Novel Direct Georeferencing-Based Method for Accurate Water Surface Mosaicking with UAS multispectral Imagery

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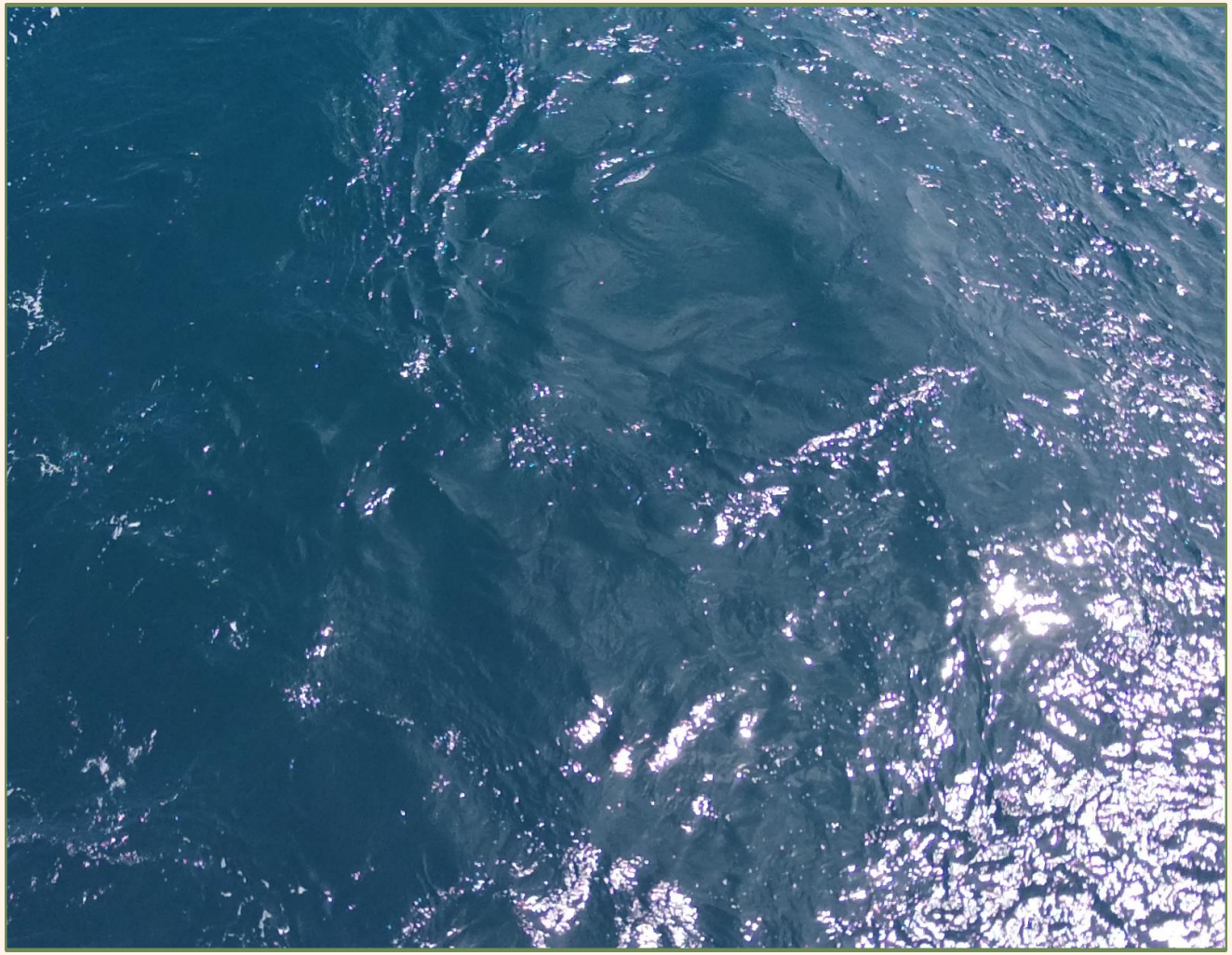
Introduction

- Unoccupied aircraft systems (UAS or drones) enable comprehensive observation of marine systems with high spatial and temporal resolutions.

- Some advantages of UAS data acquisition:

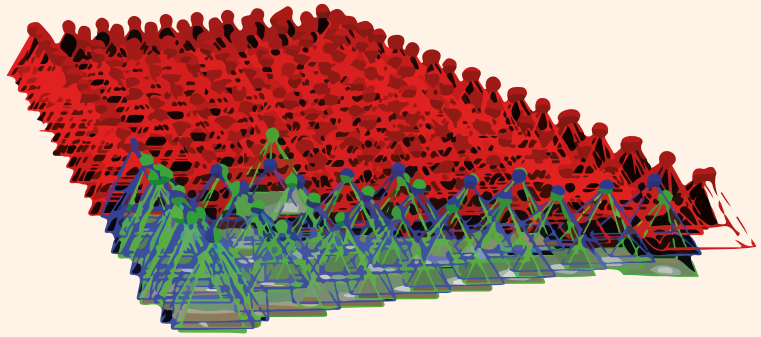
  - Not affected by cloud coverage.
  - Avoids atmospheric corrections.
  - Not facing land adjacency effects.

- Some challenges and limitations.



Challenges

SfM Photogrammetry



The absence of common features between captures limits the application of this technique on water surfaces.

