



UNIVERSITÀ  
DEGLI STUDI DELLA  
Tuscia

# Course: Applied optical remote sensing for (of?) the environment

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## **OBJECTIVES OF THE COURSE:**

The aim of the course is to give an introduction to the concepts of optical remote sensing with particular emphasis on the applications in environmental studies using also a number of practical cases.

## **EXPECTED RESULTS AND KNOWLEDGE:**

The course will introduce the basis of remote sensing and all the technical aspects needed in order to apply the technique in practical studies in the environmental domain. Students are expected to gain knowledge and understanding of the fundamental principles of the data used and methods and applying knowledge and understanding needed for the practical application, in particular for the data collection, preparation and corrections. The applications and examples will give also the needed background to develop their own judgment capacity in relation to the applicability of the methods in their specific cases.

## **PROGRAM:**

1) **Introduction to Remote Sensing concepts** [optical domain only?]

2) **The electromagnetic energy and most important physical laws**

3) **Reflectance curves**

- water and snow

- soils

- vegetation

4) **Effect of the vegetation characteristics on the reflectance**

5) **Remote sensing platforms and sensors**

- characteristics of the platforms

- BRDF

- orbits

- main missions (Sentinels, Landsat, Spot, ...)

- Earth Observation missions relevant for monitoring environmental variables (e.g. ECV) and processes.

6) **Digital images processing**

- structure of the digital data (raster and vector)

- file formats and headers

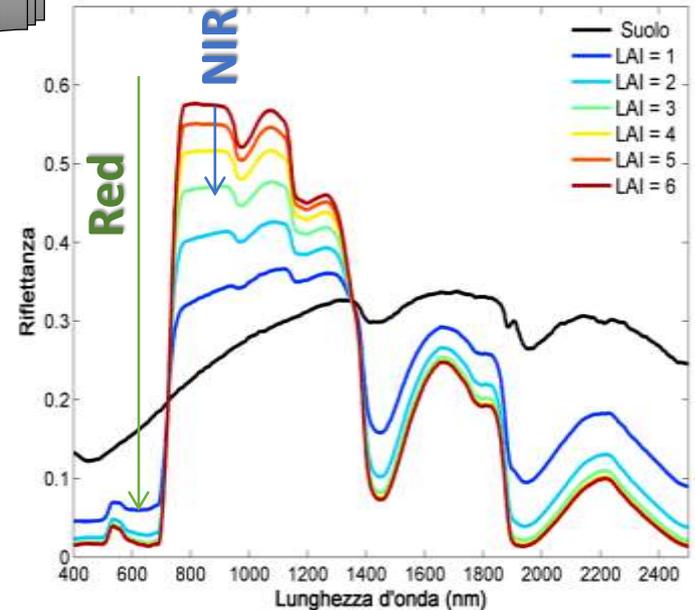
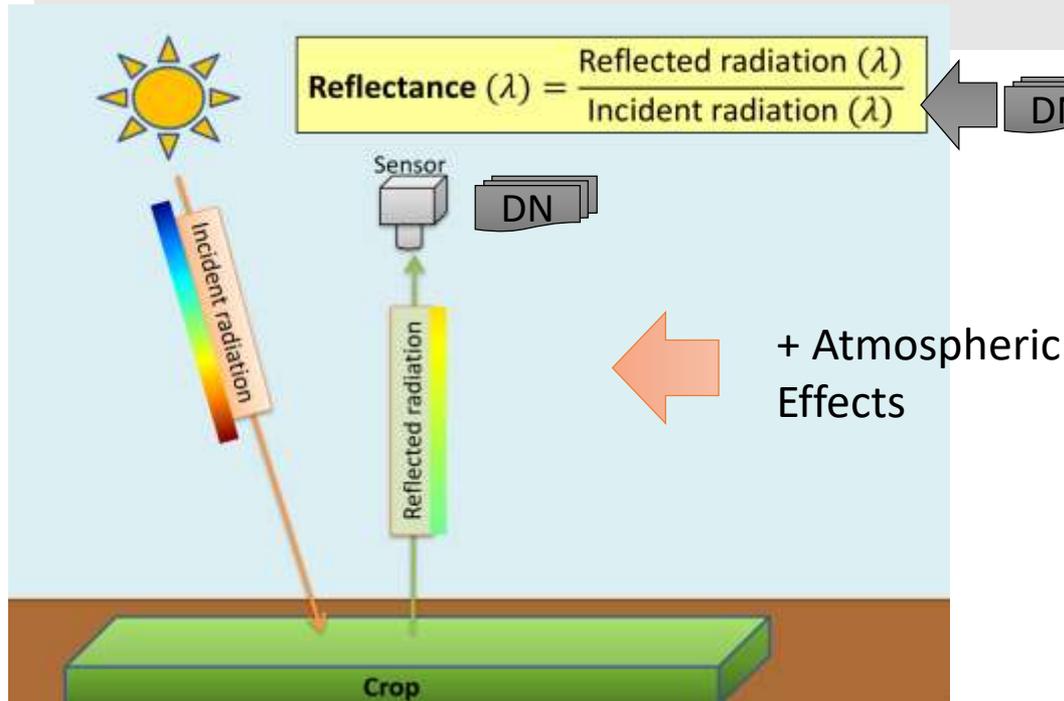
- data types

