EBERHARD KARLS
UNIVERSITÄT
TÜBINGEN

Module Handbook

as at: 10.04.24

Applied & Environmental Geoscience
Master of Science

Faculty of Science
Department of Geosciences

Contents

1. Admission Requirements

Prerequisites for the Master's program in Applied & Environmental Geoscience are

- a Bachelor's degree in one of the subjects of geology, geoecology, environmental science, geophysics, mineralogy, physical geography, soil science, mathematics, physics, chemistry, biology, computer science, civil engineering, or in a related program with environmental relevance in which a grade of 2.5 or better was achieved
    - a proof of knowledge of English at least at the level of B2 of the Common European Framework of Reference for Languages (CEFR)
    - a minimum of six credit points in each of the following subjects/areas of knowledge must be completed in the prior Bachelor's or Master's degree studies:
        Mathematics
        Physics
        Chemistry
        Geology (6 credit points of geology can be obtained within the AEG program)

If courses up to 30 CP are lacking, an admission is possible with the condition to catch up these courses within the framework of a learning agreement.

2. Qualification Goals

The international research-oriented M.Sc. program "Applied & Environmental Geoscience" (AEG) is directed towards a quantitative understanding and evaluation of environmental problems with a 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.

For an individual study focus, students choose one of three specializations

- Environmental Chemistry and Environmental Microbiology
- Environmental Physics
- Hydrogeology

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 fields and core competences in environmental chemistry, groundwater modeling and understanding global change, essential for understanding the basic paradigms and concepts in environmental geosciences taught in Tübingen. Independent of the individual focus of a student, a common 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 problems.

This enables students to

- define and analyze environmental problems,
- plan and undertake appropriate field and laboratory investigations (collecting, recording

and analyzing relevant data sets),
- present and interpret data, and
- develop ecologically and economically sound mitigation strategies.

Students benefit from close interaction with staff and research groups 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 (hydrogeological, geophysical, chemical and microbiological analysis),
- assessment of environmental risks,
- water resources 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.

3. Module Overview

To complete the program, students have to earn 120 credits points from a suite of five compulsory modules (accounting for 30 credit points), ten elective modules (60 credit points) and a Master thesis (30 credit points).

Compulsory Modules and Specializations

- **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, the fate and behavior of chemicals in the environment can be predicted.
- **Global Change** establishes a fundamental quantitative scientific understanding of various global-change processes. Different topics are presented and discussed in a combination of lectures and seminar presentations introducing and comparing climatic systems of the past and presence, climate change models, possible impacts of global change processes on various environmental systems and compartments (regions, species, pollution, land use) and future effects.
- **Groundwater Modeling 1** introduces the basic concepts of quantitative subsurface hydrology in different geological environments. Students acquire general competences in the basic physical principles of groundwater flow. They can calculate groundwater flow for simple geometries and are aware of the underlying assumptions. The students know how to set up a computer model for groundwater flow and how to calibrate it. Practical experience in groundwater-flow modeling provides them with necessary key competences needed to tackle standard hydrogeological problems and enables them to use professional standard software packages.

The two additional compulsory modules, namely **Scientific Practice** and **Scientific Presentation** (semesters 3-4), 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** in the third semester is targeted at the formulation of a research agenda for the M.Sc. thesis in the fourth semester.
- **Scientific Presentation** includes: the preparation and presentation of a poster with results of the Master Thesis project at the Master Day, an oral presentation in the respective research group, the participation in a workshop on presentation techniques and the attendance of at least 8 institute seminars.

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

Elective Modules

For each of the three specializations (*Hydrogeology*, *Environmental Chemistry and Environmental Microbiology* or *Environmental Physics*), a combination of three elective core modules (for a total of 18 credits), which are of special relevance, are defined and must be incorporated in the respective program of studies.

Specialization in *Environmental Chemistry and Environmental Microbiology* requires

- Biotransformation of Pollutants
- Environmental Analytical Chemistry
- Hydrogeochemical Modeling

Specialization in *Environmental Physics* requires

- Atmospheric Physics
- Climate Dynamics
- Physics of the Earth’s Surface

Specialization in *Hydrogeology* requires

- Groundwater Modeling 2
- Hydrogeological Field Investigation Techniques
- Remediation of Contaminated Sites

The remaining necessary forty-two credits can be chosen from any of the available elective modules. The following figures show the degree program for all three specializations.

Upon request, additional modules related to the content and qualification objectives of the course can be admitted as elective modules by the chairperson of the examination board.

Medium of Instruction

AEG courses are taught in English and course notes in English will accompany the lecture series. In the elective area, additional modules in German can be chosen.

Specialization Environmental Chemistry and Environmental Microbiology

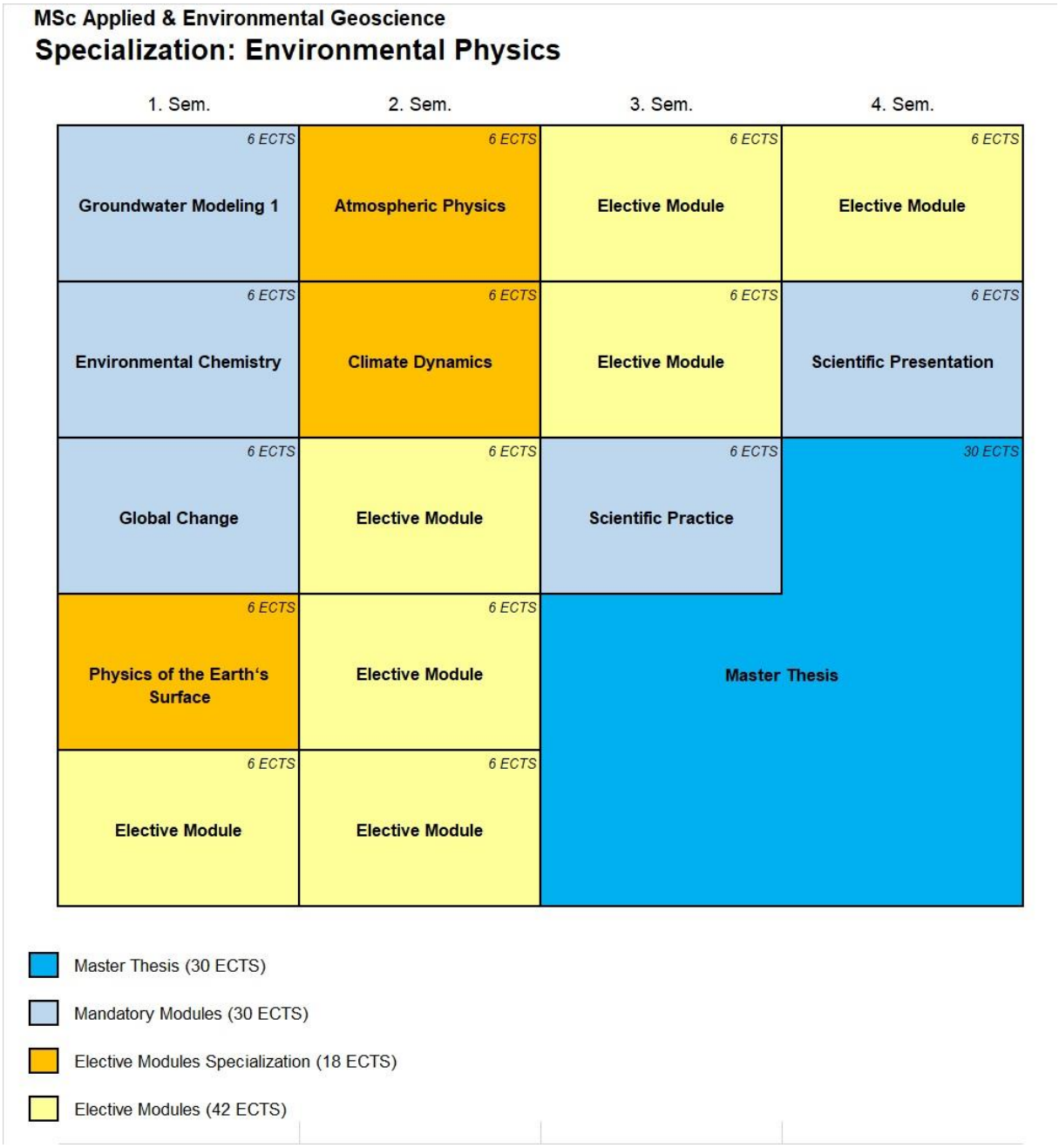
MSc Applied & Environmental Geoscience

Specialization: Environmental Chemistry and Environmental Microbiology

1. Sem.	2. Sem.	3. Sem.	4. Sem.
6 ECTS **Groundwater Modeling 1**	6 ECTS **Hydrogeochemical Modeling (Modeling of Reactions, Microbial Dynamics and Bioreactive Transport)**	6 ECTS **Elective Module**	6 ECTS **Elective Module**
6 ECTS **Environmental Chemistry**	6 ECTS **Elective Module**	6 ECTS **Elective Module**	6 ECTS **Scientific Presentation**
6 ECTS **Global Change**	6 ECTS **Elective Module**	6 ECTS **Scientific Practice**	30 ECTS **Master Thesis**
6 ECTS **Environmental Analytical Chemistry**	6 ECTS **Elective Module**		
6 ECTS **Biotransformation of Pollutants**	6 ECTS **Elective Module**		

- Master Thesis (30 ECTS)
- Mandatory Modules (30 ECTS)
- Elective Modules Specialization (18 ECTS)
- Elective Modules (42 ECTS)

Specialization Environmental Physics



Specialization Hydrogeology

MSc Applied & Environmental Geoscience

Specialization: Hydrogeology

1. Sem.	2. Sem.	3. Sem.	4. Sem.
6 ECTS **Groundwater Modeling 1**	6 ECTS **Hydrogeological Field Investigation Techniques**	6 ECTS **Elective Module**	6 ECTS **Elective Module**
6 ECTS **Environmental Chemistry**	6 ECTS **Remediation of Contaminated Sites**	6 ECTS **Elective Module**	6 ECTS **Scientific Presentation**
6 ECTS **Global Change**	6 ECTS **Groundwater Modeling 2**	6 ECTS **Scientific Practice**	30 ECTS **Master Thesis**
6 ECTS **Elective Module**	6 ECTS **Elective Module**		
6 ECTS **Elective Module**	6 ECTS **Elective Module**		

- Master Thesis (30 ECTS)
- Mandatory Modules (30 ECTS)
- Elective Modules Specialization (18 ECTS)
- Elective Modules (42 ECTS)

4. Module Handbook M.Sc. 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 2021. The module content, lecturers as well as single lectures might be subject to changes.

