LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

Module Catalogue

Master's Programme: Geophysics (Master of Science, M.Sc.)

(120 ECTS credits)

Based on the *Prüfungs- und Studienordnung* of 06 December 2019

88/066/---/M0/H/2020

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Abbreviations and annotations

CP	Credit Points, ECTS credits
ECTS	European Credit Transfer and Accumulation System
h	hours
SoSe	summer semester
SWS	contact hours
WiSe	winter semester
WP	compulsory elective course/module
P	mandatory course/module

1. The ECTS credits assigned in the Module Catalogue are designated as follows: Credit Points not listed in parentheses are awarded when the pertinent examination of the module or module parts have/has been completed successfully. Credit Points in parentheses are listed for calculatory purposes only.

2. The semester for taking a module can either be binding or may be considered as a recommendation, depending on the applicable data in Anlage 2 of the Prüfungs- und Studienordnung for your Programme. In this Module catalogue, the options are indicated as „scheduled semester“ and „recommended semester“.

3. Please note: The Module Catalogue is merely intended to serve as an orientation whereas the provisions of the applicable version of the Prüfungs- und Studienordnung (in German only) of your Programme are legally binding. See: www.lmu.de/studienangebot and select your Programme.

Module: P 1 Mathematical Geophysics

Programme	Master's Programme: Geophysics (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	P 1.1 Mathematical Geophysics (Lecture)	WiSe	60 h (4 SWS)	120 h	(6)
Exercise	P 1.2 Mathematical Geophysics (Exercise)	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Mandatory module with mandatory courses
Usability of the module in other Programmes	None
Elective guidelines	None
Entry requirements	None
Semester	Scheduled semester: 1
Duration	The completion of the module takes 1 semester.
Content	This module provides in-depth knowledge of mathematical methods required for geophysical modeling. Topics include • coordinate systems (polar, cylindrical, spherical coordinates) • vector analysis (differential operators and central theorems) • partial differential equations (modelling, classification, characterization, • properties, classical solution methods) • Green's functions • normal modes and special functions (Bessel and Legendre functions) • approximation theory (Fourier series, spherical harmonics)
Learning outcomes	The aim of the module is to provide students with theoretical foundations that are required for the understanding and critical interpretation of modern geophysical concepts. This knowledge is indispensible for numerical discretisation of such models as applied in later modules. After successful participation of this module the qualified students should be in the position to understand and apply the mathematical concepts of modern geophysical modeling.

Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Dr. Marcus Mohr, Department of Earth and Environmental Sciences, Ludwig- Maximilians-Universität München
Language(s)	English
Additional information	Literature: • Roel Snieder, *A Guided Tour of Mathematical Methods for the Physical Sciences*, Cambridge University Press • Yehuda Pinchover and Jacob Rubinstein*, An Introduction to Partial Differential Equations*, Cambridge University Press

Module: P 2 Statistical Geophysics

Programme	Master's Programme: Geophysics (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	P 2.1 Statistics for Geosciences (Lecture)	WiSe	30 h (2 SWS)	60 h	(3)
Exercise	P 2.2 Statistics for Geosciences (Exercise)	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Mandatory module with mandatory courses
Usability of the module in other Programmes	MSc Human Geography and Sustainability
Elective guidelines	None
Entry requirements	None
Semester	Scheduled semester: 1
Duration	The completion of the module takes 1 semester.
Content	This module teaches fundamentals of statistical methods which are essential for processing and analysing observational data. Topics include: • descriptive statistics • probability theory (Bayes' theorem) • distribution, expectation, variance • statistical tests (t-test, independent and matched pairs samples, nonparametric methods) • regression (linear regression, logistic regression, Poisson regression) The lecture is accompanied by practical exercises in statistical computing conducted mostly in the programming language R.
Learning outcomes	The aim of the module is to provide students with theoretical foundations of statistics required for the understanding and critical interpretation of modern geophysical concepts of data-analysis. After successful participation of this module the qualified students should be in the position to understand and critically apply statistical concepts for geophysical data analysis.

Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Dr. Marcus Mohr, Department of Earth and Environmental Sciences, Ludwig- Maximilians-Universität München
Language(s)	English
Additional information	Literature: • Students receive a script with the content of the lecture. • Brian S. Everitt und Torsten Hothorn, *A Hand-book of Statistical Analyses Using R*, CRC Press

Module: P 3 Earth System Science

Programme	Master's Programme: Geophysics (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	P 3.1 Introduction to Earth System Science 1	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	P 3.2 Introduction to Earth System Science 2	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	P 3.3 Geophysics Research: Overview on Methods and Open Questions	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Mandatory module with mandatory courses
Usability of the module in other Programmes	Courses P3.1 and P3.2 for a module in the master's programme Earth Oriented Space Science at TU Munich
Elective guidelines	None
Entry requirements	None
Semester	Scheduled semester: 1
Duration	The completion of the module takes 1 semester.
Content	The content of this module concentrates on the use of physical methods to solve problems in geosciences at various spatial and temporal scales. The module focuses on the introduction and interaction of the different systems involved (atmosphere, oceans, earth's interior) as well as the internal structure of the earth. Furthermore, the students are exposed to current research topics in the various fields of geophysics (seismology, geo- and paleomagnetism, geodynamics). P 3.1 Introduction to Earth System Science 1 & P 3.2 Introduction to Earth System Science 2 • Introduction to components of earth systems (atmosphere, oceans, cryosphere, solid earth) • processes in these systems and their interaction • geophysical and geochemical parameters and internal and external forces (gravitational and magnetic forces, tides)

	• fundamentals of modelling as well as methods and sensors for earth observation including space-born sensors P 3.3 Geophysics Research: Overview on Methods and Open Questions • Overview on challenges and open questions actively debated in the scientific community • Overview on state-of-the-art methodologies and approaches applied in modern geophysical research
Learning outcomes	The aim of the module is to expose students to the large spectrum of processes active in the Earth system. With this knowledge on processes relevant in geophysical research, students have the abilities to understand the process-related complexity as well as to identify and interpret the related components. Furthermore, after successful participation in this module students are in the position to solve general geophysical problems by using essential techniques (for example seismic methods, magnetic methods). The students are able to describe the physical fundamentals of these geophysical methods. Moreover, students are in the position to understand and explain on a basic level the relationship between structure (and dynamics) of Earth system components and the available observations. Students have obtained first insight into outstanding questions in current geophysical research and they gained an understanding of modern geophysical research with a focus on the scientific topics of relevance to the research groups at LMU Munich.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Dr. Bernhard Schuberth, Department of Earth and Environmental Sciences, Ludwig- Maximilians-Universität München
Language(s)	English
Additional information	None

