2015

MATHEMATISCH-
NATURWISSENSCHAFTLICHE
FAKULTÄT

*MATHEMATICS AND
NATURAL SCIENCES*

UNIVERSITÄT ZU KÖLN

UNIVERSITY OF COLOGNE

DEKANAT

DEAN'S OFFICE

MODULHANDBUCH
MODULE HANDBOOK

PHYSICS OF THE EARTH AND ATMOSPHERE

MASTER OF SCIENCE

VERSION 1.2

NACH DER PRÜFUNGSORDNUNG FÜR DEN MASTER-STUDIENGANG
PHYSICS OF THE EARTH UND ATMOSPHERE

*AFTER THE EXAMINATION REGULATIONS FOR THE MASTERS COURSE
PHYSICS OF THE EARTH UND ATMOSPHERE*

(FASSUNG vom 25.09.2015)

Universität zu Köln

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VERSION	28.06.2017

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Legende / *Abbreviations*

CP	*Credit Points*		
K	Kontaktzeit (engl. Contact time)		
LP	Leistungspunkte (engl. Credit points)		
WL	*Workload*		
WiSe	Wintersemester		
WT	*Winter term*		
SoSe	Sommersemester		
ST	*Summer term*		
VN	Vor-und Nachbereitungszeit (engl.: Time for preparation)		
TP	Teilnahmepflicht		
CA	Compulsory attendance		

Inhaltsverzeichnis / *contents*

1 Das Studienfach Physik der Erde und Atmosphäre / *The study programme Physics of the Earth and Atmosphere*

Der Masterstudiengang „Physics of the Earth and Atmosphere“ vereint die beiden Fachrichtungen „Geophysik“ und „Meteorologie“ in einem Studiengang und wird mit diesen beiden Schwerpunkten angeboten. Der Studiengang wird in englischer Sprache angeboten. Er findet in Kooperation mit der Universität Bonn statt. Die Regelstudienzeit beträgt 4 Semester. Bei erfolgreichem Abschluss wird der Hochschulgrad „Master of Science“ verliehen.

The master's degree „Physics of the Earth and Atmosphere“ combines the two disciplines "Geophysics" and "Meteorology" and is offered with these two focusses. The course is offered in English. It is offered in cooperation with the University of Bonn. The default duration of study is 4 semesters. Upon successful completion of university degree "Master of Science" will be awarded.

1.1 Inhalte, Studienziele und Voraussetzungen / *Content, course objectives and prerequisites*

Das Studium des Masterstudiengangs Physics of the Earth and Atmosphere vermittelt die erforderlichen Kenntnisse in Geophysik und Meteorologie, die dann zum Verständnis der vielfältigen Prozesse im System Erde führen. Die Studierenden erhalten darüber hinaus Einblicke in aktuelle Forschung in den Bereichen Messtechnik und Modellierung in beiden Fachbereichen.

The study of the Master's program in Physics of the Earth and Atmosphere provides the necessary knowledge of geophysics and meteorology, which then leads to an understanding of the various processes in the Earth’s system. Students will also receive insights into current research in the fields of measurement and modeling in both subject areas.

1.2 Studienaufbau und –abfolge / *Study design and sequence*

Das Studium ist in zwei Abschnitte gegliedert. Im ersten Studienjahr werden in Modulen, die aus Vorlesungen und Übungen bestehen, aufbauend auf den Inhalten des Bachelorstudiengangs Geophysik und Meteorologie (oder eines vergleichbaren anderen Bachelorstudiengangs) die Fachkenntnisse vertieft. Dieser Studienabschnitt ist stark lehreorientiert.

Im zweiten Studienjahr finden hingegen forschungsorientierte Module (Literature Seminar and Current Research Questions, Project Work, Master Thesis) statt. Das Studium kann sowohl im Winter- als auch im Sommersemester begonnen werden.

The course is divided into two principal sections. In the first year of study the modules, consisting of lectures and exercises, are based on the contents of the bachelor program Geophysics and Meteorology (or other comparable bachelor's degree) and deepen the knowledge. This study section is strongly course-oriented.

In the second year research-oriented modules (Literature Seminar and Current Research Questions, Project Work, Master Thesis) are offered. The course can be started both in winter and in summer semester.

1.3 LP-Gesamtübersicht */ CP- Overview*

Die 120 LP des Masterstudiums teilen sich in 90 LP für das Fachstudium und 30 LP für die Masterarbeit.

Die Masterarbeit schließt das Studium ab. Sie behandelt ein eigenständig zu bearbeitendes begrenztes Thema der Geophysik oder Meteorologie, welches mit einer schriftlichen Ausarbeitung dokumentiert, sowie in einem Kolloquium mündlich vorgetragen wird.

The 120 CP of the master's program is divided into 90 CP for course modules and 30 CP for the master's thesis.
The Master thesis concludes the study. It treats a defined topic of geophysics or meteorology, to be worked out by the student in a self-dependent way in a written report, and to be presented orally in a colloquium.

LP- Gesamtübersicht / *CP- Overview*	
Fachstudium / *Course Studies*	**90 CP**
Masterarbeit / *Master Thesis*	**30 CP**
Summe / *Sum*	**120 LP**

1.4 Semesterbezogene LP-Übersicht / *Semester-based CP- Overview*

LP-Übersicht / *CP-Overview*				
Sem.	**Modul**	**K**	**VN**	**LP / CP**
1	Prognostic Modelling	60	120	6
1	GEOMET I	75	105	6
1	GEOMET II	75	105	6
1	GEOMET III	60	120	6
1	Elective I	75	105	6
2	Inverse Modelling	60	120	6
2	GEOMET IV	60	120	6
2	GEOMET V	75	105	6
2	Elective II	75	105	6
2	Elective III	75	105	6
3	Literature Seminar and Current Research Questions	30	240	9
3	Project Work	50	410	15
3	Elective IV	75	105	6
4	Master thesis	30	870	30

1.5 Berechnung der Fachnote */ Calculation of the Grade*

Die Fachnote errechnet sich aus den mit den Werten aus der folgenden Tabelle gewichteten Modulnoten dividiert durch die Summe der Gewichte (= 120).

The grade is calculated by dividing the values from the following table with the sum of the weights (= 120) .

Prognostic Modelling PM	6
Inverse Modeling IM	6
Literature Seminar and Current Research Questions LITSEM	9
Project Work PWORK	15
GEOMET I	6
GEOMET II	6
GEOMET III	6
GEOMET IV	6
GEOMET V	6
Elective I	6
Elective II	6
Elective III	6
Elective IV	6
Masterarbeit / Master thesis	30
Summe / Sum	**120**

2 Modulbeschreibungen und Modultabellen / *Description of modules and module tables*

Im Folgenden sind die einzelnen Module im Detail beschrieben. Als „Workload“ wird der Zeitaufwand bezeichnet, den die Studierenden im gesamten Semester für das jeweilige Modul benötigen. Dazu zählt die Kontaktzeit und die Zeit des Selbststudiums (Bearbeitung der Übungen, Vor-und Nachbereitung der Vorlesung etc.). Unter Punkt „Studiensemester“ ist das empfohlene Semester nach Musterstudienplan (s. 3.1) angegeben.

The individual modules are described in detail below. The work load is the time it takes for the students throughout the semester for the entire module. This includes the contact time and the time of self-study (exercise tasks, preparation of the lecture, etc.). Sub-item "term of studying" means the recommended semester based on the suggested study plan (see 3.1).

2.1 Pflichtmodule / *Compulsory terms for Geophysics and Meteorology*

- „Prognostic Modelling (PM)“
- „Inverse Modelling (IM)“
- „Literature Seminar and Current Research Questions (LITSEM)“
- „Project Work (PWORK)“

Compulsory: Prognostic Modelling (PM)

Identification number	Workload	Credits	Term of studying	Frequency of occurrence	Duration
MN-GM-PM	180 h	6	1st or 2nd semester	Winter term	1 semester

1	Type of lessons	Contact times	Self-study times	Intended group size
	a) **Lectures**	30 h	60 h	15
	b) **Tutorials**	30 h	60 h	

2 Aims of the module and acquired skills

Aims: Understanding of prognostic numerical formulation of meteorological and geophysical problems, overview of numerical procedures and their properties and knowledge of model capabilities, limitations and model results interpretations. Acquired skills: skillful applications of meteorological and geophysical models, critical judgment of model simulations and capacity of model development.

3 Contents of the module

- Concepts and framework of meteorological and geophysical prognostic modeling
- Numerical methods for ordinary and partial differential equations
- Numerical methods used in meteorological, geophysical and space-plasma prognostic models
- Initial and boundary conditions
- Examples of meteorological (e.g. COSMO, ICON), geophysical and space-plasma models

4 Teaching/Learning methods

Lectures and tutorials. Compulsory attendance in tutorials.

5 Requirements for participation

Formal: None.

The content of the course, however, requires the undergraduate knowledge of geophysical fluids, linear algebra and basic skills in programming with Matlab, Fortran, C/C++ or similar.

6 Type of module examinations

Written Examination (graded)

7 Requisites for the allocation of credits

Regular attendance in tutorials, successful completion of at least 50 % of the assigned homework and passing a final examination.

At the end of the semester or the beginning of the following semester a possibility to repeat the examination is offered. A failed examination may be repeated twice. Additional possibilities to repeat an examination exist according to the examination regulations (§ 20 section 1).

Assessments which have been passed are not allowed to be taken again, with one exception: If at the end of a module which consists of a lecture and tutorial classes, the student takes the assessment at the first available date after having received admission to the module exam, he/she is then allowed to take the examination again at the next available date for the purpose of improving the grade, even if he/she passed the assessment the first time – in this case, the better of the two grades will count towards the final degree grade (§ 20 section 9).

The module mark is the grade obtained in the assessment. In the case of two passed assessments the module mark is the better grade.

8	**Compatibility with other Curricula** N/A
9	**Significance of the module mark for the overall grade** 6/120
10	**Module coordinator** Y. Shao, R. Neggers
11	**Additional information** **Recommended Literature:** Haltiner, J. and R.T. Williams, 1980: Numerical Prediction and Dynamic Meteorology, John Wiley & Sons Inc. Coiffier, J., 2009: Fundamentals of Numerical Weather Prediction, Cambridge University Press. Krishnamurti, T.N., H.S. Bedi, V.M. Hardiker and L. Ramaswamy, 2006: An Introduction to Global Spectral Modelling, Springer-Verlag Ames, W.F., 1977: Numerical methods for partial differential equations, Academic Press. Fletcher, C. A. J., 1991: Computational Techniques for Fluid Dynamics, Springer-Verlag. Hoffmann, J. D., 2001: Numerical Methods for Engineers and Scientists. Shearer, P., 2009: Introduction to Seismology, Cambridge University Press. Büchner et al., 2003: Space Plasma Simulation (Lecture Notes in Physics), Springer-Verlag.

