Numerical modeling and remote sensing of the land-ocean aquatic continuum

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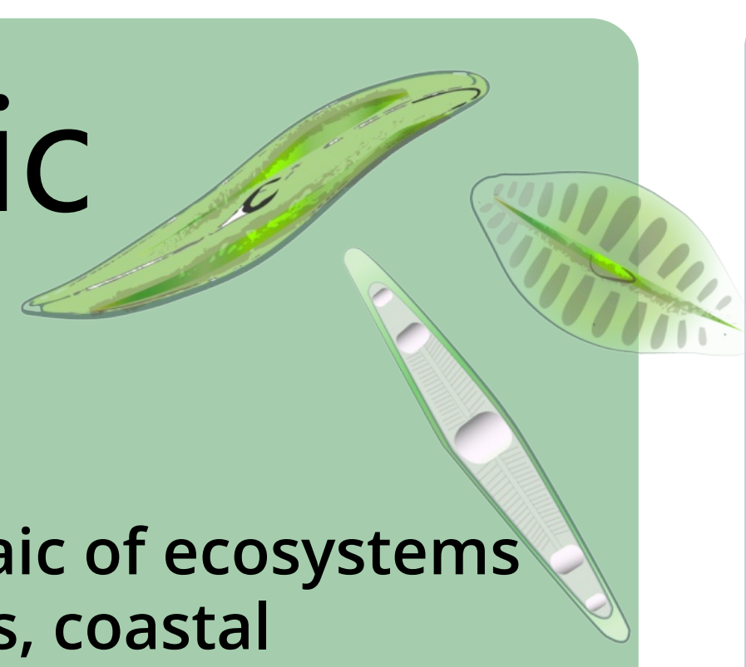
The land-ocean aquatic continuum (LOAC)



The LOAC is a mosaic of ecosystems composed by rivers, coastal wetlands (marshes, mangroves), estuaries, tidal flats and coastal waters.

These ecosystems provide many ecological functions such as high productivity, carbon sequestration, species habitat and food production.

Large amounts of nutrients and carbon transit through the LOAC to the open ocean.

The productivity of coastal ecosystems composing the land-ocean interface?

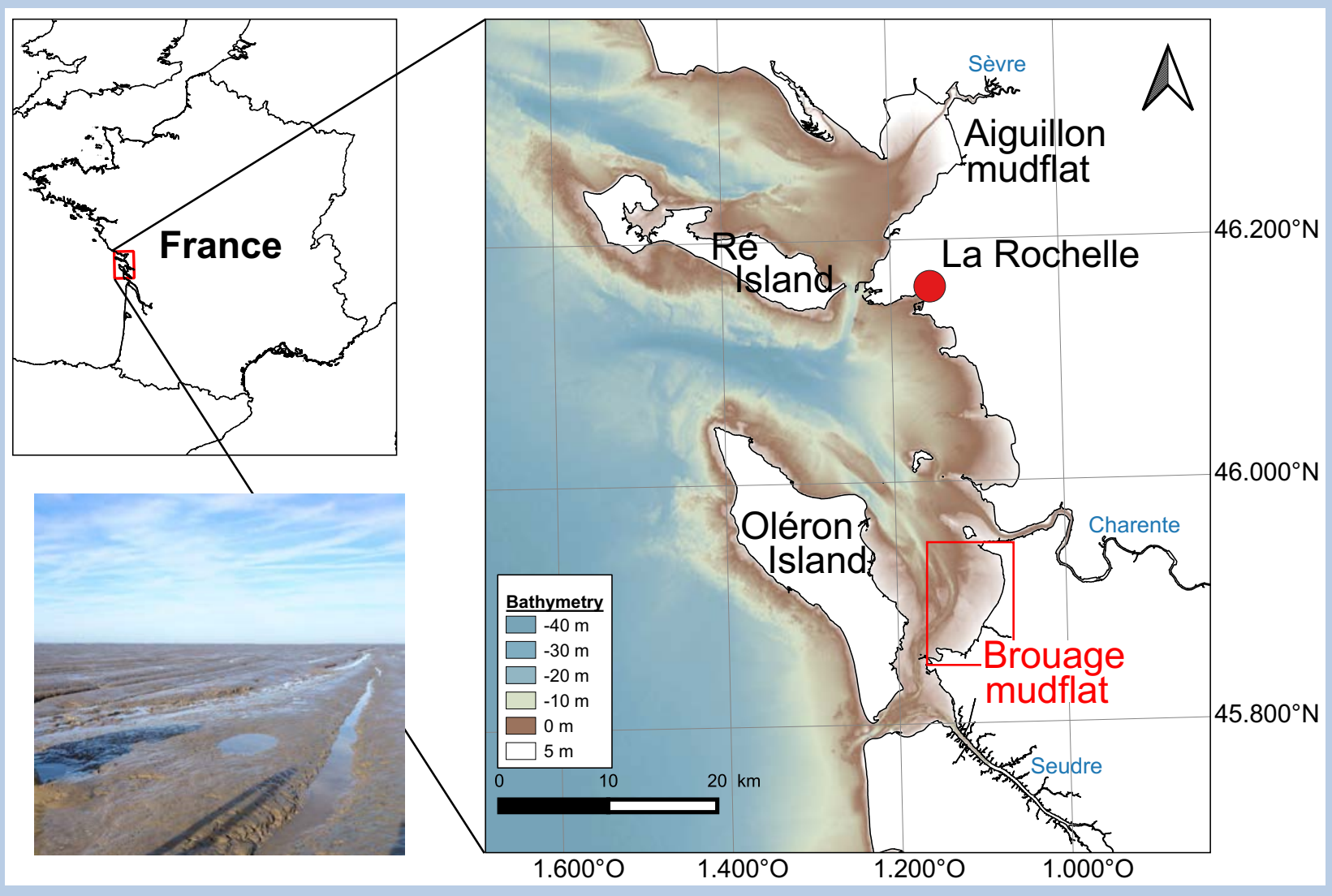
Biogeochemical exports from rivers and coastal ecosystems?

