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Risk analyses of simulated runoff and soil losses under winter wheat and maize within the Rusenski Lom watershed

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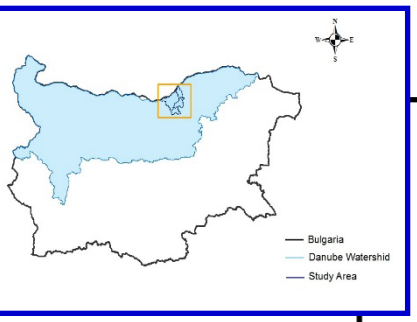
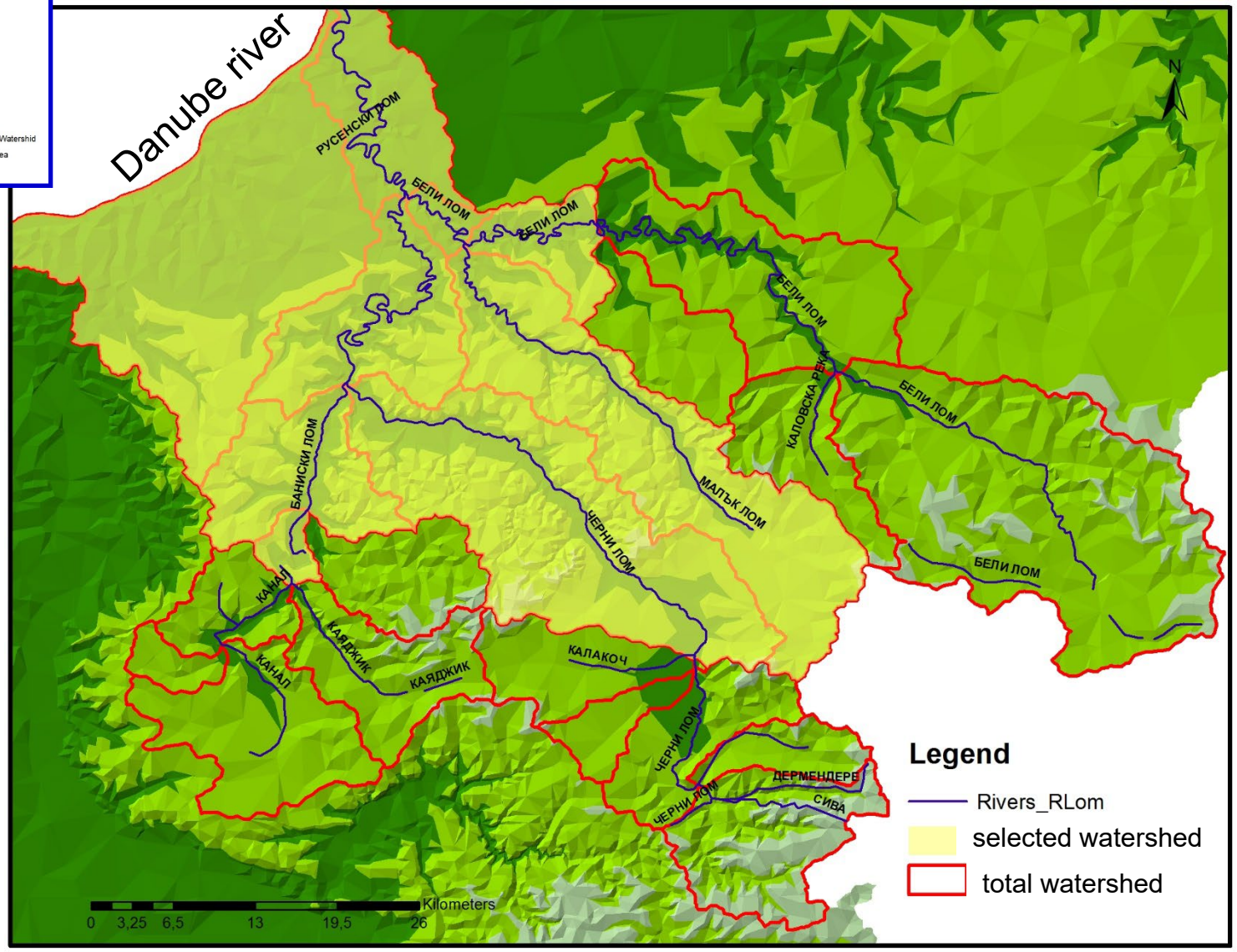
Motivation and goals