Compulsory: Inverse Modelling (IM)

Identification number	Workload	Credits	Term of studying	Frequency of occurrence	Duration
MN-GM-IM	180 h	6	1. or 2. Semester	Summer term	1 Semester

1	Type of lessons	Contact times	Self-study times	Intended group size
	a) **Lectures**	30 h	60 h	15
	b) **Tutorials**	30 h	60 h	

2 Aims of the module and acquired skills

Understanding inverse modelling methods for the determination of meteorological and geophysical parameters from measurements, gaining knowledge in major spatial-temporal data assimilation methods.

Acquired skills are the mathematical foundation of linear and non-linear inverse problems, formulation of inverse problems, assessment of statistical prerequisites and numerical complexity, assessment of inverse solutions, practical limitation of current assimilation methods, critical judgment of model simulations and capacity of model development.

3 Contents of the module

• Basics: Inverse problems in geophysics and data assimilation in meteorology, overview of methods and definitions

• Deterministic approaches: linear problems, general formulation, least-squares method, normal equations, Jacobian matrix, generalised matrix inverse, adjoint and tangent-linear models, SVD

decomposition, data and model gain matrices, data and model covariance matrices (data error and model assessment), nonlinear problems, Jacobian matrix, iterative conjugate gradient and Gauss-Newton methods, regularisation (Occam, Levenberg-Marquardt)

• Stochastic approaches, general formulation, Bayes theorem, optimal estimation, , information content, error assessment

• data assimilation, optimum interpolation, 3d-var, Kalman filtering and 4d-var

• Applications: geoelectric and electromagnetic methods, gravity, magnetics, remote sensing of the atmosphere (humidity and temperature), weather forecasting

4 Teaching/Learning methods

Lectures and tutorials (compulsory attendance in the tutorials)

5 Requirements for participation

Formal: None

Regarding content: Basics of mathematics and physics

6 Type of module examinations

Written examination (graded)

7 Requisites for the allocation of credits

Successful participation in the tutorials (50 % of the possible points have to be obtained) and passing a final examination.

At the end of the semester or to the beginning of the following semester a possibility to repeat the examination is offered. A failed examination may be repeated twice. Additional possibilities to repeat

	an examination exist according to the examination regulations (§ 20 section 1). Assessments which have been passed are not allowed to be taken again. There is an exception: If at the end of a module which consists of a lecture and tutorial classes, the student takes the assessment at the first available date after having received admission to the module exam, he/she is then allowed to take the assessment again at the next available date for the purpose of improving the grade, even if he/she passed the assessment the first time – in this case, the better of the two grades will count towards the final degree grade (§ 20 section 9). The module mark is the grade obtained in the assessment. In the case of two passed assessments the module mark is the better grade.
8	**Compatibility with other Curricula** N/A
9	**Significance of the module mark for the overall grade** 6/120
10	**Module coordinator** B. Tezkan and H. Elbern
	Additional information **Recommended Literature:** Aster, R.C., B. Borchers, C.H. Thurber, Parameter estimation and inverse problems, Elsevier, 2005. Benner, A. F., 2005. Inverse Modeling of the Ocean and Atmosphere. Cambridge University Press, ISBN: 9780521021579. Evensen, G., 2009. Data Assimilation: the Ensemble Kalman Filter. Springer, SBN 978-3-642-03711-5 Kalnay, E., 2003. Atmospheric Modelling, data assimilation and predictability, Cambridge Univ. Press, 342 pp. Meju, M.A., 1994. Geophysical data analysis: Understanding inverse problems, Theory and practice, Society of Exploration Geophysicists. Rodgers, C. D., 2000. Inverse methods for atmospheric sounding: Theory and practice. World Scientific, 238 pp. Menke, W., 2012. Geophysical Data Analysis: Discrete Inverse Theory – 3rd Ed., Elsevier. Oliver et al., 2008, Inverse Theory for Petroleum Reservoir Characterization and History Matching, Cambridge Univ. Press. Tarantola, A., 2005. Inverse Problem Theory and Methods for Model Parameter Estimation. SIAM. ISBN 978-0-89871-572-9.

Compulsory: Literature Seminar and Current Research Questions

Identification number	Workload	Credits	Term of studying	Frequency of occurrence	Duration
MN-GM-LITSEM	270 h	9	3rd semester	Every semester	1 semester

1	Type of lessons	Contact times	Self-study times	Intended group size
	a) **Seminar** b) **Presentation**	30 h	120 h 120 h	15

2 Aims of the module and acquired skills

- Methods of literature research
- Presentation of scientific results
- Preparing for the master thesis
- Scientific writing
- Argumentation
- Teaching and conveyance competence

3 Contents of the module

Students receive a topic of an already concluded module of one's field of attention or electoral module. In a seminar talk the students present the recent state of research. The necessary literature research is conducted independently by the student. The seminar content is also elaborated as a written report. The oral presentation and/or the report can be held in English or German.

4 Teaching/Learning methods

Seminar and presentation with compulsory attendance

5 Requirements for participation

Successful conclusion of at least one module for main focus or an electoral module. (Group of compulsory modules for main focus)

6 Type of module examinations

A combinatorial examination consisting of:

- Oral Examination (graded)
- Written report (graded)

The module mark is the arithmetic average of the two examination elements.

7 Requisites for the allocation of credits

Successful participation in the seminar documented by a written report marked equal or better than 4.0 and passing the oral examination. Each examination part can be repeated once during the semester.

The examination may be repeated twice. Additional possibilities to repeat exist according to the examination regulations (§ 20 section 1).

Assessments which have been passed are not allowed to be taken again. There is an exception: If at the end of a module which consists of a lecture and tutorial classes, the student takes the assessment at the first available date after having received admission to the module exam, he/she is then allowed to take the assessment again at the next available date for the purpose of improving the grade, even if he/she passed the assessment the first time – in this case, the better of the two grades will count

	towards the final degree grade (§ 20 section 9).
8	**Compatibility with other Curricula** N/A
9	**Significance of the module mark for the overall grade** 9/120
10	**Module coordinator** S. Crewell
11	**Additional information** Obligatory literature: Depends on topic.

Compulsory: Project Work

Identification number	Workload	Credits	Term of studying	Frequency of occurrence	Duration
MN-GM-PWORK	450 h	15	3rd Semester	Every semester	1 Semester

1	Type of lessons	Contact times	Self-study times	Intended group size
	a) **Seminar**	30 h	60 h	15
	b) **Project**	20 h	340 h	

2 Aims of the module and acquired skills

Induction in a lengthy recent research theme of geophysics and meteorology and its scientific presentation.

Acquired skills therefore:

- Time management
- Self-reliance
- Effective methods of working
- Rhetoric

3 Contents of the module

The project serves as the preparation for the master thesis and is supposed to build a thematic union with it. Together with the master thesis, the project deals with a lengthy research theme of geophysics or meteorology.

4 Teaching/Learning methods

Seminar (compusolry attendance) and own project

5 Requirements for participation

Acquisition of at least 48 credit points of the master course's modules.

6 Type of module examinations

Oral presentation (graded)

7 Requisites for the allocation of credits

Successful participation in the seminar including a presentation by the student which is graded 4 or better.

A failed presentation may be repeated twice. Additional possibilities to repeat an examination exist according to the examination regulations (§ 20 section 1).

Assessments which have been passed are not allowed to be taken again.

8 Compatibility with other Curricula

None

9 Significance of the module mark for the overall grade

15/120

10 Module coordinator

The chairperson of the examination board

11	**Additional information** Obligatory literature: Depends on topic.

2.2 Pflichtmodule im Schwerpunkt / *Compulsory modules for main focus*

Um das Studium fachlich zu spezifizieren müssen 5 der Pflichtmodule (GEOMET I- V) aus dem Bereich Geophysik oder Meteorologie absolviert werden.

To specify the study the students have to complete the 5 compulsory modules for main focus on geophysics or meteorology (GEOMET I-V).

Pflichtmodule im Schwerpunkt Geophysik / Compulsory *for main focus geophysics:*

- *Direct Current and Electromagnetic Exploration Methods :GEOEEM*
- *Advanced Geophysical Field Course: GEOAFC*
- *Seismology: GEOSEIS*
- *Geophysics of the solar system: GEOSOSYS*
- *Space Physics: GEOSPACE*

Pflichtmodule im Schwerpunkt Meteorologie / *Compulsory for main focus meteorology:*

- *Atmospheric Boundary Layer: METABL*
- *Clouds and Precipitation: METCLOUD*
- *Physical Climatology: METCLIMATE*
- *Atmospheric Dynamics and Modeling: METADM*
- *Radiation: METRAD*

Compulsory for main focus geophysics: Direct Current and Electromagnetic Exploration Methods

Identification number	Workload	Credits	Term of studying	Frequency of occurrence	Duration
MN-GM-GEOEEM	180 h	6	1st – 3rd semester	Winter term	1 Semester

1	Type of lessons	Contact times	Self-study times	Intended group size
	a) **Lectures**	45 h	45 h	15
	b) **Tutorials**	30 h	60 h	

2 Aims of the module and acquired skills

- Knowledge of the principles of electromagnetic methods and overview of their applications
- Theory of electromagnetic methods, data analysis and modeling of DC-resistivity and electromagnetic data in frequency and time domain
- Ability to analyse electromagnetic data and to model them with multidimensional conductivity models

3 Contents of the module

• DC methods: basic equations, potential of the single electrode, solution of the Laplace equation for 1D earth, inversion of DC data, 1D and 2D forward modelling of DC data

• Electromagnetic induction: basic equations, induction in 1D earth, 2D conductivity models, field measurements and data analysis, quantitative interpretation, passive EM methods, active EM methods (Magnetotelluric and Geomagnetic Deep Soundings, Time Domain Methods)

4 Teaching/Learning methods

Lectures and tutorials (compulsory attendance in the tutorials)

5 Requirements for participation

Formal: None

Knowledge of basics of mathematics, physics and applied geophysics is strongly advised.

6 Type of module examinations

Written examination (graded)

7 Requisites for the allocation of credits

Successful participation in the exercises (50 % of the possible points have to be obtained) and passing of the examination.

At the end of the semester or to the beginning of the following semester a possibility to repeat the examination is offered. A failed examination may be repeated twice. Additional possibilities to repeat an examination exist according to the examination regulations (§ 20 section 1).

