APPLICATION OF MODEL METQ FOR THE RIVER BASINS UNDER DIFFERENT NATURAL CONDITIONS IN LATVIA

Anda Bakute, Ansis Zīverts†, Elga Apsīte

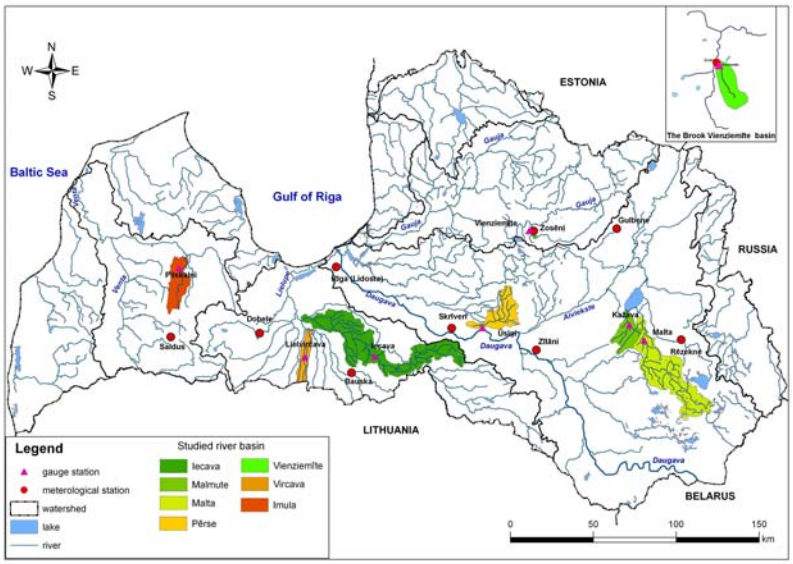
Faculty of Geographical and Earth Sciences, University of Latvia,
Raina bulv. 19, Riga LV 1586, Latvia e mail: anda.bakute@lu.lv

Introduction

The river basins of Latvia are characterized by different natural conditions – uneven relief, humid climate and geological development. The river basins of Latvia are characterized by different natural conditions – uneven relief, humid climate and geological development. These natural conditions are important aspects in hydrological regime of rivers. However, not always all parameters of hydrological regime or river basins have been observed. One of the explanations is that hydrological monitoring is rather expensive and there have been financial problems during the last fifteen years in Latvia. One possible method is the use of conceptual rainfall-runoff models which are widely used tools in hydrology. The aim of this study is to calibrate the conceptual model METQ2007BDOPT for the small rivers basins under different natural conditions, and to find relationships between parameter values and physiographic basin characteristic.

Material and methods

In this study the chosen seven river basins are located in different places of Latvia and belonged to the three largest river basins – the Daugava, the Lielupe and the Venta. The latest version METQ2007BDOPT is applied for the simulation of the daily runoff. In this conceptual model, to consider the runoff heterogeneity in runoff processes, the studied river basin were divided into hydrological response units (HRU). The HRUs characterized by a relative homogeneity with the respect to the most important parameters, which include slope, vegetation and soil characteristics. Everyone studied pilot river basins were divided into six 6 HRUs: agricultural lowlands, hilly agricultural lands, forests, swamps, sandy lowlands and lakes. However, in this study seven pilot river basins by one or two predominant HRUs or natural conditions were chosen The River Pērse basin was characterised with hilly agricultural lands and forests; the Brook Vienziemīte basin – hilly agricultural lands; the River I mula basin – agricultural hilly and lowlands; the River Vircava basin – agricultural lowlands; the River Iecava (upper reaches) basin – sandy lowlands; the River Malmuta basin – bog areas and the River Malta basin – lakes.



To according Pastor's (1987) regionalization of Latvian small rivers, the River Pērse basin belongs to the rivers' region of the Vidzeme Highland. Total drainage basin is 329 km², but upstream hydrological station Ūsiņi – 249 km². The average amount of precipitation is 800 mm per year.

The area of River Iecava drainage basin upstream hydrological station is 519 km², and it makes 1166 km² in total. The average amount of precipitation ranges from 650 to 750 mm per year. The River Iecava belongs to hilly the Upmale Plain and the Taurkalnes Plain.

