Universität Hamburg
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OFFICIAL TRANSLATION OF
Fachspezifische Bestimmungen für den Studiengang „Earth System Physics (B.Sc.)"

(Amtliche Bekanntmachung Nr. 48 vom 19. Juni 2025)

THIS TRANSLATION IS FOR INFORMATION ONLY – ONLY THE GERMAN VERSION SHALL BE LEGALLY VALID AND ENFORCEABLE!

Subject-Specific Provisions
Earth System Physics (B.Sc.)

dated 23 April 2025

On 4 June 2025 in accordance with Section 108 subsection 1 of the Hamburg higher education act (Hamburgisches Hochschulgesetz, HmbHG) dated 18 July 2001 (HmbGVBl. p. 171) and amended 19 February 2025 (HmbGVBl. p. 241), the Executive University Board of the University of Hamburg ratified the Subject-Specific Provisions for the Master of Science in Physics adopted on 23 April 2025 by the Faculty of Mathematics, Informatics and Natural Sciences in accordance with Section 91 subsection 2 no. 1 HmbHG.

Preamble

These Subject-Specific Provisions supplement the provisions of the Faculty of Mathematics, Informatics and Natural Sciences' Examination Regulations dated 20 October 2021 as amended governing bachelor of science (B.Sc.) degree programs and provide a description of the modules for the Earth System Physics degree program.

I. Supplemental provisions

Section 1
Program and examination objectives, academic degree, and implementation of the degree program

Section 1 subsection 1:
The Bachelor of Science in Earth System Physics (B.Sc.) pursues the general study objectives according to Section 1 subsection 1 Examination Regulations for the Bachelor of Science in the Faculty of Mathematics, Informatics and Natural Sciences.In addition to these general program goals, the qualification profile requires graduates to:be able to apply scientific knowledge, methods, and skills independently and continue their education on their own;understand the rules of good academic practice and implement these responsibly in their subject area;be able to apply basic physical and mathematical knowledge, apply general evaluation techniques from the field of physics, and use the findings to draw and interpret conclusions about geophysical processes on solid earth, in the ocean and in the atmosphere; have acquired the competence to diagnose and assess the dynamics of the solid earth, the oceans and the atmosphere on the basis of geophysical, oceanographic and meteorological data and models;are able to present findings in a scientifically appropriate manner, both orally and in writing;have the ability to mathematically and scientifically observe, analyze, and predict variations and changes in the solid earth, the oceans and the atmosphere, and an awareness of their socio-economic relevance.

Section 4
Program and examination organization, modules, and ECTS credits

Section 4 subsections 1 and 3:
(1) Detailed descriptions of all modules can be found in Part II. Module descriptions.
(2) The Bachelor of Science in Earth System Physics (B.Sc.) consists of a required area (90 ECTS credit points), a required elective area (60 ECTS credit points), a free elective area (18 credit points) and the final module *bachelor's thesis* (12 ECTS credit points).The recommended process for the modules is depicted in Figure 1.
(3) The required area provides students with the general basic knowledge in mathematics and -physics, as well as basic subject-specific knowledge in geophysics, oceanography, and meteorology. It comprises modules of basic physics Physics 1 (Mechanics and Thermodynamics) and Physics 2 (Electrodynamics and Optics) (total 24 ETCS credits); the mathematical foundations modules Mathematics 1 and Mathematics 2, Numerics for Earth System Physics, Differential Equations for Earth System Physics, and Statistics for Earth System Physics (total 34 ECTS credits), as well as the modules of the course-specific foundations Physics of the Earth System 1, Physics of the Earth System 2 and Physics of the Earth System—Practical Training, as well as Foundations of Fluid Dynamics (total 32 ECTS credits).
(4) The compulsory elective area provides in-depth subject-specific knowledge in the fields of geophysics, oceanography, and meteorology. The modules available in the required elective are listed in Part II. Module descriptions. Other suitable modules may be undertaken on application to the chair of the examinations board.
(5) The free elective area provides an opportunity to acquire interdisciplinary skills and broaden knowledge in one's own discipline and beyond. Students can choose modules and classes from across the university.

(6) The final bachelor's thesis module introduces students to the independent planning, execution, and documentation of academic work.

First subject semester	*Physics of the Earth System 1* 10 ECTS credits	*Mathematics 1* 8 ECTS credits	*Physics 1* (Mechanics and Thermodynamics) 12 ECTS credits	
Second subject semester	*Physics of the Earth System 2* 10 ECTS credits	*Mathematics 2* 8 ECTS credits	*Physics 2* (Electrodynamics and Optics) 12 ECTS credits	
Third subject semester	*Foundations of Fluid Dynamics* 6 ECTS credits	*Physics of the Earth System—Practical Training* 6 ECTS credits	*Numerics for Earth System Physics* 6 ECTS credits	Required elective 12 ECTS credits
Fourth subject semester	*Statistics for Earth System Physics* 6 ECTS credits	*Differential Equations for Earth System Physics* 6 ECTS credits	Required elective 12 ECTS credits	Free elective area 6 ECTS credits
Fourth subject semester	Required elective 18 ECTS credits		Free elective area 12 ECTS credits	
Fourth subject semester	Required elective 18 ECTS credits		*Bachelor's thesis* 12 ECTS credits	

Figure 1: Recommended module sequence for the Bachelor of Science in Earth System Physics (B.Sc.)

Section 5
Types of courses

As a rule, courses are taught in English. Some modules listed in Part II Module Descriptions may set German as the language of instruction.

Section 5 subsections 1 and 2:

(1) In addition to the courses listed in Section 5 subsection 1 of the Examination Regulations governing B.Sc. degree programs, the following course combinations are possible: combined lecture and practical course (lecture and practical course, L + PC).

(2) Attendance is compulsory for the following types of courses:

1. seminars, as these are generally aimed at improving students' abilities to handle criticism and to hold discussions
2. field trips, as these are designed to provide region-specific knowledge
3. internships and on-site internships, as these are intended to guide students and enable them to resolve practical problems using new methods;
4. projects, as these also serve to develop social skills (e.g., the ability to work in a team).
5. exercises, if the qualification objectives of the associated module cannot normally be fully achieved without them.

(3) Compulsory attendance does not apply to admission to repeat examinations.

(4) Any other attendance requirements for individual modules and courses are listed under II.

Section 13
Completed coursework and module examinations

Section 13 subsection 10:
The examination is generally done in English. Individual modules and courses listed under II may indicate that the examination language is German.If the examiner and the student agree, an examination for which English is indicated as the examination languages in the module description may also be taken in German, or vice versa.

Section 14
Bachelor's thesis

Section 14 subsection 2:
Admission to the final bachelor's thesis module is open to students who have earned at least 100 ECTS credits and have successfully completed the modules Mathematics 1, Mathematics 2, Physics 1 (Mechanics and Thermodynamics) and Physics 2 (Electrodynamics and Optics).

Section 14 subsection 4:
The master's thesis must be written in English.

Section 14 subsection 5
The workload for the master's thesis amounts to 30 ECTS credits. Students have 5 months to complete the thesis, and should be 25–30 pages in length.

Section 15
Evaluation of examination performance

Section 15 subsection 3:
(1) If a module examination is comprised of several course examinations, then the (overall) grade is calculated by averaging the grades from each course examination weighted according to the ECTS credits assigned to each part. Ungraded partial examinations are not taken into account when calculating the module grade.
(2) The overall final grade for the master's degree program is calculated by averaging the grades from all modules weighted according to the ECTS credits assigned to each, whereby the final module has twice the weight. Modules and classes whose examinations are graded pass/fail in accordance with Part II. Module Descriptions are not taken into account when calculating the overall grade for the bachelor's examination. Of the modules Physics 1 (Mechanics and Thermodynamics) and Physics 2 (Electrodynamics and Optics), only the module with the better grade is included in the calculation of the overall grade for the bachelor's examination. Of the modules Mathematics 1, Mathematics 2, Numerics for Earth System Physics, Differential Equations for Earth System Physics and Statistics for Earth System Physics, only the three modules with the highest grades are included in the calculation of the overall grade for the bachelor's examination. Credit points and examination achievements from the free elective area are not taken into account when calculating the overall grade of the bachelor's examination.

II. Module descriptions

II.1 Module descriptions of the compulsory modules

Module type **Title** **Module code**	**Required module** **Physics 1 (Mechanics and Thermodynamics)** **PHY-E1-EN**
Learning outcomes	Students understand the basic phenomena of mechanics and thermodynamics and can explain them. They are familiar with the basics of theoretical conceptualization and have mastered the associated mathematical methods,and understand the relationship between experimental observation and theoretical description within the framework of Newtonian mechanics.
Module content	Experimental physics: 1. Measuring process and measured variables: physical quantities, SI units, measurement accuracy and measurement errors 2. Kinematics of the center of mass: trajectory, speed, acceleration 3. Dynamics of the center of mass: Newton's laws, decomposition of forces, circular motion 4. Moving reference systems: Galilei transformation, accelerated reference systems, apparent forces 5. Gravitation: Kepler's laws, Newton's law of gravitation, gravity, and inertial mass 6. Work and energy: work, conservative forces, kinetic and potential energy, conservation of energy 7. Dynamics of mass point systems: elastic and inelastic collisions, momentum and conservation of momentum, dynamics of rigid bodies, angular momentum, and torque 8. Vibrations: harmonic oscillator, forced oscillations, resonance, coupled oscillators 9. Waves: wave equations, reflection, and transmission, standing waves, sound waves, acoustics, Doppler effect, Mach waves 10. Liquids and gases: hydro- and aerostatics, hydro- and aerodynamics 11. Thermodynamics: temperature and thermal expansion, kinetic theory of gases, heat and work, entropy, real gases, phase transitions Introduction to Theoretical Physics: 1. Kinematics: trajectory of a point particle, base and coordinates, curvilinear coordinates 2. Dynamics of a mass point: inertial systems and Galilean invariance, Newton's equation of motion, harmonic oscillator, differential equations 3. Force fields: conservative and central forces, work and existence of a potential, Kepler problem, scalar fields and vector fields, path integral, differentiation of fields 4. Dynamics of multi-particle systems: equations of motion and conservation laws, complex numbers, Fourier series 5. Special relativity: relativistic kinematics, Lorentz transformations
Type of course (given in number of course hours)	Lecture: Physics 1 (4 credit hours per week) Lecture: Introduction to Theoretical Physics 1 (3 credit hours per week) Practical courses: Exercises for Physics 1 and Introduction to Theoretical Physics 1 (3 credit hours per week)
Language of instruction	English
Prerequisites	Mandatory: none Recommended: none

