Universidad Diego Portales

The use of innovative technology for fluvial monitoring

Gravel Bed Rivers 9 - 13 January 2023

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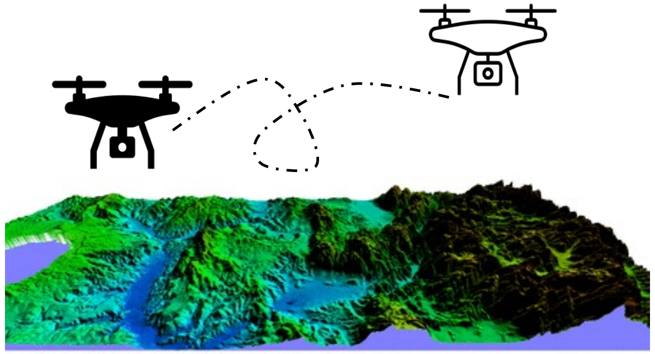

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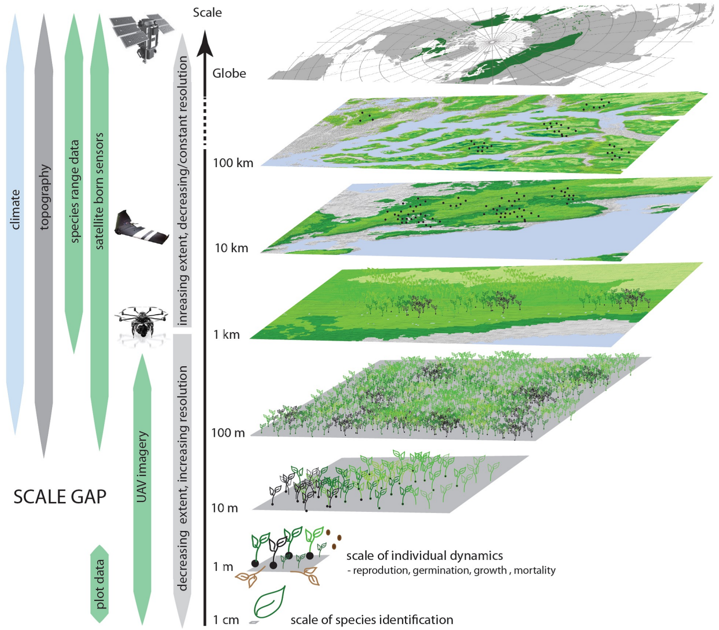
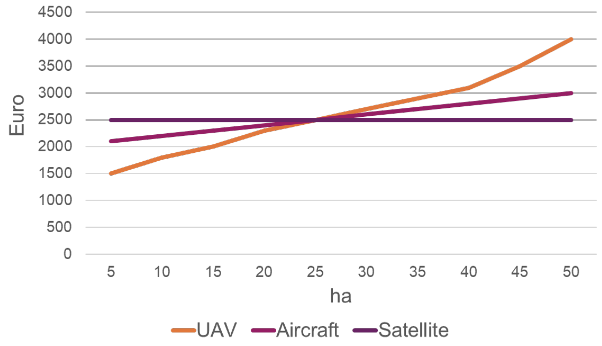
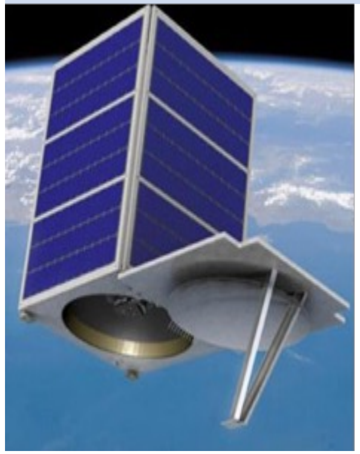
Environmental monitoring at a glance

2 Different sensing alternatives. Which one should I use?





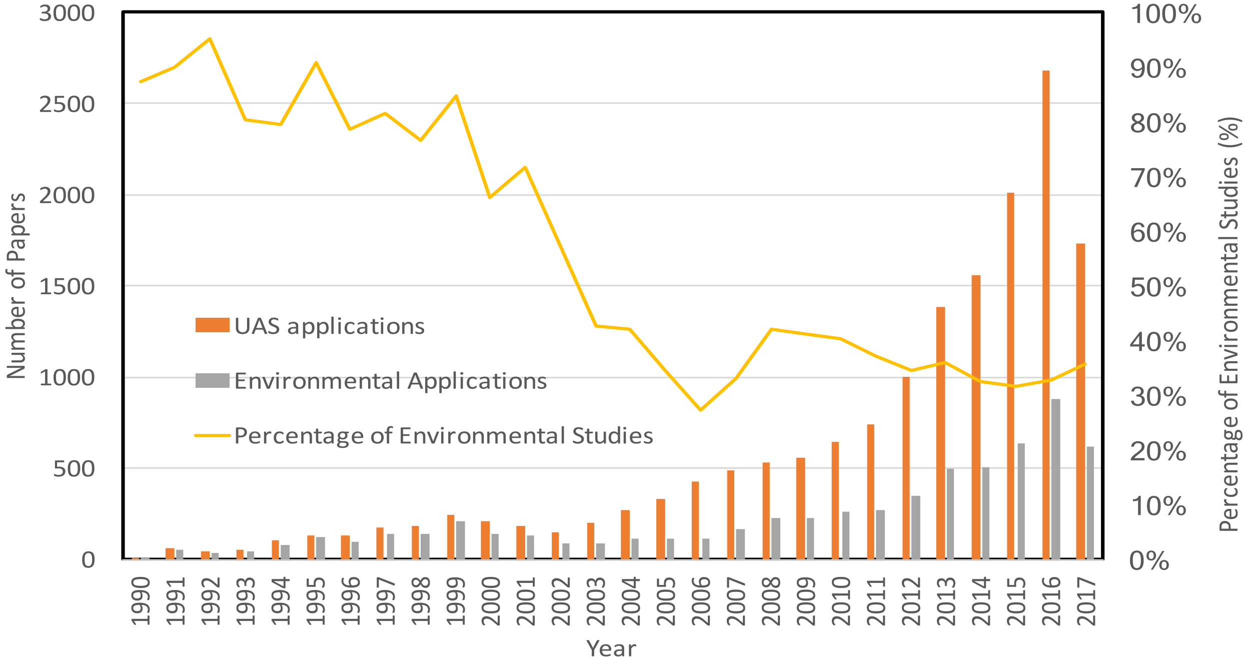
Global	~ Hectares	~ m^2
		
Up to 30cm	Up to 1cm	Up to 1cm

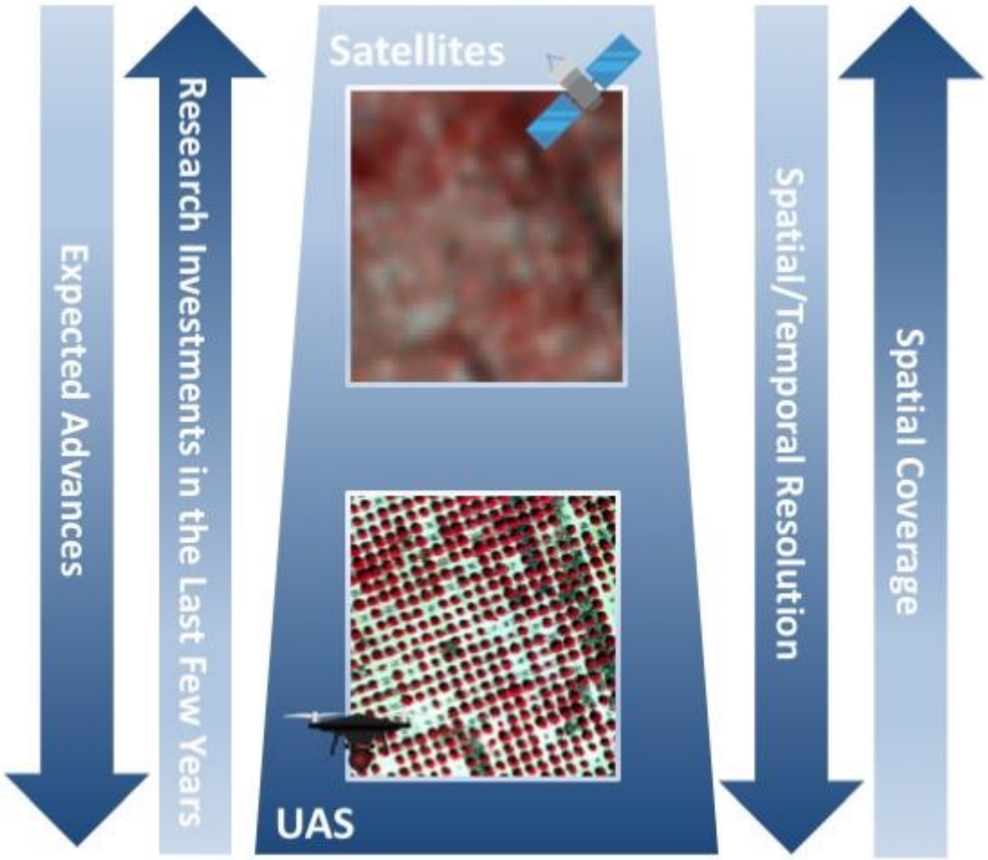
Comparable resolution

Environmental monitoring at a glance

3

Scientific contributions: UAS platform





- ✓ Decline of environmental studies
- ✓ Increase of UASs applications
- ✓ High spatial resolution

Environmental monitoring at a glance

4

Which term to use for drones

- ❑ **Drone**
- ❑ **Unmanned Aerial Vehicles (UAVs)**
- ❑ **Unmanned Aircraft Systems (UAS)**
- ❑ **Unoccupied Aircraft Systems**
- ❑ **Uncrewed Aircraft Systems**
- ❑ **Remotely Piloted Aircraft Systems (RPAS)**
- ❑ **…**

Multirotor <2 Kg

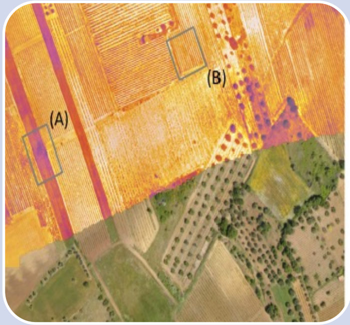
Fixed – wing <2 Kg (micro)

Multirotor 4-6 Kg

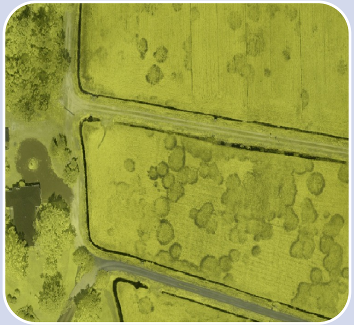
UAS applications for Environmental monitoring

5 Some (of many!) applications…

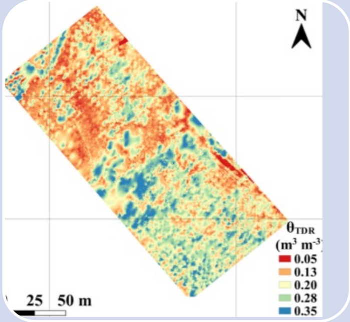
DSMs



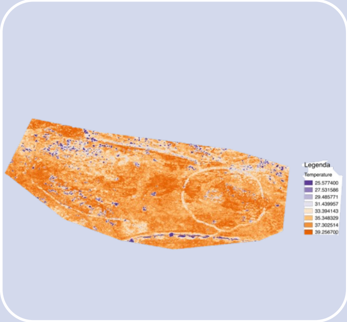
Crop water stress detection



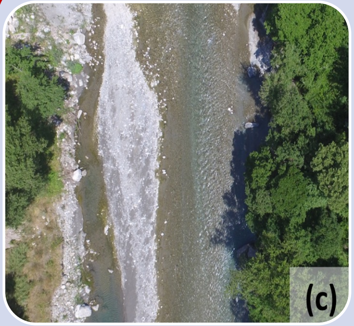
Vegetation status



Soil water content



Archaeological surveys



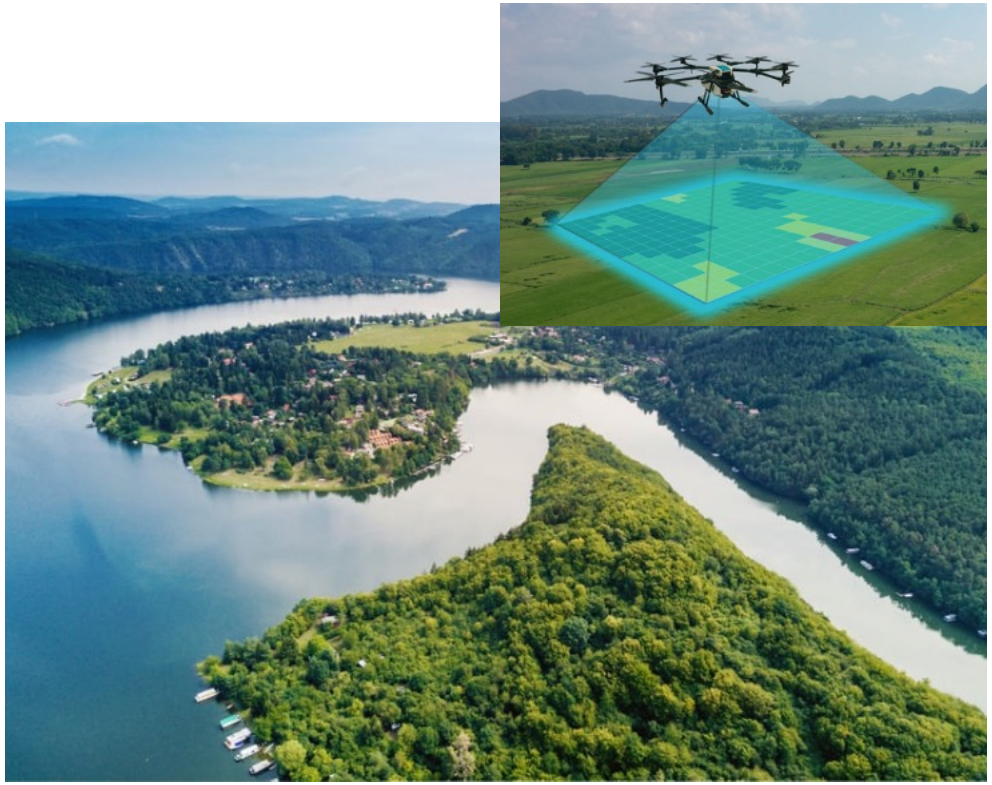
fluvial monitoring

Outline

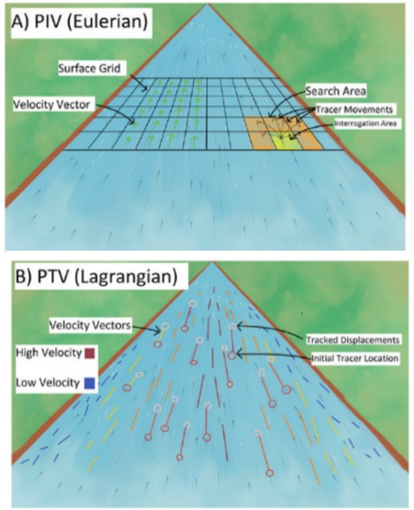
1. Seeding quantification for image velocimetry applications

