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Impact of climate changes on sediment delivery and deposition in a dammed reservoir

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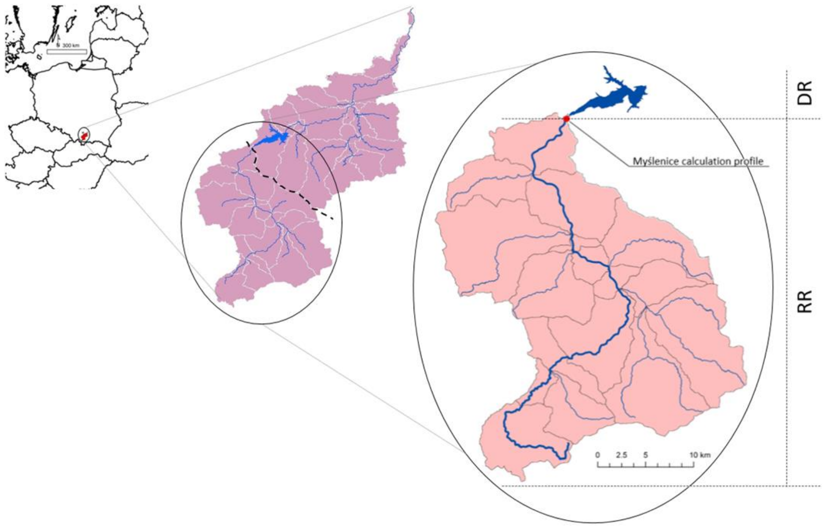
Impact of climate changes on sediment delivery and deposition in a dammed reservoir

1. Tracking sediment particles – from the source to the reservoir and beyond
2. Study area - Raba River & Dobczyce Reservoir (southern Poland)
3. Modeling tool
4. Variant scenarios (climate change and land use)
5. Sediment delivery from the catchment
6. Sediment fraction distribution in the reservoir
7. Conclusions

Source: Wilk et al., submitted

Tracking sediment particles – from the source to the reservoir and beyond

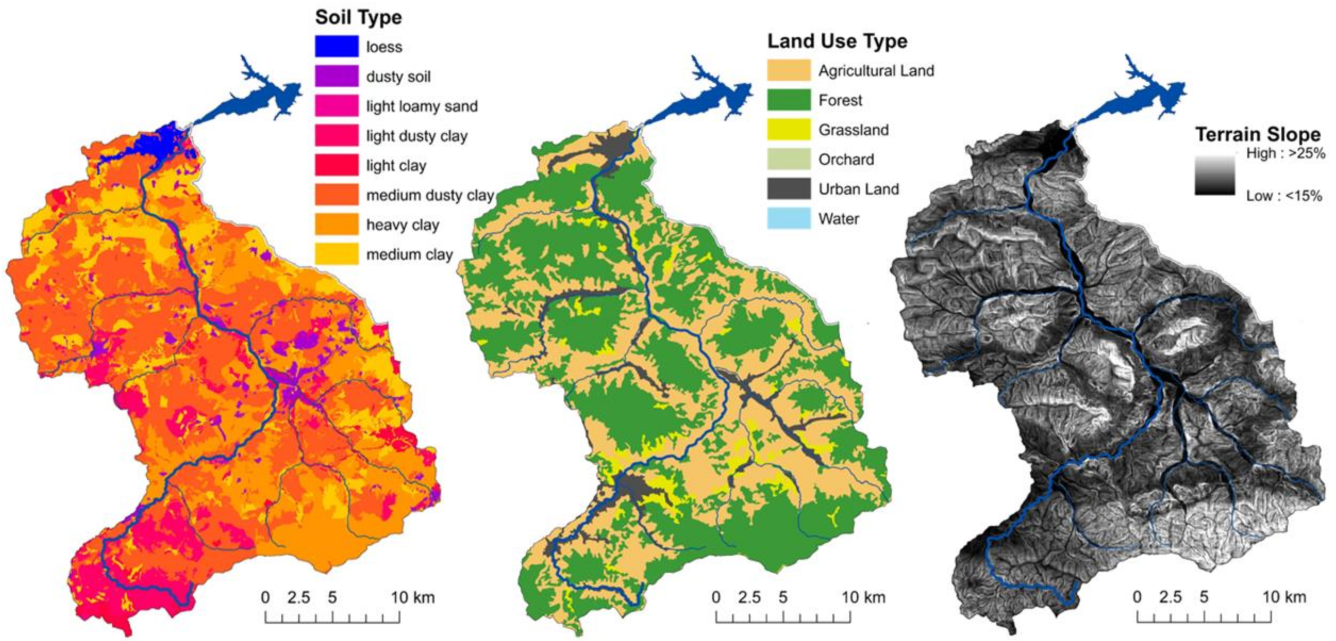


- soil loss in mountainous catchments enhanced by climate changes (Carpathian Mts.)
- trapping function of dammed reservoir even more important
- river and reservoir - two separate entities in the context of sediment transport
- tracking sediment particles from the catchment (upper Raba River) to its deposition place (Dobczyce Reservoir)

