Space technologies for public administrations in charge of controls related to the eligibility of farmers for EU aids in agriculture

Copernicus for Local and Regional Authorities

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- The Common Agricultural Policy (CAP) implements a system of agricultural subsidies and other programs which represent about **40% of the EU's yearly budget.**

- To ensure that CAP funds are properly spent, each Member State is responsible for subsidy **administration and control**, which are done by a National Control and Paying Agency (NCPA). AGEA (Agenzia per le erogazioni in agricoltura) is the Italian NCPA.

- Farmers requiring EU financial support have to declare precise localization and crop type of their agricultural parcels.

- NCPA has to control at least 5% of those declarations and to find those farmers who submit incorrect information as well as those who are eligible for funding.

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Earth Observation Satellites may successfully support controls within the CAP context:
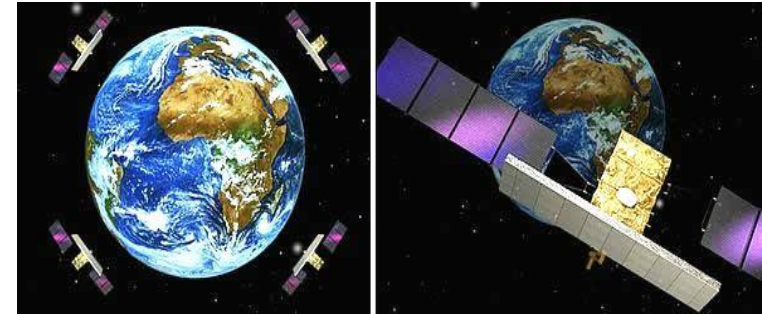
- when checks have to be done on **past situations** (physical inspections on site are useless);
- because it assures a more **complete coverage** of the areas to be checked;
- since it provides **frequent and continuous** observations;
- because it guarantees **multispectral** information.

Multi-spectral capability: Spectral signatures of different land covers

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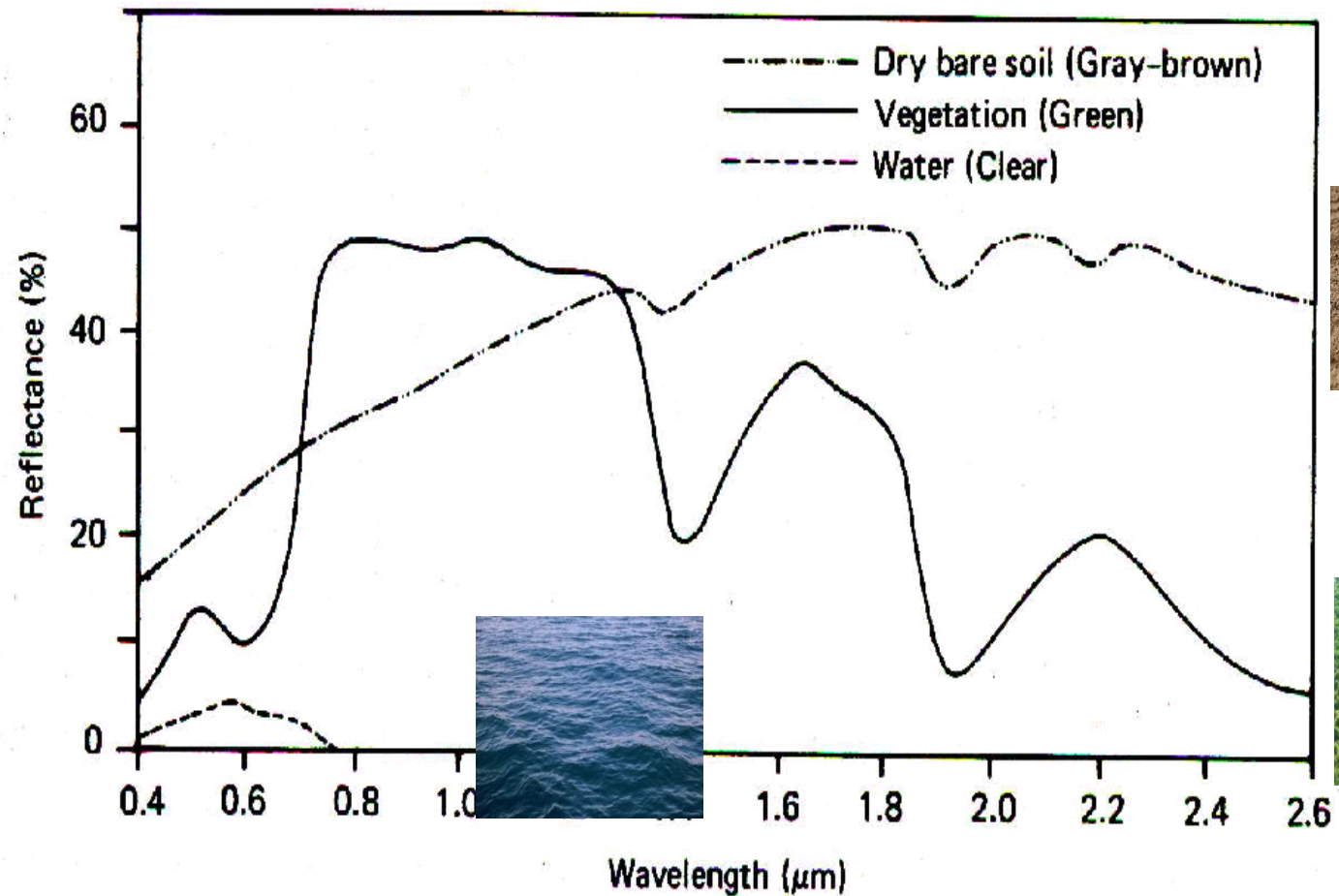
Spectral signatures of different kinds of **vegetation**:
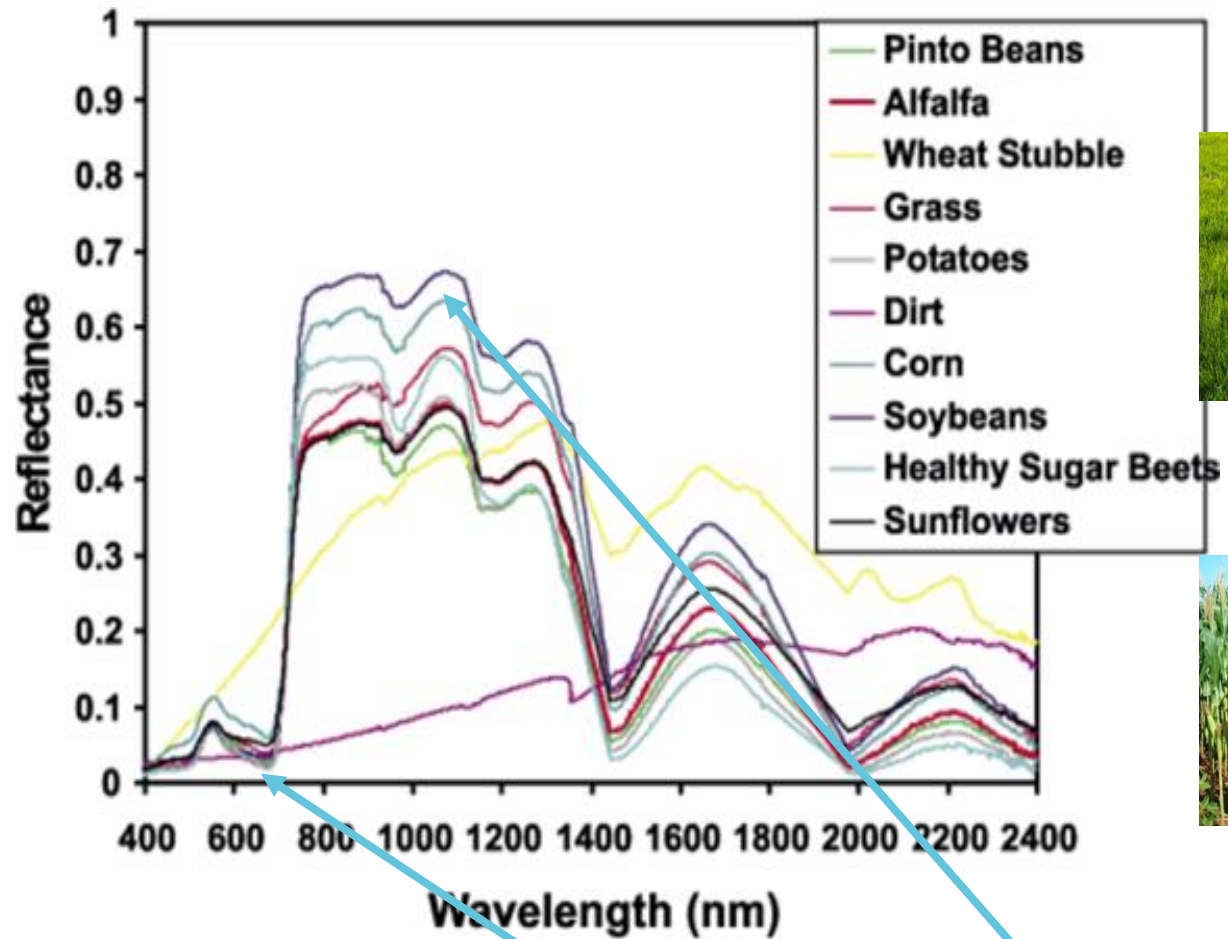


