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RECENT DYNAMICS OF SUBMERGED SHOALS AND CHANNELS AROUND THE KERKENNAH ARCHIPELAGO (TUNISIA) FROM LANDSAT TM AND MODIS

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Abstract
In the Gulf of Gabes in Tunisia, the underwater topography of Kerkennah islands is marked by the existence of shallow and the lithology is characterized by the presence of predominantly soft rocks. The topography and the nature of the rocks in addition to the sea level rise and active subsidence magnitude are important factor of vulnerability manifested by a costal retreat and active evolution of submarine channels. The satellite remote sensing allows assessing the diachronic evolution and temporal variability of these phenomena. We used the L2 MODIS (Moderate Resolution Imaging Spectrometer) AQUA 2009 satellite data. These data are produced by NASA/OBPG (Ocean Biology Processing Group) to extract distribution maps of chlorophyll and turbidity. MODIS data are completed by Landsat data which are selected on periods of summer July 1986, August 1987, June 2003 and July 2009 especially. These data are useful by their high spatial resolution (30m) and the availability of both old and new data. For water color MODIS data we applied biotic algorithms quantification of chlorophyll and turbidity. The analysis of Landsat images has been carried by the same preprocessing (atmospheric corrections, radiometric and geometric) and the same treatment in order to compare the local variation of pixel luminance. The cartography of underwater morphology change is obtained by subtraction between the TM1 bands for two satellites images between 1986 and 2009. The treatment of multi-temporal and multi-sensor date is mainly based on the mapping of recent and ancient marine dynamics around the Kerkennah islands. The changes in spatial and temporal underwater morphology show the withdrawal of the coastline by location, immersion small plots of sebkha, the emergence and expansion of some each of these submarine channels.

Keywords: Landsat-TM, MODIS-AQUA, Kerkennah, submerged shoal

1. INTRODUCTION

Kerkennah islands, located in the gulf of Gabes in Tunisia are characterized by a -10 m isobath at few kilometers away from the shoreline (fig. 1) and by a lithology composition dominated by smooth rocks (sandstone and mio-pliocene, clay). In the context of climate change on an archipelago characterized by active subsidence, the objective of this work is to show how, from satellite imagery, the progression of submarine channels. This article shows the first part of this study. The objective here is to show how, regardless of tidal phenomena, evolved channels during the tow last decades.

Operational NASA products on turbidity and chlorophyll content are extracted from MODIS data. These products are globally validated. However some discrepancies appear around Kerkennah islands. These discrepancies are likely linked with the large shallow water area (Katlane *et al.*, 2011) and this feature should explain the inaccuracies of OC5 algorithm. In order to enhance the retrieval methods we need up to date water deepness estimation on our study domain. The water deepness estimation has been carried out by a Landsat TM data processing.

An open issue should be to formally relate the bathymetric changes as assessed by Landsat TM and the observed biases in MODIS indicators.

2. DATA AND METHODS

The figure 2 displays a flowchart of the data processing. The Daily satellite imagery acquired in 2009 by MODIS AQUA, provided by the National Aeronautics and Space Administration (NASA), Ocean Biology Processing Group (OBPG) were used in this study. However, many of these images are removed because they are affected by sun glint, which is more frequent during the summer period.