Module applicability	The module is part of the following degree program(s)/profile(s): B.Sc. Earth System Physics
Module completion	Module examination: written examination Examination language: English
Workload in the individual module components (in ECTS credits)	Lecture: Physics 1 (6 ECTS credits) Lecture: Introduction to Theoretical Physics 1 (3 ECTS credits) Practical course: Exercises for Physics 1 and Introduction to Theoretical Physics 1 (3 ECTS credits)
Total module workload	12 ECTS credits
Module duration	1 semester
Module frequency	Once a year, in winter semester

Module type Title Module code	Required module Physics 2 (Electrodynamics and Optics) PHY-E2-EN
Learning outcomes	Students know the basic phenomena of electricity, magnetism and optics and can explain them. They are familiar with the fundamental principles of theoretical conceptualization in classic fields and competent in the use of computational methods of vector analysis. Students moreover understand the connection between experimental observation and theoretical description within the framework of Maxwell's theory.
Module content	Experimental physics: 1. Electrostatics: Coulomb force and electric charge, electric field, potential and voltage, superposition principle, electric dipole, capacitor and field energy, dielectrics 2. Electrical currents: continuity equation, resistance, Ohm's law, Kirchhoff's rules 3. Magnetostatics: magnetism and currents, Lorentz force, Biot-Savart law, Ampère's law, magnetic dipole, dia-, para- and ferromagnetism 4. Electrodynamics: induction, Lenz's rule, self-inductance and mutual inductance, switch-on and switch-off processes, displacement current 5. Alternating current circuits: RMS values, pointer display, complex impedances, RLC circuits, three-phase current 6. Electromagnetic waves: wave equation, transmission of waves, Hertzian dipole 7. Optics: geometric optical instruments, Huygen's principle and wave propagation in matter, interference and diffraction, coherence Introduction to Theoretical Physics: 1. Charge and current density: conservation of charge, continuity equation, delta distribution, curved surfaces and curvilinear coordinates, surface and volume integrals, sources of a vector field, divergence and Gauss' theorem 2. Electrostatics: field concept, differential and integral form of the field equations for symmetrical charge distributions, potential of point charges/charge distributions, electrostatic energy of point charges/charge distributions, electrostatic potential and Poisson's equation, vortices of a vector field, rotation, Stoke's theorem 3. Magnetostatics: differential and integral form of the field equations, solution of the field equations for symmetrical current distributions, vector potential and calibration freedom, vector potential for an arbitrary current distribution, magnetic field of an arbitrary current distribution, Biot-Savart law 4. Electrodynamics: Maxwell's equations, conservation laws, electromagnetic waves, electromagnetic potentials, Lorenz calibration
Type of course (given in number of course hours)	Lecture: Physics 2 (4 credit hours per week) Lecture: Introduction to Theoretical Physics 2 (3 credit hours per week) Practical courses: Exercises for Physics 2 and Introduction to Theoretical Physics 2 (3 credit hours per week)
Language of instruction	English
Prerequisites	Mandatory: none Recommended: successful completion of the Physics 1 (Mechanics and Thermodynamics) module examination

Module applicability	The module is part of the following degree program(s)/profile(s): B.Sc. Earth System Physics
Module completion	Module examination: written examination Examination language: English
Workload in the individual module parts (in ECTS credits)	Lecture: Physics 2 (6 ECTS credits) Lecture: Introduction to Theoretical Physics 2 (3 ECTS credits) Practical course: Exercises for Physics 2 and Introduction to Theoretical Physics 2 (3 ECTS credits)
Total module workload	12 ECTS credits
Module duration	1 semester
Module frequency	Annually, in summer semester

Module type Title Module code	Required module Mathematics 1 MATH1-EN
Learning outcomes	Confident mastery of mathematical methods based on a good understanding of mathematical theories.
Module content	1. The number sets N, Q, R and C 2. Vectors and vector spaces 3. Convergent sequences and series 4. Systems of linear equations 5. Continuity and differentiability (of functions in a variable) 6. Integration of such functions
Type of course (given in number of course hours)	Lecture: Mathematics 1 for Earth System Physics Students (4 credit hours per week) Practical course: Exercises for Mathematics 1 for Earth System Physics Students (2 credits hours per week) The practical course is subject to an attendance requirement pursuant to Section 5 subsections 1 and 2 Examination Regulations for the Bachelor of Science.
Language of instruction	English
Prerequisites	Mandatory: none Recommended: none
Module applicability	The module is part of the following degree program(s)/profile(s): B.Sc. Earth System Physics
Module completion	Module examination: written examination Examination language: English Prerequisite for the examination: regular active participation in the exercise according to Section 9 subsection 2 Examination Regulations for the Bachelor of Science (B.Sc.) in the Faculty of Mathematics, Informatics and Natural Sciences.
Workload in the individual module parts (in credit points)	Lecture: Mathematics 1 for Earth System Physics Students (6 ECTS credits) Practical course: Exercises for Mathematics 1 for Earth System Physics Students (2 ECTS credits)
Total module workload	8 ECTS credits
Module duration	1 semester
Module frequency	Once a year, in winter semester

Module type Title Module code	Required module Mathematics 2 MATH2-EN
Learning outcomes	Confident mastery of mathematical methods based on a good understanding of mathematical theories.
Module content	1. Function sequences 2. Hilbert spaces 3. Fourier series 4. Ordinary differential equations 5. Differential calculus in Rn
Type of course (given in number of credit hours)	Lecture: Mathematics 2 for Earth System Physics Students (4 credit hours per week) Practical course: Exercises for Mathematics 2 for Earth System Physics Students (2 credits hours per week) The practical course is subject to an attendance requirement pursuant to Section 5 subsections 1 and 2 Examination Regulations for the Bachelor of Science.
Language of instruction	English
Prerequisites	Mandatory: none Recommended: successful completion of the examination in the module Mathematics 1
Module applicability	The module is part of the following degree program(s)/profile(s): B.Sc. Earth System Physics
Module completion	Module examination: written examination Examination language: English Prerequisite for the examination: regular active participation in the exercise according to Section 9 subsection 2 Examination Regulations for the Bachelor of Science (B.Sc.) in the Faculty of Mathematics, Informatics and Natural Sciences.
Workload in the individual module parts (in credit points)	Lecture: Mathematics 2 for Earth System Physics Students (6 ECTS credits) Practical course: Exercises for Mathematics 2 for Earth System Physics Students (2 ECTS credits)
Total module workload	8 ECTS credits
Module duration	1 semester
Module frequency	Annually, in summer semester

Module type Title Module code	Required module Numerics for Earth System Physics ESW-B-Num
Learning outcomes	Students have developed an understanding of basic numerical methods. They have gained an insight into the existence, convergence and stability of solutions to linear and non-linear systems of equations and can apply initial algorithms to solve simple systems.
Module content	1. Introduction to the problem of numerical analysis 2. Systems of linear equations 3. Polynomial interpolation 4. Least squares method 5. Trigonometric interpolation 6. Numerical integration 7. Eigenvalue problems 8. Classical integration of linear systems 9. Multigrid method for solving linear systems 10. Nonlinear systems of equations 11. Numerical differentiation All topics can be accompanied by small programming tasks in Python.
Type of course (given in number of credit hours per week)	Lecture: Numerics for Earth System Physics (2 credit hours per week) Practical course: Exercises for Numerics for Earth System Physics (2 credit hours per week) The practical course is subject to an attendance requirement pursuant to Section 5 subsections 1 and 2 Examination Regulations for the Bachelor of Science.
Language of instruction	English
Prerequisites	Mandatory: none Recommended: successful completion of the modules Mathematics 1, Mathematics 2 and Physics of the Earth System
Module applicability	The module is part of the following degree program(s)/profile(s): B.Sc. Earth System Physics
Module completion	Module examination: Practical examination Examination language: English
Workload in the individual module parts (in ECTS credits)	Lecture: Numerics for Earth System Physics (3 ECTS credits) Practical course: Exercises for Numerics for Earth System Physics (3 ECTS credits)
Total module workload	6 ECTS credits
Module duration	1 semester
Module frequency	Annually, in winter semester

Module type	Required module
Title	**Differential Equations for Earth System Physics**
Module code	**ESW-B-DiffEqs**
Learning outcomes	Students know and understand the basic theory of ordinary and partial differential equations. They are familiar with initial methods for the numerical solution of differential equations and their application.
Module content	1. Introduction to Ordinary Differential Equations (ODEs) 2. Numerical methods for ODEs 3. Introduction to Partial Differential Equations (PDEs) 4. Numerical methods for PDEs All topics can be accompanied by small programming tasks in Python.
Type of course (given in number of credit hours per week)	Lecture: Differential Equations for Earth System Physics (2 credit hours per week) Practical course: Exercises for Differential Equations for Earth System Physics (2 credit hours per week) The practical course is subject to an attendance requirement pursuant to Section 5 subsections 1 and 2 Examination Regulations for the Bachelor of Science.
Language of instruction	English
Prerequisites	Mandatory: none Recommended: successful completion of the modules Mathematics 1, Mathematics 2, Physics of the Earth System 2, Numerics for Earth System Physics
Module applicability	The module is part of the following degree program(s)/profile(s): B.Sc. Earth System Physics
Module completion	Module examination: Term paper Examination language: English Prerequisite for the examination: regular active participation in the exercise according to Section 9 subsection 2 Examination Regulations for the Bachelor of Science.
Workload in the individual module components (in ECTS credits)	Lecture: Differential Equations for Earth System Physics (3 ECTS credits) Pracitcal course: Exercises for Differential Equations for Earth System Physics (3 ECTS credits)
Total module workload	6 ECTS credits
Module duration	1 semester
Module frequency	Annually, in summer semester