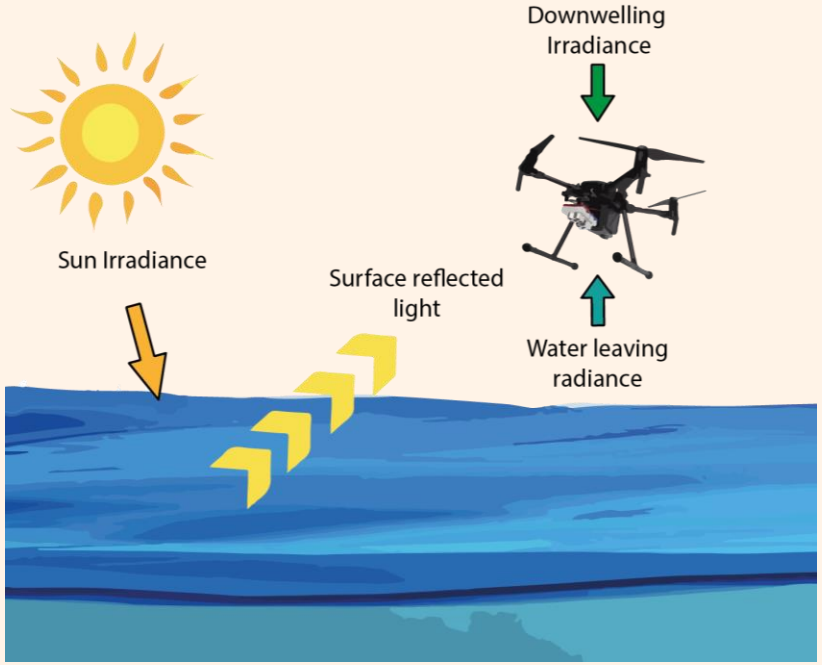
Need to **georeference** each capture individually based on their positioning information and **merge** them into a final mosaic that includes these water surfaces

R_{rs} can be retrieved from UAS-based multispectral data

$$R_{rs}(\theta,\Phi,\lambda) = \frac{L_w(\theta,\Phi,\lambda)}{E_d(\lambda)}$$

$$R_{UAS}(\theta,\Phi,\lambda) = \frac{L_T(\theta,\Phi,\lambda)}{E_d(\lambda)}$$

Need to account for **surface reflected light (L_{SR})**



$$L_T(\theta,\Phi,\lambda) = L_w(\theta,\Phi,\lambda) + L_{SR}(\theta,\Phi,\lambda) \qquad L_{SR}(\theta,\Phi,\lambda) = R_F(\theta,\Phi,\lambda) * L_{sky}(\theta,\Phi,\lambda)$$

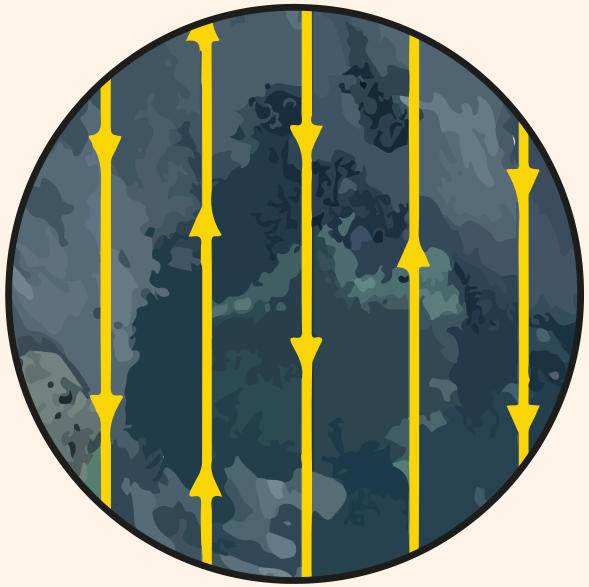
Removal of L_{SR}

Above water R_{rs} calculation

$$R_{rs}(\theta,\Phi,\lambda) = R_{UAS}(\theta,\Phi,\lambda) - \frac{L_{sky}(\theta,\Phi,\lambda) * R_F(\theta,\Phi,\lambda)}{E_D(\lambda)}$$

