Module Handbook
for the Master of Science programme
Physical Geography: Environmental History

Universität Bremen

Content

Fachbereich FB 08
Sozialwissenschaften

GEOGRAPHIE
UNIVERSITÄT BREMEN

Introductory remarks

The module handbook describes the M. Sc. study programme “Physical Geography: Environmental History” at the Institute of Geography (Faculty 8/Social Sciences of the University of Bremen).

This master programme consists of four semesters: the introductory phase (first semester), the advanced studies phase (second semester) and the individualisation phase (third semester). The final phase (fourth semester) concludes with the master thesis. The modules of the M. Sc. in “Physical Geography: Environmental History” are composed of lectures, seminars, exercises, projects, laboratory and field courses:

- Lectures comprehensively cover scientific foundations, i.e. core knowledge, specialised knowledge, and concepts of selected areas.
- In seminars the students are familiarised with specialised topics by reading original literature, presenting the scientific contents to fellow students and producing final papers.
- During exercises students carry out hands-on activities, often in the laboratory or in the computer room.
- In the context of laboratory and field courses theoretical knowledge is applied to specific research questions.
- In projects the students acquire the ability to solve problems and jointly apply and train methods and techniques developed in exercises or during laboratory and field courses.

Validity

This module handbook serves as a first orientation for students. Legally binding is the German version of the valid Examination Regulations for the M. Sc. in “Physical Geography: Environmental History”. Although the module handbook is being updated regularly, unexpected modifications may occur.

Description of the M. Sc. “Physical Geography: Environmental History”

The M. Sc. “Physical Geography: Environmental History" is a research-oriented master programme in physical geography focusing on the understanding and reconstruction of environmental and climatic history. This master programme is innovative and unique in Germany due to its distinct interdisciplinary approach including courses in physical and human geography, archaeology, geosciences, palaeobiology and environmental physics. To ensure high academic quality and practical orientation, the programme draws on both expertise within the University of Bremen and partnerships with regional scientific institutions in Bremen and Lower Saxony. All classes are taught in English, thus adding to the international visibility and attractiveness of this M. Sc. programme.

Introduction

The current debates about causes and effects of climate change illustrate the need for experts who understand and explain the complex interrelations that lead to environmental changes through time and guide societies towards a sustainable development. Meeting this demand, the consecutive M. Sc. “Physical Geography: Environmental History" complements and completes the educational concept at the Institute of Geography since the winter term of 2016/17.

Objectives

The M. Sc. “Physical Geography: Environmental History" focusses on the reconstruction of environmental and climatic history as scientific expertise in this field is paramount today. The programme provides physical-geographical background, knowledge and skills that enable students to analyse, interpret and evaluate the complex effects of natural and anthropogenic influences on environment and society. Global environmental changes are the most important social, political and cultural challenges of the 21st century. In order to cope with their complexity, it is important to develop innovative and interdisciplinary approaches in teaching and research that qualify students for combining an understanding of natural and anthropogenic phenomena. Our new M. Sc. accepts this challenge by offering a study programme, which merges natural science aspects with social scientific components such as archaeology and human geography.

Information about the past, obtained from natural, archaeological and historical archives as well as from instrumental data, enables graduate students to understand how global climate and environmental changes affect natural and socioeconomic systems and to investigate the future of our environment. Students learn to develop their own scientific questions in close relation to ongoing national and international research projects. They work in an interdisciplinary manner through research-based education and in close co-operation with research institutions in Bremen and Lower Saxony. All modules are characterised by strong links between teaching and research, while the concluding project and internship modules as well as the master thesis focus on own research. Furthermore, all classes are taught in English to address international students and to prepare graduates for an increasingly international job market. Methodological training in the field, in the laboratory and on the computer, including geographical information systems (GIS), also qualifies graduates for applied labour markets, e. g. public administration, planning offices, adult education as well as media sectors and information technology.

Structure

The M. Sc. “Physical Geography: Environmental History" leads to the degree Master of Science (M. Sc.) with at least 120 credit points (CP/ECTS) after two years of instruction. It is designed to accept students at the beginning of each winter term and consists of four compulsory and several elective modules (including the internship), of which at least six must be selected. Not included in the module structure are the study abroad, the “General Studies” and the master thesis. Since teaching is not spread over the entire third semester but concentrates into compact time slots before and after the teaching term, students can spend a semester abroad without extending their study period. In

addition, studies at foreign universities can be used to complement the technical and vocational skills. Moreover, the concept of this master programme also enables students to complete parts of the project module and/or the internship abroad. Graduates are encouraged to study abroad by making use of the numerous contacts of our faculty with international universities and research institutions.

This new master programme is structured into four semesters with different teaching and learning methods in order to meet the heterogeneous needs of its students:

- The *introductory phase* considers the different levels of knowledge and provides basic courses in the form of compulsory lectures and seminars as Consecutive Core Subjects in the disciplines of climatology, environmental physics, geosciences, limnogeology, prehistoric archaeology and vegetation history and archaeobotany. In addition, an introduction to the current literature is given and presentation techniques are applied.
- In the *advanced study phase* the Consecutive Core Subjects are continued, closely interconnected and consolidated by means of research-based and hands-on training, particularly in the framework of field and laboratory exercises. Furthermore, computer-based analyses and visualization techniques of spatio-temporal data and processes are conveyed.
- The *individualisation phase* involves project work (Research Process II) as well as additional elective modules with specialised lectures and exercises in the disciplines of environmental archives, soil science and environmental physics. Furthermore, graduates may combine these options with an internship and/or a study abroad. This results in deeper insights into research practices of environmental and climate reconstruction. Intensive course guidance by the teaching staff ensures that project module, internship and master thesis are combined in a meaningful way. During this individualisation phase, the teaching contacts between students and scientists from regional research institutes have a positive impact and lead to an intensive research experience. The options of specialisation allow students to individualise their study profile tailored in support of their professional career.
- During the *final phase*, the students work on their master theses. After successfully passing the master colloquium, the academic degree "Master of Science" (M. Sc.) is awarded.

Educational concept

Four professors are responsible for the M. Sc. “Physical Geography: Environmental History": Profs B. Marzeion and B. Zolitschka (both physical geographers), Prof. M. Flitner (human geography) and Prof. U. Halle (archaeology). Teaching imports from other faculties of the University of Bremen are arranged with the Institute of Environmental Physics (Faculty 1), the Department of Geosciences (Faculty 5) and the central scientific units “Sustainability Research Center” (artec) and “Center for Marine Environmental Sciences” (MARUM). Additional teaching import is assured from other research institutions in Bremen (State Archaeology of Bremen, Alfred-Wegener Institute, Bremerhaven) and Lower Saxony (University of Oldenburg, Lower Saxony Institute for Historical Coastal Research, Wilhelmshaven).

Guidance for this study programme is offered by the Central Student Advisory Service of the University of Bremen. Decentralised academic counselling is provided by the teaching staff at the Institute of Geography and at cooperating institutions as well as by the Study Coordinator of the Institute of Geography and the International Office of Faculty 8 (M. Thiele).

Requirements

The admission to the master programme requires a completed bachelor programme with 180 credit points (CP/ECTS) or another comparable scientific study programme with a background in physical geography, geoarchaeology or geosciences. Master applicants must draft a motivation letter, in which they explain their interests as well as their academic or professional background. A further requirement is the proof of language skills in English at the level C1 of the European Framework of Reference for Languages (or any equivalent certificate). Basic knowledge of the German language is desirable.

Guiding principles

The M. Sc. “Physical Geography: Environmental History" consistently implements the guiding principles of the University of Bremen. A *high quality of teaching* is ensured by accreditation of the study programme and by the implemented quality cycle in teaching at the Faculty 8 (Social Sciences). A *high quality of research* is achieved by attempting to publish results of the master theses in international scientific journals. Moreover, the master programme also benefits from the excellent reputation of cooperating research institutions. *Multi- and transdisciplinary orientation* is provided by interdisciplinary cooperation between the participating natural and social scientists. *Social responsibility, a high degree of sustainability and good environmental performance* go without saying in a study programme that focuses on global climate and environmental change and its impacts on natural and socioeconomic systems. The goal of *gender equality* is successfully implemented in all study programmes at the Institute of Geography with male and female students roughly balanced.

The high level of *internationalisation in teaching and research* results from teaching in English. Additionally, the structurally integrated option to complete studies abroad during the third semester with a prior definition of a learning agreement and/or to carry out an internship abroad are both possible without extending the period of study. Teaching is based on international standards and draws on ongoing international research of all participating institutions. International collaborations already exist with official partner universities of the University of Bremen, which can be used either to study abroad or for further qualification through joint field work or projects.

