SATELLITE REMOTE SENSING FOR SEAGRASS MAPPING IN THE LAGOON OF VENICE

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Abstract

Seagrass play an important role in preserving lagoon morphology and providing an environment suitable for marine organisms. Seagrass mapping is therefore particularly relevant for a correct management of the lagoon system. Remote sensing allows the estimation of seagrass extension and distribution, providing high temporal and spatial resolution maps. Moreover, costs of satellite data are lower than those currently possible with *in situ* surveys. In order to investigate the spectral properties of submerged plants, a series of *in situ* radiance measurements were collected. This spectral library has been used to calibrate a survey system based on the elaboration of remote sensing data.

Keywords: Seagrass, Venice lagoon, Remote sensing

Introduction

In 2002 a research program was started in the framework of a monitoring project carried out by Consorzio Venezia Nuova, on behalf of Magistrato alle Acque, Venice. Part of the program consisted in mapping the distribution of seagrass through remote sensing.

For this purpose, the following activities were planned:

1. definition of a methodology for radiometric data acquisition on field;
2. construction of a spectral library for the different species of seagrass and macroalgae of the Venice lagoon. This is supposed to be representative of the spatial and temporal variability of the targets' spectral behaviour, due to changes in environmental factors as well as in phenological and growing conditions of plants;
3. calibration and validation of remotely sensed data with collected *in situ* measurements;
4. development of a procedure for mapping seagrass in the Venice lagoon based on the elaboration of remote sensing images.

Field survey

Experimental activities were carried out during six and five monthly field campaigns respectively held in spring-summer 2002 and 2003.

During the first year data were measured on six 100 m^2 plots:

• 3 "pure" plots with 100% coverage of *Zostera noltii*, *Zostera marina* and *Cymodocea nodosa* respectively;
• 1 plot with mixed coverage of *Cymodocea nodosa* and *Zostera marina*;
• 2 "pure" plots with discontinuous coverage (50%) of *Cymodocea nodosa* and *Zostera marina*.

The three 100% coverage – single species plots - were also sampled in 2003. In this period, radiance data were collected for complementary targets (macroalgae, bare substratum with different granulometric composition, canal) too.

Each monthly campaign lasted six days; i. e. one plot or target per day. 8 hourly measurements of spectral signatures and ancillary parameters (turbidity, depth, Chl-a fluorescence, chemical-physical parameters, water current intensity and direction, suspended matter, PAR) were collected in a fixed representative point in order to investigate the influence of the tide effect on the spectral behaviour of targets.

Additional signatures were randomly collected in other points to enlarge the spectral collection.

Radiance data were measured with a portable radiometer PR-650 and were taken above the water surface, following an update Sea Viewing Wide Field of View Sensor (Sea WiFS) protocol (1-3,5).

Monthly measures of phenological and growth data were also collected in the pure and mixed seagrass plots, in order to investigate their influence on seagrass spectral response.

Satellite data analyses

Satellite data were collected and used to derive distribution maps of the different seagrass species living in the shallow waters of the Venice lagoon. Four Landsat 7 ETM+ scenes were acquired during the 2002 field campaigns, and in particular the 18th May scene was used for the analyses. Data were radiometrically calibrated, atmospherically corrected - using ATCOR2 based on MODTRAN 4.2 - and, finally, georeferenced. Only the VIS and NIR bands were used for the analyses.

The analysis of spectral signatures of un-vegetated lagoon floor allowed calculating an exponential relation between reflectance and water depth. The reflectance of an imaginary lagoon without submerged vegetation was simulated using the exponential relation in the green portion of the electromagnetic spectrum and considering the water heights calculated by an hydrodynamic model. Difference between simulated reflectances and those obtained with Landsat ETM+ enabled to distinguish between vegetated and bare lagoon.

An ISODATA clustering was then applied on vegetated areas, using the reflectance standard deviations calculated on spectra collected in field (4). Matching cluster spectra with those obtained in the field, clusters were grouped into four vegetation classes. A good agreement between these results and a seagrass - macroalgae map obtained from detailed surveys undertaken on the whole lagoon during spring – summer 2002 was noticed.

Distinction between *Zostera marina* and *Ulva rigida* appeared to be complex, probably due both to the similarity of their spectral responses and to the fact that they usually grow on the same areas. *Zostera noltii* was not found, probably because it was at the beginning of its growing season. *Cymodocea nodosa* was well recognized in the central lagoon, while some disagreement with field survey was found in limited areas of the southern basin (Valle Millecampi and Chioggia).

Thanks to the 2003 field campaigns, a larger spectral signatures database will be available for the recognition of vegetation species, and hence a better distinction among species will be possible.

Results

Experimental activities enabled to collect a considerable quantity of spectral data of three seagrass species and complementary targets in the lagoon of Venice, in different environmental situations as well as phenological and growing conditions of plants. This led to create an original and rich spectral database.

The preliminary study of reflectance data pointed out the close correlation between spectral measurements of different targets, underlining the relevant influence that some environmental factors have on spectral responses. In fact, this can partially or totally mask the reflectance of submerged vegetation. Factors that seem to have the highest influence are:

• depth and thickness of the water column above the submerged vegetation;
• water turbidity;
• bottom characteristics.

Preliminary elaboration of satellite data confirmed that the created spectral collection represents a considerable experimental basis for the development and calibration of a remote sensing system for seagrass mapping based on satellite imagery.

Acknowledgment. A special acknowledgment to Consorzio Venezia Nuova, Servizio Ambiente, in particular to Arch. A. G. Bernstein and Ing. L. Montobbio.

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