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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INTRODUCTION OF USE CASE

- 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.

INTRODUCTION OF USE CASE

Earth Observation Remote sensing 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.

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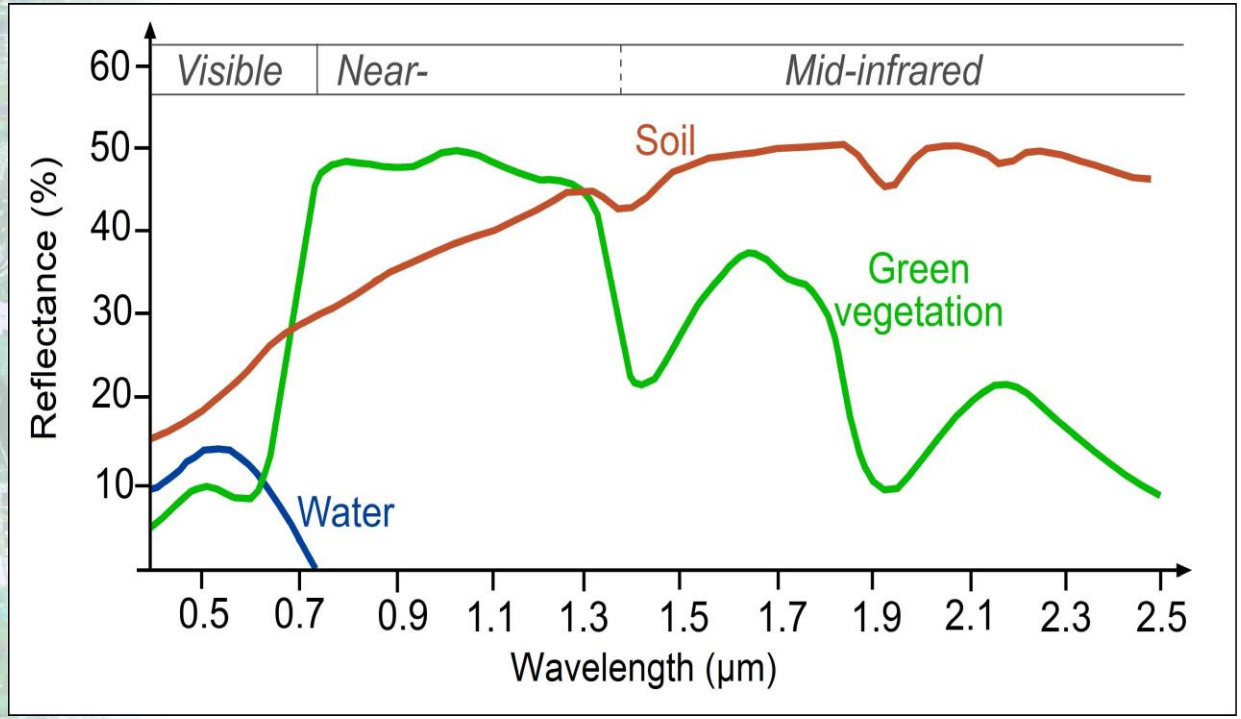
Multi-spectral capability: Spectral signatures of different land covers

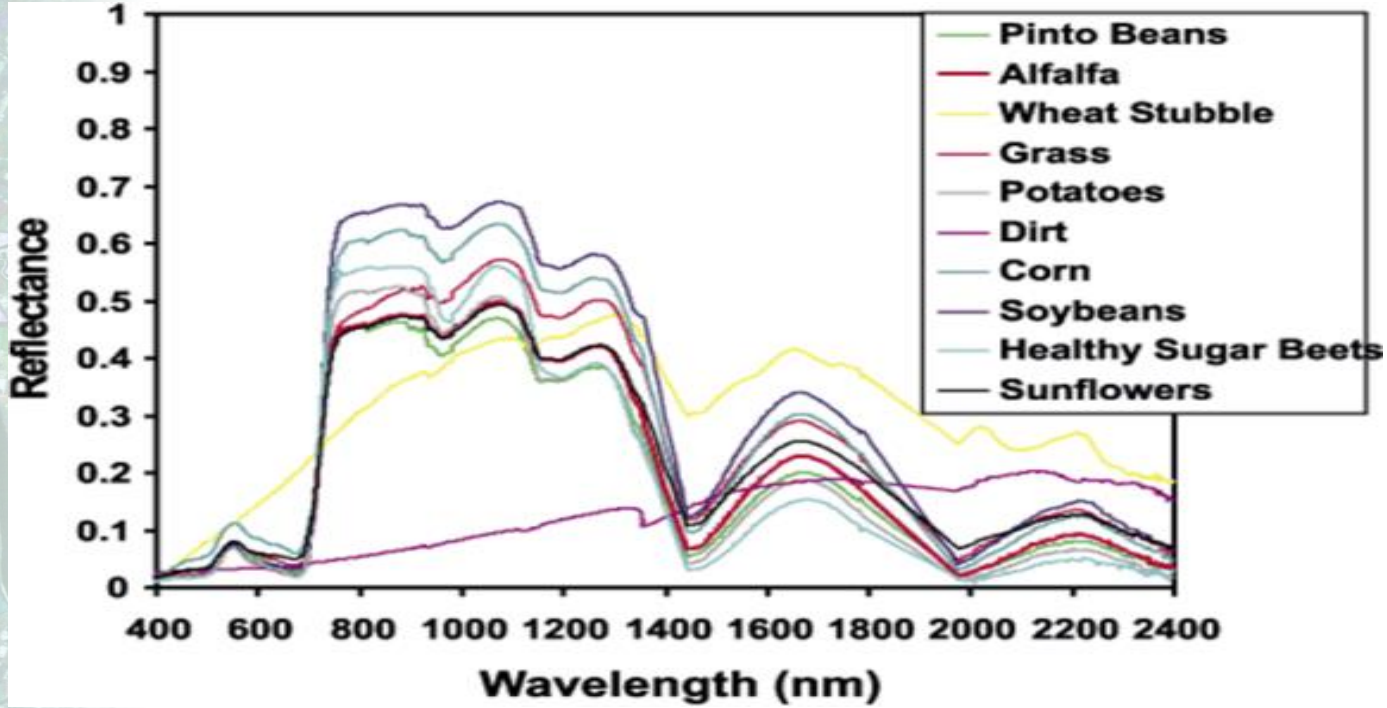


What is a Spectral Signature?