Teaching staff

Family name	First name	Title	Affiliation	email
Behrens	Anja	Dipl.-Prähist.	NIhK	behrens@nihk.de
Bickert	Torsten	Dr.	MARUM	tbickert@marum.de
Bittmann	Felix	Prof. Dr.	FB 8, IfGeo; NIhK	bittmann@uni-bremen.de
Bracher	Astrid	Prof. Dr.	FB 1, IUP	bracher@iup.physik.uni-bremen.de
Burrows	John	Prof. Dr.	FB 1, IUP	burrows@iup.physik.uni-bremen.de
Dobeneck	Tilo von	Prof. Dr.	FB 5	dobeneck@uni-bremen.de
Flitner	Michael	Prof. Dr.	FB 8, IfGeo; artec	flitner@uni-bremen.de
Gebhardt	Catalina	Dr.	AWI	catalina.gebhardt@awi.de
Halle	Uta	Prof. Dr.	FB 8, IfG	halle@uni-bremen.de
Kalinina	Olga	Dr.	Univ. Oldenburg	olga.kalinina@uni-oldenburg.de
Labuhn	Inga	Dr.	FB 8, IfGeo	labuhn@uni-bremen.de
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Mennenga	Moritz	Dr.	NIhK	mennenga@nihk.de
Möller	Marco	Dr.	FB8, IfGeo	marco.moeller@uni-bremen.de
Mulitza	Stefan	Dr.	FB 5	smulitza@uni-bremen.de
Ohlendorf	Christian	Dr.	FB 8, IfGeo	ohlen@uni-bremen.de
Palm	Mathias	Dr.	FB 1, IUP	mathias@iup.physik.uni-bremen.de
Paul	Andre	Dr.	MARUM	apaul@marum.de
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Schefuß	Enno	Dr.	FB 5	schefuss@uni-bremen.de
Schulz	Michael	Prof. Dr.	MARUM	mschulz@marum.de
Siegmüller	Annette	Dr.	NIhK	siegmueller@nihk.de
Stein	Rüdiger	Prof. Dr.	AWI	rstein@awi-bremerhaven.de
Thiele	Michael	Dipl.-Geogr.	FB 8	thiele@uni-bremen.de
Völker	Christoph	Dr.	FB 1, IUP; AWI	christoph.voelker@awi.de
Warneke	Thorsten	Dr.	FB 1, IUP	warneke@iup.physik.uni-bremen.de
Wolters	Steffen	Dr.	NIhK	wolters@nihk.de
Zabel	Matthias	Dr.	FB 5	mzabel@uni-bremen.de
Zolitschka*	Bernd	Prof. Dr.	FB 8, IfGeo	zoli@uni-bremen.de

***** responsible person for this master programme

Module coordinators

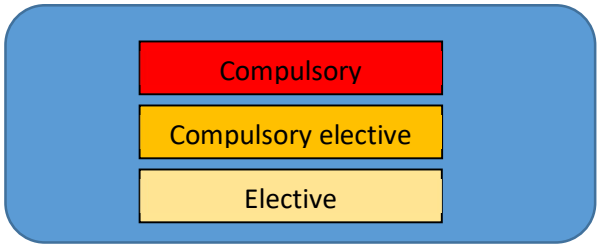
Module Name	Module Acronym	Sem.	CP/ ECTS	Module Coordinator	Deputy
Research Process I	PG-RP	1	6	B. Zolitschka	B. Marzeion
Computer-based Analyses	PG-CBA	1	6	B. Marzeion	B. Zolitschka
Climatology I	PG-CL	1	6	B. Marzeion	B. Zolitschka
Lacustrine Environmental Archives I	PG-EA	1	6	C. Ohlendorf	B. Zolitschka
Vegetation History and Archaeobot. I	PG-VA	1	6	F. Bittmann	B. Zolitschka
Archaeology I	PG-AR	1	6	B. Zolitschka	U. Halle
Atmospheric Physics	PEP-AtPhy	1	6	J. Burrows	
Climate Change I	MMG-CC1	1	6	A. Paul	
Climatology II	PG-CL2	2	6	B. Marzeion	B. Zolitschka
Lacustrine Environmental Archives II	PG-EA2	2	6	C. Ohlendorf	B. Zolitschka
Vegetation History and Archaeobot. II	PG-VA2	2	6	F. Bittmann	B. Zolitschka
Archaeology II	PG-AR2	2	6	B. Zolitschka	U. Halle
Remote Sensing	PEP-RemS	2	3	A. Bracher	
Isotopes in Environmental Physics	PEP-IEPhy	2	3	T. Warneke	
Climate Change II	MMG-CC2	2	6	A. Paul	
Historical Political Ecology	PG-HPE	2	6	M. Flitner	B. Zolitschka
Research Process II	PG-RP2	3	12	B. Marzeion	B. Zolitschka
Internship	PG-INS	3	12	M. Thiele	B. Zolitschka
Soil Science	PG-BOK	3	6	B. Zolitschka	B. Marzeion
Global Carbon Cycle	PEP-GCC	3	3	C. Völker	
Environmental Archives Methods	MMG-EA1	3	9	T. Bickert	
Master Thesis	PG-MT	4	30	B. Zolitschka	B. Marzeion

General Studies

In principal, all courses at the master level taught at the University of Bremen are acceptable as General Studies, except for those belonging to the curriculum of the study program in which the student is officially inscribed. However, the teacher of the course should always be asked and needs to agree in advance. For more information please check the webpage "Structure of General Studies": https://www.uni-bremen.de/en/lehre-studium/designing-study-programs/general-studies?no_cache=1. In addition, the online "eGeneral Studies" can be accessed here: https://egs.zmml.uni-bremen.de/index.php.

For the recognition of related credit points, only the paper form (https://www.uni-bremen.de/en/zpa/forms) will be accepted and needs to be signed by the teacher. The number of credit points for General Studies to be considered for the M. Sc. "Physical Geography – Environmental History" is limited to 12 CP. However, only at the very end of the master programme all signed General Study forms have to be handed in to the Central Examination Office (ZPA). This means, more than 12 CP can be achieved during studies but only the most appropriate 12 CP (to be decided individually by the student) will be officially recognized in the end.

Structure of the study programme and overview of modules



1st Semester – Introductory Phase

PG-RP Research Process I (6 CP)	PG-CBA Computer-based Analyses (6 CP)				
PG-CL Climatology I (6 CP)	PG-EA Lacustrine Environ-mental Archives I (6 CP)	PG-VA Vegetation History and Archaeobotany I (6 CP)	PG-AR Archaeology I (6 CP)	PEP-AtPhy Atmospheric Physics (6 CP)	MMG-CC1 Climate Change I: Fundamentals (6 CP) and PD1NM* (+3 CP)

2nd Semester – Advanced Study Phase

PG-CL2 Climatology II (6 CP)	PG-EA2 Lacustrine Environ-mental Archives II (6 CP)	PG-VA2 Vegetation History and Archaeobotany II (6 CP)	PG-AR2 Archaeology II (6 CP)	PEP-RemS Remote Sensing (3 CP) PEP-IEPhy Isotopes in Environ. Physics (3 CP)	MMG-CC2 Climate Change II: Models and Data (6 CP)
PG-HPE Historical Political Ecology (6 CP)	General Studies (6 CP)			Study Abroad (18 CP	General Studies (6 CP)

3rd Semester – Individualisation Phase

PG-RP2 Research Process II (12 CP)	PG-INS Internship (12 CP)	PG-BOK (Soil Science) Bodenkunde (6 CP)	MMG-EA1 Environmental Archives Methods (6 CP)	PEP-GCC Global Carbon Cycle (3 CP)	Add. Elective Module** CL, EA, VA, AR, AtPhy or CC1 (6 CP)

4th Semester – Final Phase

Master-Thesis (30 CP)

*The course PD1NM „Numerical Methods“ of the module MMG-PD1 is a requirement for MMG-CC1 and is offered as a block course at the beginning of winter terms.
**The Additional Elective Module denotes one of the compulsory elective modules of the first semester, which has not been chosen by the student as a consecutive module.

Module descriptions

Introductory phase (first semester – winter term)

Name of the module Acronym	Research Process I PG-RP
Module coordinator	Prof. Dr. Bernd Zolitschka +49-(0)421-218.67150; zoli@uni-bremen.de
Teaching staff	Prof. Dr. Bernd Zolitschka +49-(0)421-218.67150; zoli@uni-bremen.de
Related courses, teaching format and hours per week (hpw)	PG-RP-1 Orientation and Introduction (exercise: 1 hpw, blocked) PG-RP-2 Graduate Reading Seminar (seminar: 2 hpw)
Compulsory / Elective	Compulsory
Related to the study programme	M. Sc. Physical Geography: Environmental History
Duration of module/ Winter or summer semester	One semester / This module is scheduled for the first semester
Workload/ Calculation of Credit points (CP)	This module is rated with 6 CP (180 hours): ▪ 42 h seminar and exercise ▪ 18 h oral presentation of own completed bachelor studies ▪ 30 h reading assignments ▪ 30 h oral presentation of a scientific publication ▪ 60 h Download data from a data base, produce figures for documentation as well as description and interpretation in the form of a scientific manuscript
Requirements for participation	No
Frequency of module	Annual (winter term)

Language	English
Learning Outcome	Students obtain ▪ an understanding of the structure of the M. Sc. Programme embedded in administration needs, library, international office and central examination office at the University of Bremen, ▪ an advanced training in reading and discussing of up-to-date literature in relevant fields of science, ▪ an advanced training in oral presentation of published data and information, ▪ an advanced training in oral presentation of own data and scientific results.
Contents	▪ Introduction to the University of Bremen in general and the M. Sc. programme in particular. ▪ Preparation of two oral (a, b) and two written presentations (c, d): (a) own data and results, (b) reporting a current scientific publication, (c) describe and interpret data in the form of a scientific report and (d) provide a prior research outline. ▪ Approaching the current state of scientific discussion by reading up-to-date literature.
Study and examination achievements, Forms of examination	Module examination (combined mark): ▪ Oral presentation of a scientific paper (25 %) ▪ Final written project report (75 %) Required study work (not graded) ▪ Oral presentation of own bachelor studies ▪ Research outline (max. 2 pages) for final report
References	Will be announced in the seminar

