Bachelor in Physics
(Academic Year **2021-22**)

Physics of the Atmosphere	**Code**	800511	**Year**	3rd	**Sem.**	2nd
Module	Applied Physics	**Topic**	Compulsory for Applied Physics	**Character**	Optional	

	Total	**Theory**	**Pract./Semin.**	**Lab.**
ECTS Credits	6	4.2	1.8	
Semester hours	43	30	7	6

Learning Objectives (according to the Degree's Verification Document)

- *To acquire knowledge on the main physical characteristics and processes regulating the atmosphere's behavior.*
- *To identify the physical laws (radiation, thermodynamics, dynamics) regulating the main atmospheric processes.*
- *To acknowledge the atmosphere's role as one of the main components of the climate system, and to identify the basic aspects of the Physics of climate change.*
- *To apply the acquired knowledge to practical cases through problem solving and practical training*

Brief description of contents

Atmospheric composition; solar and terrestrial radiation; energy balance; water vapor and cloud formation; air motion equation; weather analysis and prediction; climate changes.

Prerequisites

Coordinator	Carlos Yagüe Anguís		**Dept.**	FTA
	Office	110, 4th floor, east	**e-mail**	carlos@ucm.es

Theory/Exercises – Schedule and Teaching Staff

Group	Lecture Room	Day	Time	Professor	Period/ Dates	Hours	T/E	Dept.
B	10	Mo We	17:00-18:30 16:30-18:00	Elsa Mohino Harris	Entire semester	37	T/E	FTA

T: Theory, E: Exercises

Group	Computer Lab	Day - hours	Professor	Hours	Dept.
LB1	M2	23/3, 6/4, 20/4, 27/4 (16:30 – 18:00)	Elsa Mohino Harris	6	FTA
LB2	M2	23/3, 6/4, 20/4, 27/4 (16:30 – 18:00)	Luis Durán Montejano	6	FTA

Office hours				
Group	**Professor**	**Schedule**	**E-mail**	**Location**
B	Elsa Mohino Harris	Mo: 15:30-17:00 We: 15:00-16:30 (+ 3h online)	emohino@ucm.es	105, 4th floor, east
	Luis Durán Montejano	Tu, Th: 13:00-14:30 (+ 3h online)	luduran@ucm.es	224, 4th floor, centre

Syllabus

Theory

1. Introduction. Physics of the atmosphere. Air composition. Origin of Earth's atmosphere. Vertical distribution of atmospheric mass. Vertical distribution of temperature.
2. Fundamental thermodynamic processes in the atmosphere. Equation of state for air. Virtual temperature. Hydrostatic equation. Adiabatic processes. Potential temperature.
3. Water vapor in air. Phases of water in the atmosphere. Saturation. Moisture parameters. Formation of fog and clouds.
4. Atmospheric stability and cloud formation. Ascent of air parcels: temperature variation. Dry adiabatic and saturated adiabatic lapse rates. Adiabatic and pseudoadiabatic ascent. Static stability. Convection and cloud formation. Thermodynamic diagrams.
5. Energy balance. Heat transfer in the atmosphere. Solar and terrestrial radiation. Fundamental radiation laws. Absorption, emission and equilibrium. Greenhouse effect. Total energy balance. Implications for climate change studies. Latitudinal variations of energy balance.
6. Temperature. Hemispheric seasonal variations in temperature: causes and effects. Local seasonal variations in temperature. Daily temperature variations. Measuring air temperature.
7. Air pressure and winds. Atmospheric pressure. Variation with height. Forces that influence the winds. The geostrophic wind. The gradient wind. Effect of surface friction.
8. Weather analysis and prediction. Global observing system. Meteorological maps. Weather forecasting methods using meteorological maps. Current weather forecasting. Numerical models. Weather predictability.

Practice:

Four practice sessions will be held in the computer lab.