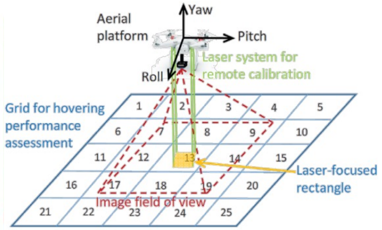
2. Footage stabilisation for image velocimetry applications

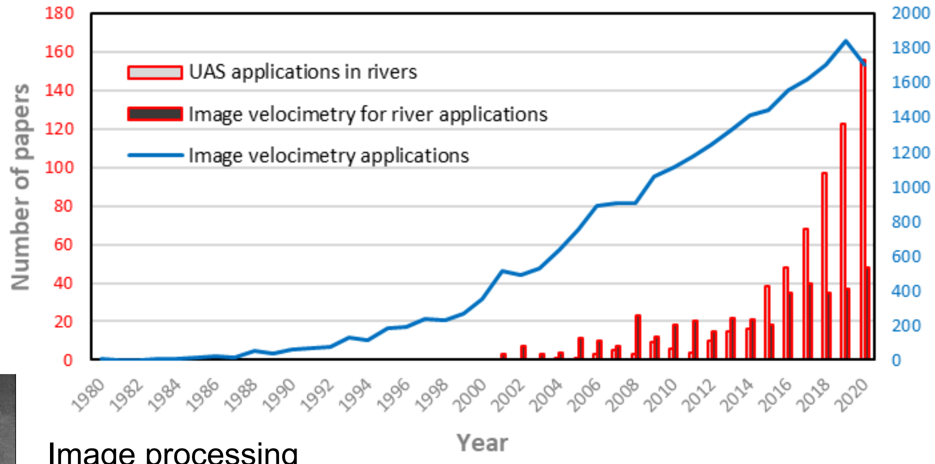
3. Water extent segmentation



Streamflow monitoring







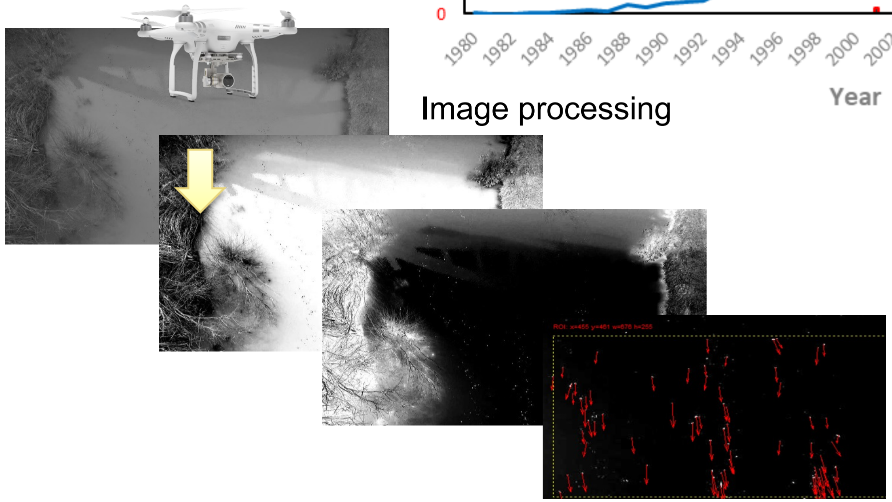
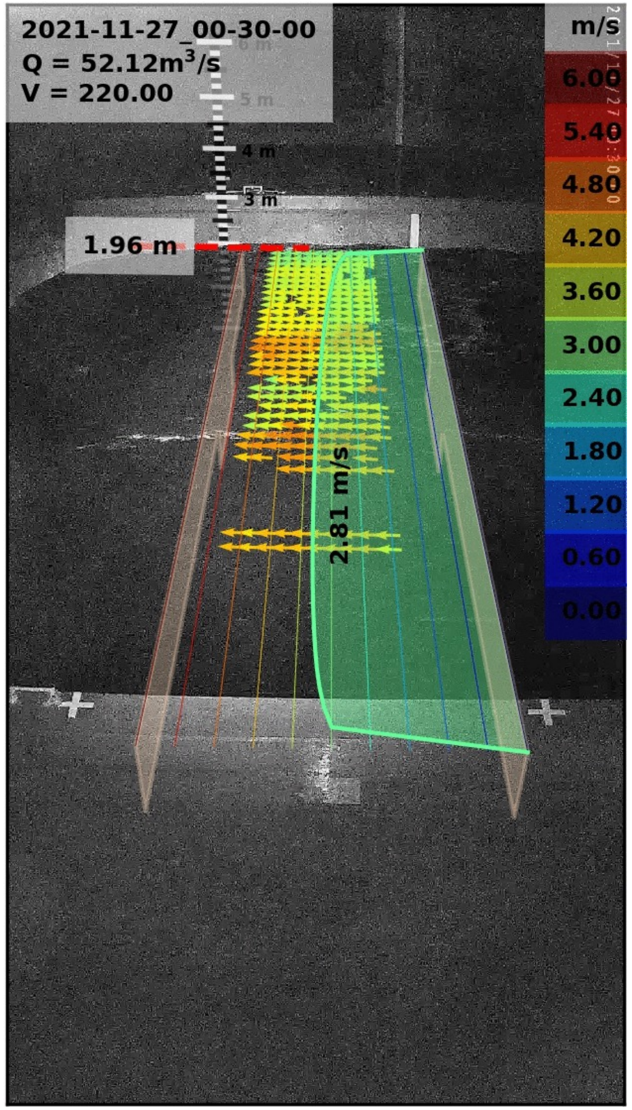


Image processing

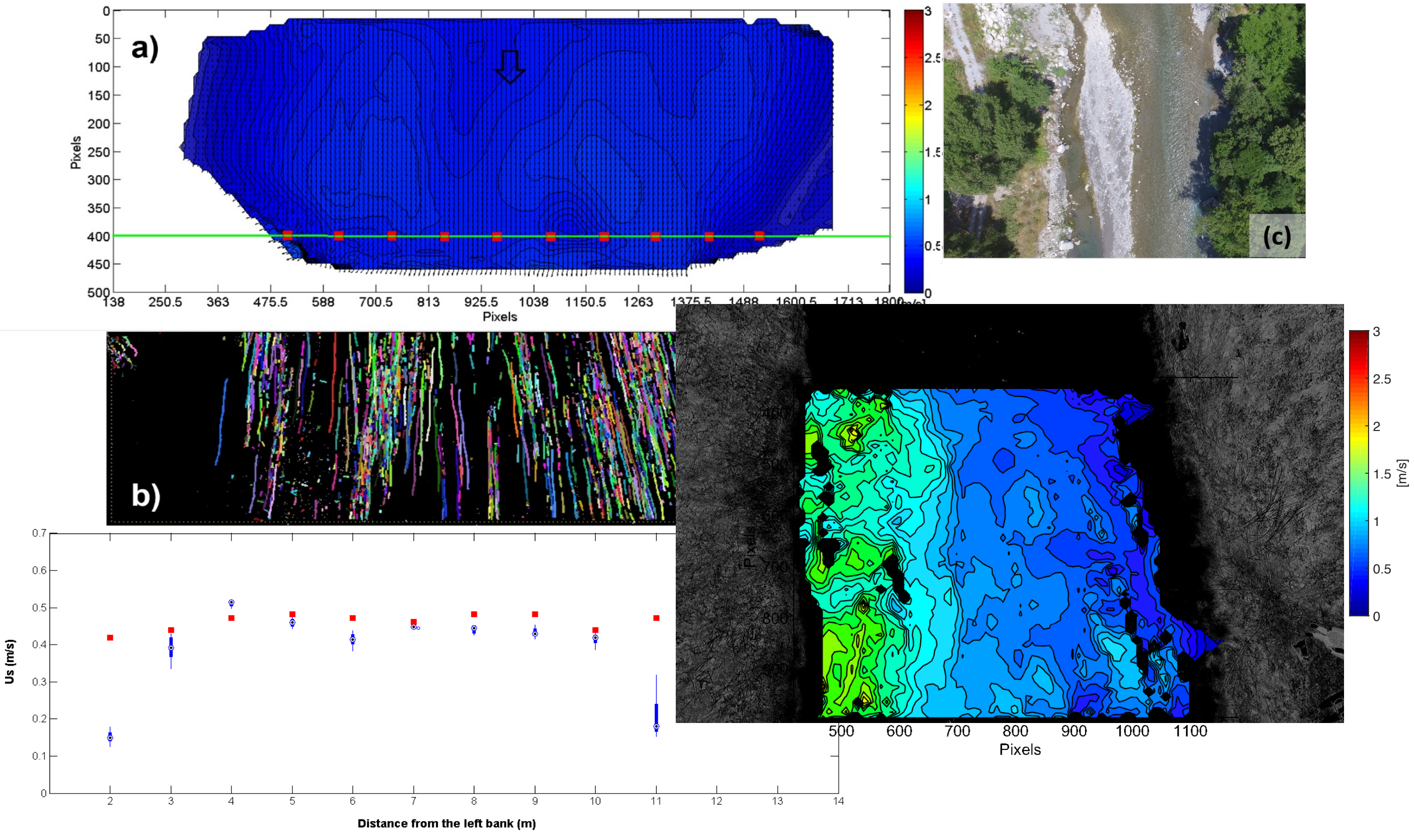


http://www.photrack.ch/dischargekeeper.html

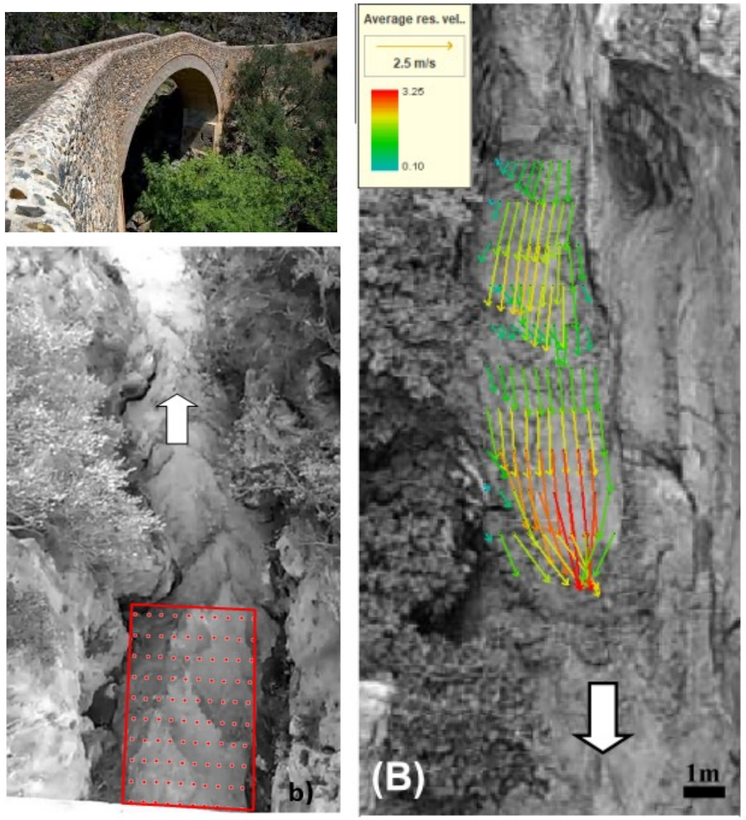
- ✓ **Scope:** Streamflow monitoring: velocities, discharge, and water levels.
- ✓ **Versatility:** smartphones, fixed cameras, UASs.

