Joint Workshop
IEA Hydropower TCP– European Commission DG RTD, Brussels

Unmanned Aerial Systems (UAS) – New opportunities for measuring, mapping and modelling rivers and lakes

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Outline

- Introduction
- Sensors
  - RGB
  - NIR
  - Thermal
- Applications
- Conclusion

Why UAS?

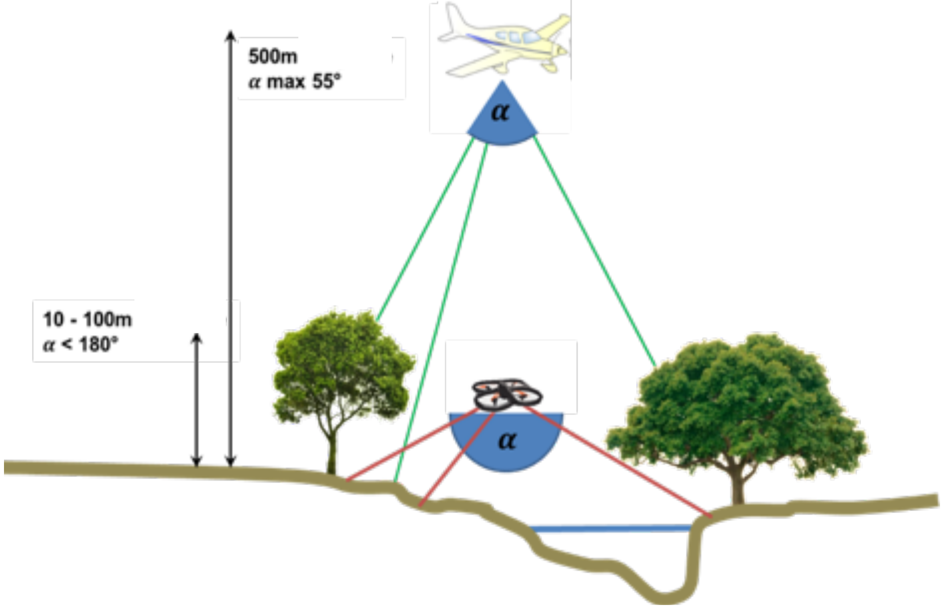
Current Monitoring strategies:

- No monitoring
- Modelling
- Single Point/ Data

Requirements of Monitoring:

<u>Monitoring strategies/ tools need to picture natural processes in time and scale!</u>

New/ additional Monitoring tools and strategies required:



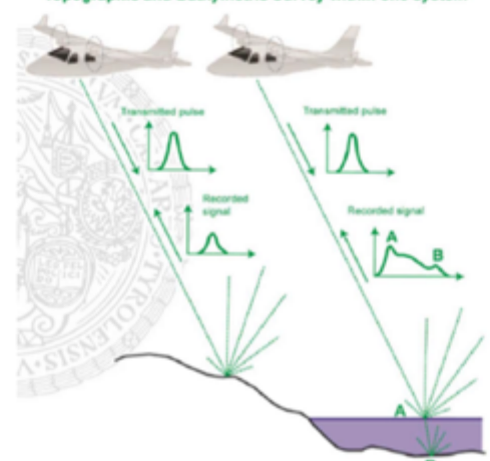
Low altitudes/ fast repeatability
→ High resolution (spatial and temporal)
→ Better learning/ understanding?

Sensors

- Cameras
  - Post Processing
    - RGB
    - NIR
    - Thermal

  - Real Time Data
    - SLAM - Simultaneous Localization and Mapping

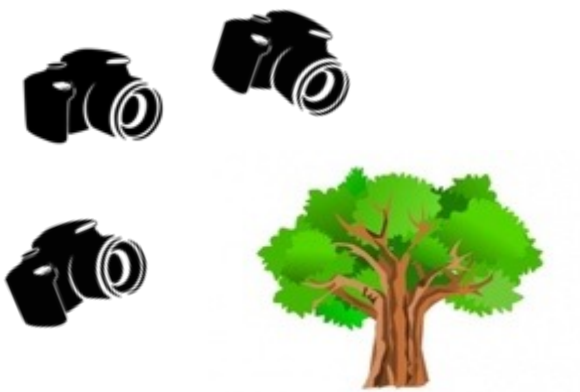
- LIDAR (Light Detection and Ranging)
    - IR LIDAR
    - Green LIDAR



(Jocham et al., University of Innsbruck)

