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Drought monitoring in Spain during the period 1987-2001, using NOAA-AVHRR images

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ABSTRACT: Droughts are a very recurrent phenomenon in Spain which cause severe damage in the agriculture greatly reducing the production of cereal crops and natural pastures The aim of the present work is to carry out a comparative study on the way droughts have affected Spain during the period extending from 1987 to 2001, as deduced by the analysis of images registered by the AVHRR sensor in the NOAA satellite series. The results obtained have been able to evaluate in an objective way the impact caused by drought in different Spanish regions during the period 1987-2001, revealing how useful spatial Remote-Sensing can be in these kinds of applications. Taking into account the long period of time comprising the study, the results obtained can be considered quite strong.

1 INTRODUCTION

Droughts are a very recurrent phenomenon in Spain which cause severe damage in agriculture greatly reducing the production of cereal crops and natural pastures. With respect to the environment, its consequences are also very significant and highly serious: the presence of droughts has been proved to increase dramatically the number of forest fires as well as the surface affected by them.

Droughts are a very complex natural phenomenon for which there is not a universally accepted definition. There are many different definitions, but in general terms, a drought is considered to exist when the rainfall in a determined period of time is inferior to the mean rainfall for the same period of time calculated in a series of reference years.

More concretely, we can talk of a meteorological drought, agricultural drought, hydrological drought and a socio-economic drought depending on the aspect which is highlighted.

Droughts are a natural disaster whose effects are greater today than 30 years ago due to a higher population rate on the Earth, which makes it more vulnerable especially in the underdeveloped and developing countries.

Since 1967, 2,800 million people have suffered the consequences of meteorological disasters according to estimations made by the World Meteorological Association, half of which were affected by droughts.

Between 1967 and 1997, droughts caused the death of 1.3 million people worldwide in a direct or indirect way (*Obasi 1994)*. In the decade of the 90's, droughts affected large areas in Europe, Africa, Australia and America (North, Central and South). In 1988, a drought caused $40,000 million worth of losses to the USA economy. During the period 1991-1992, the agricultural production in southern and eastern Africa was the lowest in the whole century affecting 24 million people. In Kajastan, there were also very significant droughts in 1991 and 1995 with losses of over 40% in the production of grain.

Spain is a country specially affected by droughts since between the period 1880-1980 more than half of the years have been classified as dry or very dry. In Spain, during the decade of the 80's, seven years were considered dry or very dry and during the 90's five years have been classified in the same way. According to Agricultural Associations, the losses in the sector caused by droughts were superior to a billion and a half pesetas during the period 1992-1995.

For more than a decade, several authors have been using remote-sensing techniques to carry out the identification and monitoring of the drought-affected areas on a regional, national and global scale. Results have been quite satisfactory so far. (*Tucker and Choudhury 1987, Gutman 1990, Teng 1990, Kogan 1997).*

The Remote Sensing Laboratories of the INIA and of the University of Valladolid have been working jointly in the study of droughts in Spain through spatial Remote-Sensing techniques since 1996. As a re-

sult of this work, a database of NOAA-AVHRR images has been constituted consisting of 4,500 images. The aim of the present work is to carry out a comparative study on the way droughts have affected Spain during the period extending from 1987 to 2001, as deduced by the analysis of images registered by the AVHRR sensor in the NOAA satellite series. The methodology developed is based upon the following of the evolution carried out by the Normalized Vegetation Index (NDVI), deduced out of the AVHRR images, in the period of time comprising the 1987-2001 study. The results obtained have been able to evaluate in an objective way the impact caused by the drought in different Spanish regions during the period 1987-2001, revealing how useful the spatial Remote-Sensing can be in these kinds of applications. Taking into account the long period of time comprising the study, the results obtained can be considered quite strong. They can be a highly useful reference for a large number of important applications in the subject of forest, agricultural and environmental management (farm insurance, risk of forest fires, etc).

2 METHODOLOGY

Methodology followed to obtain results is:

- Radiometric calibration and atmospheric correction of channels 1 and 2 of the AVHRR sensor.
- Daily determination of the Normalized Difference Vegetation Index (NDVI) calculated from channels 1 and 2.
- Geometric correction of the NDVI's images.
- Generation of the image corresponding to the maximum NDVI value (MNDVI),for each ten –day period from February to September.
- Generation of a multitemporal file for all the ten –day periods with the MNDVI images corresponding to the years 1987-2001.
- Calculation of the ratio between the MNDVI value of every ten days period in the year of study and the mean value of all the corresponding periods of the time serie 1987-2001.
- Expression of the previous ratio as a percentage.
- Characterization of the drought incidence for each year of the period 1987-2001 as the mean percentage of all the ten days periods from February-September. Values of this mean percentage below 100 indicate drought conditions (negative anomaly).