Streamflow monitoring

8 Field experience & Analysis

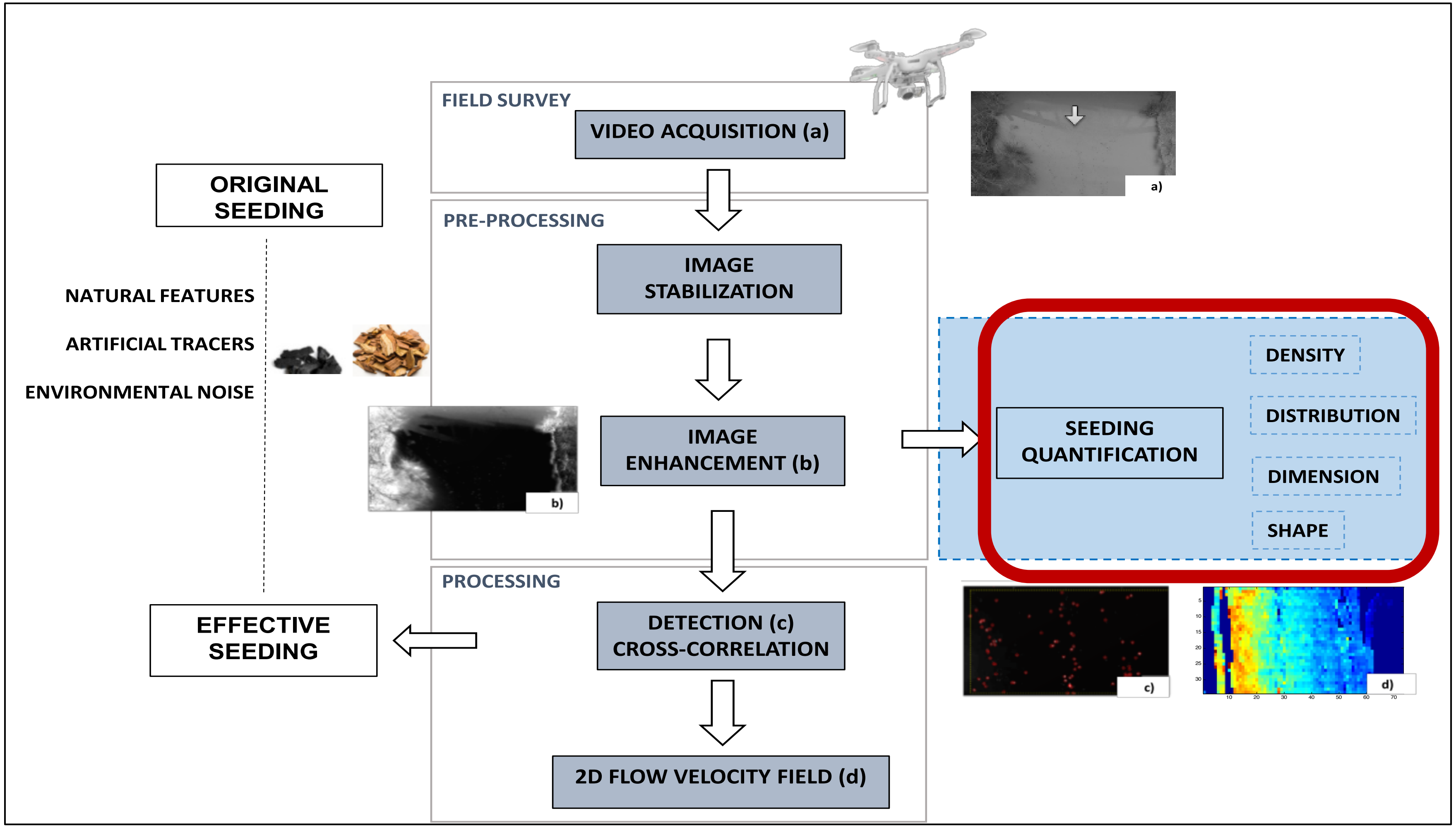


Torrente Raganello (Civita, Italy)



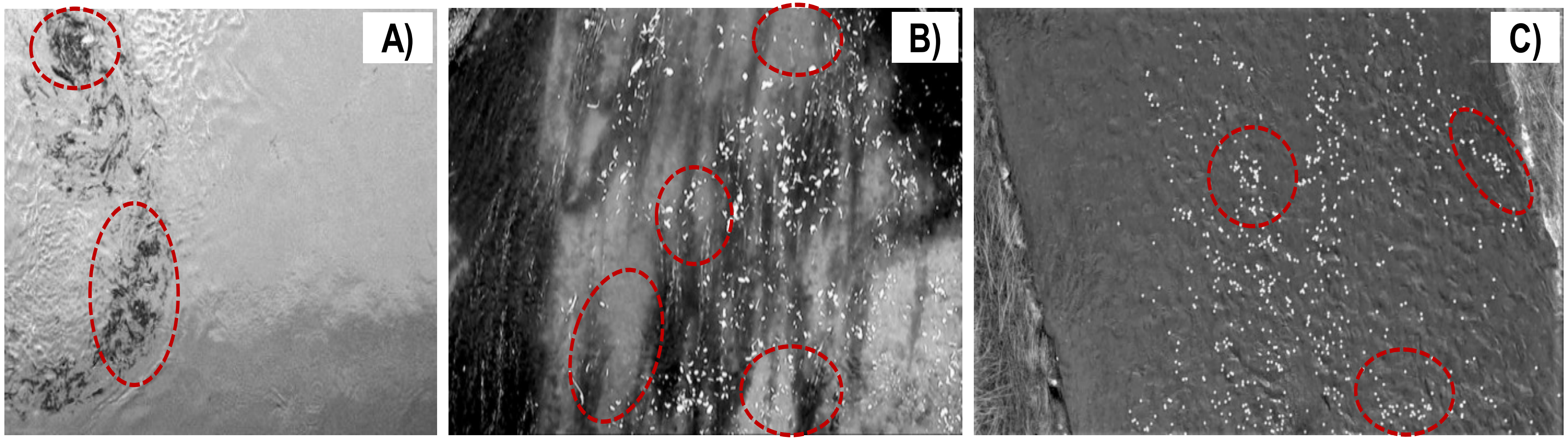
Streamflow monitoring

Workflow for image-velocimetry analysis



Seeding Quantification

10 **Image-velocimetry techniques are widely used, but How are their accuracies at field conditions?**



Examples of moving and aggregated structures on the water surface: **A)** Natural seeding; **B)** and **C)** Artificial seeding at low/intermediate flow conditions.

a) Field conditions **much more complex** than the Lab

b) Image-velocimetry detects and tracks **features**

c) Should we take a look at **features/tracers dynamics to optimise results**?

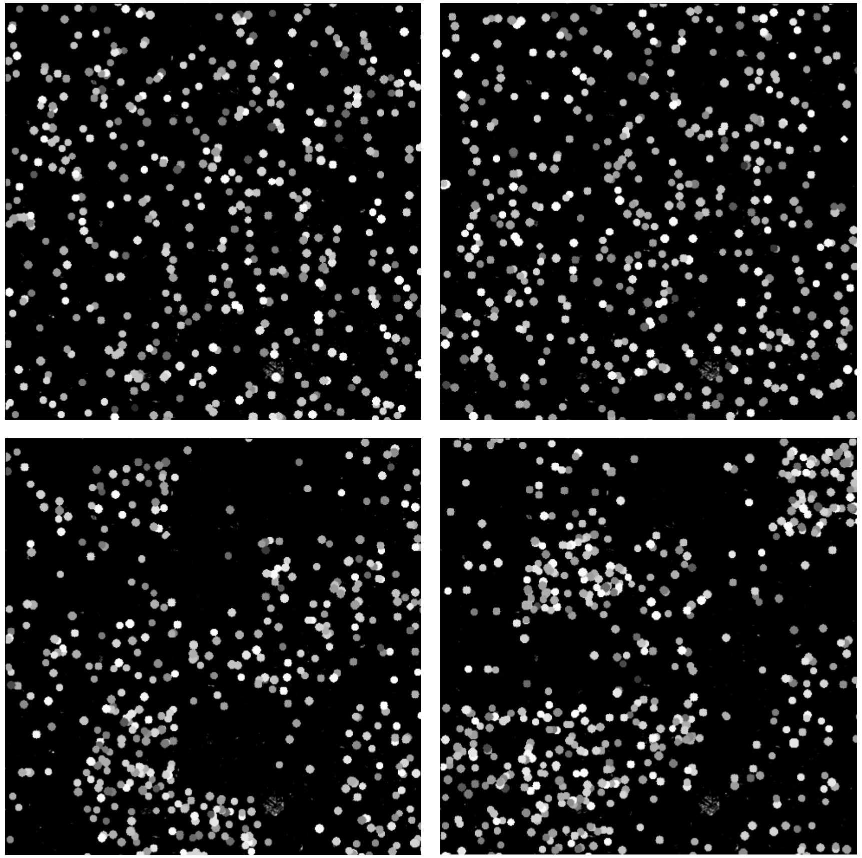
→ **Numerical approach**

Seeding Quantification

11 Numerical framework: Synthetic generation

- Synthetic tracers were randomly distributed in space with a unidirectional and constant velocity (15 px/frame).
- They consist of uniform circular shapes with diameter Dxp ≈ 10 px and uniform white colour.
- Both diameters and colours were altered with white noise in order to consider more realistic configurations.
- Their spatial distribution was controlled by a Generalised Poisson Distribution (GPD) with a theoretical seeding density λ and level of aggregation υ.
- The quality of the results was determined by the magnitude of the errors that were computed as

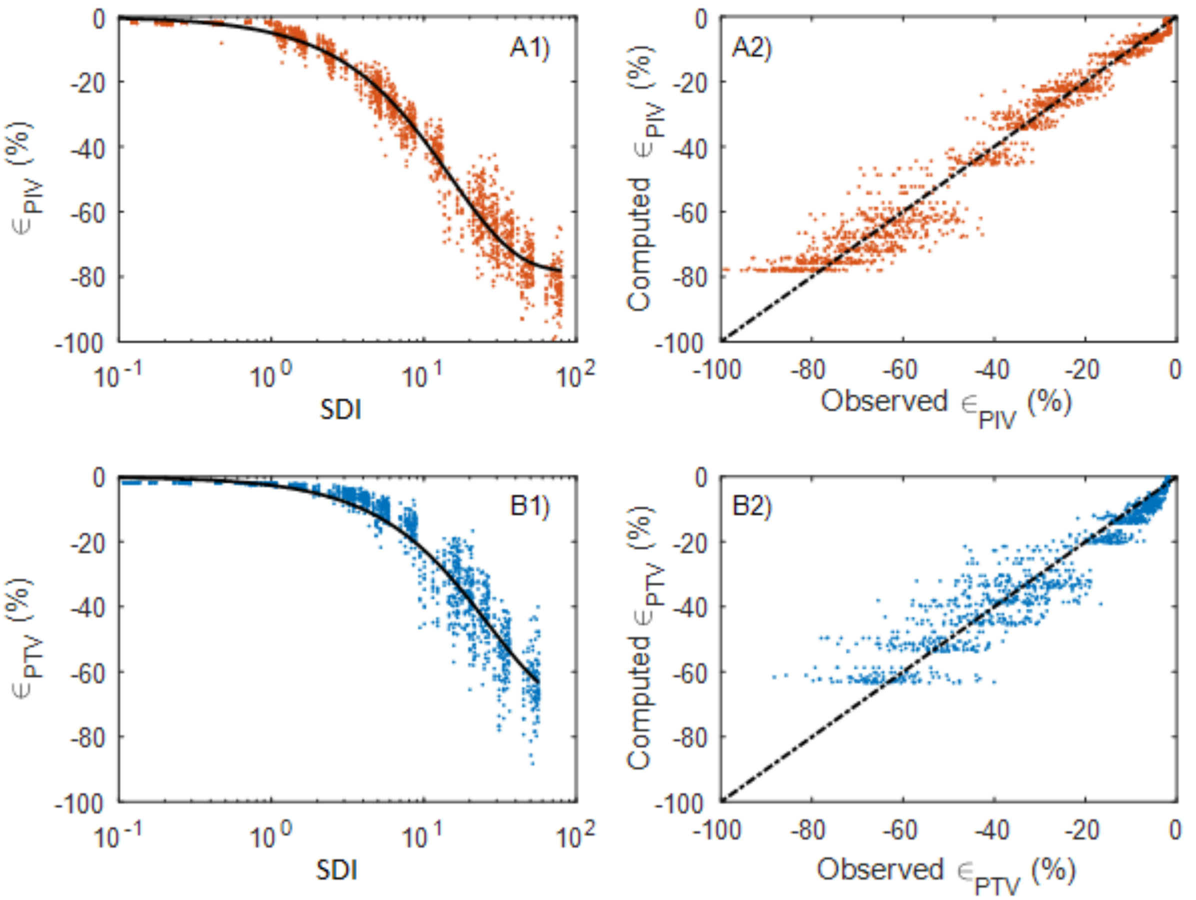
$$\epsilon = 100\times\frac{(u_c - u_R)}{u_R}$$



Numerical simulations of synthetically generated particles that present different aggregation levels: **33,600** images generated in total

