UNIVERSITÄT BAYREUTH

MSc Geography of Environmental Transformation

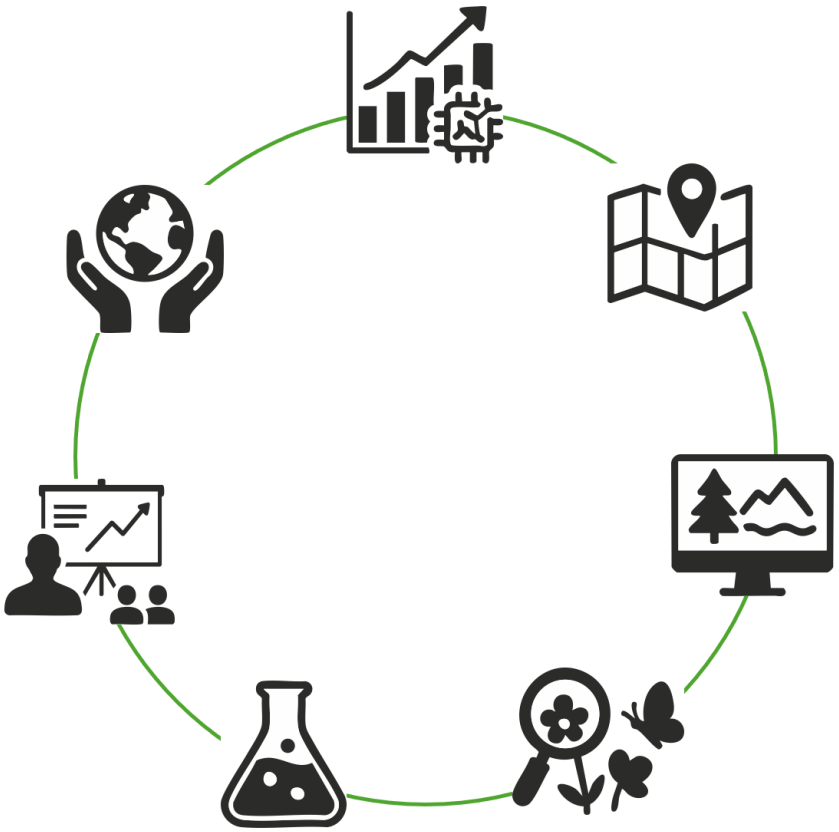
MSc Environmental Chemistry

Study Guide to the

Methods Pool

in Environmental System Sciences at GEO-UBT

(MSc Global Change Ecology, MSc Geoökologie, MSc Geography of Environmental Transformation, MSc Environmental Chemistry)



April 2026

Content

Introduction

Methodological skills are at the heart of environmental system sciences. To support you in developing those, we have created a comprehensive methods pool targeted at beginners, intermediate as well as advanced level across the MSc programs in Global Change Ecology (GCE), Geoökologie (Gecko), Geography of Environmental Transformation (GeoET), and Environmental Chemistry (EnvChem). We in Geosciences at UBT offer all the methods you need to analyse, understand, and manage environmental systems.

This includes empirical methods in the lab and the field to study chemical, physical, and ecological processes. We teach statistics, data science, and artificial intelligence to help you analyse large environmental and ecological datasets. GIS and remote sensing let you explore patterns of environmental change, ecosystem functions, and species distributions over time and space. You can learn to use computer models to simulate how climate, soil, water, air, and species interact, along with emerging ecosystem functions and services. Studying environmental solutions across policies, economies, and civil society will prepare you to contribute to the sustainable management of complex socio-ecological systems and connect science with policy. Additionally, courses in research management and science communication complement your skills. From this wide range of methods courses, you can pick the ones that fit the chosen specialisations in your MSc program and your level of skills the best. These methodological competencies will be your asset for careers in environmental sciences, corporate health, safety and environmental departments, green NGOs, or environmental government agencies.

In the following, you will find more details on each method group and the modules offered. This includes information to which specific specialisations and MSc programs the methods are linked.

