Universität Hamburg
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FAKULTÄT
FÜR MATHEMATIK, INFORMATIK
UND NATURWISSENSCHAFTEN

MODULE HANDBOOK WINTER 2019

MSC INTEGRATED CLIMATE SYSTEM SCIENCES

VERSION 1.0
SCHOOL OF INTEGRATED CLIMATE AND EARTH SYSTEM SCIENCES (SICSS)

M.SC. INTEGRATED CLIMATE SYSTEM SCIENCES AT UNIVERSITÄT HAMBURG

INTRODUCTION

The English language M.Sc. program “Integrated Climate System Sciences” (ICSS) is part of the School of Integrated Climate System Sciences (SICSS) at the Universität Hamburg. It has been established at the Department of Earth Sciences within the Faculty of Mathematics, Informatics and Natural Sciences (MIN) in close collaboration with the Faculty of Economics and Social Sciences.

STRUCTURE

The M.Sc. degree program educates students in climate system sciences, integrating elements of atmospheric, hydrospheric, cryospheric and biospheric natural sciences with economics and social sciences. The program has a focus on physics, and offers specialization in three tracks: “Physics of the Climate System” (ICSS-P), “Biogeochemistry of the Climate System” (ICSS-B) and “Climate-related Economics and Social Sciences” (ICSS-ES). The three tracks represent core scientific and educational elements, integrating student education with cutting edge research. The focus on modelling is internationally unique.

OBJECTIVES

The M.Sc. program ICSS is research oriented and imparts knowledge and skills for climate research. Based on a solid background in climate physics, students will be prepared for a career in an interdisciplinary field of science. This includes the ability to communicate with colleagues from different disciplines, to apply a diverse suite of methods from various subject areas to climate-related research questions, as well as the generation, interpretation and combination of scientific results.

COURSE OF STUDIES

The two-year curriculum is subdivided into eleven modules. During the first semester a common foundation (research skills, mathematical and physical basics, functioning and variability of the climate system, principles of economic and social sciences) is established. The second semester is designed to broaden interdisciplinary knowledge; students are free to design their own individual tailor-made study plan. In the last two semesters in-depth knowledge in one of the three tracks is acquired. Personalized course guidance and counseling is available throughout the studies. Participation in the orientation unit for first semester students at the beginning of October is strongly recommended.

PERSPECTIVES

A master degree in “Integrated Climate System Sciences” is the basis for a subsequent career in science and research, continuing with a doctorate program. At the same time, it qualifies for a career as climate science communicator in international organizations, global enterprises and agencies. All courses listed in this handbook will be given in English and are in principle open for students of related M.Sc. programs, dependent on capacities and schedule. Please contact the lecturer.

Please note that this handbook is not legally binding and does not substitute the class schedule for the current semester, which is available on the internet and informs on lecture times and places, as well as on other changes. Additional information on the course of studies, credit points, and grading can be found in the SICSS Handbook for M.Sc. Students.

CONTACTS

SCHOOL OF INTEGRATED CLIMATE SYSTEM SCIENCES, SICSS

www.sicss.de
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Track-Coordinator Physics: Prof Dr. Johanna Baehr
Track-Coordinator Biogeochemistry: Prof. Dr. Lars Kutzbach
Track-Coordinator Economic and Social Sciences: Prof. Dr. Hermann Held

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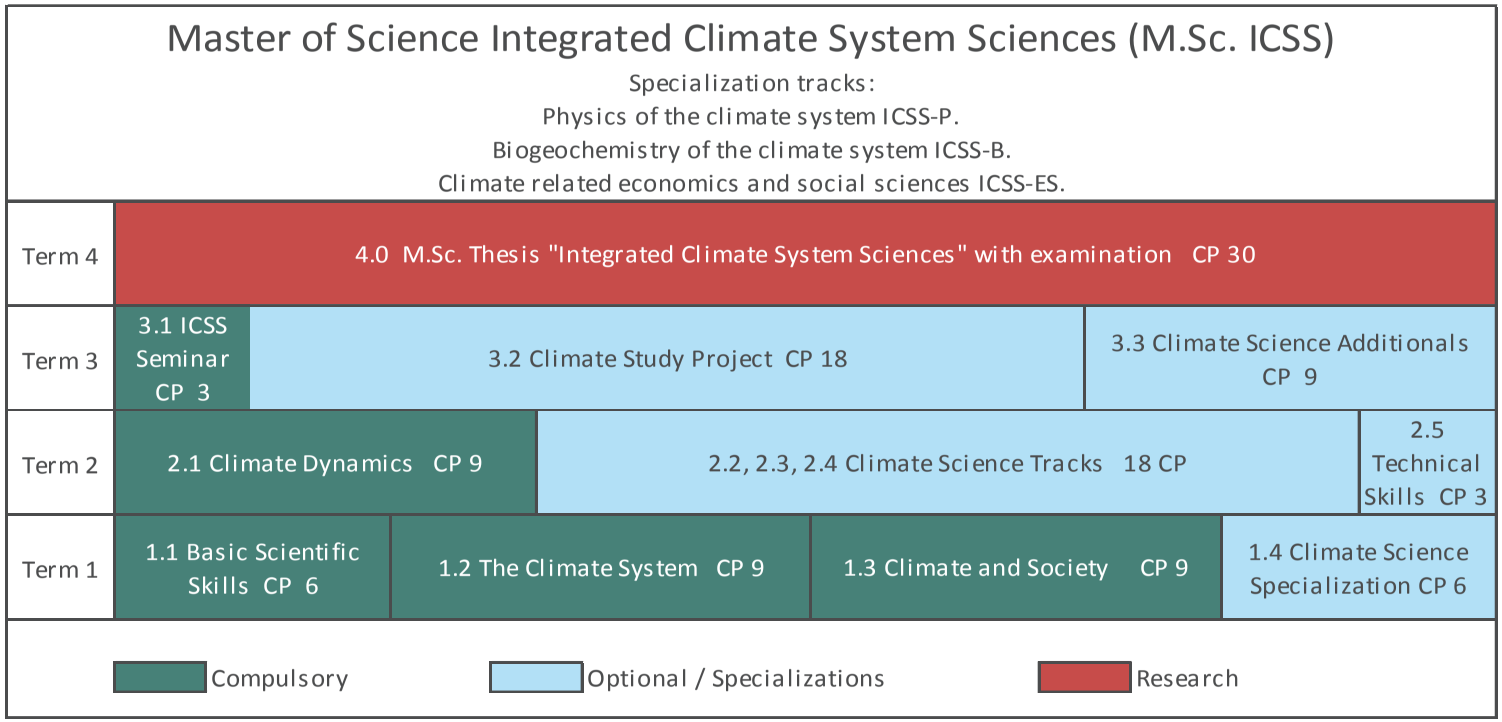
Master of Science Integrated Climate System Sciences (M.Sc. ICSS)
Specialization tracks:
Physics of the climate system ICSS-P.
Biogeochemistry of the climate system ICSS-B.
Climate related economics and social sciences ICSS-ES.
Term 4
4.0 M.Sc. Thesis "Integrated Climate System Sciences" with examination CP 30
Term 3
3.1 ICSS Seminar CP 3
3.2 Climate Study Project CP 18
3.3 Climate Science Additionals CP 9
Term 2
2.1 Climate Dynamics CP 9
2.2, 2.3, 2.4 Climate Science Tracks 18 CP
2.5 Technical Skills CP 3
Term 1
1.1 Basic Scientific Skills CP 6
1.2 The Climate System CP 9
1.3 Climate and Society CP 9
1.4 Climate Science Specialization CP 6
Compulsory
Optional / Specializations
Research

1. Semester

Module Abbreviation	1.1 CLIBASICS	
Title	**Basic Scientific Skills**	
Learning Outcomes	Students have been introduced to the concept of integrated climate research; they have gained knowledge in key disciplines of earth system sciences (physics, biology, geochemistry), as well as in applied mathematics (statistics and numerics) necessary for climate research. Students have been introduced to the fundamentals of generic research skills.	
Contents	Compulsory courses: 1.1.1 Basic Research Skills (NN) 1.1.2 Introduction to Statistics (Blender)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	See specific announcements for the individual courses	
Exam Framework	Type:	Joint module exam, as a rule: report. Deviations will be announced at the beginning of the courses.
	Requirements for registration:	none
	Language:	English
	Duration/Size:	Maximum 5 pages
Credit Points	6	
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule	
Semester	Semester 1 of M.Sc. ICSS; reference semester 1	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester, including a one-week block course in the first week of the lectures.	
Module Coordinator	Head of SCISS	

Course Number	ICSS-M-1.1.1 (63-901)	
Title	**Basic Research Skills**	
Learning Outcomes	Students have been introduced to the concept of integrated climate research; they have gained knowledge in key disciplines of earth system sciences (physics, biology, geochemistry), as well as in applied mathematics (numerical methods in climate research). Students have been introduced to generic research and technical skills.	
Contents	Introductory lectures on key disciplines of earth system sciences (physics, biology, geochemistry), introductory lectures on numerical methods in climate modelling, lectures on technical skills such as data acquisition and visualization, lectures on academic skills such as information and communication (academic writing and publication), working in libraries, good scientific practice and living, studying and working in an intercultural context.	
Educational Concept	Lectures (2 SWS), homework assignments	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Experienced knowledge of a word processing or typesetting system	
Exam Framework	Type:	Joint module exam
	Requirements for registration:	
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	0%
Credit Points	3	
Workload	Campus Study:	45 hours
	Self-study:	20 hours
	Exam Preparation:	25 hours
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 1 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Head of SICSS	
Course Lecturer(s)	K. Grannis, I. Harms and SICSS Lecturers	
Literature	Material will be provided during the course.	

Course Number	ICSS-M-1.1.2 (63-902)	
Title	**Introduction to Statistics**	
Learning Outcomes	Students know the basics of probability theory and the most important probability distribution functions. They are able to perform standard statistical analyses including hypothesis tests. The students are familiar with the basics of extreme value theory, time series analysis, and autoregressive processes.	
Contents	Probability theory, probability density functions, parameter estimation, hypothesis testing, extreme value statistics, analysis of time series, stochastic processes.	
Educational Concept	Lectures (2 SWS) including discussions, introduction to the statistical software R, practice in applications, problem solution in teams	
Language	English	
Formal Requirements for Participation	None	
Recommended Prerequisites	Unix on a basic level	
Exam Framework	Type:	Joint module exam
	Requirements for registration:	regular and active participation
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	100%
Credit Points	3	
Workload	Campus Study:	26 hours
	Self-study:	26 hours
	Exam Preparation:	38 hours
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 1 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Head of SICSS	
Course Lecturer(s)	C. Franzke	
Literature	Will be announced during the course	

Module Abbreviation	1.2 CLISYS	
Title	**The Climate System**	
Learning Outcomes	Students are familiar with the fundamental components of the physical and biogeochemical aspects of the climate system.	
Contents	Compulsory courses: 1.2.1 Physics of the Climate System (Baehr, Düsterhus) 1.2.2 Global Biogeochemical Cycles . . . (Hartmann, Kutzbach)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	See specific announcements for the individual courses	
Exam Framework	Type:	Joint module exam, as a rule: oral. Deviations will be announced at the beginning of the courses.
	Requirements for registration:	none
	Language:	English
	Duration/Size:	Maximum 60 minutes
Credit Points	9	
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule	
Semester	Semester 1 of M.Sc. ICSS; reference semester 1	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Physics, Track Coordinator Biogeochemistry	