Seeding Quantification

Numerical framework: Analysis



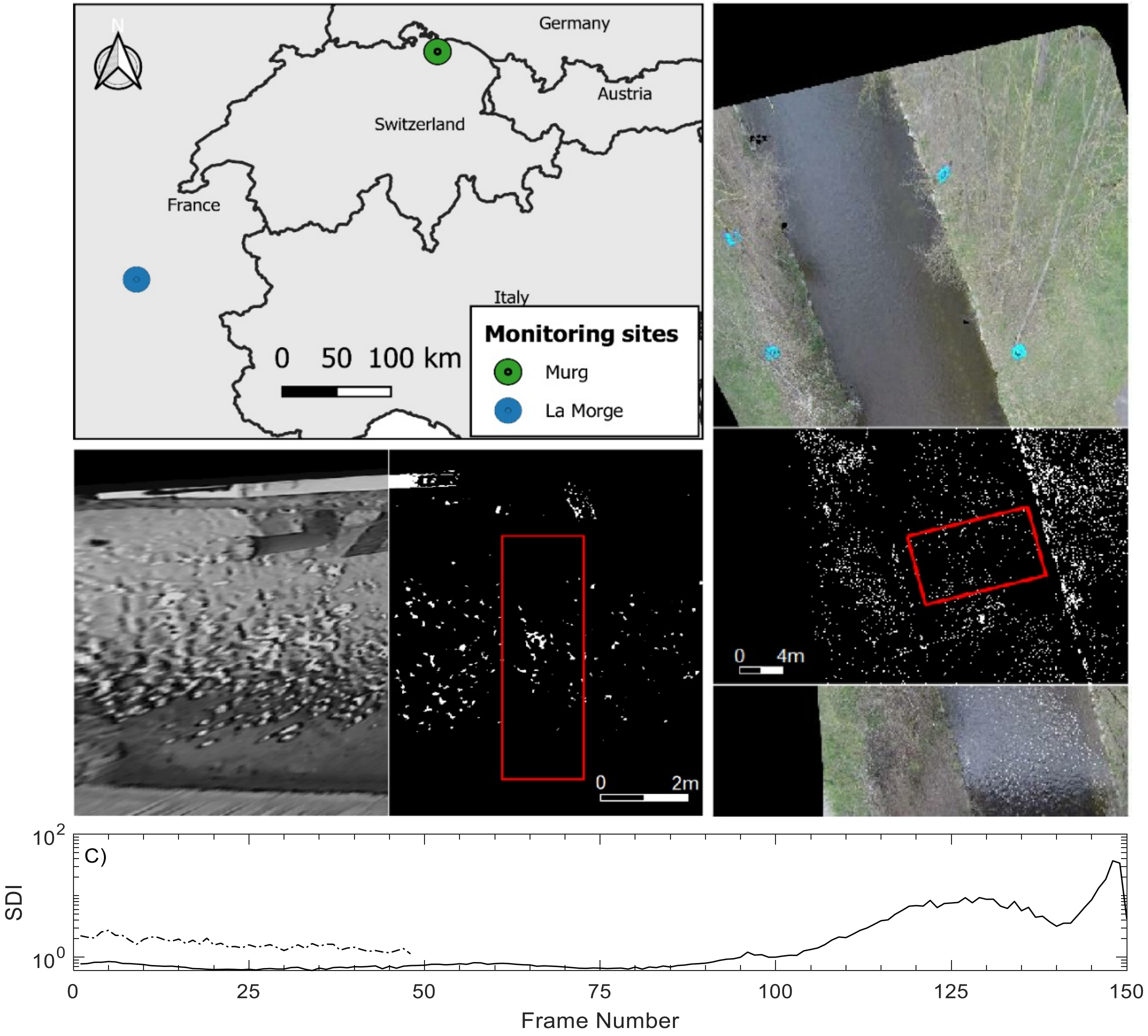
<u>Fig.</u> Numerical simulations of synthetically generated particles that present different aggregation levels.

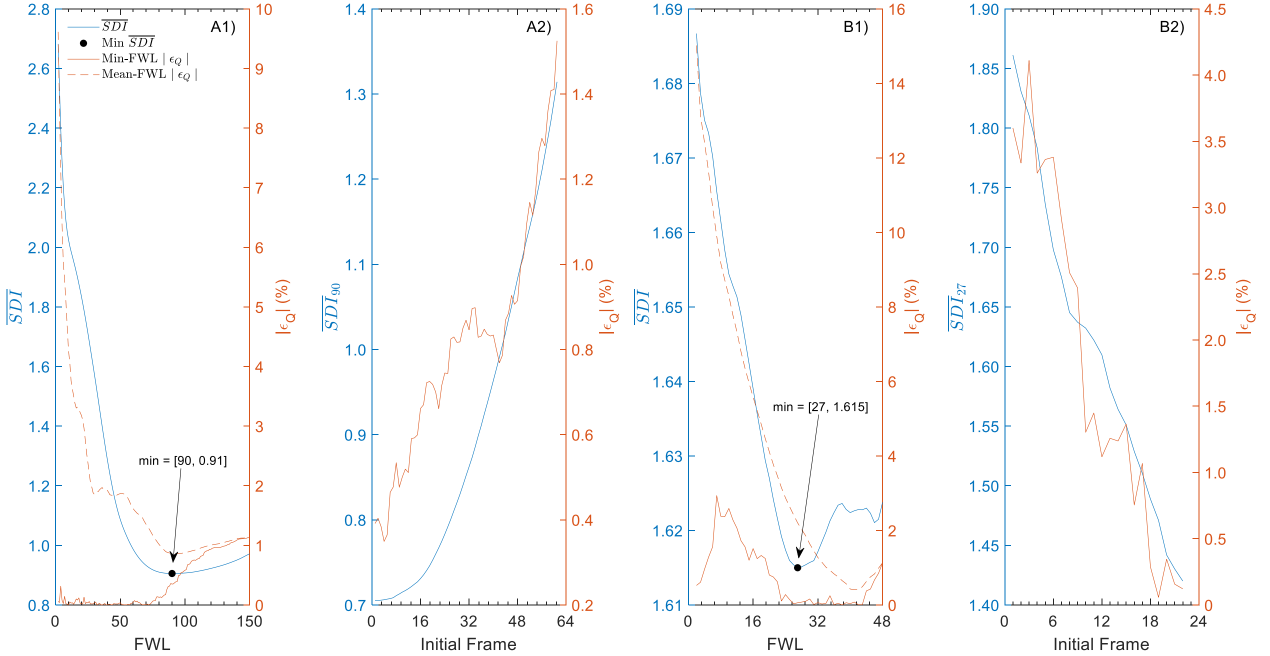
$$SDI = {D^*}^{0.1} / \left(\frac{\rho}{\rho_{cD^*1}} \right)$$

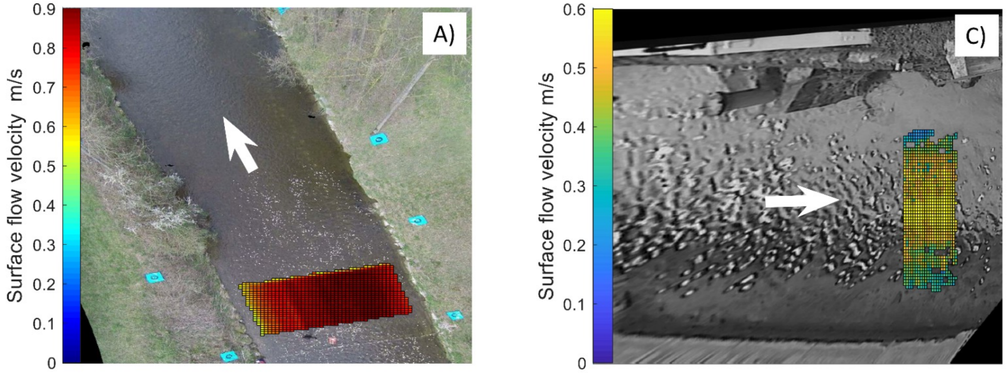
- ✓ ρ := Seeding density
- ✓ **D*** := Dispersion Index
- ✓ Clearly visible relationship between Errors and SDI.
- ✓ The lower SDI, the lower the Errors.

SDI at field conditions

13 SDI applications: 1.0

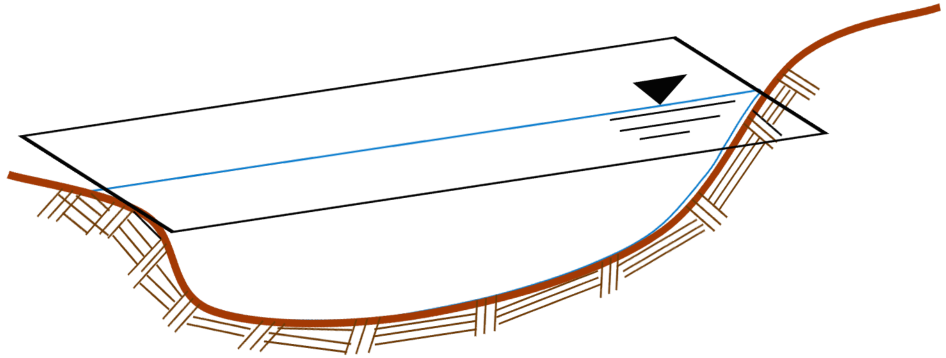




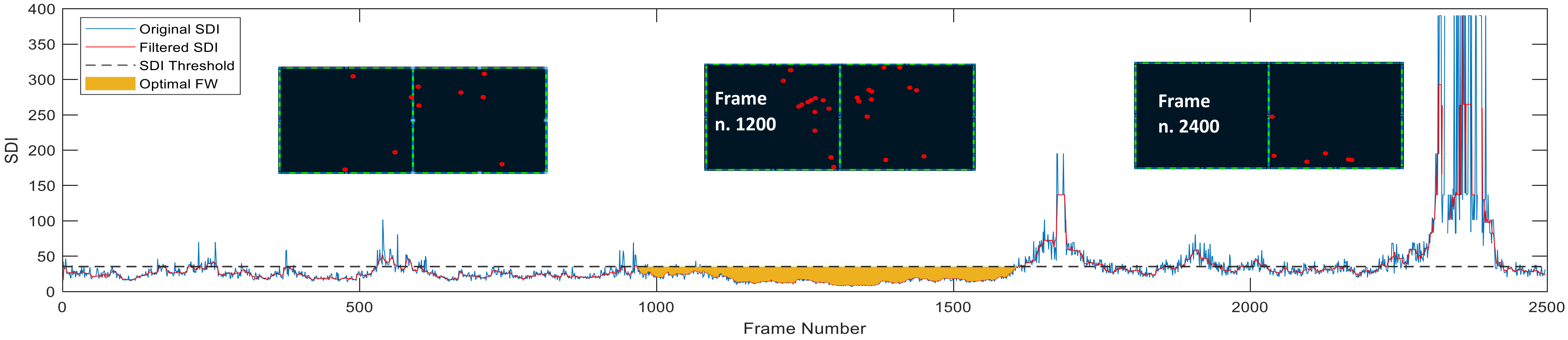


SDI at field conditions

SDI applications: 2.0



- ✓ Optimal FW approach based on SDI.
- ✓ Different spatial scales.
- ✓ Errors reduction of ~20-40 %

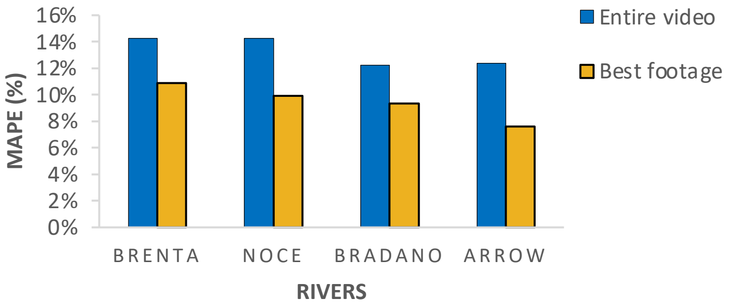


SDI at field conditions

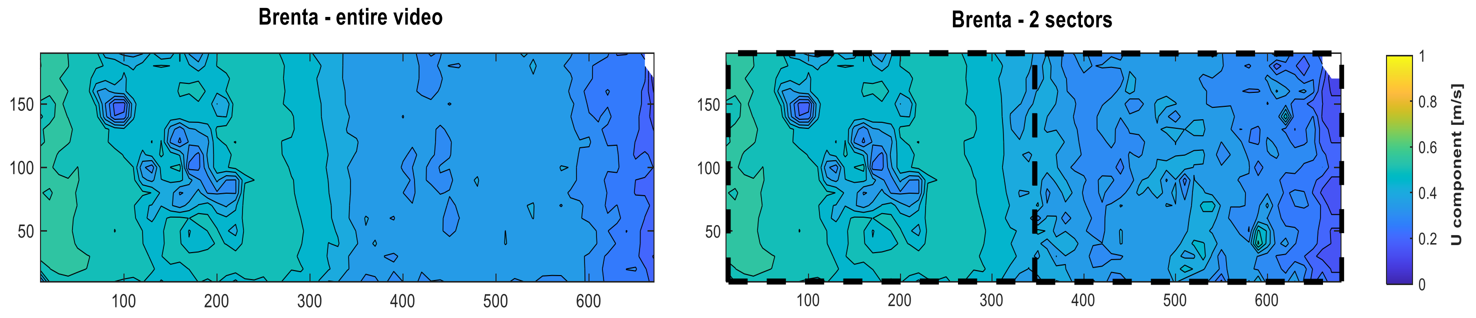
SDI applications: 2.0

- The SDI-based method improved LSPIV performances with a reduction of image velocimetry errors at sector and sub-sector scales

River	Number of frames	
	Entire video	Optimal range
Brenta	2500	153
Noce	200	70
Bradano	2496	642
Arrow	799	282

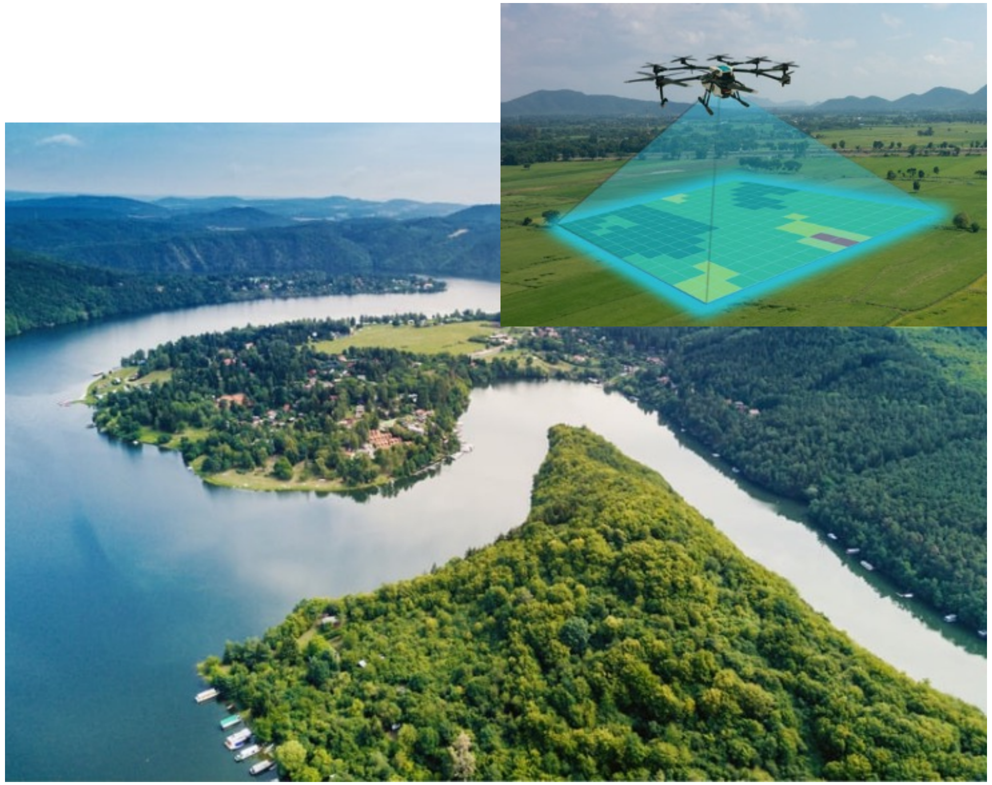


- In such cases, the average surface velocity maps contain details (e.g., velocity fluctuations and divergences) that are not visible and appreciable in the entire video configuration (standard approach).



