CC impacts on water resources availability - a case study of the Ljubljana field and Mura valley alluvial aquifers (Slovenia)

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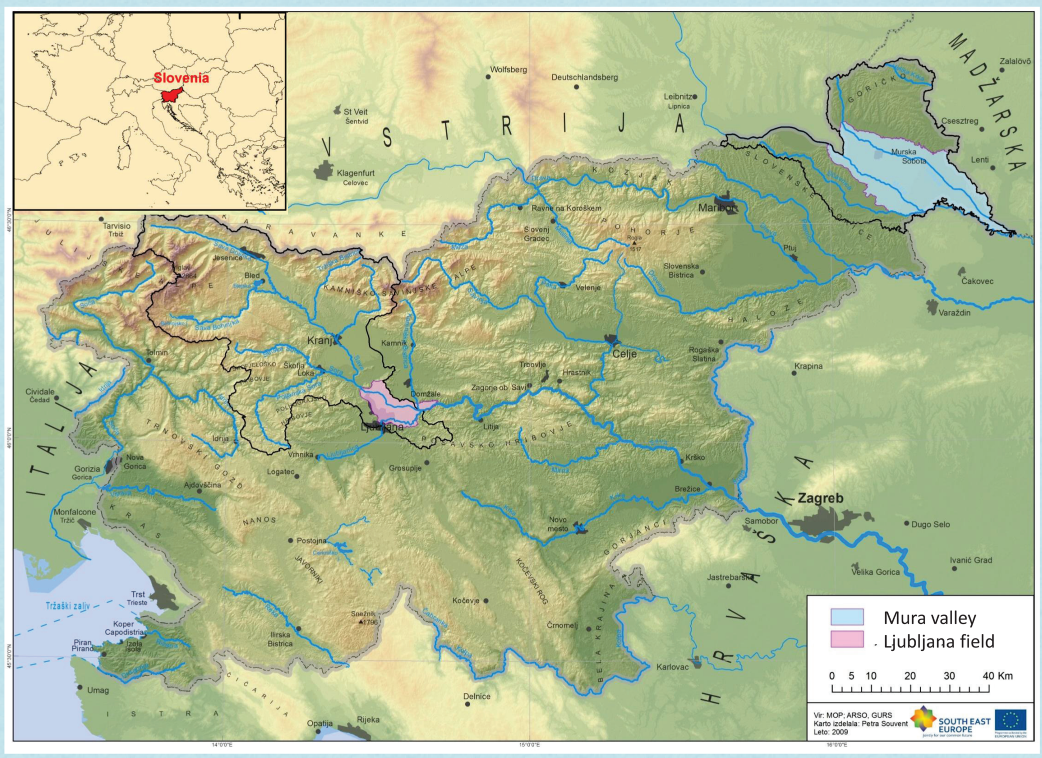
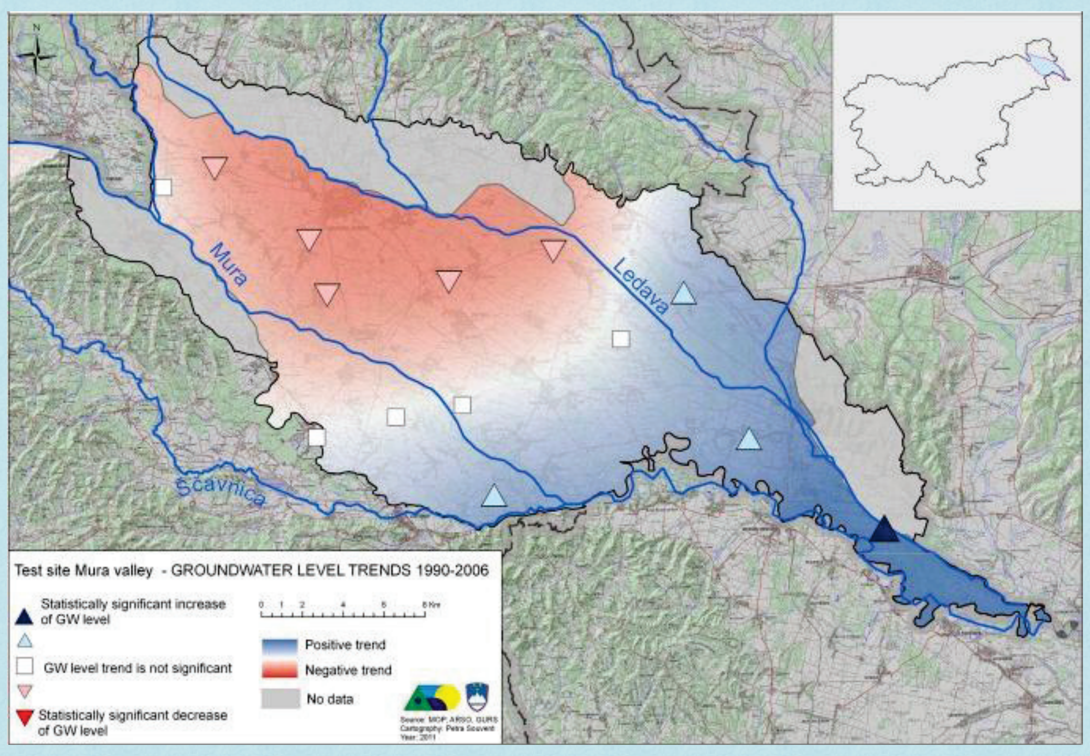
Climate change (CC) impacts on water resources availability could be a critical issue for society and economy. The anthropogenic activities modify the aquifer area, impact the hydrological balance, reduce the aquifer recharge, influence the groundwater flow characteristics, change the water resource availability and restoration and influence the quality of groundwater, what was studied in the frame of South-East project CC-WaterS.

