CLIMATE CHANGE IMPACT EVALUATION ON THE WATER BALANCE OF THE KOROŠKA BELA AREA, NW SLOVENIA

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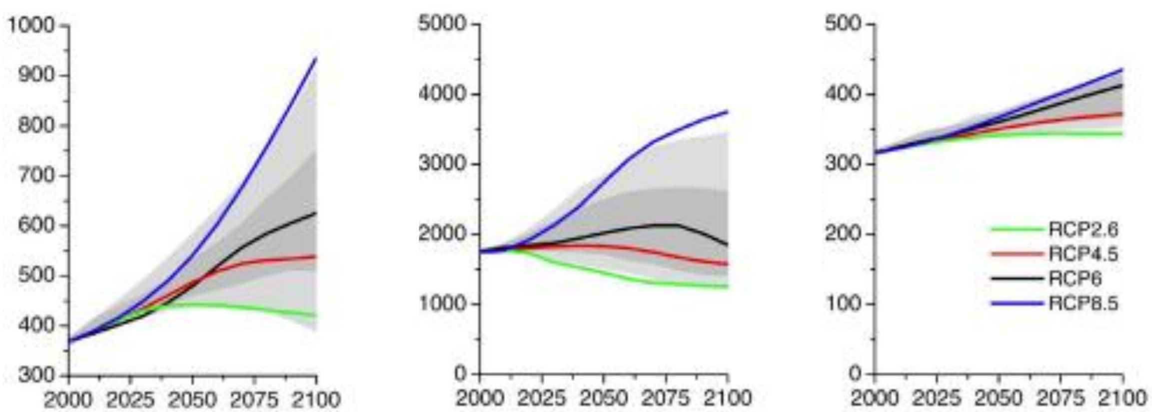
INTRODUCTION

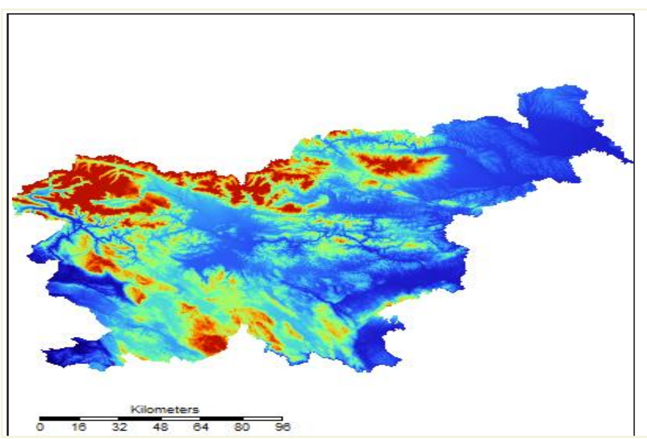
Nejc Bezak, Tina Peternel, Anže Medved, Matjaž Mikoš

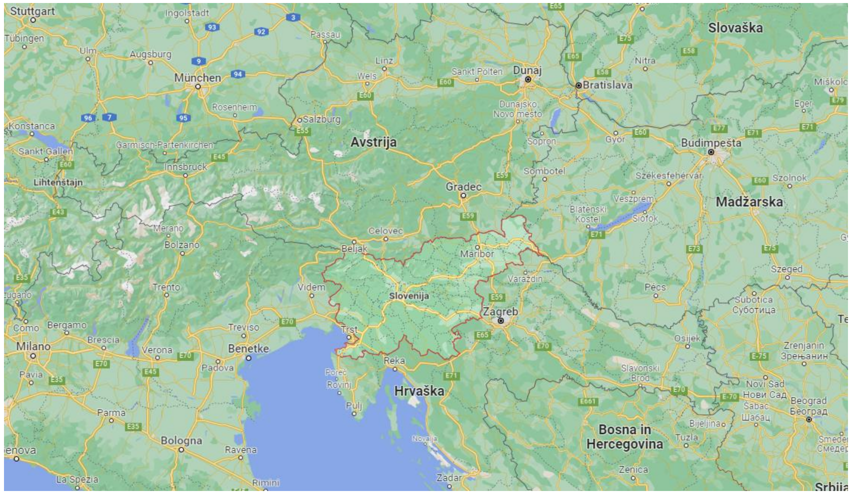
- Climate change is expected to affect the water cycle components such as rainfall, surface runoff, subsurface fluxes and their relationships.
- However, it is not clear how will the temperature increase impact on the rainfall-runoff dynamics, which is also related to the landslides and debris flows triggering mechanics.