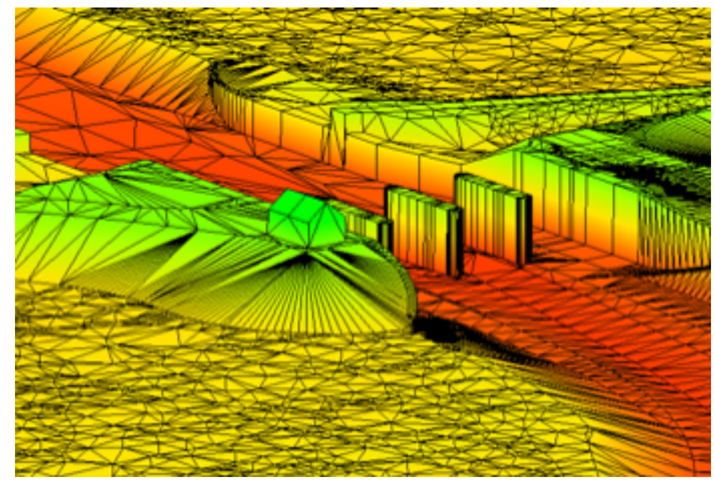
RGB imagery

2D Data



Photogrametric Analysis

3D Data



„Kinetic Depth Effect“ (Wallach u. O‘Connel 1953)

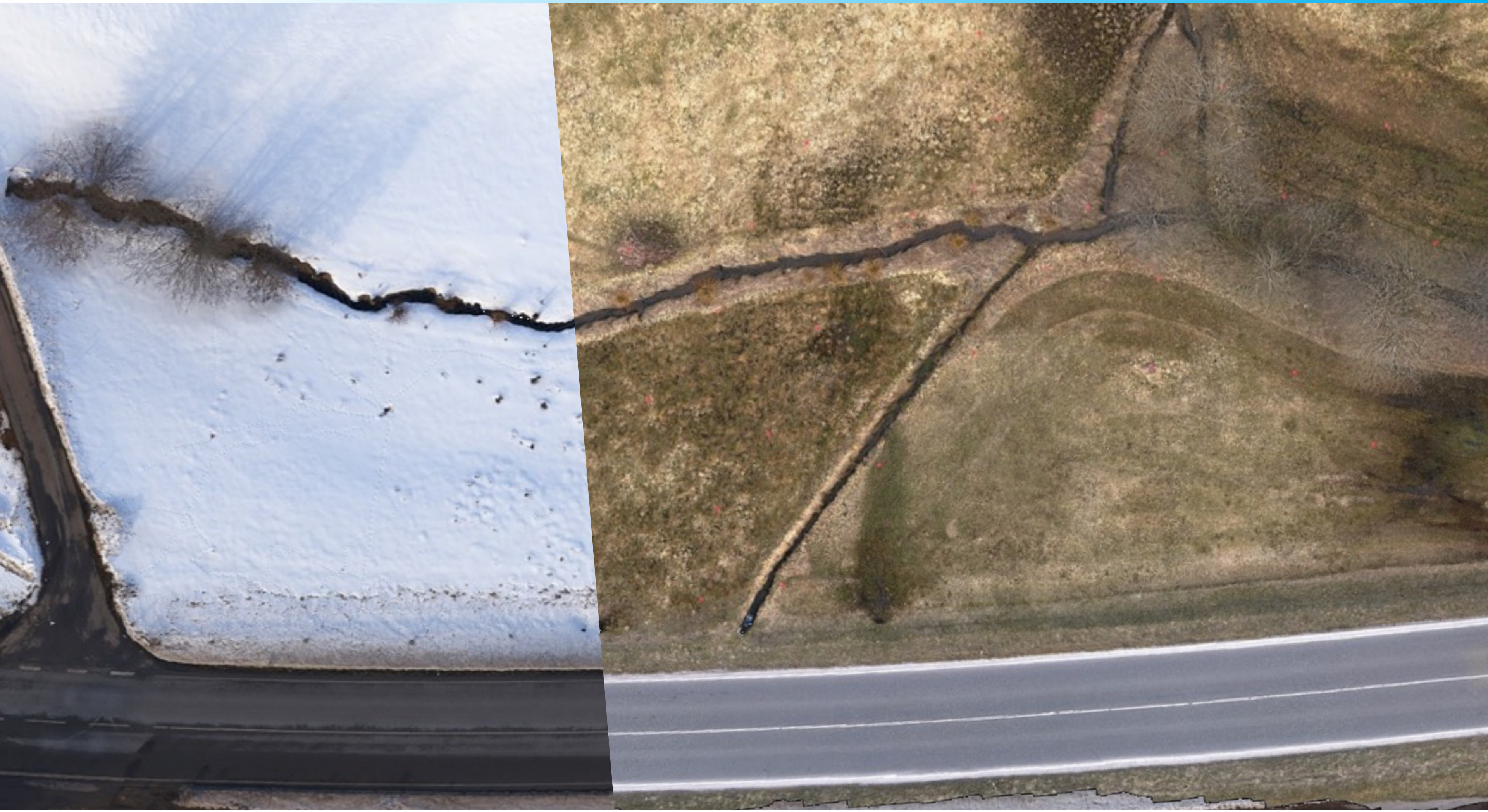
„Interpretation of Structure from Motion“ (Ullmann 1979)

