# Land Cover Dynamics in the context of Climate Change: inferences from satellite multispectral imagery

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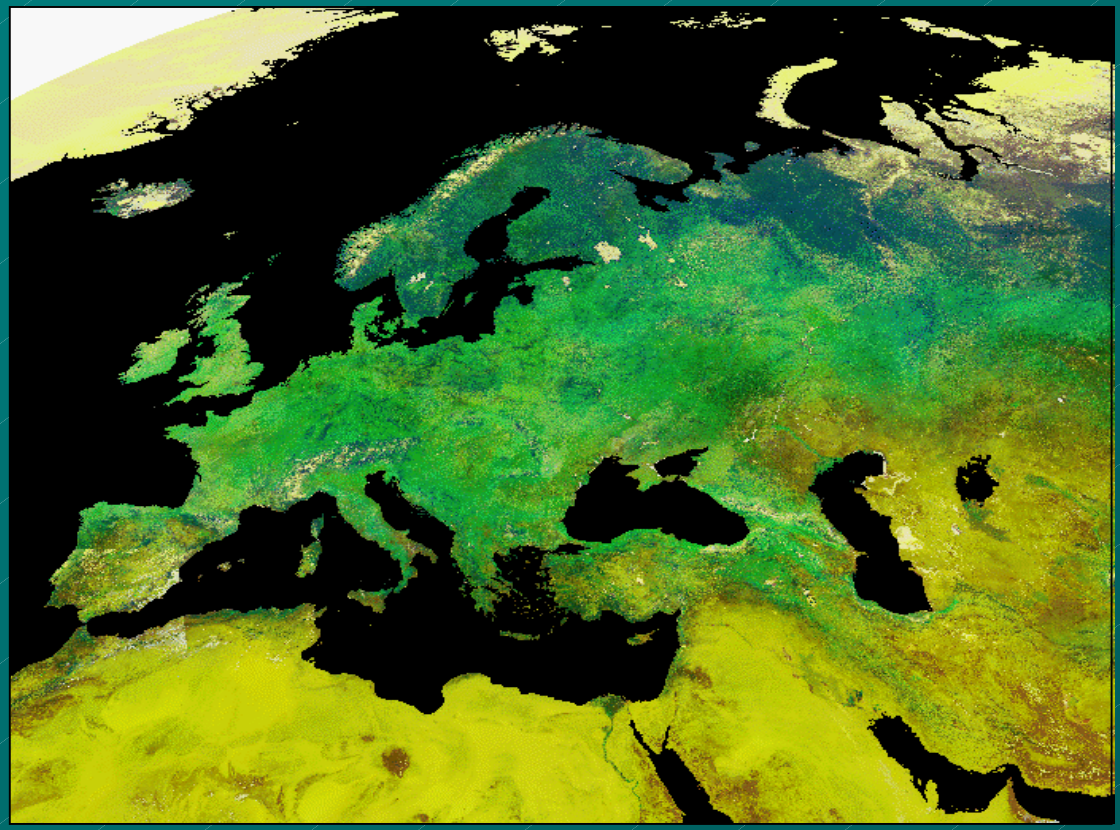
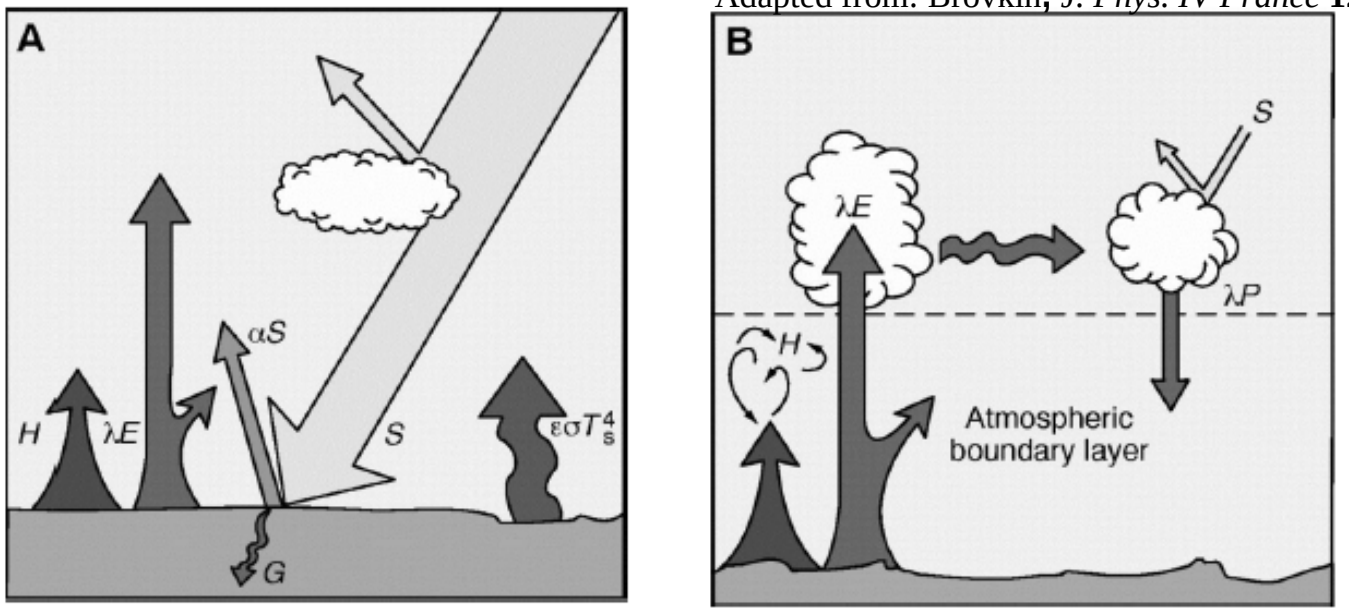


**Europe: composition of AVHRR –NDVI images over ten days**
http://www.geo.mtu.edu/rs/avhrr/global/europe.gif

May-5-06

Adapted from: Brovkin, *J. Phys. IV France* **12**,57 (2002)




Land cover modifies energy, water, momentum, and CO2 fluxes at the land surface. The net balance of the radiation absorbed by the land surface, $R_n$, is determined as

$$R_n = S(1-\alpha) + L_w - \varepsilon\sigma T_S^4,$$

where $S$ is insolation, $\alpha$ is the surface albedo, $L_w$ is downward long-wave flux, $\varepsilon$ is the surface emissivity, $\sigma$ is the Stefan-Boltzmann constant and $T$ is the land surface temperature.

$R_n$ is portioned into three heat flux terms.

$$R_n = H + \lambda E + G,$$

where $G$ is the ground heat flux, $H$ is the sensible heat flux, $E$ is the evapotranspiration rate, and $\lambda$ is the latent heat of vaporisation .

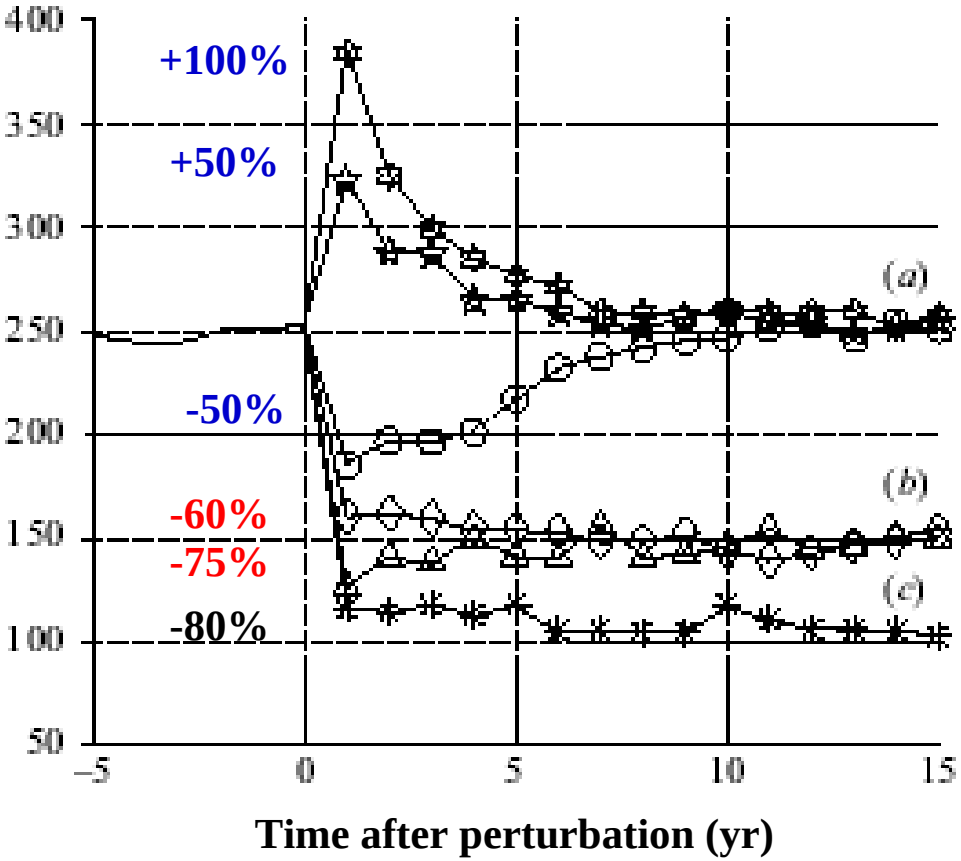
"One measure of land cover change forcing could be the perturbation to one of the components of the surface-energy balance equation prior to feedbacks from the rest of climate system"

