Karlsruhe Institute of Technology

Module Handbook

Meteorology (MSc)

SPO 2015

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KIT Department of Physics

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1. Introduction to the Study Guide

This module handbook is the relevant document describing the structure and the contents of the Master's degree program in Meteorology, and thus provides helpful information and guidance for the studies. The degree program and its subjects and modules are described in detail, thus providing the necessary information for planning an interdisciplinary course of studies tailored to each student's personal interests and needs.

The first section Study Guide specifies the organization of the degree program and further formalities in addition to the general regulations for the Study and Examination.

A key function of the module handbook is the collection of module descriptions (Section 2) and course descriptions (Section3), which provide information on the requirements and recommendations.

In addition to this module handbook, the university calendar and possibly announcements of the institutes inform about further details, for example, on times and places of lectures and classes.

Please note, that only the German version of the Regulation for the Study and Examination ("Studien- und Prüfungsordnung", SPO) is legally binding. The translated version is for the purpose of information only.

2. Qualification Goals

The graduates of the Master's program in Meteorology know and understand the scientific fundamentals of meteorology and climatology, and have deepened them in the areas of the climate system, atmospheric processes as well as applied and experimental meteorology. This also includes aspects of atmospheric composition and thus of trace gases and aerosols. They have well-founded knowledge of programming techniques, numerical methods, computer simulations and data analysis, and have the ability to explain and at least partly apply complex atmospheric measurements in the laboratory, field and from satellite. They are familiar with mechanisms of the climate system and climate change. They know the relevance of meteorological phenomena such as extreme weather events, air pollution and climate change for society, nature and economy as well as for geoscientific neighboring disciplines, and can discuss and debate them. They also have detailed knowledge in a scientific elective.

Based on the acquired knowledge, the graduates correctly classify facts and thematic areas, and have the ability to solve – or develop approaches to solve – complex problems of the atmospheric and environmental sciences in an analytical-theoretical, computer-based or experimental way. They have the ability to deduce relationships from measured or modeled data, to formulate models, to derive predictions and to concretely test them, and thus to verify or falsify them. In addition, they can apply meteorological knowledge to research-related questions and are able to solve technical problems using the methods of the subject, also employing computer programs.

The graduates furthermore have sound methodological skills with regard to clear presentation and structuring of scientific findings and research results in written and spoken texts, and are proficient in didactically appealing presentation techniques. They can work independently and have extensive communication and organizational skills, including sound knowledge of scientific English. They are able to acquire new knowledge and insights as needed and thus to achieve a broadening or deepening of their knowledge. They have learned to reflect on their actions, and to recognize and evaluate the social and ethical aspects of meteorological research and application.

The distinctiveness of the Master's program in Meteorology compared to other universities lies in the broad range of aspects of meteorology covered as well as the strong research relevance. A successful completion of the Master's program in Meteorology is an excellent foundation for a PhD in Meteorology or in related disciplines, and enables an applied or researching professional activity, i.a. in the field of weather forecasting, earth observation, satellite-based remote sensing and the compilation of environmental reports as well as in atmospheric research institutions and in the insurance and energy industries.

3. Course Program

The masters degree program in Meteorology deepens and extends the essential scientific qualifications obtained in the Bachelor's program in a research-oriented way. Consolidation occurs in the areas of Theoretical Meteorology and Numerical Weather Prediction, Climatology, Remote Sensing and Data Analysis as well as in Atmospheric Chemistry and Aerosols, while extensions take place in the area of Applied Meteorology. A comprehensive practical course familiarizes the graduates with methods of modern atmospheric measurements in the laboratory and field. With the completion of the Master's thesis, the graduates have demonstrated that they are capable of applying scientific knowledge and methods to independently solve complex research problems. In addition, they acquired detailed skills in an elective from a wide range of other natural sciences.

Subjects

The degree program in *Meteorology* comprises 120 credits corresponding to the European Credit Transfer System (ECTS) and is divided into the subjects

- Atmosphären- und Klimaprozesse (Atmospheric and Climate Processes) (24 ECTS)
- Angewandte und Experimentelle Meteorologie (Applied and Experimental Meteorology) (24 ECTS)
- Wahlpflichtbereich (Compulsory Electives) (8 ECTS)
- Überfachliche Qualifikationen (Soft Skills) (4 ECTS)
- Wissenschaftliches Arbeiten: (Scientific Work: Specialization Phase) (30 ECTS)
- Masterarbeit (Master's Thesis) (30 ECTS)
- Additional Subjects (max. 30 ECTS)

For details, see graphic on following page.

Course Program M.Sc. Meteorology (SPO 2015)

Course Program M.Sc. Meteorology (SPO 2015)

1		2		3	4
Middle Atmosphere in The Climate System	Cloud Physics	Remote Sensing of Atmospheric State Variables	Meteorological Hazards*	Specialization Phase: Scientific Concept Development	Master's Thesis
2L	2L+1E	2L+1E	2L		
Seminar on IPCC Assessment Report	Atmospheric Aerosols	Advanced Meteorological Practical Course	Turbulent Diffusion		
2S	2L+1E	5P	2L+1E		
Tropical Meteorology	Atmospheric Radiation	Field Trip	Advanced Numerical Weather Prediction		
2L+1E	2L	2F	2L		
Climate Modeling & Dynamics with ICON	Energetics	Integrated Atmospheric Measurements	Methods of Data Analysis		
2L+1E	2L	2L	2L+1E		
Climate Change*	**Module Exam Atmospheric Processes**	**Module Exam Experimental Meteorology**	Energy Meteorology		
2L	Oral Examination 12 ECTS	Oral Examination 14 ECTS	2L		
Ocean-Atmosphere Interactions	Elective 1	Elective 2	**Module Exam Applied Meteorology**		
2L	Exam 4 ECTS	Exam 4 ECTS	Oral Examination 10 ECTS		
Module Exam Components of the Climate System	Soft Skills	Soft Skills	* Lectures are offered only Irregularly		
Oral Examination 12 ECTS	2 ECTS	2 ECTS			
30 ECTS		30 ECTS		30 ECTS	30 ECTS
Components of The Climate System	Atmospheric Processes	Experimental Meteorology	Applied Meteorology	Specialization Phase	Master's Thesis
Fach Atmosphären- und Klimaprozesse (Atmosphere and climate processes)		Fach Angewandte und Experimentelle Meteorologie (Applied and experimantal meteorology)		Fach Wissenschaftliches Arbeiten (Scientific Work)	Fach Masterarbeit (Master's Thesis)

Informationen über den Umfang der zu belegenden Kurse in den Modulen finden Sie im aktuellen Modulhandbuch.
Information regarding the amount of courses you have to enrol in the modules, you can find in the current Module Handbook.
http://www.imk-tro.kit.edu/english in the category Study and Teaching.

Abbreviations: Lectures (L), Exercises (E), Seminar (S), Field Trip (F), Practical Course (P), Credits corresponding to the European Credit Transfer System (ECTS). Module Examinations are highlighted in bold. In addition, oral or written examinations may be required in elective courses.

Atmospheric and Climate Processes

This is one of two core meteorological subjects comprising two large modules on Components of the Climate System (12 ECTS, see chapter 2.1.) and Atmospheric Processes (12 ECTS, see chapter 2.2.).

Applied and Experimental Meteorology

This is one of two core meteorological subjects comprising two large modules on *Experimental Meteorology* (14 ECTS, see chapter 2.3.) and *Applied Meteorology* (10 ECTS, see chapter 2.4.).

Compulsory Electives

The study can be complemented by electives to individualize the degree program. These could thus be modules from related disciplines such as Physics, Geoecology, Geophysics, Mechanical Engineering, or Applied Geo sciences.

Examples of possible *Compulsory Elective Modules* from other disciplines are listed in section II chapter 5. All subject-specific modules, for which an examination has not already been taken, can be chosen.

Scientific Work: Specialization Phase

Students carry out an interdisciplinary *Study Project*, for which 30 ECTS are credited. The project prepares students for independent scientific working and writing, and introduces skills in project management. The *Study Project* focuses on the topic of the subsequent *Master's Thesis* and serves as a preparation for the scientific work. In addition to the competence in reading and understanding scientific literature, the students acquire abilities for independent work and critical evaluation of results in the context of the literature.

Master’s Thesis

This module is intended to provide students with in-depth aspects of scholarly writing and presentation. Building on the results from the Specialization Phase, students further advance their own research project to finally write a Master’s Thesis. The written scientific work includes a summary of the state of the literature, presentation of the goals, methods used and the results obtained as well as a discussion of the knowledge gained and the remaining open questions.

More information about the modules *Specialization Phase* and *Master’s Thesis* is provided in the Guidelines to Master’s Thesis in section 4.

4. Excerpts from the Regulation for the Study and Examination

4.1. Regular Period of Study, Organization of Study, Credits (§3, SPO)

(1) The regular period of study shall be four semesters.

(2) The curriculum of the program is divided into subjects, the subjects into modules, and the modules are divided into courses. The subjects and their scopes are defined in Article 19. Details are outlined in the module manual.

(3) The workload envisaged for passing courses and modules is expressed in credits. The criteria for assigning credits correspond to the European Credit Transfer System (ECTS). One credit corresponds to a workload of about 30 hours. Usually, the credits shall be distributed equally over the semesters.

(4) The coursework and examinations required for the successful completion of the study are measured in credits and amount to a total of 120 credits.

(5) Upon prior announcement, the courses may also be offered in English.

4.2. Module Examinations, Coursework and Assessments (§4, SPO)

(1) The master's examination shall consist of module examinations. Module examinations shall consist of one or several controls of success ("Erfolgskontrollen"). Controls of success shall consist of coursework ("Studienleistungen") and assessments ("Prüfungsleistungen").

(2) Assessments are:

- Written examinations,
- oral examinations, or
- examinations of another type.

(3) Coursework shall be written, oral, or practical work that is usually accomplished by students simultaneously to the taught courses. The master's examination must not be completed by a coursework.

(4) At least 70% of the module examinations shall be graded.

(5) In case of complementary contents, module examinations of several modules may be combined (par. 2, nos. 1-3).

4.3. Registration for and Admission to Module Examinations and Courses (§5, SPO)

(1) To participate in module examinations, students shall register online on the Students Portal for the corresponding controls of success. In exceptional cases, registration can be made in writing to the Students Office or another institution authorized by the latter. For controls of success, registration deadlines may be specified by the examiners. Registration of the master's thesis is outlined in the module manual.

To get help with the Campus System visit https://www.sle.kit.edu/imstudium/videotutorials-campus.php (currently available only in German language) or ask the *student counseling* via Mail.

(2) For admission to an examination in an elective module, students shall submit – together with their registration for the examination – a binding declaration relating to their choice of the module and its assignment to a subject prior to the first examination in this module. At the request of the student to the examination committee, the choice or assignment can be changed later. If an examination procedure in a module has already started, the choice of elective or assignment to a subject can only be changed after its completion.

(3) Admission to a control of success shall be granted to students, who

- are enrolled in the Master's Program in Meteorology at KIT; with the admission of students on leave being limited to examinations, and to students, who
- can prove that they meet the requirements for admission to a control of success outlined in the module manual and
- can prove that their entitlement to an examination in the Master's Program in Meteorology has not been lost.

(4) According to Article 30, par. 5, LHG (Landeshochschulgesetz), admission to individual mandatory courses may be restricted. The examiner shall decide on the selection of students, who have registered in due time before the deadline given by the examiner, taking into account the study progress made by these students and taking into consideration Article 13, par. 1, clauses 1 and 2, if the surplus of registrations cannot be reduced by other or additional courses. In the case of identical study progress, further criteria shall be specified by the KIT departments. The result shall be announced to the students in due time.

(5) Admission shall be refused, if the conditions outlined in pars. 3 and 4 are not fulfilled. Admission may be refused, if a control of success that was required for admission to this Master's Program was already passed in a KIT bachelor's program. This shall not apply to premature master's examinations ("Mastervorzug"). Admission to these shall be approved explicitly according to clause 1.

4.4. Execution of Controls of Success (§6, SPO)

(1) Controls of success shall be performed simultaneously to the taught courses, usually while conveying the contents of the individual modules or shortly afterwards.

(2) The type of control of success (Article 4, par. 2, nos. 1 – 3, par. 3) shall be specified by the examiner of the respective course depending on the contents of the course and teaching objectives of the module. The type of controls of success, their frequency, sequence, weighting, and the determination of the module grade, if applicable, shall be announced in the module manual six weeks prior to the start of the lecturing period at the latest. The examiner and student may change the type of examination and the examination language later on. In the former case, Article 4, par. 4 has to be observed. When organizing examinations, the needs of students with a disability or chronic disease shall be considered according to Article 13, par. 1. Article 13, par. 1, clauses 3 and 4 shall apply accordingly.

(3) In case of an unreasonably high examination workload, a written examination may also be passed orally or an oral examination may also be passed in writing. This modification shall be announced six weeks prior to the examination at the latest.

(4) In case of courses in the English language (Article 3, par. 5), the corresponding controls of success can be executed in this language. Article 6, par. 2 shall apply accordingly.

(5) Written examinations (Article 4, par. 2, no. 1) shall usually be evaluated by an examiner according to Article 17, pars. 2-4. If an evaluation is made by several examiners, the grade shall be the arithmetic mean of the individual evaluations. If the arithmetic mean does not correspond to any of the grade levels defined in Article 7, par. 2, cl. 2, the grade shall be rounded to the next higher or lower grade level. In case of equal distance to the next higher and lower levels, the grade shall be rounded to the next higher grade level. The evaluation procedure shall not exceed six weeks. Written examinations shall last at least 60 and not more than 300 minutes.

(6) Oral examinations (Article 4, par. 2, no. 2) shall be performed and evaluated as group or individual examinations by several examiners (examining board) or by one examiner in the presence of an assessor. Prior to determining the grade, the examiner shall consult the other examiners of the examining board. Oral examinations shall usually last at least 15 minutes and not more than 60 minutes per student.

Major details and results of the *oral examination* shall be minuted. The result of the examination shall be announced to the student directly after the oral examination.

Students who intend to take the same examination in a later semester shall be admitted to oral examinations as an observer depending on the space available and upon approval of the examinee. They shall not be admitted to the consultation of the examining board and the announcement of the examination results.

(7) For *examinations of another type*, (Article 4, par. 2, no. 3), appropriate deadlines and submission dates shall be specified. Proper description of the task and adequate documentation shall ensure that the examination passed can be credited to the student. Major details and results of the control of success shall be minuted.

During *oral examinations of another type*, an assessor shall be present in addition to the examiner, who shall also sign the minutes together with the examiner.

Theses or papers to be written for *an examination of another type* shall be provided with the following declaration:

> *"Ich versichere wahrheitsgemäß, die Arbeit selbstständig angefertigt, alle benutzten Hilfsmittel vollständig und genau angegeben und alles kenntlich gemacht zu haben, was aus Arbeiten anderer unverändert oder mit Abänderungen entnommen wurde."*
>
> *„I herewith declare that the present thesis/paper is original work written by me alone and that I have indicated completely and precisely all aids used as well as all citations, whether changed or unchanged, of other theses and publications."*

If the thesis/paper does not contain this declaration, it shall not be accepted. Major details and results of such a control of success shall be minuted.