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 = term paper/assignment, 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
CP:	Leistungspunkte (ECTS-Punkte)	**CP:**	Credits (ECTS)

In addition to the recommended elective modules listed in the following table under ***Applied Geoscience*** more modules offered in the M.Sc. program Geowissenschaften/Geosciences 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 B.Sc. 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

Module Number	*Module Title*	*Module Coordinator*	*CP*	*Semester*
M 101	Scientific Practice	Merkel	6	W / S
M 103	Scientific Presentation	Bocherens	6	W / S
M 104	Master Thesis (Abschlussmodul)	-	30	W / S
M 201	Groundwater Modeling 1	Cirpka	6	W
M 207	Environmental Chemistry	Zarfl	6	W
M 229	Global Change	Rehfeld	6	W

Elective Modules

Module Number	*Module Title*	*Module Coordinator*	*CP*	*Semester*
Accepted B.Sc. Modules				
B 408	Geophysik / Geophysics	Drews	6	S
B 504	Hydrology	Glaser	6	W
B 506	Water Treatment	Angenent	3	W
B 514	Introduction Earth Surface Processes	Beer	6	W
M.Sc. Modules Applied Geosciences				
M 202	Hydrogeological Field Investigation Techniques	Leven	6	S
M 203	Groundwater Modeling 2	Yuan	6	S
M 205	Remediation of Contaminated Sites	Finkel	6	S
M 206	Case Studies in Environmental Geosciences	Cirpka	6	W
M 208	Environmental Isotope Chemistry	Taubald	6	S
M 209	Environmental Chemistry Lab	Haderlein	6	W
M 210	Environmental Microbiology and Geomicrobiology	Kappler	6	S
M 211	Geomicrobiology Lab	Kappler	6	S
M 212	Advanced Geophysics	Drews	6	W
M 213	GIS and Remote Sensing	Schäuble, Lörcher	6	W
M 214	Geotechnical Engineering	Leven	6	W
M 216	Atmospheric Physics	Platis	6	S
M 218	Environmental Analytical Chemistry	Zwiener	6	W
M 219	Earth Processes	Süß	6	W

M 220	Field Seminars in Applied Geosciences	Merkel	6	W / S
M 221	Environmental and Human Health Risk Assessment of Chemicals	Escher	6	W
~~M 222~~	~~Hydrogeochemical Modeling~~ ➔ substituted by module M 242		~~6~~	~~S~~
M 225	Field Seminars in Applied Geosciences 2	Merkel	3	W / S
M 227	Sustainable Environmental Biotechnology Systems 1	Angenent	6	S
M 228	Sustainable Environmental Biotechnology Systems 2	Angenent	6	W
M 230	Geosphere-Biosphere Interactions	Dippold	6	S
M 232	Internship	Glotzbach	6	W / S
M 233	Biotransformation of Pollutants	Joshi	6	W
M 236	Modelling for Sustainable River Management	Zarfl	6	S
M 238	Rhizosphere Processes in a Changing World	Mühe	6	W
M 239	Geo-Bio-Interactions in Tropical Landscapes of Kenya	Otieno, Dippold	6	W
M 240	Isotopes in Ecosystem Sciences	Dippold, Stock	6	W
M 241	Climate Modeling	Rehfeld	6	S
M 242	Modeling of Reactions, Microbial Dynamics and Bioreactive Transport	Cirpka	6	S
M 243	Tropical Ecology of South America	Ebner	6	W, every other year
M 244	Geothermal Reservoirs	Süß	6	S
M.Sc. Modules Mineralogy and Geology, Biogeology				
M 301	Physics of the Earth's Surface	Glotzbach	6	W
M 305	Advanced Field Methods in Geoscience	Bons	6	W / S
M 308	Isotope Geochemistry	Schönberg	6	W
M 311	Carbonate Facies Analysis	Nebelsick	6	W
M 312	Advanced Sedimentology	Fitzsimmons	6	W
M 315	Glaciology	Weikusat	6	W
M 317	Data Analysis and Modeling Methods in Geoscience and Environmental Science	Drews	6	W / S
M 321	Experimental and Analytical Methods in Geoscience and Environmental Science	Schulz, Berthold	6	W
M 322	Climate Dynamics	Rehfeld	6	S
M 324	Economic Geology	Staude	6	S, every other year
M 325	Data Analysis and Modeling Methods in Geoscience and Environmental Science 2	Drews	6	W / S

M 326	Experimental and Analytical Methods in Geoscience and Environmental Science 2	Schulz, Berthold	6	S
M 409	Marine Geology and Geochemistry	Schulz	6	W
Additional Elective Modules				
T@T WiSe 23/24_SoSe 24	Biogeochemistry of Soil Contamination	Mehrnoosh Gol-Soltani	6	W 23/24 / S 24
Single Events / Teach@Tübingen Lectures / M.Sc. Modules from other Departments on demand after approval of the examination board				

<table>
<tr><td>Module Number:
M 101</td><td colspan="4">Module Title:
Scientific Practice</td><td colspan="4">Type of Module:
M.Sc. Compulsory</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:
Approx. 20 h</td><td colspan="3">Private Study:
160 h</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="3">1 semester</td><td colspan="5">Merkel</td></tr>
<tr><td>Regular Cycle</td><td colspan="8">every semester (recommended in the 3rd semester)</td></tr>
<tr><td>Language</td><td colspan="8">English</td></tr>
<tr><td>Learning- / Teaching Forms</td><td colspan="8">Individual guidance by supervisor, scientific papers</td></tr>
<tr><td>Module Content</td><td colspan="8">• 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</td></tr>
<tr><td>Qualification Goals</td><td colspan="8">• 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.</td></tr>
<tr><td>Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td></td><td>Scientific Practice</td><td>PR</td><td>c</td><td>1</td><td>6</td><td>A</td><td>-</td><td>ng</td><td>-</td></tr>
<tr><td>Applicability</td><td colspan="8">M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience</td></tr>
<tr><td>Prerequisites</td><td colspan="8">-</td></tr>
</table>

<table>
<tr><td>Module Number:
M 103</td><td colspan="4">Module Title:
Scientific Presentation</td><td>Type of Module:
M.Sc. Compulsory</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
Module Coordinator</td><td colspan="3">1 semester</td><td colspan="2">Bocherens</td></tr>
<tr><td>Regular Cycle</td><td colspan="5">every semester</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Learning- / Teaching Forms</td><td colspan="5">Oral seminar presentations and poster</td></tr>
<tr><td>Module Content</td><td colspan="5">• Four participations at the Master’s Day event, including one attendance with a poster presentation of the results of the Master’s Thesis project
• A presentation of the results of the Master Thesis in the respective research group
• Attendance at 8 institute seminars</td></tr>
<tr><td>Qualification Goals</td><td colspan="5">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.</td></tr>
<tr><td rowspan="4">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td>Attendance of 8 Institute Seminars and 4 participations on the Master Day</td><td>S</td><td>c</td><td>2</td><td rowspan="3">6</td><td>R</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Poster Project</td><td>PR</td><td>c</td><td>1</td><td>A</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Presentation of the M.Sc. thesis in the Research Group</td><td>PR</td><td>c</td><td>-</td><td>R</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Applicability</td><td colspan="5">M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience</td></tr>
<tr><td>Prerequisites</td><td colspan="5">Scientific Practice</td></tr>
</table>

Module Number: **M 104**	Module Title: **Master Thesis (Abschlussmodul)**								Type of Module: M.Sc. 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 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								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Master Thesis	*PR*	*c*	*-*	*30*	*A*	*6 months*	*g*	*1*
Applicability	M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience								
Prerequisites	Completion of all required courses								

<table>
<tr><td>Module Number:
M 201</td><td colspan="4">Module Title:
Groundwater Modeling 1</td><td>Type of Module:
M.Sc. Compulsory / 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
Module Coordinator</td><td colspan="3">1 semester</td><td colspan="2">Cirpka</td></tr>
<tr><td>Regular Cycle</td><td colspan="5">every winter semester (1st semester)</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Learning- / Teaching Forms</td><td colspan="5">Ex-cathedra lecture sessions and computer exercises</td></tr>
<tr><td>Module Content</td><td colspan="5">The module gives an introduction into the processes and mathematical description of flow and transport and aquifers and soils (physical hydrogeology and groundwater hydraulics). The emphasis is on closed-form solutions of the groundwater-flow and transport equations. Topics include:
Characterization of aquifers
Concept of the porous medium
Derivation of the groundwater-flow and Richards equation
Analytical solutions (steady-state and transient 1-D solutions, well hydraulics)
Regional groundwater flow
Multi-phase partitioning of solutes
Derivation of the advection-dispersion equation
Analytical solutions for solute transport</td></tr>
<tr><td>Qualification Goals</td><td colspan="5">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 transport. They can calculate groundwater flow and solute transport for simple geometries and are aware of the underlying assumptions. They acquire the key competences needed to tackle standard hydrogeological problems by analytical solutions.</td></tr>
<tr><td rowspan="3">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</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">Groundwater Modeling 1</td><td>L</td><td>c</td><td>4</td><td>3</td><td rowspan="2">WE</td><td rowspan="2">90</td><td rowspan="2">g</td><td rowspan="2">1</td></tr>
<tr><td>E</td><td>c</td><td>2</td><td>3</td></tr>
<tr><td>Applicability</td><td colspan="5">Compulsory: M.Sc. Applied & Environmental Geoscience; Elective: M.Sc. Geo-wissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology</td></tr>
<tr><td>Prerequisites</td><td colspan="5">Students have a firm background in mathematics and physics corresponding to the competences acquired in the BSc modules Mathematik für Naturwissenschaftler and Physik. They have basic programing skills in Matlab.</td></tr>
</table>

<table>
<tr><td>Module Number:
M 207</td><td colspan="8">Module Title:
Environmental Chemistry</td><td>Type of Module:
M.Sc. Compulsory / 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
Module coordinator</td><td colspan="5">1 semester</td><td colspan="4">Zarfl</td></tr>
<tr><td>Regular Cycle</td><td colspan="9">every winter semester (recommended for 1st 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
• 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="9">• 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">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td>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>Environmental Chemistry Exercises</td><td>E</td><td>c</td><td>2</td></tr>
<tr><td>Environmental Chemistry Tutorials</td><td>E</td><td>op</td><td>2</td></tr>
<tr><td>Applicability</td><td colspan="9">Compulsory: M.Sc. Applied & Environmental Geoscience, Elective: M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology</td></tr>
<tr><td>Prerequisites</td><td colspan="9">Basic knowledge in chemistry, physics, hydrogeology</td></tr>
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<table>
<tr><td>Module Number:
M 229</td><td colspan="4">Module Title:
Global Change</td><td colspan="4">Type of Module:
M.Sc. Compulsory / 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:
65 h / 5 SWS</td><td colspan="3">Private Study:
115 h</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="3">1 semester</td><td colspan="5">Rehfeld</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">Per week: 3 h lecture (2 h + 1 h), 2 h seminar (2 student talks of 15 minutes plus discussion with two opposing hypotheses and groups, 2 students per talk)</td></tr>
<tr><td>Module Content</td><td colspan="8">• Analytical Climate System
• Climate of Today (modern climate change including observation and models)
• Climate System of the Past
• Future Global Change including climate and resources
• Impacted Systems (regions, species, pollution, land use)
• Counter Measures</td></tr>
<tr><td>Qualification Goals</td><td colspan="8">Quantitative scientific understanding of global change (especially climate, resources, pollution), how to measure and model global-change variables in time and in sub-systems, technological options for countermeasures The students know the current state of research and are able to present and communicate the underlying concepts in presentations and discussions.</td></tr>
<tr><td rowspan="3">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</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">Global Change</td><td>L</td><td>C</td><td>39</td><td>4</td><td>WE</td><td>2</td><td>g</td><td>66, 6</td></tr>
<tr><td>S</td><td>C</td><td>26</td><td>2</td><td>R</td><td>1</td><td>g</td><td>33, 3</td></tr>
<tr><td>Applicability</td><td colspan="8">Compulsory: M.Sc. Applied & Environmental Geoscience; Elective: M.Sc. Geoökologie/Geoecology</td></tr>
<tr><td>Prerequisites</td><td colspan="8">-</td></tr>
</table>

<table>
<tr><td>Module Number:
B 408</td><td colspan="5">Module Title:
Geophysik / Geophysics</td><td colspan="4">Type of Module:
B.Sc. Compulsory / 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:
75 h / 5 SWS</td><td colspan="3">Private Study:
105 h</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="4">1 semester</td><td colspan="5">Drews</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">The module uses a combination of in-class lectures, in-class exercises, applied field exercises and online videos.</td></tr>
<tr><td>Module Content</td><td colspan="9">This module offers a broad introduction into the principles of applied geophysics with a focus on sub-surface imaging techniques using gravimetry, magnetics, seismics, geoelectrics and electromagnetics. Field based exercises are conducted in small groups offering ‘hands on’ experiences in collecting, processing and interpretation of geophysical data. In-class exercises include theoretical problem-solving, self-designed practical setup (e.g., using minicomputers and smart phones), and computational methods.</td></tr>
<tr><td>Qualification Goals</td><td colspan="9">(1) Obtain a basic understanding of geophysical sub-surface imaging techniques in theory & practice, and understand relevant earth-system processes and parameters where these techniques can be applied.
(2) Develop transferable skills in quantitative data analysis and rigorous problem solving strategies using physics and mathematics.</td></tr>
<tr><td rowspan="3">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</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">Geophysik / Geophysics</td><td>L</td><td>c</td><td>4</td><td>4</td><td>WE +A</td><td>90</td><td>g</td><td>1</td></tr>
<tr><td>FE</td><td>c</td><td>1</td><td>2</td><td>A</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Applicability</td><td colspan="9">Compulsory: B.Sc. Geowissenschaften (recommended in the 4th semester), B.Sc. Umweltnaturwissenschaften (recommended in the 2nd semester), Elective: M.Sc. Applied & Environmental Geoscience</td></tr>
<tr><td>Prerequisites</td><td colspan="9">A firm background in mathematics and physics is expected.</td></tr>
</table>

