IMAGE PROCESSING OF MODIS DATA ON MEDITERRANEAN SEA FOR A COMPARISON WITH IN SITU MEASUREMENTS OF BIO-PHYSICAL PARAMETERS.

Francesco Dessi[1], Maria Teresa Melis[2],Andrea Ortu[3], Matteo Murenu[4], Alberto Marini[5] and Angelo Cau[6]

1. University of Cagliari, Department of Earth Science, Cagliari, Italy; fdessi(at)unica.it
2. University of Cagliari, Department of Earth Science, Cagliari, Italy; telegis(at)unica.it
3. University of Cagliari, Biology and Ecology Department, Cagliari, Italy; andreaortu(at)unica.it
4. University of Cagliari, Biology and Ecology Department, Cagliari, Italy; mmurenu(at)unica.it
5. University of Cagliari, Department of Earth Science, Cagliari, Italy; marini(at)unica.it
6. University of Cagliari, Biology and Ecology Department, Cagliari, Italy; cau(at)unica.it

ABSTRACT

The aim of this work is the testing of MODIS standard products for chlorophyll -a and Sea Surface Temperature (SST) mapping on Mediterranean sea around Sardinia.

The collaboration between TeleGis Laboratory and Biology and Ecology Department of University of Cagliari is carrying out an interdisciplinary research. From 2004 TeleGis laboratory acquire MODIS data by a direct antenna system daytime and nighttime and these data are stored in the original EOS hdf format. The Biology and Ecology Department is involved in the Project MEDITS which contributes to the characterization of bottom fisheries resources in the Mediterranean in term of population distribution (relative abundance indices) as well as demographic structures (length distributions), and provide data for modelling the dynamic of the studied species. In this scope, estimation of total mortality of the exploited species constitutes an important aim. From June 14 to July 7th 2006 an oceanographic cruise around Sardinia was organized to acquire data about biological and biophysical parameters, with water samples to determine pH, salinity, conductivity, chlorophyll a concentration.

In this work the first step of this research is presented, focused on comparison of these direct information with the data model from MODIS images.

INTRODUCTION

The importance and the complexity of the marine environment need of a continuous and multidisciplinary study. The observation of the sea through satellite multispectral sensors (1,2,3) represents a suitable instrument of integration of the data obtained from the samplings carries out in the sea. In particular, the radiometers mounted on satellite platforms today supply the possibility to comprise dynamics of the phytoplankton (4). Unfortunately their data are not free from uncertainties: a phase of atmospheric correction is necessary in order to obtain data of Water-Leaving radiance, so as to remove from it the signals measured the contributions of molecules and present particles in the atmosphere, that they represent until 90% of spectral signal them. In this study there are reassumed turns out obtained from the comparison of the measures of marine parameters with the data obtained from sensor MODIS (Moderated Resolution Imaging Spectroradiometer). In particular way in this work it comes estimated the reliability of the algorithms standard of valuation of some parameters like sea surface temperature and concentration of the chlorophyll.

METHODS

Study area

The area in examination is represented from surrounding marine waters the island of the Sardinia, in the western Mediterranean. The dimensions of the Sardinia (approximately 24.000 km^2) do not concur the existence of important catchment basins and, also for via of climatic factors, the present water course has a regimen of character torrential with reduced liquid and solid capacities, and much often limpid coastal waters. This data turns out of fundamental importance for the analysis of the optical property of marine waters, being the classification of waters usually based on the various concentrations of marine constituent (5). In the bibliography it comes commonly made the distinction between case 1 waters and case 2 waters (6).The first, optically simple ones, derive their optical property in relation to the concentration of chlorophyll and organic matter, and they are water typically distal. The second ones instead are more complex because the optical property are determined also from other constituent (sediments, yellow substance), like it happens along the coasts. Although it's a classification put in argument from some authors (7), in this terms, in some particular situations it is only possible to trace along the coasts of the Sardinia waters of case 2.

MODIS data

In this study, MODIS data from Terra and Aqua satellites were used. MODIS is a sensor of multidisciplinary type, adapted to the study of the earth, the sea and the atmosphere (8).The first MODIS has been put in orbit with the satellite Terra in 1999, followed from its homologous one on the Aqua satellite launch in 2002. The satellite Terra orbits around to the globe with a heliosynchronous descendant orbit, flying daily over the Equator at 10:30 a.m., while the Aqua satellite moves along an ascending orbit passing over the Equator at 1:30 p.m.. In this way the entire land surface can be covered every two days, acquiring information in 36 bands of wavelength comprised between 0.4 and 14.4 micron, from the visible one to the infrared, with spatial resolution them variable from 250 to 1000 meters. The data are elaborated with a radiometric resolution of 12 bit: this means that for every pixel of every single band we have 4096 information. The MODIS Dataset used for this job was been acquired from the TeleGis Laboratory of the University of Cagliari (9) on 2004 with the Terascan® 2,4 X-Band LEO system, installed closed to the Laboratory of Physics of the Atmosphere of the Faculty of Mathematics, Physics and Natural Sciences of the University of Cagliari in Monserrato. The system is constituted by a parabolic antenna of reception with the diameter of 2.4 meters, protected from winds with a dome and it can be moved on three axeses. The coverage of the images comprises the entire Mediterranean river basin, including Europe, the Middle East and Africa of the North. The daily temporal resolution guarantees the acquisition at least two images in the morning, one in the evening and two nightly.