Source: Wilk et al., submitted

Study area

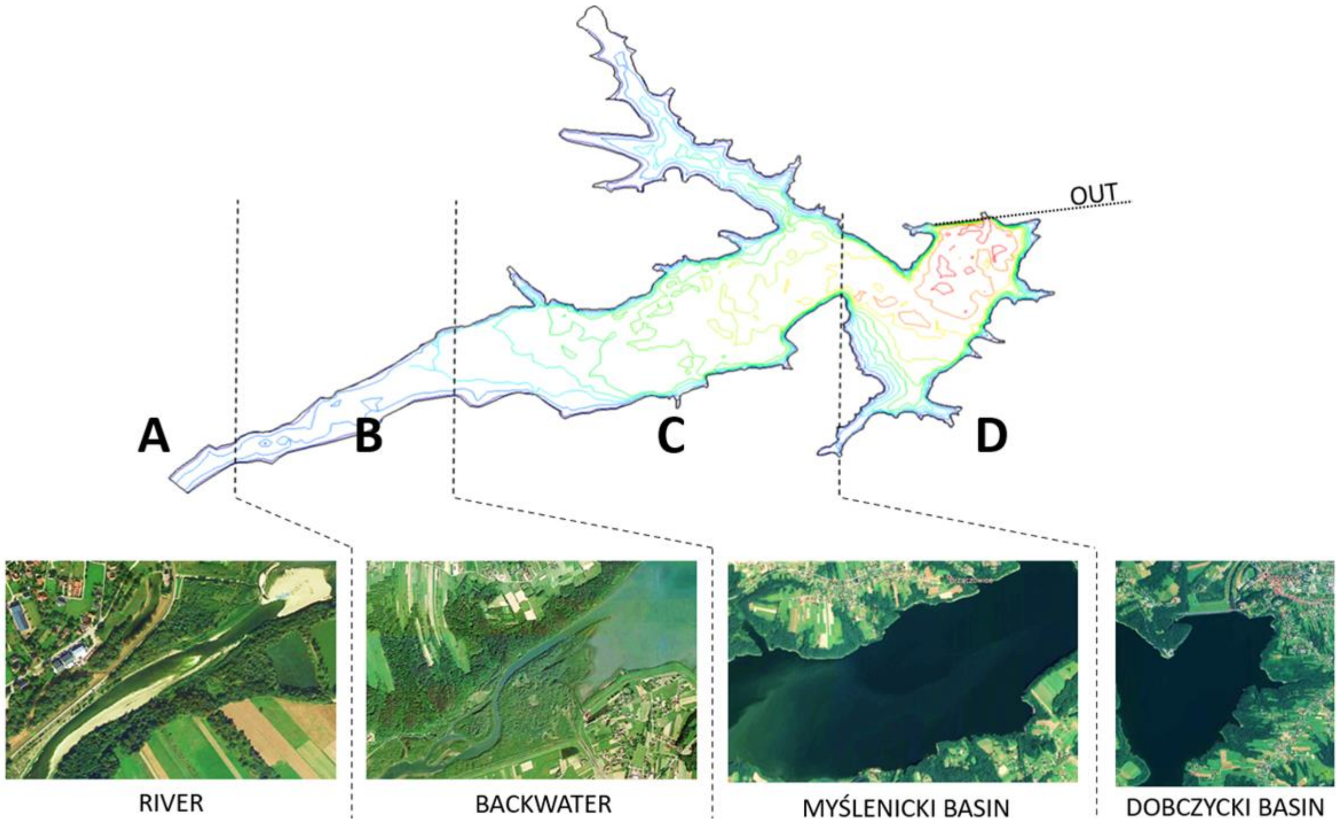
- upper Raba River - 768 km^2 of the catchment;
- average flow of 7,6 m^3/s (Myślenice);
- mountainous character of the catchment
- drinking water reservoir located at the 60. km