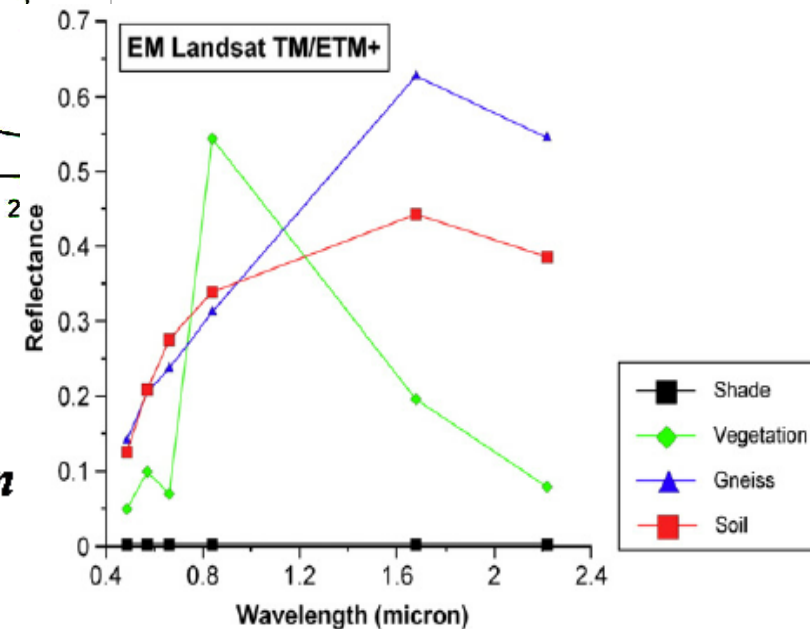**In general: low reflectivity in VIS, high reflectivity in NIR**

