european
social fund in the
czech republic

EUROPEAN UNION

MINISTRY OF EDUCATION,
YOUTH AND SPORTS

OP Education
for Competitiveness

INVESTMENTS
IN EDUCATION
DEVELOPMENT

Application of UAS photogrammetry to evaluate changes in fluvial morphology

Jakub Miřijovský[1], **Jakub Langhammer**[2]

[1] Palacký University in Olomouc, Faculty of Science,
Department of Geoinformatics

[2] Charles University in Prague, Faculty of Science,
Dept. Of Physical Geography and Geoecology

Building of Research Team in the Field of Environmental Modeling and the Use of Geoinformation Systems with the Consequence in Participation in International Networks and Programs

Registry number: CZ.1.07/2.3.00/20.0170

StatGis Team

Outline

I. Aims, context and methodology
II. Study area
III. RPAS monitoring
   - UAS photogrammetry
   - UAS granulometry
IV. Results – case study, flood in June, 2013
V. Conclusions

I. AIMS, CONTEXT METHODOLOGY

Research aims and context

Research aim

- Assessment of the dynamics of fluvial processes in montane area under disturbance

Key tasks

- Acquirement of relevant spatial data for analysis of geomorphological changes in montane streams
    - Dynamics of fluvial processes in the basins
    - Spatial distribution and volumes of bank erosion and fluvial accumulations
    - Simulation of potential future changes of riverbed dynamics

Spatial data for small catchments

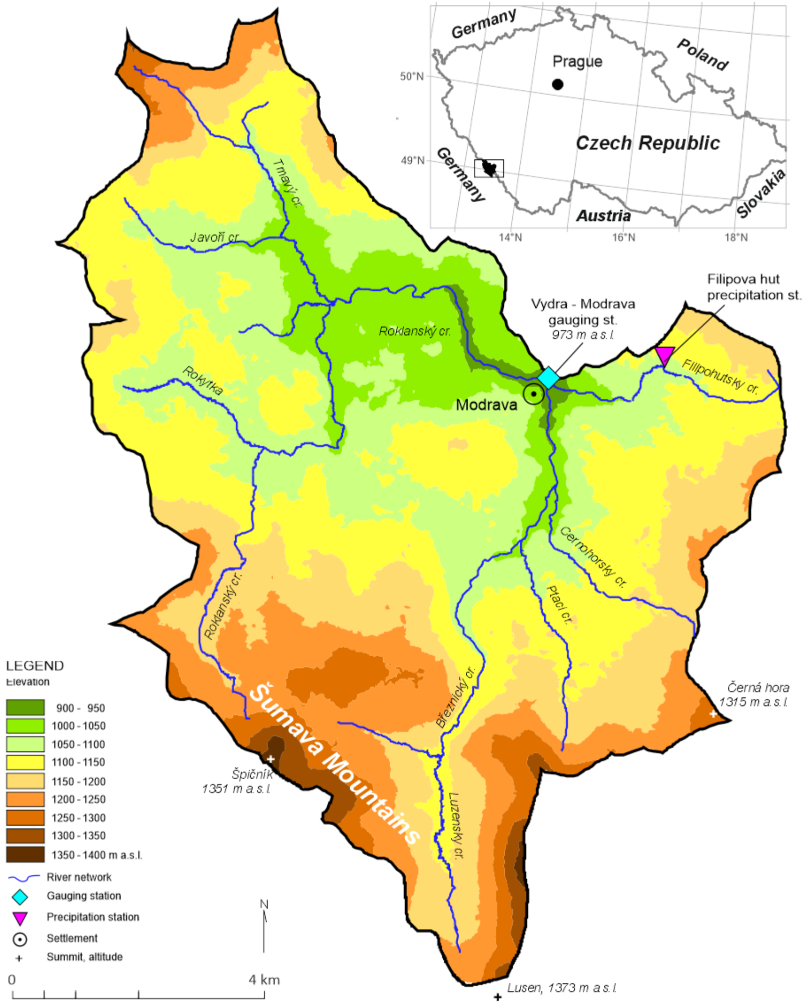
- **Small catchments have specific requirements for spatial data**
  - High spatial resolution and accuracy for detailed analysis
  - High temporal resolution for analyis of multitemporal changes
  - High operability and flexibility of survey
  - Reasonable operation costs
- **... but meet with frequent problems**
  - Lack of relevant data
  - Data of unsatisfactory spatial or temporal resolution or quality

- Potential for application of new technologies in surveying, monitoring and modeling
- Need of multidisciplinary approach

II. STUDY AREA, METHODOLOGY OF DATA ACQUISITION AND TREATMENT

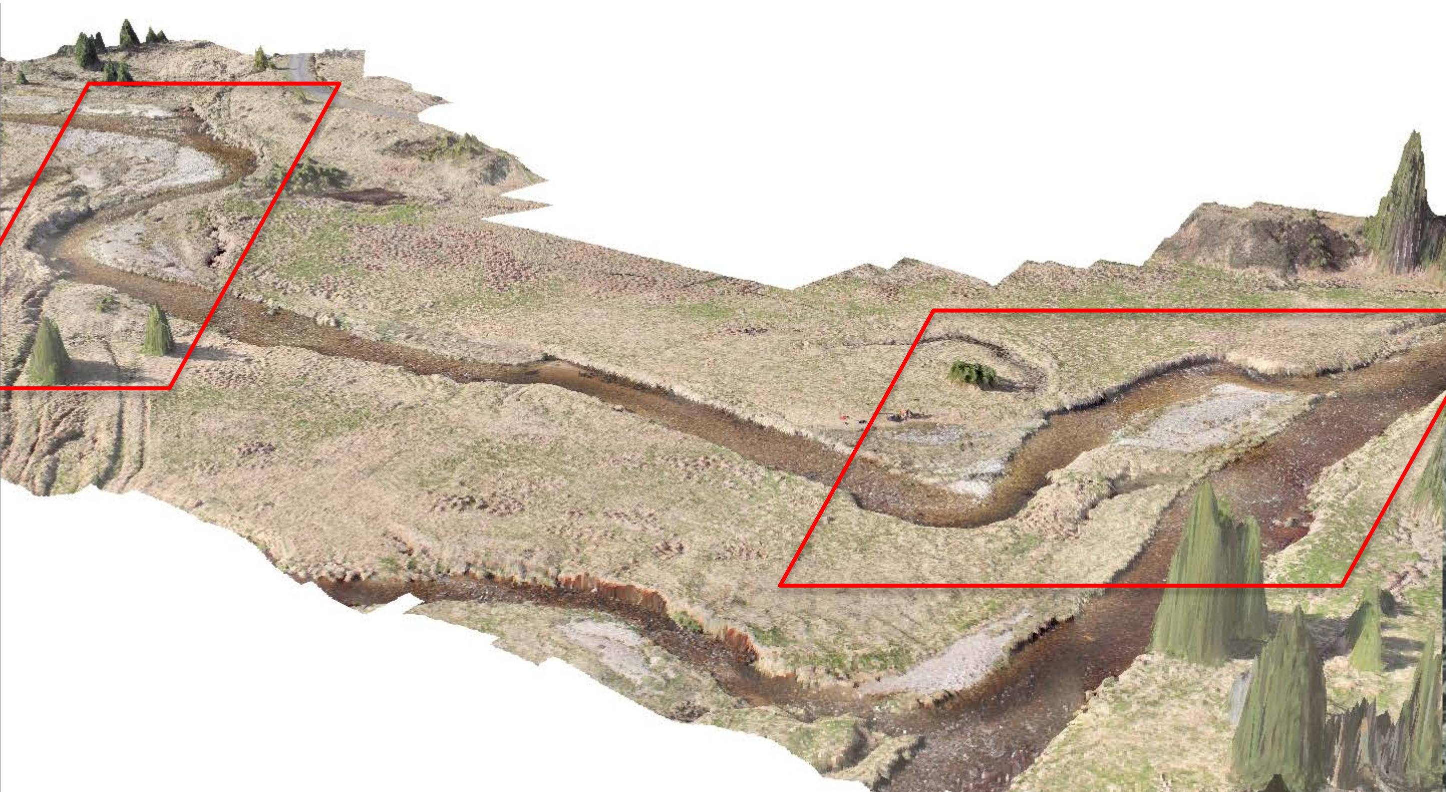
Upper Vydra basin

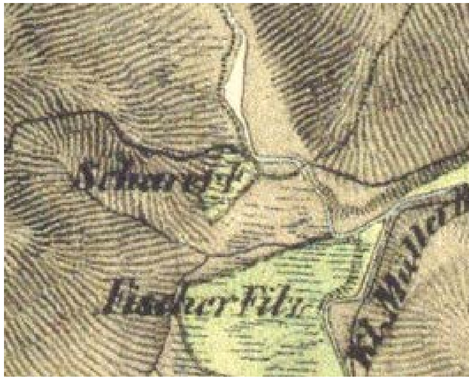
- Upper Vydra basin
  - Sumava mts., Central Europe
  - Avg altitude 1100 m a.s.l., 90 sq km.
  - Effect of climate change
    - Rise of air temperature since 1980‘s
    - Rising frequency of low magnitude flood events
  - Extensive forest disturbance
    - Bark beetle outbreak since 1990‘s
    - Deforestation at 18 % of basin area



