Please note: This English translation of our module description merely serves as an information, legally binding is the German version only.

Module Description Master Environmental Physics

Module title / code no.	01-M01-1-M1-01 Atmospheric Physics
Module assignment / Responsible for the module	Module section 1 / Basics Prof. Dr. John P. Burrows
Appendant courses, course type and SWH	Atmospheric Physics (4 semester weekly hours (SWH) / 2x lecture (L) + 2x example classes (EC))
Workload / credit points	6 CP, 180 h • presence (L + EC): 56 h (4 SWH x 14 weeks) • preparation, learning + examples: 56 h (4 SWH x 14 weeks) • preparation for exam: 68 h
Compulsory / optional	Compulsory
Assignment to study programmes	Compulsory for MSc Environmental Physics Optional compulsory for MSc Physik Optional compulsory for MSc Marine Geosciences Optional compulsory for MSc Technomathematik Optional compulsory for MSc Physical Geography: Environmental History
Duration / semester	1 semester / winter semester (1st academic year)
Requirements for participation	None
Offered frequency	Annually / winter semester
Course language	English
Learning outcome	Basics physics of the atmosphere
Content	History of the earth's atmosphere, atmospheric composition, radiation in atmosphere, physical laws, description of radiation and atmospheric radiation transport; Climate change; Atmospheric thermodynamics and hydrological cycle, Aerosols and cloud physics, Introduction into atmospheric dynamics
Course and examination performance, type of exam	Combination exam Examination performance: Written exam/oral exam (will be announced by the respective lecturer) Course performance: Successful assessment of example classes
Literature	English books: • Houghton, J.T., The physics of atmospheres, Cambridge University Press, 1977, ISBN 0 521 29656 0 • Wallace, John M. and Peter V. Hobbs, Atmospheric Science, An Introductory Survey, Academic Press, 2nd Edition 2005, ISBN 0-12-732951-x

	German books: • Physik unserer Umwelt: Die Atmosphäre Authors: Prof. Dr. Walter Roedel, Prof. Dr. Thomas Wagner ISBN: 978-3-642-15728-8 (Print) 978-3-642-15729-5 (Online)

Module title / code no.	01-M01-1-M1-02 Physical Oceanography
Module assignment / Responsible for the module	Module section 1 / Basics Prof. Dr. Monika Rhein
Appendant courses, course type and SWH	Physical Oceanography (4 semester weekly hours (SWH) / 2x lecture (L) + 2x example classes (EC))
Workload / credit points	6 CP, 180 h • presence (L + EC): 56 h (4 SWH x 14 weeks) • preparation, learning + examples: 56 h (4 SWH x 14 weeks) • preparation for exam: 68 h
Compulsory / optional	Compulsory
Assignment to study programmes	Compulsory for MSc Environmental Physics Optional compulsory for MSc Physik Optional compulsory for MSc Marine Geosciences Optional compulsory for MSc Technomathematik
Duration / semester	1 semester / winter semester (1st academic year)
Requirements for participation	None
Offered frequency	Annually / winter semester
Course language	English
Learning outcome	Basics physical oceanography
Content	External forcing, stratification, water mass formation, wind-driven ocean, geostrophy, meridional overturning, role of ocean in climate change
Course and examination performance, type of exam	Combination exam Examination performance: Written exam/oral exam (will be announced by the respective lecturer) Course performance: Successful assessment of example classes
Literature	Will be announced in the respective course.

Module title / code no.	01-M01-1-M1-03 Soil Physics
Module assignment / Responsible for the module	Module section 1 / Basics Dr. Helmut Fischer
Appendant courses, course type and SWH	Soil Physics (2 semester weekly hours (SWH) / 1x lecture (L) + 1x example classes (EC))
Workload / credit points	3 CP, 90 h • presence (L + EC): 28 h (2 SWH x 14 weeks) • preparation, learning + examples: 28 h (2 SWH x 14 weeks) • preparation for exam: 34 h
Compulsory / optional	Compulsory
Assignment to study programmes	Compulsory for MSc Environmental Physics Optional compulsory for MSc Physik Optional compulsory for MSc Marine Geosciences Optional compulsory for MSc Technomathematik Optional compulsory for MSc Physical Geography: Environmental History
Duration / semester	1 semester / winter semester (1st academic year)
Requirements for participation	None
Offered frequency	Annually / winter semester
Course language	English
Learning outcome	Fundamentals of soil physics
Content	Components of soils and their properties, interaction matrix – soil water, soil water retention curve, water transport in saturated and unsaturated soil, transport of pollutants and tracers
Course and examination performance, type of exam	Combination exam Examination performance: Written exam/oral exam (will be announced by the respective lecturer) Course performance: Successful assessment of example classes
Literature	Will be announced in the respective course.

Module title / code no.	01-M01-1-M1-04 Atmospheric Chemistry I
Module assignment / Responsible for the module	Module section 1 / Basics Prof. Dr. John P. Burrows
Appendant courses, course type and SWH	Atmospheric Chemistry I (4 semester weekly hours (SWH) / 2x lecture (L) + 2x example classes (EC))
Workload / credit points	6 CP, 180 h • presence (L + EC): 56 h (4 SWH x 14 weeks) • preparation, learning + examples: 56 h (4 SWH x 14 weeks) • preparation for exam: 68 h
Compulsory / optional	Compulsory
Assignment to study programmes	Compulsory for MSc Environmental Physics Optional compulsory for MSc Physik Optional compulsory for MSc Marine Geosciences Optional compulsory for MSc Technomathematik
Duration / semester	1 semester / winter semester (1st academic year)
Requirements for participation	None
Offered frequency	Annually / winter semester
Course language	English
Learning outcome	Basics chemistry of the atmosphere
Content	History of the atmospheres of the earth; atmospheric composition; thermodynamics, thermochemistry and chemical equilibria; photochemistry; kinetic theory of reactions and reaction rate coefficients; chain reactions; atmospheric chemical mechanisms and transformations in the thermosphere, mesosphere, stratosphere and the troposphere.
Course and examination performance, type of exam	Combination exam Examination performance: Written exam/oral exam (will be announced by the respective lecturer) Course performance: Successful assessment of example classes
Literature	• Finlayson-Pitts B. J. and J. N. Pitts, Atmospheric Chemistry • Richard P. Wayne, Chemistry of Atmospheres, Oxford University Press, 1991 • Ann M. Holloway and Richard P. Wayne, Atmospheric Chemistry, RSC Publishing, 2010 • P. W. Atkins, Physical Chemistry, Oxford University Press, 1990 • Colin Baird, Environmental Chemistry, Freeman and Company, New York,1995 • Guy Brasseur and Susan Solomon, Aeronomy of the Middle Atmosphere, D. Reidel Publishing Company, 1986 • Guy P. Brasseur, John J. Orlando, Geoffrey S. Tyndall (Eds): Atmospheric Chemistry and Global Change, Oxford University Press, 1999

