Study Plan

School: School of Sciences and Technology
Degree: Master
Course: Earth and Atmospheric Sciences (cód. 693)

Specialization Meteorology and Geophysics

1st Year - 1st Semester
Specialization Meteorology and Geophysics

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
FIS10340M	Earth and Atmospheric Physics	Physics	6	Semester	156
MAT12516M	Mathematical Analysis III	Mathematics	6	Semester	156
FIS10342M	Observation Methods and Tecniques in Earth, Atmospheric and Space Sciences	Physics	6	Semester	156
FIS10343M	Signal Analysis and Inversion Methods	Physics	6	Semester	156
FIS12541M	Fundamentals of Geodesy and Geomatics	Physics	6	Semester	156

1st Year - 2nd Semester
Specialization Meteorology and Geophysics

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
FIS10345M	Energy, Environment and Sustainability	Renewable Energy Engineering	6	Semester	156
FIS10346M	Computational Methods in Physics and Engineering	Physics	6	Semester	156
FIS12544M	Environmental Hazards	Physics	6	Semester	156

Group of Options

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
FIS10354M	Applied and Environmental Geophysics	Physics	6	Semester	156
FIS12542M	Dynamic Meteorology	Physics	6	Semester	156
FIS12540M	Micrometeorology	Physics	6	Semester	156
FIS10353M	Seismology	Physics	6	Semester	156

2nd Year - 3rd Semester
Specialization Meteorology and Geophysics

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
FIS10348M	Remote Sensing and Environmental Satellites	Physics	6	Semester	156
FIS10351M	Seminar on Earth, Atmospheric and Space Sciences	Physics	6	Semester	156

2nd Year - 3rd Semester
Specialization Meteorology and Geophysics

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Group of Options					
FIS10356M	Geothermics	Physics	6	Semester	156
FIS10349M	Synoptic Meteorology and Weather Forecast	Physics	6	Semester	156
Dissertation					

2nd Year - 4th Semester
Specialization Meteorology and Geophysics

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Dissertation					

Specialization Environmental Rehabilitation

1st Year - 1st Semester
Specialization Environmental Rehabilitation

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
GEO10363M	Environmental Hydrogeology	Geology	6	Semester	156
GEO12543M	Environmental Geochemistry	Geology	6	Semester	156
FIS10342M	Observation Methods and Tecniques in Earth, Atmospheric and Space Sciences	Physics	6	Semester	156
QUI10364M	Environmental Chemistry	Chemistry	6	Semester	156
BIO10365M	Evaluation of the state of surface freshwaters	Biological Sciences	6	Semester	156

1st Year - 2nd Semester
Specialization Environmental Rehabilitation

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
FIS10345M	Energy, Environment and Sustainability	Renewable Energy Engineering	6	Semester	156
QUI10244M	Pollution and Gas Emissions	Physics and Chemistry	6	Semester	156
GEO10080M	SIG Remote Sensing	Geology	6	Semester	156
FIS12544M	Environmental Hazards	Physics	6	Semester	156
FIS10354M	Applied and Environmental Geophysics	Physics	6	Semester	156

2nd Year - 3rd Semester
Specialization Environmental Rehabilitation

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
GEO07154M	Environmental Rehabilitation	Environment and Ecology Sciences Geological Engineering	6	Semester	156
GEO10366M	Biogeochemistry of aquatic sediments	Geology	6	Semester	156
FIS10351M	Seminar on Earth, Atmospheric and Space Sciences	Physics	6	Semester	156
Dissertation					

2nd Year - 4th Semester
Specialization Environmental Rehabilitation

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Dissertation					

Conditions for obtaining the Degree:

*** TRANSLATE ME: Área de Especialização em Meteorologia e Geofísica:

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Para aprovação na componente curricular nesta área de especialização é necessário a a provação (através de avaliação ou creditação) das seguintes unidades curriculares.