Course Number	ICSS-M-1.2.1 (63-904)	
Title	**Physics of the Climate System**	
Learning Outcomes	Students have a basic understanding of the meteorological and oceanographic processes relevant for the mean state and variability of the climate system.	
Contents	Description of oceanic and atmospheric mean state, and circulation. Ocean – atmosphere interaction. Radiation Balance. Global Energy Budget and Transports. Thermohaline Circulation. Climate Variability from Decadal to Paleoclimatic timescales. Observations and Modeling of the Climate System.	
Educational Concept	Lectures (2 SWS) and exercises (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	Joint module exam
	Requirements for registration:	successful completion of exercises handed out in class
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	4,5	
Workload	Campus Study:	52 hours
	Self-study:	52 hours
	Exam Preparation:	31 hours
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 1 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Physics, Track Coordinator Biogeochemistry	
Course Lecturer(s)	J. Baehr, A. Düsterhus	
Literature	Will be announced during the course	

Course Number	ICSS-M-1.2.2 (63-905)	
Title	**Global Biogeochemical Cycles and the Climate System**	
Learning Outcomes	Students understand the processes controlling the major global cycles of biogeochemical matter between the atmosphere, ocean and land. The students know the interactions between biogeochemical processes and the climate system.	
Contents	Biogeochemical processes relevant on the global scale. This includes the explanation of hydrologic, atmospheric, extraterrestrial, geological, biological, and human causes environmental change on time scales of tens, thousands, and millions of years.	
Educational Concept	Lectures (3 SWS) and exercises (1 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	Joint module exam
	Requirements for registration:	successful completion of exercises handed out in class
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	4,5	
Workload	Campus Study:	52 hours
	Self-study:	52 hours
	Exam Preparation:	31 hours
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule. Maximum number of participants: 30 with preference for ICSS students	
Semester	Semester 1 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Physics, Track Coordinator Biogeochemistry	
Course Lecturer(s)	J. Hartmann, L. Kutzbach	
Literature	Will be announced during the course	

Module Abbreviation	1.3 CLISOC	
Title	**Climate and Society**	
Learning Outcomes	Students are familiar with the economic and social science basics and are able to apply this knowledge to climate related problems.	
Contents	Compulsory courses: 1.3.1 Climate Policy Scenarios: Economics, Integrative Assessments and Negotiations (Held, Köhl, Wolf) 1.3.2 Human-Environment Interactions and Climate Change: Security and Sustainability (Scheffran, Schneider) 1.3.3 Introduction to Social Sciences and Climate Communication (Brüggemann, Rödder)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	See specific announcements for the individual courses	
Exam Framework	Type:	Joint module examination, written or oral. The specific type will be announced at the beginning of the lectures.
	Requirements for registration:	Course specific
	Language:	English
	Duration/Size:	maximum 120 minutes (written), 45 minutes (oral)
Credit Points	9	
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule	
Semester	Semester 1 of M.Sc. ICSS; reference semester 1	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Economic and Social Sciences	

Course Number	ICSS-M-1.3.1	
Title	**Climate Policy Scenarios: Economics, Integrative Assessments and Negotiations**	
Learning Outcomes	Students have an overview on the economic foundation and evaluation of coupled climate-energy-economy scenarios, the inventory based determination of forest stocks and management scenarios aiming in-depth at one particular policy measure, and the structure and processes of intergovernmental negotiations.	
Contents	Principles of economic welfare theory such as the concept of utility functions, social preferences and social planner, fundamental theorems in welfare economics, types of market failure; climate-target oriented integrated assessment, derivation of costs of policy interventions; based on the IPCC Guidelines on AFOLU (Agriculture, Forestry and Other Land Use), GHG reporting within the UNFCCC process. This will be done by the example of negotiations on the crediting of GHG mitigation measures in the forestry sector and the forest based industries.	
Educational Concept	Interactive Lectures (1 SWS, October - December) and subsequent block seminar (1 SWS, March)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	Written exam
	Requirements for registration:	Participation in block seminar
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	32 hours
	Exam Preparation:	30 hours
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 1 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Economic and Social Sciences	
Course Lecturer(s)	H. Held, M. Köhl, A. Wolf	
Literature	Climate Change 2014 – Synthesis Report - Summary for Policymakers; IPCC Guidelines for National Greenhouse Gas Inventories (2006)	

Course Number	ICSS-M-1.3.2 (63-907)	
Title	**Human-Environment Interactions and Climate Change: Security and Sustainability**	
Learning Outcomes	Students have a fundamental understanding of human-environment interactions, are able to assess the societal impacts and conflicts of climate change and know the conceptual, normative and theoretical foundations of security and sustainability of resource use and public goods.	
Contents	Based on a framework of human-environment interactions in the Anthropocene, the complex relationship between climate change and socio-economic systems is assessed, with a focus on the security and sustainability dimensions. Factors and conditions of environmental change and resource conflicts are critically discussed, with a focus on the debate on climate change and human security, including water scarcity, food insecurity, flood and storm disasters and environmental migration in regional hot spots. The role of sustainable development in stabilizing human environment interactions is discussed. Starting with definitions and classifications of the sustainability concept, ethical schools and normative values are introduced as well as the role of market prices and non-market services; internalization of externalities and public goods. Historical and recent perspectives and development in security and sustainability are presented.	
Educational Concept	Lectures (2 SWS) with homework assignments	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	Written/oral examination
	Requirements for registration:	Homework assignments
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	32 hours
	Exam Preparation:	30 hours
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 1 of M.Sc. ICSS	

Frequency of Offer	Annually in the winter semester
Duration	1 semester
Module Coordinator	Track Coordinator Economic and Social Sciences
Course Lecturer(s)	J. Scheffran, U. Schneider
Literature	Will be announced during the course.

Course Number	ICSS-M-1.3.3 (63-908)	
Title	**Introduction to Social Sciences and Climate Communication**	
Learning Outcomes	Students have acquired an understanding of (a) the place of the social sciences within science, (b) key social science concepts in their application to science and (c) the role and dynamics of public and media communication about climate change, climate policy and climate science.	
Contents	This course clarifies the place of the social sciences within science in comparison to the natural sciences. It introduces key social science concepts such as social roles, norms, and organisation. The course will use the case of climate change communication as one particularly relevant example of science communication to present and discuss both, the logics of the mass media and the study of the interplay of scientists, journalists and other actors in public debates about climate change. A cross-cutting theme will be to introduce social-scientific reasoning and how this can contribute to an integrated study of climate change.	
Educational Concept	Interactive Lectures (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	Oral/Written report
	Requirements for registration:	1 research essay and 1 short oral presentation incl. handout
	Language:	English
	Duration/Size:	2 Assignments, 1500 words for the essay, 15 min presentation
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	26 hours
	Self-study:	26 hours
	Exam Preparation:	38 hours
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 1 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Economic and Social Sciences	
Course Lecturer(s)	M. Brüggemann, S. Rödder	
Literature	Will be announced during the course.	

Module Abbreviation	1.4 CLISPEC	
Title	**Climate Science Specialization**	
Learning Outcomes	Students have gained disciplinary knowledge in two special disciplines of the three tracks of climate science.	
Contents	2 courses (6 CP) have to be chosen: 1.4.1 Introduction to Numerical Approaches (Behrens) 1.4.2 Sea ice physics, observations and modelling (Notz) 1.4.3 Atmospheric Circulation Systems: Part I (Borth) 1.4.4 Chemistry of Natural Waters (Hartmann) 1.4.5 Aerosols (Langmann) 1.4.6 The Role of Biota in the Climate System (Hense) 1.4.7 Introduction to modelling concepts for terrestrial ecosystem dynamics (Beer) 1.4.8 Introduction to Social Sciences' Methods (Brüggemann, Guenther)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	See specific announcements for the individual courses	
Exam Framework	Type:	Course specific exams: Written or oral exam, or oral or written report; overall test or component testing. The specific type will be announced at the beginning of the courses. The grades will be averaged.
	Requirements for registration:	Course specific
	Language:	English
	Duration/Size:	maximum 90 minutes (written), 60 minutes (oral), 15 pages (written), 20 minutes (presentation)
Credit Points	6	
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule	
Semester	Semester 1 of M.Sc. ICSS; reference semester 1	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Track Coordinators	

Course Number	ICSS-M-1.4.1 (63-911)	
Title	**Introduction to Numerical Approaches**	
Learning Outcomes	Students are familiar with the fundamentals of numerical approaches used in geophysical and climate models. They know the underlying mathematical problem formulations, the principle of numerical discretization and understand the uncertainties of corresponding models. They know how to implement numerical methods in prototypical software.	
Contents	Introduction to numerical methods and concepts of accuracy/ uncertainty evaluation, introduction to floating point numbers, condition and stability, solution of linear systems, interpolation and approximation, discretization of differential equations (finite differences), interpolation, linear approximation, numerical quadrature, trigonometric interpolation, programming introduction in MATLAB scripting.	
Educational Concept	Lectures with practical parts (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Knowledge of linear algebra, calculus and basic knowledge of computer usage, including basic programming knowledge	
Exam Framework	Type:	Assignments during semester
	Requirements for registration:	active participation
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	50%
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	30 hours
	Exam Preparation:	20 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 1 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Track Coordinators	
Course Lecturer(s)	J. Behrens	
Literature	Will be announced during the course.	

Course Number	ICSS-M-1.4.2 (63-761)	
Title	**Sea ice physics, observations and modelling**	
Learning Outcomes	This course provides a hands-on introduction into the physics of sea ice and its interaction with the atmosphere and the ocean. The students will learn how sea-ice related processes are observed in situ and from satellite, and how these processes can be modeled numerically. They will gain experience in planning an observational campaign, analysing field and laboratory data, carrying out lab experiments, and presenting research findings.	
Contents	Overview of sea ice in the Earth System; the polar climate system; sea-ice dynamics and thermodynamics; snow on sea ice; techniques of in situ and remote sensing observations; modeling sea ice; analysing field and laboratory data.	
Educational Concept	Lectures and tutorials (4 SWS)	
Language	English	
Formal Requirements for Participation	None	
Recommended Prerequisites		
Exam Framework	Type:	Written exam
	Requirements for registration:	
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	6	
Workload	Campus Study:	56 hours
	Self-study:	64 hours
	Exam Preparation:	60 hours
Course Type and Usability	Elective for MSc ICSS; open for students of related MSc programs, dependent on capacities and schedule	
Semester	Semester 1 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 Semester	
Module Coordinator	Track Coordinators	
Course Lecturer(s)	D. Notz	
Literature	Will be announced during the course	

Course Number	ICSS-M-1.4.3 (63-916)	
Title	**Atmospheric Circulation Systems: Part I**	
Learning Outcomes	Students have an overview of basic physical concepts and processes explaining the structure and dynamics of planetary atmospheres, as well as a deeper understanding of selected examples.	
Contents	Important topics are: atmospheric environment, composition and structure; moist thermodynamics and the fluid parcel concept; circulation systems (waves, vortices and turbulence) in simple idealized atmospheres.	
Educational Concept	Lectures including discussions (2 SWS); exercises and worked examples (1 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	oral
	Requirements for registration:	active participation
	Language:	English
	Duration/Size:	20 minutes
	Weight Factor for Module Grade:	50%
Credit Points	3	
Workload	Campus Study:	39 hours
	Self-study:	21 hours
	Exam Preparation:	30 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 1 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Track Coordinators	
Course Lecturer(s)	H. Borth	
Literature	Will be announced during the course.	

