BioSpace25 - Biodiversity insight from Space
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spatiotemporal evaluation and hyperspectral modelling of microphytobenthos gross primary production in estuarine environments

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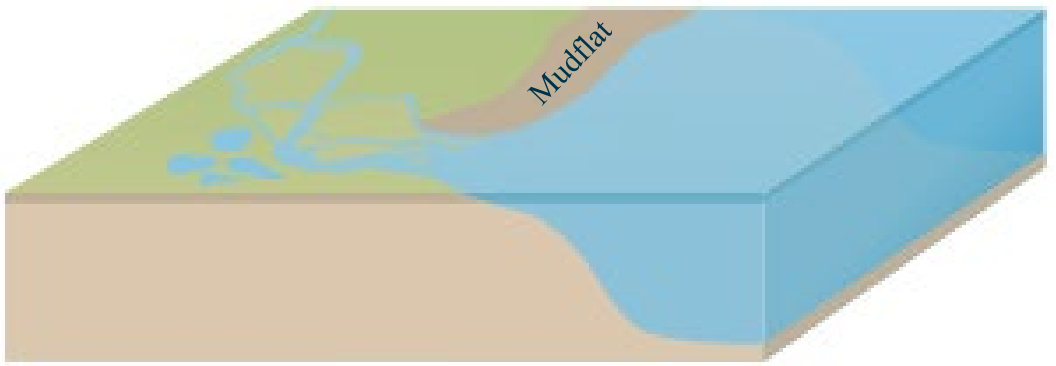
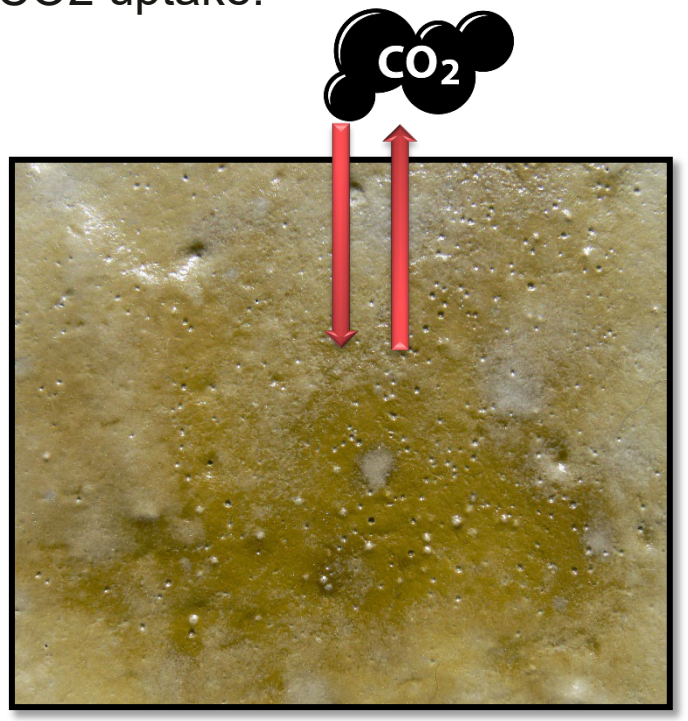
Coastal Ecosystems & Carbon Budget

Mudflats are highly productive coastal habitats. Microscopic algae called microphytobenthos (MPB) grow in sediment and help support the ecosystem functions, including CO2 uptake.

