*Workshop : « 3D underwater mapping of habitats and biological communities »*

# Case of studies: shallow and aerial acquisitions and applications


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NextGenerationEU

# POSEIDON Platform Operating in Shallow-water Environment for Imaging and Digital Object Numerization: case study of the Reunion lagoon

## TELEMAC project (WIO - France)

Simon Delsol

# Genesis

**Hydrodynamics studies**
Rugosity ($Z_0$) linked to coral topographic complexity in reef environment

Usually determined through

**« Chain and Tape » Method (Risk, 1972 ; McCormick, 1994)**

Or through Digital Elevation Model acquired by

**DGPS survey**

**UAS (Unnocupied Aerial System) (*Casella et al., 2020, Dugdale et al., 2019*)**

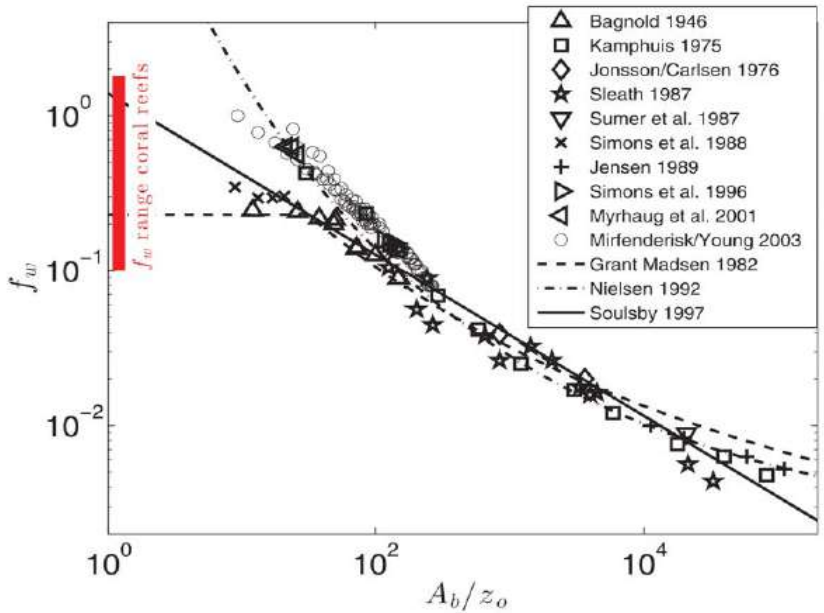
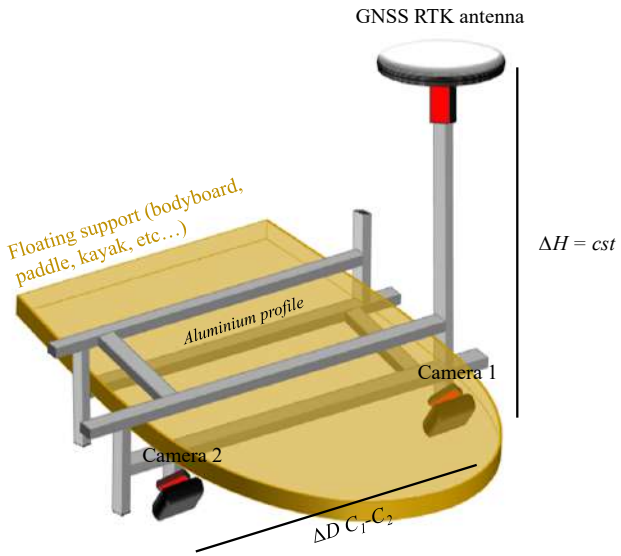


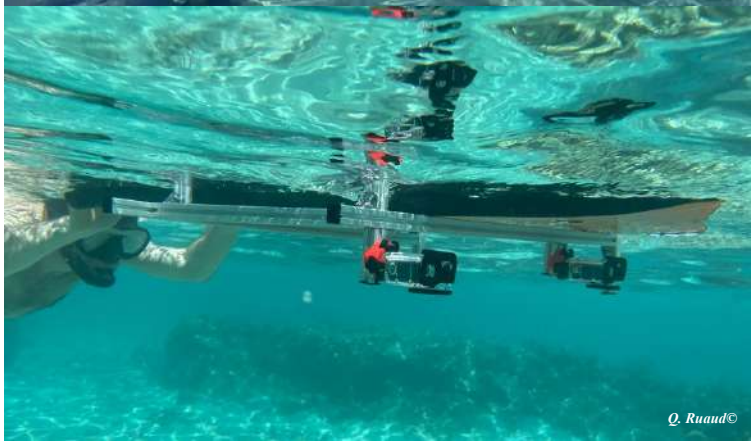

***Fig. 1 :*** evolution of the dissipation coefficient fw as a function of Ab and $Z_0$ according to different laboratory, in-situ and theoretical experiments. The range of fw values estimated in coral environment is indicated in red on the left of the figure.

# Prototype

**Low-cost & low-tech platform**
Aimed at mapping coral reef complexity and underwater structure at (sub-)centimeter resolution through **SfM photogrammetry**





