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ASSESSMENT OF SAND DUNES MOVEMENTS RATE IN ATLANTIC SAHARA DESERT USING MULTI-TEMPORAL LANDSAT IMAGERY AND GIS TECHNIQUE

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ABSTRACT

The main goal of this paper is to determine the movement rate of barchans dunes in Atlantic Sahara desert (SW of Morocco) using remote sensing and Geographic Information System (GIS) techniques. Tow Panchromatic Landsat band (15 m of resolution) covering the study area for one year were be used to get up this subject. Firstly, both bands were being processed in term of geometric and radiometric corrections. The automated extraction of dunes shape using co-occurrence measurement is the second step of this work. After extraction, a classification using Support Vector Machine (SVM) algorithm is the next step. A vectorization of classified dunes is final step which be necessary to export it in GIS platform to assess the movement rate. The results show that the annual movement rate dune varying from 15 m to 90 m according to the dunes size.
Keywords: Movement rate of dunes; Panchromatic Landsat band; classification; automated extraction; GIS.

Introduction

Sand encroachment is one of the most common and serious environmental problems in Atlantic Sahara desert (SW of Morocco) by which all fields, cultivation areas, national road, and cities, are threatened. In this area, the massive aeolian erosion due to the extreme aridity is a major factor responsible for sand dunes dynamics. The mostly dunes forms exist in this area are barchans, are in crescent-shaped propagating under limited supply of sand and in roughly unidirectional winds (Wasson and Hyde, 1983; Cooke et al., 1993) (Figure 1.C). A monthly and annual tracking of the barchans dynamics was necessary to assess its movement rate to fight it. In our study area, the movement rate of barchans was performed at a single-dune scale and was based on coupling of GPS measurements and aerial photos (Elbelrhiti, 2011). The assessment of sand dunes movement rate by manual tracing on digital aerial photos and field investigation is an intensive work. Several recent studies have been shown that the use of remote sensing data is best way to tracking sand dunes dynamics (Vermeesch and Drake, 2008; Hesse, 2009; Necsoiu et al., 2009; Bullard et al., 2011; Mohamed and Verstraeten, 2012).

The present work, we propose a new method based on coupling of multi-temporal remote sensing data and GIS techniques to evaluate movement rate of barchans in Atlantic Sahara desert.

Materials and Methodology

Study area

The study area is a part of central corridor of dunes of Atlantic Sahara desert (SW of Morocco) (Figure 1.A and B). From a climatic point of view, this region is a part of the Boreal domain of

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maritime trade winds, where precipitation is less than potential evapotranspiration (Selouane, 2008). This wind is one of the most regular winds in the world (Elbelrhiti et al., 2005). According to Oulehri (1992) and Selouane (2008), the prevailing wind is mostly from the NNE with a yearly speed ranges from 4.5 to 8 m/s. The surface of this area is dominated by flat layering of hard rocks at the surface (Moghrebian Sandstone-Limestone Slab). This flagstone is overlain by movable sand on barchans form (Figure 1.C).

Data sets

In this study, two free panchromatic bands from Landsat satellite imagery (Operational Land Imager (OLI) sensor) covering the study area were used to assessing the annual movement rate of barchans dunes in this region. Table I lists the source of each image including date of capture and spatial resolution.

Table I: Multi-temporal images used for this study.

Satellite	Date	Band used	Band resolution (m)
Landsat OLI	24.04.2013	Panchromatic	15
Landsat OLI	04.04.2014	Panchromatic	15