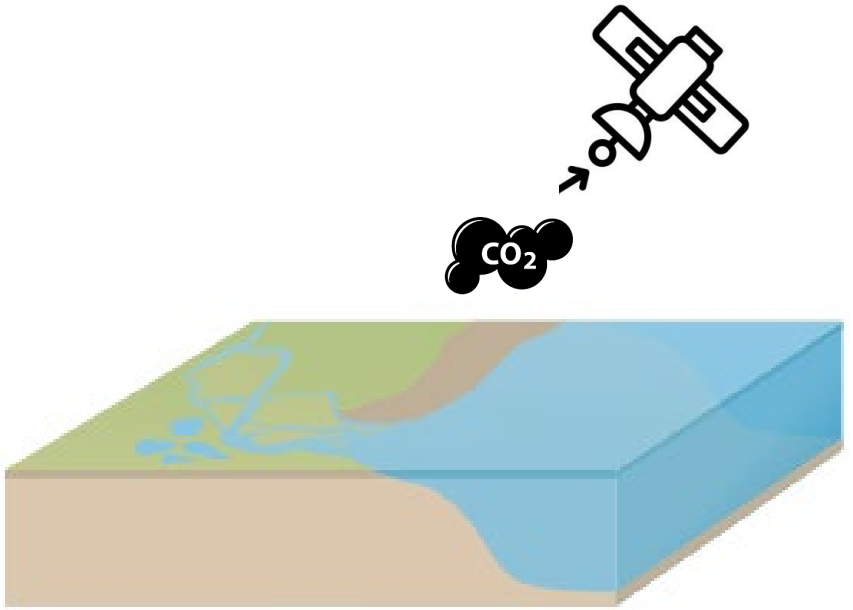




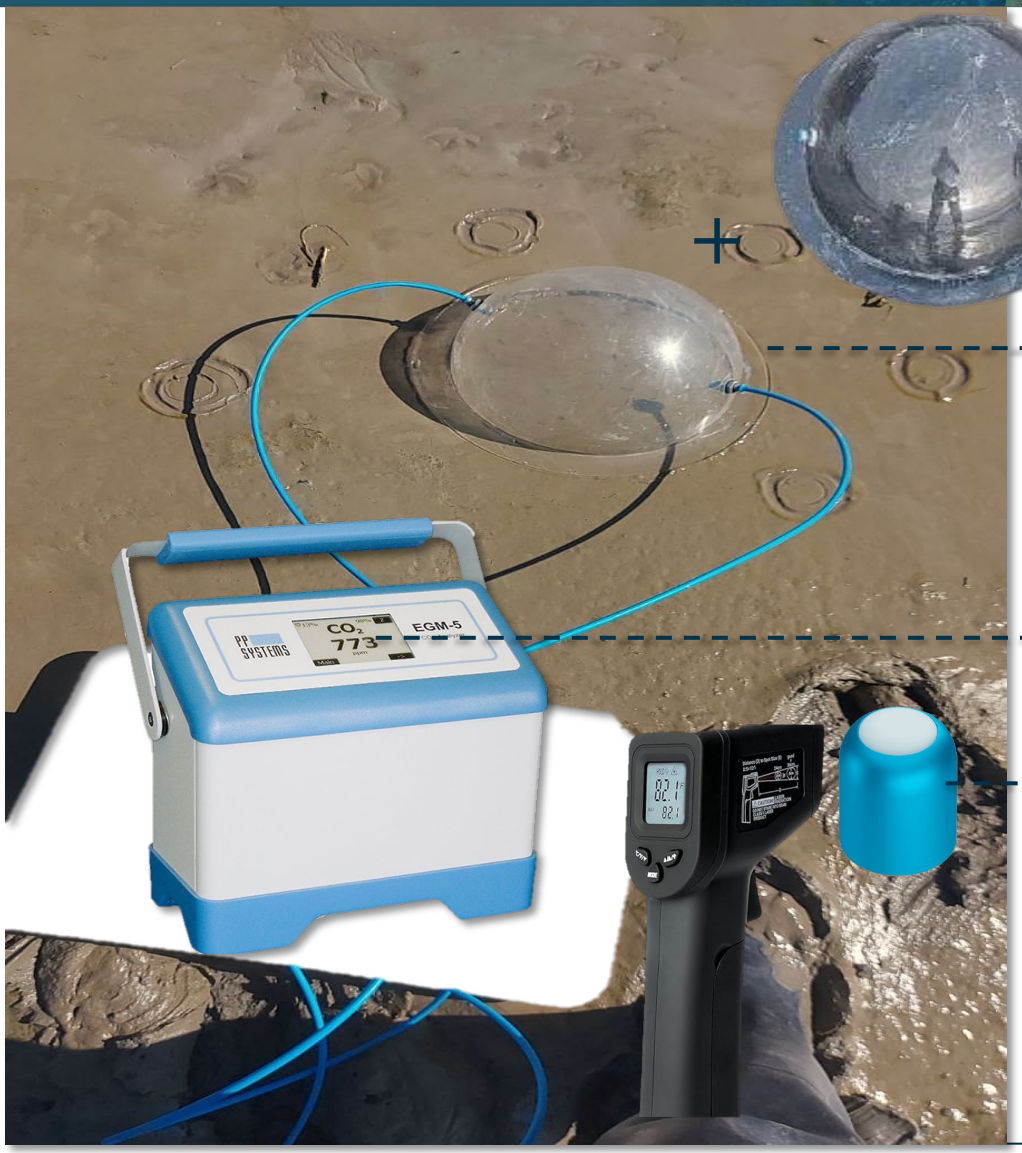
Photosynthesis → CO_2 Absorption → Carbon Storage → Gross Primary Production (GPP)

GPP= 500 Mt of C / year

GOAL: Linking carbon flux measurements and hyperspectral remote sensing techniques to create maps and temporal scenarios that evaluate how coastal ecosystems contribute to the global carbon budget.



Carbon Fluxes measurements – IRGA EMG5



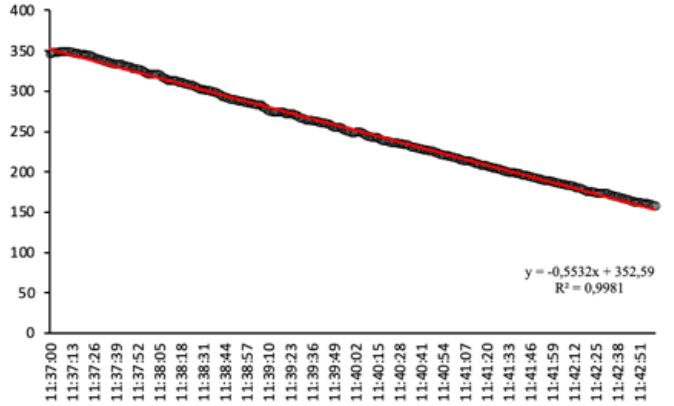
Dark chamber

Light chamber

[CO2] in ppm/s

T (°C),
PAR (µmol$m^{-2}s^{-1}$)