1º ANO

1º Semestre:

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5 UC Obrigatórias num total de 30 Ects{\}newline

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2º Semestre:

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3 UC obrigatórias num total de 18 Ects

2 UC optativas do Grupo de Optativas do semestre num total de 12 ECTS

2º ANO

{\}newline

3º Semestre:

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2 UC Obrigatórias num Total de 12 Ects

1 UC optativas do Grupo de Optativas do semestre num total de 6 ECTS{\}newline

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Para obtenção do grau, é necessário também a aprovação em Dissertação, com o total de 42 ECTS, no 3.º e 4.º Semestre{\}newline

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Área de Especialização em Recuperação Ambiental:{\}newline

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Para aprovação na componente curricular nesta área de especialização é necessário a a provação (através de avaliação ou creditação) das seguintes unidades curriculares:

1º ANO

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1º Semestre:

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5 UC Obrigatórias num total de 30 Ects{\}newline

{\}newline

2º Semestre:

{\}newline

5 UC obrigatórias num total de 30 Ects

2º ANO{\}newline

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3º Semestre:

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3 UC Obrigatórias num Total de 18 Ects{\}newline

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Para obtenção do grau, é necessário também a aprovação em Dissertação, com o total de 42 ECTS, no 3.º e 4.º Semestre

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Program Contents

Back

Earth and Atmospheric Physics (FIS10340M)

The shape of the Earth and the gravity field .
Introduction to Seismology.
Some comments about geophysical prospection.
Geomagnetism.
Introduction to paleomagnetism.
Introduction to the study of the heat flow from the Earth.
Composition and structure of the Earth's atmosphere.
Thermodynamics of the atmosphere: thermodynamic characteristics of dry and moist air. Thermodynamic processes in the atmosphere. Formation of dew, frost, fog and clouds. Statics of the atmosphere. The hydrostatic equation. Atmospheric stability. Clouds and precipitation.
Radiation: Earth radiation budget. Physical radiation laws of the blackbody. Radiation transmission in the atmosphere. Absorption. Emission and scattering. Radiative transfer equation. Greenhouse Effect. Aerosol effects. Radiative forcing.
Atmospheric dynamics: Fundamental forces in the atmosphere. Equations of fluid motion. The general circulation of the atmosphere.

Back

Mathematical Analysis III (MAT12516M)

Elements of Differential Geometry in R3: Contours. Parameterization by arc length. Curvature and torsion. Frenet-Serret formulas. Tangent plane and normal line to a surface. Orientability.
Introduction to Complex Analysis: Complex functions and analytic functions. Cauchy-Riemann equations. Laplace equation. Harmonic functions. Geometry of analytic functions. Complex integration. Fundamental Theorem of Calculus. Cauchy's theorem and its evolution. Cauchy integral formula.
Ordinary Differential Equations: Exact equations and integrating factors. Equations of 1st order. 2nd order linear equations.
Systems of ordinary Dif. Eq.: Linear systems and with constant coefficients. Stability of solutions.
Fourier series. Periodic functions. Trigonometric series. Euler formulas for Fourier coefficients. Convergence and the sum of the Fourier series. Functions with a generic period 2L. Expansion in series of sines and cosines. Periodic extensions. Complex Fourier series. Fourier integrals.

Back

Observation Methods and Tecniques in Earth, Atmospheric and Space Sciences (FIS10342M)

Study of different remote sensing ground based instruments and their physical priciples (RADAR,LIDAR, Spectroscopy, Photometry, Interphotometry). Satellite remote sensing sensors. Physical principles of remote sensing. Passive and active systems. In situ monitoring systems. Meteorological instruments and radiosounding systems. GPS. Seismometers, gravity meters, magnetometers. Global observation network. Observation, interpretation and record of distinct geophysical field data found in different places.

