Application of different types of catchment models to support understanding the hydrological and transport processes, emission patterns and model limitations related to these in a meso-scale catchment

Zsolt Jolánkai*, Tamás Ács, Máté Kardos, Zsolt Kozma, Bence Decsi, Imola Gömbös, Adrienne Clement

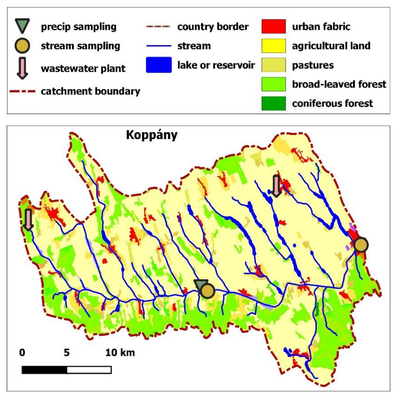
Department of Sanitary and Environmental Engineering, Budapest University of Technology and Economics, Hungary. *jolankai.zsolt@emk.bme.hu

1. Introduction: Background, motivation and objective

Nutrient management requires the quantification of sources and pathways of contaminants to the water bodies. Large scale contaminant transport models are often used for this purpose. However, emission models generally apply simplified methodology to calculate the contribution of smaller geographical regions (units) to the contaminant load exiting a larger region. Due to the rough simplifications in the model, the share of the unique sources and pathways might be highly over- or underestimated even if the model results are well in accordance with the measured values.

To be able to identify the relevance of subsurface and surface pathways of diffuse source nutrient transport a thorough site investigation have been carried out at the Koppány, a mesoscale agricultural catchment in Hungary. Along with this data collection several models have been applied on the catchment in order to gain a better understanding of the relevance of pathways in, which nutrients, especially nitrogen is transported. These were the ModFlow mode and the WetSpass model to assess subsurface water movement or budget, SWAT+ and InVEST models to assess its capabilities in the identification of hotspots.

One of the main objectives of the modelling studies is to identify hot spots in the catchment from where from nitrogen can be delivered to the streams within the timeframe of management cycles in river basin management planning. Another objective is to identify residence times for nitrate along certain subsurface flow lines. And finally, the objective of the study is also to identify model applicabilities, strengths and weaknesses in the application to achieve the goals described above.



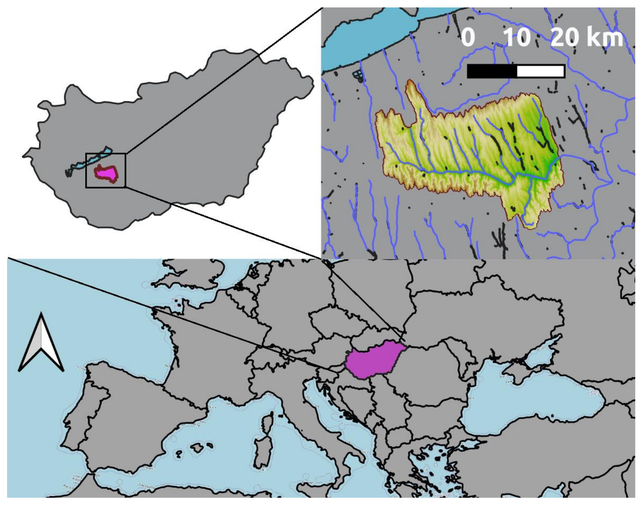


Figure 1.: Overview of the Koppány catchment in Hungary

2. Materials and methods

The methodology of the model comparison:

- A catchment with average data availability has been selected
- All models use the same input data: climatic, land use/vegetation, terrain, soil data
- Water budget are compared: evapotranspiration, groundwater flow, surface runoff (where applicable), total water yield
- Infiltration zones to be compared (where applicable)
- Strengths and advantages of the models will be highlighted
- Weaknesses and disadvantages of the models will be highlighted
- Hot spots for nutrient leaching, nutrient runoff to be highlighted by the models