Source: Wilk et al., submitted

Study area

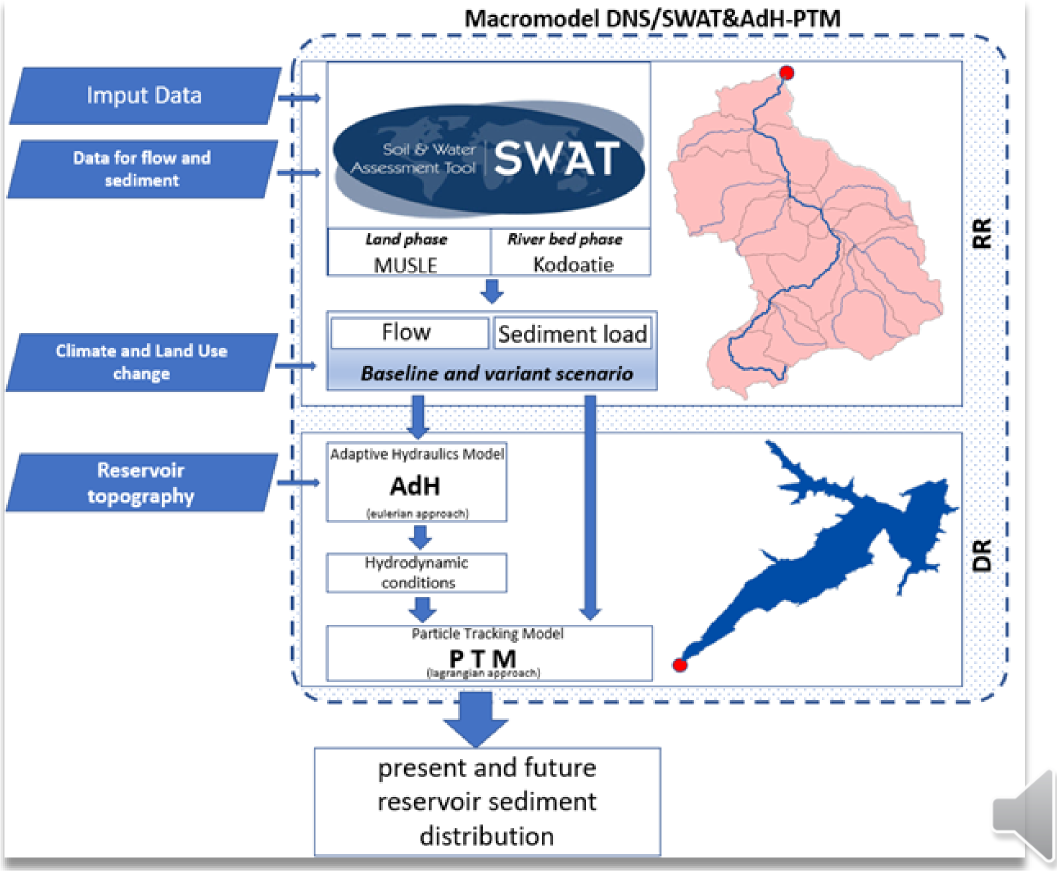
- Dobczyce Reservoir – multipurpose (*drinking water, flood & drought protection, energy production, fish farming*);
- approx. 10.7 km2 (*size - 8 by 1.6 km; avg. depth - 12 m; max. depth - 35 m*)
- divided into four zones



Source: Wilk et al., submitted

Modeling tool

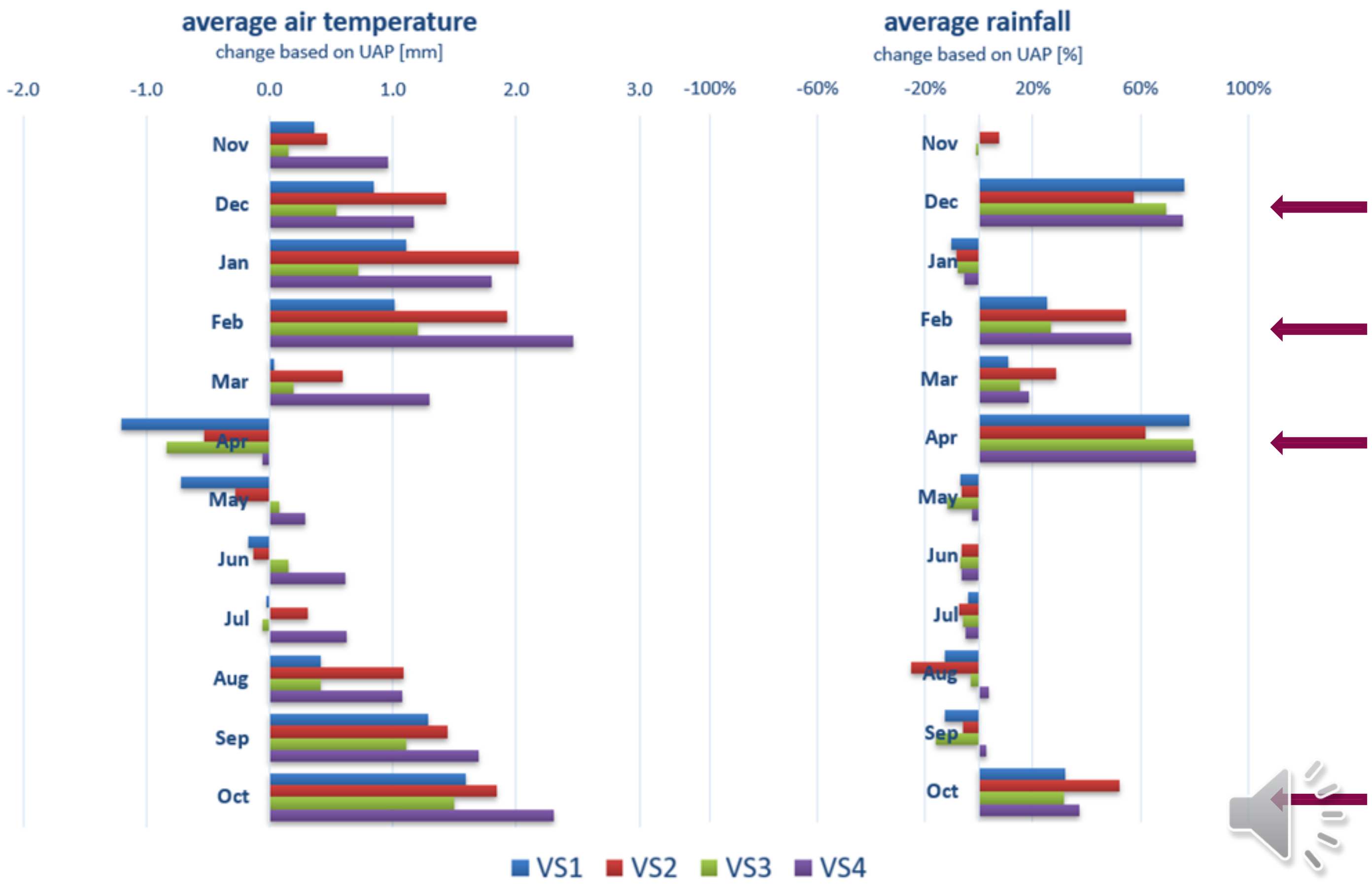
- Digital platform
- Macromodel DNS (Discharge-Nutrient-Sea)
- Platform modules:
  - SWAT – river basin
  - AdH-PTM – reservoir