INTRODUCTION

- One of the endangered in Slovenia (Central Europe) villages is the Koroška Bela that is located below the Potoška planina slow deep-seated landslides with the sliding mass composed of tectonically deformed and weathered Upper Carboniferous and Permian clastic rocks covered with a large amount of talus material.





INTRODUCTION

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- Detailed field work, lab experiments, modelling and a conceptual design of hydro-technical measures to reduce the risk was conducted at this location in the recent 2-3 years.

Technical Note

Landslides
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Nejc Bezak · Jošt Sodnik · Matej Maček · Timotej Jurček · Jernej Jež · Tina Peternel · Matjaž Mikoš

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Investigation of potential debris flows above the Koroška Bela settlement, NW Slovenia, from hydro-technical and conceptual design perspectives

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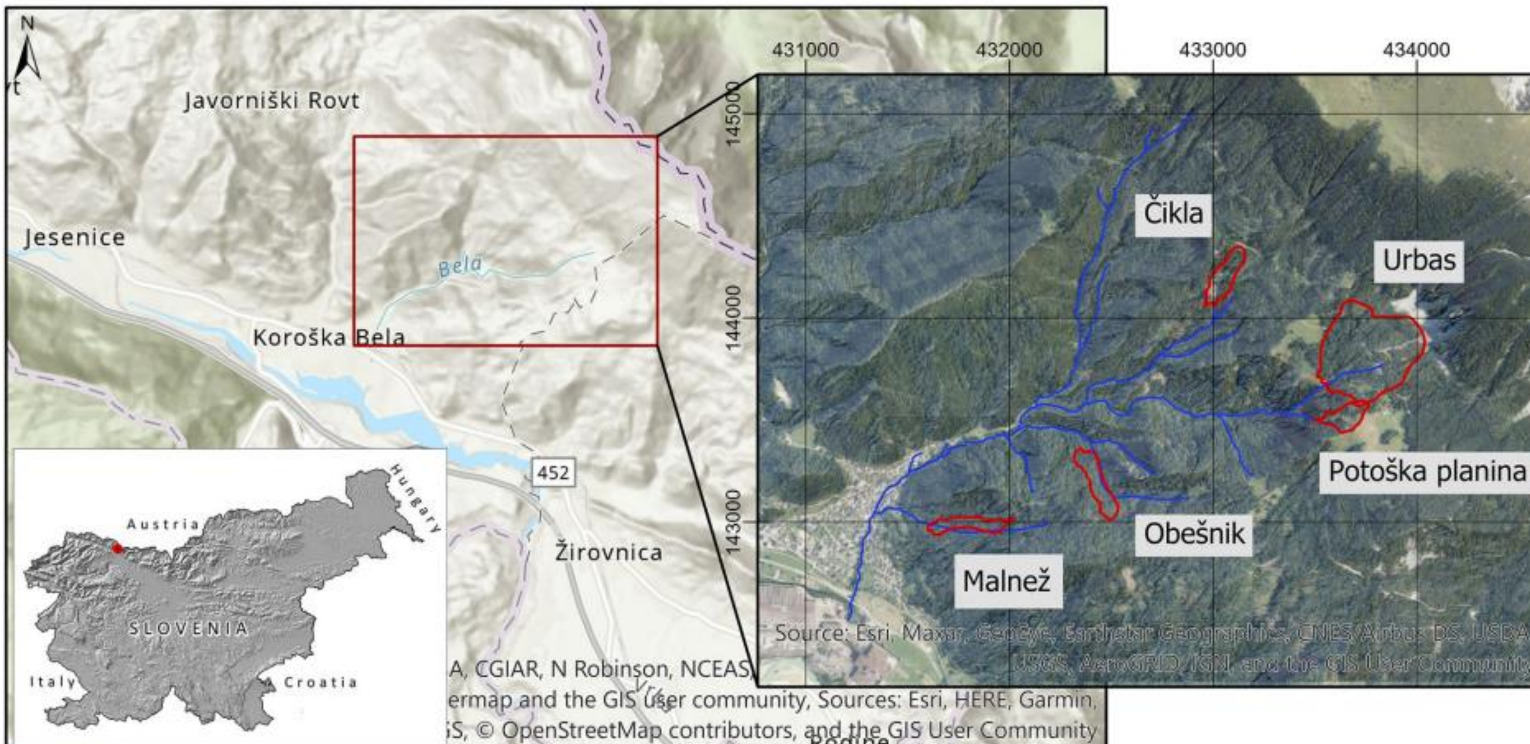
LANDSLIDES

