Universität Trier

Module Handbook

Master Degree Program

MSc Environmental Sciences

With three Focal Points

- **Environmental Monitoring and Pollution Assessment (ES I)**
- **Environmental Remote Sensing and Modelling (ES II)**
- **Environmental Conservation and Restoration Management (ES III)**

Involved disciplines:

Analytische und Ökologische Chemie (Analytical & ecological Chemistry)
Bodenkunde (Soil Science)
Geobotanik (Geobotany, Vegetation Science)
Geologie (Geology)
Hydrologie (Hydrology)
Umweltfernerkundung & Geoinformatik (Environmental Remote Sensing & Geoinformatics)
Umweltmeteorologie (Environmental Meteorology)

as of October 26, 2011 - Bearbeitung nach Reakkreditierungsauflage - Mai 2013

Table of Contents

Curriculum of the Master of Science Degree Program „Environmental Science“

First Focal Point Specialisation in Environmental Monitoring and Pollution Assessment (ES I)

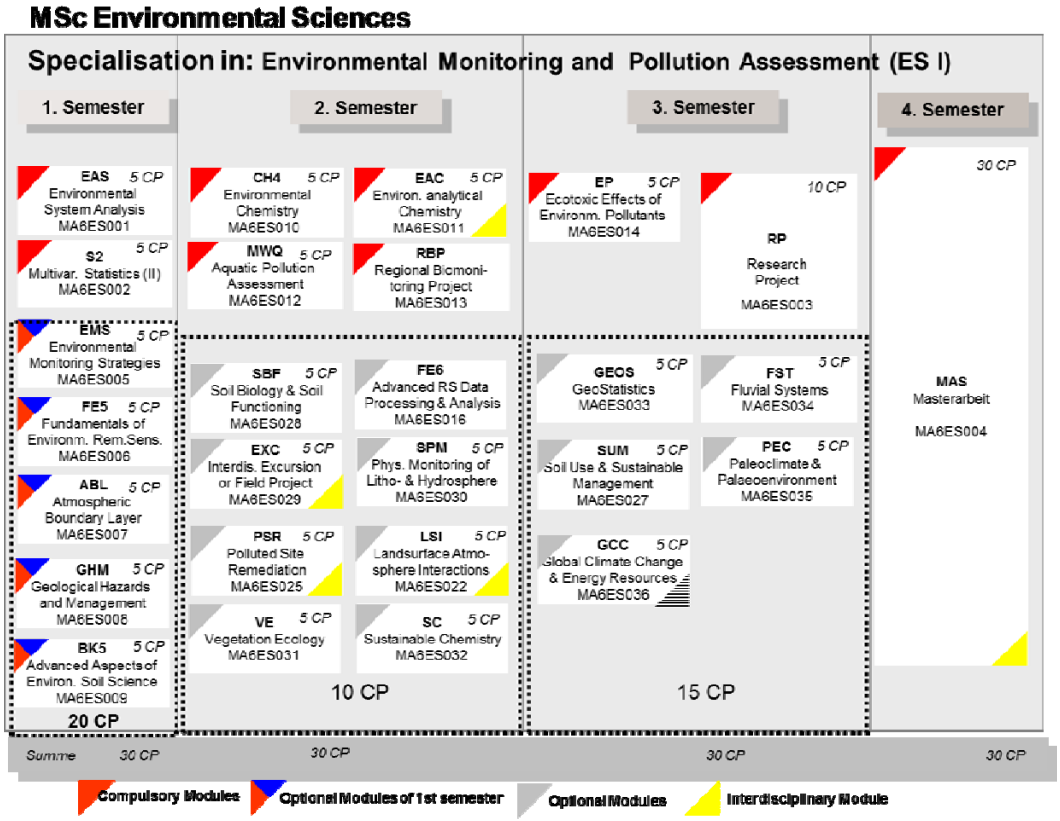

Table of courses in the Master of Science Degree Program “Environmental Sciences“ Specialisation in Environmental Monitoring and Pollution Assessment (ES I)

Semester	Module code	Module Name	Semester	CP	CP/Semester
1st		Compulsory Modules			
	MA6ES001	Environmental System analysis	1	5	
	MA6ESüü2	Multivariate Statistics	1	5	
		Optional Modules (4 of 5 Modules)			
	MA6ES005	Environmental Monitoring Strategies	1	5	
	MA6ES006	Fundamentals of Environmental Remote Sensing	1	5	
	MA6ES007	Atmospheric Boundary Layer	1	5	
	MA6ES008	Geological Hazards and Management	1	5	
	MA6ES009	Advanced Aspects of Environmental Soil Science	1	5	30
2nd		Compulsory Modules			
	MA6ES010	Environmental Chemistry and Risk Assessment	2	5	
	MA6ES011	Environmental Analytical Chemistry	2	5	
	MA6ES012	Aquatic Pollution Assessment	2	5	
	MA6ES013	Regional Biomonitoring project	2	5	
		Optional Modules (2 of 8 Modules)			
	MA6ES028	Soil Biology and Functioning	2	5	

	MA6ES016	Advanced Remote Sensing Data Processing and Analysis	2	5	30
	MA6ES029	Interdisciplinary Excursion or Field Project	2	5	
	MA6ES030	Physical Monitoring of Litho- and Hydrosphere	2	5	
	MA6ES025	Polluted Site Remediation	2	5	
	MA6ES022	Land Surface Atmosphere Interactions	2	5	
	MA6ES031	Vegetation Ecology	2	5	
	MA6ES032	Sustainable Chemistry	2	5	
3rd.		Compulsory Modules			
	MA6ES003	Research Project	3	10	
	MA6ES014	Ecotoxicological Effects of Environmental Pollutants	3	5	
		Optional Modules (2 of 5 Modules)	3	5	
	MA6ES033	Geostatistik	3	5	
	MA6ES034	Fluviatile transport processes	3	5	
	MA6ES027	Soil Use and Sustainable Management	3	5	
	MA6ES035	Palaeoclimate and Palaeoenvironment	3	5	
	MA6ES036	Global Climate Change and Energy Resources	3	5	30
4th		Compulsory Modules			
	MA6ES004	Master Thesis	4	30	30

Second Focal Point Specialisation in Environmental Remote Sensing and Modelling (ES II)

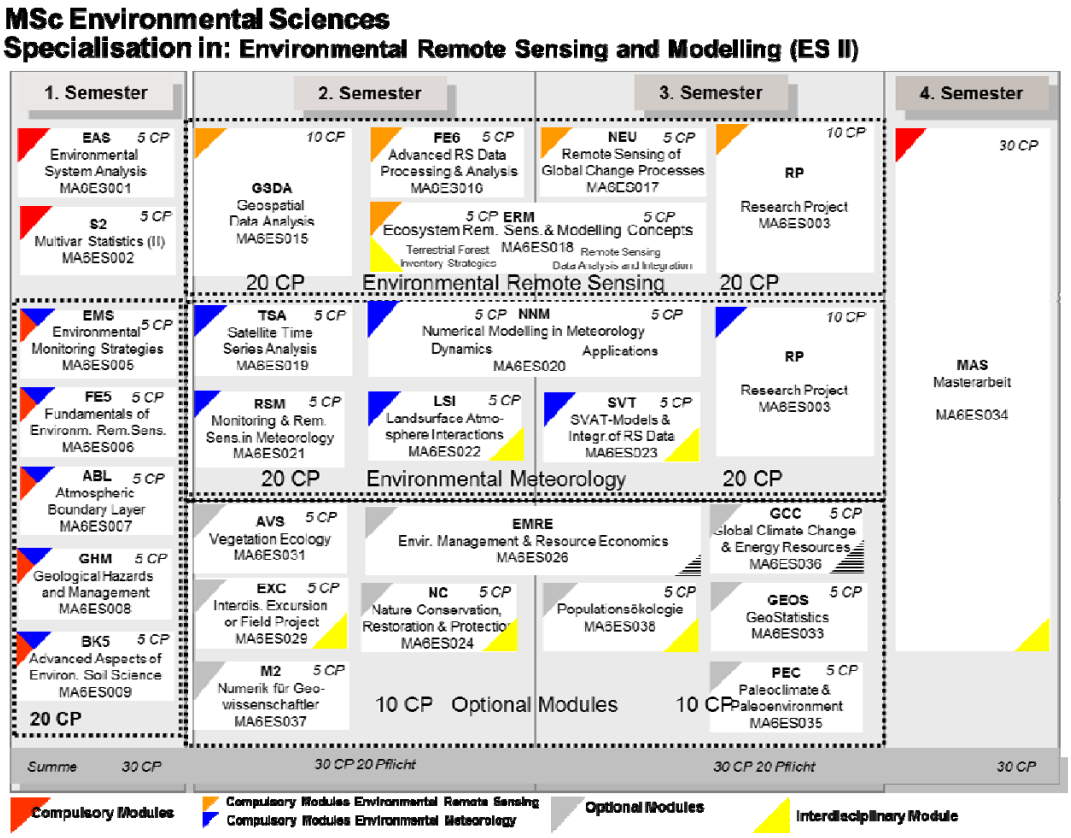

Table of courses in the Master of Science Degree Program “Environmental Sciences“Specialisation in Environmental Remote Sensing and Modelling (ES II)

Semester	Module Code	Module Name	Semester	CP	CP/Semester
1st		Compulsory Modules			
	MA6ES001	Environmental System Analysis	1	5	
	MA6ESüü2	Multivariate Statistics	1	5	
		Optional Modules (4 of 5 Modules)			
	MA6ES005	Environmental Monitoring Strategies	1	5	
	MA6ES006	Fundamentals of Environmental Remote Sensing	1	5	
	MA6ES007	Atmospheric Boundary Layer	1	5	
	MA6ES008	Geological Hazards, Risk Assessment and Management	1	5	
	MA6ES009	Advanced Aspects of Environmental Soil Science	1	5	30
2nd		Compulsory Modules			
		A. Environmental Remote Sensing**			30
	MA6ES015	Geospatial Data Analysis	2	10	
	MA6ES016	Advanced Remote Sensing Data and Analysis	2	5	
	MA6ES018	Ecosystem Remote Sensing and Modelling I	2 + 3	5	
		B. Environmental Meteorology*			
	MA6ES019	Satellite Time Series Analysis	2	5	
	MA6ES021	Monitoring and Remote Sensing in Meteorology	2	5	
	MA6ES020	Numerical Modelling in Meteorology	2 + 3	5	
	MA6ES022	Land Surface Atmosphere Interactions I	2	5	
	MA6ES023	SVAT Models and Integration of Remote Sensing Data	3	5	

		Optional Modules (for A and B; 2 of 5)			
	MA6ES031	Vegetation Ecology	2	5	
	MA6ES026	Environmental Management and Resource Economics	2 + 3	5	
	MA6ES029	Interdisciplinary Excursion or Field Project	2	5	
	MA6ES024	Nature Conservation, Restoration and Protection	2	5	
	MA6ES037	Numerik für Geowissenschaftler	2	5	
3rd		Compulsory Modules			
		A. Environmental Remote Sensing **			
	MA6ES017	Remote Sensing of Global Change Processes	3	5	
	MA6ES003	Research Project	3	10	
	MA6ES018	Ecosystem Remote Sensing and Modelling Concepts	2 + 3	5	
		B. Environmental Meteorology*			
	MA6ES020	Numerical Modelling in Meteorology	2 + 3	5	
	MA6ES003	Research Project	3	10	
	MA6ES023	SVAT Models and Integration of Remote Sensing Data	3	5	
		Optional Modules (for A and B; 2 of 5)			
	MA6ES033	Geostatistik	3	5	
	MA6ES026	Environmental Management and Resource Economics	2+3	5	
	MA6ES038	Populationsökologie	3	5	
	MA6ES036	Global Climate Change and Energy resources	3	5	
	MA6ES035	Palaeoclimate and Palaeoenvironment	3	5	30
4th		Compulsory Modules			
	MA6ES004	Master Thesis	4	30	30

*Optional Modules in Focus on Environmental Remote Sensing
**Optional Modules in Focus on Environmental Meteorological

Third Focal Point Specialisation in Environmental Conservation and Restoration Management (ES III)

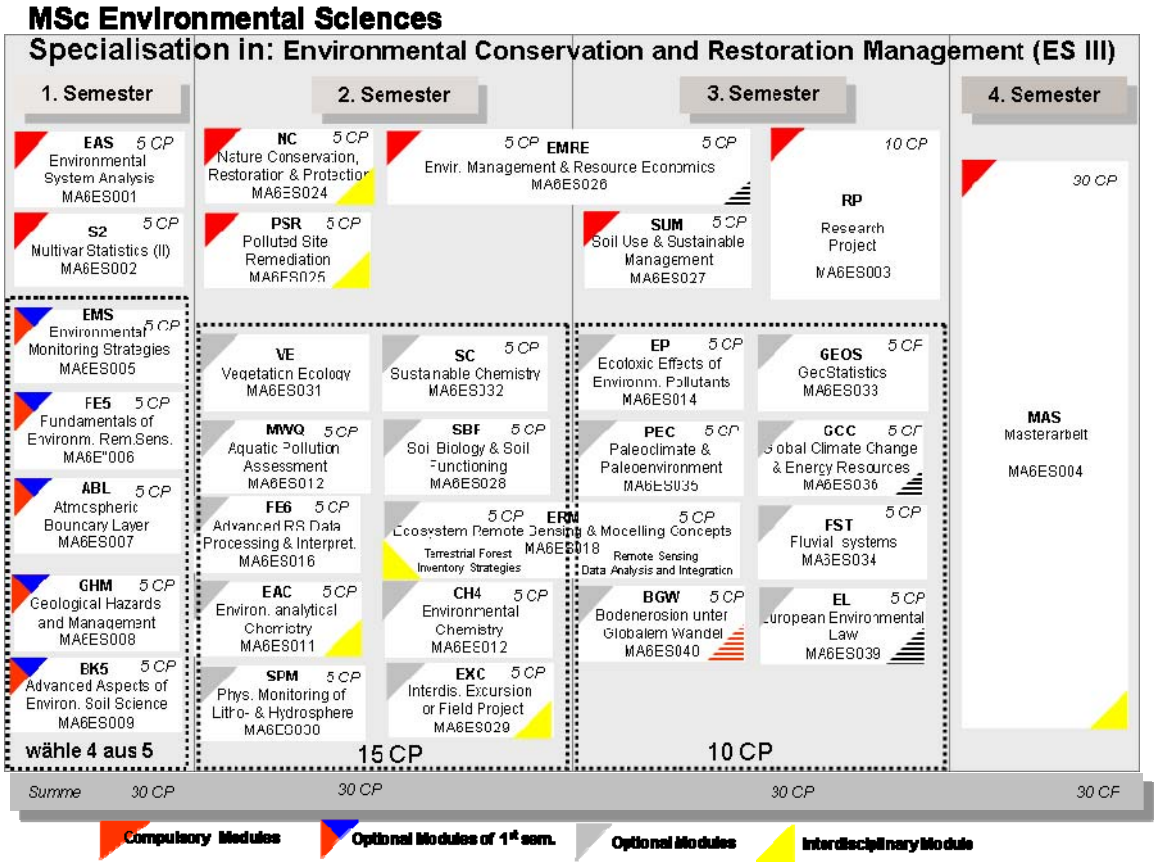

Table of courses in the Master of Science Degree Program “Environmental Sciences“Specialisation in Environmental Conservation and Restoration Management (ES III)

Semester	Module code	Module Name	Semester	CP	CP/Semester
1st		Compulsory Modules			
	MA6ES001	Environmental System Analysis	1	5	
	MA6ESüü2	Multivariate Statistics	1	5	
		Optional Modules (4 of 5 Modules)			
	MA6ES005	Environmental Monitoring Strategies	1	5	
	MA6ES006	Fundamentals of Environmental Remote Sensing	1	5	
	MA6ES007	Atmospheric Boundary Layer	1	5	
	MA6ES008	Geological Hazards and Management	1	5	
	MA6ES009	Advanced Aspects of Environmental Soil Science	1	5	30
2nd		Compulsory Modules			
	MA6ES024	Nature Conservation, Restoration and Protection	2	5	30
	MA6ES025	Polluted Site Remediation	3	5	
	MA6ES026	Environmental Management and Resource Economic	2 + 3	5	
		Optional Modules (3 of 10 Modules)			
	MA6ES031	Vegetation Ecology	2	5	
	MA6ES032	Sustainable Chemistry	2	5	
	MA6ES012	Aquatic Pollution Assessment	2	5	

