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Spatial variability of sediment loads under climate and land use changes in the Raba River catchment, Poland

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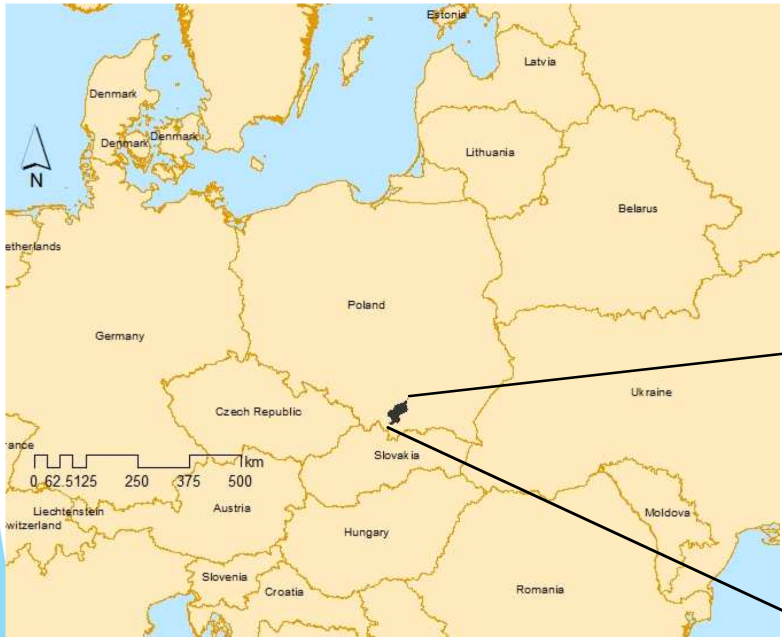
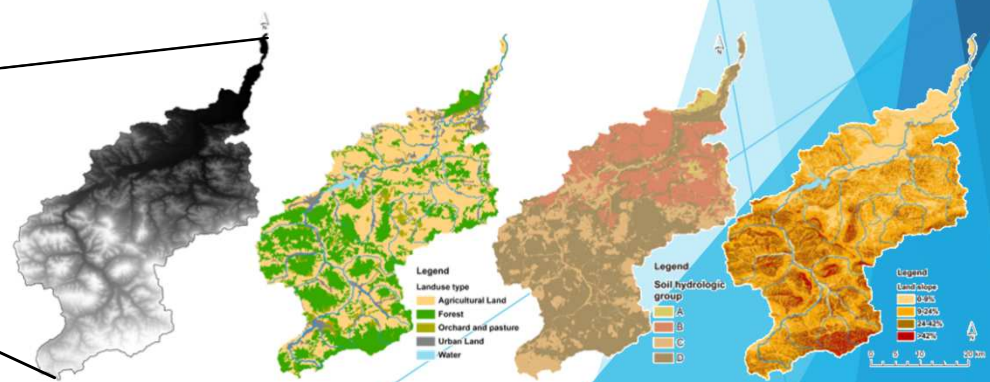
Introduction

1. As already reported sediment loads can be altered through the climate and land use changes.
2. SWAT enables sediment spatial variability analyses, and also tracking sediment transport in the catchment.
3. Assessment of spatial variability for sediment loads released for the catchments has a crucial meaning
    - reservoir management (silting)
    - water quality assessment

