

# DISTRIBUTION ET EVALUATION DE L'ETAT ECOLOGIQUE DES HABITATS BENTHIQUES EN ZONE CÔTIÈRE PAR IMAGERIE HYPERSPECTRALE

Bajjouk et al.,  
en collaboration avec :



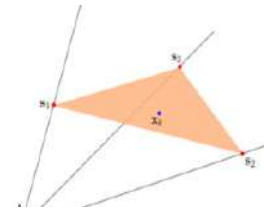
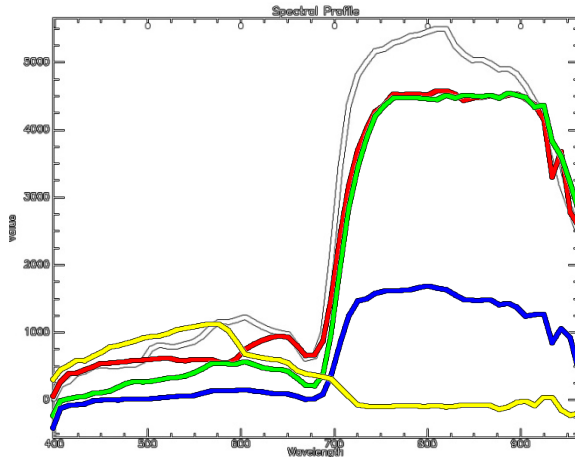
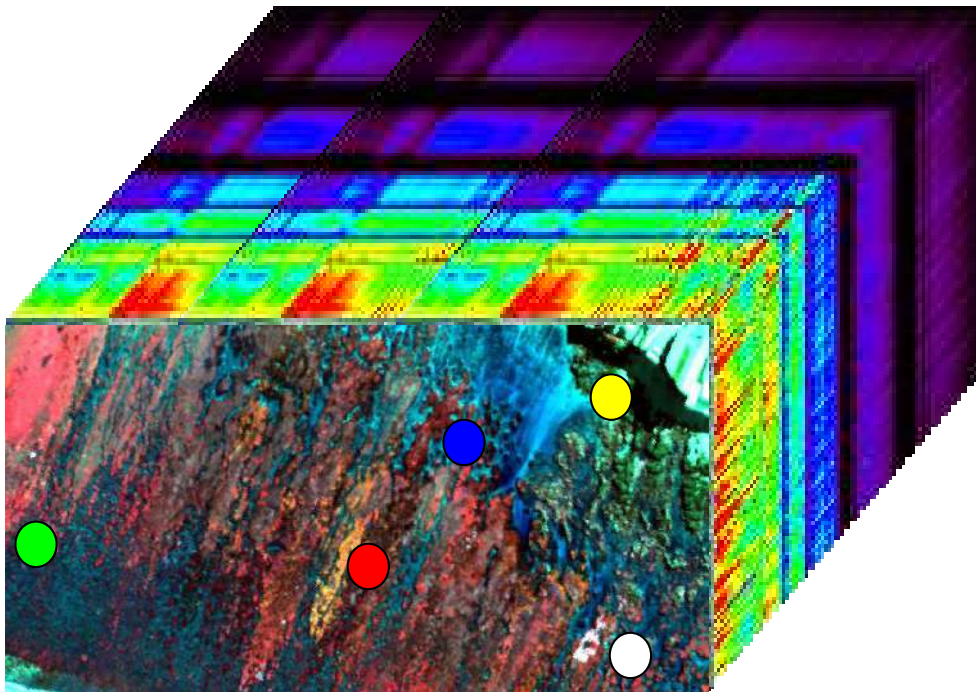




# MÉTHODES UTILISÉES

## SPECTRAL UNMIXING

Image hyperspectrale



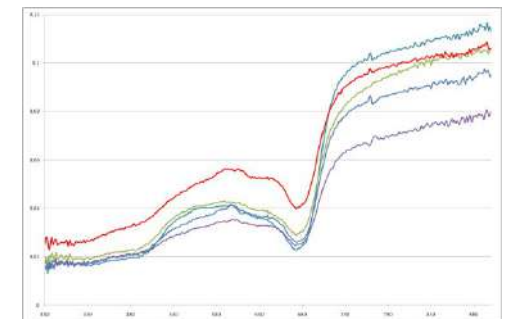
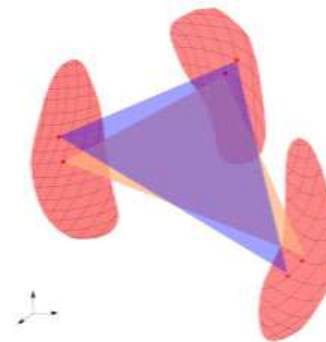
$$\mathbf{x}_n = \sum_{p=1}^P a_{pn} \mathbf{s}_p + \mathbf{e}_n$$

Linear mixing model

$n$  : pixel number  
 $P$  : Endmember number  
 $\mathbf{x}_n$  : Observed pixel  
 $S$  : Endmember spectral matrix  
 $a_n$  : Endmember abundances of pixel  $n$   
 $\mathbf{e}_n$  : Additive noise

