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
7. Wien's displacement law. Planck's law in the frequency domain.
9. Interaction of electromagnetic radiation with the Earth's surface.
12. Radiation-matter interaction in the visible, beyond the visible.
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
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.
26. Active and passive remote sensing techniques.
27. SAR techniques (outline)
   Interaction of electromagnetic radiation with the Earth's atmosphere.
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.
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.
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.
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.
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.
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.
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.

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

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

TEXTBOOKS AND ON-LINE EDUCATIONAL MATERIAL
Notes and slides of lessons
Other useful texts:

INTERACTION WITH STUDENTS
By e-mail, telephone, reception, on the dedicated dropbox folder shared with students

EXAMINATION SESSIONS (FORECAST)¹

SEMINARS BY EXTERNAL EXPERTS YES □ NO

FURTHER INFORMATION

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