- The soils occupying the sloped lands of the Danube watershed in North Bulgaria are imposed to soil water erosion as evident by the large scale soil survey and the estimations of potential and real soil erosion risk.
- The meteorolgical conditions, soil tillage and crop cultivation influence the intensity and spatiotemporal distribution of the surface run-off and soil losses which is difficult to assess without modelling.
- The objective of this study was to assess the risk of runoff and soil losses under winter wheat and maize in the subbasins of the Rusenski Lom watershed using SWAT model.

Bulgarian part of Danube watershed

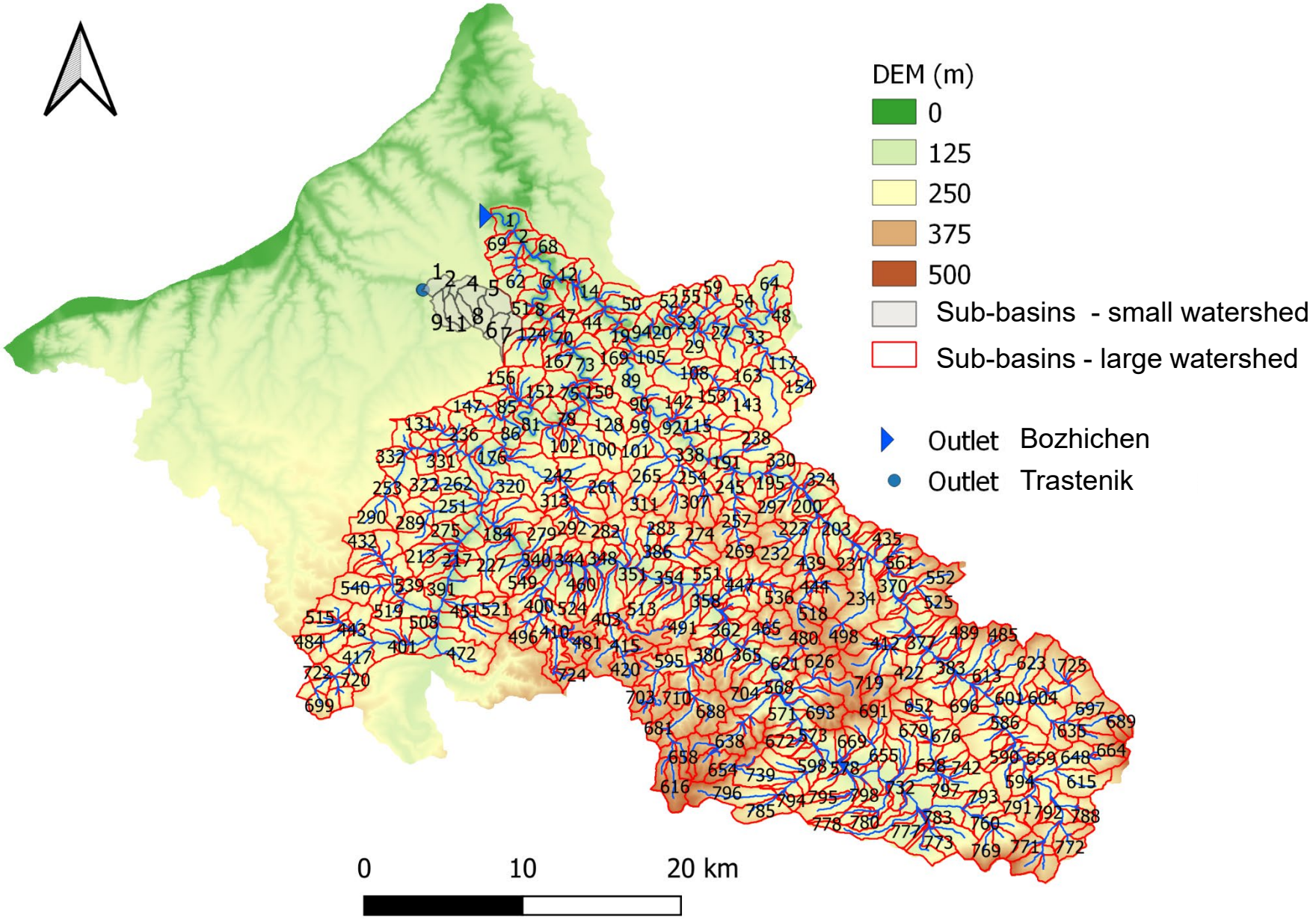
Watershed of the river Rusenski Lom and its tributaries





