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LONG TERM CHANGES ON RIVER BASIN DEDINA

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Abstract. This paper describes the effects of climate change on river basin Dědina, which is located in Eastern Bohemia. In the first part are analyzed hydrological and climate data, measured between 1960 and 2007. There are also described ongoing changes observed by local residents. They are put into the context of climate change. In the second part was used Bilan model, which determinates possible development of hydro-climatic variables. Based on this output are derived anticipated effects on the watershed and possible adaptation to respond to the resulting change in climate conditions.

Introduction

River Dědina, formerly called the Zlatý potok, and its catchment area is located in Hradec Králové Region (see Figure 1). This significant stream rises on the western slope of the Sedloňovksý hill in the Orlické Hory. The total length of the river Dědina is 58 km. The area of catchment, administered by Povodí Labe, state public enterprise, is 333,2 square kilometres.

Figure 1 – Location of the Dědina catchment

The basin is an important local water catchment area alloy, which is the main source of drinking water within the water supply system of eastern Bohemia. Groundwater is pumped from 11 deep wells up to 150m. Total consumption of water from underground springs is allowed in quantity of 250 l / s (i.e. 7884 000m^3/year).

For river basins are characterized by slopes up to 5 degrees (more than 75% of the basin). The slopes above 25° are represented in the basin at least. Less than 67% of the length of the longitudinal slope of the river bed up to 10‰. Riverbed slope greater than 40‰ is recorded only on 4% of river length. Mean slope of river reaches is 9.36‰. The average forest cover on watershed is approximately 17% which is significantly below the average compared with the nationwide average forest coverage. Vegetation on the bank and associated vegetation is frequently flooded; so on the site is especially typical of floodplain trees. Abundantly represented are mainly alder, poplar, ash, ancient oaks, maples and willows. Varied habitat composition Dědina basin, and its character and morphology of river channel, is the cause of high species diversity and presence of endangered species.

Dědina basin can be classified in the moderately warm climate, lies at the crossing wet and dry areas [CHMI]. Rainfall rates are very uneven. The most precipitation is in the Orlické Hory areas. Here are accumulated flood flows from melting snow and rainfall. In the past, the landscape faced with the problem of decreased ability of natural water accumulation and decreased retention capacity. The reason was inconsiderate of landscape management, such as inappropriate management of landscape, poor choice of crops, arable land high or inappropriate species composition. In recent years, especially after the disastrous flood in 1998, the landscape began to build anti-flood measures. In particular are, the change of use of land, grassland banks, construction of erosion control limits, etc. For the upper (mountain) area of the stream the modified banks and the route flow is typical (see Figure 2 and 3).

Figure 2 – Modified stream channel

The current status of river basin has been described on the basis of information from people which managing and farming on the river basin. Almost all respondents agreed that the biggest problem is a large volatility climatic phenomenon. Droughts alternate with floods, freezing temperatures with higher temperatures or sudden calamity snow with his lack.

This area is typical of many local precipitations in the form of torrential rains. Precipitations in the area but do not remain, quickly flushed out and carry away valuable topsoil together. River spilled out of the trough undercuts unpaved roads and choking her bed with wood and other material that clogs bridges and culverts. In 1998, devastated the catchment area the catastrophic flooding that was caused by an unexpected collision of extreme local and village Kounov enhanced by the ongoing construction of roads, open ditches for storage of telecommunications and highly compacted soil heavy machinery traversing farmers.

Figure 3 – Protective sedimentation dike

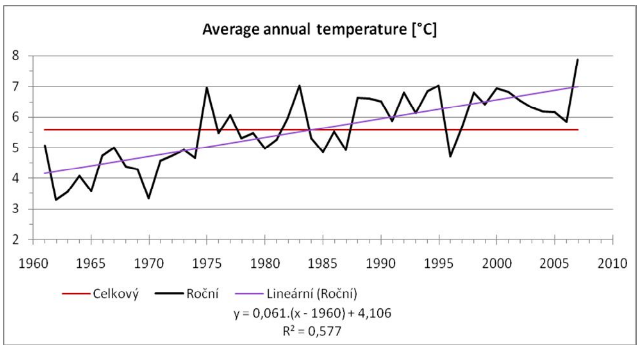
By contrast, large droughts especially in summer periods, results in death of plants, the extinction of fish, amphibians and other organisms. On the Landscape Park Orlické Hory is the drying peat. Overall, the lack of surface water basin. Tanks are added sediment and lack of maintenance. Dědina river bed is quite large, and therefore faces great evaporation. Lack of water in the trough is typical for the lower stream below the village Chabory, where the initial trough divided into two branches. Branches Dědina to Dobruška touch only a minimum of water and there is no way for the proper dilution of the water treatment plant. The Zlatý potok branch lacks water for the operation of small hydroelectric power plants.
Climate change can be seen in another species composition and animal overpopulation, or vice versa mortality of individual species. In recent years, there are more slugs, ticks, the newly discovered black storks, herons in winter. In 2009, recorded three generations of bark beetles, while in 2010 was the only one.
The basin is a relatively large number of forests. In recent years, but the ridges of the mountains deforested and replaced knees, this must be regularly renewed. Forest habitats are not extremely drying, so there are no problems with forest fires. As mentioned above, the area is threatened by erosion caused by plowing balks, destroyed hedgerows, soil compaction and no suitable farming farmers. This problem (land use change) is solved in recent years. Lot of grass area was and pastures were added at the expense of arable land remaining arable areas are effectively selected types of crops grown with less erosion vulnerability. Pastures are used mainly for breeding beef cattle, which was replaced earlier in the prolific breeding of pigs.

