periods without precipitation. Experts are trying to create prognosis for development of the meteorological elements in order to adapt to incoming changes. At present many workplaces in the world are working on the Global Circulation Models (GCMs), which provide climatic scenarios of various climatic parameters (Stehlová, Štekauerová, 2005, 2008). The beginning of mathematical modeling of climate change goes back to the late 19th century (Trenberth, 1992), but the biggest expansion came in the 70's and 80's of the 20th century, as a result of the rapid development of computer technology. Mathematical modeling of climate change includes physical and chemical processes in the atmosphere and oceans of the Earth, physical processes associated with the cryosphere, biosphere and lithosphere, if they have for climate change any meaning. Models can be simple, if they simulate only one process in the atmosphere, or complex, if they simulate processes in the whole climate system.

In the prognosis for development of meteorological elements we used global mathematical model CGCM 3.1.

Material and methods

Mathematical model CGCM 3.1 is the latest version of the Canadian related model of the atmosphere and ocean circulation. This is the first version of scenario based on CGCM 3.1 in Slovakia, which have not probably changed. Daily precipitation scenarios were constructed approximately by the methodology given in work for example Lapin et al. (2006), it means they are a time series of daily precipitation and daily average air temperature with the spatial variation given in 9 nodal points around the SR (Table 1.).

Table 1. Location of nodal points (NP) of Canadian model CGCM 3.1 in vicinity of Slovakia

NP	Longitude [°]	Latitude [°]	Altitude [m]	Nearby city
1	16,88	46,04	306,5	Zagreb, Croatia
2	19,69	46,04	239,0	Subotica, Serbia
3	22,50	46,04	483,1	Hunedoara, Rumania
4	16,88	48,84	474,1	Břeclav, Czech Republic
5	19,69	48,84	336,7	Brezno, Slovak Republic
6	22,50	48,84	463,4	Ubľa, Slovak Republic
7	16,88	51,62	193,3	Wroclaw, Poland
8	19,69	51,62	199,7	Radomsko, Poland
9	22,50	51,62	216,4	Lublin, Poland

Methodology for construction of such scenarios guarantees that in each period longer than 25 years is the variability and distribution curve of data characteristics for the expected climate in the locality. These scenarios therefore do not represent the prediction of the given element on a given day, month and year. In the period 1961 – 2000 and even then the calculated scenarios do not reflect measured data in the period 1961 – 1990 (Figures 1, 2), but have the same average total and approximately equal abundance in different intervals of occurrence. For forecasts of precipitation were chosen scenarios according to the nodal point of NP 4, and for forecasts of the air temperature were selected scenarios according to four nodal points in the vicinity (Table 1.). Reference range values were daily precipitation and daily average air temperature in the period 1961 – 1990 measured at meteorological station SHI Kuchyňa – Nový Dvor. Scenarios are calculated as the quotient of the average in the period to average in the period 1961 – 1990.

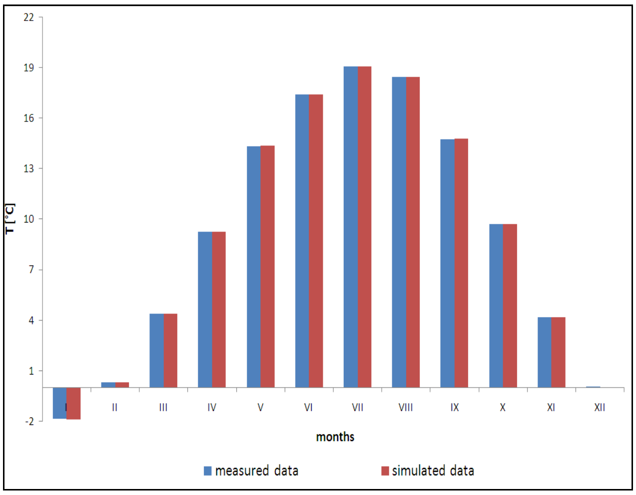

Figure 1. Comparison of average monthly air temperature (T) calculated from the measured and simulated data for the period 1961 – 1990 for the station SHI Kuchyňa