The sensitivity of the carbon cycle of the global ocean to these exports?

Numerical models and remote sensing of the LOAC: **the example of tidal flats**

Tidal flats are under multiple influences (waves, tides, river discharge, meteorological conditions) from sub-hourly to interannual scale.

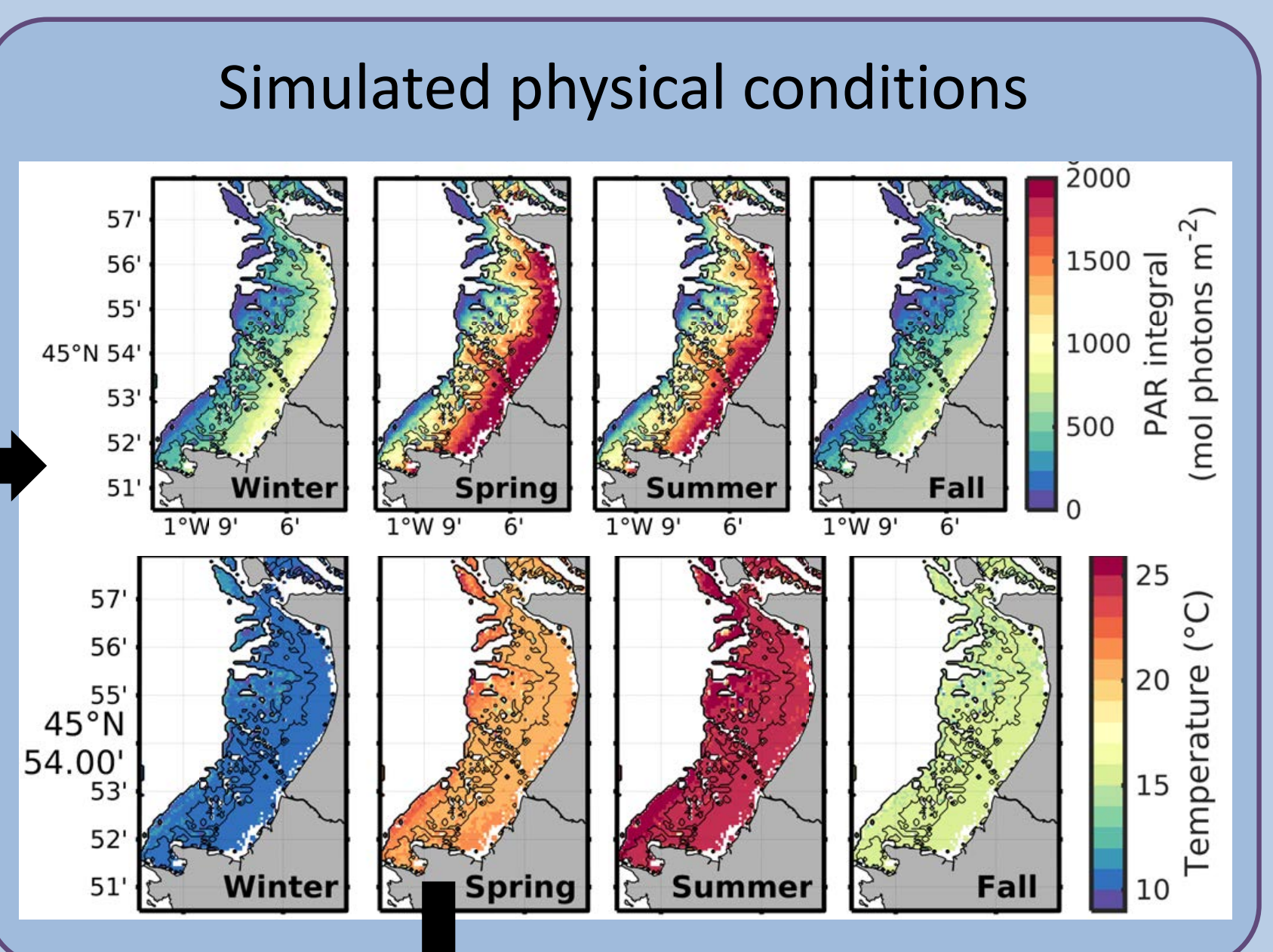
On tidal flats, benthic microalgae or microphytobenthos (MPB) support a high primary production, especially at low tide.