Module title / code no.	01-M01-2-M1-06 Climate System I
Module assignment / Responsible for the module	Module section 1 / Basics Prof. Dr. Torsten Kanzow
Appendant courses, course type and SWH	Climate System I (3 semester weekly hours (SWH) / 2x lecture (L) + 1x example classes (EC))
Workload / credit points	4 CP, 120 h • presence (L + EC): 42 h (3 SWH x 14 weeks) • preparation, learning + examples: 42 h (3 SWH x 14 weeks) • preparation for exam: 36 h
Compulsory / optional	Compulsory
Assignment to study programmes	Compulsory for MSc Environmental Physics Optional compulsory for MSc Physik Optional compulsory for MSc Marine Geosciences Optional compulsory for MSc Technomathematik
Duration / semester	1 semester / summer semester (1st academic year)
Requirements for participation	None
Offered frequency	Annually / summer semester
Course language	English
Learning outcome	Climate physics
Content	Climate on earth / climate variations / the climate system / energy balance models / radiation & convection / role of the ocean in climate
Course and examination performance, type of exam	Combination exam Examination performance: Written exam/oral exam (will be announced by the respective lecturer) Course performance: Successful assessment of example classes
Literature	Will be announced in the respective course.

Module title / code no.	01-M01-1-M2-01 Dynamics I
Module assignment / Responsible for the module	Module section 2 / Theoretical Basics Prof. Dr. Thomas Jung
Appendant courses, course type and SWH	Dynamics I (4 semester weekly hours (SWH) / 2x lecture (L) + 2x example classes (EC))
Workload / credit points	6 CP, 180 h • presence (L + EC): 56 h (4 SWH x 14 weeks) • preparation, learning + examples: 56 h (4 SWH x 14 weeks) • preparation for exam: 68 h
Compulsory / optional	Compulsory
Assignment to study programmes	Compulsory for MSc Environmental Physics Optional compulsory for MSc Physik Optional compulsory for MSc Marine Geosciences Optional compulsory for MSc Technomathematik
Duration / semester	1 semester / winter semester (1st academic year)
Requirements for participation	None
Offered frequency	Annually / winter semester
Course language	English
Learning outcome	Understanding of the basic dynamical processes in atmosphere and ocean
Content	Governing equations, conservation laws, balances, circulation and vorticity, large-scale circulation, planetary boundary layer, Rossby waves
Course and examination performance, type of exam	Combination exam Examination performance: Written exam/oral exam (will be announced by the respective lecturer) Course performance: Successful assessment of example classes
Literature	Will be announced in the respective course.

Module title / code no.	01-M01-2-M2-02 Dynamics II
Module assignment / Responsible for the module	Module section 2 / Theoretical Basics Prof. Dr. Gerrit Lohmann
Appendant courses, course type and SWH	Dynamics II (3 semester weekly hours (SWH) / 2x lecture (L) + 1x example classes (EC))
Workload / credit points	4 CP, 120 h • presence (L + EC): 42 h (3 SWH x 14 weeks) • preparation, learning + examples: 42 h (3 SWH x 14 weeks) • preparation for exam: 36 h
Compulsory / optional	Compulsory
Assignment to study programmes	Compulsory for MSc Environmental Physics Optional compulsory for MSc Physik Optional compulsory for MSc Marine Geosciences Optional compulsory for MSc Technomathematik
Duration / semester	1 semester / summer semester (1st academic year)
Requirements for participation	None
Offered frequency	Annually / summer semester
Course language	English
Learning outcome	Advanced dynamics of the ocean and atmosphere, applications in the fields of climate dynamics and fluid mechanics.
Content	Fluid dynamics, ocean circulation, atmosphere dynamics and telekonnections, bifurcations and instabilities, waves
Course and examination performance, type of exam	Combination exam Examination performance: Written exam/oral exam (will be announced by the respective lecturer) Course performance: Successful assessment of example classes
Literature	• Holton, J.R., Introduction to Dynamical Meteorology, Academic Press • Gill, A., Atmosphere-Ocean Dynamics, Academic Press • Dutton, J.A., The Ceaseless Wind, Dover • Olbers, D.J., et al., Ocean Dynamics, Springer • Cushman-Roisin, B. & Beckers, J.-M., Introduction to Geophysical Fluid Dynamics: Physical and Numerical Aspects • Marchal, J., and R. A. Plumb, 2008. Atmosphere, Ocean and Climate Dynamics: An Introductory Text. Academic Press, 344 pp; videos • Stewart, R. H., 2008: Introduction To Physical Oceanography, • Lohmann, G., 2014: Ocean Fluid Dynamics: Concepts, Scaling and Multiple Equilibria.

