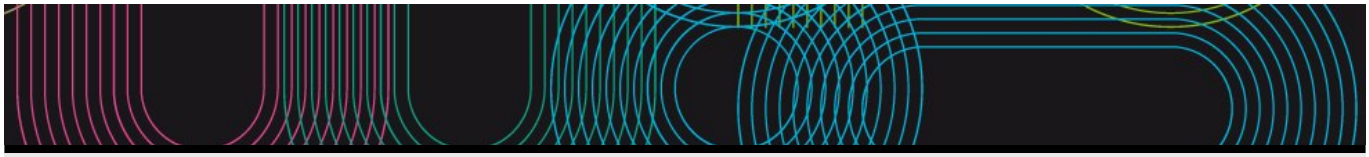

IDENTIFYING DATA				
Palaeoclimatology and Paleoceanography				
Subject	Palaeoclimatology and Paleoceanography			
Code	V10M153V01206			
Study programme	Máster Universitario en Oceanografía			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	1st	2nd
Teaching language	Spanish			
Department				
Coordinator	Marino , Gianluca			
Lecturers	Chiarenza , Alfio Alessandro Diz Ferreiro, Paula Marino , Gianluca Rey García, Daniel Varela González, Sara			
E-mail	gianluca.marino@uvigo.es			
Web	http://masteroceanografia.com/			
General description	The subject centres on the timing, magnitude, and rates of past ocean and climate change. Emphasis is given to the: (i) different timescales and patterns of (palaeo)climate change; (ii); most commonly used tools of investigation, and (iii) relationship between (palaeo)climate forcings, feedbacks, and responses of the climate system. Focusing on the investigative tools, the lectures illustrate the various micropalaeontological, geochemical, and geophysical proxies as well as the statistical methods that allow to rigorously determine confidence levels of e.g., chronological frameworks and proxy-based reconstructions. Examples are given of the different episodes of climate change that punctuated the Earth's climate history. These will be taken from the last few centuries to millennia, the last 2 million years, and the so-called 'deep-time'. Insights are also provided into the use of the palaeoclimate record to better constrain 'climate sensitivity' that is an essential metric to predict by how much, and how fast, the Earth may warm in response to the ongoing anthropogenic greenhouse gas forcing.			

Training and Learning Results	
Code	
A1	Students who have demonstrated knowledge and understanding that is founded upon and extends and/or enhances that typically associated with the first cycle, and that provides a basis or opportunity for originality in developing and/or applying ideas, often within a research context
A2	Students who can apply their knowledge and understanding, and problem solving abilities in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their field of study
A4	Students who can communicate their conclusions, and the knowledge and rationale underpinning these, to specialist and nonspecialist audiences clearly and unambiguously
A5	Students who have the learning skills to allow them to continue to study in a manner that may be largely self-directed or autonomous.
B2	The students will interpret the behaviour of the global oceanic system and their controlling factors.
B3	The students will be able to deepen in the main oceanographic processes and their spatiotemporal scales
C1	The students will be able to obtain advanced and relevant knowledge, of skilled and multidisciplinary character, in the field of the oceanography and their application to the marine environment
C3	The students will analyse situations and specific oceanographic conditions related with the global change
C7	The students will obtain knowledge that will allow them reinforce and deepen in the physical mechanisms that control the atmosphere-ocean interactions, the climatic variability, as well as the validity and contrast of climatic models.
D3	The students will be able to communicate the obtained information and their conclusions in a effective way to the general public, to other scientists and to the competent authorities, listening and answering of effective form and, using an appropriate language to the audience and to the context

Expected results from this subject

Expected results from this subject	Training and Learning Results
To obtain information from the various palaeoceanographic and palaeoclimatic proxies and comprehend how they are used to reconstruct ocean and climate changes.	A1 A2 A4 A5 B2 B3 C3 C7 D3
To integrate the information retrieved from regionally to globally distributed palaeoceanographic and palaeoclimatic records.	A1 A2 A4 A5 B2 B3 C1 C3 C7 D3
To understand the natural mechanisms of climatic change at the different temporal and spatial scales.	A1 A2 A4 A5 B2 B3 C1 C3 C7 D3
To exploit the continuous nature of the oceanic sedimentary record to reconstruct the history of Earth's climate.	A1 A2 A4 A5 B2 B3 C1 C3 C7 D3
To extract information from the palaeoclimate record and use it to better understand current climate change and improve predictions of future climate developments.	A1 A2 A4 A5 B2 B3 C1 C3 C7 D3