Course Number	ICSS-M-1.4.4 (63-357)	
Title	**Chemistry of Natural Waters**	
Learning Outcomes	Students know about important processes that control the chemical composition of natural waters (surface waters and groundwaters).	
Contents	Basic hydrochemical background knowledge, including equilibrium thermodynamics, activity-concentration relationships, the carbonate system and pH control on the composition of waters, basic knowledge about clay minerals and cation exchange, organic compounds in natural waters, redox equilibria, redox conditions in natural waters, kinetics, weathering and water chemistry. The approach is to combine background theory (e.g. thermodynamics, carbonate system (CO_2), dissolution/precipitation of matter, physics of water-air gas exchange, etc.) with case studies from the literature.	
Educational Concept	Lectures (2 SWS). Discussion of representative examples	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Good knowledge of natural sciences.	
Exam Framework	Type:	will be announced at the beginning of the course
	Requirements for registration:	active participation
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	50%
Credit Points	3	
Workload	Campus Study:	26 hours
	Self-study:	42 hours
	Exam Preparation:	22 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule. Maximum number of participants: 25	
Semester	Semester 1 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Track Coordinators	
Course Lecturer(s)	J. Hartmann	
Literature	Will be announced during the course.	

Course Number	ICSS-M-1.4.5 (63-912)	
Title	**Aerosols**	
Learning Outcomes	Students know the role of aerosols in the climate system.	
Contents	The course about 'Aerosols' is subdivided in six main topics: • Introduction and terminology • Atmospheric aerosol sources • Impacts of aerosols on climate, visibility and human health • Mathematical description of aerosols: size distributions, formation and growth processes • Three-dimensional modeling • Observations: in-situ measurements, ground based and satellite based remote sensing Besides anthropogenic aerosols, natural aerosols. e.g. volcanic ash and sulfate will be discussed in detail.	
Educational Concept	Lectures, seminar, exercises (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	Exercises; an oral presentation will serve as a final examination.
	Requirements for registration:	active participation
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	50%
Credit Points	3	
Workload	Campus Study:	26 hours
	Self-study:	48 hours
	Exam Preparation:	16 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 1 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Track Coordinators	
Course Lecturer(s)	B. Langmann	
Literature	Will be announced during the course.	

Course Number	ICSS-M-1.4.6 (63-914)	
Title	**The Role of Biota in the Climate System**	
Learning Outcomes	Students are able to understand biologically-driven, climate-relevant processes and mechanisms. They are able to identify and describe feedback loops in which the biota plays an important role.	
Contents	In this lecture biological processes involved in climate-relevant mechanisms are explained. Biologically induced changes of different Earth System components (Hydrosphere, Atmosphere, Cryosphere and Lithosphere) are presented and the mechanisms involved in climate feedback loops are discussed. Examples of the different feedback loops are provided from both the marine and terrestrial systems.	
Educational Concept	Lectures (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	Will be announced at the beginning of the course
	Requirements for registration:	active participation
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	50%
Credit Points	3	
Workload	Campus Study:	26 hours
	Self-study:	48 hours
	Exam Preparation:	16 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 1 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Track Coordinators	
Course Lecturer(s)	I. Hense	
Literature	Will be announced during the course.	

Course Number	ICSS-M-1.4.7 (63-315)	
Title	**Concepts for modelling terrestrial ecosystem processes**	
Learning Outcomes	At the conclusion of the course students will be able to: Describe contemporary questions in Earth sciences for which modelling tools are a key to solutions. Understand different mathematical modelling concepts, and their limitations, and related types of information and data that scientists use to address questions in Earth sciences. Apply dynamic or statistical modelling to address a specific question in Earth sciences. Visualize and characterize observations and model results. Evaluate and discuss model results based on observations and uncertainty estimates.	
Contents	Many questions in Earth and environmental sciences today are about ecosystem dynamics at a large spatial scale or in the past or into the future. To address such questions, models need to be used to interpolate/extrapolate and interpret observations, or to perform theoretical experiments that are hardly possible in the field or laboratory. This course is an introduction into modelling concepts and individual steps in practice. Rather than providing a comprehensive overview of all kind of terrestrial ecosystem processes, in this course there will be a focus on modelling concepts using a few exemplary biogeochemical processes, such as heterotrophic respiration or gross primary production.	
Educational Concept	Lectures and exercises (2 SWS)	
Language	English	
Formal Requirements for Participation		
Recommended Prerequisites	Basic knowledge of terrestrial ecosystem processes	
Exam Framework	Type:	Written report about case study exercise
	Requirements for registration:	Active participation
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	28 hours
	Exam Preparation:	34 hours
Course Type and Usability	Elective for MSc ICSS; open for students of related MSc programs, dependent on capacities and schedule	

Semester	Semester 1 and 3 of M.Sc. ICSS
Frequency of Offer	Annually in the winter semester
Duration	1 Semester
Module Coordinator	Track Coordinators
Course Lecturer(s)	Prof. Dr. Christian Beer
Literature	Will be announced during the course

Course Number	ICSS-M-1.4.8 (63-910)	
Title	**Introduction to Social Sciences' Methods**	
Learning Outcomes	Students are familiar with the most common quantitative and qualitative research methodologies in the social sciences: interview, survey, participant observation and content analysis.	
Contents	The aim of this course is to introduce students with a background in natural sciences or geography to relevant quantitative and qualitative research methodologies in the social sciences: interview, survey, participant observation and content analysis. The course consists of short interactive lectures and a research exercise planned as a research internship in which the students pursue their own research questions, working with real data to gain some practical experience in data acquisition and analysis in the social sciences. The course will be held in several block lectures in the second half of the winter term (January). After the lectures, students will work on their own research projects and present findings at a small conference end of March.	
Educational Concept	Interactive Lecture with practical applications of methods (2 SWS)	
Language	English	
Formal Requirements for Participation	Concurrent participation in the course *Introduction to the social sciences* (*Course 1.3.3*)	
Recommended Prerequisites	none	
Exam Framework	Type:	Oral presentation and poster
	Requirements for registration:	1 oral presentation incl. handout and 1 poster
	Language:	English
	Duration/Size:	Research exercise, poster, 20 min presentation
	Weight Factor for Module Grade:	50%
Credit Points	3	
Workload	Campus Study:	26 hours
	Self-study:	26 hours
	Exam Preparation:	38 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 1 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Track Coordinators	
Course Lecturer(s)	M. Brüggemann, L. Guenther	
Literature	Will be announced during the course.	

2. Semester

Module Abbreviation	2.1 CLIDYN	
Title	**Climate Dynamics**	
Learning Outcomes	Students have gained in-depth knowledge in the dynamics of geophysical fluids, in particular the variability on various time scales.	
Contents	Compulsory courses: 2.1.1 Climate Dynamics (Marotzke) 2.1.2 Dynamical Palaeoclimatology (Claussen) 2.1.3 Uncertain 2 degrees (Baehr, Behrens, Brüggemann, Hense, Kutzbach, Rödder, Scheffran)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	See specific announcements for the individual courses	
Exam Framework	Type:	Joint module exam, as a rule: written exam. Deviations will be announced at the beginning of the courses
	Requirements for registration:	Course specific
	Language:	English
	Duration/Size:	maximum 120 minutes (written) or 45 minutes (oral)
Credit Points	9	
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule	
Semester	Semester 2 of M.Sc. ICSS; reference semester 2	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Physics	

Course Number	ICSS-M-2.1.1 (63-879)	
Title	**Climate Dynamics**	
Learning Outcomes	Students have a thorough understanding of the theoretical basics of climate dynamics, and know the art and science of constructing conceptual models of the climate system.	
Contents	Concepts and models are introduced that help us to understand fundamental aspects of the earth's climate, such as global mean temperature, global-scale temperature differences, and what might cause these to vary on timescales of decades and longer. Particular emphasis will be placed on oceanic and coupled ocean atmosphere processes. While we cover observed elements of the climate system and a hierarchy of models ranging from the simplest models to general circulation models, the focus will be on the art and science of constructing simplified models that help us obtain conceptual understanding. Discussing what is not understood, and hence identifying areas of current and future research, will be a crucial element of the course.	
Educational Concept	Lectures (2 SWS), homework assignments	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Basic calculus and differential equations; some introduction to atmospheric or oceanic science	
Exam Framework	Type:	Joint module exam
	Requirements for registration:	An overall grade of at least 50% in homework assignments
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	24 hours
	Self-study:	36 hours
	Exam Preparation:	30 hours
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. and Ph.D. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Physics	
Course Lecturer(s)	J. Marotzke	
Literature	Will be announced during the course.	

Course Number	ICSS-M-2.1.2 (63-863)	
Title	**Dynamical Palaeoclimatology**	
Learning Outcomes	Students know the distinction between externally forced climate variability and internal climate variability at time scales of centuries and longer.	
Contents	A brief overview of climate variations and climate change since the beginning of Earth some 4.6 billion years ago is given. Climate reconstructions from paleo records are physically interpreted by using conceptual and comprehensive climate system models. Precambrian: the snowball earth. Phanerozoic: effects of long-term plate tectonics and development of the biosphere. Mesozoic and early Cenozoic: greenhouse climate and Tertiary cooling. Quaternary: Ice ages, Milankovich cycles. Pleistocene: sub-Milankovich cycles. Holocene: interglacial climate, little ice age. Anthropocene: external greenhouse gas emissions, land-cover	
Educational Concept	Lectures (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	Joint module exam
	Requirements for registration:	Regular and active participation
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	42 hours
	Exam Preparation:	20 hours
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. and Ph.D. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Physics	
Course Lecturer(s)	M. Claussen	
Literature	Will be announced during the course.	

Course Number	ICSS-M-2.1.3 (63-921)	
Title	**Uncertain 2 Degrees**	
Learning Outcomes	After completing the seminar, students will be able to (i) reproduce the emergence of uncertainties in the context of climate research and climate policy and the views of various actors, (ii) understand the causes of different approaches to the problem of "uncertainty" and (iii) think through and develop alternative options for dealing with "uncertainty". Additionally, the students will train to empathize with different actors, to position themselves with regard to certain questions and to reflect their opinion and understanding critically.	
Contents	Uncertainties in the context of climate change have long since emerged from purely scientific consideration. Nowadays, uncertainties are of concern, and influence not only science but also journalism, politics and a broad public. In the course, students and teachers will jointly understand the various causes and the development of uncertainties, experience multi-perspectivity and illuminate and understand the handling and communication processes of the various actors.	
Educational Concept	Seminar (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	Joint module exam
	Requirements for registration:	80% participation at the seminar
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	50 hours
	Exam Preparation:	12 hours
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Physics	
Course Lecturer(s)	J. Behrens, M. Brüggemann, J. Baehr, I. Hense, L. Kutzbach, S. Rödder, J. Scheffran	
Literature	Will be announced during the course.	