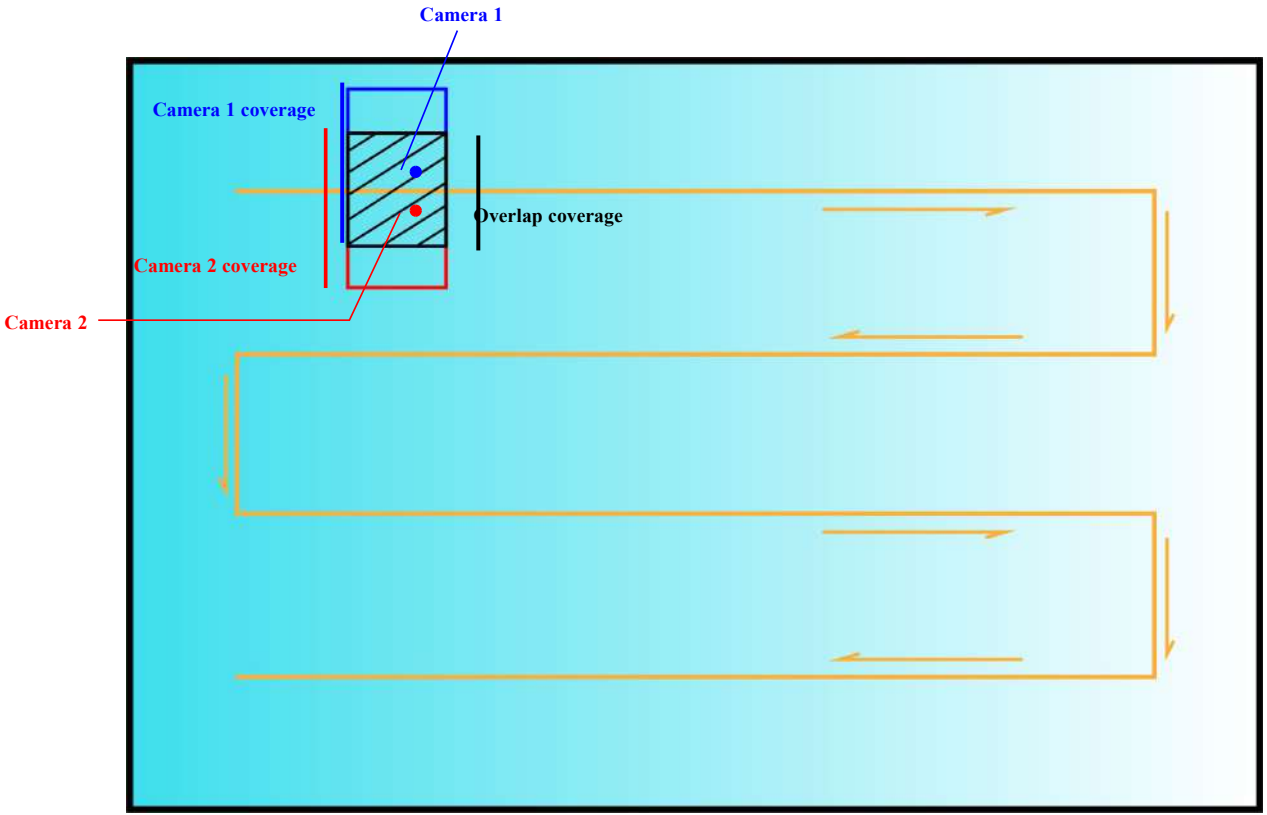


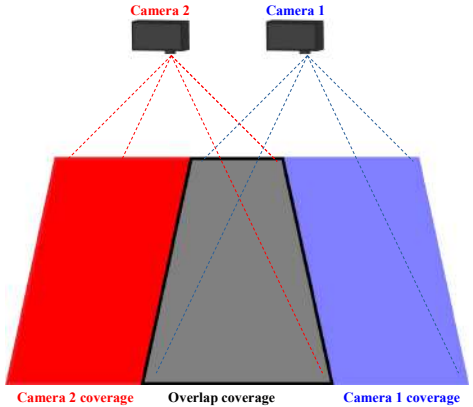

**Assets**
Can operate in very shallow waters (15 cm < d < 3 m)

Does not suffer from light reflection at the air-sea interface, contrary to drones (***Agrafiotis et al., 2020 ; Ye et al., 2016***)

***Entirely modular***

# Ideal survey




## Requires

Clear water (no turbidity)

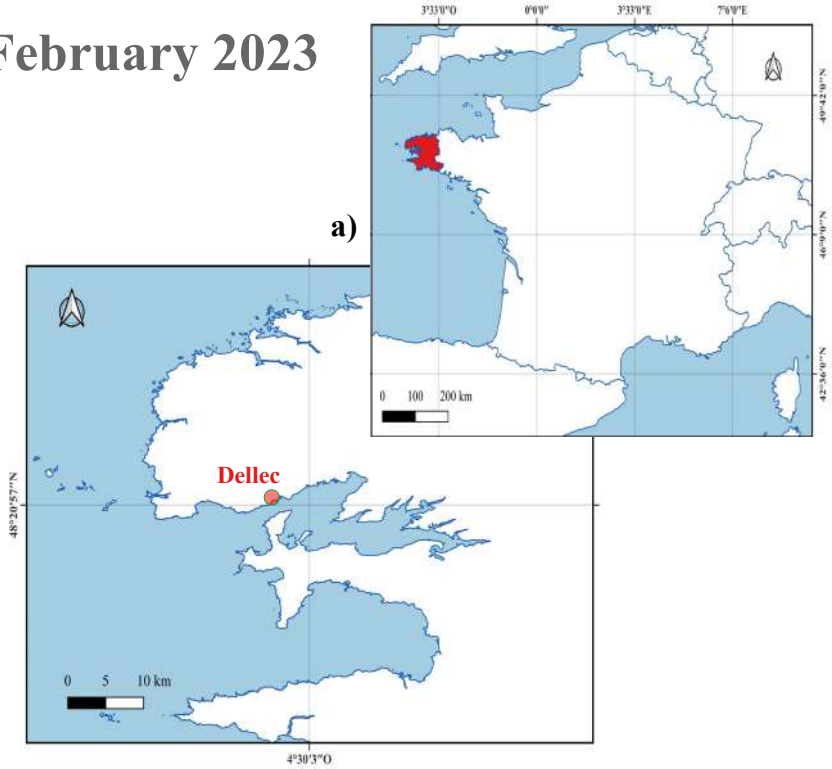
Appreciable sunlight conditions

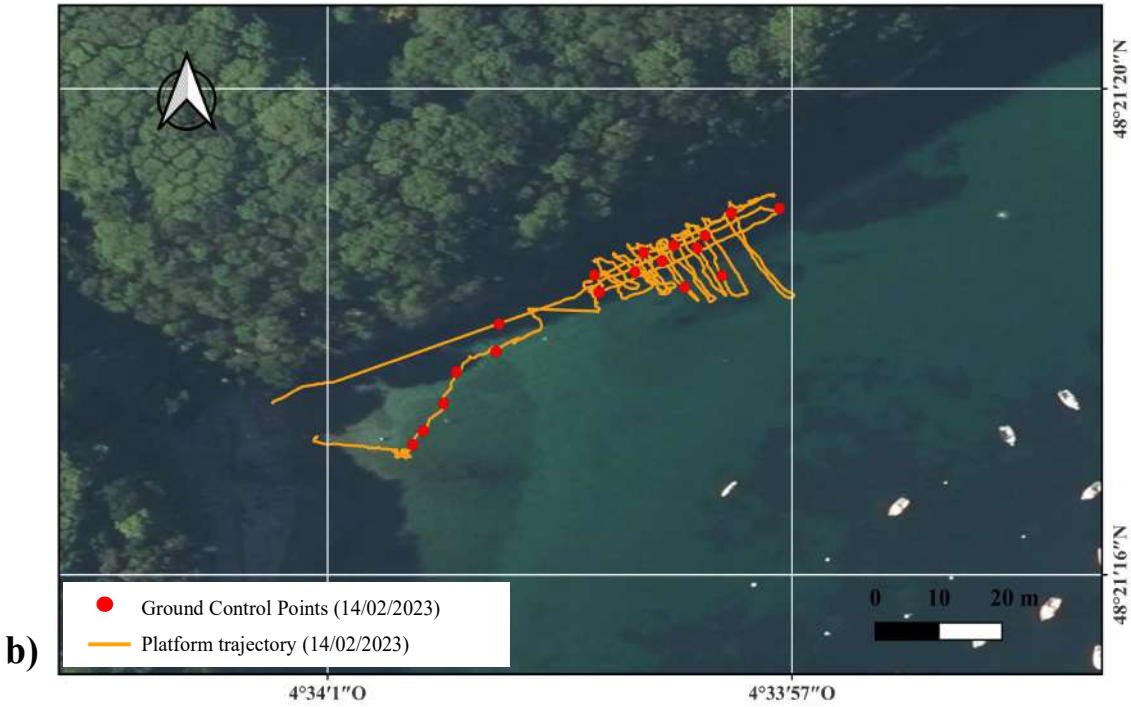
Real Time Kinematic base in range (still works in relative mode)