Module: P 4 Geocontinua

Programme	Master's Programme: Geophysics (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	P 4.1 Methods of Geocontinua (Lecture)	WiSe	30 h (2 SWS)	60 h	(3)
Exercise	P 4.2 Methods of Geocontinua (Exercise)	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Mandatory module with mandatory courses
Usability of the module in other Programmes	None
Elective guidelines	None
Entry requirements	None
Semester	Scheduled semester: 1
Duration	The completion of the module takes 1 semester.
Content	This module provides in-depth knowledge of basic geophysical modelling techniques and the underlying mathematical equations and continuum mechanical assumptions. The module provides an understanding of advanced models of the structure of the earth, the materials and processes as well as possibles observables for these models. • advanced concepts of the internal structure of the earth • influence on mass and heat transport • properties of elastic materials and their high pressure and high temperature behaviour • influence of large scale planetary dynamics on geodetic observables (gravity and rotation)
Learning outcomes	After successful completion of the module, the students have acquired the key theoretical foundations that are necessary for the understanding and critical interpretation of modern geophysical concepts, in particular as they relate to continuum mechanics. The students will also be in the position to exploit the learned concepts in the context of

	modern geophysical research. Furthermore, they will be able to deal with special topics of this scientific discipline and apply them critically in advanced modules. Students should be in the position to learn advanced scientific methods and techniques independently as well as to acquire and interpret geophysical problems.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Hans-Peter Bunge, Department of Earth and Environmental Sciences, Ludwig- Maximilians-Universität München
Language(s)	English
Additional information	Literature: Brian Kennett and Hans-Peter Bunge, „Geophysical Continua", Cambridge University Press

Module: P 5 Computational Geophysics

Programme	Master's Programme: Geophysics (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	P 5.1 Computational Geophysics (Lecture)	SoSe	30 h (2 SWS)	60 h	(3)
Exercise	P 5.2 Computational Geophysics (Exercise)	SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Mandatory module with mandatory courses
Usability of the module in other Programmes	None
Elective guidelines	None
Entry requirements	None
Semester	Scheduled semester: 2
Duration	The completion of the module takes 1 semester.
Content	This module teaches broad basic knowledge of numerical mathematics. Topics include: • basics of numerical algorithms and asymptotic complexity • rounding error analysis, condition numbers • polynomial interpolation • data fitting and least -squares problems • discretisation methods for partial differential equations (Finite Differences and Finite Elements)
Learning outcomes	After successful participation in this module students have acquired basic knowledge and understanding of numerical techniques and are in the position to independently acquire and understanding of more sophisticated algorithms used in modern specialised geophysical models.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential

	elective compulsary module parts) has/have been completed successfully.
Responsible contact	Dr. Marcus Mohr, Department of Earth and Environmental Sciences, Ludwig- Maximilians-Universität München
Language(s)	English
Additional information	Literature: • Students receive a script with the contents of the lecture.

Module: P 6 Scientific Programming

Programme	Master's Programme: Geophysics (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	P 6.1 Scientific Programming (Lecture)	SoSe	30 h (2 SWS)	60 h	(3)
Exercise	P 6.2 Scientific Programming (Exercise)	SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Mandatory module with mandatory courses
Usability of the module in other Programmes	None
Elective guidelines	None
Entry requirements	None
Semester	Scheduled semester: 2
Duration	The completion of the module takes 1 semester.
Content	This module teaches broad basic knowledge related to the application of computers for geophysical research. It focuses on the efficient and correct implementation of such algorithms on computer systems. Topics include: • fundamentals and architecture of modern computer systems • history and classification of programming languages • representation of numerical data on computer systems • programming in Fortran and/or C • classical & special data structures for scientific computing, selected algorithms • automated build-tools and version control systems • preprocessing
Learning outcomes	After successful participation in this module students are in the position to implement standard geophysical models on computer systems, compare and evaluate different such implementations and apply standard software packages for numerical simulations.
Type of examination	Written exam or oral examination

Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Dr. Marcus Mohr, Department of Earth and Environmental Sciences, Ludwig- Maximilians-Universität München
Language(s)	English
Additional information	Literature: • Students receive the slides of the lecture.

Module: P 7 Advanced Geophysics

Programme	Master's Programme: Geophysics (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Vorlesung	P 7.1 Geodynamics	SoSe	30 h (2 SWS)	60 h	(3)
Vorlesung	P 7.2 Seismology	SoSe	30 h (2 SWS)	60 h	(3)
Vorlesung	P 7.3 Geo- and Paleomagnetism	SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Mandatory module with mandatory courses
Usability of the module in other Programmes	None
Elective guidelines	None
Entry requirements	None
Semester	Scheduled semester: 2
Duration	The completion of the module takes 1 semester.
Content	This module teaches students modern quantitative methods, descriptions and applications of geophysical processes, including potential methods, partial differential equations, numerical simulation of complex (non-linear) geophysical processes by use of modern high-performance computing and data processing methods including concepts of data assimilation, optimization and inversion. P 7.1 Geodynamics • modern concepts of fluid dynamics • their relevance for the internal structure and dynamics of the earth • geological and geodetical constraints on the structure and evolution of the earth P 7.2 Seismology • introduction into modern seismology, reading exercise • stress, strain, constitutive equations, seismic wave equation, reading exercise • body waves and harmonic plane waves, computer exercise

	• surface waves, dispersion and normal modes, computer exercise • seismic inverse problems, computer exercise on localization of earthquakes • seismic tomography and phases in a spherical Earth, 1D and 3D Earth models, reading exercise • quantitative concepts of seismic sources from theory to inverse models • earthquake seismology in practice - Real faults and focal mechanisms, radiation patterns and magnitudes P 7.3 Geo- and Paleomagnetism • dynamo theory; mathematical description of magnetic fields • measurements of the historical field from observatory and satellite observations • origin of magnetic remanence in minerals and rocks • use of magnetic anisotropy in the Earth sciences • application/interpretation of magnetic records in rocks to understand the paleofield, plate tectonics and surficial processes (reversal frequency, secular variation, continental drift, pole wander, mountain building, sedimentation rate, etc.) • brief introduction to biomagnetism
Learning outcomes	Students will develop an up-to-date detailed and critical understanding in the fields of geophysics (geodynamics, seismology, geo- and paleomagnetism). They are able to define and interpret characteristics, limits, terminology and experts' opinions in the geophysical fields.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Hans-Peter Bunge, Department of Earth and Environmental Sciences, Ludwig- Maximilians-Universität München
Language(s)	English
Additional information	None

Module: P 8 Geophysical Data Acquisition and Analysis

Programme	Master's Programme: Geophysics (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Practical course	P 8.1 Geophysical Data Analysis: Practical Introduction	SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Mandatory module with mandatory course
Usability of the module in other Programmes	None
Elective guidelines	None
Entry requirements	None
Semester	Scheduled semester: 2
Duration	The completion of the module takes 1 semester.
Content	The module aims to extend and deepen the knowledge of students in applied data acquisition and analysis across fields of geophysics. The students receive hands-on training combining modern teaching aids such as python notebooks and geophysical field work in the following topics: • geophysical measurements (seismic, magnetic and gravitational) • fundamentals of spectral analysis • fundamentals of filter theory and applications • fundamentals of array data analysis • fundamentals of geophysical instruments calibration of geophysical instruments and correction of instruments
Learning outcomes	The aim of the module is to expose students to the large spectrum of data and data processing in geophysical research. With this knowledge students have the abilities to understand data processing related complexity as well as to use essential data analysis techniques. Students will practically learn to apply the common methods and analytic techniques of data collection and analysis in the Earth sciences, which includes using openly accessible seismic and magnetic catalogues for data acquisition spectral

	analysis and advanced filter theory. With successful completion of this module student are in the position to edit, analyse and interpret geoscientific data by the use of computational processes.
Type of examination	Case study
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Heiner Igel, Department of Earth and Environmental Sciences, Ludwig- Maximilians-Universität München
Language(s)	English
Additional information	None