Source: Wilk et al., submitted

Variant scenarios (climate change)

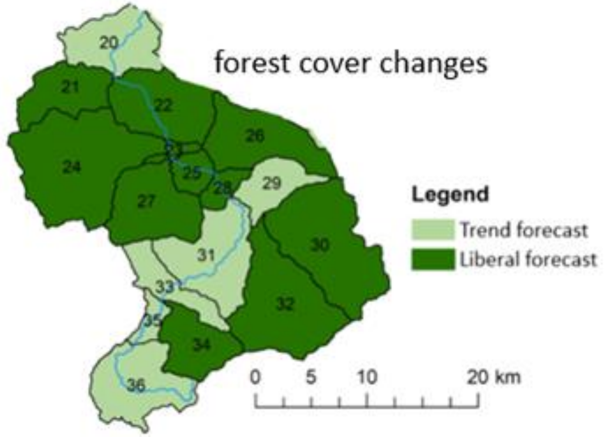
- climate change predictions based on data from Euro-CORDEX, RCM, and GCM models
- emission scenarios - RCP4.5 and RCP8.5
- time horizons - short-term (*H1 - 2026-2035*) and long-term (*H2 - 2046-2055*)
    - VS1 - RCP4.5 H1
    - VS2 - RCP4.5 H2
    - VS3 - RCP8.5 H1
    - VS4 - RCP8.5 H2

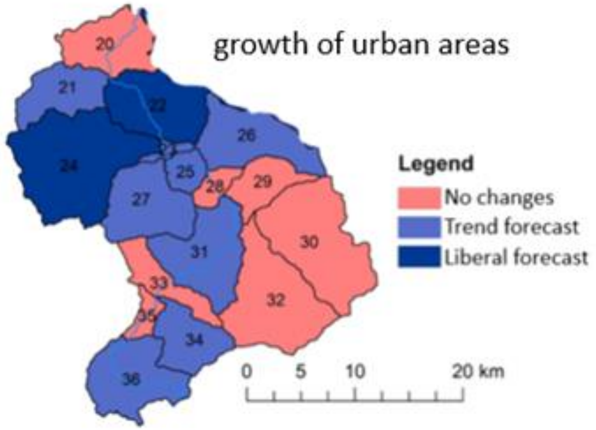


Source: Szalińska et al., 2021

Variant scenarios (land use change)

- land use changes - based on the results of the FORECOM project for forest cover and growth of urban areas
- trend forecast - growth of forest and urban areas by 23% and 10%, respectively,
- liberal forecast - growth of forest and urban areas, respectively by 30% and 15%