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**NDVI (*Normalized* Difference *Vegetation Index)*** is a "measure" of the vegetation (content, status, health, etc.) which is present within an image pixel. It is based on the measure of reflectance in VIS and NIR spectral regions
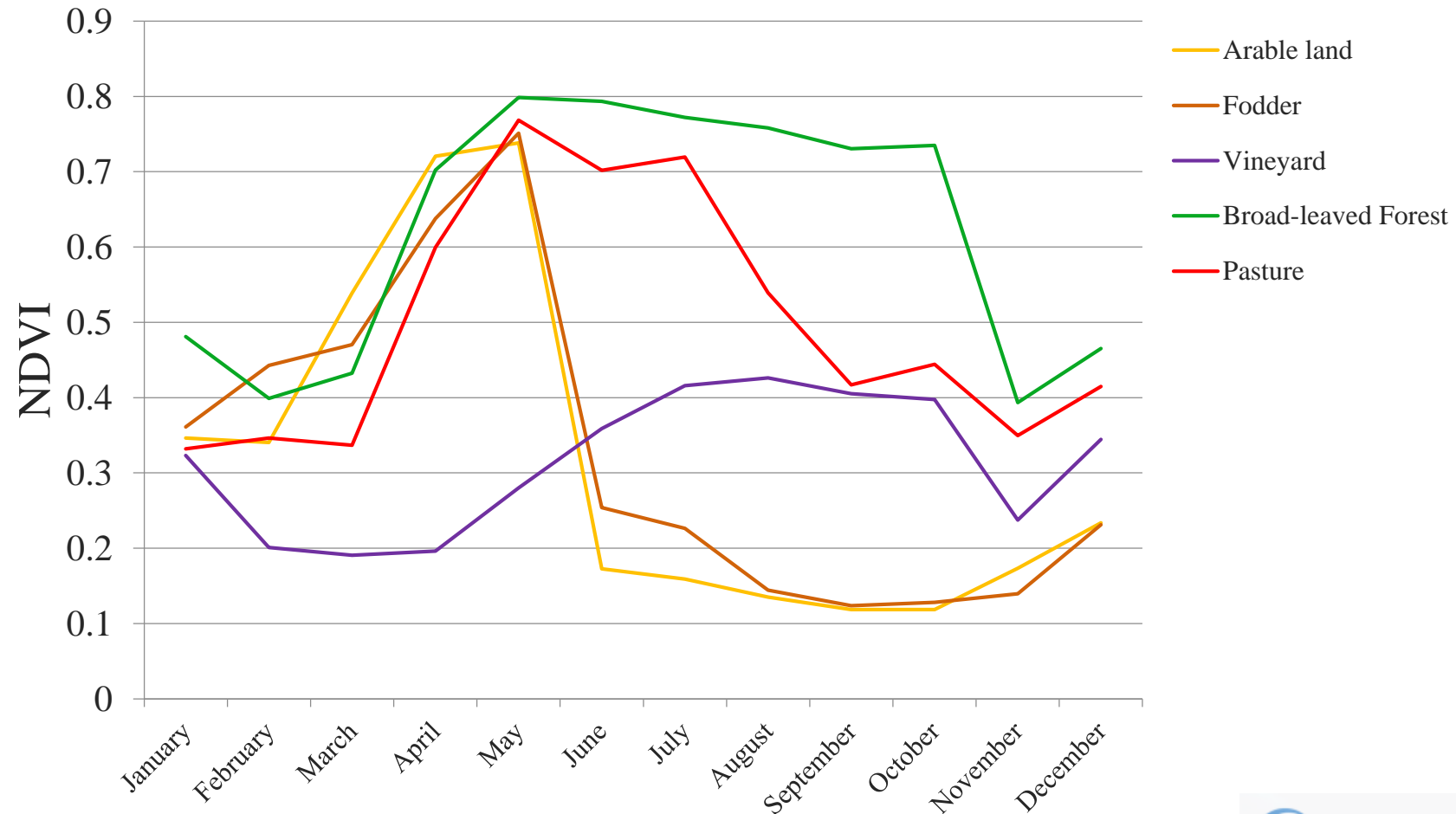
Multi-spectral EO systems may provide information about vegetation presence and status
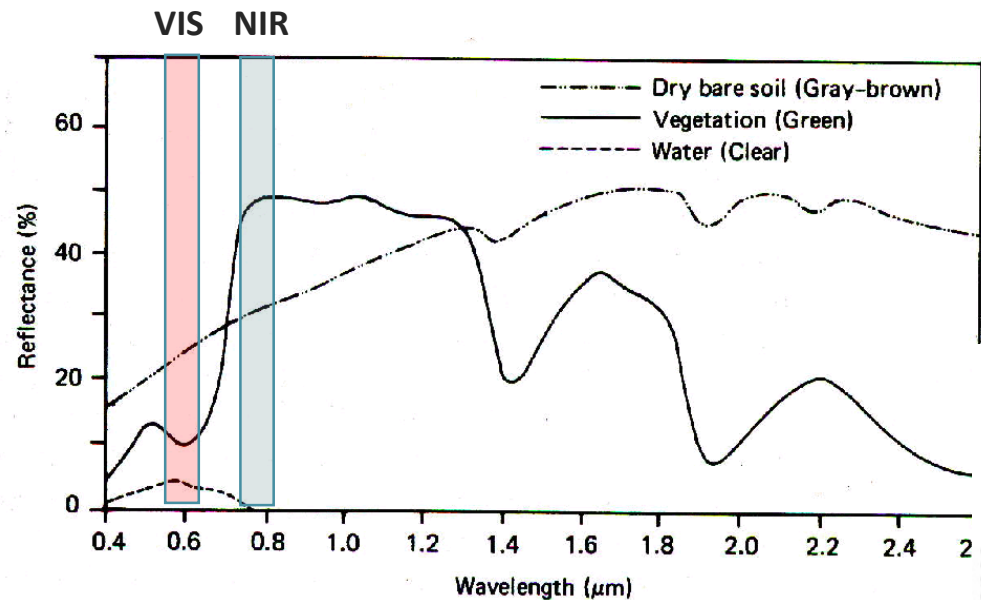
$$NDVI = \frac{R_{NIR} - R_{VIS}}{R_{NIR} + R_{VIS}} = \begin{cases} < 0 & water \\ \cong 0 & soil \\ > 0.4 - 0.8 & vegetation \end{cases}$$
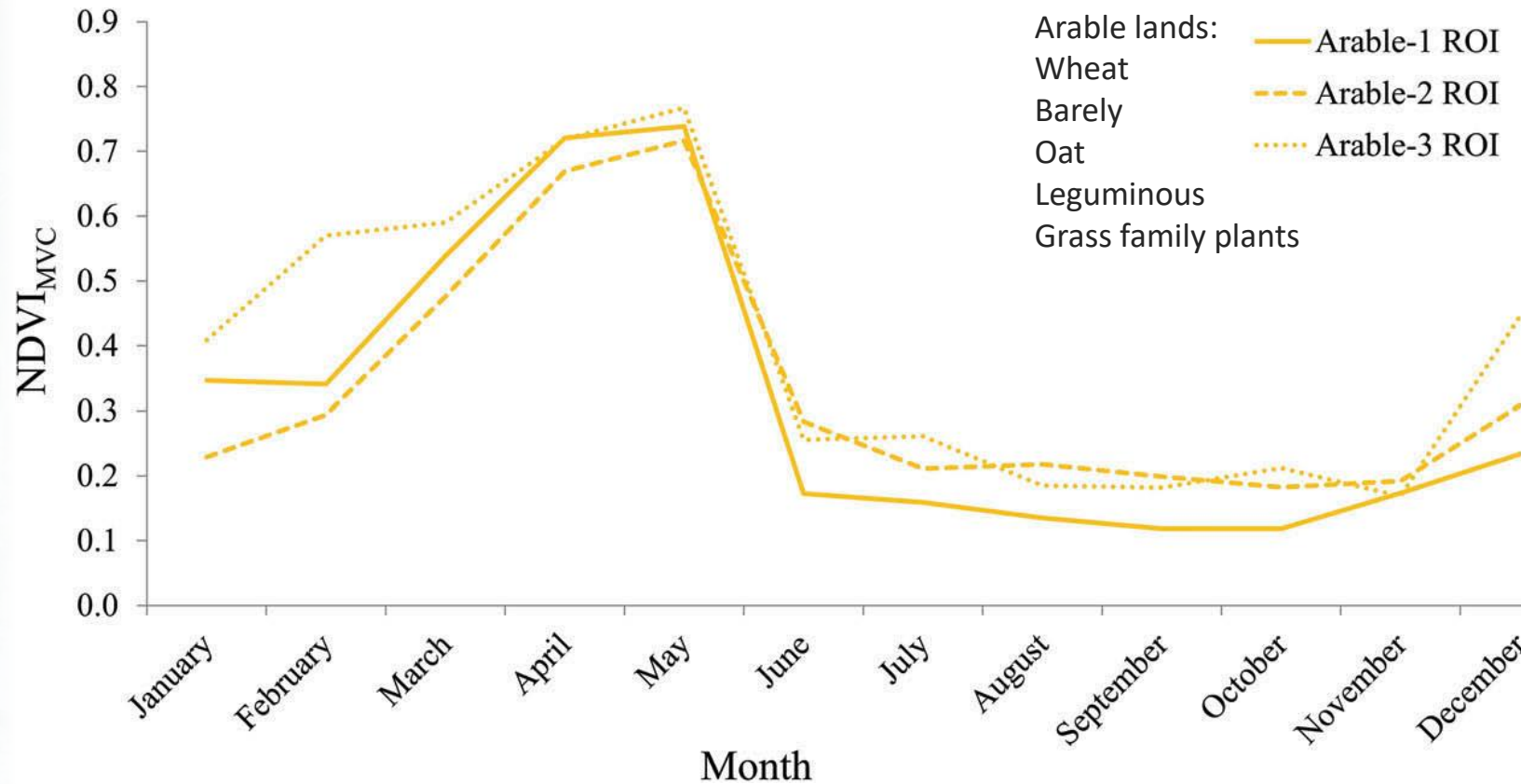
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Different vegetation types have typical NDVI **annual patterns** enabling to discriminate them by means of a multi-temporal analysis.