Roklanský + Javoří brook

- <u>Study site</u>
  - Experimental catchments
  - Monitoring of rainfall-runoff processes since 2005
  - Historical changes of stream planform
  - Recent dynamics of bank erosion





Context and methodology

I. **Acquisition of spatial information**
   – UAS photogrammetry

II. **Structure of accumulations and floodplain**
   – UAS granulometry
   – Optical granulometry
   – Terrestrial LiDAR

III. **Dynamics of hydrological processes**
   – Automated monitoring of rainfall-runoff processes
   – Hydrodynamic modelling

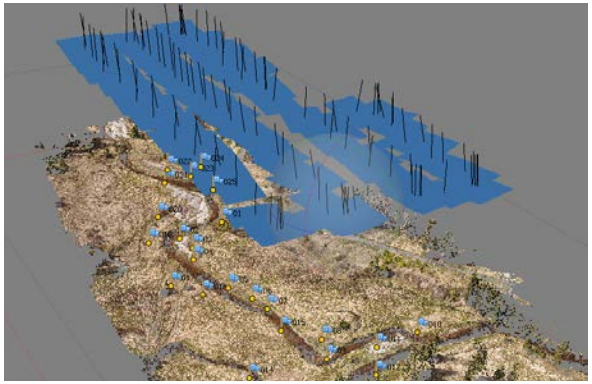
UAS photogrammetry - applied technology

- **Purpose**
  - Data for precise DEM acquisition
  - Monitoring changes in fluvial morphology

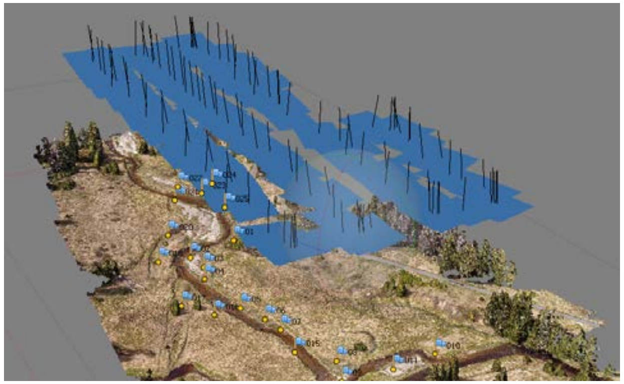
- **Technology**
  - UAS platform Mikrokopter hexacopter
  - Average flight alt. 50-90 m
  - Calibrated camera
  - Geodetic GPS for GCP capture
  - SfM method

UAS photogrammetry
- image processing

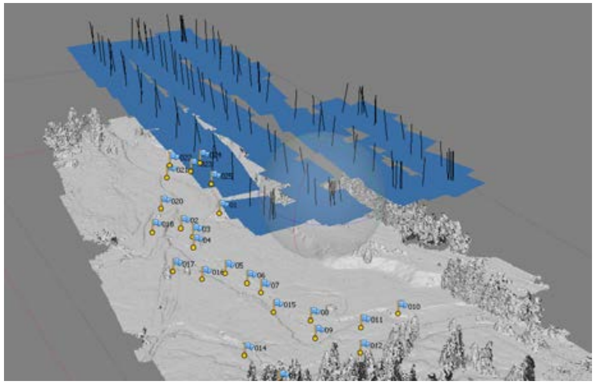
- Image processing by Structure from Motion (SfM) methods
- Special case of the stereophotogrammetry (multiple views of the object)
- Agisoft Photoscan professional software



