POLI ESCOLA SUPERIOR TECNOLOGIA GESTÃO TÉCNICO GUARDA	SUBJECT DESCRIPTION	MODELO PED.013.03

Course	**Energy and Environment**						
Subject	Climatology						
Academic year	2023/2024	Curricular year	2nd	Study period	1st semester		
Type of subject	Compulsory	Student workload (H)	Total: 112	Contact: 45	ECTS	4	
Professor(s)	Prof. Dr. **Rui Perdigão**						
☒ Area/Group Coordinator ☐ Head of Department (select)	Prof. Dr. **Rui Pitarma**						

PLANNED SUBJECT DESCRIPTION

1. LEARNING OBJECTIVES

A – Introduction to the Climate System, its multiscale dynamics and emerging multissectorial challenges. From fundamental geophysics to the interdisciplinary nexus among Earth and environmental sciences, energy and sustainability, articulated into a coherent whole of solid theoretical, practical and operational grounds.

B – Discerning processes and interactions underlying the nature and dynamics of the Climate System, along with its spatial and temporal complexity, its impacts, environmental and energetic challenges, in a synergistic systemic approach solidly grounded onto fundamental principles.

C – Empowering the scientific understanding of climatic changes and the central role of the environmental and energy sciences to tackle challenges of climatic action, energy transition and sustainable development, on a integrated cohesion among the fields of Energy and Environment in this degree programme.

D – Articulate the global dynamics of the Climate System with the regional and local realities, empowering the analysis of the signals of nature for the diagnosis, prognosis and decision support relative to atmospheric, hydrologic, oceanic and biogeophysical phenomena, their interactions and extreme events.

E – Conceptualise, in a physically intuitive and formal framework, simple models representative of key aspects of the Climate System, elucidating its "how" and "why" in the light of basic notions of mathematical analysis, thermodynamics and fluid dynamics in harmony with the other curricular units of this degree programme.

F – Distinguish and understand the various climatic types, their transformations and emerging challenges, from global scale to regional Iberian-Atlantic and Mediterranean features, along with those within Portugal itself. From the oceanic area of influence to the inner mainland interior, concluding with a scientific characterisation and operational capacitation to tackle environmental and energy challenges in local, regional and global climatic action.

2. PROGRAMME

1. General overview and fundamental notions

1.1 – Introduction to the Sciences of Climate and Climatic Change, along with their framing within the Earth System Sciences and their interdisciplinary nexus articulating energy and environmental issues.

1.2 – The Climate System. From fundamental physics and chemistry underlying its nature and composition, to the processes, forcings and interactions shaping its dynamics, impacts and emerging challenges.

1.3 – Discerning subsystems and interactions among geophysical, geoecological and broader environmental processes, along with their synergistic articulation in the Climate System and the underlying physical, chemical and systemic principles.

1.4 – Dynamics of the Climate System across spatial and temporal scales: from their invariants, patterns, feedbacks and symmetries, to their functional variability and structural transformation.

1.5 – Role of the sciences of Climate and Climatic Change in the capacitation to understand the past, manage the present and prepare the future in terms of climatic action and energy transition.

2. The Engine of the Climate System

2.1 – Energetics of Dynamical Systems and underlying physical principles

2.2 – Thermodynamics of Planet Earth and the associated Climatic Thermal Engine

2.3 – Electrodynamics of Planet Earth: radiative forcing, balance and its dynamics

2.4 – Geophysical Fluid Mechanics and principles of general oceanic and atmospheric circulation

2.5 – Conditions at and near the interface among subsystems, boundaries and exogenous forcings

3. Composition and Structure of Climate Subsystems

3.1 – Oceans: vertical, horizontal and volumetric composition and structure

3.2 – Atmosphere: vertical, horizontal and volumetric composition and structure

3.3 – Criosphere: vertical, horizontal and volumetric composition and structure

3.4 – Litosphere e Biosphere: composition, morphology and modulating role

3.5 – Perturbations: from land use and built environments to environmental pollution and disruption

4. Fluxes and Regimes in the Climate System

4.1 – Geophysical and Geochemical Fluxes: hydrologic, hydrogeologic and carbon cycles and transitions

4.2 – Energy and Entropy Fluxes: thermodynamic and radiative cycles and their transitions