Module title / code no.	01-M01-1-M2-03 Inverse Methods and Data Analysis
Module assignment / Responsible for the module	Module section 2 / Theoretical Basics Prof. Dr. Reiner Schlitzer / Prof. Dr. Emily King
Appendant courses, course type and SWH	Inverse Methods and Data Analysis (4 semester weekly hours (SWH) / 2x lecture (L) + 2x example classes (EC))
Workload / credit points	6 CP, 180 h • presence (L + EC): 56 h (4 SWH x 14 weeks) • preparation, learning + examples: 56 h (4 SWH x 14 weeks) • preparation for exam: 68 h
Compulsory / optional	Compulsory
Assignment to study programmes	Compulsory for MSc Environmental Physics Optional compulsory for MSc Physik Optional compulsory for MSc Marine Geosciences Optional compulsory for MSc Technomathematik
Duration / semester	1 semester / winter semester (1st academic year)
Requirements for participation	None
Offered frequency	Annually / winter semester
Course language	English
Learning outcome	Introduction to linear inverse methods
Content	Error analysis and statistics, techniques for the optimal solution of under and over determined systems of linear equations including methods for calculating variances and covariances of the solutions, concepts of resolution and methods to calculate them, practical examples and applications to test data sets from oceanography, image processing and atmospheric remote sensing
Course and examination performance, type of exam	Combination exam Examination performance: Written exam/oral exam (will be announced by the respective lecturer) Course performance: Successful assessment of example classes
Literature	Will be announced in the respective course.

Module title / code no.	01-M01-2-M3-01 Remote Sensing I
Module assignment / Responsible for the module	Module section 3 / Experimental Techniques Prof. Dr. Astrid Bracher / Dr. Mathias Palm
Appendant courses, course type and SWH	Remote Sensing I (3 semester weekly hours (SWH) / 2x lecture (L) + 1x example classes (EC))
Workload / credit points	4 CP, 120 h • presence (L + EC): 31,5 h (2,25 SWH x 14 weeks) • preparation report (each student 1x per semester): 16,5 h • preparation, learning + examples: 42 h (3 SWH x 14 weeks) • preparation for exam: 30 h
Compulsory / optional	Compulsory
Assignment to study programmes	Compulsory for MSc Environmental Physics Optional compulsory for MSc Physik Optional compulsory for MSc Marine Geosciences Optional compulsory for MSc Technomathematik Optional compulsory for MSc Physical Geography: Environmental History
Duration / semester	1 semester / summer semester (1st academic year)
Requirements for participation	None
Offered frequency	Annually / summer semester
Course language	English
Learning outcome	Basics of radiative transfer, spectroscopy, retrieval techniques, satellite remote sensing, MW, IR and UV-VIS techniques in atmospheric remote sensing, sea ice remote sensing, ocean color remote sensing
Content	The course introduces the theoretical background of remote sensing methods (interaction of electromagnetic radiation with matter (spectroscopy), radiative transfer, principles of satellite remote sensing). Active (radar, lidar) and passive (thermal emission, backscattered light) remote sensing techniques and their data analysis (retrievals) are explained. This is illustrated by a large number of examples available and in use in the different research groups in the Institute of Environmental Physics (IUP).
Course and examination performance, type of exam	Combination exam Examination performance: Written exam/oral exam (will be announced by the respective lecturer) Course performance: Successful assessment of example classes (exercises, report of one course lesson (5-10 min.))
Literature	Will be announced in the respective course.

Module title / code no.	01-M01-2-M3-02 Measurement Techniques
Module assignment / Responsible for the module	Module section 3 / Experimental Techniques Dr. Andreas Richter / Dr. Christian Mertens
Appendant courses, course type and SWH	Measurement Techniques (4 laboratory (Lab) + 1 lecture (L))
Workload / credit points	6 CP, 180 h • presence (L): 18 h (6 SWH x 3 weeks) • presence (Lab): 24 h (6 SWH x 4 weeks) • preparation, report: 84 h (12 SWH x 7 weeks) • preparation for exam: 54 h
Compulsory / optional	Compulsory
Assignment to study programmes	Compulsory for MSc Environmental Physics
Duration / semester	1 semester / summer semester (1st academic year)
Requirements for participation	None
Offered frequency	Annually / summer semester
Course language	English
Learning outcome	Basics of measurement techniques in Environmental Physics
Content	Measurements of meteorological quantities, atmospheric trace gases, ocean currents, environmental radioactivity, absorption cross-sections
Course and examination performance, type of exam	Combination exam Examination performance: Oral exam Course performance: Successful experiments with accepted reports
Literature	Will be announced in the respective course.

Module title / code no.	01-M01-1-M4-02 Global Carbon Cycle
Module assignment / Responsible for the module	Module section 4 / Advanced Environmental Physics Dr. Christoph Völker
Appendant courses, course type and SWH	Global Carbon Cycle (2 semester weekly hours (SWH) / 1,5x lecture (L) + 0,5x example classes (EC))
Workload / credit points	3 CP, 90 h • presence (L + EC): 28 h (2 SWH x 14 weeks) • preparation, learning + examples: 28 h (2 SWH x 14 weeks) • preparation for exam: 34 h
Compulsory / optional	Optional
Assignment to study programmes	Optional for MSc Environmental Physics Optional compulsory for MSc Physik Optional compulsory for MSc Marine Geosciences Optional compulsory for MSc Technomathematik
Duration / semester	1 semester / winter semester
Requirements for participation	None
Offered frequency	Annually / winter semester
Course language	English
Learning outcome	Understanding the interactions between the cycling of carbon and global climate
Content	• natural and anthropogenic greenhouse effect • different reservoirs of carbon in the earth system, and their role on different time-scales • role of carbon in the chemistry of the ocean and in setting its pH • glacial-interglacial cycles • carbon isotopes as analytical tool • weathering, climate regulation and the carbon cycle on geological time-scales
Course and examination performance, type of exam	Combination exam Examination performance: Written exam/oral exam (will be announced by the respective lecturer) Course performance: Successful assessment of example classes and/or successful writing of an essay
Literature	• Principles of Planetary Climate: Raymond Pierrehumbert • Ocean Biogeochemical Dynamics: Jorge L. Sarmiento & Nicolas Gruber • Earth's Climate: Past and Future: William F. Ruddiman

