JOURNÉE THÉMATIQUE PNTS

10 ans d'observations par la mission Sentinel-2 apports et perspectives

Télédétection de la biodiversité marine

Apports et perspectives de Sentinel-2 pour la classification taxonomique et l'étude de la phénologie de la végétation intertidale

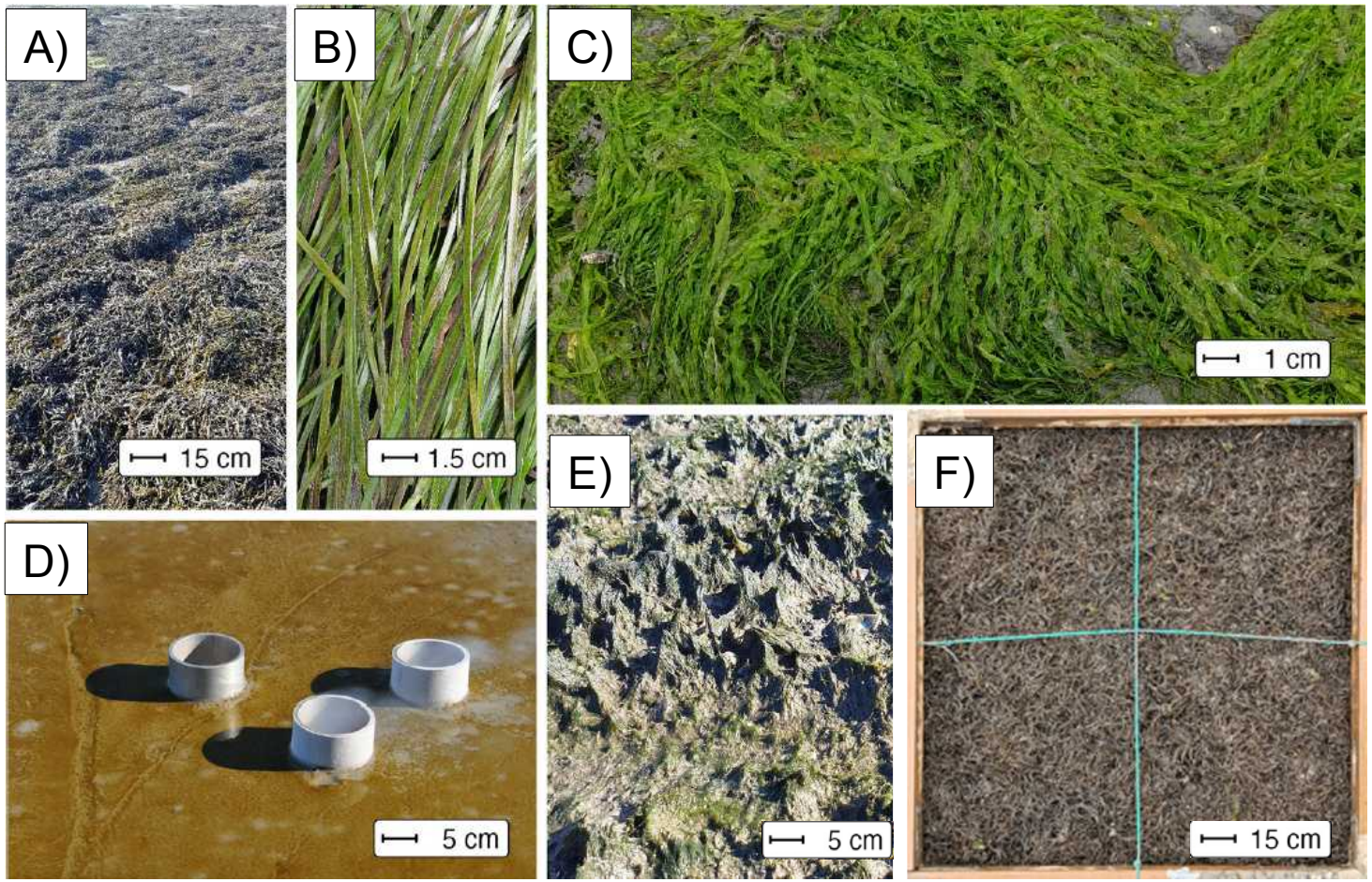
Pierre GERNEZ

Nantes Université

Bordeaux (20 Mai 2025)

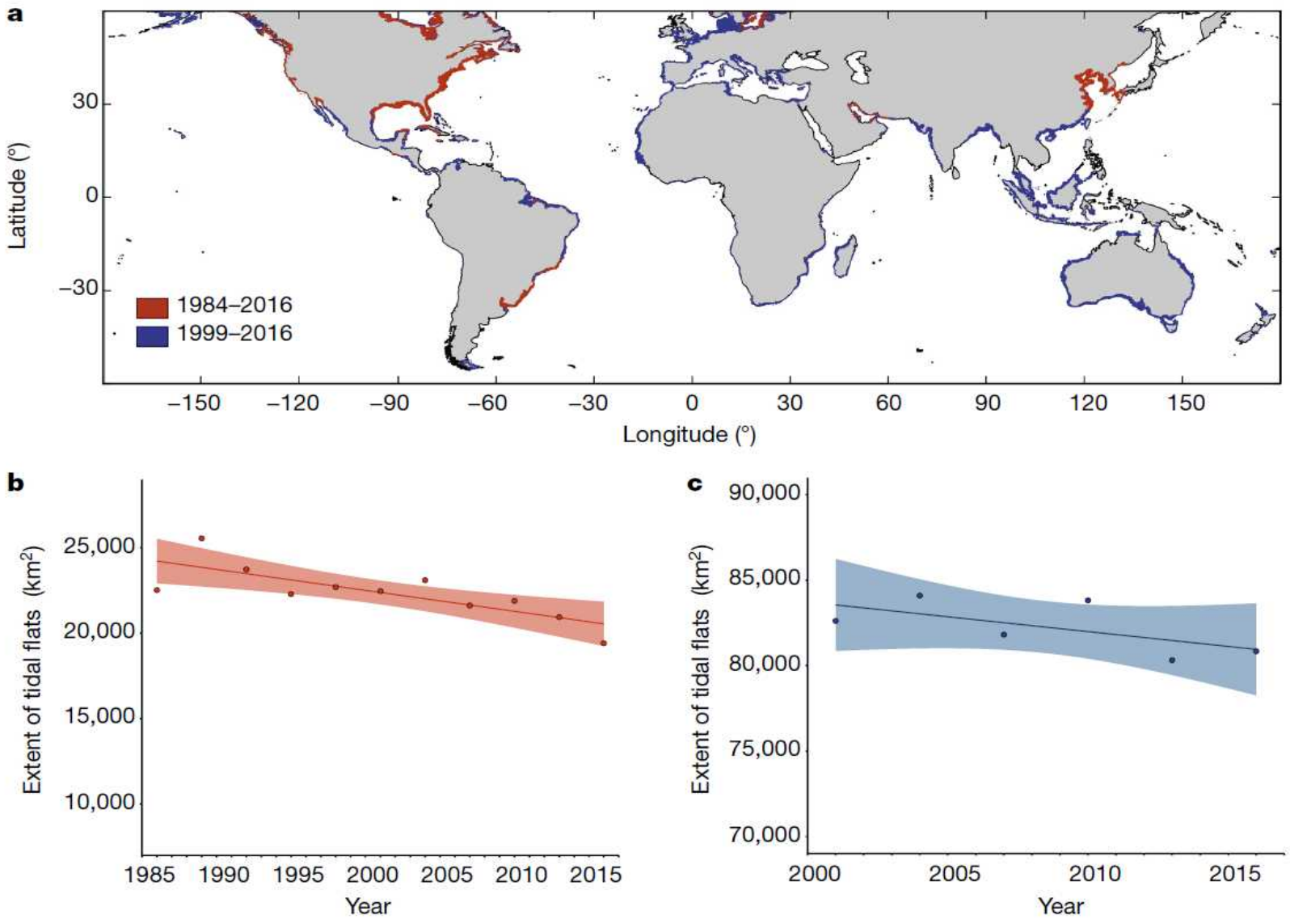
Intertidal ecosystems

Intertidal vegetation biodiversity



Brown algae (A), Seagrass (B), Green algae (C), Microphytobenthos (D), Yellow algae (E), Red algae (F)

Global decline of intertidal mudflats



Murray et al. (2018)