***High overlap***

# Method validation (Brittany, France)

**February 2023**

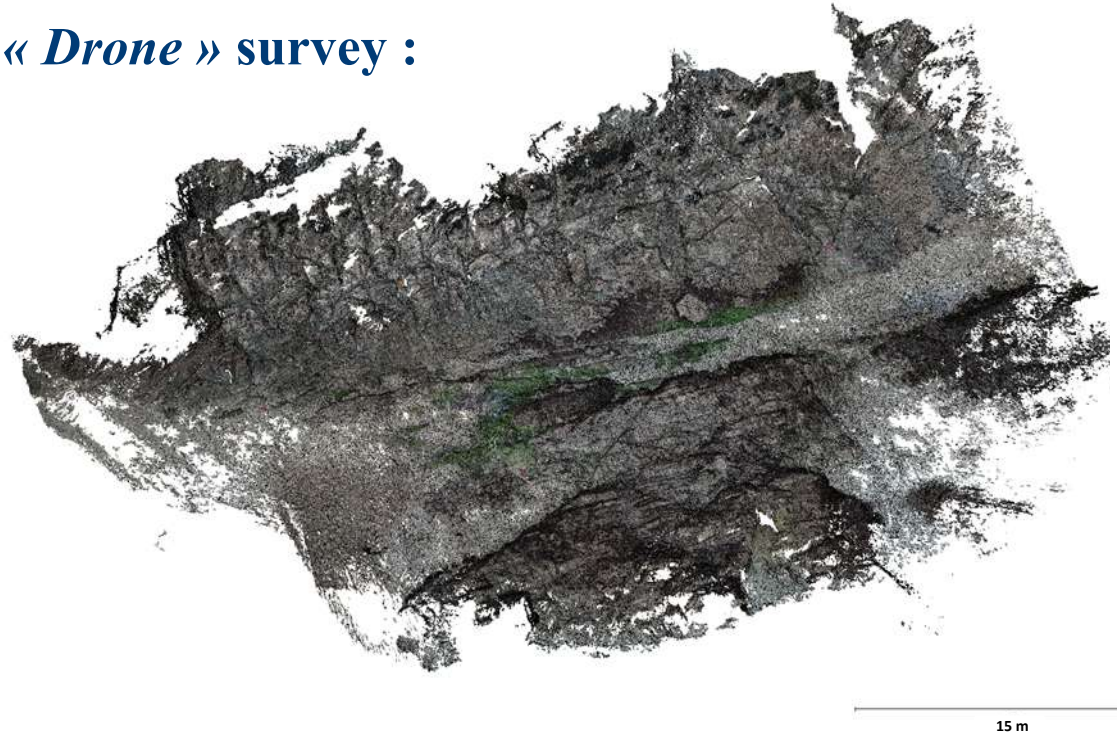


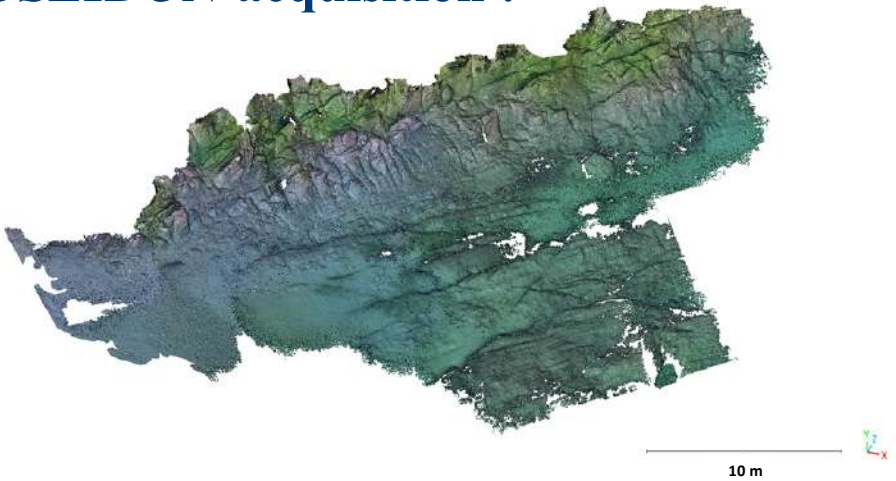

**High tidal range coast** = study zone fully emerged during spring tide

# Method validation (Brittany, France)

## « *Drone* » survey :




## *POSEIDON* acquisition :



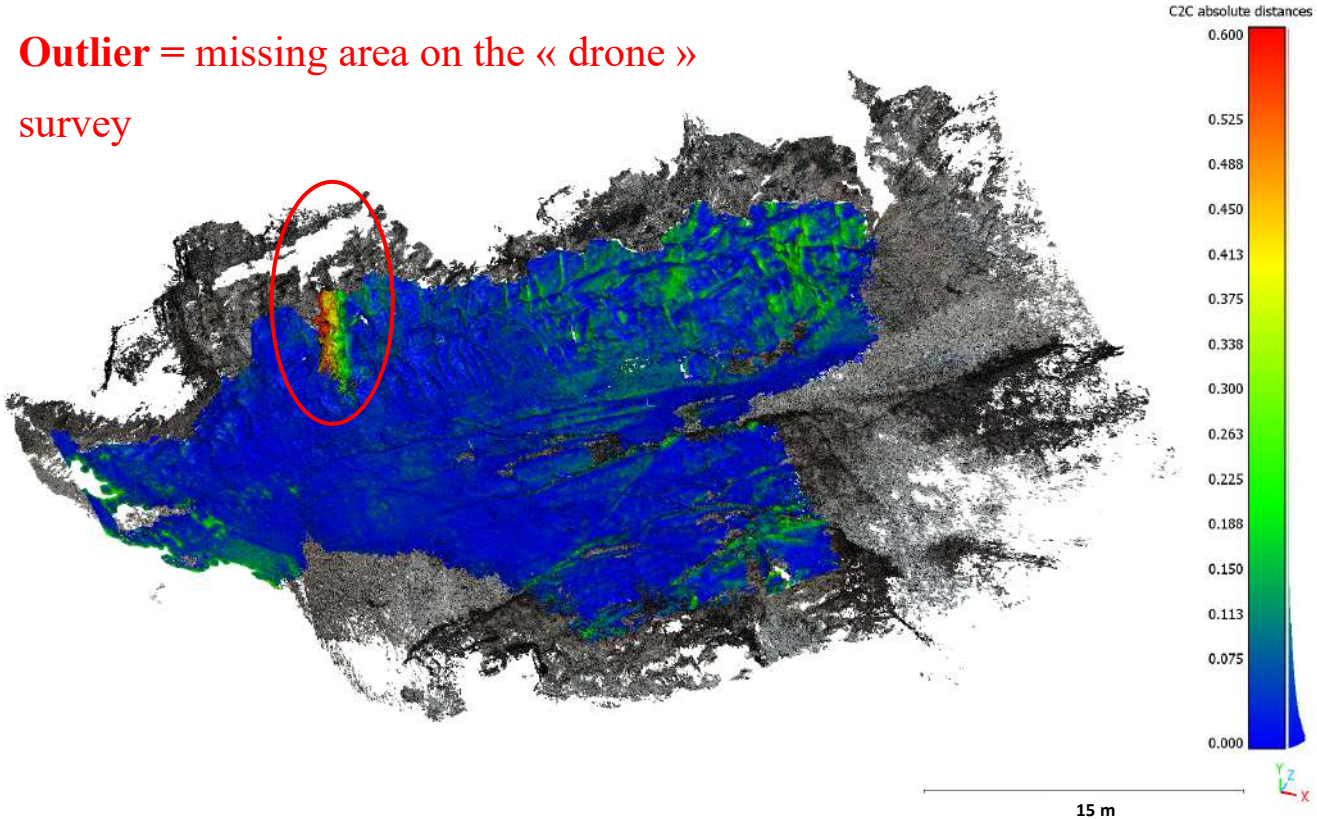

**Mean depth : 1.9 m**

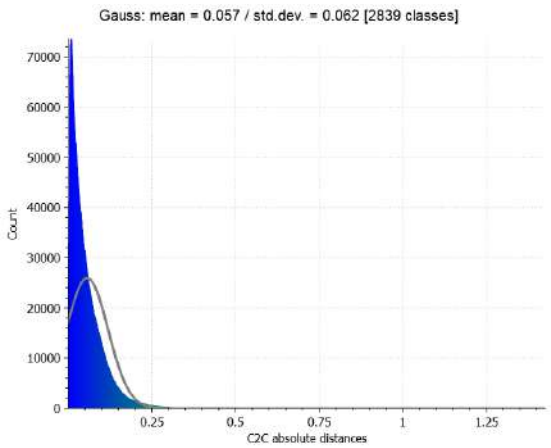