Back

Signal Analysis and Inversion Methods (FIS10343M)

Digital signal processing and inversion methods - Analysis of discrete and continues time series. Applications of multivariate analysis to geophysics and climate. Principles and techniques of signal treatment geophysics and climate. Fast Fourier Transforms (FFT), Z transforms Laplace transforms. Deconvolution, fileter design and transfer function. Spectral analysis. Inverse problem in geophysics and Atmosphere.
Methods of linear and non linear inversion. Problem of non-unicity; Analysis of data and model resolutions. Applications.

Back

Fundamentals of Geodesy and Geomatics (FIS12541M)

The course includes the study and practice of:
- Main coordinate systems and projections used in maps as well as their transformation;
- Survey of control points from terrestrial, aerial and space technologies for geophysical use.
- Connection between data obtained by space and ground / air techniques.
-Digitalization 3D from laser scanners devices. The basis of Laser technology. Technological fundamentals. Terrestrial 3Dl scanners. The basic components of 3D laser scanners.
- Digital photogrammetric systems. Principles and Components. Photogrammetric functions. Software. Automated generation of the digital terrain models and 3D structures. Orthophoto production.
-Products of multimedia cartography. Cartographic information systems and the Internet. Map formation on the Internet. Data storage and management. Cartographic databases. Interactive Internet maps. Possibilities and limitations of the Internet maps. Animation in cartography.

Back

Energy, Environment and Sustainability (FIS10345M)

1. The Earth: subsystems and their interaction. The resources: content, availability and strategic importance. Duration of resources and their distribution.
2. Sustainability and use of resources: Biocapacity and ecological footprint, the ecological balance, the water footprint and the carbon footprint. Energy and sustainability: "life-cycle assessment"in the scope of sustainability. Diagnosis for the sustainability in Portugal.
3. Energy, entropy and exergy. Thermodynamic cycles.
4. Energy sources: fossil fuels, nuclear energy and alternative sources (renewable energy).
5. Energy and exergetics analysis. Energy efficiency. Energy storage.
6. Energy and environment: pollution, greenhouse effect and climate change.

Back

Computational Methods in Physics and Engineering (FIS10346M)

1. Introduction - The actual paradigm in computation, computational algorithms and languages, computational arithmetic
2. Basic numerical methods - operation with matrix, differentiation and integration, interpolation, nonlinear equations, systems of linear equations, systems of nonlinear equations, approximation of functions
3. Differential equations - Ordinary differential equations and partial differential equations
4. Modelling of continuous systems - diffusion equation, wave equation and hydrodynamic equations
5. Spectral analysis - continuous Fourier transform, discrete Fourier transform, FFT, determination of spectral energy density
6. Optimization and inversion - Linear programming, quadratic, nonlinear and integer; linear and nonlinear inverse problem, least square method, Baysian formulation of inverse problem, a priori information, analysis of resolution and errors.

Back

Environmental Hazards (FIS12544M)

Climatic system. General Circulation of the Atmosph and Oceans, global cycles of energy, water and ang. momentum and climates on Earth. Normal and climatic classif. Variability, predictability and almost periodic oscillations. Condensation, clouds, fog, precipitation, thunderstorms and lightning. Extreme weather events. Dry. Meteorology and pollution. Meteorology and wildfires. Greenhouse effect. Radiative forcing and climate change. Future climate scenarios.
Basic concepts of seismol (propagation sources, and inelastic effects. Historical and instrumental seismicity, scales of intensity and magnit., site effect, VS30, transfer functions. Probabil. and determin. methods in the evaluation of seismic: hazard, engineering, vulnerability, risk and risk in Portugal.
Introduction to volcanology, characterization of volcanic activity and hazards. History of volcanism in the world and in Portugal. Prediction and monitoring of seismic and volcanic activity. Prevention systems and early warning.