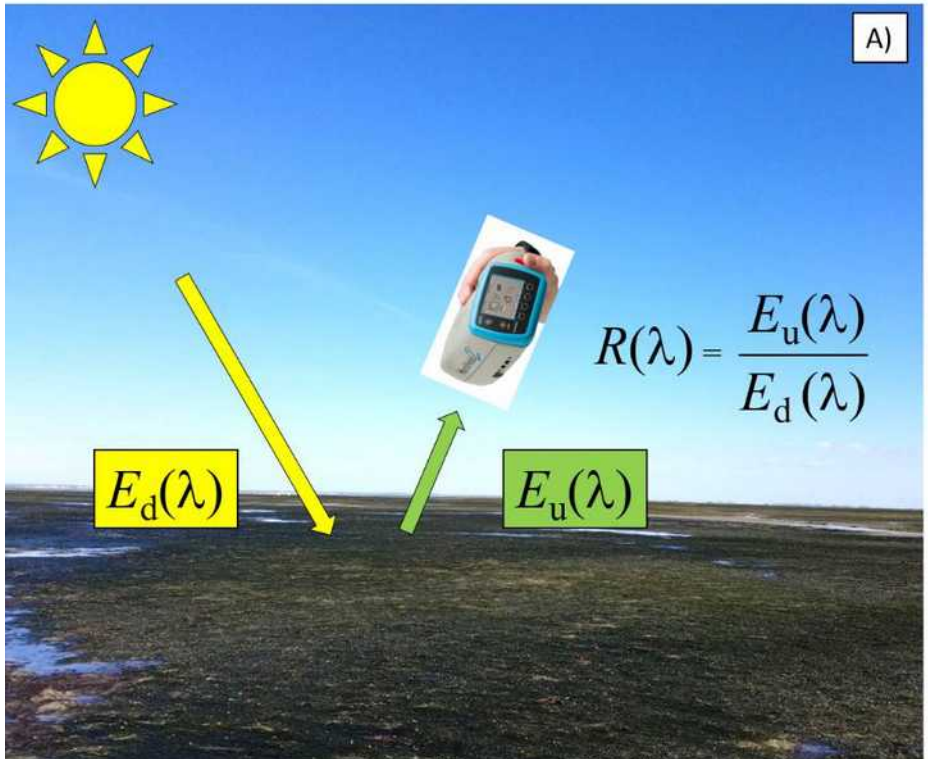
Remote Sensing

Drones and satellites
Increasingly used for mapping coastal vegetation

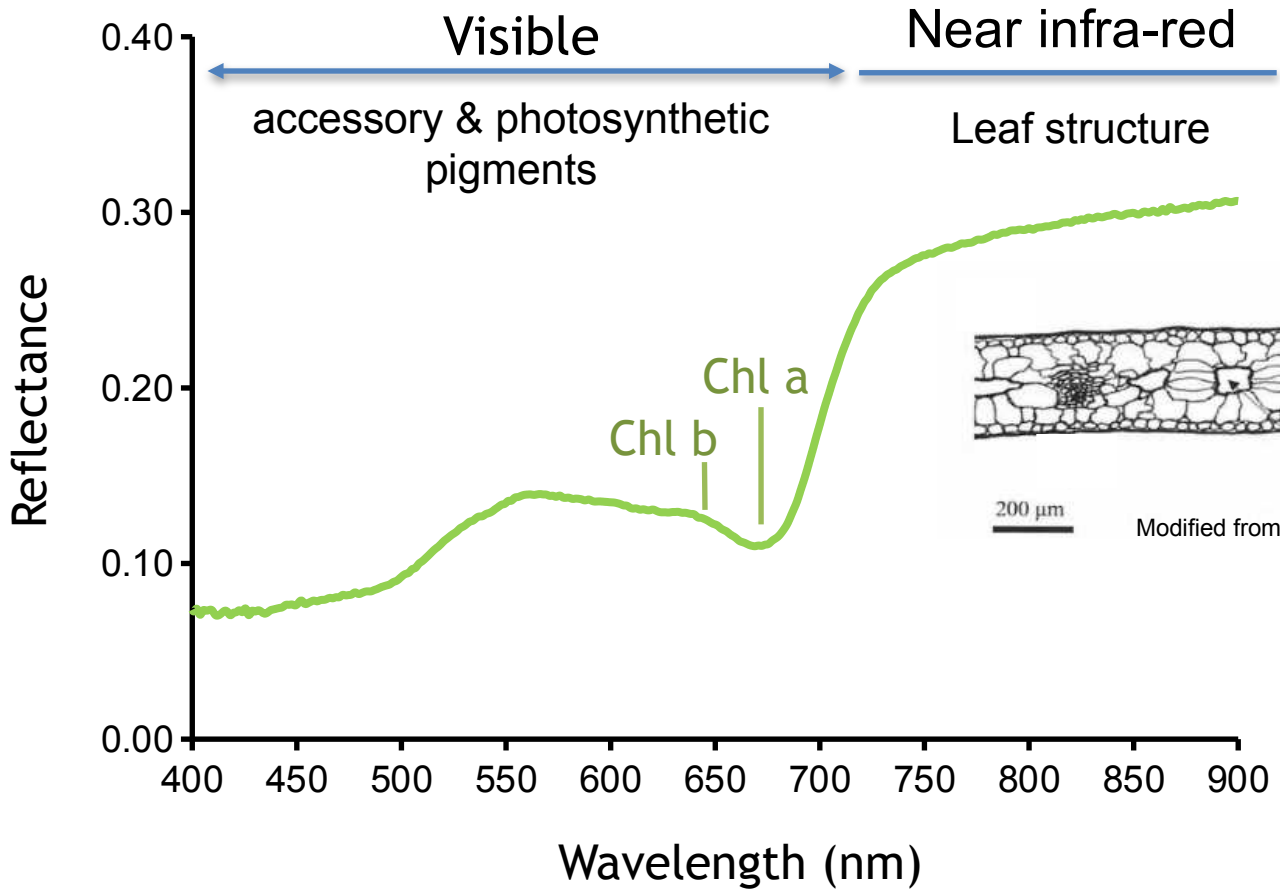
Still many challenges
- Distribution and phenology of intertidal habitat in Europe?
- How many taxonomic classes can be discriminated from satellite?
- Which satellite sensors could be used?

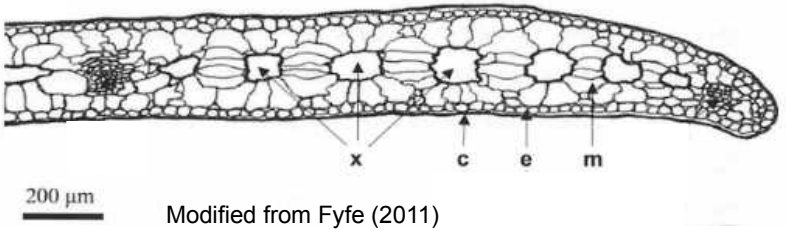
Crucial step
Select the appropriate sensor
- Characterize optical fingerprint of intertidal vegetation

Spectral reflectance $R(\lambda)$



Spectral reflectance (seagrass)





Modified from Fyfe (2011)

Spectral library

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Contents lists available at ScienceDirect

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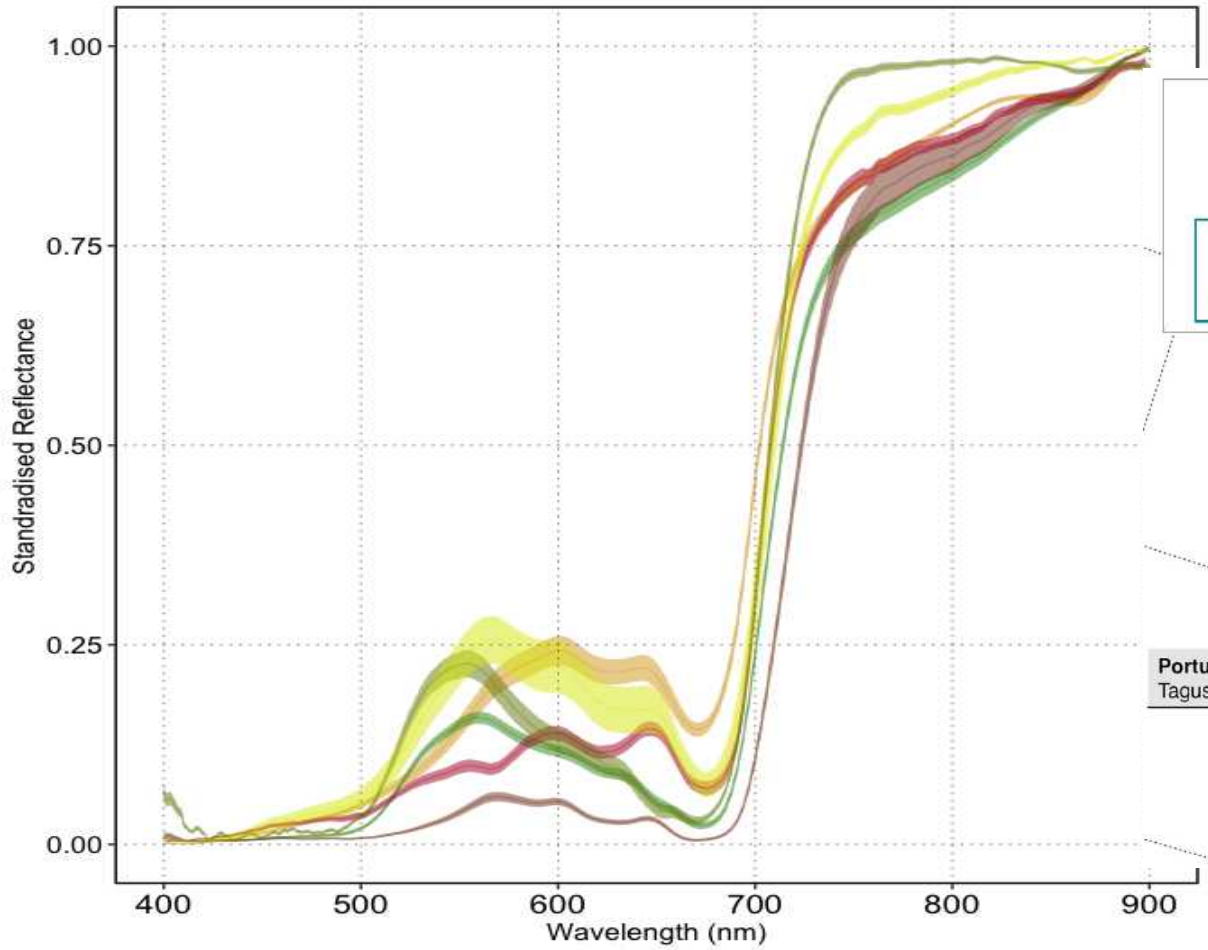
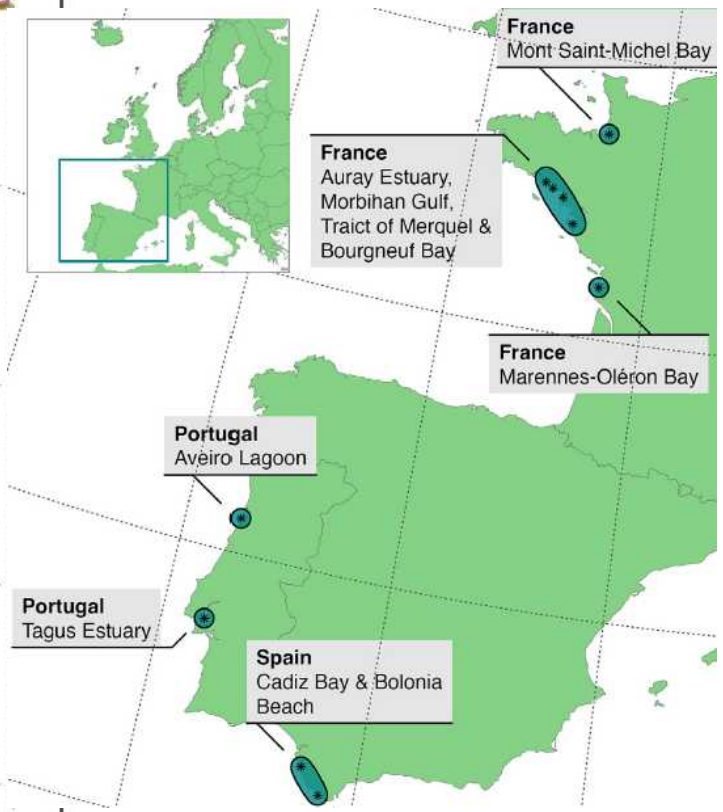
journal homepage: www.elsevier.com/locate/rse

Multi- and hyperspectral classification of soft-bottom intertidal vegetation using a spectral library for coastal biodiversity remote sensing