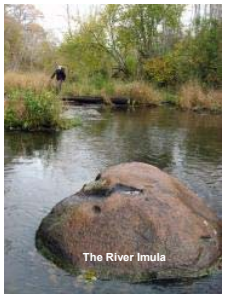
The Brook Vienziemīte basin area is 5.92 km² and it belongs to the rivers' of Vidzeme Upland. The average amount of precipitation is 800-850 mm per year.

The River Vircava basin belongs to the rivers' of the Zemgale Lowland and there average amount of precipitation is 599 mm per year. The total area of the River Vircava basin is 423 km².

The River Imula basin belongs to the Austrumkursas Upland and total basin area is 263 km². The average amount of precipitation varies from 650 to 700 mm per year.

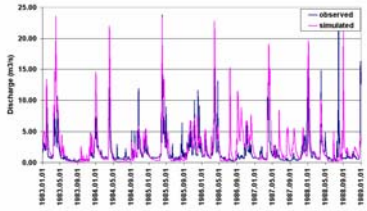
Comparing with other river basins, the Brook Vienziemīte basin receives the highest amount of precipitation, because it's located in the Vidzemes Upland. This basin characterizes also by high percentage of hilly agricultural land - 46 % cover of total basin. The most forested areas are in the Pērse River basin. Regardless of the Malta and the Malmuta river basins location in the same hydrological region, they are still different in predominant HRU. The River Malta is substantially affected by the lakes (about 35%), while the River Malmuta basin - by bogs' area (about 40%). The River Iecava basin is quite different from other river basins in terms of geomorphologic conditions. There are sandy lowlands dominating upstream of the River Iecava basin, as well as forests. The River Vircava basin is characterized by agricultural lowlands which occupies 56 % of the total drainage basin. However, the River Imula basin characterises by agricultural hilly lands (62 %).


The River Malta at Vijāni


The River Imula

Results and discussion

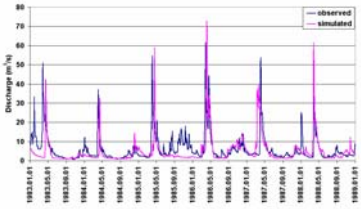
The conceptual rainfall-runoff model METQ2007BDOPT were calibrated to the seven pilot river basins for the various periods of river runoff observation records from 1956 to 2006. The best coincidence between simulated and observed daily discharge was found for the River Malta but the weaker – for the River Malmuta at Kažava. Optimized parameters of the model METQ2007BDOPT for the seven studied small river catchments with gauge stations (as results of calibration) are shown in the Table 1.



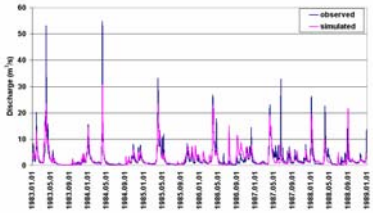
Observed and simulated daily discharge at runoff gauge station Imula – Pilskalni
results of calibration - r – 0.77 and R^2 – 0.66 (1956 – 1995)

Table 1 Optimized parameters of the model METQ2007BDOPT for the studied river basins

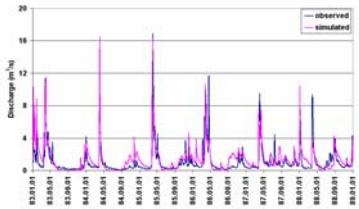
Parameters	The name of studied river basin						
	Pērse	Malta	Imula	Vircava	Iecava	Vienziemīte	Malmuta
WMAX, mm	35	30	30	70	34	35	20
ALFA	0.074	0.124	0.08	0.05	0.18	0.135	0.15
ZCAP, cm	140	130	140	150	125	110	60
A2	0.0006	0.0006	0.0007	0.001	0.0009	0.00076	0.0004
A3	0.00073	0.00079	0.0006	0.00088	0.0008	0.00056	0.0006
KU	0.56	0.61	0.61	0.57	0.57	0.62	0.58
KL	0.26	0.26	0.26	0.25	0.23	0.32	0.25
CMELT	2.5	3	2.9	3.5	2.5	3.4	2.5
T1, ^{0}C	0.5	0.5	0.5	0.5	0.4	0.5	0.5
T2, ^{0}C	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
KS	0.05	0.05	0.05	0.05	0.05	0.05	0.05
DZ, cm	70	100	100	40	75	65	40
PZ, cm	210	305	235	210	216	270	60
RCHR, mm/d	4	48	23	3	23	3	25
RCHRZ,mm/d	5	5	10	6	10	7	6
RCKR2,mm/d	21	14	20	45	67	70	25
RCHR2Z,mm/d	12	12	18	25	25	8	4
ROBK	1.5	1.5	1.5	1.5	1.4	1.5	1.5
WHC	0.1	0.1	0.1	0.1	0.1	0.1	0.1
CFR	1.2	1.2	1.2	1.2	1.2	1.2	1.2
DPERC,mm/d	0	0	0	0	0	0.04	0
AMELTK	0.08	0.05	0.05	0.09	0.08	0.08	0.07
BETA	2.1	2	2	2	2.1	2.2	2