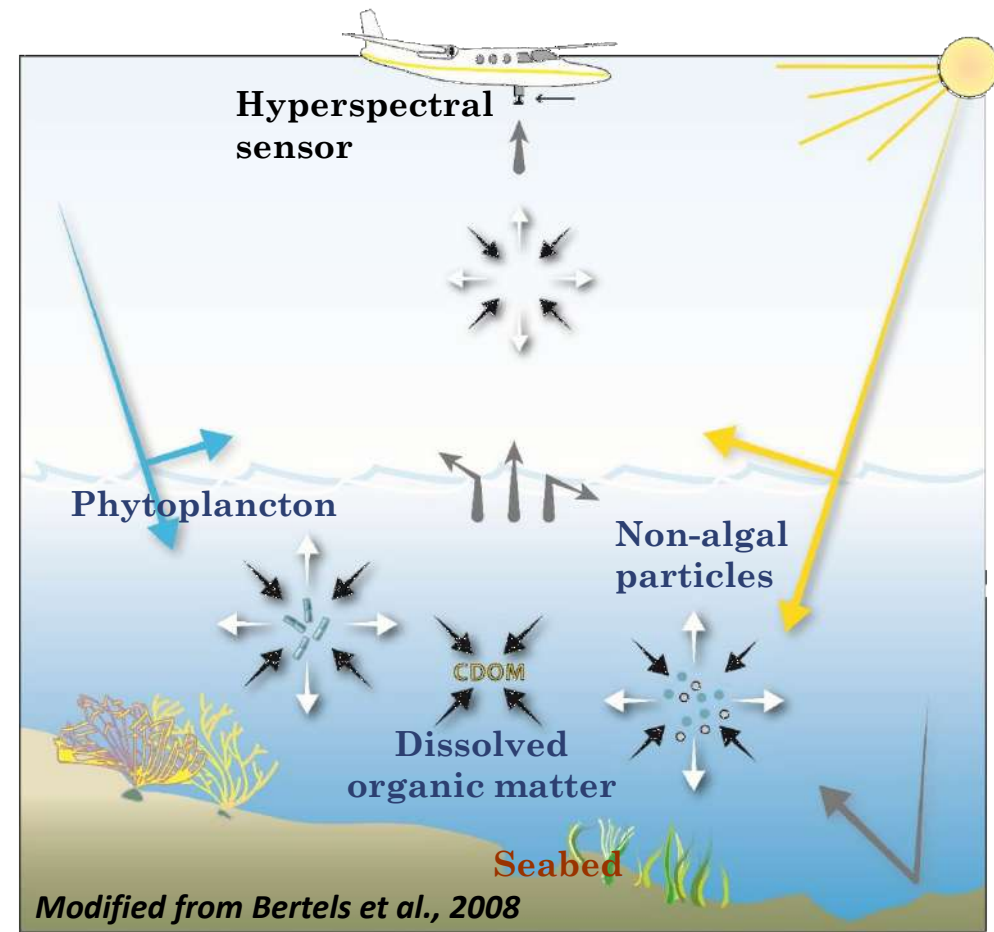
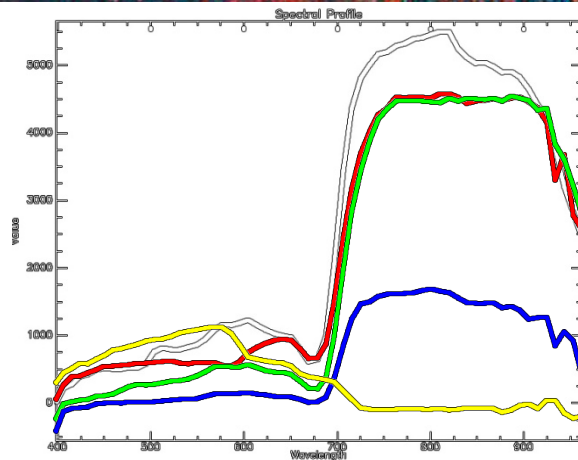
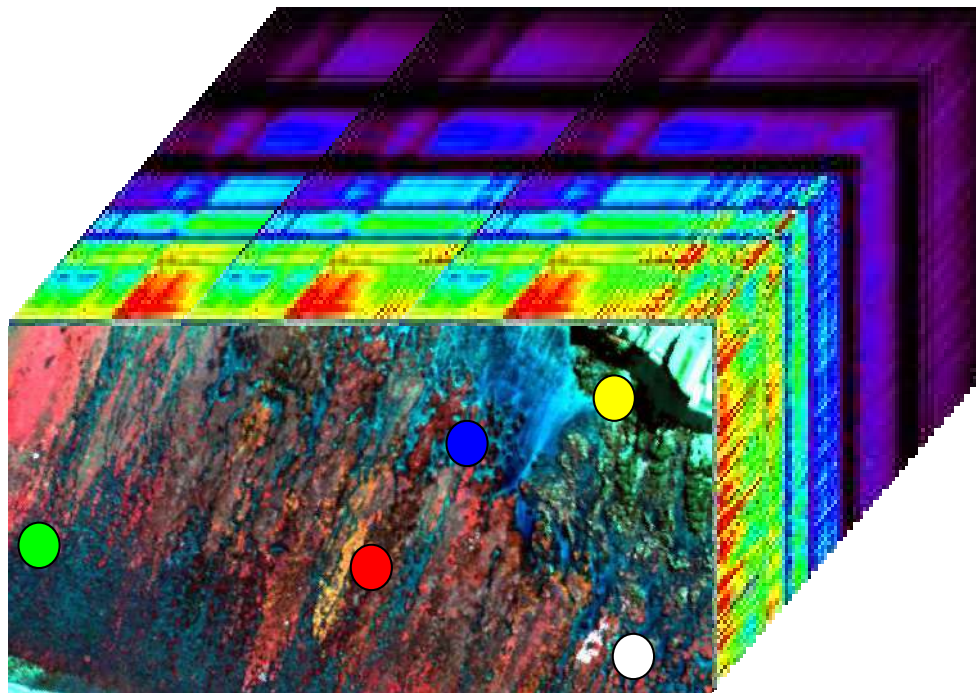
**+** 2 constraints  $\left\{ \begin{array}{l} a_{pn} \geq 0 \text{ (Non- negativity)} \\ \sum_{p=1}^P a_{pn} = 1 \end{array} \right.$  (Sum to one)

**+** Spectral variability



# MÉTHODES UTILISÉES

## INVERSION DU MODÈLE DE TRANSFERT RADIATIF



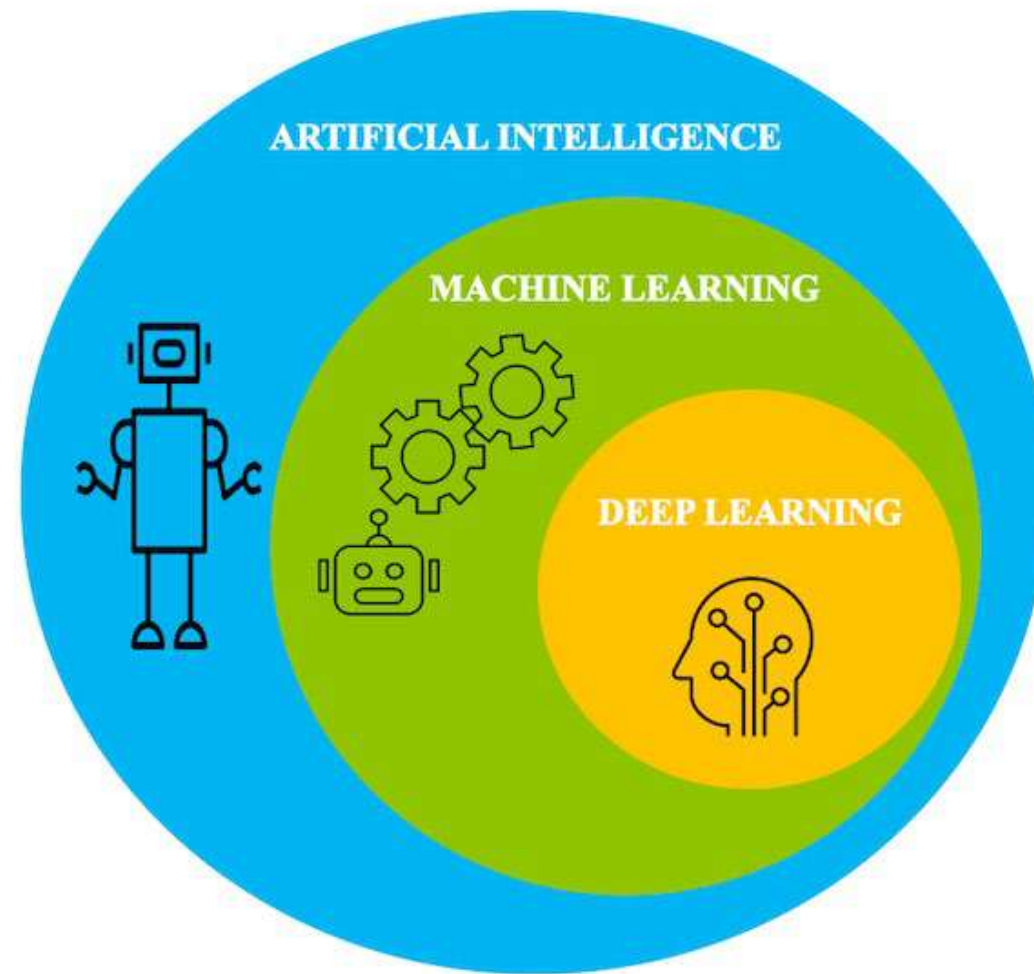
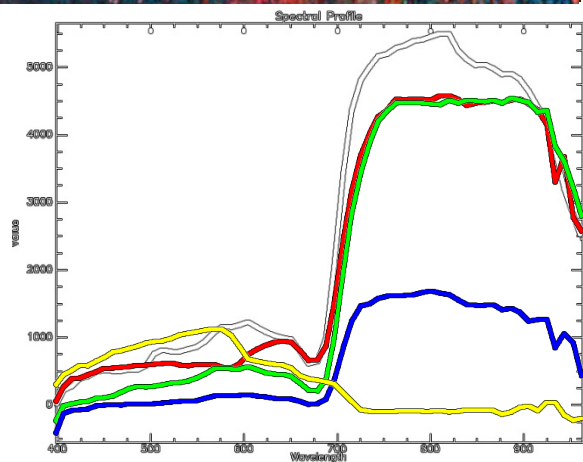
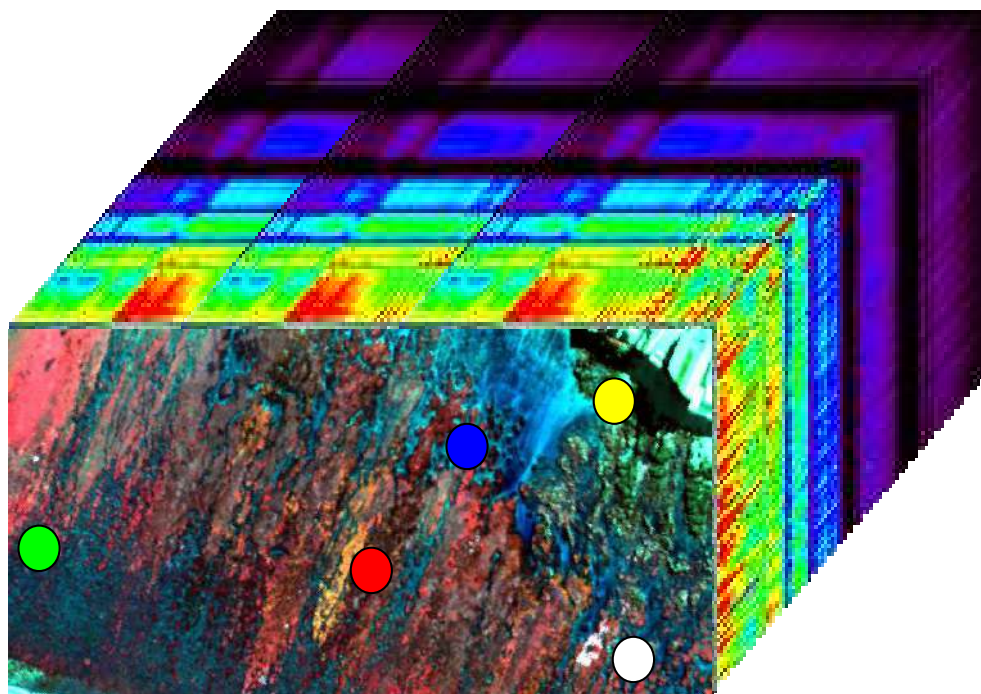
$$r_{rs}^{-}(\lambda) = r_{rs}^{dw}(\lambda) \cdot \left[ 1 - e^{-(K_d(\lambda) + K_u^C(\lambda)) \cdot H} \right] + \frac{\rho(\lambda)}{\pi} \left[ e^{-(K_d(\lambda) + K_u^B(\lambda)) \cdot H} \right]$$

