EWRA 2025

24 – 28 JUNE 2025
Palermo, Italy

XIII WORLD CONGRESS
of the European Water Resources Association

New challenges in understanding and managing water-related risks in a changing environment

How to Monitor River Turbidity Using Camera Systems: Best Practice Guidelines

Authors:
D. Miglino[1*],
S. Jomaa[2], K.C. Saddi[1,4,5],
A.C. Moe[1,4], M. Rode[2,3],
and S. Manfreda[1]

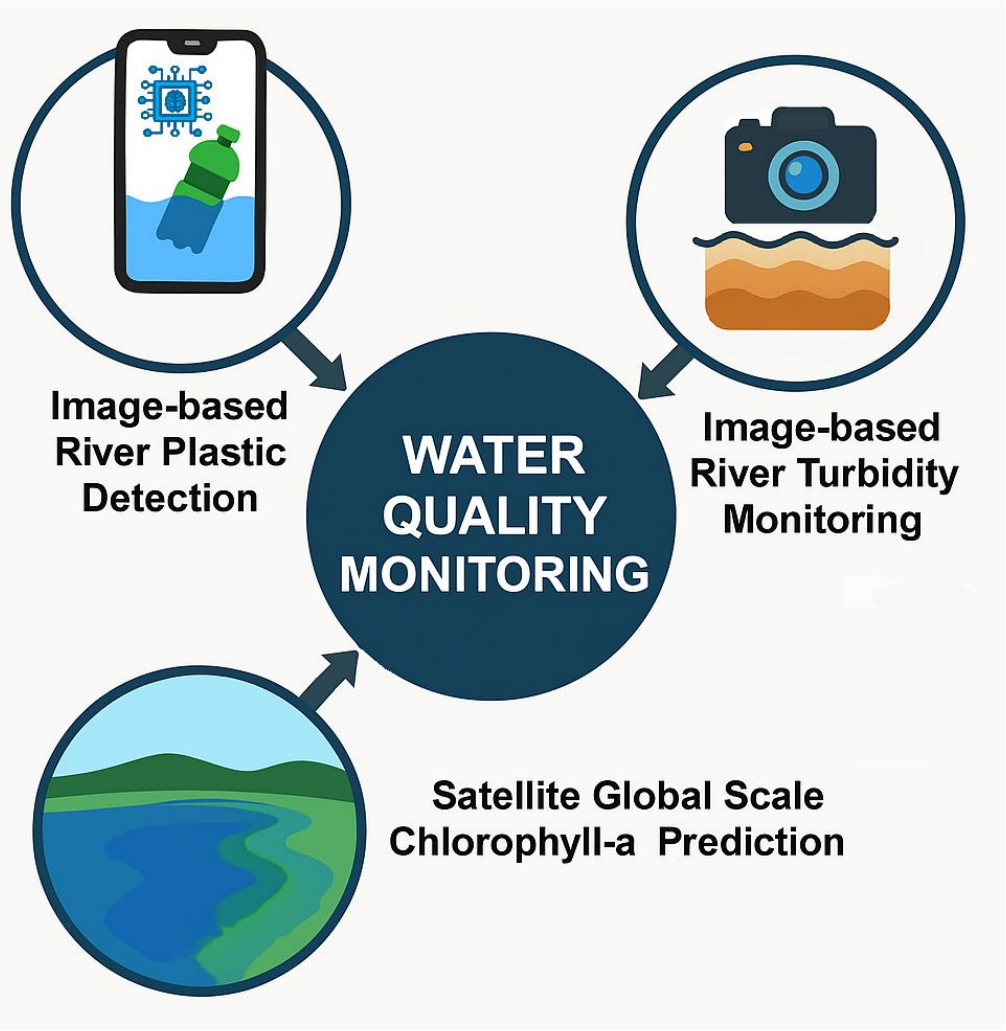
*Corresponding author email

EWRA

Università degli Studi di Palermo

HYCLIC
Hydrology & Climate Change Impacts Lab

Research framework



RiverWatch

OURMED
OUR NATURE OUR FUTURE

https://doi.org/10.5194/egusphere-2024-2172
Preprint. Discussion started: 6 September 2024

EGUsphere
Preprint repository

Technical note: Image processing for continuous river turbidity monitoring - full scale tests and potential applications

Domenico Miglino[1], Khim Cathleen Saddi[1,5,6], Francesco Isgrò[4], Seifeddine Jomaa[2], Michael Rode[2,3], and Salvatore Manfreda[1]

(in press on HESS Journal)

Advancing river monitoring using image-based techniques: Challenges and opportunities

Salvatore Manfreda, Domenico Miglino, Khim Cathleen Saddi, Seifeddine Jomaa, Anette Eltner, Matthew Perks, ...show all
Received 07 Nov 2023, Accepted 27 Feb 2024, Accepted author version posted online: 21 Mar 2024
Cite this article https://doi.org/10.1080/02626667.2024.2333846 Check for updates

Overview of Hydrolab group activities in water quality monitoring

HydroLAB

Why turbidity?

Turbidity is a key indicator of water quality, reflecting the presence of suspended solids, organic matter, and floating pollutants.