Statistics, Data Sciences and Artificial Intelligence

Scientific and societal challenge

Statistics, data science, and AI help us analyse, interpret, and model complex environmental data in a rapidly changing world. These skills are essential for addressing key societal challenges such as climate change, biodiversity loss, pollution, and the sustainable use of natural resources. By working with large and diverse datasets from sources like monitoring systems, experiments, and simulations, they turn data into meaningful insights that support informed decision-making. Combining solid data analysis with modern computational tools, they help identify patterns, understand interacting processes, improve predictions, and develop practical and innovative solutions for sustainable development and environmental management.

Learning Objectives

- Apply statistical methods and data science techniques to analyse and interpret environmental and ecological data
- Use programming tools (e.g. R) for data handling, visualisation, and reproducible analysis
- Analyse spatial and temporal data, including mapping patterns, identifying trends, and modelling time series
- Select appropriate analytical and modelling approaches from a wide range of methods (e.g. regression, multivariate statistics, time series analysis, spatial statistics, and machine learning) depending on the data and research question
- Critically evaluate data quality, methodological choices, and uncertainty in data-driven analyses
- Translate complex data into clear insights to support scientific understanding and evidence-based decision-making

Required knowledge

- Courses address different levels of prior experience; entry requirements therefore vary from basic mathematical skills to more advanced knowledge in statistics and programming
- Fundamental understanding of mathematics and statistics (e.g. algebra, basic probability)
- Basic familiarity with data handling and programming concepts (e.g. in R or similar), depending on the course level

Competences

- Apply statistical, multivariate, spatial, time series and machine learning methods to analyse environmental and ecological data.
- Interpret and synthesize complex datasets from field measurements, experiments, monitoring networks, and remote sensing to support robust conclusions.
- Work across disciplines (ecology, climatology, hydrology, soil science) and translate data-driven insights into practical solutions for sustainable management, climate adaptation, and policy.

Content of method specialisation

Modules	ECTS	MSc	Related to specialization
Introduction to R – Basics and Data Handling	2	GCE, Gecko, GeoET, EnvChem	generic
Statistical Data Analysis with R	3	GCE, Gecko, GeoET, EnvChem	generic
Spatial Statistics and Visualization with R	3	GCE, Gecko, GeoET	generic
Time Series Analysis	5	GCE, Gecko, GeoET	generic
AI in Environmental and Ecological Research[1)]	3	GCE, Gecko, GeoET	generic
Advanced Multivariate Statistical Methods in Climate Research	3	GCE	Global climate change and ecosystems
Ecoinformatics and Biogeographical Modelling	5	GCE, Gecko GeoET	Biodiversity and ecosystem functions Climate, Water, Vegetation

[1)] starting 2027/28

Contact person

Prof. Dr. Lisa Hülsmann

Prof. Dr. Manuel Steinbauer

GIS and Remote Sensing

Scientific and societal challenge

Geographic Information Systems (GIS) and Remote Sensing address the growing need to monitor, represent, analyse, and manage spatial phenomena in a rapidly changing world. Key societal challenges include climate change, urbanisation, biodiversity loss, natural hazards, and resource management. GIS and remote sensing enable evidence-based decision-making by integrating diverse and large-scale geospatial data from satellites, sensors, and field observations to support sustainable development and environmental governance.

Learning Objectives

- Understand the theoretical foundations of GIS and Remote Sensing
- Acquire skills to process, analyse, and visualise spatial data
- Apply geospatial methods to solve real-world environmental and societal problems
- Integrate remote sensing data with GIS-based analysis workflows
- Critically evaluate spatial datasets and analytical results

Required knowledge

- Understanding of cartography
- Basic statistics and mathematics

Competences

- Use of QGIS or ArcGIS for processing, analysing and visualising spatial data
- Capacity to handle and analyse potentially big and multidimensional spatial data sets generated with remote sensing techniques such as sensors onboard satellites or drones
- Understand statistics, machine learning, and image processing algorithms

Content of method specialisation

Modules	ECTS	MSc	Related to specialization
Introduction to GIS	2	GCE, Gecko	Generic
Advanced GIS	2	GCE, Gecko, GeoET	Generic
Remote Sensing	3	GCE, Gecko	Generic
Advanced Remote Sensing[1)]	3	GCE, Gecko, GeoET	Generic
AI for Spatial Data Analysis[1)]	3	GCE, Gecko, GeoET	Generic