Main goals

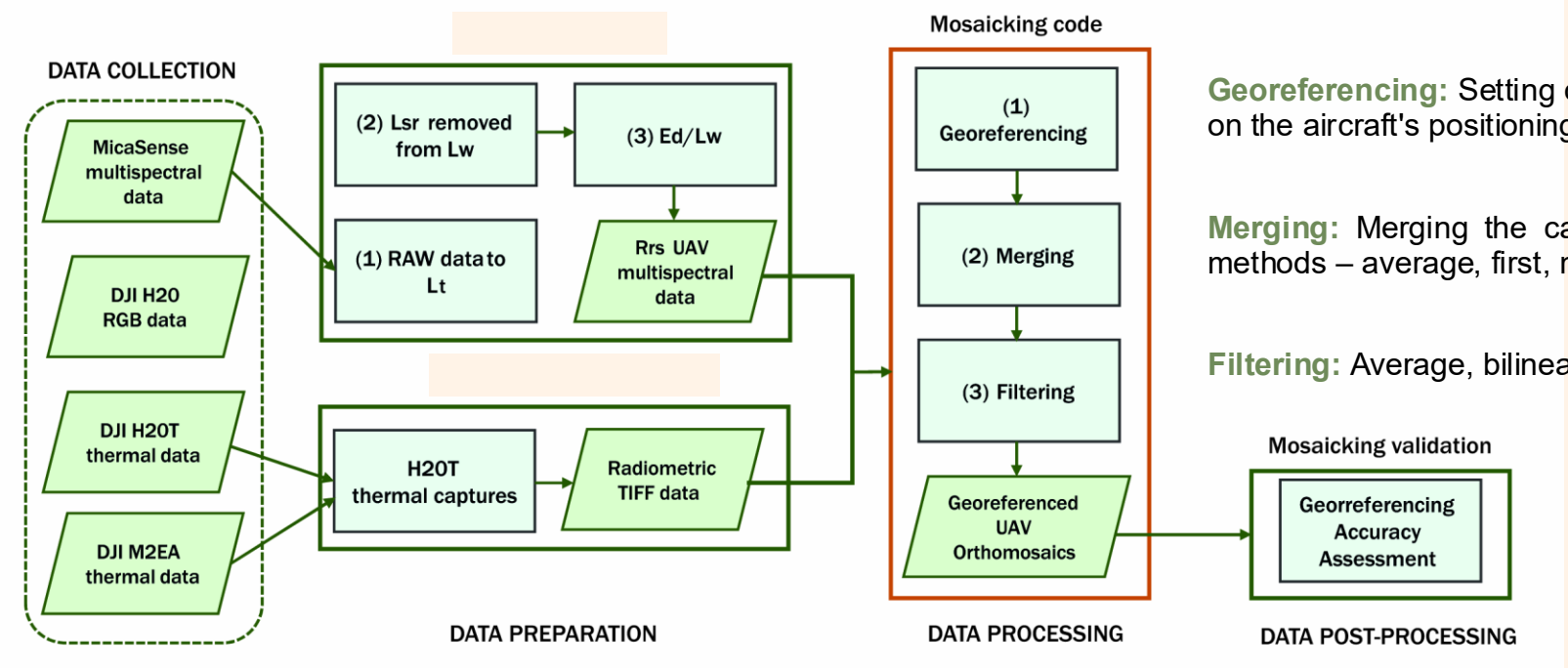
Generate an **open-source algorithm** that works with high-resolution **UAS multispectral data** to generate a final product that could be applied to resolve coastal and oceanic variability on a **fine-scale**, without resort to traditional techniques.



Generate a precise method to **georeference** and **mosaic** UAS captures

Derive more accurate $\mathbf{R_{rs}}$ **retrievals**

Georeferencing and mosaicking code



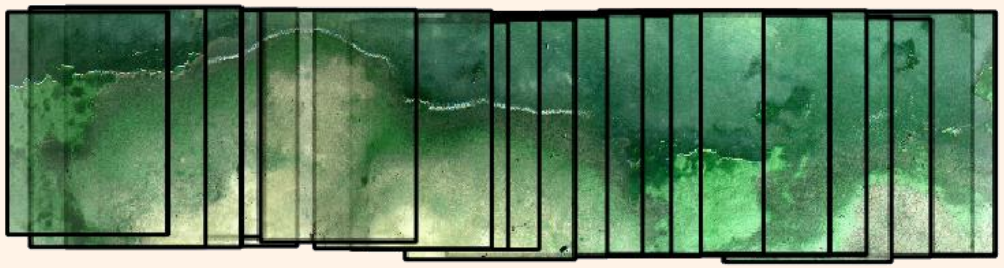
Georeferencing: Setting of GPS coordinates for each individual UAS capture based on the aircraft's positioning during flight and the sensor's specifications.

Merging: Merging the captures into a final orthomosaic according to 4 different methods – average, first, minimum, or maximum.

Filtering: Average, bilinear, or cubic downscaling method.

MORE INFO

Román et al. (2024)