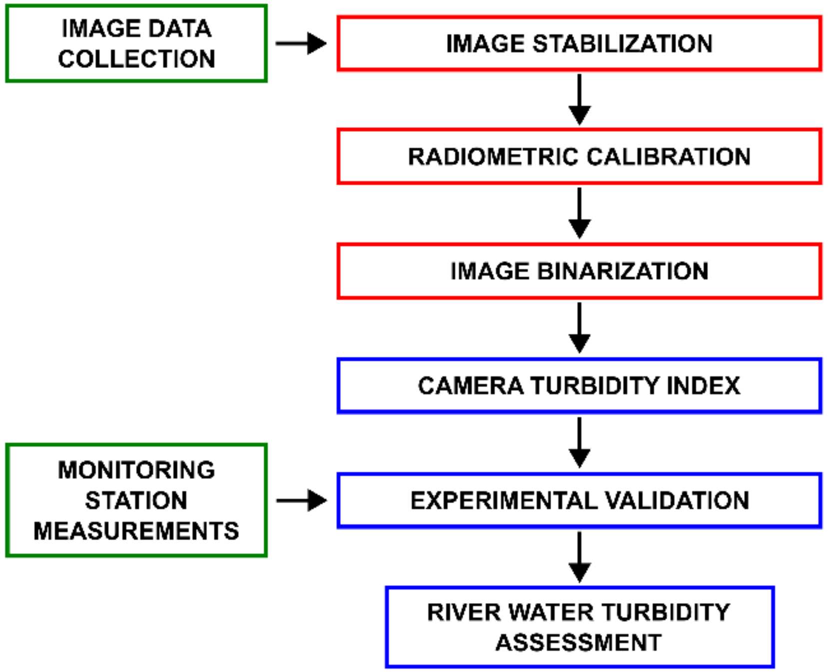
.

Why camera?

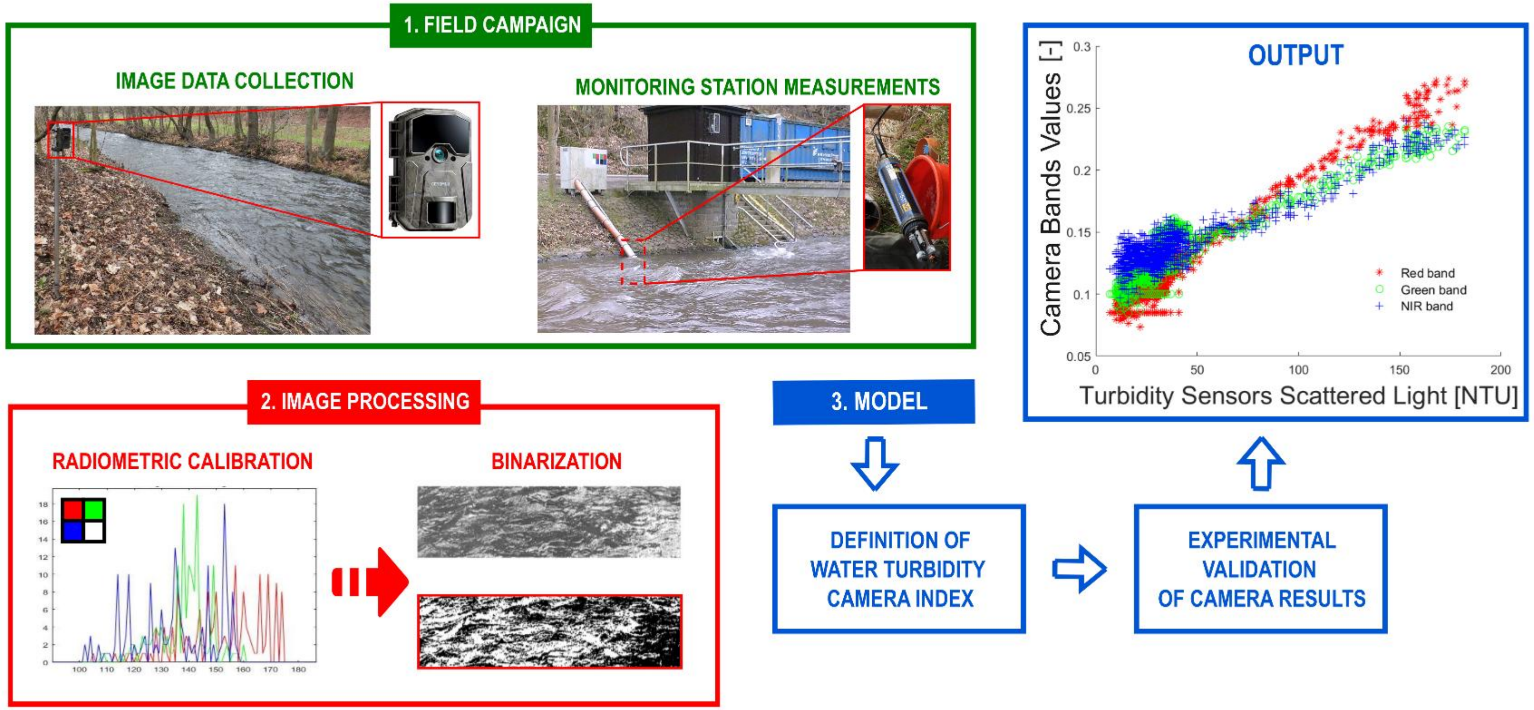
Hydrological monitoring constraints:

- Data scarcity and limitations
- Spatial and temporal variability
- Increasing demands for water resources

Why image processing is important?