Model set up and data supply

- **Model**: QSWAT, QGIS
- **Input data**
  - DEM(50/50 m)
  - Soil map(1:10000), attribute data
  - Land use (CORINE 2006, 1:100000)
  - Long-term (1961-2022) meteorological records with daily data (precipitation, air temperature, relative humidity of air, wind velocity, solar radiation).
- **Data for validation**
  - Flows at Bozhichen hydrological station (2007-2022)
  - The experimental data for the period 1981-1991 obtained in the experimental field for erosion control near to the village Trastenik, Ruse, were used for the calibration of the main model parameters (CN2, C factor and P factor of USLE). The validation was performed with data for the period 2013-2022 obtained in this field.


DEM (m)
0
125
250
375
500
Sub-basins - small watershed
Sub-basins - large watershed
Outlet Bozhichen
Outlet Trastenik
0
10
20 km

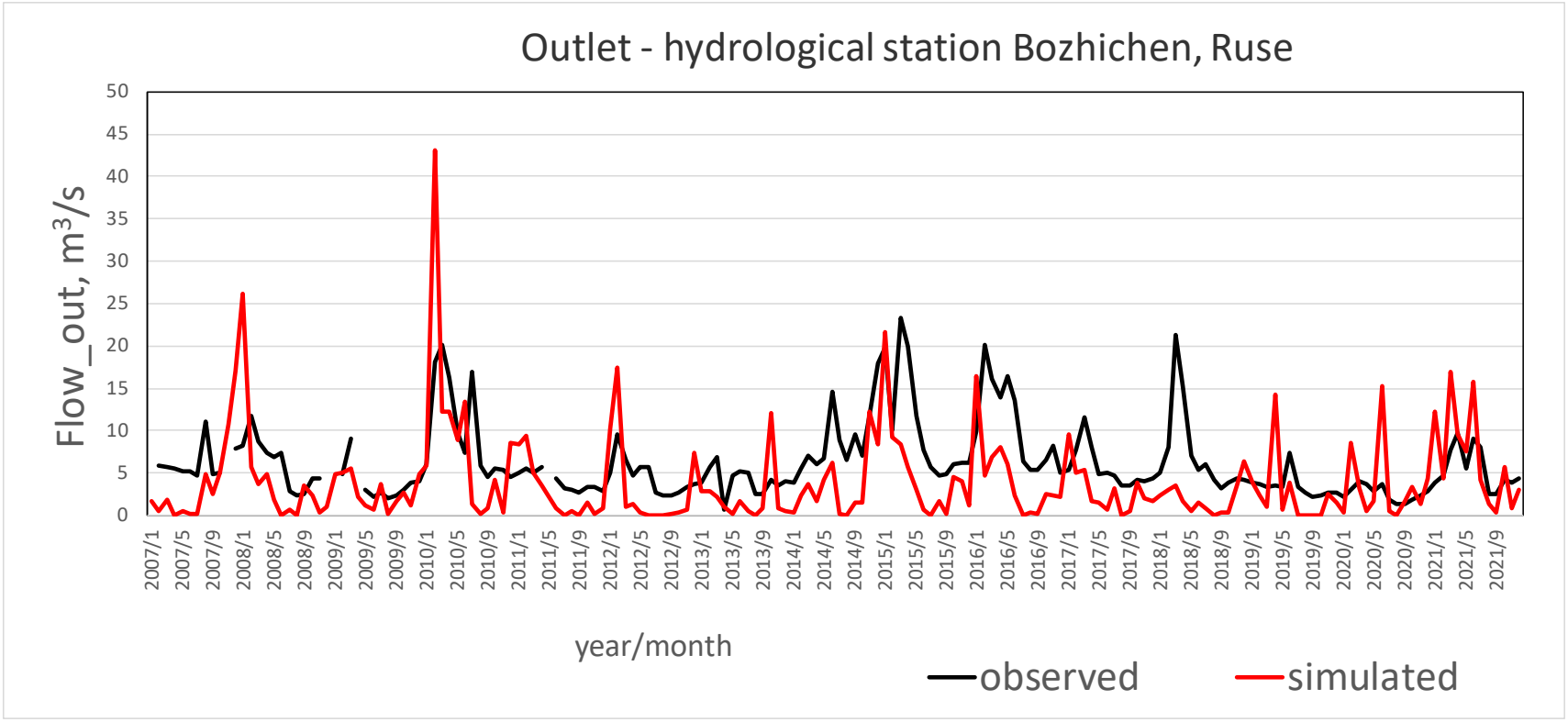
Data for 73 soil profiles are included in the database. They described the dominant soil units. The prevailing soils are Chernozems (Epicalcic, Luvic, Haplic), Phaeozems, Deluvial soils, and Fluvisols. All territotes with non-agricultural lands and water bodies are coded with “0”.