Module type Title Module code	Required module Statistics for Earth System Physics ESW-B-Stat
Learning outcomes	Students know and understand the basics of statistical evaluations in geophysics, oceanography and meteorology. They have an initial understanding of statistical methods and can apply them to simple examples,as well as a statistical and dynamic understanding of time series analysis.
Module content	Topics covered include: 1. Statistics and stochastics 2. Uncertainty, probability 3. Estimators, confidence intervals 4. Correlation, autocorrelation 5. Linear regression 6. Statistical tests 7. Time series 8. Autoregression processes Lecture material is presented using examples from geophysics, oceanography, and meteorology.
Type of course (given in number of credit hours per week)	Lecture: Statistics for Earth System Physics (3 credit hours per week) Practical course: Exercises for Statistics for Earth System Physics (2 credit hours per week) The practical course is subject to an attendance requirement pursuant to Section 5 subsections 1 and 2 Examination Regulations for the Bachelor of Science.
Language of instruction	English
Prerequisites	Mandatory: none Recommended: successful completion of the modules Mathematics 1, Mathematics 2 and Physics of the Earth System 1
Module applicability	The module is part of the following degree program(s)/profile(s): B.Sc. Earth System Physics
Module completion	Module examination: a practical examination, written examination, or term paper Examination language: English Prerequisite for the examination: regular active participation in the exercise according to Section 9 subsection 2 Examination Regulations for the Bachelor of Science.
Workload in the individual module components (in ECTS credits)	Lecture: Statistics for Earth System Physics (3 ECTS credits) Practical course: Exercises for Statistics for Earth System Physics (3 ECTS credits)
Total module workload	6 ECTS credits
Module duration	1 semester
Module frequency	Annually, in summer semester

Module type Title Module code	Required module Physics of the Earth System 1 ESW-B-PES1
Learning outcomes	Students who have successfully completed the module have an understanding of the structure and dynamics of the Earth system from a physical perspective. They are familiar with the structure of the solid earth, the ocean, and the atmosphere and the most important processes that make up their respective dynamics. They know the basic variables, forces, and measurement parameters. They have also acquired basic programming skills with Python using the Linux operating system, and can import and edit scientific data and output and visualize findings.
Module content	Introduction to the physics of the earth system: 1. Introduction to geophysical basics: structure and dynamics of the solid earth, plate tectonics, volcanism, environmental geophysics 2. Introduction to meteorological basics: structure and dynamics of the atmosphere—structure, concepts, and equations of motion 3. Introduction to oceanographic basics: structure and dynamics of the oceans—water masses, circulation, volume, and heat transport Introduction to programming with Python: 1. Computer infrastructure: Linux operating system, directories, files, commands 2. Programming concepts with Python: variables, data types, operations, arrays, branches and loops, control structures, formatted input and edition, data visualization The programming tasks use variables and examples from the Physics of the Earth System lecture.
Type of course (given in number of credit hours per week)	Lecture: Physics of the Earth System 1 (4 credit hours per week) Practical course: Introduction to Python Programming (2 credit hours per week) The practical course is subject to an attendance requirement pursuant to Section 5 subsections 1 and 2 Examination Regulations for the Bachelor of Science.
Language of instruction	English
Prerequisites	Mandatory: none Recommended: none
Module applicability	The module is part of the following degree program(s)/profile(s): B.Sc. Earth System Physics
Module completion	Module examination: term paper or take-home exam Examination language: English Prerequisite for the examination: regular active participation in the exercise according to Section 9 subsection 2 Examination Regulations for the Bachelor of Science.
Workload in the individual module components (in ECTS credits)	Lecture: Physics of the Earth System 1 (6 ECTS credits) Exercise: Introduction to Python Programming (4 ECTS credits)
Total module workload	10 ECTS credits
Module duration	1 semester
Module frequency	Annually, in winter semester

Module type Title Module code	Required module Physics of the Earth System 2 ESW-B-PES2
Learning outcomes	Students who have successfully completed the module have an understanding of the relationships between geophysical, oceanographic, and meteorological processes in the Earth system, including possible geohazards, and their interactions with the climate system. In addition, students have gained an overview of the common forms of academic work. They can derive and work on a scientific question and present the findings.
Module content	Introduction to the physical interactions in the earth system using the examples of geohazards and climate: 1. Geological hazards, geosystem monitoring, climate-relevant application 2. Earth system cycles and their interactions: Energy, atmosphere, water, carbon 3. Climate, sensitivity, feedback 4. Modeling Introduction to Academic Work: 1. Scientific knowledge process 2. Scientific writing and other forms of presentation 3. Project and time management 4. Evaluation/review process The processing of a scientific question is demonstrated using an example from the field of georisks or the climate system.
Type of course (given in number of credit hours per week)	Lecture: Physics of the Earth System 2 (4 credit hours per week) Lecture + practical course: Basics of Academic Research (2 credit hours per week) The practical course is subject to an attendance requirement pursuant to Section 5 subsections 1 and 2 Examination Regulations for the Bachelor of Science.
Language of instruction	English
Prerequisites	Mandatory: none Recommended: successful completion of the module Physics of the Earth System 1
Module applicability	The module is part of the following degree program(s)/profile(s): B.Sc. Earth System Physics
Module completion	Module examination: term paper or take-home exam Examination language: English Coursework: a presentation may be required as an academic achievement; this will be announced at the beginning of the course. Prerequisite for the examination: regular active participation in the exercise according to Section 9 subsection 2 Examination Regulations for the Bachelor of Science.
Workload in the individual module components (in ECTS credits)	Lecture: Physics of the Earth System 2 (6 ECTS credits) Lecture + practical course: Basics of Academic Research (4 ECTS credits)
Total module workload	10 ECTS credits

Module duration	1 semester
Module frequency	Annually, in summer semester

Module type Title Module code	Required module Physics of the Earth System—Practical Training ESW-B-PESPract
Learning outcomes	Students who have successfully completed the module are able to plan and carry out experiments in the field of earth system physics, guided by questions and hypotheses, and analyze and interpret the data obtained. They are familiar with basic concepts of experimental work, such as measurement uncertainty, error propagation and reproducibility, and can document their experimental work, including the evaluation, in a scientific experiment protocol.
Module content	1. Planning and conduct of laboratory experiments in a team 2. Automatic and manual recording of measurement data 3. Creating analysis scripts in Python 4. Use of dedicated measurement software 5. Evaluation of the measurements and answering the experimental question(s) 6. Preparation of an internship report
Type of course (given in number of credit hours per week)	Lecture: Accompanying Lecture for Physics of the Earth System Practical Training (1 credit hour per week) Practical course: Physics of the Earth System Practical Training (3 credit hour per week)
Language of instruction	English
Prerequisites	Mandatory: none Recommended: successful completion of the modules Physics of the Earth System 1, Physics of the Earth System 2
Module applicability	The module is part of the following degree program(s)/profile(s): B.Sc. Earth System Physics
Module completion	Module examination: completion of internship (pass/fail) Examination language: English Prerequisite for the examination: regular active participation in the internship according to Section 9 subsection 2 Examination Regulations for the Bachelor of Science.
Workload in the individual module components (in ECTS credits)	Lecture: Accompanying Lecture for Physics of the Earth System Practical Training (1.5 ECTS credits) Practical course: Physics of the Earth System Practical Training (4.5 ECTS credits)
Total module workload	6 ECTS credits
Module duration	1 semester
Module frequency	Annually, in winter semester

Module type Title Module code	Required module Foundations of Fluid Dynamics ESW-B-FluidDyn
Learning outcomes	Students who have successfully completed the module, students are familiar with the basics of working on fluid mechanics problems and are able to compile the relevant equations for simple fluid mechanics problems and to classify and describe the forces and parameters involved.
Module content	1. State variables and properties of fluids 2. Fluid statics 3. Methods of flow description 4. Conservation equations for fluids 5. Approximations of the equation of motion 6. Dimensional analysis 7. Similarity of flows
Type of course (given in number of credit hours per week)	Lecture: Foundations of Fluid Dynamics (3 credit hours per week) Practical course: Exercises for Foundations of Fluid Dynamics (1 credit hours per week) The practical course is subject to an attendance requirement pursuant to Section 5 subsections 1 and 2 Examination Regulations for the Bachelor of Science.
Language of instruction	English
Prerequisites	Mandatory: participation in the modules Mathematics 1, Mathematics 2, Physics 1 (Mechanics and Thermodynamics) and Physics 2 (Electrodynamics and Optics) Recommended: successful completion of the modules Mathematics 1, Mathematics 2, Physics 1 (Mechanics and Thermodynamics) and Physics 2 (Electrodynamics and Optics)
Module applicability	The module is part of the following degree program(s)/profile(s): B.Sc. Earth System Physics
Module completion	Module component examinations: Foundations of Fluid Dynamics lecture: written examination Exercises for Foundations of Fluid Dynamics practical course: practical examination Examination language: English Prerequisite for the examination: regular active participation in the exercise according to Section 9 subsection 2 Examination Regulations for the Bachelor of Science.
Workload in the individual module components (in ECTS credits)	Lecture: Foundations of Fluid Dynamics (4.5 ECTS credits) Practical course: Exercises for Foundations of Fluid Dynamics (1.5 ECTS credits)
Total module workload	6 ECTS credits
Module duration	1 semester
Module frequency	Annually, in winter semester

II.2 Module descriptions of the compulsory elective modules

Module type Title Module code	Required elective module Applied Geophysics ESW-B-AppGP
Learning outcomes	Students who have successfully completed the module know and understand the physical principles of applied geophysics with regard to the properties of the earth to be measured, as well as the respective measurement technology. They are able to plan and carry out simple measurements using the methods presented, and evaluate and interpret the measured data.
Module content	1. Seismic methods: Refraction seismics, reflection seismics, sediment echo sounder, multibeam 2. Non-seismic methods: Potential methods, gravimetry, direct current geoelectrics, electromagnetic induction methods, magnetics, ground penetrating radar, borehole geophysics
Type of course (given in number of credit hours per week)	Lecture: Seismic Methods (2 credit hours per week) Practical course: Exercises for Seismic Methods (1 credit hours per week) Lecture: Non-Seismic Methods (2 credit hours per week) Practical course: Exercises for Non-Seismic Methods (1 credit hour per week) An attendance requirement is stipulated for the exercises in accordance with the regulation on Section 5 subsections 1 and 2 Examination Regulations for the Bachelor of Science.
Language of instruction	English
Prerequisites	Mandatory: participation in the modules Mathematics 1, Mathematics 2, Physics 1 (Mechanics and Thermodynamics), Physics 2 (Electrodynamics and Optics) and Physics of the Earth System 1. Recommended: successful completion of the modules Mathematics 1, Mathematics 2, Physics 1 (Mechanics and Thermodynamics), Physics 2 (Electrodynamics and Optics) and Physics of the Earth System 1.
Module applicability	The module is part of the following degree program(s)/profile(s): B.Sc. Earth System Physics
Module completion	Module examination: written examination The examination is generally done in English Prerequisite for the examination: regular active participation in the exercise according to Section 9 subsection 2 Examination Regulations for the Bachelor of Science, and completion of the exercises
Workload in the individual module components (in ECTS credits)	Lecture: Seismic Methods (3 ECTS credits) Practical course: Exercises for Seismic Methods (1.5 ECTS credits) Lecture: Non-Seismic Methods (3 ECTS credits) Practical course: Exercises for Non-Seismic Methods (1.5 ECTS credits)
Total module workload	9 ECTS credits
Module duration	2 semester
Module frequency	Every semester Seismic Methods lecture: winter semester Exercises for Seismic Methods practical course: winter semester Non-Seismic Methods lecture: summer semester Exercises for Non-Seismic Methods practical course: summer semester

