Christian-Albrechts-Universität zu Kiel

Mathematisch-Naturwissenschaftliche Fakultät

Module Catalogue

for

Geophysics
Master of Science

Stand: [01.06.2017]

Table of Contents

Prologue

This document describes the modules of the MSc-program ‚Geophysics'. It is structured in the same way as the overview plan.

The first section summarizes six basic modules. The students have to select four out of these six modules in the first two semesters. The second section lists specialized modules. Students have to take two of these modules per semester for the first three semesters. Practical courses are given in the third section. The section comprises a large number of 'Digital data processing'-modules. One each has to be taken in the first three semesters. An additional compulsive practical module is 'On- and offshore geophysical field measurements and Active Tutorial'. A compulsive seminar module is in the fourth section. Some freely selectable modules are listed in the fifth section. Students may take any other modules offered at the Faculty of Mathematics and Natural Sciences. The Master-Thesis including a defense makes up the last sixth section of the Module Catalogue. In the seventh section "export modules" are listed, which are subsets of geophysical modules that may be of interest for students of other subjects.

Modules

Section 1: Basic modules

MNF-geop-GGP01a Structure and evolution of the earth

Module Name	Module Code
Structure and evolution of the earth	MNF-geop-GGP01a
Organizer	**Organisation**
Wolfgang Rabbel	Institute of Geosciences
Faculty	**Examination Office**
Faculty of Mathematics and Natural Sciences	PA of the Department of Geography and Geoscience

ECTS Credits
5
Duration
1 term
Frequency
Annual
Evaluation
Graded
Total Workload
150 hours
Workload per ECTS Credit
30 hours
Contact Time
48 hours
Independent Study
102 hours

Teaching Language	German or English
Further Information on the Teaching Language	German, English on request
Entry Requirements as Stated in the Examination Regulations	None
Recommended Requirements	The course requires previous knowledge of mathematics, physics, geology and geophysics at the level of the corresponding introductory courses of the Bachelor program.

Module Courses		
Course Type	**Course Name**	**Compulsory/Optional**
Lecture with exercises	Structure and Evolution of the Earth	WPFL
Further Information on the Courses	None	

Prerequisites for Admission to the Examination(s)	Participation in seminar
Further Requirements for Awarding ECTS Credits	Participation in seminar

Examination(s)		
Type of Examination	**Evaluation**	**Weighting**
Oral or written exam	graded	100 %
Further Information on the Examination(s)	None	

Short Summary

The lecture provides an introduction to the structure and evolution of planet earth from a geophysical perspective.

Course Content

The module is a combination of lecture and textbook seminar. In the textbook seminar, students give talks on varying themes on aspects of earth structure and evolution. The lecture provides an introduction to the structure of planet earth from an geophysical perspective covering the following themes:

1. Global earth structure:
   - Average density, moment of inertia, J2-term;
   - Adams-Williamson-Equation;
   - Global seismic depth profile; average chemical and mineral composition; Murnaghan's equation; density-depth profile.
2. Seismic earth structure:
   - Overview of seismological methods: Computation of seismic travel times in a radially symmetric earth, wave-types and "phases"; tomography, anisotropy, reflection, receiver function, Q, surface waves, free oscillations.
   - Seismic properties of rocks under in-situ conditions
   - A seismological tour through the earth: Lithosphere (global and regional examples); Asthenosphere (pT-conditions of partial melting); Transition zone (depth variation of discontinuities, p-T Clausius-Clapeyron curves, PNN-profiles, phase transitions and super-deep earthquakes); water in the mantle; lower mantle and geoid; D'' layer; inner and outer core and anisotropy in the core.
3. Thermal structure of the earth:
   - Temperature-depth profile: Fix points, adiabatic gradient
   - Heat flow and heat budget: T-modeling and $\delta T(x,y,z)$ estimation
   - Endmembers of convection models
4. Electrical structure of the earth: Magnetotelluric method and examples

Earth magnetic field: Depth structure; convection in the outer core.

Learning Outcome

- The students are deepening their knowledge on the present state and limits of knowledge, on the chaining of arguments and integrating knowledge from different disciplines, and get practice in presenting scientific results.

Reading List

- Fowler, The solid earth, Cambridge Univ Press, 2005
- Artemieva, The Lithosphere, Cambridge Univ Press, 2011
- Stein and Wysession, Introduction to seismology, Blackwell, 2010
- Ozima, Earth: Its birth and growth, Cambridge Univ Press 2012

Additional Information

None

MNF-geop-GGP02 Dynamics of the Earth

Module Name	Module Code
Dynamics of the Earth	MNF-geop-GGP02
Organizer	**Organisation**
Jörg Ebbing	Institute of Geosciences
Faculty	**Examination Office**
Faculty of Mathematics and Natural Sciences	PA of the Department of Geography and Geoscience

ECTS Credits
5
Duration
1 term
Frequency
Annual
Evaluation
Graded
Total Workload
150 hours
Workload per ECTS Credit
30 hours
Contact Time
48 hours
Independent Study
102 hours

Teaching Language	German or English
Further Information on the Teaching Language	German, English on request
Entry Requirements as Stated in the Examination Regulations	None
Recommended Requirements	They should also be able to perform simple geophysical computations.

Module Courses		
Course Type	**Course Name**	**Compulsory/Optional**
Lecture	Dynamics of the Earth	WPFL
Exercise	Dynamics of the Earth	WPFL
Further Information on the Courses	None	

Prerequisites for Admission to the Examination(s)	Exercises
Further Requirements for Awarding ECTS Credits	None

Examination(s)		
Type of Examination	**Evaluation**	**Weighting**
Oral or written exam	graded	100 %
Further Information on the Examination(s)	None	

Short Summary
The lecture explains the role of plate tectonics and the Wilson cyclus in shaping the structure of the Earth. Exercises add practical examples to understand geometric correlations and connections in 3D.
Course Content
Explanation how plate tectonics affect the surface of the Earth and what are the driving forces in the deep mantle. Geophysical description of plate kinematics, triple junctions and subduction, orogenesis, mid-oceanic ridges, rifting, GIA rebound, mantle convection and dynamic topography.
Learning Outcome
• Knowledge of the geophysical description of Wilson cycle and the current understanding of its underlying driving forces. • Knowledge of the principles of mantle convection and its link to surface deformation
Reading List
• Turcotte & Schubert – Geodynamics
Additional Information
None

MNF-geop-TGP01 Inversion Theory

Module Name	Module Code
Inversion Theory	MNF-geop-TGP01
Organizer	**Organisation**
Wolfgang Rabbel	Institute of Geosciences
Faculty	**Examination Office**
Faculty of Mathematics and Natural Sciences	PA of the Department of Geography and Geoscience

ECTS Credits
5
Duration
1 term
Frequency
Annual
Evaluation
Graded
Total Workload
150 hours
Workload per ECTS Credit
30 hours
Contact Time
48 hours
Independent Study
102 hours

Teaching Language	German or English
Further Information on the Teaching Language	German, English on request
Entry Requirements as Stated in the Examination Regulations	None
Recommended Requirements	The course requires previous knowledge of mathematics, physics, geology and geophysics that is listed in one of the documents of the course materials. The exercises require the ability to perform computations and graphics in MATLAB or a similar tool.

Module Courses		
Course Type	**Course Name**	**Compulsory/Optional**
Lecture with Exercises	Inversion theory in Geophysics	WPFL
Further Information on the Courses	None	

Prerequisites for Admission to the Examination(s)	≥50% of exercises to be solved
Further Requirements for Awarding ECTS Credits	None

Examination(s)		
Type of Examination	**Evaluation**	**Weighting**
Oral or written exam	graded	100 %
Further Information on the Examination(s)	None	

Short Summary

The lecture provides theoretical background for the quantitative interpretation of geophysical field measurements.

Course Content

The module is an introduction to mathematical methods for

- Deriving geological structure and physical rock properties of the subsurface from geophysical field measurements (e.g. seismic tomography, gravimetric inversion)
- Establishing empirical relations between geophysical and geological/petrological parameters
- Determining optimum geophysical processing parameters

The lecture deals with discrete (digital) linear and non-linear inversion problems the solution of which is approached numerically with deterministic and statistical methods. It covers the following themes accompanied by geophysical application examples:

5. Basics of Inversion Theory: Inversion as an optimization problem, norms, quality control, confidence limits, a-priori information
6. Linear and linearized non-linear problems: Matrix-methods (Gauss-Newton, singular value decomposition, Marquardt-Levenberg), linear- and quadratic programming
7. Non-linear problems: Steepest descent, Monte-Carlo, simulated annealing, genetic algorithms, swarms

Statistical approaches to inversion: Cluster analysis, neural networks.

Learning Outcome

The students gain mainly methodical expertise including

- the scientific foundation and structure of inversion methods,
- an overview of their application potential and limits,
- practice in analyzing and understanding inversion tasks
- practice in solving numerical problems and creating graphs using computing environments and programming languages

Reading List

- Tarantola, Inverse Problem Theory, 2nd edition, SIAM, 2005
- Gubbins, Time series analysis and inverse theory for geophysicists, Cambridge University Press, 2004

Additional Information

None

MNF-geop-AGP11 Digital Signal Processing

Module Name	Module Code
Digital Signal Processing	MNF-geop-AGP11
Organizer	**Organisation**
Thomas Meier	Institute of Geosciences
Faculty	**Examination Office**
Faculty of Mathematics and Natural Sciences	PA of the Department of Geography and Geoscience

ECTS Credits
5
Duration
1 term
Frequency
Annual
Evaluation
Graded
Total Workload
150 hours
Workload per ECTS Credit
30 hours
Contact Time
48 hours
Independent Study
102 hours

Teaching Language	German or English
Further Information on the Teaching Language	German, English on request
Entry Requirements as Stated in the Examination Regulations	None
Recommended Requirements	The course requires basic knowledge of mathematics, geophysics, and MATLAB.

Module Courses		
Course Type	**Course Name**	**Compulsory/Optional**
Lecture	Digital Signal Processing	WPFL
Exercise	Digital Signal Processing	WPFL
Further Information on the Courses	None	

Prerequisites for Admission to the Examination(s)	None
Further Requirements for Awarding ECTS Credits	Protocol on the exercise

Examination(s)		
Type of Examination	**Evaluation**	**Weighting**
Oral or written exam	graded	100 %
Further Information on the Examination(s)	None	

Short Summary
The course gives an introduction to methods of digital signal processing and signal analysis. It is focused on applications in geophysics.
Course Content
• Stochastic and deterministic models in geophysical signal processing • Trend correction and least squares estimates • Resampling and interpolation • Signal detection • Stacking techniques • Filtering and transforms • Correlation analysis • Properties of signals (causal, analytic, minimum phase, dispersive) • Application of ARMA models to geophysical signal processing In the exercises, MATLAB scripts related to these topics are developed.
Learning Outcome
• The students gain methodical expertise required for digital signal processing in geophysics and related fields • An understanding for the creative application of signal processing tools on geophysical data is developed • Practice of programming skills
Reading List
• Box, G., Jenkins, G., 1970. *Time series analysis: Forecasting and control.* Holden-Day, San Francisco. • Brockwell, P.J., Davis, R.A., 1987. *Time Series: Theory and Methods.* Springer. • Buttkus, B., 1991. *Spektralanalyse und Filtertheorie.* Springer. • Karl, J.H., 1989. *An Introduction to Digital Signal Processing.* Academic Press. • Robinson, E.A., Treitel, S., 1980. *Geophysical Signal Analysis.* Prentice-Hall.
Additional Information
Tutorium (question sessions) provided by graduate students.