The dominant soil in the small watershed is the Epicalcic Chernozem.

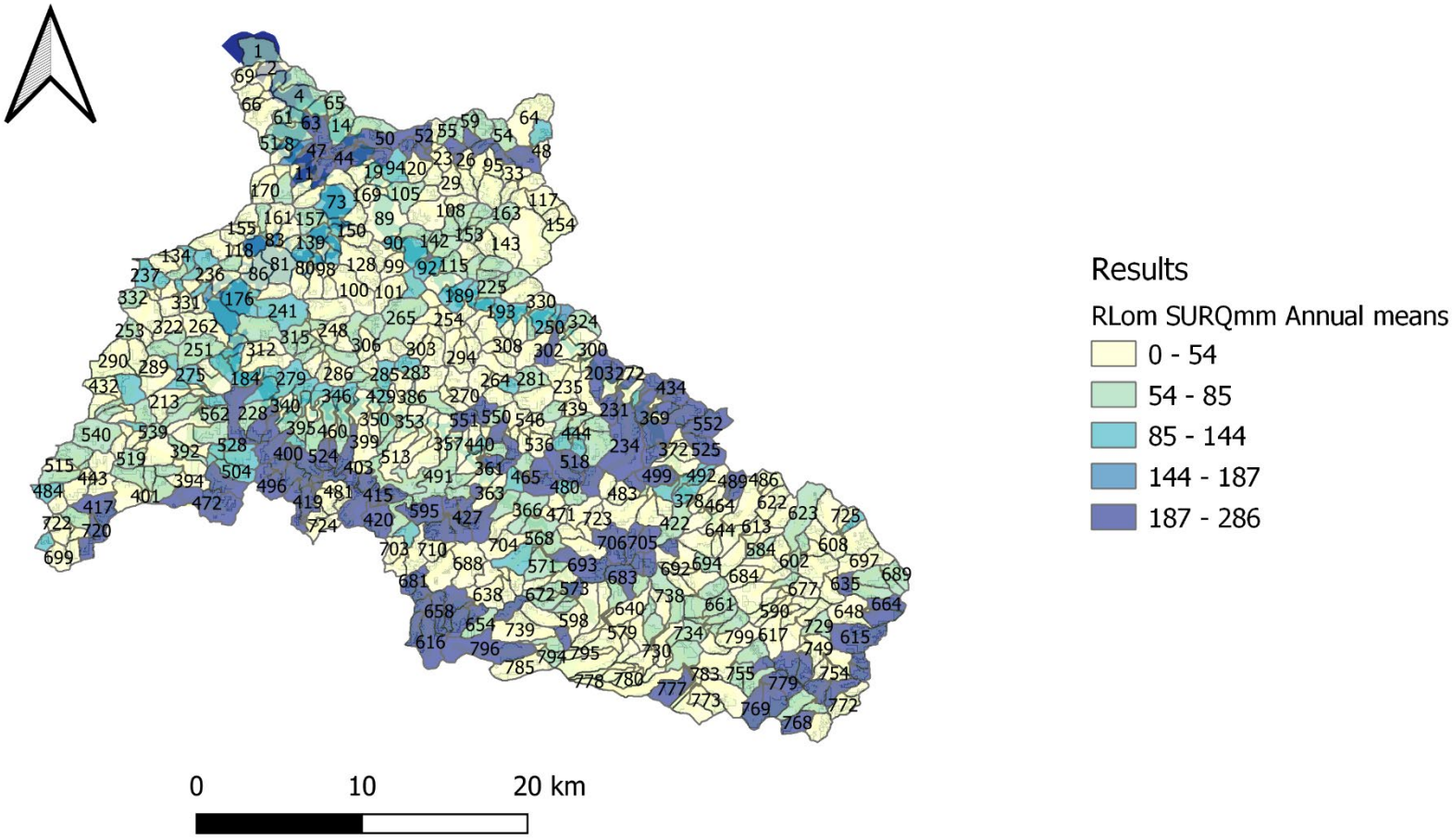
- Main soil properties of moderately eroded Epicalcic Chernozem in the experimental fiesd Trastenik