Name of the module Acronym	Computer-Based Analyses PG-CBA
Module coordinator	Prof. Dr. Benjamin Marzeion +49-(0)421-218.67170; ben.marzeion@uni-bremen.de
Teaching staff	Marco Möller +49-(0)421-218.67178; marco.moeller@uni-bremen.de Melissa Mengert +49-(0)421-218.67177; mmengert@uni-bremen.de
Related courses, teaching format and hours per week (hpw)	PG-CBA-1 Data Analysis and Visualisation (lecture, exercise: 2 hpw) PG-CBA-2 Geographical Information System (GIS) (lecture, exercise; 2 hpw)
Compulsory / Elective	Compulsory
Related to the study programme	M. Sc. Physical Geography: Environmental History
Duration of module/ **Winter or summer semester**	One semester / This module is scheduled for the second semester
Workload/ **Calculation of** **Credit points (CP)**	This module is rated with 6 CP (180 hours): ▪ 56 h lectures and practicals ▪ 90 h self-revision of lectures and additional complementary material, working on exercises in data processing ▪ 34 h preparation of final assessment and project
Requirements for participation	No
Frequency of module	Annual (summer term)
Language	English

Learning Outcome	Students will be able to ▪ process geospatial and time series data provided in the most common data formats, ▪ perform basic and common analyses of these data types using state-of-the-art software, ▪ generate effective visualisations of the results of analyses. They ▪ will obtain knowledge about the principal use of vector-based geographical information systems and ▪ will be able to capture, store, manipulate, analyse, manage and present spatial data.
Contents	Data Analysis and Visualisation: ▪ The course provides practical training in data processing, analysis, and visualisation. Emphasis will be given on techniques and methods that allow the detection of patterns and trends in complex data sets, as well as on tests for statistical significance. Different concepts of the display of quantitative data will be discussed and applied. ▪ Methods: lecture, and practical exercises at the PC. Data are provided in commonly used formats; the students are then given realistic examples of scientific questions to be answered using the data. Following these examples, the students will work through data processing and analysis, and finally identify and implement a visualisation of their results suitable to answer the scientific question. Basic theoretical concepts of Geographical Information Systems: ▪ geographical information systems ▪ characteristics of spatial data ▪ methods of geoprocessing Practical exercises: ▪ user interface of GIS software ▪ spatial geodatabases ▪ georeferencing raster datasets ▪ digitizing features ▪ joining attributes ▪ attributive and spatial selection methods ▪ basic methods of spatial data analysis ▪ cartographic map design
Study and examination achievements, Forms of examination	Module exam (combined mark): ▪ Continuous and successful participation in exercises and delivery of assignments for CBA-1 (50%) ▪ Final project for CBA-2 (50%)
References	References will be announced at the beginning of the courses.

Name of the module Acronym	Climatology I PG-CL
Module coordinator	Prof. Dr. Benjamin Marzeion +49-(0)421-218.67170; ben.marzeion@uni-bremen.de
Teaching staff	Prof. Dr. Benjamin Marzeion +49-(0)421-218.67170; ben.marzeion@uni-bremen.de Dr. Inga Labuhn +49-(0)421-218.67173; labuhn@uni-bremen.de
Related courses, teaching format and hours per week (hpw)	PG-CL-1 Introduction to Climatology (lecture, 2 hpw) PG-CL-2 Palaeoclimatology (lecture: 2 hpw)
Compulsory / Elective	Elective
Related to the study programme	M. Sc. Physical Geography: Environmental History
Duration of module/ **Winter or summer semester**	One semester / This module is scheduled for the first semester
Workload/ **Calculation of** **Credit points (CP)**	This module is rated with 6 CP (180 hours): ▪ 56 h lectures ▪ 74 h self-revision of lectures and additional complementary material, working on exercises ▪ 50 h study time for the final exam
Requirements for participation	No
Frequency of module	Annual (winter term)
Language	English

Learning Outcome	The students know and understand the ▪ key concepts of climatology ▪ causes and mechanisms of the most important phenomena in the coupled climate system, and can explain the mechanisms of variability of climate on timescales of years to centuries ▪ most important methods of reconstructing past climate from paleo archives ▪ main features of the climatic development of Earth during the recent past ▪ basic mechanisms of climate variability on millennial and longer time scales
Contents	Introduction to Climatology: ▪ the planetary energy balance ▪ the general circulation of the atmosphere as a consequence of radiative forcing ▪ variability in the radiative forcing – natural (orbital, solar, volcanic) and anthropogenic (greenhouse gases, aerosols, land use change) ▪ the global ocean circulation as a consequence of exchange of energy, momentum, and matter with the atmosphere ▪ mechanisms of internal, coupled variability ▪ mechanisms of natural, forced variability ▪ anthropogenic climate change in the coupled system ▪ climate models as a laboratory of climate science – concepts, validation, application Palaeoclimatology: ▪ methods of reconstructing past climates; proxies and dating techniques ▪ causes and mechanisms of climate variability ▪ causes and mechanisms of climate variability on orbital time scales ▪ glacial variability (Dansgaard-Oeschger cycles, Heinrich events) ▪ last glacial maximum, sequence and mechanisms of the deglaciation ▪ Holocene climate and climate variability ▪ applications of numerical models in paleoclimatology
Study and examination achievements, **Forms of examination**	Study work required: successful completion of exercises (not graded). Form of examination: joint written exam on both lectures.
References	References will be announced at the beginning of the courses.

Name of the module Acronym	Lacustrine Environmental Archives I PG-EA
Module coordinator	Dr. Christian Ohlendorf +49-(0)421-218.67153; ohlen@uni-bremen.de
Teaching staff	Dr. Catalina Gebhardt +49-(0)471-4831.2040; catalina.gebhardt@awi.de Dr. Christian Ohlendorf +49-(0)421-218.67153; ohlen@uni-bremen.de
Related courses, teaching format and hours per week (hpw)	PG-EA-1 Lakes and lacustrine sediments (lecture: 2 hpw) PG-EA-2 Methods in Limnogeology (seminar: 2 hpw)
Compulsory / Elective	Elective
Related to the study programme	M. Sc. Physical Geography: Environmental History
Duration of module/ Winter or summer semester	One semester / This module is scheduled for the first semester
Workload/ Calculation of Credit points (CP)	This module is rated with 6 CP (180 hours): ▪ 56 h lectures and practicals ▪ 74 h self-revision of lectures and additional complementary material (exercises and data processing, preparation of seminar presentation) ▪ 50 h study time for the final exam
Requirements for participation	No
Frequency of module	Annual (winter term)
Language	English

Learning Outcome	The students will obtain knowledge about ▪ abiotic and biotic processes of sediment formation in lakes ▪ lake sediments as paleoclimate and paleoenvironmental archives ▪ state-of-the-art destructive and non-destructive methods for sediment analysis ▪ state-of-the-art tools for data analysis and interpretation
Contents	▪ Introduction into lake systems ▪ Basics of limnology ▪ Field and laboratory tools in limnogeology ▪ Particle dynamics and processes in lakes ▪ Imaging of the lake floor and the sediments ▪ Lake sediments as paleoclimate archives ▪ Different proxies in lake sediments and basic statistics ▪ Dating methods and age model generation ▪ Case studies of different lake systems
Study and examination achievements, **Forms of examination**	Written / oral examination and presentation
References	▪ Bradley R.S. 2015. Paleoclimatology: reconstructing climates of the quaternary. Academic Press, Elsevier, Amsterdam [u. a.], 675 pp. ▪ Cohen, A.S., 2003: Paleolimnology: The History and Evolution of Lake Systems. Oxford University Press, USA, 485 pp ▪ Developments in Paleoenvironmental Research. Series Editor: Smol, J.P. (several specialised volumes) ▪ ▪ Håkanson L. and Jansson M. 1983. Principles of Lake Sedimentology. Springer, Berlin, Heidelberg, New York, Tokyo, 313 pp. ▪ Wetzel R.G. 2001. Limnology: lake and river ecosystems. 3rd ed., Acad. Press, San Diego, Calif, [u.a.] 1006 pp.

Name of the module Acronym	Vegetation History and Archaeobotany I PG-VA
Module coordinator	Prof. Dr. Felix Bittmann +49-(0)4421-915.146; bittmann@uni-bremen.de
Teaching staff	Prof. Dr. Felix Bittmann +49-(0)4421-915.146; bittmann@uni-bremen.de
Related courses, teaching format and hours per week (hpw)	PG-VA-1 Introduction to the History of Cultural Plants (lecture: 1 hpw) PG-VA-2 Laboratory Course in Archaeobotany (exercise; 1 week, blocked)
Compulsory /Elective	Elective
Related to the study programme	M. Sc. Physical Geography: Environmental History
Duration of module/ **Winter or summer semester**	One semester / This module is scheduled for the first semester
Workload/ **Calculation of** **Credit points (CP)**	This module is rated with 6 CP (180 hours): ▪ 60 h lectures and practical ▪ 70 h self-revision of lectures and additional complementary material (exercises, data processing, textbooks, specialised articles) ▪ 50 h study time for the final exam (oral presentation, manuscript, protocol)
Requirements for participation	No
Frequency of module	Annual (winter term)
Language	English