Work flow of the camera turbidity monitoring procedure

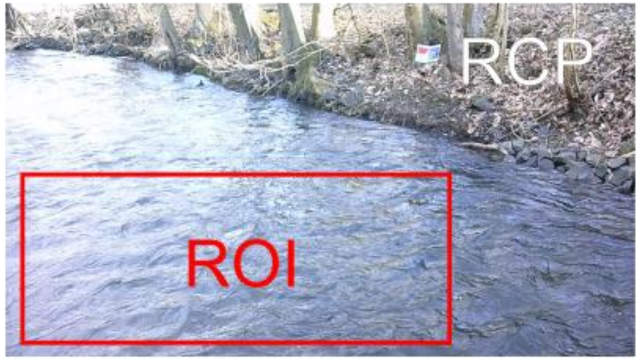


Graphical abstract of the procedure for the image-based river turbidity monitoring

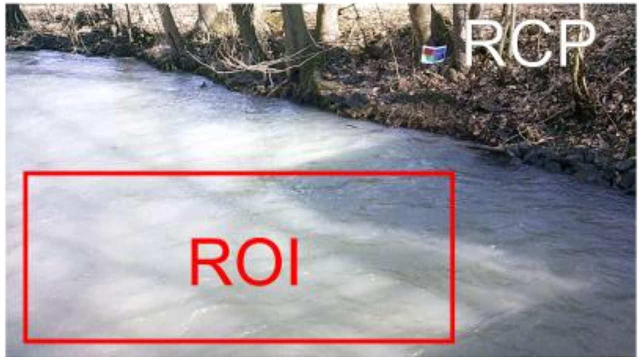
Real scale experiments of river turbidity monitoring

GERMANY 02/2023 | GERMANY 06/2023 | TUNISIA 05/2025

MONITORING START

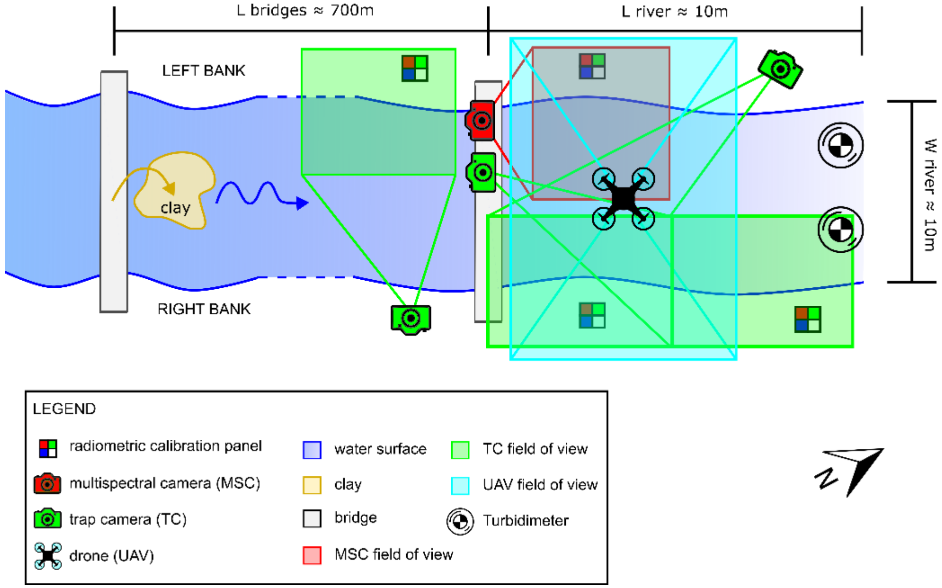


TURBIDITY PEAK

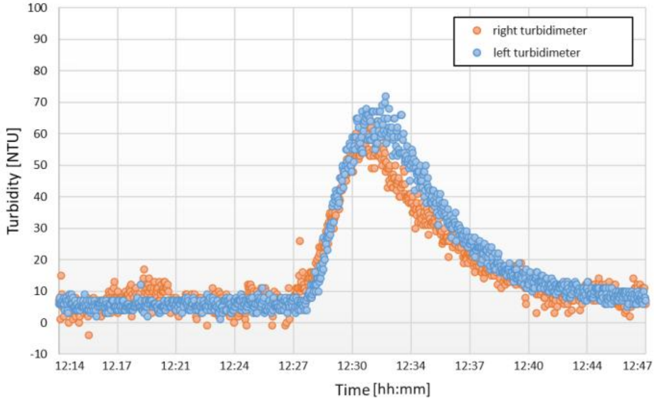


First experiment (Germany): Focus on camera types and installation setup

In this experiment **one synthetic turbidity event** has been generated, increasing the level of turbidity by using natural clay as a tracer. The monitoring has been carried out by using a **trap camera**, a **multispectral camera** and a **drone** to optimize the on-site installation setups and the camera settings, in terms of location, view angle, resolution and wavelength. The camera data has been validated by UFZ **turbidity sensors**, installed in the river.

