MONITORING SUGARCANE CROPS IN THE CAUCA RIVER VALLEY (COLOMBIA), USING MODIS SATELLITE IMAGES

By

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Abstract

MODIS product MOD13Q1 was used to monitor the sugarcane crop, using an enhanced vegetation index in the Cauca River Valley for a time series from 2000–2006. The product consists of images taken every 16 days (pixel size of 250X250 m), which makes it possible to work with fields larger than 6.25 ha. A methodology was developed for downloading, cutting, filtering and laying out the time series of the vegetation indices on Internet for the entire area planted with sugarcane. The relation between the time series and the information on crop establishment and harvesting of the fields indicated that the satellite data were consistent with the phenology of the sugarcane crop. Similarly, there was a high correlation between the cumulative vegetation index and cane production. Low index values were associated with low values of tonnes of cane per hectare; whereas high index values meant high production values.

Introduction

A practical and unique way of monitoring large extensions of agricultural zones is by means of remote perception. Studies done on different crops show that the MODIS (MODerate Resolution Imaging Spectroradiometer) 250-m data are correlated with productivity (Doraiswamy *et al.*, 2005;

Bastidas-Obando and Carbonell, 2006; Colditz *et al.*, 2006: Wardlow *et al.* 2007). The purpose of this work was to evaluate the consistency of the MOD13Q1 product and generate a model for forecasting productivity in terms of tonnes of cane per hectare (TCH) for the sugarcane crop in the Cauca River Valley (CRV).

Methodology

Study area

The study area, which covers 212 000 ha, is located in the CRV of Colombia, between 3° and 5° latitude N and 76°22’ and 75°31’ longitude W.

Processing the MOD13Q1 product

For monitoring the cane crop in the CRV, the product ‘MODIS/TERRA VEGETATION INDICES 16-DAY L3 Global 250 m SIN GRID V004’ was used. The images were cut in the study area and projected to a Transverse Mercator using the MODIS Reprojection Tools.

The time series from February 2000 to December 2006 (360 × 931 pixels) was generated using the enhanced vegetation index (EVI). The EVI time series was interpolated from QA-SDS quality data, followed by the Savitzky-Golay smoothing filter method (Chen *et al*., 2004).

Statistical analyses

For the analyses, a total of 6857 pixels were selected, corresponding to an area of 43 481 ha. A regression analysis was conducted to relate the information from MODIS with the production

data, for which the area under the curve of each crop cycle was accumulated and compared with its respective TCH.

MapServer

A Web application was developed to compare the time series with the full information from the commercial database. This application is available for the entire area planted with sugarcane in the CRV and is updated every 16 days.

Results and discussion

Figure 1 shows how using the QA-SDS quality parameters and the Savitzky-Golay filter method made it possible to obtain high-quality time series information (Chen *et al*., 2004).