Raba river

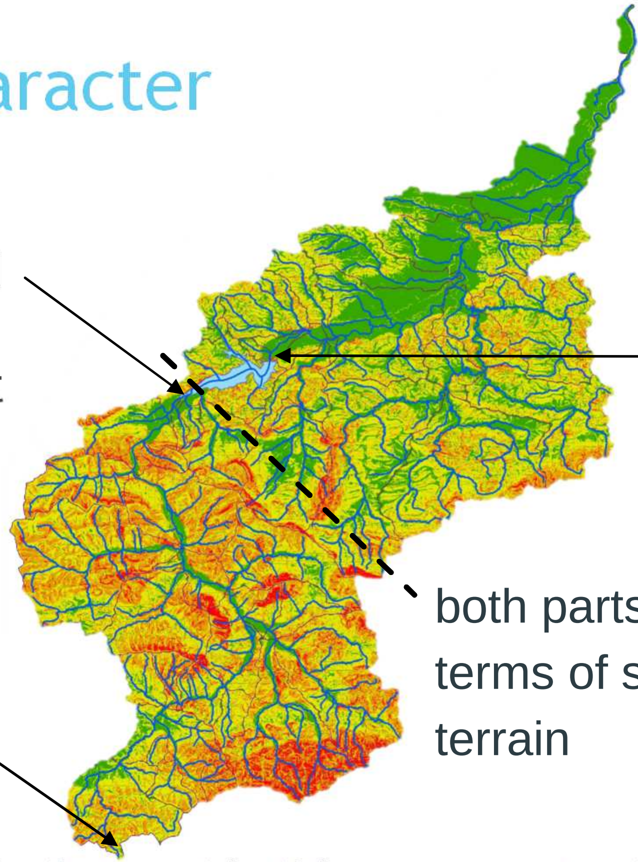
1. Discharging into the Vistula River
2. Located in the Carpathian Foothills
3. A high share of agricultural land use
4. Supplies a drinking water reservoir
5. Localization of reservoir separates the whole catchment into two parts





RABA dual character

the upper part located upstream to the reservoir has a distinct mountainous character



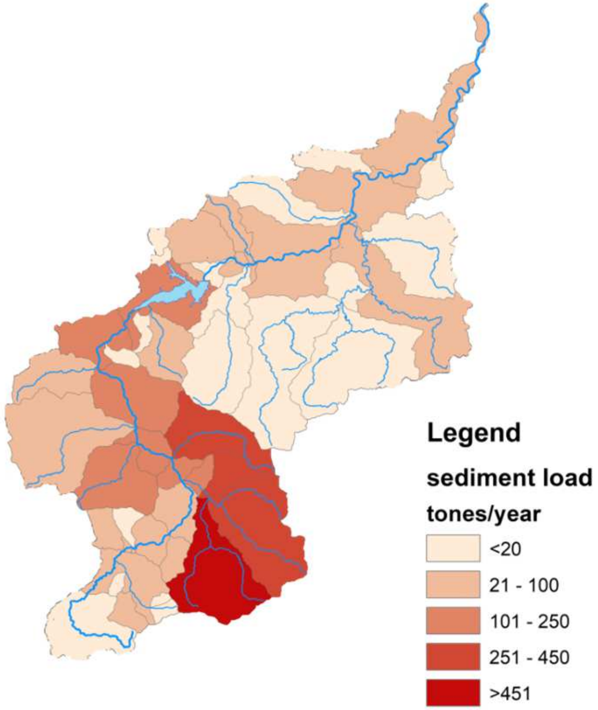
downstream reach of the river is considered a submontane

both parts are very different in terms of soil types, land use and terrain

The Raba River catchment, especially upper part, is exposed to the erosional processes, controlled mainly by land slope, soil characteristics, and land use, what has an impact on reservoir silting and water quality of lower reaches.

Research conducted in the past in this area suggests that there are significant suspended sediment loads, which will additionally vary depending on the location of the calculation profile.

Analysis scope



Sediment load simulation results for subbasins

Climate and land use changes scenarios

Analysis of subbasins reaction to scenarios

Scenarios

The analysis involve the results of variant scenarios regarding climate and land use change forecasts for this catchment and their impact on sediment loads in reaches compared to baseline simulation, emphasizing its spatial distribution.

	P1 [%] 2021-2050	P2 [%] 2071-2100	T1 [°C] 2021-2050	T2 [°C] 2071-2100
winter (Dec-Feb)	9.5	16.74	1.1	2.29
spring (Mar-May)	8	15.89	0.84	1.83
summer (Jun-Aug)	2.63	1.21	1.01	1.68
autumn (Sep-Nov)	2.11	4.25	0.95	1.88

EURO-CORDEX downscaling[1]

predicted change in forest area [%]	predicted change in urban area [%]
-2060	-2060
16	6

DYNA-Clue for Carpathian Mountains[2]