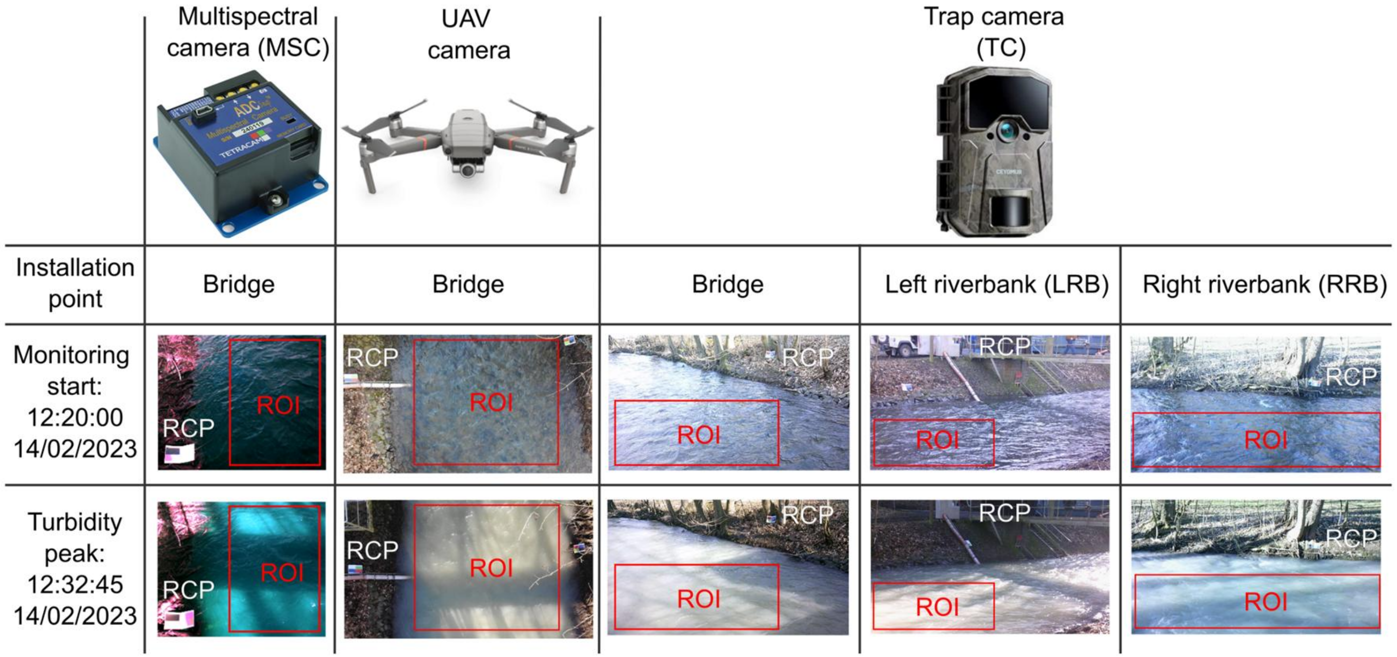


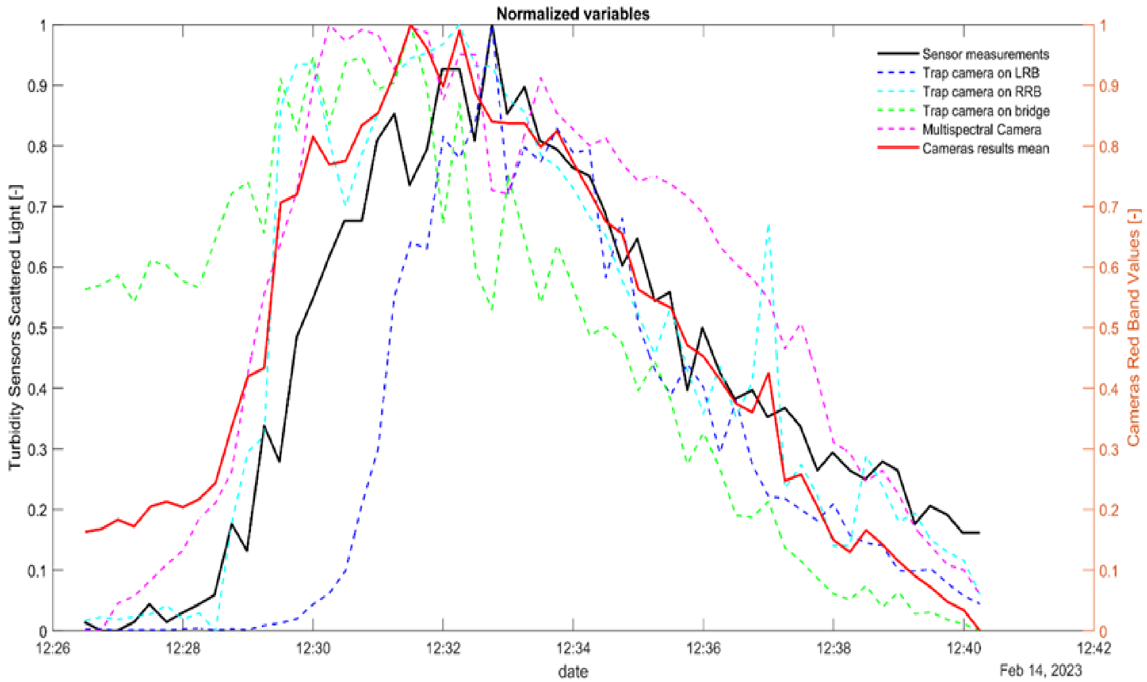
Plan of the river section for the experiment in Meisdorf monitoring station