MNF-geop-NGP03 Theory of Elastic Waves I

Module Name	Module Code
Theory of Elastic Waves I	MNF-geop-NGP03
Organizer	**Organisation**
Martin Thorwart	Institute of Geosciences
Faculty	**Examination Office**
Faculty of Mathematics and Natural Sciences	PA of the Department of Geography and Geoscience

ECTS Credits
5
Duration
1 term
Frequency
Annual
Evaluation
Graded
Total Workload
150 hours
Workload per ECTS Credit
30 hours
Contact Time
48 hours
Independent Study
102 hours

Teaching Language	German or English
Further Information on the Teaching Language	German, English on request
Entry Requirements as Stated in the Examination Regulations	None
Recommended Requirements	knowledge of math and physics

Module Courses		
Course Type	**Course Name**	**Compulsory/Optional**
Lecture with exercises	Theory of Elastic Waves I	WPFL
Further Information on the Courses	None	

Prerequisites for Admission to the Examination(s)	Successful participation in the exercises
Further Requirements for Awarding ECTS Credits	None

Examination(s)		
Type of Examination	**Evaluation**	**Weighting**
Oral or written exam	graded	100 %
Further Information on the Examination(s)	None	

Short Summary
The lecture “Theory of elastic waves I” introduces to the basic principles of elasticity and continuum mechanics. The wave equations and its solutions are derived for several problems.
Course Content
The lecture consist of: 1. Elasticity theory: strain tensor, stress tensor, strain-stress-relations (isotropic), equation of motion 2. Isotropic acoustic media: wave equation and its analytic solution, numerical solution, visualization, applications 3. Isotropic elastic media: wave equations 4. Concept of Greens functions 5. Point source in full-space: solutions for different type of source (explosion, single couple, double couple), radiation pattern, moment tensor, near- and far-field term of solution, visualization 6. Lambs problem and its solution 7. Seismic wave and interfaces: reflection, transmission for a single interface / sequence of several interfaces (matrix formulation), reflectivity method 8. Ray theory: Fermat principle, high frequency approximation of wave solution, Eikonal equation, Ray amplitudes
Learning Outcome
• understanding of the elasticity theory and the equation of motion • understanding of the seismic wave equation and its solution • concept of green functions • source effects for body waves • interaction at an interface • understanding of the ray theory
Reading List
• Müller: “Theory of Elastic Waves“ • Ben-Menahem & Singh: “Seismic Waves and sources” • Aki & Richards: “Quantitative Seismology“ • Dahlen & Tromp: “Theoretical Global Seismology” • Kennett: “The Seismic Wavefield”
Additional Information
None

MNF-geop-TGP03 Potential theory

Module Name	Module Code
Potential theory	MNF-geop-TGP03
Organizer	**Organisation**
Jörg Ebbing	Institute of Geosciences
Faculty	**Examination Office**
Faculty of Mathematics and Natural Sciences	PA of the Department of Geography and Geoscience

ECTS Credits
5
Duration
1 term
Frequency
Annual
Evaluation
Graded
Total Workload
150 hours
Workload per ECTS Credit
30 hours
Contact Time
48 hours
Independent Study
102 hours

Teaching Language	German or English
Further Information on the Teaching Language	German, English on request
Entry Requirements as Stated in the Examination Regulations	None
Recommended Requirements	Principals of magnetic and gravity method. The students should be capable of deriving basic geophysical equations.

Module Courses		
Course Type	**Course Name**	**Compulsory/Optional**
Lecture	Potential theory	WPFL
Exercise	Potential theory	WPFL
Further Information on the Courses	None	

Prerequisites for Admission to the Examination(s)	Exercises.
Further Requirements for Awarding ECTS Credits	None

Examination(s)		
Type of Examination	**Evaluation**	**Weighting**
Oral or written exam	graded	100 %
Further Information on the Examination(s)	None	

Short Summary
The lecture introduces the fundamentals of potential field theory with main application to gravity and magnetic fields and the exercises give examples.
Course Content
First, the definitions of potential, field and gradients are explained. These concepts are used to explain models of the Earth gravity and geomagnetic fields, both their stable and time-variable components. Calculations on a sphere using spherical harmonic analysis and synthesis and slepian analysis are derived and applied for regional-residual separation, field transformation, inverse and forward modelling potential fields.
Learning Outcome
• Knowledge to combine multiple gravity and magnetic data sets on a sphere and a plane • Knowledge how to separate different field components for geophysical research
Reading List
• Blakely, R.J., 1996. Potential Theory in Gravity and Magnetic Applications. Cambridge University Press. Lowrie, W., 2011. A Student's Guide to Geophysical Equations
Additional Information
None

Section 2: Specialized modules

MNF-geop-AGP05 Seismic II

Module Name	Module Code
Seismic II	MNF-geop-AGP05
Organizer	**Organisation**
Dennis Wilken	Institute of Geosciences
Faculty	**Examination Office**
Faculty of Mathematics and Natural Sciences	PA of the Department of Geography and Geoscience

ECTS Credits
5
Duration
1 term
Frequency
Annual
Evaluation
Graded
Total Workload
150 hours
Workload per ECTS Credit
30 hours
Contact Time
48 hours
Independent Study
102 hours

Teaching Language	German or English
Further Information on the Teaching Language	German, English on request
Entry Requirements as Stated in the Examination Regulations	None
Recommended Requirements	The course requires previous knowledge of mathematics and physics of elastic wave theory, geology and reflection and refraction seismics (MNF-geop-AGP3). The exercises require the ability to perform computations and graphics in MATLAB or a similar tool.

Module Courses		
Course Type	**Course Name**	**Compulsory/Optional**
Lecture	Seismic II	WPFL
Exercise	Seismic II	WPFL
Further Information on the Courses	None	

Prerequisites for Admission to the Examination(s)	≥50% of exercises solved
Further Requirements for Awarding ECTS Credits	None

Examination(s)		
Type of Examination	**Evaluation**	**Weighting**
Oral or written exam	graded	100 %
Further Information on the Examination(s)	None	

Short Summary

The course is an advanced course (based on MNF-geop-AGP3) about the seismic exploration method with focus on imaging and velocity determination methods.

Course Content

The course is an advanced course (based on MNF-geop-AGP3) about the seismic exploration method. It consists of lectures and exercises and is split in three major chapters:

- Calculation and analysis of traveltimes of seismic waves in 1D, 2D and 3D media – Understanding traveltime curves
- Determination of velocity information using 1D to 3D inversion methods (e.g. seismic Tomography) – Fitting modelled traveltimes to measured traveltimes
- Basic concepts of seismic imaging techniques, from Diffraction stack migration to Full waveform and pre-stack migration, reflectivity imaging

In detail it comprises the following sections:

- Introduction and recapitulation: seismic traveltimes, raytracing, ray-parametrisation
- Special examples of 1D velocity-models and their traveltime curves
- 1D-Traveltime analysis – calculating 1D velocity-depth models from traveltime curves (e.g. Slichter-, Wiechert-Herglotz-, and Tau-p-Method)
- 2D/3D-Traveltime analysis – Inversion-raytracing and tomography – linearised approach and damped gradient minimization
- Brief overview on applications for seismic tomography (Refraction, Surface-waves, Cross-hole)
- Resolution of seismic tomography – estimations and assessment
- Methods for modelling/calculating seismic traveltimes – Finite-Difference solutions for Eikonal-, acoustic & elastic wave equation, 3D raytracing equations
- Introduction to seismic migration
- Post-stack migration methods: Wavefront-method and ray-trace migration, Kirchhoff migration, f-k migration (Stolt- and Phase-shift-migration), Full-waveform-migration or reverse-time-migration
- Introduction to pre-stack-migration – when and why? - pre-stack-time-migration and pre-stack-depth-migration

Learning Outcome

The students gain mainly methodical expertise including

- the scientific foundation and structure of the seismic method,
- practice in analyzing and understanding wave propagation and interpretation of seismic data
- practice in evaluating the application limits of different imaging and inversion techniques
- practice in solving numerical problems and creating graphs using computing environments and programming languages

Reading List

- Sheriff and Geldart, Exploration Seismology, Cambridge University Press
- Yilmaz, Öz, Processing, Inversion, Interpretation of seismic data, SEG

Additional Information

None

MNF-geop-AGP06 Petroleum Geophysics

Module Name	Module Code
Petroleum Geophysics	MNF-geop-AGP06
Organizer	**Organisation**
Christian Berndt	Institute of Geosciences
Faculty	**Examination Office**
Faculty of Mathematics and Natural Sciences	PA of the Department of Geography and Geoscience

ECTS Credits
5
Duration
1 term
Frequency
Every two years
Evaluation
Graded
Total Workload
150 hours
Workload per ECTS Credit
30 hours
Contact Time
48 hours
Independent Study
102 hours

Teaching Language	German or English
Further Information on the Teaching Language	German, English on request
Entry Requirements as Stated in the Examination Regulations	None
Recommended Requirements	The course requires knowledge of seismic data analysis and interpretation as the main exploration tool.

Module Courses		
Course Type	**Course Name**	**Compulsory/Optional**
Lecture	Petroleum Geophysics	WPFL
Further Information on the Courses	None	

Prerequisites for Admission to the Examination(s)	None
Further Requirements for Awarding ECTS Credits	None

Examination(s)		
Type of Examination	**Evaluation**	**Weighting**
Oral or written exam	graded	100 %

Further Information on the Examination(s)	None

Short Summary
The lecture will summarize geological and geophysical principles and applications for the understanding of petroleum systems.
Course Content
The course covers • Petroleum Geology • Reservoir Geophysics • Well logs • EM exploration methods
Learning Outcome
The students will learn how to apply geophysical methods to study petroleum systems. Specifically we do not cover seismic methods as these are taught in Seismics I and II and 3D seismology, and seismic interpretation.
Reading List
• Shelley, Elements of Petroleum Geology
Additional Information
None

MNF-geop-AGP08 Near Surface Geophysics

Module Name	Module Code
Near Surface Geophysics	MNF-geop-AGP08
Organizer	**Organisation**
Wolfgang Rabbel	Institute of Geosciences
Faculty	**Examination Office**
Faculty of Mathematics and Natural Sciences	PA of the Department of Geography and Geoscience

ECTS Credits
5
Duration
1 term
Frequency
Every two years
Evaluation
Graded
Total Workload
150 hours
Workload per ECTS Credit
30 hours
Contact Time
48 hours
Independent Study
102 hours

Teaching Language	German or English
Further Information on the Teaching Language	German, English on request
Entry Requirements as Stated in the Examination Regulations	None
Recommended Requirements	The course requires previous knowledge of geophysical methods and geology at the level of introductory courses of the Bachelor program.

