MAPPING CULTIVATED AREA IN WEST AFRICA USING MODIS IMAGERY AND AGROECOLOGICAL STRATIFICATION

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ABSTRACT

The northern fringe of sub-Saharan Africa is a region that is considered particularly vulnerable to climate variability and change, and food security remained there a major challenge. To address this issue, major international research efforts are being deployed, coordinated by the ongoing project AMMA (African Monsoon Multidisciplinary Analyses). Its aim is to better understand the West African Monsoon and its variability, and to improve the predictions of the impacts of this variability on West African societies. One of the preliminary stages necessary for analysing such impacts on agriculture and food security is a reliable estimation of the cultivated domain at national level, a scale compatible with climate change studies.

The opportunity of using satellite remote sensing for agricultural statistics has been explored by the research community as well as by national departments of agriculture during the last few decades [1]. In Africa, existing global land cover maps have arisen from different initiatives such as the GLC2000 [2] or the POSTEL global land cover maps [3] but generally they are more focused on ecosystems than on agricultural systems. In the Sub-Saharan Africa countries, operational land cover mapping systems are restricted by the cost of high resolution images. Yet, the monitoring of vast ecosystems at national or continental scales typically resorts to low-resolution free images [e.g. 4; 5], but the pixel size of these images is generally too coarse for the identification of fields, especially in fragmented landscapes. Nevertheless, recent moderate-resolution sensors, such as MODIS/TERRA, with spatial resolutions as low as 250 m, offers new possibilities in the study of agricultural lands. With this increase in spatial resolution, the detection of groups of fields can now be considered. The low and medium spatial resolutions do not, by themselves, provide a completely satisfactory representation of the landscape but are compensated for by a large coverage area and by an excellent temporal resolution. This brings us to the question whether moderate-resolution satellite data, in combination with external data (thematic maps, statistics, etc.) can provide a correct assessment of the distribution of the cultivated domain at country level.

In this study, we develop a methodology for extracting cultivated areas based on their temporal behaviour as captured in time-series of moderate resolution remote sensing images. We tested this methodology in Senegal and Mali at national scale.

- First, 46 MODIS 16-days composite NDVI images (MOD13Q1/V04 product, 250 m spatial resolution) were acquired for 2004 and 2005 and NDVI time series were generated. These products include a NDVI quality band (QB). Although MODIS images have already been radiometrically corrected, we noticed some radiometric defects and noises. For dates with a Vegetation Indices Usefulness Index value in the QB data set lower than “good” quality, NDVI values were replaced by linearly interpolated values from the two closest surrounding dates with “good”, “high”, or “perfect” quality. The required set of tools was developed with IDL

(Interactive Data Language) programming language. This interpolation considerably improved the NDVI temporal profiles, eliminating abnormal drops and smoothing the profiles.
- Then, the study area was stratified in homogeneous areas from an ecological and a remote sensing point of view, to reduce the land surface reflectance variability in the dataset in order to improve the classification efficiency [6]. This stratification (16 agro-ecological zones for Senegal) was generated using an iterative process. First, we used various thematic maps (soil, vegetation, climatology, etc.) to perform an initial delimitation based on different criteria (relief, geology and soil, vegetation, rainfall and growing season duration, ethnic groups and population density, agricultural and animal production). This delimitation was then refined with the help of NDVI temporal profiles obtained from MODIS images and high-resolution Landsat ETM+ images.
- Finally, a spatiotemporal (K-means) classification was made on the MODIS NDVI time series, inside each of the agro-ecological regions. Only three classes were used: "crops", "crops mixed in the natural vegetation" and "other". We considered as "crops" all the classes constituted by more than 80 % of crops.

The cultivated area estimates obtained at the national scale for the Senegal were then compared 1. with official statistics per administrative units and 2. with the USAID vegetation map [7] and POSTEL [3] global land cover map. In the first case, considering national statistics of annual crops in the 14 administrative regions of the Senegal, we reached an accuracy of 82%. In the second case, we obtained an updated map of crop area with a better resolution than the USAID map (which is 1 km resolution) and with a nomenclature more specific of the Senegal region than suggested in the POSTEL map.
We showed through this study, that a comprehensive stratification of the area is a decisive step in the classification procedure, leading to a map of the cultivated areas at a national scale. Results on Mali are currently being processed and will be presented in the paper and at the conference.

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