[1)] starting 2027/28

Contact person

Junior Professor Dr. Meng Lu

Prof. Dr. Cyrus Samimi

Environmental Models and Simulation

Scientific and societal challenge

Climate change, biodiversity loss, and increasing environmental degradation (e.g., pollutants, land degradation) pose fundamental challenges to societies worldwide. Understanding how Earth's ecosystems, hydrological systems, and biogeochemical cycles respond to natural and anthropogenic pressures requires robust quantitative tools. Environmental models and simulations are indispensable for testing scientific hypotheses by translating complex field data into predictive insights, enabling scientists and policymakers to assess future scenarios, evaluate mitigation strategies, and support evidence-based decision-making. This group of modules addresses the growing societal demand for experts who can develop, apply, and critically evaluate simulation models across a wide range of environmental systems – from soil-plant-atmosphere interactions to landscape-scale ecosystem services and global climate feedbacks.

Learning Objectives

- Understand the theoretical foundations of environmental and ecological modelling, including mathematical and statistical frameworks used to represent complex Earth system processes.
- Select, parameterise, and apply appropriate simulation models to address specific environmental research questions across scales ranging from field to global scale.
- Critically evaluate model outputs, assess uncertainty, and communicate results effectively to scientific and non-scientific audiences.
- Apply modelling approaches to assess ecosystem services, biodiversity impacts, and environmental change under future climate scenarios.

Required knowledge

- Fundamental (Bachelor level) knowledge of geo-ecology, physical geography, earth sciences, or a related environmental discipline.
- Basic mathematical skills including calculus, linear algebra, and statistics; familiarity with differential equations is advantageous.
- Introductory programming skills (e.g. R) and willingness to work with specialized modelling software environments.

Competences

- Proficiency in applying a range of quantitative modelling approaches — including process-based, and statistical (data driven) models — to environmental systems and at various scales.
- Ability to interpret and synthesize complex environmental datasets and model outputs, including climate data, multidisciplinary and multi scale laboratory and field observations, including remote sensing data, to draw scientifically sound conclusions and design solutions.
- Capacity to work at the interface of different disciplines (ecology, climatology, hydrology, soil science and geochemistry), and to translate modelling results into policy-relevant insights for ecosystem management, land use planning, and climate adaptation strategies.

Content of method specialisation

Modules	ECTS	MSc	Related to specialization
Introduction to Environmental and Ecological Modelling	2	GCE, Gecko, GeoET	generic
Climate Data Modelling	3	GCE Gecko GeoET	Global climate change and ecosystems Earth Surface Processes and Interactions Climate, Water, Vegetation
Mathematical Modeling for Climate and Environment	8	GCE GeoET	Global climate change and ecosystems Climate, Water, Vegetation
Modelling Soil-Plant-Atmosphere Systems	5	GCE Gecko GeoET	Global climate change and ecosystems Earth Surface Processes and Interactions Climate, Water, Vegetation
Ecosystem Services Assessment of Landscapes	2	GCE, Gecko GeoET	Biodiversity and ecosystem functions Environment and Society
Modeling Ecosystem Services	3	GCE, Gecko GeoET	Biodiversity and ecosystem functions Environment and Society
Methods in Dynamic Vegetation Ecology	5	GCE, Gecko	Biodiversity and ecosystem functions
Models in Micrometeorology: Carbon and water budgets from ecosystem to landscape scale	3	Gecko	Earth Surface Processes and Interactions
Meteorologische Grundlagen erneuerbarer Energien	3	Gecko	Earth Surface Processes and Interactions
Einführung in hydrologische Modellierung	3	Gecko	Earth Surface Processes and Interactions
Quantitative Hydrologie und Reaktiver Stofftransport	5	Gecko	Earth Surface Processes and Interactions
Simulation des Stofftransports und der Stoffdynamik in Einzugsgebieten	3	Gecko	Earth Surface Processes and Interactions
Geochemical Modelling	5	Gecko, EnvChem	Biogeochemical cycles and pollution

