



National Research Council

Institute of Atmospheric Sciences and Climate



NDVI fluctuations from 1995 to 2006 in Southern Italy and Northern Africa: a search for a climate change indicator

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Outline

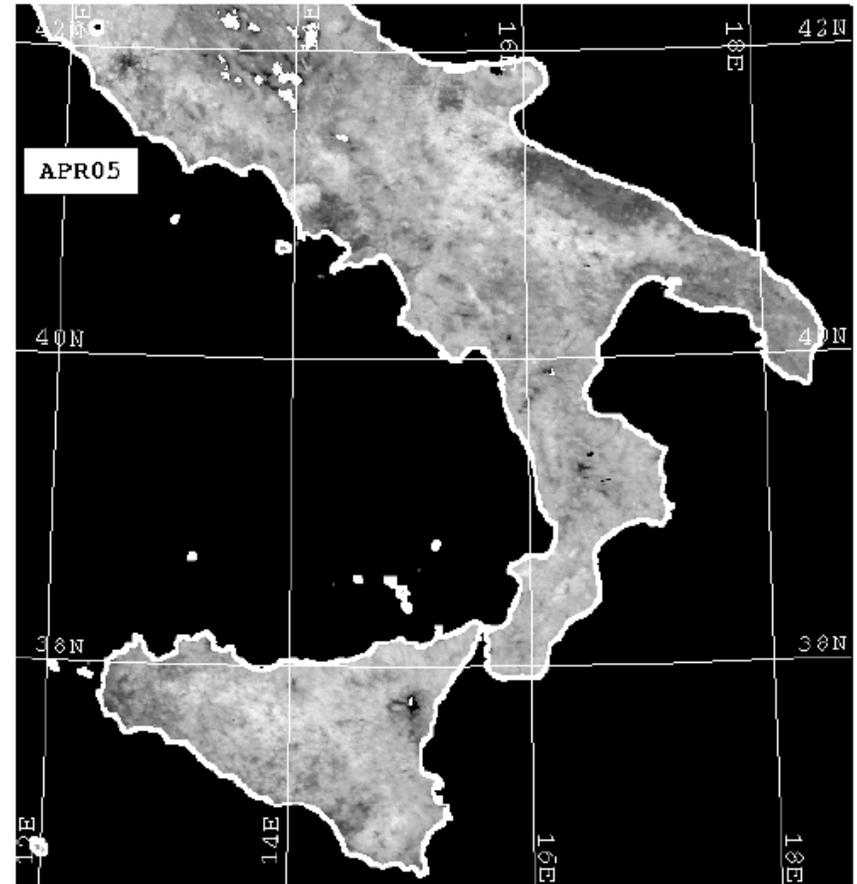
- Objective
- NDVI
- Datasets
- Analysis methods
- Results
- Conclusions and future directions

Objective

Aim of this work is to analyze NDVI seasonal and interannual vegetation trends in the last eleven years for two macro-regions, Southern Italy and Northern Africa, in search of evidence of climate changes and associated desertification processes

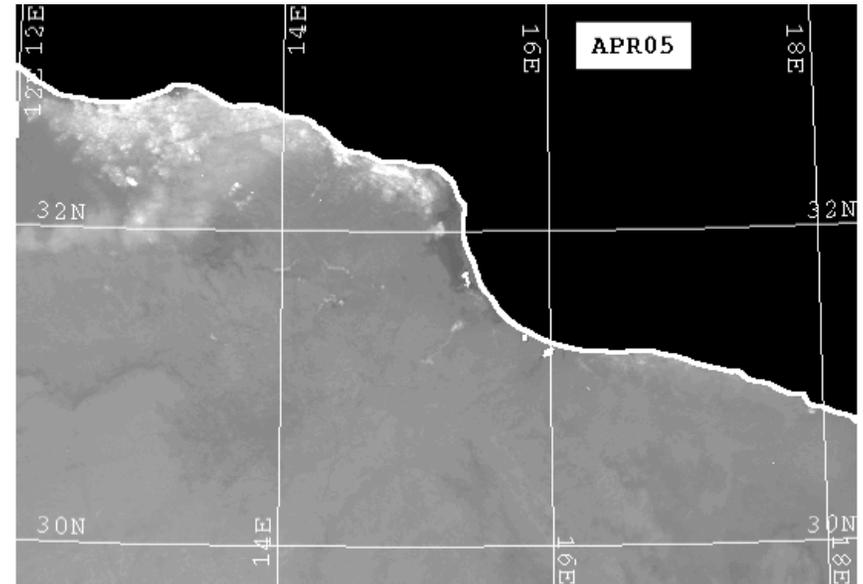
Objective

The Southern Italy region extends from 42°N to 36°N in latitude and from 12°E to 18.5°E in longitude,