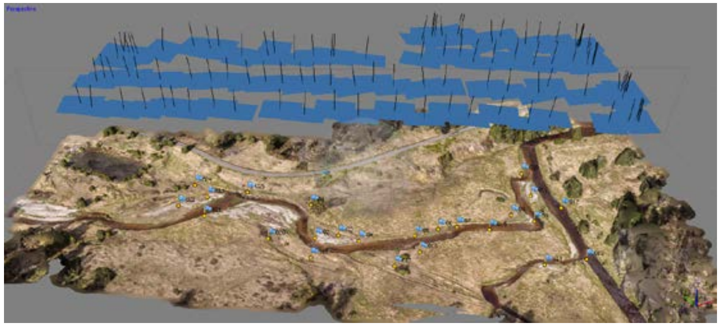
1. Photos aligning



2. Dense point cloud



3. Classification of the point cloud

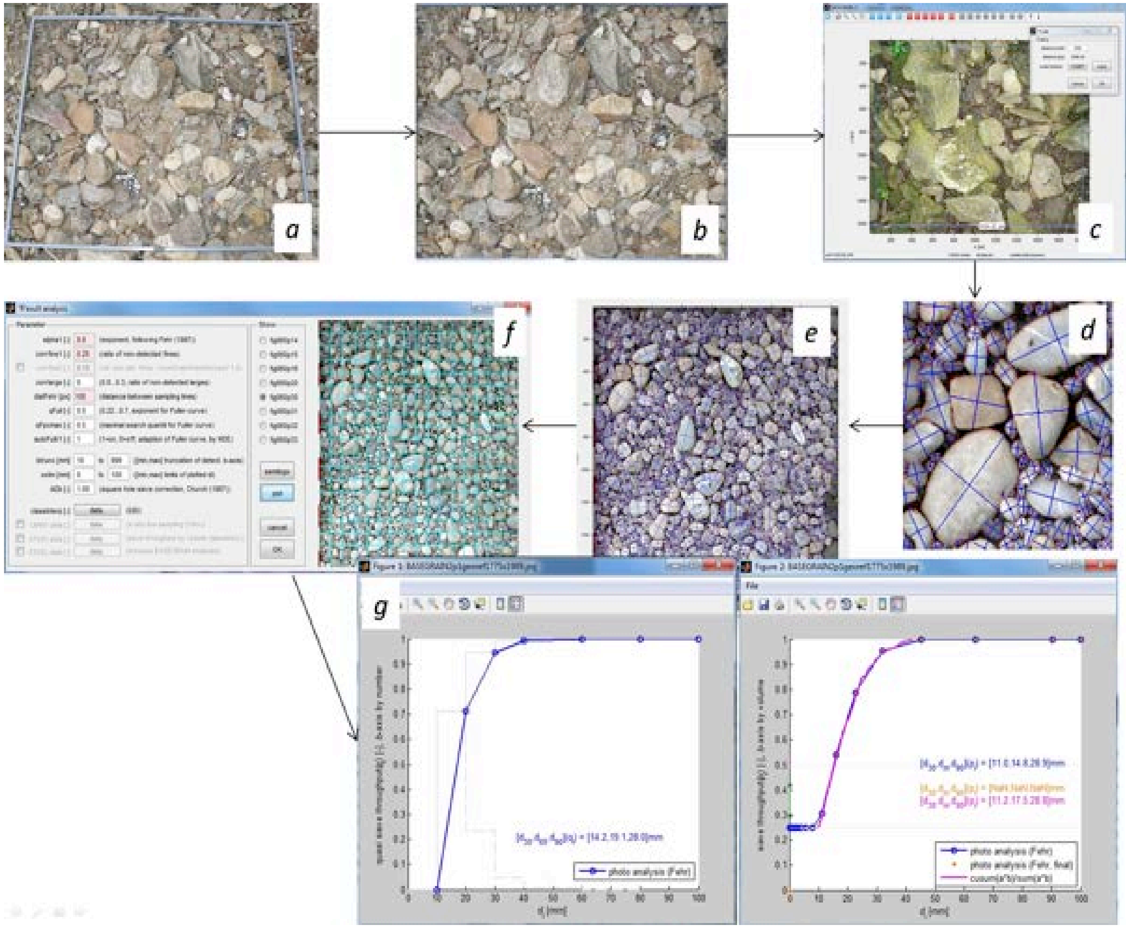


4. DSM creation – 2 900 000 vertices

5. Orthophoto

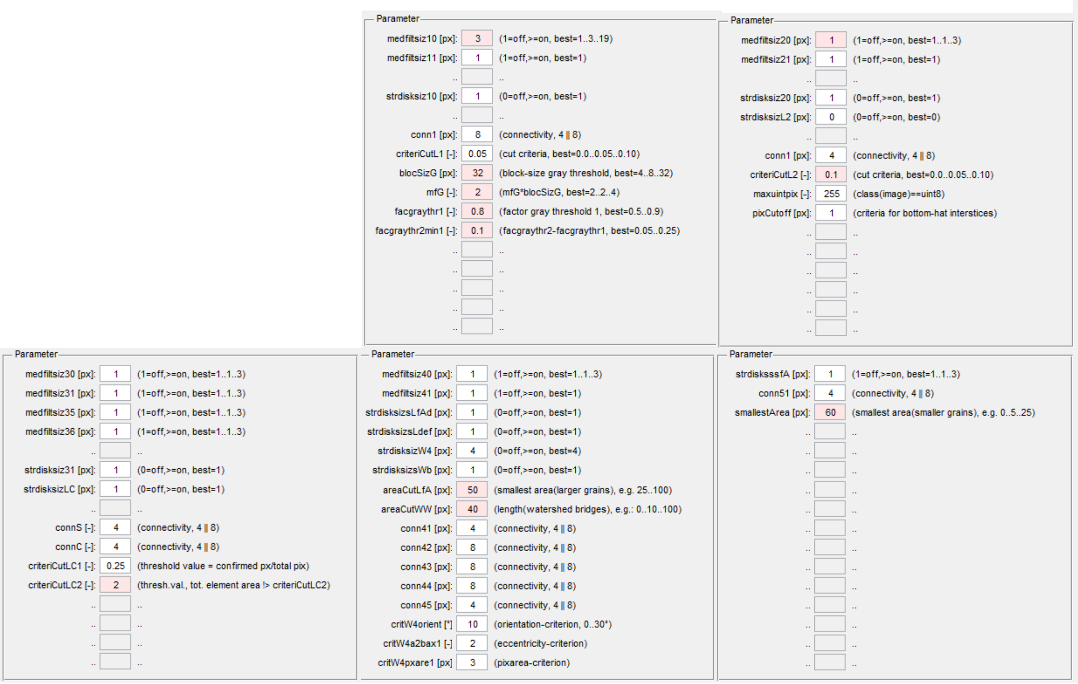
Optical granulometry - principle

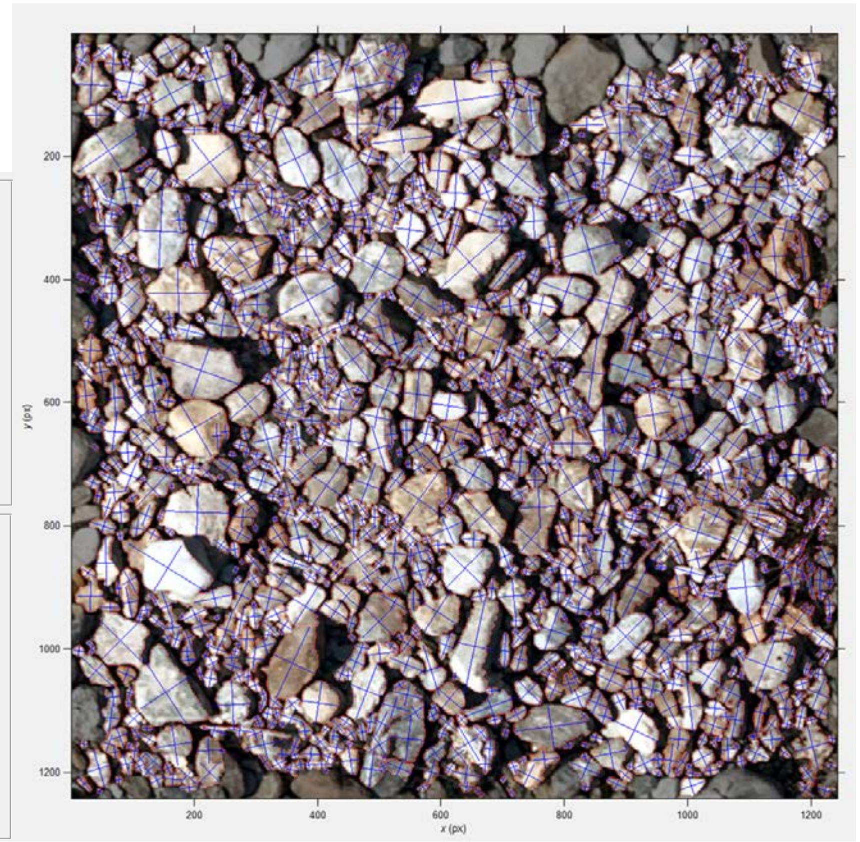
- Image analysis technique
- Automated identification of objects
  - Coarse-grained sediments
- Calibration
- Automatic calculation of grain size curves
- MatLab tool BaseGrain
- Data acquisition
  - UAS
  - Field survey



Optical granulometry
- identification of objects

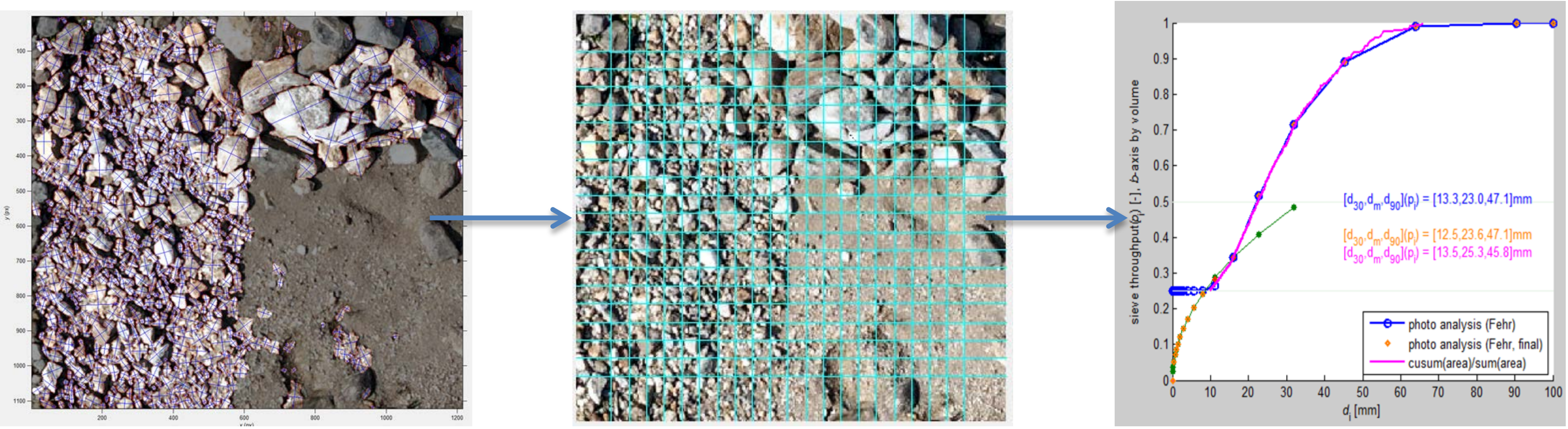
- Setting up the parameters of classification
  - image analysis thresholds
  - connectivity
  - object distance
  - object area





Optical granulometry
- analysis of results

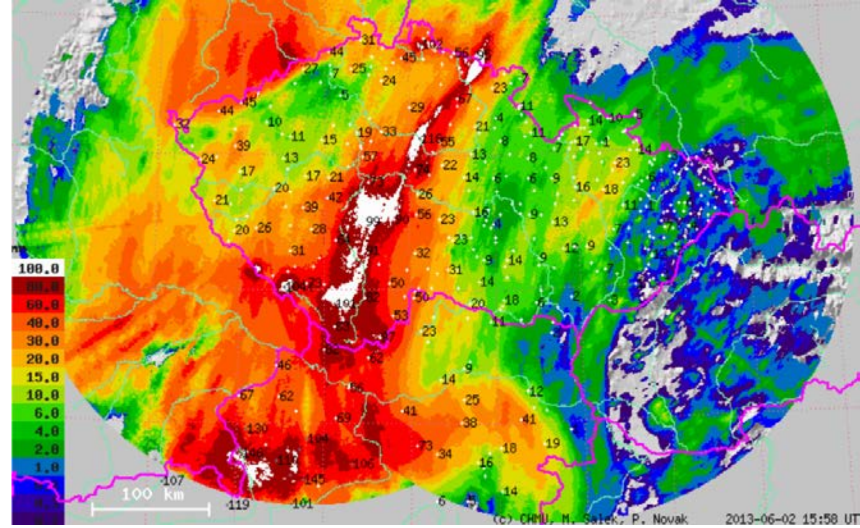
- Automatic granullometric curve calculation
- Methodology - Fehr 1987
  - image analysis
  - photo analysis
  - line sampling
  - grading curve