Sensor reflectance      Deep water reflectance      Water column attenuation      Bottom albedo      Depth



# MÉTHODES UTILISÉES

## CLASSIFICATION DES TYPES DE FONDS





# EXEMPLES D'APPLICATIONS

## MODÈLES BIOLOGIQUES

### Ecosystem engineer

“Organisms that directly or indirectly modulate the availability of resources to other species”

*[Jones et al., 1994 OIKOS]*

1 Ecosystèmes coralliens



2



Récifs d'hermelles

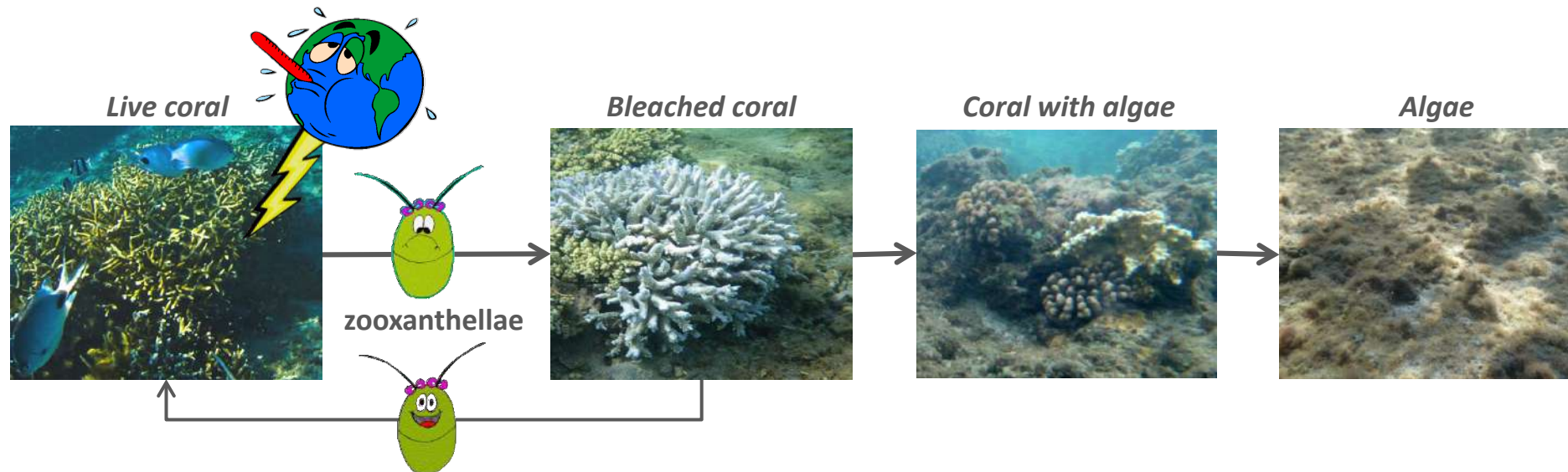
3 Phanérogames Marines



# ÉCOSYSTÈMES CORALLIENS

## CONTEXTE & ENJEUX

- 25% de la biodiversité marine
- Services écosystémiques (300 millions \$ /an)
- > 60% des récifs sont en danger immédiat



**Good Status**



+ Live coral  
+ 3D structure

**Bad status**



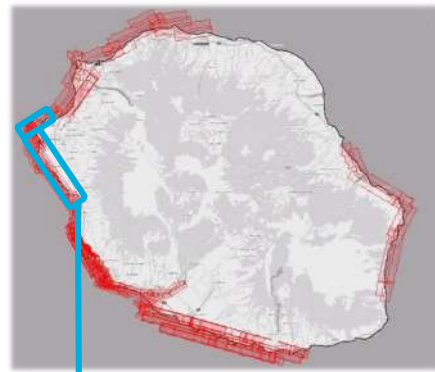
+ Turf algal  
- 3D structure



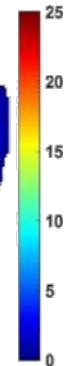
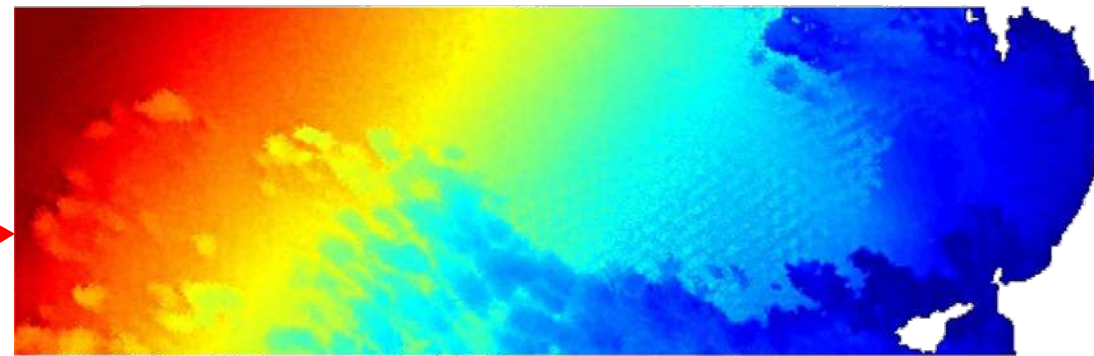


