250672 - Modeling of Environmental Systems

Coordinating unit: 250 - ETSECCPB - Barcelona School of Civil Engineering
Teaching unit: 758 - EPC - Department of Project and Construction Engineering
Academic year: 2019
Degree: MASTER'S DEGREE IN ENVIRONMENTAL ENGINEERING (Syllabus 2014). (Teaching unit Compulsory)
ECTS credits: 5
Teaching languages: Spanish, English

Teaching staff
Coordinator: JOSE M. BALDASANO RECIO
Others: JOSE M. BALDASANO RECIO, MARIA GONÇALVES AGEITOS

Opening hours
Timetable: Constantly available via email: jose.baldasano@upc.edu

Degree competences to which the subject contributes

Specific:
13340. Apply scientific concepts to environmental problems and their correlation with technological concepts.
13341. Analyze systems, environmental problems and their resolution using models and evaluate them.
13342. Acquire basic skills of laboratory work and identify the methods and instrumentation for the determination of parameters relevant to the analysis of environmental problems.

Transversal:
8562. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.
8563. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

Teaching methodology
The course consists of 3 hours a week of classes in a classroom. The 2 hours in the large size groups are devoted to theoretical lectures, in which the teacher presents the basic concepts and topics of the subject, shows examples and solves exercises. The 1 hour is devoted to solving practical problems with greater interaction with the students. The objective of these practical work and exercises is to consolidate the general and specific learning objectives. Support material in the form of detailed teaching plan is used by: content, program of learning and assessment activities conducted and literature.

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.

Introduction to numerical modeling process:
- Operation of natural processes.
- Defining and understanding the problem.
- The process of modeling.
- Stages in the development of a numerical model.
- The boundaries of a model.
- The transport equation.
- Spatial and temporal scales: Euler vs Lagrange.

Modelling of dynamic systems:
- Modeling of dynamic systems.
- Models of water quality in rivers and reservoirs.
- Air Quality Models: emissions.
- Models of dispersion of pollutants in air.
- Photochemical models.

Evaluation Model:
- Calibration / verification / validation model.
- Evaluation of results.
- Uncertainty analysis.

Introduction to numerical modelling process:
Operation of natural processes. Defining and understanding the problem.
The modelling process.
Stages in the development of a numerical model.
The limits of a model.
The transport equation.
Spatial and temporal scales: Euler vs. Lagrange.
Modeling dynamical systems:
Models of water quality in rivers and reservoirs.
Air quality models: emissions.
Models of dispersion of pollutants in air.
Photochemical models.
Evaluation models: calibration / verification / validation of the model.
Evaluation of the results.
Uncertainty analysis.

<table>
<thead>
<tr>
<th>Study load</th>
<th>Hours large group:</th>
<th>15h</th>
<th>12.00%</th>
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<tbody>
<tr>
<td></td>
<td>Hours medium group:</td>
<td>10h</td>
<td>8.00%</td>
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<td>Hours small group:</td>
<td>10h</td>
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<td>Guided activities:</td>
<td>10h</td>
<td>8.00%</td>
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<td>Self study:</td>
<td>80h</td>
<td>64.00%</td>
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# Content

<table>
<thead>
<tr>
<th>Module</th>
<th>Description</th>
<th>Learning time</th>
<th>Theory classes</th>
<th>Practical classes</th>
<th>Self study</th>
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</thead>
</table>
| 01 Introduction to numerical modeling process | * Operation of natural processes.  
* Defining and understanding the problem.  
* The modeling process.  
Exercises and practical work | 7h 11m | 2h | 1h | 4h 11m |
| 02 Stages in the development of a numerical model | Stages in the development of a model  
The limits of a model  
Exercises and practical work | 4h 48m | 1h | 1h | 2h 48m |
| 03 The transport equation | Concept of balance  
Continuity Equation  
Quantity Equation Conservation Movement  
Equation of Conservation of Energy  
Continuity equation of matter  
Exercises and practical work | 7h 11m | 2h | 1h | 4h 11m |
### 04 Spatial and temporal scales: Euler vs. Lagrange