RGB imagery

RGB imagery

Orthomosaic from 780 pictures (16 MP)
2 cm/px resolution

RGB imagery



RGB imagery

Hydropeaking

Hydropeaking on a gravel bar at river Lech, Germany

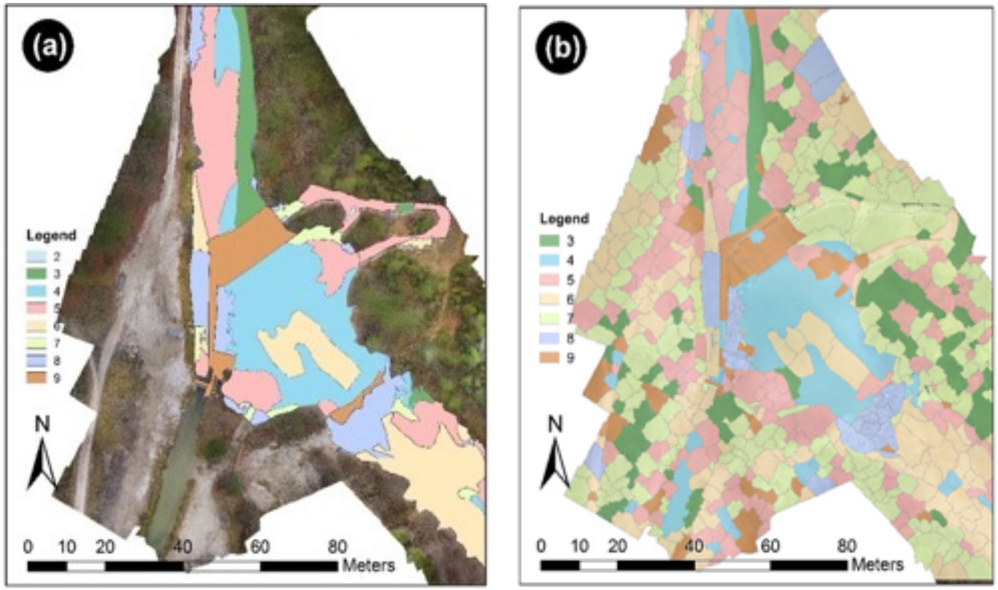
- temporal and spatial measurements of up- and down ramping events
- Control and investigate altered ramping rates for mitigation

RGB imagery

Classification:

- Supervised & unsupervised classification
- Threshold classification
- Masking
- Segmentation based classification
- Validation and analysis

