Land-use in semi-arid areas derived from NDVI images at high and low spatial resolutions

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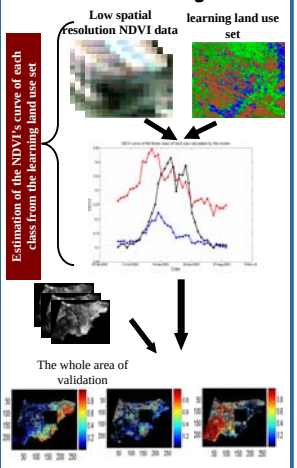
Introduction

Satellite imagery provides exhaustive information which can be used to drive crop growth and evapotranspiration models at regional scale by means of vegetation indices such as the Normalized Difference Vegetation Index (NDVI). For detecting crop phenological changes, we need a high temporal repetitivity of optical observations. The high spatial resolution sensors, such as SPOT-HRV or Landsat-TM (10 to 30 m), acquire images on a monthly basis. This low temporal resolution and the high cost of these images lead us to work with data provided by coarse spatial resolution sensors which provide users with a costless daily global coverage of the earth. We use here the SPOT-VEGETATION and TERRA-MODIS images, with pixels covering areas of 1km by 1km, 500m by 500m and of 250m by 250m, respectively. Each low resolution pixel (mixed pixel) can represent a multiple land cover, i.e. its spectral response is composed of the proportions of land surface of the different themes.

Objective

The purpose is to characterize the land use of the semi-arid region of Tensift Al Haouz (Marrakech, center of Morocco) as part of the SudMed project. We have used a series of high spatial resolution NDVI images (Landsat data and SPOT /HRV) to establish land occupation map. We used the linear unmixing model. The first step is to approximate the characteristic NDVI's curves of each class from a learning land use set, then we estimate the proportion of land use in the whole area. We have tested the linear unmixing model on two kind of data; 1) simulated low resolution data, derived from high spatial resolution images; 2) VEGETATION and MODIS images. The first type of data permits us to do an analysis of the effect of the superpositioning of images, (e.g geometric and radiometric problems), as well as to characterize the complexity of the disaggregation problem. The second provides us with the possibility of testing the method using in-situ data for validation.

The linear unmixing model



Maps of proportion of each class results of the linear model

Presentation of the site and data

1.Site

The studied area is the whole plain of Al Haouz whose area is about 1800 km². It is located in Morocco and it is a pilot site of the SUDMED project.

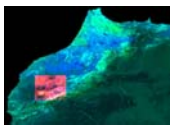


Image of Morocco derived from SPOT VEGETATION sensor. Red image represent the area of interest

2.Data

Coarse spatial resolution data

We have collected low and medium spatial satellite data during year 2002-2003 given by two sensor (Végétation (1km) and Terra-modis (500m and 250m)). These sensors provide us with a high temporal frequency.

Sensor	Products	Spatial resolution (m)	Temporal frequency (day)	Date of first image	Date of last image	Nomber of images
VEGETATION	NDVI	1000	10	01-sept-02	21-août-03	36
TERRA-MODIS	NDVI	500	16	29-août-02	13-sept-03	24
TERRA-MODIS	NDVI	250	16	29-août-02	13-sept-03	24

High spatial resolution data

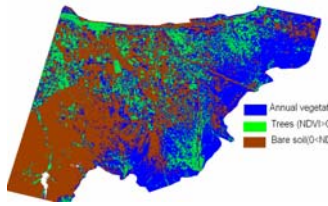
10 high spatial resolution images from Landsat ETM7 and SPOT4/5 are used to perform the land use map and to simulate low resolution data.

Sensor	Landsat TM7	Landsat TM7	Landsat TM7	Landsat TM7	SPOT4	SPOT4	SPOT4	Landsat TM7	SPOT5	SPOT5
Date	07/11/02	25/12/02	26/01/03	11/02/03	04/03/03	25/03/03	26/04/03	18/05/03	26/05/03	20/06/03

3. Land use map :

The land use map was computed using the high resolution data (Landsat ETM7 and SPOT4/5) We have three class :

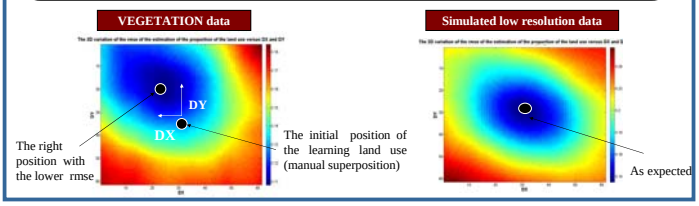
- Bare soil → 0<NDVI<0.3
- Trees → 0.3<NDVI
- Annual vegetation (mainly wheat) → other pixels