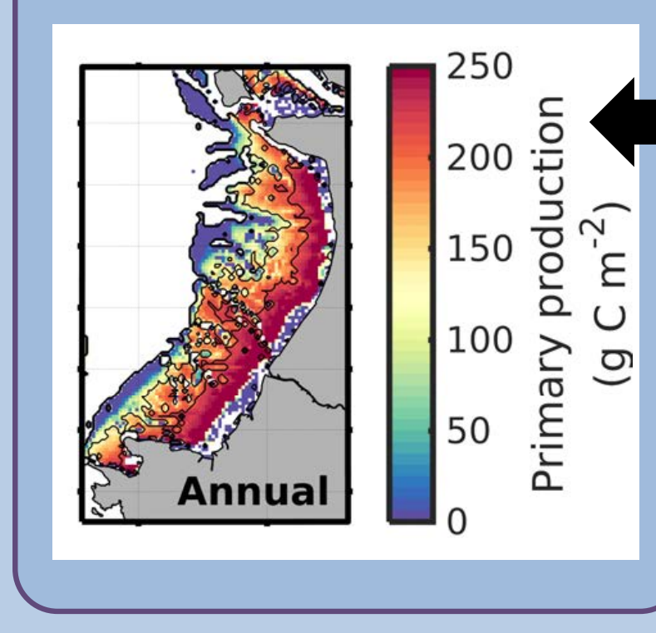
Model

Tides
Meteorological forcings

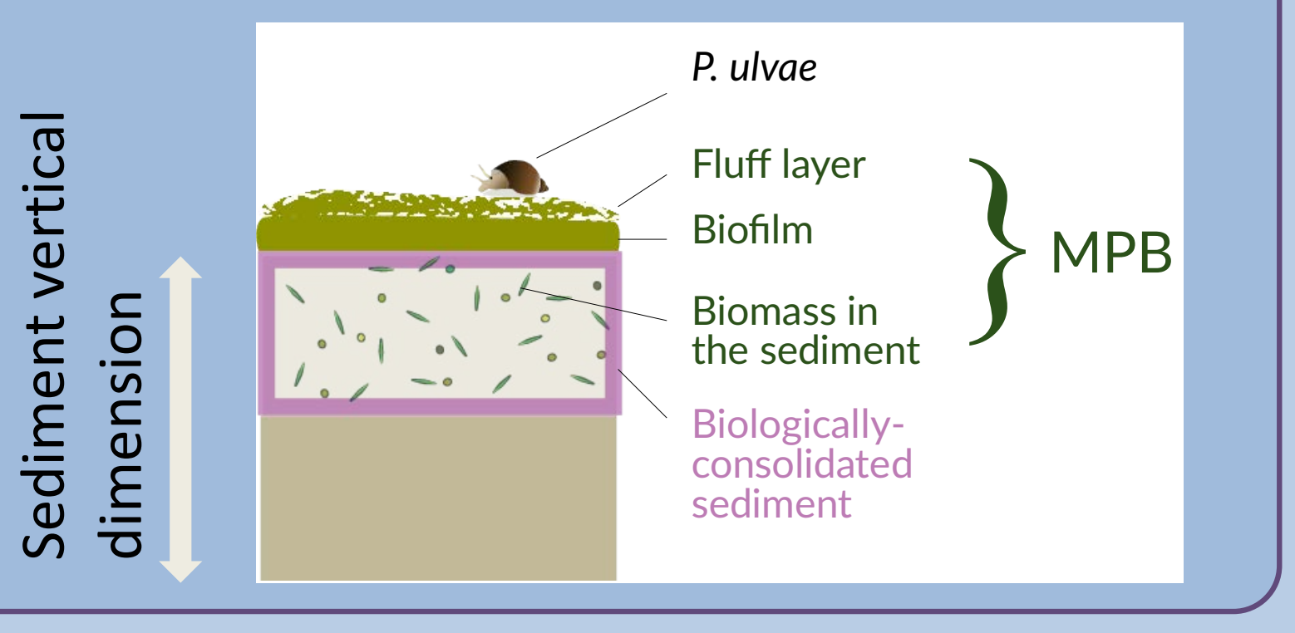
Simulated physical conditions



MPB spatiotemporal dynamics



Model of MPB



