MULTI TEMPORAL AND MULTI SPECTRAL IMAGES BASED CHANGE DETECTION OF MINE WASTES IN NORTHERN TUNISIA

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ABSTRACT

Abandoned mines cause critical problems which are among the most challenging environmental ones. This is the case in Tunisia, were effects of mining activity are well illustrated particularly in Mejerda and Mellag river watersheds. Mapping is the first step for the inventory, characterization and survey of mine wastes elsewhere. Particularly, detecting changes in images of the same scene taken at different time series is of special interest in this application domain. In this context, we applied a based MAD (Multivariate Alteration Detection) transformation method for multi temporal classification and change detection of mine wastes. For these purposes we used Landsat ETM+ time-series data.

***Index Terms*—** Mine wastes, Landsat ETM+ data, change detection, MAD.

1. INTRODUCTION

Abandoned mines cause critical problems which are among the most challenging environmental ones. The effects of mining activity in the north of Tunisia are well illustrated in Mejerda and Mellag river watersheds, where soils vegetation and water resources are threatened by wastes [1]; [2]. Monitoring the environmental risks associated with mine wastes in a quick and timely fashion is the First step towards mitigating their impact. Remote sensing techniques have been proven extremely valuable in the inventory, characterization, and remediation of mine wastes elsewhere [3]; [4]. Particularly, detecting changes in images [5] of the same scene taken at different time instants is of special interest in this application domain. In the literature, two main approaches are followed to the change detection problem: post-classification comparison and multi temporal classification. In the first case, two dates of images are independently classified and registered, and an algorithm is used to identify those pixels that change between dates. In the second case, a single classification is performed on the combined image dataset for the two dates. The post-classification approach can fail as relies on the accuracy of each classifier, while the multi temporal approach could produce best results. Many methods [6] have been proposed in the remote sensing literature to analyze changes in images, such as multi-date principal component analysis, temporal image differencing or rationing etc.

In this context, we applied a based MAD (Multivariate Alteration Detection) transformation method for multi temporal classification and change detection of mine wastes. We are particularly interest in the case study of zinc and lead mines in the north of Tunisia (North Africa). Particularly, the mine of Jebel (Hill) Hallouf-Bouaouane, which is forsaken since 1986, which is forsaken since 1987, is among several types of mines in the Mejerda river watersheds [1]. In this site, mine wastes present an alarming source of pollution that causes the environment degradation, so it had polluted soils, vegetation and water quality. The Landsat ETM+ used data are well available from much passed years at regular intervals.

2. METHODOLOGY

The methodology proposed in this study was applied using multi temporal multispectral data. Particularly, we have used both Landsat ETM+ data acquired on May 01, 2005 and January 27, 2015. The image sets were registered to one another using first-order polynomial, nearest-neighbor resampling. The RMS errors were less than 0.5 pixels. The radiometrically and atmospherically correction was performed using the "Fast Line-of-sight Atmospheric Analysis of Spectral Hypercubes" FLAASH model to estimate the spectral reflectance surface. An overview of this methodology is presented in [7]. In addition, the six bands of the Landsat ETM+ images were sharpened to the 2.5m resolution of the panchromatic SPOT 5 band with a PC fusion technique. The Landsat ETM+ images thus consisted of six spectral bands each with 15m spatial resolution.

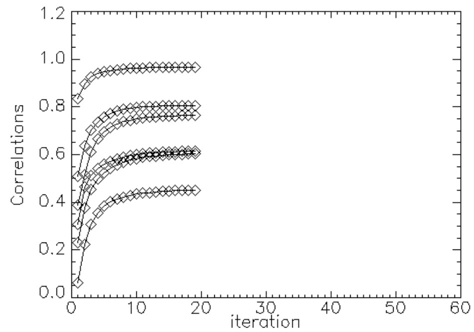

Fig.1 Canonical correlation for the Landsat ETM+ images with simulated no-change pixels.