Module type Title Module code	Required elective module Geophysics Practical Training ESW-B-GPPract
Learning outcomes	Students who have successfully completed the module are able to operate geophysical measuring equipment independently and apply geophysical measuring methods independently. They can independently collect and evaluate measurement data. They are able to plan field experiments for given questions themselves, carry out the measurements, and record them in an appropriate manner. They can interpret their own measurement data and are able to plan, conduct, and evaluate geophysical measurements for engineering offices in practice.
Module content	Geodesy (surveying), gravimetry, magnetics, Direct current geoelectrics, georadar, model seismics, field seismics.
Type of course (given in number of credit hours per week)	Seminar: Accompanying Seminar for Geophysics Practical Training (1 credit hour per week) Internship: Geophysics Practical Training (3 credit hours per week)
Language of instruction	English
Prerequisites	Mandatory: participation in the Applied Geophysics module Recommended: successful completion of the Applied Geophysics module
Module applicability	The module is part of the following degree program(s)/profile(s): B.Sc. Earth System Physics
Module completion	Module examination: completion of internship (pass/fail) The examination is generally done in English Prerequisite for the examination: regular active participation in the internship according to Section 9 subsection 2 Examination Regulations for the Bachelor of Science.
Workload in the individual module components (in ECTS credits)	Seminar: Accompanying Seminar for Geophysics Practical Training (1.5 ECTS credits) Internship: Geophysics Practical Training (4.5 ECTS credits)
Total module workload	6 ECTS credits
Module duration	1 semester
Module frequency	Annually, in summer semester

Module type Title Module code	Required elective module Machine Learning in Physical Earth System Sciences ESW-B-ML
Learning outcomes	Students who have successfully completed the module have acquired an overview of the methods of machine learning, including theory and specific applications for Earth System Sciences. They can apply various machine learning techniques to geoscientific problems using programs they have written themselves, and are familiar with various open source frameworks for machine learning. They are able to qualitatively and quantitatively evaluate the performance of their implemented algorithms.
Module content	Objects and their properties, unsupervised learning strategies, supervised learning strategies, metrics for evaluating the performance of the various algorithms.
Type of course (given in number of credit hours per week)	Lecture: Machine Learning in Physical Earth System Sciences (2 credit hours per week) Practical course: Exercises for Machine Learning in Physical Earth System Sciences (2 credit hours per week) The practical course is subject to an attendance requirement pursuant to Section 5 subsections 1 and 2 Examination Regulations for the Bachelor of Science.
Language of instruction	English
Prerequisites	Mandatory: successful completion of the module Physics of the Earth System 1; participation in the module Statistics for Earth System Physics Recommended: successful completion of the module Statistics for Earth System Physics
Module applicability	The module is part of the following degree program(s)/profile(s): B.Sc. Earth System Physics
Module completion	Module examination: Term paper The examination is generally done in English Prerequisite for the examination: regular participation in the exercise according to Section 9 subsection 2 Examination Regulations for the Bachelor of Science, and completion of the exercises
Workload in the individual module components (in ECTS credits)	Lecture: Machine Learning in Physical Earth System Sciences (3 ECTS credits) Practical course: Exercises for Machine Learning in Physical Earth System Sciences (3 ECTS credits)
Total module workload	6 ECTS credits
Module duration	1 semester
Module frequency	Annually, in winter semester

Module type Title Module code	Required elective module Geodynamics and Volcanology ESW-B-GV
Learning outcomes	Students who have successfully completed the module have a basic knowledge of large-scale dynamic processes in the solid earth system. They have an understanding of the Earth as a heat engine, and gained knowledge of the general structure of the solid Earth and the basic principles of volcanic activity.
Module content	This module introduces students to dynamic processes in the solid earth. After qualitative presentation of the relevant processes in the solid earth system, the module addresses heat transport in the Earth system, large-scale tectonic processes (underpinned with mathematical models), and establishes links to geothermal energy. Finally, the dynamic processes in the earth are explored to illuminate volcanic activity and derive simple physical models.
Type of course (given in number of credit hours per week)	Lecture: Geodynamics and Vulcanology (3 credit hours per week) Practical course: Exercises for Geodynamics and Vulcanology (1 credit hour per week) The practical course is subject to an attendance requirement pursuant to Section 5 subsections 1 and 2 Examination Regulations for the Bachelor of Science.
Language of instruction	English
Prerequisites	Mandatory: participation in the modules Mathematics 1, Mathematics 2, Physics 1 (Mechanics and Thermodynamics), Physics 2 (Electrodynamics and Optics) and Physics of the Earth System 1 Recommended: successful completion of the modules Mathematics 1, Mathematics 2, Physics 1 (Mechanics and Thermodynamics), Physics 2 (Electrodynamics and Optics) and Physics of the Earth System 1
Module applicability	The module is part of the following degree program(s)/profile(s): B.Sc. Earth System Physics
Module completion	Module examination: written examination The examination is generally done in English Prerequisite for the examination: regular participation in the exercise according to Section 9 subsection 2 Examination Regulations for the Bachelor of Science, and completion of the exercises
Workload in the individual module components (in ECTS credits)	Lecture: Geodynamics and Vulcanology (4.5 ECTS credits) Practical course: Exercises for Geodynamics and Vulcanology (1.5 ECTS credits)
Total module workload	6 ECTS credits
Module duration	1 semester
Module frequency	Annually, in summer semester

Module type Title Module code	Required elective module Data Processing and Geophysical Model Building ESW-B-DPGM
Learning outcomes	Students who have successfully completed the module are able to develop initial evaluations of data which form the basis of simple geophysical models that identify the essential physical processes that explain the data.
Module content	Data processing and geophysical modeling using three different data examples from geophysics, one from the field of potential methods, one from the field of seismology/seismics, and one from the field of geodynamics.
Type of course (given in number of credit hours per week)	Lecture: Data Processing and Geophysical Model Building (1 credit hour per week) Practical course: Exercises for Data Processing and Geophysical Model Building (3 credit hours per week) The practical course is subject to an attendance requirement pursuant to Section 5 subsections 1 and 2 Examination Regulations for the Bachelor of Science.
Language of instruction	English
Prerequisites	Mandatory: participation in the modules Mathematics 1, Mathematics 2, Numerics for Earth System Physics, Physics 1 (Mechanics and Thermodynamics), Physics 2 (Electrodynamics and Optics) and Physics of the Earth System 1 Recommended: successful completion of the modules Mathematics 1, Mathematics 2, Numerics for Earth System Physics, Physics 1 (Mechanics and Thermodynamics), Physics 2 (Electrodynamics and Optics), Physics of the Earth System 1, Applied Geophysics, Geodynamics and Volcanology
Module applicability	The module is part of the following degree program(s)/profile(s): B.Sc. Earth System Physics
Module completion	Module examination: practical examination or term paper The examination is generally done in English Prerequisite for the examination: regular participation in the exercises according to Section 9 subsection 2 Examination Regulations for the Bachelor of Science and completion of the exercises.
Workload in the individual module components (in ECTS credits)	Lecture: Data Processing and Geophysical Model Building (1.5 ECTS credits) Practical course: Exercises for Data Processing and Geophysical Model Building (4.5 ECTS credits)
Total module workload	6 ECTS credits
Module duration	1 semester
Module frequency	Annually, in winter semester

Module type Title Module code	Required elective module Geophysical Geohazard Research ESW-B-Geohaz
Learning outcomes	Students who have successfully completed the module know and understand the basics of geophysical geohazard research in theory and practice. They have basic knowledge sufficient to process selected geophysical data and interpret it with regard to the relevant Earth processes.
Module content	Geological background of geohazards due to volcanism, landslides, tsunamis, or earthquakes. Processing of selected geophysical data with a focus on seismics, seismology, or ground penetrating radar.
Type of course (given in number of credit hours per week)	Lecture: Geophysical Geohazard Research (2 credit hours per week) Practical course: Exercises for Geophysical Geohazard Research (2 credit hours per week) The practical course is subject to an attendance requirement pursuant to Section 5 subsections 1 and 2 Examination Regulations for the Bachelor of Science.
Language of instruction	English
Prerequisites	Mandatory: participation in the Applied Geophysics module Recommended: successful completion of the Applied Geophysics module
Module applicability	The module is part of the following degree program(s)/profile(s): B.Sc. Earth System Physics
Module completion	Module examination: written examination The examination is generally done in English Prerequisite for the examination: regular participation in the exercises according to Section 9 subsection 2 Examination Regulations for the Bachelor of Science and completion of the exercises.
Workload in the individual module components (in ECTS credits)	Lecture: Geophysical Geohazard Research (3 ECTS credits) Practical course: Exercises for Geophysical Geohazard Research (3 ECTS credits)
Total module workload	6 ECTS credits
Module duration	1 semester
Module frequency	Annually, in summer semester