Module Courses		
Course Type	**Course Name**	**Compulsory/Optional**
Lecture with exercises	Near Surface Geophysics	WPFL
Further Information on the Courses	None	

Prerequisites for Admission to the Examination(s)	None
Further Requirements for Awarding ECTS Credits	Participation in seminar

Examination(s)		
Type of Examination	**Evaluation**	**Weighting**
Oral or written presentation of project results	graded	100 %
Further Information on the Examination(s)	None	

Short Summary
The course provides an introduction to geophysical methods applied to solve problems of near-surface underground prospecting.
Course Content
The course provides an introduction to geophysical methods applied to solve problems of near-surface underground prospecting. It comprises lectures and exercises where the participants perform interpretational work and develop a near-surface prospecting project. Course themes include short summaries of geophysical prospecting methods (Seismic, DC-geoelectrics, EMI, GPR, borehole geophysics) as well as geophysical approaches to investigate • archaeological sites • groundwater • on- and offshore construction ground • soil type and conditions • waste disposals The seminar consists of oral presentations of the students' projects. The outcome of the students' project planning is presented also in written form in form of an extended quotation.
Learning Outcome
The students gain experience in • analyzing tasks of near surface prospecting • developing a solution based on their previous methodical knowledge • estimating costs of an exploration project • presenting and defending project plans
Reading List
• Kirsch, R. (ed.) Groundwater Geophysics. Springer, 2011 • Knödel, Klaus, Heinrich Krummel, and Gerhard Lange, eds. Handbuch Zur Erkundung Des Untergrundes Von Deponien und Altlasten: Band 3: Geophysik. Springer, 2006. • Witten, A.J. Handbook of geophysics and archaeology. Equinox Pub., 2006.
Additional Information
None

MNF-geop-AGP09 3D-Seismics

Module Name	Module Code
3D-seismics	MNF-geop-AGP09
Organizer	**Organisation**
Christian Berndt	Institute of Geosciences
Faculty	**Examination Office**
Faculty of Mathematics and Natural Sciences	PA of the Department of Geography and Geoscience

ECTS Credits
5
Duration
1 term
Frequency
Every two years
Evaluation
Graded
Total Workload
150 hours
Workload per ECTS Credit
30 hours
Contact Time
48 hours
Independent Study
102 hours

Teaching Language	German or English
Further Information on the Teaching Language	German, English on request
Entry Requirements as Stated in the Examination Regulations	None
Recommended Requirements	The course requires understanding of the basic principles of seismic acquisition and processing for 2D data. Familiarity with KingdomSuite is an asset but not required.

Module Courses		
Course Type	**Course Name**	**Compulsory/Optional**
Lecture	3D-Seismics	WPFL
Exercise	3D-Seismics	WPFL
Further Information on the Courses	None	

Prerequisites for Admission to the Examination(s)	Successful completion of the exercise
Further Requirements for Awarding ECTS Credits	None

Examination(s)		
Type of Examination	**Evaluation**	**Weighting**
Oral or written presentation of project results	graded	100 %
Further Information on the Examination(s)	None	

Short Summary
The lecture will introduce principles of 3D reflection seismic data acquisition, processing and interpretation based on lectures and hand-on interpretation exercises.
Course Content
The course builds on the theoretical seismic lectures. It focuses on the particularities of 3D seismic data compared to 2D seismic data. Subjects covered are: • 3D seismic acquisition and equipment • 3D seismic navigation • 3D seismic survey planning • 3D seismic processing • 3D seismic interpretation There is a strong practical component on 3D seismic interpretation. Students will be required to analyze a real data set across an oil field and determine the structure and size of the reservoir
Learning Outcome
Familiarity with the complexities of 3D seismic data acquisition and understanding of additional processing challenges. The course provides hand-on experience with 3D data interpretation
Reading List
• Yilmaz, Seismic data analysis, SEG
Additional Information
None

MNF-geop-AGP10 Acoustic imaging of sedimentary features in the oceans

Module Name	Module Code
Acoustic imaging of sedimentary features in the oceans	MNF-geop-AGP10
Organizer	**Organisation**
Sebastian Krastel	Institute of Geosciences
Faculty	**Examination Office**
Faculty of Mathematics and Natural Sciences	PA of the Department of Geography and Geoscience

ECTS Credits
5
Duration
1 term
Frequency
Every third term
Evaluation
Graded
Total Workload
150 hours
Workload per ECTS Credit
30 hours
Contact Time
48 hours
Independent Study
102 hours

Teaching Language	German or English
Further Information on the Teaching Language	German, English on request
Entry Requirements as Stated in the Examination Regulations	None
Recommended Requirements	Basic knowledge of marine geophysics

Module Courses		
Course Type	**Course Name**	**Compulsory/Optional**
Lecture	Acoustic imaging of sedimentary features in the oceans	WPFL
Exercise	Acoustic imaging of sedimentary features in the oceans	WPFL
Further Information on the Courses	None	

Prerequisites for Admission to the Examination(s)	None
Further Requirements for Awarding ECTS Credits	None

Examination(s)		
Type of Examination	**Evaluation**	**Weighting**
Oral or written exam	graded	100 %
Further Information on the Examination(s)	None	

Short Summary
The lecture will discuss acoustic methods for imaging the ocean floor and the internal structure of marine sediments. A focus will be on the joint interpretation of marine acoustic data sets.
Course Content
This lecture introduces acoustic methods for surveying the ocean floor and sub sea floor structures. The principal of acoustic systems (digital sediment echo sounders, sidescan sonar, multibeam sonars, seismics) are introduced at the beginning of the lecture. Practical examples are used in order to demonstrate typical applications and survey designs. Several sedimentary features in the oceans including channel-levee systems, mass wasting deposits, contourites, and shelf systems will be analyzed in order to discuss the advantages of integrated acoustic data sets. The focus of this lecture is the practical work with integrated acoustic data sets.
Learning Outcome
• Knowledge of acoustic methods for imaging marine sedimentary features • Development of concepts for acoustic surveys in the ocean • Introduction into programs for processing and interpretation of marine acoustic data sets • Interpretation of integrated acoustic data sets
Reading List
• Jones, Marine Geophysics, Exploration Seismology, Cambridge University Press • Wille, Sound images of the ocean.
Additional Information
None

MNF-geop-AGP12 Rock Physics

Module Name	Module Code
Rock Physics	MNF-geop-AGP12
Organizer	**Organisation**
Thomas Meier	Institute of Geosciences
Faculty	**Examination Office**
Faculty of Mathematics and Natural Sciences	PA of the Department of Geography and Geoscience

ECTS Credits
5
Duration
1 term
Frequency
Annual
Evaluation
Graded
Total Workload
150 hours
Workload per ECTS Credit
30 hours
Contact Time
48 hours
Independent Study
102 hours

Teaching Language	German or English
Further Information on the Teaching Language	German, English on request
Entry Requirements as Stated in the Examination Regulations	None
Recommended Requirements	Basic knowledge of geophysics, physics, and geology. The exercise requires basic knowledge of MATLAB or similar programming and plotting tools.

Module Courses		
Course Type	**Course Name**	**Compulsory/Optional**
Lecture	Rock Physics	WPFL
Exercise	Rock Physics	WPFL
Excursion	Rock Physics	WPFL
Further Information on the Courses	None	

Prerequisites for Admission to the Examination(s)	None
Further Requirements for Awarding ECTS Credits	Protocol on the exercise and participation in the excursion

Examination(s)		
Type of Examination	**Evaluation**	**Weighting**
Oral or written exam	graded	100 %
Further Information on the Examination(s)	None	

Short Summary
Physical properties of rocks will be discussed and an understanding of fundamental principles of rock physics will be developed.
Course Content
Lectures: Main topics are rock physical parameters, physics of sediments, well logging, and physical measurements at core samples. Fundamental principles of rock physics are discussed and insight in the variability of physical properties of rocks under crustal conditions is provided. Exercises: Physical properties of rocks are studied for a set of representative rock samples. Grain sizes, susceptibility, electrical conductivity, thermal conductivity, velocities of seismic body and surface waves are measured. Results of the measurements are summarized in protocols. Excursion: One-day visit of ongoing well loggings or of a core archive.
Learning Outcome
• Understanding of fundamentals of rock physics • Practice in laboratory measuring techniques of physical properties of rocks
Reading List
• Elles, D.V., Singer, J.M., *Well logging for Earth Scientists*, Springer, 2007. • Schön, J., *Petrophysik* - Physikalische Eigenschaften von Gesteinen und Mineralen, Enke, Stuttgart 1983.
Additional Information
None

MNF-geop-AGP13 Archaeogeophysics

Module Name	Module Code
Archaeogeophysics	MNF-geop-AGP13
Organizer	**Organisation**
Dennis Wilken	Institute of Geosciences
Faculty	**Examination Office**
Faculty of Mathematics and Natural Sciences	PA of the Department of Geography and Geoscience

ECTS Credits
5
Duration
1 term
Frequency
Annual
Evaluation
Graded
Total Workload
150 hours
Workload per ECTS Credit
30 hours
Contact Time
48 hours
Independent Study
102 hours

Teaching Language	German or English
Further Information on the Teaching Language	German, English on request
Entry Requirements as Stated in the Examination Regulations	None
Recommended Requirements	The course requires previous knowledge of near-surface geophysical methods at the level of introductory courses of the Bachelor program. The exercises require the ability to perform computations and graphics in MATLAB or a similar tool.

Module Courses		
Course Type	**Course Name**	**Compulsory/Optional**
Lecture	Archaeogeophysics	WPFL
Exercise	Archaeogeophysics	WPFL
Further Information on the Courses	None	

Prerequisites for Admission to the Examination(s)	≥50% of exercises solved
Further Requirements for Awarding ECTS Credits	None

Examination(s)		
Type of Examination	**Evaluation**	**Weighting**
Oral or written exam	graded	100 %
Further Information on the Examination(s)	None	

Short Summary

The course provides an introduction to geophysical methods applied to solve problems of archaeological prospecting.

Course Content

The course provides an introduction to geophysical methods applied to solve problems of archaeological prospecting. It comprises lectures and exercises where the participants apply typical processing schemes for archaeo-geophysical data. This includes third party software as well as own scripts written with MATLAB (or a similar tool).

The methods applied are magnetics, Ground Penetrating Radar (GPR), Electromagnetic Induction (EMI), geoelectrics, seismics and microgravimetry.

A focus is on the special problems and requirements for the methods applied on archaeological prospection tasks.

Learning Outcome

The students gain experience in

- analyzing tasks of archaeological prospecting,
- developing a solution based on their previous methodological knowledge,
- planning and reporting on archaeological prospection surveys
- interpreting geophysical results with respect to archaeological tasks.

Reading List

- English Heritage: Geophysical survey in archaeological field evaluation. 2008
- Witten, A.J. Handbook of geophysics and archaeology. Equinox Pub., 2006.

Additional Information

None

MNF-geop-GGP04 Introduction to Seismology

Module Name	Module Code
Introduction to Seismology	MNF-geop-GGP04
Organizer	**Organisation**
Thomas Meier	Institute of Geosciences
Faculty	**Examination Office**
Faculty of Mathematics and Natural Sciences	PA of the Department of Geography and Geoscience

ECTS Credits
5
Duration
1 term
Frequency
Annual
Evaluation
Graded
Total Workload
150 hours
Workload per ECTS Credit
30 hours
Contact Time
48 hours
Independent Study
102 hours

Teaching Language	German or English
Further Information on the Teaching Language	German, English on request
Entry Requirements as Stated in the Examination Regulations	None
Recommended Requirements	The course requires basic knowledge of geophysics and geology.