**2089 photos per camera**

Y = Northing ; X = Easting ; Z = Elevation

# Method validation (Brittany, France)

**Outlier** = missing area on the « drone » survey

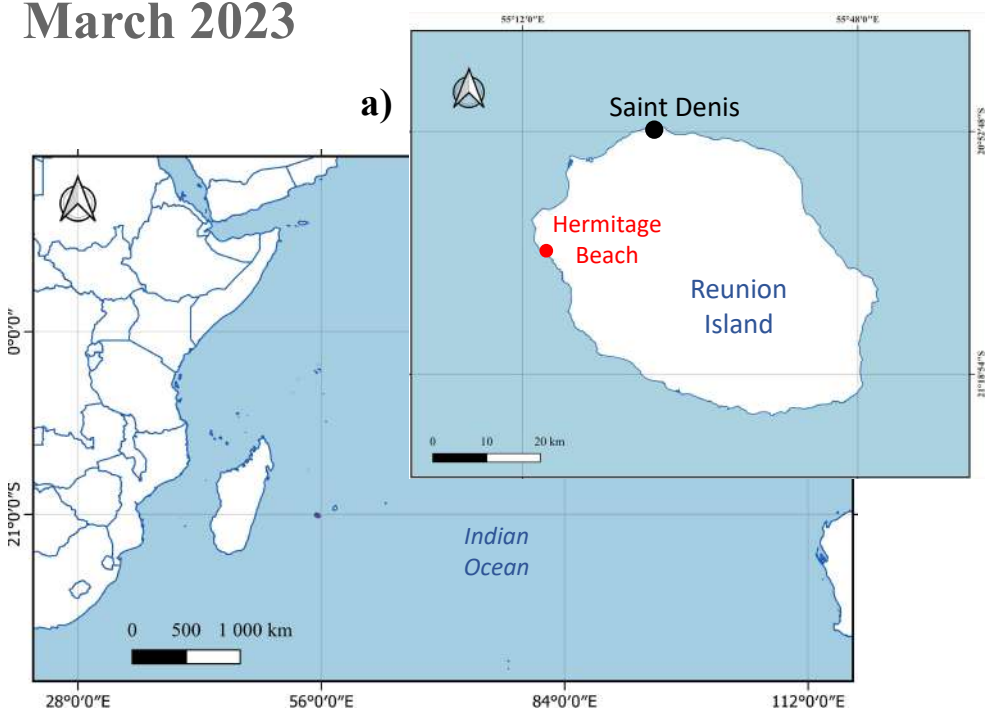


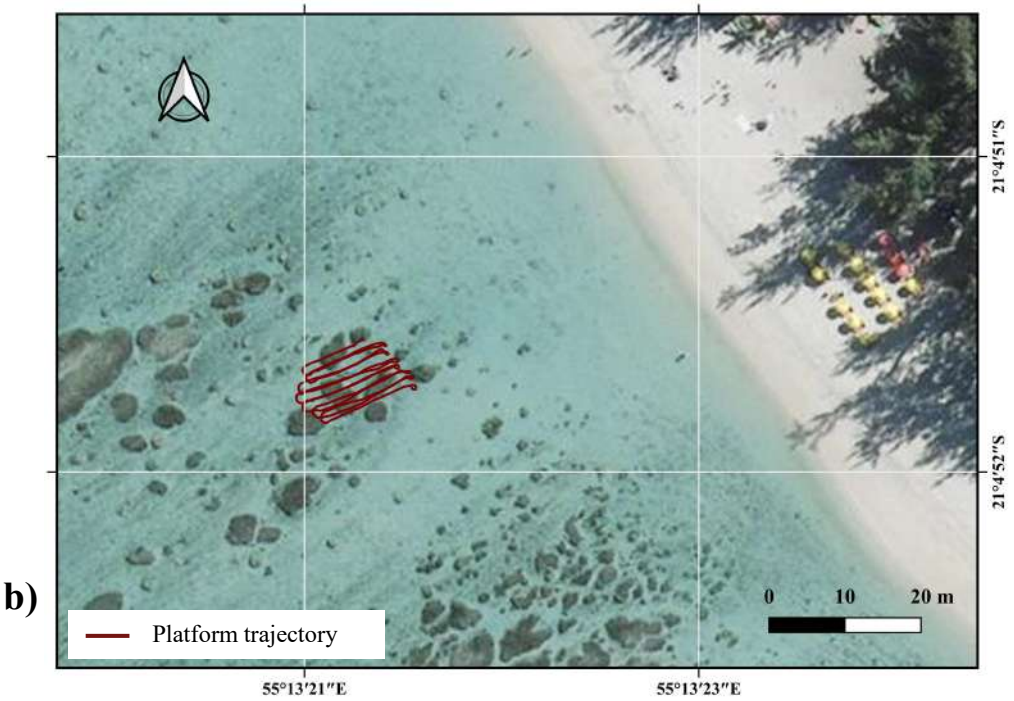




**Uniform on the zone (close to 5 cm as mean distance between the clouds)**

# La Reunion Lagoon

## March 2023

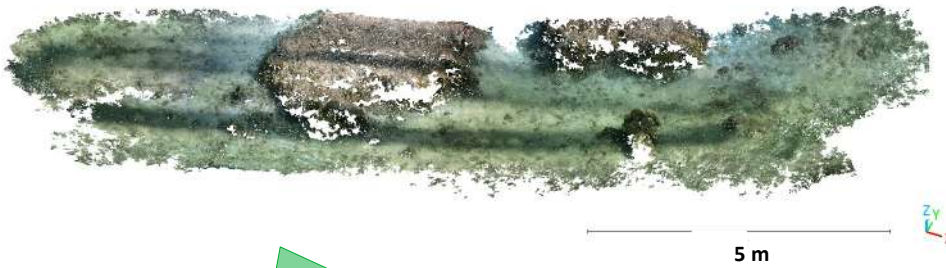


# La Reunion Lagoon

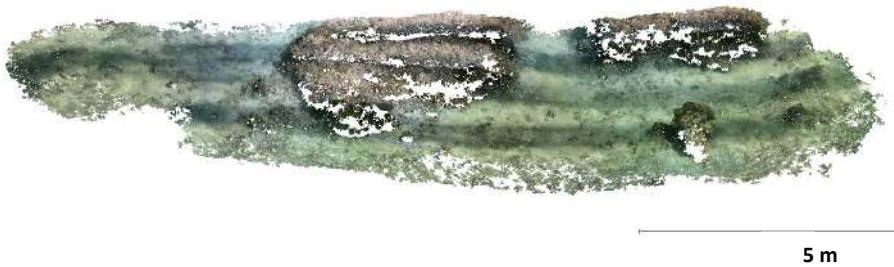
## Test 2 : tilted camera (27°)