Module title / code no.	01-M01-1-M4-04 Cloud Physics
Module assignment / Responsible for the module	Module section 4 / Advanced Environmental Physics PD Dr. Ulrike Wacker
Appendant courses, course type and SWH	Cloud Physics (2 semester weekly hours (SWH) / 1x lecture (L) + 1x example classes (EC))
Workload / credit points	3 CP, 90 h • presence (L + EC): 28 h (2 SWH x 14 weeks) • preparation, learning + examples: 28 h (2 SWH x 14 weeks) • preparation for exam: 34 h
Compulsory / optional	Optional
Assignment to study programmes	Optional for MSc Environmental Physics Optional compulsory for MSc Physik Optional compulsory for MSc Marine Geosciences Optional compulsory for MSc Technomathematik
Duration / semester	1 semester / winter semester
Requirements for participation	None
Offered frequency	Annually / winter semester
Course language	English
Learning outcome	Fundamentals of cloud physics
Content	Microstructure of clouds and precipitation, evolution of drops and ice particles due to nucleation, condensation/deposition, coagulation, riming, melting and sedimentation, treatment in complex numerical prediction models.
Course and examination performance, type of exam	Combination exam Examination performance: Written exam/oral exam (will be announced by the respective lecturer) Course performance: Successful assessment of example classes and/or successful writing of an essay
Literature	Will be announced in the respective course.

Module title / code no.	01-M01-2-M4-07 General Meteorology
Module assignment / Responsible for the module	Module section 4 / Advanced Environmental Physics PD Dr. Ulrike Wacker
Appendant courses, course type and SWH	General Meteorology (2 semester weekly hours (SWH) / 1x lecture (L) + 1x example classes (EC))
Workload / credit points	3 CP, 90 h • presence (L + EC): 28 h (2 SWH x 14 weeks) • preparation, learning + examples: 28 h (2 SWH x 14 weeks) • preparation for exam: 34 h
Compulsory / optional	Optional
Assignment to study programmes	Optional for MSc Environmental Physics Optional compulsory for MSc Physik Optional compulsory for MSc Marine Geosciences Optional compulsory for MSc Technomathematik
Duration / semester	1 semester / summer semester
Requirements for participation	None
Offered frequency	Annually / summer semester
Course language	English
Learning outcome	Fundamentals of general meteorology
Content	Typical flow patterns of the atmosphere, static (in-)stability, circulation systems, cyclones in mid-latitudes.
Course and examination performance, type of exam	Combination exam Examination performance: Written exam/oral exam (will be announced by the respective lecturer) Course performance: Successful assessment of example classes and/or successful writing of an essay
Literature	Will be announced in the respective course.

Module title / code no.	01-M01-2-M4-08 Digital Image Processing
Module assignment / Responsible for the module	Module section 4 / Advanced Environmental Physics Dr. Christian Melsheimer / Dr. Georg Heygster
Appendant courses, course type and SWH	Digital Image Processing (2 semester weekly hours (SWH) / 1,5x lecture (L) + 0,5x example classes (EC))
Workload / credit points	3 CP, 90 h • presence (L + EC): 28 h (2 SWH x 14 weeks) • preparation, learning + examples: 28 h (2 SWH x 14 weeks) • preparation for exam: 34 h
Compulsory / optional	Optional
Assignment to study programmes	Optional for MSc Environmental Physics Optional compulsory for MSc Marine Geosciences Optional compulsory for MSc Technomathematik
Duration / semester	1 semester / summer semester
Requirements for participation	None
Offered frequency	Annually / summer semester
Course language	English
Learning outcome	Fundamentals of digital image processing
Content	• Digital image, sampling • Image enhancement using filters • Image analysis methods using segmentation, feature extraction and classification • Fourier transformation of digital image, linear filters in spatial and frequency domains • Data compression
Course and examination performance, type of exam	Combination exam Examination performance: Written exam/oral exam (will be announced by the respective lecturer) Course performance: Successful assessment of example classes and/or successful writing of an essay
Literature	Will be announced in the respective course.

Module title / code no.	01-M01-2-M4-12 Statistics and Error Analysis
Module assignment / Responsible for the module	Module section 4 / Advanced Environmental Physics Prof. Dr. Reiner Schlitzer
Appendant courses, course type and SWH	Statistics and Error Analysis (2 semester weekly hours (SWH) / 1,5x lecture (L) + 0,5x example classes (EC))
Workload / credit points	3 CP, 90 h • presence (L + EC): 28 h (2 SWH x 14 weeks) • preparation, learning + examples: 28 h (2 SWH x 14 weeks) • preparation for exam: 34 h
Compulsory / optional	Optional
Assignment to study programmes	Optional for MSc Environmental Physics Optional compulsory for MSc Physik Optional compulsory for MSc Marine Geosciences Optional compulsory for MSc Technomathematik
Duration / semester	1 semester / summer semester
Requirements for participation	None
Offered frequency	Annually / summer semester
Course language	English
Learning outcome	Introduction to statistics, error calculation and data analysis
Content	Random variables, probability, density and distribution functions, expectation values, covariance and correlation, error propagation, statistical tests
Course and examination performance, type of exam	Combination exam Examination performance: Written exam/oral exam (will be announced by the respective lecturer) Course performance: Successful assessment of example classes and/or successful writing of an essay
Literature	Will be announced in the respective course.

Module title / code no.	01-M01-2-M4-13 Environmental Radioactivity
Module assignment / Responsible for the module	Module section 4 / Advanced Environmental Physics Dr. Helmut Fischer
Appendant courses, course type and SWH	Environmental Radioactivity (2 semester weekly hours (SWH) / 1x lecture (L) + 1x example classes (EC))
Workload / credit points	3 CP, 90 h • presence (L + EC): 28 h (2 SWH x 14 weeks) • preparation, learning + examples: 28 h (2 SWH x 14 weeks) • preparation for exam: 34 h
Compulsory / optional	Optional
Assignment to study programmes	Optional for MSc Environmental Physics Optional compulsory for MSc Physik Optional compulsory for MSc Marine Geosciences Optional compulsory for MSc Technomathematik Optional compulsory for MSc Physical Geography:Environmental History
Duration / semester	1 semester / summer semester
Requirements for participation	None
Offered frequency	Annually / summer semester
Course language	English
Learning outcome	Fundamentals of environmental radioactivity
Content	Radioactive decay and emitted radiation, origins of environmental radioactivity, interaction of radiation and matter, detection methods, transport processes, radiometric dating, examples from research projects
Course and examination performance, type of exam	Combination exam Examination performance: Written exam/oral exam (will be announced by the respective lecturer) Course performance: Successful assessment of example classes and/or successful writing of an essay
Literature	Will be announced in the respective course.