	MA6ES028	Soil Biology and Soil Functioning	2	5	
	MA6ES016	Advanced Remote Sensing Data Processing and Analysis	2	5	
	MA6ES018	Ecosystem remote Sensing and Modelling	2+3	5	
	MA6ES011	Environmental Analytical Chemistry	2	5	
	MA6ES012	Environmental Chemistry and Risk Assessement	2	5	
	MA6ES030	Physical Monitoring of Litho- and Hydrosphere	2	5	
	MA6ES029	Interdisciplinary Excursion or Field Project	2	5	
3rd		Compulsory Modules			
	MA6ES026	Environmental Management and Resource Economic	2 + 3	5	
	MA6ES027	Soil Use and Sustainable Management	3	5	
	MA6ES003	Research Project	3	10	
		Optional Modules (2 of 8 Modules)	3	5	
	MA6ES033	Geostatistik	3	5	
	MA6ES014	Ecotoxicological Effects of Environmental Pollutants	3	5	
	MA6ES036	Global Climate Change and Energy Resources	3	5	
	MA6ES035	Palaeoclimate and Palaeoenvironment	3	5	
	MA6ES034	Fluviatile transport processes	3	5	
	MA6ES018	Ecosystem Remote Sensing and Modelling	2+3	5	
	MA6ES039	European Environmental Law	3	5	
	MA6ES040	Bodenerosion unter Globalem Wandel	3	5	30
4th		Compulsory Modules			
	MA6ES004	Master Thesis	4	30	30

Compulsory Modules of all three Focal Points

<table>
<tr><td colspan="6">Module "Environmental Systems Analysis"</td></tr>
<tr><td>Course code
MA6ES001</td><td>Workload
150 h</td><td>Credits
5</td><td>Study Semester
1st Sem.</td><td>Frequency of course offer
annual</td><td>Duration
1 Semester</td></tr>
<tr><td>1</td><td colspan="2">Courses

a) Environmental Systems Analysis
b) Environmental Systems Modelling</td><td>Contact Hours

2 SWH/30 h
2 SWH/30 h</td><td>Private Study

30 h
60 h</td><td>Planned Group Size

25
15</td></tr>
<tr><td>2</td><td colspan="5">Learning outcomes/ Qualification objectives
After the course, students are expected
• to have an improved knowledge on environmentally oriented decision-making,
• to describe the general procedure of environmental systems analysis,
• to be able to use different tools of environmental system analysis,
• to be able to critically evaluate integrated analyses of complex environmental systems,
• to develop and apply environmental simulation models</td></tr>
<tr><td>3</td><td colspan="5">Content
a) Principles of environmental systems analysis:
• the nature of systems and the fundamentals of systems thinking
• environmental systems: connections, cycles, and feedback loops
• strategies for analyzing and using environmental system models
• basic modeling concepts in environmental systems analysis
• population development and boundaries of growth
• the meaning of catastrophes for natural systems
• regional material transport, LCA
• using simulation tools (e.g. STELLA) for system analysis
• translation of "story lines" in model equations
b) Practical application of modelling scenarios</td></tr>
<tr><td>4</td><td colspan="5">Introduction Forms
a) Lectures and seminars in conjunction with oral presentation
b) Practical exercises</td></tr>
<tr><td>5</td><td colspan="5">Conditions for Participation</td></tr>
<tr><td>6</td><td colspan="5">Examination Forms
Advanced examination effort: ~~accepted~~ term paper
Final module examination: Written Examination (120 minutes)</td></tr>
<tr><td>7</td><td colspan="5">Condition for the award of credit points
Passed final examination: written examination (120 min.)</td></tr>
<tr><td>8</td><td colspan="5">Applicability of the Module
MSc Angewandte Geoinformatik, MSc Prozessdynamik an der Erdoberfläche</td></tr>
<tr><td>9</td><td colspan="5">Value of the mark in the final mark
Without proportional weighting in the final grade (5/120).</td></tr>
<tr><td>10</td><td colspan="5">Module representative and full-time instructors
Module representative: Dr. R. Bierl</td></tr>
<tr><td>11</td><td colspan="5">Further Information
Literature:
H. Bossel: Systems and Models – Complexity, Dynamics, Evolution, Sustainability. Books on Demand, Norderstedt, 2007
Deaton, M.L., Winebrake, J.J. (2000): Dynamic modelling of environmental systems. New York, Springer.</td></tr>
</table>

<table>
<tr><td colspan="6">Module „Multivariate Statistics“</td></tr>
<tr><td>Course code
MA6ES002</td><td>Workload
150 h</td><td>Credits
5</td><td>Study Semester
1st semester</td><td>Frequency of course offer
annual</td><td>Duration
1 Semester</td></tr>
<tr><td>1</td><td colspan="2">Courses
a) Lecture „Multivariate Statistics“
b) Seminar „Multivariate Statistics“</td><td>Contact Hours
2 SWH/30 h
2 SWH/30 h</td><td>Private Study
45 h
45 h</td><td>Size of Group
200
20</td></tr>
<tr><td>2</td><td colspan="5">Qualification objectives
The overall aims of the module are to:
• gain basic knowledge in relevant multivariate methods for explorative data analysis, regression and classification, and pattern recognition
• train the usage of statistics software (R, SPSS, matlab) for multivariate data analysis
• the get the competence in critical and self-contained usage of statistical methods in research questions related to environmental sciences</td></tr>
<tr><td>3</td><td colspan="5">Content
• Introduction to linear algebra
• Variance analysis: ANOVA and MANOVA
• Multiple correlation and regression analysis
• Cluster analysis techniques: hierarchical cluster analysis and k-means clustering
• Factor analysis and principal component analysis
• Partial least square regression and principal component regression
• Discriminant analysis
• Pattern recognition: neuronal networks, kernel based regression and classification methods, Ensemble based statistical modelling</td></tr>
<tr><td>4</td><td colspan="5">Instruction Forms:
Lecture, seminar</td></tr>
<tr><td>5</td><td colspan="5">Conditions for Participation</td></tr>
<tr><td>6</td><td colspan="5">Examination Form
Advanced examination effort: excersises
Final module examination: Written examination (120 min.)</td></tr>
<tr><td>7</td><td colspan="5">Condition for the Award of Credit Points
~~Precondition: Accepted homework~~
Passed final examination: written examination (120 min.)</td></tr>
<tr><td>8</td><td colspan="5">Applicability of the Module
MSc Angewandte Geoinformatik</td></tr>
<tr><td>9</td><td colspan="5">Value of Mark in the Final Grade
Without proportional weighting in the final grade (5/120).</td></tr>
<tr><td>10</td><td colspan="5">Module Representative and Full-Time Instructor
Prof. Dr. T. Udelhoven</td></tr>
<tr><td>11</td><td colspan="5">Further Information</td></tr>
</table>

Module "Research Project"					
Course Code MA6ES003	Workload 300 h	Credits 10	Study Semester 3rd Semester	Frequency of course offer – annual -	Duration 1 Semesters

1	Courses a) Advanced Aspects in Environmental Sciences b) Research methods in Environmental Sciences	Contact Hours 1 SWH/15 h 3 SWH/45 h	Private Study 75 h 165 h	Planned Group Size 20 20
2	Learning Outcomes/Qualification Objectives • Students will be expected to conduct small research projects under guidance but practice to work self-dependant in project teams. • Students should become familiar with current methodology, experimental design and data analysis. • Students should improve their competence in literature research, scientific documentation and the presentation of scientific results.			
3	Contents • The project topics discussed are mainly related to the current environmental research of the participating departments. • The research topics may contain a field and/or laboratory component or include modelling aspects.			
4	Instruction Forms a) Seminar b) practical exercises			
5	Condition for participation			
6	Examination forms Advanced examination effort: presentation (30 min.) Final module examination: graded term paper ~~and presentation (30 min)~~			
7	Condition for the award of credit points Passed final examination: term paper			
8	Applicability of the module			
9	Value of the mark in the final mark Without proportional weighting in the final mark (10/120)			
10	Module representative and full-time instructors Module representative Prof. Dr. S. Thiele-Bruhn All lecturers of MSc Environmental Sciences			
11	Further Information			

Module "Master Thesis"						
Course code MA6ES004	Workload 900 h	Credits 30	Study Semester 4th Semester.	Frequency of course offer annual	Duration 1 Semester	
1	Courses Master Thesis Master colloquy	Contact Hours 4 SWH/60 h 2 SWH/10 h	Private Study 810 h	Planned Group Size		
2	Learning outcomes/ Qualification objectives Aptitude for independent scientific handling of a question from the basic research or applied research of a specialization in the environmental geo-scientific subjects; Mastery of appropriate methods of production, processing and display of relevant data; competence for critical discussion of developed results taking into account the current status of science and requirements to put scientific knowledge into practice; ability to understand presenting of significant results					
3	Content Independent review of a scientific question under technical guidance; use of a versatile set of methods for testing research hypotheses; making a scientific study on scientific background applied methods and significant results of studies including the critical discussion of results; presentation of significant results					
4	Introduction Forms Formulation of an independent scientific work on the basis of studies in the area, experimental field work, laboratory or a guided project work; presentation of the results in a colloquy					
5	Conditions for Participation					
6	Examination Forms ~~Graded~~ written scientific study (4/5 of the module mark); ~~graded~~ oral presentation (~~presentation of the study in a seminar or colloquium~~, 20 min. presentation~~ute lecture~~, 10 min. discussion) (1/5 of module mark)					
7	Condition for the award of credit points Passed master thesis and presentation					
8	Applicability of the Module					
9	Value of the mark in the final mark Without proportional weighting in the final grade (30/120).					
10	Module representative and full-time instructors Module representative Prof. Dr. G. Heinemann Tutor of the Master study; Lecturers in the environmental sciences subjects					
11	Further Information.					

Optional Modules of the first Semester

<table>
<tr><td colspan="7">Module “Environmental Monitoring Strategies”</td></tr>
<tr><td colspan="2">Course code
MA6ES005</td><td>Workload
150 h</td><td>Credits
5</td><td>Study Semester
3nd Sem.</td><td>Frequency of course offer
annual</td><td>Duration
1 Semester</td></tr>
<tr><td>1</td><td colspan="2">Courses
a) Monitoring in ecological research
b) Advanced environ-mental monitoring</td><td>Contact Hours
2 SWH/30 h
2 SWH/30 h</td><td>Private Study
30 h
60 h</td><td colspan="2">Planned Group Size
15
15</td></tr>
<tr><td>2</td><td colspan="6">Learning outcomes/ Qualification objectives
The overall aims of the module are:
• to provide a grounding in ecological research techniques both in the field and laboratory
• to explain and evaluate the terminology, theoretical principles and practical limitations of air, water and soil pollution monitoring and control systems
• to explain monitoring/control techniques and strategies for air, water and soil pollutants
• to assess the roles of local, national and international agencies with respect to the management of air, water and soil quality.
• to provide transferable skills in team work and individual skills in data collection and data analysis</td></tr>
<tr><td>3</td><td colspan="6">Content
• Long-term monitoring in ecosystems
• Air pollution monitoring
• Contaminant-control process monitoring
• Biosensors, bioanalytical and biomonitoring systems
• Tools and strategies for river ecology evaluationIntegrated approaches: environmental parameters that are relevant for the structure and functioning of the ecosystem</td></tr>
<tr><td>4</td><td colspan="6">Introduction Forms
a) Lectures and seminars in conjunction with oral presentation
b) Seminar</td></tr>
<tr><td>5</td><td colspan="6">Conditions for Participation</td></tr>
<tr><td>6</td><td colspan="6">Examination Forms
Advanced examination effort: term paper
Final module examination: oral examination (20 minutes)</td></tr>
<tr><td>7</td><td colspan="6">Condition for the award of credit points
Passed final examination: oral examination (20 minutes)</td></tr>
<tr><td>8</td><td colspan="6">Applicability of the Module</td></tr>
<tr><td>9</td><td colspan="6">Value of the mark in the final mark
Without proportional weighting in the final grade (5/120).</td></tr>
<tr><td>10</td><td colspan="6">Module representative and full-time instructors
Module representative Dr. R. Bierl, further instructors: Prof. Dr. W. Werner</td></tr>
<tr><td>11</td><td colspan="6">Further Information</td></tr>
</table>

<table>
<tr><td colspan="6">Module "Fundamentals of Environmental Remote Sensing"</td></tr>
<tr><td>Course code
MA6ES006</td><td>Workload
150 h</td><td>Credits
5</td><td>Study Semester
1st Sem.</td><td>Frequency of course offer
annual</td><td>Duration
1 Semester</td></tr>
<tr><td>1</td><td colspan="5">Courses
a) Lecture "Fundamentals of Environmental Remote Sensing" — Contact Hours: 2 SWH/30 h; Private Study: 45 h; planned Group Size: 200
b) Practical course "Fundamentals of Environmental Remote Sensing" — Contact Hours: 2 SWH/30 h; Private Study: 45 h; planned Group Size: 20</td></tr>
<tr><td>2</td><td colspan="5">Qualification objectives
• Knowledge and hands-on experience of multi-scale remote sensing data
• Expertise in derivation of surface parameters from data sources with different spectral and radiometric properties
• Understanding of interdisciplinary issues
• Formulation, preparation and presentation of research questions and interpretation strategies</td></tr>
<tr><td>3</td><td colspan="5">Content
Introduction to multi-scale remote sensing systems
- Specific sensor characteristics
- Object signatures, scaling effects
- Data archives
Advanced radiometric processing of multi-spectral data
- Sensor calibration
- Radiative transfer models
- Integration of topography- and Minnaert correction
- Procurement of long-term time series
Derivation of qualitative surface characteristics
- Land use classification and land cover archives (MODIS, CORINE)
- Land use change detection based on time series (e.g. MODIS)
Biophysical parameters
- Vegetation (e.g. cover, LAI, biomass)
- Soil (e.g. organic and inorganic carbon, mineral content)
- Indicators of productivity and disturbance
Development of a processing and interpretation workflow
- Implementation of digitale image processing concepts and specific analysis techniques in the frame of a case study
- Vegetation indices and linear transformations (e.g. PCA, Tasseled Cap, Spectral Mixture Analysis)</td></tr>
<tr><td>4</td><td colspan="5">Instruction Forms
Lecture, Practical course</td></tr>
<tr><td>5</td><td colspan="5">Conditions for Participation</td></tr>
<tr><td>6</td><td colspan="5">Examination Form
Advanced examination effort: oral presentation
Final module examination: Portfolio</td></tr>
<tr><td>7</td><td colspan="5">Condition for the Award of Credit Points
Passed final examination: Portfolio</td></tr>
<tr><td>8</td><td colspan="5">Applicability of the Module</td></tr>
<tr><td>9</td><td colspan="5">Value of Mark in the Final Grade
Module mark is accepted without proportional weighting in final grade (5/120)</td></tr>
<tr><td>10</td><td colspan="5">Module Representative and Full-Time Instructor
Prof. Hill, Dipl.-Geogr. Mader, Dr. M. Stellmes</td></tr>
<tr><td>11</td><td colspan="5">Further Information
LIANG, S. (2003): Quantitative Remote Sensing for Land Surface Characterization.
SCHÖNERMARK, M. V., GEIGER, B., RÖSER, H.P. (2004): Reflection Properties of Vegetation and Soil.
QUATTROCHI, D.A.& GOODCHILD, M.F. (1997): Scale in Remote Sensing and GIS.</td></tr>
</table>

<table>
<tr><td colspan="7">Module "Atmospheric Boundary Layer"</td></tr>
<tr><td colspan="2">Course Code
MA6ES007</td><td>Workload
150 h</td><td>Credits
5</td><td>Study Semester
1st Semester</td><td>Frequency of course offer - annual -</td><td>Duration
1 Semester</td></tr>
<tr><td>1</td><td colspan="2">Courses
a) Lecture ABL
b) Exercises ABL</td><td>Contact Hours
2 SWH/30h
2 SWH/30h</td><td>Private Study
45 h
45 h</td><td colspan="2">Planned Group Size
120
20</td></tr>
<tr><td>2</td><td colspan="6">Learning Outcomes/Qualification Objectives
- Understanding the role of the atmospheric boundary layer (ABL), processes in the ABL and their interactions
- Knowledge of parameterization of exchange processes
- Independent, problem oriented, scientifically founded, methodologically work</td></tr>
<tr><td>3</td><td colspan="6">Contents
This module is the basis for all modules, which deal with the soil-plant-atmosphere exchange, both for the modules with measurements of exchange processes and their modeling. In particular, the following topics are covered:
• Structure of the atmospheric boundary layer,
• turbulent flux densities,
• surface energy balance,
• exchange processes and budgets in the ABL,
• hydrodynamic equations,
• laws and parameterizations</td></tr>
<tr><td>4</td><td colspan="6">Instruction Forms
a) Lecture, b) Exercises</td></tr>
<tr><td>5</td><td colspan="6">Condition for participation
None</td></tr>
<tr><td>6</td><td colspan="6">Examination forms
Advanced examination effort: term paper
Final module examination: Written examination (120 minutes)</td></tr>
<tr><td>7</td><td colspan="6">Condition for the award of credit points
Passed final examination: written examination (120 min.)</td></tr>
<tr><td>8</td><td colspan="6">Applicability of the module</td></tr>
<tr><td>9</td><td colspan="6">Value of the mark in the final mark
without proportional weighting in the final mark (5/120)</td></tr>
<tr><td>10</td><td colspan="6">Module representative and full-time instructors
Prof. Dr. G. Heinemann, Dr. C. Drüe</td></tr>
<tr><td>11</td><td colspan="6">Further Information</td></tr>
</table>

