Bytes and rates: multiple combinations of different remote sensing data for biogeomorphic interaction of river system

RUSNÁK Miloš, GOGA Tomáš, AFZALI Hamid, OPRAVIL Šimon, MICHALEJE Lukáš, MD Ashraf

Institute of Geography SAS, Bratislava, SLOVAKIA

Introduction

River channels play a crucial role in maintaining landscapes by transferring energy, matter, and nutrients. Nowadays, modern fluvial geomorphology emphasizes the integration and complex understanding of the mutual relationship between river processes and floodplain ecology with an emphasis on riparian vegetation. For this study, the braided-wandering river system of the Belá River was selected for assessment. This river system is a rare and valuable wetland ecosystem affected by morphological degradation and incision. A combination of old historical aerial images (1949-2018) with 50 centimetres accuracy and modern low-resolution (10 meters) satellite data (from 2016) was used for the evaluation and monitoring of biogeomorphological interaction. For extraction of environmental variables (height above the channel, morphometry, vegetation cover), the study used surface and terrain elevation models derived from lidar data. The spatial extent of vegetation was automatically classified from historical black-and-white aerial imagery (1949-1992), RGB orthophotos (2002-2006) and RGB+NIR orthophotos (2009-2018). Monitoring and response to geomorphic adjustment were analysed based on vegetation and moisture indices were calculated from Sentinel-2 satellite data.

1 Aim and motivation

- combining of high-resolution aerial with low-resolution satellite images and lidar topograhy information

historical aerial images
- *long-range-temporal information (from 1949)*
- *floodplain morphology evolution*
- *higher spatial resolution*
- *low temporal density*

lidar data
- *accurate vertical elevation*
- *higher spatial resolution*
- *low temporal density*
- *up-to-date information - missing historical evolution*

satellite images
- *middle-range temporal information (from 1975)*
- *lower spatial resolution*
- *spectral information about vegetation properties*

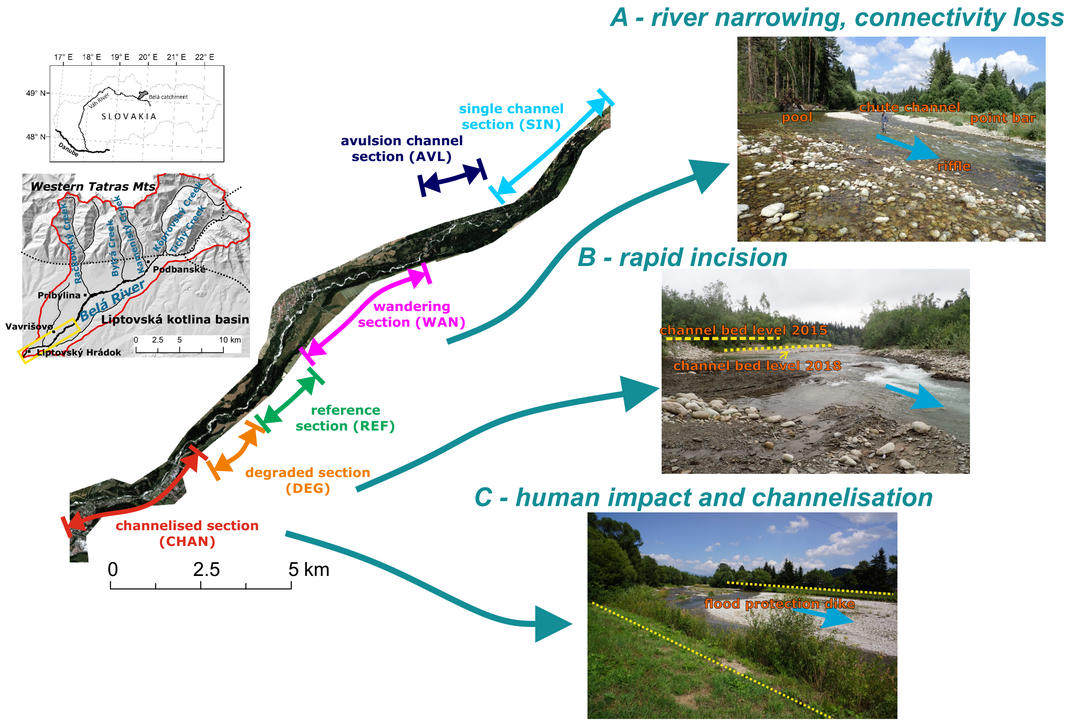
How to combine and using the best properties of of them?