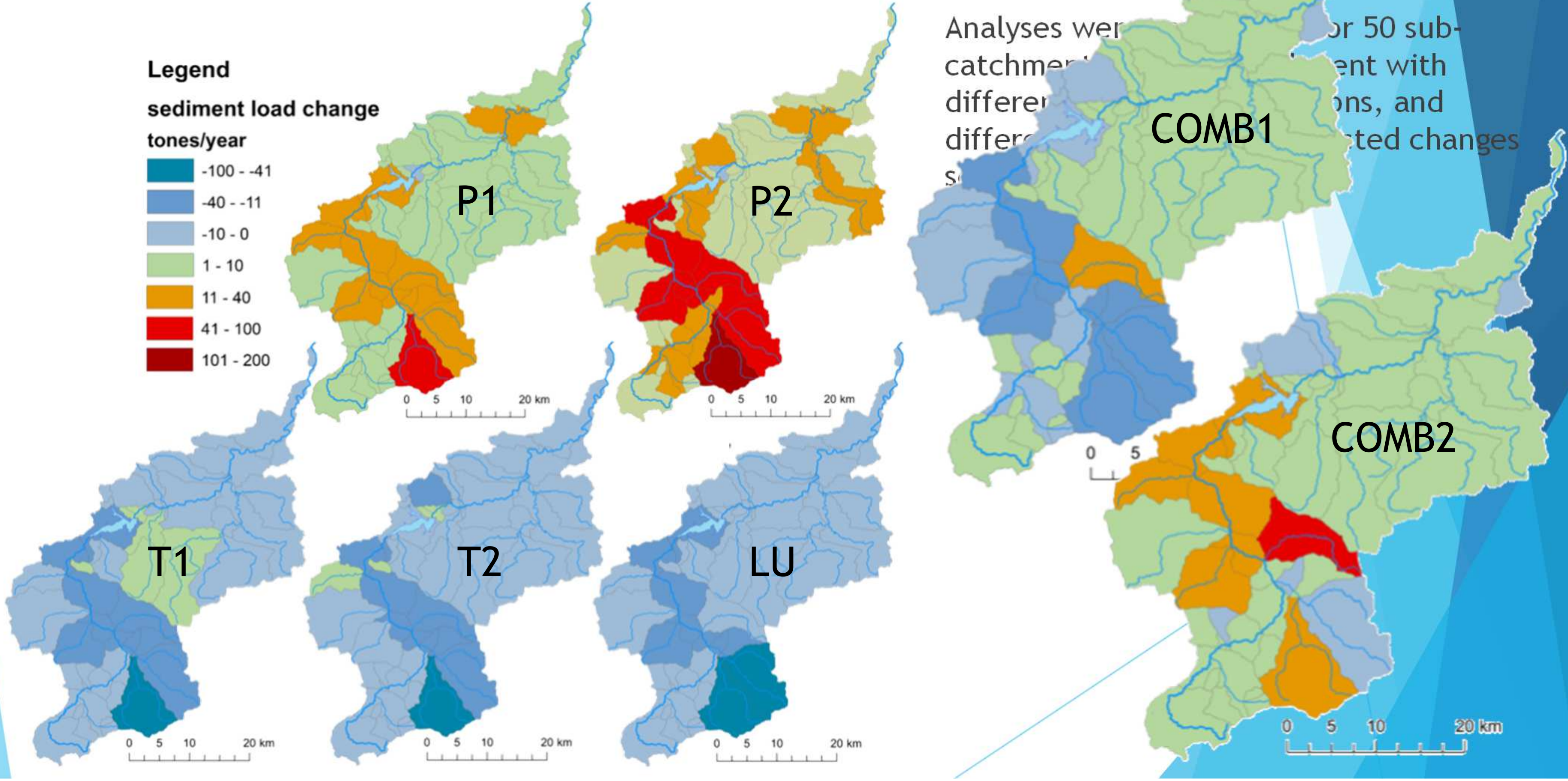
→

COMB1	COMB2
P1+T1+LU	P2+T2+LU

[1]Mezghani, A., Piniewski, M. et al.(2017). CHASE-PL Climate Projection dataset over Poland –bias adjustment of EURO-CORDEX simulations.