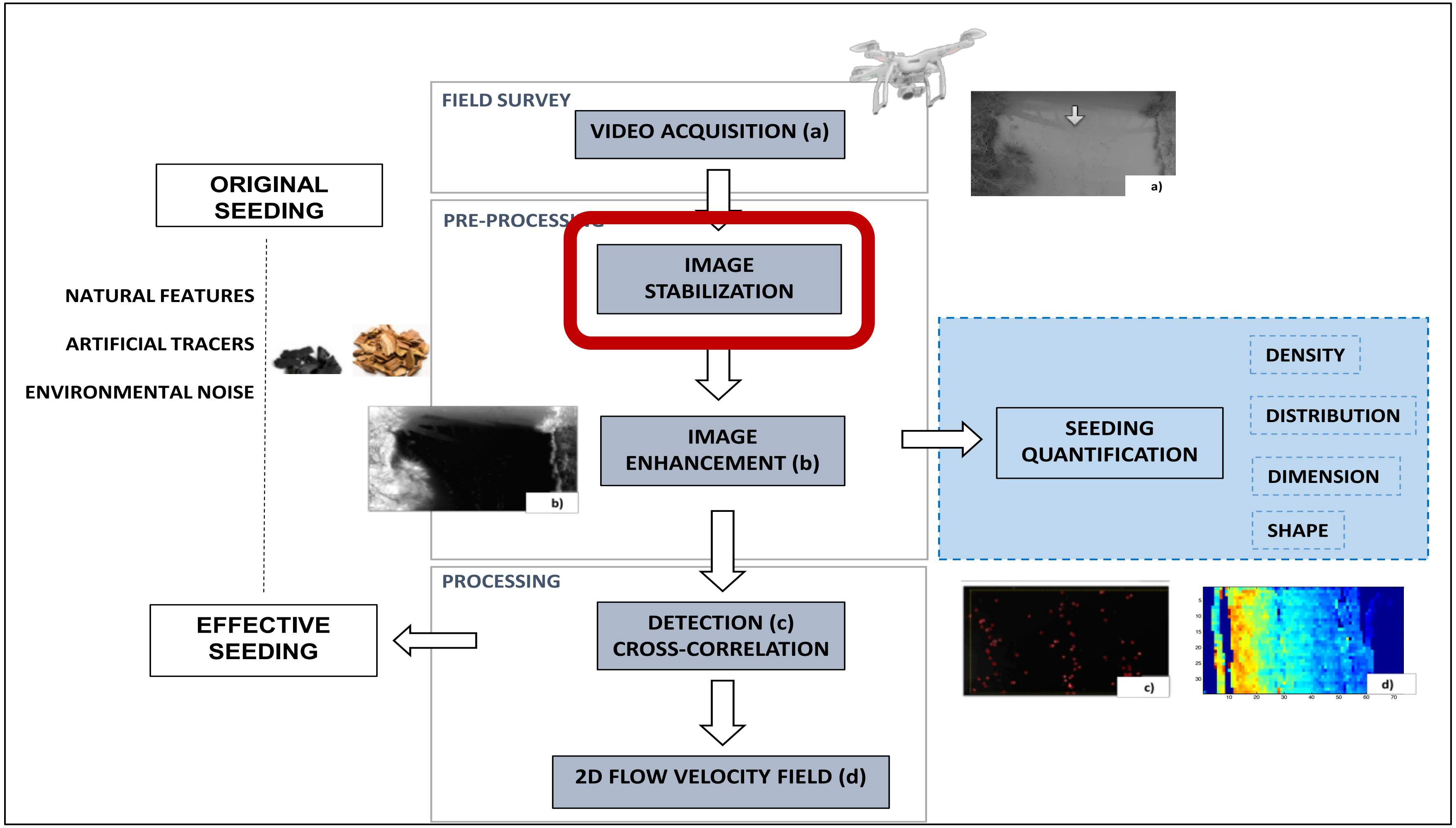
Outline

1. Seeding quantification for image velocimetry applications
2. Footage stabilisation for image velocimetry applications
3. Water extent segmentation



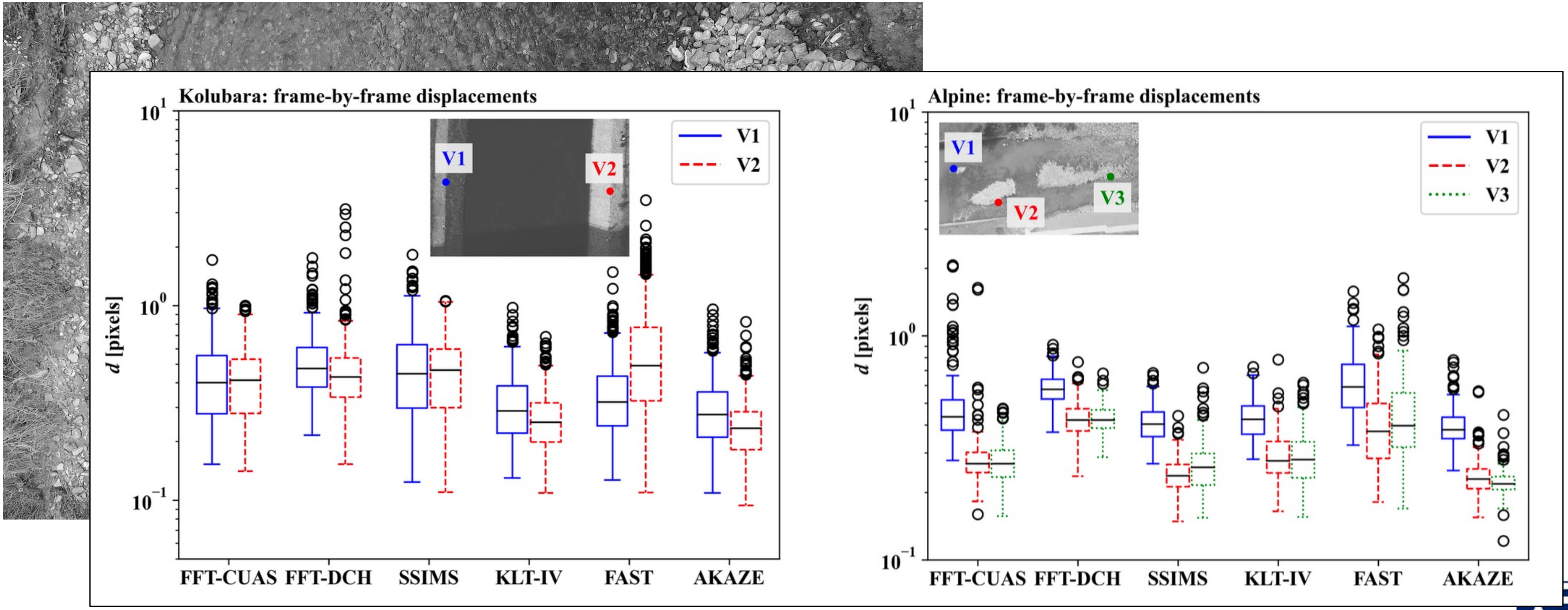
Streamflow monitoring

17 Workflow for image-velocimetry analysis



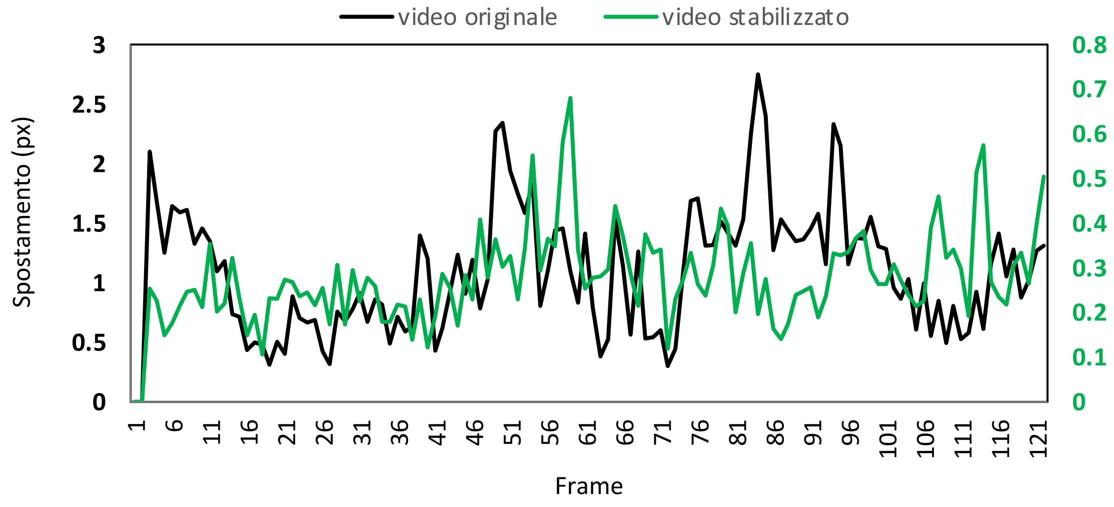
Streamflow monitoring

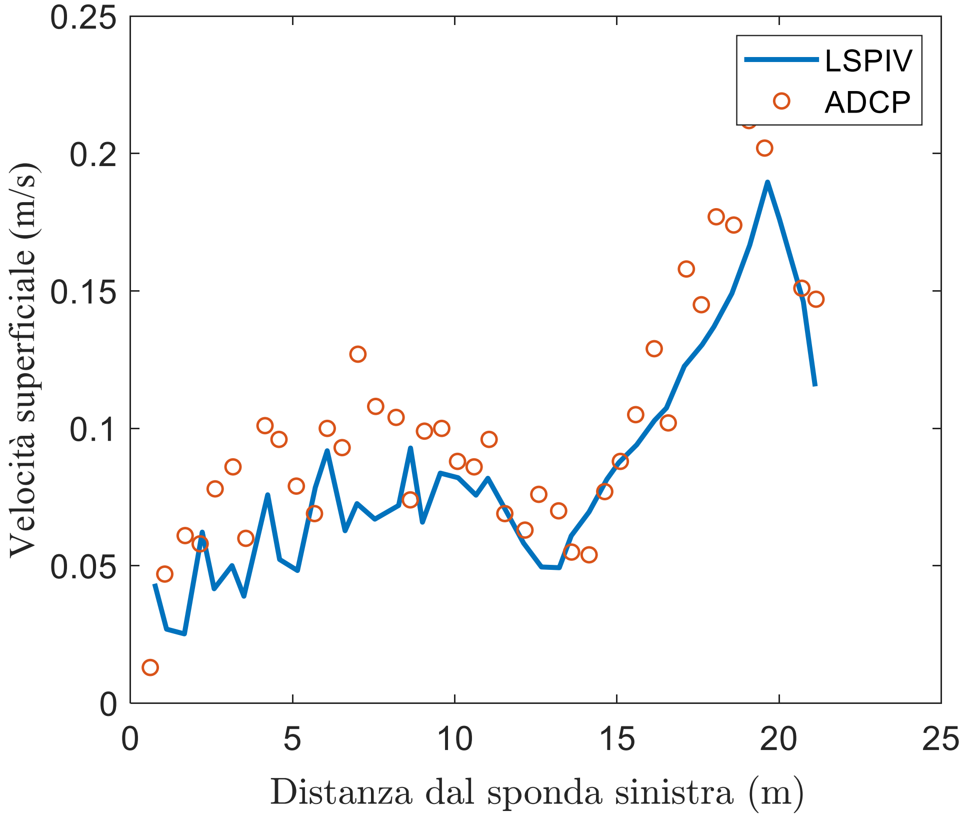
18 Stabilisation issues



Stabilisation for image velocimetry

VISION: VIdeo StabilisatION using automatic features selection for image velocimetry analysis in rivers





Sezione	Componente di Velocità	RMSE (m/s) Video non stabilizzato	RMSE (m/s) Video stabilizzato	Riduzione errore (%)
S1	v	0.07	0.06	8%
	u	0.02	0.02	-1%
	m	0.07	0.07	7%
S2	v	0.08	0.07	8%
	u	0.03	0.03	6%
	m	0.08	0.07	8%