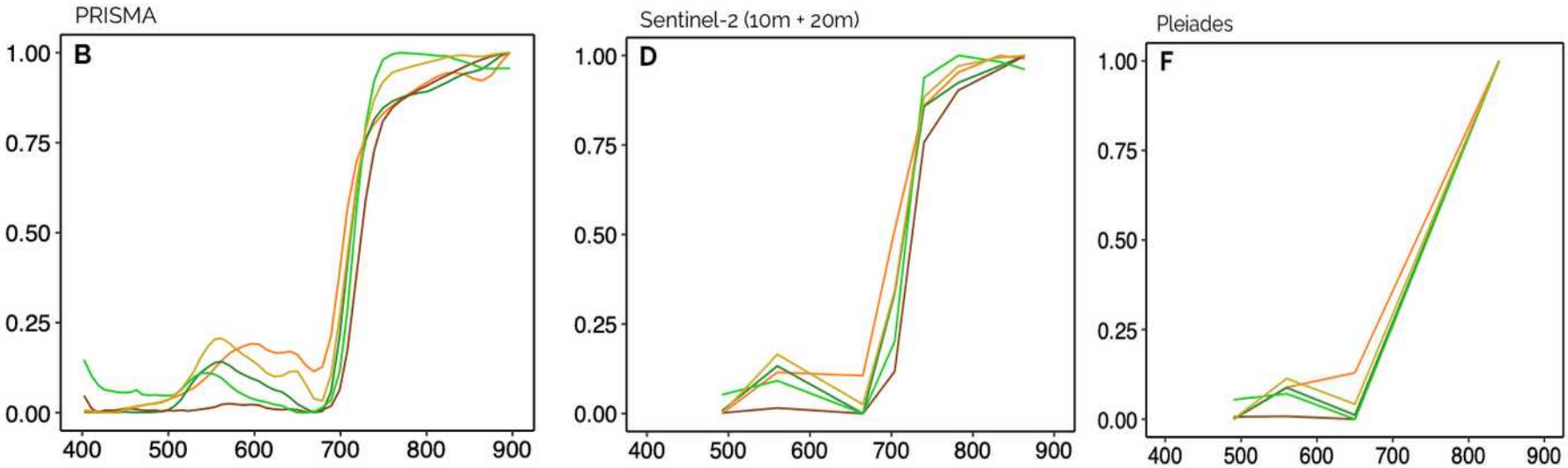
Bede Ffinian Rowe Davies [a,*], Pierre Gernez [a], Andréa Geraud [a], Simon Oiry [a], Philippe Rosa [a], Maria Laura Zoffoli [b], Laurent Barillé [a]

Spectral biodiversity (more than 350 *R* spectra)

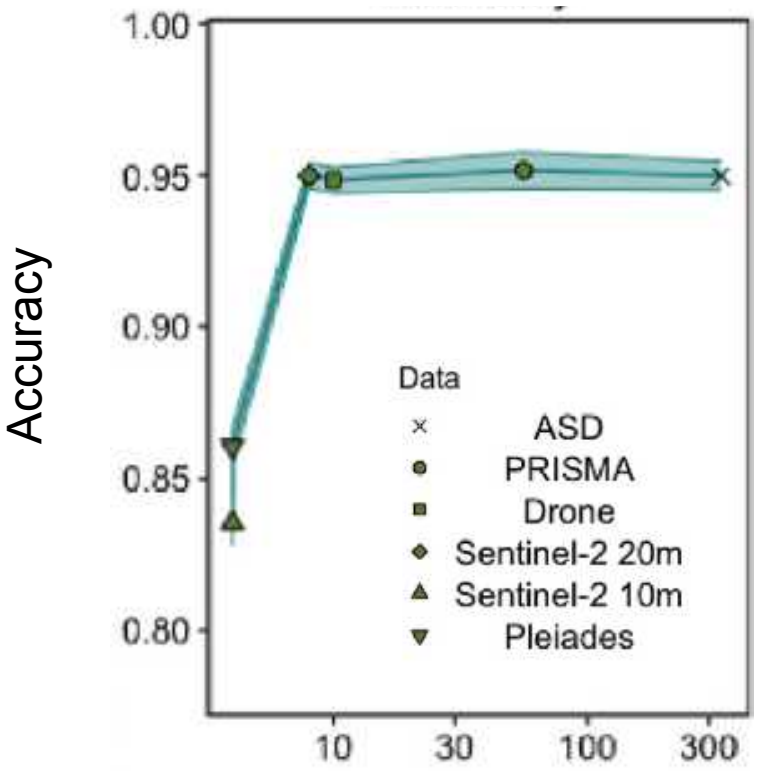




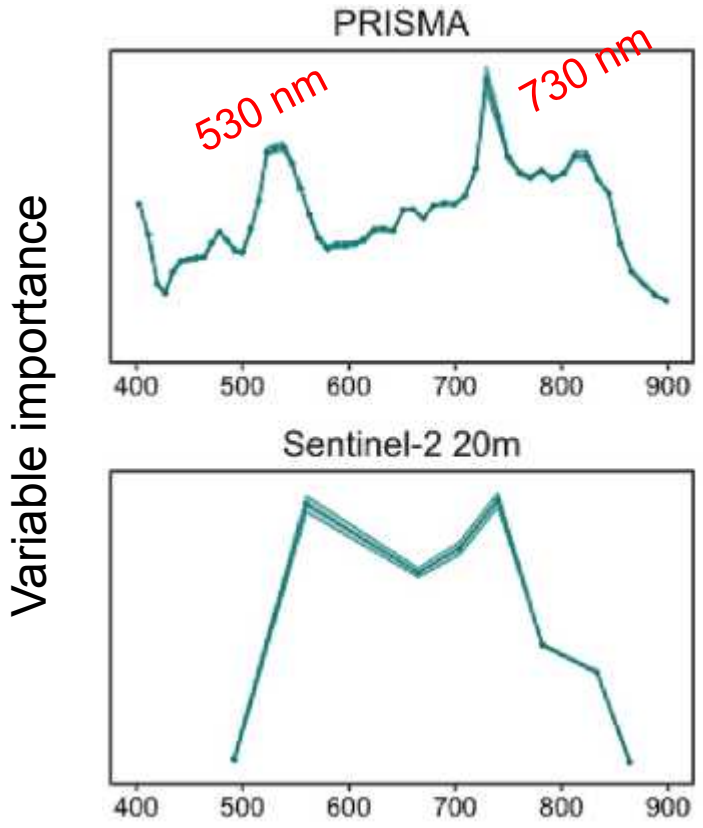
Influence of spectral resolution



Classification accuracy (Random Forest)



Number of spectral bands (log scale)

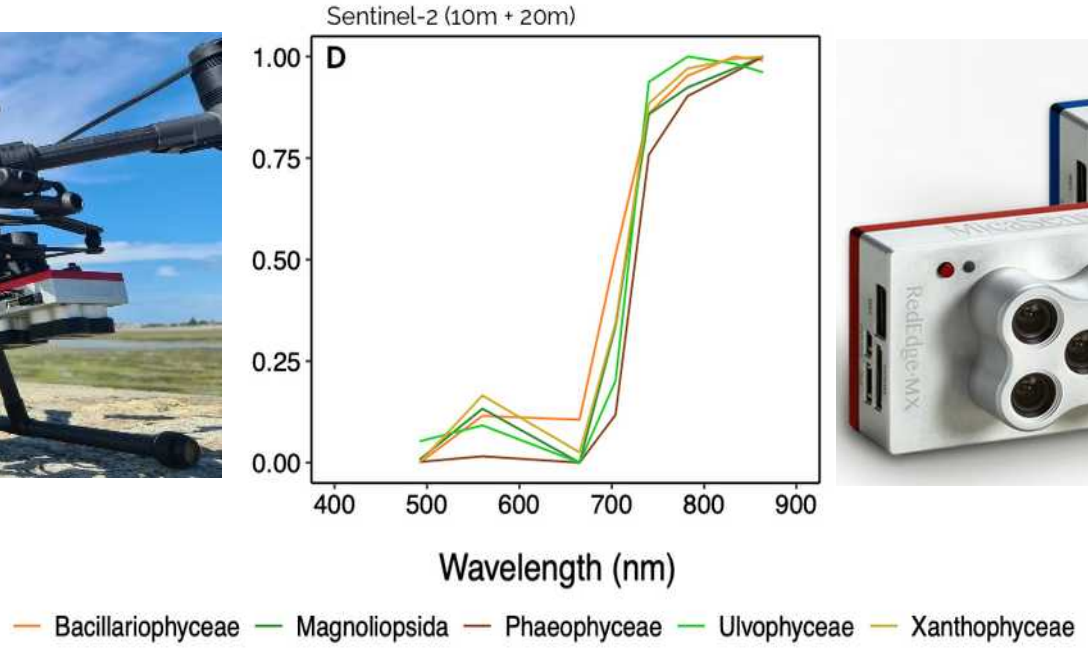


Wavelength (nm)