Back

Applied and Environmental Geophysics (FIS10354M)

1. Introduction to geophysical methods
2. Gravimetric method
3. Magnetic method
4. Seismic methods
5. Electromagnetic methods
6. Electrical method
7. Planning a geophysical survey
8. Conducting a geophysical survey
9. Conducting a final report

Back

Dynamic Meteorology (FIS12542M)

Real and apparent forces in a rotating fluid. The atmospheric primitive equations of energy, mass and momentum conservation. Scale analysis of the equations of motion. Vertical coordinates used in meteorology. Elementary applications of the equations of motion: geostrophic, cyclostrophic and gradient wind, thermal wind and vertical motion. Circulation, vorticity and divergence. Atmospheric oscillations: sound, gravity and Rossby waves. Local winds and mesoscale circulations. Cyclones, thunderstorms, hurricanes, anticyclones and fronts. The general circulation of the atmosphere and the global cycles of angular momentum and energy.

Back

Micrometeorology (FIS12540M)

1. Introduction - Scope of Micrometeorology. Atmospheric scales. The atmospheric boundary layer (ABL) and sublayers. Diurnal evolution of the ABL. Typical profiles of the temperature, wind speed and water vapour. Atmospheric stability and convection.
2. Energy and water balances at the surface.
3. Basic atmospheric equations, turbulence and the closure problem.
4. Parameterisation of turbulent fluxes of momentum, energy and mass in the atmospheric inertial sublayer.
5. Methods for estimating the surface fluxes of momentum, energy and water vapour
6. Atmospheric stability, diffusion and transport of pollutants- Gaussian plume models.
7. Climates of non-homogeneous terrain.

Back

Seismology (FIS10353M)

1) Complements of continuum mechanics.
2) Equations of motion.
3) wave propagation inside the Earth.
4) Internal waves, surface waves.
5) inelasticity and anisotropy.
6) Earth eigenmodes.
7) Seismic Source.
8) synthetic seismograms.
10) Analysis of seismic data.

Back

Remote Sensing and Environmental Satellites (FIS10348M)

1. Introduction: Basic concepts in remote sensing; Brief history of remote sensing; Benefits of Remote Sensing in Earth Sciences. 2. Fundamentals of radiation: Nature and properties of radiation: The electromagnetic spectrum; Radiometric quantities and measurement unit: Laws of radiation: Interaction of radiation with the environment; Introduction to radiative transfer; Radiative transfer codes. 3. Satellites and sensors: Orbital mechanics and types of orbits; Observation geometries; Types of sensors; Satellite images and resolutions; Global spatial observation system; Environmental missions; Geographic information system: a useful tool in remote sensing; Other open access computer applications. 4. Image processing and analysis: Introduction; Pre-processing; Enhancement operations and transformations; Classification and analysis; 5. Calibration and validation; 6. Environmental applications: The problem of inversion in remote sensing; Monitoring; Emergency and alert.

Back

Seminar on Earth, Atmospheric and Space Sciences (FIS10351M)

Due to the specific objectives of this curricular unit, the contents will vary from year to year, being influenced mainly 1) by the scientific partnerships established within the scope of ongoing research projects in which the teaching staff are working and 2) by the events that take place and can be easiliy integrated into the topics of the UC.
However, the program will provide advanced knowledge in the areas of Earth, Atmosphere and Space Sciences, in particular in the following domains: Meteorology, Climate, Climate Variability and Climate Change, Observation and detection systems and techniques for monitoring the atmosphere and the space, Seismology and seismic risk, Geophysical prospecting, Genesis and dynamics of geological materials, mineral resources, environmental impacts, genesis and dynamics of geological materials, distribution of geological materials on the Earth's surface.

Back

Geothermics (FIS10356M)

Introduction. Some data . Heat transport mechanisms. Thermal properties of the rocks. Heat originated by radioactive elements. Heat flow in oceans, age of the crust and bathymetry.
Heat flow in continents. Problems found in the calculus of geotherms in continents. Heat flow from the mantle.
Secular variations of temperature and heat flow. Secular cooling of the lithosphere. Secular decrease of the heat flow from the mantle and thickness increase of the lithosphere.
Thermal perturbations related with orogenies, metamorphism, erosion or material deposition. Thermal regime in extension regions. Horizontal heat transport.
Some problems associated with depth temperature calculation, based on data obtained from the surface. Adiabatic gradient.
Analysis of maps of Portugal with thermal springs and chemical classification and water temperature.
Prospection of geothermal systems. Geophysical methods used.