Module Abbreviation	2.2 CLITRAC-P	
Title	**Climate Science Track Physics**	
Learning Outcomes	Students have gained detailed experience and are specialized in questions, methods and results in physical climate sciences.	
Contents	A maximum of 9 CP from the following courses will be accredited (contributing to the total of 18 CP that have to be accumulated out of module 2.2, 2.3 and 2.4): 2.2.1 Waves and Turbulence (Eden) 2.2.2 Waves and Turbulence Practicals (Czeschel, Griesel) 2.2.3 Advanced Numerical Methods . . . (Behrens) 2.2.4 Concepts of Climate Modeling (Baehr) 2.2.5 Weather and Climate Risk (Franzke) 2.2.6 Atmospheric Circulation Systems: Part II (Borth)	
Language	English	
Formal Requirements for Participation	See specific announcements for the individual courses	
Recommended Prerequisites	See specific announcements for the individual courses	
Exam Framework	Type:	Joint module exam, as a rule: oral. Deviations will be announced at the beginning of the courses
	Requirements for registration:	Course specific
	Language:	English
	Duration/Size:	Maximum 45 minutes (oral)
Credit Points	3, 6, or 9 are possible	
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule	
Semester	Semester 2 of M.Sc. ICSS; reference semester 2	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Physics	

Course Number	ICSS-M-2.2.1 (63-732)	
Title	**Waves and Turbulence**	
Learning Outcomes	Students will have obtained knowledge about the physical theoretical foundations of the spectrum of variability in the ocean (from periodic processes to mesoscale eddies to turbulence). They understand the fundamental mechanisms, their mathematical description and their treatment in ocean general circulation models.	
Contents	Sound, internal and planetary waves, propagation in variable environment, instability of waves. Three- and two-dimensional turbulence, generation and dissipation, energy and entropy cascades, relationship between turbulence and mixing, parameterization of turbulence in models.	
Educational Concept	Lectures (4 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	Joint track exam
	Requirements for registration:	Active participation
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	56 hours
	Self-study:	14 hours
	Exam Preparation:	20 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Physics	
Course Lecturer(s)	C. Eden	
Literature	Will be announced during the course.	

Course Number	ICSS-M-2.2.2 (63-733)	
Title	**Waves and Turbulence Practicals**	
Learning Outcomes	Students will have obtained in depth practical experience of solving common theoretical problems. They will understand the fundamental mechanisms and the mathematical description of ocean theory. They will gain experience about ocean general circulation models.	
Contents	Various wave solutions and their practical application of internal and planetary waves. Common problems of linear stability analysis and instability of waves. Mixing and parameterizations in ocean models.	
Educational Concept	Exercises (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	Joint track exam
	Requirements for registration:	Active participation
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	48 hours
	Exam Preparation:	14 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Physics	
Course Lecturer(s)	L. Czeschel, A. Griesel	
Literature	Will be announced during the course.	

Course Number	ICSS-M-2.2.3 (63-938)	
Title	**Advanced Numerical Methods for Climate Modeling**	
Learning Outcomes	Students have gained insight in advanced numerical methods for climate modeling, especially for conservation laws, efficient parallel solvers for large linear systems of equations, multi-level methods, etc.	
Contents	Introduction to numerical methods for the implementation of conservation laws: introduction to structure of conservation laws, finite volume methods, discontinuous Galerkin methods, finite element methods, advanced time integration schemes, issues in high performance computing. Parallel solution of large systems of linear equations: introduction to parallel architectures and HPC systems, iterative solution of large systems of equations: Krylov subspace methods, multi-level methods, efficient pre-conditioners.	
Educational Concept	Lectures, practical exercises (2 SWS)	
Language	English	
Formal Requirements for Participation	Regular participation in the course *Introduction to Numerical Approaches*.	
Recommended Prerequisites	Knowledge of mathematical concepts in ordinary and partial differential equations, basic knowledge of theoretical meteorology and/or oceanography	
Exam Framework	Type:	Joint track exam
	Requirements for registration:	Active participation
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	42 hours
	Exam Preparation:	20 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Physics	
Course Lecturer(s)	J. Behrens	
Literature	Will be announced during the course.	

Course Number	ICSS-M-2.2.4 (63-937)	
Title	**Concepts of Climate Modeling**	
Learning Outcomes	Students will have a basic understanding of the advantages and limitations of climate models, and their use to enhance our understanding of the climate system.	
Contents	Investigate the use of (components of) climate models. The analysis will be guided by questions posed by the instructor as well as the students themselves.	
Educational Concept	Lectures and tutorials (4 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	Joint track exam
	Requirements for registration:	Active participation
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	6	
Workload	Campus Study:	28 hours
	Self-study:	32 hours
	Exam Preparation:	30 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Physics	
Course Lecturer(s)	J. Baehr	
Literature	Will be announced during the course.	

Course Number	ICSS-M-2.2.6 (63-932)	
Title	**Weather and Climate Risk**	
Learning Outcomes	Students have learned the fundamental physics of extreme weather and climate events. They have an understanding of the socioeconomic aspects of weather and climate risks, especially the insurance and catastrophe modeling sectors. Students will learn about best practice how to communicate weather and climate risks to different stakeholders and the public.	
Contents	The course covers the physics of extreme weather and climate events, the basics of the insurance and catastrophe modeling sectors and weather derivatives through illustrative examples and case studies. In addition, the course covers risk communication.	
Educational Concept	Lectures (2 SWS).	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Knowledge of basic meteorology and climate dynamics	
Exam Framework	Type:	Joint track exam
	Requirements for registration:	Active participation
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	42 hours
	Exam Preparation:	20 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. and Ph.D. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Physics	
Course Lecturer(s)	C. Franzke	
Literature	Will be announced during the course.	

Course Number	ICSS-M-2.2.7 (63-931)	
Title	**Atmospheric Circulation Systems: Part II**	
Learning Outcomes	Students have gained a deeper insight into selected atmospheric circulation systems and acquire basic knowledge on global atmospheric circulation modeling.	
Contents	Important topics are: moist entropy and tropical circulation systems; potential vorticity and mid-latitude dynamics; atmospheric global circulation modeling; atmospheric transport	
Educational Concept	Lectures including discussions (2 SWS); exercises and worked examples (1 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Participation in the course *Atmospheric Circulation Systems: Part I*	
Exam Framework	Type:	Joint track exam
	Requirements for registration:	Active participation
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	39 hours
	Self-study:	21 hours
	Exam Preparation:	30 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Physics	
Course Lecturer(s)	H. Borth	
Literature	Will be announced during the course.	

Module Abbreviation	2.3 CLITRAC-B	
Title	**Climate Science Track Biogeochemistry**	
Learning Outcomes	Students have gained detailed experience and are specialized in questions, methods and results in biogeochemical climate sciences.	
Contents	A maximum of 9 CP from the following courses will be accredited (contributing to the total of 18 CP that have to be accumulated out of module 2.2, 2.3 and 2.4): 2.3.1 Soil, Water and Vegetation Processes and Their Coupling to the Atmosphere (Kutzbach, Knoblauch) 2.3.2 Dynamics of Marine Ecosystems (Hense) 2.3.3 Selected Topics of Marine Ecosystem Dynamics (Hense) 2.3.4 Soils and Land Use of Wetlands (Pfeiffer, Kutzbach) 2.3.5 Field Course on Soil-Atm. Coupling (Kutzbach, Knoblauch)	
Language	English	
Formal Requirements for Participation	See specific announcements for the individual courses	
Recommended Prerequisites	See specific announcements for the individual courses	
Exam Framework	Type:	Joint module exam, as a rule: oral. Deviations will be announced at the beginning of the courses
	Requirements for registration:	Course specific
	Language:	English
	Duration/Size:	Maximum 45 minutes (oral)
Credit Points	3, 6, or 9 are possible	
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule	
Semester	Semester 2 of M.Sc. ICSS; reference semester 2	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Biogeochemistry	

Course Number	ICSS-M-2.3.2 (63-313)	
Title	**Soil, Water and Vegetation Processes and Their Coupling to the Atmosphere**	
Learning Outcomes	Students have knowledge of the biogeochemical and biophysical processes in soils and the vegetation, and their interaction with the atmosphere. They will obtain a good scientific basis for both measurement- and model-based studies of the coupled processes of soils, vegetation and atmosphere.	
Contents	Atmospheric boundary layer characteristics, wind and turbulence mass and energy exchange; aeolian transport and deposition of elements; soil energy budget; soil water dynamics; plant- soil-microorganism interactions; soil organic matter processes, organic matter humification and mineralization, heterotrophic respiration; soil methane cycle: production, oxidation and soil- atmosphere transport mechanisms; lateral transport of carbon and nutrients; soil-vegetation-atmosphere water and carbon exchange processes, evapotranspiration, photosynthesis, autotrophic respiration; instrumentation for biometeorological measurements (e.g. closed chambers, eddy covariance method, isotope analyses).	
Educational Concept	Lectures with short group work exercises (2 SWS).	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Basic knowledge of soil science and/or plant ecophysiology and/or meteorology	
Exam Framework	Type:	Joint track exam
	Requirements for registration:	Active participation in exercises
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	32 hours
	Exam Preparation:	30 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Biogeochemistry	
Course Lecturer(s)	L. Kutzbach, C. Knoblauch	
Literature	Will be announced during the course.	

Course Number	ICSS-M-2.3.3 (63-942)	
Title	**Dynamics of Marine Ecosystems**	
Learning Outcomes	Students are able to understand and interpret spatial and temporal distribution patterns of marine ecosystem variables. This includes time series and distribution maps of biological and physico-chemical variables in the ocean. The students are able to identify and describe the underlying processes leading to the variability in the biological fields.	
Contents	In this lecture the factors and processes regulating marine primary production and transfer to higher trophic levels are explained. The spatial and temporal distribution patterns and variability in biological, nutrient and physical fields in the ocean are presented and the interaction between the biota and its physico-chemical environment is discussed. Examples include coastal regions, upwelling systems, fronts and oligotrophic oceans.	
Educational Concept	Lectures (2 SWS)	
Language	English	
Formal Requirements for Participation	Regular participation in the lecture courses *Physics of the Climate System* and *Global Biogeochemical Cycles and the Climate System*	
Recommended Prerequisites	Basic knowledge of physical oceanography and biogeochemical cycles	
Exam Framework	Type:	Joint track exam
	Requirements for registration:	Active participation
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	45 hours
	Exam Preparation:	17 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Biogeochemistry	
Course Lecturer(s)	I. Hense	
Literature	Will be announced during the course.	

Course Number	ICSS-M-2.3.4 (63-943)	
Title	**Selected Topics of Marine Ecosystem Dynamics**	
Learning Outcomes	Students are able to present scientific results from other people's work. They have become acquainted with state-of-the-art research topics in the field of biological oceanography/marine ecosystems. The students are able to identify the major gaps in current research.	
Contents	In this seminar topical papers from high-ranking peer reviewed journals in the field of biological oceanography and marine ecosystems are presented and discussed. The articles cover a wide range of topics and deal with recent advances made in research during the past five years.	
Educational Concept	Seminar (2 SWS)	
Language	English	
Formal Requirements for Participation	Concurrent participation in the course *Dynamics of Marine Ecosystems*.	
Recommended Prerequisites	Basic knowledge of physical oceanography and biogeochemical cycles	
Exam Framework	Type:	Joint track exam
	Requirements for registration:	>80% participation in the seminar
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	45 hours
	Exam Preparation:	17 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Biogeochemistry	
Course Lecturer(s)	I. Hense	
Literature	Will be announced during the course.	