Evaluation of measured values

In addition to subjective evaluations, mentioned in the previous chapter, to assess the development climate in the basin Dědina was used data from Czech Hydrometeorologic Institut.

Average annual air temperature

To obtain a complete time series in steps of one month was necessary to replace the small amount of data calculation. For the purposes of statistical analysis, data were replaced using linear regression of the month. Specifically, it was the November-December calendar year 1960, October-December calendar year 1973 from January to April of the calendar year 1974 and the entire calendar year 1981. After obtaining all the average monthly temperatures Destne station in 1961-2007 were calculated individual average annual temperatures. The average annual temperature for the entire period 1961-2007 is 5.58 ° C. The lowest average annual temperature of 3.3 ° C period was calculated for the year 1962, the highest contrast for 2007, namely 7.9 ° C.
Graph 1 shows the time series of average annual temperatures, the line spacing and the overall average for the period 1961-2007. Until 1974, the individual average annual temperatures are below the overall average. On the contrary, since 1988, all average annual temperature higher than the overall average, with one exception in 1996.

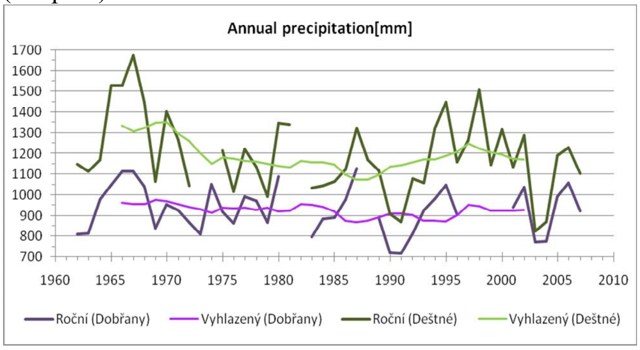


Graph 1 - The course of average annual temperatures (Deštné, 1961-2007)

We can say that the linear trend line is positive (coefficient of determination R^2 = 0.577) and mean annual temperature would it grew by 0.061°C per year, i.e. 0.61°C per 10 years.

Annual precipitation

There was a time series of daily rainfall from two meteorological stations in the basin of Dědina years 1961-2007. One is located in Dobřany, the second in Deštné. The original daily total precipitations were calculated annual precipitation of hydrological years. Average annual rainfall for the entire period 1961-2007 is 930 mm at Dobřany station, and at stations Deštné 1192 mm. The lowest annual rainfall of this period (716 mm) was recorded in 1991 Dobřany station. The highest rainfall was 1675 mm in 1967 Deštné station. Nevertheless, especially the lower part of the catchment are characterized and classified as climatically arid region. This is due to a high proportion runoff and less water retention in the basin. This is, together with the uneven distribution of rainfall, low utilization of water for organisms and also a small supply of groundwater and surface water. For clarification and greater readability graphically processed precipitation time series, the original series smoothed moving average with a length of 11 values (Graph 2).



Graph 2 - The course of the annual total precipitation (Dobřany, Deštné, 1961-2007)

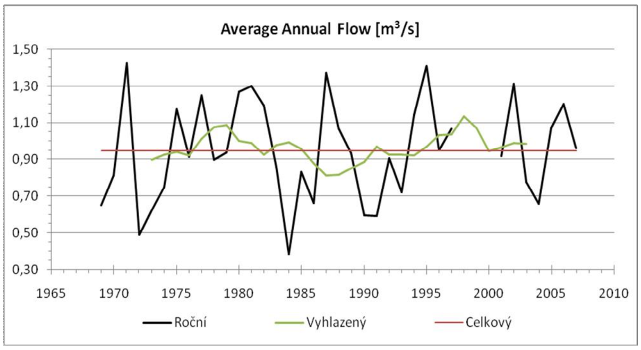
Linear regression showed that the trend of this series is negative and annual total precipitation in his declining by 3.9 mm per year, ie 39 mm per 10 years.

