# Course guide
# 250MEA004 - 250MEA004 - Climate Change and Global Warming

**Last modified:** 17/09/2024

**Unit in charge:** Barcelona School of Civil Engineering
**Teaching unit:** 758 - EPC - Department of Project and Construction Engineering.

**Degree:** MASTER'S DEGREE IN ENVIRONMENTAL ENGINEERING (Syllabus 2024). (Compulsory subject).

**Academic year:** 2024 **ECTS Credits:** 5.0 **Languages:** Spanish

## LECTURER

**Coordinating lecturer:** MARIA GONÇALVES AGEITOS

**Others:** MARÍA GONÇALVES AGEITOS

## TEACHING METHODOLOGY

The course consists of 3 hours per week of face-to-face classes in the classroom.
2 hours are dedicated to theoretical classes, in which the teachers explain the basic concepts and materials of the subject, present examples.
1 hour is dedicated to problem solving and debate with greater interaction with the students. Exercises and practical work are carried out in order to consolidate the general and specific learning objectives.
Support material is used in the form of a detailed teaching plan through: content, programming of assessment and directed learning activities and bibliography.
Although most of the sessions will be taught in the language indicated in the guide, sessions in which there is support from other invited experts may occasionally be carried out in another language.

## LEARNING OBJECTIVES OF THE SUBJECT

This course studies the causes, impacts and consequences of current climate change. It establishes the bases for the evaluation, prediction and prevention of the impacts that it generates on the Earth's climate system and on human society.
The bases of climate are presented, its difference with Time and the implications of current climate change are analyzed. The space-time scales of the climate system are analyzed.
The Atmosphere-Earth radiative balance, the Albedo and Greenhouse effects, the role played by Greenhouse Gases (GHG) and their warming potential, as well as the accumulated radiative forcing are presented and analyzed.
The evolution of emissions of the different GHGs is analyzed. The specific contribution from different sources, current and historical.
The progress of knowledge of current climate change is presented from the IPCC reports, and the move from scientific knowledge to climate policy (UNFCCC, PK, AP) both globally and within the framework of the European Union.
The strategies and consequences of the denialist movement are described and analyzed.

## STUDY LOAD

| Type | Hours | Percentage |
|---|---|---|
| Hours large group | 25,5 | 20.38 |
| Self study | 80,0 | 63.95 |
| Hours medium group | 9,8 | 7.83 |
| Hours small group | 9,8 | 7.83 |

**Total learning time:** 125.1 h

## CONTENTS

### 1. Earth's climate system

**Description:**
• Global change and Anthropocene
• Difference between clima and weather.
• What is the Climate System?
• Climate variability versus climate change
• Space and time scales.
• Climate teleconnections: how climate and weather interconnect across space and time
• History of global warming and climate change.
• Albedo effect
• Greenhouse effect: natural versus forced
• Greenhouse gases (GHG)
• Irradiance (Sun) versus radiance (Earth)
• Radiative balance: Atmosphere-Earth
• Increase in radiative forcing (W/m2)
• The cooling processes of the atmosphere.
• Climate Sensitivity.

**Specific objectives:**
Understand the Earth's Climate System from the perspective of its impact due to the modification of the radiative balance due to GHGs.

**Related activities:**
Practical work

**Full-or-part-time:** 13h
Theory classes: 6h
Self study : 7h

### 2. The current Climate Change. Cause

**Description:**
• Differences between air pollution and climate change
• Solar activity. Solar constant. Sunspot cycles.
• Milankovic's astronomical theory
• Volcanic emissions
• GHG: Evolution of its concentration in the atmosphere.
• GHG: Residence time in the atmosphere
• Atmospheric water vapor as GHG
• CO2 versus air temperature
• GHG and air temperature in the last million years
• Arctic amplification
• Reference period for calculating the air temperature anomaly: 1850-1900
• How much energy have we retained? Where has it been held?
• Increased air temperature and heat in the atmosphere and oceans.
• Attribution, radiative forcing
• Speed â□□â□□of change
• Global Warming Potential (GWP)

**Specific objectives:**
Know and value the role and participation that natural factors and different GHGs play in current climate change.

**Related activities:**
Practical work

**Full-or-part-time:** 13h
Theory classes: 6h
Self study : 7h

### 3. Climatic indicators. IPCC AR6 Evidence

**Description:**
• Climatic indicators= f(Evidence)
• Impact Indicators. Consequences
• Global temperature changes: Atmosphere and Oceans
• Increase in ocean heat content
• Sea level: thermal expansion and melting
• Marine heat waves and storm surges
• Variation of glaciers, ice and snow layers
• Variation in the Arctic and Antarctica
• Ocean acidification. pH variation
• Variation of terrestrial heat waves
• Changes in precipitation patterns. Floods
• Increase in droughts
• Variation in the duration of the seasons.
• Alteration of the tropopause
• Extreme phenomena. Variation in frequency and intensity

**Specific objectives:**
Analyze the set of evidence that confirms the current situation of global warming and the consequent climate change. Know and assess the climatic, impact and consequence indix that will be used for its assessment.