Introduction



BASIC DATA	LJUBLJANA FIELD	MURA VALLEY
Size: Length/Width	20.14 km / 11.14 km	53.23 km / 20.25 km
Height (in m above sea level)	254.5 – 639.4	146.2 – 328.4
Average ann. precipitation (1961-1990)	1358 mm	817.42 mm
Mean ann. temperature (1961-1990)	9 °C	9.5 °C
Permeability (mean)	10-2 m/s – 3.7x10^{-3} m/s	10-4 m/s
Depth to groundwater (mean)	5 - 30 m	4 m

Slovene test areas were two shallow alluvial aquifers. First, the Ljubljana field aquifer is an unconfined porous aquifer, belongs to Ljubljana basin and is in the central part of the country. It is a source for drinking water for almost 300.000 people. The thickness exceeds 100 m, the groundwater recharges from rainfall (50 %) and from the river Sava (50 %). The three quarters of the aquifer lie beneath the urbanised and agricultural area. The second test area was Mura valley's unconfined porous aquifer, which is located in the north-eastern part of Slovenia and is part of Pannonian basin. It is a source for drinking water for about 70.000 people. The aquifer is shallower, the average thickness is 17 m, the groundwater recharges mainly from precipitation (only about 20% from the river Mura) and most of the aquifer lies beneath the agricultural area.



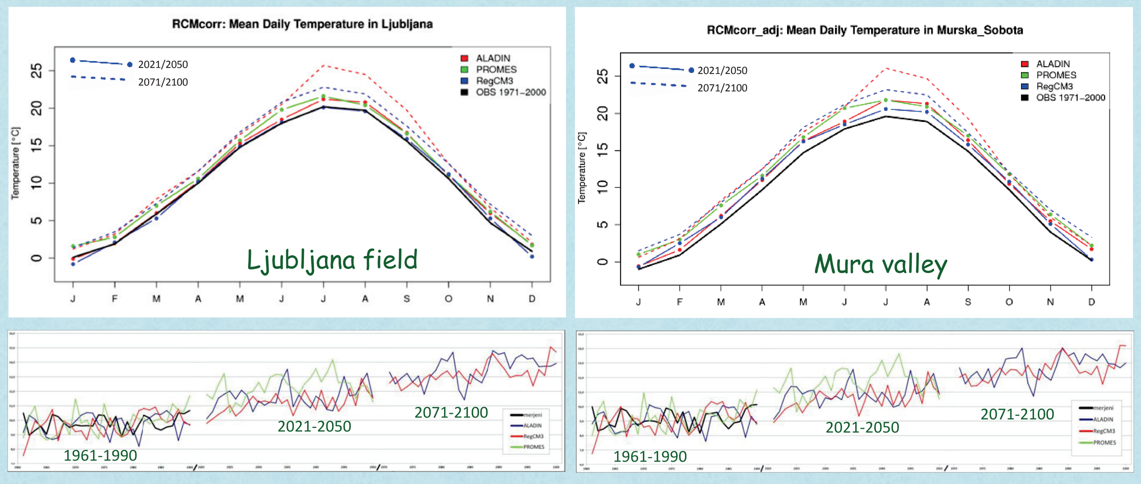
As the groundwater levels show a decreasing trend over the last few decades, especially in the Mura valley, the question arises whether this is due to human interventions, e.g. groundwater pumping surpassing groundwater recharge rates or climate-related decrease in groundwater recharge.