It is the variation of reflectance or emittance of a material respect to the wavelengths.

USE CASE: FACTS

Spectral signatures of different kinds of vegetation:



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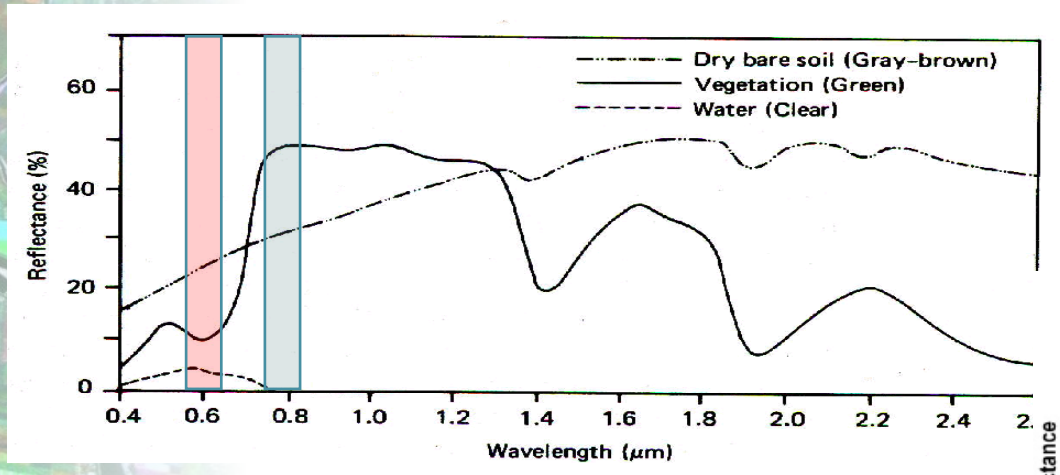
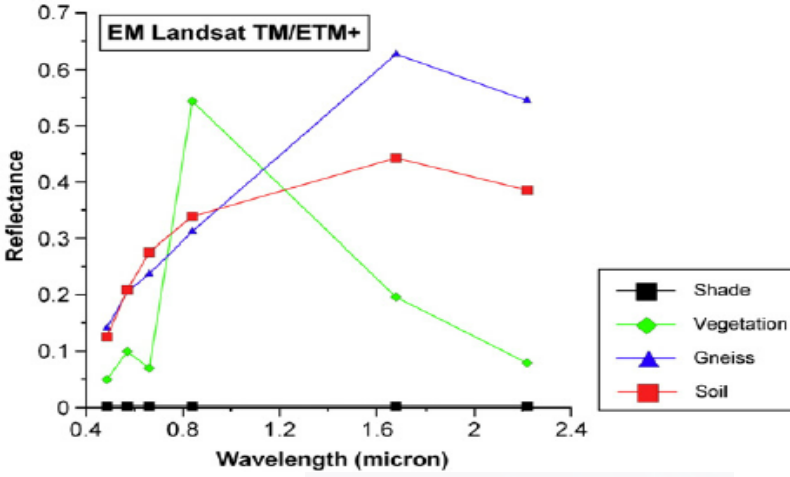
NDVI (*Normalized* Difference *Vegetation Index)* is a "measure" of the vegetation (content, status, health, etc.) which is present within an image pixel.



$$NDVI = \frac{R_{NIR} - R_{VIS}}{R_{NIR} + R_{VIS}}$$

$$NDVI = \frac{R_{NIR} - R_{VIS}}{R_{NIR} + R_{VIS}} = \begin{cases} < 0 & water \\ \cong 0 & soil \\ > 0.4 - 0.8 & vegetation \end{cases}$$



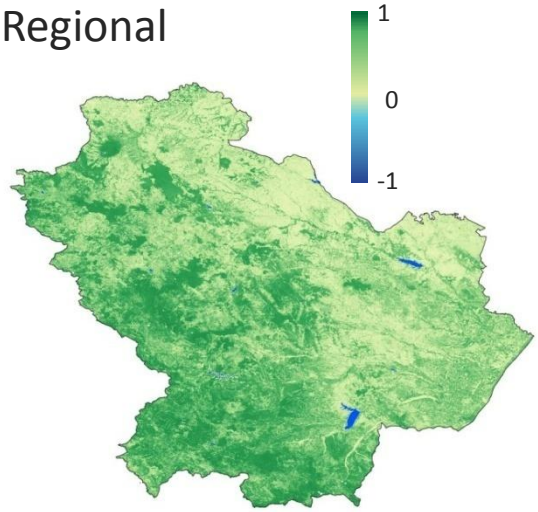
MONITORING VEGETATION FROM SPACE

$$NDVI(x,y,t) = \frac{R_{NIR}(x,y,t) - R_{VIS}(x,y,t)}{R_{NIR}(x,y,t) + R_{VIS}(x,y,t)}$$