Multispectral resolution @ 10 bands

Matrix 300 DJI

MicaSense Dual Sensor



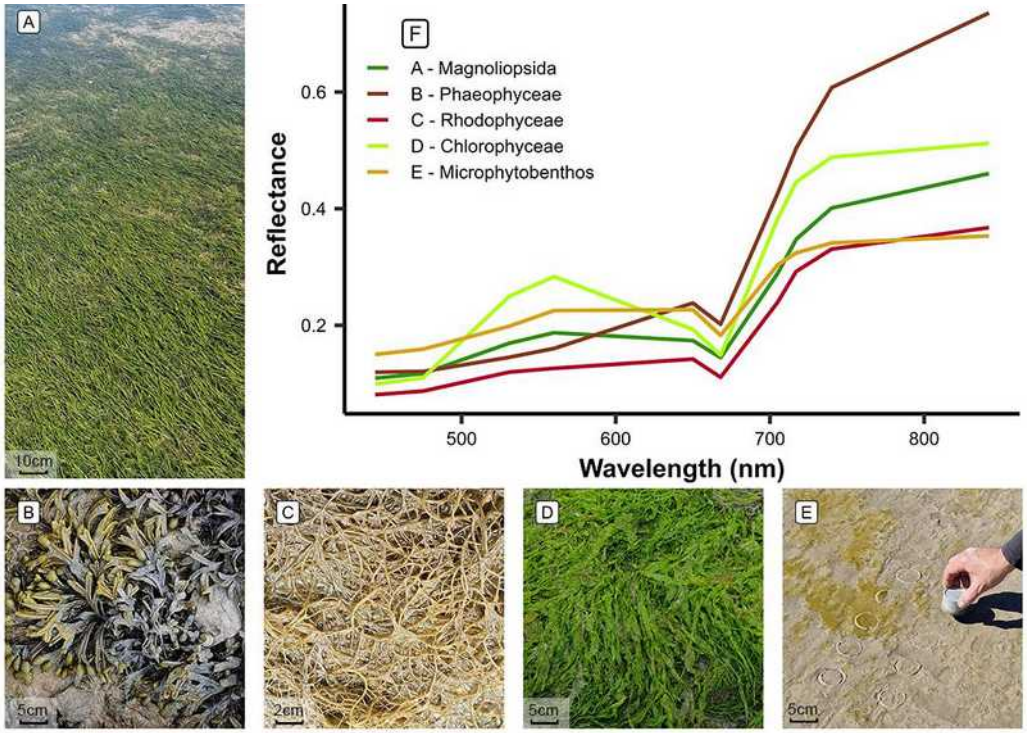
remote sensing

MDPI

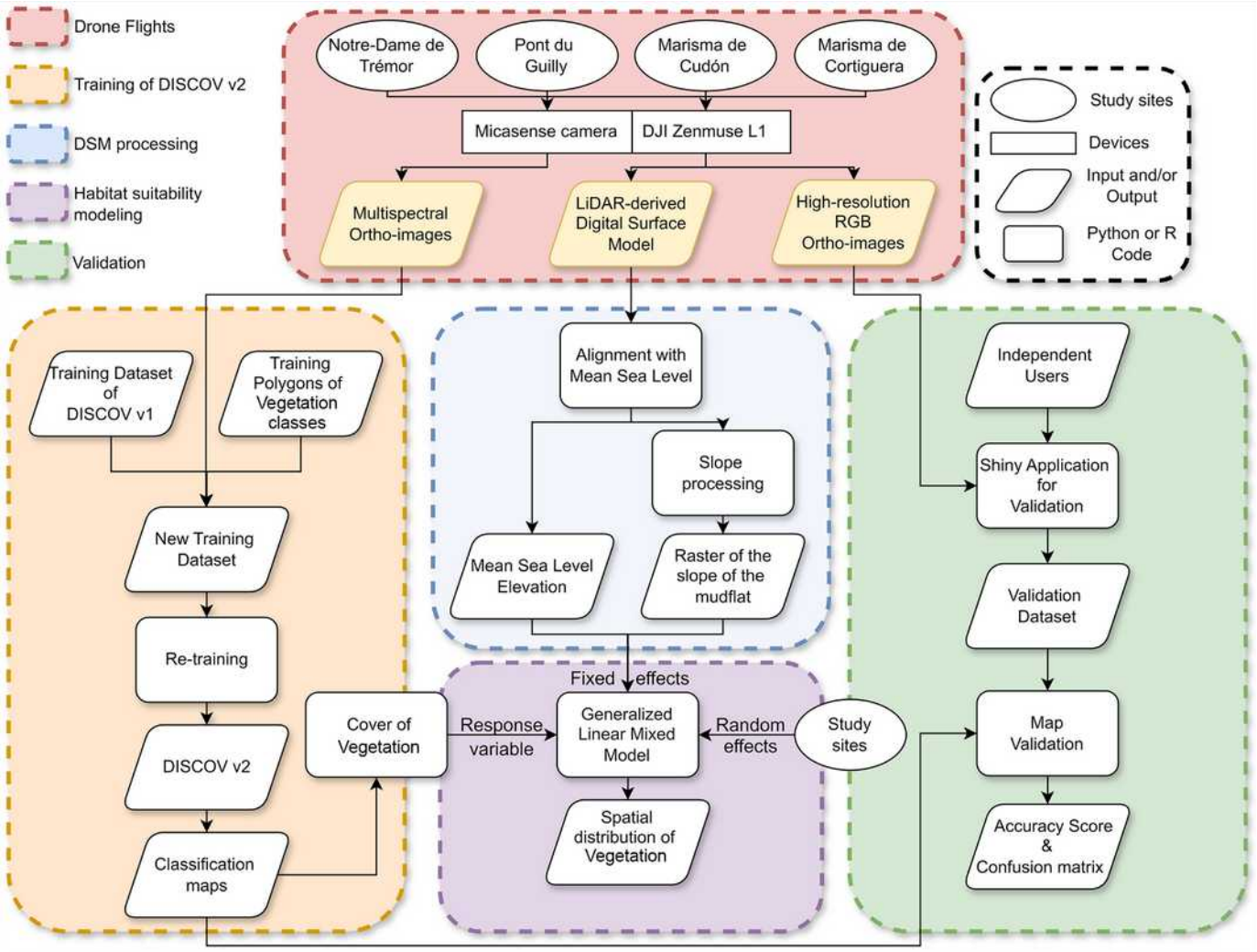
Article

Discriminating Seagrasses from Green Macroalgae in European Intertidal Areas Using High-Resolution Multispectral Drone Imagery

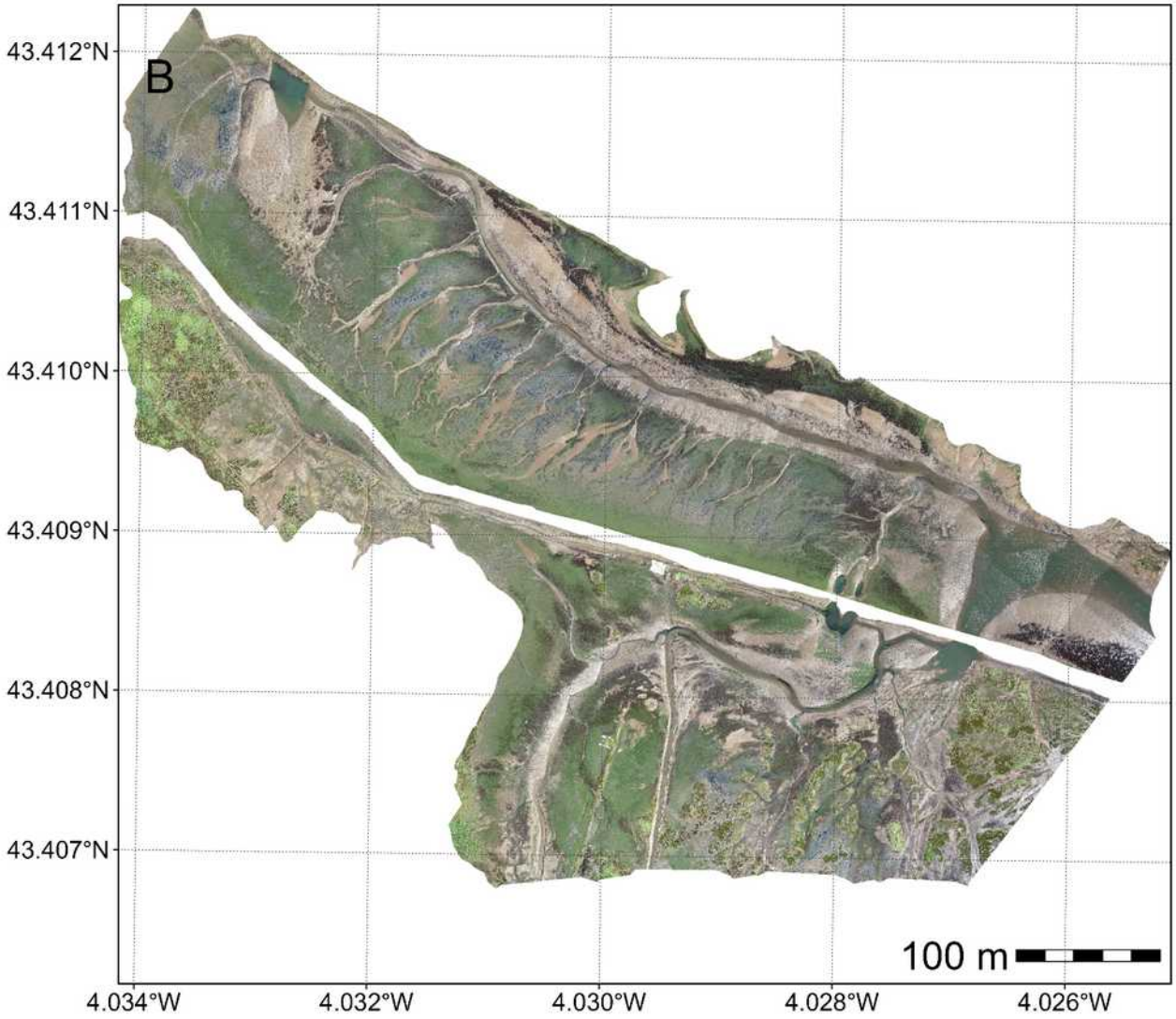
Simon Oiry [1], Bede Ffinian Rowe Davies [1], Ana I. Sousa [2], Philippe Rosa [1], Maria Laura Zoffoli [3], Guillaume Brunier [4], Pierre Gernez [1] and Laurent Barillé [1,*]



