EBERHARD KARLS
UNIVERSITÄT
TÜBINGEN

Study Guide and Module Handbook

Applied & Environmental Geoscience
Master of Science

Winter Semester 2020/21

Faculty of Science
Department of Geosciences

Contents

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1. Qualification Goal

The international research-oriented M.Sc. program "Applied & Environmental Geoscience" (AEG) is directed towards an quantitative understanding and evaluation of environmental problems with an special emphasis on subsurface environments such as industrial, urban and agricultural pollution of drinking water supplies from groundwater resources, the non-sustainable use of natural resources, the impact of short and long term waste disposal, impact of climate and land-use change on soil and water quality, among others.

In order to reach this qualification goal the AEG program aims to convey the necessary subject-specific and general skills and competences by using a multidisciplinary teaching approach combining in-depth scientific knowledge along with acquisition of key generic skills e.g. self-management, organization and problem solving skills.

While the detailed subject specific competences acquired in AEG depend on the individual study focus of a student, three compulsory modules get students acquainted with relevant core competences in hydrogeology, environmental modeling and aquatic chemistry, essential for understanding the basic paradigms and concepts in environmental geosciences taught in Tübingen.

Independent from the individual focus of the student (Hydrogeology, Environmental Chemistry and Environmental Microbiology or Environmental Physics and Environmental Modeling) one main goal is that graduates acquire advanced competences for a comprehensive understanding of the physical, chemical, and biological mechanisms relevant in environmental geosciences. The focus is laid on a distinct quantitative, process-oriented approach to address the geo- and hydrosphere, along with the acquisition of essential practical skills (both in the lab and in the field) with respect to environmentally relevant problem sets.

This enables students

- to define and analyze environmental problem sets,
- to plan and undertake appropriate field and laboratory investigations (collecting, recording and analyzing relevant data sets),
- to present and interpret data
- and to develop ecologically and economically sound mitigation strategies.

In the compulsory modules "Scientific Practice 1 and Scientific Practice 2" and "Scientific Presentation" students gain additional practical interdisciplinary skills. They benefit from close interaction with staff and research groups as well as from an early start of the master thesis in the 3rd semester and are encouraged to apply their lecture-based knowledge in practice. The international mix of students in the program with their different academic and cultural background fosters intercultural competences and enables students to communicate and work in an international context.

Key employers for graduates of the AEG program are **environmental consultancies** working in:

- characterization of sites (hydrogeology, geophysics, chemical and micorbiological analysis),
- assessment of environmental risks,
- water ressources management and water exploration,
- design and operation of remediation technologies,
- modeling of flow and reactive transport in subsurface systems.

AEG graduates are also well trained for jobs in **environmental agencies** and **(re-)insurance companies** covering costs of environmental risks and remediation. Furthermore the AEG programs lays an excellent foundation for **doctoral studies** in programs of earth sciences, environmental sciences, and environmental engineering.

2. Module Overview

To complete the program students have to earn 120 credits points from a suite of six compulsory modules accounting for 36 credit points, nine elective modules (54 credit points) and a master thesis (30 credit points).

Compulsory Modules and Master Thesis

The three compulsory modules **Hydrogeology, Aquatic and Environmental Chemistry** and **Environmental Modeling 1**, introduce students to the necessary theoretical and quantitative aspects of three crucial core areas of environmental and applied geosciences. All three modules are taught in the first semester, allowing students to focus on their respective fields of specialization in semesters 2-4.

- **Hydrogeology** is the science of groundwater. The course has a strong emphasis on physical hydrogeology, covering flow and transport in groundwater systems. Emphasis is given on quantitative description of groundwater flow and solute transport, deriving governing equations and analytical solutions for simple configurations. Computer methods for the solution of groundwater problems are taught in the courses of environmental modeling.
- **Environmental Modeling 1** deals with the simulation of the terrestrial water cycle with particular emphasis on computer models for groundwater flow. The class, however, also includes modeling of hydrological processes at the land surface, river hydraulics, and general aspects of modeling spatial processes, such as interpolation methods. Hands-on exercises with computer programs used in practice are combined with introductions to the underlying principles.
- **Aquatic and Environmental Chemistry** covers chemical thermodynamics in aqueous systems, sorption and partitioning processes of organic and inorganic compounds in the hydrosphere and practical case studies. The objective is to gain quantitative evaluation and prediction capabilities for important hydrogeochemical parameters based on sound thermodynamic concepts and quantitative structure activity relationships. By this, fate and behaviour of chemicals in the environment can be predicted.

The three additional compulsory modules, namely **Scientific Practice 1+2** and **Scientific Presentation** (semesters 2-4), allow the students to gain practical interdisciplinary skills in the course of their studies. They acquire methodological, conceptual as well as practical skills for scientific research in close interaction with staff and research groups.

- **Scientific Practice 1** is a research-oriented internship within the work groups at University of Tübingen participating in the AEG program or an external internship in industry, environmental administration or research institutions. The key objective is to participate in research projects from the second semester of the study program on. **Scientific Practice 2** in the third semester, scientific practice is targeted at the formulation of a research agenda for M.Sc. thesis in the fourth semester.
- Integral part of the scientific-practice program is the presentation of the thesis results in the form of a seminar talk and the design of a thesis-related web page in the fourth semester ("**Scientific Presentation**").

The third and fourth semesters focus mainly on the elaboration of a **master thesis**, which can be started in the third semester.

Elective Modules

In addition to the comprehensive compulsory program, students according to their individual focus of studies, specialize in one of the three distinct fields of environmental and applied

geosciences namely: Hydrogeology (1), Environmental Chemistry and Environmental Microbiology (2), Environmental Physics and Environmental Modeling (3).

In order to study any of the above specializations, a defined combination of three elective core modules, which are of special relevance, must be incorporated in the respective program of studies.

Specialization in Hydrogeology requires

- Applied Hydrogeology
- Contaminant Hydrogeology
- Geotechnical Engineering

Specialization in Environmental Chemistry and Environmental Microbiology requires

- Environmental Microbiology and Geomicrobiology
- Hydrogeochemical Modeling
- Environmental Analytical Chemistry

Specialization in Environmental Physics and Environmental Modeling requires

- Environmental Modeling 2
- Case Studies in Environmental Geoscience
- Physics of the Atmospheric Boundary Layer

The remaining necessary thirty credits can be chosen from any of the available elective modules. Figure 1-3 show the degree program for all three specializations along with recommended elective modules and the semesters they are offered in (WiSe –Winter Semester / SoSe – Summer Semester).

Additional elective modules offered from other departments and/or universities can be accepted by the chairman of the examination committee after prior consultation.

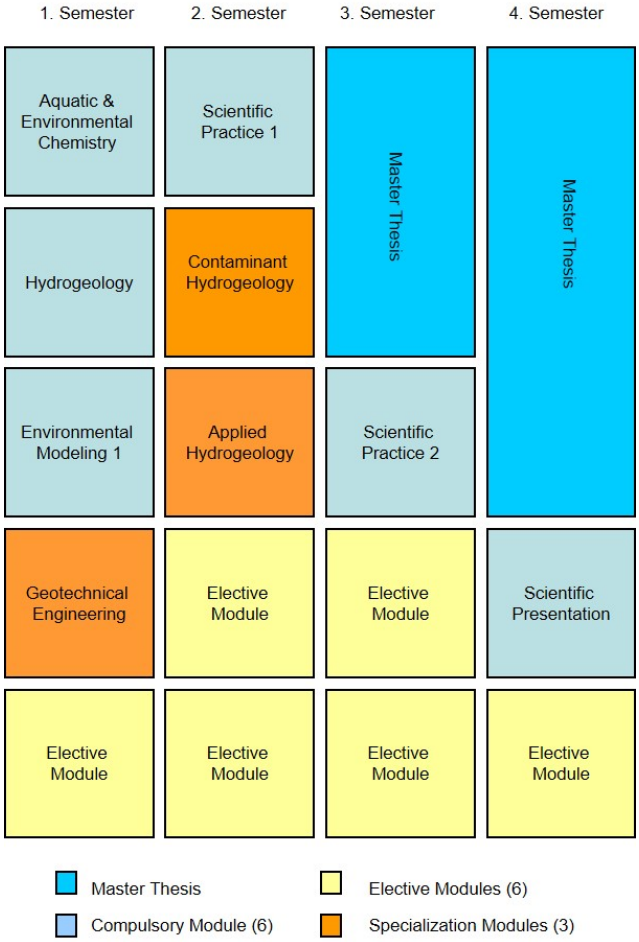
Course Language

AEG courses are taught in English and course notes in English will accompany the lecture series.

Degree

The degree will be Master of Science in Applied & Environmental Geosciences and qualifies to enter in doctoral programmes.

Curricular module overview (Specialization 1: Hydrogeology)



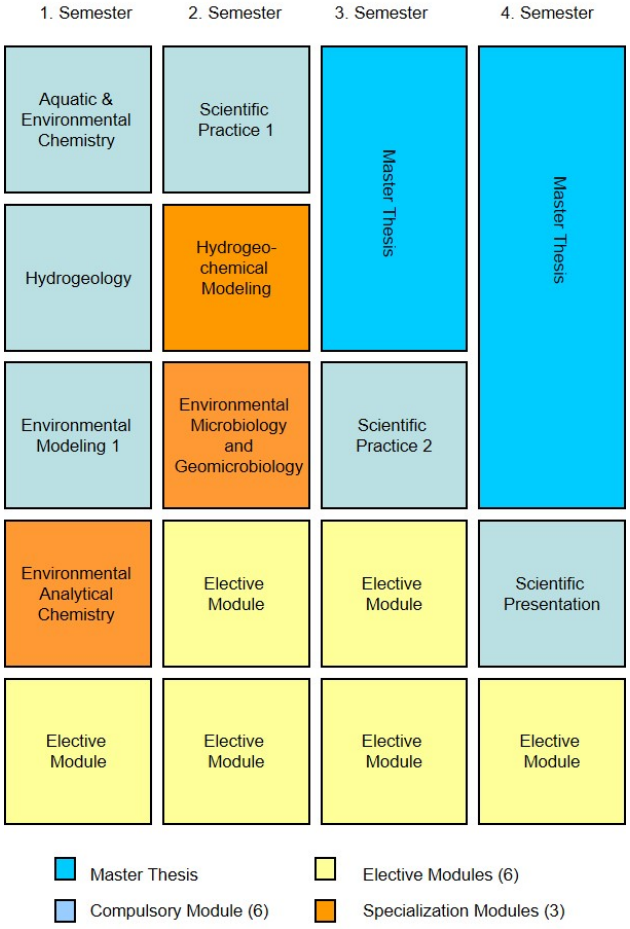
Elective Modules (6 Credits)

Case Studies in Environmental Geoscience (WiSe)
GIS and Remote Sensing (WiSe)
Environmental Modeling 2 (SoSe)
Physics of the Atmospheric Boundary Layer (SoSe)
Environmental Microbiology and Geomicrobiology (SoSe)
Geomicrobiology Lab (WiSe)
Environmental Analytical Chemistry (WiSe)
Environmental Isotope Chemistry (SoSe)
Lab Course Environmental Chemistry (WiSe)
Environmental Risk Assessment (WiSe)
Hydrogeochemical Modeling (SoSe)
Field Seminars in Applied Geosciences (WiSe/ SoSe)
Advanced Topics in Flow and Transport (SoSe)
Geophysics (SoSe)
Applied Data Analysis and Modeling for Geoscientists (WiSe 20/21)
Sustainable Environmental Biotechnology Systems 1 (SoSe)
Sustainable Environmental Biotechnology Systems 2 (WiSe)
Introduction to Earth Surface Processes (WiSe)
Applied Thermochronology and Quaternary Dating: Techniques, Interpretation and Applications (SoSe 21)
Climate Dynamics, Probability and Statistics (SoSe 21)

Elective Modules (3 Credits)

Earth Processes (WiSe or SoSe) / Water Treatment (WiSe) / Field Seminars in Applied Geosciences (WiSe/SoSe) /

Curricular module overview (Specialization 2: Environmental Chemistry and Environmental Microbiology)



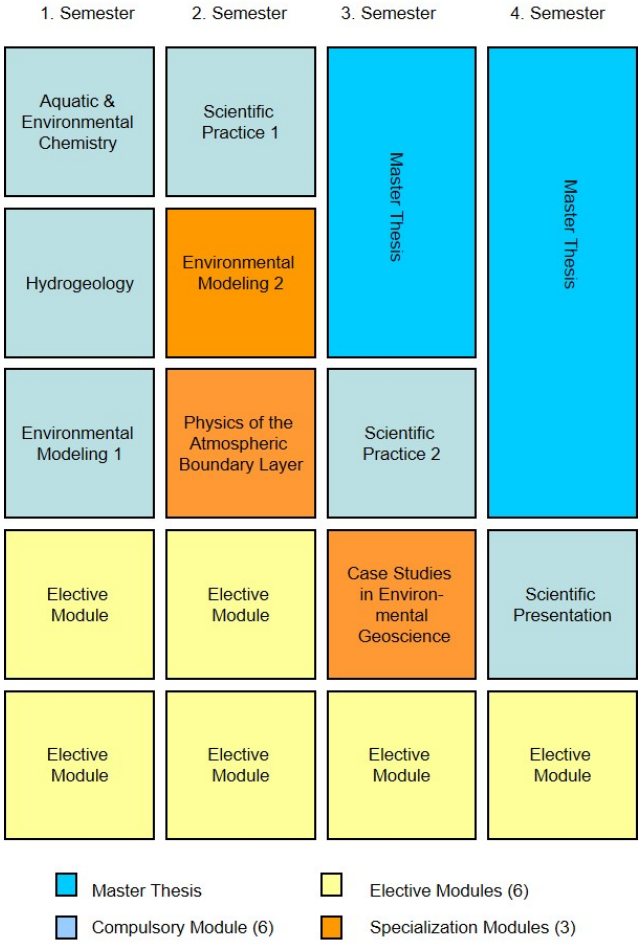
Elective Modules (6 Credits)

Environmental Isotope Chemistry (SoSe)
Geotechnical Engineering (WiSe)
Applied Hydrogeology (SoSe)
Contaminant Hydrogeology (SoSe)
Case Studies in Environmental Geoscience (WiSe)
GIS and Remote Sensing (WiSe)
Environmental Modeling 2 (SoSe)
Physics of the Atmospheric Boundary Layer (SoSe)
Laboratory Course Geomicrobiology (WiSe)
Lab Course Environmental Chemistry (WiSe)
Environmental Risk Assessment (WiSe)
Advanced Topics in Flow and Transport (SoSe)
Geophysics (SoSe)
Applied Data Analysis and Modeling for Geoscientists (WiSe 20/21)
Field Seminars in Applied Geosciences (WiSe/SoSe)
Sustainable Environmental Biotechnology Systems 1 (SoSe)
Sustainable Environmental Biotechnology Systems 2 (WiSe)
Introduction to Earth Surface Processes (WiSe)
Applied Thermochronology and Quaternary Dating: Techniques, Interpretation and Applications (SoSe 21)
Climate Dynamics, Probability and Statistics (SoSe 21)

Elective Modules (3 Credits)

Earth Processes (WiSe) / Water Treatment (WiSe) / Field Seminars in Applied Geosciences (WiSe/SoSe)

Curricular module overview (Specialization 3: Environmental Physics and Environmental Modeling)



Elective Modules (6 Credits)

Geotechnical Engineering (WiSe)
Applied Hydrogeology (SoSe)
Contaminant Hydrogeology (SoSe)
GIS and Remote Sensing (WiSe)
Laboratory Course Geomicrobiology (WiSe)
Lab Course Environmental Chemistry (WiSe)
Environmental Microbiology and Geomicrobiology (SoSe)
Environmental Isotope Chemistry (SoSe)
Environmental Analytical Chemistry (WiSe)
Environmental Risk Assessment (WiSe)
Hydrogeochemical Modeling (SoSe)
Field Seminars in Applied Geosciences (WiSe/SoSe)
Advanced Topics in Flow and Transport (SoSe)
Geophysics (SoSe)
Applied Data Analysis and Modeling for Geoscientists (WiSe 20/21)
Sustainable Environmental Biotechnology Systems 1 (SoSe)
Sustainable Environmental Biotechnology Systems 2 (WiSe)
Introduction to Earth Surface Processes (WiSe)
Applied Thermochronology and Quaternary Dating: Techniques, Interpretation and Applications (SoSe 21)
Climate Dynamics, Probability and Statistics (SoSe 21)

Elective Modules (3 Credits)

Earth Processes (WiSe) / Water Treatment (WiSe) / Field Seminars in Applied Geosciences 2 (WiSe/SoSe)

3. Module Handbook MSc Applied & Environmental Geoscience

The following module descriptions give a comprehensive overview of the Applied & Environmental Geoscience Master Course (AEG). The information compiled reflects the course profile as of October 2015. The module content, lecturers as well as single lectures might be subject to changes.