**Related activities:**
Practical work

**Full-or-part-time:** 13h
Theory classes: 6h
Self study : 7h

### 4. GHG emissions: Global-EU-Spain-Catalonia

**Description:**
• Units used
• Analysis of global CO2 emissions from 1750 to the present
• Emissions by source, fuel, GHG, country, per capita
• Source-sink relationship
• Anthropogenic disturbance of the global carbon cycle
• Analysis of CH4 and N2O emissions from 1750 to the present
• Biogenic methane vs. fossil origin relationship
• Global CH4 and N2O balance
• Sector by sector: where do global GHG emissions come from?
• Global Carbon Project: CO2, CH4, N2O and CFC's
• Balance of remaining GHG emissions

**Specific objectives:**
A review is made of the set of GHG emission patterns, their historical evolution from the Industrial Revolution to the current situation.

**Related activities:**
Practical work

**Full-or-part-time:** 5h
Theory classes: 2h
Self study : 3h

### 5. Risk Indicators. Definitions, Levels and Criteria

**Description:**
• What is a land heat wave?
• Maximum value of the minimum night temperature
• What is a marine heat wave?
• Types of drought
• Restrictions at each alert level in case of drought
• Forest fire risk levels
• Warning criteria for an adverse meteorological phenomenon

**Specific objectives:**
The set of operational indicators used to define the different risk levels are presented, analyzed and discussed.

**Related activities:**
Practical work

**Full-or-part-time:** 5h
Theory classes: 2h
Self study : 3h

### 6. Proxy-data - Natural thermometers

**Description:**
• What is a data proxy?
• Historical information
• Coral reefs
• Pollen
• Ice drilling
• Tree rings
• Sediments of oceans and lakes

**Specific objectives:**
The set of systems used to understand the evolution of paleoclimatic data are presented, analyzed and discussed.

**Related activities:**
Practical work

**Full-or-part-time:** 5h
Theory classes: 2h
Self study : 3h

### 7. Tipping points in the Earth's climate system

**Description:**
• What is a climate tipping point?
• Climate tipping point concept
• Resilience concept
• Key critical tipping points
• Shutdown of the Atlantic Meridional Overturning Circulation
• West Antarctic ice sheet disintegration
• Amazon rainforest dieback
• West African monsoon shift
• Permafrost and methane hydrates
• Coral reef die-off
• Indian monsoon shift
• Greenland ice sheet disintegration
• Boreal forest shift
• Other tipping points

**Specific objectives:**
The set of critical tipping points that current climate change causes in the Earth's climate system are presented, analyzed and discussed, with special attention to the case of AMOC.

**Related activities:**
Practical work

**Full-or-part-time:** 5h
Theory classes: 2h
Self study : 3h

## 8. Climate modeling

**Description:**
• Projection and forecasting of the evolution and impacts of current climate change
• Simple predictive models from the 1970s
• From GCMs to AOGCMs and Earth system modelling
• AOGCM: Dynamic core. Resolution of the complete compressible primitive equations:
• How are the primitive equations solved? Discretization
• Computing infrastructure
• Projections of future climate changes
• Coupled Model Intercomparison Project Phase 7 (CMIP7) Experimental Design and Organization
• Computation time and volume of input and output files
• Uncertainties in climate modelling
• Why regionalization and downscaling from global models?
• Regional modelling for Catalonia
• Application in different sectors

**Specific objectives:**
Numerical models used in climate projection and forecasting are presented and analyzed.

**Related activities:**
Practical work

**Full-or-part-time:** 5h
Theory classes: 2h
Self study : 3h

## 9. IPCC UNFCCC Kyoto Protocol-Paris Agreement

**Description:**
• The scientific response to climate change: IPCC
• The political response to climate change: UNFCCC-COP's
• IPCC reports
• IPCC: Emissions inventories. Methodology reports
• Kyoto Protocol
• Paris Agreement
• Keeping the global average temperature "well below" 2 °C, and not exceeding 1.5 °C
• What do pre-industrial temperature levels mean or imply?
• What are Nationally Determined Contributions (NDC)
• Conference of the Parties (COP's)

**Specific objectives:**
The process of adopting political measures agreed upon within the framework of the United Nations since 1992 to combat current climate change is presented and analyzed.

**Related activities:**
Practical work

**Full-or-part-time:** 13h
Theory classes: 6h
Self study : 7h

### 10. Climate Policy: UN-EU-Spain (PNIEC)-Catalonia

**Description:**
• Mitigation and Adaptation Strategies
• United Nations: UNFCCC and SDGs
• European Union: Green Deal
• Spain: PNIEC
• Why is it urgent?
• Energy transition vs. Ecological transition
• Catalan Strategy for Adaptation to Climate Change 2021-2030 (ESCACC30)

**Specific objectives:**
The programmes and political measures agreed upon within the framework of the European Union and Spain to combat current climate change are presented and analysed.