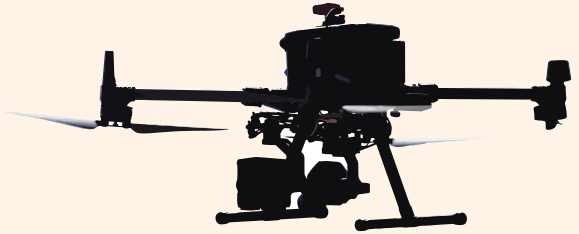


Georeferencing

Merging

Mosaicking results

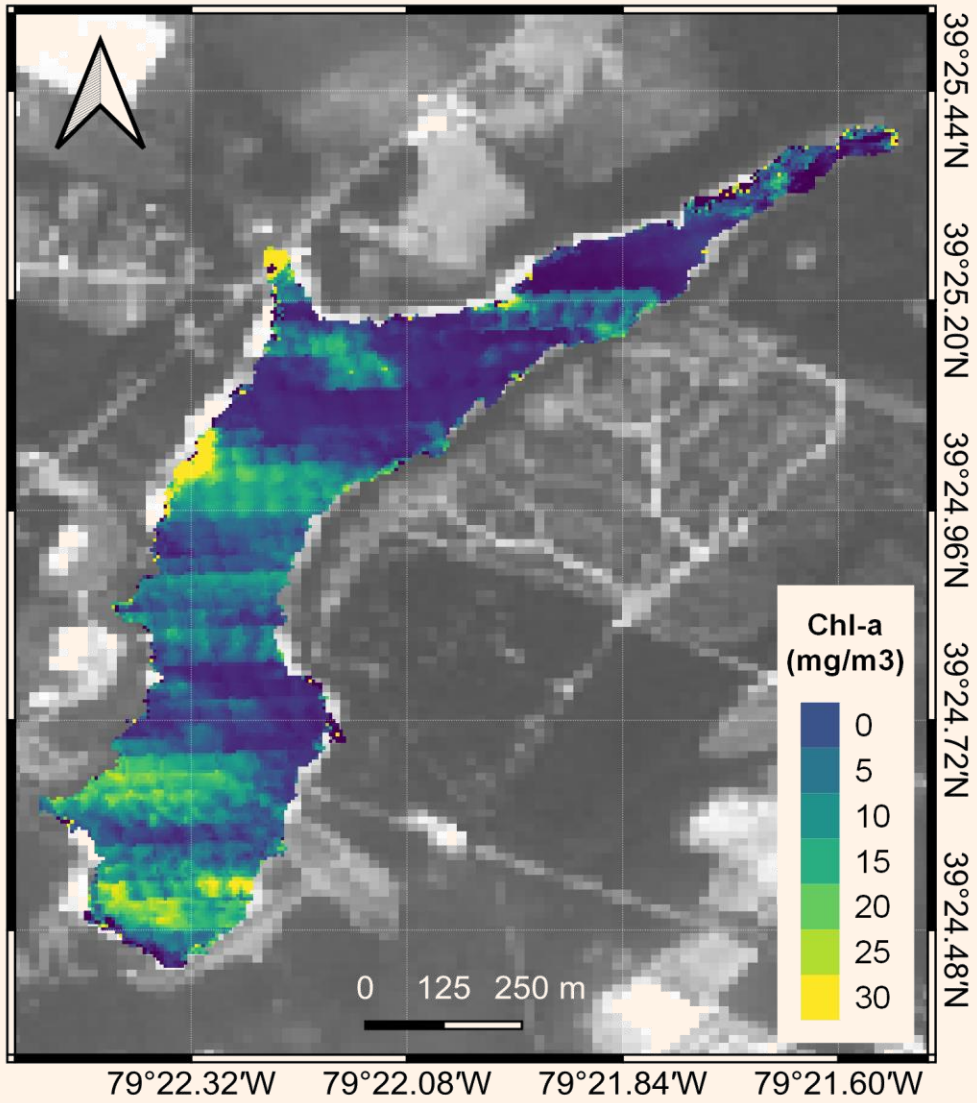
- RGB Imagery collected with a DJI Zenmuse H20T sensor mounted on a DJI Matrice 300 RTK.