Land use map of Tensift plaine of Morocco 2002-2003 (spatial resolution 30m)

Superposition of land use map and reel data VEGETATION and MODIS

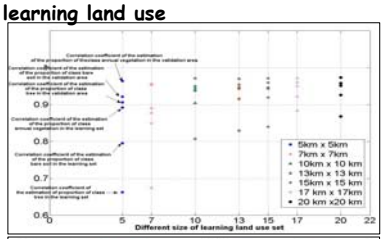
When we use the Vegetation and Modis data we have to deal with the geometric problem such as superpositioning of images. First we manually do a coarse superposition, then the idea is to move the learning land use set with a step equal to pixel by pixel (DX and DY) all over an area that surround it. For each land use set we applied the linear unmixing model and calculated the rmse of the estimation of the different proportions of the land use. The lower rmse the best superpositionning of images is.



Choice of the representative set of learning land use

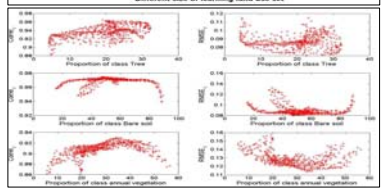
Spatial size .. ?

We have tested different size of learning land use set from 5km by 5km to 20 km by 20km in order to have the lower spatial size with a high and better correlation between the proportion of classes estimated and those observed. We noticed that correlation increases whith the spatial size.



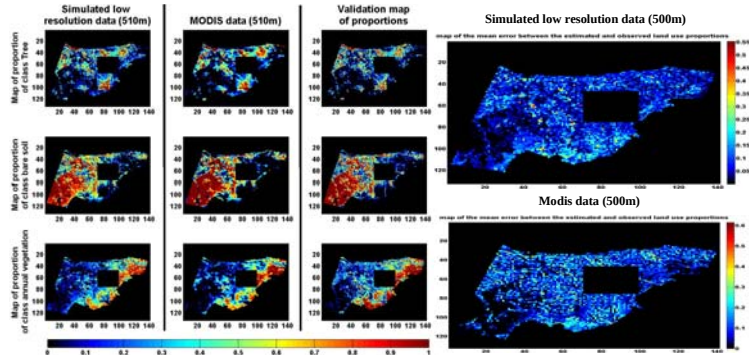
Proportion of class .. ?

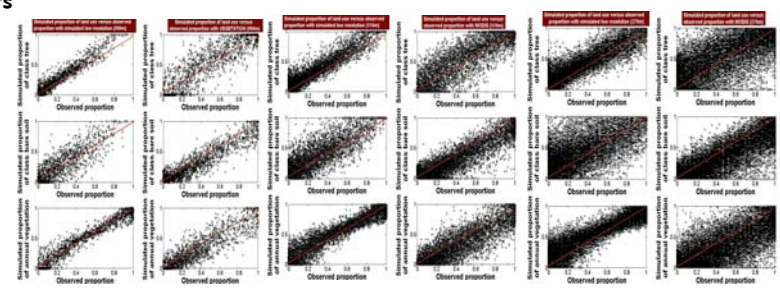
We applied the linear unmixing model on different learning land use set with different proportion of land use. We plot the rmse and the correlation versus the proportion of each class. we conclude that good results (lower rmse) dont depend on the proportions of each class in the learning land use set.



Results

We tested the model with 2 kinds of data ;1) simulated low resolution Data;2)VEGETATION data (1km) and MODIS data (500m and 250m) . The learning land use map is fixed. It is the same for all simulations and its size is 15km by 15km. Results and figures are presented below.





	Simulated data (1Km)	VEGETATION (1Km)	Simulated data (500m)	MODIS (500m)	Simulated data (250m)	MODIS (250m)
mean of the Rmse	0.095	0.137	0.115	0.149	0.138	0.189
mean of the Correlation R	0.953	0.901	0.941	0.905	0.928	0.865

Conclusion

In general, we obtained correct results in terms of correlation between the proportions of land use estimated by the model and those observed for all kind of data with less good correlation for the MODIS 250m data (0.86). We noticed also that the quality of results decrease with the spatial resolution data.