Module Courses		
Course Type	**Course Name**	**Compulsory/Optional**
Lecture	Introduction to Seismology	WPFL
Exercise	Introduction to Seismology	WPFL
Further Information on the Courses	None	

Prerequisites for Admission to the Examination(s)	None
Further Requirements for Awarding ECTS Credits	None

Examination(s)		
Type of Examination	**Evaluation**	**Weighting**
Oral or written exam	graded	100 %
Further Information on the Examination(s)	None	

Short Summary
The course provides an introduction to Seismology. It focusses on fundamental seismological observations and seismotectonics.
Course Content
Lecture: • Aims of seismological research • Seismic waves and phases • Intensity, magnitude, seismic moment • Significant earthquakes (worldwide, in Europe, in Germany, in northern Germany) • Properties of the magnitude-frequency distribution • Seismic hazard and early warning • spatial distribution of earthquakes and the concept of plate tectonics • spatio-temporal clustering of earthquakes • Source mechanisms and stress field • Non-earthquake seismic signals Exercise: • ongoing seismic activity is followed and discussed • reading of seismograms • location of seismic events • determination of source mechanisms
Learning Outcome
• Overview on aims and methods of seismological research • Overview on seismotectonics • Practicing of seismogram reading, location of seismic events, and determination of source mechanisms
Reading List
• P. Bormann (ed.), 2002. *IASPEI - New Manual of Seismological Observatory Practice*, GFZ Potsdam. • P. Shearer, 1999. *Introduction to seismology,* Cambridge University Press. • S. Stein, M. Wysession, 2003. *An introduction to seismology, earthquakes and Earth structure*, Blackwell.
Additional Information
None

MNF-geop-GGP01b Regional Geophysics

Module Name	Module Code
Regional Geophysics	MNF-geop-GGP01b
Organizer	**Organisation**
Thomas Meier	Institute of Geosciences
Faculty	**Examination Office**
Faculty of Mathematics and Natural Sciences	PA of the Department of Geography and Geoscience

ECTS Credits
5
Duration
1 term
Frequency
Annual
Evaluation
Graded
Total Workload
150 hours
Workload per ECTS Credit
30 hours
Contact Time
48 hours
Independent Study
102 hours

Teaching Language	German or English
Further Information on the Teaching Language	German, English on request
Entry Requirements as Stated in the Examination Regulations	None
Recommended Requirements	Previous knowledge of geology and geophysics as well as basic physical and geophysical theory (e.g. seismic wave propagation).

Module Courses		
Course Type	**Course Name**	**Compulsory/Optional**
Lecture with exercises	Regional Geophysics	WPFL
Further Information on the Courses	None	

Prerequisites for Admission to the Examination(s)	Seminar presentation
Further Requirements for Awarding ECTS Credits	None

Examination(s)		
Type of Examination	**Evaluation**	**Weighting**
Oral or written exam	graded	100 %

Further Information on the Examination(s)	None

Short Summary

The lecture will discuss regional lithospheric and asthenospheric structures in different tectonic regimes and how geophysics is an important tool in their determination.

Course Content

The course gives an overview of regional (sub-) continental scale geophysical methods to image the crust and upper mantle. On several regional examples in various tectonic environments, geophysical investigations are presented and discussed in the context of plate tectonics and surface geology.

The topical regions are chosen to present “on the edge” scientific knowledge based on research experience of the involved teaching staff.

The course includes also a brief presentation of the most relevant geophysical methods, e.g. seismic tomography, receiver function imaging, magnetotellurics.

The course consists of lectures and seminar talks held by the students.

Learning Outcome

- The students gain overview over the potentials and pitfalls of using regional geophysical investigations to understand regional geodynamics and tectonics. They also familiarize themselves with general structure of the uppermost solid Earth (crust, upper mantle) and learn to infer geological discrimination from geophysical data.

Reading List

- Manuscript

Additional Information

None

MNF-geop-GGP05 Remote sensing

Module Name	Module Code
Remote sensing	MNF-geop-GGP05
Organizer	**Organisation**
Jörg Ebbing	Institute of Geosciences
Faculty	**Examination Office**
Faculty of Mathematics and Natural Sciences	PA of the Department of Geography and Geoscience

ECTS Credits
5
Duration
1 term
Frequency
Every third term
Evaluation
Graded
Total Workload
150 hours
Workload per ECTS Credit
30 hours
Contact Time
48 hours
Independent Study
102 hours

Teaching Language	German or English
Further Information on the Teaching Language	German, English on request
Entry Requirements as Stated in the Examination Regulations	None
Recommended Requirements	Principle knowledge of signal processing and geophysical methods.

Module Courses		
Course Type	**Course Name**	**Compulsory/Optional**
Lecture with exercises	Remote sensing	WPFL
Further Information on the Courses	None	

Prerequisites for Admission to the Examination(s)	None
Further Requirements for Awarding ECTS Credits	None

Examination(s)		
Type of Examination	**Evaluation**	**Weighting**
Oral or written exam	graded	100 %
Further Information on the Examination(s)	None	

Short Summary
The course will introduce remote sensing techniques and their application in geophysical research.
Course Content
Principles of laser profiling and image processing of different signal types (e.g. GPS, spaceborne SAR). The course covers a broad range of remote sensing techniques and applications across the Earth, environmental and planetary sciences. The focus is on physical principles of measurement techniques and signal characteristics, giving students a deeper understanding of remote sensing systems and their possibilities in Earth observation.
Learning Outcome
• Knowledge of the principles of remote sensing and its applications in Earth, environmental and planetary sciences. Understanding of sensor and signal physics relevant to remote measuring techniques. • Practice through a step-by-step approach, in quantitative and qualitative interpretation of signals and processed remote-sensing products.
Reading List
• Rees, Physical Principles of Remote Sensing
Additional Information
None

MNF-geop-NGP01 Geoinformatics

Module Name	Module Code
Geoinformatics	MNF-geop-NGP01
Organizer	**Organisation**
Sabine Schmidt	Institute of Geosciences
Faculty	**Examination Office**
Faculty of Mathematics and Natural Sciences	PA of the Department of Geography and Geoscience

ECTS Credits
5
Duration
1 Term
Frequency
Every two years
Evaluation
graded
Total Workload
150 hours
Workload per ECTS Credit
30 hours
Contact Time
48 hours
Independent Study
102 hours

Teaching Language	German or English
Further Information on the Teaching Language	German, English on request
Entry Requirements as Stated in the Examination Regulations	None
Recommended Requirements	Basic knowledge on computing and programming skills (e.g. MATLAB or Python)

Module Courses		
Course Type	**Course Name**	**Compulsory/Optional**
Lecture	Geoinformatics	WPFL
Exercise	Geoinformatics	WPFL
Further Information on the Courses	None	

Prerequisites for Admission to the Examination(s)	None
Further Requirements for Awarding ECTS Credits	None

Examination(s)		
Type of Examination	**Evaluation**	**Weighting**
Oral or written exam	graded	100 %

Further Information on the Examination(s)	None

Short Summary
The module will discuss and train typical space-oriented tasks in geoscientific software environments and their impact in user defined data and data models.
Course Content
An introductory overview of typical geophysical implementations and typical problems of space-oriented tasks. The analysis, modeling, storage, visualization, administration of spatial data (= geodata) is discussed. In particular, we will cover the implementation of • Triangle and triangulation properties • Interpolation • Orientation of geometry objects (triangles, polygons etc.) Discussion of classical solutions (point in polygon, consistency checks etc.) and helpers (barycentric coordinates).
Learning Outcome
The module extends the understanding of the technical functioning and structure of geophysical software, and thus helps to get oriented in geophysical software environments. The recognition and overcome of typical user problems is trained.
Reading List
None
Additional Information
None

MNF-geop-NGP04 Theory of Elastic Waves II

Module Name	Module Code
Theory of Elastic Waves II	MNF-geop-NGP04
Organizer	**Organisation**
Martin Thorwart	Institute of Geosciences
Faculty	**Examination Office**
Faculty of Mathematics and Natural Sciences	PA of the Department of Geography and Geoscience

ECTS Credits
5
Duration
1 term
Frequency
Annual
Evaluation
graded
Total Workload
150 hours
Workload per ECTS Credit
30 hours
Contact Time
48 hours
Independent Study
102 hours

Teaching Language	German or English
Further Information on the Teaching Language	German, English on request
Entry Requirements as Stated in the Examination Regulations	None
Recommended Requirements	Knowledge of math and physics, lecture “Theory of Elastic Waves I”

Module Courses		
Course Type	**Course Name**	**Compulsory/Optional**
Lecture with exercises	Theory of Elastic Waves II	WPFL
Further Information on the Courses	None	

Prerequisites for Admission to the Examination(s)	Successful participation in the exercises
Further Requirements for Awarding ECTS Credits	None

Examination(s)		
Type of Examination	**Evaluation**	**Weighting**
Oral or written exam	Graded	100 %
Further Information on the Examination(s)	None	

Short Summary

The lecture “Theory of elastic waves II” is a follow-up lecture of “Theory of elastic waves I”. It consists of 3 major blocks: “seismic anisotropy & absorption”, “surface waves” and “numerical modeling”.

Course Content

The lecture consist of:

1. Anisotropic elastic media: rock physics, strain-stress-relation, types of seismic anisotropy, wave equation and its solution, shear wave splitting, phase- and group velocities, polarization, applications
2. Absorption: viscoelasticity, rock models, body wave dispersion, applications
3. Huygens principle, Born approximation for inhomogeneity, sensitivity kernels, adjoint method
4. Surface waves: Rayleigh wave in homogenous half-space, Love-wave for layer over half-space: mathematical derivations (eigenvalue problem, dispersion, amplitude vs. depth) & physical explanation (constructive superposition of reflected SH-waves), source effects (radiation pattern, generation), change of dispersion and amplitude pattern due to the velocity model, applications
5. Numerical simulation of wave propagation: Gemini, finite difference, finite elements, spectral elements (Lecture and exercises)
6. Harmonics of the earth

Learning Outcome

- Understanding of anisotropy and viscoelasticity: causes and its effects
- Understanding “Sensitivity kernels” as a background of tomography
- Surface waves: mathematical approach, physical explanation, characteristics, velocity model effects
- How to simulate seismic wave propagation
- Identifying physical effects and relating them to applications

Reading List

- Müller: “Theory of Elastic Waves“
- Ben-Menahem & Singh: “Seismic Waves and sources”
- Aki & Richards: “Quantitative Seismology“
- Dahlen & Tromp: “Theoretical Global Seismology”
- Kennett: “The Seismic Wavefield”

Additional Information

None

geopMaNGP09_1 Numerical Fluid Dynamics I

Titel	Modulcode
Numerical Fluid Dynamics I Flow in porous media with Matlab/Python and OpenFOAM	geopMaNGP09_1-01a
Modulverantwortliche/r	
Prof. Lars Rüpke	
Veranstalter	
Helmholtz-Zentrum für Ozeanforschung (GEOMAR)	
Fakultät	
Mathematisch-Naturwissenschaftliche Fakultät	
Prüfungsamt	
Prüfungsamt Geographie und Geowissenschaften	

Status[1] *(P / WP / W)*	WP
Leistungspunkte	5
Bewertung *(benotet/unbenotet)*	graded
Dauer	1 Semester
Angebotshäufigkeit	every 3rd term, start in WS 2020/2021
Arbeitsaufwand pro Leistungspunkt	30 h
Arbeitsaufwand insgesamt	150 h
Präsenzstudium	48 h
Selbststudium	102 h

Lehrsprache	German or English
Zugangsvoraussetzung laut Prüfungsordnung	none
Empfohlene Zugangsvoraussetzung*	Basic knowledge of working with computers and basic mathematical skills

Modulveranstaltung(en)			
Lehrveranstaltungsform	**Lehrveranstaltungstitel**	**Pflicht/Wahlpflicht/Wahl**	**SWS**
Excercises	Numerical Fluid Dynamics I	WPFL	4

