

COURSE: Remote Sensing of the Environment	
ACADEMIC YEAR: 2019-2020	
TYPE OF EDUCATIONAL ACTIVITY: (Basic, Characterizing, Affine, Free choice, Other)	
TEACHER: Prof. Valerio Tramutoli	
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Language: Italian/English	

ECTS: (lessons e tutorials/practice) 9	n. of hours: (lessons e tutorials/practice) 81	Campus: Potenza School: School of Engineering Program: LM in Engineering for the Environment and the Territory [0236]	Semester: II
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**EDUCATIONAL GOALS AND EXPECTED LEARNING OUTCOMES**

The course aims to provide a thorough understanding of the basic elements of remote sensing and to develop autonomous capability for evaluating potential applications in the field of monitoring and mitigation of major natural and environmental hazards.

**PRE-REQUIREMENTS**

Basic concepts of Mathematics (e.g. trigonometry) and Physics (e.g. mechanics)

**SYLLABUS**

Introduction: physical principles and basics

1. Definition and brief history of remote sensing.
2. Basic concepts of electromagnetism. Regions of the e.m. spectrum
3. Measurement of e.m radiation. Concepts of radiance, irradiance, radiant power, brightness, emittance, etc.
4. Decay of the emittance with the square of distance from the source
5. Black body radiation. Planck's law.
6. Concepts of emissivity and brightness temperature.
7. Wien's displacement law. Planck's law in the frequency domain.
8. Rayleigh-Jeans approximation. Approximation of Wien. Stephan-Boltzmann law.
9. Interaction of electromagnetic radiation with the Earth's surface.
10. Radiation-matter interaction. Concept of Transmittance, Absorbance, Reflectance.
11. Kirchoff's law. Relation emissivity-reflectance for opaque bodies.
12. Radiation-matter interaction in the visible, beyond the visible.
13. Spectral response curves, spectral signatures of soils, vegetation, water.
14. Interpretation of spectral signatures of vegetation.
15. Basic principle of multi-spectral observation.
16. Lambertian and specular surfaces. Bidirectional reflectance distribution function (BRDF). Bidirectional Reflectance Factor (BRF).
17. Theoretical and practical exercises in the laboratory: spectro-radiometric characterization of black bodies and other sources.
18. Theoretical and practical exercises: laboratory measurement of spectral signatures in reflectance of vegetation, minerals and man-made materials
19. Radiation-matter interaction at the surface of opaque bodies. Reyleigh criterion for roughness.
20. Atomic spectroscopy. Emission spectra and absorption. Spectrum of the hydrogen atom.
21. The Bohr atom and the prediction of spectroscopic terms of atoms. Molecular spectra (features).
22. Spectra of minerals and rocks in reflectance and emissivity.
23. Composition of spectral signatures (linear mixing).
24. Theoretical explanation and generalization of the basic principle of multi-spectral observation.
25. Natural sources for observing the Earth from space: the Sun, the Earth.