Last update October 21, 2020

Legende		**Legend**	
Benotungs-system:	b = benotet ub = unbenotet (bestanden/nicht bestanden) kP = keine Prüfung	**Grading System:**	g = graded ng = not graded (pass/fail) nE = no exam
Prüfungsform / Studienleistung:	K = Klausur MP = Mündliche Prüfung H =Hausarbeit/Hausaufgaben, Bericht R = Referat/Präsentation LP =Laborprotokoll ET = erfolgreiche Teilnahme	**Assessment / Study Requirement:**	WE = written assessment OE = oral assessment A = assignment / term paper, written report R = report, presentation LP = lab protocol / journal SP = successful participation
Prüfungsdauer:	Dauer der Prüfung in *min*	**Duration of Assessment:**	Duration of the assessment in *min*
Gewichtung:	Gewichtung der Prüfungsnote für die Modulnote	**Weighting:**	Weighting of grade for the module
SWS:	Semesterwochenstunden	**CH:**	Credit Hours
Status:	o = obligatorisch f = fakultativ	**Status:**	c = compulsory op = optional
Art der Lehrform:	V = Vorlesung S = Seminar Ü = Übung/Tutorium GÜ = Geländeübung LP = Laborpraktikum PR = Projekt	**Type of Lecture:**	L = lecture S = seminar E = exercise/tutorial FC = field course LC = laboratory course PR = project
LP:	Leistungspunkte (ECTS-Punkte)	**CR:**	Credits (ECTS)

In addition to the recommended elective modules listed in the following table under ***Applied Geoscience*** more modules offered by the Department of Geoscience from the fields ***Mineralogy and Geology*** and ***Biogeology*** can be chosen as elective modules. Participation in these modules cannot be guaranteed and requires:

- admission by the respective lecturer
- and proof of the required prerequisites

More elective modules (including a maximum of 2 BSc modules) can be approved by the chairman of the examination committee upon request. In order for a module to be accepted it is necessary that it matches the profile of the AEG program and the individual specialization of the student.

Compulsory Modules

Modulnummer / Module Number	Modulname / Module Title	Modul-koordinator / Module Coordinator	LP / Credits	Semester	Studiengang / Study Program 1 Geoscience 2 Geoecology 3 AEG P=Pflicht/Compulsory W=Wahl/ Elective
M 101	Scientific Practice 1	Merkel	6	WiSe/SoSe	P 1,2,3
M 102	Scientific Practice 2	Merkel	6	WiSe/SoSe	P 1,2,3
M 103	Scientific Presentation	Bocherens	6		P 1,2,3
M 104	Master Thesis / Masterarbeit	-	30	WiSe/SoSe	P 1,2,3
M 201	Hydrogeology	Cirpka	6	WiSe	W 1,2 / P 3
M 203	Environmental Modeling 1	Cirpka	6	WiSe	W 1,2 / P 3
M 207	Aquatic & Environmental Chemistry	Zarfl	6	WiSe	W 1,2 / P 3

Elective Modules of the Department of Geosciences

Accepted BSc Modules

B 408	Geophysics	NN	6	SoSe	
B 506	Water Treatment	Zwiener	3	WiSe	
B 514	Introduction Earth Surface Processes	Drews	6	WiSe	
MSc Modules Applied Geosciences					
M 202	Applied Hydrogeology	Leven	6	SoSe	W 1,2,3
M 204	Environmental Modeling 2	Cirpka	6	SoSe	W 1,2,3
M 205	Contaminant Hydrogeology	Grathwohl	6	SoSe	W 1,2,3
M 206	Case Studies in Environmental Geosciences	Cirpka	6	WiSe	W 1,2,3
M 208	Environmental Isotope Chemistry	Taubald	6	SoSe	W 1,2,3
M 209	Environmental Chemistry Lab	Haderlein	6	WiSe	W 1,2,3

M 210	Environmental Microbiology and Geomicrobiology	Kappler	6	SoSe	W 1,2,3
M 211	Geomicrobiology Lab	Kappler	6	SoSe	W 1,2,3
M 213	GIS and Remote Sensing	Schäuble, Lörcherl	6	WiSe	W 1,2,3
M 214	Geotechnical Engineering	Leven	6	WiSe	W 1,2,3
M 216	Physics of the Atmospheric Boundary Layer	Bange	6	SoSe	W 1,3
M 218	Environmental Analytical Chemistry	Zwiener	6	WiSe	W 1,2,3
M 219	Earth Processes	NN	3	WiSe	W 3
M 220	Field Seminars in Applied Geosciences	Merkel	6	WiSe/SoSe	W 3
M 221	Environmental Risk Assessment	Escher	6	WiSe	W 1,2,3
M 222	Hydrogeochemical Modeling	Spahr	6	SoSe	W 1,2,3
M 223	Advanced Topics in Flow and Transport	Cirpka	6	SoSe	W 1,2,3
M 225	Field Seminars in Applied Geosciences 2	Merkel	3	WiSe/SoSe	W 1
M 227	Sustainable Environmental Biotechnology Systems 1	Angenent	6	SoSe 20	W 1,2,3
M 228	Sustainable Environmental Biotechnology Systems 2	Angenent	6	WiSe (starting 20/21)	W 1,2,3
M 603	Interactions of geomorphology, dams and flood hazards in fluvial systems	Lucía Vela	3	SoSe	W 1,2,3
MSc Modules Mineralogy and Geology, Biogeology, Geography (taught in German or in English)					
M 301	Applied Tectonics and Surface Processes	Ehlers	6	WiSe	W 1,2,3
M 305	MSc Mapping Course	Bons	6	WiSe/SoSe	W 1,3
M 308	Isotope Geochemistry	Schönberg	6	SoSe	W 1,2,3
M 311	Carbonate facies Analysis	Nebelsick	6	WiSe	W 1,3
M 315	Glaciology	Weikusat	6	WiSe/SoSe	W 1,3
M 317	Applied Data Analysis and	Drews	6	WiSe 20/21	W 1,2,3

	Modeling for Geoscientists				
M 321	Applied Thermochronology and Quaternary Dating: Techniques, Interpretation and Applications	Glotzbach	6	SoSe (starting 2019)/ every other year	W 1,2,3
M 322	Climate Dynamics, Probability and Statistics	Mutz	6	SoSe (starting 2019)/ every other year	W 1,2,3
M 324	Economic Geology	Staude	6	SoSe (starting 2020)/ every other year	W 1
M 409	Marine Geology and Geochemistry	Schulz	6	WiSe	W 1,2,3
M 606	Numerical Modelling in Geodynamics	Koptev	6	WiSe 20/21	W 1,3
GEO 79	Bodenschutz	Lehmann	6	WiSe	W 1,2.3
T@T, one-time events, modules from other departments					
T@T WiSe 20/21	Astrobiology: life in extreme environments	Samuels	3	WiSe 20/21	W 1,3
Bio-ZMBP	Applications of electron microscopy in cell biology, microbiology and virology	Fischer	6	WiSe	W 1,2,3

Compulsory Modules

<table>
<tr><td>Module Number:
M 101</td><td colspan="6">Module Title:
Scientific Practice 1 / Wissenschaftliches Arbeiten 1</td><td colspan="2">Type of Module:
MSc Compulsory</td></tr>
<tr><td>Credits (ECTS)*</td><td colspan="8">6</td></tr>
<tr><td>Workload*
- Contact Time
- Private Study</td><td colspan="3">Workload:
180 h</td><td colspan="3">Contact Time:
variable depending on the activity</td><td colspan="2">Private Study:
variable depending on the activity</td></tr>
<tr><td>Duration of Module*
Module Coordinator</td><td colspan="4">1 Semester</td><td colspan="4">Merkel</td></tr>
<tr><td>Regular Cycle*</td><td colspan="8">Every semester (recommended in the 2nd semester)</td></tr>
<tr><td>Language</td><td colspan="8">English and German</td></tr>
<tr><td>Learning- / Teaching Forms*</td><td colspan="8">Literature research and/or internship report, participation in the Master Seminar (min. 8 attendances at seminars)</td></tr>
<tr><td>Module Content*</td><td colspan="8">• Internship in one of the research groups at the Institute of Geoscience, participation in ongoing research projects and /or
• External internship in a company of the private sector or a different institution of the university (only after prior consultation and in agreement with the responsible supervisor) and/or
• Independent literature research on an individual topic in agreement with a responsible supervisor
• Participation in the lecture series 'Scientific Presentation'
• In agreement with the responsible supervisor combinations of the individual elements of the module (internships and literature research) are possible (e.g. 50% literature research, 50% internship)</td></tr>
<tr><td>Qualification Goals*</td><td colspan="8">• Students are, according to their personal interests, provided an insight in various research activities at the department, current research topics and are able to collect practical professional experience
• The module offers the opportunity to collect hands-on experience in special scientific research fields and provides an overview and orientation on possible fields of specialization for the Master Thesis
• The mandatory participation in the Master Seminar exposes students to a comprehensive overview of current Master projects of prior semesters from the various research groups and provides insights into various topics of environmental geoscience</td></tr>
<tr><td rowspan="3">Prerequisites for the allocation of credits / grades (if necessary weighting)*</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CR</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td rowspan="2">Scientific Practice 1</td><td>S</td><td>c</td><td>1</td><td>1</td><td>-</td><td>-</td><td>ng</td><td>-</td></tr>
<tr><td>PR</td><td>c</td><td>-</td><td>5</td><td>A</td><td>-</td><td>ng</td><td>-</td></tr>
<tr><td>Applicability*</td><td colspan="8">MSc Applied & Environmental Geoscience, MSc Geowissenschaften, MSc Geoökologie</td></tr>
<tr><td>Participation Prerequisites*</td><td colspan="8"></td></tr>
</table>

Module Number: **M 102**	**Module Title:** **Scientific Practice 2 / Wissenschaftliches Arbeiten 2**								**Type of Module:** MSc Compulsory
Credits (ECTS)*	6								
Workload* **- Contact Time** **- Private Study**	Workload: 180 h	Contact Time: Approx. 20 h							Private Study: 160 h
Duration of Module* **Module Coordinator**	1 Semester				Merkel				
Regular Cycle*	Every semester (recommended in the 3rd semester)								
Language	English and German								
Learning- / Teaching Forms*	Individual guidance by supervisor, scientific papers								
Module Content*	• Compilation of an example research proposal of an individually selected topic in agreement and under supervision of a responsible supervisor • Independent studies in the selected topic including literature research • Formulation of an appropriate problem set, analysis of relevant processes, presentation of the research outline, the required methodologies and the research goals • Set-up of a research schedule including the individual milestones • Writing of the research proposal								
Qualification Goals*	• In addition to well-founded professional competence, successful scientific work also requires conceptual and planning competences before and during a research project. In setting up an exemplary research proposal students will collect experiences in all important steps of planning a research project. • Preparing a research proposal in a written report helps students to acquire important methodological expertise to become acquainted with new fields of research, to identify and discuss relevant problem scenarios, to develop feasible methodological approaches and to present them in an appropriate written form.								
Prerequisites for the allocation of credits / grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Scientific Practice 2	*PR*	*c*	*1*	*6*	*A*	*-*	*ng*	*-*
Applicability*	MSc Applied & Environmental Geoscience, MSc Geowissenschaften, MSc Geoökologie								
Participation Prerequisites*	Scientific Practice 1								

Module Number: **M 103**	**Module Title:** **Scientific Presentation / Wissenschaftliches Präsentieren**								**Type of Module:** MSc Compulsory
Credits (ECTS)*	6								
Workload* **- Contact Time** **- Private Study**	Workload: 180 h		Contact Time: 30h /2 SWS						Private Study: 150 h
Duration of Module* **Module Coordinator**	1 Semester				Bocherens				
Regular Cycle*	Every Semester (recommended in the 4th semester)								
Language	English								
Learning- / Teaching Forms*	Oral seminar presentations and poster								
Module Content*	• Preparation and presentation of a poster on a scientific topic of personal choice (e.g. MSc topic) • Oral presentation in the Master Seminar • A presentation of the results of the Master Thesis in the respective research group								
Qualification Goals*	A professional presentation of scientific research projects and their results is a fundamental prerequisite of a successful career both in scientific as well as in the economic world. Students are able to present their research projects in various forms (oral presentation and poster) and acquire in communication skills and presentation competence through oral presentation and discussion with a competent audience.								
Prerequisites for the allocation of credits / grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Scientific Presentation	*S*	*c*	*2*	*6*	*R*	-	-	-
	Poster Project	*PR*	*c*			*A*	-	-	-
	Presentation of the MSc thesis in the Research Group	*PR*	*c*			*R*	-	-	-
Applicability*	MSc Geowissenschaften, MSc Geoökologie, MSc Applied & Environmental Geoscience; Seminar attendance (8 times) as part of the module Scientific Practice 1								
Participation Prerequisites*	Scientific Practice 1 & 2								

Module Number: **M 104**	**Module Title:** **Master Thesis / Masterarbeit**								**Type of Module:** MSc Compulsory
Credits (ECTS)*	30								
Workload* **- Contact Time** **- Private Study**	Workload: 900 h	Contact Time: variable depending on the activity							Private Study: variable depending on the activity
Duration of Module* **Module Coordinator**	1 Semester				Respective supervisors				
Regular Cycle*	Every semester								
Language	German or English (for AEG only in English)								
Learning- / Teaching Forms*	Independent research project under supervision (100%)								
Module Content*	Literature research, field and/or laboratory tasks preparation of a scientific essay								
Qualification Goals*	• Students independently prepare a research outline and perform a scientific study • Preparation of a scientific essay								
Prerequisites for the allocation of credits / grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Master Thesis	*PR*	*c*	*-*	*30*	*A*	*6 Months*	*g*	*1*
Applicability*	MSc Applied & Environmental Geoscience, MSc Geowissenschaften, MSc Geoökologie								
Participation Prerequisites*	Completion of all required courses								

Module Number: **M 201**	**Module Title:** **Hydrogeology**		**Type of Module:** MSc Compulsory / Elective
Credits (ECTS)*	6		
Workload* **- Contact Time** **- Private Study**	Workload: 180	Contact Time: 90 h / 6 SWS	Private Study: 90 h
Duration of Module* **Module Coordinator**	1 Semester	Cirpka	
Regular Cycle*	Every winter semester (1st semester)		
Language	English		
Learning- / Teaching Forms*	Ex-cathedra lecture sessions are accompanied by exercise tutorials in which problem examples and regular homework are discussed in small groups.		
Module Content*	The module gives an introduction in the science of groundwater. The course has a strong emphasis on physical hydrogeology and the quantitative description of groundwater flow and solute transport. Topics include: • Characterization of aquifers • Concept of the porous medium • Vadose zone (hydrostatics and steady-state flow) • Derivation of conservation laws for water, solute mass, and heat in porous media • Groundwater flow with analytical solutions for different geometries • Well hydraulics • Groundwater transport with analytical solutions in one and multiple dimensions		
Qualification Goals*	Students know the basic concepts of quantitative subsurface hydrology in different geological environments and acquire general competences in the basic physical principles of groundwater flow and solute transport in the saturated and unsaturated zone. They can calculate groundwater flow and solute transport for simple geometries and are aware of the underlying assumptions. With practical experience in groundwater resource development they can address standard hydrogeological problems.		