$$NEE = \frac{\Delta[CO2]}{\Delta t} * \frac{V}{A}$$



$$NEE = GPP - R$$

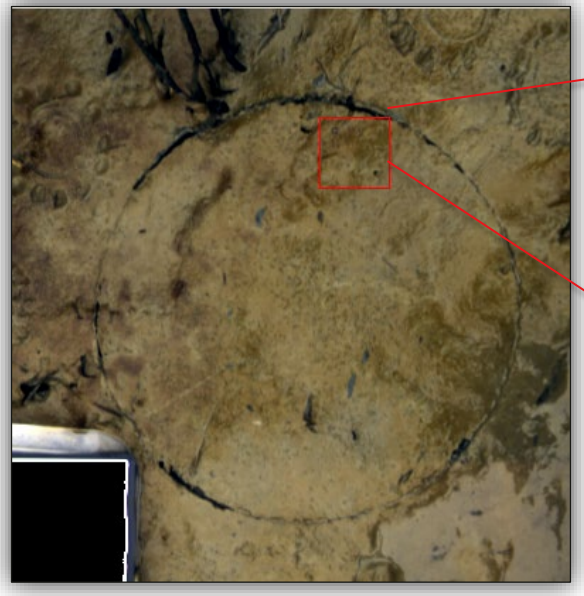
$$GPP = NEE_{light} + NEE_{dark} \ (R)$$

