FACULTY OF
SCIENCE
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http://hydro.natur.cuni.cz

UAV monitoring of fluvial dynamics of montane streams

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I. MOTIVATION AND AIMS

Motivation and aims

Motivation

- Rising variability of runoff in montane areas results in elevated fluvial dynamics
- Limited options for rapid, high-resolution and repeatable analysis of the changes in granulometric properties of streams after flood pulses

Goals

- Development of new methods, merging the UAV photogrammetry with the digital optical granulometry
- Testing the new method in an area with elevated recent fluvial dynamics

LANGHAMMER, J., LENDZIOCH, T., MIŘIJOVSKÝ, J., HARTVICH, F., 2017. UAV-Based Optical Granulometry as Tool for Detecting Changes in Structure of Flood Depositions. Remote Sensing, 9(3), p.240. IF=3.244

II. CASE STUDY

Study area

Šumava mts.

- border range CZ/D
- cca 1100 m a.s.l.

Changes in environmental properties

Past changes

- Land-use alterations
- Stream modifications

Recent changes

- Effects of climate change
- Forest disturbance

Accelerated fluvial dynamics

- Rise of runoff variability
- Repeated floods
- Acceleration of fluvial dynamics

Study site

Meandering belt of Javoří brook

III. APPLIED METHODS

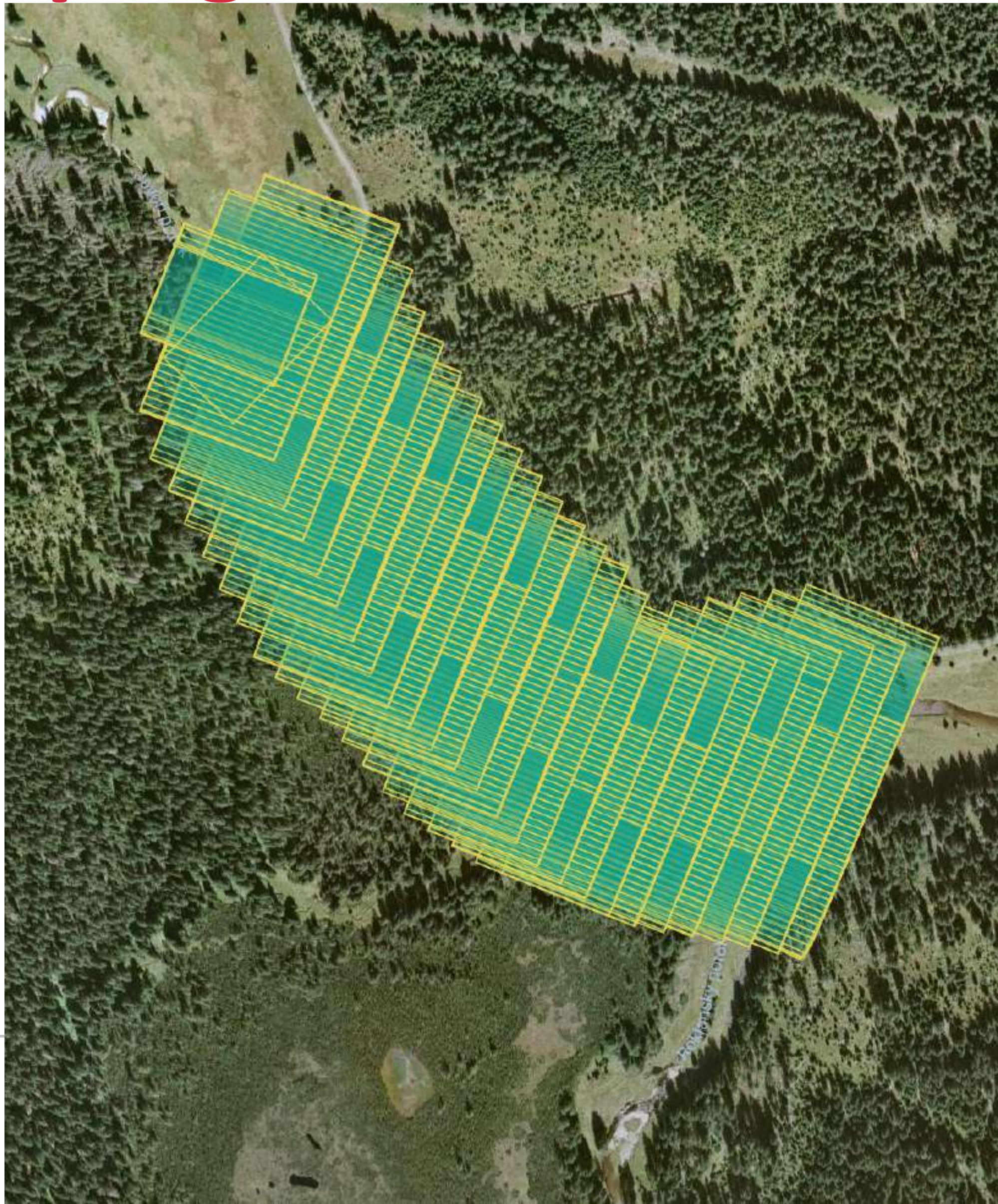
UAV Imaging campaigns

Monitoring since 2013

- 2 campaigns per year
- Aims of monitoring
  - Dynamics of meandering belt
  - Granulometric changes

- **Meandering belt**
  - Active meandering belt length 800 m, width 150 m
  - Resolution 1-2 cm/px
  - Flight levels 60-70 m

- **Point bar granulometry**
  - Selected active point bar length 50 m width 20 m
  - Ultra-high resolution (1-2 mm)
  - Near-ground flight levels (6-8 m)



UAV Imaging platforms

Mikrokopter OctoXL

since 2013

- Panasonic Lumix GX7
- MFT sensor
- 16 MPx, 4608 x 3456
- Panasonic
  lens 24 mm (eq.)

DJI Inspire 1 Pro

since 2015

- Zenmuse X5 camera
- MFT sensor
- 16 MPx 4608 x 3456
- Olympus M.Zuiko ED
  lens 24 mm (eq.)