A drone-based Machine Learning algorithm

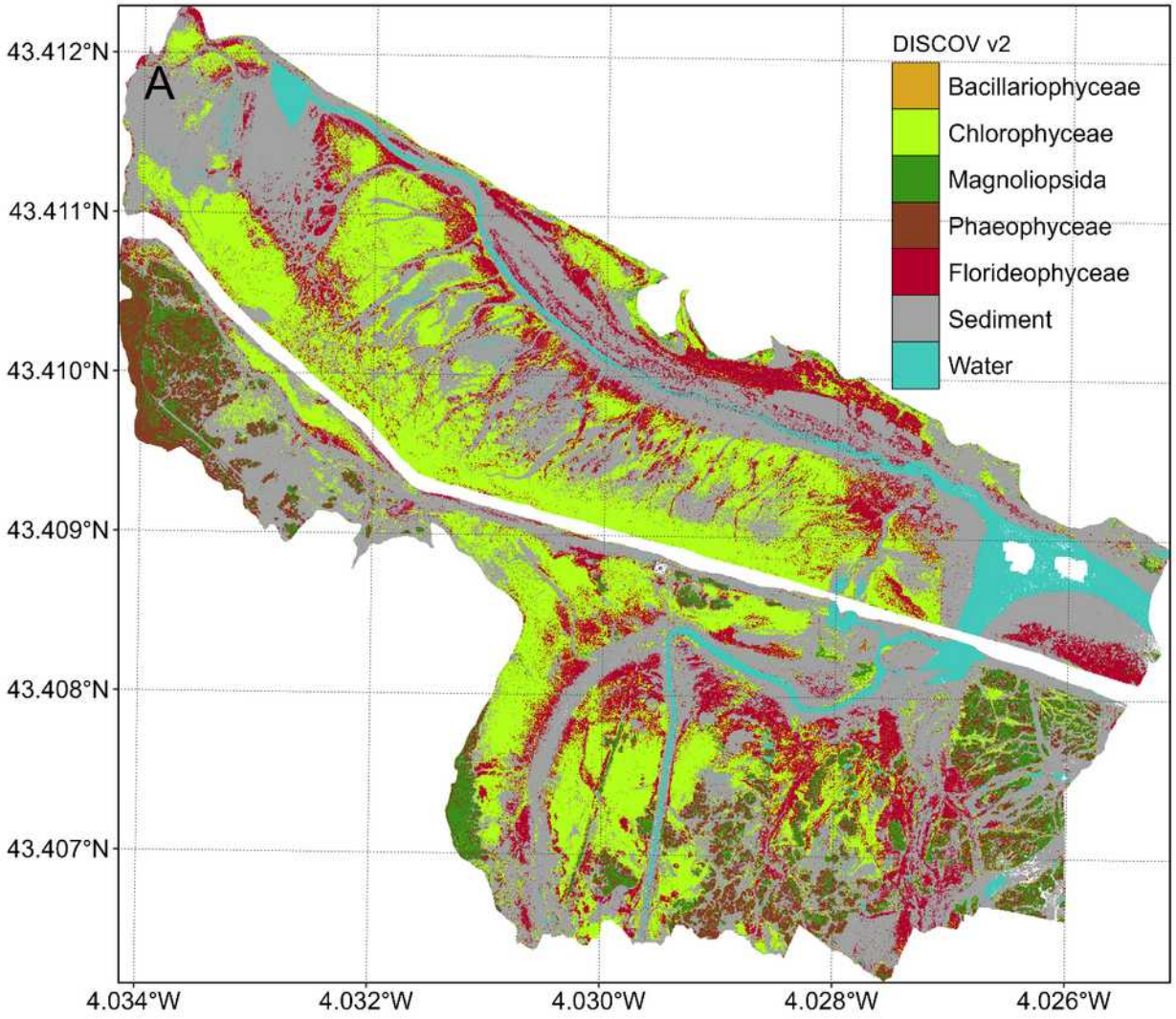


Map of soft-bottom vegetation Saja estuary



RGB image

Map of soft-bottom vegetation Saja estuary



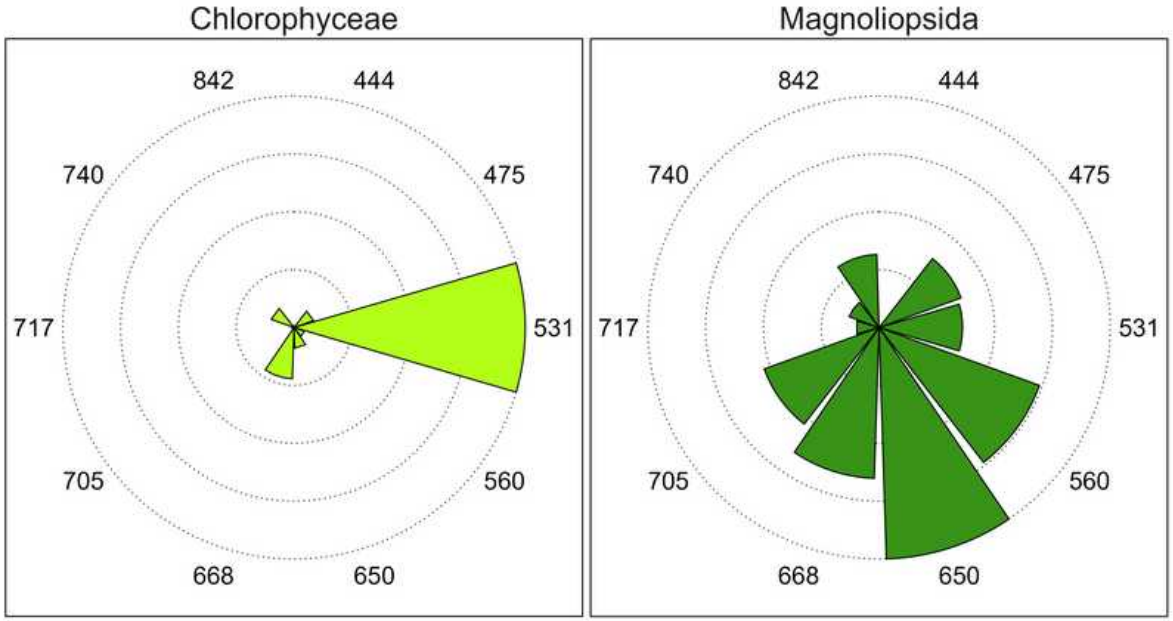
10 bands multispectral

DISCOV algorithm for drone

Drone Intertidal Substrate Classification Of Vegetation

Neural network classifier built on ~10 different sites
Overall accuracy 94% using ~500,000 pixels of validation

Operational tool for mapping at ultra-high spatial resolution

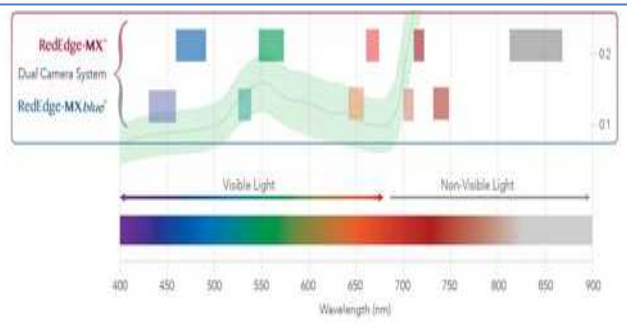


Wavelengths importance of the Neural Network Classifier

Spectral reflectance up-scaling

Hyperspectral field spectroradiometry

Drone multispectral sensor



Sentinel-2 multispectral sensor

From drones to satellites

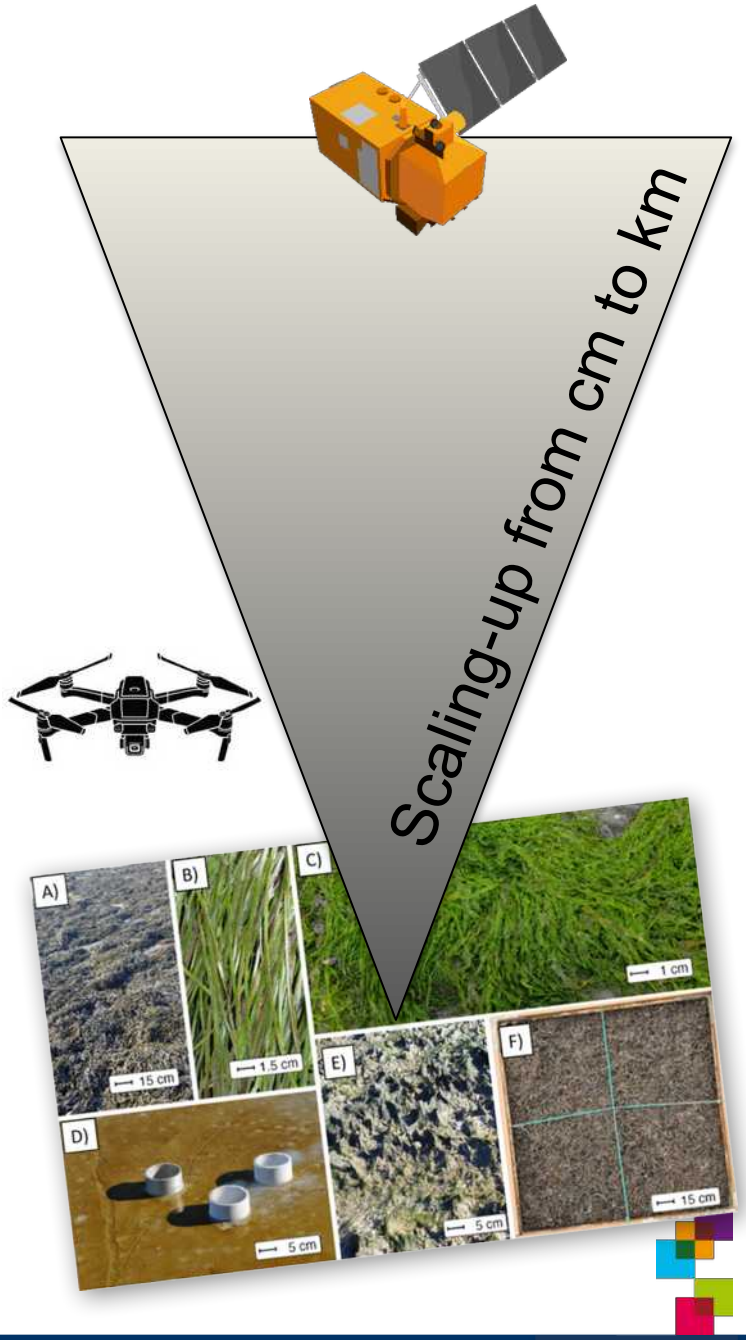
1) Drone: ultra-high spatial resolution (< 1 cm)
- accurate identification of taxonomic class

2) Resample drone images at 10 m spatial resolution

3) Train a deep learning, neural network using thousands of labelled satellite pixels

4) Validate satellite-derived seagrass class

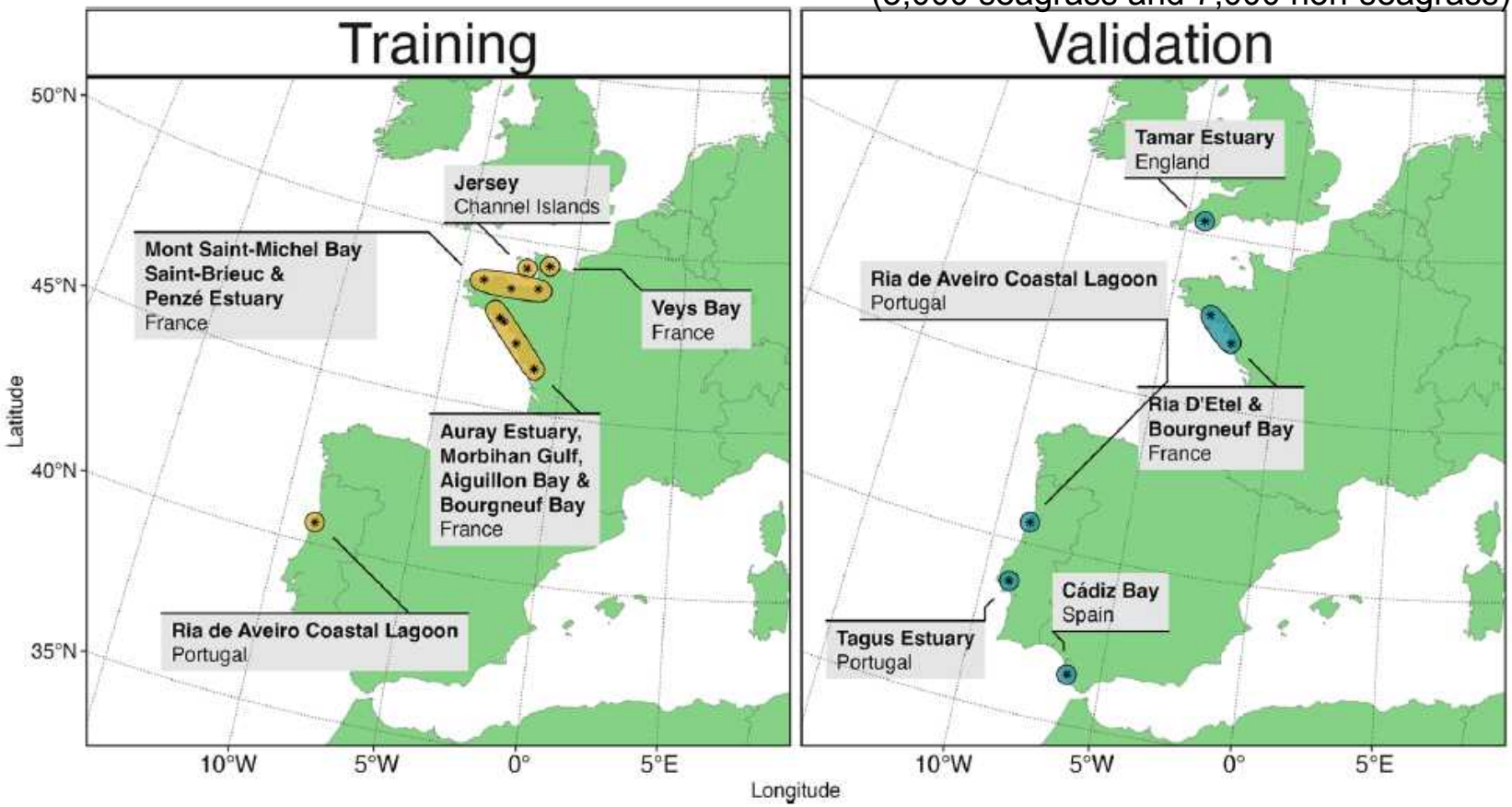
5) Apply model to study seagrass distribution & phenology at regional, national and continental scale