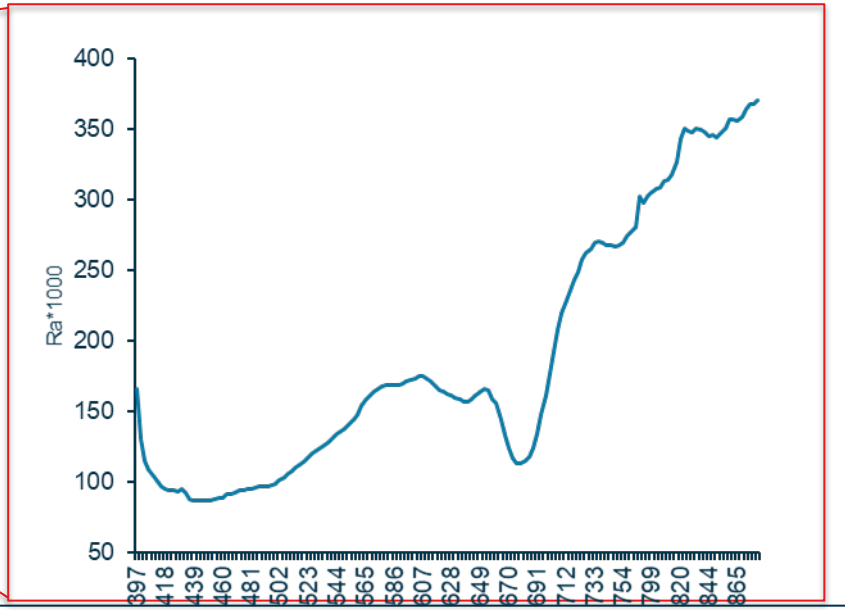
$$NEE_{light} >> NEE_{dark}$$

Strong carbon **uptake** during daylight ⇨ Highly productive ecosystem

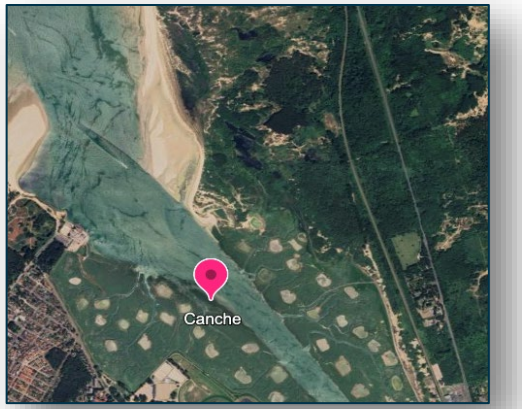
Hyperspectral Camera – Specim IQ

Specim IQ-Hyperspectral Camera





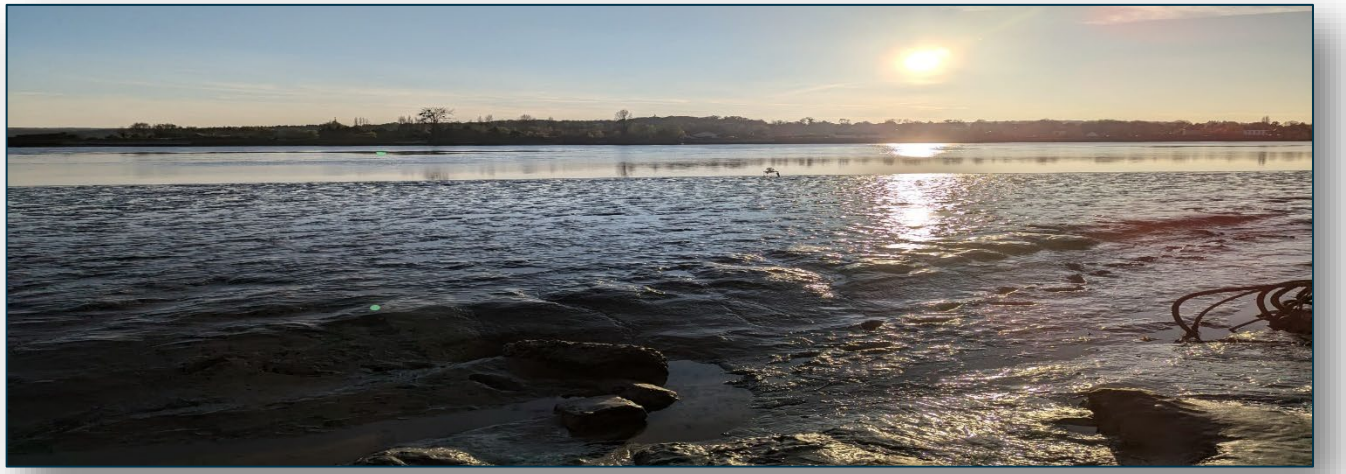
Field Campaigns



Le Touquet,
Canche estuary

Corsept, Loire
estuary

Le trait, Lillebonne,
Vasière Nord,
Seine estuary



- ❑ 5 stations, 3 estuaries
- ❑ Autumn and Summer 2024
- ❑ GPP, temperature (T), and PAR
- ❑ Hyperspectral data: 2 stations

Carbon Fluxes & Hyperspecral data for GPP Estimation

Benthic chambers for CO_2 fluxes
+
Climatic

Photosynthesis
&
Respiration

Solar radiation
&
Temperature

$\frac{dCO2}{dT}$

NEE

PAR, T

GPP

Remote Sensing data

Hyperspectral camera
Specim IQ

Image
Enhancement

Noise correction (MNF)

Subsampling Footprint chambers

Hyperspectral indices

Biomass indices

PAR indices

Variables

Spatio-Temporal evaluation

Multiple Linear Regression (MLR)

GPP= β0 +β1HYINDEX +β2PAR+ β3T+ϵ

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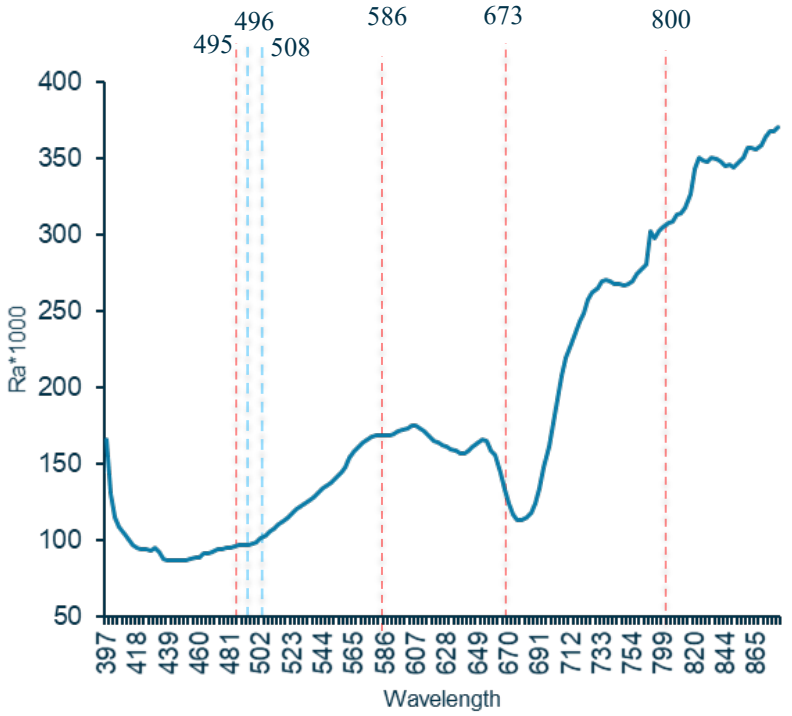
Hyperspectral sensitive Indices