Informs

Remote sensing

Horizontal distribution of MPB

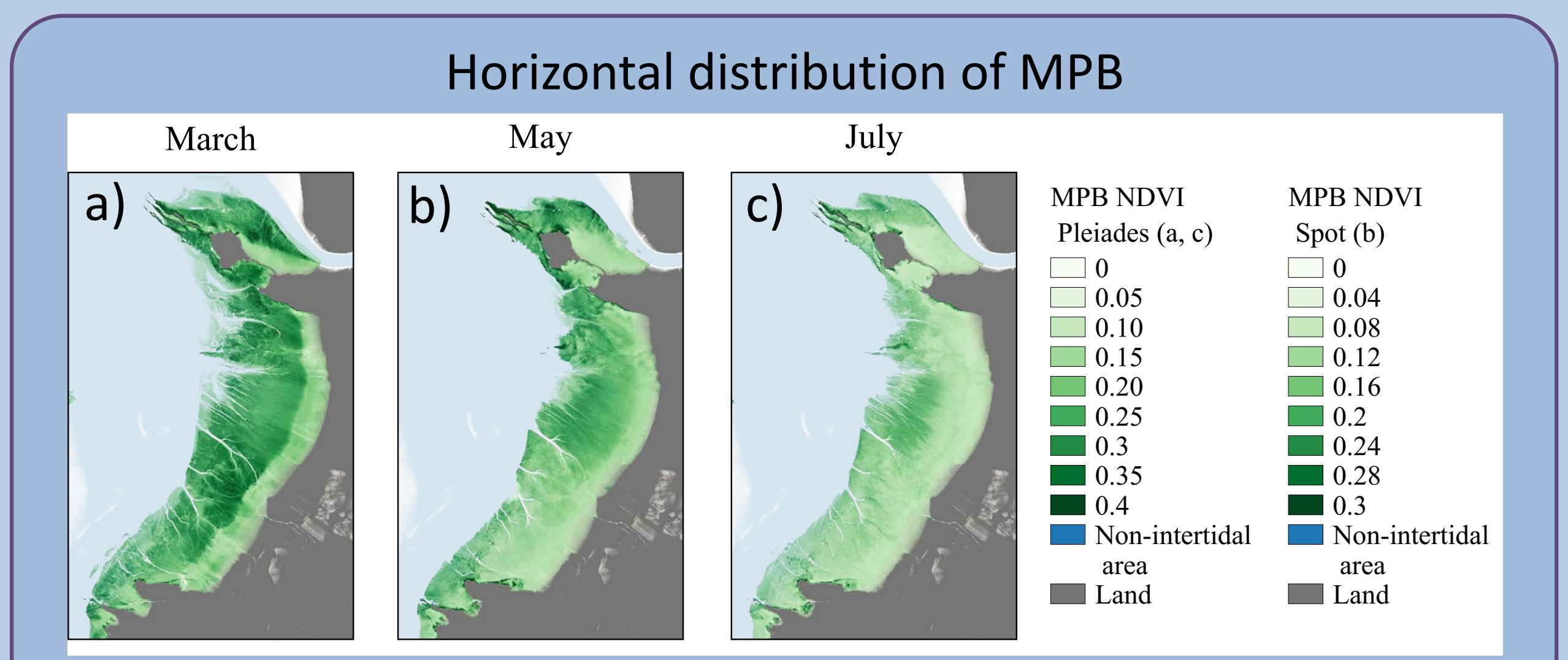


Figure 2. Normalized Difference Vegetation Index (NDVI) of MPB. From Méléder et al., 2020.