DJI Matrice 210 RTK

since 2018

- Zenmuse X4s camera
- 1“ sensor
- 20 MPx
- fixed lens 28 mm (eq.)
- RTK navigation

Photogrammetric processing

Agisoft Photoscan/Metashape Pro

Structure from Motion

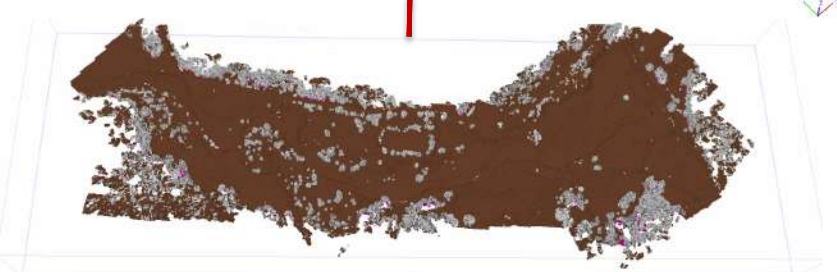
- Typical campaign – 450-600 images
- PC Core i7 6700 at 4,0 GHz, 64 GB RAM
- GPU acceleration 2x NVIDIA GTX 960

Unstructured imagery

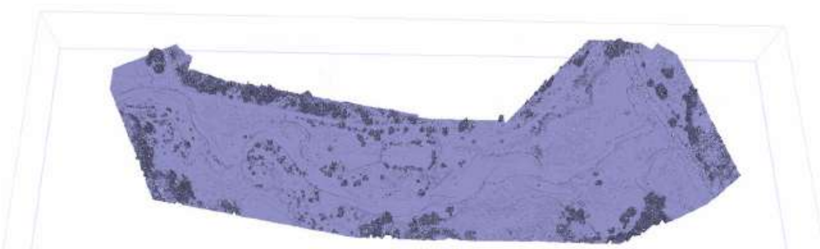
Imagery alignement

Tie points (sparse cloud, 3,5 mil. points)

Dense point cloud (371 mil. points)



Classified dense cloud (ground, vegetation)



3D model

Optical granulometry

1) Calibration of digital image

- Calibration of image scale
- Removing redundant parts of the scene (sand, vegetation)
- Setting of parameters (methods, thresholds)

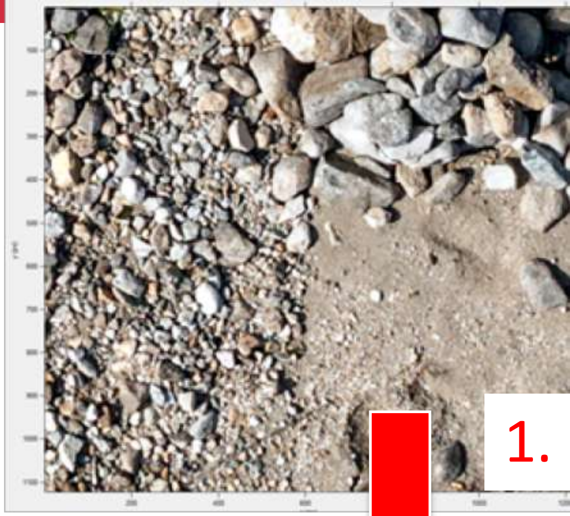
2) Recognition and measurement of objects

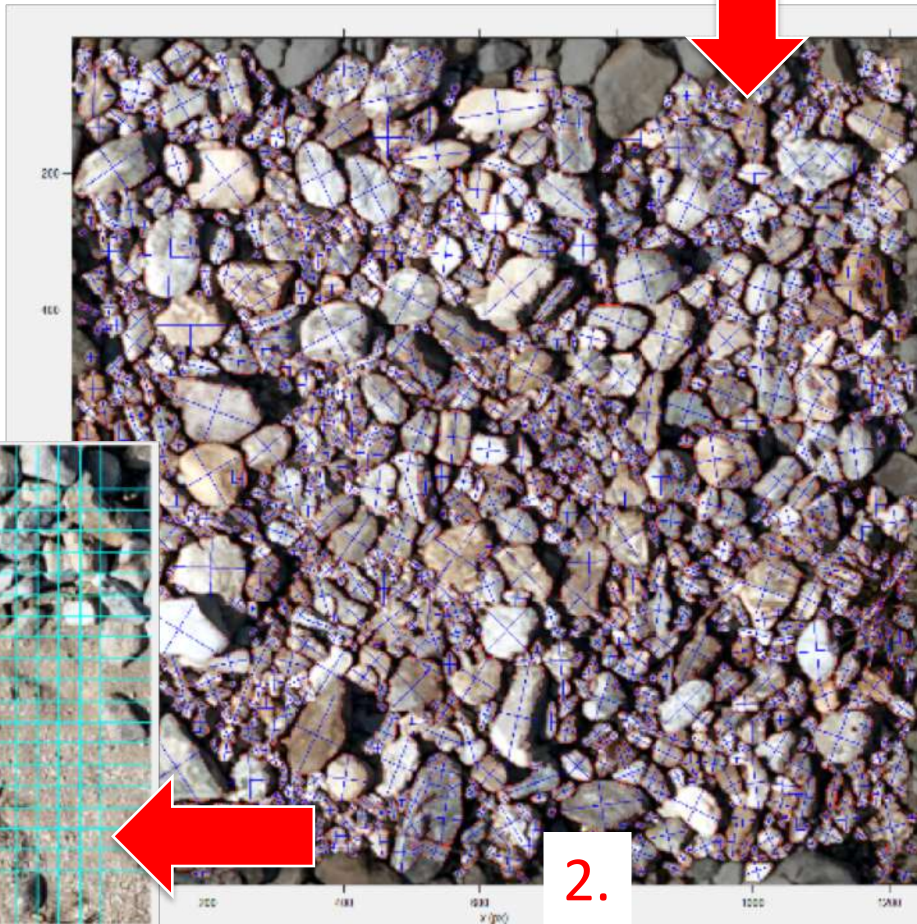
- Semi-automated classification
- Merging, splitting, deleting of objects