Software for this approach: ERDAS IMAGINE, Matlab, eCognition & Arc GIS

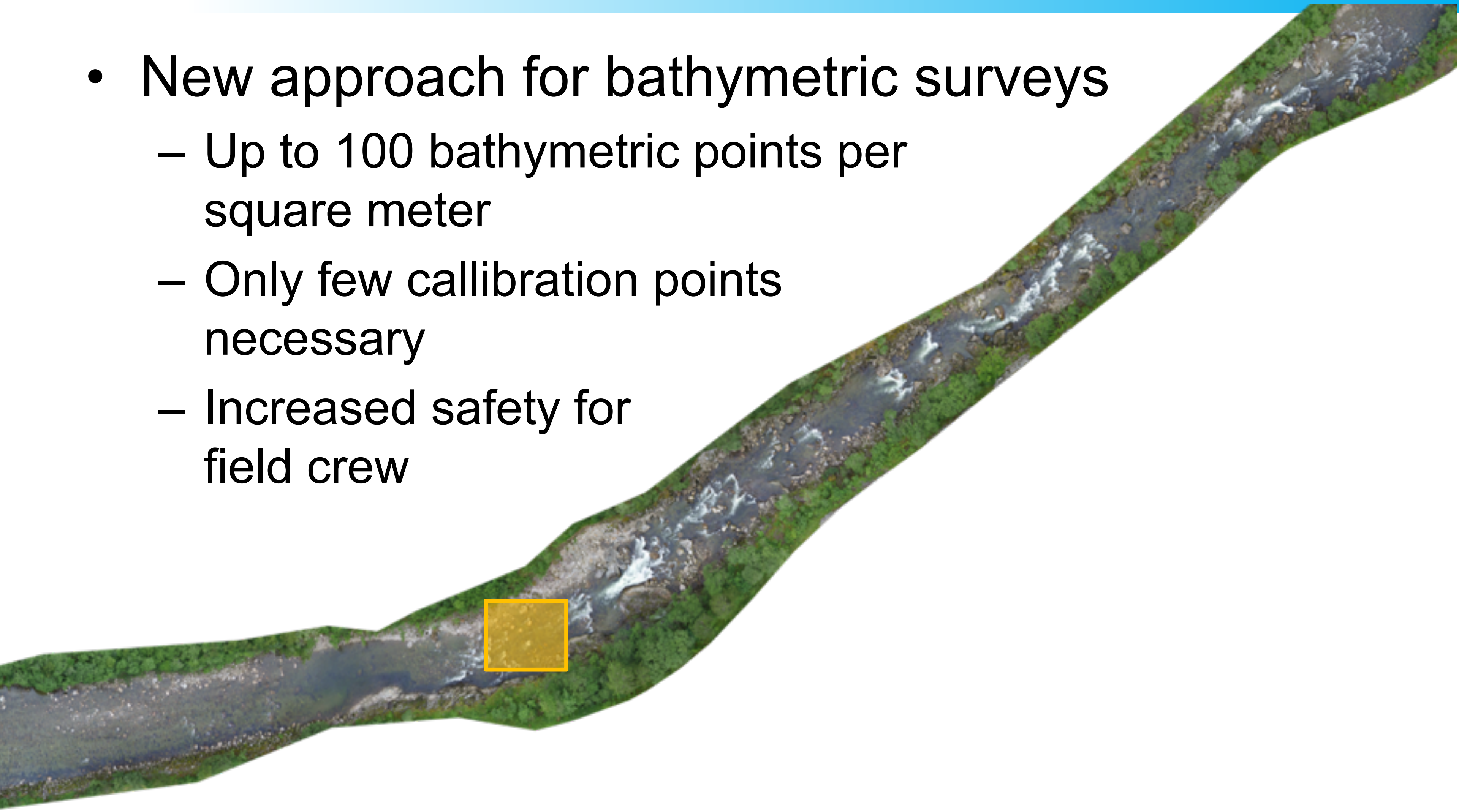


Comparative illustration of substrate classified map