Module: WP 1 Geodynamics I

Programme	Master's Programme: Geophysics (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Seminar	WP 1.1 Modern Geodynamics	SoSe	30 h (2 SWS)	60 h	(3)
Seminar	WP 1.2 Special Topics in Geodynamics	WiSe and SoSe	30 h (2 SWS)	30 h	(2)
Colloquium	WP 1.3 Geophysical Colloquium	WiSe and SoSe	30 h (2 SWS)	0 h	(1)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other Programmes	None
Elective guidelines	The module can be chosen in compliance with the following rule: With regard tot he compulsory elective modules WP 1 – WP 3, one compulsory elective module must be chosen.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	This module enables students to understand a wide range of geophysical and geological observations in the context of the underlying geodynamical processes. Special emphasis is placed on global processes both in the crust an the deeper earth, and connection to the similar processes in the terrestrial planets are drawn when ever possible. WP 1.1 Modern Geodynamics • quantitative concepts on fluid and elasto-dynamics • spatial and temporal scales of internal earth deformation • relevant non-dimensional numbers geological and geodetic constraints to infer the structure of evolution of the deep earth

	WP 1.2 Special Topics in Geodynamics • This course deals with up-to-date topics in the geodynamic literature. The aim of the course is to introduce students to research work currently done by members of the geodynamics group in order to prepare them for their master thesis and a potential later doctoral project. WP 1.3 Geophysical Colloquium • This colloquium consists of a number of presentations by varying scientists. Its function is to introduce students to the wide range of current research topics in the geosciences both at the Department of Earth and Environmental Sciences and internationally. This will prepare them for choosing a topic for their master thesis and a potential subsequent doctoral project.
Learning outcomes	After successful participation in this module students have a detailed understanding of modern concepts and methods in the field of geodynamics. Students are able to integrate these complex concepts with geophysical observations and to apply their knowledge to research questions in the recent literature. They are able to adequately reference previous scientific results in the field of geodynamics.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Dr. Bernhard Schuberth, Department of Earth and Environmental Sciences, Ludwig- Maximilians-Universität München
Language(s)	English
Additional information	None

Module: WP 2 Seismology I

Programme	Master's Programme: Geophysics (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 2.1 Modern Seismology	SoSe	30 h (2 SWS)	60 h	(3)
Seminar	WP 2.2 Special Topics in Seismology	WiSe and SoSe	30 h (2 SWS)	30 h	(2)
Colloquium	WP 2.3 Geophysical Colloquium	WiSe and SoSe	30 h (2 SWS)	0 h	(1)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other Programmes	None
Elective guidelines	The module can be chosen in compliance with the following rule: With regard tot he compulsory elective modules WP 1 – WP 3, one compulsory elective module must be chosen.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	This module teaches students an overview of current scientific methodologies applied in seismology. The seminar and colloquium will provide students with information on ongoing research projects and will bridge seismology to other topics in Earth System research.
Learning outcomes	Students are capable of employing basic methodologies to carry out research in seismology. They are capable of locating seismological research in a wider Earth Science context.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.

Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Heiner Igel, Department of Earth and Environmental Sciences, Ludwig- Maximilians-Universität München
Language(s)	English
Additional information	None

Module: WP 3 Magnetism I

Programme	Master's Programme: Geophysics (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 3.1 Regional Rock- and Paleomagnetism	SoSe	15 h (1 SWS)	45 h	(2)
Field exercise	WP 3.2 Rock Sampling for Magnetic Studies	SoSe	-	30 h	(1)
Colloquium	WP 3.3 Geophysical Colloquium	WiSe and SoSe	30 h (2 SWS)	0 h	(1)
Exercise	WP 3.4 Collecting and Analysing Magnetic Data	SoSe	30 h (2 SWS)	30 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 5 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other Programmes	None
Elective guidelines	The module can be chosen in compliance with the following rule: With regard tot he compulsory elective modules WP 1 – WP 3, one compulsory elective module must be chosen.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	This module teaches students advanced knowledge, from both a theoretical and practical point of view, in the field of palaeo- and rock magnetism. WP 3.1 Regional Rock- and Paleomagnetism This theoretical course teaches the students the various steps to extract, ascertain and interpret the magnetic signal contained in palaeomagnetic cores. It includes an in-depth presentation of the rock-magnetic, demag-netisation and palaeointensity techniques. WP 3.2 Rock Sampling for Magnetic Studies

	This practical course teaches the students how to collect palaeomagnetic samples in real field conditions for a given scientific problem. In particular it includes: • the identification of suitable outcrops; • the measurement of bedding attitudes; • the drilling and orienting of palaeomagnetic cores. WP 3.3 Geophysical Colloquium This colloquium offers an overview of the possible applications of the palaeomagnetic method to solve a wide range of problems in the field of Earth and planetary sciences. WP 3.4 Collecting and Analysing Magnetic Data This course applies the theoretical knowledge acquired in courses WP3.1 and WP3.3 to the analysis of the palaeomagnetic samples collected in the framework of the field exercise WP3.2. It includes: • the preparation of the samples; • the achievement of rock- and palaeomagnetic measurements; • the interpretation of the results.
Learning outcomes	After successful participation in this module students will have a deepened knowledge of the rock- and palaeomagnetic methods to solve complex problems in the field of Earth and planetary sciences. Students will be qualified to design a sampling strategy, conduct the required measurements and analyse the results in an antonomous way.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Stuart Gilder, Department of Earth and Environmental Sciences, Ludwig- Maximilians-Universität München
Language(s)	English
Additional information	None

Module: P 9 Research Training

Programme	Master's Programme: Geophysics (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Seminar	P 9.1 Presentation, Communication and Publication	WiSe	30 h (2 SWS)	60 h	(3)
Project	P 9.2 Individual Research Project	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Mandatory module with mandatory courses
Usability of the module in other Programmes	None
Elective guidelines	None
Entry requirements	None
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	This module teaches students practical skills for conducting and presenting scientific work. P 9.1 Presentation, Communication and Publication This course teaches students the necessary skills for conducting literature research, writing a scientific report, giving a scientific talk and preparing a grant proposal following the standards of the geophysics community. Through the analysis of scientific material and the achievement of practical exercises, the students will learn how to: • structure a scientific document; • master the codes of the scientific language; • deal with data and statistics in a scientific context; • cite and organise references using dedicated tools; • produce ready-to-publish tables and figures. P 9.2 Individual Research Project Under the guidance of an advisor students will conduct a small research project that shall be associated with the

	topic of their later thesis. The project can take various forms such as e.g. an intial study of exisisting literature, preparatory field- or laboratory work, or familiarising oneself with a certain simulation code and running first models on a supercomputer. This research project will form an important stepping stone for the student to define their individual master's project.
earning outcomes	After successful participation in this module students will be qualified to present scientific work in oral and written form, and have formulated and presented a proposal for the research work to be conducted in their master thesis.
Type of examination	Presentation and project proposal
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Dr. Florian Lhuillier, Department of Earth and Environmental Sciences, Ludwig- Maximilians-Universität München
Language(s)	English
Additional information	None