<table>
<tr><td colspan="6">Module "Geological hazards, risk assessment and management"</td></tr>
<tr><td colspan="2">Course Code
MA6ES008</td><td>Work Load
150 h</td><td>Credits
5</td><td>Study Semester
1st Semester.</td><td>Frequency of Course offer
annual</td><td>Duration
1 Semester</td></tr>
<tr><td>1</td><td colspan="2">Course

a) lecture
b) seminar
c) field trip</td><td>Contact Hours

2 SWS/30 h
1 SWS/15h
1 SWS/30 h</td><td>Private Study

15 h
30 h
30 h</td><td colspan="2">Planned Group Size

120
20
20</td></tr>
<tr><td>2</td><td colspan="6">Learning Outcomes/Qualification Objectives
• Understanding and quantification of short term geological processes (earthquake, volcanism, mass movements, tsunamis, etc.)
• Prediction of geological hazards
• Risk Assessment
• Emergency Management and Mitigation
• Consequences of human activity on geological processes
• Effects of geohazards on humans and ecosystems</td></tr>
<tr><td>3</td><td colspan="6">Contents
a) Introduction to geological disasters & hazard evaluation
b) Geogenic hazards
1. Volcanoes
2. Earthquakes & Tsunamis
3. Coastal Processes
4. Hurricanes & Tornadoes
5. River Floods
6. Mass Movements & Erosion
7. Global Climate Change
c) Anthropogenic hazards
8. Mining of Mineral & Energy Resources
9. Water Resources & Pollution
10. Agriculture & Soils
11. Brownfields</td></tr>
<tr><td>4</td><td colspan="6">Introduction Forms
lecture, seminar, field trip</td></tr>
<tr><td>5</td><td colspan="6">Condition for participation</td></tr>
<tr><td>6</td><td colspan="6">Examination Forms
Advanced examination effort: oral presentation and field trip report
Final module examination: written examination (90 min.)</td></tr>
<tr><td>7</td><td colspan="6">Condition for the award of credit points
Passed final examination: written examination (90 min.)</td></tr>
<tr><td>8</td><td colspan="6">Applicability of the module</td></tr>
<tr><td>9</td><td colspan="6">Value of the mark in the final mark
Without proportional weighting in the final mark (5/120)</td></tr>
<tr><td>10</td><td colspan="6">Module representative and full-time instructors
Prof. Dr. J.F. Wagner</td></tr>
<tr><td>11</td><td colspan="6">Further Information</td></tr>
</table>

Module "Advanced Aspects of Environmental Soil Science"					
Course code MA6ES009	Workload 150 h	Credits 5	Study Semester 1st Semester	Frequency of course offer annual	Duration 1 Semester

1	Courses	Contact Hours	Private Study	Planned Group Size
	a) Lecture:" Environmental Soil Science"	2 SWH/30 h	40 h	120
	b) Practical course: "Advanced Methods in Soil Science"	2 SWH/30 h	50 h	20

2 Learning outcomes/ Qualification objectives

key qualifications:

- In-depth understanding of interdisciplinary and multi-focus relations and interactions
- Application of system-oriented mindsets and methods
- Planning and organisation of laboratory operational procedures; quality control
- Handling of scientific literature, respective data banks and scientific English

Expertise:

- Adjustment of soil scientific basic knowledge among graduates from different bachelor programmes
- Communication and compilation of in-depth expert knowledge on specific aspects from soil chemistry, physics and biology.
- Acquisition of relevant analytical, recording, and modelling methods in theory and practise.

3 Content

- Mechanisms and kinetics of sorption, mobilisation, transformation and translocation of nutrients and pollutants in soil.
- Modern functional concepts of and analytical methods for soil organic matter
- Soil organism communities and their interaction with biotic and abiotic factors
- Soil water balance at saturated and unsaturated conditions and impact on discharge within and on the soil
- Mechanic loading capacity, limits and loadings of soils and measures to prevent soil from degradation through compaction
- Instruction to different analytical and recording methods to investigate processes and mechanisms within the above mentioned fields of soil science
- Achievement of competence for field and laboratory investigation of relevant parameters from the above mentioned fields of soil science

4 Introduction Forms

a) Lecture (deepen basic knowledge in soil science with focus on soil functions and threats),
b) Practical course on special topics from soil chemistry, physics and biology

5 Conditions for Participation

6 Examination Forms

Final module examination: oral examination (30 minutes)

7 Condition for the award of credit points

Passed final examination: oral examination (30 min.)

8 Applicability of the Module

Mandatory module within MSc Prozessdynamik an der Erdoberfläche, optional module within MSc Umweltbiowissenschaften

9 Value of the mark in the final mark

Without proportional weighting in the final grade (5/120).

10 Module representative and full-time instructors

. Prof. Dr. S. Thiele-Bruhn, Dr. R. Schneider, apl. Prof. Dr. C. Emmerling, Dr. M.-O. Aust

11 Further Information

Literature:

SCHEFFER/SCHACHTSCHABEL: Lehrbuch der Bodenkunde. Spektrum Akademischer Verlag.
SPARKS D.: Environmental Soil Chemistry. Academic Press.
HILLEL D. et al.: Encyclopedia of Soils in the Environment. Academic Press
HARTGE K.H., HORN R.: Einführung in die Bodenphysik. Enke.
BLUME H.-P. et al. (2011) Bodenkundliches Praktikum. 3rd ed., Spektrum Akademischer Verlag.

Compulsory Modules of Focal Point I: Environmental Monitoring and Pollution Assessment (ES I)

<table>
<tr><td colspan="6">Module "Environmental Chemistry and Risk Assessment"</td></tr>
<tr><td colspan="2">Course Code
MA6ES010</td><td>Workload
150 h</td><td>Credits
5</td><td>Study Semester
2nd Semester</td><td>Frequency of course offer – annual -</td><td>Duration
1 Semester</td></tr>
<tr><td>1</td><td colspan="6">Courses:

a) Lecture 1:Environmental Fate and Reactions of Pollutants — Contact Hours: 2 SWH/30 h — Private Study: 30 h — Planned Group Size: 125
b) Seminar: Environmental Risk Assessment — Contact Hours: 2 SWH/30 h — Private Study: 30 h — Planned Group Size: 125
c) Laboratory research course — Contact Hours: 2 SWH/30 h — Planned Group Size: 12</td></tr>
<tr><td>2</td><td colspan="6">Learning outcomes/Qualification Objectives
The students should:
• learn to understand environmental media and environmental compartments as chemical reactors,
• apply and deepen the knowledge acquired in the BSc-UGW about the connection between molecular structure/functionality and reactivity of environmental chemicals,
• be introduced to current research topics on environmental chemistry,
• learn about priority and newly spreading pollutant classes,
• develop an understanding of important abiotic substance transformation processes and be able to attribute them to fundamental (organic) chemical reaction mechanisms,
• be able to evaluate the importance of these types of reactions for the various environmental compartments and pollutant classes,
• be able to portray the influence of physical-chemical parameters on reaction conversion and reaction speed,
• be able to understand and critically judge the derivation of limit values and other load indicator values,
• be able to differentiate different "Environmental Risk Assessment" models and methods with regard to their output premises and objectives.</td></tr>
<tr><td>3</td><td colspan="6">Content
• Structural and physicochemical characteristics of priority and new emerging classes of environmental chemicals,
• Important abiotic degradation mechanisms (hydrolysis, oxidation, reduction, radical reactions, substitution reactions, coupling reactions, photolysis, surface and metal-ion-catalyzed reactions),
• Correlation between the number and steric arrangement of structural units / functional groups and reactivity of molecules belonging to one congeneric substance group,
• Importance of specific degradation mechanisms for different environmental compartments,
• Influence of physicochemical environmental conditions on mechanism and rate of substance transformation,
• Stabilization and sensibilization of environmental chemicals by sorptive bonding,
• Interrelations between phase transfer and degradation processes,
• Concepts and models of "Environmental Risk Assessments",
• Risk concept and its application to behavior and effect of chemicals / environmental toxicants,
• (Eco-) toxicological bases for environmental endangerment estimations and critical level / limit value settings,
• Kinds of limit and other regulation and/or indication values,
• Methods of limit value deduction, compromise character of limit values,
• Legal impact of limit values, action options in case of exceeding of critical levels.</td></tr>
<tr><td>4</td><td colspan="6">Instruction Forms
Lecture, seminar, laboratory research practical (one week ~~long~~ block event or the whole day/individual days distributed throughout the semester).</td></tr>
<tr><td>5</td><td colspan="6">Condition for Participation</td></tr>
<tr><td>6</td><td colspan="6">Examination Form: successful (qualified protocol) participation at the laboratory practical and seminar</td></tr>
<tr><td>7</td><td colspan="6">Condition for the award of credit points: Passed final examination: written examination (90 min.) examination</td></tr>
<tr><td>8</td><td colspan="6">Applicability of the Module: Compulsory Module in MSc Umweltbiowissenschaften, focus „Molekularbiologie von Umweltsubstanzen und Umwelteinflüssen (MUU)"</td></tr>
<tr><td>9</td><td colspan="6">Value of the mark in the final mark: Without proportional weighting in final grade (5/120).</td></tr>
<tr><td>10</td><td colspan="6">Module representative and full-time instructor
Module representative: Prof. Dr. Dr. K Fischer, other lecturers: Dr. A. Meyer, Dr. J. Bonifas, Dr. Dr. A.-M. Florea.</td></tr>
<tr><td>11</td><td colspan="6">Further Information
Course books:
SCHWARZENBACH, R.P., GSCHWEND, P.M., IMBODEN, D.M.: Environmental Organic Chemistry. New York, etc. (J. Wiley & Sons).</td></tr>
</table>

	Hodgson, A Textbook of Modern Toxicology 4th edition Wiley; ISBN-10: 047046206X, ISBN-13: 978-0470462065

Module "Environmental Analytical Chemistry"

Course code	Workload	Credits	Study Semester	Frequency of course offer	Dauer
MA6ES011	150 h	5	2nd Sem.	annual	1 Semester

1	Courses	Contact Hours	Private Study	Planned Group Size
	a) Environmental Monitoring and Trace Analysis	2 SWH/30 h	30 h	25
	b) Instrumental Analytical Techniques	4 SWH/30 h	60 h	15

2 Learning outcomes/ Qualification objectives

By the end of the course students are able to:

- identify, analyse and solve environmental analytical problems,
- understand the basic theory and relevant parameters in environmental analytical chemistry,
- select proper sample preparation methods for different media,
- apply methods of instrumental analysis based on chromatography, spectrometry and spectroscopy for target analysis of environmental pollutants in complex environmental matrices,
- prepare reports on the basis of experimental results and draw critical conclusions,
- apply methods of analytical quality assurance and good laboratory practice.

3 Content

a) Environmental Monitoring and Trace Analysis

- Introduction to the basic concepts of environmental analysis and monitoring
- Introduction to sampling, sample extraction, clean-up methods and analytical techniques for the analysis of water and solid samples
- Techniques for trace and ultra-trace analysis of environmental pollutants
  - Spectroscopic methods
  - Chromatography/mass spectrometry
  - Elemental analysis
- Case-studies related to environmental pollutants
- In-situ measurement techniques and devices for field monitoring and automated analysis

b) The practical component of this module involves the application of analytical techniques to environmental samples.

4 Introduction Forms

a) Lectures and theoretical exercises.
b) Case studies (practical laboratory exercises) and project work.

5 Conditions for Participation

6 Examination Forms

Advanced examination effort: Report
Final module examination: Oral examination (30 minutes)

7 Condition for the award of credit points

Passed final examination: oral examination (30 min.)

8 Applicability of the Module

Optional module within MSc Umweltbiowissenschaften

9 Value of the mark in the final mark

Without proportional weighting in the final grade (5/120).

10 Module representative and full-time instructors

Dr. R. Bierl, Prof. Thiele-Bruhn

11 Further Information

Literature:
FIFIELD, F.W. & HAINES, P.J.(2000): Environmental Analytical Chemistry, 2nd ed., John Wiley & Sons

<table>
<tr><td colspan="6">Module "Aquatic Pollution Assessment"</td></tr>
<tr><td>Course code
MA6ES012</td><td>Workload
150 h</td><td>Credits
5</td><td>Study Semester
2nd Semester</td><td>Frequency of course offer
annual</td><td>Duration
1 Semester</td></tr>
<tr><td>1</td><td colspan="5"><table>
<tr><td>Courses</td><td>Contact Hours</td><td>Private Study</td><td>Planned Group Size</td></tr>
<tr><td>a) Aquatic ecology and impact of pollution</td><td>2 SWH/30 h</td><td>60 h</td><td>15</td></tr>
<tr><td>b) Case studies in river catchments</td><td>2 SWH/30 h</td><td>30 h</td><td>15</td></tr>
</table></td></tr>
<tr><td>2</td><td colspan="5">Learning outcomes/ Qualification objectives
The course intends to qualify the student for understanding the impact of pollution on freshwater ecosystems. It integrates different aspects of chemistry, physics and biology determining freshwater ecosystems with an emphasis on human impacts and interactions with aquatic systems. After the course, the students will be able
• to understand the main ecological processes occurring in freshwater ecosystems,
• to describe water characteristics and properties of water quality,
• to apply concepts of water quality and pollution processes in rivers and lakes,
• to plan sampling programs and conduct laboratory experiments,
• to communicate critically results of studies both orally and in written form.</td></tr>
<tr><td>3</td><td colspan="5">Content
Lectures describe fundamental ecological processes and biotic communities in freshwater ecosystems as well as the impact of pollution:
• Catchment characteristics
• Organic matter dynamics
• Biogeochemistry and nutrient cycling
• Freshwater ecology: structure and dynamics of riparian zones, stream habitats, biofilms, hyporheic zone
• Structure, function and dynamics of the aquatic food webs
• Anthropogenic influences, e.g. the ecological impacts of urban stormwater runoff quality, eutrophication, global warming
• Water quality standards in a regional context
• Water quality data evaluation
• Invertebrates as indicators of pollution
• Impacts of contamination and structural changes
• Localization of sources of contamination

The lab and field practical will consist of identification of algae and macroinvertebra-tes, basic ecological experiments, analytical techniques and comparison of surveys of biological and chemical water quality at various stations.</td></tr>
<tr><td>4</td><td colspan="5">Introduction Forms
a) Lectures and seminars in conjunction with oral presentation
b) Lab and field course</td></tr>
<tr><td>5</td><td colspan="5">Conditions for Participation</td></tr>
<tr><td>6</td><td colspan="5">Examination Forms
Final examination: graded term paper</td></tr>
<tr><td>7</td><td colspan="5">Condition for the award of credit points
Passed final examination: term paper</td></tr>
<tr><td>8</td><td colspan="5">Applicability oft he Module
Mandatory or optional module MSc Environmental Science</td></tr>
<tr><td>9</td><td colspan="5">Value of the mark in the final mark
Without proportional weighting in the final grade (5/120).</td></tr>
<tr><td>10</td><td colspan="5">Module representative and full-time instructors
Dr. R. Bierl, N.N.</td></tr>
<tr><td>11</td><td colspan="5">Further Informations
Literature:
DODDS, WALTER K.(2002): Freshwater Ecology: Concepts and Environmental Applications.
Academic Press.</td></tr>
</table>