4.5. **Controls of Success by a Multiple Choice Test (§6a, SPO)**

It is outlined in the module manual whether and to what extent controls of success can be made by a multiple choice test.

4.6. **Repetition of Examinations, Ultimate Failure (§8, SPO)**

(1) Students may repeat once a written examination that has not been passed (Article 4, par. 2, no. 1). In case a repeated written examination is given the grade of "nicht ausreichend" (5.0, failed), an oral reexamination shall take place soon after the date of the failed examination. In this case, the grade of this examination may not be better than "ausreichend" (4.0, sufficient).

(2) Students may repeat once an oral examination that has not been passed (Article 4, par. 2, no. 2).

(3) Repeated examinations according to paragraphs 1 and 2 shall correspond to the first examination in terms of contents, scope, and type (oral or written). At request, exceptions may be approved by the responsible examination committee.

(4) Examinations of another type (Article 4, par. 2, no. 3) can be repeated once.

(5) Coursework can be repeated several times.

(6) An examination shall ultimately not be passed, if the oral reexamination according to par. 1 was evaluated with the grade of "nicht ausreichend" (5.0, failed). The examination also shall ultimately not be passed, if the oral examination according to par. 2 or the examination of another type according to par. 4 was evaluated twice with the grade of "nicht bestanden" (failed).

(7) The module shall ultimately not be passed, if an examination required for passing the module is ultimately not passed.

(8) A second repetition of the same examination according to Article 4, par. 2 shall be possible in exceptional cases at the request of the student only ("Antrag auf Zweitwiederholung" – application for a second repetition). As a rule, the application shall be submitted in writing to the examination committee within two months after announcement of the grade.

The examination committee shall decide on the first application of a student for a second repetition. If the examination committee dismisses the application, a member of the Presidential Committee shall decide. Upon comment of the examination committee, a member of the Presidential Committee shall decide on further applications for a second repetition. If the application is accepted, the second repetition shall take place on the next but one examination date at the latest. Paragraph 1, clauses 2 and 3 shall apply accordingly.

(9) Repetition of a passed examination shall not be permitted.

(10) In case a Master's thesis has been granted the grade “nicht ausreichend” (5.0, failed), it can be repeated once. A second repetition of the Master's thesis shall be excluded.

4.7. **Loss of the Entitlement to an Examination (§9, SPO)**

In case coursework or an examination required according to the present Regulations for Study and Examination is ultimately not passed or the master’s examination, including potential repetitions, is not passed completely by the end of the examination period of the seventh semester, the entitlement to examination in the Master’s Program in Meteorology shall expire, unless the student is not responsible for having exceeded the deadline. The decision on extending the deadline and on exceptions from the deadline regulations shall be made by the examination committee taking into account the activities listed in Article 32, par. 6, LHG at the request of the student. This request shall be made in writing usually six weeks prior to the expiry of the deadline.

4.8. **Deregistration, Absence, Withdrawal (§10, SPO)**

(1) Students can revoke their registration for *written examinations* until the issue of the examination tasks without having to indicate any reasons (deregistration). Deregistration can be made online on the Students Portal by 12 pm on the day before the examination or in justified exceptional cases with the Students Office during office hours. If the deregistration is addressed to the examiner, the latter shall ensure that the deregistration is documented in the Campus Management System.

(2) In case of *oral examinations*, deregistration shall be declared to the examiner at least three working days before the date of examination. Withdrawal from an oral examination less than three working days before the date of examination shall be possible under the conditions outlined in par. 5 only. In principle, withdrawal from oral reexaminations in the sense of Article 9, par. 1 shall be possible under the conditions of par. 5 only.

(3) Withdrawal from *examinations of another type* and from *coursework* shall be subject to the provisions given in the module manual.

(4) An examination shall be deemed to have been “nicht ausreichend” (5.0, failed), if the student fails to be present at the examination without a good reason or if she/he withdraws from the examination after its start without a good reason. The same shall apply, if the master’s thesis is not submitted within the period envisaged, unless the student is not responsible for having exceeded the deadline.

(5) The reason given for withdrawal after the start of the examination or absence shall be notified immediately, credibly, and in writing to the examination committee. In case of sickness of the student or of a child cared for by the student alone or of a relative in need of care, submission of a medical certificate may be required.

4.9. **Maternity Leave, Parental Leave, Assumption of Family Obligations (§12, SPO)**

(1) At the student's request, the maternity protection periods as defined by the Act on the Protection of the Working Mother (Mutterschutzgesetz, MuSchG), as amended, shall be considered. The required evidence shall be enclosed with this request. The maternity protection periods suspend any deadline according to the present examination regulations. The duration of maternity protection shall not be included in the deadline given.

(2) At request, the deadlines of parental leave shall be considered according to the valid legislation (Bundeselterngeld- und Elternzeitgesetz (Parental Benefit and Parental Leave Act – BEEG)). Four weeks prior to the desired start of the parental leave period at the latest, the student shall inform the examination committee in writing about the time when she/he wishes to be on parental leave. The required evidence shall be enclosed. The examination committee shall then check whether the legal prerequisites would justify an employee's claim for parental leave and inform the student immediately of the result and the new times of examination. The period of work on the Master's thesis may not be interrupted by parental leave. In this case, the thesis shall be deemed to have not been assigned. After expiry of the parental leave period, the student shall receive a new subject that is to be dealt with within the period defined in Article 14.

(3) At request, the examination committee shall decide on the flexible handling of examination deadlines according to the provisions of the Act of Baden-Württemberg on Universities and Colleges (LHG), if students have to assume family obligations. Paragraph 2, clauses 4 to 6 shall apply accordingly.

4.10. Students with a Disability or Chronic Disease (§13, SPO)

(1) When organizing degree programs and examinations, the needs of students with a disability or chronic disease shall be considered. In particular, students with a disability or chronic disease shall be granted preferred access to courses with a limited number of participants and the order for passing certain courses shall be adapted to their needs. According to the Federal Equality Act (Bundesgleichstellungsgesetz, BGG) and Vol. 9 of the Social Code (SGB IX), students are disabled, if their bodily function, mental capacity, or emotional health most probably deviates from the state typical of the age for a period longer than six months and, hence, their participation in social life is impaired. At the request of the student, the examination committee shall decide on the existence of conditions outlined in clauses 2 and 3. The student shall submit the required evidence for this purpose.

(2) If a student provides evidence of a disability or chronic disease, as a result of which she/he is not able to pass examinations completely or partly within the planned time or in the form envisaged, the examination committee may permit examinations within other time periods or in another form. In particular, disabled students shall be permitted to use the required aids.

(3) In case students provide evidence of a disability or chronic disease, as a result of which they are not able to attend courses regularly or to pass the required coursework or examinations as outlined in Article 19, the examination committee may permit at the student's request passing of certain coursework and examinations after the expiry of the deadlines given in the present Regulations for Study and Examination.

(4) Examples of possible compensations of disadvantages:

- Modified form of exams, for instance oral exams instead of written exams, and vice versa
- Conducting exams in a separate room
- Allowing necessary utilities and assistance, e.g. sign language interpreter
- Additional breaks during time-limited exams
- Extension of the periods between exams

4.11. **Master's Thesis (§14, SPO)**

The *Master's Thesis* is an independent scientific study and includes the theoretical and/or experimental work on a complex problem. Students deal with the current state of research and apply the expertise and scientific methods acquired during the studies. They can document, discuss and evaluate the obtained results. Furthermore, they can present and defend the essential findings. The topic of the *Master's Thesis* depends on the subject area chosen for the thesis.

(1) For admission to the master's thesis module, module examinations worth 70 credits must have been passed successfully. In particular, module examination in the subject of "Wissenschaftliches Arbeiten" (Scientific Work) must have been passed successfully. At the request of the student, the examination committee shall decide on exceptions.

(1a) 30 credits are assigned to the master's thesis module. It consists of the master's thesis and a presentation. The presentation shall be given four weeks after submission of the master's thesis at the latest.

(2) The master's thesis topic can only be given out by university teachers ("Hochschullehrer(in)"), habilitated scientists, and leading scientists ("leitende(r) Wissenschaftler(in)") according to Article 14, par. 3, clause 1, KITG. In addition, the examination committee can authorize other examiners to give out the topic according to Article 17, pars. 2-4. The student shall be given the possibility of making proposals for the topic. If the master's thesis is to be written outside of the KIT Department of Physics, the approval of the examination committee shall be required. The master's thesis may also be accepted in the form of group work, if the contribution of the individual student to be evaluated in the examination can be distinguished clearly based on objective criteria and if the requirement outlined in par. 4 is fulfilled. In exceptional cases, the chairperson of the examination committee shall take care of the student receiving a topic for the master's thesis within four weeks after her/his request. In this case, the topic is issued by the chairperson of the examination committee.

(3) The subject, task, and scope of the master's thesis shall be limited by the supervisor such that it can be handled with the workload outlined in par. 4.

(4) The master's thesis shall demonstrate that the student is able to deal with a problem of her/his subject area in an independent manner and within a limited period of time using scientific methods. The scope of the master's thesis shall correspond to 30 credits. The maximum duration of work on the thesis shall amount to six months. The subject and task shall be adapted to the scope envisaged. The examination committee shall specify in which languages the master's thesis can be written. At the request of the student, the examiner can permit the master's thesis to be written in a language other than German.

(5) When submitting the master's thesis, the student shall assure in writing that the thesis is original work by her/him alone and that she/he has used no sources and aids other than indicated, marked all citations in word and content, and observed the Rules of KIT for Safeguarding Good Scientific Practice, as amended. If this declaration is not contained, the thesis will not be accepted.

The wording of the declaration may be:

> *"Ich versichere wahrheitsgemäß, die Arbeit selbständig verfasst, alle benutzten Hilfsmittel vollständig und genau angegeben und alles kenntlich gemacht zu haben, was aus Arbeiten anderer unverändert oder mit Abänderungen entnommen wurde sowie die Satzung des KIT zur Sicherung guter wissenschaftlicher Praxis in der jeweils gültigen Fassung beachtet zu haben."*
>
> *"I herewith declare that the present thesis is original work written by me alone and that I have indicated completely and precisely all aids used as well as all citations, whether changed or unchanged, of other theses and publications, and that I have observed the Rules of KIT for Safeguarding Good Scientific Practice, as amended."*

If the declaration is not true, the master's thesis shall be evaluated "nicht ausreichend" (5.0, failed).

(6) The time of giving out of the topic of the master's thesis shall be recorded in the files of the examination committee by the supervisor and the student. The time of submission of the master's thesis shall be recorded in the files of the examination committee by the examiner. The student shall be allowed to return the topic of the master's thesis once only within the first month of the period of work on the thesis. At the justified request of the student, the examination committee may extend the time of work on the thesis given in par. 4 by three months at the maximum. If the master's thesis is not submitted in time, it shall be deemed to have been "nicht ausreichend" (failed, 5.0), unless the student is not responsible for this failure.

(7) The master's thesis shall be evaluated at least by one university teacher ("Hochschullehrer(in)") or leading scientist ("leitende(r) Wissenschaftler(in)") according to Article 14, par. 3, clause 1, KITG and another examiner. Usually, one of the examiners is the person who gave out the thesis topic according to par. 2. In case of deviating evaluations of both persons, the examination committee shall fix the grade of the master's thesis within the limits of the evaluations of both persons. It may also appoint another expert. The evaluation period shall not exceed eight weeks after submission of the master's thesis.

4.12. **Additional Achievements (§15, SPO)**

(1) Up to 30 further credits may be acquired in courses offered by KIT (additional achievements, "Zusatzleistungen"). Articles 3 and 4 of the examination regulations shall remain unaffected. These additional achievements shall not be considered when calculating the final and module grades. The credits not considered when determining the module grade shall be listed as additional achievements in the transcript of records. At the student's request, additional achievements shall be indicated in the master's certificate and marked as additional achievements. Additional achievements shall be listed with the grades outlined in Article 7.

(2) The student shall declare a module examination an additional achievement when registering for this examination. At the student's request, allocation of the module can be changed later on.

4.13. **Transferable Skills (Soft Skills) (§15a, SPO)**

Apart from scientific qualifications, KIT attaches high importance to transferable skills. These skills of 4 credits shall be part of the Master's Program in Meteorology. Transferable skills may be achieved additively or integratively.

A wide range of interdisciplinary qualifications is offered by

- the House of Competence (HOC)
- the Sprachenzentrum (language center)
- the Center for Cultural and General Studies (ZAK)

4.14. **Recognition of Coursework and Examinations as well as of Study Periods (§18, SPO)**

(1) Coursework and examinations completed, as well as study periods passed, in study programs at state or state-recognized universities and universities of cooperative education of the Federal Republic of Germany or at foreign state or state-recognized universities shall be recognized at the request of the student, if the competencies acquired do not differ considerably from the achievements or degrees to be replaced. For this, no schematic comparison, but an overall analysis shall be made. As regards the scope of a coursework to be recognized, the principles of the ECTS shall be applied.

(2) The student shall submit the documents required for recognition. Students newly enrolled in the Master's Program in Meteorology shall submit the application together with the documents required for recognition within one semester after enrollment. If documents are not available in the German or English language, an officially certified translation may be required. The examination committee shall bear the burden of proving that the application does not meet the recognition requirements.

(3) If achievements from outside of the KIT are recognized, they are listed as "anerkannt" (recognized) in the certificate. If grades exist, they shall be taken as is in case of comparable grade scales and shall be included in the calculation of module grades and the final grade. In case of incomparable grade systems, the grades can be converted. In the absence of grades, the note "bestanden" (passed) shall be entered.

(4) When recognizing coursework and examinations passed outside of the Federal Republic of Germany, the equivalence agreements adopted by the Conference of Ministers of Education and the German Rectors' Conference as well as agreements concluded within the framework of university partnerships shall be considered.

(5) Knowledge and skills acquired outside of the university system shall be recognized, if they are equivalent to the coursework and examinations to be replaced in terms of contents and level and if the institution, where the knowledge and skills were acquired, has a standardized quality assurance system. Recognition may be refused in parts when more than 50% of the university's study program is to be replaced.

(6) The examination committee (§16, SPO) shall be responsible for recognition. To determine whether a considerable difference in the sense of par. 1 exists, the responsible subject representatives shall be heard. Depending on the type and scope of coursework and examinations to be recognized, the examination committee shall decide on admission to a higher semester.

4.15. **Accomplishments obtained outside of the Higher Education System**

Accomplishments made outside of the higher education system, as for example vocational training, can be accredited if the acquired competences contribute to the qualification goals of the Master's program. Recognition is requested with the respective form of the examination committee.

The examination committee verifies to which extent the acquired knowledge and capabilities can be recognized, and which parts of the program they can replace. At maximum, 50 % of the university education can be replaced. The form for recognition must be submitted to the study advisor, who will transfer it to the examination committee and the "Studierendenservice".