# ÉCOSYSTÈMES CORALLIENS

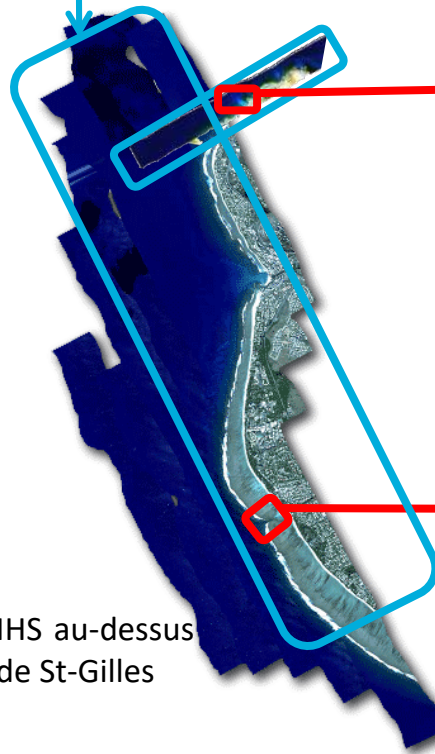
## INVERSION DU MODÈLE DE TRANSFERT RADIATIF



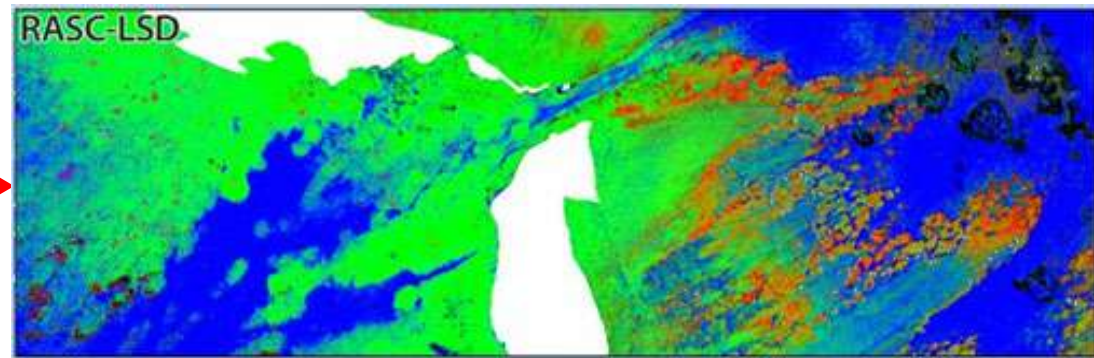
Site : Boucan



Estimation fiable de la bathymétrie jusqu'à 25m

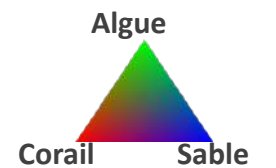


IHS au-dessus de St-Gilles



Site : Ermitage

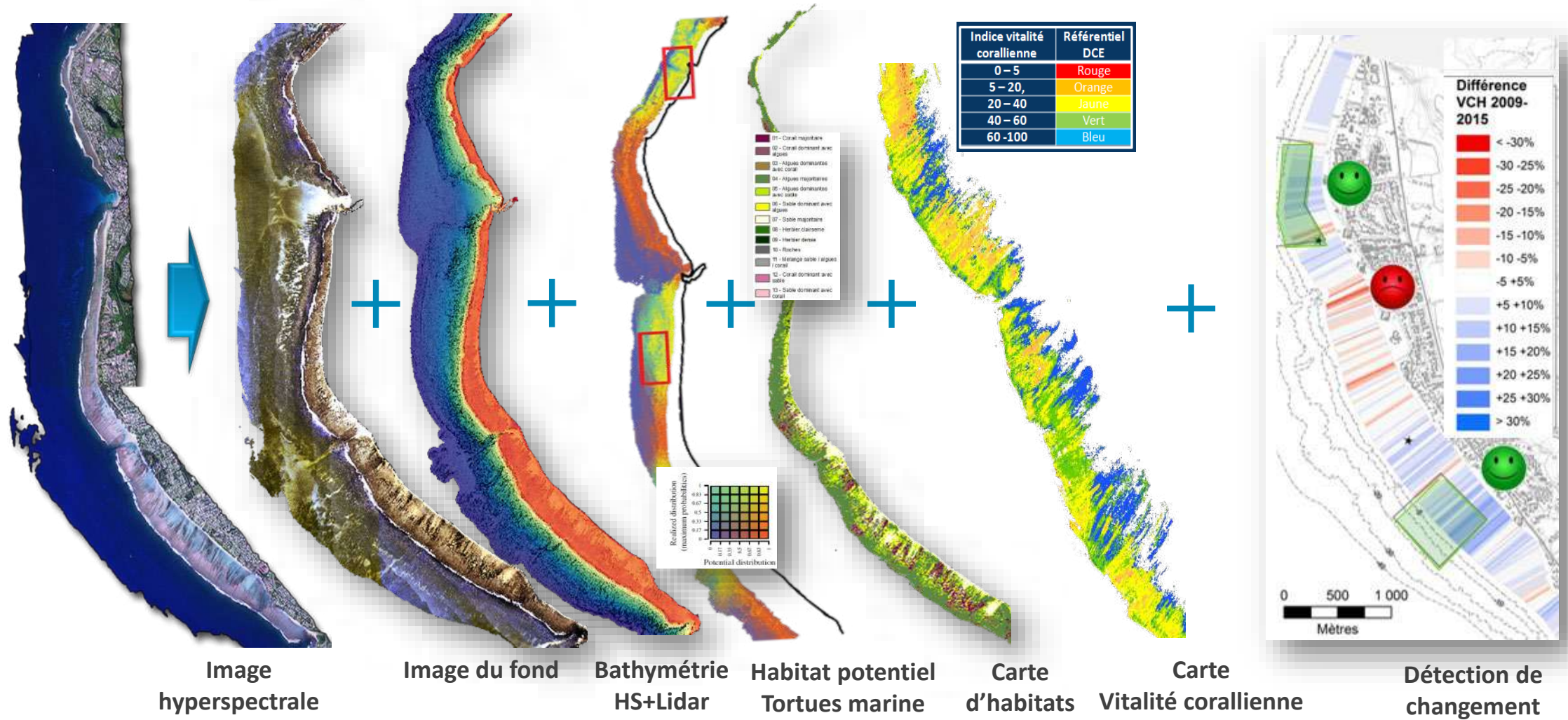
Estimation types de fonds jusqu'à 15 m





# ÉCOSYSTÈMES CORALLIENS

## INVERSION DU MODÈLE DE TRANSFERT RADIATIF



Bajjouk et al., Ecol.Ind. (2019)

Chambault et al., Ecography (2021)

**SPECTRHABENT - HYScores**




# RÉCIFS D'HERMELLES

## CONTEXTE & ENJEUX

### ROLE ECOLOGIQUE

Hot-Spot Biodiversité



Fonctionnement du réseau trophique

Stock de sédiments calcaires

### MENACES



### Suivi stationnel



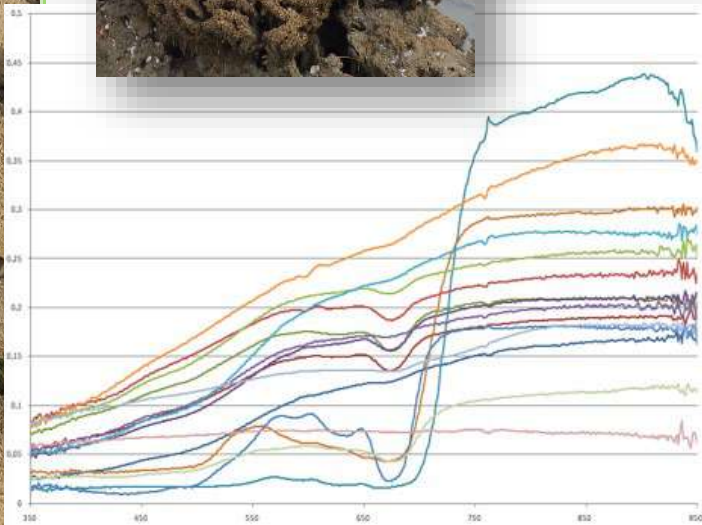
Déterminer **la Structure spatiale** et cartographier les **phases écologiques** des différents types de bio-constructions d'hermelles