Course Number	ICSS-M-2.3.5 (63-945)	
Title	**Soils and Land Use of Wetlands**	
Learning Outcomes	Students have gained knowledge about the genesis, properties and functions of hydromorphic soils of marshes and peatlands in the coastal lowlands of Northern Germany. They have developed their understanding of how landscape development, geomorphology, hydrology, and land use are interlinked with the diversity and distribution of wetland soils. The students are able to evaluate the ecological and economic functions of wetlands and their response to land use and climate changes.	
Contents	Landscape development of the coastal lowlands of Northern Germany; geologic processes during Pleistocene and Holocene; geomorphology of marshes and river floodplains; land use history, diking and agriculture; soils of tidal flats and different marsh types; soils and vegetation of bogs and fens; German, US and international soil classification systems; ecological and economic functions; impact of past and present land use and climatic changes.	
Educational Concept	3 full days of excursion and 0.5 day seminar, practical group-work (6-8 students each)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Basic knowledge of soil science	
Exam Framework	Type:	Joint track exam
	Requirements for registration:	Active participation, field protocol (5 pages)
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	35 hours
	Self-study:	30 hours
	Exam Preparation:	25 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually in the summer semester	
Duration	Block course	
Module Coordinator	Track Coordinator Biogeochemistry	
Course Lecturer(s)	E.-M. Pfeiffer, L. Kutzbach	
Literature	Will be announced during the course.	

Course Number	ICSS-M-2.3.6 (63-946)	
Title	**Field Course on Soil-Atmosphere Coupling**	
Learning Outcomes	Students advance their experience with soil-scientific field measurement campaigns, gas flux measurements and data analysis for investigating soil-vegetation-atmosphere interactions.	
Contents	Soil-scientific survey and description of reference soil profiles, soil gas concentration profile measurements, closed-chamber approach to measure land-atmosphere fluxes of trace gases, flux calculation, basic statistical data analysis.	
Educational Concept	Field (2 full days) and laboratory practice (0.5 day) plus seminar (1 full day).	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Basic knowledge about soil processes, e.g. through participation in course *Soil, water and vegetation processes and their coupling to the atmosphere*.	
Exam Framework	Type:	Joint track exam
	Requirements for registration:	Active participation, 80% presence at the seminar
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	30 hours
	Self-study:	30 hours
	Exam Preparation:	30 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually in the summer semester	
Duration	3-day block + 0.5-day block, both after the lecture period (or in the semester break) plus preparation meeting at beginning of semester	
Module Coordinator	Track Coordinator Biogeochemistry	
Course Lecturer(s)	L. Kutzbach, C. Knoblauch	
Literature	Literature recommendations will be given at the planning meeting.	

Module Abbreviation	2.4 CLITRAC-ES	
Title	**Climate Science Track Economic and Social Sciences**	
Learning Outcomes	Students have gained detailed experience and are specialized in questions, methods and results in economic and social climate sciences.	
Contents	A maximum of 9 CP from the following courses will be accredited (contributing to the total of 18 CP that have to be accumulated out of module 2.2, 2.3 and 2.4): 2.4.1a Energy Landscape and Climate Policy (Scheffran) 2.4.1 b Models of Human-Environment Interaction (Scheffran) 2.4.2 Estimating Sustainable Land Use (Schneider) 2.4.3 Agent-based Modelling – Theory and Applications in the Social Sciences (Scheffran, Hokamp) 2.4.4 Integrated Climate-Economic Modeling (Held) 2.4.5 Climate Communication (Brüggemann)	
Language	English	
Formal Requirements for Participation	See specific announcements for the individual courses	
Recommended Prerequisites	See specific announcements for the individual courses	
Exam Framework	Type:	Joint module exam, as a rule: oral. Deviations will be announced at the beginning of the courses
	Requirements for registration:	Course specific
	Language:	English
	Duration/Size:	Maximum 45 minutes (oral)
Credit Points	3, 6, or 9 are possible	
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule	
Semester	Semester 2 of M.Sc. ICSS; reference semester 2	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Economic and Social Sciences	

Course Number	ICSS-M-2.4.1a (63-951)	
Title	**Energy Landscape and Climate Policy**	
Learning Outcomes	The students have an understanding of the key factors and patterns in energy landscapes and climate policy on national and international levels, and are able to assess different energy pathways according to multiple criteria and strategies.	
Contents	Introduction to geographic, socio-economic and political aspects of energy landscapes, resources and technologies, including fossil, nuclear and renewable energy systems. Different assessment dimensions will be covered: energy security and sustainability; environmental impacts and CO2-emissions from energy production; climate change mitigation and adaptation strategies; comparison of energy and climate policy regimes and institutions; energy transformation and governance mechanisms.	
Educational Concept	Lectures (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	Joint track exam
	Requirements for registration:	Active participation
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	32 hours
	Exam Preparation:	30 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Every other year in the summer semester	
Duration	Block course	
Module Coordinator	Track Coordinator Economic and Social Sciences	
Course Lecturer(s)	J. Scheffran	
Literature	Will be announced during the course	

Course Number	ICSS-M-2.4.1b (63-954)	
Title	**Models of Human-Environment Interaction**	
Learning Outcomes	Students have achieved knowledge and basic skills about models and integrated frameworks of human-environment interaction, including major model types, computational means and software tools, and key phenomena at the intersection of human and natural systems.	
Contents	The lecture provides an introduction to models of human-environment interaction, relevant in integrative geography, complexity science, conflict research, climate and sustainability science. Overview of basic model types: dynamic systems and spatial models, statistical and probability models, complex adaptive systems and cellular automata, agent-based and network models, game theory, decision and optimization models, integrated assessment and world models. Instructive application areas will be used to demonstrate the relevance of models at the intersection of environmental and socio-economic systems, including climate change, energy, natural resources, sustainable development, environmental conflict and cooperation.	
Educational Concept	Lectures (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	Joint track exam
	Requirements for registration:	Active participation
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	32 hours
	Exam Preparation:	30 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Every other year in the summer semester	
Duration	Block course	
Module Coordinator	Track Coordinator Economic and Social Sciences	
Course Lecturer(s)	J. Scheffran	
Literature	Will be announced during the course	

Course Abbreviation	ICSS-M-2.4.3 (63-952)	
Title	**Estimating Sustainable Land Use**	
Learning Outcomes	Students will learn how to design, program, and apply an integrated assessment model for the investigation of sustainable land use pathways.	
Contents	Integrated agricultural sector analysis; Partial equilibrium modelling; Applied mathematical programming with GAMS (Numerical solution to constrained optimization problems); Environmental policy analysis (Internalization of ecosystem services); Weak and strong sustainability; Ecological guardrails; Dynamic optimization under uncertainty; Value of information;	
Educational Concept	Lectures with many hands-on exercises in computer lab	
Language	English	
Formal Requirements for Participation	Successful participation in "Introduction to GAMS" course	
Recommended Prerequisites	None	
Exam Framework	Type:	Written/oral report
	Requirements for registration for examination:	Participation in lectures and programming assignments
	Language:	English
	Duration/Size:	2 SWS in weekly lecture
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	32 hours
	Exam preparation:	30 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually in the summer semester	
Duration	1 Semester	
Module Coordinator	Track Coordinator Economic and Social Sciences	
Course Lecturer(s)	Prof. Uwe Schneider	
Literature	Draft Book "Forest and Agricultural Sector Analysis" available from instructor and contained literature references	

Course Number	ICSS-M-2.4.4 (63-953)	
Title	**Integrated Climate-Economic Modeling**	
Learning Outcomes	Students have an overview on integrated climate-economic modeling that supports an assessment of how, and by what policy instruments global warming could be mitigated.	
Contents	The status of the scientific arguments behind global warming mitigation targets and instruments is reviewed, covering competing schools within climate economics. The necessary modeling tools are introduced together with a module-adjusted short course on resource economics and economic growth theory.	
Educational Concept	Lectures (2 SWS) in an interactive format (interactive elements: discussion of homework; test exam and discussion)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Bachelor-level of applied mathematics, climate dynamics, an introduction to welfare economics, and scientific English.	
Exam Framework	Type:	Joint track exam
	Requirements for registration:	Active participation
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	32 hours
	Exam Preparation:	30 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Track Coordinator Economic and Social Sciences	
Course Lecturer(s)	H. Held	
Literature	Will be announced during the course	

Course Number	ICSS-M-2.4.5 (63-955)	
Title	**Climate Communication Research**	
Learning Outcomes	Students will have learned about current patterns and dynamics in the global debate on climate change: How do scientists, journalists and political actors interact and produce public communication about climate change? Why is the climate debate different in different media contexts and in different countries? By exploring these questions in small projects, students get an enhanced understanding of climate communication, of how to conduct qualitative content analysis and how to collaborate with students across disciplines.	
Contents	- Current research in the field of climate communication - The climate debate in different countries - Traditional ways of climate reporting and new types of outlets - How to do qualitative (and quantitative) content analysis	
Educational Concept	Seminar (2 SWS): Groups of students from journalism studies and from ICSS will work together on small research projects on climate communication, doing a content analysis of climate coverage in different countries or different kinds of news outlets.	
Language	English	
Formal Requirements for Participation	For ICSS students: prior attendance of the introduction into social sciences/climate communication (Brüggemann/Rödder) For Journalism students: having attended all classes due in the first semester of the MA JKW Other students (dependent on capacities): having attended an introduction into social science research, its approaches and methods; and a seminar on media/journalism	
Recommended Prerequisites	For ICSS students: Attendance of the introduction into methods in the social sciences (Brüggemann/Rödder)	
Exam Framework	Type:	Research report
	Requirements for registration:	-
	Language:	English
	Duration/Size:	-
	Weight Factor for Module Grade:	-
Credit Points	6	
Workload	Campus Study:	28 hours
	Self-study:	28 hours (JKW) – 56 hours (ICSS)
	Exam Preparation:	-
Course Type and Usability	Elective for M.Sc. ICSS; open for students from MA JKW; further programs: dependent on capacities	
Semester	Semester 2 of M.Sc. ICSS	

Frequency of Offer	Annually in the summer semester
Duration	1 semester
Module Coordinator	Track Coordinator Economic and Social Sciences
Course Lecturer(s)	Prof. Dr. Michael Brüggemann
Literature	Hoffman, Andrew J. (2015): How culture shapes the climate change debate. Stanford, California: Stanford University Press Contributions in: Oxford Encyclopedia of Climate Change Communication. URL: http://climatescience.oxfordre.com/page/climate-change-communication/

Module Abbreviation	2.5 CLITECH	
Title	**Technical Skills**	
Learning Outcomes	Students have gained working knowledge in tools used for scientific programming and data analysis or software development.	
Contents	2 courses have to be chosen: 2.5.1 Scientific Programming in Python I (Sadikni) 2.5.2 Scientific Programming in Python II (Sadikni) 2.5.3 Geographic Information Systems and Science (Heider) 2.5.4 MATLAB in Earth System Science (Borth, Schubert, Zhu) 2.5.5 Introduction to GAMS (Schneider) 2.5.6 Scientific Visualization Course (Brisc)	
Language	English	
Formal Requirements for Participation	See specific announcements for the individual courses	
Recommended Prerequisites	See specific announcements for the individual courses	
Exam Framework	Type:	Course specific exam (pass/fail), as a rule: practicals. Deviations will be announced at the beginning of the courses
	Requirements for registration:	>80% attendance of the courses
	Language:	English
	Duration/Size:	
Credit Points	3	
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule	
Semester	Semester 2 of M.Sc. ICSS; reference semester 2	
Frequency of Offer	Annually in the summer semester	
Duration	1 semester	
Module Coordinator	Head of SICSS	

Course Number	ICSS-M-2.5.2 (63-968)	
Title	**Scientific Programming in Python I**	
Learning Outcomes	Students have learned the programming language Python from scratch. They got in touch with common scientific libraries for analyzing and plotting geoscientific data.	
Contents	Introduction to Python: data types, control flow statements, data structures, functions, input / output, modules, errors and exceptions, classes. Introduction to scientific libraries like numpy, scipy and matplotlib. This course is designed for novice programmers and will focus on the basics of programming.	
Educational Concept	Lectures with practical training (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	Practicals pass/fail
	Requirements for registration:	Regular participation (> 80%)
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	1,5	
Workload	Campus Study:	28 hours
	Self-study:	17 hours
	Exam Preparation:	0 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually during the winter semester	
Duration	1 semester	
Module Coordinator	Head of SICSS	
Course Lecturer(s)	R. Sadikni	
Literature	Material will be provided.	