**Related activities:**
Practical work

**Full-or-part-time:** 9h
Theory classes: 3h
Self study : 6h

### 11. Denialism, Skepticism, Climategate, Retardism

**Description:**
• Climate change denialism
• Scientific denialism. Scientific consensus
• Corporate denialism
• Role of oil and energy companies
• Role of think tanks
• Role of governments
• What was climategate? The hockey stick
• Climate change 'fake news'
• Climate change refusal syndrome
• What is climate retardation?
• Greenwashing
• Climate disobedience: the rebellion of citizens and scientists
• Climate justice / Climate litigation

**Specific objectives:**
An analysis is made of the denial process promoted mainly by oil companies since the 1950s and 1960s in order to continue using fossil fuels.

**Related activities:**
Practical work

**Full-or-part-time:** 5h
Theory classes: 2h
Self study : 3h

## GRADING SYSTEM

The course grade will be obtained from continuous assessment scores and corresponding practical work.
Continuous assessment consists in several activities, both individually and in group, of additive and formative characteristics, carried out during the course (in the classroom and beyond).
The evaluation tests consist of a part with basic issues and questions about concepts associated with the learning objectives of the course with in terms of knowledge or understanding concepts, and a set of exercises for understanding and application.
The teaching takes place according to the following criteria:
NF = r*NE +(1-r)*NAC r = 0,5
NAC = q*NAEP +(1-q)*NACET q = 0,5

NF: Final Note
NE: Exam Note
NAC: Note from continuous assessment
NAEP: Note teachings practical assessment (works, presentations, etc.)
NACET: Note continued evaluation of the theoretical teachings (test, etc.)

## EXAMINATION RULES.

Failure to perform a laboratory or continuous assessment activity in the scheduled period will result in a mark of zero in that activity.

## BIBLIOGRAPHY

**Basic:**
- Goosse, H. Climate system dynamics and climate modelling. New York, NY: Cambridge University Press, 2015. ISBN 9781107445833.
- Archer, D. Global warming: understanding the forecast. 2nd ed. Hoboken, N.J : Chichester: Wiley, 2012. ISBN 0470943416.

**Complementary:**
- Climate change 2021: the physical science basis: Working Group I contribution to the Fifth assessment report of the Intergovernmental Panel on Climate Change [on line]. New York: Cambridge University Press, 2021 [Consultation: 05/07/2024]. Available on: https://doi.org/10.1017/9781009157896. ISBN 9781107661820.
- Baldasano, José Mª. El actual cambio climático: una versión holística de la crisis climática [on line]. Barcelona: RAED, 2019 [Consultation: 05/07/2024]. Available on: https://raed.academy/wp-content/uploads/2019/07/discurso-ingreso-Jose-Maria-Baldasano-Actual-cambio-climatico-compr.pdf. ISBN 978-84-09-13018-4.

## RESOURCES

**Other resources:**
WMO Global Annual Decadal Climate Update 2024-2028 https://wmo.int/publication-series/wmo-global-annual-decadal-climate-update-2024-2028 />
ESSD Indicators of Global Climate Change 2023 https://essd.copernicus.org/articles/16/2625/2024/essd-16-2625-2024-discussion.html />
2024 CAT Briefing_Guide To Good NDCs https://newclimate.org/news/press-release-cat-guide-to-a-good-2035-ndc-target />
Explainer: Nine 'tipping points' that could be triggered by climate change https://www.carbonbrief.org/explainer-nine-tipping-points-that-could-be-triggered-by-climate-change/ />
Encyclopedia CLIMA ESPERE: http://www.espere.net/ />

Páginas web:

A pragmatic guide to Climate Change https://www.tmrow.com/climatechange.html />realclimate http://www.realclimate.org/index.php/archives/2007/05/start-here/ />Copernicus: https://climate.copernicus.eu/climate-bulletins />Libro-Introduction ClimateDynamics-ClimateModelling-2008: http://www.climate.be/textbook/ />Global carbon projects, videos: http://www.globalcarbonproject.org/carbonbudget/14/video.htm />Glosario términos: http://www.lenntech.es/efecto-invernadero/glosario-cambio-climatico.htm />Global Warming, Clouds, and Albedo: Feedback Loops:

http://www.windows2universe.org/earth/climate/warming_clouds_albedo_feedback.html />Centro internacional para la investigación del fenómeno del niño (CIIFEN): http://www.ciifen.org/ />NASA:
http://climate.nasa.gov/news/2199/ />http://www.nasa.gov/content/goddard/nasa-satellites-see-arctic-surface-darkening-faster/ />https://data.giss.nasa.gov/gistemp/ />NSIDC (National Snow Ice Data Center): http://nsidc.org/ />NOAA: Artic
http://www.arctic.noaa.gov/essay_serreze.html
http://www.arctic.noaa.gov/Report-Card/Report-Card-2016