Module type Title Module code	Required elective module Seismology and Earthquakes ESW-B-SEQ
Learning outcomes	Students who have successfully completed the module have learned the basics of travel-time seismology, are familiar with methods of analysis and evaluation for structural and focal investigations and are able to apply them. They are equally familiar with handling seismological travel-time data as creating velocity models from travel-time data. They can classify seismic 3D tomography. They are familiar with array methods and can use them to localize earthquakes and other seismic sources.
Module content	Propagation of elastic waves, seismic rays, through the earth, ray parameters, global travel-time curves and phases, determination of structures in the subsurface and tomography, sources and localization of earthquakes.
Type of course (given in number of credit hours per week)	Lecture: Seismology and Earthquakes (3 credit hours per week) Practical course: Exercises for Seismology and Earthquakes (1 credit hour per week) The practical course is subject to an attendance requirement pursuant to Section 5 subsections 1 and 2 Examination Regulations for the Bachelor of Science.
Language of instruction	English
Prerequisites	Mandatory: Participation in the modules Mathematics 1, Mathematics 2, Physics 1 (Mechanics and Thermodynamics), Physics 2 (Electrodynamics and Optics) and Physics of the Earth System 1 Recommended: successful completion of the modules Mathematics 1, Mathematics 2, Physics 1 (Mechanics and Thermodynamics), Physics 2 (Electrodynamics and Optics) and Physics of the Earth System 1
Module applicability	The module is part of the following degree program(s)/profile(s): B.Sc. Earth System Physics
Module completion	Module examination: written examination The examination is generally done in English Prerequisite for the examination: regular active participation in the exercises according to Section 9 subsection 2 Examination Regulations for the Bachelor of Science, and completion of the exercises
Workload in the individual module components (in ECTS credits)	Lecture: Seismology and Earthquakes (4.5 ECTS credits) Practical course: Exercises for Seismology and Earthquakes (1.5 ECTS credits)
Total module workload	6 ECTS credits
Module duration	1 semester
Module frequency	Annually, in winter semester

Module type Title Module code	**Required elective module** **Fundamentals of Physical Oceanography** **ESW-B-PhysOcean**
Learning outcomes	Students who have successfully completed the module understand the basic structure of the oceans, including their stratification and circulation, and the underlying dynamic processes. They are also familiar with oceanic investigation methods, measured variables, the principles of measuring instruments and basic evaluation techniques, and have an up-to-date overview of the subject.
Module content	Basic content includes: water mass analysis, influence of the Earth's rotation on dynamic processes (e.g. Ekman dynamics, geostrophy), wind-driven and thermohaline ocean circulation, effect of the atmosphere on the ocean, oceanic fronts, heat and radiation balance of the Earth
Type of course (given in number of credit hours per week)	Lecture: Fundamentals of Physical Oceanography (2 credit hours per week) Practical course: Exercises for Fundamentals of Physical Oceanography (2 credit hours per week) The practical course is subject to an attendance requirement pursuant to Section 5 subsections 1 and 2 Examination Regulations for the Bachelor of Science.
Language of instruction	English
Prerequisites	Mandatory: participation in the modules Physics 1 (Mechanics and Thermodynamics), Physics 2 (Electrodynamics and Optics), Physics of the Earth System 1 and Physics of the Earth System 2 Recommended: none
Module applicability	The module is part of the following degree program(s)/profile(s): B.Sc. Earth System Physics
Module completion	Module examination: written examination Examination language: English Prerequisite for the examination: regular active participation in the exercise according to Section 9 subsection 2 Examination Regulations for the Bachelor of Science and completion of the exercises.
Workload in the individual module components (in ECTS credits)	Lecture: Fundamentals of Physical Oceanography (3 ECTS credits) Practical course: Exercises for Fundamentals of Physical Oceanography (3 ECTS credits)
Total module workload	6 ECTS credits
Module duration	1 semester
Module frequency	Annually, in winter semester

Module type Title Module code	Required elective module Coastal and Shelf Sea Oceanography ESW-B-CoastShelf
Learning outcomes	Students who have successfully completed the module know the basic structure of shelf and marginal seas in terms of stratification and circulation, and understand the essential underlying dynamics.
Module content	Comparative analysis of the coastal shelf regions and marginal seas.Hydrography of arid and humid marginal seas; interactions with land and atmosphere; tides; mixing in boundary layers; wind- and thermohaline-driven circulation; exchange processes of surface and bottom water through passages; hydraulic control; front formation; upwelling areas; water mass analysis; typification of estuaries, sediment and suspended sediment transport, wave dynamics at coasts, erosion, sedimentation.
Type of course (given in number of credit hours per week)	Lecture: Coastal and Shelf Sea Oceanography (2 credit hours per week)
Language of instruction	English
Prerequisites	Mandatory: participation in the modules Physics of the Earth System 1 and Physics of the Earth System 2 Recommended: parallel participation in the Fundamentals of Physical Oceanography module
Module applicability	The module is part of the following degree program(s)/profile(s): B.Sc. Earth System Physics
Module completion	Module examination: presentation or written examination Examination language: English
Workload in the individual module components (in ECTS credits)	Lecture: Coastal and Shelf Sea Oceanography (3 ECTS credits)
Total module workload	3 ECTS credits
Module duration	1 semester
Module frequency	Annually, in winter semester

Module type Title Module code	Required elective module Ocean and Ice in the Climate System ESW-B-OceanIce
Learning outcomes	Students have knowledge of climate-relevant oceanic processes and phenomena (ocean-atmosphere interactions at high latitudes, the role of the cold water sphere). They have an overview of the variability of the ocean on interannual and decadal time scales.
Module content	Earth's radiation balance; hydrological cycle, heat and material cycles; climate-relevant processes; role of ocean circulation in climate; ocean as a heat reservoir, sea level rise; role of sea ice; fluctuations in ocean circulation and the Earth's climate with time scales of several years to several thousand years; El Nino, North Atlantic Oscillation; Dansgaard-Oeschger cycles; simple climate models.
Type of course (given in number of credit hours per week)	Lecture: Role of the Ocean and Ice in the Climate System (2 credit hours per week) Practical course: Exercises for Ocean and Ice in the Climate System (2 credit hours per week) The practical course is subject to an attendance requirement pursuant to Section 5 subsections 1 and 2 Examination Regulations for the Bachelor of Science.
Language of instruction	English
Prerequisites	Mandatory: participation in the modules Physics of the Earth System 1 and Physics of the Earth System 2 Recommended: none
Module applicability	The module is part of the following degree program(s)/profile(s): B.Sc. Earth System Physics
Module completion	Module examination: Term paper Examination language: English Prerequisite for the examination: regular active participation in the exercise according to Section 9 subsection 2 Examination Regulations for the Bachelor of Science.
Workload in the individual module components (in ECTS credits)	Lecture: Role of the Ocean and Ice in the Climate System (3 ECTS credits) Practical course: Exercises for Ocean and Ice in the Climate System (3 ECTS credits)
3 ECTS credits	6 ECTS credits
Module duration	1 semester
Module frequency	Annually, in summer semester

Module type Title Module code	Required elective module Oceanographic Field Work ESW-B-OceanField
Learning outcomes	Students who have successfully completed the module are able to use oceanographic measuring instruments and apply the methods independently. They can independently collect and analyze their own measurement data. Students are able to plan field experiments for given research questions, carry out the measurements, and document them in an appropriate manner (online logbook). Students can process and analyze standard measurement data from a sea voyage. They are able to present the findings in a report and communicate them in a presentation.
Module content	During a group practical exercise, taken on a trip at sea, students collect samples and data to describe the physical oceanography with additional auxiliary measurements (from chemistry, biology or meteorology) if necessary. Working in teams, they take on different roles, use different oceanographic equipment, and gain experience planning and carrying out marine fieldwork. The preparatory seminar serves for planning the trip, learning how to handle the devices, and introducing processing and analytical software. The students work with software specialized for oceanographic measuring devices and process the measurement data collected during the trip. Data is analyzed in a short scientific report and compared with selected publications in the subject area.
Type of course (given in number of credit hours per week)	Seminar: Preparation Seminar for Oceanographic Field Work (1 credit hour per week) Group practical exercises: Oceanographic Field Work (3 credit hours per week) Seminar: Analysis of Oceanographic Field Work Data (4 credit hours per week)
Language of instruction	English
Prerequisites	Mandatory: participation in the modules Physics of the Earth System 1 and Physics of the Earth System 2 Recommended: successful completion of the module Fundamentals of Physical Oceanography
Module applicability	The module is part of the following degree program(s)/profile(s): B.Sc. Earth System Physics
Module completion	Partial module examinations (pass/fail): completion of the practical group exercise Oceanographic Field Work Prerequisite for the examination: regular active participation in the practical group exercise according to Section 9 subsection 2 Examination Regulations for the Bachelor of Science. Analysis of Oceanographic Field Work Data seminar: term paper Prerequisite for the examination: regular active participation in the seminar according to Section 9 subsection 2 Examination Regulations for the Bachelor of Science and presentation during the seminar Examination language: English
Workload in the individual module components (in ECTS credits)	Seminar: Preparation Seminar for Oceanographic Field Work (1.5 ECTS credits) Practical group exerises: Oceanographic Field Work (4.5 ECTS credits) Seminar: Analysis of Oceanographic Field Work Data (6 ECTS credits)

3 ECTS credits	12 ECTS credits
Module duration	2 semester
Module frequency	Annually, starting in the summer semester Preparation Seminar for Oceanographic Field Work seminar: summer semester Oceanographic Field Work group practical exercise: summer semester Analysis of Oceanographic Field Work Data seminar: winter semester

Module type Title Module code	Required elective module Fundamentals of Dynamical Oceanography ESW-B-DynOcean
Learning outcomes	After successfully completing this module, students will have acquired in-depth knowledge of fluid dynamics for unstratified and stratified fluids in a rotating system. They have dealt in depth with the methods of theoretical oceanography (scaling, linearization, approximations).
Module content	Phenomenology of dynamic processes in the ocean and their mathematical description. Topics include: Large-scale circulation and mixing, dynamic instabilities (barotropic and baroclinic), waves, eddies, vortex shedding, internal waves, jets, topographic effects, boundary currents, intrusions, bottom-driven density currents, convection.
Type of course (given in number of credit hours per week)	Lecture: Fundamentals of Dynamical Oceanography (2 credit hours per week) Practical course: Exercises for Fundamentals of Dynamical Oceanography (2 credit hours per week) The practical course is subject to an attendance requirement pursuant to Section 5 subsections 1 and 2 Examination Regulations for the Bachelor of Science.
Language of instruction	English
Prerequisites	Mandatory: participation in the modules Mathematics 1, Mathematics 2, Numerics for Earth System Physics, Differential Equations for Earth System Physics and Fundamentals of Fluid Dynamics Recommended: none
Module applicability	The module is part of the following degree program(s)/profile(s): B.Sc. Earth System Physics
Module completion	Module examination: written examination Examination language: English Prerequisite for the examination: regular active participation in the exercise according to Section 9 subsection 2 Examination Regulations for the Bachelor of Science.
Workload in the individual module components (in ECTS credits)	Lecture: Fundamentals of Dynamical Oceanography (3 ECTS credits) Practical course: Exercises for Fundamentals of Dynamical Oceanography (3 ECTS credits)
Total module workload	6 ECTS credits
Module duration	1 semester
Module frequency	Annually, in winter semester