[2]Price, B. et al.(2017). ...: the case of future forest cover expansion in the Polish Carpathians and Swiss Alps.

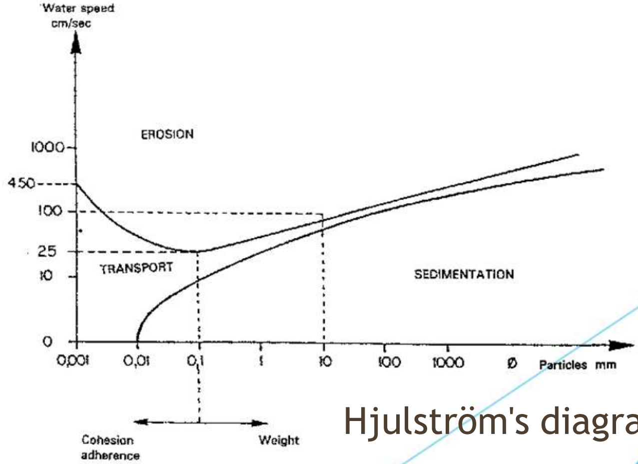
Scenarios results



Erosion intensity

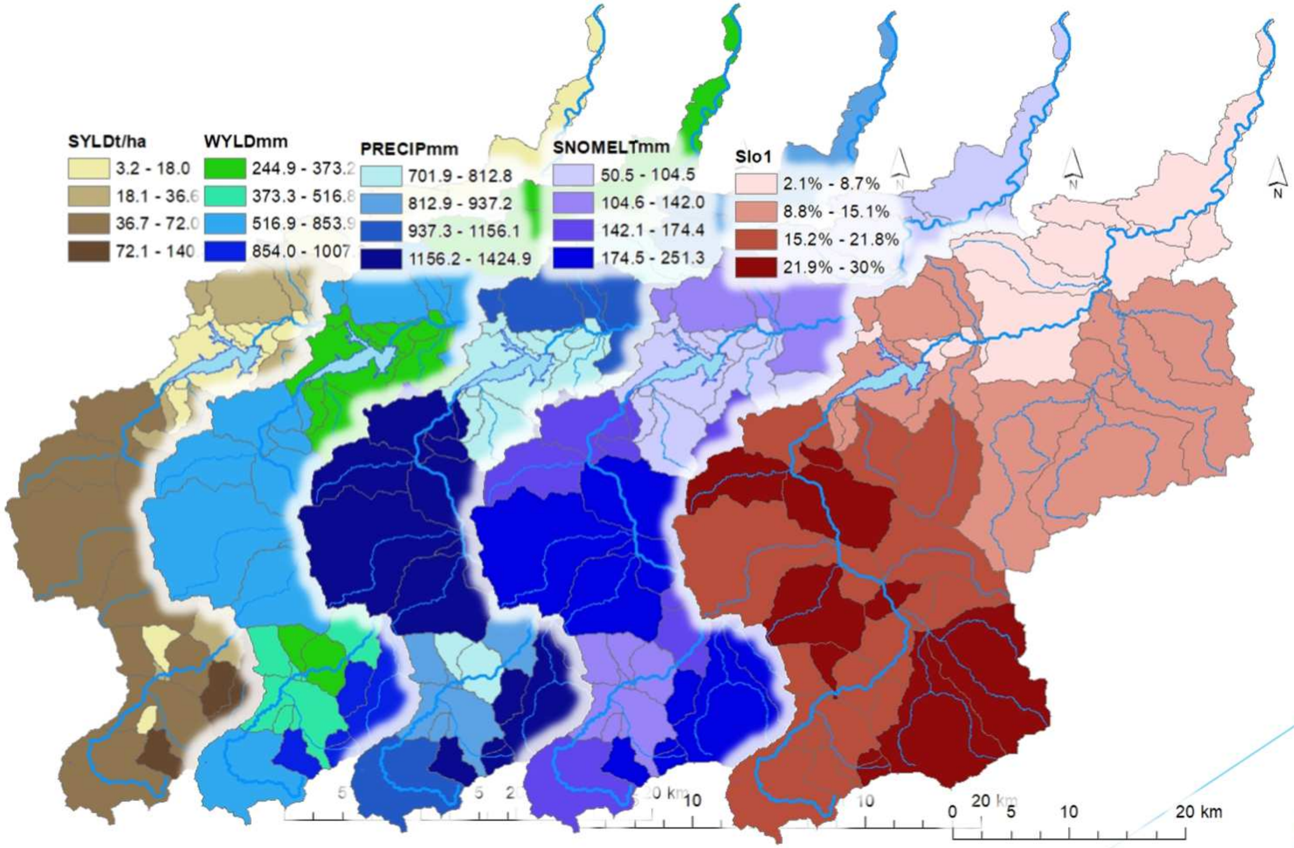
- Soil
- Organic content in soil
- Slope
- Slope length
- Terrain shape
- Meteorology:
  - precipitation amount
  - precipitation intensity
  - rain drop sizes
- Land use

