4. Projected future climate change in the Hungarian-Serbian cross-border region

Viktória Blanka, Zsuzsanna Ladányi, Gábor Mezősi

Introduction

The change in the available water resources is one of the most dominant limiting factors in the region for the nature and the economy. We could see that in the past decades, the available water resources have decreased in the region due to the change of climate parameters, the frequency of drought has increased and extreme droughts have occurred more frequently. The effect of this change on the environmental system was demonstrated in the previous chapter. The observations from the past decades indicate that climate change could become more and more important. That is why better knowledge of the future climate change is essential. At present the most suitable method to analyse the expected future climate change is probably the application of climate models. Climate models have been developed in order to study the complex operation of the climatic system. The most important elements are the surface (soil) model, aerochemistry (aerosols, CO_2 cycle), the ocean models (sea currents, sea ice) and the biospheric model. By means of understanding the global and regional processes in the climate system and the future projections, the society will be able to prepare for the consequences of the projected changes (Bartholy and Pongrácz 2005).

Global scale numerical climate models can characterize the global features of climate change. In parallel with the development of scientific knowledge and that of computer capacity, the resolution and accuracy of models have progressed and are able to provide relatively good physical approach to the atmospheric and ocean-related processes following the various future emission scenarios (Bartholy and Pongrácz 2005). The resolution of the global models is 100-200 km (Mika 2011). The future human activity is one of the most important and most uncertain factors. As the direction of social and economic development cannot be predicted precisely, several hypotheses (scenarios) for the future development tendencies were set up on the basis of changes of population, energy consumption, industrial and agricultural structure. These scenarios assume different greenhouse and aerosol emission and different corresponding concentration. Global models are run by taking into consideration the optimistic, pessimistic and average versions (Nakicenovic and Swart 2000).

The resolutions of the demonstrated global models can not provide sufficient information for smaller scale regional analysis. Regional climate models were developed in close relation with the global climate models which simulate the climatic system in continent or smaller scale. They are suitable to give more precise description of the physical processes, since in this scale, the relief (and other surface features) can be considered more exactly. This way the extreme phenomena could be described in a more reliable way. (Szépszó and Zsebeházi 2010).

Methods

The results of simulations run by the REMO and ALADIN regional climate models were used to examine the future climate change in the region. The models were run and the climate data production took place at the Numerical Modelling and Climate Dynamics Division of the Hungarian Meteorological Service. The resolution of the simulated climate data is 0.22°, thus being more suitable to analyse smaller areas. While running the models, AIB scenario was utilised for the prediction of human processes which can represent average changes.

Two modelled periods were evaluated during the analysis. Daily temperature and precipitation data for the periods from 2021–2050 and 2071–2100 were used for the calculations. Monthly and annual mean data for daily temperature and precipitation were calculated, then they were analysed with respect to the data of reference period of 1961-1990.

During the assessment of the future climate change, the change of climate parameters mostly affecting the environmental change were analysed and drought indices were calculated. The change in drought hazard can be estimated by calculating drought indeces, which had been developed to describe the drought severity of certain periods or years. For the calculations, the Pálfai- Drought Index (PaDI) and the Standardized Precipitation Index were used.

The simplified PaDI using monthly precipitation and temperature data was calculated for the analysed two future periods of 2012- 2050 and 2071-2100. Monthly mean temperature and precipitation were calculated from the daily data. The Standardized Precipitation Index (SPI) is used to determine the climatic variability of precipitation on the given area. It has the advantage of low data demand, but has the disadvantage of not reflecting the drought situation appropriately. The index also has the benefit that it can be calculated from shorter periods than PaDI (e.g. 1 month to 12 months) therefore seasonal changes can also be analysed. Seasonal (3 months) SPI was calculated for the estimation of changes. Even though these indices consider few parameters and do not define the complex system of the environmental factors, they are applicable to outline the tendencies. On the basis of the results, the most critical areas affected by drought can be outlined and the temporal aspects of changes can also be projected.

Results

Expected tendencies of climate change in the Carpathian Basin in the 21st century on the basis of REMO and ALADIN climate models

The regional climate models project a small decrease of annual precipitation in the Carpathian Basin for the 21st century. More significant change in seasonal precipitation is expected: increasing precipitation in winter, whereas more intensive decrease for summer is projected. On the basis of the models the number of days with high precipitation will increase; the number of days with precipitation will decrease, which means that the length of periods without precipitation / dry periods could also rise. The annual mean temperature, just like in global projections, will increase – the result of models reflects a rise of temperature by 3.5°C until 2100. More days with extremely high temperature (heat) are predicted and at the same time, decrease of frost days can be expected. The differences between the years are expected to increase.

Increasing annual mean temperature and uncertain annual precipitation change

The change of the annual mean temperature on the study area compared to the reference period indicates increasing warming for the two analysed future periods. In the first modelled period (2021- 2050), both applied models indicated the highest temperature rise in the south-eastern area of the region, in Central Banat, while the north-eastern part of Bács-Kiskun County showed the smallest warming. An increase of temperature by 1.5-1.7 °C is detected for this period compared to the reference period of 1961-1990. For the second modelling period (2071-2100), the tendency of warming will continue; an increase of temperature by 3.5-3.7°C is predicted for this period. The spatial differences will follow the same pattern as in the previous period.

In case of annual precipitation, the models projections are less certain. The applied models have different projections for the direction of change and its rate. Both models indicate only minor changes, the average values are more or less similar to the reference period of 1961-1990. Based on the model simulations, an annual change of (-60)-(+35) mm is predicted for the region, which is less than 10% of the annual precipitation of the reference period.