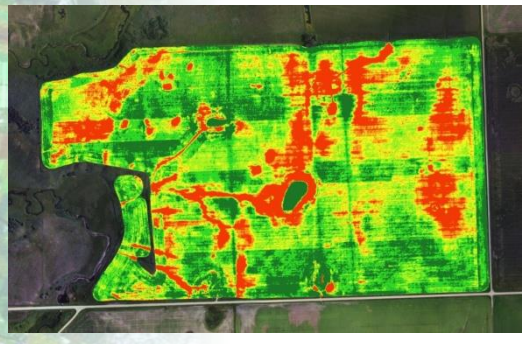
Useful at different spatial scales

National

Regional

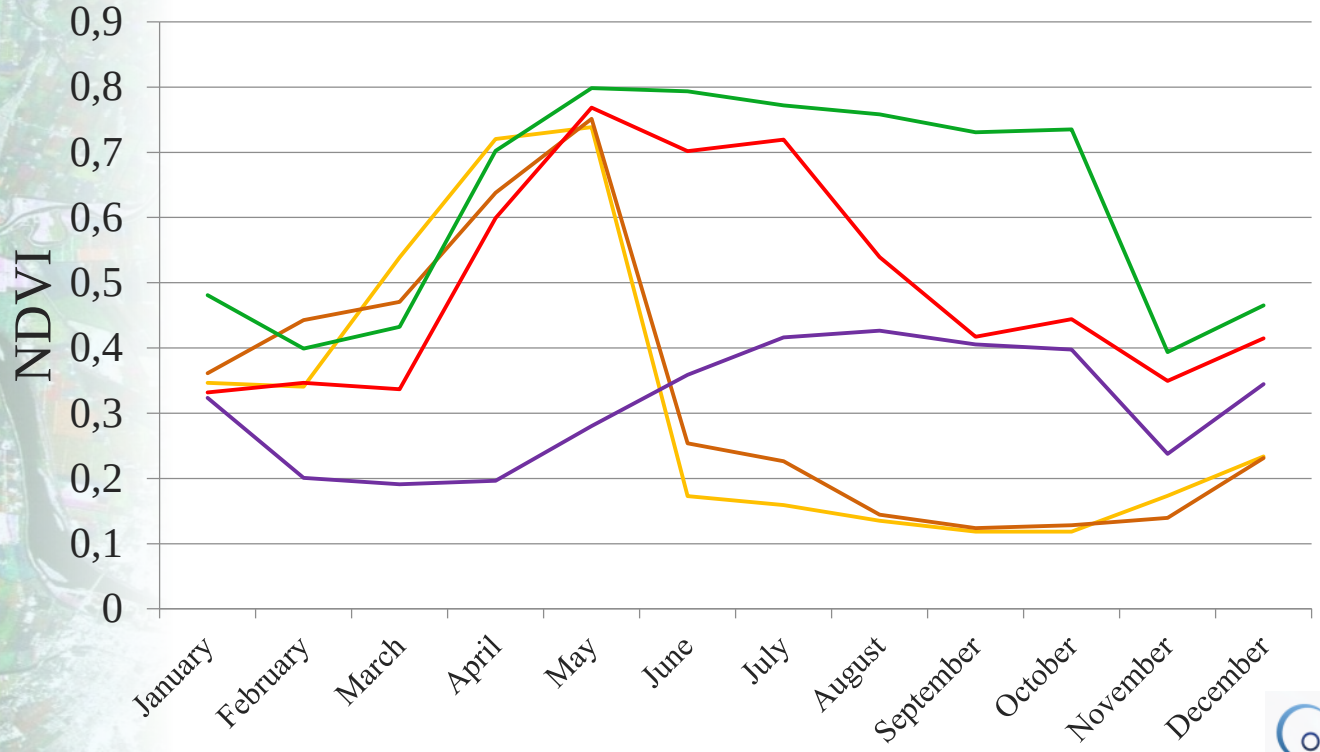


Local



USE CASE: METHODOLOGY

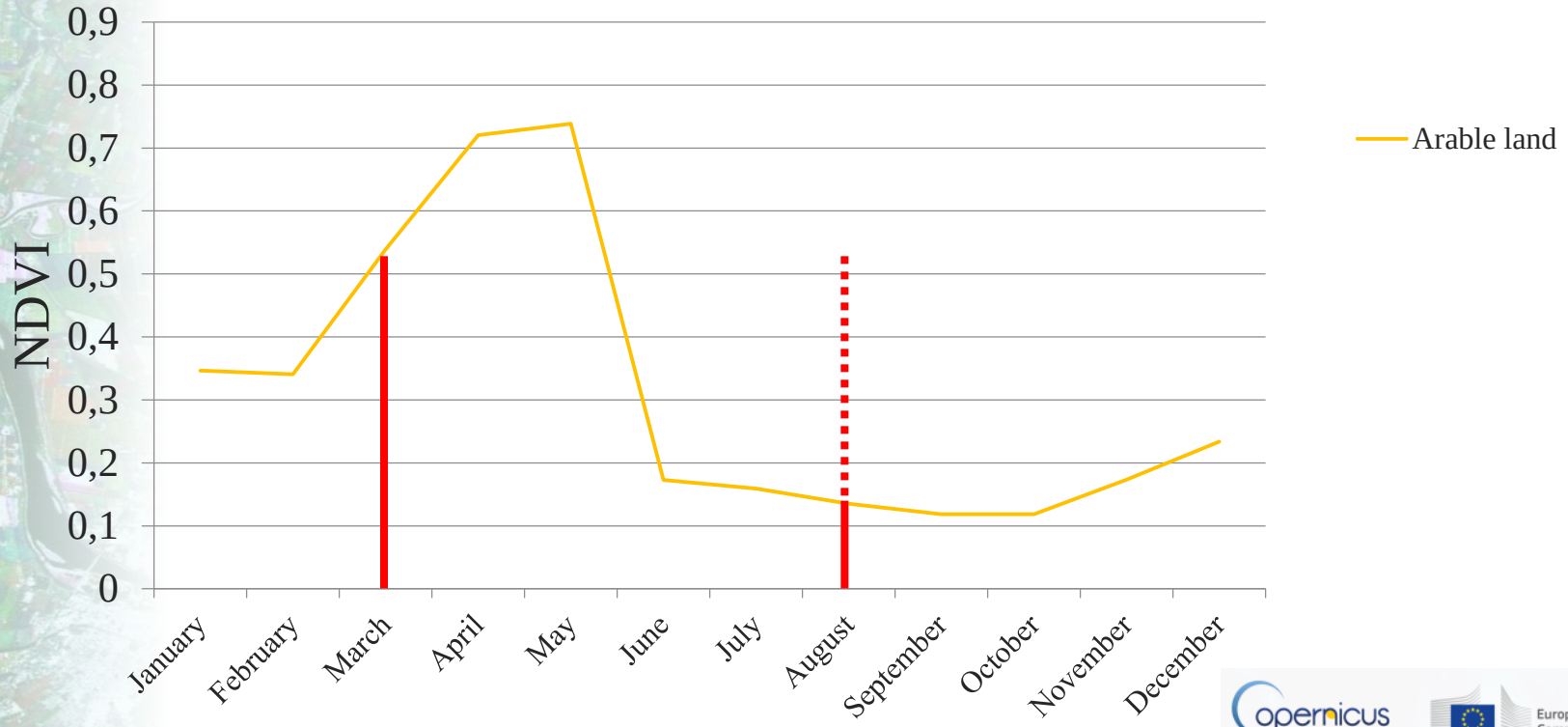
Different vegetation types have typical NDVI **annual patterns** enabling to discriminate them by means of a multi-temporal analysis.



MVC is the greater value of the NDVI in a time slot.