Methods & results

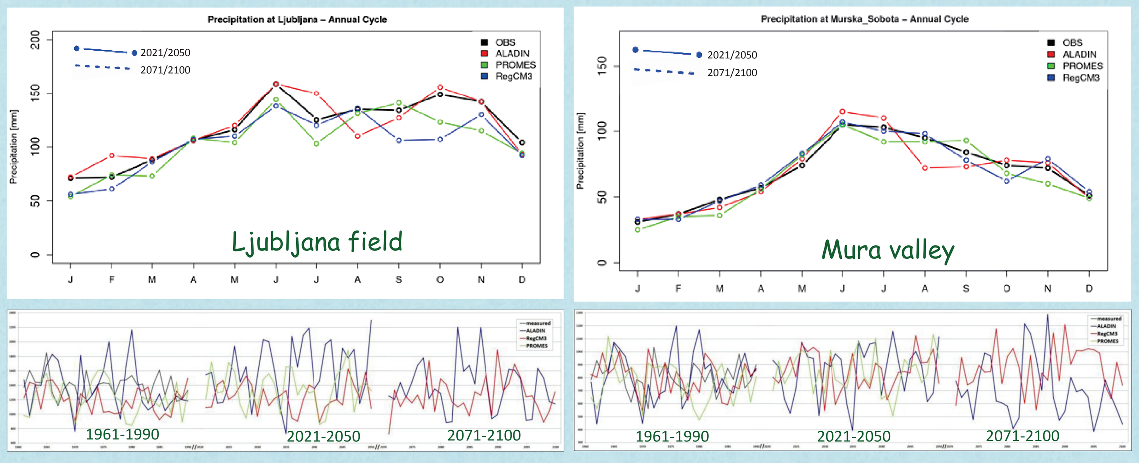
Temperature & precipitation

Daily data were obtained from RCM models, based on EOBS data base: RegCM3, ALADIN and PROMES. A greenhouse gas emission scenario, the A1B scenario was used with these models for the two future periods: 2021-2050 and 2071-2100. RCM predictions were adjusted to local observations by the quantile mapping method approach (Bergant & Muri 2010).