Different vegetation types have typical NDVI **annual patterns** enabling to discriminate them by means of a multi-temporal analysis.



Arable lands:
Wheat
Barely
Oat
Leguminous
Grass family plants

Arable-1 ROI
Arable-2 ROI
Arable-3 ROI

The difference in NDVI maps computed in two different periods will help to **distinguish arable from non-arable lands** (the **Te**mporal **N**DVI **D**ifference - TeND index):

$$TeND(x,y,t_1,t_2) = NDVI(x,y,t_1) - NDVI(x,y,t_2)$$
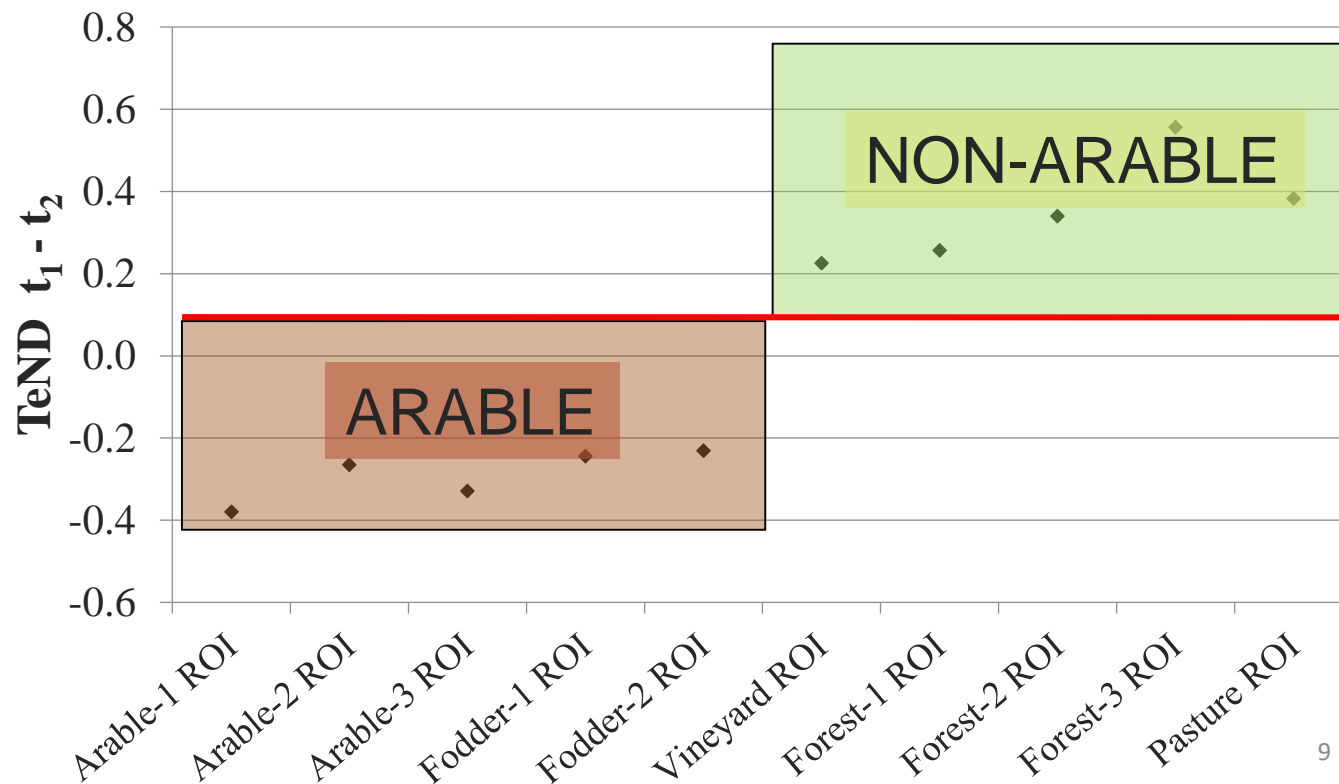


Filizzola et al. 2017, IJRS, submitted.

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- Basilicata Regional Authority activated the Council Reg. 2078/1992 through a local program approved by the European Commission. The program was based on six 'measures' aiming at protecting environment, defending public health, and guaranteeing farmers adequate incomes by:

  – reducing the use of polluting vehicles;

  – extensification of grass, arboreal, and zootechnical productions in order to reduce overproductions;

  – set-aside (no use for twenty years) to restore hydro-geological balance of the main basins.

Basilicata farmers actively participated to the EU program, with a large participation of farms (4162) and about 78000 ha of land interested.

In recent years, the Italian NCPA (AGEA) suspected **frauds**. Unfortunately, many of suspected applications referred to parcel situations for which only ortho-photos taken were available. In order to take a decision, **ortho-photo interpretations were not possible or not sufficient**, thus a working group was specifically established by Basilicata Region **required to provide an independent method to verify that some areas were actually 'arable lands' before farmers' applications for EU contributions**, as requested by the Council Reg. n. 2078/1992.

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**Landsat** data (30m spatial resolution 16 days temporal repetition rate), have been used because they offer a historical archive availability as long as 30+ years to identify and monitor land cover changes during the last decades.