Model training and validation

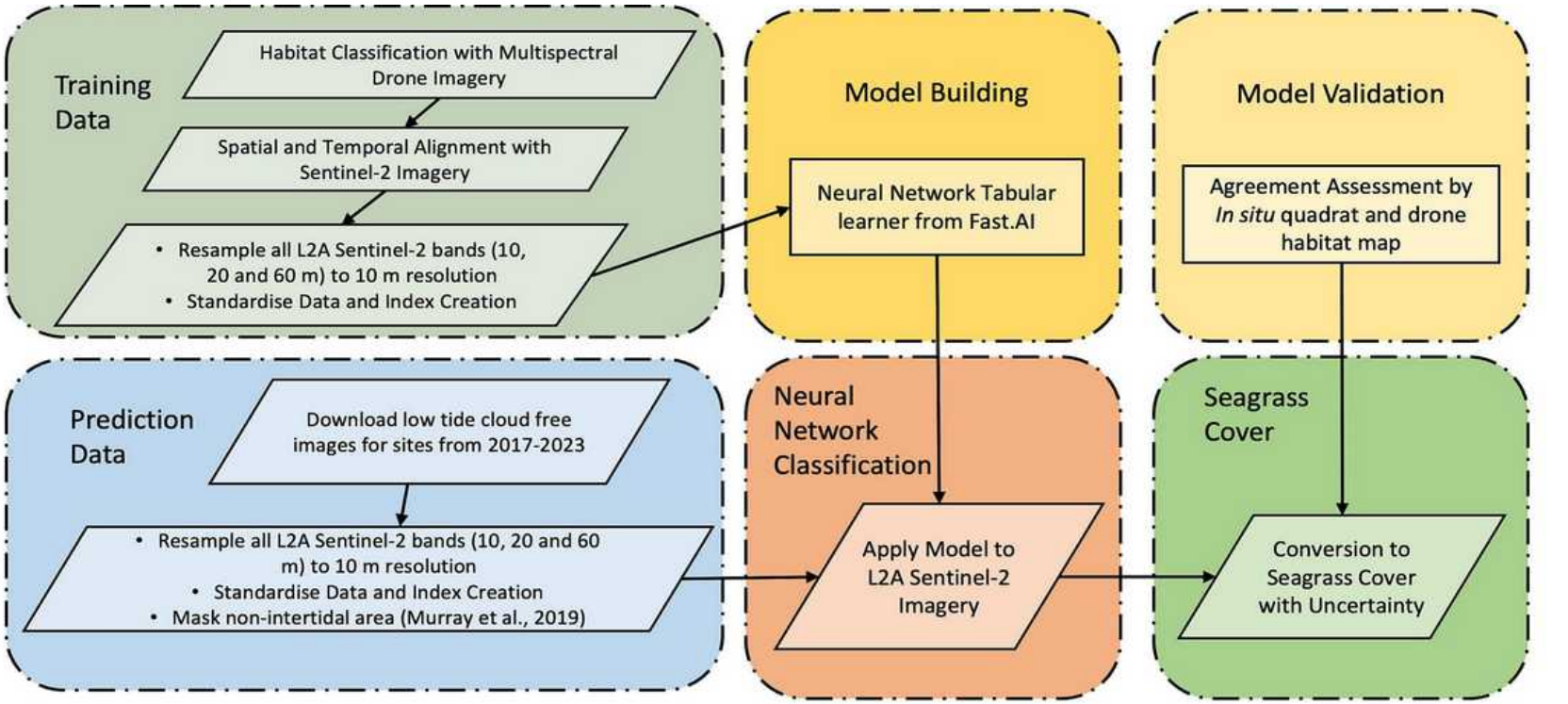
~374,000 labelled pixels

~12,000 pixels
(5,000 seagrass and 7,000 non-seagrass)



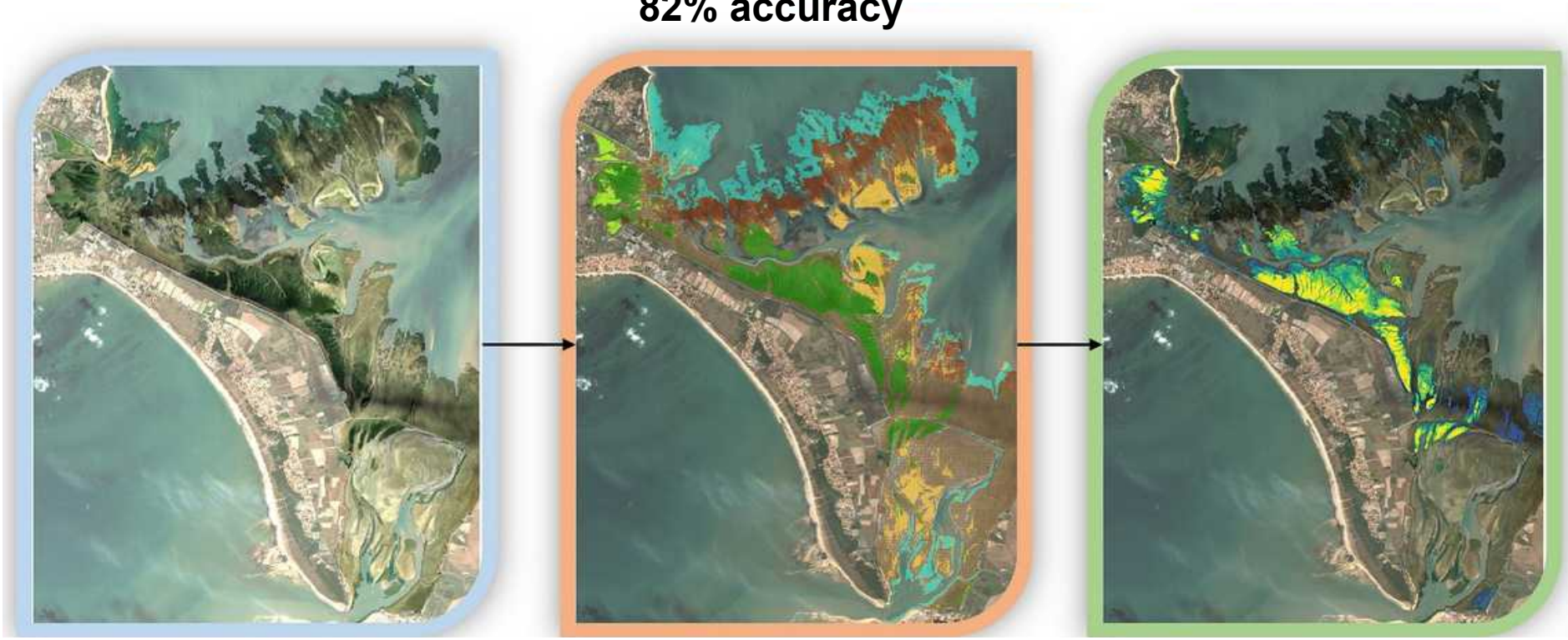
ICE CREAMS model

Intertidal **C**lassification of **E**urope: **C**ategorising **R**eflectance of **E**merged **A**reas of **M**arine vegetation with **S**entinel-2



