MASTER OF RESEARCH IN SCIENCE AND MANAGEMENT OF CLIMATE CHANGE

LEVEL II – EDITION TWO
A.A. 2019-2020

Presentation

Climate change is one of the main challenges facing the planet's population. The World Economic Forum ranks climate change and the failure to implement effective policies among the top five economic risks for the business world. Its impacts are pervasive and deeply interrelated with all aspects of our society. Hence the need to prepare professional leaders with a high-level scientific profile thanks to the integration of the Master with the PhD Programme in Science and Management of Climate Change.

Objectives

The Master of Research in Science and Management of Climate Change is a 1-year programme aimed at creating experts capable of managing the complex and multi-faceted dimensions of the grand challenges posed by climate risk by integrating the scientific and socio-economic aspects in a unique programme. It prepares experts with a broad and thorough scientific background in economics, climate science, valuation techniques, and with specific modelling skills.
During this Master you will learn to understand and synthesize the biophysical and socio-economic nature of climate change, evaluate the socio-economic implications of climate change risks, and design innovative policy solutions and risk management strategies. You will acquire familiarity with a suite of methodological, analytical, statistical and modelling tools you will be able to apply in order to:

- Explain the physical and economic nature of climate change and their uncertainty
- Assess the socio-economic impacts of climate change, their costs and benefits
- Estimate and manage climate change risk
- Analyze, evaluate, and design innovative climate policy solutions
- Assess the economic costs and benefits of mitigation and adaptation policies and projects
- Conceive transformational pathways in the context of sustainable development
- Synthesize and communicate the different dimensions of climate change and their uncertainties to different users

The new edition 2019-2020 has a new study plan.

Master students will have the opportunity to choose the 12 courses (72 CFU) among 23 courses offered to the PhD and Master Students, for an overall amount of coursework of 400 hours, including labs, guest lectures from international experts, seminars, hands-on sessions, group activities, presentation of group/individual projects.

Introduction to climate dynamics

The course will offer an introduction to the concepts of climate, climate system and climate change and to the underlying dynamics and thermodynamics. The objective is to provide students with a common knowledge basis on climate, climate dynamics and climate change. The course will introduce the fundamental physical principles to understand how climate works and it will explain the physical of climate change. Current and future climate change will be quantitatively documented.

Atmospheric Dynamics

The course will introduce the scope of dynamical meteorology, scales and types of motion in the atmosphere. Forces in geophysical fluids, scale analysis, structure of the atmosphere, coordinates. Conservation laws, basic applications, vorticity, atmospheric oscillations, quasi-geostrophic theory, baroclinic instability. The planetary atmospheric circulation: observed features and example theoretical models (e.g. the Rossby model for stationary eddies). Variability at different time scales.

Numerical Methods and Modeling for Geophysical Fluid Dynamics

The objective of the course is to introduce the students to the evolution of deterministic and noisy dynamical systems. Stability of equilibria, bifurcations and phase portraits will be discussed with a focus on the Hamiltonian systems and indicators of chaotic behavior such as Lyapunov exponents. Starting from polynomial approximation and interpolation the basic tools to integrate first order differential equations will be developed. The Langevin equation and Fokker-Planck will be introduced jointly with the fluctuation dissipation theorem. Finite difference schemes for the advection and diffusion equations will be presented discussing their stability with a reference to geophysical fluids.

Mathematical Methods for Climate Change Analysis

The objective of the course is to provide students with the understanding of dynamic systems. It will begin with some preliminary concepts (linear algebra, eigenvalues, complex numbers, etc.) and then introduce mathematical instruments for dynamic system. In particular, finite difference equations (FDE) and differential equations (DE), systems of FDE and DE, with a focus on the linear case, stability analysis, the non-linear case, as well as elements of bifurcation and chaos. Examples and suggestions of possible applications to environmental problems will be proposed.

Statistical methods for climate change analysis

The objective of the course is to provide students with a practical understanding of statistical instruments that are useful in climate change studies. It will discuss and illustrate several important statistical methods through the use of case studies. Students will learn how to specify, fit and interpret a variety of statistical models and how to use them to answer scientific questions about the climate. Hands-on sessions with the R statistical software will be an integral part of the course.

Climate Change Economics: Theory, Methods and Applications

The objective of the course is to introduce students to the concept of climate change economics starting from the foundations of environmental economics. Students will understand the specific features of the climate change problem. They will learn about the concepts of market failures and environmental externalities. Students will understand how to use policy instruments to global externalities such as climate change. Each lecture will combine a frontal lecture with in-class activities (hands-on sessions, students' presentations).