- Five major active landslides are located in the torrential watershed of the Bela torrent.



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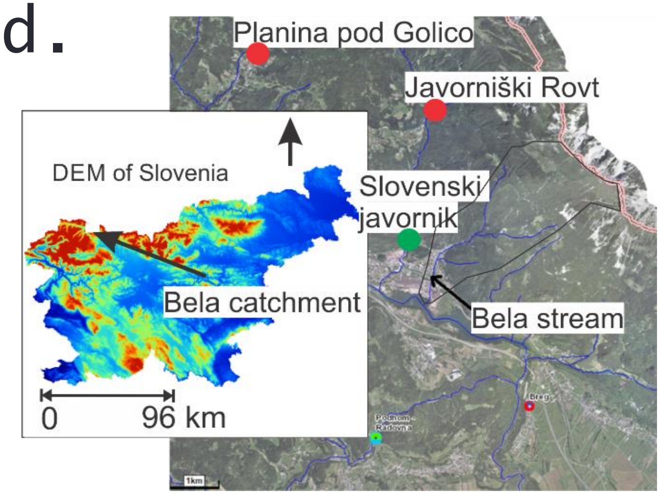
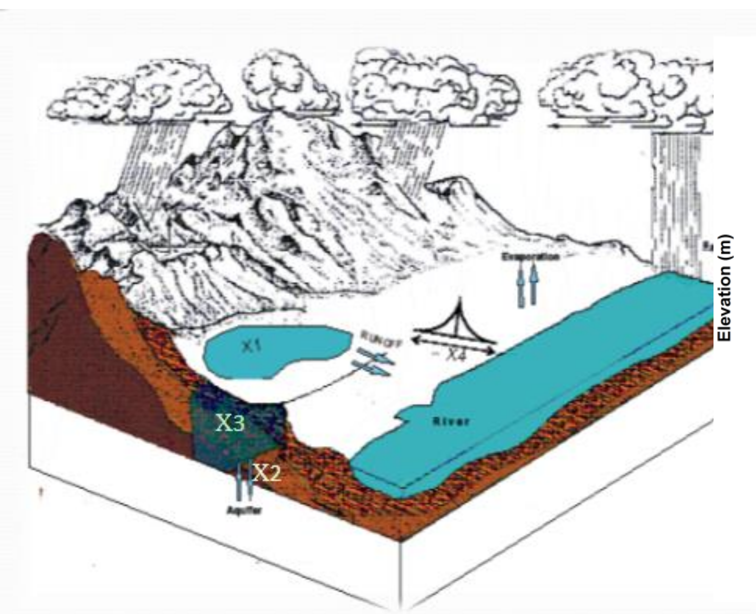
AIMS

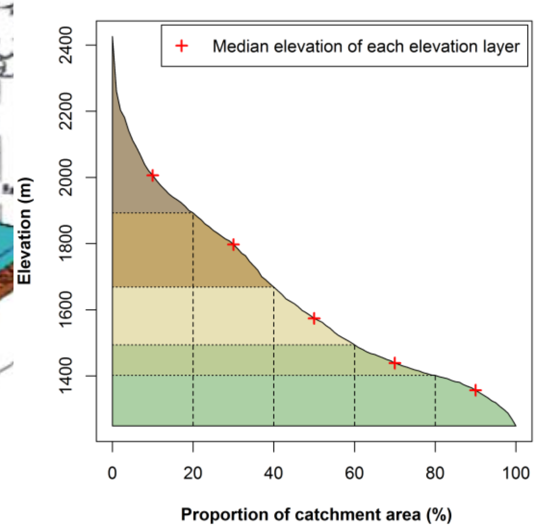
- Therefore, the main aim of this contribution was to evaluate climate change (RCP 4.5 scenario was used) impact on the water cycle in the Koroška Bela area where several potential landslides are located. More specifically, impact on the rainfall, evapotranspiration, air temperature, surface and subsurface runoff were investigated.