Weitere Bemerkungen zu der/den Modulveranstaltung(en)*	The course consists of 12 -14 blocks. Each block consists of a short seminar plus supervised exercise (4 h).
Voraussetzungen für die Zulassung zu der/den Prüfung(en) (Vorleistungen)*	None

Prüfung(en)				
Prüfungstitel	**Prüfungsform**	**Bewertung**	**Pflicht/Wahlpflicht/Wahl**	**Gewicht**[2]
Numerical Fluid Dynamics I	Oral examen	graded	WPFL	

Weitere Bemerkungen zu der/den Prüfung(en)*	

1 Status des gesamten Moduls
2 Gewicht der Prüfung innerhalb des Moduls

Kurzzusammenfassung*
The course introduces methods and tools in geophysical fluid dynamics. The goal is to learn about the complete workflow from formulating a geoscientific hypothesis to testing it using numerical techniques. We will achieve this aim by first solving simplified examples problems with MATLAB (and/or Python) before progressing towards using the popular Computational Fluid Dynamics (CFD) package OpenFOAM. In terms of numerical methods, we will learn about finite-differences and finite-volumes including their respective strengths and limitations. Topic-wise, we will focus on porous flow processes with a special emphasis on hydrothermal flow problems like submarine black smoker systems and hydrothermal cooling of magmatic intrusions.
Lehrinhalte
- Introduction to computational fluids dynamics / Navier-Stokes, Stokes, Darcy - Numerical methods / finite differences and finite volumes (MATLAB/Python) - Computational Fluid Dynamics with OpenFOAM - Visualization with Paraview - Hydrothermal systems - Project work on transport in porous media
Lernziele
Ability to perform independent modeling work on geoscientific problems. Knowledge of numerical techniques and of how to solve partial differential equations using numerical methods (MATLAB/Python). In-depth knowledge of OpenFOAM (problem setup, meshing, solvers, 2D -> 3D, visualization). Preparation to a possible MSc project in geophysical fluid dynamics.
Literatur
www.openfoam.org und www.openfoam.com Hasenclever et al., (2014): Hybrid shallow on-axis and deep off-axis hydrothermal circulation at fast-spreading ridges, Nature
Weitere Angaben*

Verwendbarkeit des Moduls		
Verwendung	**Pflicht/Wahl**	**Fachsemester**

geopMaNGP09_2 Numerical Fluid Dynamics II

Titel	Modulcode
Numerical Fluid Dynamics II Finite elements / markers-in-Cell / mantle dynamics	geopMaNGP09_2-01a
Modulverantwortliche/r	
Prof. Lars Rüpke	
Veranstalter	
Helmholtz-Zentrum für Ozeanforschung (GEOMAR)	
Fakultät	
Mathematisch-Naturwissenschaftliche Fakultät	
Prüfungsamt	
Prüfungsamt Geographie und Geowissenschaften	

Status[3] *(P / WP / W)*	WP
Leistungspunkte	5
Bewertung *(benotet/unbenotet)*	graded
Dauer	1 Semester
Angebotshäufigkeit	every 3rd term, start in SS 2021
Arbeitsaufwand pro Leistungspunkt	30 h
Arbeitsaufwand insgesamt	150 h
Präsenzstudium	48 h
Selbststudium	102 h

Lehrsprache	German or English
Zugangsvoraussetzung laut Prüfungsordnung	keine
Empfohlene Zugangsvoraussetzung*	No need to first attend the Numerical Fluid Dynamics I course before joining this one.

Modulveranstaltung(en)			
Lehrveranstaltungsform	**Lehrveranstaltungstitel**	**Pflicht/Wahlpflicht/Wahl**	**SWS**
Excercise	Numerical Fluid Dynamics II	WPFL	4

Weitere Bemerkungen zu der/den Modulveranstaltung(en)*	
Voraussetzungen für die Zulassung zu der/den Prüfung(en) (Vorleistungen)*	This is a stand-alone course – no need to first attend the Numerical Fluid Dynamics I course.

Prüfung(en)				
Prüfungstitel	**Prüfungsform**	**Bewertung**	**Pflicht/Wahlpflicht/Wahl**	**Gewicht**[4]
Numerical Fluid Dynamics II	Oral examen	graded	WPFL	

Weitere Bemerkungen zu der/den Prüfung(en)*	

[3] Status des gesamten Moduls
[4] Gewicht der Prüfung innerhalb des Moduls

Kurzzusammenfassung*
The focus of this course is on learning finitel elements on how to use for solving problems in mantle dynamics. Finite elements are one of the main numerical methods in mechanics and are also used in the popular geodynamics community code ASPECT. Here we will first learn about the basics before progressing towards writing our own mantle convection code and using it to address various geodynamic problems ranging from subduction to seafloor spreading. The course will also cover the marker-in-cell method, which becomes increasingly popular in the geodynamics community. All examples will be implemented in MATLAB and/or Python using the FENICS framework.
Lehrinhalte
- Introduction to the finite element method (FEM) - Matlab/Python implementation of the FEM in 1D und 2D - Stokes-Flow - Project work on geodynamical topics - Introduction to marker-in-cell method
Lernziele
Ability to solve geodynamics problems using numerical models. Knowledge of numerical techniques and of how to solve partial differential equations using numerical methods (MATLAB/Python). Modeling. Preparation to a possible MSc project in geophysical fluid dynamics.
Literatur
Practical Finite Element Modeling in Earth Sciences, Guy Simpson, Wiley Blackwell Introduction to Numerical Geodynamic Modelling, Taras Gerya, Cambridge University Press aspect.geodynamics.org fenicsproject.org
Weitere Angaben*
Verwendbarkeit des Moduls

Verwendung	**Pflicht/Wahl**	**Fachsemester**

geopMaGGP07-01a Tectonophysics

Titel	Modulcode
Tectonophysics	geopMaGGP07-01a
Modulverantwortliche/r	
Prof. Jörg Ebbing	
Veranstalter	
Inst. f. Geowissenschaften	
Fakultät	
Mathematisch-Naturwissenschaftliche Fakultät	
Prüfungsamt	
Prüfungsamt Geographie und Geowissenschaften	

Status[5] *(P / WP / W)*	WP
Leistungspunkte	5
Bewertung *(benotet/unbenotet)*	Not graded
Dauer	1 Term
Angebotshäufigkeit	Every 3rd term
Arbeitsaufwand pro Leistungspunkt	30 h
Arbeitsaufwand insgesamt	150 h
Präsenzstudium	48 h
Selbststudium	102 h

Lehrsprache	German or English
Zugangsvoraussetzung laut Prüfungsordnung	None
Empfohlene Zugangsvoraussetzung*	None

Modulveranstaltung(en)			
Lehrveranstaltungsform	**Lehrveranstaltungstitel**	**Pflicht/Wahlpflicht/Wahl**	**SWS**
Lecture	Tektonophysics	WPFL	2
Exercise	Tektonophysics	WPFL	2
Weitere Bemerkungen zu der/den Modulveranstaltung(en)*			
Voraussetzungen für die Zulassung zu der/den Prüfung(en) (Vorleistungen)*			

Prüfung(en)				
Prüfungstitel	**Prüfungsform**	**Bewertung**	**Pflicht/Wahlpflicht/Wahl**	**Gewicht**[6]
Tektonophysics	Report	Not graded	WPFL	
Weitere Bemerkungen zu der/den Prüfung(en)*				

Kurzzusammenfassung*

5 Status des gesamten Moduls
6 Gewicht der Prüfung innerhalb des Moduls

This module addresses the physical processes in the lithosphere and their relation to geophysical observables. Petrophysical and geophysical observables will be modelled in a forward and inverse manner in an integrated framework. In the course, we address both the physical relation between the parameters and the methods to define consistent models. Hereby, we consider the sensitivity and resolution of the individual data sets reaching from satellite data to seismological and petrological models.

Lehrinhalte

- Introduction thermodynamic Heat Equation, Relation density-seism. velocities, Isostasy
- Basics of model calculation under consideration of pressure, temperature and composition
- Introduction to LitMod3D, sensitivity studies and case examples
- Project work on petrological-geophysical modelling of the lithosphere

Lernziele

Fundamental knowledge of interdisciplinary modelling of geophysical data in a forward and inverse manner. Ability to adopt integrated modelling scheme in 2D und 3D. Acquisition of skills in reporting on project results.

Literatur

Fullea, J., Afonso, J.C., Connolly, J.A.D., Fernandez, M., Garcia-Castellanos, D., Zeyen, H. (2009). LitMod3D: an interactive 3D software to model the thermal, compositional, density, rheological, and seismological structure of the lithosphere and sublithospheric upper mantle. Geochem. Geophys. Geosyst, 10, Q08019, doi:10.1029/2009GC002391. PDF

Weitere Angaben*

Verwendbarkeit des Moduls

Verwendung	**Pflicht/Wahl**	**Fachsemester**

Section 3: Practical modules

MNF-geop-AGP14 On- and offshore geophysical field measurements & Active Tutorial

Module Name	Module Code
On- and offshore geophysical field measurements & Active Tutorial	MNF-geop-AGP14
Organizer	**Organisation**
Wolfgang Rabbel	Institute of Geosciences
Faculty	**Examination Office**
Faculty of Mathematics and Natural Sciences	PA of the Department of Geography and Geoscience

ECTS Credits
5
Duration
1 term
Frequency
Every term
Evaluation
Not graded
Total Workload
150 hours
Workload per ECTS Credit
30 hours
Contact Time
50 hours
Independent Study
100 hours

Teaching Language	German or English
Further Information on the Teaching Language	German, English on request
Entry Requirements as Stated in the Examination Regulations	None
Recommended Requirements	The course requires previous knowledge in the respective geophysical methods

Module Courses		
Course Type	**Course Name**	**Compulsory/Optional**
Practical Exercises	On- and offshore geophysical field measurements	PFL
Practical Exercise	Active Tutorial Geophysics	PFL
Further Information on the Courses	None	

Prerequisites for Admission to the Examination(s)	None
Further Requirements for Awarding ECTS Credits	None

Examination(s)		
Type of Examination	**Evaluation**	**Weighting**
Report (On- and offshore geophysical field measurements)	Not graded	n.a.
Report (Active Turorial)	Not graded	n.a.
Further Information on the Examination(s)	None	

Short Summary
The module consists of two practical courses focusing on conducting geophysical field measurements and teaching geophysical methods to undergraduate students.
Course Content
In the first part of the module students participate for a minimum of 10 days in geophysical field measurements performed mainly in the framework of ongoing research projects. The students participate in preparing and performing geophysical field measurements. In the second part of the module the students act as “active tutors” supporting undergraduate students in understanding geophysical lectures and performing practical exercises. The graduate students learn and practice to transfer their knowledge and skills to undergraduate students in order to improve their communication and organization skills and to reactivate previous knowledge. The students perform tutorials accompanying lectures, exercises and practical courses of the undergraduate Geophysics program. They get advice and instruction from the corresponding teachers.
Learning Outcome
The students • learn to plan, prepare and perform geophysical field measurements • learn to apply geophysical methods in a scientifically or economically relevant context • get familiar with technical and social problems during field campaigns • reactivate and apply previous knowledgereactivate previous knowledge • learn to prepare and organize teaching events • gain experience in presenting and explaining scientific methods • learn to react to expected and unforeseen questions
Reading List
• will be provided by the lecturers depending on the topics of investigation
Additional Information
None