Bibliography

BASIC

- C.D. Ahrens and R. Henson (2019). Meteorology Today, 12th edition. Cengage. Also online resource from the library: https://ucm.on.worldcat.org/oclc/1227788986
- J.M. Wallace and P.V. Hobbs (1977, 1st edition; 2006, 2nd edition). Atmospheric Science: An Introductory Survey. Academic Press. Elsevier

COMPLEMENTARY

- R.B. Stull (2000). Meteorology for Scientists and Engineers, 2nd ed. Brooks/Cole Thomson Learning.
- Sendiña Nadal and V. Pérez Muñuziri (2006). Fundamentos de Meteorología. Academic Press. Universidad de Santiago de Compostela (Servicio Publicaciones).
- M. Ledesma Jimeno (2011). Principios de Meteorología y Climatología. Ediciones Paraninfo S.A.
- Zúñiga López, Ignacio; Crespo del Arco, Emilia; Fernández Sánchez, Julio; Santos Burguete,Carlos (2016). Problemas de meteorología y climatología. UNED.

Online Resources

Virtual campus

Meteorology and Climate virtual laboratory: http://meteolab.fis.ucm.es/

Methodology

On-campus teaching 100% (Scenario 0)

The following training activities will be conducted:

- Theory lessons where the main concepts of Physics of the Atmosphere will be explained, including examples and applications.
- Problem solving classes will be combined with theory lessons to provide an adequate complement.
- Questionnaires and/or practical exercises will be proposed through the use of Virtual Campus.
- Practice sessions in the Computer Lab. Four practice sessions will be conducted (90 minutes each) to reinforce the explained theoretical concepts.

For the theory lessons, projected computer presentations and explanations with the blackboard will be used. Occasionally, the lessons can be complemented with real cases of particular meteorological situations.

The computer presentations and proposed exercises will be provided to the students through the virtual campus in advance.

As part of the continuous evaluation, students will have to hand in the proposed exercises and practice reports in due time, as specified.

Semi-online teaching (Scenario 1)

Modality A will be followed. Training activities will be provided as in 'Scenario 0' to one of the subgroups in which the students will be grouped (if room restrictions prevent the whole group from attending the lesson). The rest of the students will be able to follow the lesson on-line, rotating each week the attending subgroup. The lesson will be broadcasted synchronously using a webcam (and on-line software as Google Meet or similar), so the at-distance subgroup will be able to follow the blackboard explanations and computer presentations, which will be provided in advance through the Virtual Campus.

Practice sessions in the computer lab will be 100% on-campus.

On-line connections for individual and group tutorials will be favored, with Google Meet or similar applications.

Online teaching (Scenario 2)

On-campus theory lessons will be replaced by recorded videos, which will be provided asynchronously to students through the Virtual Campus. In addition, synchronous on-line sessions will be held to allow for clarification of students' questions, and further explanations regarding the general content provided in the videos and particular details of problem solving. Such synchronous on-line sessions will use the official time slots provided. The provision of the computer presentations as well as the handing over of exercises for the continuous evaluation will be kept.

Practice sessions will be adapted in this scenario by providing the students, if necessary, with the required software and data. This adaptation will include synchronous sessions with students, who will later on work separately.

On-line connections for individual and group tutorials will be used Google Meet or similar applications.

Evaluation Criteria		
Exams	**Weight:**	70%
A Final Exam will be performed, which can consist of multiple-choice questions, short questions with theoretical and/or practical argumentation and/or problem solving. No reference material will be allowed. The Final Exam (Nexam) will be marked over 10.		
Other Activities	**Weight:**	30%
Throughout the course, as part of the continuous evaluation, students will hand in the proposed exercises in due time, as specified. A partial test can be proposed in class time. It can include multiple-choice questions and/or exercises. The test will be announced in advance in class and through the Virtual Campus. Lab practices, to which attendance is compulsory, will be held as programmed. Students will hand in a report for each of them. The overall mark for Other Activities (NOtherActiv) will be provided over 10.		
Final Mark		
The final mark will be the result of the following equation: $$CFinal = 0.7 \times NExam + 0.3 \times NOtherActiv,$$ where NOther is the mark for Other Activities and NExam the one obtained in the Final Exam. The mark for the June-July resit will be obtained following the same evaluation procedure.		