- Agrotechnical factors:
  - vegetation cover
  - crops
  - agricultural operations
  - soil compaction

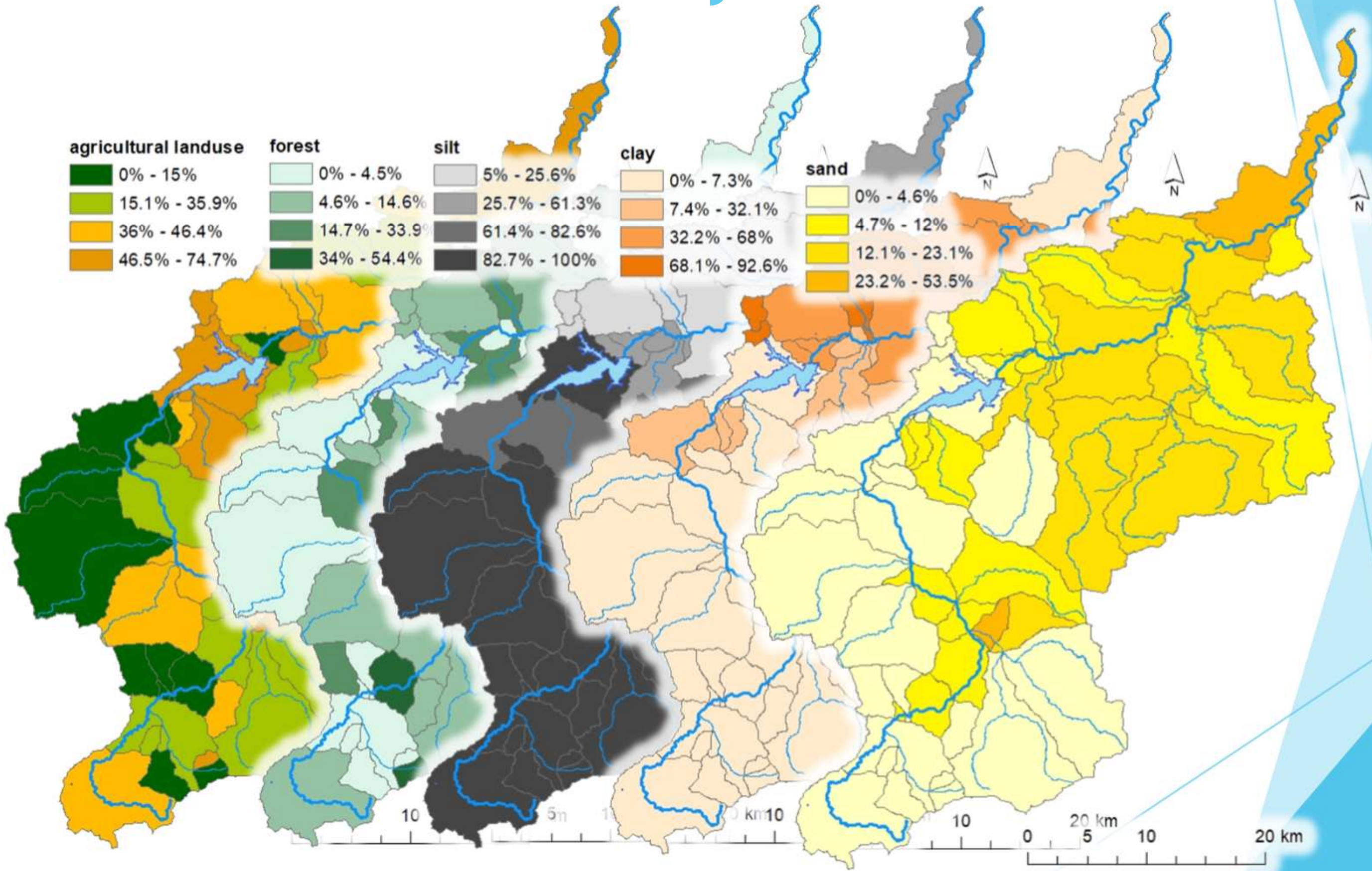


Hjulström's diagram

Spatial distribution analysis



Spatial distribution analysis



Results

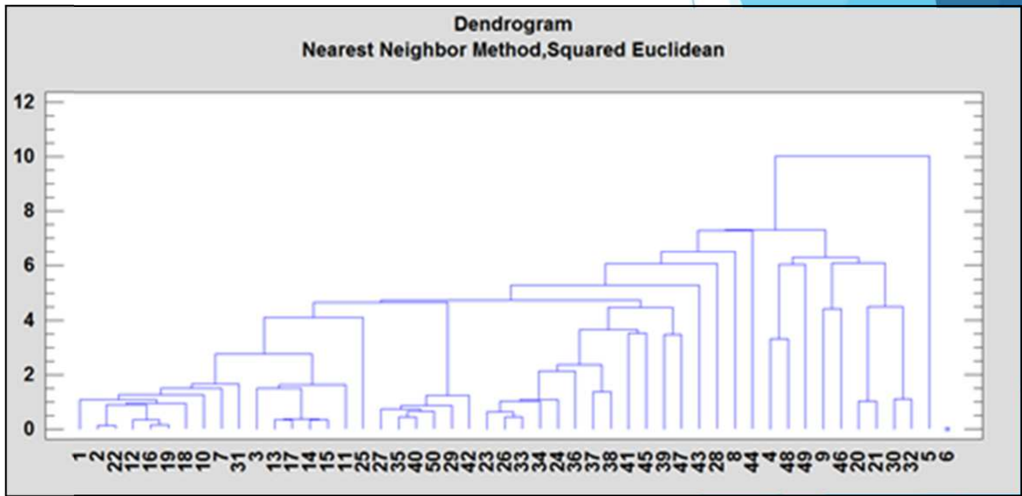
		Standard	T	
Parameter	Estimate	Error	Statistic	P-Value
CONSTANT	-2,75194	3,03276	-0,907403	0,4155
gr1w2.AGRI	-0,596723	0,0779646	-7,65377	0,0016
gr1w2.Csl	0,230818	0,0468285	4,929	0,0079
gr1w2.FOREST	-0,0796426	0,0311243	-2,55886	0,0627
gr1w2.GLINA	-2,23632	0,432478	-5,17096	0,0066
gr1w2.LESS	-0,7648	0,0984794	-7,76609	0,0015
gr1w2.PRECIPmm	3,13669	2,13223	1,47108	0,2152
gr1w2.SAND	-0,100161	0,0784889	-1,27611	0,2710
gr1w2.Sll	1,29606	0,801813	1,61642	0,1813
gr1w2.Slope	-1,98046	0,425682	-4,65243	0,0096
gr1w2.SNOMELTmm	-0,308151	0,422162	-0,729936	0,5059
gr1w2.WYLDmm	0,160057	1,16946	0,136864	0,8978

