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title: **The impact of climate change on hydrological patterns in headwater catchments of Czech GEOMON network**

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INTRODUCTION

This paper is focused on changes in flow patterns due to projected climate change in micro-scales such as headwater catchments. The investigated Lysina (LYS, 0.27 km^2, 829–949 m a.s.l.) and Pluhův Bor (PLB, 0.22 km^2, 690–804 m a.s.l.) catchments are situated in the western part of the Czech Republic. Lesní Potok (LES, 0.70 km^2, 400–495 m a.s.l.) and Salačova Lhota (SAL, 1.68 km^2, 557–744 m a.s.l.) catchments are situated in the central part.

MATERIALS AND METHODS

The Brook90 model was used for hydrological modelling. Brook90 is a deterministic, process-oriented, lumped parameter hydrological model that can be used to simulate most land surfaces at a daily time step year-round (Federer et al., 2003). The model uses the Shuttleworth and Wallace (1985) method for separating transpiration and soil evaporation from sparse canopies, and evaporation of interception. Meteorological model input data for the studied catchments (minimum and maximum daily air temperature, daily precipitation depths, average daily wind speed and length of daylight) for the period 1961–2006 were taken from climatic stations of the Czech Hydrometeorological Institute (CMHI). Air temperature data were corrected based on a lapse rate, in order to represent the average catchment altitudes. Daily precipitation amounts were corrected by a factor calculated from the difference between average annual precipitation amounts measured by bulk precipitation collectors at the investigated catchments and precipitation amounts measured at CHMI climatic stations. Investigated catchments are equipped with water-level recorders, installed in combination with V-notch weirs. The calibration of Brook90 and validation of model performance were based on daily discharge data from the catchment outlets for the period 1990–2006 (Lysina, Pluhův Bor) and 1993–2006 (Lesní Potok, Salačova Lhota).

The climate model data used were obtained as a result of dynamical downscaling by the regional climate model RCAO (the Rossby Centre regional Atmosphere-Ocean model; Döscher et al., 2002). The RCAO model uses large-scale lateral boundary conditions from two GCMs: HadAM3H (Hadley Centre, United Kingdom; hereafter RCAO-H) and ECHAM4/OPYC3 (European Centre Hamburg Model, developed at Max Planck Institute for Meteorology, Germany, hereafter RCAO-E), each run with A2 and B2 emission scenarios. These future climate scenarios are based on the IPCC (Intergovernmental Panel on Climate Change) A2 and B2 SRES (Special Report on Emissions Scenarios) anthropogenic CO_2 emissions scenarios (Nakićenović et al., 2000).

Simulated daily maximum and minimum temperatures, daily amounts of precipitation, global radiation, and average daily wind speed were downloaded from the PRUDENCE project (Prediction of Regional scenarios and Uncertainties for Defining EuropeaN Climate change risks and Effects) (Christensen et al., 2007). These datasets are available for 0.44° grids (~50 km resolution) for a control period from 1961–1990 and a predicted period from 2071–2100.

Simulated RCAO atmospheric data for the control period (1961–1990) differed notably from measured data, and therefore had to be transformed for hydrological modelling purposes. We calculated a correction factors based on long-term monthly difference between RCAO climatic outputs and measured data in the control period. Under an assumption that it provides a local scale conditions correction, we used the factors for correction of the projected RCAO climatic outputs.

RESULTS

In general, Brook90 well reproduces the discharge conditions in the investigated catchments, including both individual flood events and long-term runoff. The correlation coefficient for the validation period (2000–2006) varied between 0.85–0.93 (r_{crit}= 0.2199, n= 84, p= 0.05) for monthly data and 0.67–0.73 (r_{crit}= 0.1966, n= 2557, p= 0.05) for daily data.

Annual runoff is predicted to decline by 6–90%, and impacts on the distribution of monthly flow are predicted to be significant, with summer-autumn decreases of 30–96% and winter increases of up to ~50% (for the higher altitude catchments) compared to mean flow from control period (Fig. 1). Concerning uncertainties in our study the selection of the GCM providing boundary conditions for the process of downscaling has larger impact on the projected hydrological change than the selection of emission scenario or RCM used for downscaling. The hydrological model in combination with future projected data is sensitive to change of leaf area index within the year influencing winter-spring evapotranspiration. This is probably due to anticipated shift in vegetation season.

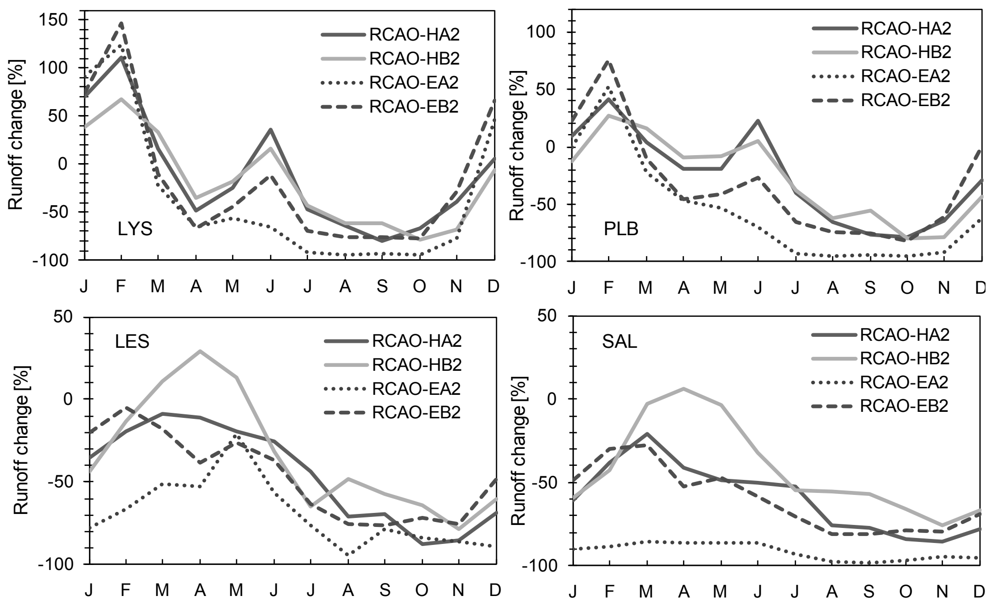

Figure 1. Mean annual cycle of runoff changes for Lysina (LYS), Pluhův Bor (PLB), Lesní Potok (LES) and Salačova Lhota (SAL). Changes between runoff were calculated using observed data for the control period (1961–1990, respective 1961–1990 for LYS and PLB) and future runoff in 2071–2100 was simulated based on bias-corrected RCAO outputs (using the HadAM3H and ECHAM4/OPYC3 with SRES A2, B2 scenarios).

CONCLUSIONS

The calibrated hydrological model Brook90 provides a suitable tool for the modelling of future changes in hydrological patterns in small-forested catchments.

The annual runoff is expected to decrease and the annual cycle will change significantly. Winter runoff is expected to increase, the runoff maxima will shift, and runoff in summer and autumn will decrease notably. The predicted declines in mean daily flows indicate that studied streams might regularly dry up for short periods in the summer and autumn that can be already recently seen at some locations.

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