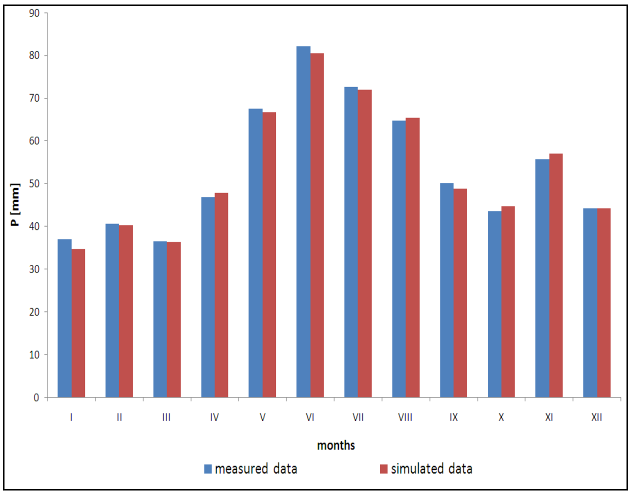

Figure 2. Comparison of average monthly precipitation (P) calculated from the measured and simulated data for the period 1961 – 1990 for the station SHI Kuchyňa

By the regional modifications were used emission scenarios A2 and B1. Continued growth of greenhouse gas concentrations in the atmosphere depends on the measures for reduce emissions to the atmosphere. Emission scenarios are based on a wide range of future forecasts, affecting the economic, demographic and political factors. Group A2 corresponds to the idea of a very heterogeneous world. The basic idea is to rely on themselves and to preserve local identity, respect local traditions. Population in the 21st century, continuously growing, economic development is strongly regional oriented, technological change and growth in gross domestic product is considerably slower than other group of scenarios. Group B1 corresponds to the idea of convergence world, with the same population as in A1, with the rapid development of informatics, services, loading of clean and efficient technologies, reducing material intensity. The emphasis is on global solving of economic and social problems, environmental protection (Melo, 2004).

Using the CGCM 3.1 model was made the simulation of the average daily air temperature and daily precipitation for the station SHI Kuchyňa for the period 1961 – 2100 for both emission scenarios A2 and B1.
Whereas as the reference period was selected thirty years 1961 – 1990, simulated data were also divided into three time horizons 2010, 2030 and 2075, which represents a thirty-year periods: 1996 – 2025, 2016 – 2045 and 2061 – 2090, which we compared.

Results and disscussion

In this paper we compare outputs of modified scenarios of average daily air temperature and daily precipitation for the two emission scenarios A2 and B1, as well as the observed 30-year period with each other. For better comparison of simulation outputs were processed the daily data in the average monthly values.
The air temperature has according to both scenarios increasing trend. The air temperature gradually increases by the comparing all three time horizons. Exceptions are in the pessimistic scenario A2 months January and February, when in the time horizon 2030 are expected lower temperature than in the previous time horizon 2010 (Figure 3.). In the optimistic scenario B1 is in all months the same trend of increase of temperature in the 21st century (Figure 4.).

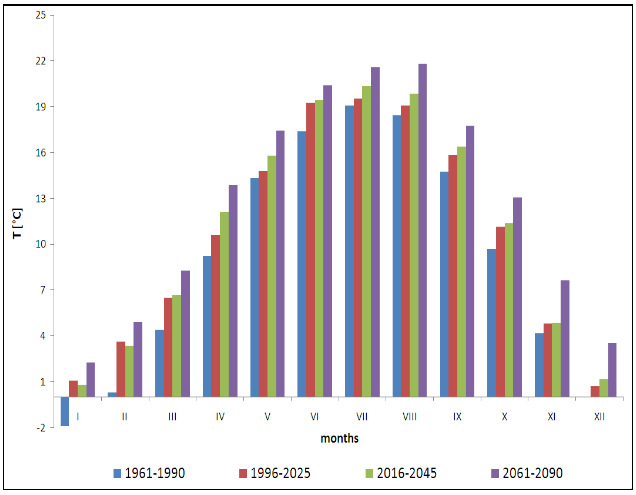

Figure 3. Comparison of simulated average monthly air temperature (T) for the station Kuchyňa according to pessimistic scenario A2 in the reference period 1961 – 1990 in the time horizons 2010, 2030 and 2075