Prerequisites for the allocation of credits / grades (if necessary weighting)*

Courses	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
Hydrogeology	*L*	*c*	*4*	*4*	*WE*	*90*	*g*	*1*
	E	*c*	*2*	*2*				

Applicability*	MSc Applied & Environmental Geoscience, MSc Geowissenschaften, MSc Geoökologie
Participation Prerequisites*	Students have a firm background in mathematics and physics corresponding to the competences acquired in the BSc modules Mathematik für Naturwissenschaftler and Physik.

Module Number: **M 203**	**Module Title:** **Environmental Modeling 1**								**Type of Module:** MSc Compulsory / Elective
Credits (ECTS)*	6								
Workload* **- Contact Time** **- Private Study**	Workload: 180 h		Contact Time: 90 h / 6 SWS						Private Study: 90 h
Duration of Module* **Module Coordinator**	1 semester			Cirpka					
Regular Cycle*	Every winter semester (1st semester)								
Language	English								
Learning- / Teaching Forms*	Theoretical aspects of basic environmental modeling are taught in ex-cathedra lecture sessions. In computer exercises and homework students obtain practical modeling skills.								
Module Content*	The module introduces important basic concepts including: • Principles of parameter identification and • Interpolation of spatial data Modeling water balance is key aspect of the module and involves the topics: • Water and energy balance at the land surface (precipitation, infiltration, evapotranspiration, surface runoff) • Modeling of groundwater flow [main focus] • Modeling of open-channel flow								
Qualification Goals*	Students know basic modeling principles in Environmental Geosciences. They understand relevant modeling parameters and necessary data handling and processing procedures. They are acquainted with important surface processes in the hydrologic cycle and are able select and apply adequate environmental models, their discretization and parameterization. The students know how to set up a computer model for groundwater flow and how to calibrate it. Practical experience in environmental modeling of various systems and scales, with a focus on groundwater modeling provides them with necessary key competences needed to tackle standard hydrogeological problems and enables them to use professional standard software packages.								
Prerequisites for the allocation of credits / grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Environmental Modeling 1	*L*	*c*	*2*	*3*	*WE*	*180*	*g*	*1*
		E	*c*	*2*	*2*	*A*	*-*	*-*	*-*
	Matlab	*E*	*c*	*2*	*1*	*A*	*-*	*-*	*-*
Applicability*	MSc Applied & Environmental Geoscience (MSc Geowissenschaften, MSc Geoökologie								
Participation Prerequisites*	Students have a firm background in mathematics and physics corresponding to the competences acquired in the BSc modules mathematics for scientists and physics.								

<table>
<tr><td>Module Number:
M 207</td><td colspan="3">Module Title:
Aquatic & Environmental Chemistry (Environmental Chemistry 1)</td><td>Type of Module:
MSc Compulsory / Elective</td></tr>
<tr><td>Credits (ECTS)*</td><td colspan="4">6</td></tr>
<tr><td>Workload*
- Contact Time
- Private Study</td><td>Workload:
180 h</td><td colspan="2">Contact Time:
90 h / 6 SWS</td><td>Private Study:
90 h</td></tr>
<tr><td>Duration of Module*
Module coordinator</td><td colspan="2">1 semester</td><td colspan="2">Zarfl</td></tr>
<tr><td>Regular Cycle*</td><td colspan="4">Every winter semester</td></tr>
<tr><td>Language</td><td colspan="4">English</td></tr>
<tr><td>Learning- / Teaching Forms*</td><td colspan="4">Lectures, Exercises, Tutorial, Team work</td></tr>
<tr><td>Module Content*</td><td colspan="4">• Chemical thermodynamics in aqueous systems
• Sorption and partitioning processes of organic and inorganic compounds
• Sorption kinetics
• Practical applications and case studies</td></tr>
<tr><td>Qualification Goals*</td><td colspan="4">• Role of particles as sorbents, vectors and reactants for contaminants
• Quantitative understanding of partitioning and sorption mechanisms of organic and inorganic compounds in the hydrosphere
• Knowledge of sorption QSARs for various classes of contaminants
• Sorption kinetics and retarded diffusion in porous media
• Assessment of contaminant release and cleanup strategies at contaminated sites</td></tr>
<tr><td rowspan="4">Prerequisites for the allocation of credits /grades (if necessary weighting)*</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CR</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td>Aquatic & Environmental Chemistry Lecture</td><td>L</td><td>c</td><td>2</td><td rowspan="3">6</td><td rowspan="3">WE</td><td rowspan="3">120</td><td rowspan="3">g</td><td rowspan="3">1</td></tr>
<tr><td>Aquatic & Environmental Chemistry Exercises</td><td>E</td><td>c</td><td>2</td></tr>
<tr><td>Aquatic & Environmental Chemistry Tutorials</td><td>E</td><td>op</td><td>2</td></tr>
<tr><td>Applicability*</td><td colspan="4">MSc Applied & Environmental Geoscience (c), MSc Geoökologie (e), MSc Geowissenschaften (e)</td></tr>
<tr><td>Participation Prerequisites*</td><td colspan="4">Basic knowledge in Chemistry, Physics, Hydrogeology</td></tr>
</table>

Elective Modules

Accepted BSc Modules

Module Number: **B 408**	**Module Title:** **Geophysik / Geophysics**								**Type of Module:** BSc Compulsory
Credits (ECTS)*	6								
Workload* **- Contact Time** **- Private Study**	Workload: 180 h		Contact Time: 90 h / 6 SWS						Private Study: 90 h
Duration of Module* **Module Coordinator**	1 semester				NN				
Regular Cycle *	Every summer semester (recommended for the 4th semester)								
Language	English								
Learning- /Teaching Forms*	The module uses a variety teaching forms. Classroom exercises and practical field work allow students to apply their theoretical classroom knowledge and gain practical skills.								
Module Content*	**Geophysics** introduces students to the fundamentals of general and applied geophysics including the topics: • gravity field, magnetic field, seismology, physical parameters of Earth • methods of gravity, geomagnetics, palaeomagnetics and environmental magnetics, geoelectrics, electromagnetics, ground penetrating radar, seismics, tomography Field based exercises in small groups offer 'hands on' experiences in collecting, processing and interpretation of data.								
Qualification Goals*	Students have a basic understanding of physical processes and properties associated with Earth. They know the most important geophysical methods for subsurface investigations and have practical skills in performing and interpreting basic geophysical investigations.								
Prerequisites for the allocation of credits /grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Geophysik / Geophysics	*L*	*c*	*4*	*4*	*K*	*90*	*g*	*1*
		FE	*c*	*2*	*2*	*A*	-	-	-
Applicability*	BSc Umweltnaturwissenschaften, MSc Applied Environmental Geoscience								
Participation Prerequisites*	Students have a firm background in mathematics and physics.								

<table>
<tr><td>Module Number:
B 506</td><td colspan="4">Module Title:
Water Treatment</td><td colspan="4">Type of Module:
BSc Elective</td></tr>
<tr><td>Credits (ECTS)*</td><td colspan="8">3</td></tr>
<tr><td>Workload*
- Contact Time
- Private Study</td><td colspan="2">Workload:
90 h</td><td colspan="3">Contact Times:
45 h/3 SWS</td><td colspan="3">Private Study:
45 h</td></tr>
<tr><td>Duration of Module*
Module Coordinator</td><td colspan="4">1 Semester</td><td colspan="4">Zwiener</td></tr>
<tr><td>Regular Cycle*</td><td colspan="8">Every Winter semester</td></tr>
<tr><td>Language</td><td colspan="8">English (on demand)</td></tr>
<tr><td>Learning- / Teaching Forms*</td><td colspan="8">The module includes lectures and accompanying exercises</td></tr>
<tr><td>Module Content*</td><td colspan="8">The module includes
• Coagulation, filtration, sedimentation
• Adsorption
• Membrane Filtration
• Oxidation
• Disinfection
Combination of individual processes
Up-to- date examples of drinking water treatment plants</td></tr>
<tr><td>Qualification Goals*</td><td colspan="8">Students understand the basics of physical and chemical processes of drinking water treatment. They know the approaches of different treatment technologies and are able to apply suitable processes to remove selected pollutants. They are able to combine suitable process steps to treatment trains which are able to solve given problems.</td></tr>
<tr><td rowspan="3">Prerequisites for the allocation of credits /grades (if necessary weighting)*</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CR</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td rowspan="2">Water Treatment</td><td>L</td><td>c</td><td>2</td><td rowspan="2">3</td><td rowspan="2">WE</td><td rowspan="2">120</td><td rowspan="2">g</td><td rowspan="2">1</td></tr>
<tr><td>E</td><td>c</td><td>1</td></tr>
<tr><td>Applicability*</td><td colspan="8">The module is an elective module in the BSc programs of “Geowissenschaften,” “Umweltnaturwissenschaften“, „Geoökologie“ and in the MSc ”Applied & Environmental Geoscience“.</td></tr>
<tr><td>Participation Prerequisites*</td><td colspan="8">Basic background in Chemistry and Physics comparable to contents that can be accquired in the modules of the BSc program</td></tr>
</table>

Module Number: **B 514**	**Module Title:** **Introduction to Earth Surface Processes**								**Type of Module:** BSc Elective
Credits (ECTS)*	6								
Workload* **- Contact Time** **- Private Study**	Workload: 180 h		Contact Times: 60 h/ 4 SWS						Private Study: 120 h
Duration of Module* **Module Coordinator**	1 Semester				Reinhard Drews				
Regular Cycle*	Offered every odd numbered year, winter semester (starting WS 2017/18)								
Language	English								
Learning- / Teaching Forms*	Lectures and Exercises								
Module Content*	• This course presents the physical basis for mass transport at the Earth's surface. Mechanisms for the production of topography and erosion/sedimentation processes are discussed. • An introduction to the physics of the following processes will be covered: the chemistry and mechanics of rock weathering; glacier flow, erosion, and depositional landforms; fluvial erosion, transport, and deposition; and hillslope mechanics. • Examples of the geophysical and geomorphic methods for quantifying the rates of glacial, fluvial, and hillslope processes.								
Qualification Goals*	At the end of the course the students will have: • A good understanding of the theoretical underpinnings of the physics and chemistry of the Earth's surface; • Practical experience using computer programing (Matlab or Python) and GIS/remote sensing; • Interpreting landscape evolution using observations and theory for applications such as risk assessment (e.g. hillslope failure, outburst floods) and geo-engineering.								
Prerequisites for the allocation of credits /grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Introduction to Earth Surface Processes	*L*	*c*	*2*	*6*	*OE*	*15 min.*	*g*	
		E	*c*	*2*					
Applicability*	The module is an elective module in the BSc programs of "Geowissenschaften", "*Geoökologie","Geographie" and "Umweltnaturwissenschaften* and complements these programs.								
Participation Prerequisites*	Introductory Geology (*Dynamik der Erde)*. Mathematik für Naturwissenschaftler 1, 2 (recommended)								

Modules Applied Geosciences

Module Number: **M 202**	**Module Title:** **Applied Hydrogeology**								**Type of Module:** MSc Elective
Credits (ECTS)*	6								
Workload* **- Contact Time** **- Private Study**	Workload: 180 h		Contact Time: 90 h / 6 SWS						Private Study: 90 h
Duration of Module* **Module Coordinator**	1 Semester			Leven					
Regular Cycle*	Each summer semester (subsequent to the module Hydrogeology)								
Language	English								
Learning- / Teaching Forms*	Lecture with exercises (during semester) and field course (1 week block course)								
Module Content*	The module deals with methods of applied hydrogeology, and focuses in particular on techniques for hydrogeologic site investigation for which the theoretical basis of hydrogeological investigation techniques is taught and consolidated in exercises. As part of a field course, the hydrogeological site investigation techniques are is transferred into practice. Methods, which are discussed in the module include among others: drilling methods, well construction, groundwater sampling, pumping tests under various boundary conditions, single well methods, and tracer testing.								
Qualification Goals*	Students are able to independently plan, carry out, and evaluate hydrogeological field tests. They develop investigation strategies for a hydrogeological exploration of a site, guide and carry out site investigations and collect and analyze data. They generate a local hydrogeological site characterization of the aquifer resp. the subsurface and provide hydrogeological parameters of the subsurface. They are able to apply their knowledge and understanding as well as their problem solving skills in new and unfamiliar situations.								
Prerequisites for the allocation of credits / grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Hydrogeological Investigation Techniques	*L/E*	*c*	*3*	*3*	*WE*	*180*	*g*	*0.5*
	Hydrogeological Field Course	*FC*	*c*	*3*	*3*	*A*	*-*	*g*	*0.5*
Applicability*	The module is an elective module in the MSc program Applied & Environmental Geosciences. It is related to other method-oriented modules of Applied Geosciences (e.g. Geotechnical Engineering, Praktische Hydrogeologie, Grundwasserhydrologie, Geophysics).								
Participation Prerequisites*	The module requires the competences of the module “Hydrogeology” (MSc).								

Module Number: **M 204**	**Module Title:** **Environmental Modeling 2**								**Type of Module:** MSc Elective
Credits (ECTS)*	6								
Workload* **- Contact Time** **- Private Study**	Workload: 180 h		Contact Time: 90 h / 6 SWS						Private Study: 90 h
Duration of Module* **Module Coordinator**	1 Semester			Cirpka					
Regular Cycle*	Every summer semester (recommended 2nd semester)								
Language	English								
Learning- / Teaching Forms*	Theoretical aspects of basic environmental modeling are taught in ex-cathedra lecture sessions. Extensive computer exercise tutorials provide students with 'hands on' experiences in modeling various environmentally relevant scenarios.								
Module Content*	Contents of the advanced environmental modeling module are: • Modeling of energy and mass balance in mixed systems (e.g. temperature model of a lake) • Modeling of conservative transport in porous media and open channels • Modeling of reactive transport • Coupling to mass transfer • Coupling to (bio)chemical transformations								
Qualification Goals*	Based on their firm understanding of conservation principles students are able to set up mathematical models to determine transport, fate and behavior of aqueous-phase compounds in groundwater. They are experienced in addressing the behavior of relevant contaminant groups and apply modeling principles to practical examples of solute transport. They are able to understand and interpret the interactions between transport processes, inter-phase mass transfer, and chemical transformation processes in environmental systems, mainly in porous media.								
Prerequisites for the allocation of credits / grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Environmental Modeling 2	*L*	*c*	*4*	*4*	*WE*	*180*	*g*	*1*
		E	*c*	*2*	*2*				
Applicability*	MSc Applied & Environmental Geoscience, MSc Geowissenschaften, MSc Geoökologie								
Participation Prerequisites*	Students have competences corresponding to those of MSc Modules Hydro-geology and Environmental Modeling 1, Aquatic and Environmental Chemistry.								

