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.

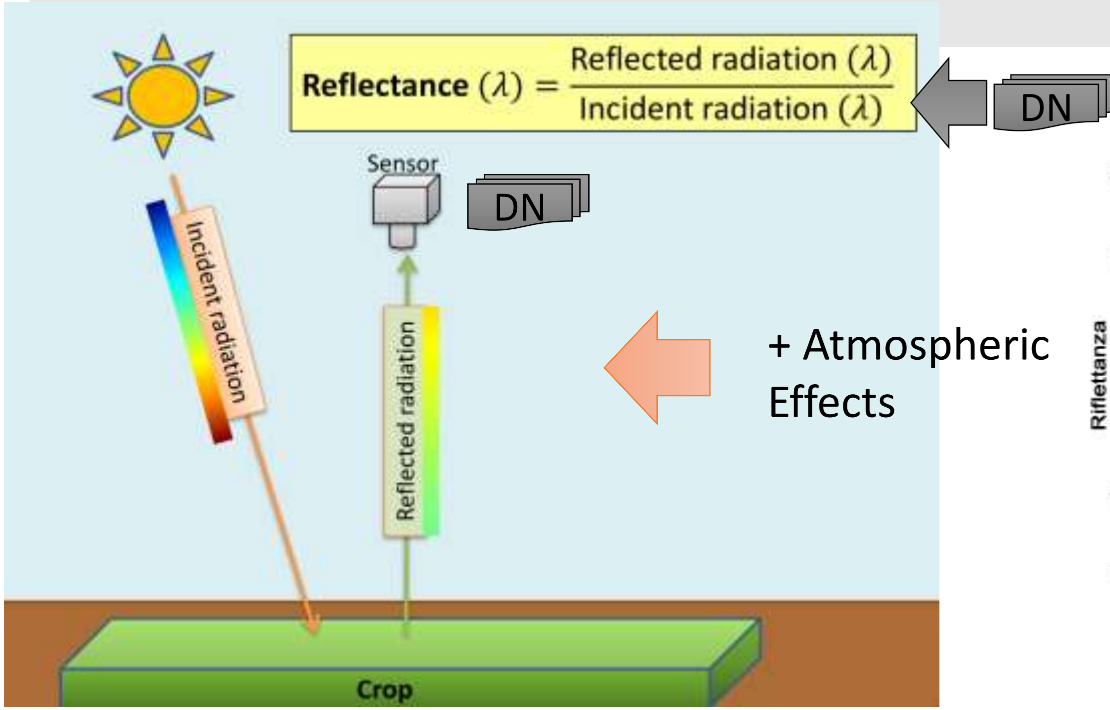
6) **Digital images processing**

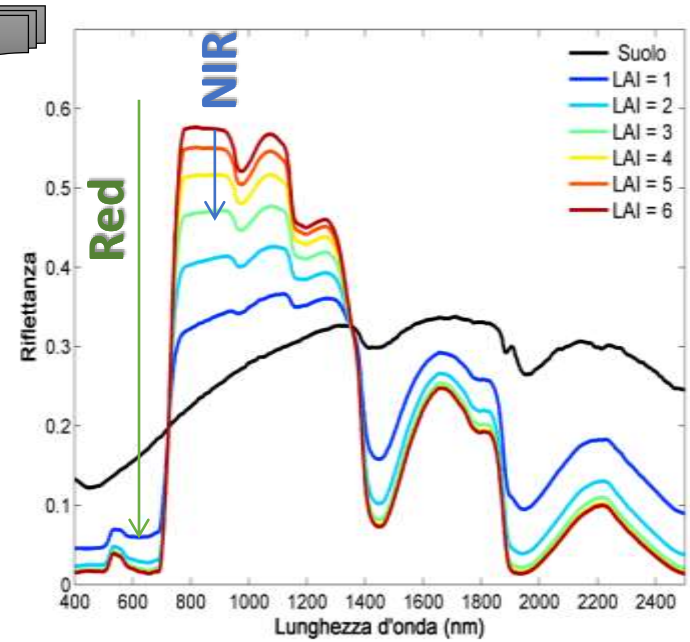
- structure of the digital data (raster and vector)
- file formats and headers
- data types

7) **Digital images visualization**

- color visualization
- palette

What does an optical sensor measure?