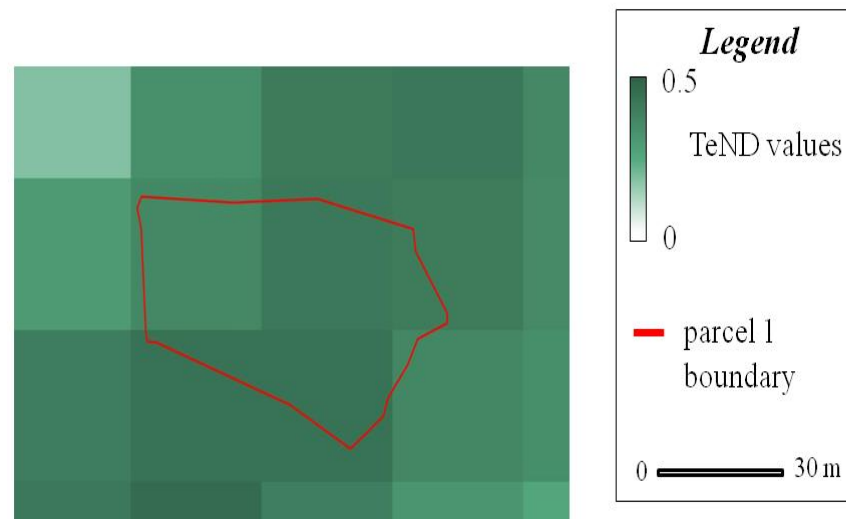| Landsat-7 ETM+ Bands (µm) | | | Landsat-8 OLI and TIRS Bands (µm) | | |
|---|---|---|---|---|---|
| | | | 30 m Coastal/Aerosol | 0.435 - 0.451 | Band 1 |
| Band 1 | 30 m Blue | 0.441 - 0.514 | 30 m Blue | 0.452 - 0.512 | Band 2 |
| Band 2 | 30 m Green | 0.519 - 0.601 | 30 m Green | 0.533 - 0.590 | Band 3 |
| Band 3 | 30 m Red | 0.631 - 0.692 | 30 m Red | 0.636 - 0.673 | Band 4 |
| Band 4 | 30 m NIR | 0.772 - 0.898 | 30 m NIR | 0.851 - 0.879 | Band 5 |
| Band 5 | 30 m SWIR-1 | 1.547 - 1.749 | 30 m SWIR-1 | 1.566 - 1.651 | Band 6 |
| Band 6 | 60 m TIR | 10.31 - 12.36 | 100 m TIR-1 | 10.60 – 11.19 | Band 10 |
| | | | 100 m TIR-2 | 11.50 – 12.51 | Band 11 |
| Band 7 | 30 m SWIR-2 | 2.064 - 2.345 | 30 m SWIR-2 | 2.107 - 2.294 | Band 7 |
| Band 8 | 15 m Pan | 0.515 - 0.896 | 15 m Pan | 0.503 - 0.676 | Band 8 |
| | | | 30 m Cirrus | 1.363 - 1.384 | Band 9 |
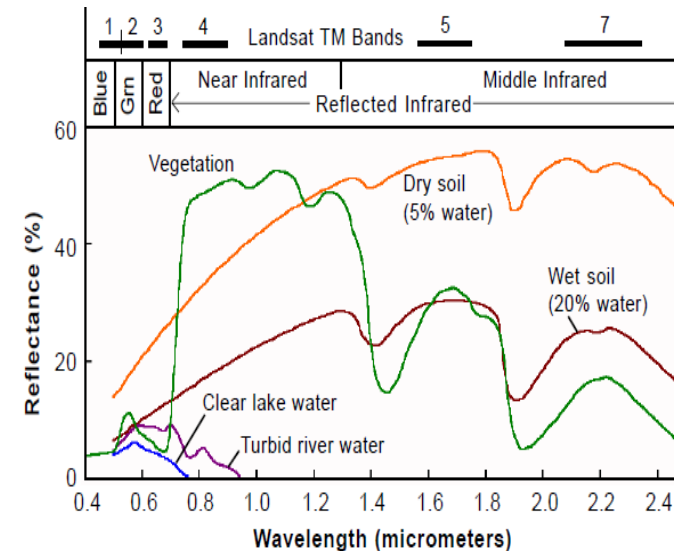
Earth Observation data supported Basilicata Region, Department of Agriculture, to take decisions about local farmers' EU funds eligibility
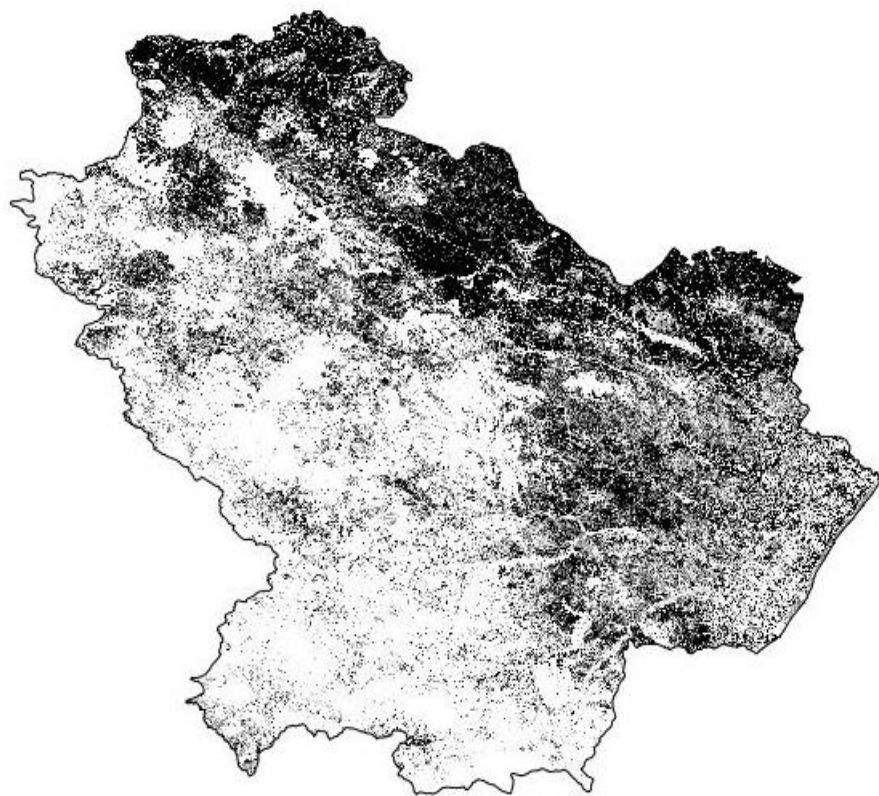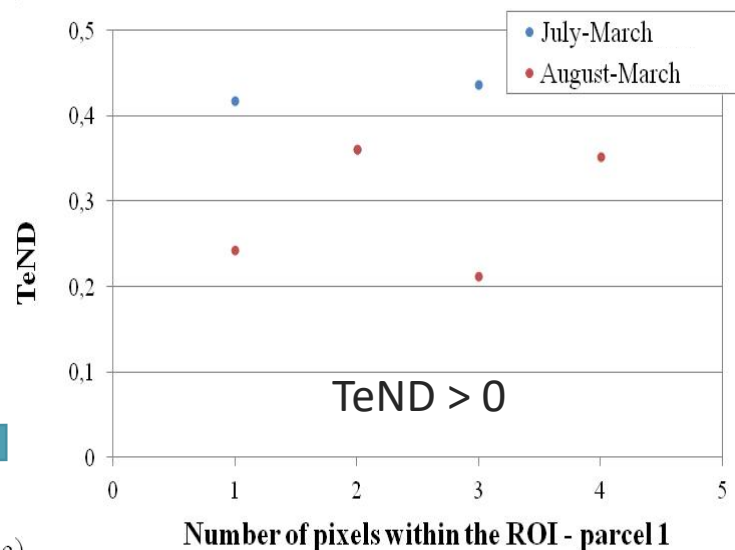