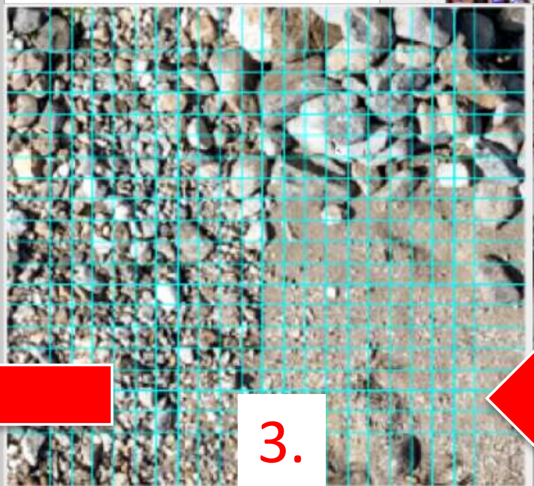
3) Digital sieving

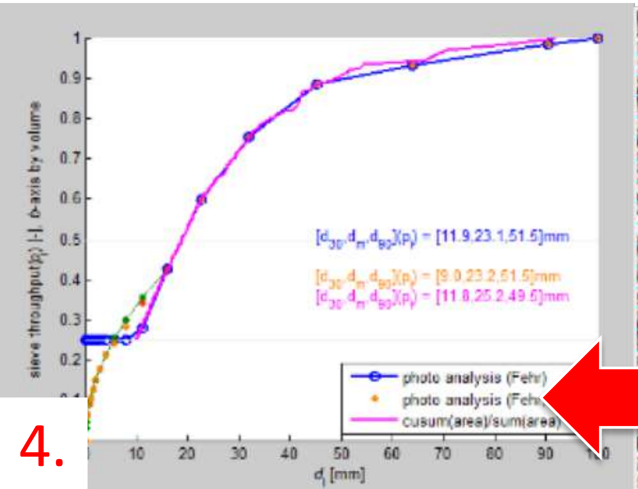
4) Determination of grading curves

- Fehr (1987)









UAV Optical granulometry

Goal

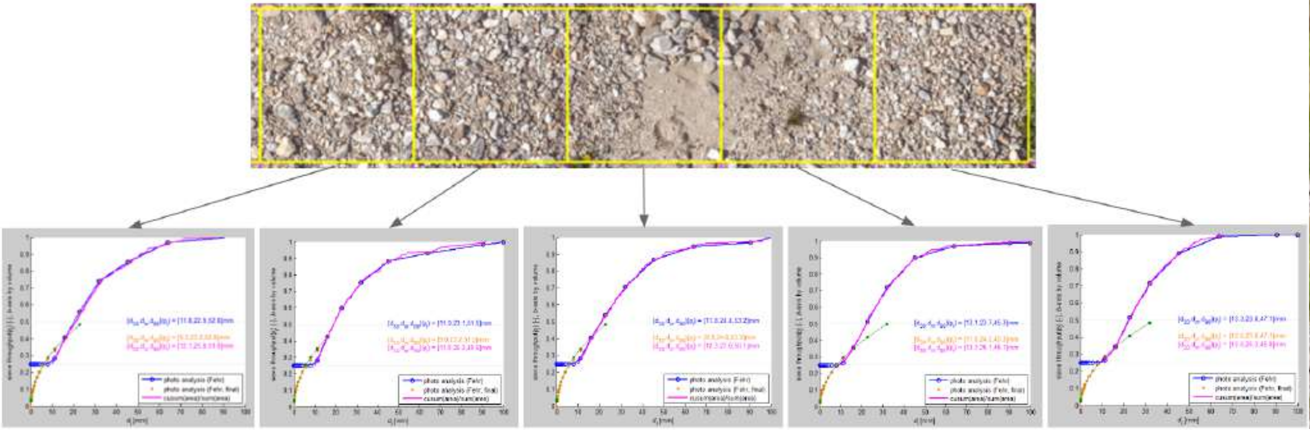
- UAV-based semsless orthoimage, enabling granulometric analysis

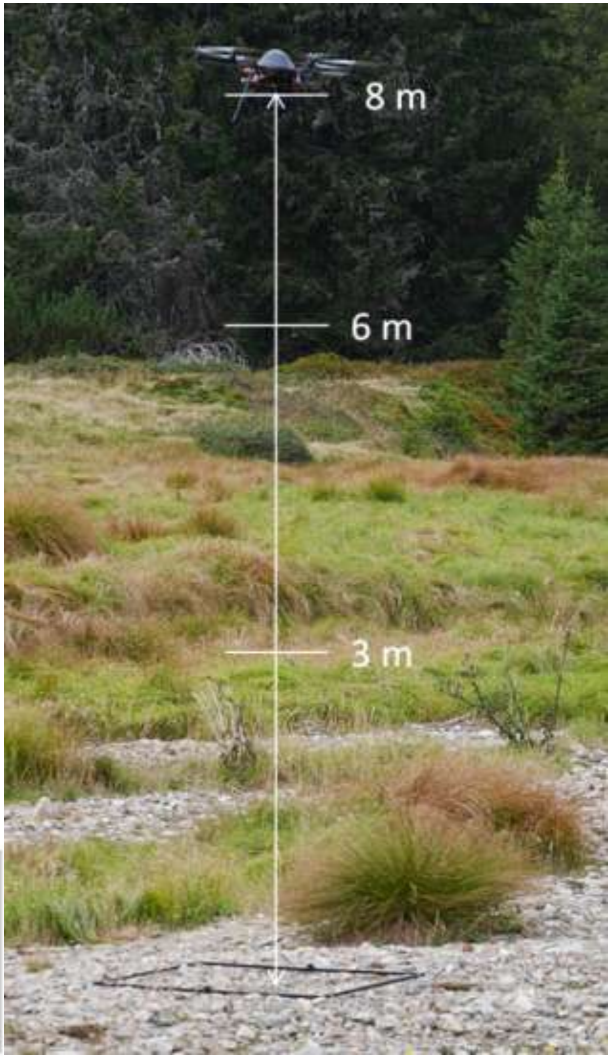
Features

- Ultra-high resolution of imagery, enabling distinction of gravel categories (1-2 mm/px)
- Enabling granulometric analysis in transects/areas
- Enabling multitemporal granulometric analysis