Horizon	Depth, cm	Sand,%	Silt, %	Clay, %	Soil texture	Corg., %	USLE_K, t ha h / ha MJ mm
Apk	0-30	12.6	61.7	25.8	SiL	1.06	0.03
Abk	30-50	12.2	61.9	25.9	SiL	0.87	
Bk	50-80	11.2	64.3	24.5	SiL	0.42	
BCk	80-120	12.2	63.8	24.0	SiL	0.28	

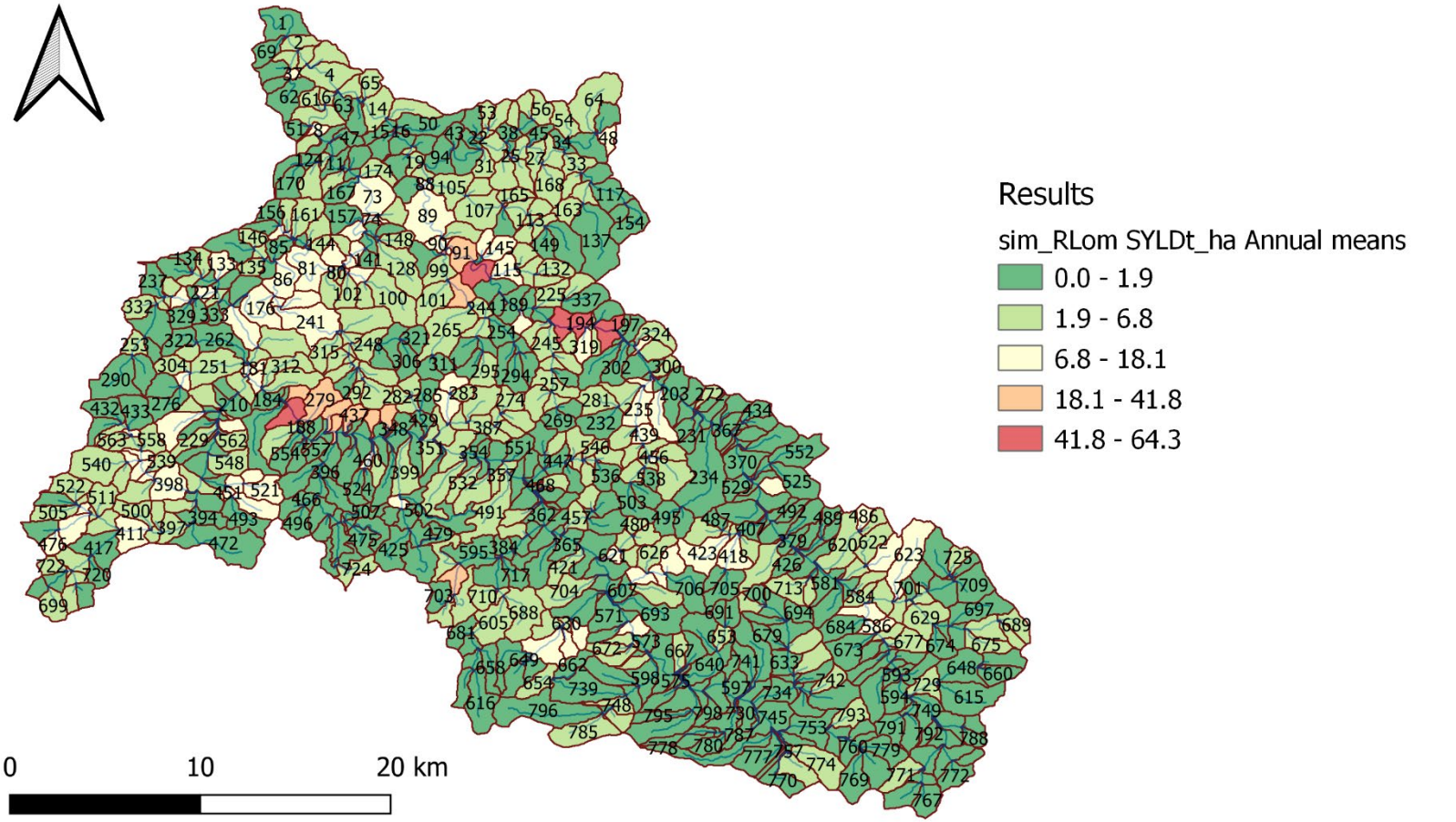
Observed and simulated average for month daily stream flow out of reach (FLOW_OUT, m^3/s) flow-outs at the hydrological station Bozhichen (outlet of the large watershed)