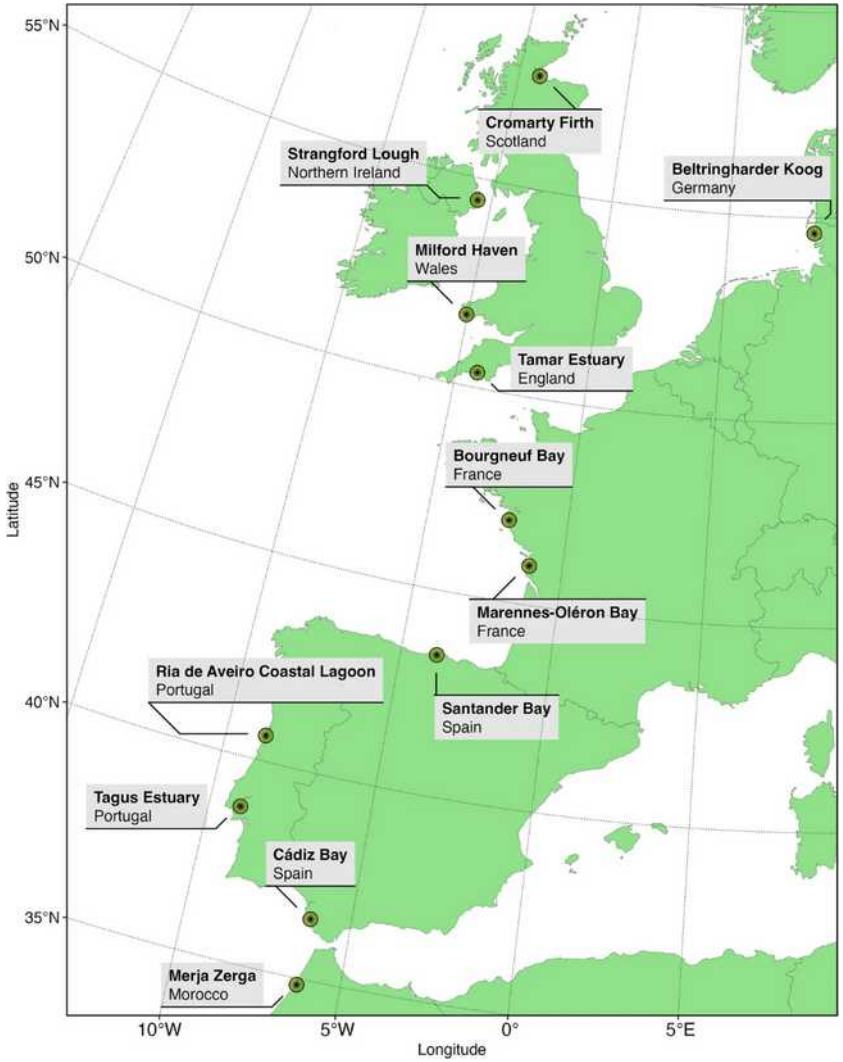
Performance metrics

Seagrass classification
82% accuracy

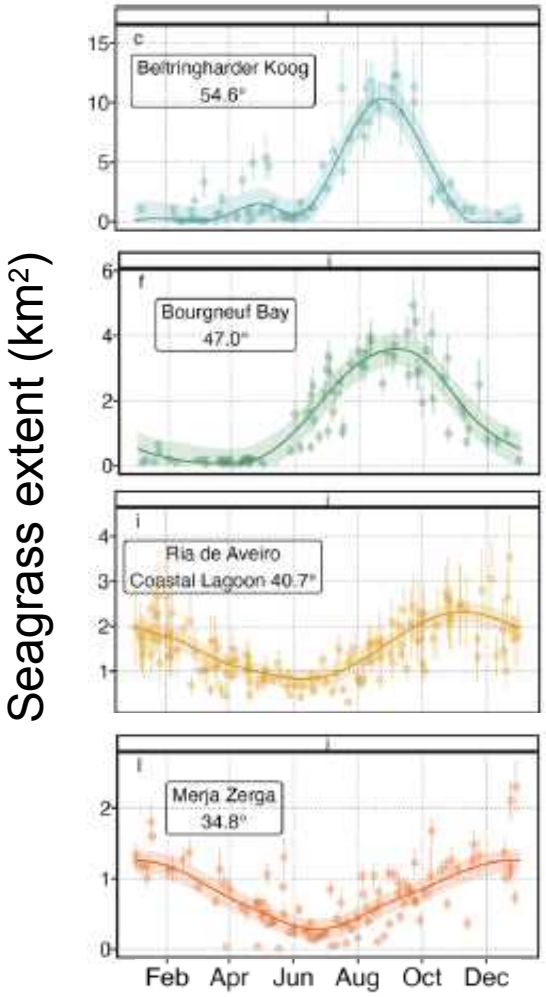


Seagrass cover estimation
19% RMSD

Intertidal seagrass phenology observed by Sentinel-2

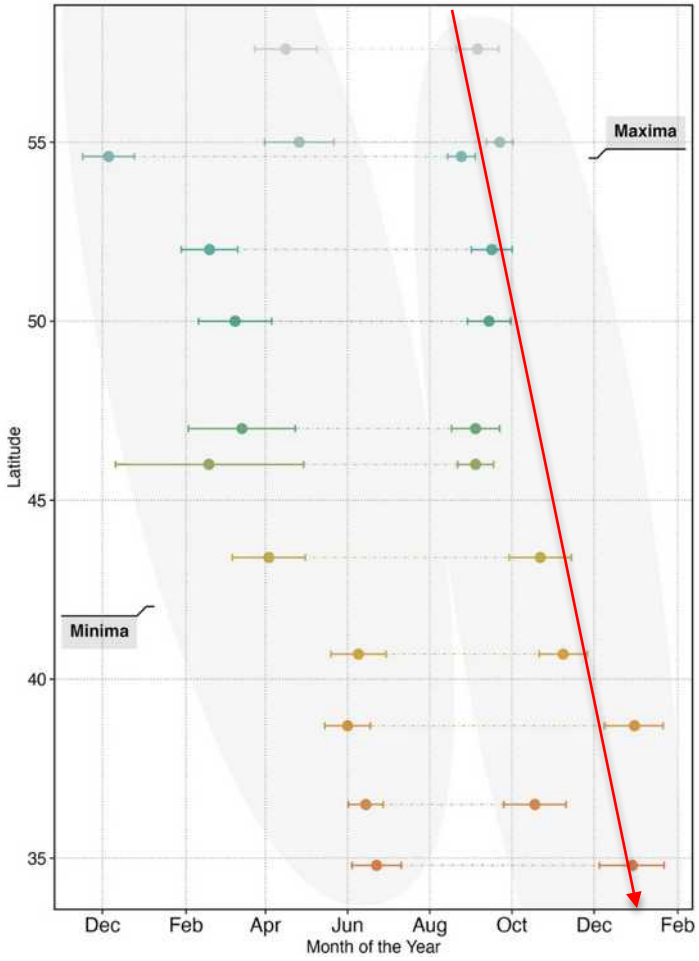


Composite year (2017-2023)



Latitudinal shift in seasonal cycle

From late summer at 57°N…



… to mid winter at 35°N

communications earth & environment

Article

https://doi.org/10.1038/s43247-024-01543-z

A sentinel watching over inter-tidal seagrass phenology across Western Europe and North Africa

Check for updates

Bede Ffinian Rowe Davies[1], Simon Oiry[1], Philippe Rosa[1], Maria Laura Zoffoli[2], Ana I. Sousa[3], Oliver R. Thomas[4], Dan A. Smale[5], Melanie C. Austen[4], Lauren Biermann[4], Martin J. Attrill[4,6], Alejandro Roman[7], Gabriel Navarro[7], Anne-Laure Barillé[8], Nicolas Harin[8], Daniel Clewley[9], Victor Martinez-Vicente[9], Pierre Gernez[1] & Laurent Barillé[1]

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Results showcased by ESA

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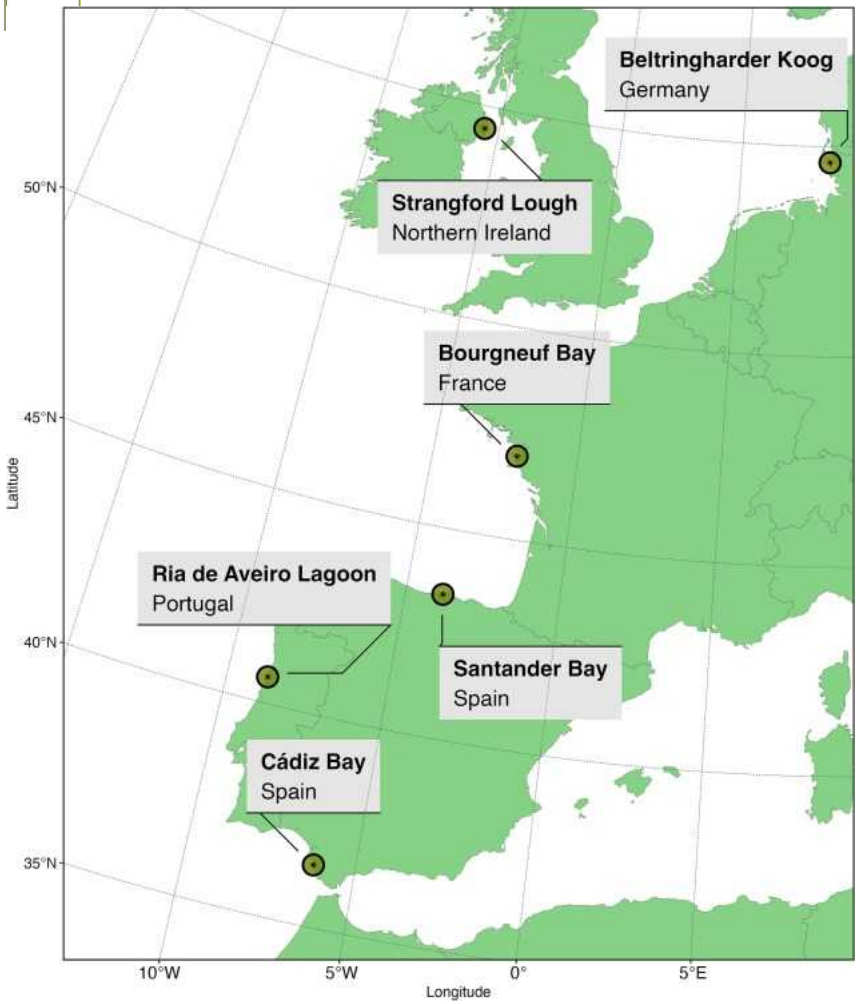
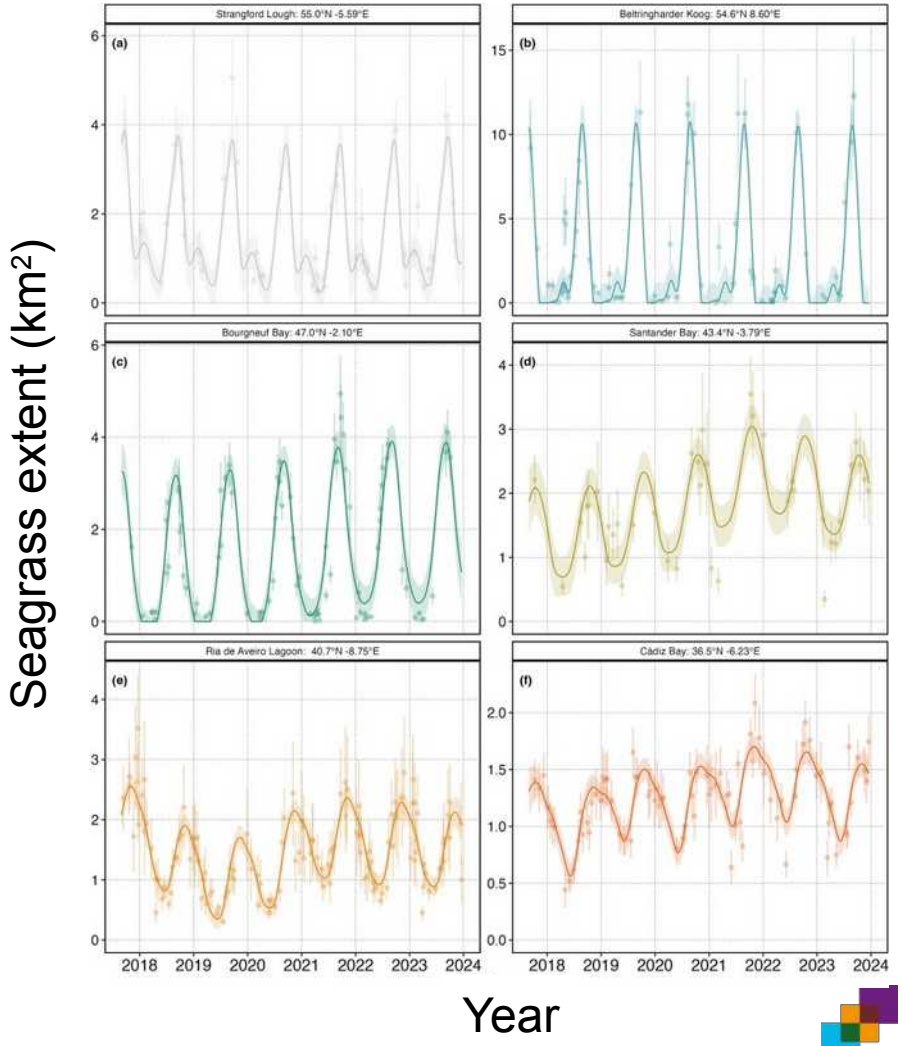
Intertidal seagrass trajectory from 2018 – 2024