What is the reaction of vegetation to morphological adjustment?

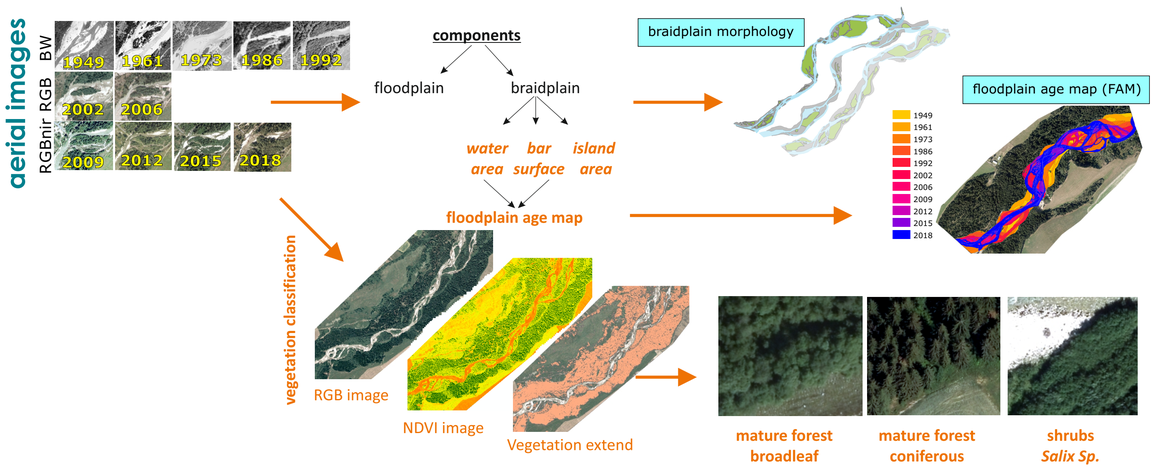
How to set up effective long-term monitoring?