Long-term average annual run-off (SURFQ, mm) in the large watershed simulated with QSWAT model.

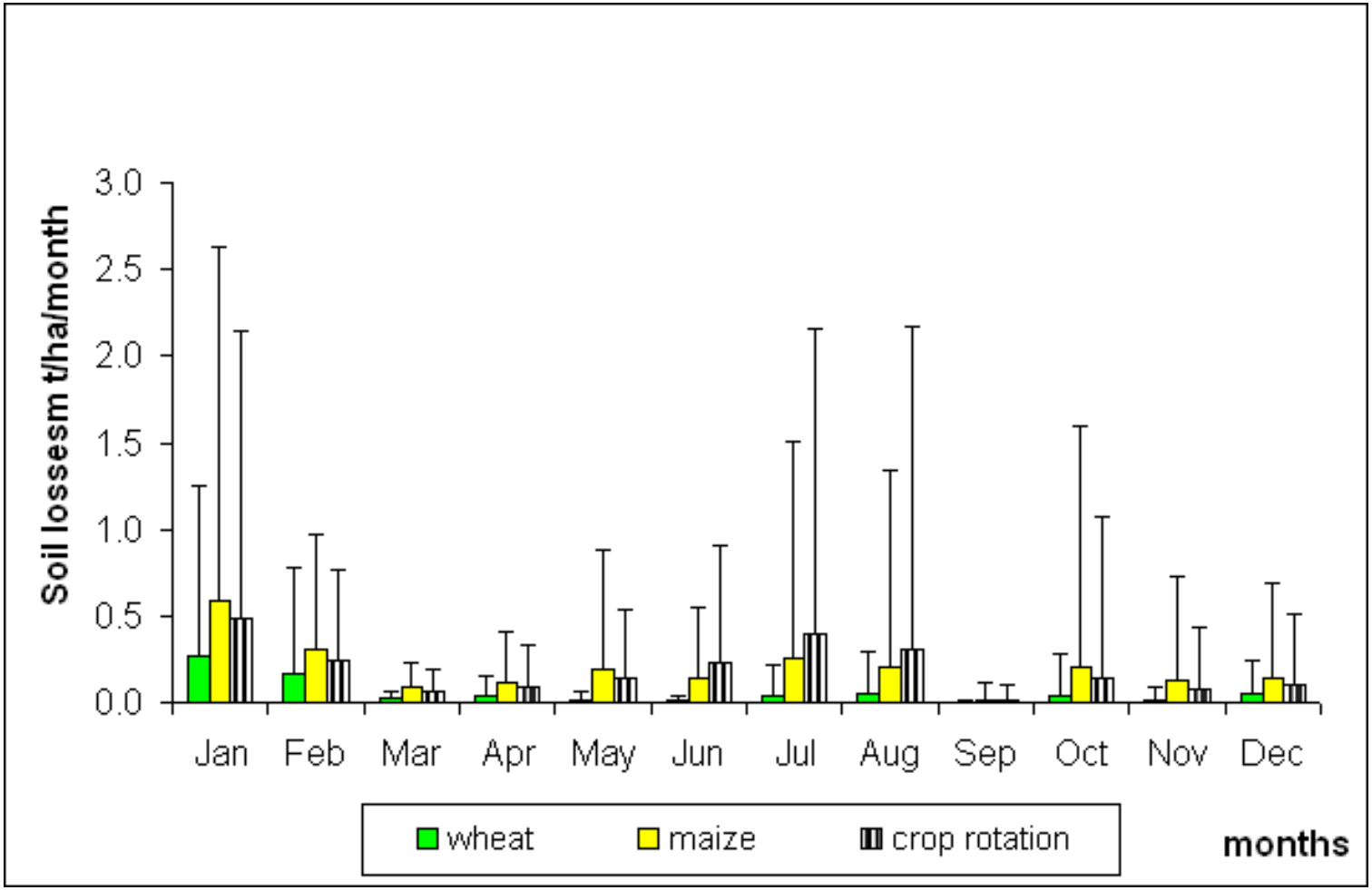


Long-term average annual soil losses (SYLD, t/ha) in the large watershed simulated with QSWAT model



Maize and winter wheat are the main crops cultivated in the region. Three scenarios for the crop cultivation were investigated in the **small watershed** on crop lands: continuous growing of winter wheat and maize, and crop rotation.

After a calibration of the main model parameters (CN2, C factor and P factor of USLE) a good coincidence of simulated and measured surface run-off and soil losses for the period April-October was achieved. The average soil losses for 8 years continuous winter wheat cultivation were 0.704 t/ha/y, while the simulated average value for this period was 0.671 t/ha/y. Under continuous maize cultivation for this period, the measured soil losses were 2.380 t/ha/y in average, while the simulated value was 2.460 t/ha/y. The bias can be result of different space representativeness of the experimental plots and the simulated area.