<table>
<tr><td colspan="7">Module "Regional Biomonitoring Project"</td></tr>
<tr><td colspan="2">Course Code
MA6ES013</td><td>Work Load
150 h</td><td>Credits
5</td><td>Study Semester
2nd Semester</td><td>Frequency of course offer - Annual -</td><td>Duration
1 Semester</td></tr>
<tr><td>1</td><td colspan="2">Courses
a) Research concept and data analysis
b) Field and Laboratory Course</td><td>Contact Hours
1 SWH/15h
3 SWH/45h</td><td>Private Study
50 h
40 h</td><td colspan="2">Planned Group Size
24
24</td></tr>
<tr><td>2</td><td colspan="6">Learning Outcomes/Qualification Objectives
• Application of standardized passive and active Biomonitors as sensitive or accumulation monitors
• Observation, sampling and measurement of biological material (passiv sampled or active exposed).
• Development and evaluation of sensitive effect ctriteria and quality management and assurance of chemical analysis.
• Practice with highly standardizes invetigation methods and assessement of reproducibility, sensitivity, specifity, validity and representativity of biomonitoring investigation concepts
• Interpolation of point shaped measurements to whole area investigated with application of geostatistical methods.
• Application of gas flux models to quantify fluxes of gaseous pollutants into leaves
• Development of Critcal Loads and Levels
• Knowledge and application of modern monitoring projects within the framework of UNECE ICP Vegetation and ICP-Forests</td></tr>
<tr><td>3</td><td colspan="6">Contents
• Exposition of bioindicators for chosen pollutants (for instance ozone: Tobacco BEL W3, different sensitive clones of beans, clover and poplar) on chosen localities in Tier region.
• Exposure of active (standardized gras- & culy kale cultures) and passive accumulation Monitors for air pollutants and particulate matter in the Trier region
• Application of quantitative chemical analytical methods for measuring heavy metals concentrations in plant exposed material (AAS), POPs or nitrogen accumulation in lichens and mosses
• Measuring of different ecophysiological parameters for characterization of effects from pollutants on plants. (for instance leaf conductivity, pigment concentrations and chlorophyll fluoreszenz
• Geostatistics and aerial interpolation of point shaped measurements including error maps
• Time series analysis of monitoring data
• Evaluation of results with aid of legal limits, chemical detection limits, and statistical methods
• Calculation and application of indices and gas fluxes to evaluate dose effect responses from gaseous pollutants on organisms (for instance: AOT40, SOMO 35 and POD_x)</td></tr>
<tr><td>4</td><td colspan="6">Instruction Forms
a) seminar, b) field and laboratory course</td></tr>
<tr><td>5</td><td colspan="6">Condition for participation</td></tr>
<tr><td>6</td><td colspan="6">Examination forms
Advanced examination efforts: exercises
Final module examination: Graded term paper</td></tr>
<tr><td>7</td><td colspan="6">Condition for the award of credit points
Passed final examination: term paper</td></tr>
<tr><td>8</td><td colspan="6">Applicability of the module
MSC Umweltbiowissenschaften focus Biogeographie, Ökologie und Monitoring (BÖM) optional and focus „Molekularbiologie von Umweltsubstanzen und Umwelteinflüssen (MUU)" mandatory module</td></tr>
<tr><td>9</td><td colspan="6">Value of the mark in the final mark
Without proportional weighting in the final mark (5/120)</td></tr>
<tr><td>10</td><td colspan="6">Module representative and full-time instructors
extraordinary Prof. Dr. Willy Werner</td></tr>
<tr><td>11</td><td colspan="6">Further Information
ARNDT U., NOBEL W. & SCHWEIZER B. 1987: Bioindikatoren: Möglichkeiten, Grenzen und neue Erkenntnisse. Ulmer, Stuttgart
MARKERT B. [ED.] 1993: Plants as Biomonitors: Indicators for heavy metals in the terrestrial environment. VCH Weinheim.
Manual for modelling and mapping critical loads & levels:
http://icpvegetation.ceh.ac.uk/manuals/documents/Ch3revisedsummer2010final_221010_.pdf
Moss survey protocol:
http://icpvegetation.ceh.ac.uk/manuals/documents/UNECEHEAVYMETALSMOSSMANUAL2010POPsadaptedfinal_220510_.pdf</td></tr>
</table>

<table>
<tr><td colspan="7">Module "Ecotoxicological Effects of Environmental Pollutants"</td></tr>
<tr><td colspan="2">Course code
MA6ES014</td><td>Workload
150 h</td><td>Credits
5</td><td>Study Semester
2nd Sem.</td><td>Frequency of course offer
annual</td><td>Duration
1 Semester</td></tr>
<tr><td>1</td><td colspan="6">Courses
a) Principles of Molecular Environmental Toxicology — Contact Hours: 2 SWH/30 h — Private Study: 20 h — Planned Group Size: 15
b) Toxicant Effects in the Environment — Contact Hours: 1SWH/15 h — Private Study: 10 h — Planned Group Size: 15
c) Experiments on selected Endpoints — Contact Hours: 1 SWH/15 h — Private Study: 60 h — Planned Group Size: 15</td></tr>
<tr><td>2</td><td colspan="6">Learning outcomes/ Qualification objectives
key qualifications:
• Indepth understanding of interdisciplinary contexts and interactions
• Application of system-oriented mindset and operation methods, enabling the students to analyze complex environmental problems, to develop and present approaches for solutions,
• Self dependent, problem-oriented and targeted, scientifically based inquest, assessment and aggregation of (English) scientific or technical information, in part done in groups
• Presentation of results as written text and oral presentation
• Self dependent planning and organization of experiments and laboratory operations; data evaluation; quality assurance.
Professional competences:
• Gather and work out in-depth expert knowledge on specific topics of ecotoxicology in the intersection area of the disciplines toxicology/ecotoxicology, hydrology and soil science.
• Basic knowledge in toxicology, modes of action and principles of action (effect and adverse effect).
• Learn fundamental as well as legally prescribed analysis and test methods in theory and practice.
• Integrate acquired expert knowledge on the fate and disposition of pollutants in different environmental compartments in the context of the aspect of effects.</td></tr>
<tr><td>3</td><td colspan="6">Content
a) Toxicology/Ecotoxicology
• Relevant toxicological parameters: Transport through barriers, dose, introduction to structure-effect-problem, metabolism, classification of toxic effects, differences among species
b) Hydrology & Soil Science
• Aquatic ecotoxicology: ecotoxicological risk potential of complex environmental samples (waste water, seepage water, surface water), assessment of environmental samples with aquatic biotest systems, ecological boundary conditions
• Soil ecotoxicology: Effects on the level of organisms, populations, communities; determination and relevant endpoints, relevant boundary conditions, mixture toxicity, reactions of organisms
c) Toxicology/Ecotoxicology , Hydrology, Soil Science
• Experiments on the determination of the effects of selected pollutants on different endpoints</td></tr>
<tr><td>4</td><td colspan="6">Introduction Forms
a), b) Lecture
c) Laboratory Course</td></tr>
<tr><td>5</td><td colspan="6">Conditions for Participation</td></tr>
<tr><td>6</td><td colspan="6">Examination Forms
Advanced examination effort: report
Final module examination: Oral presentation (15 minutes)</td></tr>
<tr><td>7</td><td colspan="6">Condition for the award of credit points
Passed final examination: laboratory report and oral presentation</td></tr>
<tr><td>8</td><td colspan="6">Applicability of the Module</td></tr>
<tr><td>9</td><td colspan="6">Value of the mark in the final mark
Without proportional weighting in the final grade (5/120).</td></tr>
<tr><td>10</td><td colspan="6">Module representative and full-time instructors: Prof. Dr. S. Thiele-Bruhn, Prof. Dr. B. Blömeke, Dr. R. Bierl</td></tr>
<tr><td>11</td><td colspan="6">Further Information: Literature:
NAIDU R. (2008) Chemical Bioavailability In Terrestrial Environments. Elsevier.
ALEXANDER M. (1999) Biodegradation and Bioremediation, 2nd Ed. Academic Press.
VOHR, H.-W. (2010): Toxikologie, Bd. 1: Grundlagen der Toxikologie. ISBN 978-3-527-32319-</td></tr>
</table>

Compulsory Modules of Focal Point II: "Environmental Remote Sensing and Modelling" (ES II)

A. Environmental Remote Sensing

<table>
<tr><td colspan="6">Module "Geospatial Data Analysis"</td></tr>
<tr><td>Course code
MA6ES015</td><td>Workload
300 h</td><td>Credits
10</td><td>Study Semester
2nd Semester</td><td>Frequency of course offer
Annual</td><td>Duration
1 Semester</td></tr>
<tr><td>1</td><td colspan="5">Courses
a) Pattern Recognition in long-term global satellite archives (Lecture)
b) Pattern Recognition in long-term global satellite archives (Practical course)
c) Advanced Methods in GIS and Applications

Contact hours
2 SWS/30 h
2 SWS/30 h
3 SWS/ 45 h

Private Study
60 h
60 h
75 h

Planned Group Size
200
20
20</td></tr>
<tr><td>2</td><td colspan="5">Learning outcomes/Qualification objectives
a/b)
• Getting acquainted with global satellite archives, related data formats and metadata
• Introduction in time-series analysis methods, concepts and techniques
• Practical exercises in the analysis of spatio-temporal patterns using the R and IDL/ENVI software environments
• Relating statistical results and global/regional environmental processes
c)
• Fundamentals of geographical information processing and data management
• Problem-oriented integration of vector and raster data
• Knowledge and application of advanced geomatics methods</td></tr>
<tr><td>3</td><td colspan="5">Instruction Forms:
a/b)
a) Introduction:
- Overview about major long-term global satellite data archives (eg MODIS,SPOT VGT, NOAA-AVHRR)
- Statistical problems in dealing with autocorrelated data
- Introduction in the R system and relevant libraries for time-series analysis
- Introduction of the IDL/ENVI software environment
b) Time-series analysis
- Introduction and definitions of time-series analysis methods and concepts
- Homogeneity analysis of time-series: absolute and relative methods
- The problem of temporal/spatial autocorrelation
- Exponential smoothing
- ARIMA-Models: model specification, estimation and validation
- Trend analysis: parametric and non-parametric methods
- Spectral and cross-spectral analysis
- (Multivariate) regression of autocorrelated data
- Continuous and discrete wavelet analysis (CWA, DWA)

c) Lining statistical temporal patterns with environmental processes
- Practical examples using different regional/global long-term satellite archives
c)
1. Introduction to geodata management
- Thematic and topographic data sources
- Remote sensing data sources
- Mobile GIS applications
2. Advanced analysis methods
- Cost surface models
- Topographic analysis
3. Automisation of GIS workflows
- Object-oriented graphical macro languages
4. Development of GIS projects
- Problemoriented integration of geodata (raster and vector data)
- GIS project management (softskills)
- Presentation and map layout</td></tr>
</table>

4	Instruction Forms a) Lecture b) Practical course c) Practical course
5	Conditions for Participation
6	Examination Form Advanced examination effort: excercises (b and c) Final module examination: Written Examination (90 minutes)
7	Condition for the Award of Credit Points Passed final examination: written examination (90 min.)
8	Applicability of the Module Compulsory Module MSc Angewandte Geoinformatik (in German) (a/b) Compulsory Module MSc Environmental Sciences (a/b/c)
9	Value of Mark in the Final Grade Without proportional weighting in final grade (10/120)
10	Module Representative and Full-Time Instructor Prof. Dr. T. Udelhoven, Dr. A. Röder, Dr. J. Stoffels
11	Further Information MAGUIRE, D.J. ET AL. (2005): GIS, Spatial Analysis and Modeling WILSON, J.P. ET AL. (2000): Terrain Analysis: Principles and Applications MULLIGAN, M. / WAINWRIGHT, J. (2011): Environmental Modeling: Finding Simplicity in Complexity

<table>
<tr><td colspan="6">Module "Advanced Remote Sensing Data Processing & Analysis"</td></tr>
<tr><td>Course code
MA6ES016</td><td>Workload
150 h</td><td>Credits
5</td><td>Study Semester
2nd Semester</td><td>Frequency of course offer
annual</td><td>Duration
1 Semester</td></tr>
<tr><td>1</td><td colspan="2">Courses
a) Practical course
b) Field course</td><td>Contact Hours
3 SWH/45 h
1 SWH/15 h</td><td>Private Study
60 h
30 h</td><td>Size of Group
20
20</td></tr>
<tr><td>2</td><td colspan="5">Qualification objectives
• Expertise in radiative transfer modelling of hyperspectral imagery
• Skills in derivation of surface properties from multi- and hyperspectral data
• Understanding of interdisciplinary issues
• Formulation, preparation and presentation of scientific topics
• Competence in coordination of group work</td></tr>
<tr><td>3</td><td colspan="5">Content
a)
Parametric geocoding of hyperspectral imagery
Radiometric processing of hyperspectral imagery
- Radiative transfer modelling (Photometer measurements, Cross-Track Illumination Correction)
- Water vapour estimation, sensor recalibration
Compression and transformation of hyperspectral data
- Spectral Mixture Analysis
- Principal Component Analysis vs. Partial Least Square-Regression
- Minimum Noise Fraction
Classification and interpretation strategies
- Parametric and non-parametric methods (e.g. Maximum Likelihood, Support Vector Machines, Spectral Angle Mapper, Spectral Feature Fitting)
- Empirical approaches (e.g. hierarchical or support vector regression models)
Multisensor approaches (algorithms und applications)
- Sensor intercalibration
- Data fusion
b)
Planning and execution of a hyperspectral field campaign
- Field survey of reference data
- Atmospheric measurements</td></tr>
<tr><td>4</td><td colspan="5">Instruction Forms:
Practical course, Field course</td></tr>
<tr><td>5</td><td colspan="5">Conditions for Participation</td></tr>
<tr><td>6</td><td colspan="5">Examination Form
Advanced examination effort: exercises
Final module examination: Graded term paper</td></tr>
<tr><td>7</td><td colspan="5">Condition for the Award of Credit Points
Passed final examination: term paper</td></tr>
<tr><td>8</td><td colspan="5">Applicability of the Module
Optional Module within MSc Angewandte Geoinformatik</td></tr>
<tr><td>9</td><td colspan="5">Value of Mark in the Final Grade
Module mark is accepted without proportional weighting in final grade (5/120)</td></tr>
<tr><td>10</td><td colspan="5">Module Representative and Full-Time Instructor
Prof.Dr. J. Hill, Prof. Dr. T. Udelhoven, Dr. A. Röder</td></tr>
<tr><td>11</td><td colspan="5">Further Information
SCHOTT, J.R. (1997): Remote sensing - the image chain approach
RICHARDS, J.R. & JIA, X. (1999): Remote Sensing Digital Image Analysis
LIANG, S. (2004): Quantitative Remote Sensing of Land Surfaces, Wiley/New York</td></tr>
</table>

Module "Remote Sensing of Global Change Processes"					
Course code MA6ES017	Workload 150 h	Credits 5	Study Semester 3.Sem.	Frequency of course offe yearly	Duration 1 Semester

1	Courses	Contact Hours	Private Study	Planned Group Size
	a) Remote Sensing of global Change Processes (Seminar)	3 SWH/30 h		20
	b) Remote Sensing of Global Change Processes (Computer Course)	1 SWH/15 h	105 h	20

2 Qualification objectives

- Understanding of global environmental processes and analytical approaches
- Conceptual knowledge and methodological expertise in applied environmental remote sensing and modelling techniques
- Skills in independent scientific treatise of specific research questions
- Competence in coordination of group-based field work and presentation techniques

3 Content

Global Change: modelling concepts
- Carbon sequestration
- Global biomass and biodiversity
- Land use change syndromes

Remote sensing based assessment of processes coupled social-ecological systems
- Global processes
- Regional processes

Lanscape pattern analysis
- Metric indices and neutral models
- Spatially explicit indicators

Remote sensing contributions to conservation management
- REDD processes
- Desertification
- Biodiversity
- Metapopulation models and assimilation of remote sensing data
- Territorial behaviour and movement patterns of animal populations
- Delineation of conservation areas

Remote sensing applications in crisis management
- „Geohazards", empirical modelling of environmental pollution
- „Rapid Mapping", support to emergency services

4 Instruction Forms: Seminar, Computer Course

5 Conditions for Participation

6 Examination Form

Advanced examination effort: oral presentation
Final module examination: Graded term paper

7 Condition for the Award of Credit Points: Passed final examination: term paper

8 Applicability of the Module

9 Value of Mark in the Final Grade

Without proportional weighting in final grade (5/120)