Assessments which have been passed are not allowed to be taken again. There is an exception: If at the end of a module which consists of a lecture and tutorial classes, the student takes the assessment at the first available date after having received admission to the module exam, he/she is then allowed to take the assessment again at the next available date for the purpose of improving the grade, even if he/she passed the assessment the first time – in this case, the better of the two grades will count towards the final degree grade (§ 20 section 9).

The module mark is the grade obtaines in the assessment. In the case of two passed assessments

	the module mark is the better grade.
8	**Compatibility with other Curricula** • Other modules of equal value can be admitted and announced by the examination board after agreement • Suitable as an elective course for mathematics, physics and geoscience students
9	**Significance of the module mark for the overall grade** 6/120
10	**Module coordinator** B. Tezkan
11	**Additional information** **Recommended literature:** W.E. Telford et. al., Applied Geophysics, Cambridge University Press, 1990. O. Koefed, Geosounding principles, Vol. 1, Springer Verlag, 1985. Nabighian, M.N., Electromagnetic soundings in applied geophysics, SEG,1987. Simpson and Bahr, Practical magnetotellurics, Cambridge University Press, 2005. M.S. Zhadanov and G.V. Keller, The geoelectrical methods in applied geophysics, SEG, 1987. B. Buttkus, Spektralanalyse und Filtertheorie in der Angewandten Geophysik , Springer Verlag, 1991. D. S. Parasanis, Principles of Aplied Geophysics, Halsted Press Book, 1979.

<table>
<tr><th colspan="7">Compulsory for main focus geophysics: Advanced Geophysical Field Course</th></tr>
<tr><td colspan="2">Identification number
MN-GM-GEOAFC</td><td>Workload
180 h</td><td>Credits
6</td><td>Term of studying
1. - 3. Semester</td><td>Frequency of occurrence
Summer term</td><td>Duration
1 Semester</td></tr>
<tr><td>1</td><td colspan="2">Type of lessons
a) Seminar
b) Practical Training</td><td>Contact times
30 h
30 h</td><td>Self-study times
60 h
60 h</td><td colspan="2">Intended group size
Maximum 9</td></tr>
<tr><td>2</td><td colspan="6">Aims of the module and acquired skills
Practical experience in direct current resistivity and electromagnetic prospection techniques, survey design, target identification, resolution of the methods, data evaluation, 1D and 2D modelling. General overview of th methods and their strength and weaknesses.
Acquired skills :
• Ability to plan, conduct, protocol, interpret and document direct current resistivity and electromagnetic geophysical measurements
• Ability to choose the most appropiate method for a given exploration problem
• The ability in scientific writing and oral presentation is trained during the seminar</td></tr>
<tr><td>3</td><td colspan="6">Contents of the module
• Direct Current Method with Multielectrode System (2D-DC)
• Radiomagnetotelluric (RMT)
• In-Loop Transient Electromagnetic Soundings (TEM)
• LOTEM data analysis and modelling
• Ground Penetrating Radar (GPR) / Ground conducting meters (HLEM)
Accounting for new developments in electromagnetic methods of applied geophysics and/or instrumentation the above methods may be replaced.</td></tr>
<tr><td>4</td><td colspan="6">Teaching/Learning methods
Seminar about methods and field course (compulsory attendance for all parts)</td></tr>
<tr><td>5</td><td colspan="6">Requirements for participation
Formal: None
Basics of electric and electromagnetic methods are strongly recommended.</td></tr>
<tr><td>6</td><td colspan="6">Type of module examinations
Written examination (graded)</td></tr>
<tr><td>7</td><td colspan="6">Requisites for the allocation of credits
1. Successful participation in the seminar about methods is prerequisite for admission to the written exam:
• Short oral presentation of one method (ungraded)
• Successful preparation/complition of the practical courses (testified ungraded)
• Written report (20 pages maximum) of one method including results of the field</td></tr>
</table>

	survey (ungraded) Each failed part can be repeated once during the semester before the written examination. 2. Successful participation of the written exam. At the end of the semester or to the beginning of the following semester a possibility to repeat the examination is offered. A failed examination may be repeated twice. Additional possibilities to repeat an examination exist according to the examination regulations (§ 20 section 1). Assessments which have been passed are not allowed to be taken again. The module mark is the grade obtained in the assessment.
8	**Compatibility with other Curricula** None
9	**Significance of the module mark for the overall grade** 6/120
10	**Module coordinator** B. Tezkan and R. Bergers
11	**Additional information** **Recommended literature:** W.E. Telford et. al., Applied Geophysics, Cambridge University Press, 1990. Nabighian, M.N., Electromagnetic soundings in applied geophysics, SEG,1987. M.S. Zhadanov and G.V. Keller, The geoelectrical methods in applied geophysics, SEG, 1987. D. S. Parasanis, Principles of Applied Geophysics, Halsted Press Book, 1979.

Compulsory for main focus geophysics: Seismology

Identification number	Workload	Credits	Term of studying	Frequency of occurrence	Duration
MN-GM-GEOSEIS	180 h	6	1. -3. Semester	Winter term	1 Semester

1	Type of lessons	Contact times	Self-study times	Intended group size
	a) **Lectures**	45 h	60 h	15
	b) **Exercise**	30 h	45 h	

2 Aims of the module and acquired skills

Understanding of physical processes that cause and transport seismic energy.

Acquired skills are the ability to determine basic parameters from seismic records for earthquake location. Basic knowledge of seismological measuring techniques and data processing.

In addition: communication skills, capacity for enthusiasm, self-dependency.

3 Contents of the module

- Elasticity theory and seismic waves
- Body waves and ray geometry
- Surface waves and free oscillations of the Earth
- Kinematic and dynamic effects of earthquake sources
- Seismometry and seismogram interpretation
- Seismotectonics
- Local earthquakes
- Earthquakes and buildings
- Time series analysis
- History of seismology

4 Teaching/Learning methods

Lectures and exercises (Compulsory attendance)

5 Requirements for participation

Formal: None

With regards to content: Basics of mathematics, physics and geophysics

6 Type of module examinations

Written examination (graded)

7 Requisites for the allocation of credits

Successful participation in the exercises (50 % of the possible points have to be obtained) and passing of the examination.

At the end of the semester or the beginning of the following semester a possibility to repeat the examination is offered. A failed examination may be repeated twice. Additional possibilities to repeat an examination exist according to the examination regulations (§ 20 section 1).

	Assessments which have been passed are not allowed to be taken again, with one exception: If at the end of a module which consists of a lecture and tutorial classes, the student takes the assessment at the first available date after having received admission to the module exam, he/she is then allowed to take the examination again at the next available date for the purpose of improving the grade, even if he/she passed the assessment the first time – in this case, the better of the two grades will count towards the final degree grade (§ 20 section 9). The module mark is the grade obtained in the assessment. In the case of two passed assessments the module mark is the better grade
8	**Compatibility with other Curricula** • Other modules of equal value can be admitted and announced by the examination board after agreement. • Suitable as an elective course for mathematics, physics and geoscience students
9	**Significance of the module mark for the overall grade** 6/120
10	**Module coordinator** K.-G. Hinzen
11	**Additional information** **Compulsory Literature:** P.M. Shearer, Introduction to Seismology, Cambridge University Press, 2006. T. Lay and T.C. Wallace, Modern Global Seismology, Acadamic Press, 1995. **Additional Literature:** K. Aki and P.G. Richards, Quantitative Seismology, University Science Books, 2002. D. Gubbins, Time Series Analysis and Inverse Theory for Geophysicists, Cambridge University Press, 2004

Compulsory for main focus geophysics: Geophysics of the solar system

Identification number	Workload	Credits	Term of studying	Frequency of occurrence	Duration
MN-GM-GEOSOSYS	180 h	6	1. -3. Semester	Winter term	1 Semester

1	Type of lessons	Contact times	Self-study times	Intended group size
	a) **Lectures**	30 h	60 h	30
	b) **Exercise**	30 h	60 h	

2 **Aims of the module and acquired skills**

Students will get an overview of the planetary bodies in our solar system, their geophysical properties and interactions.

Acquired skills are mathematical/geophysical tools to describe: global properties of planetary bodies, dynamical evolution of planetary bodies.

Non-specific skills: Critical assessment of scientific knowledge.

3 **Contents of the module**

- Structure/Overview of the solar system
- Formation of the solar system
- Dynamics of the solar system:
  - Point masses and Kepler's laws
  - n-body problem
  - Dynamics on finite rigid bodies (e. g. precession and nutation)
  - Dynamics of non-rigid bodies (tidal interactions)
- Internal structure of the planets
- Planetary atmospheres
- Planetary magnetic fields, their space plasma environments including aurorae
- The sun
- Minor bodies: Comets, asteroids, ...
- Extra-solar solar planets

4 **Teaching/Learning methods**

Lectures and exercises (exercises require attendance)

5 **Requirements for participation**

Formal: None

With regards to content: Basic knowledges in Classical mechanics, ordinary differential equations, Laplace equation in spherical coordinates.

6	**Type of module examinations** Written examination (graded).
7	**Requisites for the allocation of credits** Successful participation in the exercises (50 % of the possible points have to be obtained) and passing of the examination. At the end of the semester or the beginning of the following semester a possibility to repeat the examination is offered. A failed examination may be repeated twice. Additional possibilities to repeat an examination exist according to the examination regulations (§ 20 section 1). Assessments which have been passed are not allowed to be taken again, with one exception: If at the end of a module which consists of a lecture and tutorial classes, the student takes the assessment at the first available date after having received admission to the module exam, he/she is then allowed to take the examination again at the next available date for the purpose of improving the grade, even if he/she passed the assessment the first time – in this case, the better of the two grades will count towards the final degree grade (§ 20 section 9). The module mark is the grade obtained in the assessment. In the case of two passed assessments the module mark is the better grade
8	**Compatibility with other Curricula** • Other modules of equal value can be admitted and announced by the examination board after agreement. • Suitable as an elective course for mathematics, physics and geoscience students
9	**Significance of the module mark for the overall grade** 6/120
10	**Module coordinator** J. Saur
11	**Additional information** **Recommended Literature:** Beatty et al., The New Solar System, Sky Publishing Corporation and Cambridge University Press. Advanced Literature: Baumjohann und Treumann, Basic Space Plasma Physics, Imperial College Press.

Compulsory for main focus geophysics: Space Physics

Identification number	Workload	Credits	Term of studying	Frequency of occurrence	Duration
MN-GM-GEOSPACE	180 h	6	1. -3. Semester	Summer term	1 Semester

1	Type of lessons	Contact times	Self-study times	Intended group size
	a) **Lectures**	45 h	45 h	30
	b) **Exercise**	30 h	60 h	

2 Aims of the module and acquired skills

Understanding the space environment around the earth, other planetary bodies and the solar wind. Understanding basic properties of space plasmas including their mathematical/physical descriptions.