"…a regional climate change potential could offer a new metric useful for developing more useful protocol…"

Pielke et al, "**The influence of land-use change and landscape dynamics on the Climate System:relevance to climate-change policy beyond the radiative effect of greenhouse gases**", *Phil. Trans. R. Soc. Lond. A* ,***360***,*1705*, *(2002)*

# Multiple equilibria in the coupled atmosphere-vegetation system

## The Sahel Ecosystem under vegetation perturbation




Adapted from:Higgins et al. *Phil. Trans. R. Soc. Lond.* B, **357**, 647-655(2002)

# Satellite data for the study of land cover dynamics

## NOAA-AVHRR(*) data

**Average Orbital height: 830 km**

**Spatial resolution : Global Area Coverage: 4.4 Km**

**Local Area Coverage: 1.1 Km**

**Coverage: 2 times per day per satellite**

**Records Data in 5 Wavelength Intervals**

1. **Visible (0.58-0.68 microns)**
2. **Near Infrared (0.72-1.10 microns)**
3. **Mid Infrared (2.53-2.93 microns)**
4. **Thermal Infrared (10.3-11.3 microns)**
5. **Thermal Infrared (11.5-12.5 microns)**

(*) NOAA- National Oceanic and Atmospheric Administration

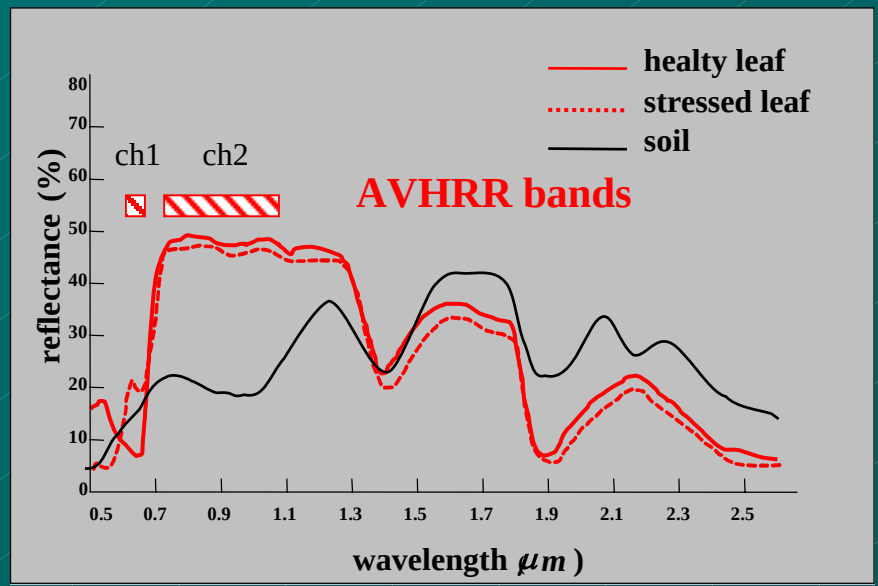
AVHRR- Advenced Very High Resolution Radiometer (Polar Orbiting Satellites)

# NDVI (Normalized Difference Vegetation Index)

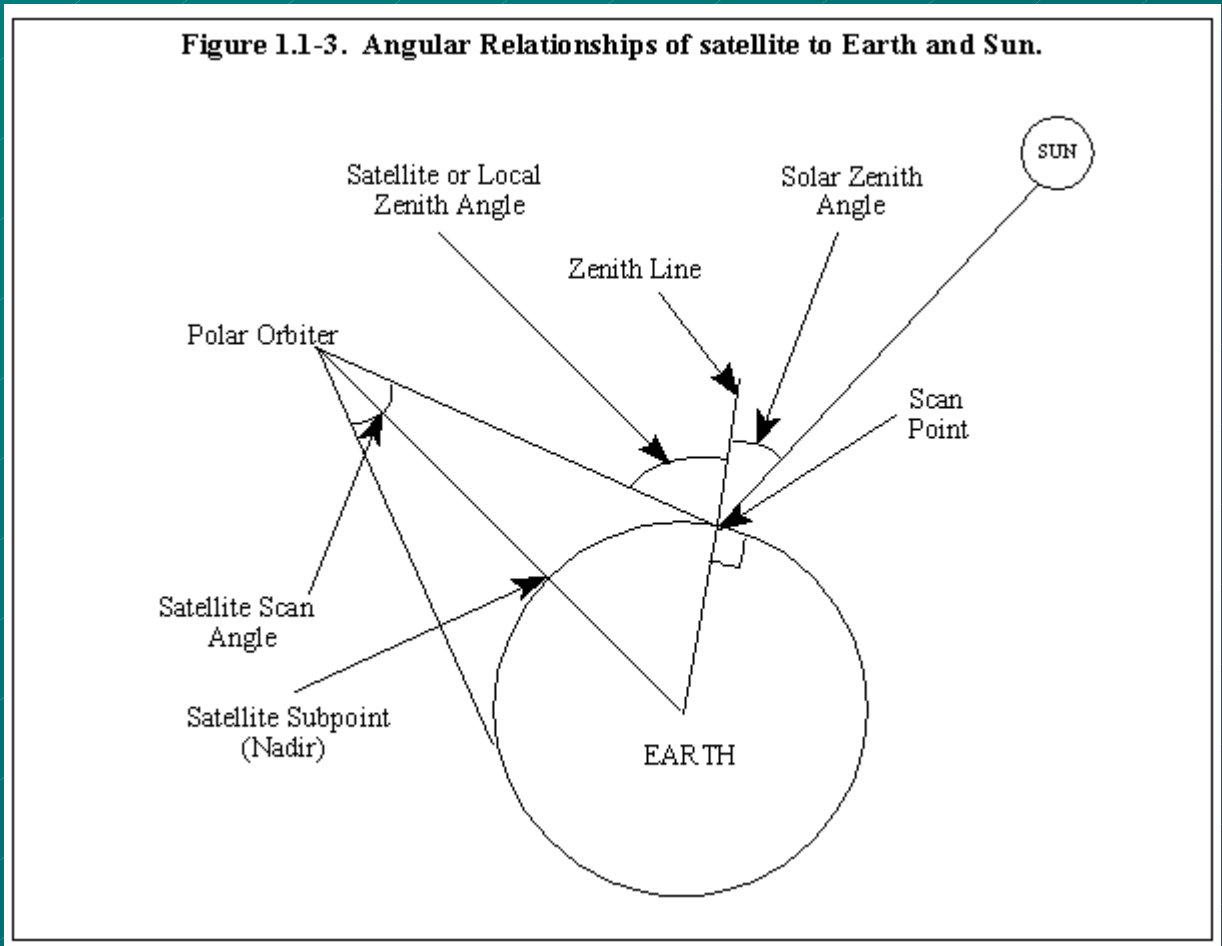
NOAA_AVHRR Channels

| range (μm) | Channel-1 | Channel -2 | Channel -3 | Channel -4 | Channel -5 |
|---|---|---|---|---|---|
| | 0.58-0.68 | 0.725-1.1 | 3.55-3.93 | 10.3-11.3 | 11.4-12.4 |