■ Arable lands

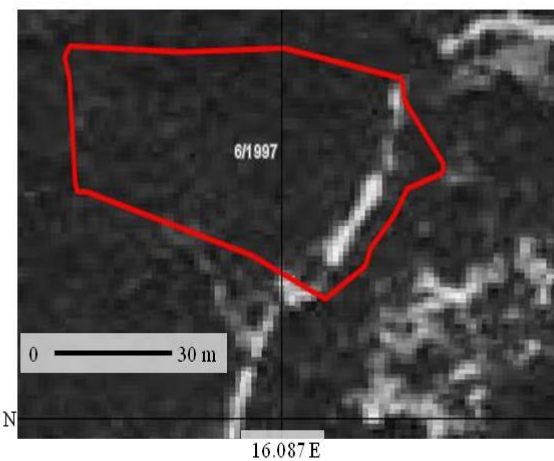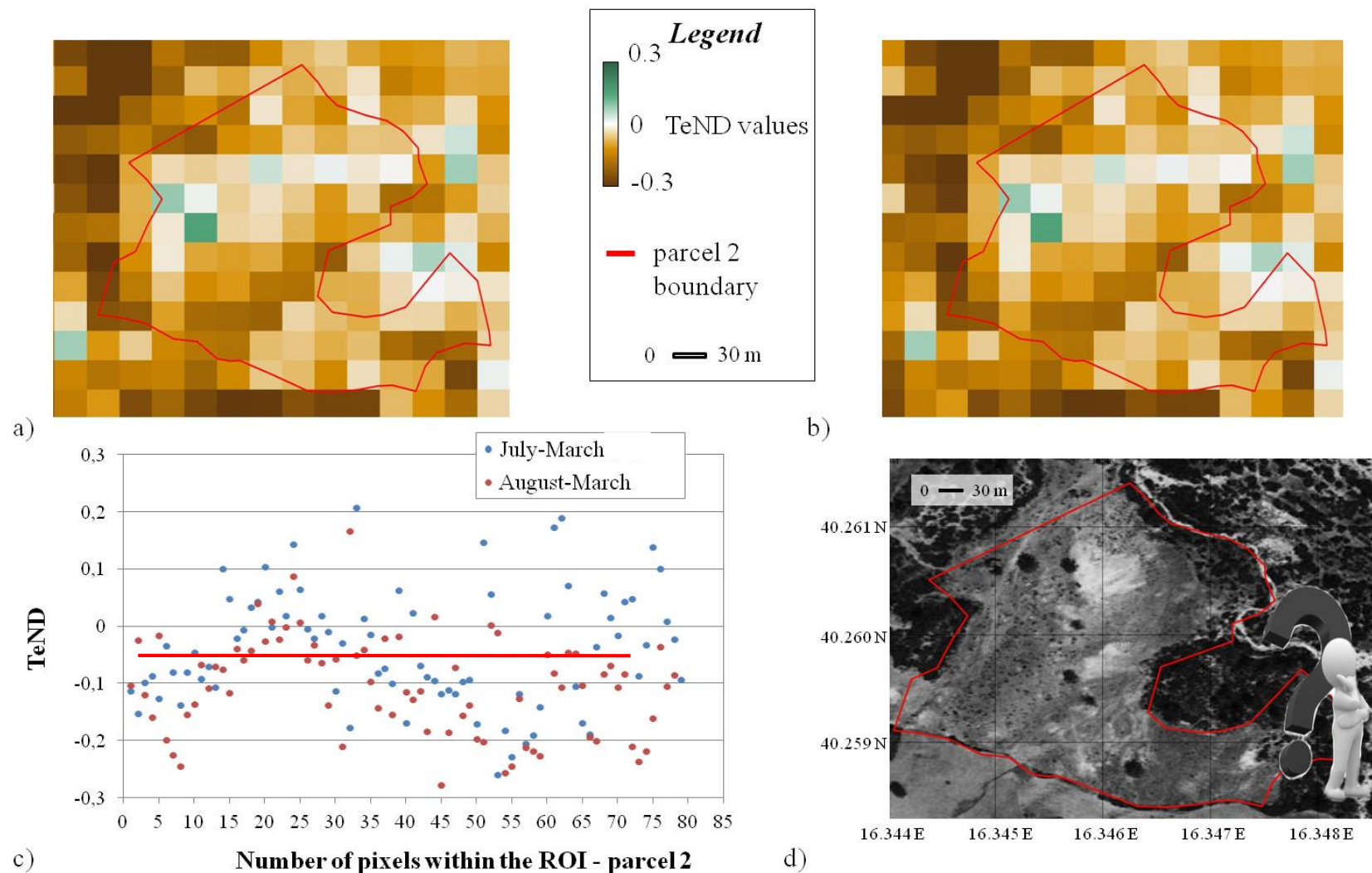□ Non-arable lands
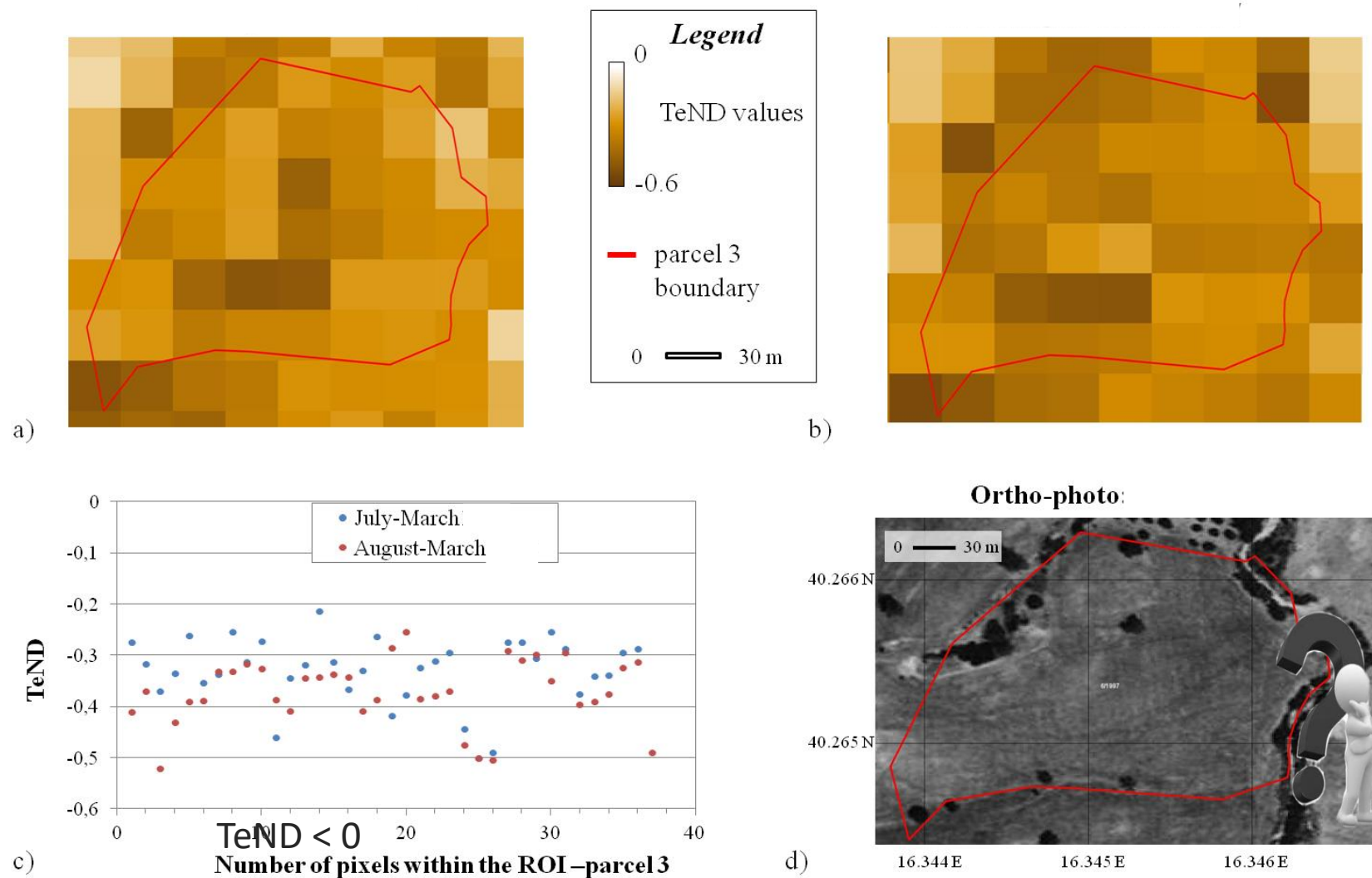
Example of a TeND map (1997)