Module Number: **B 504**	Module Title: **Hydrology**					Type of Module: B.Sc. Elective			
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h	Contact Time: 60 h / 4 SWS				Private Study: 120 h			
Duration Module Coordinator	1 Semester	Glaser							
Regular Cycle	every winter semester								
Language	English								
Learning- / Teaching Forms	Lecture and Exercise								
Module Content	The module is divided into thematic blocks that build on each other and become increasingly specific. The first block describes the global water quantity and its distribution to essential compartments, as well as the circulation in the water cycle. The next block focuses on the hydrological catchment area as the basic unit for hydrological considerations of all kinds and outlines the main quantitative catchment processes up to the discharge at the outlet of the area. Another block deals with material balance and river load, qualitative aspects of hydrological transport systems, also under consideration of the respective time scale.								
Qualification Goals	The students • understand the dynamics of water and how it circulates between compartments and are able to formulate the water balance equation for specific problems • understand hydrological catchments as system units and are able to reconstruct essential catchment processes, such as flood generation • recognize the complexity of water and water quality aspects • can carry out flux calculations and set up mass balances • understand the interactions between geology, climate, hydrology and landscape development • know important aspects of water management and the conflicts arising from it, e.g. hydropower use - water protection								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Hydrology	*L* *E*	*o* *o*	*2* *2*	*3* *3*	*WE*	*90*	*g*	*1*
Applicability	B.Sc. Geowissenschaften, B.Sc. Geoökologie, B.Sc. Umweltnaturwissenschaften Due to the intensive interconnection of the hydrological cycle with all compartments and the social importance of water as a resource, the knowledge imparted is very helpful for understanding most environmentally relevant issues, such as pollutant transport, climate change or nature conservation. Furthermore, one of the main focuses of the module is the understanding of fluxes and setting up mass balances. These skills are of practical relevance to any natural scientist beyond the field of hydrology.								
Prerequisites	a solid basic education in natural sciences and geology/geomorphology								

<table>
<tr><td>Module Number:
B 506</td><td colspan="5">Module Title:
Water Treatment</td><td>Type of Module:
B.Sc. Compulsory / Elective</td></tr>
<tr><td>Credits (ECTS)</td><td colspan="7">3</td></tr>
<tr><td>Workload
- Contact Time
- Private Study</td><td colspan="2">Workload:
90 h</td><td colspan="3">Contact Time:
45 h / 3 SWS</td><td>Private Study:
45 h</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="3">1 semester</td><td colspan="4">Angenent</td></tr>
<tr><td>Regular Cycle</td><td colspan="7">every winter semester</td></tr>
<tr><td>Language</td><td colspan="7">English</td></tr>
<tr><td>Learning- / Teaching Forms</td><td colspan="7">The module includes lectures and accompanying exercises</td></tr>
<tr><td>Module Content</td><td colspan="7">The module includes
• Basics of Water and Wastewater Treatment
- Coagulation, filtration, sedimentation
- Adsorption
- Membrane Filtration
- Oxidation
- Disinfection
- Activated Sludge Plants
- Sludge Treatment
- Anaerobic Digestion
- Alternative and modern processing
• Combination of individual processes
• Up-to-date examples of drinking water treatment plants and wastewater treatment plants</td></tr>
<tr><td>Qualification Goals</td><td colspan="7">Students understand the basics of physical, chemical, and biological processes of drinking water treatment and wastewater 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">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</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="7">B.Sc. Geowissenschaften, B.Sc. Geoökologie, B.Sc. Umweltnaturwissenschaften, M.Sc. Applied & Environmental Geoscience</td></tr>
<tr><td>Prerequisites</td><td colspan="7">Basic background in Chemistry and Physics comparable to contents that can be accquired in the modules of the BSc program</td></tr>
</table>

<table>
<tr><td>Module Number:
B 514</td><td colspan="4">Module Title:
Introduction to Earth Surface Processes</td><td>Type of Module:
B.Sc. 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 Times:
60 h / 4 SWS</td><td>Private Study:
120 h</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="3">1 Semester</td><td colspan="2">Beer</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">Lectures and Exercises</td></tr>
<tr><td>Module Content</td><td colspan="5">• 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: rock weathering; glacier flow, fluvial and eolian erosion, transport, and deposition; and hillslope mechanics.
• Field examples and application of geomorphic methods for quantifying the rates of fluvial and hillslope processes, and landscape modelling.</td></tr>
<tr><td>Qualification Goals</td><td colspan="5">At the end of the course the students will have:
• A good understanding of the theoretical underpinnings of the physics and chemistry of Earth’s surface processes;
• Interpreting landscape evolution using observations and theory for applications such as risk assessment (e.g. hillslope failure, outburst floods) and geo-engineering.
• Practical experience using field instrumentation, basic computer modelling of landscape evolution (Matlab) and remote sensing</td></tr>
<tr><td rowspan="3">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</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">Introduction to Earth Surface Processes</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"></td></tr>
<tr><td>E</td><td>c</td><td>2</td></tr>
<tr><td>Applicability</td><td colspan="8">B.Sc. Geowissenschaften, B.Sc. Geoökologie, B.Sc. Umweltnaturwissenschaften, M.Sc. Applied & Environmental Geoscience</td></tr>
<tr><td>Prerequisites</td><td colspan="8">"Introduction to Geosciences", "Mathematik 1 für Naturwissenschaftler", "Mathematik 2 für Naturwissenschaftler" (recommended)</td></tr>
</table>

Module Number: **M 202**	Module Title: **Hydrogeological Field Investigation Techniques**								Type of Module: M.Sc. Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: 90 h / 6 SWS						Private Study: 90 h
Duration Module Coordinator	1 semester				Leven				
Regular Cycle	every summer semester (subsequent to the module Groundwater Modeling 1)								
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.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*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	M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience It is related to other method-oriented modules of applied geosciences (e.g. Geotechnical Engineering, Praktische Hydrogeologie, Hydrogeologie und Wasserchemie, Geophysics).								
Prerequisites	The module requires the competences of the M.Sc. module "Groundwater Modeling 1".								

<table>
<tr><td>Module Number:
M 203</td><td colspan="4">Module Title:
Groundwater Modeling 2</td><td colspan="4">Type of Module:
M.Sc. 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
Module Coordinator</td><td colspan="4">1 semester</td><td colspan="4">Yuan</td></tr>
<tr><td>Regular Cycle</td><td colspan="8">every summer semester (recommended 2nd semester)</td></tr>
<tr><td>Language</td><td colspan="8">English</td></tr>
<tr><td>Learning- / Teaching Forms</td><td colspan="8">Theoretical aspects of numerical flow-and-transport modeling are taught in ex-cathedra lecture sessions. Extensive computer exercise tutorials provide students with ‘hands on’ experiences in modeling groundwater-flow and transport problems.</td></tr>
<tr><td>Module Content</td><td colspan="8">The module gives an introduction into the numerical modeling of groundwater flow and conservative transport. Topics include:
Discretization methods for groundwater flow (Finite Volume Method) and solute transport (particle tracking, Finite Volume Method)
Finite Volumes “by hand”
Modeling of steady-state and transient groundwater flow with MODFLOW
Calibration of numerical groundwater-flow models
Modeling of solute transport with MT3DMS</td></tr>
<tr><td>Qualification Goals</td><td colspan="8">Students understand the principles of computer models for groundwater flow and solute transport. They can set up simple numerical models themselves. They can use standard computer codes for groundwater flow-and-transport problems. They are proficient in the workflow of practical groundwater-flow modeling studies (design of a site-specific conceptual model, discretization of the problem, use of professional simulation software, calibration of the model to data, reporting).</td></tr>
<tr><td rowspan="3">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</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">Groundwater Modeling 2</td><td>L</td><td>c</td><td>4</td><td>4</td><td rowspan="2">WE</td><td rowspan="2">180</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="8">M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience</td></tr>
<tr><td>Prerequisites</td><td colspan="8">Students have competences corresponding to those of the MSc Module Groundwater Modeling 1. They have basic programing skills in Matlab.</td></tr>
</table>

<table>
<tr><td>Module Number:
M 205</td><td colspan="4">Module Title:
Remediation of Contaminated Sites</td><td>Type of Module:
M.Sc. 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
Module Coordinator</td><td colspan="3">1 semester</td><td colspan="2">Finkel</td></tr>
<tr><td>Regular Cycle</td><td colspan="5">every summer semester (recommended in the 3rd semester)</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Learning- / Teaching Forms</td><td colspan="5">Flipped classroom: Students work individually on lectures, which are followed by discussion sessions including tutorials; additionally, students work on case study projects to address practical problems quantitatively.</td></tr>
<tr><td>Module Content</td><td colspan="5">• 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</td></tr>
<tr><td>Qualification Goals</td><td colspan="5">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.</td></tr>
<tr><td rowspan="3">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</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">Remediation of Contaminated Sites</td><td>L,E</td><td>c</td><td>2</td><td>3</td><td>A</td><td>2h</td><td>g</td><td>0,5</td></tr>
<tr><td>PR</td><td>c</td><td>2</td><td>3</td><td>R</td><td>-</td><td>g</td><td>0,5</td></tr>
<tr><td>Applicability</td><td colspan="5">M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience</td></tr>
<tr><td>Prerequisites</td><td colspan="5">M.Sc. modules "Groundwater Modeling 1", "Environmental Chemistry" or equivalent competences</td></tr>
</table>

Module Number: **M 206**	Module Title: **Case Studies in Environmental Geosciences**								Type of Module: M.Sc. Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: 30 h / 2 SWS						Private Study: 150 h
Duration 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.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*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	M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience								
Prerequisites	Competences corresponding to the M.Sc. modules "Grondwater Modeling 1" and "Groundwater 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:
M.Sc. 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
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 geochemistry (definitions, fractionation mechanisms, etc.)
• Relevant isotope systems for the hydrosphere (esp. C, H, O, N, S)
• Organic and Compound-specific organic isotope chemistry
• Application of isotope systems for 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">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</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">A</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">M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience</td></tr>
<tr><td>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>Type of Module:
M.Sc. 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
Module coordinator</td><td colspan="3">1 semester</td><td colspan="2">Haderlein</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">Lab experiments in small teams; project, seminar</td></tr>
<tr><td>Module Content</td><td colspan="5">• Analytical methods for organic & inorganic contaminants in environmental samples
• Concepts and methods for the quantification of contaminants and degradation processes
• Insights in current research projects in the fields of environmental chemistry & environmental microbiology</td></tr>
<tr><td>Qualification Goals</td><td colspan="5">• Knowledge and application of key lab techniques in environmental chemistry (Sampling, extraction- & enrichment techniques, chromatography (IC, GC, HPLC); mass spectrometry; stable isotope analyses)
• Experimental design; practical laboratory skills; evaluation and interpretation of experimental data and their uncertainty.
• Knowledge of current research topics in environmental chemistry & microbiology.</td></tr>
<tr><td rowspan="4">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</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>LC</td><td>c</td><td>5</td><td rowspan="2">6</td><td>SP</td><td>-</td><td>g</td><td>0,4</td></tr>
<tr><td>PR</td><td>c</td><td>1</td><td>LP</td><td>-</td><td>g</td><td>0,6</td></tr>
<tr><td colspan="8">Grading is based on the lab performance, lab protocols and final report; no final exam.</td></tr>
<tr><td>Applicability</td><td colspan="5">M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience</td></tr>
<tr><td>Prerequisites</td><td colspan="5">General chemistry; aquatic chemistry; micobiology on B.Sc. level
M.Sc. module "Environmental Chemistry 1"</td></tr>
</table>