The acquired skills are the applications of mathematical/physical tools from statistical mechanics and fluid dynamics as applied to plasmas. Derivations of the plasma descriptions from first principles.

Non-specific skills: Critical assessment of scientific knowledge.

3 Contents of the module

- Introduction into space plasmas
- Single particle dynamics
- Kinetic theory (Boltzmann and Vlasow equation)
- Derivation of magnetohydrodynamic (MHD) equations
- Properties of MHD fluids
- Waves in plasmas
- Shocks and discontinuities
- Instabilities
- Magnetospheres, solar wind, aurorae

4 Teaching/Learning methods

Lectures and exercises (exercises require attendance)

5 Requirements for participation

Formal: None

With regards to content: Classical mechanics, electro-magnetism, basics of statistical mechanics

6 Type of module examinations

Written examination (graded).

7 Requisites for the allocation of credits

Successful participation in the exercises (50 % of the possible points have to be obtained) and passing of the examination.

At the end of the semester or the beginning of the following semester a possibility to repeat the examination is offered. A failed examination may be repeated twice. Additional possibilities to repeat an examination exist according to the examination regulations (§ 20 section 1).

	Assessments which have been passed are not allowed to be taken again, with one exception: If at the end of a module which consists of a lecture and tutorial classes, the student takes the assessment at the first available date after having received admission to the module exam, he/she is then allowed to take the examination again at the next available date for the purpose of improving the grade, even if he/she passed the assessment the first time – in this case, the better of the two grades will count towards the final degree grade (§ 20 section 9). The module mark is the grade obtained in the assessment. In the case of two passed assessments the module mark is the better grade
8	**Compatibility with other Curricula** • Other modules of equal value can be admitted and announced by the examination board after agreement. • Suitable as an elective course for mathematics, physics and geoscience students
9	**Significance of the module mark for the overall grade** 6/120
10	**Module coordinator** J. Saur
11	**Additional information** **Required literature:** Baumjohann und Treumann, Basic Space Plasma Physics, Imperial College Press **Additional literature:** Chen, Introduction to Plasma Physics and Controlled Fusion, Plenum Press. Kivelson & Russell, Introduction to Space Physics, Cambridge Univ. Press. Treumann und Baumjohann, Advanced Space Plasma Physics, Imperial College Press.

Compulsory for main focus meteorology: Atmospheric Boundary Layer

Identification number	Workload	Credits	Term of studying	Frequency of occurrence	Duration
MN-GM-METABL	180 h	6	1. -3. Semester	Summer term	1 Semester

1	Type of lessons	Contact times	Self-study times	Intended group size
	a) **Lectures**	45 h	45 h	15
	b) **Exercise**	30 h	60 h	

2 Aims of the module and acquired skills

To create understanding of:

- the atmospheric boundary layer and its role in weather and climate;
- turbulent and convective flow;
- the turbulent kinetic energy budget and its use in determining atmospheric stability;
- the interaction between the atmospheric boundary layer and the Earth's surface;
- the closure problem and associated parameterization techniques;
- boundary layer clouds

Acquired skills:

- Describing turbulent flow using perturbed prognostic equations
- Reynolds averaging
- Stability analysis using the dimensionless Richardson number and Obukhov length
- Parameterization of turbulent fluxes using K-theory
- Applying similarity theory to interpret measurements
- Experience with and interpretation of the bulk mixed-layer model
- Programming experience and presentation skills
- Interpretation of measurements of boundary-layer processes

3 Contents of the module

- Definition of the atmospheric boundary layer
- Mathematical tools (statistics)
- Governing equations of turbulent flows
- Prognostic equations for turbulent fluxes and variances
- Turbulent kinetic energy, stability and scaling
- Turbulence closure techniques
- Boundary conditions and external forcings
- Mathematical tools (time series analysis)
- Similarity theory
- Measurement and simulation
- The convective mixed layer
- Stable boundary layer
- Boundary layer clouds

4 Teaching/Learning methods

Lectures and exercises. Exercises have a compulsory attendance. In addition a one-day excursion to the JOYCE observational site will be organized to perform and interpret measurements of

	boundary-layer processes (attendance recommended but not compulsory)
5	**Requirements for participation** Formal: None With regards to content: Basic knowledge of the governing equations of atmospheric flow; Vector calculus; Linear algebra; Tensor notation
6	**Type of module examinations** Written Examination (graded)
7	**Requisites for the allocation of credits** Successful participation in the exercises (50 % of the possible points have to be obtained) and passing of the examination. At the end of the semester or the beginning of the following semester a possibility to repeat the examination is offered. A failed examination may be repeated twice. Additional possibilities to repeat an examination exist according to the examination regulations (§ 20 section 1). Assessments which have been passed are not allowed to be taken again, with one exception: If at the end of a module which consists of a lecture and tutorial classes, the student takes the assessment at the first available date after having received admission to the module exam, he/she is then allowed to take the examination again at the next available date for the purpose of improving the grade, even if he/she passed the assessment the first time – in this case, the better of the two grades will count towards the final degree grade (§ 20 section 9). The module mark is the grade obtained in the assessment. In the case of two passed assessments the module mark is the better grade
8	**Compatibility with other Curricula** - Other modules of equal value can be admitted and announced by the examination board after agreement. - Suitable as an elective course for mathematics, physics and geoscience students
9	**Significance of the module mark for the overall grade** 6/120
10	**Module coordinator** R. Neggers
11	**Additional information** Recommended Literature: Stull; 1988: An Introduction to Boundary Layer Meteorology. Kluwer Academic Publishers. Garratt, J. R., 1992: The Atmospheric Boundary Layer. Cambridge University Press

Compulsory for main focus meteorology: Clouds and Precipitation

Identification number	Workload	Credits	Term of studying	Frequency of occurrence	Duration
MN-GM-METCLOUD	180 h	6	1. - 3. Semester	Winter term	1 Semester

1	Type of lessons	Contact times	Self-study times	Intended group size
	a) **Lectures**	30 h	60 h	15
	b) **Exercise**	30 h	60 h	

2 Aims of the module and acquired skills

- Understanding the role of clouds for meteorology and in the climate system
- Knowledge of cloud microphysical processes
- Understanding the mechanisms for precipitation formation and efficiency
- Ability to interprete remote sensing observations of clouds and precipitation
- Understanding the links of cloud physics with dynamic meteorology, atmospheric radiative transfer and climatology.
- Computer practice for problem solving, critical assessment and discussion of scientific work presentation technique, time managagement

3 Contents of the module

- Basic overview of clouds in the atmosphere
- Thermodynamic concepts
- Homogeneous & heteorogeneous nucleation; Köhler theory
- Development of cloud droplet spectra (diffusional growth, collision-coalescence, entrainment, turbulence, breakup)
- Ice nucleation, ice crystal habits and ice microphysical processes
- Precipitation formation, thunderstorm development and life cycle, severe storms
- Modification of clouds
- In-situ measurements and remote sensing of cloud parameters including radar polarimetry
- Representation of clouds in numerical weather prediction and climate models, e.g. DWD models COSMO and ICON

4 Teaching/Learning methods

Lectures and exercises - Excercises with compulsory attendance

5 Requirements for participation

Formal: None

With regards to content: Basics of mathematics, physics and meteorology (mandatory)

6 Type of module examinations

Written examination (graded).

7 Requisites for the allocation of credits

Successful participation in the exercises (50 % of the possible points have to be obtained) and passing of the examination.

At the end of the semester or the beginning of the following semester a possibility to repeat the examination is offered. A failed examination may be repeated twice. Additional possibilities to repeat

	an examination exist according to the examination regulations (§ 20 section 1). Assessments which have been passed are not allowed to be taken again, with one exception: If at the end of a module which consists of a lecture and tutorial classes, the student takes the assessment at the first available date after having received admission to the module exam, he/she is then allowed to take the examination again at the next available date for the purpose of improving the grade, even if he/she passed the assessment the first time – in this case, the better of the two grades will count towards the final degree grade (§ 20 section 9). The module mark is the grade obtained in the assessment. In the case of two passed assessments the module mark is the better grade
8	**Compatibility with other Curricula** - Other modules of equal value can be admitted and announced by the examination board after agreement. - Suitable as an elective course for mathematics, physics and geoscience students
9	**Significance of the module mark for the overall grade** 6/120
10	**Module coordinator** S. Crewell
11	**Additional information** **Recommended literature:** Rogers, R. R. & M. K. Yau, 1989: "A short course in cloud physics", 3rd Edition, Butterworth-Heinemann, Int. Series in Nat. Philosophy, Vol. 113 Further Literature: Pruppacher und Klett, 1997: „Microphysics of cloud and precipitation“ AOS Library, Vol. 18, Kluwer Academic Publishers

Compulsory for main focus meteorology: Physical Climatology

Identification number	Workload	Credits	Term of studying	Frequency of occurrence	Duration
MN-GM-METCLIMATE	180 h	6	1. – 3. Semester	Summer term	1 Semester

1	Type of lessons	Contact times	Self-study times	Intended group size
	a) **Lectures**	30 h	60 h	15
	b) **Exercise**	30 h	60 h	

2 Aims of the module and acquired skills

Understanding of global climate system, processes and interactions; Correct interpretation of climate observations and simulations; Overview of climate modeling and analysis.

3 Contents of the module

- Climate as a dynamic system
- Atmospheric general circulation
- Global energy, water and carbon cycles
- Ocean dynamics and circulation
- Atmosphere – ocean interactions
- Atmosphere – land and ice interactions
- Regional and global reanalysis with examples from the HErZ project
- Large-scale interactive climate systems
- Introduction to global climate models
- Climate scenarios and projections

4 Teaching/Learning methods

Lectures and tutorials (compulsory attendance in tutorial)

5 Requirements for participation

Formal: None

Bachelor level meteorology, mathematics and scientific programming.

6 Type of module examinations

Written examination (graded).

7 Requisites for the allocation of credits

Successful participation in the exercises (50 % of the possible points have to be obtained) and passing of the examination.

At the end of the semester or the beginning of the following semester a possibility to repeat the examination is offered. A failed examination may be repeated twice. Additional possibilities to repeat an examination exist according to the examination regulations (§ 20 section 1).