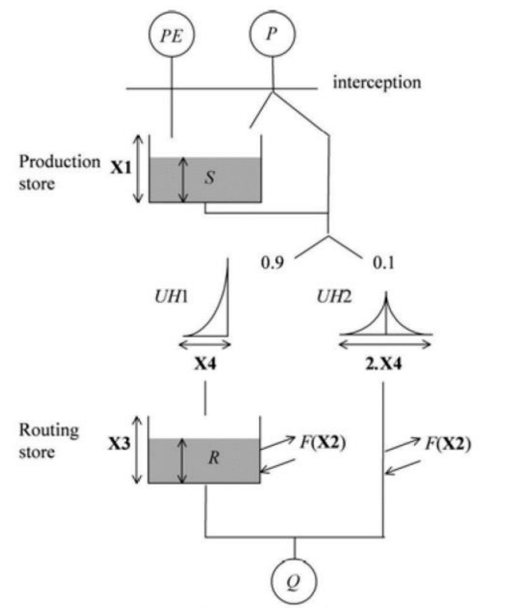


METHODS

- In order to evaluate the climate change impact on the hydrological cycle lumped conceptual hydrological model named GR4J and GR6J with included snow module CemaNeige was used.



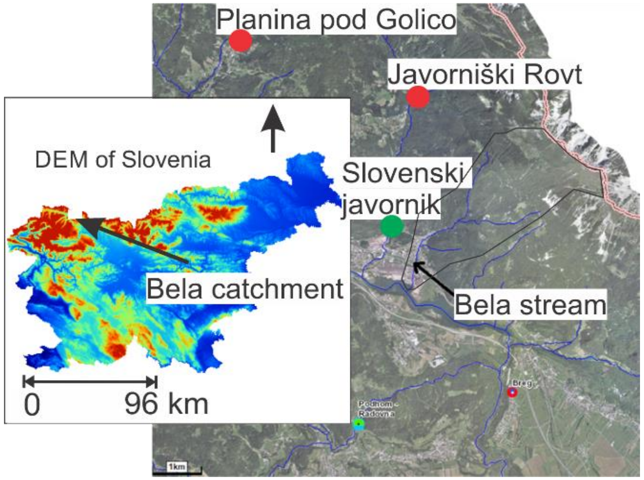




X1 Capacity of the production store (mm)
X2 Water exchange coefficient (mm)
X3 Capacity of the nonlinear routing store (mm)
X4 Unit hydrograph time base (day)

DATA

- For the rainfall data, we used Javorniški Rovt station, for air temperature data, we used Planina pod Golico. In order to calibrate the model, discharge data from the Slovenski Javornik station on the Javornik stream was used. Ratio between catchment areas shown in Table was used.



Properties	Javornik	Bela
Catchment area [km²]	16.5	6.6
Mean catchment slope [%]	Around 46	Around 51
Mean stream slope [%]	Around 20	Around 27
Three major land-use types	82% forest, 12% pastures, 2% urban areas	72% forest, 18% pastures, 5% urban areas
Mean annual precipitation [mm]	Around 1900	Around 1900