Module title / code no.	01-M01-2-M4-17 Mathematical Modelling
Module assignment / Responsible for the module	Module section 4 / Advanced Environmental Physics Dr. Silke Thoms
Appendant courses, course type and SWH	Mathematical Modelling (2 semester weekly hours (SWH) / 1x lecture (L) + 1x example classes (EC))
Workload / credit points	3 CP, 90 h • presence (L + EC): 28 h (2 SWH x 14 weeks) • preparation, learning + examples: 28 h (2 SWH x 14 weeks) • preparation for exam: 34 h
Compulsory / optional	Optional
Assignment to study programmes	Optional for MSc Environmental Physics Optional compulsory for MSc Marine Geosciences Optional compulsory for MSc Technomathematik
Duration / semester	1 semester / summer semester
Requirements for participation	None
Offered frequency	Annually / summer semester
Course language	English
Learning outcome	Ability to understand and analyze models, their behaviour and the fundamental numerical techniques used in them
Content	Steps in the development of a model Types of behaviour of linear / nonlinear dynamical systems Basic numerical techniques: - iterative solution of algebraic equations - solution of difference equations and ordinary differential equations - methods to solve partial differential equations - optimization methods
Course and examination performance, type of exam	Combination exam Examination performance: Written exam/oral exam (will be announced by the respective lecturer) Course performance: Successful assessment of example classes and/or successful writing of an essay
Literature	• Modeling Methods for Marine Science: David M. Glover, William J. Jenkins, Scott C. Doney • Numerical Recipes: William H. Press, Saul Teukolsky, William T. Vetterling und Brian P. Flannery

Module title / code no.	01-M01-1-M4-19 Microwave Remote Sensing
Module assignment / Responsible for the module	Module section 4 / Advanced Environmental Physics Dr. Christian Melsheimer / Dr. Georg Heygster
Appendant courses, course type and SWH	Microwave Remote Sensing (2 semester weekly hours (SWH) / 1,5x lecture (L) + 0,5x example classes (EC))
Workload / credit points	3 CP, 90 h • presence (L + EC): 28 h (2 SWH x 14 weeks) • preparation, learning + examples: 28 h (2 SWH x 14 weeks) • preparation for exam: 34 h
Compulsory / optional	Optional
Assignment to study programmes	Optional for MSc Environmental Physics Optional compulsory for MSc Marine Geosciences Optional compulsory for MSc Technomathematik
Duration / semester	1 semester / winter semester
Requirements for participation	None
Offered frequency	Annually / winter semester
Course language	English
Learning outcome	Fundamentals of remote sensing using microwaves
Content	• Microwaves • Microwave antennas, working principle of radiometers and radars • Interaction of microwaves with the atmosphere and the earth surface, radiative transfer • Retrieval of geophysical parameters from microwave measurements • Current microwave instruments and satellites
Course and examination performance, type of exam	Combination exam Examination performance: Written exam/oral exam (will be announced by the respective lecturer) Course performance: Successful assessment of example classes and/or successful writing of an essay
Literature	Will be announced in the respective course.

Module title / code no.	01-M01-2-M4-22 Physical Oceanography II
Module assignment / Responsible for the module	Module section 4 / Advanced Environmental Physics Prof. Dr. Monika Rhein
Appendant courses, course type and SWH	Physical Oceanography II (2 semester weekly hours (SWH) / 1x lecture (L) + 1x example classes (EC))
Workload / credit points	3 CP, 90 h • presence (L + EC): 28 h (2 SWH x 14 weeks) • preparation, learning + examples: 28 h (2 SWH x 14 weeks) • preparation for exam: 34 h
Compulsory / optional	Optional
Assignment to study programmes	Optional for MSc Environmental Physics Optional compulsory for MSc Physik Optional compulsory for MSc Marine Geosciences Optional compulsory for MSc Technomathematik
Duration / semester	1 semester / summer semester
Requirements for participation	None
Offered frequency	Annually / summer semester
Course language	English
Learning outcome	Special topics physical oceanography
Content	Tides, waves, energy dissipation, small scale processes and their importance for the large scale circulation
Course and examination performance, type of exam	Combination exam Examination performance: Written exam/oral exam (will be announced by the respective lecturer) Course performance: Successful assessment of example classes and/or successful writing of an essay
Literature	Will be announced in the respective course.

Module title / code no.	01-M01-1-M4-24 Climate II
Module assignment / Responsible for the module	Module section 4 / Advanced Environmental Physics Prof. Dr. Gerrit Lohmann / Dr. Martin Werner
Appendant courses, course type and SWH	Climate II (2 semester weekly hours (SWH) / 1,5x lecture (L) + 0,5x example classes (EC))
Workload / credit points	3 CP, 90 h • presence (L + EC): 28 h (2 SWH x 14 weeks) • preparation, learning + examples: 42 h (3 SWH x 14 weeks) • preparation for exam: 20 h
Compulsory / optional	Optional
Assignment to study programmes	Optional for MSc Environmental Physics Optional compulsory for MSc Marine Geosciences Optional compulsory for MSc Technomathematik
Duration / semester	1 semester / winter semester
Requirements for participation	None
Offered frequency	Annually / winter semester
Course language	English
Learning outcome	Advanced climate course: Theories, models, observations
Content	Climate models, possibilities and limitations to observe climate change, ice ages, holocene, scenarios, sea level, proxy data, biogeochemical cycles, feedbacks
Course and examination performance, type of exam	Combination exam Examination performance: Written exam/oral exam (will be announced by the respective lecturer) Course performance: Successful assessment of example classes and/or successful writing of an essay
Literature	• Bradley, Paleoclimatology-Reconstructing climates of the Quaternary, 1999 • Saltzman, Dynamical Paleoclimatology - A generalized theory of global climate change, Academic Press, San Diego, 2002 • Ruddiman, Earth's Climate Past and Future • Paleoclimate, Global Change and the Future, 2003 by Keith D. Alverson, Raymond S. Bradley, Thomas F. Pedersen (Editors) • Broecker, THE GLACIAL WORLD ACCORDING TO WALLY