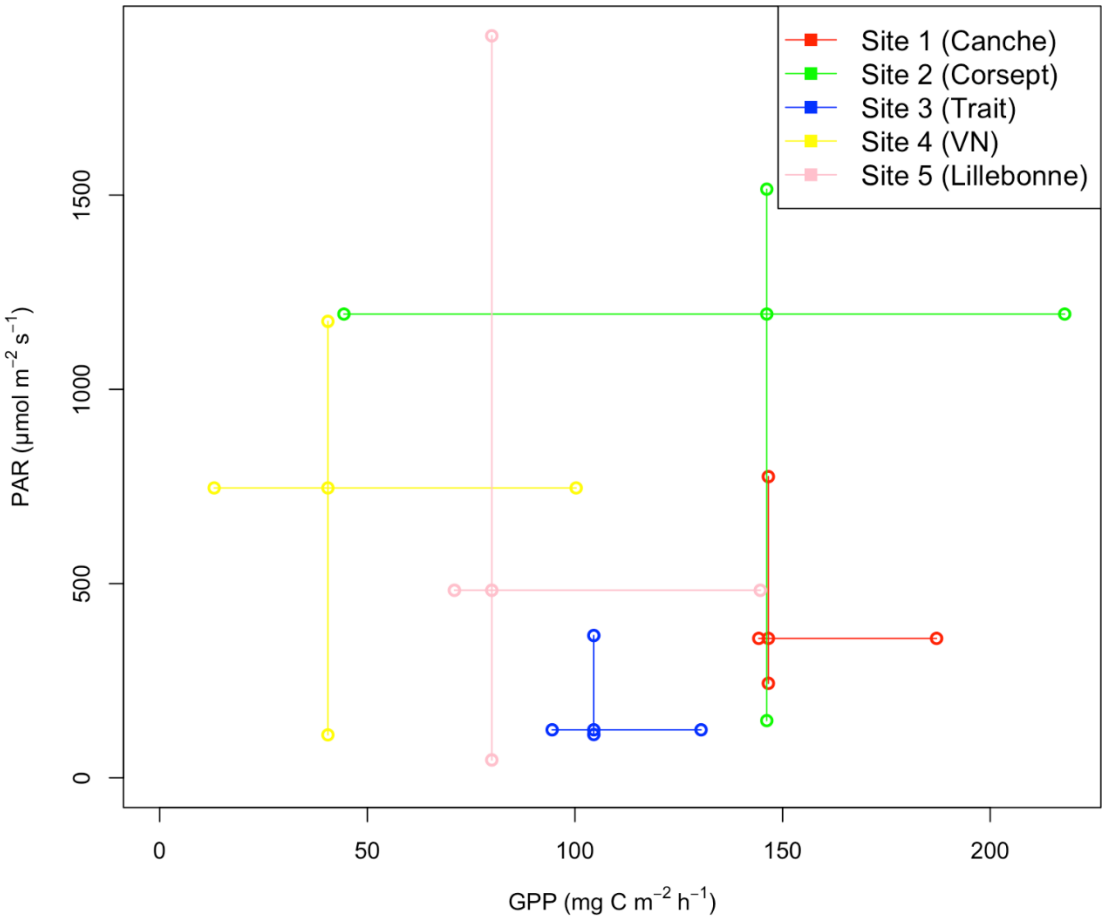
$$NDVI_{HR} = \frac{R_{800} - R_{673}}{R_{800} + R_{673}}$$