5. **Forthcoming Changes**

- The course Polar meteorology will not be offered in the winter term 2019/20.

II Modules

1. Components of the Climate System

Module Code	**M-PHYS-100951**
Responsible Lecturer	Prof. Dr. Andreas Fink
Level	4
Components of the module: Compulsory Electives	T-PHYS-107692 Seminar on IPCC Assessment Report T-PHYS-107693 Tropical Meteorology T-PHYS-108928 Climate Modeling & Dynamics with ICON T-PHYS-108931 Middle Atmosphere in the Climate System T-PHYS-108932 Ocean-Atmosphere Interactions
ECTS Credits	12
Study Program	MSc *Meteorology*, compulsory module in the subject Atmospheric and Climate Processes
Instruction Language	English
Duration	1 semester
Module Frequency	Each winter semester
Module Content	This module aims to give students an overview of important components of the climate system, their physical and chemical backgrounds and their temporal and spatial changes. This includes lectures, course work, computer and modelling classes on individual components of the climate system (e.g. tropics, polar regions, ocean, middle atmosphere) and on climate dynamics and change.
Workload	Presence time in lectures, exercises: 120 hours Preparation / follow-up: 120 hours Exam preparation: 120 hours
Controls of Success	
Prerequisite: Coursework (“Studienleistung”)	For type of Coursework see Course description (“Teilleistungsbeschreibung”) → successful completion of the prerequisites entitles to exam
Examination:	**T-PHYS-109138 Components of the Climate System (Module Exam)**
Assessment (“Prüfungsleistung”)	Oral exam (approx. 60 minutes) in accordance with § 4 (2) No. 2 SPO Master's Meteorology

Special Features of the Exam	None
Grade	Grade of the oral exam
Exam Requirements	In the module *Components of the climate system* courses (C) are offered with lectures (L) and exercises (2L1E) and lectures without exercises (2L). Registration for this examination is only possible if courseworks have been made in a sufficient amount. There are different ways to do this: - 3C with 2L1E - 2C with 2L1E and 2C with 2L - 1C with 2L1E and 4C with 2L
Recommendations	Basic knowledge about the climate system is helpful.
Conditions	None

Learning Outcomes

The students can explain essential components of the climate system and their physical properties. They are capable of explaining causes of climate change expertly to present and critically discuss. Students can designate monitoring systems for climate monitoring and how they work of climate models. The students can designate essential processes in the atmosphere and ocean and explain with physical and chemical laws. They are able to analyze and interpret climate and weather data on the basis of diagnostic methods. In addition, they can expertly present and discuss learned or self-developed scientific findings.

2. Atmospheric Processes

Module Code	M-PHYS-100952
Responsible Lecturer	Prof. Dr. Corinna Hoose
Level	4
Components of the module:	T-PHYS-107694 Cloud Physics T-PHYS-107695 Energetics T-PHYS-108938 Atmospheric Aerosols T-PHYS-107696 Atmospheric Radiation
ECTS Credits	12
Study Program	MSc Meteorology, compulsory module in the subject Atmospheric and Climate Processes
Instruction Language	English
Duration	1 semester
Module Frequency	Each winter semester
Module Contents	This module aims to give students an overview of important physical and chemical processes in the atmosphere. This includes lectures and course work on cloud physics, radiation, aerosols, and energetics of the atmosphere. For more information concerning details of the courses, please consult the course descriptions ("Teilleistungsbeschreibungen").
Workload	Presence time in lectures, exercises: 113 hours Preparation / follow-up: 87 hours Exam preparation: 160 hours
Controls of Success	
Prerequisite: Coursework ("Studienleistung")	For type of Coursework see Course description ("Teilleistungsbeschreibung") → successful completion of the prerequisites entitles to exam
Examination:	**T-PHYS-108939 Atmospheric Processes (Module Exam)**
Assessment ("Prüfungsleistung")	Oral exam (approx. 60 minutes) in accordance with § 4 (2) No. 2 SPO Master's Meteorology
Special Features of the Exam	None
Grade	Grade of the oral exam
Exam Requirements	All Courses must be passed.

Recommendations	None
Conditions	None

Learning Outcomes

The students can name essential processes in the atmosphere and explain these using physical and chemical laws. In particular, they are capable of explaining structure and dynamics of different cloud systems and estimating the micro physical processes in clouds or calculating them directly for idealized conditions. In addition, the students are capable of mathematically evaluating the radiation transport in the atmosphere and describe the importance of radiation processes for the structure of the atmosphere, for climate change and for the measurement of different atmospheric variables. They can also explain the chemical structure and the composition of the aerosols in the troposphere and the stratosphere on the basis of the atmospheric physico-chemical processes and transformations. The students are able to understand the chemical and physical causes of stratospheric ozone hole and its future development, know the main aerosol-cloud processes and are familiar with the *Köhler theory* and the classical nucleation theory.

3. Experimental Meteorology

Module Code	**M-PHYS-100953**
Responsible Lecturer	Prof. Dr. Christoph Kottmeier
Level	4
Components of the module:	T-PHYS-109133 Remote Sensing of Atmospheric State Variables T-PHYS-109902 Integrated Atmospheric Measurements T-PHYS-109135 Advanced Practical Course T-PHYS-109136 Field Trip
ECTS Credits	14
Study Program	MSc Meteorology, compulsory module in the subject *Experimental and Applied Meteorology*
Instruction Language	English
Duration	1 semester
Module Frequency	Each summer semester
Module Contents	This module is intended to provide students with an overview of modern measurement methods in meteorology and practical aspects of application. In particular, this includes: • **remote sensing** (physical basics, radiation transfer, inverse methods, basics of satellite remote sensing, techniques and applications), • radar techniques (scattering and absorption of electromagnetic waves, radar equation, radar reflectivity factor and rain rate, technical aspects, radar beams in a stratified medium, wind information from Doppler radar data) and laser processes (properties and propagation of light, basics of the laser, functional principles of laser remote sensing, technical structure of lidar systems, overview of common lidar measuring methods, space-based lidar systems) as **integrated atmospheric measurements**. • In addition, the module provides the students with an insight into and **practical experience** with modern measuring methods, such as those used in research at KIT and other institutions, on the basis of the internship and the excursion.
Workload	Presence time in lectures, exercises: 57 hours Attendance time in excursion and practicals 100 hours Preparation / follow-up: 143 hours Exam preparation: 120 hours
Controls of Success	

Prerequisite: Coursework ("Studienleistung")	For type of Coursework see Course description (Teilleistungsbeschreibung) → successful completion of the prerequisites entitles to exam
Examination:	**T-PHYS-109137 Experimental Meteorology (Module Exam)**
Assessment ("Prüfungsleistung")	Oral exam (approx. 60 minutes) in accordance with § 4 (2) No. 2 SPO Master's Meteorology
Special Features of the Exam	None
Grade	Grade of the oral exam
Requirements	All Courses must be passed.
Recommendations	None
Conditions	None

Learning Outcomes

The students can explain the functionality of modern meteorological measuring methods and measuring principles and name their possible uses. This is especially true for remote sensing, advanced in-situ, trace gas and aerosol measurements. The students are able to build and execute experiments in the lab or in the field according to instructions, to record and evaluate data scientifically founded and then interpret and present the results.

4. Applied Meteorology

Module Code	M-PHYS-100954
Responsible Lecturer	Prof. Dr. Joaquim Pinto
Level	4
Components of the module:	T-PHYS-109142 Methods of Data Analysis T-PHYS-109139 Advanced Numerical Weather Prediction T-PHYS-109140 Meteorological Hazards! T-PHYS-109141 Energy Meteorology T-PHYS-108610 Turbulent Diffusion!
ECTS Credits	10
Study Program	MSc Meteorology, compulsory module in the subject *Experimental and Applied Meteorology*
Instruction Language	English
Duration	1 semester
Module Frequency	Each summer semester
Module Contents	This module aims to give students an overview of important applications of meteorology in areas such as weather forecasting and warning, insurance and energy industry, air quality and data analysis. In particular, the module deals with the following aspects: • **Methods of data analysis** that are widely used in the Geo sciences. and particularly in meteorology / climate research are presented (e.g., statistical methods, correlation analyzes, least-squares (linear, multi-linear, and nonlinear regression), principal component analysis, Fourier analysis) • Methods of **numerical weather prediction** (hydrodynamic equation systems, spectral approximation methods, differential approximation on irregular lattices, statistical data assimilation methods, operational aspects of weather forecasting) • **Meteorological natural hazards** (extreme events, extra tropical and tropical cyclones, convection, thunderstorms, super cells, tornadoes, convective storm gusts, derechos, hail, climate change and extreme events) • **Energy meteorology** (fundamentals of the energy system, application of meteorological expertise in the energy industry, in particular for the integration of renewable energies wind power, solar energy and hydro power, deepening of individual meteorological aspects of particular relevance) • Dispersion of atmospheric constituents (relevant trace gases, diurnal cycles of emissions and concentrations, temperature and flow evolution in the lower

	atmosphere, **turbulent diffusion**, turbulence parameterization, chemical conversion processes, numerical models)
Workload	Presence time in lectures, exercises: 90 hours Preparation / follow-up: 90 hours Exam preparation: 120 hours
Controls of Success	
Prerequisite: Coursework (“Studienleistung”)	For type of Coursework see Course description (Teilleistungsbeschreibung) → successful completion of the prerequisites entitles to exam
Examination:	**T-PHYS-109143 Applied Meteorology (Module Exam)**
Assessment (“Prüfungsleistung”)	Oral exam (approx. 60 minutes) in accordance with § 4 (2) No. 2 SPO Master's Meteorology
Special Features of the Exam	None
Grade	Grade of the oral exam
Requirements	In the module *Applied Meteorology* courses (C) are offered with lectures (L) and exercises (2L1E) and lectures without exercises (2L). Registration for this examination is only possible if courseworks have been made in a sufficient amount. There are different ways to do this: Methods of Data Analysis & • 1C with 2L1E and 1C with 2L, or • 3C with 2L
Recommendations	Basic knowledge in statistics is helpful.
Conditions	None
Learning Outcomes	

The students can professionally explain essential aspects of application aspects of meteorology and assign them to specific application areas. They are capable to describe the functionality of a modern weather forecasting system in detail and are able to predict potential for extreme events and their impact on the population and the insurance industry depending on the region and the season. The students are capable to derive the Impact on air pollution and generating regenerative energy from weather information. They are capable of analyzing meteorological data using statistical and computer-based methods.

5. Compulsory Elective Modules

5.1. Modern Theoretical Physics for Teacher Students

Module Code	**M-PHYS-101664**
Responsible Lecturer	Dr. Stefan Giesecke
Level	4
Components of the module	T-PHYS-103203 – Moderne Theoretische Physik für Lehramt – Vorleistung T-PHYS-103204 – Moderne Theoretische Physik für Lehramt – Prüfung
ECTS Credits	Prerequisite: 0 Exam: 8
Study Program	Physics LA Bachelor
Instruction Language	German
Duration	1 semester
Module Frequency	Each winter semester
Module Contents	• Electrostatics: basic equations, scalar potential, examples. • Magneto statics: basic equations, vector potential, examples. • Special relativity theory, relativistic formulation of electrodynamics. • Time-dependent fields and radiation phenomena: basic equations, Poynting theorem. • Electromagnetic waves: plane waves, polarization, wave packets, spherical waves, electromagnetic potentials and gauge transformations, Hertzian dipole. • Basic equations of quantum mechanics. Uncertainty principle. Interpretation of the wave function. A particle in one dimension. Multi-particle states, Pauli principle. Energy eigenstates of the hydrogen atom. Atomic structure and periodic table of the elements in the model of hydrogen-like atoms.
Workload	240 hours
Controls of Success	
Prerequisite: Coursework (“Studienleistung”)	Exercise sheets → successful completion of the prerequisite entitles to exam

Examination:	**T-PHYS-103204 – Moderne Theoretische Physik für Lehramt – Prüfung**
Assessment (“Prüfungsleistung”)	Oral exam (approx. 60 minutes) in accordance with § 4 (2) No. 2 SPO Master's Meteorology
Special Features of the Exam	**None**
Grade	Grade of the oral exam
Requirements	Modules Classical Theoretical Physics I and II
Recommendations	Basic knowledge in statistics are helpful.
Conditions	None

Learning Outcomes

Know the basics of the theory of electric and magnetic fields and the electrical and magnetic properties of matter. Fundamentals of quantum mechanics with simple applications.

5.2. **Modern Theoretical Physics I, Quantum Mechanics I**

Module Code	**M-PHYS-101707**
Responsible Lecturer	Prof. Dr. Frans Klinkhamer (ITP)
Level	4
Components of the module	T-PHYS-102317 – Moderne Theoretische Physik I, Quantenmechanik 1, Vorleistung 1 T-PHYS-105134 – Moderne Theoretische Physik I, Quantenmechanik 1
ECTS Credits	8
Study Program	MSc Meteorology
Instruction Language	German
Duration	1 semester
Module Frequency	Each summer semester
Module Content	• Introduction: Historical Remarks, Limitations of Classical Physics • Dualism particle and wave: wave mechanics, matter waves, wave packets, uncertainty principle, Schrödinger equation, qualitative understanding of simple cases. • Mathematical tools: Hilbert space, Bra and Ket, operators, hermiticity, unitarity, eigenvectors and eigenvalues, observable, basis, completeness. • Postulates of quantum mechanics: measurement process, time evolution, time evolution of expectation values, Ehrenfest theorem and classical borderline case. • One-dimensional potentials: Potential wells, harmonic oscillator. • Bound states in a three-dimensional potential: separation of variables, central potential, angular momentum, rotational symmetry and spin, degeneracy, particles in the external electromagnetic field, hydrogen atom. • Time-independent perturbation theory: Neat and degenerate case, fine structure of the hydrogen spectrum, Stark effect. • Basics of Scattering Theory: Differential cross section, Born series and Born approximation, partial waves and scattering phases, optical theorem.
Workload	240 hours
Controls of Success	
Prerequisite: Coursework	successful completion of the exercises

("Studienleistung")	→ successful completion of the prerequisite entitles to exam
Examination:	**T-PHYS-105134 – Moderne Theoretische Physik I, Quantenmechanik 1**
Assessment ("Prüfungsleistung")	Oral exam (approx. 45 min.) in accordance with § 4 (2) No. 2 SPO Master's Meteorology
Special Features of the Exam	None
Grade	Grade of the oral exam
Requirements	None
Recommendations	None
Conditions	None

Learning Outcomes

The student learns the basic concepts of single-particle quantum mechanics and applies them to important questions. He / she lays the foundation for a fundamental understanding of the microscopic world.