Module: P 10 Geophysical Research

Programme	Master's Programme: Geophysics (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Integrated learning activity	P 10.1 Tools, Techniques and current Trends in Geophysical Research 1	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Integrated learning activity	P 10.2 Tools, Techniques and current Trends in Geophysical Research 2	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Mandatory module with mandatory courses
Usability of the module in other Programmes	None
Elective guidelines	None
Entry requirements	None
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	The master's programme in Geophysics is a research oriented master's programme. Thus, it is important to incorporate classes in the curriculum that expose students to current research topics in the community. In this module students must choose two courses out of a varying offering of scientific presentations. The content depends on the focus of the special presentations and includes topics from geo- and paleomagnetism, seismology, rocks and mineral physics, risk analysis and geodynamics as wells as associated numerical algorthims and high-performance simulation. Topics focus on quantitative methods and technical concepts that are used to describe the earth magnetic field, tectonic deformation and seismic wave propagation. Special emphasis is placed on the interdisciplinary cross-links between the fields involved.
Learning outcomes	After successful participation in this module students have acquired an overview of current research questions and

	can critically evaluate which scientific research directions they should pursue in the selected areas.
Type of examination	Oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Hans-Peter Bunge, Department of Earth and Environmental Sciences, Ludwig- Maximilians-Universität München
Language(s)	English
Additional information	None

Module: WP 4 Geodynamics II

Programme	Master's Programme: Geophysics (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Integrated learning activity	WP 4.1 Current Questions in Geodynamics 1	WiSe	30 h (2 SWS)	60 h	(3)
Integrated learning activity	WP 4.2 Current Questions in Geodynamics 2	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other Programmes	None
Elective guidelines	The module can be chosen in compliance with the following rule: With regard tot he compulsory elective modules WP 4 – WP 6, one compulsory elective module must be chosen.
Entry requirements	None
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	This module enables students to work on specific topics in geodynamics that are of relevance to the current scientific research in the field. The students will interact with scientists of the geodynamics group and discuss the challenges, open questions and possible strategies to solve them. Modern techniques used in geodynamic research can be trained and applied to chosen topics (e.g., high-performance computing in geodynamics, seismic signature of geodynamic structures, geological imprint of dynamic processes in the mantle, lithosphere and crust, visualization of scientific results). WP 4.1 Current Questions in Geodynamics 1 • Focus on methods applied in geodynamics WP 4.1 Current Questions in Geodynamics 2

	• Focus on recent literature and adequate presentation of scientific results in geodynamics
Learning outcomes	After successful participation in this module students are in the position to conduct independent scientific work in the field of geodynamics. Students are able to understand outstanding issues in geodynamics and to motivate choices for certain approaches to tackle the problems at hand. The can argue independently, can integrate complex concepts of modern geodynamics and apply their knowledge to current research questions. They are qualified to conduct scientific research independently and can adequately present their work in oral and written form.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Dr. Bernhard Schuberth, Department of Earth and Environmental Sciences, Ludwig- Maximilians-Universität München
Language(s)	English
Additional information	None

Module: WP 5 Seismology II

Programme	Master's Programme: Geophysics (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 5.1 New Methods in Seismology (Lecture)	WiSe	30 h (2 SWS)	60 h	(3)
Exercise	WP 5.2 New Methods in Seismology (Exercise)	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other Programmes	None
Elective guidelines	The module can be chosen in compliance with the following rule: With regard tot he compulsory elective modules WP 4 – WP 6, one compulsory elective module must be chosen.
Entry requirements	None
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	This module covers the theory of elastic wave propagation and fundamentals of earthquake physics building the bridge to observations of seismic ground motion and how to interpret them.
Learning outcomes	The student has a fundamental understanding of seismic observations, can identify wave types and phases, understands the sources of seismic waves, and has an understanding how seismic waves can be used to solve Earth and planetary science problems.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.

Responsible contact	Prof. Dr. Heiner Igel, Department of Earth and Environmental Sciences, Ludwig- Maximilians-Universität München
Language(s)	English
Additional information	None

Module: WP 6 Magnetism II

Programme	Master's Programme: Geophysics (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Seminar	WP 6.1 Measurement Techniques in Magnetism	WiSe	30 h (2 SWS)	60 h	(3)
Practical course	WP 6.2 Application of Magnetic Methods in Practice	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other Programmes	None
Elective guidelines	The module can be chosen in compliance with the following rule: With regard tot he compulsory elective modules WP 4 – WP 6, one compulsory elective module must be chosen.
Entry requirements	None
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	This module teaches students advanced knowledge, from both a theoretical and practical point of view, concerning the observation and modelling of the Earth's magnetic field. WP 6.1 Measurement Techniques in Magnetism This course focusses on the various measurement techniques to investigate the evolution of the Earth's magnetic field, starting from the acquisition of data to their interpretation using mathematical tools. Observational techniques: • observatory and satellite measurements • archaeo- and palaeomagnetic measurements • measurements of sea-floor magnetic anomalies Mathematical techniques: • potential field representation of the magnetic field • spherical harmonic models of the historical field

	• stastistical models of the ancient field WP 6.2 Application of Magnetic Methods in Practice This course based on tutorials and practicals deepens methodological aspects related to the observation and modelling of the Earth's magnetic field. observational aspects: • conducting absolute measurements with a fluxgate theodolite • measuring scalar fields with a proton magnetometer • measuring field components with a fluxgate magnetometer physical aspects: • calculating magnetic fields from Maxwell's equations • solving simple induction problems • deriving the geodynamo's equations computational aspects: • representing the field using spherical harmonic models • creating his own inverse problems to describe the field • running dynamo simulations to mimick the field behaviour
Learning outcomes	After successful participation in this module students will have a deepened knowledge of the techniques to observe the Earth's magnetic field and interpret its evolution. Students will be qualified to conduct magnetic measurements and their interpretation in an autonomous way.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Dr. Florian Lhuillier, Department of Earth and Environmental Sciences, Ludwig- Maximilians-Universität München
Language(s)	English

Additional information	None

Module: WP 7 Gravity and Magnetic Field from Space

Programme	Master's Programme: Geophysics (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 7.1 Gravity and Magnetic Field from Space (Lecture)	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other Programmes	Master's programme Earth Oriented Space Science at TU Munich, part of the module "Earth Observation Satellites"
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory elective modules WP 1 – WP 21, there must be taken modules with a total of 12 ECTS credits. By choosing the compulsory elective module WP 7, you may not choose the compulsory elective module WP 8 and vice versa. By choosing the compulsory elective module WP 13, you may not choose the compulsory elective module WP 14 and vice versa.
Entry requirements	None
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	The module introduces students to potential field theory including: • principles of satellite gravimetry and magnetometry • mission concept and goals of the satellite gravity missions CHAMP, GRACE, GOCE • mission concept and goals of the magnetic field missions ØRSTED, SAC-C, SWARM • applications of satellite gravity and magnetic field data in earth sciences
Learning outcomes	After the successful completion of the module, students are able to • to understand the basics of potential field theory and the mathematical description of the Earth s gravity and magnetic field • to understand the basic mission concepts and objectives of satellite gravity and magnetic field missions