- Distributed saturated zone hydraulic model
- Steady state or transient

- Distributed water balance model
- Monthly time step

- Distributed water balance on cell level (no hierarchy)
- Annual averages

- Semi-distributed hydrological model
- Full water balance on HRU level (cell also)
- Daily time step

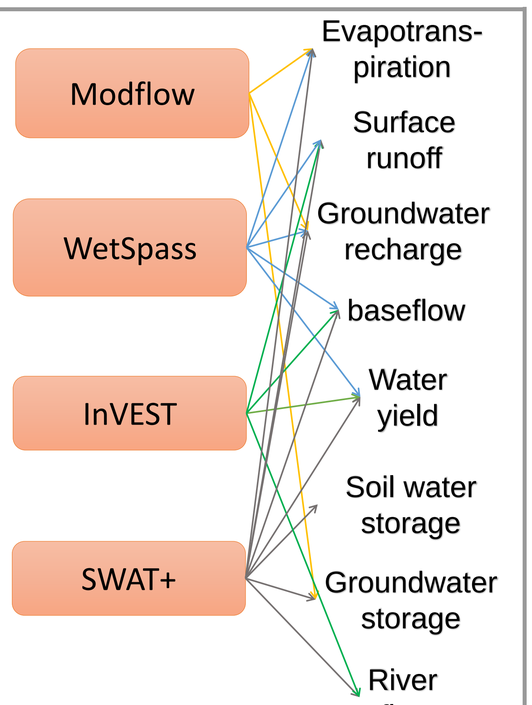


Figure 2.: some characteristics of the applied models

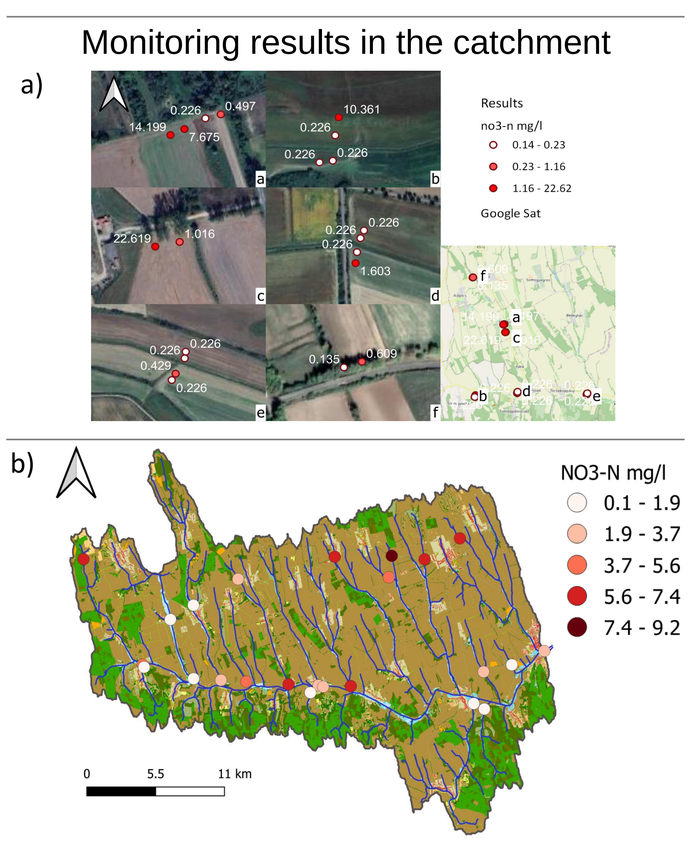


Figure 3: a) nitrate in shallow groundwater boreholes; b) nitrate in stream baseflow in March 2023