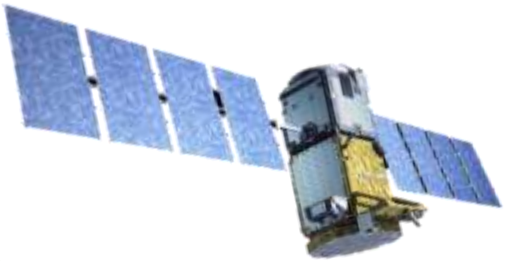




Vegetation index: mathematical expressions of **reflectance**

NDVI
(Normalized Differenc
Vegetation Index)

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



"Free"	esa	sentinel-2
~0.01 €/ha*	BlackBridge	RAPIDEYE
~0.3 €/ha*	DigitalGlobe	WorldView-2

~60 €/ha

S110 NIR

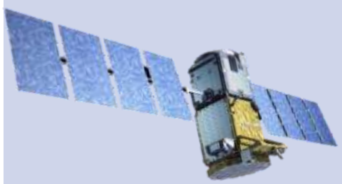
TETRACAM INC

~70-120 €/ha

MULTISPEC 4C

~4-15 €/ha*

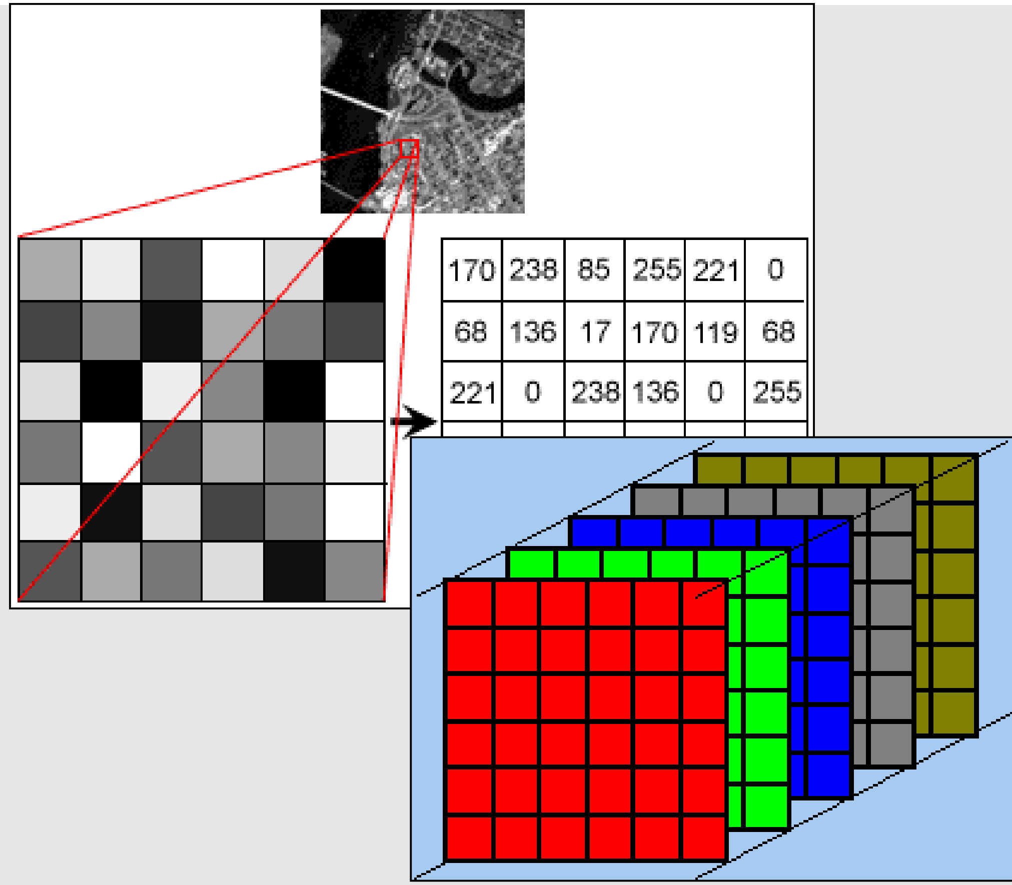
YARA	N-Sensor
Trimble	GreenSeeker
Holland Scientific	Crop Circle
TOPCON Precision Agriculture	CropSpec