Oceanographic campaign data

The samplings of sub-surface waters have been carry out in the period comprised between the 14 june and the 7 July 2006 in different zones around Sardinia and at several distances from the coast, during the campaigns of MEDITS project (Mediterranean International Trawl Survey). MEDITS is an international research program, beginning at the end of 1993, and its main objective is the study of marine resources along Mediterranean coasts of Spain, France, Italy and Greek. From 1996 Balkan countries were involved (Albania, Croatia, Slovenia). The program collects and elaborates biological data on the biological communities of the dragged fishing areas of the continental platform and of a part of the continental escarpment, from 10 to 800 meters of depth, thanks to a fishing activity carried out during the late spring- summery experiments. Such campaigns supply moreover, for all the points of sampling placed according to a design random stratified, values of Temperature, pH, Conductivity and Chlorophyll. With regard to the campaigns carried out in 2006, we have the availability of two series of data. Be a matter of experimental fish campaigns, we have various systems of acquisition. One first series is relative to measures of temperature carried out from probes set on the fishing tools and on the hull of the boat, with variable depths and for a total of 88 points of sampling. The second series regards measures carried out on all the wa-

ter column from one multi-parametric probe descent in sea during the fishing activity, for a total of 128 points.

Images elaboration

The first operation carried out has been to select all useful data from MODIS Aqua by means of geographic and temporal selection. The choice to use exclusively the data of Aqua is mainly due to the fact that such satellite journeys above the area studied around to hours 13 (local hour) and this has allowed to consider a greater number of in situ measures. It has been therefore carried out a choosing between these data through the visualization of the QuickLook with the aim to eliminate from the elaborations all the images that introduced an excessive cloud cover, element generally negative, creating an appropriate database. The amount of data to deal has been further slimmed, isolating the area of interest in all the images through one procedure of subset. From this step it is proceeded to the containing crossing between database of the satellite images and database with the dates and the hours of the samplings in sea, choosing the contained satellite acquisitions in a hour range of 3 hours regarding the moment of the sampling: such approximation has become necessary because generally it's impossible to carry out every time the measures in the sea during the acquisition of the satellite. The processing of data MODIS has performed with the SEADAS (SeaWiFS Data Analysis System) (10)) software, distributed free of charge from NASA. There are different MODIS Aqua elaborated levels, Level 0 (raw data), level 1 (distinguished in L1A and L1B) and level 2, (in which the products are found standard). A level 3 exists also, constructed beginning from level 2 with a spatial and temporal resampling. The software SEADAS uses, in the processing from the level 1 tot he level 2, MSI12 code, developed from the NASA' s Ocean Biology Processing Group (OBPG)and characterizing the optical property of the ozone and water masses and carrying out the atmospheric correction based on meteorological ancillary data. In the case of satellite measures of marine parameters it is necessary to execute the atmospheric correction because much more of 90% of the radiance to the sensor is not coming from the water column, but it is due just to the atmosphere. Therefore the radiance measured from the sensor has to be corrected from the atmospheric contribution, so as to have an effective valuation of Water-Leaving radiance $L_w(\lambda)$, which represents the first data in order to obtain the quantitative valuation of sea constituent like the chlorophyll concentration. The approach for the atmospheric correction of data MODIS (11)) (12)) analogous to how much happens for the SeaWiFS data (13,14,15)) for waters of case 1 consists in the assumption that L_w is null in close infrared (NIR). The MODIS has two channels with suitable characteristics: bands 15 and 16 with 748 and 869 nm. It is spoken about hypothesis of black pixel (16) and in short it can be said that through the measured radiance from the sensor in the two bands of close infrared it succeeded to characterize the type of present aerosol in the sight cone of the sensor. The hypothesis of black pixel is respected, like the spectral profile of the water-leaving radiance shows in one of the sites of measure (Figure 1), the asymptotic curve is present in all the situated points of measure.