10 Module Representative and Full-Time Instructor

Prof. Dr. J. Hill, Dr. A. Röder, Dr. J. Stoffels

11 Further Information

MAGUIRE, D.J. ET AL. (2005): GIS, Spatial Analysis and Modeling
MULLIGAN, M. , WAINWRIGHT, J. (2011): Environmental Modeling: Finding Simplicity in Complexity
CHUVIECO, E. (2007): Earth Observation of Global Change: The Role of Satellite Remote Sensing in Monitoring the Global Environment
LAMBIN, E.F. & GEIST, H.J. (2006): Land use and Land cover change: local processes and global impacts
MEA (2005): Ecosystems and Human Well-being: General Synthesis
FORMAN, R.T.T. & WILSON, E.O. (1995): Land Mosaics: The Ecology of Landscapes and Regions
WIENS, J. & MOSS, M. (2005): Issues and Perspectives in Landscape Ecology
CHAPIN III, F., KOFINAS, G., FOLKE, C. (2009): Principles of Natural Resources Stewardship: Resilience-Based Management in an Changing World

<table>
<tr><td colspan="7">Module “Ecosystem Remote Sensing and Modelling Concepts”</td></tr>
<tr><td colspan="2">Course code
MA6ES018</td><td>Workload
150/300 h</td><td>Credits
5/10</td><td>Study Semester
2nd & 3rd Semester</td><td>Frequency of course offer
annual</td><td>Duration
2 Semester</td></tr>
<tr><td>1</td><td colspan="2">Courses
a) Ecosystem Inventory Strategies (Seminar)
b) Field course
c) Practical course</td><td>Contact Hours

2 SWH/30 h
2 SWH/30 h
3 SWH/45 h</td><td colspan="2">Private Study

45 h
45 h
105 h</td><td>Planned Group Size

20
20
20</td></tr>
<tr><td>2</td><td colspan="6">Learning outcomes/Qualification objectives
a)+b)
• Understanding of interdisciplinary ecosystem assessment and resource inventories
• Knowledge of advanced concepts in plant physiology and vegetation remote sensing
• Hands-on experience in ground surveying techniques and experimental/analytical laboratory methods
c)
• Expertise in spatial analysis of point data and scaling issues
• Expertise in ecosystem monitoring techniques using multi-temporal remote sensing data
• Understanding of productivity models and assimilation of remote sensing-derived data
a)+b)+c)
• Competence in coordination of group-based field work and presentation techniques</td></tr>
<tr><td>3</td><td colspan="6">Content
a)+b)
Specific topics in plant ecology and site characterisation
Interaction between leaf reflectance and plant physiology
Planning and execution of field survey campaigns
- Scaling in remote sensing data
- Inventory of site characteristics and biophysical variables (e.g. tree density, age, crown closure, species composition, LAI)
- Optical instruments and measurement concepts (LAI-2000, Hemiphotos, Laserscanning etc.)
Laboratory experiments
- Ecophysiological measurements
- Spectrometry
c)
Advanced data analysis
- Long-term monitoring networks
- Geostatistical analysis
- GIS-integration of field survey data
Productivity and growth models (e.g. Biome-BGC, SILVA)
- Concepts and implementation
- Assimilation strategies for remote sensing data
- Error estimation
Estimation of biophysical plant- and site-parameters
- Parameterisation of empirical and physical-based reflectance models
- Preparation of map products of plant- and site-related parameters
- Image-based retrospective change detection and monitoring</td></tr>
<tr><td>4</td><td colspan="6">Instruction Forms: Seminar, Field course, Practical course</td></tr>
<tr><td>5</td><td colspan="6">Conditions for Participation</td></tr>
<tr><td>6</td><td colspan="6">Examination Form
Advanced examination effort: exercises
Final module examination: Graded term paper</td></tr>
<tr><td>7</td><td colspan="6">Condition for the Award of Credit Points
Passed final examination: term paper</td></tr>
<tr><td>8</td><td colspan="6">Applicability of the Module
Compulsory Module MSc Environmental Sciences ES2A, Voluntary Module (part a)+b)) for MSc Applied Geoinformatics</td></tr>
<tr><td>9</td><td colspan="6">Value of Mark in the Final Grade
Without proportional weighting in final grade (10/120)</td></tr>
<tr><td>10</td><td colspan="6">Module Representative and Full-Time Instructor
Prof. Dr. J. Hill, Prof. Dr. T. Udelhoven, Dr. A. Röder, Dr. J. Stoffels</td></tr>
</table>

11	Further Information HILDEBRANDT, G. (1996): Fernerkundung und Luftbildmessung für Forstwirtschaft, Vegetationskartierung und Landschaftsökologie, (Heidelberg: Wichmann). WULDER, M.A., S.E. FRANKLIN, EDS., (2003): Remote Sensing of Forest Environments. Concepts and Case Studies, (Boston/Dordrecht/London: Kluwer Academic Publishers). SWAIN, PH.H., S.M. DAVIS, EDS., (1978): Remote Sensing. The Quantitative Approach, (New York McGraw Hill). RENCZ, A., S. USTIN, EDS.(2004): Remote Sensing for Natural Resource Management and Environmental Monitoring, Manual of Remote Sensing, vol. 4, (John Wiley & Sons). LIANG, S., ED., (2004): Quantitative Remote Sensing, (Hoboken, New Jersey: John Wiley & Sons).

B. *Environmental Meteorology*

Module “Satellite time series analysis”					
Course code MA6ES019	Workload 150 h	Credits 5	Study Semester 2nd Semester	Frequency of course offer Annual	Duration 1 Semester

1	Courses	Contact hours	Private Study	Planned Group Size
	a) Pattern Recognition in long-term global satellite archives (Lecture)	2 SWS/30 h	60 h	200
	b) Pattern Recognition in long-term global satellite archives (Practical course)	2 SWS/30 h	60 h	20

2 Learning outcomes/Qualification objectives

- Getting acquainted with global satellite archives, related data formats and metadata
- Introduction in time-series analysis methods, concepts and techniques
- Practical exercises in the analysis of spatio-temporal patterns using the R and IDL/ENVI software environments
- Relating statistical results and global/regional environmental processes

3 Instruction Forms:

d) Introduction:
- Overview about major long-term global satellite data archives (eg MODIS,SPOT VGT, NOAA-AVHRR)
- Statistical problems in dealing with autocorrelated data
- Introduction in the R system and relevant libraries for time-series analysis
- Introduction of the IDL/ENVI software environment

e) Time-series analysis
- Introduction and definitions of time-series analysis methods and concepts
- Homogeneity analysis of time-series: absolute and relative methods
- The problem of temporal/spatial autocorrelation
- Exponential smoothing
- ARIMA-Models: model specification, estimation and validation
- Trend analysis: parametric and non-parametric methods
- Spectral and cross-spectral analysis
- (Multivariate) regression of autocorrelated data
- Continuous and discrete wavelet analysis (CWA, DWA)

f) Lining statistical temporal patterns with environmental processes
- Practical examples using different regional/global long-term satellite archives

4 Instruction Forms

a) Lecture
b) Practical course

5 Conditions for Participation

6 Examination Form

Advanced examination effort: exercises
Final module examination: Graded term paper

7 Condition for the Award of Credit Points

Passed final examination: graded term paper

8 Applicability of the Module

Compulsory Module MSc Angewandte Geoinformatik (in German)

9 Value of Mark in the Final Grade

Without proportional weighting in final grade (5/120)

10 Module Representative and Full-Time Instructor

Prof. Dr. T. Udelhoven

11 Further Information

Module "Numerical Modeling in Meteorology"					
Course Code MA6ES020	Work Load 300 h	Credits 10	Study Semester 2nd & 3rd Semester	Frequency of course offer – annual -	Duration 2 Semesters

1	Courses	Contact Hours	Private Study	Planned Group Size
	a) Dynamics (Lecture)	2 SWH/30 h	60 h	120
	b) Dynamics (Computer Course)	2 SWH/30 h	30 h	20
	c) Applications (Lecture)	2 SWH/30 h	30h	120
	d) Applications (Computer Course)	2 SWH/30 h	60 h	20

2 Learning Outcomes/Qualification Objectives

- Independent, problem oriented and purposeful, scientifically founded, critical appraisal of methods; acquisition of presentation and teamwork abilities
- Application of numerical models; understanding of atmospheric processes

3 Contents

This module deepens the knowledge acquired in the BSc on atmospheric dynamics and gives an introduction in practical work with a complex numerical model.

Dynamics

- Basics of the dynamics of the atmosphere (hydrodynamic equations, coordinate systems, scale analysis, hydrostatic balance, geostrophic balance, thermal wind)
- Dynamics of mid-latitude cyclones (vorticity and divergence, vorticity equation, quasi-geostrophic approximation, quasi-geostrophic diagnostics, omega equation)
- Dynamics of fronts (air mass theory, front types and weather, field theory for fronts, frontogenesis)

Applications

- Overview of numerical models in weather and climate forecasting
- Numerics (basic equations and approximations, waves, discretisation of differential equations, time step and advection methods)
- Work with a complex numerical model (e.g. numerical weather forecast, sea ice model), application of evaluation and validation techniques

4 Instruction Forms

a), c) Lecture, b), d) Exercises (computer course)

5 Condition for participation

6 Examination forms

Advanced examination effort: exercises
Final module examination: Oral examination (30 minutes)

7 Condition for the award of credit points

Passed final examination: oral examination (30 min.)

8 Applicability of the module

9 Value of the mark in the final mark

Without proportional weighting in the final mark (10/120)

10 Module representative and full-time instructors

Prof. Dr. G. Heinemann, NN

11 Further Information

<table>
<tr><td colspan="6">Module "Monitoring and Remote Sensing in Meteorology"</td></tr>
<tr><td>Course Code
MA6ES021</td><td>Work Load
150 h</td><td>Credits
5</td><td>Study Semester
2nd Semester</td><td>Frequency of course offer - annual -</td><td>Duration
1 Semester</td></tr>
<tr><td>1</td><td colspan="5">Courses
a) Systems and Algorithms
b) Practical Applications

Contact Hours
2 SWH/30h
2 SWH/30h

Private Study
30 h
60 h

Planned Group Size
120
15</td></tr>
<tr><td>2</td><td colspan="5">Learning Outcomes/Qualification Objectives
• Independent, problem oriented and purposeful, scientifically founded, critical appraisal of methods
• Acquisition of team work and presentation skills
• Acquisition of knowledge about physical bases of the meteorological remote sensing systems and procedures
• Ability to apply remote sensing data in the area of boundary layer meteorology and climate monitoring</td></tr>
<tr><td>3</td><td colspan="5">Contents
This module deals with different aspects of meteorological remote sensing.

1) Satellite-based meteorological remote sensing and climate monitoring
Meteorological satellites in geostationary and near-polar orbits, overview of monitoring systems, meteorological data products, remote sensing of the atmosphere, work with satellite data and determination of meteorological quantities, work with remote sensing data.
2) Ground-based meteorological remote sensing
Ground-based systems (inter alia LIDAR, SODAR, RADAR, Scintillometer), remote sensing of the atmosphere, work with remote sensing data.</td></tr>
<tr><td></td><td colspan="5">Instruction Forms
a) Lecture, b) Exercises (computer course)</td></tr>
<tr><td>5</td><td colspan="5">Condition for participation</td></tr>
<tr><td>6</td><td colspan="5">Examination forms
Final module examination: Graded term paper</td></tr>
<tr><td>7</td><td colspan="5">Condition for the award of credit points
Passed final examination: term paper</td></tr>
<tr><td>8</td><td colspan="5">Applicability of the module</td></tr>
<tr><td>9</td><td colspan="5">Value of the mark in the final mark
Module mark is accepted without proportional weighting in the final mark (5/120)</td></tr>
<tr><td>10</td><td colspan="5">Module representative and full-time instructors
Dr. C. Drüe, Dr. S. Willmes</td></tr>
<tr><td>11</td><td colspan="5">Further Information</td></tr>
</table>

<table>
<tr><td colspan="6">Module "Land Surface-Atmosphere Interactions"</td></tr>
<tr><td>Course Code
MA6ES022</td><td>Work Load
150 h</td><td>Credits
5</td><td>Study Semester
2nd Semester</td><td>Frequency of course offer - annual -</td><td>Duration
1 Semester</td></tr>
<tr><td>1</td><td colspan="2">Courses
a) Introduction to Land-Surface-Atmosphere Interactions
b) Micro-meteorological and eco-physiological measurements</td><td>Contact Hours
2 SWH/30 h

4 SWH/60 h</td><td>Private Study
30 h

30 h</td><td>Planned Group Size
120

20</td></tr>
<tr><td>2</td><td colspan="5">Learning Outcomes/Qualification Objectives
- Independent, problem oriented and purposeful, scientifically founded, critical appraisal of methods
- Acquisition of presentation abilities and teamwork
- Understanding of the interaction processes atmosphere-plant-soil
- Knowledge of modern measuring methods</td></tr>
<tr><td>3</td><td colspan="5">Contents
The emphasis of this module is on measurements of exchange processes of the system soil/plant /atmosphere with modern measuring methods. The theoretical basis will be laid through the lecture; field surveys and evaluations will be practiced through handling modern measuring instruments and the use of evaluation methods learned. Contents of the partial modules are:
• Laws of the turbulent exchange in the Prandtl layer (atmosphere and plants), turbulent flux densities, computation of the components of the surface energy balance, stability measures, eco-physiological methods for the measurement of the gas exchange of plants, computation of conductivity, transpiration and net photosynthesis, morphologically anatomical modifications and their effects on the gas change. Measuring methods of the water condition and derivable statements from this. Models on the gas change and water regime of plants and plant stocks.
• Exercises with measurements at a common measuring point in the local area: Boundary layer measurements (e.g. energy balance components, CO_2 fluxes), measurements with a gas change porometer to determine the transpiration and photosynthesis activity on leaf level as a function of radiation, temperature and humidity; measurements of the xylem sap flow and the conductivity of a plant individual as well as measurements of the total water potential of plants and plant parts with leaf and stem psychrometers.</td></tr>
<tr><td>4</td><td colspan="5">Instruction Forms
a) Lecture
b) Practical Exercises (block course)</td></tr>
<tr><td>5</td><td colspan="5">Condition for participation</td></tr>
<tr><td>6</td><td colspan="5">Examination forms
Advanced examination effort: report (measuring report, about micrometeorological and eco-physiological measurements; b)
Final module examination: oral presentation (30 minutes)</td></tr>
<tr><td>7</td><td colspan="5">Condition for the award of credit points
Passed final examination: oral presentation (30 min.)</td></tr>
<tr><td>8</td><td colspan="5">Applicability of the module</td></tr>
<tr><td>9</td><td colspan="5">Value of the mark in the final mark
Module mark is accepted without proportional weighting in the final mark</td></tr>
<tr><td>10</td><td colspan="5">Module representative and full-time instructors
Prof. Dr. G. Heinemann, Dr. C. Drüe, Prof. Dr. F. Thomas, apl. Prof. Dr. W. Werner</td></tr>
<tr><td>11</td><td colspan="5">Further Information</td></tr>
</table>

<table>
<tr><td colspan="6">Module “SVAT-Models and Integration of Remote Sensing Data”</td></tr>
<tr><td>Course Code
MA6ES023</td><td>Work Load
150 h</td><td>Credits
5</td><td>Study Semester
3rd Semester</td><td>Frequency of course offer - Annual -</td><td>Duration
1 Semester</td></tr>
<tr><td>1</td><td colspan="5">Courses
a) Remote Sensing of SVAT-Model Parameters
b) Theory and Practical Use of SVAT Models

Contact Hours
2 SWH/30h

2 SWH/30h

Private Study
30 h

60 h

Planned Group Size
15

15</td></tr>
<tr><td>2</td><td colspan="5">Learning Outcomes/Qualification Objectives
• Acquisition of knowledge and methodological abilities for the integration of remote sensing data into space oriented modeling approaches
• Acquisition of knowledge on the modeling of the atmosphere - soil - plant exchange</td></tr>
<tr><td>3</td><td colspan="5">Contents
This module shall enable students obtain the theory and methods of remote sensing of surface properties and the interaction processes of the atmosphere - soil - plant exchange as well as practical work with a soil vegetation atmosphere transfer (SVAT) - model. Contents of the partial modules are:

a) Possibilities of supplying quantitative variables for SVAT models through evaluation of multi-spectral remote sensing data (Landsat TM) and modeling of the following model inputs: energy balance quantities: albedo, global radiation, radiation balance, radiation temperature, emission coefficient, surface temperature; Land use variables: Land use class, leaf area index, vegetation coverage, water regime: ETA
b) Theoretical basis of a SVAT (Soil-Vegetation-Atmosphere-Transfer) models, parameterization of processes, practical work with a SVAT model, linking of SVAT model and remote sensing data</td></tr>
<tr><td>4</td><td colspan="5">Instruction Forms
a), b) Computer Course (Exercises)</td></tr>
<tr><td>5</td><td colspan="5">Condition for participation</td></tr>
<tr><td>6</td><td colspan="5">Examination forms
Advanced examination effort: report
Final module examination: Oral presentation (20 minutes)</td></tr>
<tr><td>7</td><td colspan="5">Condition for the award of credit points
Passed final examination: oral presentation</td></tr>
<tr><td>8</td><td colspan="5">Applicability of the module</td></tr>
<tr><td>9</td><td colspan="5">Value of the mark in the final mark
Without proportional weighting in the final mark (5/120)</td></tr>
<tr><td>10</td><td colspan="5">Module representative and full-time instructors
Prof. Dr. G. Heinemann, apl. Prof. Dr. M. Vohland, Dr. S. Willmes</td></tr>
<tr><td>11</td><td colspan="5">Further Information</td></tr>
</table>