Course Number	ICSS-M-2.5.3 (63-968)	
Title	**Scientific Programming in Python II**	
Learning Outcomes	Students have learned the programming language Python from scratch. They got in touch with common scientific libraries for analyzing and plotting geoscientific data.	
Contents	Introduction to Python: data types, control flow statements, data structures, functions, input / output, modules, errors and exceptions, classes. Introduction to scientific libraries like numpy, scipy and matplotlib. This course is designed for novice programmers and will focus on the basics of programming.	
Educational Concept	Lectures with practical training (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	Practicals pass/fail
	Requirements for registration:	Regular participation (> 80%)
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	1,5	
Workload	Campus Study:	28 hours
	Self-study:	17 hours
	Exam Preparation:	0 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually during the winter semester	
Duration	1 semester	
Module Coordinator	Head of SICSS	
Course Lecturer(s)	R. Sadikni	
Literature	Material will be provided.	

Course Number	ICSS-M-2.5.4 (63-652)	
Title	**Geographic Information Systems and Science**	
Learning Outcomes	Students know basic GIS concepts, how to create, access and manage geodata and obtain a comprehensive overview to vector and raster related tools and analyses.	
Contents	This course gives a comprehensive overview to the fundamentals of Geographic Information Systems (GIS) and related scientific applications.	
Educational Concept	Lectures with practical training (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	Practicals pass/fail
	Requirements for registration:	regular and active participation
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	1,5	
Workload	Campus Study:	28 hours
	Self-study:	17 hours
	Exam Preparation:	0 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually during the lecture-free period	
Duration	1 week block course	
Module Coordinator	Head of SICSS	
Course Lecturer(s)	K. Heider	
Literature	Will be announced during the course.	

Course Number	ICSS-M-2.5.5 (63-963)	
Title	**MATLAB in Earth System Science: An Introduction**	
Learning Outcomes	Students can handle the basic operators as well as data and control structures of Matlab and apply those to typical simple problems of data manipulation and visualization in Earth System Science.	
Contents	The course offers an introduction to Matlab as a high-level programming language as well as an introduction to data streaming, analysis and visualization in Matlab with worked examples from Earth System Science	
Educational Concept	Seminar (1 SWS) and exercises (1 SWS). The course consists of lecture units, worked examples and hands-on exercises.	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Background in geosciences and some experience with structured problem solving typical for natural sciences. Basic knowledge of Linux will be helpful.	
Exam Framework	Type:	Practicals pass/fail
	Requirements for registration:	regular and active participation and a report for a worked example
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	1,5	
Workload	Campus Study:	25 hours
	Self-study:	10 hours
	Exam Preparation:	10 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually during the lecture-free period	
Duration	1 week block course	
Module Coordinator	Head of SICSS	
Course Lecturer(s)	H. Borth, S. Schubert, X. Zhu	
Literature	Tutorials, worked examples and documentation presented in the official MathWorks Documentation Center (www.mathworks.de -> support -> documentation -> matlab). Further literature or reading will be announced at the beginning of the course.	

Course Number	ICSS-M-2.5.6 (63-964)	
Title	**Introduction to GAMS (Generalized Algebraic Modeling System)**	
Learning Outcomes	Students have learned mathematical programming of optimization problems.	
Contents	Overview (capabilities, applicability, requirements, help); basic modelling (representation of mathematical problems, sets, data, variables, equations, conditions, model types, model solving, error detection and correction); output (interpretation, modification, option commands, report writing, export).	
Educational Concept	Exercises in computer lab (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	Practicals pass/fail
	Requirements for registration:	regular and active participation
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	1,5	
Workload	Campus Study:	20 hours
	Self-study:	25 hours
	Exam Preparation:	0 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually during the lecture-free period	
Duration	3 day block course	
Module Coordinator	Head of SICSS	
Course Lecturer(s)	U. Schneider	
Literature	B.A. McCarl, T.H. Spreen: Applied Mathematical Programming Using Algebraic Systems (http://agecon2.tamu.edu/people/faculty/mccarlbruce/books.htm).	

Course Number	ICSS-M-2.5.8 (63-965)	
Title	**Scientific Visualization Course**	
Learning Outcomes	Upon completion of the course, the students know: the latest techniques used in scientific visualization; hands-on ways to use visualization in research work, publications and presentations; where to locate further visualization resources.	
Contents	Overview of scientific visualization (history, goals, definitions): Color theory and color systems; data representation in scientific visualization (data types and formats, conversion tools, grids - structured and unstructured, scattered data); visualization software and resources; traditional and state-of-the-art visualization techniques; methods of effective use of visualization throughout the stages of research work; data analysis and visual communication; display methods and devices - from computer screen to virtual and immersive 3D worlds.	
Educational Concept	Lectures with practical training (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	Practicals pass/fail
	Requirements for registration:	>80% participation
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	1,5	
Workload	Campus Study:	28 hours
	Self-study:	17 hours
	Exam Preparation:	0 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 2 of M.Sc. ICSS	
Frequency of Offer	Annually during the lecture-free period	
Duration	1 week block course	
Module Coordinator	Head of SICSS	
Course Lecturer(s)	F. Brisc	
Literature	Material will be provided.	

3. Semester

Module Abbreviation	3.1 CLISEM	
Title	**Climate System Science Seminar**	
Learning Outcomes	Students are able to present aspects of their work in the study project to an audience with similar background but different specialization. Students have an overview of current topics and the state-of-the-art in integrated climate system sciences.	
Contents	Compulsory seminars: 3.1.1 Climate System Science Seminar (Eschenbach)	
Language	English	
Formal Requirements for Participation	Concurrent participation in module *Climate Study Project*	
Recommended Prerequisites	See specific announcements for the individual courses	
Exam Framework	Type:	Presentation and report
	Requirements for registration:	>80% attendance of the courses
	Language:	English
	Duration/Size:	Oral presentation of 20-30 minutes. Report of 3 to 5 pages (1000 to 1500 words).
Credit Points	3	
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule	
Semester	Semester 3 of M.Sc. ICSS; reference semester 3	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Head of SICSS	

Course Number	ICSS-M-3.1.1 (63-949)	
Title	**Climate System Science Seminar**	
Learning Outcomes	Students are able to present a concept of their work performed as part of the study project to an audience with similar background but different specialization.	
Contents	Seminar presentation and discussion on the pre-thesis work of the ICSS students.	
Educational Concept	Seminar event (1 SWS)	
Language	English	
Formal Requirements for Participation	Concurrent participation in courses *Climate Study Project* and *Scientific Writing*.	
Recommended Prerequisites	none	
Exam Framework	Type:	Presentation and report
	Requirements for registration:	regular and active participation
	Language:	English
	Duration/Size:	Oral Presentation of 20-30 minutes. Report of 3 to 5 pages (1000 to 1500 words).
	Weight Factor for Module Grade:	75% presentation and 25% report
Credit Points	3	
Workload	Campus Study:	14 hours
	Self-study:	76 hours
	Exam Preparation:	0 hours
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 3 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester, seminar in February	
Duration	1 semester, 3 day seminar event	
Module Coordinator	Head of SICSS	
Course Lecturer(s)	Eschenbach	
Literature		

Module Abbreviation	3.2 CLISTUDY	
Title	**Climate Study Project**	
Learning Outcomes	Students have gained the necessary background knowledge, as well as methodological, technical and writing skills to begin a master thesis in one of the three tracks.	
Contents	Compulsory courses: 3.2.1 Climate Study Project (Eschenbach) 3.2.2 Scientific Writing (Baehr, Kutzbach)	
Language	English	
Formal Requirements for Participation		
Recommended Prerequisites	See specific announcements for the individual courses	
Exam Framework	Type:	Report
	Requirements for registration:	
	Language:	English
	Duration/Size:	20-25 pages
Credit Points	18	
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule	
Semester	Semester 3 of M.Sc. ICSS; reference semester 3	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Head of SICSS	

Course Number	ICSS-M-3.2.1 (63-950)	
Title	**Climate Study Project**	
Learning Outcomes	Students are able to carry individual project studies related to climate system sciences.	
Contents	Projects related to integrated climate system sciences are being performed. Individual research with supervision by advisor in preparation of the M.Sc. thesis.	
Educational Concept	Theoretical and practical training (10 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	Report
	Requirements for registration:	regular and active participation
	Language:	English
	Duration/Size:	20-25 pages
	Weight Factor for Module Grade:	
Credit Points	15	
Workload	Campus Study:	360 hours
	Self-study:	90 hours
	Exam Preparation:	0 hours
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 3 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Eschenbach	
Course Lecturer(s)	Eschenbach and ICSS thesis advisors	
Literature	Will be announced during the project	

Course Number	ICSS-M-3.2.2 (63-966)	
Title	**Scientific Writing**	
Learning Outcomes	Students acquired science communication skills. They are able to concisely present (i) what they will do in their study project, (ii) why this specific research question/topic is of interest and (iii) how they will address the research question (which method they will use)	
Contents	The structure of a scientific paper will be presented; the most important ingredients of an abstract "what", "why", "how" will be elaborated. Students will prepare their own abstract, which will be discussed in class and revised afterwards.	
Educational Concept	Comments on oral presentations and written abstracts	
Language	English	
Formal Requirements for Participation	Participation and Homework.	
Recommended Prerequisites		
Exam Framework	Type:	report: pass/fail
	Requirements for registration:	Active participation, submission and presentation of homework
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	14 hours
	Self-study:	76 hours
	Exam Preparation:	0 hours
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 3 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Head of SICSS	
Course Lecturer(s)	J. Baehr, L. Kutzbach	
Literature	Will be announced during the course.	