Assessments which have been passed are not allowed to be taken again, with one exception: If at the end of a module which consists of a lecture and tutorial classes, the student takes the assessment at the first available date after having received admission to the module exam, he/she is then allowed to take the examination again at the next available date for the purpose of improving the grade, even if he/she passed the assessment the first time – in this case, the better of the two grades will count towards the final degree grade (§ 20 section 9).

The module mark is the grade obtained in the assessment. In the case of two passed assessments

	the module mark is the better grade
8	**Compatibility with other Curricula** - Other modules of equal value can be admitted and announced by the examination board after agreement. - Suitable as an elective course for mathematics, physics and geoscience students
9	**Significance of the module mark for the overall grade** 6/120
10	**Module coordinator** Y. Shao, F. Steffany
11	**Additional information** **Recommended literature:** Trenberth KE 2010: Climate system modeling. ISBN-10: 0521128374 Peixoto JP and AH Oort 2007: Physics of Climate. ISBN-10: 0883187124 Grotjahn R 2004: Global Atmospheric Circulation: Observations and Theories. ISBN-10: 019517481X Robinson W 2001: Modeling Dynamic Climate Systems. ISBN-10: 0387951342 Lau K-M and D Waliser 2012: Intraseasonal Variability in the Atmosphere-Ocean Climate System. ISBN-10: 3642139132. Robinson, W., Modeling Dynamic Climate Systems, 2001. Lau, K.-M. and D. Waliser, Intraseasonal Variability in the Atmosphere-Ocean Climate System, 2012. Rayner, J.N., Dynamic Climatology: Basis in Mathematics and Physics, 2000.

Compulsory for main focus meteorology: Atmospheric Dynamics and Modelling					
Identification number MN-GM-METADM	**Workload** 180 h	**Credits** 6	**Term of studying** 1. - 3. Semester	**Frequency of occurrence** Winter term	**Duration** 1 Semester

1	**Type of lessons**	**Contact times**	**Self-study times**	**Intended group size**
	a) **Lectures**	30 h	60 h	15
	b) **Exercise**	30 h	60 h	

2 Aims of the module and acquired skills

Aims: Advanced understanding of atmospheric dynamics and modeling with emphasis on the physics core of global climate and numerical weather prediction models. Acquired skills: capacity for model applications, development and construction, and capacity for model data analysis and critical assessment.

3 Contents of the module

- Review on atmospheric dynamics and governing equations
- Review on atmospheric waves and implications to atmospheric modeling
- Model closure
- Parameterization of the atmospheric boundary layer
- Parameterization of land and ocean surface processes
- Parameterization of convection and clouds
- Introduction to non-linear system theory and ensemble forecast
- Weather and climate predictability

4 Teaching/Learning methods

Lectures and tutorials (Compulsory attendance in tutorial)

5 Requirements for participation

Undergraduate level understanding of general and theoretical meteorology.

6 Type of module examinations

Written examination (graded).

7 Requisites for the allocation of credits

Successful participation in the exercises (50 % of the possible points have to be obtained) and passing of the examination.

At the end of the semester or the beginning of the following semester a possibility to repeat the examination is offered. A failed examination may be repeated twice. Additional possibilities to repeat an examination exist according to the examination regulations (§ 20 section 1).

Assessments which have been passed are not allowed to be taken again, with one exception: If at the end of a module which consists of a lecture and tutorial classes, the student takes the assessment at the first available date after having received admission to the module exam, he/she is then allowed to take the examination again at the next available date for the purpose of improving the grade, even if he/she passed the assessment the first time – in this case, the better of the two grades will count towards the final degree grade (§ 20 section 9).

The module mark is the grade obtained in the assessment. In the case of two passed assessments the module mark is the better grade

8	**Compatibility with other Curricula** - Other modules of equal value can be admitted and announced by the examination board after agreement. - Suitable as an elective course for mathematics, physics and geoscience students
9	**Significance of the module mark for the overall grade** 6/120
10	**Module coordinator** Y. Shao, H. Elbern
11	**Additional information** **Recommended literature:** Stensrud DJ 2010: Parameterization Schemes: Keys to Understanding Numerical Weather Prediction Models. ISBN-10: 0521126762 Stull RB 2008: An Introduction to Boundary Layer Meteorology. ISBN-10: 9027727694 Kalnay E 2002: Atmospheric modeling, data assimilation and predictability. ISBN 0-521-79629-6. Trenberth KE 2010: Climate system modeling. ISBN-10: 0521128374 Domenico P and FW Schwartz, 2008: Physical and Chemical Hydrogeology. ISBN-10: 0471597627Stull, R.B.; 2008: An Introduction to Boundary Layer Meteorology. Kalnay, E.; 2002: Atmospheric modeling, data assimilation and predictability. Trenberth, K.E.; 2010: Climate system modeling. Domenico, P. and F.W. Schwartz; 2008: Physical and Chemical Hydrogeology.

<table>
<tr><th colspan="7">Compulsory for main focus meteorology: Atmospheric Radiation</th></tr>
<tr><td colspan="2">Identification

MN-GM-METRAD</td><td>Workload

180h</td><td>Credit points

6 LP</td><td>Academic semester

1. -3. Sem.</td><td>Frequency

Winter term</td><td>Duration

1 Semester</td></tr>
<tr><td>1</td><td colspan="3">Teaching
a) Lecture
b) Exercises</td><td>Contact time
45 h
30 h</td><td>Self-study
45 h
60 h</td><td>Expected students
15</td></tr>
<tr><td>2</td><td colspan="6">Module objective and acquirable skills
Understanding the relevance of atmospheric radiation for weather and climate
Understanding the interaction of atmospheric radiation with atmospheric gases, aerosols, clouds and precipitation
Basic knowledge of modern remote sensing methods
Solving problems in atmospheric radiation and cloud physics
Computational techniques to address radiative transfer
Programming experience and presentation skills
Evaluation and interpretation of radiation sensor measurements
Critical assessment and discussion of scientific work, presentation techniques, faculity of abstraction, conceptional, analytic and logical way of thinking</td></tr>
<tr><td>3</td><td colspan="6">Module content
Basic concepts and definitions, EM waves, electromagnetic spectrum
Reflection and refraction
Thermal emission, Planck's function, radiation laws, brightness temperature
Absorption and scattering by atmospheric gases and particles
Radiative transfer in different spectral regions,
Broadband fluxes and heating rates, atmospheric radiation budget
Measurements of atmospheric radiation, ground-based & satellite
Remote sensing of atmospheric water vapor, clouds and precipitation.</td></tr>
<tr><td>4</td><td colspan="6">Types of teaching
Lecture, exercises (compulsory attendance)
Exercises: Task sheets for strengthening the understanding of atmospheric radiation concepts, PC-exercises on radiative transfer & heating rates determined with the COSMO model, Evaluation, interpretation and presentation of broadband short- and long-wave measurements of atmospheric radiation (surface and satellite-based), Remote sensing applications</td></tr>
<tr><td>5</td><td colspan="6">Requirememts of successful participation
None.</td></tr>
<tr><td>6</td><td colspan="6">Final exam, type
Written examination (graded)</td></tr>
<tr><td>7</td><td colspan="6">Requisites for the allocation of credits</td></tr>
</table>

	Successful participation in the exercises (50 % of the possible points have to be obtained) and passing of the examination. At the end of the semester or the beginning of the following semester a possibility to repeat the examination is offered. A failed examination may be repeated twice. Additional possibilities to repeat an examination exist according to the examination regulations (§ 20 section 1). Assessments which have been passed are not allowed to be taken again, with one exception: If at the end of a module which consists of a lecture and tutorial classes, the student takes the assessment at the first available date after having received admission to the module exam, he/she is then allowed to take the examination again at the next available date for the purpose of improving the grade, even if he/she passed the assessment the first time – in this case, the better of the two grades will count towards the final degree grade (§ 20 section 9). The module mark is the grade obtained in the assessment. In the case of two passed assessments the module mark is the better grade
8	**Compatibility with other Curricula** - Other modules of equal value can be admitted and announced by the examination board after agreement. - Suitable as an elective course for mathematics, physics and geoscience students
9	**Significance of the module mark for the overall grade** 6/120
10	**Module coordinator** U. Löhnert
11	**Additional information**

2.3 Wahlpflichtmodule / *Elective Modules*

Ergänzend zu den Pflichtmodule des jeweiligen Schwerpunktes müssen 4 Wahlpflichtmodule gewählt werden. Diese können gewählt werden aus:

1. der Gruppe der Wahlpflichtmodule.

- Physics oft he Atmosphere (für Studierende mit wenig meteorologischem Hintergrund, nur mit Zustimmung des Prüfungsausschusses): METPHA
- Atmospheric Chemistry : METCHEM
- Advanced Remote Sensing: METRS
- Challenging Meteorological Topics: METTOP
- Compact Course (Jülich, as an elective part of the METTOP module)
- Energy Meteorology (block course); METEN
- Energy Meteorology + (block course); METEN+

2. aus den Pflichtmodulen des jeweils anderen Schwerpunktes

3. aus den folgenden Bereichen der physikalischen Institute: Atomphysik, Quantenphysik, Statistische Physik, Astrophysik

4. aus den folgenden Bereichen des mathematischen Instituts: Analysis, Angewandte Analysis, Numerische Mathematik und Wissenschaftliches Rechnen, Diskrete Mathematik und Mathematische Optimierung, Mathematische Informatik

5. aus dem Angebot des Partnerstudiengangs der Universität Bonn

In addition to the compulsory modules of the main focus 4 elective modules must be chosen. These can be chosen from:

1. the group oft he elective modules:

- *Physics oft he Atmosphere (for students with little meteorological background, only with permission of the examination committee): METPHA*
- *Atmospheric Chemistry : METCHEM*
- *Advanced Remote Sensing: METRS*
- *Challenging Meteorological Topics: METTOP*
- *Compact Course (Jülich, as an elective part of the METTOP module)*
- Energy Meteorology (block course); METEN
- Energy Meteorology + (block course); METEN+

2. the group of the compulsory modules of the other main focus

3. the following areas of physics institutes: Nuclear Physics, Quantum Physics, Statistical Physics, Astrophysics

4. the following areas of the Mathematical Institute: Analysis, Applied Analysis, Computational Mathematics and Scientific Computing, Discrete Mathematics and Mathematical Programming, Mathematical computer science