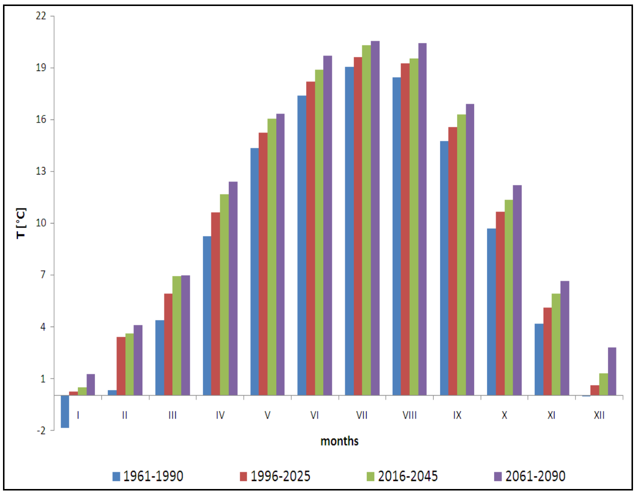

Figure 4. Comparison of simulated average monthly air temperature (T) for the station Kuchyňa according to optimistic scenario B1 in the reference period 1961 – 1990 in the time horizons 2010, 2030 and 2075

In comparison of average monthly values of air temperature in Kuchyňa station, we found that the biggest differences in comparison to real measured data are in February (Table 2). The maximum difference is around 3 °C. The exception is the time horizon 2075 in a pessimistic scenario A2, where the biggest difference 4.63 °C was found in April.

Table 2. Differences in simulated average monthly air temperature in time horizons 2010, 2030 and 2075 to the measured average monthly air temperature in the reference period 1961 – 1990 for the station Kuchyňa

	Air temperature (T)						
	1961-1990	1996-2025		2016-2045		2061-2090	
	[°C]	different [°C]		different [°C]		different [°C]	
Month	**measured**	**A2**	**B1**	**A2**	**B1**	**A2**	**B1**
I	-1.87	2.93	2.09	2.68	2.35	4.12	3.12
II	0.31	3.30	3.11	3.02	3.28	4.57	3.78
III	4.38	2.12	1.54	2.31	2.54	3.88	2.57
IV	9.25	1.33	1.38	2.83	2.42	4.63	3.14
V	14.32	0.47	0.91	1.46	1.72	3.11	1.99
VI	17.39	1.87	0.80	2.07	1.51	2.99	2.29
VII	19.06	0.46	0.55	1.30	1.25	2.54	1.50
VIII	18.44	0.65	0.82	1.39	1.09	3.35	2.00
IX	14.74	1.11	0.83	1.65	1.56	3.00	2.17
X	9.70	1.43	0.97	1.65	1.66	3.34	2.50
XI	4.19	0.62	0.91	0.65	1.71	3.45	2.45
XII	0.02	0.70	0.59	1.15	1.28	3.51	2.78

The Figures 3 and 4, as well as the Table 2 show that air temperature more changes in the months January, February and March, and in consequently of it we can expected warmer winters. While in the first time horizon 2010 are differences around 1.3 °C, in the second time horizon it is already 1.8 °C and in the last horizon 2075 it is 3 °C (in the pessimistic scenario A2 it is till 3.54 °C).

The biggest precipitation totals are currently achieved in May, June and July. This should not change in the future; in addition to this month will be added also September and November. According to the pessimistic scenario A2 (Figure 5.) precipitation should increase with increasing time. Exceptions are the months July and August. In July are expected decrease of precipitation at the end of the century and over the August should not even be achieved the measured average precipitation from period 1961 – 1990.

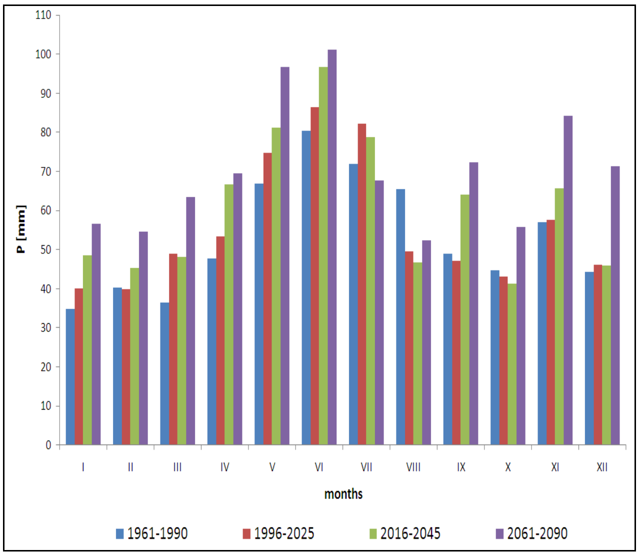

Figure 5. Comparison of simulated average monthly precipitation (P) at the station Kuchyňa according to pessimistic scenario A2 in the reference period 1961 – 1990 in the time horizons 2010, 2030 and 2075