Module type Title Module code	Required elective module Ocean Modeling ESW-B-OceanMod
Learning outcomes	Students who have successfully completed the module have mastered various methods and procedures of modeling in marine science and their application to selected case studies. Students are able to create their own model codes and apply or modify existing modules.
Module content	Topics include: 1. Various types of prognostic and diagnostic partial differential equations and the treatment of initial and boundary value problems 2. Finite difference methods (explicit and implicit) and their stability analysis 3. Direct and iterative solution of linear systems of equations 4. Multi-grid processes 5. Solving non-linear systems of equations 6. Structured and unstructured grids, grid dispersion, as well as discretizations and numerical diffusion 7. Critical analysis of model results with knowledge of potential sources of error 8. Parallelization of programs where possible, model codes are compared with analytical solutions.
Type of course (given in number of credit hours per week)	Lecture: Ocean Modeling 2 credit hours per week) Practical course: Exercises for Ocean Modeling (2 credit hours per week) The practical course is subject to an attendance requirement pursuant to Section 5 subsections 1 and 2 Examination Regulations for the Bachelor of Science.
Language of instruction	English
Prerequisites	Mandatory: successful completion of the modules Mathematics 1, Mathematics 2, Numerics for Earth System Physics, Differential Equations for Earth System Physics and Physics of the Earth System 1 Recommended: successful completion of the Fundamentals of Dynamic Oceanography module and knowledge of a higher programming language, e.g. Python, Fortran or C and Matlab
Module applicability	The module is part of the following degree program(s)/profile(s): B.Sc. Earth System Physics
Module completion	Module examination: Term paper Examination language: English Prerequisite for the examination: regular active participation in the exercise according to Section 9 subsection 2 Examination Regulations for the Bachelor of Science.
Workload in the individual module components (in ECTS credits)	Lecture: Ocean Modeling (3 ECTS credits) Practical course: Exercises for Ocean Modeling (3 ECTS credits)
Total module workload	6 ECTS credits
Module duration	1 semester
Module frequency	Annually, in summer semester

Module type	**Required elective module**
Title	**The Cryosphere**
Module code	**ESW-B-Cryo**
Learning outcomes	Students who have successfully completed the module are able to physically understand cryospheric processes in the Earth system, simulate them in the form of simple numerical models, classify the role of interactions, understand relevant specialist publications and carry out basic laboratory experiments on freezing and melting.
Module content	Freezing and melting; cryosphere in the Earth system; snow; glaciers; ice sheets; sea ice; permafrost; ice clouds; cryosphere in climate change
Type of course (given in number of credit hours per week)	Lecture: The Cryosphere (2 credit hours per week) Practical course: Exercises for The Cryosphere (2 credit hours per week) The practical course is subject to an attendance requirement pursuant to Section 5 subsections 1 and 2 Examination Regulations for the Bachelor of Science.
Language of instruction	English
Prerequisites	Mandatory: none Recommended: participation in the modules Mathematics 1, Mathematics 2, Physics 1 (Mechanics and Thermodynamics), Physics 2 (Electrodynamics and Optics), Physics of the Earth System 1
Module applicability	The module is part of the following degree program(s)/profile(s): B.Sc. Earth System Physics
Module completion	Module examination: Term paper Examination language: English Prerequisite for the examination: regular active participation in the exercise according to Section 9 subsection 2 Examination Regulations for the Bachelor of Science.
Workload in the individual module components (in ECTS credits)	Lecture: The Cryosphere (3 ECTS credits) Practical course: Exercises for The Cryosphere (3 ECTS credits)
Total module workload	6 ECTS credits
Module duration	1 semester
Module frequency	Annually, in winter semester

Module type **Title** **Module code**	**Required elective module** **Atmospheric Thermodynamics** **ESW-B-AtmoTherm**
Learning outcomes	Students who have successfully completed the module have an overview of classical and atmospheric thermodynamics. They have mastered the concepts of thermal equilibrium, internal energy, heat and entropy, which are necessary to describe the observed natural processes. Students are able to derive and apply equations of state for air, water, and their mixtures in order to describe relevant atmospheric variables, atmospheric processes, and the static stability of the atmosphere. They understand non-equilibrium thermodynamics and transport phenomena and know equilibrium equations to describe atmospheric dynamics.
Module content	1. Zeroth law: the concept of temperature 2. First law: the conservation of energy 3. Second law: the increase in entropy 4. Variable composition and phase equilibrium 5. Water in the atmosphere 6. Atmospheric processes 7. Static stability of the atmosphere 8. Non-equilibrium thermodynamics 9. Equilibrium equations 10. Transportation phenomena
Type of course (given in number of credit hours per week)	Lecture: Atmospheric Thermodynamics (2 credit hours per week) Practical course: Exercises for Atmospheric Thermodynamics (2 credit hours per week) The practical course is subject to an attendance requirement pursuant to Section 5 subsections 1 and 2 Examination Regulations for the Bachelor of Science.
Language of instruction	English
Prerequisites	Mandatory: none Recommended: none
Module applicability	The module is part of the following degree program(s)/profile(s): 1. B.Sc. Earth System Physics 2. B.Sc. Meteorology
Module completion	Module examination: oral examinations Examination language: English Prerequisite for the examination: regular active participation in the exercise according to Section 9 subsection 2 Examination Regulations for the Bachelor of Science.
Workload in the individual module components (in ECTS credits)	Lecture: Atmospheric Thermodynamics (3 ECTS credits) Practical course: Exercises for Atmospheric Thermodynamics (3 ECTS credits)
Total module workload	6 ECTS credits
Module duration	1 semester
Module frequency	Winter semester

Module type Title Module code	Required elective module Atmospheric measurements ESW-B-AtmoMess
Learning outcomes	Students have an overview of instruments and measurement methods used operationally for atmospheric measurements, and know their physical operating principles. This enables them to evaluate the possible applications and interpret measurements scientifically, including their uncertainties and representativeness.
Module content	The course first introduces classical and modern measurement methods for basic meteorological variables such as temperature, humidity, and wind. This serves as a basis for the presentation of the profiling of the atmosphere with in-situ measurements and remote sensing,including a focus on ground-based active remote sensing using radar, lidar, and sodar, concluding with a discussion of airborne and satellite-based remote sensing, especially of clouds.
Type of course (given in number of credit hours per week)	Lecture: Atmospheric Measurements (2 credit hours per week)
Language of instruction	German
Prerequisites	Mandatory: none Recommended: none
Module applicability	The module is part of the following degree program(s)/profile(s): 1. B.Sc. Earth System Physics 2. B.Sc. Meteorology
Module completion	Module examination: exercise completion (pass/fail) Examination language: German
Workload in the individual module components (in ECTS credits)	Lecture: Atmospheric Measurements (3 ECTS credits)
Total module workload	3 ECTS credits
Module duration	1 semester
Module frequency	Winter semester

Module type Title Module code	Required elective module Synoptics ESW-B-Syn
Learning outcomes	The course teaches the basic contents of synoptic meteorology in the synopsis of meteorological phenomena in their spatial distribution, and temporal change with the aim of weather analysis and weather forecasting. Students gain insight into the methods that lead from analyzing the current state of the atmosphere to weather forecasting, and knowledge of the dynamics and interaction of weather-related processes. The course is designed to enable students to interpret the diversity of representations of the predicted three-dimensional state of the atmosphere. Particular attention is paid to the question of which weather-determining and weather-changing processes come into effect in different synoptic constellations. The weather briefing practical exercise examines how theoretical concepts are applied in the real atmosphere.
Module content	1. Analysis products: ground weather maps, altitude weather maps 2. Uplift as a driver for weather changes 3. General circulation 4. Jet streams/Rossby waves 5. Fronts/frontogenesis 6. Medium-width printing formations: high, ideal cyclone, Shapiro-Keyser cyclone, polar low 7. Cyclogenesis from the perspective of quasigeostrophic theory: omega equation and the processes involved 8. Cyclogenesis through preservation of isentropic potential vorticity (leeward cyclogenesis, dry intrusion), shear vorticity, vergences on jet streaks 9. Vorticty equation 10. Boundary layer processes 11. TEMPs and their general role in short-term forecasting 12. Forecasting convection and thunderstorms using TEMP analysis
Type of course (given in number of credit hours per week)	Lecture: Synoptics (2 credit hours per week) Practical course: Exercises in Synoptics I (1 credit hour per week) Practical course: Exercises in Synoptics II (1 credit hour per week) Seminar: Seminar on Synoptics (1 credit hour per week) The practical course is subject to an attendance requirement pursuant to Section 5 subsections 1 and 2 Examination Regulations for the Bachelor of Science.
Language of instruction	German
Prerequisites	Mandatory: none Recommended: participation in the modules Introduction to Meteorology I and Introduction to Meteorology II or Physics of the Earth System 1 and Physics of the Earth System 2
Module applicability	The module is part of the following degree program(s)/profile(s): 1. B.Sc. Meteorology 2. Earth System Physics
Module completion	Module component examinations: Synoptics, Exercises in Synoptics I and Exercises in Synoptics II lecture:written exam (graded) Seminar on synoptics: presentation (pass/fail) Prerequisite for the examination: regular active participation in the exercise according to Section 9 subsection 2 Examination Regulations for the Bachelor of Science.