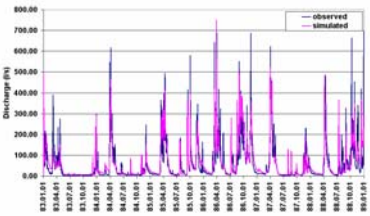
Observed and simulated daily discharge at runoff gauge station Malta – Vijāni
results of calibration: r – 0.88 and R^2 – 0.78 (1976 – 1995)



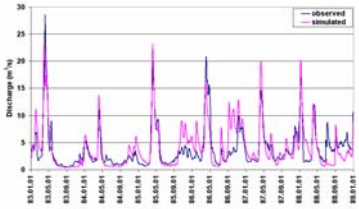
Observed and simulated daily discharge at runoff gauge station Pērse – Ūsiņi
results of calibration: r – 0.85 and R^2 – 0.72 (1956 – 2006)



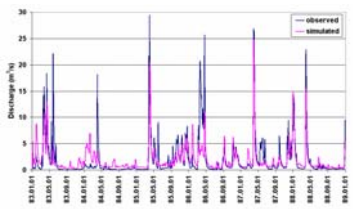
Observed and simulated daily discharge at runoff gauge station Malmuta – Kažava
results of calibration: r – 0.78 and R^2 – 0.60 (1980 – 2006)



Observed and simulated daily discharge at runoff gauge station Vienziemīte – Vienziemīte
results of calibration: r – 0.87 and R^2 – 0.77 (1956 – 2002)



Observed and simulated daily discharge at runoff gauge station Iecava – Dupši
results of calibration: r – 0.82 and R^2 – 0.66 (1956 – 1995)



Observed and simulated daily discharge at runoff gauge station Vircava – Llelvircava
results of calibration: r – 0.80 and R^2 – 0.63 (1983 – 2006)

The numerical values of model parameters for each river basin reflect the physiogeographical conditions, including geomorphological, land use, soil etc., of the studied drainage areas. Estimation of threshold value of water storage in the root zone is based on the previous studies of irrigation regime in Latvia. In the river basins rich in bogs, i.e. the River Malmuta basin, value of WMAX is 20 mm. Soil conditions play an important role in the runoff generation. According to the results, fillabale porosity (ALFA) is one of the main parameters which could reflect the geomorphologic conditions of rivers basin. The highest parameter value of ALFA was defined for the River Iecava basin. It may be explained by dominating sandy lowlands. In accordance with the hydrophysical properties of the soil structure, the highest value of fillabale porosity is for sands. Height of capillary rise (ZCAP) depends on the soil grading composition. The highest value of ZCAP was identified for the heavy soils, i.e. the River Pērse basin, while these values are lower for light soils like sandy ones. Value of coefficient of snow melting (CMELT) in the river basin is higher in more open, not forested areas such as the River Vircava basin. The results obtained from the model calibration show that the model METQ2007BDOPT is widely applicable for this kind of pilot basins.

Acknowledgments

This study was supported by *the European Social Fund (ESF)* for financial support in Doctoral studies of Anda Bakute, also by the National Research Program *Climate change impact on water environment in Latvia*, and data were provided by *Latvian Environment, Geology and Meteorology Agency* and *SIA Meliorprojekts*. Authors would like to thank also Professor Ansis Zīverts for generously provided consultations and knowledge about modelling basics.