7) **Digital images visualization**

- color visualization

- palette

# What does an optical sensor measure?



Vegetation index: mathematical expressions of **reflectance**



## NDVI

(Normalized Difference Vegetation Index)

$$NDVI = \frac{(R_{800} - R_{670})}{(R_{800} + R_{670})}$$



“Free”

~0.01 €/ha\*

~0.3 €/ha\*



RAPIDEYE



~60 €/ha

~70-120 €/ha



**S110 NIR**



**TETRACAM INC**



**MULTISPEC 4C**



~4-15 €/ha\*



N-Sensor



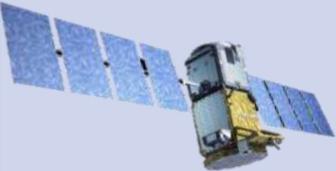
GreenSeeker



Crop Circle



CropSpec

Platform	Spatial resolution	Frequency & timeliness	Spectral resolution	Data processing needs
	<b>sentinel-2</b> 10-20 m	1 – 30 days (depends on clouds) delivery: ~1-10 days	4-10 bands  bandwidth 15-70 nm	+/- atmosph. corr. Vegetation indices... ... biophysical products
	<b>RAPIDEYE</b> 5 m			
	<b>WorldView-2</b> 2 m			
	0.05 – 0.15 m	On demand  delivery ~2 -7 days	2-4 bands  bandwidth 50- 200 nm	+mosaiking +geom.registration + radiometric corr. +atmosph. corr. +Vegetation indices...
	0.5 – 5 m	On demand  Delivery immediate	2-4 bands  bandwidth 3- 20 nm	none if on-the-gosystem  +filtering if map based