<table>
<tr><td>Module Number:
M 210</td><td colspan="3">Module Title:
Environmental Microbiology and Geomicro-biology</td><td>Type of Module:
M.Sc. 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:
60 h / 4 SWS</td><td>Private Study:
120 h</td></tr>
<tr><td>Duration
Module coordinator</td><td colspan="2">1 semester</td><td colspan="2">Kappler</td></tr>
<tr><td>Regular Cycle</td><td colspan="4">every summer semester</td></tr>
<tr><td>Language</td><td colspan="4">English</td></tr>
<tr><td>Learning- / Teaching Forms</td><td colspan="4">Lecture and seminar (student presentations)</td></tr>
<tr><td>Module Content</td><td colspan="4">• General environmental microbiology and geomicrobiology
• Microbial degradation of pollutants
• Redox zonation, thermodynamics
• Microbe-mineral interactions
• Bioremediation
• Biogeochemical cycles</td></tr>
<tr><td>Qualification Goals</td><td colspan="4">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)</td></tr>
<tr><td rowspan="2">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td>Environmental Microbiology and Geomicrobiology</td><td>L,S</td><td>c</td><td>4</td><td>6</td><td>R</td><td>45</td><td>g</td><td>1</td></tr>
<tr><td>Applicability</td><td colspan="4">M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience</td></tr>
<tr><td>Prerequisites</td><td colspan="4">Geomicrobiology; basic knowledge in microbial physiology and in microbial ecology</td></tr>
</table>

<table>
<tr><td>Module Number:
M 211</td><td colspan="4">Module Title:
Geomicrobiology Lab Course</td><td colspan="4">Type of Module:
M.Sc. 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
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 exercises</td></tr>
<tr><td>Module Content</td><td colspan="8">• Cultivation and microscopic characterization of microorganisms
• Quantification of microbial activities
• Analysis of nucleic acids (DNA, qPCR)
• 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">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</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">M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience</td></tr>
<tr><td>Prerequisites</td><td colspan="8">Geomicrobiology; basic knowledge in microbial physiology and in microbial ecology</td></tr>
</table>

<table>
<tr><td>Module Number:
M 212</td><td colspan="4">Module Title:
Advanced Geophysics</td><td>Type of Module:
M.Sc. 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
Module coordinator</td><td colspan="3">1 semester</td><td colspan="2">Drews</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">The module uses a combination of in-class lectures, in-class & applied exercises, and online videos.</td></tr>
<tr><td>Module Content</td><td colspan="5">This module teaches advanced methods in geophysics including data acquisition, processing and modelling. In each semester we will typically explore one or two methods in-depth (e.g., refraction seismics, electrical resistivity tomography, ground-penetrating radar, magnetics) and develop a full processing chain from first principals, e.g., including survey planning, data acquisition, forward modeling and data integration using computational inverse techniques.</td></tr>
<tr><td>Qualification Goals</td><td colspan="5">(1) Gain an advanced understanding for specific geophysical methods.
(2) Understand the principals of forward and inverse modelling and apply it with computational methods.
(3) Build-up transferable skills (e.g., signal analysis and numerical modeling) also applicable in many other geo- and environmental disciplines.</td></tr>
<tr><td rowspan="3">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</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 Geophysics</td><td>L</td><td>o</td><td>4</td><td>4</td><td rowspan="2">WE/ OE</td><td rowspan="2">90</td><td rowspan="2">g</td><td rowspan="2">1</td></tr>
<tr><td>FC</td><td>o</td><td>2</td><td>2</td></tr>
<tr><td>Applicability</td><td colspan="5">M.Sc. Geowissenschaften/Geosciences, M.Sc. Applied & Environmental Geoscience</td></tr>
<tr><td>Prerequisites</td><td colspan="5">Solid understanding of basic geophysical sub-surface imaging taught at the BSc levels. Programming skills are helpful but not strictly essential and can also be acquired in class.</td></tr>
</table>

<table>
<tr><td>Module Number:
M 213</td><td colspan="4">Module Title:
GIS and Remote Sensing</td><td colspan="4">Type of Module:
M.Sc. 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:
75 h / 5 SWS</td><td colspan="3">Private Study:
105 h</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="3">1 semester</td><td colspan="5">Schäuble, Lörcher</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">Lectures and accompanying guided computer exercises, project assignment.</td></tr>
<tr><td>Module Content</td><td colspan="8">• 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="8">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 rowspan="3">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</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">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>
<tr><td>Applicability</td><td colspan="8">M.Sc. Applied & Environmental Geoscience, (M.Sc. Geowissenschaften/Geosciences and M.Sc. Geoökologie/Geoecology if capacity allows)</td></tr>
<tr><td>Prerequisites</td><td colspan="8">Smartphone (Android, iOS or other brand)</td></tr>
</table>

<table>
<tr><td>Module Number:
M 214</td><td colspan="4">Module Title
Geotechnical Engineering</td><td>Type of Module:
M.Sc. 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
Module Coordinator</td><td colspan="3">1 semester</td><td colspan="2">Leven</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 with exercises (during semester) and lab course (1 week block course)</td></tr>
<tr><td>Module Content</td><td colspan="5">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.</td></tr>
<tr><td>Qualification Goals</td><td colspan="5">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.</td></tr>
<tr><td rowspan="3">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Course</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td>Geotechnical Engineering</td><td>L</td><td>c</td><td>2</td><td>3</td><td>WE</td><td>120</td><td>g</td><td>0.5</td></tr>
<tr><td>Soil Mechanics Lab</td><td>LC</td><td>c</td><td>3</td><td>3</td><td>A</td><td>-</td><td>g</td><td>0.5</td></tr>
<tr><td>Applicability</td><td colspan="5">M.Sc. Geowissenschaften/Geosciences, M.Sc. Applied & Environmental Geosciences, (M.Sc. Geoecology if capacity allows)
It is related to other method-oriented modules of applied geosciences (e.g. Hydrogeological Field Investigations Techniques, Haydrogeologie and Water Chemistry, Geophysics).</td></tr>
<tr><td>Prerequisites</td><td colspan="5">Basic physical, mathematical, and geological knowledge</td></tr>
</table>

<table>
<tr><td>Module Number:
M 216</td><td colspan="4">Module Title:
Atmospheric Physics</td><td>Type of Module:
M.Sc. 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
Module Coordinator</td><td colspan="3">1 semester</td><td colspan="2">Platis</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">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.</td></tr>
<tr><td>Module Content</td><td colspan="5">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)</td></tr>
<tr><td>Qualification Goals</td><td colspan="5">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.</td></tr>
<tr><td rowspan="4">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type ofLecture</td><td>Status</td><td>CH</td><td>CP</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">Atmospheric Physics</td><td>L</td><td>c</td><td>2</td><td>3</td><td>WE</td><td>120</td><td>g</td><td>0,66</td></tr>
<tr><td>E</td><td>c</td><td>1</td><td>2</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>S</td><td>c</td><td>1</td><td>1</td><td>R</td><td>-</td><td>-</td><td>0,33</td></tr>
<tr><td>Applicability</td><td colspan="5">M.Sc. Geowissenschaften/Geosciences, M.Sc. Applied & Environmental Geosciences</td></tr>
<tr><td>Prerequisites</td><td colspan="5">Lectures on mathematics and physics of a B.Sc. study, completed by lectures on thermodynamics, atmospheric physics and basics in flow mechanics (UWP1 and UWP2 of the B.Sc. Umweltnaturwissenschaften)</td></tr>
</table>

Module Number: **M 218**	Module Title: **Environmental Analytical Chemistry**								Type of Module: M.Sc. Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: 90 h / 6 SWS						Private Study: 90 h
Duration 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 theoreti-al 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.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*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	M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience								
Prerequisites	Basic knowledge in chemistry, environmental analytics and statistics								

Module Number: **M 219**	Module Title: **Earth Processes**					Type of Module: M.Sc. Elective			
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h	Contact Time: 45 h / 3 SWS				Private Study: 135 h			
Duration Module Coordinator	1 semester	Süß							
Regular Cycle	every winter 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.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Earth Processes	*L, E*	*c*	*3*	*6*	*WE*	*90*	*g*	*1*
Applicability	M.Sc. Applied & Environmental Geoscience for students with little or no background in geology								
Prerequisites	none								

<table>
<tr><td>Module Number:
M 220</td><td colspan="4">Module Title:
Field Seminars in Applied Geosciences</td><td colspan="4">Type of Module:
M.Sc. 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:
variable</td><td colspan="3">Private Study:
variable</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="4">1-4 semester</td><td colspan="4">Merkel</td></tr>
<tr><td>Regular Cycle</td><td colspan="8">variable offers mainly in the summer semester</td></tr>
<tr><td>Language</td><td colspan="8">English</td></tr>
<tr><td>Learning- / Teaching Forms</td><td colspan="8">In research field seminars and excursions students identify, outline, describe and discuss selected geological situations in the field with lecturers, fellow students and researchers.</td></tr>
<tr><td>Module Content</td><td colspan="8">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.</td></tr>
<tr><td>Qualification Goals</td><td colspan="8">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.</td></tr>
<tr><td rowspan="3">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td>Various Field Seminars in Applied Geosciences</td><td>FC</td><td>op</td><td>-</td><td>1-6</td><td>A</td><td>-</td><td>ng</td><td>-</td></tr>
<tr><td colspan="9">Depending on the type and workload of field seminars variable numbers of credits points can be awarded to individual field seminars. The module is complete when the activities add up to 18 days of field work. The applied nature of field seminars needs to be approved prior to participation.</td></tr>
<tr><td>Applicability</td><td colspan="8">M.Sc. Applied & Environmental Geoscience</td></tr>
<tr><td>Prerequisites</td><td colspan="8">Fundamentals in hydrogeology, environmental chemistry and applied geo-sciences</td></tr>
</table>

<table>
<tr><td>Module Number:
M 221</td><td colspan="3">Module Title:
Environmental and Human Health Risk Assessment of Chemicals</td><td>Type of Module:
M.Sc. 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:
60 h / 2 SWS + 1 week block course</td><td>Private Study:
120 h</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="2">1 semester + 1st week of March (block course)</td><td colspan="2">Escher</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">Lecture and exercises
Groups of three students conduct a comprehensive environmental and human health risk assessment for one selected chemical each according to the European regulation for industrial chemicals. The risk assessment is performed stepwise in the exercises in groups and then compiled by each student into a written technical report (chemical risk assessment dossiers)
Seminar
In the first week of March, there is a 5-day block with seminar-style applications and special topics and presentations of the chemical risk assessment dossiers. At the end of the week the chemical risk assessment dossiers are completed and will be graded.</td></tr>
<tr><td>Module Content</td><td colspan="4">• Regulatory methods for environmental risk assessment of chemicals (industrial chemicals, pesticides, pharmaceuticals), European regulation REACH, human vs. ecological risk assessment
• PBT assessment (persistence, bioaccumulation, toxicity), classification and labelling of chemicals
• Environmental exposure analysis: emission patterns, multimedia fate and transport models for quantifying environmental exposure, predicted and measured exposure concentration
• Environmental effect analysis: estimation of hazard potential, tests for ecotoxicity, dose-effect relationships, extrapolation methods, classification of chemicals according to modes of toxic action
• Human health risk assessment of chemicals. Exposure estimations and human health effects, cancer risk, risk quotient
• Integrated testing strategy for toxicity and ecotoxicity including prediction methods
• Risk assessment methods (deterministic vs. probabilistic), risk assessment vs. hazard assessment, uncertainty and sensitivity analyses, precautionary principle
• Specific topics: risk assessment of mixtures, risk assessment of transformation products, dynamic risk assessment, water quality assessment</td></tr>
<tr><td>Qualification Goals</td><td colspan="4">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">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</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 rowspan="3">6</td><td>A</td><td>-</td><td>g</td><td>1</td></tr>
<tr><td>S</td><td>c</td><td>2</td><td>R</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td></td><td></td><td></td><td></td><td>-</td><td>-</td><td>-</td></tr>
</table>

Applicability	M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience
Prerequisites	

Module M 222 "Hydrogeochemical Modeling" is substituted by module M 242 "Modeling of Reactions, Microbial Dynamics and Bioreactive Transport".

