Tidal flat gross primary production mapping using hyperspectral remote sensing: mesoscale approach

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Tidal flats constitute one of the most productive ecosystems on Earth mainly due to the presence of microscopic algae colonizing sediments (i.e. microphytobenthos, MPB). MPB are the main primary producers of these tidal flats providing important services such as, maintaining high nutrient levels in benthic and pelagic compartments, biodiversity depositories, and shoreline stabilization. Despite representing only 0.03% of the ocean area (~130.000 km^2), tidal flats significantly contribute to carbon sequestration, with a global annual Gross Primary Production (GPP) in the order of 500 million tons of carbon; these ecosystems can make up 20% of the ocean GPP. Albeit their high contribution to the Global Carbon Budget, the actual contribution of tidal flats remains unknown. The best way to fill this knowledge gap is to use remote sensing imagery calibrated with C-flux measurements. The use of hyperspectral technology (hundreds or thousands of wavelength bands) is the only one able to detect and map biological changes and physiological processes involved in GPP.

The objective of this study was to develop algorithms at the mesocale level (cm^2) to estimate tidal GPP based on hyperspectral imagery using natural biofilms sampled at varied seasons using sediment cores. Biofilm hyperspectral reflectance (400 – 900 nm), PAM fluorometry, and chamber carbon flux were measured *ex situ* under controlled condition of light (50 to 2300 $\mu mol.m^{-2}.s^{-1}$) and temperature (15, 25 and 40 °C). First, light curves from C-fluxes, expressed in $mgC.m^{-2}.h^{-1}$, and from PAM fluorometry, expressed in rETR (relative Electron Transfer Rate) and photosynthetic parameters (alpha, Ek and Pmax) for each temperature and each season were compared. Second, absorption coefficient α obtained by a biofilm optical model and Chlorophyll *a* concentration obtained by HPLC were used to retrieve the absorption cross-section (a*), and then to calculate the electron transport rate (ETR). Third, radiometric indices (MBP_{LUE}, SlopeChla) were tested to estimate primary production expressed in rETR and quantum yield of CO_2 ($molCO_2.mol^{-1}photon$). Finally, the developed algorithm was used to map GPP at the sediment core scale and is expected to be applied on a higher scale.