Module title / code no.	01-M01-1-M4-33 Ocean Optics and Ocean Color Remote Sensing
Module assignment / Responsible for the module	Module section 4 / Advanced Environmental Physics Prof. Dr. Astrid Bracher
Appendant courses, course type and SWH	Ocean Optics and Ocean Color Remote Sensing (2 semester weekly hours (SWH) / 1,5x lecture (L) + 0,5x example classes (EC))
Workload / credit points	3 CP, 90 h • presence (L + EC): 28 h (2 SWH x 14 weeks) • preparation essay + short talk: 34 h • preparation for exam: 28 h
Compulsory / optional	Optional
Assignment to study programmes	Optional for MSc Environmental Physics Optional compulsory for MSc Marine Geosciences Optional compulsory for MSc Technomathematik
Duration / semester	1 semester / winter semester
Requirements for participation	None
Offered frequency	Annually / winter semester
Course language	English
Learning outcome	Basics of radiative transfer in water (inherent and apparent properties) and ocean color remote sensing, ocean optics measurement techniques, atmospheric correction, empirical, semi-analytical, neuronal network retrieval techniques to determine water constituents and radiation in the water, validation and application techniques
Content	First, the course covers the principles of ocean optics. Topics included are basic physics of light and interaction of light with matter, inherent and apparent optical properties, radiative transfer equation, light fields within the ocean, water-leaving radiance and remote-sensing reflectance, effects of various seawater constituents on ocean reflectance, optical instrumentation and measurement techniques. Secondly, the lecture focuses on ocean color remote sensing. This includes the principles of ocean color remote sensing, the technology of the instruments commonly used ocean color satellite sensors, atmospheric correction, retrieval techniques of ocean color data products, such as phytoplankton biomass, phytoplankton photosynthetic activity, major PFTs, other particulates, coloured disolved organic matter and light penetration depth. Finally, also validation techniques of ocean color data products and application of these data in global ecosystem and biogeochemical models is presented.
Course and examination performance, type of exam	Combination exam Examination performance: Written exam/oral exam (will be announced by the respective lecturer) Course performance: Successful assessment of example classes and/or successful writing of an essay
Literature	Will be announced in the respective course.

Module title / code no.	01-M01-1-M4-40 Chemistry and Dynamics of the Ozone Layer
Module assignment / Responsible for the module	Module section 4 / Advanced Environmental Physics PD Dr. Markus Rex / PD Dr. Björn-Martin Sinnhuber
Appendant courses, course type and SWH	Chemistry and Dynamics of the Ozone Layer (block course)
Workload / credit points	3 CP, 90 h • presence (L + EC): 40 h (block course 5 days) • preparation, learning + examples: 25 h • preparation for exam: 25 h
Compulsory / optional	Optional
Assignment to study programmes	Optional for MSc Environmental Physics Optional compulsory for MSc Marine Geosciences Optional compulsory for MSc Technomathematik
Duration / semester	1 semester / winter semester
Requirements for participation	None
Offered frequency	Annually / winter semester
Course language	English
Learning outcome	Understanding of chemistry-dynamics-interactions including numerical techniques
Content	Dynamics and chemistry of the ozone layer, implementation of a numerical model of the ozone layer and model based analyses
Course and examination performance, type of exam	Combination exam Examination performance: Written exam/oral exam (will be announced by the respective lecturer) Course performance: Successful assessment of example classes and/or successful writing of an essay
Literature	Will be announced in the respective course.

Module title / code no.	01-M01-2-M4-41 Molecular Physics
Module assignment / Responsible for the module	Module section 4 / Advanced Environmental Physics Prof. Dr. Justus Notholt
Appendant courses, course type and SWH	Molecular Physics (2 semester weekly hours (SWH) / 1,5x lecture (L) + 0,5x example classes (EC))
Workload / credit points	3 CP, 90 h • presence (L + EC): 28 h (2 SWH x 14 weeks) • preparation, learning + examples: 28 h (2 SWH x 14 weeks) • preparation for exam: 34 h
Compulsory / optional	Optional
Assignment to study programmes	Optional for MSc Environmental Physics Optional compulsory for MSc Marine Geosciences Optional compulsory for MSc Technomathematik
Duration / semester	1 semester / summer semester
Requirements for participation	None
Offered frequency	Annually / summer semester
Course language	English
Learning outcome	Basics of spectroscopy, understanding and interpretation of measured spectra with regard to the structure of the molecules. Basics of the FTIR-spectroscopy, understanding of remote sensing methods.
Content	Prismen and grating spectrometers, Fourier-Transform-Spectroscopy, transitions, rotational spectra, vibrational spectra, rotational-vibrational spectra, remote sensing methods
Course and examination performance, type of exam	Combination exam Examination performance: Written exam/oral exam (will be announced by the respective lecturer) Course performance: Successful assessment of example classes and/or successful writing of an essay
Literature	Will be announced in the respective course.