5.3. Physics of Planetary Atmospheres

Module Code	M-PHYS-104488
Responsible Lecturer	Prof. Dr. Thomas Leisner (IMK)
Level	4
Components of the module	T-PHYS-109177 – Physics of Planetary Atmospheres T-PHYS-109180 – Exam on Physics of Planetary Atmospheres
ECTS Credits	10
Study Program	MSc Meteorology, Compulsory Elective MSc Physics, Minor Subjects MSc Physics, Supplementary Module
Instruction Language	English
Duration	1 semester
Module Frequency	Each winter semester
Module Content	The module gives a broad introduction into the formation and properties of planets and their atmospheres and tries to constrain possible planetary atmospheres by applying fundamental principles of physics. In this respect, the module will focus on the planetary atmospheres in our solar system. Moreover, recently developed methods for the remote sensing of extra solar planets are introduced and the current understanding of their atmospheres is presented. A focus is the energy budget of planetary atmospheres, where clouds play a central role. Their formation and growth will be covered in a generalized fashion.
Workload	240 hours
Controls of success	
Prerequisite: Coursework (“Studienleistung”)	T-PHYS-109177 – Physics of Planetary Atmospheres At least 50% of the points in the exercise → successful completion of the prerequisite entitles to exam
Examination:	T-PHYS-109180 – Exam on Physics of Planetary Atmospheres
Assessment (“Prüfungsleistung”)	Oral exam (approx. 45 min.) in accordance with § 4 (2) No. 2 SPO Master's Meteorology
Special Features of the Exam	None
Grade	Grade of oral exam
Requirements	None
Recommendations	Basic knowledge in Physics, Physical Chemistry and Fluid Dynamics at BSc

	level
Conditions	None

Learning Outcomes

The students acquire the basic knowledge of atmospheric physics. Based on concrete case studies from current research, the students learn to understand the concepts and are enabled to apply the learned methods independently.

Emphasis is placed on the basic physical and chemical principles, so that knowledge can be generally applied to planetary atmospheres and not limited to the earth. This is supported by correspondingly created exercises.

One focus is the experimental methods of atmospheric remote sensing.

5.4. Fluidmechanik und Turbulenz

Module Code	**M-BGU-101876**
Responsible Lecturer	Prof. Dr. Oliver Eiff
Level	4
Components of the module	**Electives I:** T-BGU-106612 – Advanced Fluid Mecanics T-BGU-103561– Analysis of Turbulent Flows **Electives II:** T-BGU-110411 – Flow Measurement Techniques T-BGU-103563 – Gebäude- und Umweltaerodynamik
ECTS Credits	9
Study Program	MSc Meteorology, Compulsory Elective
Instruction Language	German Flow Measurement Techniques: English
Duration	2 semester
Module Frequency	Each winter semester
Module Content	**Advanced Fluid Mecanics** teaches the advanced fundamentals of fluid mechanics and forms the basis for environmental fluid mechanics. Based on the underlying local conservation laws, the phenomena of the various flow classes and their possible analytical solutions are dealt with. This includes the general and specific forms of the basic equations, flow kinematics, incompressible viscous flows, ideal fluid flows, shallow water flows, and buoyancy effects in flows. Furthermore, waves and turbulence are addressed and various analysis methods such as scaling are dealt with. **Analysis of Turbulent Flows** provides a general introduction to the analysis of turbulent flows. The mathematical-physical basis for the quantitative description of turbulent flows is worked out, i. both the properties of the conservation equations themselves, as well as the necessary mathematical tools and the usual modeling approaches for engineering problems. The course "Fluid Mechanics of Turbulent Flows" introduces the phenomenology of turbulent flows, introduces the statistical description, defines characteristics of free shear flows and near-wall flows, and analyzes the turbulent energy cascade. The course "Turbulence models: RANS and LES" deals with the statistical model approach based on Reynolds' averaging (RANS) from the simple algebraic model to the Reynolds stress transport model. Furthermore, the concept of coarse-grain simulation (LES) is introduced.

	Flow measurement technology provides the basics of measuring flow velocities using laser-optical measurement techniques, such as those described in U.S. Pat. used in wind tunnels, are in the focus of interest. Building and environmental aerodynamics provide the basics of natural wind conditions and their interaction with buildings. The wind effect on structures and the engineering load rating are shown in detail. In the second part of the lecture, an introduction to environmental aerodynamics will be given, focusing in particular on the interaction of atmospheric strong wind events and natural structures.
Workload	**Elective Block I:** T-BGU-106612 – Advanced Fluid Mecanics: 180 h T-BGU-103561– Analysis of Turbulent Flows: 90h **Electives Block II:** T-BGU-110411 – Flow Measurement Techniques: 90 h T-BGU-103563 – Gebäude- und Umweltaerodynamik: 90 h
Controls of success	
Prerequisite: Coursework (“Studienleistung”)	optional variants of pre-calculation, exercise sheets, written exam → successful completion of the prerequisite entitles to exam
Examination: Assessment (“Prüfungsleistung”)	One examination has to be taken in one of the Electives I: **"Analysis of Turbulent Flows"** or **"Advanced Fluid Mechanics":** 1. T-BGU-106612: Written exam (approx. 90 min) in accordance with § 4 (1) SPO Master's Meteorology 2. T-BGU-103561: Oral exam (appr. 45 min) in accordance with § 4 (1) SPO Master's Meteorology and one other examination in one of the Electives II: **"Flow Measurement Technique"** or **"Gebäude- und Umweltdynamik".:** 1. T-BGU-110411: Oral exam (appr. 30 min) in accordance with § 4 (1) SPO Master's Meteorology 2. T-BGU-103563: Oral exam (appr. 30 min) in accordance with § 4 (1) SPO Master's Meteorology
Special Features on the Exam	None
Grade	Module grade is a weighted average of grades from compulsory elective block 1, **Advanced Fluid Mechanics** or **Analysis of Turbulent Flows**, and compulsory Elective Block 2, **Flow Measurement Techniques** or **Building and Environmental Aero Dynamics**.

Requirements	None
Recommendations	Basics in Mathematics and Hydromechanics; prior knowledge in programming with Matlab is helpful for the course "Analysis of Turbulent Flows"

Learning Outcomes

The students are able to explain basic terms and concepts in the field of fluid mechanics with appropriate terminology and attribute them to physical laws. They are familiar with examples of application, modeling and measurement.

5.5. Computer Vision and GIS

Module Code	**M-BGU-102757**
Responsible Lecturer	Prof. Dr. Stefan Hinz (IPF)
Level	4
Components of the module	T-BGU-103541 – Einführung in GIS für Studierende natur-, ingenieur- und geowissenschaftlicher Fachrichtungen, Vorleistung T-BGU-101681 – Einführung in GIS für Studierende natur-, ingenieur- und geowissenschaftlicher Fachrichtungen T-BGU-101732 – Image Processing and Computer Vision
ECTS Credits	9
Study Program	
Instruction Language	German
Duration	1 semester
Module Frequency	Each winter semester
Module Content	
Workload	
Controls of success	
Prerequisite: Coursework (“Studienleistung”)	Online test 'Introduction to GIS for Students of Natural, Engineering and Geo Sciences' **(T-BGU-103541)** → successful completion of the prerequisite entitles to exam
Examination: Assessment (“Prüfungsleistung”)	**T-BGU-101681 – Einführung in GIS für Studierende natur-, ingenieur- und geowissenschaftlicher Fachrichtungen** Written exam (approx. 90min) in accordance with § 4 (2) SPO Master's Meteorology
Special Features on the Exam	None
Grade	Grade of written exam
Requirements	None
Recommendations	
Learning Outcomes	

5.6. GIS und Fernerkundung

Module Code	M-BGU-102758
Responsible Lecturer	Prof. Dr. Stefan Hinz (IPF)
Level4	4
Components of the module	T-BGU-103541 – Einführung in GIS für Studierende natur-, ingenieur- und geowissenschaftlicher Fachrichtungen, Vorleistung T-BGU-101681 – Einführung in GIS für Studierende natur-, ingenieur- und geowissenschaftlicher Fachrichtungen T-BGU-105725 – Einführung in Klassifizierungsverfahren der Fernerkundung
ECTS Credits	9
Study Program	
Instruction Language	German
Duration	1 semester
Module Frequency	Each winter semester
Module Content	
Workload	
Controls of success	
Prerequisite: Coursework ("Studienleistung")	Online test 'Introduction to GIS for Students of Natural, Engineering and Geo Sciences' (**T-BGU-103541)** → successful completion of the test entitles to exam
Examination: Assessment ("Prüfungsleistung")	**T-BGU-101681 – Einführung in GIS für Studierende natur-, ingenieur- und geowissenschaftlicher Fachrichtungen** Written exam (approx. 90min) in accordance with § 4 (2) SPO Master's Meteorology
Special Features on the Exam	None
Grade	Grade of written exam
Requirements	None
Recommendations	
Learning Outcomes	

5.7. Computer Vision und Fernerkundung

Module Code	**M-BGU-102759**	
Responsible Lecturer	Dr. Jan Cermak (ASF), Dr. Uwe Weidner (IPF)	
Level	4	
Components of the module	T-BGU-105725 – Einführung in Klassifizierungsverfahren der Fernerkundung	4 ECTS
	Compulsory Elective Subject:	
	T-BGU-101732 – Image Processing and Computer Vision	4 ECTS
	T-BGU-106333 – Remote Sensing of a Changing Climate, Vorleistung	4 ECTS
	T-BGU-106334 – Remote Sensing of a Changing Climate, Prüfung	4 ECTS
	T-PHYS-108283 T-PHYS-108286- Platzhalter MA MET Computer Vision und Fernerkundung für Meteorologen	4 ECTS
ECTS Credits	8	
Study Program		
Instruction Language	German/English	
Duration	2 semesters	
Module Frequency	Each semester	
Module Content		
Workload		
Controls of success		
Prerequisite: Coursework ("Studienleistung")	optional variants of pre-calculation, exercise sheets, written exam → successful completion of the prerequisite entitles to exam	
Examination:	**T-BGU-106334 – Remote Sensing of a Changing Climate, Prüfung**	
Assessment ("Prüfungsleistung")	The success check is carried out as a written exam (approx. 90min) in accordance with § 4 (2) SPO Master's Meteorology	
Special Features on the Exam		
Grade	Grade of written exam	
Requirements	None	
Recommendations	None	
Conditions		
Learning Outcomes		

5.8. GIS and Geo Data Infrastructures

Module Code	**M-BGU-102760**
Responsible Lecturer	Prof. Dr. Stefan Hinz (IPF)
Level	4
Components of the module	1) T-BGU-103541 – Einführung in GIS für Studierende natur-, ingenieur- und geowissenschaftlicher Fachrichtungen, Vorleistung T-BGU-101681 – Einführung in GIS für Studierende natur-, ingenieur- und geowissenschaftlicher Fachrichtungen 2) T-BGU-101757 – Geodateninfrastrukturen und Web-Dienste, Vorleistung T-BGU-101756 – Geodateninfrastrukturen und Web-Dienste
ECTS Credits	1) 6 2) 4
Study Program	
Instruction Language	Deutsch
Duration	1 semester
Module Frequency	Each summer semester
Module Content	
Workload	
Controls of success	
Prerequisite: Coursework (“Studienleistung”)	1) Online test 'Introduction to GIS for Students of Natural, Engineering and Geo Sciences' (T-BGU-103541) 2) 'Geo data Infrastructures and Web-Services, Prerequisite' (T-BGU-101757) has to be passed to entitle to exam (T-BGU-101756) → successful completion of the prerequisites entitles to exam
Examination: Assessment (“Prüfungsleistung”)	**1) T-BGU-101681 – Einführung in GIS für Studierende natur-, ingenieur- und geowissenschaftlicher Fachrichtungen** Written exam (90min) in accordance with § 4 (2) SPO Master's Meteorology **2) T-BGU-101756 – Geodateninfrastrukturen und Web-Dienste** Oral exam (approx. 20min) in accordance with § 4 (2) SPO Master's Meteorology
Special Features of the Exam	None

Grade	The grade results from the weighted average of both examinations
Requirements	None
Recommendations	None
Conditions	
Learning Outcomes	

5.9. Satellite climatology: Remote Sensing of a Changing Climate

Module Code	M-BGU-105095
Responsible Lecturer	Prof. Dr. Jan Cermak (IPF)
Level	4
Components of the module	T-BGU-103304 – Satellite Climatology: Remote Sensing of a Changing Climate, Prerequisite T-BGU-110305 – Satellite Climatology: Remote Sensing of a Changing Climate, Examination
ECTS Credits	4
Study Program	
Instruction Language	Deutsch
Duration	1 semester
Module Frequency	Each summer semester
Module Content	
Workload	
Controls of success	
Prerequisite: Coursework (“Studienleistung”)	optional variants of pre-calculation, exercise sheets, written exam → successful completion of the prerequisite entitles to exam
Examination: Assessment (“Prüfungsleistung”)	**T-BGU-110305 – Satellite Climatology: Remote Sensing of a Changing Climate, Examination** Oral exam (approx. 20min) in accordance with § 4 (2) SPO Master's Meteorology
Special Features of the Exam	None
Grade	
Requirements	None
Recommendations	None
Conditions	
Learning Outcomes	

5.10. **Informatics for Meteorology Students**

Module Code	**M-INFO-102980**
Responsible Lecturer	Bernhard Beckert (ITI)
Level	4
Components of the module	**Compulsory Elective Subject:** 1) T-INFO-101345 – Parallelrechner und Parallelprogrammierung — 4 ECTS 2) T-INFO-101298 – Verteiltes Rechnen — 4 ECTS 3) T-INFO-102061 – Mobile Computing und Internet der Dinge — 5 ECTS 4) T-INFO-101305 – Analysetechniken für große Datenbestände — 4 ECTS 5) T-INFO-101497 – Datenbanksysteme — 4 ECTS 6) T-INFO-101275 – Visualisierung — 5 ECTS 7) T-PHYS-108279 – T-PHYS-108282 Platzhalter MA MET INF für Stud. benotet oder unbenotet — 4 ECTS
ECTS Credits	8
Study Program	Informatics
Instruction Language	German
Duration	1 or 2 semesters
Module Frequency	Summer or winter semester
Module Content	1) Die Vorlesung gibt eine Einführung in die Welt moderner Parallel- und Höchstleistungsrechner, des Supercomputings bzw. des High-Performance Computings (HPC) und die Programmierung dieser Systeme. Zunächst werden allgemein und exemplarisch Parallelrechnersysteme vorgestellt und klassifiziert. Im Einzelnen wird auf speichergekoppelte und nachrichtengekoppelte System, Hybride System und Cluster sowie Vektorrechner eingegangen. Aktuelle Beispiele der leistungsfähigsten Supercomputer der Welt werden ebenso wie die Supercomputer am KIT kurz vorgestellt. Im zweiten Teil wird auf die Programmierung solcher Parallelrechner, die notwendigen Programmierparadigmen und Synchronisationsmechanismen, die Grundlagen paralleler Software sowie den Entwurf paralleler Programme eingegangen. Eine Einführung in die heute üblichen Methoden der parallelen Programmierung mit OpenMP und MPI runden die Veranstaltung ab. 2) Die Vorlesung „Verteiltes Rechnen“ gibt eine Einführung in die Welt des verteilten Rechnens mit einem Fokus auf Grundlagen, Technologien und Beispielen aus Grid, Cloud und dem Umgang mit Big Data.