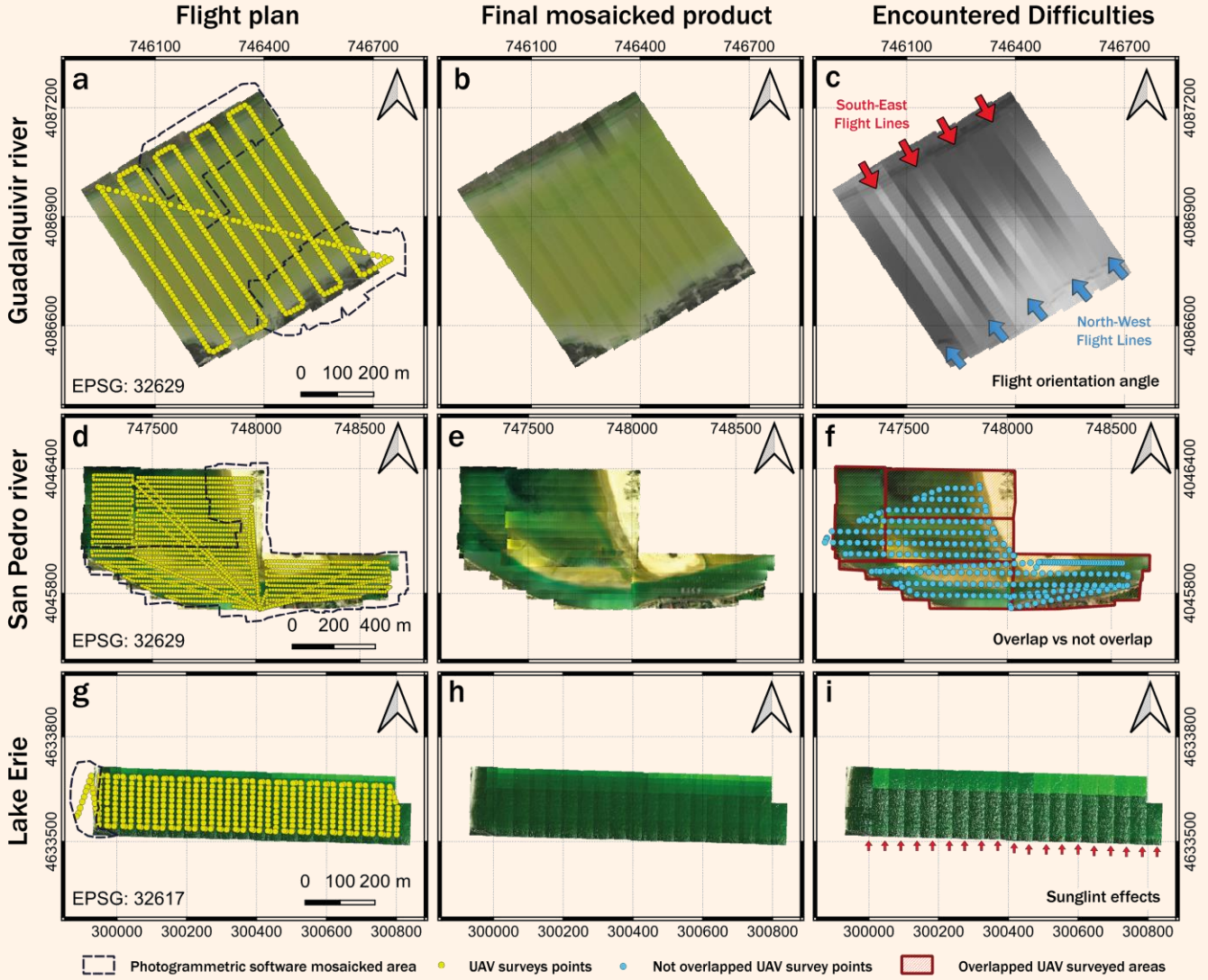


- **86%** and **61%** of water coverage recovered from S*f*M photogrammetry.

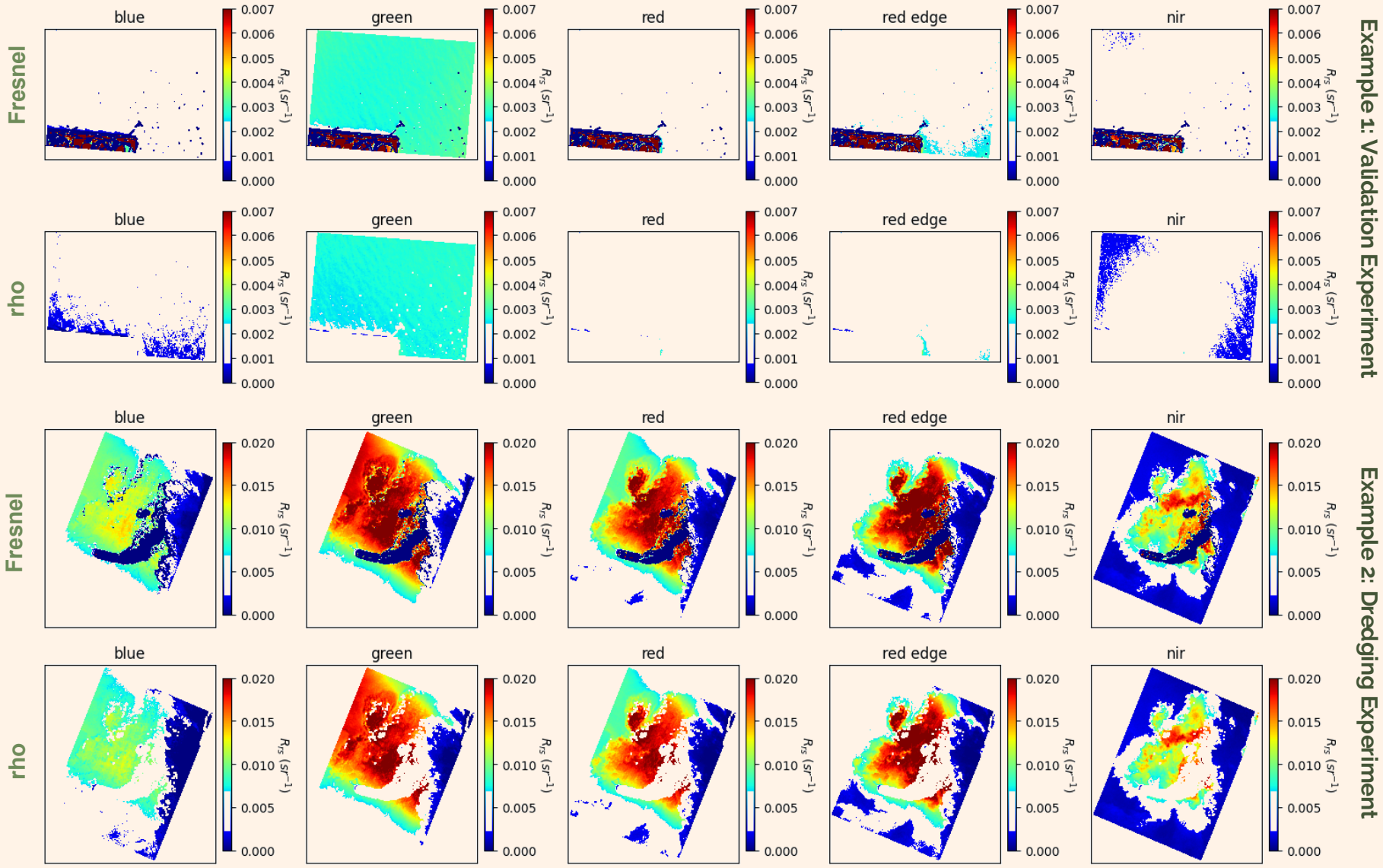
- Best georeferencing accuracies of **< 5 m RMSE** and **< 3 m standard deviation**.