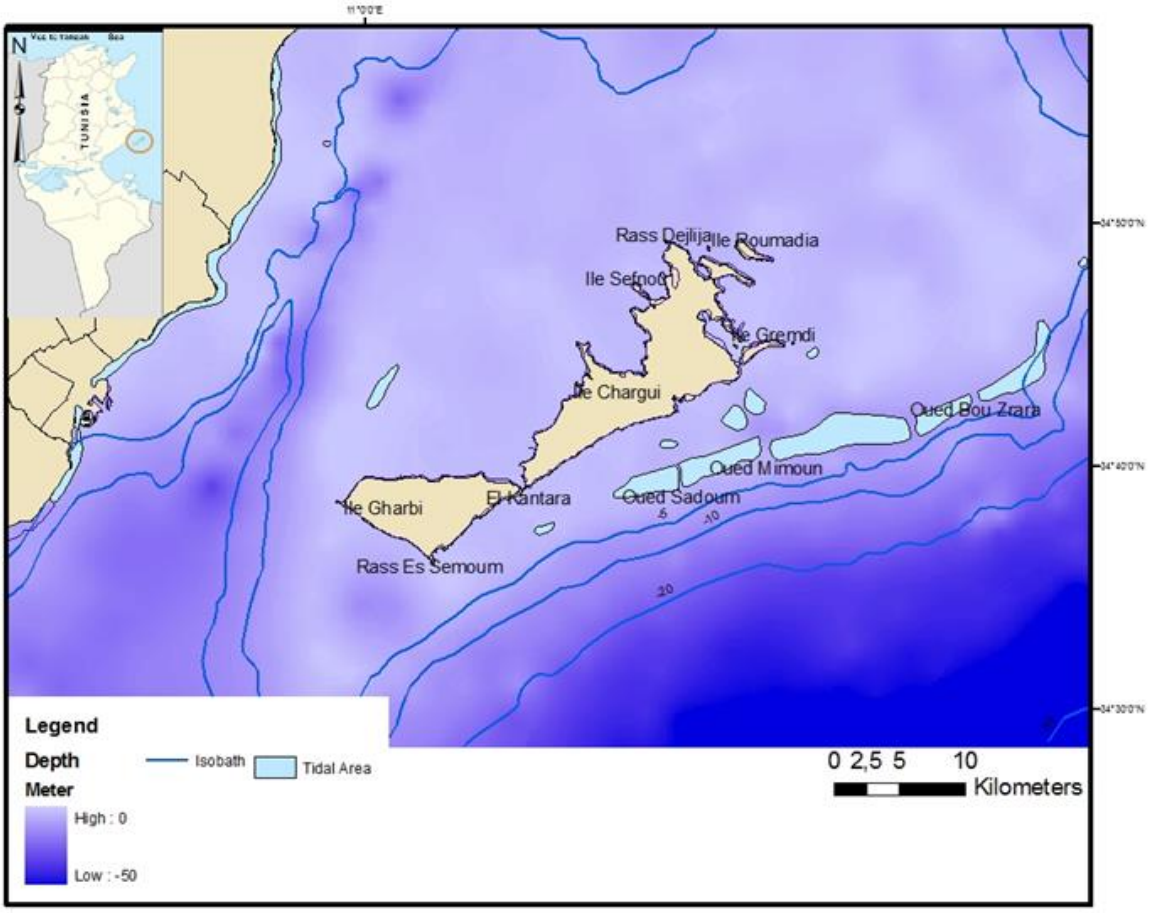

Figure 1. Numerical model of the seabed around Kerkennah islands

The Level 2 (L2) satellite data products, available from http://oceancolor.gsfc.nasa.gov/, contain the geophysical value for each pixel, derived from the Level-1B. Landsat 5 Thematic Mapper imagery was downloaded via GSFC/ NASA were selected images from July 1986, August 1987, June 2003 and July 2009.

Radiometric calibration, geometric correction, atmospheric correction and application of bio-optical algorithms to MODIS L2 data were applied. The Chlorophyll is mapped using OC5, a semi-analytical algorithm of Gohin *et al*. (2002). This algorithm tends to correct overestimation of chlorophyll in turbid waters by using a Look up Table adapted to the French Coastal Northern waters and based on thresholds of Rrs at 555 nm, and at 412 nm (Katlane *et al.*, 2012).

To estimate TU (and TSM) around Kerkennah islands, the bio-optical algorithm (1) of Nechad *et al*. 2009) was applied to MODIS remote sensing reflectance at band 667 nm (Rrs_{667}).

$$TUMODIS\ (NTU) = 50.46 \times (\pi\ Rrs_{667}/(0.1736-\rho))$$

The primary approach to TSM product validation is by "match-up" validation, comparing the data value for a satellite pixel with an in situ measurement from a location within that pixel and acquired almost simultaneously (Katlane *et al*., 2011). In situ data were collected from 5th to 7th July 2009 and on the 6th and 8th of October 2009 around kerkennah and Kneiss islands, concurrently with the satellite overpass. These seaborne measurements consist of TU (NTU), TSM (mg/l) and chlorophyll (µg/l) (in Table 1).