Module Number: **M 205**	**Module Title:** **Contaminant Hydrogeology**								**Type of Module:** MSc Elective
Credits (ECTS)*	6								
Workload* **- Contact Time** **- Private Study**	Workload: 180 h		Contact Time: 60 h / 4 SWS						Private Study: 120 h
Duration of Module* **Module Coordinator**	1 Semester			Grathwohl					
Regular Cycle*	Every summer semester (recommended in the 3rd semester)								
Language	English								
Learning- / Teaching Forms*	Lectures are followed by tutorial sessions in which practical problems are quantitatively addressed.								
Module Content*	• Subsurface contaminant distribution • Non aqueous phase liquids in porous media (NAPLs): Behavior and dissolution kinetics • Dissolved compounds: Transport in groundwater • Site investigation and sampling strategies • Integral pumping tests • In situ and ex situ source zone remediation technologies • Plume remediation: Natural attenuation, permeable reactive barriers, pump-and-treat • Remediation technology selection: Technical, economical and environmental aspects • Integrated contaminated land management								
Qualification Goals*	Students learn to address real case scenarios of contaminated sites and to interpret the inherent contamination characteristics due to subsurface conditions and the compounds under consideration. The comprehensive overview on practical aspects of contaminant hydrogeology involves building of conceptual models of a contaminated site, assessing potential risks and developing solution strategies for subsurface contaminations, a key competence of environmental geoscientists.								
Prerequisites for the allocation of credits / grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Contaminant Hydrogeology	*L*	*c*	*2*	*3*	*R*	*-*	*g*	*1*
		E	*c*	*2*	*3*				
Applicability*	MSc Applied & Environmental Geoscience, MSc Geoökologie, MSc Geowissenschaften								
Participation Prerequisites*	MSc modules Hydrogeology, Aquatic & Environmental Chemistry or equivalent competences								

Module Number: **M 206**	**Module Title:** **Case Studies in Environmental Geosciences**								**Type of Module:** MSc Elective
Credits (ECTS)*	6								
Workload* **- Contact Time** **- Private Study**	Workload: 180 h		Contact Time: 30 h / 2 SWS						Private Study: 150 h
Duration of Module* **Module coordinator**	1 semester			Cirpka					
Regular Cycle*	Every winter semester (recommended 3rd semester)								
Language	English								
Learning- / Teaching Forms*	The module uses several seminar sessions at the beginning of the semester to introduce problems sets which are to be solved in teams. Several project meetings with the lecturer give the individual groups feedback on their work on a regular basis. Project presentations and discussion complete the module.								
Module Content*	This course is aimed to apply methods and techniques acquired in previous modules on typical environmental problems. • Several case studies will be presented along with all relevant data • Students will work in small groups addressing specific problem scenarios • Starting from initial data sets students will analyze the problem, develop solution strategies and present their solution								
Qualification Goals*	Highly specific subject oriented projects enable students to analyze a problem, set up fundamental assumptions, collect and evaluate available data. Solving complex problems in environmental geosciences generally includes multidisciplinary approaches from various fields of expertise such as hydrogeology and hydrogeochemistry. Dealing with such scenarios students gain experience in designing conceptual site models, define the relevant physical and chemical processes involved and develop a solution strategy. The integrative module fosters a variety of competences including the capacity for analysis and teamwork, quantitative problem solving skills and presentation and reporting skills.								
Prerequisites for the allocation of credits /grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Case Studies in Environmental Geosciences	*PR*	*c*	*2*	*6*	*R*	*30*	*g*	*1*
Applicability*	MSc Applied & Environmental Geoscience, MSc Geoökologie, MSc Geowissenschaften								
Participation Prerequisites*	Students have competences corresponding to those of Hydrogeology, Environmental Modeling 1, Environmental Modeling 2								

<table>
<tr><td>Module Number:
M 208</td><td colspan="4">Module Title:
Environmental Isotope Chemistry
(Environmental Chemistry 2)</td><td>Type of Module:
MSc Elective</td></tr>
<tr><td>Credits (ECTS)*</td><td colspan="5">6</td></tr>
<tr><td>Workload*
- Contact Time
- Private Study</td><td colspan="2">Workload:
180 h</td><td colspan="2">Contact Time:
90 h / 6 SWS</td><td>Private Study:
90 h</td></tr>
<tr><td>Duration of Module*
Module coordinator</td><td colspan="3">1 semester</td><td colspan="2">Taubald</td></tr>
<tr><td>Regular Cycle*</td><td colspan="5">Every summer semester</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Learning- / Teaching Forms*</td><td colspan="5">Lectures, exercises, team work, presentations</td></tr>
<tr><td>Module Content*</td><td colspan="5">• Basic principles of isotope chemistry
• Relevant isotope systems for the hydrosphere (esp. C, H, O, N, S)
• Compound-specific organic isotope chemistry
• Application of isotope systems for dating, forensic and process identification purposes
• Principles of isotope analysis
• Applications and case studies</td></tr>
<tr><td>Qualification Goals*</td><td colspan="5">• Knowledge of prospects, limitations and applications of isotope methods in environmental chemistry
• Knowledge of theory and interpretation of isotope fractionation processes
• Knowledge of basic principles and applications of core methods for isotope analysis
• Application of isotope methods in the context of contaminant hydrology (natural attenuation and tracer studies)</td></tr>
<tr><td rowspan="5">Prerequisites for the allocation of credits /grades (if necessary weighting)*</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CR</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td>Inorganic Environmental Isotope Chemistry</td><td>L</td><td>c</td><td>2</td><td rowspan="2">3</td><td rowspan="2">WE</td><td rowspan="2">120</td><td rowspan="2">g</td><td rowspan="2">0,5</td></tr>
<tr><td>Inorganic Environmental Isotope Chemistry Exercises</td><td>E</td><td>c</td><td>1</td></tr>
<tr><td>Organic Environmental Isotope Chemistry</td><td>L</td><td>c</td><td>2</td><td rowspan="2">3</td><td rowspan="2">WE</td><td rowspan="2">120</td><td rowspan="2">g</td><td rowspan="2">0,5</td></tr>
<tr><td>Organic Environmental Isotope Chemistry Exercises</td><td>E</td><td>c</td><td>1</td></tr>
<tr><td>Applicability*</td><td colspan="5">MSc Applied & Environmental Geoscience, MSc Geoökologie, MSc Geowissenschaften</td></tr>
<tr><td>Participation Prerequisites*</td><td colspan="5">Basic knowledge in chemistry and physics for geoscientists</td></tr>
</table>

<table>
<tr><td>Module Number:
M 209</td><td colspan="4">Module Title:
Environmental Chemistry Lab
(Environmental Chemistry 3)</td><td colspan="4">Type of Module:
MSc Elective</td></tr>
<tr><td>Credits (ECTS)*</td><td colspan="8">6</td></tr>
<tr><td>Workload*
- Contact Time
- Private Study</td><td colspan="2">Workload:
180 h</td><td colspan="3">Contact Time:
90 h / 6 SWS</td><td colspan="3">Private Study:
90 h</td></tr>
<tr><td>Duration of Module*
Module coordinator</td><td colspan="4">1 semester</td><td colspan="4">Haderlein</td></tr>
<tr><td>Regular Cycle*</td><td colspan="8">Every winter semester</td></tr>
<tr><td>Language</td><td colspan="8">English</td></tr>
<tr><td>Learning- / Teaching Forms*</td><td colspan="8">Lab experiments under supervision, accompanying seminar</td></tr>
<tr><td>Module Content*</td><td colspan="8">• Analytical methods for organic & inorganic contaminants in environmental samples
• Concepts and methods for the quantification of contaminants and degradation processes
• Participation in current research projects in the field of environmental chemistry & microbiology</td></tr>
<tr><td>Qualification Goals*</td><td colspan="8">• Practical application of key lab techniques in environmental analytics (Extraction- & Enrichment techniques, basics of chromatography (GC, HPLC) & Mass spectrometry)
• The students learn to determine experimentally analysis data as well as to evaluate and interpret them quantitatively
• Knowledge of current research in environmental chemistry & microbiology</td></tr>
<tr><td rowspan="4">Prerequisites for the allocation of credits /grades (if necessary weighting)*</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CR</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td rowspan="3">Environmental Chemistry Lab</td><td>E</td><td>c</td><td>5</td><td rowspan="2">6</td><td>SP</td><td>-</td><td>g</td><td>0,5</td></tr>
<tr><td>S</td><td>c</td><td>1</td><td>LP</td><td>-</td><td>g</td><td>0,5</td></tr>
<tr><td colspan="8">Grading is based on the lab performance during the course and lab protocols, no final exam.</td></tr>
<tr><td>Applicability*</td><td colspan="8">MSc Applied & Environmental Geoscience, MSc Geoökologie, MSc Geowissenschaften</td></tr>
<tr><td>Participation Prerequisites*</td><td colspan="8">Physics, Chemistry, Biology for geoscientists
BSc Module Biogeochemie and/or Aquatic & Environmental Chemistry</td></tr>
</table>

Module Number: **M 210**	**Module Title:** **Environmental Microbiology and Geomicrobiology**								**Type of Module:** MSc Elective
Credits (ECTS)*	6								
Workload* **- Contact Time** **- Private Study**	Workload: 180 h	Contact Time: 60 h / 4 SWS							Private Study: 120 h
Duration of Module* **Module coordinator**	1 semester				Kappler				
Regular Cycle*	Every summer semester								
Language	English								
Learning- / Teaching Forms*	Lecture and seminar (student presentations)								
Module Content*	• General environmental microbiology and geomicrobiology • Microbial degradation of pollutants • Redox zonation, thermodynamics • Microbe-mineral interactions • Bioremediation • Biogeochemical cycles								
Qualification Goals*	The students • can read and evaluate current literature about various topics in Environmental Microbiology and Geomicrobiology and can present these topics to an interdisciplinary audience of students • obtain an advanced and detailed understanding of current topics Geomicrobiology and Environmental Microbiology • understand the kinetics and energetics of microbially catalyzed processes and the consequences of these processes for the environment • know about the contribution role of microbial processes for biogeochemical cycling (C, N, S, Fe, Si, P) • know about environmental behavior and microbial transformation of selected organic and inorganic pollutants • understand the interactions of microorganisms with solid substrates (minerals and surfaces)								
Prerequisites for the allocation of credits / grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Environmental Microbiology and Geomicrobiology	*L,S*	*c*	*4*	*6*	*R*	*45*	*g*	*1*
Applicability*	MSc Applied & Environmental Geoscience, MSc Geoökologie, MSc Geowissenschaften								
Participation Prerequisites*	Geomicrobiology; basic knowledge in microbial physiology and in microbial ecology								

<table>
<tr><td>Module Number:
M 211</td><td colspan="4">Module Title:
Geomicrobiology Lab</td><td colspan="4">Type of Module:
MSc Elective</td></tr>
<tr><td>Credits (ECTS)*</td><td colspan="8">6</td></tr>
<tr><td>Workload*
- Contact Time
- Private Study</td><td colspan="2">Workload:
180 h</td><td colspan="3">Contact Time:
90 h</td><td colspan="3">Private Study:
90 h</td></tr>
<tr><td>Duration of Module*
Module coordinator</td><td colspan="4">2 weeks lab course; report writing afterwards</td><td colspan="4">Kappler</td></tr>
<tr><td>Regular Cycle*</td><td colspan="8">Every summer semester</td></tr>
<tr><td>Language</td><td colspan="8">English</td></tr>
<tr><td>Learning- / Teaching Forms*</td><td colspan="8">Lab excercises</td></tr>
<tr><td>Module Content*</td><td colspan="8">• Cultivation and microscopic characterization of microorganisms
• Quantification of microbial activities
• Active participation in a current research project of the Geomicrobiology research group</td></tr>
<tr><td>Qualification Goals*</td><td colspan="8">The students
• can apply various microbial lab techniques (sterile working techniques)
• are able to follow and interpret microbial activities quantitatively
• know about different microbial metabolic pathways, in particular microbial formation and transformation of minerals
• know about current topics in geomicrobiology
• understand and are able to present research questions, hypotheses, experimental approaches and methods, results from their experiments and the data evaluation and interpretation</td></tr>
<tr><td rowspan="3">Prerequisites for the allocation of credits /grades (if necessary weighting)*</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CR</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td rowspan="2">Geomicrobiology Lab</td><td rowspan="2">LC</td><td rowspan="2">c</td><td rowspan="2">6</td><td rowspan="2">6</td><td>SP</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>R</td><td>-</td><td>g</td><td>1</td></tr>
<tr><td>Applicability*</td><td colspan="8">MSc Applied & Environmental Geoscience, MSc Geoökologie, MSc Geowissenschaften</td></tr>
<tr><td>Participation Prerequisites*</td><td colspan="8">Geomicrobiology; basic knowledge in microbial physiology and in microbial ecology.</td></tr>
</table>

<table>
<tr><td>Module Number:
M 213</td><td colspan="3">Module Title:
GIS and Remote Sensing</td><td>Type of Module:
MSc Elective</td></tr>
<tr><td>Credits (ECTS)*</td><td colspan="4">6</td></tr>
<tr><td>Workload*
- Contact Time
- Private Study</td><td>Workload:
180 h</td><td colspan="2">Contact Time:
75 h / 5 SWS</td><td>Private Study:
105 h</td></tr>
<tr><td>Duration of Module*
Module Coordinator</td><td colspan="2">1 Semester</td><td colspan="2">Schäuble, Lörcher</td></tr>
<tr><td>Regular Cycle*</td><td colspan="4">Every winter semester</td></tr>
<tr><td>Language</td><td colspan="4">English</td></tr>
<tr><td>Learning- / Teaching Forms*</td><td colspan="4">Lectures and accompanying guided computer exercises, project assignment.</td></tr>
<tr><td>Module Content*</td><td colspan="4">General introduction to GIS (definition, components, applications and samples)
Acquisition of geo-datasets: getting field data with personal GPS-smartphones (Android, iOS) and public datasets using web sources
Application of GIS by considering the most important aspects in practice, e.g. map projections, georeferencing of scanned images, GPS-data, digitizing of maps, analysis of vector and raster datasets, presentation and visualization of spatial datasets.
Usage of free software: QGIS (with plugins) for scientific analysis and Google Earth Pro for data preparation and distribution to the public
Introduction to remote sensing and advanced raster analysis, e.g. surface analysis and hydrological simulations.
Students have to complete a small GIS project at the end of the course</td></tr>
<tr><td>Qualification Goals*</td><td colspan="4">Students will get the knowledge to use Geographical Information Systems (GIS) in general and for their own scientific projects. They will learn how get the geodata to do that as well. This course combines lectures, computer exercises and GPS field work. Special emphasis is set on practical applications, usability and simplicity. Only GIS software will be used that is freely available (QGIS). Thus knowledge and workflows can be applied at any time with private notebooks, tablets and smartphones.
After completion, the students will have a basic but complete understanding of all relevant aspects of GIS from A-Z. They can start with their own projects from the scratch. QGIS has implemented additional and high-rated GIS software as well (GRASS, SAGA), so every scientific examination can be done.</td></tr>
<tr><td>Prerequisites for the allocation of credits / grades (if necessary weighting)*</td><td colspan="4"><table>
<tr><th>Courses</th><th>Type of Lecture</th><th>Status</th><th>CH</th><th>CR</th><th>Type of Exam / Study Requirement</th><th>Duration of Exam</th><th>Grading System</th><th>Weighting</th></tr>
<tr><td rowspan="2">Geographical information systems and Remote Sensing</td><td>L</td><td>c</td><td>2</td><td rowspan="2">6</td><td rowspan="2">A</td><td rowspan="2">-</td><td rowspan="2">g</td><td rowspan="2">1</td></tr>
<tr><td>E</td><td>c</td><td>2</td></tr>
</table></td></tr>
<tr><td>Applicability*</td><td colspan="4">MSc Applied & Environmental Geoscience (MSc Geoökologie and MSc Geowissenschaften if capacity allows)</td></tr>
<tr><td>Participation Prerequisites*</td><td colspan="4">Smartphone (Android, iOS or other brand)</td></tr>
</table>

Module Number: **M 214**	**Module Title** **Geotechnical Engineering**								**Type of Module:** MSc Elective
Credits (ECTS)*	6								
Workload* **- Contact Time** **- Private Study**	Workload: 180 h		Contact Time: 90 h / 6 SWS						Private Study: 90 h
Duration of Module* **Module Coordinator***	1 Semester			Leven					
Regular Cycle*	Each winter semester								
Language	English								
Learning- / Teaching Forms*	Lecture with exercises (during semester) and lab course (1 week block course)								
Module Content*	The module deals with methods of soil mechanics and geotechnical engineering. In a lecture the basic principles of geotechnical classification of soils and rocks, geotechnical investigation methods, and procedures for determining mediated soil and geomechanical parameters are taught and will be consolidated in exercises. During the soil mechanics laboratory course, various geotechnical laboratory methods for determining basic geotechnical soil and rock parameters are practically applied, analyzed, and evaluated.								
Qualification Goals*	Students are able to independently develop an investigation plan for a geo-technical and soil mechanical investigation at a site, to carry out and guide a sampling campaign. Evaluating the soil mechanical data, they determine relevant geotechnical parameters, analyze them and present them in a report The students are able to apply their knowledge and understanding as well as their problem solving skills in new and unfamiliar situations.								
Prerequisites for the allocation of credits / grades (if necessary weighting)*	*Course*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Geotechnical Engineering	*L*	*c*	*2*	*3*	*WE*	*120*	*g*	*0.5*
	Geotechnical Engineering Lab	*LC*	*c*	*3*	*3*	*A*	*-*	*g*	*0.5*
Applicability*	The module is an elective module in the MSc programs Applied & Environmental Geosciences and Geowissenschaften. It is related to other method-oriented modules of Applied Geosciences (e.g., Applied Hydrogeology, Praktische Hydrogeologie, Grundwasserhydrologie, Geophysics).								
Participation Prerequisites*	The module requires a basic physical, mathematical, and geological knowledge.								