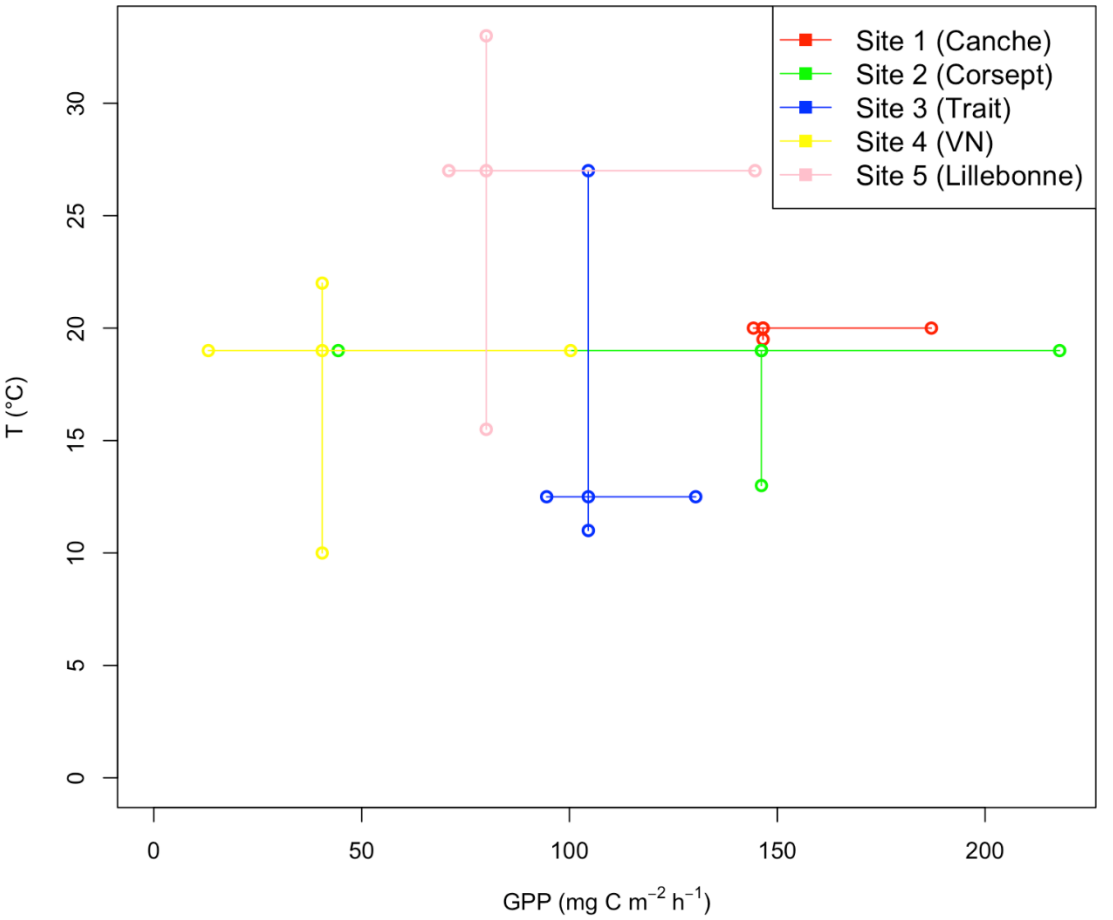
(Launeau et al., 2018) → MPB Biomass

$$MPBI = \frac{2 * R_{586}}{R_{495} + R_{673}} - 1$$

$$MPBI_{LUE} = \frac{R_{496}}{R_{508}}$$ (Meleder et al., 2018) → MPB Photosynthetic Activity

Spatio – Temporal Evaluation

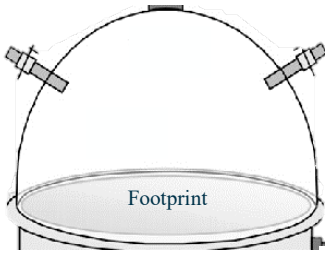




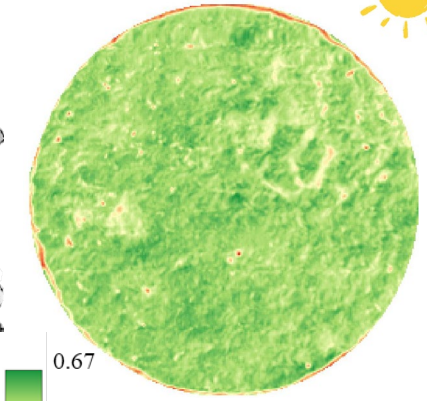
- Higher GPP in the Loire (Corsept) and Canche estuaries
- Lower GPP in the Seine estuary: Vasière Nord (VN) site

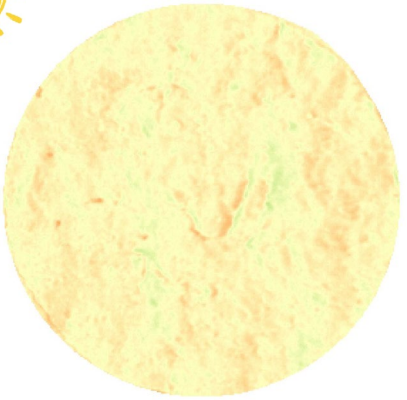
- Higher GPP at higher mudflat temperatures during summer season
- Lower GPP at lower mudflat temperatures during autumn