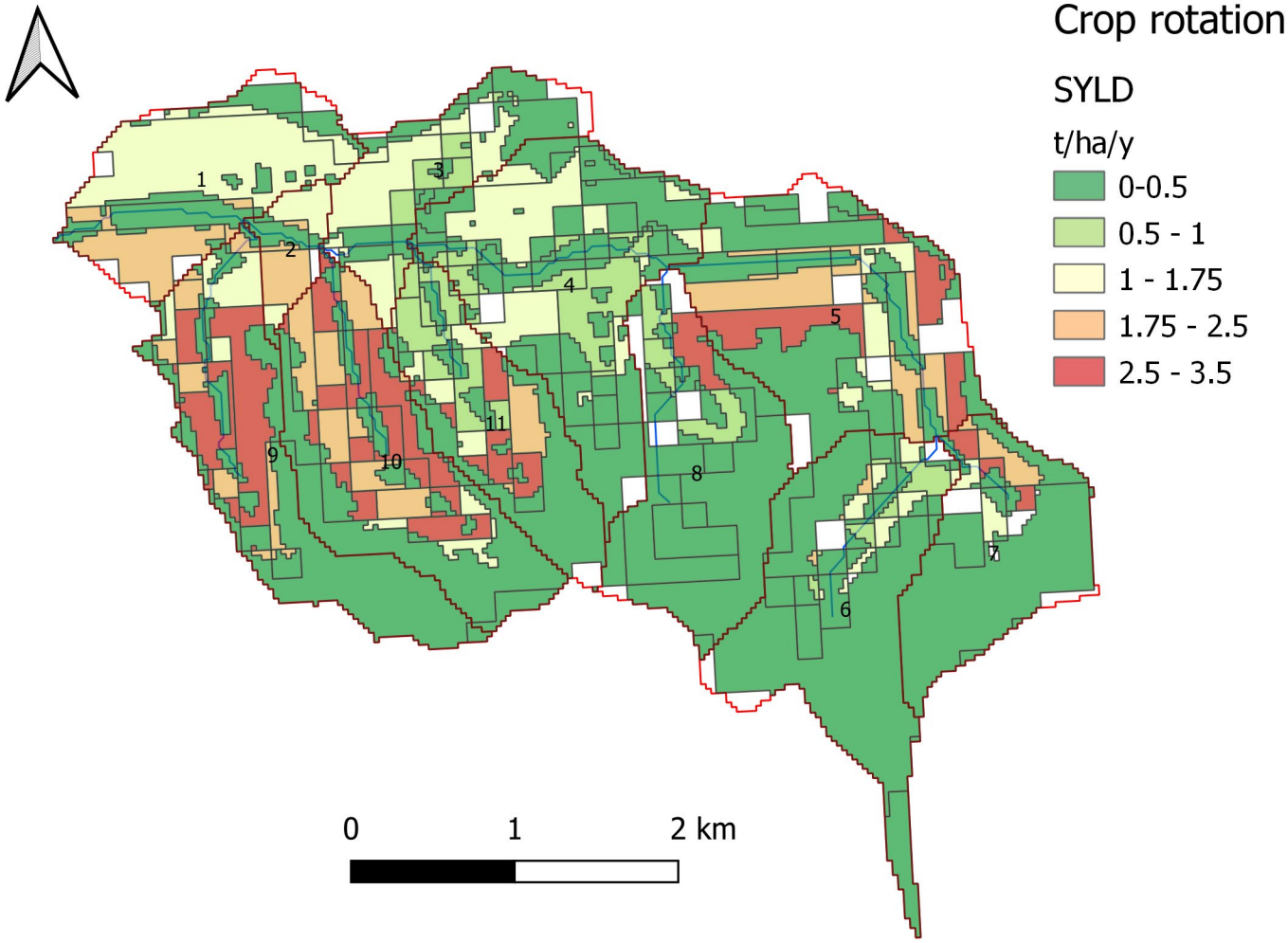


Long-term average (columns) and 0.9 percentile (bars) of simulated monthly totals of soil losses (SYLD, t ha^{-1} $month^{-1}$) for the studied scenarios (sub-basin 1 of small watershed, moderately eroded Epicalcic Chernozem)

The simulated annual soil losses for the period 1964-2022 were in average 0.5, 2.7 and 1.7 t/ha/year for winter wheat, maize and crop rotation, respectively.

The actual risk for soil water erosion under continuous maize growing was assessed as moderate (5-10 t/ha/y) in 49% of the years and moderate to high (10-20 t/ha/y) in 15% of the years. The lowest risk was observed under continuous winter wheat growing. In this scenario, only 5% of the years were with moderate risk for soil water erosion. In case of crop rotation, such rates of losses can occur in 17% of the years.

Simulated annual totals of soil losses (SYLD, t ha^{-1} y^{-1}) for 2021 year in case of maize-winter wheat crop rotation



Discussion

- The variations of the annual totals for winter wheat (0.1 to 5.9 t ha^{-1} y^{-1}) and maize (1 to 22 t ha^{-1} y^{-1}) are greater than the reported experimental data for this region which correspondingly are 3.8-7.8 t ha^{-1} y^{-1} and 7.6-15.7 t ha^{-1} y^{-1}.
- The changes of soil conditions, such as an increase of subsoil compaction can also effect on model performance, which needs further investigations.

Conclusions

- The compiled input database for SWAT model allow to perform different scenarios for the investigation of the influence of climate, soil properties, cropping system, and topology on soil water erosion processes in the watershed of the river Rusenski Lom, a tributary of the Danube river.
- The observed bias between simulated and observed data for soil losses can be explained with different scales and heterogeneity within HRU also with a need of more precise calibration. Further improvement of the model performance will be obtained by applying the SWAT-Cup .

Thank you for your attention!

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