Module title / code no.	01-M01-2-M4-42 Physics of Polar Ice Core Records
Module assignment / Responsible for the module	Module section 4 / Advanced Environmental Physics Dr. Maria Hörhold
Appendant courses, course type and SWH	Physics of Polar Ice Core Records (2 semester weekly hours (SWH) / 1x lecture (L) + 1x example classes (EC))
Workload / credit points	3 CP, 90 h • presence (L + EC): 28 h (2 SWH x 14 weeks) • preparation, learning + examples: 35 h (2,5 SWH x 14 weeks) • excursion to the AWI: 7 h • preparation for exam: 20 h
Compulsory / optional	Optional
Assignment to study programmes	Optional for MSc Environmental Physics Optional compulsory for MSc Marine Geosciences Optional compulsory for MSc Technomathematik
Duration / semester	1 semester / summer semester
Requirements for participation	None
Offered frequency	Annually / summer semester
Course language	English
Learning outcome	Basic programming with Python, basic knowledge on polar ice core records
Content	Data processing and analysis using Python, physical background and interpretation of ice core records
Course and examination performance, type of exam	Combination exam Examination performance: Written exam/oral exam (will be announced by the respective lecturer) Course performance: Successful assessment of example classes and/or successful writing of an essay
Literature	Will be announced in the respective course.

Module title / code no.	01-M01-2-M4-44 Polar Oceanography
Module assignment / Responsible for the module	Module section 4 / Advanced Environmental Physics Prof. Dr. Torsten Kanzow
Appendant courses, course type and SWH	Polar Oceanography (2 semester weekly hours (SWH) / 1,5x lecture (L) + 0,5x example classes (EC))
Workload / credit points	3 CP, 90 h • presence (L + EC): 28 h (2 SWH x 14 weeks) • preparation, learning + examples: 28 h (2 SWH x 14 weeks) • preparation for exam: 34 h
Compulsory / optional	Optional
Assignment to study programmes	Optional for MSc Environmental Physics Optional compulsory for MSc Marine Geosciences Optional compulsory for MSc Technomathematik
Duration / semester	1 semester / summer semester
Requirements for participation	None
Offered frequency	Annually / summer semester
Course language	English
Learning outcome	Introduction to polar oceanography
Content	Properties of cold sea water, sea ice formation, ocean – sea ice interaction, arctic circulation and water mass formation, antarctic circulation and water mass formation, ocean – ice shelf interaction
Course and examination performance, type of exam	Combination exam Examination performance: Written exam/oral exam (will be announced by the respective lecturer) Course performance: Successful assessment of example classes and/or successful writing of an essay
Literature	Will be announced in the respective course.

Module title / code no.	01-M01-1-M4-45 The Upper Atmosphere
Module assignment / Responsible for the module	Module section 4 / Advanced Environmental Physics Dr. Holger Winkler
Appendant courses, course type and SWH	The Upper Atmosphere (2 semester weekly hours (SWH) / 1x lecture (L) + 1x example classes (EC))
Workload / credit points	3 CP, 90 h • presence (L + EC): 28 h (2 SWH x 14 weeks) • preparation, learning + examples: 28 h (2 SWH x 14 weeks) • preparation for exam: 34 h
Compulsory / optional	Optional
Assignment to study programmes	Optional for MSc Environmental Physics Optional compulsory for MSc Marine Geosciences Optional compulsory for MSc Technomathematik
Duration / semester	1 semester / winter semester
Requirements for participation	None
Offered frequency	Annually / winter semester
Course language	English
Learning outcome	Fundamentals of physics and chemistry of the upper atmosphere
Content	Properties of mesosphere, ionosphere and lower thermosphere, dynamical and chemical processes, extraterrestrial influences, plasma processes
Course and examination performance, type of exam	Combination exam Examination performance: Written exam/oral exam (will be announced by the respective lecturer) Course performance: Successful assessment of example classes and/or successful writing of an essay
Literature	Will be announced in the respective course.

Module title / code no.	01-M01-1-M4-46 Aerosol and Radiative Aspects in Clouds
Module assignment / Responsible for the module	Module section 4 / Advanced Environmental Physics Dr. Marco Vountas / Dr. Luca Lelli
Appendant courses, course type and SWH	Aerosol and Radiative Aspects in Clouds (2 semester weekly hours (SWH)/ 1,5x lecture (L) + 0,5x example classes (EC))
Workload / credit points	3 CP, 90 h • presence (L + EC): 28 h (2 SWH x 14 weeks) • preparation, learning + examples: 28 h (2 SWH x 14 weeks) • preparation for exam: 34 h
Compulsory / optional	Optional
Assignment to study programmes	Optional for MSc Environmental Physics Optional compulsory for MSc Physik Optional compulsory for MSc Marine Geosciences Optional compulsory for MSc Technomathematik
Duration / semester	1 semester / winter semester
Requirements for participation	None
Offered frequency	Annually / winter semester
Course language	English
Learning outcome	Advanced knowledge of the atmosphere and light scattering
Content	Description of atmospheric aerosols, their composition and measuring methods. Introduction to radiative transfer in the troposphere with emphasis on aerosols and clouds
Course and examination performance, type of exam	Combination exam Examination performance: Written exam/oral exam (will be announced by the respective lecturer) Course performance: Successful assessment of example classes and/or successful writing of an essay
Literature	Will be announced in the respective course.

Module title / code no.	01-M01-2-M4-47 Atmospheric Chemistry II
Module assignment / Responsible for the module	Module section 4 / Advanced Environmental Physics PD Dr. Annette Ladstätter-Weißenmayer
Appendant courses, course type and SWH	Atmospheric Chemistry II (2 semester weekly hours (SWH) / 1x lecture (L) + 1x example classes (EC))
Workload / credit points	3 CP, 90 h • presence (L + EC): 28 h (2 SWH x 14 weeks) • preparation, learning + examples: 28 h (2 SWH x 14 weeks) • preparation for exam: 34 h
Compulsory / optional	Optional
Assignment to study programmes	Optional for MSc Environmental Physics Optional compulsory for MSc Physik Optional compulsory for MSc Marine Geosciences Optional compulsory for MSc Technomathematik
Duration / semester	1 semester / summer semester
Requirements for participation	None
Offered frequency	Annually / summer semester
Course language	English
Learning outcome	Advanced Atmospheric Chemistry II
Content	Global biochemical cycles of elements, important biophysical processes in atmosphere and ocean, carbon-, methane-, nitrogen and water cycle, greenhouse gases
Course and examination performance, type of exam	Combination exam Examination performance: Written exam/oral exam (will be announced by the respective lecturer) Course performance: Successful assessment of example classes and/or successful writing of an essay
Literature	Will be announced in the respective course.