III. RESULTS

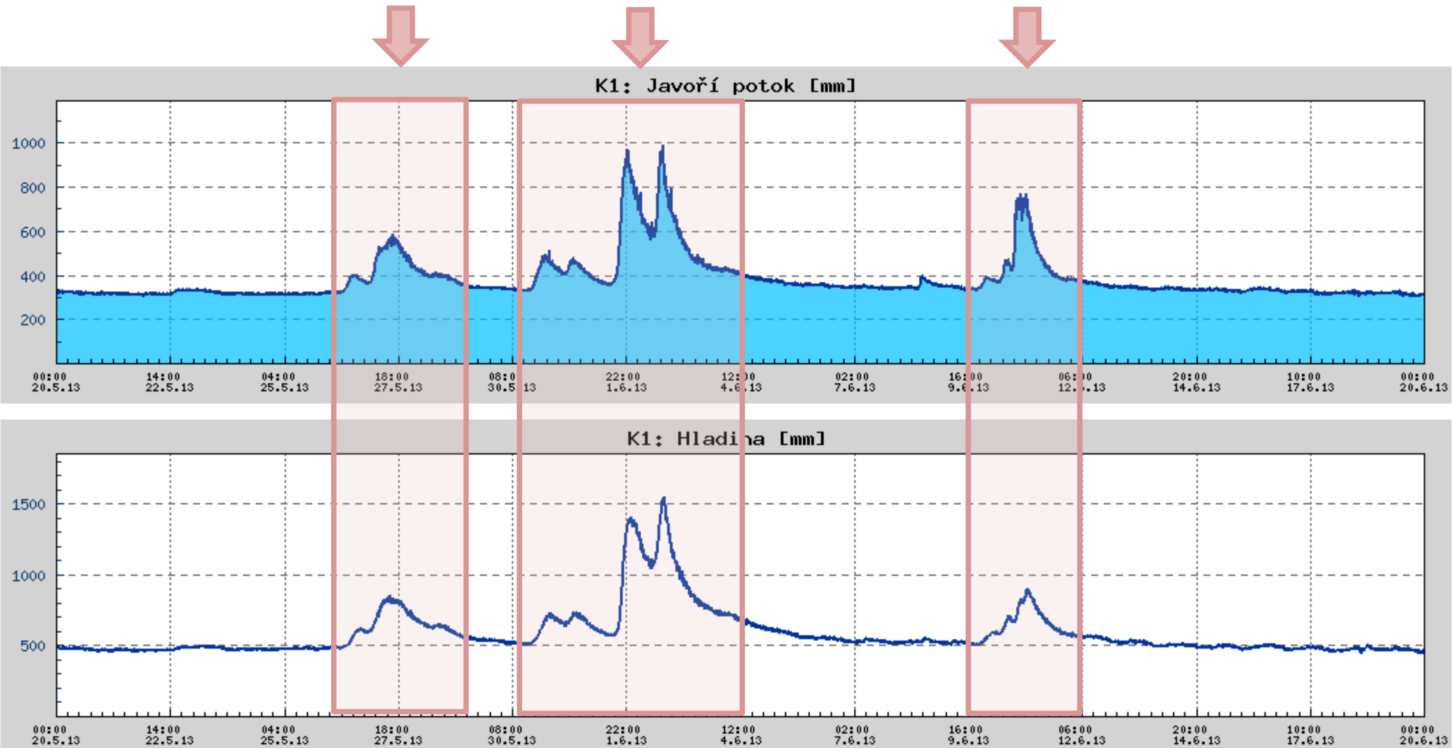
Case study
Flood 2013-06

- **Roklanský/Javoří cr.**



1 flood

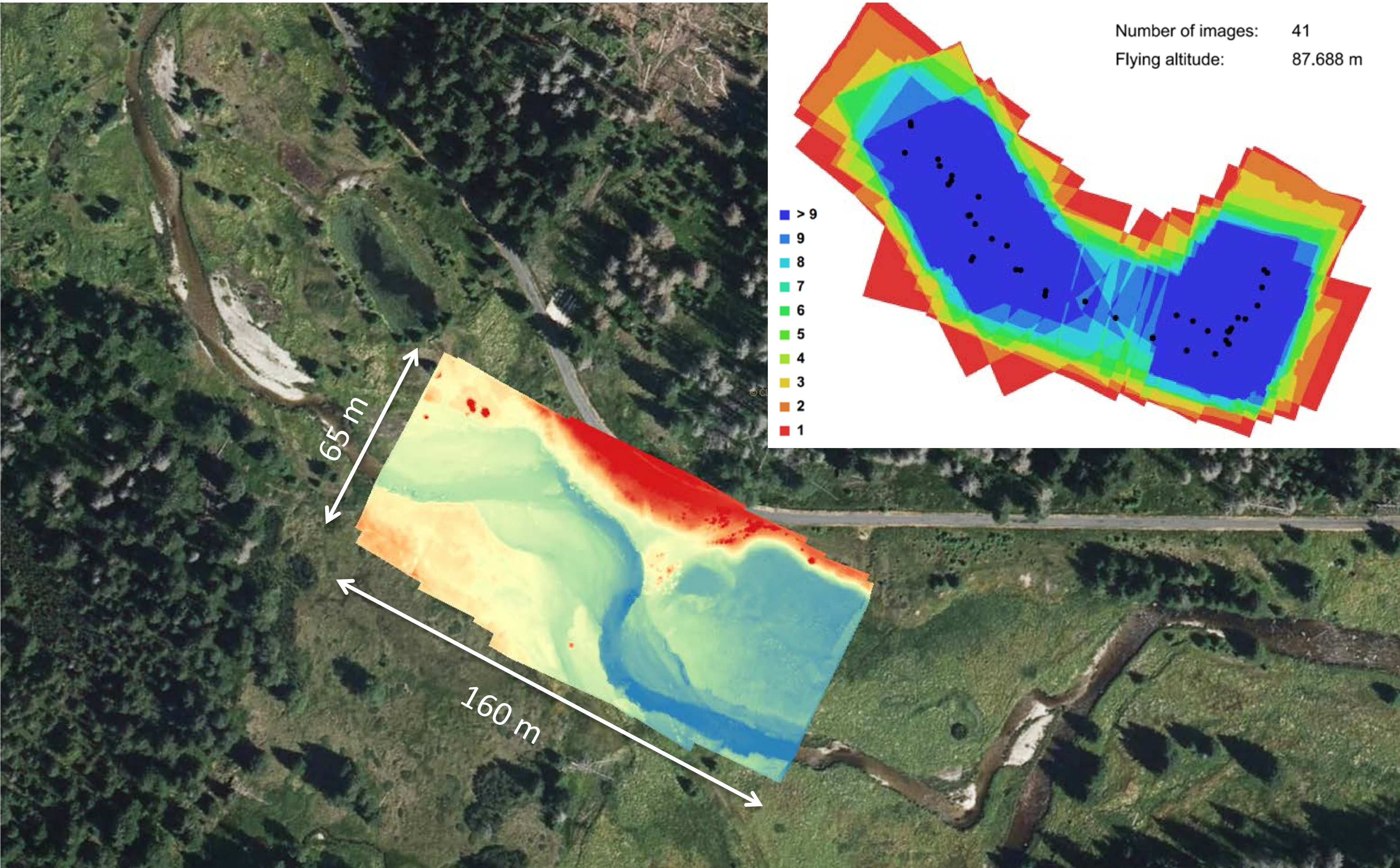
3 events **26-27.5.** **<u>30.5-2.6.</u>** **11.6.**