Platform	Spatial resolution	Frequency & timeliness	Spectral resolution	Data processing needs
	sentinel-2 10-20 m RAPIDEYE 5 m WorldView-2 2 m	1 – 30 days (depends on cluds) delivery: ~1-10 days	4-10 bands bandwidth 15-70 nm	+/- atmosph. corr. Vegetation inidices…. …. biophysical products
	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 inidices….
	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

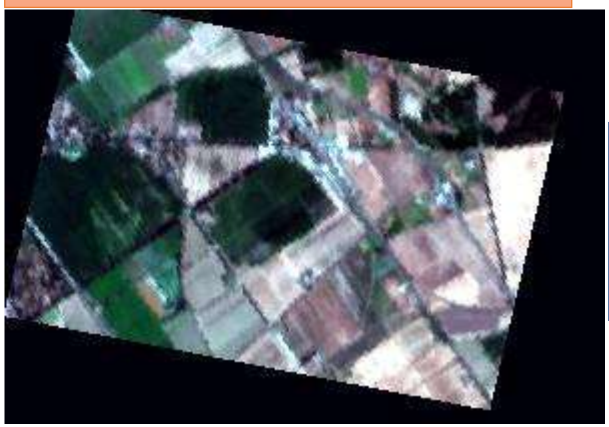
12) **Vegetation indexes and their use, fluorescence**
- NDVI
- Soil line based VIs
- PRI
- fluorescence

Problems with vegetation indices

Solution?

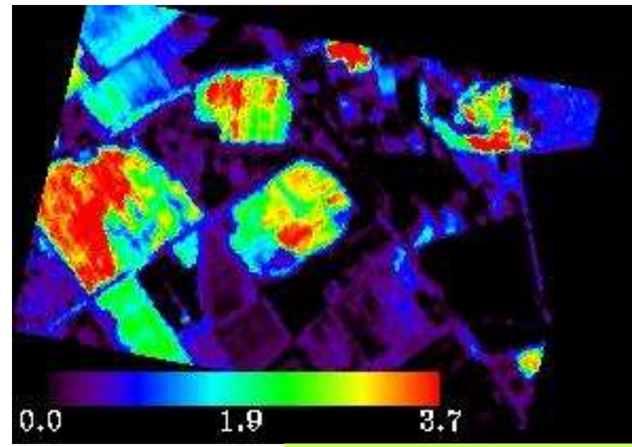
Use agronomical variables (biophysical) instead of vegetation indices

Image
satellite CHRIS-Proba

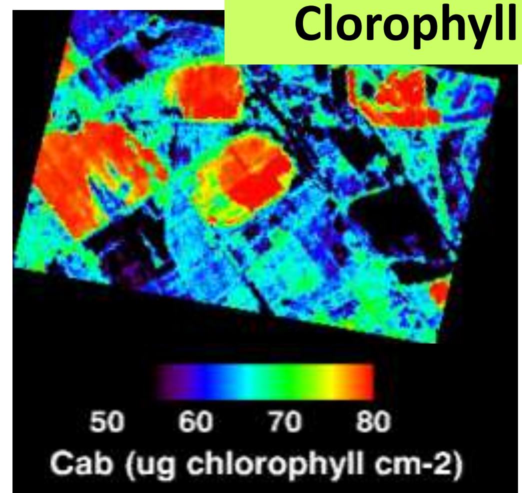


Physically based algorithms

Leaf area index (LAI)



Clorophyll



Already operational products for low resolution satellites ...

13) **Remote sensing and modeling**
- RUE models
- concept of radiative transfer models