showing spatial distribution of the sediment types:

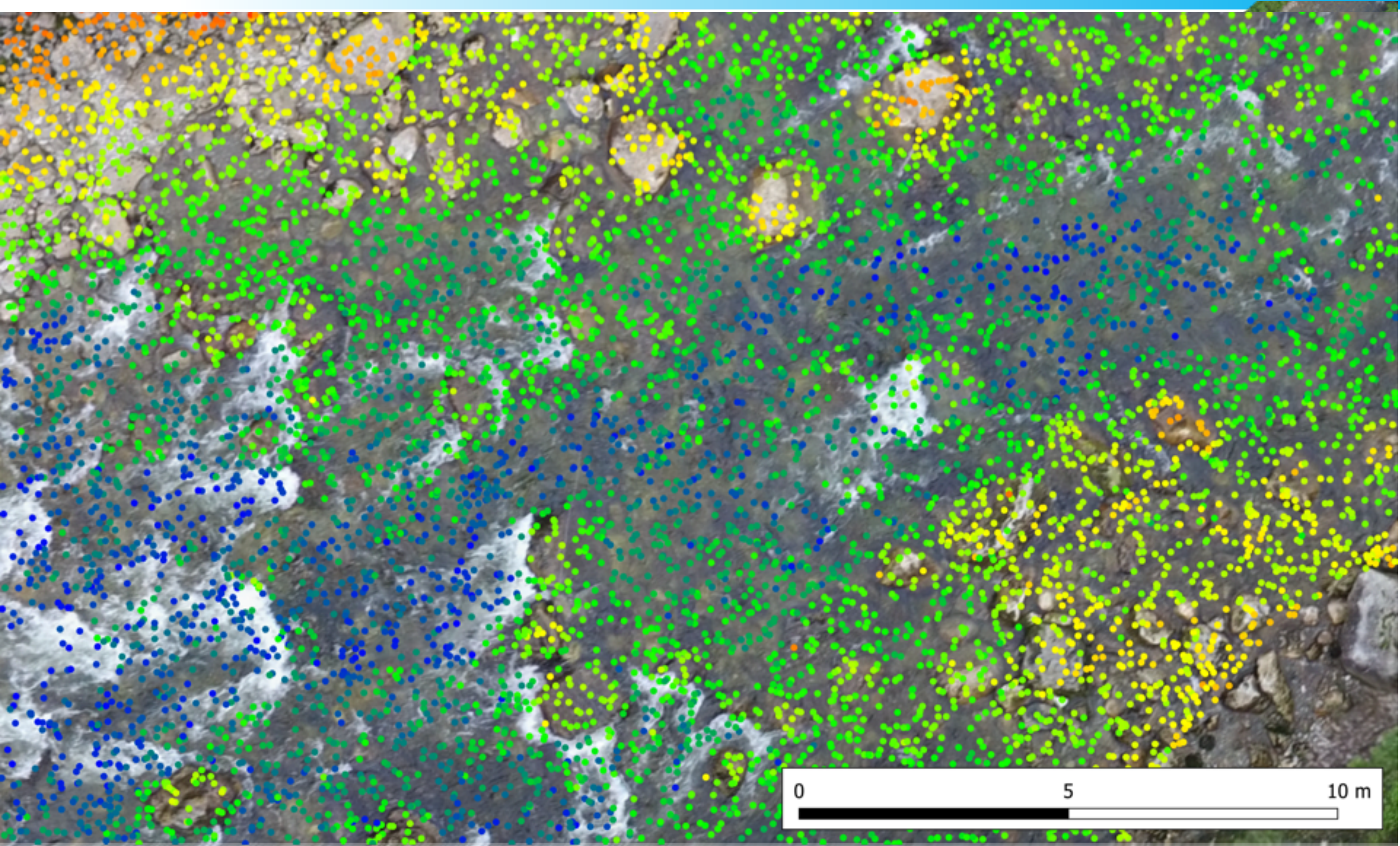
1) Manually mapped substrate - (a)
2) Automatically mapped substrate - (b)