## 8) Enhancement of RS images

- false and true color images
- stretch
- filters
- RGB-HSL and pan-sharp

## 9) Radiometric corrections

- Radiometric calibration
- stripping and other errors correction

## 10) Geometric corrections

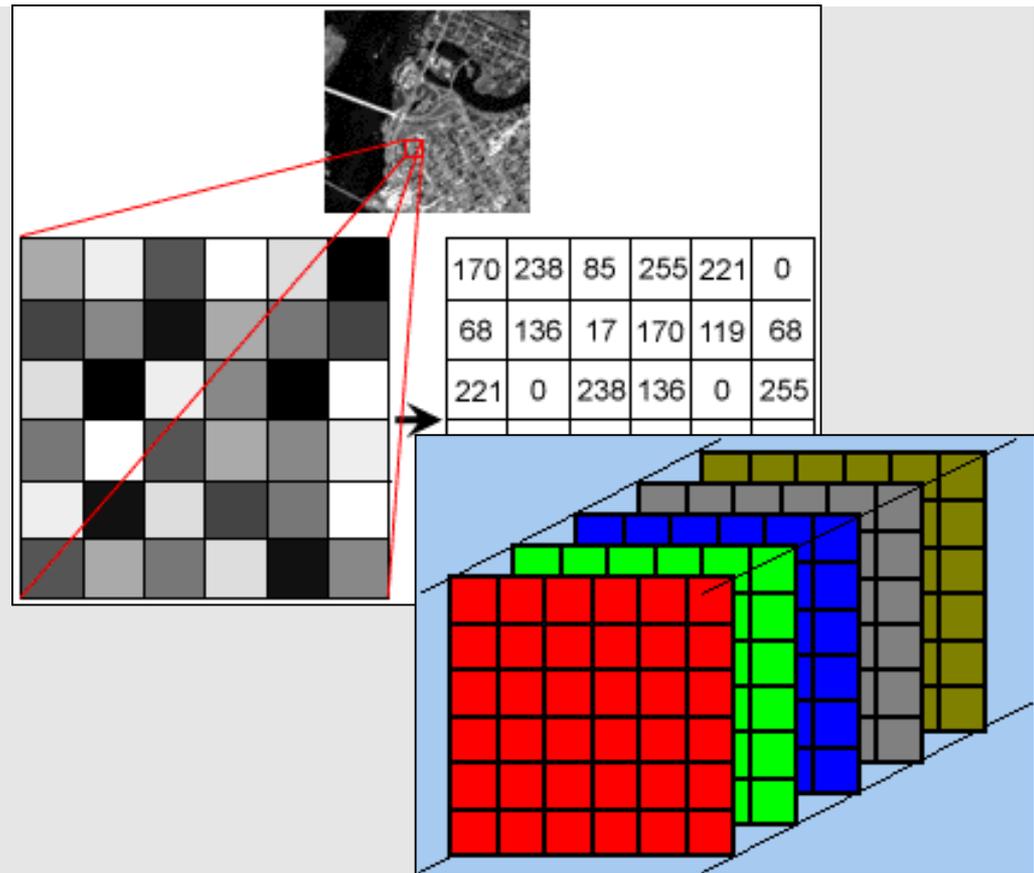
- georeferencing
- orthorectification
- geometric distortions

## 11) Atmospheric corrections

- effect of the atmosphere on radiation
- path radiance
- image based methods to correct or minimize the atmosphere effect

## 12) Vegetation indexes and their use, fluorescence

- NDVI
- Soil line based VIs
- PRI
- fluorescence

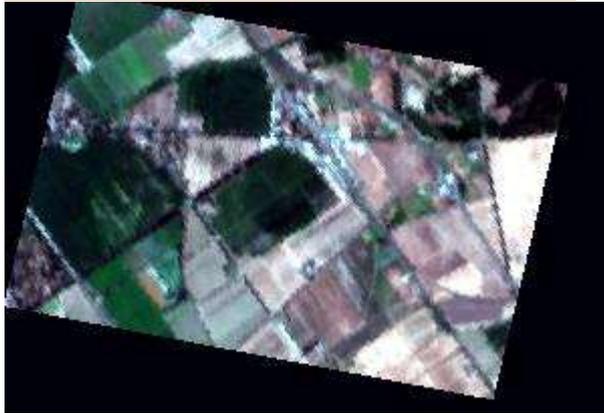


# Problems with vegetation indices

Use agronomical variables (biophysical) instead of vegetation indices

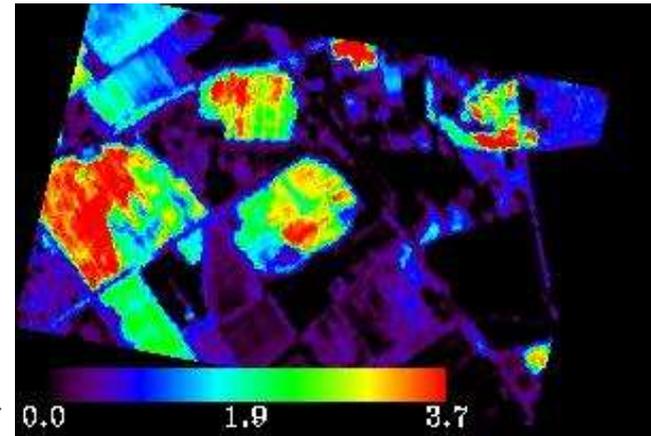
Solution?