4.3 – Oceanic Circulation Regimes

4.4 – Atmospheric Circulation Regimes

4.5 – Phase transitions and fluxes of interface among climatic subsystems

5. Climate Regimes at Local and Regional Scales

5.1 – Regional and Local Oceanic Regimes: from the North Atlantic Gyre to the Portuguese coast

5.2 – Regional and Local Atmospheric Regimes: from the Euro-Atlantic area to the Portuguese interior

5.3 – Interface regimes among Coastal, estuarine, orographic, biogeophysical and built environments

5.4 – Multiscale impacts and feedbacks among global, regional and local circulation regimes

5.5 – Characterisation of the climatic regimes of Portugal, along with their dynamics and challenges

6. Transient Intraclimatic Dynamics: at event scales

6.1 – Meteorological, hydrologic, oceanic and biogeophysical conditions and tendencies

6.2 – Diagnostic and prognostic: from tendencies to short, mid and long term variations

6.3 – Interaction between short and long scales in time and space: between “events” and “climates”

6.4 – Extreme events and natural hazards: from extreme storms and floods to heat waves and fires

6.5 – Early warning signs and prevention of extreme events and multihazard risk emergence

7. Climatic Variability, Teleconnections and Impacts

7.1 – Oceanic and Atmospheric variability regimes at meso and large spatial and temporal scales

7.2 – Variability regimes in the Ocean-Atmospheric interactions and associated climatic indices

7.3 – Teleconnections among variability regimes and associated climatic indices

7.4 – Impacts of variability regimes and their teleconnections onto the regional and transient dynamics

7.5 – Dynamic complexity and predictability of the Climate System

8. Systemic Evolution and Climatic Changes

8.1 – Nature of the problem, its evolution and underlying causal nexus

8.2 – Perturbations of endogenous, exogenous and coevolutionary nature

8.3 – Paleoclimatic and historical evolution: from proxy reconstruction to instrumentation and modelling

8.4 – Climatic data, models, scenarios, projections and associated predictability

8.5 – Processing, visualisation and scientific communication of Climatic Changes

9. Climate Action and Energetic-Environmental Strategies

9.1 – Climatic Change impacts and emerging challenges

9.2 – Mechanisms of climatic action and underlying scientific basis

9.3 – Strategies of decarbonisation and energy transition

9.4 – Objectives and measures for sustainable development

9.5 – Challenges associated to climatic action and energetic-environmental strategies

10. Analysis, Modelling and Decision Support

10.1 – Data analysis pertaining the Climate System, its subsystems and interactions

10.2 – Prediction models in Meteorology, Oceanography, Climatology and Hydrology

10.3 – General models for Earth System Dynamics and Climatic Changes

10.4 – Monitoring, visualisation, processing and decision support systems

10.5 – Collaborative project and final report for the curricular unit.

3. COHERENCE BETWEEN PROGRAMME AND OBJECTIVES

The overall, interdisciplinary and multifaceted scope of objectives A and B is developed and fulfilled throughout all programme points, synergistically articulated as a coherent whole, in line with the vision of the curricular unit and its role in the systemic articulation of the degree programme in Energy and Environment.

Objective C is developed and achieved through programme points 6 to 10, as these focus on the understanding of the dynamics, impacts, strategies and techniques to approach such questions.

Objective D encompasses all programme points since its fulfilment entails the understanding of the Climate System, its dynamics and events across the various scales and interactions, developed along the various programme points of the curricular unit.

Objective E, entailing a more methodological tenor, permeates across the various programme points with special emphasis onto the first one with general notions, principles and fundamentals, along with the last one, taking the formalism of analysis, modelling and decision support in a deeper and detailed manner, after having explored and worked onto the various points of the programme.

Objective F is nurtured across the programme points 1 to 4, through the development of general principles and of global scope, and on point 5 the more regional and local focus, following then to the event scales worked in point 6, then to finally work the issues of variability, changes, impacts and emerging challenges across points 7 to 10, articulating the various programme points without loss of focus onto point 5.

4. MAIN BIBLIOGRAPHY

[Base/Classes] Perdigão, Rui A. P. (2022): *Dinâmica do Sistema Climático: da Ciência Fundamental às Fronteiras da Complexidade*. [Development and gradual communication throughout the semester]

[Mandatory] Peixoto, J. Pinto e A. Oort (1992); *Physics of Climate*. American Institute of Physics, Massachusetts, USA.