Learning Outcome	The students will obtain knowledge about ▪ Domestication processes ▪ Preconditions for domestication ▪ Domestication centres ▪ Chronological developments – origin and spread of cultural plants ▪ Field methods ▪ Identification of botanical macro remains
Contents	▪ Introduction to the history of cultural plants ▪ Introduction to seed morphology ▪ Identification of macro remains (cultural plants and related species) ▪ Sample preparation (e.g., floating, sieving) ▪ Wood and charcoal analysis
Study and examination achievements, **Forms of examination**	Protocol including an extended description of a certain aspect/problem of plant domestication and spreading (oral presentation of the latter)
References	▪ Zohary, D., Hopf, M., Weiss, E., 2012. Domestication of plants in the Old World. The origin and spread of domesticated plants in Southwest Asia, Europe and the Mediterranean Basin. 4th ed., Oxford University Press ▪ Cappers, R.T.J., Bekker, R.M., Jans, J.E.A., 2006. Digital Seed Atlas of the Netherlands. Groningen Archaeological Studies 4, Barkhuis Publishing, Eelde ▪ Cappers, R.T.J., Neef, R., Bekker, R.M., 2010. Digital Atlas of Economic Plantsthe Netherlands. Groningen Archaeological Studies 9, Barkhuis Publishing, Eelde ▪ Jacomet, S., Kreuz, A., 1999. Archäobotanik. Aufgaben, Methoden und Ergebnisse vegetations- und agrargeschichtlicher Forschung. Ulmer, Stuttgart ▪ Körber-Grohne, U., 1987 (2. Aufl. 1994). Nutzpflanzen in Deutschland. Kulturgeschichte und Biologie. Stuttgart

Name of the module Acronym	Archaeology I PG-AR
Module coordinator	Prof. Dr. Bernd Zolitschka +49-(0)421-218.67150; zoli@uni-bremen.de
Teaching staff	Prof. Dr. Uta Halle +49-(0)421-361.14238; halle@uni-bremen.de
Related courses, teaching format and hours per week (hpw)	PG-AR-1 Introduction to European Prehistoric Archaeology (lecture: 2 hpw) PG-AR-2 Methods of European Prehistoric Archaeology (exercise: 5 days, blocked with one field trip to megalithic graves and burial-mounds in the surroundings of Bremen)
Compulsory / Elective	Elective
Related to the study programme	M. Sc. Physical Geography: Environmental History
Duration of module/ **Winter or summer semester**	One semester / This module is scheduled for the first semester
Workload/ **Calculation of** **Credit points (CP)**	This module is rated with 6 CP (180 hours): ▪ 56 h lectures and practicals ▪ 74 h self-revision of lectures and additional complementary material (exercises, textbooks, etc.) ▪ 50 h study time for the final exam
Requirements for participation	No
Frequency of module	Annual (winter term)
Language	English

Learning Outcome	The students should have an overview and first understanding of ▪ Chronology, ▪ Material culture and major socio-economic issues, ▪ Interpretative themes relating to prehistoric Europe. They should be ▪ able to identify some of the principal monuments and key types of artefacts from prehistoric landscapes, ▪ aware of some of the regional cultures of prehistoric times, ▪ familiar with relevant terminology.
Contents	▪ Development of European prehistory as a discipline; ▪ Earliest occupation of Europe; ▪ European Neanderthals; ▪ Arrival of modern humans in Europe; ▪ Origins of farming and its spread across Europe; ▪ Neolithisation of the north; ▪ Emergence of elites and the development of long-distance connections; ▪ Development of metallurgy and hierarchical societies in the Bronze Age and the Iron Ages; ▪ Impact of Rome on European societies ▪ Rural Settlement and graveyards of the 5th and 11th centuries AD ▪ Growth of (pre-)urban centres in Europe ▪ Conversion to Christianity, church and monasteries ▪ Development of trading and manufacturing settlements and later of defended towns
Study and examination achievements, **Forms of examination**	Oral or written examinations: term papers, presentations, reports, project reports, excerpts, test
References	▪ Evans, J., O'Connor, T., 1999. Environmental Archaeology. Principles and Methods, Stroud ▪ Fehring, G.P., 2015. The Archaeology of Medieval Germany. An Introduction. London: Routledge Library Editions: Archaeology, 22 ▪ Renfrew, C., Bahn, P., 2000. Archaeology. Theories, Methods and Practice; London ▪ Silberman, N.A., 2012. The Oxford companion to archaeology. 2nd ed., New York: Oxford University Press

Name of the module Acronym	Atmospheric Physics PEP-AtPhy
Module coordinator	Prof. Dr. John P. Burrows burrows@iup.physik.uni-bremen.de
Teaching staff	Prof. Dr. John P. Burrows burrows@iup.physik.uni-bremen.de
Related courses, teaching format and hours per week (hpw)	PEP-AtPhys Atmospheric Physics (lecture, exercise: 4 hpw)
Mandatory/Compulsory	Compulsory
Related to the study programme	Teaching import from the M. Sc. Environmental Physics (PEP) of Faculty 1 (University of Bremen)
Duration of module/ **Winter or summer semester**	One semester / This module is scheduled for the first semester of study (winter term)
Workload/ **Calculation of** **Credit points (CP)**	This module is rated with 6 CP (180 hours): ▪ 56 h lectures and practicals ▪ 74 h self-revision of lectures and additional complementary material (exercises, textbooks, etc.) ▪ 50 h study time for the final exam
Requirements for participation	No
Frequency of module	Annual (winter term)
Language	English

Learning Outcome	▪ The students become familiar with the physical fundamentals of the atmosphere. ▪ The most important measuring techniques will be introduced.
Contents	▪ The course starts with a description of the Earth atmosphere and its evolution. ▪ Next the present atmosphere and key processes will be discussed which drive not only the "weather machine" but also determine the global atmospheric temperature structure and the distribution of trace gases such as stratospheric ozone. ▪ This includes a discussion on the role of water and its thermodynamic properties in the atmosphere, global circulation pattern, and ▪ Also covers issues like the microphysics of cloud formation. ▪ Closely related to the atmosphere is climate, after all the greenhouse effect is responsible for a mean temperature suitable for the biosphere to develop into its present state. ▪ A very basic introduction to climate and climate change will be given. ▪ This naturally leads to questions discussed in detail only in the courses *Environmental Physics (Ocean)* and *Environmental Physics (Terrestrial)*, such as the role of the ocean and ocean dynamics and the effects of land surfaces on global climate.
Study and examination achievements, **Forms of examination**	2 hours written or oral exam (67%; prerequisite to take part in the exam: passed with at least 75% from 10 exercises and acted at least once as rapporteur)
References	▪ Turco, R.P., 1997. Earth under Siege, from Air Pollution to Global Change, Oxford University Press. ▪ Wallace, John M. and Peter V. Hobbs, Atmospheric Science, Academic Press, 1977, ISBN 0-12-732950-1

Name of the module Acronym	Climate Change I: Fundamentals MMG-CC1
Module coordinator	Dr. André Paul +49-(0)421-218.65450; apaul@marum.de
Teaching staff	Dr. André Paul +49-(0)421-218.65450; apaul@marum.de Prof. Dr. Michael Schulz +49-(0)421-218.65500; mschulz@marum.de Prof. Dr. Rüdiger Stein +49-(0)471-4831.1576; rstein@awi-bremerhaven.de
Related courses, teaching format and hours per week (hpw)	MMG-CC1-1 Earth System Modelling (lecture, exercise: 3 hpw) MMG-CC1-2 The Role of High Latitudes Oceans in Climate Change (lecture, exercise: 3 hpw)
Compulsory / Elective	Elective
Related to the study programme	Teaching import from the M. Sc. Marine Geosciences (MMG) of Faculty 5 (University of Bremen)
Duration of module/ **Winter or summer semester**	One semester / This module is scheduled for the first semester (winter term)
Workload/ **Calculation of** **Credit points (CP)**	This module is rated with 6 CP (180 hours): ▪ 84 h hours for presence time ▪ 48 h working hours for preparation ▪ 48 h exam preparation hours
Requirements for participation	▪ Successful completion of the module Numerical Methods in Geosciences (MMG-PD1NM – a blocked course of 70 hours and 3 extra CP prior to CC1) is required. a flexible organizational framework to acquire competences in advanced methods of digital data processing and programming in theory and practice. ▪ For this module at the Department of Geosciences we have restricted access for up to 8 students
Frequency of module	Annual (winter term)
Language	English

Learning Outcome	Students ▪ obtain a basic understanding of the physics of the climate system; ▪ get an overview of global climate development at tectonic to centennial time scales with an emphasis on the polar regions; ▪ become able to assess the opportunities and limitations of numerical climate models and (paleo-)climate data; ▪ acquire essential skills in scientific programming and data analysis.
Contents	The blocked course (MMG-PD1NM) prior to CC1 follows a flexible organizational framework to acquire competences in advanced methods of digital data processing and programming in theory and practice. CC1 is the first of two modules on climate change and gives an overview of the basic components of the climate system, introduces nonlinear processes and feedbacks and proceeds from conceptual to comprehensive numerical models of the atmosphere, ocean, ice sheets and the Earth system. This is complemented by the paleoclimatic history of the Arctic and Antarctic polar regions during the Cenozoic and Pleistocene, which includes the tectonic development and its impact on the ocean circulation and high-latitude biota, as well as the development of polar ice sheets and their effects on sea level and global thermal differentiation. Computer and sediment lab exercises introduce scientific programming and data analysis on the one hand and high latitude sediments on the other hand.
Study and examination achievements, **Forms of examination**	Module exam (100 % oral exam)
References	Hartmann, Dennis L.: Global Physical Climatology. Elsevier, 2nd edition, 498 pp., 2016. Open University: Ocean Circulation. Butterworth-Heinemann, 2nd revised edition, 286 pp., 2004. Ruddiman, W.F.: Earth's climate: past and future. W.H. Freeman, 3rd revised edition, 464 p., 2013.