$$NDVI = \frac{ch_2 - ch_1}{ch_2 + ch_1}$$



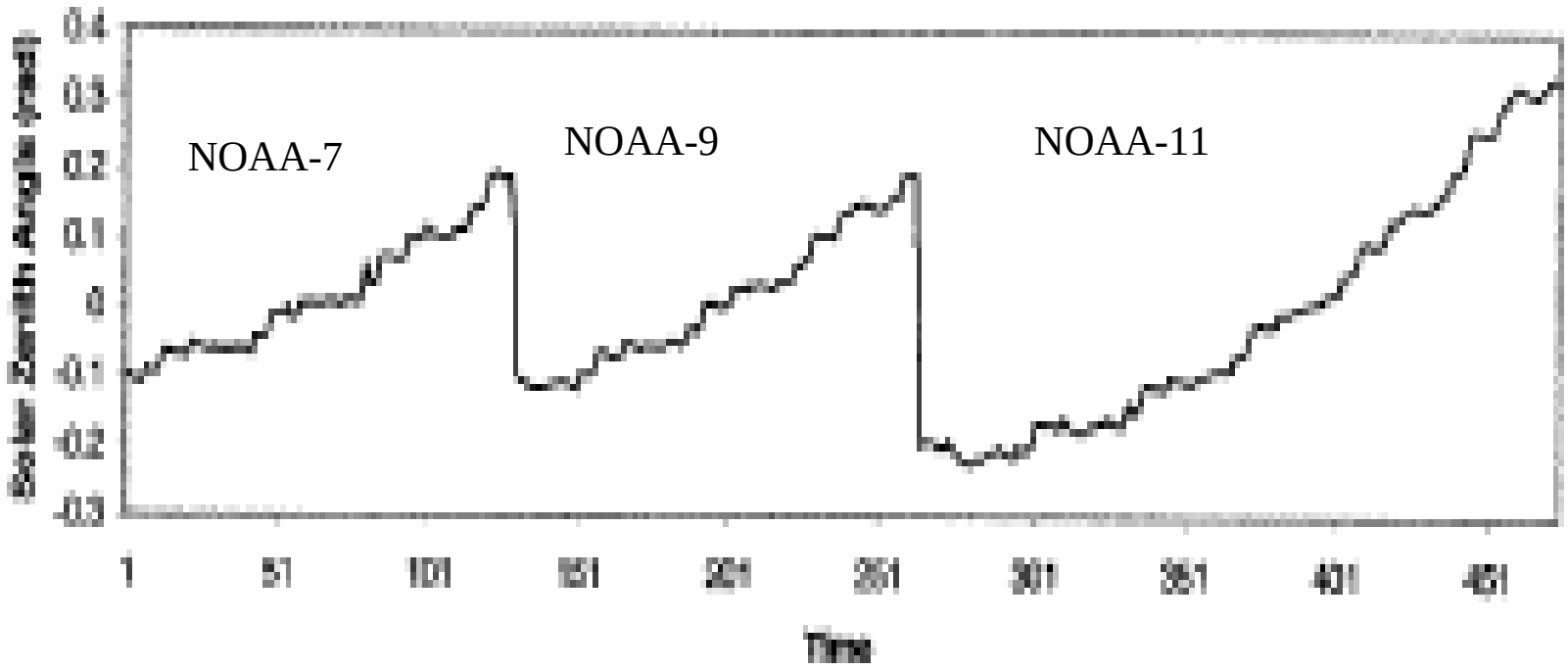
# Sun-Sensor-Target Geometry

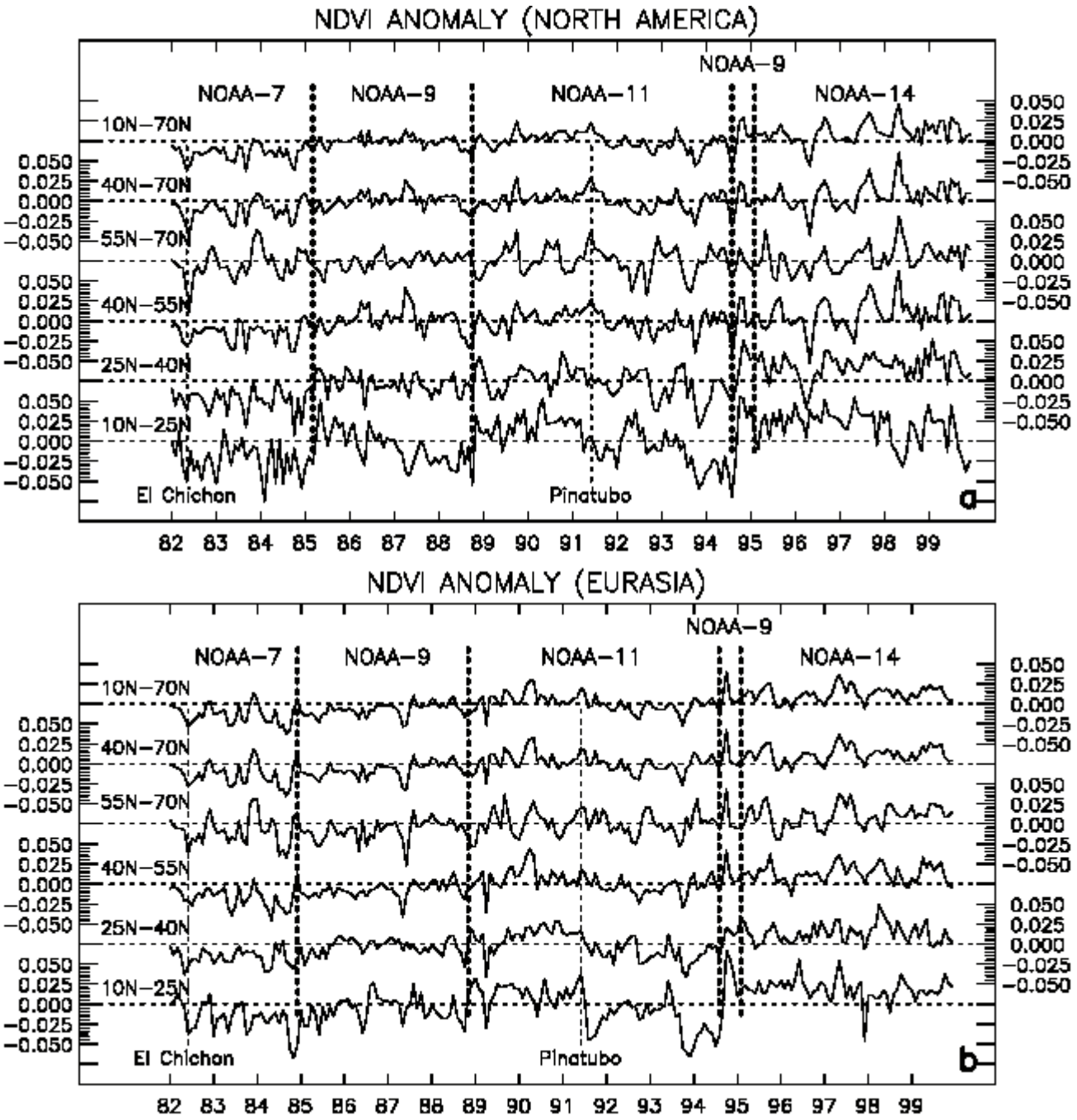



from: NOAA Polar Orbiter Data User's Guide
http://www2.ncdc.noaa.gov/docs/podug/

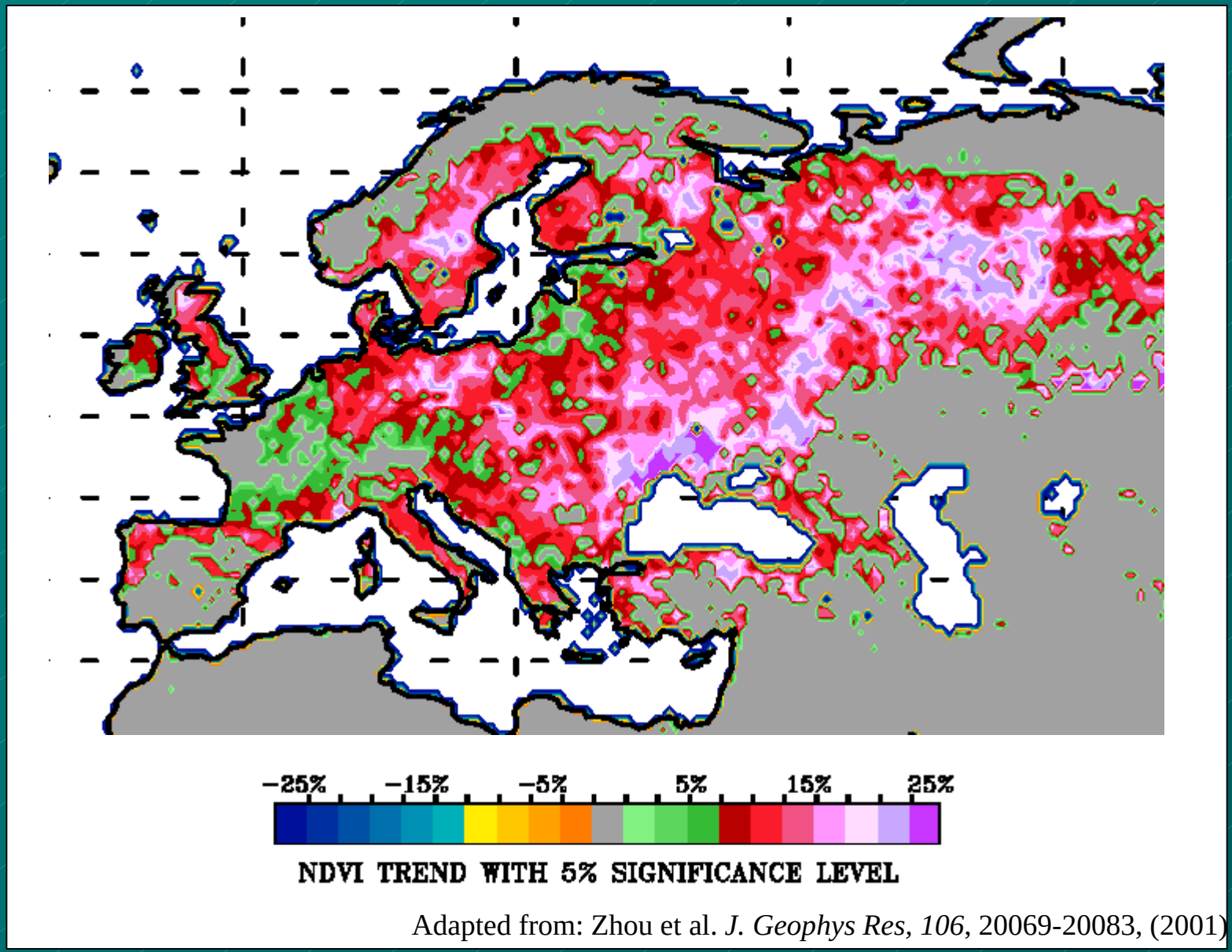