Compulsory and Optional Modules of Focal Point III: "Environmental Conservation and Restoration Management" (ES III)

<table>
<tr><td colspan="7">Module "Nature Conservation, Restoration & Protection”</td></tr>
<tr><td colspan="2">Course Code
MA6ES024</td><td>Work Load
150 h</td><td>Credits
5</td><td>Study Semester
2nd Semester</td><td>Frequency of course offer - annual -</td><td>Duration
1 Semesters</td></tr>
<tr><td>1</td><td colspan="2">Courses
a) Soil Protection Concepts
b) Nature Conservation</td><td>Contact Hours
2 SWH/30 h
2 SWH/30 h</td><td>Private Study
45 h
45 h</td><td colspan="2">Planned Group Size
20
20</td></tr>
<tr><td>2</td><td colspan="6">Learning Outcomes/Qualification Objectives
key qualifications:
• Indepth understanding of interdisciplinary contexts and interactions
• Application of system-oriented mindset and operation methods, enabling the students to analyze complex environmental problems, to develop and present approaches for solutions,
• Self dependent, problem-oriented and targeted, scientifically based inquest, assessment and aggregation of (English) scientific or technical information, in part done in groups
• Presentation of results as written text and oral presentation
Expertise:
• Gain theoretical knowledge on soil impacts, soil protection and remediation/restoration with perspective on different and specific soil functions
• Learn examples for measures of soil remediation, recultivation and amelioration
• Indicators of soil stress and contamination and aspects of soil protection planning
• Assess the endangerment of species and biotopes
• Know, apply and judge strategies of nature protection
• Develop plans for biotope management
• Contribute to aspects of landscape planning</td></tr>
<tr><td>3</td><td colspan="6">Contents
A. Seminar Soil Protection Concepts
1. Soil Degradation
- Acidification, salinisation, contamination, imbalances of nutrients, humus degradation, water and wind erosion, soil compaction, sealing, removal of soil, emerging pollutants, decentral flood prevention, legal framework
2. Soil Remediation
- Mechanical, chemical, biological and soil management methods, soil utilization and recycling
3. Soil melioration and renaturation
4. Soil restoration and recultivation
5. Recycling of organic wastes
B: Seminar Nature Conservation
1. Endangerment of species and biotopes
2. Causes of endangerment and deterioration
3. Mapping of biotopes
4. Protection of species and biotopes
5. „Rote Listen“, FFH appendix 2 list
6. Legal basics of nature conservation; 7. Categories of protective areas
8. Biotope management, plans of biotope maintenance (selected case studies); 9. Biotope connection, biotope networks
10. Nature conservation economics; 11. Landscape planning and ecology</td></tr>
<tr><td>4</td><td colspan="6">Instruction Forms
a) Seminar on current topics in soil conservation; b) Seminar on nature conservation</td></tr>
<tr><td>5</td><td colspan="6">Condition for participation</td></tr>
<tr><td>6</td><td colspan="6">Examination forms: Advanced examination effort: seminar presentation
Final module examination: graded term papers in each seminar (50%, 50%)</td></tr>
<tr><td>7</td><td colspan="6">Condition for the award of credit points: Passed final examination: term papers</td></tr>
<tr><td>8</td><td colspan="6">Applicability of the module: Optional Module with in MSc Prozessdynamik an der Erdoberfläche</td></tr>
<tr><td>9</td><td colspan="6">Value of the mark in the final mark: Without proportional weighting in the final mark (5/120)</td></tr>
<tr><td>10</td><td colspan="6">Module representative and full-time instructors
Prof. Dr. Thiele-Bruhn, apl. Prof. Dr. Emmerling, Dr. Schneider, Dr. Erwin Manz</td></tr>
<tr><td>11</td><td colspan="6">Further Information
BLUME ET AL.: Handbuch des Bodenschutzes, ecomed.
ALEXANDER: Biodegradation and Bioremediation. Academic Press</td></tr>
</table>

Module "Polluted Site Remediation"						
Course Code MA6ES025	Workload 150 h	Credits 5	Study Semester 3rd Semester.	Frequency of course offer - annual -		Duration 1 Semester
1	Courses a) lecture b) seminar c) field course		Contact Hours 2 SWH/30 h 1 SWH/15h 1 SWH/15 h	Private Study 15 h 30 h 30 h		Planned Group Size 1 20 20
2	Learning outcomes/ Qualification Objectives • Description and quantification of pollutant fluxes in the subsoil • Polluted Site characterisation & Risk assessment • Criteria for choice of remediation technique (active and passive) and remediation targets • Land recycling					
3	Content • Geology for polluted sites • International and national policies and legislations • Chemistry for polluted sites • Site characterisation • Risk assessment • Remediation techniques					
4	Introduction Forms lecture, seminar, field course					
5	Conditions for Participation					
6	Examination Forms Advanced examination effort: oral seminar presentation and field exercise report Final module examination: Written examination (90 minutes)					
7	Conditions for the award of credit points Passed final examination written examination (90 min)					
8	Applicability of the module					
9	Value of Mark in the Final Grade Without proportional weighting in final grade (5/120)					
10	Module representative and full time instructors Prof. Dr. J.F. Wagner					
11	Further Information http://www.bmu.de http://www.epa.gov/superfund/ http://www.umweltbundesamt.de/					

Module "Environmental Management and Resource Economics"					
Course code MA6ES026	Workload 300 h	Credits 10 CP	Study Semester 2nd & 3rd Semester	Frequency of course offer annual	Duration 2 Semesters

1	Courses	Contact Hours	Private Study	Planned Group Size
	a) Environmental Economics b) Resource Economics	2 SWH/30 h 2 SWH/30 h	120 h 120 h	unlimitted 25

2 Learning outcomes/ Qualification objectives

Key qualifications:

- Understanding of the economic structure of environmental problems
- Ability to handle environmental policy issues scientifically and to discuss instruments
- Ability to work out economic aspects in interdisciplinary environmental projects

Expertise:

- Implementation of cost-benefit analysis in the environmental field
- Application of game theory on the strategic interaction between actors in the environmental field
- Determining the economically optimal use of environmental policy instruments
- Identifying sub-optimal use of resources in a market economy
- The formulation, specification and implementation of efficiency and sustainability concepts.

3 Content

Environmental problems as market failure
- Social dilemma for public goods and common-pool resources
- Property rights, transaction costs and Coase negotiated solutions

Environmental policy instruments
- Regulatory approaches
- Taxes and eco-taxes
- Tradable emission allowances, Hybrid Systems
- Voluntary agreements

Valuation of environmental goods
- Evaluation quotas (CVM)
- Transport cost approach, hedonic pricing methods, and other approaches

Resources analysis
- Determination of price and quantity of paths of natural resources (Hotelling model)
- Strong and weak sustainability
- A business-like and economically efficient use of resources

Integrated Assessment Models
- Integration of model components from different disciplines in a single evaluation approach
- Integrated models of global climate change
- - Global policies, cooperation and conflict in the use of resources

4 Introduction Forms

a) Lecture; b) Seminar

5 Conditions for Participation

6 Examination Forms

Final module examination: Written examination (60 Min, 50%), graded term paper and presentation (Seminar, 50%)

7 Condition for the award of credit points

Passed final examination. written examination (60 min.) and term paper inclusive presentation

8 Applicability of the Module: import module from FB IV: MSc Environmental Management and Resource Economics

9 Value of the mark in the final mark

Without proportional weighting in the final grade (5/120).

10 Module representative and full-time instructors

Prof. Dr. G. Müller-Fürstenberger

11 Further Information

Literature:

STEPHAN G. & M. AHLHEIM (1996). Ökonomische Ökologie. Springer, Berlin u.a.
TIETENBERG, T. (2006). Environmental and Natural Resource Economics, 7th ed..
Pearson Addison Wesley, Boston et al.
KAHN, R. (2005). The Economic Approach to Environmental & Natural Resources, 3rd ed. Thomson South-Western, Mason

Module "Soil use and Sustainable Management"						
Course code MA6ES027	Workload 150 h	Credits 5	Study Semester 3rd Semester	Frequency of course offer annual	Duration 1 Semester	
1	Courses a) Soil Use in Agriculture (Lecture) b) Forest Site Assessment (Seminar) c) Waste Management (Seminar)	Contact Hours 2 SWS/30h 1 SWS/15h 1 SWS/15h	Private Study 50 h 20 h 20 h	Planned Group Size no limitation 15 15		
2	Qualification objectives a) Introduction in Agronomy and Crop Science and the interaction with soil. b) Assessment of forest sites and sustainable use of forests c) Introduction in waste management and application of biowastes in agriculture, visitations, presentation and discussion					
3	Content *A. Lecture: Agricultural Land-use* Introduction & History of Agriculture Recent Situation and Trends (Germany & Europe) Agricultural Systems (incl. Crop Rotation) Agricultural Management towards Sustainability Soil Tillage Application of Organic Wastes in Agriculture Growth and Yield Factors Plant Nutrition & Fertilization Agricultural Crops (Grain) Agricultural Crops (Remaining) Renewable Resources & Energy Crops Plant Protection, Plant Breeding & GMOs *B. Seminar: Forest Site Assessment* 1. Demands of forest trees 2. Forest management 3. Forest Monitoring 4. Visitation of a forest measurement station *C. Seminar: Waste Management* Visitation of a Sewage Sludge Plant Visitation of a Compost Plant Visitation of a Biogas Plant Presentations concerning the application of biowastes in agriculture					
4	Instruction Forms: a) Lecture b) Seminar c) Seminar with field trips					
5	Conditions for Participation					
6	Examination Form Advanced examination effort: accepted homework and oral presentation (15 minutes) Final module examination: Written examination (90 minutes)					
7	Condition for the Award of Credit Points Passed final examination: written examination (90 minutes)					
8	Applicability of the Module Optional Module within MSc Umweltbiowissenschaften and MSc Prozessdynamik an der Erdoberfläche					
9	Value of Mark in the Final Grade Without proportional weighting in final grade (5/120)					
10	Module Representative and Full-Time Instructor apl. Prof. Dr. C. Emmerling; apl. Prof. Dr. G. Schüler					
11	Further Information LECTURE NOTES: Land-use in Agriculture LAEGREID ET AL.: Agriculture, Fertilzers and the Environment. CABI					

Optional Modules

<table>
<tr><td colspan="7">Module “Soil Biology and Soil Functioning”</td></tr>
<tr><td colspan="2">Course code
MA6ES028</td><td>Workload
150 h</td><td>Credits
5</td><td>Study Semester
2nd Semester</td><td>Frequency of course offer
annual</td><td>Duration
1 Semester</td></tr>
<tr><td>1</td><td colspan="2">Courses
a) Biology & Ecology of Soil Organisms (Lecture)
b) Practical course in Soil Biology</td><td>Contact Hours
2 SWH/30 h

2 SWH/30 h</td><td>Private Study
45 h

45 h</td><td colspan="2">Planned Group Size
a) no limitation
b) 15</td></tr>
<tr><td>2</td><td colspan="6">Qualification objectives
• In-depth understanding of soil biological functions and interactions
• Application of system-oriented mindsets and methods
• Planning and organisation of laboratory operational procedures
• Handling of scientific literature and scientific English</td></tr>
<tr><td>3</td><td colspan="6">Content
• Soil as a habitat for soil organisms
• Diversity of life in soil
• Organism interactions and soil processes
• Microbial activity and nutrient availability
• Linkages between soil biological communities and plants
• Trophic interactions and soil biological communities
• Methods for sampling, enumeration and investigation of soil biological communities
• Methods for applied soil microbiology and biochemistry
• Soil organisms related to land use, tillage, crop rotation and soil properties
• Soil organisms as bio-indicators
• Soil organisms and Applied Biotechnology</td></tr>
<tr><td>4</td><td colspan="6">Instruction Forms:
a) Lecture
b) Field and laboratory course</td></tr>
<tr><td>5</td><td colspan="6">Conditions for Participation</td></tr>
<tr><td>6</td><td colspan="6">Examination Form
Accordant to the respective examination regulations of the module in the economic discipline of faculty IV (FB IV)</td></tr>
<tr><td>7</td><td colspan="6">Condition for the Award of Credit Points
Passed final examination: term paper</td></tr>
<tr><td>8</td><td colspan="6">Applicability of the Module
Optional Module within MSc Umweltbiowissenschaften</td></tr>
<tr><td>9</td><td colspan="6">Value of Mark in the Final Grade
Without proportional weighting in final grade (5/120)</td></tr>
<tr><td>10</td><td colspan="6">Module Representative and Full-Time Instructor
apl. Prof. Dr. C. Emmerling</td></tr>
<tr><td>11</td><td colspan="6">Further Information
BARDGETT ET AL.: Biological Diversity and Functions in Soil. Cambridge Univ. Press.
RITZ ET AL.: Beyond the Biomass. John Wiley & Sons.
BENCKISER ET AL.: Fauna in Soil Ecosystems. Marcell Dekker.
BENCKISER & SCHNELL: Biodiversity in Agricultural Production Systems. Taylor & Francis</td></tr>
</table>

<table>
<tr><td colspan="6">Module "Interdisciplinary Excursion or Field Project"</td></tr>
<tr><td>Course code
MA6ES029</td><td>Workload
150 h</td><td>Credits
5</td><td>Study Semester
2nd Semester.</td><td>Frequency of course offer
annual</td><td>Duration
1 Semester</td></tr>
<tr><td>1</td><td colspan="5"><table>
<tr><td>Courses</td><td>Contact Hours</td><td>Private Study</td><td>Planned Group Size</td></tr>
<tr><td>a) Seminar</td><td>2 SWH/30 h</td><td rowspan="2">40</td><td>24</td></tr>
<tr><td>b) 10-day Field Trip</td><td>5,3 SWH/80 h</td><td>24</td></tr>
</table></td></tr>
<tr><td>2</td><td colspan="5">Qualification goals
Key qualifications:
• In-depth understanding of interdisciplinary contexts and interactions
• Self-dependent, problem-oriented and targeted, scientifically based inquest, assessment and aggregation of (English) scientific or technical information, in part done in groups
• Presentation of results as written text and oral presentation
Expertise:
• Understand the characteristic physical-geographic and socio-economic factors as well as their relevance for the geoecology (climate, geomorphology, geology, soil science, vegetation, land use, landscape history, anthropogenic activities etc.)
• Analyze the pollution, impacts and degradation of a geographic region and gather the possibilities and limits of a usage management and protection measures, respectively
• Examples for the (successful) implementation of procedural methods for a sustainable usage of nature services and for the guidance of diverse interests of usage
• Analyze the potentials for development and endangerment, respectively, of a landscape unit
• Elaborate an excursion/field project protocol
• Improve the abilities to write up a report on a considerable topic in a precise, concise and structured manner
• Improve the oral presentation technique and also the ability to discuss scientific aspects</td></tr>
<tr><td>3</td><td colspan="5">Content
• In-depth presentation of a region out of the German low mountain range in the frame of an excursion or in-depth scientific work on an environmental problem in the frame of a field project with special regard to the boundary conditions for the utilization and/or valorisation of a region
• Self-dependent elaboration of a seminar paper on specific aspects of the excursion area or field project</td></tr>
<tr><td>4</td><td colspan="5">Introduction Forms
a) Seminar
b) Excursion or field trip (field project with measurements/investigations)</td></tr>
<tr><td>5</td><td colspan="5">Conditions for Participation</td></tr>
<tr><td>6</td><td colspan="5">Examination Forms
Advanced examination effort: seminar presentation
Final module examination: graded term paper (excursion protocol and/or project protocol)</td></tr>
<tr><td>7</td><td colspan="5">Condition for the award of credit points
Passed final examination: term paper</td></tr>
<tr><td>8</td><td colspan="5">Applicability of the Module</td></tr>
<tr><td>9</td><td colspan="5">Value of the mark in the final mark
Without proportional weighting in the final grade (5/120).</td></tr>
<tr><td>10</td><td colspan="5">Module representative and full-time instructors
Module representative: ap. Prof. Dr. W. Werner and Lecturers of the faculty Geography and Geosciences (FB VI)</td></tr>
<tr><td>11</td><td colspan="5">Further Information</td></tr>
</table>