USE CASE: METHODOLOGY

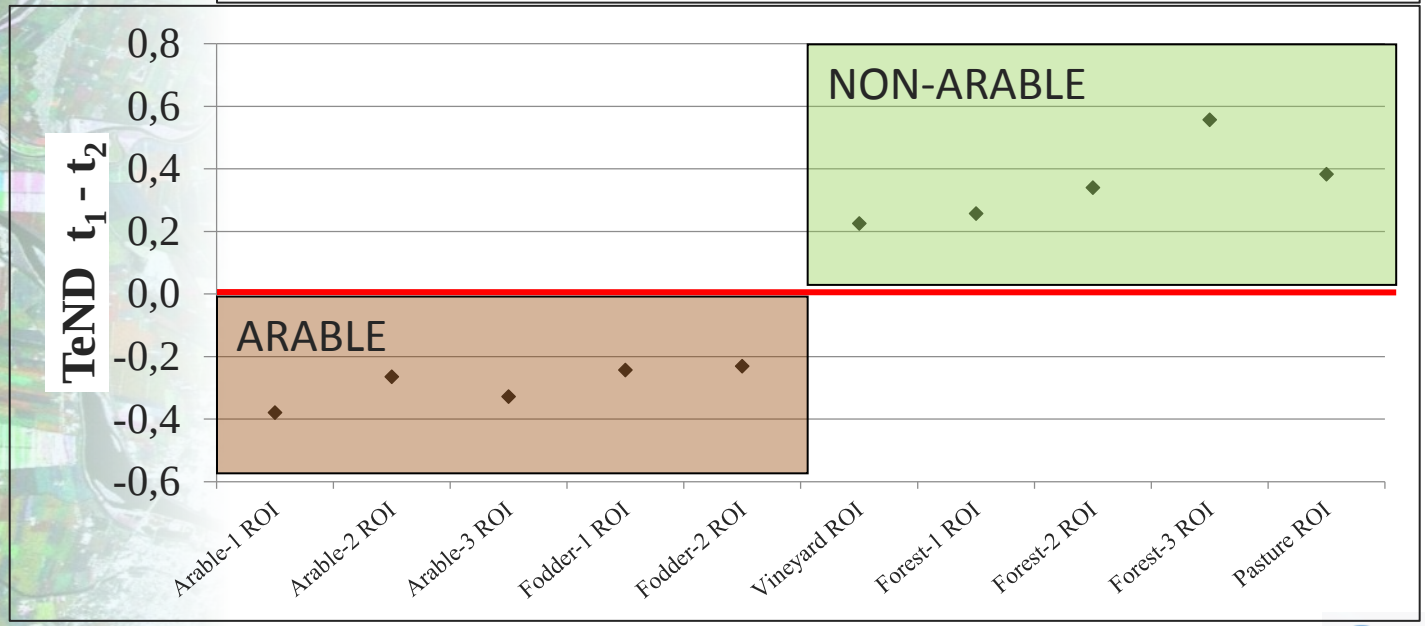
Different vegetation types have typical NDVI **annual patterns** enabling to discriminate them by means of a multi-temporal analysis.



USE CASE: METHODOLOGY

The difference in NDVI maps computed in two different periods will help to **distinguish arable from non-arable lands** (the Temporal NDVI Difference TeND – index):

$$TeND(x,y,t_1,t_2) = NDVI_{MVC}(x,y,t_1) - NDVI_{MVC}(x,y,t_2)$$



USE CASE: TEST AREA
Basilicata region (Southern Italy)

Basilicata activated the Council Reg. 2078/1992 through a local program approved by the European Commission in 1994. 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.

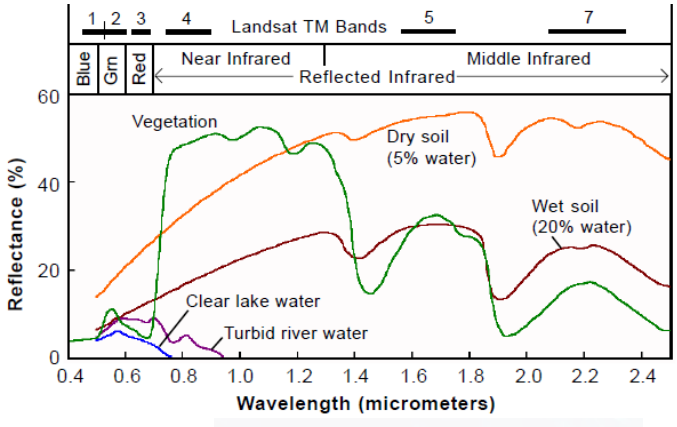
Basilicata farmers actively participated to the EU program, with a large participation of farms (4162) and about 78000 ha of land interested during the period 1994-1997.

In recent years, the Italian NCPA (AGEA) suspected frauds. Unfortunately, many of suspected applications referred to parcel situations **in the 1995 and 1997** for which only ortho-photos taken in 1997 were available. In order to take a decision, not only based on ortho-photo interpretations, a working group specifically established by Basilicata Region required 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.

USE CASE: TECHNOLOGY

Landsat data have the right trade-off between spatial resolution (30 m) and temporal repetition rate (16 days), also offering a historical archive availability as long as 30+ years to identify and monitor land cover changes during the last decades.

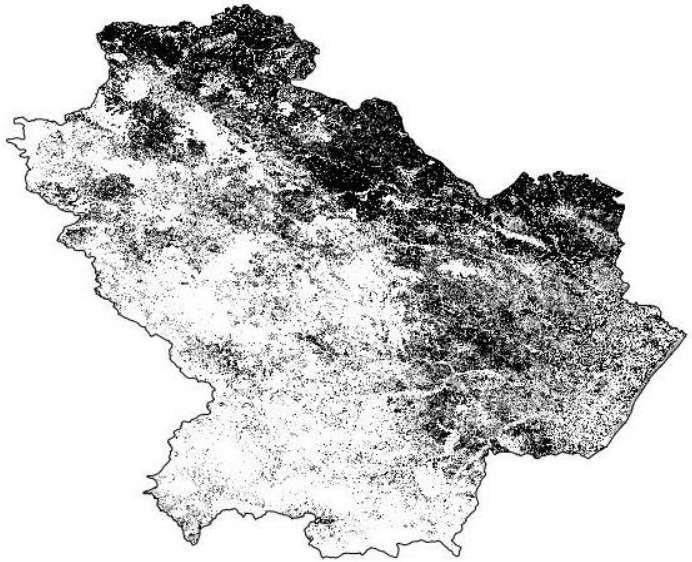
Landsat-7 ETM+ Bands (µm)			Landsat-8 OLI and *TIRS* Bands (µm)		
			30 m Coastal/Aerosol	0.435 - 0.451	Band 1
Band 1	30 m Blue	0.441 - 0.514	30 m Blue	0.452 - 0.512	Band 2
Band 2	30 m Green	0.519 - 0.601	30 m Green	0.533 - 0.590	Band 3
Band 3	30 m Red	0.631 - 0.692	30 m Red	0.636 - 0.673	Band 4
Band 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