# RÉCIFS D'HERMELLES

## ANALYSE DES SIGNATURES SPECTRALES

### Librairie hyperspectrale *in situ*



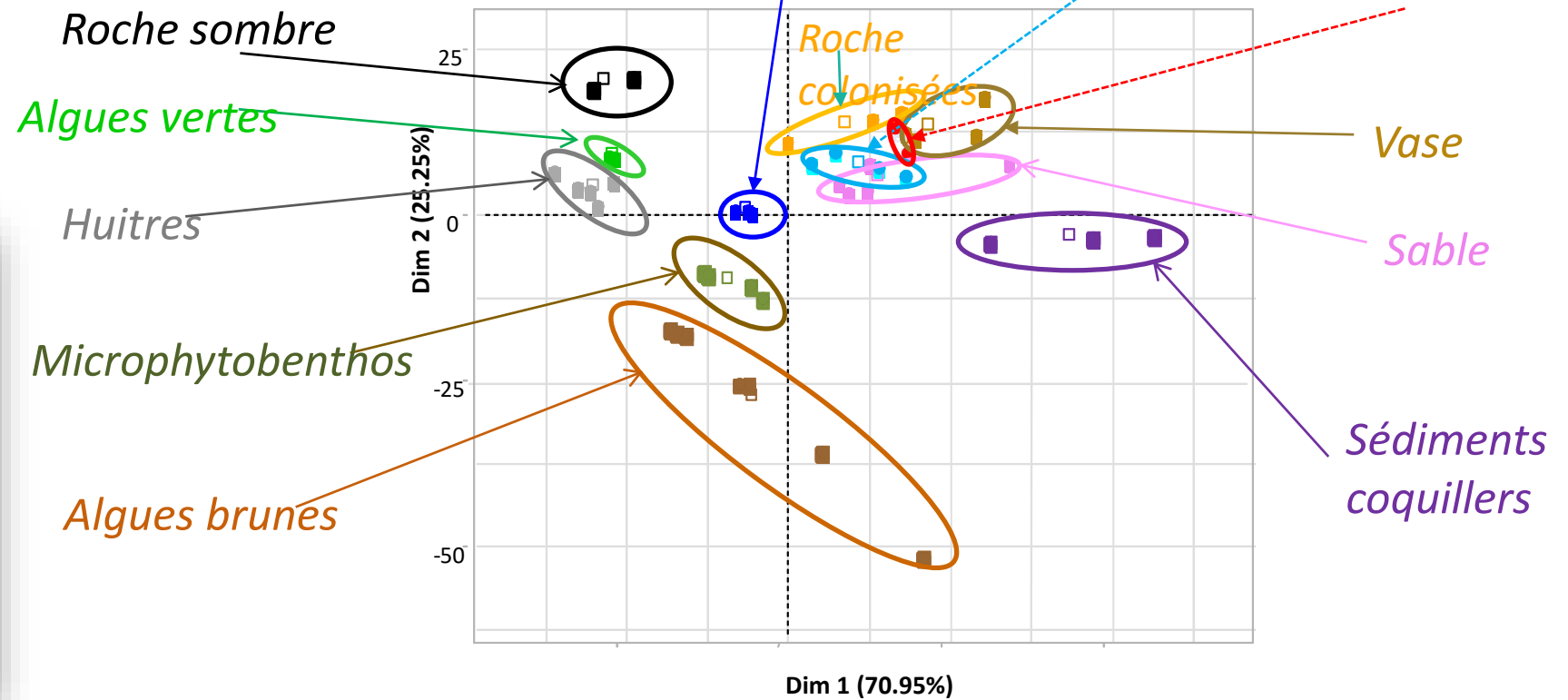
Hermelles en bon état



Hermelles moyennement dégradées

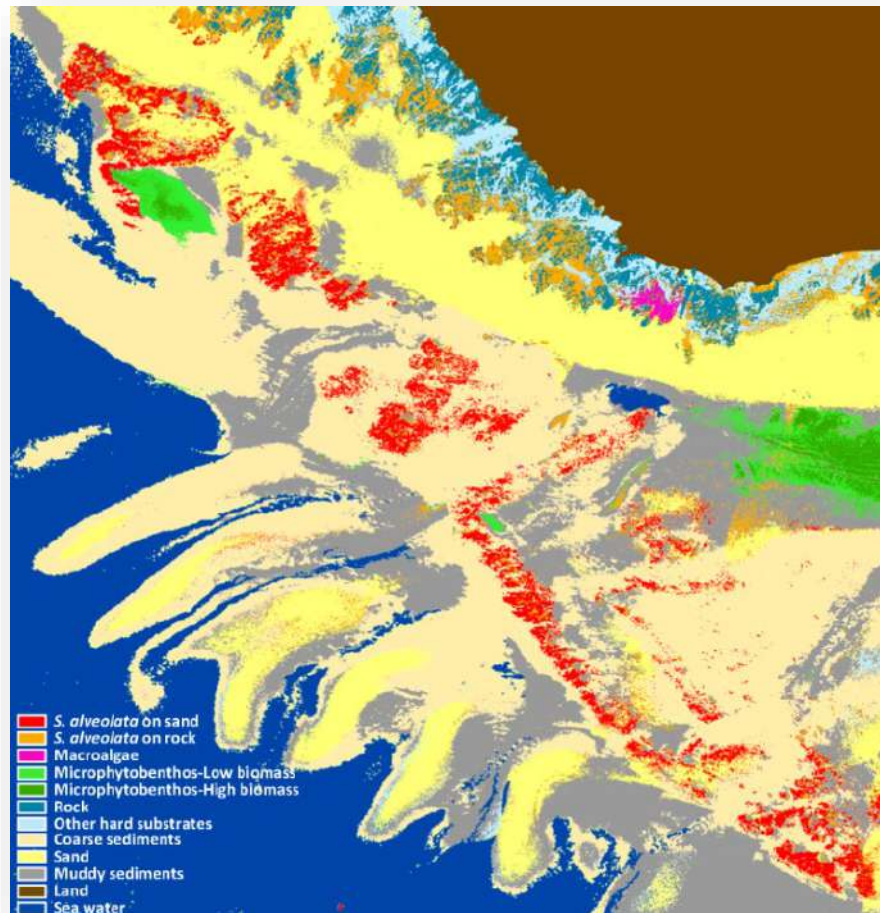


Hermelles très dégradées



# RÉCIFS D'HERMELLES

## CARTOGRAPHIE D'HABITATS & EVALUATION DE L'ÉTAT

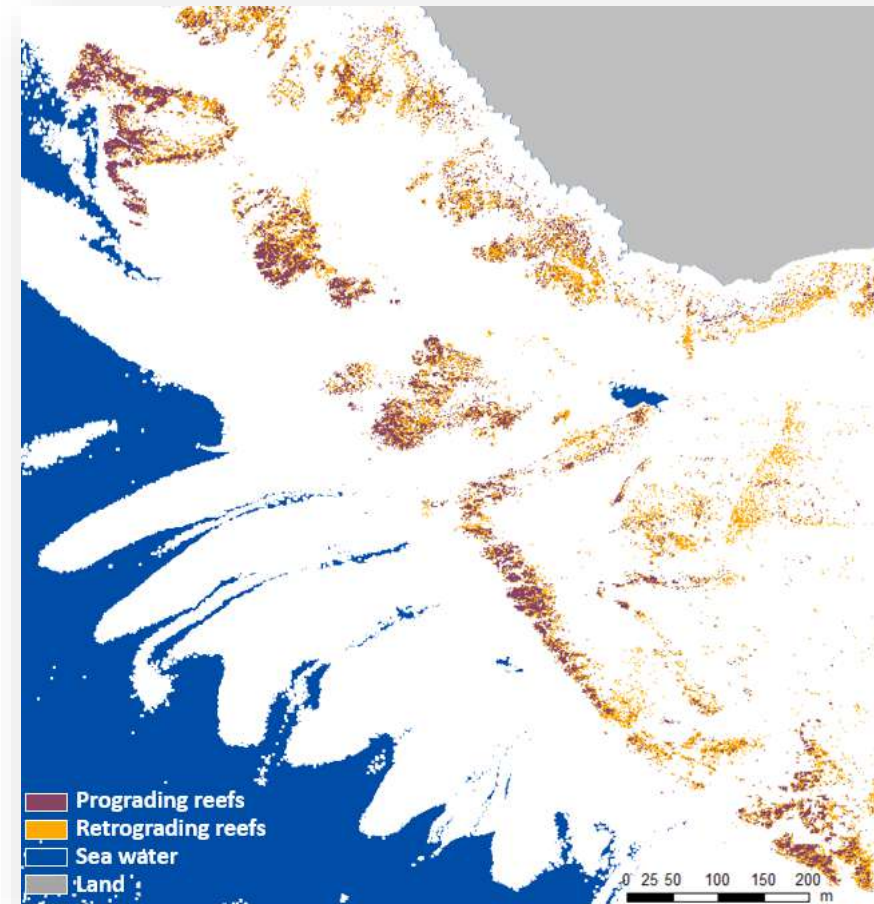


**Validation :**

**Khi<sup>2</sup> (p-value < 0,0001)**

**Overall accuracy = 88 %**

**Kappa = 0.853**



**Validation :**

**Khi<sup>2</sup> (p-value < 0,0001)**

**Overall accuracy = 93%**

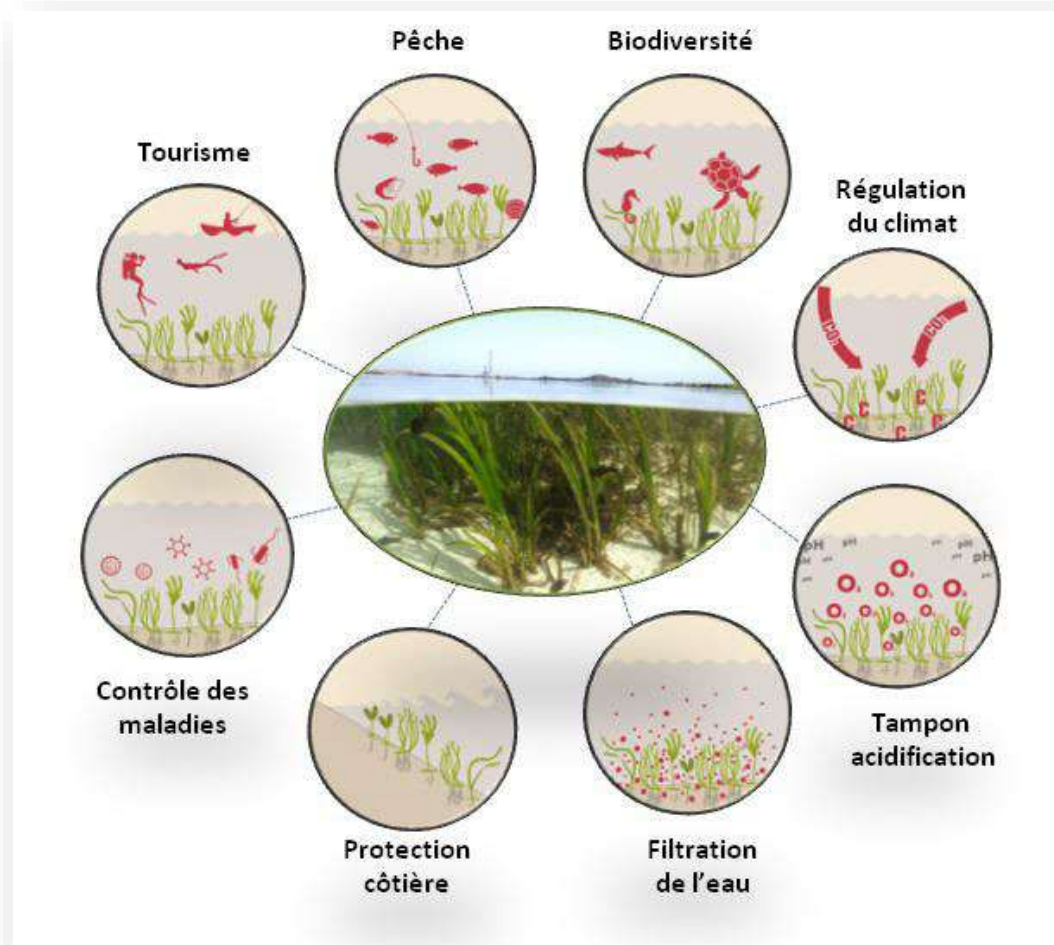
**Kappa = 0.86**



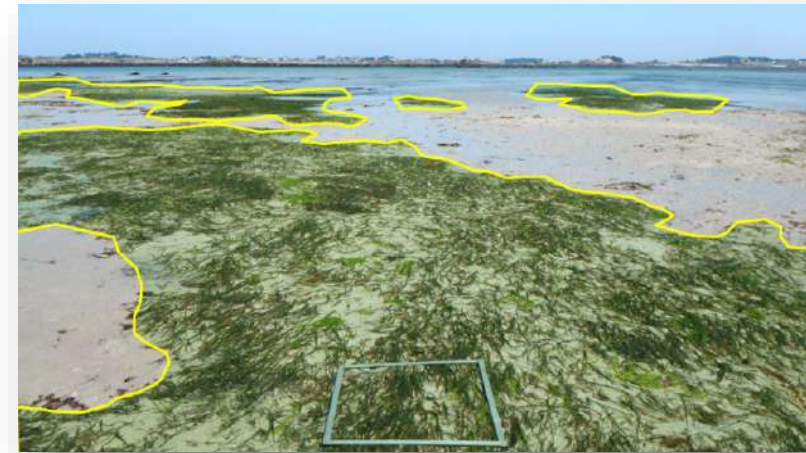
# HERBIERS MARINS

## CONTEXTE & ENJEUX

- Plus de 300000 km<sup>2</sup>
- Perte de 7% chaque année
- Nurserie pour plus 1/5 des 25 plus grandes pêcheries mondiale



*Zostera noltei*  
(Intertidal)



*Zostera marina*  
(intertidal + subtidal)



