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Impact of climate changes on groundwater recharge in the alluvial aquifer of Mura valley, Slovenia

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CC-WaterS

Introduction

The impact of climate change on water resources is a critical issue for society and economy. An extent of climate change and impact on water resources, particularly on public water supply is studied in the frame of South-East European project CC-WaterS. The main water supply problems are related to the significant change of groundwater quantity and quality observed in the last decades as an effect of land use practices and are very likely linked to climate change.

Mura valley aquifer

Slovene test area is alluvial aquifer of Mura valley (**Figure 1**), which is located in the western edge of Pannonian basin with continental climate with mean annual temperature (1971-2000): 9.6°C and mean annual precipitation 787 mm. Landuse is mostly agriculture (**Figure 2**). Mura valley is an alluvial plain among hills with altitudes up to 400 m, stretching from NW to SE. In the southern part of the valley runs river Mura and in the northern river Ledava, which both inetract with groundwater. Mean annual discharge of Mura river is 153 m^3/s and of Ledava 1,2 m^3/s. Groundwater recharges from precipitation, surface and groundwater runoff from the surrounding hills (mainly from Goričko hills in N, less from Slovenske Gorice in SW). Aquifer in this area is unconfined with mean thickness of 17 m. Mean depth to groundwater is 4 m. Mean hydraulic permeability is $5 \cdot 10^{-4}$ m/s. There are three supply systems and providers with ten major water well fields. In 2008, the uptake for the public water supply in Mura valley was $10{,}15 \cdot 10^6$ m^3.

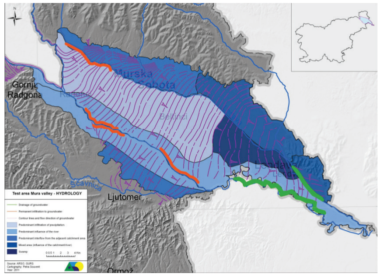


Figure 1: Hydrological map of Mura valley

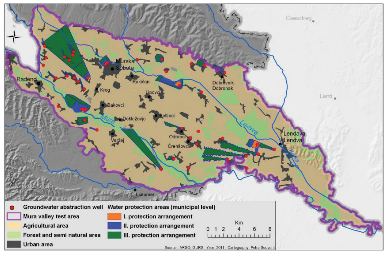


Figure 2: Landuse in Mura valley and abstraction wells with water protection zones

3 Aquifers:

1st aquifer:
- shallow, mainly unconfined
- quaternary sediments
- extensive and highly productive (>50 l/s)
- mean permeability: 5 x 10^{-4} m/s
- mean thickness of saturated zone: 17 m
- mean thickness of unsaturated zone: 4 m
- interaction with the river Mura and Ledava

2nd aquifer:
- confined
- tertiary sediments
- mean permeability: 1 x 10^{-6} m/s
- mean thickness : >40 m

3rd aquifer:
- confined
- thermal
- mean permeability: 1 x 10^{-7} m/s
- mean thickness : >200 m

Water balance model GROWA-SI

Water balance was modelled with empirical model GROWA (**Figure 3**), developped by Research Center Jülich in Germany (Kunkel & Wendland 2002*). The model consists of several modules determining evapotranspiration, total runoff, direct runoff and groundwater recharge. Evapotranspiration for the present state was calculated according to Penman equation, whereas evapotranspiration for projected periods was calculated according to Thornthwaite formula, since wind parameters and radiation have very low reliability. Total runoff is calculated from difference between precipitation and evapotransiration. In order to determine groundwater discharge, a runoff separation is performed. The reliability of calculated area-differentiated runoff values was checked by verification on monthly runoff data from representative hydrological stations.

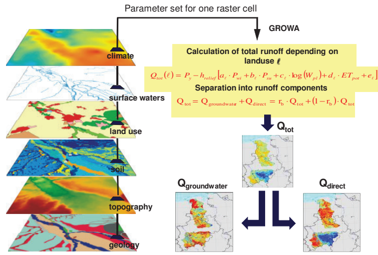


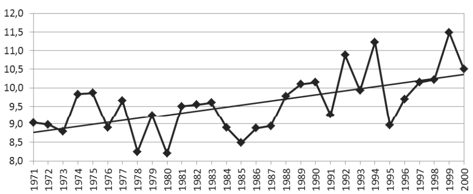
Figure 3: GROWA model layers

Data for GROWA water balance model:

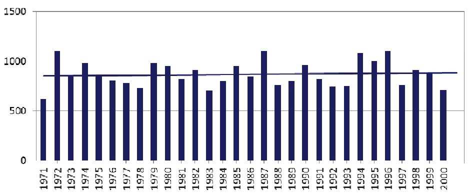
Data base		Scale / spatial resolution	Data source
Climate data (2006)		100 x 100 m	The Environment Agency of the Republic of Slovenia
Landuse	Landuse categories	25 ha	CORINE data base
Soil data		1:25 000	Pedological map of the Biotechnical Faculty
Topography	Slope & exposure	100 x 100 m	DMR
Geology	Hydrogeologic units	1:100 000	Geological Survey of Slovenia
Runoff data (1971-2000)	Catchments Daily Runoff	1:25 000	The Environment Agency of the Republic of Slovenia

*Kunkel, R., Wendland, F. 2002: The GROWA98 model for water balance analysis in large river basins.- Journal of Hydrology 259: 152-162.