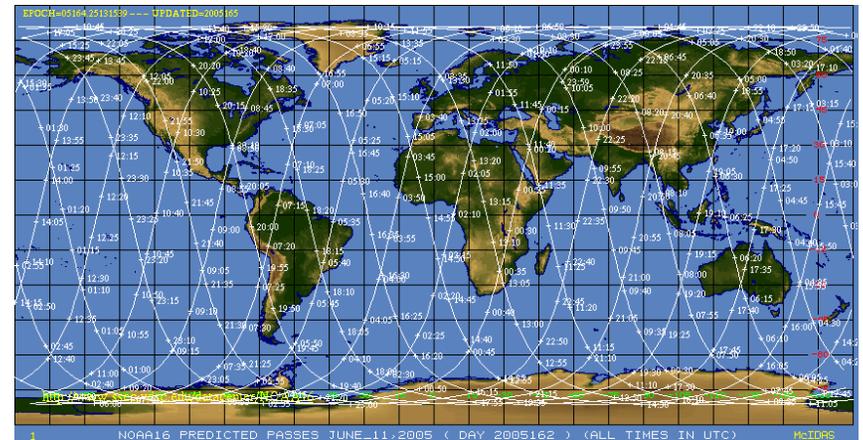
Objective

Northern Africa
extends from
 33.4°N to 29.8°N in
latitude and still
from 12°E to
 18.5°E in longitude



NDVI background

Past decades of Earth Observation data have improved our understanding of the intra- and interannual vegetation dynamic at different scales (regional, continental and global scales)



NDVI background

The Normalized Difference Vegetation Index (NDVI) derived from the Advanced Very High Resolution Radiometer (AVHRR) emerged as one of the most robust tools for monitoring vegetation and since the 1980s the NOAA AVHRR satellites have provided data vital to a range of land applications



NDVI background

For the AVHRR sensor, the NDVI is defined as the ratio

$$\frac{\text{channel 2 reflectance} - \text{channel 1 reflectance}}{\text{channel 2 reflectance} + \text{channel 1 reflectance}}$$

where channel 1 is the 550-680 nm wavelength band (or red band) and channel 2 is 725-1100 wavelength (or near-infrared band)

NDVI background

Chlorophyll absorbs light in the red channel and foliage reflects light in near infrared channel

Higher photosynthetic activity will result in lower reflectance in the red channel and higher reflectance in the near infrared channel

NDVI background

Typical NDVI values for various cover types in Maximum Value Composite (MVC) AVHRR data (*Holben, 1986*) are:

COVER TYPE	NDVI
Dense vegetation	0,7
Dry bare soil	0,025
Clouds	0,002
Snow and ice	-0,046
Water	-0,257

Datasets

The NDVI dataset employed in this study was retrieved from the DLR/EOWEB data archive which cover the whole Europe and North Africa and it is available in the form of composite daily, weekly and monthly NDVI

The screenshot displays the EOWEB Earth Observation Data Service interface in Microsoft Internet Explorer. The browser window title is "EOWEB - Earth Observation Data Service - Microsoft Internet Explorer". The address bar shows the URL: <http://taurus.caf.dlr.de:8080/ser/vlets/template/welcome/entryPage.vm>. The page header includes the DLR logo, the text "Cluster Angewandte Fernerkundung", and the EOWEB logo. A navigation bar contains links for "Home / Impressum / Contact" and "You are logged in as gquarta". Below the navigation bar, there are tabs for "Catalogue", "UserSet", and "ShopCart". The "Catalogue" tab is active, showing a "Collections" list with the following items:

- Deselect all
- Expand/collapse
- 1 Collection selected
- Vegetation Index NDVI (NOAA AVHRR) monthly maps
- Vegetation Index NDVI (NOAA AVHRR) weekly maps
- Vegetation Index NDVI (NOAA AVHRR) daily maps
- Land Surface Temperature (NOAA AVHRR)
- Sea Surface Temperature (NOAA AVHRR)

The "Query Mode" is set to "Standard". The "Date" section has a "Choose a Date" dropdown and a date range from "2004-08-28 00:00:00" to "2005-08-28 23:59:59". The "Area" section has a "Rectangle" dropdown and a "Center Lat/Lon" field with values "40.745" and "13.919". The "Extension Lat/Lon" field has values "13.088" and "13.037". A "Step by range" dropdown is also present. The main content area shows a globe with a red rectangle indicating the search area. Below the globe, a table displays "11 out of 11 Items returned":

Id	Abstract	Product Type
1	Vegetation Index NDVI NOAA AVHRR	Month_Composit
2	Vegetation Index NDVI NOAA AVHRR	Month_Composit
3	Vegetation Index NDVI NOAA AVHRR	Month_Composit
4	Vegetation Index NDVI NOAA AVHRR	Month_Composit
5	Vegetation Index NDVI NOAA AVHRR	Month_Composit
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7	Vegetation Index NDVI NOAA AVHRR	Month_Composit
8	Vegetation Index NDVI NOAA AVHRR	Month_Composit
9	Vegetation Index NDVI NOAA AVHRR	Month_Composit
10	Vegetation Index NDVI NOAA AVHRR	Month_Composit
11	Vegetation Index NDVI NOAA AVHRR	Month_Composit

The interface also includes a "Start Search" button and a "Results" section with "Display" and "Print" options.