Workload in the individual module components (in ECTS credits)	Lecture: Synoptics (2 ECTS credits) Practical course: Exercises in Synoptics I (1 ECTS credits) Practical course: Exercises in Synoptics II (1 ECTS credits) Seminar on synoptics (2 ECTS credits)
Total module workload	6 ECTS credits
Module duration	2 semesters
Module frequency	Annually, starting in the winter semester Synoptics lecture: winter semester Exercises in Synoptics I practical course: winter semester Exercises in Synoptics II practical course: summer semester Seminar on synoptics: summer semester

Module type Title Module code	Required elective module Dynamics of Weather and Climate ESW-B-DynWeather
Learning outcomes	Students who have successfully completed the module have systematically acquired knowledge of equations and concepts and their use to understand synoptic weather and climate processes on time scales ranging from a few days to decades, in increasing complexity. Students know the simplifications of primitive equations that describe large-scale circulation fluctuations with a focus on the extratropics and develop the ability to apply the theory to interpret observations and model simulations.
Module content	1. Primitive equations of atmospheric movements on a large scale in the pressure system 2. Vorticity equation and its simplification for synoptic scales 3. Barotropic Rossby waves and potential Rossby vorticity 4. Quasi-geostrophic approximations 5. Baroclinic instability and energy conversions 6. Equations for the zonally averaged circulation, concept of momentum fluxes 7. Large-scale circulation cells: perspective of the power function
Type of course (given in number of credit hours per week)	Lecture: Dynamics of Weather and Climate (2 credit hour per week) Practical course: Exercises for Dynamics of Weather and Climate (2 credit hour per week) The practical course is subject to an attendance requirement pursuant to Section 5 subsections 1 and 2 Examination Regulations for the Bachelor of Science.
Language of instruction	English
Prerequisites	Mandatory: none Recommended: none
Module applicability	The module is part of the following degree program(s)/profile(s): 1. B.Sc. Earth System Physics 2. B.Sc. Meteorology
Module completion	Module examination: written examination Examination language: English Prerequisite for the examination: regular active participation in the exercise according to Section 9 subsection 2 Examination Regulations for the Bachelor of Science.
Workload in the individual module components (in ECTS credits)	Lecture: Dynamics of Weather and Climate (3 ECTS credits) Practical course: Exercises for Dynamics of Weather and Climate (3 ECTS credits)
Total module workload	6 ECTS credits
Module duration	1 semesters
Module frequency	Summer semester

Module type Title Module code	Required elective module Weather Forecasting and Modeling ESW-B Forecast
Learning outcomes	On completion of the module, students will have acquired basic knowledge of numerical weather prediction. The module focuses on basic physical concepts and components of weather forecasting in operational weather services such as DWD and ECMWF, as well as on the use of forecast products. The module provides a basic understanding of how prognostic equations learned in other courses become weather maps.
Module content	Components of numerical weather prediction (NWP) process as an initial value problem. Concept and historical development of the "First Guess". Statistical principles of data assimilation: least squares estimation and function fitting. The concept of covariances and correlations and application to surface observations and probe time series. Statistical interpolation. Examples with some observations and with Lorenz models. Continuous data assimilation in the satellite age: Overview of the modern NWP. Analysis and reanalysis data sets and their downscaling. Prediction without physical equations: machine learning. The use of weather forecasts in the energy sector.
Type of course (given in number of credit hours per week)	Lecture: Weather Forecasting and Modeling (2 credit hours per week)
Language of instruction	English
Prerequisites	Mandatory: none Recommended: none
Module applicability	The module is part of the following degree program(s)/profile(s): 1. B.Sc. Meteorology 2. Earth System Physics
Module completion	Module examination: Practical examination Examination language: English
Workload in the individual module components (in ECTS credits)	Lecture: Weather Forecasting and Modeling (3 ECTS credits)
Total module workload	3 ECTS credits
Module duration	1 semesters
Module frequency	Summer semester

Module type Title Module code	Required elective module Air Chemistry ESW-B-AirChem
Learning outcomes	After completing the module, students will have detailed knowledge in the field of atmospheric chemistry. They know the trace substances and material cycles occurring in the atmosphere and have understood ozone chemistry.
Module content	The introduction to atmospheric chemistry includes an introduction to the basics of general chemistry and a study of chemical trace substances in the atmosphere. In particular, the atmospheric lifetime, toxicological environmental relevance and radiation effectiveness of trace substances are discussed. An introduction to the general kinetics of chemical reactions is followed by an explanation of ozone formation in the stratosphere and the troposphere. This includes discussion of annually recurring ozone depletion in the stratosphere at the beginning of the Antarctic spring (“hole in the ozone layer”) and the formation of summer smog in the presence of nitrogen oxides, carbon monoxide, and volatile organic compounds.
Type of course (given in number of credit hours per week)	Lecture + practical course: Air Chemistry (2 credit hours per week)
Language of instruction	English
Prerequisites	Mandatory: none Recommended: none
Module applicability	The module is part of the following degree program(s)/profile(s): 1. B.Sc. Meteorology 2. Earth System Physics
Module completion	Module examination: written examination Examination language: English
Workload in the individual module components (in ECTS credits)	Lecture + practical course: Air Chemistry (3 ECTS credits)
Total module workload	3 ECTS credits
Module duration	1 semesters
Module frequency	Winter semester

Module type Title Module code	Required elective module Cloud Physics ESW-B-CloudPhys
Learning outcomes	Students have an overview of the sources and sinks of different types of atmospheric aerosols. They understand the basic mechanisms of cloud and fog formation and, based on this, can recognize, understand and classify observed clouds. Students have learned methods for describing the equilibrium of aerosol and cloud droplets as a function of ambient humidity. They know approaches to describe the size and mass growth of hydrometeors in clouds at different levels of complexity, and mechanisms of precipitation formation. They are able to apply the concepts learned to develop parametric approaches to describe clouds and precipitation in regional and global circulation models.
Module content	The class introduces the physics of aerosol particles and clouds, with a focus on microphysics, i.e., how droplets and ice crystals form from water vapor, how they then grow and finally fall to earth as precipitation. The structure of the lecture is based on the life cycle of the particles: from aerosols to nucleation problems, then on to growth from the vapor phase and finally to mechanisms of precipitation formation. Separate chapters are devoted to the topic of ice particles and clouds in circulation models.
Type of course (given in number of credit hours per week)	Lecture: Cloud Physics (2 credit hours per week) Practical course: Exercises for Cloud Physics (2 credit hours per week) The practical course is subject to an attendance requirement pursuant to Section 5 subsections 1 and 2 Examination Regulations for the Bachelor of Science.
Language of instruction	English
Prerequisites	Mandatory: none Recommended: none
Module applicability	The module is part of the following degree program(s)/profile(s): 1. B.Sc. Earth System Physics 2. B.Sc. Meteorology
Module completion	Module examination: oral examinations Examination language: English Prerequisite for the examination: regular active participation in the exercise according to Section 9 subsection 2 Examination Regulations for the Bachelor of Science.
Workload in the individual module components (in ECTS credits)	Lecture: Cloud Physics (3 ECTS credits) Practical course: Exercises for Cloud Physics (3 ECTS credits)
Total module workload	6 ECTS credits
Module duration	1 semesters
Module frequency	Winter semester

Module type Title Module code	**Required elective module** **Environmental Meteorology** **ESW-B-EnvMet**
Learning outcomes	Students have essential basic knowledge in core areas of environmental meteorology, which enables them to conduct assessments in the fields of pollutant dispersion, renewable energies or urban planning.
Module content	1. Dispersion calculation 2. Urban climatology 3. Energy meteorology
Type of course (given in number of credit hours per week)	Lecture: Environmental Meteorology (2 credit hours per week) Practical course: Exercises for Environmental Meteorology (2 credit hours per week) The practical course is subject to an attendance requirement pursuant to Section 5 subsections 1 and 2 Examination Regulations for the Bachelor of Science.
Language of instruction	English
Prerequisites	Mandatory: none Recommended: none
Module applicability	The module is part of the following degree program(s)/profile(s): 1. B.Sc. Earth System Physics 2. B.Sc. Meteorology
Module completion	Module examination: project completion Examination language: English Prerequisite for the examination: regular active participation in the exercise according to Section 9 subsection 2 Examination Regulations for the Bachelor of Science.
Workload in the individual module components (in ECTS credits)	Lecture: Environmental Meteorology (3 ECTS credits) Practical course: Exercises for Environmental Meteorology (3 ECTS credits)
Total module workload	6 ECTS credits
Module duration	1 semester
Module frequency	Winter semester

Module type Title Module code	Required elective module Climate Physics ESW-B-CliPhys
Learning outcomes	Students are familiar with the basic ways of thinking and methods of climate physics. They know the significance of the various climate system components in the climate system and have understood the material cycles in the climate system (water, carbon cycle). They are able to qualitatively record processes in the climate system (trends, fluctuations). They are familiar with the basic methods of climate system analysis and know which model types can be used to describe the dynamics of the climate system.
Module content	The lecture begins with a definition of the terms climate and climate system, before clarifying other important terms such as climate drive and climate feedback. The Earth's radiation budget, which ultimately determines the climate, is then examined. Chapter 3 deals with the central issue of climate sensitivity, how much is the planet warming for a given radiative forcing? This leads to the important topic of climate feedback, which is dealt with in the following chapters: water vapor, temperature gradient and ice albedo in chapter 4, then clouds and the biosphere in chapter 5. Chapter 6 deals with the topic of material cycles, with a particular focus on the cycles of water and carbon. The carbon cycle provides a natural perspective on the entire history of the Earth system, the topic of the seventh and final chapter of the lecture.In the exercises, the acquired knowledge is used to solve simple tasks.
Type of course (given in number of credit hours per week)	Lecture: Climate Physics (2 credit hours per week) Practical course: Exercises for Climate Physics (2 credit hour per week) The practical course is subject to an attendance requirement pursuant to Section 5 subsections 1 and 2 Examination Regulations for the Bachelor of Science.
Language of instruction	English
Prerequisites	Mandatory: none Recommended: none
Module applicability	The module is part of the following degree program(s)/profile(s): 1. B.Sc. Earth System Physics 2. B.Sc. Meteorology
Module completion	Module examination: oral examinations Examination language: English Prerequisite for the examination: regular active participation in the exercise according to Section 9 subsection 2 Examination Regulations for the Bachelor of Science.
Workload in the individual module components (in ECTS credits)	Lecture: Climate Physics (3 ECTS credits) Practical course: Exercises for Climate Physics (3 ECTS credits)
Total module workload	6 ECTS credits
Module duration	1 semester
Module frequency	Summer semester