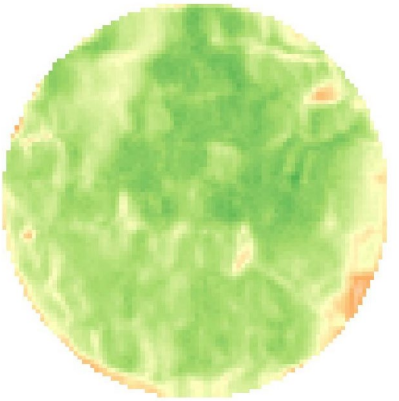
MLR For GPP Estimation



July







0.67

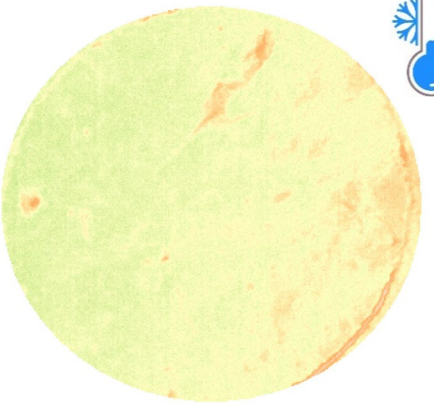
0.22

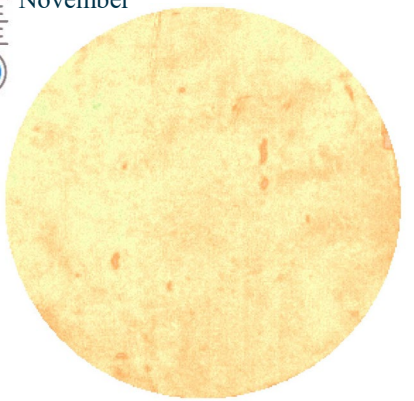
GPP=144.26

GPP=146.57

GPP=187.07

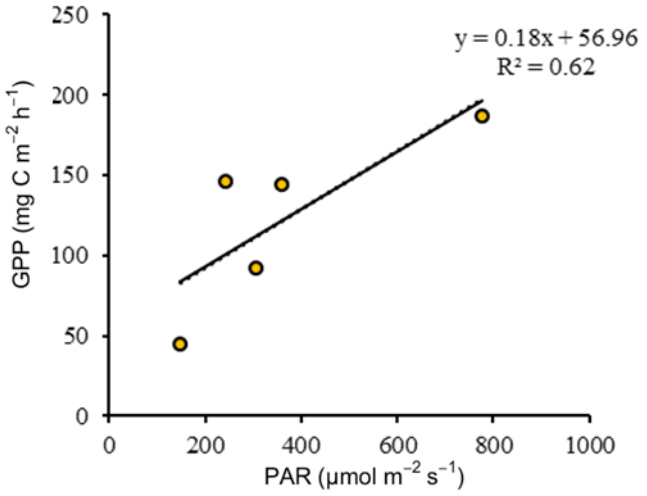
November

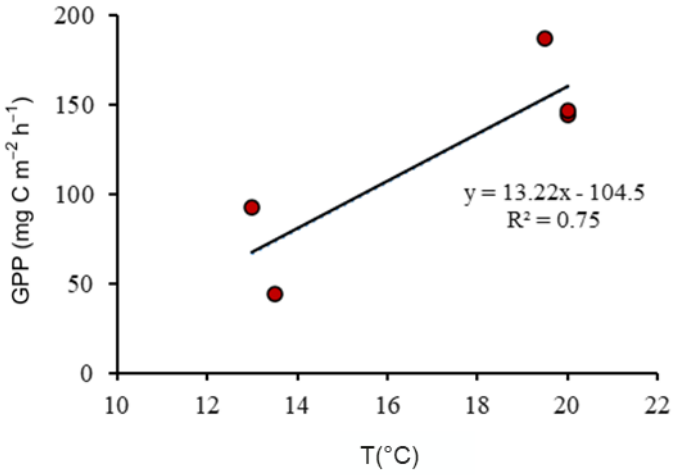


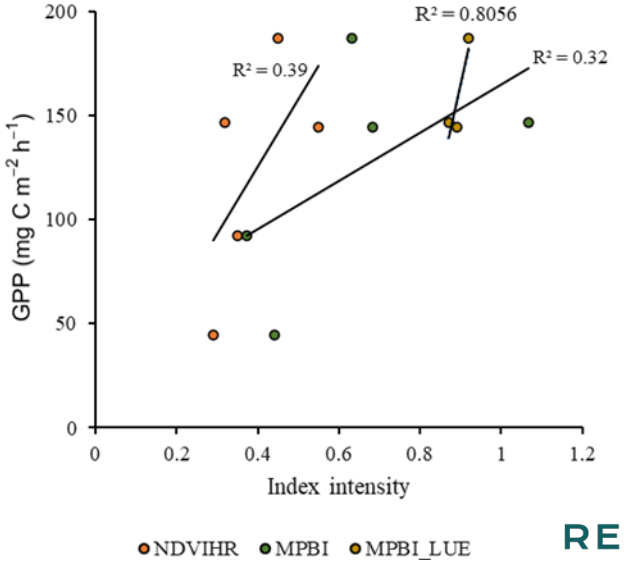


GPP=92.57

GPP=44.36







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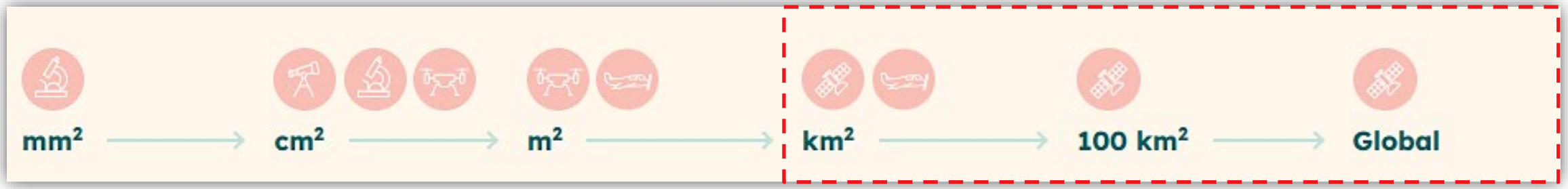
Spatio – Temporal Evaluation and Hyperspectral indices