Zuerst wird eine Einführung in die Hauptcharakteristika verteilter Systeme gegeben. Danach wird auf die Thematik Grid näher eingegangen und es werden Architektur, Grid Services, Sicherheit und Job Ausführung vorgestellt. Am Beispiel des WLCG (der Grid Infrastruktur zur Verteilung, Speicherung und Analyse der Daten des LHC-Beschleunigers am CERN) wird die enge Verwandtschaft zwischen Grid Computing und verteiltem Daten-Management dargestellt.

Im zweiten Teil werden Prinzipien und Werkzeuge zum Management großer bzw. verteilter Daten vorgestellt - dies schließt Datenlebenszyklus, Metadaten und Archivierung ein. Beispiele aus Wissenschaft und Industrie dienen zur Veranschaulichung. Moderne Speichersysteme wie z.B. dCache, xrootd, Ceph und HadoopFS werden als praktische Beispiele vorgestellt.

Der dritte Teil der Vorlesung geht auf das Thema Cloud ein. Nach der Definition grundlegender Begriffe und Prinzipien (Iaas, PaaS, SaaS, public vs. private Clouds), auch mittels Beispielen, wird das Thema Virtualisierung als grundlegende Technik des Cloud Computing vorgestellt. Den Abschluss bildet MapReduce als Mechanismus zur Verarbeitung und Analyse großer, verteilter Datenbestände wie es auch von Google eingesetzt wird.

3) Die Vorlesung bietet eine Einführung in Methoden und Techniken des mobile Computing und des Internet der Dinge (Internet of Things, IoT). Die Übung vertieft das in der Vorlesung erworbene Wissen in einem Praxisprojekt. Im praktischen Teil wird insbesondere die Erstellung von Benutzerschnittstellen für Anwendungen im Bereich Mobile Computing und dem Internet der Dinge sowie von Software-Apps erlernt. Die praktische Übung startet mit den Aspekten Benutzerschnittstellenentwurf und Software-Entwurf. Es begleitet dann mit kleinen Programmieraufgaben die technischen Teile der gesamte Vorlesung.

Die Vorlesung gliedert sich in folgende Themenbereiche:

Mobile Computing:

• Plattformen: SmartPhones, Tablets, Glasses

• Mensch-Maschine-Interaktion für Mobile Computing

• Software Engineering, -Projekte und Programmierung für mobile Plattformen (native Apps, HTML5)

• Sensoren und deren Einsatz

• Plattformen und Software Engineering für das Internet der Dinge: Raspberry Pi und Arduino

• Personal Area Networks: Bluetooth (4.0), ANT

• Home Networks: ZigBee/IEEE 802.15.4, CEBus, m-bus

• Technologien des Internet der Dinge, IoT: RFID, NFC, Auto-ID, EPC, Web of Things

4) Techniken zur Analyse großer Datenbestände stoßen bei Anwendern auf großes Interesse. Das Spektrum ist breit und umfasst klassische Branchen wie Banken und Versicherungen, neuere Akteure, insbesondere Internet-Firmen oder Betreiber neuartiger Informationsdienste und sozialer Medien, und Natur- und Ingenieurswissenschaften. In allen Fällen besteht der Wunsch, in sehr großen, z. T. verteilten Datenbeständen die Übersicht zu behalten, mit möglichst geringem Aufwand interessante Zusammenhänge aus dem Datenbestand zu extrahieren und erwartetes Systemverhalten mit dem tatsächlichen systematisch vergleichen zu können. In der Vorlesung geht es sowohl um die Aufbereitung von Daten als Voraussetzung für eine schnelle und leistungsfähige Analyse als auch um moderne Techniken für die Analyse an sich.

5) Datenbanksysteme gehören zu den entscheidenden Softwarebausteinen in modernen Informationssystemen und sind ein zentrales Thema der Universitätsstudiengänge im Gebiet der Informatik. Ziel der Vorlesung ist die Vermittlung von Grundkenntnissen zur Arbeit mit Datenbanken. Die wichtigen Themen der Vorlesung sind guter Datenbankentwurf, der Zugriff auf Datenbanken und die Anbindung an Anwendungen, Mehrbenutzerbetrieb und eine Übersicht über unterschiedliche Datenbanktypen (relational vs. NoSQL insbesondere).

6) Die Visualisierung beschäftigt sich mit der visuellen Repräsentation von Daten aus wissenschaftlichen Experimenten, Simulationen, medizinischen Scannern, Datenbanken etc., mit dem Ziel ein größeres Verständnis oder eine einfachere Repräsentation komplexer Vorgänge zu erhalten. Hierzu werden u.a. Methoden aus der interaktiven Computergrafik herangezogen und neue Methoden entwickelt. Diese Vorlesung behandelt die sogenannte Visualisierungspipeline, spezielle Algorithmen und Datenstrukturen und zeigt praktische Anwendungen.

Themen dieser Vorlesung sind u.a.:

• Einführung, Visualisierungspipeline

• Datenakquisition und -repräsentation

• Perzeption und Abbildung (Mapping) auf grafische Repräsentationen

• Visualisierung von Skalarfeldern (Isoflächenextraktion, Volumenrendering)

• Visualisierung von Vektorfeldern (Particle Tracing, texturbasierte Methoden)

• Tensorfelder und Daten mit mehreren Attributen

	• Informationsvisualisierung
Workload	> 240 h
Controls of success	
Prerequisite: Coursework ("Studienleistung")	optional variants of pre-calculation, exercise sheets, written exam → successful completion of the prerequisite entitles to exam
Examination: Assessment ("Prüfungsleistung")	1) Die Erfolgskontrolle erfolgt in Form einer mündlichen Prüfung im Umfang von i.d.R. 20 Minuten nach § 4 Abs. 2 Nr. 2 der SPO. 2) Die Erfolgskontrolle erfolgt in Form einer schriftlichen Prüfung (ca. 60 Min) nach § 4 Abs. 2 Nr. 1 SPO. Abhängig von der Teilnehmerzahl wird sechs Wochen vor der Prüfungsleistung angekündigt (§ 6 Abs. 3 SPO), ob die Erfolgskontrolle: a) in Form einer mündlichen Prüfung nach § 4 Abs. 2 Nr. 2 SPO oder b) in Form einer schriftlichen Prüfung nach § 4 Abs. 2 Nr. 1 SPO stattfindet. 3) Die Erfolgskontrolle erfolgt in Form einer mündlichen Prüfung nach § 4 Abs. 2 Nr. 2 SPO, in der auch Übungsresultate bewertet werden. 4) Die Erfolgskontrolle erfolgt in Form einer mündlichen Prüfung nach § 4 Abs. 2 Nr. 2 der SPO. 5) Die Erfolgskontrolle erfolgt in Form einer schriftlichen Prüfung im Umfang von i.d.R. 60 Minuten nach § 4 Abs. 2 Nr. 1 SPO. Durch die erfolgreiche Teilnahme am Übungsbetrieb als Erfolgskontrolle anderer Art (§4(2), 3 SPO 2007) bzw. Studienleistung (§4(3) SPO 2015) kann ein Bonus erworben werden. Die genauen Kriterien für die Vergabe eines Bonus werden zu Vorlesungsbeginn bekannt gegeben. Liegt die Note der schriftlichen Prüfung zwischen 4,0 und 1,3, so verbessert der Bonus die Note um eine Notenstufe (0,3 oder 0,4). Der Bonus gilt nur für die Haupt- und Nachklausur des Semesters, in dem er erworben wurde. Danach verfällt der Notenbonus. 6) Die Erfolgskontrolle erfolgt in Form einer mündlichen Prüfung über die Vorlesung im Umfang von i.d.R. 25 Minuten nach § 4 Abs. 2 Nr. 2 SPO.
Special Features of the Exam	None
Grade	Grade of examination
Requirements	1) Keine 2) Keine

3) Keine
4) Keine
5) Keine
6) Keine

Recommendations

1) Kenntnisse zu Grundlagen aus der Lehrveranstaltung *Rechnerstrukturen* sind hilfreich.
2) Das Modul: Einführung in Rechnernetze wird vorausgestzt.
3) Keine
4) Datenbankkenntnisse, z.B. aus der Vorlesung *Datenbanksysteme*
5) *Der Besuch von Vorlesungen zu Rechnernetzen, Systemarchitektur und Softwaretechnik wird empfohlen, aber nicht vorausgesetzt.*
6) Vorkenntnisse aus der Vorlesung „Computergraphik" (24081) werden vorausgesetzt.

Learning Outcomes

1) Studierende erörtern die Grundbegriffe paralleler Architekturen und die Konzepte ihrer Programmierung. Sie analysieren verschiedene Architekturen von Höchstleistungsrechnern und differenzieren zwischen verschiedene Typen anhand von Beispielen aus der Vergangenheit und Gegenwart.

   Studierende analysieren Methoden und Techniken zum Entwurf, Bewertung und Optimierung paralleler Programme, die für den Einsatz in Alltags- oder industriellen Anwendungen geeignet sind und wenden diese an. Studierende können Probleme im Bereich der Parallelprogrammierung beschreiben, analysieren, und beurteilen.

2) Studierende verstehen die Grundbegriffe verteilter Systeme, im Speziellen in den aktuellen Techniken des Grid und Cloud Computing sowie des Management großer bzw. verteilter Daten. Sie wenden zugrundeliegenden Paradigmen und Services auf gegebene Beispiel an.

   Studierende analysieren Methoden und Technologien des Grid und Cloud Computing sowie verteilten Daten-Managements, die für den Einsatz in alltags- und industriellen Anwendungsgebieten geeignet sind bzw. welche heute von Google, Facebook, Amazon, etc. eingesetzt werden. Hierfür vergleichen die Studierenden Web/Grid Services, elementare Grid Funktionalitäten, Datenlebenszyklen, Metadaten, Archivierung, Cloud Service Typen (IaaS, SaaS, PaaS) und Public/Private Clouds anhand von Beispielen aus der Praxis.

3) Mobile Computing und Internet der Dinge ermöglichen es im beruflichen und privaten Alltag ubiquitär auf Informationen und Dienste zuzugreifen. Diese Dienste reichen von Augmented-Reality Informationsdiensten über den Ad-Hoc Austausch von Daten zwischen benachbarten Smartphones bis hin zur Haussteuerung.

   Ziel der Vorlesung ist es, Kenntnisse über Grundlagen, weitergehende Methoden und Techniken des Mobile Computing und des Internet der Dinge zu erwerben.

   Nach Abschluss der Vorlesung können die Studierenden

• Techniken zur Gestaltung von Mobile Computing Software und Benutzerschnittstellen für Mobile Computing Anwendungen benennen, beschreiben und erklären und bewerten

• Software- und Kommunikationsschnittstellen für das Internet der Dinge und Basiskenntnisse zu Personal Area Networks (PAN) bennenen, beschreiben, vergleichen und bewerten

• selbständig Systeme für Mobile Computing und das Internet der Dinge entwerfen, Entwürfe analysieren und bewerten

• eine adaptive Webseite entwerfen, implementieren und auf ihre Usability hin untersuchen

• eine eigene App konzipieren und implementieren, die über Bluetooth mit einem Gerät kommuniziert

4) Am Ende der Lehrveranstaltung sollen die Teilnehmer die Notwendigkeit von Konzepten der Datenanalyse gut verstanden haben und erläutern können. Sie sollen unterschiedliche Ansätze zur Verwaltung und Analyse großer Datenbestände hinsichtlich ihrer Wirksamkeit und Anwendbarkeit einschätzen und vergleichen können. Die Teilnehmer sollen verstehen, welche Probleme im Themenbereich der Vorlesung derzeit offen sind, und einen Einblick in den diesbezüglichen Stand der Forschung gewonnen haben.

5) Der/die Studierende

• ist in der Lage den Nutzen von Datenbank-Technologie darzustellen,

• kennt die Modelle und Methoden bei der Entwicklung von funktionalen Datenbank-Anwendungen,

• ist in der Lage selbstständig einfache Datenbanken anzulegen und Zugriffe auf diese zu tätigen,

kennt und versteht die entsprechenden Begrifflichkeiten und die Grundlagen der zugrundeliegenden Theorie

6) Die Studierenden lernen in dieser Vorlesung wichtige Algorithmen und Verfahren der Visualisierung kennen und können diese unterschiedlichen Anwendungsfeldern zuordnen, sie analsieren und bewerten. Die erworbenen Kenntnisse sind in vielen Bereichen der Forschung in der Computergrafik, und der (Medizin-/Bio-/Ingenieurs-)Informatik wertvoll. Die Studierenden können für ein gestelltes Problem geeignete Visualisierungstechniken auswählen und selbst implementieren.

5.11. Geophysical Analysis of Natural Hazards

Module Code	**M-PHYS-103336**
Responsible Lecturer	Dr. Ellen Gottschämmer (GPI)
Level	4
Components of the module	T-PHYS-103553 – Einführung in die Vulkanologie, Vorleistung T-PHYS-103644 – Einführung in die Vulkanologie, Prüfung

	T-PHYS-107673 – Seminar on recent topics of risk science
ECTS Credits	8
Study Program	
Instruction Language	English
Duration	2 semester
Module Frequency	Each summer semester
Module Contents	See Course description ("Teilleistungsbeschreibung")
Workload	
Controls of success	
Prerequisite: Coursework ("Studienleistung")	T-PHYS-103553 – Einführung in die Vulkanologie, Vorleistung Active and regular attendance of lecture and practicals, preparation and follow-up of lectures (at home), assignments, presentation of a volcano in a short (10 – 15 minute) talk with slides. T-PHYS-107673 – Seminar on recent topics of risk science Preparation and presentation of a talk based on a scientific publication, critical discussion of the scientific results.
Examination: Assessment ("Prüfungsleistung")	T-PHYS-103644 – Einführung in die Vulkanologie, Prüfung Exam of another type in accordance with § 4 (2) SPO Master's Meteorology Scientific essay about the presentation, approx. 8-10 pages, submitted electronically.
Special Features of the Exam	None
Grade	The grade of the module results from grade of of the scientific essay.
Requirements	None
Recommendations	None
Conditions	None
Learning Outcomes	

The Students know and understand the basic concepts of physical volcanology. They are able to classify volcanoes by their tectonic location, can discriminate between different eruption types and describe different volcanic edifices with respect to their tectonic environment. They understand the concept of volcanic hazard and risk and are able to apply it. They can explain the physics of volcanic monitoring methods and know about their advantages and disadvantages. They gained insight into numerical modelling tools and can name several appliations. The students understand the impact of volcanic eruptions on climate and know both, presently as well as historically active volcanoes and their prominent eruptions.

The students have gained an overview about active volcanoes and recent eruptions and are able to summerize the main characteristics and scientific achievements about one volcano of their choice in a 10-15 minute talk. They are able to discuss and answer questions related to their subject. They can summarize their research about the volcano of their choice in a scientific essay (8-10 pages).