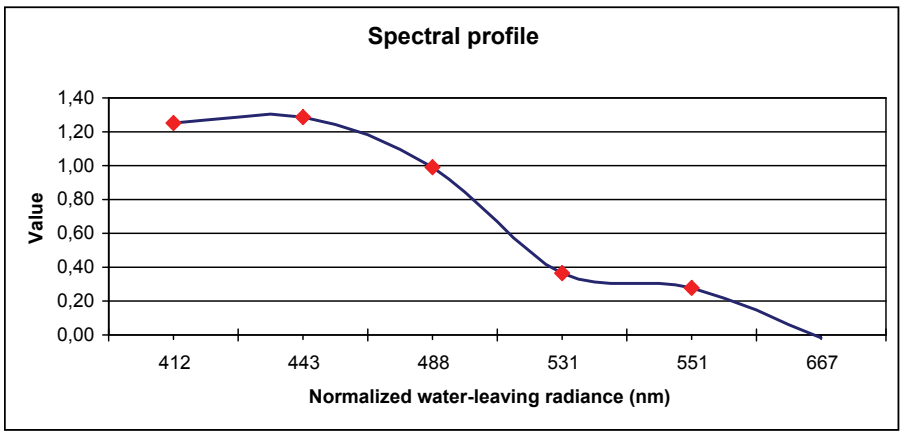

Figure 1 Spectral profile of the water-leaving radiance for one of the set points of measure; the radiance stretches to zero while the wavelength grows.

During the phase of elaboration from level 1 to level 2 a new file was created for every acquisition in .hdf format containing the following geophysical parameters of interest:

- Normalized water-leaving radiance at 412, 443, 488, 531, 551, 667 nm (mW cm^{-2} μm^{-1} sr^{-1})
- Aerosol optical thickness at 869 nm (dimensionless)
- Angstrom coefficient from 531 to 869 nm (dimensionless)
- Epsilon of aerosol correction at 748 and 869 nm (dimensionless)
- Diffuse attenuation coefficient at 490 nm (m^{-1})
- Chlorophyll concentration, Algorithm OC3M (mg m^{-3})
- Sea surface temperature SST (°C)

The next step was the extraction of the values of interest from the elaborated images (Figure 2): through SEADAS it is possible to characterize the coordinates of every pixel and therefore to read the values estimates from the algorithm in correspondence of the sampling points.

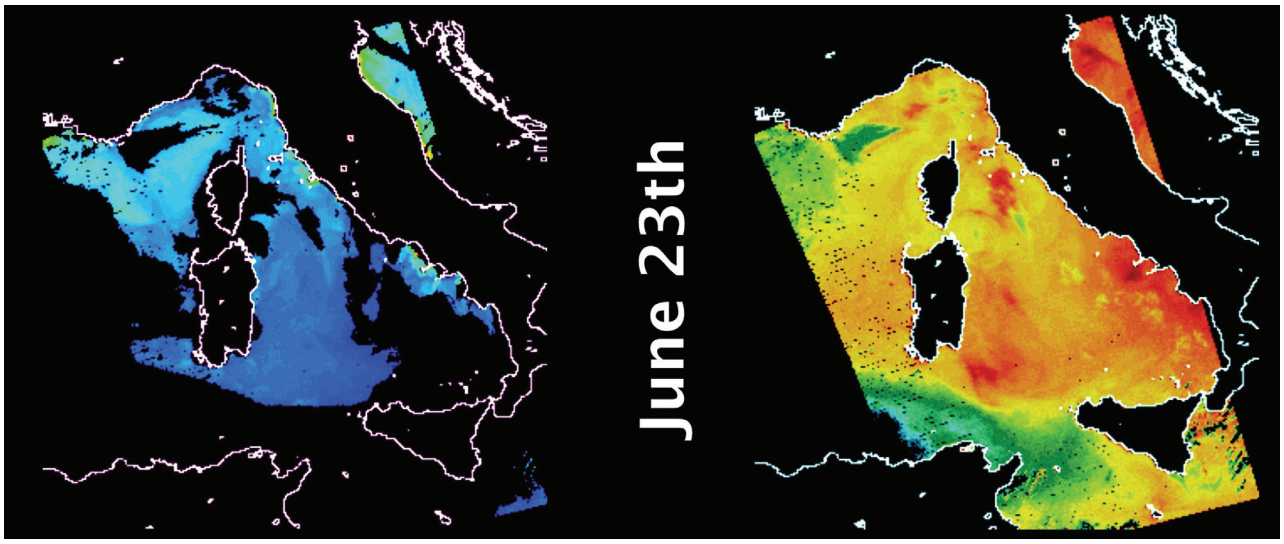

Figure 2 Example of elaborations of data MODIS AQUA obtained with the SEADAS software for the acquisition of the 23 June 2006: valuation of chlorophyll (on the left) and temperature (to right)

RESULTS

Data correlation

In this first phase of the research we have considered exclusively the acquired data of temperature through the probes put on the instruments of fishing and the hull of the boat. In the selection of the correlated pixel to the situated ones of measure, we have discard all pixel that introduced obvious disturbs naturally given from the sporadic presence cloud beyond to all those values that did not fall back in the hour range and therefore deprive of meant. In this way the number of carried out correlations is passed from 88 to 41, like shown in Figures 3 and 4.