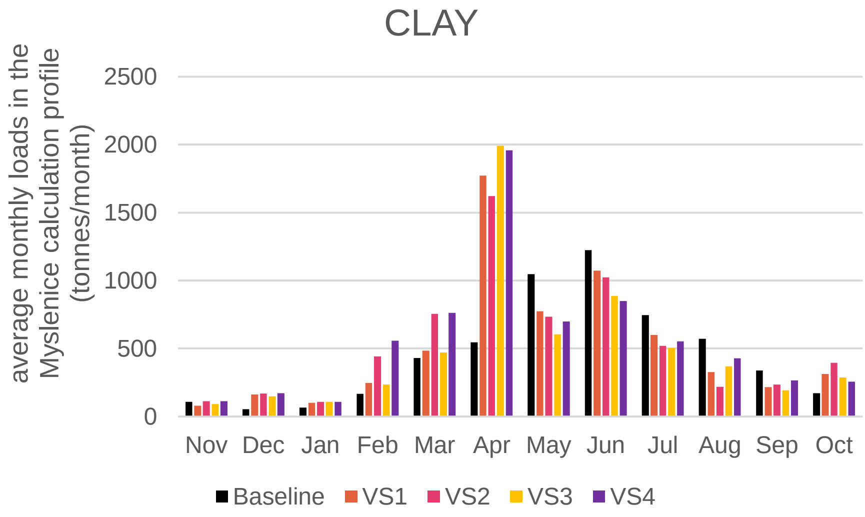


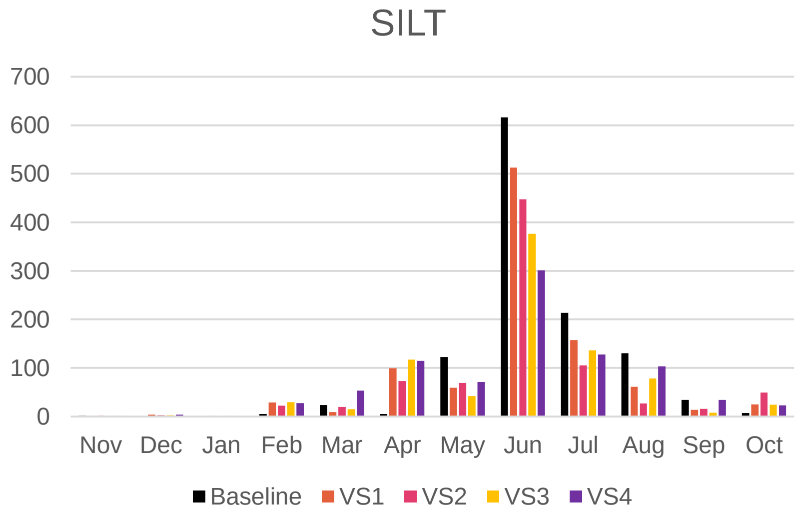


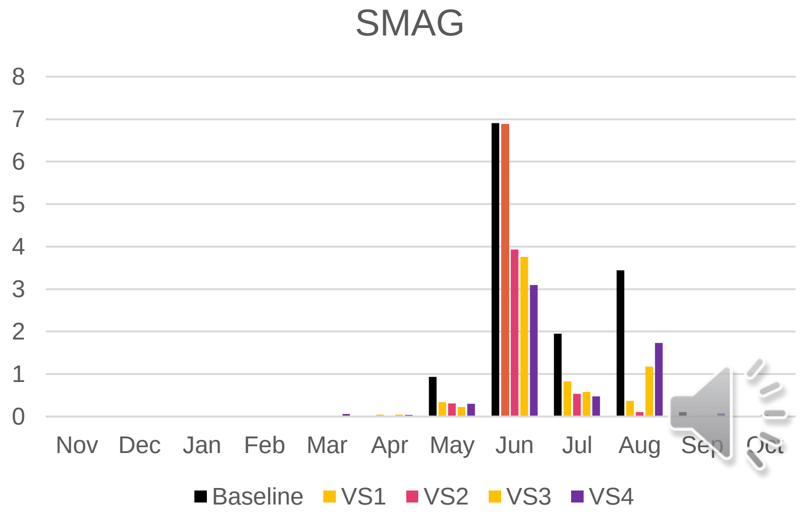
Source: Orlińska-Woźniak et al., 2020; http://www.gis.geo.uj.edu.pl/FORECOM/index.htm

Sediment delivery from the catchment

- SWAT module
- average monthly loads in the Myslenice calculation profile (*tonnes/month*)
- 3 analysed sediment fractions (*mineral: CLAY - 0-0.004 mm, SILT - 0.004-0.062 mm, and mineral/organic: SMAG - 0.03 mm*)