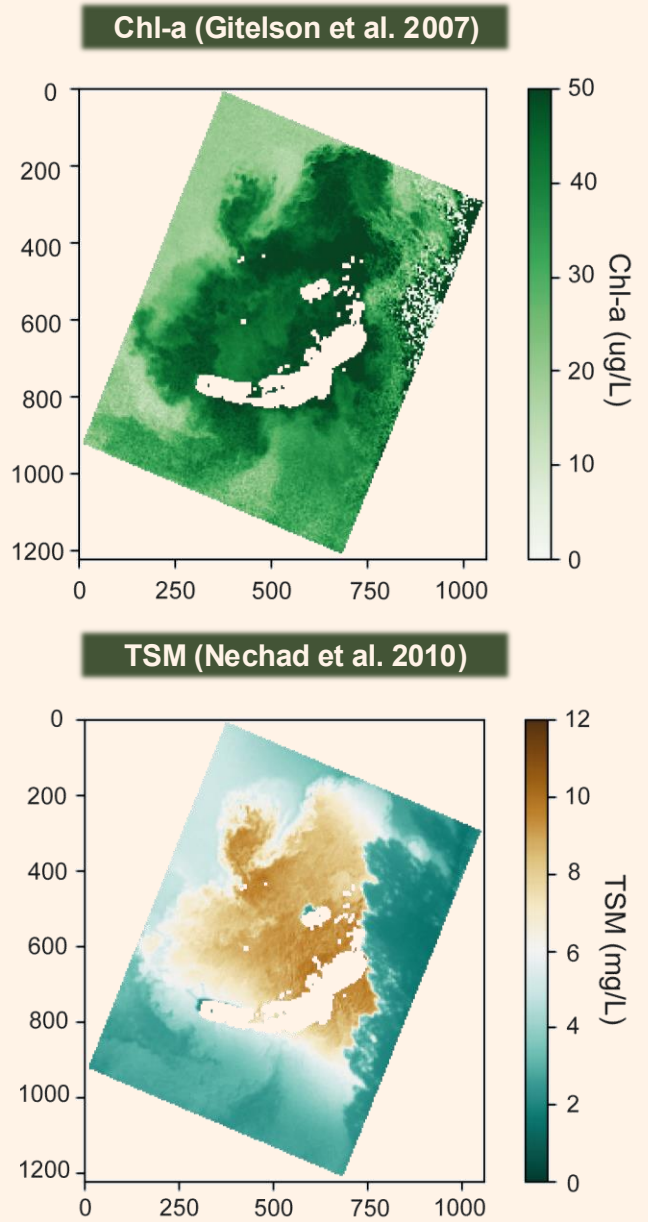
Best practices for using the mosaicking code on multispectral imagery