Module Number: **M 216**	**Module Title:** **Physics of the Atmospheric Boundary Layer**		**Type of Module:** MSc Compulsory / Elective
Credits (ECTS)*	6		
Workload* **- Contact Time** **- Private Study**	Workload: 180	Contact Time: 60 h / 4 SWS	Private Study: 120 h
Duration of Module* **Module Coordinator**	1 semester	Bange	
Regular Cycle	Every summer semester		
Language	English		
Learning- / Teaching Forms*	Theoretical aspects of atmospheric physics that are taught in lectures are accompanied by exercises and tutorials in small groups. Field exercises provide 'hands-on' experience and insights in handling atmospheric research.		
Module Content*	This course presents the main features of atmospheric physics with a focus on the boundary layer and airborne research. Aircraft have been applied very effectively in many aspects of environmental research and are a powerful instrument for studying the Earth's surface and atmosphere. Instrumented aircraft in situ measurements with minimum disturbances to the atmosphere between sensor and object. Since the recent development of small unmanned aerial vehicles (UAV) research aircraft have opened new possibilities in boundary layer research. This module gives an introduction to these exciting research topics and covers the following topics in lecture, tutorials and hands-on practice: • Introduction to atmospheric physics and the boundary layer • history of research flight • the physics of flight: aerodynamics, avionics and inertial navigation systems, coordinate systems, aircraft icing • measurement and calibration of basic thermodynamic quantities: temperature, pressure, altitude, water vapour, wind vector • turbulent fluxes and small-scale turbulence • flight strategies and field exercise (with UAV) • software strategies for atmospheric data analysis (using RAMA)		
Qualification Goals*	Students are familiar with the potential and limits of research aircraft in general, especially regarding UAV, airborne measurement instruments and flight strategies. They will be able to decide what instruments (in terms of suitable aircraft and sensors) are suited for certain environmental studies, particularly regarding costs and experimental effort. They plan, carry out and analyze flight experiments for environmental studies in the lower troposphere.		

Prerequisites forthe allocation of credits / grades (if necessary weighting)*

Courses	*Type ofLecture*	*Status*	*CH*	*CR*	*Type of Exam / Study*	*Duration of Exam*	*Grading System*	*Weighting*
Physics of the Atmospheric Boundary Layer	*L*	*c*	*2*	*3*	*WE*	*120*	*g*	*1*
	E	*c*	*1*	*2*	*A*	*-*	*-*	*-*
	S	*c*	*1*	*1*	*-*	*-*	*-*	*-*

Applicability*	The module is an elective module in the MSc program Applied & Environmental Geosciences and a prerequisite for its specialization in Environmental Physics and Environmental Modeling.
Participation Prerequisites*	Lectures on mathematics and physics of a BSc study completed by lectures on thermodynamics, atmospheric physics and basics in flow mechanics (UWP1 and UWP2 of the BSc Umweltnaturwissenschaften)

Module Number: **M 218**	**Module Title:** **Environmental Analytical Chemistry**								**Type of Module:** MSc Elective
Credits (ECTS)*	6								
Workload* **- Contact Time** **- Private Study**	Workload: 180 h		Contact Time: 90 h / 6 SWS						Private Study: 90 h
Duration of Module* **Module Coordinator**	1 semester				Zwiener				
Regular Cycle*	Every winter semester (recommended for the 1st semester)								
Language	English								
Learning- / Teaching Forms*	The module combines classroom lectures and exercises with a one week laboratory practical course, which allows students to apply their theoretical classroom knowledge and gain practical laboratory skills. Regular homework and lab presentations give feedback on individual study progress.								
Module Content*	The module focuses on: • Analysis of new emerging and polar compounds in environmental media • Basic principles of atmospheric pressure ionization techniques and mass spectrometry • Advanced applications of instrumental analytical techniques with liquid chromatography-mass spectrometry • Special approaches for ultratrace analysis								
Qualification Goals*	Students understand the properties of polar compounds. They acquire the theoretical competence to select appropriate problem-oriented analytical methods for environmental pollutants. At the same time the acquired practical skills allow them to handle sophisticated analytical instruments and to develop suitable analytical methods for variable contamination scenarios on demand. Both, the theoretical knowledge and the practical laboratory skills are key competences for environmental scientists.								
Prerequisites for the allocation of credits /grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Environmental Analytical Chemistry	*L*	*c*	*3*	*3*	*WE*	*120*	*g*	*0,5*
		LC	*c*	*3*	*3*	*LP*	*-*	*g*	*0,5*
Applicability*	The module is an elective module in the MSc Applied & Environmental Geoscience, MSc Geoökologie, MSc Geowissenschaften.								
Participation Prerequisites*	Basic knowledge in chemistry, environmental analytics and statistics.								

Module Number: **M 219**	**Module Title:** **Earth Processes**					**Type of Module:** MSc Elective			
Credits (ECTS)*	3								
Workload* **- Contact Time** **- Private Study**	Workload: 90	Contact Time: 45h / 3 SWS				Private Study: 45 h			
Duration of Module* **Module Coordinator**	1 Semester	NN							
Regular Cycle*	Winter or Summer semester								
Language	English								
Learning- / Teaching Forms*	Lectures are accompanied by exercises and computer tutorials.								
Module Content*	• General introduction to geology for non-geologists • Understanding the System Earth (e.g. rocks and minerals) • Surface Processes acting on depositional environments (e.g. rivers, wind, oceans) • Landscape Evolution • Internal Processes (e.g. earthquakes, plate tectonics)								
Qualification Goals*	Students with no or little geological background will get a first comprehensive introduction to geology. They understand relevant geological processes and principles acting on earth's surface and subsurface and improve their understanding of interaction of geological processes with various aspects of environmental geosciences.								
Prerequisites for the allocation of credits /grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Earth Processes	*L, E*	*c*	*3*	*3*	*WE*	*90*	*g*	*1*
Applicability*	Elective module for students of the MSc Applied & Environmental Geoscience with little or no background in geology.								
Participation Prerequisites*	none								

Module Number: **M 220**	**Module Title:** **Field Seminars in Applied Geosciences**								**Type of Module:** MSc Elective
Credits (ECTS)*	6								
Workload* **- Contact Time** **- Private Study**	Workload: 180 h		Contact Time: variable						Private Study: variable
Duration of Module* **Module Coordinator**	1-4 semester				Merkel				
Regular Cycle*	Variable offers mainly in the summer semester								
Language	English								
Learning- / Teaching Forms*	In research field seminars and excursions students identify, outline, describe and discuss selected geological situations in the field with lecturers, fellow students and researchers.								
Module Content*	The module focuses on the practical field experiences in applied geosciences. Possible activities include field seminars and excursions, project field campaigns on topics of the applied geosciences e.g. hydrogeology, engineering geology, contaminant hydrogeology.								
Qualification Goals*	The capacity to apply knowledge in the field is a key competence of geoscientists. Field seminars and excursions allow students to complement lecture-based knowledge with observational and practical skills. They learn to merge different aspects of applied geosciences in a holistic manner and to apply it to different geological situations. Thematically focused excursions in e.g. contaminant hydrogeology or water resources management deepen the knowledge of regional geology and various specialized topics. Discussing complex problems in the field in groups develops communication and problem solving skills.								
Prerequisites for the allocation of credits / grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Various Field Seminars in Applied Geosciences	*FC*	*op*	*-*	*1-6*	*A*	*-*	*ng*	*-*
	Depending on the type and workload of field seminars variable numbers of credits points can be awarded. The module can account for either 3 or 6 credit points and is successfully passed by presenting either. Additional credit points cannot be considered. The applied nature of field seminars needs to be approved prior to participation.								
Applicability*	The module is an elective module in the MSc program Applied & Environmental Geosciences.								
Participation Prerequisites*	Fundamentals in Hydrogeology, Environmental Chemistry and Applied Geosciences.								

<table>
<tr><td>Module Number:
M 221</td><td colspan="4">Module Title:
Environmental Risk Assessment</td><td>Type of Module:
MSc Elective</td></tr>
<tr><td>Credits (ECTS)*</td><td colspan="5">6</td></tr>
<tr><td>Workload*
- Contact Time
- Private Study</td><td colspan="2">Workload:
180 h</td><td colspan="2">Contact Time:
60 h / 4 SWS</td><td>Private Study:
120 h</td></tr>
<tr><td>Duration of Module*
Module Coordinator</td><td colspan="3">1 semester</td><td colspan="2">Escher</td></tr>
<tr><td>Regular Cycle*</td><td colspan="5">Every winter semester</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Learning- / Teaching Forms*</td><td colspan="5">Lecture and accompanying seminar (exercises, presentations)
Groups of three students conduct a comprehensive risk assessment for one selected chemical each according to the European regulation for industrial chemicals. The risk assessment is performed stepwise in the exercises and then compiled into a written technical report that will be graded. In addition, each student presents a paper in the seminar on a specialized topic in environmental risk assessment.</td></tr>
<tr><td>Module Content*</td><td colspan="5">• Regulatory methods for environmental risk assessment of chemicals (industrial chemicals, pesticides, pharmaceuticals), European regulation REACH, human vs. ecological risk assessment
• Exposure analysis: emission patterns, multimedia fate and transport models for quantifying environmental exposure, persistence and long-range transport, predicted and measured exposure concentration
• Effect analysis: estimation of hazard potential, tests for ecotoxicity and human health, dose-effect relationships, extrapolation methods, classification of chemicals according to modes of toxic action, prediction methods (QSARs and integrated testing strategy)
• Risk assessment methods (deterministic vs. probabilistic), risk assessment vs. hazard assessment PBT assessment (persistence, bioaccumulation, toxicity), uncertainty and sensitivity analyses, precautionary principle
• Site specific risk assessment and management, water quality assessment
• Specific topics: risk assessment of mixtures, risk assessment of transformation products, dynamic exposure and effect assessment</td></tr>
<tr><td>Qualification Goals*</td><td colspan="5">The students are familiar with regulatory approaches to environmental risk assessment of chemicals and can perform a regulatory risk assessment for an industrial chemical. They are aware of pitfalls and challenges and know about new approaches to risk assessment that are still in the research stage.</td></tr>
<tr><td rowspan="4">Prerequisites for the allocation of credits /grades (if necessary weighting)*</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CR</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td rowspan="3">Environmental Risk Assessment</td><td>L</td><td>c</td><td>2</td><td>4</td><td>WE</td><td>90</td><td>g</td><td>1</td></tr>
<tr><td rowspan="2">S</td><td rowspan="2">c</td><td rowspan="2">2</td><td>1</td><td>R</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>1</td><td>A</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Applicability*</td><td colspan="5">MSc Applied & Environmental Geoscience, MSc Geowissenschaften, MSc Geoökologie.</td></tr>
</table>

Participation Prerequisites*	

<table>
<tr><td>Module Number:
M 222</td><td colspan="7">Module Title:
Hydrogeochemical Modeling
(Environmental Chemistry 4)</td><td colspan="2">Type of Module:
MSc Elective</td></tr>
<tr><td>Credits (ECTS)*</td><td colspan="9">6</td></tr>
<tr><td>Workload*
- Contact Time
- Private Study</td><td colspan="3">Workload:
180 h</td><td colspan="3">Contact Time:
60 h / 4SWS</td><td colspan="3">Private Study:
135 h</td></tr>
<tr><td>Duration of Module*
Module coordinator</td><td colspan="5">1 semester</td><td colspan="4">Haderlein</td></tr>
<tr><td>Regular Cycle*</td><td colspan="9">Every summer semester</td></tr>
<tr><td>Language</td><td colspan="9">English</td></tr>
<tr><td>Learning- / Teaching Forms*</td><td colspan="9">Lectures, exercises, tutorial, team work</td></tr>
<tr><td>Module Content*</td><td colspan="9">• Chemical thermodynamics in aqueous systems
• Chemical speciation modelling (quantitative hydrochemistry)
• Sorption and Partitioning processes of organic and inorganic compounds in the hydrosphere
• Practical case studies</td></tr>
<tr><td>Qualification Goals*</td><td colspan="9">• Knowledge of basic principles and features of chemical speciation software codes
• Quantitative understanding and prediction of aqueous speciation, dissolution of and complex formation at minerals, redox using chemical modelling software
• Informed application of PHREQC software</td></tr>
<tr><td rowspan="4">Prerequisites for the allocation of credits /grades (if necessary weighting)*</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CR</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td rowspan="3">Hydrogeochemical Modeling</td><td>E</td><td>o</td><td rowspan="2">3</td><td rowspan="3">6</td><td>WE</td><td>120</td><td>g</td><td>0,5</td></tr>
<tr><td>E</td><td>o</td><td>SP</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>S, PR</td><td>o</td><td>1</td><td>A</td><td>-</td><td>g</td><td>0,5</td></tr>
<tr><td>Applicability*</td><td colspan="9">MSc Applied & Environmental Geoscience, MSc Geoökologie, MSc Geowissenschaften</td></tr>
<tr><td>Participation Prerequisites*</td><td colspan="9">Physics, Chemistry, Biology for geoscientists
BSc Module Biogeochemie and/or Environmental Chemistry 1</td></tr>
</table>