Contact person

Prof. Dr. Efstathios Diamantopoulos

Prof. Dr. Thomas Koellner

Field Surveys and Experiments (coming soon)

Scientific and societal challenge

Learning Objectives

Required knowledge

-
-
-

Competences

-
-
-

Content of method specialisation (add description in full sentences)

Modules	ECTS	MSc	Related to specialization
Vegetation Science	3	GCE, Gecko	Biodiversity and ecosystem functions
Alpine Field Course in Vegetation Science	5	GCE, Gecko	Biodiversity and ecosystem functions
Experimental Ecology, Biodiversity and Ecosystem Functioning	5	GCE, Gecko	Biodiversity and ecosystem functions
Ökologie von Insekten-Pflanzen Interaktionen	5	Gecko	Biodiversity and ecosystem functions
Bodenexkursion	10	Gecko	Biogeochemical cycles and pollution
Applications of Stable Isotopes in Aquatic Ecology	5	Gecko	Biogeochemical cycles and pollution
Nutzpflanzen der Tropen	3	Gecko	Umweltmanagement und Naturschutz
Nutzpflanzen gemäßigter Breiten	2	Gecko	Umweltmanagement und Naturschutz

Contact person

Prof. Dr. Anke Jentsch

Prof. Dr. Eva Lehndorff

Lab methods

Scientific and societal challenge

Current environmental challenges, such as climate change, biodiversity loss, or pollution, require experts in analytics who can design experimental studies, collect, handle and analyze a variety of complex environmental samples, evaluate the obtained data and develop effective solutions to address these critical challenges.

The "Laboratory Methods" section introduces core principles of environmental analytics and provides hands-on training across a broad range of laboratory techniques, all within the context of ecosystem and environmental research.

Learning Objectives

Students develop practical research skills in environmental analytics that are relevant for a career, for instance, in research, industry or environmental consultancy. They apply a range of standard and advanced laboratory methods with a focus on accuracy, safety, and proper data recording, while also having the opportunity to specialize in novel, innovative technologies of specific disciplines (such as Agroecology, Soil Science, Hydrology). Students apply chemical calculations and suitable statistics to evaluate their data and relate them to scientific concepts. They are able to apply their acquired knowledge to other scientific disciplines to solve analytical problems.

Required knowledge

- Entry requirements vary since courses address basic to more advanced laboratory methods.
- Basic chemical calculations
- Basics of Statistics
- Principles of Good Laboratory Practice

Competences

- Assess the importance of proper sample handling and preparation
- Identify and manage laboratory risks and handle chemical reagents safely
- Understand principles and applications of laboratory instruments and equipment (e.g., instruments for elemental analysis, spectroscopy, HPLC, GC, MS, IRMS)
- Prepare clear and well-organized lab reports
- Critically evaluate the analytical results (e.g., the reliability or accuracy of data)
- Interpret and discuss the data

Content of method specialisation

Modules	ECTS	MSc	Related to specialization
Isotope Biogeochemistry	5	Gecko EnvChem	Biogeochemical cycles and pollution
Soil Organic Chemistry	5	Gecko	Biogeochemical cycles and pollution
Environmental Analytical Chemistry I – Basic Methods	5	Gecko EnvChem	Biogeochemical cycles and pollution

Environmental Analytical Chemistry II – Advanced Methods	5	Gecko EnvChem	Biogeochemical cycles and pollution
Mass Spectrometry	5	Gecko	Biogeochemical cycles and pollution
Analytical Microscopy Project	5	EnvChem	

Contact person

Prof. Dr. Johanna Pausch

Dr. George Metreveli

Analysis of Environmental Solutions in Policies, Economies and the Civil Society

Scientific and societal challenge

This method specialisation addresses the complex global challenges arising from climate change, biodiversity loss, environmental degradation, and the transformation toward sustainable societies and economies. It tackles the need for effective governance frameworks, robust environmental law, transparent corporate sustainability practices, and scientifically grounded assessment tools for guiding political and business decisions. A further challenge lies in navigating multilateral environmental negotiations, understanding power dynamics among global stakeholders, and integrating science effectively into policy processes. The programme therefore engages with the intertwined ecological, economic, political, and societal dimensions that shape global environmental futures.