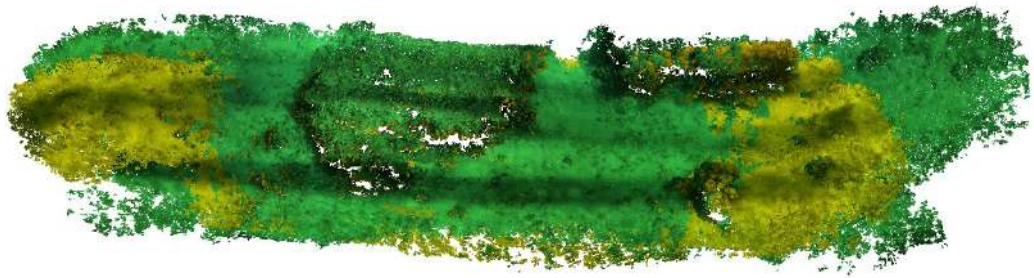
723/926 aligned photos (~ 78%)




## Test 2 : camera at nadir (0°)

683/864 aligned photos (~ 79%)



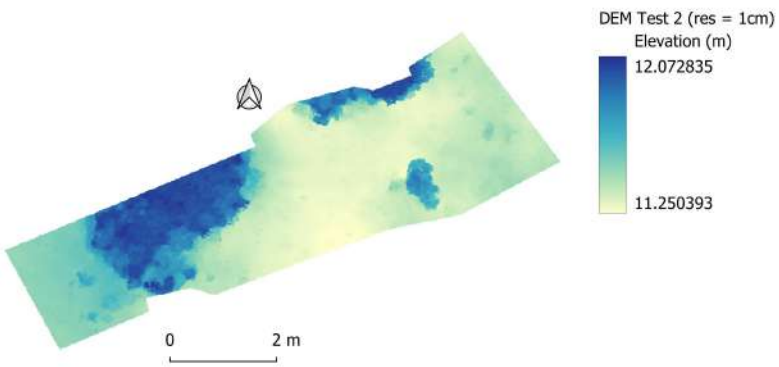



5 m

Y = Northing ; X = Easting ; Z = Elevation

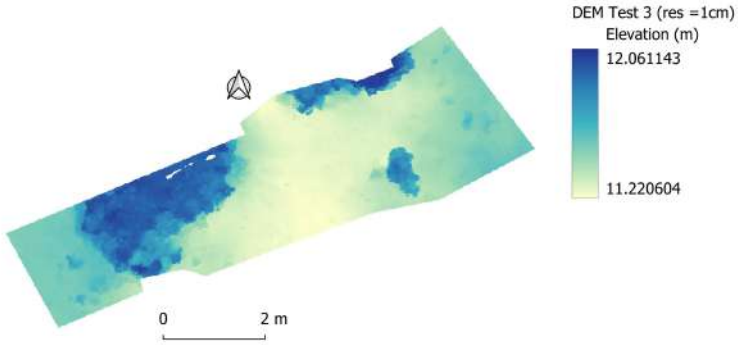
# La Reunion Lagoon

## Test 2 : tilted camera (27°)




**Rugosity ($Z_0$) = 1.600143**

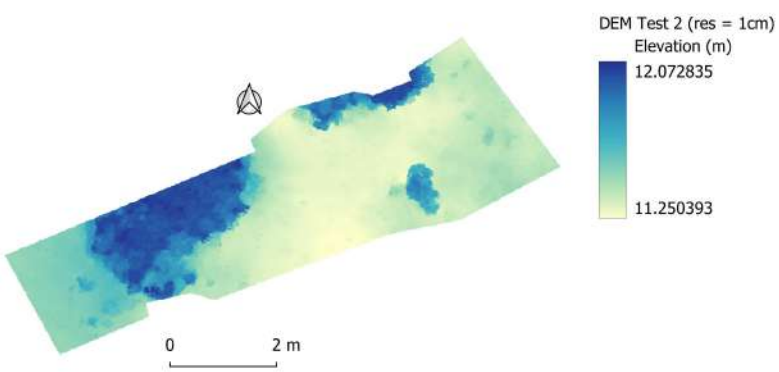
## Test 2 : camera at nadir (0°)




**Rugosity ($Z_0$) = 1.586271**

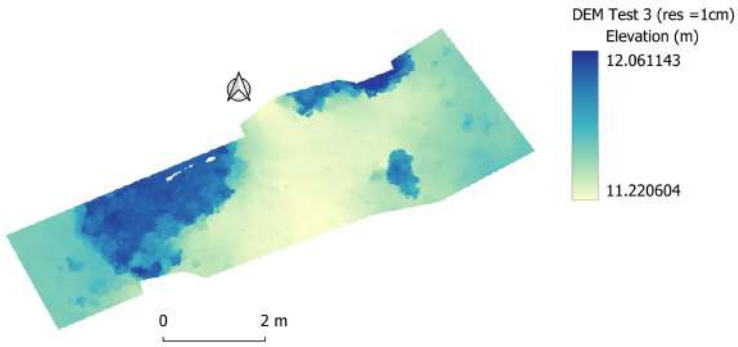
# La Reunion Lagoon

## Test 2 : tilted camera (27°)




**Rugosity ($Z_0$) = 1.600143**

## Test 2 : camera at nadir (0°)



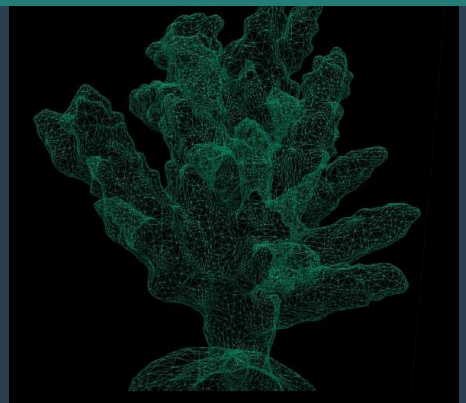

**Rugosity ($Z_0$) = 1.586271**

**Soon© : Run further tests (complete zone, Green canal), comparison between the test, comparison with the drone-derived rugosity**

# Thank you for your attention !

# Underwater and drone photogrammetry applications for coral reefs conservation programs: case study of the Future Maore Reefs project (WIO - Mayotte, France)

*Isabel Urbina-Barreto*



# Thanks to all collaborators, funding and partners


Financé par l'Union européenne
NextGenerationEU

**PI Aline Tribollet (LOCEAN) ; PI François Guilhaumon (UMR ENTROPIE)**

Clément Lelabousse (PNMM - OFB) ; Georgeta Stoica, Philippe Charpentier (CUFR) ;

Isabel Urbina-Barreto (IRD) ; Anne Chauvin (IRD) ; Marta Gentilucci (CUFR) ; Thomas Claverie (CUFR) ; Swanne Gonthare (Sorbonne Univ) ; Pascale Cuet (Univ. Réunion) ; Eric Douville (CEA – LSCE) ; Lionel Bigot (Univ. Réunion) ; Sophie Bureau (Univ. Réunion); Justine Daudon (IRD) ; Sylvain Poulain (IRD) ; Julien Barde (IRD) ; Diego Alaguarda (Sorbonne Univ) ; Joelle Robbe Sorbonne (Univ–MCAM) ; Orlane Velin (Univ. Réunion) ; Antoine Ringard (Sorbonne Univ) ; Ariane Fô (l'Ecole M3 - Lyon) ; Julie Closse-independent ; Florinah Razafimandimby (Univ. Réunion) ; Matéo Moreau (ENSC, Bordeaux) ; Marion Jaud (IUEM, Brest)