Module Number: **M 225**	Module Title: **Field Seminars in Applied Geosciences 2**								Type of Module: M.Sc. Elective
Credits (ECTS)	3								
Workload - Contact Time - Private Study	Workload: 90 h		Contact Time: variable						Private Study: variable
Duration 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.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Various Field Seminars in Applied Geosciences	*FC*	*op*	*-*	*3*	*A*	*-*	*ng*	*-*
	Depending on the type and workload of field seminars variable numbers of credits points can be awarded to individual field seminars. The module is complete when the activities add up to 9 days of field work. The applied nature of field seminars needs to be approved prior to participation.								
Applicability	M.Sc. Applied & Environmental Geoscience								
Prerequisites	Fundamentals in hydrogeology, environmental chemistry and applied geo-sciences								

Module Number: **M 227**	Module Title: **Sustainable Environmental Biotechnology Systems 1**					Type of Module: M.Sc. Elective			
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h	Contact Time: 90 h (6 SWS)				Private Studies: 90 h			
Duration Module Coordinator	1 semester	Angenent							
Regular Cycle	every summer semester								
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.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*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	M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience, M.Sc. Biologie								
Prerequisites	Basic knowledge in microbiology or chemistry or physics or geosciences or engineering								

<table>
<tr><td>Module Number:
M 228</td><td colspan="4">Module Title:
Sustainable Environmental Biotechnology Systems 2</td><td>Type of Module:
M.Sc. 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 Studies:
90 h</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="3">1 semester</td><td colspan="2">Angenent</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">The module combines class room lectures and a group design project.</td></tr>
<tr><td>Module Content</td><td colspan="5">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.</td></tr>
<tr><td>Qualification Goals</td><td colspan="5">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.</td></tr>
<tr><td rowspan="3">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</td><td>Type of Exam / Study Requirements</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td rowspan="2">Sustainable Environmental Biotechnology Systems 2</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>4</td></tr>
<tr><td>Applicability</td><td colspan="5">M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience, M.Sc. Biologie</td></tr>
<tr><td>Prerequisites</td><td colspan="5">Basic knowledge in microbiology or chemistry or physics or geosciences or engineering
"Sustainable Environmental Biotechnology Systems 1"</td></tr>
</table>

<table>
<tr><td>Module Number:
M 230</td><td colspan="4">Module Title:
Geosphere-Biosphere Interactions</td><td>Type of Module:
M.Sc. Compulsory / Elective</td></tr>
<tr><td>Credits (ECTS)</td><td colspan="6">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 colspan="2">Private Study:
90 h</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="3">1 semester</td><td colspan="3">Dippold</td></tr>
<tr><td>Regular Cycle</td><td colspan="6">every summer semester</td></tr>
<tr><td>Language</td><td colspan="6">English</td></tr>
<tr><td>Learning- / Teaching Forms</td><td colspan="6">A wide spectrum of teaching methods is to be used comprising lectures with interactive self-preparation sessions, exercises, and presentations. The practical course will cover a complete experimental setup including field experiment, laboratory analysis, data analysis and result presentation and thus will teach practical, multi-step scientific project work.</td></tr>
<tr><td>Module Content</td><td colspan="6">The course will focus on biogeochemical interactions between the Geosphere and the Biosphere and will start with an introduction into the biogeochemical cycles (C, N, P, S, Fe, water). Thereafter, key interactions at bio-geochemical interfaces will be analyzed process-based regarding their impact on and feedbacks between bio- and geosphere. These processes include weathering and multidirectional fluxes by plant roots (rhizosphere processes), lichens and biofilms, bioturbation by animals, erosion (and its prevention by living organisms), and many more.</td></tr>
<tr><td>Qualification Goals</td><td colspan="6">Students are familiar with the processes at biogeochemical interfaces including an understanding on feedback mechanisms of bio-geosphere interactions. They have the ability to identify such interfaces, describe them and design experimental approaches to quantitatively describe the magnitude of interaction e.g. of biogeochemical fluxes from bio- to geosphere and vice versa.</td></tr>
<tr><td rowspan="3">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</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">Geosphere-Biosphere Interactions</td><td>V</td><td>c</td><td>2</td><td rowspan="2">6</td><td rowspan="2">OE</td><td rowspan="2">20</td><td rowspan="2">g</td><td rowspan="2">1</td></tr>
<tr><td>Ü</td><td>c</td><td>4</td></tr>
<tr><td>Applicability</td><td colspan="6">Compulsory: M.Sc. Geoökologie/Geoecology; Elective: M.Sc. Applied & Environmental Geoscience</td></tr>
<tr><td>Prerequisites</td><td colspan="6"></td></tr>
</table>

Module Number: **M 232**	Module Title: **Internship**					Type of Module: M.Sc. Elective			
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: -			Private Study: 180 h			
Duration Module coordinator	4 weeks			Glotzbach					
Regular Cycle	every semester								
Language	English								
Learning- / Teaching Forms	Work experience								
Module Content	The module consists of a 4-week internship in a company or consultancy active in the field of geoscience, geoecology and /or environmental consulting.								
Qualification Goals	Students get practical training and contact potential employers. They aquire work experience in the occupational fields dealing with geoscientific and environmental topics. They bring their theoretical knowledge into practice and improve presentation and discussion skills.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Internship	*PR*	*c*	*-*	*-*	*R*	*-*	*ng*	
Applicability	M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience								
Prerequisites	-								

<table>
<tr><td>Module Number:
M 233</td><td colspan="4">Module Title:
Biotransformation of Pollutants</td><td>Type of Module:
M.Sc. 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:
45 h / 3 SWS</td><td>Private Study:
135 h</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="3">1 semester</td><td colspan="2">Joshi</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">Lectures, presentation by students, group projects</td></tr>
<tr><td>Module Content</td><td colspan="5">• Environmental significance of different pollutant classes
• Geochemical principles controlling the abiotic transformation of pollutants
• Physiological and biochemical basis for biotransformation of pollutants
• Differences between environmental systems and compartments within systems determining pollutant turnover
• Transformation reactions and pathways for various organic (e.g. BTEX, chlorinated hydrocarbons) and inorganic pollutants (e.g. radionuclides, nitrate)
• Advances in applied remediation techniques and methods to assess pollutant turnover</td></tr>
<tr><td>Qualification Goals</td><td colspan="5">• Gain knowledge about prominent pollutant compound classes present in the environment as well as their abiotic and biotic transformation reactions
• Learn how environmental conditions affect abiotic and biotic pollutant turnover
• Apply knowledge gained over the semester to design remediation schemes at contaminated sites and monitor remediation progress</td></tr>
<tr><td rowspan="3">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</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">Biotransformation of pollutants</td><td>L</td><td>c</td><td>1</td><td>2</td><td rowspan="2">R</td><td rowspan="2">-</td><td rowspan="2">g</td><td rowspan="2">1</td></tr>
<tr><td>S</td><td>c</td><td>2</td><td>4</td></tr>
<tr><td>Applicability</td><td colspan="5">M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience</td></tr>
<tr><td>Prerequisites</td><td colspan="5">Content from M.Sc. module "Environmental Chemistry"
Basic knowledge about environmental microbiology (recommended)</td></tr>
</table>

Module Number: **M 236**	Module Title: **Modelling for Sustainable River Management**								Type of Module: M.Sc. Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: 60 h / 4 SWS						Private Study: 120 h
Duration Module Coordinator	1 semester				Zarfl				
Regular Cycle	every summer semester								
Language	English								
Learning- / Teaching Forms	Lecture and accompanying seminar (exercises, presentations, discussions)								
Module Content	• Introduction into different mathematical modelling approaches to describe environmental processes with a specific focus on freshwater ecosystems (including differential systems but beyond), parameter estimation techniques and uncertainty analysis • Understanding interdependent environmental system dynamics within the (socio-)hydrological cycle across scales and system boundaries • Application of models to environmental challenges • Models as tools for decision/discussion support/ sustainable water management								
Qualification Goals	The students are familiar with a variety of modelling approaches and their suitability for specific research questions related to environmental processes. They can deal with uncertainty in parameter values and model structure; evaluate model results and simulated system dynamics. They are aware of current developments in environmental systems analysis and can discuss strengths and weaknesses of applied model approaches. Drawing from a solid understanding of mathematical modeling and socio-hydrological interdependencies, they can critically analyse the role of conceptual and mathematical models in decision support and sustainable water management across spatial and temporal scales.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Modelling and Simulation for Environmental Process Understanding	*L*	*c*	*2*	*6*	*A*	*-*	*g*	*0.5*
		S	*c*	*2*		*R*	*-*	*g*	*0.5*
Applicability	M.Sc. Geoökologie/Geoecologie, M.Sc. Applied & Environmental Geoscience								
Prerequisites	recommended: B.Sc. course "Modellierung in den Geo- und Umweltwissen-schaften"								

Module Number: **M 238**	Module Title: **Rhizosphere Processes in a Changing World**								Type of Module: M.Sc. Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: 80 h / 5 SWS						Private Study: 100 h
Duration Module Coordinator	1 semester				Mühe				
Regular Cycle	block course, every winter semester								
Language	English								
Learning- / Teaching Forms	Lecture, Seminar (student presentation) and Practical (two-week lab project)								
Module Content	Soils are globally being degraded by human activity. Abundant and clean water resources are becoming scares. Food production is pushed to new limits to ensure feeding a growing population. Rhizosphere processes play a crucial role in all of these systems, and thus, can contribute to dealing with these global challenges. This course covers the different aspects of rhizosphere processes, namely root activity and growth, soil geochemistry and mineralogy, and soil microbial ecology. It evaluates their contribution in different environmental scenarios including food production, soil and water remediation, water filtration, and contamination.								
Qualification Goals	The learning goals are: 1. To develop the learner's ability to analyze multidisciplinary research literature (agriculture, biogeochemistry, microbial ecology, root-soil processes) and to professionally present it to an interdisciplinary audience. 2. To comprehend and analyze how root-microbe-mineral interactions link to plant productivity, food quality, water and soil health. 3. To envision ways of improving plant-microbe and/or soil traits to ultimately improve soil health, water quality, plant output, and food quality. 4. To evaluate differences in rhizosphere processes during a two-week long laboratory project. 5. To obtain an appreciation for sustainable agriculture in feeding a growing global population.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Rhizosphere Processes	*L/S*	*c*	*2*	*6*	*R* *LP*		*g*	*1*
	Laboratory Practical Project	*PR*	*c*	*3*					
Applicability	M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience, open to students from other departments if capacity allows								
Prerequisites	Basic competences in microbiology, (bio)geochemistry, soil science and/or plant science are required.								