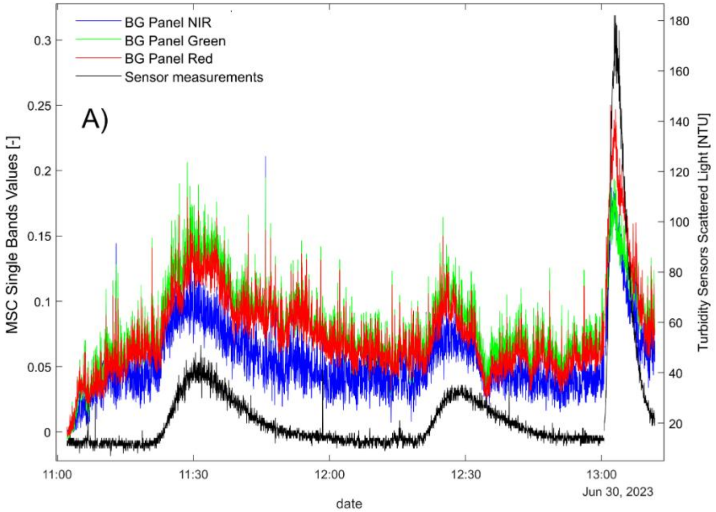
First experiment (Germany): Focus on camera types and installation setup

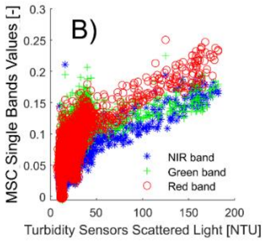
EWRA 2025

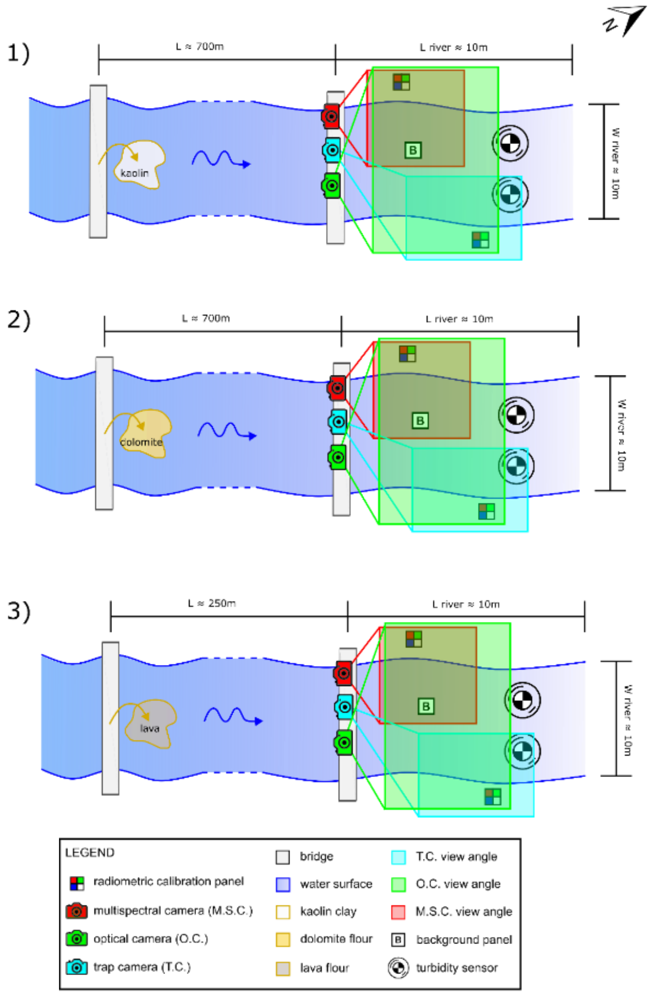


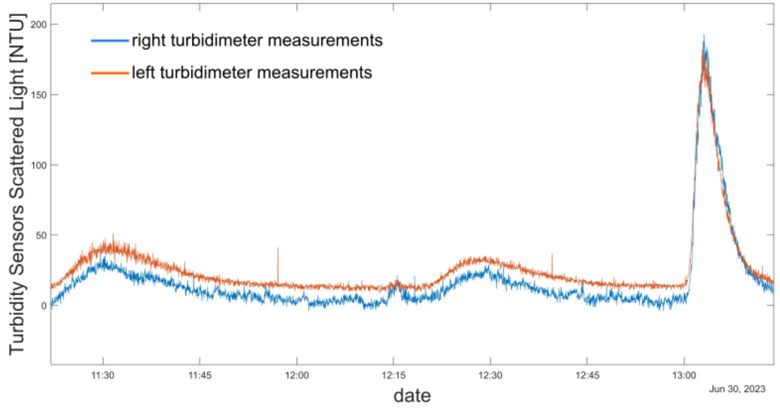


Second experiment (Germany): Focus on varying the turbidity event characteristics