Back

Synoptic Meteorology and Weather Forecast (FIS10349M)

The general circulation of the atmosphere and the scales in meteorology. Global meteorological observations and synoptic weather charts. Structure and evolution of the main synoptic weather systems.
Synoptic meteorology equations: The fundamental equations of the atmospheric motions; scale analysis and approximations; circulation and vorticity; the vorticity equation;
The quasi-geostrophic approach and the extra-tropical circulations; Diagnosis of the vertical motion.
Introduction to numerical weather prediction: historical aspects of weather forecasting; methods of discretization and numerical integration of the equations.
Parametrization and representation of sub-scale physical phenomena in NWP models: turbulence, clouds and precipitation, radiation, surface-atmosphere interaction.
Data assimilation and meteorological analysis. Predicatbility and Probabilistic prediction.
Nowcasting and
Very Short Term Forecasting

Back

Environmental Hydrogeology (GEO10363M)

Rational exploitation, over-exploitation, methods of contamination and protection of aquifers against contamination. Wellhead protection areas. Remediation measures in aquifers. Remediation of groundwater contaminated with metals. Remediation of hydrocarbons, volatile or nonvolatile, dense or light. Remediation of organic contaminants, chlorinated solvents, sulfates, nitrates and other contaminants. Methodologies used for treatment of groundwater, bioremediation, oxidation/reduction chemistry, in situ flushing, air sparging, permeable reactive barriers, electrochinectics, thermal methods, steam, treatment by UV/oxidation, horizontal holes, vertical circulation holes, hydraulic and pneumatic fracturing applied to groundwater remediation, stabilization/solidification, natural attenuation, etc. .. Interaction groundwater/surface water. Methodology for identification and their importance in the hydrological cycle. Groundwater-dependent ecosystems. Methodology of identification.

Back

Environmental Geochemistry (GEO12543M)

1. Geochemistry as a geoscience to the study of interaction of geospheres in the Earth surface.
2. Chemical equilibria: Ions in solution and ionic mobility in natural fluids. Equilibrium acid-base on natural fluids.
3. Geochemistry of the oxide-reduction process: sedimentary environments and pH and Eh boundaries,Oxide-reduction and the sedimentation.
4. Analytical methods in environmental geochemistry: analytical chemistry techniques and phase composition techniques.
5. Geochemistry of weathering.

5.a. Weathering of the rocks monuments: Mechanisms in the decline of the rocks of monuments, pathologies: characterization and diagnosis, examples.

6. Adsorption and ionic exchange on the surface of minerals.
7. New Minerals: Precipitation-dissolution and stability, Retention of pollutant metals, wastes and landfills
8. Hydro-geochemistry and transport of pollutants
9. Potentially toxic metal geochemistry: Origins of metals, Mobility of metals in natural environments
10. Correction strategies

Back

Environmental Chemistry (QUI10364M)

1. Introduction

1.1 General concepts

1.2 Pollution and environmental problems. Natural pollution versus anthropogenic pollution

2. Water and liquid effluents

2.1 Water pollution. Surface and groundwater. Parameters that determine water quality and methods of analysis used

2.2 European and national legislation

2.3 Characterization of water and wastewater:

2.3.1 Physical parameters

2.3.2 Chemical parameters

2.3.3 Biological parameters

3. Water and effluent treatment processes

3.1 Water treatment processes for human consumption (WTP's)

3.2 Wastewater treatment processes (WWTPs)

4. Soil chemistry

4.1 Contamination of the soil. Organic and inorganic pollutants (trace metals)

5. Remediation of contaminated soils and food safety

5.1 Chemical and biological remediation

6. Phytoremediation of soil and water

6.1 Case Studies

Back

Evaluation of the state of surface freshwaters (BIO10365M)