Module descriptions

Advanced study phase (second semester – summer term)

Name of the module **Acronym**	**Climatology II** **PG-CL2**
Module coordinator	Prof. Dr. Benjamin Marzeion +49-(0)421-218.67170; ben.marzeion@uni-bremen.de
Teaching staff	Prof. Dr. Benjamin Marzeion +49-(0)421-218.67170; ben.marzeion@uni-bremen.de Melissa Mengert +49-(0)421-218.67177; mmengert@uni-bremen.de
Related courses, teaching format and hours per week (hpw)	PG-CL2-1 Sea-level Change (lecture: 2 hpw) PG-CL2-2 Methods in Climatology (seminar/exercise; 2 hpw)
Compulsory / Elective	Elective
Related to the study programme	M. Sc. Physical Geography: Environmental History
Duration of module/ **Winter or summer semester**	One semester / This module is scheduled for the summer semester
Workload/ **Calculation of** **Credit points (CP)**	This module is rated with 6 CP (180 hours): ▪ 56 h lectures and practicals ▪ 94 h self-revision of lectures and additional complementary material, working on project/exercises and preparation of presentation ▪ 30 h study time for the final exam
Requirements for participation	Contents of module Climatology I
Frequency of module	Annual (summer term)

Language	English
Learning Outcome	▪ The students understand processes and mechanisms responsible for global mean and regional sea-level change on multimillennial to hourly time scales, ▪ they understand the basic processes that dynamically shape the coastal landscape, and ▪ they know about methods of reconstructing and projecting global and regional sea-level changes. ▪ they know principle methods of climatology; they can assess the power and limitations of different methods, and are able to identify approaches suitable for addressing particular climatological problem sets.
Contents	Sea-level Change: ▪ steric and dynamic sea-level change ▪ exchange of mass with glaciers, ice sheets, and terrestrial water reservoirs; associated gravitational, rotational, tectonic effects ▪ tides and storm surges ▪ erosion, transportation, and sedimentation in coastal environments ▪ methods of sea-level reconstruction and projection Methods in Climatology: The first 9 weeks of the semester, students will work on small scientific projects, continuously advised by the teaching staff. The topics of these projects will be aligned with current scientific questions and can be of experimental/practical nature (e.g., analysis of data from a weather station), of theoretical nature (e.g., analysis of a simple, conceptual model), or based on a review of recent literature. During the remaining five weeks of the semester, the projects will be presented and discussed among all students.
Study and examination achievements, Forms of examination	50 % written exam, 50 % written paper on, and presentation of, the project work.
References	References will be announced at the beginning of the courses.

Name of the module Acronym	Lacustrine Environmental Archives II PG-EA2
Module coordinator	Dr. Christian Ohlendorf +49-(0)421-218.67153; ohlen@uni-bremen.de
Teaching staff	Dr. Catalina Gebhardt +49-(0)471-4831.2040; catalina.gebhardt@awi.de Dr. Christian Ohlendorf +49-(0)421-218.67153; ohlen@uni-bremen.de
Related courses, teaching format and hours per week (hpw)	PG-EA2-1 Field Course in Limnogeology (exercise: 1 week, blocked) PG-EA2-2 Laboratory Course in Limnogeology (exercise: 1 week, blocked)
Compulsory / Elective	Elective
Related to the study programme	M. Sc. Physical Geography: Environmental History
Duration of module/ Winter or summer semester	One semester / This module is scheduled for the second semester (summer term)
Workload/ Calculation of Credit points (CP)	This module is rated with 6 CP (180 hours): ▪ 90 h participation ▪ 45 h additional complementary material (exercises, data analyses, etc.) ▪ 45 h preparation of oral/poster presentation
Requirements for participation	Contents of module Lacustrine Environmental Archives I
Frequency of module	Annual (summer term)
Language	English

Learning Outcome	Students will obtain ▪ basic practical skills in water column and sediment sampling ▪ basic practical skills in geoacoustic methods ▪ knowledge about sediment core treatment, lithological description and subsampling in the laboratory ▪ knowledge on standard physical and geochemical measurements of sediments, their processing and interpretation
Contents	▪ Field course focussing on water column analyses, sediment coring techniques and geoacoustic measurements ▪ Laboratory course focussing on core splitting and description, non-destructive core logging and scanning techniques (physical properties, core images, XRF scanning), destructive techniques (grain-size analysis, CNS analysis, water content, loss on ignition)
Study and examination achievements, **Forms of examination**	Active participation, oral presentation of own results during a self-organised student conference; term paper
References	▪ Cohen, A.S., 2003. Paleolimnology: The History and Evolution of Lake Systems. Oxford University Press, USA, 485 pp ▪ Developments in Paleoenvironmental Research. Series Editor: Smol, J.P. (several specialised volumes) ▪ ▪ Wetzel R.G. 2001. Limnology: lake and river ecosystems. 3rd ed., Acad. Press, San Diego, Calif, [u.a.] 1006 pp. ▪ Tucker, M.E., 1988.Techniques in Sedimentology, Blackwell Scientific Publications, 294 pp.

Name of the module Acronym	Vegetation History and Archaeobotany II PG-VA2
Module coordinator	Prof. Dr. Felix Bittmann +49-(0)4421-915.146; bittmann@uni-bremen.de
Teaching staff	Prof. Dr. Felix Bittmann +49-(0)4421-915.146; bittmann@uni-bremen.de Dr. Steffen Wolters +49 (0)4421-915.147; wolters@nihk.de
Related courses, teaching format and hours per week (hpw)	PG-VA2-1 Vegetation history of Central Europe: Introduction to pollen analysis and related palaeoecological methods (lecture: 1 hpw) PG-VA2-2 Pollen analytical practical (exercise; 1+5 days, blocked)
Compulsory / Elective	Elective
Related to the study programme	M. Sc. Physical Geography: Environmental History
Duration of module/ Winter or summer semester	One semester / This module is scheduled for the second semester
Workload/ Calculation of Credit points (CP)	This module is rated with 6 CP (180 hours): ▪ 60 h lectures and practical ▪ 70 h self-revision of lectures and additional complementary material (exercises, data processing, textbooks, etc.) ▪ 50 h study time for the final exam (oral presentation, manuscript, protocol)
Requirements for participation	No
Frequency of module	Annual (summer term)
Language	English

Learning Outcome	The students will obtain knowledge about ▪ Late- and post-glacial vegetation development in Central Europe based on pollen analyses ▪ Basic knowledge about additional (related) palaeoecological methods (e.g., Chironomidae, Cladocera, Diatomeae, macrofossils, non-pollen palynomorphs) ▪ Basic knowledge in plant systematics and pollen morphology ▪ Anthropogenic indicators ▪ Dating methods
Contents	Lecture: ▪ Introduction to vegetation and vegetation history of central Europe ▪ Introduction to palaeoecological methods used for reconstructions of former environments Exercise: ▪ Microscopic pollen analytical studies (pollen morphology, identification, counting, data processing, graphical display) ▪ Fieldwork (coring of peat profiles)
Study and examination achievements, Forms of examination	Protocol including an extended description of a certain aspect/problem of pollen analysis (oral presentation of the latter)
References	▪ Smol J.P. (Series Editor) Developments in Paleoenvironmental Research (several specialised volumes) ▪ Faegri K., Iversen J., Kaland P.E., Krzywinski K., 1992. Text book of pollen analysis, 4th edition, Wiley ▪ Beug H.-J., 2004. Leitfaden der Pollenbestimmung für Mitteleuropa und angrenzende Gebiete. F. Pfeil, München ▪ Moore P.D., Webb J.A., Collinson M.E., 1994. Pollen Analysis. Wiley-Blackwell ▪ Berglund B.E. (ed.), 1986 (reprinted 2003). Handbook of Holocene Palaeoecology and Palaeohydrology, Blackburn ▪ Elias S.A. (ed.), 2007. Encyclopaedia of Quaternary Science. Elsevier, Amsterdam ▪ Punt W. et al., 1976-2003. The Northwest European Pollen Flora (NEPF) Vol. I (1976), Vol. II (1980), Vol. III (1981), Vol. IV (1984) Vol. V (1988), Vol. VI (1991), Vol. VII (1996), Vol. VIII (2003), Vol. IX (2009). Elsevier, Amsterdam ▪ Lang G., 1994. Quartäre Vegetationsgeschichte Europas. Gustav Fischer, Jena ▪ Firbas F., 1949/52. Spät- und nacheiszeitliche Waldgeschichte Mitteleuropas nördlich der Alpen. Bd. 1: Allgemeine Waldgeschichte, Bd. 2: Waldgeschichte der einzelnen Landschaften. Gustav Fischer, Jena

Name of the module Acronym	Archaeology II PG-AR2
Module coordinator	Prof. Dr. Bernd Zolitschka +49-(0)421-218.67150; zoli@uni-bremen.de
Teaching staff	Dr. Moritz Mennenga +49-(0)4421-915.124; moritz.mennenga@nihk.de Dr. Annette Siegmüller +49-(0)4421-915.114; siegmueller@nihk.de
Related courses, teaching format and hours per week (hpw)	PG-AR2-1 Introduction into the practical methods of settlement and maritime archaeology (exercise: 1 hpw, blocked) PG-AR2-2 Introduction to field archaeology and excavation techniques (field course, exercise: 3 weeks, blocked)
Compulsory / Elective	Elective
Related to the study programme	M. Sc. Physical Geography: Environmental History
Duration of module/ Winter or summer semester	One semester / This module is scheduled for the second semester of study (summer term)
Workload/ Calculation of Credit points (CP)	This module is rated with 6 CP (180 hours): ▪ 134 h participation in exercise and field course ▪ 26 h self-revision of exercise and additional complementary material ▪ 20 h preparation of the protocol for the field course
Requirements for participation	Module Archaeology I
Frequency of module	Annual (summer term)
Language	English