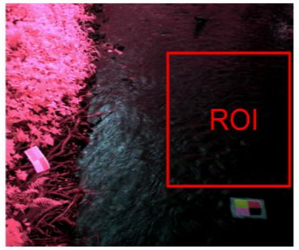




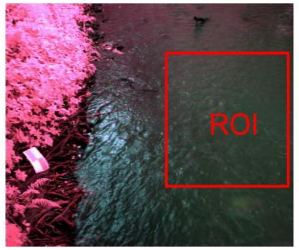
Second experiment (Germany): Focus on varying the turbidity event characteristics

Multispectral Camera

monitoring start: 30-Jun-2023 11:02



main turbidity peak: 30-Jun-2023 13:03



Trap Camera

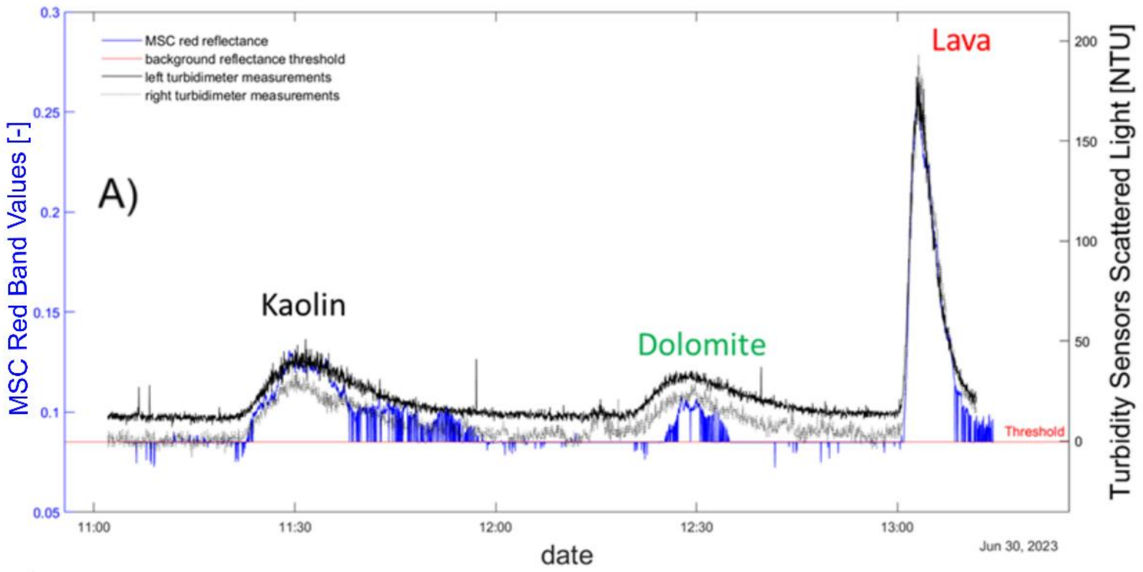
monitoring start: 30-Jun-2023 11:15

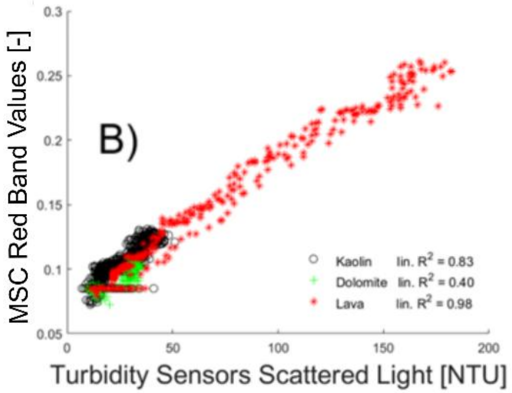
main turbidity peak: 30-Jun-2023 13:03

Digital Camera

monitoring start: 30-Jun-2023 11:23

main turbidity peak: 30-Jun-2023 13:03





Third experiment (Tunisia): Work in progress… stay tuned

What we understood

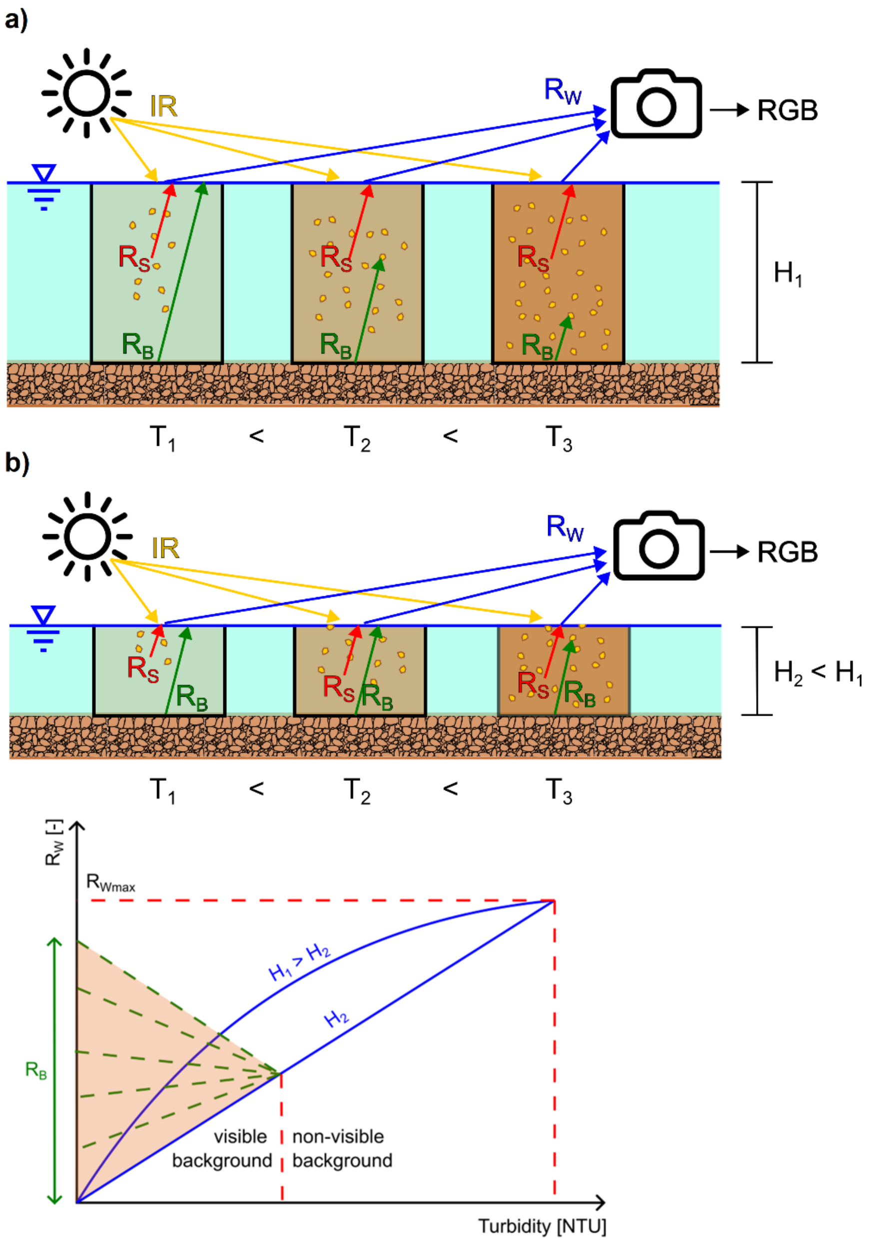
- Significant **variations in illumination** cause notable differences in reflectance across days and seasons.
- Changing sun direction and resulting **shadows** alter the scene during the day.
- **Flow conditions** and ripples may affect the water reflectance.
- Suspended **sediment color variations** can also impact the camera signal.

What we understood

- Significant **variations in illumination** cause notable differences in reflectance across days and seasons.
- Changing sun direction and resulting **shadows** alter the scene during the day.
- **Flow conditions** and ripples may affect the water reflectance.
- Suspended **sediment color variations** can also impact the camera signal.
- Wind, human activity, or animal presence might disrupt **camera positioning** or even induce vibrations.