Demanding flight campaigns

- Determination of optimum altitude
- Keeping consistent altitude and flight tracks
- Securing overlaps





Field survey

- **Reference spots**
  - Same spots, two methods
  - Validation for UAV optical granulometry

- **Field granulometry**
  - Collection of granulometric samples from reference spots
  - Lab sieving and processing

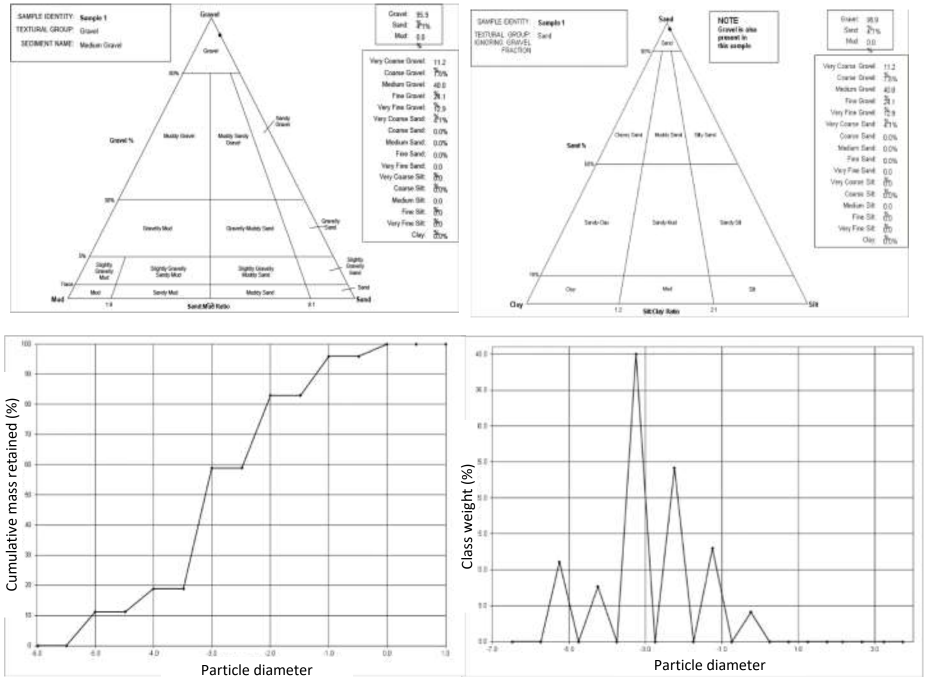
- **Optical granulometry**
  - Calibrated frames
  - Manual digital imaging
  - Image processing

Grain size distribution (manual sieving)

Used as reference for validation of optical granulometry
Analysis using Gradistat