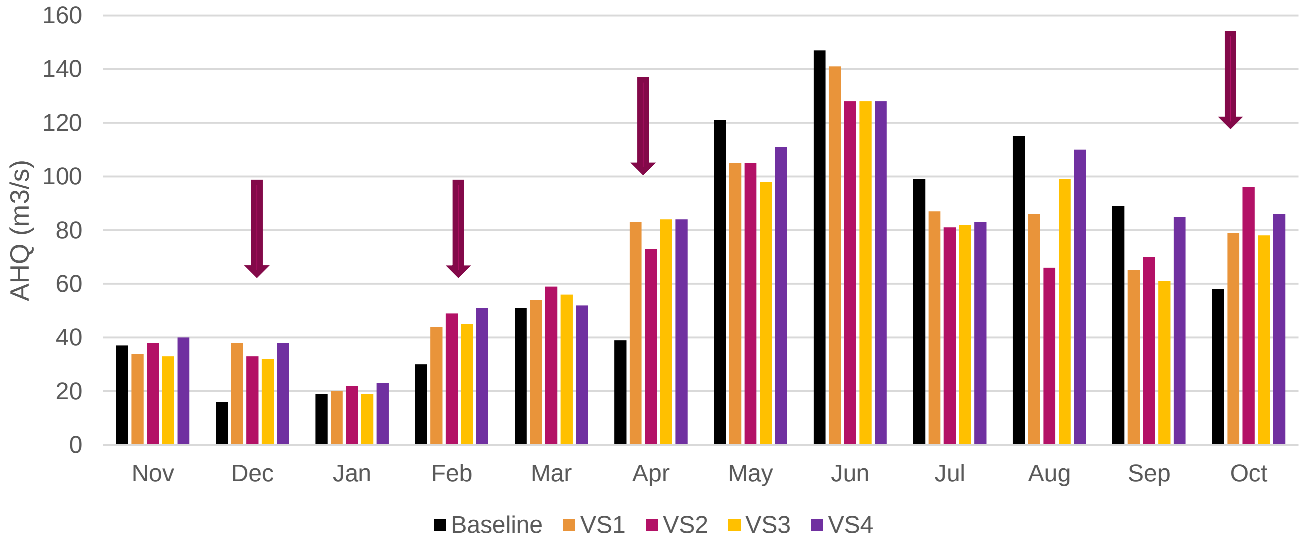




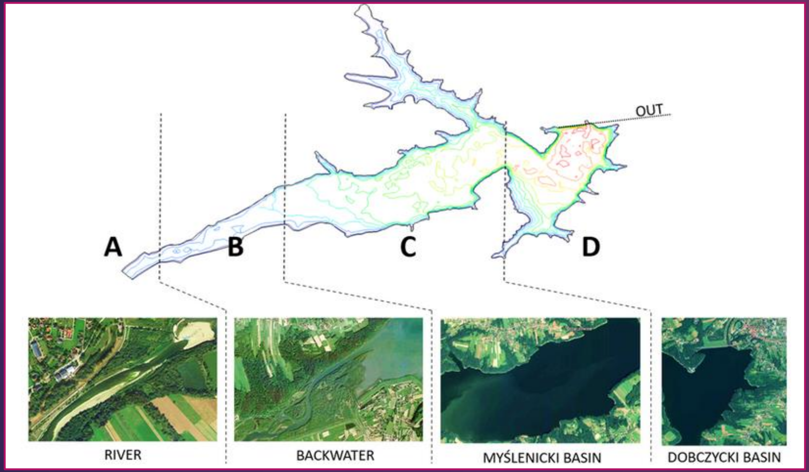
Sediment fraction distribution in the reservoir

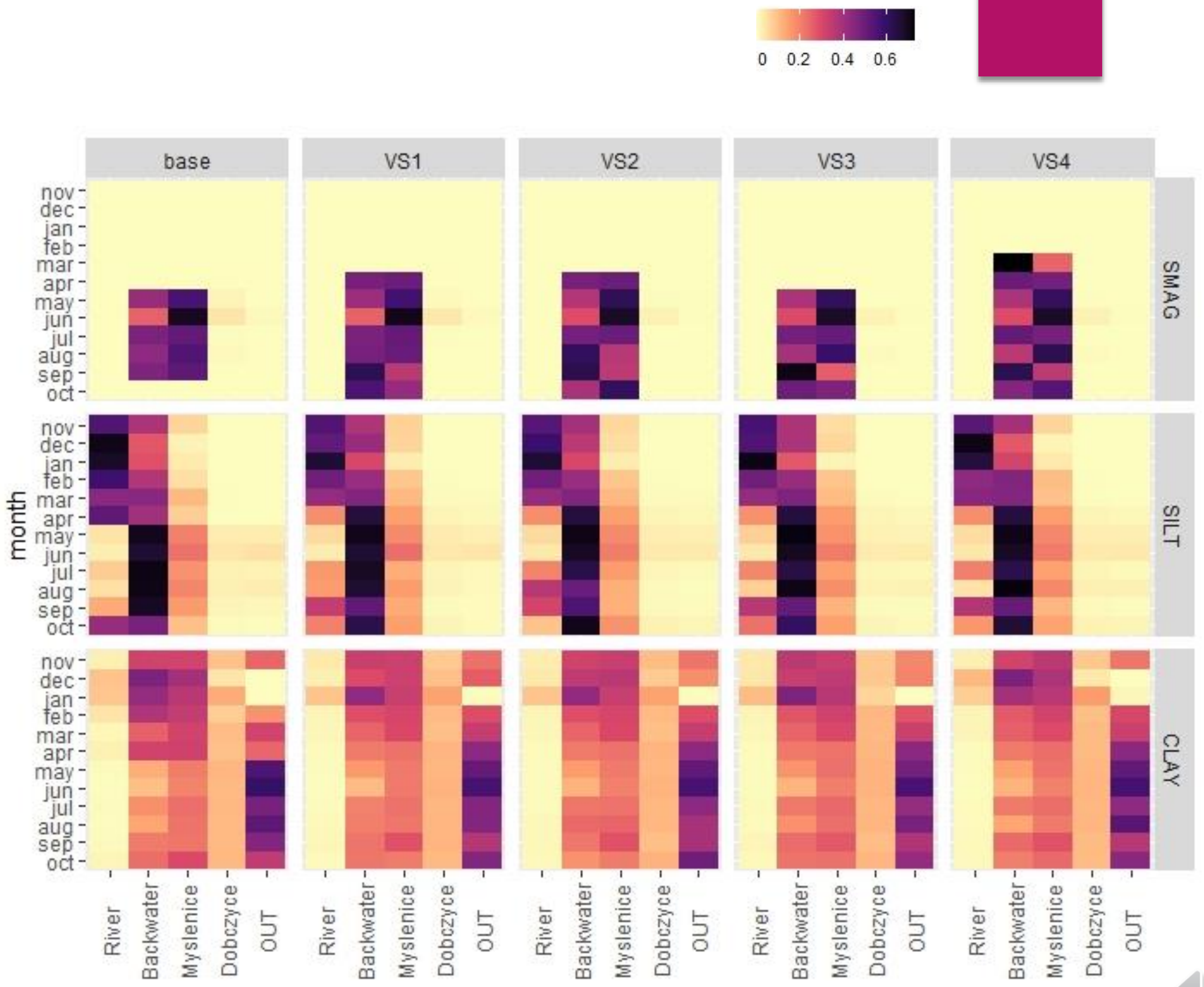
- AdH/PTM module
- simulations based on AHQ (*average high discharges*) for the Myslenice calculation profile (*m3/s*)