What we understood

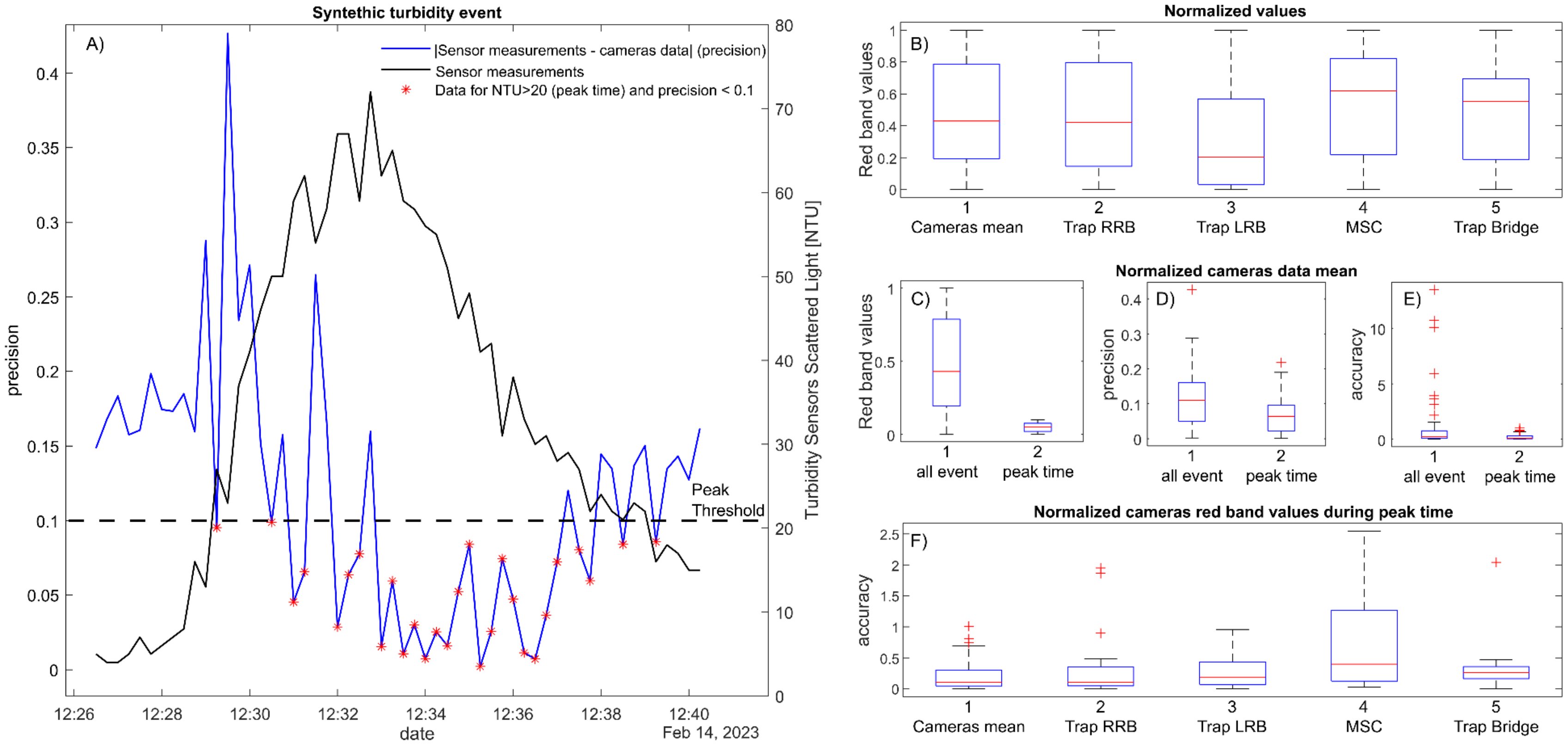
- Significant **variations in illumination** cause notable differences in reflectance across days and seasons.
- Changing sun direction and resulting **shadows** alter the scene during the day.
- **Flow conditions** and ripples may affect the water reflectance.
- Suspended **sediment color variations** can also impact the camera signal.
- Wind, human activity, or animal presence might disrupt **camera positioning** or even induce vibrations.
- The effect of **riverbed background reflectance** must be taken in account, especially in shallow waters



Cameras can be seen as three-band radiometers, able to measure the water-leaving spectral response.
The actual **water upwelling light** that reaches the camera lens, schematically shown in the figure, it's the **sum of various reflectance components** of the suspended particles, the riverbed background and the water itself.
One component could prevail over the others, depending on the **variability of hydrological** (water level, flow velocity, etc..) **and environmental** (total suspended solids concentration, floating pollutants, etc..) **characteristics of the river**.
Digital cameras receive these inputs and return a signal in terms of **pixel intensity values** in the red, green, blue or other non-visible bands.

What we understood

- Significant **variations in illumination** cause notable differences in reflectance across days and seasons.
- Changing sun direction and resulting **shadows** alter the scene during the day.
- **Flow conditions** and ripples may affect the reflectance.
- Suspended **sediment color variations** can also impact the camera signal.
- Wind, human activity, or animal presence might disrupt **camera positioning** or even induce vibrations.
- The effect of **riverbed background reflectance** must be taken in account, especially in shallow waters
- **Higher the turbidity, more reliable the procedure**, in the range investigated.



Plots of results precision (A, D) and accuracy (E, F) for each camera (B), considering the entire turbidity event and only the peak time (C, D, E, F).

Implication in river monitoring practices

- The **added value** of the study lies in the development of a river monitoring procedure that can be **directly implemented on-site**, without spatial and temporal limitations of data acquisition

- By providing a **near real-time**, continuous, and automated system for water turbidity assessment, this research contributes to the ability to **track fast changes in response to environmental events**, such as flash floods or pollution incidents

- The broad adoption of this procedure could enhance **understanding of ecohydrological dynamics at basin-scale**

Conclusions

- **Image processing can effectively provide water turbidity trends** using cameras, as demonstrated by real-scale experiments in Germany

- Results highlight a **significant match** between camera indexes and turbidity sensor measurements, **especially for high turbidity levels**

- **Long-term data** reflects greater variability than short-term data in changing hydrological and environmental conditions

- **Ongoing experiments** are assessing the effects of river sections, background, temporal windows, sediment composition, camera types and settings on method replicability

- In particular, the proper image decomposition of the **reflectance components of riverbed background, especially for shallow waters**, and the water itself can be crucial for implementing the reliability of the procedure for long-term monitoring practical applications

Thank you for your attention