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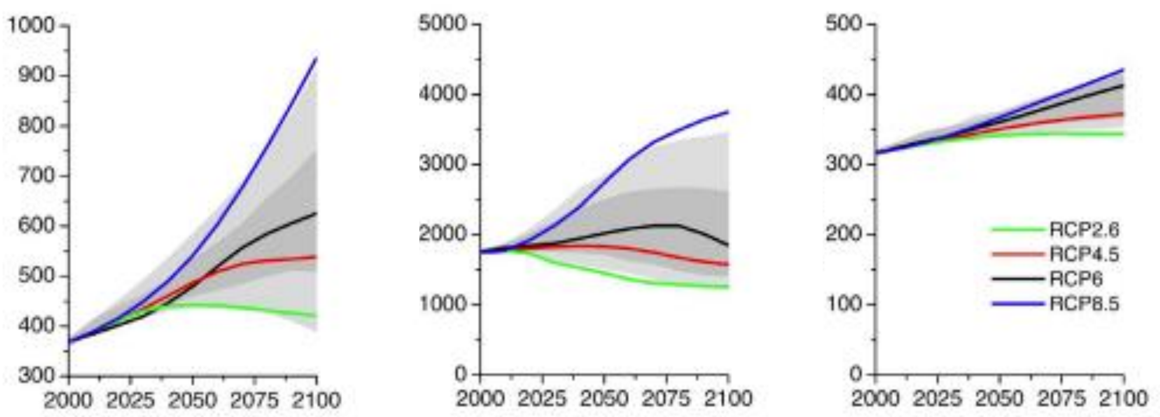
CLIMATE CHANGE

- For the purpose of this study, we used five different combinations of global climate models (GCM) and regional climate models (RCM), namely (GCM/RCM): CNRM-CM5-LR/CCLM4-8-17 (model 1), MPI-ESM-LR/CCLM4-8-17 (model 2), MPI-ESM-LR/RCA4 (model 3), EC-EARTH/HIRHAM5 (model 4), and IPSL-CM5A-MR/WRF331F (model 5) (i.e. RCP4.5 scenario was used). The data is now available with a 1 km resolution. We used bias-corrected and downscaled data (1 km grid).



MODEL CALIBRATION

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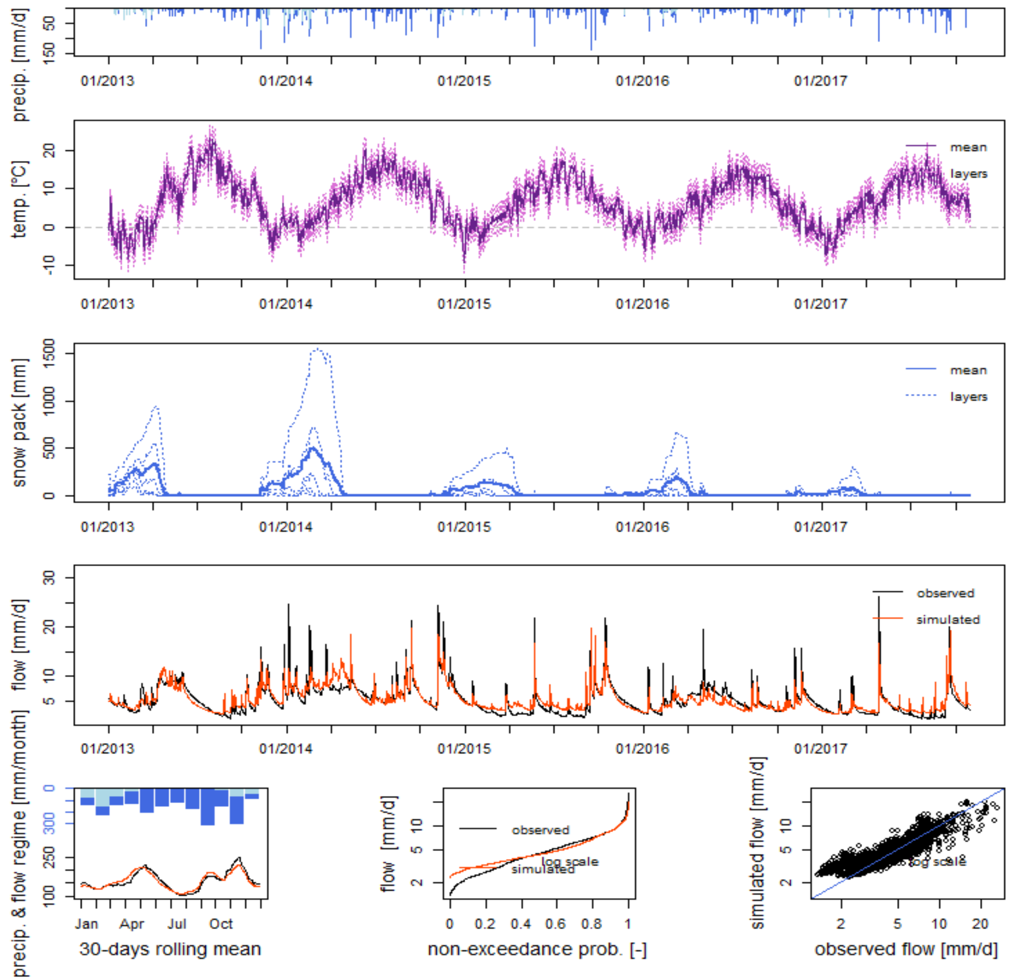
- Calibration model results using measured data are shown on the right figure.
- Nash-Sutcliffe coefficient was 0.75 where a value of 1 would indicate a perfect fit between measured and modelled data and this coefficient ranges between −∞ and 1.