5. the offer of the partner's program at the University of Bonn

Elective: Physics of the Atmosphere						
Identification number MN-GM-METPHA		**Workload** 180 h	**Credits** 6	**Term of studying** 1. - 3. Semester	**Frequency of occurrence** Winter term	**Duration** 1 Semester
1	**Type of lessons** a) **Lectures** b) **Exercise**	**Contact times** 45 h 30 h		**Self-study times** 45 h 60 h	**Intended group size** 15	
2	**Aims of the module and acquired skills** • Derivation and interpretation of equations governing atmospheric motion and state, i.e. primitive equations • Atmospheric radiation and application to the energy balance (e. g. greenhouse effect) and optical appearences • Knowledge of the earth's climate zones and basic principles of the general circulation • Acquired skills are computer practice, presentation techniques, general comprehension of systems, critical assessment and discussion of scientific work and time management.					
3	**Contents of the module** • Meteorological variables and primitive equations • Composition and spatio-temporal structure of the atmosphere • Radiative transfer • Cloud physics and formation of precipitation • Atmospheric boundary layer and turbulence • Atmospheric dynamics • Weather systems • Atmospheric circulation • Climate dynamic					
4	**Teaching/Learning methods** Lectures and exercises - Exercises with compulsory attendance					
5	**Requirements for participation** Formal: Permission by the Examination Board With regards to content: Basics of mathematics and physics.					
6	**Type of module examinations** Written examination (graded).					
7	**Requisites for the allocation of credits** Successful participation in the exercises (50 % of the possible points have to be obtained) and passing of the examination. At the end of the semester or the beginning of the following semester a possibility to repeat the examination is offered. A failed examination may be repeated twice. Additional possibilities to repeat					

	an examination exist according to the examination regulations (§ 20 section 1). Assessments which have been passed are not allowed to be taken again, with one exception: If at the end of a module which consists of a lecture and tutorial classes, the student takes the assessment at the first available date after having received admission to the module exam, he/she is then allowed to take the examination again at the next available date for the purpose of improving the grade, even if he/she passed the assessment the first time – in this case, the better of the two grades will count towards the final degree grade (§ 20 section 9). The module mark is the grade obtained in the assessment. In the case of two passed assessments the module mark is the better grade
8	**Compatibility with other Curricula** - Other modules of equal value can be admitted and announced by the examination board after agreement. - Suitable as an elective course for mathematics, physics and geoscience students
9	**Significance of the module mark for the overall grade** 6/120
10	**Module coordinator** S. Crewell
11	**Additional information** **Recommended literature:** Wallace, J. und Hobbs, P., 2006: Atmospheric Science: An Introductory Survey. Academic Press, 2nd edition, New York. H. Kraus, 2005: Die Atmosphäre der Erde. Eine Einführung in die Meteorologie. Springer Verlag Heidelberg, Paperback Vieweg Verlag. D. Etling, 2002: Theoretische Meteorologie, Eine Einführung. Springer Verlag Heidelberg.

Elective: Atmospheric Chemistry					
Identification number MN-GM-METCHEM	**Workload** 180 h	**Credits** 6	**Term of studying** 1. - 3. Semester	**Frequency of occurrence** Winter term	**Duration** 1 Semester

1	**Type of lessons**	**Contact times**	**Self-study times**	**Intended group size**
	a) Lectures	30 h	60 h	15
	b) Exercises	30 h	60 h	

2 Aims of the module and acquired skills

- Comprehension of how physical/chemical processes affect composition and changes of the atmosphere
- Knowledge of several trace substance cycles
- Comprehension of spatial and temporal gradients of trace substances
- Application of reaction mechanisms on the decomposition of trace substances
- Acquired skills are computer practice, general comprehension of systems, critical assessment and discussion of scientific work

3 Contents of the module

• Chemical elementary reactions
• Chemical composition of the atmosphere
• Simple reaction systems
• Chemical and atmospheric persistence
• Photochemistry
• Biogenic and anthropogenic emissions
• Atmospheric deposition processes
• Climate efficiency of trace gases
• Aerosol chemistry and physics
• Atmospheric distribution of trace substances

• Trace substance cycles of CO, methane, hydrocarbons, sulfur compounds, nitric oxides
• Chemistry of the hydroxyl radical
• Complex ways of decomposition of trace substances
• Photochemistry of the decomposition of trace substances, radical cycles
• Formation of ozone in the troposphere
• Trace substance balance, troposphere, stratosphere
• Stratospheric ozone chemistry
• Climate development

4 Teaching/Learning methods

Lectures and tutorials

5 Requirements for participation

None

6 Type of module examinations

Written examination (graded).

7 Requisites for the allocation of credits

Successful participation in the exercises (50 % of the possible points have to be obtained) and

	passing of the examination. At the end of the semester or the beginning of the following semester a possibility to repeat the examination is offered. A failed examination may be repeated twice. Additional possibilities to repeat an examination exist according to the examination regulations (§ 20 section 1). Assessments which have been passed are not allowed to be taken again, with one exception: If at the end of a module which consists of a lecture and tutorial classes, the student takes the assessment at the first available date after having received admission to the module exam, he/she is then allowed to take the examination again at the next available date for the purpose of improving the grade, even if he/she passed the assessment the first time – in this case, the better of the two grades will count towards the final degree grade (§ 20 section 9). The module mark is the grade obtained in the assessment. In the case of two passed assessments the module mark is the better grade
8	**Compatibility with other Curricula** - Other modules of equal value can be admitted and announced by the examination board after agreement. - Suitable as an elective course for mathematics, physics and geoscience students
9	**Significance of the module mark for the overall grade** 6/120
10	**Module coordinator** A. Wahner, T. Mentel
11	**Additional information**

Elective: Advanced Remote Sensing

Identification number	Workload	Credits	Term of studying	Frequency of occurrence	Duration
MN-GM-METRS	180 h	6	1. -3. Semester	Summer term	1 Semester

1	Type of lessons	Contact times	Self-study times	Intended group size
	a) **Lectures**	45 h	45 h	15
	b) **Project Work**	30 h	60 h	

2 Aims of the module and acquired skills

To create understanding of:

- the remote sensing principles that enable remote sensing of atmospheric and Earth surface characteristics
- the use of different spectral ranges of electromagnetic radiation in remote sensing
- of remote sensing instrumentation and the global meteorological observation network
- the principles, development and application of retrieval algorithms

Skills:

- Ability to interpret and to quantitatively analyse remote sensing observations
- Development and assessment of statistical assumptions, numerical complexities and practical limits of retrieval and assimilation techniques
- Programming experience, presentation skills, team work in hands-on-training

3 Contents of the module

- Remote sensing principles, meteorological satellites and orbits
- Principles of retrieval algorithms for the inversion from radiances to geophysical parameters
- Passive remote sensing of the atmosphere at visible, infrared and microwave wavelengths for temperature, humidity, clouds and aerosol
- Active remote sensing of the atmosphere with cloud and precipitation radar, lidar, wind profiler, sodar and GPS, use of polarimetric techniques
- Remote sensing of the ocean (temperature, color, wind, waves) with passive instrumentation, altimeter and scatterometer
- Remote sensing of Earth Surface and vegetation (SAR, NDVI)
- Hands-on training with ground-based remote sensing instrumentation at the Jülich Observatory for Cloud Evolution (JOYCE), at the Environmental Research Station Schneefernerhaus on Mt. Zugspitze and/or the polarimetric radar Bonn
- Application of remote sensing data for evaluation of reanalysis and dynamic models, e.g. COSMO and ICON
- Excursion to ESA, EUMETSAT or DWD

4 Teaching/Learning methods

Lecture and project work including remote sensing measurements at ground-based sites: set-up, calibrate & carry out; interpretation and presentation of remote sensing measurements (satellite & ground-based) and model forecasts; PC-exercises on radiative transfer & remote sensing;

5 Requirements for participation

Formal: none

With regards to content: Basics of mathematics, physics, experience in programming (mandatory)

6 Type of module examinations

	Written examination (graded).
7	**Requisites for the allocation of credits** Successful participation in the project work documented by a written report marked equal or better than 4.0 and passing the oral examination. The examination part may be repeated once during the semester. A failed examination may be repeated twice. Additional possibilities to repeat an examination exist according to the examination regulations (§ 20 section 1).
8	**Compatibility with other Curricula** - Other modules of equal value can be admitted and announced by the examination board after agreement. - Suitable as an elective course for mathematics, physics and geoscience students.
9	**Significance of the module mark for the overall grade** 6/120
10	**Module coordinator** S. Crewell
11	**Additional information** **Recommended literature:** Kidder, S.Q. and von der Haar, T.H.; 1995: Satellite Meteorology: An Introduction, Academic Press, 466 pp. Rodgers, C.D.; 2000: Inverse methods for atmospheric sounding: Theory and practice. World Scientific, 238 pp.

<table>
<tr><th colspan="7">Elective: Challenging research topics</th></tr>
<tr><td colspan="2">Identification

MN-GM-METTOP</td><td>Workload

180h</td><td>Credit points

6</td><td>Academic semester

2. or 3. Semester</td><td>Frequency

Every semester</td><td>Duration

1 semester</td></tr>
<tr><td>1</td><td colspan="3">Teaching
a) Lecture
b) Seminar</td><td>Contact time
45 h
45 h</td><td>Self-study
45 h
45 h</td><td>Expected students
15</td></tr>
<tr><td>2</td><td colspan="6">Module objective and acquirable skills
• Insight in current challenging topics in atmospheric research
• In-depth understanding in specialized research topics
• Ability to judge success, potential and limitation in atmospheric research</td></tr>
<tr><td>3</td><td colspan="6">Module content
• lectures on challenging atmospheric research topics, e.g. aerosol modelling, radar remote sensing, new development in atmospheric monitoring, new techniques in atmospheric modelling, airborne meteorology etc.
• seminars on actively debated topics and new hypothesis, such as latest IPCC report, geoengineering, uncertainties in the global energy budget, arctic amplification etc. Mini research projects on the related topics will be carried out and presented in the seminars.</td></tr>
<tr><td>4</td><td colspan="6">Types of teaching
Lectures, research projects, seminars with compulsory attedance</td></tr>
<tr><td>5</td><td colspan="6">Requirememts for participation
None</td></tr>
<tr><td>6</td><td colspan="6">Type of module examination
Oral examination (graded)</td></tr>
<tr><td>7</td><td colspan="6">Requisites for the allocation of credits
Successful participation in the seminar and passing the oral examination.
At the end of the semester or the beginning of the following semester a possibility to repeat the examination is offered. A failed examination may be repeated twice. Additional possibilities to repeat an examination exist according to the examination regulations (§ 20 section 1).</td></tr>
<tr><td>8</td><td colspan="6">Compatibility with other Curricula
- Other modules of equal value can be admitted and announced by the examination board after agreement.
- Suitable as an elective course for mathematics, physics and geoscience students</td></tr>
<tr><td>9</td><td colspan="6">Significance of the module mark for the overall grade
6/120</td></tr>
</table>