**Description:**  
The spatial scales  
The time cycles  
Eulerian vs Lagrangian Scheme  
Exercises and practical work

**Learning time:** 4h 48m  
Theory classes: 1h  
Practical classes: 1h  
Self study: 2h 48m

### 12 Evaluation

**Learning time:** 16h 48m  
Laboratory classes: 7h  
Self study: 9h 48m

### 05 Water Quality Models: rivers and reservoirs

**Description:**  
Classification of water quality models (WQM)  
Criteria for the classification of WQM  
historical development  
Dynamics and processes: cycles  
Basic components of the MCA  
Self-purification process  
Simplified temperature model for rivers  
Model QUAL2E  
Reservoir temperature and hydrodynamics  
Water quality model for a reservoir  
Exercises and practical work

**Learning time:** 7h 11m  
Theory classes: 2h  
Practical classes: 1h  
Self study: 4h 11m
| 06 Air quality models: emissions | Learning time: 7h 11m  
Theory classes: 2h  
Practical classes: 1h  
Self study: 4h 11m |
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<tbody>
<tr>
<td><strong>Description:</strong></td>
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<tr>
<td>Types and models of emission inventory</td>
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<td>Activity factor, emission sources, typology</td>
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<tr>
<td>Emission Factors</td>
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<td>Emission sources of air pollutants</td>
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<td>Approach top-down vs bottom-up</td>
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<td>SNAP nomenclature groups</td>
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<td>Criteria breakdown</td>
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<td>Criteria of quality analysis inventory</td>
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<td>Speciation</td>
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<td>Exercises and practical work</td>
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| 07 Models of pollutant dispersion | Learning time: 7h 11m  
Theory classes: 2h  
Practical classes: 1h  
Self study: 4h 11m |
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<tbody>
<tr>
<td><strong>Description:</strong></td>
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<tr>
<td>Historical development</td>
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<tr>
<td>Gaussian model</td>
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<td>Lagrangian model</td>
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<td>Box Model</td>
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<tr>
<td>Eulerian model</td>
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<td>Exercises and practical work</td>
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| 08 Photochemical models         | Learning time: 7h 11m  
Theory classes: 2h  
Practical classes: 1h  
Self study: 4h 11m |
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<tbody>
<tr>
<td><strong>Description:</strong></td>
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<td>Ozone Formation</td>
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<td>Formation of secondary aerosols</td>
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<td>Chemical mechanisms</td>
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<td>Exercises and practical work</td>
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### 09 Evaluation of models: calibration, verification, validation

<table>
<thead>
<tr>
<th>Description:</th>
<th>Learning time: 4h 48m</th>
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<tbody>
<tr>
<td>Evaluation Process</td>
<td>Theory classes: 1h</td>
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<tr>
<td>Calibration / Verification / Validation / Hindcast</td>
<td>Practical classes: 1h</td>
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<tr>
<td>Exercises and practical work</td>
<td>Self study: 2h 48m</td>
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### 10 Performance: metrics

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<thead>
<tr>
<th>Description:</th>
<th>Learning time: 7h 11m</th>
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<tbody>
<tr>
<td>Variables to evaluate</td>
<td>Theory classes: 2h</td>
</tr>
<tr>
<td>Metrics</td>
<td>Practical classes: 1h</td>
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<tr>
<td>Thresholds / Data Quality</td>
<td>Self study: 4h 11m</td>
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<tr>
<td>Categorical statistical</td>
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<td>Statistical Discrete</td>
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<td>Diagram Taylor</td>
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<td>Graphics</td>
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<td>Exercises and practical work</td>
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### 11 Analysis of uncertainty

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<thead>
<tr>
<th>Description:</th>
<th>Learning time: 2h 24m</th>
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<tbody>
<tr>
<td>Evaluation criteria</td>
<td>Theory classes: 1h</td>
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<tr>
<td>Uncertainty Analysis</td>
<td>Self study: 1h 24m</td>
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<td>Acceptance Criteria</td>
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<td>Sensitivity Analysis</td>
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<td>Model intercomparison</td>
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**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:

\[ \text{NF} = r \times \text{NE} + (1 - r) \times \text{NAC} \quad r = 0.5 \]

\[ \text{NAC} = q \times \text{NAEP} + (1 - q) \times \text{NACET} \quad q = 0.5 \]

- **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 practical work, laboratory or continuous assessment activity in the scheduled period will result in a mark of zero in that activity.

**Bibliography**

**Basic:**