Table 1. In situ concentrations ranges: TU: Turbidity; TSM: Total suspended matter; CHL: Chlorophyll concentration; Minimum and maximum values for the two July and October 2009 cruises

Locations	TU (NTU) min, max	TSM (mg/l) min, max	CHL (µg/l) min, max	Date	Nb of stations
Kneiss	0.2, 5.5	0.7, 6.1	<0.5, 4.7	05-07/07/09 and 09/10/09	18
Sfax-Kerkennah	1, 3.1	1.6, 3.9	<0.5, 1.3	19/10/09	6

The depth assessment has been carried out by an empiric method based on Landsat 5 TM1 channel which has the better water penetration properties (up to 25 m).(Jupp,1988). We focused on summer period and selected images from July 1986, August 1987, June 2003 and July 2009 we applied the same preprocessing (atmospheric corrections, radiometric and geometric). All bands were visualized and analyzed in order to extract relevant information, on the coastline, water land interface, and on the marine environment around the Kerkennah islands. We started processing (Fig.2) by applying a mask on the continent using the near infrared to minimize the effect of the brightness of the continent. The processing used to extract area time evolution. Unsupervised comparison between two different dates acquired by the same sensor has been carried out. Indeed the change attribute is used as the local variation of luminance pixel obtained by subtraction between the bands TM1 images available.

3. RESULTS

3.1. Optical remote sensing of underwater submarine shelf

A regression was found between in situ and satellite measurement (TUMODIS=0.588 x TUin situ - 0.339) illustrates the positive relationship with a fairly good correlation (68.9 %) covering the range [0.5-4 NTU]. Concerning the CHL, the scatter plots between in situ measurement and MODIS CHL derived from OC5 is 68 % (CHLMODIS_OC5 = 1.11 CHLin situ).

Multi-temporal maps of TU and CHL were then produced for 2009 (Fig.3). The highest TU concentrations are located around the islands (Kerkennah and Kneiss).

The MODIS Ocean Color OC5, as shown for the 5th of July image (Fig. 3.b), especially around Kerkennah, Kneiss, where high CHLOC5 values are probably linked to shallow water and bottom reflection. The monthly distribution concentration of chlorophyll for 2009 records its highest value in August, September and October, due to algal blooms during these months (Katlane *et al*., 2012)

