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
The Raba River catchment, especially the upper part located upstream to the reservoir, has a distinct mountainous character. 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. The downstream reach of the river is considered a submontane.

Both parts are very different in terms of soil types, land use, and terrain. Reservoir sedimentation is expected to affect the significant suspended sediment loads, which will additionally vary depending on the location of the calculation profile. Reservoir silting and water quality of lower reaches are influenced by land use and erosion processes, controlled mainly by land slope, soil characteristics, and land use, which has an impact on reservoir silting and water quality of lower reaches.
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.

EURO-CORDEX downscaling\(^1\)

<table>
<thead>
<tr>
<th></th>
<th>P1 [%]</th>
<th>P2 [%]</th>
<th>T1 [°C]</th>
<th>T2 [°C]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2021-2050</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>winter (Dec-Feb)</td>
<td>9.5</td>
<td>16.74</td>
<td>1.1</td>
<td>2.29</td>
</tr>
<tr>
<td>spring (Mar-May)</td>
<td>8</td>
<td>15.89</td>
<td>0.84</td>
<td>1.83</td>
</tr>
<tr>
<td>summer (Jun-Aug)</td>
<td>2.63</td>
<td>1.21</td>
<td>1.01</td>
<td>1.68</td>
</tr>
<tr>
<td>autumn (Sep-Nov)</td>
<td>2.11</td>
<td>4.25</td>
<td>0.95</td>
<td>1.88</td>
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</tbody>
</table>

DYNA-Clue for Carpathian Mountains\(^2\)

<table>
<thead>
<tr>
<th></th>
<th>P1+T1+LU</th>
<th>P2+T2+LU</th>
</tr>
</thead>
<tbody>
<tr>
<td>predicted change in forest area [%]</td>
<td>P1+T1+LU</td>
<td>P2+T2+LU</td>
</tr>
<tr>
<td>-2060</td>
<td>16</td>
<td>6</td>
</tr>
<tr>
<td>2060</td>
<td></td>
<td></td>
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</tbody>
</table>


Scenarios results

Analyses were carried out for 50 sub-catchments of the Raba catchment with different erodibility conditions, and different potential impacts of forecasted changes such as P1, P2, T1, T2, LU, COMB1, and COMB2.
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

Hierarchical Clustering

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>Statistic</th>
<th>P-Value</th>
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</thead>
<tbody>
<tr>
<td>CONSTANT</td>
<td>-2.751</td>
<td>0.03276</td>
<td>-0.907403</td>
<td>0.4155</td>
</tr>
<tr>
<td>gr1w2.AGRI</td>
<td>-0.596723</td>
<td>0.0779646</td>
<td>-7.65377</td>
<td>0.0016</td>
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<tr>
<td>gr1w2.Csl</td>
<td>0.23008</td>
<td>0.0408285</td>
<td>4.929</td>
<td>0.0079</td>
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<tr>
<td>gr1w2.FOREST</td>
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<td>0.0311243</td>
<td>-2.55886</td>
<td>0.0627</td>
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<tr>
<td>gr1w2.GLINA</td>
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<td>0.432248</td>
<td>-5.17096</td>
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<tr>
<td>gr1w2.LESS</td>
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<td>0.0984794</td>
<td>-7.76669</td>
<td>0.0015</td>
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<tr>
<td>gr1w2.PRECIPmm</td>
<td>3.13069</td>
<td>2.13233</td>
<td>1.47108</td>
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<tr>
<td>gr1w2.SAND</td>
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<td>0.0784889</td>
<td>-1.27011</td>
<td>0.2710</td>
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<tr>
<td>gr1w2.SII</td>
<td>1.29066</td>
<td>0.801813</td>
<td>1.61642</td>
<td>0.1813</td>
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<tr>
<td>gr1w2.Slope</td>
<td>-1.98046</td>
<td>0.425882</td>
<td>-4.65243</td>
<td>0.0096</td>
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<tr>
<td>gr1w2.SNOMEL.Tmn</td>
<td>-0.308151</td>
<td>0.422162</td>
<td>-0.729936</td>
<td>0.5059</td>
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<tr>
<td>gr1w2.WYLDmm</td>
<td>0.160057</td>
<td>0.16946</td>
<td>0.93884</td>
<td>0.3578</td>
</tr>
</tbody>
</table>

Analysis of Variance

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum of Squares</th>
<th>Df</th>
<th>Mean Square</th>
<th>F-Ratio</th>
<th>P-Value</th>
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<tbody>
<tr>
<td>Model</td>
<td>0.588784</td>
<td>11</td>
<td>0.0535258</td>
<td>50.55</td>
<td>0.0024</td>
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<tr>
<td>Residual</td>
<td>0.0070942</td>
<td>4</td>
<td>0.00175235</td>
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<tr>
<td>Total (Crr.)</td>
<td>0.595794</td>
<td>15</td>
<td></td>
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</tbody>
</table>

R-squared = 98.8235 percent
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 a need for further investigation of erosion, transport, and deposition differences in subbasins.
4. Analysis consists 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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