CLIMATE CHANGE

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- Climate change impact on different variables was evaluated (note different units):

Table 2 Climate change impact on the rainfall.

Rel. difference [%]	2021-2060 in comparison to 1981-2020			2061-2100 in comparison to 1981-2020		
Model	1st quartile	Mean	3rd quartile	1st quartile	Mean	3rd quartile
1	0.0	-6.8	-12.9	0.0	6.9	0.8
2	0.0	1.9	-2.7	0.0	6.5	6.8
3	0.0	4.9	2.4	0.0	18.2	25.3
4	0.0	5.9	4.8	0.0	2.7	-14.7
5	0.0	8.2	6.5	0.0	3.8	-13.3
Average	0.0	2.8	-0.4	0.0	7.6	1.0

Table 3 Climate change impact on the average air temperature.

Temp. anomaly [°C]	2021-2060 in comparison to 1981-2020			2061-2100 in comparison to 1981-2020		
Model	1st quartile	Mean	3rd quartile	1st quartile	Mean	3rd quartile
1	0.9	0.7	0.5	1.7	1.6	1.4
2	1.0	1.1	1.1	1.6	1.5	1.3
3	1.0	1.0	0.9	2.0	1.9	1.6
4	0.7	0.8	0.8	1.0	1.4	1.4
5	1.3	1.3	0.9	1.9	2.1	1.6
Average	1.0	1.0	0.8	1.6	1.7	1.5

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- Climate change impact on different variables was evaluated:

Table 4 Climate change impact on the average evapotranspiration.

Rel. difference [%]	2021-2060 in comparison to 1981-2020			2061-2100 in comparison to 1981-2020		
Model	1st quartile	Mean	3rd quartile	1st quartile	Mean	3rd quartile
1	9.7	3.1	1.9	8.5	4.6	4.6
2	4.5	4.3	4.6	7.1	3.6	2.4
3	9.7	5.3	5.3	7.1	5.1	4.6
4	5.0	3.3	3.0	7.7	7.4	6.6
5	7.2	7.0	7.1	18.0	11.3	11.0
Average	7.2	4.6	4.4	9.7	6.4	5.8

Table 5 Climate change impact on the effective rainfall.

Rel. difference [%]	2021-2060 in comparison to 1981-2020			2061-2100 in comparison to 1981-2020		
Model	1st quartile	Mean	3rd quartile	1st quartile	Mean	3rd quartile
1	0.0	-6.5	-16.1	0.0	8.8	-1.7
2	0.0	0.7	-11.0	0.0	6.5	-3.0
3	0.0	4.8	2.0	0.0	19.7	22.3
4	0.0	4.3	-0.5	0.0	1.1	-17.6
5	0.0	7.3	0.7	0.0	2.7	-16.7
Average	0.0	2.1	-5.0	0.0	7.8	-3.3

CLIMATE CHANGE

- Climate change impact on different variables was evaluated:

Table 6 Climate change impact on the runoff from the Bela stream catchment.