Module „Physical monitoring of lithosphere and hydrosphere"					
Course code MA6ES030	Workload 150 h	Credits 5	Study Semester 2nd Semester	Frequency of course offer annual	Duration 1 Semester

1	Courses	Contact hours	Private Study	Planned Group Size
	a) Lectures on basics and introduction	1 SWS/15 h	15 h	120
	b) Practical course on geophysical systems, data processing and presentation	2 SWS/30h	30 h	24
	c) Tutorial-based seminar on selected topics	2 SWS/30 h	30 h	24

2 Learning outcomes/Qualification objectives

Soft skills:

- Planning, elaboration and discussion of a geophysical monitoring program and its interdisciplinary aspects in a research team
- Competency for critical comments and discussions in the context of complex and controversly discussed scientific topics
- Ability of elaboration and discussion of complex scientific processes in working groups, which are alternated guided by the participants

Expertise:

- Knowledge of physical properties of soils, sediments, rocks, waste deposits and water columns in oceans and lakes. Furthermore, reasons for changes in these physical properties should become clear.
- Overview of methods which can be used to monitor the geophysical properties of the underground: e.g. ground penetration radar (GPR), multi beam, parametric echo sounding, gravity, geoelectrical and magnetic measurements, conductivity-temperature-depth (CTD) analyzers
- Knowledge and applications of distinct monitoring systems: e.g. thermohaline structure of oceans as key factor for ocean circulations, sediment structures and their implications for drilling or building projects, changes in the ground water level, archeological investigations, structure and water distribution in waste deposits.
- Capacity to interpret GPR, echo and seismic diffractograms and CTD profiles
- Georeferenciation, 3D and ArcGIS-based visualisation of geophysical properties
- Calibration and comparison of geophysical data with related sampling or core drilling
- Competency concerning a critical review on the progress in new techniques concerning geophysical monitoring of lithosphere and hydrosphere
- Evaluation of selected methods and their implications based on data calculation, interpolation, calibration as well as ArcGIS-based volume and mass calculations

3 Content

a) Lectures:

Introduction concerning geophysical properties of soft rocks, sediments, waste deposits as well as lacustrine and marine water columns. Presentation of selected methods to visualize the geophysical properties including geoelectric, geomagnetic, geoacustic, gravimetrical methods and Ground Penetrating Radar.

b) Practical training with selected methods and techniques:

Georeferenciation, graphic presentation, calibration, evaluation and interpretation of geophysical records, including especially parametric echo sounding, ground penetrating radar, CTD measurements of water columns and magnetic suscep-tibility of sediment records.

c) Seminar:

Critical evaluation and presentation (in small working groups) of selected newly published methods and the general progress in these methods

4 Introduction Forms

a) Lecture
b) Practical course
c) Seminar with presentations

5 Conditions for Praticipation

6 Examination Form

Advanced examination effort: oral seminar presentation, accepted reports
Final module examination: Written examination (90 minutes)

7 Conditions for the award of credit points

Passed final written examination (90 minutes)

8 Applicability of the module

9	Value of Mark in the Final Grade Without proportional weighting in final grade (5/120)
10	Module representative and full time instructors apl. Prof. Dr. Rolf Kilian (Geologie).
11	Further Information Butler, D.K. (e.d.) (2005): Near-surface geophysics. 732 p., Society of Exploration Geophysic. Fowler, C.M.R. (2004): The Solid Earth: An Introduction to Global Geophysics. 704 p., Cambride University Press. ISBN-10: 0521893070 Idziak, A.F. and Dubiel, R. (2011): Geophysics in Mining and Environmental Protection. 150 p., Springer, ISBN: 3642190960. Jones, E.J.W. (1999): Marine Geophysics. 474 p., Wiley, ISBN-10: 0471986941. Kaufman, A. and Hansen, R.O. (2007): Principles of the Gravitational Method, Volume 41 (Methods in Geochemistry and Geophysics). 258 p., Elsevier. Lowrie, W. (2009): Fundamentals of Geophysics. 381 p., (2nd ed.) Cambridge University Press. ISBN-10: 0521675960. Spichak, V. (2006): Electromagnetic Sounding of the Earth's Interior, Volume 40 (Methods in Geochemistry and Geophysics). 404 p., Elsevier. Waltham T. et al. (2005): Sinkholes and Subsidence (Springer Praxis Books / Geophysical Sciences). 413 p., Springer.

Module "Vegetation Ecology"					
Course Code MA6ES031	Work Load 150 h	Credits 5	Study Semester 2nd Semester	Frequency of course offer -annual -	Duration 1 Semester

1	Courses	Contact Hours	Private Study	Planned Group Size
	c) Research concept and data analysis	1 SWH/15h	50 h	24
	d) Field and Laboratory Course	3 SWH/45h	40 h	24

2 Learning Outcomes/Qualification Objectives

Students become acquainted with synecolgical research

Identification and interpretation between presence of species or the development of plant associations and specificity of ecological factors like water and nutrient supply micro climate conditions and radiation (Ecological Indicator Concept (ELLENBERG). physiological potency and ecological existence).

Knowledge of plant species, Classification of ecological factors in field (humus form, soil profile, water and nutrient supply, micro climatic conditions of vegetation)

Aspects of plant population ecology (Dissemination, germination, safe site concept (nurse plants), inter- und intraspecific competition)

Knowledge and interpretation of indicators to classify matter and energy budget of ecosystems (Ellenberg's indicator values, Grime's C-S-R-strategies)

Knowledge of research and data analysis concepts to investigate correlations between presence of species and abiotic and biotic ecological factors as well as critical evaluation of this results (multivariate statistical methods).

3 Contents

Identification and classification of plant associations and their site factors in the field (with aid of index and differential species and with aid of indicator values as well as with characteristic values of water and nutrient budget of the soil:

Application of methods for documentation of species composition (Vegetation releve) and soil and description of soil profile, soil classification (with aid of 'Bodenkundliche Kartieranleitung' inclusive humus forms and field capacity) as well as measurement and documentation of different site gradients.

- Light gradients on forest edges, water gradients on soils with different hydromorphic characteristics , nitrogen supply gradients in extensive and intensive managed grass- and farmland
- Effects on species composition of different intensive land use concerning C-S-R-Strategies of plants (for example extensive and intensive managed grass- and farmland, attributes of eutrophication of plant communities by N-Deposition and/or liming
- Correlations between soil acidification and presence/absence of plant species or the development of plant associations and soil types, humus forms and buffer ranges of soils.
- Measurement of pH, cat ion exchange capacity, C/N-ratio, phosphor concentrations, nitrogen mineralization, nutrient concentrations and nutrient ratios in plant organs
- Biological Interactions between organisms (competition, predation, commensalism, symbiosis) and experimental approaches for their investigation
- Statistical data analysis: logistic correlations between presence of species and differentiation of site factors, similarity an correspondence between site factors and species composition (correspondence analysis, ordinations, cluster- und discriminant analysis).

4 Instruction Forms: a) seminar, b) field and laboratory course

5 Condition for participation

6 Examination forms: Final module examination: Graded term paper

7 Condition for the award of credit points: Passed final examination: term paper

8 Applicability of the module

Optional Module within MSc Umweltbiowissenschaften, focus Biogeographie, Ökologie und Monitoring (BÖM)

9 Value of the mark in the final mark: Without proportional weighting in the final mark (5/120)

10 Module representative and full-time instructors: extraordinary Prof. Dr. Willy Werner

11 Further Information

ELLENBERG H, LEUSCHNER C. 2010: Vegetation Mitteleuropas mit den Alpen in ökologischer, dynamischer und historischer Sicht. Ulmer Verlag, 6. Auflage

ELLENBERG H., WEBER H.E., DÜLL R., WIRTH V. & W. WERNER 2001: Zeigerwerte von Pflanzen in Mitteleuropa Goltze Verlag, Göttingen 3. Aufl.

GRIME J.P. 2001: Plant Strategies, Vegetation Processes, and Ecosystem Properties. (2nd edition) Wiley

DIERSCHKE H. 1994: Pflanzensoziologie Ulmer Verlag.

AG BODENKUNDE 2005: Bodenkundliche Kartieranleitung 5. Hannover.

SCHEFFER/SCHACHTSCHABEL 2010: Lehrbuch der Bodenkunde, Enke Verlag.

Module "Sustainable Chemistry"						
Course Code MA6ES032		Workload 150 h	Credits 5	Study Semester 2nd Semester.	Frequency of course offer - annual -	Duration 1 Semester
1	Courses a) Lecture: Principles of Sustainable Chemistry b) Practical: Chemical Exploitation of Renewable Resources c) Laboratory Exercises		Contact Hours 2 SWH/30 h 1 SWH/15 h 2 SWH/30 h		Private Study 45 h 15 h 15 h	Planned Group Size 125 30 12
2	Learning outcomes/Qualification objectives The students should: • be able to understand the fundamentals, historical roots and ethical objective of the sustainability concept • be able to review and apply environmental sustainability and measuring categories • be in a position to apply sustainability criteria to material and energy cycles, to products and processes • arrive at an idea of the possible contribution of chemistry to the achievement of sustainable development, • know the chemical exploitation potential of renewable raw materials and biomass residual materials.					
3	Content • Basic principles of sustainability, historical background, ethical concept, central values • Milestones of sustainable development, sustainability and measuring categories, minimizing and optimizing requirements • Energy and material use from the sustainability point of view • Evaluation procedures for chemical products and processes, life cycle analysis • New design of chemical syntheses: claim of the "Green Chemistry" • 12 point program of the "Green Chemistry" • Renewable raw materials and biomass residual materials as alternative starting materials for chemical processes and syntheses • Concept of the "Green biorefinery" • Systematic of the utilizable biological materials and their sources • Transformation of the biological raw materials to industrial chemicals and end products • Application possibilities in the environmental protection technology • Chemical analytical methods for determining value substance concentrations • Basic laboratory tests to extract chemical raw materials from biomass					
4	Instruction forms Lecture, practical course, laboratory exercise or research internship (block event or one whole day/specific day distributed throughout the semester).					
5	Condition for participation					
6	Examination forms Final module examination: graded term paper					
7	Condition for the award of credit points Passed final examination: term paper					
8	Applicability of the module Optional module in the MSc "Umweltbiowissenschaften"					
9	Value of mark in final grade Module mark is accepted without proportional weighting in the final mark (5/120)					
10	Module representative and full-time instructor Module representative: Prof. Dr. Dr. K. Fischer, other lecturer: Dr. A. Meyer.					
11	Further information: Course books: Anastas, P.T., Warner, J.C. (1998): Green Chemistry – Theory and Practice. Oxford (University Press). Anastas, P.T., Heine, L.G., Williamson, T.C. [Eds.] (2000): Green Chemical Syntheses and Processes. ACS Symp. Ser. 767. Washington, D.C. (ACS).					

Modul "Geostatistik"						
Course code MA6ES033	Workload 150 h	Credits 5	Study Semester 3rd Sem.	Frequency of course offer annual	Duration 1 Semester	
1	Courses a) Geostatistik (Vorlesung) b) Geostatistik (Übung)	Contact hours 2 SWH/30 h 2 SWH/30 h	Private Study 45 h 45 h	Size of Group 200 20		
2	Qualification objectives • Introduction in spatial point patterns and geostatistical methods, concepts and techniques • Practical exercises in the analysis of spatial patterns using the R and ArcGIS software environments • Competences in the critical assessment of different geostatistical methods and approaches					
3	Instruction Forms: *a)* Introduction: - Statistical and geostatistical concepts - Introduction in the R system and relevant geostatistical libraries b) Spatial point patterns: - Analysis of spatial point patterns: independence/randomness and interaction, Poisson processes - Statistical tests for the assessment of spatial point patterns - Concepts for statistical modelling and simulation of spatial point patterns - Monte-Carlo simulations c) Geostatistical interpolation: - Variogramm analysi - Spatial trend analysis - Regionalisation: Kriging and its variants; cokriging - Model validation - Geostatistial examples					
4	Instruction Forms a) Lecture b) Computer excersises					
5	Conditions for Participation					
6	Examination Form Advanced examination effort: Regular participation, testified homework Final module examination: Written Examination (90 minutes)					
7	Condition for the Award of Credit Points Passed final examination: written examination (90 min.)					
8	Applicability of the Module MSc Angewandte Geoinformatik					
9	Value of Mark in the Final Grade Module mark is accepted without proportional weighting in final grade (5/120)					
10	Module Representative and Full-Time Instructor Prof. Dr. T. Udelhoven					
11	Further Information The Module will be teached in german language Das Modul wird in deutscher Sprache gehalten					

Module "Fluvial transport processes"					
Course code MA6ES034	Workload 150 h	Credits 5	Study Semester 3rd Sem.	Frequency of course offer annual	Duration 1 Semester

1	Courses	Contact Hours	Private Study	Planned Group Size
	c) Particulate Transport in River Catchments	2 SWH/30 h	45 h	25
	d) Water Quality Modeling	2 SWH/30 h	45 h	15

2 Learning outcomes/ Qualification objectives

The objective of this course is to give an overview of the analytical methods used in the development of water quality models, and the application of these models to stream and river systems. Special care is drawn to the transport of sediments and particle-bound substances in river catchments. Mathematical conceptualization and formulation of water quality constituent transport and fate mechanisms will be discussed. After the course, the students will be able

- to understand basic physical, chemical, biological and hydrological processes for sediment and water quality dynamics of streams,
- to understand principles of water quality modeling with basic experience of some water quality models,
- to expand capabilities in teamwork, report writing, and presentation,
- to communicate critically results of studies both orally and in written form.

3 Content

a) Particulate Transport in River Catchments

- Runoff generation process and identification of particle sources
- Natural tracer and runoff components
- Erosion and suspended sediment transport
- Physico-chemical properties of suspended sediments
- Relationship between dissolved and suspended phase
- Spatial and temporal dynamics of aquatic sediments
- Transport and reactions of particle-bound contaminants in rivers

b) Water Quality Modeling

- Introduction to water quality modelling
- Hydrologic and hydraulic principles relating to water quality modelling
- Coupling of models of water quality and flow
- Application of various water quality models
- Eutrophication problem and nutrient modeling
- Model calibration and verification

4 Introduction Forms

a) Lectures and seminars in conjunction with oral presentation
b) Seminars and computer course

5 Conditions for Participation

6 Examination Forms

Final module examination: oral examination (20 min.)

7 Condition for the award of credit points

Passed final examination: oral examination (20 min.)

8 Applicability of the Module

Mandatory or optional module MSc PdEO

9 Value of the mark in the final mark

Without proportional weighting in the final grade (5/120).

10 Module representative and full-time instructors

Dr. R. Bierl, N.N.

11 Further Information

Literature:

Chapra, S.C. (1997): Surface Water-Quality Modeling. New York, McGraw-Hill
Allan, J.D. & Castillo, M.M. (2007): Stream Ecology: Structure and Function of Running Waters. Springer

Module "Palaeoclimate and Palaeoenvironmental Changes"					
Course code MA6ES035	Workload 150 h	Credits 5	Study Semester 3rd Semester	Frequency of course offer annual	Duration 1 Semester

1	courses	Contact Hours	Private Study	Planned Group Size
	a) Lectures on geological time scales, age determinations, climate archives	1 SWH/15 h	15 h	120
	b) Practical Courseon climate archives, data processing and presentation	2 SWH/30h	30 h	24
	c) Seminar	2 SWH/30 h	30 h	24

2 Learning outcomes/Qualification objectives

Soft skills:

- Learning of planning, elaboration and discussion of a scientific work program in a research team
- Competency for critical comments and discussions in the context of complex and controversly discussed scientific topics
- Ability of elaboration and discussion of complex scientific processes in working groups, which are alternated guided by the participants

Expertise:

- Knowledge of changes in the global geochemical cycles (e.eg. carbon, sulphur, phosphate, nitrogen silica) including calculation of mass transport and accumulation
- Understanding the complex interaction of geochemical cycles at different regional and geological time scales scales
- Knowledge of geological time scale and age determination methods
- Competency for critical discussion of major palaeoclimate controlling factors
- Overview and critical view of palaeoclimate and palaeoenvironmental archives as well as selected environmental and climate proxies
- Knowledge on access of international palaeoclimate data bases, data comparison and data presentation forms
- Critical evaluation of the importance of newly published (International Journals) high resolution palaeoclimate reconstructions world-wide and their interhemispheric linkages.