The students understand scientific literature regarding current topics of natural hazards and risk. They can summarize a selected topic, describe and explain the main idea to their fellow students in an oral presentation (30-40 minutes). They know how to structure and present a scientific talk. They are able to understand the topics presented by their fellow students, discuss and analyze the content critically. They are able to compare those research results and evaluate the content critically

5.12. Geoecology

Module Code	M-BGU-103398
Responsible Lecturer	Prof. Dr. Wolfgang Wilcke (IFGG)
Level	4
Components of the module	1) T-BGU-107486 – Field Course Soil Science 2) T-BGU–107487 – Geomorphologie und Bodenkunde
ECTS Credits	1) 1 2) 7
Study Program	
Instruction Language	German
Duration	1 semester
Module Frequency	Each summer semester
Module Contents	
Workload	1) 30 h 2) 240 h
Controls of success	
Prerequisite: Coursework (“Studienleistung”)	**T-BGU-107486 – Field Course Soil Science** Participation → successful completion of the prerequisite entitles to exam
Examination:	**T-BGU–107487 – Geomorphologie und Bodenkunde**
Assessment (“Prüfungsleistung”)	Written examination (60 min) in accordance with § 4 (2) SPO Master's Meteorology
Special Features of the Exam	None
Grade	Grade of written examination
Requirements	None
Recommendations	None
Conditions	None
Learning Outcomes	

5.13. **Basics of Estimation Theory and its Application in Geo science Remote Sensing**

Module Code	**M-BGU-103422**
Responsible Lecturer	Prof. Dr. Jan Cermak (IMK-ASF) Prof. Dr. Stefan Hinz (IPF)
Level	4
Components of the module	1) T-BGU-106821 – Grundlagen der Schätztheorie, Coursework 2) T-BGU-106633 – Data Analysis in Geo science Remote Sensing Projects, Coursework T-BGU – 106822 – Grundlagen der Schätztheorie und ihrer Anwendung in geowissenschaftlicher Fernerkundung, Oral Exam
ECTS Credits	1) 1 2) 2 3) 5
Study Program	
Instruction Language	German
Duration	1 semester
Module Frequency	Each summer semester
Module Contents	
Workload	
Controls of success	
Prerequisite: Coursework (“Studienleistung”)	→ successful completion of the prerequisites entitles to exam
Examination: Assessment (“Prüfungsleistung”)	**T-BGU – 106822 – Grundlagen der Schätztheorie und ihrer Anwendung in geowissenschaftlicher Fernerkundung, Oral Exam** Oral examination in accordance with § 4 (2) SPO Master's Meteorology
Special Features of the Exam	None
Grade	Grade of oral examination
Requirements	None
Recommendations	
Conditions	
Learning Outcomes	

5.14. **Geological Hazards and Risk**

Module Code	**M-PHYS-101833**
Responsible Lecturer	Dr. Ellen Gottschämmer (GPI)
Level	4
Components of the module	T-PHYS-103525 - Geological Hazards and Risks
ECTS Credits	8
Study Program	
Instruction Language	English
Duration	1 semester
Module Frequency	Each winter semester
Module Content	See course description (“Teilleistungsbeschreibung”)
Workload	240 h
Controls of success	
Prerequisite: Coursework (“Studienleistung”)	Active and regular attendance of lecture and practicals.
Examination: Assessment (“Prüfungsleistung”)	Examination of another type in accordance with §4(2) SPO Master’s Meteorology
Special Features of the Exam	None
Grade	Grade of examination of other type: To be evaluated: Exercise sheets, written project work.
Requirements	None
Recommendations	None
Conditions	None
Learning Outcomes	

The students understand basic concepts of hazards and risk. They can explain in detail different aspects of earthquake hazard, volcanic hazard as well as other geological hazards, can compare and evaluate those hazards. The have fundamental knowledge of risk reduction and risk management. They know methods of risk modeling and are able to apply them.

6. Research Work: Specialization Phase

Module Code	M-PHYS-100955
Responsible Lecturer	Prof. Dr. Peter Knippertz
Level	5
Components of the module	T-PHYS-101563 – Scientific Concept Development
ECTS Credits	30
Study Program	*MSc Meteorology*
Language	English or German. On agreement with the examiner(s), the *Study Project* can also be written in other languages.
Duration	1 semester
Module Frequency	Each semester
Module Content	Conducting a meteorological, interdisciplinary project work. This may be of a theoretical and/or experimental type. The focus is on the development of conclusions using scientific methods, project management and presentation of the results. Students are invited to make suggestions for topics. It is possible to conduct the project in cooperation with external partners.
Workload	6 months (900 h)
Controls of success	
Module examination: Coursework ("Studienleistung")	Examination of other type in accordance to §4(2) No. 3 SPO Master's Meteorology: Final presentation (20-25 minutes) in the *Seminar on Specialization Phase*, followed by a short discussion with the audience (15 minutes). Afterwards a short feedback meeting with the examiners and the supervisor about the progress and next steps will take place. Please notice that the seminar only takes place within the semester on Wednesday (15:45 – 17:15 pm) in Bldg. 30.23, Room 13-2. To get a seminar slot, please contact Kathi Maurer (student advisor) via E-Mail.
Special Features of the Exam	None
Grade	Ungraded
Requirements	Students need to have successfully completed all four module exams in the subjects *Atmospheric and Climate Processes* and *Applied and Experimental Meteorology*. *Soft skills* and complementary elective can still be incomplete.
Recommendations	None
Conditions	None

Learning Outcomes

Students are able to work on a meteorological or interdisciplinary research project using scientific methods.

They can, with guidance, plan, structure, prepare, conduct, and document a study. They can select appropriate methods for the solution of the given problem.

Students are able to work self-organized and structured. They possess skills in the field of project management and presentation, both orally and in writing.

7. Master’s Thesis

Module Code	M-PHYS-100956
Responsible Lecturer	Prof. Dr. Peter Knippertz
Level	5
Components of the module	T-PHYS-109616 Master’s Thesis
ECTS Credits	30
Study Program	MSc *Meteorology*
Language	English or German. On agreement with the examiner(s), the *Study Project* can also be written in other languages.
Duration	1 semester
Module Frequency	Each semester
Content	After choosing a subject area and topic at the beginning of the module *Specialization Phase* and preparing their thesis, the students start their original scientific study. The Master’s Thesis includes the theoretical and/or the experimental work on a complex problem using scientific methods. It is possible to conduct the project in cooperation with external partners, for example an external research institution or an institution from the professional background.
Workload	6 months (900 h) (SPO§14 Abs. 1a)
Controls of success	
Module examination: **Assessment (“Prüfungsleistung”)**	Written report (Master’s thesis) and presentation (SPO §14 (1a)) in accordance with § 14 SPO Master's Meteorology evaluated by at least one professor, one habilitated scientist of the KIT-Faculty of Physics or one leading scientist in accordance with § 14 Abs. 3 para. 1 KITG and one other examiner. The overall assessment will be recorded in a written report. The evaluation period shall not exceed eight weeks upon submission of the Master's thesis.
Special Features of the Exam	None
Grade	The overall grade results from the evaluation of the thesis. This includes the final presentation.
Requirements	Students have successfully completed modules with a minimum of 70 ECTS credits, especially the module *Specialization Phas*e must be successfully completed (SPO §14 (1)).
Recommendations	Attendance of the Karlsruhe Meteorological Colloquium and the depart-

	mental seminars (IMK-TRO, IMK-ASF, IMK-AAF).
Conditions	None

Learning Outcomes

Students can independently develop and carry out a scientific work. To this end, they deal with the latest state of research and apply the knowledge and the methods acquired during studies. They can discuss and evaluate the obtained results and present them in writing as well as defend the work in a presentation.

The students are able to work on a coherent problem from their field of study independently and in a limited time according to scientific methods and then present the knowledge gained in a written paper and in a presentation in an understandable and precise manner and to discuss it competently.

III Courses

T-PHYS-101563 – Scientific Concept Development

Course Code	T-PHYS-101563 – Scientific Concept Development
Responsible Lecturer	**Prof. Dr. Peter Knippertz**
Part of	M-PHYS-100955 Research Work: Specialization Phase
ECTS Credits	30
Workload	6 months (900 h)
Language	English or German. On agreement with the examiner(s), the *Study Project* can also be written in other languages.
Duration	1 semester
Course Frequency	Each semester
Type of examination	Exam: Assessment ("Prüfungsleistung")

Semester	Course-No.	Course	Kind	SWS	Lecturer
SS 20	**4052904**	Seminar on Specialization Phase	Seminar (S)	2	Chr. Kottmeier, C. Hoose, P. Knippertz, J. Pinto, A. H. Fink, M. Kunz, J. Orphal, T. Leisner, P. Braesicke

Controls of Success	Final presentation (20-25 minutes) in the *Seminar on Specialization Phase*, followed by a short discussion with the audience (15 minutes). Afterwards a short feedback meeting with the examiners and the supervisor about the progress and next steps will take place. Please notice that the seminar only takes place within the semester on Wednesday (15:45 – 17:15 pm) in Bldg. 30.23, Room 13-2. To get a seminar slot, please contact Kathi Maurer (student advisor) via Mail.
Requirements	Students have successfully completed all four module exams in the subjects *Atmospheric and Climate Processes* and *Applied and Experimental Meteorology*. *Soft skills* and *Supplementary Modules* can be incomplete.
Course Contents	See module description

T-PHYS-102317 – Moderne Theoretische Physik I, Quantenmechanik 1, Vorleistung 1

Course Code	T-PHYS-102317
Responsible Lecturer	**Prof. Dr. Ulrich Nierste**
Part of	M-PHYS-101707 Modern Theoretical Physics I, Quantum Mechanics I
ECTS Credits	4
Workload	Presence time in lectures 90 hours Preparation / follow-up, exercises 30 hours
Language	German
Course Frequency	Each summer semester
Duration	1 semester
Type of examination	Prerequisite: Coursework ("Studienleistung")

Semester	Course-No.	Course	Kind	SWS	Lecturer
SS 19	**4010141**	Moderne Theoretische Physik I (Theorie D, Quantenmechanik I)	Lectures(V)	4	U. Nierste
SS 19	**4010142**	Übungen zu Moderne Theoretische Physik I	Exercises (Ü)	2	U. Nierste, I. Nisandzic

Controls of Success	Exercise sheets
Requirements	None
Course Contents	See module description

T-PHYS-102317 – Moderne Theoretische Physik I, Quantenmechanik 1

Course Code	T-PHYS-105134 – Exam
Responsible Lecturer	**Prof. Dr. Ulrich Nierste**
Part of	M-PHYS-101707 Modern Theoretical Physics I, Quantum Mechanics I
ECTS Credits	4
Workload	Exam preparation: 120 hours
Language	German
Course Frequency	Each summer semester
Type of examination	Exam: Assessment ("Prüfungsleistung")
Controls of Success	Oral exam (approx. 45 min.) in accordance with § 4 (2) No. 2 SPO Master's Meteorology
Requirements	Successful participation in T-PHYS-102317

T-PHYS-103203 – Moderne Theoretische Physik für Lehramt – Vorleistung

Course Code	T-PHYS-103203
Responsible Lecturer	**Prof. Dr. Ulrich Nierste**
Part of	M-PHYS-101664 Moderne Theoretische Physik für Lehramt
ECTS Credits	4
Workload	Presence time in lectures 90 hours Preparation / follow-up, exercises 30 hours
Language	German
Course Frequency	Each winter semester
Duration	1 semester
Type of examination	Prerequisite: Coursework (“Studienleistung”)

Semester	Course-No.	Course	Kind	SWS	Lecturer
WS 19/20	**4012131**	Moderne Theoretische Physik für Lehramtskandidaten	Lectures(V)	4	S. Gieseke
WS 19/20	**4012132**	Übungen zu Moderne Theoretische Physik für Lehramtskandidaten	Exercises (Ü)	4	S. Gieseke

Controls of Success	Exercise sheets
Requirements	Modules Classical Theoretical Physics I and II
Course Contents	See module description

T-PHYS-103203 – Moderne Theoretische Physik für Lehramt – Prüfung

Course Code	T-PHYS-103204
Responsible Lecturer	**Prof. Dr. Ulrich Nierste**
Part of	M-PHYS-101664 Moderne Theoretische Physik für Lehramt
ECTS Credits	4
Workload	Exam preparation: 120 hours
Language	German
Course Frequency	Each summer semester
Type of examination	Exam: Assessment (“Prüfungsleistung”)
Controls of Success	Oral exam (approx. 45 min.) in accordance with § 4 (2) No. 2 SPO Master's Meteorology
Requirements	Successful participation in T-PHYS-103203

T-PHYS-103525 - Geological Hazards and Risks

Course Code	T-PHYS-103525
Responsible Lecturer	**Dr. Ellen Gottschämmer**
Part of	M-PHYS-101833 Geological Hazards and Risks
ECTS Credits	8
Workload	240 h
Language	English
Course Frequency	Each winter semester
Duration	1 semester
Type of examination	Prerequisite: Coursework ("Studienleistung")

Semester	Course-No.	Course	Kind	SWS	Lecturer
SS 19	**4060121**	Geological Hazards and Risks	Lecture (V)	2	E. Gottschämmer, J Daniell
SS 19	**4060122**	Exercises on Geological Hazards and Risks	Exercises (Ü)	2	E. Gottschämmer, J. Daniell

Controls of Success: Exercise sheets, written project work.

Requirements: None

Course Contents

- Earthquake Hazards
  - Short introduction to seismology and seismometry (occurrence of tectonic earthquakes, types of seismic waves, magnitude, intensity, source physics)
  - Induced seismicity
  - Engineering seismology, Recurrence intervals, Gutenberg-Richter, PGA, PGV, spectral acceleration → hazard maps
  - Earthquake statistics
  - Liquefaction
- Tsunami Hazards
- Landslide Hazards
- Hazards from Sinkholes
- Volcanic Hazards
  - Short introduction to physical volcanology
  - Types of volcanic hazards
- The Concept of Risk, Damage and Loss
- Data Analysis and the use of GIS in Risk analysis
- Risk Modeling – Scenario Analysis

- Risk Reduction and Risk Management
- Analysis Feedback and Prospects in the Risk Modeling Industry

T-PHYS-103553 – Einführung in die Vulkanologie, Vorleistung

Course Code	T-PHYS-103553
Responsible Lecturer	**Dr. Ellen Gottschämmer**
Part of	M-PHYS-103336 Geophysical Analysis of Natural Hazards
ECTS Credits	3
Workload	90 h
Language	English
Course Frequency	Each summer semester
Duration	1 semester
Controls of Success	Coursework (“Studienleistung”)

Semester	Course-No.	Course	Kind	SWS	Lecturer
SS 19	**4060251**	Introduction to Volcanology	Lecture (V)	2	E. Gottschämmer, A. Riedbrock
SS 19	**4060252**	Exercises to Introduction to Volcanology	Exercises (Ü)		E. Gottschämmer, A. Riedbrock

Controls of Success Active and regular attendance of lecture and practicals, preparation and follow-up of lectures (at home), assignments, presentation of a volcano in a short (10 – 15 minute) talk with slides.