Image  
satellite CHRIS-Proba

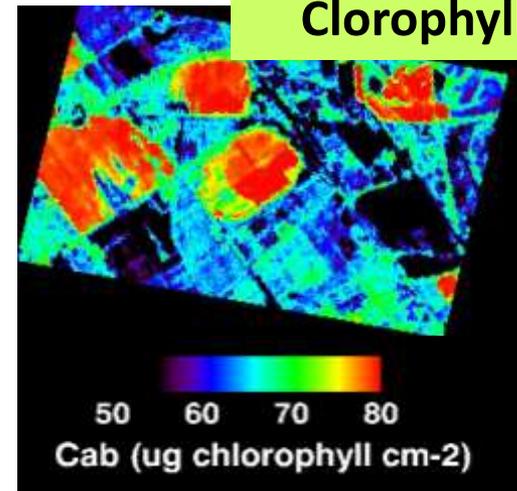


Physically  
based  
algorithms

Leaf area index (LAI)



Chlorophyll



Already operational products for low resolution  
satellites ...

### 13) Remote sensing and modeling

- RUE models
- concept of radiative transfer models

### 14) Model optimization and validation

- model definition and components
- strategy for model validation and optimization
- empirical and process-based models
- multiple constrain in models parameterization

### 15) Supervised and Unsupervised classifications

- hard and soft classification
- minimum distance and maximum likelihood
- unsupervised clustering

### 16) Artificial Neural Networks

- principles
- FFBP Neural Networks
- concepts of validation
- applications as soft classification



17) **Practical applications:** land applications: land use and land cover; change detection and multitemporal analysis; vegetation status and its disturbance; land surface temperature; terrain motion and critical infrastructure monitoring; vegetation biophysical retrievals; flood and water bodies monitoring; agricultural monitoring; fire detection; urban mapping; monitoring of the hydrological cycle, etc.

□ **Practicals exercise:** e.g. using ESA toolboxes (e.g. SNAP) and other freeware tools (e.g. EnMAP toolbox QGIS for hyperspectral data). **Intro to programming? Matlab, Python, R ???**

The screenshot displays the SNAP software interface. On the left, a tree view shows the 'Product Operator' menu. The main window is titled 'MSAVI Algorithm Specifications' and contains the following text:

**MSAVI**

The Modified Soil Adjusted Vegetation Index algorithm was developed by...

The adjustment factor  $L$  for SAVI depends on the level of vegetation cover but this leads to the circular problem of needing to know the vegetation cover but what gives you the vegetation cover.

The basic idea of MSAVI was to provide a variable correction factor  $L$ . The correction factor used is based on the product of NDVI and WWI. This is convergence to a single point.

The MSAVI results from the following equation:

$$MSAVI = (1 + L) * (IR_{near} * near_{IR} - red_{factor} * red) / (IR_{near} + near_{IR})$$

where  $L = 1 - 2 * a * NDVI * WWI$  and  $a$  is the soil line slope.

Not all soils are alike. Different soils have different reflectance spectra. All of the vegetation indices assume that there is a soil line, where there is a decrease, it is often the case that there are soils with different RED-NIR slopes also, if the assumption about the vegetation lines (parallel or intersecting a changes in soil moisture) (which move along vegetation lines) will give even the problem of soil noise is most acute when vegetation cover is low.

The following group of indices attempt to reduce soil noise by altering the shape of the soil line, and the way that they attempt to reduce soil noise (vegetation flagging).

**WARNING:** These indices reduce soil noise at the cost of decreasing the dynamic range. These indices are slightly less sensitive to changes in vegetation cover than NDVI (for comparison).

These indices are also more sensitive to atmospheric variations than NDVI (for comparison).