Rel. difference [%]	2021-2060 in comparison to 1981-2020			2061-2100 in comparison to 1981-2020		
Model	1st quartile	Mean	3rd quartile	1st quartile	Mean	3rd quartile
1	-9.8	-8.6	-8.2	5.4	7.7	9.1
2	-8.6	-0.4	3.3	0.2	5.4	10.3
3	2.0	3.3	4.9	17.1	20.2	21.6
4	2.6	4.0	4.2	-4.1	-0.4	2.1
5	3.8	6.8	9.4	-0.1	0.5	-0.9
Average	-2.0	1.0	2.7	3.7	6.7	8.5

Table 7 Climate change impact on the production store level (i.e. conceptual underground reservoir).

Rel. difference [%]	2021-2060 in comparison to 1981-2020			2061-2100 in comparison to 1981-2020		
Model	1st quartile	Mean	3rd quartile	1st quartile	Mean	3rd quartile
1	-2.5	-1.9	-1.5	0.6	1.1	1.6
2	-2.2	-0.9	0.4	-0.2	0.6	1.8
3	-0.4	-0.3	1.0	3.0	3.2	3.5
4	0.1	0.5	0.9	-1.7	-0.7	0.3
5	0.2	0.8	1.8	-0.7	-0.5	0.1
Average	-1.0	-0.4	0.5	0.2	0.7	1.5

CLIMATE CHANGE

Climate change impact evaluation on the water balance of the Koroška Bela area, NW Slovenia

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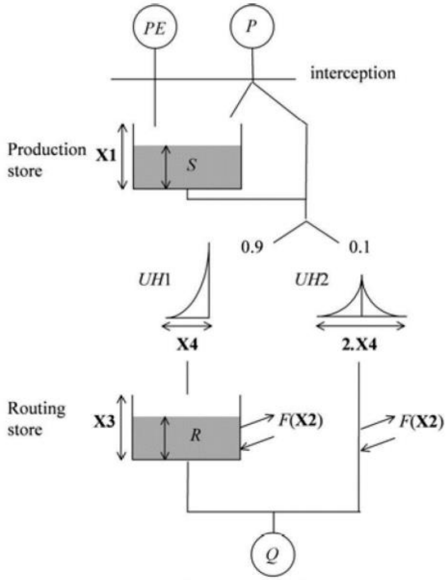
- Climate change impact on different variables was evaluated.
- Production store level was used as a proxy of wetness conditions in the catchments by:

Original Paper | Open Access | Published: 05 April 2019

Application of hydrological modelling for temporal prediction of rainfall-induced shallow landslides

Nejc Bezak, Mateja Jemec Auflič & Matjaž Mikoš

Landslides 16, 1273–1283 (2019) | Cite this article



X1 Capacity of the production store (mm)
X2 Water exchange coefficient (mm)
X3 Capacity of the nonlinear routing store (mm)
X4 Unit hydrograph time base (day)

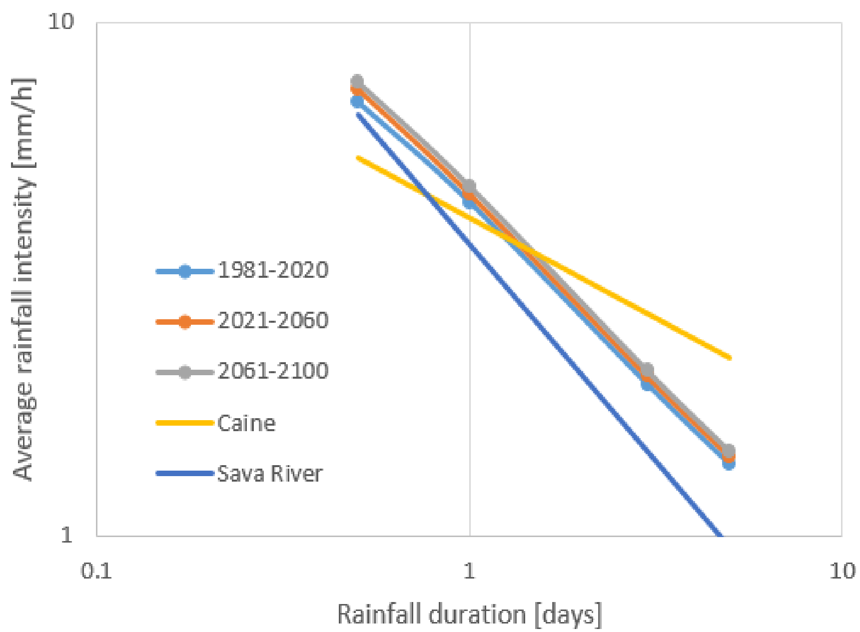
Table 8 Climate change impact on the percolation from production store level (i.e. conceptual underground reservoir).