Outline

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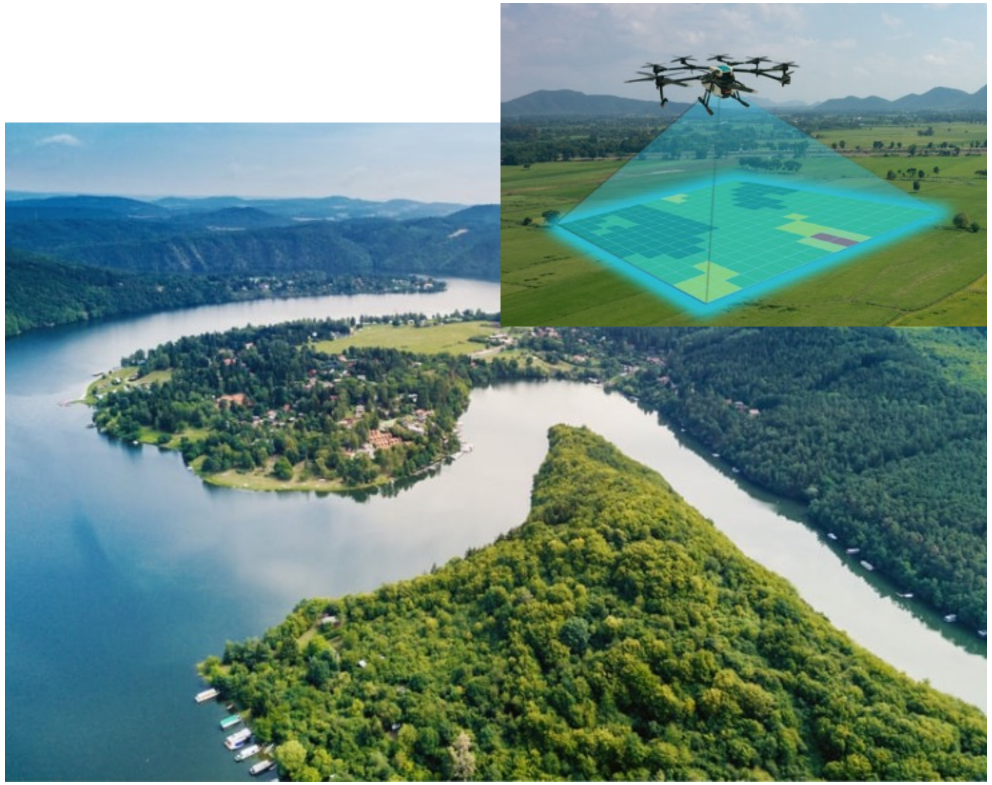


Water extent segmentation

21

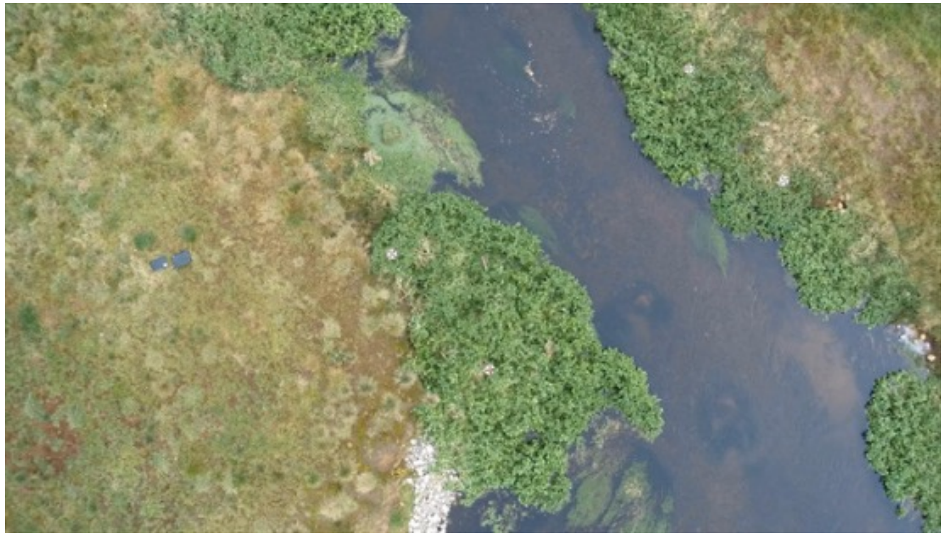
How do we (computers) see rivers?

Humans:

- Colour
- Sound
- Water movement
- etc

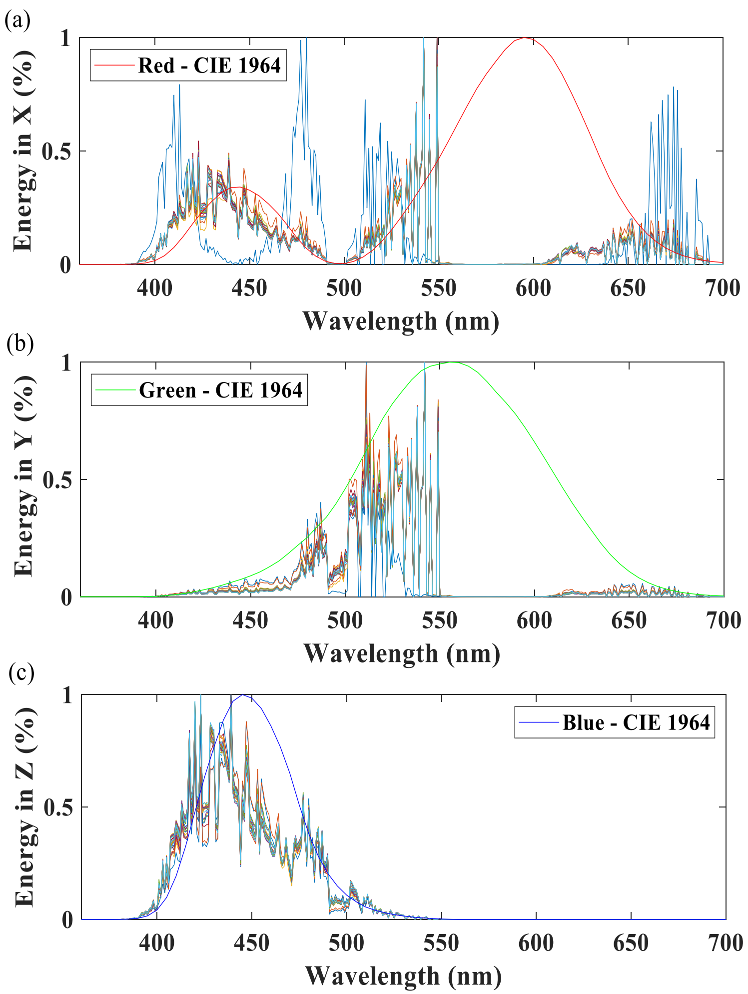
Computers:

- Ones & Zeros

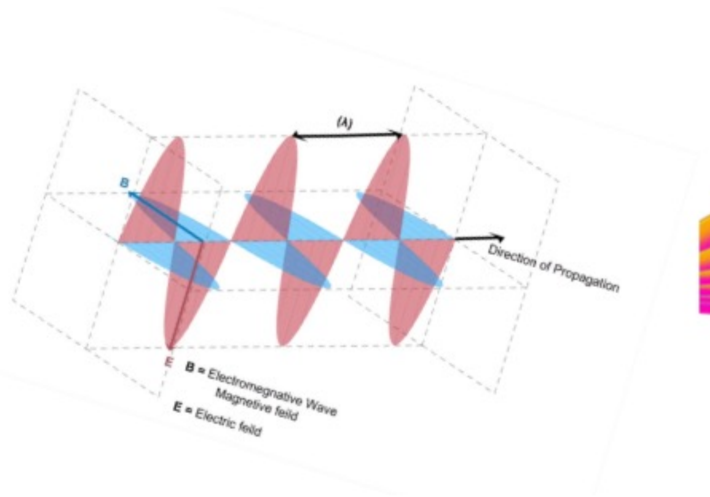


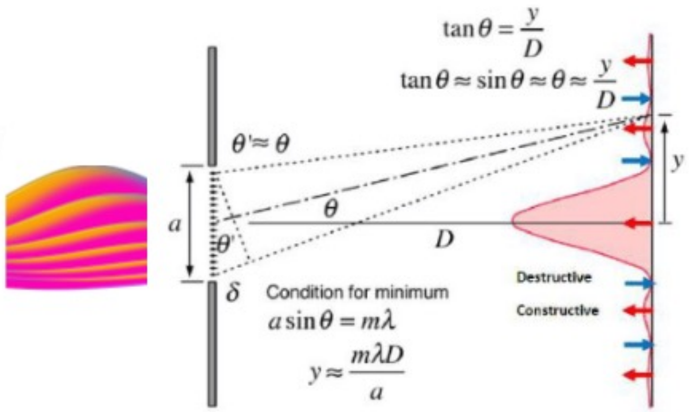
Water extent segmentation

Water extent segmentation by single slit diffraction correction?



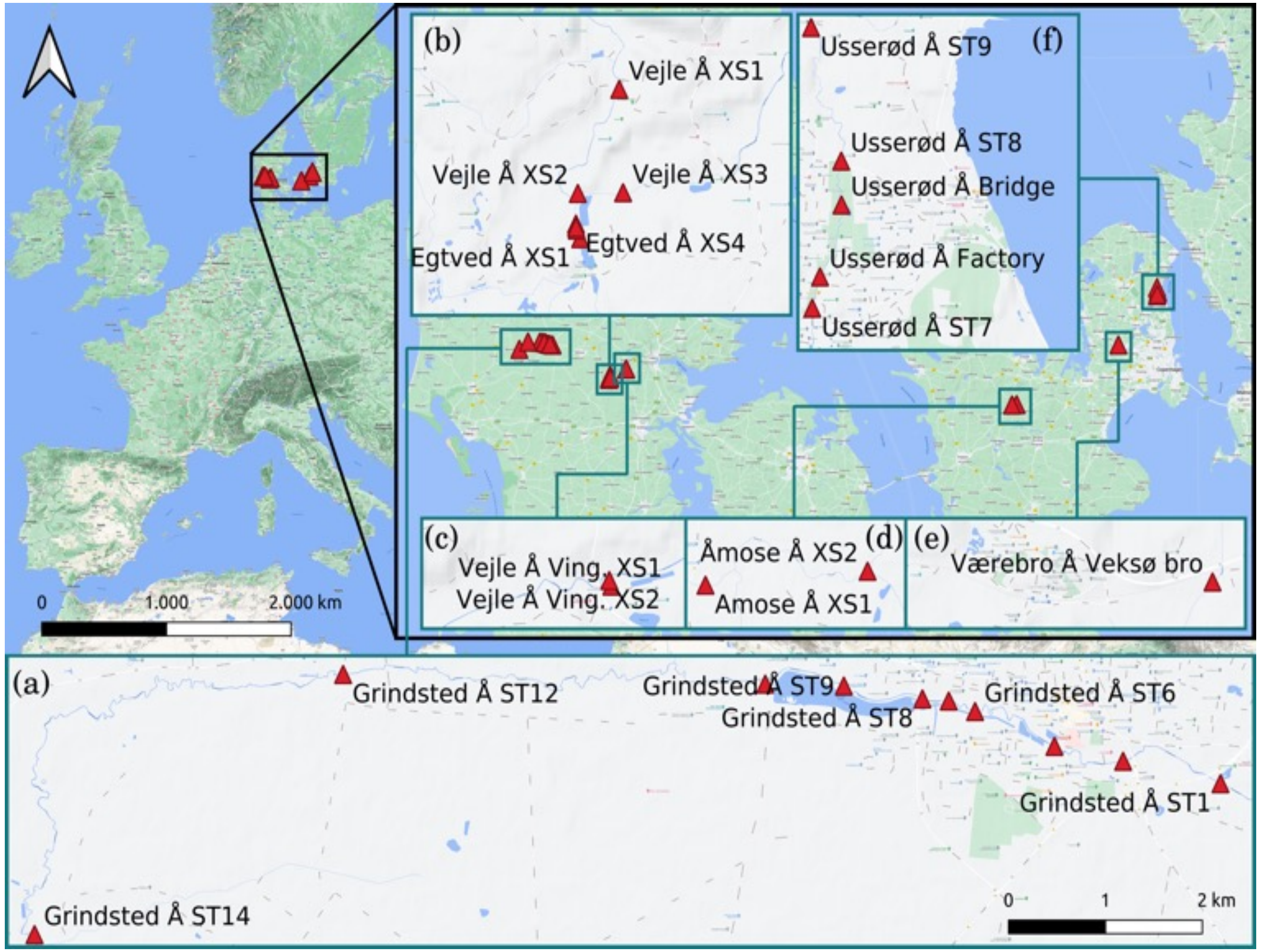
- Cameras are always affected by quantum interference
- CIE standard is a standardised way to represent colours
- What is acquired by the camara can be corrected to follow the CIE standard