Methods and Tools for Climate Analysis

The objective of the course is to introduce students to two important tools that are increasingly used in the analysis of climate change related issues. The first module will present introductory elements of econometrics, the second module of machine learning.

Climate of the past

The objective of the course is to introduce students to climate studies, including origins of the solar system, time scales, and climate in human history. Students will learn about 1) the methods for detecting climate change, including proxies, ice cores, instrumental records, and time series analysis, 2) physical and chemical processes in climate, including primordial atmosphere, ozone chemistry, carbon and oxygen cycles, and heat and water budgets, 3) internal feedback mechanisms, including ice, aerosols, water vapor, clouds, and ocean circulation, 4) climate forcing, including orbital variations, volcanism, plate tectonics, and solar variability, 5) climate models and mechanisms of variability, including energy balance, coupled models, and global ocean and atmosphere models.

General circulation models

This course provides an intermediate-level introduction to the field of Ocean general circulation models. The equations of motion are reviewed together with basic concepts and methods on numerical discretization using finite differences. Analytical and numerical, using the Princeton Ocean Model, solutions are compared to highlight concepts and methods. The second module aims at introducing the global circulation models, with particular reference to atmospheric models, and provide the basics to use them. At the end of the course students will acquire the theoretical concepts underlying the functioning of the models, the technical expertise with regard to their functioning, the competence on parameterizations of the components, and the capability to understand the differences between forecasts and projections, and finally they will be able to run GCM on a CMCC computer.

Climate Dynamics and Predictability

The course will investigate the basics of climate dynamics, from the feedbacks that maintain the mean climate to phenomenology and mechanisms of the main modes of climate variability. Furthermore, the predictability of the processes driving tropical and extra-tropical climate fluctuations will be explored and the main climate prediction tools discussed.

Geophysical Fluid Dynamics

Aim of this course is to present results in Geophysical Fluid Dynamics regarding the instability of large scale flows in the ocean and atmosphere. The stability of fluid flows with respect to infinitesimal disturbances will be examined, using methodologies developed for linear stability analysis applied to homogenous and stratified fluids. The topics covered by this course are a necessary conceptual preface to a study of geostrophic turbulence in both ocean and atmosphere.

Ocean Dynamics

In this course the response of the ocean to transient and steady winds and buoyancy forcing will be analyzed in tropical and extra-tropical regions. The steady circulation (horizontal gyres, thermohaline circulation and ventilated thermocline) will be derived. A hierarchy of models, from simple analytical to realistic numerical models will be presented to study the role of the waves, convection, instabilities and other physical processes in the circulation of the oceans.

Decision theory and multi-criteria analysis

The objective of the course is to provide students with methodological basis of Decision Theory with uncertainty and under certainty condition. The course will focus on methods as well as applications. Among them we recall Utility Theory, Decision Tree, Group Decision, Weighted Averaging, Ordered Weighted Averaging, and other. Students will learn how to understand, specify, describe some problems in this field, and to implement a resolution strategy. The course will also cover methods for optimization problems, in particular Linear Programming approach and some extensions.

Climate Change and Environmental Contamination

The course seeks to impart a broad understanding of the thermodynamic and chemical aspects of climate change, and to the risks posed by the possible effects on environmental contamination.
In the first part of the course, basic concepts of environmental chemistry and thermodynamics will be introduced. Hence, the main focus will shift towards introducing the climate system under a chemical and thermodynamic perspective. In the second part of the course, the possible effects of climate change on environmental chemical pollution will be discussed. The concepts of environmental chemistry introduced in the first part of the course will help in understanding how pollutants behave once emitted in the environment, and how a different climate may influence their fate and transport.
Furthermore, in order to provide the student a complete frame of contaminants' management, the last part of the course will consist on the introduction of environmental risk assessment by exposure to chemicals.

Climate Risk Modelling and Assessment

The objective of the course is to provide students with theoretical and practical understanding of methods and tools to estimate climate change risk and assess the economic benefits of climate adaptation. It also introduces students to the analysis of climate policies and management of risks deriving from climate change and variability.

Polar Climate and Sea Ice

This course will cover the principles of polar climate dynamics and will examine the role of sea ice in climate. The course will provide an extensive overview of:

- the current system and water masses in the Arctic Ocean-Nordic Seas system and Antarctic Ocean;
- the present and projected role of the Arctic in climate;
- sea ice structure and processes.