Datasets

Level 3 products Maximum Value Composite (MVC) monthly NDVI was chosen, as it ensures a good quality by excluding atmospheric alterations by clouds and aerosols

The geometrical resolution of the instrument is approximately 1,1 km at nadir but reduced because of the large swath and earth curvature, to about 6 km near the pass edges

Moreover, maps chosen are calibrated, with clouds and water detected and labeled

Datasets

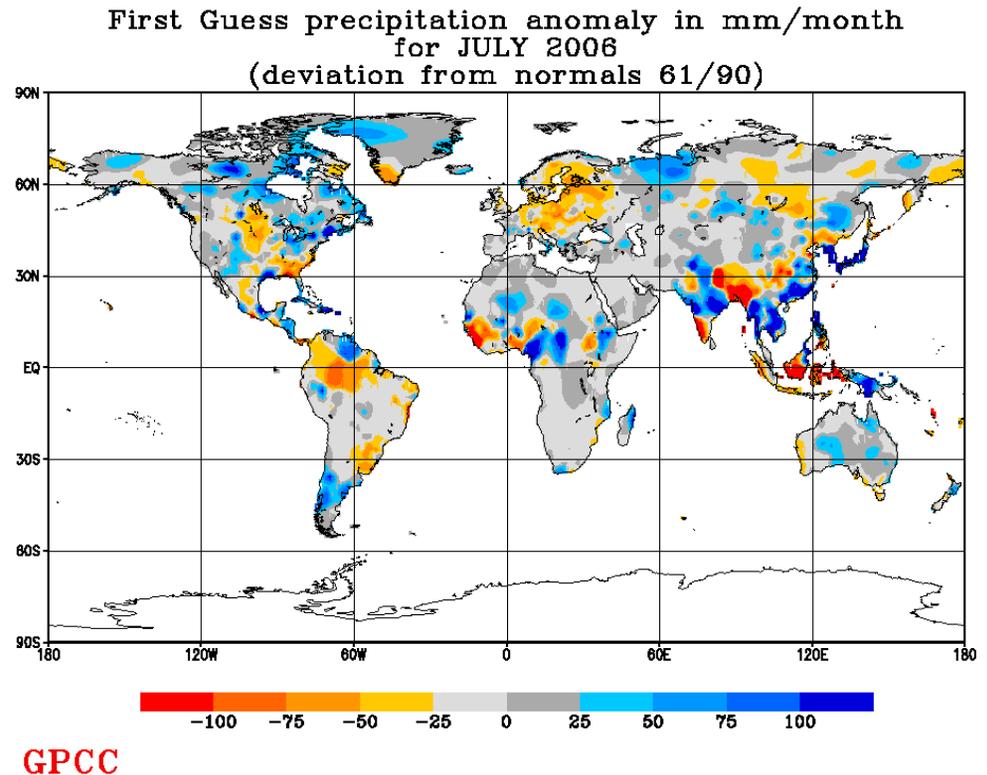
The NDVI monthly sequences for the macro-regions under study have been extracted from the full product by means of a specific procedure which makes use of the commercial software TeraScan. This procedure consists of the following steps:

- HDF-4 to “raw” conversion of the full product;
- geo-referencing of the full product;
- extraction of the two areas of interest on their original Mercator projection;

Datasets

Rainfall data are obtained from the Global Precipitation Climatology Centre (GGPC)

The data related to the two regions of interest were extracted (resolution 0.5°) for the twelve years from 1993 to 2004



Analysis methods

Two methods of analysis were applied in this work to both areas under study:

- a) an evaluation of vegetation trend, obtained by analyzing the total NDVI and its spatial average for each month and year;
- b) an estimation of spatial average of long term NDVI anomaly, according to the analysis methods described by *Myneni et al (1998)*