	• to recognize the relationship between the measurements and the respective potential field parameters • to apply these concepts for the solution of practical problems • to analyze and to interpret the results • to link the observation of the global gravity and magnetic field and its changes to the global monitoring of the Earth system
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Roland Pail, Department of Civil, Geo and Environmental Engineering, Technical University of Munich
Language(s)	English
Additional information	Literature: • Wolfgang Torge, and Jürgen Müller, Jürgen, *Geodesy,* 4th ed., De Gruyter, 2012 • Claudia Stolle, Nils Olsen, Arthur D. Richmond and Hermann J. Opgenoorth (Hg.), Earth's magnetic field - Understanding Geomagnetic Sources from the Earth's Interior and its Environment, Springer, Space sciences series of ISSI, vol. 60, 2018

Module: WP 8 Gravity Field and Satellite Missions

Programme	Master's Programme: Geophysics (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 8.1 Gravity Field and Satellite Missions (Lecture)	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other Programmes	Master's programme Geodesy and Geoinformation at TU Munich
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory elective modules WP 1 – WP 21, there must be taken modules with a total of 12 ECTS credits. By choosing the compulsory elective module WP 7, you may not choose the compulsory elective module WP 8 and vice versa. By choosing the compulsory elective module WP 13, you may not choose the compulsory elective module WP 14 and vice versa.
Entry requirements	None
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	This module exposes students to topics in the field of gravity measurements and associated satellite mission. It improves their knowledge about: • Methods of global gravity field determination • Gravity field data sources • Data combination & combined solutions • Quality analysis and validation • Satelliten missions: Gravity field, Altimetry • Future mission concepts
Learning outcomes	After successful participation in this module students are capable to • understand the mathematical basis of gravity field determination, • apply the methods of gravity field determination, • apply gravity field observation techniques, • analyze real gravity data, • apply methods of gravity data combination,

	• assess different and complementary techniques as well as the quality of gravity field models, • develop concepts for future gravity field observation from space, and • assess the impact of different observation concepts to geoscientific tasks and objectives.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Dr. Thomas Gruber, Department of Civil, Geo and Environmental Engineering, Technical University of Munich
Language(s)	English
Additional information	Literature: • Hofmann-Wellenhof B., Moritz H., *Physical Geodesy,* Springer • Torge W., *Geodäsie*, De Gruyter, Berlin • script of the lecture • selected actual publications from journals and/or science reports • information material for satellite missions

Module: WP 9 Orbit Mechanics

Programme	Master's Programme: Geophysics (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 9.1 Orbit Mechanics (Lecture)	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other Programmes	Master's programme Earth Oriented Space Science at TU Munich, part of the module "Introduction to Satellite Navigation and Orbit Mechanics"
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory elective modules WP 1 – WP 21, there must be taken modules with a total of 12 ECTS credits. By choosing the compulsory elective module WP 7, you may not choose the compulsory elective module WP 8 and vice versa. By choosing the compulsory elective module WP 13, you may not choose the compulsory elective module WP 14 and vice versa.
Entry requirements	None
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	Satellite-based observation techniques play an important role for data acquisition and monitoring for geophysical applications. This course shall make the students familiar with fundamentals of celestial mechanics, representation of orbits and applications for specific orbit types. The course contains: • reference systems in space and time for representing orbits • two-body problem and Keplerian motion of satellites • orbit representations, Keplerian elements, groundtracks, repeat orbits • orbit perturbations, osculating elements, Gaussian perturbation equations, types of perturbations • gravitational perturbations by third bodies and Earth's gravity field

	• special orbit types: GNSS, geostationary, sun-synchronous, critical inclination, frozen orbits Labs with Matlab are integrated into the course to deepen the understanding in representing orbits in different frames and in calculation of ephemerides of artificial Earth satellites.
Learning outcomes	After successful participation in this module students are able to understand the basic concepts and methods of celestial mechanics, to understand and interpret the motion of satellites, to compute ephemerides of Earth satellites and to convert them to different reference frames, to understand the concept of orbit perturbations, to analyze and to assess the properties of special orbits and to understand their use for specific applications, to understand the concept of ground track repeatability and its relevance in practice.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Urs Hugentobler, Department of Civil, Geo and Environmental Engineering, Technical University of Munich
Language(s)	English
Additional information	Literature: Montenbruck and Gill, „Satellite Orbits“, Springer, 2000

Module: WP 10 Remote Sensing

Programme	Master's Programme: Geophysics (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Integrated learning activity	WP 10.1 Photogrammetry and Remote Sensing	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other Programmes	Master's programme Earth Oriented Space Science at TU Munich, part of the module "Introduction to Photogrammetry, Remote Sensing and Digital Image Processing"
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory elective modules WP 1 – WP 21, there must be taken modules with a total of 12 ECTS credits. By choosing the compulsory elective module WP 7, you may not choose the compulsory elective module WP 8 and vice versa. By choosing the compulsory elective module WP 13, you may not choose the compulsory elective module WP 14 and vice versa.
Entry requirements	None
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	This module introduces student to topics from the the field of photogrammetra and remote sensing such as: • the definition Photogrammetry and Remote Sensing • characteristics of Photogrammetry, applications and development • characteristics of Remote Sensing, applications and development • introduction to Photogrammetry: stereoscopic vision and measurement, photogrammetric image analysis, digital stereo processing • introduction to Remote Sensing: Radiometric basics, multispectral classification • optical basics: models and geometric quality of optical projections, description of image quality
Learning outcomes	After successful participantion students:

	• are capable of analysing applications from different points of view • can plan aerial image campaigns • understand the principles of stereoscopic records • are able to evaluate stereo records and produce anaglyphe images • understand concepts of photogrammetric image analysis • remember the physical basics of the electromagnetic spectrum and radiometric basics • understand the principles of supervised and unsupervised classification • can apply different classifiers and evaluate the classification results
Type of examination	Written exam
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Ludwig Hoegner, Department of Civil, Geo and Environmental Engineering, Technical University of Munich
Language(s)	English
Additional information	Literature: • Albertz J., Wiggenhagen M., *Taschenbuch zur Photogrammetrie und Fernerkundung*, Wichemann, Heidelberg, 2008 • Kraus K., *Photogrammetrie Band 1: Geometrische Informationen aus Photographien und Laserscanneraufnahmen*, deGruyter, Berlin, 2003 • Albertz J, *Grundlagen der Interpretation von Luft- und Satellitenbildern*, Wissenschaftliche Buch-gesellschaft, Darmstadt, 2001

Module: WP 11 Deformation and Transformation

Programme	Master's Programme: Geophysics (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Integrated learning activity	WP 11.1 Rheology of Rocks	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other Programmes	The module appears as WP 25.1 Rheology of Rocks in the master's programme Geomaterials and Geochemistry .
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory elective modules WP 1 – WP 21, there must be taken modules with a total of 12 ECTS credits. By choosing the compulsory elective module WP 7, you may not choose the compulsory elective module WP 8 and vice versa. By choosing the compulsory elective module WP 13, you may not choose the compulsory elective module WP 14 and vice versa.
Entry requirements	None
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	The module presents modern concepts of deformation and transformation processes in rocks of the Earth's interior. The students will learn how to use the microfabric of rocks to infer the deformation mechanisms, transformation processes and conditions. Flow laws and paleopiezometers derived from deformation experiments are discussed and applied to specific microfabrics to obtain quantitative data on the stress and strain rate history. The topics will be addressed by a combination of lectures and exercises. The primary goal is to enable students to use the grain-scale microstructural record of metamorphic rocks to obtain information on the deformation and stress history and to relate this to the large-scale rheological behaviour of the lithosphere.
Learning outcomes	The learning outcomes of this module are for students to acquire advanced knowledge and to connect theory and practice in interpreting geological events on the base of the

	deformation and transformation record of rocks. It is also to enable students to learn, understand and critically discuss the microstructural record, limits and terminology that define the fields of deformation and transformation of rocks, as well as to apply this knowledge in solving specific problems on the rheology of rocks.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Claudia Trepmann, Department of Earth and Environmental Sciences, Ludwig- Maximilians-Universität München
Language(s)	English
Additional information	None