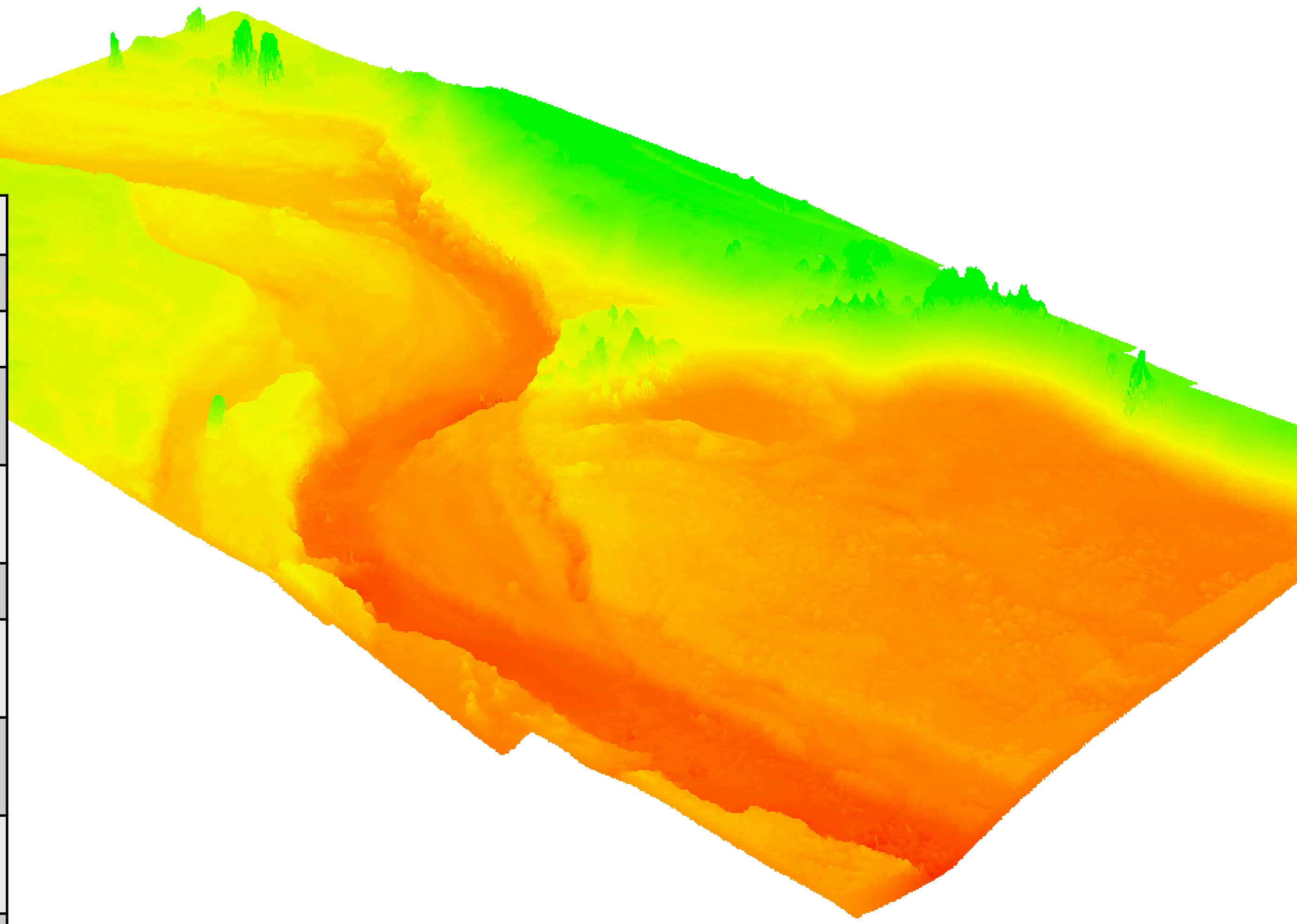
Source data

- **Sensor network**
  2 monitoring profiles
- **UAV scans**
  - 9.5.2013
  - 27.9.2013
- **Optical granulometry**