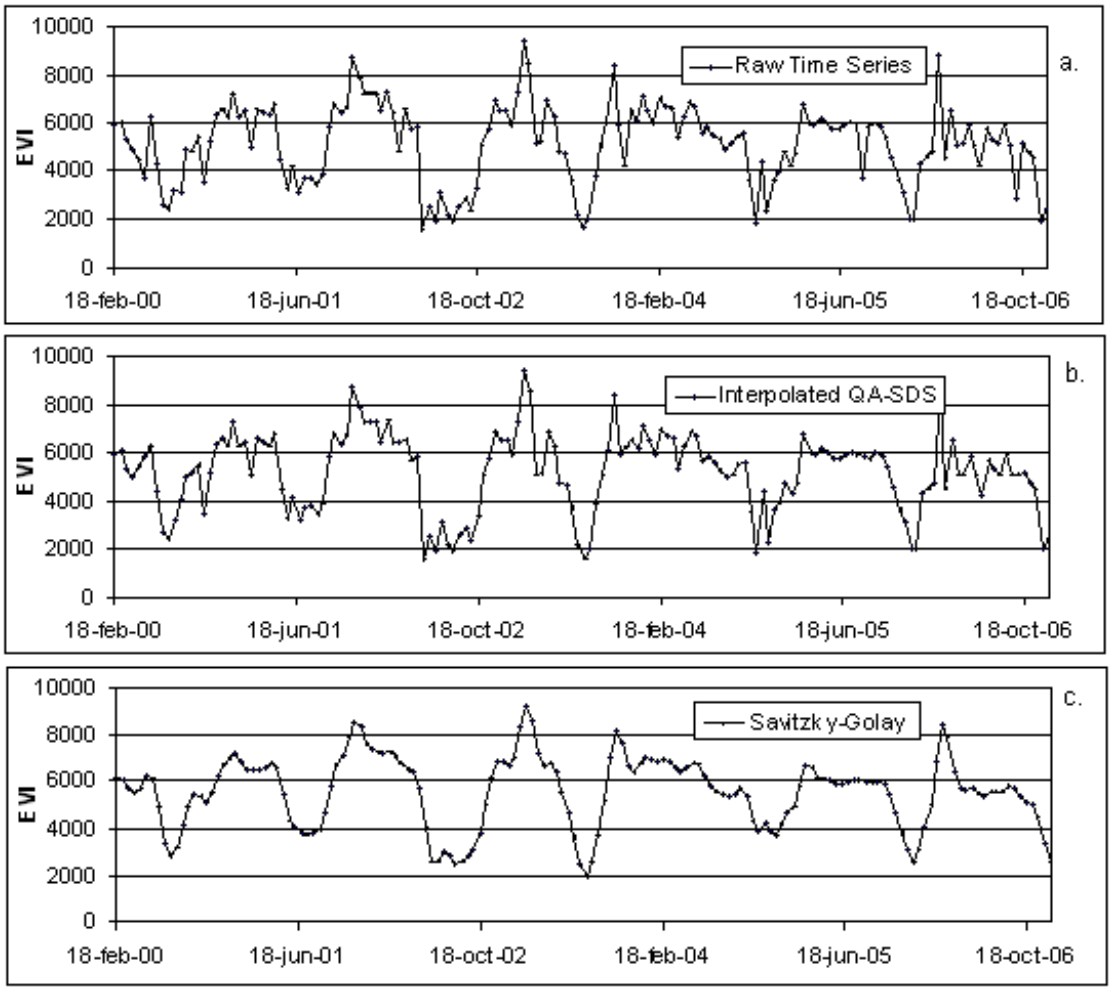

Fig. 1—Processing of time series pertaining to the INCAUCA Sugar Mill, Hacienda Cachimbalito North, Lot 15: (a) original time series; (b) interpolation according to the QA-SDS quality data; and (c) application of the Savitzky-Golay filter (high-quality series) (Chen *et al*., 2004).

A total of 48 cumulative EVI ranges were determined, and the existing TCH data for each range were averaged. These data were used in a regression analysis, weighted for the number of data for each interval, as follows:

$e = 0.0005\ x + 53.139$ (where: e = TCH; x = Cumulative EVI)

with a regression coefficient of determination r^2=0.83, which is a high value given that the ranges cover the entire variation due to variety, agro-ecological zones, agronomic practices and age at cut.

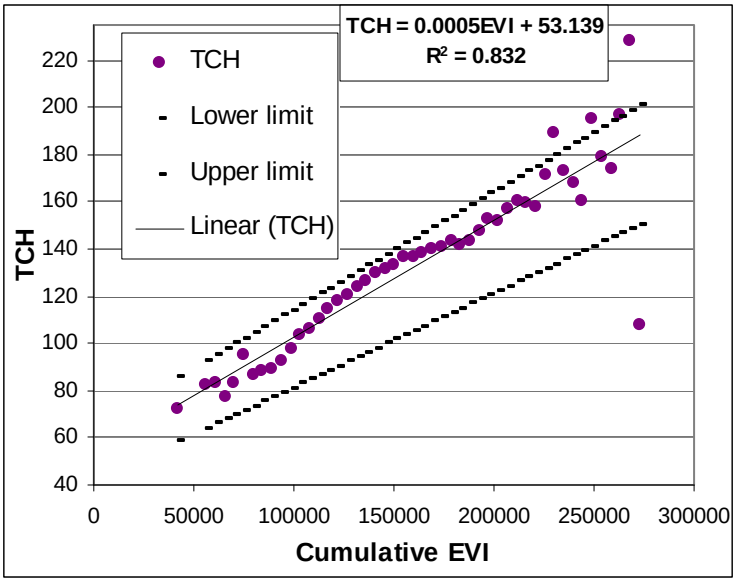

Fig. 2—Model for forecasting cane productivity.