TEST AREA:
Basilicata region (Southern Italy)

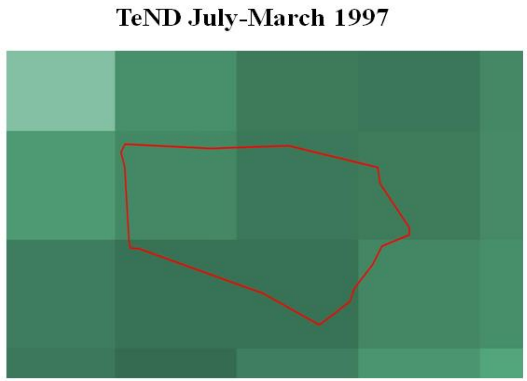
Example of a TeND map by means Landsat data

(July-March 1997)

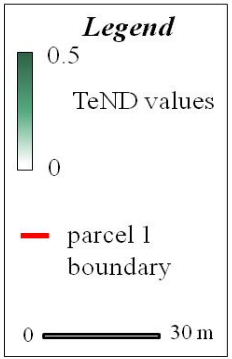


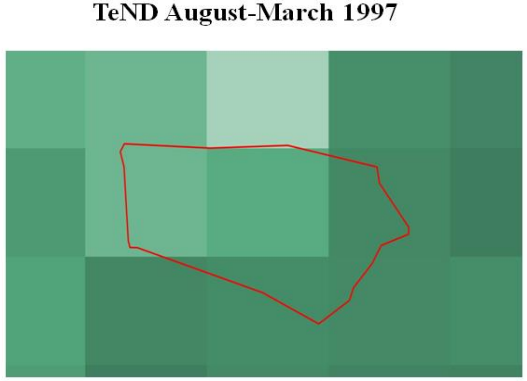
- Arable lands
- Non-arable lands

USE CASE: RESULTS

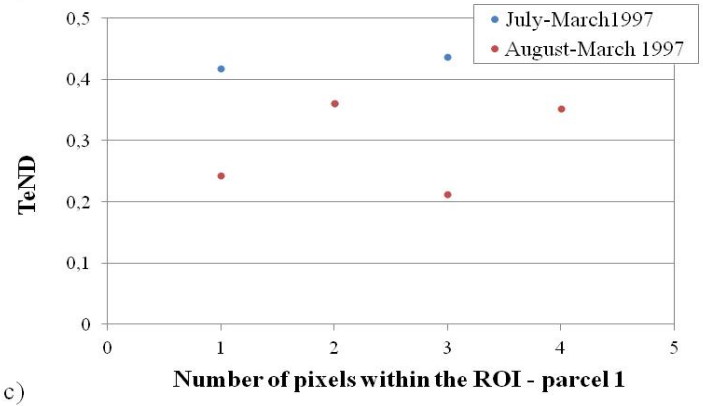


a)

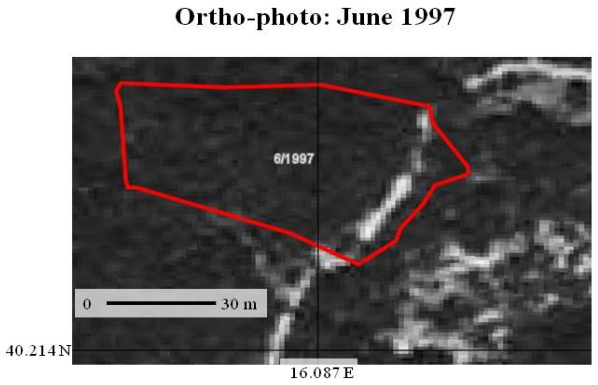




b)



c)