Satellite imagery analysis confirmed the presence of non arable lands (forests)

a)

b)

c)

d)

**Satellite imagery analysis confirmed the coexistence of arable and non-arable lands**

Legend
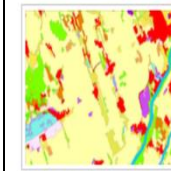
0

TeND values

-0.6

— parcel 3 boundary

0 ▭ 30 m

a)

b)

c)

- July-March
- August-March

TeND

TeND < 0

Number of pixels within the ROI –parcel 3

Ortho-photo

d)

**Satellite imagery analysis suggested the presence of arable lands only**

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**Validation with Corine Land Cover (CLC)**

| CLC classes | | Number of points of the two grids [A] | No data [B] | Number of points with actual TeND values [A-B] | Correctly identified by TeND [C] | [C]/[A-B] % | NOT correctly identified by TeND [D] | [D]/[A-B] % |
|---|---|---|---|---|---|---|---|---|
| Arable land | 211 | 876 | 207 | 669 | 548 | **82%** | 121 | **18%** |
| | 212 | 0 | 0 | 0 | 0 | | 0 | |
| | 213 | 0 | 0 | 0 | 0 | | 0 | |
| Non-arable (all other classes) | | 1452 | 480 | 972 | 665 | **68%** | 307 | **32%** |
| TOT | | 2328 | 687 | 1641 | 1213 | **74%** | 428 | **26%** |

**An overall accuracy of ~75% has been achieved for the Basilicata territory**

CORINE Land Cover
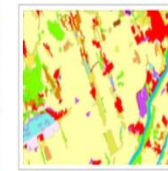
CLC 1990    CLC 2000    CLC 2006
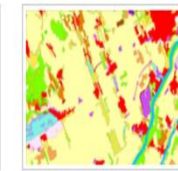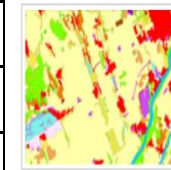
CLC 2012    LCC 1990-2000    LCC 2000-2006

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The here presented methodology was designed by University of Basilicata and implemented by Geospazio Italia srl.

The TeND index is basically independent from the specific satellite data.

The same approach can be easily exported over new generation satellite images, such as data acquired by the **Multi-Spectral Instrument (MSI) onboard Sentinel-2**.

Sentinel-2a is already orbiting around Earth
and has been operational since June 2015.

**Sentinel-2b has been successfully launched on March 7, this year and is now operational!**

Weekly image
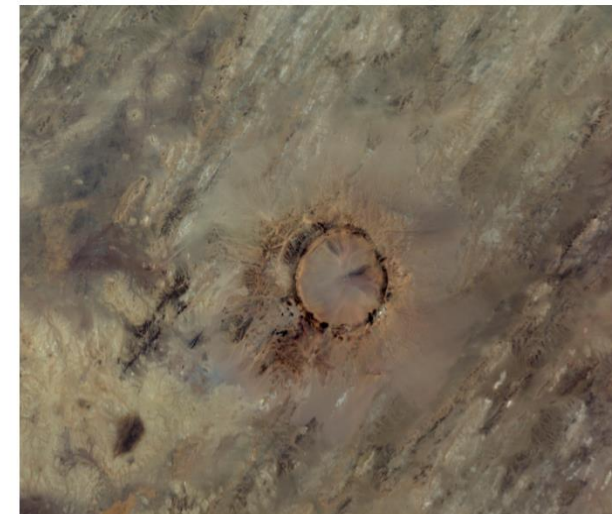


*Mauretania Crater, 6 June 2017*

**EU-ESA Mission Status Report 91, 3-10 June 2017**

Benefits from the use of **Multi-Spectral Instrument (MSI) onboard Sentinel-2** may be expected for this application especially because it is characterized by:

- a 10-day revisit time (**5 days** after the launch of Sentinel-2b) which could allow having a larger number of cloud-free images over the area of interest and more accurate NDVI maps;
- a higher spatial resolution (**10/20 m**) that can enable to identify smaller areas with arable lands.



| | Spatial Res. | Temporal Res. |
|---|---|---|
| **LANDSAT** | 30 m | 16 days |
| **SENTINEL-2** | 10 m | 5 days |

| Sentinel-2 Bands | Central Wavelength (μm) | Resolution (m) |
|---|---|---|
| Band 1 - Coastal aerosol | 0.443 | 60 |
| Band 2 - Blue | 0.490 | 10 |
| Band 3 - Green | 0.560 | 10 |
| Band 4 - Red | 0.665 | 10 |
| Band 5 - Vegetation Red Edge | 0.705 | 20 |
| Band 6 - Vegetation Red Edge | 0.740 | 20 |
| Band 7 - Vegetation Red Edge | 0.783 | 20 |
| Band 8 - NIR | 0.842 | 10 |
| Band 8A - Vegetation Red Edge | 0.865 | 20 |
| Band 9 - Water vapour | 0.945 | 60 |
| Band 10 - SWIR - Cirrus | 1.375 | 60 |
| Band 11 - SWIR | 1.610 | 20 |
| Band 12 - SWIR | 2.190 | 20 |

The European Commission produced a short **video tutorial**, briefly describing this EO-based use case for Local and Regional Authorities and practically showing how implementing it within common ICT tools (e.g. Qgis). The video, made with the contribution of NEREUS, is now available on-line at:

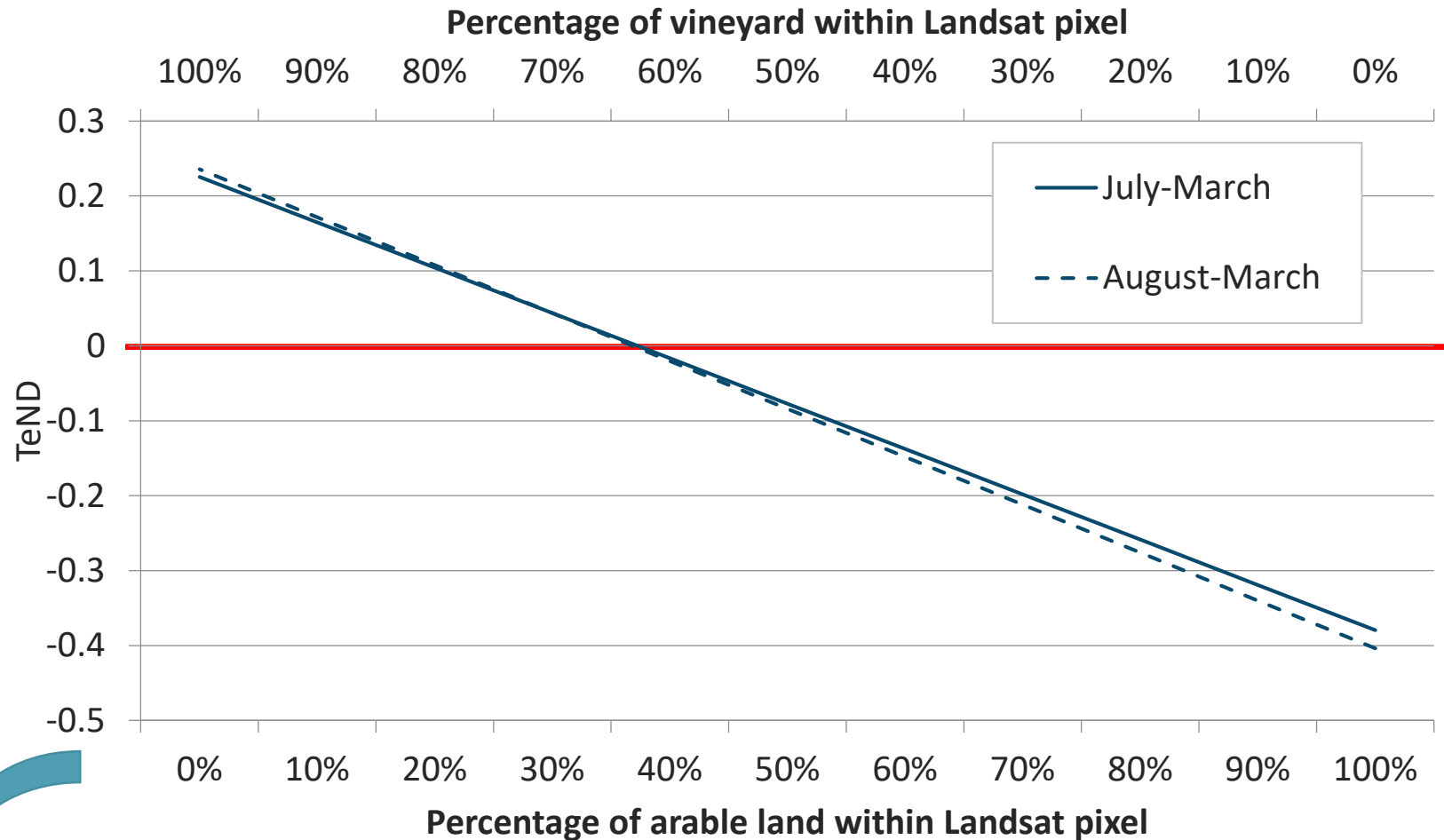https://www.youtube.com/
watch?v=9Fd1yNobCGw
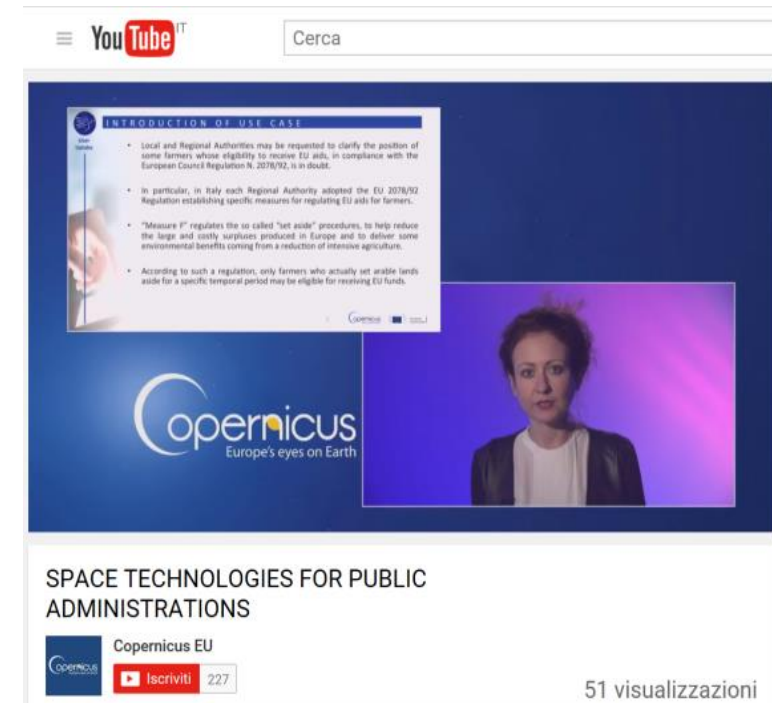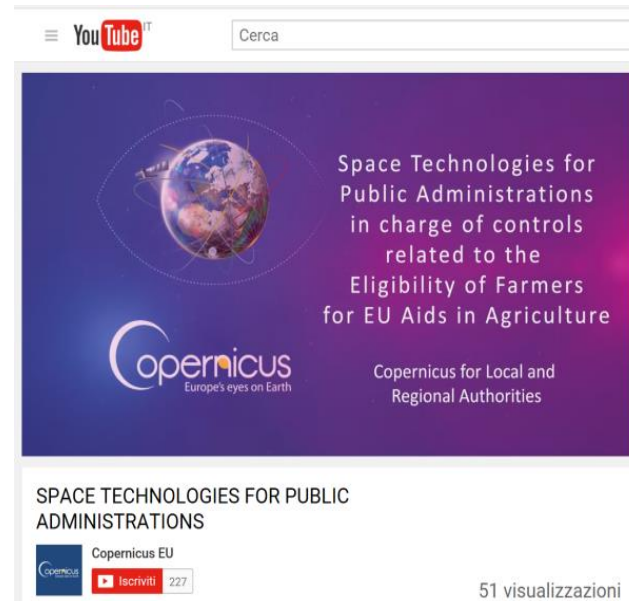
THANKS FOR YOUR ATTENTION

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**Percentage of vineyard within Landsat pixel**

A minimum percentage of ~35% of arable land within the LANDSAT pixel is required for the methodology to sucseed (for a two component pixel)