<table>
<tr><td>Module Number:
M 239</td><td colspan="4">Module Title:
Geo-Bio-Interactions in Tropical Landscapes of Kenya</td><td>Type of Module:
M.Sc. 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:
120 h / 8 SWS</td><td>Private Study:
60 h</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="3">1 Semester</td><td colspan="2">Otieno, Dippold</td></tr>
<tr><td>Regular Cycle</td><td colspan="5">Wintersemester/Summersemester (March/April)</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Learning-/Teaching Forms</td><td colspan="5">Besides transfering basic knowledge via lectures, the field course will include practical excercises in various landscape and ecological zones of Kenya (monitoring data will be collected, evaluated and scientifically discussed). Pre- and post-field trip presentations will deepen the understanding of relevant processes in the respective landscapes and ecosystems.</td></tr>
<tr><td>Module Content</td><td colspan="5">The module contains basic lectures on geology, geomorphology, hydrology, pedology and ecology of the visited landscapes with specific focus on Biosphere-Geosphere Interactions. The following landscapes and ecosystems will be covered:
Marine and costal ecosystems
Dry and humid savannah (several national parks and mzima springs)
Highland landscapes (rift valley formation, volcanism (Mt. Elgon) and inland lakes systems)
Tropical rainforests (national park)
Lake Victoria basin landscapes
Anthropogenically affected areas will be characterized in parallel to their natural systems (mostly national parks) to understand human impact on African ecosystems. Collected knowledge and data will be summarized in scientific presentations at the end of the course.</td></tr>
<tr><td>Qualification Goals</td><td colspan="5">Students will gain a fundamental understanding of the processes shaping Geo- and Biosphere in tropical landscapes and be able to describe the ecosystems in detail. They will be able to characterize interactions between parent material, geomorphology, water availability and movement, soil development (WRB classification) and the living organisms and their ecological interactions of a broad set of tropical ecosystems and landscape units. Students will be able to describe and quantify human impact on tropical ecosystems.</td></tr>
<tr><td rowspan="3">Requirements for obtaining Credit, Grading, Weight, etc.)</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</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">Field Course on Geo-Bio-Interactions in tropical landscapes of Kenya</td><td>L,S</td><td>c</td><td>2</td><td rowspan="2">6</td><td rowspan="2">R</td><td rowspan="2">2 x 15 min</td><td rowspan="2">g</td><td rowspan="2">1</td></tr>
<tr><td>FC</td><td>c</td><td>6</td></tr>
<tr><td>Applicability</td><td colspan="5">M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology (can be used for Field Ecology 2), M.Sc. Applied and Environmental Geoscience</td></tr>
<tr><td>Prerequisites</td><td colspan="5">It is recommended but not obligatory to have participated in the module Geosphere-Biosphere Interactions (M 230).</td></tr>
</table>

<table>
<tr><td>Module Number:
M 240</td><td colspan="4">Module Title:
Isotopes in Ecosystem Sciences</td><td>Type of Module:
M.Sc. Elective</td></tr>
<tr><td>Credits (ECTS)</td><td colspan="6">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 colspan="2">Private Study:
90 h</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="3">1 semester</td><td colspan="3">Dippold, Stock</td></tr>
<tr><td>Regular Cycle</td><td colspan="6">every winter semester</td></tr>
<tr><td>Language</td><td colspan="6">English</td></tr>
<tr><td>Learning- / Teaching Forms</td><td colspan="6">A diverse spectrum of teaching methods is to be used comprising lectures with interactive video section on practical steps in the work with isotopes and individual exercises. Besides introducing into a wide field of possible isotope applications, the course aims to teach the skills in defending project concepts of isotope-based study designs. For this, an interactive seminar simulating a reviewer panel project defense situation will be organized.</td></tr>
<tr><td>Module Content</td><td colspan="6">The module starts with an introduction into isotope biogeochemistry and tracer-based approaches, the understanding of stabile and radioactive isotopes + methods to analyze them (incl. radiation protection).
Thereafter, the focus will be on the isotope application in process based research, i.e. identifying processes and rates in C cycle and organic matter transformation in the terrestrial environment. What specifics occur at the interface plant-soil/biosphere-geosphere? How can incubation studies with isotopes contribute to our understanding on mineralization, soil-atmosphere interactions, contaminant degradation and microbial ecology? Comparable topics will be targeted in the nitrogen and phosphorus cycle always considering bulk or compound-specific isotope analysis. Additionally, water isotopes and their application in ecohydrology but also microbial growth dynamics will be targeted. Radiocarbon dating, erosion quantification, radionuclide-based imaging, and further methods, their advantages and shortcomings will be discussed.</td></tr>
<tr><td>Qualification Goals</td><td colspan="6">The course addresses M.Sc. students, who intend to use a set of isotope-based natural abundance or tracer methods. Students will learn to apply complex and potentially coupled isotope methods in scientific studies. They will learn to conceptualize an isotope-based study and to present its design and outcome in front of a theoretical reviewer panel simulating a proposal defense.</td></tr>
<tr><td rowspan="3">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</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">Isotopes in Ecosystem Sciences</td><td>L</td><td>c</td><td>3</td><td rowspan="2">6</td><td rowspan="2">R & A</td><td rowspan="2">15</td><td rowspan="2">g</td><td rowspan="2">1:1</td></tr>
<tr><td>S/E</td><td>c</td><td>3</td></tr>
<tr><td>Applicability</td><td colspan="6">M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience</td></tr>
<tr><td>Prerequisites</td><td colspan="6"></td></tr>
</table>

<table>
<tr><td>Module Number:
M 241</td><td colspan="4">Module Title:
Climate Modelling</td><td>Type of Module:
M.Sc. 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
Module Coordinator</td><td colspan="3">1 semester</td><td colspan="2">Rehfeld</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">Climate models are a powerful tool for understanding climate change, and are continuously growing more detailed and accurate. Models help us to work through complicated problems and understand complex systems.
Lectures introduce how the climate system is represented in models. In the exercises, students experiment with models, and learn the practical programming required for climate data analysis and scientific understanding of global warming. The exercise includes tutorials that enable students to run simulations with an Earth System Model of Intermediate Complexity. Students document and present their results at the end of the course in a term paper.</td></tr>
<tr><td>Module Content</td><td colspan="5">The module will cover fundamentals of climate systems, climate components, energy balance, key climate drivers and the hierarchy of climate models. This will include box models, models of intermediate complexity and fully coupled models. It will explain the underlying basics and the numerical formulation of the fundamental equations in climate models, including parameterisation of processes not directly resolved by the climate model. This module will further emphasize on radiation and convection schemes in model and the aspects determining climate sensitivity to greenhouse gas increase.
Specifically, this module will address the following questions:
• What equations do climate models solve?
• How do climate models solve these equations?
• What components of the climate system are represented in climate models?
• What are the capabilities and limitations of these models?
• How do we evaluate the performance of climate models?</td></tr>
<tr><td>Qualification Goals</td><td colspan="5">At the end of this course students will be able to:
• Understand the fundamental physics in climate models.
• Assess the quality of model results.
• Analyze the output and document their findings.</td></tr>
<tr><td rowspan="3">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</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 Modelling</td><td>L</td><td>c</td><td>2</td><td>2</td><td rowspan="2">A/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">M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience</td></tr>
<tr><td>Prerequisites</td><td colspan="5">Advanced knowledge on the climate system or advanced programming experience is required.</td></tr>
</table>

<table>
<tr><td>Module Number:
M 242</td><td colspan="4">Module Title:
Modeling of Reactions, Microbial Dynamics and Bioreactive Transport</td><td>Type of Module:
M.Sc. 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
Module Coordinator</td><td colspan="3">1 semester</td><td colspan="2">Cirpka</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">Theoretical aspects of reaction and microbial dynamics and bioreactive transport are taught in ex-cathedra lecture sessions. Extensive computer exercise provide students with ‘hands on’ experiences in modeling (bio)reactive systems in mixed reactors and coupled to solute transport.</td></tr>
<tr><td>Module Content</td><td colspan="5">The module gives an introduction into mathematical and numerical modeling of reactions, inter-phase mass transfer, microbial dynamics, and reactive transport relevant for the fate of compounds and microorganisms in porous media. Topics include:
• Modeling of mixed systems:
o Mass balance considerations in mixed systems
o Speciation calculation
o Competitive sorption in equilibrium
o Mass-transfer kinetics
o Stoichiometry of bioreactions
o Rate laws of microbial dynamics
o Numerical simulation of isotope fractionation
• Modeling of bioreactive transport
o Coupled simulation of 1-D transport, microbial dynamics and turnover of reactants
o Multi-dimensional, mixing-controlled bioreactive transport
o Analysis of controlling factors</td></tr>
<tr><td>Qualification Goals</td><td colspan="5">Students can formulate mathematical models of reactive systems (with and without transport) and solve them numerically. They can critically assess which processes dominate under which conditions. They acquire key competences in the quantitative, process-based analysis of reactive systems influenced by microbial processes.</td></tr>
<tr><td rowspan="3">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</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">Modeling of Reactions, Microbial Dynamics and Bioreactive Transport</td><td>L</td><td>c</td><td>2</td><td>3</td><td>WE</td><td rowspan="2">120</td><td rowspan="2">g</td><td>0.5</td></tr>
<tr><td>E</td><td>c</td><td>2</td><td>3</td><td>A</td><td>0.5</td></tr>
<tr><td>Applicability</td><td colspan="5">M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience</td></tr>
<tr><td>Prerequisites</td><td colspan="5">Students have competences corresponding to those of the M.Sc. Modules "Groundwater Modeling 1" and "Environmental Chemistry". They have basic programing skills in Matlab.</td></tr>
</table>

Module Number: **M 243**	Module Title: **Tropical Ecology of South America**		Type of Module: M.Sc. Elective
Credits (ECTS)	6		
Workload - Contact Time - Private Study	Workload: 180 h	Contact Time: 10 SWS	Private Studies: 30 h
Duration Module Coordinator	1 Semester	Ebner	
Regular Cycle	winter semester (every other year)		
Language	English		
Learning- / Teaching Forms	Field camp, excursions, seminar		
Module Content	This interdisciplinary course deals with the structure, function and dynamics of neotropical ecosystems under different geological, climatic and land-use-related conditions. To record bio-geo-interactions in South American habitats, methods used in botany, zoology, ecophysiology, paleontology, and anthropogeography as well as from earth and environmental sciences are applied. The following topics will be addressed: geology and geological history of South America, water and carbon balance of tropical forests, flora and fauna of different biomes, food relationships, bionics, bioindicators, characterization of river basins, shallow water ecosystems, water relationships between plants, soils and atmosphere, climate change today and in the past, land and forest management systems. Particular attention is paid to the importance of biological diversity for the stability and functionality of tropical ecosystems. Possibilities of sustainable land use while maintaining important ecosystem functions (such as recycling of water, sequestration of carbon, etc.), e.g. through agroforestry systems, are highlighted. The course is conducted in cooperation with various partner universities. The field trip is accompanied by a seminar on n Neotropical ecosystems, focusing on the Atlantic rainforest of Brazil, with its, botanical, zoological, geological and climatic characteristics. Topics are: vegetation and soils of selected regions as a reflection of the climatic and geological boundary conditions, geology and earth history, nutrient and water relationships in tropical rainforests, biodiversity patterns, bioindicators, treetops as a pool of ideas for bionics, ecophysiology of epiphytes, climate change effects and adaptations, soils and agriculture, principles and methods of near-natural reforestation, agroforestry systems. The course ends with a summary of the results and a final exam.		
Qualification Goals	During the field camp, students learn to apply field methods for recording the natural conditions (e.g. vegetation recordings, describing soil profiles, creating geological maps, sediment analyses, measuring the microclimate and soil water balance, recording the animal population, bio-indicators), as well as measuring environmental processes (e.g. runoff quantities and particle load in streams, atmospheric deposition, plant-driven water and carbon fluxes), nutrient relationships (e.g. analysis of stomach contents of frogs) and reconstruction of ecosystem history (e.g. through pollen analysis. It provides a platform to expand species knowledge related to Neotropical fauna and flora. The data collected will be analyzed and discussed in terms of biodiversity patterns, ecosystem functions, response of neotropical ecosystems to climate change and anthropogenic influences. Various forms of land use (in particular agroforestry systems, cacao rubber, yerba mate, araucaria) are examined and evaluated with regard to their impact on biodiversity and ecosystem functions. A comparison of different forms of land use takes place in the context of global requirements and socio-economic conditions of the Global South.		

Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirements*	*Duration of Exam*	*Grading System*	*Weighting*
	Preparatory seminar	*L*	*c*	*2*	*6*	*WE*	*120*	*g*	*1*
	Geoecological field internship Brazil (3 weeks)	*S*	*c*	*10*					
Applicability	M.Sc. Geoökologie/Geoecology, MSc Geowissenschaften, MSc Applied Environmental Geoscience, applicable in M.Sc. Evolution und Ökologie								
Prerequisites	Language course Portuguese is recommended								

Module Number: **M 244**	Module Title: **Geothermal Reservoirs**								Type of Module: M.Sc. Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: 70 h / 5 SWS			Private Studies: 110 h			
Duration Module Coordinator	1 semester			Süß					
Regular Cycle	every summer semester								
Language	English								
Learning- / Teaching Forms	Lectures accompanied by exercises and computer tutorials & block course								
Module Content	• General introduction to principles of deep geothermal energy extraction • Understanding geothermal reservoir geology and reservoir dynamics • Exploration methods for geothermal reservoirs • Reservoir characterization techniques for geothermal reservoirs • Field development and economics of deep geothermal energy production								
Qualification Goals	The students with little or no background in deep subsurface exploration will learn about the key technologies needed to characterize the underground. This will include the mapping of reservoir rocks using seismic method and the quantification of reservoir volumes using well information. The students will learn the integration of the data into static and dynamic models for geothermal energy production, including the analysis of key uncertainties and their impact on the economic viability of a geothermal energy production project.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirements*	*Duration of Exam*	*Grading System*	*Weighting*
	Exploration of deep geothermal reservoirs	*L, E*	*c*	*3*	*3*	*WE*	*45*	*g*	*50%*
	Modelling of deep geothermal reservoirs	*L, E*	*c*	*2*	*3*	*WE*	*45*	*g*	*50%*
Applicability	M.Sc. Geowissenschaften/Geosciences, M.Sc. Applied & Environmental Geoscience								
Prerequisites	Introduction to Geosciences or equivalent								

<table>
<tr><td>Module Number:
M 301</td><td colspan="4">Module Title:
Physics of the Earth’s Surface</td><td>Type of Module:
M.Sc. Elective</td></tr>
<tr><td>Credits (ECTS)</td><td colspan="6">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 colspan="2">Private Study:
90 h</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="3">1 semester</td><td colspan="3">Glotzbach</td></tr>
<tr><td>Regular Cycle</td><td colspan="6">every winter semester</td></tr>
<tr><td>Language</td><td colspan="6">English</td></tr>
<tr><td>Learning- / Teaching Forms</td><td colspan="6">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.</td></tr>
<tr><td>Module Content</td><td colspan="6">This module gives an introduction into the physics of Earth’s surface, with emphasis on processes shaping the Earth’s surface on human and geological timescales. Most importantly an overview of the relevant cycles (energy, water, relevant elements/gases) acting on Earth’s surface will be given.
Specific topics addressed in the lecture include:
• Earth’s surface energy balance
• Carbon and hydrological cycle and mass balance
• 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, glacial, and biotic processes.
• Topics addressed in the exercises and discussion include:
• Computer exercises using Arc or Q-GS to visualize and analyze Earth’s surface
• Computer exercises using Matlab and other software to investigate physical and geochemical processes discussed in lectures.</td></tr>
<tr><td>Qualification Goals</td><td colspan="6">Goals of this class center around enabling students to:
• Understand the physics and relations between Earth’s shaping processes on different temporal and spatial scales
• Visualize, quantify and model Earth’s surface processes using computer software tools.
• Develop skills in critically reading scientific literature.</td></tr>
<tr><td rowspan="3">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</td><td>Type of Exam / Study</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td rowspan="2">Physics of the Earth’s Surface</td><td>L</td><td>c</td><td>4</td><td>4</td><td>WE</td><td>90</td><td>g</td><td>0,7</td></tr>
<tr><td>E</td><td>c</td><td>2</td><td>2</td><td>R</td><td></td><td>g</td><td>0,3</td></tr>
<tr><td>Applicability</td><td colspan="6">M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience
This module compliments other geoscience, applied environmental geoscience and geoecology modules. Students are provided with the context for how the atmosphere (climate), hydrosphere, biosphere, and tectonic processes interact to produce the Earth’s surface. It also complements modules in physical geography by providing a physics and math based understanding of surface processes active both human relevant, and geologic (million year) timescales.</td></tr>
<tr><td>Prerequisites</td><td colspan="6">Introductory geology</td></tr>
</table>

Module Number: **M 305**	Module Title: **Advanced Field Methods in Geoscience**								Type of Module: M.Sc. Compuslory / Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: circa 14 field days			Private Studies: 0-40 h			
Duration Module Coordinator	Block course, circa 14 days			Bons					
Regular Cycle	annual								
Language	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.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirements*	*Duration of Exam*	*Grading System*	*Weighting*
	Advanced Field Methods in Geoscience	*FC*	*c*	*6*	*6*	*A*	*-*	*g*	*1*
Applicability	Compulsory: M.Sc. Geowissenschaften/Geosciences, Elective: M.Sc. Applied & Environmental Geoscience								
Prerequisites	Successfully completed B.Sc. degree in geosciences								

<table>
<tr><td>Module Number:
M 308</td><td colspan="4">Module Title:
Isotope Geochemistry</td><td>Type of Module:
M.Sc. 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
Module Coordinator</td><td colspan="3">1 semester</td><td colspan="2">Schönberg</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">Lectures, exercises, oral and written presentations</td></tr>
<tr><td>Module Content</td><td colspan="5">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="5">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">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</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">M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience</td></tr>
<tr><td>Prerequisites</td><td colspan="9">Basic knowledge from the B.Sc. Geowissenschaften or from a comparable B.Sc. degree</td></tr>
</table>

Module Number: **M 311**	Module Title: **Carbonate Facies Analysis**								Type of Module: M.Sc. Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: 60 h / 4 SWS						Private Studies: 120 h
Duration Module Coordinator	1 semester				Nebelsick				
Regular Cycle	last time winter semester 2025/26								
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.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*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*				
		P R	*c*	*2*	*2*				
Applicability	M.Sc. Geowissenschaften/Geosciences, M.Sc. Applied & Environmental Geoscience								
Prerequisites	Basics in earth history and paleontology								

<table>
<tr><td>Module Number:
M 312</td><td colspan="4">Module Title:
Advanced Sedimentology</td><td colspan="4">Type of Module:
M.Sc. 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
Module Coordinator</td><td colspan="3">1 semester</td><td colspan="5">Fitzsimmons</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">The range of sedimentary environments will be introduced in the seminars (4 ECTS). Homework exercises will include preparation for the exercises and will assist students to learn the lecture material. Accompanying exercises (2 ECTS) will involve the active discussion of case studies and exploration of methods for investigating sediments and sedimentary rocks.</td></tr>
<tr><td>Module Content</td><td colspan="8">This course will focus on modern (and Quaternary) sediments, by:
• Reviewing the various environmental and climatic settings for the production, transport and deposition of different sediment types
• Gaining familiarity with the range of analytical techniques used to characterise and quantify modern sedimentary environments
• Placing sedimentary environments in the context of land-water-atmosphere interactions
• Investigating changes in sedimentary environments through time, including Anthropocene and potential future changes
Exercises will include the identification of different sediment types, exposure to a range of analytical techniques, and journal club discussions relating to the above.</td></tr>
<tr><td>Qualification Goals</td><td colspan="8">Students will gain familiarity with the different types of modern (and Quaternary) sedimentary environments as analogues for the sedimentary rocks covered in the Bachelor degree. They will be exposed to the various analytical techniques used for investigating and quantifying modern and Quaternary sedimentary processes. The skills learnt in this course will prepare students for dealing with a range of geological problems in active sedimentary environments, including addressing Anthropocene and future change.</td></tr>
<tr><td rowspan="3">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</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 sedimentology</td><td>S</td><td>c</td><td>4</td><td>4</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><td>2</td></tr>
<tr><td>Applicability</td><td colspan="8">M.Sc. Geowissenschaften/Geosciences, M.Sc. Applied & Environmental Geoscience</td></tr>
<tr><td>Prerequisites</td><td colspan="8">Successfully completed B.Sc. degree in Geosciences or Advanced Environmental Geosciences.</td></tr>
</table>

Module Number: **M 315**	Module Title: **Glaciology**								Type of Module: M.Sc. Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: 90 h / 6 SWS						Private Studies: 90 h
Duration Module Coordinator	1 semester				Weikusat				
Regular Cycle	every winter 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).								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Glaciology	*L* *E* *S*	*c* *c* *c*	*4* *1* *1*	*4* *1* *1*	*R*	*-*	*g*	*1*
Applicability	M.Sc. Geowissenschaften/Geosciences, M.Sc. Applied & Environmental Geoscience The module covers topics related to the material of the core modules mineralogy, geodynamics and applied geosciences.								
Prerequisites	Fundamentals in geology/mineralogy and physics								

<table>
<tr><td>Module Number:
M 317</td><td colspan="3">Module Title:
Data Analysis and Modeling Methods in Geoscience and Environmental Science</td><td>Type of Module:
M.Sc. 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:
3 x 20 h / 4 SWS</td><td>Private Study:
3 x 40 = 120 h</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="2">1-2 semester</td><td colspan="2">Drews</td></tr>
<tr><td>Regular Cycle</td><td colspan="4">every semester</td></tr>
<tr><td>Language</td><td colspan="4">English</td></tr>
<tr><td>Learning- / Teaching Forms</td><td colspan="4">Lectures and Computer Exercises for Data Analysis and Modeling</td></tr>
<tr><td>Module Content</td><td colspan="4">World-wide technical advances in monitoring the surface and sub-surface result in a new data environment for modern Geo- and Environmental sciences. Problem solving increasingly requires rigorous models and also integration of observations varying in space and time. Extracting the relevant information is achieved with computational methods that also require an understanding of the underlying mathematical principles.
It is subdivided into units, which include:
Finite Element Method
Fourier- and Laplace-Transform Techniques
Geographical Information Systems
Introduction Scientific Programming (Matlab)
Introduction Scientific Programming (Python)
Introduction to R
Introduction to Time Series Analysis
Machine Learning 1
Machine Learning 2
Principles of Model Calibration
Remote Sensing of River Systems
Each unit counts for two credits. Students are free to select 3 units out of the units offered. Another 3 units can be used to fill a second container module M325 (Data-Analysis and Modeling Methods in Geo- and Environmental Sciences 2).
The individual units are offered either over four weeks within the lecturing period of the semester, or as one-week block course.
The selection of units may vary with the instructors from year to year. Some units require prior participation in other units of this module (check with instructors beforehand).</td></tr>
<tr><td>Qualification Goals</td><td colspan="4">The goals of this module are
that students are able to understand selected mathematical concepts
that they can implement them computationally, that they can apply them to geo- and environmental related problems
develop relevant technical skills for data analysis and modelling
applied problem solving skills using Matlab / Python / R</td></tr>
<tr><td>Requirements for Obtaining Credit, Grading, Weight if appl.</td><td colspan="4"><table>
<tr><th>Courses</th><th>Type of Lecture</th><th>Status</th><th>CH</th><th>CP</th><th>Type of Exam / Study</th><th>Duration of Exam</th><th>Grading System</th><th>Weighting</th></tr>
<tr><td>Variable Topics</td><td>L,E</td><td>c</td><td>2</td><td>2</td><td>R,A</td><td>-</td><td>g</td><td>1/3</td></tr>
<tr><td>Variable Topics</td><td>L,E</td><td>c</td><td>2</td><td>2</td><td>R,A</td><td>-</td><td>g</td><td>1/3</td></tr>
</table></td></tr>
</table>

	Variable Topics	*L,E*	*c*	*2*	*2*	*R,A*	*-*	*g*	*1/3*
Applicability	Compulsory: M.Sc. Geowissenschaften/Geosciences, Elective: M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geosciences This module compliments other geology, geoecology, and environmental sciences courses (e.g. Advanced Geophysics, Climate Dynamics, Physics of the Earth's Surface) by providing a background for quantitative data analysis and modelling.								
Prerequisites	(TBD w.r.t. Python, Matlab, R)								