MNF-geop-NGP02a.1 Digital data processing in geophysics: Structural seismology

Module Name	Module Code
Digital data processing in geophysics: Structural seismology	MNF-geop-NGP02a.1
Organizer	**Organisation**
Thomas Meier	Institute of Geosciences
Faculty	**Examination Office**
Faculty of Mathematics and Natural Sciences	PA of the Department of Geography and Geoscience

ECTS Credits
5
Duration
1 term
Frequency
Every third term
Evaluation
Not graded
Total Workload
150 hours
Workload per ECTS Credit
30 hours
Contact Time
48 hours
Independent Study
102 hours

Teaching Language	German or English
Further Information on the Teaching Language	German, English on request
Entry Requirements as Stated in the Examination Regulations	None
Recommended Requirements	The course requires previous knowledge in programming, seismological methods and signal processing

Module Courses		
Course Type	**Course Name**	**Compulsory/Optional**
Exercises (Project work)	Digital data processing in geophysics: Structural seismology	WPFL
Further Information on the Courses	None	

Prerequisites for Admission to the Examination(s)	None
Further Requirements for Awarding ECTS Credits	None

Examination(s)		
Type of Examination	**Evaluation**	**Weighting**
Report	Not graded	100 %
Further Information on the Examination(s)	None	

Short Summary
The course focuses on translation of theoretical formulations of seismological data interpretation to real data application of seismological methods. Introductions are given to required programming tools, seismological data and signal analysis.
Course Content
Digital signal processing is a fundamental step in interpreting geophysical data. In seismology, numerous methods exist that are well formulated in theory but translating them into a usable computer program is a rarely documented step. In this course, we will focus on translating theoretical formulations of seismological data processing to actual computer programs and apply them on selected case studies with real data.
Learning Outcome
The students acquire knowledge in translating methodical theory into application by developing and applying data processing routines.
Reading List
• Manuscript
Additional Information
None

MNF-geop-NGP02b.1 Digital data processing in geophysics: Seismic reflection processing

Module Name	Module Code
Seismic reflection processing	MNF-geop-NGP2b.1
Organizer	**Organisation**
Sebastian Krastel	Institute of Geosciences
Faculty	**Examination Office**
Faculty of Mathematics and Natural Sciences	PA of the Department of Geography and Geoscience

ECTS Credits
5
Duration
1 term
Frequency
Every third term
Evaluation
Not graded
Total Workload
150 hours
Workload per ECTS Credit
30 hours
Contact Time
48 hours
Independent Study
102 hours

Teaching Language	German or English
Further Information on the Teaching Language	German, English on request
Entry Requirements as Stated in the Examination Regulations	None
Recommended Requirements	Principles of seismic reflection processing

Module Courses		
Course Type	**Course Name**	**Compulsory/Optional**
Exercises (Project work)	Seismic reflection processing	WPFL
Further Information on the Courses	None	

Prerequisites for Admission to the Examination(s)	None
Further Requirements for Awarding ECTS Credits	None

Examination(s)		
Type of Examination	**Evaluation**	**Weighting**
Report	Not graded	100 %
Further Information on the Examination(s)	None	

Short Summary
A seismic data set will be processed starting with the raw data to final migrated stacks.
Course Content
All major steps during reflection seismic data processing will be done by for a selected data example. These steps include quality control of the data, setup of the geometry, binning, filtering, deconvolution, velocity analysis, nmo-correction, stacking and migration. Different software packages for reflection seismic processing will be introduced (e.g. Seismic Unix, Vista Seismic processing).
Learning Outcome
• Introduction to seismic reflection processing packages • Practical application of most important processing steps during reflection seismic data processing
Reading List
• Yilmaz. Seismic Data processing, Investigations in geophysics, SEG
Additional Information
None

MNF-geop-NGP02c.1 Digital data processing in geophysics: Seismic interpretation

Module Name	Module Code
Seismic Interpretation	MNF-geop-NGP2c.1
Organizer	**Organisation**
Sebastian Krastel	Institute of Geosciences
Faculty	**Examination Office**
Faculty of Mathematics and Natural Sciences	PA of the Department of Geography and Geoscience

ECTS Credits
5
Duration
1 term
Frequency
Every third term
Evaluation
Not graded
Total Workload
150 hours
Workload per ECTS Credit
30 hours
Contact Time
48 hours
Independent Study
102 hours

Teaching Language	German or English
Further Information on the Teaching Language	German, English on request
Entry Requirements as Stated in the Examination Regulations	None
Recommended Requirements	Basic knowledge of seismic data acquisition

Module Courses		
Course Type	**Course Name**	**Compulsory/Optional**
Exercises (Project work)	Seismic interpretation	WPFL
Further Information on the Courses	None	

Prerequisites for Admission to the Examination(s)	None
Further Requirements for Awarding ECTS Credits	None

Examination(s)		
Type of Examination	**Evaluation**	**Weighting**
Report	Not graded	100 %
Further Information on the Examination(s)	None	

Short Summary
This lecture will introduce the principles of seismic interpretation using state of the art software and examples from various geological settings.
Course Content
This lecture starts with introducing the basic concepts and principles of seismic interpretation and stratigraphy. This will be done using examples from different tectonic and geological settings. Afterwards, we will interpret one data set in detail using IHS Kingdom Suite (full seismic interpretation software). We load the data, define seismic units, analyze seismic facies, investigate sea level fluctuations and integrate well data (lithology and logging).
Learning Outcome
Concepts of seismic interpretation and seismic stratigraphy Practical work with a seismic data sets Combined interpretation of seismic and drilling data
Reading List
• Bally: Atlas of seismic stratigraphy. • Bacon, M., Simm,R., Redshaw, T., 2007, “3-D seismic interpretation”, Cambridge University Press • Virtual seismic Atlas, http://www.seismicatlas.org/
Additional Information
None

MNF-geop-NGP02d.1 Digital data processing in geophysics: Wide-angle Seismics and Inversion

Module Name	Module Code
Wide-angle Seismics and Inversion	MNF-geop-NGP02d.1
Organizer	**Organisation**
Martin Thorwart	Institute of Geosciences
Faculty	**Examination Office**
Faculty of Mathematics and Natural Sciences	PA of the Department of Geography and Geoscience

ECTS Credits
5
Duration
1 term
Frequency
Every third term
Evaluation
Not graded
Total Workload
150 hours
Workload per ECTS Credit
30 hours
Contact Time
48 hours
Independent Study
102 hours

Teaching Language	German or English
Further Information on the Teaching Language	German, English on request
Entry Requirements as Stated in the Examination Regulations	None
Recommended Requirements	Basic knowledge of working with computers, knowledge of refraction seismic

Module Courses		
Course Type	**Course Name**	**Compulsory/Optional**
Exercises (Project work)	Refraction Seismic and Inversion	WPFL
Further Information on the Courses	The course consists of 12 -14 blocks. Each block consists of a supervised exercise (4 h).	

Prerequisites for Admission to the Examination(s)	None
Further Requirements for Awarding ECTS Credits	None

Examination(s)		
Type of Examination	**Evaluation**	**Weighting**
Report	Not graded	100 %
Further Information on the Examination(s)	None	

Short Summary
A seismic wide-angle dataset is analyzed and processed in order to determine a subsurface model in terms of seismic velocities.
Course Content
The course introduces to the processing and interpretation of active seismic wide-angle measurements. The aim is to determine the subsurface structure in terms of seismic velocities. Both on- and offshore example datasets are used. The analysis sequence consists of identifying arrivals, picking the onsets of refracted and reflected travel time branches, performing different types of travel time inversion (Wiechert-Herglotz, wavefront method, inversion ray-tracing, refraction tomography). As a help for identifying arrivals and validating results we apply forward modeling of travel-times (ray-tracing) and wave forms (reflectivity method, FD solution of equation of motion). The results of the seismic inversion is interpreted in petrophysical terms and compared to non-seismic information.
Learning Outcome
• How to analyze seismic data sets. • How to develop and realize a strategy of data interpretation and to validate results • How to integrate specific results in a more general context
Reading List
• Will be provided during the course
Additional Information
None

MNF-geop-NGP02e.1 Digital data processing in geophysics: Local Seismicity

Module Name	Module Code
Local Seismicity	MNF-geop-NGP02e.1
Organizer	**Organisation**
Martin Thorwart	Institute of Geosciences
Faculty	**Examination Office**
Faculty of Mathematics and Natural Sciences	PA of the Department of Geography and Geoscience

ECTS Credits
5
Duration
1 term
Frequency
Every third term
Evaluation
Not graded
Total Workload
150 hours
Workload per ECTS Credit
30 hours
Contact Time
48 hours
Independent Study
102 hours

Teaching Language	German or English
Further Information on the Teaching Language	German, English on request
Entry Requirements as Stated in the Examination Regulations	None
Recommended Requirements	Basic knowledge of working with computers, knowledge of seismological methods

Module Courses		
Course Type	**Course Name**	**Compulsory/Optional**
Exercises (Project work)	Processing of Local Seismicity	WPFL
Further Information on the Courses	The course consists of 12 -14 blocks. Each block consists of a supervised exercise (4 h).	

Prerequisites for Admission to the Examination(s)	None
Further Requirements for Awarding ECTS Credits	None

Examination(s)		
Type of Examination	**Evaluation**	**Weighting**
Report	Not graded	100 %
Further Information on the Examination(s)	None	

Short Summary
A dataset of local seismicity is processed with a seismological tool.
Course Content
The course introduces to the processing sequence of passive seismological dataset of a temporal local network. The sequence consists of triggering of potential earthquakes, picking of onsets, determining the location of the earthquake by different methods (single event, master event, joint hypocenter, double difference). The focal mechanism and moment tensor are derived for some events, an optimum 1D-model is estimated and a local earthquake tomography is performed. The results are compared with other geophysical and non-geophysical results and interpreted in term of petrology.
Learning Outcome
• How to identify an earthquake and to pick different onsets • How to locate an earthquake • How to estimate the focal mechanism of an earthquake • How to calculate an local earthquake tomography
Reading List
• Havskoy & Ottemöller: “Routine Data Processing in Earthquake Seismology”
Additional Information
None

MNF-geop-NGP02f .1Digital data processing in geophysics: Acoustic imaging of sedimentary features in the oceans

Module Name	Module Code
Bathymetry	MNF-geop-NGP02f.1
Organizer	**Organisation**
Jens Greinert	Institute of Geosciences
Faculty	**Examination Office**
Faculty of Mathematics and Natural Sciences	PA of the Department of Geography and Geoscience

ECTS Credits
5
Duration
1 term
Frequency
Every third term
Evaluation
Not graded
Total Workload
150 hours
Workload per ECTS Credit
30 hours
Contact Time
48 hours
Independent Study
102 hours

Teaching Language	German or English
Further Information on the Teaching Language	German, English on request
Entry Requirements as Stated in the Examination Regulations	None
Recommended Requirements	Basic knowledge of multibeam systems, good computer skills / working with command line code and simple programming

Module Courses		
Course Type	**Course Name**	**Compulsory/Optional**
Exercises (Project work)	Digital Processing of Bathymetric data	WPFL
Further Information on the Courses	None	

Prerequisites for Admission to the Examination(s)	None
Further Requirements for Awarding ECTS Credits	None

Examination(s)		
Type of Examination	**Evaluation**	**Weighting**
Report	Not graded	100 %
Further Information on the Examination(s)	None	