Requirements None

Course Contents

- Introduction, Overview
- Volcanoes and Plate Tectonics
- Magma and Volcanic Deposits
- Eruption types
- Volcanic Edifices
- Volcanic Hazard and Risk
- Volcano Monitoring
- Volcano Seismology
- Numerical Modelling of Volcanic Products
- Historic Eruptions
- Volcanoes and Climate

T-PHYS-103644 – Einführung in die Vulkanologie, Prüfung

Course Code	T-PHYS-103644
Responsible Lecturer	**Dr. Ellen Gottschämmer**
Part of	M-PHYS-103336 Geophysical Analysis of Natural Hazards
ECTS Credits	1
Workload	30 h
Language	English
Course Frequency	Each summer semester
Duration	1 semester
Controls of Success	Examination of another type ("Prüfungsleistung anderer Art")
Controls of Success	Scientific essay about the presentation, approx. 8-10 pages, submitted electronically.
Requirements	Successful participation in T-PHYS-103553 Einführung in die Vulcanology, Prerequisite

T-PHYS-107673 – Seminar on recent topics of ris science

Course Code	T-PHYS-107673
Responsible Lecturer	**Dr. Ellen Gottschämmer**
Part of	M-PHYS-103336 Geophysical Analysis of Natural Hazards
ECTS Credits	4
Language	German
Course Frequency	Each winter semester
Duration	1 semester
Controls of Success	Coursework ("Studienleistung")

Semester	Course-No.	Course	Kind	SWS	Lecturer
WS 19/20	**4060284**	Seminar über aktuelle Themen aus der Risikoforschung (Literaturseminar)	Seminar (S)	2	E. Gottschämmer

Controls of Success	Preparation and presentation of a talk based on a scientific publication, critical discussion of the scientific results.
Requirements	None
Course Contents	The students will read and discuss current literature about current topics of natural hazards and risk.

T-PHYS-107692 – Seminar on IPCC Assessment Report

Course Code	T-PHYS-107692
Responsible Lecturer	**Prof. Dr. Joaquim Pinto**
Part of	M-PHYS-100951 Components of the Climate System
ECTS Credits	0
Language	English
Course Frequency	Each winter semester
Duration	1 semester
Controls of Success	Coursework ("Studienleistung")

Semester	Course-No.	Course	Kind	SWS	Lecturer
WS 19/20	**4052204**	Seminar on IPCC Assessment Report	Seminar (S)	2	Joaquim Pinto

Controls of Success Study of a chapter of the current IPCC report with subsequent presentation (~ 20-25 min) and submission of a written summary (1 page).

Requirements

Course Contents Causes of climate change and paleoclimate (external and internal influence factors on the climate, results and structure of simple climate models with and without feedbacks, radiation effect and importance of greenhouse gases, results of model projections of the global climate, IPCC process structure and importance for the life on earth).

The objectives of this Seminar are to provide an overview of the last IPCC Report (currently 2013) and to develop scientific presentation and discussion skills.

T-PHYS-107693 – Tropical Meteorology

Course Code	T-PHYS-107693
Responsible Lecturer	**Prof. Dr. Peter Knippertz**
Part of	M-PHYS-100951 Components of the Climate System
ECTS Credits	0
Language	English
Course Frequency	Each winter semester
Duration	1 semester
Controls of Success	Coursework ("Studienleistung")

Semester	Course-No.	Course	Kind	SWS	Lecturer
WS 19/20	**4052111**	Tropical Meteorology	Lectures(V)	2	P. Knippertz
WS 19/20	**4052112**	Tropical Meteorology	Exercises (Ü)	1	P. Knippertz, M. Maier-Gerber

Coursework	At least 50% of the points in the exercises
Requirements	None
Course Contents	Dynamics and climate of the Tropics (tropical circulation, Hadley and Walker cells, monsoons, El Niño, equatorial waves, Madden-Julian Oscillation, easterly waves, tropical cyclones, tropical squall lines).

T-PHYS-107694 – Cloud Physics

Course Code	T-PHYS-107694
Responsible Lecturer	**Prof. Dr. Corinna Hoose**
Part of	M-PHYS-100952 Atmospheric Processes
ECTS Credits	0
Language	English
Course Frequency	Each winter semester
Duration	1 semester
Controls of Success	Coursework ("Studienleistung")

Semester	Course-No.	Course	Kind	SWS	Lecturer
WS 19/20	**4052081**	Cloud Physics	Lectures(V)	2	C. Hoose
WS 19/20	**4052082**	Cloud Physics	Exercises (Ü)	2	C. Hoose, A. Keinert

Coursework	At least 50% of the points for the exercises and presentation of the solution at least once.
Requirements	None

Course Contents	Phenomenology, cloud dynamics of stratiform and convective clouds, micro physics of warm and cold clouds, collision and coalescence, primary and secondary ice formation, condesational and depositional growth.

T-PHYS-107695 – Energetics

Course Code	T-PHYS-107695
Responsible Lecturer	**Prof. Dr. Andreas H. Fink**
Part of	M-PHYS-100952 Atmospheric Processes
ECTS Credits	0
Language	English
Course Frequency	Each winter semester
Duration	1 semester
Controls of Success	None

Semester	Course-No.	Course	Kind	SWS	Lecturer
WS 19/20	**4052121**	Energetics	Lectures (V)	2	A. H. Fink

Coursework	None
Requirements	None

Course Contents

Mean meridional circulation, stationary and transient eddies; basic forms, budget equations and transport processes of energy in the atmosphere; principle of available potential energy; Lorenz cycle: energy reservoirs and transformation processes, eddy and thermally driven jets (EP flux vectors).

Table of content:

- Literature & Learning goals
- The Climate System
- Basic Equations of the Climate System
- Decomposition of the general circulation
- Radiation budget and energy transports
- Consequences of the radiation and surface energy budgets
- Atmospheric water budget
- Atmospheric and oceanic energy budget
- Concept of „Available Potential Energy (APE)“

T-PHYS-107696 – Atmospheric Radiation

Course Code	T-PHYS-107696
Responsible Lecturer	**PD Dr. Michael Höpfner**
Part of	M-PHYS-100952 Atmospheric Processes
ECTS Credits	0
Language	English
Course Frequency	Each winter semester
Duration	1 semester
Controls of Success	None

Semester	Course-No.	Course	Kind	SWS	Lecturer
WS 19/20	**4052071**	Atmospheric Radiation	Lectures (V)	2	M. Höpfner

Coursework	None
Requirements	None

Course Contents

- Relevance: Weather/Climate, Chemistry, Remote Sensing
- Short history of light
- Properties of electromagnetic radiation
- Radiometric quantities
- The electromagnetic spectrum
- Boundary conditions: Sun, Earth's surface; reflection and emission
- Radiative transfer in the thermal infrared region: black body radiation, local/non-local thermodynamic equilibrium, transmission, radiative transfer, application in remote sensing
- Molecular spectroscopy, line-broadening
- Radiative transfer in the UV/Visible: absorption and scattering by particles
- Single scattering properties: Rayleigh, Mie-approximations
- Optical phenomena: rainbows, halos
- Radiative transfer with multiple scattering: why are clouds white?, two-stream approximation
- Radiative budget, climate engineering

T-PHYS-108610 – Turbulent Diffusion

Course Code	T-PHYS-108610
Responsible Lecturer	**Dr. Bernhard Vogel**
Part of	M-PHYS-100954 Applied Meteorology
ECTS Credits	0
Language	English
Course Frequency	Each summer semester
Duration	1 semester
Controls of Success	Coursework (“Studienleistung”)

Semester	Course-No.	Course	Kind	SWS	Lecturer
SS 19		Turbulent Diffusion	Lectures(V)	2	B. Vogel, H. Vogel
SS 19		Turbulent Diffusion	Exercises (Ü)	2	B. Vogel, H. Vogel

Coursework	After a short introduction, the students independently conduct model simulations with ICON-ART. The results are prepared, evaluated with regard to relevant questions, analyzed and presented in the group exercises.
Requirements	None
Course Contents	Propagation of air bubbles (relevant trace gases, daily cycles of emissions and concentrations, temperature history and movements in the lower atmosphere, turbulent diffusion, turbulence parameterization, chemical transformation processes, numerical models)

T-PHYS-108928 – Climate Modeling & Dynamics with ICON

Course Code	T-PHYS-108928
Responsible Lecturer	**Prof. Dr. Joaquim Pinto, Dr. Aiko Voigt**
Part of	M-PHYS-100951 Components of the Climate System
ECTS Credits	0
Language	English
Course Frequency	Each winter semester
Duration	1 semester
Coursework	Coursework ("Studienleistung")

Semester	Course-No.	Course	Kind	SWS	Lecturer
WS 19/20	**4052151**	Climate Modeling & Dynamics with ICON	Lectures(V)	2	J. Pinto, A. Voigt
WS 19/20	**4052152**	Climate Modeling & Dynamics with ICON	Exercises (Ü)	1	N. Albern, G. Papavasileiou

Controls of Success	At least 50% of the points in the exercises
Requirements	

Course Contents

Introduction to the ICON model, baroclinic life cycles, cloud impact on large-scale circulation of the atmosphere, climate change response of extra tropical jet stream, aerosol impact on tropical rain belts.

Numerical modeling and analysis of climate and climate change (climate system, conceptual models for processes and feedback, chaotic dynamic systems, numerical climate models (EMICS, Global models, regional models), (statistical) analysis methods.

Table of contents:

- Fundamentals of climate modeling
- Introduction to ICON
- Cloud-radiative interactions
- Climate change

T-PHYS-108931 – Middle Atmosphere in the Climate System

Course Code	T-PHYS-108931
Responsible Lecturer	**PD Dr. Michael Höpfner**
Part of	M-PHYS-100951 Components of the Climate System
ECTS Credits	0
Language	English
Course Frequency	Each winter semester
Duration	1 semester
Controls of Success	None

Semester	Course-No.	Course	Kind	SWS	Lecturer
WS 19/20	**4052061**	Middle Atmosphere in the Climate System	Lectures (L)	2	M. Höpfner, M. Sinnhuber

Coursework Requirements

Course Contents

- History of science of the middle atmosphere (MA)
- Mean state of the MA: temperature, wind, chemical composition
- Radiation: sun, radiative transfer, energy budget, photolysis
- Measurements: in-situ/remote sounding, ground-based, airborne/balloon, satellite
- Aerosols: stratospheric background aerosol layer, volcanic enhancement, polar stratospheric clouds, polar mesospheric clouds, meteoric dust
- Chemistry: general concepts, global ozone layer, polar ozone chemistry
- Dynamics: fundamental description, meridional circulation, equatorial circulation, waves and tides, stratospheric warmings, tracer and age-of-air, upper troposphere/lower stratosphere, cross-tropopause transport
- Coupling and climate: chemistry-climate coupling, trends,

T-PHYS-108932 – Ocean-Atmosphere Interactions

Course Code	T-PHYS-108932
Responsible Lecturer	**Prof. Dr. Andreas H. Fink**
Part of	M-PHYS-100951 Components of the Climate System
ECTS Credits	0
Language	English
Course Frequency	Each winter semester
Duration	1 semester
Controls of Success	None

Semester	Course-No.	Course	Kind	SWS	Lecturer
WS 19/20	**4052121**	Ocean-Atmosphere Interactions	Lectures (L)	2	A. H. Fink

Coursework

Requirements

Course Contents

- Literature
- Learning goals
- Physical and chemical properties of the upper ocean layers
  - Properties of ocean waters
    - Salinity content and density
    - Temperature distribution in the ocean
    - Horizontal salinity distribution in the ocean
    - Vertical salinity distribution
    - Horizontal and vertical density distribution
    - Characteristic water masses in the oceans
    - Dissolved gases in the ocean
    - Molecular transport
  - Properties of humid air
  - Ocean surface and its immediate environment
- Wind-driven ocean surface currents

	◦ Equation of motion ◦ Ekman' s solution of the equation of motion ◦ Mass transport associated with the Ekman current ◦ Up-welling in the ocean ◦ Sverdrup regime ◦ Westerly boundary current: Stommel' s contribution ◦ Munk's solution • Ocean waves ◦ Generation of ocean waves by wind ◦ Description of ocean waves ◦ Global view on ocean wave climates ◦ Ocean wave modeling ◦ Ocean wave measurements • Summary

T-PHYS-108938 – Atmospheric Aerosols

Course Code	T-PHYS-108938
Responsible Lecturer	**Dr. Prof. Dr. Ottmar Möhler**
Part of	M-PHYS-100952 Atmospheric Processes
ECTS Credits	0
Language	English
Course Frequency	Each winter semester
Duration	1 semester
Controls of Success	Coursework ("Studienleistung")

Semester	Course-No.	Course	Kind	SWS	Lecturer
WS 19/20	**4052041**	Atmospheric Aerosols	Lectures(V)	2	O. Möhler,
WS 19/20	**4052042**	Atmospheric Aerosols	Exercises (Ü)	2	O. Möhler, L. Lacher

Coursework

Requirements

Course Contents	Gas particle processes (kinetics, diffusion, condensation), aerosol properties (diffusion, coagulation, sedimentation, impaction), aerosol thermodynamics (chemical potential, solubility, crystallization), aerosol cloud processes (Köhler theory, ice nucleation).

T-PHYS-109133 – Remote Sensing of Atmospheric State Variables

Course Code	T-PHYS-109133
Responsible Lecturer	**Prof. Dr. Johannes Orphal, Dr. Björn-Martin Sinnhuber**
Part of	M-PHYS-100953 Experimental Meteorology
ECTS Credits	0
Language	English
Course Frequency	Each summer semester
Duration	1 semester
Controls of Success	Coursework ("Studienleistung")

Semester	Course-No.	Course	Kind	SWS	Lecturer
SS 19	**4052151**	Remote Sensing of Atmospheric State Variables	Lectures(V)	2	J. Orphal, B.-M. Sinnhuber
SS 19	**4052152**	Remote Sensing of Atmospheric State Variables	Exercises (Ü)	1	J. Orphal, B.-M. Sinnhuber

Coursework

Requirements

Course Contents

- physical basics
- radiation transfer
- inverse methods
- basics of satellite remote sensing
- techniques and applications

T-PHYS-109135 – Advanced Practical Course

Course Code	T-PHYS-109135
Responsible Lecturer	**Prof. Dr. Ch. Kottmeier**
Part of	M-PHYS-100953 Experimental Meteorology
ECTS Credits	0
Language	English
Course Frequency	Each summer semester
Duration	1 semester
Controls of Success	Coursework ("Studienleistung")

Semester	Course-No.	Course	Kind	SWS	Lecturer
SS 19	**4051103**	Advanced Meteorological Practical Course	Practicals (Pr)	5	C. Kottmeier, R. Wagner, M. Höpfner, M. Kohler

Coursework	The students conduct experiments in small groups according to instructions. From each experiment, a protocol is created from a scientific point of view. The practical is passed, if all protocols have been accepted by the supervisors.
Requirements	None

Course Contents

Available experiments include:

- atmospheric measurements with gliders (IMK-TRO)
- surface energy balance (IMK-TRO)
- infrared spectroscopy (IMK-ASF)
- AIDA cloud and aerosol chamber (IMK-AAF)

T-PHYS-109136 – Field Trip

Course Code	T-PHYS-109135
Responsible Lecturer	**Prof. Dr. Christoph Kottmeier**
Part of	M-PHYS-100953 Experimental Meteorology
ECTS Credits	0
Language	English
Course Frequency	Each summer semester
Duration	1 semester
Controls of Success	Coursework ("Studienleistung")

Semester	Course-No.	Course	Kind	SWS	Lecturer
SS 19	**4052263**	Field Trip	Excursion (E)	2	P. Knippertz, J. Pinto, C. Kottmeier, M. Kunz

Coursework	The students work on and present assigned topics within the excursion group in order to prepare themselves and the group specifically for visits at research institutes and observatories.
Requirements	None
Course Contents	The course comprises a one-week excursion to research institutes and observatories in Germany and neighbouring countries.