Module title / code no.	01-M01-1-M4-48 Instrumental Techniques for Environmental Measurements
Module assignment / Responsible for the module	Module section 4 / Advanced Environmental Physics Prof. Dr. Mihalis Vrekoussis
Appendant courses, course type and SWH	Instrumental Techniques for Environmental Measurements (2 semester weekly hours (SWH)/1x lecture (L) + 1x example classes (EC))
Workload / credit points	3 CP, 90 h • presence (L + EC): 28 h (2 SWH x 14 weeks) • preparation, learning + examples: 28 h (2 SWH x 14 weeks) • preparation for exam: 34 h
Compulsory / optional	Optional
Assignment to study programmes	Optional for MSc Environmental Physics Optional compulsory for MSc Physik Optional compulsory for MSc Marine Geosciences Optional compulsory for MSc Technomathematik
Duration / semester	1 semester / winter semester
Requirements for participation	None
Offered frequency	Annually / winter semester
Course language	English
Learning outcome	Students are expected to enhance their knowledge on the theoretical aspects, design and operation of a number of instruments used in environmental analysis. Ultimately, students will improve their analytical thinking by recognizing and understanding the advantages and disadvantages of the environmental instrumental methods to be used depending on the material under investigation.
Content	Theoretical aspects on spectroscopy, chromatography, electrochemistry. Introduction to the principle of operation and design of instruments used in environmental analysis.
Course and examination performance, type of exam	Combination exam Examination performance: Written exam/oral exam (will be announced by the respective lecturer) Course performance: Successful assessment of example classes and/or successful writing of an essay
Literature	Quantitative chemical analysis, 8th edition, (Daniel. C. Harris) Modern Analytical Chemistry, 1st Edition (Harvey, David)

Module title / code no.	01-M01-1-M5-06 Proseminar on Presentation Techniques in Environmental Physics
Module assignment / Responsible for the module	Module section 5 / Research in Environmental Physics Dr. Andreas Richter
Appendant courses, course type and SWH	Proseminar on Presentation Techniques in Environmental Physics (2 PS)
Workload / credit points	3 CP, 90 h • presence (L): 28 h (2 SWH x 14 weeks) • preparation of two talks: 40 h (20 h/week x 2 weeks) • preparation of one poster / extended abstracts: 22 h
Compulsory / optional	Compulsory
Assignment to study programmes	Compulsory for MSc Environmental Physics
Duration / semester	1 semester / winter semester (2nd academic year)
Requirements for participation	None
Offered frequency	Annually / winter semester
Course language	English
Learning outcome	Presentation techniques in environmental physics
Content	Structure and content of oral presentations, slides, giving oral presentations, questions and answers, posters, extended abstracts, literature research and citation
Course and examination performance, type of exam	Combination exam Examination performance: 1 poster or extended abstract (4 pages) Course performance: Successful assessment of 2 oral presentations
Literature	Will be announced in the respective course.

Module title / code no.	Preparatory Project
Module assignment / Responsible for the module	Module section 5 / Research in Environmental Physics Prof. Dr. John P. Burrows, Prof. Dr. Justus Notholt, Prof. Dr. Monika Rhein, PD Dr. Annette Ladstätter-Weißenmayer as well as further university lecturers of the IUP (Institute of Environmental Physics) / AWI (Alfred Wegener Institute for Polar and Marine Research) depending on the area of research
Appendant courses, course type and SWH	Working in the laboratories of the Institute of Environmental Physics / AWI Individual instruction (practical training) Preparation of a thesis paper on a possible research project which - as a rule - should be closely related to the subsequent Master's Thesis.
Workload / credit points	18 CP, 540 h
Compulsory / optional	Compulsory
Assignment to study programmes	Compulsory for MSc Environmental Physics
Duration / semester	Winter semester (2nd academic year)
Requirements for participation	None
Offered frequency	Annually / winter semester
Course language	English
Learning outcome	• Transfer of a scientific problem/question into an experimental and/or theoretical study • Successful strategies for the planning and conducting of scientific studies • Summarize and present preliminary scientific results in a thesis paper
Content	The content is related to the respective area of research of the preparatory project.
Course and examination performance, type of exam	Module examination • Successful assessment of the preparatory project • Thesis paper on research project which can be conducted within the context of the Master's Thesis
Literature	Will be announced in the respective course.

Module title / code no.	Module Master's Thesis
Module assignment / Responsible for the module	Module 6 / Final Module Prof. Dr. John P. Burrows, Prof. Dr. Justus Notholt, Prof. Dr. Monika Rhein, PD Dr. Annette Ladstätter-Weißenmayer as well as further university lecturers of the IUP (Institute of Environmental Physics) / AWI (Alfred Wegener Institute for Polar and Marine Research) depending on the area of research
Appendant courses, course type and SWH	Master's Thesis Colloquium to the Master's Thesis
Workload / credit points	30 CP, 900 h
Compulsory / optional	Compulsory
Assignment to study programmes	Compulsory for MSc Environmental Physics
Duration / semester	1 semester / summer semester (2nd academic year)
Requirements for participation	Required for the application for the Master's Thesis is the passing of all the mandatory exams of the module sections 1 – 3 and the module "preparatory project".
Offered frequency	Annually / summer semester
Course language	English
Learning outcome	• Transfer of a scientific problem/question into an experimental and/or theoretical study • Successful strategies for the planning and conducting of scientific studies • Ability for a critical evaluation, assessment and discussion of own scientific results • Summarize and present scientific results in a Master's Thesis
Content	The content is related to the respective area of research of the Master's Thesis.
Course and examination performance, type of exam	• Successful assessment of the Master's Thesis • Successful colloquium to the Master's Thesis • Credit points for the finale module are granted on the basis of the marks for the Master's Thesis and the colloquium.
Literature	Will be announced in the respective course.