Learning Outcome	Students will obtain ▪ basic skills in methods of settlement and maritime archaeology ▪ basic skills in excavation techniques ▪ basic knowledge about the material culture of the focused area and period of investigation ▪ knowledge about salvage and documentation of archaeological finds, features and structures ▪ basic skills in sampling strategies ▪ practical experience in scientific technical drawing, photography and photogrammetry as well as measurement techniques using different equipment ▪ knowledge on processing and interpretation of the gained information
Contents	▪ The exercise focusses on the methodology of Settlement and Maritime Archaeology and its practical implementation on sites in different environments, of different character and different chronological setting. ▪ The field course in archaeological practice focusses on survey, excavation, documentation and salvaging strategies and techniques. In addition, the course introduces into gathering and evaluation of archaeological data as well as on find registration and find classification (on-site and off-site) and their scientific interpretation against the background of their particular historical setting.
Study and examination achievements, **Forms of examination**	▪ Protocol (ca. 5 pages, to be written during the field course)
References	▪ Aston, M., 1985. Interpreting the landscape. Landscape Archaeology in local studies. London. ▪ Evans, J., O'Connor, T., 2001. Environmental Archaeology: Principles and Methods. Stroud. ▪ Flemming, N.C., Çağatay, N., Chiocci, F.L., Galanidou, N., Jöns, H., Lericolais, G., Missiaen, T., Moore, F., Rosentau, A., Sakellariou, D., Skar, B., Stevenson, A., Weerts, H., 2014. Land beneath the waves: research strategies in submerged landscapes and sea level change – A joint geoscience-humanities research strategy for European Continental Shelf Prehistoric Research. Chu, N.C. & McDonough, N. (eds), Position paper 21 of the European Marine Board, Ostend. ▪ Renfrew, C., Bahn, P., 2000. Archaeology. Theories, Methods and Practice. London.

Name of the module Acronym	Remote Sensing PEP-RemS
Module coordinator	Prof. Dr. Astrid Bracher bracher@iup.physik.uni-bremen.de
Teaching staff	Prof. Dr. Astrid Bracher bracher@iup.physik.uni-bremen.de Dr. Mathias Palm mathias@iup.physik.uni-bremen.de
Related courses, teaching format and hours per week (hpw)	01-01-03-RemS Remote Sensing: 2 hpw (lecture: 1.5 hpw, exercise: 0.5 hpw)
Compulsory / Elective	Elective
Related to the study programme	Teaching import from the M. Sc. Environmental Physics (PEP) of Faculty 1 (University of Bremen)
Duration of module/ **Winter or summer semester**	One semester / This module is scheduled for the second semester of study (summer term)
Workload/ **Calculation of** **Credit points (CP)**	This module is rated with 3 CP (90 hours): ▪ 28 h presence for lectures and exercises ▪ 32 h preparation and re-analysing examples ▪ 30 h preparation for exam
Requirements for participation	No. This course needs to be combined with “Isotopes in Environmental Physics” to end up with the necessary 6 CP for a compulsory elective module.
Frequency of module	Annual (summer term)
Language	English

Learning Outcome	Basics of radiative transfer, spectroscopy, retrieval techniques. Overview of remote sensing from satellite, ground and airborne platforms in MW, IR and UV-VIS spectral range. Techniques in atmospheric remote sensing, sea ice remote sensing, ocean colour remote sensing.
Contents	During the last decades remote sensing has developed to one of the most important tools to collect the data on our environment necessary to get a better understanding of the state of our environment and its change. This rapid progress was possible due to the technological improvements in sensor performance, and the availability of Earth orbiting platforms (satellites) offering global coverage in short time intervals at reasonable cost. With very few exceptions remote sensors make use of the electromagnetic spectrum over the wavelength range extending from 30 cm (microwaves) to 0.3 µm (ultraviolet). The course will introduce the theoretical background like interaction of electromagnetic radiation with matter (spectroscopy), radiative transfer and data processing. Also, the different measuring techniques will be discussed in quite some detail, this includes sensors measuring thermal emission, instruments detecting backscattered light, and active techniques based on the RADAR principle. The course content will be illustrated by a large number of examples available and in use in the different research groups in the institute of Environmental Physics, covering the atmosphere, ice and ocean.
Study and examination achievements, **Forms of examination**	Combination exam: Examination performance: Written exam (or as announced by the respective lecturer) Course performance: Portfolio (series of exercise sheets or as announced by the respective lecturer)
References	▪ Elachi, Wiley, C., 1987. Introduction to the Physics and Techniques of Remote Sensing, Wiley. ▪ Stephens, G.L., 1994. Remote Sensing of the Lower Atmosphere, Oxford University Press. ▪ Seelye, M., 2004. An Introduction to Ocean Remote Sensing, Cambridge University Press, ISBN 13: 9780521802802 More literature will be announced in the different courses.

Name of the module Acronym	Isotopes in Environmental Physics PEP-IEPhy
Module coordinator	Dr. Thorsten Warneke warneke@iup.physik.uni-bremen.de
Teaching staff	Dr. Thorsten Warneke warneke@iup.physik.uni-bremen.de
Related courses, teaching format and hours per week (hpw)	01-01-03-IEPhy Isotopes in Environmental Physics: 2 hpw (lecture: 1 hpw, exercises: 1 hpw)
Compulsory / Elective	Elective
Related to the study programme	Teaching import from the M. Sc. Environmental Physics (PEP) of the University of Bremen
Duration of module/ **Winter or summer semester**	One semester / This module is scheduled for the second semester of study (summer term)
Workload/ **Calculation of** **Credit points (CP)**	This module is rated with 3 CP (90 hours): ▪ 28 h presence in lectures and exercises ▪ 28 h preparation, learning and examples ▪ 34 h preparation for exam
Requirements for participation	No. This course needs to be combined with “Remote Sensing” to end up with the necessary 6 CP for a compulsory elective module.
Frequency of module	Annual (summer term)
Language	English
Learning Outcome	Understanding isotopic fractionation, radioactive decay and the use of isotopes in paleoclimatology and for source characterization

Contents	Stable and radioactive isotopes have a wide range of applications in environmental studies. The isotopic composition of stable elements is widely used to identify their sources and the knowledge about the climate in the Earth's history heavily relies on isotopic measurements. The main application of radioactive isotopes in environmental studies is dating. The objective of the course is to introduce the principles and applications of stable and radioactive isotope analysis to study environmental processes. The lectures about stable isotopes will cover the terminology/notation, the theory of equilibrium and kinetic fractionation as well as the measurement techniques. For the radioactive isotopes the different forms of radioactive decay and the emitted radiation will be presented. The main focus of the lecture will be on applications of isotopes in environmental studies. Selected topics will be presented by the students. These will be partly presented by the students in the “example classes”.
Study and examination achievements, **Forms of examination**	Combination exam: Examination performance: Oral exam (or as announced by the respective lecturer) Course performance: 1 presentation (or as announced by the respective lecturer)
References	More literature will be announced in the course.

Name of the module Acronym	Climate Change II: Models and Data MMG-CC2
Module coordinator	Dr. André Paul +49-(0)421-218.65450; apaul@marum.de
Teaching staff	Dr. Stefan Mulitza +49-(0)421-218.65536; smulitza@uni-bremen.de Dr. André Paul +49-(0)421-218.65450; apaul@marum.de Prof. Dr. Michael Schulz +49-(0)421-218.65500; mschulz@marum.de
Related courses, teaching format and hours per week (hpw)	MMG-CC2-1 Abrupt Climate Changes (lecture, exercise, seminar: 2,5 hpw) MMG-CC2-2 Modelling Past and Future Climate Changes (lecture, exercise: 2,5 hpw)
Compulsory / Elective	Elective
Related to the study programme	Teaching import from the M. Sc. Marine Geosciences (MMG) of Faculty 5 (University of Bremen)
Duration of module/ **Winter or summer semester**	One semester / This module is scheduled for the second semester of study (summer term)
Workload/ **Calculation of** **Credit points (CP)**	This module is rated with 6 CP (180 hours): ▪ 70 h presence time ▪ 56 h working hours for preparation/follow-up work of the course(s) and/or self-study ▪ 54 h exam preparation
Requirements for participation	▪ Contents of module Climate Change I: Fundamentals. ▪ For this module at the Department of Geosciences we have restricted access for up to 8 students.
Frequency of module	Annual (summer term)
Language	English
Learning Outcome	The students

	▪ become familiar with the reconstructed climate variations for selected time intervals of the Cenozoic ▪ gain an understanding of the dynamics of abrupt climate changes ▪ analyse proxy data and compare them to the results of numerical climate models ▪ become able to assess the respective roles of natural and anthropogenic climate variations in past and future climate changes
Contents	This second module ▪ introduces to the reconstruction and modelling of abrupt climate changes, ▪ provides an overview of paleo and historical climate changes (from the role of oceanic gateways in the Cenozoic through Pleistocene climate cycles to natural climate variability during the Holocene) and ▪ presents an outlook on future climate changes in response to projected anthropogenic climate forcing. ▪ Available evidence for past climate changes (from ice and marine sediment cores) as well as current climate change (from historical and instrumental data) is discussed. ▪ Computer lab exercises with conceptual climate models and results of comprehensive climate models are used throughout to investigate the processes that cause those climate changes.
Study and examination achievements, **Forms of examination**	Module exam (100 % oral exam)
References	Alley et al.: Abrupt Climate Change: Inevitable Surprises. National Academy Press, Washington, DC, 238 pp., 2002. Ruddiman, W.F.: Earth's climate: past and future. W.H. Freeman, 3rd revised edition, 464 p., 2013.