Module: WP 12 Active Tectonics

Programme	Master's Programme: Geophysics (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Integrated learning activity	WP 12.1 Modern Active Tectonics	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other Programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory elective modules WP 1 – WP 21, there must be taken modules with a total of 12 ECTS credits. By choosing the compulsory elective module WP 7, you may not choose the compulsory elective module WP 8 and vice versa. By choosing the compulsory elective module WP 13, you may not choose the compulsory elective module WP 14 and vice versa.
Entry requirements	None
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	This module represents a subdiscipline of geology that studies processes related to active deformation of the Earth's lithosphere. The students are introduced to the modern concepts from active tectonics that underlie our current understanding of the deformation the Earth. Special emphasis is placed on seismotectonics and on the tectonics and mechanics of accretionary wedges, orogenic wedges, and subduction zones. Specific topics treated in this module component change on a yearly basis.
Learning outcomes	The goal of this module is for students to acquire advanced knowledge and to connect theory and practice in the field of modern active tectonics. It is also to enable students to learn and understand the specific features, limits and terminology that define this field, and to apply their knowledge in solving specific problems.

Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Dr. Sara Carena, Department of Earth and Environmental Sciences, Ludwig- Maximilians-Universität München
Language(s)	English
Additional information	None

Module: WP 13 Geophysical Methods in Archaeology

Programme	Master's Programme: Geophysics (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 13.1 Archaeological Prospection and Aerial Archaeology	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other Programmes	The module can be chosen by students oft he master's programme in „Vor- und frühgeschichtliche Archäologie" as WP 16.
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory elective modules WP 1 – WP 21, there must be taken modules with a total of 12 ECTS credits. By choosing the compulsory elective module WP 7, you may not choose the compulsory elective module WP 8 and vice versa. By choosing the compulsory elective module WP 13, you may not choose the compulsory elective module WP 14 and vice versa.
Entry requirements	None
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	• Application of modern geophysical methods like gravimetry, seismic & geoelectric methods, magnetometry and GPR • Introduction in the practical use of these techniques applied to environmental and industrial questions, interpretation of such data and avoiding errors • theoretical basics and physical parameters of the geophysical methods • current examples and case studies in e.g. geology, site investigation, pollution management, non-destructive testing and mineral deposit mapping
Learning outcomes	The aim of the module is to develop in-depth knowledge and obtain hands-on experience of applied geophysical methods, data acquisition, data interpretation and evaluation applied to environmental and industrial problems. After successful participation students are in the

	position to choose and apply the right geophysical method to solve corresponding problems as well as to evaluate and interprete the geophysical data of such sites. Students are able to explain the societal importance of these geophysical techniques.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Dr. Roland Linck, Bavarian State Office for t he Preservation of Monuments
Language(s)	English
Additional information	None

Module: WP 14 Geophysical Methods in Engineering

Programme	Master's Programme: Geophysics (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 14.1 Engineering Geophysics	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other Programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory elective modules WP 1 – WP 21, there must be taken modules with a total of 12 ECTS credits. By choosing the compulsory elective module WP 7, you may not choose the compulsory elective module WP 8 and vice versa. By choosing the compulsory elective module WP 13, you may not choose the compulsory elective module WP 14 and vice versa.
Entry requirements	None
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	• Application of modern geophysical methods like gravimetry, seismic & geoelectric methods, magnetometry and GPR • Introduction in the practical use of these techniques applied to environmental and industrial questions, interpretation of such data and avoiding errors • theoretical basics and physical parameters of the geophysical methods • current examples and case studies in e.g. geology, site investigation, pollution management, non-destructive testing and mineral deposit mapping
Learning outcomes	The aim of the module is to develop in-depth knowledge and obtain hands-on experience of applied geophysical methods, data acquisition, data interpretation and evaluation applied to environmental and industrial problems. After successful participation students are in the position to choose and apply the right geophysical

	method to solve corresponding problems as well as to evaluate and interprete the geophysical data of such sites. Students are able to explain the societal importance of these geophysical techniques.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Dr. Roland Linck, Bavarian State Office for t he Preservation of Monuments
Language(s)	English
Additional information	None

Module: WP 15 Geophysical Inverse Problems

Programme	Master's Programme: Geophysics (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Integrated learning activity	WP 15.1 Inverse Problems in Geophysics	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory course
Usability of the module in other Programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory elective modules WP 1 – WP 21, there must be taken modules with a total of 12 ECTS credits. By choosing the compulsory elective module WP 7, you may not choose the compulsory elective module WP 8 and vice versa. By choosing the compulsory elective module WP 13, you may not choose the compulsory elective module WP 14 and vice versa.
Entry requirements	None
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	Fundamental theory of linear(-ized) and nonlinear inverse problems, probabilistic inverse problems, parameter space sampling with applications to geophysics.
Learning outcomes	The student can relate data fitting problems to corresponding inverse problem methodologies and has a fundamental understanding of the pros and cons of the various approaches.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.

Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Heiner Igel, Department of Earth and Environmental Sciences, Ludwig- Maximilians-Universität München
Language(s)	English
Additional information	None

Module: WP 16 Principles of Geology

Programme	Master's Programme: Geophysics (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Integrated learning activity	WP 16.1 Tectonics, Geomorphology and Stratigraphy	WiSe	30 h (2 SWS)	60 h	(3)
Exercise	WP 16.2 Tectonics, Geomorphology and Stratigraphy (Tutorial)	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other Programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory elective modules WP 1 – WP 21, there must be taken modules with a total of 12 ECTS credits. By choosing the compulsory elective module WP 7, you may not choose the compulsory elective module WP 8 and vice versa. By choosing the compulsory elective module WP 13, you may not choose the compulsory elective module WP 14 and vice versa.
Entry requirements	None
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	This module represents the subdisciplines of geology that study processes which are in part sensitive to convective activity in the sublithospheric mantle, including tectonics, geomorphology and stratigraphy. In principles of geology the students are introduced to the modern concepts from tectonics, geomorphology and stratigraphy that form the basis of these subdisciplines. Special emphasis is placed on an integrative approach to the analysis of these processes that also involves considerations of convective stresses in the sublithospheric mantle. Specific topics treated in this module component change on a yearly basis.