Average annual flow

The basic framework for description and statistical analysis of average annual flow, average seasonal flow and extreme flows of river Dědina, forms daily flows obtained from the profile watcher Chábory. There were daily flows from the end of calendar year 1968 to 2007.

From the measured daily flow of the river Dědina, were calculated the average annual flow of the hydrological years. The average annual flow in Chábory profile for the entire period 1968-2007 is 0.95 m^3 / s. The lowest average annual flow of this period was 0.38 m^3 / s. It was recorded in 1984. The highest annual flow was 1.43 m^3/s in 1971. Graph 3 shows the time series of average annual flow in the years 1968-2007 obtained from the profile Chábory and a range of values smoothed moving average of length of 9 values.

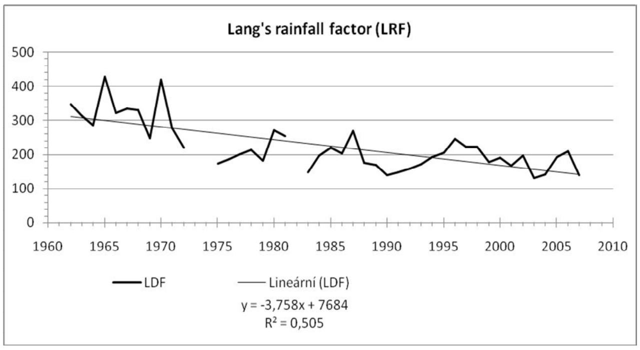
Graph 3 also shows the total average annual flow for the period 1968-2007. Course smoothed time series of average annual flow can be compared in terms of overall average flow rate of the period divided into three sections. The first section is the period 1977-1985, the average annual values are mostly above average flow. The second section is the period 1986-1994 with most below-average values of annual flows. The third section is the period 1995-2003, there are again above average annual flow.



Graph 3 - The course of average annual flow (Chábory, 1968-2007)

Relations of hydrometeorological variables

According to information obtained from the Climate Atlas of the Czech [CHMI] the relationship between atmospheric precipitation and air temperature determines Lang's rain factor (LRF), which is used for classifying areas according to the availability of moisture. LRF is calculated by dividing the annual total precipitation [mm] and average annual temperature [°C]. It takes the LRF values of less than 70, have a higher probability of occurrence of meteorological droughts in a given season. Figure 4 shows the development of LRF values during 1961-2007 in the station Deštné. After fitting a straight line LRF time series using linear regression was found that the line has a statistically significant downward trend. Annual LRF size decreases of 3.8, which mean an annual reduction of the natural landscape irrigation. According to the linear model LRF reaches a critical value of 70 in 2026.[Kvasnickova]



Graph 4 - Lang's rain factor (Deštné, 1961-2007)

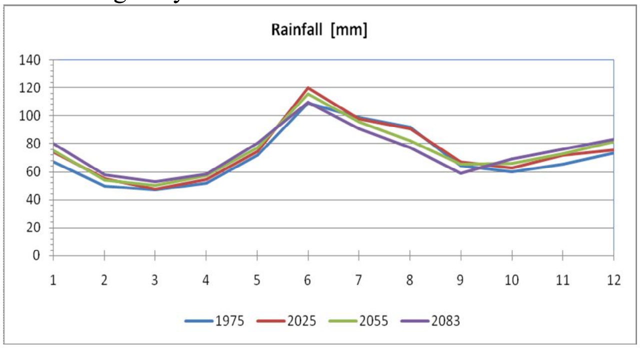
The use of modeled data

In terms of possible adaptation to climate change is also necessary to study the measured data also resolve the future situation in the basin. For the prediction of climate evolution is necessary to use data modeling. For modeling data were used hydrological balance model Bilan, who is in the monthly version from the 90th of the 20 century commonly used for hydrologic analysis of river basin in the Czech [Horacek et al.].