$$AHQ_m = \frac{\sum_{i=1}^{Y} \max_{m,y}(Q_d)}{Y}$$



Sediment fraction distribution in the reservoir

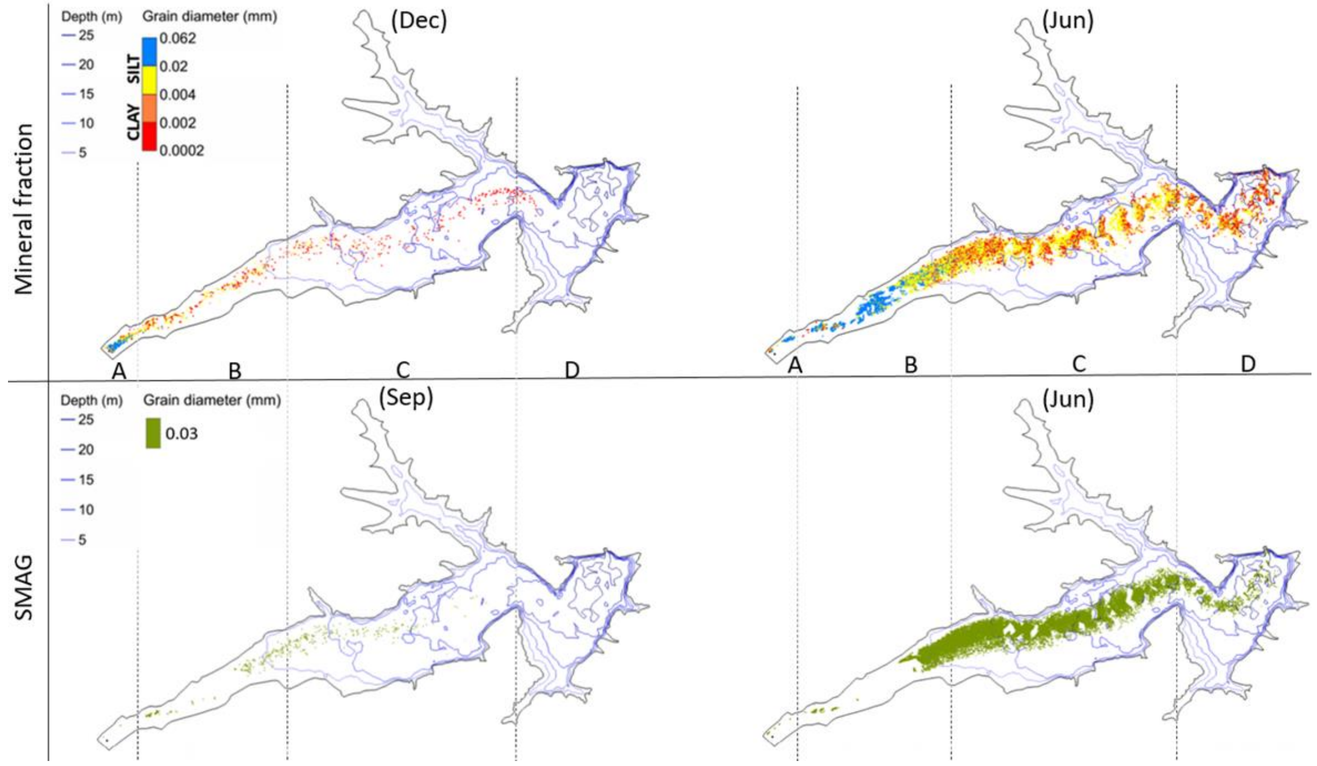




Source: Wilk et al., submitted

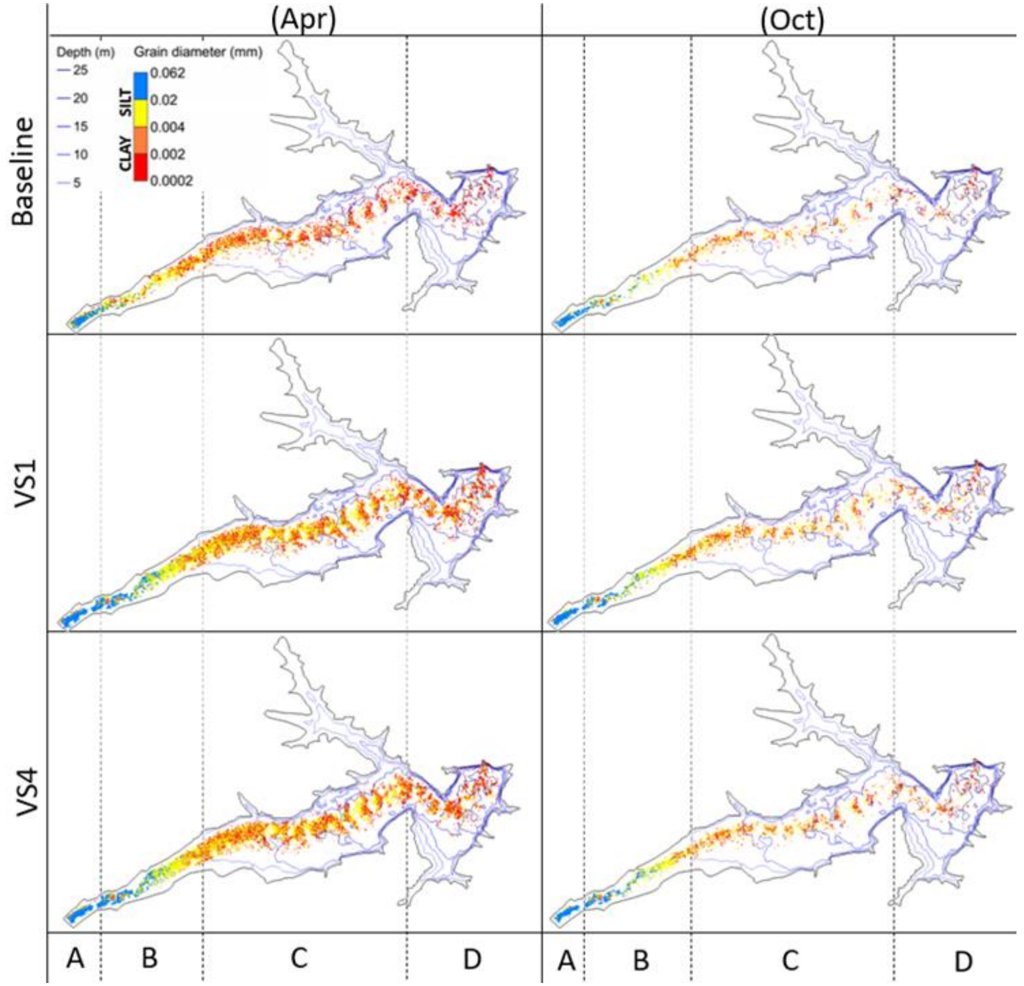
Sediment fraction distribution in the reservoir

- baseline scenario
- deposition of larger particles in zone A and B (*Oct-Apr - low flows*);
- transport of CLAY particles to zones C & D (and beyond) (*May - Sep - high flows)*



Sediment fraction distribution in the reservoir

- Variant scenarios
- zones A & B will remain the main depositional section (*SILT*)