Name of the module Acronym	Historical Political Ecology PG-HPE
Module coordinator	Prof. Dr. Michael Flitner +49-(0)421-218.61800; flitner@uni-bremen.de
Teaching staff	Prof. Dr. Michael Flitner +49-(0)421-218.61800; flitner@uni-bremen.de
Related courses, teaching format and hours per week (hpw)	PG-HPE Historical Political Ecology (seminar: 2 hpw)
Compulsory / Elective	Mandatory
Related to the study programme	M. Sc. Physical Geography: Environmental History
Duration of module/ **Winter or summer semester**	One semester / This module is scheduled for the second semester
Workload/ **Calculation of** **Credit points (CP)**	This module is rated with 6 CP (180 hours): ▪ 28 h seminar participation ▪ 70 h self-revision of seminar and additional complementary reading ▪ 82 h preparation of oral presentation and essay
Requirements for participation	None
Frequency of module	Annual (summer term)
Language	English

Learning Outcome	The students will ▪ gain knowledge about key approaches and topics in political ecology and ▪ basic knowledge about major theoretical traditions in human, cultural and political ecology; ▪ make exemplary practical experience in historical political ecology research and ▪ develop critical awareness of the theoretical and methodological challenges in carrying out historical studies in political ecology or closely related fields.
Contents	▪ Text-centred course focussing on classical publications as well as on recent developments in historical political ecology ▪ Theoretical and methodological issues in historical studies of environmental problems in the social sciences ▪ Exemplary library or archival work regarding regional issues of historical political ecology
Study and examination achievements, **Forms of examination**	Oral presentation of self-revised materials during seminar, written essay
References	▪ Biersack, A., (ed.), 2006. Reimagining political ecology. Duke University Press. ▪ Offen, K.H., 2004. Historical political ecology: an introduction. Historical Geography 32, 19-42. ▪ Peet, R., Robbins, P., Watts, M.J., (eds.), 2011. Global Political Ecology. Routledge. ▪ Robbins, P., 2012. Political ecology: a critical introduction. 2nd ed. Wiley-Blackwell.

Module descriptions

Individualisation phase (third semester – winter term)

Name of the module Acronym	Internship PG-INS
Module coordinator	Michael Thiele +49-(0)421-218.67001; thiele@uni-bremen.de
Teaching staff	Organisation of the colloquium by the module coordinator Evaluation of reports: Teaching staff of the M. Sc. programme
Related courses, teaching format and hours per week (hpw)	Colloquium
Compulsory / Elective	Elective
Related to the study programme	M. Sc. Physical Geography: Environmental History
Duration of module/ **Winter or summer semester**	8 weeks during the summer break before the third semester or during the third semester. In the latter case it should be combined with the module "Research Process II". The internship can also be carried out earlier, e.g. before starting the M. Sc. programme. It is recommended to complete the internship before the end of the third semester.
Workload/ **Calculation of** **Credit points (CP)**	12 CP (360 hours) ▪ equivalent to 8 weeks full time work (320 hours) ▪ preparation of written report and presentation in colloquium (40 hours)
Requirements for participation	None
Frequency of module	Annual

Language	English
Learning Outcome	Students should be able to: ▪ Broaden their understanding of the possible range of employment opportunities, ▪ Help to choose their best possible career path, ▪ Reflect on the tasks and personal development experienced during the internship, ▪ Summarize their experiences in a reflective final report, ▪ Critically assess their personal and professional development, ▪ Articulate a deepened knowledge of transferable skills and their applicability in both academic and workplace settings.
Contents	Internships provide students with a structured introduction to the contexts of professional practice. Emphasis is placed on the identification and negotiation of learning objectives, activities and outcomes in relation to a professional context. Students are required to find a suitable position, complete eight weeks of work and prepare and present their experience to their supervisors and peers.
Study and examination achievements, **Forms of examination**	Module exam (one mark): ▪ Written final report, ca. 10 pages (50%) ▪ Oral and/or poster presentation, ca. 20 minutes (50%)
References	For detailed rules refer to the official “Internship Regulations” (Praktikumsordnung) to the M. Sc. in “Physical Geography: Environmental History”

Name of the module Acronym	Environmental Archives Methods MMG-EA1
Module coordinator	Dr. Torsten Bickert +49-(0)421-218.65535; tbickert@marum.de
Teaching staff	Dr. Torsten Bickert +49-(0)421-218.65535; tbickert@marum.de Prof. Dr. Tilo von Dobeneck +49-(0)421-218.65310; dobeneck@uni-bremen.de Dr. Stefan Mulitza +49-(0)421-218.65536; smulitza@uni-bremen.de Dr. Enno Schefuß +49-(0)421-218.65526; schefuss@uni-bremen.de Dr. Matthias Zabel +49-(0)421-218.65103; mzabel@uni-bremen.de
Related courses, teaching format and hours per week (hpw)	MMG-EA1-1 Marine Ecosystems as Environmental Indicators (lecture, exercise: 1 hpw) MMG-EA1-2 Environmental Magnetism (lecture, exercise, seminar: 1 hpw) MMG-EA1-3 Terrigenous Signals (lecture, seminar: 1 hpw) MMG-EA1-4 Stable Isotopes and Trace Elements in Palaeoenvironmental Research (lecture, exercise: 1 hpw)
Compulsory / Elective	Elective
Related to the study programme	Teaching import from the M. Sc. Marine Geosciences (MMG) of Faculty 5 (University of Bremen)
Duration of module/ **Winter or summer semester**	One semester / This module is scheduled for the third semester of study (winter term)
Workload/ **Calculation of** **Credit points (CP)**	This module is rated with 6 CP (180 hours): ▪ 56 h presence time ▪ 84 h working hours for preparation ▪ 40 h time for exam preparation

Requirements for participation	▪ Undergraduate expertise in chemistry, geochemistry and marine geology is required. Additional basic understanding in biology and expertise in scientific calculation is advantageous. ▪ For this module at the Department of Geosciences we have restricted access for up to 8 students.
Frequency of module	Annual (winter term)
Language	English
Learning Outcome	The students will ▪ become familiar with proxy development and application ▪ gain an understanding of the most important processes in palaeoenvironmental change ▪ be able to apply the methods to case studies of actual research ▪ work objective-oriented and problem-based individually as well as in a team
Contents	▪ This first of two modules on environmental archives aims at introducing and applying the most important methods to describe the marine environment in the past and to understand the processes of environmental change. ▪ Proxy implementation follows the stages of proxy development, validation and application. Proxy research is strongly interdisciplinary. ▪ This module, therefore, integrates geochemical, geological, geophysical and paleontological methodology. ▪ Stratigraphic methods are important in environmental studies and therefore implemented in several exercises.
Study and examination achievements, Forms of examination	Module exam: written exam
References	Mostly research papers, announced in the different courses

Name of the module Acronym	Bodenkunde (Soil Science) PG-BOK
Module coordinator	Prof. Dr. Bernd Zolitschka +49-(0)421-218.67150; zoli@uni-bremen.de
Teaching staff	Dr. Thomas Pollmann +49-(0)441-798.3320; thomas.pollmann@uni-oldenburg.de Dr. Olga Kalinina +49-(0)441-798.3335; olga.kalinina@uni-oldenburg.de
Related courses, teaching format and hours per week (hpw)	PG-BOK-1 Bodenkunde (Soil Science) (lecture: 1 hpw – in German) PG-BOK-2 Geo-ökologische Prozesse (Geoecological Processes) (lecture: 2 hpw – in German) PG-BOK-3 System Erde – Teil: Einführung Bodenkunde (Earth System – Part: Introduction to Soil Science) (lecture: 1 hpw – in German)
Compulsory / Elective	Elective
Related to the study programme	Teaching import from the B. Sc. Umweltwissenschaften and from the M. Sc. Landschaftsökologie of the University of Oldenburg
Duration of module/ **Winter or summer semester**	One semester / This module is scheduled for the third semester
Workload/ **Calculation of** **Credit points (CP)**	This module is rated with 6 CP (180 hours): ▪ 56 h seminar ▪ 90 h self-revision of seminar and additional complementary reading ▪ 34 h oral presentation of selected topics for BOK-3
Requirements for participation	No
Frequency of module	Annual (winter term)
Language	All lectures in German

Learning Outcome	The students will gain knowledge about ▪ fundamentals of soil sciences ▪ intensified knowledge about pedo-diversity and chemical/physical processes in soils ▪ formation, classification and distribution of major soils of the world
Contents	(BOK-1) Bodenkunde und (BOK-3) System Erde – Teil: Einführung Bodenkunde (in German) ▪ Genese von Böden Mitteleuropas und Bodenklassifikation ▪ Transformations- und Translokationsprozesse ▪ Physikalisch-chemische Prozesse in Böden (BOK-2) Geo-ökologische Prozesse (in German): ▪ Böden in Stoffkreisläufen ▪ Physikalisch-chemische Prozesse in Böden ▪ Nährstoffe und Schadstoffe ▪ Bodenschutz, Bodenbewertung, Bodensanierung ▪ Gefährdung und Schutz von Böden in unterschiedlichen Landschaften
Study and examination achievements, **Forms of examination**	Oral examination (30 minutes)
References	▪ Scheffer, F., Schachtschabel, P., 2009. Lehrbuch der Boden-kunde. Spektrum Akademischer Verlag, 16. Aufl., Stuttgart ▪ Stahr, K., Kandeler, E., Herrmann, L., Streck, T., 2008. Boden-kunde und Standortlehre – Grundwissen Bachelor. Ulmer, Stuttgart. ▪ Blum, W.E.H., 2012. Bodenkunde in Stichworten. Hirt, 8. Aufl., Stuttgart ▪ Blume, H.-P., Brümmer, G.W., Horn, R., Kandeler, E., Kögel-Knabner, E., Kretschmar, R., Stahr, K., Wilke, B.-M., 2015. Soil Science. Spektrum Akademischer Verlag, Heidelberg ▪ Schroeder, D., 1984. Soils, facts and concepts. Hirt, Stuttgart.