UAS – Deriving the DEM

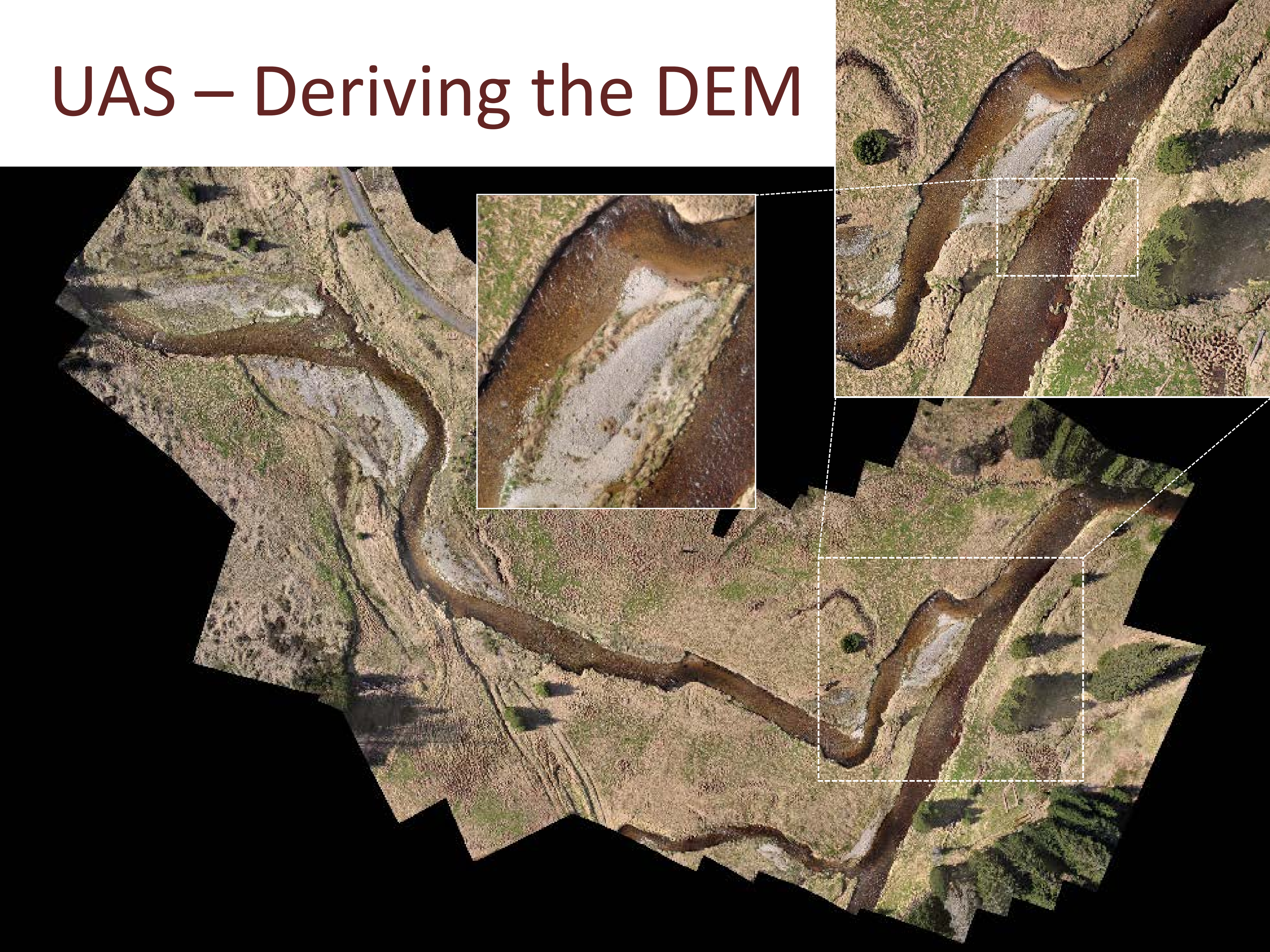


UAS – Deriving the DEM

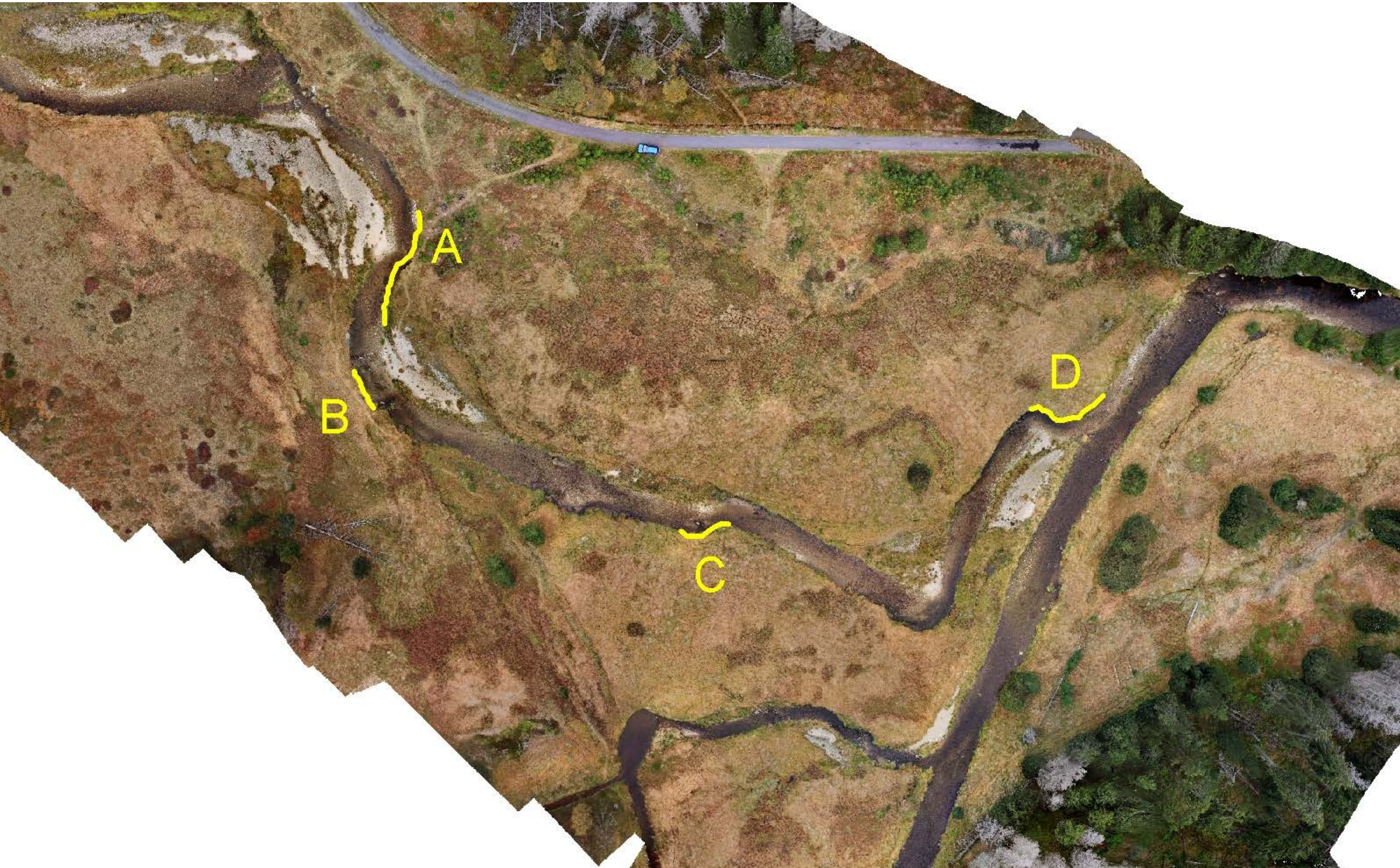


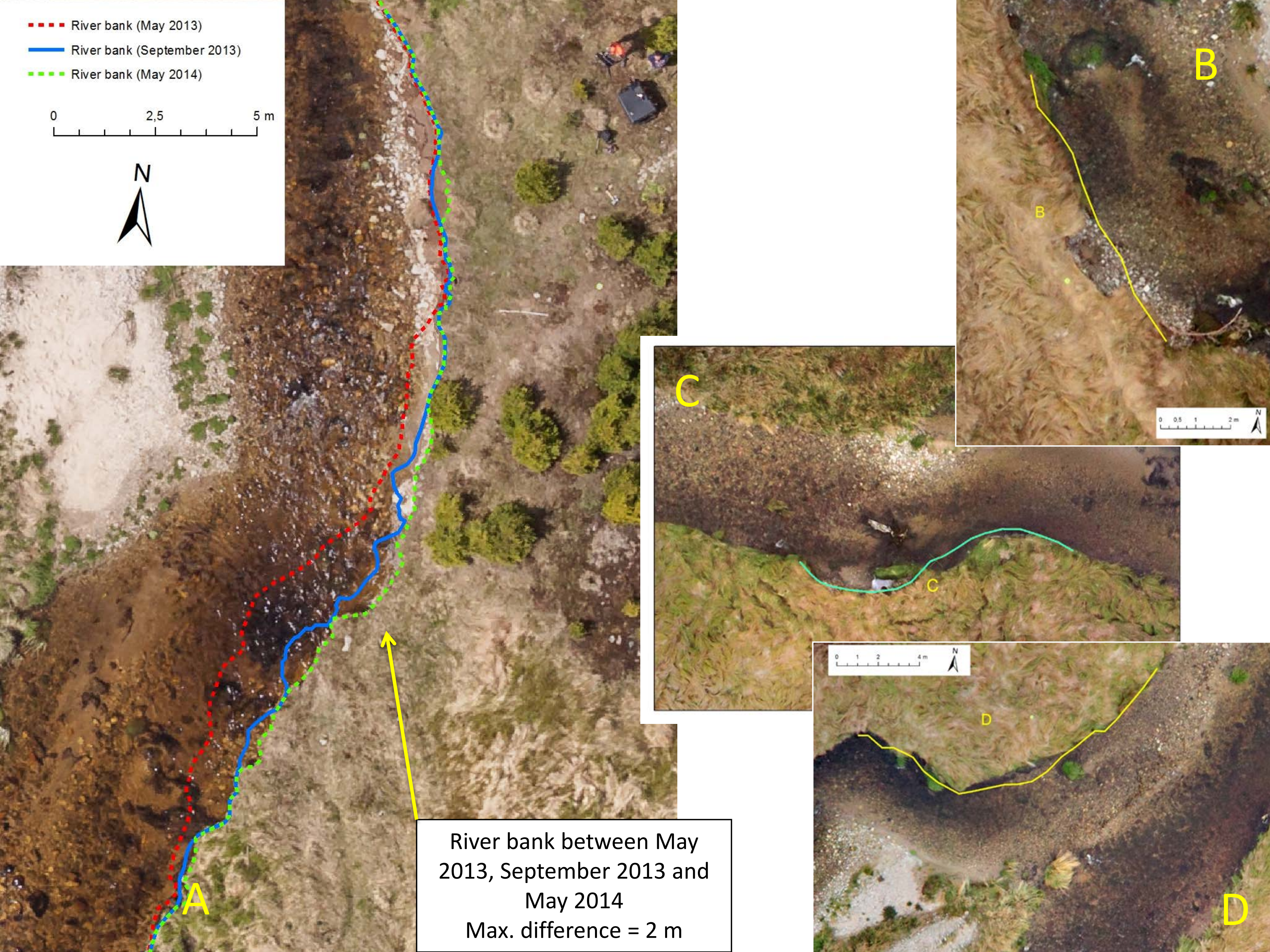
Parameter	Javori br.
Number of images	41
Flying altitude (m)	**88**
Ground sample distance (cm)	**2**
Number of Ground control points	34
Number of Tie points	215803
Error of the image coordinates (pix)	0,67
Point density (points/m²)	201
The average error in Z (m)	0,001
$RMSE_Z$ (m)	0,021

UAS – Deriving the DEM



UAS – change detection
- lateral erosion after flood 2013



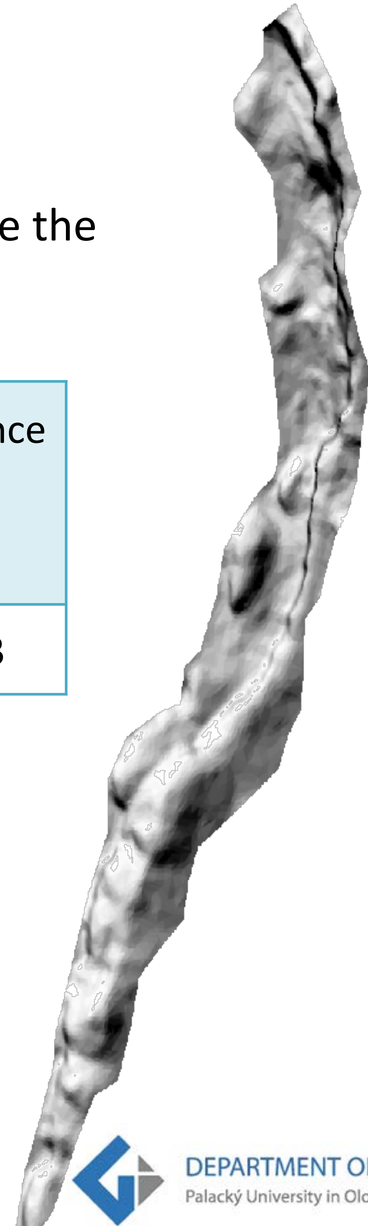

River bank (May 2013)
River bank (September 2013)
River bank (May 2014)
0
2,5
5 m
N
A
B
C
D
River bank between May 2013, September 2013 and May 2014
Max. difference = 2 m