Contents	
Topic	
Topic 0. Introduction to palaeoclimatology and paleoceanography	0.1. Aims of the course; 0.2. Lectures and of topics addressed by the course; 0.3. Laboratory practicals; 0.4. Seminars; 0.5. Assessment.
Topic 1. Basic concepts and current climate change	1.1. Overview of climate change and methods of investigation; 1.2. Spatial and temporal scales of climate change; 1.3. Climate change and climate variability; 1.4. Earth's climate and energy budget; 1.5. Forcing, feedback, and response mechanisms of the climate system; 1.6. Transient climate response, equilibrium climate sensitivity, and Earth system sensitivity; 1.7. Global warming and the 1.5ºC and 2.0ºC climate thresholds.

Topic 2. Proxies of past ocean and climate change	2.1. Introduction to proxies and tracers; 2.2. Micropaleontological proxies and transfer functions; 2.3. Geochemical proxies; 2.4. Geophysical proxies; 2.5. Sedimentological and mineralogical proxies.
Topic 3. Chronologies of past ocean and climate change	3.1. The importance of chronology to decipher timing and rates of change; 3.2. Radiometric methods of dating (e.g., uranium-thorium, radiocarbon); 3.3. Oxygen isotope stratigraphy; 3.4. Site to site correlations.
Topic 4. Tectonic-Scale Climate Change	4.1. Plate tectonics, weathering, CO2, and long-term climate; 4.2. Greenhouse and icehouse climates.
Topic 5. Orbital-Scale Climate Change	5.1. Astronomical control of solar radiation; 5.2. Insolation control of ice sheets; 5.3. Insolation control of monsoons; 5.4. Orbital-scale forcing, feedbacks, and responses; 5.5. The 40,000- and the 100,000-year ice-age cycles.
Topic 6. Millennial- and centennial-scale (suborbital) climate variability	6.1. Patterns and mechanisms of sub-orbital climate variability; 6.2. The role of Northern Hemisphere ice sheets; 6.3. The role of the Atlantic Meridional Overturning Circulation; 6.4. The role of solar output; 6.5. Dansgaard-Oeschger, Heinrich events, and Bond cycles.
Topic 7. The role of the ocean in atmospheric CO2 variations	7.1. Terrestrial, atmospheric, and oceanic reservoirs of carbon; 7.2. Ocean carbonate chemistry and the carbonate compensation feedback; 7.3. Glacial-interglacial variations in atmospheric CO2 concentrations.
Laboratory practicals	Quantitative exercises and/or practical, analytical examples related with the subjects developed during the course. The course involves 3 laboratory practicals: Laboratory practical 1 (foraminiferal proxies); Laboratory practical 2 (climate sensitivity); Laboratory practical 3 (magnetism applied to palaeoclimatology).
Seminars	The course includes 3 seminars that will deepen some of the main topics of the course (patterns of palaeoclimate change, palaeoclimate proxies, ocean-atmosphere interactions, palaeoclimate variability).

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	33	30	63
Laboratory practical	9	5	14
Presentation	2	22	24
Seminars	6	3	9
Presentation	2	5	7
Essay	0	5	5
Laboratory practice	0	3	3

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	Lectures on the 7 topics of the program. Coverage of the topics will be flexible to address questions and issues that may arise over the duration of the course. Some lectures will be given by (foreigner) guest lecturers and done by remote-connection.
Laboratory practical	They illustrate those methods and protocols that are commonly used to generate sedimentological, geophysical, and/or geochemical data from deep-sea sediment cores. Laboratory practicals will centre on: (1) foraminifera as proxies os past ocean conditions; (2) the topic climate sensitivity based on palaeoclimate data; and (3) on the methods of magnetism applied to palaeoclimate research. Attendance is mandatory.
Presentation	Oral presentations on topics that are related to those addressed during the lectures.
Seminars	Additional presentations centred on specific, timely topics within the wider fields of palaeoclimatology and paleoceanography (patterns of palaeoclimate change, palaeoclimate proxies, ocean-atmosphere interactions, palaeoclimate variability). Attendance is mandatory.