# NOAA AVHRR 8-km NDVI Data Set

# change in the Solar Zenith Angle

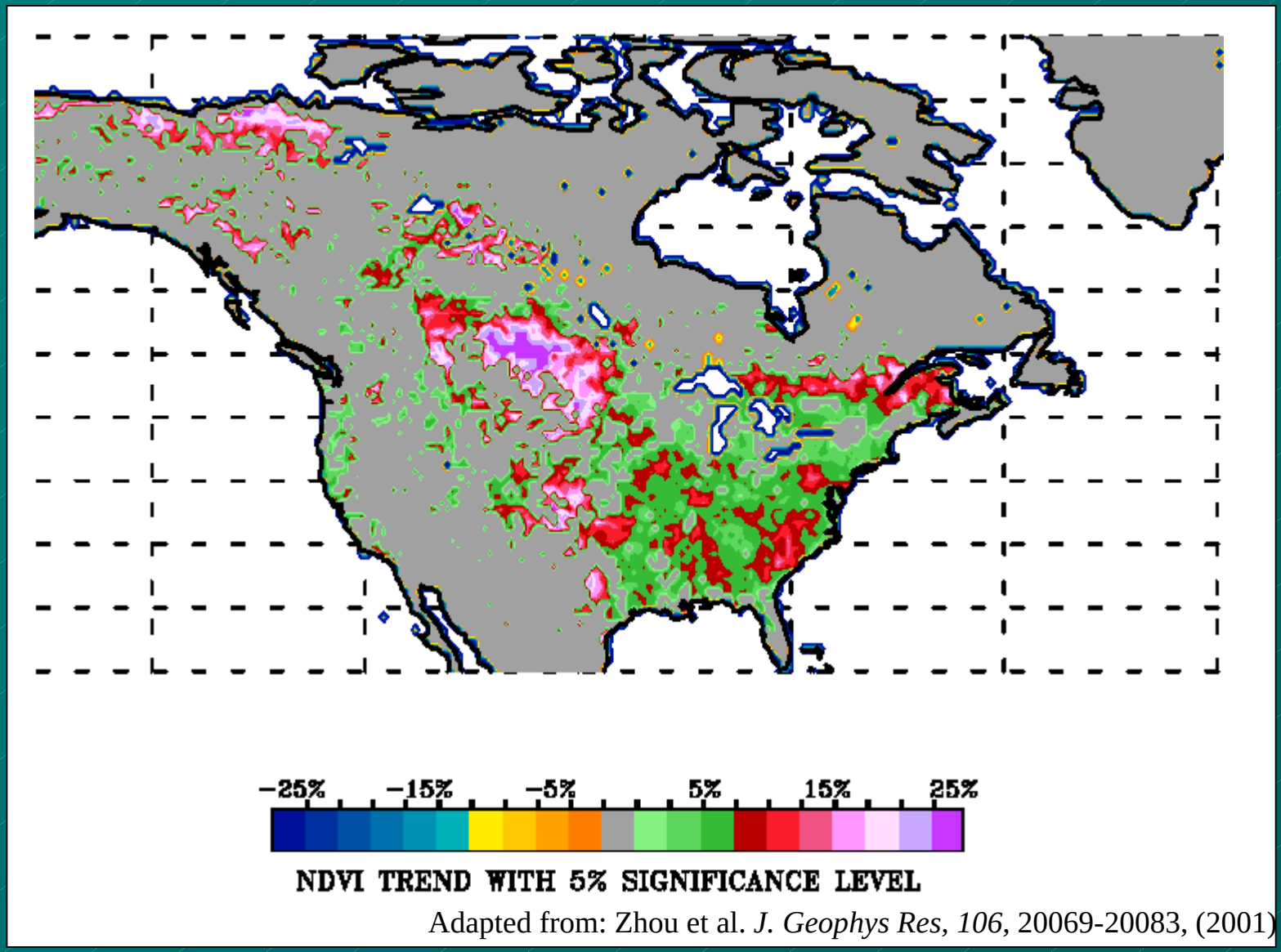





from: Zhou et al. *J. Geophys Res*, *106*, 20069-20083, (2001)




Adapted from: Zhou et al. *J. Geophys Res*, *106*, 20069-20083, (2001)