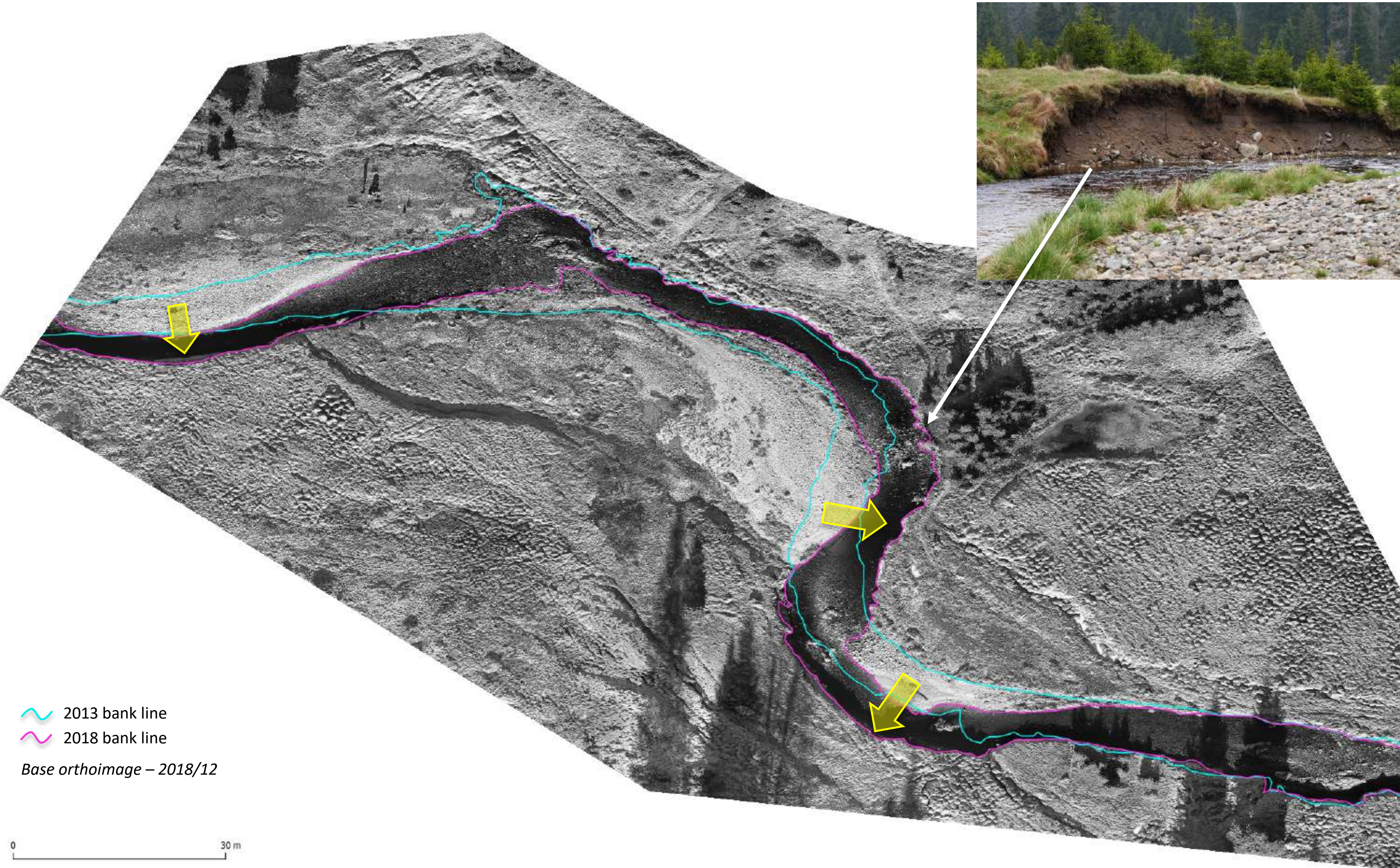
October 2018

Transect B

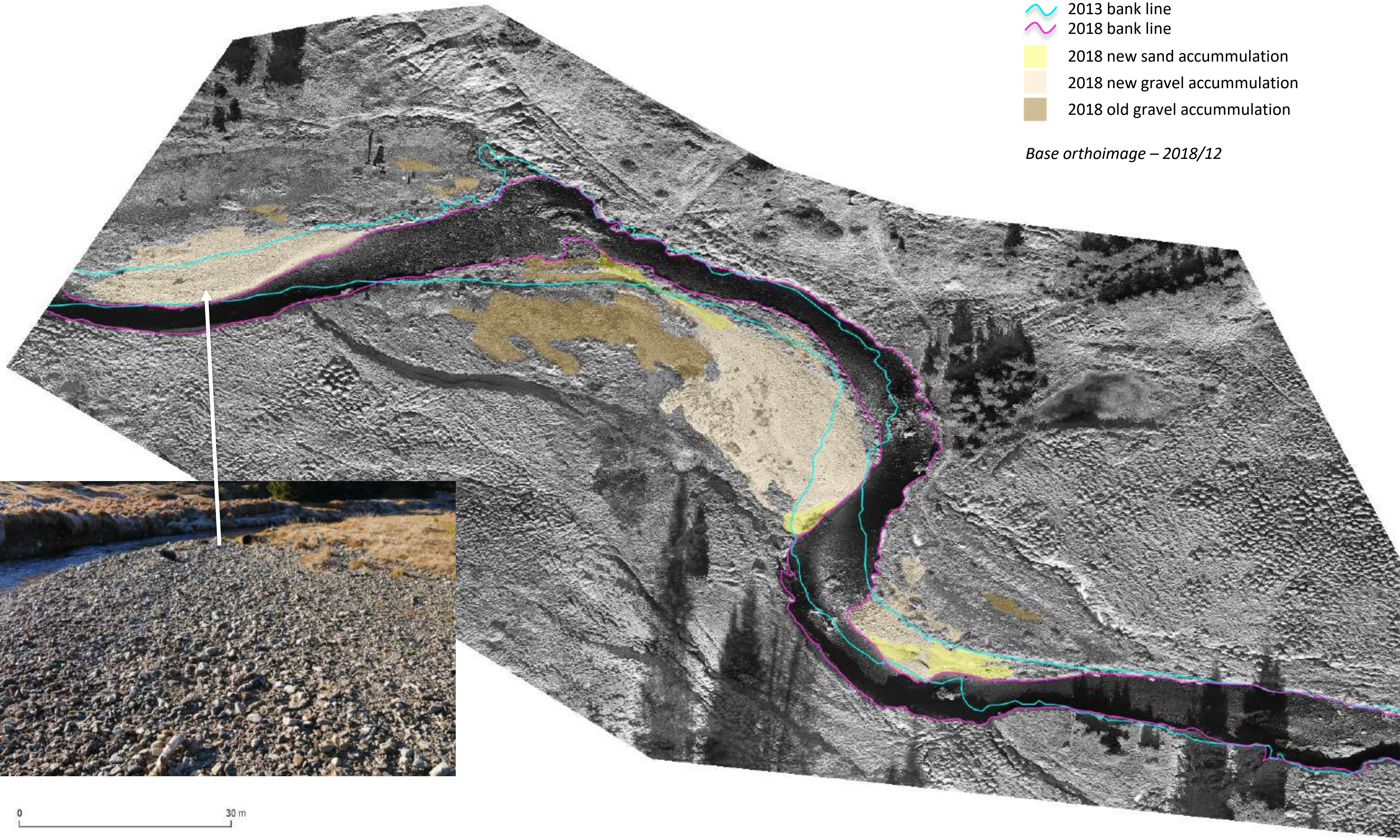


IV. RESULTS

Change of the stream line

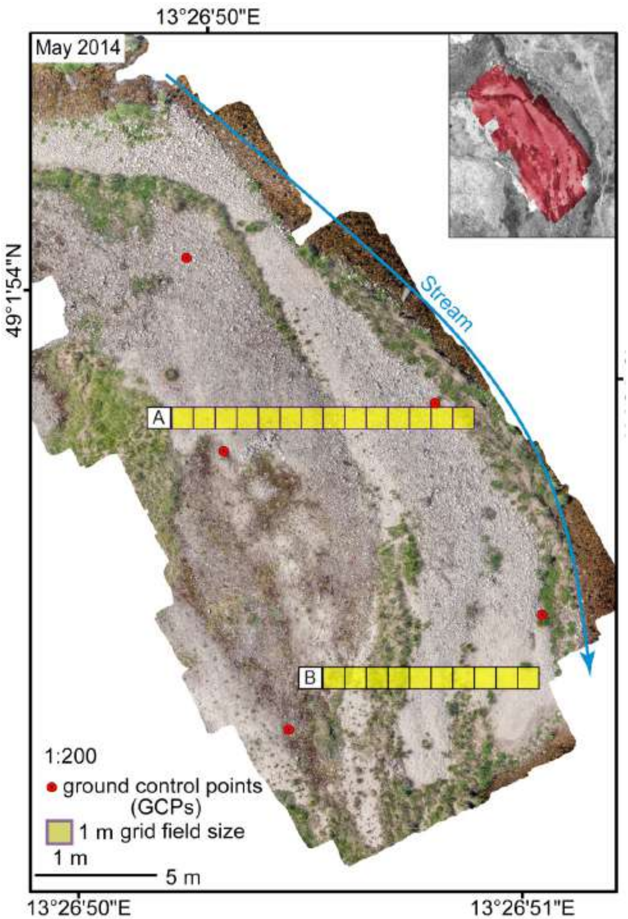