Short Summary
The exercise will present different software packages for processing and visualizing multibeam-based bathymetric data. MB-Systems, GMT and SAGA will be introduced as freely available software packages, the commercial software packages Fledermaus and ArcGIS will be used as well. All software packages will be used in practical exercises. For the final report, an example data set will be processed, visualized and data set specific questions need to be answered.
Course Content
This excise will give detailed introduction into different ways of processing, plotting and manipulating bathymetric data, create bathymetric maps, manipulate processed DTMs, create derivatives and compare data sets. Computer-based exercises will be done during the lecture. Particularly the freely available software tools MB-Systems and GMT will be used.
Learning Outcome
• Processing and editing of bathymetric data with MB-Systems and Fledermaus • Visualizing Bathymetric data with GMT, SAGA, ArcGIS and Fledermaus • Compute derivatives, extract sub-data sets and properties from DTMs and visualize them Understand how processing and plotting steps influence resulting DTMs and the appearance of maps
Reading List
• MB-Systems and GMT cookbooks and tutorials • H. Medwin et al., Sounds in the Sea – from Ocean Acoustics to Acoustical Oceanography (Cambridge University press 2005) X Lurton, An Introduction to Underwater Acoustics – Principles and Applications (2nd edition, Springer 2010)
Additional Information
None

MNF-geop-NGP02g.1 Digital data processing in geophysics: Airborne Geophysics

Module Name	Module Code
Airborne Geophysics	MNF-geop-NGP02g.1
Organizer	**Organisation**
Jörg Ebbing	Institute of Geosciences
Faculty	**Examination Office**
Faculty of Mathematics and Natural Sciences	PA of the Department of Geography and Geoscience

ECTS Credits
5
Duration
1 term
Frequency
Every third term
Evaluation
Not graded
Total Workload
150 hours
Workload per ECTS Credit
30 hours
Contact Time
48 hours
Independent Study
102 hours

Teaching Language	German or English
Further Information on the Teaching Language	German, English on request
Entry Requirements as Stated in the Examination Regulations	None
Recommended Requirements	Basic knowledge of gravity, surface deformation and radar methods

Module Courses		
Course Type	**Course Name**	**Compulsory/Optional**
Exercises (Project work)	Airborne Geophysics	WPFL
Further Information on the Courses	None	

Prerequisites for Admission to the Examination(s)	None
Further Requirements for Awarding ECTS Credits	None

Examination(s)		
Type of Examination	**Evaluation**	**Weighting**
Report	Not graded	100 %
Further Information on the Examination(s)	None	

Short Summary
The course will give a practical introduction in how to work with airborne derived geophysical data sets.
Course Content
2 or 3 different types of airborne data (e.g. Grav, Mag, EM) are individually processed and used for a joint interpretation of the near-surface. We use standard industry software and typical processing steps (levelling, heading correction, topography correction, data merge, field continuation, high-pass/low-pass filter) are introduced and applied to the real data sets. Integration of data through a GIS environment will be used to aid interpretation.
Learning Outcome
• Knowledge of airborne data processing software • Integration in GIS environment • Interpretation of airborne data sets
Reading List
• Reeves, Aeromagnetic surveys • Dentith, Mudge – Geophysics for the Mineral Exploration Geoscientist
Additional Information
None

MNF-geop-NGP02h.1 Digital data processing in geophysics: Satellite Geophysics

Module Name	Module Code
Satellite Geophysics	MNF-geop-NGP02h.1
Organizer	**Organisation**
Jörg Ebbing	Institute of Geosciences
Faculty	**Examination Office**
Faculty of Mathematics and Natural Sciences	PA of the Department of Geography and Geoscience

ECTS Credits
5
Duration
1 term
Frequency
Every third term
Evaluation
Not graded
Total Workload
150 hours
Workload per ECTS Credit
30 hours
Contact Time
48 hours
Independent Study
102 hours

Teaching Language	German or English
Further Information on the Teaching Language	German, English on request
Entry Requirements as Stated in the Examination Regulations	None
Recommended Requirements	Basic knowledge of gravity, surface deformation and radar methods

Module Courses		
Course Type	**Course Name**	**Compulsory/Optional**
Exercises (Project work)	Satellite Geophysics	WPFL
Further Information on the Courses	None	

Prerequisites for Admission to the Examination(s)	None
Further Requirements for Awarding ECTS Credits	None

Examination(s)		
Type of Examination	**Evaluation**	**Weighting**
Report	Not graded	100 %
Further Information on the Examination(s)	None	

Short Summary
The course will give a practical introduction in how to work with satellite derived geophysical data sets. A focus will be on the introduction of software packages and algorithms.
Course Content
2 or 3 different types of satellite data (e.g. Grav, GPS, InSAR) will be processed and used for a simple interpretation of surface motion. For the processing, open academic software codes (partly implemented in MATLAB) will be used and typical steps of data analysis explained and performed (spherical harmonic analysis, complex and two-dimensional signal processing). The application to real data sets is the focus on the course and an introduction of the participants to joint interpretation for surface deformation is the final course aim.
Learning Outcome
• Knowledge of and practice with satellite data processing software • Knowledge and practice in quantitative data analysis and integrated interpretation for dynamic Earth processes
Reading List
• Vermeersen: The iGOCE book • Ferreti - Satellite InSAR Data: Reservoir Monitoring from Space
Additional Information
None

MNF-geop-NGP02i.1 Digital data processing in geophysics: Digital data processing in geophysics: Geoelectrics, EMI, GPR

Module Name	Module Code
Digital data processing in geophysics: Geoelectrics, EMI, GPR	MNF-geop-NGP2i.1
Organizer	**Organisation**
Tina Wunderlich	Institute of Geosciences
Faculty	**Examination Office**
Faculty of Mathematics and Natural Sciences	PA of the Department of Geography and Geoscience

ECTS Credits
5
Duration
1 term
Frequency
Every third term
Evaluation
Not graded
Total Workload
150 hours
Workload per ECTS Credit
30 hours
Contact Time
48 hours
Independent Study
102 hours

Teaching Language	German or English
Further Information on the Teaching Language	German, English on request
Entry Requirements as Stated in the Examination Regulations	None
Recommended Requirements	Knowledge of Matlab and the methods geoelectrics, EMI and GPR at the level of the Bachelor program

Module Courses		
Course Type	**Course Name**	**Compulsory/Optional**
Exercises (Project work)	Digital data processing in geophysics: Geoelectrics, EMI, GPR	WPFL
Further Information on the Courses	None	

Prerequisites for Admission to the Examination(s)	None
Further Requirements for Awarding ECTS Credits	None

Examination(s)		
Type of Examination	**Evaluation**	**Weighting**
Report	Not graded	100 %
Further Information on the Examination(s)	None	

Short Summary
Different data sets of geoelectrics, electromagnetic induction (EMI) and Ground Penetrating Radar (GPR) are processed and interpreted together.
Course Content
Different data sets of geoelectrics, electromagnetic induction (EMI) and Ground Penetrating Radar (GPR) are processed using third party software and own scripts written in MATLAB or a similar tool. Resolution issues and pitfalls of processing will be discussed. Problems from different applications (archaeology, groundwater, soil type/conditions) are addressed. A focus is on the combined interpretation of the results of different methods.
Learning Outcome
The students gain experience in • Using (non-)commercial software and own scripts for processing of geoelectric and electromagnetic data sets • Interpretation of the results • Combination of different methods for improved interpretation.
Reading List
None
Additional Information
None

Section 4: Seminars

MNF-geop-SGP05 Module of Geophysical Seminars

Module Name	Module Code
Module of Geophysical Seminars	MNF-geop-SGP05
Organizer	**Organisation**
Jörg Ebbing Sebastian Krastel	Institute of Geosciences
Faculty	**Examination Office**
Faculty of Mathematics and Natural Sciences	PA of the Department of Geography and Geoscience

ECTS Credits
5
Duration
2 terms
Frequency
Every term
Evaluation
Not graded
Total Workload
150 hours
Workload per ECTS Credit
30 hours
Contact Time
78 hours
Independent Study
72 hours

Teaching Language	German or English
Further Information on the Teaching Language	German, English on request
Entry Requirements as Stated in the Examination Regulations	None
Recommended Requirements	The course requires previous knowledge in the respective geophysical methods

Module Courses		
Course Type	**Course Name**	**Compulsory/Optional**
Seminar	Principles of scientific work	PFL
Seminar	Seminar Current Research Topics (“Seminar Aktuelle Forschungsthemen “SAFT”) (attested participation in a total of 20 scientific talks during all terms)	PFL
Seminar	Geophysical Seminar	PFL
Further Information on the Courses	None	

Prerequisites for Admission to the Examination(s)	None
Further Requirements for Awarding ECTS Credits	None

Examination(s)		
Type of Examination	**Evaluation**	**Weighting**
Oral presentation (Principles of scientific work)	Not graded	n.a.
Oral presentation (Geophysical seminar)	Not graded	n.a.
Attestation for 20 scientific talks (SAFT)	Not graded	n.a.
Further Information on the Examination(s)	None	

Short Summary

The module consists of 3 seminars focusing on the principles of conducting scientific work, on independently accessing a scientific working field through performing literature research, on presenting a scientific talk, and acquiring knowledge on current geophysical research.

Course Content

The module consists of 3 seminar courses.

The first of seminar is dedicated to the principles of scientific work including the following items

- Preparation and presentation of an interesting talk with a clear message
- Structure of written reports and scientific publications
- Preparation of an introduction of a scientific paper or thesis
- Scientific standards and science ethics
- Funding sources

The second seminar consists of oral presentations given by the students. The general topic of the seminar will be newly selected each term. The students review available reading lists for this topic and prepare and present a talk focusing on sub-topics. The

The third seminar consists in the participation in scientific talks presented mainly by invited external scientists (Seminar Aktuelle Forschungsthemen “SAFT”). Of the latter 20 SAFT talks are to be attended over the time of studying.

Learning Outcome

The students will be able to present scientific results in oral or written form following scientific standards, to summarize selected reading list in an oral presentation, and they acquire knowledge of the current research topics in geophysics and of national and international research projects.