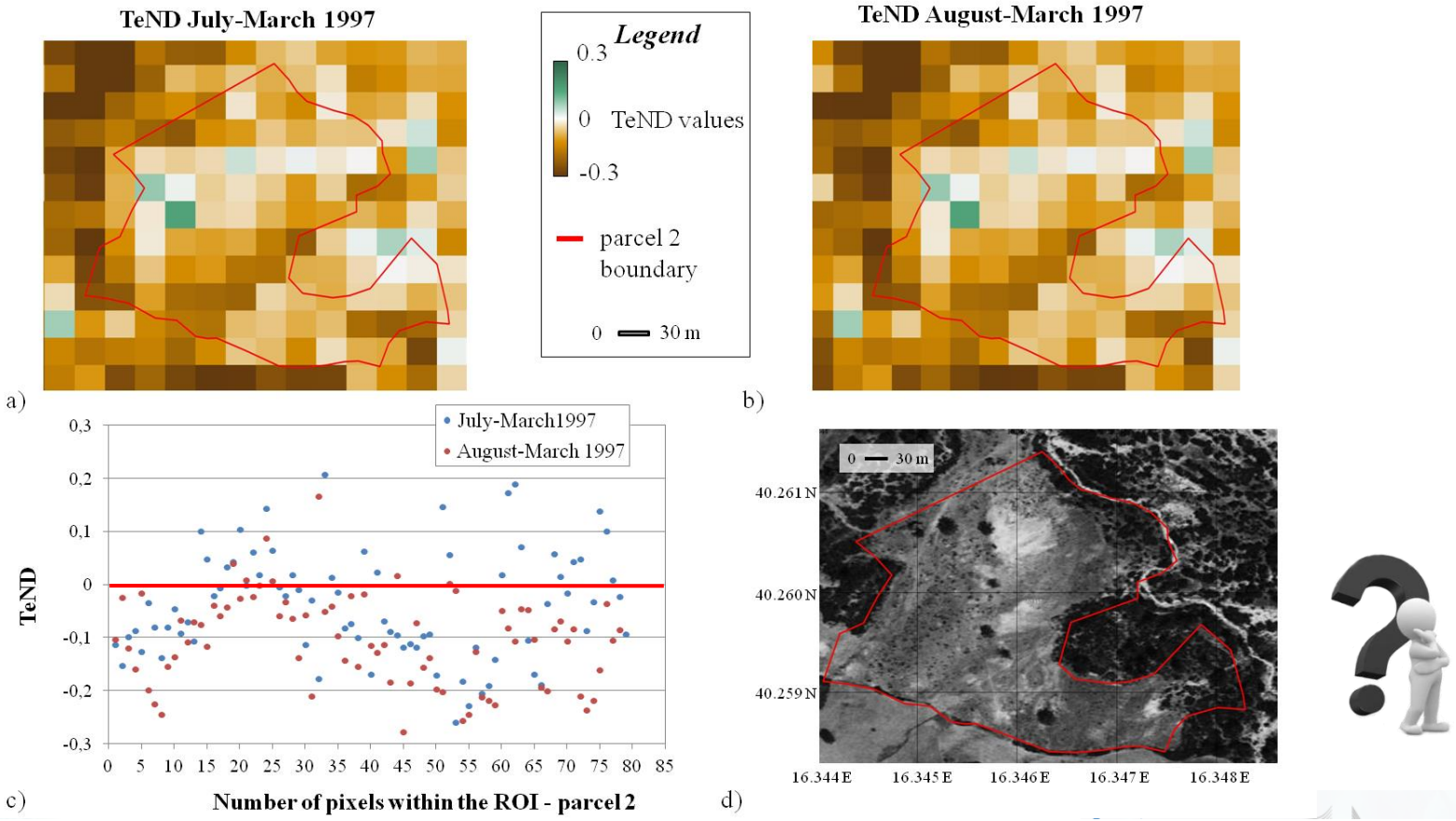


d)

Fraud!

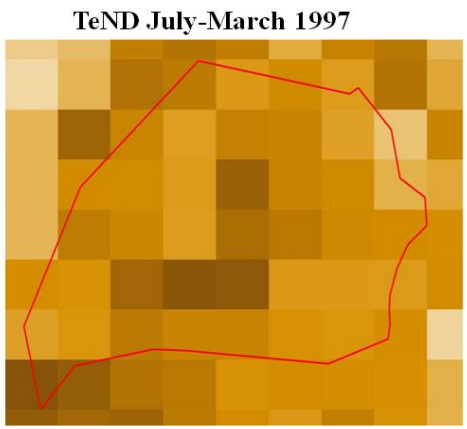
Satellite imagery analysis confirmed the presence of non arable lands (forests)

USE CASE: RESULTS

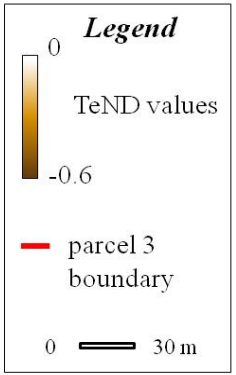


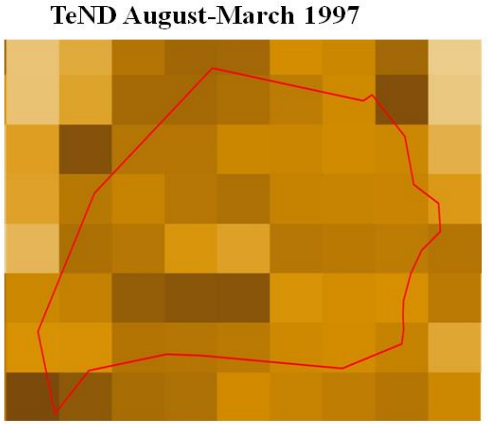
Satellite imagery analysis confirmed the coexistence of arable and non-arable lands

USE CASE: RESULTS

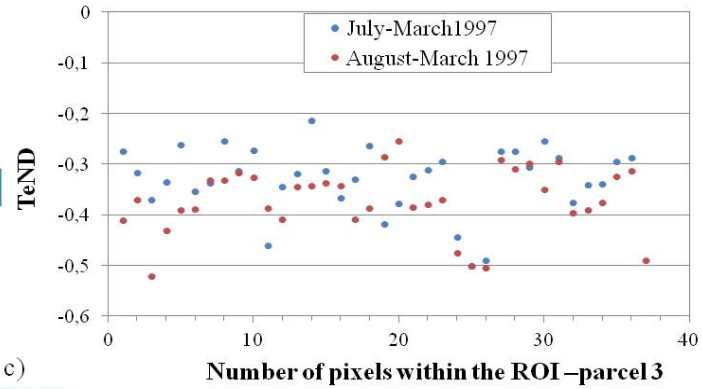


a)

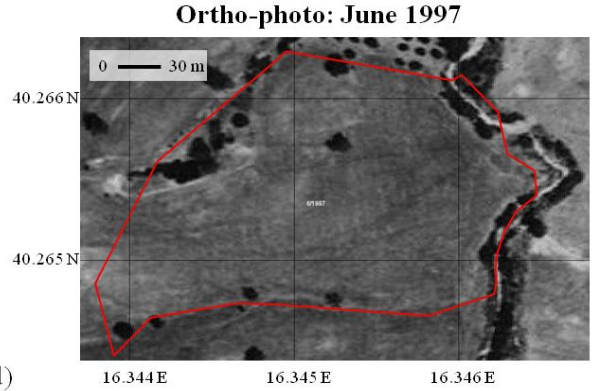




b)



c)



d)

Satellite imagery analysis suggested the presence of arable lands only

The TeND index EXPORTABILITY

Benefits from the use of **Multi-Spectral Instrument (MSI) onboard Sentinel-2** may be expected in such a case because it is characterized by:

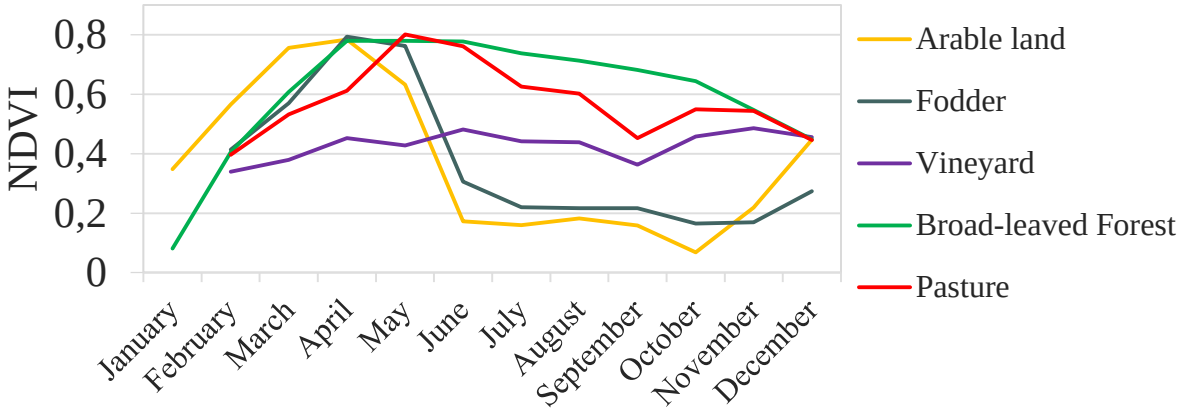
- A **5 day** revisit time (now with both Sentinel-2a and Sentinel-2b in orbit) which allows having the possibility of a larger number of cloud-free images over the area of interest and a better defined NDVI maps;
- a higher spatial resolution (**10 m**) that enables to identify smaller areas with arable lands.

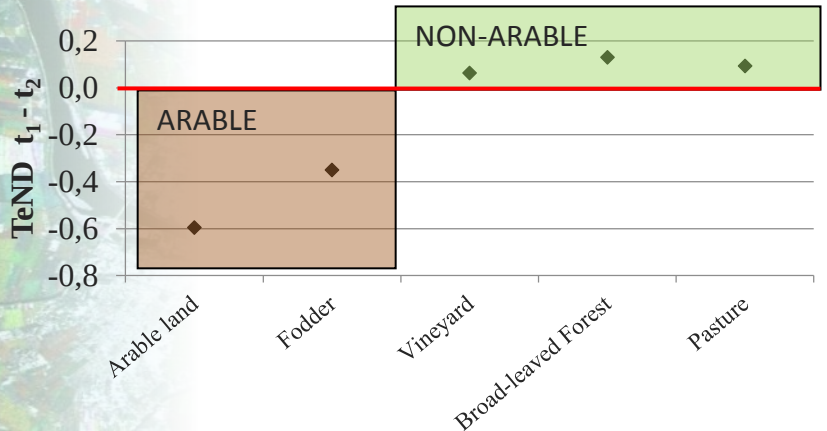
	Spatial Res.	Temporal Res.
LANDSAT	30 m	16 days
SENTINEL-2	10 m	5 days

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 TeND index EXPORTABILITY

Sentinel 2A (NDVI monthly Maximum Value Composite over period 2016-2017)

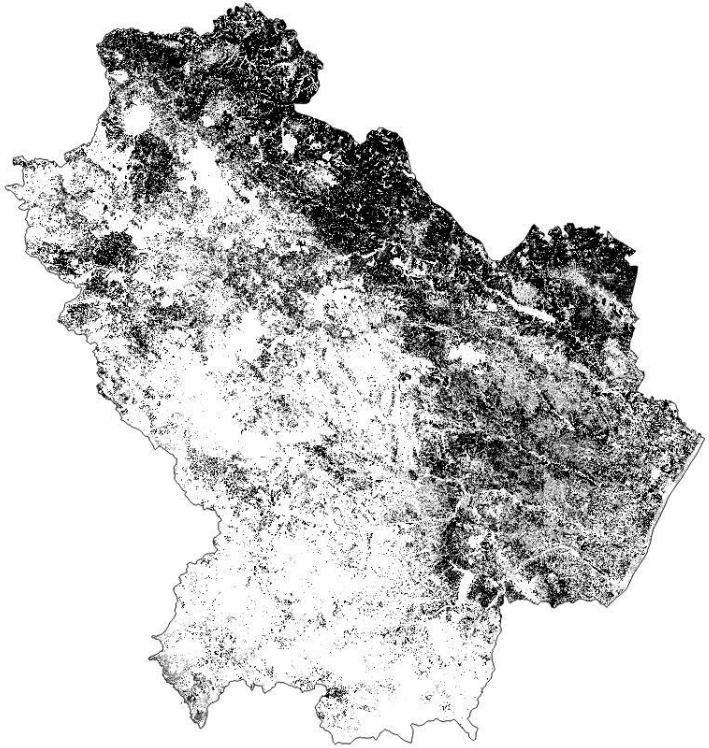




$$TeND(x,y,t_1,t_2) = NDVI_{MVC}(x,y,t_1) - NDVI_{MVC}(x,y,t_2)$$

The TeND index EXPORTABILITY

TeND map (July-March 2017) based on Sentinel 2A data



- Arable lands
- Non-arable lands

The TeND index EXPORTABILITY

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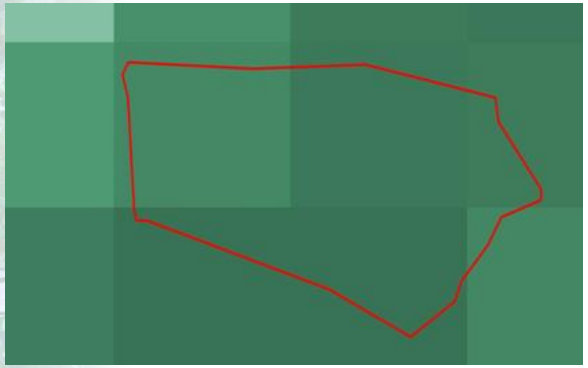
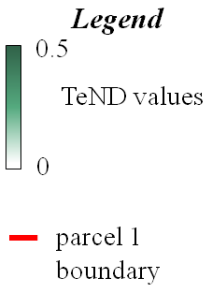
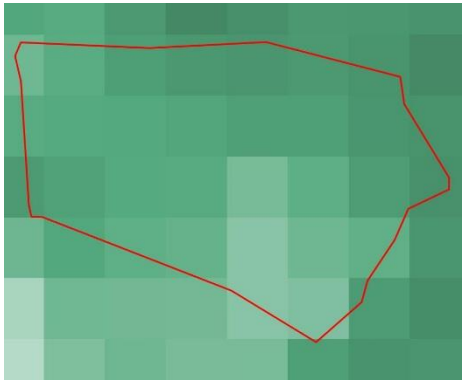
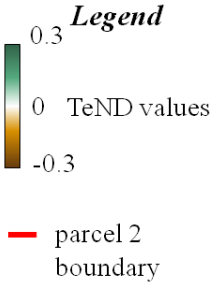
TeND July-March 1997 (Landsat data)