1D modeling of the export of MPB biomass from tidal flats

Bed shear stress from waves and tides

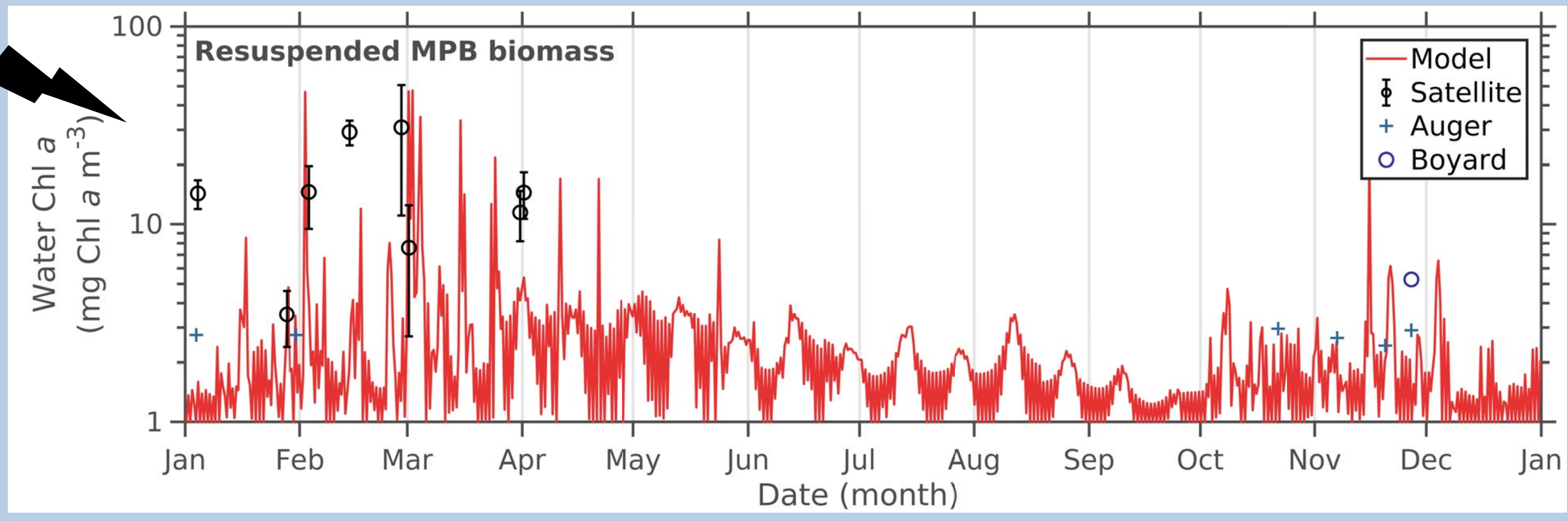
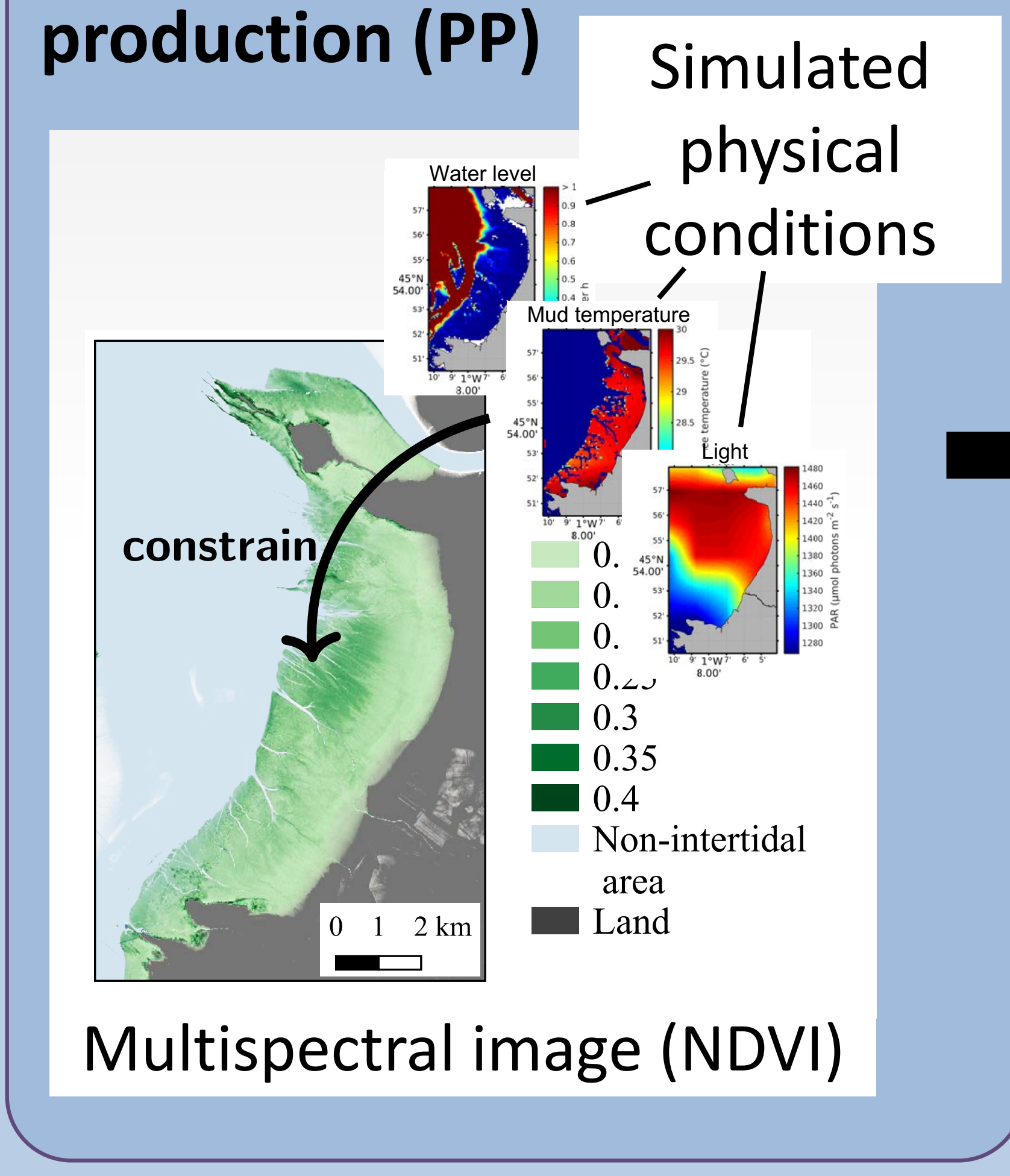