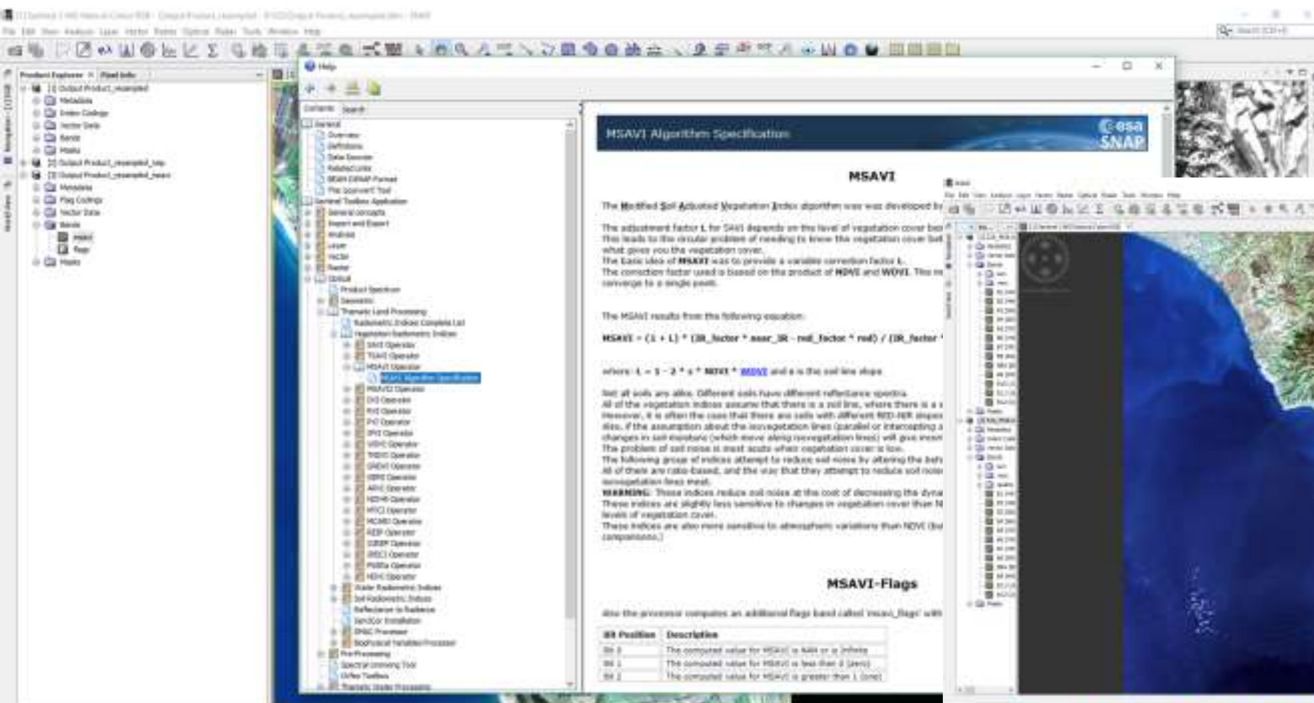
14) **Model optimization and validation**
- model definition and components
- strategy for model validation and optimization
- empirical and process-based models
- multiple constrain in models parameterization

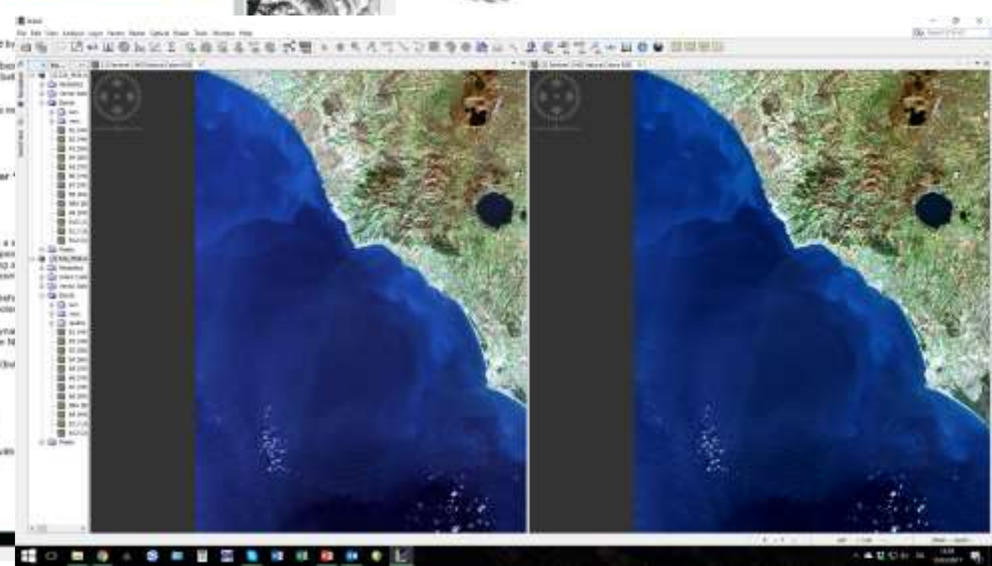
15) **Supervised and Unsupervised classifications**
- hard and soft classification
- minimum distance and maximum likelihood
- unsupervised clustering

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.