<table>
<tr><td>Module Number:
M 223</td><td colspan="5">Module Title:
Advanced Topics in Flow and Transport</td><td colspan="4">Type of Module:
MSc Elective</td></tr>
<tr><td>Credits (ECTS)*</td><td colspan="9">6</td></tr>
<tr><td>Workload*
- Contact Time
- Private Study</td><td colspan="3">Workload:
180 h</td><td colspan="3">Contact Time:
60 h / 4 SWS</td><td colspan="3">Private Study:
120 h</td></tr>
<tr><td>Duration of Module*
Module Coordinator</td><td colspan="4">1 semester</td><td colspan="5">Cirpka</td></tr>
<tr><td>Regular Cycle*</td><td colspan="9">Every summer semester</td></tr>
<tr><td>Language</td><td colspan="9">English</td></tr>
<tr><td>Learning- / Teaching Forms*</td><td colspan="9">Lectures are accompanied by exercises, literature studies, and computer tutorials.</td></tr>
<tr><td>Module Content*</td><td colspan="9">Yearly changing topics covering aspects of mathematical modeling of flow and solute transport in rivers, soils, and aquifers. Potential topics may include:
Conformal mapping and other analytical methods for potential flows
Laplace-transform ad Fourier-transform techniques for transport
Calculation of sensitivities
Uncertainty quantification
Dispersion theories
Unsaturated and multi-phase flow in porous media
Simulation of groundwater-induced land subsidence
Finite Element Methods
Solving ordinary differential equations
Linearization of large systems of equations
Numerical methods of parameter estimation</td></tr>
<tr><td>Qualification Goals*</td><td colspan="9">Students understand and can apply advanced analytical and numerical techniques used in the simulation of flow and transport in terrestrial aquatic systems. They are able to choose appropriate schemes for particular applications and implement smaller self-developed codes.</td></tr>
<tr><td rowspan="3">Prerequisites for the allocation of credits / grades (if necessary weighting)*</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CR</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td rowspan="2">Advanced Topics in Flow and Transport</td><td>L</td><td>c</td><td>3</td><td>2</td><td rowspan="2">A</td><td rowspan="2">-</td><td rowspan="2">g</td><td rowspan="2">1</td></tr>
<tr><td>PR</td><td>c</td><td>1</td><td>4</td></tr>
<tr><td>Applicability*</td><td colspan="9">MSc Applied & Environmental Geoscience, MSc Geoökologie, MSc Geowissenschaften</td></tr>
<tr><td>Participation Prerequisites*</td><td colspan="9">Students have successfully participated in Environmental Modeling 1 and Hydrogeology.</td></tr>
</table>

Module Number: **M 225**	**Module Title:** **Field Seminars in Applied Geosciences 2**								**Type of Module:** MSc Elective
Credits (ECTS)*	3								
Workload* **- Contact Time** **- Private Study**	Workload: 90 h		Contact Time: variable						Private Study: variable
Duration of Module* **Module Coordinator**	1-4 semester				Merkel				
Regular Cycle*	Variable offers mainly in the summer semester								
Language	English								
Learning- / Teaching Forms*	In research field seminars and excursions students identify, outline, describe and discuss selected geological situations in the field with lecturers, fellow students and researchers.								
Module Content*	The module focuses on the practical field experiences in applied geosciences. Possible activities include field seminars and excursions, project field campaigns on topics of the applied geosciences e.g. hydrogeology, engineering geology, contaminant hydrogeology.								
Qualification Goals*	The capacity to apply knowledge in the field is a key competence of geoscientists. Field seminars and excursions allow students to complement lecture-based knowledge with observational and practical skills. They learn to merge different aspects of applied geosciences in a holistic manner and to apply it to different geological situations. Thematically focused excursions in e.g. contaminant hydrogeology or water resources management deepen the knowledge of regional geology and various specialized topics. Discussing complex problems in the field in groups develops communication and problem solving skills.								
Prerequisites for the allocation of credits / grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Various Field Seminars in Applied Geosciences	*FC*	*op*	*-*	*1-3*	*A*	*-*	*ng*	*-*
	Depending on the type and workload of field seminars variable numbers of credits points can be awarded. After collecting a total of 3 credit points the module is successfully passed. Additional credit points cannot be considered. The applied nature of field seminars needs to be approved prior to participation.								
Applicability*	The module is an elective module in the MSc program Applied & Environmental Geosciences.								
Participation Prerequisites*	Fundamentals in Hydrogeology, Environmental Chemistry and Applied Geosciences.								

Module Number: **M 227**	**Module Title:** **Sustainable Environmental Biotechnology Systems 1**								**Type of Module:** Elective
Credits (ECTS)*	6								
Workload* **- Contact Time** **- Private Study**	Workload: 180 h		Contact Time: 90 h (6 SWS)						Private Studies: 90 h
Duration of Module* **Module Coordinator**	1 Semester				Angenent				
Regular Cycle *	Every Summer Semester starting 2020								
Language	English								
Learning- /Teaching Forms*	The module combines class room lectures and field trips.								
Module Content*	This course will offer a systems approach to understand energy systems that include a bioprocessing step, such as anaerobic digestion, anaerobic fermentation, microbial fuel cells, and photobioreactors with algae. In general, this course focuses on biomass-to-bioenergy conversion, including introduction to major treatment steps, such as pretreatment steps, fermentation steps, and product separation steps. The course integrates physics, engineering, environmental impacts, economics, and sustainable development. Different energy generation technologies will be compared to gain an understanding of the advantages and limitations of these technologies. Students are expected to be interested in and appreciate the need for quantitative aspects of energy systems. An emphasis of this course is technical and economic analysis of large-scale energy systems and their conceptual design.								
Qualification Goals*	This course is intended to students to gain the capabilities to: 1. Use a systems approach to design renewable bioenergy systems. 2. Explain the energy conversion processes for biomass systems. 3. Evaluate the advantages and limitations of renewable bioenergy systems. 4. Assess a system by using nontechnical factors (environmental impacts, economics, and sustainable development) during the design phase. 5. Identify which information is missing during the design phase.								
Prerequisites for the allocation of credits /grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirements*	*Duration of Exam*	*Grading System*	*Weighting*
	Sustainable Environmental Biotechnology Systems 1	*L*	*c*	*3*	*6*	*A*	*-*	*g*	*0,5*
		E	*c*	*3*		*A*	*-*	*g*	*0,5*
Applicability*	MSc Applied & Environmental Geoscience, MSc Geoökologie, MSc Geowissenschaften, MSc Biology								
Participation Prerequisites*	Basic knowledge in microbiology or chemistry or physics or geosciences or engineering								

Module Number: **M 228**	**Module Title:** **Sustainable Environmental Biotechnology Systems 2**								**Type of Module:** Elective
Credits (ECTS)*	6								
Workload* **- Contact Time** **- Private Study**	Workload: 180 h	Contact Time: 90 h (6 SWS)							Private Studies: 90 h
Duration of Module* **Module Coordinator**	1 Semester				Angenent				
Regular Cycle *	Every Winter Semester (starting 2020/21)								
Language	English								
Learning- /Teaching Forms*	The module combines class room lectures and a group design project.								
Module Content*	This course will offer a systems approach to understand energy systems that include a bioprocessing step, such as anaerobic digestion, anaerobic fermentation, microbial fuel cells, and photobioreactors with algae. In general, this course focuses on biomass-to-bioenergy conversion, including introduction to major treatment steps, such as pretreatment steps, fermentation steps, and product separation steps. The course integrates physics, engineering, environmental impacts, economics, and sustainable development. Different energy generation technologies will be compared to gain an understanding of the advantages and limitations of these technologies. Students are expected to be interested in and appreciate the need for quantitative aspects of energy systems. An emphasis of this course is technical and economic analysis of large-scale energy systems and their conceptual design.								
Qualification Goals*	This course is intended to students to use the capabilities from Sustainable Environmental Biotechnology Systems 1 to: 1. Excel in a team-oriented design experience, focused on the application of renewable bioenergy technologies. 2. Design a “real life” renewable bioenergy system.								
Prerequisites for the allocation of credits /grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirements*	*Duration of Exam*	*Grading System*	*Weighting*
	Sustainable Environmental Biotechnology Systems 2	*L* *E*	*c* *c*	*2* *4*	*6*	*A*	*-*	*g*	*1*
Applicability*	MSc Applied & Environmental Geoscience, MSc Geoökologie, MSc Geowissenschaften, MSc Biology								
Participation Prerequisites*	Basic knowledge in microbiology or chemistry or physics or geosciences or engineering, Sustainable Environmental Biotechnology Systems 1								

Module Number: **M 603**	**Module Title:** **Interactions of geomorphology, dams and flood hazards in fluvial systems**								**Type of Module:** MSc Elective
Credits (ECTS)*	3								
Workload* **- Contact Time** **- Private Study**	Workload: 90 h	Contact Times: 40 h/ 3 SWS							Private Study: 50 h
Duration of Module* **Module Coordinator**	1 Semester					Lucía			
Regular Cycle*	Summer semester 2020 and 2021								
Language	English								
Learning- / Teaching Forms*	Seminar (student presentations)								
Module Content*	This course is designed to introduce students to the interactions between hydrological, geomorphological and anthropogenic factors in fluvial systems with a strong focus on fluvial geomorphology as well as sediment and wood transport. Students will learn about the effects that increasing pressures have on river systems, ranging from floods increasing in frequency and magnitude to a boom in hydropower dam construction. This will be complemented by knowledge on current attempts to mitigate the undesired effects, e.g. through flood hazard mapping and engineering measures, as well as river restoration. The course will be complemented with 1-day fieldtrip to Braunsbach, where a flash flood occurred in 2016.								
Qualification Goals*	By the end of the course, students will be able to (i) understand the interactions between severe floods and dam construction and fluvial geomorphology (ii) know about different alternatives to mitigate flood hazard risk and restore river channels.								
Prerequisites for the allocation of credits /grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Interactions of geomorphology, dams and flood hazards in fluvial systems	*S*	*c*	*3*	*3*	*R*	*45*	*g*	*1*
Applicability*	The module is an elective module in the MSc programs of “Geowissenschaften” and Applied Environmental Geosciences and complements competences acquired in both programs.								
Participation Prerequisites*									

Modules from Mineralogy and Geology, Biogeology and Geography (taught in German or in English)

Module Number: **M 301**	**Module Title:** **Applied Tectonics and Surface Processes**								**Type of Module:** MSc Elective
Credits (ECTS)*	6								
Workload* **- Contact Time** **- Private Study**	Workload: 180 h	Contact Time: 90 h / 6SWS							Private Study: 180 h
Duration of Module* **Module Coordinator**	1 semester				Ehlers				
Regular Cycle*	Every winter semester								
Language	English								
Learning- / Teaching Forms*	This module includes a combination of lectures and exercises where the exercises include either computer exercises or scientific paper discussions related to the lecture topics.								
Module Content*	This course highlights current methods used to quantify how tectonics and surface processes interact to form Earth's topography and sedimentary basins. Emphasis is placed on understanding how different geologic, geophysical, and geochemical tools can be used to understand mountain building processes and the evolution of Earth's surface. Specific topics addressed in lectures include: • How and why tectonics, topography, and climate interact over short and long (million year) timescales. • Physical and mathematical approaches for understanding erosion and sedimentation by rivers, hillslopes, and glacial processes. • Geochemical and other dating techniques for quantifying tectonic and surface processes, including thermochronology and cosmogenic isotopes. • Examples of how the previous methods have been applied to different mountain ranges around the world. Topics addressed in the exercises and discussion include: • Computer exercises using Matlab and other software to investigate physical and geochemical processes discussed in lectures. • Group discussions on scientific papers that provide examples of how different techniques discussed in class are applied to geoscience studies.								
Qualification Goals*	Goals of this class center around enabling students to: • Apply different geologic, geochemical, and geophysical data sets to understand tectonic and surface processes in different settings. • Apply different computer software tools to investigate physical and geochemical processes associated with mountain building. • Develop skills in critically reading scientific literature.								
Prerequisites for the allocation of credits /grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Applied Tectonics and Surface Processes	*L*	*c*	*4*	*4*	-	-	-	-
		LC	*c*	*2*	*2*	*A*		*g*	*1*

Applicability*	This module compliments other geoscience modules in structural geology, isotope geochemistry, geophysics, and sedimentology by providing a regional context for the driving mechanisms of mountain building, basin formation, and topographic development. It also compliments modules in physical geography by providing a quantitative understanding of surface processes and paleoclimate.
Participation Prerequisites*	Introductory geology

Module Number: **M 305**	**Module Title:** **MSc Mapping Course**					**Type of Module:** Elective			
Credits (ECTS)*	6 Credits.								
Workload* **- Contact Time** **- Private Study**	Workload: 180 h	Contact Time:: circa 14 field days				Private Studies: 0-40 h			
Duration of Module* **Module Coordinator**	Block course, circa 14 days	Bons							
Regular Cycle *	annual								
Language	German or English								
Learning- /Teaching Forms*	Supervised field exercise in small groups. Mapping and analysis of geological data, in conjuction with report writing and graphical data presentation (geological maps, stratigraphic columns, cross sections, etc.)								
Module Content*	One mapping course entails: Geological mapping of an area, individually or in small groups Drawing of a geological map, as well a graphical representation of the stratigraphy and/or lithological relationships in the form of stratigraphical columns, cross sections, etc. Writing of a report that summarizes the observations and interpretation of the geology and geological history of the mapping area Depending on the duration of the course, credits may need to be gained with additional assignments. This must be defined and announced by the course leader before the mapping course itself. These can be, for example, additional field days, participation in preparation seminars, home work, etc.								
Qualification Goals*	Students learn to independently apply geological field methods and techniques and gain practical experience in the geological analysis of a new area. They will undertake measurements, determine lithologies and stratigraphic sequences and will put these in their spatial context. The ability to make geological maps, cross sections and stratigraphical columns is among the core competencies of a geoscientist.								
Prerequisites for the allocation of credits /grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirements*	*Duration of Exam*	*Grading System*	*Weighting*
	MSc Mapping Course	*FC*	*op*	*6*	*6*	*A*	*-*	*g*	*1*
Applicability*	Elective module MSc Geosciences								
Participation Prerequisites*	Successfully completed BSc-degree in geosciences								

<table>
<tr><td>Module Number:
M 308</td><td colspan="5">Module Title:
Isotope Geochemistry</td><td colspan="4">Type of Module:
MSc Elective</td></tr>
<tr><td>Credits (ECTS)*</td><td colspan="9">6</td></tr>
<tr><td>Workload*
- Contact Time
- Private Study</td><td colspan="3">Workload:
180 h</td><td colspan="3">Contact Time:
90 h / 6 SWS</td><td colspan="3">Private Study:
90 h</td></tr>
<tr><td>Duration of Module*
Module Coordinator</td><td colspan="4">1 semester</td><td colspan="5">Schönberg</td></tr>
<tr><td>Regular Cycle*</td><td colspan="9">Every summer semester</td></tr>
<tr><td>Language</td><td colspan="9">English</td></tr>
<tr><td>Learning- / Teaching Forms*</td><td colspan="9">Lectures, exercises, oral and written presentations</td></tr>
<tr><td>Module Content*</td><td colspan="9">The module consists of 3 main parts:
1. Theory of isotope geochemistry: Detailed view on applications of radiogenic isotope systems as geochemical indicators for assimilation and fractionated crystallization (AFC). U-Th disequilibrium dating and its applications. Heavy ‘non-traditional’ stable isotope systems (e.g. Cr, Fe, Mo) and their applications.
2. Theory of Mass spectrometry: Basic instrumental set-up of various mass spectrometers, focusing on systems used to determine isotope ratios. Isotope dilution for exact quantitative element concentration analysis.
3. Literature study: The experience gained during parts 1&2 of this module are applied to isotope geochemical literature. Papers published in international journals will be summarized in oral and written presentations.</td></tr>
<tr><td>Qualification Goals*</td><td colspan="9">Upon completion of the module students:
• have detailed knowledge how radiogenic isotope ratios can be used for the identification and quantification of magmatic processes
• understand how the U-Th disequilibrium can be used in dating young rocks/minerals and those in turn allow statement about changes in climate and bioproductivity understand how stable isotope variations of heavy elements (transition metals) allow statements on the formation mineral deposits as well as in the field of environmental geochemistry can be used to identify sources of contamination
• know the basic set-up of a mass spectrometer, the methodological differences with respect to other analytical techniques
• will be able to assess the quality of published isotope data and the interpretations drawn from those</td></tr>
<tr><td rowspan="4">Prerequisites for the allocation of credits / grades (if necessary weighting)*</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CR</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td>Isotope Geochemistry</td><td>L, E</td><td>c</td><td>3</td><td>3</td><td rowspan="2">WE</td><td rowspan="2">120</td><td rowspan="2">g</td><td rowspan="2">1</td></tr>
<tr><td>Mass Spectrometry</td><td>L,E</td><td>c</td><td>2</td><td>2</td></tr>
<tr><td>Literature Study</td><td>E</td><td>c</td><td>1</td><td>1</td><td>R</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Applicability*</td><td colspan="9">Elective module in the MSc Geosciences, key module in the specializations Mineralogy and General Geosciences</td></tr>
<tr><td>Participation Prerequisites*</td><td colspan="9">Basic knowledge from the BSc Geowissenschaften or from a comparable BSc degree</td></tr>
</table>