Figure 3. Simulated resuspended MPB biomass along with satellite and *in situ* observations. From Savelli et al., 2019.

- High export in winter-fall due to high MPB biomass in the sediment and strong waves
- Annually, the export of MPB biomass = 43% of MPB primary production (PP)

Coupling a 3D model with space remote sensing

Algorithm of MPB primary production (PP)



Multispectral image (NDVI)

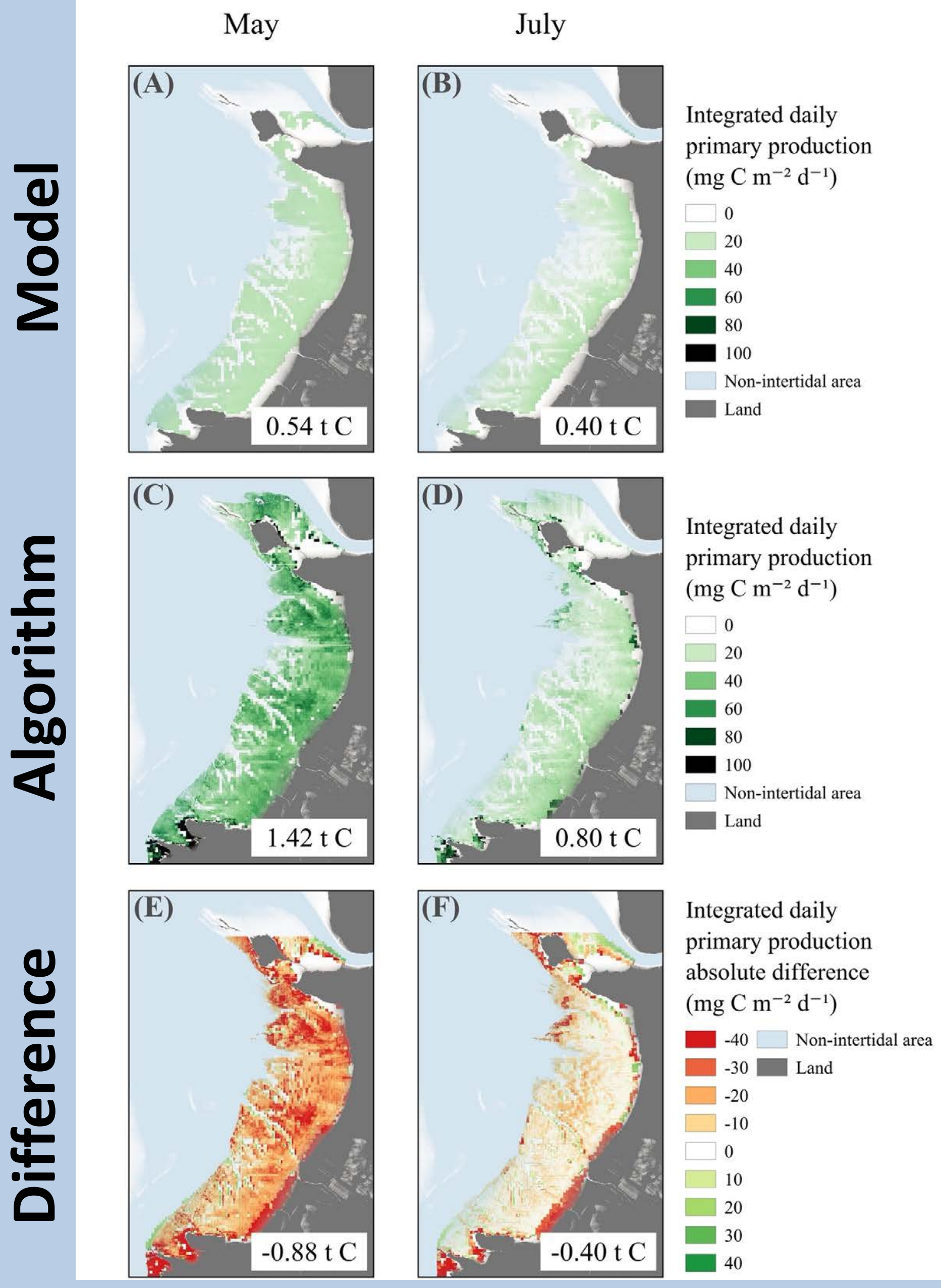
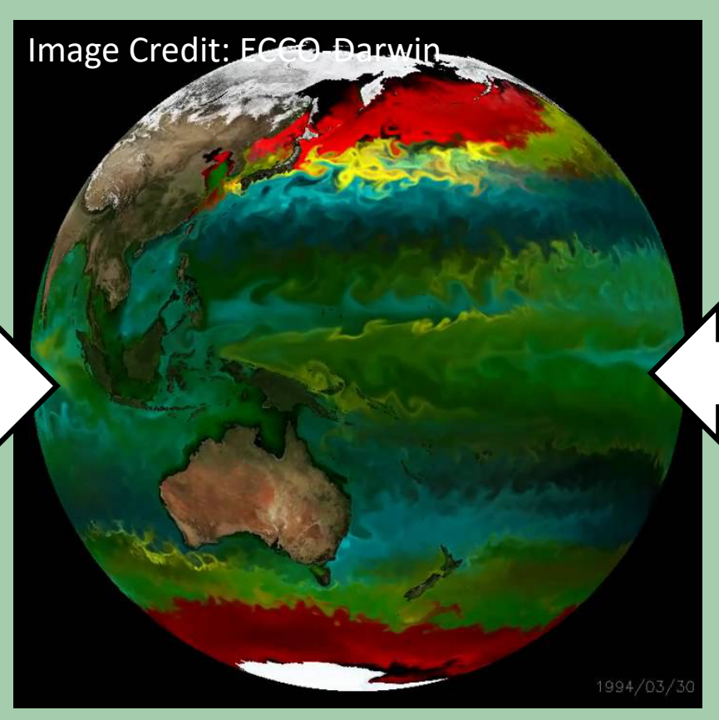
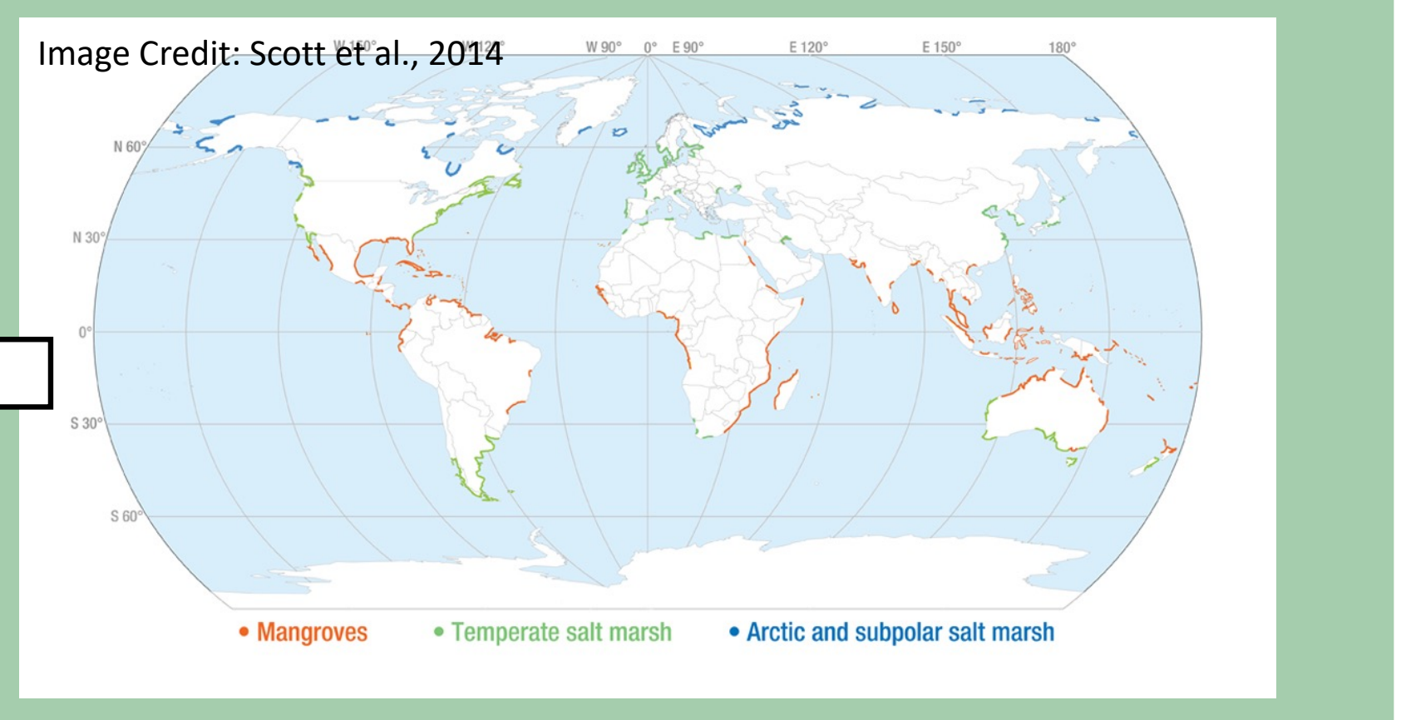