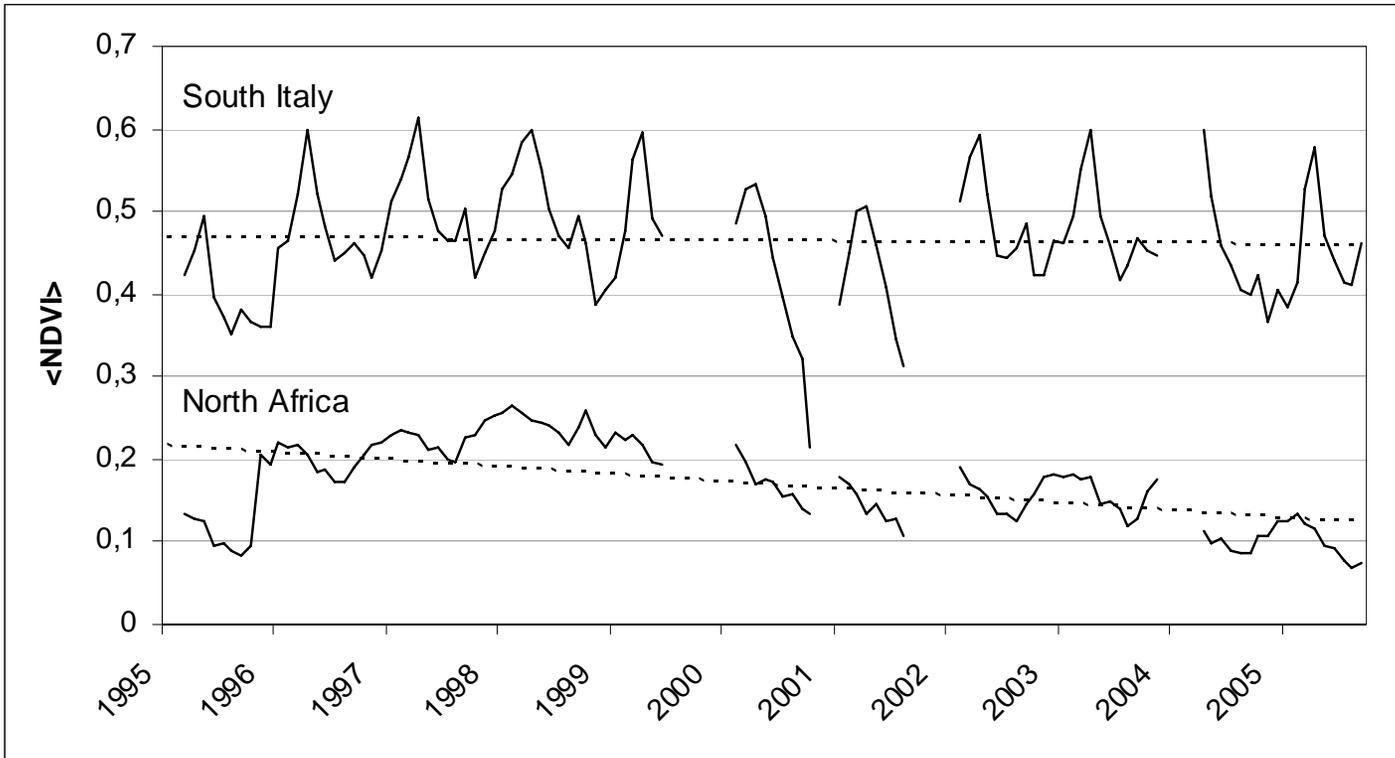
Analysis methods (a)

For the first method: let $x(k, m, y)$ be the MVC monthly NDVI of pixel k in month m and year y , the spatial average can be computed as

$$\bar{x}(m, y) = \frac{1}{N_p} \sum_{k=1}^{N_p} x(k, m, y)$$

where N_p is the number of pixel of the analyzed area. This spatial average is performed by only considering the pixels not corresponding to water, clouds or snow/ice covers, these being easily identified in the NDVI maps.

Result (a)



South Italy analysis according method a, displays marked seasonal oscillations, with low values in the autumn of year 1995, 2000 and 2001.

For both areas the regression lines indicating the long term trend, are decreasing, with a steeper slope for the North Africa data set ¹⁷

Analysis methods (b)

For the second method a modification of Myneni et al. methodology for long term monthly NDVI anomaly evaluation, was developed; this new method is based on the use of the *median*, rather than of the *mean*

Analysis methods (b)

Let $\hat{x}(k, m)$ be the long term monthly *median* value of pixel k in month m , the monthly NDVI anomaly $x'(k, m, y)$ is computed as:

$$x'(k, m, y) = [x(k, m, y) - \hat{x}(k, m)]$$

The monthly anomaly represents a simple measure of the offset of NDVI, for a given pixel, month and year, with respect to its long term mean behavior. The long term NDVI anomaly can be spatially averaged in order to achieve a vegetation trend indication.

Analysis methods (b)

Why using the *median* rather than of the *mean*?