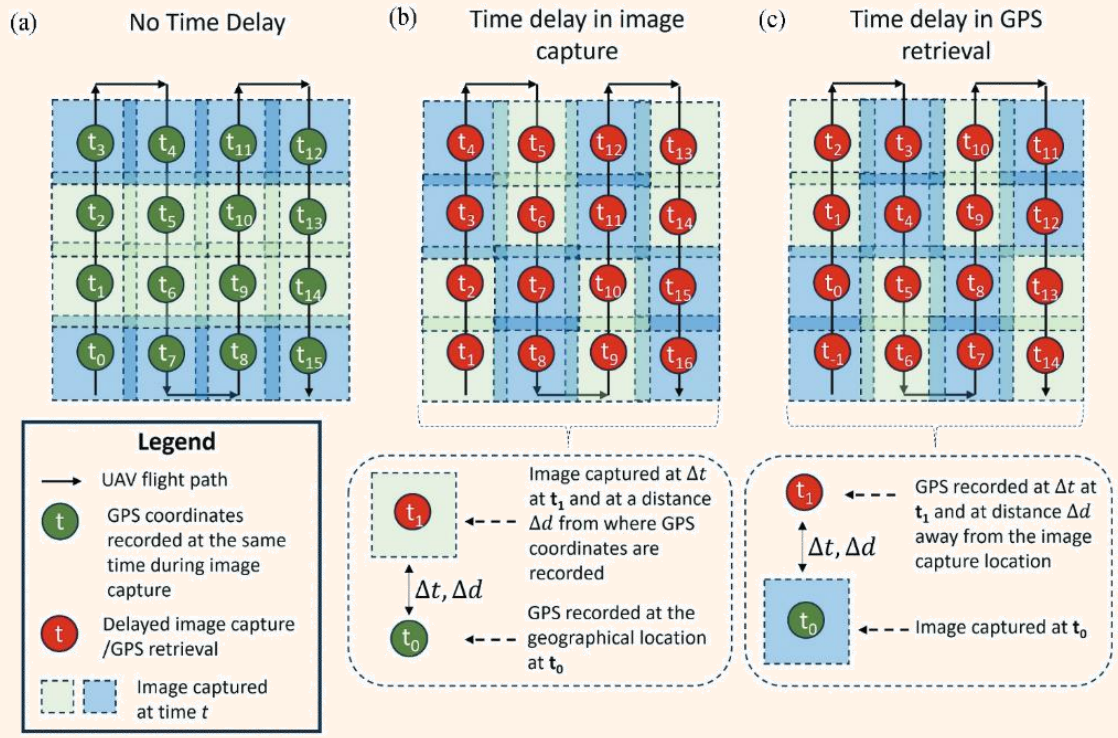
Water quality outputs



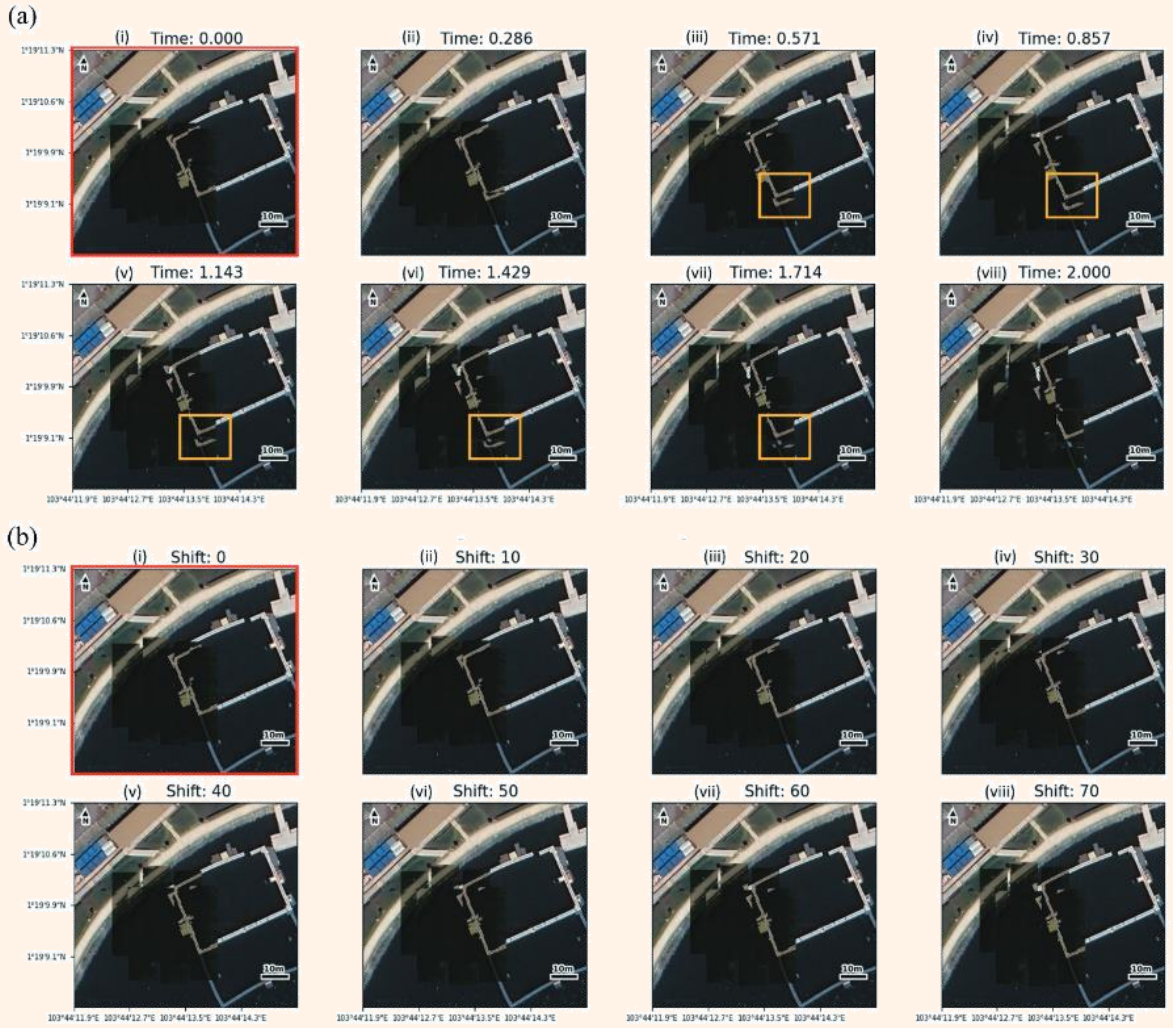


Impact on the field

- Base for the development of new versions that improve some of the caveats of the code.