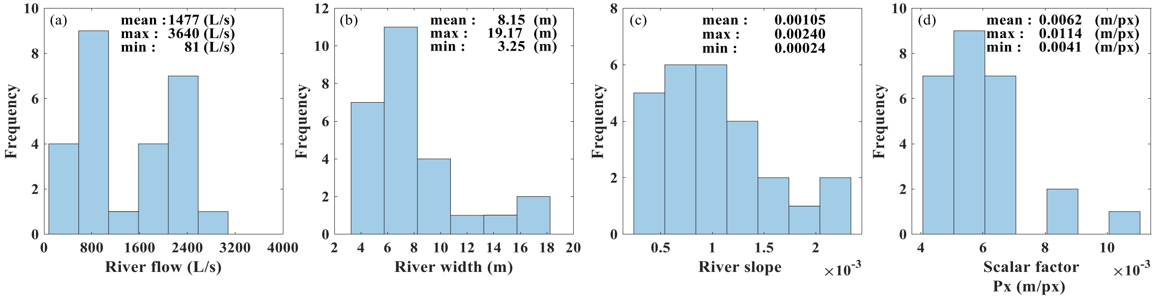


Water extent segmentation

Case studies to test the model

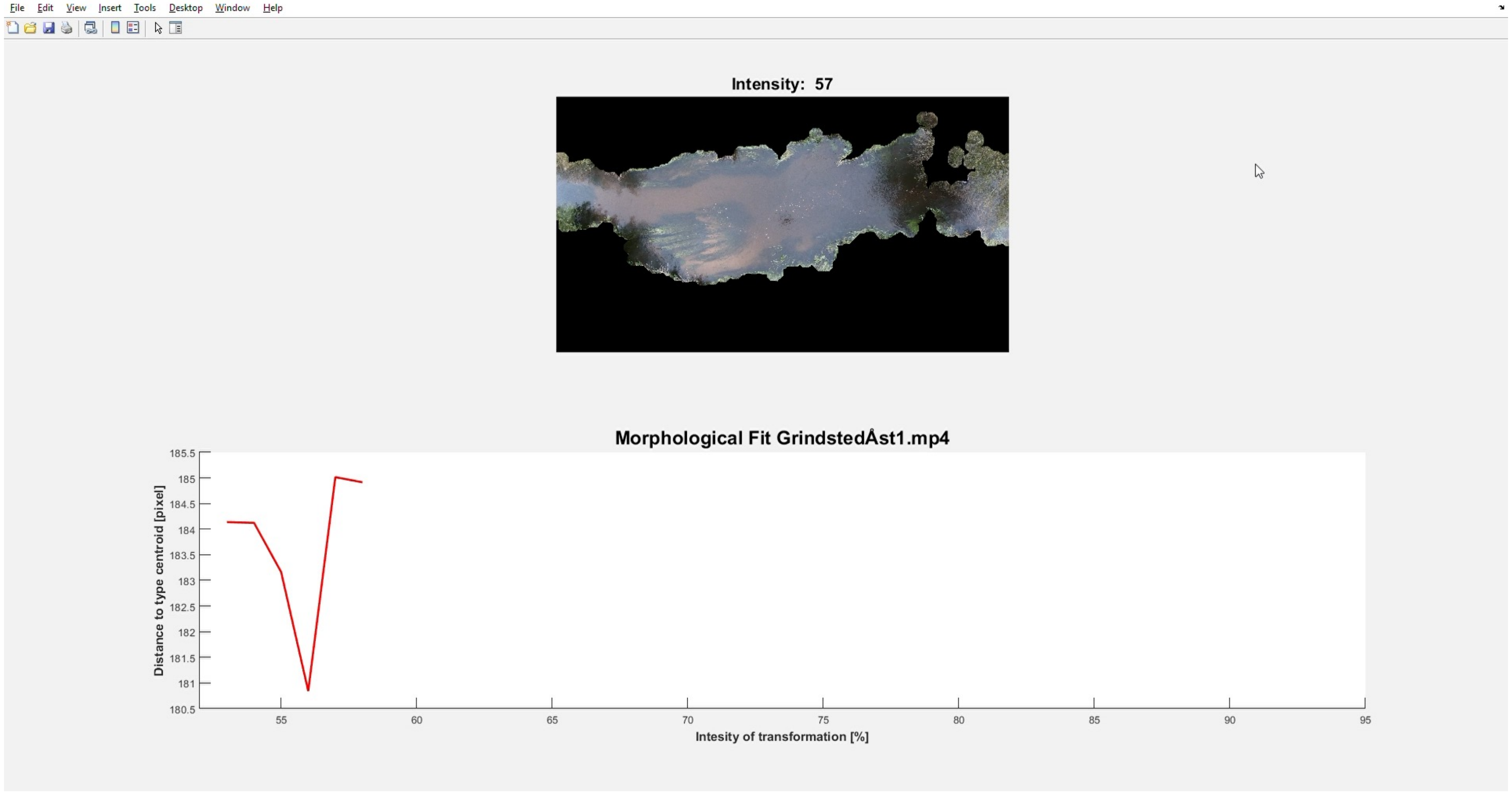


- 27 case studies located in Denmark
- Huge difference between them, e.g. Q ranges between 81 and 1477 L/s
- Riverbed in same cases has vegetation



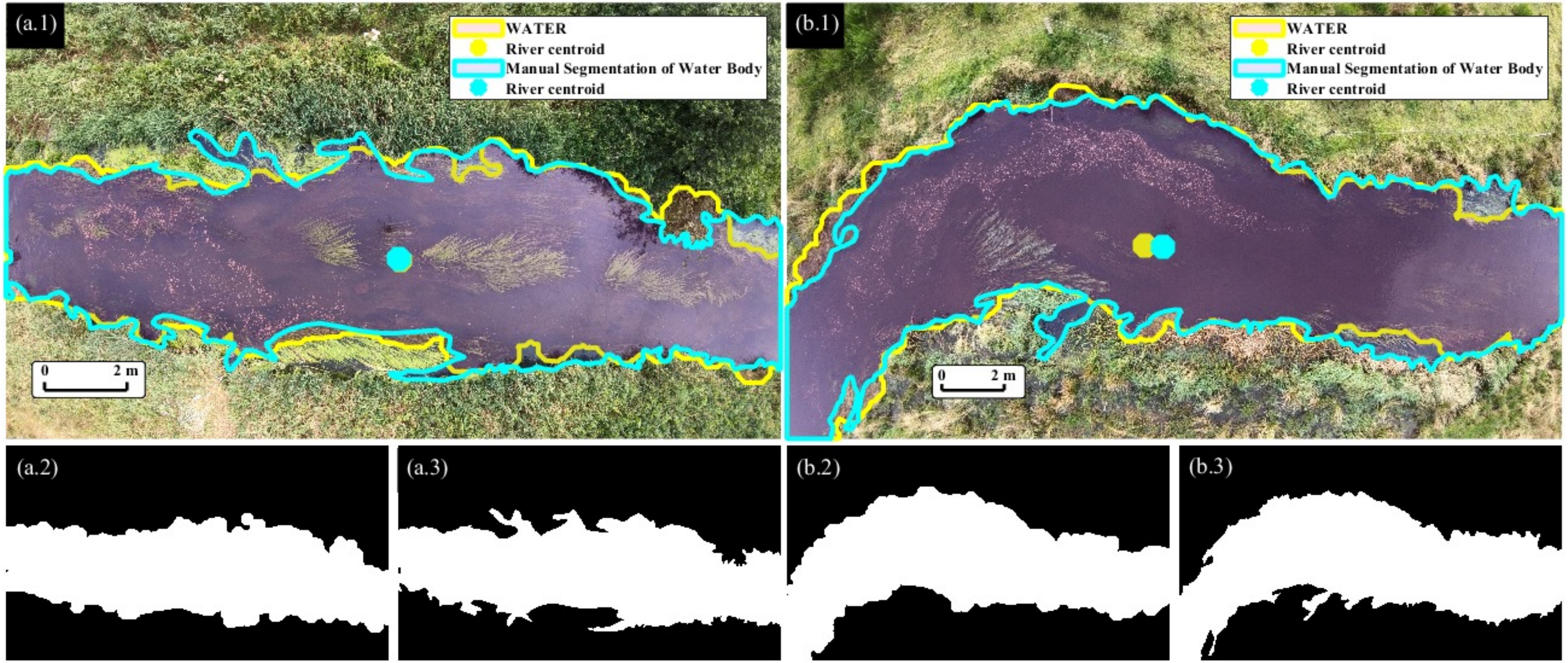
Water extent segmentation

Water **A**u**T**omatic s**E**gmentation in **R**ivers (WATER)



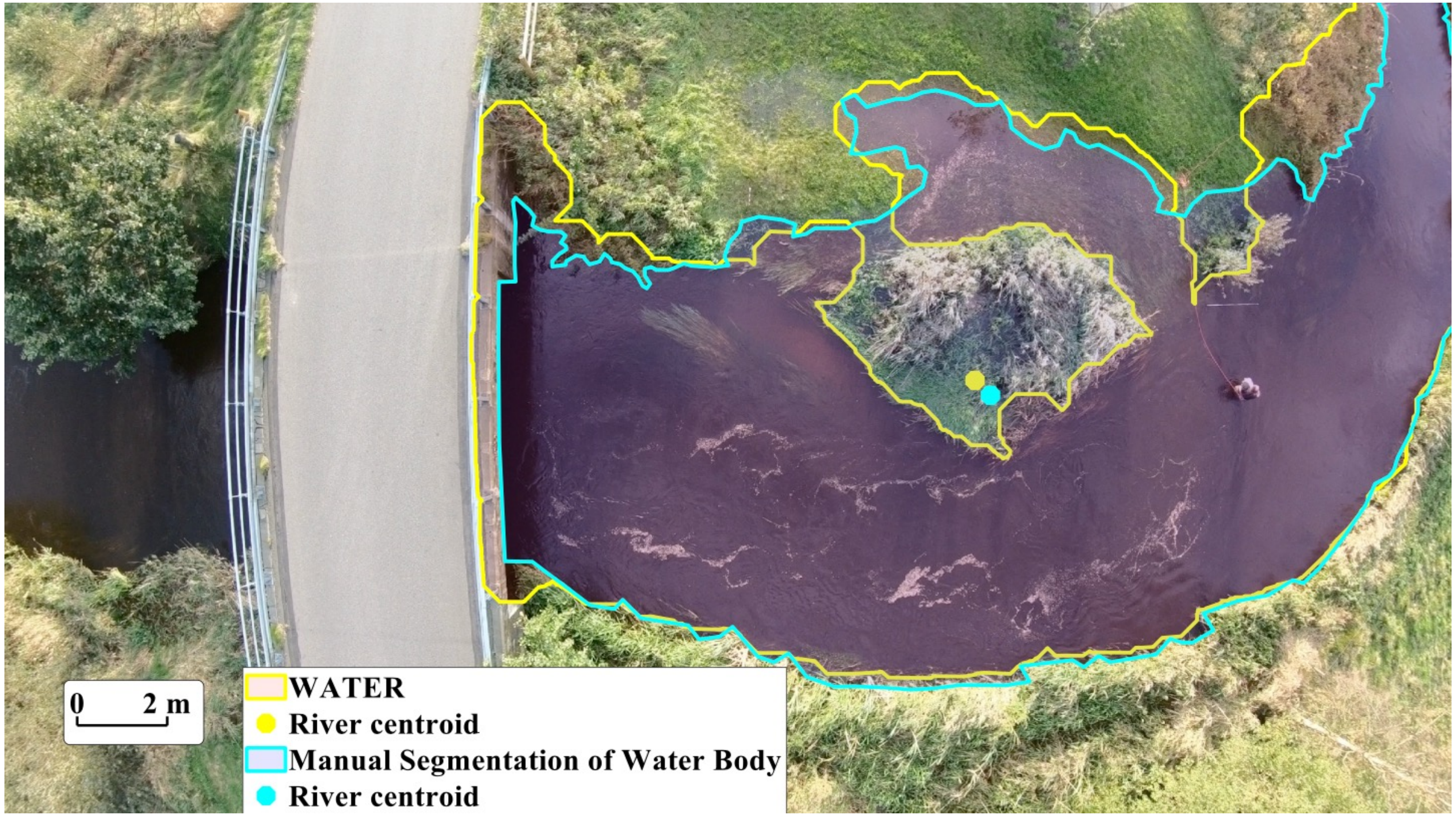
Water extent segmentation

Human (manually-based) vs Machine (automatic)

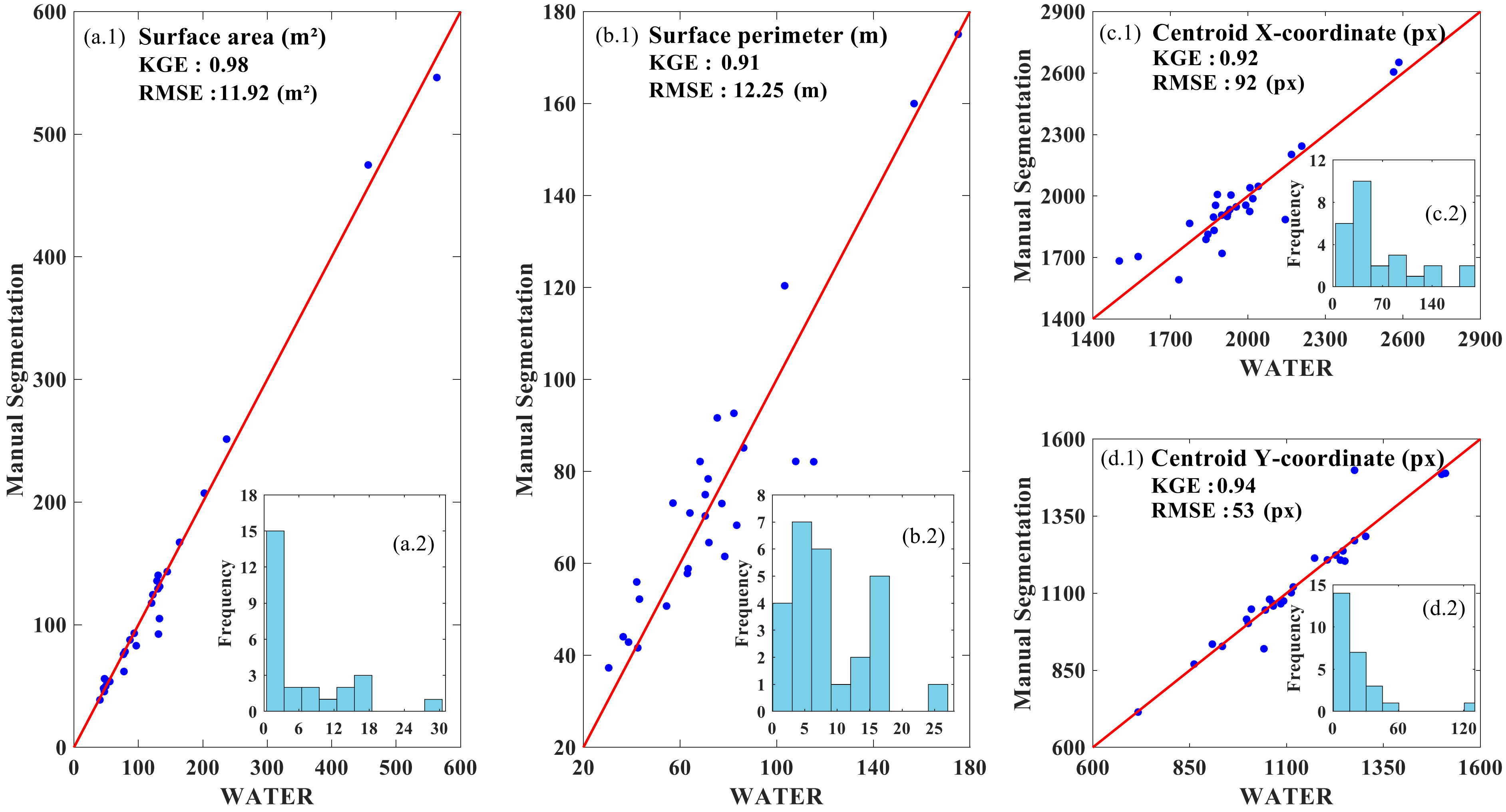


Water extent segmentation

What happen when a vegetated bar is in the middle of the river?