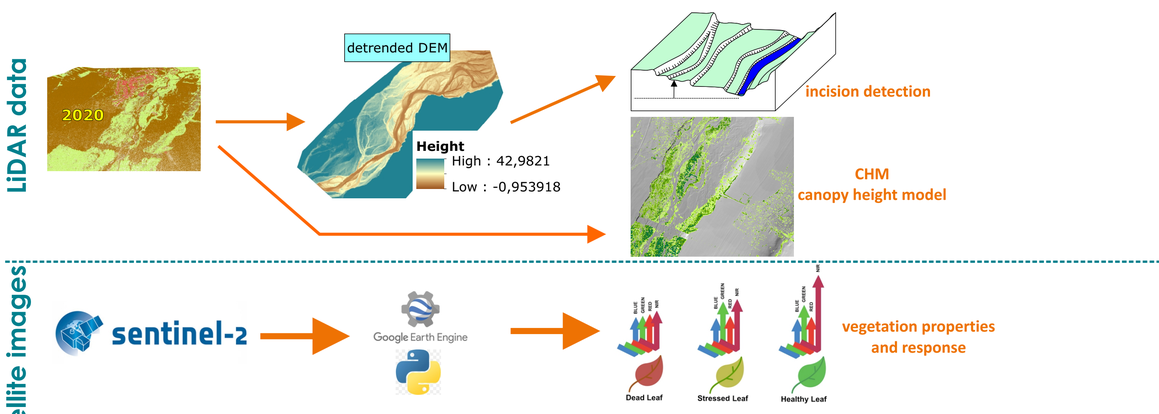
2 Study area and river transformation

- negative human impact to river system



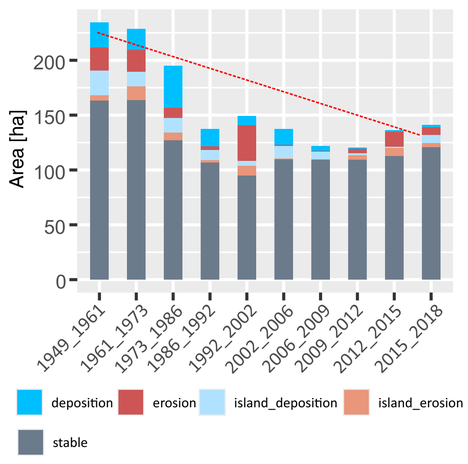
3 Data and processing

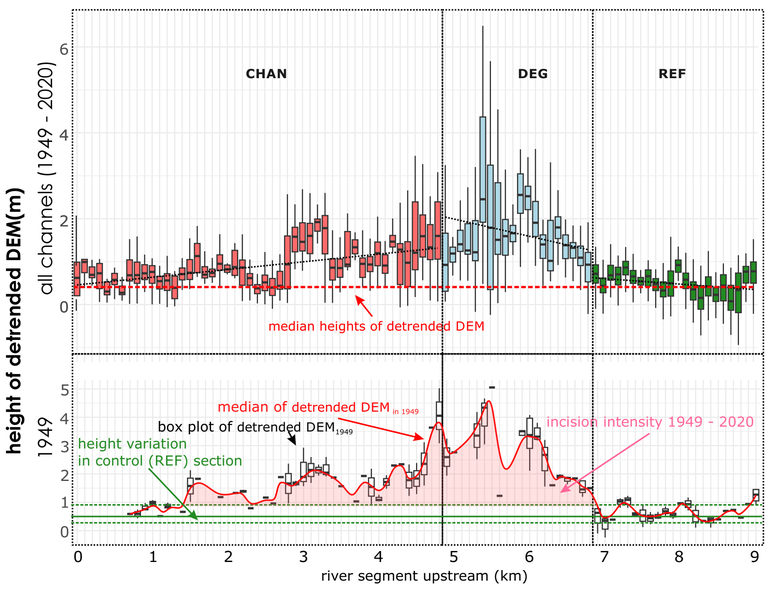




4 Morphology evolution

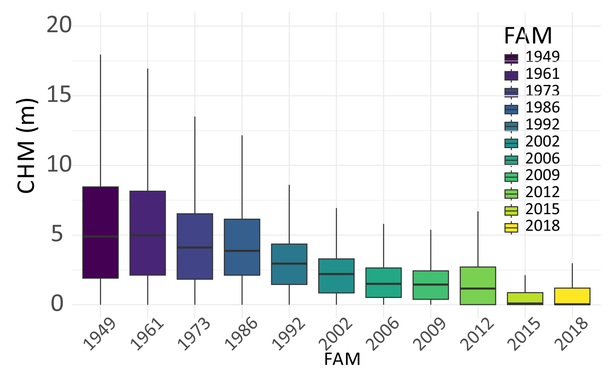
- decrease in braidplain width
- decline of gravel bar
- decline of lateral processes
- channel incison

