



FRM4DRONES
fiducial reference
measurements
for water using
drones



The workshop will begin in a few minutes.

To help keep the session structured and smooth, we kindly ask that you:

- Mute your microphones during presentations
- If you have questions, post them in the chat and tag the presenter using @
- Turn on your camera when speaking

Active participation in a respect way is encouraged.



Welcome to the first FRM4Drones -AQUA Workshop





Practical Info & House Rules

- The session is being recorded for internal use only – it will not be distributed
- Questions during presentations ?
 - Use the chat – presenters will answer there
- After the presentations:
 - Interactive session with polls and open discussion
 - Use the “Raise Hand” function to speak
 - Please mute your microphone when not speaking
 - Use your camera when speaking, if possible
- We encourage active participation !

Have a great meeting !



Online Workshop: Data Acquisition and Processing Protocols

Wednesday, June 11, 2025 | 15:00 - 17:00 CET



FRM4DRONES-AQUA

Towards FRM drone data
for satellite aquatic
reflectance Cal/Val





Workshop Agenda

- Welcome & Round-the-table – *5 min*
- FRM4Drones-AQUA Introduction – *10 min*
- Expert Presentations – *60 min*
- Polls & Questionnaires – *10-15 min*
- Break - *5 min*
- Feedback Poll & Open Discussion – *20 min as needed*





Welcome – Workshop objectives

- Share expertise on drone-based aquatic reflectance and Cal/Val
- Identify needs and user practices
- Shape the roadmap towards Fiducial Reference Measurements (FRM) from drones for aquatic Cal/Val

1st WS on data acquisition & processing protocol

2nd WS on Uncertainty & Traceability (date to be announced)





Let's Get to Know the Audience

No round-the-table –
instead, live poll questions

Options to join :

- 1) Link to poll in chat
- 2) Scan QR code with mobile
- 3) Go to : [menti.com](https://www.menti.com); Code: 5667 0260
- 4) Go to

<https://www.menti.com/algznkxmvpn3>





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Drones for water applications

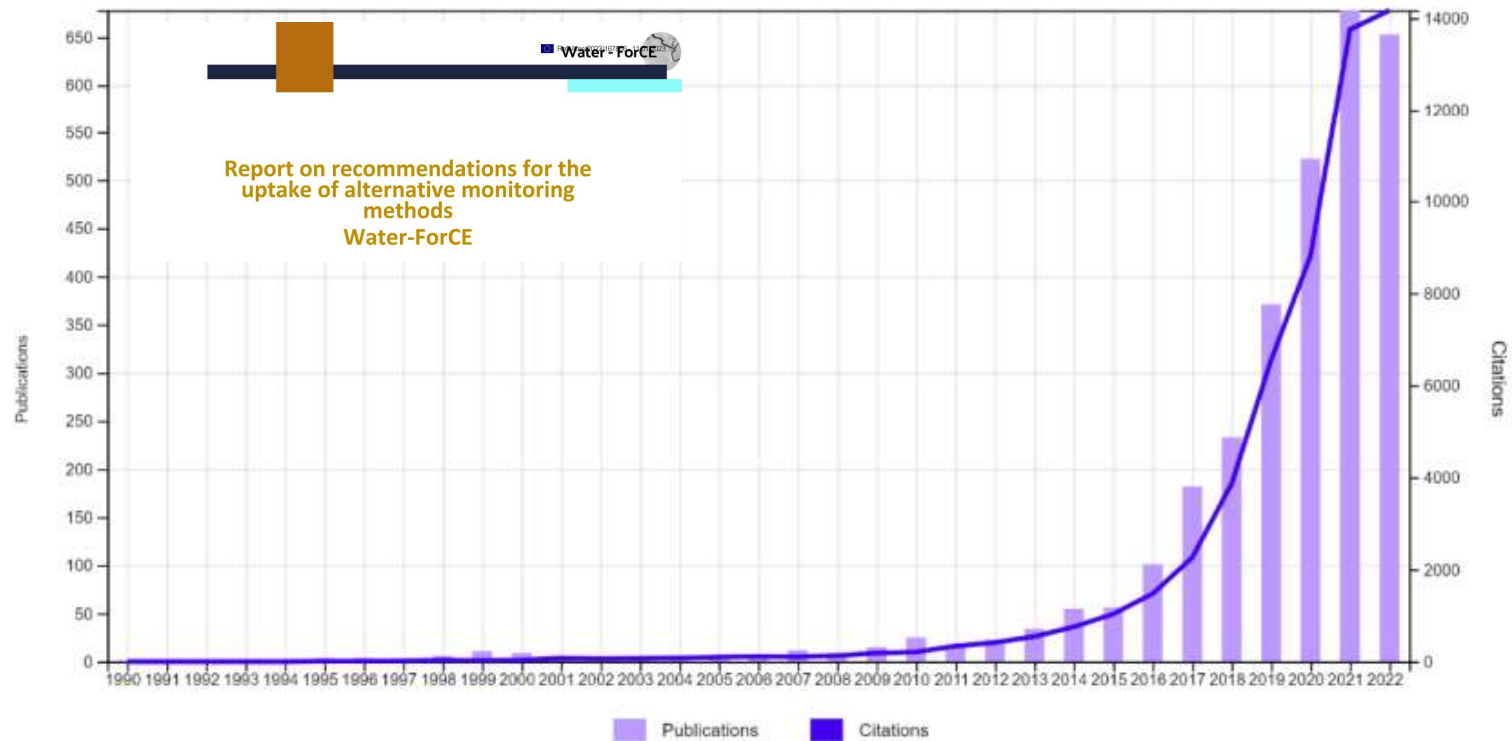


Figure 3. Results for the literature search 1. ("Drone" or "UAV" or "UAS") & "water".