Module Number: **M 311**	**Module Title:** **Carbonate Facies Analysis**								**Type of Module:** MSc Elective
Credits (ECTS)*	6								
Workload* **- Contact Time** **- Private Study**	Workload: 180 h		Contact Time: 60 h / 4 SWS						Private Studies: 120 h
Duration of Module* **Module Coordinator**	1 Semester				Nebelsick				
Regular Cycle*	Every winter semester								
Language	English								
Learning- / Teaching Forms*	The necessary basic and advanced knowledge will be mediated during lectures. In the practical part of the course, the students will learn to analyze thin sections and use other methods to identify components, reconstruct ecological parameters and interpret the importance carbonates in the rock record. Data and methodologies recovered from the literature as well as from project work based on specific case studies will be presented.								
Module Content*	The identification of the most important abiotic and biotic components and resulting facies types as found in carbonates. The reconstruction of depositional environments in both recent and fossil carbonate systems including both non-marine and marine facies ranging from shelf deposits including reefs to deep water. Application of relevant methodologies applied to carbonate facies analysis including thin section analysis and other techniques.								
Qualification Goals*	The students will obtain the basic knowledge needed to identify, analyze and interpret the constituent components and diagenetic processes of carbonate facies. They will learn the composition and distribution of both recent and fossil carbonate facies of both marine and non-marine sedimentary environments. They will learn to use the relevant methodologies to study carbonates including high resolution microscopy, quantification methodologies and statistical analysis of component distributions. The students will be able to interpret depositional environments with respect to both abiotic and biotic parameters. The participants will analyze carbonates with respect to the evolution of organisms as well as their contribution to depositional environments and thus to the rock record through time.								
Prerequisites for the allocation of credits / grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Carbonate Facies Analysis	*L*	*c*	*2*	*2*	*A, R, LP, SP*	*-*	*f*	*1*
		E	*c*	*2*	*2*				
		PR	*c*	*2*	*2*				
Applicability*	MSc Geowissenschaften								
Participation Prereq-uisites*	Basics in Earth History and Paleontology								

Modulnummer: **M 313**	**Modultitel:** **Explorationspraxis (Letztmalig im WiSe 20/21)**		**Art des Moduls:** MSc Wahlpflicht
ECTS-Punkte*	6		
Arbeitsaufwand* **- Kontaktzeit** **- Selbststudium**	Arbeitsaufwand: 180 h	Kontaktzeit: 150 h / 10 SWS	Selbststudium: 30 h
Moduldauer* **Modulkoordinator**	1 Semester	Aigner	
Häufigkeit des Angebots*	Letztmalig im WiSe 20/21		
Unterrichtssprache	Deutsch und Englisch		
Lehr- /Lernformen*	Das Modul besteht im Wesentlichen aus praxisorientierten Vorlesungen und Übungen. Wechselnde Blockveranstaltungen zu Spezialthemen aus dem Bereich Erdöl/Erdgas Exploration werden von externer Spezialisten aus der Erdölindustrie vorgestellt: Neben umfangreichen Übungen an Original-Datensätzen aus der Explorationspraxis, kommt neuste 3D Modellierungssoftware zum Einsatz. Praktische Projektarbeiten sowie Industriepraktika können in diesem Modul integriert werden.		
Modulinhalt*	Das Modul befasst sich mit sedimentären Lagerstätten mit einem Fokus auf Erdöl-Erdgas-Exploration (Petroleumgeologie). Die wichtigsten Methoden in der Erdölexploration werden vorgestellt und praktisch eingeübt. Behandelte Themenbereiche sind z.B. Erdölgeologie, Seismische Interpretation, Strukturelle Interpretation, Seismische Stratigraphie, Well-Log-Interpretation, Beckenanalyse und –modellierung. Die angebotenen Einzelveranstaltungen bieten eine direkten Einblick in ‚State of the Art' Entwicklungen und können daher in ihren Inhalten von Jahr zu Jahr variieren.		
Qualifikationsziele*	Studierende kennen die Grundzüge der Lagerstätten-Exploration/Erkundung, im Bereich Erdöl-Erdgas. Sie verfügen über umfangreiches Wissen zum aktuellen Stand der Forschung und sind in der Lage selbstständig Informationen der wichtigsten Explorationsmethoden zu sichten, analysieren und interpretieren. Aus einer Vielzahl der unterschiedlichen Daten sind sie in der Lage komplexe Strukturmodelle zu erstellen, die die Grundlage für das Auffinden von potentiellen Erdöl/Erdgaslagerstätten sind.		

Voraussetzung für die Vergabe von Leistungspunkten/ Benotung (ggf. Gewichtung)*	*Lehrveranstaltungen*	*Art der Lehrform*	*Status*	*SWS*	*LP*	*Prüfungsform / Studienleistung*	*Prüfungsdauer*	*Benotungssystem*	*Gewichtung*
	Explorationspraxis wechselnde Blockveranstaltungen von externen Dozenten	*V,Ü*	*o*	*10*	*6*	*A*	*-*	*b*	*1*

Verwendbarkeit*	Das Modul vermittelt fortgeschrittene Kompetenzen für die Vertiefungsrichtung Exploration
Teilnahmevoraussetzungen*	Grundlage für die Teilnahme ist die erfolgreiche Teilnahme an den MSc Modulen Modul Fazies-Analyse und Angewandte Sedimentgeologie.

Module Number: **M 315**	**Module Title:** **Glaciology**								**Type of Module:** MSc Elective
Credits (ECTS)*	6								
Workload* **- Contact Time** **- Private Study**	Workload: 180 h		Contact Time: 90 h / 6 SWS						Private Studies: 90 h
Duration of Module* **Module Coordinator**	1 Semester				Weikusat				
Regular Cycle*	Every summer semester								
Language	English/German (can be held in German depending on students)								
Learning- / Teaching Forms*	Two weeks block course including lectures, tutorials and exercises. Poster presentations								
Module Content*	Topics covered in lectures and exercises: • Components of the earth's cryosphere in recent and palaeo-time scales • Cryosphere and climate (sea level) • Ice cores (palaeo-climate records) • Material ice (modifications, crystal structure, defects, physical properties) • Micro-dynamics of ice (deformation and recrystallization mechanisms) • Formation processes of natural ice (e.g. meteoric glacial ice, sea ice, ice shelf ice, marine ice) • Mass balance of glaciers and ice sheets (ablation and accumulation measurements and processes, e.g. melting, calving) • Ice dynamics (stress and strain, deformation modes, flow features, flow law) Poster session on hot topics in glaciological research (exam): • basics poster preparation and presentation techniques • present a topic / recent research paper on a poster and a 5 min. oral presentation and 5 min questions / discussion								
Qualification Goals*	During the course the students will: • Gather general knowledge of the field about the cryosphere and the related glaciological subtopics • Develop an understanding of the physical processes relevant for the cryo-sphere • Acquire an up to date overview of current glaciological research topics and being able to evaluate conclusions in a critical way • Acquire expertise in assessing cryosphere related information with respect to modern climate change discussions • Gather practical experience in simple ice core data processing and ice dynamic modelling (exercises and tutorials).								
Prerequisites for the allocation of credits /grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study*	*Duration of Exam*	*Grading System*	*Weighting*
	Glaciology	*L*	*c*	*4*	*4*	*R*	*-*	*g*	*1*
		E	*c*	*1*	*1*				
		S	*c*	*1*	*1*				

Applicability*	Elective module in the MSc program Geowissenschaften. The glaciology module covers topics related to the material of the core modules mineralogy, geodynamics and applied geosciences.
Participation Prerequisites*	Fundamentals in geology/mineralogy and physics

<table>
<tr><td>Module Number:
M 317</td><td colspan="4">Module Title:
Applied Data Analysis and Modeling for Geoscientists</td><td>Type of Module:
MSc Elective</td></tr>
<tr><td>Credits (ECTS)*</td><td colspan="5">6</td></tr>
<tr><td>Workload*
- Contact Time
- Private Study</td><td colspan="2">Workload:
180 h</td><td colspan="2">Contact Time:
60 h / 4SWS</td><td>Private Study:
120h</td></tr>
<tr><td>Duration of Module*
Module Coordinator</td><td colspan="3">1 semester</td><td colspan="2">Drews</td></tr>
<tr><td>Regular Cycle*</td><td colspan="5">WiSe 20/21</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Learning- / Teaching Forms*</td><td colspan="5">Lectures and computer exercises for data analysis and modelling.</td></tr>
<tr><td>Module Content*</td><td colspan="5">This lecture teaches universal mathematical concepts and applies them to a wide range of geologic, geoecology, and applied geology problems ranging from analysis of satellite displacement fields, to landscape evolution and isotope records of climate change. Topics include:
• Which function fits my data?
✓ Linear/non-linear regression and curve fitting
✓ Statistical metrics and error analysis
• What signals are in my data?
✓ Time series analysis and Fourier Transform
✓ Signal processing (e.g. bandpass-pass filtering, deconvolution)
✓ Principal Component Analysis
✓ Denoising and invariants in raster data
• Modelling the real world, but how?
✓ Differential equations with finite-differences/finite-element modelling
• Which model best describes my data?
✓ Inverse modelling for data integration</td></tr>
<tr><td>Qualification Goals*</td><td colspan="5">• Numerical programming in Matlab and/or Python
• Application of universal mathematical concepts (calculus, linear algebra, differential equations) for geoscientific problems using computers.</td></tr>
<tr><td>Prerequisites for the allocation of credits /grades (if necessary weighting)*</td><td colspan="5"><table>
<tr><th>Courses</th><th>Type of Lecture</th><th>Status</th><th>CH</th><th>CR</th><th>Type of Exam / Study Requirement</th><th>Duration of Exam</th><th>Grading System</th><th>Weighting</th></tr>
<tr><td rowspan="2">Applied Data Analysis and Modeling for Geoscientists</td><td>L</td><td>c</td><td>2</td><td rowspan="2">6</td><td rowspan="2">R</td><td rowspan="2">25</td><td rowspan="2">g</td><td rowspan="2">100</td></tr>
<tr><td>E</td><td>c</td><td>2</td></tr>
</table></td></tr>
<tr><td>Applicability*</td><td colspan="5">This module compliments many other geology, geoecology, and applied geology courses (e.g. geophysics, geochemistry, climatology and ecosystems, applied tectonics and surface processes, remote-sensing) by providing a toolbox for quantitative data analysis and modelling. It provides a good baseline for students who want to go further in certain topics in their respective projects.</td></tr>
<tr><td>Participation Prerequisites*</td><td colspan="5">Calculus, linear algebra and ODEs, although some concepts will be reviewed in class. Prior knowledge of programming is helpful but not a hard prerequisite.</td></tr>
</table>

Module Number: **M 321**	**Module Title:** **Applied Thermochronology and Quaternary Dating: Techniques, Interpretation and Applications**								**Type of Module:** Elective
Credits (ECTS)*	6								
Workload* **- Contact Time** **- Private Study**	Workload: 180 h		Contact Time: 90 h (6 SWS)						Private Studies: 90 h
Duration of Module* **Module Coordinator**	1 Semester				Glotzbach				
Regular Cycle *	Every other year on odd numbered years starting SS 2019, 2 week block course (10 days).								
Language	English								
Learning- /Teaching Forms*	Two weeks block course including lectures (in the morning), tutorials and exercises (in the afternoon).								
Module Content*	In this block course the following topics will be lectured and practically learned: - General principles of absolute and relative dates - Radiometric dating methods - Cosmogenic radionuclide dating - Optical- and thermo-stimulated luminescence dating - Heat transport in the crust - Low-temperature thermochronology - Fission track dating method - (U-Th)/He dating method - Detrital thermochronology data interpretation - Thermal history modelling - Thermo-kinematic modelling								
Qualification Goals*	After this block course the students: - Know the theoretical basis of different dating techniques - Have acquired practical (laboratory) experience in thermochronology - Use computer skills to quantitatively interpret thermochronological data - Gain expertise in deriving geodynamic models from data through case studies								
Prerequisites for the allocation of credits /grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirements*	*Duration of Exam*	*Grading System*	*Weighting*
	Applied Thermochronology and Quaternary Dating	*LE*	*c*	*6*	*6*	*R*	*-*	*g*	*1*
Applicability*	MSc Geowissenschaften, Geoecology, Applied & Environmental Geoscience also open for interested MSc students from other institutions if capacity allows								
Participation Prerequisites*	Introductory Geology								

<table>
<tr><td>Module Number:
M 322</td><td colspan="4">Module Title:
Climate Dynamics, Probability and Statistics</td><td>Type of Module:
MSc Elective</td></tr>
<tr><td>Credits (ECTS)*</td><td colspan="5">6</td></tr>
<tr><td>Workload*
- Contact Time
- Private Study</td><td colspan="2">Workload:
180 h</td><td colspan="2">Contact Time:
60 h / 4 SWS</td><td>Private Study:
120 h</td></tr>
<tr><td>Duration of Module*
Module Coordinator</td><td colspan="3">1 semester</td><td colspan="2">Mutz</td></tr>
<tr><td>Regular Cycle*</td><td colspan="5">Every other summer semester</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Learning- / Teaching Forms*</td><td colspan="5">Lectures introduce fundamental concepts of statistics, probability theory and the processes governing the climate system on different space and time scales. In computer exercises, specific empirical-analytical methods are described in more detail. In class, these are applied to describe, explain and predict different elements of the climate system. Students prepare presentations on how they applied a taught method to a specific (palaeo)climatological problem.</td></tr>
<tr><td>Module Content*</td><td colspan="5">This module offers an introduction to atmospheric processes and climate change of the past, present and future. Furthermore, it teaches theoretical and practical knowledge of probability theory, and basic to advanced methods from descriptive and inferential statistics, which are required for the description, explanation and prediction of climate and other Earth systems. Module core content includes:
processes governing the climate system on different scales;
climate change of the past, present and future;
physics- and statistics-based modelling of the atmosphere;
concepts of frequentist and Bayesian probabilities and statistics;
data handling: from high dimensionality to sparse records;
synoptic statistical tools for (palaeo)climatology and geoscience;
detection and explanation of patterns in large datasets;
intelligent, self-improving models: letting models learn from new data.</td></tr>
<tr><td>Qualification Goals*</td><td colspan="5">Students have a basic understanding of the processes governing climate and climate change and are able to understand and apply basic and advanced tools of descriptive and inferential statistics to typical problems in climatology and geoscience. The students will be able to implement these tools as self-developed (Python or other) programming code.</td></tr>
<tr><td rowspan="3">Prerequisites for the allocation of credits / grades (if necessary weighting)*</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CR</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td rowspan="2">Climate Dynamics, Probability and Statistics</td><td>L</td><td>c</td><td>2</td><td>2</td><td rowspan="2">R</td><td rowspan="2">25</td><td rowspan="2">g</td><td rowspan="2">1</td></tr>
<tr><td>E</td><td>c</td><td>2</td><td>2</td></tr>
<tr><td>Applicability*</td><td colspan="5">MSc Geoscience, MSc Applied & Environmental Geoscience, MSc Geoecology.</td></tr>
<tr><td>Participation Prerequisites*</td><td colspan="5">Basic knowledge of statistics and programming is useful, but not required.</td></tr>
</table>