An optimistic scenario B1 (Figure 6.) assumes overall lower

	Precipitation (P)						
	1961-1990	1996-2025		2016-2045		2061-2090	
	[mm]	different [mm]		different [mm]		different [mm]	
Mon.	**measured**	**A2**	**B1**	**A2**	**B1**	**A2**	**B1**
I	36.95	3.02	1.88	11.62	-1.04	19.62	29.18
II	40.63	-0.75	-5.70	4.65	-5.77	13.85	3.58
III	36.50	12.48	11.86	11.58	10.35	27.00	20.72
IV	46.77	6.63	12.34	19.91	8.56	22.62	18.68
V	67.56	7.17	15.70	13.56	19.71	29.05	24.55
VI	82.12	4.28	2.97	14.58	-2.63	19.10	3.02
VII	72.57	9.63	15.43	6.22	5.39	-4.84	0.53
VIII	64.69	-15.21	-1.64	-17.95	-8.33	-12.40	-9.60
IX	50.06	-3.01	19.29	13.92	23.61	22.16	24.01
X	43.62	-0.53	0.92	-2.34	-1.23	12.23	14.90
XI	55.72	1.94	17.91	9.97	22.39	28.56	31.68
XII	44.15	1.88	5.33	1.69	8.80	27.06	12.23

Table 3. Differences of simulated average monthly precipitation in the time horizons 2010, 2030 and 2075 and measured average monthly precipitation in the reference period 1961 – 1990 in the station Kuchyňa

precipitation total than A2 scenario. Also this scenario expects the increase of average monthly precipitation in the Kuchyňa site. Exceptions are besides July and August (as in scenario A2) also the months February and October, when assumes the decrease of precipitation in the time horizons 2010 and 2030 and repeated increase at the end of the century.

More detailed numerical expression of differences in both scenarios to the real measured data from the period 1961 – 1990 provides Table 3, in which are marked maximum differences in the each scenario and observed time horizons. The maximum difference 31.68 mm between the simulated and measured average monthly precipitation should occur in the time horizon 2075 in November according to optimistic scenario B1. The biggest differences according to both scenarios are predicted in the last time horizon 2075.

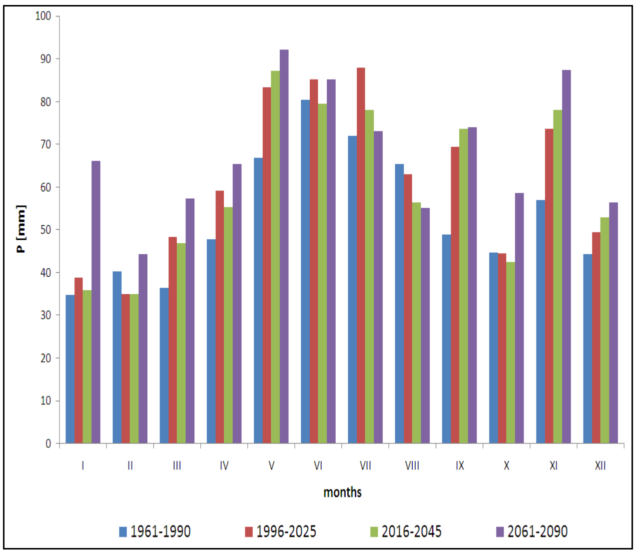

Figure 6. Comparison of simulated average monthly precipitation (P) in the station Kuchyňa according to optimistic scenario B1 in the reference period 1961 – 1990 in the time horizons 2010, 2030 and 2075

Conclusions

In this paper we dealt with impacts of climate change on the course of two meteorological elements, namely air temperature and precipitation in the area of Kuchyňa in Záhorie region. Using the output from global climate model CGCM 3.1 for two scenarios A2 and B1, we did an analysis of development prognoses of these two meteorological elements. We wanted to point out differences between both scenarios, but also on the comparison of the outputs with the measured data of reference period 1961 – 1990. Generally it can be state, that the model CGCM 3.1 indicates the growth of daily precipitation extremes. This concerns even more of pessimistic scenario A2, which provides even greater warming. Depending on the human behaviour the temperature at the end of the century can increase over 3 to 4 °C and precipitation can rise up about 30 mm.
Prognosis of development of meteorological elements may not be exact, but is important in terms of preparedness to residents, whether on the flood or extreme dry periods in the future.

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