Module type	Required elective module
Title	**Radiation and Remote Sensing**
Module code	**ESW-B-RRS**
Learning outcomes	Students have a basic knowledge of the essential processes that control radiation transport, their significance for the energy balance, and typical optical phenomena that can be explained in the context of geometric or wave optics. They are familiar with the basics of radiative transfer calculation and have experience in radiative transfer modeling. They have basic knowledge of common remote sensing methods and their areas of application and can assess the potential and limitations of the remote sensing methods covered. They also know the most important meteorological satellites and their instruments.
Module content	The course starts with the propagation of electromagnetic waves in clear, turbid, and cloudy atmosphere (refraction, reflection, diffraction, polarization; radiative transfer equation, scattering, absorption, emission), considering the frequency spectrum from the optical to the high-frequency range. Basic relationships between radiative transfer and the energy balance of the atmosphere (e.g., energy flows, mean temperature profile, greenhouse effect) as well as conclusions for optical phenomena (e.g., sky blue, scintillation, rainbow, halo, corona, aureole) are discussed. The most common active and passive remote sensing methods are introduced, and emphasizing that different remote sensing methods are each based on different special cases of the radiative transfer equation. Parallel to the other content, a meteorological satellite is presented in a short portrait in each lecture. The learning content is deepened through accompanying exercises.
Type of course (given in number of credit hours per week)	Lecture: Radiation and Remote Sensing (2 credit hours per week) Practical course: Exercises for Radiation and Remote Sensing (2 credit hours per week) The practical course is subject to an attendance requirement pursuant to Section 5 subsections 1 and 2 Examination Regulations for the Bachelor of Science.
Language of instruction	English
Prerequisites	Mandatory: none Recommended: none
Module applicability	The module is part of the following degree program(s)/profile(s): 1. B.Sc. Earth System Physics 2. B.Sc. Meteorology
Module completion	Module examination: written examination Examination language: English Prerequisite for the examination: regular active participation in the exercise according to Section 9 subsection 2 Examination Regulations for the Bachelor of Science.
Workload in the individual module components (in ECTS credits)	Lecture: Radiation and Remote Sensing (3 ECTS credits) Practical course: Exercises for Radiation and Remote Sensing (3 ECTS credits)
Total module workload	6 ECTS credits
Module duration	1 semester
Module frequency	Annually, in summer semester

Module type Title Module code	Required elective module Climate Variability and Diagnostics ESW-B-CVD
Learning outcomes	Student who have successfully completed this module have in-depth knowledge that enables them to verify statements about past and future climate variability. They have gained a thorough understanding of the components of the climate system as well as climate variables and indices. They are also familiar with methods for calculating, observing, and simulating these variables. Students are able to classify findings in the context of natural and anthropogenic climate variability.
Module content	Conceptual consideration of the climate system and its interaction with society, climate variability, climate indices, tools of climate diagnostics, such as fingerprint methods or multivariate regressions. Using case studies, students reflect on the knowledge gained and its uncertainties, particularly with regard to past and future climate developments.
Type of course (given in number of credit hours per week)	Lecture: Climate Variability and Diagnostics (2 credit hours per week) Seminar: Climate Variability and Diagnostics (2 credit hours per week)
Language of instruction	English
Prerequisites	Mandatory: none Recommended: successful completion of the module Ocean and Ice in the Climate System
Module applicability	The module is part of the following degree program(s)/profile(s): B.Sc. Earth System Physics
Module completion	Module examination: Examination language: English
Workload in the individual module components (in ECTS credits)	Lecture: Climate Variability and Diagnostics (3 ECTS credits) Seminar: Climate Variability and Diagnostics (3 ECTS credits)
Total module workload	6 ECTS credits
Module duration	1 semester
Module frequency	Annually, in summer semester

Module type Title Module code	Required elective module **Data Analysis and Software Development** **ESW-B-Data**
Learning outcomes	Students learn how to process scientific data using standard tools and procedures. Students who have successfully completed the class are able to process scientific data in various formats. They can use common software tools and automate tasks in a Linux environment. They have also acquired basic knowledge of methods of software development in Earth System Sciences. The class also makes it easier for students to work in scientific working groups, for example as part of their final thesis.
Module content	The course introduces tools and working methods used in Earth System Sciences and thus also forms a basis for an introduction to the Fortran programming language. 1. Work on the command line and shell programming to automate tasks, and the required Linux tools and regular expressions use of an editor 2. Data processing based on different data formats working with netCDF data format processing data with nco and cdo tools 3. Fundamentals of software development in Earth System Sciences version control using git, tools for software development 4. Text processing: introduction to Latex for editing large documents and maintaining a literature database.
Type of course (given in number of credit hours per week)	Lecture: Data Analysis and Software Development (2 credit hours per week) Practical course: Exercises for Data Analysis and Software Development (2 credit hours per week) The practical course is subject to an attendance requirement pursuant to Section 5 subsections 1 and 2 Examination Regulations for the Bachelor of Science.
Language of instruction	English
Prerequisites	Mandatory: participation in the module Physics of the Earth System 1 Recommended: successful completion of the module Physics of the Earth System 1
Module applicability	The module is part of the following degree program(s)/profile(s): B.Sc. Earth System Physics
Module completion	Module examination: Exercise completion or term paper (pass/fail) Examination language: English Prerequisite for the examination: regular active participation in the exercise according to Section 9 subsection 2 Examination Regulations for the Bachelor of Science.
Workload in the individual module components (in ECTS credits)	Lecture: Data Analysis and Software Development (3 ECTS credits) Practical course: Exercises for Data Analysis and Software Development (3 ECTS credits)
Total module workload	6 ECTS credits
Module duration	1 semester
Module frequency	Annually, in winter semester

Module type	**Required elective module**
Title	**Programming in Fortran**
Module code	**ESW-B-Fortran**
Learning outcomes	The class enables students to write their own programs for specific purposes. They acquire basic knowledge of Fortran concepts, structure and syntax. This allows data to be fully processed:create, modify, read in, release. Basic mathematical problems can be formulated and solved.In the same way, Fortran program code, which is very extensive (numerical models, global climate models, evaluation programs), can also be read and expanded. The knowledge acquired is applied to scientific issues, for example in the bachelor's thesis. It also makes learning similar programming languages easier.
Module content	1. Program structure, compile 2. Data types, branches, loops, fields 3. Input/Output, Formats 4. Subroutines, modules, intrinsic functions 5. Namelists, structures
Type of course (given in number of credit hours per week)	Lecture: Programming in Fortran (2 credit hours per week) Practical course: Exercises for Programming in Fortran (2 credit hours per week) The practical course is subject to an attendance requirement pursuant to Section 5 subsections 1 and 2 Examination Regulations for the Bachelor of Science.
Language of instruction	English
Prerequisites	Mandatory: none Recommended: Physics of the Earth System 1, participation in the Data Analysis and Software Development module
Module applicability	The module is part of the following degree program(s)/profile(s): B.Sc. Earth System Physics
Module completion	Module component examinations: Programming in Fortran lecture: written examination Exercises for Programming in Fortran practical course: practical examination Examination language: English Prerequisite for the examination: regular active participation in the exercise according to Section 9 subsection 2 Examination Regulations for the Bachelor of Science.
Workload in the individual module components (in ECTS credits)	Lecture: Programming in Fortran (3 ECTS credits) Practical course: Exercises for Programming in Fortran (3 ECTS credits)
Total module workload	6 ECTS credits
Module duration	1 semester
Module frequency	Annually, in winter semester

Module type Title Module code	Required elective module Thesis Seminar ESW-B-ThesisSem
Learning outcomes	Students who have successfully completed the module have developed a concept for their bachelor's thesis in reflection on their own work process, and in consultation with their supervisor. In addition, students will be able to present such a plan and other scientific content to an audience in a confident and motivated manner and be able to summarize it in writing. Through intensive literature study and discussions in their working group, they have acquired in-depth knowledge in the oceanographic, meteorological, and/or geophysical specialty in which the bachelor's thesis is written.
Module content	Input on in-depth scientific work and the associated work process. Reflection on the work process in individual and group tasks.
Type of course (given in number of credit hours per week)	Seminar: Thesis seminar (2 credit hours per week)
Language of instruction	English
Prerequisites	Mandatory: none Recommended: none
Module applicability	The module is part of the following degree program(s)/profile(s): B.Sc. Earth System Physics
Module completion	Module examination: presentation (pass/fail) Examination language: English
Workload in the individual module components (in ECTS credits)	Thesis Seminar (3 ECTS credits)
Total module workload	3 ECTS credits
Module duration	1 semester
Module frequency	Every semester

II.3 Module description of the final module

Module type Title Module code	Final module Bachelor's thesis ESW-B-ESP-Thesis
Learning outcomes	The master's thesis will demonstrate the student's ability to independently address a scientific question in the field of oceanography using scientific methods and document it in accordance with scientific standards. They can use literature research to work through the current state of science and, based on this, develop solutions to their questions and implement them under supervision. They are able to present and critically evaluate the findings in an appropriate manner.
Module content	Students are familiar with a research topic of limited scope, which they subsequently research and assess. Students can document results in writing, utilizing appropriate illustrations, and diagrams. Students are familiar with the techniques of scientific work and possess professional expertise and methodology skills in literature research, working with and developing information, documentation of scientific issues.
Type of course (given in number of credit hours per week)	Individual learning
Language of instruction	English
Prerequisites	Mandatory: admission to the final module bachelor's thesis is possible for students who have earned at least 120 ECTS credits and have completed the modules Mathematics 1, Mathematics 2, Numerics for Earth System Physics, Differential Equations for Earth System Physics, Statistics for Earth System Physics as well as Physics 1 (Mechanics and Thermodynamics) and Physics 2 (Electrodynamics and Optics) Recommended: none
Module applicability	The module is part of the following degree program(s)/profile(s): B.Sc. Earth System Physics
Module completion	Module examination: bachelor's thesis (generally 25–30 pages)
Workload in the individual module components (in ECTS credits)	Bachelor's thesis: 12 ECTS credits
Total module workload	12 ECTS credits
Module duration	1 semester
Module frequency	Every semester

Section 23
Effective date

These subject-specific provisions become effective on the day following official publication by the University of Hamburg.They first apply to students commencing their studies in Winter Semester 2025/26.Students who started their studies in the degree program Geophysics/ Oceanography (B.Sc.) earlier can apply to the chair of the examinations board to switch to the new examination regulations.

Hamburg, 19 June 2025
University of Hamburg