RGB imagery

- New approach for bathymetric surveys
  - Up to 100 bathymetric points per square meter
  - Only few callibration points necessary
  - Increased safety for field crew



RGB imagery



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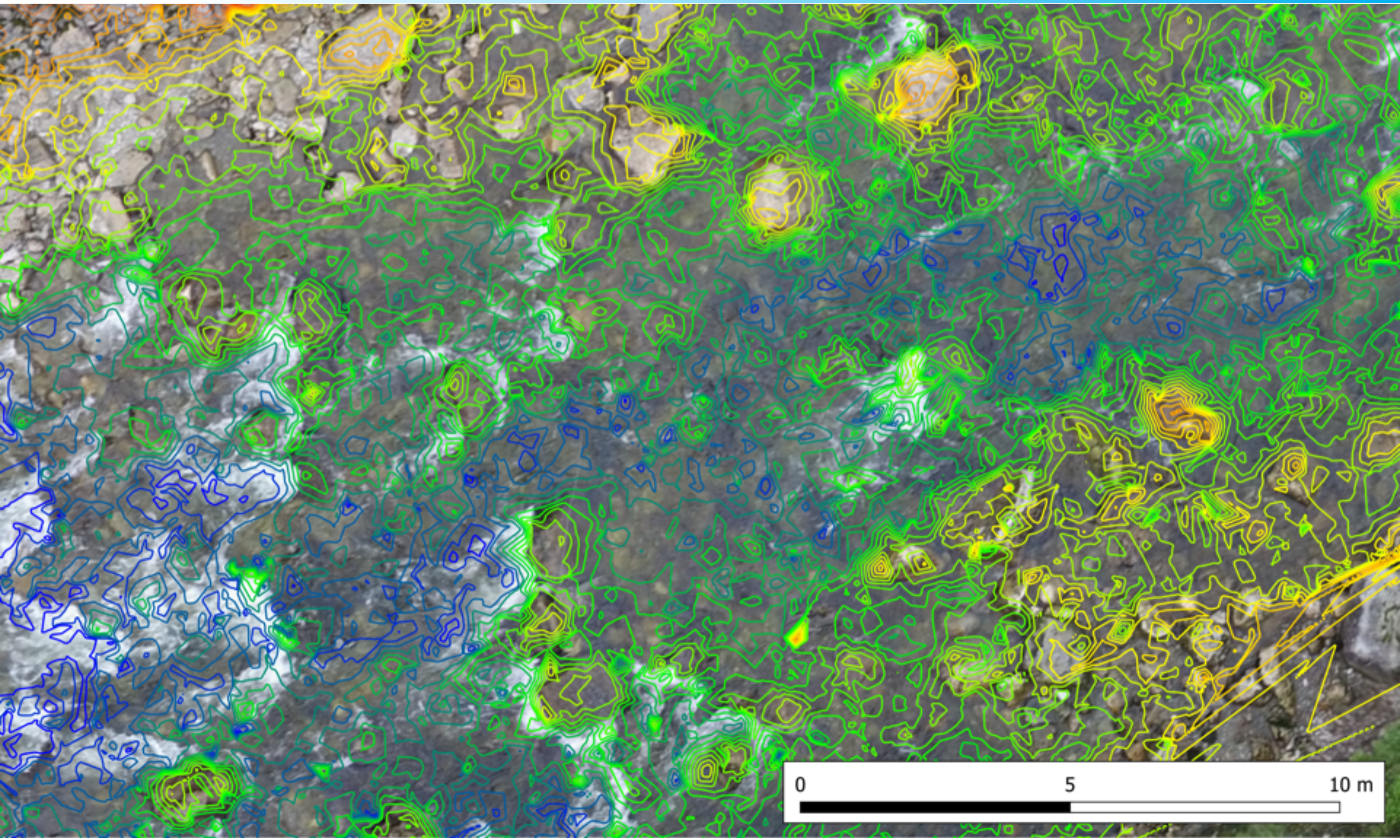
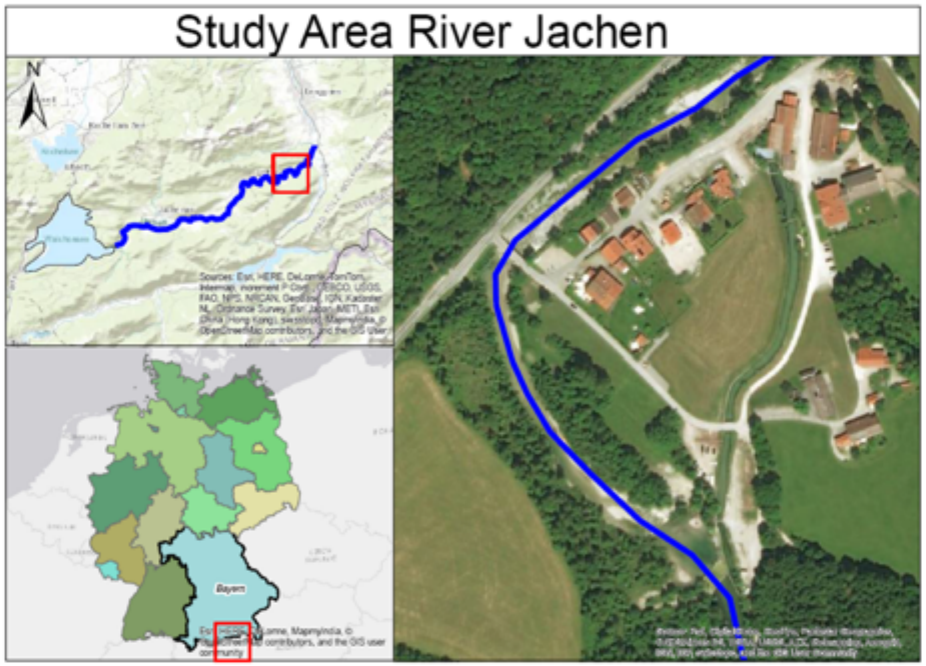
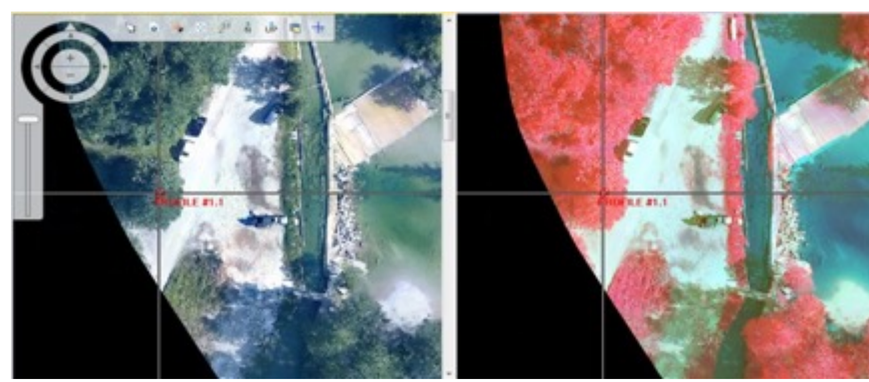
RGB imagery