Module Number: **M 321**	Module Title: **Experimental and Analytical Methods in Geoscience and Environmental Science**								Type of Module: M.Sc. Compulsory / Elective
Credits (ECTS)	6 (3x2)								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: 90 h						Private Study: 90 h
Duration Module Coordinator	1 semester			Schulz, Berthold					
Regular Cycle	every winter semester								
Language	English								
Learning- / Teaching Forms	Laboratory exercises and lectures								
Module Content	The module is designed to advanced students to gain access to and knowledge of selected and frequently used analytical methods in geosciences, lectured by analytical experts/groups of the institute in theory and "hands on the machines". Units are: • Environmental Nanoscience • Instrumental Chemical Analysis Methods • Introduction to Dating Rocks and Sediments • Introduction to Electron Microscopy • Material Characterization Methods • Methods of Structural Analysis: X-ray Diffraction and Infrared/Raman Spectroscopy • Wet Chemical Analysis of Major and Trace Elements Each unit counts for 2 credits. Students are free to select 3 units out of the units offered. More advanced techniques are offered in module M326 (Experimental and Analytical Methods in Geoscience and Environmental Science 2). The individual units are offered either over 4 weeks within the lecturing period of the semester, or as one-week block course. In small groups, the units allow direct contact to staff scientists, advanced laboratories and institute infrastructure. Group sizes are limited, based on the maximum available staff and laboratory capacities.								
Qualification Goals	The courses are designed to learn and test a variety of instrumental methods and to get familiar with the laboratory work flows and routines.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Variable Topics	*L,E*	*c*	*2*	*2*	*R,A,OE*	*-*	*g*	*1/3*
	Variable Topics	*L,E*	*c*	*2*	*2*	*R,A,OE*	*-*	*g*	*1/3*
	Variable Topics	*L,E*	*c*	*2*	*2*	*R,A,OE*	*-*	*g*	*1/3*
Applicability	Compulsory: M.Sc. Geowissenschaften/Geosciences, Elective: M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geosciences								
Prerequisites	-								

<table>
<tr><td>Module Number:
M 322</td><td colspan="4">Module Title:
Climate Dynamics</td><td>Type of Module:
M.Sc. Elective</td></tr>
<tr><td>Credits (ECTS)</td><td colspan="5">6</td></tr>
<tr><td>Workload
- Contact Time
- Private Study</td><td>Workload:
180 h</td><td colspan="2">Contact Time:
60 h / 4 SWS</td><td colspan="2">Private Study:
120 h</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="2">1 semester</td><td colspan="3">Rehfeld</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 introduce fundamental concepts of climatology, the physical processes governing the climate system on different space and time scales, and empirical ways to describe and detect climate change.
In computer exercises, students learn to model basic physical processes in the atmosphere and apply classic and modern mathematical-statistical methods to describe, explain and predict different elements of the climate system.</td></tr>
<tr><td>Module Content</td><td colspan="5">This module offers an introduction to atmospheric processes, factors governing climate and climate change, links between climate and other Earth systems, and climate change of the past, present and future. Furthermore, it teaches the theoretical and practical knowledge of numerical models and mathematical-statistical techniques required for the description, explanation and prediction of climate. Module core content includes:
processes governing the climate system on different scales: from orbital and tectonic controls to fast local feedbacks
interactions between climate and other Earth systems (e.g. oceans and biosphere)
climate change and its causes in the past, present and future
physics-based numerical modelling of the atmosphere
common empirical tools for climatology</td></tr>
<tr><td>Qualification Goals</td><td colspan="5">Students have a basic understanding of the physical processes governing climate and climate change and are able to understand and apply basic numerical models and common empirical techniques to typical problems in climatology. The students will be able to apply these models and implement these tools as self-developed programming code.</td></tr>
<tr><td rowspan="3">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</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</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">M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience, M.Sc. Geographie</td></tr>
<tr><td>Prerequisites</td><td colspan="5">Knowledge of statistics and programming is useful, but not strictly required. No prior knowledge of climatology or meteorology is required.</td></tr>
</table>

<table>
<tr><td>Module Number:
M 324</td><td colspan="4">Module Title:
Economic Geology</td><td colspan="4">Type of Module:
M.Sc. Elective</td></tr>
<tr><td>Credits (ECTS)</td><td colspan="8">6</td></tr>
<tr><td>Workload
- Contact Time
- Private Time</td><td colspan="3">Workload:
180 h</td><td colspan="3">Contact times:
90 h / 6 SWS</td><td colspan="2">Private Studies:
90 h</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="4">1 semester</td><td colspan="4">Staude</td></tr>
<tr><td>Regular Cycle</td><td colspan="8">every other summer semester</td></tr>
<tr><td>Language</td><td colspan="8">English / German (can be held in German depending on students)</td></tr>
<tr><td>Learning- /Teaching Forms</td><td colspan="8">The module consists of lectures, complemented by exercises, and reflected light microscopy practice</td></tr>
<tr><td>Module Content</td><td colspan="8">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.</td></tr>
<tr><td>Qualification Goals</td><td colspan="8">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.</td></tr>
<tr><td rowspan="4">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td>Applied Economic Geology</td><td>L</td><td>c</td><td>3</td><td>3</td><td rowspan="3">WE</td><td rowspan="3">120</td><td rowspan="3">g</td><td>0.5</td></tr>
<tr><td rowspan="2">Ore Petrology and Reflected Light Microscopy</td><td>L</td><td>c</td><td>1</td><td rowspan="2">3</td><td rowspan="2">0.5</td></tr>
<tr><td>E</td><td>c</td><td>2</td></tr>
<tr><td>Applicability</td><td colspan="8">M.Sc. Geowissenschaften/Geosciences, M.Sc. Applied & Environmental Geoscience
The module is in close context to the M.Sc. module "Igneous Processes"</td></tr>
<tr><td>Prerequisites</td><td colspan="8">The completion of the B.Sc. module "Georessourcen" (or similar lecture, including basics in reflected light microscopy) is required.</td></tr>
</table>

<table>
<tr><td>Module Number:
M 325</td><td colspan="7">Module Title:
Data Analysis and Modeling Methods in Geoscience and Environmental Science 2</td><td colspan="2">Type of Module:
M.Sc. Elective</td></tr>
<tr><td>Credits (ECTS)</td><td colspan="9">6</td></tr>
<tr><td>Workload
- Contact Time
- Private Study</td><td>Workload:
180 h</td><td colspan="4">Contact Time:
3 x 20 h / 4 SWS</td><td colspan="4">Private Study:
3 x 40 = 120 h</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="4">1 semester</td><td colspan="5">Drews</td></tr>
<tr><td>Regular Cycle</td><td colspan="9">every semester</td></tr>
<tr><td>Language</td><td colspan="9">English</td></tr>
<tr><td>Learning- / Teaching Forms</td><td colspan="9">Lectures and Computer Exercises for Data Analysis and Modeling</td></tr>
<tr><td>Module Content</td><td colspan="9">This module is for students who want to increase their knowledge about data analysis and modeling methods acquired in module M317 (Data Analysis and Modeling Methods in Geoscience and Environmental Science 1). The content of the module is described in module M317.
The individual units are offered either over four weeks within the lecturing period of the semester, or as one-week block course.
The selection of additional 3 units out of the units offered in M317 can be used to fill module M325 (each unit counts for two credits). Some units require prior participation in other units of this module (check with instructors beforehand).</td></tr>
<tr><td>Qualification Goals</td><td colspan="9">The goals of this module are
• that students are able to understand selected mathematical concepts
• that they can implement them computationally, that they can apply them to geo- and environmental related problems
• develop relevant technical skills for data analysis and modelling
• applied problem solving skills using Matlab / Python / R</td></tr>
<tr><td rowspan="4">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</td><td>Type of Exam / Study</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td>Variable Topics</td><td>L,E</td><td>c</td><td>2</td><td>2</td><td>R,A</td><td>-</td><td>g</td><td>1/3</td></tr>
<tr><td>Variable Topics</td><td>L,E</td><td>c</td><td>2</td><td>2</td><td>R,A</td><td>-</td><td>g</td><td>1/3</td></tr>
<tr><td>Variable Topics</td><td>L,E</td><td>c</td><td>2</td><td>2</td><td>R,A</td><td>-</td><td>g</td><td>1/3</td></tr>
<tr><td>Applicability</td><td colspan="9">Compulsory: M.Sc. Geowissenschaften/Geosciences, Elective: M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geosciences
This module compliments other geology, geoecology, and environmental sciences courses (e.g. Advanced Geophysics, Climate Dynamics, Physics of the Earth's Surface) by providing a background for quantitative data analysis and modelling.</td></tr>
<tr><td>Prerequisites</td><td colspan="9">(TBD w.r.t. Python, Matlab, R)</td></tr>
</table>

Module Number: **M 326**	Module Title: **Experimental and Analytical Methods in Geoscience and Environmental Science 2**								Type of Module: M.Sc. Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: 90 h						Private Study: 90 h
Duration Module Coordinator	1 semester			Schulz, Berthold					
Regular Cycle	every summer semester								
Language	English								
Learning- / Teaching Forms	Lectures and laboratory exercises								
Module Content	The module is for students deeply interested in analytical methods. It offers access to more "advanced" techniques. Units are: • Advanced Electron Microscopy • Advanced Methods for Dating Rocks and Sediments • Quaternary Case Studies: Putting together the Story of Lake Filling and Drying in the Australian Desert • Dating Quaternary Sediments • Introduction to Mössbauer Spectroscopy • Material Orientated Computer Tomography • The Geology of Building Stones (starting summer semester 2024) Each unit counts for 2 credits. Students are free to select 3 units out of the units offered, including the units offered in module M321 (Experimental and Analytical Methods in Geoscience and Environmental Science 1). In small groups, the units allow direct contact to staff scientists, advanced laboratories and institute infrastructure. Group sizes are limited, based on the maximum available staff and laboratory capacities. The individual units are offered either over 4 weeks within the lecturing period of the semester, or as one-week block course.								
Qualification Goals	The courses are designed to learn and to test a variety of specific instrumental methods and to get familiar with the laboratory work flows and routines.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Variable Topics	*L,E*	*c*	*2*	*2*	*R,A,OE*	*-*	*g*	*1/3*
	Variable Topics	*L,E*	*c*	*2*	*2*	*R,A,OE*	*-*	*g*	*1/3*
	Variable Topics	*L,E*	*c*	*2*	*2*	*R,A,OE*	*-*	*g*	*1/3*
Applicability	M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geosciences								
Prerequisites	-								

<table>
<tr><td>Module Number:
M 409</td><td colspan="4">Module Title:
Marine Geology and Geochemistry</td><td>Type of Module:
M.Sc. 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 Studies:
90 h</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="3">1 semester</td><td colspan="2">Schulz</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">Teacher-centered teaching; studying literature on the subject, talk/exposé, handouts, laboratory practice.</td></tr>
<tr><td>Module Content</td><td colspan="5">• 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</td></tr>
<tr><td>Qualification Goals</td><td colspan="5">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.</td></tr>
<tr><td rowspan="4">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</td><td>Type of Exam / Study Requirements</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td>Marine Geochemistry</td><td>L,S</td><td>c</td><td></td><td>2</td><td rowspan="3">R</td><td rowspan="3">-</td><td rowspan="3">g</td><td rowspan="3">1</td></tr>
<tr><td>Marine Geology</td><td>L,S</td><td>c</td><td></td><td>2</td></tr>
<tr><td>Marine Geology</td><td>E</td><td>c</td><td></td><td>2</td></tr>
<tr><td>Applicability</td><td colspan="5">M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience
Related M.Sc. modules are "Paleoecology of Marine Systems", "Isotope Geochemistry" and "Carbonate Facies Analysis"</td></tr>
<tr><td>Prerequisites</td><td colspan="5">B.Sc. modules "Einführung in die Geowissenschaften", "Erdgeschichte", "Sedimente und Stratigraphie", "Paläontologie"
Course limited to 14 students.</td></tr>
</table>