**PI Julien Barde (UMR MARBEC )**

Sylvain Poulain (IRD) ;

Justine Talpaert (IRD)

**OpenDroneMap** – IRD workstation/server *coll. G2OI projet, S. Poulain & J. Barde - UMR Marbec*

**Automated post processing** by R code, Phyton modul (Metashape) →

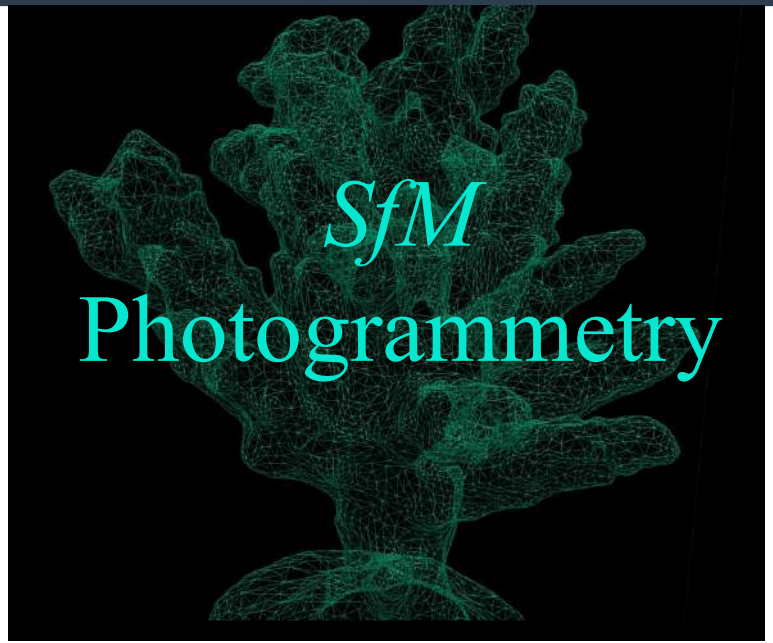
*françois.guilhamon@ird.fr*

## Temporal monitoring:

- coral colonies
- artificial reefs
- coral nubins

## *« Upscaling »* study:

*Combining drone (UAVs) and underwater (UWP) photogrammetry to map coral reef complexity at centimeter resolution over large extents.*
talk - Geohab 2023.
*coll. G2OI S. Poulain & J. Barde - UMR Marbec*




## Spatial monitoring:

*From natural to artificial reefs: using SfM modeling to study coral community functioning and tune restoration solutions in Mayotte. talk - WIOMSA 2022*

## Awareness actions:

Education program
Artistic project – *CORAUX 22 -24*

## Automated labeling on orthomosaics:

*GEOAI for marine ecosystem monitoring : a complete workflow to generate maps AI model predictions*. Conference proceedings FOSS4G 2023.
*coll. G2OI – J. Talpaert & J. Barde - UMR Marbec*