10	**Modul coordinator** S. Crewell
11	**Additional information**

<table>
<tr><td colspan="7">Elective: Future Challenges of Meteorology</td></tr>
<tr><td colspan="2">Identification

MN-GM-METFUT</td><td>Workload

180h</td><td>Credit points

6</td><td>Academic semester

2. or 3. Semester</td><td>Frequency

On special announcement</td><td>Duration

1 semester</td></tr>
<tr><td>1</td><td colspan="3">Teaching
Project</td><td>Contact time
90 h</td><td>Self-study
90 h</td><td>Expected students
5</td></tr>
<tr><td>2</td><td colspan="6">Module objective and acquirable skills
• Insight in current challenging topics in atmospheric research
• In-depth understanding in specialized research topics
• Ability to judge success, potential and limitation in atmospheric research</td></tr>
<tr><td>3</td><td colspan="6">Module content
• Project work on challenging atmospheric research topics, e.g. aerosol modelling, radar remote sensing, new development in atmospheric monitoring, new techniques in atmospheric modelling, airborne meteorology etc. During contact time, discussions on actively debated topics and new hypothesis, such as latest IPCC report, geoengineering, uncertainties in the global energy budget, arctic amplification etc.</td></tr>
<tr><td>4</td><td colspan="6">Types of teaching
Project, hands-on supervision</td></tr>
<tr><td>5</td><td colspan="6">Requirememts for participation
None</td></tr>
<tr><td>6</td><td colspan="6">Type of module examinations
Presentation (graded) with written report (graded)</td></tr>
<tr><td>7</td><td colspan="6">Requisites for the allocation of credits
Successful presentation and successful report
At the end of the semester or the beginning of the following semester a possibility to repeat the presentation or the report is offered. A failed examination may be repeated twice. Additional possibilities to repeat an examination exist according to the examination regulations (§ 20 section 1).</td></tr>
<tr><td>8</td><td colspan="6">Compatibility with other Curricula
- Other modules of equal value can be admitted and announced by the examination board after agreement.
- Suitable as an elective course for mathematics, physics and geoscience students</td></tr>
<tr><td>9</td><td colspan="6">Significance of the module mark for the overall grade
6/120</td></tr>
<tr><td>10</td><td colspan="6">Modul coordinator
S. Crewell</td></tr>
</table>

11	**Additional information**

Elective: Atmospheric Chemistry and Dynamics (compact course)					
Identification number MN-GM-METACD	**Workload** 90 h	**Credits** 3	**Term of studying** 1. - 3. Semester	**Frequency of occurrence** Winter term	**Duration** 1 Semester

1	**Type of lessons**	**Contact times**	**Self-study times**	**Intended group size**
	a) **Lectures**	30 h	30 h	32
	b) **Exercise**	15 h	15 h	

2 Aims of the module and acquired skills

Understanding of role of atmospheric chemistry and dynamics, with focus on air quality and its interactions with global and regional climate.

Basic knowledge in advanced atmospheric measurement and modelling techniques.

3 Contents of the module

- Atmospheric thermal-dynamic structure
- Wind systems, advection and turbulent diffusion
- Atmospheric composition
- Photochemistry, radicals and gas phase kinetics
- Anthropogenic impacts on tropospheric chemistry
- Modelling of chemistry and transport of trace gases
- Remote sensing of pollutants
- Experimental methods for analysis of atmospheric trace gases
- Aerosol radiative forcing on atmosphere
- Global change of atmospheric composition and impact on climate

4 Teaching/Learning methods

Lecture and tutorials (compulsory attendance)

5 Requirements for participation

Formal: Non. Bachelor degree in natural Sciences.

With regards to content: Basics of mathematics and physics (mandatory)

6 Type of module examinations

Oral examination.

7 Requisites for the allocation of credits

Successful participation in the tutorials (50 % of the possible points have to be obtained) and passing the examination.

A failed examination may be repeated twice. Additional possibilities to repeat an examination exist according to the examination regulations (§ 20 section 1).

8 Compatibility with other Curricula

- Other modules of equal value can be admitted and announced by the examination board after agreement.
- Suitable as an elective course for mathematics, physics and geoscience students

9 Significance of the module mark for the overall grade

	3/120
10	**Module coordinator** H. Elbern
11	**Additional information** **Recommended literature:** • J.H. Seinfeld and S.N. Pandis, Atmospheric Chemistry and Physics, Wiley 1998. • W. Roedel, Physik unserer Umwelt, Springer Verlag. • G. Brasseur, J. Orlando, and G. Tyndall, Atmospheric chemistry and global change, Oxford University Press. • Haltiner, G.J. and Williams, R.T., 1980: Numerical Prediction and Dynamic Meterology, 2nd edition, John Wiley & Sons. • Holton, J., 1991: An Introduction to Dynamic Meteorology. third edition, International Geophysics Series, Academic Press, New York. • H. Kraus, Die Atmosphäre der Erde: Eine Einführung in die Meteorologie, Vieweg, 2000.

<table>
<tr><td colspan="7">Elective: Energy Meteorology (compact course)</td></tr>
<tr><td colspan="2">Identification

MN-GM-METEN</td><td>Workload

90h</td><td>Credit points

3</td><td>Academic semester

2. or 3. Semester</td><td>Frequency

On special announcement</td><td>Duration

1 semester</td></tr>
<tr><td>1</td><td colspan="3">Teaching
Lectures</td><td>Contact time
40 h</td><td>Self-study
50 h</td><td>Expected students
10</td></tr>
<tr><td>2</td><td colspan="6">Module objective and acquirable skills
Understanding the meteorological requirements and conditions for a meaningful generation of electricity from wind and solar power
Gaining insight into the operation of an electrical grid with weather-dependent renewable energies</td></tr>
<tr><td>3</td><td colspan="6">Module content
Physical basics of energy supply
Economic and regulatory framework in the energy system
On- and off-shore wind parks
Photovoltaic and concentrating solar thermal energy systems
Site auditing – including complex terrain and cloudy and aerosol-loaded locations for wind and solar technologies
Wind and solar forecasting – deterministic and probabilistic approaches
Possible impact of climage change</td></tr>
<tr><td>4</td><td colspan="6">Types of teaching
Lectures (block course)</td></tr>
<tr><td>5</td><td colspan="6">Requirememts for participation
Formal: None
Undergraduate knowledge of meteorology (e.g. atmospheric dynamics, boundary layer physics, radiation, remote sensing) is presupposed.</td></tr>
<tr><td>6</td><td colspan="6">Type of module examinations
Oral examination (graded)</td></tr>
<tr><td>7</td><td colspan="6">Requisites for the allocation of credits
Passing the examination.
The module mark is the mark of the examination.
A failed examination may be repeated twice. Additional possibilities to repeat an examination exist according to the examination regulations (§ 20 section 1).</td></tr>
<tr><td>8</td><td colspan="6">Compatibility with other Curricula
Other modules of equal value can be admitted and announced by the examination board after agreement.
Suitable as an elective course for mathematics, physics and geoscience students</td></tr>
<tr><td>9</td><td colspan="6">Significance of the module mark for the overall grade</td></tr>
</table>

	This module contributes with 3 CP to the elective area.
10	**Modul coordinator** Stefan Emeis
11	**Additional information** **Recommended literature:** Emeis, S., Wind Energy Meteorology, Springer, 2012 Kaltschmitt, M., W. Streicher, A. Wiese (Eds.), Erneuerbare Energien - Systemtechnik, Wirtschaftlichkeit, Umweltaspekte. 5th edition, Springer, 2013 Heinemann, D. (Ed.), 2015: Meteorologische Aspekte der Nutzung erneuerbarer Energien. promet 39 (3/4), 133-244. van Kuik, G.A.M. + 26 co-authors, 2016: Long-term research challenges in wind energy – a research agenda by the European Academy of Wind Energy. Wind Energ. Sci., 1, 1-39. DOI: 10.5194/wes-1-1-2016 (Open Access) Jan Kleissl; Solar Energy Forecasting and Resource Assessment, Elsevier M. Sengupta, A. Habte, S. Kurtz, A. Dobos, S. Wilbert, E. Lorenz, T. Stoffel, D. Renné, D. Myers, S. Wilcox, P. Blanc, and R. Perez, Best Practices Handbook for the Collection and Use of Solar Resource Data for Solar Energy Applications, Technical Report, NREL/TP-5D00-63112, prepared in collaboration with the International Energy Agency, Solar Heating and Cooling Programme Task 36 and 46 (open access)

<table>
<tr><td colspan="7">Elective: Energy Meteorology +</td></tr>
<tr><td colspan="2">Identification

MN-GM-METEN+</td><td>Workload

180 h</td><td>Credit points

6</td><td>Academic semester

2. or 3. Semester</td><td>Frequency

On special announcement</td><td>Duration

1 semester</td></tr>
<tr><td>1</td><td colspan="3">Teaching
Lectures
Project
Seminar</td><td>Contact time
40 h
40 h
10 h</td><td>Self-study
50 h
20 h
20 h</td><td>Expected students
10</td></tr>
<tr><td>2</td><td colspan="6">Module objective and acquirable skills
Understanding the meteorological requirements for a meaningful generation of electricity from wind and solar power
Gaining insight into the operation of an electrical grid with weather-dependent renwable energies
Project and seminar give the opportunity to deepen knowledge in one of the three fields “wind power”, “solar power”, or “grid operation”</td></tr>
<tr><td>3</td><td colspan="6">Module content
Physical basics of energy supply
Economic and regulatory framework in the energy system
On- and off-shore wind parks
Photovoltaic and concentrating solar thermal energy systems
Site auditing – including complex terrain and cloudy and aerosol-loaded locations for wind and solar technologies
Wind and solar forecasting – deterministic and probabilistic approaches
Possible impact of climage change</td></tr>
<tr><td>4</td><td colspan="6">Types of teaching
Lectures (block course)
The student is assigned a project after the block course has finished. The duration of the project is about one week.
The student presents the results of this project in a seminar.</td></tr>
<tr><td>5</td><td colspan="6">Requirememts for participation
Formal: None
Undergraduate knowledge of meteorology (e.g. atmospheric dynamics, boundary layer physics, radiation, remote sensing) is presupposed.</td></tr>
<tr><td>6</td><td colspan="6">Type of module examinations
Seminar (ungraded)
Oral examination (graded)</td></tr>
<tr><td>7</td><td colspan="6">Requisites for the allocation of credits
Participation in the project, passing the ungraded seminar, passing the examination.
The module mark is the mark of the oral examination.</td></tr>
</table>