3. Preliminary results and conclusions

Modflow model – groundwater depth

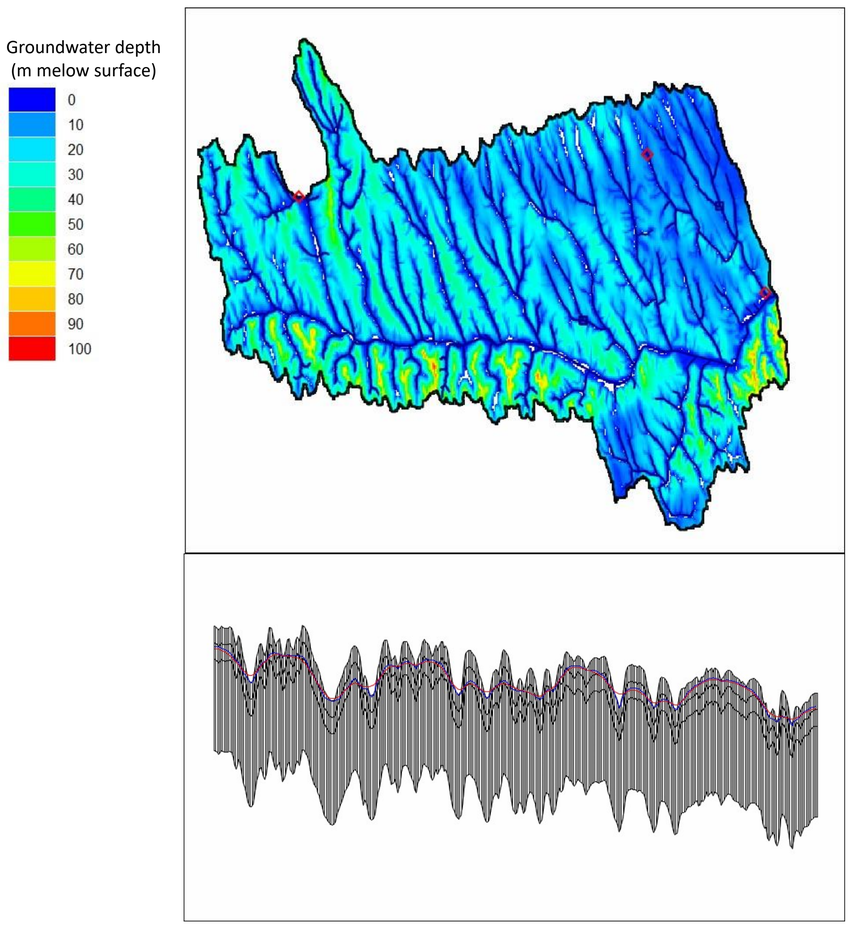


Figure 4.: Calibration result for the steady state modflow model

SWAT+ model – annual lateral flow (mm/y)