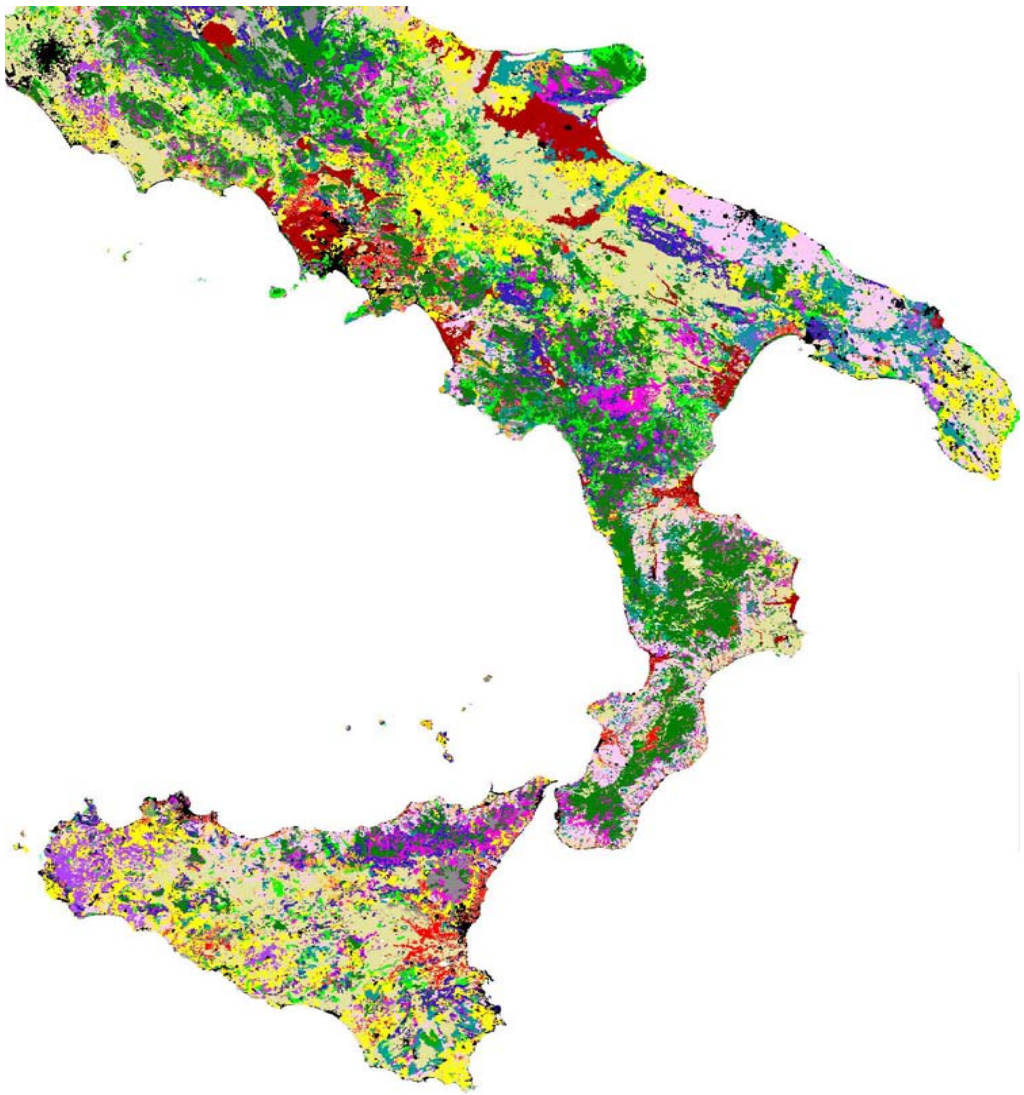



Adapted from: Zhou et al. *J. Geophys Res*, *106*, 20069-20083, (2001)

# IMAA-AVHRR DATABASE

**Data from Dundee University for 1983-1994 (NOAA 9 and 11).**

**Since 1995, data are acquired daily by means of a NOAA high-resolution picture transmission receiver installed at the Institute of Advanced Methodologies for Environmental Analysis (IMAA)-National Council Research (CNR) in Potenza, Italy.**



- Artificial Surfaces
- Non-irrigated arable land
- Permanently irrigated land
- Vineyards
- Fruit trees and berry plantations
- Olive groves
- Pastures
- Annual crops associated with permanent crops
- Complex cultivation patterns
- Cultivated areas with significant natural vegetation
- Agro-forestry areas
- Forest
- Natural grassland
- Moors and heathland
- Sclerophyllous vegetation
- Transitional woodland-scrub
- Open spaces with little or no vegetation
- Inland and coastal wetlands
- Inland and marine waters

Corine Land Cover Map (MDC-Environmental Satellite Data Center)

AVHRR data

Stable Classes Identification

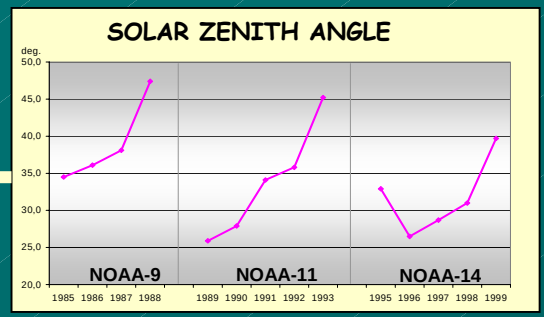
HISTORICAL DATA

FIELD SURVEYS

ORTOFOTO

LANDSAT DATA

Illumination Adjustments for the Stable Classes (NOAA-9)

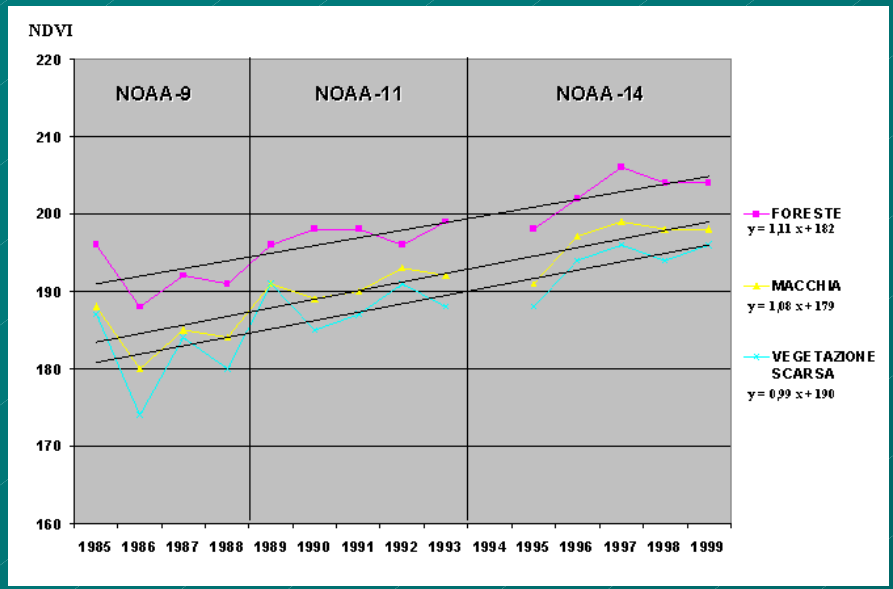



Calibration adjustments for the Stable Classes (NOAA-11/14)

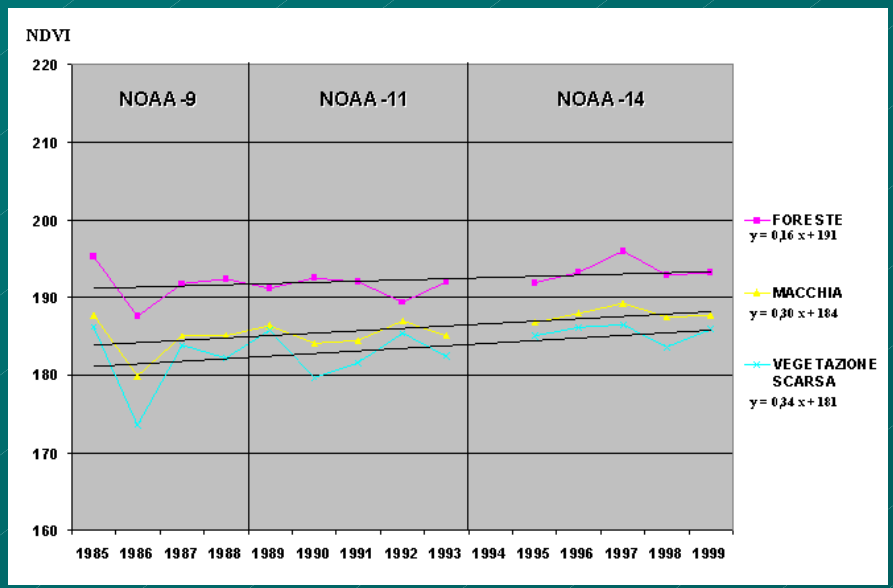
Removal of Illumination and Calibration Errors from all classes