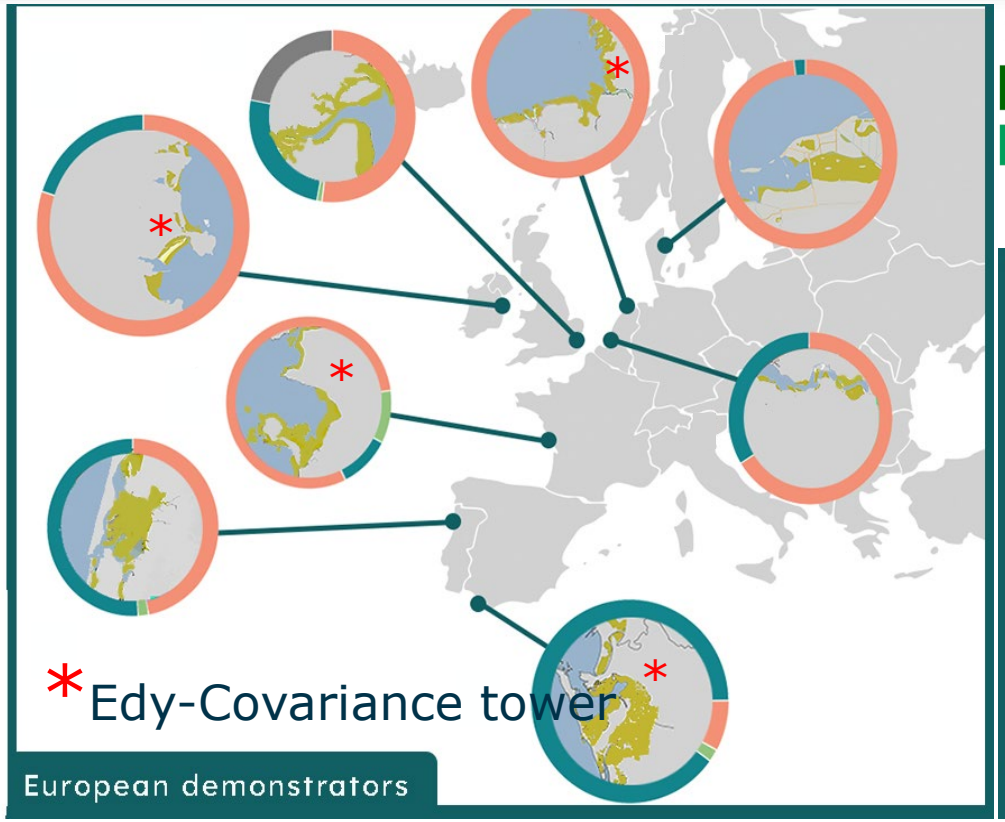
- ✓ **Spatial Variability** – Differences in GPP across sites, possibly due to variations in sediment type, hydrodynamics, or nutrient availability.

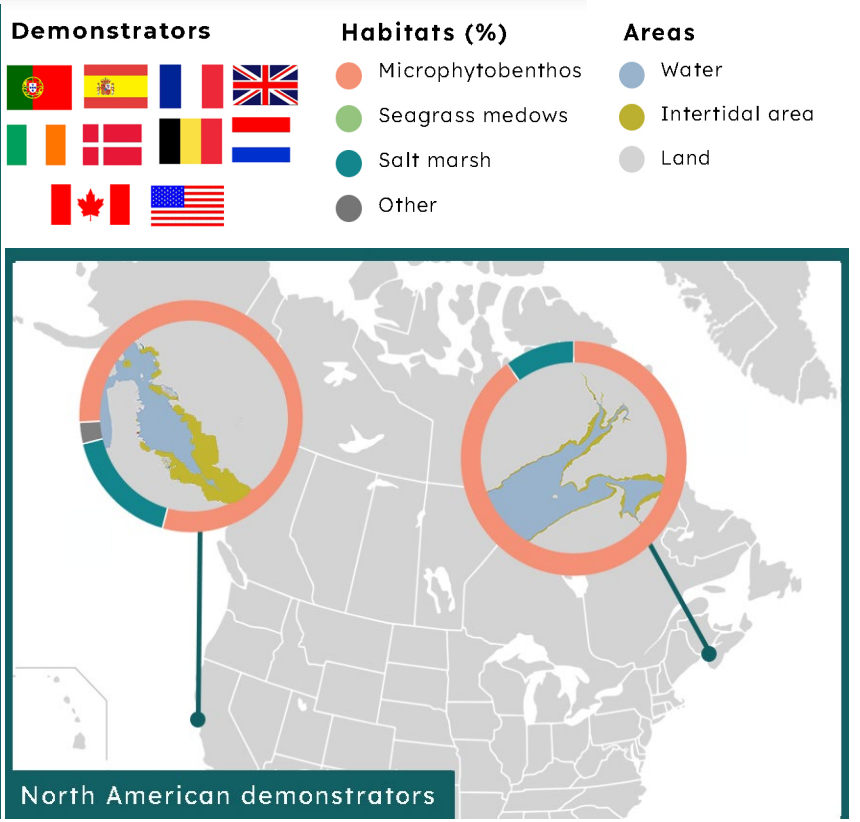
- ✓ **Temporal Patterns –** GPP Seasonal trends influenced by temperature (T) and photosynthetically active radiation (PAR).

- ✓ **GPP and Hyperspectral Indices –** A significant correlation was observed between GPP and MPB-sensitive hyperspectral indices, particularly for the MPB_LUE index.

Future work: GPP Upscaling







Key recommendations

- **High-resolution hyperspectral and thermal remote sensing**
- **Expand the network of eddy covariance towers in coastal ecosystems**
- **Support long-term field validation campaigns**

* University of New Brunswick (Canada), Mudflat Microphytobenthos Detection and Associated Carbon Flux (Poster Session).

Thank you for your attention !

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Nantes Université

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