Rel. difference [%]	2021-2060 in comparison to 1981-2020			2061-2100 in comparison to 1981-2020		
Model	1st quartile	Mean	3rd quartile	1st quartile	Mean	3rd quartile
1	-11.8	-8.7	-7.4	3.0	6.1	8.3
2	-10.4	-2.2	1.8	-0.8	4.1	9.6
3	-2.0	1.0	5.2	15.9	17.3	18.9
4	0.3	2.6	4.6	-8.0	-2.5	1.3
5	1.0	5.0	9.4	-3.3	-1.3	0.7
Average	-4.6	-0.5	2.7	1.4	4.7	7.7

IDF curves

- We also evaluated climate change impact on the IDF curves where bias-corrected downscaled point data was used for this purpose. The analysis was carried for rainfall durations of 0.5, 1, 3 and 5 days.

For example, for the 100-year return period and for the 24 h rainfall duration, the design rainfall should increase for 2% and 4% for the 2021-2060 and 2061-2100 periods, respectively.



CONCLUSIONS

- Total and effective rainfall, air temperature, evapotranspiration and runoff from the Bela stream catchment might increase in the future. For most of the variables, the average differences calculated using five difference GCM/RCMs are in the range of 5% with the exception of the air temperature where temperature anomalies are in the range of 1-2 °C.
- The production store level that can be understand as a proxy of the catchment wetness conditions is projected to be more or less the same as in the past (i.e. relative difference less than 1%). This could indicate that landslides activity in the future could be similar to the situation in the past.

CONCLUSIONS

- Moreover, future changes in the IDF curves are also mostly in the range of 5%.
- However, it should be noted that there exist relatively large differences among five tested GCM/RCMs and that some models predict more significant future changes. Moreover, it should be noted that we have evaluated the RCP4.5 scenario and not the RCP2.6 and RCP8.5 scenarios, which could lead to different dynamics of the water cycle processes. Moreover, the RCP4.5 can be regarded as a midway scenario positioned between the optimistic (i.e. RCP2.6) and pessimistic (i.e. RCP8.5) scenarios.

CONCLUSIONS

- Please see other publications regarding the Koroška Bela published in Landslides and thank you for your attention.

Article

Investigation of potential debris flows above the Koroška Bela settlement, NW Slovenia, from hydro-technical and conceptual design perspectives

Debris flows are one of the natural disasters that can occur in the alpine environment, cause large economic damage, and endanger human lives. This study presents an overview of recent research done in relation t...

Nejc Bezak, Jošt Sodnik, Matej Maček, Timotej Jurček, Jernej Jež... in *Landslides (2021)*

Open Access

Understanding of landslide risk through learning by doing: case study of Koroška Bela community, Slovenia

Activities toward better understanding and reducing landslide disaster risk are an important part of the voluntary commitment written into the ISDR–ICL Sendai Partnerships 2015–2030. The present study highlights ...

ič, Špela Kumelj, Tina Peternel, Jernej Jež in *Landslides (2019)*

Coupling of GPS/GNSS and radar interferometric data for a 3D surface displacement monitoring of landslides

Persistent scatterer interferometry (PSI) is capable of millimetric measurements of ground deformation phenomena occurring at radar signal reflectors (persistent scatterers, PS) that are ph

Marko Komac, Rachel Holley, Pooja Mahapatra, Hans van der Marel, Miloš Bavec in

Article

The variety of landslide forms in Slovenia and its immediate NW surroundings

The Post-Forum Study Tour following the 4th World Landslide Forum 2017 in Ljubljana (Slovenia) focuses on the variety of landslide forms in Slovenia and its immediate NW surroundings, and the best-known examples ...

Mateja Jemec Auflič, Jernej Jež, Tomislav Popit, Adrijan Košir, Matej Maček... in *Landslides (2017)*

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CONCLUSIONS

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- Questions?