Like shown from the diagrams, it has been obtained a good correlation between the temperatures measured in situ and those estimated from satellite, with a coefficient of correlation 0.857.

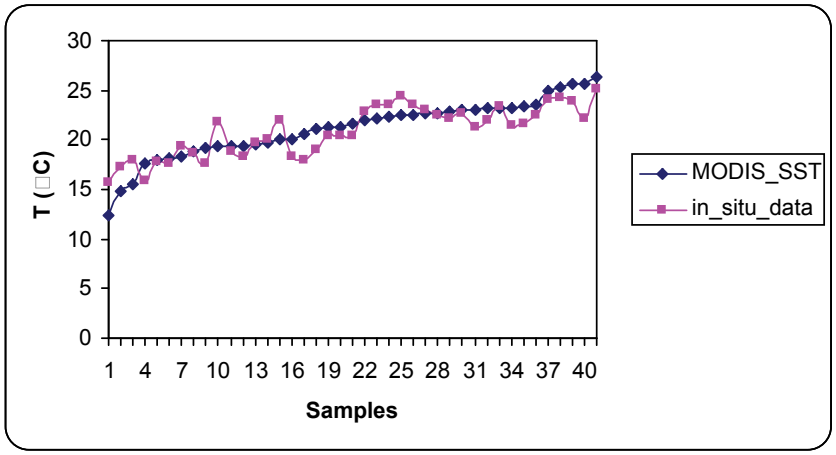

Figure 3: Comparison between in situ measures and valuation from the satellite of temperature of the sea.

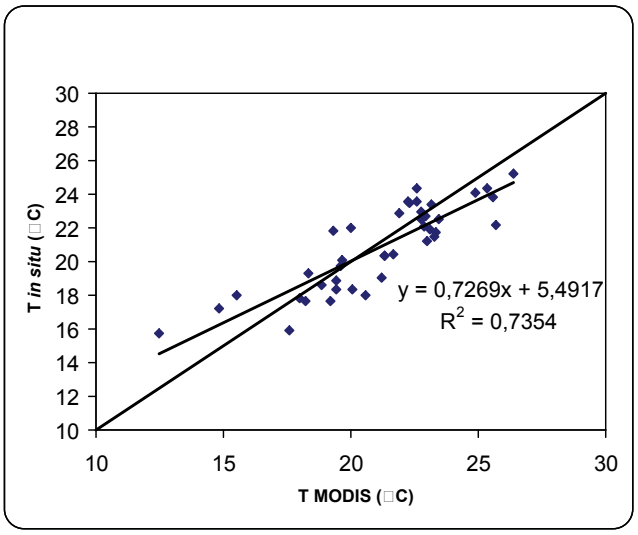

Figure 4: Diagram of dispersion between the temperatures estimated from MODIS sensor and the temperatures measured in situ.

DISCUSSION

The main aim of this work is to verify the performance of some standard products obtained from the processing of the data of MODIS sensor through comparison with measures carried out in sea. The valuation of these parameters from satellite depends on an accurate extraction of the Water-leaving radiance nLw and therefore the phase of the atmospheric correction covers particular attention because the quality of the atmospheric correction determines the quality of the evaluation of the nL_w. The standard product MODIS uses one band at 748 nm: in some cases (17) it has been demonstrated that such approach does not concur to estimate the nLw accurately; but it was be a matter of turbid coastal waters of the Baltic Sea much, where high concentrations of TSM carry to a meaningful one backscatter that contributes to the reflectance in the wavelengths of close infrared. In the case in examination, instead, the waters that encircle the Sardinia do not possess elevated turbidity and this could concur to estimate with accuracy the nLw, also considering the good relationship that marks noise offered from present sensor MODIS on the Aqua satellite. The quite good correlation could be justified by the delay between the measure in the sea and the acquisition of the sensor, beyond to the fact that the ground resolution of MODIS data is 1 km and a local measure could not be representative. Moreover it must consider that the temperature estimated

from the satellite refers to the surface (skin temperature) while the measures *in situ* used it in this job are referred not only to the precise surface.

CONCLUSIONS

The results obtained here for the first series of temperature data show a decidedly good level of correlation. In the immediate future it will be deepened the existing relations between the second series of temperature measures and the measures of chlorophyll concentration sampled during the oceanographic campaigns of MEDITS project. On the base of the new correlations, the studies of right parameters to apply to the standard algorithms so as to calibrate them locally, will be prepare. Of particular interest it will turn out the study of the distribution of the chlorophyll, confronting turns out also with other studies (18,19).

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Data MODIS of the Mediterranean area can be requested to the TeleGis Laboratory of the University of Cagliari, to the web address http://telegis.unica.it/progetto/antenna .

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