With the recorded data, cumulative EVI ranges were formed with respect to what one lot of sugarcane should have at a given crop age (in months) in order to reach a TCH value with a 95% confidence level (Table 1). This makes it possible to evaluate whether there is an anomaly in the development of the crop, thereby facilitating an early warning about its current condition.

Table 1—Monthly cumulative EVI values and their relation to final production.

	Crop age (months)				
	3	4	5	6	7
No. of observations	2019	2196	2396	2380	2391
SD TCH	25.43	26.31	25.12	24.66	23.95
Average TCH	125.23	121.69	124.29	125.44	126.72
TCH limit (Low–High)	124.12–126.33	120.58–122.78	123.28–125.29	124.45–126.43	125.76–127.68
Cumulative EVI range	27 662–28 460	37 132–38 161	50 743–51 958	63 292–64 678	76 240–77 773
Error (95% confidence level)	1.1	1	1	0.99	0.96

Conclusions

The use of the quality data and the application of the Savitzky-Golay filter (Chen *et al.*, 2004) improve the original MOD13Q1 time series. The information is consistent with the development of the cane crop and its productivity. Discounting the intercept, the model TCH = *0.0005 EVI + 53.139* revealed that, for every 10 000 cumulative EVI units, there is an increase of 5 TCH.

The effect of agronomic practices such as the application of fertilisers, herbicides, maturants and irrigation on the crop's spectral response needs to be evaluated. Similarly, there is a need to identify patterns or cumulative values early enough in order to develop an expert system based on the MODIS data.

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UTILISATION DES IMAGES SATELITE MODIS POUR LE SUIVI DE LA PRODUCTION DE CANNE DANS LA VALLEE DE LA RIVIERE CAUCA (COLOMBIE)

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MOTS-CLES: Canne à Sucre, Prévision du Rendement, MODIS, Indice de Végétation Amélioré, Série Temporelle.

Résumé

LE PRODUIT MOD13Q1 de MODIS a été utilisé pour suivre la production de la canne à sucre avec un indice de végétation amélioré dans la vallée de la rivière Cauca pour la série temporelle 2000-2006. Le produit comprend des images (taille de pixel 250 × 250m) pris chaque 16 jours, ce qui permet de travailler avec des champs d'une superficie supérieure à 6.25 ha. Une méthodologie pour télécharger, couper, filtrer et étendre la série temporelle des indices de végétation sur Internet a été développée pour toute la zone plantée de canne à sucre. La relation entre la série temporelle et les informations sur l'établissement de la culture et la récolte des champs a indiqué que les données satellite étaient consistantes avec la phénologie de culture de canne à sucre. Il y avait aussi une forte corrélation entre l'indice cumulatif de végétation et la production de canne. Des faibles valeurs d'indices étaient associées avec des faibles tonnages de canne à l'hectare alors que des valeurs fortes indiquaient des fortes productions.

MONITOREO DEL CULTIVO DE LA CAÑA DE AZUCAR EN EL VALLE DEL CAUCA (COLOMBIA) USANDO IMAGENES SATELITALES MODIS

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PALABRAS CLAVE: Caña de Azúcar, Predicción del Rendimiento, MODIS, Índice de Vagetación Mejorado, Series de Tiempo.

Resumen

EL PRODUCTO MOD13Q1 de MODIS, fue usado para realizar un seguimiento del cultivo de la caña de azúcar en el valle del río Cauca para la serie de tiempo comprendida entre 2000 y 2006 usando un índice de vegetación. El producto consta de imágenes compuestas cada 16 días con un tamaño de píxel de 250 × 250 m, lo que permite trabajar con campos mayores a 6.25 ha. Fue desarrollada una metodología para la descarga, corte, filtrado y disposición de las series de tiempo de los índices de vegetación en Internet para toda el área sembrada con caña de azúcar. La relación entre las series de tiempo con la información de establecimiento y cosecha de los campos indica que los datos satelitales son consistentes con la fenología o desarrollo vegetal del cultivo de la caña de azúcar. A su vez se evidencia una alta correlación entre el índice de vegetación acumulado y la producción de caña. Valores bajos de índice están asociados con bajos tonelajes de caña por hectárea (TCH), y por el contrario, altos valores del índice significan altos valores de TCH.