NIR imagery



Low-cost multicamera system
(Haas et al. 2016)



RGB orthomosaic NIR orthomosaic

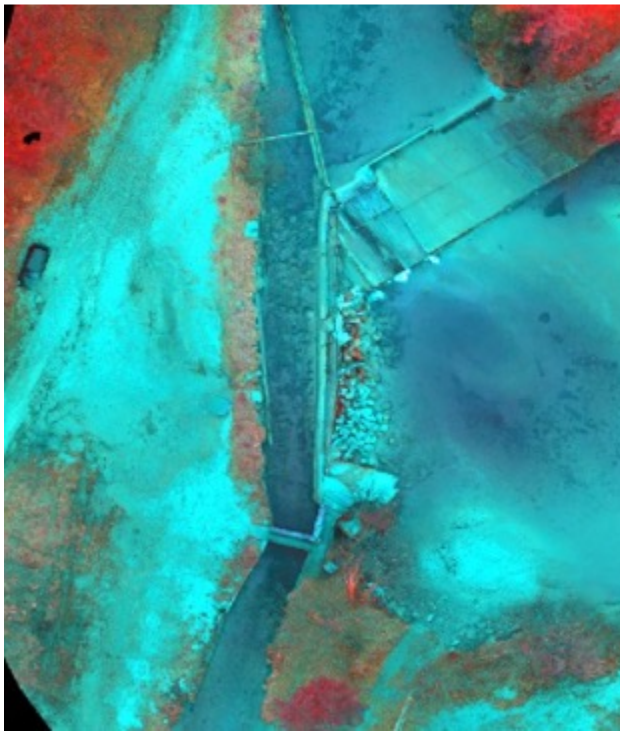
NIR imagery

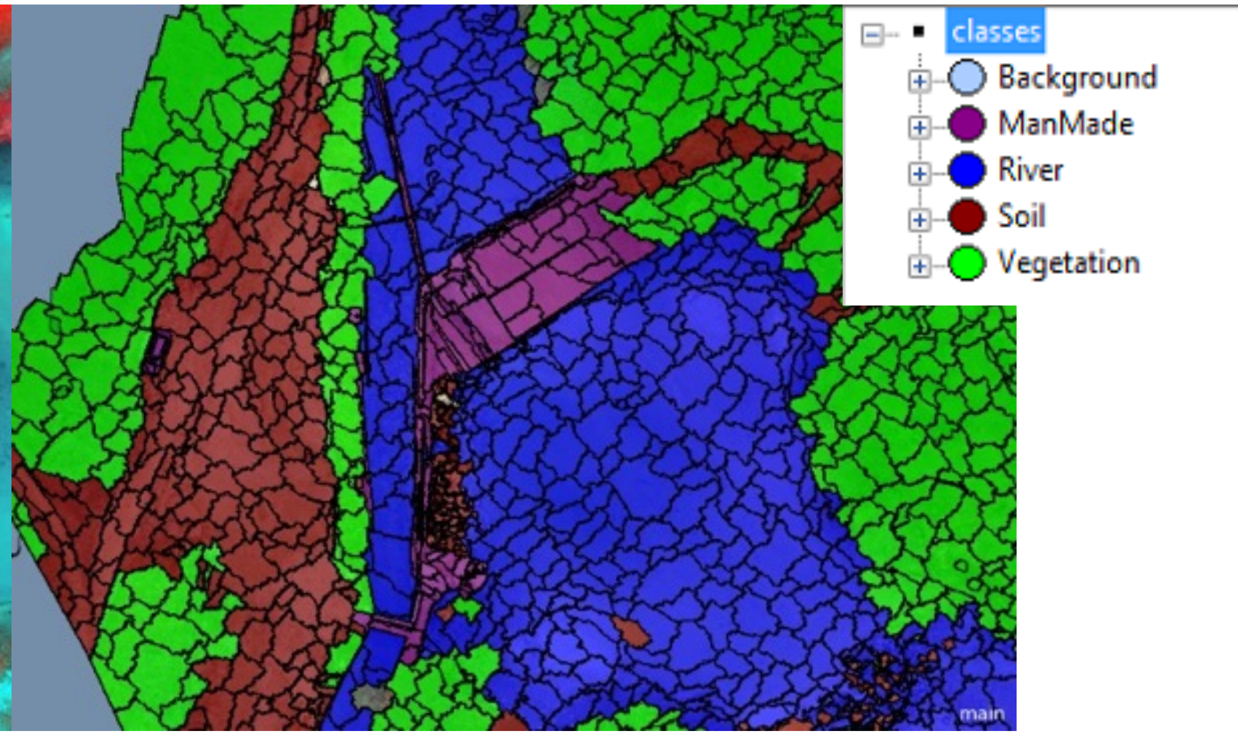
Vegetation indices from multispectral imagery*

Index	Formula	Description
DVI	$DVI = \mathrm{NIR} - \mathrm{RED}$	**Difference Vegetation Index**, it is used to separate soil from vegetation. It is sensitive to illuminations conditions.
SR	$SR = \frac{NIR}{REd}$	**Simple Ratio Index** shows high values for vegetation and lower ones for soil. Compensates differences in lighting conditions
NDVI	$NDVI = \frac{NIR - RED}{NIR + REd}$	**Normalized Difference Vegetation Index** used to estimate amount of vegetation, good to distinguish vegetation from soil. More Robust applicable to both reflectance and Radiance. Reduces the effect of no uniform illumination.

(*Jones and Vaughan, 2010)