Module Abbreviation	3.3 CLIADD	
Title	**Climate Science Additionals**	
Learning Outcomes	Students have sufficient specialization in one of the 3 tracks.	
Contents	3.3.1 Global Circulation and Climate (Stevens, Schmidt) 3.3.2 Predictability and Predictions of Climate (Baehr) 3.3.3 Urban Climatology (Schlünzen, Grawe) 3.3.4 The Asian Monsoon System (Zhu) 3.3.5 Tracer Transport Simulation Lab (Behrens) 3.3.6 Marine Biogeochemical and Ecosystem Modeling (Hense) 3.3.7 Climate Engineering – Carbon Dioxide Removal and Other Options (Amann) 3.3.8 Using the Eddy Covariance Method for Analyzing Land-Atmosphere Fluxes (Kutzbach, Rößger) 3.3.9 Permafrost Soils and Landscapes . . . (Beer, Kutzbach) 3.3.10 Application of Stable Isotopes . . . (Knoblauch) 3.3.11 Terrestrial Ecosystem Processes within ESMs (Brovkin) 3.3.12 Microeconomics (Perino) 3.3.13 Integrated Assessment Modelling of Global Change (Held, Hokamp) 3.3.14 Decision under Uncertainty in the Integrated Assessment of the Energy-Climate Problem (Held) 3.3.15 Climate Policy: Actors, Institutions, Instruments (Aykut)	
Language	English	
Formal Requirements for Participation	See specific announcements for the individual courses	
Recommended Prerequisites	See specific announcements for the individual courses	
Exam Framework	Type:	Course specific: Written or oral; oral or written report; overall test or component testing. The specific type will be announced at the beginning of the courses
	Requirements for registration:	Course specific
	Language:	English
	Duration/Size:	Course specific
Credit Points	9	
Course Type and Usability	Compulsory for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule	
Semester	Semester 3 of M.Sc. ICSS; reference semester 3	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	SICSS Track Coordinators	

Course Number	ICSS-M-3.3.1 (63-952)	
Title	**Global Circulation and Climate**	
Learning Outcomes	Students will develop a structured way of thinking about climate model errors in general, will become familiar with typical model deficiencies, and basic concepts of climate science related to them.	
Contents	Current global climate models agree well on several aspects of the climate system, but they also show disconcerting biases in other areas that put into question their ability to predict climate changes with sufficient regional detail for reliable impact studies and the planning of adaptation measures. These model biases challenge our understanding of the functioning of the climate system, which should be represented in the models. Inspired by biases in the climate models developed and operated at the Max Planck Institute for Meteorology we will focus, in this lecture, on roughly six different areas where models have biases or disagree in their responses to forcings, among them stability in the tropical upper troposphere, boundary layer clouds, sea surface temperatures in the tropics, the high latitude lower stratosphere, the oceanic meridional overturning circulation, and the surface pressure distribution. We will review the theory behind phenomena relevant for these issues, potential consequences for global circulation, and approaches to improve the model performance.	
Educational Concept	Lecture	
Language	English	
Formal Requirements for Participation	None	
Recommended Prerequisites	Bachelor in Meteorology or related subject	
Exam Framework	Type:	Written exam
	Requirements for registration:	Participation in at least 2/3 of the lectures
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	50 hours
	Exam Preparation:	12 hours
Course Type and Usability	Elective for MSc ICSS; open for students of related MSc programs, dependent on capacities and schedule	

Semester	Semester 2. of M.Sc. ICSS
Frequency of Offer	To be decided
Duration	1 Semester
Module Coordinator	Track Coordinators
Course Lecturer(s)	B. Stevens, H. Schmidt
Literature	Will be provided during lectures

Course Number	ICSS-M-3.3.2 (63-741)	
Title	**Predictability and Predictions of Climate**	
Learning Outcomes	Students will be familiar with the techniques used to investigate predictability and the methods used to make predictions of climate variability at seasonal to decadal timescales with a focus on coupled ocean-atmosphere processes.	
Contents	Introduction to predictability of climate; Lorenz model; determination of predictability; ensemble forecasting; forecast initialization; ensemble initialization; error propagation and assessment of forecast reliability/ quality; present understanding of the processes that determine predictability; seasonal to decadal predictions of the climate system.	
Educational Concept	Lectures and research seminar (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	Will be specified at the beginning of the course
	Requirements for registration:	regular and active participation
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	32 hours
	Exam Preparation:	30 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 3 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	SICSS Track Coordinators	
Course Lecturer(s)	J. Baehr	
Literature	Palmer and Hagedorn (Eds.), 2006: Predictability of weather and climate. Additional literature will be announced during the course	

Course Number	ICSS-M-3.3.3 (63-835)	
Title	**Urban climatology**	
Learning Outcomes	Students participating in this course will learn the factors that influence climate in the urban area and can assess the potential of adaptation strategies for climate change on the urban scale. After attending this course, students have acquired solid specialist knowledge which improves their employability and facilitates the choice of a topic for the master thesis.	
Contents	The lecture teaches micro-meteorological specialist knowledge using practical questions of the field of urban climatology as examples. The course explains the special features of the urban boundary layer and of the urban micro climate as well as transport processes within and above the roughness sublayer. Urban modifications of the fluxes of momentum, energy, humidity and trace gases are illustrated. The lecture further conveys the meteorological assessment of possible adaptation strategies to climate change.	
Educational Concept	Lecture with exercises	
Language	English (German if agreed by all participants)	
Formal Requirements for Participation	None	
Recommended Prerequisites	None	
Exam Framework	Type:	Written exam
	Requirements for registration:	none
	Language:	English (German answers allowed)
	Duration/Size:	90 minutes
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	30
	Self-study:	40
	Exam Preparation:	20
Course Type and Usability	This course is part of the MSc Meteorology. It is also suitable for students of other subjects with a mathematical or physical basis.	
Semester	Semester 3. of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester.	
Duration	1 Semester	
Module Coordinator	Track Coordinators	
Course Lecturer(s)	Prof. Heinke Schlünzen, David Grawe	
Literature	Included in the lecture notes.	

Course Number	ICSS-M-3.3.4 (63-885)	
Title	**The Asian Monsoon System**	
Learning Outcomes	Students have developed an understanding of characteristics of the Asian monsoon and the related dynamical systems and mechanisms. Specifically, they have developed a holistic view of the monsoon system in the context of global climate systems, in particular, regarding its interaction with other large-scale climate modes (ENSO, MJO). Students are able to calculate various monsoon indices and identify the related characteristic circulation patterns from reanalysis data or numerical model outputs.	
Contents	Monsoon definitions; circulation characteristics, centers of action, and related thermal-dynamical processes of the Asian (summer and winter) monsoon systems; key elements of the Asian Monsoon (AM) systems such as the Tibetan Plateau topographic forcing; literature review on the AM and the Tibetan uplift; interaction of the AM with climate modes like ENSO and MJO (Madden-Julian Oscillation) and its evolution in a warmer climate.	
Educational Concept	Lectures (2 SWS)	
Language	English	
Formal Requirements for Participation	Successful participation in the course *Introduction to Statistics*.	
Recommended Prerequisites	none	
Exam Framework	Type:	Will be specified at the beginning of the course
	Requirements for registration:	regular and active participation
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	32 hours
	Exam Preparation:	30 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 3 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	SICSS Track Coordinators	
Course Lecturer(s)	X. Zhu	
Literature	Will be announced during the course.	

Course Number	ICSS-M-3.3.5 (63-954)	
Title	**Tracer Transport Simulation Lab**	
Learning Outcomes	The students hold experiences with tracer transport modeling, including knowledge about the numerical schemes, hands-on experience with passive transport algorithms, programming and visualization.	
Contents	Lecture chapters on: • introduction to the underlying equations and short recapitulation of corresponding numerical schemes • mathematization and discretization of passive geophysical tracer transport • introduction to reacting tracer transport (advection-reaction-diffusion-equation) and corresponding numerical schemes • introduction to the time-discretization of stiff systems of differential equations • practical implementation of simple 1D and 2D methods for tracer transport • issues in data acquisition, simulation management, and visualization • advanced issues: conservation properties, adaptive methods for multi-scale phenomena, including adaptive mesh refinement	
Educational Concept	Lectures and practical training (2 SWS)	
Language	English	
Formal Requirements for Participation	Successful completion of the courses 1.1.4 “Introduction to Numerical Approaches”, and 2.2.3 “Advanced Numerical Methods for Climate Modelling” or similar	
Recommended Prerequisites	Some experience in programming	
Exam Framework	Type:	Written report
	Requirements for registration:	Active participation
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	6	
Workload	Campus Study:	28 hours
	Self-study:	40 hours
	Exam Preparation:	20 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 3 of M.Sc. ICSS	

Frequency of Offer	Bi-Annually in the winter semester
Duration	First half of the semester
Module Coordinator	SICSS Track Coordinators
Course Lecturer(s)	J. Behrens
Literature	Will be announced during the course

Course Number	ICSS-M-3.3.6 (63-954)	
Title	**Marine Biogeochemical and Ecosystem Modeling**	
Learning Outcomes	Students are able to use the "modelling language", to select the most appropriate methods and approaches for a number of specific applications, to formulate simple ecosystem models, to analyze and present the results. They have learned to identify and evaluate model strengths and weaknesses.	
Contents	The basics of model structures are explained, including factors and processes which are generally considered in aquatic ecosystem and biogeochemical models. Focus will be on plankton dynamics: growth and mortality processes of phyto- and zooplankton. Examples of biogeochemical models based on carbon and nitrogen are presented.	
Educational Concept	Lectures (1 SWS), exercises (1 SWS), seminars (2 SWS)	
Language	English	
Formal Requirements for Participation	Good knowledge of a programming language and a visualization tool. Successful completion of the course *Dynamics of Marine Ecosystems*, or individual permission by the lecturer	
Recommended Prerequisites	Basic knowledge in ecosystem dynamics and theoretical ecology	
Exam Framework	Type:	Will be specified at the beginning of the course
	Requirements for registration:	>80% participation in the weekly exercises and seminars
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	6	
Workload	Campus Study:	64 hours
	Self-study:	90 hours
	Exam Preparation:	26 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 3 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	First half of the semester	
Module Coordinator	SICSS Track Coordinators	
Course Lecturer(s)	I. Hense	
Literature	Will be announced during the course	

Course Number	ICSS-M-3.3.7 (63-958)	
Title	**Climate Engineering - Negative emission technologies and other options**	
Learning Outcomes	The goal of this lecture is to become acquainted with options to actively remove CO_2 from the atmosphere, as they grow more important in the climate change discourse.	
Contents	Climate engineering, the deliberate and large-scale intervention in the Earth's climatic system, has been in discussion as an option to battle climate change for a few years now. This lecture will address this highly topical issue by introducing several options that are envisioned to be potentially deployed, with a clear focus on negative emission technologies. Strategies for solar radiation management will be presented briefly. Benefits and side effects from local to global scales will be shown for matter and energy fluxes. At the same time, the matter is highly controversial on an ethical level. Issues like governance, moral hazard and intergenerational justice will be succinctly addressed.	
Educational Concept	Lectures (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Basic understanding of the carbon cycle and the biogeochemical processes involved.	
Exam Framework	Type:	written exam
	Requirements for registration:	regular and active participation
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	31 hours
	Exam Preparation:	31 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 3 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	SICSS Track Coordinators	
Course Lecturer(s)	T. Amann	
Literature	Will be announced during the course	

Course Number	ICSS-M-3.3.8 (63-321)	
Title	**Using the Eddy Covariance Method for Analyzing Land- Atmosphere Fluxes**	
Learning Outcomes	Students have gained knowledge about the theoretical basics of the micrometeorological eddy covariance approach. They have learned how an eddy covariance flux measurement system is set-up and maintained, and how the data is recorded. They will be able to handle and process the complex and massive rawdata streams to derive the energy and matter fluxes. They obtain competence to apply the micrometeorological eddy covariance approach for the analysis of soil- vegetation- atmosphere fluxes of energy, water and carbon on the landscape scale.	
Contents	Introduction to the micrometeorological eddy covariance theory; requirements for instrumentation and measurement site; set-up and maintenance of an eddy covariance flux measurement system; introduction to the flux calculation software EdiRe; basic flux calculation from rawdata streams; flux corrections; data visualization; quality control; application of eddy covariance data for the investigation of land- atmosphere exchange fluxes of energy, water and carbon.	
Educational Concept	Seminar (1 SWS), exercises including a field trip (1 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Basic knowledge of boundary layer meteorology.	
Exam Framework	Type:	Written report
	Requirements for registration:	regular and active participation
	Language:	English
	Duration/Size:	4 pages
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	36 hours
	Exam Preparation:	26 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 3 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	SICSS Track Coordinators	
Course Lecturer(s)	L. Kutzbach, N. Rößger	
Literature	Will be announced during the course	