CORINE LAND COVER

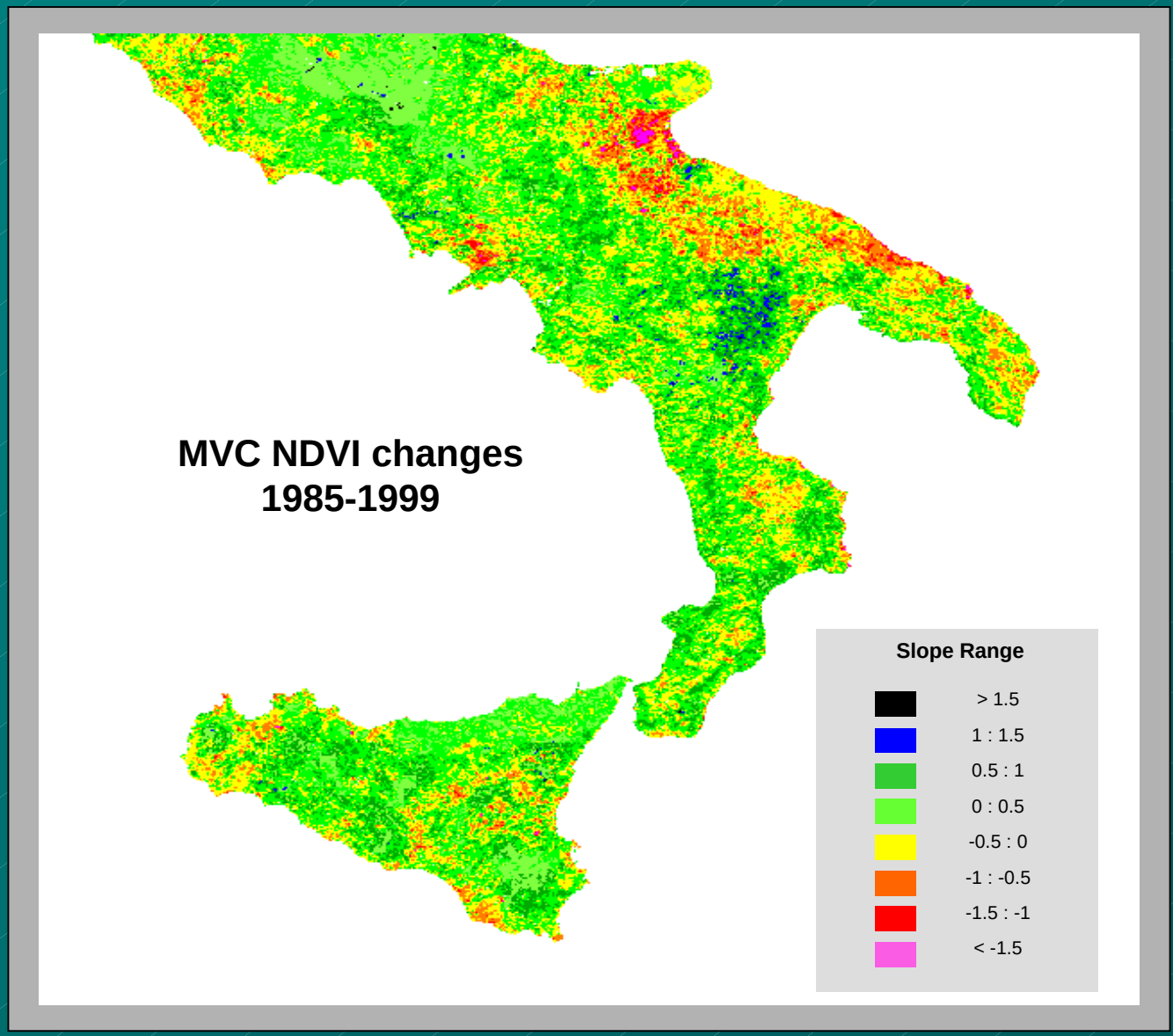
# Effects of systematic errors in NDVI time series