Advanced Topics in Geophysical Fluid Dynamics

The course will provide an exposure to advanced topics in planetary dynamics, starting from a review of the elementary vorticity dynamics, introducing the conservation theorems and the special case of the Ertel's potential vorticity. The generation and propagation of stationary planetary Rossby waves for zonal mean and time mean basic state will be discussed. Zonal flow-eddy interactions will be discussed next, leading to the non-acceleration theorems, and the role of dissipation and forcing in the maintenance of the zonal flow. Eliassen-Palm fluxes and its generalizations to non-symmetric basic state will also be discussed. Observations and models simulations and/or experiments will be used to clarify and discuss these ideas. The student will be required to discuss a recent paper in the literature.

Natural climate variability and its modes

This course will provide a review of our current understanding of natural climate variability. Topics will range from the characterization, attribution and simulation of natural climate variability to its predictability and prediction. Focus will be on intrinsic climate variability and its underlying processes, and on natural forcing agents of climate - including volcanic and tropospheric aerosols, and variations in solar activity - and their associated response mechanisms. Lectures will make practical reference to several prominent modes of natural climate variability on interannual to centennial time scales, such as the El Niño-Southern Oscillation, the Pacific Decadal Oscillation, the Atlantic Multidecadal Oscillation, and the North Atlantic Oscillation. These modes will serve to illustrate the uncertainties arising from the interaction between the climatic response to external natural forcing and the background climate, including the mean climate state and the phase of ongoing internal climate variability. Recent significant advancements in the understanding and prediction of natural climate variability and associated outstanding issues, hence major opportunities for progress, will be discussed in the light of the representation of climate modes and the implementation of natural forcing in current climate models.

Socio-Economics Impacts of Climate Change and Adaptation Strategies

The course will provide students with an overview of the approaches used to study the socio-economic impacts of climate change and the adaptation responses. The first part of the course will focus on four different topics emphasizing in particular the related modelling aspects: discounting, impacts assessment, mitigation and adaptation policy assessments. The second part of the course will focus on a particular category of economic models, Computable General Equilibrium (CGE) models. Students will learn the theoretical foundations of those models and learn how to apply them for the analysis of the socio-economic impacts of climate change.

Risk Assessment and Decision Support System for Environmental Impacts of Climate Change

The course seeks to impart a broad understanding of the methods, tools and skills required for conducting analyses of environmental impacts, vulnerability and risks posed by climate change in the context of global environmental changes. The course emphasizes the integration of disciplinary knowledge and covers a wide range of subjects, including scenario development, environmental risk analysis, impact and vulnerability assessment, decision support systems. Attention is paid to both, theoretical and practical aspects of vulnerability and risk assessment, underpinned by examples from recent international research. Following an introduction to the key concepts and the state of the art in environmental impact, risk and vulnerability assessment methodologies, the course will provide an overview of the main assessment and management tools applied to relevant case studies.
Then, we will go on to the analysis of Decision Support Systems (DSSs) for the assessment and management of environmental impacts of climate change. An introduction to the concept of DSS and their applications will provide a preliminary insight into the theme. Review of some existing Decision Support System to be compared and evaluated will add technical and analytical aspects. Application to a case study will be instrumental in order to explore flexibility of DSSs and the use of existing tools.

Adaptive Management of Natural Resources and Agricultural Systems

The objective of the course is to introduce students to the principles of natural resources management and the challenges of designing and implementing operational approaches in the real, changing world. The focus is on the interactions between the natural and human components within the socio-ecosystems, with a focus on agro-ecosystems. The notions of sustainability and sustainable development are a common inspiration of the course. Spatial and temporal dynamics are explored with concrete examples and case studies, with a common approach based upon system dynamics techniques and geographical information systems. Each lecture will combine a frontal lecture with in-class activities (e.g. team work on selected case studies).

Climate Change Policies – Negotiations, Implementation and Assessment

The objective of the course is to introduce students to the use of 1) econometric methods to evaluate historical environmental and climate policies, with an empirical focus on their impacts on innovation and employment and 2) ex-ante modeling tools and scenario approaches to evaluate and design of future climate policies. Students will learn about the problem of climate change as an economic problem as well as the process of international negotiations on climate change. They will learn how to evaluate the socio-economic implications of mitigation and adaptation policies, how to apply economic methods to analyze and design innovative climate policy solutions.