[Recommended] Ghil, Michael; and Valerio Lucarini (2020): The physics of climate variability and climate change. Rev. Mod. Phys. 92, 035002. DOI: 10.1103/RevModPhys.92.035002.

[Recommended] Stull, Roland (2017): *Practical Meteorology: An Algebra-based Survey of Atmospheric Science* - version 1.02b. University of British Columbia, Canada. ISBN 978-0-88865-283-6.

[Recommended] Peixoto, José Pinto (1987); O HOMEM; O CLIMA E O AMBIENTE: I O Sistema Climático e as Bases Físicas do Clima; II As Variações do Clima e o Ambiente III A Influência do Homem no Clima e no Ambiente. Coleção o Ambiente e o Homem, Gabinete de Estudos e Planeamento da Administração do Território, Secretaria de Estado do Ambiente e dos Recursos Naturais, Lisboa.

[Recommended] Miranda, Pedro M. A. (2009): *Meteorologia e Ambiente*. 2ª Edição, Universidade Aberta, Lisboa.

5. TEACHING METHODOLOGIES (INCLUDING EVALUATION)

The teaching methodologies employed in theoretical (T), theory-practice (TP) and tutorial orientation and guidance (OT) reflect the conciliation between the vast interdisciplinary span and scientific depth of the programme, in a coherent, synergistic and integrated manner. Therefore, each content is contextualised in the problematic and objectives of the curricular unit, being worked from: 1) expositive and interactive manners to anchor and strengthen the basis, such as in the constructions of schemes and formulations on the board and through various media platforms in a co-criative manner involving the students in each step of the development to cement concepts and ways of constructions, formalisation and discussion of the knowledge as it is developed in class; 2) Discussion of problems and their relevance, formulation of hypothesis, construction of strategies for their resolution based on the principles worked through methodology 1, and learning towards the resolution of such problems, both in generic cases to cement the basics, as in concrete cases to empower real-world action; 3) Development of practical works by the students, entailing from technical-scientific stydies to operational works with special emphasis onto challenges of analysis, modelling and decision support to approach matters relevant to the Climate System and its articulation with the overall challenges of climatic changes, their impacts and emerging challenges at the interface between energetic and environmental issues; 4) Discussion and debate of the works towards learning and evaluation, for the latter centres mostly onto preparing a final written report with oral presentation and discussion.

Across all pedagogic methodologies there is involvement and incentive for participatory dynamics, of debate and individual and group reflection, along with exploring and consolidating technical-scientific foundations for the fundamental scientific understanding and concrete resolution of problems in practice, along with their communication both in an academic scope and in training to communicate Climate science to decision makers, citizens and other actors of socio-environmental relevance.

The continuous evaluation encompasses the following parameters: presence (10%), development of in-class activities (20%) and final written report with oral discussion (70%). The larger weight is bestowed onto the final report since in substantive terms it integrates efforts within and beyond the class environment conducted throughout the semester.

The student will be approved in the curricular unit if achieving an overall classification of at least 10 (on a scale of 0 to 20). If the student does not successfully complete the continuous evaluation, then successfully a final exam will be required for approval, at a weight of 100% for the final grade.

6. COHERENCE BETWEEN TEACHING METHODOLOGIES AND OBJECTIVES

The teaching methodologies employed in theoretical (T), theory-practice (TP) and tutorial orientation and guidance (OT) reflect the conciliation between the vast interdisciplinary span and scientific depth of the programme, in a coherent, synergistic and integrated manner, with contextualisation and articulation into the problematic and objectives of the curricular unit.

7. ATTENDANCE

Active presence and participation in class is strongly recommended, in order to enable the full fruition of the objectives and activities of the curricular unit, and achieving such in a more enriching, empowering and interesting manner, as not all that is approached and developed in class can be found in the literature.

8. CONTACTS AND OFFICE HOURS

Contacts of the professor of the course

Professor of the course

Name: Prof. Dr. Rui Perdigão

Email: perdigao@ipg.pt

Office hours: Wednesday: 11:30 to 12:30.

9. OTHERS

Other than attendance, students must be punctual in class and avoid unnecessary interruptions.

DATE

September 18th, 2023

SIGNATURES

Professor(s), Area/Group Coordinator or Head of Department signatures

Area/Group Coordinator

(*Prof. Dr. Rui Pitarma*)

Professor

(*Prof. Dr. Rui Perdigão*)