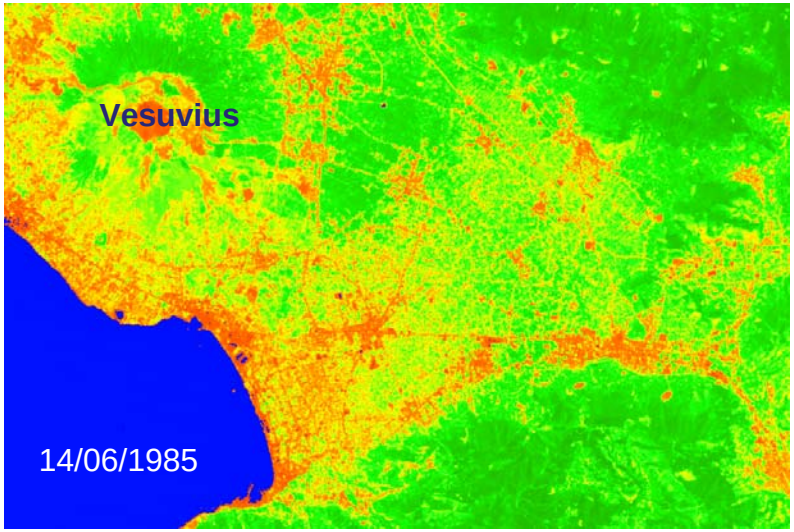

Before correction

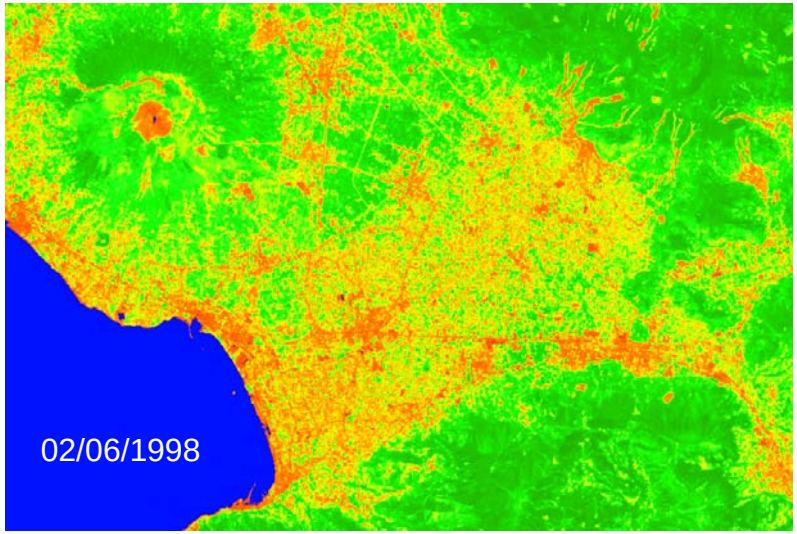


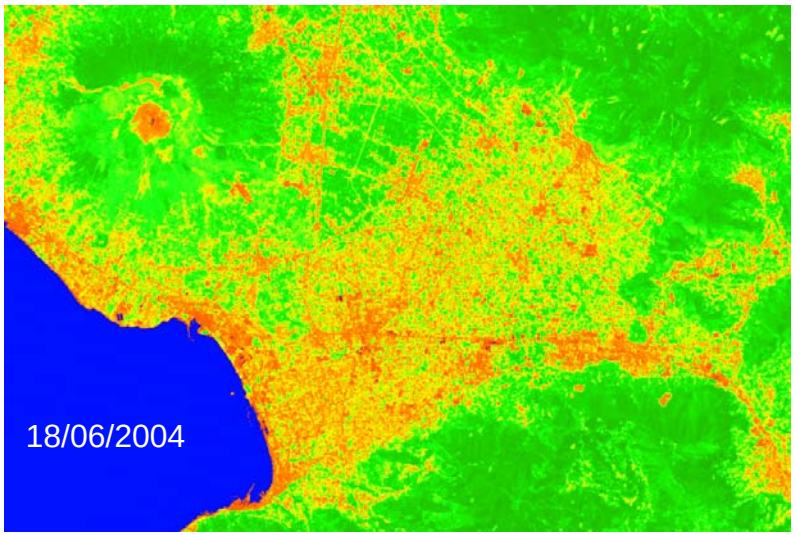

After




Adapted from Cuomo et al,. *J.Geophys. Res.* 106 (D16) 17863-17876 (2001

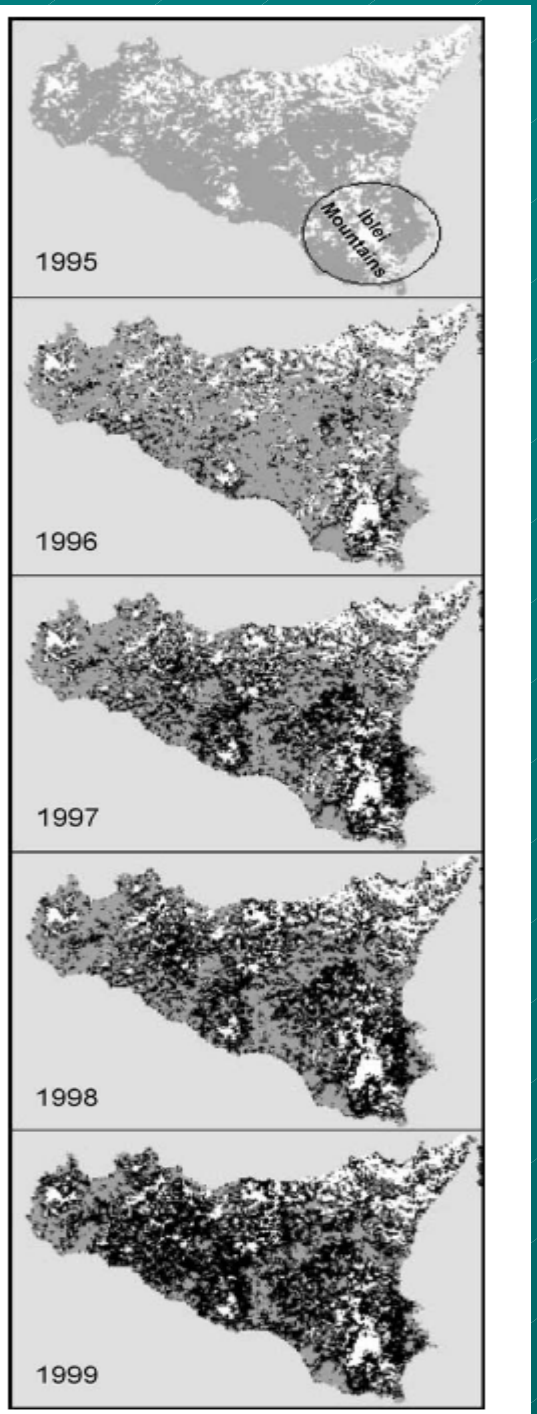



NDVI from Landsat data

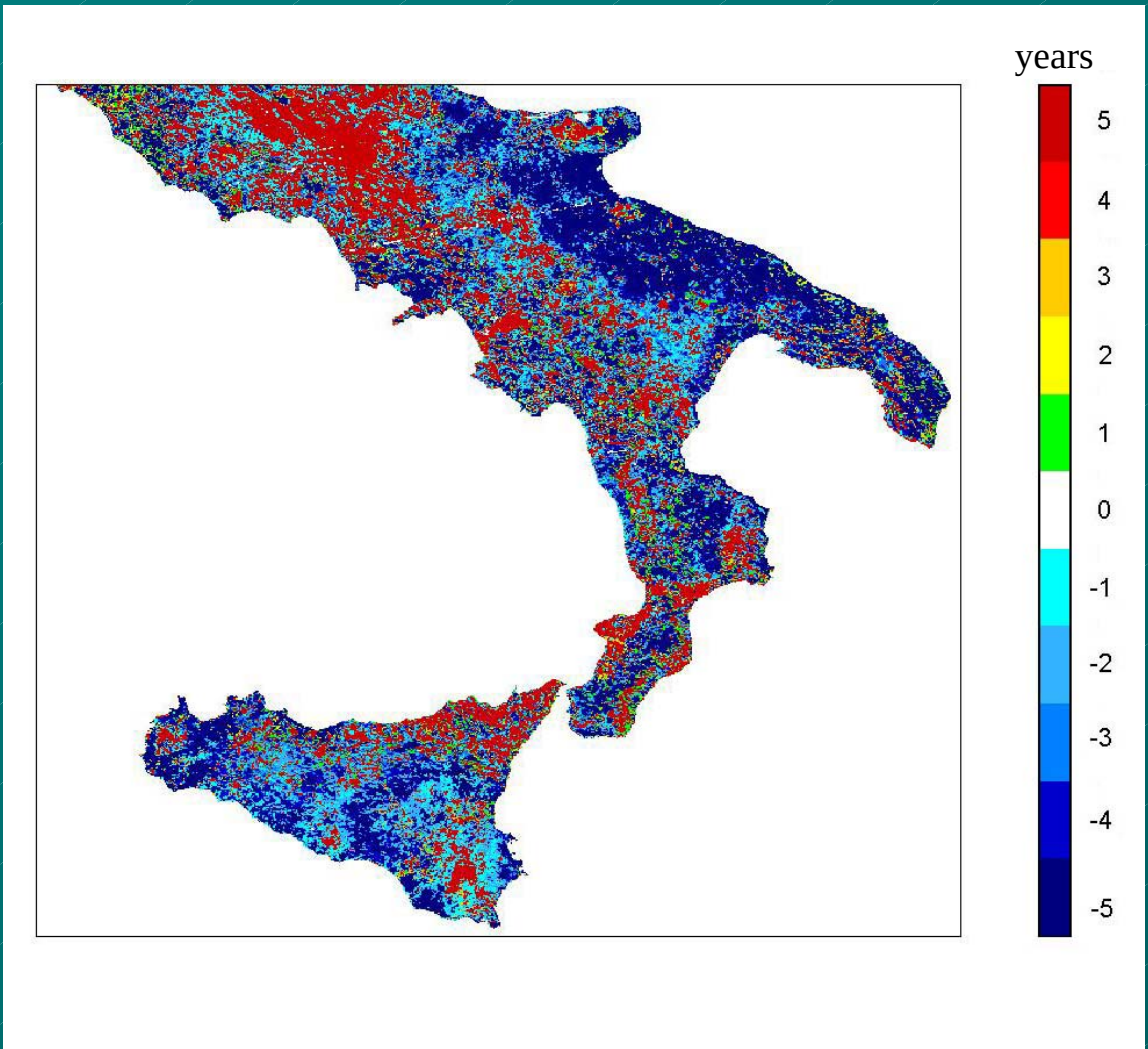
< 130 140 150 160 170 180 190 >200




Persistence maps per year relative to the island of Sicily. The colours white, grey, and black indicate survived positive trends, survived negative trends, and extinct trends, respectively.

By looking at black pixels, we can see how the trend extinction processes work. The size of black areas increases with time. During this expansion process, some thick clusters that resist to extinction over all the investigated period can be detected. This effect is particularly impressive over the positive area including the Iblei Mountains.

