Learning objectives of the subject

CE01 - Apply scientific concepts to environmental problems and their correlation with technological concepts.
CE02 - Analyze systems, environmental problems and their resolution using models and evaluate them.
CE03 - Acquire basic skills of laboratory work and identify the methods and instrumentation for the determination of parameters relevant to the analysis of environmental problems.

Very aware of the structure of land, water and artificial ecosystems and their interactions.
Meet the ecology and the cycling of elements.
Meet the major environmental problems globally.
Analyzes energy bases, stoichiometric and kinetic of different processes.
Modeling process and quantifies the performance and efficiency of systems.
Determines the basis of environmental hazards to human health and ecosystems.
Apply material balances and energy to environmental problems.
Interprets water-rock and water - air interactions using thermodynamic and kinetic methods.
Meet the pollutants and identify their impact.
Learn the basics of how the atmosphere and applies them in maintaining air quality.
Learn the basics of climate and discusses the implications of current climate change.
Conceptualized an environmental problem described by equations and poses analytical or numerical solution.
Identifies the codes you need to solve a problem as conceptualized.
Recognizes the spatial and temporal scales required to resolve the problem.
Is familiar with solutions to problems relating to dynamical systems.
Learn about simple solutions to problems advection-dispersion-reaction. Recognizes the existence of uncertainty in the parameters of the equations and is capable of performing an uncertainty analysis and sensitivity. Learn methods for information and action on various parameters or variables. Understand that any measure inherently carries an associated error and is able to work with them. It is critical to the values reported by others when the measurement method is not specified. He has worked in the laboratory measurement of some parameters of environmental interest.

Description of the climate system and its components.
The atmosphere, oceans, cryosphere, land surface and biosphere.
The balance of power: land-atmosphere.
The hydrological and carbon cycles.
History of climate change: causes and mechanisms.
Internal climate variability.
Evolution of Earth's climate.
Modelling the climate system.
Components of a climate model.
Evaluation of results.
The climate system response to a disturbance.
Influences of human activities on climate and climate change.

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Study load

<table>
<thead>
<tr>
<th>Total learning time: 125h</th>
<th>Theory classes: 15h</th>
<th>12.00%</th>
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<tbody>
<tr>
<td>Practical classes: 10h</td>
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<tr>
<td>Laboratory classes: 10h</td>
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<td>Guided activities: 10h</td>
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<tr>
<td>Self study: 80h</td>
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<td>64.00%</td>
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<td>Content</td>
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<tr>
<td><strong>1. Description of the climate system and its components</strong></td>
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<tr>
<td><strong>Description:</strong></td>
<td><strong>Learning time:</strong> 7h 11m</td>
<td></td>
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<tr>
<td>The atmosphere</td>
<td>Theory classes: 2h</td>
<td></td>
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<tr>
<td>Composition and temperature</td>
<td>Practical classes: 1h</td>
<td></td>
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<tr>
<td>General circulation of the atmosphere</td>
<td>Self study: 4h 11m</td>
<td></td>
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<tr>
<td>Precipitation</td>
<td></td>
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<tr>
<td>Exercises and practical work</td>
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</tbody>
</table>

| **2. The atmosphere, oceans, cryosphere, land surface and biosphere** |
| **Description:** | **Learning time:** 7h 11m |
| The ocean | Theory classes: 2h |
| * Composition and properties | Practical classes: 1h |
| * Oceanic circulation | Self study: 4h 11m |
| * Temperature and salinity | |
| The cryosphere | |
| * Components of the cryosphere | |
| * Properties of the cryosphere | |
| The land surface and the terrestrial biosphere | |
| Exercises and practical work | |

| **3. The energy balance: land-atmosphere** |
| **Description:** | **Learning time:** 7h 11m |
| The energy balance of the Earth | Theory classes: 2h |
| * The heat balance at the top of the atmosphere: a global view | Practical classes: 1h |
| * The "greenhouse" | Self study: 4h 11m |
| * today insolation at the top of the atmosphere | |
| * The heat balance at the top of the atmosphere: geographical distribution | |
| * Heat storage and transport | |
| * Heat balance at the surface | |
| Exercises and practical work | |
### 4. The hydrological and carbon cycles

**Description:**
The hydrological cycle  
The carbon cycle  
* General information  
* Ocean Carbon Cycle  
* Terrestrial Carbon Cycle  
Exercises and practical work

**Learning time:** 7h 11m  
Theory classes: 2h  
Practical classes: 1h  
Self study: 4h 11m

### 13 Assessment

**Learning time:** 14h 23m  
Laboratory classes: 6h  
Self study: 8h 23m

### 5. History climate change: causes and mechanisms

**Description:**  
History of Climate Change: causes and mechanisms

**Learning time:** 2h 24m  
Theory classes: 1h  
Self study: 1h 24m

### 6. Internal climate variability

**Description:**  
Internal climate variability  
* El Niño-Southern Oscillation  
* North Atlantic Oscillation  
* The Southern Annular Mode  
Exercises and practical work

**Learning time:** 7h 11m  
Theory classes: 2h  
Practical classes: 1h  
Self study: 4h 11m
### 7 Evolution of the Earth's Climate

**Description:**
- The climate since the Earth's formation
  - Precambrian climate
  - Phanerozoic climate
  - Cenozoic climate
- The last million years: glacial interglacial cycles
  - Variations in orbital parameters and insolation
  - The orbital theory of paleoclimates
  - Glacial-interglacial variations in the atmospheric CO2 concentration
- The Holocene and the last 1000 years
  - The current interglacial
  - The last 1000 years
  - The last century

**Exercises and practical work**

### 8 Modelling the Climate System

**Description:**
- Modelling the climate system
- Introduction
  - What is a climate model?
  - Types of models
  - Models of energy balance
  - Models intermediate complexity
  - The general circulation models

**Exercises and practical work**
### 9 Components of a climate model

**Description:** Components of a climate model
- Atmosphere
- Ocean
- Sea ice
- Land surface
- Marine biogeochemistry
- Ice sheets
- Coupling between the models of systems components to Earth
- Numerical solution of the equations
- Consistency, stability and convergence
- The time and space discretizations using finite difference

**Exercises and practical work**

<table>
<thead>
<tr>
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### 10. Analysis and evaluation of results

**Description:** Checking the validity of the models
- Verification, validation, test
- Evaluate the performance of the model

**Exercises and practical work**

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### 11. The response of the climate system to a perturbation

**Description:**
- The climate system response to a disturbance
- Climate and climate change response
  - The concept of radiative forcing
  - Equilibrium response of the climate system - a definition of feedback
  - Transient response of the climate system
- Direct physical assessments
  - Steam water gradient feedback and comments
  - Retroalimentación Clouds
  - Evaluations Cryospheric
- Exercises and practical work

**Learning time:** 7h 11m
- Theory classes: 2h
- Practical classes: 1h
- Self study: 4h 11m

### 12. Influences of human activities on climate and of climate change on ecosystems and human activity

**Description:**
- Influences of human activities on climate and climate change.
  - Emissions
  - Land use changes
  - Ecosystems

**Learning time:** 4h 48m
- Theory classes: 2h
- Self study: 2h 48m

### Qualification 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:

\[
NF = r \times NE + (1-r) \times NAC\quad r = 0.5 \\
NAC = q \times NAEP + (1-q) \times NACET\quad q = 0.5
\]

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.)
Regulations for carrying out activities

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

Bibliography