Learning Objectives

You gain a comprehensive understanding of international environmental politics, law, and governance, including current regulatory developments and real-world negotiation processes. You learn to critically analyse nature- and climate-related risks, evaluate sustainability reporting standards, and apply methodological tools such as life cycle assessment and social science research methods.

The programme also builds your competencies in observing, interpreting, and actively engaging in global environmental negotiations, while strengthening your ability to synthesise complex information for academic, policy, and corporate audiences. Overall, you learn to integrate interdisciplinary knowledge to assess environmental policies, support sustainable decision-making, and reflect on the science–policy interface.

Required knowledge

- General foundation in environmental science, policy, or sustainability
- Familiarity with basic economic or social science concepts
- No specialised technical expertise required (legal, methodological, financial, and analytical concepts introduced step by step)
- Curiosity about global governance, international cooperation, and evidence-based decision-making

Competences

- Competencies in policy and regulatory analysis, environmental law interpretation, and evaluation of sustainability-related risks and opportunities
- Skills in scientific methodology (qualitative and quantitative social science) and practical expertise in environmental assessment tools
- Abilities in negotiation observation, science–policy reflection, and clear communication through policy briefs and presentations, strengthening analytical and interdisciplinary problem-solving skills

Content of method specialisation

Modules	ECTS	MSc	Related to specialization
Sustainable Finance and Corporate Nature Reporting	3	GCE	Global Policies, Economies, Civil Society and the Environment
Life Cycle Assessment of Products	2	GCE	Global Policies, Economies, Civil Society and the Environment

International Environmental and Sustainable Development Law	5	GCE	Global Policies, Economies, Civil Society and the Environment
Global Environmental Negotiations: Observing, Engaging, and Reflecting	2	GCE	Global Policies, Economies, Civil Society and the Environment
Methodology of Social Sciences	3	GCE	Global Policies, Economies, Civil Society and the Environment

Contact person

Dr. Stephanie Thomas

Prof. Dr. Thomas Koellner

Research Management and Science Communication

Scientific and societal challenge

Effective research management and science communication are essential for addressing complex environmental problems. Bridging scientific, societal, and policy domains requires the ability to coordinate interdisciplinary research, engage diverse actors, and communicate evidence clearly to non-experts.

Learning Objectives

You develop a solid understanding of the principles, challenges, and strategies involved in communicating scientific knowledge to non-expert audiences while strengthening your critical thinking and decision-making skills for choosing appropriate communication tools. At the same time, you gain practical insight into project and research management in scientific and international contexts, coordinate projects, and collaborate within interdisciplinary teams. Through this, you also build competencies at the natural–social science interface, deepening your understanding of the possibilities and limitations of inter- and transdisciplinary research.

Required knowledge

- Basic understanding of environmental or sustainability-related topics
- General interest in communication, coordination, and interdisciplinary collaboration
- No specialised technical knowledge required (methods and tools introduced step by step)

Competences

- Science communication (communication strategies, outreach, stakeholder engagement)
- Project and research management (basics of project management, coordination, cooperation, effective teamwork, communication, project planing)
- Inter- and transdisciplinary collaboration (working across scientific and societal boundaries)
- Critical reflection and decision-making related to communication and research strategies
- Practical skills in visual storytelling and film production, presenting, discussing, and defending scientific arguments in societal contexts

Content of method specialisation

Modules	ECTS	MSc	Related to specialization
Science and Communication	3	GCE	Generic
Project Management	2	GCE	Generic
Research at the Natural and Social Science Interface	1	GCE	Generic
Creative Science Communication for People and the Planet	5	Gecko EnvChem	Generic

Contact person

Dr. Stephanie Thomas

Prof. Dr. Martin Obst

Contact person and further information

Prof. Dr. Thomas Koellner

Master's programs in Environmental System Sciences at Earth Sciences, UBT

- Environmental Chemistry (M.Sc.)
- Environmental Geography (M.Sc.)
- Geoecology - Environmental Sciences (M.Sc.)
- Global Change Ecology (M.Sc.)

All study programs in Earth Sciences, UBT

https://www.bcg.uni-bayreuth.de/en/study/earth_sciences/