**MSAVI-Flags**

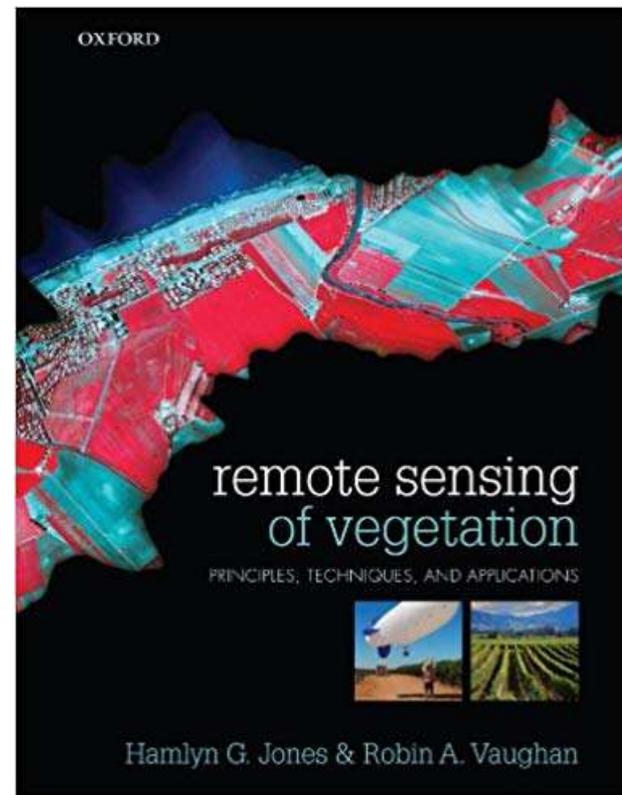
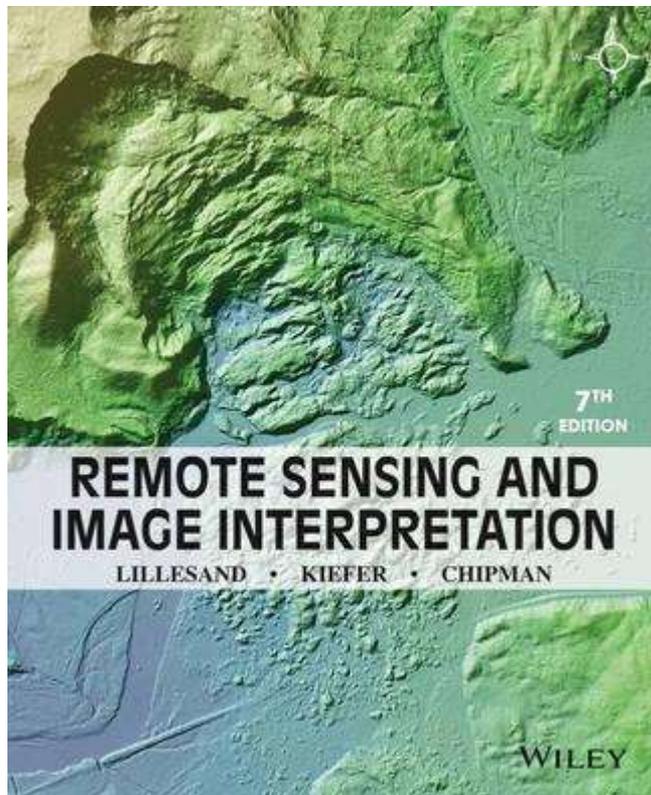
Also the processor computes an additional flag band called 'msavi\_flags' with

IR Position	Description
IR 0	The computed value for MSAVI is null or is infinite
IR 1	The computed value for MSAVI is less than 1 (low)
IR 2	The computed value for MSAVI is greater than 1 (low)

On the right, a satellite image of a coastal area is shown, with a legend on the far right. The ESA logo is visible in the top right corner of the interface.

## Suggested books

- Remote Sensing and Image Interpretation - T.M. Lillesand, R.W. Kiefer, J.W. Chipman, Wiley Interational 7<sup>th</sup> Edition (2015)
- Remote Sensing of the Environment: An Earth Resource Perspective - John R. Jensen, Prentice Hall
- Jones H.G., Vaughan R. (2010). Remote sensing of vegetation. Oxford University Press, Oxford (GB), 384 pp



## **Assessment methodology**

Knowledge of the theory and ability to apply the methods learned will be evaluated through the solution of complex practical cases, where a clear knowledge of remote sensing basis, concepts and tools available is needed. The exam can be given in written or oral forms and the choice is left to the student.