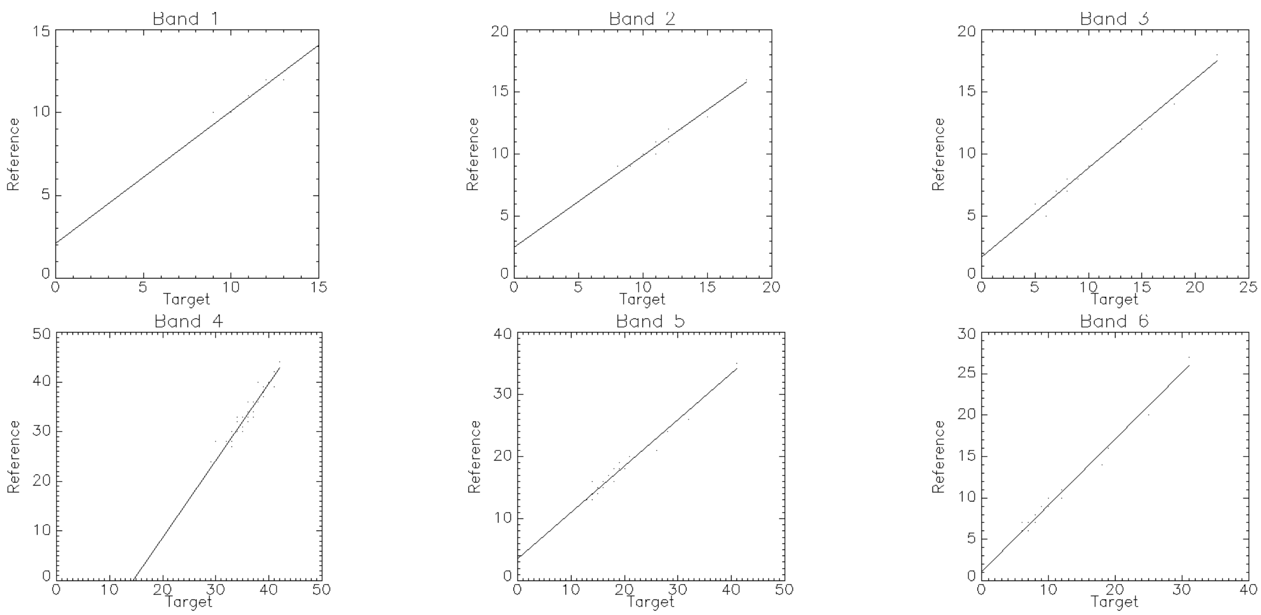

Fig.2 IR-MAD normalization: Orthogonal regressions on spectral bands 1 to 6 for a 10% simulated no-change fraction in the Landsat ETM+ multi temporal image. Only pixels identified as unchanged are plotted.

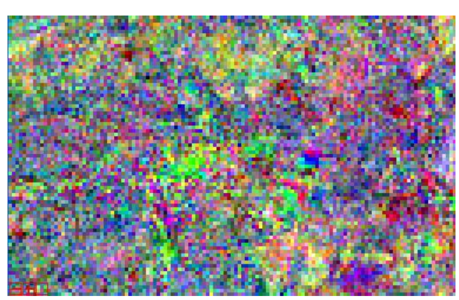

Fig.3 Color compositions of MAD components

All image processing was performed within the ENVI remote sensing image analysis environment (ITT Visual Information Solutions). Extensions to ENVI for image registration, PC fusion, the IR-MAD transformation and radiometric normalization were written in the IDL language [8]. Radiometric normalization [6] was after that processed and programmed in IDL language. The Landsat ETM+ image acquired on 2005 has been used as reference image. With the aim of carrying out a radiometric normalization the pixels that satisfy Pr □No-change□ ≥ t are chosen, where *t* is a decision threshold, usually 95%. The steps involved in the radiometric normalization are the following: [8]

- Choose the values of weights equal to one for every pixel in the multi temporal scene.
- Repeat until the canonical correlations stop changing significantly:
    - Carry out a weighted sample of the multi temporal image so as to determine its mean vector and the covariance matrix.
    - Run canonical correlation CCA and build the MAD components *Mi, i=1,...,N.*
    - Recalculate the weights according to [8].