1. Freshwater ecosystems: diversity at a global scale (Definition of inland water ecosystems; Climate, hydrology and spatial and temporal scales; Components of the hydrological regime; Physical, chemical and biological processes; Links at river basin scale; Hydrographic network, river basins and hydrographic regions in Portugal (regional scale))
2. Lentic ecosystems (Physical-chemical and biological processes)
3. Lotic ecosystems (Physical-chemical and biological processes)
4. Biological indicators (Natural disturbances versus anthropogenic disturbances; European Union Water Framework Directive (WFD))
5. Ecosystem Services (Commitment, synergy and disservice; biodiversity; Valorization and benefits of Ecosystem Services; involvement and perception of social actors)
6. Ecological Conservation and Restoration (Dimensions of restoration; uncertainty, challenges/opportunities, success; Public perception of river restoration; Naturally Based Solutions

Back

Pollution and Gas Emissions (QUI10244M)

Dispersion of pollutants in the atmosphere. Elements of atmospheric physics and dynamics. Atmospheric circulations and the transport of pollutants. Atmospheric Boundary Layer and Turbulence. Air pollution dispersion models.
Air pollutants and its action. Strotospheric ozone. Photochemical smog. Acid rain. Air particles in suspension. Volatile organic compounds. Greenhouse effect gases. Metals and metalic compounds. Air pollutants monitoring. Environmental laws. Standard methods for monitoring the main air pollutants. Methods for gaseous emission treatment. Gravity settlers. Cyclones. Electrostatic precipitators. Filtration. Washers.

Back

SIG Remote Sensing (GEO10080M)

GENERAL CONCEPTS
Graphic representations; Projection Systems; Georeferencing.
Spatial data informatics.
Raster and vector data.
Organization of information.
Data types and structures.

GIS
Symbology and labels.
Creation of vector data.
Treatment and vector data.
Creating Layouts.

RS
Aerial, drone and satellite photography, principles of image acquisition and processing.
Orthorectified and stereoscopic images.
Creation of digital elevation and terrain models.

Project
Problematization, design and implementation of a DR & GIS project applied to geosciences.
Final report writing.

Back

Environmental Rehabilitation (GEO07154M)

Introduction to the concepts of environmental rehabilitation and ecological restoration. The objectives, criteria, benchmarks of recovery.
Impacts due to mining, quarries and gravel pits. Correction of impacts related to noise and vibration.
Management of toxic and radioactive waste. Treatment of degraded areas.
Correction of impacts on water systems. Surface Water. Rehabilitation of Aquifers.
Contamination of soils, sediments and water by heavy metals from mines. Decontamination of land.
Tailings dams.
Correction of impacts on air quality, soil, landscape and ecological systems.
Introduction to Environmental Geotechnics. Sustainable development.
Correction of impacts in Linear Works (road and rail).
Characterization and classification of waste management and waste disposal.
Management and recovery of waste in geotechnical works. Legislative framework for the recovery of waste.
Environmental recovery methods for coastal and estuarine areas.

Back

Biogeochemistry of aquatic sediments (GEO10366M)

Biogeochemistry of aquatic systems: Introduction
River Sediments: Characteristics of rivers, Material flows through rivers, Chemical fluxes and dynamics of rivers.
Lacustrine sedimentation in artificial systems: The natural erosion and accelerated erosion of soils in the watersheds of the lake systems, Physical and chemical processes in lake systems, Dams and reservoirs and nutrient cycles, Factors controlling the transport of materials and sedimentation in dams, Transport and sedimentation of materials, Mechanisms of Transport and Deposition of Clay Minerals, Chemical fluxes and dynamics of lakes.
Biogeochemistry of river and lake sediments: major elements (Ca, Mg, Na, K, Na), metallic elements, trace metals, nitrogen, phosphorus, carbon, methane, redox potential.
Pollution and remediation of aquatic systems: Acidification, Pollution by pathogens and toxins, Eutrophication, The redox potential and recovery of lakes, Dredging as a recovery technique.