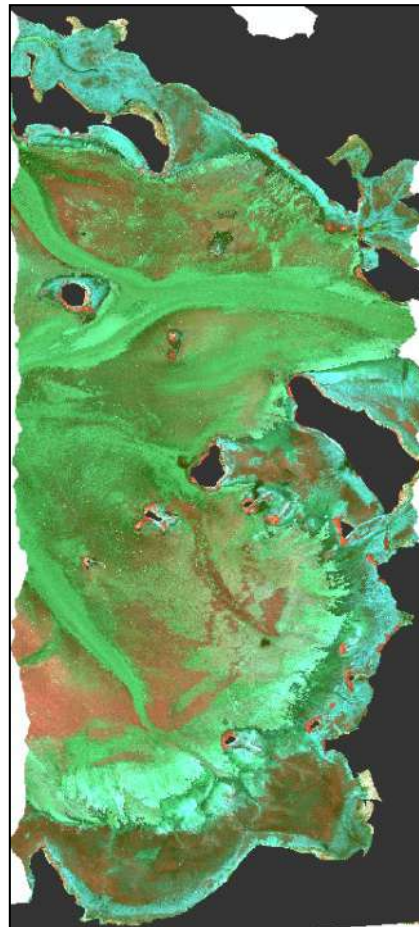
# HERBIERS MARINS

## EXTRACTION D'INFORMATION EN APPUI À LA GESTION

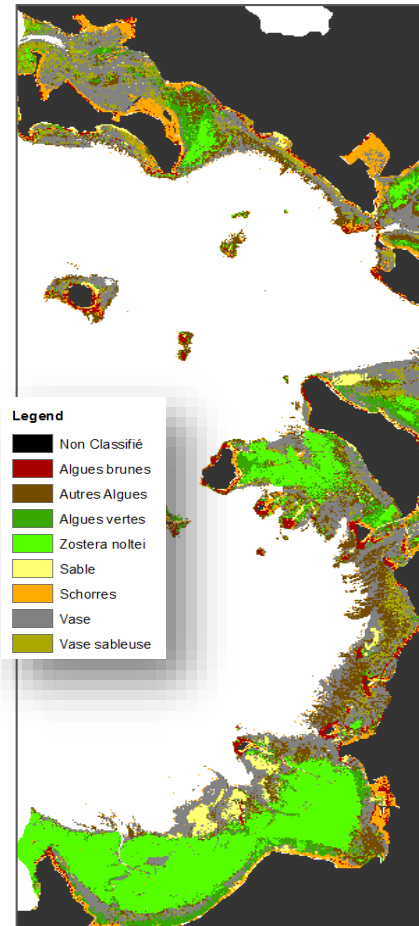
Composition colorée  
(PIR, R, V)



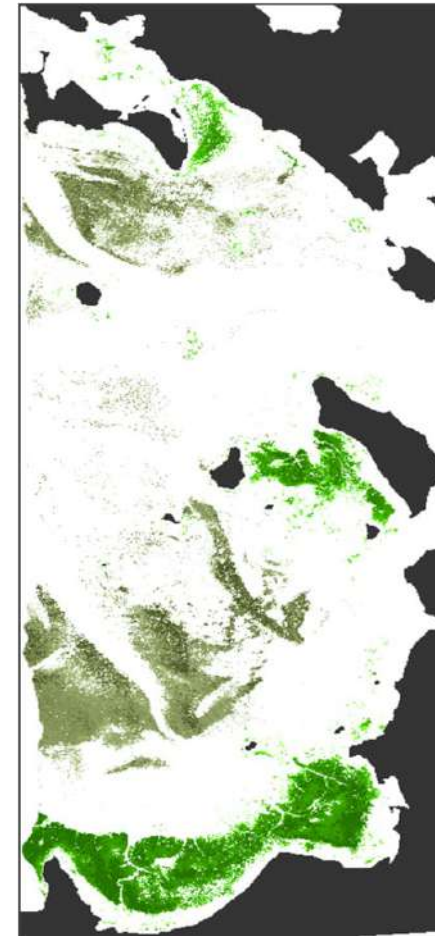
Image corrigée  
Effet colonne d'eau



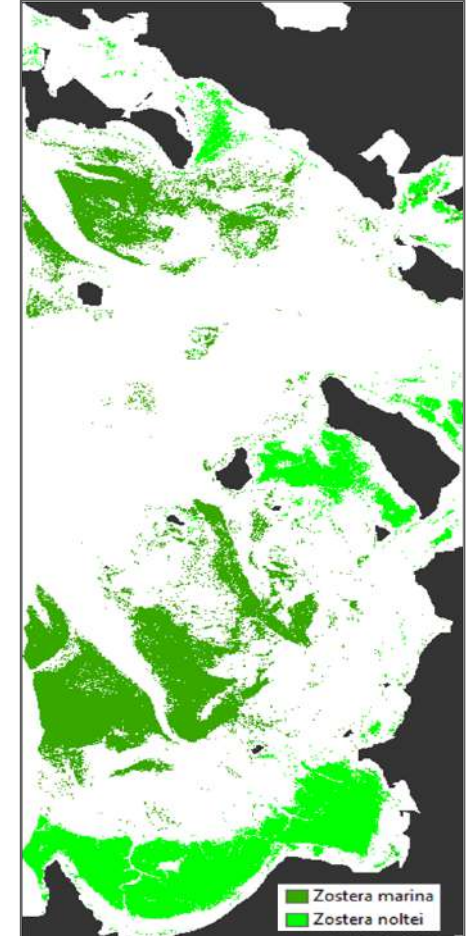
Classification par  
Réseaux de Neurones