If the long term monthly average NDVI of a given pixel, in a month m and year y , is computed as the arithmetic mean, if some spike occurs the anomaly evaluation can be altered because the value representing the mean behavior is altered.

On the contrary, the *median* is not influenced by spikes and gives a better description of the long term mean behavior

Analysis methods (b)

How can we spatial average the anomaly?

Being $x'(k, m, y)$ the long term monthly anomaly of pixel k , in month m and year y , the spatial averaging operation can be performed in two ways:

Analysis methods (b)

How can we spatial average the anomaly?

$$x'(k, m, y) \rightarrow \bar{x}'(m, y)$$

1. by only considering those pixels having a corresponding long term monthly median value larger than a fixed threshold

With this method the pixels taken into account will vary from month to month but will remain almost constant from year to year this method is called Vary Month Constant Year (VMCY) and is best suited to study climate-induced variations in NDVI

Analysis methods (b)

How can we spatial average the anomaly?

$$x'(k, m, y) \rightarrow \bar{x}'(m, y)$$

2. by only considering those pixels having a corresponding long term monthly median value larger than a fixed threshold in May ($k = 5$)

This method is called Constant Month Years (CMY) because the pixels involved in the average is constant from month to month and from year to year. The spatial average of NDVI anomaly performed according to this method highlights NDVI seasonality. In this definition, the month of May was chosen as the “greenest” month of the year for the study areas.

Analysis methods (b)

How spatial averaging the anomaly?

In both cases, the pixels taken into account must satisfy a further criterion:

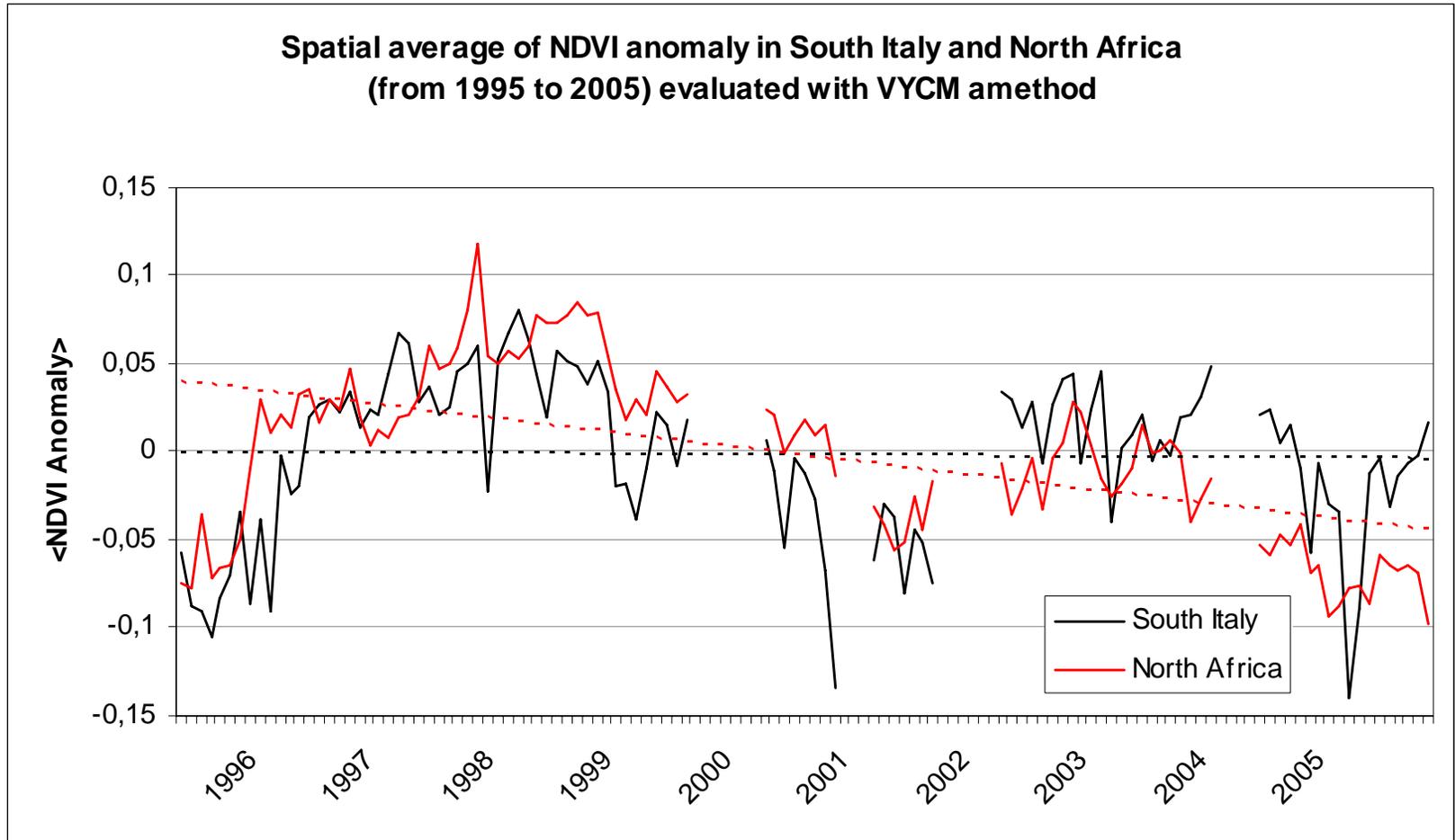
$$x'_s(k, m, y) < |3\sigma|$$

where x'_s , the standardized anomaly, is defined as:

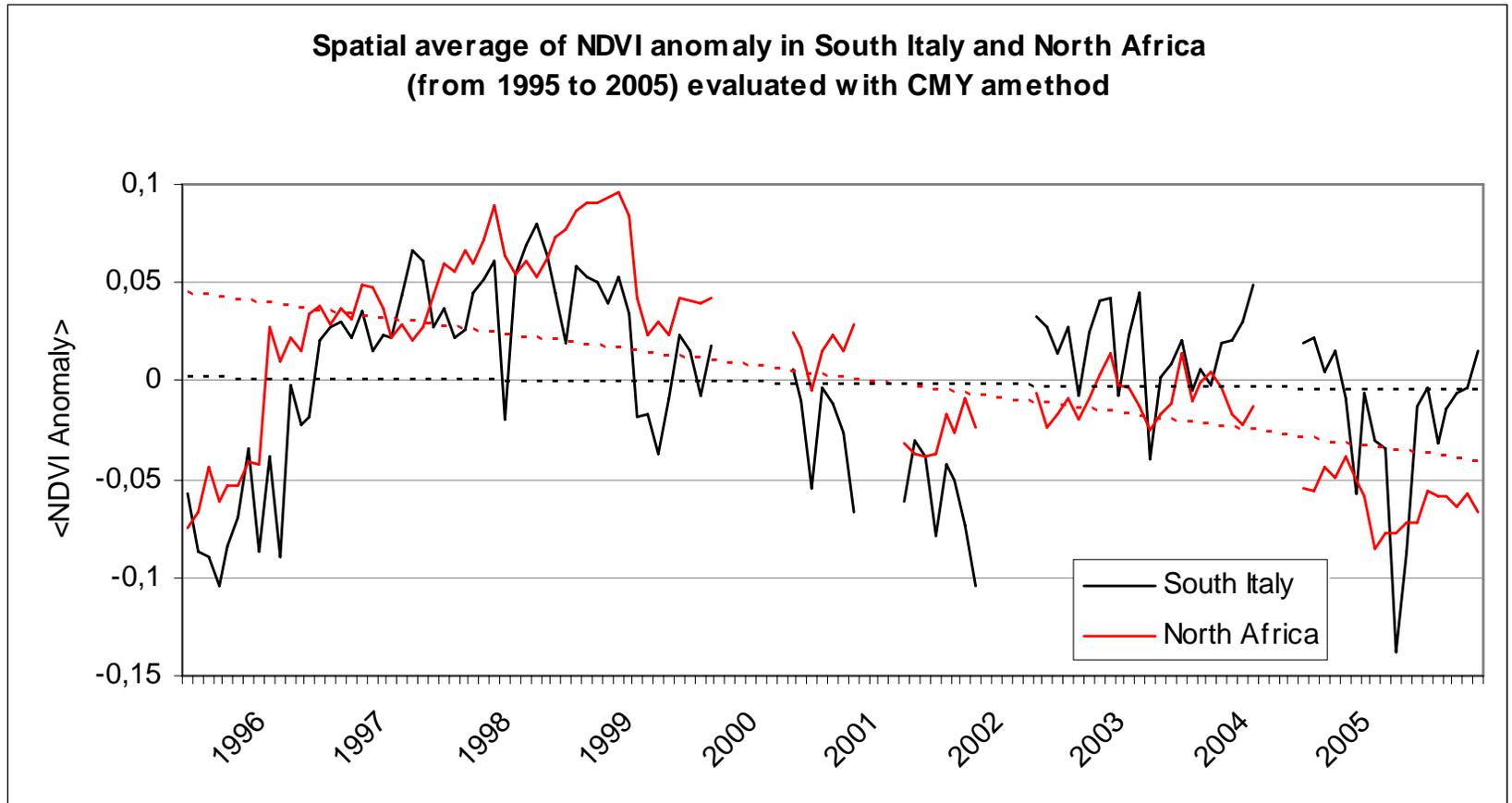
$$x'_s(k, m, y) = \frac{[x(k, m, y) - \hat{x}(k, m)]}{\sigma(k, m)}$$

As a consequence, the pixels for which $x'_s(k, m, y) \geq |3\sigma|$ are not included in the spatial average and are considered as outliers.