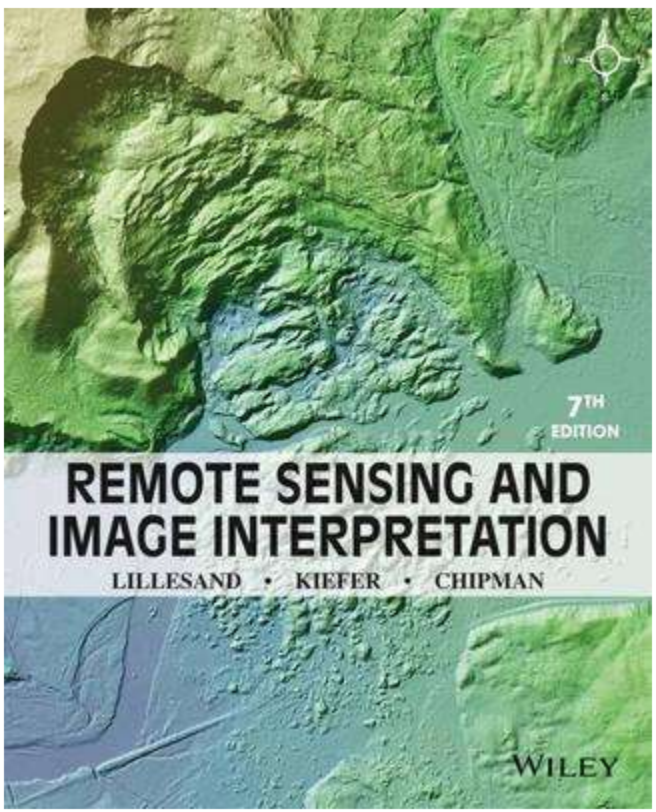
- **Practicals exercise:** e.g. using ESA toolboxes (e.g. SNAP) and other **freeware** tools (e.g. EnMAP toolbox QGIS for hyperspectral data). **Intro to programming? Matlab, Python, R ???**

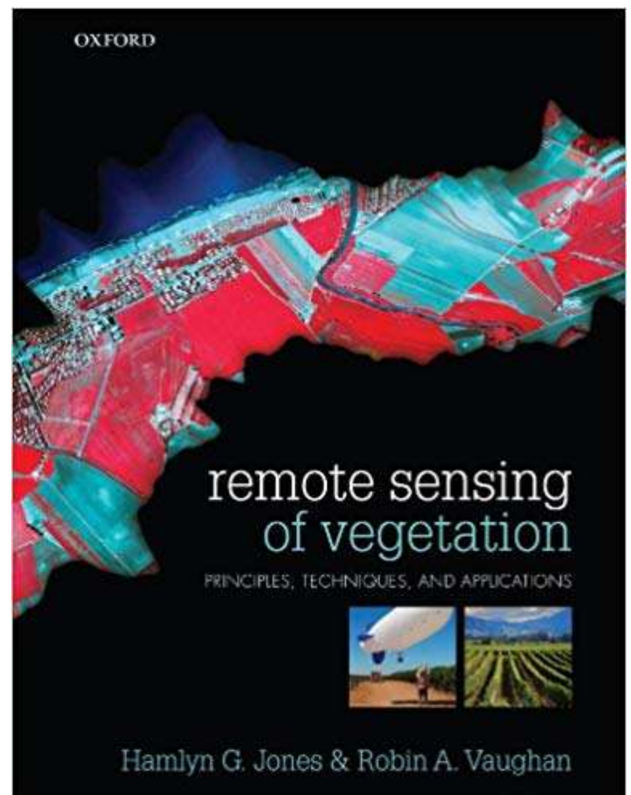




Suggested books

- Remote Sensing and Image Interpretation - T.M. Lillesand, R.W. Kiefer, J.W. Chipman, Wiley Interational 7th 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 trough 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.