Course Number	ICSS-M-3.3.9 (63-319)	
Title	**Permafrost Soils and Landscapes in the Climate System**	
Learning Outcomes	The students will have knowledge about permafrost landscapes, soils and vegetation and their role in the climate system. A focus will be set on periglacial and cryopedogenetic processes, and related observation and modelling techniques. The students have improved their understanding of environmental and climatic changes in the arctic region. They have obtained competence for the evaluation of ecosystem functions and resources of permafrost landscapes.	
Contents	High-latitude terrestrial processes in periglacial landscapes; permafrost and active layer processes; soils of different permafrost landscapes; cryosols in the international soil classifications; patterned-ground processes, frost-action processes, cryoturbation; tundra vegetation, boreal forests and peatlands, tree- and shrubline dynamics; carbon in permafrost soils and sediments; role of high-latitude terrestrial systems in the global climate system; impact of climate and land use change on arctic and boreal ecosystems and permafrost soils; observational versus model results of permafrost changes due to climate change; land-atmosphere feedbacks specific to permafrost landscapes.	
Educational Concept	Lectures (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Basic knowledge of soil science	
Exam Framework	Type:	Written exam
	Requirements for registration:	regular and active participation
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	60 minutes
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	36 hours
	Exam Preparation:	26 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 3 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	SICSS Track Coordinators	
Course Lecturer(s)	C. Beer, L. Kutzbach	
Literature	Will be announced during the course	

Course Number	ICSS-M-3.3.10 (63-322)	
Title	**Application of Stable Isotopes in Terrestrial Ecosystems**	
Learning Outcomes	Students will be familiar with the potential of stable isotope measurements for studying element fluxes in terrestrial ecosystems. They will be able to interpret natural carbon isotope signatures in soils, vegetation and the climate relevant trace gases CO and methane. They will also be able to use ^{13}C-tracers for quantifying carbon turnover of different carbon pools in the environment.	
Contents	Introduction to the fundamentals of stable isotope biogeochemistry. Laboratory experiments for quantifying carbon fluxes in the environment, based on natural abundance measurements and isotope tracers. Calculation of CO_2 and methane-fluxes from different carbon pools.	
Educational Concept	Practical laboratory course complemented by introductory lectures and exercises on data analysis (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Fundamental biogeochemical knowledge	
Exam Framework	Type:	Will be announced at the beginning of the course
	Requirements for registration:	regular and active participation
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	47 hours
	Exam Preparation:	15 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule. Maximum number of participants: 10	
Semester	Semester 3 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	SICSS Track Coordinators	
Course Lecturer(s)	C. Knoblauch	
Literature	Sharp, Z., 2007. Principles of stable isotope geochemistry. Pearson Prentice Hall, Upper Saddle River. Hoefs, J. (2008). Stable isotope geochemistry. Springer, Berlin. Further literature will be announced during the course.	

Course Number	ICSS-M-3.3.11 (63-959)	
Title	**Land Processes and Carbon Feedbacks in the Earth System Models**	
Learning Outcomes	Students have theoretical knowledge and practical skills in terrestrial ecosystem modeling and feedbacks between vegetation and climate and understand and are able to utilize terrestrial biosphere models used for future climate projections.	
Contents	The course starts with introduction into main biological and biophysical processes: photosynthesis, land surface hydrology and biophysics, carbon cycle, and plant ecology. The main focus is given on current state-of-the-art in modeling of these processes within Earth System models. Examples of topics include modeling of landuse effects on terrestrial ecosystem and biogeochemistry; modeling of vegetation dynamics under changed climate; assessment of feedbacks between terrestrial ecosystems and climate on multiple spatial and temporal scales. Biogeophysical and biogeochemical effects of land cover and landuse change are analyzed for future climate as well for several chosen paleo climates.	
Educational Concept	Lectures (2 SWS) and practical exercises (1 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Basic knowledge of biological processes; basic skills in programming on Python, R, or MatLab for solving simple equilibrium or dynamical system equations.	
Exam Framework	Type:	oral
	Requirements for registration:	regular and active participation
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	42 hours
	Self-study:	32 hours
	Exam Preparation:	16 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 3 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	SICSS Track Coordinators	
Course Lecturer(s)	V. Brovkin	
Literature	Will be announced during the course	

Course Number	ICSS-M-3.3.12 (23-36.905.142)	
Title	**Microeconomics**	
Learning Outcomes	Students have learned the tools to understand and conduct applied microeconomic analysis.	
Contents	This course covers key concepts in the areas of consumer and producer theory, market equilibria, welfare analysis and game theory. It provides both intuition and formal treatment of standard microeconomic theory supplemented by insights from behavioral economics.	
Educational Concept	Lectures (2 SWS) and Practical (1 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Familiarity with basic microeconomic concepts and simple analytical optimization techniques	
Exam Framework	Type:	Written exam
	Requirements for registration:	none
	Language:	English
	Duration/Size:	60 minutes
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	42 hours
	Self-study:	120 hours
	Exam Preparation:	18 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 3 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	SICSS Track Coordinators	
Course Lecturer(s)	G. Perino	
Literature	Gravelle, H. and R. Rees, 2004, Microeconomics, 3rd ed. Pearson; Bowles, S., 2006, Microeconomics: Behavior, Institutions, and Evolution, Princeton University Press	

Course Number	ICSS-M-3.3.13 (63-961)	
Title	**Integrated Assessment Modelling of Global Change**	
Learning Outcomes	Students have gained a general understanding of integrated assessment models of global change.	
Contents	The seminar provides an introduction to integrated assessment modelling of global change. The course considers climate engineering, Negishi-weighting and delayed climate policy with a view to their implementation in the integrated assessment models DICE, RICE, MIND and REMIND.	
Educational Concept	Seminar (2 SWS)	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	Bachelor-level of applied mathematics and scientific English. Prior knowledge of programming is not required but highly recommended.	
Exam Framework	Type:	Oral presentation and written report
	Requirements for registration:	≥80% participation in the seminar
	Language:	English
	Duration/Size:	1 hour presentation, 10-15 pages written report
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	32 hours
	Exam Preparation:	30 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 3 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	SICSS Track Coordinators	
Course Lecturer(s)	H. Held, S. Hokamp	
Literature	Will be announced during the course	

Course Number	ICSS-M-3.3.14 (22-31.000)	
Title	**Decision under Uncertainty in the Integrated Assessment of the Energy- Climate Problem**	
Learning Outcomes	Students will have obtained the pre-requisites to start a master thesis within climate-economic modeling that is dealing with mitigation, impact or adaptation issues under system response uncertainty. This includes a treatment of uncertainty and interpretation of model results. The outcomes of and the key assumptions behind some major modeling assessments within the climate policy arena will have been obtained during the course.	
Contents	Treatment of uncertainty in climate-economic modeling with respect to climate and the techno-economic system properties as well as global warming impacts. In-depth discussion of model assumptions including underlying theories within macroeconomics as well as climate science and land use economics. Treatment of uncertainty including stylized decision under (predominantly epistemic) uncertainty, made up by uncertain system properties/model parameters.	
Educational Concept	Interactive lectures (4 SWS)	
Language	English	
Formal Requirements for Participation	Successful completion of the course Integrated Climate-Economic Modeling or Master of Economics course Climate dynamics and climate economics or individual permission by the lecturer.	
Recommended Prerequisites	Bachelor-level of applied mathematics and scientific English.	
Exam Framework	Type:	Will be announced at the beginning of the course
	Requirements for registration:	regular and active participation
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	6	
Workload	Campus Study:	56 hours
	Self-study:	64 hours
	Exam Preparation:	60 hours
Course Type and Usability	Elective for M.Sc. ICSS; open for students of related M.Sc. programs, dependent on capacities and schedule.	
Semester	Semester 3 of M.Sc. ICSS	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	SICSS Track Coordinators	
Course Lecturer(s)	H. Held	
Literature	Will be announced during the course	

Course Number	ICSS-M-3.3.15 (24-204.14)	
Title	**Climate Policy: Actors, Institutions, Instruments**	
Learning Outcomes	The central learning outcome of the course is to enable students to understand the evolution, dynamic and specificities of climate policy as a field of public policy, as well as its relation to and inheritances from other, adjacent policy domains. The focus is on the global and European levels.	
Contents	Since the 1990s, climate policy has progressively evolved into a policy domain with its own dynamic, institutions, instruments and actor coalitions. While institution-building at the global and European levels (UNFCCC, Kyoto Protocol and Paris agreement, EU Directorate-General for Climate Action) indicates an increasing autonomy of the field, climate policy is also characterized by path-dependences from adjacent policy domains, such as technological and cognitive lock-ins in energy policy, or existing actors coalitions in environmental policy. Drawing on examples from the European and global levels, the course will analyze the historical evolution and shaping of climate policy, with a focus on actors, instruments and framings. We will also discuss the paradoxes and failures of climate policy, as well as the intrinsic difficulties to effectively regulate global climate change.	
Educational Concept	The course combines readings, empirical examples from my own research, presentations and discussion formats, in which current evolutions in climate policy are analyzed through the prism of the academic literature.	
Language	English	
Formal Requirements for Participation	none	
Recommended Prerequisites	none	
Exam Framework	Type:	Short presentation, handout *and* term paper (Hausarbeit).
	Requirements for registration:	active participation
	Language:	English
	Duration/Size:	
	Weight Factor for Module Grade:	
Credit Points	3	
Workload	Campus Study:	28 hours
	Self-study:	42 hours
	Exam Preparation:	110 hours
Course Type and Usability		

Semester	Semester 3 of M.Sc. ICSS
Frequency of Offer	Annually in the winter semester
Duration	1 semester
Module Coordinator	SICSS Track Coordinators
Course Lecturer(s)	Prof. Dr. Stefan C. Aykut
Literature	J Vogler, Climate Change in World Politics, Palgrave, 2016 EL Boasson, J Wettestad, EU Climate Policy. Industry, Policy Interaction and External Environment, Routledge, 2013

4. Semester

Module Abbreviation	4.0 CLITHESIS	
Title	**M.Sc. Thesis "Integrated Climate System Sciences"**	
Learning Outcomes	The graduate has demonstrated the ability to prepare and to present an innovative M.Sc. thesis in a specific disciplinary or interdisciplinary field of climate system sciences.	
Contents	Practical work, writing the master thesis and oral presentation of the master thesis [ICSS thesis advisors; 30 CP]	
Language	English	
Formal Requirements for Participation	Completion of 60 CP of the M.Sc. ICSS	
Recommended Prerequisites	See specific announcements for the individual courses	
Exam Framework	Type:	M.Sc. thesis (80% of the grade) and oral presentation (20% of the grade)
	Requirements for registration:	
	Language:	English
	Duration/Size:	maximum 60 minutes (oral presentation: 20 minutes, questions from the examiners: 20 minutes, and questions from the audience: 20 minutes)
Credit Points	30	
Course Type and Usability	Compulsory for M.Sc. ICSS	
Semester	Semester 4 of M.Sc. ICSS; reference semester 4	
Frequency of Offer	Annually in the winter semester	
Duration	1 semester	
Module Coordinator	Head of SICSS	