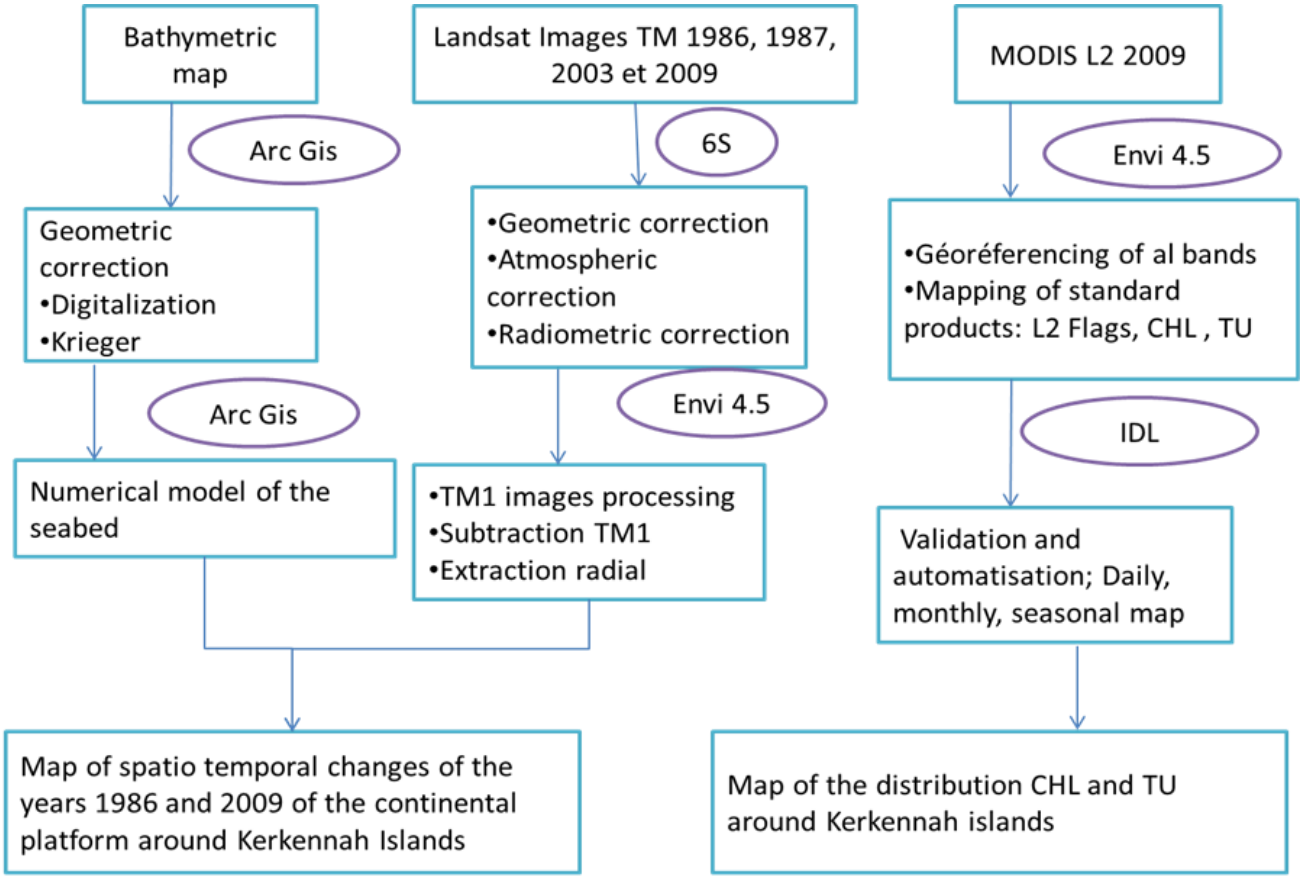

Figure 2. Flowchart of the processing and interpretation approach of MODIS L2 and Landsat data

3.2. The dynamics of underwater submarine shelf

Subtraction values between TM1 bands 1986 and 2009 shows the changes in time and space, of the submarine morphology of the continental shelf around the islands (Fig. 4). This reflectance change is induced by changes in depth especially after the removed components in seawater and the influence of suspended sediment transport and also minimized the effect of the tide as the images used have been downloaded all during the same local time.