Analysis of Variance

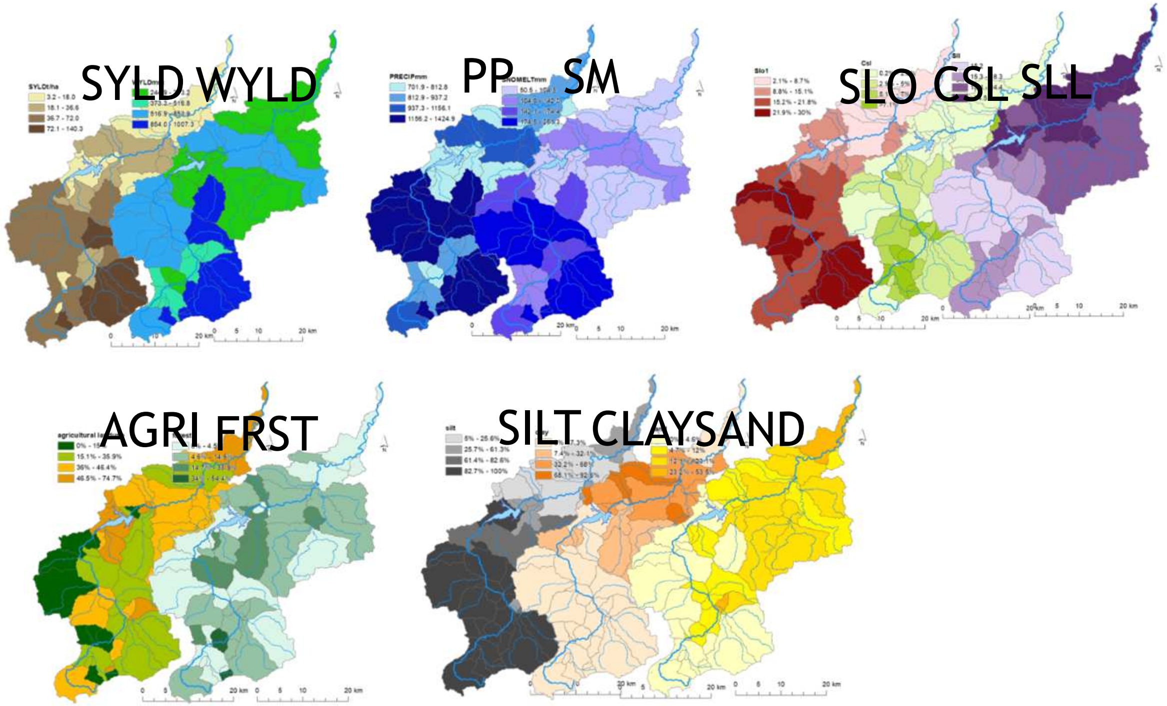
Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	0,588784	11	0,0535258	30,55	0,0024
Residual	0,00700942	4	0,00175235		
Total (Corr.)	0,595794	15			