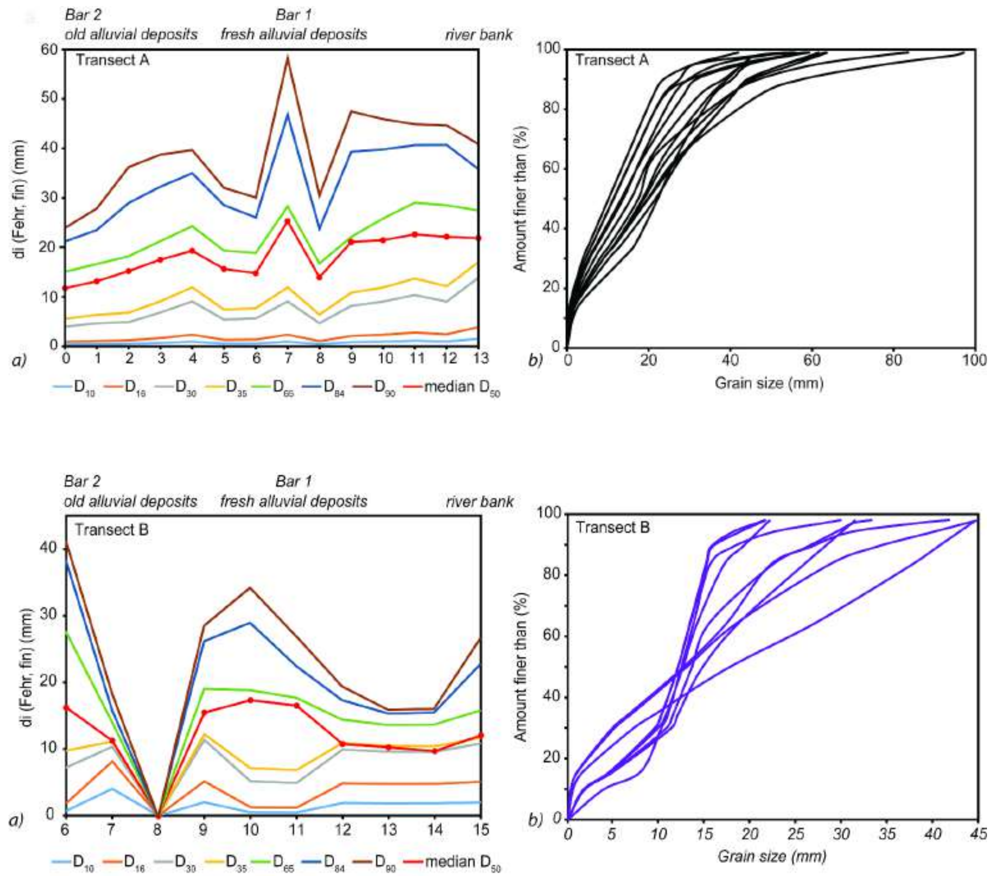
Fluvial accummulations



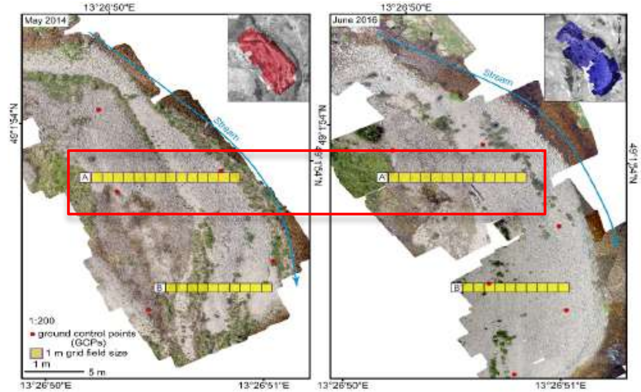
Point bar reconstruction

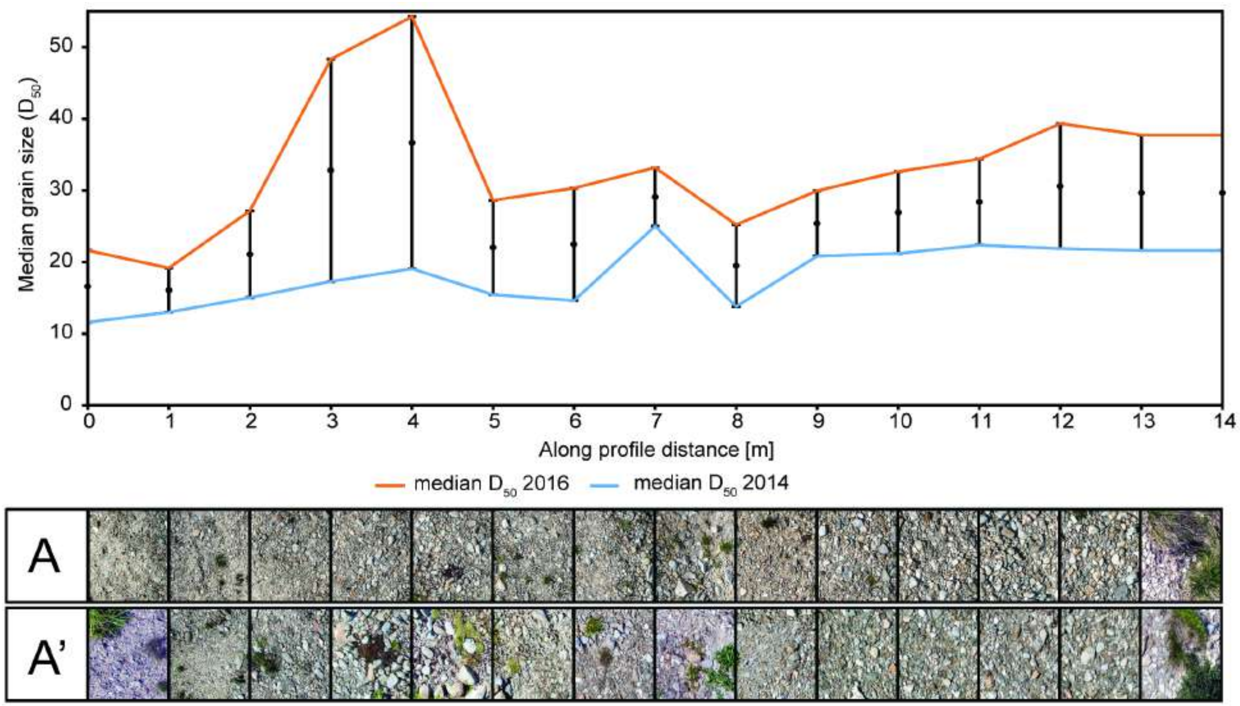
Grain size distribution (Basegrain)