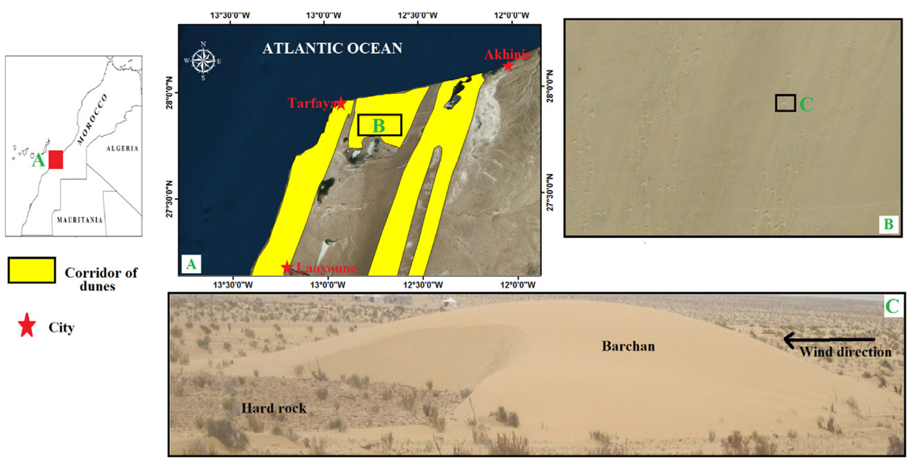

Figure 1. The location map of study area.

Methodology

The practical aspects implemented in this study involve several steps as shown in Figure 2. The methodology will be started by processing of both panchromatic bands in term of geometric and radiometric corrections. For geometric correction, both images were transformed to a common projected coordinate system WGS84 UTM zone 28N. In addition, the radiometric correction procedures account to equalizing the brightness of all bands for that the interactive stretching and histogram matching were applied. The automated extraction of dunes shape using co-occurrence measurement is the second step of this work. The co-occurrence measurement tool product eight bands following three groups: contrast group (contrast, homogeneity and dissimilarity), Orderliness group (angular second moment and entropy) and Statistics group (mean, variance and correlation). In this work, we mask the contrast group bands to extract the dunes form. After extraction, a classification step was necessary for differencing sand dunes from the hard rock that outcrop in surface. This classification was achieved by using Support Vector Machine (SVM) algorithm. A vectorization of classified data is final step which be necessary to export the dunes in GIS platform to assess its movement rate.

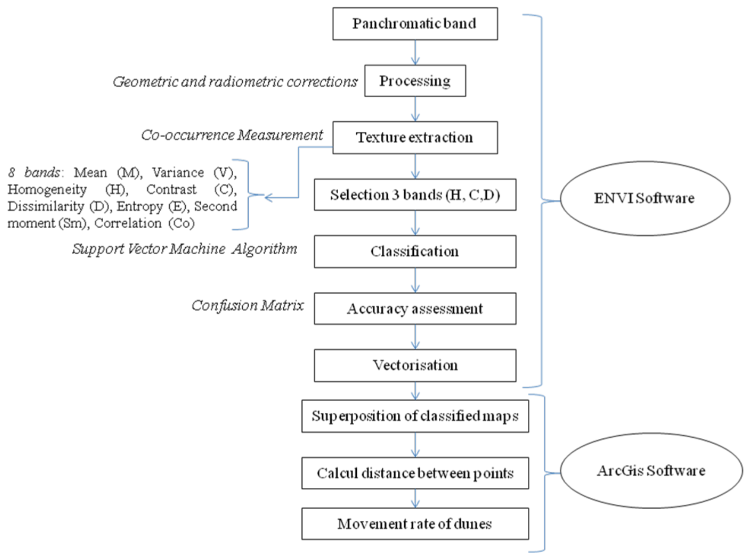

Figure 2. Methodology flow chart.

Results

The accuracy assessment for both dunes maps was made with an error matrix and was undertaken with the representative sites. The global accuracy was computed as well as the user's accuracy and the producer's accuracy for sand dunes and hard rock. The results obtained from the application of confusion matrix to classified data show that both classes are better classified, with high overall prediction accuracy and low rates of both commission and omission errors (Table II). Figure 3 show the superposition of both classified dunes maps.