T-PHYS-109139 – Advanced Numerical Weather Prediction

Course Code	T-PHYS-109139
Responsible Lecturer	**Prof. Dr. Peter Knippertz**
Part of	M-PHYS-100954 Applied Meteorology
ECTS Credits	0
Language	English
Course Frequency	Each summer semester
Duration	1 semester
Controls of Success	None

Semester	Course-No.	Course	Kind	SWS	Lecturer
SS 19	**4052051**	Advanced Numerical Weather Prediction	Lecture (V)	2	P. Knippertz

Coursework	None
Requirements	None
Course Contents	• Introduction • Parametrisations • Data assimilation • Ensemble predictions • Verification • Post-processing

T-PHYS-109140 – Meteorological Hazards

Course Code	T-PHYS-109140
Responsible Lecturer	**Prof. Dr. Michael Kunz**
Part of	M-PHYS-100954 Applied Meteorology
ECTS Credits	0
Language	English
Course Frequency	irregular
Duration	1 semester
Controls of Success	None

Semester	Course-No.	Course	Kind	SWS	Lecturer
SS 18	**4052121**	Meteorological Hazards	Lecture (V)	2	M. Kunz

Coursework	None
Requirements	None
Course Contents	Meteorological natural hazards such as: • extreme events, • extra tropical and tropical cyclones, • convection, • thunderstorms, • super cells, • tornadoes, • convective storm gusts, • derechos, • hail, • climate change

This course will not be offered in the summer semester 2019.

T-PHYS-109141 – Energy Meteorology

Course Code	T-PHYS-109141
Responsible Lecturer	**Prof. Dr. Joaquim Pinto**
Part of	M-PHYS-100954 Applied Meteorology
ECTS Credits	0
Language	English
Course Frequency	Each summer semester
Duration	1 semester
Controls of Success	Coursework (“Studienleistung”)

Semester	Course-No.	Course	Kind	SWS	Lecturer
SS 19	**4052191**	Energy Meteorology	Lecture (V)	2	S. Emeis, M. Schroedter-Homscheidt, J. Pinto

Coursework

Requirements

Course Contents

- Overview Energy Meteorology
- Physical basics – Wind energy
- Physical basics of energy supply
- Economic basics of energy supply
- Onshore and offshore wind parks
- Wind energy siting – complex terrain
- Physical basics – Solar energy
- Tracking and concentrating solar systems
- Wind measurements
- Radiation forecasts
- Wind energy – yield forecasts
- Climate change & energy system
- Community energy meteorology and where to work

T-PHYS-109142 – Methods of Data Analysis

Course Code	T-PHYS-109142
Responsible Lecturer	**Prof. Dr. Joaquim Pinto**
Part of	M-PHYS-100954 Applied Meteorology
ECTS Credits	0
Language	English
Course Frequency	Each summer semester
Duration	1 semester
Controls of Success	Coursework ("Studienleistung")

Semester	Course-No.	Course	Kind	SWS	Lecturer
SS 19	**4052171**	Methods of Data Analysis	Lecture (V))	2	J. Pinto, P. Knippertz, S. Lerch
SS 19	**4052172**	Methods of Data Analysis	Exercises (Ü)	1	J. Pinto, P. Knippertz, S. Lerch, F. Ehmele

Controls of Success	At least 50% of the points in the exercises
Requirements	None

Course Contents

1. Basics
2. Significance testings
3. Regression
4. Time series
5. Fourier wavelet analysis
6. Spatial analysis
7. Clustering
8. Machine Learning
9. Summary

T-PHYS-109177 – Physics of Planetary Atmospheres

Course Code	T-PHYS-109177
Responsible Lecturer	**Prof. Dr. Thomas Leisner**
Part of	M-PHYS-104488 Physics of Planetary Atmospheres
ECTS Credits	8
Workload	Presence time in lectures, exercises: 45 hours Preparation / follow-up: 120 hours
Language	English
Course Frequency	Each winter semester
Duration	1 semester
Controls of Success	Prerequisite: Coursework (“Studienleistung”)

Semester	Course-No.	Course	Kind	SWS	Lecturer
WS 19/20	**4052161**	Physics of Planetary Atmospheres	Lecture (V)	2	T. Leisner
WS 19/20	**4052162**	Physics of Planetary Atmospheres – Exercises	Exercises (Ü)	2	T. Leisner, A. Abdelmonem

Controls of Success	At least 50% of points in exercises
Requirements	None
Course Contents	See module description

T-PHYS-109177 – Exam on Physics of Planetary Atmospheres

Course Code	T-PHYS-109180
Responsible Lecturer	**Prof. Dr. Thomas Leisner**
Part of	M-PHYS-104488 Physics of Planetary Atmospheres
ECTS Credits	2
Workload	Exam preparation: 75 hours
Language	English
Course Frequency	Each winter semester
Type of examination	Exam: Assessment (“Prüfungsleistung”)
Controls of Success	Oral exam (approx. 45 min.) in accordance with § 4 (2) No. 2 SPO Master's Meteorology
Requirements	Successful participation in T-PHYS-109177

T-PHYS-109616 – Master's Thesis

Course Code	T-PHYS-109616– Master's Thesis
Responsible Lecturer	**Prof. Dr. Peter Knippertz**
Part of	M-PHYS-100956 – Master's Thesis
ECTS Credits	30
Workload	840 hours
Language	English or German. On agreement with the examiner(s), the Master's Thesis can also be written in other languages.
Duration	1 semester
Course Frequency	Each semester
Controls of Success	Written report (Master's thesis) and presentation (SPO §24)

Semester	Course-No.	Course	Kind	SWS	Lecturer

Controls of Success	The assessment is based on § 14 SPO Master's Meteorology and consists of the evaluation of the Master's Thesis and the related presentation by at least one professor, one habilitated scientist of the KIT-Faculty of Physics or one leading scientist in accordance with § 14 Abs. 3 para. 1 KITG and one other examiner. The overall assessment will be recorded in a written report. The evaluation period shall not exceed eight weeks upon submission of the Master's thesis.
Requirements	Students have successfully completed all four module exams in the subjects *Atmospheric and Climate Processes* and *Applied and Experimental Meteorology*. *Soft skills* and *Supplementary Modules* can be in progress.
Course Contents	See module description

T-PHYS-109902 – Integrated Atmospheric Measurements

Course Code	T-PHYS-109902– Integrated Atmospheric Measurements
Responsible Lecturer	**Prof. Dr. Chr. Kottmeier**
Part of	M-PHYS-100953 – Experimental Meteorology
ECTS Credits	0
Language	English
Duration	1 semester
Course Frequency	Each Summer semester
Controls of Success	Coursework (“Studienleistung”)

Semester	Course-No.	Course	Kind	SWS	Lecturer
SS 19	**4052131**	Integrated Atmospheric Measurements	Lecture (L)	2	C. Kottmeier

Controls of Success	Short presentation on selected contents (approx. 20 min)
Requirements	None
Course Contents	Brief Introduction to advanced atmospheric observation techniques like eddy covariance measurements, Doppler Lidar, Doppler Radar and aircraft measurements. Principle and objectives of Integrated Observation. Examples of Integrated Observation from Polar Research, Convection Studies and Orographic Flow analysis.

This course will be offered for the first time in the summer semester 2019.

IV Guidelines to Master's Thesis

In the following, the most important steps and necessary formalities related to the compilation and submission of the Master's thesis are described. The description comprises the closely interlinked modules "Specialization Phase" and "Master's Thesis", thus two semesters or a 12-month period. It is a guideline, not a legally binding regulation document. Questions can be directed to Andreas Fink (andreas.fink@kit.edu) or Katharina Maurer (katharina.maurer@kit.edu).

1. Finding a topic and supervisor

The "standard" case is that you will obtain a topic and supervisor from the list at our homepage. Please approach the respective supervisor(s) for more details in case you are interested. Please note that it is possible to chose topics that were not listed under the above-mentioned URL. In this case, approach professors, "Privatdozenten", and group leaders directly.

In this context, it shall be noted that the Institute of Meteorology and Climate Research (IMK) has three departments: **TRO** focuses on the troposphere, **AAF** on aerosols, **ASF** on atmospheric trace gases and remote sensing. Master theses can be written in all three departments.

2. Registration and Deadlines

Before the start of the module *Specialization Phase*, students need to personally visit the Examination Office of the KIT Faculty of Physics:

Prüfungssekretariat, Ms. Anja Müller

Physics Building 30.21, 9th floor, Room 9-13;

email: pruefungssekretariat@physik.kit.edu

Phone 0721 608-43438

If all requirements are met, a signed and stamped form will be issued.

Students use this form to contact their Advisor to discuss and fill in, amongst others, the fields "Advisor/ Co-Advisor", "Preliminary title of thesis", and "Start of the thesis".

The Advisor signs the form and sends it back to the Examination Office.

The Examination Office will register the thesis in the Campus Management System with the preliminary working title, the advisors and the start date. The deadline for submission of the thesis is calculated by the system and monitored by the Examination Office (12 months after starting date). These information are visible for the student in the Campus student portal. The following points are worthy of note:

- The application for the Master's thesis will be accepted by Ms. Müller, if all four meteorology modules of the 1st and 2nd MSc semester are entered in the Campus Management System. The modules *Soft Skills* and *Complementary Elective* may still be incomplete and should be completed in the course of the *Specialization Phase*.
- If the oral module exam has already been passed in one or more of the meteorological modules but has not yet been entered, an e-mail from the Responsible Lecturer to Ms. Müller, confirming the successful completion of the module, is sufficient.
- Important: If one of the four Master modules has not been passed because course components ("Teilleistungen") have not yet been completed and therefore the prerequisites for the oral examination have not yet been met, please speak to the study advisor Prof. Dr. Andreas H. Fink, to prevent an unnecessary delay of the study by one semester.
- Deadline extensions are handled very restrictively and are only possible in justified individual cases.

3. The module *Specialization Phase*

Formally, the first six months of final thesis work belong to the module *Specialization Phase*. In these six months, a seminar will be given in the *Seminar on the Specialization Phase* (“Studierendenseminar”) in the context of the *Scientific Concept Development*. It should be noted that this seminar must be given in the “Studierendenseminar” that usually takes place during the lecture period on Wednesdays from 15:45-17:15 o'clock. Suggestions for dates and seminar titles should be sent to Kathi Maurer, ideally before the semester starts. The current seminar-calendar can be found on the website.

Important: Please register in the Campus Management System before the seminar on the S*pecialization Phase*. Formally, this is possible when 3 of the 4 master modules in meteorology in the Campus Management System have been passed.

The seminar talk should take 20-25 minutes, followed by a discussion. The total duration should not exceed 45 minutes. After the seminar, there should be a feedback discussion with the Advisors and the Supervisor, in which the progress made so far is evaluated and next steps are discussed.

Advisors or Supervisors sign a form, which documents the presentation of the lecture with date and title.

Please forward the signed form to Mrs. Stenschke or Prof. Knippertz, who will enter the S*pecialization Phase* in the Campus Management System.

4. The module *Master’s Thesis*

Within the 12-month period, the Master's thesis is to be submitted to Ms. Müller as a written scientific paper.

Five bound copies must be made, with three copies being submitted to Ms. Müller, all three signed by the first Examiner with a text like for example:

„Accepted as an examination copy.“

Please note: With this signature the first examiner declares that the work is graded at least with a mark of 4.0! If doubts as to the latter grading exists, the examiner will write on all three copies a text like:

„Inspection copy.“

Ms. Müller confirms the receipt of the copies, which are then submitted to the first and second Examiners and on the basis of which the reports are prepared. This delivery is relevant for the 12-month deadline.

Please give the fourth and fifth bound copy to Frau Schönbein for the library at Campus South and the DWD library. Please send a PDF of the submitted work to Mr. Brückel, the IT administrator at Campus South. This PDF file is available for free download on the *IMK* website pending on the consent of the Advisor.

After submission, a 20-25 minute seminar must be held in the respective seminars of the department TRO, ASF, or AAF (cf. Section 4.1), where the thesis was written. This seminar can be held after the 12-month period and should take place at one of the next possible dates. Note: This final seminar can only take place during the lecture period.

After the seminar, a form must be completed, signed by the Advisor and the Co-Advisor or Supervisor and sent to Ms. Stenschke. The reports will be prepared by the Advisors only after the final presentation, as this is part of the assessment and is included in the evaluation.

Glossary

- **Advisor ("Berichterstatter or" Gutachter"):** This is usually a professor or a "Privatdozent" who acts as the first examiner.
- **Co-Advisor ("Zweitgutachter"):** This is usually a professor or a "Privatdozent" who acts as the second examiner.
- **Supervisor ("Betreuer"):** He/she supervises the Master Student, is often the Advisor or Co-Advisor, but can also be research staff (see also "group leader").
- **"Privatdozent":** This is an habilitated staff member. He can act as an Advisor. However, the second examiner must be a full professor in this case. This is also true for so-called "apl. Professor".
- **Group Leader ("Gruppenleiter"):** Group leaders in Campus North are senior scientists. They can act as Supervisors, but not as Advisors if they are not habilitated or are an "apl. Professor" (please see "Privatdozent").
- **"Responsible Lecturer":** This is the "Modulverantwortliche" who enters the final grade of his/her module into the Campus Management System.
- **"Examination Office" ("Prüfungssekretariat"):** This is the "Prüfungssekretariat" of the Faculty of Physics. The Examination Office is currently managed by Ms. Müller.
- **Campus Management System (CAS):** Amongst others, results of modules are entered in CAS.
- **"Course Component":** This is the so-called "Teilleistung", often a lecture.
- **"Seminar on the Specialization Phase":** This is also referred to as "Studierendenseminar", in which also BSc students give their talks. It is currently scheduled on Wednesdays 15:45-17:15 hours.