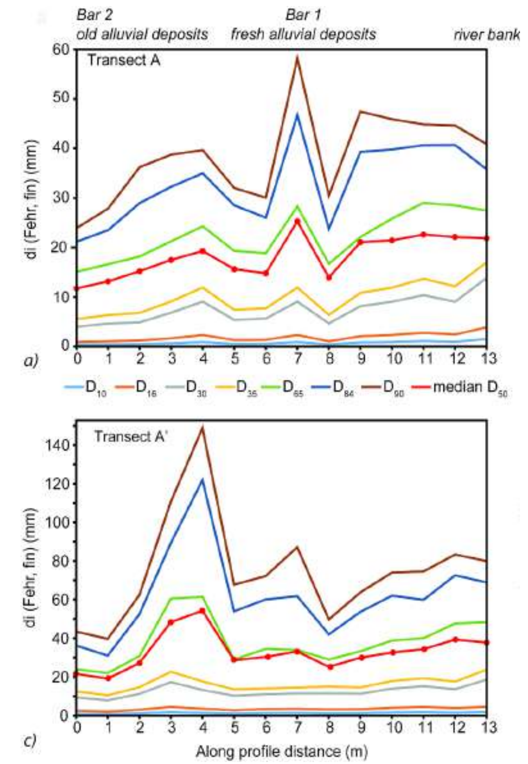




Multitemporal change







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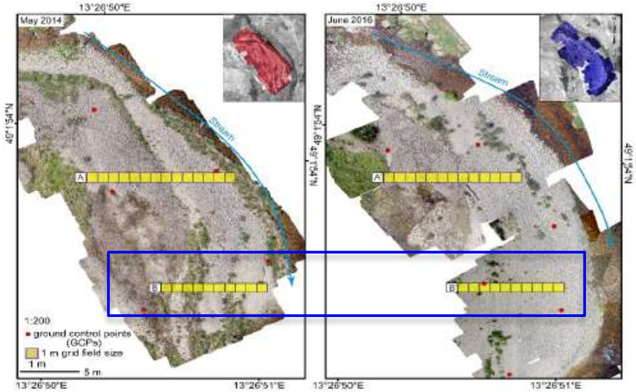
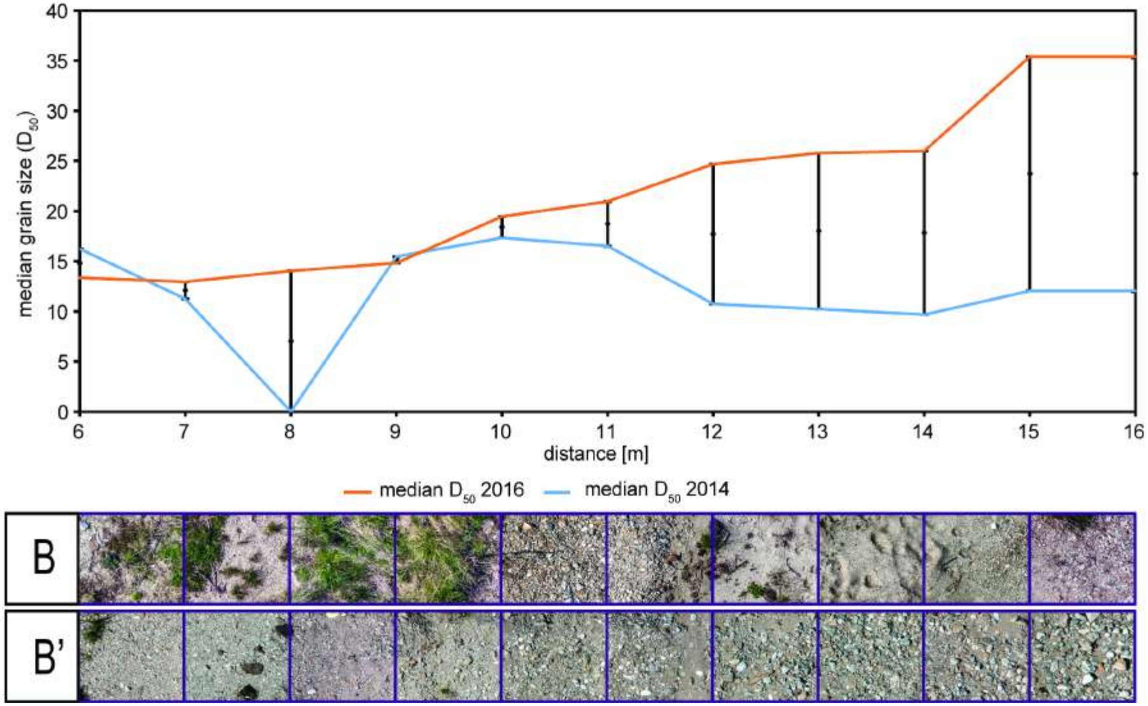
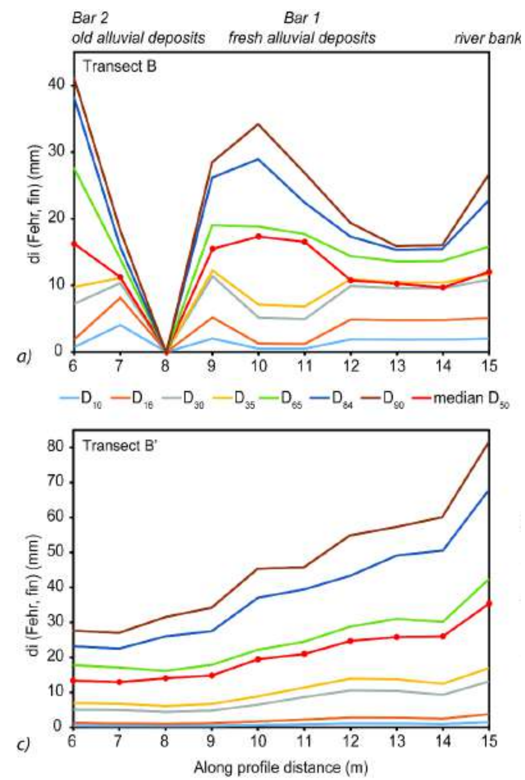