Site-specific, but overal stable or with increasing trend (good news)

Nantes Université

Preliminary conclusions

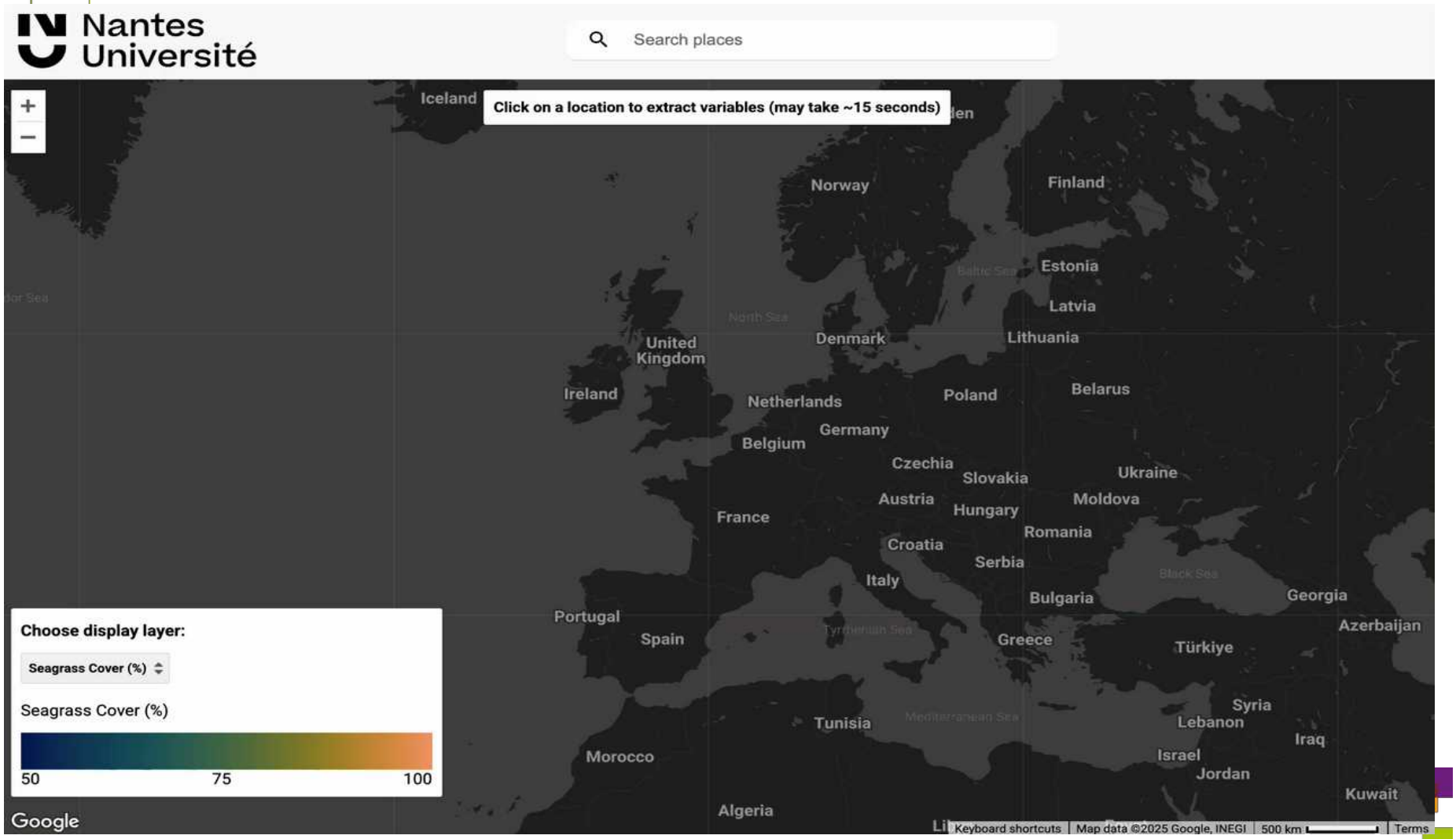
- ✓ Intertidal seagrass can accurately be classified by Sentinel-2 satellite using ICE CREAMS model
- ✓ Methods provide an up-to-date intertidal seagrass assessment tool
- ✓ Latitudinal shift in phenology from Northern to Southern Europe (Atlantic)
- ✓ Intertidal seagrass meadow inter-annual variation is site specific

Preliminary conclusions

- ✓ Intertidal seagrass can accurately be classified by Sentinel-2 satellite using ICE CREAMS model
- ✓ Methods provide an up-to-date intertidal seagrass assessment tool
- ✓ Latitudinal shift in phenology from Northern to Southern Europe (Atlantic)
- ✓ Intertidal seagrass meadow inter-annual variation is site specific
- x Applied only to 12 intertidal meadows
- ☾ Next step: map intertidal seagrass at continental scale (whole Europe)

Open access interactive map

Work in progress: stay tuned



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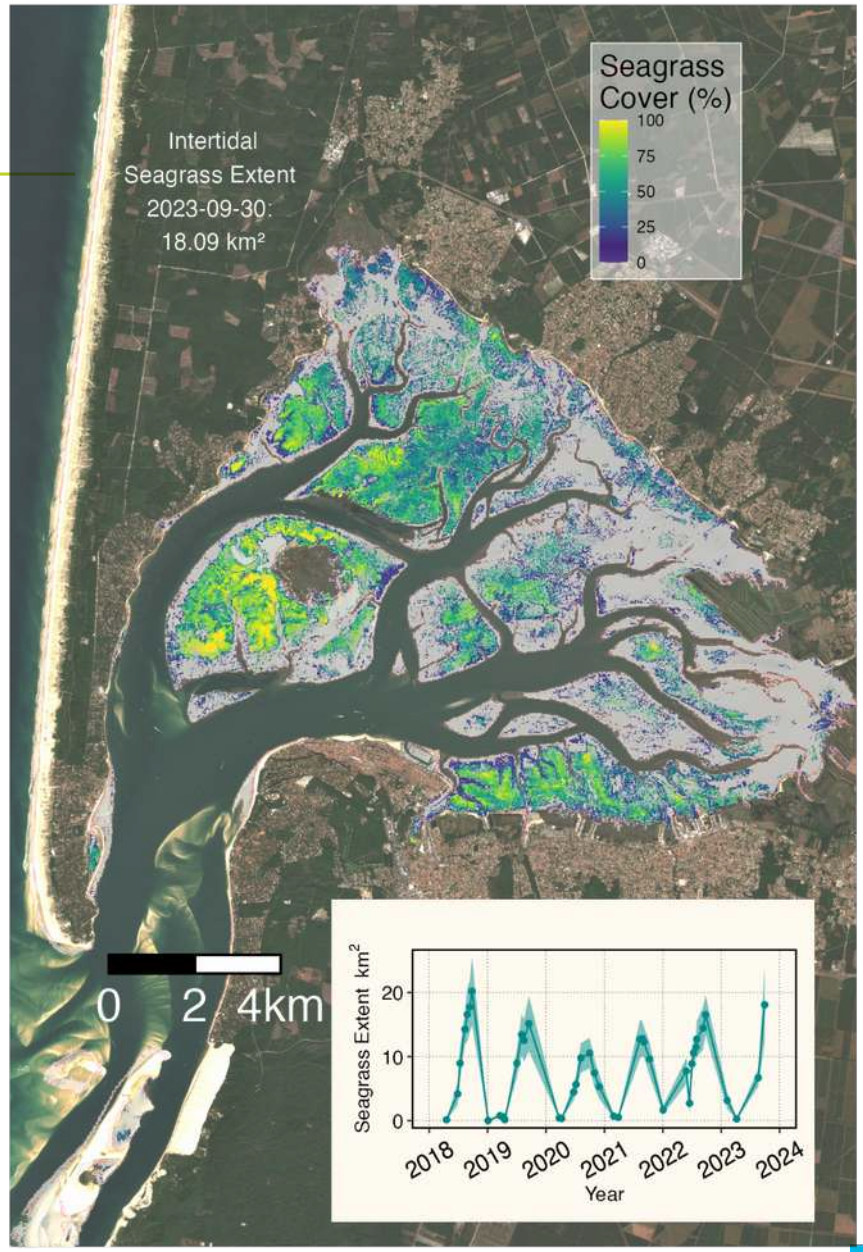
Zoom on Arcachon



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Remote sensing for biodiversity

Satellites as a support of ecological conservation & restoration

- Provide baseline information
- Looking back at past trends through time
- Make it possible to monitor changes and identify pressures
- Build up scientific knowledge to support and guide local actions

Nature Restoration Regulation

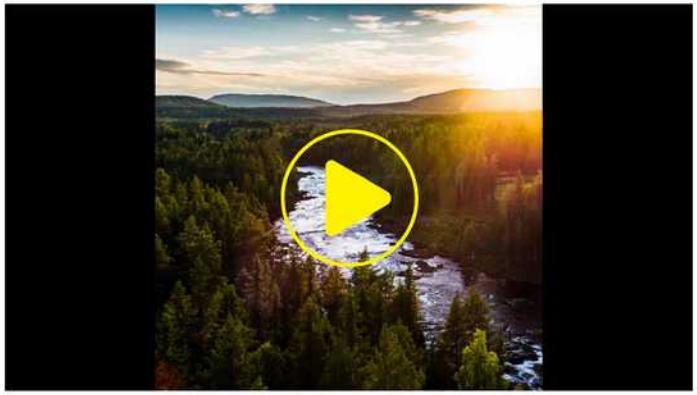
European Commission

Supporting the restoration of ecosystems for people, the climate and the planet

The Nature Restoration Regulation is the first continent-wide, comprehensive law of its kind. It is a key element of the EU Biodiversity Strategy, which sets binding targets to restore degraded ecosystems, in particular those with the most potential to capture and store carbon and to prevent and reduce the impact of natural disasters.

Europe's nature is in alarming decline, with more than 80% of habitats in poor condition. Restoring wetlands, rivers, forests, grasslands, marine ecosystems, and the species they host will help

- increase biodiversity



Watch our video

Conclusion and perspectives

Sentinel-2 is great for intertidal biodiversity studies

- Observation of intertidal seagrass phenology at continental scale
- First full map of intertidal seagrass in Europe
- Potential to map other vegetation classes (green algae)

Spectral requirements to improve classification taxonomic vegetation
additional bands to better detect marker pigments

- 545 nm for phycoerythrin (red algae)
- 620 nm for phycocyanin (cyanobacteria) *planned with S2 Next Gen*
- 630 nm for chlorophyll-c (brown algae)
- 650 nm for chlorophyll-b (green algae) *planned with S2 Next Gen*

Thank you!

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