3 Content

a) Lectures:

Geological time scale and age determination methods (e.g. K/Ar, Th/U, ^{14}C, ^{10}Be, palaeomagnetismus, fission track, luminescence methods)

Global and regional geochemical cycles (C, N, P, S, Si) with reservoirs, residence and transfer times as well as enrichment and depletion processes

Major controlling factors on palaeoclimate

Palaeoclimate and palaeoenvironmental archives (e.g. tree rings, ice cores, stalag-mites, peat and soils, lacustrine and marine sediments), and selected environmental and climate proxies (geochemical and isotopic, mineralogical and paleontological proxies)

b) Practical training with selected climate archives and proxies:

Tree rings: Computer-aided analysis to create tree ring chronologies

Stalagmites: annual laminations in thin sections; Processing, evaluation, time series analyses and interpretation of geochemical (Mg, Ca, U, Sr, Fe, Mn, Y) and isotopic data (O-, C- and Sr- isotopes)

Lake sediments: Investigation of warved lake sediments in thin sections (optical micro-scope; warve structures and counting) and electron scatter microscope (minerogenic and biogenic warve components).

Marine sediments: core logging and sampling; geochemical, mineralogical, micro-structural and palaeontological investigations

Tutorial-based and computer-aided elaboration, comparison with peleoclimate data base (http://wdc.cricyt.edu.ar/paleo/recons.html) and presentation of results in small working groups

c) Seminar:

Critical evaluation and presentation (in small working groups) of selected newly published high resolution palaeoclimate reconstructions and interhemispheric linkages

New aspects of global geochemical cycles (methan, gas hydrates, ecological impacts)

4 Introduction Forms

a) Lecture
b) Practical course
c) Seminar with presentations

5 Conditions for Praticipation

6 Examination Form

	Advanced examination effort: oral seminar presentation, accepted reports Final module examination: Written examination (90 minutes)
7	Conditions fort he award of credit points Passed final examination: written examination (90 min.)
8	Applicability oft he module Wahlpfichtmodul in MSc Prozessdynamik an der Erdoberfläche
9	Value of Mark in the Final Grade Without proportional weighting in final grade (5/120)
10	Module representative and full time instructors apl. Prof. Dr. R. Kilian (Geologie).
11	Further Information Alverson, K.D., Bradley, R.S., Pederson, T.F. (2003): Paleoclimate, global change and the future. 235 p., Springer Cronin, T.M. (2009): Paleoclimates: Understanding Climate Change Past and Present. 448 p.; Bradley, R.S. (1999): Paleoclimatology: reconstructing climates of the Quaternary. 614 p., Elsevier, Fischer, G. and Wefer, G. (1999): Use of proxies in paleoceanography. 727 p.,

Module "Global Climate Change and Energy Resources"					
Course code MA6ES036	Workload 150 h	Credits 5	Study Semester 2nd Sem.	Frequency of course offer annual	Duration 1 Semester

1	Courses	Contact Hours	Private Study	Planned Group Size
	a) Global Climate Change	2 SWH/30 h	45 h	unlimited
	b) Energy Resources and renewable Energy	2 SWH/30 h	45 h	unlimited

2 Learning outcomes/ Qualification objectives

- Indepth understanding of interdisciplinary contexts and interactions with focus on energy production and consequences of energy use
- Application of system-oriented mindset and operation methods, enabling the students to analyze complex environmental problems, to develop and present approaches for solutions
- Improvement of international exchange and mobility

3 Content

Global Climate Change

- Concepts in climatology, general circulation of the atmosphere and oceans, the influence of the thermohaline circulation on global climate.
- The importance of biogeochemical cycles in the climate system with particular reference to the ' carbon pump'
- Introduction to temporal and spatial scales in the climate system, ranging from 100s of millions of years to annual temporal scales, and from global to local spatial scales
- The quantitative revolution - palaeo - reconstructions and climate models
- the use of transfer functions in quantitative reconstruction of sea surface temperatures, recent advances in our understanding of the climate system based on Global Circulation Models
- Mechanisms of change - Milankovitch Theory and the role of oceans in the glacial - interglacial cyclicity of the past several million years, from sub - millennial to decadal climate change during the last glacial cycle, the role of solar radiation in climate change, natural versus. Anthropogenic variability
- The science of Global Warming, implications of change, global policy

Energy Resources and Renewable Energies

- Energy Resources and Energy Use
- Fossil Resources
- Basic principles of renewable energy use
- Solar radiation, Wind energy, Hydroelectricity, Biomass, Geothermal energy

4 Introduction Forms

a), b) Lecture

5 Conditions for Participation

6 Examination Forms

Final module examination: Written examination (60 minutes)

7 Condition for the award of credit points

Passed final examination: written examination (60 min.)

8 Applicability of the Module

9 Value of the mark in the final mark

Without proportional weighting in the final grade (5/120).

10 Module representative and full-time instructors: Tonie van Dam, University of Luxembourg

11 Further Information

Literature:

ROULET (2004): Santé et quailté de l'environnement intérieur dans les bâtiments, Lausanne

FEIST,W. (1998): Das Niedrigenergiehaus, C.F. Müller

RWE (2004): Bau Handbuch,VWEW Energieverlag,

KALTSCHMITT M., A. WIESE, W. STREICHER (2003): Erneuerbare Energien 3. Auflage, Springer Verlag

WISSENSCHAFTLICHER BEIRAT DER BUNDESREGIERUNG (2003): Energiewende zur Nachhaltigkeit - globale Umweltveränderungen, Springer-Verlag

M. KALTSCHMITT, H. HARTMANN (2001): Energie aus Biomasse, Springer-Verlag

PIECKERT S. (1999): Entwicklungspolitische Optionen für eine umweltverträgliche Energieversorgung in Entwicklungsländern, Diss. Univ. Oldenburg, BIS-Verlag Univ. Oldenburg

Modul „Numerik für Geowissenschaftler"						
Course code MA6ES037	Workload 150 h	Credits 5	Study Semester 2nd Semester	Frequency of course offer annual	Duration 1 Semester	
1	Courses a) lecture b) course	Contact hours 2 SWS/30 h 1 SWS/15 h	Private Study 105	Planned Group Size Unlimited 20		
2	Learning outcomes/Qualification objectives • Einführung in die Grundgedanken der Numerik • Anwendungen numerischer Verfahren insbesondere in den Geowissenschaften					
3	Content – Zahldarstellung im Rechner – Direkte Methoden zur Lösung von Gleichungssystemen – Interpolation (Polynome, Splines, Bezierfunktionen) – Iterative Methoden zur Lösung von Gleichungssystemen – Ausgleichsrechnung und Approximation – Eigenwerte					
4	Introduction Forms a) lecture b) course					
5	Conditions for Praticipation					
6	Examination Form Final module examination: Written examination (60 min.) Advanced examination effort:					
7	Conditions for the award of credit points Passed final examination					
8	Applicability of the module					
9	Value of Mark in the Final Grade Without proportional weighting in final grade (5/120)					
10	Module representative and full time instructors Dr. M. Ries; Mathematik, FB IV					
11	Further Information The Module will be teached in german language Das Modul wird in deutscher Sprache gehalten					

Modul „Populationsökologie"					
Course code MA6ES038	Workload 150 h	Credits 5	Study Semester 1st Semester	Frequency of course offer Annual	Duration 1 Semester

1	Courses d) Populationsökologie (Lecture) e) Populationsökologie (Practical course)	Contact hours 2 SWS/30 h 0,5 SWS/7,5 h	Private Study 60 h 52,5 h	Planned Group Size unbegrenzt 24

2	Learning outcomes/Qualification objectives a/b) • Vertiefte theoretische und praktische Kenntnisse in der Populationsökologie, sowie Kenntnisse ihrer Anwendung in Ökologie, Phylogenie, Biogeographie und Naturschutz • Verständnis der Dynamik natürlicher Systeme durch Prozessmodellierung; Verständnis der mathematischen Formalisierung von Populationsprozessen.
3	Instruction Forms: a/b) • Populationsökologie und Konkurrenz (geschlossene und offene Populationen, Populationswachstum, Dichteregulation, Prädation und Populationsdynamik,, Räuber-Beute-Beziehungen, Parasitismus, Mutualismus, Symbiose, Populationsschwankungen, intra- und interspezifische Konkurrenz, r/K-Strategien, Dispersion und Migration, Tierwanderungen,) • Metapopulationstheorie, • Lifetables, Lebenszyklusstrategien. • Modellierung von Populationsprozessen mittels Simulationssoftware.
4	Instruction Forms a) Vorlesung b) Übung
5	Conditions for Participation Keine
6	Examination Form a/b) Klausur (60 Minuten)
7	Condition for the Award of Credit Points Regelmäßige Teilnahme an Lehrveranstaltungen, akzeptiertes Protokoll, Erfüllung der Prüfungsleistung
8	Applicability of the Module Pflichtmodul Master Umweltbiowissenschaften
9	Value of Mark in the Final Grade Modulnote geht ohne Gewichtung anteilig in Endnote ein (5/120)
10	Module Representative and Full-Time Instructor Prof. Dr. T. Schmitt (Modulbeauftragter); Prof. Dr. M. Veith
11	Further Information Townsend, C. R. Begon, M. & Harper, J. L. Ökologie. 2nd ed. (Springer, Berlin, Heidelberg, 2009).ISBN-3540958967 Hastings, A. Population biology. Concepts and models (Springer, New York, 1997). ISBN-0-387-94853-8 The Module will be teached in german language Das Modul wird in deutscher Sprache gehalten

<table>
<tr><td colspan="6">Module "European Environmental Law"</td></tr>
<tr><td>Course code
MA6ES039</td><td>Workload
150 h</td><td>Credits
5</td><td>Study Semester
3. Sem.</td><td>Frequency of course offer
yearly</td><td>Duration
1 Semester</td></tr>
<tr><td>1</td><td colspan="5">Courses
a) Lecture
b) Tutorial

Contact Hours
2 SWS/30 h
1 SWS/15 h

Private Study
65 h
40 h

Size of Group
a) no limitation
b) no limitation</td></tr>
<tr><td>2</td><td colspan="5">Qualification objectives
• Advanced expertice in environmental law with specific focus on European Environmental Law</td></tr>
<tr><td>3</td><td colspan="5">Content
a) Lecture 'European Environmental Law'
a. The legal system of environmental law in the European Union
b. Comparison of European and National legal systems of EU25
c. European Law of immission control
d. European Waste Legislation
e. European Nature Protection Law
f. European Laws pertaining to Water and Waterways
g. European Soil protection Charta
b) Tutorial
• Presentation and discussion of specific aspects of environmental law in the European Union compared to national laws
• Intensive study of the instruments of environmental law in the EU
• Environmental standards and national strategies in the EU25 countries</td></tr>
<tr><td>4</td><td colspan="5">Instruction Forms:
a) Lecture
b) Tutorial</td></tr>
<tr><td>5</td><td colspan="5">Conditions for Participation</td></tr>
<tr><td>6</td><td colspan="5">Examination Form
Final module examination: Written examination (120 minutes)</td></tr>
<tr><td>7</td><td colspan="5">Condition for the Award of Credit Points
Passed final examination: written examination (120 min.)</td></tr>
<tr><td>8</td><td colspan="5">Applicability of the Module</td></tr>
<tr><td>9</td><td colspan="5">Value of Mark in the Final Grade
Without proportional weighting in final grade (5/120)</td></tr>
<tr><td>10</td><td colspan="5">Module Representative and Full-Time Instructor
Module Representative: N.N. (Dekanat)
Instructor Dr. Kerkmann (Lehrbeauftragter)</td></tr>
<tr><td>11</td><td colspan="5">Further information</td></tr>
</table>

Modul „Bodenerosion unter Globalem Wandel"						
Course code MA6ES040	Workload 150 h	Credits 5 CP	Study Semester 3. Sem.	Frequency of course offer yearly	Duration 1 Semester	
1	Courses	Contact Hours	Private study	Size of Group		
	a) VL: Bodenerosion unter Globalem Wandel	2 SWS/30 h	30 h	30		
	b) HS: Forschungsbezogene Fragestellungen zur aktuellen Geomorphodynamik in subhumiden bis semiariden Gebieten	2 SWS/30 h	60 h	max. 15		
2	Qualification objectives • Vertieftes Verständnis für fächer- und themenübergreifende Zusammenhänge u. Wechselwirkungen • Selbstständiges, problemorientiertes und zielgerichtetes, wissenschaftlich fundiertes, methodenkritisches Arbeiten • Mündliche und schriftliche Präsentation eines anspruchsvollen wissenschaftlichen Themas Fachkompetenzen: • Bodenerosion als weltweites Problem kennen lernen • Verschiedene theoretische Konzepte zum Suspensionsfrachtverlust auf Globaler Ebene kennen lernen und die Probleme auf dieser Maßstabsebene erkennen. • Prozessen, Einflussfaktoren und Ursachen der Bodenerosion kennen lernen • räumliche Verbreitungsmuster der Bodenerosion auf größeren Maßstabsebenen (regional bis lokal) erkennen können • Schwierigkeiten bei der Bewertung des Schweregrades von Bodenerosion auf unterschiedlichen Maßstabsebenen erkennen und Lösungsmöglichkeiten diskutieren • Szenarios der Bodenerosionsentwicklung unter sich verändernden Umweltbedingungen (Klima-, Landnutzungswandel) entwickeln und bewerten lernen • Verfahren der Erosionsvermeidung kennen und bewerten lernen • Mündliche und schriftliche Präsentation eines anspruchsvollen wissenschaftlichen Themas					
3	Content a) Als Einführungsveranstaltung in den Studiengang kommt dem Modul Bodenerosion unter Globalem Wandel eine zentrale Stellung innerhalb des Studienganges zu. Sowohl prozessuale und kausale Interdependenzen als auch die gesellschaftliche Relevanz dieses weltweiten Problemfeldes in seiner spezifischen räumlichen Differenzierung werden im Rahmen einer Vorlesung vorgestellt bzw. erarbeitet. Zu den Inhalten gehören folgende Einheiten: • Bodenerosion im weltweiten Vergleich, Globaler Wandel (Klima- und Landnutzungswandel), Definitionen von Bodenerosion, Prozesse und Formen der Bodenerosion, Bodenerosion als historisches Phänomen • Faktoren der Bodenerosion wie Erosivität des Niederschlages, Erodibilität des Bodens etc.. • Erfassungsmethoden wie qualitative, semiquantitative und quantitative Verfahren sowie experimentelle Messverfahren. • Methodische Probleme einzelner Erfassungsmethoden. • Bodenerosionsmodelle wie empirische Modelle ("Blackbox"-Modelle), prozessorientierte, physikalisch basierte Modelle, z. B. EUROSEM (European Soil Erosion Modell), CREAMS (Chemicals, Runoff and Erosion from Agriculture Management System), WEPP (Water Erosion Prediction Project), Produktivitäts-Modelle (EPIC, Erosion Productivity Impact Calculator), Erosion 2D und Erosion 3D • Kombination aus Testflächenkartierungen und Fernerkundungsdaten, Rasterklassifikation und V/G-Komplex, Erosionsprognosemodelle. • Bodenschutzmaßnahmen, wie z.B. Konzept vom 'Tolerierbaren Bodenabtrag. • Erosionskontrolle (Technische Maßnahmen, sozio-ökonomische und politische Rahmenbedingungen, neue Konzepte für die Bodenerosionsforschung) b) Im Hauptseminar: Vertiefung ausgewählter Themen aus a) unter besonderer Berücksichtigung aktueller Ergebnisse aus laufenden Forschungsprojekten in semihumiden bis semiariden Gebieten.					
4	Introduction Forms a) Vorlesung; b) Hauptseminar (15): mit Vortrag und schriftlicher Ausarbeitung					
5	Conditions for Participation: keine					
6	Examination Form: b) Schriftliche Hausarbeit					
7	Condition for the Award of Credit Points Regelmäßige Teilnahme, Vortrag und mind. ausreichend benotete Schriftliche Hausarbeit					
8	Applicability of the Module MA Angewandte Humangeographie, M.Sc. Angewandte Geoinformatik, M.Sc. Umweltbiowissenschaften					
9	Value of Mark in the Final Grade: 5/120					
10	Module Representative and Full-Time Instructor: Prof. J.B. Ries und wiss. Mitarbeiter					
11	Further Information The Module will be teached in german language Das Modul wird in deutscher Sprache gehalten Grundlagenliteratur: Richter 1998, Lal 2000, Ries 2000, Morgan 2002, Hudson 2004 und entsprechende Zeitschriftenartikel aus Geomorphologie, Catena, ZFG, MDBG.					