A NEW APPROACH TO MICROPHYTOBENTHOS BIOMASS MAPPING BY INVERSION OF THE RADIATIVE TRANSFER MODEL : APPLICATION TO HYSPEX IMAGES OF BOURGNEUF BAY

Farzaneh Kazemipour [a], *Patrick Launeau* [a], *Vona Méléder* [b]

[a] Laboratoire de Planétologie et Géodynamique, UMR-CNRS 6112, Université de Nantes,
2 rue de la Houssinière BP 92208, 44322 Nantes Cedex 3, France

[b] Equipe Mer, Molécules et Santé- EA 2160, 2 rue de la Houssinière BP 92208, 44322 Nantes Cedex 3, France

1. INTRODUCTION

Microphytobenthos (MPB) consists of the benthic unicellular phototrophic microorganisms, mainly Diatoms, inhabiting the first µm of the sediment and forming a biofilm at the mudflat surface during diurnal low tide and can covers several hectares [16]. Despite the importance of such shellfish ecosystem, only a few number of studies has dealt with microphytobenthic structure on mesoscale and macroscale because of the difficulties to reach [4], [16]. The study site is Bourgneuf Bay (French Atlantic coast), a costal ecosystem which plays an important economical and environmental role in north-west region of France where the diatoms are a major food source for cultivated oysters. Previous studies provided the map of fractional cover and biomass, expressed in chl***a*** ($mg.m^{-2}$), by comparing a synthesized spectral library with Dais airborne images [5]. Insufficient spectral resolution of Dais images (~19nm) makes appeared some confusions between Diatoms and Euglena, two groups of microalgal cells with very similar spectral shapes, and errors might be introduced because of the limitation in spectral library and. It is therefore of interest to establish a physical model, based on a simple optical system, In order to get a more exhaustive and accurate quantification of biomass.

In this work we present a new approach of biomass evaluation, based on a radiative transfer model of Microphytobenthic biofilm, from HySpex airborne images. We have made an attempt to investigate the inversion model application to pixels where Diatoms could be considered as more dominant material. These regions are already isolated by a classification approach based on spectral shape analyses and indices. Owing to combination of good spatial and spectral resolutions of HySpex images with a robust physical model, a more reliable biomass map will be performed.

2. METHODOLOGY

Here we present a two-step procedure for the biomass retrieval in Bourgneuf bay:

1- Mapping the regions dominated by Diatoms and mask all other present materials
2- Biomass estimation by a physical model already validated in laboratory

2.1. MPB mapping from HySpex images

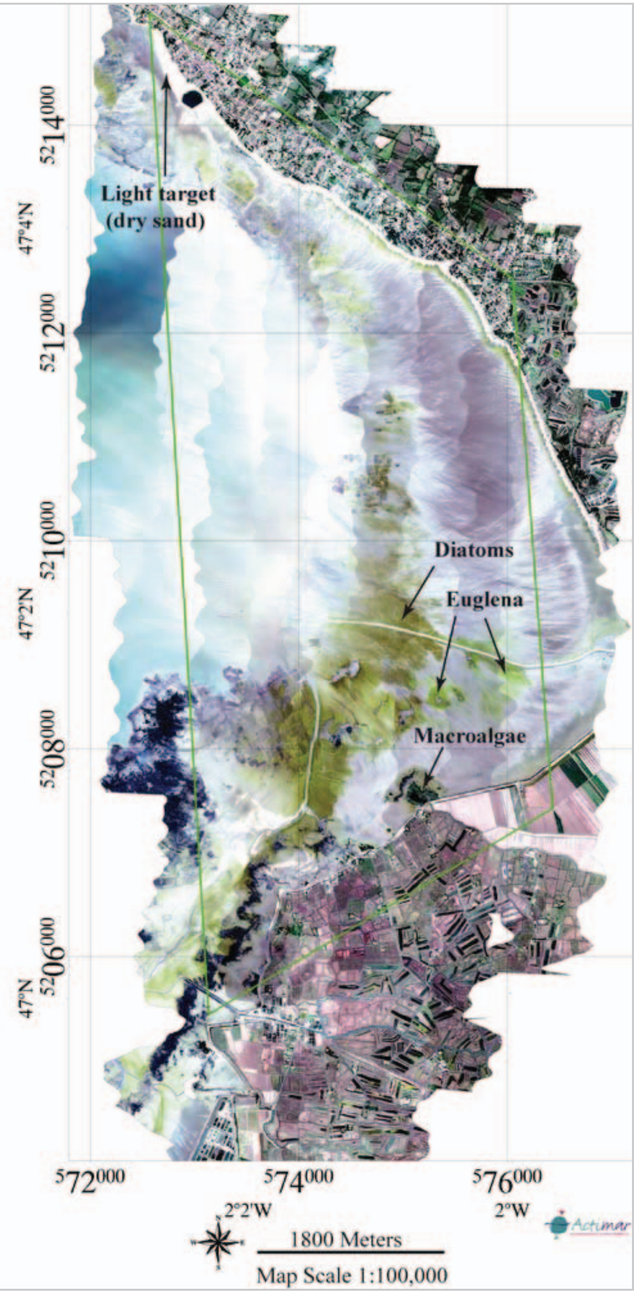

Figure 1: HySpex radiance image of Bourgneuf Bay provided by Actimar. RGB colors associated with channels at 640, 550 and 485 nm, respectively.