TEMPERATURE



PRECIPITATION

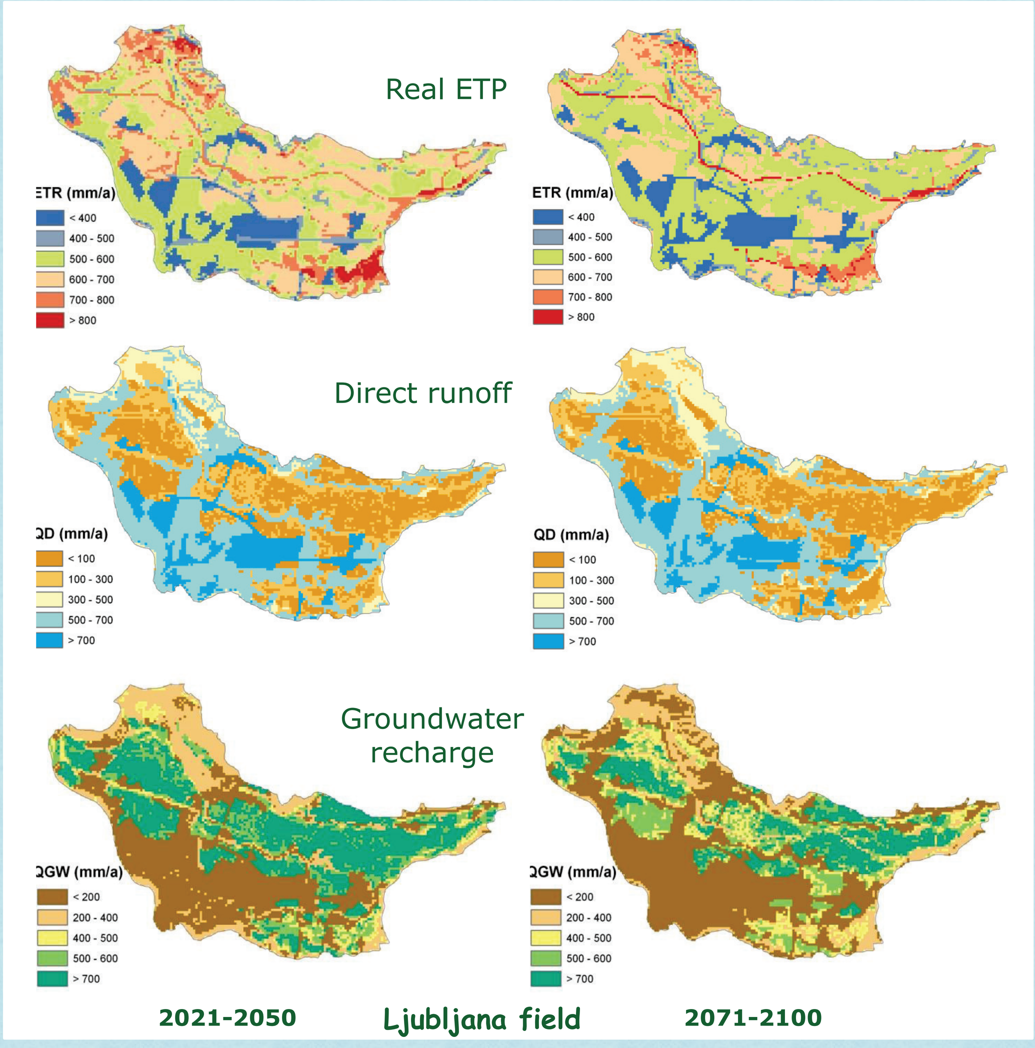


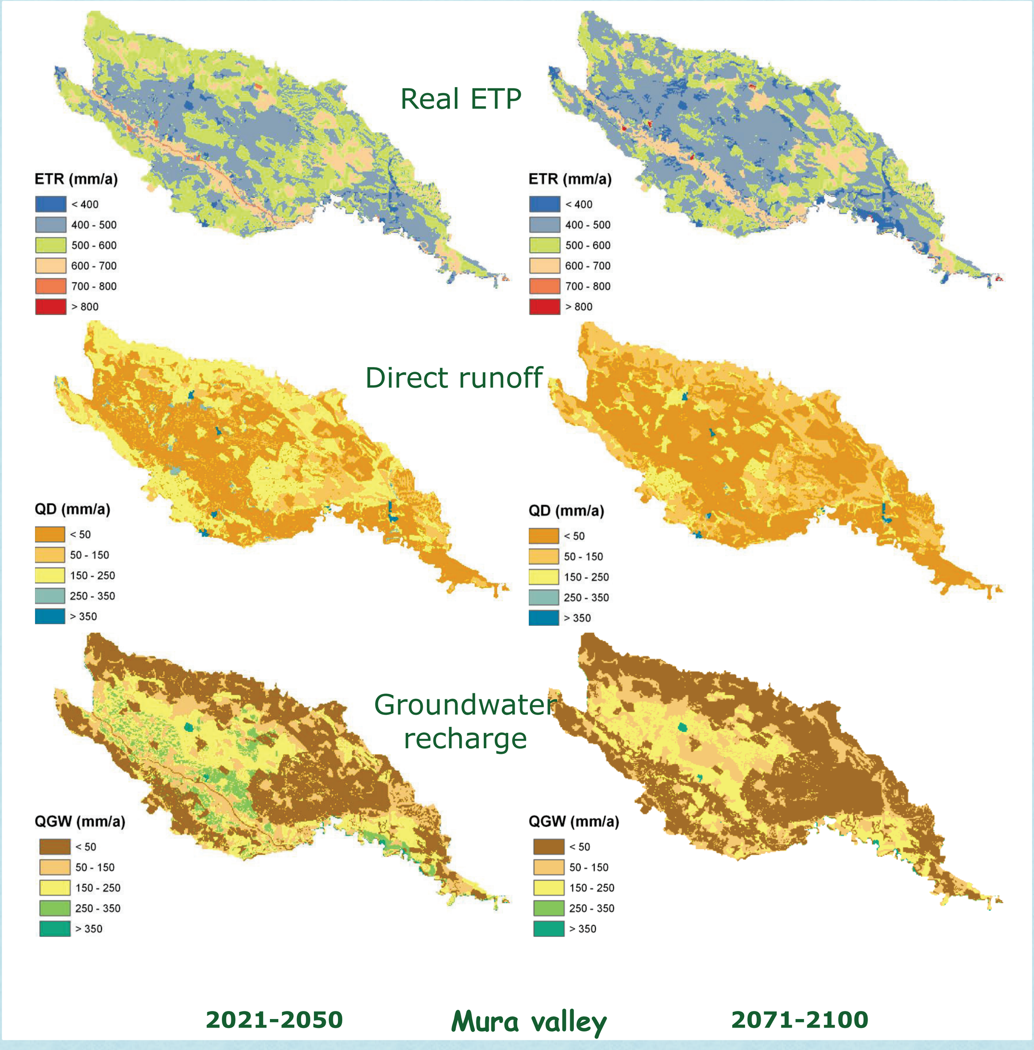
The increase in air temperature was the largest in the warm part of the year, particularly in the summer for both test areas. Precipitation data manifested a high degree of ambiguity in the future periods, but the model simulations agreed on a general trend pointing to less precipitation in the summer. Modeled data also indicated trends in the direction of longer duration of dry spell and greater maximum daily rainfall.