Name of the module Acronym	Global Carbon Cycle PEP-GCC
Module coordinator	Dr. Christoph Völker; christoph.voelker@awi.de
Teaching staff	Dr. Christoph Völker christoph.voelker@awi.de
Related courses, teaching format and hours per week (hpw)	01-01-03-GCC Global Carbon Cycle (lecture: 2 hpw)
Mandatory/ Compulsory	Elective
Related to the study programme	Teaching import from the M. Sc. Environmental Physics (PEP) of Faculty 1 (University of Bremen)
Duration of module/ **Winter or summer semester**	One semester / This module is scheduled for the third semester (winter term)
Workload/ **Calculation of** **Credit points (CP)**	This module is rated with 3 CP (90 hours): ▪ 28 h lectures ▪ 28 h preparation and learning ▪ 34 h preparation for exam
Requirements for participation	No
Frequency of module	Annual (winter term)
Language	English
Learning Outcome	▪ The students become familiar with knowledge of the different carbon reservoirs on Earth, and their role on different timescales, from current to geological. ▪ Understanding that the cycling of carbon between reservoirs is related to global climate by a number of feedbacks.
Contents	The ongoing rise in the concentration of carbon dioxide and other greenhouse gases in the atmosphere lead to warming of the Earth. In

	this course we will start with an overview about the current rise in greenhouse gases, future projections, and the attempts to limit it, and with future projections of climate change in the 21st century contained in the recent IPCC report. In the course of the lecture we will then try to understand how changes in atmospheric CO_2 lead to changes in temperature, today, in the future and during past climates. This influence is not a one-way-street, however, so we will also try to understand also, how climate has influenced that carbon cycle over earth's history. For this aim the cycling of carbon through the main important reservoirs (atmosphere, terrestrial biosphere, ocean, ocean sediments) will be investigated. **Topics covered:** - Introduction, Overview on C data sets, time scales - Radiative forcing- Emission scenarios and the future - Terrestrial biosphere I - Terrestrial biosphere II - Gas Exchange Ocean - Atmosphere - Ocean 1, Dissolved Inorganic Carbon - Ocean 2, Organic Carbon - Ocean 3, $CaCO_3$ cycle - Orbital Forcing - The Holocene, last 10,000 yr - The Pleistocene, last 2,000,000 yr - Weathering and the Phanerozoic, last 600,000,00 yr
Study and examination achievements, **Forms of examination**	Module exam: Examination by oral exam (or as announced by the respective lecturer)
References	▪ Pierrehumbert, R.: Principles of Planetary Climate ▪ Sarmiento, J.L. & Gruber, N.: Ocean Biogeochemical Dynamics ▪ Ruddiman, W.F.: Earth's Climate: Past and Future

Name of the module Acronym	Research Process II PG-RP2
Module coordinator	Prof. Dr. Benjamin Marzeion +49-(0)421-218.67170; ben.marzeion@uni-bremen.de
Teaching staff	Prof. Dr. Felix Bittmann +49-(0)4421-915.146; bittmann@uni-bremen.de Dr. Inga Labuhn +49-(0)421-218.67173; labuhn@uni-bremen.de Prof. Dr. Benjamin Marzeion +49-(0)421-218.67170; ben.marzeion@uni-bremen.de Dr. Christian Ohlendorf +49-(0)421-218.67153; ohlen@uni-bremen.de Prof. Dr. Bernd Zolitschka +49-(0)421-218.67150; zoli@uni-bremen.de
Related courses, teaching format and hours per week (hpw)	PG-RP2 Project (blocked seminars; 4 hpw; independent studies)
Compulsory / Elective	Compulsory
Related to the study programme	M. Sc. Physical Geography: Environmental History
Duration of module/ Winter or summer semester	One semester / This module is scheduled for the third semester
Workload/ Calculation of Credit points (CP)	This module is rated with 12 CP (360 hours): ▪ Conception and preparation (step 1: 40 hours until October 31st) ▪ Project work (step 2: 200 hours until January 15th) ▪ Documentation and written report (step 3: 80 hours until March 1st) ▪ Oral presentation of results (step 4: 40 hours during last week of March)
Requirements for participation	Project-specific knowledge and skills
Frequency of module	Annual (winter term)
Language	English

Learning Outcome	▪ The project trains practical skills of a professional and general research character and prepares for the master thesis. ▪ It enables the students to realize own conceptions, to acquire additional fields of competence and to establish contacts, which may improve the chances on the job market. ▪ It fosters personal initiatives and „learning by doing“, but also represents a supervised and output-oriented project documented by written reports as well as oral presentations. ▪ Students will have acquired knowledge to develop and defend a thesis proposal and to obtain a thorough understanding of methods and literature relevant to their thesis projects.
Contents	▪ The module introduces students to the processes involved in planning, developing and presenting research projects. Topics are selected in collaboration with prospective thesis advisors ▪ A large extent of independence and teamwork is expected for development and presentation of the project by every student. ▪ The project can be field or laboratory work or related to a technical development, a school or media project or a contribution to a national or international scientific investigation. ▪ Team projects with well-defined task sharing are favoured. ▪ Techniques of scientific inquiry and sound scientific conduct are communicated and discussed. <u>Conception and preparation (step 1):</u> ▪ An introduction to the module is scheduled for the Orientation Week in early October. Step 1 is carried out until the end of October. ▪ Students develop a concept for their project work. ▪ The scientific state-of-the-art and the conception of the chosen subject is based on current topics in the geosciences. ▪ Discussed and developed are: scientific rationale, research questions, hypotheses, methodological approach and work plan for the proposed study. ▪ Step 1 ends with a written exposé including scientific rationale and research questions or hypotheses which is presented to the advisor until October 31st. <u>Project work (step 2):</u> ▪ During the practical part of the project students apply their knowledge gained during the preceding two semesters and exercise their skills with a high degree of self-responsibility. ▪ Step 2 ends with an updated and revised exposé handed in to the project advisor until January 15th. <u>Documentation and written report (step 3):</u> ▪ Finally, step 1 and 2 are combined as a written report including a scientific discussion in context with the state-of-the-art and an outlook. ▪ The written report (due March 1st) should be written in the form of a scientific publication and submitted to the advisor. <u>Oral presentation of results (step 4):</u> ▪ In the last week of March, an oral presentation of results is given during a blocked seminar in the presence of all fellow students and the advisor.

Study and examination achievements, Forms of examination	Module exam (combined marks): ▪ Exposé (work required) ▪ Revised exposé (15 %) ▪ Written project report (50 %) ▪ Oral presentation (35 %)
References	Case-dependent - will be provided by the teaching staff

Module description

Final phase (fourth semester – summer term)

Name of the module Acronym	Master Thesis (and colloquium) PG-MT
Module coordinator	Prof. Dr. Bernd Zolitschka +49-(0)421-218.67150; zoli@uni-bremen.de
Compulsory / Elective	Compulsory
Related to the study programme	M. Sc. Physical Geography: Environmental History
Duration of module/ Winter or summer semester	One semester – in winter and summer semester
Workload/ Calculation of Credit points (CP)	This module is rated with 30 CP (900 hours): ▪ Conception of the master thesis (200 hours) ▪ Master thesis research and writing (660 hours) ▪ Oral presentation (colloquium) of the results of the master thesis including preparation (40 hours)
Requirements for participation	Evidence of at least 60 CP are required for the registration of the master thesis. Completion of the module Research Process II is highly recommended.
Frequency of module	Every (winter and summer) term
Language	English
Learning Outcome	Students are capable of ▪ developing a research concept with related research questions for the topic of their master thesis; ▪ carrying out scientific investigations; ▪ applying a set of appropriate methodologies; ▪ merging their thesis work with professional qualifications; ▪ writing a well-structured final thesis; ▪ orally presenting the main results of their thesis; ▪ discussing selected aspects of their thesis conclusively
Contents	▪ The topic of the master thesis has to be arranged with both examiners.

	▪ Once the content is settled, the thesis work is carried out independently by the student and under guidance of the examiners.
Study and examination achievements, Forms of examination	Master thesis and colloquium ▪ A combined grade is awarded. ▪ The grades of the written master thesis (24 CP) and the oral colloquium (6 CP) are weighted according to their CP. ▪ Both together form the final grade of the module.
References	Independent literature research