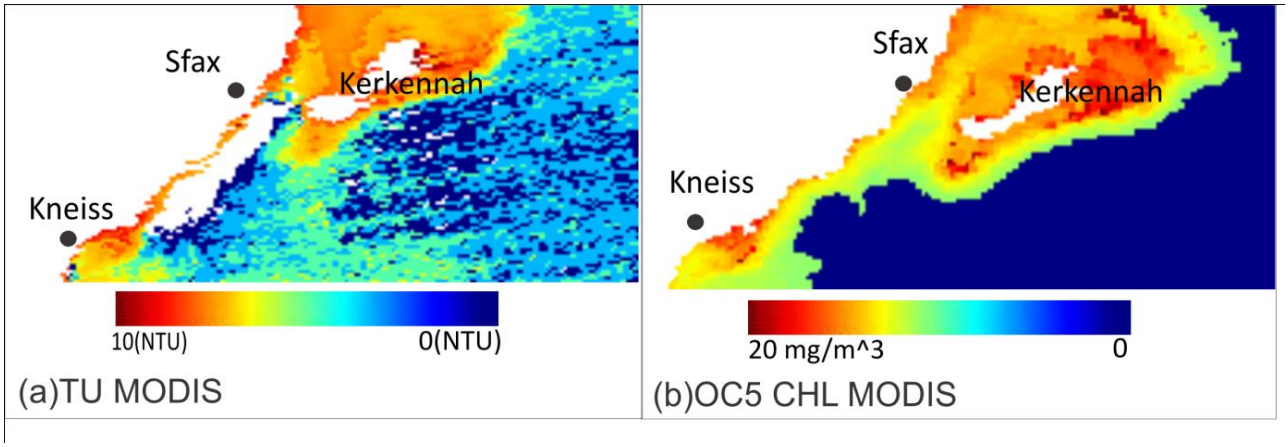

Figure 3. MODIS imagery over the Gulf of Gabes on July 5th 2009 at 13:00 UTC (a) Turbidity TU(NTU), (b) CHL (mg/m3) with OC5

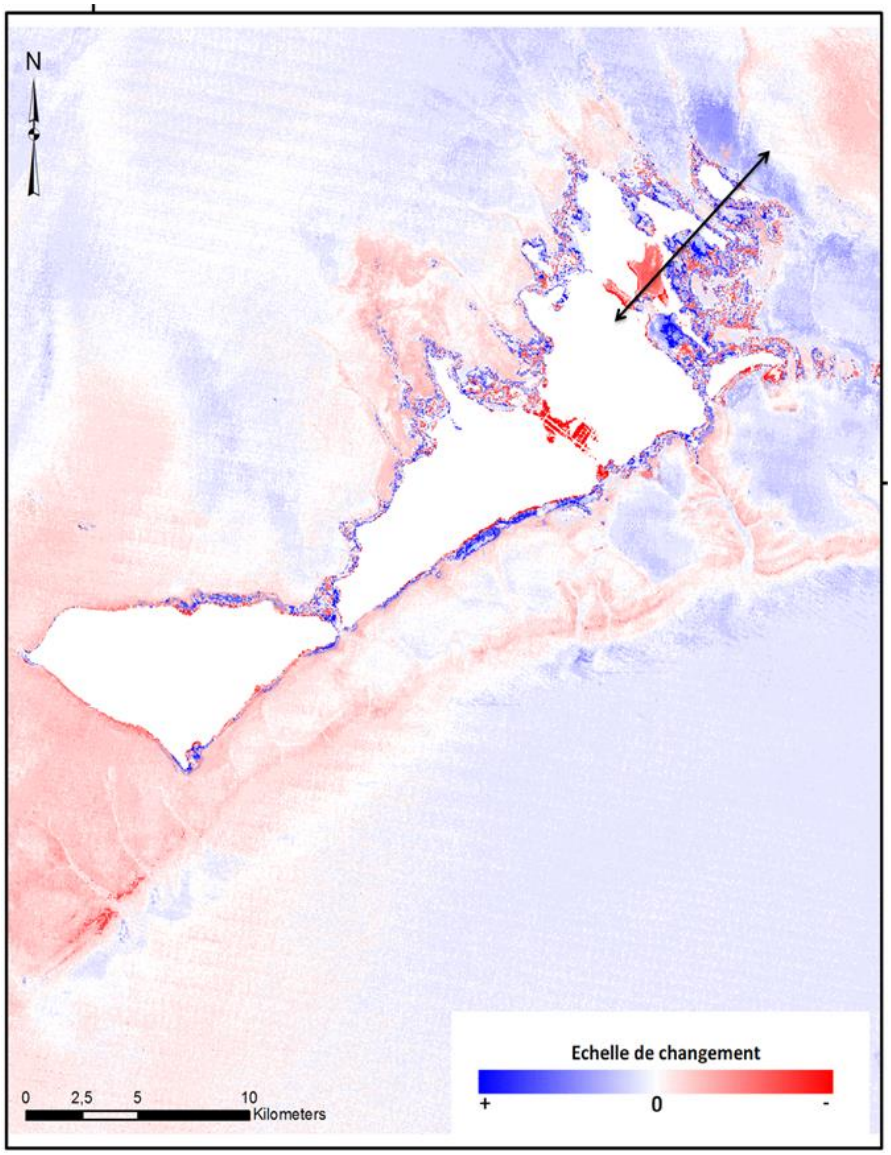

Figure 4. Submarine morphology changes of the continental shelf around the islands: Reflectance difference between 1986 and 2009 (the blue color means a maximum positive change and red means a maximum negative change). The black arrow indicates the position of profile on which the radiance values were extracted for 1986, 2007 and 2009.