multi band imagery



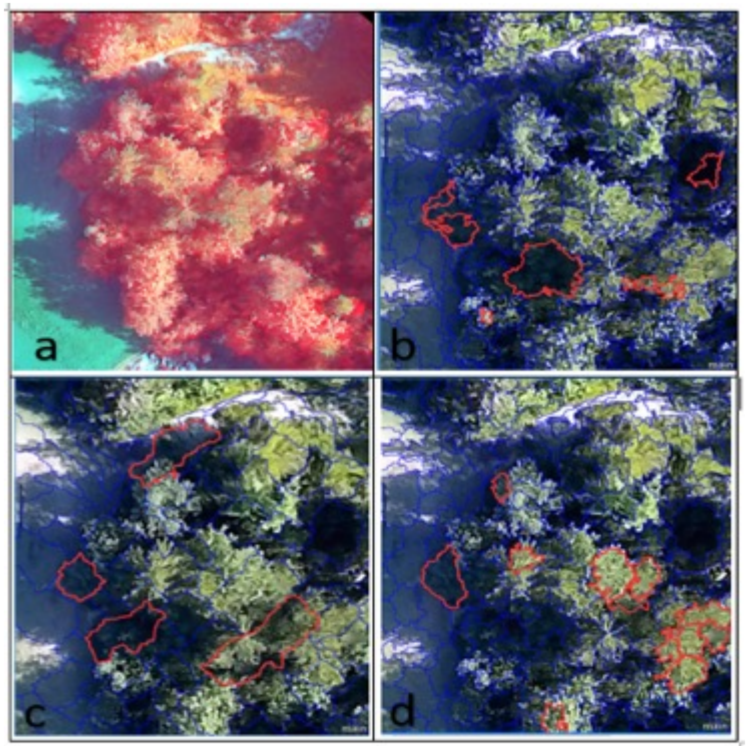


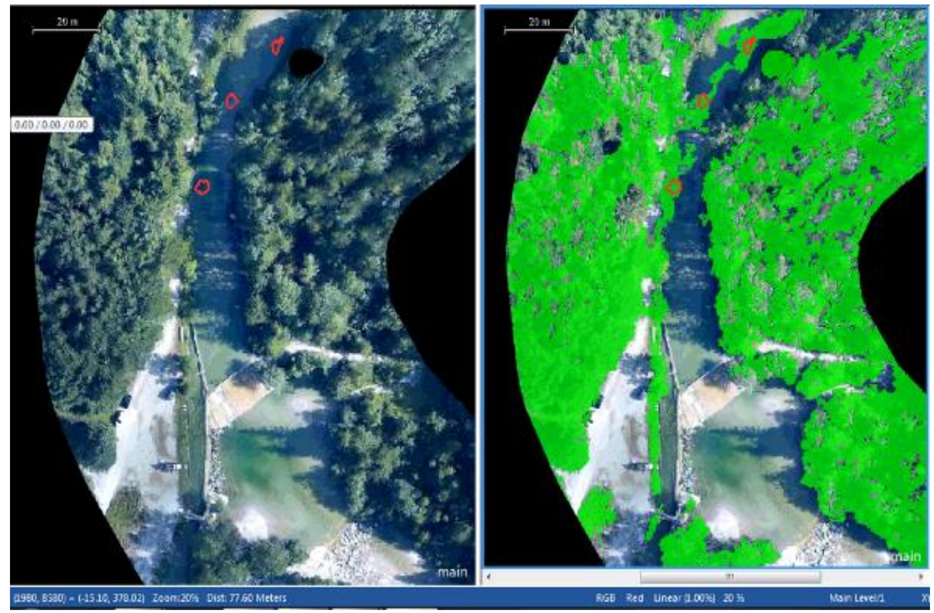
Multi-band image combines visible RGB and NIR

Automated classification of the landscape into user-defined groups

multi band imagery

Vegetated regions identified and grouped using NIR and RGB imagery



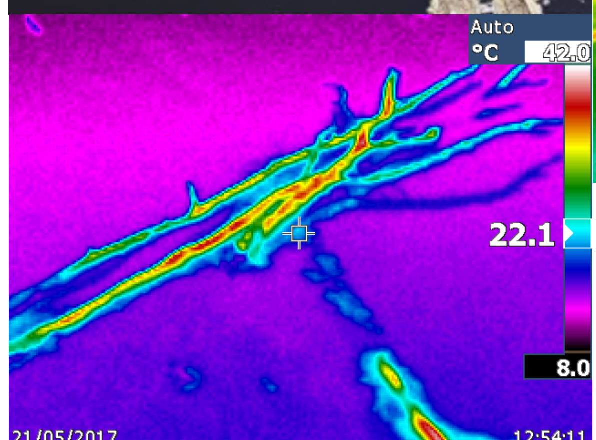


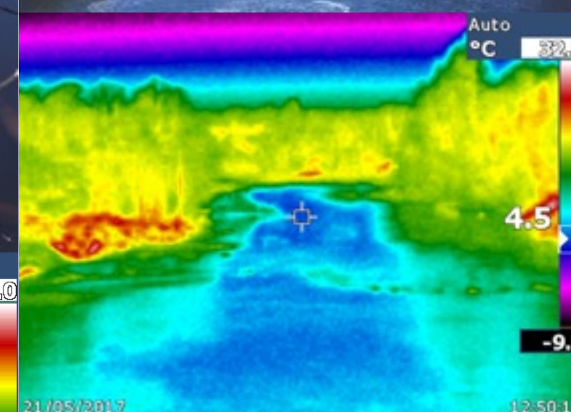
- Data used to compare changes in vegetation over different periods
- interpretation aided by overlay with aerial imagery

Thermal imagery

Assessment of:

- Thermopeaking
- Discharge
- Upwelling and downwelling (heat stress)
- Persist “memory effects” of shading and illumination
- Effects of heat sinks (walls, boulders)





Conclusion

- UAVs are a valuable tool for monitoring surface waterbodies and regulated rivers
  - Ecology
  - Hydrology
  - Hydraulics
  - Morphology

  Ecohydraulics
- High spatial and temporal resolution
  - Dynamic processes and changes
    - Hydropeaking
    - Thermopeaking
    - Erosion/Deposition
- Reliable data
  - High Quality
  - Increased quantity
  - Reproducible

Conclusion

- Increased safety aspect for field crew
- Potential for further research and development
  - Hardware
  - Applications
  - Software
- Time and cost efficient method
  - Low cost hardware + knowledge
    → High quality output
- Legal framework?

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Our aim is to use existing technologies to effectively quantify uncertainty in aquatic environments

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