Learning outcomes	The goal of this module is for students to acquire advanced knowledge and to connect theory and practice in the concepts of tectonics, geomorphology and stratigraphy with broad geodynamic considerations. It is also a goal to enable students to learn and understand the specific features, limits and terminology that define each field, and to apply this knowledge in solving specific problems.
Type of examination	Written exam or oral examination or written report or presentation
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Anke Friedrich, Department of Earth and Environmental Sciences, Ludwig- Maximilians-Universität München
Language(s)	English
Additional information	None

Module: WP 17 Precise Global Navigation Satellite Systems

Programme	Master's Programme: Geophysics (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 17.1 Precise Global Navigation Satellite Systems (Lecture)	WiSe	30 h (2 SWS)	60 h	(3)
Exercise	WP 17.2 Labs in Precise Global Navigation Satellite Systems	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other Programmes	Master's programme Earth Oriented Space Science at TU Munich, module is similar to module "Precise GNSS"
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory elective modules WP 1 – WP 21, there must be taken modules with a total of 12 ECTS credits. By choosing the compulsory elective module WP 7, you may not choose the compulsory elective module WP 8 and vice versa. By choosing the compulsory elective module WP 13, you may not choose the compulsory elective module WP 14 and vice versa.
Entry requirements	None
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	Precise positioning and monitoring using Global Navigation Satellite Systems (GNSS) play an important role in the areas of tectonics and geodynamics. This module allows students to obtain basic knowledge on GNSS, to get familiar with data, models, analysis strategies, and applications. The module consists of a lecture and a lab: Precise GNSS lecture: • principle of GNSS and status, signal structure, operations of current systems (GPS, GLONASS, Galileo, BeiDou)

	• analyzing and modelling methods, propagation corrections, methods for ambiguity resolution, relevance for reference systems • application of high-precision GNSS in geodesy and geodynamic studies Precise GNSS lab: • practical exercises with real-world GNSS data in the computer room • investigation of the influence of different effects and analysis strategies and use of evaluation methods for positioning results by advanced experiments with a scientific analysis software • students work in groups and preparate short reports or presentations of their results
Learning outcomes	After successful participation in this module students are able to understand, interpret and describe the concept of GNSS and the measuring and modelling methods of GNSS and they are able to optimize analysis strategies to specific use cases and to assess the quality of positioning results.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Urs Hugentobler, Department of Civil, Geo and Environmental Engineering, Technische Universität München
Language(s)	English
Additional information	Literature: • Hofmann-Wellenhof, Lichtenegger, Collins, "GPS-Theory and Practice", Springer, 2001 • Teunissen, Montenbruck (Eds.) , "Handbook of Global Navigation Satellite Systems", Springer, 2017 • Bernese GNSS Software Version 5.2 User Manual

Module: WP 18 Atmosphere and Oceans

Programme	Master's Programme: Geophysics (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 18.1 Atmospheric Physics and Remote Sensing	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 18.2 Satellite Altimetry and Physical Oceanography	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other Programmes	Master's programme Earth Oriented Space Science at TU Munich
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory elective modules WP 1 – WP 21, there must be taken modules with a total of 12 ECTS credits. By choosing the compulsory elective module WP 7, you may not choose the compulsory elective module WP 8 and vice versa. By choosing the compulsory elective module WP 13, you may not choose the compulsory elective module WP 14 and vice versa.
Entry requirements	None
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	The module consists of two lectures "Atmospheric Physics and Remote Sensing" and "Oceanography and Satellite Altimetry" that are addressing aspects of the important and tighly coupled Earth system components atmosphere and ocean in a complemenary and integrative manner. WP 18.1 Atmospheric Physics and Remote Sensing Introduction to atmospheric physics with an emphasis on remote sensing of atmospheric components and processes from space: • atmospheric layers, circulation and greenhouse effect • atmospheric composition • water vapor and carbon dioxide • aerosols, clouds, and Earth's radiation budget • atmospheric dynamics • passive Remote Sensing • lidar remote sensing of aerosols

	• wind and water vapor lidars • meteorology and weather forecasts • global climate change • new observational needs WP 18.2 Oceanography and Satellite Altimetry • equation of motion • geostrophic currents • hydrostatic balance • temperature, salinity, and density • ocean tides, tidal analysis • radar altiemtry: signal theory and estimation process • radar altimetry: atmosperhic and geophysical corrections to estimate sea level • altimeter mission overview • description of altimetry data products • repeat pass and crossover analysis • mean sea surface, geoid, dynamic ocean topography, sea level variability, sea level rise
Learning outcomes	After the successful conclusion of the module, the students are able • to understand the basic principles of atmosphere, weather, and climate and the methods for determining • atmospheric composition and dynamics from space, • to apply these principles and methods for practical problems, • to apply the most basic principles of physical oceanography and recognize satellite altimetry as an operational • remote sensing technique with important applications in geodesy, oceanography and other geosciences, • to understand the concept of satellite altimeter missions, • to apply altimetric observation techniques and the necessary measurement correction, • to know about data and product availability and data access, • to understand important analysis methods in satellite altimetry, and • to apply them to practical problems, • to understand the geophysical application of satellite altimetry and, • to develop overarching concepts for monitoring several components of the Earth system
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential

	elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Roland Pail, Department of Civil, Geo and Environmental Engineering, Technische Universität München
Language(s)	English
Additional information	Literature: • U. Schumann, Atmospheric Physics, Research Topics in Aerospace series, Springer, 2012 • F.W. Taylor, *Elementary Climate Physics*, Oxford University Press, 2005 • J.M. Wallace and P.V. Hobbs, *Atmospheric Science: An Introductory Survey*, Academic Press, 2nd edition, 2006 • W. Roedel*, Physik unserer Umwelt: Die Atmosphäre*, Springer, 3. Auflage, 2000 • L. Bergmann und C. Schaefer, *Lehrbuch der Experimentalphysik Band 7: Erde und Planeten*, de Gruyter, 2. Auflage, 2001 • Stewart, R., *Introduction to Physical Oceanography* open source book • Fu, L.L. and A. Cazenave (Eds.), *Satellite Altimetry*, International Geophysics Series, Vol. 69, San Diego, CA, 2000

Module: WP 19 Rheology and Thermal Analysis of Melts

Programme	Master's Programme: Geophysics (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 19.1 Theory of Physics and Chemistry of Melts	WiSe	30 h (2 SWS)	60 h	(3)
Integrated learning activity	WP 19.2 Applied Physics and Chemistry of Melts	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other Programmes	The module appears as P 7 Rheology and Thermal Analysis of Melts in the master's programme Geomaterials and Geochemistry
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory elective modules WP 1 – WP 21, there must be taken modules with a total of 12 ECTS credits. By choosing the compulsory elective module WP 7, you may not choose the compulsory elective module WP 8 and vice versa. By choosing the compulsory elective module WP 13, you may not choose the compulsory elective module WP 14 and vice versa.
Entry requirements	None
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	This module conciliates knowledge of the central role that silicate melts play in both nature and technology and the potential of glass as a monitor of the processes involved. P 7.1 Theory of Physics and Chemistry of Melts (Lecture) The lecture will focus on geo-scientifically and techno-logically important properties of natural and synthetic glasses, melts and magma. Methods to measure rheologic and thermodynamic properties like the glass transition, volume, density, enthalpy and derivative properties like heat capacity and thermal expansivity are introduced. The effect of temperature, pressure and composition on these properties is analysed. Finally recent models for prediction are discussed and case studies are presented.