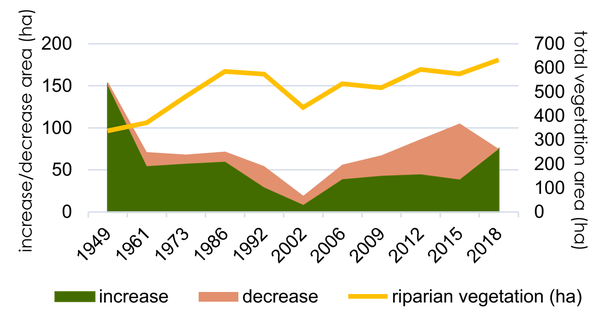


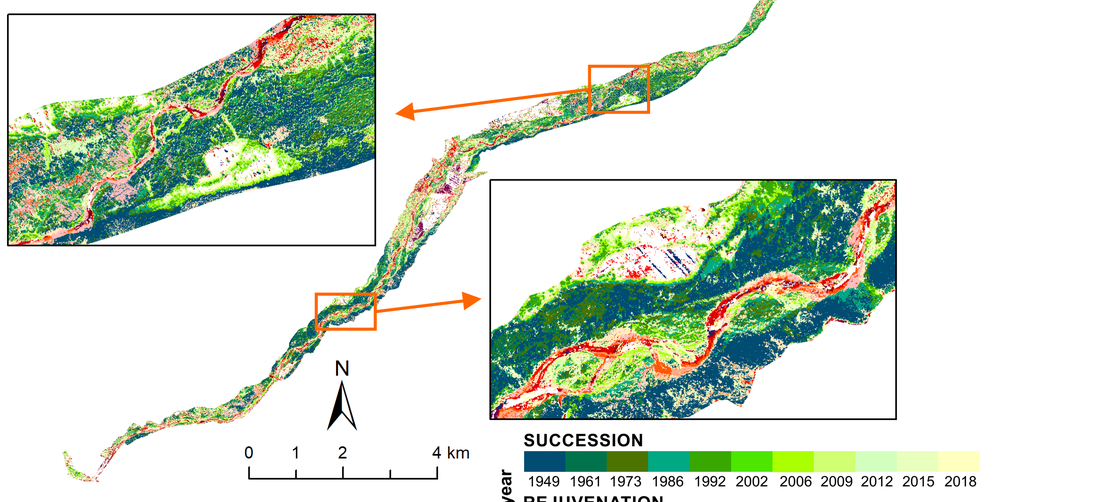


5 Biogeomorphic transformation

- increase in riparian vegetation area
- stabilisation of riparian forest belt
- erosion of older stable part (dominantly Picea Abies)
- succesion of new forest in form of Salix Sp.
- young forest belt in close proximity of channel

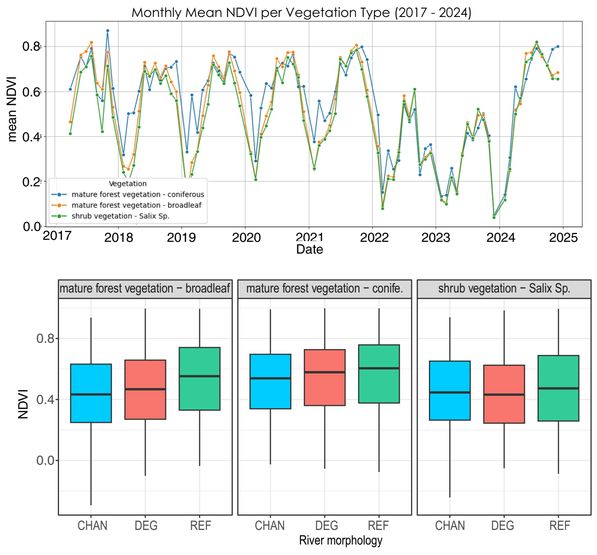


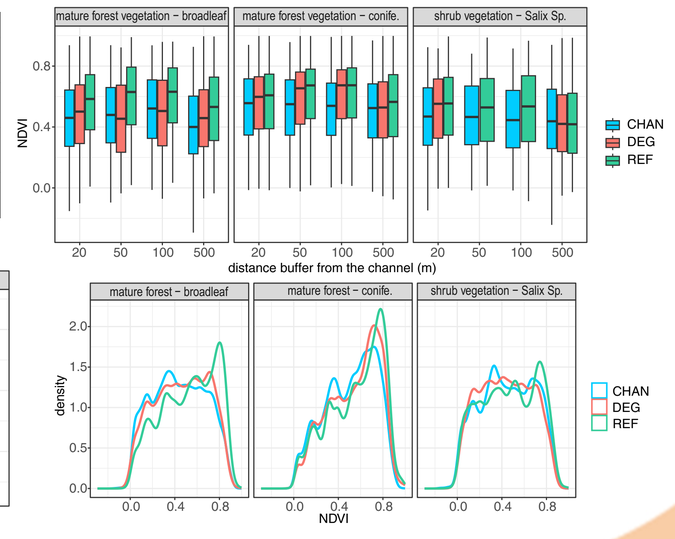




6 Vegetation monitoring

- NDVI - proxy-value for vegetation health
- negative response of degraded river reach





Read more:

RUSNÁK, M., KAŇUK, J., KIDOVÁ, A., LEHOTSKÝ, M., PIÉGAY, H., SLÁDEK, J., MICHALEJE, L. (2024). Inferring channel incision in gravel-bed rivers: Integrating LiDAR data, historical aerial photographs and dronebased SfM topo-bathymetry. Earth Surface Processes and Landforms, 49(8), 2475-2497. https://doi.org/10.1002/esp.5840

RUSNÁK, M., OPRAVIL, Š., DUNESME, S., AFZALI, H., REY, L., PARMENTIER, H., PIÉGAY, H. (2025). A channel shifting GIS toolbox for exploring floodplain dynamics through channel erosion and deposition. Geomorphology, 477, 109688. https://doi.org/10.1016/j.geomorph.2025.109688