Result (b, VMCY)



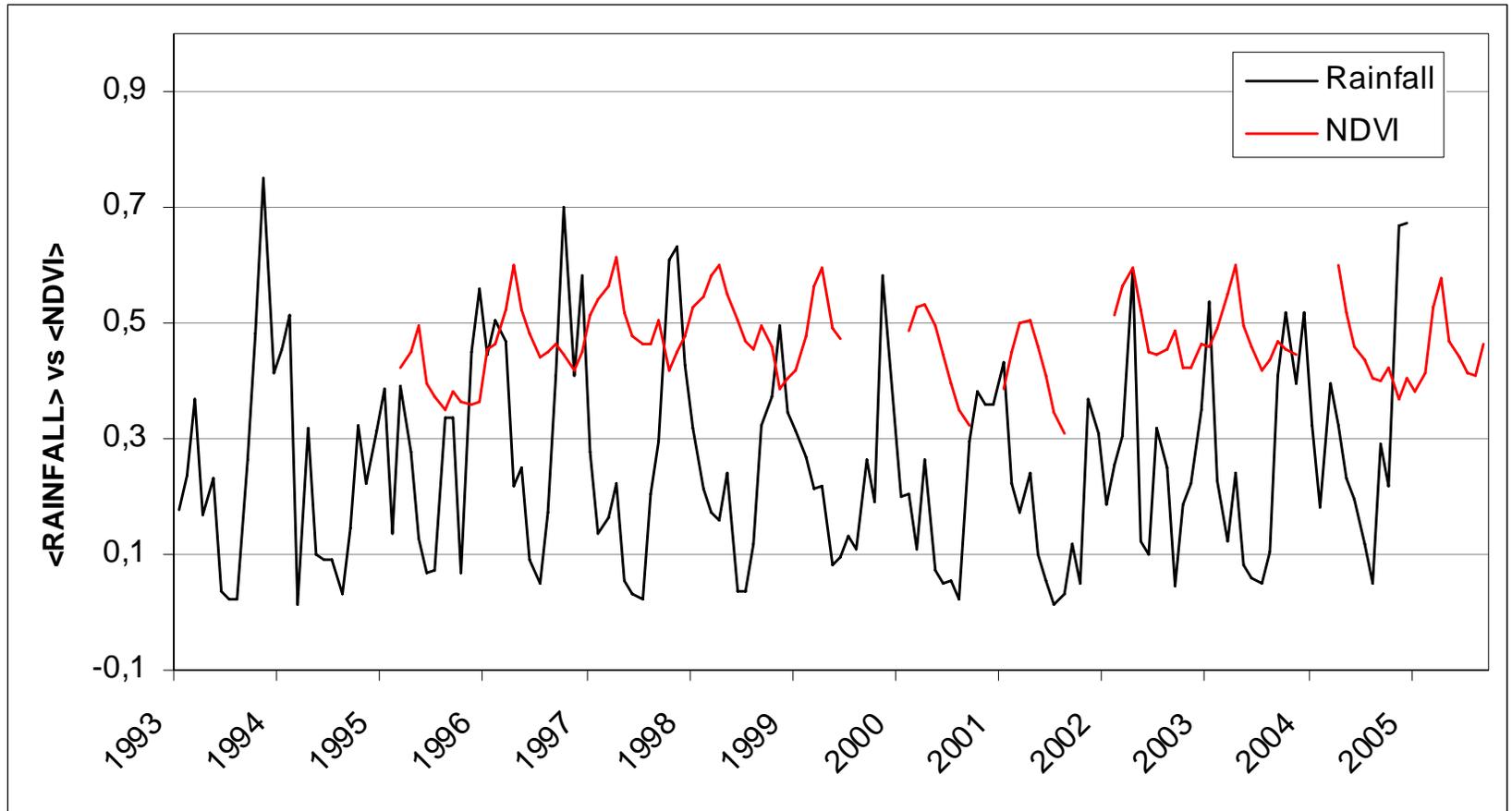
Result (b, CMY)