3 RESULTS AND CONCLUSIONS

The results achieved, shown in figure 2, show the level of impact caused by drought in the different Spanish regions, in an objective way, during the 1987-2001 period. Particularly the larger part of Spanish territory was affected by the huge drought conditions observed in 1989-1992 period.

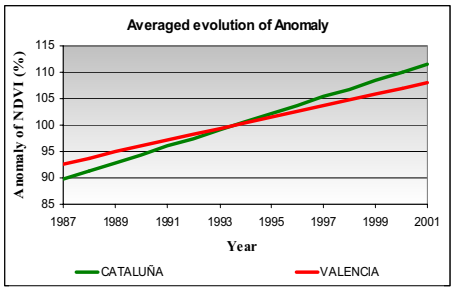

Figure 1. Analysis of regression for the two extremes autonomous communities in Spain: Cataluña, the better and Valencia, the worse

Table 1. Analysis of regression of anomalies for all autonomous communities in Spain

	Slope (m)	Correlation (r)
CAST.LEON	1.254	0.541
GALICIA	1.368	0.803
NAVARRA	1.414	0.65
ARAGON	1.489	0.642
CATALUÑA	1.554	0.784
VALENCIA	1.093	0.556
ANDALUCIA	1.279	0.595
MURCIA	1.129	0.435
EXTREMAD	1.196	0.564
MADRID	1.221	0.563
LA_RIOJA	1.354	0.606
CAST.MANCH	1.286	0.578
BALEARES	1.393	0.606
CANTABRIA	1.182	0.677
ASTURIAS	1.286	0.747
PVASCO	1.25	0.677

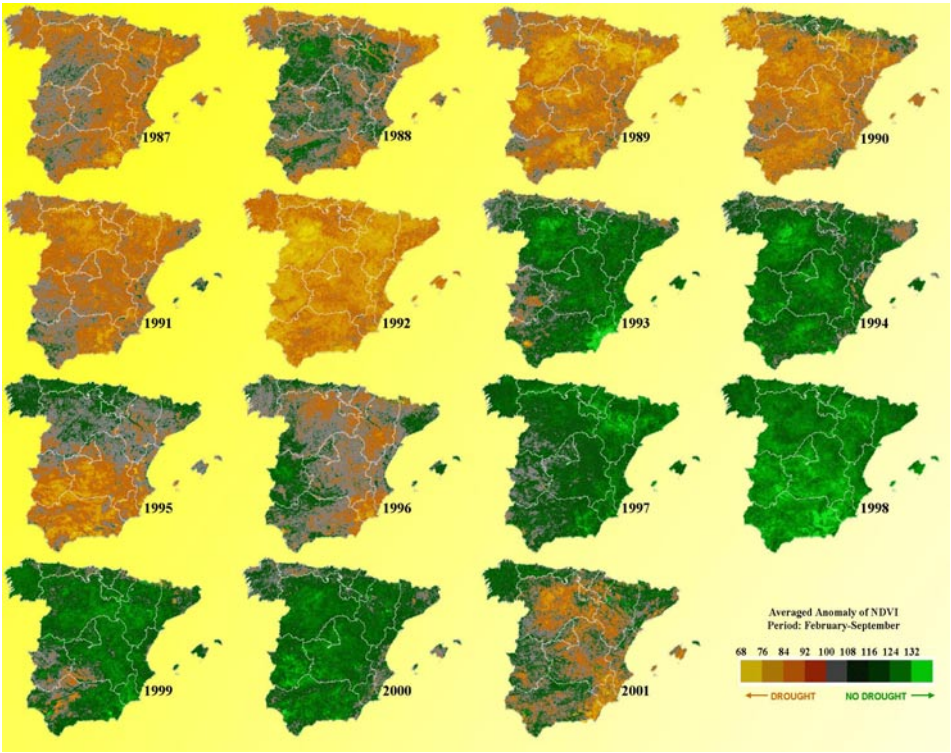

Figure 2. Serie of images of anomaly for Spain, on the period 1987-2001

In a drought trend basis, the regression analysis of the MNDVI anomalies over the analysed period (1987-2001) show a positive evolution in every Spanish region (see table 1).

While the best evolution (higher slope) of MNDVI anomalies was observed in Cataluña region, the one related to Valencia was the worst. Rising temperatures, longer vegetative periods and precipitation increased since 1996, could explain the previous trendy results. This result can be observed on figure 1

The obtaining of remote sensing series of data over longer periods of time, will make it possible to improve the accuracy and strength of this methodology with a view to obtaining a truly effective system for early detection and prevention of drought.

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