Most active zone of erosion

Volumetric change

The volume of material above the reference plane

May 2013 (m^3)	September 2013 (m^3)	Difference (m^3)
8.984	5.841	3.143

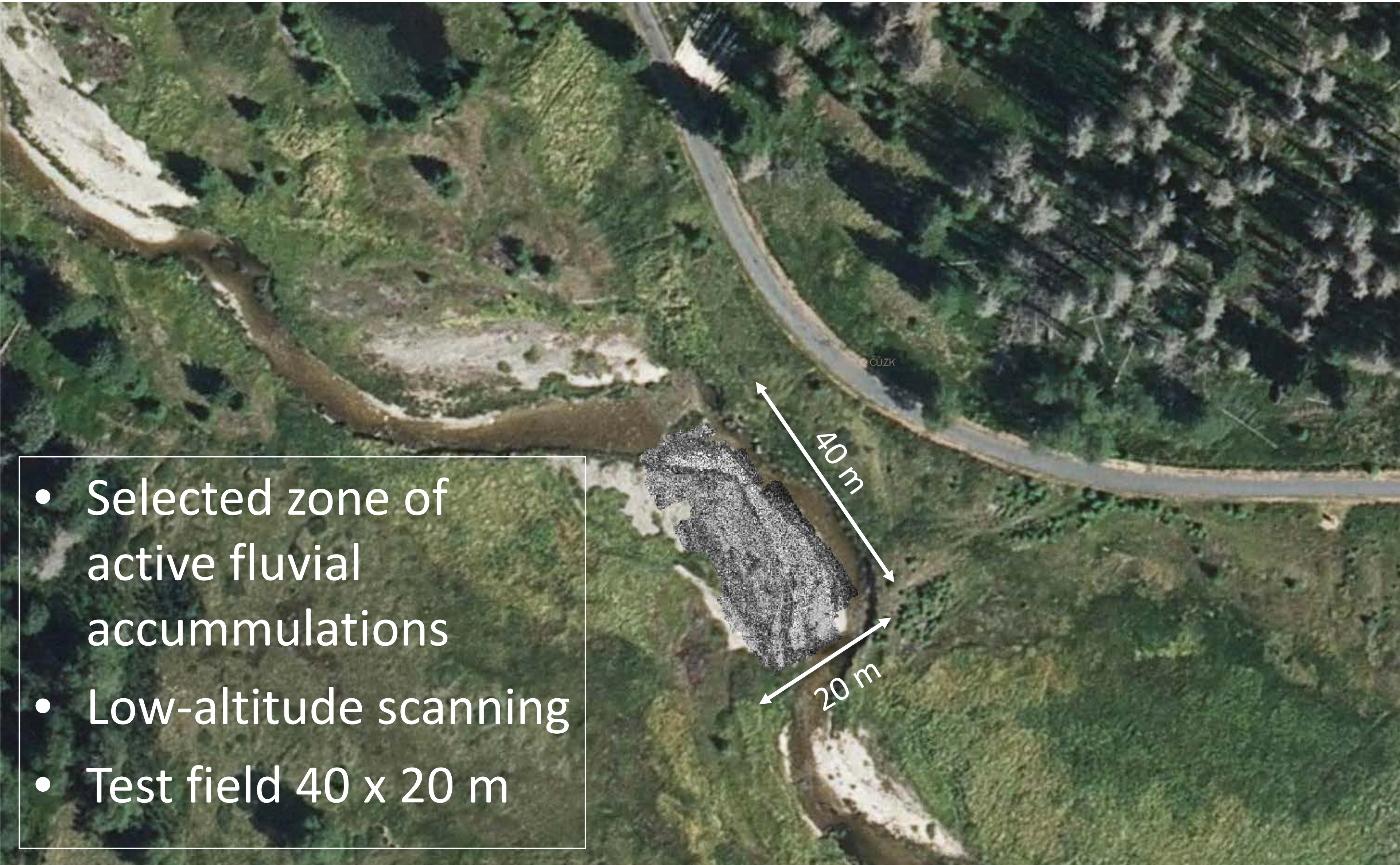


May 2013

September 2013

DEPARTMENT OF GEOINFORMATICS
Palacký University in Olomouc | Faculty of Science

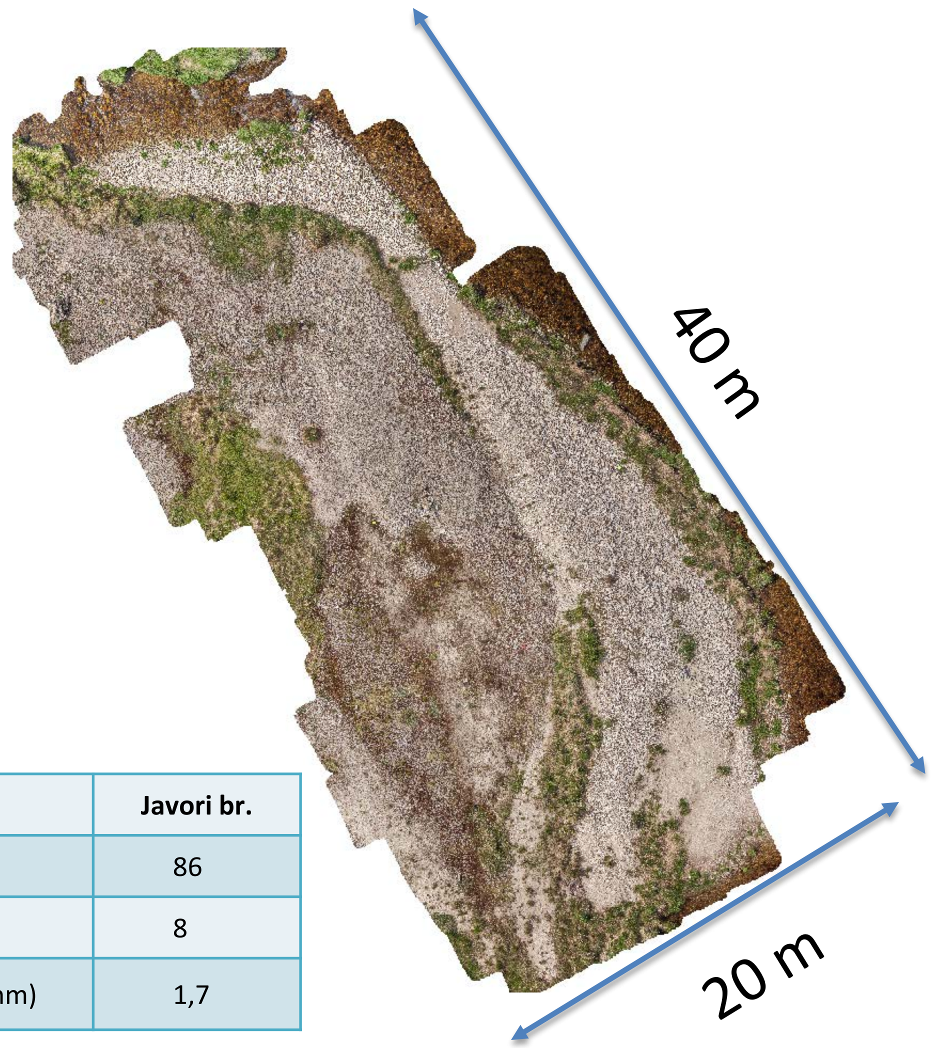
UAV based optical granulometry



- Selected zone of active fluvial accummulations
- Low-altitude scanning
- Test field 40 x 20 m

UAV based optical granulometry

- Calibrated digital image
- Automated gravelometry classification
  - Coarse-grained sediments
  - Calculation of grain size curves
  - Sedimetrics
  - BaseGrain2



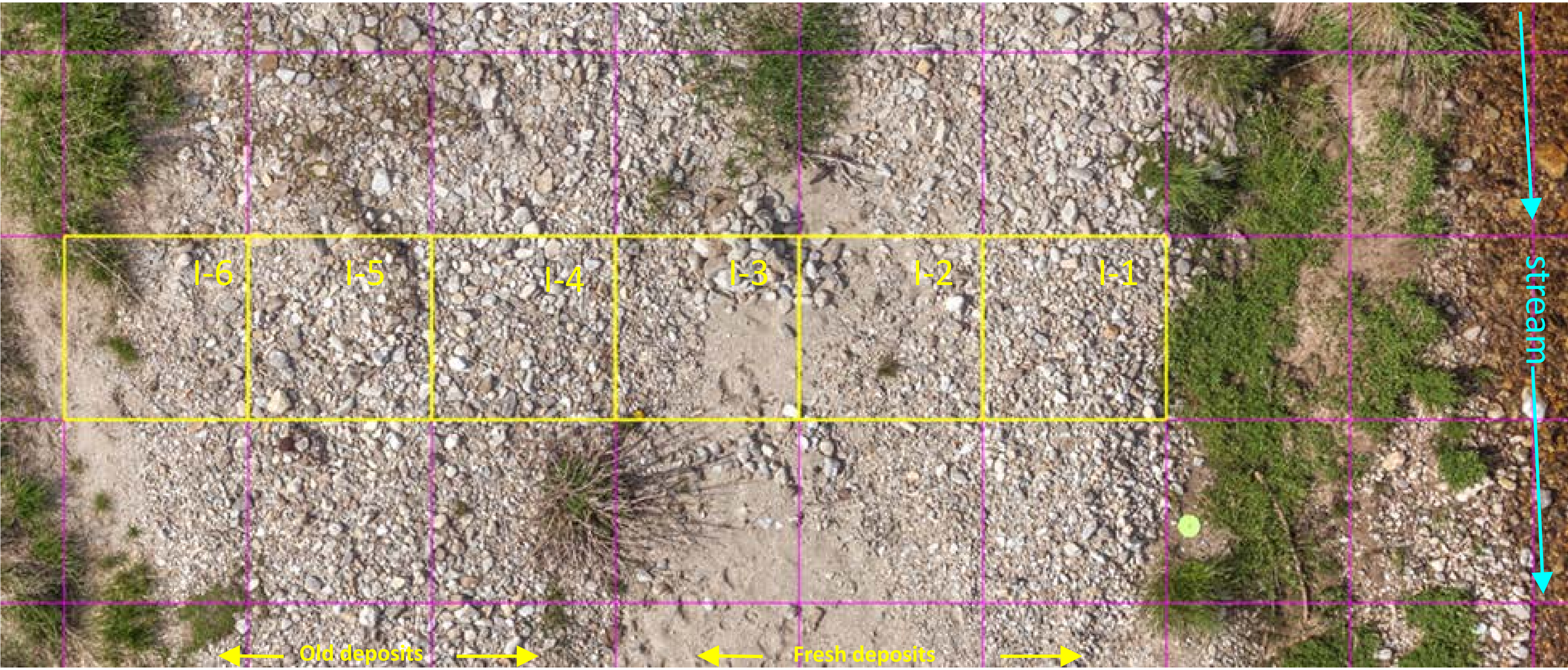
Parameter	Javori br.
Number of images	86
Flying altitude (m)	8
Ground sample distance (mm)	1,7