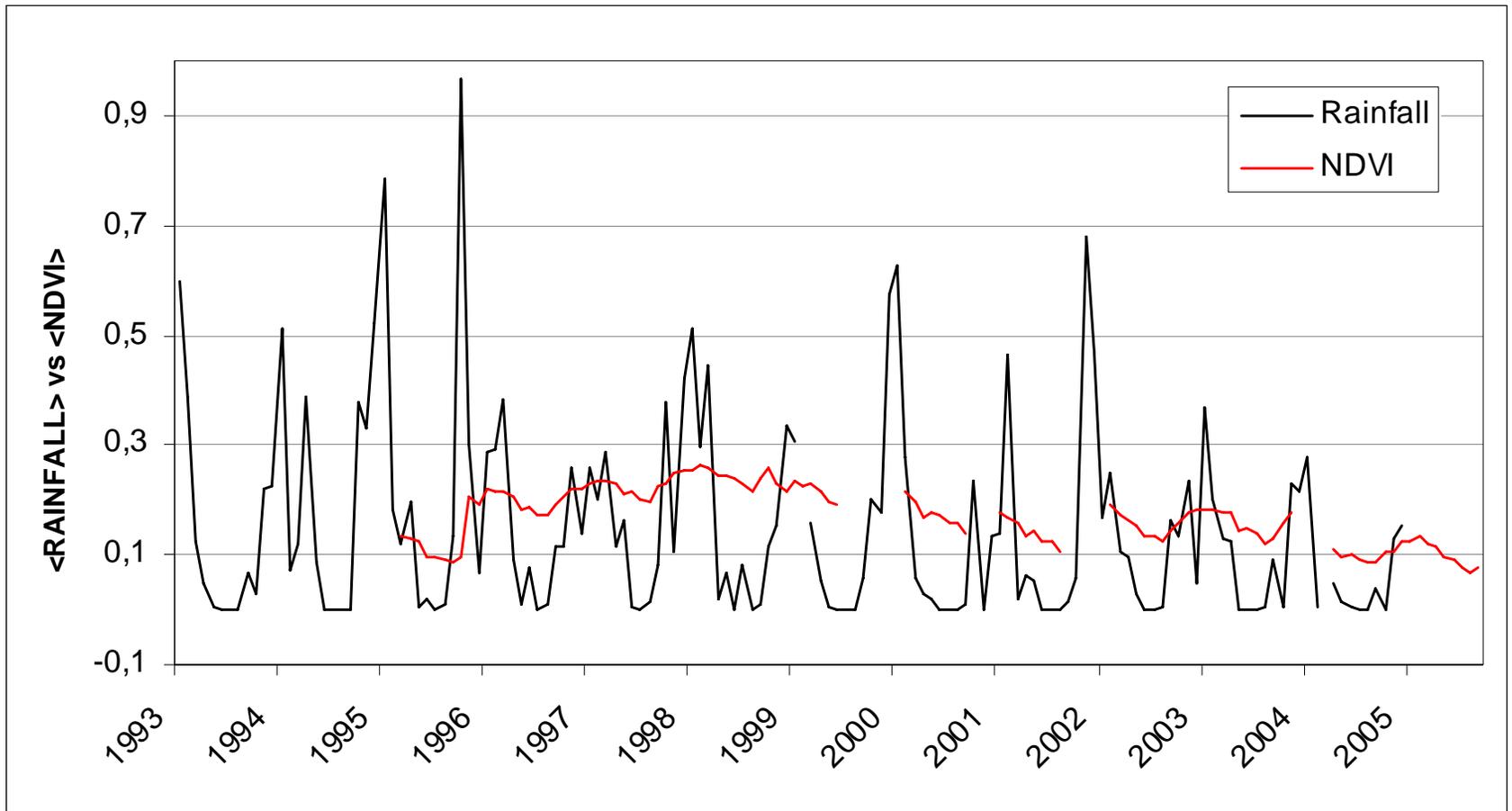
Result (b)

For both South Italy and North Africa, the two analysis according to VYCM and CMY methods look very similar and this demonstrates that the two methods are almost equivalent

Result (Rainfall, Southern Italy)



Result (Rainfall, Northern Africa)



Result (Rainfall)

As vegetation development is clearly linked to rainfall

The visual inspection reveals a strong, lagged, correlation between rainfall and NDVI curves, with a time-lag of 1-2 month

Conclusion and future direction

The analysis of average NDVI long term trend shows a moderate decline for South Italy but a more marked one for North Africa

The same can be said for NDVI anomaly computed by both methods described above: a steep decrease for North Africa and a modest one for South Italy. It can be concluded that both indexes, average NDVI and NDVI anomaly, can be used as climate change indicators: this holds in particular for North Africa macro-region, with NDVI anomaly being especially sensitive to climatic variations

Conclusion and future direction

Some issues still remain to be investigated:

- the steep declines of NDVI in South Italy in the autumn of years 2000, 2001 and 2002 and their relation with environmental factors
- the marked negative peaks of NDVI anomaly for South Italy in the autumn of year 2001 and in January 2005 and their relation with environmental factors
- the time lag between rainfall and NDVI curves by means of the cross-correlation function