Ice Sheets and Glaciers in the Climate System

The course aims to provide a framework of polar processes related to ice sheets and glaciers dynamics in the past, in the present and in the future. The idea is to provide the basis of the processes related to past ice sheet dynamics 1) through the use of ice-sheet related or ocean-related proxies in geological archive or by using geophysical methods to depict the past dynamics, 2) through the study of the polar high latitude atmospheric and oceanic dynamical processes affecting and interacting with the ice sheets and glaciers based on numerical modeling and or the direct comparison/integration of past and current observation in numerical models. The course is divided in two main parts.

Duration and summary of didactic activities and university credits (CFU)

The Master's lasts for **one year** with **400 hours of didactic activities**. A **250 hour internship** forms an integral part of the course and represents an excellent opportunity to enter the workplace. However, for students already working professionally in the sector, the internship is optional and may be replaced by targeted **project work**.
Including individual study and preparation of a final thesis, the course requires an overall commitment of **1800 hours**, for a total of **90 CFU.**

Qualification issued

Students attending the didactic activities, completing the internship and passing the intermediate verifications and final examination will be awarded a 2nd Level Master of Research in Science and Management of Climate Change

Course period

September 2019 - September 2020

Teaching method

Frontal lectures, hands-on-sessions, discussion groups, labs, seminars, guest lectures from international experts

Language

English

Attendance

Attendance will be monitored by signing a register. Regular attendance in the classroom is obligatory to passing the individual modules. Absences must not in any case exceed 20% of teaching hours for each individual module. Credits are assigned with completion of the individual modules and internship/project work activities and passing of the final examination. Students employed in a professional activity coherent with the Master's course may ask for this to be recognised in calculating the credits allocated to internship and work placement activities.

Course location

Ca’ Foscari Challenge School, via della Libertà 12, 30175 Venezia (Parco Vega) / Economic Campus San GIobbe

Admission requirements

SECOND LEVEL
To enroll on the Master's, candidates must be in possession of at least a second cycle, specialization or pre-reform (Italian Ministerial Decree no. 509/99) degree in a scientific or economic subject
On the discretion of the Master's Board of Professors, candidates with other degrees, or foreign qualifications, may be considered on the basis of their previous education and training and in respect of current legislation
Equivalent foreign university qualification, following approval from the Teachers' Board
English language to at least level B2

Admission application

Candidates must fill in the online admission application, the details of which are defined under article 3 of the University's Call for Applications. Only applications accompanied by all the required documentation will be considered. The Call for Applications and relative attachments can be downloaded from the Master's web profile.

Selection procedure

A specific Board will assess candidates based on their CVs, qualifications submitted and a face-to-face interview (the date, time and place will be communicated by email with sufficient advance notice; on motivated request, the interview may take place by video-conference).
The oral admission test, in English, will aim to ascertain the candidate's motivations, but also to verify the competencies already acquired in subjects necessary for quantitative analysis and mathematical and statistical modelling, as well as the candidate's ability to express themselves in English.
The main factors considered for the purposes of selection will be: qualifications, motivation, relational skills, relevant former educational and professional experiences and a willingness to respect the necessary attendance requirements.

Graduate eligibility

Students about to graduate may also be admitted to the course, provided they qualify within one month from the start of the course. In this case, enrolment on the Master’s may be finalised only after the valid qualification for admission has been awarded. Candidates without a degree may enroll as auditors and will be awarded a certificate of attendance.

Available places

Maximum number of available places: **15**

Course fees: € 6.000

1st instalment by 31/08/2019: € 3.016 (including € 16 stamp duty)*
2nd instalment by 10/01/2020: € 3.000
* *Stamp duty is not refundable.*

Study support

Loans are available from the University's partner banks (for more information: http://www.unive.it/pag/8560/).

Enrolment

ADMISSION APPLICATION SUBMISSION (online procedure, Call for Applications, art. 3)
by June 21th 2019
SELECTION AND RESULT ANNOUNCEMENT
by July 10th 2019
ENROLMENT COMPLETION (online procedure, Call for Applications, art. 6)
by August 31st 2019
Beginning of courses: September 2019. See https://www.unive.it/data/7886/ for updates

Course director

Prof.ssa Enrica De Cian

Website

www.unive.it/clima

For information

On **enrolment procedures and internships**, contact the Post-lauream office
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On **didactic activities** and the **calendar** of lessons, contact:
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