# **FAIR** objectifs – IRD, Future Maore Reefs project (south countries)

**F** indability

**A** ccessibility

**I** nteroperabillity

**R** eusability

1- OpenDroneMap & automated R code

2- Reef surveys by drone

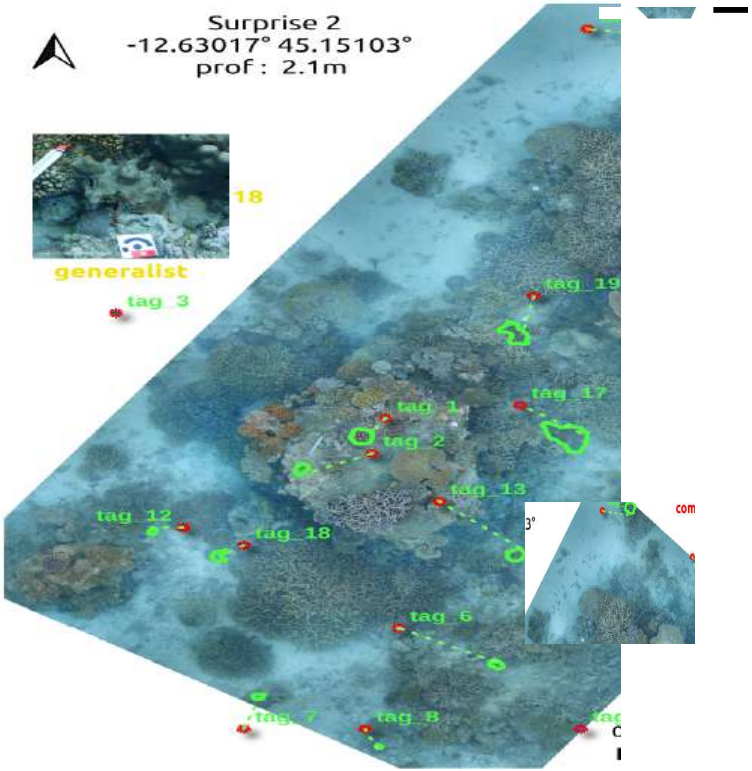
3- Coupled sampling UAVs and UWP

Rapid assessment - monitoring
—> Gestion, monitoring, restoration <—

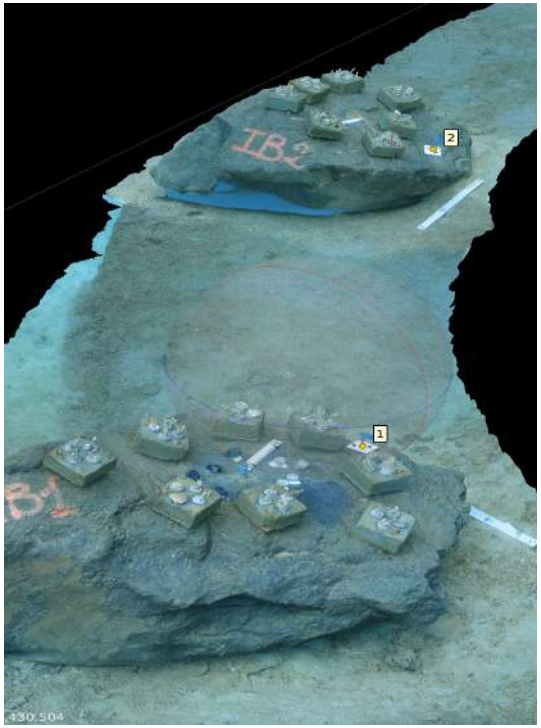
# SfM Photogrammetry applications

- **Temporal monitoring:**

*coral nubins*




*coral colonies*

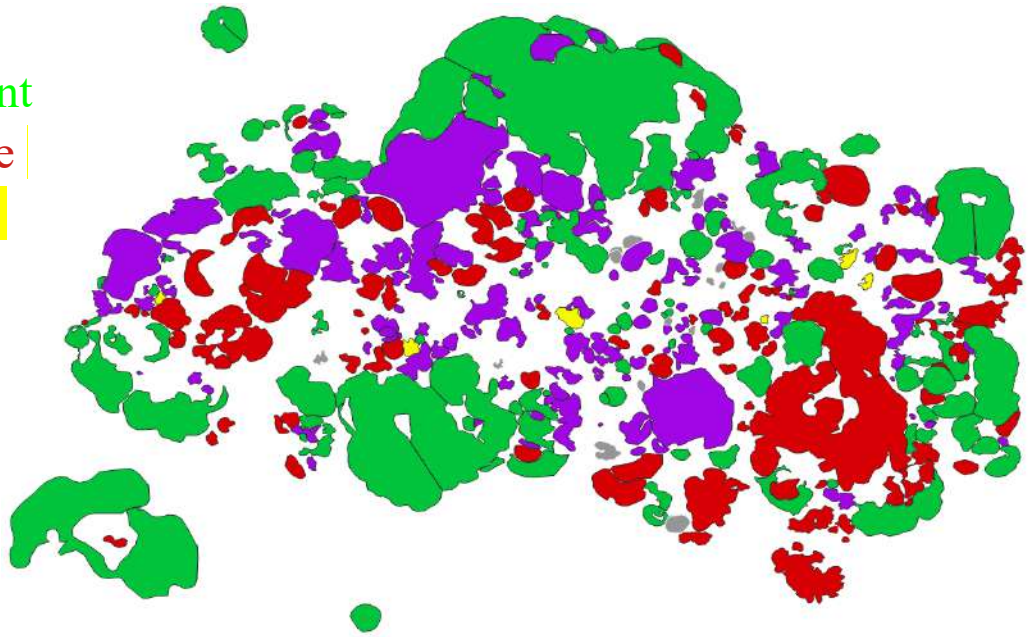


*Artificial reefs*

# SfM Photogrammetry applications

- **Spatial monitoring:** *From natural to artificial reefs: using SfM modeling to study coral community functioning and tune restoration solutions in Mayotte. talk - WIOMSA 2022.*

Weedy
Stress tolerant
Competitive
Generalist



**Descriptors**

Total shelter (liters / $m^2$) =115

Surface complexity = 2.4

Abundances:

WEE = 108

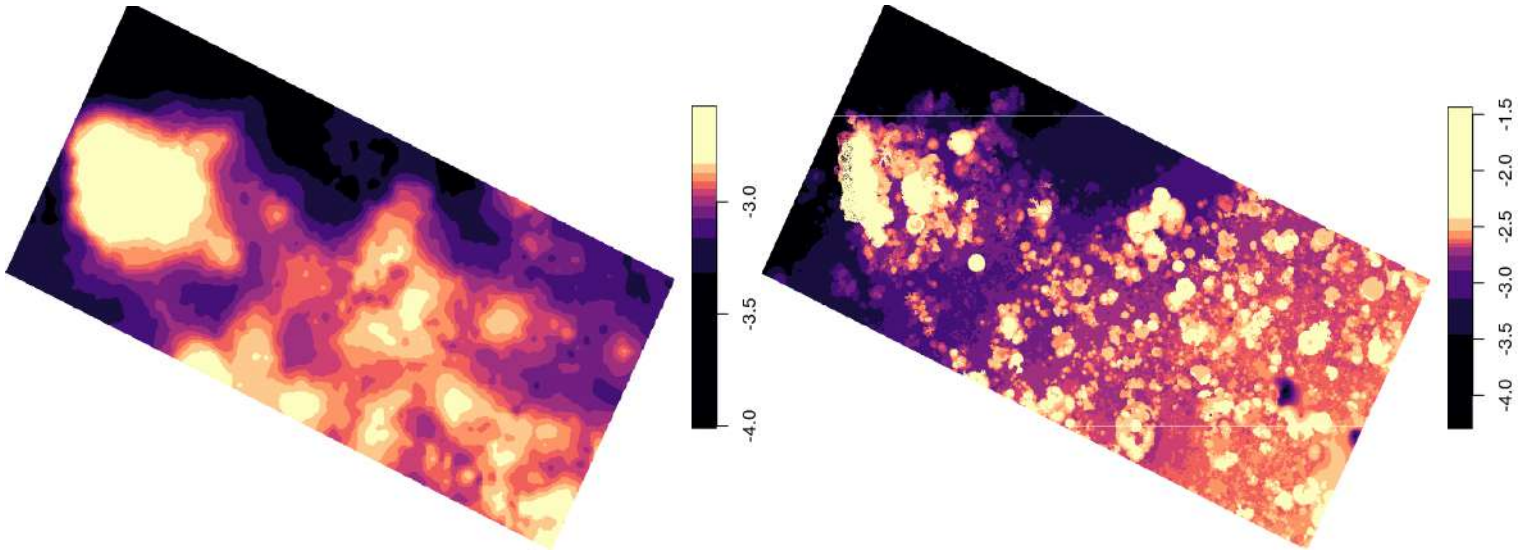
STO = 97

COM = 93

GEN = 10

# SfM Photogrammetry applications

- ***« Upscaling »* study:** talk - Geohab 2023. *Combining drone (UAVs) and underwater (UWP) photogrammetry to map coral reef complexity at centimeter resolution over large extents.* coll. *G2OI S. Poulain & J. Barde - UMR Marbec*




**ranked descriptors values** → *across all sites the relationship between ranked descriptor values is strong and provide substantial predictability (**all $R^2 > 0.9$**) ; site dependecy…*

# SfM Photogrammetry applications

- **Automated labeling on orthomosaics:**

*GEOAI for marine ecosystem monitoring : a complete workflow to generate maps AI model predictions.* Conference proceedings FOSS4G 2023. *coll. G2OI – J. Talpaert & J. Barde - UMR Marbec*

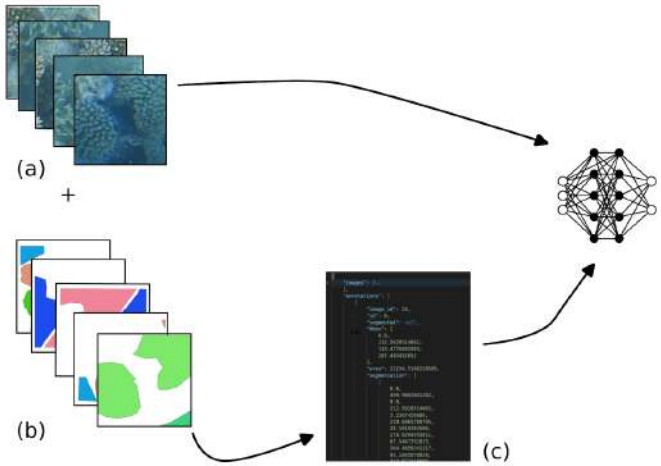
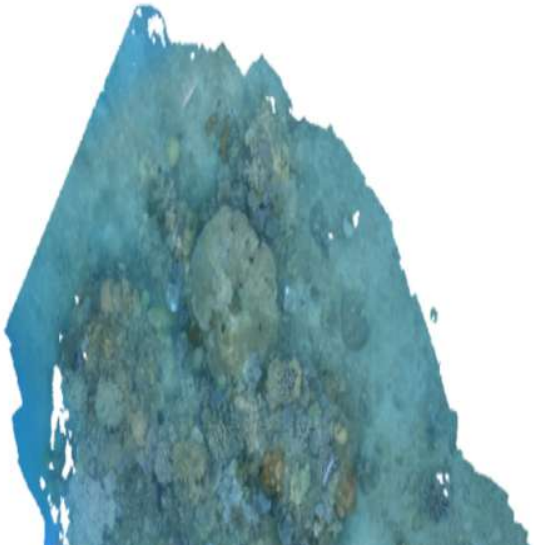



Figure 4. Labeled raster tiles (.tif format) (a) and vector tiles of annotation (.geojson format) (b). COCO file containing annotations (c) to train models.