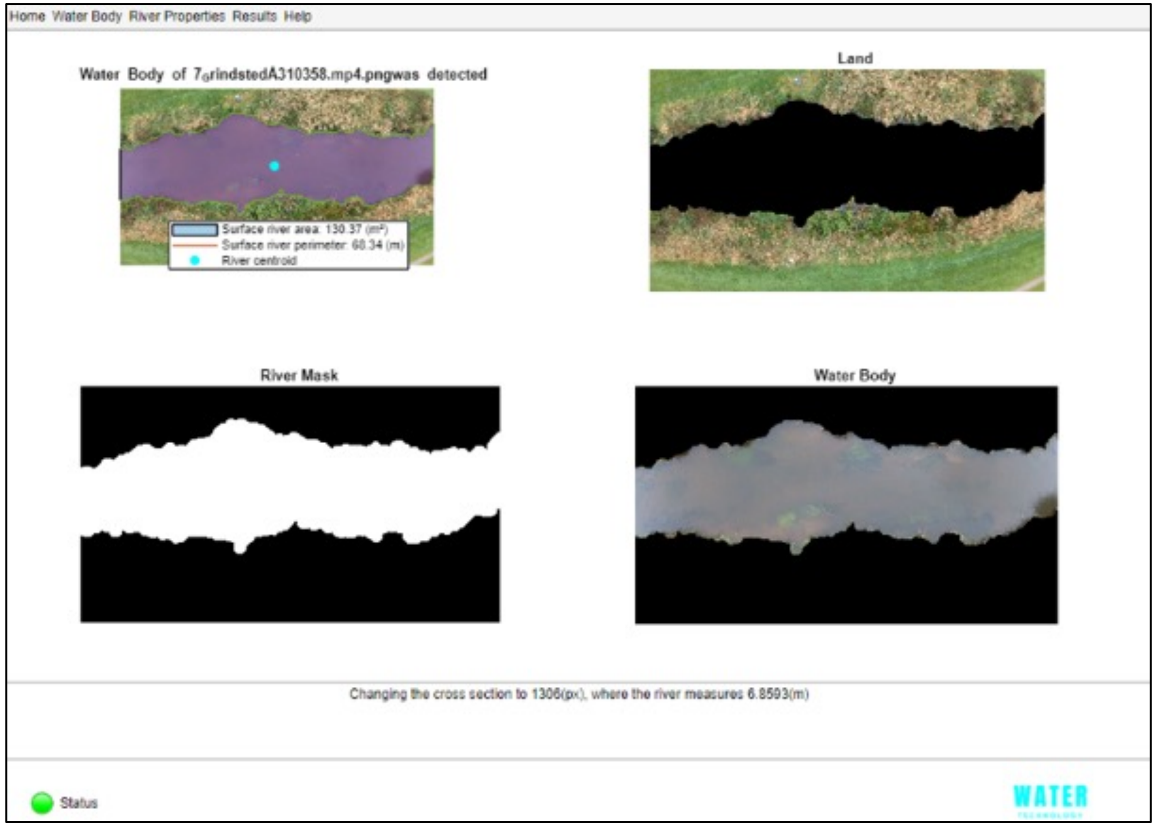


Water extent segmentation



Water extent segmentation

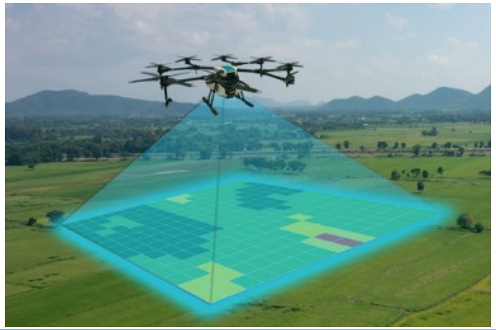
Software development and Graphical User Interface (GUI)



Main UAS limitations and Future perspectives

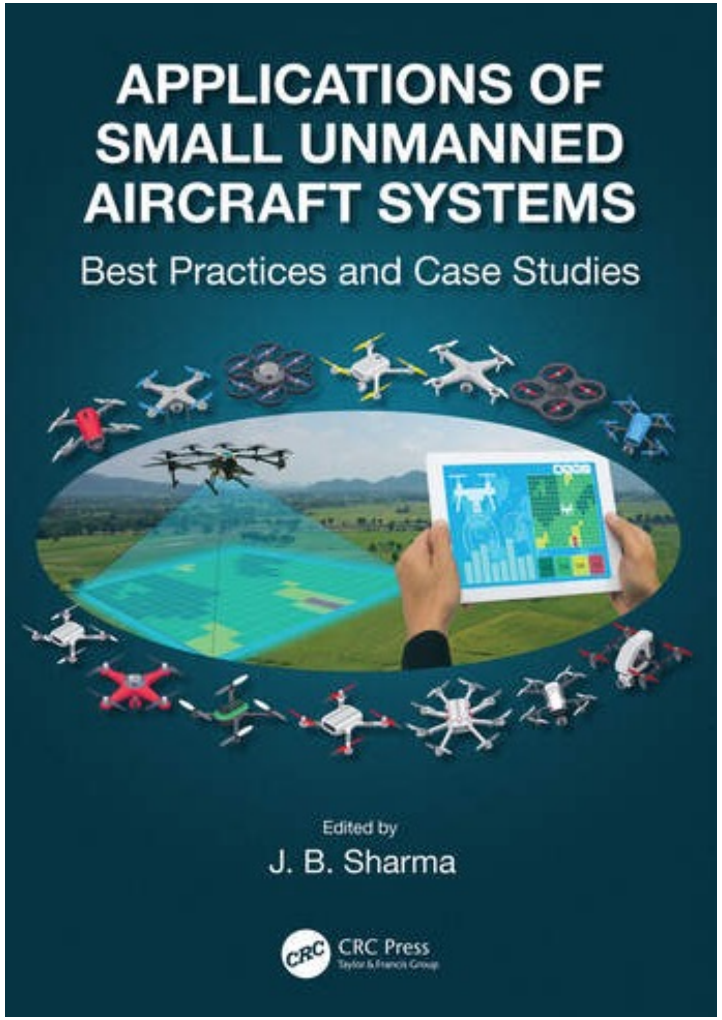
- UAS **maximum payload**, which limits the ability to use multiple sensors and communication hardware;

- National **flight regulations**, which limit the use of UAS, particularly in urban areas;
- The need for **continuous power supply** for frequent flight missions;



- The inability to fly in **extreme meteorological conditions**;
- The **amount of data** to manage.

UAS books (recommended)



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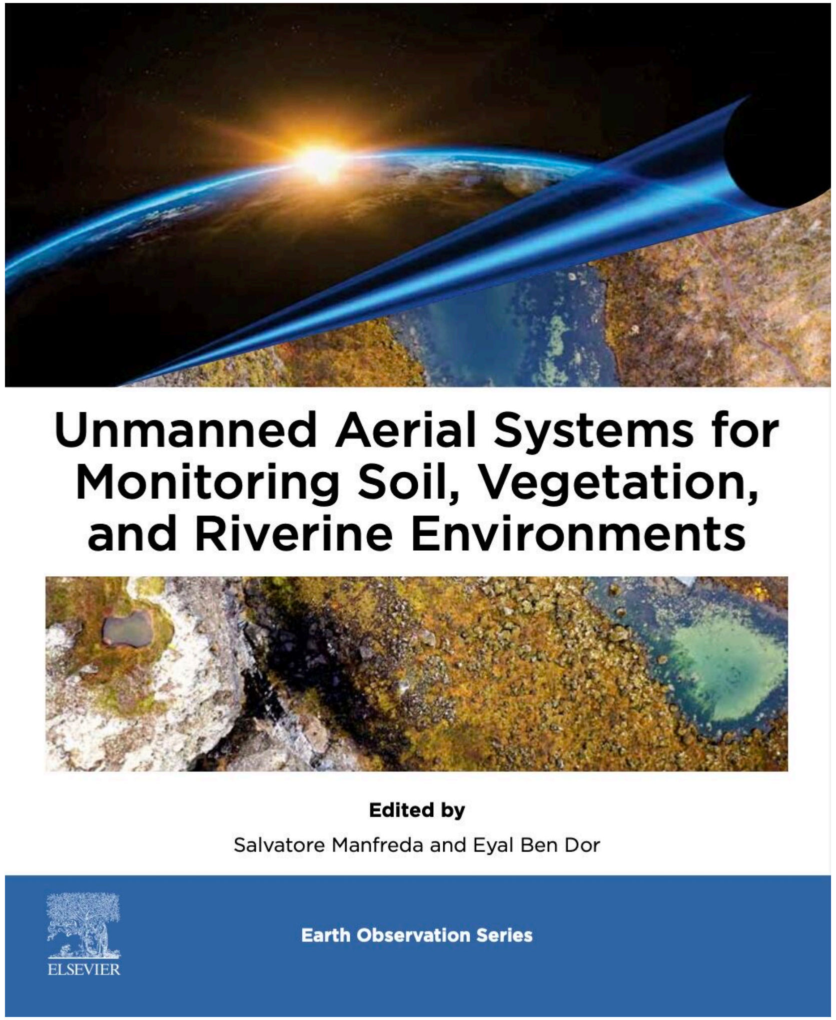
1st Edition - 2022
Best Practices and Case Studies
Edited By J.B. Sharma



Unmanned Aerial Systems for Monitoring Soil, Vegetation, and Riverine Environments
1st Edition - January 2023
Editors: Salvatore Manfreda, Ben Dor Eyal

Codes and Data availability (some of them!)

- Pizarro, A., Latorre, M. A. G., & Alcayaga, H. (2022, December 8). Automatic Segmentation of Water Bodies Using RGB Data: A Physically-Based approach. **https://doi.org/10.17605/OSF.IO/3JXFD**

- Pizarro, A., Dal Sasso, S. F., & Manfreda, S. (2022, March 1). VISION: VIdeo StabilisatION using automatic features selection. **https://doi.org/10.17605/OSF.IO/HBRF2**

- Dal Sasso SF, Pizarro A, Pearce S, Maddock I, Manfreda S. 2021. Increasing LSPIV performances by exploiting the seeding distribution index at different spatial scales (Version 0.1). [codes] OSF. **https://doi.org/10.17605/OSF.IO/3AJNR**

- Pizarro, A., Dal Sasso, S. F., & Manfreda, S. (2020, September 28). Refining image-velocimetry performances for streamflow monitoring: Seeding metrics to errors minimisation. **https://doi.org/10.17605/OSF.IO/B7EAW**

- Pizarro, A., Dal Sasso, S. F., Perks, M. T., and Manfreda, S. 2020. Identifying the optimal spatial distribution of tracers for optical sensing of stream surface flow (Version 0.1), [codes], OSF, **https://doi.org/10.17605/OSF.IO/8EGQW**

References & Recommended papers [1/2]

- Bandini, F., Olesen, D., Jakobsen, J., Kittel, C. M. M., Wang, S., Garcia, M., and Bauer-Gottwein, P.: Technical note: Bathymetry observations of inland water bodies using a tethered single-beam sonar controlled by an unmanned aerial vehicle, Hydrol. Earth Syst. Sci., 22, 4165–4181, 2018
- Dal Sasso, Pizarro, A.et al. (2021) "Increasing LSPIV performances by exploiting the seeding distribution index at different spatial scales". Journal of Hydrology, 598, 126438. https://doi.org/10.1016/j.jhydrol.2021.126438
- Dal Sasso, S. F., A. Pizarro, C. Samela, L. Mita, and S. Manfreda, Exploring the optimal experimental setup for surface flow velocity measurements using PTV, Environmental Monitoring and Assessment, 190:460, (doi: 10.1007/s10661-018-6848-3) 2018.
- Dal Sasso, S. F., Pizarro, A.et al. (2020)"Metrics for the Quantification of Seeding Characteristics to Enhance Image Velocimetry Performance in Rivers". Remote Sensing, 12(11), 1789; https://doi.org/10.3390/rs12111789
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Thanks for your attention!

Questions?