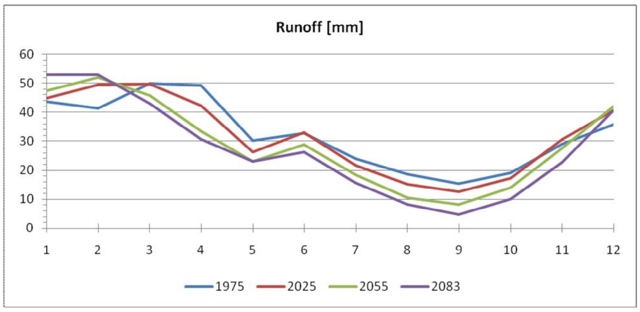
The output from the Bilan model was data in the monthly step for years 2025, 2055 and the 2083rd. Calibration of the model took data series at the level of 1975, namely from 1968 until 1990. In total, the modeled values used 28 different climate models. The first modification to this data was set the elimination of models with incomplete data series, which were for a shorter interval forecasts. It was the models able to simulate the data only until 2050 (CNRM_ARP, CRCM_CCC, HIR_BCM, HIR_Q0, CHMI_OBS, PROMES_Q0, RRCM_Q0).

Further courses have been created each modeled variables (precipitation, flow rates, primary runoff, store water in the unsaturated soil, underground water supply in the saturated areas, infiltration, air temperature and humidity) in the level of individual models. As seen in Figure 5, 6 and 7 Graphs are ENS_AVE model, created by the Ensemble project.

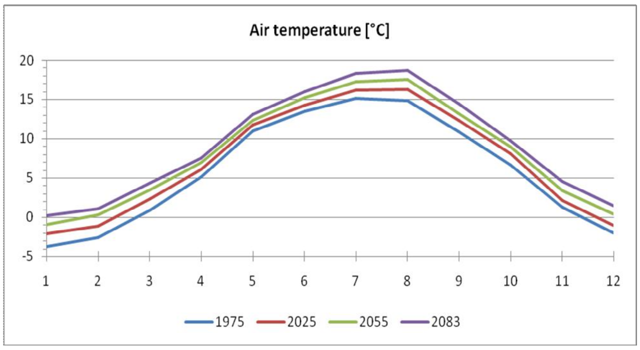
From these graphs is apparent evolution of the variables in time during the year.



Graph 5 - The course of precipitation in each level for years 1975, 2025, 2055 and 2083



Graph 6 - The course of runoff in each level for years 1975, 2025, 2055 and 2083



Graph 7 - The temperature of air in each level for years 1975, 2025, 2055 and 2083

This adjusted data was divided into three coherent and well-arranged groups. The first group consists of models suitable for modeling climate variables for the Czech Republic in the methodology for assessing the impacts of climate change and adaptation measures in the draft water management linked to the risk eliminated [Kos].

Another group consists of all models (modeling through the year 2050), which are divided into separate subgroups due to the emergence of individual models. This is a subgroup

•ECHAM5 driven (Jungclaus 2006)

•HadCM3Q0, HadCM3Q3, HadCM3Q16 driven (Collins et al. 2006)

•ARPEGE4.5 and 5.1 driven (Salas-Mélia et al. 2005)

•BCM2.0 driven (Furevik et al. 2003).

The last group is left without further division of models.There are included all possible variants of modeling.

Adaptation applicable to the basin Dědina

The development of climate change on river basin Dědina has been studied as based on an evaluation of statistical data (1960 - 2007), as well as evaluation of mayors, farmers and other people working actively within the watershed. A number of historical data and projected scenarios of the society was then modeled the expected future evolution of climate on the territory.

Very simply, one could argue that the temperature will gradually rise and runoff together with precipitation will be lower in summer and in winter higher. This will shift from summer precipitation (drier) periods in spring, and thus to deepen the dry periods during the summer. This illustrates how a linear extrapolation of Lang's rain factor, as well as models of rainfall / runoff for time horizons 2025, 2055 and the 2083rd. Regardless of the unfortunate experience of extreme floods 1998 is therefore a major problem anticipated drought. While this does not mean that there is extreme precipitation similar to that of 1998, but given the experience and changing land use in the watershed is not the risk is too high. Conversely, loss of water, especially in the lower part of the basin where is water catchment area Litá (important for supplying drinking water to eastern areas), it is necessary to prepare in advance. One option is the construction of reservoirs in this profile. Infiltration support and retention of water in the basin should be given the importance of drinking water supply priority. It is necessary to promote the recycling of water and its efficient use (separate of supply water and drinking water). Natural and semi-natural ecosystems deal with the climate change generally easier [Bolom et al.]. It is necessary to intensify anti-erosion measures on arable areas, for water bodies need to take care (pond mud removal, treatment and stabilization of river bed). In particular, long-term goals should be leveraged into strategic documents and plans (River basin management plan, Structural plan, etc.), the refining of development can then be applied even more detailed proposals and measures.

Acknowledgements

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