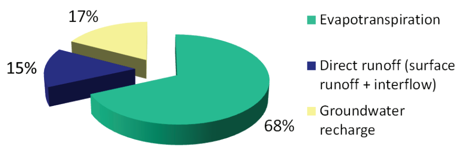
Water balance – 1971-2000 (year 2006)



Mean annual temperature in Murska Sobota (°C).

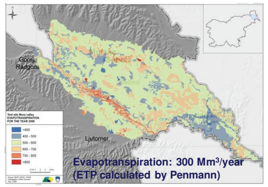


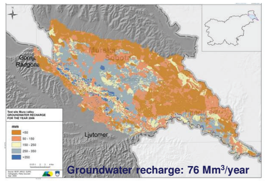
Total annual precipitation in Murska Sobota (mm)

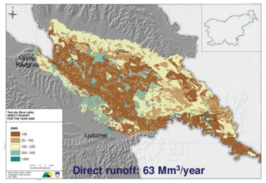


Water balance according to GROWA model for 2006

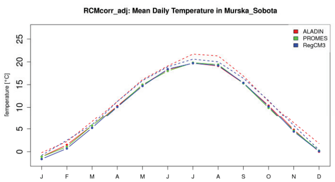
Precipitation: 439 Mm^3/year



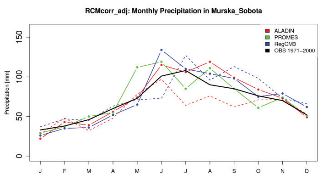




Climate data for periods 2021-2050 and 2071-2100



Temperature differences among RCMcorr_adj in the two future periods at Murska Sobota (solid line with bullets denotes 2021-2050 period, while dashed line denotes 2071-2100 period)



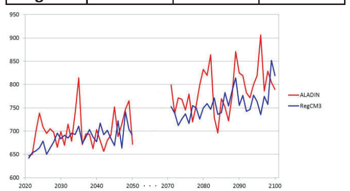
Precipitation differences among RCMcorr in the two future periods at Murska Sobota (solid line with bullets denotes 2021-2050 period, while dashed line denotes 2071-2100 period)

Yearly averages of air temperature differences [°C] between 2021-2050, 2071-2100 and 1971-2000 periods for Murska Sobota:

Model	Annual averages of air temperature	
	Between 1971-2000 and	
	2021-2050	2071-2100
ALADIN	1,4	3,2
PROMES	2	-
RegCM3	1,2	3

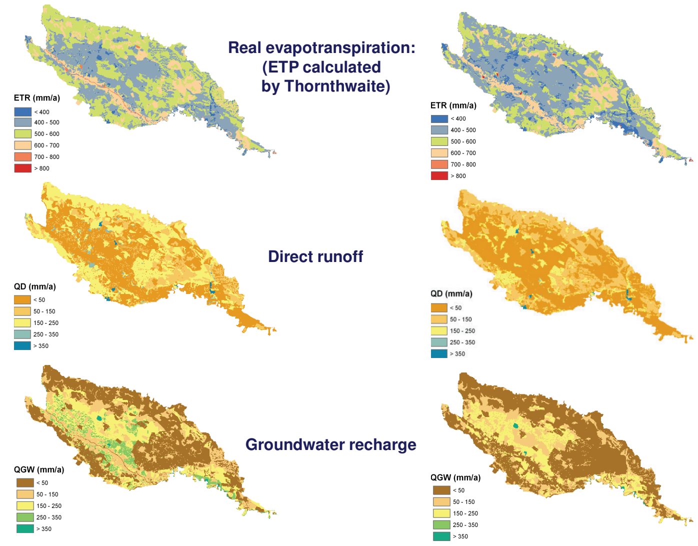
Annual precipitation [mm] in the reference and future periods in Murska Sobota:

Model	Total annual precipitation [mm]		
	1971-2000	2021-2050	2071-2100
ALADIN	806	855	709
PROMES	760	842	-
RegCM3	802	850	878



Annual calculated evapotranspiration [mm] for two future periods in Murska Sobota

Water balance – 2021-2050 and 2071-2100



Water balance according to GROWA-SI model for the period 2021-2050

Water balance according to GROWA model for period 2071-2100

Aknowledgement
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