A comparison plot radiance values (mW.cm-2.sr-1.µm-1) along a radial with mesh 30 m along an axis 10 km in order to show changes over time between the summer of 1986, 2003 and 2009 (Fig. 5). The first pixel from 0 to 80 for the years 1986 and 2003 shows an occupied land, while in 2009 this same area becomes flooded.

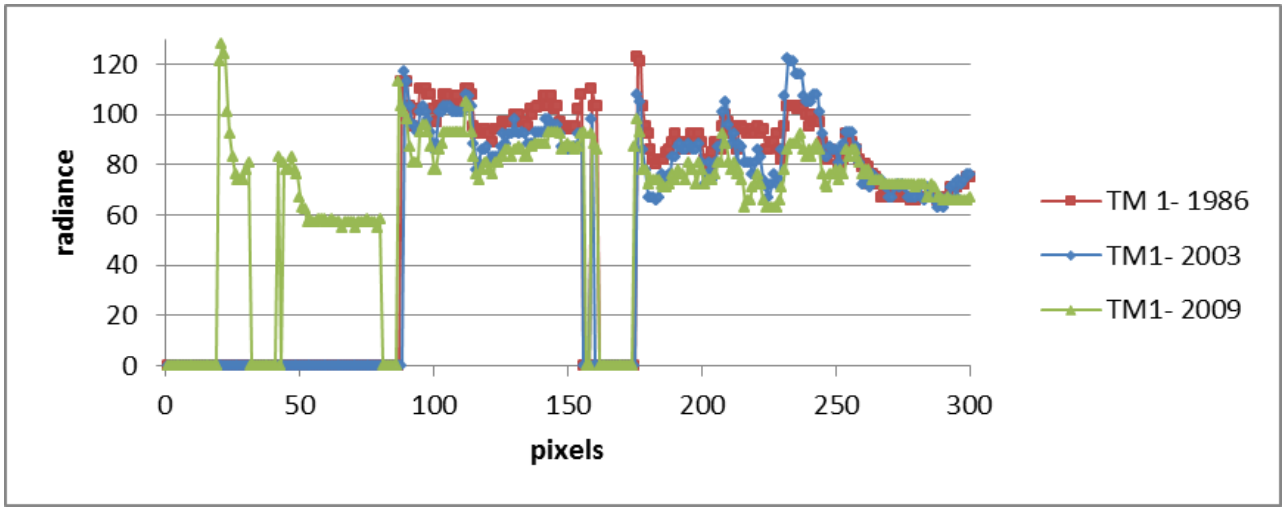

Figure 5: Radial value (mW.cm-2.sr-1.µm-1) along a 10 km profile on the eastern part of Kerkennah for July 1986, August 2003 and August 2009 the position of the radial is in figure 4.

DISCUSSION AND CONCLUSION

MODIS data provides information on the constituent water CHL and TU with a resolution of 1 km and overestimation of data values compared to in situ data for this we used the Landsat 5 data with spatial resolution of 30m to understand the dynamics of the seabed around the islands Kerkennah. Since the overestimation of chlorophyll and turbidity data are linked to the weakness of the water column Thus, this study has allowed us to map and monitor the evolution of the area over time.

This work is indeed a preliminary stage on remote sensing assessment on Kerkennah coastal environment changes. A main difficulty on this topic is the scarcity of surface measurements. This limitation make necessary to rely on sediment transport by numerical modelling.

Another planned development is to resume the processing on full series of Landsat TM imagery. Of course this extension will require enhancing our processing system in order to deal with unequal data quality. The main issue in extending our Landsat TM database will be to relate littoral changes with significant meteorological (tempest, flood). We expect from the results of this program a better support of decision makers in local risk prevention.

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