Module Number: **M 324**	**Module Title:** **Economic Geology**								**Type of Module:** MSc Elective
Credits (ECTS)*	6								
Workload* **- Contact Time** **- Private Time**	Workload: 180 h		Contact times: 90 h / 6 SWS						Private Studies: 90 h
Duration of Module* **Module Coordinator**	1 Semester			Staude					
Regular Cycle*	Every second summer semester (starting 2020)								
Language	English / German (can be held in German depending on students)								
Learning-/Teaching Forms*	The module consists of lectures, complemented by exercises, and reflected light microscopy practice								
Module Content*	This module gives insights into the exploration and mining practices used by geologists in the mineral and metal mining sector. The lecture will cover initial theoretical exploration praxis to practical greenfield and brownfield exploration, mining development stages, and mining geology. The focus is set on drilling (methods, planning, supervising, logging), data handling (databases, QAQC – Quality Assurance Quality Control, modelling) and data reporting (JORC code). The practical part focusses on ore textures and their interpretation and the identification of ore and gangue minerals and frequent mineral assemblages by reflected light microscopy.								
Qualification Goals*	In this module the students learn the methods and procedures of the international exploration and mining industry, independently of the commodity. A main aim is to learn the importance of data quality and data management throughout the exploration and mining stages. Graduates will be able to analyse ore minerals and their textures to establish genetic interpretations and identify economic and ecologic impacts.								
Prerequisites for the allocation of credits / grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Applied Economic Geology	*L*	*c*	*3*	*3*	*WE*	*120*	*g*	*0.5*
	Ore Petrology and Reflected Light Microscopy	*L*	*c*	*1*	*3*				*0.5*
		E	*c*	*2*					
Applicability*	The module ‘Economic Geology‘ is in close context to the module "Magmatische Prozesse".								
Participation Prerequisites*	The completion of the module ‘Georessourcen’ (or similar lecture, including basics in reflected light microscopy) is required.								

Module Number: **M 409**	**Module Title:** **Marine Geology and Geochemistry**								**Type of Module:** MSc Elective
Credits (ECTS)*	6 Credits.								
Workload* **- Contact Time** **- Private Study**	Workload: 180 h		Contact Time: 90 h (6 SWS)						Private Studies: 90 h
Duration of Module* **Module Coordinator**	1 Semester				Dr. Hartmut Schulz				
Regular Cycle *	Every Winter Semester								
Language	English								
Learning- /Teaching Forms*	Teacher-centered teaching; studying literature on the subject, talk/exposé, handouts, laboratory practice.								
Module Content*	• Evolution and structure of ocean basins and –margins • Marine sedimentation and –accumulation • Marine natural resources • Ocean circulation/effects of currents and waves • Chemical evolution of the ocean system • Natural and anthropogenic tracers • Methods of survey and sampling								
Qualification Goals*	Students will understand the marine-geological processes between the ocean floor, sedimentation, ocean circulation and the biogeochemical cycles. Candidates learn to analyse and interpret the modern depositional facies, and how to describe elemental fluxes and –fractionations of the oceans. Laboratory and methodological practice on sediment processing and -characterization will provide skills and competence using the large variety of sediment core profiles from the Tübingen repository.								
Prerequisites for the allocation of credits /grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirements*	*Duration of Exam*	*Grading System*	*Weighting*
	Marine Geochemistry	*L,S*	*c*		*2*	*R*	*-*	*g*	*1*
	Marine Geology	*L,S*	*c*		*2*				
	Marine Geology	*E*	*c*		*2*				
Applicability*	Elective module in MSc Geowissenschaften and MSc Geoökologie. Related modules are Paleoecology of Marine Systems, Isotope Geochemistry, Sedimentgeochemie and Faziesanalyse.								
Participation Prerequisites*	BSc-modules of Dynamics of the Earth (Dynamik der Erde), Earth History (Erdgeschichte), Sediments and Stratigraphy (Sedimente und Stratigraphie), Paläontologie (Paleontology), Course limited to 14 students.								

Module Number: **M 606**	**Module Title:** **Numerical Modelling in Geodynamics**		**Type of Module:** MSc Elective
Credits (ECTS)*	6		
Workload* **- Contact Time** **- Private Study**	Workload: 180 h	Contact Time: 60 h / 4 SWS	Private Study: 120 h
Duration of Module* **Module Coordinator**	1 Semester	Koptev	
Regular Cycle*	Winter semester 2020/21		
Language	English		
Learning- / Teaching Forms*	This module includes a combination of lectures and computer exercises (MatLab) related to the lecture topics.		
Module Content*	Numerical modeling of geodynamic processes is an area of frontier research in integrated solid Earth science. This course provides an introduction of the underlying principles and essential elements in numerical geodynamic models, covering the following particular topics: - 1D steady-state thermal structure of the lithosphere: the role of radiogenic heating in the crust and the effect "thermal blanketing" by the sedimentary cover. - 1D rheological structure of the lithosphere: viscous and brittle (plastic) rheologies assigned by a Christmas tree-like criterion, lithospheric strength and effective elastic thickness. - 2D modelling of non-steady-state temperature field: an explicit finite-difference numerical scheme to solve diffusion equation. - 2D modelling of local and regional isostasy: a flexural response of the lithosphere subjected to surface loading/unloading. - 3D modelling of landscape evolution: stream power law river incision combined to diffusional hillslope processes. - 3D coupling of the landscape evolution model with the isostatic rebound of the lithosphere.		
Qualification Goals*	The major goal of this class centers on enabling students to understand the fundamental and intrinsic link between the evolution of surface topography, thermo-rheological structure of the lithosphere and geodynamic processes operating in the Earth interiors. At the same time the acquired technical skills allow students: - to estimate quantitatively the principal mechanical characteristics of the lithosphere (integrated strength, flexural rigidity, effective elastic thickness) based on its composition, thermal state and rheological properties; - to handle the basic principles of discretization of differential equations and to address numerically the key issues in geodynamics and geomorphology; - to develop coupled numerical models of the thermal diffusion in the crust and upper mantle, local or regional isostatic adjustment of the lithosphere and differential fluvial erosion on the surface. The students will be able to perform the quantitative estimates and to design the modelling experiments using self-developed (MatLab) programming scripts.		

Prerequisites for the allocation of credits / grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Numerical Modelling in Geodynamics	*L*	*c*	2	6	*A*	-	*g*	*1*
		E	*c*	2					
Applicability*	MSc Geoscience, MSc Applied & Environmental Geoscience								
Participation Pre-requisites*	Introductory geology. Basic knowledge of programming is useful, but not required.								

Modulnummer: GEO 79	Modultitel: Umwelt I: Bodenschutz		Art des Moduls: Wahlpflicht
ECTS-Punkte	6		
Arbeitsaufwand	Arbeitsaufwand: 180 h	Kontaktzeit: 60 h / 4 SWS	Selbststudium: 120 h
Moduldauer	1 Semester		
Turnus	Wintersemester		
Sprache	Deutsch		
Gruppengröße	20		
Lehrformen	Vorlesung und Übung (2,5 SWS), Seminar (1 SWS), Exkursion (0,5 SWS)		
Modulinhalt	In diesem Modul werden die Fähigkeiten zur Bodenbewertung, zum Ermitteln der Empfindlichkeit und Schutzwürdigkeit von Böden im gesamten Nutzungsspektrum, hin bis zum Bodenschutz auf Baustellen (Bodenkundliche Baubegleitung) vermittelt und trainiert. Zum Egalisieren der Vorkenntnisse und auf die Fragestellungen des Bodenschutzes spezifiziert werden allgemeine Grundlagen der Bodenkunde und im Besonderen wiederholt und geübt. Insbesondere die Fähigkeit zur sicheren ad hoc-Einordnung und Bewertung eines Standorts wird vermittelt. Technische und organisatorische Grundlagen von Maßnahmen des Naturschutzes, der Land- und Forstwirtschaft sowie der Bauausführung und deren jeweiligen Bezüge zum Bodenschutz werden vermittelt. Ethische, rechtliche und administrative Inhalte des Bodenschutzes werden erarbeitet UND eingeordnet: Die Kommunikation von Inhalten des Bodenschutzes bei Beteiligung verschiedener Interessensgruppen wird geübt. Die vermittelten Kenntnisse werden von den Studierenden im Rahmen von Exkursionen und Seminarvorträgen angewandt.		
Qualifikationsziele	• Studierende können Böden und ihre Schutzbedürftigkeit im Landschafts- und Nutzungsbezug systematisch einordnen und interpretieren sowie Schutzmaßnahmen diskutieren, d.h. sie können den Praxisbezug ihrer Bodenkundlichen Kenntnisse herstellen, die sie in dieser und vorrangegangenen Veranstaltungen erworben haben • Sie können Verantwortung in Gruppenarbeiten übernehmen und methodologische Abläufe und Arbeitsschritte planen und koordinieren • Sie sind mit feldbodenkundlichen Techniken vertraut, können den Bedarf an bodenchemischen und bodenphysikalischen Untersuchungen abschätzen sowie entsprechende Ergebnisse interpretieren • Sie haben die Prinzipien der Umweltverwaltung verstanden • Sie sind in der Lage zu Bodenschutzfragen im Sinne eines Interessensausgleich Stellung zu nehmen • Sie können in angemessener Weise Themen des Bodenschutzes kommunizieren und präsentieren		
Gewichtung der Benotung	Studienleistung: erfolgreiche Teilnahme Prüfungsleistung: schriftliche Ausarbeitung		
Verwendbarkeit	MSc Umweltgeographie, MSc Geoökologie, MSc Geowissenschaften, MSc AEG		
Teilnahme-voraussetzungen	BSc Geographie, BSc Geoökologie, BSc Geowissenschaften oder vergleichbar		
Modulverantwortlicher	Andreas Lehmann, Thomas Scholten		
Dozenten	Andreas Lehmann		
Literatur / Materialien	Bekanntgabe oder Weitergabe während der Veranstaltung		

<table>
<tr><td>Module Number:
M T@T WiSe 20/21</td><td colspan="6">Module Title:
Astrobiology: life in extreme environments</td><td colspan="3">Type of Module:
Elective</td></tr>
<tr><td>Credits (ECTS)*</td><td colspan="9">3</td></tr>
<tr><td>Workload*
- Contact Time
- Private Study</td><td colspan="3">Workload:
90 h</td><td colspan="3">Contact Times:
30 h/ 2 SWS</td><td colspan="3">Private Study:
60 h</td></tr>
<tr><td>Duration of Module*
Module Coordinator</td><td colspan="4">1 Semester</td><td colspan="5">Toby Samuels</td></tr>
<tr><td>Regular Cycle*</td><td colspan="9">One time offer WiSe 2020/21</td></tr>
<tr><td>Language</td><td colspan="9">English</td></tr>
<tr><td>Learning- / Teaching Forms*</td><td colspan="9">Lectures, exercises, journal club discussions and a group project</td></tr>
<tr><td>Module Content*</td><td colspan="9">• This course introduces astrobiology, with a particular focus on microbial life in extreme environments and space exploration.
• Topics covered include origin of life theories, habitability, experiments in low-Earth orbit and human health in space.
• Students will undertake a group project in which they select a future landing site for a speculative mission to Mars, based upon their analyses of provided data.</td></tr>
<tr><td>Qualification Goals*</td><td colspan="9">At the end of the course students will have:
• An appreciation for the numerous methodological and conceptual approaches required to address fundamental questions in an interdisciplinary field.
• An understanding of how knowledge acquired in extreme environments on Earth informs our search for life elsewhere.
• An ability to critically analyze data published in scientific literature.
• An ability to manipulate, analyze and present data relevant to planetary exploration.</td></tr>
<tr><td rowspan="2">Prerequisites for the allocation of credits /grades (if necessary weighting)*</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CR</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td>Astrobiology: life in extreme environments</td><td>L,S, E</td><td>c</td><td>2</td><td>3</td><td>R</td><td></td><td>g</td><td>1</td></tr>
<tr><td>Applicability*</td><td colspan="9">The module adresses students from various fields of Geosciences taught by a T@T lecturer and complements competences acquired in these programs.
Applicants from outside these programs interesting in taking the course should contact the module coordinator to determine suitability.</td></tr>
<tr><td>Participation Prerequisites*</td><td colspan="9">A bachelor’s degree in a scientific discipline (biology, chemistry, geosciences, physics). Undergraduate-level knowledge of microbiology will be useful but is not essential.</td></tr>
</table>

Module Number: **Bio-ZMBP (Modul aus der Biologie)**	**Module Title:** **Applications of electron microscopy in cell biology, microbiology and virology / Anwendung der Elektronenmikroskopie in Zellbiologie, Mikrobiologie und Virologie**					**Type of Module:** MSc Elective			
Credits (ECTS)*	6								
Workload* **- Contact Time** **- Private Study**	Workload: 180 h	Contact Time: 90 h / 6 SWS				Private Study: 90 h			
Duration of Module* **Module Coordinator**	1 Semester	Fischer							
Regular Cycle*	Winter semester								
Language	English								
Learning- / Teaching Forms*	Lecture, exercise/tutorial, seminar								
Module Content*	The aim of the practical is to give participants a comprehensive and critical overview of the possibilities of electron microscopy in biological research based on their own preparative experience on selected objects in different institutes (University, University clinics, MPI, NMI): Preparation of bacterial cells, viruses and proteins: negative contrasting, plunge freezing for cryo-transmission electron microscopy. Preparation of cells, tissues, organisms: chemical fixation, cryofixation, embedding for ultramicrotomy, ultra-thin section technique, freeze-drying and freeze-breaking, critical point drying; methods of immunolabelling for electron microscopy, correlative light and electron microscopy, cryo-scanning electron microscopy, sample processing with focused ion beam (FIB) in scanning electron microscope, energy dispersive X-ray spectroscopy (EDX). Design and function of various microscopes: fluorescence and confocal laser scanning microscopes, (cryo)transmission and (cryo)scanning electron microscopes. Image analysis: Image montages, analysis and evaluation (addressing typical artifacts) of SEM & TEM image material using Open Source Software packages								
Qualification Goals*	- Introduction to independent microscopic work - Knowledge of fluorescence microscopy (basics) and transmission and scanning electron microscopic imaging techniques and important preparation methods - Analysis and interpretation of microscopic images - Documenting and communicating the results of examinations - Knowledge of the advantages and disadvantages of the respective techniques and methods - Critical work and development of a sound professional judgement - Ability to work in a team - Presentation of results in English language								
Prerequisites for the allocation of credits / grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
		L	*c*	*1*	*1*	*LP*	*-*	*g*	*1*
		E	*c*	*4*	*4*				

		S	*c*	*1*	*1*				
Applicability*	MSc Applied & Environmental Geoscience, MSc Geowissenschaften, MSc Geoökologie								
Participation Pre-requisites*	none								