	A failed examination may be repeated twice. Additional possibilities to repeat an examination exist according to the examination regulations (§ 20 section 1).
8	**Compatibility with other Curricula** - Other modules of equal value can be admitted and announced by the examination board after agreement. - Suitable as an elective course for mathematics, physics and geoscience students
9	**Significance of the module mark for the overall grade** This module contributes with 6 CP to the elective area.
10	**Modul coordinator** Stefan Emeis
11	**Additional information** **Recommended literature.** Emeis, S., Wind Energy Meteorology, Springer, 2012 Kaltschmitt, M., W. Streicher, A. Wiese (Eds.), Erneuerbare Energien - Systemtechnik, Wirtschaftlichkeit, Umweltaspekte. 5th edition, Springer, 2013 Heinemann, D. (Ed.), 2015: Meteorologische Aspekte der Nutzung erneuerbarer Energien. promet 39 (3/4), 133-244. van Kuik, G.A.M. + 26 co-authors, 2016: Long-term research challenges in wind energy – a research agenda by the European Academy of Wind Energy. Wind Energ. Sci., 1, 1-39. DOI: 10.5194/wes-1-1-2016 (Open Access) Jan Kleissl; Solar Energy Forecasting and Resource Assessment, Elsevier M. Sengupta, A. Habte, S. Kurtz, A. Dobos, S. Wilbert, E. Lorenz, T. Stoffel, D. Renné, D. Myers, S. Wilcox, P. Blanc, and R. Perez, Best Practices Handbook for the Collection and Use of Solar Resource Data for Solar Energy Applications, Technical Report, NREL/TP-5D00-63112, prepared in collaboration with the International Energy Agency, Solar Heating and Cooling Programme Task 36 and 46 (open access)

2.4 Master-Arbeit / *Master Thesis*

Zum Abschluss des Masterstudiums folgt die Masterarbeit in der ein begrenztes Problem der Geophysik und Meteorologie nach wissenschaftlichen Methoden selbstständig bearbeitet wird und wissenschaftlich schriftlich und mündlich dargestellt werden muss.

The Master Thesis concludes the Master Degree Program. A well-defined problem of Geophysics or Meteorology is treated in a self-dependent way using scientific methods and presented in written and oral form.

<table>
<tr><td colspan="6">Compulsory: Master Thesis</td></tr>
<tr><td colspan="2">Identification number
MN-GM-MASTER</td><td>Workloa
900 h</td><td>Credits
30</td><td>Term of studying
4. Semester</td><td>Frequency of occurrence
Every semester</td><td>Duration
1 Semester</td></tr>
<tr><td>1</td><td colspan="2">Type of lessons
a) Colloquium (seminar)
b) Master thesis</td><td>Contact times
30 h</td><td>Self-study times
870 h</td><td colspan="2">Intended group size
N/A</td></tr>
<tr><td>2</td><td colspan="6">Aims of the module and acquired skills
Self-reliant processing of a limited problem of geophysics or meteorology. Application of modern methods as well as the funded written presentation of scientific results.
Acquired skills therefore:
• Time management
• Scientific argumentation
• Ability of argumentation and documentation
• Deepening of English as a natural scientific foreign language
• Reading skills
• Writing skills</td></tr>
<tr><td>3</td><td colspan="6">Contents of the module
The master thesis deals with a limited topic of geophysics or meteorology, worked on independently, that is documented in an elaboration of 70 pages maximum length.</td></tr>
<tr><td>4</td><td colspan="6">Teaching/Learning methods
Colloquium (seminar, compulsory attendance) and independent work</td></tr>
<tr><td>5</td><td colspan="6">Requirements for participation
Acquisition of at least 84 credit points of the modules of the master course. The examination board can allow exceptions in well-justified cases.</td></tr>
<tr><td>6</td><td colspan="6">Type of module examinations
• Written master thesis (graded, enters with a weight of 75% into the module mark)</td></tr>
</table>

	• Presentation of the results of the master thesis in a colloquium (graded, enters with a weight of 25% into the module mark)
7	**Requisites for the allocation of credits** Both the written master thesis and the colloquium have to be passed to allocate the credits. The master thesis is evaluated by the two referees of appointed by the examination board. These two referees also evaluate the colloquium.
8	**Compatibility with other Curricula** None
9	**Significance of the module mark for the overall grade** 30/120
10	**Module coordinator** The chairperson of the examination committee.
11	**Additional information** Obligatory literature: Depends on topic.

3 Studienhilfen / *Study Aids*

3.1 Musterstudienplan / *Suggested study plan*

Die folgenden Musterstudienpläne entsprechen der Empfehlung des Instituts für Geophysik und Meteorologie. Die Pläne sind auf den Studienbeginn zum Wintersemester und zum Sommersemester zugeschnitten. Selbstverständlich kann, unter Beachtung der jeweiligen Modulvoraussetzungen, auch eine andere Reihenfolge der Module gewählt werden. In diesem Fall wird aber dringend empfohlen, diese individuelle Wahl im Rahmen der Studienberatung zu besprechen.

The following study plans comply with the recommendation of the Institute of Geophysics and Meteorology. They are tailored to the begin of studies in the winter semester and summer semester, respectively. A different course of studies is possible if it is compliant with the respective module prerequisites. In case this is desired, it is strongly advised to obtain the advice of the student counseling.

Studienverlaufsplan Master Physics of the Earth and Atmosphere

Suggested study plan for Master Physics of the Earth and Atmosphere

Studienbeginn im Wintersemester / *Start in winter term*

Prognostic Modelling 6	Inverse Modelling 6	Literature Seminar and current Research Questions 9	Master Thesis 30
Schwerpunkt Pflichtmodul 1 *Compulsory for main focus 1* 6	Schwerpunkt Pflichtmodul 4 *Compulsory for main focus 4* 6	Project Work 15	
Schwerpunkt Pflichtmodul 2 *Compulsory for main focus 2* 6	Schwerpunkt Pflichtmodul 5 *Compulsory for main focus 5* 6		
Schwerpunkt Pflichtmodul 3 *Compulsory for main focus 3* 6	Wahlpflicht 2 *Elective 2* 6		
Wahlpflicht 1 *Elective 1* 6	Wahlpflicht 3 *Elective 3* 6	Wahlpflicht 4 *Elective 4* 6	

Summe der Leistungspunkte pro Semester
Sum of the credit points of each semester

30	30	30	30

Studienverlaufsplan Master Physik der Erde und Atmosphäre
Suggested study plan for Master Physics of the Earth and Atmosphere

Studienbeginn im Sommersemester / *Start in summer term*

Inverse Modelling 6	Prognostic Modelling 6	Literature Seminar and current Research Questions 9	Master thesis 30
Schwerpunkt Pflichtmodul 1 *Compulsory for main focus* 1 6	Schwerpunkt Pflichtmodul 3 Compulsory for main focus 3 6	Project work 15	
Schwerpunkt Pflichtmodul 2 Compulsory for main focus 2 6	Schwerpunkt Pflichtmodul 4 Compulsory for main focus 4 6		
Wahlpflicht 1 Elective 1 6	Schwerpunkt Pflichtmodul 5 Compulsory for main focus 5 6		
Wahlpflicht 2 *Elective 2* 6	Wahlpflicht 3 Elective 3 6	Wahlpflicht 4 Elective 4 6	

Summe der Leistungspunkte pro Semester *Sum of the credit points of each semester*			
30	30	30	30

3.2 Fach- und Prüfungsberatung

Neben der Allgemeinen Studienberatung durch die Zentrale Studienberatung der Universität bietet das Institut für Geophysik und Meteorologie eine Fachstudienberatung. Verantwortlich hierfür ist Herr Dr. Wennmacher mit Schwerpunkt Geophysik und Herr Dr. Steffany mit Schwerpunkt Meteorologie.
Individuelle persönliche Gesprächstermine können meist kurzfristig per Telefon oder E-Mail evereinbart werden. Detaillierte Fragen werden auch per E-Mail oder Telefon beantwortet.
Im Rahmen der Studienberatung werden auch allgemeine Fragen zu Prüfungen und deren Organisation behandelt. Daneben stehen für Fragen zur Prüfungsorganisation auch die Mitarbeiterinnen des Prüfungsamtes zur Verfügung.

In addition to the general study advice from the Student Advice Centre the Institute of Geophysics and Meteorology offers academic advicing. Responsible for this is Dr. Wennmacher (focus in geophysics) and Dr. Steffany (focus in meteorology).
Individual appointments can usually be made by phone or email shortly. Questions will be answered by e-mail or telephone.
In the advice general questions on exams and their organization are treated. Additionally, the staff of the Examination Office is available to answer questions about the organization.

3.3 Weitere Informations- und Beratungsangebote

Das Institut für Geophysik und Meteorologie hat sehr engagierte Studierende, die im Rahmen ihrer **Fachschaftsarbeit** umfangreiche Hilfestellung für die Studierenden anbieten. Dies umfasst z.B. Orientierungseinheiten zu Beginn des Studiums, aber auch Beratungstätigkeiten während des Studiums.

Für Studierende, die über das **Erasmusprogramm** einen Teil Ihres Studiums im Ausland absolvieren möchten steht eine Beratung über die Organisation eines Auslandssemesters bei Dr. Wennmacher sowie eine Beratung beim Erasmus-Beauftragten des Departments für Geowissenschaften, Dr. Bödeker, zur Verfügung.

Neben den Beratungsangeboten des Faches steht den Studierenden an der Universität zu Köln ein reichhaltiges Beratungsangebot zur Verfügung. Die wichtigsten Ansprechpartner sind in der folgenden Tabelle aufgelistet.

Zentrale Studienberatung *http://verwaltung.uni-koeln.de/abteilung21/content/beratungsangebote/faecheruebergreifende_studienberatung/index_ger.html*	Allgemeine Fragen zum Studium, Fächerwahl etc.

Studierendensekretariat *http://verwaltung.uni-koeln.de/studsek/content/*	Fragen zur Einschreibung, Rückmeldung etc.
Kölner Studentenwerk *http://www.kstw.de/*	Soziale Aspekte im Zusammenhang mit dem Studium
ASTA *http://www.asta.uni-koeln.de/*	Studierendenvertretung
Rektoratsbeauftragter für Menschen mit Behinderung *http://www.hf.uni-koeln.de/34502*	Studieren mit Behinderung
Akademisches Auslandsamt *http://verwaltung.uni-koeln.de/international/content/incoming/studium_in_koeln/index_ger.html*	Studieren mit Migra-tionshintergrund
Zentrale Gleichstellungsbeauftragte *http://www.gb.uni-koeln.de/*	Vereinbarkeit von Familie und Studium, Sexualisierte Diskriminierung