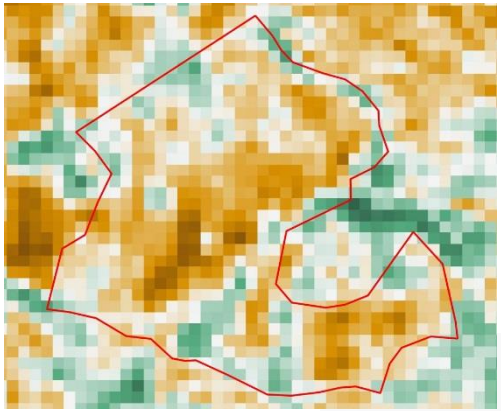




TeND July-March 2017 (Sentinel data)







European Commission

The TeND index EXPORTABILITY

The TeND index has been implemented using **Sentinel-2A** data over a small area of the Basilicata Region in order to verify the possibility of highlighting land cover changes that can be relevant within the CAP context.

Fixing a specific month M and analysing two contiguous years, the TEND index can allow us to **evaluate significant changes of land cover**:

$$TeND(x,y,t_1,t_2) = NDVI_{MVC}(x,y,t_1) - NDVI_{MVC}(x,y,t_2)$$

$$\mathbf{TeND_M(x,y,Y_1,Y_2) = NDVI_{MVC\_M}(x,y,Y_1) - NDVI_{MVC\_M}(x,y,Y_2)}$$

M = fixed month
Y_1 = year 1
Y_2 = year 2
($Y_1 > Y_2$)

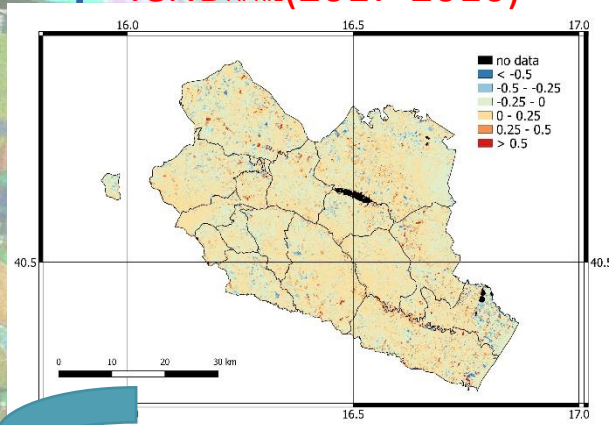
The TeND index EXPORTABILITY

SENTINEL-2 DATA

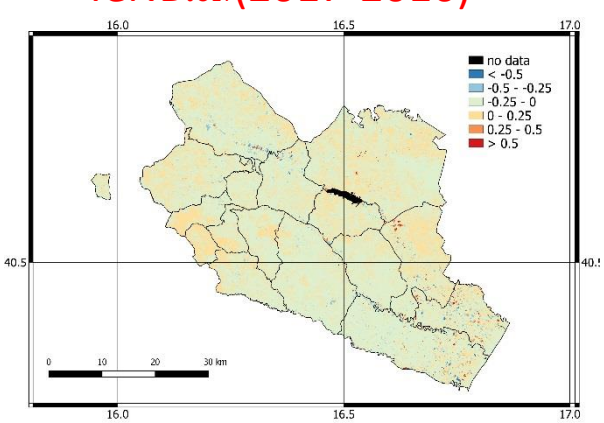
$TeND_M(x,y,Y_1,Y_2)$

(x,y) ∈ Miglionico Basin (Basilicata, Southern Italy)
M=meaningful month to discriminate changes
Y_1=2017
Y_2=2016

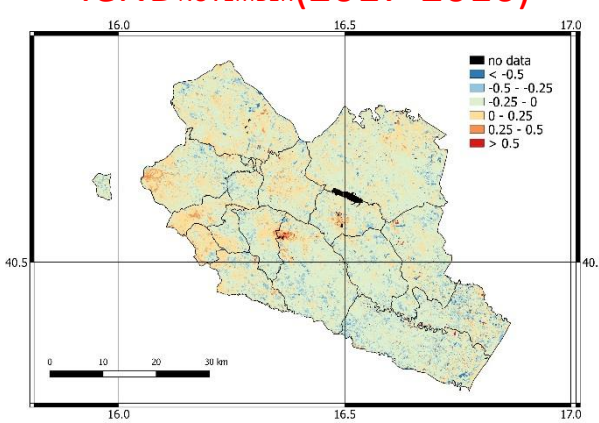
$TeND_{APRIL}(2017-2016)$



$TeND_{JULY}(2017-2016)$



$TeND_{NOVEMBER}(2017-2016)$



Reddish and **Bluish** colors identify significant changes, **orange/green** means no changes

EXPORTABILITY on Sentinel-2 data

Monitoring parcels to be left uncultivated to receive EU contribution

No data

$TeND_M \leq -0.5$

$-0.5 < TeND_M \leq -0.25$

$-0.25 < TeND_M \leq 0$

$0 < TeND_M \leq 0.25$

$TeND_M > 0.5$

- Known that in 2016 the parcel is “non arable”
- $TeND_M$(2017-2016) indexes indicate **NO SIGNIFICANT** changes

In 2017, the parcel is confirmed as “non arable”

EXPORTABILITY on Sentinel-2 data

Copernicus

Monitor parcels to be cultivated with a specific crop for which EU contribution is received

$TeND_M \leq -0.5$

$TeND_M > 0.5$

- Known crops in 2016
- $TeND_M$ indexes indicate **SIGNIFICANT** changes

In 2017, diversified crops

According to the months of changes, the new crop types may be inferred

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European Commission

CONCLUSION

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 as well as from the geographic area.

The approach (designed and developed for LANDSAT) has been easily exported on the new generation **Multi-Spectral Instrument (MSI)** data onboard **Copernicus Sentinel-2** satellite constellation.

ADDITIONAL INFORMATION

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 available on-line at:

https://www.youtube.com/watch?v=9Fd1yNobCGw

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THANKS FOR YOUR ATTENTION

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