Figure 4. MPB primary production. From Savelli et al., 2020.

- Significant advance in the estimation of PP over large productive tidal flats
- 1st coupling of modeling and remote sensing for PP mapping in the intertidal domain

Current project: what rivers and coastal wetlands bring into the global ocean ?





Nutrient river runoff

- Multielement and multiform (C, N, P, Si)
- 6152 watersheds

ECCO-DARWIN model

- Ocean biogeochemistry model
- Data-assimilative

Coastal wetlands exports

- Different types of vegetation
- Specific parametrization of exports

At the global scale and the regional scale (Gulf of Mexico and Mackenzie river delta):

- The **first non-adhoc estimate of the contribution of rivers and coastal wetlands to the air-sea CO_2 air fluxes of the global ocean**
- The **phytoplankton activity and diversity in response to the biogeochemical exports**

References

Savelli, R., Bertin, X., Orvain, F., Gernez, P., Dale, A., Coulombier, T., … & Le Fouest, V. (2019). Impact of chronic and massive resuspension mechanisms on the microphytobenthos dynamics in a temperate intertidal mudflat. Journal of Geophysical Research: Biogeosciences, 124(12), 3752-3777.
Méléder, V., Savelli, R., Barnett, A., Polsenaere, P., Gernez, P., Cugier, P., … & Lavaud, J. (2020). Mapping the intertidal microphytobenthos gross primary production part I: coupling multispectral remote sensing and physical modeling. Frontiers in Marine Science, 7, 520.
Savelli, R., Méléder, V., Cugier, P., Polsenaere, P., Dupuy, C., Lavaud, J., … & Le Fouest, V. (2020). Mapping the Intertidal Microphytobenthos Gross Primary Production, Part II: Merging Remote Sensing and Physical-Biological Coupled Modeling. Frontiers in Marine Science, 7, 521.
Scott, D. B., Frail-Gauthier, J., & Mudie, P. J. (2014). Coastal wetlands of the world: geology, ecology, distribution and applications. Cambridge University Press.

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