- higher number of particles (*CLAY*) reaching C & D zones
- also flowing downstream from the reservoir



Conclusions

- tracking fractions of sediment particles (SMAG, SILT, CLAY) from the source to the deposition place;
- combined performance of two models (SWAT and AdH/PTM) under the umbrella of Macromodel DNS numeric platform;
- two first reservoir zones will trap sediment particles (SILT) even during forecasted high delivery seasons;
- increased mobility of the finer particles (CLAY);

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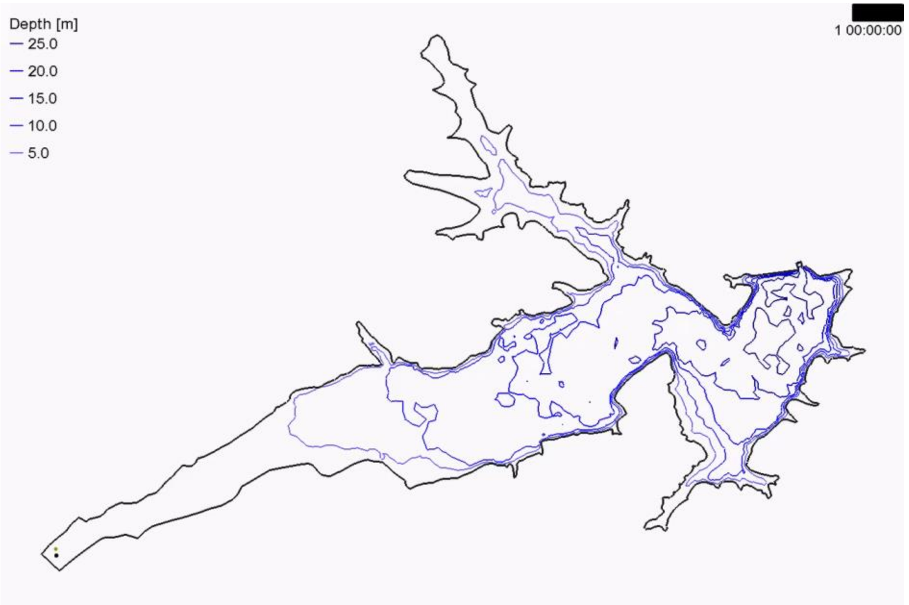

- thank you
- questions?