	P 7.2 Applied Physics and Chemistry of Melts (Exercise) The course deepens the contents of the accompanying lecture and serves the practice of the techniques presented there.
Learning outcomes	At the end of the module the students have acquired a deeper understanding of the basic nature of the molten and glassy state of silicates and the description of their petrogenetically and technologically relevant properties and processes.
Type of examination	Written exam or roal examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Dr. Kai-Uwe Hess, Department of Earth and Environmental Sciences, Ludwig- Maximilians-Universität München
Language(s)	English
Additional information	None

Module: WP 20 Geokinematics and Continental Hydrology

Programme	Master's Programme: Geophysics (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 20.1 Geokinematics	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 20.2 Continental Hydrology	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other Programmes	Master's programme Earth Oriented Space Science at TU Munich
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory elective modules WP 1 – WP 21, there must be taken modules with a total of 12 ECTS credits. By choosing the compulsory elective module WP 7, you may not choose the compulsory elective module WP 8 and vice versa. By choosing the compulsory elective module WP 13, you may not choose the compulsory elective module WP 14 and vice versa.
Entry requirements	None
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	• Introduction: concepts of geodetic reference systems, their realizations, the International Terrestrial Reference System (ITRS) • The ITRF: General aspects, review on existing ITRS realizations, geodetic space techniques, combination strategies, inconsistencies and challenges • Alternative reference frames: epoch reference frames, regional reference frames • Current developments and most recent research topics: non-linear station motions, physical datum definition, the Global Geodetic Observing System (GGOS), inter-disciplinary scientific applications • Satellite radar altimetry for inland water bodies, Inland altimetry databases • Other space-based hydrogeodetic observation techniques: Laser and Delay Doppler/SAR altimetry, GNSS-reflectometry, GRACE-FO, SWOT • Monitoring of rivers systems and estimation of river discharge • Volume changes of lakes

	• Observing continental hydrology with the GRACE gravity mission • Assimilation/calibaration of hydrologocal models using hydrogeodetic information • Numerical exercises: Computation of water levels, river discharge and lake volume changes from satellite altimetry data
Learning outcomes	After the successful completion of the module, the students are able to • understand the definition and the datum realization of the ITRS, • classify different realizations of geodetic reference systems (regional, global, epoch-wise, multi-year), • evaluate observations of space geodetic observation techniques regarding information content and accuracy, • describe different concepts for the realization of the ITRS, • discuss inconsistencies and to evaluate current limitations of current ITRS realizations, • assess the potential of current developments for the accuracy of terrestrial reference frames, • describe the importance of accurate terrestrial reference frames for various inter-disciplinary applications, • understand the measurement principle of radar altimetry and its potential for hydrological applications, • apply satellite altimetry data for the estimation of lake volumes and river discharge, • evaluate the quality of inland altimetry data, and • understand the application of satellite data for the calibration of hydrological models
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Florian Seitz, Department of Aerospace Engineering and Geodesy, Technische Universität München, Technische Universität München
Language(s)	English
Additional information	Literature for Geokinematics: • Lecture Notes

- Kovalevsky J., Mueller I., Kolaczek B., *Reference Frames in Astronomy and Geophysics*, Kluwer Academic Publishers, Dordrecht, 1989
- Seeber G., *Satellite Geodesy*, Walter de Gruyter, Berlin, 2003
- Xu G., *Sciences in Geodesy-I/II*, Springer, Berlin, 2010/2013
- Plag H.-P., Pearlman M., *Global Geodetic Observing System*, Springer, Berlin, 2009
- Selected scientific publications (distributed in the course)

Literature for Hydrogeodesy:

- Lecture notes
- Fu L., Cazenave A., *Satellite Altimetry and Earth Sciences: A Handbook of Techniques and Applications*, 2000
- *International Geophysics Series*, Vol. 69, San Diego, CA
- Calmant et al., *Monitoring Continental Surface Waters by Satellite Altimetry*, Surv. Geophys. 29:247-269, 2008
- Selected scientific publications (distributed in the course)

Module: WP 21 Petrophysics

Programme	Master's Programme: Geophysics (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 21.1 Petrophysics (Lecture)	WiSe	30 h (2 SWS)	60 h	(3)
Exercise	WP 21.2 Petrophysics (Exercise)	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other Programmes	The module appears as P 2 Petrophysics in the master's programme Geomaterials and Geochemistry
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory elective modules WP 1 – WP 21, there must be taken modules with a total of 12 ECTS credits. By choosing the compulsory elective module WP 7, you may not choose the compulsory elective module WP 8 and vice versa. By choosing the compulsory elective module WP 13, you may not choose the compulsory elective module WP 14 and vice versa.
Entry requirements	None
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	This module investigates the physical properties of rocks (and other geomaterials) such as for instance porosity, permeability, elastic and mechanical properties, thermal and electrical properties. WP21.1 Petrophysics (Lecture) The students are introduced to the theoretical background of petrophysics. Petrophysical properties are explored in the light of the different rock types. The properties are discussed individual as well as against each other. Methods of measuring these properties (direct or indirect are discussed) are discussed and examples for the usage of petrophysical properties in different fields of geomaterials and geoscience are given.

	WP21.2 Petrophysics (Exercise) The students will be introduced to some of the laboratory methods explained in WP21.1 and will train to apply these methods in laboratory exercises; they will learn to interpret and discuss the results of their measurements.
Learning outcomes	At the end of the module the student are familiar with petrophysical properties of different rock types. The students will be able to understand or interpret petrophysical parameters of different geomaterials. The students can apply methods they learned in the practical part of the module.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	PD Dr. Bettina Scheu, Department of Earth and Environmental Sciences, Ludwig- Maximilians-Universität München
Language(s)	English
Additional information	None

Module: P 11 Final Module

Programme	Master's Programme: Geophysics (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Master's Thesis	P 11.1 Master's Thesis	WiSe and SoSe	-	870 h	(29)
Disputation	P 11.2 Disputation	WiSe and SoSe	-	30 h	(1)

For successful completion of the module, 30 ECTS credits have to be acquired. Class attendance averages about 0 contact hours. Including time for self-study, 900 hours have to be invested.

Module type	Mandatory module
Usability of the module in other Programmes	None
Elective guidelines	None
Entry requirements	Successful completion of the module P 7 and of a total of at least 15 ECTS credits from modules P 5, P 6, P 8 and WP 1 – WP 3
Semester	Recommended semester: 4
Duration	The completion of the module takes 1 semester.
Content	This module consists of two parts. In the first part students are expected to perform independent scientific research on a complex problem of geophysics under the guidance of one or multiple advisors and to develop a new solution to the problem. In the second part the results of this research must adequately be presented by writing a scientific work and giving an oral presentation as well as discussing the results obtained with colleagues and scientists from the field of geophysics.
Learning outcomes	Students learn to transfer their advanced and technical knowledge in geophysics as well as their scientific competences in geophysics to a scientific research problem. They are able to solve a complex scientific problem independently, create, evaluate and interpret scientific data sets and write a scientific report. Students are in the position to discuss and

	present their results in front of a critical scientific audience.
Type of examination	Master's thesis and disputation
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Dr. Marcus Mohr, Department of Earth and Environmental Sciences, Ludwig- Maximilians-Universität München
Language(s)	English
Additional information	None