The IR-MAD method is applied to Landsat ETM+ images. The development of iterations of the canonical correlation (Figure 1) shows that the first iterations are the more important ones. In order to evaluate the process of normalization the program saves one in every three pixels of NO-change to carry out a reliability test. The mean and the variance are calculated before and after the normalization as well as the statistical hypothesis test of invariant pixels in both images.

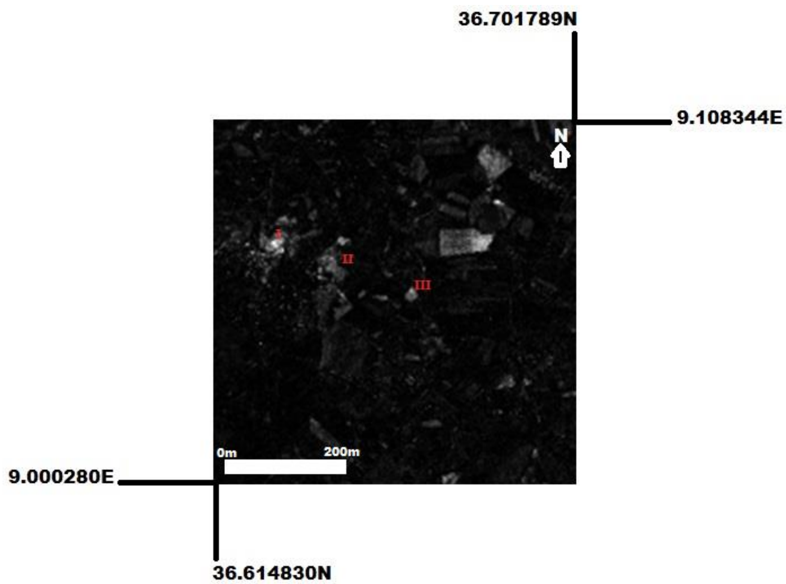

Fig. 4 Intensity of change calculated after a chi-square test of 6 bandes.I and II indicate the localization of dykes. III locates wastes near Oued Kasseb.

3. RESULTS AND DISCUSSION

As shown in the table 1, the radiometric normalization can be accepted. Figure 2 shows typical regression lines. It is evident that invariant pixels are discriminated after application of the IR-MAD transformation. The results of MAD transformation generate three components (Figure 3). Maximal change areas show white pixels (positive change) and black pixels (negative change). Through a color combination of the three MAD components a new image (Figure 3) is obtained where change is shown in magenta color. A change image can be finally set up after a Chi-two test on six bands (Figure 4).

The change in intensity shows the differences between the reference image 2005and the target image 2015. Indeed, the color white represents the invariant pixels (no change) located especially at the dyke of the Jebel Hallouf. However, changed pixels are detected at Bouaouane dyke and in the immediate surroundings (grayscale pixels). The eroded and disposed wastes near Wadi Kasseb are marked by change intensity. The effects of water and wind erosion are almost shown in this part. Soils, agricultural areas and olive groves near Mining District, show the most changed classes. This is explained by the seasonal change between image acquisition dates, the winter season (January 27, 2015) and the spring season (Mai 05, 2005), suitable for vegetation development. It can be seen that a large amount of waste was changed in the ten years between 2005 and 2015.

4. CONCLUSION AND PERSPECTIVES

This study presents a considerable contribution in the identification of changed wastes during these ten years. Particularly, it shows the contribution of the IR-MAD based method for multi temporal change detection of wastes in the semi-arid context. Landsat ETM+ time-series data were used in this method. In the future, we propose the using of hyperspectral data for improving characterization and change detection of mine wastes.

5. REFERENCES

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