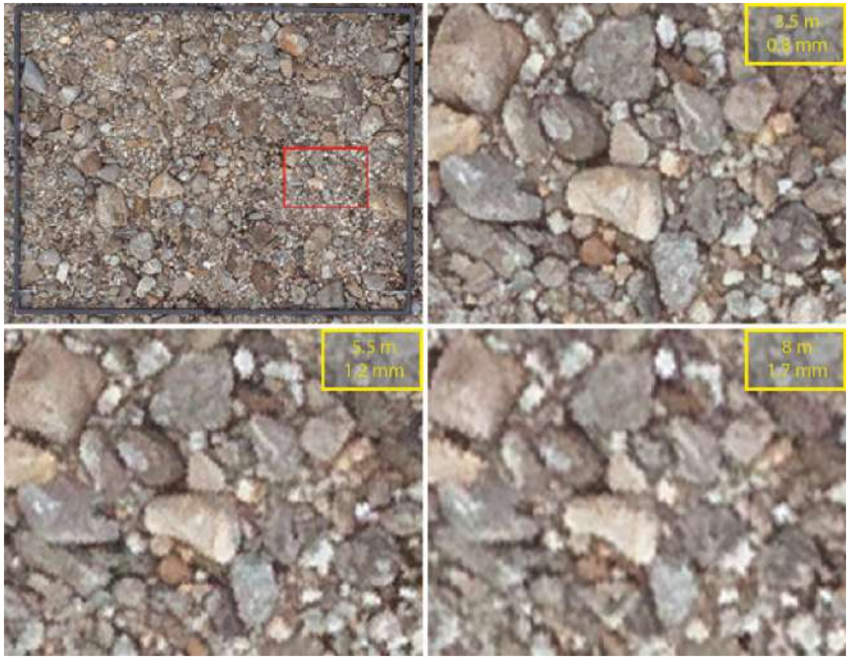




Limitations: imaging parameters

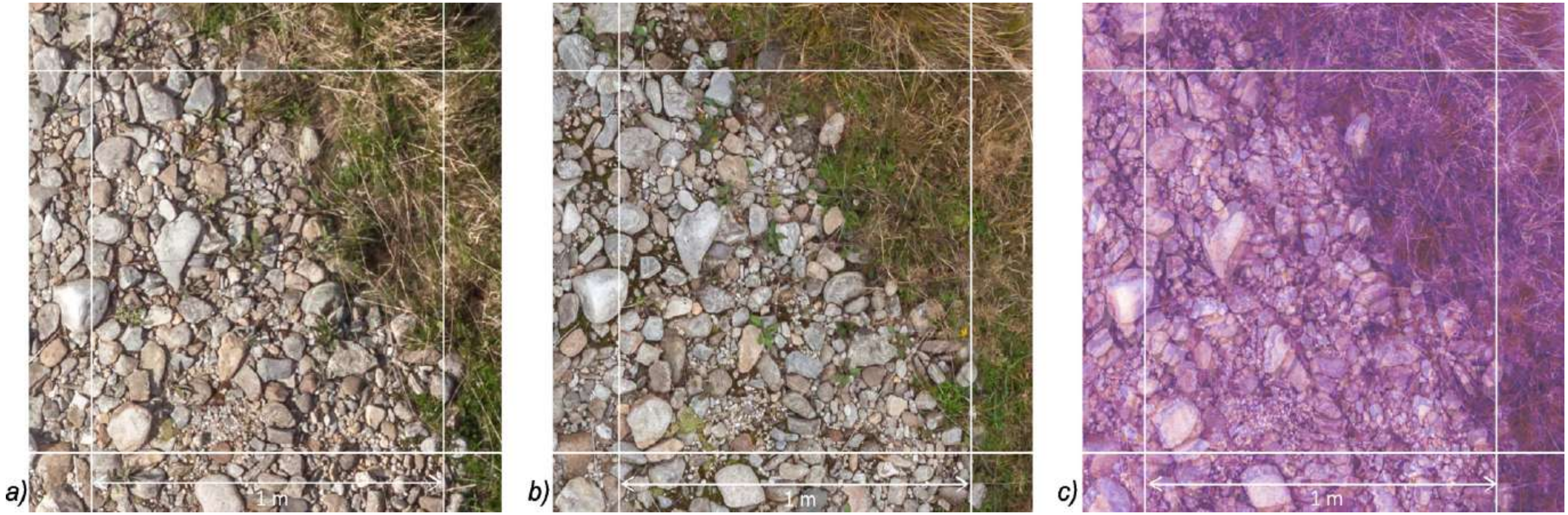
Need to balance the parameters of imaging

Sensor resolution x Flight altitude x Overlaps x Flight speed



Limitations: accuracy of positioning

Substantial for multitemporal analysis
Limitation - accuracy of positioning
GNSS positioning with RTK corrections: centimeter-scale accuracy
Slight shift of scenes in absolute position
unimportant for relative grain size distribution



V. CONCLUSIONS

Conclusions

- **Development of UAV granulometry as new method for seamless granulometric analysis**
- Fusion of ultra high-resolution UAV photogrammetry and optical granulometric analysis for semi-automated classification of grain size distribution
- Application in area with accelerated dynamics of fluvial processes
- Testing for over 4 years proved reliability of the method, when compared to the field and manual optical granulometry

- **<u>Significant benefits</u>**
  - Analytical flexibility across the study sites
  - Ability to perform multitemporal analysis to areas undergoing significant morphological changes.

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Thank you for your attention!

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