# SfM Photogrammetry applications

**OpenDroneMap:** IRD workstation/server https://opendronemap.ird.fr/
Coll. G2OI project, *S. Poulain & J. Barde - UMR Marbec*


- ✔ SfM photogrammetry
- ✔ Multispectrale photogrammetry
- ✔ Esaly Web User interface → 2D et 3D models visualization
- ✔ GCP's creation without uploaded images. Automatic markers detection → aditionals plugins
- ✔ Rolling shutter :
- ✔ Homography: rapid processing for urgency cases, survey to natural disaster e.g.cyclone, floods earthquak... (equivalent of Pix4D fields ou React)
- ✔ User gestion, sharing / collaboratif projects
- ✔ API remote automated processing

**Demo** → Video (*S. Poulain*)

# SfM Photogrammetry applications

- **Awareness actions:**

Education program

Arts –
*2022 -2024*

# SfM Photogrammetry applications

*Workshop : Underwater and aerial image processing - drones: mapping with artificial intelligence and photogrammetry*

*Malagasy National Oceanographic Data Center*

**F**indability

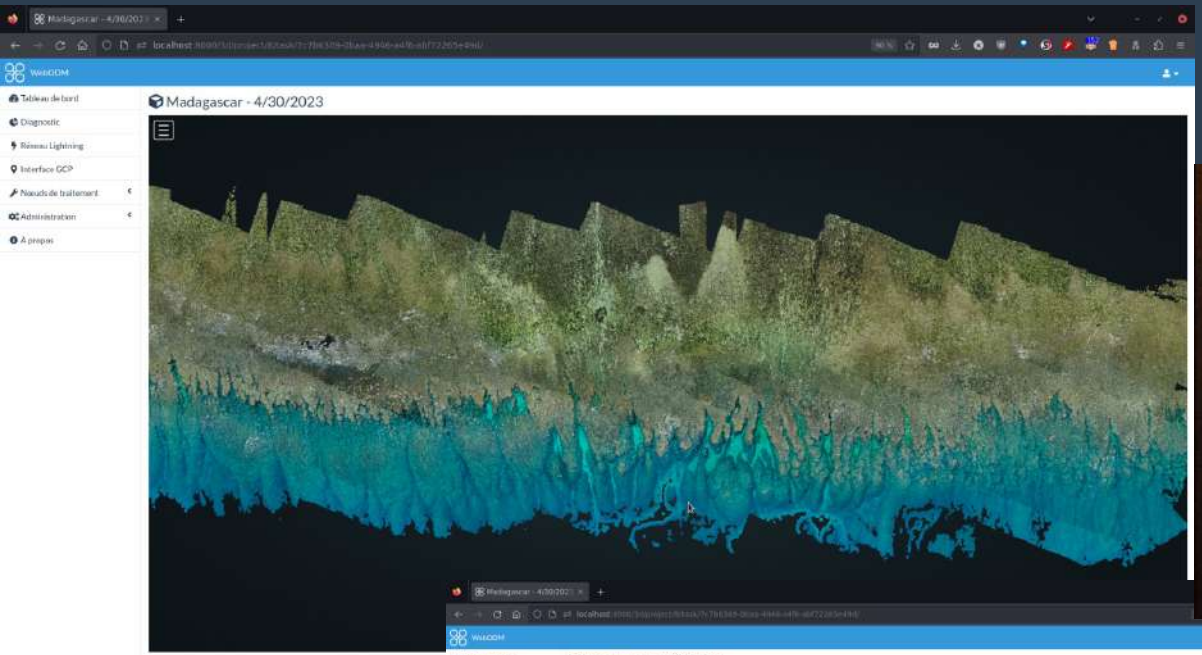
**A**ccessibility

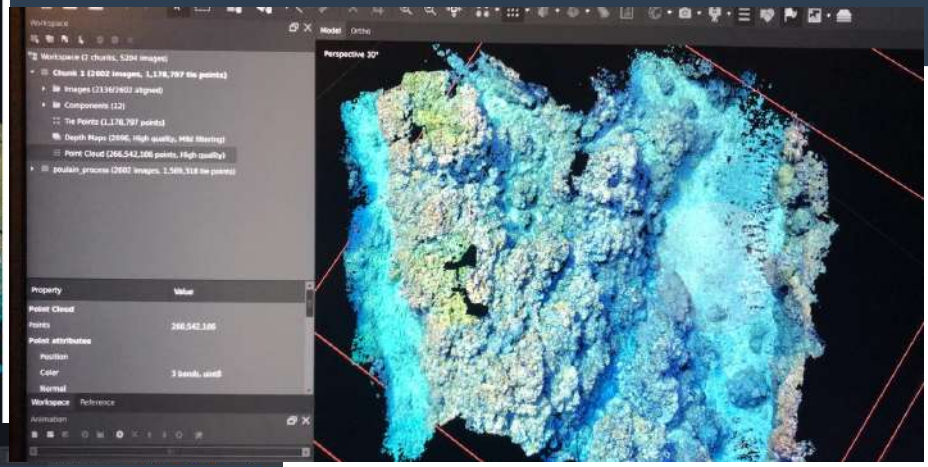
**I**nteroperabillity

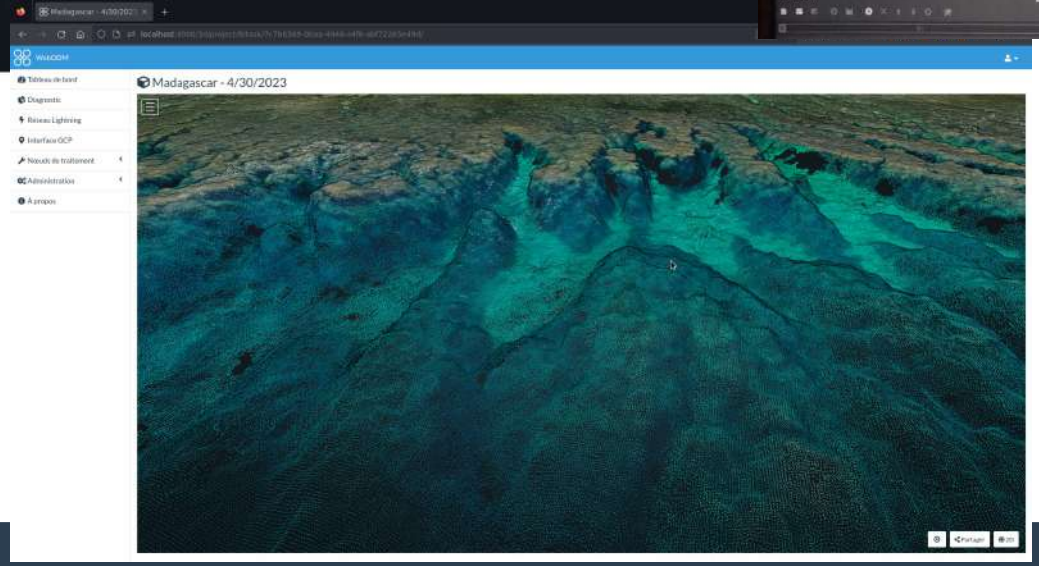
**R**eusability

Coll. G2OI project

# SfM Photogrammetry applications






*Nosy-Ve reef aerial- drone survey and underwater sampling*

G2OI project
S. Poulain & J. Barde

RÉPUBLIQUE FRANÇAISE
*Liberté*
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IRD Institut de Recherche pour le Développement FRANCE

OFB OFFICE FRANÇAIS DE LA BIODIVERSITÉ

Centre Universitaire MAYOTTE

FUTURE MAORE REEFS

# Thank you

# Questions ?

Financé par l'Union européenne
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GEOHAB Marine Geological and Biological Habitat Mapping