The LPGNantes provides the HySpex VNIR 1600 camera with a spectral resolution of 4.5 nm in 160 channels between 400 and 1000 nm. Actimar was in charge of the airborne operations (September 2009) and chose the flight conditions for a spatial resolution of around 1 m. Figure 1 presents a mosaic of radiance images of the region where we can easily distinguish the important present materials by choosing the pertinent wavelengths. The ground control points on various neutral surfaces in the range of 400-1000 nm were also acquired by ASD FieldSpec3 spectrometer to check the radiometry and atmospheric correction performance.

In order to remove the effects of surface scattering (roughness), shadowing and any other filed parameter effecting the overall shape (continuum) of the reflectance spectra, [5] proposed to subtract a continuum fraction based on a straight-line function in logarithm reflectance space and in wavenumber. This causes the confusion between Diatoms and Euglena by reducing their spectral distance in bleu-green range (500-600 nm). The method used in this work is based on the trend curve of the spectrum and is comparatively easier and faster and was tested successfully in geological aims and also for ROSIS images of Bourgneyf Bay [24]. Here the pixels for which each of Euglena or Diatoms dominates are correctly detected and any other confusion will be totally removed in final map (previously obtained for ROSIS images).

2.2. Biomass retrieval

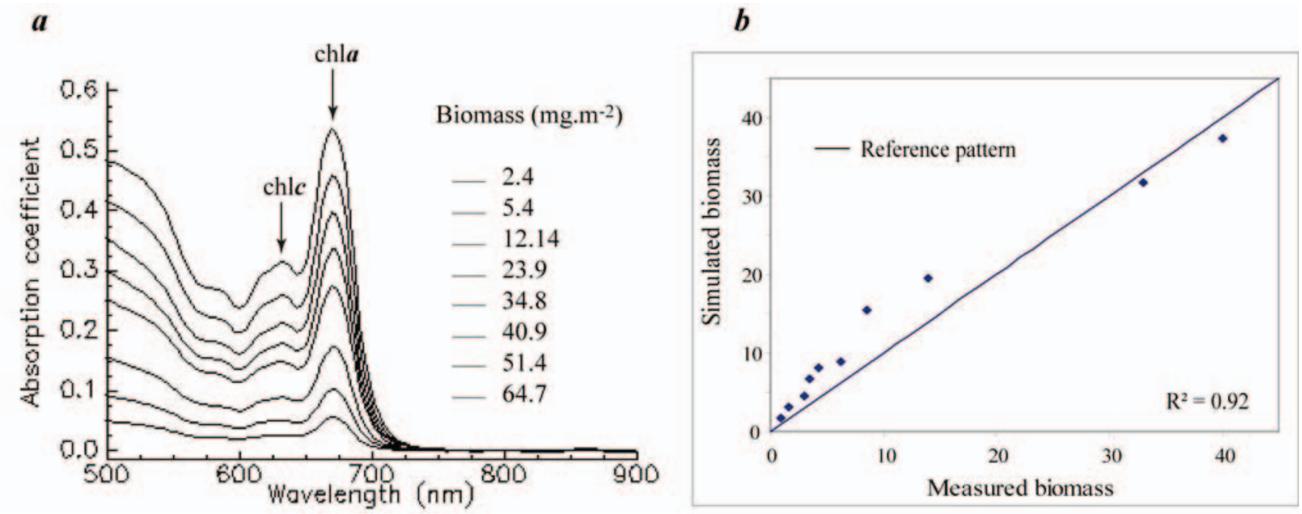

Figure 2: (a) Simulated absorption spectra of 8 laboratory biofilms of increasing biomass. (b) Comparison of model derived biomass versus reference biomass measured by HPLC for validation data set.

The optical properties of a laboratory simulated biofilm, incorporating the E.Paludosa cells, were calculated by using the reflectance measurements derived from HySpex images in laboratory and under controlled situations. The biofilm was simulated as a slow filtering of different culture concentrations, diluted by seawater, on the polycarbonate filters [19]. The absorption coefficient and refractive index are calculated from the corrected reflectance and transmittance, irrespectively of the background reflectance, by means of an iteration procedure and the Fresnel reflectance/ transmittance of each sample interface [1], [6], [15], [20], [13],[22] (Figure 2-a). The high correlation of biomass concentration with absorption coefficient in corresponding absorbing wavelength (673nm) makes us able to estimate the biomass concentration corresponding to any possible absorption coefficient [12]. This latter was validated for an independent data set and an acceptable determination coefficient between measured biomass and simulated biomass was obtained (Figure 2-b).

Finally, the model could be applied to corrected images. The substrate reflectance spectra must be derived from a spectral library carried out by multiple in-situ measurements. Regarding the transparency of a MPB biofilm in NIR region, the reflectance level in this range could be considered as a fair representation of the substrate reflectance. Thus, the substrate spectra must be calibrated and normalized for a superposition of substrate/apparent reflectance in NIR zone. These reflectance spectra combined with the other data, taken into account for first modelling stage, provided the input data for inversion model. The biomass content could be simulated for each pixel of image and provides the biomass map of Bourgneuf Bay.

3. CONCLUSION

Our objective was to evaluate a model of biochemical properties retrieval, especially chl***a*** content, of Microphytobenthic biofilm in Bourgneuf Bay from HySpex airborne images. Regarding the absorption coefficient as an additive function of all pigment absorption coefficient and their concentration, the concentration of each pigment can be retrieved directly from the absorption coefficient at its specific absorbing wavelength. Accordingly, the regression of chl***a*** concentration versus absorption peak at 673nm produces uniformly a high R^2 value (0.94). An acceptable estimation of this pigment in comparison with measured values by HPLC (R^2=0.92), for an independent data set, justifies the application of inverse model to hyperspectral airborne images as a relevant mapping approach.

4. BIBLIOGRAPHY

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