Reading List

- Manuscript

Additional Information

None

Section 5: Freely selectable modules

MNF-geop-NGP0 Introduction to Matlab

Module Name	Module Code
Introduction to Matlab	MNF-geop-NGP0
Organizer	**Organisation**
Nils Holzrichter	Institute of Geosciences
Faculty	**Examination Office**
Faculty of Mathematics and Natural Sciences	PA of the Department of Geography and Geoscience

ECTS Credits
2
Duration
1 term
Frequency
Every term
Evaluation
Not graded
Total Workload
60 hours
Workload per ECTS Credit
30 hours
Contact Time
24 hours
Independent Study
36 hours

Teaching Language	German or English
Further Information on the Teaching Language	German, English on request
Entry Requirements as Stated in the Examination Regulations	None
Recommended Requirements	Basic knowledge on working with computers

Module Courses		
Course Type	**Course Name**	**Compulsory/Optional**
Exercise	Introduction to Matlab	FRW
Further Information on the Courses	None	

Prerequisites for Admission to the Examination(s)	None
Further Requirements for Awarding ECTS Credits	None

Examination(s)		
Type of Examination	**Evaluation**	**Weighting**
Written exam	Not graded	100 %

Further Information on the Examination(s)	None

Short Summary
The course provides a basic introduction to the tool MATLAB for solving typical small everyday tasks for course exercises or for first own scientific work (preparing a thesis).
Course Content
MATLAB is a very useful tool for students, facing typical everyday tasks such as: • Reformatting measured data or file formats, • Interpolation of irregular data, • Preparing a special file format, • Calculation and meaning of statistic parameters, • Plotting graphs and histograms with arbitrary data, • Calculation of geographic projections and plotting maps. The possibilities go far beyond what may be solved with Microsoft Excel. The course consists of mainly hands-on exercises with one computer per student.
Learning Outcome
The students will be qualified to design and realize own programs and to understand and use the MATLAB help function in order to increase their own skills without further instruction by a teacher.
Reading List
MATLAB internal help function (Mathworks Inc.)
Additional Information
None

MNF-geop-NGP10 Introduction to Generic Mapping Tool (GMT)

Module Name	Module Code
Introduction to Generic Mapping Tool (GMT)	MNF-geop-NGP10
Organizer	**Organisation**
Martin Thorwart	Institute of Geosciences
Faculty	**Examination Office**
Faculty of Mathematics and Natural Sciences	PA of the Department of Geography and Geoscience

ECTS Credits
2
Duration
1 term
Frequency
Annual
Evaluation
Not graded
Total Workload
60 hours
Workload per ECTS Credit
30 hours
Contact Time
40 hours
Independent Study
20 hours

Teaching Language	German or English
Further Information on the Teaching Language	German, English on request
Entry Requirements as Stated in the Examination Regulations	None
Recommended Requirements	Basic knowledge of working with computers

Module Courses		
Course Type	**Course Name**	**Compulsory/Optional**
Exercises	Introduction to Generic Mapping Tool	FRW
Further Information on the Courses	The course consists of 10 blocks. Each block consists of a lecture (1 h) and a supervised exercise (3 h). The course would last 1 week.	

Prerequisites for Admission to the Examination(s)	None
Further Requirements for Awarding ECTS Credits	None

Examination(s)		
Type of Examination	**Evaluation**	**Weighting**
Report	Not graded	100 %
Further Information on the Examination(s)	None	

Short Summary
The course provides a basic introduction to the GMT collections of commands for creating geographical maps and x-y plots.
Course Content
The course introduces several GMT-commands and explains their syntax. Basic GMT-commands are psbasemap, psxy, pscoast, pstext and pslegend. Those commands are used in the exercises to create a simple map, x-y plot and t-x-plot. Other commands like grdfilter, grdmath, surface, grdimage can be used to manipulate, to process and to plot 2-D datasets like bathymetry, gravimetry anomaly or wave heights. A short introduction to the Java Applet “GeoMapApp” (based on GMT) is given.
Learning Outcome
• Knowledge of the GMT-commands and their syntax • Development and Generation of simple and complex maps and plots (2D and 3D) • Knowledge of processing and analysis 1D and 2D-datasets with GMT
Reading List
• gmt.soest.hawaii.edu • gmt.soest.hawaii.edu/gmt4/gmt/html/GMT_Docs.html
Additional Information
None

MNF-geop-NGP11 Introduction to Python

Module Name	Module Code
Introduction to Python	MNF-geop-NGP11
Organizer	**Organisation**
Thomas Meier	Institute of Geosciences
Faculty	**Examination Office**
Faculty of Mathematics and Natural Sciences	PA of the Department of Geography and Geoscience

ECTS Credits
2
Duration
1 term
Frequency
Annual
Evaluation
Not graded
Total Workload
60 hours
Workload per ECTS Credit
30 hours
Contact Time
40 hours
Independent Study
20 hours

Teaching Language	German or English
Further Information on the Teaching Language	German, English on request
Entry Requirements as Stated in the Examination Regulations	None
Recommended Requirements	The course requires previous knowledge in programming (e.g. Matlab course)

Module Courses		
Course Type	**Course Name**	**Compulsory/Optional**
Exercises	Introduction to Python	FRW
Further Information on the Courses	None	

Prerequisites for Admission to the Examination(s)	Report
Further Requirements for Awarding ECTS Credits	None

Examination(s)		
Type of Examination	**Evaluation**	**Weighting**
Oral exam	Not graded	100 %
Further Information on the Examination(s)	None	

Short Summary
Introduction to Python programming with application to geophysical problems
Course Content
The course is an introductory programming course to the high-level programming language Python, with a focus on its use in typical scientific applications (numerical calculations, data in-/output). Examples will be primarily related to seismological data processing.
Learning Outcome
The students acquire basic knowledge in scientific programming with Python, with a focus on signal processing tools.
Reading List
• Manuscript
Additional Information
None

MNF-geop-GGP06 Geophysical field trip

Module Name	Module Code
Geophysical field trip	MNF-geop-GGP06
Organizer	**Organisation**
Sebastian Krastel	Institute of Geosciences
Faculty	**Examination Office**
Faculty of Mathematics and Natural Sciences	PA of the Department of Geography and Geoscience

ECTS Credits
2
Duration
1 term
Frequency
Annual
Evaluation
Not graded
Total Workload
60 hours
Workload per ECTS Credit
30 hours
Contact Time
48 hours
Independent Study
12 hours

Teaching Language	German or English
Further Information on the Teaching Language	German, English on request
Entry Requirements as Stated in the Examination Regulations	None
Recommended Requirements	None

Module Courses		
Course Type	**Course Name**	**Compulsory/Optional**
Field trip	Geophysical filed trip	FRW
Further Information on the Courses	None	

Prerequisites for Admission to the Examination(s)	None
Further Requirements for Awarding ECTS Credits	None

Examination(s)		
Type of Examination	**Evaluation**	**Weighting**
Report	Not graded	100 %

Further Information on the Examination(s)	None

Short Summary
Several different locations of interest for geophysicists will be visited during a 6 day field trip.
Course Content
The field trip will visit several (changing) locations of interest for geophysicists. This may include other institutes and universities, industry locations, ongoing field surveys, and outcrops.
Learning Outcome
The students will gain knowledge on possible applications of geophysical techniques in different environments.
Reading List
None
Additional Information
None

Section 6: Master-Thesis and Defense

MNF-geop-MTD Master-Thesis and Defense

Module Name	Module Code
Master-Thesis and Defense	MNF-geop-MTD
Module Coordinator	**Organizer**
Chairperson of the Examination Board of the M.Sc. Geophysics (presently Wolfgang Rabbel)	Thesis advisor
Faculty	**Examination Office**
Faculty of Mathematics and Natural Sciences	PA of the Department of Geography and Geoscience

ECTS Credits
30
Duration
6 month
Frequency
Anytime
Evaluation
Graded
Total Workload
900 hours
Workload per ECTS Credit
30 hours
Contact Time
n.a.
Independent Study
900 hours

Teaching Language	
Further Information on the Teaching Language	German or English
Entry Requirements as Stated in the Examination Regulations	More than 2/3 of courses of the master program (≥60 ECTS credits) completed
Recommended Requirements	Lectures and practical courses connected with the theme of the thesis should have been completed beforehand.

Module Courses		
Course Type	**Course Name**	**Compulsory/Optional**
n.a.	n.a.	n.a.
Further Information on the Courses	n.a.	

Prerequisites for Admission to the Examination(s)	n.a.
Further Requirements for Awarding ECTS Credits	n.a.

Examination(s)		
Type of Examination	**Evaluation**	**Weighting**
Master thesis (written)	graded	100 %
Oral presentation (“Defense”)		0 %

Further Information on the Examination(s)	Students and teachers of the M.Sc. Geophysics program are to be invited to attend the oral presentation of the results of the Master-thesis. The thesis advisors are responsible for timely sending respective invitations.

Short Summary
The Master thesis and related oral presentation are the outcome of a scientific study conducted independently by each student under the guidance of 1 or 2 advisors.
Course Content
Master students conduct an independent scientific study the theme of which is usually provided by a teacher of Geophysics acting as main advisor. The results of the study are presented by the student in form of a Master thesis and a defense. The defense consists of an oral presentation followed by a public discussion of results.
Learning Outcome
Master thesis and defense show that the student is capable to perform a scientific study and to present the results according to the standards of the scientific community.
Reading List
Provided by thesis advisor(s).
Additional Information
Provided by thesis advisor(s).

Section 7: Export Modules

MNF-geop-SGP01 Geophysical Seminar

Module Name	Module Code
Geophysical Seminar	MNF-geop-SGP01
Organizer	**Organisation**
Jörg Ebbing	Institute of Geosciences
Faculty	**Examination Office**
Faculty of Mathematics and Natural Sciences	PA of the Department of Geography and Geoscience

ECTS Credits
2
Duration
1 term
Frequency
Every term
Evaluation
Not graded
Total Workload
60 hours
Workload per ECTS Credit
30 hours
Contact Time
24 hours
Independent Study
36 hours

Teaching Language	German or English
Further Information on the Teaching Language	German, English on request
Entry Requirements as Stated in the Examination Regulations	None.
Recommended Requirements	None.

Module Courses		
Course Type	**Course Name**	**Compulsory/Optional**
Seminar	Geophysical Seminar	PFL
Further Information on the Courses	None	

Prerequisites for Admission to the Examination(s)	None
Further Requirements for Awarding ECTS Credits	None

Examination(s)		
Type of Examination	**Evaluation**	**Weighting**
Oral presentation	Not graded	n.a.
Further Information on the Examination(s)	None	

Short Summary
The students will present a talk about selected geophysical topics
Course Content
A topic will be selected each term. The students will review available reading list for this topic and prepare and present a talk focusing on sub-topics.
Learning Outcome
The student will be able to summarize selected reading list in an oral presentation.
Reading List
Will be provided during the seminar.
Additional Information
None

MNF-geop-AGP04 On- and offshore geophysical field measurements

Module Name	Module Code
On- and offshore geophysical field measurements	MNF-geop-AGP04
Organizer	**Organisation**
Wolfgang Rabbel	Institute of Geosciences
Faculty	**Examination Office**
Faculty of Mathematics and Natural Sciences	PA of the Department of Geography and Geoscience

ECTS Credits
3
Duration
1 term
Frequency
Every term
Evaluation
Not graded
Total Workload
90 hours
Workload per ECTS Credit
30 hours
Contact Time
80 hours
Independent Study
10 hours

Teaching Language	German or English
Further Information on the Teaching Language	German, English on request
Entry Requirements as Stated in the Examination Regulations	None
Recommended Requirements	The course requires previous knowledge of the methods applied in the field measurements

Module Courses		
Course Type	**Course Name**	**Compulsory/Optional**
Practical field work	On- and offshore geophysical field measurements	PFL
Further Information on the Courses	Students can participate in different excursions. In total, every student has to attend a minimum of 10 days of field measurements.	

Prerequisites for Admission to the Examination(s)	None
Further Requirements for Awarding ECTS Credits	Participation and report

Examination(s)		
Type of Examination	**Evaluation**	**Weighting**
Report	Not graded	n.a.

Further Information on the Examination(s)	None

Short Summary
The students participate in preparing and performing geophysical field measurements that are carried out on- and offshore in the framework of ongoing research projects.
Course Content
The students participate in preparing and performing geophysical field measurements that are carried out on- and offshore in the framework of ongoing research projects. In total, every student has to attend a minimum of 14 days of field measurements.
Learning Outcome
The students • learn to plan, prepare and perform geophysical field measurements • learn to apply geophysical methods in a scientifically or economically relevant context • get familiar with technical and social problems during field campaigns • reactivate and apply previous knowledge
Reading List
• depends on excursion
Additional Information
None