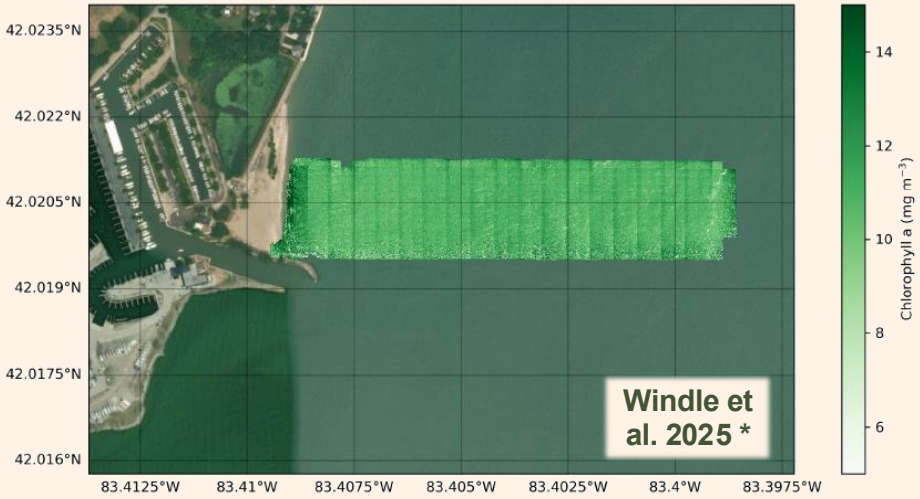


Pak Hui Ying et al. 2025

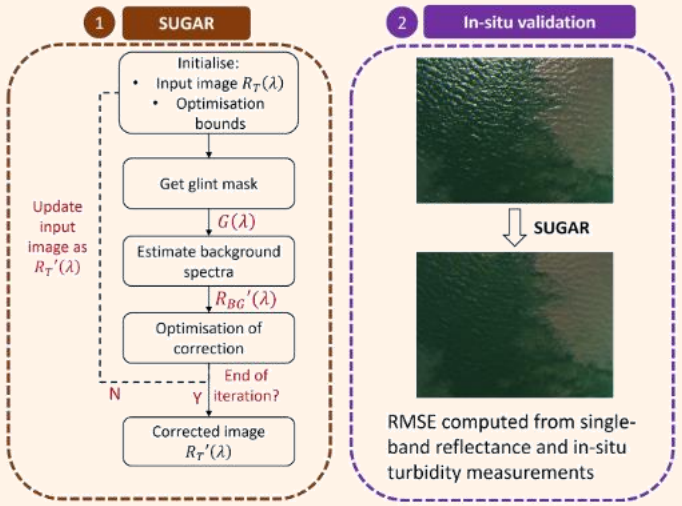


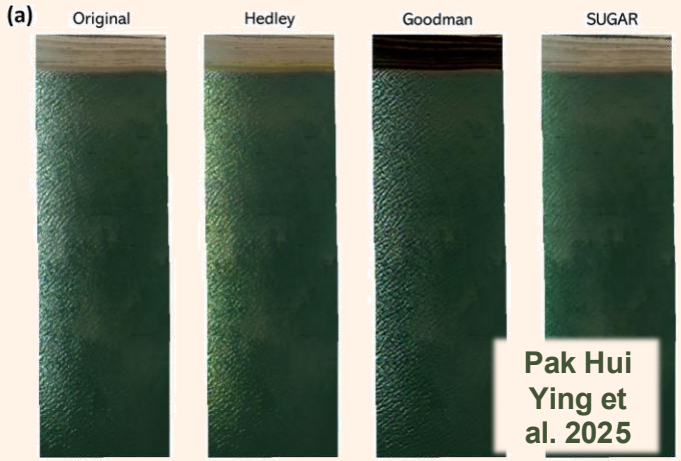
Impact on the field

- Integration on DroneWQ package.



- Application of new sunglint correction methods.



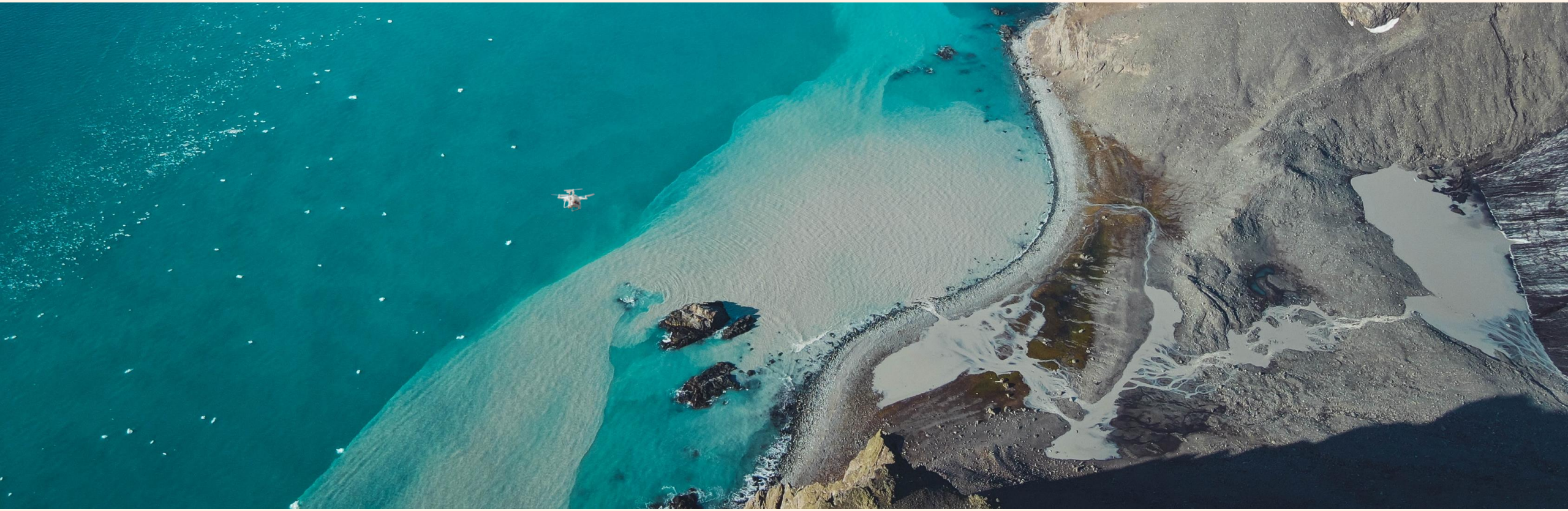


- Data collection for validation and adaptation to new sensors.

Conclusions

1. The new georeferencing and mosaicking algorithm addresses the significant difficulties associated with UAV remote sensing over aquatic environments. It offers a solution that is open-source, transferable, and user-friendly, enhancing the detailed comprehension of fine-scale marine processes.

2. The developed processing approach for extracting R_{rs} from UAV-captured multispectral data should enhance previous techniques by considering the water surface's geometry to more effectively eliminate surface-reflected light from the measurements.



Acknowledgements:

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Thank you!

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