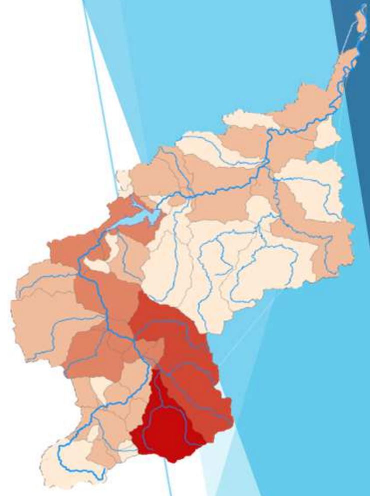
R-squared = 98,8235 percent

Hierarchical Clustering



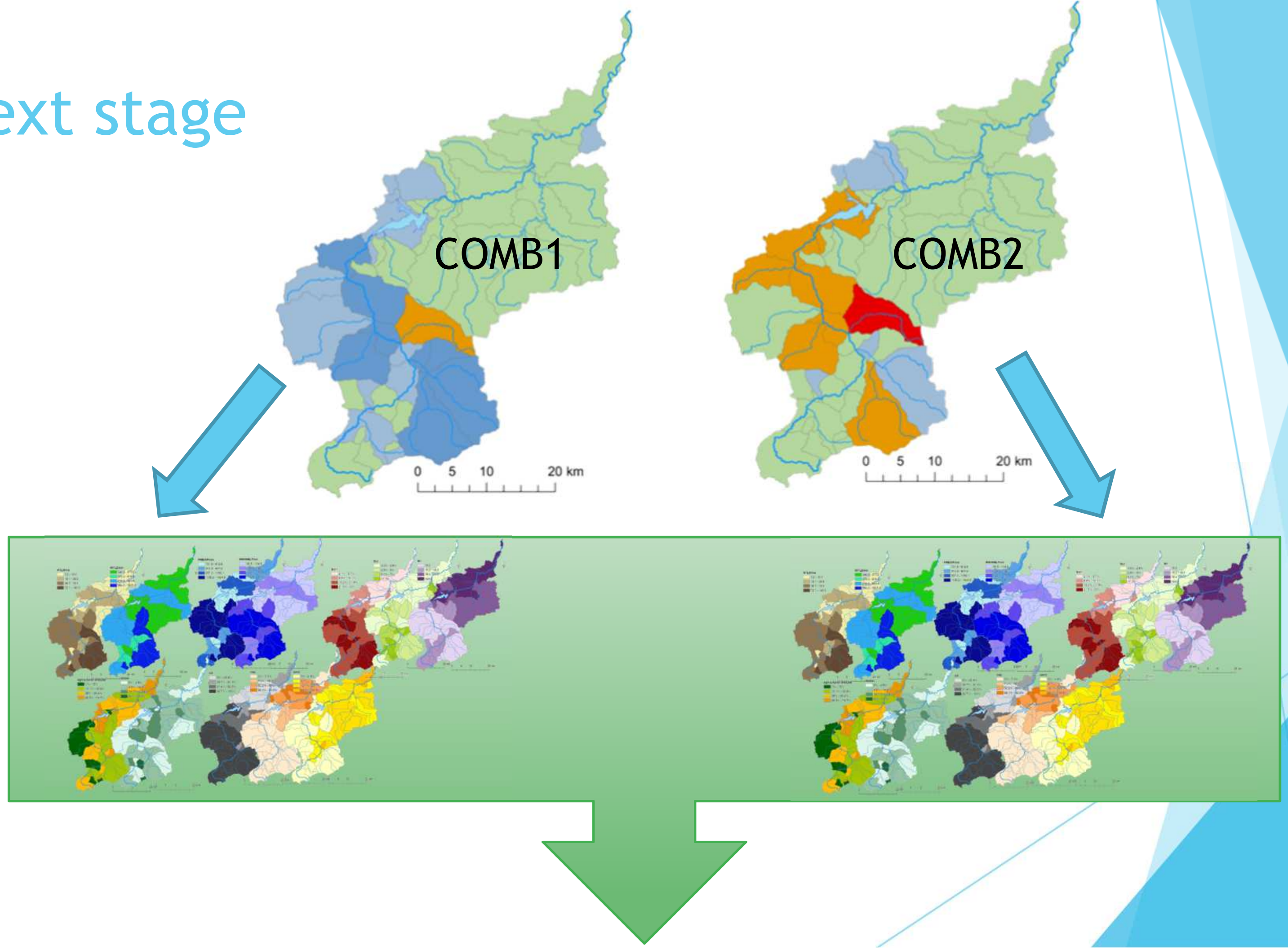
Results





Parameter	Regression
SNOMELTmm	0.585484
SYLD t/ha	0.434867
AGRI	0.325462
SAND	0.278794
PRECIPmm	0.23472
Csl	0.218972
Slope	0.186951
WYLDmm	0.15585
SILT	-0.2149
FOREST	-0.25562
Sll	-0.50117
CLAY	-0.54013

Next stage



Conclusion

1. The results revealed changes in sediment loads in subbasins outlets
2. Additionally subbasins showed different reaction to changes in climate conditions and land use extent
3. Sediment load spatial variability indicates need of further investigation of erosion, transport and deposition differences in subbasins
4. Analysis consist of three stages:
    - designation of parameters set (sensitivity analysis for sediment load) and correlation analysis
        - for baseline simulation
        - for scenarios (COMB1, COMB2)
    - assessment of the spatial variation in sediment load reaction in subbasins for climate and land use change scenarios

Additional outcome

The performed analyses are also helpful in answering one of the key questions for future water management in this catchment:

1. What effects on the quantity of suspended sediment will be imposed by the expected climate changes (temperature and precipitation)?
2. Whether it is possible to limit this impact through alterations of the land use of the catchment?
3. How the forecasted changes will affect the reservoir capacity, and potentially deplete its storage time?

Thank you for your attention

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