Water balance & river discharges

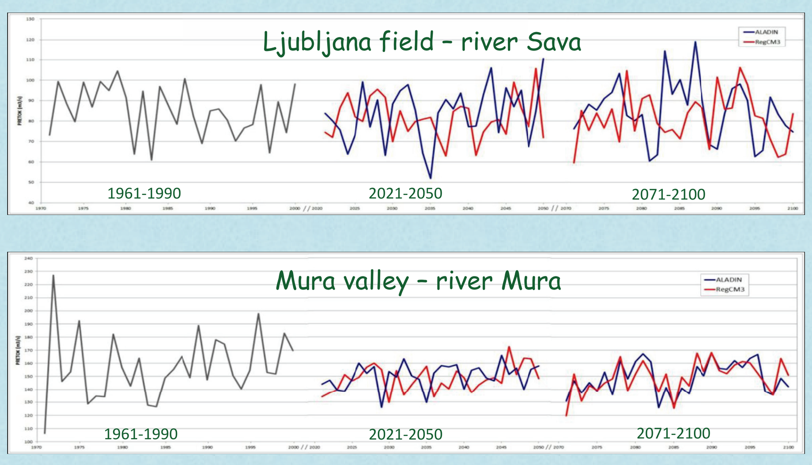
The water balance for the past (1971-2000) and two future periods were calculated with the GROWA-SI model (Kunkel & Wendland, 2002). The GROWA-SI model consists of several modules for determining the real evapotranspiration, total runoff, direct runoff and groundwater recharge. The input data for the model are climate parameters modelled with ALADIN and RegCM3. As Ljubljana field aquifer is extensively fed from the river Sava (50%), impacts of surface water flow regime was expected to affect groundwater in the future. Future river discharges were calculated for both, Sava and Mura river, as linear correlation between standardized variables, the different combinations of cause-effect relationship and considered hydrometeorological time series (Prohaska et al. 2011).

WATER BALANCE – GROWA





RIVER DISCHARGES



Available water resources and water use for 1971-2000 / 2021-2050 / 2071-2100 (Mm³/year)		
	LJUBLJANA FIELD	MURA VALLEY
ALADIN	81 / 91 / 75	78 / 73 / 48
RegCM3	87 / 87 / 86	72 / 73 / 75
Water use	20.2 / 20.7 / 21.4	3.8 / 3.5 / 3.2

With assumption that the river bed would not change in the next 100 years, results had shown that trends of mean annual discharges would not change significantly, whereas the variability would increase - higher values of maximum and lower values of minimum discharge are expected.

Discussion & Conclusions

Water balance results have shown decrease of groundwater recharge in the Ljubljana field as well as in the Mura valley in the future. In the period 2021-2050 the groundwater recharge will decrease up to 10% and in the period 2071-2100 up to 15%. This could also be a socio economic and political issue, since already now there is a great competition for water, mainly among public water supply and agriculture, especially in summer months.

It could be concluded, from the current available groundwater data, that the anthropogenic activities modify the observed aquifer areas, already, impact the hydrological balance, reduce the aquifer recharge, influence the groundwater flow characteristics, change the water source availability and restoration and influence the quality of groundwater, whereas agricultural activities impact the water quality. If to all this, the climate variability and change through recharge processes due to climate changes is added, significant changes in the availability of groundwater could be expected in the future, especially in the areas where groundwater is already stressed.

References Kunkel, R., Wendland, F. 2002. The GROWA98 model for water balance analysis in large river basins.- Journal of Hydrology 259: 152-162. Muri, B., Bergant, K. (2010). CC-WaterS, WP 3 Climate Change, Applications to Slovene project test areas. 40p. Prohaska, S., Ilić, A., Majlić, B. (2011). Application of VNC mathematical model for assessment of river discharge in climate changing conditions for two test sites in Slovenia. 19p.

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