Laurea Magistrale
Atmospheric Science and Technology (LMAST)

SUBJECT TITLE	Satellite Earth observation
TEACHER NAME(S)	Frank S. Marzano (3 CFU), Nazzareno Pierdicca (3 CFU)
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Teacher meeting	Wednesday, h. 15-16
Teacher office address	Via Eudossiana 18, Rome (S. Peter in chain site)
DISCIPLINE (SSD)	ING-INF/02 (Electromagnetic fields)
Semester (1-4) and location	1 (first) & Rome at Via Eudossiana
Credits (CFU/ECTS)	6
Lecture hours (h)	60 (45 lectures + 15 exercise/laboratory)
Prerequisite and learning activity	Electromagnetics fundamentals, Elements of meteorology
Teaching language and method	English & Lectures, exercises and homeworks
Assessment method	Oral examination and optional dissertation on a selected state-of-the-art topic
SUBJECT WEBSITE	https://cispio.diet.uniroma1.it/marzano/EODataAnalysis.html

OBJECTIVES

Main goals are to:

- provide a general background on the remote sensing systems for Earth Observation from spaceborne platforms
- explain a system approach to fulfil the final user requirements in different domains of application
- apply wave-interaction and radiative transfer models to physically interpret EO imagery and data
- overview of the most important applications and retrieval of bio-geophysical parameters (atmosphere, ocean, land)
- illustrate and apply data processing techniques for Earth observation applications using computer languages and tools

OUTCOMES (Dublin descriptors: knowledge, understanding, explain, skill, ability)

After the successful completion of this module, the student should be able to:

- know the main remote sensing sensors and satellite missions for Earth observation.
- address the main applications of remote sensing in geomatics, geophysics and environmentrics.
- understand the requirements of an Earth observation system from user point of view.
- deal with system components and main characteristics affecting the fulfilment of user requirements.
- exploit remote sensing products and the fundamental data processing steps and product levels.
- mange basic data processing techniques to perform image rectification and image classification.

PROGRAM CONTENT

EARTH OBSERVATION PRINCIPLES AND CONCEPTS. Remote sensing and its applications. EO big data and research support services. Strolling around EO applications: atmospheric monitoring, climate analysis, natural hazards, geodesy, geophysics, urban planning, deforestation surveillance, environmental to monumental diagnosis. Remote sensing basics. Electromagnetic radiation basics. Earth observation system basics. EO electromagnetic sensors and user requirements. Remote sensing platforms. Satellite Keplerian orbits.

MODELING RADIATION FOR EARTH OBSERVATION. Wave-matter interaction mechanisms. Radiation, emission, surface interaction, volume interaction, reflection and refraction. Radiative transfer theory: integral-differential equation, formal integral solution and special cases, application to absorbing and scattering atmospheres. Application to space and ground remote sensing. Radiation backscatter theory: wadar equation, Doppler effect and signal statistics.

EARTH OBSERVATION SENSORS AND MISSIONS. Earth observation remote sensors: EO sensor classification and requirements. Passive optical sensors: photocamera principles. Electro-optical sensors: spectroradiometer, interferometer and lidar. Electro-optical sensor scanning systems and geometric distortions. Microwave sensors, imaging radiometers and sounders. Active microwave sensors: altimeter, scatterometer and SAR. Main Earth observation satellite missions.

EARTH OBSERVATION APPLICATIONS. Information content in remote sensing observations: Information content in visible and near-infrared remote sensing, Information content in thermal-infrared and microwave remote sensing. Remote sensing of Earth sea environment: Sea water spectral response, transmittance and reflectance, Visible, near-infrared and thermal-infrared passive remote sensing, Microwave remote sensing: scatterometry, SAR, altimeter and radiometry. Remote sensing of Earth atmosphere. Remote sensing of Earth solid surface.

EARTH OBSERVATION DATA PROCESSING. EO image data processing: Levels of EO data processing, Color perception and synthesis. Image format and data structure, Image analysis. EO inverse problem and retrieval techniques. EO feature extraction and classification. Statistical Bayesian classification method. Thematic mapping and image texture exploitation.

LABORATORY. Guide and use of open-source toolboxes for EO data analysis and image processing (link with ESA/ESRIN).

REFERENCES AND MATERIAL

- Texts and slides provided by the teachers and available on the course web site.
- Elachi C., *Introduction to the Physics and Techniques of Remote Sensing*, John Wiley & Sons, 1987.
- Marzano F.S. and G. Visconti, Eds., *Remote sensing of atmosphere and ocean from space*, Kluwer-Springer, 2002.
- Richards J.A. and X. Jia, *Remote Sensing Digital Image Analysis. An Introduction*, Springer Verlag, 2006.
- Solimini D., *Understanding Earth Observation: the Electromagnetic Foundation of Remote Sensing*, Springer, 2016.