More intense warming and drying in summer

The average change of temperature in summer months (July-August) on the study area shows more intensive warming than the yearly average changes in the two future periods compared to the reference period. In the first modelled period (2012-2050) on the basis of simulations, a rise by 1.4-3.7°C in the mean temperature is supposed compared to the reference period of 1961-1990. Data of both models illustrate that more significant changes is expected on the southern part of the study area, especially the southern and eastern parts of Vojvodina and the eastern part of Csongrád County. More intense temperature change is predicted for the second model period (2071-2100). The spatial differences are similar to that of the previous period.

The change of precipitation amount in summer for the two observed future periods suggests more substantial decrease than the annual values compared to the reference period. Models indicated a slight reduction for the period of 2012-2050 compared to the reference period, however even 50 mm decrease could occur for the period of 2071-2100. In the reference period, the regional average amount of precipitation for July-August reached 110 mm, thus, the projected decrease of 50 mm might even indicate a drop of 40% by the end of the century.

Temperature in the summer months plays an important role in the agricultural production since temperature increase could be accompanied by the rise of evaporation, more intense need for water, reduction of morning vapour formation. Model simulations also predict intensive temperature increase in parallel with the significant decrease of precipitation. This might further intensify the water shortage which could even result in a more significant damage in the economy. It might overwhelm the yield loss experienced in the drought years in the past decades.

Change of drought hazard

Both the rate of drought hazards and that of the climate change is expected to change in the 21st century. The Pálfai Drought Index focuses on the drought which occurs in the vegetation period describing the drought in an agricultural year with one numeric value. Thus it can be used to analyse agricultural drought especially in the climate condition of the Carpathian Basin. Based on the spatial pattern of the PaDI drought index (Fig. 4.1 on page 147), the north-eastern part of Bács-Kiskun County and nearly all the territory of Csongrád County were more prone to drought in the reference period. Based on 30-year average data, the Pálfai-index value of 4.4-5.5 for the reference period could describe the study area. Average values for a period of 30 years are expected to increase remarkably in the future: the mean value of 5.3-6.6 for the period of 2021-2050, and a mean value of 6.2-8.0 could be typical for the period of 2071-2100. The pattern is similar to that of the reference period, however, besides Bács-Kiskun County and Csongrád County, North-Banat in Vojvodina, also the northern part of Central Banat and the north-eastern part of South-Banat are more likely to be affected by the drought hazard. Among the counties located in Serbia, Western Banat is the least likely to be affected by the increase of drought hazard.

Besides the general tendencies of the change of drought hazard, it is important to know how often serious drought (PaDI>10) occur in the modelled periods and what spatial distribution is expected. In the period of 1961-1990 serious droughts were not typical; only on the north-eastern part of the region occurred in one year (Fig. 4.2 on page 148). Based on average data of ALADIN and REMO model simulations, for the period of 2021-2050 in the Hungarian counties 9-10 years out of 30 years are likely to be affected by serious drought, while in the counties in Vojvodina 7-8 years out of 30 years; between 2071-2100, 9-12 years of drought will have significant impact in almost all areas. This means that by the end of the century almost every second or third year could be strongly influenced by drought. The studied region will face more increased drought hazard in the future by the end of the century, so the regional plans need to be prepared soon.

Besides characterising the whole vegetation period, the seasonal precipitation change could also provide substantial information. The SPI index for a period of 3 months can also provide important data about this. The amount of precipitation in spring is vital for the vegetation growth. In order to receive information regarding the future need for irrigation, it is important to know the tendency of precipitation change. On the basis of the calculated SPI for the 3 months period of spring (March-May), the ALADIN and REMO regional climate models show insignificant change for 2021-2050 compared to the reference period, and the direction of change is also uncertain. The model simulations indicate a more uniform picture for the period of 2071-2100. More intensive negative precipitation anomaly is projected for the region of Southern Backa, while there are patches in Csongrád and Bács-Kiskun counties where the result not show remarkable changes in the future.

The three summer months (June-August) are the most critical regarding drought. In spite of the uncertainty of precipitation forecast for this period, both models show that the drought hazard will increase by the end of the 21st century (Fig. 4.3 on page 151). The values of SPI index (-0.5 to -1.5) shows significant negative precipitation anomaly for the period of 2071-2100. The highest negative values refer to the driest areas. Regarding the spatial distribution, REMO

projects the most significant negative precipitation anomaly in the central and southern areas of Vojvodina, while according to ALADIN model, only the central areas of Vojvodina are effected.

In the precipitation in autumn months (September-November), the SPI index values, calculated from REMO and ALADIN model results outline different tendencies. Data of REMO model project negative precipitation anomaly for 2021-2050, whereas ALADIN projects increasing precipitation. However, for the period of 2071-2100, increasing precipitation is projected by both models. REMO refer to a more significant growth, especially in the Western part of Vojvodina, while ALADIN model simulations indicated slighter precipitation increase.

The amount of precipitation in winter months (December-February) considerably contributes to the increase of water reserves of the soil. It is really essential to see how it will change in the future. The projected picture of the future is not definite, since results from both models indicate different tendencies. By the end of this century (2071-2100) REMO shows more intensive precipitation increase in winter, especially for Bács-Kiskun County. On the contrary, ALADIN shows a slight decrease especially in the north and north-eastern part of Csongrád and Bács-Kiskun counties, and the eastern part of Central Banat.

Drought hazard estimates based on modelled climate data have pointed out that the drought hazard will increase in the cross-border area by 2100. The most affected areas today will be mostly influenced. In these areas in the 21st century, even more serious drought related problems could occur. Although the rate of change may be slow, it has to be taken into account in the regional planning, since this could support the preparation for the environmental hazard.