In this research, the movement rate of selected barchans is between 15 m and 90 m per annum. This parameter is in relationship with the dunes size. Bagnold (1941) confirms that the movement rate of barchans decrease with its size. Figure 4 confirm this relation where the coefficient of determination (R^2) is in order of 0.93. According to Elbelrhiti 2011, the small barchans (1 m of height) are moved by 100 m per annum whereas the big barchans (7 m of height) are displaced by 25 m. The comparison of this research with our results confirm the potentiality of using the remote sensing and GIS techniques in assessment the movement rate of sand dunes.

Table II. Error matrix of SVM classification for both scenes

Date		1	2	User Accuracy (%)	Producer Accuracy (%)	Overall Accuracy (%)	Kappa coefficient (%)
24.04.2013	1.Sand dunes	85.8	3.7	84.62	85.83	94.29	0.82
	2. Hard rock	14.2	96.3	96.62	96.3		
04.04.2014	1.Sand dunes	87.9	2.39	89.71	87.93	95.75	0.86
	2. Hard rock	12.1	97.6	97.15	97.61		

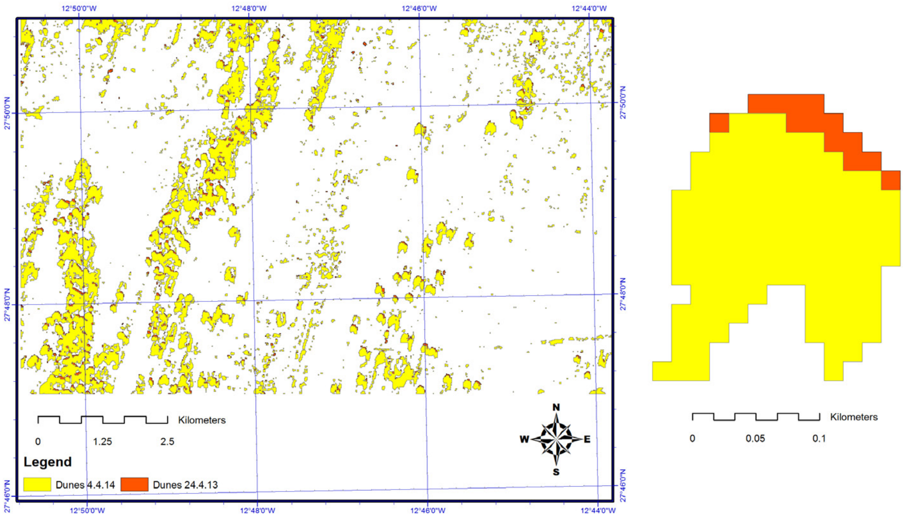

Figure 3. Superposition of two classified dunes maps.

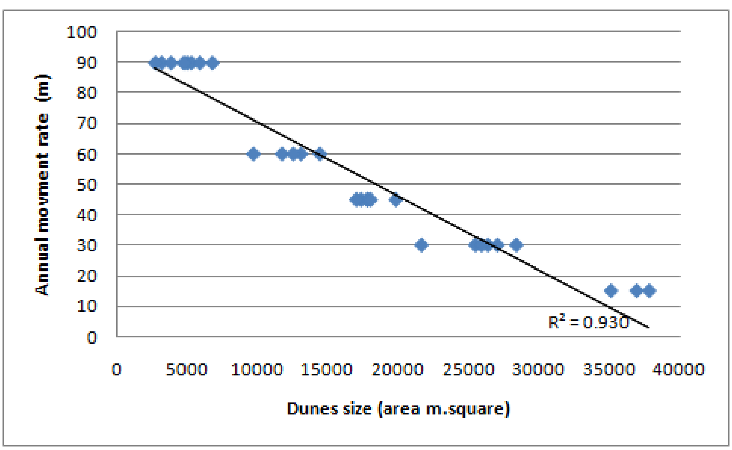

Figure 4. Reltion between barchans size and its movement rate.

Conclusion

The assessment of barchans movement rate in Atlantic Sahara desert is the subject of this research. This work present a new method based on using remote sensing and GIS techniques. The results of this study confirm the importance of using this new method in assessment of sand dunes movement rate.

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