Enhancing Satellite Cal/Val with Aerial Drones

Traditional in-situ Cal/Val

From ships, fixed stations (e.g., AERONET-OC, HYPERNET)

Limitations:

- Limited spatial coverage
- Representativeness issues for satellite pixel scale

Aerial Drones as a Complementary Solution:

- Assess the spatial & temporal variability surrounding fixed stations
 - ✓ Improves understanding of how representative point measurements are at satellite scale
- Aerial drones to conduct transects from the shoreline to the open sea
 - ✓ Supports validation of atmospheric correction algorithms (e.g., adjacency effects)



A holistic approach combining traditional in situ methods with drone observations improves the accuracy and reliability of satellite Cal/Val processes





Cal/Val reference data needs “FRM-label”

Cal/Val of satellite products requires high-quality in situ measurements, referred to as [Fiducial Reference Measurements \(FRM\)](#).

Before a measurement can be labelled as FRM, it should:

- be accompanied by an **uncertainty** budget,
- adhere to openly available measurement **protocols and community-wide practices**
- have documented evidence of International **System of Units (SI) traceability**
- be **independent** of the satellite retrieval process.

Ruddick et al. (2019)





FRM4VEG



fiducial reference
measurements
for vegetation

FRM4Veg considerations



Transferable Concepts:

- Calibration transfer & traceability
- Uncertainty quantification (metrology-based)
- Flight planning & execution (to some extent)

Limitations:

- No reference panels on water
- Sun/sky glint requires new corrections
- No GCPs on water for georeferencing
- Water dynamics require precise timing with satellites

Good Practice Guidelines for UAV-based Surface Reflectance Validation

Authors: Origo, N., Kalacska, M., Arroyo-Mora, J.-P., Soffer, R., Smigaj, M., Brede, B., De Los Reyes, R., Koehler, C., Pflug, B., Niro, F., Sinclair, M., Ong, C., Lau, I., Byrne, G., Morris, H., Suomalainen, J., Kooistra, L., Brell, M., Randall, G., Latini, D., Wilk, J., Raqueno, N., Gerace, A., Dash, J., Camacho, F., Sanchez-Zapero, J., Martinez, E., Brown, L., Morrone, R., Mota, B., Gillespie, J., Merrington, A., Van der Zee, J., Petracca, I., Thankappan, M., Ormane, R., Scholes, M., Honkavaara, E., Broomhall, M. & Boccia, V. – others to be included / order subject to change



Image credit: Johannes Wilk
Cover page design: Raissa Ormane





FRM4SOC



fiducial reference
measurements for
satellite ocean colour

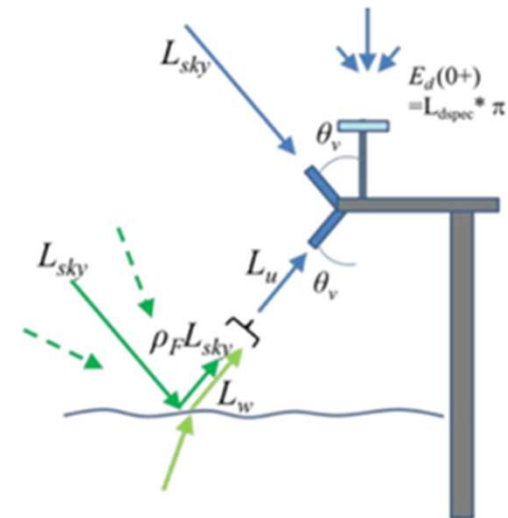
Transferable Concepts:

- Set of minimum requirements for qualifying ocean colour radiometers and their measurements as FRM

(Banks et al. 2020)

Limitations:

- Developed for field-based systems
- Assumes stable, fixed geometry and straightforward downwelling irradiance/sky radiance measurements
- Does not address UAV-specific challenges (e.g. dynamic platform, variable geometry, atmosphere)





FRM4drones - challenges



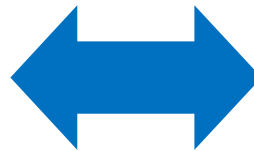


Aquatic reflectance

What we need :

The remote-sensing reflectance $R_{rs}(\theta, \phi, \lambda) = \frac{L_w(\theta, \phi, \lambda)}{E_d(\lambda)}$

The aquatic reflectance $R_w(\lambda) = \pi \cdot R_{rs}(\lambda) = \pi \cdot \frac{L_w(\lambda)}{E_d(\lambda)}$



What UAV measures :

$$L_T^{UAS}(\lambda) = L_{path}(\lambda) + t(\lambda)L_{SR}(\lambda) + t(\lambda)L_w(\lambda)$$

Atmosphere

Surface (sky glint, sun glint, white caps)

$$L_{SR}(\lambda) = L_{skyG}(\lambda) + L_{sunG}(\lambda) + L_{WF}(\lambda)$$



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Introducing Our Presenters



Liesbeth De Keukelaere



Anna Windle



Carmen Cillero



Alejandro Román





Poll & Questionnaires

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Thank you