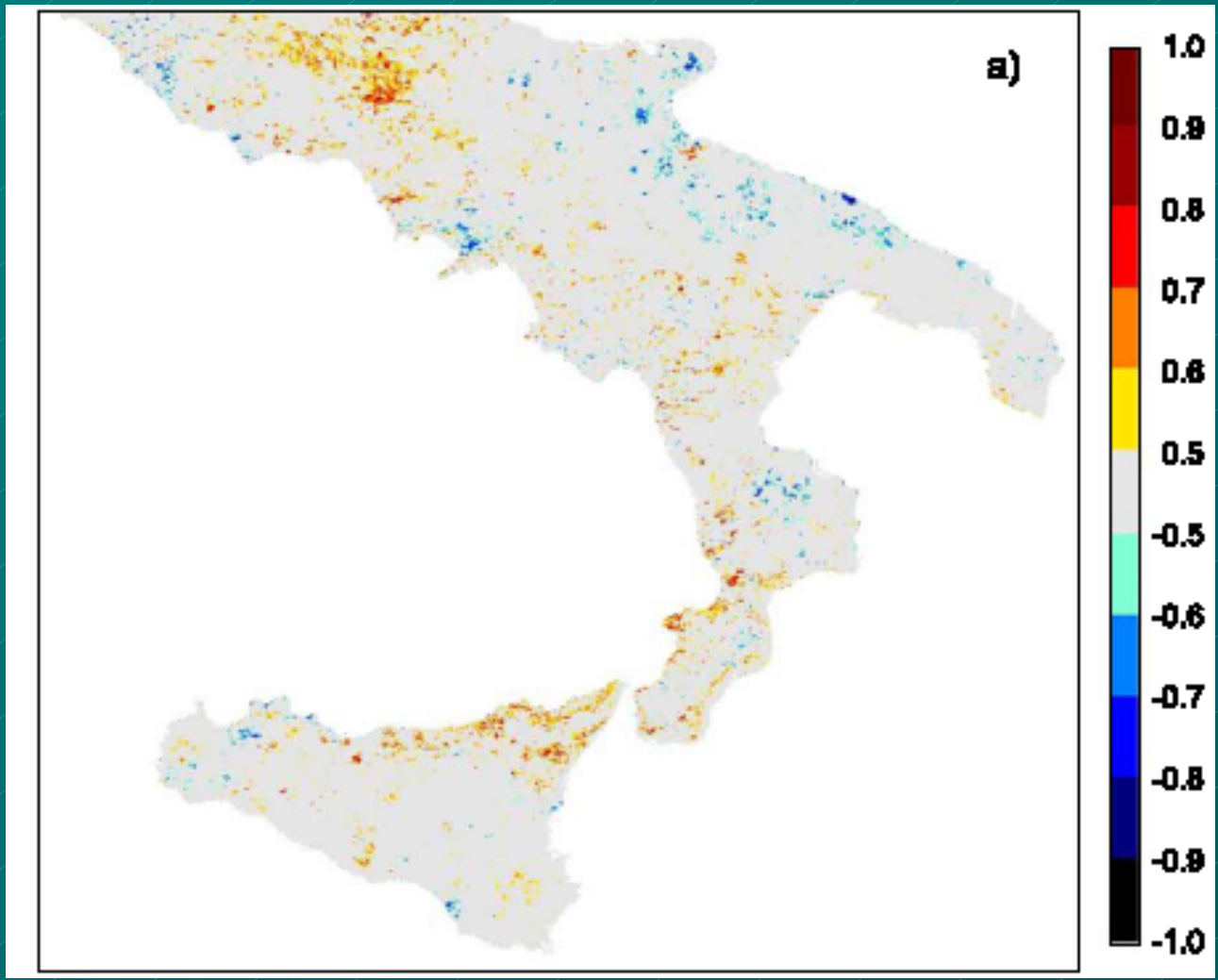
# Map of survived trends in the period 1995-1999




from: Lanfredi et al. *RSE*, **93,** 565–576 (2004)

# Intersection between trend and persistence analysis

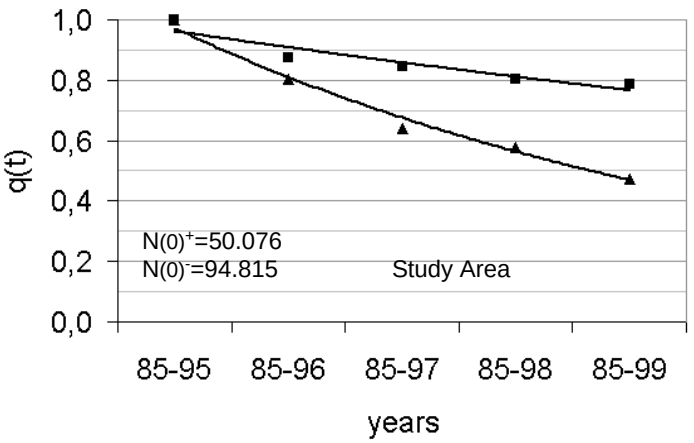
Absolute values greater than 0.5 indicate pixels where NDVI is changing with statistical confidence greater than 90%

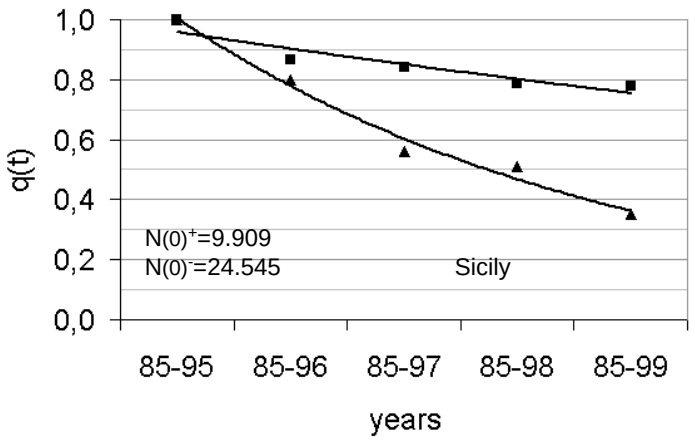


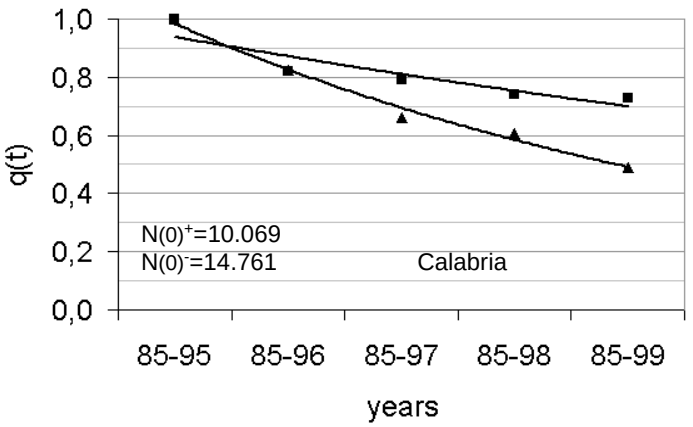

from: Lanfredi et al. *RSE*, **93,** 565–576 (2004)

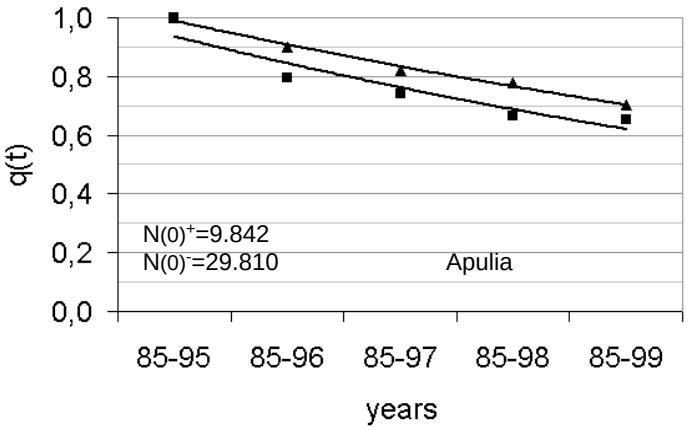
# Estimated persistence probability

Best fits are estimated according to exponential decay




from: Lanfredi et al. *RSE*, **93,** 565–576 (2004)

**Table 1.**

| | Positive trends | | Negative trends | |
|---|---|---|---|---|
| **Area** | $\tau$ | $R^2$ | $\tau$ | $R^2$ |
| Study area | 17.6 | 0.89 | 5.5 | 0.98 |
| Sicily | 16.5 | 0.87 | 4.0 | 0.98 |
| Calabria | 13.6 | 0.83 | 5.7 | 0.98 |
| Apulia | 9.7 | 0.89 | 11.7 | 0.98 |
| Background | 7.4 | 0.90 | 4.5 | 0.98 |
| **Land cover** | $\tau$ | $R^2$ | $\tau$ | $R^2$ |
| Forests | 20.5 | 0.80 | 5.8 | 0.98 |
| Maquis | 23.5 | 0.80 | 3.7 | 0.99 |
| Cultivated Areas | 15.0 | 0.92 | 5.7 | 0.98 |

Mean lifetimes (years) of NDVI trends over Southern Italy

from: Lanfredi et al. *RSE*, **93,** 565–576 (2004)