Test fields

- Test fields
  - 1x1 m
  - 48 fields

- Transects
  - 8 transects A-I
  - fresh x old accumulations
  - expected differentiated gradation

Example - transect I

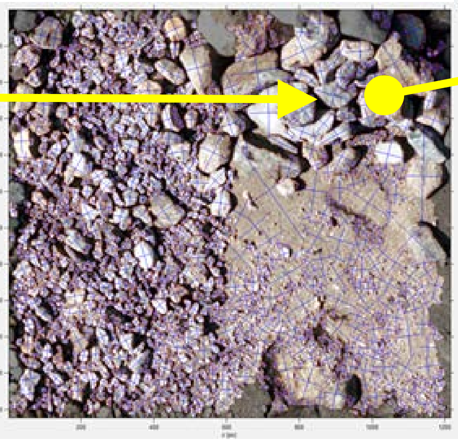


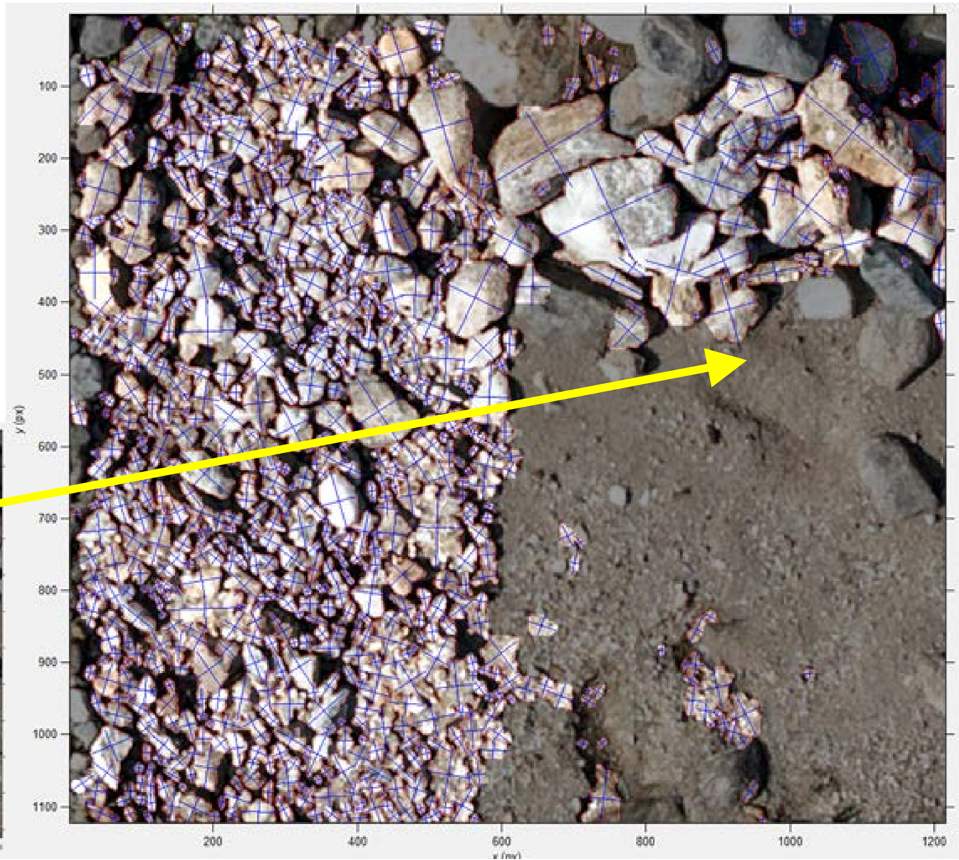
Data calibration and corrections

- Calibration of parameters
  - recognition of objects
  - appropriate object size

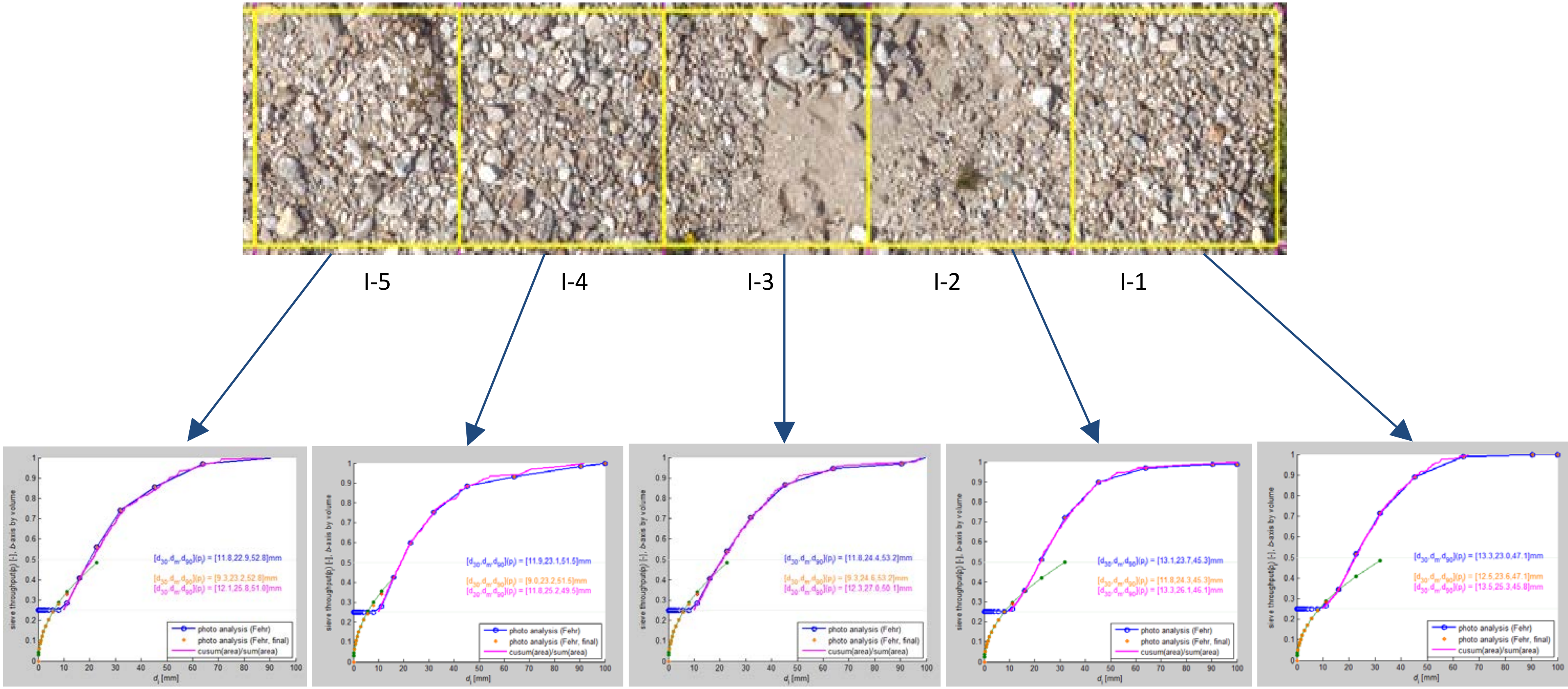
- Corrections of classification
  - removing redundant objects (sand, vegetation)
  - merging and splitting of objects
  - deleting of redundant objects

I-3





Grading curves



Conclusions

Contribution of UAS in fluvial morpohology

- **Acquisition of spatially precise data**
  - Highly accurate DEM for river channel model,
  - Monitoring of changes in riverbed and floodplain,
  - Analysis of volumetric changes in floodplain,
  - Relevant resolution for detailed analyses in fluvial morphology, far beyond the traditional data sources.
- **Operability**
  - Quick acquisition of necessary data for assessment and for model building,
  - Operation according the needs of research plan,
  - Acquisition of data in remote and uncovered areas.

esf
european
social fund in the
czech republic

EUROPEAN UNION

MŠMT
MINISTRY OF EDUCATION,
YOUTH AND SPORTS

OP Education
for Competitiveness

INVESTMENTS
IN EDUCATION
DEVELOPMENT

Jakub Miřijovský, Jakub Langhammer

BUILDING OF RESEARCH TEAM IN THE FIELD OF ENVIRONMENTAL MODELING AND THE USE OF GEOINFORMATION SYSTEMS WITH THE CONSEQUENCE IN PARTICIPATION IN INTERNATIONAL NETWORKS AND PROGRAMS

RESEARCH IS SUPPORTED BY CZECH SCIENCE FOUNDATION PROJECT P209/12/0997 **THE IMPACT OF DISTURBANCE ON THE DYNAMICS OF FLUVIAL PROCESSES IN MOUNTAIN LANDSCAPES**

GAČR
CZECH SCIENCE FOUNDATION