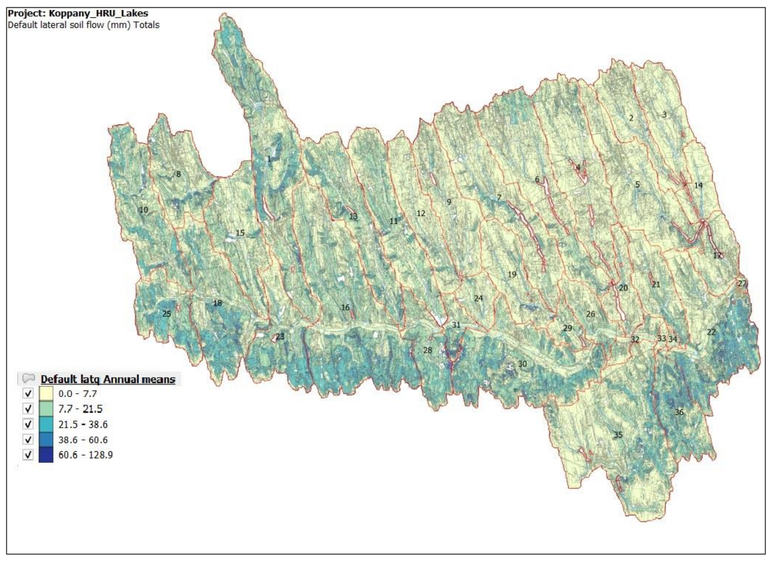
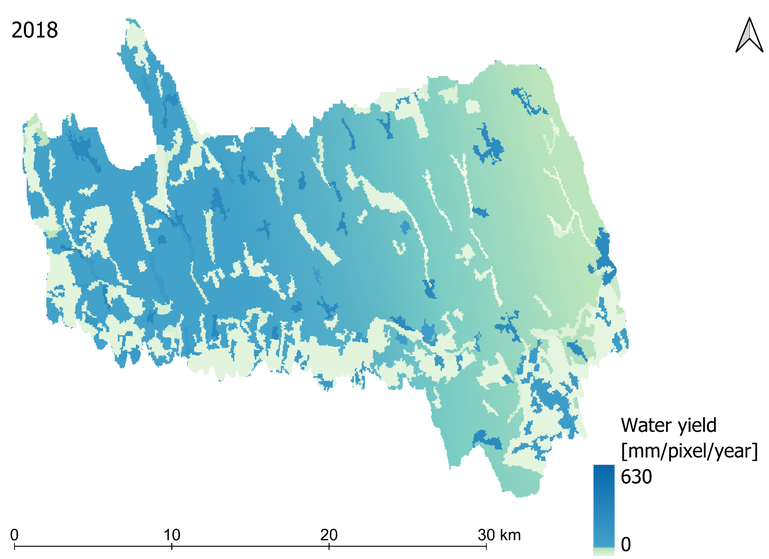
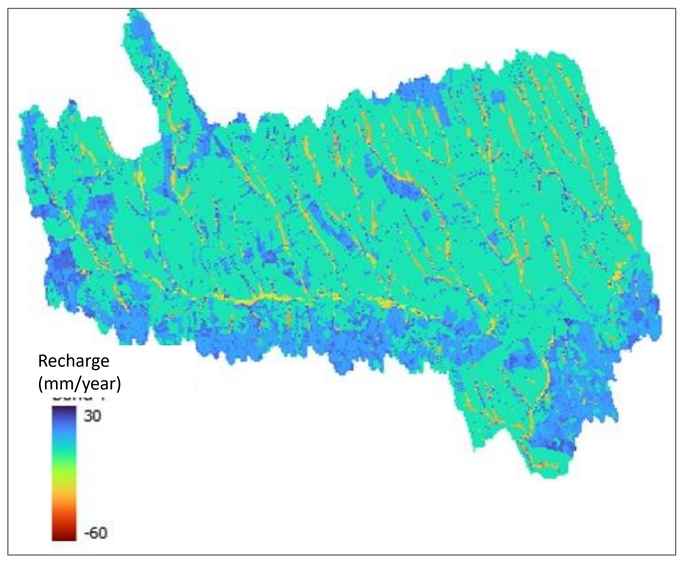


Figure 4.: Initial results of the applied models related to hydrology

InVEST model –annual water yield



WetSpass model – monthly recharge



Some results of the model comparison:

- The Modflow and WetSPASS models both indicates that the groundwater reaches the terrain in the river valleys, causing baseflow discharge in annual average conditions
- Modfllow indicates 30-90 meter deep gw. at hilltops, which indicate high recharge time
- The SWAT+ model indicates that there are zones with significant lateral discharge (in the steeper hilly areas)
- The InVEST model indicates highest yields in the steeper, forested parts of the basin.

General conclusion:

Using separate models have the advantage that individual processes can be examined in greater detail, the effects of the factors can be better evaluated, and variables/indicators are also output as results (e.g. groundwater residence times), which cannot be calculated with an integrated model.

Acknowledgements: The research presented was carried out within the framework of the Széchenyi Plan Plus program with the support of the RRF 2.3.1 21 2022 00008 and was co-financed by the National Research Development and Innovation Office (NKFIH) through the OTKA Grant SNN 143868.