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26. Active and passive remote sensing techniques.
  27. SAR techniques (outline)  
Interaction of electromagnetic radiation with the Earth's atmosphere.
  28. Structure and chemical-physical composition of Earth's atmosphere.
  29. Radiation-matter interaction in the atmosphere. Rayleigh scattering and Mie (features).
  30. Spectral windows for the observation of the Earth's surface under standard and variables conditions.
  31. Extinction of radiation e.m. in atmosphere. Cross section of extinction, absorption, scattering.
  32. Cross section per unit mass. The absorption coefficient. Source function.
  33. General equation of radiative transfer.
  34. Law of Beer-Bouguer-Lambert. Optical path.
  35. Schwarzschild equation and its solutions, in the case of nadir radiances. Optical thickness.
  36. Line broadening as a function of pressure (height) in the atmosphere (outline)
  41. Penetration of the e.m. waves in the matter. Complex refractive index. Attenuation length.
  42. Interaction of radiation e.m. in the atmosphere: meteorological clouds.
  43. Spectral bands diagnostic of the presence of clouds and of snow cover.
- Tools and Techniques of Remote Sensing in the optical band
44. Satellite systems for Earth observation. Space segment and ground segment
  45. Polar and geostationary orbits.
  46. Non-rotating orbits. Sun-synchronous orbits. Orbits of Molnyia.
  47. Equation of the rocket and launch of a satellite: payload.
  48. Real orbits. Life time of a satellite, orbit's decay.
  49. Strengths and weaknesses of the observation from geostationary and polar satellite. Constellations of satellites.
  50. Radiometers. Radiance to the sensor and S / N ratio
  51. Advantages and disadvantages of active and passive systems.
  52. Calibration of a passive sensor.
  53. Optomechanical image systems. linear CCD. Whiskbroom scanners.
  54. Across track scanning. Relationship between orbital parameters (V / H) and scanning speed.
  55. Along Track Scanning. Two-dimensional CCD: pushbroom scanners.
  56. Advantages and disadvantages of the acquisition along-track and across-track.
  57. Scanning from a geostationary platform.
  58. Construction of digital images
  59. Spatial, spectral, temporal and radiometric resolution of a sensor.
  60. Interdependence between spatial, spectral and time resolution of a sensor. S/N ratio.
  61. The main satellite missions: the high and very high spatial resolution
  62. The main satellite missions: the high and very high temporal resolution.
  63. Sensor selection: competition between spatial, spectral and temporal resolution.
- Processing and interpretation of remotely sensed data.
64. Definition of multispectral digital image. Pre-processing of digital images.
  65. Calibration: calibration curve. In-flight calibration of thermal infrared sensors.
  66. Atmospheric corrections. Navigation of satellite images.
  67. Scatterogram.
  68. Classification of satellite images: supervised classification
  69. Unsupervised classification.
- Remote Sensing in Natural and Environmental Risks: methods and applications.
70. Concepts of spectral, spatial, temporal, intensity, signatures. Vegetation indices and NDVI
  71. Examples of use of the observation from aircraft and the high spectral resolution for the identification of Serpentinite outcrops in the National Park of Pollino.
  72. Application of robust techniques for supervised classification: Spectral Angle Mapper
  73. Integrated use of spatial and spectral signatures. Example: mapping of Pines Loricati in the national park of Pollino.
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74. Temporal signatures: mapping of flooded areas.
  75. Satellite techniques (split window) for the estimation of sea (SST) and land (LST) surface temperature.
  76. Dependence of brightness temperatures in the MIR and TIR measured on cells partially affected by fire.
  77. Relationship between spatial resolution and radiometric resolution: minimum size of detectable hot spots.
  78. Intensity signatures (identification of forest fires)
  79. Application of integrated satellite techniques for forecasting and / or monitoring extreme events (floods, volcanic eruptions, earthquakes, etc.).
  80. Intensity signatures: main techniques for monitoring volcanic activity.
  81. Integrated use of intensity and temporal signatures. Example: robust techniques for monitoring the thermal volcanic eruption clouds, of oil spills at sea, at the Earth's thermal emission of strong earthquakes.
  82. Appropriate choice of technologies in an operational context. Feasibility study and cost / benefits. Example: delimitation of the areas hit by fire for the purposes of L. 353/2000.
- Theoretical and practical exercises and laboratory
83. Laboratory measurement of black-body radiation and temperature estimation of the source by the Law of Wien
  84. Laboratory measurement of reflectance spectral signatures of vegetation, minerals and artificial surfaces.
  85. Multiplication of spectral response curves.
  86. Comparison graph of spectral curves of vegetation (recognition of water stress conditions and / or disease).
  87. Calculation of NDVI MODIS images and characterization of clouds, water and vegetated and non vegetated soils.
  88. Calculation of the difference image of the brightness temperatures at 11 and 12 microns for the discrimination of meteorological clouds from eruptive clouds and sandstorms.
  89. Planck function calculation and verification of the Wien's law.
  90. Analysis of spectral signatures of ocean, land and clouds from MODIS spectral images.
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#### TEACHING METHODS

Theoretical lessons, Classroom tutorials, Laboratory tutorials, Project works, Technical visits, Seminars.

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#### EVALUATION METHODS

Intermediate verifications, Discussion of a project work, Practical test, Oral examination.

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#### TEXTBOOKS AND ON-LINE EDUCATIONAL MATERIAL

Notes and slides of lessons

K. N. Liou An Introduction to Atmospheric Radiation - Second Edition – Academic Press (2002, 1980)

R. P. Gupta Remote Sensing Geology, Springer & Verlag, (1991).

W.G. Rees, Physical Principles of Remote Sensing, Cambridge University Press (1990)

Other useful texts:

P.J. Curran, Principle of Remote Sensing, Longmann (1985).

J.B. Campbell Introduction to Remote Sensing, Taylor & Francis (1996)

N. M. Short The Remote Sensing Tutorial Edited by Jon Robinson: available in the UNIBAS library on CD-ROM and on

NASA website: <http://code935.gsfc.nasa.gov/Tutorial/TofC/Coverpage.html>

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#### INTERACTION WITH STUDENTS

By e-mail, telephone, reception, slides of lessons and lab materials shared with students on a dedicated dropbox folder

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#### EXAMINATION SESSIONS (FORECAST)<sup>1</sup>

29/6/ 2020, 28/7/ 2020, 21/9/2020, 19/10/2020, 21/12/2020, 15/2/2021, 12/4/2021

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SEMINARS BY EXTERNAL EXPERTS    YES X    NO

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#### FURTHER INFORMATION

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<sup>1</sup> Subject to possible changes: check the web site of the Teacher or the Department/School for updates.



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