Personalized assistance

Methodologies	Description

Lecturing	Questions and doubts that may arise during lectures will be addressed during tutorials. In order to schedule a tutorial students and/or group of students should contact the professors well in advance in order to efficiently schedule the tutorial.
Laboratory practical	Questions and doubts that may arise during laboratory practicals will be addressed during tutorials. In order to schedule a tutorial students and/or group of students should contact the professor well in advance in order to efficiently schedule the tutorial.
Presentation	Prior to the final presentation the students can contact the professors in order to be advised about literature material that could be used to develop the presentation topic.
Seminars	Questions and doubts that may arise during seminars will be addressed during tutorials. In order to schedule a tutorial students and/or group of students should contact the professors well in advance in order to efficiently schedule the tutorial.

Assessment

	Description	Qualification	Training and Learning Results			
Presentation	Oral presentation on a topic related to those developed during the course.	40	A1		C3	D3
Essay	Short, written reports on two topics related to those developed during the course.	40		B2 B3	C1 C7	
Laboratory practice	Exercises related to the laboratory practicals.	20	A2 A5	B3		

Other comments on the Evaluation

Attendance at seminars and laboratory practicals is mandatory and essential requirement to obtain a positive evaluation. Students that cannot attend some of these activities are expected to provide a proper justification for their absence. If not, failure to attend them precludes the option to sit the 2nd opportunity exam.

The oficial dates of evaluation tests will be available at: http://masteroceanografia.com/horarios/

All tests can be evaluated on the second chance.

Students are strongly requested to fulfil an honest and responsible behaviour. It is considered completely unacceptable any alteration or fraud (i.e., copy or plagiarism) contributing to modify the level of knowledge and abilities acquired in exams, evaluations, reports or any kind of teacher□s proposed work. Fraudulent behaviour may cause failing the course for a whole academic year. An internal dossier of these activities will be built and, when reoffending, the university rectorate will be asked to open a disciplinary record.

Sources of information

Basic Bibliography

Archer, D.E., **The Global Carbon Cycle**, Princeton Primers in Climate, 2010

Barron, E.J., **Climatic Variation in Earth History**, University Science Books, 1996

Clement, A. & Peterson, L., **Mechanisms of abrupt climate change of the last glacial period**, AGU, 2008

Cronin, T. M., **Paleoclimates: Understanding Climate change past and present**, Columbia University Press, 2010

Gornitz, V. (ed.), **Encyclopedia of Paleoclimatology and ancient environments**, Springer, 2009

Hemming, S., **Heinrich Events: Massive Late Pleistocene detritus layers on the North Atlantic and their global climate imprint.**, Reviews in Geophysics, 42, 2004

Stocker, T.F. et al. (Ed.), **IPCC, 2013: Climate Change 2013: The Physical Science Basis**, Cambridge University Press, 2013

Pierrehumbert, R.T., **Principles of Planetary Climate**, Cambridge University Press, 2010

Rapp, D., **Ices Ages and interglaciars: measurements, interpretations and models**, Springer-Verlag, 2009

Ruddiman, W. F., **Earths' Climate. Past and Future**, W. H. Freeman and Company, 2008

Wilson, R. C.L., Drury, S. & Chapman, A., **The Great Ice Age**, Routledge, 2000

Complementary Bibliography

Recommendations

Subjects that are recommended to be taken simultaneously

Design and Carrying out of Oceanographic Campaigns/V10M153V01301
Biological Oceanography/V10M153V01CF103
Physical Oceanography/V10M153V01CF101

Geological Oceanography/V10M153V01CF104
Chemical Oceanography/V10M153V01CF102

Subjects that it is recommended to have taken before

Geological Oceanography/V10M153V01CF104
Geological Processes in Continental Margins and Ocean Basins/V10M153V01104

Other comments

Students willing so could attend personal tutorials to solve doubts and/or uncertainties. To better optimise the procedure, the student is requested to previously contact his/her teacher with reasonable anticipation. Students are strongly requested to fulfil a honest and responsible behaviour. It is considered completely unacceptable any alteration or fraud (i.e., copy or plagiarism) contributing to modify the level of knowledge and abilities acquired in exams, evaluations, reports or any kind of teacher□s proposed work. Fraudulent behaviour may cause failing the course for a whole academic year. An internal dossier of these activities will be built and, when reoffending, the university rectorate will be asked to open a disciplinary record.