Inversion + démelange  
spectral



Distribution  
des espèces de zostères





# HERBIERS MARINS

## CONTEXTE & ENJEUX

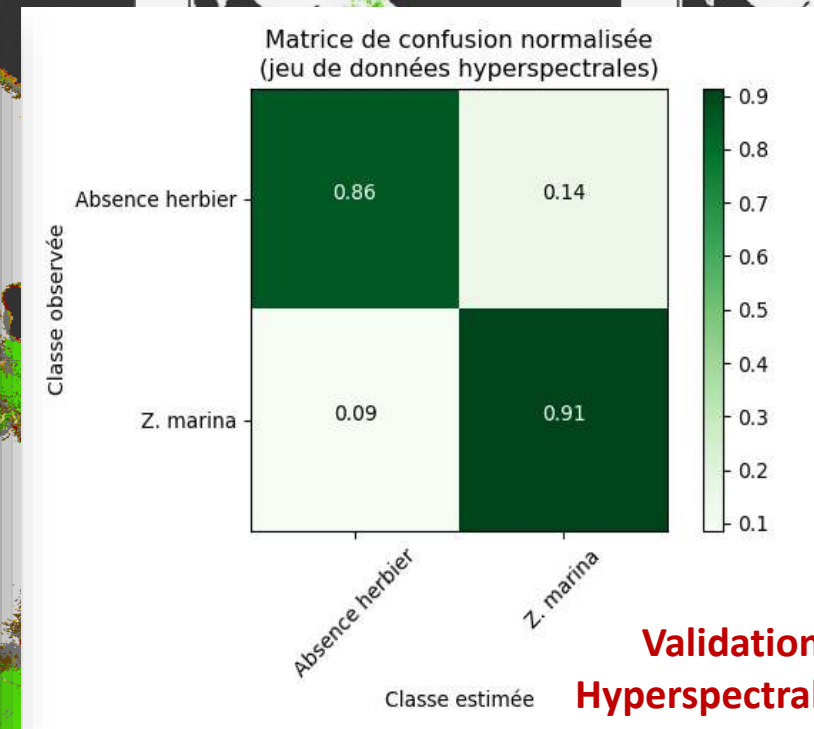
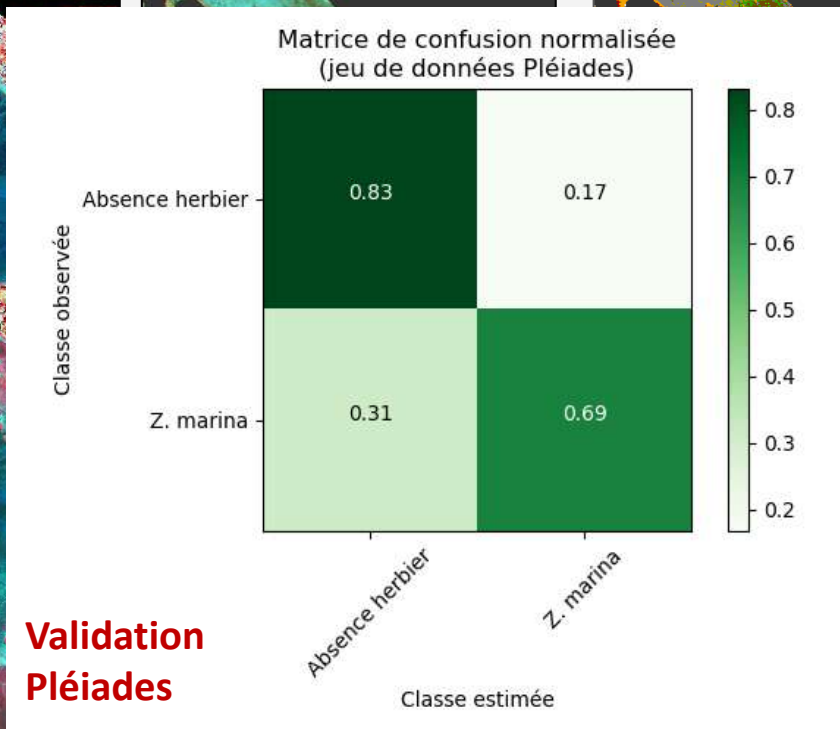
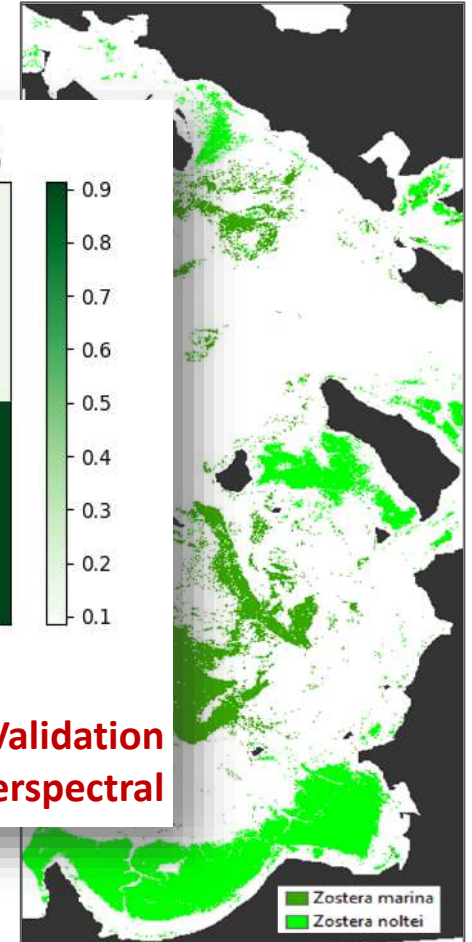
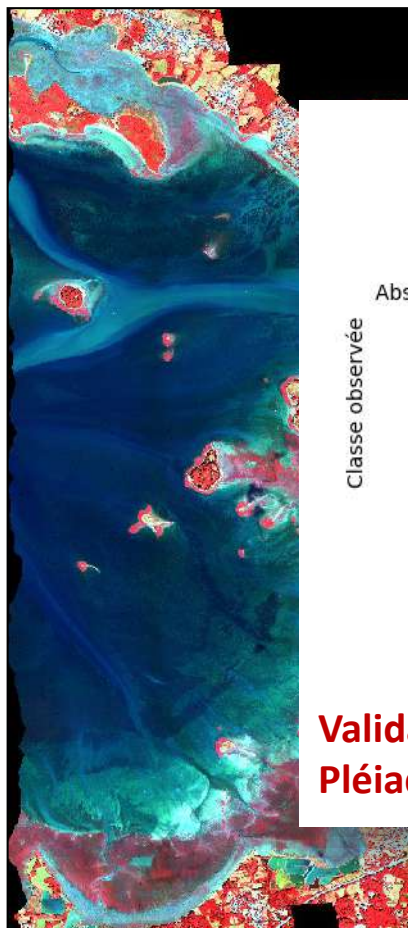
Composition colorée  
(PIR, R, V)

Image corrigée  
Effet colonne d'eau

Classification par  
Réseaux de Neurones

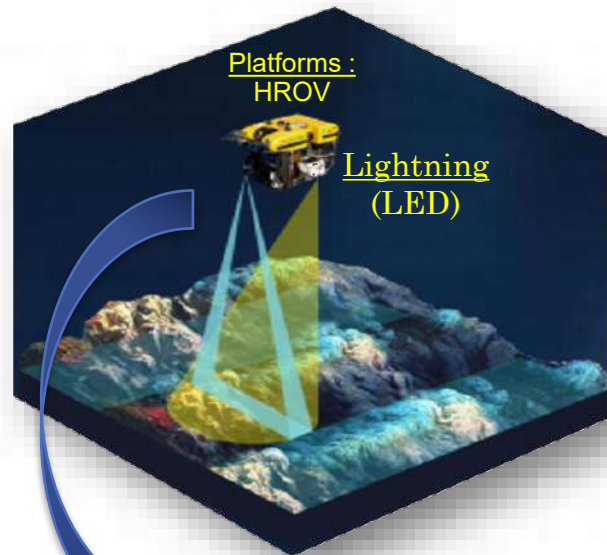
Inversion + démelange  
spectral

Distribution  
des espèces de zostères

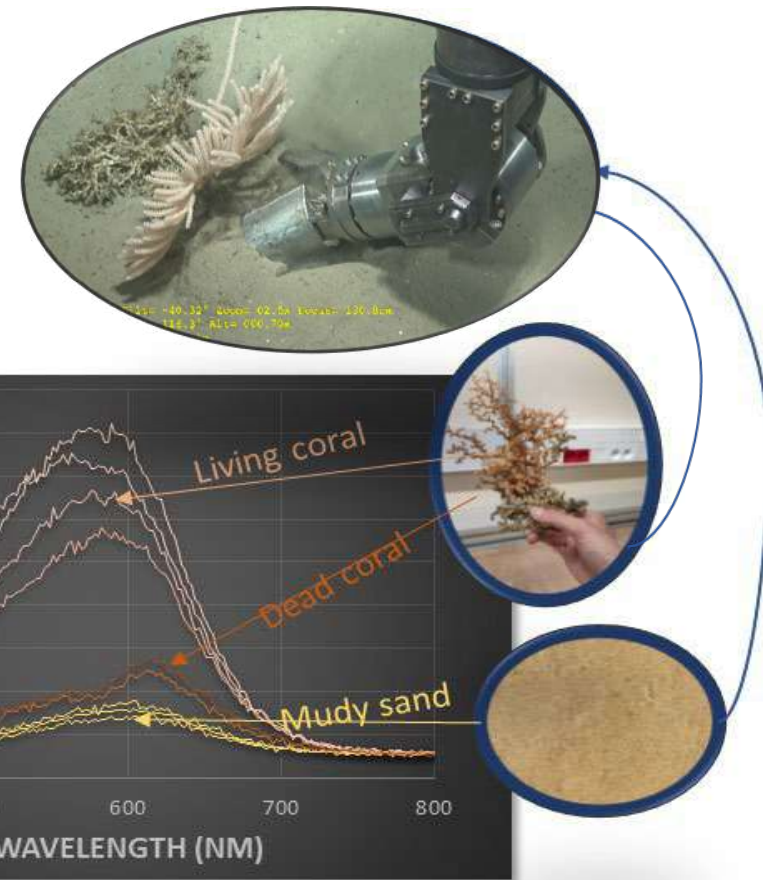


# HYPERSPECTRAL SOU-MARINS

## TECHNOLOGIE EN PLEIN DÉVELOPPEMENT



Lampaul Canyon (Atlantique)  
Chereef-2021  
Profondeur 750-1000 m





An underwater photograph of a coral reef. The scene is dominated by various types of coral, including branching yellow and orange corals and a large, dark red, leafy coral structure on the left. The water is a deep blue, and the overall lighting is somewhat dim, typical of an underwater environment. The text "Merci pour votre attention" is overlaid in the center in a white, sans-serif font.

**Merci pour votre attention**